Reactor $\bar{\nu}$ oscillations and Geoneutrinos in SNO+

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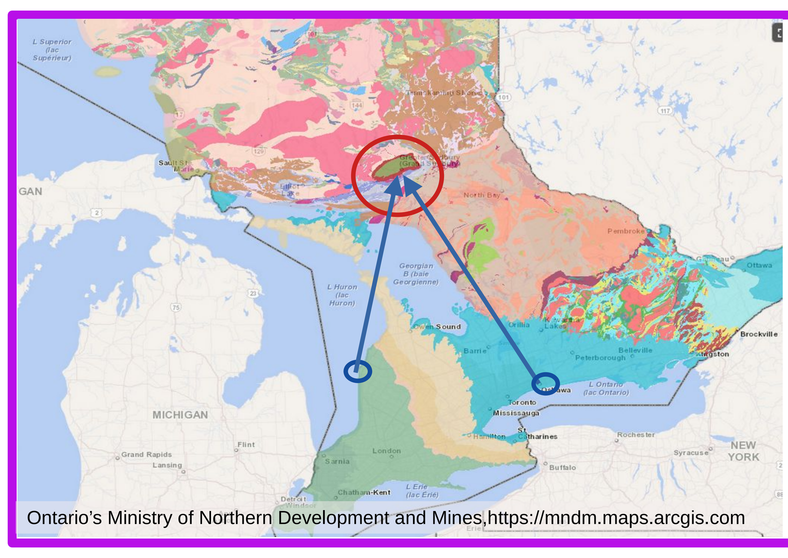


The SNO+ detector is located 2 km deep at SNOLAB, in Canada

Around half of the expected antineutrino flux is from nuclear power plants at 240 km and 350 to 355 km away

Antineutrino inverse beta decay ($\bar{\nu}$ + p → e^+ + n) analysed, with increasing sensitivity to oscillations and geoneutrinos

Evidence of antineutrinos from distant reactors using pure water, *PRL 130, 09180 (2023)*
Water phase data from 2018/19

Initial measurement of reactor antineutrino oscillation, *submitted to PRD (2024)*
Partial fill phase data from 2020

Measurement of reactor antineutrino oscillation and geoneutrino flux *(2024)*
Full fill phase data from 2022/23

SNO+ presents a new measurement of Δm^2_{12} from long baseline reactor $\bar{\nu}$ oscillations

The geoneutrino flux at SNOLAB is fit from the same data but still with low sensitivity

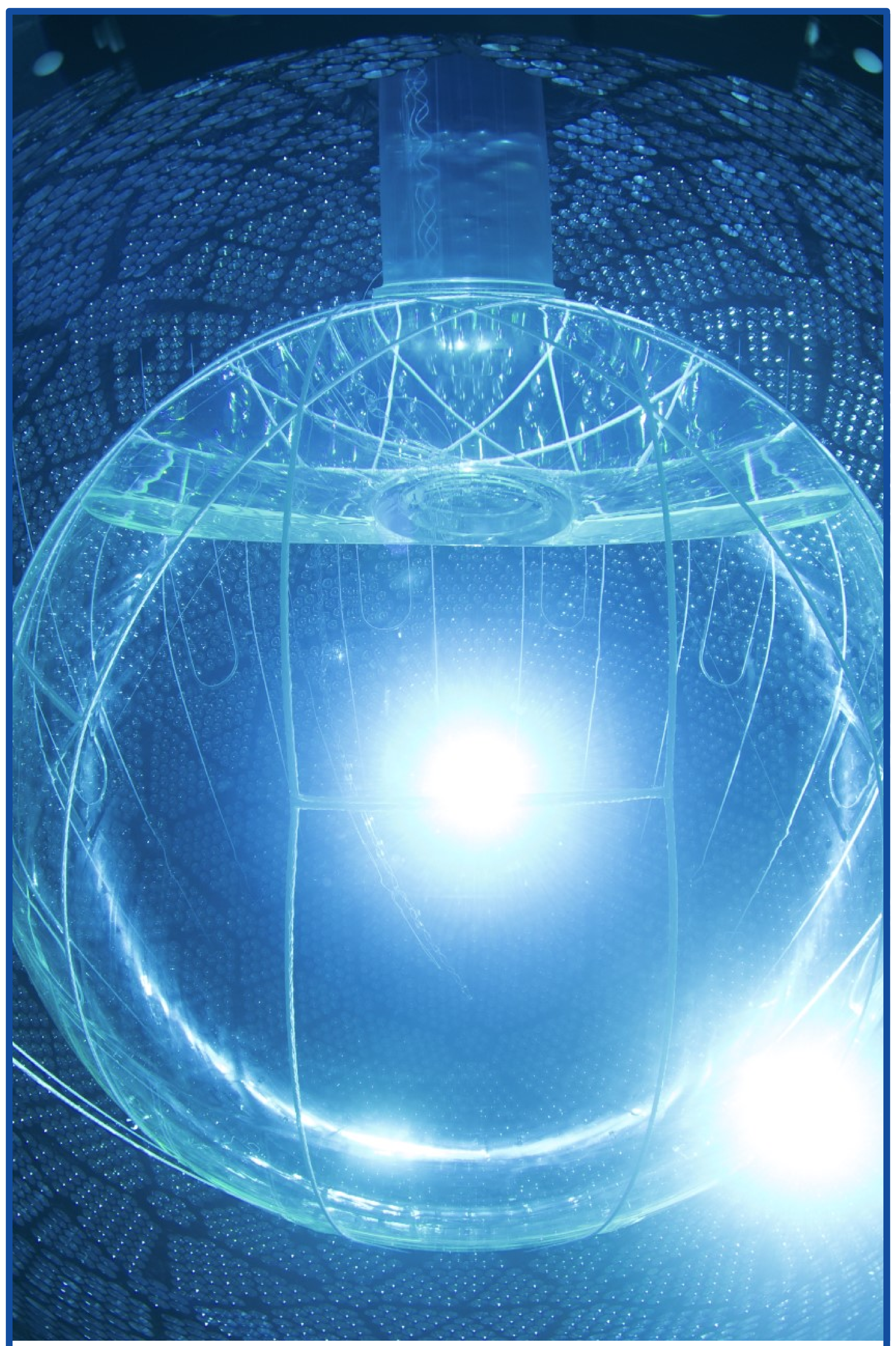


Photo of the SNO+ detector in 2020. Liquid scintillator is fed from the top of the 6-m radius sphere, replacing the pure water. 9362 PMTs sit at 9 m from the center.

oscillated reactor $\bar{\nu}$

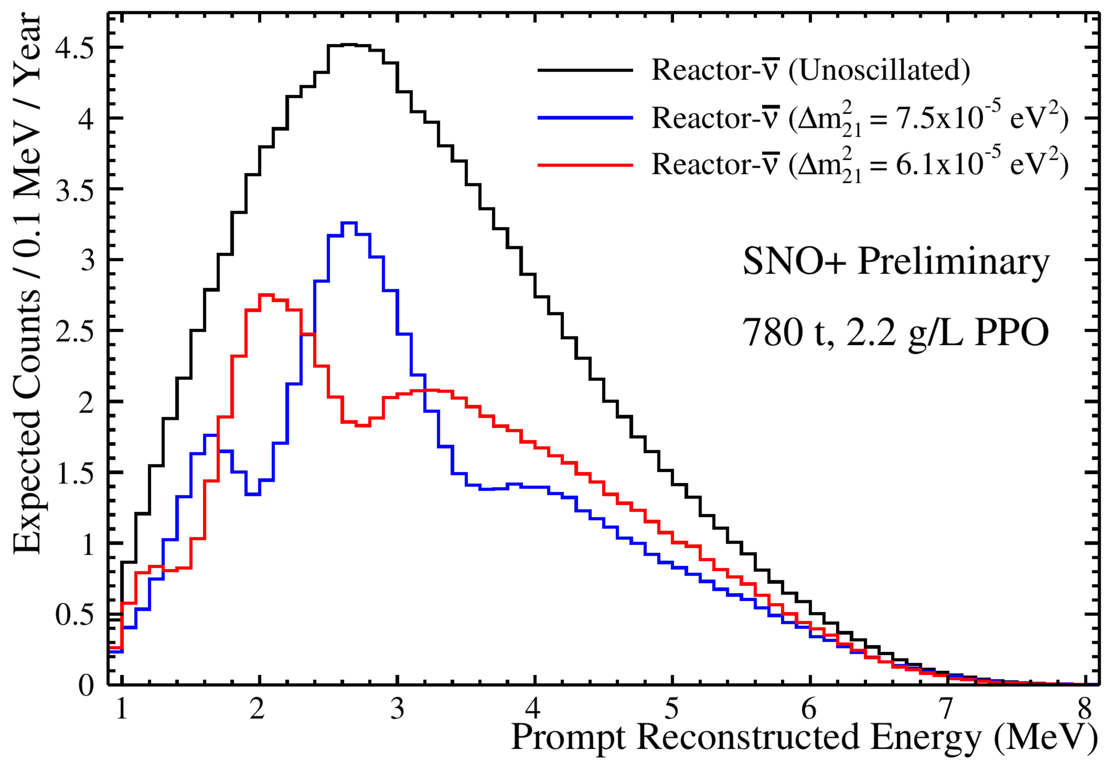
60% of reactor $\bar{\nu}$ flux from PHWR canadian reactors, constant refueling and hourly power info

40% of reactor $\bar{\nu}$ flux from PWR/BWR around the world average over 100 reactor with monthly power info

All reactors are assigned the same conservative uncertainty

Three neutrino mixing framework including matter effects over a constant density along the North American crust

Δm^2_{12} sensitivity similar to measurement by KamLAND (easy to distinguish from solar neutrino data only result)



(α,n) background

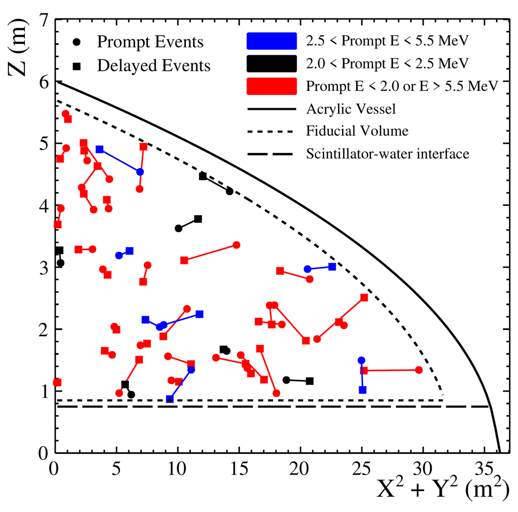
α + ^{13}C → ^{16}O* + n (low E) BR~9% with O* de-excitation

α + ^{13}C → ^{16}O + n (high E) BR~91% with neutron scatter on protons and C

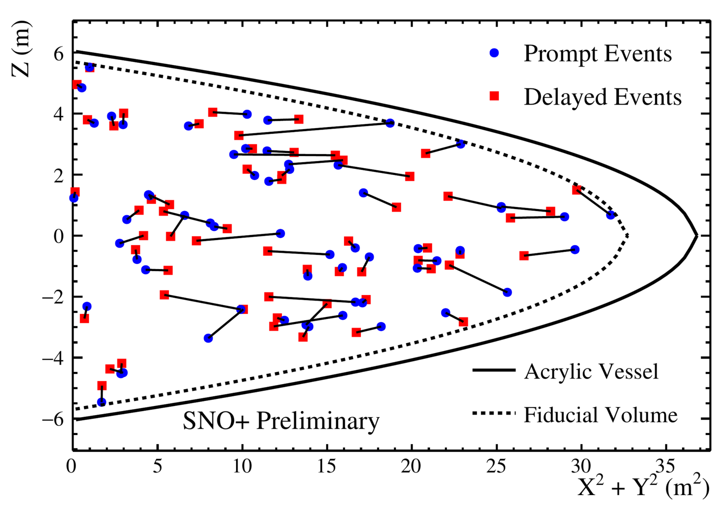
large uncertainty in modeling (α,n) differential cross-section

main source of α are ^{210}Po decays, directly measured in data, specific activity decreased with time from partial to full fill

Partial-fill event pairs



Full-scintillator-fill event pairs

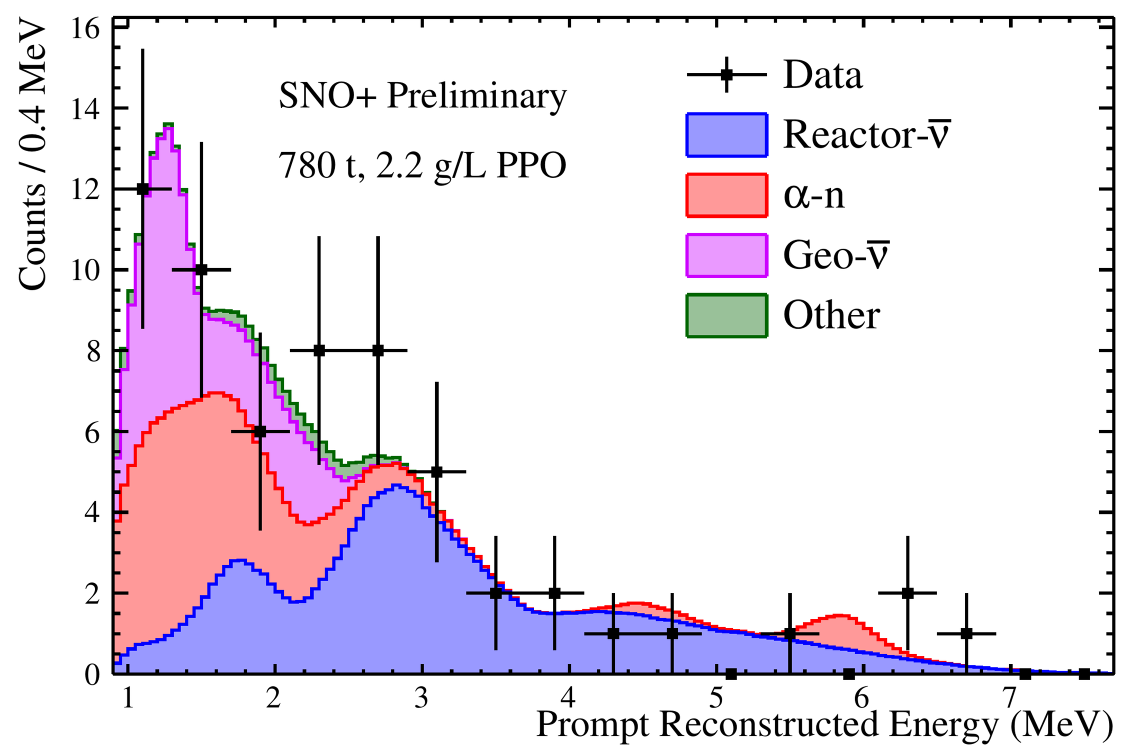


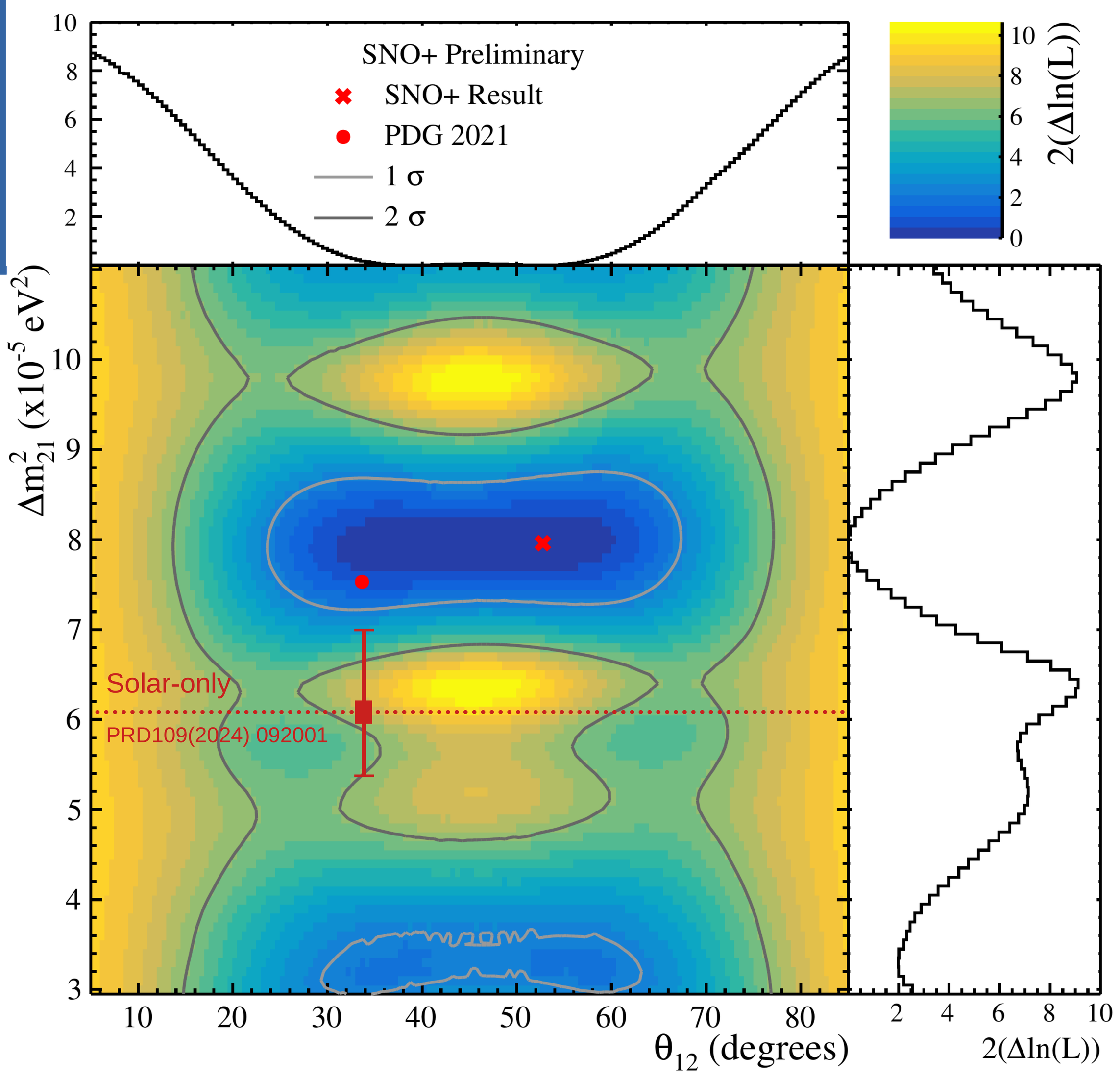
U+Th geoneutrinos

SNO+ will make the first measurement of geoneutrinos from the North American continental crust

The sensitivity is limited by statistics and (α,n) background

Geoneutrino with average survival probability at all energies and 70 TNU flux (U: 55 TNU; Th: 15 TNU)





spectral fit results

SNO+ Preliminary: event numbers from oscillation fit

	Reactor IBD	Geo IBD	(α,n) bkg.	Data (*sum)
Partial Fill 114 ton-yr	9.5 ± 0.3	2.5 ± 2.1	32.4 ± 5.6	45 (44.6)
Full LS fill 286 ton-yr	28.0 ± 0.8	9.9 ± 6.9	18.4 ± 4.7	59 (57.5)
400 ton-yr Total exposure	37.5	12.4	50.8	104
external constraints	± 3%	± 30% U / Th	30% O 100% O*	

*sum of expectations includes O(1 event) from other backgrounds

SNO+ Preliminary: spectral fits for oscillation and geoneutrinos

	SNO+ $\bar{\nu}$ only	SNO+ with PDG2021
mixing angle, θ_{12}	$53^{o}\,^{+9^o}_{-25^o}$	33.6º ± 0.8º
mass difference, Δm^2_{12} (10^{-5} eV²)	$7.96\,^{+0.48}_{-0.41}$	$7.59\,^{+0.18}_{-0.17}$
geoneutrino flux @SNOLAB	70 ± 48 TNU	64 ± 44 TNU

SNO+ data compatible with global oscillation parameters

1.5 σ tension between reactor $\bar{\nu}$ and solar ν oscillations

future prospects

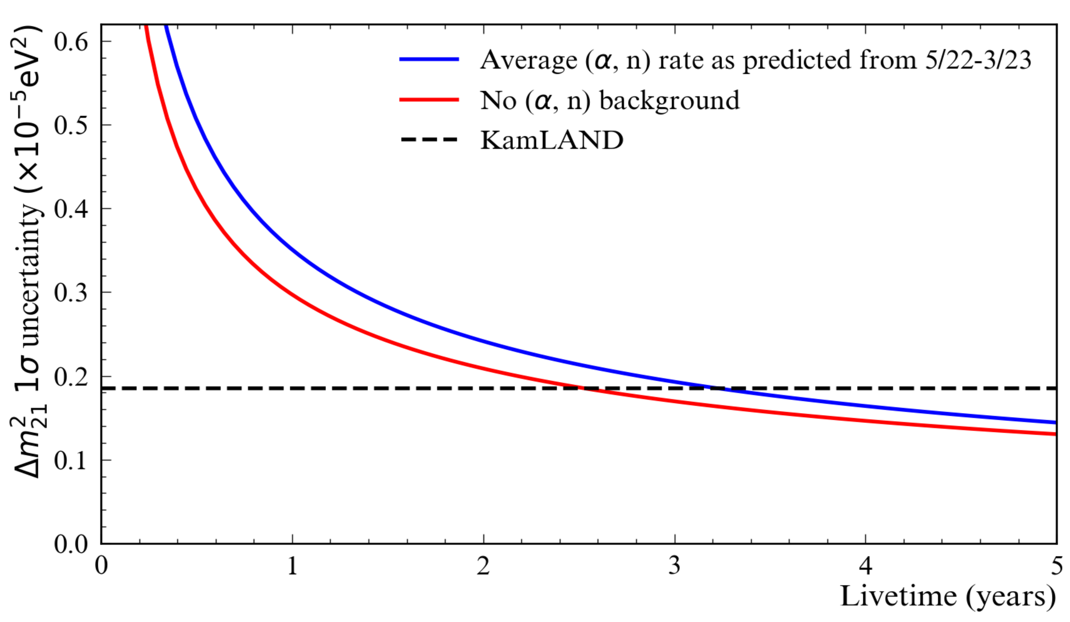
In 3 years, SNO+ is expected match KamLAND precision on Δm^2_{12}

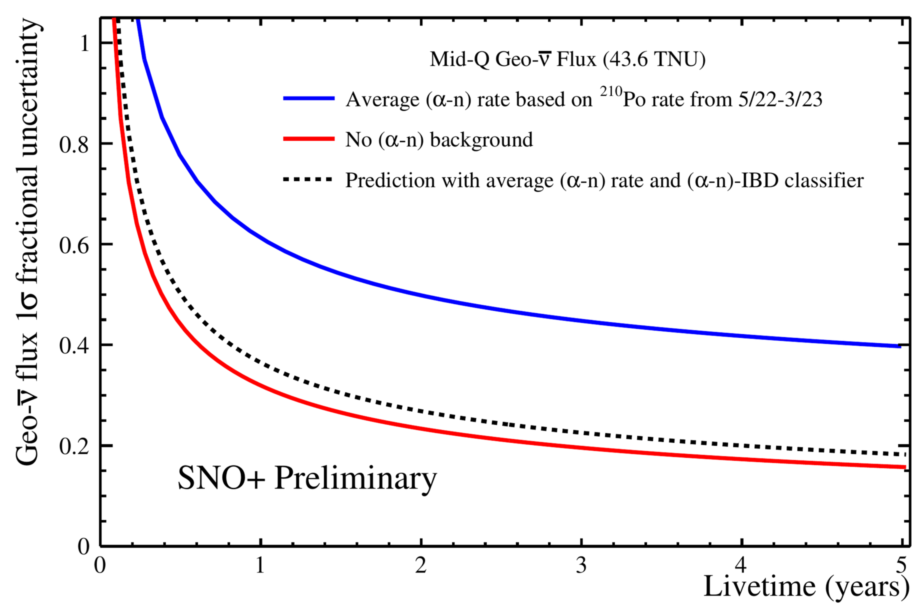
Geoneutrino sensitivity strongly impacted by improved (α,n) rejection

***(poster #483)** Event-by-event classification of (α,n) and IBD interactions at SNO+*

SNO+ measures oscillations from reactor and solar neutrinos together

***(poster #544)** Measuring solar neutrino oscillations in the SNO+ detector*





https://snoplus.ca/

PTDC/FIS-PAR/2679/2021

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