WIN 2025

9–13 June 2025
University of Sussex, Brighton, UK

WiN 25

XENON

清華大學
Tsinghua University

Into the Neutrino Fog

First Measurement of Solar B8 CEvNS and Light WIMPs Search in XENONnT

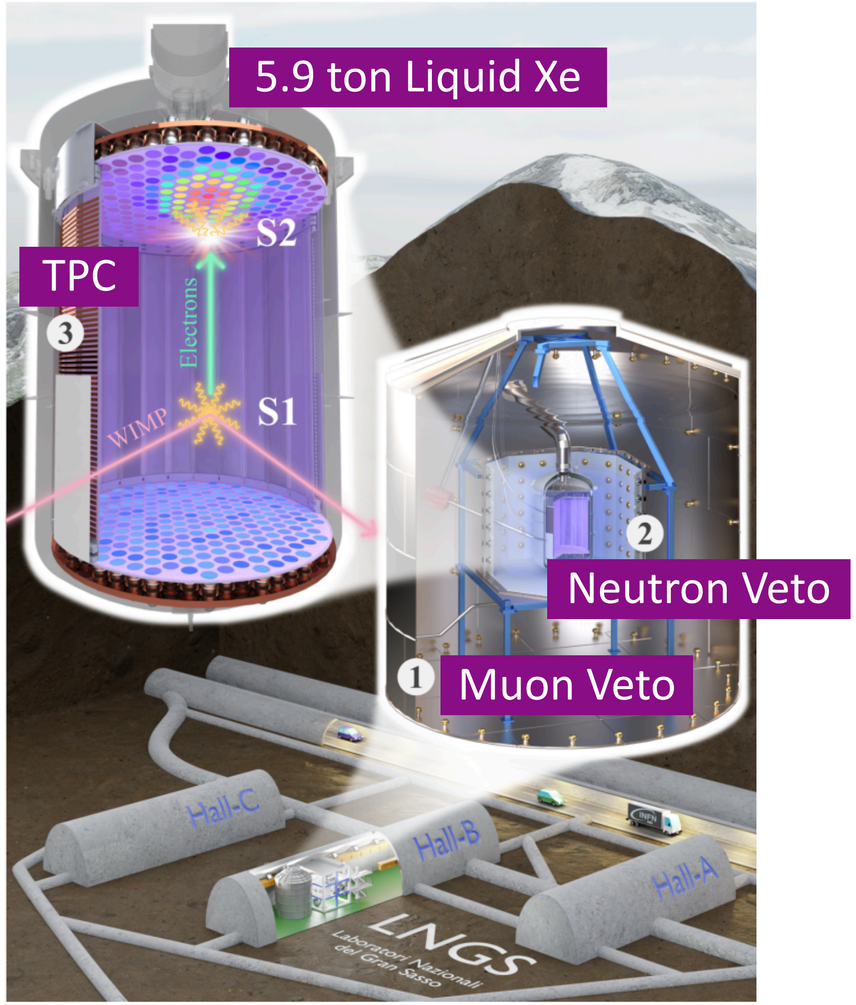
Kexin Liu(刘可欣)

On behalf of the XENON Collaboration

WIN 2025 @ University of Sussex

XENONnT : Dark Matter Direct Detection

XENON

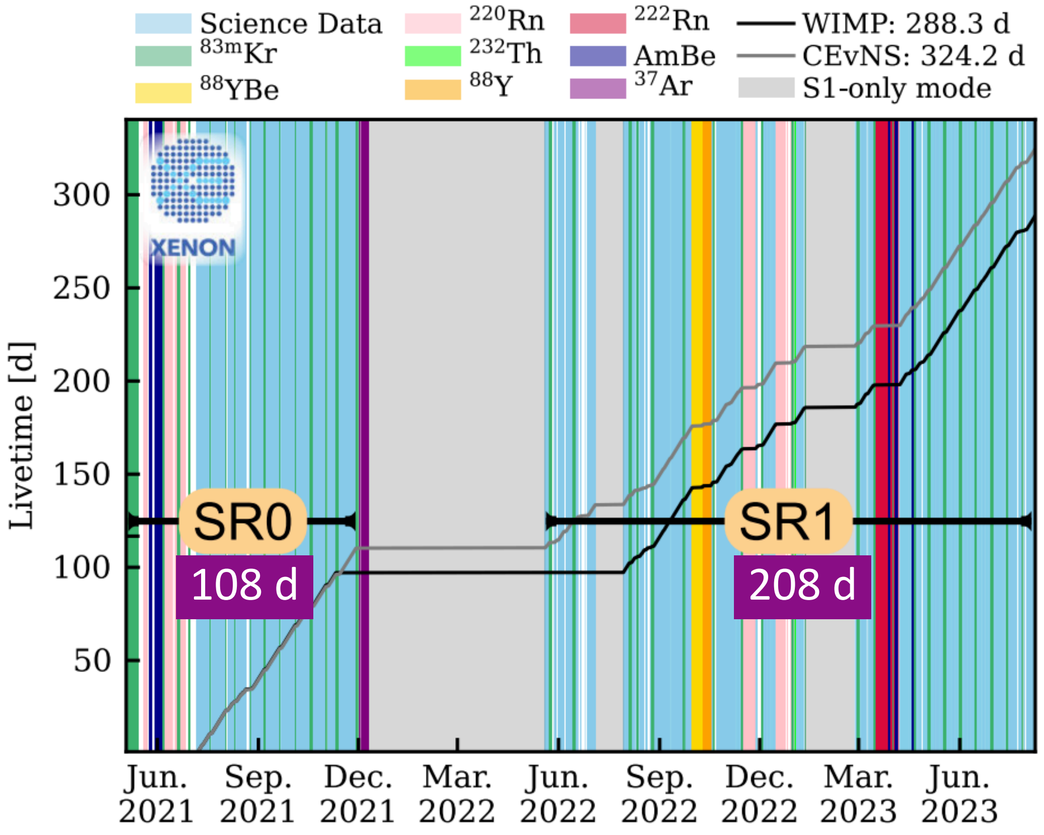


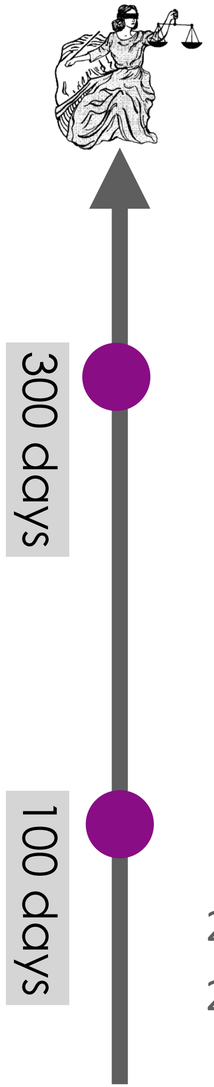
arXiv.2502.04209

XENON COLLABORATION
~200 SCIENTISTS 30 INSTITUTIONS 12 COUNTRIES

Science Data and Science Results from XENONnT

Fiducial Mass 4t ×

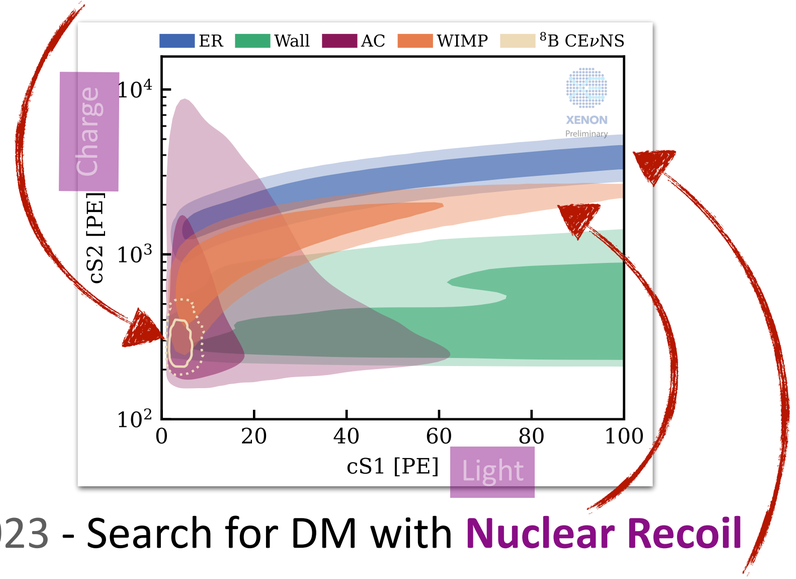




2025 - Search for DM with **Nuclear Recoil**

2025 - First search for **light DM** in the neutrino fog

2024 - First measurement of the **Solar ^{8}B CEvNS**

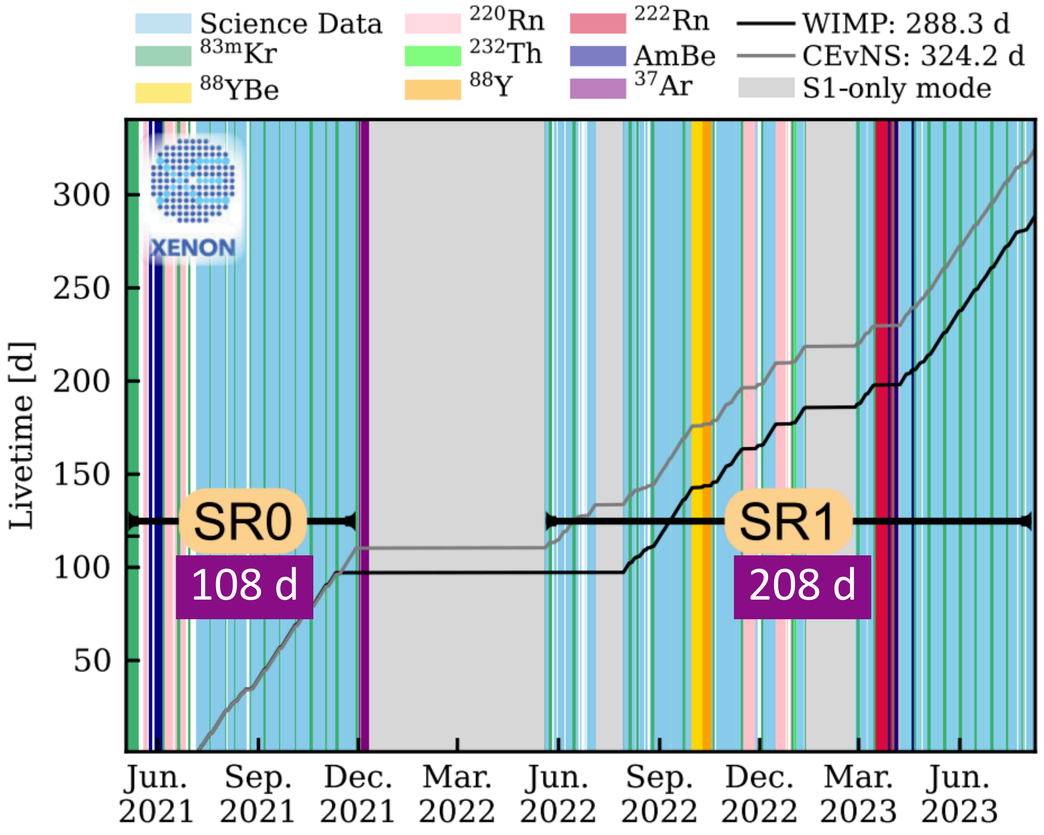


2023 - Search for DM with **Nuclear Recoil**

2022 - Search for DM with **Electronic Recoil**

Science Data and Science Results from XENONnT

Fiducial Mass 4t ×



300 days

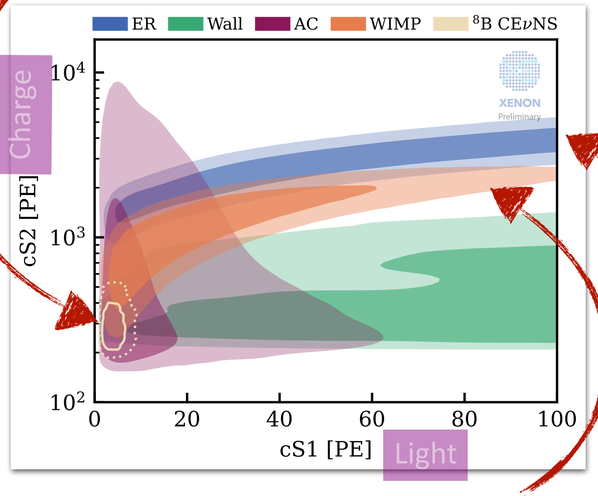
100 days

2025 - Search for DM with **Nuclear Recoil**

2025 - First search for **light DM** in the neutrino fog

2024 - First measurement of the **Solar ^{8}B CEvNS**

Today's talk

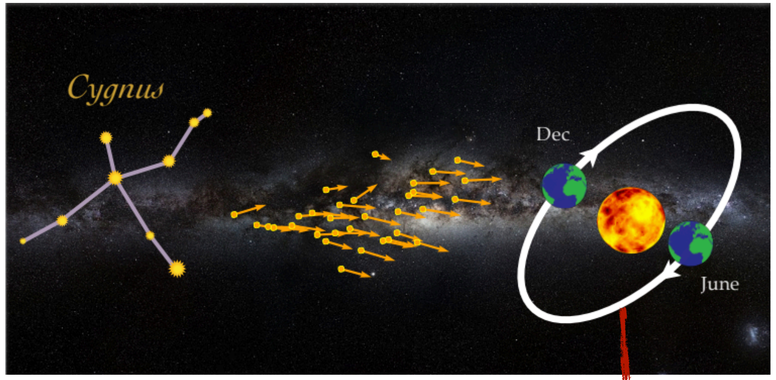


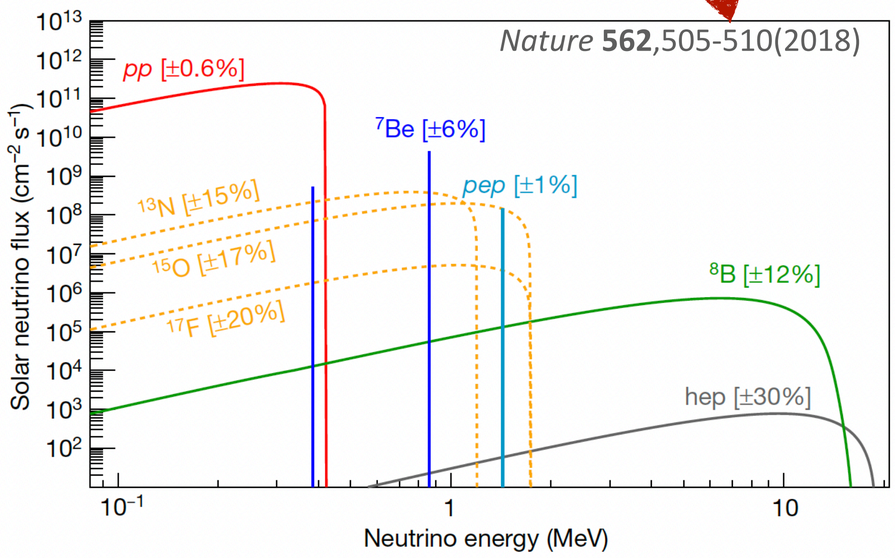
2023 - Search for DM with **Nuclear Recoil**

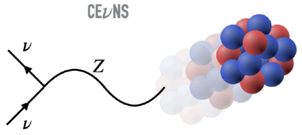
2022 - Search for DM with **Electronic Recoil**

Chat to me after!

The 'Neutrino Fog' for DM Direct Detection

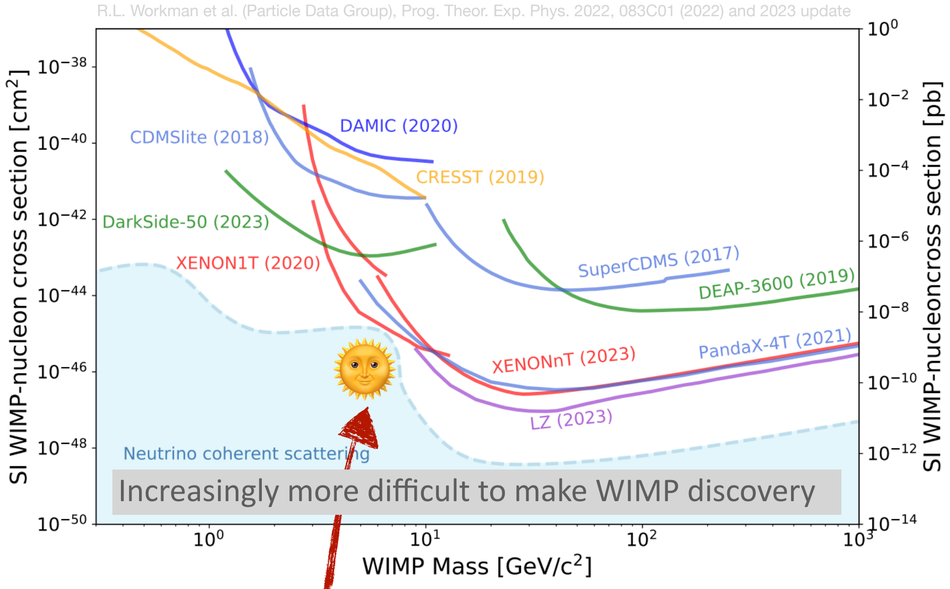


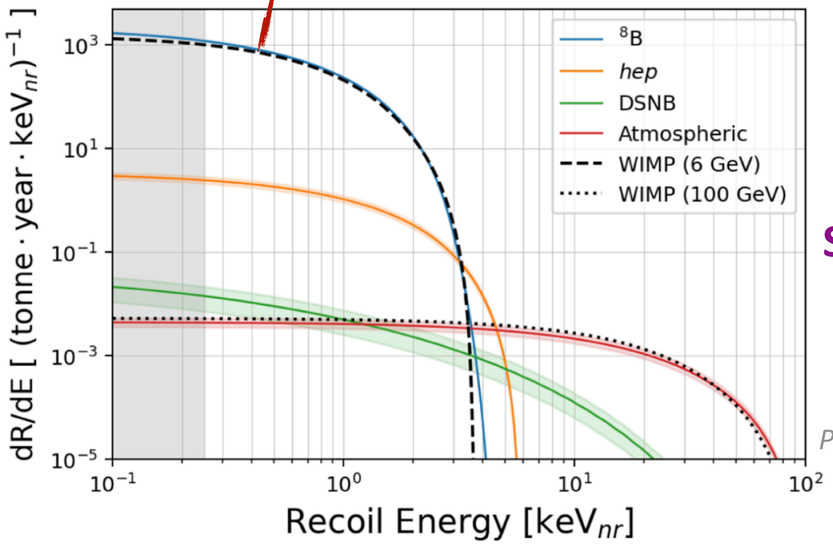




Coherent **E**lastic **N**eutrino-**N**ucleus **S**cattering **(CEvNS)**

$$\sigma \propto N^2_{neutron}$$





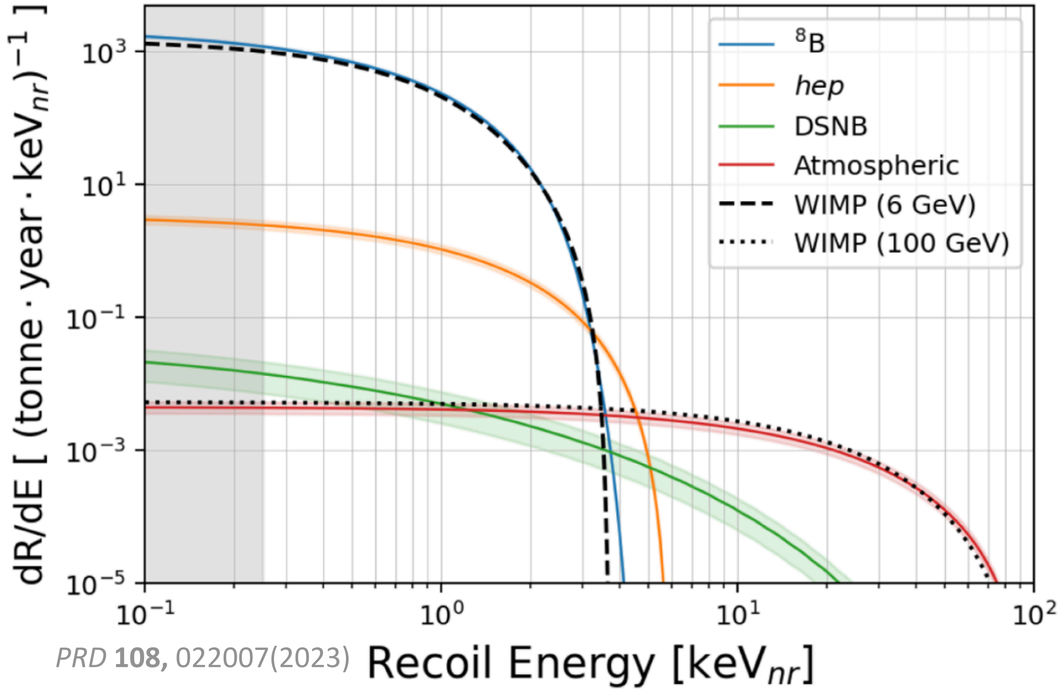
Similar spectrum!

PRD **108,** 022007(2023)

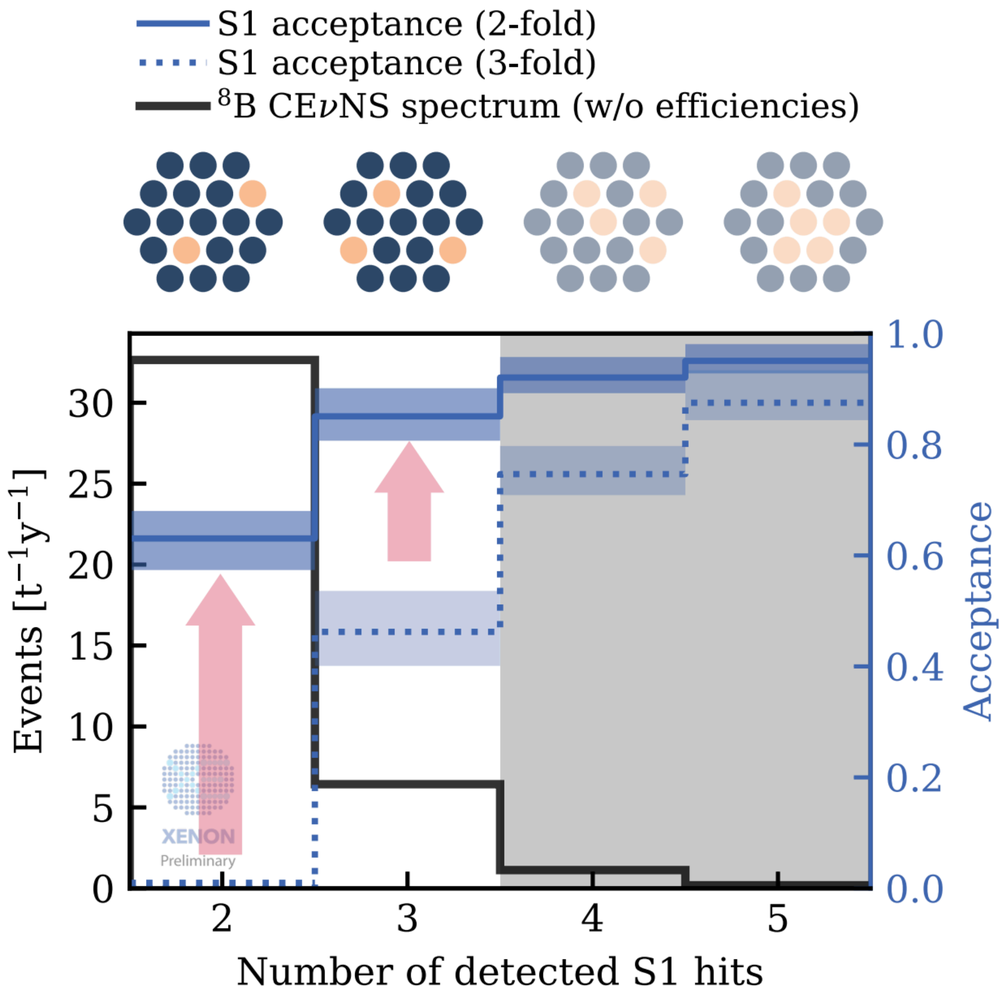
Solar ^{8}B CEvNS: Very Low Energy NR

$$S/\sqrt{N}$$
$$\delta S, \delta N$$

- Expect **only 0.23** in the SR0 WIMPs search with 3-fold
- Need to lower the energy threshold:
  - Searching for **2 or 3 photons S1**, S2 in [120, 500] PE **(~4-17) electrons**



PRD **108**, 022007(2023)



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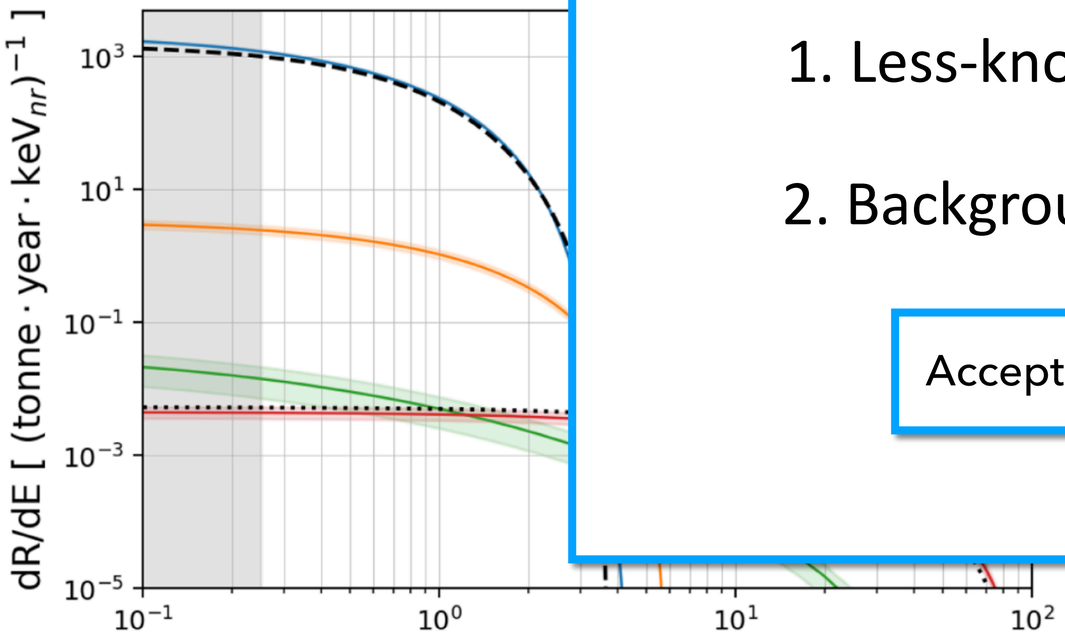
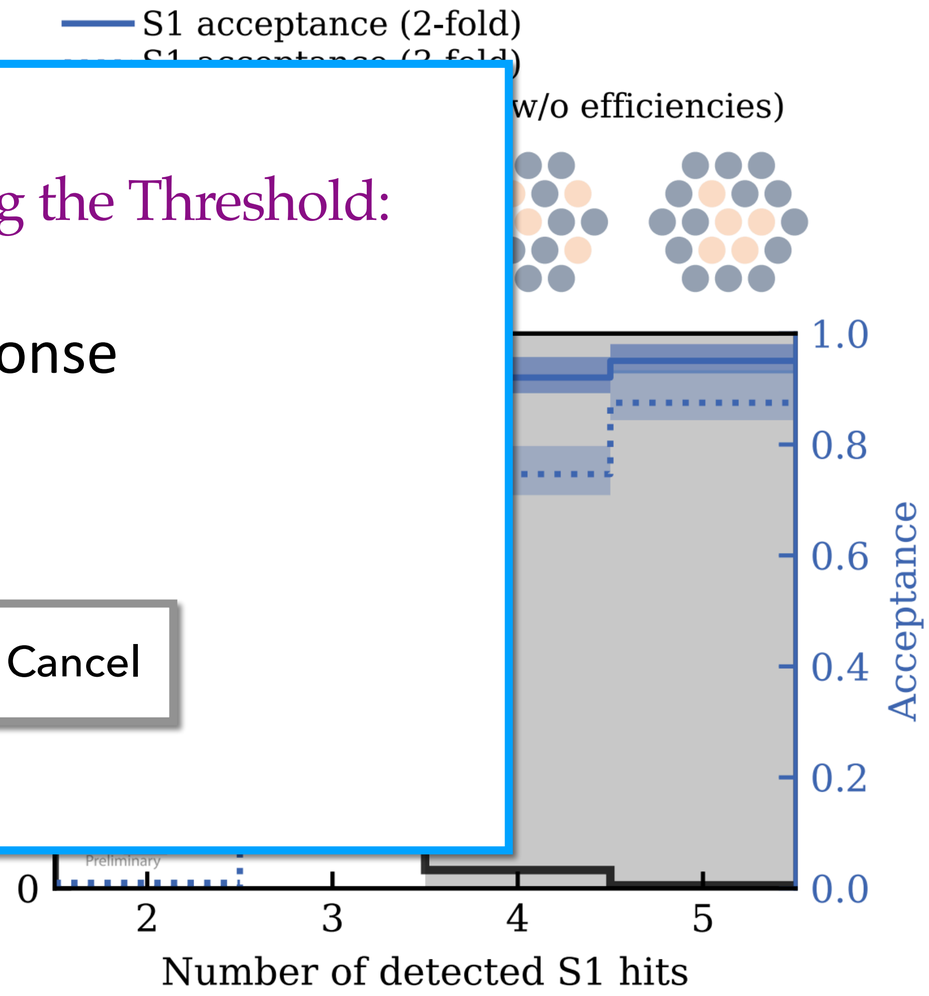


PRD **108**, 022007(2023)



×

😈Challenges for Lowering the Threshold:

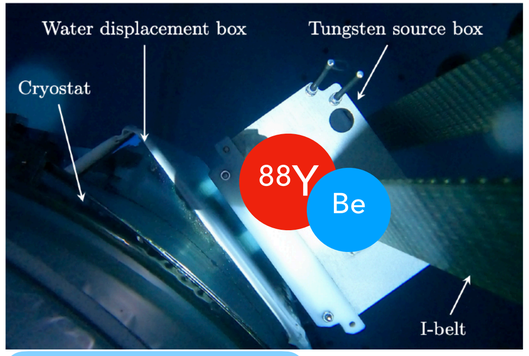
1. Less-known LXe response
2. Background Spike

Accept

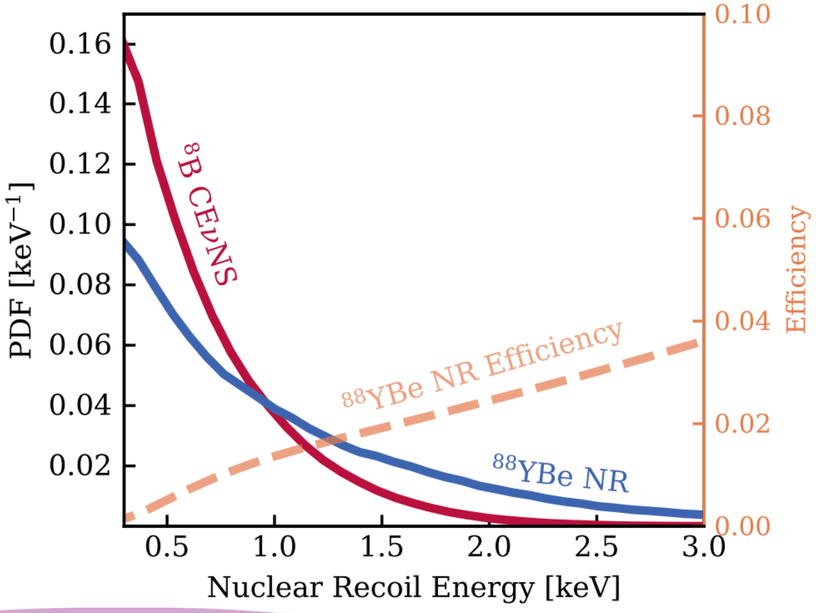
Cancel

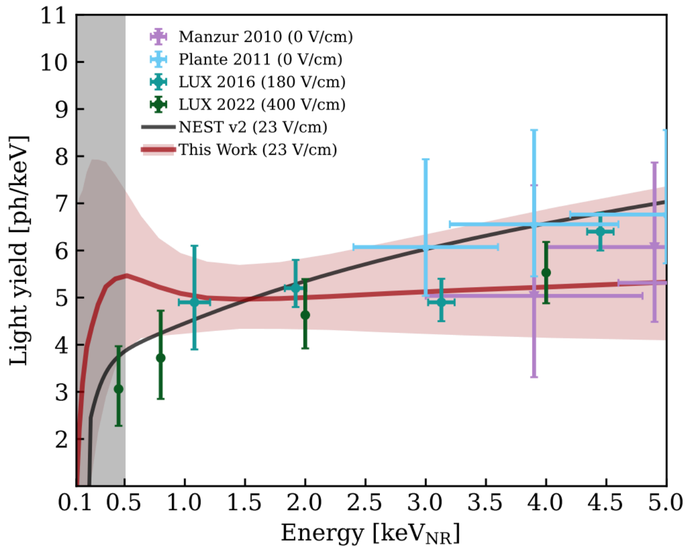
Signal: NR Calibration with ^{88}YBe

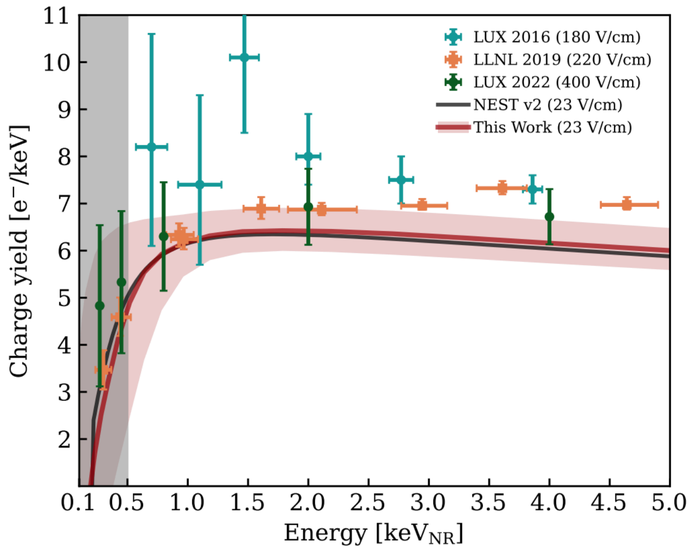
$\gamma + {}^{9}\mathrm{Be} \rightarrow n + {}^{8}\mathrm{Be}$



arXiv:2412.1045



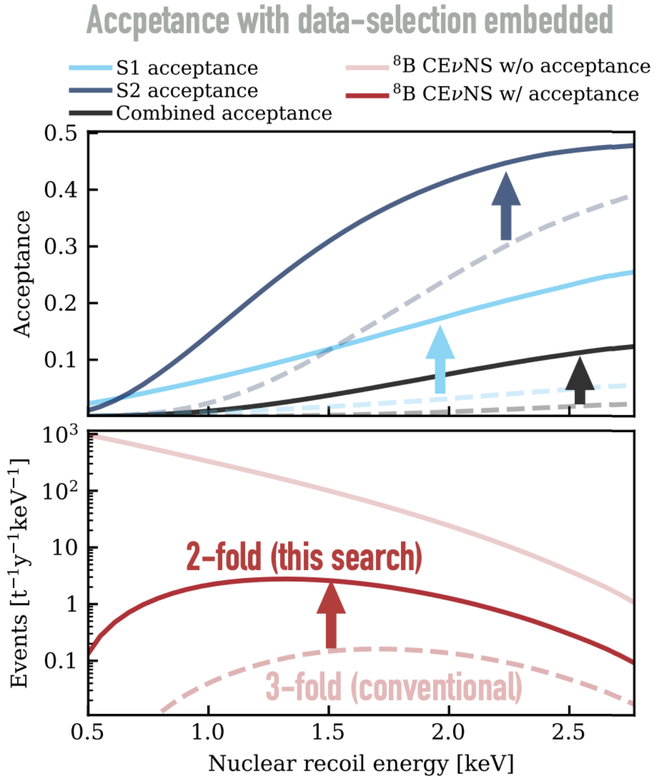




$$12^{\nu}/\sqrt{N}$$

$\delta S, \delta N$

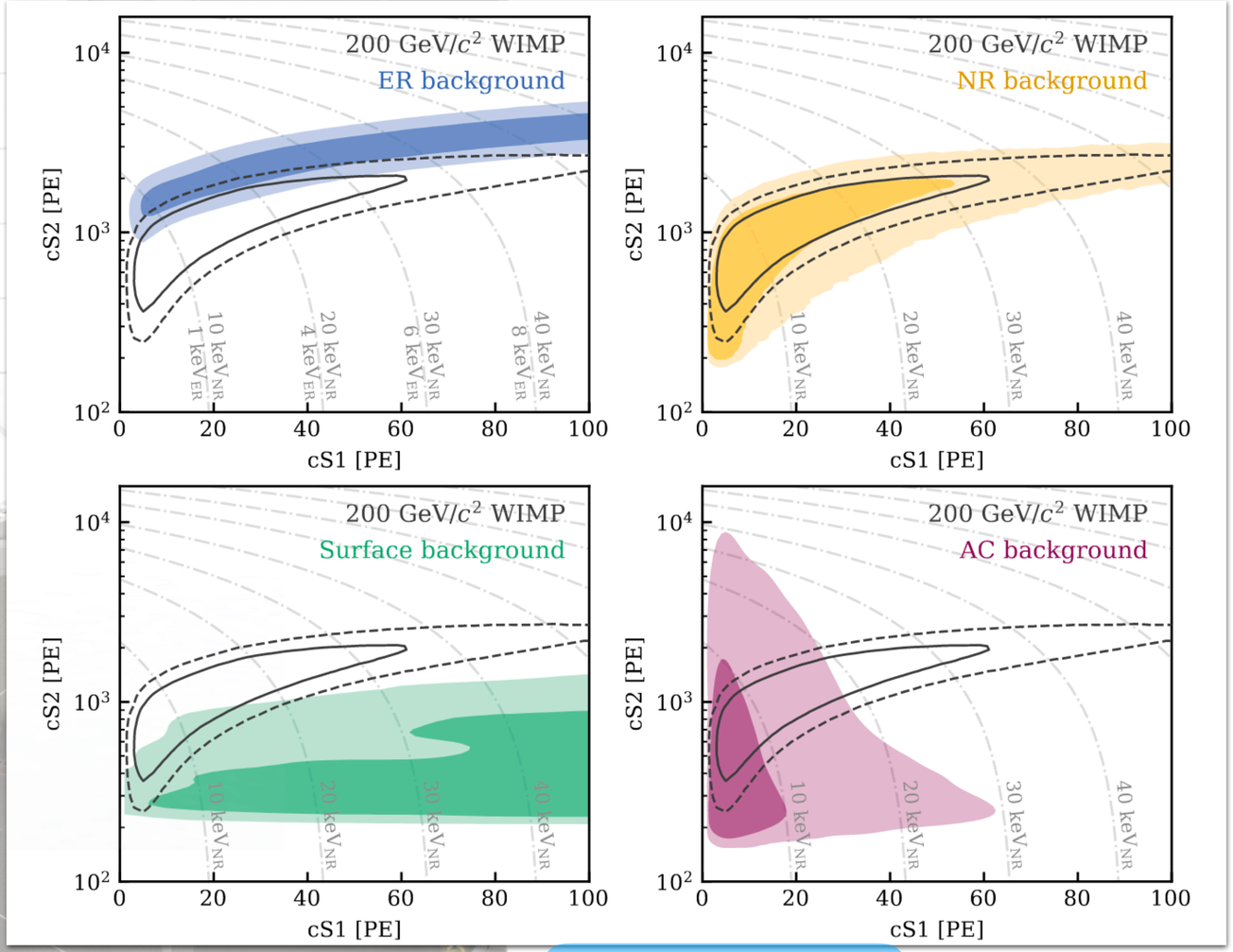
35%, from Yield model + Selection efficiency

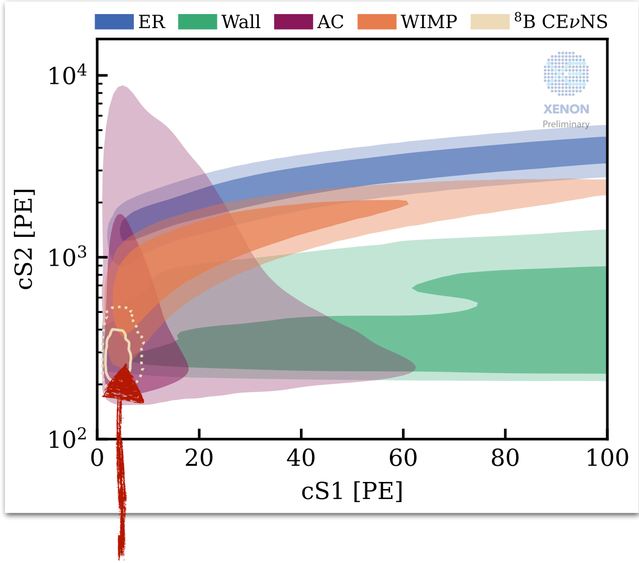


~17 TIMES MORE EVENTS

Background

Background models in XENONnT WIMP search

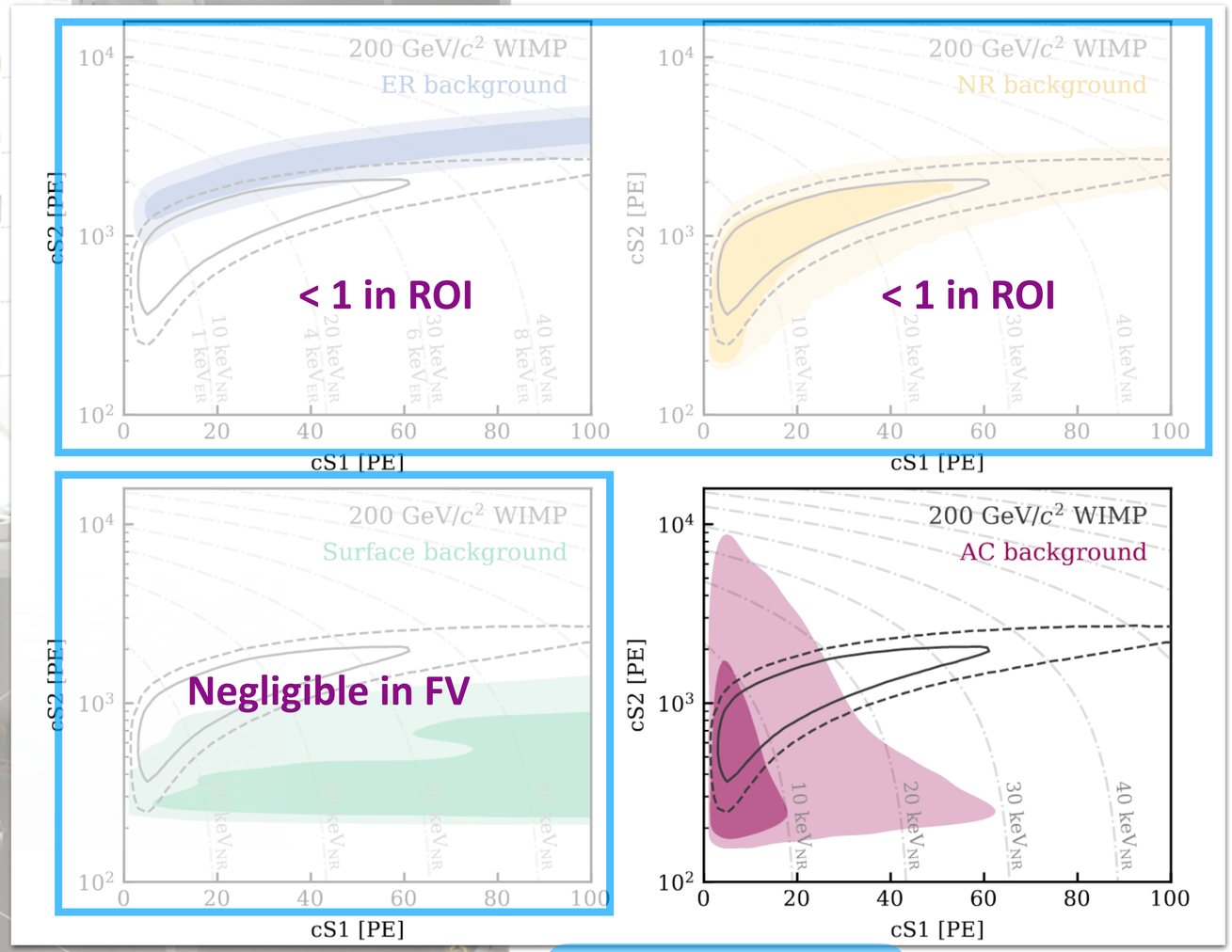


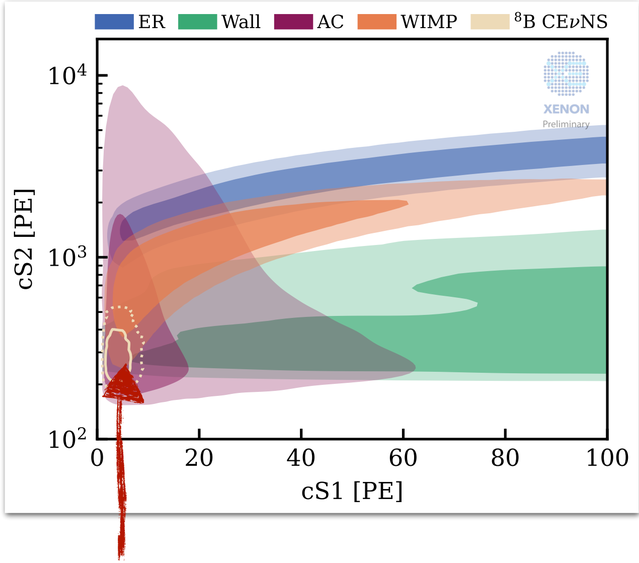


Phys. Rev. D **111**, 103040

Background

Background models in XENONnT WIMP search

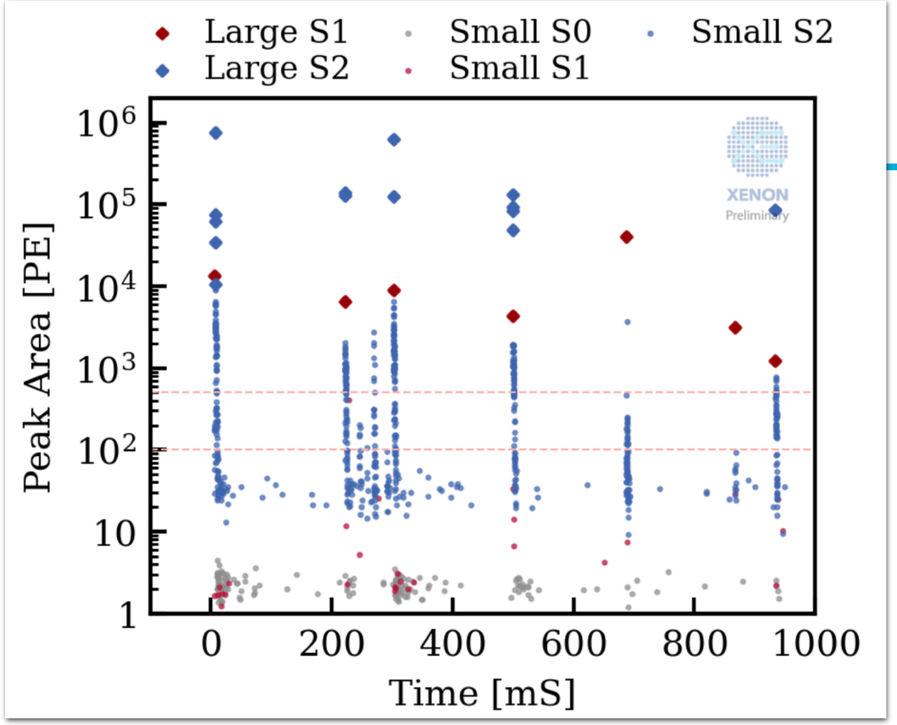




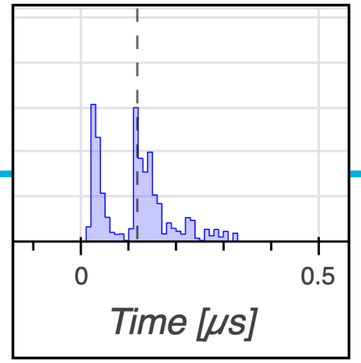
Phys. Rev. D **111**, 103040

Background: Accidental Coincidence (AC)

$$12/\sqrt{10000}\,?$$

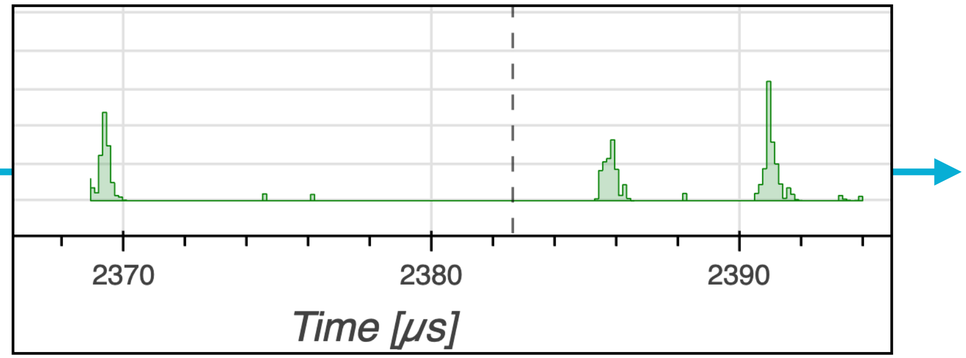


Isolated S1



PMT lone-hits pile-ups, …

Isolated S2

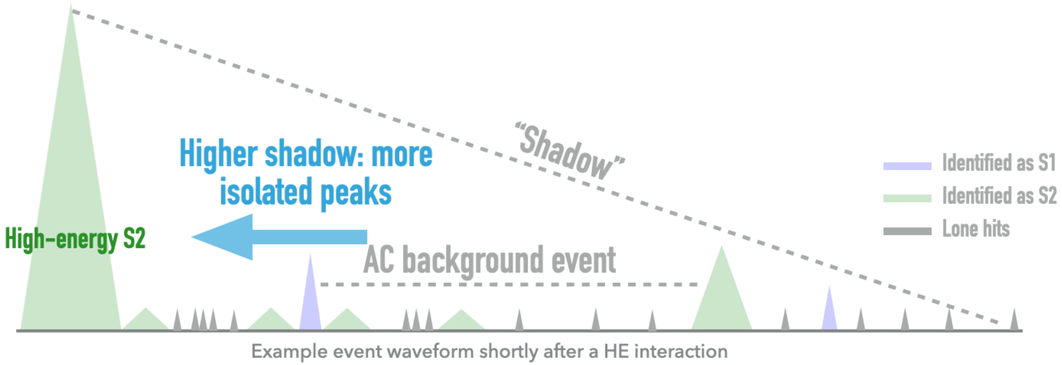


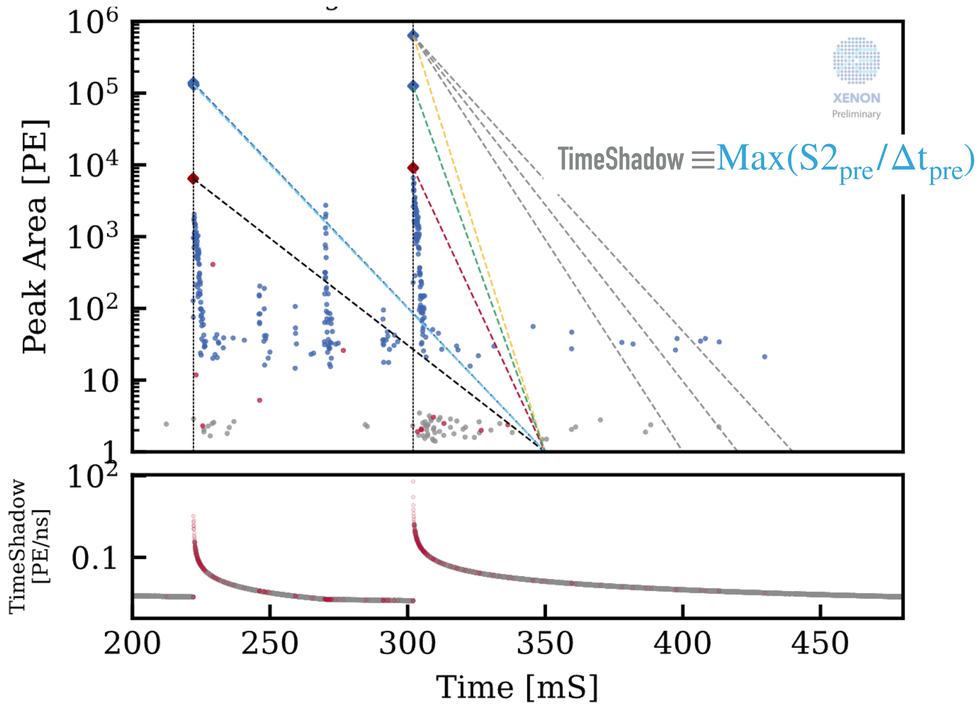
Hypothesis: delayed electrons, from electrodes …

$$Count_{AC} = \int_{t_0}^{t_1} R_{S1}(t) \times R_{S2}(t) \times T_{max} dt$$

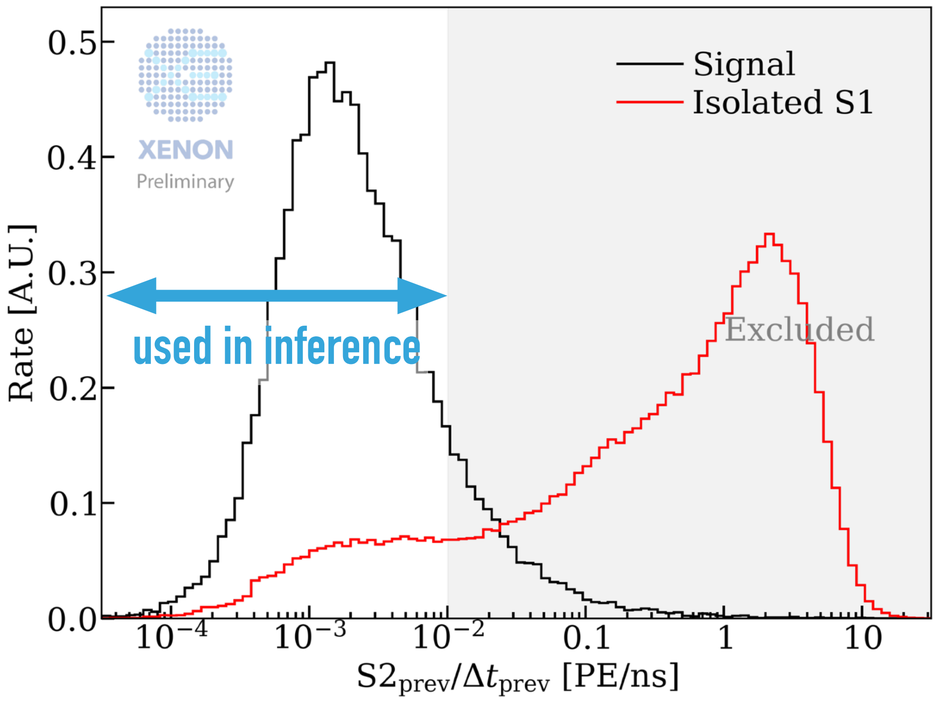
Before any suppression: 15 Hz → 0.15 Hz → 2.2 ms (23 V/cm) → ~ 400/day

AC Discrimination: by Correlations to HE peaks





Remove the **20%** worst exposure with high isolated peaks rate



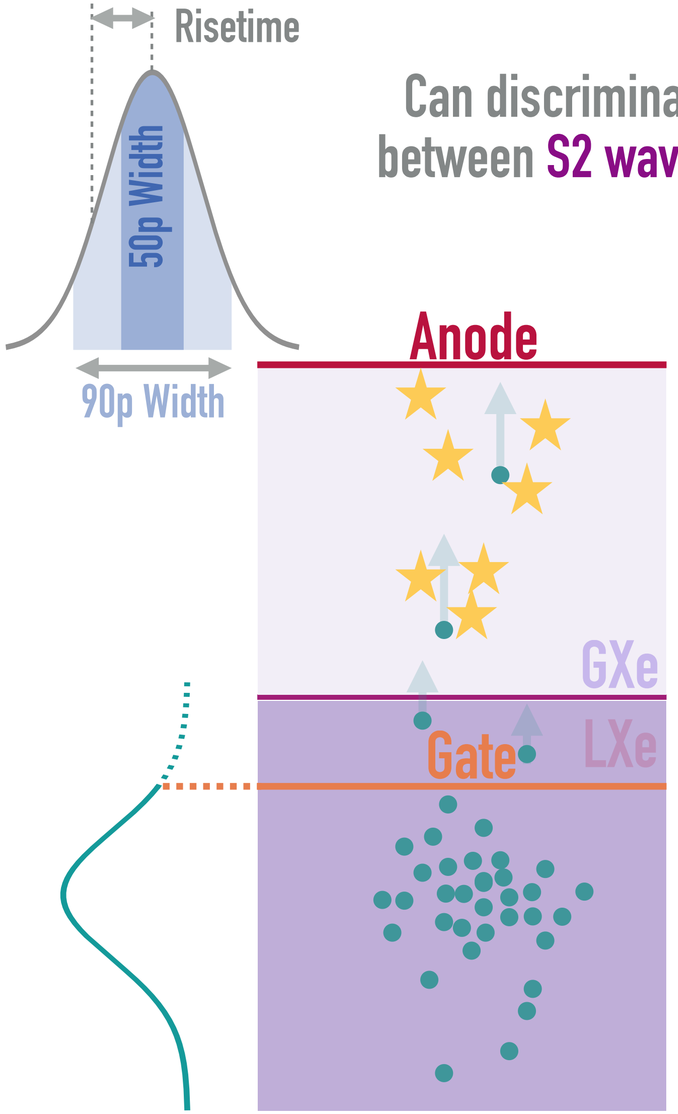
Illustrations courtesy: Dr. Lanqing YUAN

AC Discrimination: by S2 Diffusion

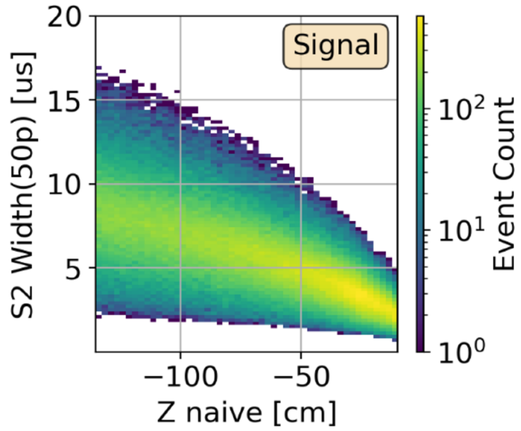
$$12/\sqrt{26}$$

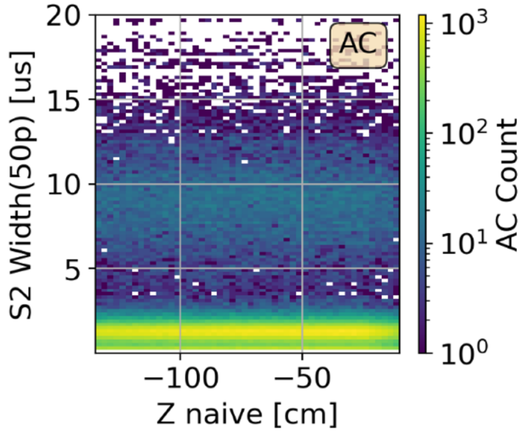
$\delta S = 35\,\%\,,\ \delta N$

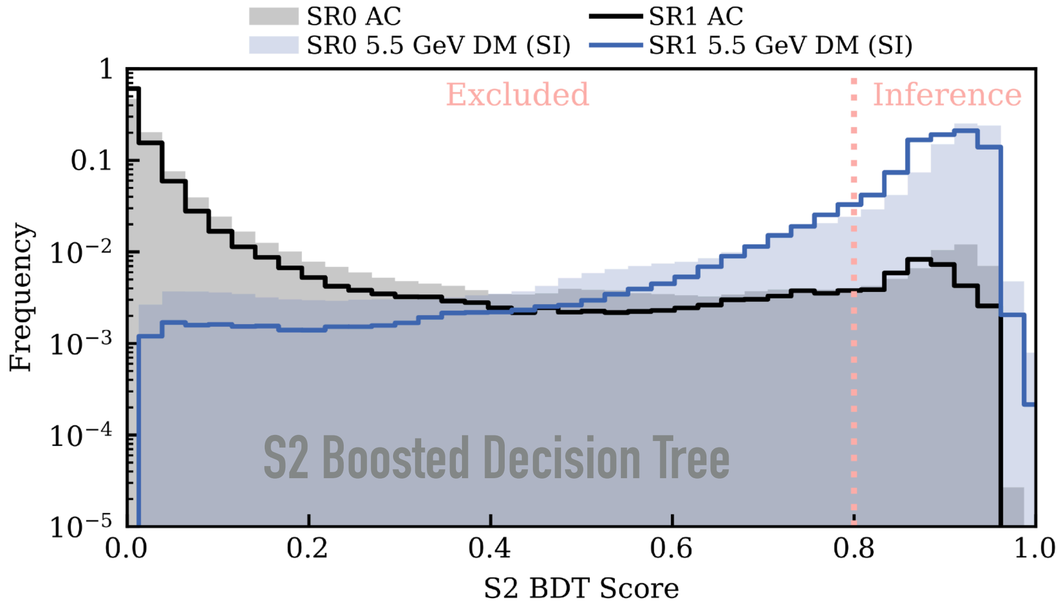
SR0:9%, SR1: 6% from sideband validation



Can discriminate against AC by correlation between **S2 waveform width** and **drift time (Z)**





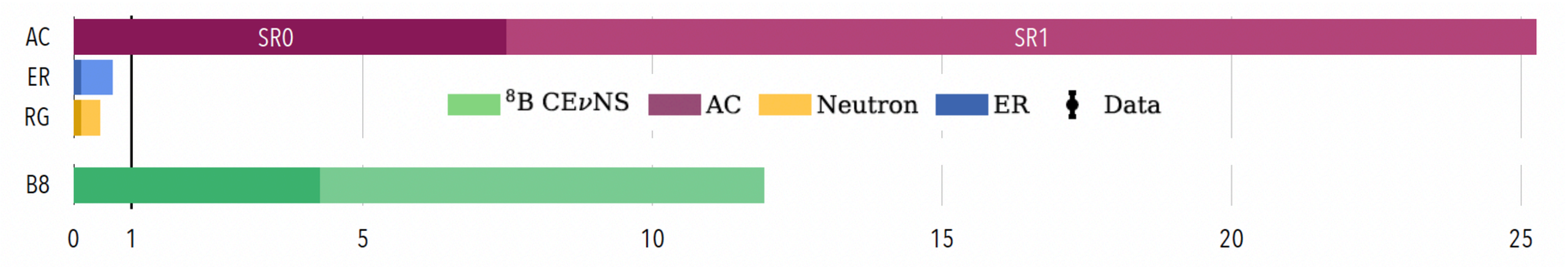


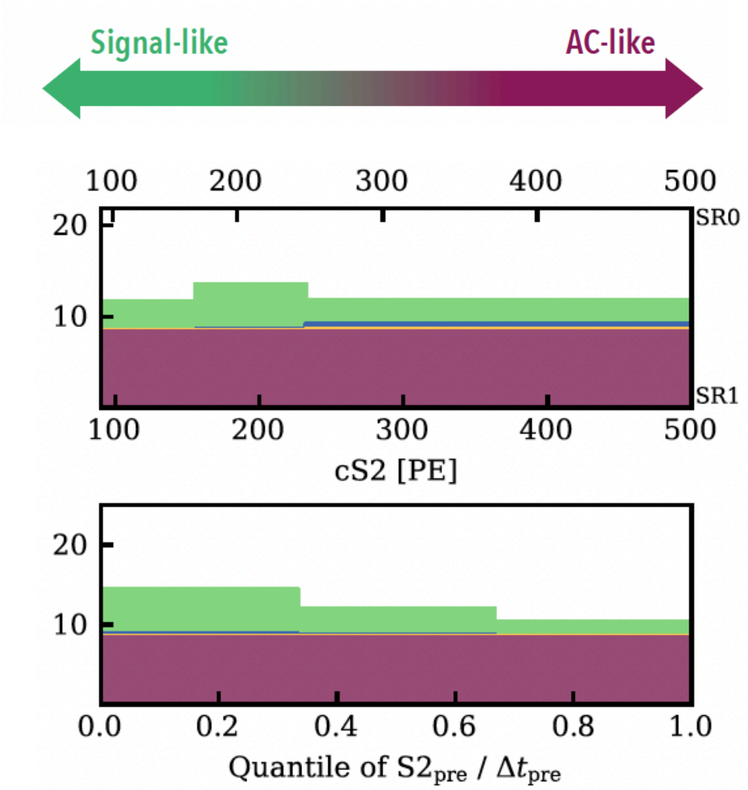
- Features ranked in importance:
  - 50-percent area range
  - Risetime
  - 90-percent area range
  - Drift-time

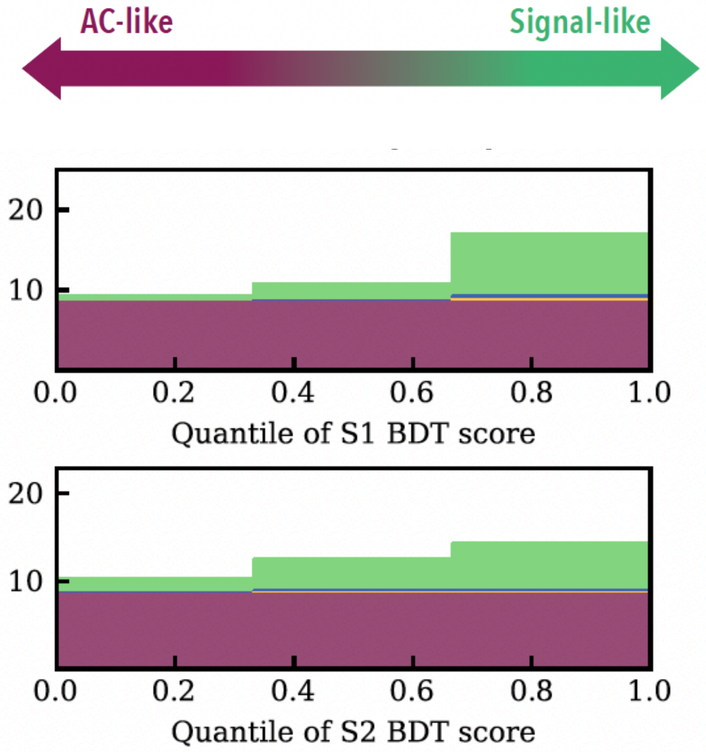
Reject about 90 % AC with 80 % signal acceptance

Illustrations courtesy: Dr. Lanqing YUAN

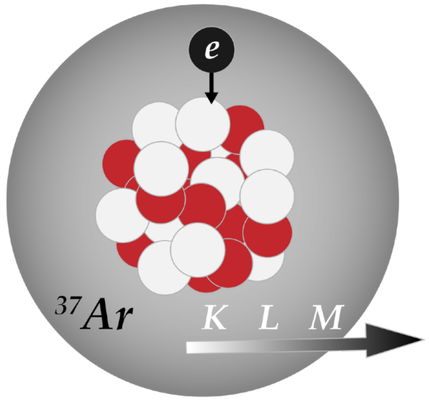
Final Predictions





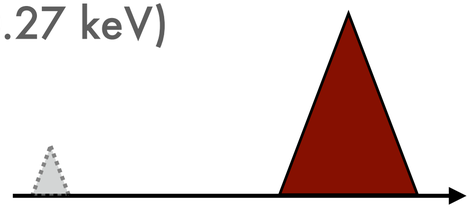


Rehearsal: search for Ar37 L-shell EC (0.27 keV ER)

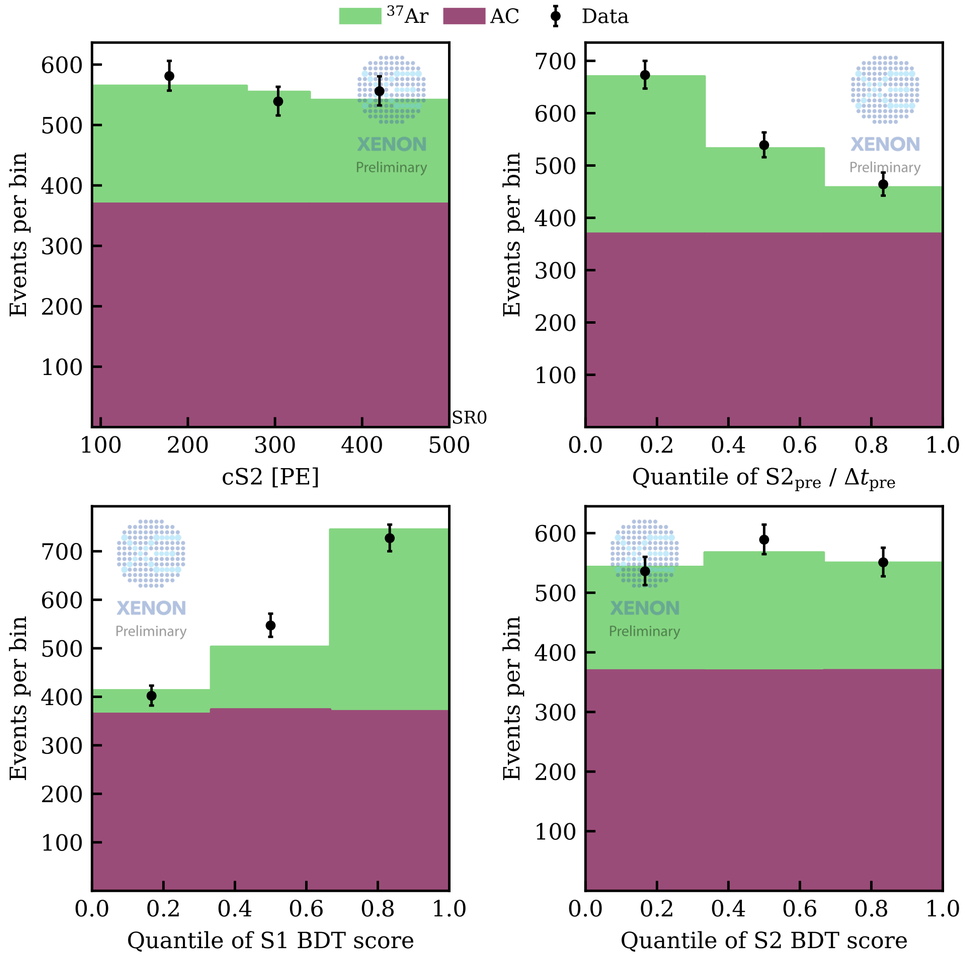


L-shell Electron Capture

(0.27 keV)

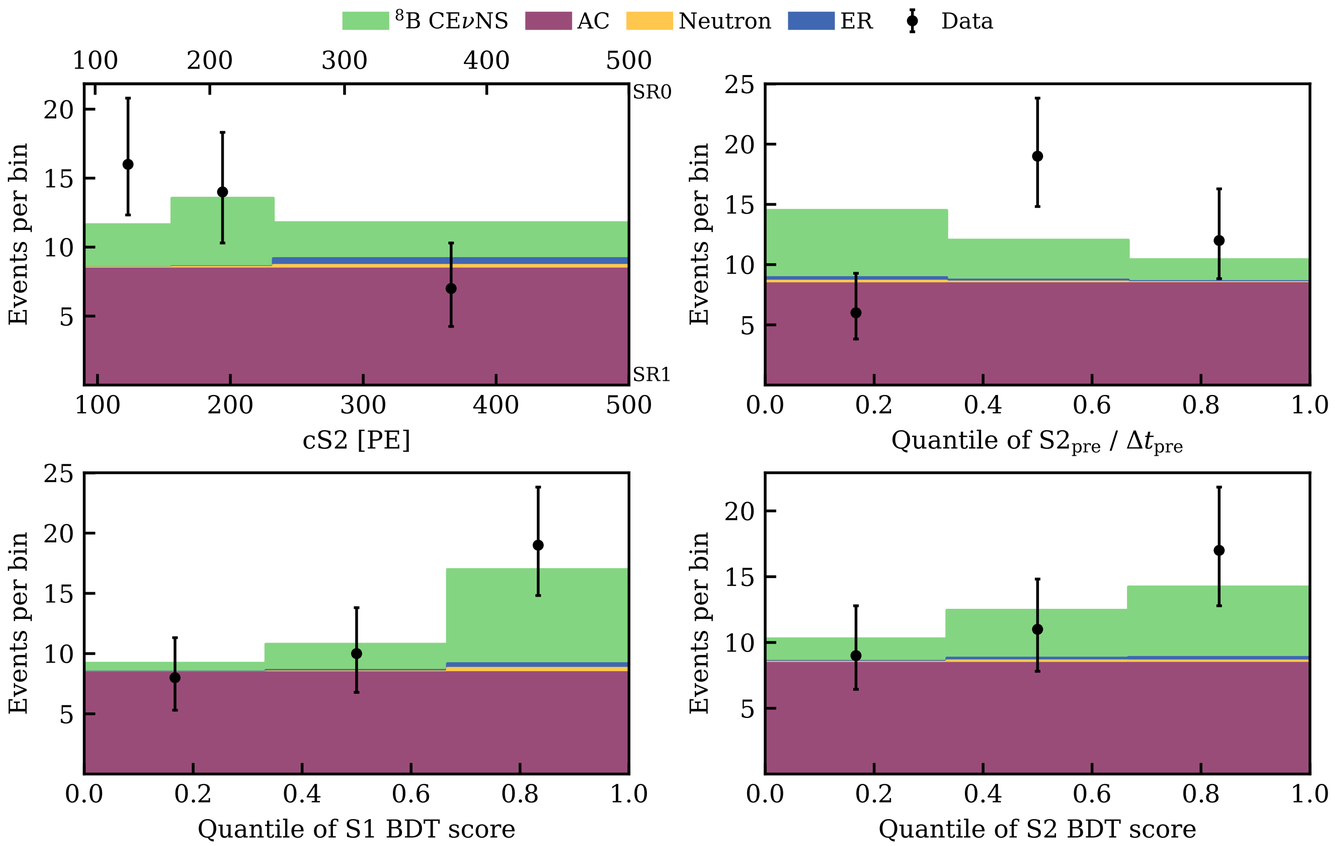


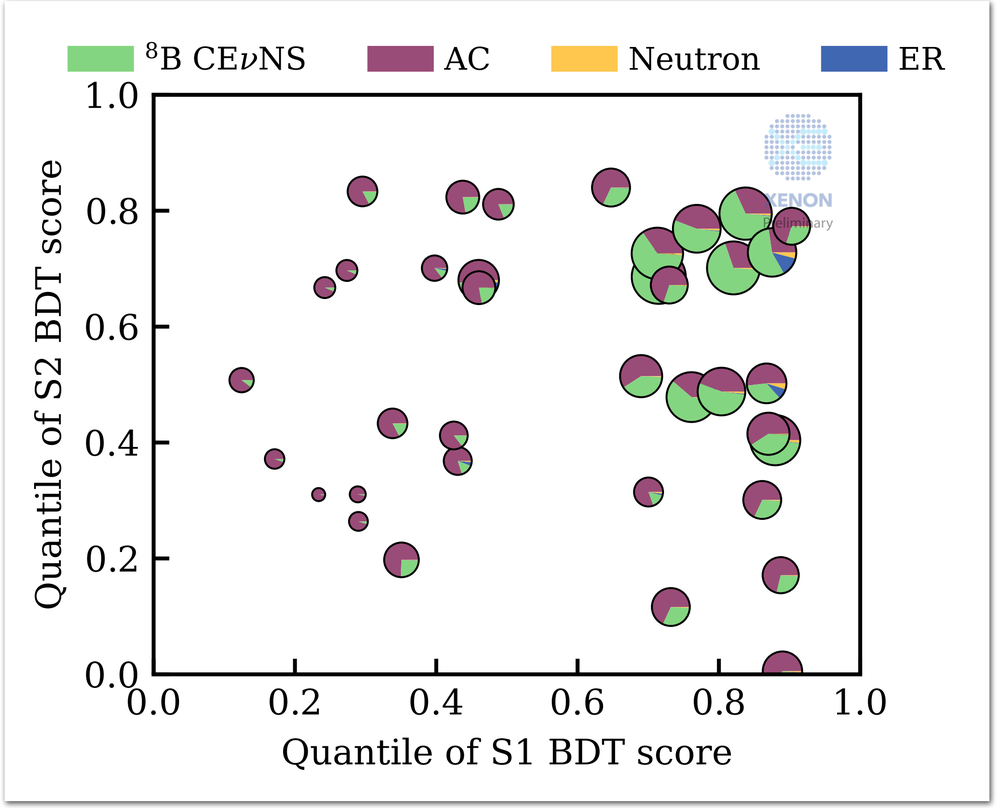
Tiny S1, barely detectable



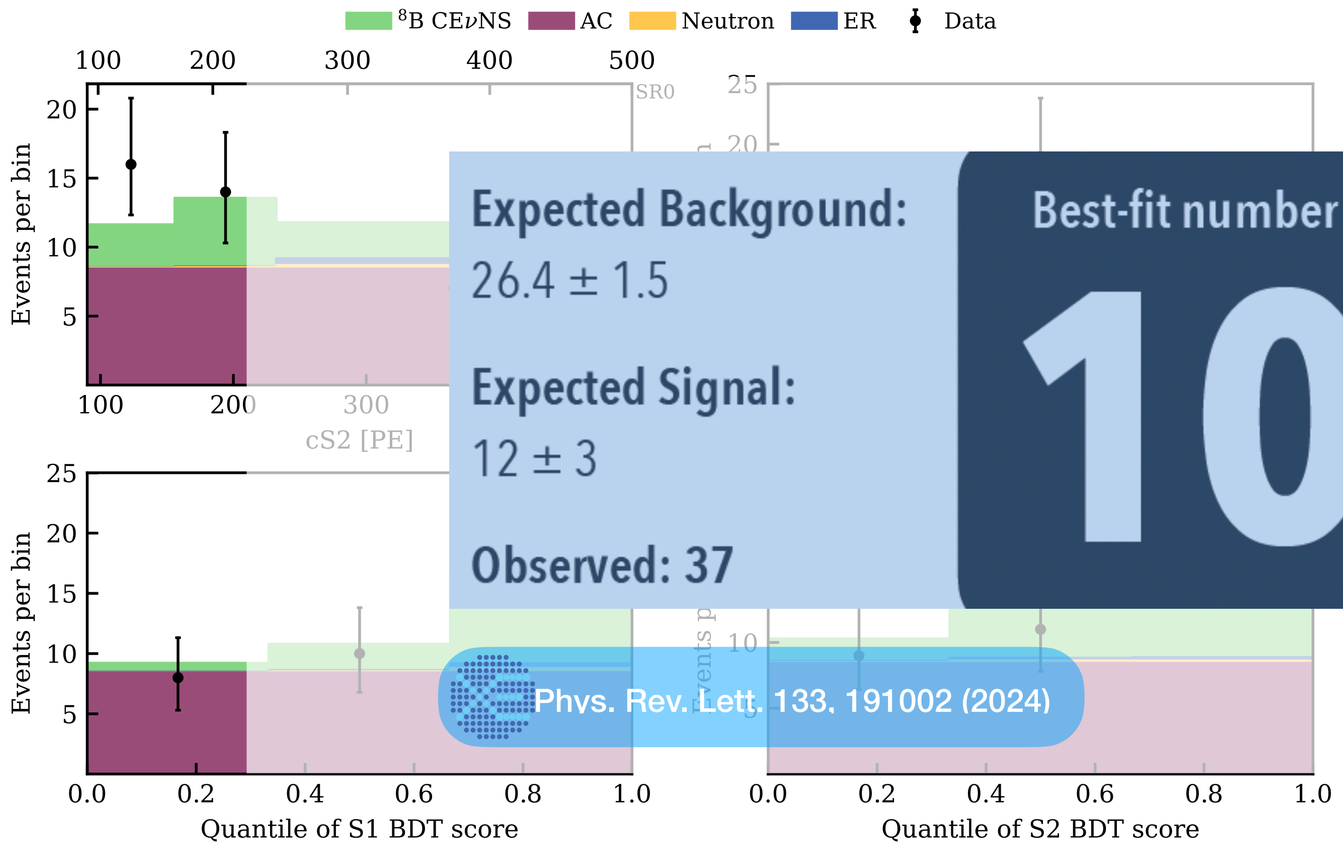
- Validate the AC model method
- Test the **4-dimension inference framework**
- Predict 1062 ± 53 AC, observe 1676 events

Results


^{8}B CEνNS
AC
Neutron
ER
Data
SR0
SR1
Events per bin
cS2 [PE]
Quantile of $S2_{pre}$ / Δt_{pre}
Quantile of S1 BDT score
Quantile of S2 BDT score


^{8}B CEνNS
AC
Neutron
ER
Quantile of S2 BDT score
Quantile of S1 BDT score
XENON
Preliminary

Results



Expected Background:
26.4 ± 1.5

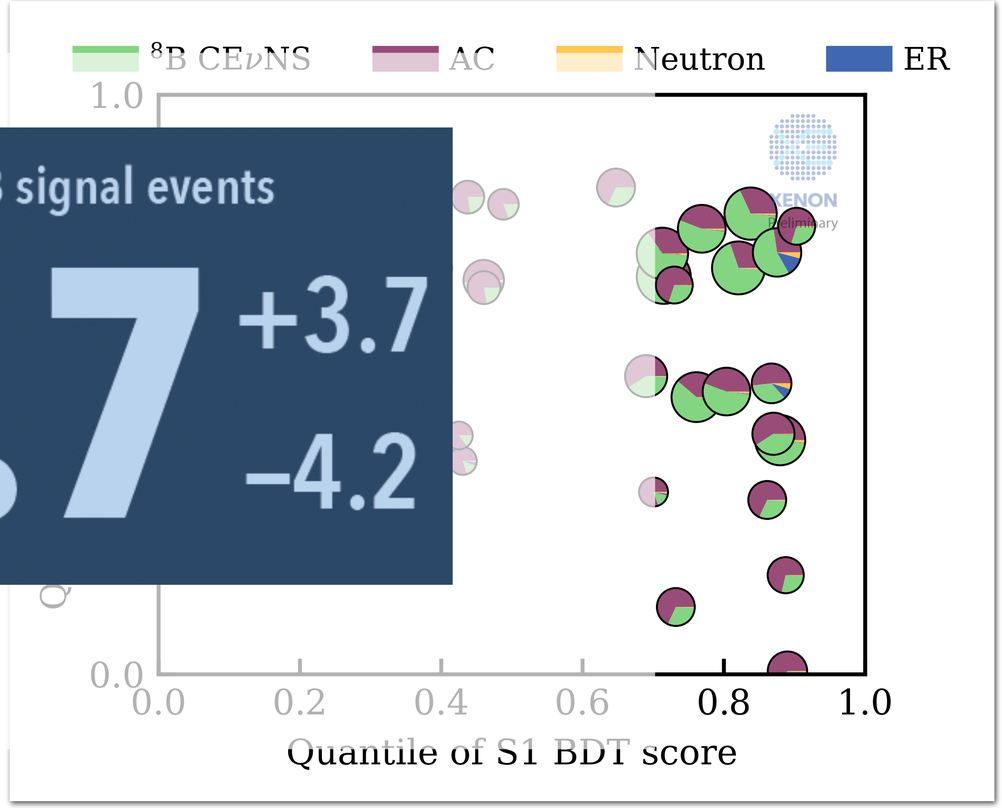
Expected Signal:
12 ± 3

Observed: 37

Best-fit number of ^{8}B signal events

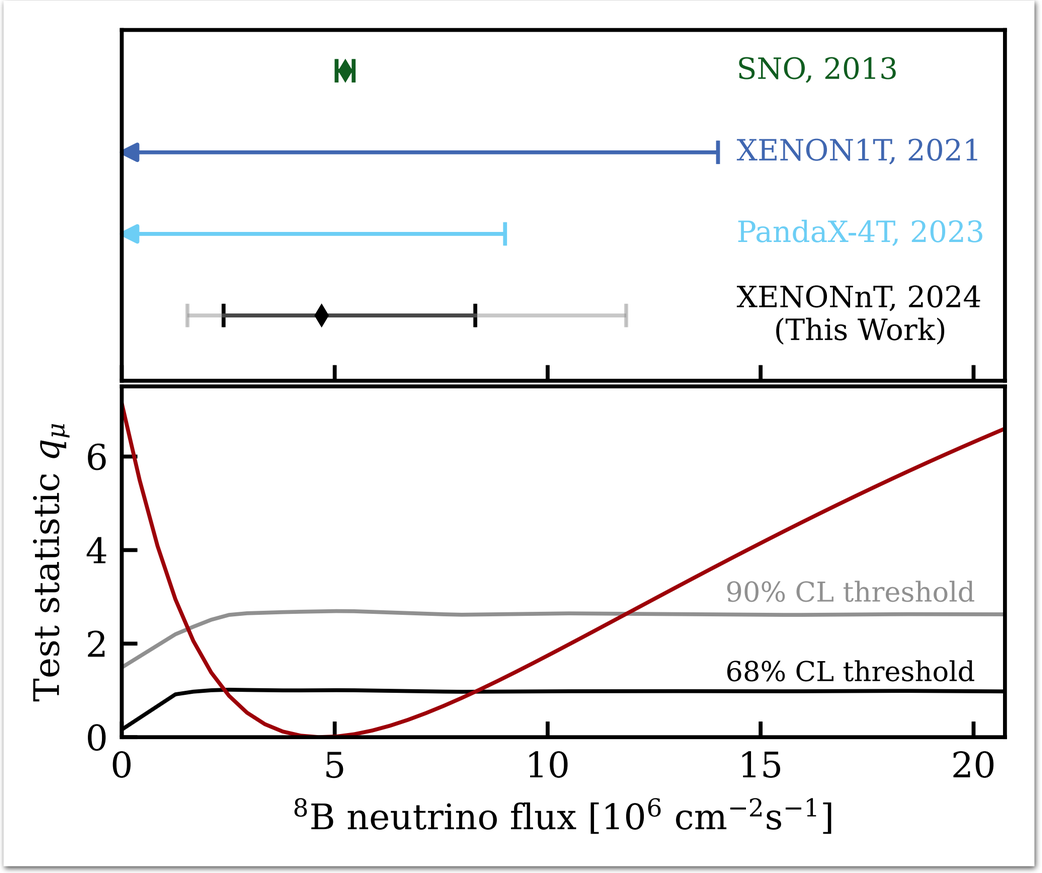
$10.7^{+3.7}_{-4.2}$

Phys. Rev. Lett. 133, 191002 (2024)



First measurement of Solar ^{8}B CEvNS

- Discovery significance: **2.73** σ (1/300 chance to be background only)
- Measured ^{8}B flux: $(4.7^{+3.6}_{-2.3}) \times 10^6 \mathrm{cm}^{-2}\mathrm{s}^{-1}$
- Fix flux →First **measurement of** CEvNS on **Xe target**
- **5** σ discovery & precision measurement in reach for XENONnT with future data



Similar result from PandaX-4T (Phys. Rev. Lett. 133, 191001 (2024))

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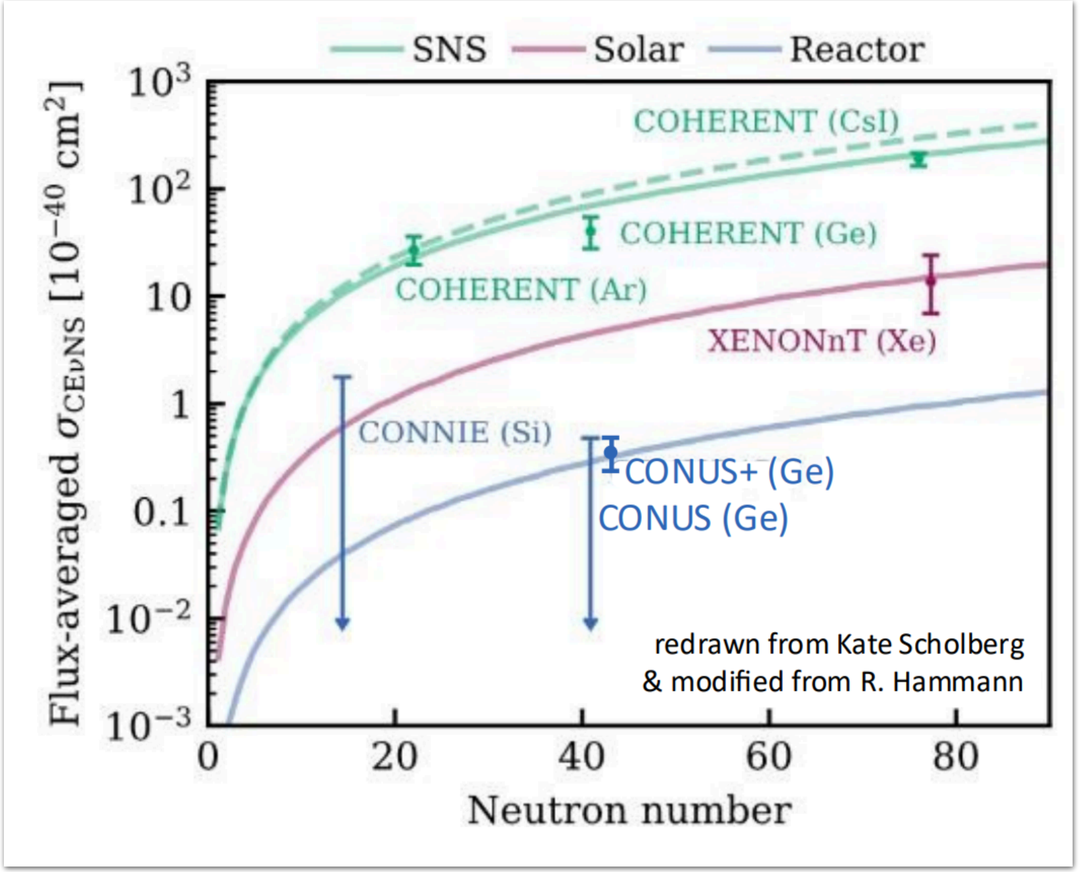
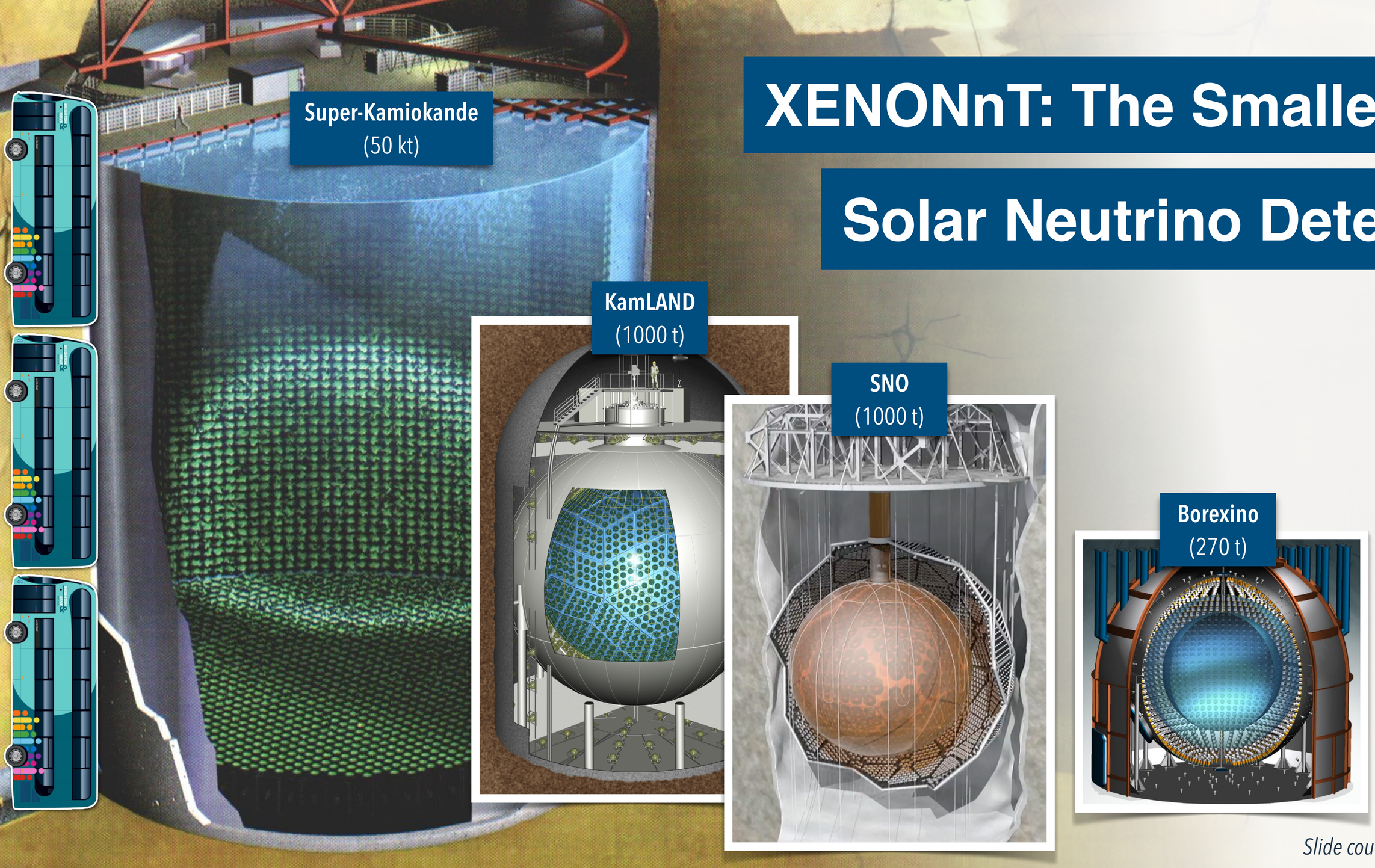
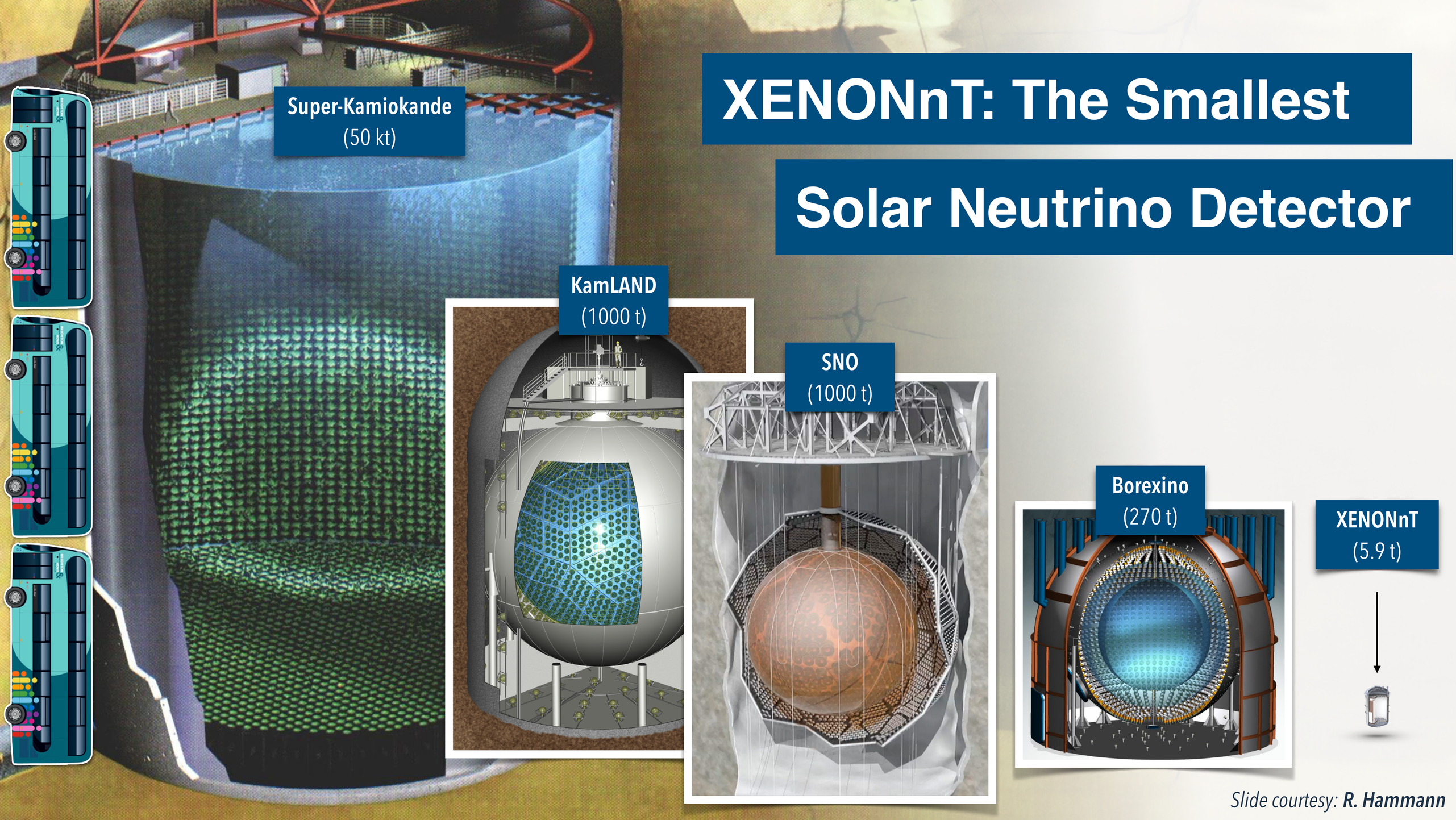


XENONnT: The Smallest Solar Neutrino Detector



Slide courtesy: ***R. Hammann***

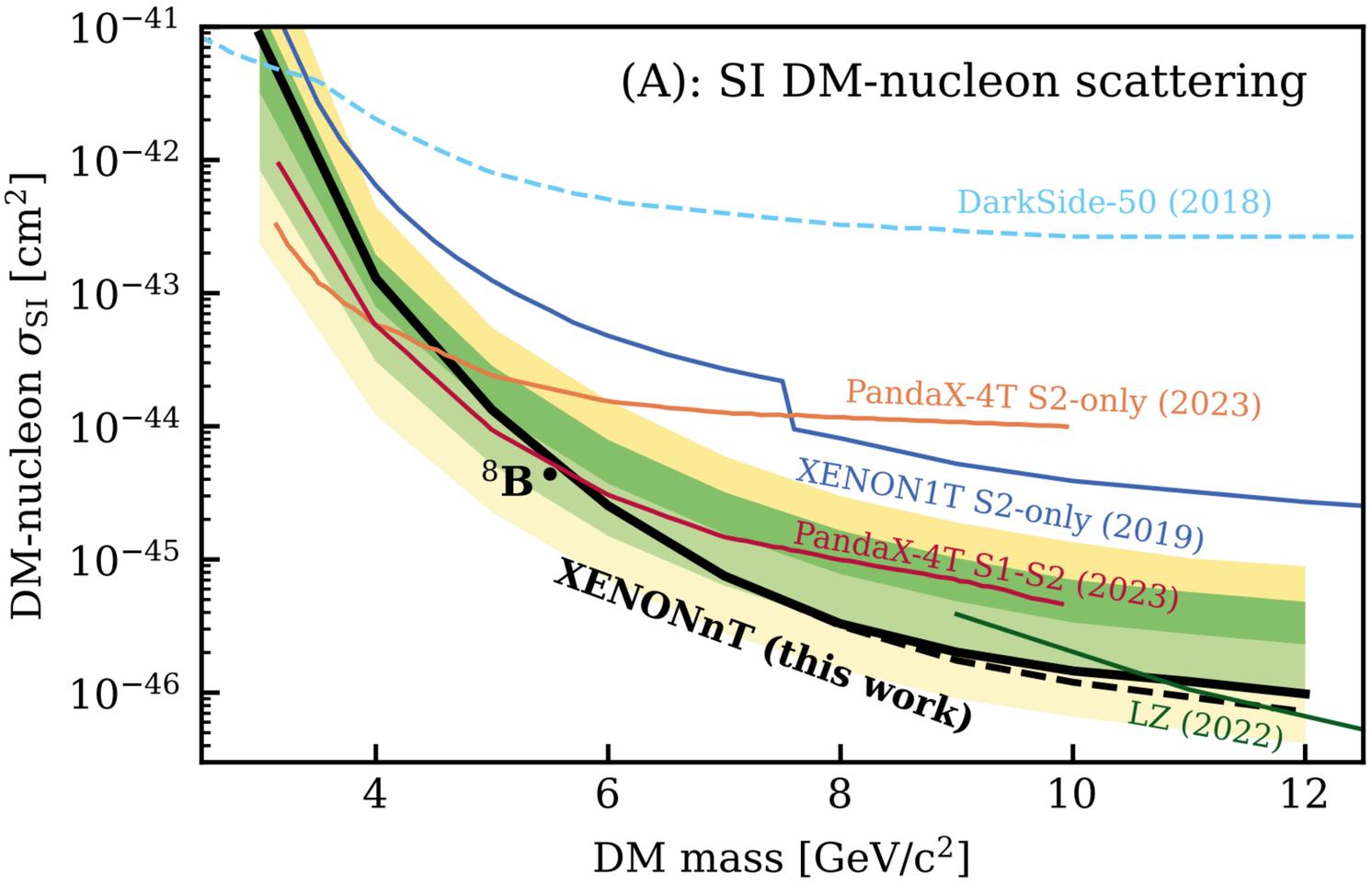
XENONnT: The Smallest Solar Neutrino Detector



Slide courtesy: ***R. Hammann***

Search for Light WIMPs in the neutrino fog

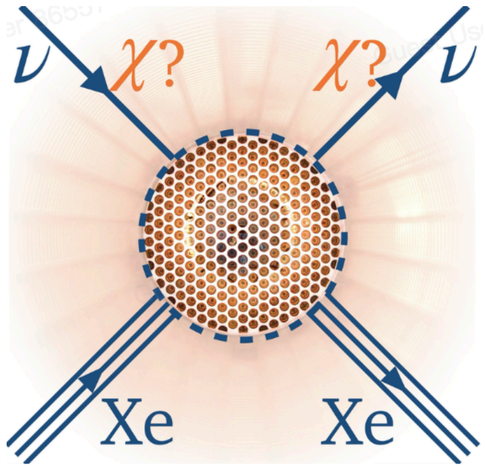
- Use same dataset and analysis framework for ^{8}B CEvNS search
- ^{8}B CEvNS as background
- No excess above backgrounds
  - New limit set
  - First step into the neutrino fog



Phys. Rev. Lett. 134,111802 (2025)

Thanks for your attention!

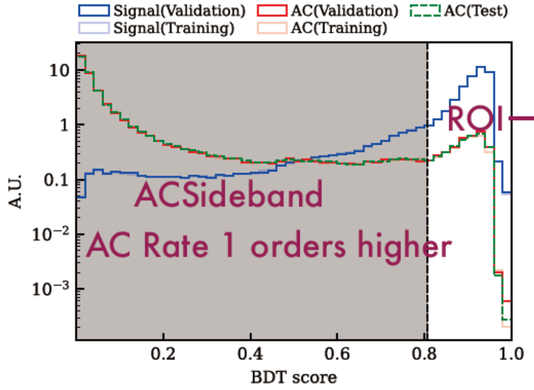
lkx21@mails.tsinghua.edu.cn



Backup

Validation on Science data ACSideband

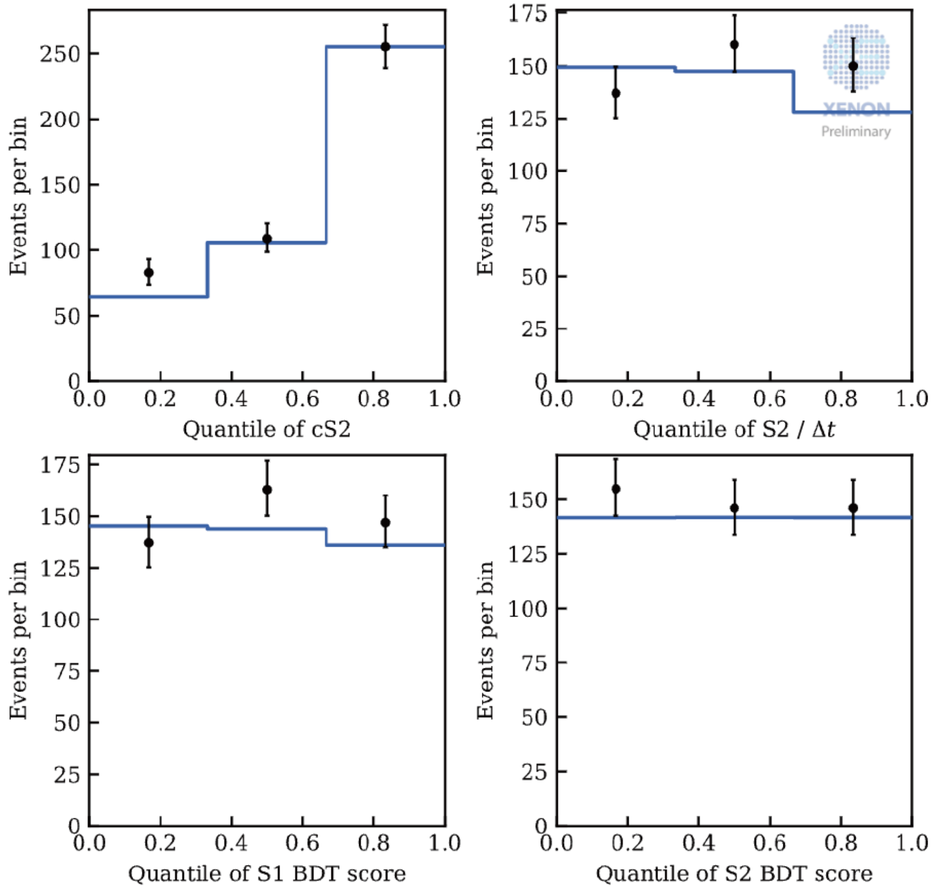
Determine Systematic Uncertainty



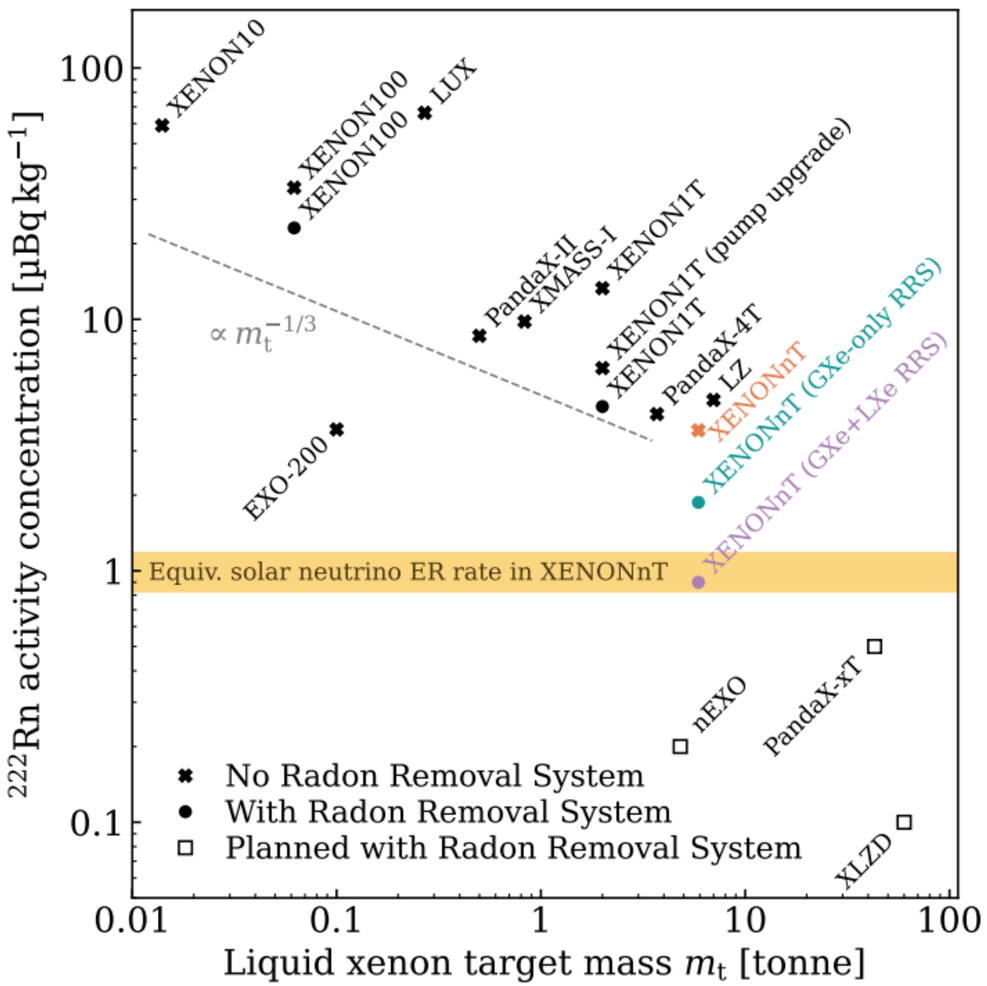
	AC Rate[/t/y]
SR0	6.37
SR1	7.58

- 'Unblind' shows within 2-sigma, use the statistic uncertainty of ACSideband to be the systematics
- 4D GoF test: p-value=0.17 ✅

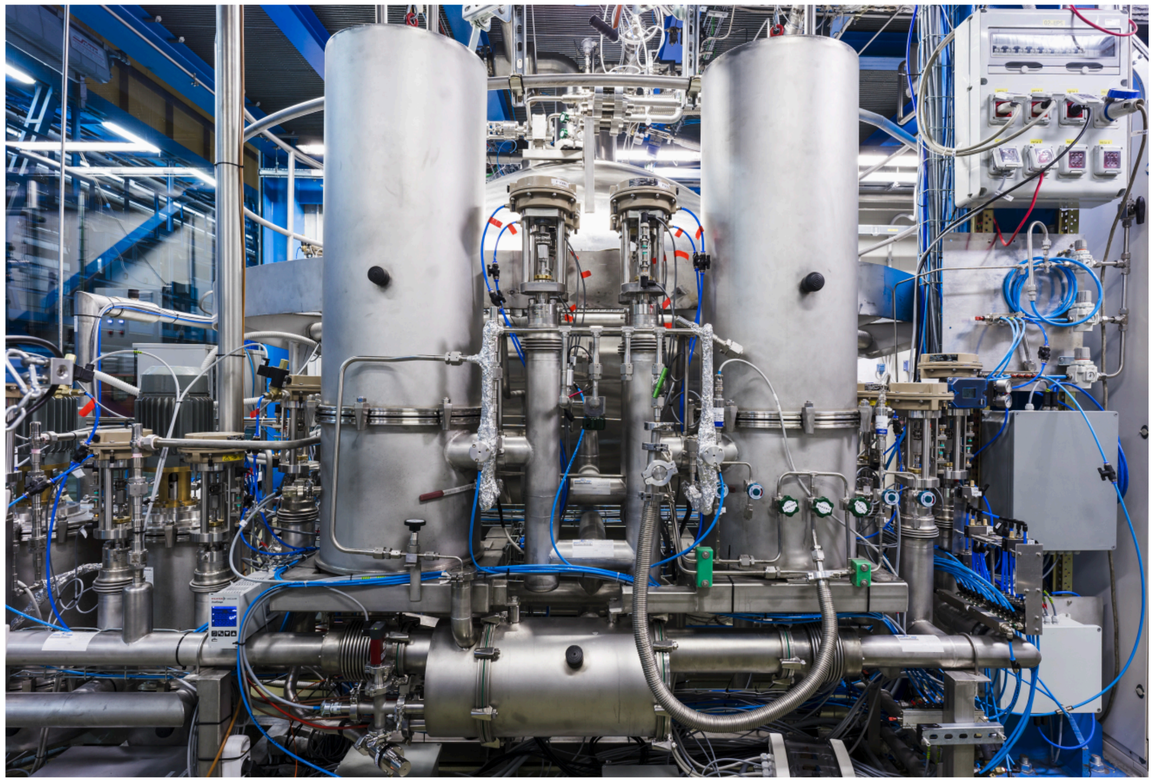
Dataset	Predicted	Observed	Relative Uncertainty
SR0	122.7	121	9.04%
SR1	302.5	326	5.76%
Total	425.2	447	/



XENONnT: Purest liquid XENON (ER rate down to solar neutrino ER level)



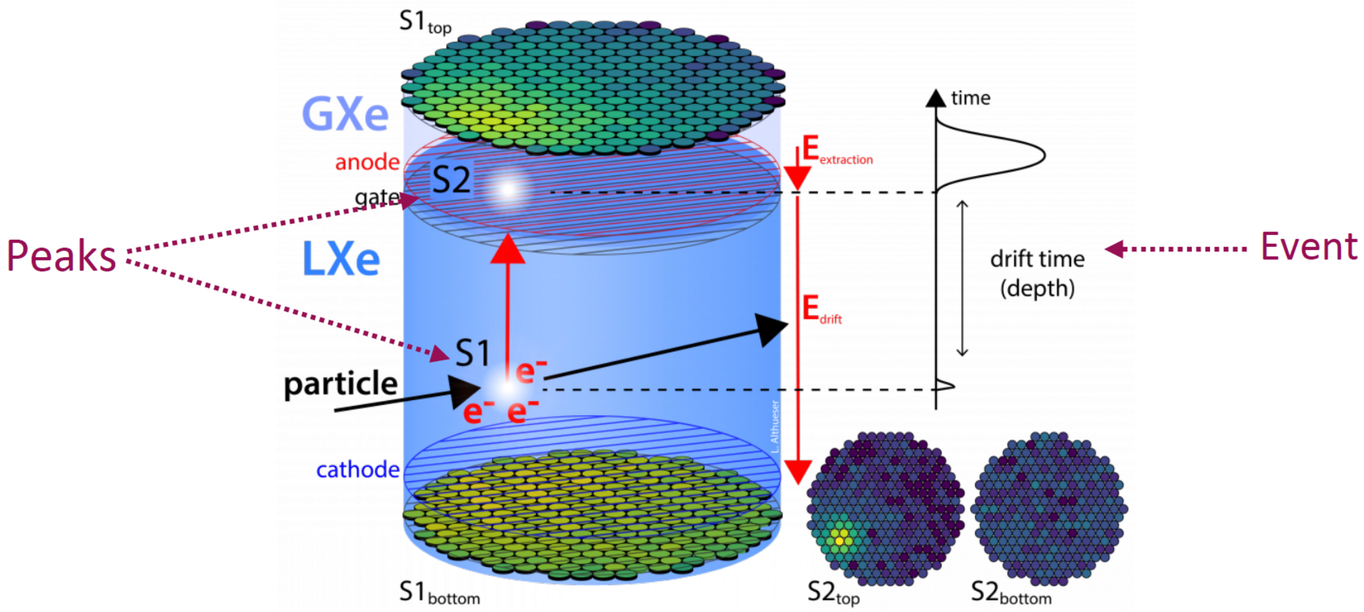
- High E-life –> Low threshold

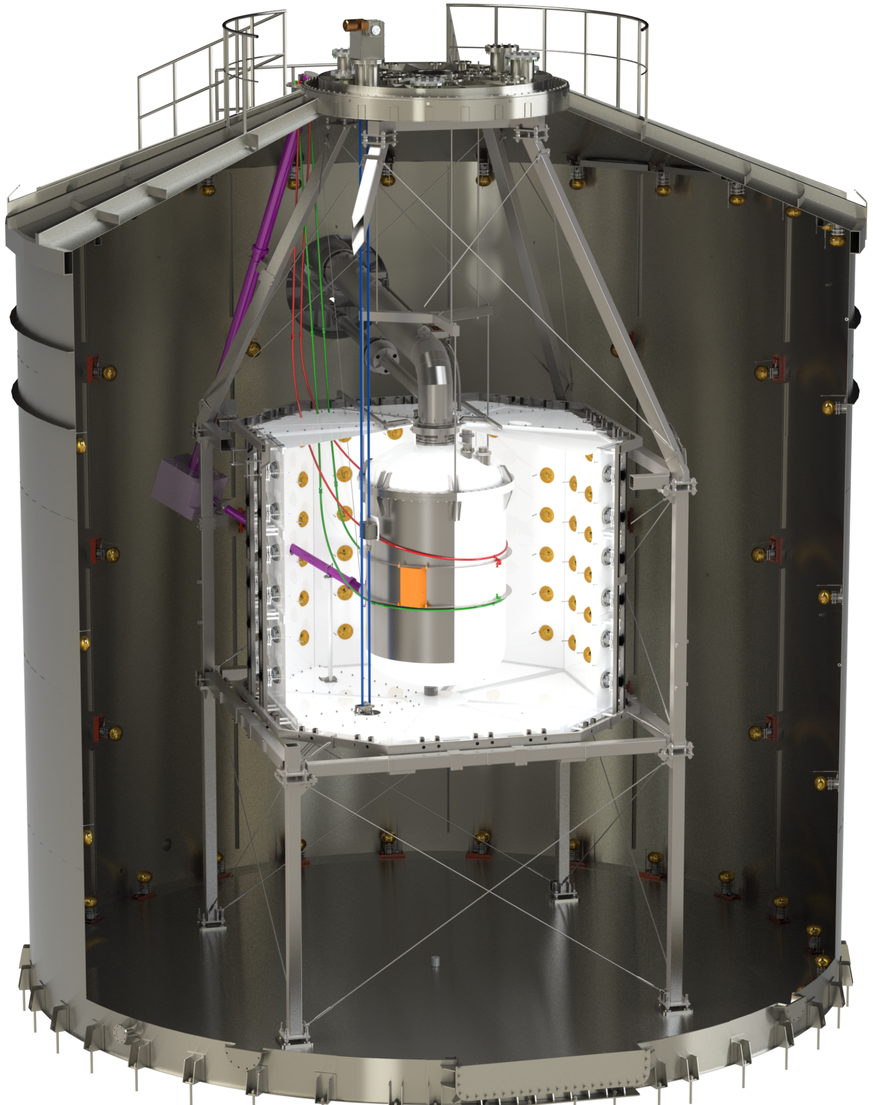


- **0.9 days** for entire **8.6 tonnes**
- About **90%** of the electrons **survive the full drift**

XENONnT Detector and Event Building

Two-Phase LXe TPC





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