0νββ Target Out Analysis for the SNO+ Experiment

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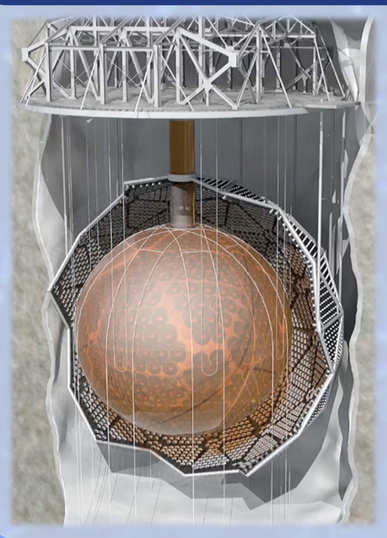
The SNO+ Experiment

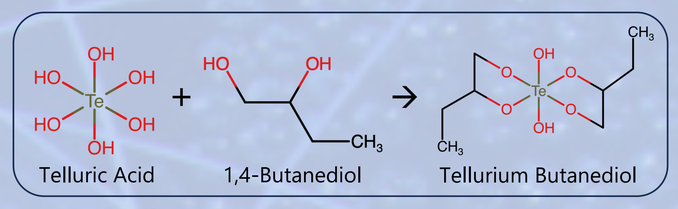


Multi-purpose liquid scintillator detector [1]
- Located 2070 m underground at SNOLAB
- 7000 m^3 ultrapure water shielding
- 904 m^3 acrylic vessel (main detector body)
- Events observed with 9362 PMTs
- Extensive Physics Programme [2-6]

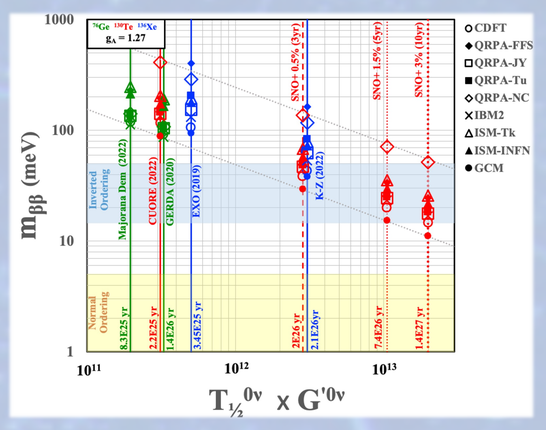
SNO+ Liquid Scintillator [7]
- 792 tonnes Linear Alkylbenzene (LAB)
- 2.2 g/L 2,5-Diphenyloxazole (PPO)
- 4.9 mg/L 1,4-Bis(2-methylstyryl) benzene (Bis-MSB)
- 6.5 mg/L Butylated Hydroxytoluene (BHT)

0νββ Programme

Primary SNO+ Objective: Searching for 0νββ in ^{130}Te
- Initial deployment of 3.9 tonnes ^{nat}Te
- Only planned future ^{130}Te 0νββ experiment
- Technique developed to load Te in LAB [8]

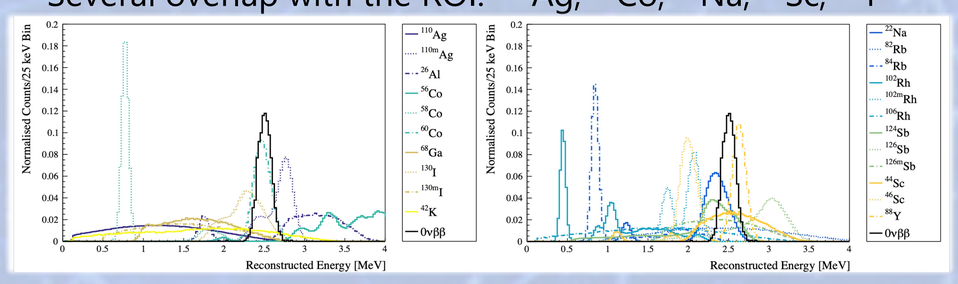


Region of Interest (ROI)
- ^{130}Te Q-Value = 2.527 MeV
- ROI = [-0.5 – 1.5] σ = [2.42– 2.56] MeV



Target Out Advantage: Scintillator backgrounds can be measured before deployment of tellurium

Cosmogenics
- Numerous isotopes created from muon spallation on on Te nuclei
- Several overlap with the ROI: ^{110}Ag, ^{60}Co, ^{22}Na, ^{44}Sc, ^{88}Y



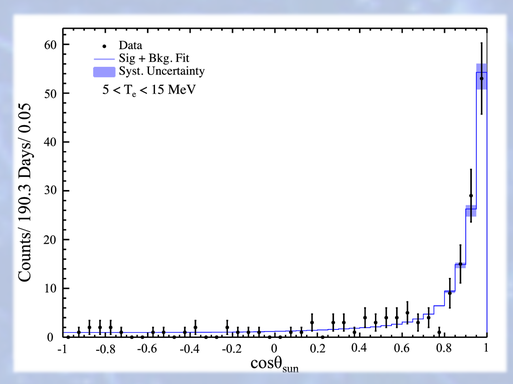
- Mitigated through "cooling off" and purification
- Te brought underground from 2015-2018

Expected cumulative ROI counts:
(after purification)
0.11 counts/year

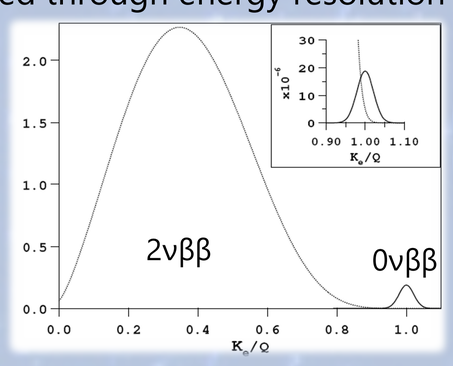
Solar Neutrinos
- ^{8}B solar neutrino spectrum overlaps with ROI
- May be mitigated by recovering particle directionality
- Rate measured and constrained by SNO+ and other experiments [2]

Total flux = $5.16^{+2.5\%}_{-1.7\%} \times 10^{6}$ $cm^{-2}s^{-1}$

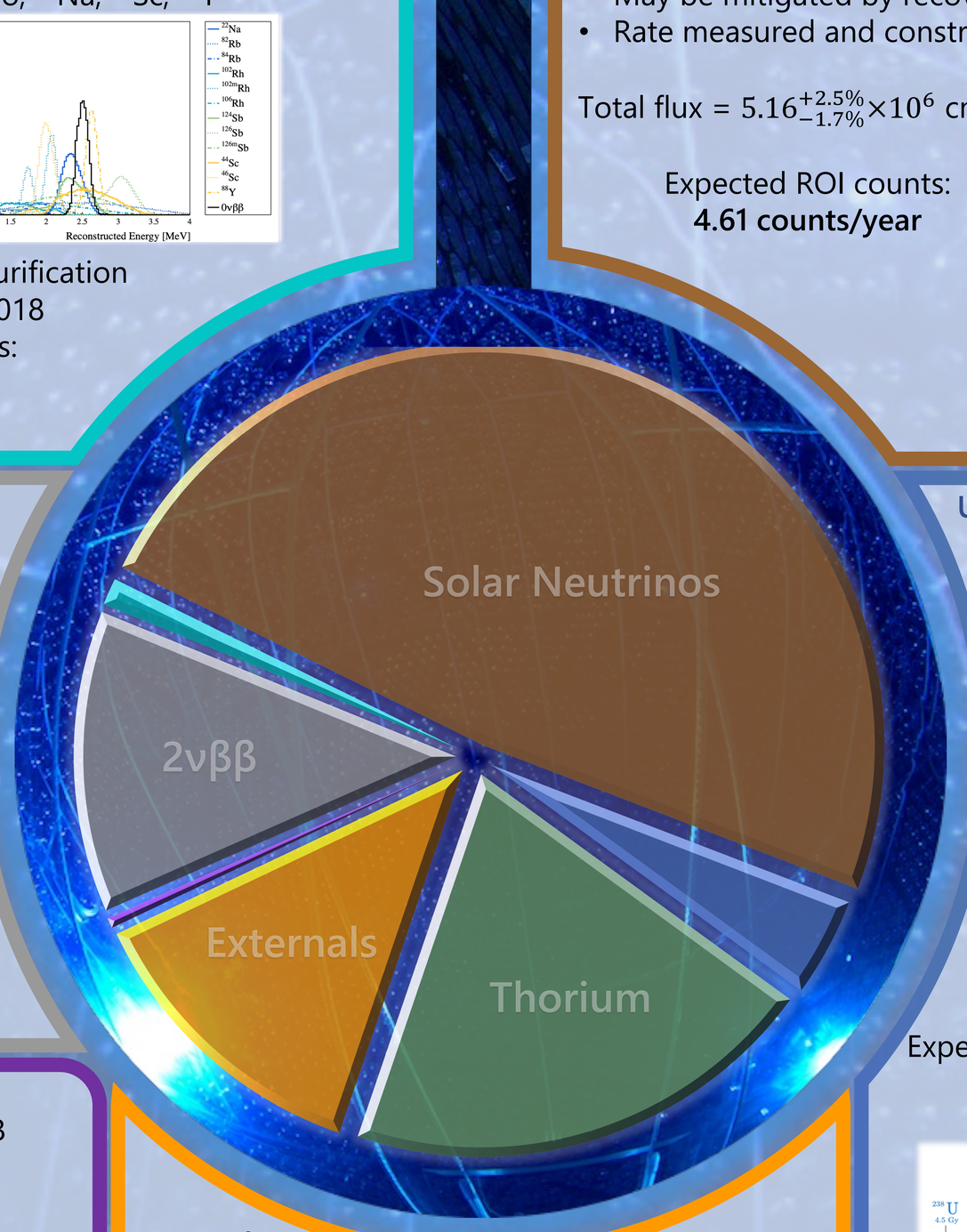
Expected ROI counts:
4.61 counts/year



Two neutrino double beta decay
- Standard model process from ^{130}Te
- Intrinsic to any search for 0νββ
- Mitigated through energy resolution



Expected ROI counts:
1.21 counts/year

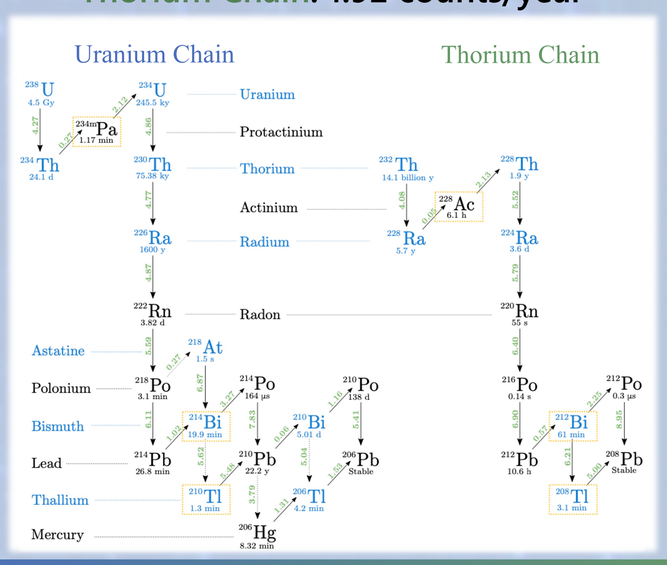


Uranium and Thorium
- Intrinsic contamination in all materials
- Mitigated through purification
- **Measured in scintillator to be sub-dominant to those expected in Te**

^{238}U Chain:
- Potential ROI contributions from ^{234m}Pa, ^{214}Bi, ^{210}Tl
- Measured at $(5.3\pm0.3)10^{-17}$ g/g

^{232}Th Chain:
- Potential ROI contributions from ^{228}Ac, ^{212}Bi, ^{208}Tl
- Measured at $(5.7\pm0.3)10^{-17}$ g/g

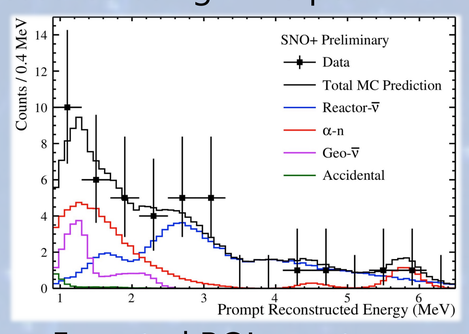
Expected ROI count (including expected in Te):
Uranium Chain: **0.40 counts/year**
Thorium Chain: **1.92 counts/year**



(α,n) interactions
- Caused by α interacting with ^{13}C in LAB

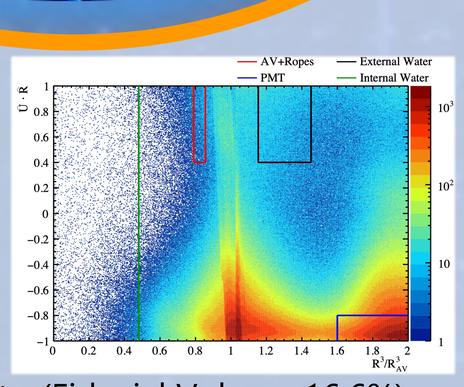
$$^{13}C + \alpha \rightarrow {}^{16}O + n$$

- Rate measured using ^{210}Po peak



Expected ROI counts:
0.02 counts/year

External γ
- γs from decays of ^{214}Bi (^{238}U) and ^{208}Tl (^{232}Th)
- Mitigated by fiducialisation
- Measured when filled with water

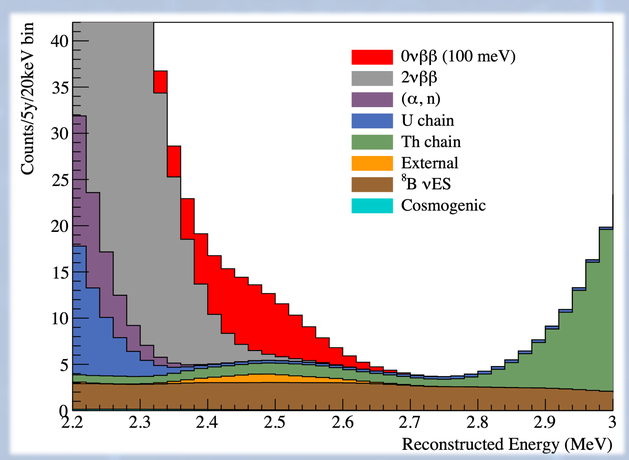


Expected ROI counts: (Fiducial Volume 16.6%)
1.21 counts/year

Conclusions

- Initial target out analysis performed, ongoing to constrain the presence of unknown backgrounds
- Total expected ROI count rate of 9.48 counts/year
- Projected Sensitivity: $S_{1/2}^{0\nu} = 9.20\times10^{25}$ years after 1 year live time (90% C.L.)
- Te purification and deployment hardware installed, in late stages of commissioning

All backgrounds measured except for those potentially introduced during Te deployment. Final sensitivity depends on purity achieved during Te loading.



References and Acknowledgements

[1] SNO+ Collaboration (2021) JINST **16** P08059
[2] SNO+ Collaboration (2019) Phys.Rev.D. **99** 012012
[3] SNO+ Collaboration (2019) Phys.Rev.D **99** 032008
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[8] Auty et al. (2023) Nuc.Inst.Meth.A **1051** 168204

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