SNO+ Status and Prospects

Lake Louise Winter Institute 2016

David Auty
University of Alberta
For the SNO+ collaboration

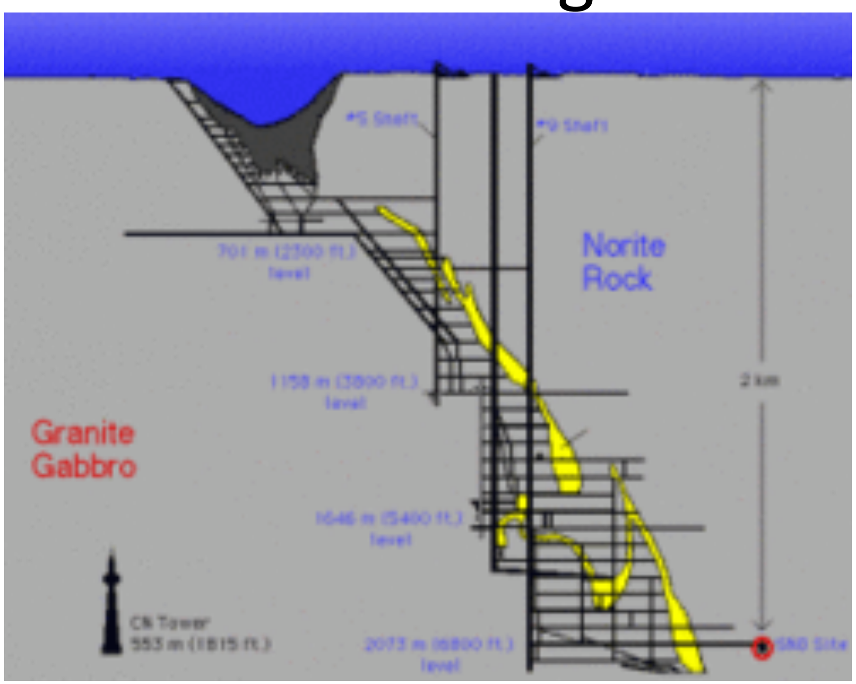
12th February 2016

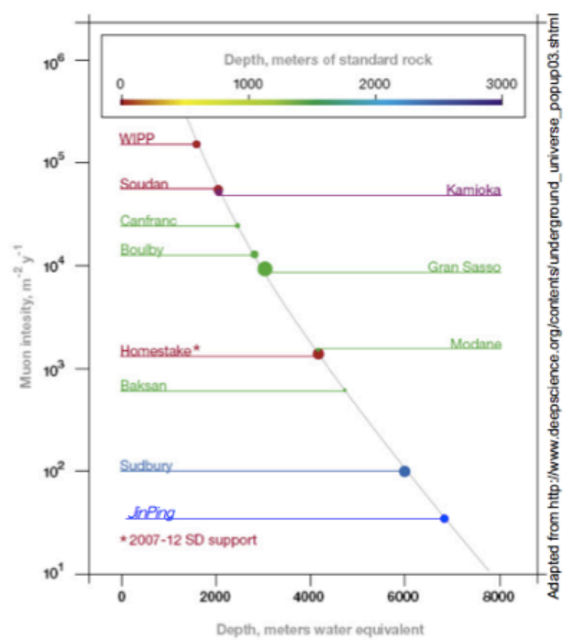
Overview

- About SNO+
- Physics goals
- What's new this year

SNO+

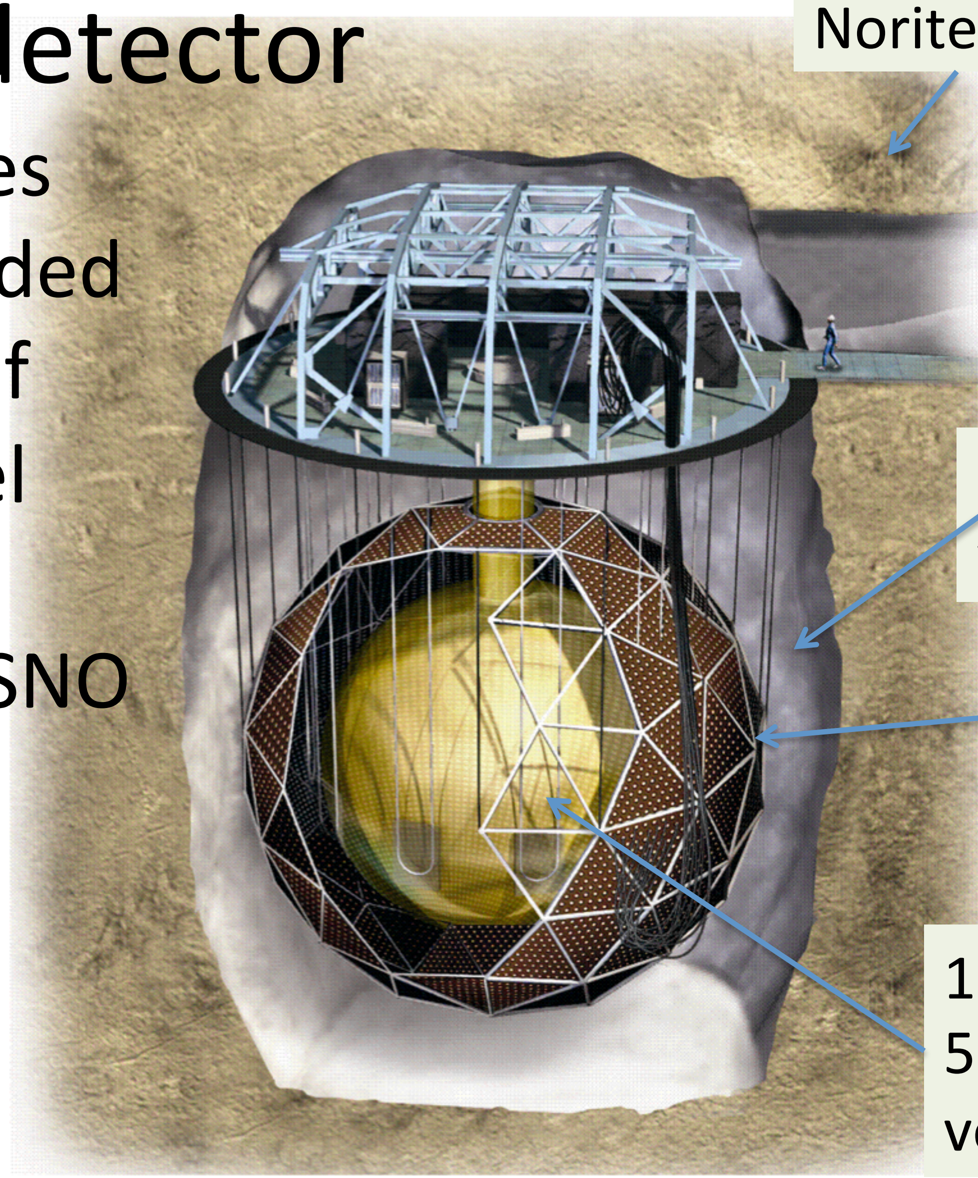
- Large multi-purpose liquid scintillator detector based in the Creighton Mine, Sudbury, Canada
- Situated in a clean lab, SNOLAB, with 2092 m flat overburden (5890 ± 94 m.w.e)
- Muon flux through the detector is 63 day^{-1}





SNO+ detector

- SNO+ uses an upgraded version of the Nobel prize winning SNO detector



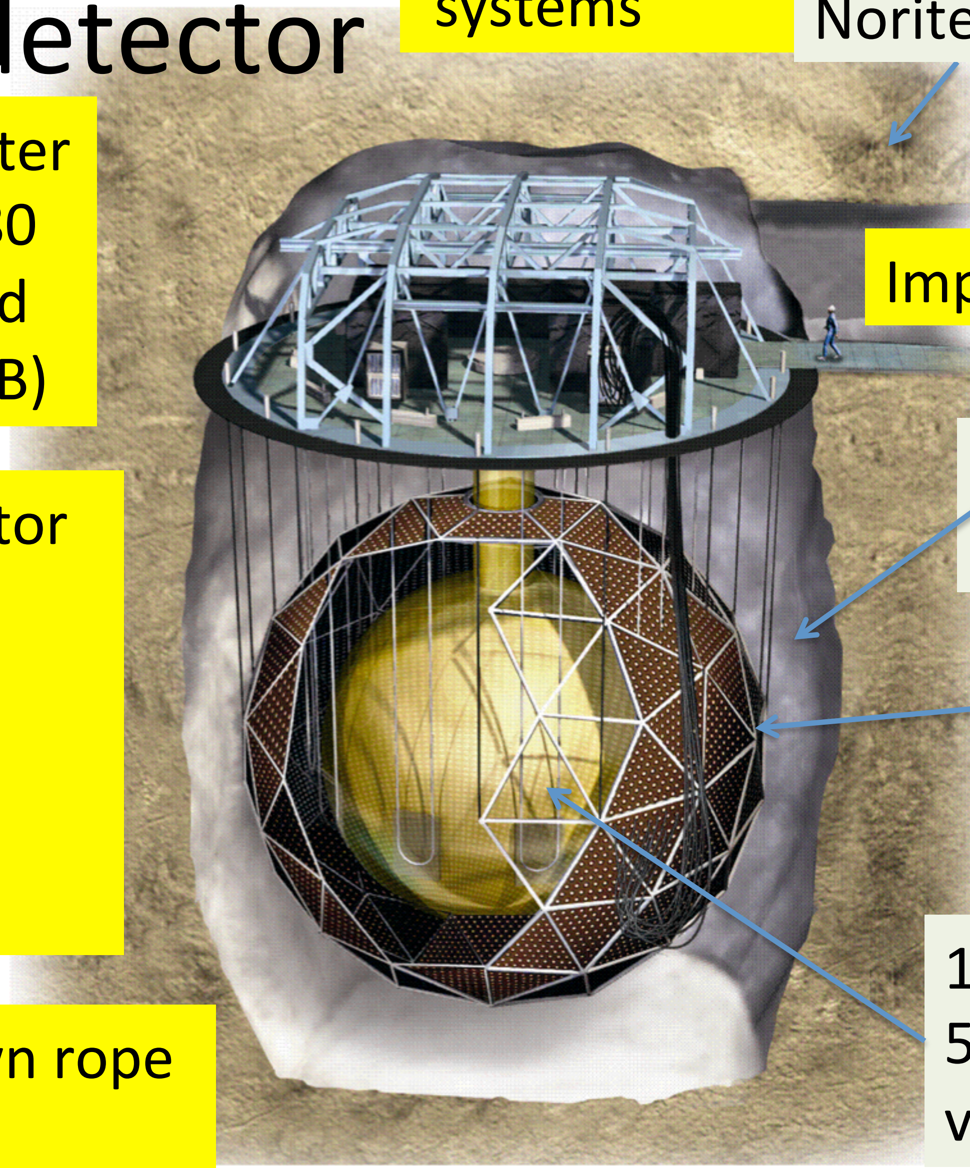
SNO+ detector

New Calibration systems

Norite + granite/gabbro

SNO heavy water replaced by 780 tonnes of liquid scintillator (LAB)

Improved electronics



7kt ultra pure water shield

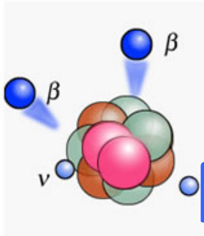
Liquid scintillator will be loaded with varying amounts of double-beta isotope

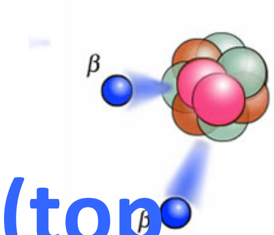
~9300 PMTs (54% coverage) 18 m diameter

12 m diameter 5cm thick acrylic vessel (AV)

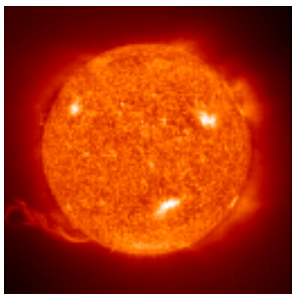
New hold-down rope system

SNO+ Physics



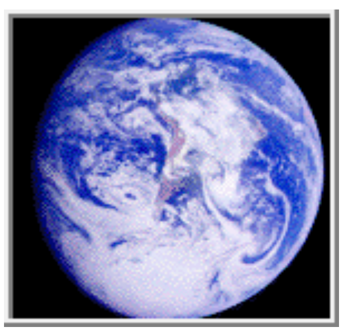


Neutrinoless Double Beta Decay (top priority)



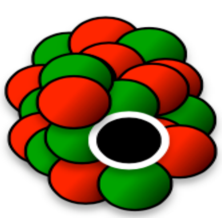
Low Energy Solar Neutrinos

Reactor Antineutrinos



Geo-Neutrinos

Supernova Neutrinos



$n \to \nu\nu\nu$

Invisible nucleon decay

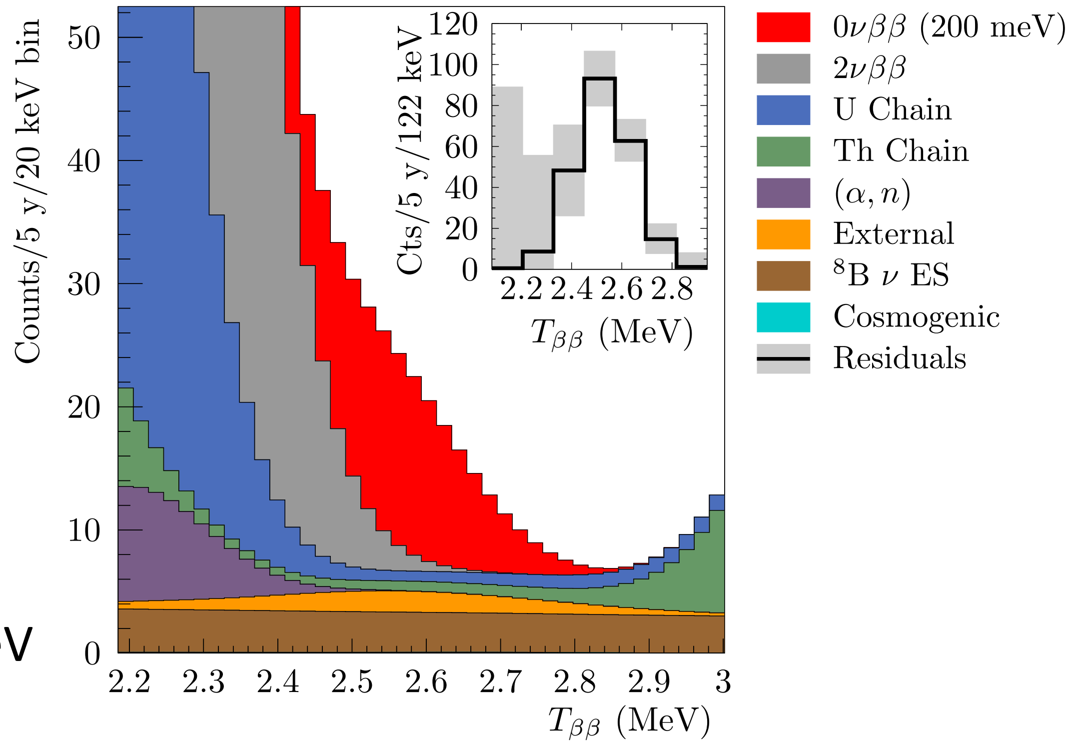
SNO+ running schedule

- Filling with light water now
  - Full water summer 2016
- Run with water
  - Nucleon decay, Supernova
- Begin fill with pure scintillator in late 2016
  - Detector commissioning
  - Look for backgrounds
  - Geo-neutrinos, Reactor neutrinos, Solar Neutrinos, Supernova
- 2017 add Te to scintillator (phase I 0.3% – 0.5%)
  - Neutrinoless double-beta decay
- Future phase II increase loading
  - Increase to higher loadings, as possible

Neutrinoless double-beta decay

- Review paper released this year (S. Andringa, E. Arushanova, S. Asahi, et al., “Current Status and Future Prospects of the SNO+ Experiment,” *Advances in High Energy Physics*, vol. 2016, Article ID 6194250, 21 pages, 2016. doi:10.1155/2016/6194250)

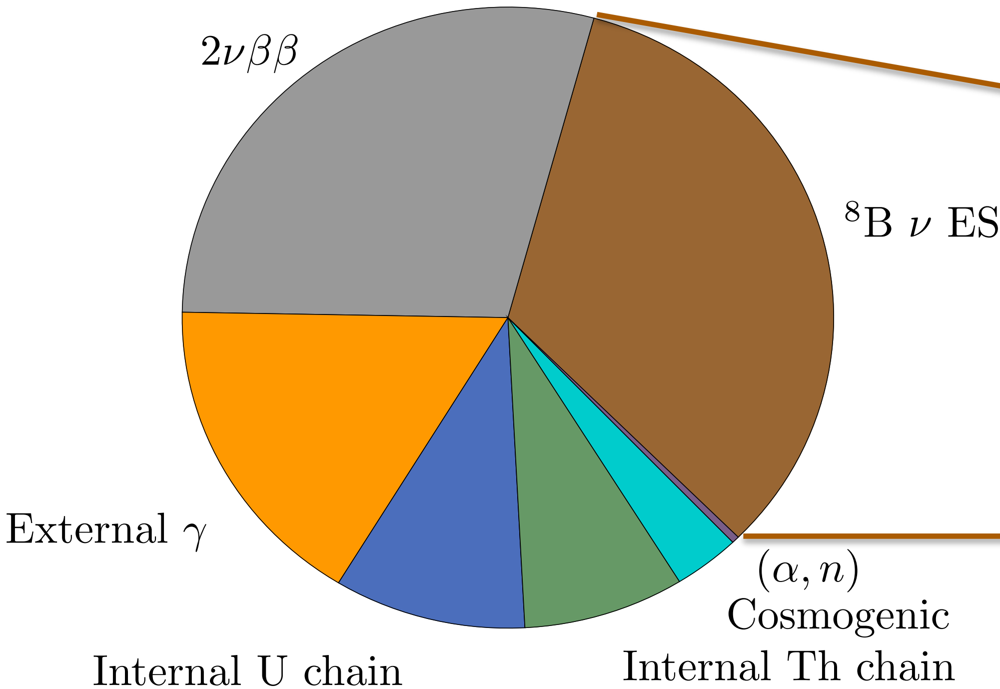
- Expected spectrum for 5 years assuming:
  - 0.3% ^{nat}Te loading
    - Have funding for 0.5%
  - Fiducial radius of 3.5 m
  - 99.99% rejection of ^{214}BiPo
  - 98% of ^{212}BiPo
  - Light yield of 200 Nhits/MeV



	$T^{0\nu\beta\beta}_{1/2}$	$m_{0\nu\beta\beta}$
0.3% Te, 1 yr	3.9 x 10^{25} yrs	~105 meV
0.3% Te, 5yrs	9 x 10^{25} yrs	55 – 133 meV
3% Te, HQE PMTs, 5 yrs	7 x 10^{26} yrs	19 – 46 meV

Assuming a phase space factor G=3.69x10^{-14} yr^{-1} and g_A=1.269
Mass range due to different nuclear matrix elements

0ββ Backgrounds

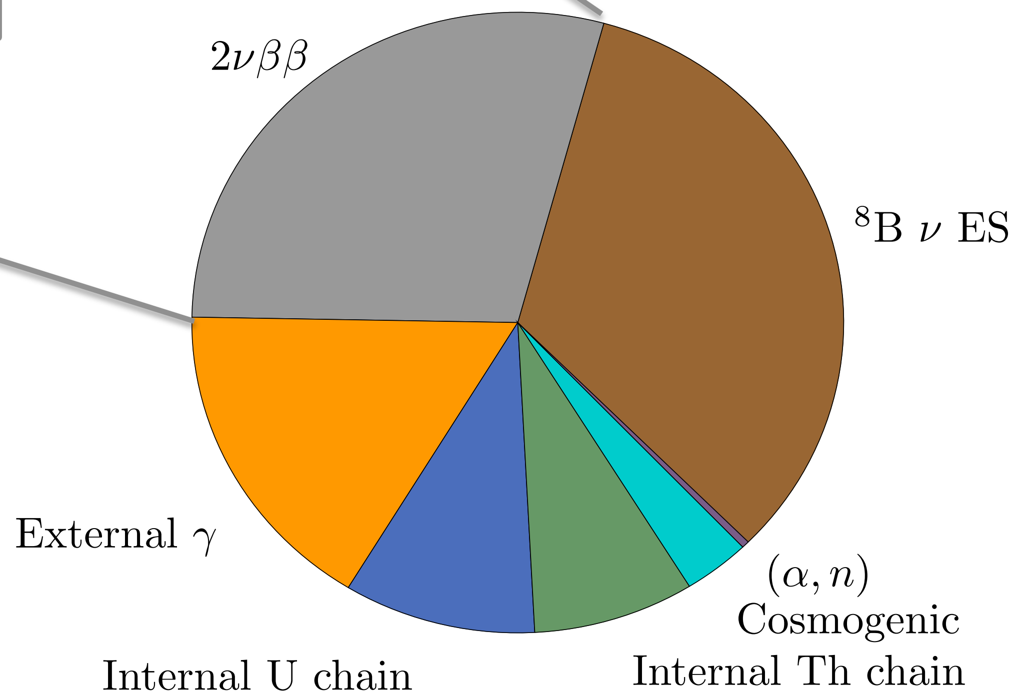


Solar ^{8}B:

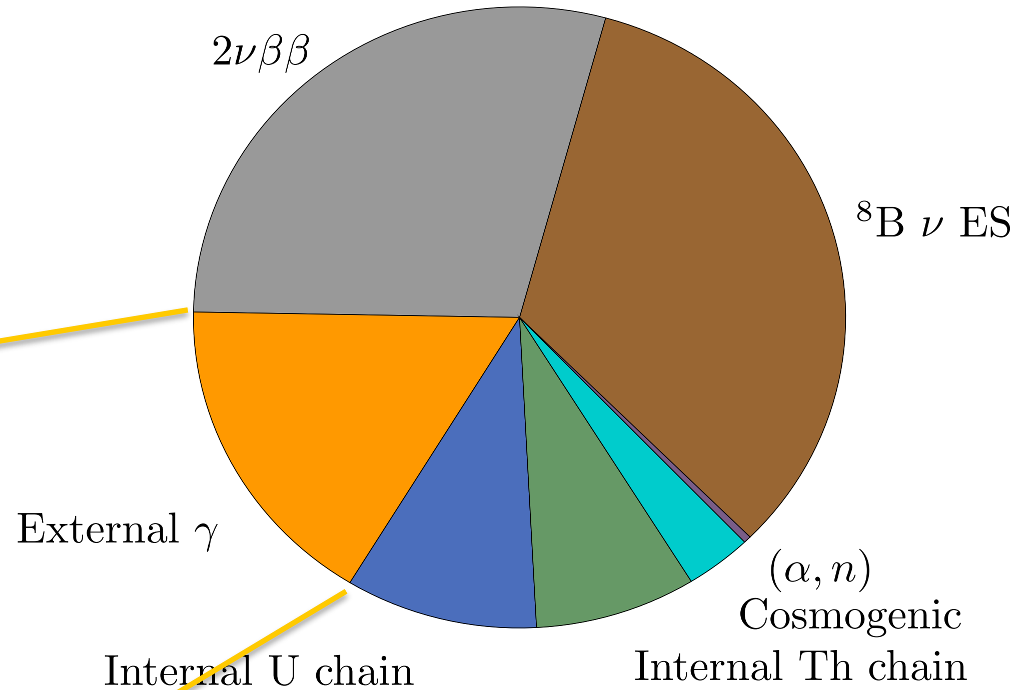
- Flat spectrum
- Constrained by SNO/SK
- Limited by energy resolution
- 7.3 events per year

0ββ Backgrounds

2νββ:
- Sharply falling with energy
- Asymmetric ROI about 0νββ signal
- Limited by energy resolution
- 6.3 events per year



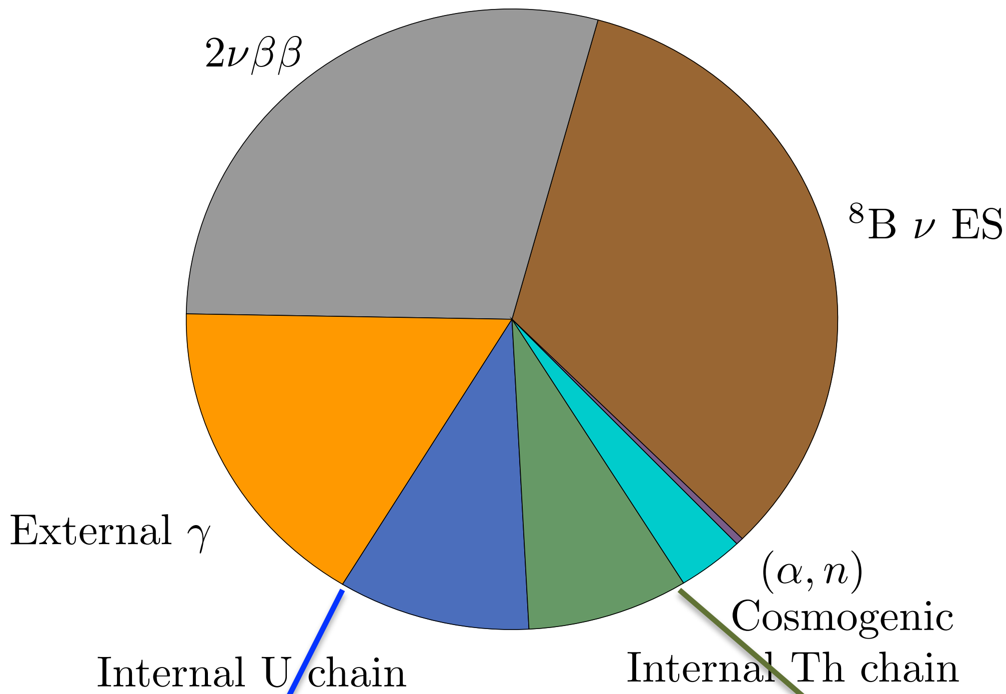
0ββ Backgrounds



External BGs:

- From AV, ropes, PMTs, …
- Reduced by fiducial volume
- Requires good timing
- 3.6 events per year

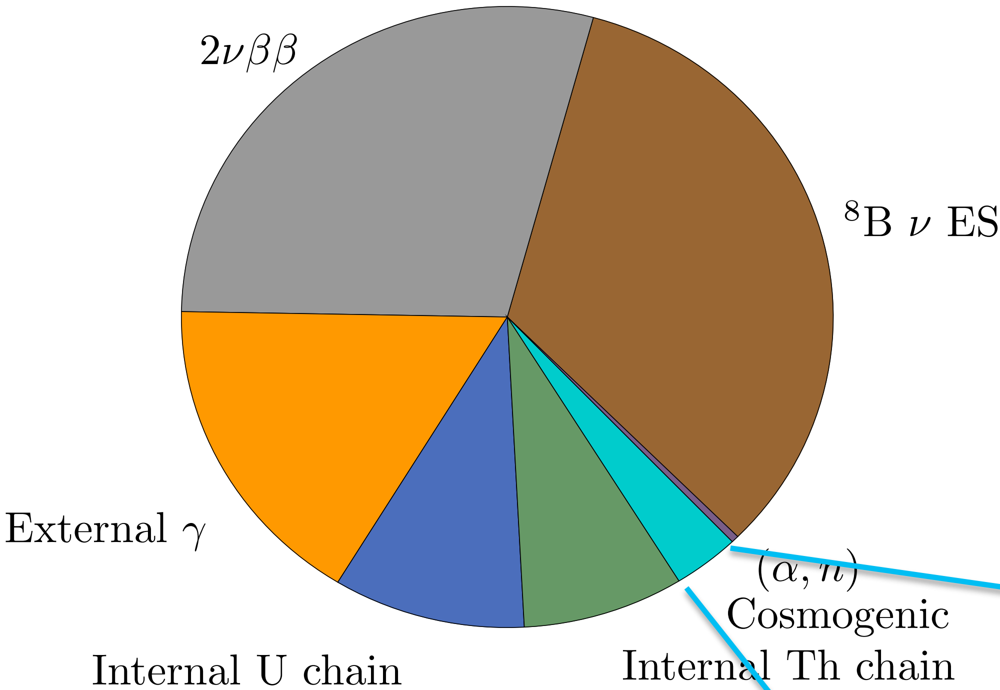
0ββ Backgrounds



Internal U/Th Chains:

- β from ^{214}BiPo and ^{212}BiPo
- Tag using time-coincidence of α follower
- 3.8 events per year

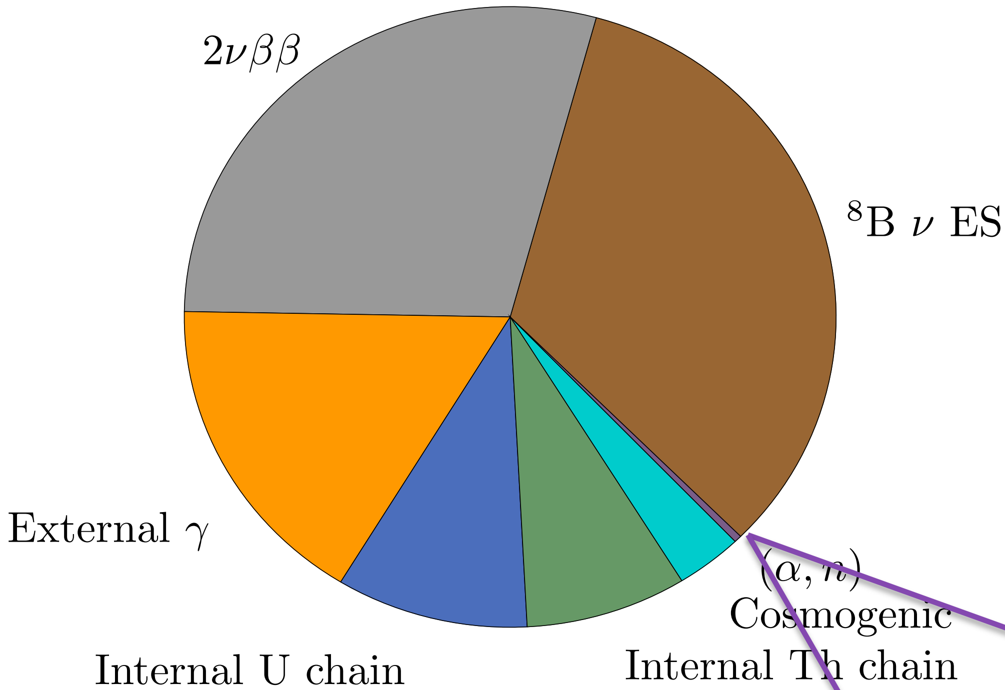
0ββ Backgrounds



Cosmogenics:

- ^{120}Sb, ^{60}Co, ^{110m}Ag, ^{88}Y, ^{22}Na
- Reduced UG cool down period and purification
- 0.7 events first year
- 0.8 events for 5 years

0ββ Backgrounds



α-n:

- Absorption of α produces neutron
- Tagged using time-coincidence between prompt light and neutron capture gamma
- 0.1 events per year

Tellurium Purification

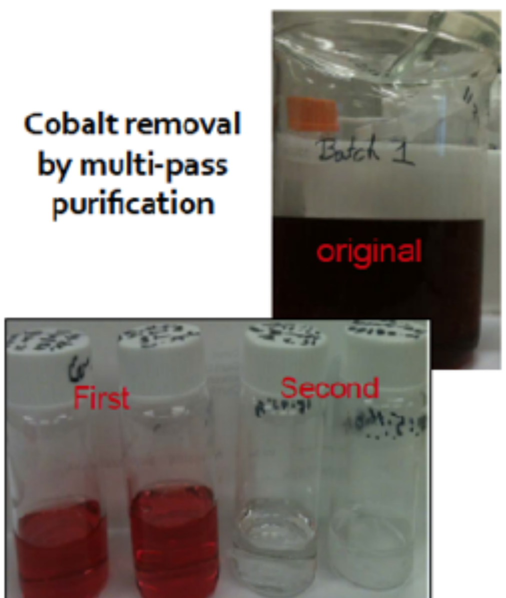
- Cosmic ray activation in tellurium produces long-lived isotopes with Q > 2 MeV and T > 20d

  V. Lozza and J. Petzoldt, *“Cosmogenic activation of a natural tellurium target”*, Astroparticle Physics 61 (2015) 62-71

  – First batch of tellurium is underground now

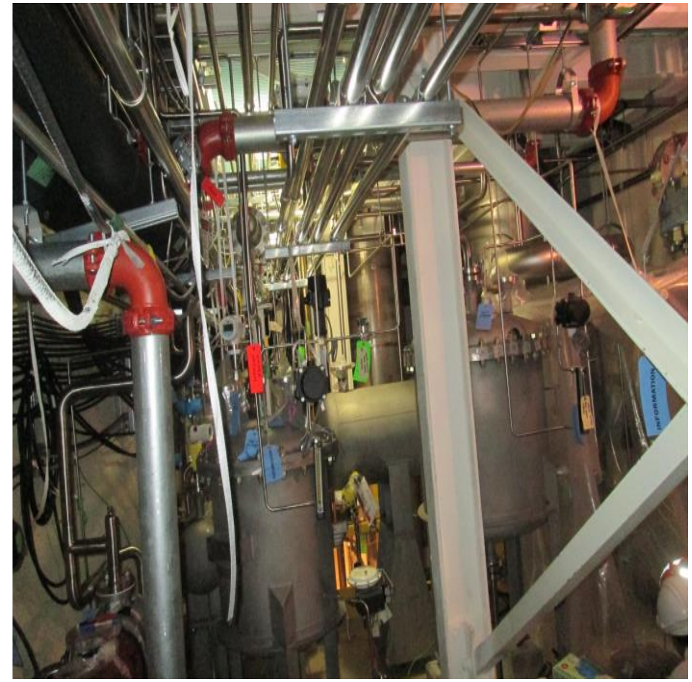
  – Underground purification using water/acid rinse, 10^6 reduction ^{60}Co and reduced optical impurities

    S.Hans et al, *“Purification of telluric acid for SNO+ neutrinoless double-beta decay search”*, NIM. A795 (2015) 132-139

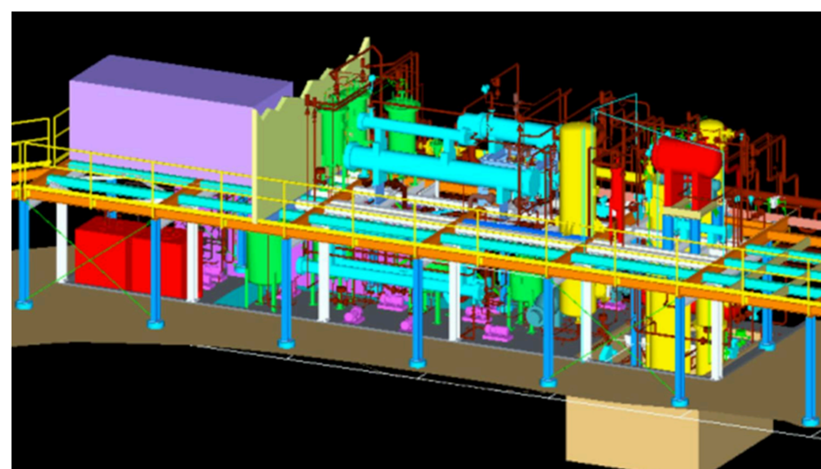


Scintillator Plant

- 2015:
  - Helium leak checking seals and valves, cleaning and passivation complete
  - Insulation installed
  - Some pre-commissioning of pumps/valves complete



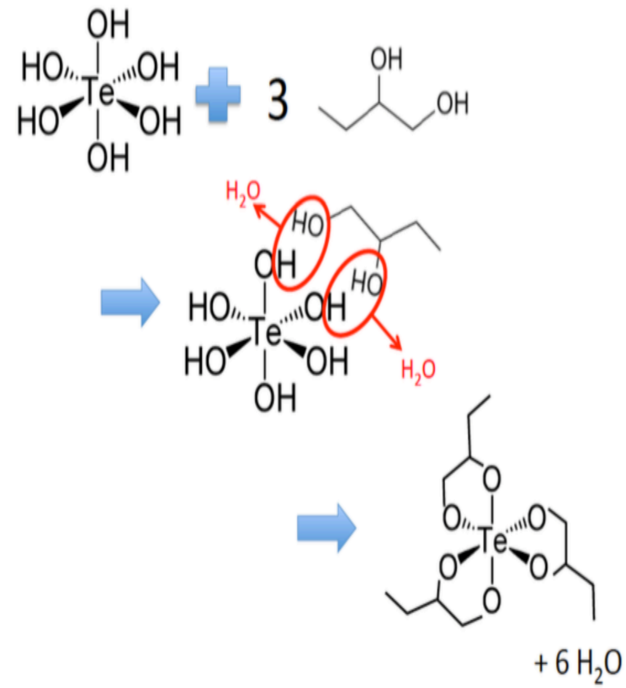
- 2016:
  - Commission with water/ scintillator and a safety review

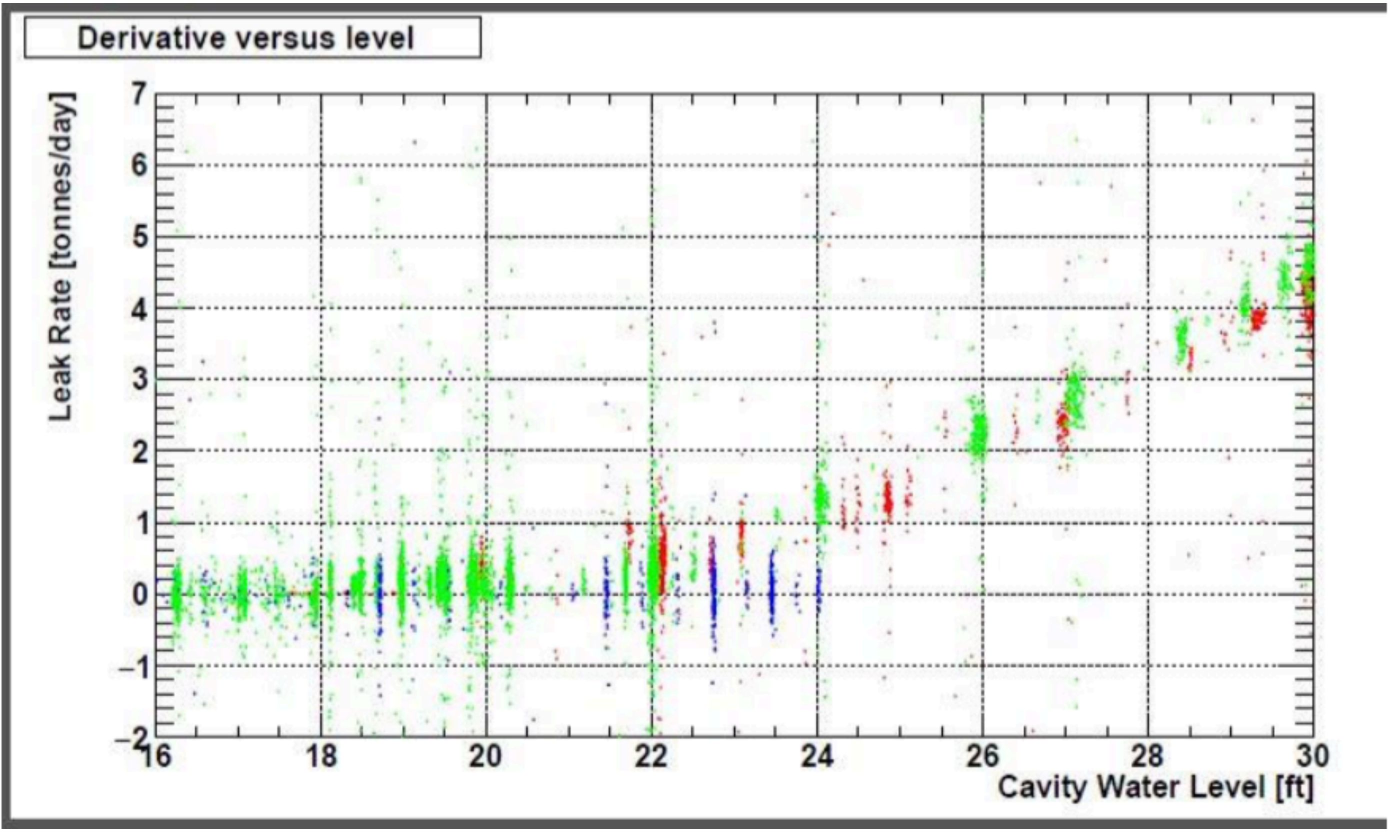


- Expected completion this autumn

Te loading plan

- We have completed the down select of the Te loading method.
  - Diol method
- Still to design, install, and commission plant
- Expected adding Te to detector 2017





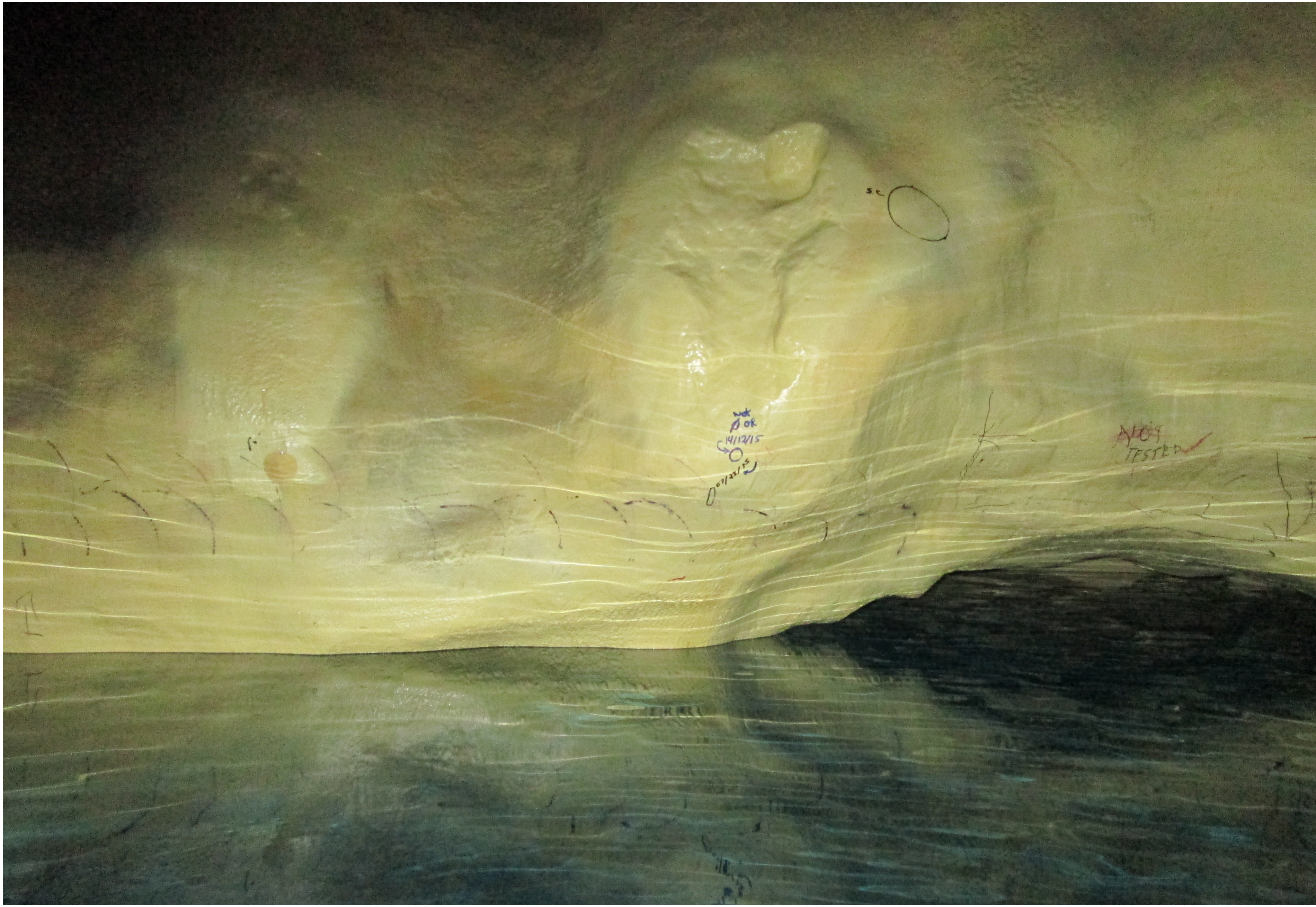
Red: Oct 2014

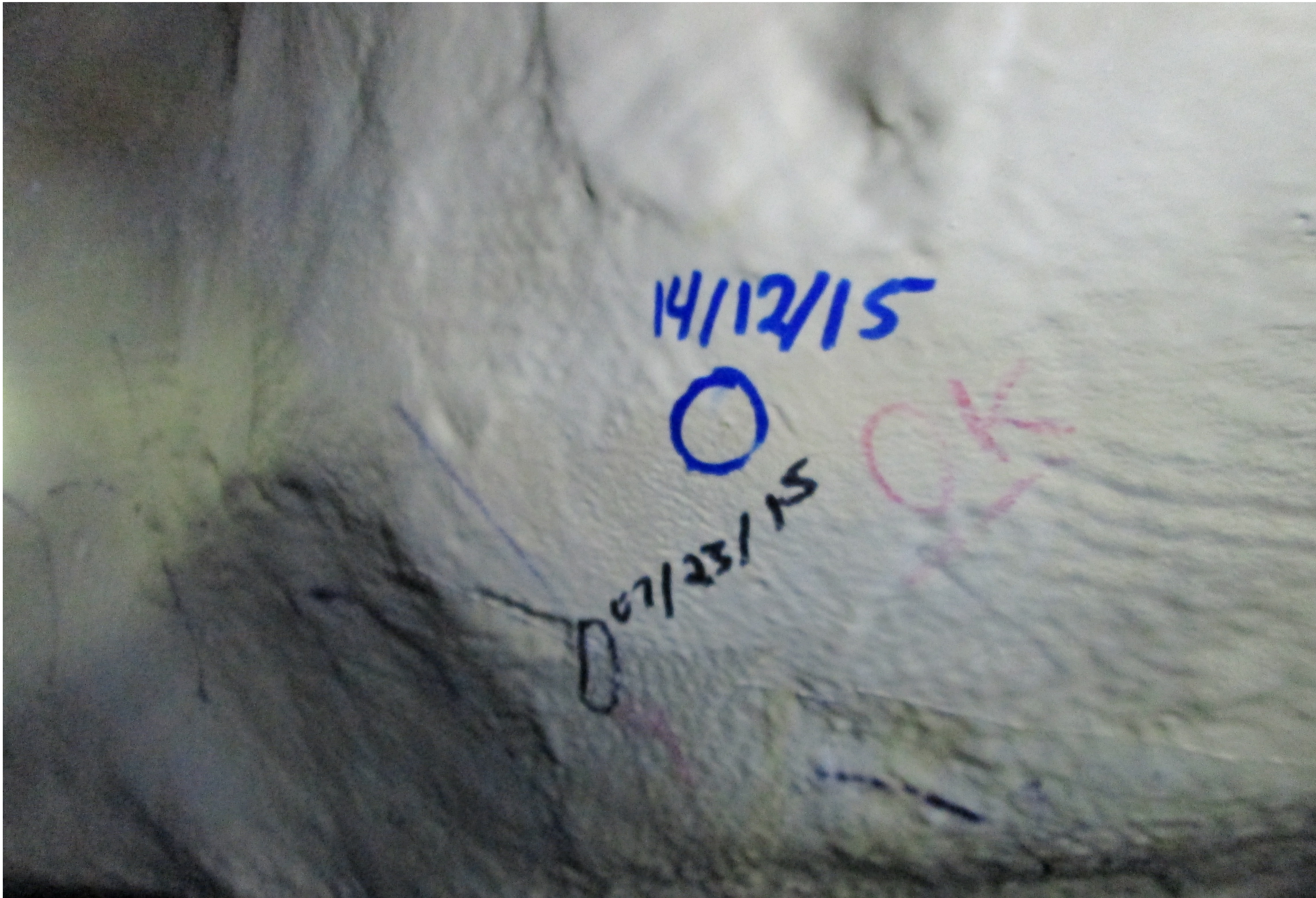
Green: Feb 2015

Blue: Jan 2016

Leak Repair

- While filling in Oct 2014, significant water loss from cavity
  - Equivalent to 60 tonnes per day when cavity full
- Completely drained cavity to inspect it and find the leak point
- Leak patched and currently re-filling
  - Three suspect patches


NOT TESTED


14/12/15
07/23/15

Thank you

- **Canada:** Alberta
  Laurentian
  Queens
  SNOLAB
  TRIUMF

Germany: TUD

Mexico: UNAM

Portugal: LIP

UK: Lancaster
Liverpool
Oxford
QMUL
Sussex

USA: Armstrong
Atlantic
UCBerkeley/LBNL
BNL
UCDavis
UChicago
UNC
Norwich
UPenn
Washington