Status of the SNO+ experiment

Richie Bonventre for the SNO+ collaboration

WIN 2017

Lawrence Berkeley National Lab

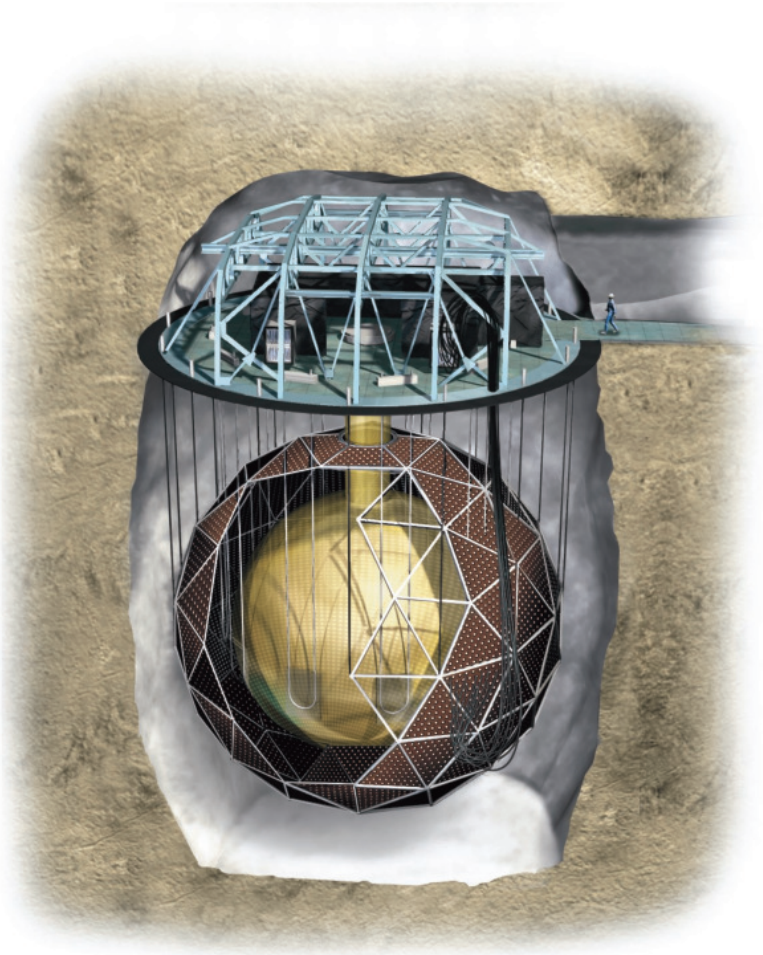
The SNO+ collaboration

120 members of 23 institutions over 6 countries

- University of Alberta
- Armstrong Atlantic State University
- University of California, Berkeley / LBNL
- Black Hills State University
- Brookhaven National Laboratory
- University of California, Davis
- University of Chicago
- Technical University of Dresden
- Lancaster University
- Laurentian University
- LIP Lisboa and Coimbra
- University of Liverpool
- University of North Carolina at Chapel Hill
- Oxford University
- University of Pennsylvania
- Queen Mary University of London
- Queen's University
- SNOLAB
- University of Sussex
- TRIUMF
- Universidad Nacional Autonoma de Mexico
- University of Washington

The SNO detector

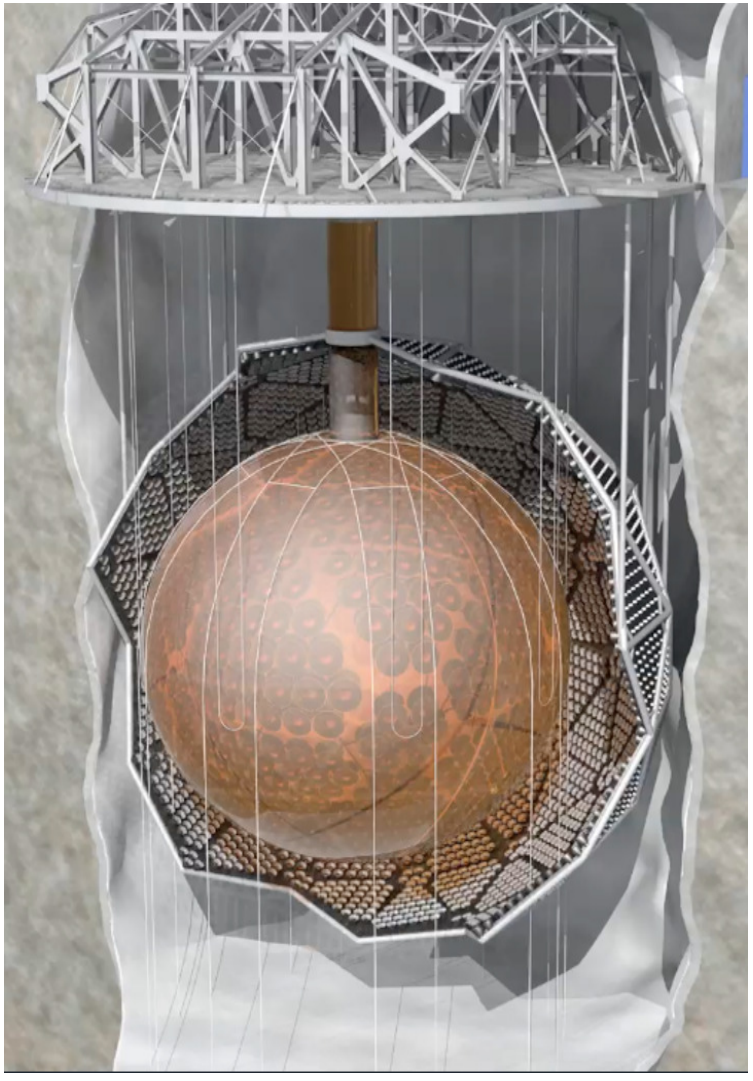
- 2km underground, 6010 mwe
  - ∼63 cosmic muons per day
- Support structure holding ∼9300 PMTs (∼50% coverage)
- 7 kT ultra pure water shielding
- Target volume contained in 6m radius acrylic vessel



The SNO detector $\rightarrow$ SNO+ detector

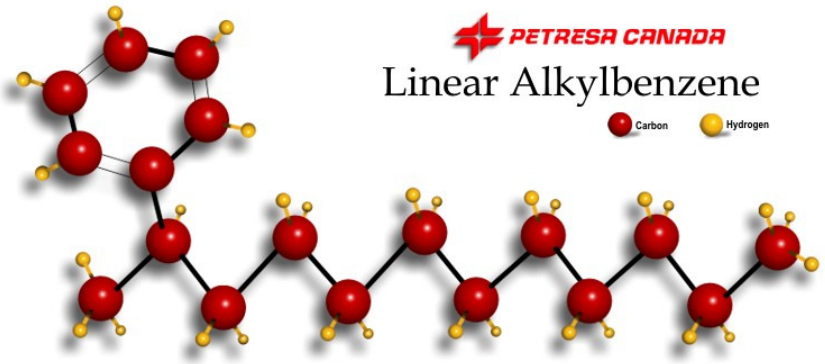
SNO+ detector upgraded to look for neutrinoless double beta decay

- Target material changing from heavy water to liquid scintillator
  - Lower energy threshold and higher resolution
  - Load with ^{130}Te for $0\nu\beta\beta$ measurement
- Hold-down ropes: compensate for buoyancy of scintillator
- Upgraded electronics: handle higher event rates ($>$1kHz)
- Repaired PMTs
- Installed new LED calibration system

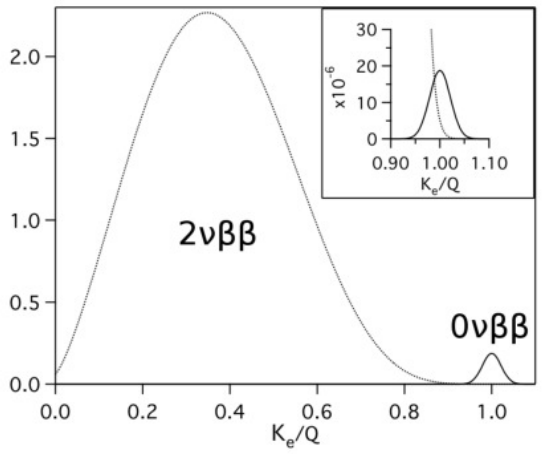


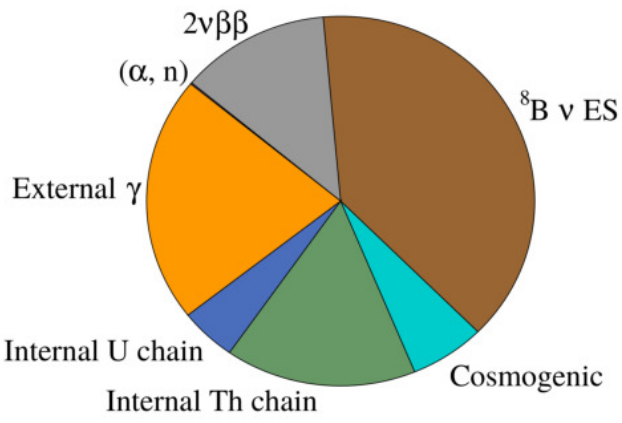
Liquid scintillator + Tellurium

- Scintillator: Linear Alkylbenzene
  - High light yield (∼1000 photons/MeV)
  - Long attenuation length (∼20 m)
  - High flash point (safe)
- Wavelength shifter: PPO
  - x10 light yield
  - α/β discrimination
- Double beta decay isotope: ^{130}Te
  - Long $2\nu\beta\beta$ lifetime: ∼7x10^{20} yrs
  - High Q value ∼2.5 MeV
  - High natural abundance
  - No absorption lines in PMT sensitive region
  - Plan for 0.5% loading with Te-butanediol (∼1330 kg of ^{130}Te)

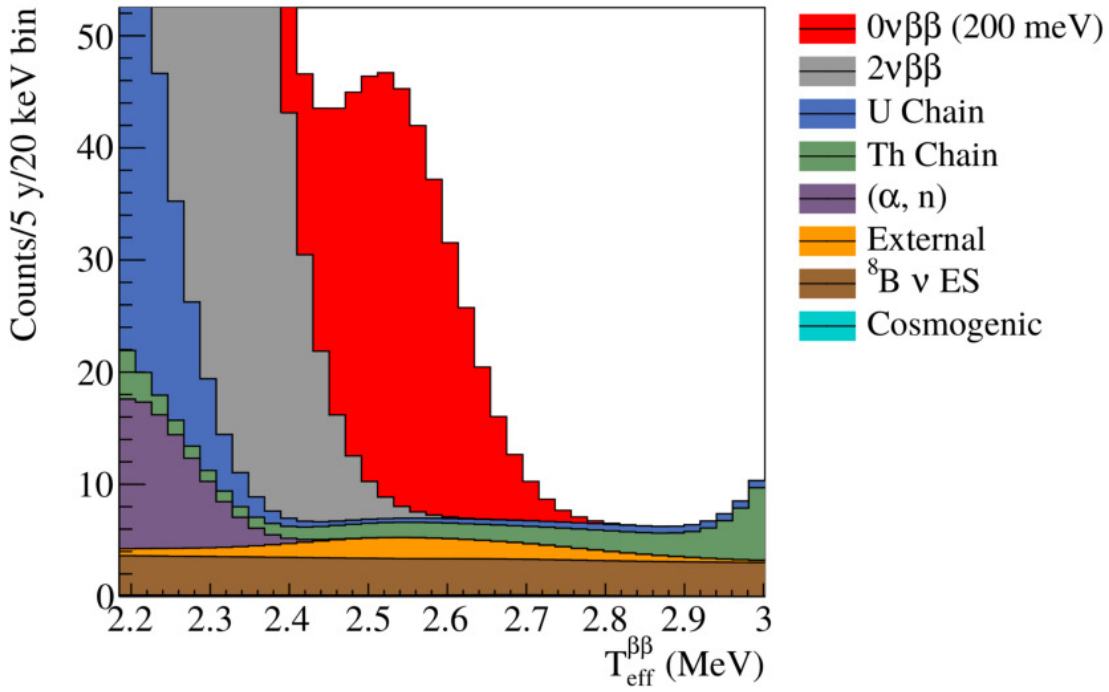


Double beta decay signals and backgrounds



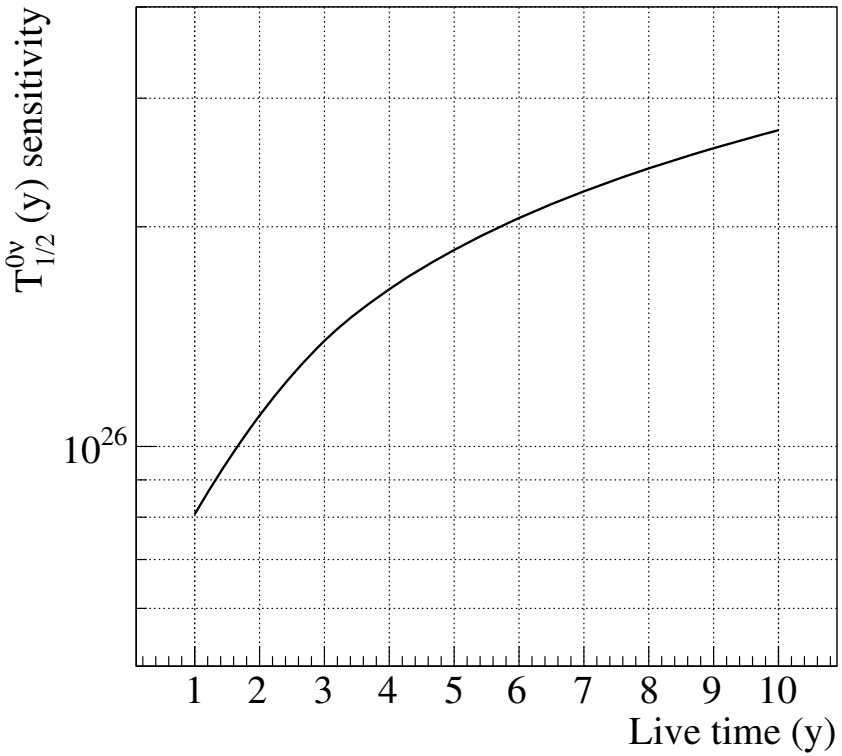


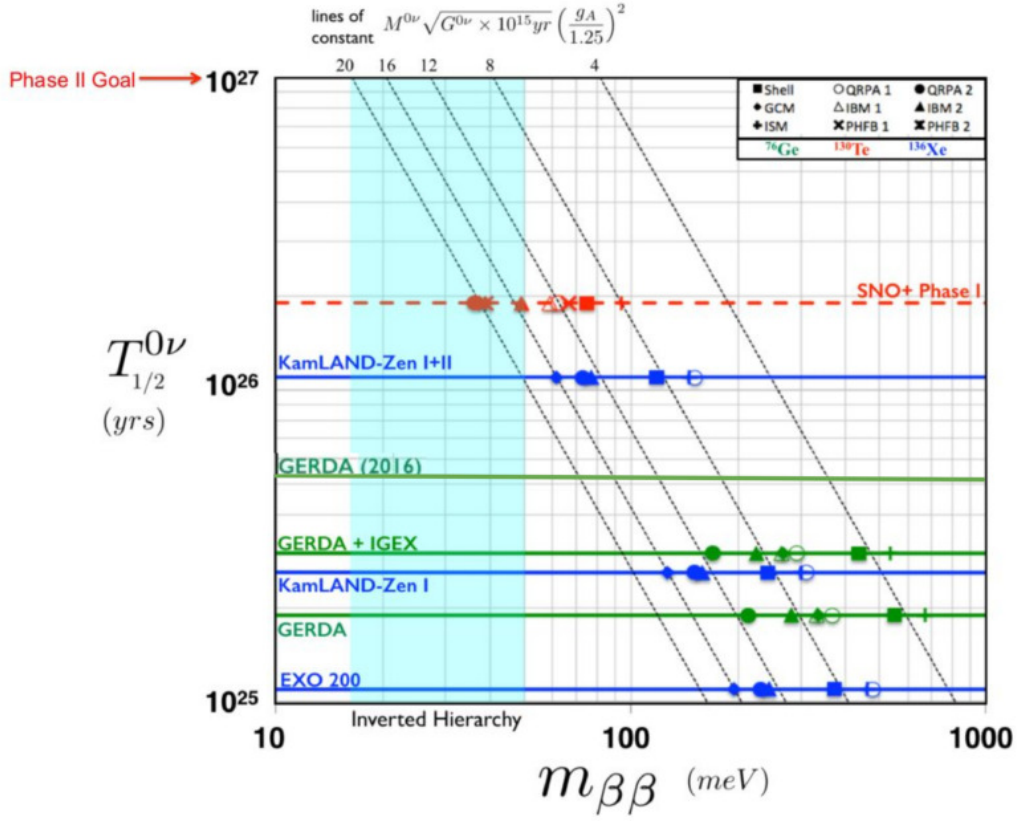
- ∼13 counts/year backgrounds in first year



- Expected spectrum after full 5 year run with 0.5% loading, with $m_{\beta\beta} = 200$meV

Double beta decay sensitivity

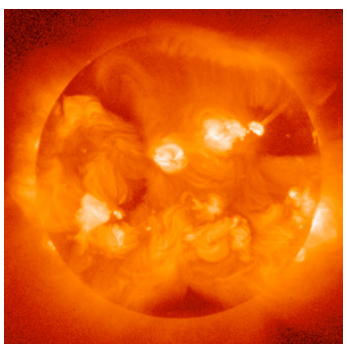
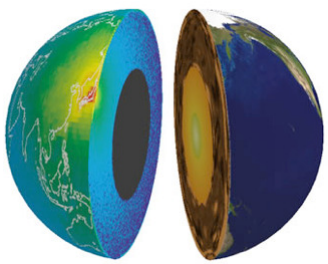
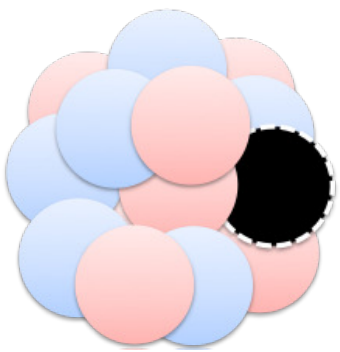




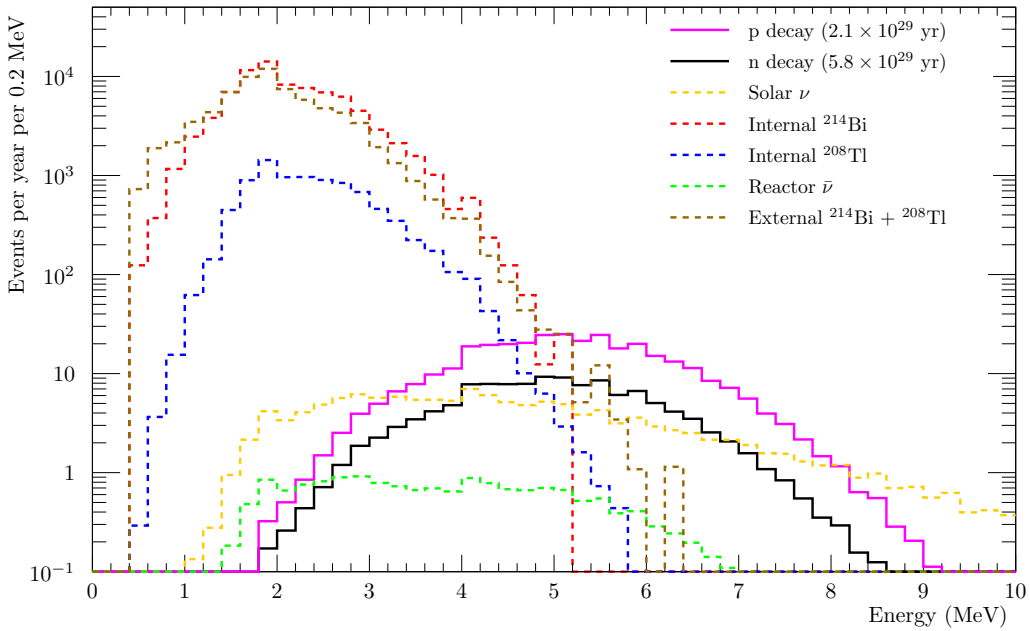
- Phase I:
  - $T_{1/2} \sim 2 \times 10^{26}$ years
- Phase II: Increased Te loading, HQE PMTs

Other physics with SNO+

	Water Phase	Pure Scintillator Phase	Te-loaded Scintillato Phase
Neutrinoless double beta decay			×
^{8}B solar neutrinos		×	×
Low energy solar neutrinos		×	
Reactor and geo neutrinos		×	×
Exotics searches (ex.: nucleon decay)	×	×	×
Supernova	×	×	×

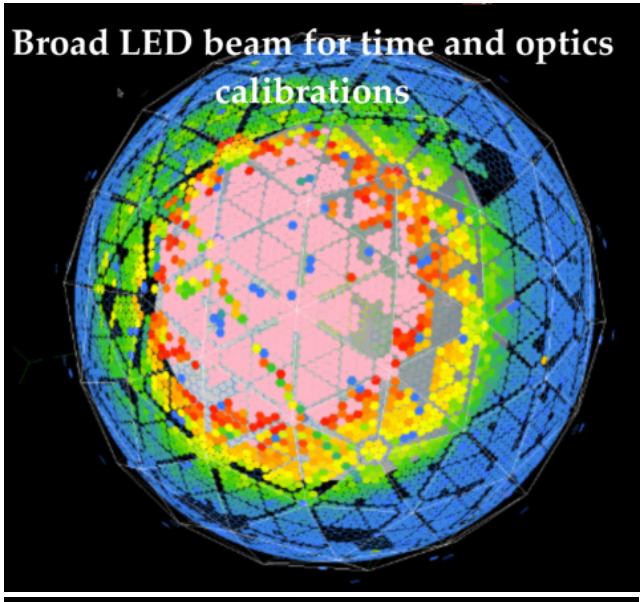




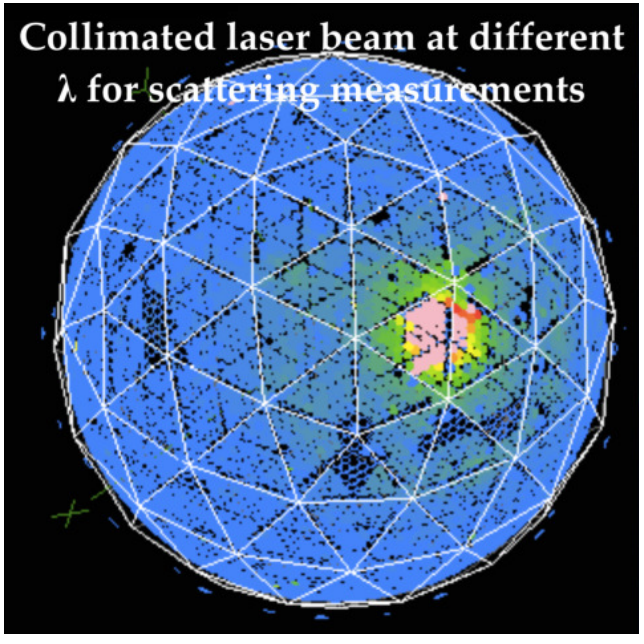

Nucleon decay

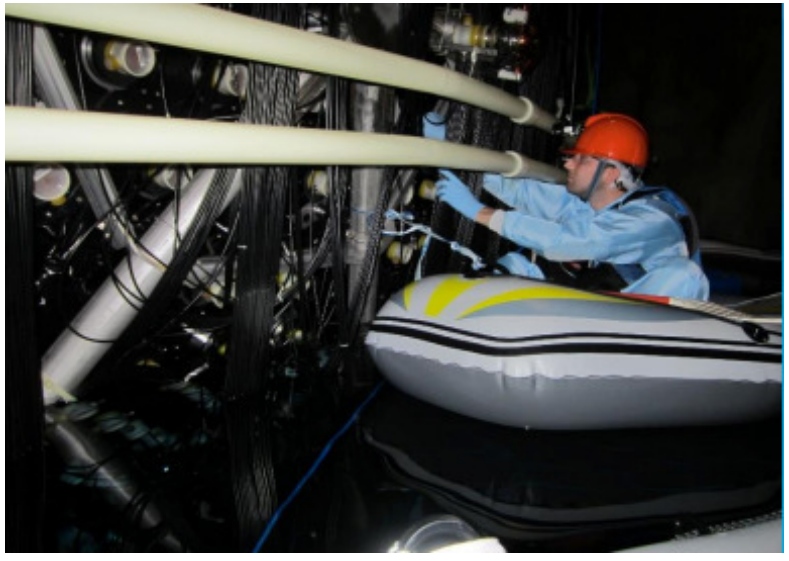


- Look for invisible decay, e.g.: $n \rightarrow \nu\nu\nu$
- $^{16}O \rightarrow ^{15}O^*$ or $^{15}N^*$, $\sim$ 5 MeV visible energy
- 6 months of data $\rightarrow$ 30 background counts in ROI
- 90% CL:
  - τ_n=1.2x10^{30} years (current limit KamLAND: 5.8x10^{29})
  - τ_p=1.4x10^{30} years (current limit SNO: 2.1x10^{29})

Upgrades and commissioning progress





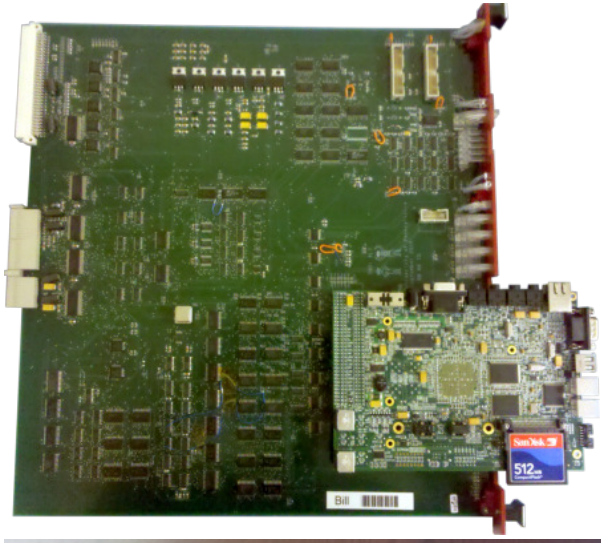


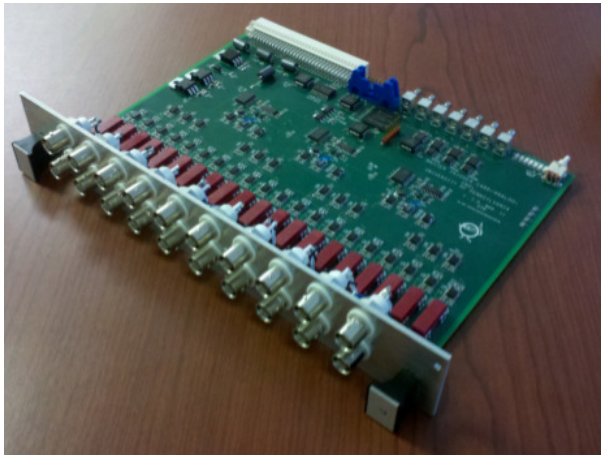
- Repaired leaks in cavity and replaced repaired PMTs
- LED/Laser calibration system installed
- Hold down ropes installed - buoyancy test carried out over several periods of water filling

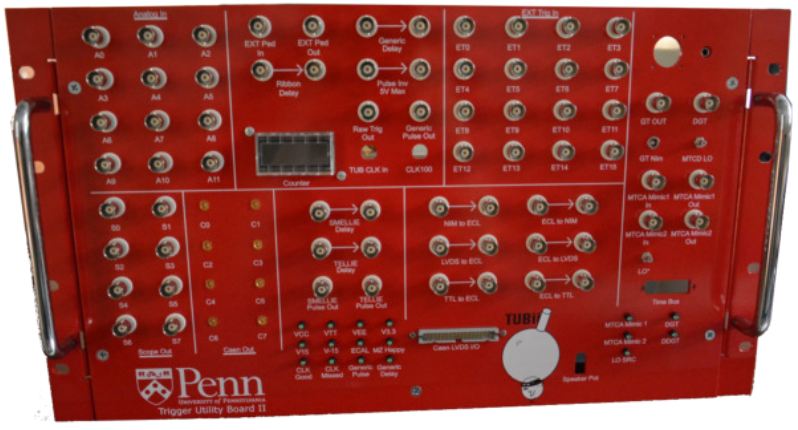
Upgrades and commissioning progress

- Scintillation plant installed and being commissioned
- LAB shipments underground started
- TeA stored underground
- Tellurium purification plant construction started

Upgrades and commissioning progress

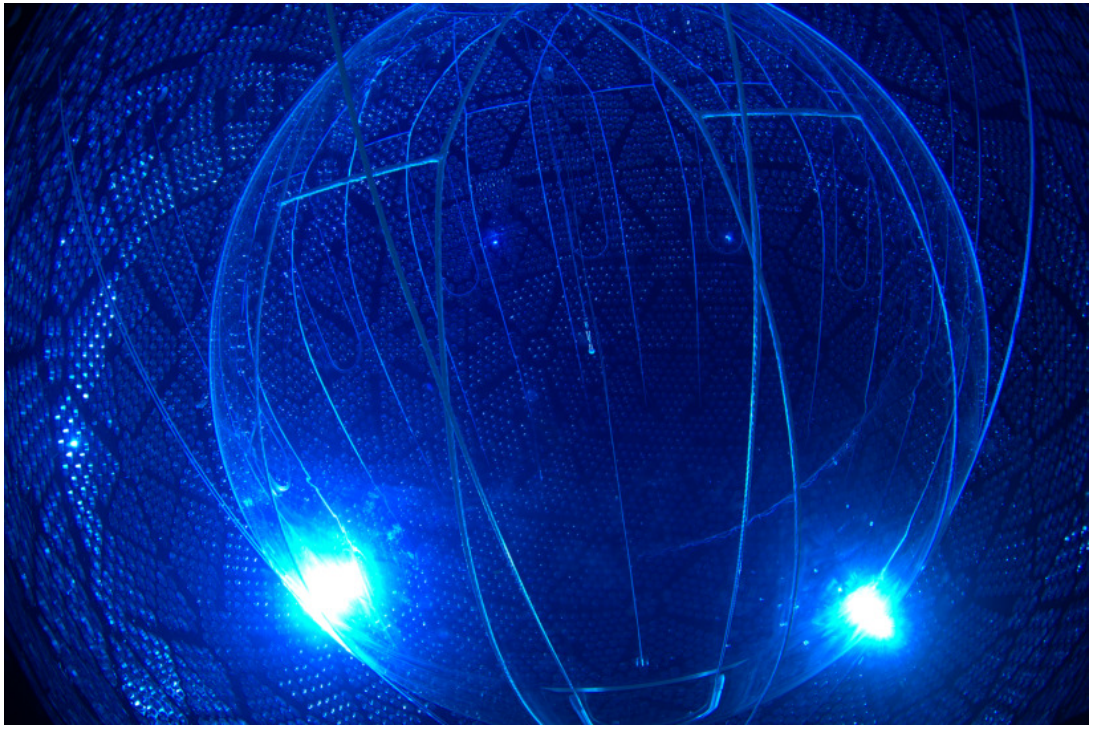






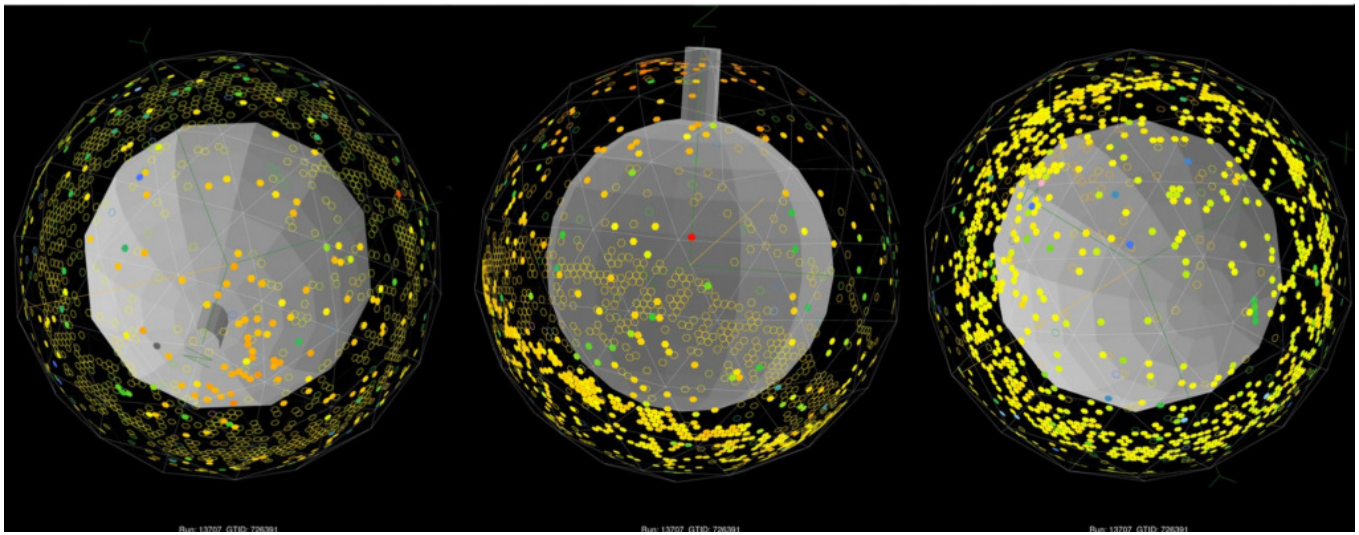
- Upgraded electronics and DAQ tested at high data and trigger rates

Current Status



- Inner and outer volumes filled with water
- Laser and ^{16}N source calibrations
- Water phase data taking has begun
  - Nucleon decay measurement
  - Characterize external backgrounds for future phases

Conclusion



Candidate atmospheric neutrino event

- SNO+ is currently filled with water and taking physics data
  - In 6 months of running it will provide the strongest limit on invisible nucleon decay
- Scintillator purification system being commissioned
- Tellurium systems under construction
- Neutrinoless double beta decay phase will begin in 2018
  - In 5 years will reach the top of the inverted hierarchy