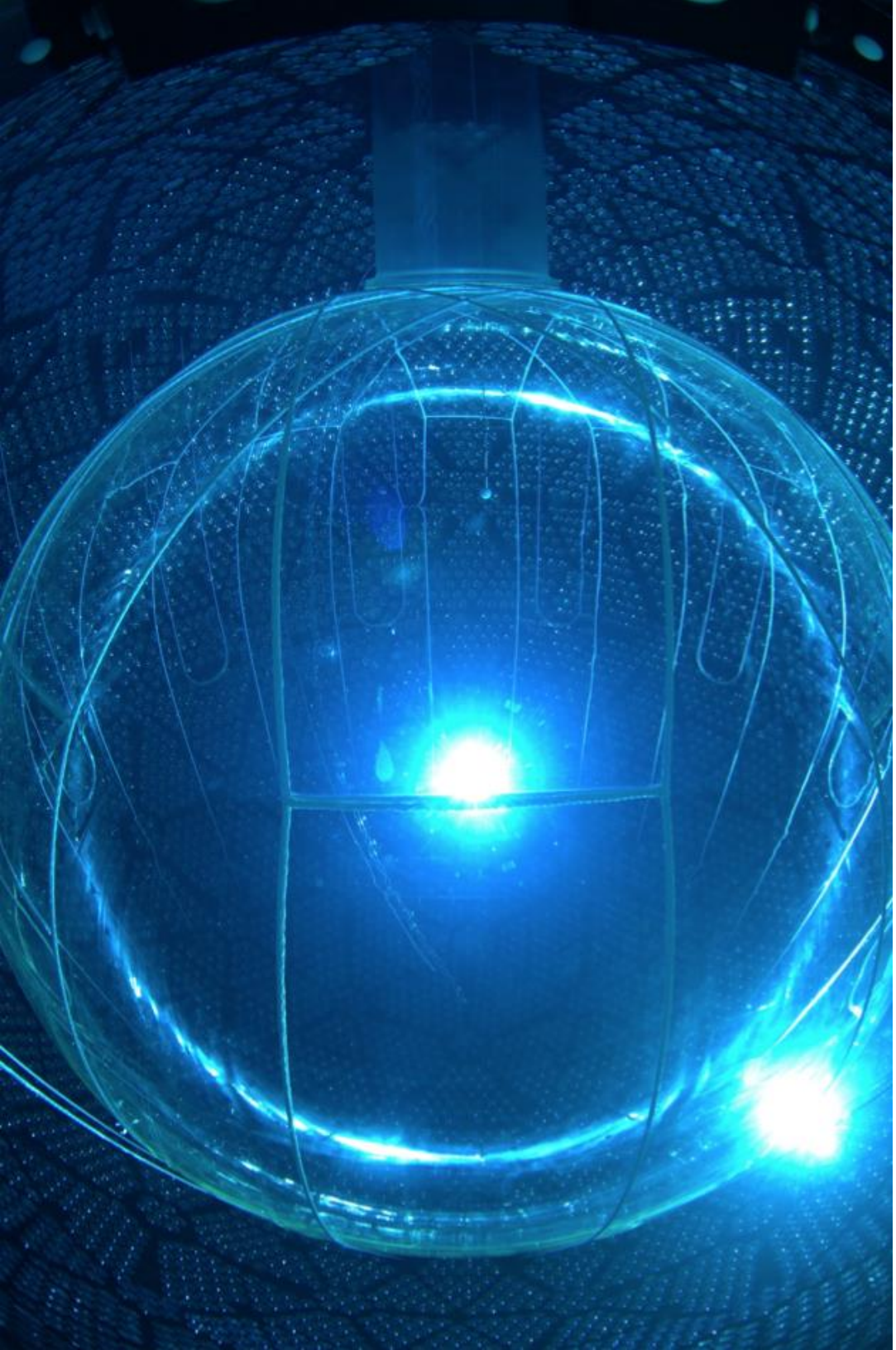
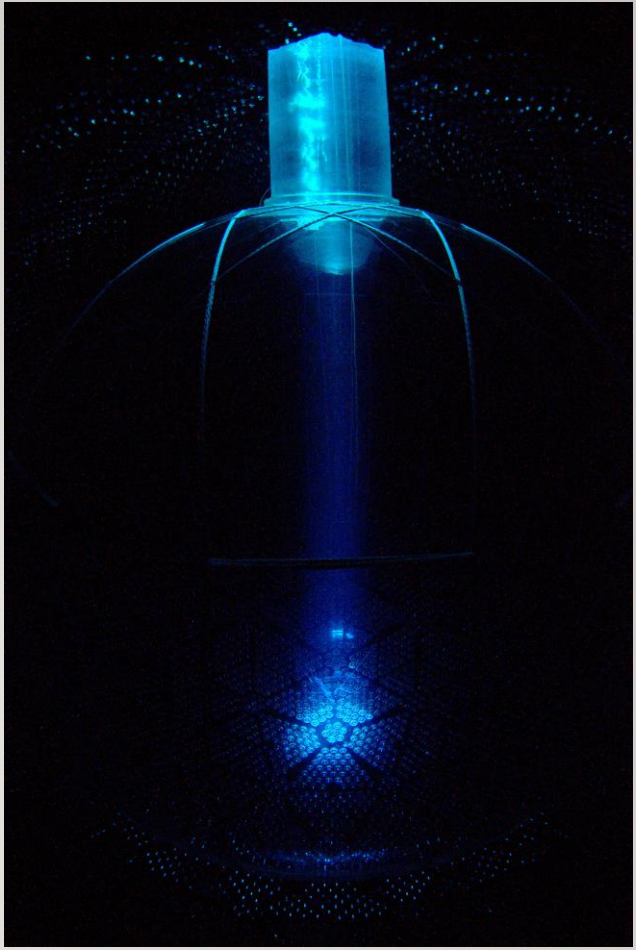


SNO+

IPP AGM @ CAP 2019

Mark Chen
Queen's University
June 7, 2019

STATUS



Water-filled phase: 2017-2018 complete

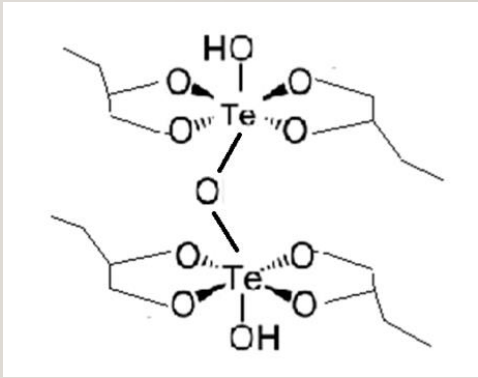
- 2 physics results published
- additional papers in preparation

Liquid Scintillator fill underway 2018-2019

- vacuum leaks in distillation halted fill for several months
- now repaired (other problems fixed too), soon to resume

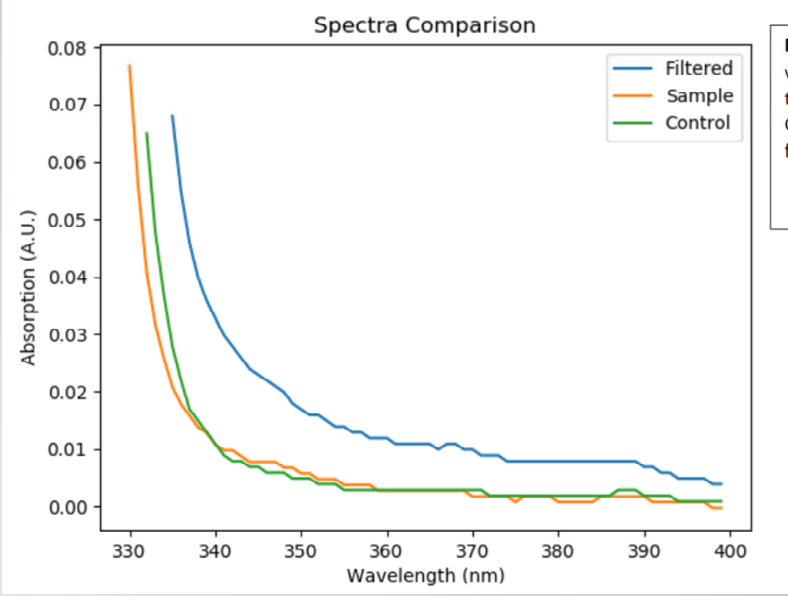
Tellurium systems installation complete

- ➢ Major milestone – all SNO+ infrastructure installed!
- Tellurium loading starts in 2020 after conclusion of pure scintillator phase (including physics)



CAS # 2173121-84-9
"Tellurium, 1,2-butanediol hydroxy oxo complexes"

STATUS

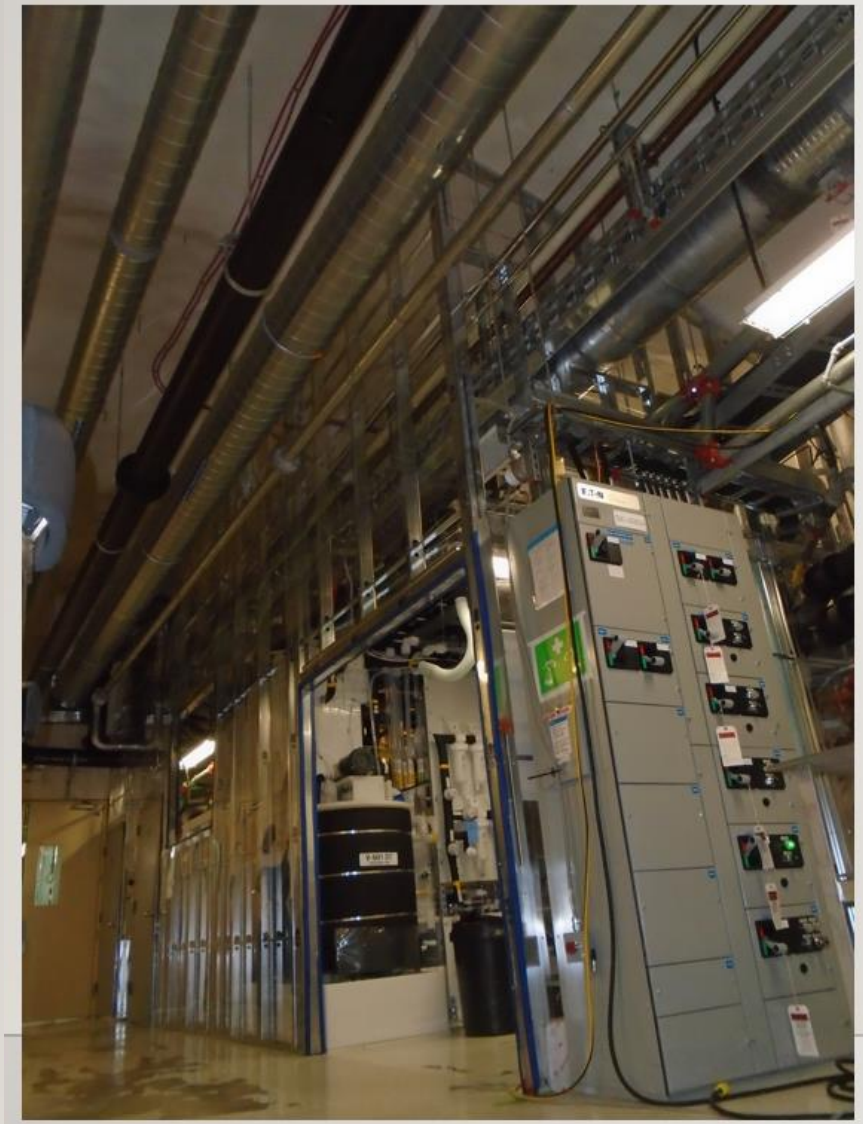


Water-filled phase: 2017-2018 complete

- 2 physics results published
- additional papers in preparation

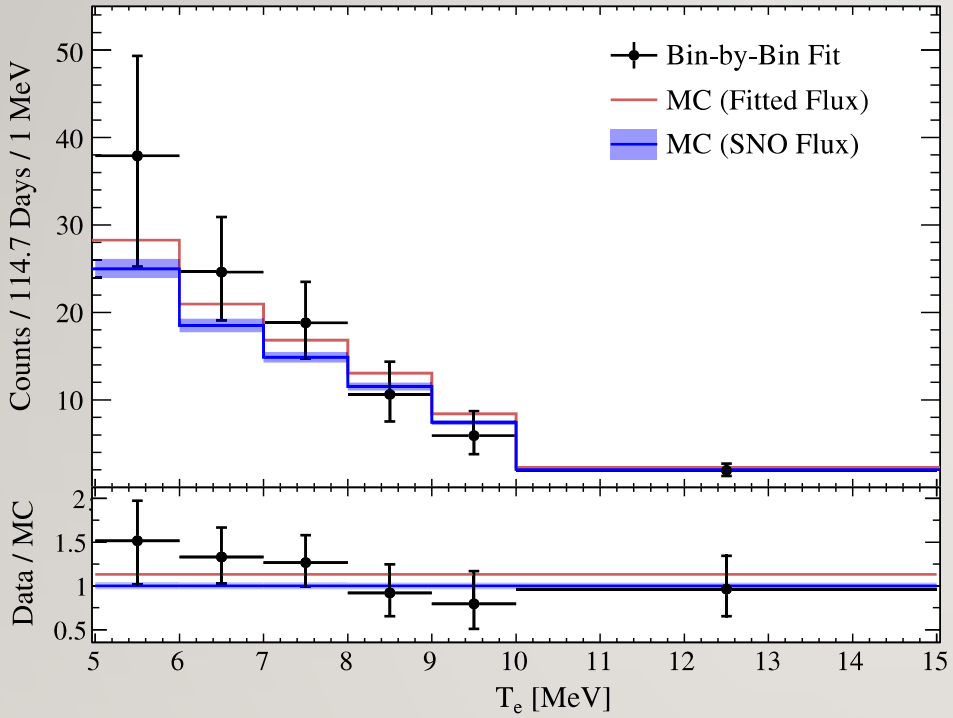
Liquid Scintillator fill underway

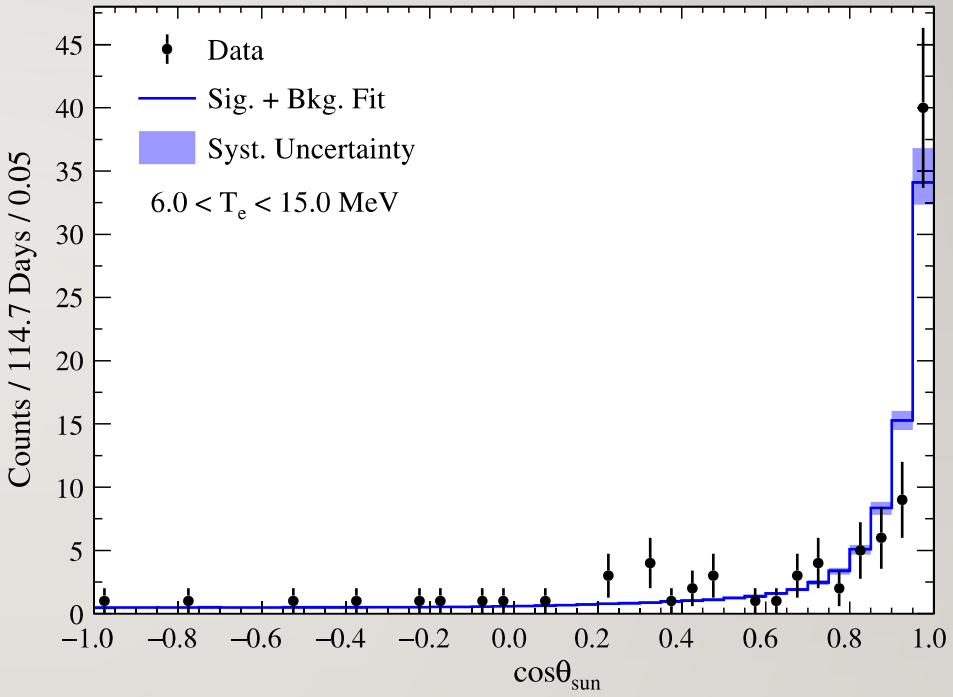
TELLURIC ACID



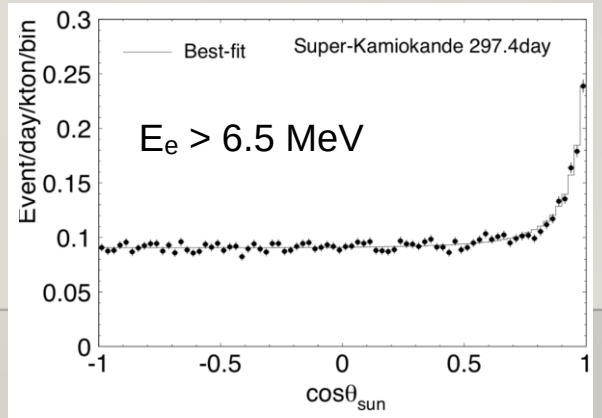
TE-DIOL SYNTHESIS

^{8}B SOLAR NEUTRINOS MEASURED BY SNO+ WITH VERY LOW BACKGROUNDS



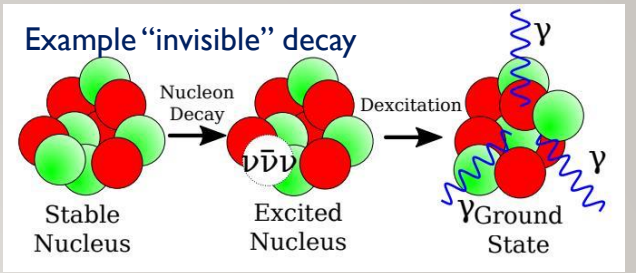


^{8}B solar neutrino spectrum and flux measured by SNO+

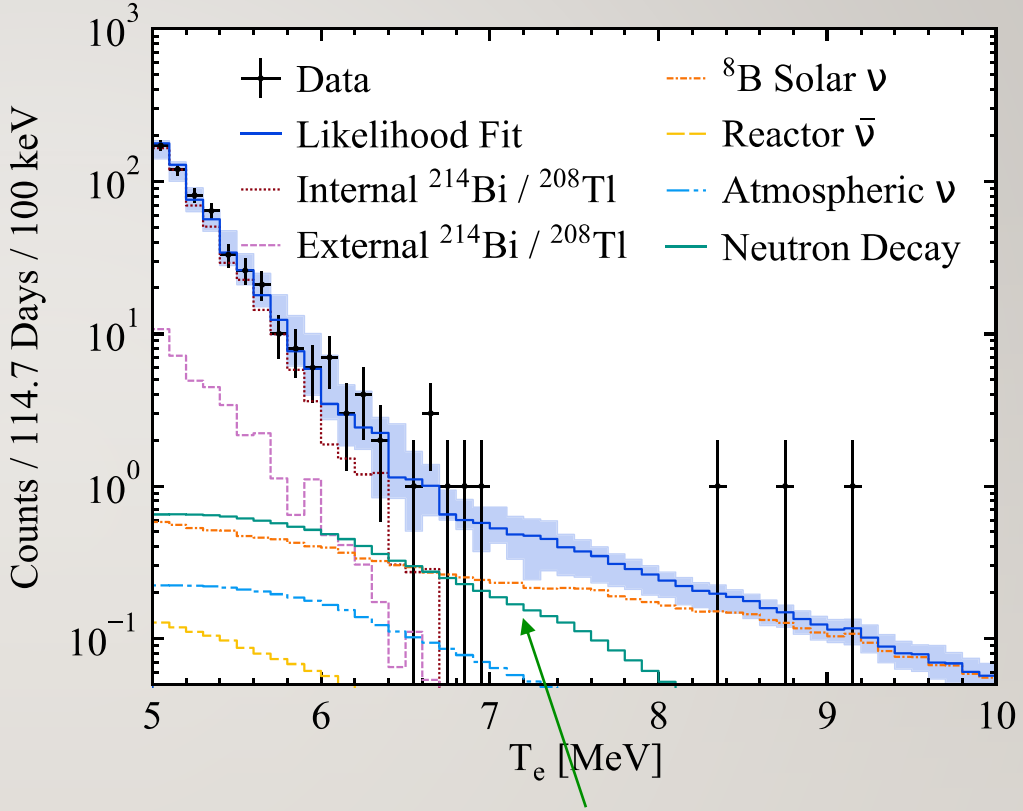


M. Anderson et al., (SNO+ Collaboration), "Measurement of the ^{8}B solar neutrino flux with very low backgrounds", Physical Review D **99**, 012012 (2019)

INVISIBLE NUCLEON DECAY



Spectral analysis	
n	2.5×10^{29} y
p	3.6×10^{29} y
pp	4.7×10^{28} y
pn	2.6×10^{28} y
nn	1.3×10^{28} y



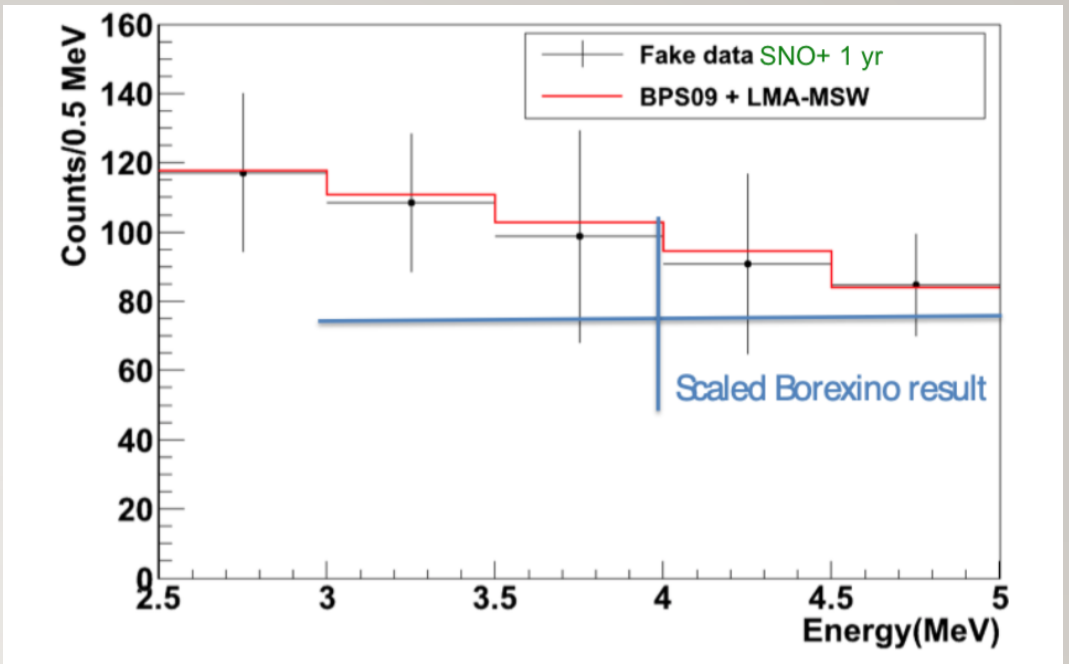
90% CL lower limit half-life for various invisible nucleon decay modes
- improving on (or comparable to) existing limits, in some cases by 3 orders of magnitude

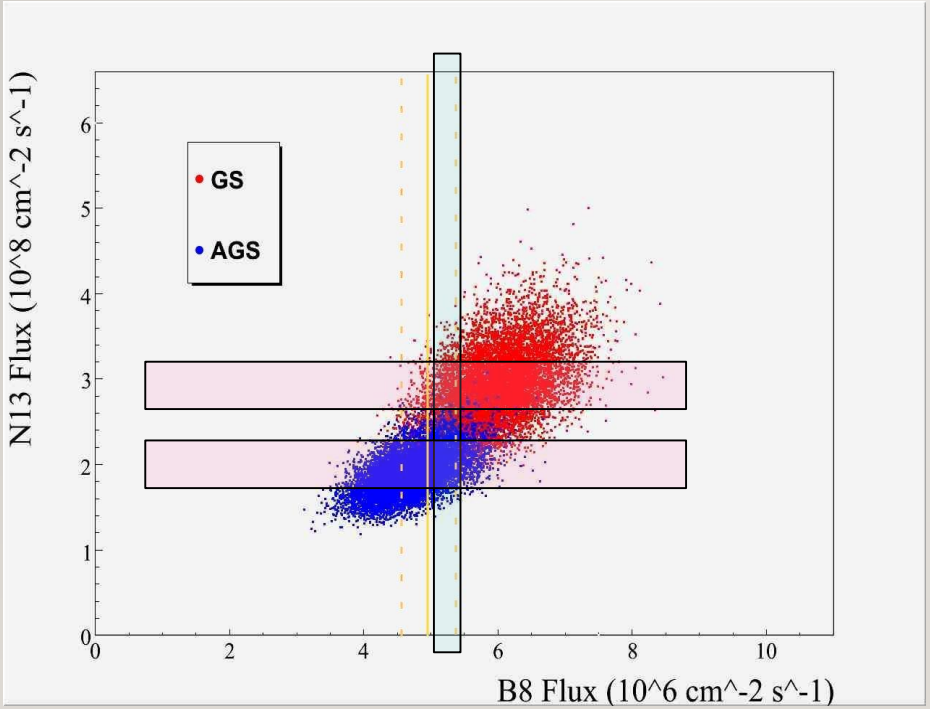
maximum likelihood invisible neutron decay compared to backgrounds

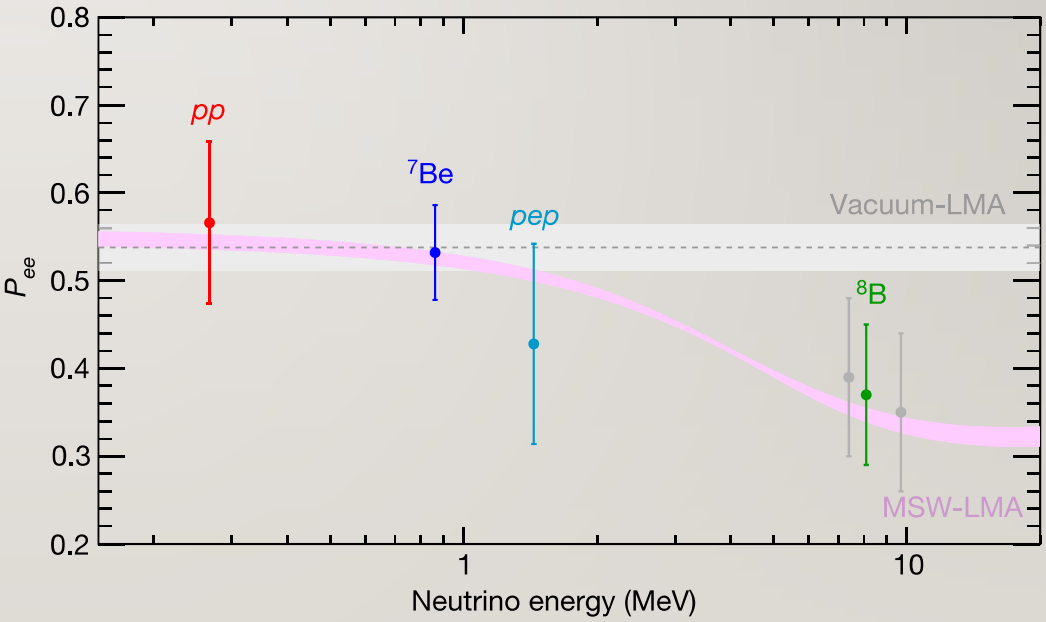
M. Anderson et al., (SNO+ Collaboration), "Search for invisible modes of nucleon decay in water with the SNO+ detector", Physical Review D **99**, 032008 (2019)

SOLAR NEUTRINOS SCINTILLATOR PHASE

- pep and CNO solar neutrinos
- low energy ^{8}B solar neutrinos





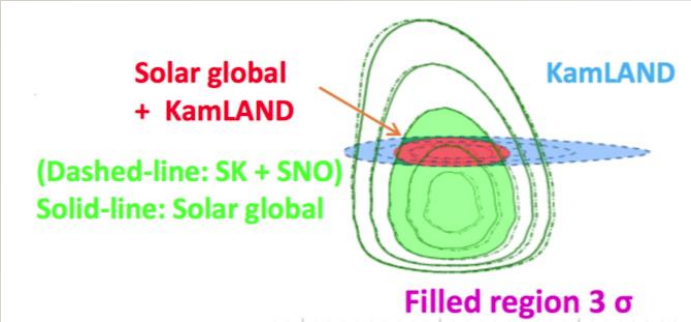


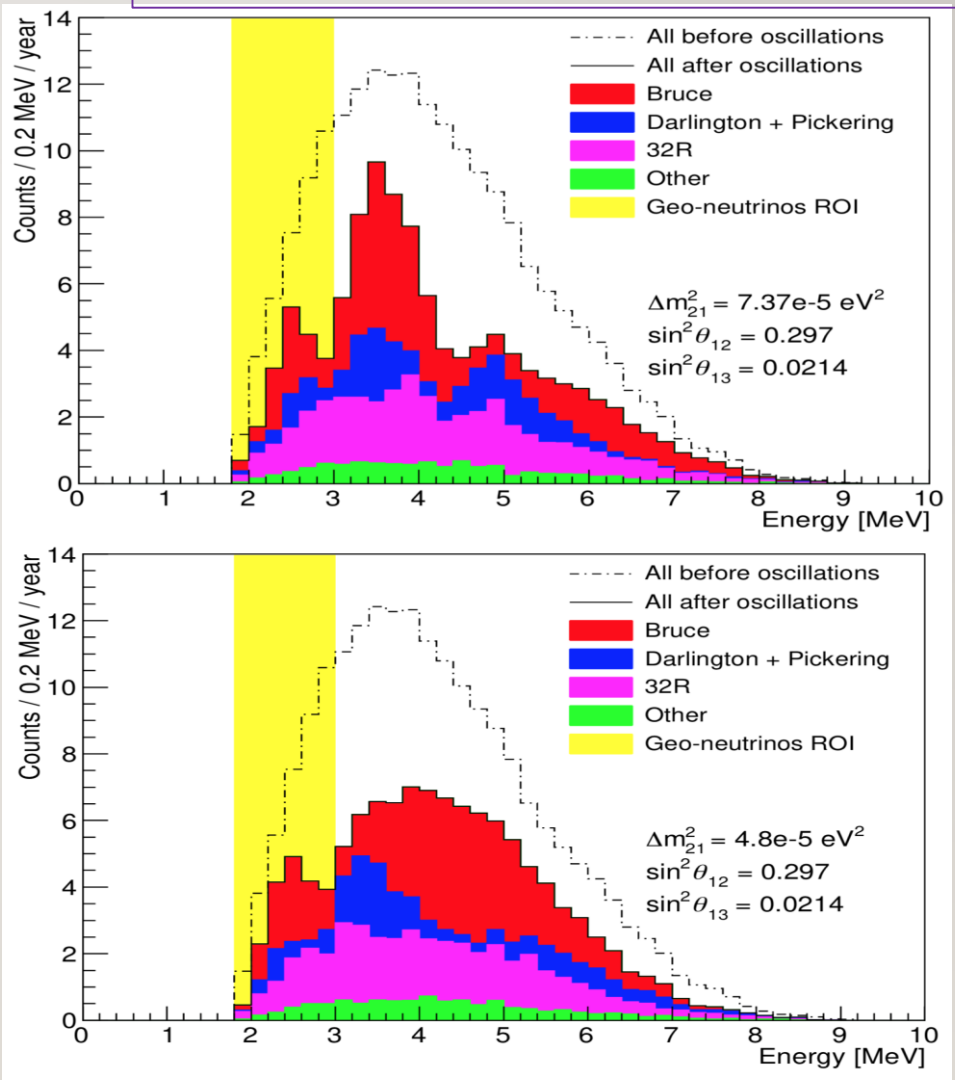
solar neutrino survival probability

solar metallicity with CNO neutrinos

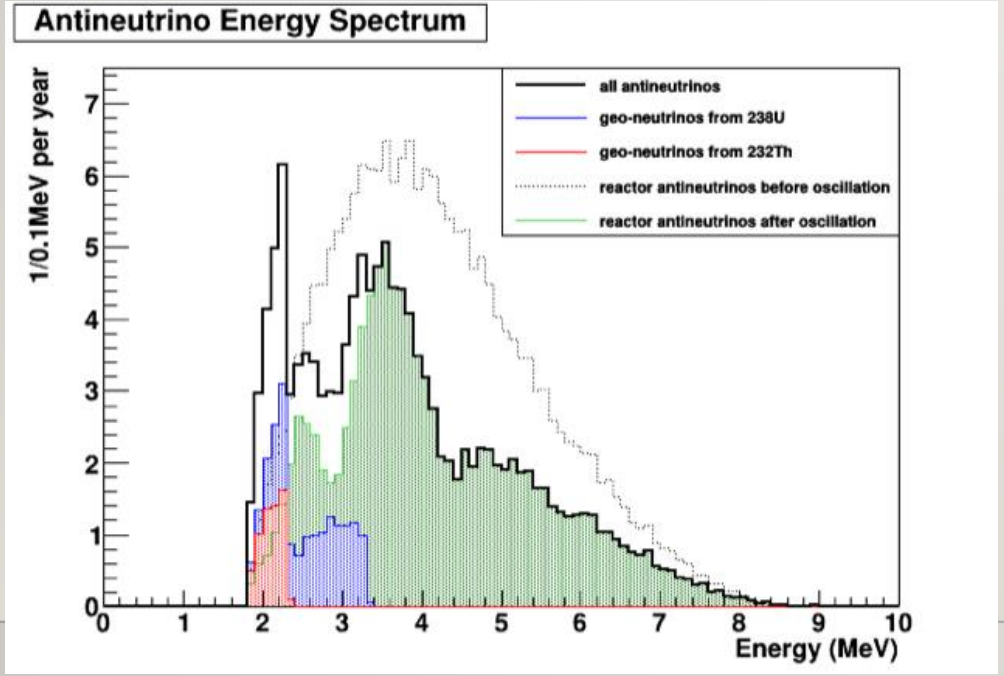
ANTINEUTRINOS – GEO AND REACTOR SCINTILLATOR PHASE

$\pm 0.7 \times 10^{-5}$ eV^2 precision possible with 6-months of SNO+ data

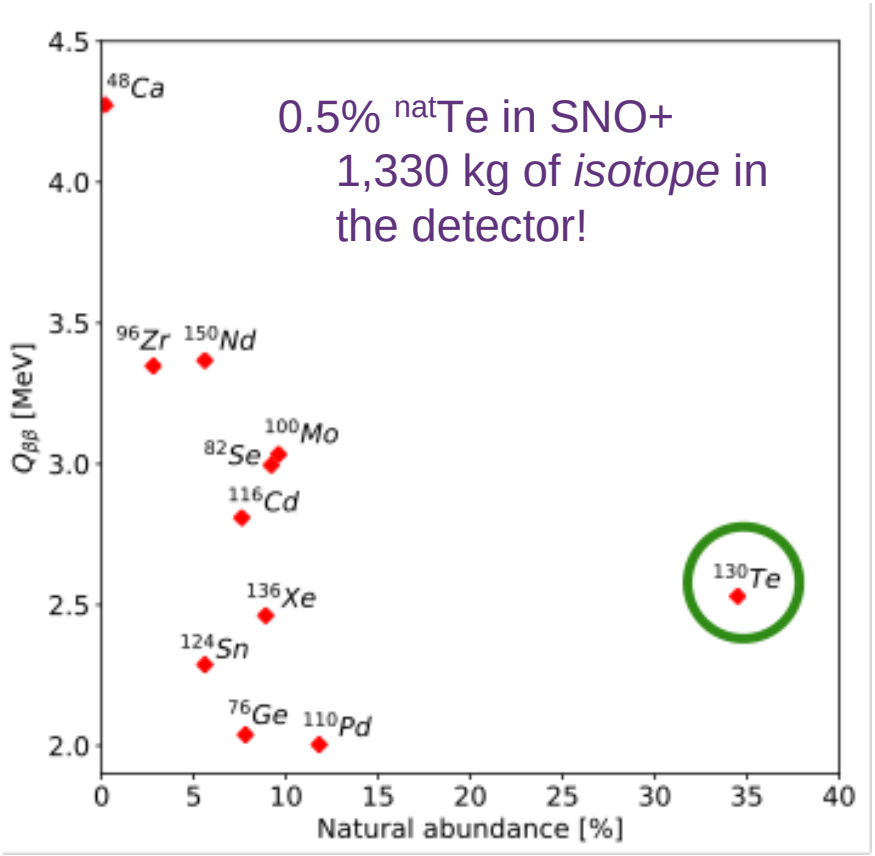




Geo Neutrinos in SNO+



Tellurium for Double Beta Decay



Large natural isotopic abundance 34% for ^{130}Te

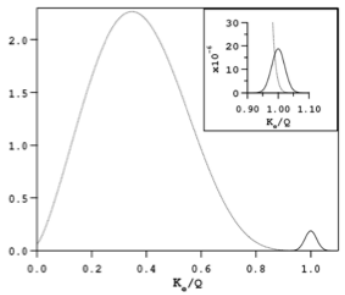
tonne-scale for ^{130}Te:
cost is $1.5 million

compare to O($100 million) for tonne-scale of enriched isotope

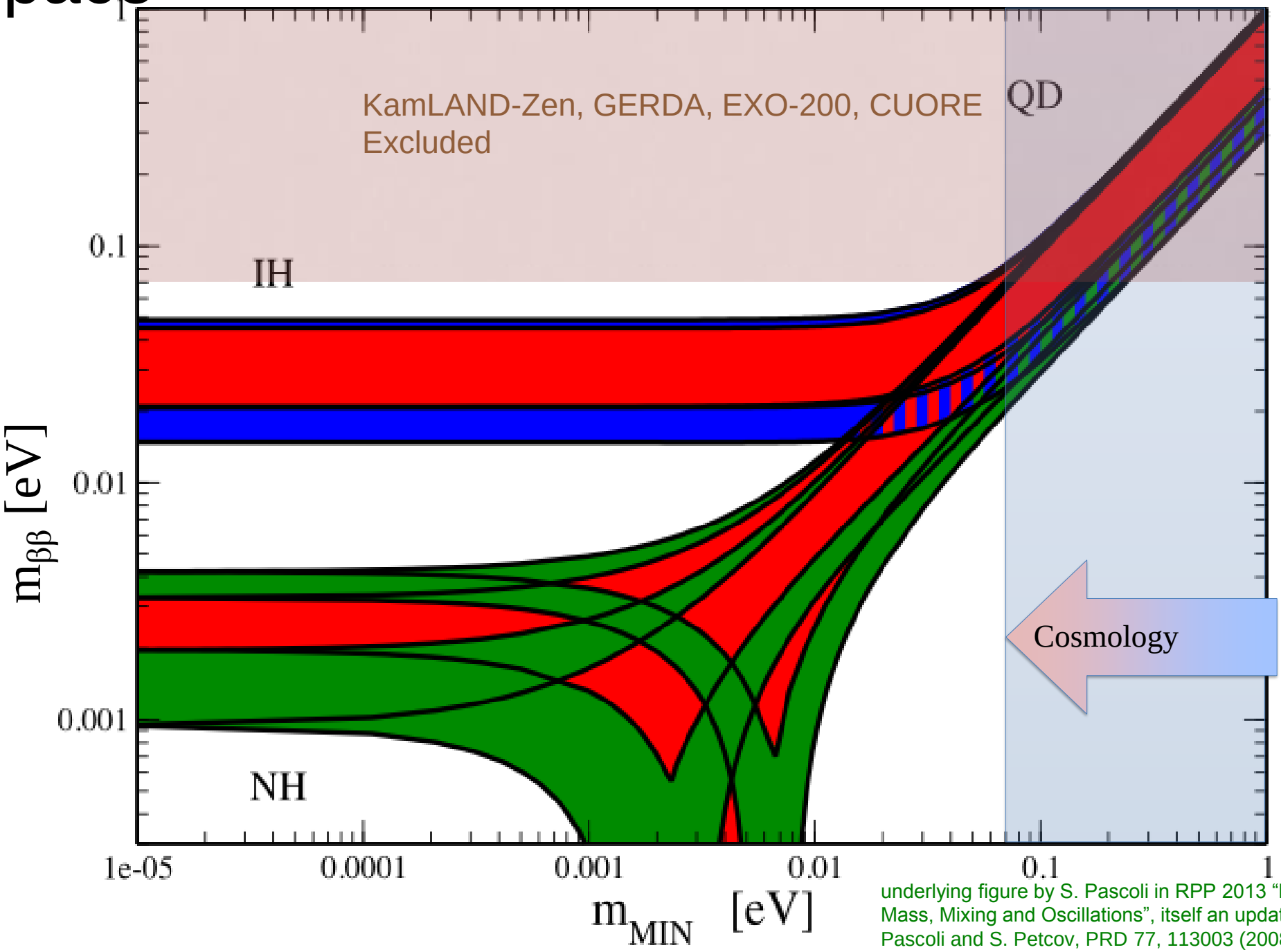
potential to increase loading from 0.5% to 3-5% ($15 million cost)

Background suppression
in the 0νββ ROI (Q=2.53 MeV),
U, Th backgrounds can be tagged and rejected by suppression factors >5,000
(e.g. ^{214}Bi-^{214}Po coincidence)

^{130}Te and ^{136}Xe have the smallest 2νββ/0νββ ratio

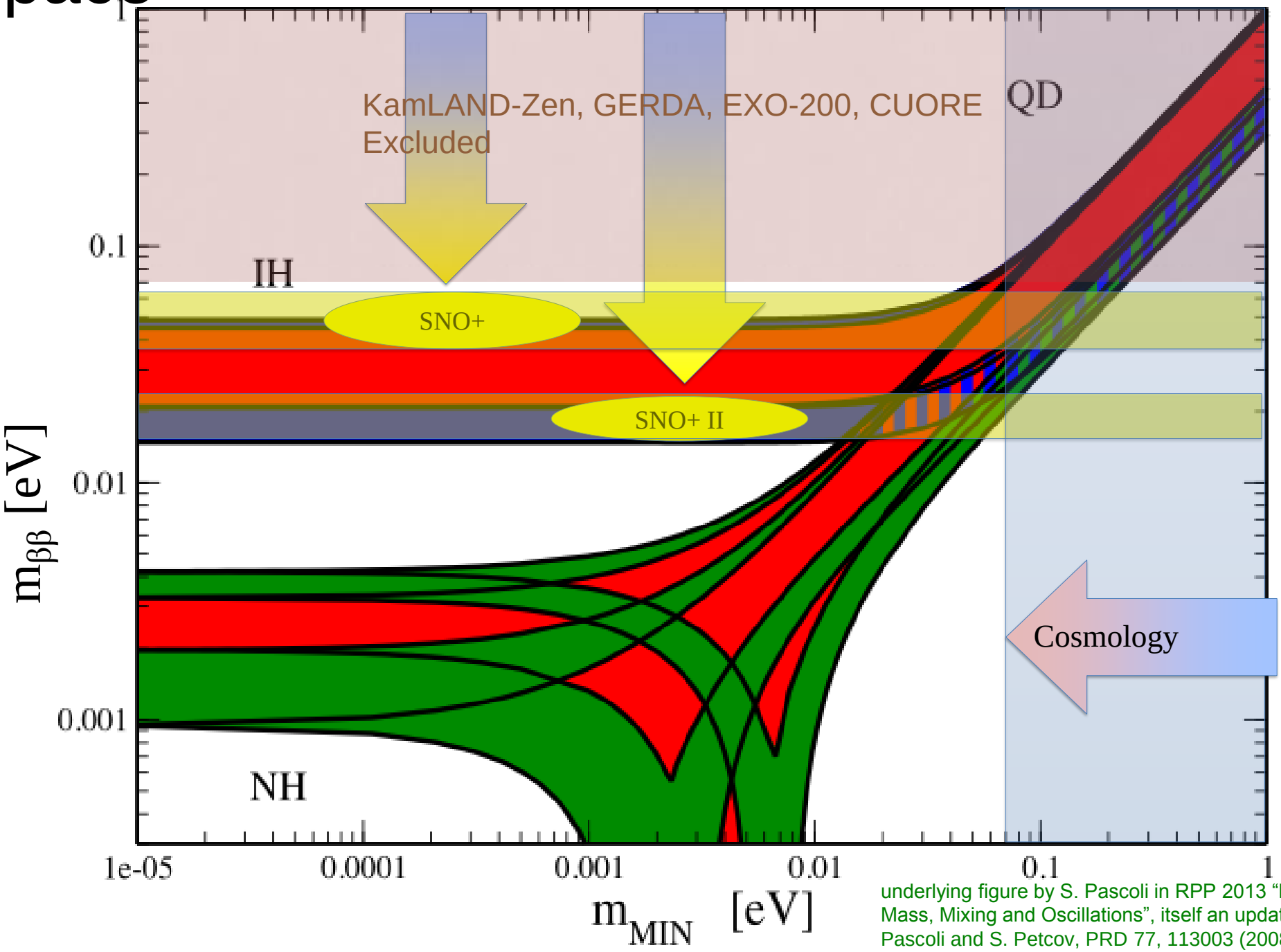


Double Beta Decay Allowed Parameter Space



underlying figure by S. Pascoli in RPP 2013 “Neutrino Mass, Mixing and Oscillations”, itself an update from S. Pascoli and S. Petcov, PRD 77, 113003 (2008)

Double Beta Decay Allowed Parameter Space



underlying figure by S. Pascoli in RPP 2013 “Neutrino Mass, Mixing and Oscillations”, itself an update from S. Pascoli and S. Petcov, PRD 77, 113003 (2008)

SNO+ Computing

- SNO+ takes data 24/7. During the water phase, this resulted in ~70 GB of raw data each day.
- Data is moved from SNOLAB to three grid sites (Simon Fraser University- Canada, Rutherford Appleton Laboratory- UK, and Fermi National Accelerator Laboratory- US).
- The majority of data processing occurs at the Cedar cluster operated by Compute Canada.
  - All incoming data gets automatically processed within 36 hours. For the water phase, this took around 600 CPU hours for each day of data.
  - All reprocessing requests for major analyses are also performed at Cedar.
- For Monte Carlo production, Cedar is the primary site with additional opportunistic production from other sites in the US and Canada and the European Grid Institute using mainly sites in the UK and Portugal.

- In scintillator phase, the data rate increases by a factor x50 – DEPENDS on backgrounds, thresholds, pre-scale,…
- Compute Canada allocation for SNO+ 2019-2020

  303 core years on the **cedar-compute** system

  2,250 TB of dCache storage on the **ndc-sfu** system
- Potential shortage: factor ~2 for computing cores; allocation for storage OK
- **Longer-term data storage is a longer-term concern**

Requested CA Stats for IPP AGM @ CAP

- MSc students: 5
- PhD students: 7
- Postdocs: 7
- RAs: 3
- Tech: 5
- Co-op/Summer students: lots

19 Faculty (Alberta, Laurentian, Queen’s, SNOLAB, TRIUMF)
8.5 FTE

Medium and Long-Term Plans for SNO+

- Fill with scintillator – take data
- Publish physics results from water phase and pure scintillator phase
- Purify and load tellurium – NOVEL RESEARCH!
- Conduct leading/competitive neutrinoless double beta decay search

- Prepare for and evaluate future prospects:
  - SNO+ DBD Phase II with %-loading Te
  - Long-term prospects for neutrino physics w/o Te: solar,, geo, reactor, supernova