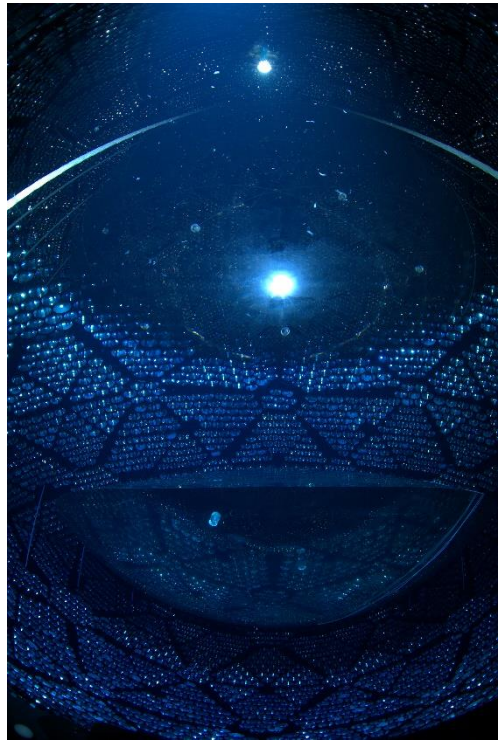


SNO+ experiment

IPP Townhouse meeting – June 14th 2015

Christine Kraus

LaurentianUniversity
UniversitéLaurentienne

Canada
Canada Research Chairs

SNO+ experiment

- 780 tonnes of liquid scintillator as active volume
  - Can be loaded with double beta decay isotope
- ~9500 PMTs
- 1500 + 5300 tons ultra-pure water shielding
- 6800’ underground in SNOLAB

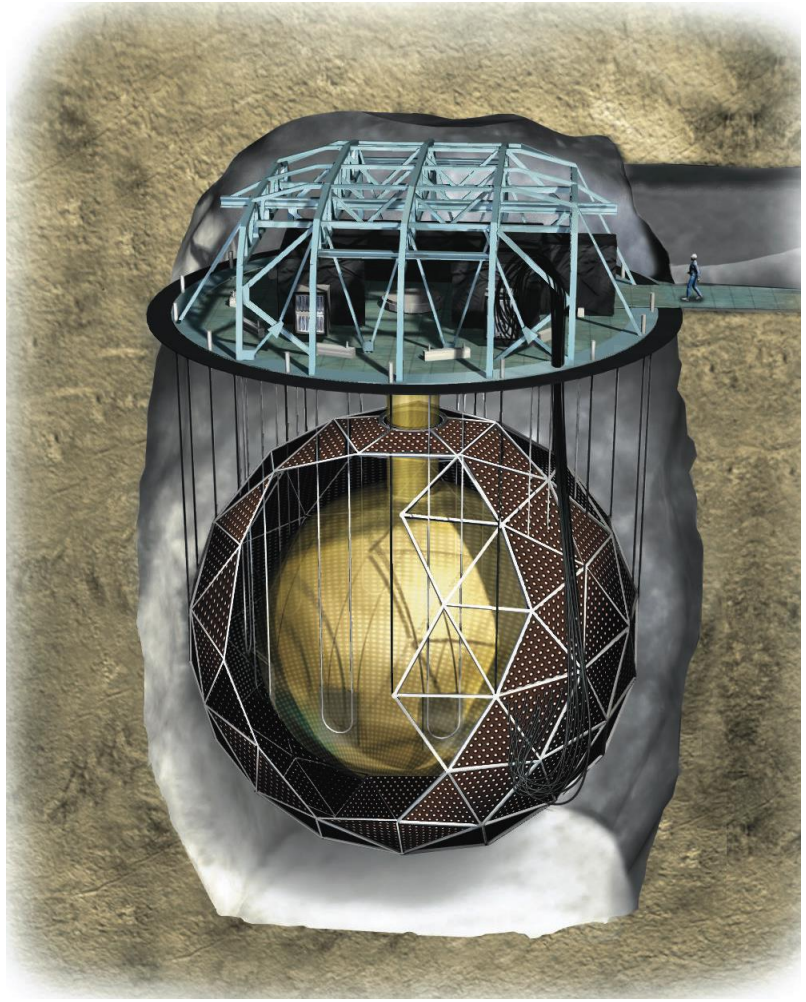
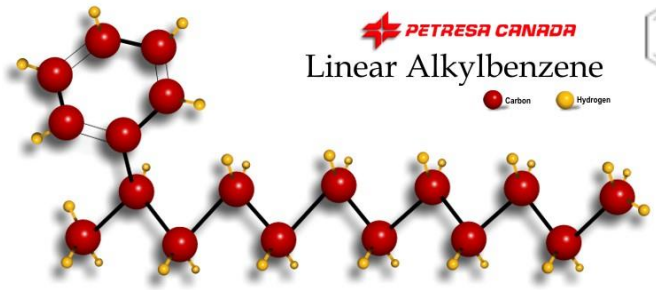
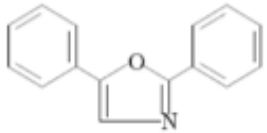


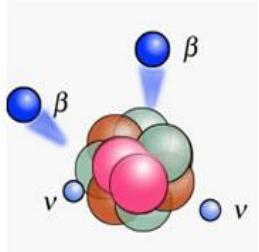
Image courtesy National Geographic



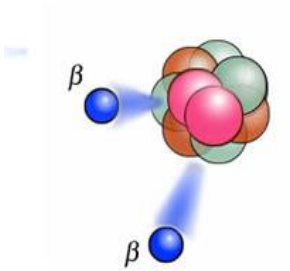


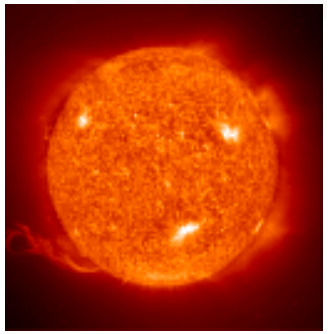
Organic scintillator Linear Alcyl Benzene (LAB) and PPO
Add 130Te and surfactant for double beta phase

Physics goals - scintillator



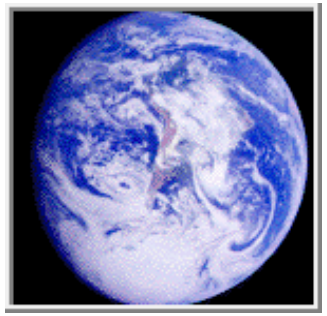
Neutrinoless Double Beta Decay



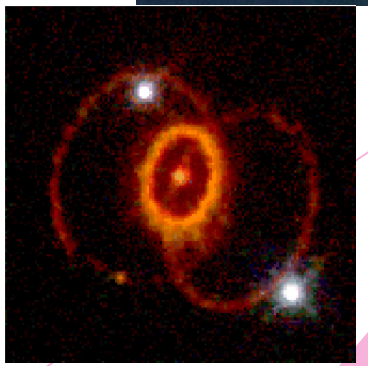


Low Energy Solar Neutrinos

Reactor Antineutrinos



Geo-Neutrinos

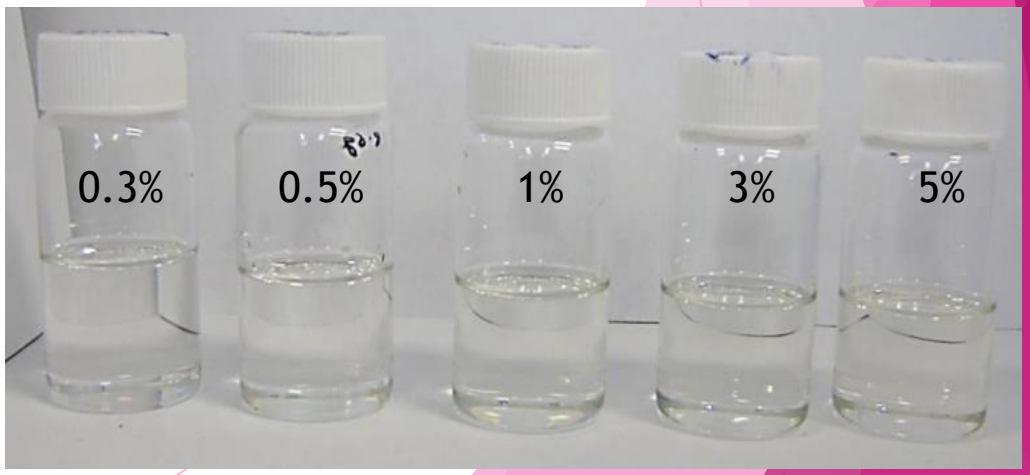


Supernova Neutrinos

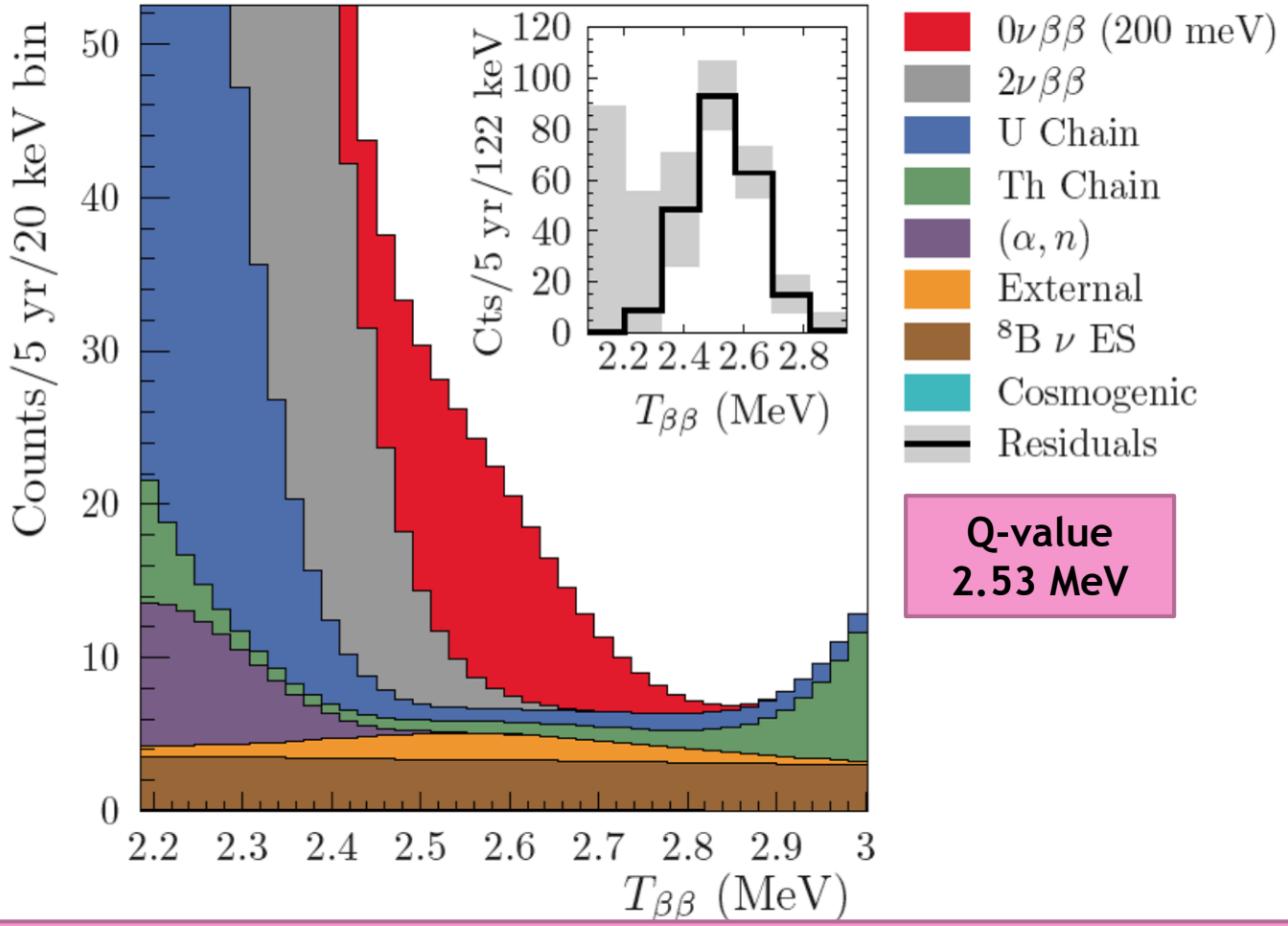
Phase I – SNO+ with Te-loaded Liquid Scintillator – starting in 2017

- large natural isotopic abundance 34% for ^{130}Te
  - tonne scale for ^{130}Te isotope, cost is only $1.5 million (because using natural tellurium without enrichment)
    - …compare to O($100 million) for tonne scale of enriched isotope
  - 0.3% Te (by weight) in SNO+ is 2.34 tonnes of Te or **800 kg** of ^{130}Te ***isotope***
- *recently, SNO+ received additional funding – should allow us to go to **0.5% Te loading** or **1,300 kg of isotope***
  - … CFI and provincial matching

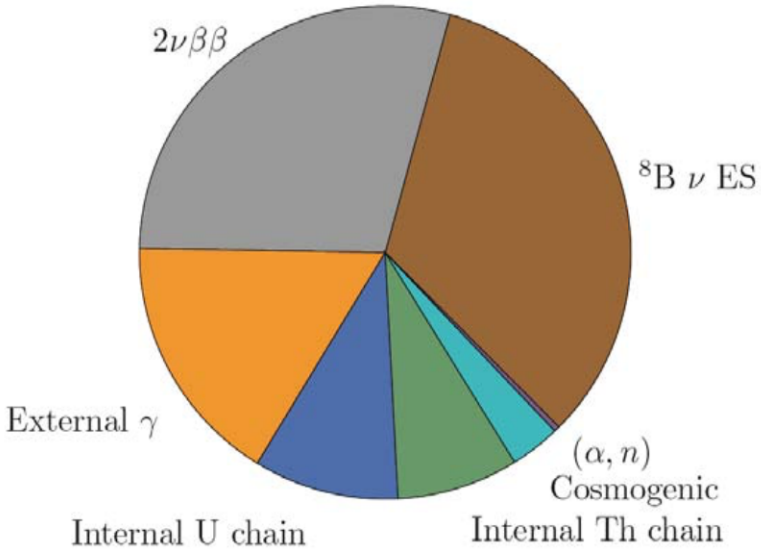
LAB scintillator with different Te loading



SNO+ simulated spectrum



Q-value 2.53 MeV



~ 22 events/year

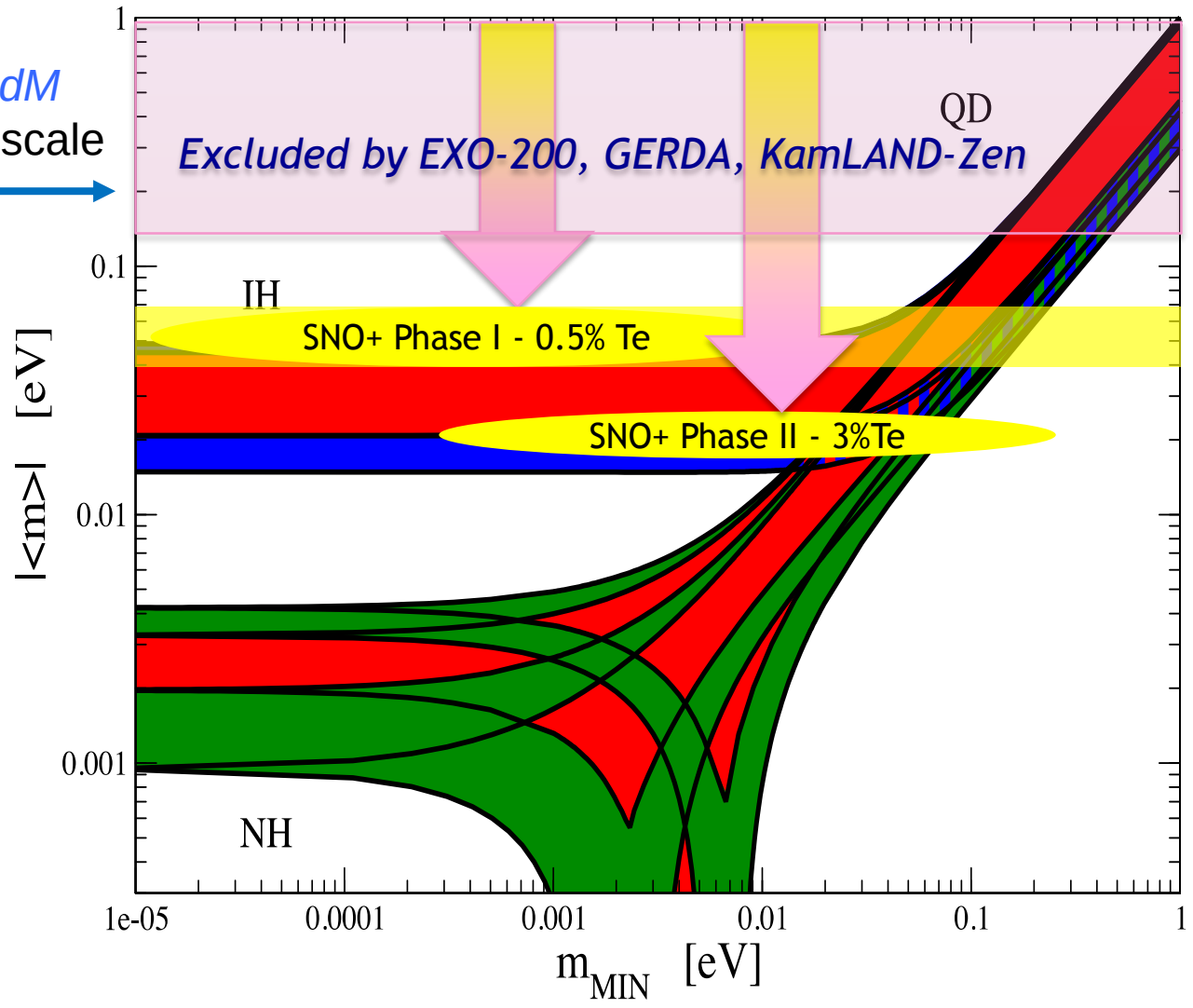
- Fiducial volume cut at 3.5 m radius (20%)
- 200 hits/MeV and 5 years
- Tagging 214Bi > 99.99% efficient

> Factor 50 reduction in pileup 212/214Bi/Po
> Negligible cosmogenic isotopes
> m(0vßß) = 200 meV **

***J. Barca et.al. Phys. Rev. C87 (2013)*

SNO+ neutrinoless double beta decay

e.g. HdM
10 kg scale



1000 kg scale

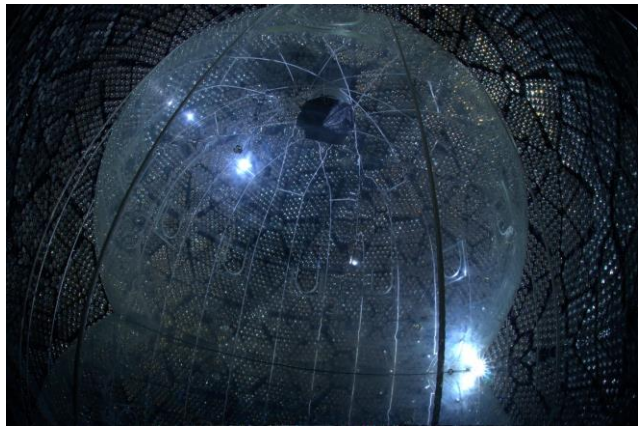
Extremely low background compensates for modest energy resolution.

If the TeLS is sufficiently radiopure, the dominant background in SNO+ will be ^{8}B solar neutrinos. Then sensitivity scales directly with Te loading!

A staged approach will give SNO+ leading sensitivity for years to come.

Background plot adapted from PRD 77, 113003 (2008)

Last year …

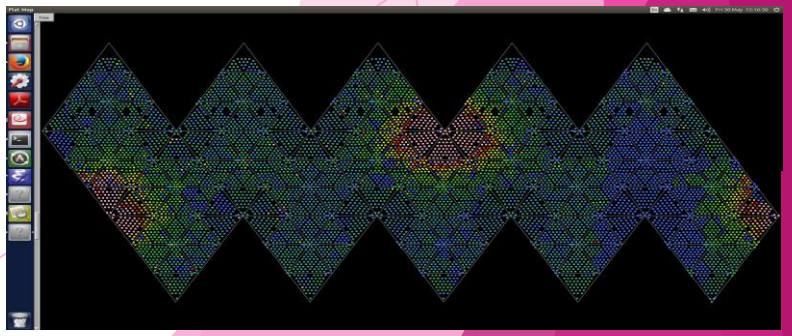


Waterfill 1/3 – complete initial hold-down rope system check successfully to 1/3 loading

Scintillator plant pipe installation complete
He-leak checking of 1.6 km of piping, vessels, kettles etc. **DONE**

Sliding floor around universal interface
Installed and neck position monitor,
Including dark barrier

DAQ and electronics commissioning,
run detector with PMTs under water,
testing fibre system/calibrations



Cover gas system installed and tested, PMT repairs, Fibre calibration
System installation 2/3 complete, and more …

Currently

- Completing mechanical installation of scintillator plant – this summer
- Cleaning and Passivation now ongoing – complete within weeks
- Pre-commissioning started
- Completing DAQ development
- Working on Te purification

Timeline

- 2015 – complete water fill
- Water-filled data taking to study external backgrounds, detector optics, nucleon decay
- 2015 – commissioning of scintillator plant
- 2016 – scintillator fill and start taking data
- 2016 – complete Tellurium purification, install skid
- 2016 – add Te to SNO+ liquid scintillator

- TIME PERIOD 2017 – 2021 is running time

HQP training - Canada

- **University of Alberta**
- 3-4 graduate students, currently 4
- Typically 2 undergrad students in the summer
- Postdocs/RA's:
  - Kalpana Singh (Hold-down system, Anti-neutrino analysis)
  - David Auty (Data flow)
  - Aleksandra Bialek (Coordination He-leak checking, cleaning & Passivation, support water fill) located at SNOLAB

HQP training - Canada

- **Queen's University**
- 6-7 graduate students
- Typically 2 undergrad student for the summer
- Postdocs/RA's:
  - Szymon Manecki (PRS group lead)
  - Lianpeng (Chemisty, PRS)
  - Peter Skensved (Calibration/Dectector…)
  - Xin Dai (Te chemisty) - part of the year at Queen's
- Assay technician – located at SNOLAB/Laurentian
  - Dimpal Chaupan (Water assay's, Radon)
  - Brad Hreljac (Chemistry, Te R&D)

HQP training - Canada

- **Laurentian University/SNOLAB**
- Graduate students 4-5, currently 5
- Typically 2 undergrad students co-op for at terms
- Additional 2 undergrad students for the summer
- Postdoc/RA's
  - Oleg Chkevorets (Assays, Te R&D, Spike, counting)
  - Erica Caden (Calibration hardware and analysis)
- Technical – David Braid (Detector, UG supervision, Installation, Documentation)

In addition C. Kraus (as site activity coordinator) has supervision of all visiting Students, Postdocs, etc. during their time on site, including undergrad students collaborators sent, long-term stays (up to 12 month) of graduate students and Postdocs

Funding for SNO+, Equipment needs

- Capital funding from CFI, moving forward a grant for improving double beta
- Long term operations needs not covered by CFI IOF
- For 2017-2021 don't expect CFI request, possibly later for higher loadings of Tellurium
- Canadian resources from NSERC operations – expect steady state and significant needs for site operations – this includes maintenance and replacements parts for failing equipment
- Site operations will be shared with non-Canadian collaborations to cover costs for scintillator plant operators, detector manager, professional detector operator, assay technicians, IT support …

TRIUMF, MRS, SNOLAB

- **Triumf** workshop has been used to fabricate Universal Interface (UI) – which will be completed shortly
- No major equipment need for 2017 – 2021
- **Queen's MRS** – Phil Harvey (programmer) for DAQ support
- **Alberta-Toronto MRS** - Mircea Cadabeschi and Chris Ng for Engineering: such as Te purification design, calibration hardware design
- **SNOLAB** and SNO+ are working closely together
- SNOLAB operations group and technical support is a significant fraction of our water needs, supports commissioning team and assay group
- SNOLAB personnel (Brian Morisette, Taylor Shantz) has covered part of SNO+ project management, installation support (mechanical completion of scintillator plant)
- SNO+ key people are integrated in the SNOLAB structure, located at SNOLAB, such as commissioning engineer (Mark Hodak) and Te engineer (Doug Horne)

Computing requirements

- Using local storage for data taking (SNOLAB and SNO+)
- Using grid for long term storage and processing
  Westgrid, US as well as UK
- Compute Canada – need to work on defining our needs this fall – will ramp up with data taking starting, so far we didn't use all allocations
  - 2013 100 core years
  - 2014 170 core years
  - 2015 146 core years
- Estimated need for data taking storage: 20 TB per week

Relation ship with other projects Canadian subatomic community

- **DEAP** – shared resources, acrylic vessel
- **HALO** – close – shared resources, joint supernova analysis potential (Clarence Virtue leads SNO+ Supernova group)
- **EXO/nEXO** – also looking for neutrinoless double beta decay - competitors

The collaboration

Armstrong Atlantic State University
Brookhaven National Laboratory
Lancaster University
Laurentian University
LIP Coimbra
LIP Lisboa
Oxford University
Queen Mary, University of London
Queen's University
SNOLAB
Technical University of Dresden
TRIUMF

Universidad Nacional Autónoma de México
University of Alberta
University of California – Berkeley
& Lawrence Berkeley National Laboratory
University of California - Davis
University of Chicago
University of Liverpool
University of North Carolina at Chapel Hill
University of Pennsylvania
University of Sussex
University of Washington

Total 130 with Canada (49), US (39), UK (31), Portugal (6), Germany (4) and Mexico (1)

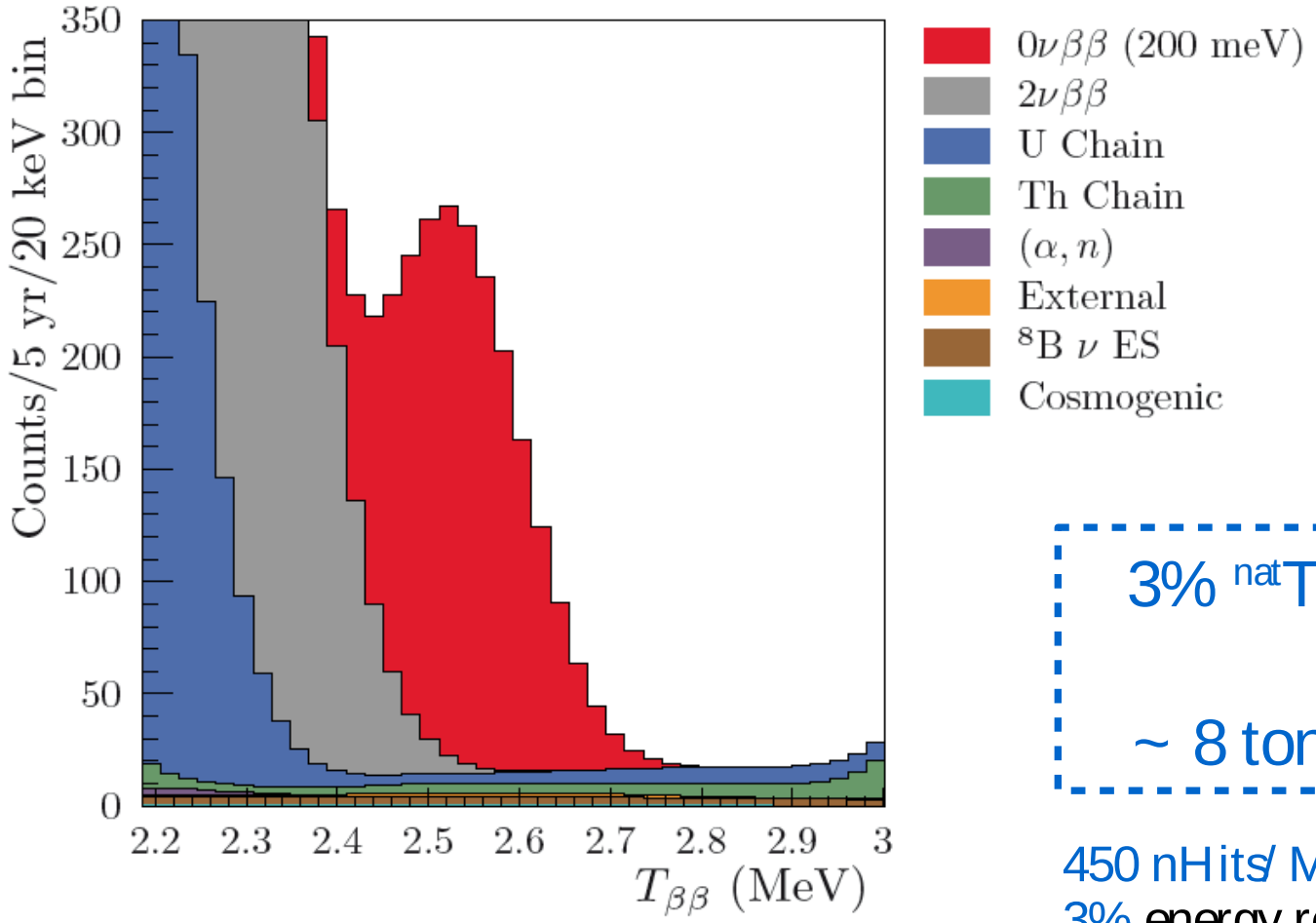
International partners - collaboration

- US DOE and NSF – have been supported and will be supported
- UK STFC
- Previous and hopefully continued support from Germany and Portugal
- Maybe future support from Mexico

Total 130 with
Canada (49), US (39), UK (31),
Portugal (6), Germany (4) and Mexico (1)

Backup

SNO+ Phase 2 with 3% TeLS



3% ^{nat}Te loading

=

~ 8 tonnes ^{130}Te

450 nHits/ MeV

3% energy resolution at $Q_{\beta\beta}$