



# Upgrading and Commissioning the SNO+ Detector and Initial Data Taking

#### Billy Liggins on behalf of the SNO+ collaboration

12/04/17































Rock













































































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#### Reactor anti-neutrinos ( $\Delta m_{12}^2$ )



Neutrinoless double beta decay







#### Reactor anti-neutrinos ( $\Delta m_{12}^2$ )



#### Neutrinoless double beta decay

![](_page_14_Figure_6.jpeg)

Observed in 11 isotopes

Search for in 1.3 tonnes of  $^{\rm 130}{\rm Te}$ 

![](_page_14_Picture_9.jpeg)

![](_page_15_Picture_0.jpeg)

![](_page_15_Picture_2.jpeg)

#### Reactor anti-neutrinos ( $\Delta m_{12}^2$ )

![](_page_15_Figure_4.jpeg)

Neutrinoless double beta decay

![](_page_15_Figure_6.jpeg)

![](_page_15_Picture_7.jpeg)

Mon 2pm D

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![](_page_16_Picture_0.jpeg)

![](_page_16_Picture_2.jpeg)

#### Reactor anti-neutrinos ( $\Delta m^2_{12}$ )

![](_page_16_Figure_4.jpeg)

Neutrinoless double beta decay

![](_page_16_Figure_6.jpeg)

![](_page_16_Picture_7.jpeg)

Invisible nucleon decay 16O

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![](_page_17_Picture_0.jpeg)

![](_page_17_Picture_2.jpeg)

BRÜNSWICK

#### Reactor anti-neutrinos ( $\Delta m^2_{12}$ )

VERMONT

Québec Cit

![](_page_17_Figure_4.jpeg)

![](_page_17_Figure_5.jpeg)

Neutrinoless double beta decay

![](_page_17_Figure_7.jpeg)

Observed in 11 isotopes

![](_page_17_Picture_9.jpeg)

![](_page_17_Figure_10.jpeg)

Invisible nucleon decay <sup>16</sup>O

12/04/17

~6MeVγ

See talk: Matt Parnell Mon 2pm B

Billy Liggins

See talk: Mark Stringer Mon 2pm D

Search for in 1.3 tonnes

![](_page_18_Picture_0.jpeg)

![](_page_18_Picture_2.jpeg)

![](_page_19_Picture_0.jpeg)

![](_page_19_Picture_2.jpeg)

- New scintillation plant built.
- $\rightarrow$  10<sup>-17</sup>g/g<sub>LAB</sub> purity.
- Currently being commissioned with 40 tonnes of LAB.

![](_page_19_Picture_6.jpeg)

![](_page_19_Picture_7.jpeg)

First shipment arrived Nov. 8 2016

![](_page_20_Picture_0.jpeg)

![](_page_20_Picture_2.jpeg)

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First shipment arrived Nov. 8 2016

![](_page_20_Picture_9.jpeg)

- Hold down rope net deigned, installed and commissioned
- → Installed in 2012.
- Buoyancy test carried out over several periods of water filling.

![](_page_21_Picture_0.jpeg)

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![](_page_21_Picture_9.jpeg)

- Hold down rope net deigned, installed and commissioned
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- → Redesigned and upgraded N<sub>2</sub> cover gas system.
- → Seal detector and adjust for pressure differences.
- → Installed and commissioned in 2014.

![](_page_21_Picture_16.jpeg)

![](_page_21_Picture_17.jpeg)

![](_page_22_Picture_0.jpeg)

![](_page_22_Picture_2.jpeg)

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![](_page_22_Picture_6.jpeg)

![](_page_22_Picture_7.jpeg)

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![](_page_22_Picture_16.jpeg)

- → New universal interface.
- → Veto PMTs.
- → Various level sensors.

![](_page_22_Picture_20.jpeg)

Installed and commissioned Nov 2016.

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![](_page_23_Picture_0.jpeg)

![](_page_23_Picture_2.jpeg)

- $\rightarrow$  New scintillation plant built.
- $\rightarrow$  10<sup>-17</sup>g/g<sub>LAB</sub> purity.
- Currently being commissioned with 40 tonnes of LAB.

![](_page_23_Picture_6.jpeg)

![](_page_23_Picture_7.jpeg)

<u>Tasks</u> <u>Completed</u> ✓ Helium Leak Checking.

 Cleaning and Passivation.

 Fire suppression

- system.
- Pipe insulation.
- ✓ Water

commissioning.

![](_page_23_Picture_15.jpeg)

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- → New universal interface.
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![](_page_23_Picture_27.jpeg)

Installed and commissioned Nov 2016.

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![](_page_24_Picture_0.jpeg)

![](_page_24_Picture_2.jpeg)

- → 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.

![](_page_24_Picture_9.jpeg)

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

![](_page_24_Picture_14.jpeg)

![](_page_24_Figure_15.jpeg)

![](_page_25_Picture_0.jpeg)

# DAQ upgrades

![](_page_25_Picture_2.jpeg)

- → 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.

O SNO+ Control Panel								
			<b>D</b>					
Run Control	Select a Standard Run or create a new one	Runs HV Master	Detector State Set	tings	Run Type Word			
Run status	Refresh Standard Runs Run Type:	Current value Hit100Hi -2.7	Default Test run 100.0 100.0	NHits	Maintenance			
Run Number: 349	ECA V NH	t100Med 941.2	500.0 500.0	NHIItS	Physics     Deployed Source			
Run Version:	Test runs:	NHit20Hi 1936.7	100.0 100.0	NHits	External Source			
Time Started:	DEFAULT	NHit20Lo 118.9	100.0 100.0	NHits	Diagnostic			
Time Elapsed:	Load Stored Values	OWLN -2.8	73.6 73.6	NHits	Experimental			
Kun Type word:		ESumHi 3571.8	4863.3 4863.3	mV	Spare			
Stop After: 10 secs Repeat	Load Default Values	ESumLo 4521.5	1398.9 1398.9	mV	Spare Spare			
		OWLEHi 1132.8	4912.1 4912.1	mV				
EXPERT MODE	Overwrite stored values	OWLEL0 7771.0	2324.2 2324.2	mV				
	Overwrite default values	Prescale 200.0	100.0 100.0		PCA			
Quick Links		PulseGT 100.0	10.0 10.0	Hz	ECA_PDST			
OPERATOR MANUAL SHIFT REPORT	EC	SMELLIE   TELLIE			Spare			
REPORT BUG	Sta	t ECA Standard Run		_	Spare Spare Spare DCR Activity			
Detector control		Comp. Coils. OFF PMTs OFF						
Init crates with XiLinx Init crates without XiLinx	Calibratio	Bubblers ON Recirculation						
Triggers ON Triggers OFF	TSlope p	Unusual activity Spare						
SET HIGH THRESHOLDS	SET HIGH THRESHOLDS Number of events 1							
PANIC DOWN	Pulser rate fo	r ECA 10	Hz		Refresh names			
PMT HV is OFF								

![](_page_25_Figure_11.jpeg)

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![](_page_26_Picture_0.jpeg)

### Calibration

![](_page_26_Picture_2.jpeg)

![](_page_26_Figure_3.jpeg)

#### In situ Sources

#### SMELLIE

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

<u>TELLIE</u>

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

![](_page_26_Picture_13.jpeg)

#### AMELLIE

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

![](_page_27_Picture_0.jpeg)

# First Data from water fill

![](_page_27_Picture_2.jpeg)

![](_page_27_Picture_3.jpeg)

SNO+ Monitoring Status L2 Stream Detector - Nearline RAT PMTcal - Data Quality - Alarms Do

Dispatcher: minard.sp.snolab	ca				3 months 🗸
	2017	Jan 27,	12 PM	March	
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OWLEH-Baseline		-0.000013			
	2017	lan 27.	12 PM	March	

![](_page_27_Picture_6.jpeg)

![](_page_27_Figure_7.jpeg)

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![](_page_28_Picture_0.jpeg)

### Outlook

![](_page_28_Picture_2.jpeg)

- → 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 0vββ search will be carried out alongside Solar, geo and reactor neutrinos searches.
- → <sup>130</sup>Te loading is scheduled for early 2018. After which the 0vββ search will begin.

![](_page_28_Picture_10.jpeg)

![](_page_28_Picture_12.jpeg)

![](_page_29_Picture_0.jpeg)

![](_page_29_Picture_1.jpeg)

### References

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

![](_page_30_Picture_0.jpeg)

![](_page_30_Picture_1.jpeg)

#### Back up

![](_page_31_Picture_0.jpeg)

![](_page_31_Picture_1.jpeg)

### Water Level

![](_page_31_Figure_3.jpeg)

![](_page_32_Picture_0.jpeg)

![](_page_32_Picture_2.jpeg)

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

![](_page_32_Picture_4.jpeg)

![](_page_33_Picture_0.jpeg)

![](_page_33_Picture_2.jpeg)

→ Upgraded analogue trigger card (MTC/A+).

loads.

→ Handles larger current

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![](_page_34_Picture_5.jpeg)

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![](_page_34_Picture_10.jpeg)

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![](_page_34_Picture_12.jpeg)

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- → 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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![](_page_35_Picture_20.jpeg)

![](_page_35_Picture_21.jpeg)

![](_page_36_Picture_0.jpeg)

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![](_page_36_Picture_20.jpeg)

![](_page_36_Picture_21.jpeg)

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