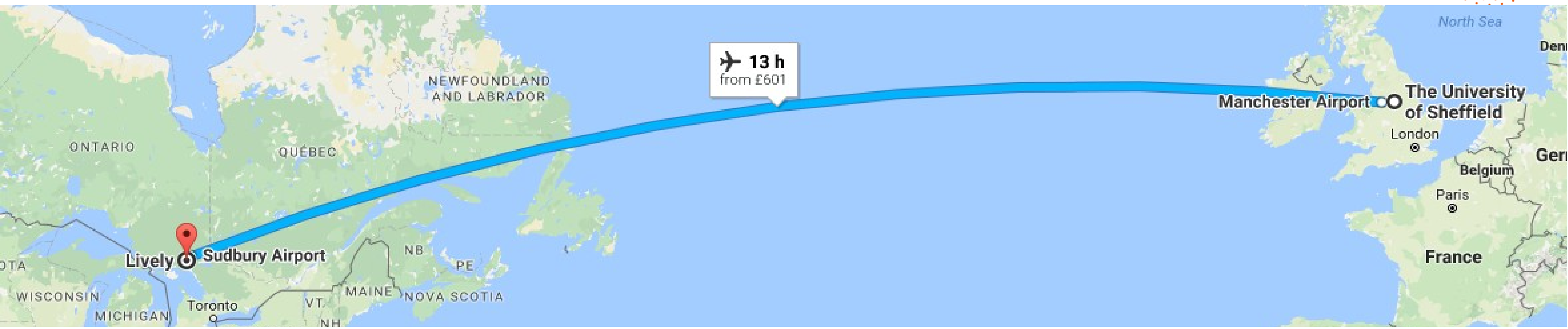
Upgrading and Commissioning the SNO+ Detector and Initial Data Taking

Billy Liggins
on behalf of the SNO+ collaboration

SNO+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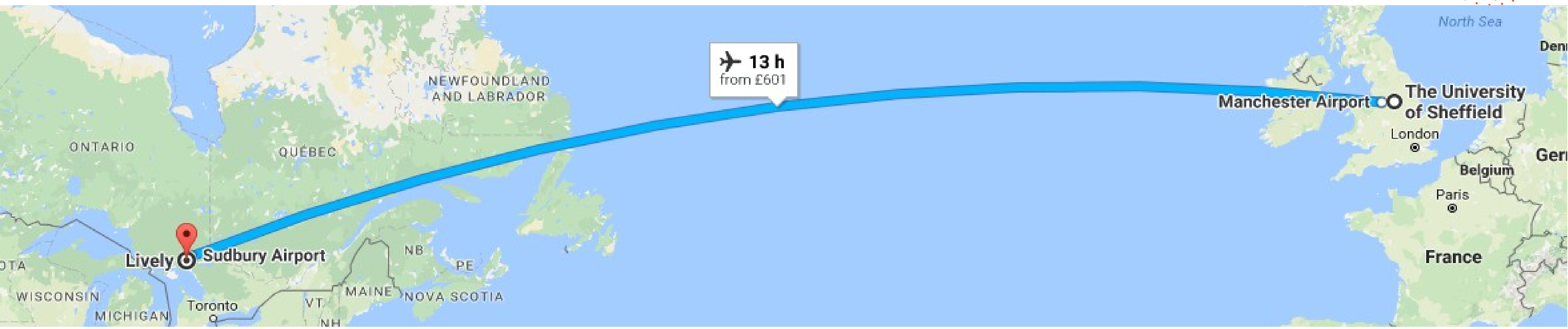
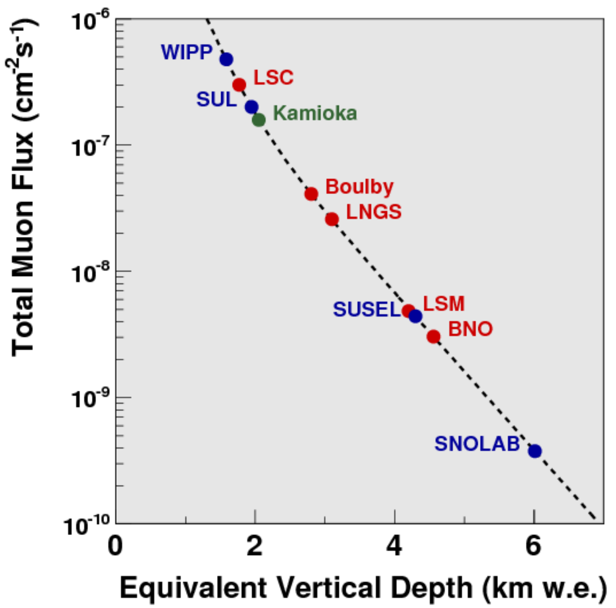


SNOLAB, 2km below surface in shaft 9 Creighton mine



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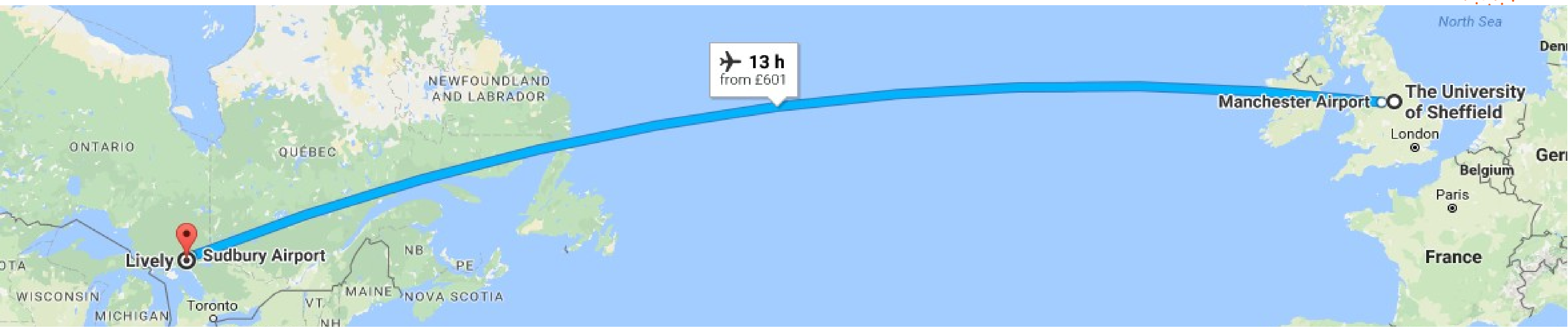

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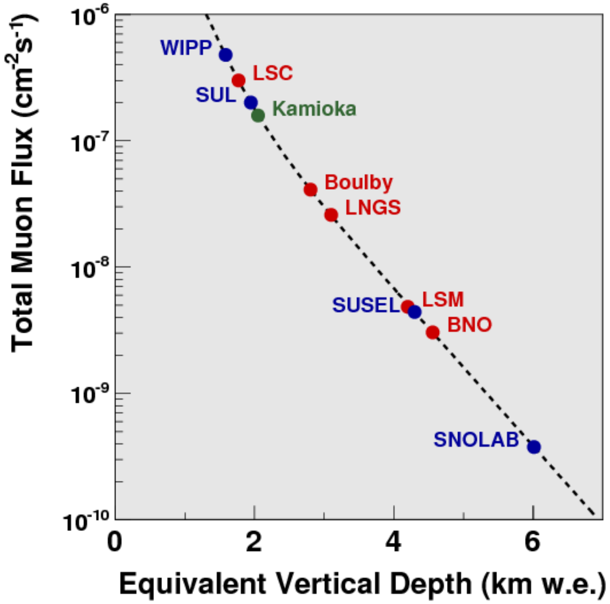

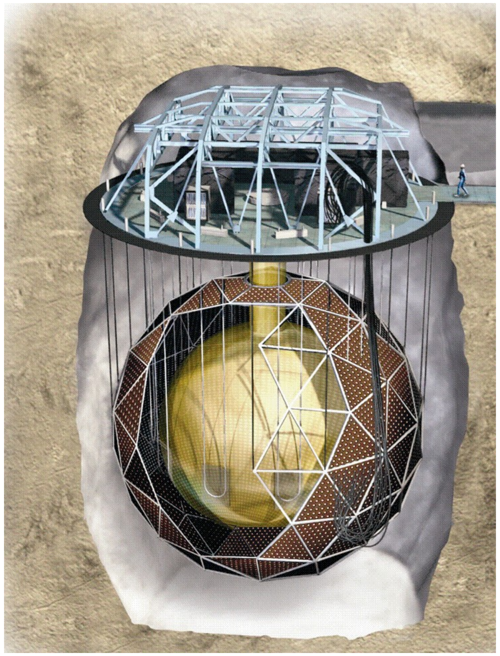

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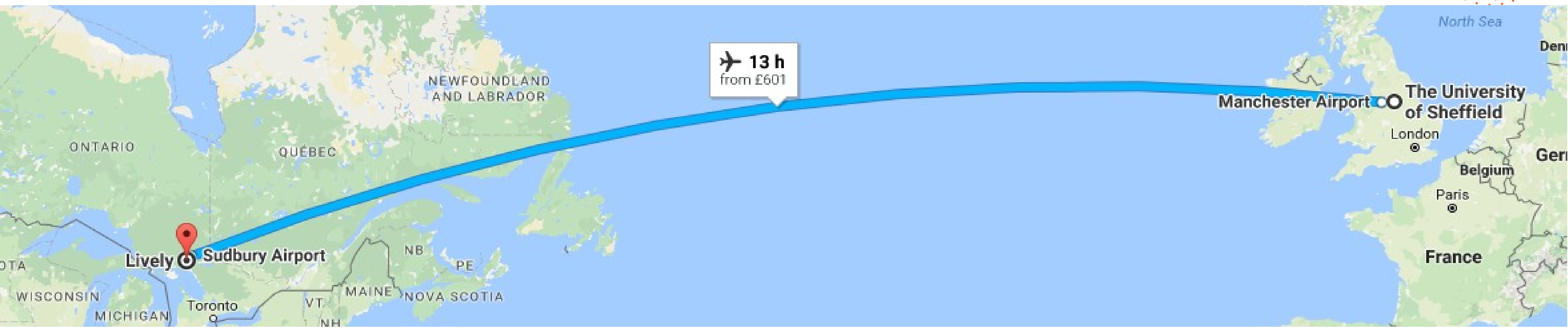

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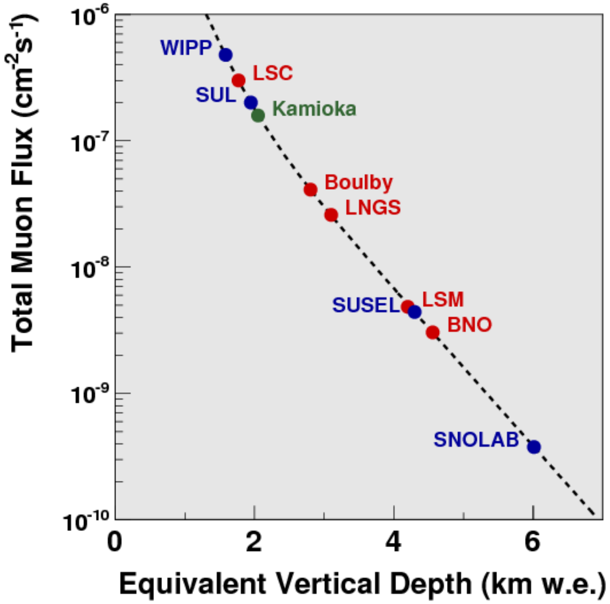

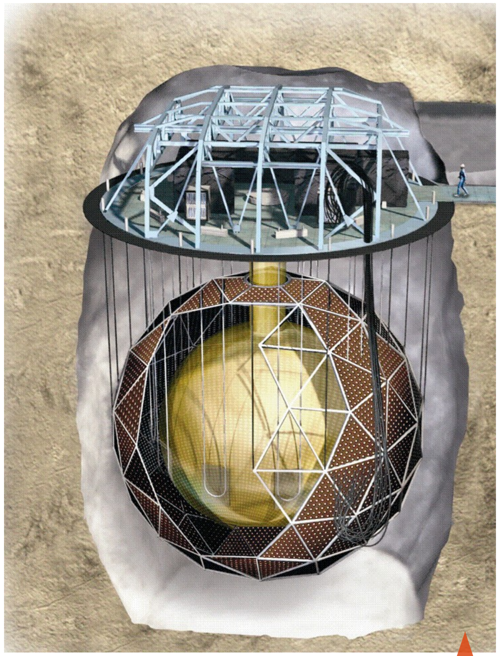

Rock

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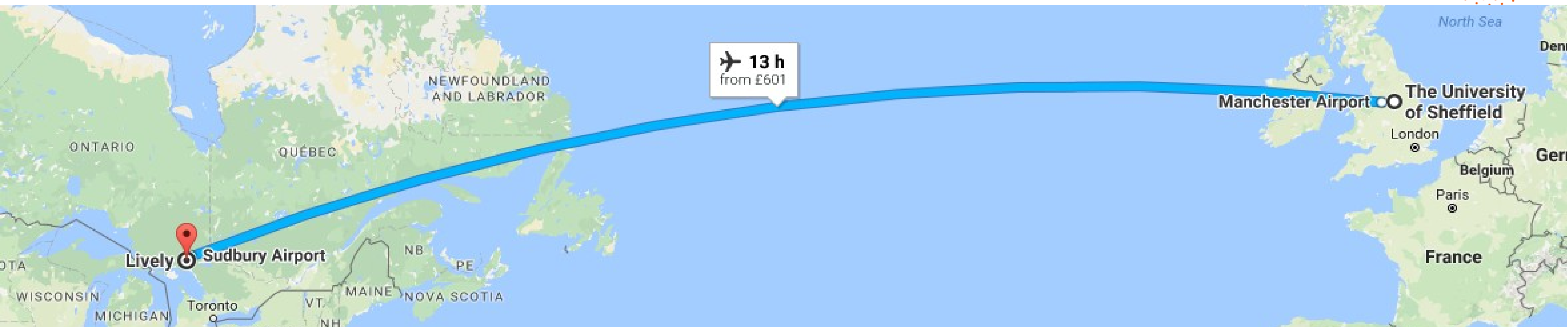

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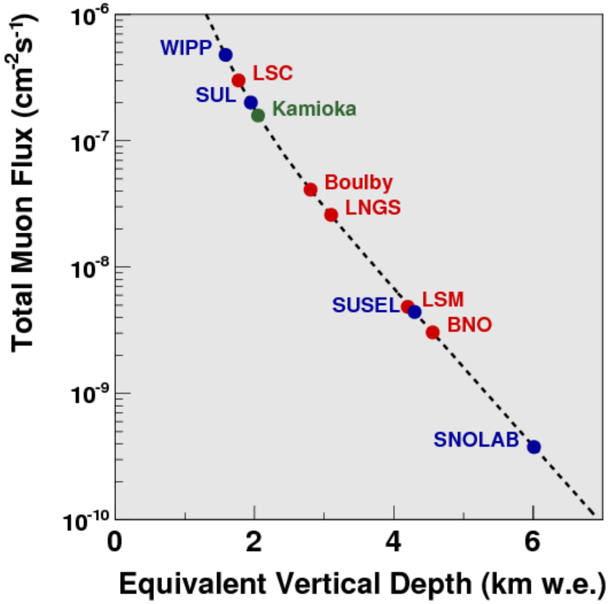

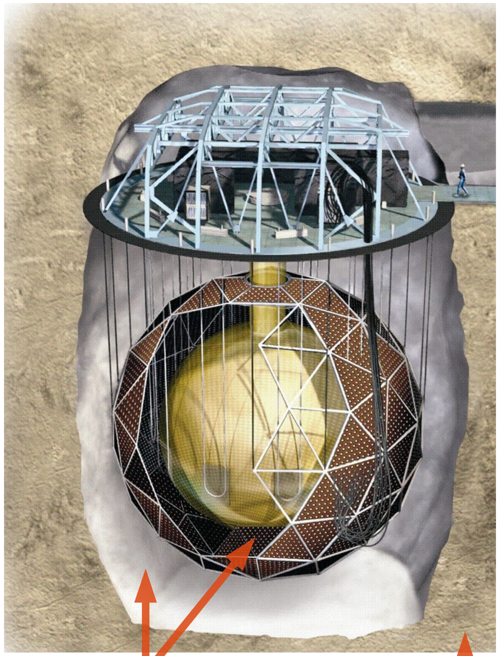

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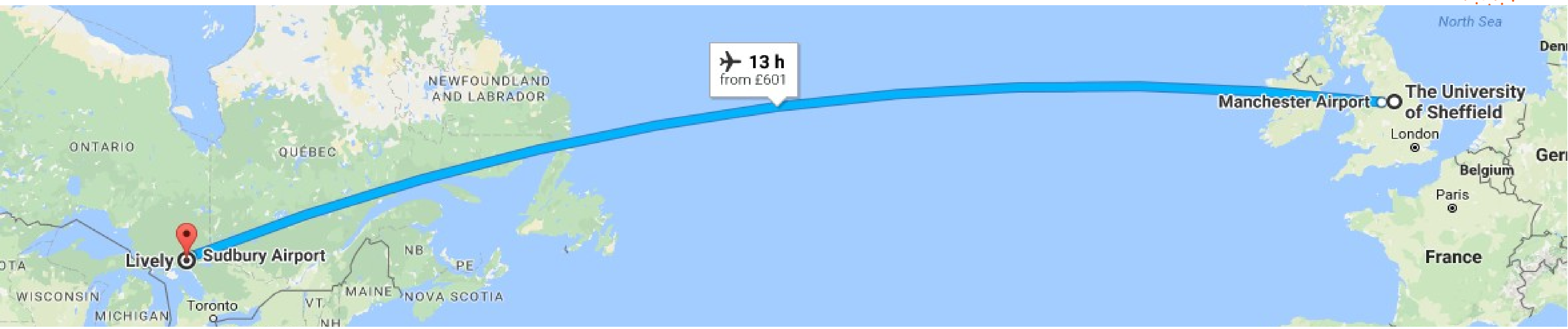

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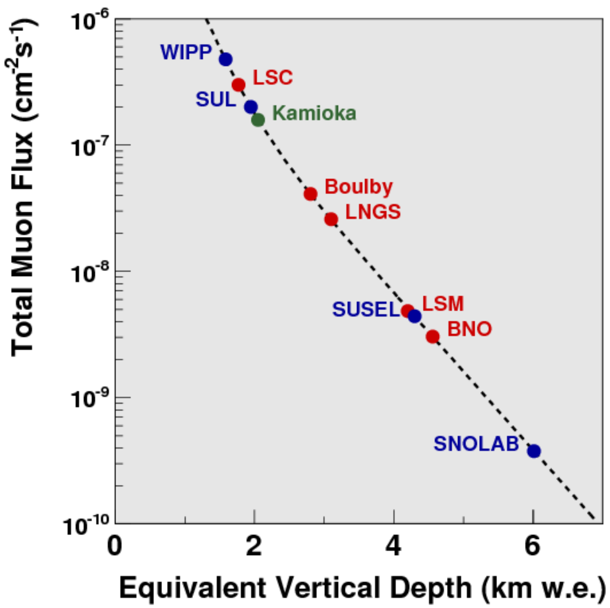

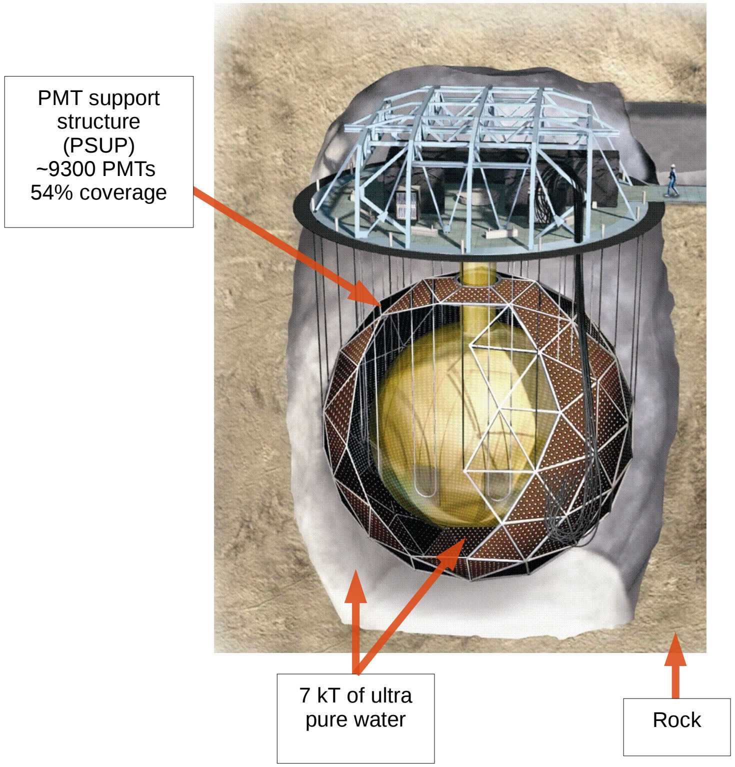

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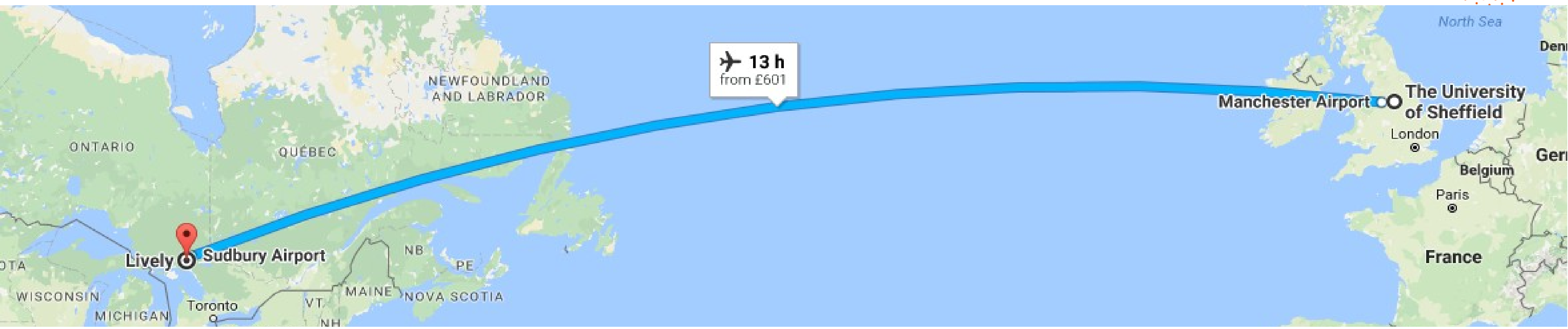

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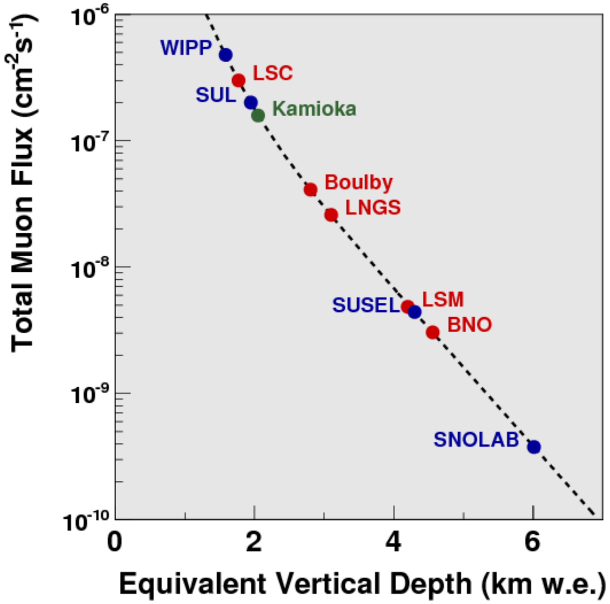

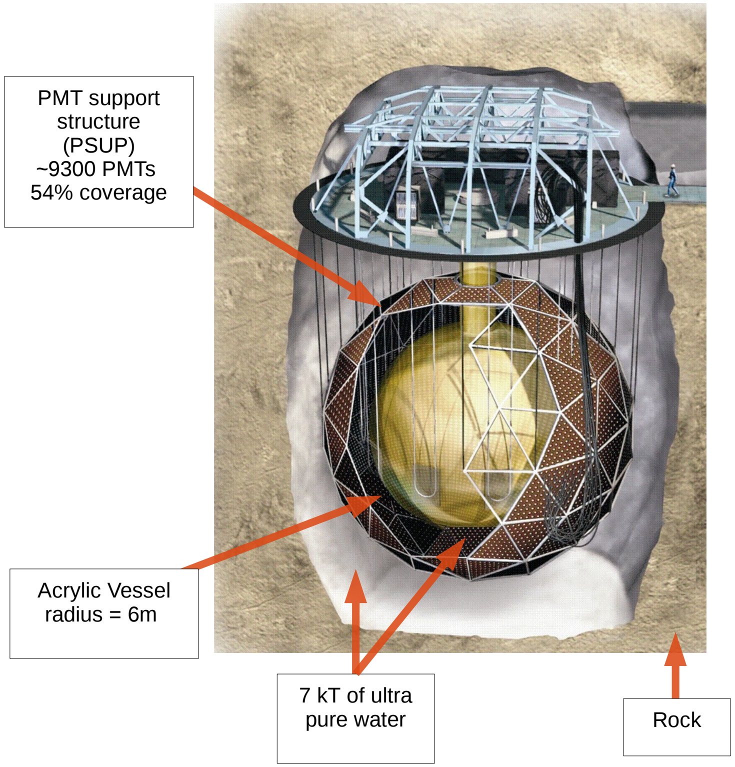

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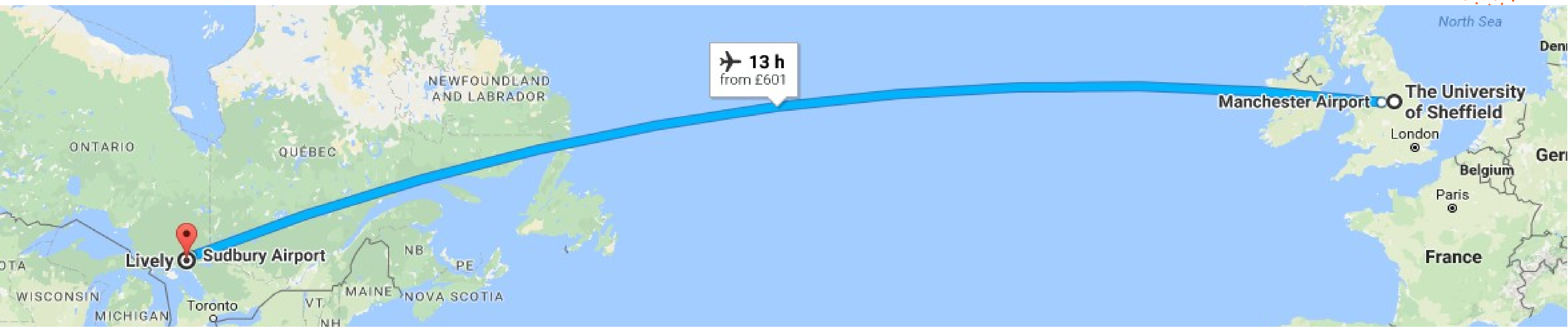

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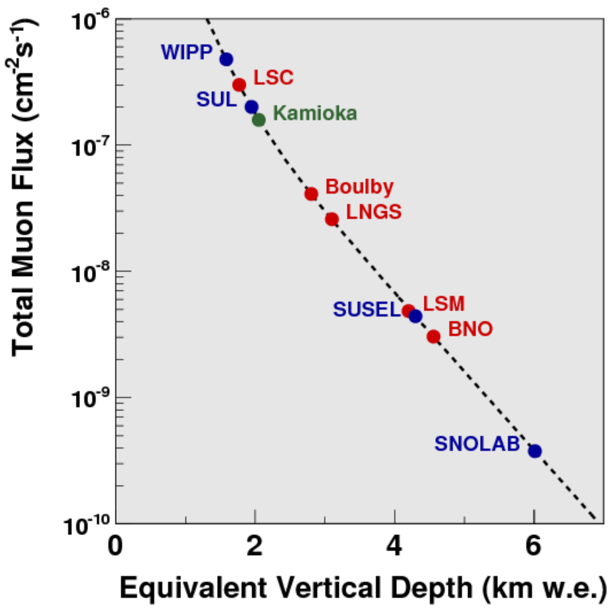

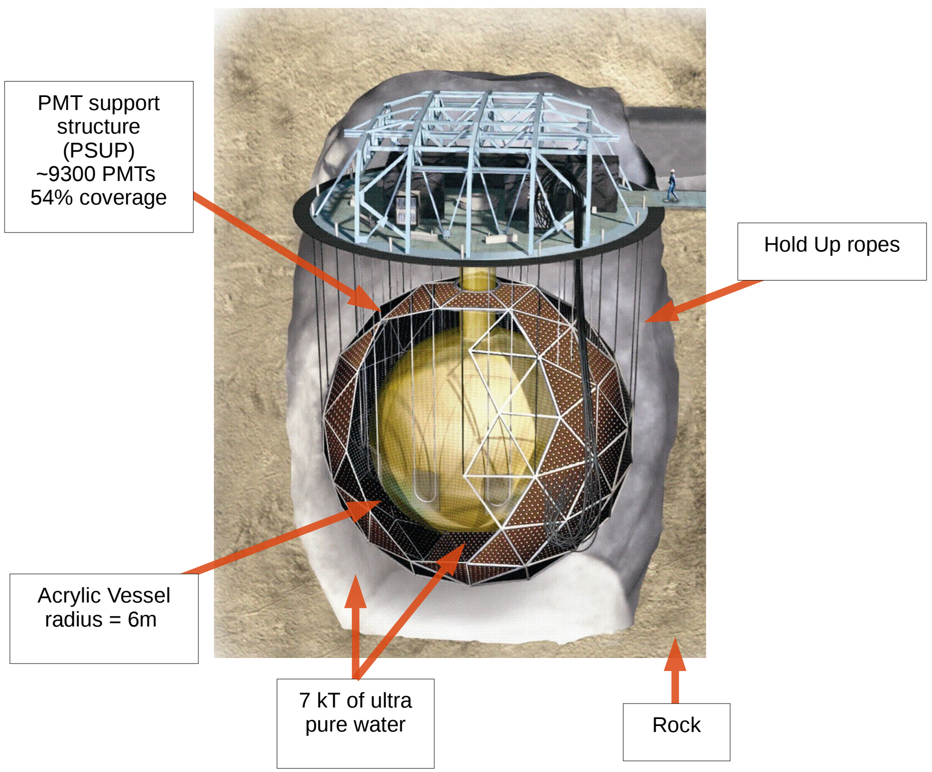

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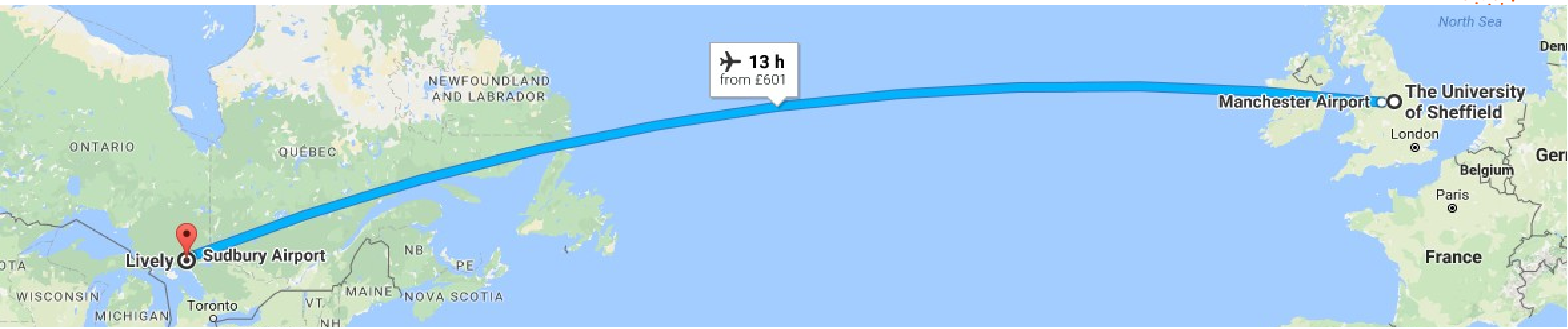

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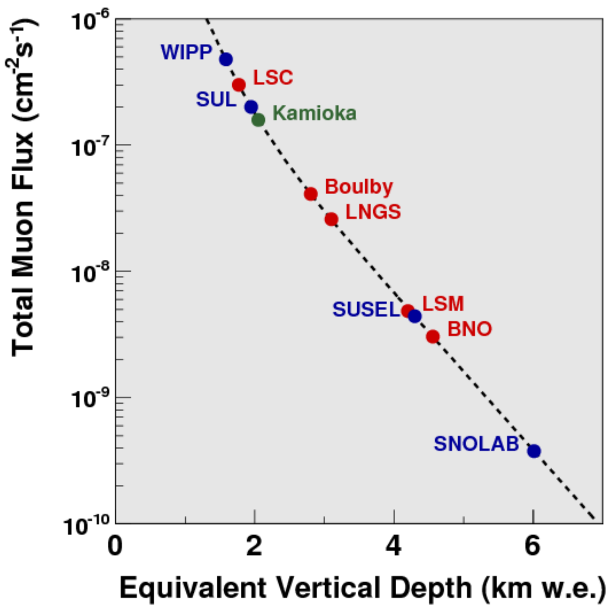

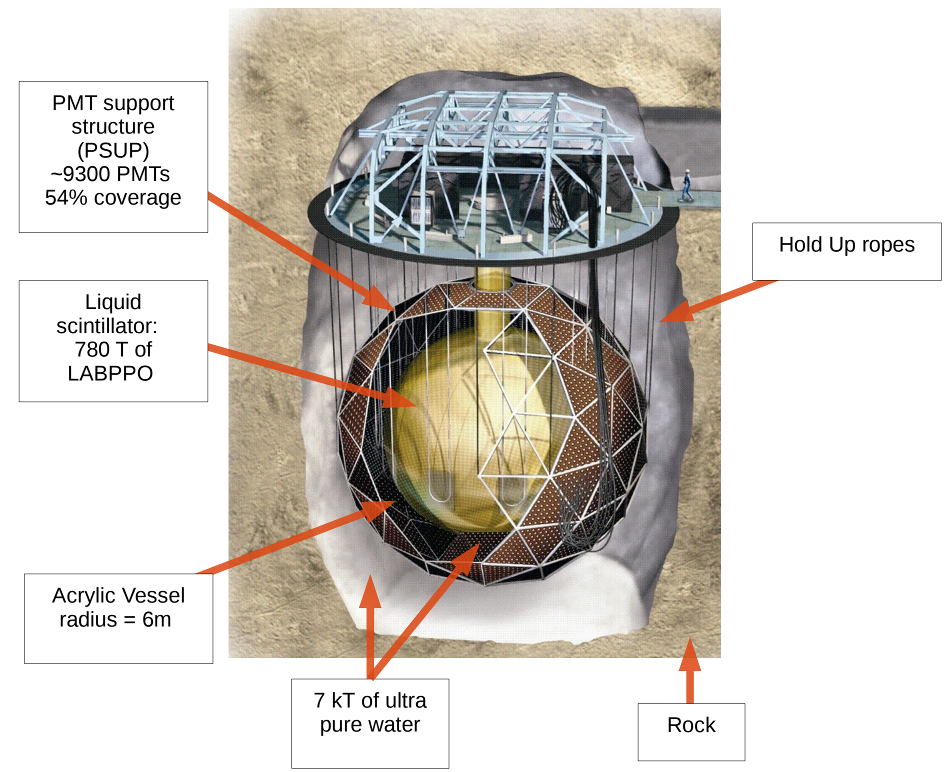

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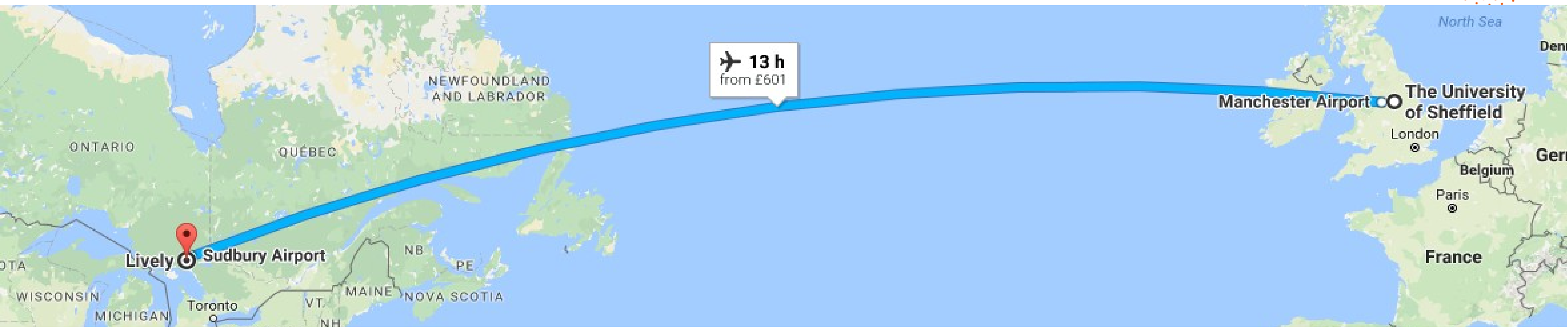

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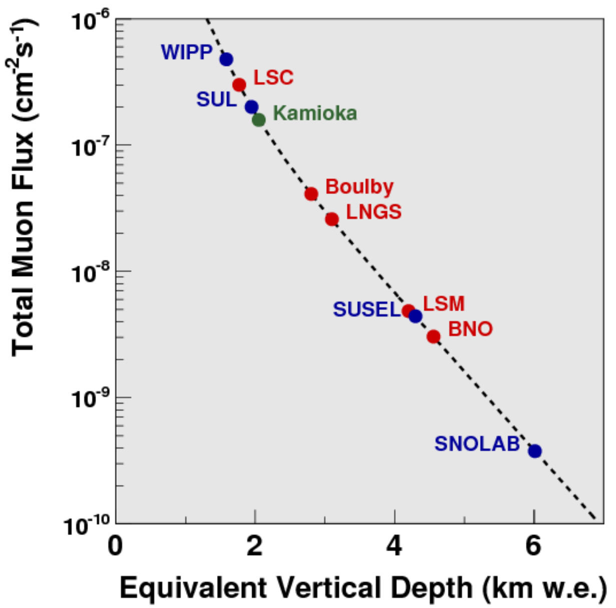

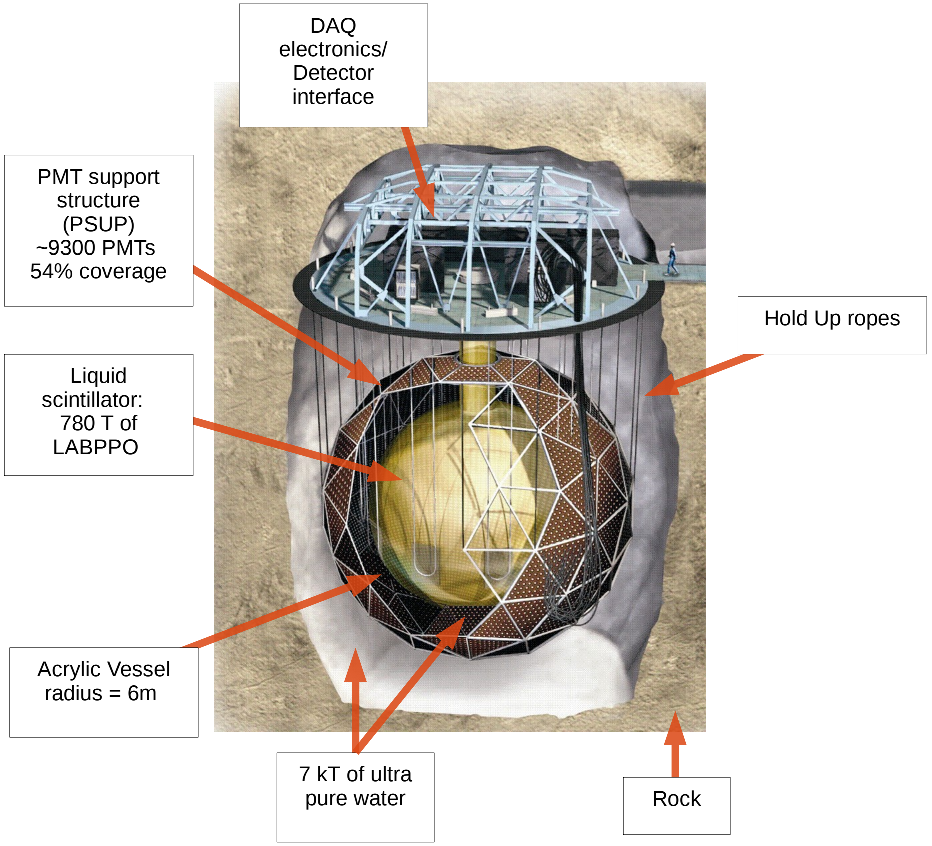

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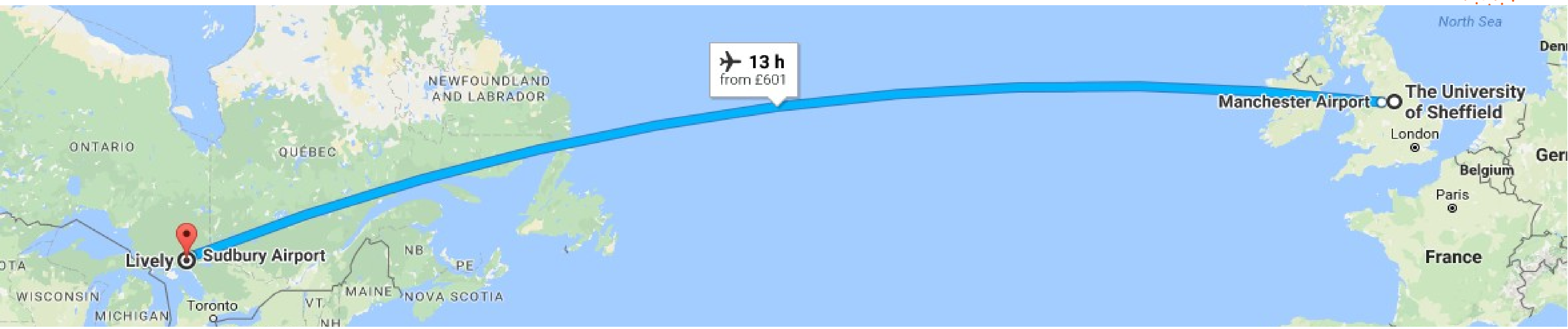

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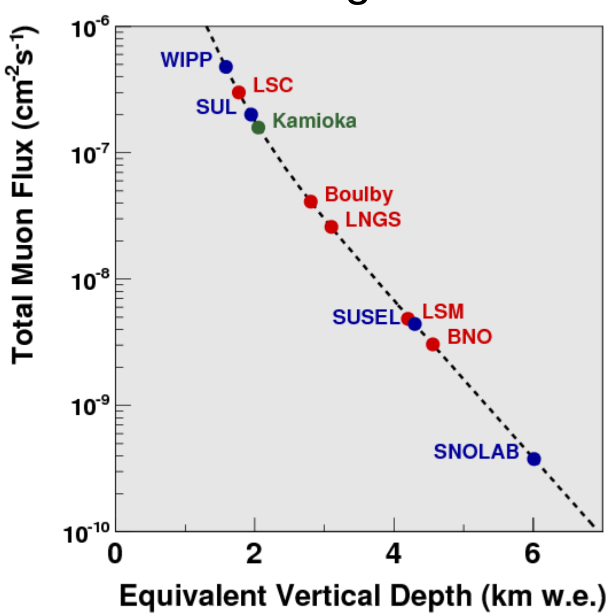
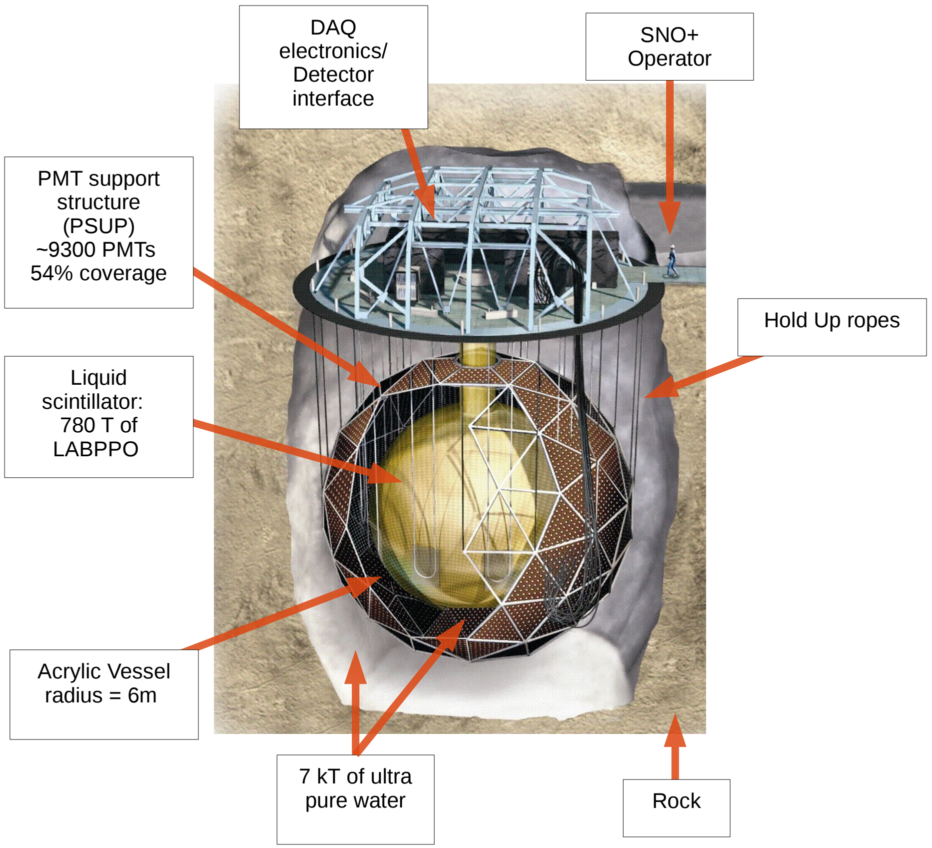
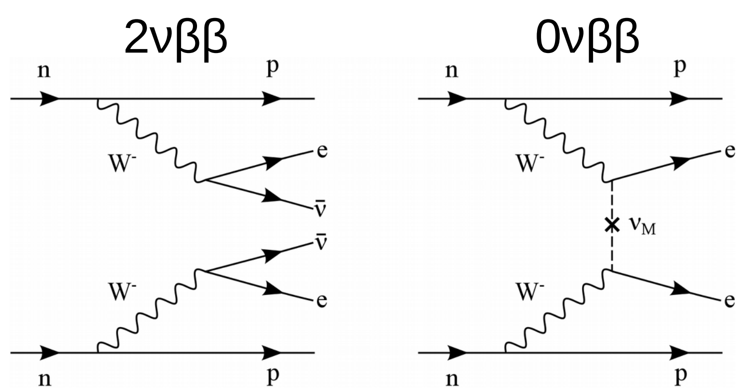




Physics Program[1]

Neutrinoless double beta decay



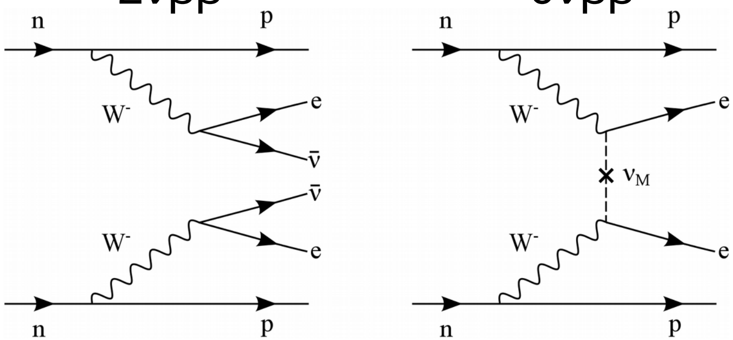
Observed in 11 isotopes

Search for in 1.3 tonnes of ^{130}Te

Physics Program[1]

Reactor anti-neutrinos (Δm^2_{12})

Neutrinoless double beta decay



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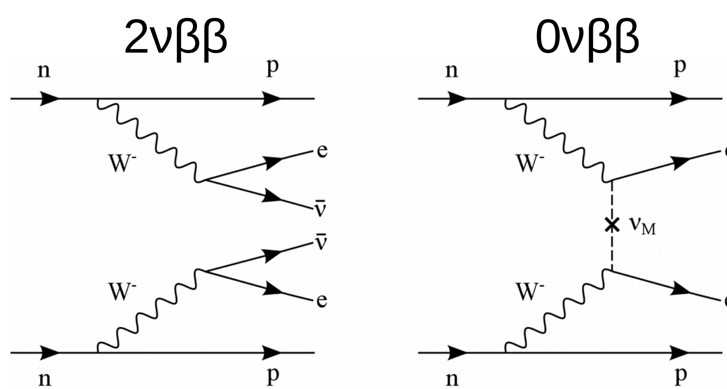

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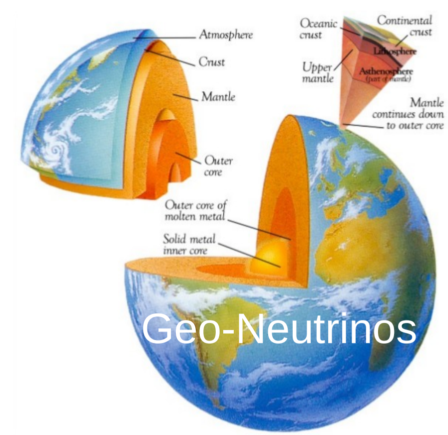

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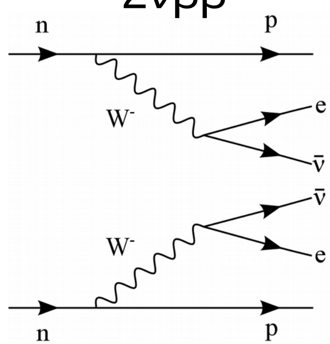
$2\nu\beta\beta$



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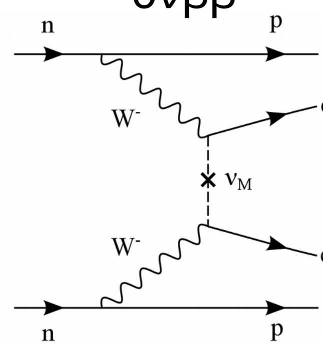

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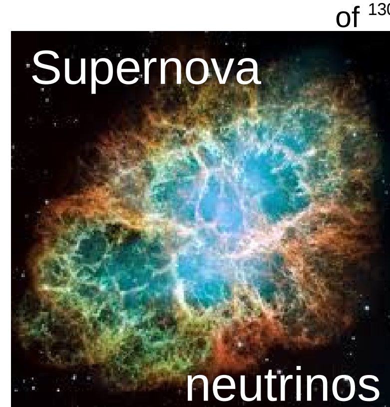
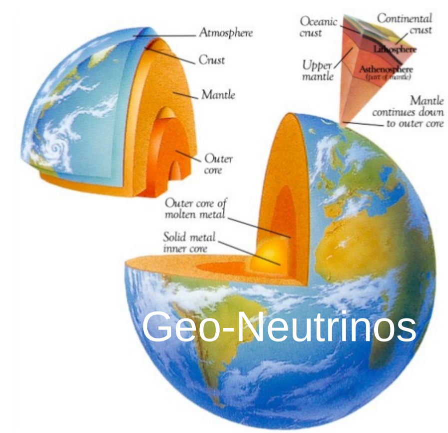


See talk:
Mark Stringer
Mon 2pm D



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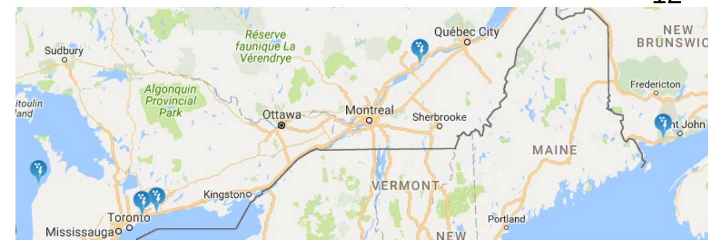
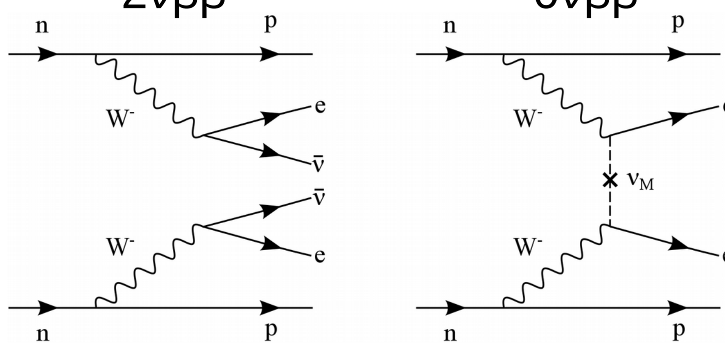


Neutrinoless double beta decay

2νββ | 0νββ



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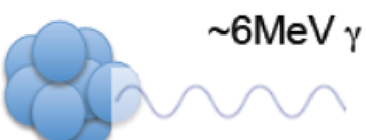
Search for in 1.3 tonnes of ^{130}Te

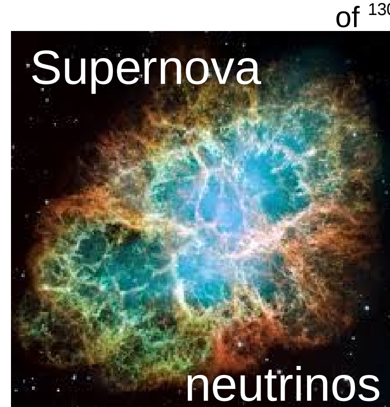
Invisible nucleon decay

^{16}O



~6MeV γ

See talk:
Matt Parnell
Mon 2pm B



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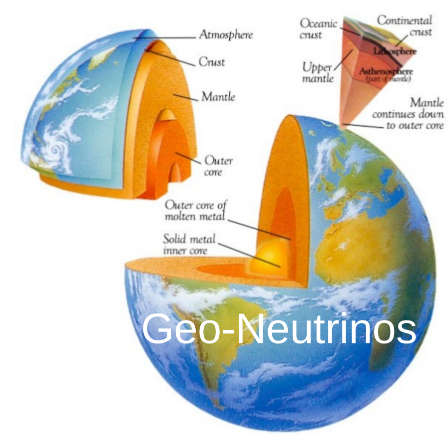
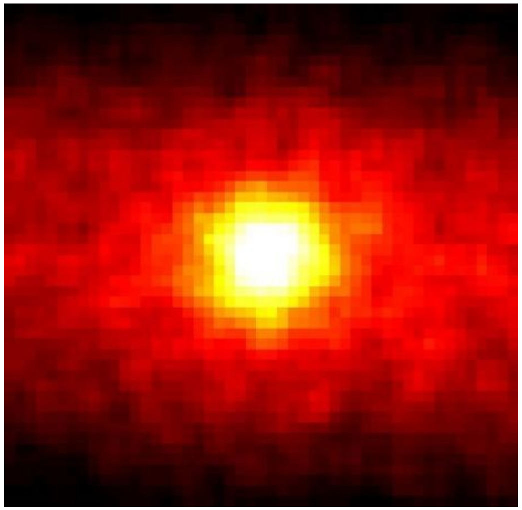


Physics Program[1]

Reactor anti-neutrinos (Δm^2_{12})

Solar neutrinos



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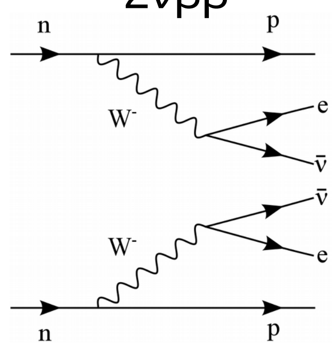

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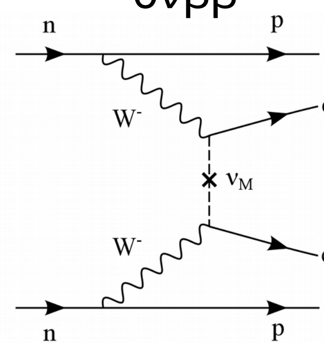

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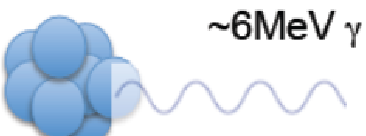

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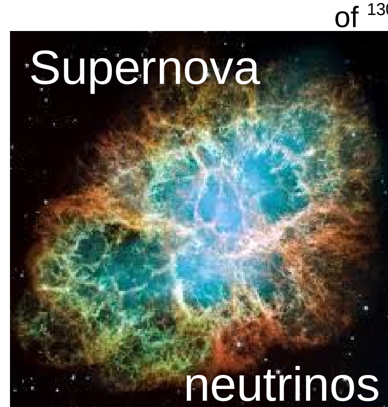

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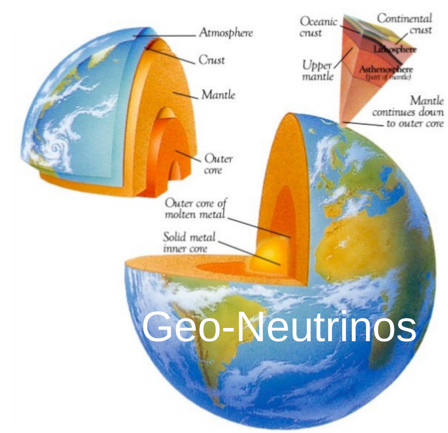

Detector Updates

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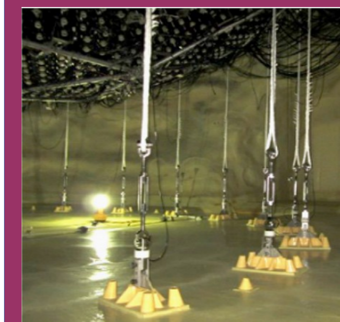

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- Veto PMTs.
- Various level sensors.

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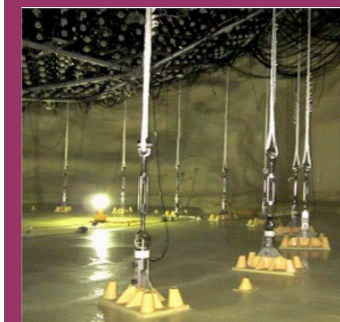
Tasks Completed

- ✔ Helium Leak Checking.
- ✔ Cleaning and Passivation.
- ✔ Fire suppression system.
- ✔ Pipe insulation.
- ✔ Water commissioning.



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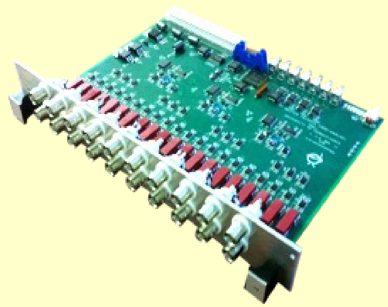
Electronics upgrades

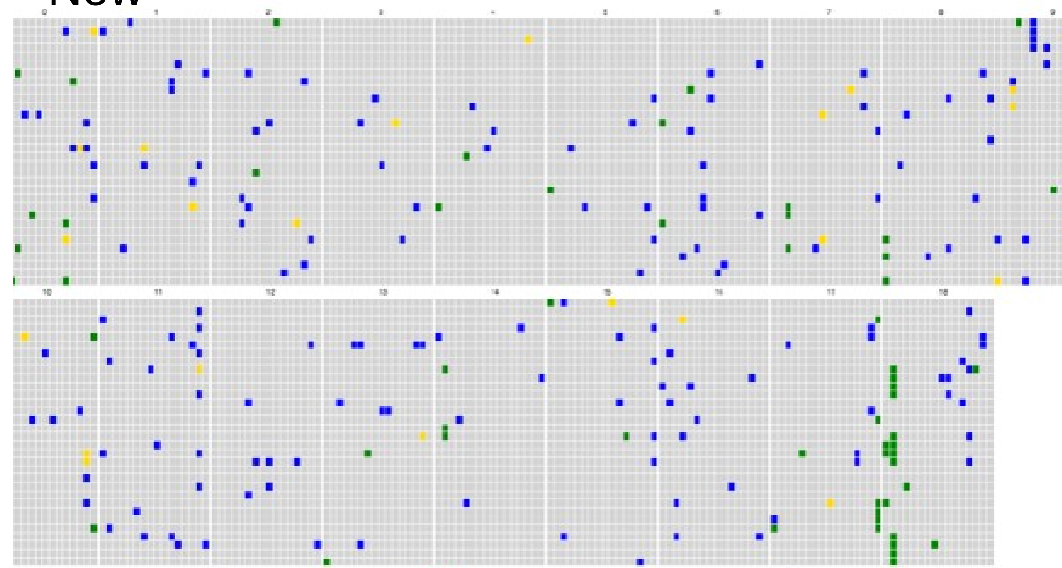
- Upgraded analogue trigger card (MTC/A+).
- Handles larger current loads.



- New XL3 cards.
- Interface between DAQ and electronics.
- Built to handle increased data rates.
- Communicate over ethernet.

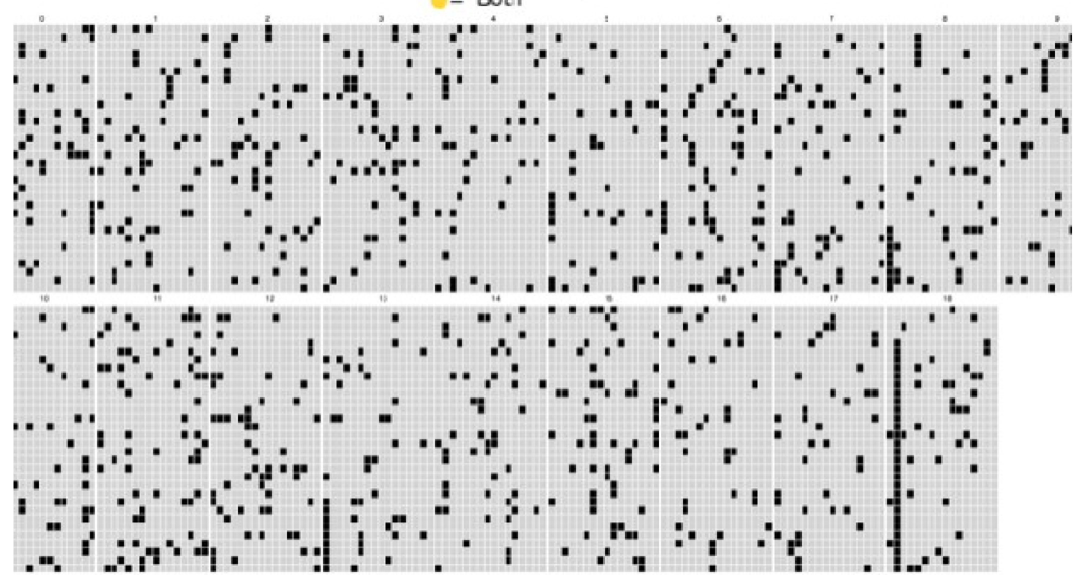
- Tubii is a trigger utility board.
- Extra trigger ports
- Detector wide timing.
- On the fly trigger logic

Now



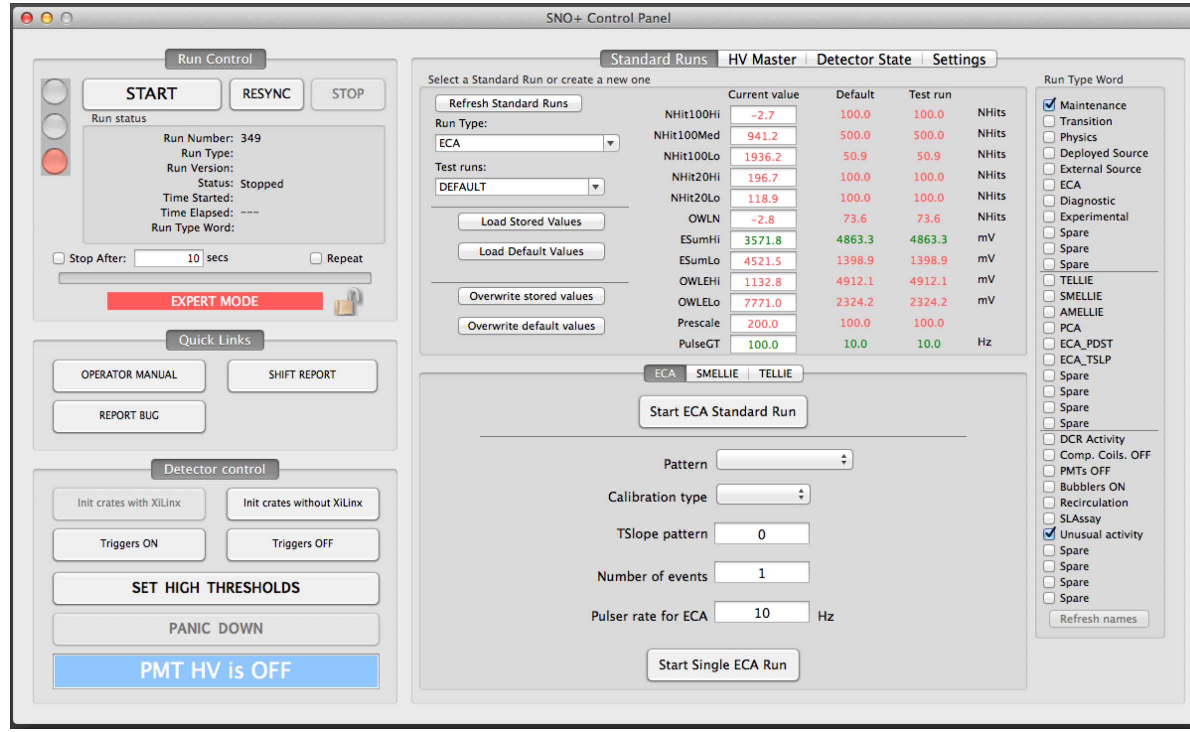
End of SNO

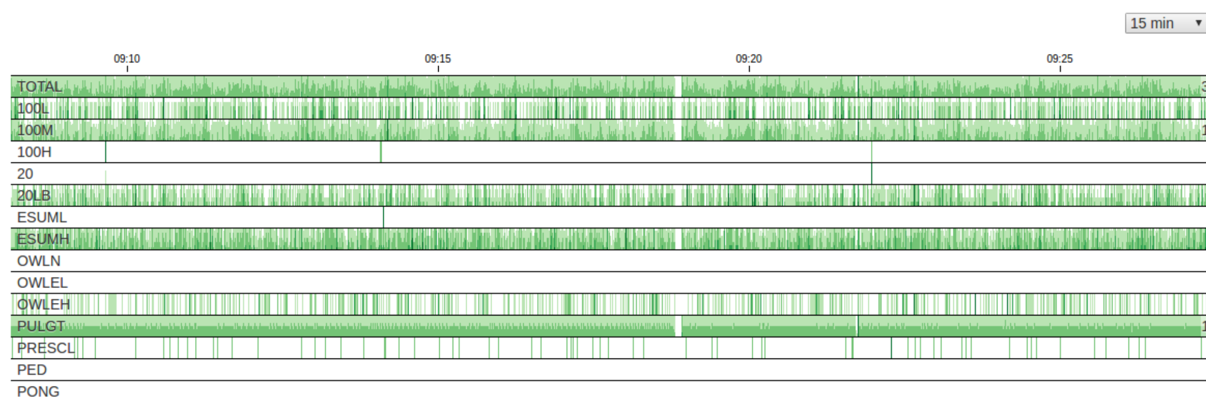
= Digital Issue
= PMT Missing/Pulled
= Both
Hardware missing



DAQ upgrades

- Redesign of DAQ framework.
- Central user interface is built in ORCA.
- Now data flow is decoupled from detector controls.
- Modular approach taken improving stability and increasing control.
- A suite of web based monitoring tools have been developed.
- Stress testing at high trigger rates have taken place on various occasions during air fill, partial water fill and now water fill.
- Multiple mock data processing challenges have provided the opportunity to test data flow and grid storage systems.

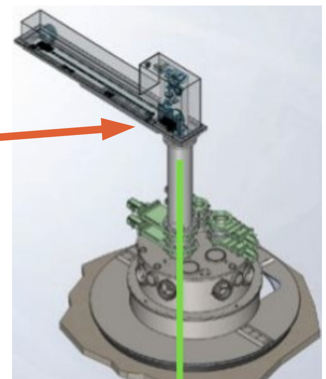


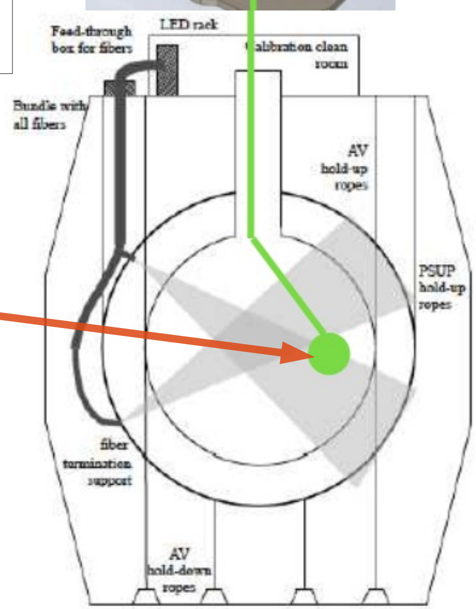


Calibration

External Sources

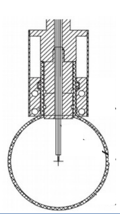
- New umbilical retrieval mechanisms for scintillator fill.
- Provides the required background control.





- New laser ball designed.
- ~7º shadow compared to ~30º from SNO.

SNO



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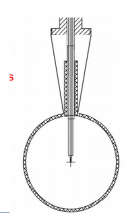
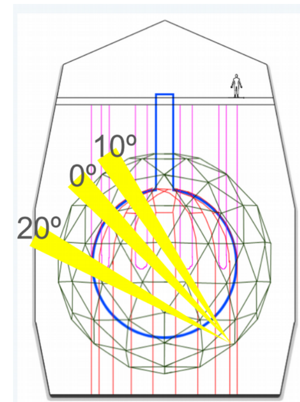


In situ Sources

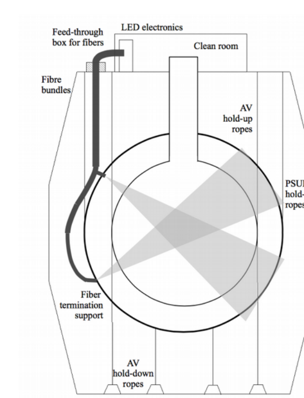


SMELLIE

- Scattering length measurements.
- Powered by supercontinuum laser.
- 15 collimated fibres at 5 locations on PSUP, angled in three directions.

TELLIE

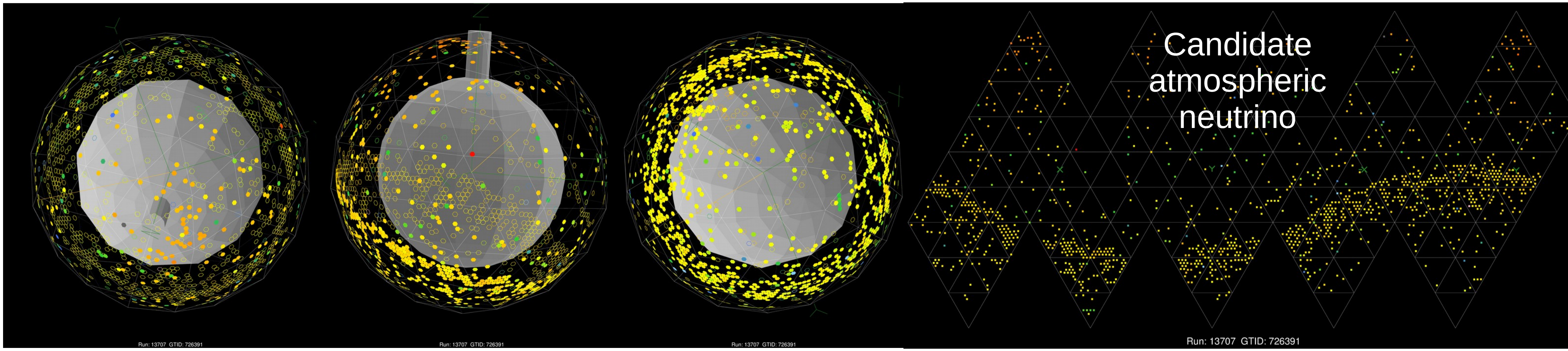
- PMT Timing measurements.
- 92 fibres mounted on the PSUP.
- Fire rate spans 10Hz - 10kHz.

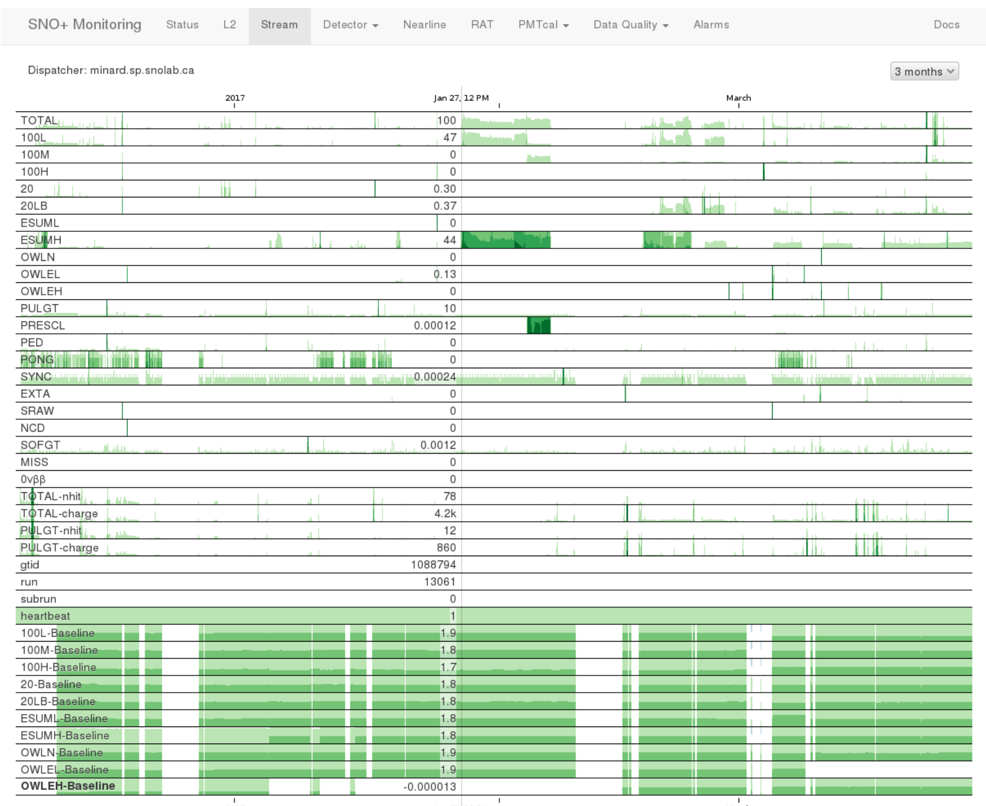


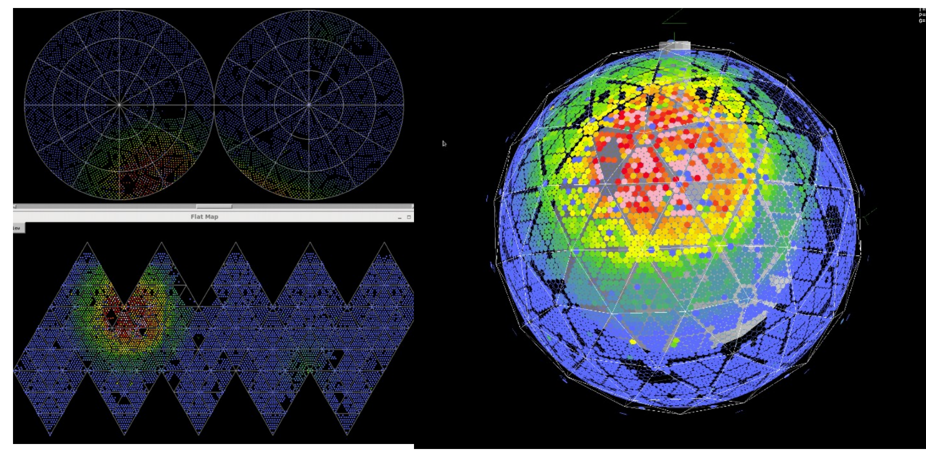
AMELLIE

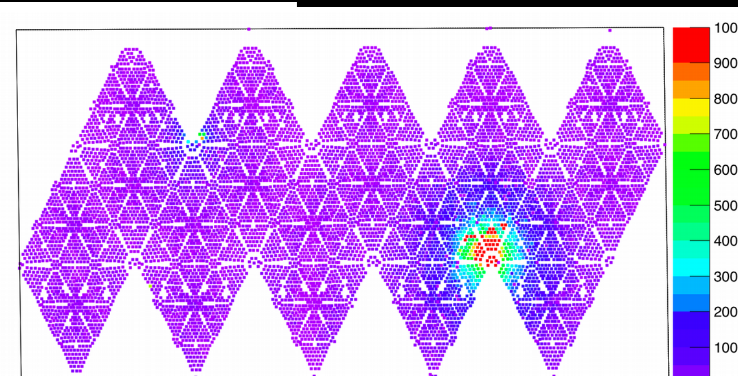
- Attenuation measurement.
- Monitoring stability of detecting medium.
- Coming online for scintillator phase.

First Data from water fill









Outlook

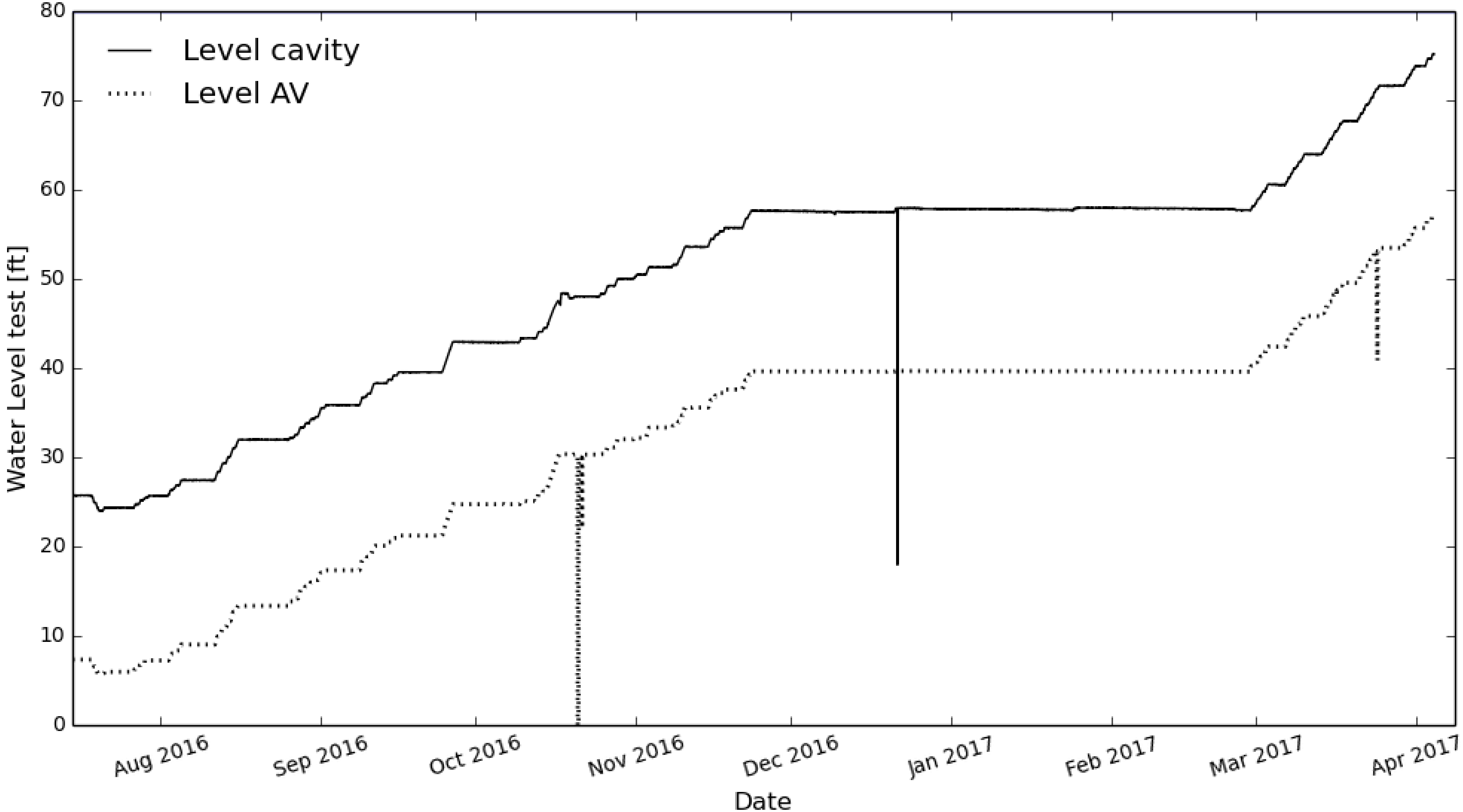
- Ultra pure water fill is ongoing.
- PSUP covered allowing for calibration.
- Water phase will run until early August.
- Commissioning of ELLIE/DAQ, background measurements and invisible nucleon decay search will take place.
- Scintillator fill is scheduled to take ~3 months.
- With the detector full of scintillator, radioactive background and optical studies characterising the LAB ready for $0\nu\beta\beta$ search will be carried out alongside Solar, geo and reactor neutrinos searches.
- ^{130}Te loading is scheduled for early 2018. After which the $0\nu\beta\beta$ search will begin.

References

[1] Andringa S, et al. 2016 Advances in High Energy Physics 2016 Article ID 6194250

Back up

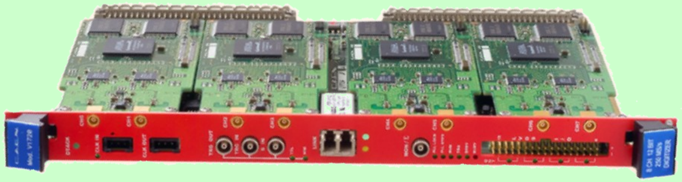
Water Level



Level cavity
Level AV
80
70
60
50
40
30
20
10
0
Water Level test [ft]
Aug 2016
Sep 2016
Oct 2016
Nov 2016
Dec 2016
Jan 2017
Feb 2017
Mar 2017
Apr 2017
Date

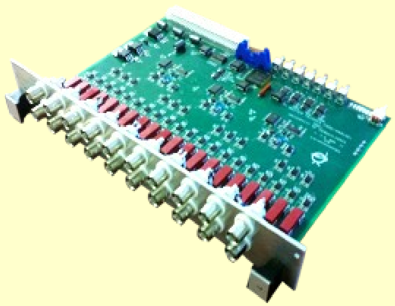
Electronics upgrades

- Instrumental background tagging can be achieved through triggered waveforms produced by the CAEN v1720 digitizer .



Electronics upgrades

- Upgraded analogue trigger card (MTC/A+).
- Handles larger current loads.



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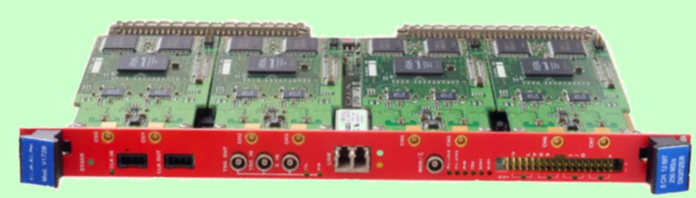

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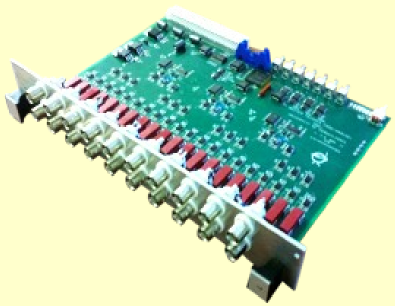
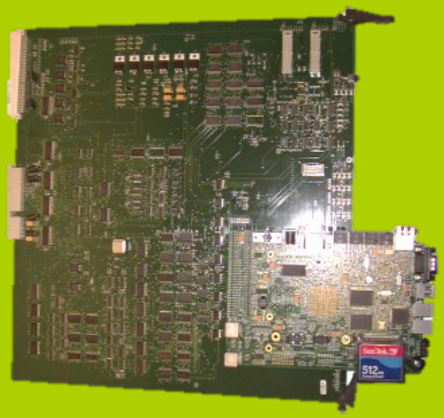


- New XL3 cards.
- Interface between DAQ and electronics.
- Built to handle increased data rates.
- Communicate over ethernet.



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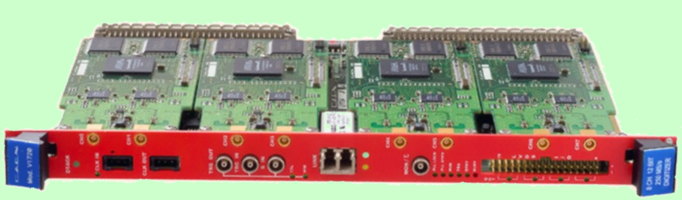

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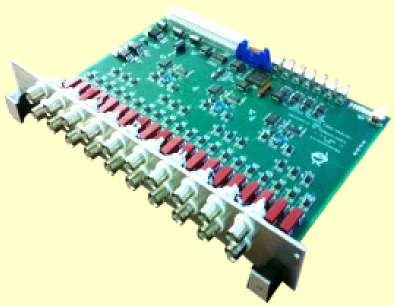

- New XL3 cards.
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- Tubii is a trigger utility board.
- Extra trigger ports
- Detector wide timing.
- On the fly trigger mask
- programming
- Built around MicroZed development board.
- Running a FPGA alongside Linux processing system.
- Integrated Zynq chip.

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