THEME [INFRA-2011-2.1.1.]
[Design studies for research infrastructures in all S&T fields]

Grant agreement for: Collaborative project*

Annex I - "Description of Work"

Project acronym: LAGUNA-LBNO

Project full title: " Design of a pan-European Infrastructure for Large Apparatus studying Grand Unification, Neutrino Astrophysics and Long Baseline Neutrino Oscillations "

Grant agreement no: 284518

Date of last change: 2011-06-14

Preparation of the DoW date:

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Part A

Workplan Tables

A1:
Project summary

Project Number [1]	284518	Project Acronym [2]	LAGUNA-LBNO

One form per project

General information

Project title [3]	Design of a pan-European Infrastructure for Large Apparatus studying Grand Unification, Neutrino Astrophysics and Long Baseline Neutrino Oscillations		
Starting date [4]	01/09/2011		
Duration in months [5]	36		
Call (part) identifier [6]	FP7-INFRASTRUCTURES-2011-1		
Activity code(s) most relevant to your topic [7]	INFRA-2011-2.1.1.: Design studies for research infrastructures in all S&T fields		
Free keywords [8]		Deep underground science, particle physics, astroparticle physics, long baseline neutrino oscillations	

Abstract [9]

Key questions in physics can be answered only by constructing a giant underground observatory to search for rare events and study terrestrial and astrophysical neutrinos. The Astroparticle Roadmap of ApPEC/ASPERA strongly supports this, recommending that: “a new large European infrastructure of 100'000-500'000 ton for proton decay and low-energy neutrinos be evaluated as a common design study together with the underground infrastructure and eventual detection of accelerator neutrino beams”. The latest CERN roadmap also states:
“a range of very important non-accelerator experiments takes place at the overlap of particle and astroparticle physics exploring otherwise inaccessible phenomena; Council will seek with ApPEC a coordinated strategy in these areas of mutual interest.”
Reacting to this, uniting scientists across Europe with industrial support to produce a very strong collaboration, the LAGUNA FP7 design study has had a very positive effect. It enabled, via study of seven pre-selected locations (Finland, France, Italy, Poland, Romania, Spain and UK), a detailed geo-technical assessment of the giant underground cavern needed, concluding finally that no geo-technical show-stoppers to cavern construction exist. Building on this, the present design study will address two challenges vital to making a final detector and site choice: (i) to determine the full cost of construction underground, commissioning and long-term operation of the infrastructure, and (ii) to determine the full impact of including long baseline neutrino physics with beams from CERN.

A2:
List of Beneficiaries

Project Number [1]	284518	Project Acronym [2]	LAGUNA-LBNO

List of Beneficiaries

No	Name	Short name	Country	Project entry month[10]	Project exit month
1	Eidgenössische Technische Hochschule Zürich	ETH Zurich	Switzerland	1	36
2	UNIVERSITAET BERN	U-Bern	Switzerland	1	36
3	UNIVERSITE DE GENEVE	UNIGE	Switzerland	1	36
4	LOMBARDI ENGINNERING SA	LOMBARDI	Switzerland	1	36
5	EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH	CERN	Switzerland	1	36
6	JYVASKYLAN YLIOPISTO	JYU	Finland	1	36
7	HELSINGIN YLIOPISTO	UH	Finland	1	36
8	OULUN YLIOPISTO	UOULU	Finland	1	36
9	Kalliosuunnittelu Oy Rockplan Ltd	ROCKPLAN	Finland	1	36
10	COMMISSARIAT A L ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES	CEA	France	1	36
11	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	CNRS-IN2P3	France	1	36
12	TECHNISCHE UNIVERSITAET MUENCHEN	TUM	Germany	1	36
13	UNIVERSITAET HAMBURG	UHAM	Germany	1	36
14	THE HENRYK NIEWODNICZANSKI INSTITUTE OF NUCLEAR PHYSICS, POLISH ACADEMY OF SCIENCES	IFJ-PAN	Poland	1	36
15	INSTYTUT PROBLEMOW JADROWYCH IM.ANDRZEJA SOLTANA - ANDRZEJ SOLTAN INSTITUTE FOR NUCLEAR STUDIES	IPJ	Poland	1	36
16	POLITECHNIKA WROCLAWSKA	PWr	Poland	1	36
17	KGHM CUPRUM SP ZOO CENTRUM BADAWCZO-ROZWOJOWE	KGHM CUPRUM	Poland	1	36
18	CONSORCIO PARA EL EQUIPAMIENTO Y EXPLOTACION DEL LABORATORIO SUBTERRANEO DE CANFRANC	LSC	Spain	1	36
19	UNIVERSIDAD AUTONOMA DE MADRID	UAM	Spain	1	36
20	AGENCIA ESTATAL CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS	CSIC	Spain	1	36

No	Name	Short name	Country	Project entry month[10]	Project exit month
21	ACCIONA INGENIERIA SA	ACCIONA	Spain	1	36
22	IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE	IMPERIAL	United Kingdom	1	36
23	UNIVERSITY OF DURHAM	UDUR	United Kingdom	1	36
24	THE CHANCELLOR, MASTERS AND SCHOLARS OF THE UNIVERSITY OF OXFORD	UOXF-DL	United Kingdom	1	36
25	THE UNIVERSITY OF LIVERPOOL	U-LIVERPOOL	United Kingdom	1	36
26	THE UNIVERSITY OF SHEFFIELD	USFD	United Kingdom	1	36
27	SCIENCE AND TECHNOLOGY FACILITIES COUNCIL	RAL	United Kingdom	1	36
28	THE UNIVERSITY OF WARWICK	WARWICK	United Kingdom	1	36
29	QUEEN MARY AND WESTFIELD COLLEGE, UNIVERSITY OF LONDON	QMUL	United Kingdom	1	36
30	TECHNODYNE INTERNATIONAL LIMITED	Technodyne	United Kingdom	1	36
31	ALAN AULD GROUP LIMITED	ALAN AULD LTD	United Kingdom	1	36
32	RHYAL ENGINEERING LIMITED	REL	United Kingdom	1	36
33	SOCIETE FRANCAISE D ETUDES ET DE REALISATIONS D EQUIPEMENTS GAZIERS SOFREGAZ SA	SOFREGAZ	France	1	36
34	AGT INGEGNERIA SRL	AGT Ingegneria Srl	Italy	1	36
35	NATIONAL CENTER FOR SCIENTIFIC RESEARCH "DEMOKRITOS"	DEMOKRITOS	Greece	1	36
36	INSTITUTUL NATIONAL DE CERCETARE -DEZVOLTARE PENTRU FIZICA SI INGINERIE NUCLEARA "HORIA HULUBEI" (IFIN-HH)	IFIN - HH	Romania	1	36
37	UNIVERSITATEA DIN BUCURESTI	UoB	Romania	1	36
38	Institute for Nuclear Research	INR	Russian Federation	1	36
39	B.P.Konstantinov PETERSBURG NUCLEAR PHYSICS INSTITUTE RUSSIAN ACADEMY OF SCIENCES	PNPI	Russian Federation	1	36
40	INTER-UNIVERSITY RESEARCH INSTITUTE CORPORATION, HIGH ENERGY ACCELERATOR RESEARCH ORGANISATION	KEK	Japan	1	36

A3:
Budget Breakdown

Project Number [1]	284518	Project Acronym [2]	LAGUNA-LBNO

One Form per Project

Participant number in this project [11]	Participant short name	Fund. % [12]	Ind. costs [13]	Estimated eligible costs (whole duration of the project)					Total receipts	Requested EU contribution
				RTD / Innovation (A)	Demonstration (B)	Management (C)	Other (D)	Total A+B+C+D		
1	ETH Zurich	75.0	T	846,400.00	0.00	320,000.00	0.00	1,166,400.00	0.00	322,200.00
2	U-Bern	75.0	T	248,800.00	0.00	0.00	0.00	248,800.00	0.00	45,000.00
3	UNIGE	75.0	T	543,360.00	0.00	0.00	0.00	543,360.00	0.00	68,000.00
4	LOMBARDI	75.0	T	160,000.00	0.00	0.00	0.00	160,000.00	0.00	120,000.00
5	CERN	75.0	T	2,208,107.20	0.00	0.00	0.00	2,208,107.20	0.00	1,656,080.00
6	JYU	75.0	T	192,000.00	0.00	0.00	0.00	192,000.00	0.00	120,000.00
7	UH	75.0	T	47,840.00	0.00	0.00	0.00	47,840.00	0.00	8,700.00
8	UOULU	75.0	T	70,400.00	0.00	0.00	0.00	70,400.00	0.00	15,000.00
9	ROCKPLAN	75.0	T	416,000.00	0.00	0.00	0.00	416,000.00	0.00	312,000.00
10	CEA	75.0	A	445,300.00	0.00	0.00	0.00	445,300.00	0.00	143,000.00
11	CNRS-IN2P3	75.0	T	624,559.33	0.00	57,600.00	0.00	682,159.33	0.00	179,000.00
12	TUM	75.0	T	144,000.00	0.00	0.00	0.00	144,000.00	0.00	94,000.00
13	UHAM	75.0	T	205,120.00	0.00	0.00	0.00	205,120.00	0.00	57,000.00
14	IFJ-PAN	75.0	T	22,400.00	0.00	0.00	0.00	22,400.00	0.00	8,960.00
15	IPJ	75.0	T	22,400.00	0.00	0.00	0.00	22,400.00	0.00	8,960.00
16	PWr	75.0	T	31,200.00	0.00	0.00	0.00	31,200.00	0.00	23,400.00
17	KGHM CUPRUM	50.0	A	53,200.00	0.00	0.00	0.00	53,200.00	0.00	26,600.00
18	LSC	75.0	T	52,160.00	0.00	0.00	0.00	52,160.00	0.00	17,000.00
19	UAM	75.0	T	25,600.00	0.00	1,216.00	0.00	26,816.00	0.00	19,640.00
20	CSIC	75.0	A	252,480.00	0.00	0.00	0.00	252,480.00	0.00	54,000.00
21	ACCIONA	50.0	A	60,000.00	0.00	0.00	0.00	60,000.00	0.00	30,000.00

A3:
Budget Breakdown

Participant number in this project [11]	Participant short name	Fund. %[12]	Ind. costs[13]	Estimated eligible costs (whole duration of the project)					Total receipts	Requested EU contribution
				RTD / Innovation (A)	Demonstration (B)	Management (C)	Other (D)	Total A+B+C+D		
22	IMPERIAL	75.0	T	41,760.00	0.00	0.00	0.00	41,760.00	0.00	31,320.00
23	UDUR	75.0	T	213,508.80	0.00	67,675.20	0.00	281,184.00	0.00	154,270.00
24	UOXF-DL	75.0	T	113,056.00	0.00	0.00	0.00	113,056.00	0.00	84,792.00
25	U-LIVERPOOL	75.0	T	378,854.40	0.00	0.00	0.00	378,854.40	0.00	65,000.00
26	USFD	75.0	T	35,520.00	0.00	0.00	0.00	35,520.00	0.00	17,000.00
27	RAL	75.0	A	65,400.00	0.00	0.00	0.00	65,400.00	0.00	49,050.00
28	WARWICK	75.0	T	228,424.00	0.00	0.00	0.00	228,424.00	0.00	47,000.00
29	QMUL	75.0	T	64,000.00	0.00	0.00	0.00	64,000.00	0.00	48,000.00
30	Technodyne	75.0	T	282,080.00	0.00	0.00	0.00	282,080.00	0.00	211,560.00
31	ALAN AULD LTD	75.0	S	433,275.00	0.00	0.00	0.00	433,275.00	0.00	323,160.00
32	REL	75.0	T	256,000.00	0.00	0.00	0.00	256,000.00	0.00	190,000.00
33	SOFREGAZ	50.0	F	384,000.00	0.00	0.00	0.00	384,000.00	0.00	192,000.00
34	AGT Ingegneria Srl	75.0	T	96,000.00	0.00	0.00	0.00	96,000.00	0.00	68,000.00
35	DEMOKRITOS	75.0	S	134,000.00	0.00	0.00	0.00	134,000.00	0.00	48,000.00
36	IFIN - HH	75.0	F	55,231.20	0.00	0.00	0.00	55,231.20	0.00	9,600.00
37	UoB	75.0	T	103,040.00	0.00	0.00	0.00	103,040.00	0.00	9,600.00
38	INR	75.0	T	4,000.00	0.00	0.00	0.00	4,000.00	0.00	3,000.00
39	PNPI	75.0	F	4,146.00	0.00	0.00	0.00	4,146.00	0.00	3,108.00
40	KEK	75.0	T	168,000.00	0.00	0.00	0.00	168,000.00	0.00	17,000.00
Total				9,731,621.93	0.00	446,491.20	0.00	10,178,113.13	0.00	4,900,000.00

Note that the budget mentioned in this table is the total budget requested by the Beneficiary and associated Third Parties.

*** The following funding schemes are distinguished**

Collaborative Project (if a distinction is made in the call please state which type of Collaborative project is referred to: (i) Small of medium-scale focused research project, (ii) Large-scale integrating project, (iii) Project targeted to special groups such as SMEs and other smaller actors), Network of Excellence, Coordination Action, Support Action.

1. Project number

The project number has been assigned by the Commission as the unique identifier for your project, and it cannot be changed. The project number **should appear on each page of the grant agreement preparation documents** to prevent errors during its handling.

2. Project acronym

Use the project acronym as indicated in the submitted proposal. It cannot be changed, unless agreed during the negotiations. The same acronym **should appear on each page of the grant agreement preparation documents** to prevent errors during its handling.

3. Project title

Use the title (preferably no longer than 200 characters) as indicated in the submitted proposal. Minor corrections are possible if agreed during the preparation of the grant agreement.

4. Starting date

Unless a specific (fixed) starting date is duly justified and agreed upon during the preparation of the Grant Agreement, the project will start on the first day of the month following the entry info force of the Grant Agreement (NB : entry into force = signature by the Commission). Please note that if a fixed starting date is used, you will be required to provide a detailed justification on a separate note.

5. Duration

Insert the duration of the project in full months.

6. Call (part) identifier

The Call (part) identifier is the reference number given in the call or part of the call you were addressing, as indicated in the publication of the call in the Official Journal of the European Union. You have to use the identifier given by the Commission in the letter inviting to prepare the grant agreement.

7. Activity code

Select the activity code from the drop-down menu.

8. Free keywords

Use the free keywords from your original proposal; changes and additions are possible.

9. Abstract

10. The month at which the participant joined the consortium, month 1 marking the start date of the project, and all other start dates being relative to this start date.

11. The number allocated by the Consortium to the participant for this project.

12. Include the funding % for RTD/Innovation – either 50% or 75%

13. Indirect cost model
A: Actual Costs
S: Actual Costs Simplified Method
T: Transitional Flat rate
F :Flat Rate

Workplan Tables

Project number

284518

Project title

LAGUNA-LBNO—Design of a pan-European Infrastructure for Large Apparatus studying Grand Unification, Neutrino Astrophysics and Long Baseline Neutrino Oscillations

Call (part) identifier

FP7-INFRASTRUCTURES-2011-1

Funding scheme

Collaborative project

WT1
List of work packages

Project Number [1]	284518	Project Acronym [2]	LAGUNA-LBNO

LIST OF WORK PACKAGES (WP)

WP Number [53]	WP Title	Type of activity [54]	Lead beneficiary number [55]	Person-months [56]	Start month [57]	End month [58]
WP 1	Management, Project Steering, Outreach, International relations	MGT	1	56.40	1	36
WP 2	Deep Underground Facility Construction Plan and Costing	RTD	31	182.60	1	36
WP 3	Detector Lifetime Operation Strategy, Safety and Risks	RTD	6	166.11	1	36
WP 4	Long Base Line Neutrino Beams Prospects and Scenarios for Detector Magnetization	RTD	5	332.15	1	36
WP 5	Underground Science Assessment and Physics Potential Optimization	RTD	23	387.20	1	36
			Total	1,124.46		

WT2:
List of Deliverables

Project Number [1]	284518	Project Acronym [2]	LAGUNA-LBNO

List of Deliverables - to be submitted for review to EC

Delive-rable Number [61]	Deliverable Title	WP number [53]	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
D1.1	First report	1	1	25.00	R	PU	18
D1.2	Final report	1	1	25.00	R	PU	36
D2.1	Draft report on risk identification with risk register for underground construction	2	31	35.00	R	CO	12
D2.2	Report on updated reference tank and underground layout options	2	30	50.00	R	CO	18
D2.3	Interim report ancillary facility and liquid transfer infrastructure and costs, liquid risk analysis	2	31	30.00	R	CO	24
D2.4	Final report feasibility of underground construction, cost and risks	2	31	50.00	R	CO	36
D3.1	Report on costs, safety and risks for production, installation and commission of all instrumentatio	3	6	40.00	R	CO	12
D3.2	Report on costs, safety and risks of liquid process	3	6	40.00	R	CO	18
D3.3	Report on costs, safety and risks of installing the liquids for full lifetime operations	3	6	30.00	R	CO	24
D3.4	Final report on lifetime commissioning and operational	3	6	40.00	R	CO	36

Delive-rable Number [61]	Deliverable Title	WP number [53]	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
	costs, safety and risks of the RI						
D4.1	Final report future conventional beams	4	5	280.00	R	PU	36
D4.2	Report on design and feasibility of magnet configurations	4	5	40.00	R	PU	36
D5.1	Interim report on unified detector simulations and impact on LAGUNA-LBNO detector design	5	23	80.00	R	PU	12
D5.2	Report on comparison of detector-site options for LBL	5	23	100.00	R	PU	24
D5.3	Report on comparison of detector-site options for non-accelerator physics	5	23	70.00	R	PU	24
D5.4	Final report on physics reach of LAGUNA-LBNO options, impact on design and down-select scenarios	5	1	100.00	R	PU	36
			Total	1,035.00			

Project Number [1]	284518	Project Acronym [2]	LAGUNA-LBNO

One form per Work Package

Work package number [53]	WP1	Type of activity [54]	MGT
Work package title	Management, Project Steering, Outreach, International relations		
Start month	1		
End month	36		
Lead beneficiary number [55]	1		

Objectives

Coordinate the contractual, financial and administrative aspects of the Design Study and oversee the technical and scientific work of the other work packages. Ensure that the project milestones are achieved and the deliverables produced on time. Take care of the knowledge management for the Design Study, coordinating the protection, use and dissemination of the knowledge generated during the project.

Description of work and role of partners

• Coordination task: coordination of the contractual, financial and administrative aspects of the Design Study, including delivery of annual reports and control of the funds.
• Oversight task: oversight of the technical and scientific aspects of the Design Study, including the monitoring of milestones and ensuring that deliverables are produced on time.
• Knowledge task: management of the knowledge generated by the Design Study, including its protection, use and dissemination.
• Promote international contacts with North America and Asia. Develop outreach activities in Europe.
• Promote the development of a funding network through the activity of the International Finance Committee

Task 1.1. Development of a management framework
The first task is to establish a management structure to allow efficient coordination of all contractual, financial and administrative aspects of the Design Study. This will be completed within the first 4 months of the project, although the management network created will continue, through the various WP leaders, to monitor milestones, ensuring that deliverables are produced on time.

Task 1.2. Yearly progress and final reports
This task represents the preparation and submission of the project reporting documents to the EC. Based on the findings, a recommendation will be made for the feasibility of the project with respect to scientific performance, underground construction, engineering infrastructure, and cost. This will include a CDR for the facilities and storage vessels selected.
Task 1.3. Steering of the LAGUNA project and definition of the next steps

This next phase will develop the LAGUNA concept to outline design stage for three of the original sites to provide sufficient information to enable a final decision to be made on a suitable site. This decision will be made based on a number of factors including overall cost, and the preferred location of the facility. Any decision of this nature will inevitably be based on a number of compromises. The base information prepared during this next stage of the project will enable weighting to be applied to each of the key headings likely to affect the final location of the facility. An auditable trail would thus be established to reach the final decision more easily. This base information is therefore important since it will provide detailed budget construction costs and schedules for each element of the project to be able to confirm an overall budget cost estimate for the construction of the facility based on a locally modified concept design for construction at each of the three sites. Once the final site has been chosen the next phase will be to refine these costs and programme data based on any new or updated information and then to move onto outline design.
The International Finance Committee (as defined in Section B2.1) will be implemented and will meet several times in order to foster good communication and understanding between the LAGUNA consortium and funding agencies.

Task 1.4 Prospects for interdisciplinary underground science at the LAGUNA site
A facility of the scale and logistic requirements of LAGUNA in a deep underground site opens prospects for many interdisciplinary activities. There is interest to consider these as part of a drive to maximise the user-base and hence benefit to society, yet this also implies potentially significant impacts on the costs and risks to the facility that should be understood in outline before final decisions are made. Work will be carried out to:
• Assess the potential of the LAGUNA facility for, and level of interest in, interdisciplinary activity, particularly in areas of geo-science and engineering, bio-sciences, energy services including carbon sequestration research; the requirements also for outreach to the general public.
• Assess the additional risks, design implications and additional costs implied by such activity and a strategy for its control and management

Task 1.5 Development of a task governance for potential future phases of the project
A key challenge related to the potential realization of LAGUNA is a proper governance structure to manage the different project phases, from construction and commissioning to long-term operation. The governance structure should match the needs of a system acting at a European, National and Regional level. The central issues at stake in the various critical stages of the implementation of LAGUNA should be addressed. Particular attention will be given to the following aspects: (a) The best way of optimizing the use of resources and of the allocated funds through a well-structured and transparent funds management system in order to avoid any waste of resources. (b) How to optimize the involvement of industries, specialized spin off and stakeholders in all the various stages of implementation. The main objective is to promote productive interactions between public and private actors by stimulating a convergence of interests and a close cooperation. Investments at national, regional and local level will be attempted. New funding schemes and strategies will be investigated. (c) Work groups in which LAGUNA's managers and the managers of National and International research laboratories such as CERN, Fermilab or KEK can interact and share the relevant expertise will be set up as well as an advisory panel investigating the best location for LAGUNA RI.
The people involved in this task will promote a set of workshop and meetings. Main goal is to support arrangements of policies across different levels, usually resulting in negotiations or networks of executives and representatives of special interests and actors that are or could be committed in the development of the LAGUNA RI. An interactive grid of relations at all the various levels (intergovernmental, supranational, national, regional and local) involving all the competent actors will be promoted. This action wants to remove the barriers often arising from the interaction in between international and the domestic governance and act as a cohesive system building the widest multilevel political consensus supporting the various stages in view of LAGUNA RI implementation. Workshops and meetings will be promoted in between scientists, stakeholders and experts coming from the industrial world at all the various levels in order to optimize their interaction on the view of LAGUNA RI implementation.

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
1	ETH Zurich	39.60
5	CERN	1.00
6	JYU	3.00
9	ROCKPLAN	1.00
11	CNRS-IN2P3	4.00
19	UAM	0.50
22	IMPERIAL	1.80
23	UDUR	5.00
31	ALAN AULD LTD	0.50
	Total	56.40

List of deliverables

Delive-rable Number [61]	Deliverable Title	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
D1.1	First report	1	25.00	R	PU	18
D1.2	Final report	1	25.00	R	PU	36
		Total	50.00			

Description of deliverables

D1.1) First report: Report of 1st year activities, summarizing the work done by all the WPs and comparing progress against milestones and deliverables. [month 18]

D1.2) Final report: Final report, describing the achievements of the Design Study, including CDR for the facility, checking that all deliverables have been delivered. [month 36]

Schedule of relevant Milestones

Milestone number [59]	Milestone name	Lead benefi-ciary number	Delivery date from Annex I [60]	Comments
MS1	Establish consortium	1	3	Kickoff collaboration meeting, signing Consortium Agreement
MS2	Kickoff General meeting	1	1	
MS3	General meeting #2	1	4	
MS4	General meeting #3	1	7	
MS5	General meeting #4	1	10	
MS6	General meeting #5	1	13	
MS7	General meeting #6	1	16	
MS8	General meeting #7	1	19	Mid Term Review
MS9	General meeting #8	1	22	
MS10	General meeting #9	1	25	
MS11	General meeting #10	1	28	
MS12	General meeting #11	1	31	
MS13	General meeting #12	1	34	
MS14	Final General meeting	1	36	

WT3:
Work package description

Project Number [1]	284518	Project Acronym [2]	LAGUNA-LBNO

One form per Work Package

Work package number [53]	WP2	Type of activity [54]	RTD
Work package title	Deep Underground Facility Construction Plan and Costing		
Start month	1		
End month	36		
Lead beneficiary number [55]	31		

Objectives

To perform all necessary tasks to reach cavern and tank designs and their construction plans, that will allow full costing of the construction of the tank facility for the chosen site and detector configurations including risk analysis. The focus will be on example combinations of MEMPHYS-Fréjus (with scintillator option); GLACIER-Pyhäsalmi; GLACIER-Umbria; LENA- Pyhäsalmi. Close coordination with WP3 and WP5.

Description of work and role of partners

• Appraisal and assessment of the LAGUNA background information; general risk identification and production of risk register.
• Assessment of the feasibility and cost of tank construction underground including enabling works, site interface, cavern-tank construction plan, services and management
• Appraisal and update of tank and cavern underground layouts
• Design, costing and assessment of requirements for auxiliary tanks and liquid transfer infrastructure and pipelines required for safety purposes, including liquid bund enclosures and forced emergency ventilation underground
• Final combined risk analysis and costs for construction aspects up to completion underground of the tank infrastructure, covering the chosen site-tank options and with identification of any major risks.

Task 2.1 Appraisal and assessment of the LAGUNA background
The background information and findings of LAGUNA, principally focused at the rock engineering aspects of the sites, will form the foundations for this WP. This task will consist in a set of very focused meetings accompanied by technical visits to the three sites Fréjus, Pyhäsalmi, Umbria, and will be involving old and new industrial partners, transferring knowledge and creating the necessary team spirit for the successful accomplishment of successive tasks.

Task 2.2 General risk identification, preliminary analysis and risk registry
In many countries it is a legal requirement that all accidents resulting in injury or having the potential to cause harm be reported. The minimum standards are determined by the individual codes and rules set out by the specific site owners, the local law, and the governmental site inspectorate, and would include appropriate training, safety equipment, emergency procedures, and protocols. Mine sites have different issues compared to tunnel sites with regard to emergency egress, ventilation systems, fires, large volume liquid gas emergencies, production of liquid cryogens and air quality monitoring. AAE acting as a risk management consultant, in synergy with the other industrial partners, will identify potential failures or unexpected incidents and their effect on the project and develop the corresponding risk registry. In addition to leaks, fire, engineering delays and scientific underperformance, these should include discovery of unacceptable rock properties during cavern excavation, major underground rock collapse in either the cavern or the access routes, and closure of the host site should it become economically unviable. Although catastrophic rupture of a liquid or liquid noble gas tank in an underground site is by far the worst-case scenario, the technologies involved in large tank production coupled with many decades of incident free operation reduce concern. Leaks are far more likely to occur due to thermal expansion of liquid scintillator or during transfer from the storage facility to the main experimental tanks. In this case total liquid containment is essential and the report will detail ancillary equipment, procedures, control systems, and environmental monitors required to achieve this.

Task 2.3 Feasibility of construction of the underground tanks

This task will be coordinated by AAE, relying largely on its expertise in the field of underground civil, mining engineering and construction. A tank of the required dimension for LAGUNA in an underground environment has never been considered nor built. It is therefore of utmost importance to assess its feasibility and associated costs with experts in the field. In Europe the relevant expertise in the field of underground construction and mining, as well as construction of surface tanks has been identified. This task brings these two fields of expertise together. A strong synergy between all industrial partners will be required: on one hand, Lombardi, AGT and Rockplan will provide input from the rock mechanics and engineering point of view. On the other, Technodyne, Paresa, Ryhal Engineering and Sofregaz will bring their long-standing expertise in the field of very large reservoirs. In order to study the feasibility of the underground tank construction and assess its cost, the sequencing of tank construction will be developed in detail. In addition, industrial partners specialized in the surface construction of large tanks or vessels will be involved. The task will consider the following subtasks:

Subtask 2.3.1 Enabling works: To define site access, temporary construction camp, services including, power, water sewerage, data and communications. These items will be broadly similar with some local variations of individual elements.

Subtask 2.3.2 Site Interface: Each of the three considered sites has specific costs and issues of related to working at that particular location. Preliminary investigations indicate that these could be significantly different at each site and may have a significant effect on the overall budget. Typically big differences have been identified between working at a live mine site and a dedicated laboratory accessed from a road tunnel. This subtask uses information supplied by the project and from the sites and tailor it based on our own knowledge and data.

Subtask 2.3.3 Tank Construction: This subtask will focus on the Logistics for i) manufacture of tank elements; ii) transport to site; iii) transport to erection site underground; iv) erection of tank; v) initial commissioning of tank.

Subtask 2.3.4 Tank Service Infrastructure: This subtask will handle i) Supply of argon, quantities and handling systems; ii) Transport to facility; iii) Surface handling and storage plant; iv) Transport underground; v) Underground cryogenic infrastructure (handling, filling and maintenance); vi) Filling process and safety systems; vii) Site management; viii) Emergency leak infrastructure and safety systems; ix) Vent plant to surface; x) Emergency Escape and fresh air refuge systems; xi) Airlocks to separate tank room from facility; xii) Ventilation of tank chamber and other tunnels.

Subtask 2.3.5 U/G Laboratory Facilities: This subtask will handle i) Cavern and access tunnel construction
Fit out and environmental control; ii) Data links and communication services; iii) Services (power, water, drainage etc.); iv) Workshops, & stores.

Subtask 2.3.6 Site Management: This subtask will handle i) Surface facilites - Offices, car parking, visitor access etc;. ii) Services, water drainage, power etc. (HVAC); iii) Computer systems and data handling; iv) Transport; v) Site maintenance.

Task 2.4 Update of the tank reference designs
Technodyne will update tank designs based on the feedback and an iterative process between the underground infrastructure and access design, and the tank requirements, taking into accounts constructability and safety in a deep underground environment.

Task 2.5 Update of the underground layouts and logistics of cavern construction
The beneficiaries Lombardi, AGT and Rockplan will be responsible for this task. Based on the extensive work performed during the LAGUNA DS, the general design of layout and tasks based on and by combining of
• engineering design of layout
• excavation work (results from LAGUNA-DS/WP2) of the main detector cavern (MDC)
• tank construction (results of Technodyne from task 2.4)
• construction process of the tank (task 2.3.3 to 2.3.5)
• liquid handling, transport, purification & filling (to be studied in WP3)
• implementation of liquid handling in layout (task 2.5)
• adapting of risk mitigating measurements (task 2.2 & 2.7)
• on surface needed construction, actions and works (subtask 2.3.2 & 2.3.6)

In addition, the beneficiary AAE, together with Lombardi, AGT and Rockplan will address the logistics of the cavern construction. Lombardi, AGT and Rockplan will be main parties responsible for this part of the design, i.e.
• Cavern Design and associated tunnels
• Instrumentation & monitoring

• Excavation, temporary support, logistics of spoil handling and materials
• Construction & long term cavern support systems.

Task 2.6 Auxiliary Tanks and Liquid Transfer Infrastructure
The beneficiary AAE will be responsible for this task. A significant risk from long-term operation comes from underground handling of the large quantities of liquids needed, as required e.g. for routine or forced detector maintenance, as assessed by the risk registry. This task will design and cost additional large caverns for auxiliary tanks, liquid bund enclosures and forced emergency ventilation underground. These operational needs require site and liquid-specific infrastructure and associated safety apparatus that are additional to that of the main detector cavern. A big item here is the design and cost of the large extra caverns and tanks needed for storage and/or provision of rapid transport routes to the surface, such as dedicated pipelines. There is much more flexibility available in the design of these caverns and tanks than is the case for the main cavern and tank. The second related issue is the costly operational infrastructure required to facilitate safe maintenance operations of the detector instrumentation where access is needed into the detector tank, necessitating removal of some or all of the liquid. Both these items need to consider also provision for additional power and ventilation services necessary for safety during these procedures. For the latter an assessment and costing is needed for the provision of new or adapted bore-holes to the surface (or alternatives). Three sub-tasks are foreseen:

Sub-task 2.6.1: Auxiliary cavern and tank infrastructure: Given the cost of the liquids involved, it has been recognised that there is a likely need for additional large caverns and tanks for underground storage of liquid in the case of: (i) forced emptying of the main liquid tanks, (ii) need for an instrument repair or upgrade during the lifetime of the facility. This entails additional excavation and cost and associated safety. This includes: (a) Assessment, costs and risks of generic requirements for emergency transfer of liquids for GLACIER, LENA and MEMPHYS; cost and risk comparison (site independent aspects); (b) Design and cost for extra large cavern excavation for emergency liquid storage (site dependent); (c) Design of tanks and/or bunds for forced liquid storage inside the storage caverns: addressing risk of cavern movement etc (partly site independent); (d) Requirement for handling emergency ventilation, power spikes and other services underground.

Sub-task 2.6.2: Large volume liquid transfer during long-term operation: Assessment and comparison of the risks, safety and costs over facility lifetime for MEMPHYS, LENA, GLACIER. The sub-task includes:
• Completion of assessment of first fill liquid delivery and procurement logistics to the underground tank; relative cost dependence on detector and specific sites (site dependent);
• Assessment, costs and risks of all infrastructure requirements for routine transfer of large volumes of liquids for GLACIER, LENA and MEMPHYS; cost and risk comparison (partly site independent)
• Assessment of infrastructure costs and risks for transfer of liquids out of the site if necessary (site dependent): relevant also to decommissioning
• Design and costs of large volume liquid control and monitoring instrumentation and safety systems

Sub-task 2.6.3: Strategy in case of major event
• Strategy for quick transfers of liquid underground between main tanks and emergency tanks in case of incidents; back-up procedures, staff evacuation (partly site independent);
• Critical risks mitigation strategy and costs

Task 2.7 Final risk analysis and identification of any major risks
The beneficiary AAE will be responsible for this task. Risk assessment is particularly pertinent for a project of the size of LAGUNA. The risk registry will be continuously kept up-to-date to reflect the state-of-art in terms of underground layout, tank construction, and mitigation measures.

Task 2.8 Costing exercise for all options and comparison
The beneficiary AAE will be responsible for this task. The cost of securing reliable operation for such a complex experiment, ensuring that operation is done safely and that risks are mitigated, is considered also to be greater than the cost of the main cavern construction. This includes the need to consider any associated major ancillary infrastructures required for operation, such as emergency storage tanks, needed to mitigate safety and risk factors. This task will require strong synergy between all partners and will be a combined exercise of AGT/Lombardi/Rockplan on one side and AAE/Technodyne/Ryhal Engineering/Sofregaz on the other.

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
1	ETH Zurich	7.20
2	U-Bern	7.00
4	LOMBARDI	7.20
6	JYU	1.00
8	UOULU	2.00
9	ROCKPLAN	24.00
10	CEA	4.00
11	CNRS-IN2P3	12.25
12	TUM	6.00
17	KGHM CUPRUM	14.50
18	LSC	4.50
19	UAM	0.50
21	ACCIONA	17.00
26	USFD	11.00
30	Technodyne	10.50
31	ALAN AULD LTD	17.25
32	REL	9.70
33	SOFREGAZ	3.00
34	AGT Ingegneria Srl	10.00
35	DEMOKRITOS	3.00
36	IFIN - HH	4.50
37	UoB	5.00
40	KEK	1.50
	Total	182.60

List of deliverables

Deliverable Number [61]	Deliverable Title	Lead beneficiary number	Estimated indicative person-months	Nature [62]	Dissemination level [63]	Delivery date [64]
D2.1	Draft report on risk identification with risk register for underground construction	31	35.00	R	CO	12
D2.2	Report on updated reference tank and underground layout options	30	50.00	R	CO	18

List of deliverables

Delive-rable Number [61]	Deliverable Title	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
D2.3	Interim report ancillary facility and liquid transfer infrastructure and costs, liquid risk analysis	31	30.00	R	CO	24
D2.4	Final report feasibility of underground construction, cost and risks	31	50.00	R	CO	36
		Total	165.00			

Description of deliverables

D2.1) Draft report on risk identification with risk register for underground construction: Draft report on risk identification with risk register for underground constructions for the LAGUNA-LBNO RI [month 12]

D2.2) Report on updated reference tank and underground layout options: Report on updated reference tank and underground layout options [month 18]

D2.3) Interim report ancillary facility and liquid transfer infrastructure and costs, liquid risk analysis: Interim report on ancillary infrastructure and liquid transfer infrastructure and costs, liquid risk analysis [month 24]

D2.4) Final report feasibility of underground construction, cost and risks: Final report on main underground construction, costs, and risks [month 36]

Schedule of relevant Milestones

Milestone number [59]	Milestone name	Lead benefi-ciary number	Delivery date from Annex I [60]	Comments

WT3:
Work package description

Project Number [1]	284518	Project Acronym [2]	LAGUNA-LBNO

One form per Work Package

Work package number [53]	WP3	Type of activity [54]	RTD
Work package title	Detector Lifetime Operation Strategy, Safety and Risks		
Start month	1		
End month	36		
Lead beneficiary number [55]	6		

Objectives

To make a full assessment of the costs, safety and risks associated with operation of the LAGUNA-LBNO Research Infrastructure for its full lifetime of >30 years, including initial installation and commissioning of all instrumentation, detector, liquid purification plants. In particular also to identify any show-stoppers or other factors associated with operation, installation and running costs, including potential emergency mitigation, that may impact on the construction phase design and costs and potentially on the site-detector final choice. Close coordination with WP2 and WP5.

Description of work and role of partners

• To assess costs, risks, safety and procedures for transfer and installation underground of all instrumentation - covering all example of site-detector combinations (with LENA, GLACIER, MEMPHYS)
• Report on costs, safety and risks of producing and maintaining liquid purification infrastructure.
• To assess costs, risks, safety and procedures for the critical first transfer underground and fill of liquid into the tanks and of continuous liquid operation for duration of the project
• To assess the full lifetime costs of LAGUNA-LBNO including covering major long-term risks, environmental aspects, staff requirements and safety issues associated with operations of the facility and experiment for the full lifetime and assessment of the impact on construction design and costs (link to WP2).

Task 3.1 Transfer and Installation Underground of Scientific Instrumentation - Costs, Safety and Risks
The beneficiary JYF will be responsible for this task. The task will focus on assessing the full cost, risks and safety issues associated with production of the detector instrumentation and associated components suitable for underground installation, transfer to the underground site and initial commissioning. It will build on existing knowledge of the detector costs for GLACIER, LENA and MEMPHYS, requiring only any essential additional costing and design work associated with aspects arising from the need to tailor designs to the particular on-site conditions, including design to ensure ease of transport from the site of production through shafts and tunnels to the completed tank infrastructure underground. This includes, for instance, modest design work to produce manageably sized segments of the main detector components appropriate to the sites.
Assessment of the costs, risks and safety aspects of this is needed for each of the detector concepts separately, including all aspects of assembly underground, both outside and inside the tank infrastructure, by physicists and instrument engineers. The design, cost and risk assessments here will assume that the tank structure itself has been completed and commissioned in advance, as covered in WP2 and that certain infrastructure, such as crane systems are in place. The assumption here is that the facility is handed over from the tank and cavern construction engineers in a clean room state, as a safe working environment at civil levels, akin to the procedures adopted for instance for construction of the SuperKamiokande experiment and that it is ready to accept both the instrumentation itself, likely to be highly sensitive to dirt and radio-contamination, and the personnel appropriate for its installation, being physicists and instrument engineers. Three sub tasks are foreseen:

Sub-task 3.1.1: Detector module and ancillary instrumentation design for underground installation
- strategy, risks and costs: This includes consideration of modularisation design and cost of all detector instrumentation in segments appropriate for transportation from production site to underground tank in clean room conditions

- costs and risks. This needs to cover all three detector concepts, GLACIER, LENA and MEMPHYS. It includes consideration of all tank internal components, such as the PMT array structures and veto assemblies for MEMPHYS and LENA, and the charge readout panels for GLACIER. It includes the electronics and data acquisition infrastructure and also any other ancillary equipment external to the tank required for monitoring and safe routine running of the experiments.

Sub-task 3.1.2: Instrumentation installation and outfitting for science
- strategy and costs: This part covers the work plan and associated costs, risks and safety issues for transport of the instrumentation components covered above, to the underground infrastructure, for all the installation of this instrumentation in and around the tank. Detailed consideration is needed here of the logistics for instrument construction, with particular attention to safety in the tank site because this period will be the first time that scientists rather than construction engineers will be present on-site in significant numbers.

Sub-task 3.1.3: Instrumentation commissioning prior to liquid fill
This aspect follows from above to cover all essential instrumentation tests and safety checks, inspections and potential modifications that can and must be completed up to the point of starting the first liquid fill of the tank. This includes high voltage tests, dummy operation of slow control instrumentation, safety pumps and ventilation, tests of cabling, computing and data acquisition electronics, tests of emergency procedures and communications.

Task 3.2 Transfer and Installation Underground of Purification Plant Infrastucture, Maintenance of Liquid Quality, Costs and Safety Impact

The beneficiary ETHZ will be responsible for this task. Successful long-term operation of LAGUNA requires major infrastructure to guarantee that the liquids used are installed with exceptional purity into the tank and that this purity is maintained for 30 years. In all cases although there is significant prior knowledge, the scale of purification plant required underground is new and must be assessed for capital cost, ancillary cavern construction, operational cost or the safety infrastructure needed underground. There are two broad types of purity infrastructure to consider: (i) that needed to guarantee proper detector functionality, such as removal of electro-negative elements in liquid argon to ensure a long electron drift distance, and (ii) that needed to guarantee the necessary radio-purity to achieve low background, such as removal of U, Th and radon isotopes to achieve a low neutrino energy threshold for particle astrophysics searches.
The former requires design work to allow extrapolation from current knowledge towards the much larger plant requirements for LAGUNA. For the radio-purity issue, a physics assessment is first needed of the contamination levels of U, Th and other radioactive elements that can be tolerated in relation to the physics objectives. Comparison with the technical capability and cost of building radio-purification apparatus will then lead to a cost-benefit analysis to determine a best design relative to the science feasible. Coordination with WP5 is required on the physics requirements and with WP2 on the interface with the tank infrastructure.
A task focuses on the design and costs for the infrastructure required to produce and maintain for long periods the necessary liquid purity required for the liquid to function safely as an efficient detector medium. For GLACIER this includes infrastructure for the initial cleaning of the tank by gas flushing, the necessary pumps, cryogenic traps, ventilation and gas handling systems. Then for continuous operation the cryogenic liquid pumping apparatus, getter, molecular sieve and purification chemical manifolds, the necessary safety and control instrumentation, valves, gauges and pipe network, including connection to the emergency tanks. For LENA and MEMPHYS an infrastructure is needed to remove contaminants from the liquid, and to monitor the quality. Scintillator leaks in the purification network do pose potential safety and environmental hazards in the long term and need to be addressed. For water, the issue is one of major scale-up in purification plant infrastructure and the issue of the input quality from local sources underground or from nearby reservoirs.
Key to the final assessment of the operational and construction costs for the purification infrastructure are the real site-specific requirements. This includes, for instance, the local cost of providing the services, power, operating staff, safety apparatus and procedures for accident mitigation. History clearly shows that the greater risks are present from the continuous operation of fluids in the plant infrastructure external to the main tank, including human error. So particular attention is needed to assessment of safety risks and mitigation against these.

Task 3.3 Initial Liquid Fill and Liquid Operation Commissioning
The beneficiary TUM will be responsible for this task. Once all the scientific and monitoring instrumentation is installed, the liquid purification plant in place and the initial commissioning completed (covered in the tasks above), the next critical phase in the LAGUNA project would be to perform the initial liquid fill. This task aims to adress the work-plan, costs, risks and safety implications of this aspect. It includes assessment of the

practical logistics of collecting, transporting to the site surface and subsequent staging underground of the liquids into the appropriate tanks. The work needs to cover the three detector options and example sites, tailored to those as appropriate, allowing for critical comparison. A key aspect is the procedure for safe liquid movement underground to and through the purification plant such as to minimise the risk of spills and of contamination. Close coordination is again needed with WP2 as this area will impact on infrastructure requirements, for instance for additional roadways or pipelines underground. Three subtasks will be carried out:

Sub-task 3.3.1: Cost and timescale assessment for collection, delivery and staging of liquid to the site surface entrance: This involves surveying with industrial partners involved in the production of the liquids the detailed logistics of transporting, by road, rail or sea, liquids to the site in readiness for transfer underground. Multiple suppliers from different nations may be needed, in particular for liquid argon. Environmental issues are likely to be involved due to the quantity and because of surface storage needs.

Sub-task 3.3.2: Costs, risks and timescales for transfer underground to the tank: Various options for transfer underground have been outlined, including via dedicated pipeline, purpose-built road declines, dedicated containers and trucks. These need a cost and risk analysis comparison and detailed consideration of the implications for additional infrastructure needed, including for instance of ventilation bores. This action requires a close link also to the task covering the emergency storage tank facility.

Sub-task 3.3.3: Liquid operation commissioning: This task covers the final stage of commissioning, culminating in first switch on of the instrumentation in the liquid prior to the start of routine full operation; as well as demonstration of purity.

Task 3.4 Full Lifetime Operational Costs and Implications of the LAGUNA-LBNO Research Infrastructure
The beneficiary UAM will be responsible for this task. A major new research infrastructure such as LAGUNA needs to guarantee lifetime operations. The task will focus on assessing the full cost, procedures, major long-term risks, staff requirements and safety issues associated with operations of the facility and experiment for the full lifetime. The objective then will be to produce a document containing a critical assessment of these aspects, backed by an outline quality assurance procedure, relevant to an assumed operating lifetime of LAGUNA-LBNO of 30 years. Most importantly, any critical risks associated with long-term operation of particular site-detector combinations will be identified, for which there may be no reasonable mitigation strategy. An important expected output will be to highlight generic differences between tunnel sites and mine sites regarding long-term operational costs and safety.
It has been realised that to guarantee safe continuous operation, in addition to normal running costs, significant major components will need periodic replacement to avoid unexpected failure. A strategy for this planned component redundancy, associated costs, logistics implications and risks is thus included. An example would be replacement of major cryogenic or scintillator apparatus, such as pumps, pipe work and chemical filters in the purification plants. These costs and risks are additional to those of the normal operation and hold particular safety hazards. An operational risk register, change control and quality assurance strategy is also required to manage these issues. To aid management the focus will be first on the detector instrumentation lifetime procedures and costs, undertaken largely independent of sites, and secondly on the additional impact and costs associated with operation underground, concentrating mainly on the chosen site options. The separation between detector specific aspects and site specific aspects where possible is deliberate to allow maximum flexibility in the use of the results, for instance in extrapolation to other sites, including outside Europe. Significant differences in the risks and costs of operation between the three detector types are expected, particularly regarding cryogenic components. These are also important to understand in determining a final choice between technologies. Three sub-tasks will be carried out:

Sub-task 3.4.1: Full assessment and comparison of the risks, safety and costs of underground operations and maintenance over facility lifetime of GLACIER, LENA and MEMPHYS instrumentation and liquids, focused on site independent aspects. This includes:
• Critical power, water, ventilation and other services annual costs for safe operation and backup; critical implication and costs of service failure such as of power and mitigation of these;
• Operational persons costs: staff requirements for long-term shifts, technical support and training;
• Planned redundancy strategy of major components and costs: risks of detector or other component failure and associated costs over the project lifetime. Cost requirement for and risk from safety inspections;
• Planned changes to or replacement of liquids for maintenance: liquid top-up requirements; strategy, costs and risks;
• Requirement and cost of long-term safety instrumentation, slow control and trained staff requirements, remote monitoring.

Sub-task 3.4.2: Full assessment and comparison of the impact on annual costs, risks and safety from site specific aspects of normal operations and maintenance over facility lifetime of GLACIER, LENA and MEMPHYS. The focus here is on selected example sites with capability for extrapolation to other tunnel and mine sites as required. This includes:
• Variance and additional risks and costs for normal maintenance and operation associated with each detector operation at specific sites, including delivery of services, access and transport, risk of delays;
• Impact of LAGUNA-LBNO operation on the host site operators including additional risks and costs, implications for long-term rent and lease costs and risks;
• Implications on safety for site host main-users (mines inspectorate or civil authority interactions);
• Extrapolation to other sites.

Sub-task 3.4.3: Total facility operational strategy for risk mitigation, risk register, safety procedures and quality assurance plus associated costs. This includes:
• Quality assurance structure and operational strategy, including risk mitigation and component redundancy plans and costs;
• Complete operational cost comparisons for the three detector options;
• Total operation risks, safety and costs for >30 year lifetime of LAGUNA-LBNO with cost tables for operations; risk register and mitigation strategy, safety assessment; comparison between detector and site options.

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
1	ETH Zurich	10.80
2	U-Bern	7.00
6	JYU	36.00
8	UOULU	4.00
9	ROCKPLAN	11.00
10	CEA	3.00
11	CNRS-IN2P3	9.00
12	TUM	3.50
16	PWr	7.00
16	PWr	0.50
17	KGHM CUPRUM	4.00
18	LSC	2.50
19	UAM	2.20
25	U-LIVERPOOL	10.90
26	USFD	1.50
30	Technodyne	5.50
31	ALAN AULD LTD	6.00
32	REL	7.50
33	SOFREGAZ	6.86
34	AGT Ingegneria Srl	4.25
35	DEMOKRITOS	15.50
36	IFIN - HH	5.40

WT3:
Work package description

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
37	UoB	2.20
	Total	166.11

List of deliverables

Deliverable Number [61]	Deliverable Title	Lead beneficiary number	Estimated indicative person-months	Nature [62]	Dissemination level [63]	Delivery date [64]
D3.1	Report on costs, safety and risks for production, installation and commission of all instrumentatio	6	40.00	R	CO	12
D3.2	Report on costs, safety and risks of liquid process	6	40.00	R	CO	18
D3.3	Report on costs, safety and risks of installing the liquids for full lifetime operations	6	30.00	R	CO	24
D3.4	Final report on lifetime commissioning and operational costs, safety and risks of the RI	6	40.00	R	CO	36
		Total	150.00			

Description of deliverables

D3.1) Report on costs, safety and risks for production, installation and commission of all instrumentatio: Report on costs, safety and risks for production, installation and commissioning of all scientific instrumentation, identification of show-stoppers [month 12]

D3.2) Report on costs, safety and risks of liquid process: Report on costs, safety and risks of liquid process [month 18]

D3.3) Report on costs, safety and risks of installing the liquids for full lifetime operations: Report on costs, safety and risks of installing the liquids for full lifetime operations [month 24]

D3.4) Final report on lifetime commissioning and operational costs, safety and risks of the RI: Final report on lifetime commissioning and operational costs, safety and risks of the full LAGUNA-LBNO research infrastructure [month 36]

Schedule of relevant Milestones

Milestone number [59]	Milestone name	Lead beneficiary number	Delivery date from Annex I [60]	Comments

WT3:
Work package description

Project Number [1]	284518	Project Acronym [2]	LAGUNA-LBNO

One form per Work Package

Work package number [53]	WP4	Type of activity [54]	RTD
Work package title	Long Base Line Neutrino Beams Prospects and Scenarios for Detector Magnetization		
Start month	1		
End month	36		
Lead beneficiary number [55]	5		

Objectives

To develop schemes for construction of new neutrino beams at CERN for the LAGUNA-LBNO programme. This includes study of designs to profit from an increased SPS beam power to 700 kW including layout, and engineering, of a new conventional neutrino beam line based on the CNGS technology, directed towards a LAGUNA site. Also to study a new high power proton accelerator using the LP-SPL followed by a synchrotron and delivering 2MW of beam power at 30-50 GeV. To define layouts at CERN for a 4-5 GeV proton line from the SPL, accumulator and compressor ring and target for a superbeam to Fréjus; a similar NF layout; a 400 GeV proton line from SPS for the target region of a conventional superbeam towards Pyhäsalmi; the proton line from the SPL injecting in the HP-PS synchrotron and extracting protons towards the target of the conventional superbeam considered above. Finally to study synergies with the R&D towards the NF and its potential layout at CERN.

Description of work and role of partners

• To study the impact of CERN SPS accelerator intensity upgrade to neutrino beams
• To assess a CNGS intensity upgrade
• To develop a conceptual design of the CN2PY neutrino beam
• To perform a feasibility study of a 30-50 GeV high power PS
• To determine the definition of the accelerator and beamline layout at CERN
• To study the magnetic configuration for the LAGUNA detector
• To define requirements for near detectors and define their conceptual designs

The tasks described in the following will evolve under the supervision and with the expertise of several key persons in the accelerator groups at CERN. The accomplishment of the tasks will rely on dedicated manpower.

Task 4.1. Study of impact of CERN SPS accelerator intensity upgrade to neutrino beams
This task will be led by CERN. The objective of this task is to determine how one might obtain, through a relatively modest SPS accelerator upgrade programme, the ultimate intensity of 400 GeV protons at CERN, the main specific aim being to bring the beam power up to 750 kW if not within reach of the foreseen upgrade project as LHC injector. In particular this task contains three main topics of investigation: (a) general studies of possible upgrades within the foreseen upgrades for the SPS as the LHC injector; (b) study of what would be required to further increase the SPS beam power to reach 750 kW (from 510 kW today), (3) a study of the limitations and possible mitigation options in the present extraction and primary transfer beam lines for the CNGS beam in order to produce an increased beam power to 750 kW.

Task 4.2 Assessment of intensity upgrade of CNGS facility
This task will be led by CERN and will study the impact on the upgraded SPS intensity in the CNGS secondary beam components and installation. This requires study of the target region, the target and focusing systems, and the decay tunnel and services. The physical layout and civil engineering aspects also need to be considered in relation to the impact on the site, including also provision for installation of a near detector and its required service infrastructure. An important aspect here is the need to determine and resolve issues related to the increased radiation dose.

Task 4.3 Conceptual design of the CN2PY neutrino beam

This task will be led by CERN and will develop the conceptual design of a new beamline, which in contrast to the present CNGS beam pointing South, will correspond to a North localization and will aimed at producing a neutrino beam directed towards the Pyhäsalmi LAGUNA site. The concept will heavily rely on the proven CNGS technology and but capitalizing on experience based on actual operation of the present CNGS facility. The main difference will be that the new beam will be designed for a nominal SPS proton power of 750 kW with the possibility to upgrade to 2MW. Three sub-tasks are foreseen:

Subtask 4.3.1: Optimization studies of the focusing systems in order to get the best possible neutrino flux and purity given the requirements of the energy spectrum coming from studies performed in WP5 and in complementarity to those in Task 4.2. The potential benefits of moving focusing elements will be considered, as, for example, the movable horn system of the NUMI beam line at Fermilab, to vary the beam energy distribution. A full neutrino beam simulation using FLUKA/GEANT4 and a method to optimize the magnetic focusing of the pions will be employed. Such tools will lead to a comparison of various superbeams facilities.

Subtask 4.3.2: Development of the basic conceptual design of the target and focusing region based on the parameters defined above, and the sensitivity to these parameters, using expertise obtained in the design of a similar system for a graphite target for the T2K (Japan) project and in studies for a beryllium target for the LBNE (FNAL) project.

Subtask 4.3.3: Dealing with the layout study of the facility considering the new primary beam transfer line with extraction from an appropriate region of the SPS, the target station, the secondary beam as well as the decay tunnel and near detector location determined as a compromise between physics requirements and feasibility.

Task 4.4 Feasibility study of a 30-50 GeV high power PS
This task will be led by CERN. To provide a new very high power and high energy proton source for the CN2PY facility as a potential longer term upgrade of the facility considered in Task 4.3, the feasibility study of a new accelerator HP-PS based on the PS2 but dedicated to the injection to the CN2PY neutrino beam will be performed. The requirements for the LP-SPL to operate as an injector for the new HP-PS will be studied. The work will involve converging on a set of basic parameters of the machine, and will be followed by activities aimed at understanding its feasibility and at defining its main layout (e.g. lattice, size, etc.) and basic components (e.g. magnet parameters, RF, etc). In addition, the option of the HP-SPL as a 5 GeV beam injector coupled to an accumulator ring providing a high-power beam low energy neutrino beam towards the Fréjus site will be studied, focusing on the parameters of the transfer lines and of the accumulator. In performing this work, the impact on the design of complementing the accumulator with a second ring (buncher) to produce an adequate beam for a high power target serving a neutrino factory will be envisioned.

Task 4.5 Definition of the accelerators and beamlines layout at CERN
This task will be led by CERN. The conceptual feasibilities of new beam lines and/or new accelerators, such as those considered in tasks 4.3 and 4.4, must be complemented with potential implementation within the complex CERN landscape. Because accelerators are presently located underground at different levels and potentially in different region of CERN, it is necessary to perform a 3D layout of the new facilities. Concretely, a designer will be focusing on the update and definition on the CERN territory for (a) a 4-5 GeV proton line from the SPL to an accumulator and a compressor ring followed by a target region for a superbeam directed towards Fréjus; (b) a similar layout but for the target region of a NF and the corresponding NF layout; (c) a 400 GeV proton line from SPS for the target region of a conventional superbeam towards Pyhäsalmi, Finland; (d) the proton line from the SPL injecting in the HP-PS synchrotron and extracting protons towards the target of the conventional superbeam considered above under item (c). The task will be performed in synergy with the R&D towards the NF and its potential layout at CERN.

Task 4.6 Study of the Magnetic Configuration for the LAGUNA detector
This task will be led by CERN. The use of magnetic fields for momentum spectrometry in particle detectors has a long history and most of the problems have been studied in the past. And this task recognises the need to consider the design issues surrounding magnetisation into the LAGUNA detector, for instance as mandatory with a neutrino factory. Large magnets for detectors have used a variety of configurations in the past: solenoids, the most frequent type, but also toroids or dipoles. Factors to considers are the peak fields, the forces and the stored energies. Usually solenoids are favored. However, toroids (and for certain cases also dipoles) have field lines always perpendicular to the particle trajectory, whose advantages will be addressed in WP5. The final evaluation depends critically on the physics scope and on the actual layout of the detector. If relatively low fields are acceptable (~0.25-0.5 T) toroids could be advantageous, for higher fields (~1 T), certainly solenoids look more promising. These figures must be coupled with consideration of the size of the detector. The GLACIER

option with the liquid argon at its boiling point of 87 K makes it accessible to High Temperature Superconductors like Bi-2223 (Tcr = 110 K) and Ybco (Tcr = 93 K). Recent improvement in performance makes possible the design of Sc magnets at high temperature with a natural synergy between the cryostat and cryogenic system of the LAr chamber and the one of the magnet. Based on this we will study several concepts, classified here according to the degree of synergy between magnet and LAr chamber:
(a) Moderate synergy: study of the use of the LAr chamber as a thermal shield; this implies operation of SC coils at 4 K, as adopted for the ATLAS Sc solenoid. However in the case of our study we would push the possible synergy very far by examining also the possibility to work at higher temperature, i.e. 10-25 K, by using He gas and MgB2 superconductor.
(b) High degree of synergy: study of the LAr chamber as a cryostat of the magnet, with the coil container working at 65-70 K. This is possible by use of cryocoolers. This solution would enable use of Bi-2223 and Ybco.
(c) Full synergy: study of the LAr fluid as coolant for the coils such that the coils can be posed directly in the LAr chamber, with only a thin wall to separate them from the bath to avoid contamination. The advantage in cost and integration are evident here, however the performance of the superconductors at 87 K is much reduced. However, given the big advantage, this solution must be fully investigated.
All of these solutions must be compared with the classical solution of using helium cooled Sc magnets based on Nb-Ti stabilized with pure aluminum. The study should include evaluation of the basic performance of various configurations, evaluation of the performance of the most promising Superconductors, and evaluation of the structure, integration issues and cost of the different options. As a final task the cost resources needed for building such systems will be evaluated for the various options with a possible time schedule to carry out a full technical design, for building a prototype of significant size and then the manufacture of the full magnetic system.

Task 4.7 Definition of near detector requirements and development of conceptual design
The beneficiary UniGe will be responsible for this task. The next generation of neutrino oscillation experiments is aimed at observation of CP asymmetry and/or matter effects. For the superbeam, this will emphasize precise measurement at the distant, large detector location, of the probabilities of both of electron-neutrino appearance in a muon neutrino beam and electron-antineutrinos appearance in a muon-antineutrino beam. For the betabeam and neutrino factory, this will emphasize the need to measure the muon neutrino (or antineutrino) appearance in an electron neutrino (resp. antineutrino) beam. For the neutrino factory the appearance of tau neutrinos (or antineutrinos) in the electron neutrino (antineutrino) beam is another premium allowing further elimination of parameter ambiguities. These measurements lead to several requirements:
☐ the beam intensity at the source must be carefully predicted and monitored;
☐ the beam composition at the source must be determined both by calculations and measurements;
☐ the cross-sections for the appearance signals and for their backgrounds must be determined in conditions as identical as possible to those of the far detector.
This will require a suite of instrumentation, starting with measurements of the relevant source parameters. For the superbeam, these consist of measurements of particle production in the primary target, control of proton beam parameters, and beamline instrumentation. The neutrino beam composition and the measurements of relevant cross-sections will require a neutrino detector installed near the source on the beamline, called near detector. In the superbeam, this has to be the same beamline, at a distance following the end of the decay tunnel that has to be determined by consideration of feasibility and possible geometrical aberrations. The detector technology has to be chosen such that it allows for the much higher intensity seen in the near detector than in the far detector. For instance, in the T2K experiment, although the far detector is a water Cherenkov, the near detector material is mostly plastic scintillator. To take full advantage of the capabilities of the far detector, the near detector must have efficiencies and coverage that are equal or superior to the far detector. Because the superbeam is not a pure muon neutrino (or antineutrino) beam but contains unavoidable amounts of electron neutrinos and antineutrinos, and also a wrong charge component (antineutrinos in the neutrino beam and vice versa) a magnetic detector may be advisable. In addition the backgrounds to appearance signal involve particle misidentification, typically when a neutral or charged meson is confused with a lepton (π^0 to electron confusion in the super-beam, charged pion to muon confusion in the betabeam; π, K or D decay in to muons in the neutrino factory). These backgrounds must be measured in the near detector, since the underlying theory of particle production by neutrino interactions is not known reliably enough. It should be emphasized that the neutrino energies considered for the superbeams from CERN, either around 300 MeV for the neutrino beam to Fréjus or 4.5 GeV for the superbeam to Pyhäsalmi, are different from any neutrino beam considered elsewhere and require their own cross-sections and background measurements. The low energy beam, in particular, is very demanding on the near detector design.

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
1	ETH Zurich	7.20
3	UNIGE	32.40
5	CERN	231.20
6	JYU	1.00
10	CEA	23.00
11	CNRS-IN2P3	2.50
12	TUM	1.00
24	UOXF-DL	3.00
25	U-LIVERPOOL	11.20
27	RAL	3.50
36	IFIN - HH	2.30
37	UoB	3.30
38	INR	3.50
40	KEK	7.05
	Total	332.15

List of deliverables

Delive-rable Number [61]	Deliverable Title	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
D4.1	Final report future conventional beams	5	280.00	R	PU	36
D4.2	Report on design and feasibility of magnet configurations	5	40.00	R	PU	36
		Total	320.00			

Description of deliverables

D4.1) Final report future conventional beams: Final report on future CERN conventional neutrino beams, feasibility of existing accelerator upgrades and new high power proton sources [month 36]

D4.2) Report on design and feasibility of magnet configurations: Report on design and feasibility of magnet configurations for LAGUNA detectors [month 36]

Schedule of relevant Milestones

Milestone number [59]	Milestone name	Lead beneficiary number	Delivery date from Annex I [60]	Comments
MS41	Impact of CERN SPS accelerator intensity upgrade	5	24	Held meeting on definition of subtasks
MS42	Assessment of SPS proton intensity	5	18	Held meeting on definition of subtasks
MS43	Magnetic Configuration of LAGUNA Detector	5	12	Held meeting on definition of subtasks

Project Number [1]	284518	Project Acronym [2]	LAGUNA-LBNO

One form per Work Package

Work package number [53]	WP5	Type of activity [54]	RTD
Work package title	Underground Science Assessment and Physics Potential Optimization		
Start month	1		
End month	36		
Lead beneficiary number [55]	23		

Objectives

This work package considers the underground science potential of LAGUNA-LBNO with particular emphasis on the impact of using neutrino beams from CERN and on consideration of the potential cost and strategy impact on the detector design depending on physics priorities. Close coordination with WP2, WP3 and WP4 is foreseen. The work develops coherent detector simulations for all three options to study key parameters (backgrounds, resolutions, thresholds, efficiencies); study optimization of the beam parameters (conventional and NF or beta-beam); produce comparison of the physics performance of the detector options and the various example selected sites; understand better the new science to be expected with LAGUNA in the fields of proton decay, neutrino astrophysics (including atmospheric, solar) and geo-science.

Description of work and role of partners

• To produce a common and unified simulation of the performance of each detector option, leading to unified studies of the physics reach
• To assess detector performance for the long baseline neutrino oscillation and high energy neutrino physics areas
• To perform phenomenological studies of neutrino properties in long baseline neutrino oscillation experiments
• To consider high energy astrophysical neutrino aspects including atmospheric neutrinos
• To study low energy neutrinos including from supernovae, geo-physical and man-made sources (reactors and oscillometry)
• To extend proton decay studies, including assessment of site depth requirements

Task 5.1 Common and unified simulation of the detectors performance
UDUR will be responsible for this task.

Task 5.1 is designed to address the coordination and synergy among the activities involved in the study of the large scale facilities, from the experimental, theoretical and phenomenological points of view. Strong links are present with WP3 and WP4 (see Figure 6).

Subtask 5.1.1 Unified studies of the physics reach of the detectors. The detectors under consideration allow us to study proton decay and a variety of neutrinos, from accelerator (studies in WP4) to man-made low energy neutrinos, to astrophysical neutrinos. The simulations will develop a synergetic approach to the full exploitation of the large-scale facilities. The simulation tools will contain the necessary physics inputs:
• The modeling of the sources (solar and supernova neutrinos, supernova relic neutrinos, geo-neutrinos, neutrinos from beams and reactors).
• The propagation of neutrinos to the detector - This includes modeling of matter effects in the propagation of neutrinos through the Earth and inside the supernovae.
• The performances of each detector and the impact of the underground location (with input from WP3).

Subtask 5.1.2 Unified approach to detector simulations. In order to optimise and compare the three detector technology options, a common framework for detector simulations will be set up and used to evaluate the performances of all considered experiments and their physics reach. The detailed simulation of the response of the three types of detectors will include accurate description of geometry and materials and details on light propagation and detection. This simulation will be the basis for evaluating the impact of backgrounds, for optimising the detector design and for evaluating their physics reach in the different physics channels. A common analysis tools for the extraction of (or the determination of the limit on) the measured parameters will be developed. As a result, a decision will be made as to which approaches are the most efficient for the suppression of backgrounds, thus enhancing the sensitivity of the three experiments.

Subtask 5.1.3 Coordination between theoretical, phenomenological and experimental studies. The facilities considered will address fundamental questions on elementary particles and on astrophysical environments. The sensitivity to the relevant physical parameters will help in shaping the design of the detectors and in identifying the critical performance indicators. Given the technical and experimental constraints, the available detector options will be studied in Tasks 5.2 and 5.5 and will need to be assessed based on their physics reach in Tasks 5.3, 5.4 , 5.5 and 5.6. In order to achieve optimised setups with the best physics performance, multiple iterations between the experimental studies and phenomenological ones are needed. The form in which the results of the simulations in Task 5.2 and 5.5 will be provided to the phenomenology groups involved in Tasks 5.3, 5.4 5.5 and 5.6 will be discussed and agreed among the groups involved. A strong coordination and a common strategy will be developed.

Task 5.2 Detector performance for Long Baseline Neutrino Oscillations and High Energy neutrinos
In long baseline neutrino experiments, neutrinos with hundreds of MeV to GeV energies are produced and detected after they have oscillated into muon, electron and tau neutrinos. For each of the three detector options, under consideration: MEMPHYS, LENA and GLACIER, detailed simulations of the response of each detector type will be carried out and will include:
- the study of efficiencies, with their dependence on energy and oscillation channel, versus backgrounds, fiducial volume and energy resolution. Migration matrices will be generated to describe the performance of the detector and the dependence on the energy;
- the evaluation of systematic errors and possible strategies for their reduction;
- the possible tau neutrino detection, depending on the neutrino energy, and its impact on backgrounds;
- the role of magnetization, if relevant;
- the reduction of impact of intrinsic background, for example by comparing near-far detector ratios. This will require close collaboration with the activities in WP4.

The scaling of these performance indicators with detector size will be evaluated. The work will adhere to the guidelines developed in Task 5.1 and performed by experimentalists with input from the phenomenology work carried out in Tasks 5.3 and 5.4. The task is organised around the three detector technologies and hybrid LAGUNA-iron detectors and includes the following subtasks:

Subtask 5.2.1 MEMPHYS option. CNRS - PARIS 7 will be responsible for this subtask focusing on the MEMPHYS performance.

Subtask 5.2.2 LENA option. Hamburg will be responsible for this activity on the LENA performance for high-energy neutrino detection.

Subtask 5.2.3 GLACIER option. U-Warwick, QMUL and UCBL will co-lead this subtask on the performance expected with GLACIER. The impact of the magnetization of GLACIER will be contemplated for neutrino detection and background reduction, in collaboration with WP4.

Subtask 5.2.4 Hybrid detectors. IFIC will coordinate the study of detectors constituted by the LAGUNA one complemented by MIND, a 100 kton iron magnetised detector, which serves as a muon catcher for providing charge discrimination.

Task 5.3 Phenomenological studies of neutrino properties in long baseline neutrino oscillation experiments
UDUR will lead this task. Long baseline neutrino oscillation experiments are the tool of choice for the study of the unknown neutrino parameters: the mixing angle theta13, CP-violation and the type of neutrino mass hierarchy. Using the detector performances established in Task 5.2, the sensitivity to these important unknown neutrino properties will be established for the different experimental configurations with dedicated numerical simulations performed by phenomenology groups. The precision on the measurement of the mass squared differences and on the solar and atmospheric mixing angles will also be assessed and tests of the three-neutrino mixing scenario will be devised, by looking for non-standard neutrino interactions and the existence of sterile neutrinos. Superbeam experiments could be followed by more sensitive experiments, such as a neutrino factory or betabeams. Strong synergy and complementarity is present with a low energy neutrino factory, which could use similar detectors, e.g. a magnetised liquid Argon TPC detector, and the same baselines and consequently same underground location. Coordination with the activities of Task 5.2 and Tasks 3.1, 3.2 and 4.1, 4.2, 4.3, 4.4, 4.5 and 4.6, concerning the accelerator complex, detector technology and detector location will be ensured. WP4

will provide the beam spectra to be used in this task and conversely the physics reach obtained will be used to guide the optimisation of beams in WP4.

Task 5.4 High energy astrophysical neutrinos
IFIC will lead this task. Hundreds of MeVs and GeV neutrinos are produced copiously in the atmosphere and can be used to study neutrino properties, such as neutrino mass squared differences and the neutrino mass hierarchy. The role of magnetisation and/or very large detector size is very important in establishing the neutrino mass hierarchy by comparing neutrinos versus anti-neutrinos. Lower energy neutrino detection is relevant for studies of the atmospheric mixing angle. The sensitivity to the known and unknown neutrino parameters will be established for the different detector technologies, with magnetisation if appropriate, and for the hybrid detector. Attention will be devoted to tau neutrinos, which play a particularly relevant role. If dark matter is constituted by weakly interacting heavy particles, it is expected that high densities of dark matter arise in the core of astrophysical objects. Their annihilation will provide a flux of high-energy neutrinos, which can be studied to provide information on dark matter properties. The assessment of the reach of the detectors will be briefly considered.
The detailed simulation of the physics reach of the detectors will require the input of detector performance from Task 5.2 and the study of the synergy with the long baseline studies in Task 5.3. It will also be an input for backgrounds for Tasks 5.5.2 and 5.6.

Task 5.5 Low energy neutrinos
Low energy neutrinos in the few to tens of MeVs range are produced in many astrophysical objects, the Sun, the Earth, for geo-neutrinos, supernovae, or can be man-made such as reactor neutrinos. The detection of these neutrinos allows us on the one side to determine their properties, e.g. the solar mixing angle, the type of neutrino mass hierarchy, the mass squared differences, and on the other to study the evolution of astrophysical objects such as e.g. supernovae explosions.

Subtask 5.5.1 LENA-option performance for low energy neutrinos. Hamburg will lead this subtask. The detector performance for low energy neutrinos will be studied by means of detailed simulations in order to assess the efficiencies, depending on energy and reaction channel, versus fiducial volume, energy resolution and background rates. The detection sensitivity at low energies is mostly determined by the radio-purity of the target liquid and the used detector materials. As the cleanliness of detector and liquid handling system are of great importance, there is a strong interconnection with the tasks included in WP2 and WP3. A further background to be investigated is neutrons and radioisotopes induced by the residual cosmic muon flux, that depends on the underground location. Finally, the results of Task 5.4 will be valuable as low-energetic signals of atmospheric neutrinos pose an important background for diffuse SN neutrinos and indirect dark matter search.

Subtask 5.5.2 Supernova neutrinos and other astrophysical neutrinos. Hamburg will lead this subtask. Measuring neutrinos from the next galactic supernova is at the frontier of low-energy neutrino physics and astrophysics. A high-statistics neutrino signal can confirm, refute or extend the standard paradigm of stellar core collapse and determine detailed neutrino "light curves" and spectra. Additionally, the observable SN neutrino signal might reveal the imprint of favour oscillation effects that are sensitive to the unknown 1-3 leptonic mixing angle and neutrino mass hierarchy. The input of already available information on the performance of GLACIER and MEMPHYS options at these energies and the results of Task 5.5.2 for LENA will be used. Other astrophysical neutrinos, such as solar neutrinos and geo-neutrinos will be used as a tool to study their parent astrophysical object, for example the helioseismic g-modes in the solar center and the investigation of terrestrial radiogenic heat production.
Subtask 5.5.3 Man-made low energy neutrinos and oscillometry. PNPI will lead the study of the physics reach and experimental challenges of these setups. Man-made low energy neutrinos such as reactor neutrinos and neutrinos generated by portable accelerators allow us to study the values of mass squared differences and mixing angles, in particular the precise measurement of the theta solar and determination of theta13. Low energy mono-energetic neutrinos following electron capture by the nucleus can be used for precise measurement of the mixing angle theta13. This subtask will focus on the study of low energy man-made neutrinos (sources, detection and physics impact) in the LAGUNA detector options.

Task 5.6 Proton decay
UDUR will be responsible for this task. The LAGUNA detector has the unique opportunity to search for proton decay, testing one of the fundamental symmetries in Nature, the baryon number, and giving indirect information on the physics at very high-energy scales. The theoretical prospects for proton decay will be reviewed and the sensitivity to different proton decay channels will be updated using the performances of detectors obtained in

Task 5.2. The study of atmospheric neutrinos in Task 5.4 will be important as input to evaluate the backgrounds for proton decay searches in the different detectors.

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
1	ETH Zurich	18.00
2	U-Bern	14.00
3	UNIGE	18.00
6	JYU	12.00
7	UH	4.60
8	UOULU	5.50
10	CEA	9.00
11	CNRS-IN2P3	33.25
12	TUM	11.00
13	UHAM	53.00
14	IFJ-PAN	18.60
15	IPJ	12.50
19	UAM	1.50
20	CSIC	42.50
23	UDUR	26.00
24	UOXF-DL	9.00
25	U-LIVERPOOL	20.20
26	USFD	1.00
28	WARWICK	24.00
29	QMUL	29.30
36	IFIN - HH	4.00
37	UoB	6.30
38	INR	3.00
39	PNPI	2.10
40	KEK	8.85
	Total	387.20

List of deliverables

Delive-rable Number [61]	Deliverable Title	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
D5.1	Interim report on unified detector simulations and impact on LAGUNA-LBNO detector design	23	80.00	R	PU	12
D5.2	Report on comparison of detector-site options for LBL	23	100.00	R	PU	24
D5.3	Report on comparison of detector-site options for non-accelerator physics	23	70.00	R	PU	24
D5.4	Final report on physics reach of LAGUNA-LBNO options, impact on design and down-select scenarios	1	100.00	R	PU	36
		Total	350.00			

Description of deliverables

D5.1) Interim report on unified detector simulations and impact on LAGUNA-LBNO detector design: Interim report on unified detector simulations and impact on LAGUNA-LBNO detector design [month 12]

D5.2) Report on comparison of detector-site options for LBL: Report on phenomenology and sensitivity comparison of detector-site options for long baseline neutrino physics [month 24]

D5.3) Report on comparison of detector-site options for non-accelerator physics: Report on sensitivity comparisons of detector-site options for non-accelerator physics with low backgrounds [month 24]

D5.4) Final report on physics reach of LAGUNA-LBNO options, impact on design and down-select scenarios: Final report on physics reach of LAGUNA-LBNO options, impact on design and down-select scenarios [month 36]

Schedule of relevant Milestones

Milestone number [59]	Milestone name	Lead benefi-ciary number	Delivery date from Annex I [60]	Comments

WT4:
List of Milestones

Project Number [1]	284518	Project Acronym [2]	LAGUNA-LBNO

List and Schedule of Milestones

Milestone number [59]	Milestone name	WP number [53]	Lead beneficiary number	Delivery date from Annex I [60]	Comments
MS1	Establish consortium	WP1	1	3	Kickoff collaboration meeting, signing Consortium Agreement
MS2	Kickoff General meeting	WP1	1	1	
MS3	General meeting #2	WP1	1	4	
MS4	General meeting #3	WP1	1	7	
MS5	General meeting #4	WP1	1	10	
MS6	General meeting #5	WP1	1	13	
MS7	General meeting #6	WP1	1	16	
MS8	General meeting #7	WP1	1	19	Mid Term Review
MS9	General meeting #8	WP1	1	22	
MS10	General meeting #9	WP1	1	25	
MS11	General meeting #10	WP1	1	28	
MS12	General meeting #11	WP1	1	31	
MS13	General meeting #12	WP1	1	34	
MS14	Final General meeting	WP1	1	36	
MS41	Impact of CERN SPS accelerator intensity upgrade	WP4	5	24	Held meeting on definition of subtasks
MS42	Assessment of SPS proton intensity	WP4	5	18	Held meeting on definition of subtasks
MS43	Magnetic Configuration of LAGUNA Detector	WP4	5	12	Held meeting on definition of subtasks

WT5:
Tentative schedule of Project Reviews

Project Number [1]	284518	Project Acronym [2]	LAGUNA-LBNO

Tentative schedule of Project Reviews			
Review number [65]	Tentative timing	Planned venue of review	Comments, if any
RV 1	10	General meeting #4	
RV 2	19	General meeting #7	Mid Term Review
RV 3	28	Brussels	

WT6:
Project Effort by Beneficiary and Work Package

Project Number [1]	284518	Project Acronym [2]	LAGUNA-LBNO

Indicative efforts (man-months) per Beneficiary per Work Package

Beneficiary number and short-name	WP 1	WP 2	WP 3	WP 4	WP 5	Total per Beneficiary
1 - ETH Zurich	39.60	7.20	10.80	7.20	18.00	82.80
2 - U-Bern	0.00	7.00	7.00	0.00	14.00	28.00
3 - UNIGE	0.00	0.00	0.00	32.40	18.00	50.40
4 - LOMBARDI	0.00	7.20	0.00	0.00	0.00	7.20
5 - CERN	1.00	0.00	0.00	231.20	0.00	232.20
6 - JYU	3.00	1.00	36.00	1.00	12.00	53.00
7 - UH	0.00	0.00	0.00	0.00	4.60	4.60
8 - UOULU	0.00	2.00	4.00	0.00	5.50	11.50
9 - ROCKPLAN	1.00	24.00	11.00	0.00	0.00	36.00
10 - CEA	0.00	4.00	3.00	23.00	9.00	39.00
11 - CNRS-IN2P3	4.00	12.25	9.00	2.50	33.25	61.00
12 - TUM	0.00	6.00	3.50	1.00	11.00	21.50
13 - UHAM	0.00	0.00	0.00	0.00	53.00	53.00
14 - IFJ-PAN	0.00	0.00	0.00	0.00	18.60	18.60
15 - IPJ	0.00	0.00	0.00	0.00	12.50	12.50
16 - PWr	0.00	0.00	7.50	0.00	0.00	7.50
17 - KGHM CUPRUM	0.00	14.50	4.00	0.00	0.00	18.50
18 - LSC	0.00	4.50	2.50	0.00	0.00	7.00
19 - UAM	0.50	0.50	2.20	0.00	1.50	4.70
20 - CSIC	0.00	0.00	0.00	0.00	42.50	42.50
21 - ACCIONA	0.00	17.00	0.00	0.00	0.00	17.00
22 - IMPERIAL	1.80	0.00	0.00	0.00	0.00	1.80

WT6:
Project Effort by Beneficiary and Work Package

Beneficiary number and short-name	WP 1	WP 2	WP 3	WP 4	WP 5	Total per Beneficiary
23 - UDUR	5.00	0.00	0.00	0.00	26.00	31.00
24 - UOXF-DL	0.00	0.00	0.00	3.00	9.00	12.00
25 - U-LIVERPOOL	0.00	0.00	10.90	11.20	20.20	42.30
26 - USFD	0.00	11.00	1.50	0.00	1.00	13.50
27 - RAL	0.00	0.00	0.00	3.50	0.00	3.50
28 - WARWICK	0.00	0.00	0.00	0.00	24.00	24.00
29 - QMUL	0.00	0.00	0.00	0.00	29.30	29.30
30 - Technodyne	0.00	10.50	5.50	0.00	0.00	16.00
31 - ALAN AULD LTD	0.50	17.25	6.00	0.00	0.00	23.75
32 - REL	0.00	9.70	7.50	0.00	0.00	17.20
33 - SOFREGAZ	0.00	3.00	6.86	0.00	0.00	9.86
34 - AGT Ingegneria Srl	0.00	10.00	4.25	0.00	0.00	14.25
35 - DEMOKRITOS	0.00	3.00	15.50	0.00	0.00	18.50
36 - IFIN - HH	0.00	4.50	5.40	2.30	4.00	16.20
37 - UoB	0.00	5.00	2.20	3.30	6.30	16.80
38 - INR	0.00	0.00	0.00	3.50	3.00	6.50
39 - PNPI	0.00	0.00	0.00	0.00	2.10	2.10
40 - KEK	0.00	1.50	0.00	7.05	8.85	17.40
Total	56.40	182.60	166.11	332.15	387.20	1,124.46

WT7:
Project Effort by Activity type per Beneficiary

Project Number [1]	284518	Project Acronym [2]	LAGUNA-LBNO

Indicative efforts per Activity Type per Beneficiary

Activity type	Part. 1 ETH Zur	Part. 2 U-Bern	Part. 3 UNIGE	Part. 4 LOMBARD	Part. 5 CERN	Part. 6 JYU	Part. 7 UH	Part. 8 UOULU	Part. 9 ROCKPLA	Part. 10 CEA	Part. 11 CNRS-IN	Part. 12 TUM	Part. 13 UHAM	Part. 14 IFJ-PAN
1. RTD/Innovation activities														
WP 2	7.20	7.00	0.00	7.20	0.00	1.00	0.00	2.00	24.00	4.00	12.25	6.00	0.00	0.00
WP 3	10.80	7.00	0.00	0.00	0.00	36.00	0.00	4.00	11.00	3.00	9.00	3.50	0.00	0.00
WP 4	7.20	0.00	32.40	0.00	231.20	1.00	0.00	0.00	0.00	23.00	2.50	1.00	0.00	0.00
WP 5	18.00	14.00	18.00	0.00	0.00	12.00	4.60	5.50	0.00	9.00	33.25	11.00	53.00	18.60
Total Research	43.20	28.00	50.40	7.20	231.20	50.00	4.60	11.50	35.00	39.00	57.00	21.50	53.00	18.60
2. Demonstration activities														
Total Demo	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3. Consortium Management activities														
WP 1	39.60	0.00	0.00	0.00	1.00	3.00	0.00	0.00	1.00	0.00	4.00	0.00	0.00	0.00
Total Management	39.60	0.00	0.00	0.00	1.00	3.00	0.00	0.00	1.00	0.00	4.00	0.00	0.00	0.00
4. Other activities														
Total other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	82.80	28.00	50.40	7.20	232.20	53.00	4.60	11.50	36.00	39.00	61.00	21.50	53.00	18.60

WT7:
Project Effort by Activity type per Beneficiary

Activity type	Part. 15 IPJ	Part. 16 PWr	Part. 17 KGHM CU	Part. 18 LSC	Part. 19 UAM	Part. 20 CSIC	Part. 21 ACCIONA	Part. 22 IMPERIA	Part. 23 UDUR	Part. 24 UOXF-DL	Part. 25 U-LIVER	Part. 26 USFD	Part. 27 RAL	Part. 28 WARWICK
1. RTD/Innovation activities														
WP 2	0.00	0.00	14.50	4.50	0.50	0.00	17.00	0.00	0.00	0.00	0.00	11.00	0.00	0.00
WP 3	0.00	7.50	4.00	2.50	2.20	0.00	0.00	0.00	0.00	0.00	10.90	1.50	0.00	0.00
WP 4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.00	11.20	0.00	3.50	0.00
WP 5	12.50	0.00	0.00	0.00	1.50	42.50	0.00	0.00	26.00	9.00	20.20	1.00	0.00	24.00
Total Research	12.50	7.50	18.50	7.00	4.20	42.50	17.00	0.00	26.00	12.00	42.30	13.50	3.50	24.00
2. Demonstration activities														
Total Demo	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3. Consortium Management activities														
WP 1	0.00	0.00	0.00	0.00	0.50	0.00	0.00	1.80	5.00	0.00	0.00	0.00	0.00	0.00
Total Management	0.00	0.00	0.00	0.00	0.50	0.00	0.00	1.80	5.00	0.00	0.00	0.00	0.00	0.00
4. Other activities														
Total other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	12.50	7.50	18.50	7.00	4.70	42.50	17.00	1.80	31.00	12.00	42.30	13.50	3.50	24.00

WT7:
Project Effort by Activity type per Beneficiary

Activity type	Part. 29 QMUL	Part. 30 Technod	Part. 31 ALAN AU	Part. 32 REL	Part. 33 SOFREGA	Part. 34 AGT Ing	Part. 35 DEMOKRI	Part. 36 IFIN -	Part. 37 UoB	Part. 38 INR	Part. 39 PNPI	Part. 40 KEK	Total
1. RTD/Innovation activities													
WP 2	0.00	10.50	17.25	9.70	3.00	10.00	3.00	4.50	5.00	0.00	0.00	1.50	182.60
WP 3	0.00	5.50	6.00	7.50	6.86	4.25	15.50	5.40	2.20	0.00	0.00	0.00	166.11
WP 4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.30	3.30	3.50	0.00	7.05	332.15
WP 5	29.30	0.00	0.00	0.00	0.00	0.00	0.00	4.00	6.30	3.00	2.10	8.85	387.20
Total Research	29.30	16.00	23.25	17.20	9.86	14.25	18.50	16.20	16.80	6.50	2.10	17.40	1,068.06
2. Demonstration activities													
Total Demo	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3. Consortium Management activities													
WP 1	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	56.40
Total Management	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	56.40
4. Other activities													
Total other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	29.30	16.00	23.75	17.20	9.86	14.25	18.50	16.20	16.80	6.50	2.10	17.40	1,124.46

WT8:
Project Effort and costs

Project Number [1]	284518	Project Acronym [2]	LAGUNA-LBNO

Project efforts and costs

Benefi-ciary number	Beneficiary short name	Estimated eligible costs (whole duration of the project)						Total receipts (€)	Requested EU contribution (€)
		Effort (PM)	Personnel costs (€)	Subcontracting (€)	Other Direct costs (€)	Indirect costs OR lump sum, flat-rate or scale-of-unit (€)	Total costs		
1	ETH Zurich	82.80	654,000.00	0.00	75,000.00	437,400.00	1,166,400.00	0.00	322,200.00
2	U-Bern	28.00	155,500.00	0.00	0.00	93,300.00	248,800.00	0.00	45,000.00
3	UNIGE	50.40	309,600.00	0.00	30,000.00	203,760.00	543,360.00	0.00	68,000.00
4	LOMBARDI	7.20	100,000.00	0.00	0.00	60,000.00	160,000.00	0.00	120,000.00
5	CERN	232.20	1,265,067.00	0.00	115,000.00	828,040.20	2,208,107.20	0.00	1,656,080.00
6	JYU	53.00	120,000.00	0.00	0.00	72,000.00	192,000.00	0.00	120,000.00
7	UH	4.60	29,900.00	0.00	0.00	17,940.00	47,840.00	0.00	8,700.00
8	UOULU	11.50	44,000.00	0.00	0.00	26,400.00	70,400.00	0.00	15,000.00
9	ROCKPLAN	36.00	260,000.00	0.00	0.00	156,000.00	416,000.00	0.00	312,000.00
10	CEA	39.00	445,300.00	0.00	0.00	0.00	445,300.00	0.00	143,000.00
11	CNRS-IN2P3	61.00	353,349.58	0.00	73,000.00	255,809.75	682,159.33	0.00	179,000.00
12	TUM	21.50	90,000.00	0.00	0.00	54,000.00	144,000.00	0.00	94,000.00
13	UHAM	53.00	128,200.00	0.00	0.00	76,920.00	205,120.00	0.00	57,000.00
14	IFJ-PAN	18.60	14,000.00	0.00	0.00	8,400.00	22,400.00	0.00	8,960.00
15	IPJ	12.50	14,000.00	0.00	0.00	8,400.00	22,400.00	0.00	8,960.00
16	PWr	7.50	19,500.00	0.00	0.00	11,700.00	31,200.00	0.00	23,400.00
17	KGHM CUPRU	18.50	44,400.00	0.00	0.00	8,800.00	53,200.00	0.00	26,600.00
18	LSC	7.00	32,600.00	0.00	0.00	19,560.00	52,160.00	0.00	17,000.00
19	UAM	4.70	16,000.00	0.00	760.00	10,056.00	26,816.00	0.00	19,640.00
20	CSIC	42.50	157,800.00	0.00	0.00	94,680.00	252,480.00	0.00	54,000.00
21	ACCIONA	17.00	42,000.00	0.00	0.00	18,000.00	60,000.00	0.00	30,000.00

WT8:
Project Effort and costs

Beneficiary number	Beneficiary short name	Estimated eligible costs (whole duration of the project)						Total receipts (€)	Requested EU contribution (€)
		Effort (PM)	Personnel costs (€)	Subcontracting (€)	Other Direct costs (€)	Indirect costs OR lump sum, flat-rate or scale-of-unit (€)	Total costs		
22	IMPERIAL	1.80	20,100.00	0.00	6,000.00	15,660.00	41,760.00	0.00	31,320.00
23	UDUR	31.00	150,740.00	0.00	25,000.00	105,444.00	281,184.00	0.00	154,270.00
24	UOXF-DL	12.00	70,660.00	0.00	0.00	42,396.00	113,056.00	0.00	84,792.00
25	U-LIVERPOO	42.30	197,784.00	0.00	39,000.00	142,070.40	378,854.40	0.00	65,000.00
26	USFD	13.50	19,200.00	0.00	3,000.00	13,320.00	35,520.00	0.00	17,000.00
27	RAL	3.50	55,400.00	0.00	10,000.00	0.00	65,400.00	0.00	49,050.00
28	WARWICK	24.00	142,765.00	0.00	0.00	85,659.00	228,424.00	0.00	47,000.00
29	QMUL	29.30	40,000.00	0.00	0.00	24,000.00	64,000.00	0.00	48,000.00
30	Technodyne	16.00	176,300.00	0.00	0.00	105,780.00	282,080.00	0.00	211,560.00
31	ALAN AULD	23.75	325,000.00	0.00	0.00	108,275.00	433,275.00	0.00	323,160.00
32	REL	17.20	160,000.00	0.00	0.00	96,000.00	256,000.00	0.00	190,000.00
33	SOFREGAZ	9.86	320,000.00	0.00	0.00	64,000.00	384,000.00	0.00	192,000.00
34	AGT Ingegn	14.25	60,000.00	0.00	0.00	36,000.00	96,000.00	0.00	68,000.00
35	DEMOKRITOS	18.50	74,000.00	0.00	4,500.00	55,500.00	134,000.00	0.00	48,000.00
36	IFIN - HH	16.20	46,026.00	0.00	0.00	9,205.20	55,231.20	0.00	9,600.00
37	UoB	16.80	64,400.00	0.00	0.00	38,640.00	103,040.00	0.00	9,600.00
38	INR	6.50	2,500.00	0.00	0.00	1,500.00	4,000.00	0.00	3,000.00
39	PNPI	2.10	3,455.00	0.00	0.00	691.00	4,146.00	0.00	3,108.00
40	KEK	17.40	105,000.00	0.00	0.00	63,000.00	168,000.00	0.00	17,000.00
	Total	1,124.46	6,328,546.58	0.00	381,260.00	3,468,306.55	10,178,113.13	0.00	4,900,000.00

1. Project number

The project number has been assigned by the Commission as the unique identifier for your project. It cannot be changed. The project number **should appear on each page of the grant agreement preparation documents (part A and part B)** to prevent errors during its handling.

2. Project acronym

Use the project acronym as given in the submitted proposal. It cannot be changed unless agreed so during the negotiations. The same acronym **should appear on each page of the grant agreement preparation documents (part A and part B)** to prevent errors during its handling.

53. Work Package number

Work package number: WP1, WP2, WP3, ..., WPn

54. Type of activity

For all FP7 projects each work package must relate to one (and only one) of the following possible types of activity (only if applicable for the chosen funding scheme – must correspond to the GPF Form Ax.v):

• **RTD/INNO =** Research and technological development including scientific coordination - applicable for Collaborative Projects and Networks of Excellence

• **DEM =** Demonstration - applicable for collaborative projects and Research for the Benefit of Specific Groups

• **MGT =** Management of the consortium - applicable for all funding schemes

• **OTHER =** Other specific activities, applicable for all funding schemes

• **COORD =** Coordination activities – applicable only for CAs

• **SUPP =** Support activities – applicable only for SAs

55. Lead beneficiary number

Number of the beneficiary leading the work in this work package.

56. Person-months per work package

The total number of person-months allocated to each work package.

57. Start month

Relative start date for the work in the specific work packages, month 1 marking the start date of the project, and all other start dates being relative to this start date.

58. End month

Relative end date, month 1 marking the start date of the project, and all end dates being relative to this start date.

59. Milestone number

Milestone number:MS1, MS2, …, MSn

60. Delivery date for Milestone

Month in which the milestone will be achieved. Month 1 marking the start date of the project, and all delivery dates being relative to this start date.

61. Deliverable number

Deliverable numbers in order of delivery dates: D1 – Dn

62. Nature

Please indicate the nature of the deliverable using one of the following codes

R = Report, **P** = Prototype, **D** = Demonstrator, **O** = Other

63. Dissemination level

Please indicate the dissemination level using one of the following codes:

• **PU =** Public

• **PP =** Restricted to other programme participants (including the Commission Services)

• **RE =** Restricted to a group specified by the consortium (including the Commission Services)

• **CO =** Confidential, only for members of the consortium (including the Commission Services)

• **Restreint UE =** Classified with the classification level "Restreint UE" according to Commission Decision 2001/844 and amendments

• **Confidentiel UE =** Classified with the mention of the classification level "Confidentiel UE" according to Commission Decision 2001/844 and amendments

• **Secret UE =** Classified with the mention of the classification level "Secret UE" according to Commission Decision 2001/844 and amendments

64. Delivery date for Deliverable

Month in which the deliverables will be available. Month 1 marking the start date of the project, and all delivery dates being relative to this start date

65. Review number

Review number: RV1, RV2, ..., RVn

66. Tentative timing of reviews

Month after which the review will take place. Month 1 marking the start date of the project, and all delivery dates being relative to this start date.

67. Person-months per Deliverable

The total number of person-month allocated to each deliverable.

PART B

COLLABORATIVE PROJECT

Table of Contents

B1. Concept and objectives, progress beyond state-of-the-art, S/T methodology and work plan

B1.1 Concept and project objective(s)

Why next-generation underground neutrino detectors?

Underground neutrino detectors based on large, surface-instrumented, liquid volumes have achieved fundamental results in particle and astro-particle physics, and were able simultaneously to collect events from several different sources. Neutrinos can travel very large distances in space and traverse dense zones of the Universe, since they only very weakly interact with matter, and provide therefore unique information on their sources and an extremely rich physics programme.

In order to move forward, a next-generation very large multipurpose underground neutrino observatory of a total mass in the range of 100 000 to 500 000 tons is needed. This new facility will provide new and unique scientific opportunities, very likely leading to fundamental discoveries. It will allow unprecedented measurement of fundamental neutrino properties, providing us with new and deep insights into their sources, notably the Sun, the core-collapse supernovae and the Earth itself. It will aim at a significant improvement in the sensitivity to proton decay, extending the proton lifetime sensitivities up to 10^{35} years, a range compatible with several theoretical models, pursuing the only possible path to directly test physics at the GUT scale. Moreover, it will detect neutrinos as messengers from further-distant astrophysical objects as well as from the Early Universe, to give us information on processes happening in the Universe, which cannot be studied otherwise. In particular, it will sense a large number of neutrinos emitted by exploding galactic and extragalactic type-II supernovae, allowing an accurate study of the mechanisms driving the explosion. The neutrino observatory will also allow precision studies of other astrophysical or terrestrial sources of neutrinos like solar and atmospheric ones, and search for new sources of astrophysical neutrinos, like, for example, the diffuse neutrino background from relic supernovae or those produced in Dark Matter (WIMP) annihilation in the centre of the Sun or the Earth.

Keeping European leadership and expertise

There is currently no infrastructure in the world able to host instruments of this size, although many European national underground laboratories with high-level technical expertise are currently operated with forefront smaller-scale underground experiments.

Europe is currently leading deep underground science with its four long running deep underground laboratories. But these fields of research are at the forefront of astro-particle and particle physics and are the subject of intense investigation worldwide. The DUSEL (Deep Underground Science and Engineering Laboratory) initiative in the USA and the Japanese plans for a large upgrade at the Kamioka site represent serious competition. European leadership is endangered by the lack of decision on a new and bigger research infrastructure capable of hosting next generation large volume experiments.

A coherent and coordinated study group aimed towards common physics goals was formed at the ApPEC "Munich meeting" in November 2005 with the aim of developing conceptual designs for European large underground detectors, investigating physics complementarities and common R&D needs, fostering work in synergy and problem-solving activities, as well as taking into account the unique technological expertise in Europe and other existing or planned programmes in the world.

This research infrastructure, if built in Europe, will attract scientists from many parts of the globe and will ensure that Europe can continue to play a leading role in the field. Europe must act coherently and in a unified way in deep underground science. The very successful history of CERN, the largest particle physics laboratory in the world, shows that this is in principle possible.

Since 2008, the LAGUNA design study (EC FP7 Grant Agreement No. 212343 FP7-INFRA-2007-1) has had a very positive effect on the European prospects. It has enabled resources to start assessing the feasibility of a large European underground research infrastructure with strong industrial support in seven pre-selected locations (Finland, France, Italy, Poland, Romania, Spain, United Kingdom), to host one or more instrumented tanks filled with liquids (water, liquid scintillator, or liquid Argon).

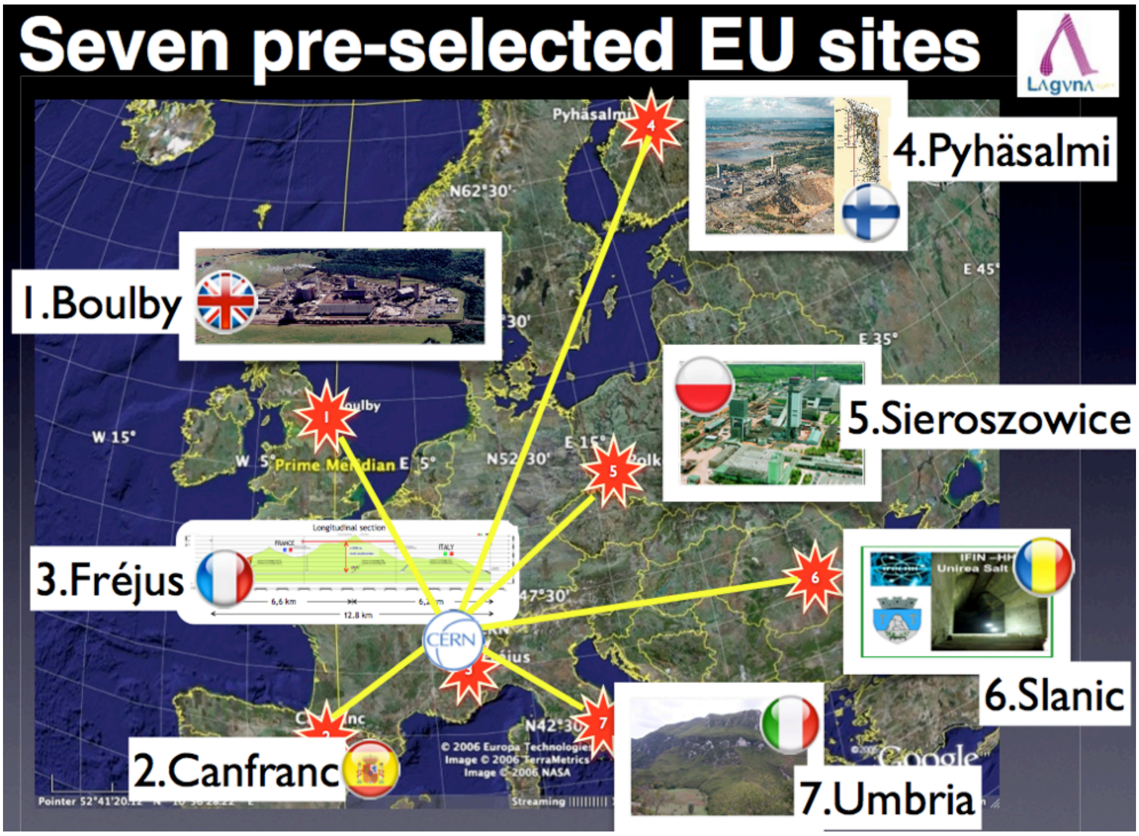

Figure 1 The seven pre-selected sites in the LAGUNA design study.

The LAGUNA design study has also played a really fundamental role in fostering coherence and union among the European scientific community interested in this kind of physics goal. As a result, a very strong collaboration has developed and a very large amount of technical expertise has been gathered to reach the conclusions. No obvious geo-technical show-stoppers have been found so far but several challenges like the cost of deep underground construction, liquid procurement, financing, etc. have been identified.

Comparison with advances in similar projects worldwide, namely LBNE in USA[1] and next generation long-baseline experiments at J-PARC in Japan[2], highlights a clear case for more detailed and advanced design studies of the considered European large underground infrastructure, as well as a broadening of the physics scope to include *prospects for long baseline neutrino physics with artificial beams from accelerators*. When coupled to an artificial neutrino beam, the large underground neutrino detector will measure with unprecedented sensitivity the last unknown mixing angle θ_{13} and unveil the existence of CP violation in the leptonic sector, which in turn could provide an explanation of the matter–antimatter asymmetry in the Universe.

The present DS will be a unique opportunity to act coherently and in a unified way in deep underground science and take a leading role in research fields of fundamental importance for particle and astro-particle physics. The DS will provide the scientific and objective information to make an optimized choice of the site(s) for a European Underground Infrastructure capable of hosting large mass, underground observatories.

B1.2 Progress beyond the state of the art

The need to plan even larger and better instruments

The present DS will include the different detector technologies currently being investigated by various European research institutes, and the different potential underground sites. The objective is now to identify in detail the scientifically and technically most cost-effective strategy for future large-scale underground detectors in Europe. The main deliverable will be a CDR report which will contain all the relevant information for a construction decision around 2013.

In this DS, three technologies (GLACIER, MEMPHYS, LENA) will be evaluated, specifically the full construction and operational costs and risks. This DS will create the opportunity for a concerted effort towards a global optimization of the projects, increasing the probability of success with the elaboration of shared strategies. The three mentioned detector types represent a variety of complementary aspects.

The LAGUNA background

The findings of the LAGUNA design study relevant for the present study are:

1. All the pre-selected sites appear technically and environmentally feasible, so there are several options (unlike in Japan or now USA), though not all sites are interested in all detector options.

2. It appears technically feasible to excavate the desired underground caverns and infrastructures, to build the necessary tanks underground, and to fill them with the desired liquids.

3. The liquid procurement with the needed quantities is feasible for all sites and for all liquids (Water, LAr, LScint), although it might take several calendar years to reach the full *in-situ* procurement.

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[1] The Long Baseline Neutrino Experiment (LBNE) has received CD-0 from the US Department of Energy (DOE). See http://lbne.fnal.gov/.

[2] KEK Roadmap. See http://www.kek.jp/Roadmap/index-en.html.

4. The cost of the excavation, although non-negligible, is not the dominant cost of the project. Thus, in order to proceed towards a technology choice, a better understanding of the costs of the full detector design and construction is now needed, covering also the detector instrumentation and the long-term operation costs

5. Studies indicate that some European options offer potential physics and/or technical advantages that need to be specially and carefully confronted with other options worldwide.

6. The physics goals play a dominant role in selecting the site.

Although significant differences in the cost of the underground infrastructure are expected for the various detector options only moderate differences in the cavern excavation costs for the seven pre-selected sites were found. Furthermore, in all cases, it was recognized that the cavern and associated underground infrastructures themselves, although non negligible, are not the major cost. In order to proceed with the project, a better understanding of the costs of the full detector design and construction including their instrumentation for the three detector options and the full lifetime operational costs of the infrastructure is now essential. This design study is therefore the next logical step.

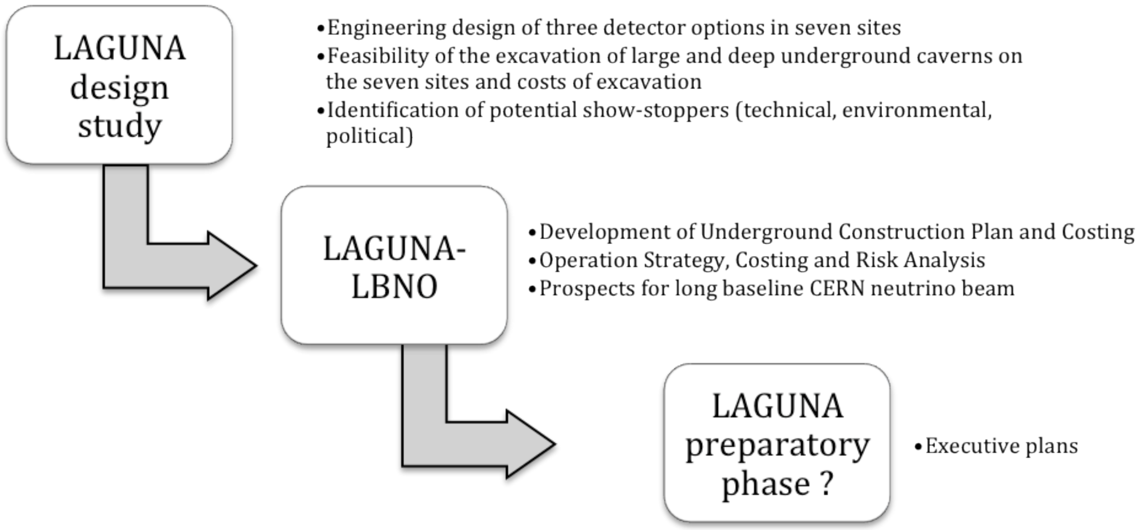


Figure 2: Graded strategy towards the technical definition of the LAGUNA project.

Prospects for long baseline neutrino beams from CERN

The scientific and technical competitiveness of Europe compared to the US and Japan must be evidenced with highest priority. In Europe, CERN has a long tradition in neutrino physics and is currently operating a long baseline neutrino beam to Gran Sasso (CNGS).

Since its beginning, an important point for LAGUNA is the possibility to eventually couple the research instruments with existing or future neutrinos produced with accelerators. In Europe, the CERN Council at its December 1999 meeting had approved the CNGS project. Construction started in September 2000, and the first beam was obtained in the fall 2006. This beam will serve the OPERA experiment at LNGS until 2013. It was known already that further improvement in knowledge of neutrinos oscillation parameters could require more precise measurements of parameters governing neutrino oscillations, which would need new high intensity neutrino oscillation facilities in which neutrino beams are generated using new and highly challenging concepts. But whatever the kind of beam that would be technically realisable, it would require a massive underground detector as a far detector. Therefore, LAGUNA already addressed a fundamental point in the feasibility of a future long baseline neutrinos programme, since it assessed where in Europe, very large underground detectors could be conceivable and at what cost.

The comparison with advances in similar projects worldwide calls for a concrete consideration of *prospects for long baseline neutrino physics with artificial beams from accelerators as an integral part of the LAGUNA-LBNO programme*.

CERN is considered as the only plausible source of high intensity neutrino beams in the near future. It is not possible at this stage to choose between different proton driver accelerator options (so called HP-SPL to be used for the neutrino factory (NF) or the LP-SPL+HP-PS as a driver for the conventional neutrino superbeam). *However, a LAGUNA site can be selected in order to provide an adequate baseline for both options.* Furthermore, in order for the LAGUNA detector to perform physics at a potential future NF beam, the practicability of magnetizing very large volumes must also be considered.

Europe has thus *a priori* the benefit of more flexibility in choice of beam, baseline, and detector technology. Recognising the challenge of investigating all these options we will focus on two combinations and compare them to an option based on the existing infrastructure (CNGS). These represent cases where CERN-LAGUNA can be particularly competitive in a world context:

(a) shortest baseline, no matter effect ➠ Fréjus 130km

(b) longest baseline, matter effect ➠ Pyhäsalmi 2300 km

(c) current baseline with the CNGS beam ➠ Umbria (or LNGS') 650-732km

Create the necessary consortium to fully answer the right questions

The LAGUNA-LBNO consortium will involve the highest-level expertise in Europe for the required tasks. All major European underground laboratories are partners or will be consulted, and all candidate sites are represented. The best companies in underground engineering have been selected as partners. All universities and institutes participating in the collaborations of the suggested experiments are taking part in the project. Human resources include more than 60 top-level scientists, representing also the scientific community taking advantage of the results of the experiments to be performed in the laboratories.

Towards a site and technology choice, and the risk of falling behind other continents

Without any doubt, a very large underground detector facility has an extremely rich physics programme. The construction and operation clearly represents a difficult technological challenge and a significant investment on the scale of several hundred millions of Euros. It is intimately connected to the question of large underground infrastructures. The choice of the most appropriate technology, of the site and of the designs of such super-massive detectors should be carefully optimized taking into account the technical feasibility and all predicted costs over the lifetime of at least 30 years, the multiple physics goals, and also the possible existence of accelerator neutrino beams. The technical and economical feasibility of an underground observatory of this magnitude, perhaps ultimate in size, requires strong coordination and a coherent European strategy and will be heavily reliant on the possibility to contain costs compared to today's state-of-the-art by a careful optimization of all elements involved in the project: (1) the excavation and preparation of the underground space, (2) the design and construction of the tank, (3) the instrumentation, (4) commissioning and lifetime operation, and (5) the safety and risk aspects. This implies that cost is optimized at all levels of the project, and must heavily rely on careful design and engineering.

This study will develop a coherent and well-coordinated EU-wide design effort towards a large infrastructure, taking into account the unique technological expertise in rare event detection technologies, underground excavation and construction, such that mature designs and credible scenarios can be proposed around 2013.

B1.3 S/T Methodology and associated work plan

B1.3.1 Overall strategy and general description

The work breakdown structure (WBS) of the LAGUNA project is shown below. The main goal of this DS is to bring together on the one hand the scientific community interested in this kind of research infrastructure and on the other the industrial and technical experts able to help assess its feasibility. The DS is subdivided into 5 work packages (WP), interconnected with each other. The list of WP is shown in Figure 3.

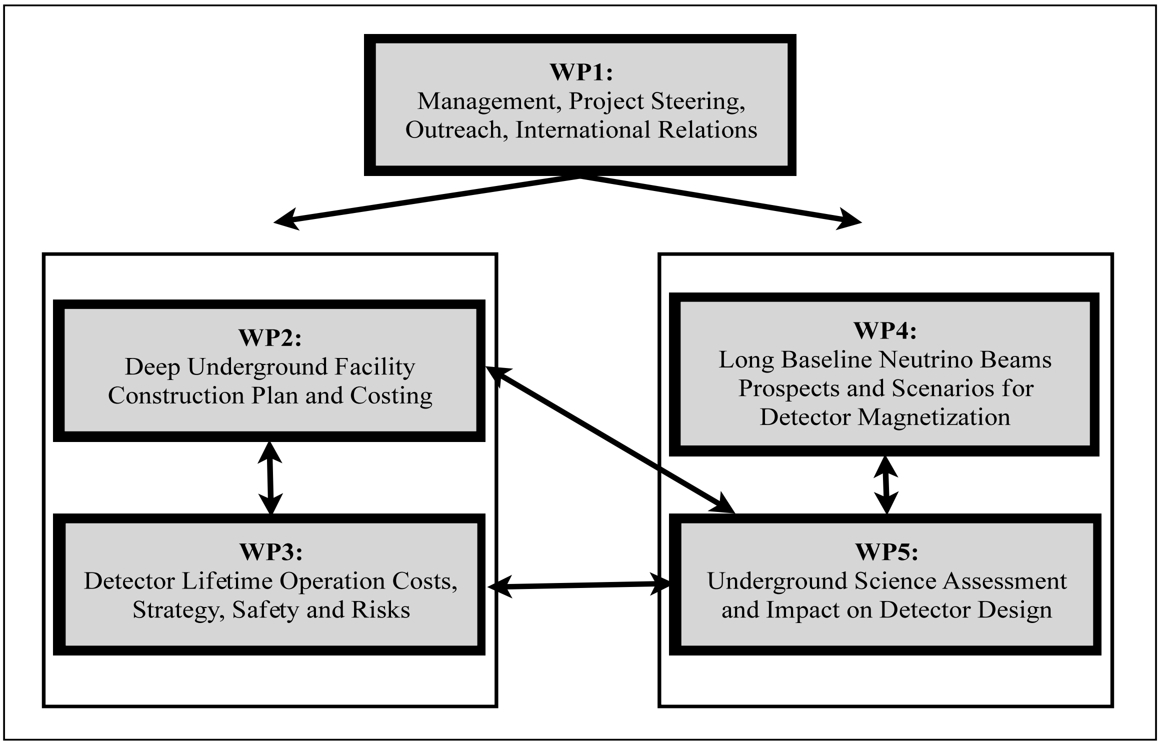


Figure 3 Relationship among work packages.

WP1 – Management, Project Steering, Outreach, International relations
This WP will be led by ETHZ and will be coordinated by André Rubbia (ETHZ). The management WP will coordinate the contractual, financial and administrative aspects of the Design Study and will oversee the technical and scientific work of the other WPs. It will be responsible for ensuring the project milestones are achieved and the deliverables produced on time. Furthermore, this WP will be responsible for knowledge management for the Design Study, coordinating the protection, use and dissemination of the knowledge generated during the project.

WP2 – Deep Underground Facility Construction Plan and Costing
This WP will be led by the AAE beneficiary and will be coordinated by John Elliot (AAE). One of the next challenges is to understand the costs of the detectors, in order to make a

choice. The main purpose of WP2 is therefore to coordinate and perform all necessary tasks in order to reach cavern and tank designs and their construction plans, which will allow to cost the construction of the facility for the chosen site and detector configurations.

In order to minimize duplications and avoid a large number of options, we focus on the following options:

1. MEMPHYS at the Fréjus site, composed of (a) two independent tanks filled with water, or (b) one mixed solution with 1 LENA tank and two WC modules;
2. GLACIER at the Pyhäsalmi site on the 900 level;
3. LENA at the Pyhäsalmi site on the 1400 level;
4. GLACIER at the Umbria site.

In the case of the cryogenic liquid (GLACIER) investigations in the first phase of LAGUNA and advising from experts in the field strongly recommended a decoupling of the cavern and tank. The retained solution is therefore that of the self-standing tank. For the MEMPHYS and LENA options, the tank solution is either that of a cavern lining or a self-standing tank. These aspects will be analysed further as part of this work-package.

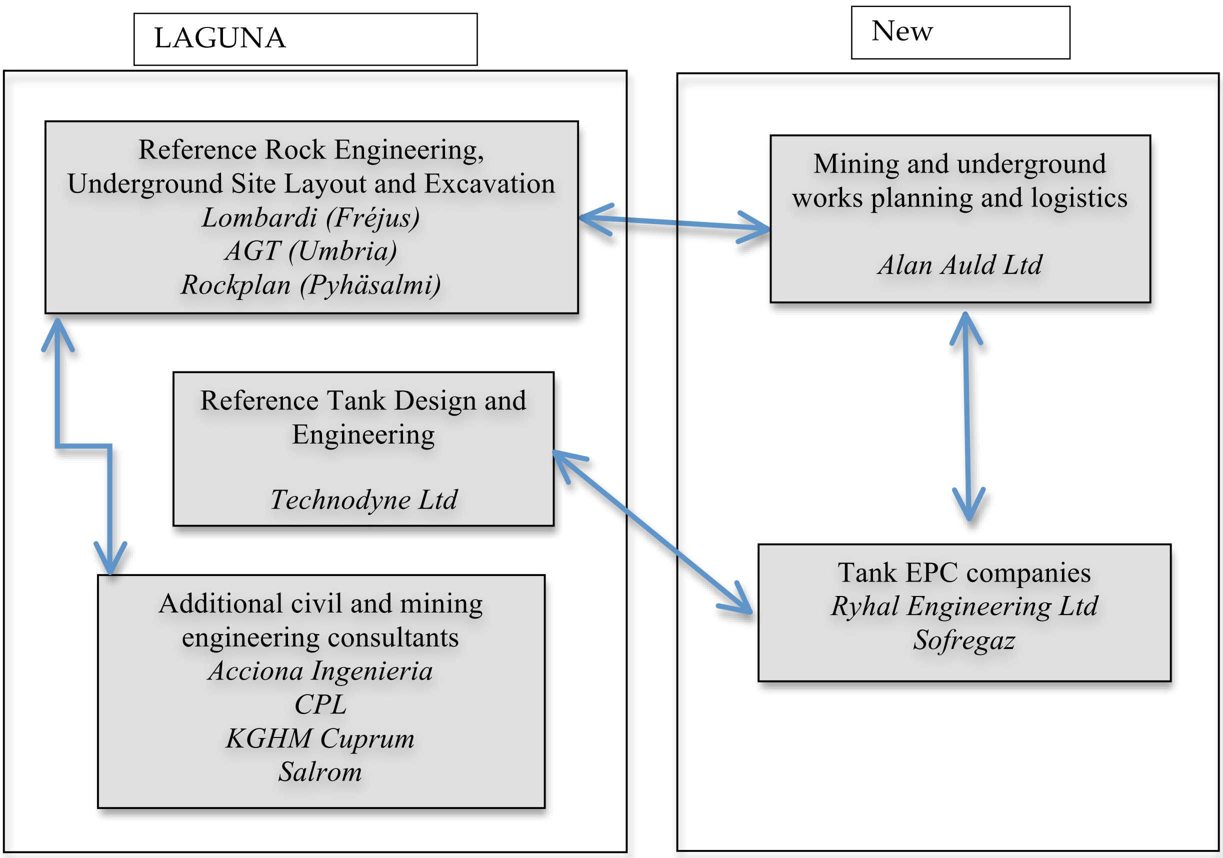


Figure 4: Relationship among industrial partners and their competence for WP2. The partners that have newly joined the project are shown. The other industrial partners were already involved in the LAGUNA project.

WP3 – Production and Installation of Instrumentation, Commissioning and Facility Lifetime Costs

This WP will be led by the JYF beneficiary and will be coordinated by Wladyslaw Traszka (University of Jyväskylä). The WP3 focuses on the subsequent phase of producing and installing complex scientific detector infrastructures inside and around the tank, the costs and risks of this, and the costs and risks of onward operation of the complete facility safely for the full expected lifetime. WP3 recognizes that construction of the detector components and their safe installation inside the completed main tank facility represents a cost and risk challenge that need to be addressed as part of a feasibility study. Further, that construction of LAGUNA implies a commitment to reliable operation for likely for more than 30 years. Careful consideration of detector installation and long term operational challenges is important also because they may reveal critical design or other issues for which solutions are needed at an early stage, or that possibly do not have solutions for the whole duration of the project at reasonable cost, even though initial construction of the facility itself may be regarded as feasible. An example is the cost impact of changes in site ownership or safety policy.

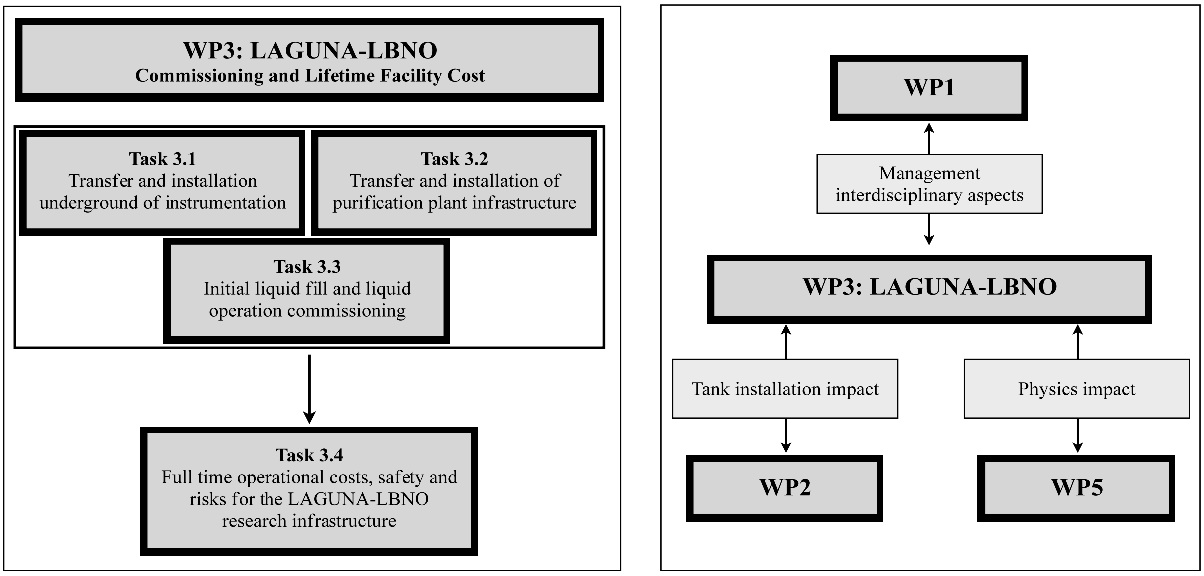


Figure 5 Relationship between the WP3 tasks and other work-packages required to meet the objective of a complete understanding of the cost, risks and safety implications of the LAGUNA-LBNO infrastructure.

WP4 – Long Base Line Neutrino Beams Prospects and Scenarios for Detector Magnetization

This work package will be led by CERN. On the horizon of 10-15 years, the CERN SPS will remain the highest intensity source of protons. The SPS intensity will be further increased in the coming years as part of the planned LHC luminosity upgrade. A conventional neutrino beam line with proven and affordable technologies based on the existing CNGS expertise with a power up to 700 kW and directed towards a LAGUNA site, can be realistically built within a technically driven timescale of 6 years. On a timescale beyond 2025 new CERN proton accelerators could be available, allowing new types or more intense neutrino beams to be considered. These could include the High Power Superconducting Proton Linac (HP-SPL 5

GeV protons, 4 MW) or the new concept Low Power-SPL coupled to a High Power Proton Synchrotron accelerator (LP-SPL+HP-PS 30-50 GeV, 2 MW). The HP-SPL can be used as a proton driver for a neutrino factory (NF, as studied in the FP7 EUROnu design study[3]) while the LP-SPL+HP-PS would be a new driver to increase the conventional neutrino superbeam power from 700 kW to at least 2 MW. At the present state of knowledge of the lepton flavour oscillation phenomenology, it is not possible to select between the HP-SPL or LP-SPL+HP-PS options. The final choice will be driven by: (a) experimental results yielding better understanding of the neutrino mixing matrix and long baseline neutrino oscillations, and (b) the outcome of the NF R&D. For the specific case of the Fréjus site, the HP-SPL could be used to produce a low-energy high-power neutrino superbeam (depending on the outcome of the high power target and horn focusing work as addressed in EUROnu), and/or a beta-beam could be considered (depending on the outcome of the beta-beam R&D as addressed in EUROnu). Input and collaboration with WP5 is envisaged.

This work-package will proceed through the following steps:

1. Definition of the precisions needed for this suite of measurements, and understanding of the added value of a magnetic near detector;

2. Review of the possibilities offered by known technologies and search for new solutions if necessary, as we anticipate will be the case;

3. Conceptual design of the near detector based, first, on general physics considerations;

4. After defining the required level of detail, simulations of the measurement;

5. Finally, the issue of using different neutrino target materials in the near and far detector will be addressed.

WP5 – Underground Science Assessment and Impact on Detector Design

The experimental setups under consideration, using the GLACIER, LENA and MEMPHYS options, will allow us to gain crucial information on elementary particle properties, by studying man-made neutrinos, astrophysical neutrinos, and proton decay. This information is unique and of crucial importance in order to understand the fundamental laws of Nature and the behavior in extreme environments, such as the cores of supernovae.

This WP, lead and coordinated by UDUR S. Pascoli, will focus on the physics goals of future large-scale detectors which is a mandatory task to guide the detector designs and to aid the choice of underground location. It is necessary to consider the sources of neutrinos of interest, study their propagation and, most of all, identify the critical detector parameters which impact on the physics performance of the facilities, by means of detailed simulations of the detector performances. The outcomes of WP5 will be critical in shaping the future neutrino and astro-particle physics program in Europe and worldwide.

The activities of WP5 require a coherent and coordinated effort between particle theorists, phenomenologists and experimentalists. In Europe a wide effort is devoted to the physics of future large underground facilities. A very large number of Universities and Laboratories carry out this work in an often fragmented and disconnected manner. WP5 will help coordinate this work in a synergetic effort (see Figure 6). This coordination will be achieved at different levels:

[3] See http://www.euronu.org/

- Among different experimental groups which perform research on the same detector technology. It is important to optimise European efforts to avoid repetition of similar studies, so as to build on the wide and excellent expertise already available;
- Among experimental groups involved in the study of different detector technologies. Here it is important to highlight differences and synergies. Also, the underground location presents common challenges, e.g. the impact of backgrounds (from WP3) needs to be addressed for each technology;
- Between particle theorists and experimentalists. Important here in order to best design the facilities to advance our understanding of the fundamental physics questions we are addressing. On the one side, theorists define the relevant physics goals and phenomenologists study how they can be achieved in idealised setups. On the other experimentalists design the experimental facilities, given the technical constraints, and determine their performance. It is of paramount importance to optimise the physics reach of a future facility by aligning these two approaches. Strong synergy is present with WP3 and WP4.

The activities of WP5 have strong links and complementarities between different tasks within WP5 and with other tasks in WP2, WP3 and WP4 as detailed in Figure 6.

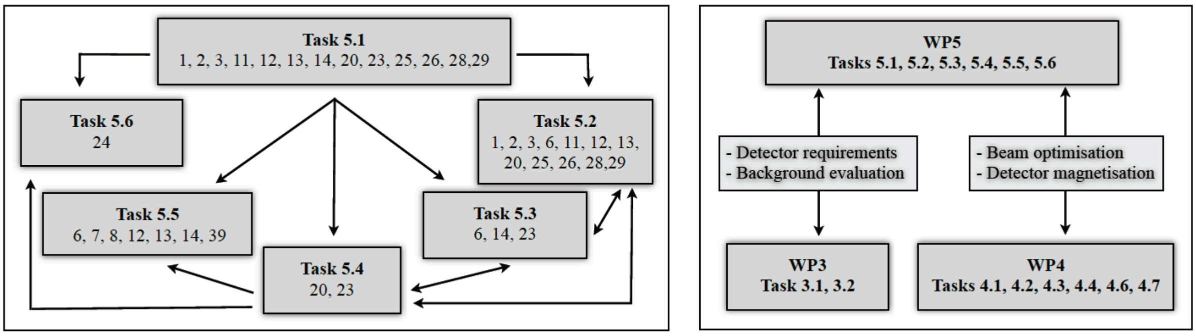
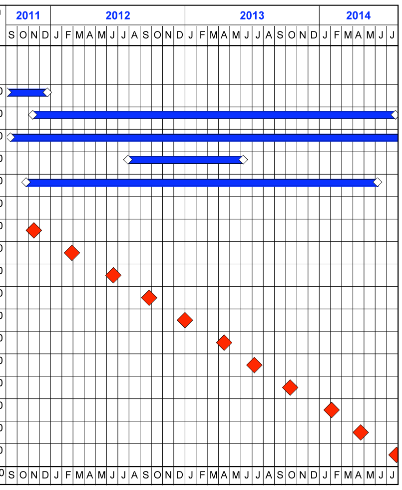


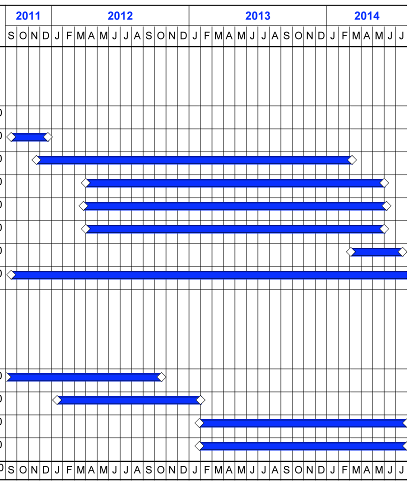
Figure 6 Left: Synergies and complementarities between Tasks in WP5 with the beneficiaries contributing to each Task. Right: Connection between WP5 with WP3 and WP4.

B1.3.2 Timing of work packages and their components

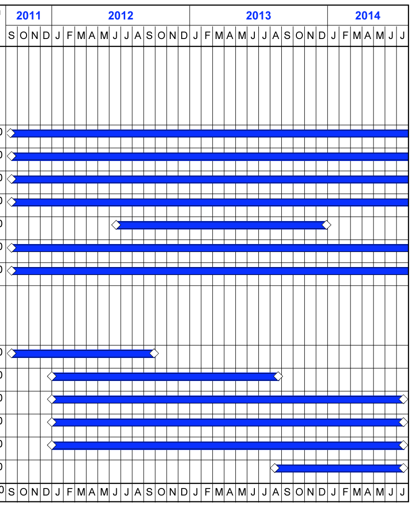
	Activity Name	Start Date	Finish Date	Duration (Work Days)
1	**WP1 – Management, Outreach, International relations**			
2	Task 1.1	5/9/11	23/12/11	80.00
3	Task 1.2	14/11/11	25/7/14	705.00
4	Task 1.3	12/9/11	26/9/14	795.00
5	Task 1.4	30/7/12	7/6/13	225.00
6	Task 1.5	24/10/11	6/6/14	685.00
7	Kickoff meeting	15/7/11	15/7/11	0.00
8	General meeting #2	15/11/11	15/11/11	0.00
9	General meeting #3	27/2/12	27/2/12	0.00
10	General meeting #4	18/6/12	18/6/12	0.00
11	General meeting #5	24/9/12	24/9/12	0.00
12	General meeting #6	31/12/12	31/12/12	0.00
13	General meeting #7	15/4/13	15/4/13	0.00
14	General meeting #8	8/7/13	8/7/13	0.00
15	General meeting #9	14/10/13	14/10/13	0.00
16	General meeting #10	3/2/14	3/2/14	0.00
17	General meeting #11	21/4/14	21/4/14	0.00
18	General meeting #12	28/7/14	28/7/14	0.00
				15,100.00



	Activity Name	Start Date	Finish Date	Duration (Work Days)
19	**WP2 - Deep Underground Facility Construction Plan and Costing**			
20	Task 2.1	4/7/11	12/8/11	30.00
21	Task 2.2	15/9/11	21/12/11	70.00
22	Task 2.3	21/11/11	7/3/14	600.00
23	Task 2.4	2/4/12	30/5/14	565.00
24	Task 2.5	26/3/12	6/6/14	575.00
25	Task 2.6	2/4/12	30/5/14	565.00
26	Task 2.7	3/3/14	18/7/14	100.00
27	Task 2.8	15/9/11	20/8/14	765.00
28	**WP3 - Production and Installation of Instrumentation, Commissioning and Facility Lifetime Costs**			
29	Task 3.1	5/9/11	19/10/12	295.00
30	Task 3.2	16/1/12	1/2/13	275.00
31	Task 3.3	28/1/13	1/8/14	395.00
32	Task 3.4	28/1/13	1/8/14	395.00
				15,100.00



	Activity Name	Start Date	Finish Date	Duration (Work Days)
33	**WP4 - Long Base Line Neutrino Beams Prospects and Scenarios for Detector Magnetization**			
34	Task 4.1	12/9/11	19/9/14	790.00
35	Task 4.2	15/9/11	27/8/14	770.00
36	Task 4.3	15/9/11	27/8/14	770.00
37	Task 4.4	15/9/11	27/8/14	770.00
38	Task 4.5	18/6/12	27/12/13	400.00
39	Task 4.6	15/9/11	27/8/14	770.00
40	Task 4.7	15/9/11	27/8/14	770.00
41	**WP5 - Underground Science Assessment and Impact on Detector Design**			
42	Task 5.1	15/9/11	26/9/12	270.00
43	Task 5.2	2/1/12	23/8/13	430.00
44	Task 5.3	2/1/12	18/7/14	665.00
45	Task 5.4	2/1/12	18/7/14	665.00
46	Task 5.5	2/1/12	18/7/14	665.00
47	Task 5.6	12/8/13	18/7/14	245.00
				15,100.00



B2. Implementation
B 2.1 Management structure and procedures

ETHZ will be the Coordinator of the LAGUNA-LBNO project and will provide the Project Management Office. The administrative, legal and financial services of ETHZ will provide adequate support to the Project Management Team. The management structure and procedures of LAGUNA-LBNO are based on successful experience and best practice from the management of large EU projects of similar size and complexity, and of those of several large project in the field of high-energy particle physics or astro-particle physics.

Figure 7 shows a schematic layout of the LAGUNA-LBNO organisational structure whose main components are the Institution Board, the Executive Committee, the Technical Board and the Scientific Board. The structure of the project foresees in addition to the coordinator, the existence of the Institution Board (IB), of the Secretariat and Administration office, and of the Technical and Science Boards. Their tasks are defined in the following.

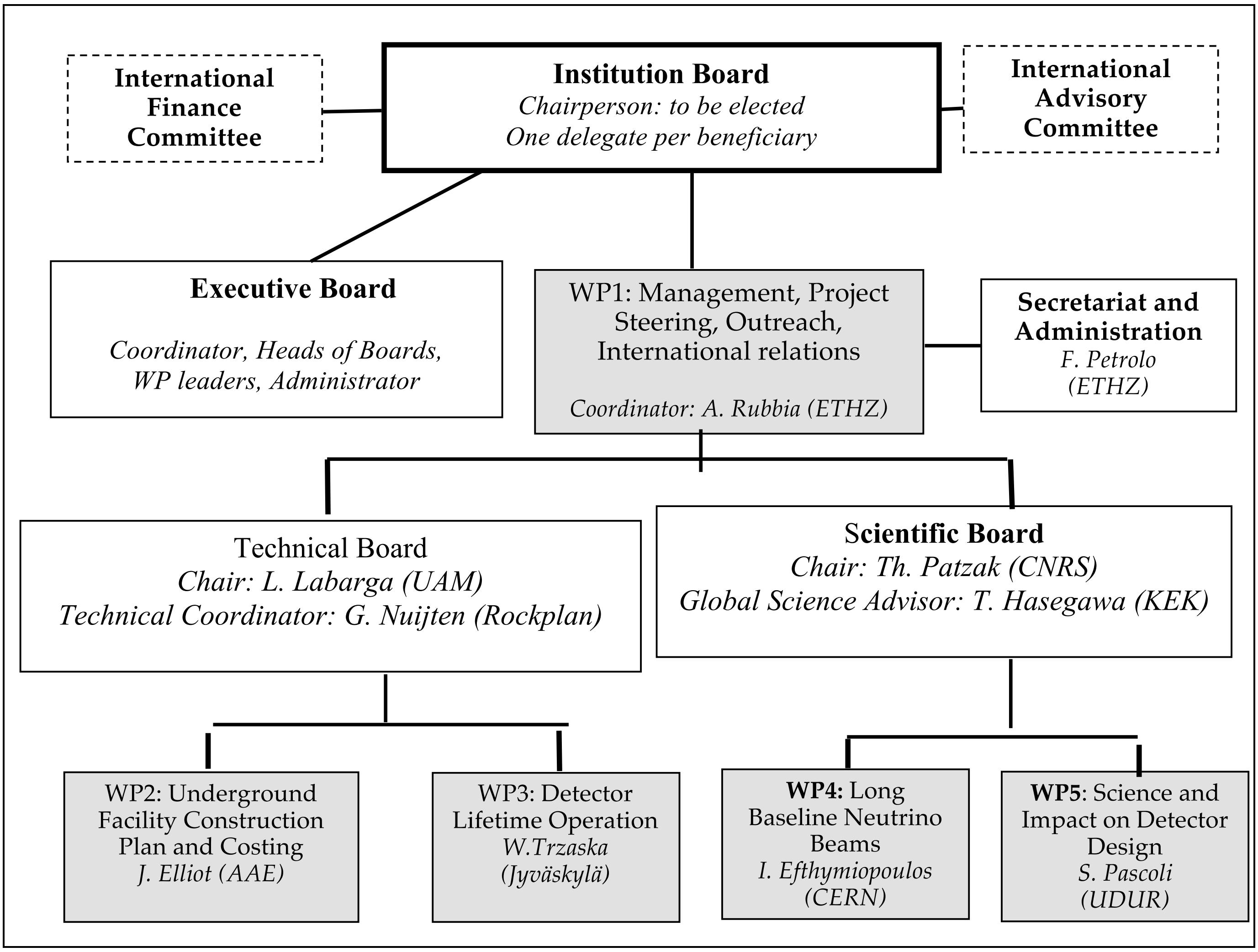


Figure 7 Organizational structure of the project.

Institution Board (IB)

The **Institution Board (IB)** is the top-level decision-making and arbitration body. It has one representative with voting rights from each beneficiary and third party in the project, and includes the Project Coordinator (ex-officio, non-voting rights). In this way all participants – the beneficiaries and the third parties – will contribute equally to the decisions taken by the IB. The types of decisions and the corresponding voting procedure and rules will be described in the Consortium Agreement. The IB has the authority to decide, upon Executive Committee proposals, on strategic issues, such as modifications of the project programme of work (if necessary) and admission of new participants. The IB will review the progress of the project at the annual meetings, and, where necessary, will decide on changes in the work plan and budget allocation for the next reporting period. It may settle possible disputes in case of failure of partners to meet their project assignments. In addition to the annual meetings, the IB Chairman may call for intermediary teleconference meetings. The Chairman of the IB will be elected by its voting members.

Executive Board

The **Executive Board** (EB) assures the day-to-day follow-up of the program and it is formed by the coordinator, the workpackage leaders plus the administration responsible members. It will be responsible for the co-ordination and harmonization of all LAGUNA actions and particularly for the administrative and co-operative support of all transnational research activities. It will follow up all important horizontal issues and will prepare the IB meetings of the LAGUNA consortium. It will also be responsible for public relation issues and for the contents of the LAGUNA website. It will meet at least every two months, and decisions will be taken on a unanimity basis. On exceptional cases differences may be resolved by qualified majority rule (2/3 of the members) or can be directed to an exceptional IB meeting.

Technical Board

The **Technical Board** (TB), coordinated by the Chair and the Technical Coordinator, manages the technical follow-up of the project, in particular for the work performed in WP2 and WP3. It ensures that all four site-detector options will be treated equally. The Chair, overseeing WP2 and WP3, will not take any position in ranking or down selecting the sites. This is primarily the duty of the scientific community itself via proposals of the Executive Board and approved by the Institution Board.

Scientific board

The **Scientific board** (SB), coordinated by the Chair and the Global Science Advisor, manages the scientific follow-up of the project, in particular for the work performed in WP4 and WP5. It ensures that all four site-detector options will be treated equally. The Chair will not take any position in ranking or down selecting the detector options. This is primarily the duty of the scientific community itself via proposals of the Executive Board and approved by the Institution Board.

Work Package Leaders

The WP Leaders will manage and coordinate the activities in the framework of their own WP. They will have the responsibility for ensuring the effective cooperation between the beneficiaries and the third parties in each WP, for monitoring the progress of the tasks, and for reviewing the Milestone and Deliverable reports that will be prepared by the Task Leaders within the respective Work Packages. The WP Leaders will prepare all other reports concerning their WP's, as requested by the Executive Board. They will make the results of the work available to the LAGUNA-LBNO collaboration and will be in charge of providing the relevant public dissemination material to WP1. They will coordinate the review of all publications that will result from the work in their own WP.

International Advisory Committee

The **International Advisory Committee** will be setup to provide independent advice to the Project and guidance to the IB. The International Advisory Panel shall usually meet every year and an extraordinary meeting can be held at any time. It will make recommendations on the crucial technical choices according to the international context, on the distribution of resources to comply with priorities, and on activity planning.

International Finance Committee

The **International Finance Committee** will be composed of representatives from the various national and international funding agencies and research ministries and will be setup to provide recommendations to the Project and guidance to the IB from the point of view of the Funding Agencies. The International Finance Panel shall usually meet every year. It will make recommendations on the use of resources and financing for the various implementation phases of the LAGUNA research infrastructure. The Coordinator shall chair all meetings.

Coordinator

The **Coordinator** is responsible for the overall legal, contractual, ethical, financial and administrative management of the consortium, the coordination of knowledge management and other innovation-related activities, overseeing the promotion of gender equality in the project and overseeing science and society issues related to the research activities conducted within the project. He will ensure general liaison between the contractors and the Commission. He will submit financial statements, will receive in trust for the consortium all payments from the Commission and will distribute them among the contractors according to their decisions. He will represent the Design Study to the public and especially to partner councils inside and outside the EU not yet participating in the network. He will be accountable for keeping all contract commitments, for submitting all reports and financial records required from the Commission, for overlooking the joint secretariat, for supervising the implementation of the decisions of the Institution Board. The LAGUNA-LBNO coordinator is André Rubbia (ETHZ).

Secretariat and Administration

The **Secretariat and Administration** takes care of the financial issues of the Project. In particular, managing the various administrative issues, the accountancy, funds control, budget preparation and budget revision, financial planning, financial Reporting, carrying out transactions, managing the financial relations with the beneficiaries and with the EC. Additionally the Administration provides the secretarial support.

General Meetings of the collaboration

The General Meetings assume a vital role for the project. It serves the following purposes:

- To disseminate the scientific activities to the members of the collaboration and the whole community, and collect their scientific reactions;
- To critically review the overall scientific progress of the collaboration;
- To inform the members of the Institution Board;
- To inform the members of the Scientific Advisory Board and receive their input;
- To address collectively any outstanding organizational issues for the consortium.

The Meetings will consist of comprehensive presentations of the achievements of the individual activities and tasks. They will include a meeting of the Institution Board. The General Meetings will be hosted by different participants. In addition, the Executive Committee will organize a kick-off meeting of the consortium at the start of the project to launch the project and the work according to the planning for the first reporting period.

Decision-making mechanisms

At the beginning of the project the participating institutes will formally conclude a Consortium Agreement that sets forth the terms and conditions pursuant to which the participants agree to function and cooperate in the performance of their respective tasks in the project. The Consortium Agreement will specify the responsibilities of the Coordinating Institution and the terms of reference of the Institution Board and the Executive Board, including the relevant decision making mechanisms.

Decisions concerning the implementation of the work programme within the Work Packages will be taken by the relevant Work Package and Task Leaders. Issues concerning the overall work programme and interrelations between Work Packages will be discussed and decided by the Executive Board. In the rare cases where significant modifications of the work programme and/or re-distribution of EC funding are deemed necessary by the Executive Board, such matters will be brought forward to the Institution Board.

The project implementation will be aimed at taking decisions by achieving consensus on most issues. Where this is not possible, and in cases defined in the Consortium Agreement, decisions will be taken after voting by the Executive Board or the Institution Board, depending on the character of the issue at stake. The project will use, via its Internal web-site, modern IT tools, e.g. a collaborative workspace, to guarantee the distribution of all project related information to the beneficiaries and the third parties involved, so that decisions can be taken with all necessary information available in advance.

B 2.2 Beneficiaries

P1- [ETH Zürich] – Swiss Federal Institute of Technology Zurich, Physics Department

The ETH Zurich, often called Swiss Federal Institute of Technology, is a science and technology university in the city of Zurich, Switzerland. Its full name is Eidgenössische Technische Hochschule Zürich, with ETHZ also being a common unofficial abbreviation. The ETH is an internationally oriented university. It is a member of the IDEA League and the International Alliance of Research Universities IARU.

The Institute for Particle Physics (IPP) belongs to the Physics Department. The Institute's main research projects address fundamental questions in the following three research fields:
(1) experiments at the frontier of high-energy interactions between fundamental particles, (2) experiments in neutrino physics and 3) experiments in Astroparticle Physics.

Profile of staff members who will be undertaking the work:

- Prof. Dr. A. Rubbia, head of the institute of particle physics (IPP-ETHZ), group leader, leading the ArDM and GLACIER R&D efforts. Coordinator of the LAGUNA DS. Chairman of CHIPP (Swiss Institute for Particle Physics. Elected member of the T2K executive board. Attended CERN course of management. Competences in experimental high-energy particle and astro-particle physics, search for neutrino flavor oscillations, search for proton/neutron decay, physics with positron/positronium, particle detector R&D, novel developments in LAr TPC technology, direct search for dark matter in the Universe, phenomenology, physics computing. Present and past international research projects: NA61, T2K, OPERA, ArDM, ICARUS, NOMAD, L3.
- Dr. A. Curioni, senior postdoc, Experimental high-energy neutrino physics, Direct Dark Matter searches, Gamma ray astrophysics, Noble liquid detectors, Detector R&D for applications to homeland security. Present and past international research projects: T2K, ArDM, LUX, MiniBooNE, ICARUS-Milano collaboration
- Dr. A. Marchionni, PostDoc researcher, neutrino beams and neutrino physics, expertise in detectors and accelerators, detector development, liquid Argon TPC detectors, electronic and readout systems
- Dr. S. Horikawa, senior postdoc Experimental high-energy particle and astro-particle physics, Direct search for Dark Matter in the universe, Search for neutrino flavor oscillations, Detector R&D. Present and past international research projects: ArDM, T2K, DIRAC, COMPASS.
- Dr. B.Rossi, PostDoc, LAr TPC, physics. Experience in computing, DAQ and LAr detector construction and operation.
- Dr. L. Esposito, Postdoc, Experience in hadron production measurement, large neutrino experiment (OPERA/T2K).
- Mr. Federico Petrolo, Graduate in Political Science, Post Graduate in International Relations (Politics and Institutions of the EU), MSc of the London School of Economics and Political Science in European Studies, Swiss Graduate School of Public Administration. Financial Officer (CERN Associated Member of the Personnel), CERN Host States Relations Office, Responsible for Administration, Finances and Funds Control of the FP7 DS LAGUNA.
- D. Lussi, PhD student, LAr TPCs development.
- F. Resnati, PhD student, LAr TPCs development.
- L. Epprecht, PhD student, LAr TPCs development.
- A. Gendotti, ETHZ mechanical engineer, cryogenic, LAr TPC systems, magnets.

P2 - [U-Bern] University of Bern, Laboratory for High Energy Physics (LHEP)

The University of Bern is one of the most important Swiss Universities. Already in 1528 it was structures as a " Hohe Schule". Today there are about 20000 students subdivided in 8 faculties: Theology, Law, Economics and Social Sciences, Medicine, Veterinary Medicine, Human Sciences and Science. The faculty of Science provides teaching and researches in the fields of Mathematics, Physics astronomy and phylosophy, Chemistry and Biochemistry, Biology, Geology and Geography. Physics is subdivided into three institutes (Physics, Applied Physics and Theoretical Physics). The laboratory for High Energy Physics (LHEP) is one of the three departments of the Physics Institute. More information can be found in: http://www.unibe.ch/and http://www.philnat.unibe.ch/

LHEP has also a long tradition in research and teaching. Elementary particle physics is one of the key specializations of the Institute of Physics at the University of Bern. It was introduced by H. Greinacher (lecturer 1924-1950) and F. Houtermans (lecturer 1952-1966), who was appointed to succeed H. Greinacher in 1952. F. Houtermans founded a working group in Bern who pursued fundamental

researches in the area of particle physics with a view to researching the fundamental building blocks of matter and their interactions. After the death of F. Houtermans (1966), J. Geiss was appointed as Head of the Institute of Physics. At the request of J. Geiss, the faculty and the government decided to set up an independent department of elementary particle physics at the Institute of Physics and to create a full professorship in this specialization. B. Hahn was appointed to this chair in 1968. K. Pretzl succeeded B. Hahn in 1988. He started a series of new projects in the field of particle physics. In particular he contributed to the search of strange-quark matter with the NA52 experiment in the heavy ion beam at the CERN Super Proton Synchrotron (SPS). Under his leadership the LHEP participated in the conceptual design of the ATLAS experiment for LHC. He also started a line of research on neutrino physics, joining the OPERA experiment for the search for neutrino oscillations.
After retirement of K. Pretzl in 2006, A. Ereditato was appointed as his successor and is presently leading LHEP. He contributed to the creation in Bern of the Albert Einstein Center for Fundamental Physics, one of the largest Swiss institutes devoted to research in experimental and theoretical particle physics. The current activities of LHEP include the ATLAS, OPERA, EXO and T2K experiments in addition to medical physics and R&D studies on novel particle detectors (as in particular LAr TPCs). As far as the latter subject is concerned we are realizing at LHEP a 5 m long LAr TPC detector (ARGONTUBE), in the framework of the GLACIER R&D program.
In the context of the LAGUNA-LBNO project a new research activity recently established at LHEP can be of particular interest. This is muon tomography by nuclear emulsion films. We exploit the unsurpassed space and angular resolution of emulsions to perform measurements of the interior of large structures like mountains or volcanoes, with the goal of detecting variations of density of the medium traversed by cosmic muons. This research exploits the expertise of LHEP researchers in the field of the automatic emulsions scanning and could be well conducted within LAGUNA-LBNO in collaboration with our industrial partners active on the study of envisioned underground sites.

Profile of the staff members who will be undertaking the work:

- Prof. Dr. A. Ereditato, group leader, LAr detectors, management, physics. Competences in neutrino and astroparticle physics. Experience with large neutrino physics experiments at CERN and LNGS (CHARM II, CHORUS, ICARUS, OPERA). Experience with particle detectors: calorimeters, LAr TPC, emulsion detectors, imaging.
- Dr. M. Messina, Senior PostDoc, physics, LAr detectors, underground sites, outreach. Experience in particle, neutrino and astroparticle physics. Experience with cryogenic imaging detectors.
- PD Dr. I. Kreslo, Privat Dozent, particle detectors, DAQ, liquid scintillators, imaging. Experience with high space-resolution detectors (emulsions, capillaries, scintillator trackers, liquid scintillators, imaging).
- Dr A. Ariga, Senior Post Doc, emulsion detectors. Experience with neutrino physics, particle detectors, emulsions.
- Dr T. Ariga, Post Doc, emulsion detectors. Experience with neutrino physics, automatic emulsion scanning, emulsions.
- Dr C. Pistillo, Engineer, emulsion detectors. Experience with neutrino physics, computing, emulsion analysis, simulations.
- M. Zeller, PhD student, cryogenics, LAr TPCs.

P3 - [UNIGE] Université de Genève, DPNC

Established in 1559, the Université de Genève is today the second largest High Education institution in Switzerland. Highmark of the city of Calvin, the institution enjoys a large International influence and cultivates its opening to the world. Université de Genève is distinguished by quality education covering most domains in sciences arts and littérature, as well as cutting edge research.
The Department of Particle Physics (DPNC) of the School of Physics belongs to the Faculty of Sciences. It comprises about 70 personnel of which 5 full professors, 5 permanent senior scientists and more than 30 postdocs and PhD students. The research is based on three pillars: High energy frontier with a strong group involved on the ATLAS experiment at LHC; Astroparticle physics with a group involved in the AMS experiment and the CTA project; and the neutrino group. The DPNC enjoys a

strong technical team.
The neutrino group, led by Pr. Blondel, was created in 2002. It plays leading roles in the T2K experiment, the HARP and NA61 experiment at CERN, the MICE experiment at the Rutherford Appleton Laboratory, thus combining expertise in detectors design and construction, physics analysis as well as in advanced accelerator technology (muon cooling). It has been traditionally leading efforts in Europe towards advanced neutrino sources and in particular the neutrino factory and the low energy superbeam to Fréjus. It presently counts one professor, one assistant professor, 5 Post-docs and 5 PhD students.

The personnel who will be involved in the project are:

- Prof. Alain Blondel, PhD in 1979 on the Gargamelle experiment at CERN (observation and study of open charm production in neutrino interactions) , e+ e- collisions at MARKII (SLAC) and ALEPH (LEP). Played a leading role in th measurement of the number of neutrino families and in the precise measurement of the Z mass and width using resonant beam depolarization at LEP. Initiated the ECFA study groups of future neutrino facilities in 1998 and the NUFACT series of workshops, led the Neutrino Detector group of the International Scoping Study for neutrino factory, beta-beam and superbeam, and presently leads the EUCARD networking activity NEU2012 towards the definition of a future neutrino program in Europe, as well as the AIDA workpackage on neutrino detector test beam activities. Initiated and leads the International Muon Ionization Cooling Experiment and presently elected spokesperson. Initiated with a few others the European participation in the T2K experiment and led the physics analysis. Initiated the T2K related measurement program in the NA61 experiment at CERN. Member (2003-2010) of the CERN Scientific Policy Committee at CERN.
- Dr Fanny Dufour: PhD at Boston University on the study of Long baseline upgrade possibilities for the T2K experiment, presently involved in the T2K experiment.
- Dr Yordan Karadhzov, PhD at Sofia University on the MICE experiment and the simulation of the neutrino factory near detector.
- A PhD student for the simulation of the near detector performance.

P5 - CERN

It is the world's largest particle physics centre and operates the world's largest complex of particle accelerators. The 55-year history of CERN is marked with impressive achievements in the construction and operation of powerful linear and circular accelerators. CERN is currently bringing the Large Hadron Collider (LHC) into operation. With proton-proton collisions at 14 TeV, the LHC will be the most powerful accelerator in the world, awaited so eagerly by the particle physics communities on all continents. Throughout its history CERN has coordinated ever-larger particle physics experiments and has made fundamental contributions to the development of the technologies involved (particle detection, data acquisition, simulation, analysis techniques).

Main responsible staff who will be managing the work:

- Prof. L. Rossi, Leader of the Magnets, Cryostats and Superconductors Group and Deputy Head of the CERN Technology Department. At University of Milan until 2001, he has been responsible for the first LHC superconducting dipole prototype and of the superconductor and magnet development for the LHC experiment ATLAS. Broad expertise and experience in magnet design and technologies and applied superconductivity. 2007 IEEE-Council of Superconductivity Award for sustained and significant contribution to the field of Applied Superconductivity.
- Dr. C. Bracco previously worked on the studies, design and commissioning of the collimation system for the LHC, and was recruited into the Accelerator Beam Transfer group in 2009. She is working on LHC commissioning and the design of beam transfer systsems for various projects and studies. The Accelerator Beam Transfer group is in charge of the design, commissioning and operation of the transfer lines linking the different CERN accelerator complex, and of the injection, extraction and beam dumping systems.
- Dr. I. Efthymiopoulos, deputy group leader of the Machines and Experimental Areas group in the

CERN Engineering Department, leads the section on particle beam design and interface with the experiments in the CERN accelerator complex. Experimental high-energy particle physics research and detector R&D as member for the ATLAS experiment: Tile hadronic and Liquid Argon electromagnetic calorimeters, physics computing. High-power target R&D for Neutrino Physics, MERIT high-power liquid mercury target experiment. Operation of the CNGS neutrino beam. Present and past international research projects: HiRadMat@SPS, EUROnu, EUCARD, IDS-NF, ATLAS, ALEPH.

- Dr. R. Garoby, has been working as an RF engineer on the design and operation of particle accelerators at CERN since 1978. He is presently the coordinator of the SLHC-Preliminary Phase Project supported by the EU in the context of its 7th Framework Programme. Inside CERN, he is leading the SPL R & D and the Project for the "LHC Injectors Upgrade" (LIU) which prepares for the high luminosity operation of the LHC beyond 2017. He is the Deputy Department Head for the "Beams" department (BE) at CERN.
- Dr. B.Goddard, in charge of beam transfer studies across the CERN complex, has worked on design, construction, commissioning and operation of beam transfer systems at CERN since 1992, for the LHC, its injectors and for other projects and studies. He is presently deputy group leader of the Accelerator Beam Transfer group, in charge of the design, commissioning and operation of the transfer lines linking the different CERN accelerator complex, and of the injection, extraction and beam dumping systems.
- Dr. E. Gschwendtner, PhD, Beam Line Physicist in the Accelerator and Technology Sector of CERN. Liaision with experimental areas. She has wide experience in the design, construction and operation of particle beams and experimental areas. Among other CERN beam lines she is the responsible physicist for the CERN Neutrinos to Gran Sasso secondary beam. Previous experience includes detector development for the LHC beam instrumentation as well as background benchmarking studies for the ATLAS experiment.
- Dr. M. Meddahi, she has been working in accelerator design and commissioning since 1989. From 2000 to 2006, she was deputy project leader of the CERN Neutrino to Gran Sasso project and supervised the proton beam line and target R&D. From 2007 to 2009, she was participating both to the CERN Neutrino Factory effort and to the LHC upgrade programme. Since 2009, she is a member of the Accelerator Beam Transfer group. This group is in charge of the design, commissioning and operation of the transfer lines linking the different CERN accelerator complex, and of the injection, extraction and beam dumping systems. During 2010 she was also acting as LHC operation coordinator and member of the LHC beam commissioning team, which is in charge of setting-up the accelerator to produce the required beams for physics. In the frame of the LHC upgrade phase, she is acting as the LHC Injector Upgrade (LIU) deputy project leader and a member of the LIU-SPS upgrade working group.
- Dr. R. Steerenberg, head of the PS section within the CERN Beams department operations group, responsible for the operation of the CERN Proton Synchrotron, performs various machine development studies in view of performance and reliability optimisation, in particular for high intensity and high brightness beams. Core member of the CERN Machine Studies Working Group (MSWG). Involved in PS related projects and studies, leading PS Neutrino Facility pre-study, drawing up specifications and member of the PS Complex access and safety system project steering committee.
- Dr. J.Uythoven has worked as an engineer on LEP operation, and in the LEP RF group. He joined the Accelerator Beam Transfer group in 1998, and worked on the design of kicker systems for the LHC and its injectors. He is presently responsible for LHC commissioning of beam transfer systems and the design of beam transfer systsems for various projects and studies. The Accelerator Beam Transfer group is in charge of the design, commissioning and operation of the transfer lines linking the different CERN accelerator complex, and of the injection, extraction and beam dumping systems.

P6 - [JYU] University of Jyväskylä

The University of Jyväskylä is one of the best and most popular Universities in Finland. It mainly attracts the students from the central part of the country. Natural sciences and mathematics, humancentred sciences, sport and health sciences as well as teacher education form the core fields of the research and education. The University has the third highest number of Centres of Excellence in Finland and has been named a University of Excellence in Adult Education by the Finnish Ministry of Education.

The Department of Physics performs research and offers education at highest international level on nuclear and accelerator-based physics, materials physics and high-energy physics. In addition, it hosts a teacher education program. The accelerator laboratory is a Centre of Excellence under the national centre of excellence program. Part of the research is done at CERN. There is also a very strong theory group.

The main task of Jyväskylä is to work in close cooperation with CUPP on the design of the underground infrastructure for the new underground laboratory (WP2), address safety and environmental issues (WP5) and contribute to science impact and outreach (WP6). In addition, Jyväskylä team has started a research program to develop new techniques on the detection of geoneutrinos and is willing to contribute to theoretical studies relevant to LAGUNA.

Profile of the staff members who will be undertaking the work:

- Dr. Wladyslaw H. Trzaska. Scientific background in experimental nuclear and high energy physics, Project Leader of ALICE T0 detector, coordinator of the Nuclear Reaction Research at Jyväskylä, spokesman of the underground experiment EMMA. WP3, WP5.
- Prof. Jukka Maalampi, Head of the Department. Scientific background in theoretical physics, strong interest in sterile neutrinos. WP5.
- Prof. Jouni Suhonen. Scientific background in theoretical physics, strong interest in beta decay and matrix element calculations; author of a textbook for advanced students on nuclear concepts and microscopic theory. WP5.

P8 - [UOULU] University of Oulu

The University of Oulu is an active scientific learning and research community of 17 000 students and 3000 staff members. Its task is to promote well-being and education in Northern Finland by implementing high-quality international research. The Universitys six faculties and their departments form a multidisciplinary academic institution that enables diversified studies and multifaceted research.

The University of Oulu runs an underground laboratory in the Pyhäsalmi mine, referred to as the Centre for Underground Physics in Pyhäsalmi (CUPP). Oulu Southern Institute administers it, which is a regional organisation of the University of Oulu. CUPP has been running an underground laboratory since 1997. CUPP has hosted or realised many small-scale experiments in the laboratory. The current experimental activity focuses on a cosmic-ray experiment EMMA running at a shallow depth underground.

Profile of the staff members who will be undertaking the work:

- Prof. Kalevi Mursula. Scientific background: space physics.
- Dr. Timo Enqvist, manager of the Pyhäsalmi laboratory. Scientific background: experimental nuclear physics and astroparticle physics.

P7 - [UH] University of Helsinki, Department of Physics

The University of Helsinki (http://www.helsinki.fi/university/), established in 1640, is the most versatile university in Finland. It includes eleven faculties: Agriculture and Forestry, Arts, Behavioral Sciences, Biosciences, Law, Medicine, Pharmacy, Science, Social Sciences, Theology, and Veterinary Medicine. The University has ca. 35 000 students and 8 000 employees. The activities are located on four campuses (http://www.helsinki.fi/inbrief/index.html). The University of Helsinki is a member of the League of the European Research Universities (LERU).

The Department of Physics at the University of Helsinki conducts research in materials science, particle physics, cosmology, atmospheric sciences, astronomy, space physics and geosciences. The department is the largest particle physics research centre in Finland, and it has a central role in Finnish participation to CERN. It hosts the Helsinki Institute of Physics (HIP).

Profile of staff members who will be undertaking the work:

- Prof. Kari Rummukainen, head of the theoretical physics program. Head of the theory program at the Helsinki Institute of Physics (from 2011). Professor of theoretical particle physics. Expert in numerical simulations of theories of particle physics, including QCD and Electroweak theories and beyond-the-standard model theories.
- Prof. Katri Huitu, head of the division of the particle physics. Professor of particle physics phenomenology. Extensive experience in the phenomenology of the Standard Model and its extensions, including supersymmetric theories.

P10 - [CEA] CEA-IRFU

Irfu (CEA) is one of the two national French institutes devote to particle and nuclear physics. It also funds major programs in astroparticle physics.
Based in Saclay, Irfu, the Institute of Research into the Fundamental Laws of the Universe, is a basic research institute of the CEA. Its scientific activities cover the fields of particle physics, nuclear physics and astrophysics. First called DAPNIA, it was created in 1991. In 2010 Irfu employed a total of 760 persons (180 physicists, 235 engineers, 172 technicians, 45 administrative staff, and 130 non permanent staff: PHD, postdocs). Irfu is composed of eight services.
The CEA and IN2P3 run the Fréjus-Modane Underground Laboratory (LSM) since 25 years and are involved in a wide spectrum of neutrino and astroparticle experiments. Irfu has strong activities at CERN and all the other major particle physics facilities around the world. The institute has developed world leading competences in all technical fields related to particle physics: detectors, electronics, computing, accelerators conception and realization, superconducting magnets.
Irfu is strongly involved in the T2K experiment in Japan (construction of the TPCs for the near detector and data analysis). It is also part of the EUROnu and Laguna FP7 projects. In EUROnu we have developed a full neutrino beam simulation using FLUKA/GEANT4 and a method to optimize the magnetic focusing of the pions. In LAGUNA we have applied these tools to a first comparison of various Super Beam facilities. This expertise will be a precious asset in the future work of WP4. Physicists at Irfu will develop further the neutrino beam simulation and optimization and evaluate the physics performances. Also, on the detector side, a R&D program on running Micromegas detectors in double phase gas-liquid Argon has started. The Irfu group will focus its activity in the WP4 and WP5.

Profile of staff members who will be undertaking the work:

- Dr. Marco Zito, senior researcher at CEA/IRFU, Leader of the T2K team at Saclay and of the EUROnu Super Beam package.
- Dr. Olivier Besida, senior researcher at CEA/IRFU.
- Dr. Georges Vasseur, senior researcher at CEA/IRFU.

P11 - IN2P3 (CNRS)

The Centre National de la Recherche Scientifique (National Centre for Scientific Research) is a government-funded research organisation, under the administrative authority of France's Ministry of Research. CNRS' annual budget represents a quarter of French public spending on civilian research. As the largest fundamental research organisation in Europe, CNRS carries out research in all fields of knowledge, via its CNRS Institutes. Its own laboratories as well as those it maintains jointly with universities, other research organisations, or industry are located throughout France, but also overseas with international joint laboratories located in several countries. Measured by the amount of human and material resources it commits to scientific research or by the great range of disciplines in which its scientists carry on their work, the CNRS is clearly the hub of research activity in France. It is also an important breeding ground for scientific and technological innovation, and has been one of the most active participants to previous and current European Framework Programmes.

IN2P3 has been created in 1971 as an institute of CNRS devoted to particle and nuclear physics, and more recently to astroparticle physics. It is tied by decree ties with the University research and has also strong connections with DAPNIA (CEA)(Dapnia) and CNES (Spatial program). IN2P3 is composed of 23 Laboratories most of which are contracting with universities and CNRS (so called UMR). One of thèse laboratories, the CCIN2P3, is a Computing Center supported and used by both DAPNIA (20%) and IN2P3 (80%).). In 2005 the total IN2P3 permanent staff was 2488 persons (491 CNRS researchers, 304 University professors, 1460 CNRS staff, 233 University staff). For both DAPNIA and IN2P3 there are about 180 graduate students. The IN2P3 & CEA run the Fréjus-Modane Underground Laboratory (LSM) since 25 years and are involved in a wide spectrum of neutrino and astroparticle experiments.

Profile of staff members who will be undertaking the work:
• Prof. Dr. Thomas Patzak, full Professor at University Paris Diderot, project director at APC/IN2P3: leads the IN2P3 group of this project. Scientific activity in neutrino physics and particle physics detector development.
• Prof. Dr. Alessandra Tonazzo, full Professor at University Paris Diderot, APC/IN2P3, has contributed to different highenergy collider experiments, both with detector development and with data analysis
• Prof. Dr. Francois Vannucci , full Professor at University Paris Diderot, APC/IN2P3, has contributed to different highenergy collider experiments, both with detector development and with data analysis
• Dr. Davide Franco, junior scientist CNRS, neutrino physics)
• Dr. Luigi Mosca (LSM, IN2P3), ex-director of the LSM laboratory
• Dr. Fabrice Piquemal (LSM, IN2P3), director of the LSM laboratory
• Dr. Michel Zampaolo (LSM, IN2P3)
• Dr. Gisele Martin-Chassard, (LAL/IN2P3), research engineer, expert for the development of analog front-end ASICs.
• Dr. Selma Conforti, (LAL/IN2P3), research engineer, expert for the development of analog front-end ASICs.
• Dr. Jean-Luc Borne, (LAL/IN2P3), research engineer, expert for mechanical ingeneering
• Dr. Cristina Volpe, permanent CNRS researcher, expert in theoretical neutrino physics and astrophysics
• Dr. Dominique Duchesneau, researcher at LAPP/IN2P3. Leader of the LAPP neutrino group. Participation to OPERA experiment. Scientific interest in neutrino physics and astrophysics
• Dr Henri Pessard, researcher at LAPP/IN2P3. Scientific background in neutrino physics with participation in Bugey, Nomad and OPERA experiments
• Dr. Amina Zghiche, researcher at LAPP/IN2P3. Scientific interest in neutrino physics, participating in OPERA experiment
• Dr . Dario Autiero (IPNL/IN2P3), responsible of the neutrino group at IPN Lyon. Scientific background in neutrino physics with the NOMAD and OPERA experiments. Leads the local group of the LAGUNA project.
• Dr. Lionel Chaussard (UCBL/IPNL/IN2P3) responsible of the software working group in OPERA
• Dr. Yves Declais (IPNL/IN2P3), spokesman of the OPERA experiment and of the past CHOOZ experiment. Long standing scientific background in neutrino oscillation searches
• Dr. Jacques Marteau (UCBL/IPNL/IN2P3), project leader of the data acquisition system in OPERA
• Dr. Claude Girerd (IPNL/IN2P3), research engineer, main designer of the OPERA data acquisition system based on a Ethernet network of 1200 smart sensors with on-board linux processors.
• Dr. Hervez Mathez (IPNL/IN2P3), research engineer, head of the electronics service at IPN Lyon, with a
long experience in low noise analog front-end
• Dr. Edouard Bechetoille (IPNL/IN2P3), research engineer, newly hired designer expert for the development of analog front-end ASICs.

P12 - [TUM] Technische Universität München, Physikdepartment, Chair for Experimental Astroparticle Physics

The Chair for Experimental Astroparticle Physics of the faculty of Physics at the Technische Universität München, Germany, is playing a leading role in its field. Expertise has been achieved in the measurement of solar neutrinos (GALLEX, GNO, and BOREXINO experiments), Dark Matter search (CRESST experiment), and experiments for investigating intrinsic neutrino properties (GÖSGEN, BUGEY, DOUBLE-CHOOZ, GERDA). Technical expertise has been obtained in the development of scintillating detectors with extremely low levels in radioactivity. In addition, large experience has been gained in cryogenic detector developments and in methods to characterize background levels with neutron activation and high sensitivity gamma spectroscopy. For this purpose a shallow site underground laboratory in Garching has been built. Experience in working in deep underground laboratories was obtained in the Italian Gran Sasso facility. Knowledge on electronics, data acquisition, single photon counting, data analysis, and Monte-Carlo calculations has been acquired. Connections to the High-Tech companies Vericold, Ketek, Infineon (D), Aquiris (CH) and ETEL (UK) are fostered, as well as to companies producing organic liquids and liquid handling systems: Helm AG, Wacker AG, Pürstinger High Purity Systems (D) and Cepsa (E). The institute enforces public outreach with open doors days, information days for pupils, public seminars, by supporting the science-Lab of the Technical Museum in Munich. The group consists of 2 professors, 5 senior researchers and 14 PhD-students. A mechanical workshop including 2 engineers belongs to the institute. The group under Prof. S. Schönert is active in this field since 30 years.

Profile of the staff members who will be undertaking the work:

- Prof. Dr. Stefan Schönert, chairman of the institute. Expertise in neutrino and underground physics, and detector technology.
- Prof. Dr. Lothar Oberauer, Extraordinarius. Expertise in neutrino physics at low energies, rare event physics, detector technology and underground low background physics.
- Dr. Marianne Göger-Neff, senior researcher. Expertise in neutrino physics and scintillator development.
- Dr. Walter Potzel, senior researcher. Expertise in Moessbauer-effect, low temperature detectors, neutrino
- physics, and Dark Matter.
- Prof. Dr. Franz von Feilitzsch retired in 2010 but is still supporting the project. Expertise in dark matter, neutrino and underground physics, and detector technology.

P13 - [UHAM] Universität Hamburg, Physikdepartment

As North Germany's largest research and educational institution and Germany's third-largest University, Universität Hamburg combines diverse study opportunities with excellent research. It provides a broad disciplinary spectrum with numerous interdisciplinary opportunities and pursues cooperation with an extensive network of top regional, national and international institutions. Universität Hamburg is devoted to long-term scholarship and science and promotes sustainability research in all schools.
The II. Institut für Theoretische Physik is focused on nearly all areas of elementary particle theory. The variety of activities range from the phenomenology of particle physics and the investigation of new approaches to unified theories up to fundamental questions in quantum field theory and string theory.

The Chair for Experimental Neutrino Physics at the University of Hamburg is significantly contributing to the neutrino oscillation experiment OPERA at LNGS. Expertise has been achieved in building and operating the precision tracker of the OPERA muon spectrometer consisting of 10000 drift tubes. An important part of the electronics and other supporting systems for this module has been developed and optimized in Hamburg. In addition expertise in measuring and analyzing neutrinos from a neutrino beam has been gained. Our expertise in precision measurements of muon tracks has been used for calibration purposes of the BOREXINO solar neutrino detector. In the last years the group became a member of the COBRA double beta decay collaboration. We are developing shielding concepts and especially investigate the use of liquid scintillator as an active shielding for the CdZnTe detector. Therefore we have also acquired expertise in the field of low level radioactivity. At present we are setting up a shallow site underground measurement facility in the old HERA tunnel. The institute enforces public outreach with open doors days, participation in the Uni Hamburg experimental physics programs for pupils, public seminars and girls days. The group consists of 1 professor, 2 senior researchers and 9 PhD-students. A mechanical workshop, an electronics workshop and a technical drawing team belongs to the institute.

Profile of staff members who will be undertaking the work:

- Prof. Dr. Caren Hagner. Expertise in neutrino physics (solar neutrinos, neutrino beams) and detector technology (tracking detectors and liquid scintillator).
- Dr. Joachim Ebert, senior researcher. Expertise in detector technology (neutrino physics and high energy physics).
- Dr. Björn Wonsak, senior researcher. Expertise in neutrino physics (LNGS neutrino beam, COBRA) and software development
- Jun. Prof. Dr. Alessandro Mirizzi. Theoretical astroparticle physics: supernova neutrinos, axions and light weakly interacting particles in astrophysics and cosmology.
- Prof. Dr. Günter Sigl. Theoretical astroparticle physics: cosmic rays, dark matter, primordial magnetic fields, neutrino physics
- Dr. Michael Wurm, senior researcher. Expertise in neutrino physics and scintillator development
- Dr. Sovan Chakraborty. Post-doctoral researcher. Supernova neutrinos and dark matter
- Dr. Nina Saviano. PhD student. Supernova neutrinos

P14 - IFJ PAN

The H. Niewodniczanski Institute of Nuclear Physics of the Polish Academy of Sciences (IFJ PAN) in Cracow is one of the leading and of the largest Polish research institutes. The Institute carries out basic as well as applied research in physics. At present the Institute is involved, as a contractor, in eight projects of the Seventh Framework Programme, LAGUNA being one of them. The basic research, both theoretical and experimental, concerns particle physics and astrophysics, low and high energy nuclear physics and condensed matter physics. In the field of particle physics and astrophysics the experimental teams from IFJ PAN participate in large international collaborations: ATLAS, LHCb and ALICE at LHC (CERN), ZEUS and H1 at HERA (DESY), Belle at KEKB (KEK), PHOBOS at RHIC (BNL), Auger in Argentina, ICARUS at Gran Sasso, T2K at J-PARC and ILC. Physicists in these teams are assisted by an excellent technical staff whose mandate comprises the design and construction of detector mechanical structures, cooling systems, readout electronics, DAQ and trigger systems for experiments. This staff has also provided a significant contribution to the LHC Computing Grid and to the construction of the LHC accelerator.
In the LAGUNA project the group from IFJ PAN was engaged in all aspects of the work for the Polkowice-Sieroszowice site in Poland and in WP4. In the LAGUNA-LBNO project the group will concentrate on the neutrino long baseline physics with the GLACIER option.
Profile of the staff members who will be undertaking the work:

- Prof. A. Zalewska – head of the Department of Neutrino and Dark Matter Studies, experience in particle physics at colliders and in neutrino physics, at present in the T2K and ICARUS experiments, scientific member of Poland to the CERN Council.
- Dr K. Cieslik – postdoc, particle physicist, member of the ICARUS collaboration, experience in the reconstruction and data analysis using liquid argon TPC.

P15 - [IPJ] Soltan Institute for Nuclear Studies

The Soltan Institute for Nuclear Studies (SINS), with branches in Warsaw (Department of High Energy Physics), Swierk, near Warsaw (Department of Accelerator Physics and Technology) and Lodz (Department of Cosmic Ray Physics) is involved in a basic research in nuclear and particle physics, cosmic ray physics and plasma physics as well as in a development and implementation of new technologies in nuclear science and electronics. SINS has a long term experience in ionisation radiation detectors, dosimetry, theory and technology of accelerators, nuclear electronics and the use of computer techniques in simulation of nuclear processes. The research performed at the intersection of pure and applied physics enables SINS to efficiently transmit the theoretical knowledge to practical applications and to industry. The Institute is also engaged in education through its special PhD studies programme. The Institute is entitled to award the PhD and habilitation degrees. The SINS physicists and engineers are participating in preparation of modern experiments at (large) accelerators (CERN, FNAL, KEK, RHIC). The strong group interested in neutrino physics is active in the institute since 2000, consisting of 5 seniors, 4 PhD students (presently) and technical support in electronics and mechanics. The group is gaining experience in the liquid Argon TPC technology. One of the members has experience in neutrino physics starting in IMB detector, through Super-Kamiokande from its beginning. The activity in dark matter searches includes in particular the simulation of backgrounds from radioactive materials and from cosmic muons. Also significant experience exists in registration of neutrons generated in cosmic ray interactions. Observations were made on surface and in the underground laboratory 15 meters underneath using mostly helium counters. The thermal neutron background from energetic neutron background can be distinguished.

Profile of the staff members who will be undertaking the work:

- Prof. Ewa Rondio – leader of the group, experience in muon accelerator experiments at CERN (EMC, NMC, SMC, Compass)
- Dr hab. Danuta Kiełczewska, long experience in neutrino physics (IMB, Super-Kamiokande, K2K)
- Dr Tadeusz Kozłowski, experience in nuclear physics and in precise measurements performed at PSI
- Prof. Joanna Stepaniak, experience in hadronic interactions at low energies (Lear, Wasa)
- Prof. Maria Szeptycka , experience in Delphi, detector construction
- Dr Jacek Szabelski, experience in cosmic ray physics and neutron measurements.

P16 - [PWr] Wroclaw University of Technology, Faculty of Mechanical and Power Engineering.

Wrocław University of Technology (www.pwr.wroc.pl) is a public institution which was founded in 1945, but its academic legacy dates back over 160 years to the Lviv University. Our position in the research and teaching field places us among the three best technical universities in Poland. Over 32 000 students study here, under the guidance of 2 000 academic teachers, at the 12 faculties (Architecture, Civil Engineering, Chemistry, Electronics, Electrical Engineering, Geoengineering Mining and Geology, Environmental Studies, Computer Science and Management, Mechanical and Power Engineering, Mechanical Engineering, Fundamental Problems of Technology, Microsystems Electronics and Photonics).

The Faculty of Mechanical and Power Engineering belongs to the oldest faculties of Wroclaw University of Technology. The Chairs, which in 1954 became part of the Faculty of Mechanical and Power Engineering, were established between 1945-1950 within the Faculty Mechanical Engineering and Electrotechnics. After it had been split they were part of the Faculty of Mechanical Engineering. The Faculty of Mechanical and Power Engineering was founded in1954. It specializes in thermodynamics, fluid mechanics, process engineering, power generation, aircraft engineering, refrigeration and cryogenics. The Faculty collaborates with CERN, ITER IO and DESY in the field of analysis and development of cryogenic systems and risk analysis.

Profile of staff members who will be undertaking the work:

- Prof. Maciej Chorowski, Dean of the Faculty, head of the Cryogenics and Automatic Control Group, experience in analysis and development of cryogenic devices and systems (Joule-Thomson refrigerators, LHC cryogenic system, ITER cryogenic system), elected member of International Inst. of Refrigeration and Int. Cryogenic Eng. Committee.
- Dr. J. Polinski; Assistant Professor, cryogenic systems performance and safety analysis, cryogenic system design, low temperature heat transfer, vacuum thermal insulations, low temperature measurements, applications of cryocooler.
- Dr. W. Gizicki, Assistant Professor, analysis of thermal processes, market oriented analysis and gas anf cryogenic system feasibility.
- Dr. A. Piotrowska-Hajnus: Post-doc., Joule-Thomson systems, risk analysis, applications of cryocoolers.

P22 - [IMPERIAL] Imperial College London

Imperial College London is a science-oriented research-intensive university located in South Kensington, London, UK. It regularly features in lists of the world's top universities. Imperial has about 13,500 students and 3,300 faculty and staff, with an annual research income of over 350 million Euro, and numbers 14 Nobel Laureates amongst its alumni and (current and former) faculty.
Profile of staff members who will be undertaking the work:

- Prof. Dave Wark is a Professor of Physics at Imperial College and at the STFC Rutherford Appleton Laboratory. He has been involved in neutrino physics for almost 30 years as a member of many experiments, was the UK co-spokesperson for the SNO experiment and is currently the International Co-Spokesperson of the T2K neutrino oscillation experiment in Japan. He has served on numerous international review committees, including the SPSC and the SPC at CERN, was awarded the 2004 Institute of Physics Rutherford Prize for contributions to astroparticle physics, is the former Chair of the European Physical Society High Energy Particle Physics Division and a former President of the Physics Section of the British Association for the Advancement of Science, and is a Fellow of the Royal Society.

P27 - [RAL] Rutherford Appleton Laboratory/Science and Technology Facilities Council

The Rutherford Appleton Laboratory (RAL) is the main national scientific research laboratory in the UK and is operated by the Science and Technology Facilities Council (STFC). RAL is located on the Harwell Science and Innovation Campus at Chilton near Didcot in Oxfordshire, United Kingdom. It hosts ISIS, the world's brightest pulsed neutron source, the Central Laser Facility including Vulcan, the world's highest intensity focused laser, the synchrotron light source Diamond, RAL Space, and large Technology, Accelerator R&D and Particle Physics Departments. It has a staff of approximately 1,200 people who carry out original research and support the work of over 10,000 scientists and engineers, chiefly from the university research community. RAL is named after the physicists Lord Ernest Rutherford and Sir Edward Victor Appleton and in 2007 celebrated its 50th anniversary of world-class science.
The High Power Targets Group belongs to the Technology Department and specializes in analytical, experimental and project work in the realization of target technology for the new generation of particle accelerator driven facilities. Recent projects have included the target, window and beam dump for the T2K neutrino facility, ILC beam dump studies, the development of a new tungsten powder jet target technology, ISIS target studies and LBNE target studies.

Profile of Staff members who will be undertaking the work:

- Dr CJ Densham, head of the High Power Targets Group; T2K UK Beam & Target WP manager; joint targets co-ordinator for International Design Study for a Neutrino Factory (IDS); EUROnu Superbeam WP deputy manager; Co-ordinator of following conceptual design study Accords with Fermilab: LBNE, Mu2e and NuMI.

- Dr O Caretta: Chartered mechanical engineer working on the development of a new fluidised powder based generic high power target system. Expertise in FLUKA, Matlab, CFX and ANSYS Autodyn, now working on NuMI target study for FNAL.
- Dr T Davenne: Chartered mechanical engineer, projects include ILC beam dumps, liquid mercury target and dump studies for Neutrino Factory, DiPOLE laser project, now working on LBNE and Mu2e target studies for Fermilab. Expertise in FLUKA, ANSYS Autodyn and CFD codes.
- Dr MD Fitton: Chartered Mechanical engineer and key member of the UK T2K beamline team for the past 3 years. Responsible for the engineering design and analysis of the target and baffle/collimator. Expertise in Computational Fluid Dynamics (CFD), stress analysis, heat transfer and materials. Working on DiPOLE laser project and ISIS targets.
- Mr P Loveridge: Chartered mechanical engineer with expertise is in structural/thermal/magnetic analysis and design. He has experience working in collaborative high energy physics projects, including installing and commissioning RICH2 detector for LHCb at CERN, generic powder target R&D programme at RAL, and combined target and magnetic horn studies for LBNE.
- Mr M Rooney: Chartered Mechanical Engineer. Expertise in finite element analysis, particularly relating to stress waves resulting from pulsed beams. He was responsible for the complete T2K target station beam window project. Experience and knowledge of beam windows for high powers and of remotely operable vacuum seals.

P26 - [USFD] University of Sheffield

The University of Sheffield is a premier research University in the UK, participating here through the Department of Physics and Astronomy and the Department of Civil and Structural Engineering. Members of the Physics department (led by Spooner) play a leading role in UK and European Astroparticle Physics through development of underground detector technology (for dark matter and neutrino physics) in the Boulby Underground Laboratory at Boulby Mine, North Yorkshire. The Civil Engineering Department group active in LAGUNA (led by Cripps) is world-leading in relevant geo-mechanics and has played a key role in LAGUNA as the only non-industrial experts in geo-technology in the collaboration. Boulby was selected as one of the potential sites for LAGUNA in 2007. Our role at Boulby gives us unique experience to be a major contributor to LAGUNA-LBNO - the Palmer Laboratory Facility at Boulby is the largest and longest running deep mine-based laboratory in Europe. Established in 1988 and expanded in 1999 with new facilities, is has been host to successful dark matter (NAIAD, ZEPLIN, DRIFT) and other experiments and has a strong record of R&D in connection with the ILIAS FP6 programme. The groups (currently five academics and 10 students, technicians and PDRAs in Physics and 2 academics in Civil Engineering) has extensive experience gained over 15 years directly relevant to the workpackages in LAGUNA-LBNO including: excavation and mine operations; geo-mechanics, geology, rock mechanics, development of large underground infrastructures and laboratories in mine environments; underground background and environment research; scintillator, liquid argon, photon detection, electronics and data acquisition technology for underground detectors; engineering of unusual pressure vessels for underground use; interaction with non-physics applications, industrial cooperation and public outreach.

Profile of the staff members who will be undertaking the work:

- Prof. Neil Spooner, Boulby Laboratory, USFD Particle Physics group leader, expertise in dark matter, neutrino and underground physics, and detector technology
- Dr. Vitaly Kudryavtsev, Senior Lecturer, expertise in dark matter and rare event physics, detector technology and underground background simulations
- Dr. Lee Thompson, Reader of Physics, expert in neutrino physics detector design and construction, neutrino particle astrophysics
- Dr. Chris Booth, Reader of Physics, expert in high energy beam target mechanics and electronics

- Dr. Susan Cartwright, Senior Lecturer, expert in neutrino oscillation physics, data analysis including use of water cherenkov and simulations
- Dr. John Cripps, Senior Lecturer, leader in geo-mechanics and geology research including assessment of rock mass stabilities and structure
- Dr. Terry Bennett, Lecturer, expert in geo-mechanics and geology research including finite element analysis simulations and cavern structure research
- Dr. Sean Paling, senior researcher. Expertise in underground operations and engineering, rare event physics, analysis and detector development
- Dr. Dan Walker,researcher. Expertise in detector installations and operation including logistics, costing and risk analysis, mine operations and engineering, rare event physics, novel readout techniques
- Dr Matt Robinson, senior researcher. Expertise in data reduction, data analysis, simulations and data acquisition systems particularly of liquid argon tracking simulations
- Mr. Mark Pipe, PhD student working on detector development using charge readout relevant to liquid argon

P23 - [UDUR] Durham University

Durham University is a world-class university in the city of Durham and at the Queen's Campus in Stockton, in the United Kingdom. It is engaged in high-quality teaching and learning and advanced research and partnership with business. Its academic teaching and research programmes are delivered through departments contained within three faculties: Arts and Humanities, Science, and Social Sciences and Health. The Department of Physics is part of the Science Faculty.
The Institute for Particle Physics Phenomenology (IPPP) was founded in 2000 as a joint venture of Durham University and the UK Particle Physics and Astronomy Research Council (PPARC). The IPPP is part of the Centre for Particle Theory (CPT) in Durham, based jointly in the Departments of Mathematical Sciences and Physics, with a number of academic staff having joint appointments in the two Departments. Its aim is to foster world-class research in particle physics phenomenology, and to provide a forum for interaction between experimentalists and theorists, coordinating common interests and future research through a series of discussion meetings, workshops and conferences. Within a short space of time, the IPPP has achieved international recognition and the recent Second International Review of UK Research in Physics and Astronomy stated ``The IPPP has had major successes: creating a critical mass of particle theorists in Durham. There have been very healthy interactions reviving particle phenomenology throughout the UK."
The IPPP currently comprises 14 permanent staff (Professors Khoze (Director), Abel, Ball, Glover, Richardson and Drs Heinrich, Krauss, Jaeckel, Maitre, Maxwell, Pascoli, Signer and from Jan 2011, Dr. Boehm and Feldmann) as well as 14 fixed term research staff and 28 postgraduate students. An extensive visitor programme brings world-class researchers to the IPPP for periods ranging from a few days to a year. Training for the next generation of particle physicists is provided through guidance in research, and dedicated graduate lecture programmes and summer schools.
Research activities cover all aspects of particle phenomenology and, in particular, topics directly related to the LAGUNA_LBNO project, namely physics Beyond the Standard Model of Particle Physics, astroparticle physics and neutrino physics. Well-known experts work on i) neutrino phenomenology, concerning the study of neutrino properties in present and future experiments, ii) theoretical aspects of neutrino physics with particular focus on the origin of neutrino masses, iii) the role of neutrinos in the Early Universe and in the evolution of astrophysical objects as supernovae. Expertise on extensions of the Standard Model, which predict proton decay, and on dark matter is also present.

Durham will lead the activities of WP5 and coordinate the different Tasks in WP5 among themselves and with the work carried out in WP2, WP3, and WP4. In addition, S. Pascoli will be responsible for Tasks 5.1 and 5.3 concerning the common and unified simulation of the detectors performance and the study of the physics reach for long baseline neutrinos experiments in order to fully exploit and optimise the physics potential of the LAGUNA-LBNO research infrastructures.

Profile of the members who will be undertaking the work:

- Dr. S. Pascoli, faculty member. Research in neutrino physics, extensions of the Standard Model, astroparticle physics and cosmology.
- Dr. C. Boehm, faculty member. Research expertise in astroparticle physics and related topics.
- Dr. M. Schmidt, post-doctoral researcher. Expertise in neutrino phenomenology, theory of neutrino mass generation, problem of leptonic flavour, dark matter.
- Dr. J. Lopez-Pavon, postdoctoral researcher. Expertise in neutrino phenomenology, theory and astroparticle physics.
- P. Ballett, PhD student. Study of long baseline neutrino experiments.
- J. Davis, PhD student. Study of long baseline neutrino experiments.
- T. Li, PhD student. Study of long baseline neutrino experiments.
- C.-F. Wong, PhD student. Studies on sterile neutrinos and neutrino properties.

P24 - [UOXF-DL] University of Oxford, Sub-Department of Particle Physics

The University of Oxford is one of the major and best research universities worldwide. It regularly appears among the top 10 universities in almost any international lead table. It concentrates on first class education and research in all areas from the sciences, medicine to the humanities. It is a member of the Russell group of leading research universities in the UK.
The sub-department of particle physics is part of the MPLS division at the University of Oxford and has a wide research program in particle physics, covering the energy and intensity frontier as well as dark matter and low energy precision experiments. The department also houses the Adams institute of accelerator science.
Profile of the staff members undertaking the work

- Dr. Alfons Weber, academic, MINOS UK spokesperson and elected member of the MINOS Executive Committee, member of PPAN one of the most influential advisory panels in STFC, experience with development of hardware especially electronics for HEP experiments and analysis of neutrino oscillation experiments, worked on new particle searches and electroweak physics. Present and past international research projects: T2K, LBNR, MINOS, INF, MICE, L3, LEP
- Dr. Giles Ba, academic, leader of the Oxford T2K group, member of the MINOS Executive Committee, wide experience in neutrino and hadron production experiments, one of the worlds experts in atmospheric neutrino flux calculations, Past and present international research projects: T2K, LBNE and MINOS, NA31, NA48, NA49
- Dr. Jeff de Jong, post-doctoral researcher, currently working on MINOS & LBNE with expertise in detector calibration, cosmic ray and neutrino oscillations physics.

P28 - [WARWICK] University of Warwick

The University of Warwick is consistently rated one of the top universities in the UK, being ranked 8th overall in the UK in the 2011 Times University league tables, and 53rd overall in the QS World University Rankings Results 2010. The physics department is one of the largest in the UK and is well-regarded both for the quality of its teaching and its research. Warwick is one of the few UK physics departments to be awarded the maximum of 24 points in the assessment exercise carried out by the government's Quality Assurance Agency. The Particle Physics group of the physics department has major commitments to experimental neutrino physics through involvement with the T2K project and R&D activity related to next-generation neutrino projects. The group has expertise and experience that is directly relevant to our proposed involvement in WP5 which includes current R&D programmes into liquid argon TPC readout and the development of simulation and reconstruction algorithms of neutrino interactions in liquid argon TPC's.
Profile of staff members who will be undertaking the work:

- Dr. Gary Barker, Associate Professor , expertise in neutrino detector design and construction, liquid argon neutrino- interaction reconstruction algorithms

- Dr. Ben Morgan, Senior Research fellow, expert in detector simulation and object-oriented software design
- Dr. Yorck Ramachers, Associate Professor , expert in detector development: simulation, design and construction
- New PostDoc, we are currently interviewing for a new post in experimental neutrino physics

P29 - [QMUL] Queen Mary University of London

Queen Mary and Westfield College, University of London (QMUL) is one of the UK's leading research-focused higher education institutions. Amongst the largest of the colleges of the University of London, QMUL's 3,000 staff delivers world class research across a wide range of subjects in Science and Engineering, Medicine and Dentistry and Humanities. QMUL has recently been ranked 11th among the leading research Universities in the UK according to the 2008 Research Assessment Exercise (RAE) and fourth amongst University of London multi-faculty colleges. With a budget of £260 million per annum and a yearly economic impact on the UK economy of some £600 million, Queen Mary is a research-focused university, which has made a strategic commitment to the highest quality of research.
The School of Physics has an international reputation for its research, whose landmarks include: participating in the Nobel-award discovery of the W and Z bosons at CERN, playing a leading role in the development of superstring theory, participating in the BaBar experiment mentioned in the 2008 Nobel Prize awarded to Profs. Kobayashi and Maskawa, participating in the IRAS satellite mission, building a spectrometer for the Infrared Space Observatory (ISO), playing a leading role in the balloon-born experiment BOOMERANG, the invention of the Martin-Puplett polarising interferometer.
Profile of the Staff members who will be undertaking the work:

- Dr. Francesca Di Lodovico, Reader in Particle Physics (academic), deputy group leader of the QMUL Particle Physics Research Centre and leader of the neutrino group, that she founded in 2004, PI of the “T2KQMUL” ERC Starting Independent Research Grant, coordinator of the data quality of the T2K near detectors. Competences in particle physics, neutrino oscillations, CP violation, rare B decays, Higgs boson search, worldwide averages (HFAG –advisor for the PDG- chair, semileptonic group). Present and past international research projects: T2K, BaBar, CMS, L3.
- Dr. Roberto Sacco, Research Associate. Competences in experimental particle and astro-particle physics, neutrino, B and Kaon physics, cosmic protons, calorimetry. Present and past international research projects: T2K, BaBar, ATLAS, NA48, CLUE.

P25 - [U-LIVERPOOL] University of Liverpool, Department of Physics

Founded in 1881, the University of Liverpool is one of the UK’s top 20 research-led universities with strategic partners worldwide and a £123m pa research budget. It is a principal centre of excellence in many disciplines, including science, engineering, medicine, dentistry, business and law. The Physics Department has a long and distinguished history including 3 Nobel Prize winners (Barkla, Chadwick, Rottblat), in-house particle accelerators from 1936 up to the 1980s, and currently strong experimental nuclear and particle physics groups and the Liverpool Semiconductor Detector Centre consisting of a mechanical workshop and suite of clean rooms with the associated team of engineers, technical physicists and technicians. The Particle Physics group has in recent years designed, constructed, and delivered the 130,000cm^2 ATLAS EndCap-C silicon array, the LHCb silicon vertex detector (VeLo), and most of the T2K 60-tonne ND280 electromagnetic calorimeter, the largest component for a Japanese experiment ever built in Europe.
The Neutrino group, initiated in 2004 by professor C. Touramanis, is a major partner in the T2K neutrino oscillations experiment in Japan, has a fully operational 40-litre Liquid Argon prototype detector designed and built in-house, participates in the SNO+ experiment in preparation in Sudbury Canada, and has been a partner in the KM3NeT EU-funded DS. The group has expertise in the design

and delivery of detectors, planning, operation, and analysis of complex experiments, large-volume data handling and analysis, and planning and management of large international projects in Europe, America, and Asia.

Profile of the staff members who will be undertaking the work:

- Prof. Christos Touramanis, head of the group, member of the CERN SPS Committee, ex-member of the STFC Particle Physics Grants Panel, convener responsible for the ECAL subsystem of the T2K Near Detector, member of the T2K Analysis Steering Group. Competences in detector design, construction, operations, data analysis, collider-based experiments, CP Violation, neutrino physics, searches for physics beyond the Standard Model, science and project management at international level. Experience from CPLEAR (CERN), BABAR (SLAC), T2K (Japan), KM3NeT.
- Dr Neil McCauley, Lecturer (faculty), member of the SNO+ collaboration and ex member of the SNO collaboration, currently software release coordinator and convener of the electron neutrino analysis group for the T2K Near Detector. Competences in neutrino physics and detection, solar, atmospheric, and high energy neutrinos, low background and underground environments, simulation and analysis, large scale software project management. Experience from SNO, T2K, SNO+.
- Dr Jonathon Coleman, Royal Society University Research Fellow, ex SLAC Research Fellow, member of the international Heavy Flavor Averaging Group, expert advisor for the Particle Data Group. Competences in data and physics analysis, simulation, detector operations and data handling, advanced statistical methods. Experience from BABAR (SLAC).
- Dr Kostas Mavrokoridis, post-doctoral research associate. Competences in noble liquid and gas detectors, detector design, construction, and commissioning, low-radiation measurements, pulse-shape analysis, photon-neutron discrimination, Dark Matter searches, research in underground labs. Experience from ArDM.

P9 - [Rockplan] KALLIOSUUNNITTELU OY ROCKPLAN LTD

Rockplan is a consulting company founded in 1986 and has over 20 years experience in every kind of underground facilities. For the most part acting as main designer, the company has gained experience through various projects in the field of rock engineering. The staff is mainly made up of architects, civil and rock engineers and geologists. The staff of 30 persons is mainly made up of architects, civil and rock engineers and geologists. The company is SME. The company has specialized in managing the design, general design, rock engineering design and structural design. Additional plans and designs are produced in co-operation with experienced subcontractors.

- Kalliosuunnittelu Oy Rockplan Ltd, (Rockplan), is able to act as Design Manager, coordinating and controlling the work or as a main designer.
- General design by Rockplan embraces both layout design and architectural design. In carrying out general design the company aims to create a suitable, safe, technically high quality underground facility meeting the client's requirements.
- The aim of Rockplan in rock engineering design is to use properties of the rock to the best advantage, and to prepare high quality plans excavation, reinforcing the rock surface, sealing and waterproofing. A fundamental consideration of the design is safety during construction.
- Rockplan aims to produce structural designs that take account of the special requirements of underground construction in cost effective manner. Structural design is required for among other things: entrance ramps and shafts, internal floors and structures and blast-resistant barriers.

Additional plans and designs are produced in co-operation with experienced subcontractors.
The main task of Rockplan in this Design Study is to make the preliminary design and technical feasibility study of the underground construction in the Finnish site, within WP2, working in close collaboration with Oulu. Rockplan is involved also in WP3 (tanks) and WP5 (safety).

Rockplan has been actively taken part in innovate new technology underground projects. One of the first steps was Hirvihaara deep storage of natural gas in Southern Finland. Rock lined cavers of total

volume of 1.6 M m^3 were located in 850 meters depth. The detailed design of hoisting and service systems was carried out in years 1990-92 for Neste Oy Natural Gas. To the same client Rockplan designed also a concept of steel lined natural gas storage. The client discontinued these projects.
Rockplan has completed design of a 150.000 m^3 steel lined petroleum storage in Finland. The storage consists of 5 tanks with diameter of 35 meters. This storage has been operated for 16 years. Client and details are confidential information.
Kamppi Centre (Kampin keskus), the largest single construction project that has been carried out in Finland, was the best construction site of the year 2003. The jury grounded the election on Kamppi's visionary rock engineering in difficult circumstances and innovative technical solutions. The blasting work has been remote sensored in realtime and the effects has been analysed for security purpose before the next coming blast.
Salmisaari, underground coal storage. The overall project involves 3,5 km of tunnel with 40 different cross sections. Total excavation of 550.000 m^3 of granite/gneiss has being undertaken, all of which was crushed and screened for reuse by the local construction industry. The underground silos are each 65 m-high x 40 m-diameter with circular plan cross-section. The volumetric capacity of each silo is 81.000 m^3. The Salmisaari coal transport tunnel will be re-equipped to charge the silos and a newly mined conveyor retrieval tunnel will be used to discharge the coal.

The staff members undertaking the work will include:
- Jarmo Roinisto, Chairman of the Board, Managing Director, M.Sc. (Civ.Eng.): Project management, design and supervision of rock engineering, tunnelling and underground spaces
- Juha Salmelainen, Development Director, M.Sc. (Eng.Geol.): management of rock engineering projects, site investigations and rock mechanical modelling
- Raimo Matikainen, emeritus professor of rock engineering, former Director General of the Finnish Geological Survey, Board member and vice chairman of The Finnish Academy of Technology: wide experience of engineering in mining industry and geological research
- Matti Hakala, Special Designer: rock modelling in 2D and 3D using the most advanced calculation programs
- Guido Nuijten, M.Sc. (civil eng), Manager of the rock engineering dpt., head of design in underground projects

P4 - [LOMBARDI] Lombardi Engineering Ltd

Lombardi Engineering Ltd. was founded in 1989 as the successor to Giovanni Lombardi Ph. D. Consulting Engineers, active since 1955 in the civil engineering sector. With approximately 100 employees at the head office in Minusio (Switzerland) and its affiliated companies, Lombardi Ltd. offers a wide range of engineering services in various construction fields. The provided services cover the design, construction and operation stages of civil works, from preliminary studies to the continuous monitoring under normal and exceptional conditions. The continuing improvement of these services through an optimal combination of experience and innovation has consolidated the company's position in the Swiss and international civil engineering markets. Visionary and innovative projects, brought to successful completion by a strong partnership with customers, are the best credentials for outstanding and high quality engineering services.
In the future, Lombardi Ltd. will continue to develop customer tailored and innovative solutions combining technological innovation with proven engineering practice. Significant resources are invested annually for research, development and optimisation of both traditional and specialised engineering services in order to offer best quality services resulting finally in optimised project costs.
The Lombardi SA Foundation is supporting young civil engineers promoting research and developments mainly in rock mechanics and hydraulic structures. A dynamic and experienced management team, and the independence from contractors or suppliers, are milestones of a proven company's organisation promoting customer partnership. Faithful to its commitment of quality and customer satisfaction, Lombardi Ltd. has the necessary potential to contribute actively in tomorrow's challenges in civil engineering sector.

Lombardi SA developed the design of the Fréjus safety tunnel. The information gained on geology, behaviour of the rock to excavation and tunnel operation will be made available within this research.

The staff members who would be undertaking the work:

- Eng. P.F. Bertola, Chief Director, 40 years experience, Member of the Scientific Commission of the Institute of Science of the Soil (Swiss Italian Professional University), designer of rock engineering and tunnelling projects.
- Eng. F. Amberg, Head of technical and scientific division, 15 years experience, Member of the Swiss Committee of Dams, expert in rock mechanics modelling.
- Eng. A. Mordasini, Head of civil engineering division, 22 years experience, designer of Fréjus safety tunnel. He is in charge as safety officer for major road tunnels among them the Mount Blanc tunnel, Fréjus tunnel and the motorway tunnels between Turin (I) and Chambery (F).
- Eng. U. Drost, Head of the electromechanical and security department, 16 years experience.
- Eng. U. Grässlin, IT and supervision specialist, 44 years experience.

P34 - [AGT] AGT Ingegneria Srl

AGT Ingegneria Srl (ISO 9001 accredited company), together with its partner (sub-contractor) Geoingegneria Srl, are both companies that work and collaborate in the field of road and geotechnical engineering.

Ing. Marco Temussi (T.D of AGT Ingegneria) and Ing. Giuseppe Ristaino (T.D. of Geoingegneria) have more that 20 year experience in the above fields; their jobs in design have been committed by some of the most important Italian purchasers, in the public and in the private sectors (both building firms and engineering companies).
The most significant achievements in the recent years are:

- the preliminary design of all the road and railway connections in the General Contractor tender for the bridge over the "Stretto di Messina" (coordinator: Ing. M. Temussi), which includes several tunnels longer than 1 km;
- advise, as consultants, about design, geotechnical/geomechanical and related computing matters in many executive designs committed for the renovation of several parts of the Salerno-Reggio Calabria motorway, including natural tunnels with double pipe, for a total length of 5,744 km, and all the needed connections;
- advise, as consultants, about design, geotechnical/geomechanical and related computing matters in the executive design and the construction of the closest part to Terni of the new highway Civitavecchia-Orte-Terni-Rieti; which includes three natural tunnels (the "Valnerina" Tunnel - about 4 km long - the "Svincolo Valnerina" Tunnel and the intermediate access, called "Discenderia" Tunnel) for about a total length of 5,060 km, together with all the artificial excavations needed to connect them;
- currently: advise, as consultants, about design, geotechnical/geomechanical and related computing matters in the executive design and the construction of the tunnels (six tunnels for a total length of about 2,5 km) in road connection to La Spezia Seaport Hub (variation to SS 1 "Aurelia");
- currently: advise, as consultants, about design, geotechnical/geomechanical and related computing matters in the executive design and the construction of the tunnel (2 single-direction tunnels, with a total length of about 7 km, without junctions) in 1st lot of the road connection between Highway A4 and Valtrompia.

The study proposed by AGT Ingegneria, in co-operation with Geoingegneria and other experienced subcontractors and advisors, will include:

- The determination of the optimal location for the underground laboratory, based on the geological, the geomorphological and the hydro geological characteristics of the site, and taking into account the scientific requirements as well – updating and fine tuning, resting on developments in study of tank construction and integrations in study of needed instrumentation;
- The geological, geotechnical and geomechanical characterization of the formations found in the

area under investigation and in the selected site; the prediction of the mechanical behaviour of the rocks and the preliminary design of the underground pits, including the assessment and the check of the stabilization work for the excavation, achieved through the use of specific computing programs based either on custom code, developed within the companies, or on standard technical codes (f.e.m.), internationally used– updating and fine tuning, resting on developments in study of tank construction and integrations in study of needed instrumentation;

- Design of civil works needed for infrastructure equipments (ventilation, power supply, etc.);
- Support in risk analysis;
- Updating – resting on developments in study of tank construction and integrations in study of needed instrumentation – of the preliminary design of the road links within the site, at all phases of the project (building, assembling and installation of the scientific equipment, normal working of the laboratory);
- Assessment of the environmental impact of the project;
- Estimation of the costs for civil works (excavation, structures, external roads) and of the time for the e execution of the excavation and of the subsequent works;
- Meeting participation and support for development of hypothesis of "near detector" construction (if necessary).

The staff members who would be undertaking the work:

- Ing. Marco Temussi – LAGUNA-LBNO Project Leader – Technical Director of AGT Ingegneria – Project management, design and supervision of rock engineering, tunnelling and underground spaces
- Ing. Giancarlo Galvanin – Technical Director of AGT Ingegneria – Project management, design and supervision of rock engineering, tunnelling and underground spaces – Health and safety aspects
- Ing. Giuseppe Ristaino – Technical Director of Geoingegneria – Geotechnical aspects – Numerical modelling and rock mass stability analysis
- Prof. Giorgio Minelli – Associate Professor in Structural Geology in Università di Perugia – Geological Sciences Department
- Dott. Claudio Bernetti – Expert Geologist

P17 - KGHM CUPRUM

The KGHM CUPRUM Ltd. Research and Development Centre (KGHM CUPRUM), which is a part of the KGHM Polska Miedź SA capital group, has existed for over 35 years. During the first few years of its activity the company developed the research and design studies for the Polish copper basin and then for many other home and foreign mine projects, which gave it a stable position in the non-ferrous metals, salt mining and mine construction industries. At present it widens its activity range participating in geological and mining projects of the European Union.
Being aware of the XXI-st century challenges the company widens its activity undertaking problems of environmental protection and companies restructuring. It is at the same time consultant, expert and authority in geology, extractive industry, minerals processing and environmental protection.
KGHM CUPRUM has a highly qualified and experienced team of specialists (over 140) who create the most modern technical solutions and guarantee services on a high quality level. It also has the ISO 9001 and 14001 certificates.
The company has its own, fully accredited laboratory of rock mechanics with excellent equipment for investigating rock behaviour under any kind of load. It has a special purpose software and unique test instruments like chromatographs for gas mixtures and volatile liquids analyses, an X-ray diffractometer, a spectrometer of infrared radiation, a modern noise level gauge, a portable system for gas emission measurements, a kit for measuring and analysing vibrations, thermovision equipment, instruments for non-destructive laboratory and field tests, and a set for water analyses.
The research activity of KGHM CUPRUM Ltd. RDC is presently focused on: geology, hydrogeology

and mining projects feasibility studies, mining, including rock mechanics, mines electrification, automation, mechanisation and ventilation, minerals processing, environmental protection with its monitoring and wastes management, companies restructuring, economical studies, technical expertise and engineering concepts evaluation used mainly for copper mines (among them also the Sieroszowice mine) exploited by KGHM Polska Miedź S.A.
KGHM CUPRUM participated in geological and hydro geological, mining and environmental projects of the European Union within 5th and 6th FP including:

- Life Cycle Assessment of Mining Projects for Waste Minimization and Long Term Control of Rehabilitated Sites (LICYMIN) - G1RD - CT - 2000 – 00162
- Chemically Stabilized Layers (CLOTADAM) – G1RD-CT-2001-00480
- Lifetime Engineering of Buildings and Civil Infrastructures - (LIFETIME) - GTC1-2001-43046
- Network on European Extractive Mining Industries (NESMI) - G1RT-CT-2002-05078
- Search for a sustainable way of exploiting black ores using biotechnologies (BIOSHALE) – NMP2-CT-2004-50571

For many years CUPRUM has been organising domestic and international scientific conferences and seminars on roof bolting, minerals processing, metallurgy, environmental protection and mining in difficult rock-mass conditions. The company has an authorisation granted by the Minister of Environmental Protection, Natural Resources and Forestry to deal with: atmosphere protection, land surface protection, environmental impact assessments of investments and building structures.
The KGHM Cuprum contribution to the Laguna project will cover feasibility studies for large caverns, problems concerning the site accessibility, evaluating the geomechanical limitations excavation technology, ventilation requirements, costs evaluation (WP2), local geomechanical hazards assessment due to mine activity and environment protection analyses (WP5).

The staff members undertaking the work will include:

- Dr. hab. Witold Pytel – project leader, M.Sc. (Civ. Eng.), MBA: background in soil and rock mechanics, numerical modeling and rock mass stability analyses, risk assessment and management,
- Dr. Andrzej Grotowski, : expertise in environmental protection and mineral processing,
- Dr. Andrzej Markiewicz, Geologist: expertise in geological survey and tectonic structure research,
- Miroslaw Raczynski, M.Sc. (Electr. Eng.): expertise in electric power supply and automation in mines,
- Zbigniew Sadecki, M.Sc. (Min. Eng.): expertise in mine planning and equipment selection,
- Dr. Slawomir Gajosinski, M.Sc. (Min. Eng.): expertise in mine ventilation and air-conditioning

P21 - ACCIONA INGENIERÍA and STMR

ACCIONA INGENIERÍA (former IBERINSA), in association with STMR (Servicios Técnicos de Mecánica de Rocas) are the civil engineering firms that have developed the LAGUNA WP2 for the Laboratorio Subterráneo de Canfranc.

ACCIONA INGENIERÍA is specialized not only in underground works design and monitoring, but also in other engineering aspects, such as road and railway design, environmental assessment, and electrical and mechanical installations for tunnelling or other civil engineering purposes.
Recent references of this work are the design of Lot 1 of the Pajares High Speed Railway Tunnel (24 km long, recently finished), the Ontígola High Speed Railway Tunnel (more than 4 km long, on operation next months), the Jalón-Grío diversion tunnel for the Mularroya Dam (12 km long), or the Ralco Hydroelectrical Power Plant cavern in the Ralco Dam (BíoBío river, Chile). The manager of the Geotechnical Department is Clemente Sáenz, civil engineer, 20 years experience in geotechnics, specialized in engineering geology and teacher of Applied Geology in the Politechnical School of Madrid. Mr. Saénz has been also responsible for the design of different railway, metro and road tunnels.

STMR is directed by Prof. Manuel Romana, civil engineer with almost 50 years experience, and rock mechanics Professor at the Polytechnical School in Valencia, and one of the most well-recognized Spanish and European experts on this matter, and consultant for lots of undergorund facilities, including 500 km of tunnels and several caverns. Professor Romana has been technical assessor for the design and construction of caverns such as Aldeadávila 2, La Yesca, or the actual LSC cavern at Canfranc, and for different tunnels such as Paracuellos (Madrid-Zaragoza High Speed Railway Line, 4 km long), Guadiaro-Majaceite diversion tunnel (12 km long), the twin tunnel of Guadarrama (28 km long in the Madrid - Valladolid High Speed Railway Line), and many others for road and railway purposes.

The association of these two leading expertise companies shall also be assessed by Prof. Alonso Gullón, mining engineer, with almost 40 years experience as mining consultant and former Quality and Environmental Manager of Obras Subterráneas, a Spanish company specialized in construction and management of underground works. Mr. Gullón is also professor of the School of Mining Engineers of the Politechnical School of Madrid.

ACCIONA INGENIERÍA belongs to ACCIONA group, a world-wide construction contractor, specialized in civil works and in energy and water facilities and supplies, operating in Europe, North and South America, Asia and Australia. ACCIONA and OBRAS SUBTERRÁNEAS were the Contractors of the Somport Tunnel, which is one of the underground facilities located next to the LAGUNA site studied at Canfranc.

The staff members undertaking the work will include:

- Mercedes Alba, MSC Industrial Engineer by the Technical University of Madrid. Master of Business Administration by the EOI Business School. Head of Mechanical Installations and Tunnel Facilities Department.
- Gerardo Cabezas, MSC Industrial Engineer by the Technical University of Madrid. Master in Theory and Practical Application of Finite Element Method and Simulation by the UNED University. Head of Industrial Works Department. Specialist in FE Structural Calculation.
- Iñaki Aramburu Urretavizcaya, MSC Industrial Engineer by the University of Navarra. Engineer of Mechanical Installations and Tunnels Facilities.Department.
- Eduardo Becerril Villa, Geologist by the Complutense University of Madrid. Senior Geologist of Geology & Geotechnics Department.

P30 - Technodyne International Ltd

Technodyne International is a specialist Engineering Design consultancy, based in Eastleigh, on the UK South coast. Their main focus is on the design and engineering of Cryogenic Storage tanks but their broad scope of experience and flexible approach enables them to undertake a diverse range of projects, providing cost-effective and dependable solutions for their worldwide client base. Their in-house team of approximately 20 highly experienced and qualified engineers has accumulated over 300 man-years of valuable experience in the engineering industry, including Aviation, Automotive, Energy Supply, Marine, Nuclear, Oil & Gas, and Petrochemicals. During the last 10 years, they have worked on designs for over 40 large cryogenic storage tanks, including the current world's largest tanks for LNG storage, and they have been retained as engineering consultants on many others. No other company can combine this capability with their ability to harness the knowledge and experience gained from executing many very large and sophisticated projects for industrial applications, and defence projects: these are invariably "one-offs" (there are never any prototypes, or "trial runs", they must work first time). Their projects range from small consultancy roles, to involvement in those projects with a capital value in the hundreds of millions of Euros. As an ISO 9001 accredited company, their work is carried out to the highest quality standards, while their Health & Safety training complies with best industry practices.
The staff members undertaking the work will include:

- M. Haworth, director responsible for engineering, member of the institute of mechanical engineers, member of royal aeronautical society. Experience: 10 years as founder director, 4 years corporate management British Gas, 15 years in cryogenic tank and vessel engineering, and construction in the Petrochemical industry, 6 years experience in Defence and Aerospace special projects, total 35 years of experience in engieneering design, engineering, project management and construction of multi-discipline teams in small and large companies. Consultant of Owner's Team for tanks specs 3 new LNG tanks for Isle of Grain (UK), Owner Engieneer Team member for new LNG terminal in Europe, consultant on refurbishment Design of LNG tank for Isle of Grain, fitness for purpose assessment of LNG tank, India, Review seismic capability of existing LNG tank (UK), assessment of ability to meet current codes, calculations, establish failure rates, meeting with HSE. LNG piping stress analysis. Design of 4 LPG tanks for Agip (Italy). Design of LNG tank (China). Design of Propane tank (Spain). Design of 80'000 m3 LPG tanks (full design package of calc, detail drawings, MTO). Modifications to LNG tank Dynevor.

- D. Gurney, engineering manager, team leader. Professional and competent computer systems engineer. Experienced in leading teams of software and hardware engineers and in the use of a variety of computers, operating systems and programming languages. Has an in-depth knowledge of software quality control systems, cost/time estimation and the use of structured methods to ensure successful project completion. Lead Engineer for the design of 7500m^3 Liquid Ethylene Tank for Vijay Tanks, India. Lead Engineer for the concept design of a 75000m^3 Liquid Argon Tank for basic element physics research. Lead Engineer for the design of a 10000m^3 LNG Tank for Chemtex, China. Design and specification of insulation systems for various Cryogenic Tanks including LNG, Liquid Ethylene, Propane, Butane and Argon.
- J. Thompson, administration, finance, electrical and C&I engineering. Experience: 40 years in electrical and project engineering; 10 years as Director of Technodyne International Limited, a company specialising in cryogenic storage facilities for LNG, LPG etc, and in the design and supply of aerospace and industrial test facilities; Extensive project management experience of major electrical equipment installations worldwide; Bid preparation, equipment marketing and sales of high value capital projects worldwide; Corporate Management of USA subsidiary company.
- R. Rogers, mechanical engineer. Engineering manager, over 35 years experience of mechanical engineering design and management on a wide range of capital plant and equipment. Work has included direct line management and direction of multi-disciplined engineering and design.
- B. Brockway, senior mechanical design-engineer. Design of Cryogenic Tank components, detail draughting. Responsible for design and supply contracts for 3x80'000 m^3 LPG tanks, 15'000 m^3 Ethylene tank (China), 25'000 m^3 LPG tanks.
- Pool of three analysts and up to 8 drafters for engineering analysis

P33 - [SOFREGAZ] Société Francaise d'Etudes et de Réalisations d'Equipements Gaziers

SOFREGAZ is an Engineering Contractor working mainly in the natural gas, with more than 800 projects in 50 countries founded in 1959 with full name "SOCIETE FRANCAISE D'ETUDES ET DE REALISATIONS D'EQUIPEMENTS GAZIERS". SOFREGAZ' expertise ranges from gas fields to natural gas end-users, and includes treatment, transmission and liquefaction of natural gas; our outstanding dependability, expertise and safety consciousness distinguishes SOFREGAZ as one of the leaders in the Natural Gas market place. SOFREGAZ provides its clients and partners with high quality services from feasibility studies to EPC turnkey contracts. Our primary ambition is to develop, execute and maintain capital projects on schedule, within budget using operational excellence. The size of our company allows flexibility to answer quickly to our Client's requirements Through its 50-year activity in the natural gas industry, SOFREGAZ offers the combined experience of an Engineering contractor and a Consulting firm, keeping fully abreast of the rapidly evolving gas sector environment

Profile of staff members who will be undertaking the work:

- Engineer SIALELLI Jérôme, Research, Innovation and Development Director
- Engineer DUCHATEL Lionel, Static Equipment and storage Leader

- Engineer GIROUD Philippe, Cost Estimating Leader

[REL] Ryhal Engineering Ltd.

Formed in 1998 by managing director Bob Thomson, Rhyal Engineering Ltd has grown to become one of the UK's leading site built storage tank and vessel design, fabrication and construction contractors.
The company is based in Pembrokeshire, UK and serves the Petrochemical, Aviation, Power, Water and Bulk Storage industries throughout the UK and overseas. It has a large client base which has been established upon long term close working relationships, through professionalism, trust and cooperation with a high focus on the successful delivering of projects to meet Client's specific needs and demands.
Rhyal Engineering Ltd has invested heavily in the most up to date equipment, systems and training available and are consistently looking to continue investment in future technologies which will provide a safer, more efficient and quality product. They are a also a company member of various trade associations, which include the following:

- Engineering Construction Industry Association (ECIA)
- Institute of Petroleum.
- British Safety Council
- TWI (The Welding Institute)
- Accredited to BS EN ISO 9001:2008.

Profile of staff members who will be undertaking the work:

- Mr R Thomson, Managing Director, 35 years storage tank and vessel construction and refurbishment experience including cryogenic tank construction (LNG, Propane, Butane) knowledge and experience.
- Mr S Judd, Project Manager. Graduate in Civil Engineering (1995), 15 years post graduate experience in heavy civil engineering and storage vessel construction projects, including bridges, rail infrastructure, roads, water and waste water treatment process, aviation fuel storage facilities, bio-ethanol storage and bending facilities.
- Mr H Campbell, Project Manager, 45 years storage tank and vessel construction and refurbishment experience including cryogenic tank construction (LNG, Propane, Butane) knowledge

P31 - [ALAN AULD LTD] Alan Auld Engineering Ltd., Specialist Construction Consultants

The Alan Auld Group companies have been developed to provide a specific focus for each specialist area of construction consultancy meeting the design, management and commercial requirements of a broad and expanding portfolio of clients. Originally incorporated in 1989 as a single company, the practice has expanded with its growing world-wide reputation for quality, excellence and pragmatism. There is particular strength in mining and underground works consultancy but the expertise is by no means limited to this area. Working with the latest technology and supported by a network of leading experts, the Alan Auld Group can provide you with the most comprehensive and effective solution to almost all your technical, commercial and managerial requirements. Our focus is on quality and cost effectiveness in the shortest possible time. Centrally located in the UK close to major communication networks, we are able to provide a personal and efficient service to our Clients both in the UK and throughout the world.
The staff members who would be coordinating the work:

- Dr F. ALAN AULD, BSc. PhD. C Eng. P Eng. FICE. FIMMM, Chairman, Managing Director and Founder, Alan has 40 years post qualification experience in civil and structural engineering. He is acknowledged throughout the world as an expert in the design of sub surface structures and ground freezing schemes and has published widely on his specialist subjects. In common with the other directors, Alan has spent a significant proportion of his career working for contractors in the construction and mining industries. This contractor background, carefully maintained in the selection of new staff and directors, has lead to the enviable reputation the company now has for its pragmatic and buildable solutions to engineering challenges.

- BRIAN E MASKERY, MSc MRICS MCIArb The Commercial and Financial Director of the company, Brian joined Alan Auld in 1999/2000 and has helped to shape and direct the development of the business into the thriving and growing entity it is today. Moving from work in professional quantity surveying offices on general building and civil engineering projects to become a specialist tunnelling contractor until 1999, Brian contributes more than 30 years commercial and contractual experience in construction and mining to the benefit of our clients.
- JOHN ELLIOTT, BSc., John is the Projects Director with specific responsibility for the development of engineering solutions and their management during the construction phases. John joined the company in 2005 bringing to the company 25 years of underground construction experience, including the sequencing and management of complex underground works schemes. An energetic and passionate professional, he is highly regarded by clients for his particular talent in devising innovative, cost effective and exceptionally practical solutions to difficult engineering problems.
- CHRIS THOMPSON, BSc. MRICS. ACIArb, Chris joined in 2008 from a senior position with one of the UK's top five contractors, to become managing director of Alan Auld Commercial Ltd. Bringing over 30 years experience of commercial management within the construction industry to our clients, his experience encompasses all aspects of project delivery from inception to final account including claims and dispute resolution.
- STAFF AND ASSOCIATES: The company has an expanding number of permanent staff, a network of professional associates (most of whom have good second degrees), university professors, barristers and other professional consultants who work either individually or together, as the task requires.

P19 - [UAM] University Autonoma Madrid

The University Autonoma Madrid is one of the most important Spanish universities in scientific research. Its Department of Theoretical Physics has among its members very relevant Scientists in the field of Particle Physics in both, theory and experiment.

Profile of the staff members who will be undertaking the work:

- Prof. Luis Labarga. He has a large experience in experimental particle physics. He has contributed substantially to the following experiments: TASSO at PETRA (DESY), MARK II at the SLC (SLAC), ZEUS at HERA (DESY) and to the design and construction of ATLAS at the LHC (CERN). Currently he is fully involved in the Super-Kamiokande neutrino and proton decay experiment.

P20 - [CSIC] Consejo Superior de Investigaciones Científicas

CSIC is the large Spanish research institution, Consejo Superior de Investigaciones Científicas (Council for Advance Scientific Research). Its structure reminds that of Italian INFN or French IN2P3. IFIC, Instituto de Física Corpuscular (Institute for Corpuscular Physics) is a join venture between CSIC and the University of Valencia. It is the largest center devoted to basic research in experimental particle and nuclear physics in Spain.

The staff members who would be coordinating the work:

- Prof. Dr. Juan José Gómez Cadenas. Head of the experimental department at IFIC, spokesperson of NEXT, a new experiment to search for neutrinoless double beta decay at the Spanish Laboratory of LSC (at Canfranc, Huesca). Professor Gómez-Cadenas is also the group leader of the neutrino physics group of IFIC, that participates also in the T2K and SciBoone experiments. He has worked previously in K2K, Harp and NOMAD, and made many relevant contributions to the field of neutrino physics in particular with studies of the physics potential of the neutrino factory and super-beams.

- Prof. Dr. Pilar Hernández. Full professor at the department of theoretical physics, is a leading theorist in the field of neutrino physics. She has made numerous contributions to the physics of neutrino factories, beta-beams and super-beams.
- Dr. Andrea Donini is a visiting scientist at IFIC. He is staff of the CISC and has made a successful career in neutrino phenomenology.
- Dr. Anselmo Cervera is CSIC associated professor. He is the leader of the T2K effort in the IFIC neutrino group and has made many contributions to neutrino physics.
- Dr. Michel Sorel is CSIC assistant professor. He is the leader of the SCIBOONE effort at the IFIC neutrino group, and the physics convener of the NEXT experiment. He has made numerous contributions to neutrino physics.
- Dr. Sanjib Argawalla is a post-doctoral associated at IFIC. He has made a quick and impressive career in neutrino phenomenology.

P18 - [LSC] Laboratorio Subterráneo de Canfranc

The LSC is a new facility for Underground Science. It is located under the Pyrenees mountain "El Tobazo" in Canfranc (Huesca, Spain). The over burden at the site provides 2500 meters water equivalent of shielding. Administratively, it is conceived as a Consortium of the Spanish Ministry of Education and Science, the Aragon Regional Government and the University of Saragossa.
Profile of the staff members who will be undertaking the work:

- Prof. Alessandro Bettini. LSC Director. He has a vast experience in experimental particle physics covering fixed target, collider and underground experiments with pivotal contributions to the LEBC-EHS, UA1, ICARUS and GERDA experiments. He is one of the few world leaders responsible of last decade's boost of neutrino physics to its actual top place in scientific research. He has been Director of the "Laboratori Nazionali del Gran Sasso" of the INFN, the largest underground scientific facility in the world, during the years 1997 to 2003.
- Dr. Iulian Bandac has experience in low radioactive background experiments, such as CUORE, and at LSC is responsible of the service for low background measurements and materials characterisation
- Dr. Silvia Borjabad is the chemist responsible of the chemical laboratory, cryogenics and clean rooms at LSC
- Ing. Jose Jimenez, expert in underground engineering, is responsible of the installations, maintenance and safety at LSC

P36 - [IFIN-HH] "Horia Hulubei" National Institute of R&D for Physics and Nuclear Engineering and [IFIN-HH] The origins of the National Institute of R&D for Physics and Nuclear Engineering - Horia Hulubei, IFIN-HH go back to as early as 1949 when a small Institute of Physics of the Romanian Academy was founded. It was reshaped in 1956 and renamed as the Institute of Atomic Physics (IFA), http://www.nipne.ro.
In 1977 the Central Institute of Physics (ICEFIZ) was set up to co-ordinate the entire physics research in Romania. The main institute of this system was the Institute of Physics and Nuclear Engineering (IFIN). In late 1996, IFIN was elevated to national institute and was named after Horia Hulubei, its original founder, becoming the Horia Hulubei National Institute of R&D for Physics and Nuclear Engineering (IFIN-HH).
IFIN-HH is a National Institute of Research & Development mainly funded by the Ministry of Education and Research
Facilities: U120 Cyclotron, 1959, MP Tandem Accelerator, 1974, Radioisotope Production Center, 1974, Nuclear Waste Processing and Storage Centers, 1974, Multipurpose High Dose Gamma-Ray Irradiator, 2000, cosmic ray muon detector WILLI (1995), Underground Laboratory – Slanic Prahova (2006)
The main research and development areas: theoretical physics and high energy, particle and astroparticle physics, atomic physics and nuclear structure, interdisciplinary researches with accelerated particle beams, nuclear technologies and radiation metrology, radiation biophysics and

biochemistry, radioecology, instrumentation for nuclear research and technologies, information systems, data bases and computer networks

Profile of the staff members who will be involved in the work:

- Dr. Romul Mircea MARGINEANU, senior scientist, founder and head of the Romanian Underground Laboratory – Slanic Prahova, high resolution gamma spectrometry, muon measurement.
- Dr. Bogdan MITRICA, scientist, works on cosmic ray muons, extensive air shower
- Dr. Iliana BRANCUS: senior scientist, head of the Romanian group of astroparticle physics, work on cosmic ray muons, Extensive Air Showers
- Dr. Ana-Maria BLEBEA-APOSTU: research assistant, work on high resolution gamma ray spectrometry
- Dr. Ileana RADULESCU, research assistant, work on high resolution gamma ray spectrometry
- Dr. Mirela VASILE, scientist, radiochemist, work on Uranium and Thorium separation
- Alexandra SAFTOIU: PhD student, engineer, work on cosmic ray muons, Extensive Air Showers
- Dr. Sabin STOICA: senior scientist, work on theoretical physics: neutrinos, double beta decay
- Eng. Mirel PETCU: senior scientist, electronic specialist (DAQ)
- Daniela CHESNEANU, PhD student, research assistant, work on theoretical physics of neutrinos
- Denis STANCA, PhD student, research assistant, works on cosmic ray muons
- Dr. Gabriel TOMA, scientist, works on cosmic ray muons, extensive air shower
- Dr. Mihai VARLAM: senior scientist, Director coordinator of National Center for Hydrogen & Fuel Cell, expertise in isotope separation technologies and measurements methodology
- Dr. Mihai CULCER, senior researcher, expertise in cryogenic technologies, measurements of parameters at low temperatures
- Dr. Anisia BORNEA: senior scientist, expertise in mathematical modeling for isotope separation systems
- Dr. Elena CARCADEA: senior researcher, mathematician.
- Eng. Cristian Adrian OPRINA, design and execution of underground excavation,
- Eng. Florinel CHIPESIU, design and execution of underground excavation,
- Eng. Liviu MIHAILESCU, design and execution of drillings,
- Ana Maria PANTEA, economist, economic prospects, financial management
- Assoc. Prof. Dr. Eng. Emil SMEU – project manager for the participant UPB-FOCUM, main designer, Electronics engineer & Senior Researcher. Expertise in Photonics, data acquisition & processing, measurements on high critical temperature superconductor samples (Ybco, Research Fellowship at Istituto Electrotecnico Nazionale IEN "Galileo Ferraris", Turin, Italy), software for computer simulation of some special high-current switching circuits and nonlinear magnetic circuits. Several papers published in ISI-quoted journals and ISI-listed Proceedings, 3 books. Director of the first joint research project coordinated by the Physics Dept. and funded by EC (2002-2006).
- Prof. Dr. Eng. Paul STERIAN – Director of the Center FOCUM, head of the Chair Physics 2. Expertise in Photonics and Technical Physics. Over 100 ISI papers and 20 books, PhD students supervisor, director of many research projects.

P37 - [UoB], University of Bucharest, Faculty of Physics and

Since its foundation in 1864 by Prince Alexandru Ioan Cuza, as the successor to higher education structures dating back to the Princely Academy founded in 1694, the University of Bucharest has contributed to the development and modernisation of Romanian education, science and culture. The University of Bucharest is one of the leading institutions of higher education and one of the most important centres of scientific research in Romania.
Now, the University comprises twenty faculties and departments. In the actual organisation, the Faculty of Physics was founded in 1962 as an independent branch of the Faculty of Mathematics and

Physics of the University. Its academic staff comprises around 90 members and tens of researchers working in the Chairs of: Atomic and nuclear physics; Electricity and biophysics; Mechanics, molecular physics, polymers and atmospheric physics, Mathematics and theoretical physics; Optics, spectroscopy, plasma and lasers, Solid state physics.
Elementary particle physics and nuclear physics (at low energy and relativistic energies), radioactivity, cosmic rays and astrophysics, reactors, medical physics, are some key directions of interest. The Chair of atomic and nuclear physics has a tradition in elementary physics using bubble chamber and streamer detectors (at CERN, Dubna and Torino), emulsions, and more recently its members participated as individuals or small groups in experiments as L3 and AMS at CERN, BRHAMS and small collaborations at BNL and JLab, KASCADE, KASCADE-GRANDE, LOPES at Karlsruhe..

Profile of the staff members who will be undertaking the work:

- Prof. Dr. Alexandru JIPA, Dean, scientific background in relativistic nuclear physics, large experiments instrumentations, (Brahms, Brookhaven –USA), detectors.
- Prof. Dr. Ionel LAZANU, Scientific background in particle and neutrino phenomenology, detectors and degradation in radiation fields, author of textbooks for advanced students on accelerators, nuclear physics, elementary particles, cosmology concepts
- Prof. Dr. Octavian SIMA, extensive muon air shower simulation, environmental radioactivity
- Prof. Dr. Octavian Gheorghe DULIU, radiation doses, radiopurity, radiation field simulation
- Dr. Ovidiu TESILEANU, researcher, computing in astrophysics
- Claudia Mariana GOMOIU, PhD student, thermoluminiscence of rocks,
- Tiberiu ESANU, PhD student, relativistic nuclear physics.
- Prof. Dr. Eng. Victor ARAD, Head of Chair of Mining Engineering and Industrial Safety, Mining Faculty, rock mechanics, geomechanics, geotechnical risks in underground excavation, stability of underground galleries.
- Prof. Dr. Eng. Ilie ONICA, stability of underground excavations, finite element analysis,
- Associate Prof. Dr. Eng. Susana ARAD, electricity engineering in underground, finite element analysis, statistical analysis.
- Associate Prof. Dr. Eng. Samuel VEREŞ IOEL, mining topography, geodesy, GIS
- Eng. Raluca ROTARU, PhD student, geology, mining geology

P38 - [INR] Institute for Nuclear Research of the Russian Academy of Sciences, Russia

One of the leading research centers in Russia. The INR main research activity address fundamental questions in the following research fields: (1) theoretical particle physics, (2) experiments at high-energy and high intensity accelerators, (3) experiments in neutrino and astroparticle physics, (4) nuclear physics experiments, (5) neutron physics, (6) physics of linear accelerators. INR has the Baksan underground neutrino laboratory (BNO) which carries the Ga-Ge solar neutrino experiment, double-beta decay experiments, and cosmic ray experiment. INR runs the deep underwater neutrino experiment at Baikal Lake in Siberia. A wide program of experiments with neutrons, nuclear physics experiments, and nuclear medicine is based on the INR high intensity linear proton accelerator.
Profile of staff members who will be undertaking the work:

- Prof. V.A. Matveev, Director of INR, Member of Russian Academy of Sciences, Academician-secretary of the Physics Division of the Russian Academy of Sciences, Head of High Energy Division of INR. High-energy and particle theory, neutrino and high-energy experiments. . Present and past international research projects: SAGE (at Baksan), CAST, CMS, OPERA, K2K, T2K (at KEK/JPARC).
- Prof. Yu.Kudenko, Head of Laboratory, experimental particle physics, neutrino oscillation experiments, rare kaon decay experiments, detector R&D. Present and past international research projects: E246 (at KEK), E949 (at BNL), K2K, T2K (at KEK and JPARC).
- Dr. S.Gninenko, Senior researcher, experimental high-energy and particle physics, phenomenology. Present and past international research projects: NOMAD, ICARUS,CMS
- Dr. O.Mineev, Senior researcher, expertise in scintillator detectors, photodetectors, detector development, electronic and readout systems.

- Dr. N.Yershov, Researcher, detector development, design and assembly, expertise in readout systems
- Mr. A.Khotjansev, Researcher, detector development, Monte-Carlo simulations.

P39 - [PNPI] Petersburg Nuclear Physics Institute

PNPI is one of the biggest institute for Nuclear and Particle physics in Russia. For a long time it was a branch of the famous in Russia A. Ioffe Physical-Technical institute. Since 1971 it is an independent institution with about 2000 employers which incorporates a very wide spectrum of scientific programmes. Measurements of the neutron dipole moment, beta-decay of the neutron, investigation of catalysis are some of them that brought PNPI the international recognition. Participation in many other experiments in particle physics is underway abroad. They include a strong participation in the LHC-programs (ATLAS, ALICE, CMS), in RHIC and PSI, and in other advanced projects throughout the world. The scientific work at PNPI is based on the different installations, among them are the nuclear 18 MW-reactor and 1 GeV proton synchro-cyclotron. New 100 MW heavy water research reactor PIK is preparing for commissioning very soon.
The founder of the theoretical department of the institute V. Gribov was the first who joined Bruno Pontecorvo in his pioneering work in neutrino oscillations. The experimental interest in neutrino is corroborated by participation in the Borexino project. Another contribution in neutrino physics concerns the search for the new candidates for neutrino mass measurements in the electron capture sector and for resonant double electron capture process. The measurements are under progress in different ion trap laboratories (CERN, GSI) with the PNPI participation.
One of the latest activity in neutrino physics concerns proposal of a new experiment on very slow monoenergetic neutrino oscillometry within the sizes of a big underground detector. R&D for observation of this phenomenon is developing. This work is carried out in close collaboration with the CUPP group of Jyväskylä and Oulu Universities (Finland) and with the TUM, Muenchen (Germany) and Ioanina University (Greece). The production of appropriate monoenergetic neutrino sources can be performed at the high-flux reactor PIK of PNPI.
The main task of PNPI concerns the science impact and outreach (WP5), providing R&D for neutrino oscillometry and expertise in other very low energy neutrino physics.
The implementation of the oscillometry programme will serve as a direct complement to the long baseline oscillation experiments within the framework of LAGUNA-LBNO and as a unique in the world will keep European leadership in the field.

Profile of the staff members who will be undertaking the work:

- Prof., Doctor of Sciences Yuri N. Novikov, leading scientist of PNPI and Professor of St.Petersburg State University. Research in neutrino physics, nuclear structure and astrophysics. Spokesperson of different international projects at PNPI, CERN, GSI, Jyväskylä over the last years. A member of the Nuclear Physics Board of European Physical Society (1999-2005).
- Dr., Candidate of Sciences Sergey A. Eliseev, researcher in neutrino physics, mainly mass of neutrino and double electron capture. Leading expert in ion trapping and mass spectrometry. Spokesperson of projects at ISOLTRAP (CERN) and SHIPTRAP (GSI).
- Dr., Candidate of Sciences, Alexey N. Erykalov, deputy director of theoretical department of PNPI, expert in reactor physics, production of neutrino sources.
- Mr. Dmitry A. Nesterenko, PhD student, simulations of oscillometry processes.

P35 - [DEMOKRITOS] NCSR DEMOKRITOS – National Centre for Scientific Research "Demokritos", Institute of Nuclear Technology – Radiation Protection, System Reliability & Industrial Safety Laboratory

The System Reliability & Industrial Safety Laboratory (SRISL) is part of the Institute of Nuclear Technology & Radiation Protection of the National Centre for Scientific Research "Demokritos". Since 1986, SRISL has been performing applied research and development in selected areas of reliability and safety of complex technological systems. Consequences may vary in a broad spectrum from simple financial ones (installation destruction, loss of certain important services or products) to severe consequences on the health of the workers, thehealth of the general public and the environment. The system complexity, the severity of consequences, the huge cost and the relative scarcity of catastrophic failures do not allow an analysis solely based on past experience (real facts) or on experiments. The Quantitative Risk Assessment (QRA) approach employed by SRISL establishes the ways in which failures may occur through the failure of existing safety functions and/or barriers, assessing sequences of hardware failures and/or human actions that leadto major failures and their consequences, and evaluates their occurrence probabilities based on partial information that may exist for parts of the complex system..,

Research activities in SRISL involve safety assessment of industrial installations (chemical/nuclear), reliability assessment of technological systems, quantitative risk assessment, consequence assessment of major industrial accidents (chemical-Seveso, nuclear), decision support for land-use planning around hazardous facilities, emergency response plans for major industrial accidents, management of large natural disasters, occupational risk assessment, use of virtual reality in industrial safety enhancement, and human reliability assessment, reliability analysis and risk assessment of critical infrastructure systems, safety management systems etc.

SRISL has coordinated and participated in many European research projects, including «Benchmark Exercise on Major Hazards Analysis», « SOCRATES: Safety Optimization and Risk Assessment Tools for Emergencies and Sitting», «Auditing and Safety Management for Safe Operation and Land Use Planning», «LUPACS: Land Use Planning and Chemical Sites», «Development of an integrated technical and management risk control and monitoring methodology for managing and quantifying on-site and off-site risks», «Assessment of Uncertainties in Risk Analysis of Chemical Establishments», « S2S: A gateway to Plant and Process Safety», «PRISM Network: Process Industries Safety Management», «SHAPE RISK: Sharing Experience on Risk Management», «Pre-emergencies», «VIRTHUALIS: Virtual Reality and Human Factors», « WORM: Work Occupational Risk Model», INTEG-RISK «Early Recognition, Monitoring, and Integrated Management of Emerging, New Technology Related Risk», and the risk assessment work package of «KM3NeT».

Profile of the staff members who will be undertaking the work:

- Dr. I.A. Papazoglou, Director of the Institute of Nuclear Technology & Radiation Protection and Head of the System Reliability and Industrial Safety Laboratory – Electrical engineer with 35 years of experience in system reliability, risk assessment and safety of chemical and nuclear installations acquired at MIT, Brookhaven National Laboratory and NCSR "Demokritos". He has co-authored numerous scientific papers and technical reports, and has been the principal investigator in projects in the areas of industrial risk assessment, reliability analysis, decision analysis and nuclear safety.
- Dr. O. Aneziris, Senior Researcher – Chemical Engineer with 22 years experience in the areas of industrial safety and probabilistic risk assessment (mainly process and chemical industries) acquired at NCSR "Demokritos". She has co-authored many scientific papers and technical reports, and has been principal investigator in projects in the areas of industrial risk assessment, reliability analysis, and decision analysis.
- Dr. E.C. Marcoulaki, Researcher – Chemical engineer with 18 years of experience in process systems engineering and optimization, and stochastic processes acquired at NTU Athens, UMIST, Universities of Surrey and Piraeus, and 3 years of experience in reliability analysis, risk assessment and safety optimization acquired at NCSR "Demokritos". Main author of extensively cited research papers in leading chemical engineering journals.
- Dr. Myrto Konstandinidou, Chemical Engineer with 10 years experience in the areas of industrial safety acquired at NCSR "Demokritos". Her doctoral research was carried out in SRISL, involved the risk analysis of industrial accidents, in collaboration with the Greek Petroleum Refineries.

P40 - [KEK] – High Energy Accelerator Research Organization

KEK, the High Energy Accelerator Research Organization, is one of the world's leading accelerator science research laboratories using high-energy particle beams and synchrotron light sources to probe the fundamental properties of the nature, located in Japan. With state-of-the-art infrastructure, KEK is advancing understanding of the universe with primarily focusing on the elementary particle physics. In addition to the researches based on the infrastructure of its own, KEK is engaged in the various worldwide cooperative research efforts in the foreign institutes such as CERN.

Profile of staff members who will be undertaking the work:

- Prof. Dr. Takuya Hasegawa, Group leader, Major in experimental high-energy particle and astro-particle physics, recently focused on search for neutrino flavor oscillations, search for nucleon decay and liquid Argon TPC detector R&D, Present and past involvement in the international research projects are T2K, NA61, Super-Kamiokande, K2K and ZEUS.
- Prof. Dr. Koichiro Nishikawa, Director of Institute of Particle and Nuclear Studies, KEK, Major in experimental high-energy particle and astro-particle physics, Expertise in neutrino beam and neutrino physics
- Prof. Dr. Takashi Kobayashi, Spokesperson of T2K, Major in experimental high-energy particle and astro-particle physics, Expertise in neutrino beam and neutrino physics, Present and past involvement in the international research projects are T2K, NA61, Super-Kamiokande and K2K
- Prof. Dr. Masakazu Yoshioka, Senior staff researcher, Major in accelerator science, Expertise in accelerator, large scale infrastructure and large scale civil engineering for accelerator/experimental facilities
- Associate Prof. Dr. Takasumi Maruyama, Senior staff researcher, Major in experimental high-energy particle and astro-particle physics, Expertise in neutrino beam, neutrino physics and liquid Argon TPC detectors including detector design and detector construction, Present and past involvement in the international research projects are T2K, K2K, CDF and Super-Kamiokande
- Associate Prof. Dr. Kunio Koseki, Senior staff researcher, Major in accelerator science, Expertise in accelerator, power supplier for high power accelerator equipment, high power devices and electronics
- Assistant Prof. Dr. Takeshi Nakadaira, Senior staff researcher, Major in experimental high-energy particle and astro-particle physics, Expertise in neutrino beam, neutrino physics and accelerator, Present and past involvement in the international research projects are T2K, NA61, Super-Kamiokande, K2K and Belle
- Assistant Prof. Dr. Ken Sakashita, Senior staff researcher, Major in experimental high-energy particle and astro-particle physics, Expertise in neutrino beam, neutrino physics, control system for large scale equipment and electronics, Present and past involvement in the international research projects are T2K, NA61, Super-Kamiokande and KEK-PS E391
- Dr. Masashi Tanaka, Post Doc. researcher, Major in experimental high-energy particle and astro-particle physics, Expertise in liquid Argon TPC detectors including detector design and detector construction, electronics and readout systems, Present and past involvement in the international research projects are T2K and CDF

B 2.3 Consortium as a whole

The consortium includes very different participants from academic, research laboratories and industrial sectors and is very well balanced to reach the desired goals, combining the best European expertise in their technical and scientific fields. The industrial partners will be involved in those tasks that require high level of expertise and in some area of management where the problems to be tackled require the professional handling of the project. Due to the many stages involved in the transferral of concepts into functional technical plans, dissemination of knowledge is guaranteed between the scientific community and industry throughout the process. This guarantees the best possible potential for the exploitation of the results of this study and of the subsequent steps.

There is a clear complementarity of expertise among the scientific partners of the consortium. They are united by common physics goals and form a community speaking the same language. The study gathers some of the top specialists in the field, working at some of the leading institutes in European particle and astroparticle physics. A long and well-structured preparation process has brought the members closer together and created a strong spirit of togetherness.

At the same time, a clear fraction of the consortium is composed of industries. We are fortunate to have them as partners rather than subcontractors. In this way, they will be better integrated in the workflow and the exchange between scientists and engineers will be more efficient. In addition, the synergy between different companies in different countries working together, exchanging local expertise, to study multiple sites, with open access to information, will be an enriching experience.

Table 1 below lists the participants in the LAGUNA-LBNO Consortium, as well as their key competences and expertise needed for this project. The domains of expertise are broad and interdisciplinary as required to tackle the feasibility of LAGUNA-LBNO. They span the following fields: (a) Particle Physics, (b) Astroparticle Physics, (c) Accelerator Technology, (d) Civil Engineering, (e) Rock Engineering, (f) Mining Engineering, (g) Chemical Engineering, and (h) Underground Science. All academic participants have a proven track record in the development of particle physics experiments, in particular in the design and/or construction of detectors. All industrial partners have been selected following preliminary encounters and details presentation of the projects, the foreseen tasks and in-depth discussions.

Selecting the participants in the Work Packages has been done according to their scientific background and complementary competences in the tasks of the various Work Package programmes. The role of the participants has been defined in order to address the objectives of the project in the most optimal way, and to give overall coherence to the Consortium and the project execution. These activities are often fragmented in Europe and LAGUNA-LBNO represents a unique opportunity to develop a coherent and synergetic effort.

Table 1 List of participants and key expertise in LAGUNA-LBNO. Status lists whether organization is "beneficiary" or "subnode". (*) means that it was also a LAGUNA DS beneficiary. Domain of expertise: PP=Particle Physics, AP=Astroparticle Physics, AT=Accelerator Technology, CE=Civil Engineering, RE=Rock Engineering, ME=Mining Engineering, CHE=Chemical Engineering, US=Underground Science

Country	Participant short name	Key competence and expertise for LAGUNA LBNO
Switzerland	ETHZ	PP,AP: Project management, Administration, Project Steering, extensive experience in neutrino physics, neutrino beams, underground detector, detector technologies
Switzerland	U-Bern	PP: Long experience in neutrino physics, via its participation to the CHORUS experiment, and furthermore in neutrino oscillation physics thanks to its participation to several experiments like CHORUS, OPERA and T2K.
Switzerland	UNIGE	PP: Novel Neutrino beams, neutrino detector simulation/analysis
Switzerland	LOMBARDI	CE, RE: Responsible of Fréjus site; underground layout, rock mechanics, costing, risk analysis
International Organisation	CERN	PP,AT: accelerators, neutrino beams, large infrastructures, large magnets
Finland	JYU	AP, US: Reactor neutrino background, neutrino phenomenology, underground experiments, nuclear

		instrumentation and methods, oscillometry
Finland	UH	AP: theory of neutrino physics in BSM theories and cosmology
Finland	UOULU	AP,US: low energy neutrinos, underground physics, detector development, oscillometry
Finland	ROCKPLAN	CE, RE: Project design leadership as well main, general, rock mechanical and constructive engineering & design of complex underground constructions.
France	CEA	PP, AP: neutrino beam simulations, optimization, near detector
France	CNRS-IN2P3	PP, AP: detector costing, simulations, management
Germany	TUM	AP: liquid-scintillator detectors for low energy neutrinos: scintillator production, handling and characterization data acquisition and analysis for low-energy neutrinos and low background searches phenomenology/simulation for low-energy neutrinos and backgrounds for rare event searches participation in running low-energy experiments (Borexino, Double-Chooz, CRESST, GERDA)
Germany	UHAM	PP, AP: theory, phenomenology, supernovae neutrinos
Poland	IFJ-PAN	PP, AP: responsible for Sierosowcize site; detector simulations
Poland	IPJ	PP, AP: experience with neutrino experiments (SK and long baseline), reconstruction and visualization, particle ID, measurements of low level background in underground laboratories, muon backgrond, multivariable analysis for event classification
Poland	PWr	CY: expertize in cryogenics for liquid argon handling and purification
Poland	KGHM CUPRUM	CE, RE, ME: Expertize in rock mechanics, mining and geo-engineering.
Spain	LSC	AP, US: The second largest underground laboratory in Europe. The 7 approved experiments and those under evaluation aim to shed light to fundamental problems in Particle Physics like dark matter and neutrino properties, and in Geological Science.
Spain	UAM	PP, AP: 26 years expertise in the design, construction, running and extracting the scientific output of large, international, experiments covering a broad range of fundamental problems in Particle Physics.
Spain	CSIC	PP, AP: Expertise in neutrino physics, underground science, low energy neutrinos.
Spain	ACCIONA	CE, RE: Acciona-Ingnieria and STMR did the very detailed viability design for the LSC to host a LAGUNA experiment. They together have full capabilities and experience, in Spain and abroad, both in geotechnical engineering and industrial installations including LNG. STMR had a pivotal role in the geotechnical safety of the LSC deep cavern.
United Kingdom	IMPERIAL	PP, AP, US: Expertise in neutrino physics, deep underground science, low energy neutrinos, management, international relations, T2K International Co-Spokesman

United Kingdom	UDUR	PP, AP: Phenomenology, long baseline neutrino simulations, theory of neutrino masses, neutrinos in cosmology, dark matter.
United Kingdom	UOXF-DL	PP, AP: Expertise in long baseline neutrino oscillation physics via MINOS and T2K, world experts in atmospheric neutrino calculations, wide experience in instrumentation (electronics/DAQ) and detector construction for HEP neutrino experiments
United Kingdom	U-LIVERPOOL	PP, AP: near detector concept, neutrino beams, neutrino oscillations
United Kingdom	USFD	PP, AP, US: Underground physics experiment and infrastructure design, construction and installation; responsible for Boulby site; neutrino simulations: liquid argon; scintillator; geo-technical engineering and rock mechanics; underground construction and long-term operation.
United Kingdom	RAL	PP, AP, AT: realization of target technology for the new generation of particle accelerator driven facilities. Recent projects have included the target, window and beam dump for the T2K neutrino facility, ILC beam dump studies, the development of a new tungsten powder jet target technology, ISIS target studies and LBNE target studies.
United Kingdom	Warwick	PP: The Warwick group have expertise in and experience of simulating neutrino detector response based on their contributions to the T2K project and from work on large future detectors.
United Kingdom	QMUL	PP: The QMUL group have expertise in and experience of simulating neutrino detector response based on their contributions to the T2K project.
United Kingdom	Technodyne	CE, CY: tank engineering, costing
United Kingdom	Alan Auld Ltd	CE, ME, RE: consultant with large expertise, mining engineering, underground construction engineering, risk analysis, project management
United Kingdom	REL	CE, CY: tank EPC, piping
France	Sofregaz	CE, CY, CHE: tank EPC, liquid processes
Italy	AGT	CE, RE: Reference, as industrial partner, for Umbria Site - Expertise in civil/rock engineering and environmental aspects
Greece	Demokritos	Risk analysis+CHE: will provide risk assessment and management of large technological systems. Identification of potential failure modes, their relative frequency, the range and corresponding frequencies of their consequences and assessment of ways to prevent the failures and mitigate their consequences.
Romania	IFIN-HH	AP: theoretical and experimental physics, particle and astroparticle physics, cryogenic technologies, numerical simulation and optimization of electromagnetic structures, consultancy and expertise in geology, salt extractive industry, salt processing and environmental protection
Romania	UoB	AP: elementary particle physics and nuclear physics cosmic rays

		and astrophysics, reactors, solid-state physics, electricity and magnetism, theoretical physics, rock mechanics and analyses of rock mass stability, geotechnical risks, design of large excavation and stability analyses
Russia	INR	PP, AP: extended expertise in neutrino detectors, neutrino physics
Russia	PNPI	AP: low energy neutrino sources and detection
Japan	KEK	PP, AT: world recognized international High Energy Physics Research Laboratory, world leader in accelerator based long baseline neutrino project, high power neutrino beamline, high power proton accelerator, large infrastructure, international relations and coordination

Admission of additional participants

During the implementation of LAGUNA-LBNO, new groups may be expected to join the project. This process will be defined in the Consortium Agreement, and will involve discussions in the Executive Committee and approval of the Institution Board. The main criteria for admission will be linked to the objectives, deliverables and milestones.

Sub-contracting

At present no sub-contracting is foreseen.

Other countries

Although Russia is not a member of EU, Russian scientists and institutes have always been part of European science. They excel in many fields relevant to LAGUNA-LBNO including light sensors (PMT), accelerator technology, purified and enriched materials, and theoretical physics. PNPI will lead the study of man-made low energy neutrinos and oscillometry and INR will contribute to WP4 and WP5.

This design study will also maintain very close contact with the beneficiaries from Japan (KEK). Their participation to this project is vital and justified by their extensive expertise in the field considered in this design study. In addition, KEK is leading the T2K project (Japan), with strong European participation and with large overlap with the present beneficiaries. T2K contains many precursor elements of those considered in LAGUNA (fast cycling synchrotron, high power neutrino beamline, etc.). In addition, the results of T2K will be determinant for the LAGUNA physics programme. KEK will be investing several person-month in this project, spread in WP1 (in particular aspects of international relations and mutual understanding), WP2&WP3 with potential interface with Japanese construction companies, and WP4 with contributions to the accelerator and beamline design.

B 2.4 Resources to be committed

The total estimated budget for academic partners is based on the experience of the participants in carrying out R&D programmes within large collaborations associated with the engineering-oriented design of complex facilities for which advanced medium-to-high-risk technologies are employed. Planning and optimization of financial and human resources have been done according to the FP7 financial regulations by European research laboratories with international reputations in carrying out similar projects. The total budget related to the activities includes the cost of:

(1) Personnel-staff and temporary contract salaries of scientists, engineers and technicians, post-doctoral and Ph.D. fellowships;
(2) Travel and subsistence costs for coordination and managerial activities and attendance at the planned meetings and workshops;
(3) Indirect costs(overheads) according to the financial rules of each participant.

B3. Impact

B 3.1 Strategic impact

The "added-value" of the DS revolves around the need for an integrated and coherent European effort towards next generation large-scale underground science and long baseline neutrino physics.

Impact of this DS on scientific performance of Europe

The Reports resulting from this DS will be delivered to the appropriate funding agencies and policy makers (ApPEC, ASPERA, national agencies) for their evaluation. After appropriate reviews and consultancy, the respective organisations are expected to make decisions to realise the considered infrastructures. These Reports should contain necessary technical information required for the decisions, to be combined with the scientific priorities of the decision time.

The physics studies related to or motivated by this Design Study may widen our understanding of the universe and the properties of elementary particles. Particularly these studies may have major impact on many other experiments using similar kind of infrastructures, techniques or equipment.

Impact of the planned experiments on particle and astroparticle physics

Astroparticle physics has become a thriving field of research at the interface between particle physics, astrophysics and cosmology. It can uniquely address questions on the fundamental laws of Nature, its constituents and the evolution of the Universe by combining experimental techniques and theoretical tools from particle physics and astrophysics and cosmology. Particle physics focusses on the infinitely small, trying to understand what the fundamental constituents of Nature are and how they interact with each other. Astrophysics addressed the physical processes which take place in extreme environments such as celestial bodies are while cosmology considers the evolution of the Universe as a whole. These fields of research are intimately connected: particle physics provides some of the ingredients for understanding the questions in astrophysics and cosmology and conversely cosmological observations allow to gain unique information on particle properties and forces. A prime example of this synergy and complementarity is the physics of neutrinos: they are the least known elementary particle and at the same time the most abundant in the Universe. By combining the knowledge coming from neutrino terrestrial experiments and cosmological observations it is possible to gain information on their properties, e.g. their masses, their number, which could not be obtained otherwise.

With a copious amount of new experimental and observational results which will become available in the coming years, astroparticle physics is posed on the verge of making important discoveries. It is crucial to combine the available information, develop an interdisciplinary understanding of these fields and design experiments which can provide data on a variety of aspects or complement each other. LAGUNA has served as an important step in this direction, by bringing together experimentalists from different detector technologies, phenomenologists and technical staff in order to study the feasibility of a large underground facility in Europe. One of the main physics goals of the megaton scale detectors such as the ones considered in LAGUNA and LAGUNA-LBNO is the study of long baseline neutrino oscillations. This aspect was marginally present in LAGUNA. However, neutrino long baseline oscillations are the tool of choice for the study of crucial neutrino properties and are complementary to the information coming from the study of astrophysical and low energy neutrinos. From an experimental perspective it is remarkable that the same detectors which can be used for astroparticle neutrino physics searches and for proton decay can serve as the detectors for long baseline neutrino beams. This DS focusses on this complementarity, trying to address all these aspects in a coherent and synergetic effort. It will explore on one side the different detector technologies with various possible underground laboratory locations and on the other the beams which can be sourced at CERN for a long baseline experiment. These two areas will serve as inputs for the study of the physics reach of the sensitivities in order to identify the best strategy for future large-scale facilities for low energy neutrino astronomy, accelerator neutrino studies and the direct investigation of Grand Unification of the known elementary forces via proton decay searches. The proposed large-scale detectors have unique capabilities in determining fundamental neutrino properties at an unprecedented level of accuracy, providing crucial input for the understanding of the elementary structure of matter. In addition, the neutrinos detected in these facilities are the very powerful and unique tool to probe the properties of the astrophysical objects where they are produced, in particular the Sun, core-collapse supernovae, and the Earth.

The novel focus of LAGUNA-LBNO, with respect to LAGUNA, is long baseline neutrino oscillations. This requires the combination of the study of the beam, of the neutrino propagation through the Earth and the detection at one of the LAGUNA detectors. It is necessary to go from the present status in which phenomenological simulations use realistic but quite approximate detector parameters to the use of very detailed detector performances which account for the complexity of the experimental setups. The physics sensitivity can change by factors of a few when a better understanding of the detector is included. Similar studies are ongoing in Japan and the US and it is critical at this point in time that the same level of accuracy and detail is achieved in Europe in order to provide a fair comparison between the various experimental options. By providing expertise in all the relevant areas in a coherent effort between WP3, WP4 and WP5, LAGUNA-LBNO will allow to obtain a detailed and reliable evaluation of the sensitivity of the setups, far beyond the status of the art. The experimental setups considered in this DS for long baseline neutrino oscillations might allow to discover the existence of CP violation, which might be linked to the origin of the matter-antimatter asymmetry of the Universe, and to determine with unprecedented precision other crucial neutrino parameters such as the mixing angles, the neutrino mass hierarchy and the number of neutrinos.

The second focus of the physics in this DS is the study of other high-energy neutrinos, namely atmospheric neutrinos. These will be detected with very high statistics, superior angular resolution, and in some detector configurations, with charge discrimination, allowing for better measurements of atmospheric neutrino oscillation parameters and the possibility to address the neutrino mass hierarchy.

The third focus of LAGUNA-LBNO from a physics perspective is the study of low energy neutrinos, namely solar neutrinos, geo-neutrinos, supernova and man-made neutrinos. The solar neutrino flux could be measured with unprecedented accuracy and real-time observations of the Sun in the ``light of neutrinos'' could take place. Solar neutrinos will be used as a tool to probe the processes which take place in the inner Sun and to better understand its composition. The Earth itself produces large amounts of very low energy neutrinos from the decay of natural radioactive elements in the mantle and the crust. These geo-neutrinos can be uniquely studied in these detectors and allow a geological investigation of the Earth interior, opening a new field of research. The large scale detectors under consideration allow also for the study of neutrinos produced in a nearby supernova explosion and the diffuse supernova neutrino background. If a supernova explosion takes place in our galaxy during the lifetime of the detectors, it will be possible to observe in detail the spectral and temporal features of the "neutrino light curve" and to test our current understanding of the core-collapse paradigm and the delayed explosion mechanism. These neutrinos undergo oscillations in the supernovae with specific features which are due to the very high density environment and which have been discovered only in the past couple of years. By studying these effects it will be possible to extract important information on neutrino properties, e.g. the mixing angles and their number. In addition, the first detection of the cosmic diffuse supernova neutrino background that originates from all past core-collapse events in the universe could be achieved in these detectors. In this manner, neutrino astronomy can tell us about the past history of the Universe and in particular on the cosmic star formation history. Finally, low energy neutrinos are also produced by man-made sources, namely in reactors and by weak processes as studied in oscillometry. Reactor anti-neutrinos are produced very copiously and constitute a very large background for the measurements of low energy neutrinos discussed above. Consequently, some of the locations considered are far away from nuclear reactors in order to minimise their impact. On the other hand, reactor anti-neutrinos, if detected in large numbers as it is possible at locations close to areas of large reactor activity, allow for useful measurements of some oscillation parameters. A source of monoenergetic low energy neutrinos is given by nuclear electron capture. This novel technique promises to allow for accurate measurements of the mixing angle theta13 and requires very large detectors, due to the very low counting rates. The LAGUNA detectors are ideally suited for this task.

Beyond neutrino physics, the other major objective of LAGUNA detectors is the search for proton decay. This process has eluded detection so far and constitutes an indirect test of the physics at scales such that cannot be reached otherwise, namely the physics at the grand unification scale. Most of the theoretical models predict such process at a rate which might be close to the sensitivities of LAGUNA detectors. The detection of proton decay and the identification of the decay channels would be a ground-breaking discovery, implying that one of the fundamental symmetries of Nature, baryon number, is not conserved and giving us a unique insights into the structure of matter at extremely small scales or high energies.

The physics studied by the LAGUNA detectors is complementary to the searches at colliders, and in particular at the LHC, and in Lepton Flavour Violation experiments (LFV). It provides a unique window on fundamental constituents of matter and their interactions, aiming at understanding the origin of neutrino masses and of the flavour problem. It should be pointed out that recently a strong theoretical effort has emerged on the study of models of neutrino masses at the TeV scale. These extensions of the Standard Models assume the existence of new particles which can be search for at colliders. The information coming from LAGUNA detectors is important to constrain the properties of these models and should be combined to the one coming from colliders and LFV searches. Moreover, the LHC will test the extension of the particle spectrum at the TeV scale, which is required for the unification of the known couplings of the electromagnetic, weak and strong forces. The type of extension constrains the scale at which proton decay is mediated, significantly affecting the predicted proton lifetime, and impacts on its decay channels.

Impact to technological development capacity in Europe

In addition to a boost to all the physics and engineering technologies associated with the tank and detector aspects of the project, we highlight here the anticipated major impact on the technological expertise of Europe in all aspects of underground engineering, safety and environmental fields across a range of disciplines. There is an ever-increasing demand for underground space worldwide and Europe holds leading positions in the field. However, there remain major engineering challenges so solve. An underground laboratory would provide both the academic and industrial communities with low-cost, long-term access to underground research sites to address these issues. For instance, progressive and sustained underground research is needed to develop new technologies for accurate prediction of rock behaviour, to understand the stability of deep underground constructions, the consequences of engineering activity there, the strength dependencies and mechanical properties of rock and the wider environmental impacts.

A deep massive volume underground laboratory as proposed provides a unique opportunity to address these challenges by making available a dedicated volume of rock directly accessible for long-term scientific and engineering research. A wide collection of rock engineering studies can then address fundamental questions in rock geophysics, expanding our technological capacity in areas such as fluid flow in rocks, excavation stability vs. rock fracture, and the relationship between high rock stress and increases in hazardous ground behaviours. A large, dedicated facility would also allow trials of new underground equipment to take place under controlled conditions free from constraints imposed by mining or tunnel operations.

All these aspects are core impacts available from the LAGUNA DS, which requires an engineering program to include rock characterization, design and construction, rock engineering, underground technology and safety. The engineering research envisaged will stimulate advances in underground construction techniques, improving cost-effectiveness and reducing risk. It will benefit European capacity and efficiency in the field by uniting expertise from different sub-fields, notably mining engineering with road tunnel engineering, and uniting activities across many countries. This process can build also on the demonstrated success of the FP6 ILIAS underground laboratory programme, which has, for instance, developed new approaches to the technology of safety underground.

A particular aspect anticipated will be technological impact on the development of better sensing techniques to characterise rock at depth - the development of emerging remote imaging technologies. This would be a core component of the underground engineering program providing an excellent opportunity for geoscientists and engineers to cooperate on new technologies. Studies of rock variables include hydrodynamics, plastic flow, gases, impact strength and fracture mechanisms. The ability to recognize and characterize rock complexity is important for design and construction of large underground caverns. Meanwhile, the combination of depth and large span plus the need for stability for over 50 years stretches current knowledge. The construction period itself provides a unique opportunity for development of excavation technologies and designs.

Of the highest importance, for what will be a civil facility possibly in a working mine or transport tunnel, is safety and environmental impact. These must be fully integrated throughout the planning, design and construction stages. The design study and subsequent laboratory thus provide an ideal route for developing advances in safety systems and technology. Particular attention would go to advances in areas such as underground communication, fire prevention, ventilation, access, emergency egress and refuge design. Advances in environmental science and engineering are also possible. For instance, rock temperatures increase typically at 1-3 ºC per 100 m of depth. This provides a means to undertake mechanical-systems research into environmental life support such as air conditioning and filtration at depth.

Impact on society

Environmental pressures, global warming, increasing population densities, increasing energy requirements, water shortages and protection of water supplies, growing transport systems, waste storage and disposal issues, increasing demand for scarce minerals and raw materials and concern for Earthquakes are all contributing to an accelerating demand worldwide for underground activity and the technology to support it. The LAGUNA programme, can provide clear impact on this demand from society.

For instance, new and deep underground laboratory space can provide vital access for research into geothermal energy and water flow behaviour in relation to fissures and rock mechanics. The latter can provide input to reservoir design and development to allow improved protection of drinking supplies. Bioengineering has a role to play here in understanding water purity aspects but also the possibility of improving waste disposal underground and carbon sequestration as a route to reduction of CO_2 in the atmosphere.

Radon emanation and fluid flow underground is now known to be related to rock seismic activity at depth. This opens the possibility of a route to prediction of Earthquakes. New underground laboratory space would offer the opportunity to measure directly the relationships and confirm the seismic properties of rock in this respect. In particular, this would allow researchers to understand the time-development of fault processes and hence produce improved computer simulations to allow predictions to be made of possible future earthquake activity that could have severe impact on local populations.

Life is now known to exist underground, in fact accounting for around 50% of the Earth's biomass. It is even possible that life originated deep underground. A new discipline in biology, geomicrobiology, has emerged to study this deep subsurface microbe population ("dark life"). The studies could have extreme implications for society, including progress towards an understanding of the origins of life, the impact of the biomass on the environment and evolution of the Earth. Development of pristine underground areas is now vital to the research and would stimulate further merger of fields as diverse as geochemistry, geology and hydrology with biology and genetics. The interaction of this life with the environment past and present is not understood and there are likely new practical applications that will emerge. The future large underground facility will offer an exceptional opportunity to carry out the studies needed.

B 3.2 Plan for the use and dissemination of foreground

This DS has a clear "user chain" flow for dissemination and exploitation, as illustrated in Figure 8. As was mentioned in the ApPEC/ASPERA roadmap, this DS emerges from a need of the scientific community. During the DS, the many reports to be compiled (see deliverables list) will serve as database of open documents. A certain number of reports will be opened to the public and be disseminated in various ways:

- The intermediate results and the status of the project will be reported to the scientific community by regular presentations in conferences, workshops and seminars.

- Technical reports resulting from this DS will be made available for all interested parties by electronic distribution.
- Scientific results will be published according to good scientific traditions in journals, reports and conferences.
- The final reports will be announced on month 36 and distributed to the community, to the funding agencies, and where appropriate to the press.
- The LAGUNA web site will remain active even after month 36, although updates will be less likely to occur.

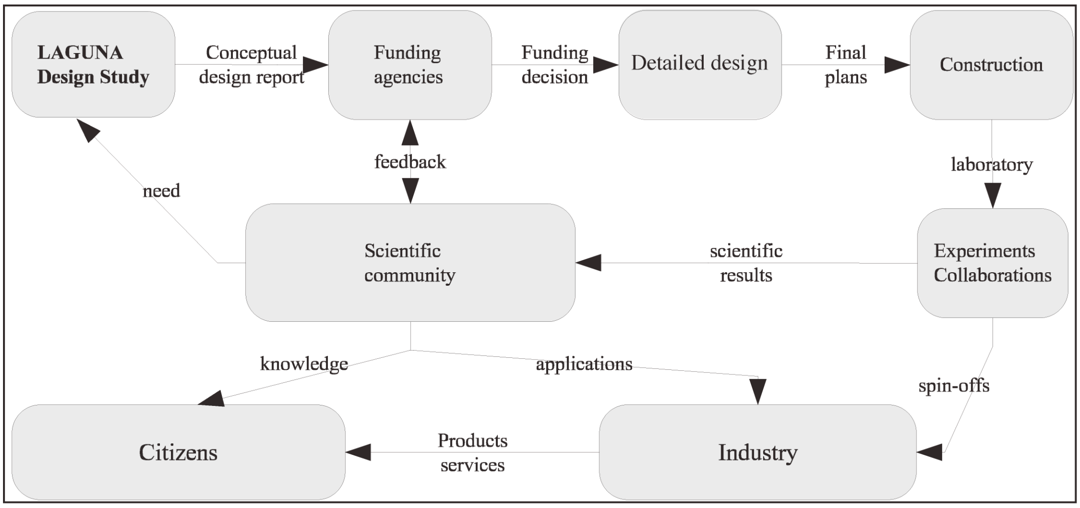


Figure 8 User chain flow.

The results of the studies will be published in a series a document, culminating with the final report document. The report will contain the objective and scientific information needed to reach the funding and construction phase. Assuming a positive feed-back from the funding agencies, the final technical report will be a starting point for a subsequent detailed design work. This would lead to final plans for construction and approval of the new research infrastructure. The experimental results to be obtained in the research infrastructure will provide top-class, forefront scientific results, which will feedback to the scientific community. Of course, citizens will be part of the process and will acquire knowledge from the scientific community. Similarly, direct spin-offs and applications will feed into the industrial component, which itself via products and services will provide improved quality of life to the citizens.

LAGUNA web sites

There will be two web sites: (a) the public outreach web site and (b) the public internal website. They will be the main information and communication tools for storage and dissemination of project results. They will act as the central hub of knowledge dissemination to the scientific community, the industry, and the general public. They will consist of an overview section for non-experts, appropriate information about the goals and status of the different activities of LAGUNA, as well as a section about project results. Some technical deliverables will be made available on the public web-site (See Deliverables for details), and thus at disposal of any interested parties. It is also intended to develop dedicated outreach sections for the general public and for educational resources related to detectors for particle physics.

Scientific publications are the main means of persistent dissemination of the project results to the scientific community. The Steering Committee will encourage the swift publication of scientific and technical results in refereed journals and conference proceedings, and will ensure the quality of the publications by implementing an internal review procedure prior to their submission. A dedicated publication database will provide a central repository for project-related publications.

Presentations

Presentation of results at events such as relevant international scientific conferences and workshops, and the General meeting will also ensure publicity of LAGUNA's work. The General meetings will be open to all participants, third parties and associated partners of the project, but also to the interested user community from outside of the consortium, whose active feedback will be sought. The General Meeting will enhance the flow of information and the interaction between the participants and the community, strengthening the consensus and the support of the community for the existing and future detector facilities in Europe. An events calendar on the public website will list the relevant conferences and workshops to the project.

Open Access

The Particle Physics community widely supports the principle of Open Access to all results that are generated through publicly funded research. Therefore, in line with the efforts of the European Commission to ensure widest possible dissemination of FP7 results, the Executive Committee will encourage LAGUNA-LBNO publications to be submitted to Open Access journals. In this way, all internet users will have free and unrestricted access to these peer-reviewed publications.

Management of intellectual property

No serious issues related to intellectual properties management are expected, as the design study will produce information to the public, except otherwise governed by specific intellectual property rights or a confidentiality agreement, like e.g. in a few explicit internal items related to the exploitation of particular sites. In particular, some information about the mines will not be made public.

The principles for dissemination, access and use of knowledge generated through the project (Foreground) will fully comply with the Rules for participation in FP7 and for dissemination of research results, adopted by the European Council and Parliament in December 2006. Foreground arising from work carried out under the project shall be the property of the participant carrying out the work generating that Foreground. Where several participants have jointly carried out work generating Foreground, they shall have joint ownership of such Foreground.

Previous knowledge and knowhow (Background), which is necessary for completion of the project objectives, will be granted free access to the other participants. The participants will specify in an annex to the Consortium Agreement all Background for which they specifically need to limit or exclude the access, e.g. Background that is generated and owned by other groups / departments / institutes of the same university.

Unless stipulated otherwise, the access rights to Foreground knowledge shall not include the right of sub-licensing to third parties, not participating in the project. Access rights to Background or to Foreground needed by a participant for use for internal research purposes shall be granted on a royalty free basis. Access rights to Background or to Foreground needed by a participant for commercial use of its own Foreground shall be granted under reasonable conditions. Access rights to third parties (not participating in the project), whether for research or for commercial purposes, shall be granted upon written request, and with the agreement of all participants that own the Foreground.

As outlined in the previous section, the participants will endeavour to publish the results of the project as swiftly as possible in conference proceedings and scientific journals. The Consortium Agreement will specify the conditions for publication of results that have been generated by several participants, in order to respect the intellectual property rights of each institute. Results that are potentially usable for commercial exploitation and/or may need to be protected, will be evaluated by the Technology Transfer Offices of each participant, prior to their publication. The Consortium shall endeavour to respect the intellectual property practices and principles of each participant.

B4. Ethical issues (if applicable)
No ethical issues are expected to arise during the course of the Design Study.

B5. Gender aspects (optional)
Both genders are naturally represented in the DS. During the duration of the DS, all efforts will be made to promote gender equality in an appropriate way, and to treat minorities on an equal basis.