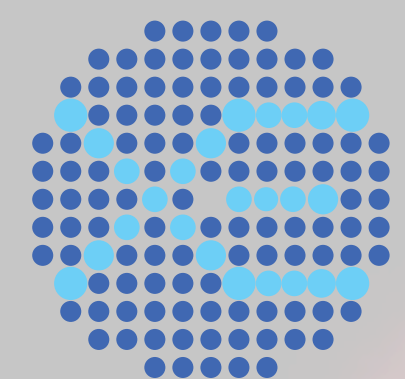




XENON



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Tsinghua University



Into the Neutrino Fog

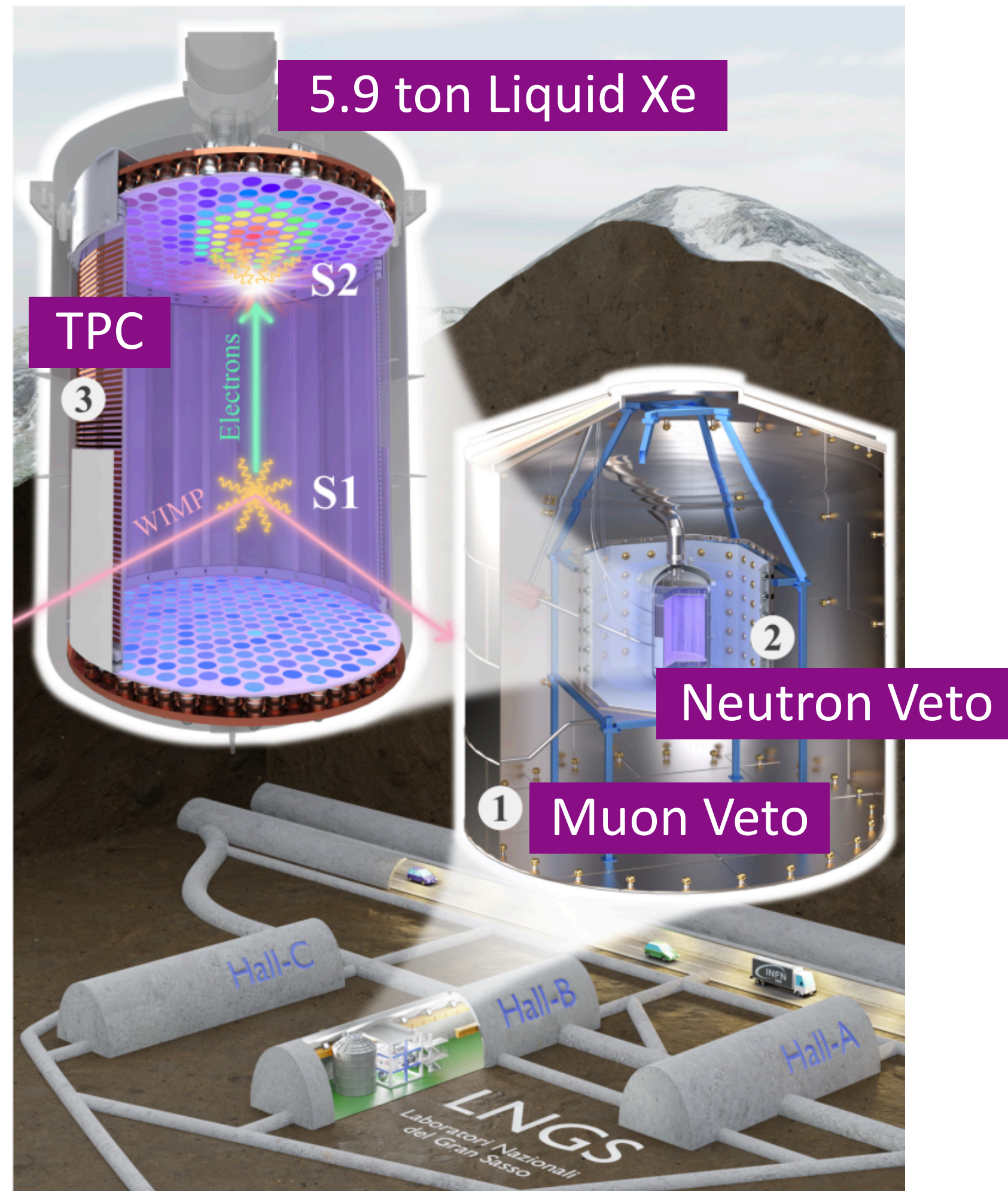
First Measurement of Solar ^8B CE ν NS
in XENONnT

Kexin Liu (刘可欣)

On behalf of the XENON Collaboration

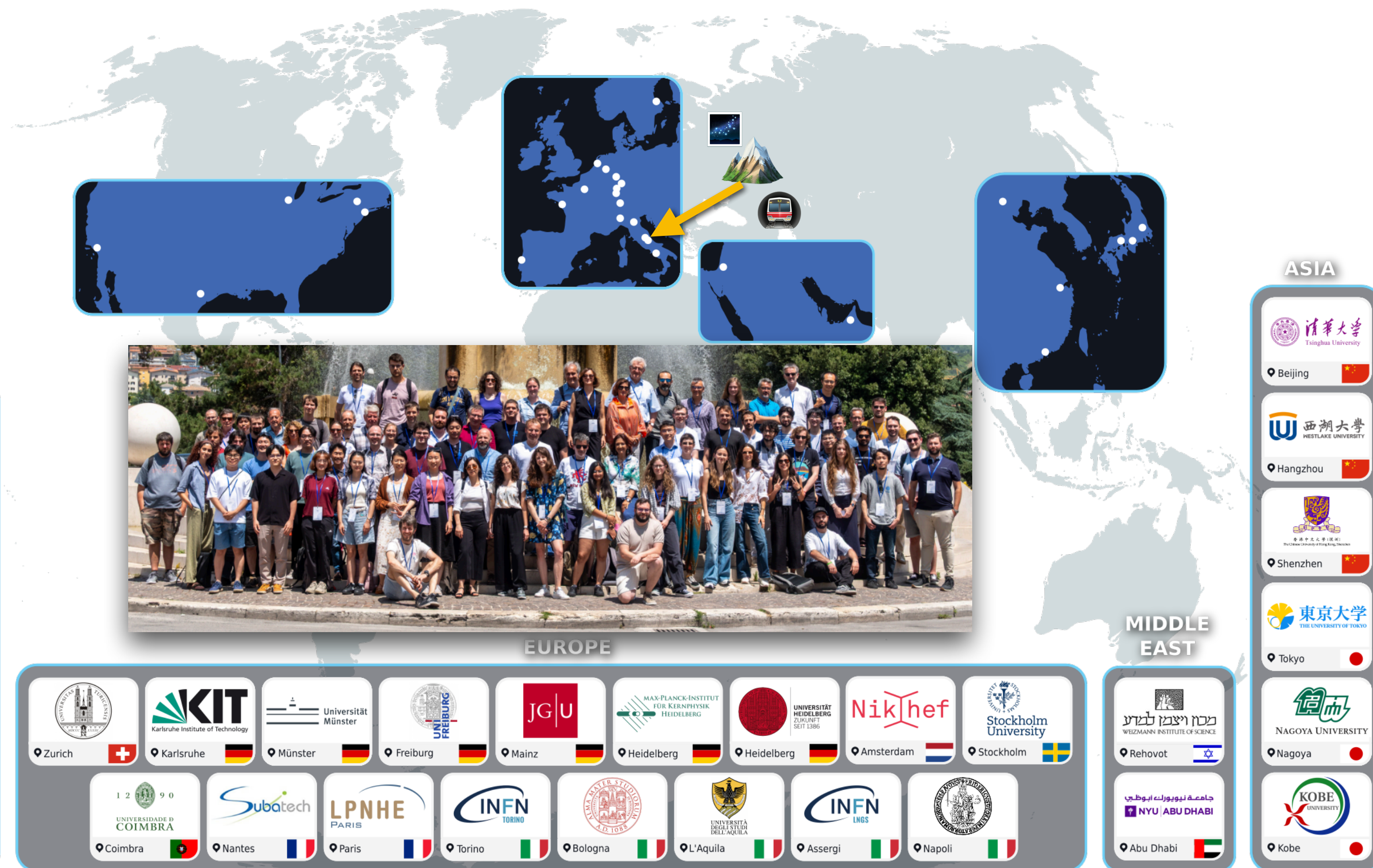
TAUP 2025 @ Xichang

XENONnT : Dark Matter Direct Detection



Eur.Phys.J.C 84 (2024) 8, 784

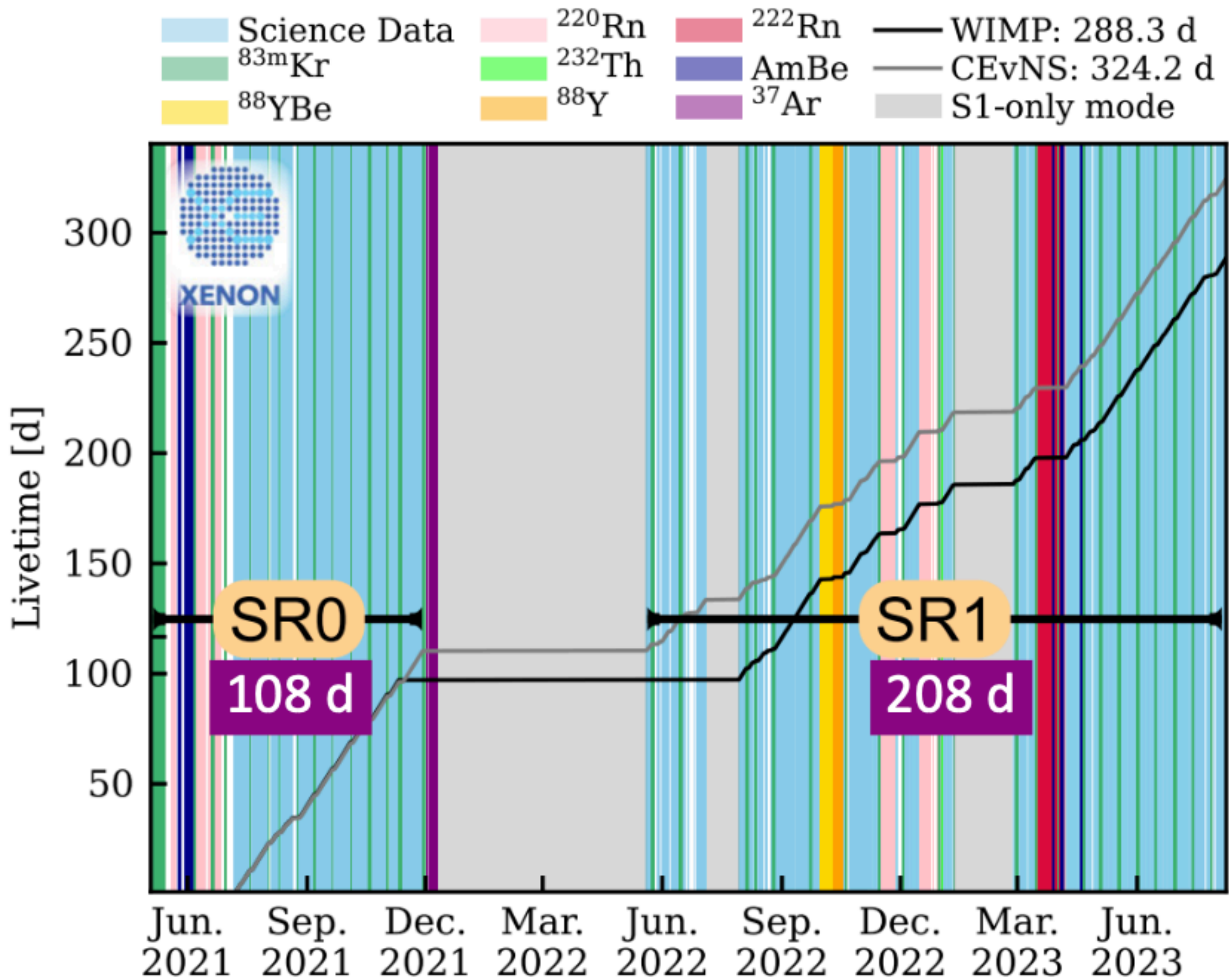
XENON COLLABORATION
 ~200 SCIENTISTS 30 INSTITUTIONS 12 COUNTRIES



Science Data and Science Results from XENONnT



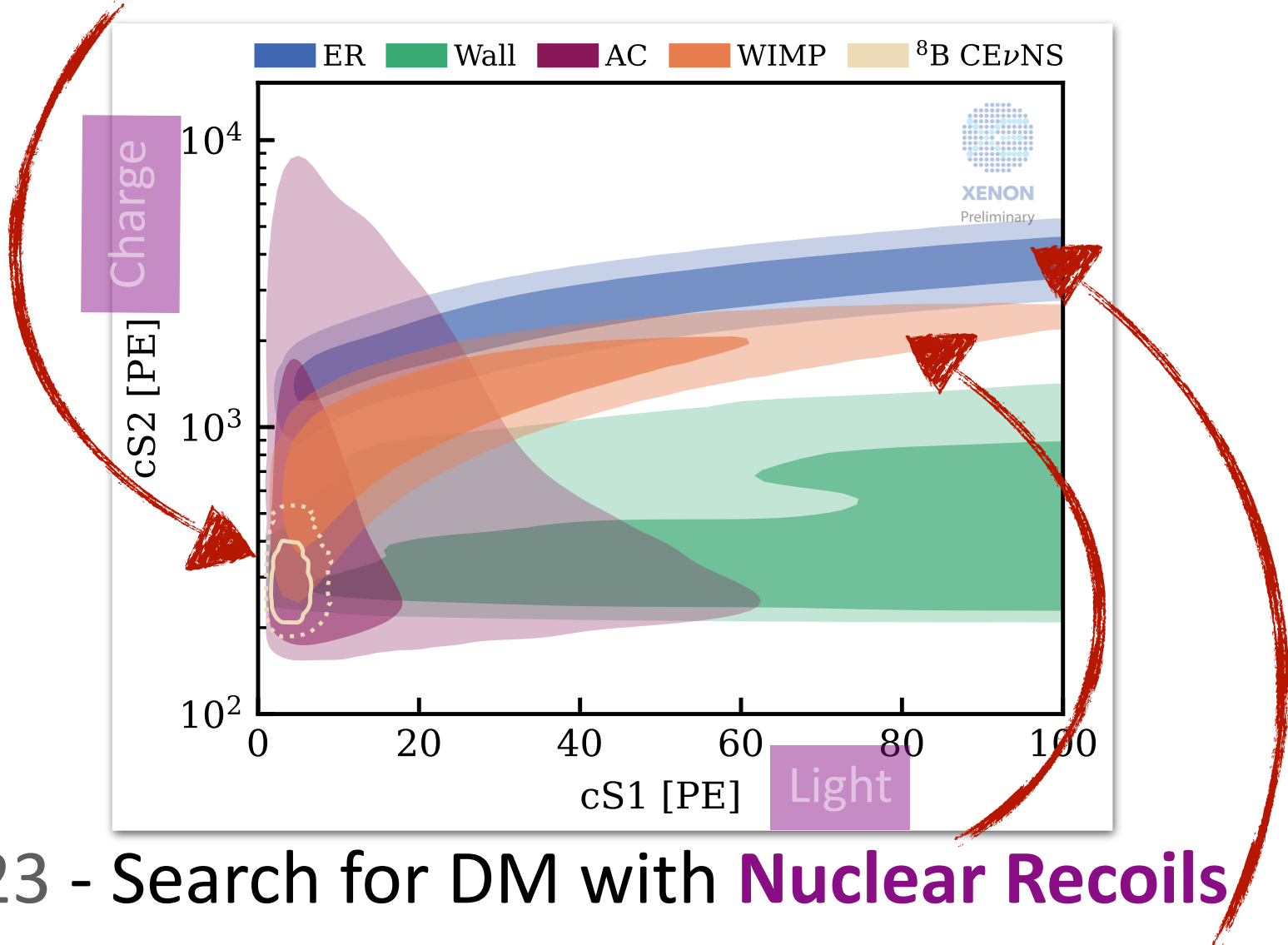
Fiducial Mass 4t × Livetime



300 days

100 days

- 2025 - Search for DM with **Nuclear Recoils**
- 2025 - First search for **light DM** in the neutrino fog
- 2024 - First measurement of the **Solar ^8B CEvNS**

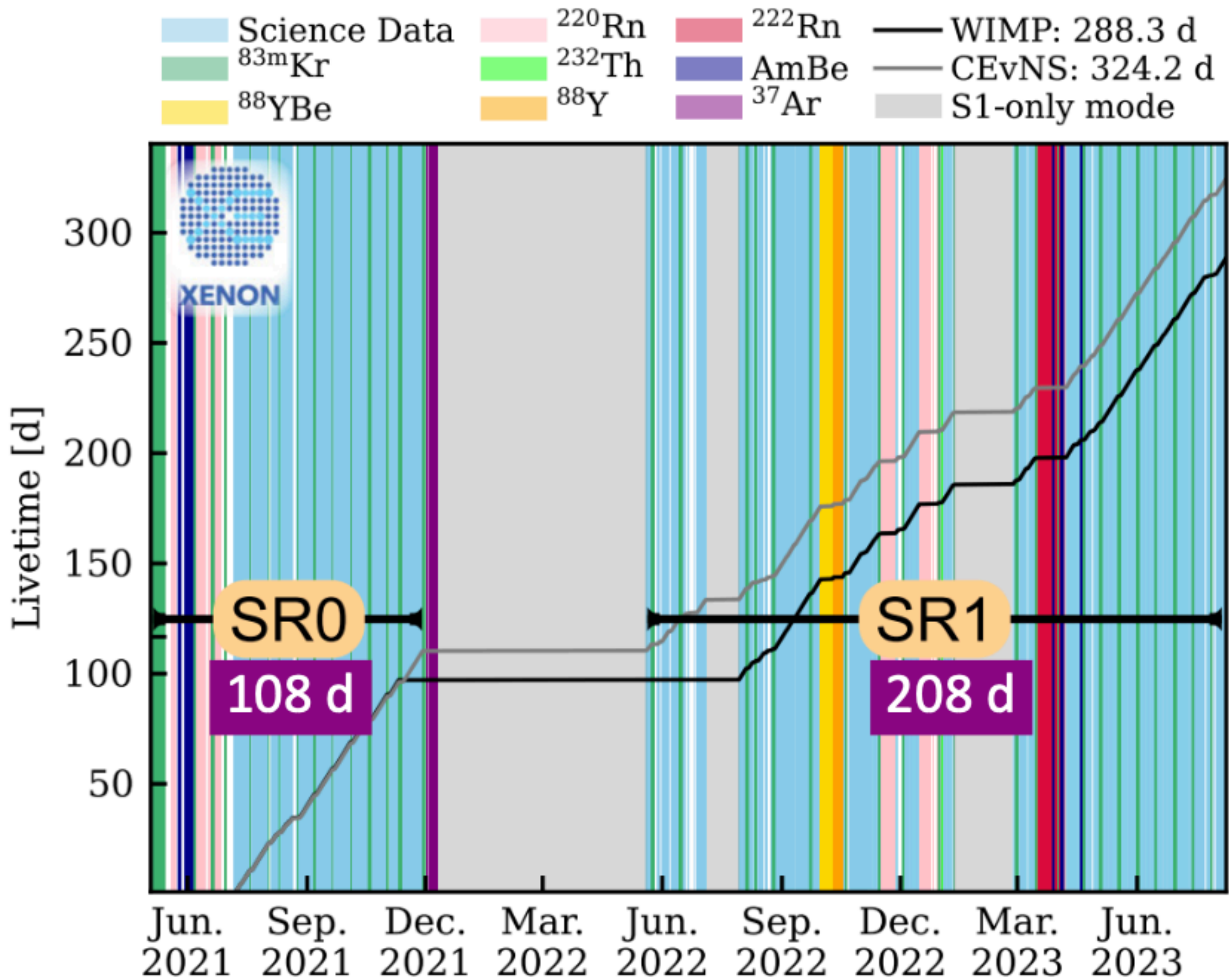


- 2023 - Search for DM with **Nuclear Recoils**
- 2022 - Search for DM with **Electronic Recoils**

Science Data and Science Results from XENONnT



Fiducial Mass 4t × Livetime



300 days

100 days

WIMP results from XENONnT with 3.1 tonne × year of exposure

Aug 25, 2025, 2:00 PM

20m

Conference Room F2-R1

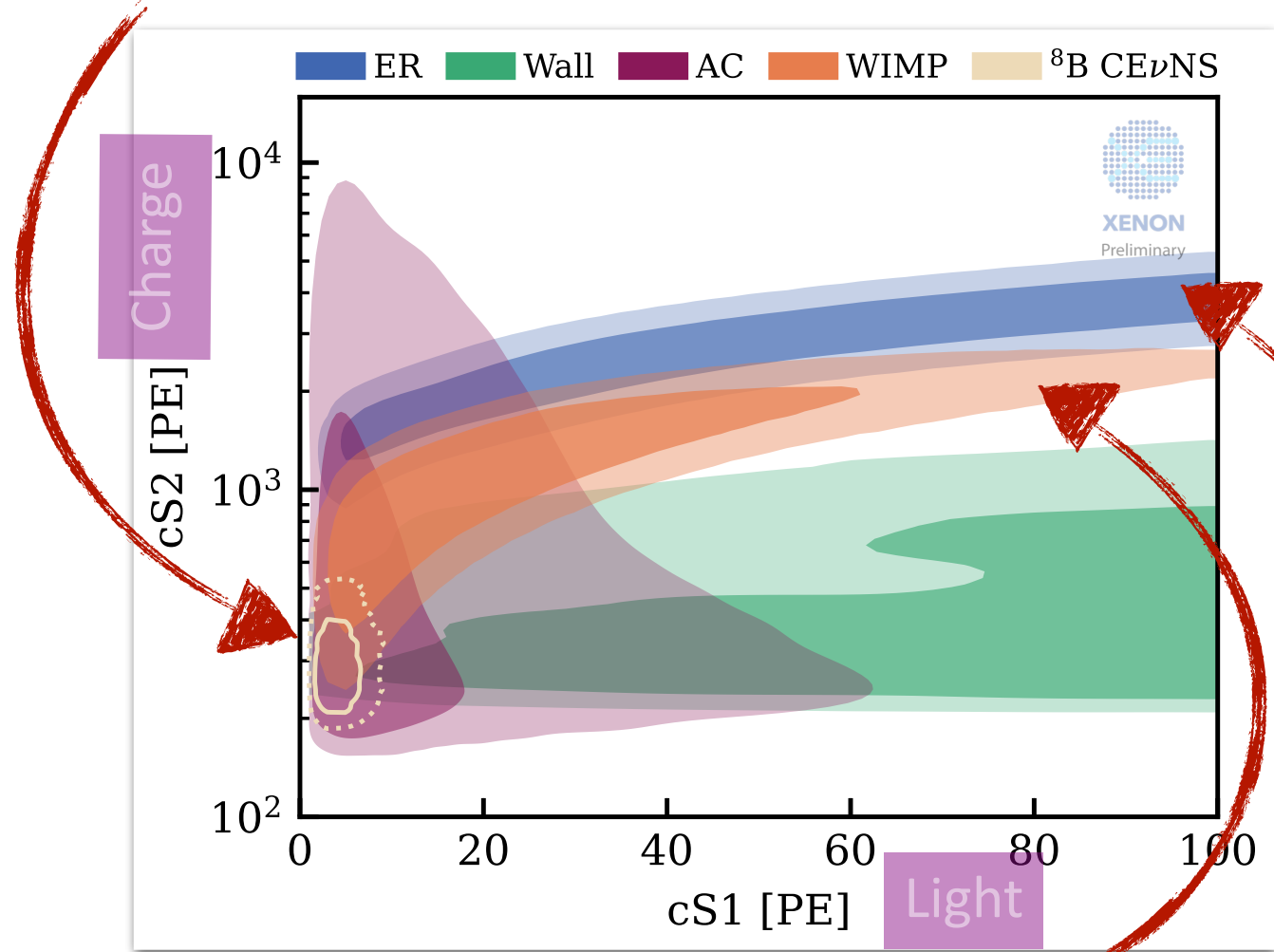
Speaker

Maxime Pierre (Nikhef)

dedicated talk Aug 25 by Maxime

- 2025 - Search for DM with Nuclear Recoils
- 2025 - First search for light DM in the neutrino fog
- 2024 - First measurement of the Solar ^8B CEvNS

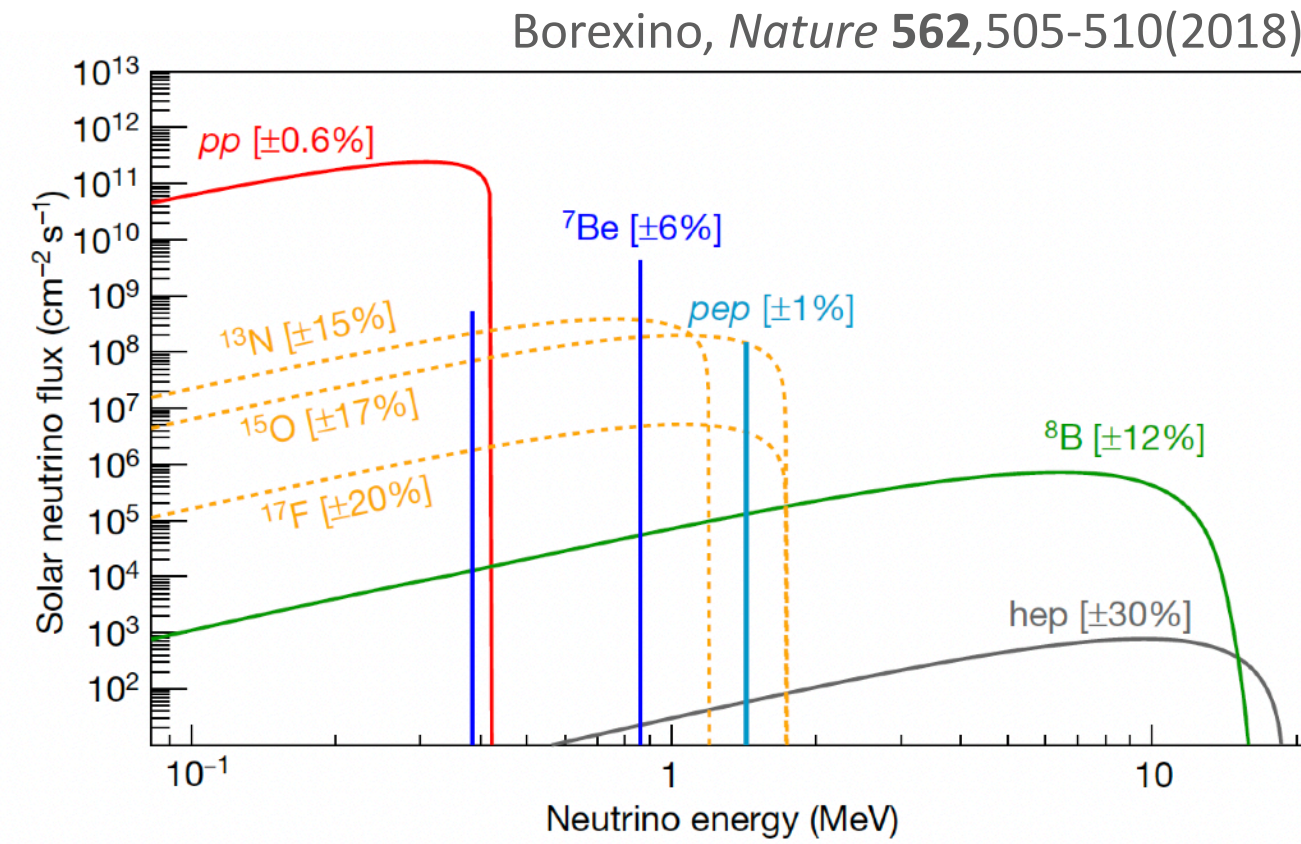
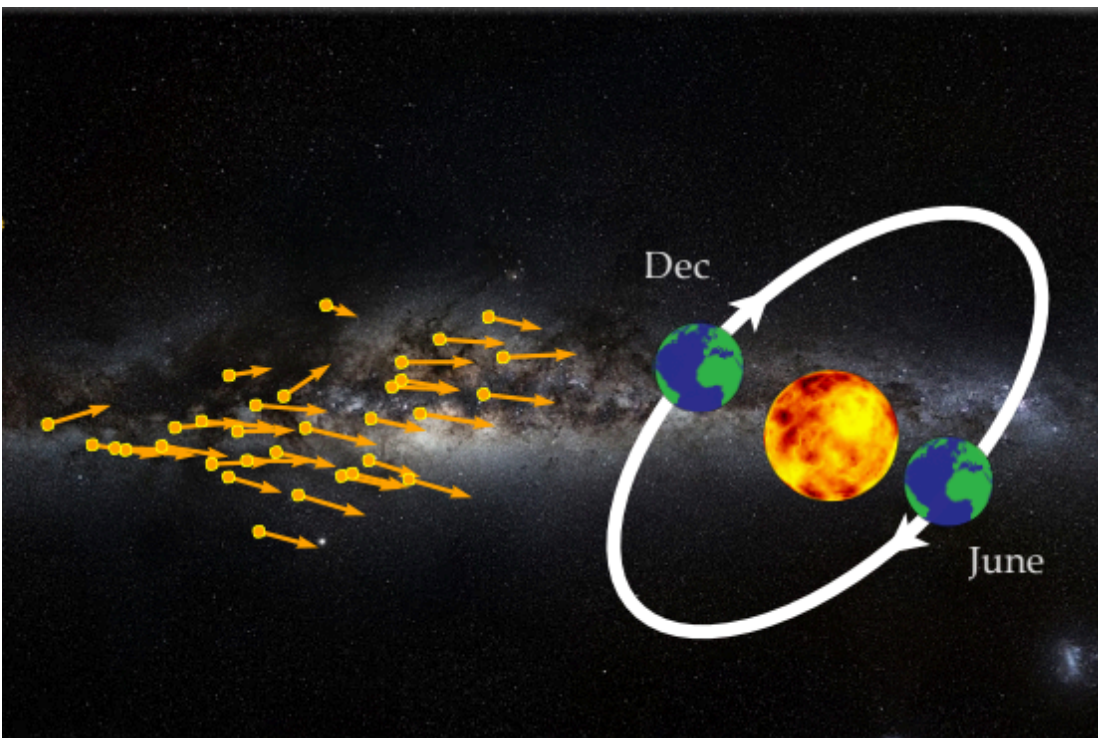
Today's talk



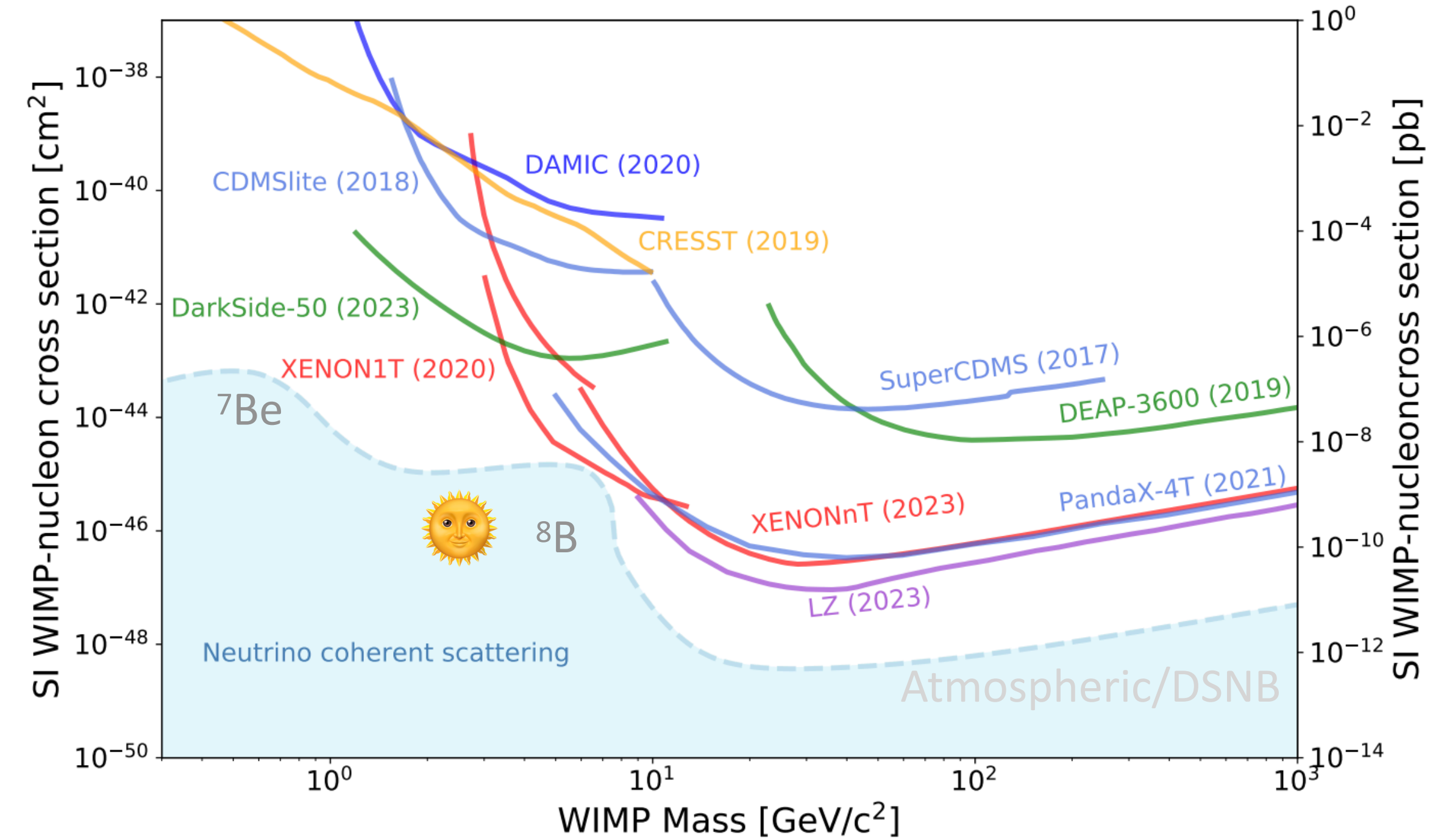
- 2023 - Search for DM with Nuclear Recoils
- 2022 - Search for DM with Electronic Recoils

Chat to me after!

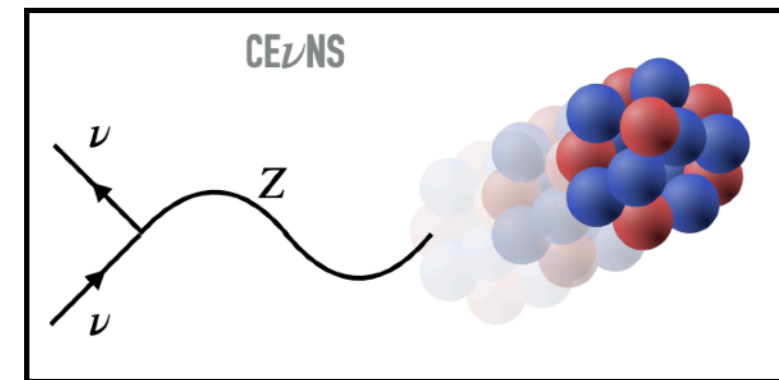
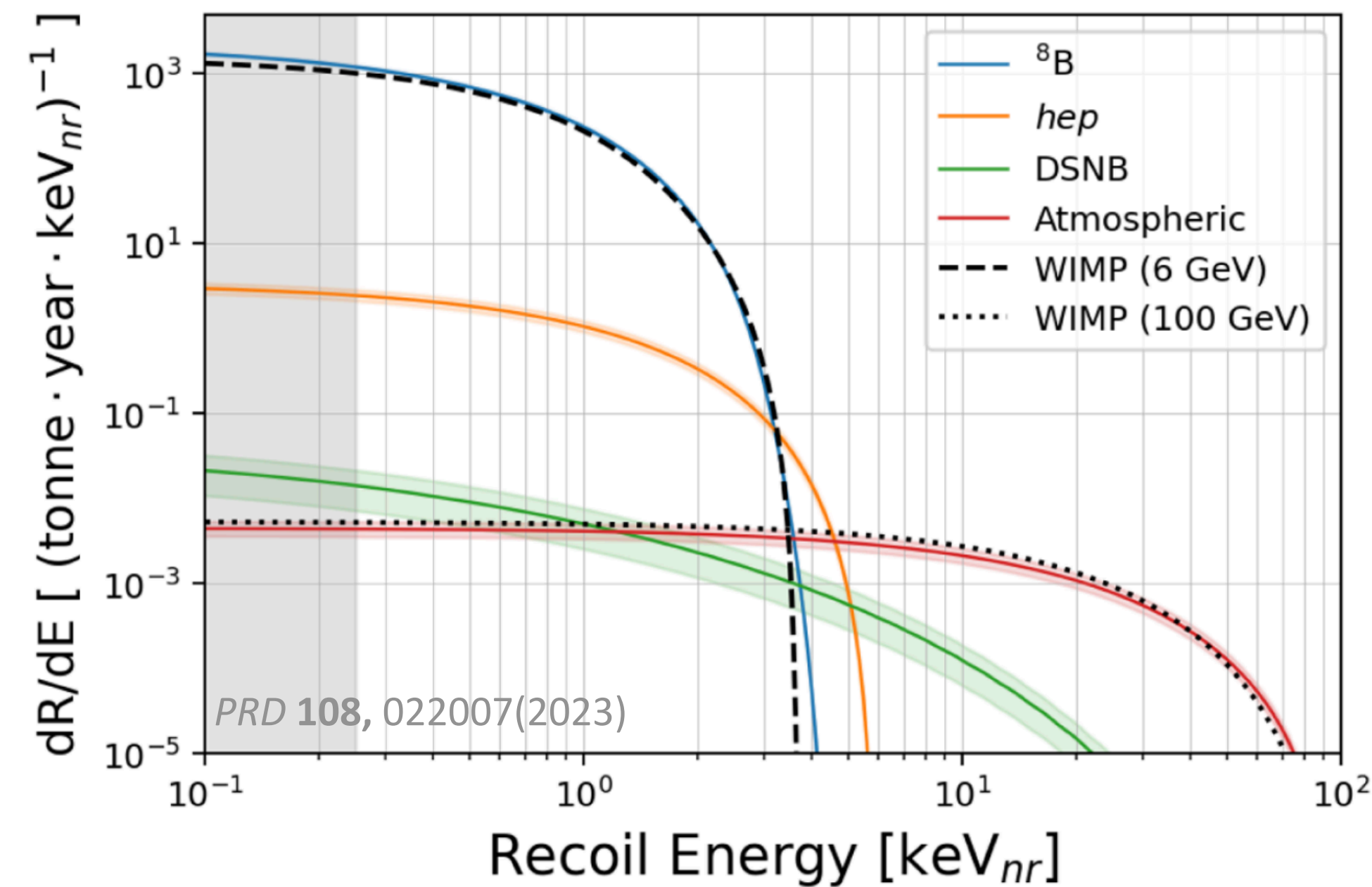
The 'Neutrino Fog' for DM Direct Detection



R.L. Workman et al. (Particle Data Group), *Prog. Theor. Exp. Phys.* 2022, 083C01 (2022) and 2023 update



→ Irreducible background for the WIMPs search



$$\sigma \propto N_{\text{neutron}}^2$$

Coherent Elastic
Neutrino-Nucleus
Scattering (CEvNS)

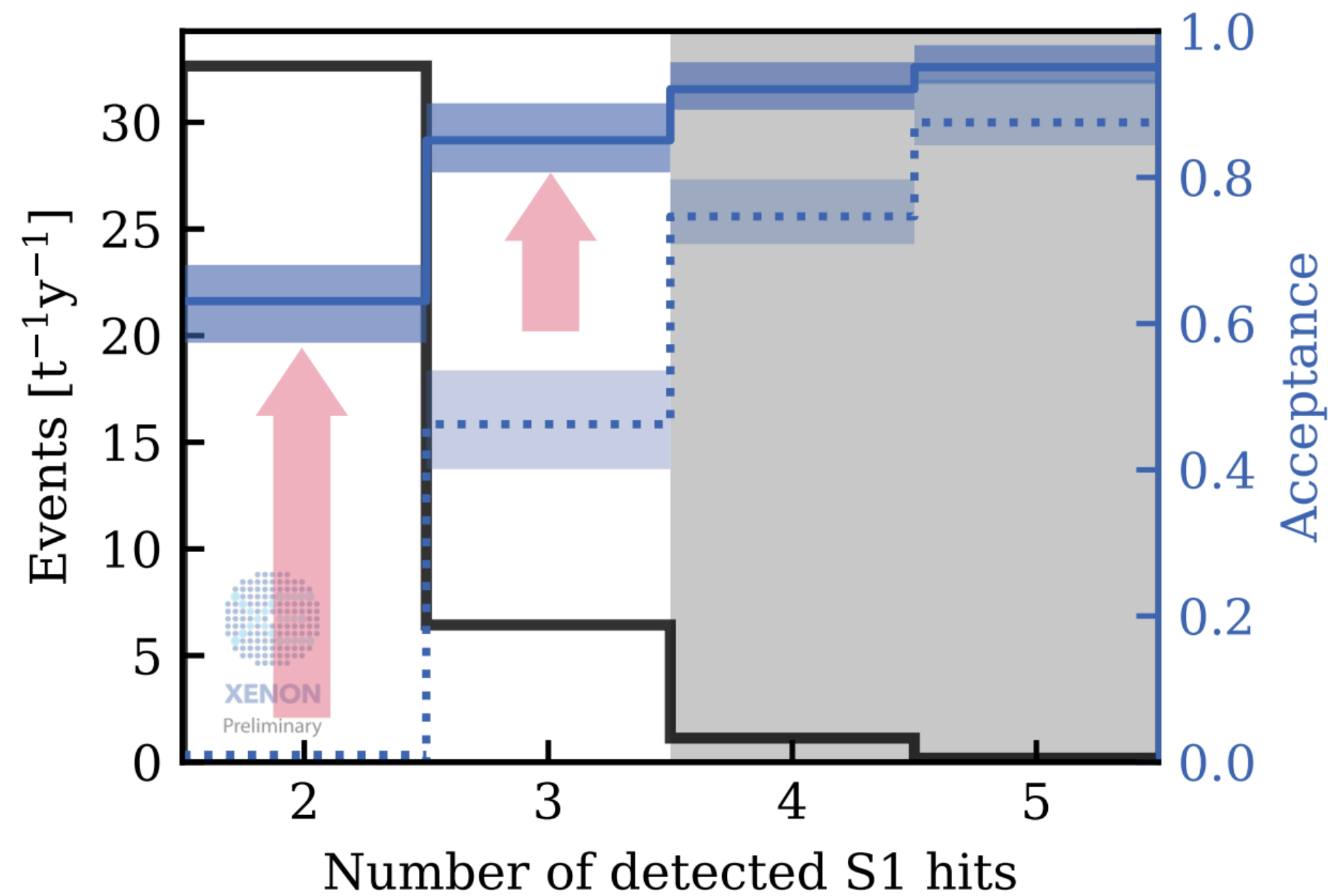
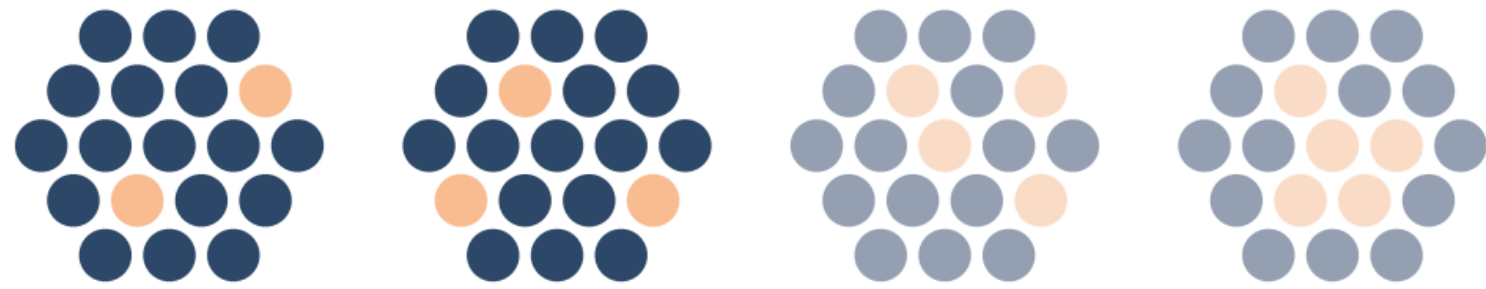
Solar ^8B CE ν NS: Very Low Energy NR

$$\frac{S}{\sqrt{N}}$$

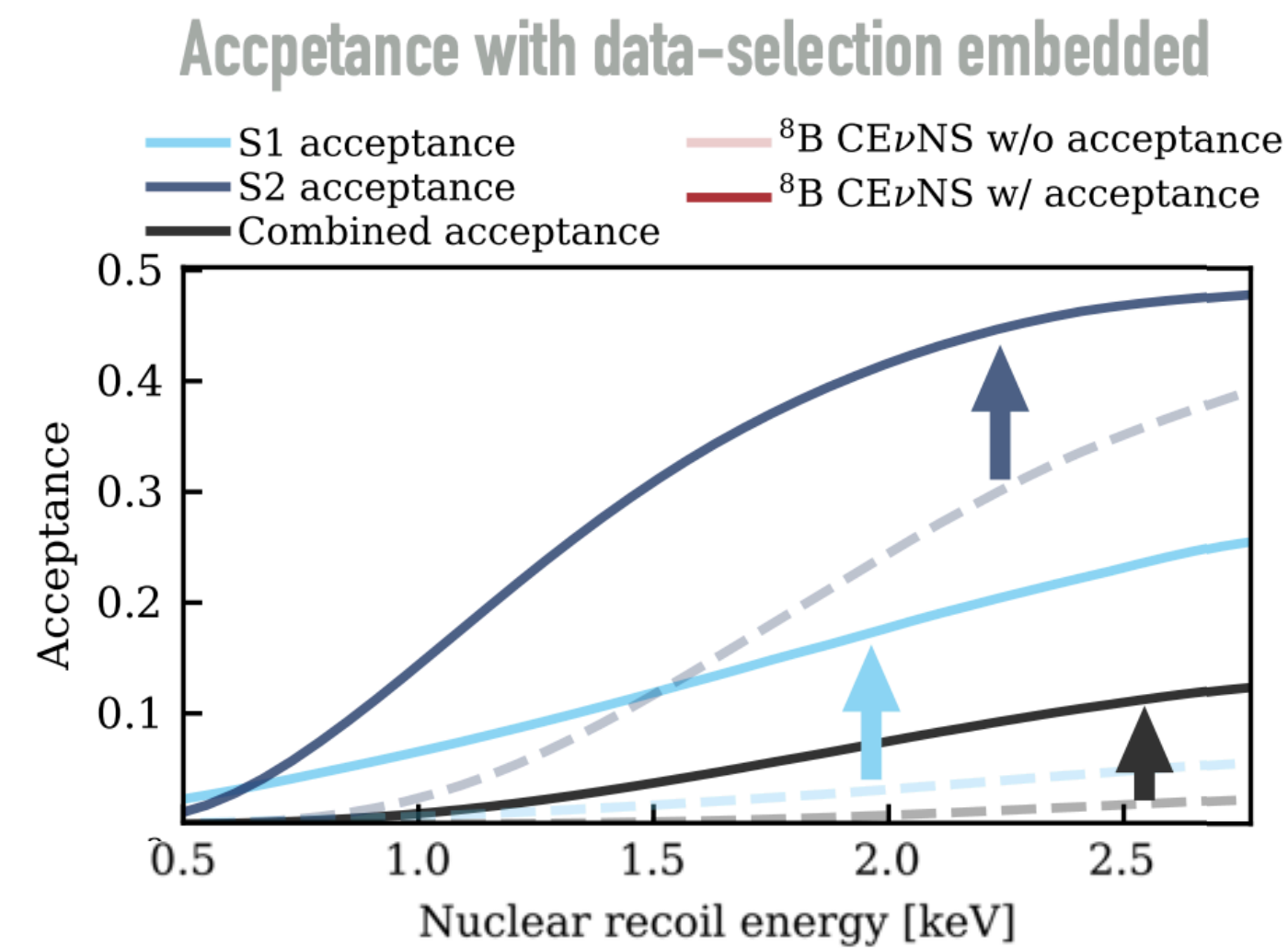
$$\delta S, \delta N$$



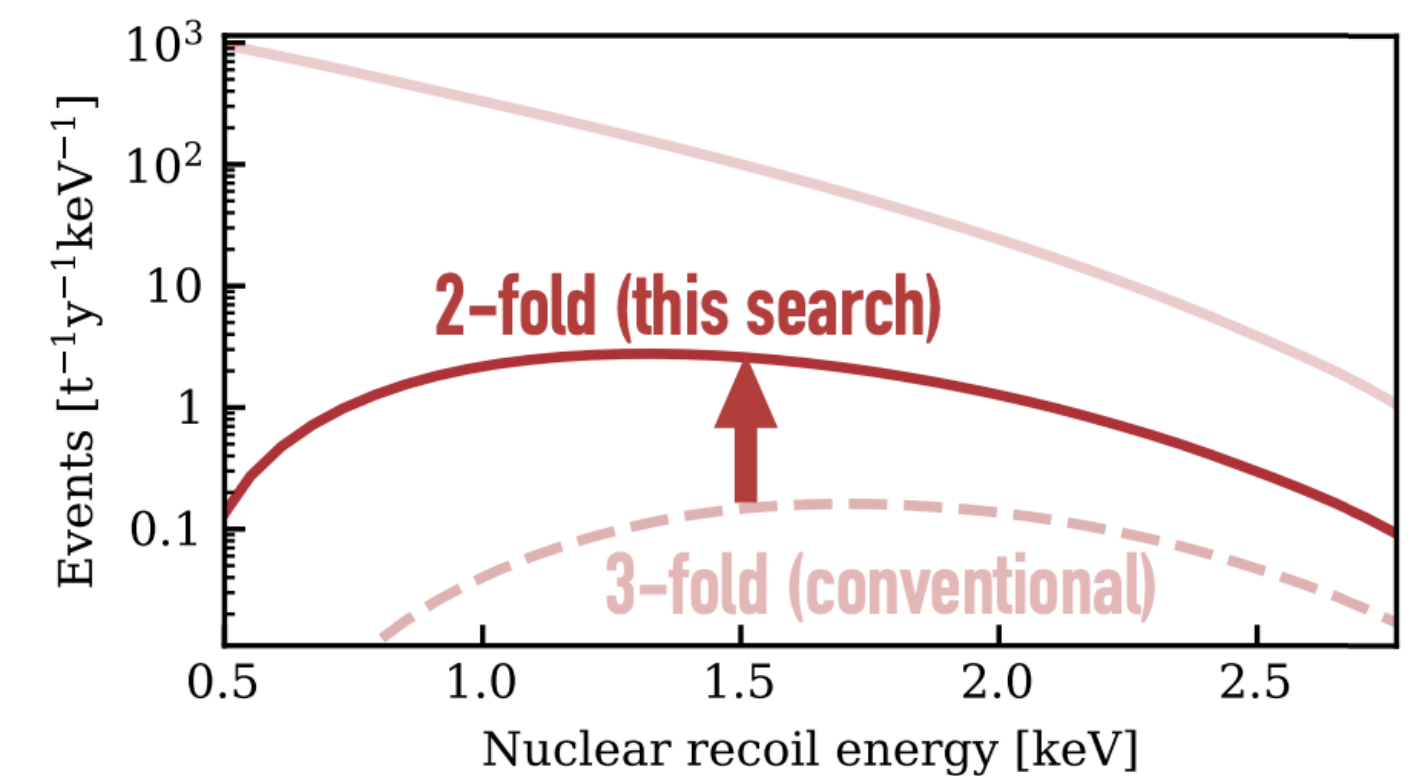
- S1 acceptance (2-fold)
- ... S1 acceptance (3-fold)
- ^8B CE ν NS spectrum (w/o efficiencies)

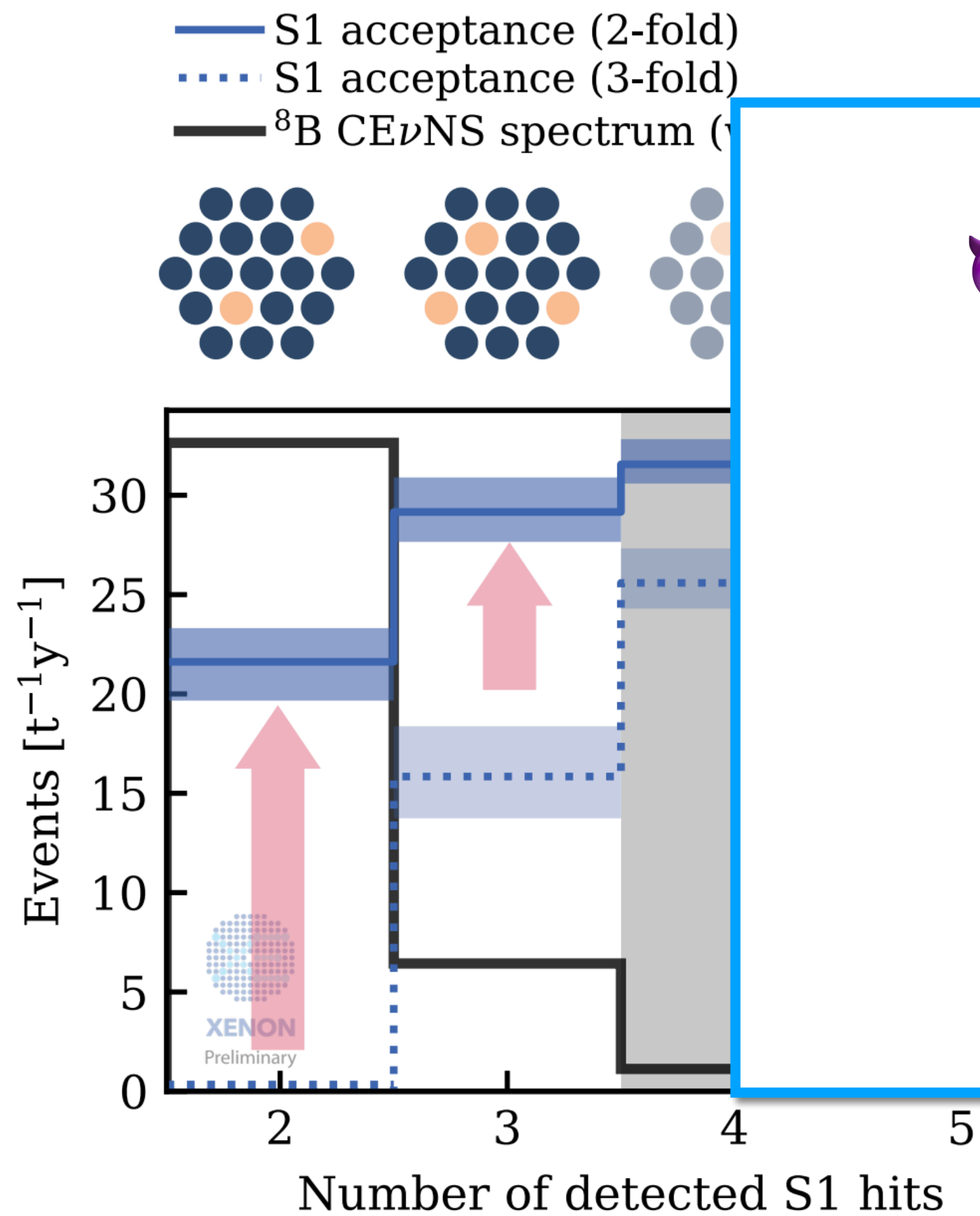


- Expect **less than 1 event /yr** in the WIMPs search data
- Need to lower the energy threshold to increase detection efficiency
- ROI: **2 or 3 photons detected in S1, ~4-17 electrons in S2**



~ 20 times more events

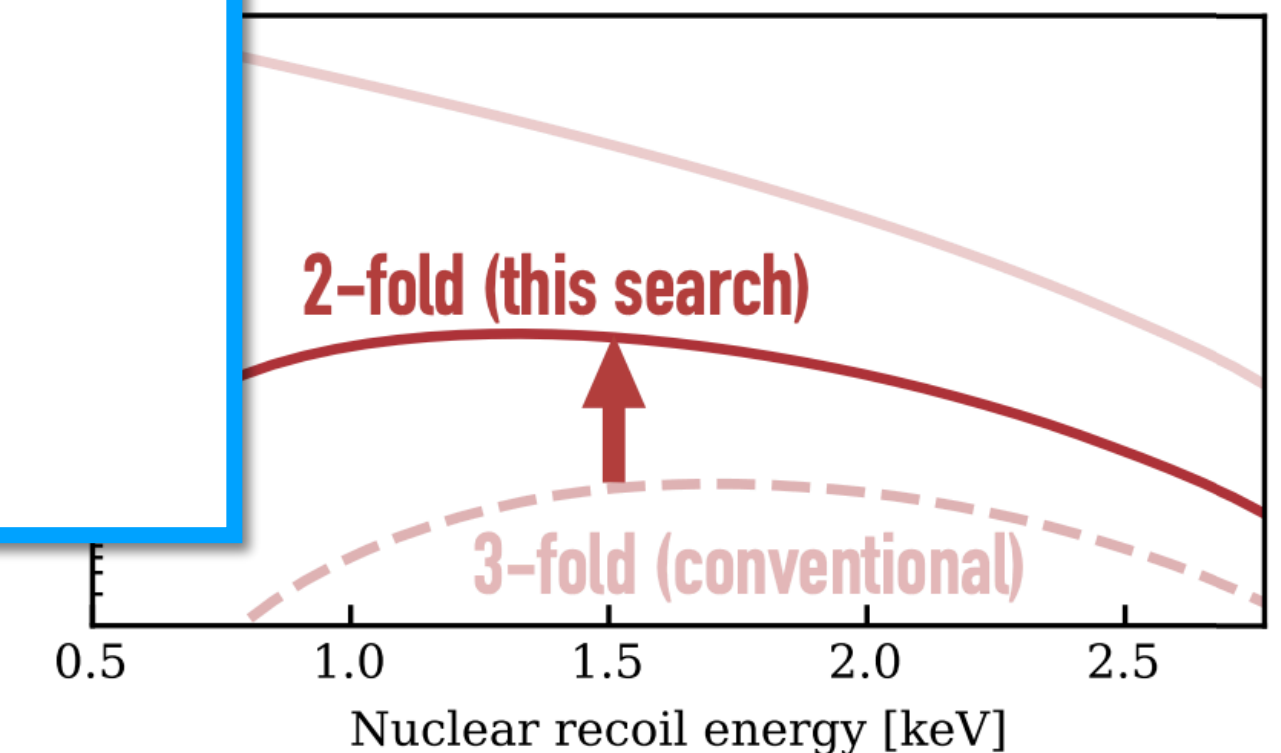
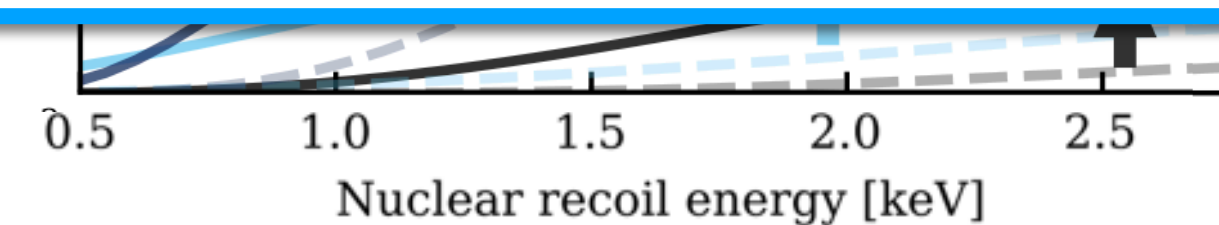


$$S/\sqrt{N}$$
$$\delta S, \delta N$$


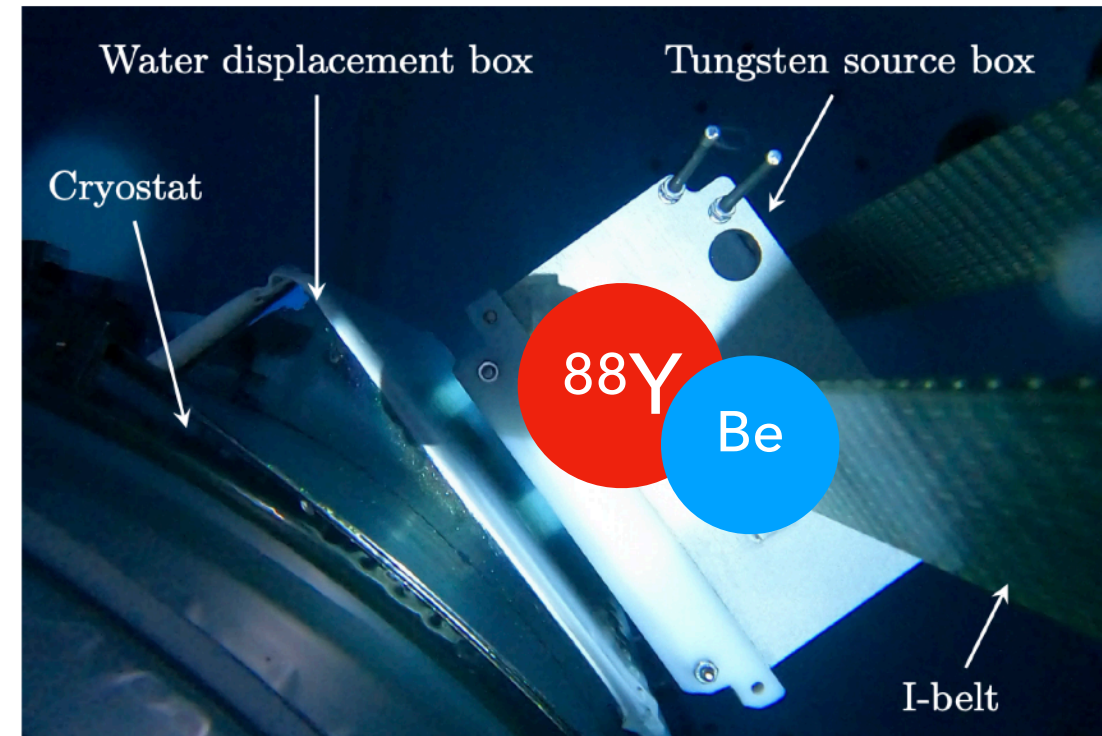
1. Less-known LXe response
2. Steep Background Increase

Cancel

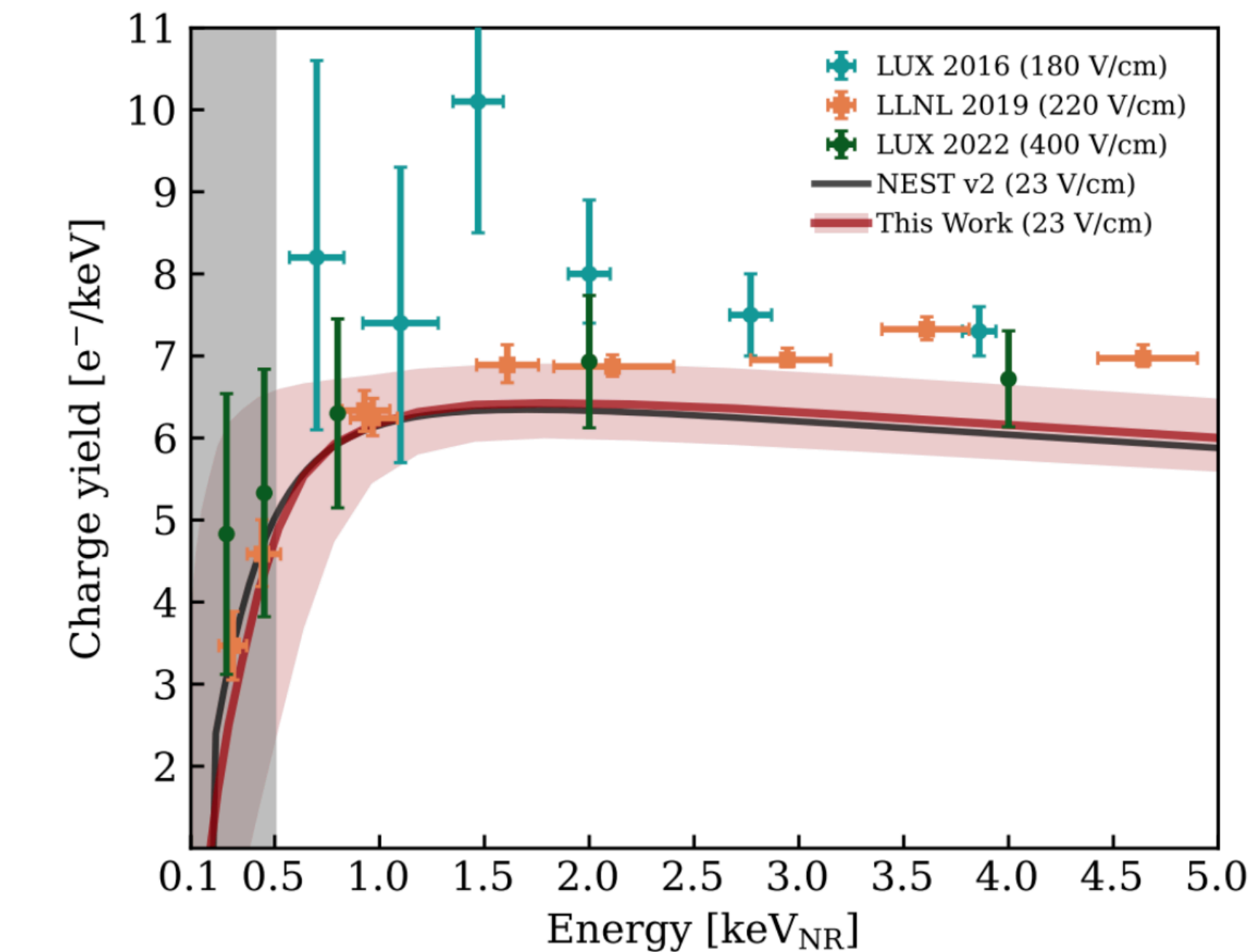
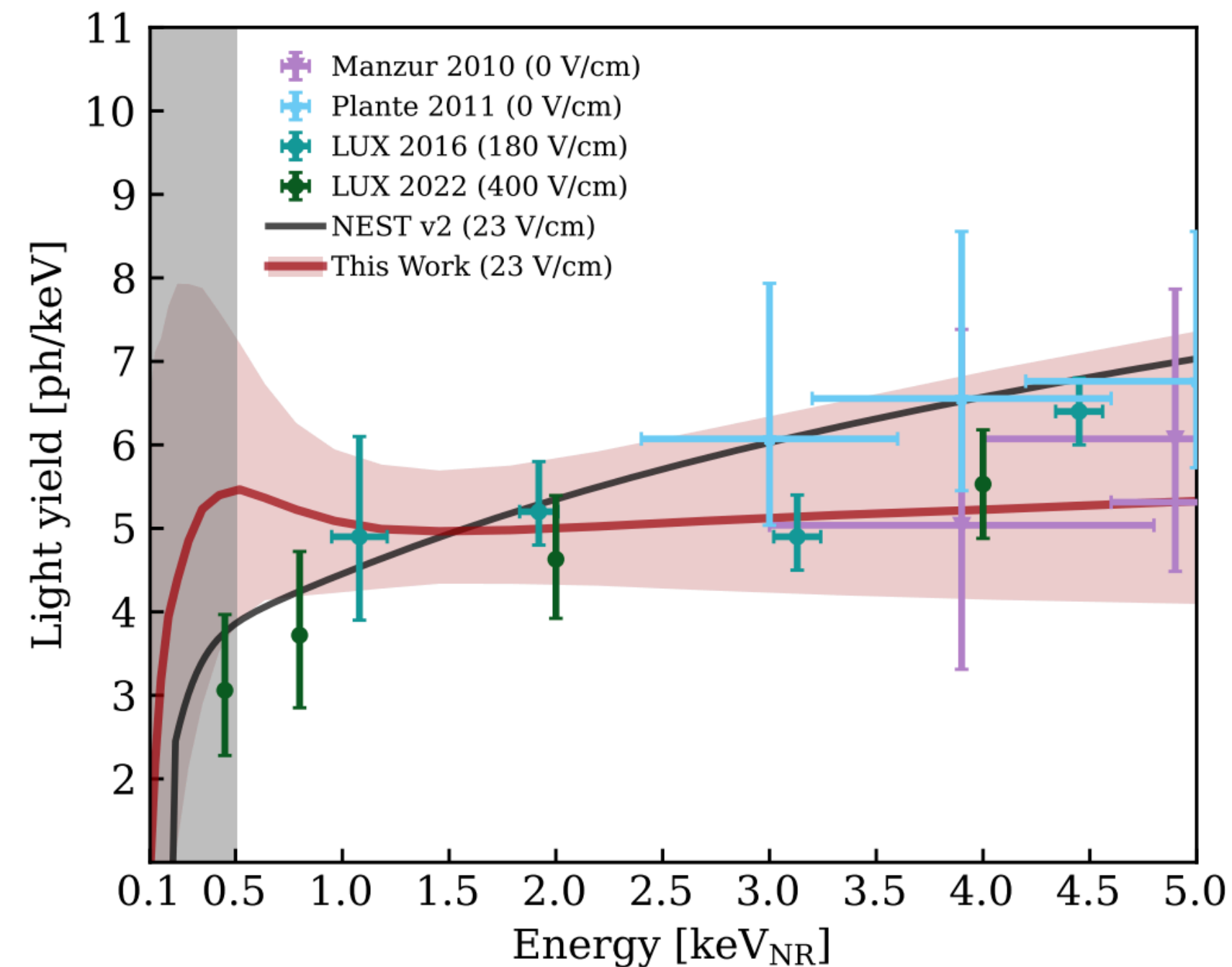
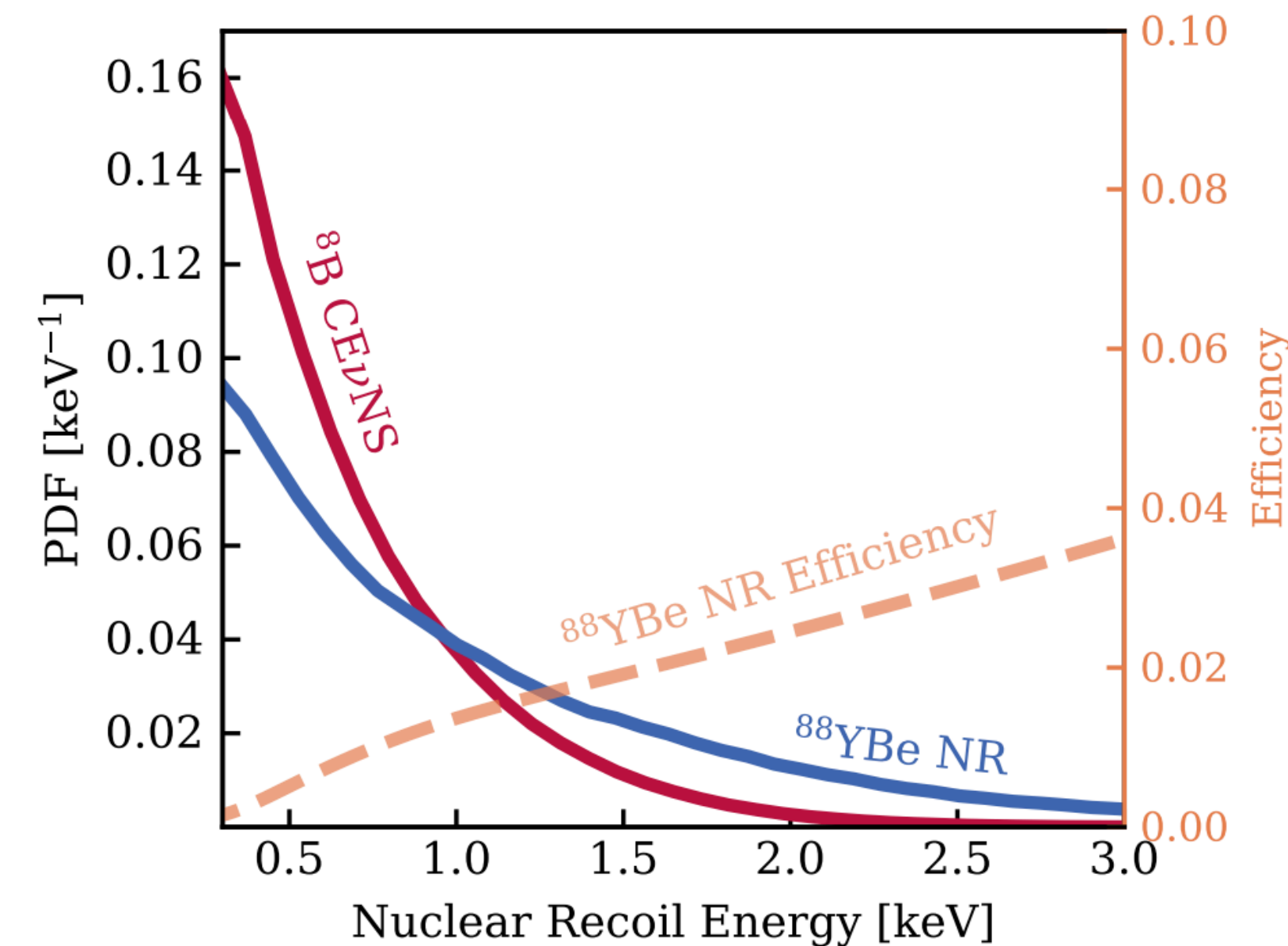
10 times more events



Signal: NR Calibration with ^{88}YBe



arXiv:2412.1045

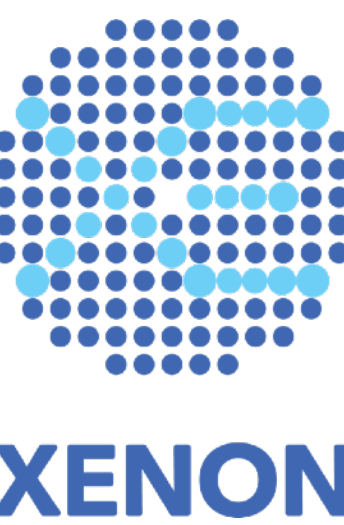


3.6 tonne·yr exposure

$$12/\sqrt{N}$$

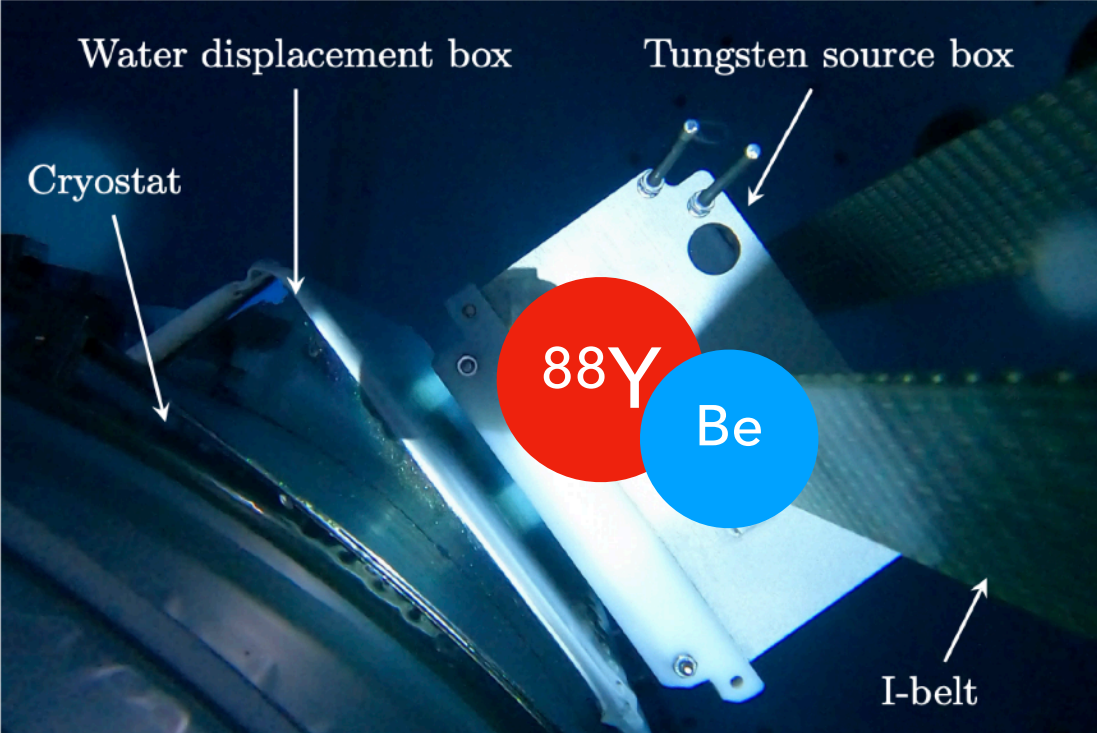
$$\delta S = 35\%, \delta N$$

from Yield model + Selection efficiency

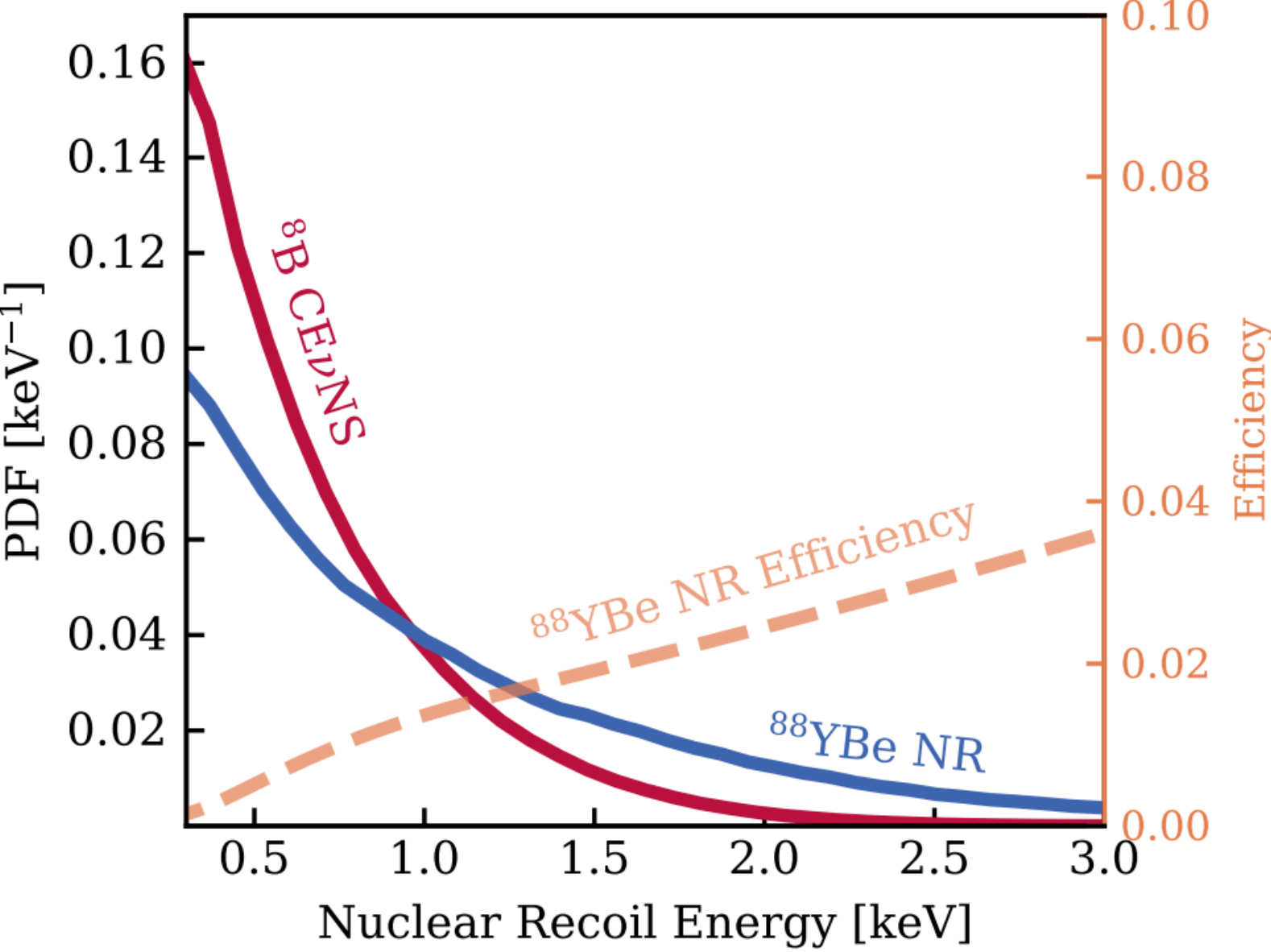


- Light and charge yields calibrated with the 152 keV ^{88}YBe photoneutron source
- Yield uncertainties propagated via two parameters (tLy, tQy)
 - which control relative shift from Ly, Qy from median to $\pm 1\sigma$

Signal: NR Calibration with ^{88}YBe



arXiv:2412.1045



Low-energy Yttrium-Beryllium calibration in XENONnT

Aug 28, 2025, 6:00 PM

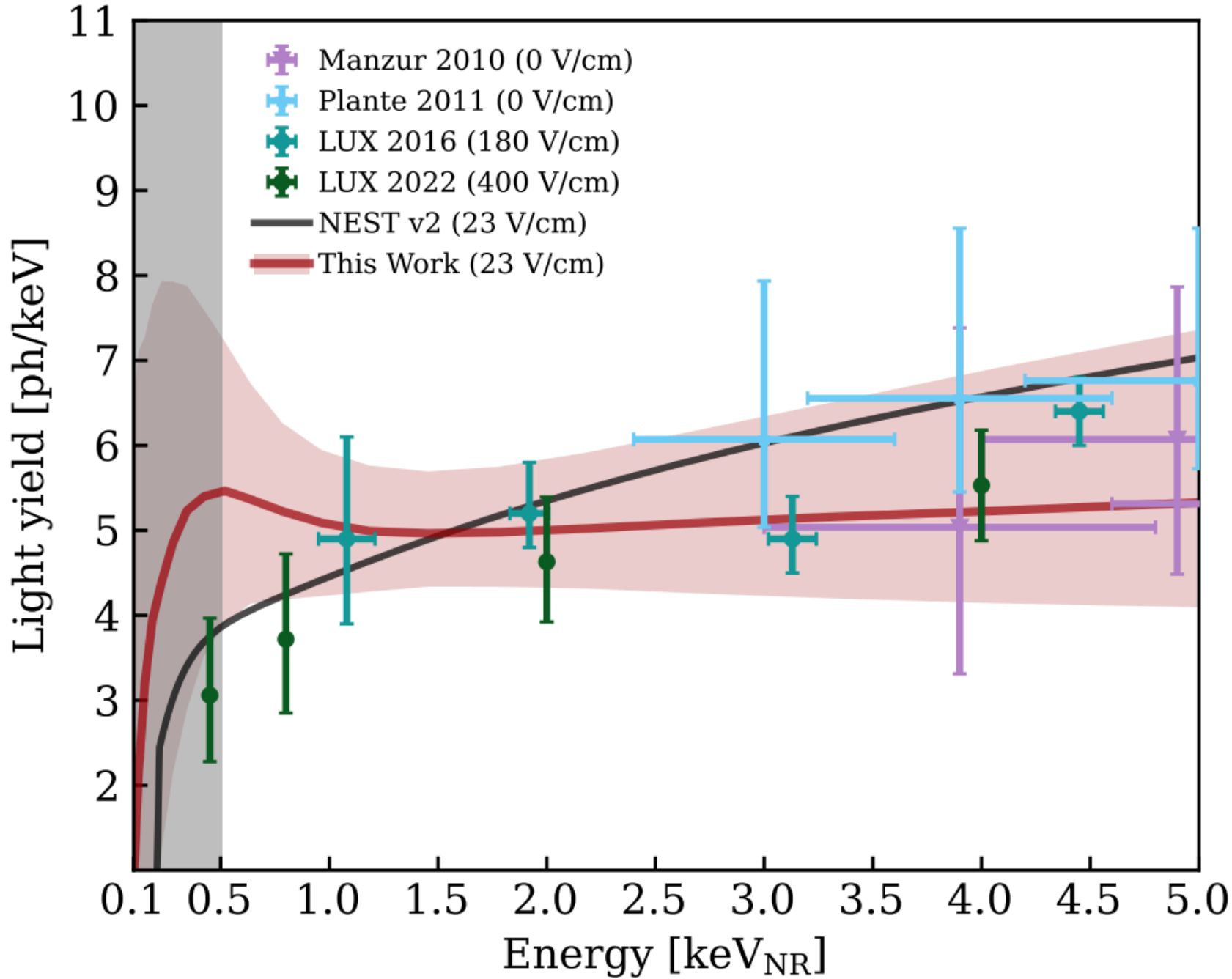
20m

Conference Room F2-R2

Speaker

Shengchao Li (西湖大学 Westlake University)

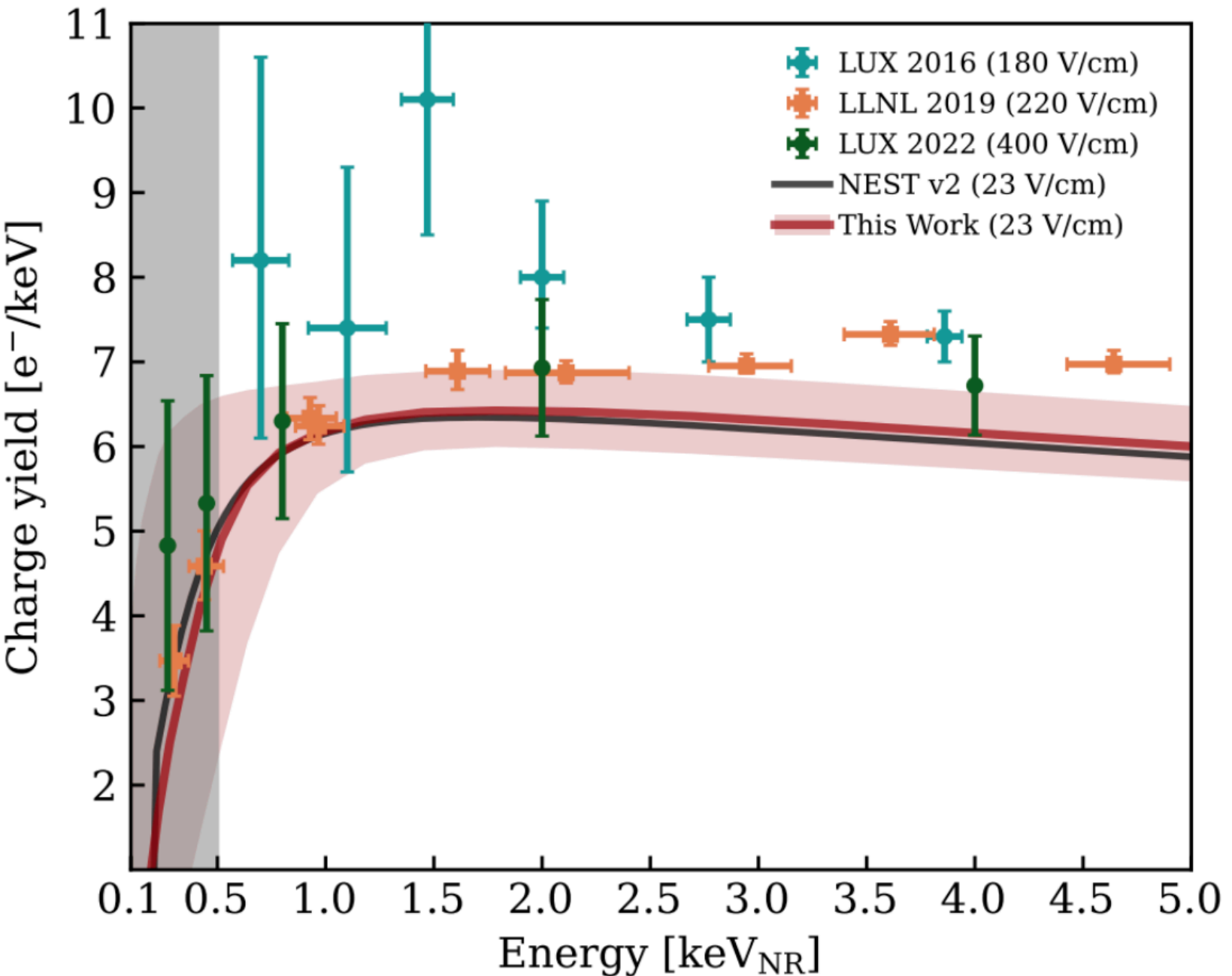
dedicated talk Aug 28 by Shengchao



3.6 tonne·yr exposure

$$12/\sqrt{N}$$
$$\delta S = 35\%, \delta N$$

from Yield model + Selection efficiency

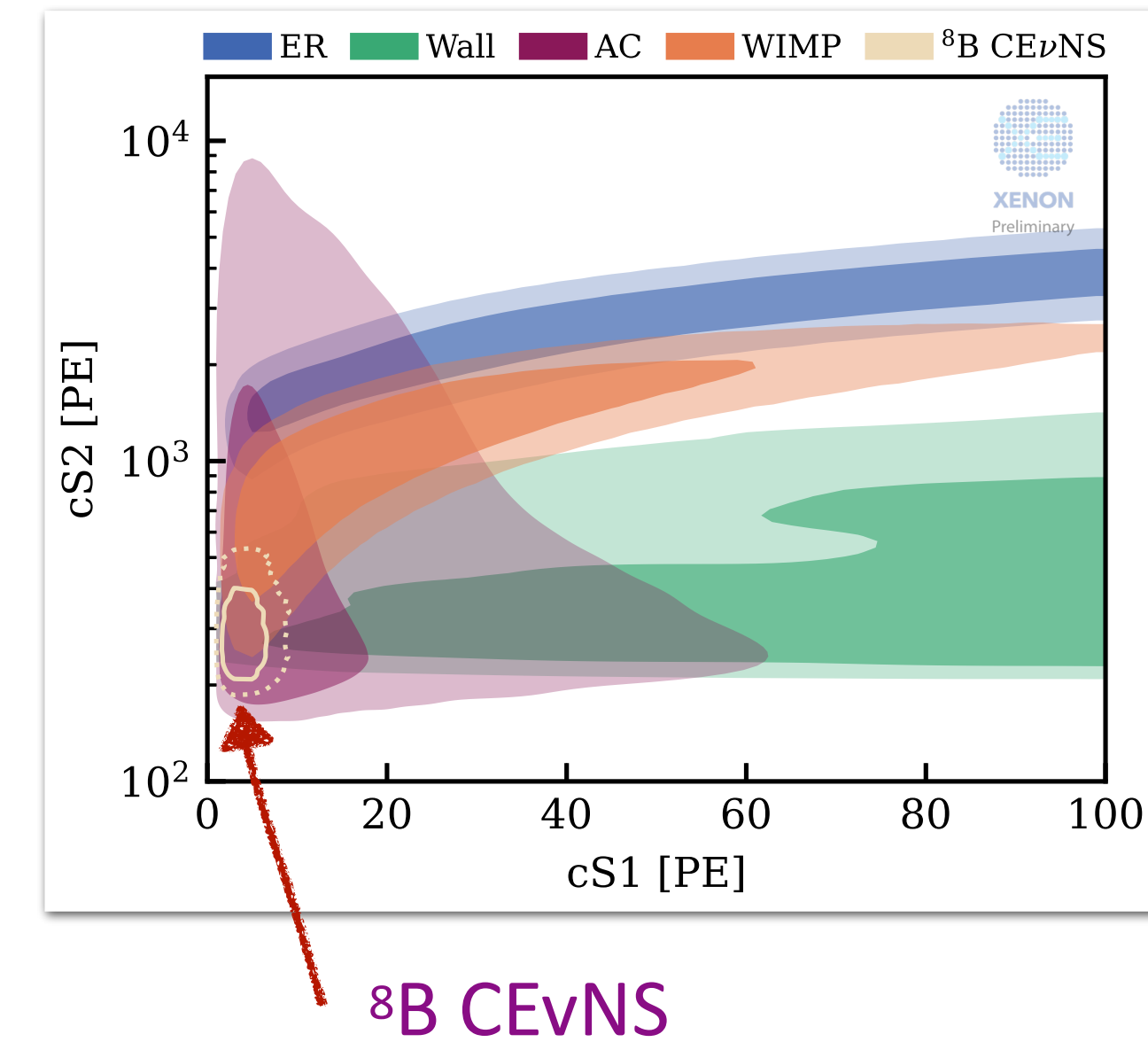
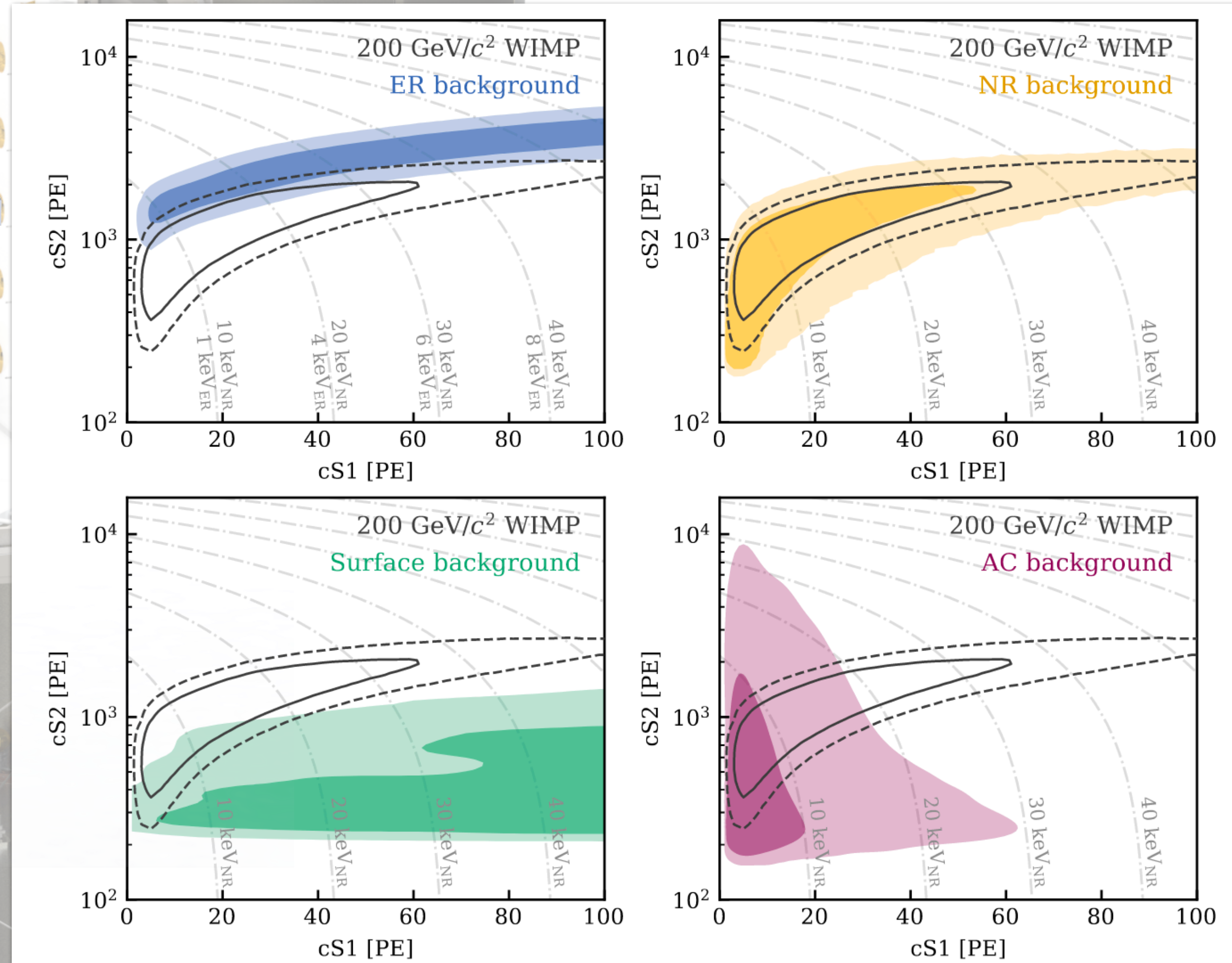


- Light and charge yields calibrated with the 152 keV ^{88}YBe photoneutron source
- Yield uncertainties propagated via two parameters (tLy, tQy)
 - which control relative shift from Ly, Qy from median to $\pm 1\sigma$



Background

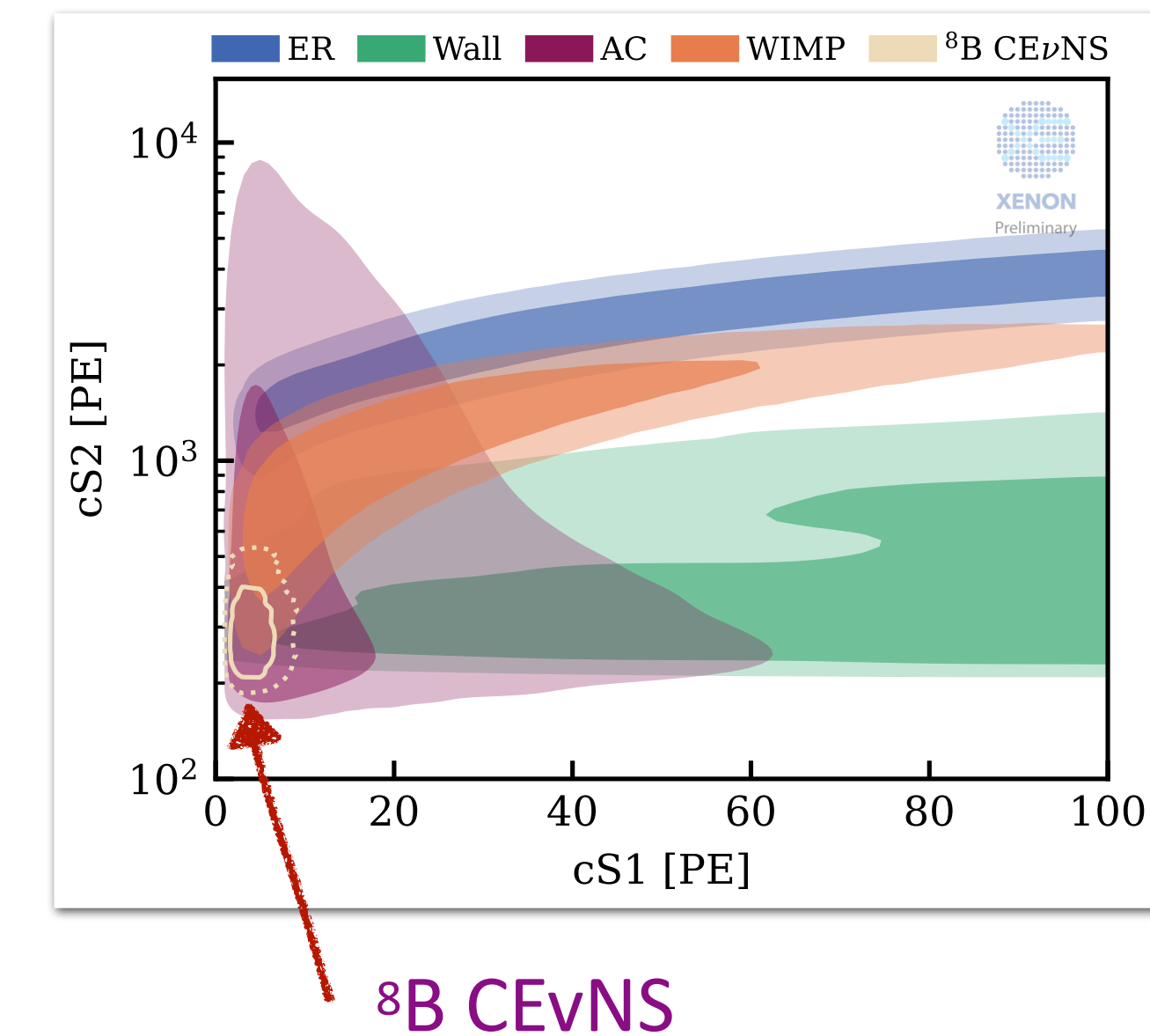
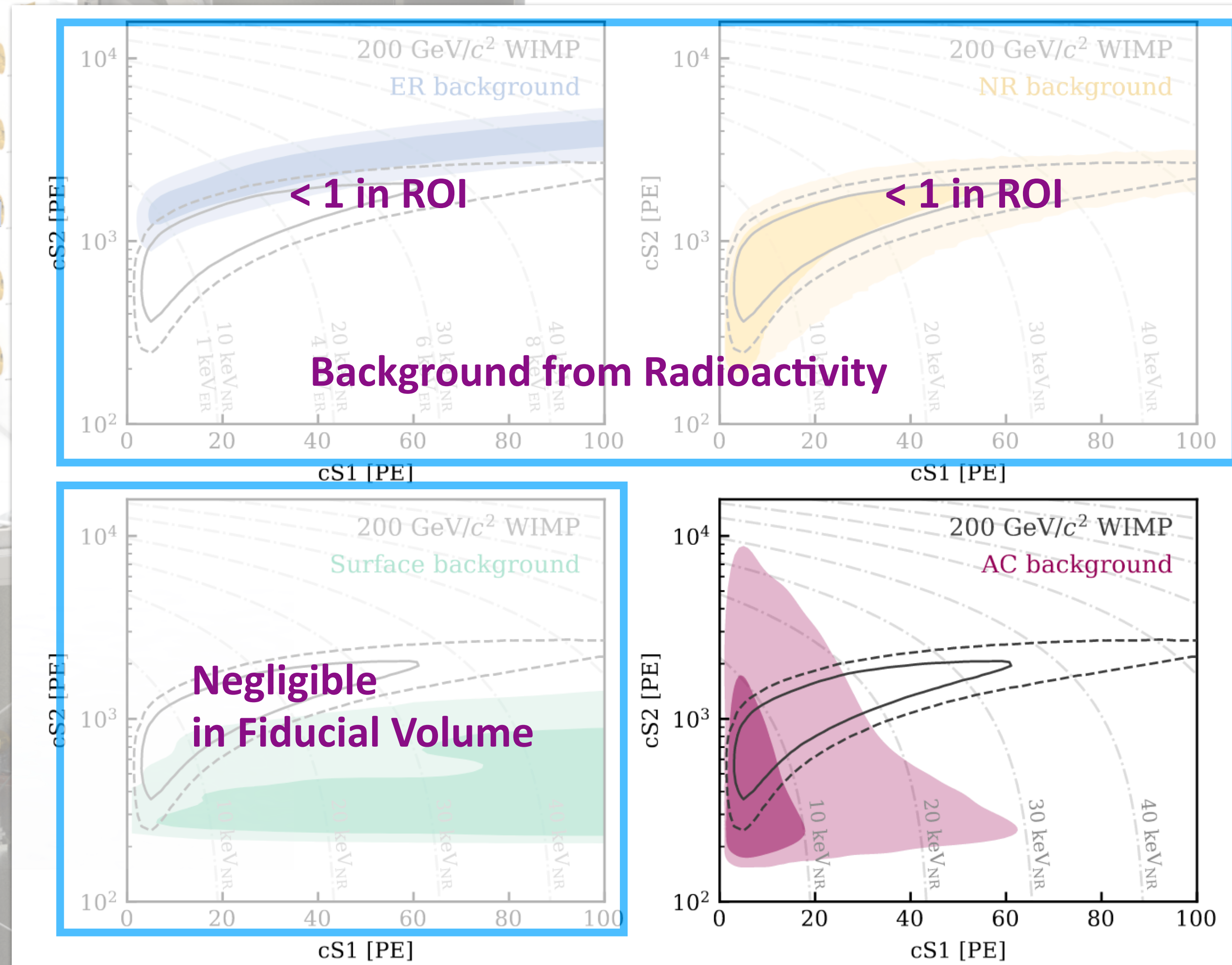
Background models in XENONnT WIMP search



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

Background

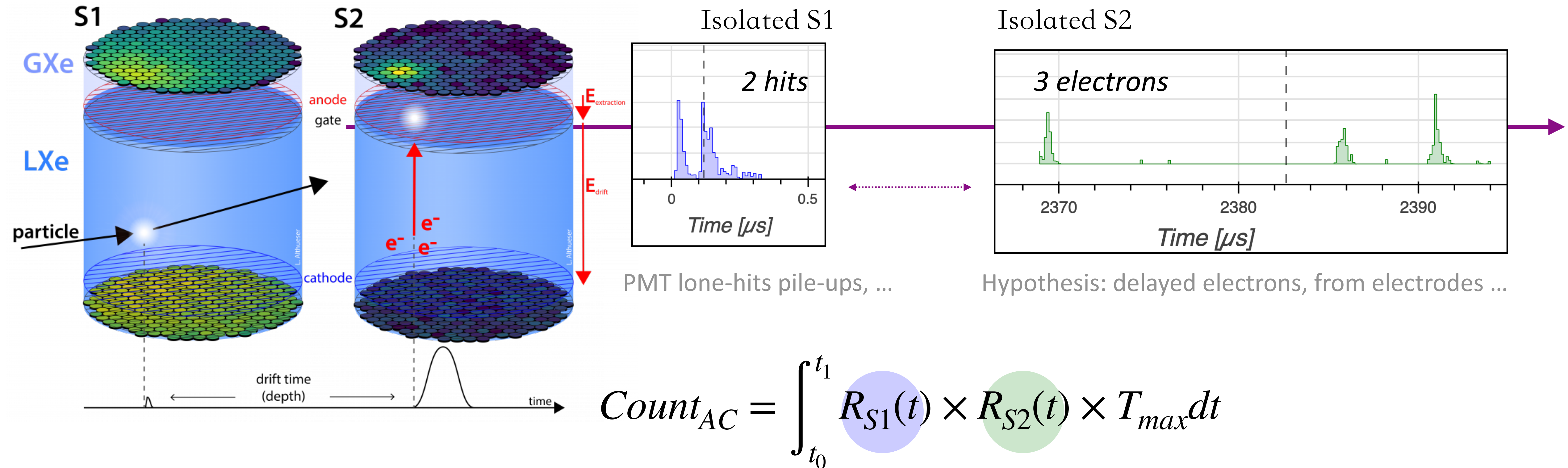
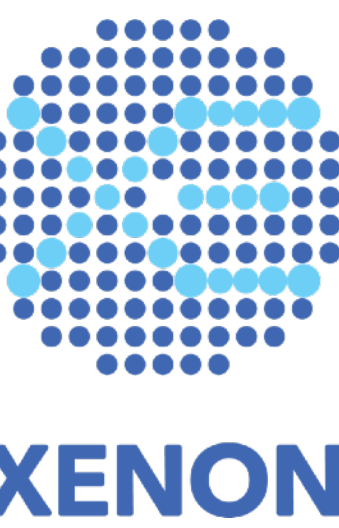
Background models in XENONnT WIMP search



Background: Accidental Coincidences (AC)

3.6 tonne·yr exposure

$$12/\sqrt{} \approx 10^5 ?$$



AC rate before any suppression:

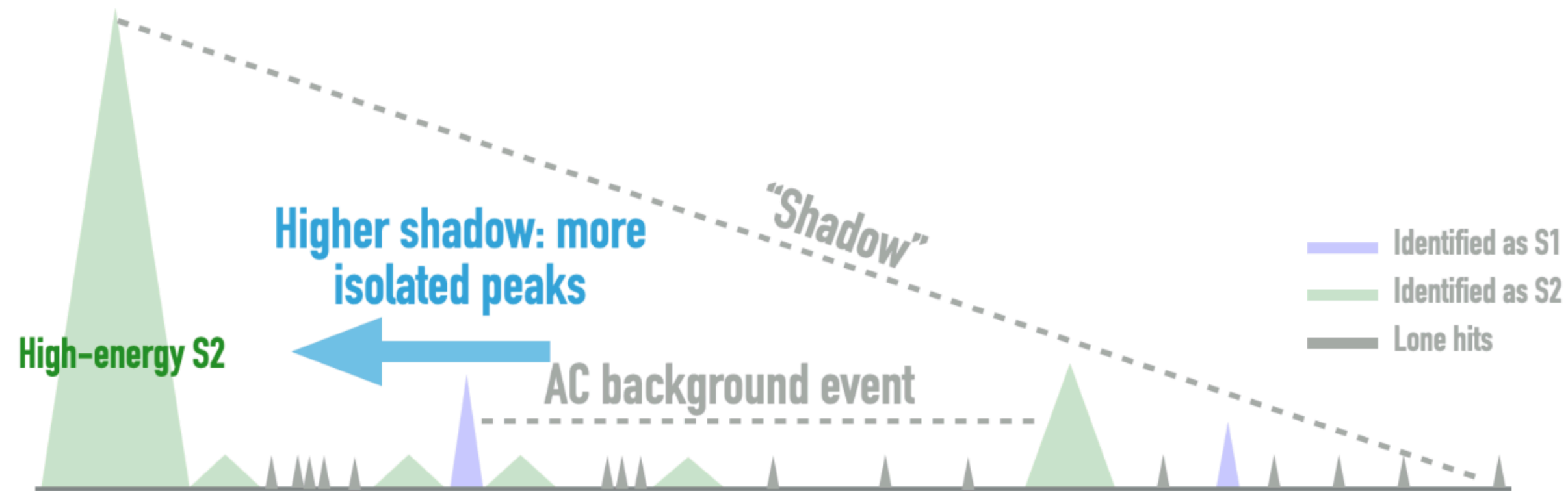
$$15 \text{ Hz} \times 0.15 \text{ Hz} \times 2.2 \text{ ms} \rightarrow \sim 10^5/\text{yr}$$

(23 V/cm)

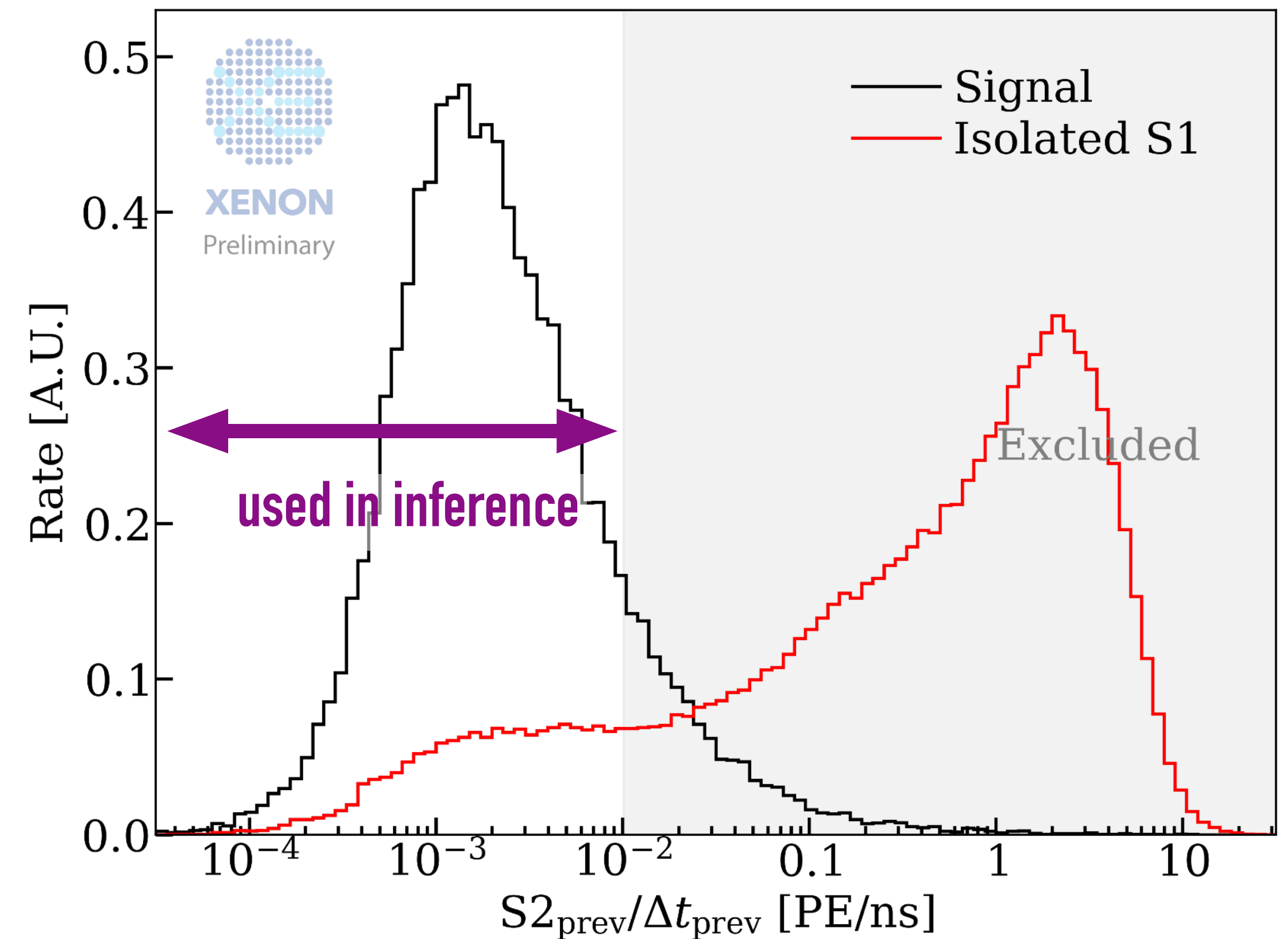
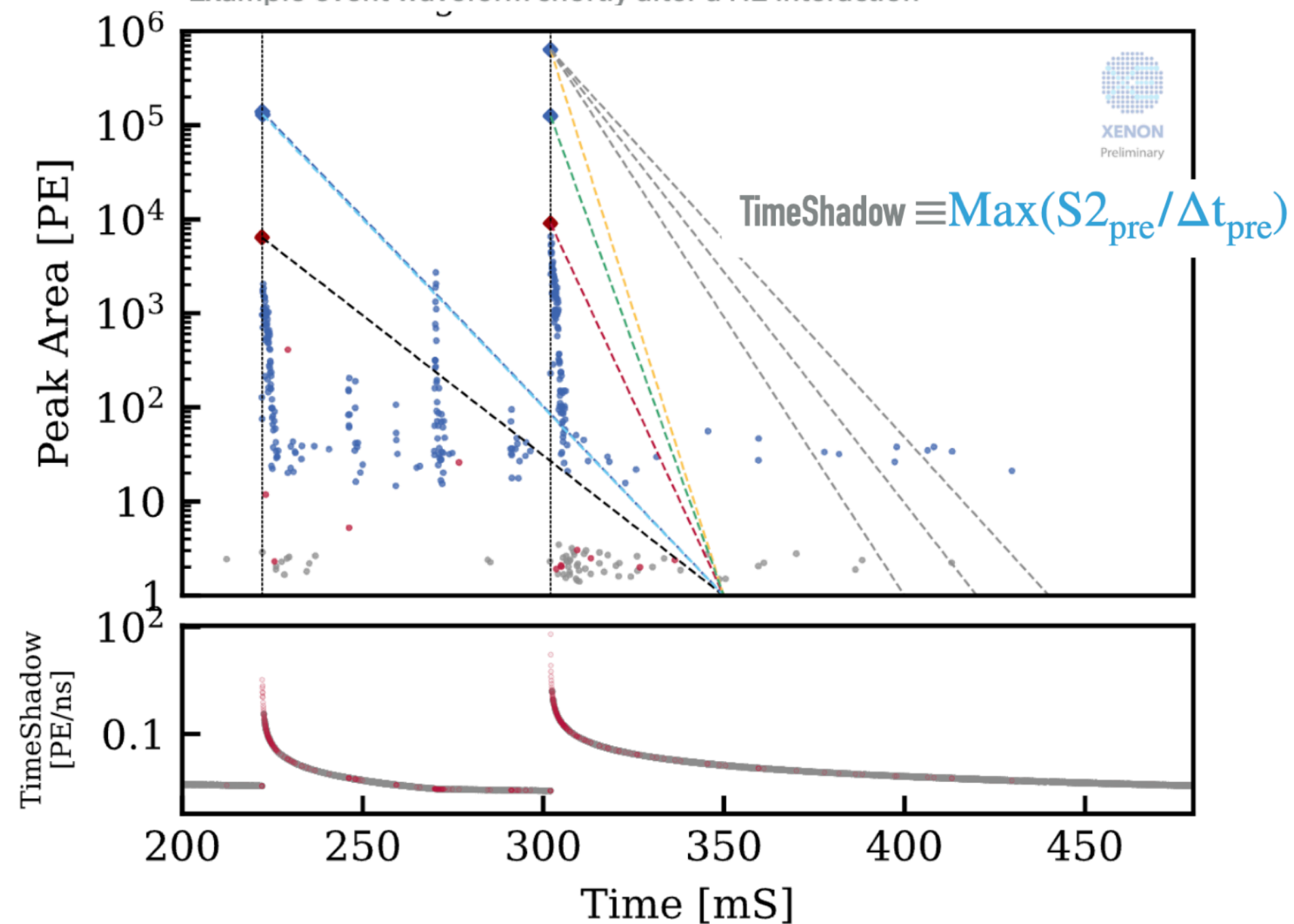
AC Discrimination: by Correlation with High Energy Signals



XENON



Example event waveform shortly after a HE interaction



- Remove the **20%** worst exposure
- Suppress the isolated S1 / S2 rate **by 1 orders of magnitude**

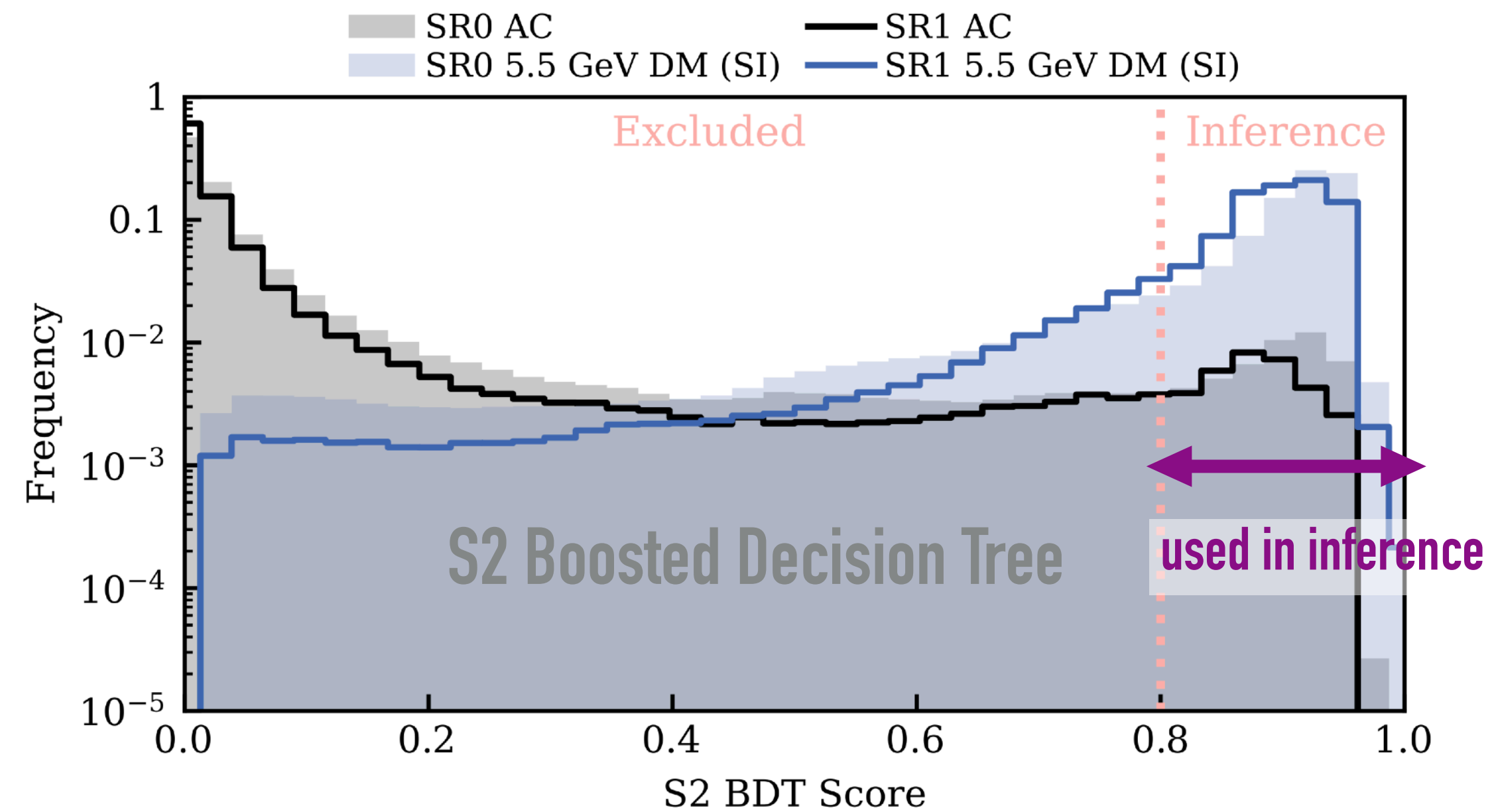
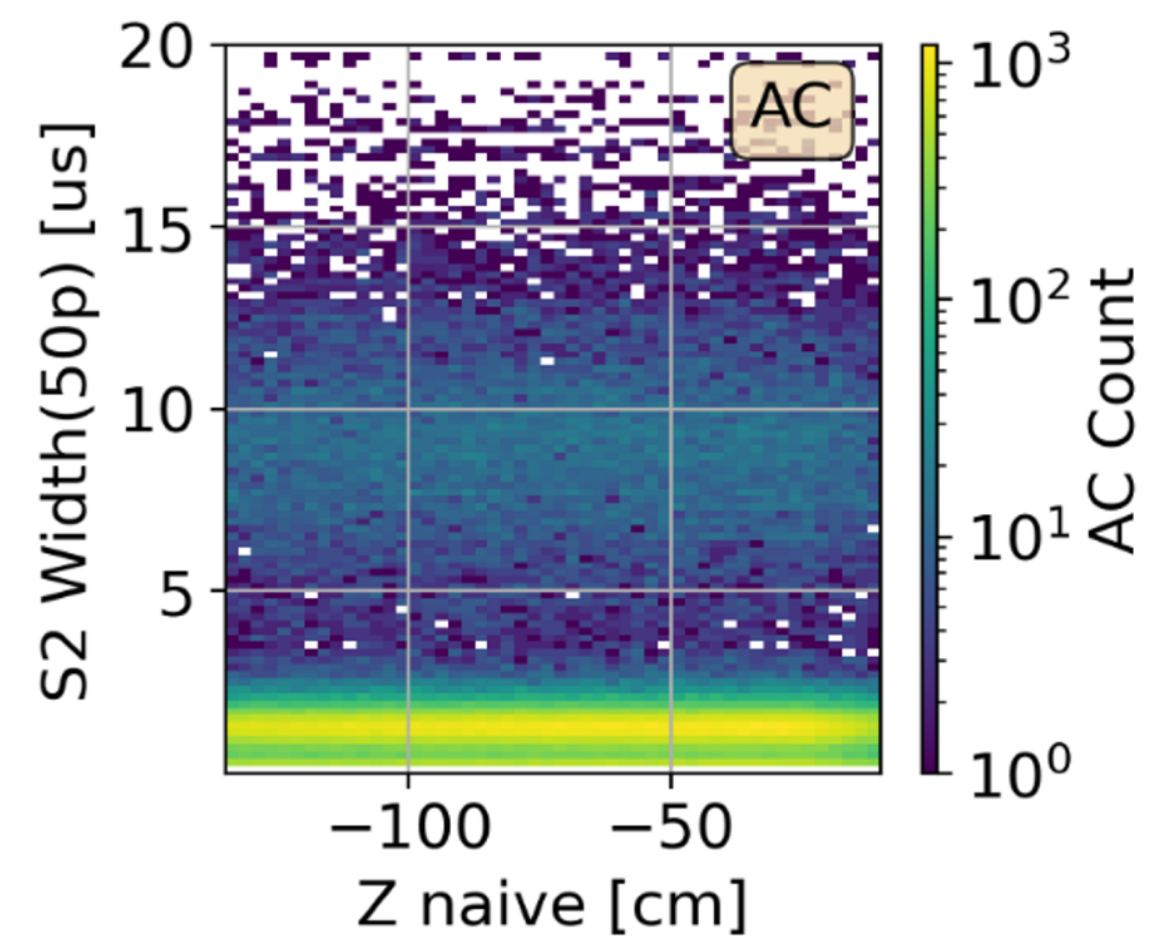
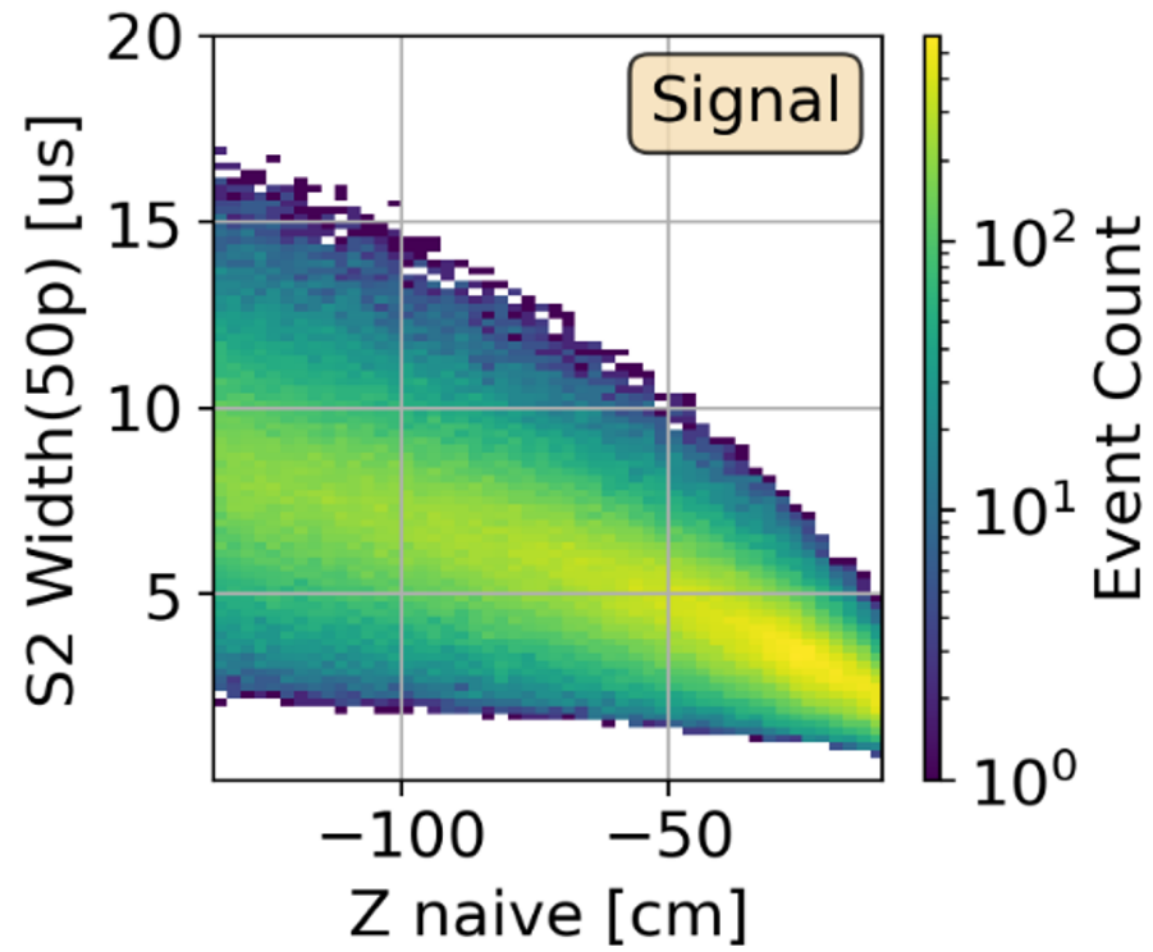
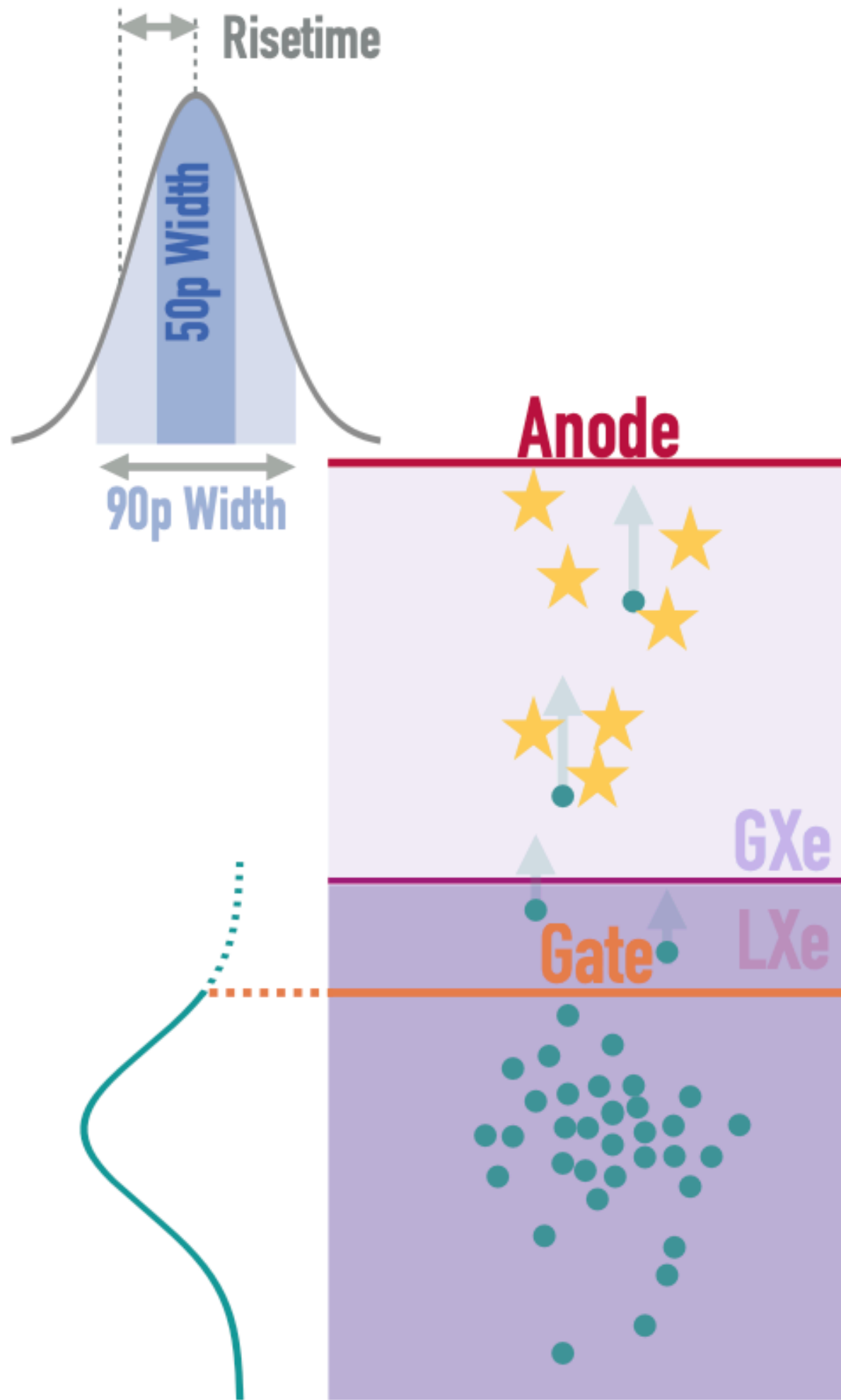
— **2.3 Hz** — **18 mHz** — **2.2 ms** — **~10³/yr**

AC Discrimination: by using e-diffusion



$$12/\sqrt{26}$$
$$\delta S = 35\%, \delta N$$

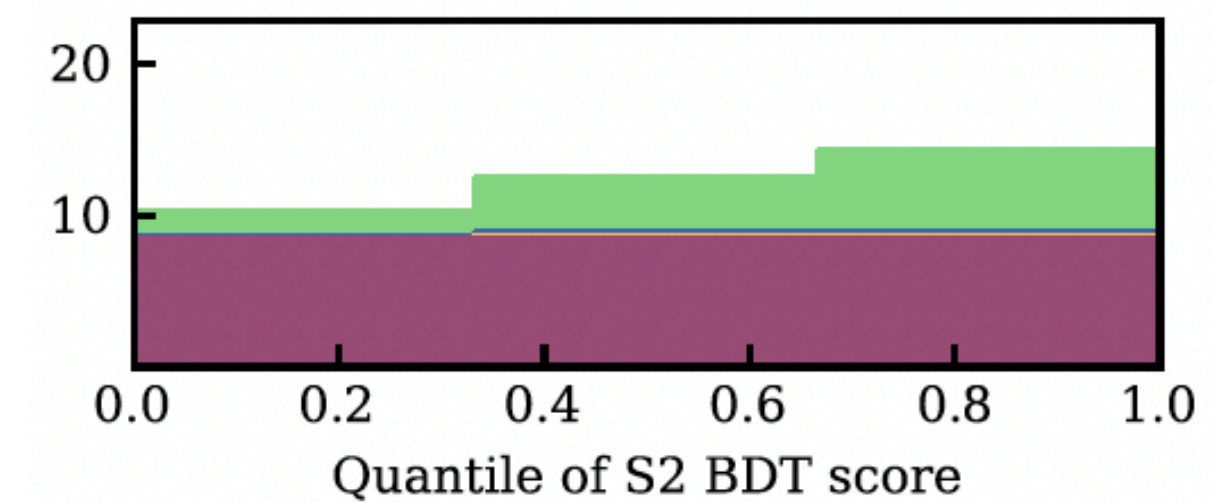
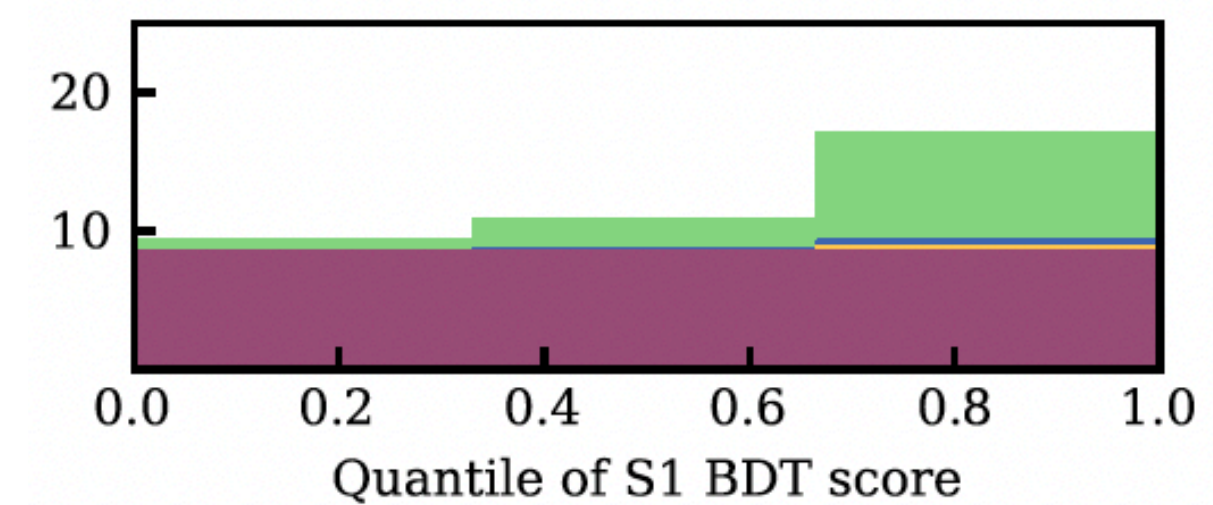
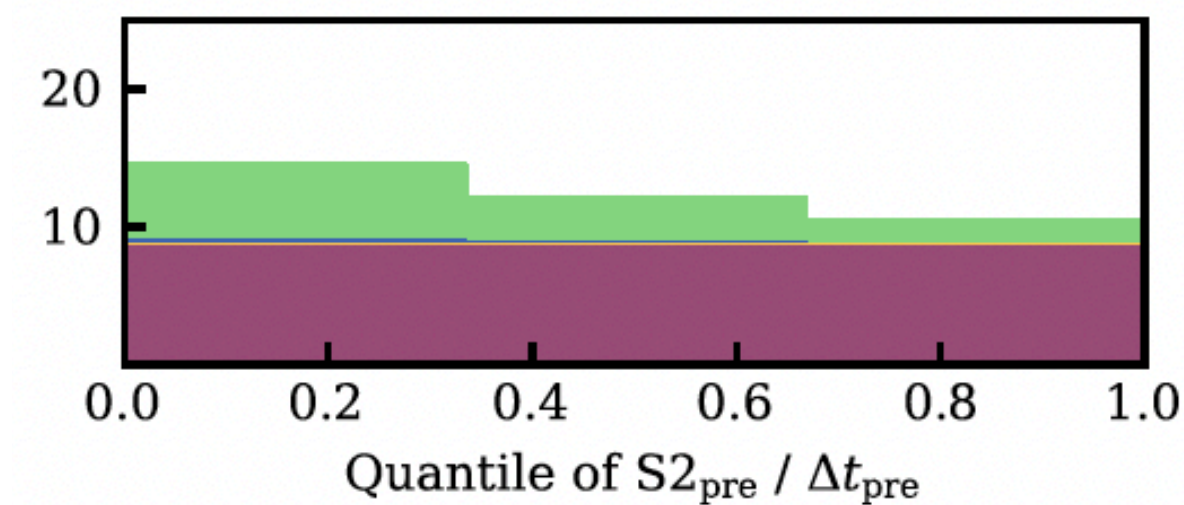
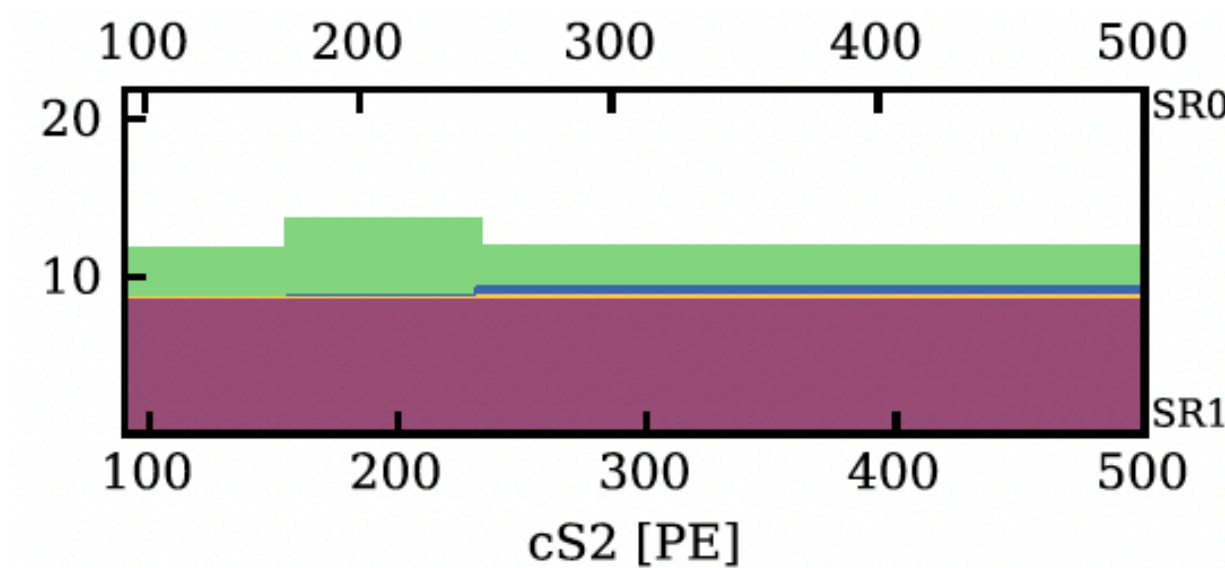
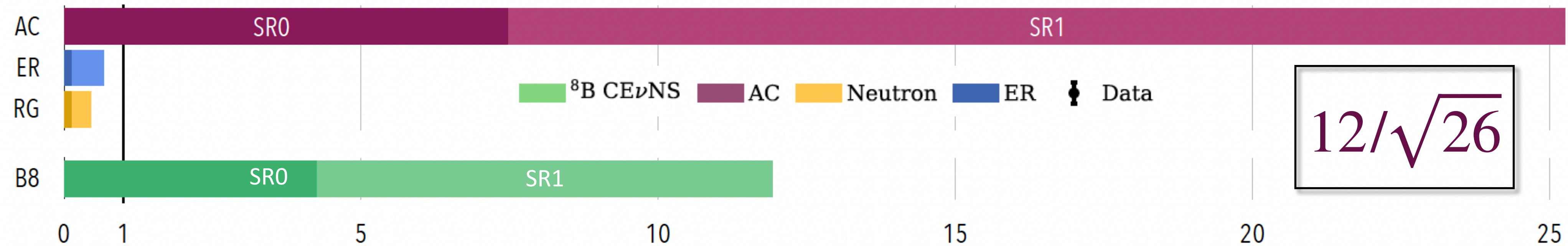
9% (6%) in SR0 (SR1) w/ sideband dataset



- AC discrimination using the correlation between **S2 waveform width** and **drift depth (Z)**
- Remove **95%** AC events with **80%** signal acceptance

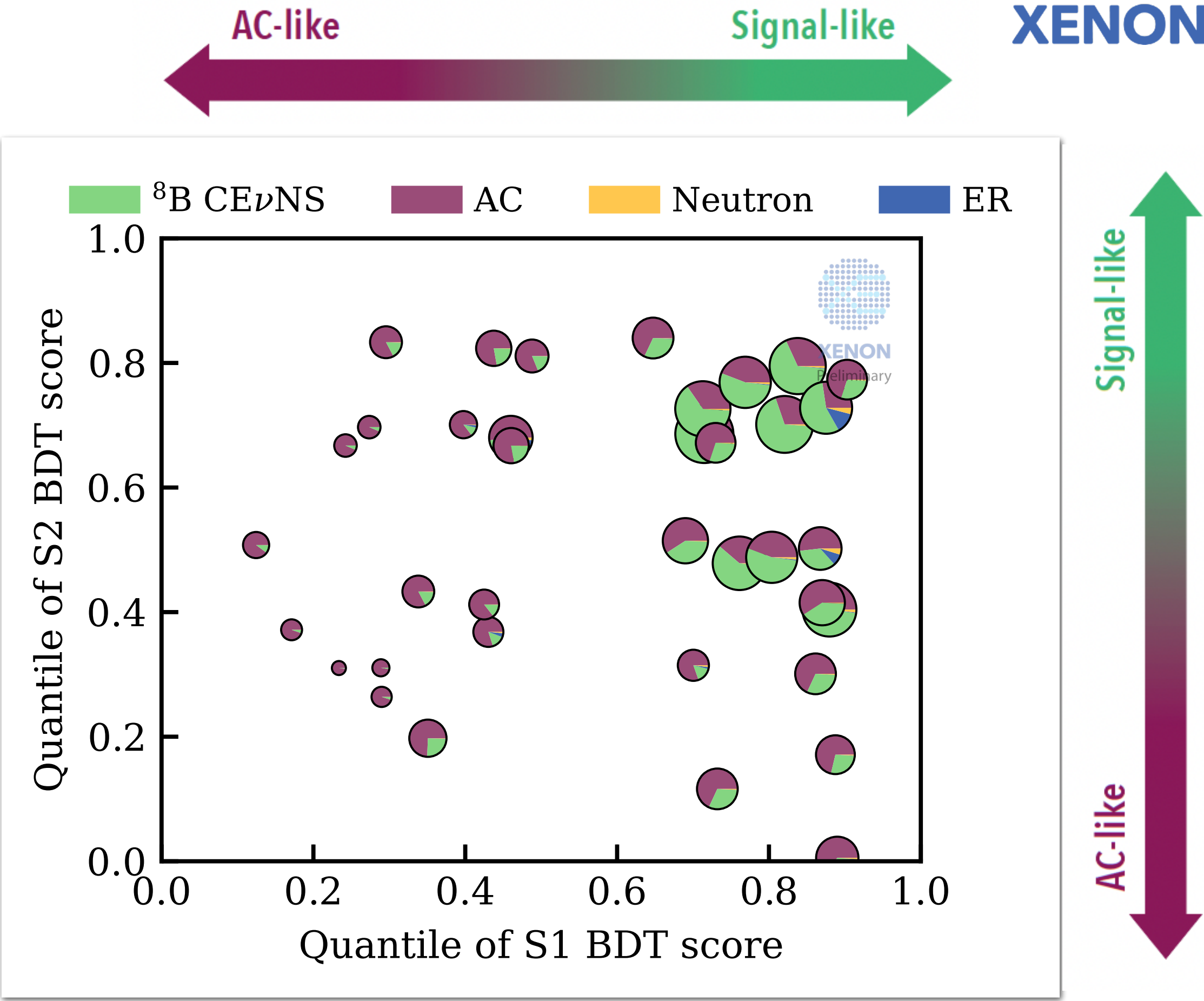
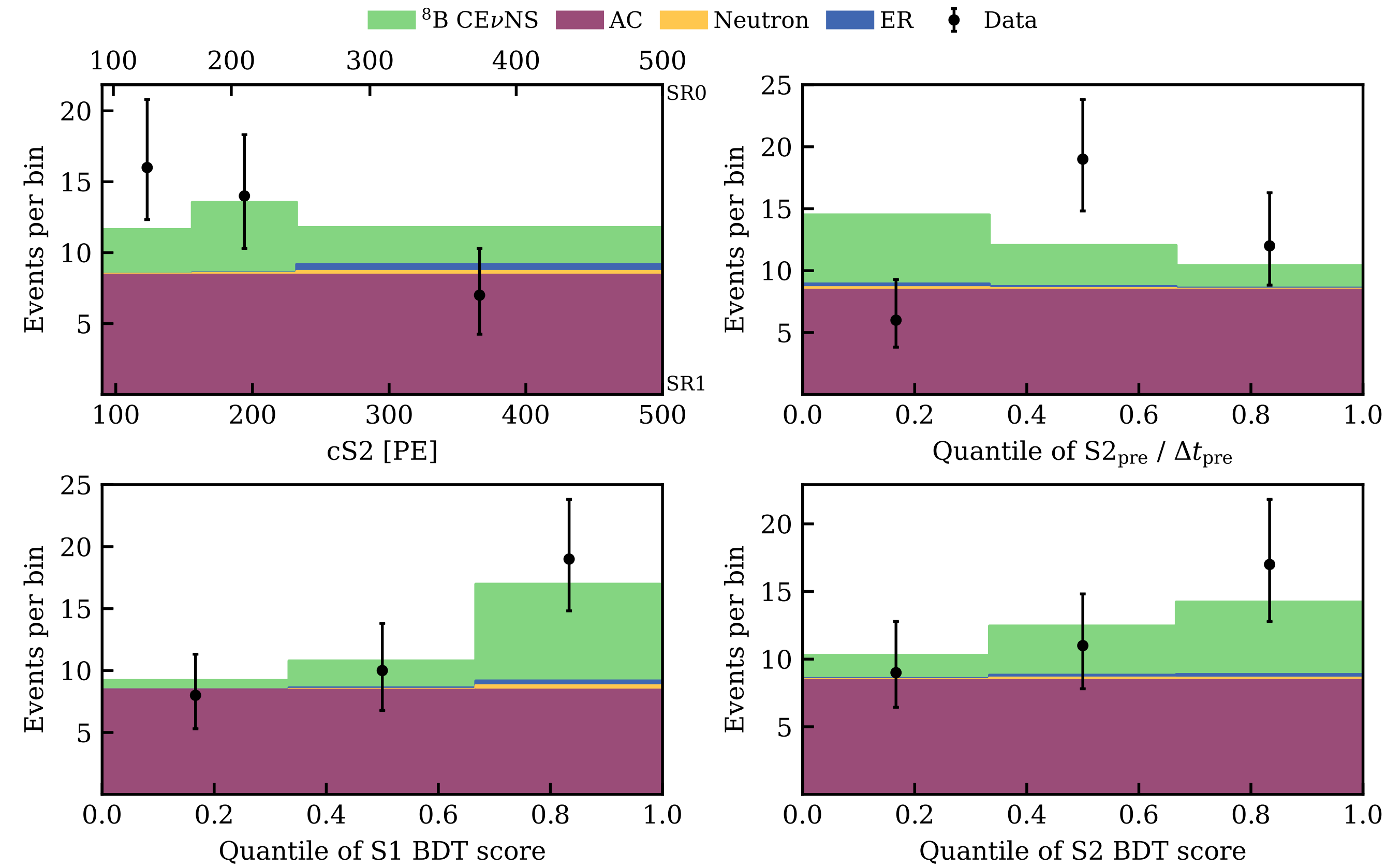
Final Predictions

3.6 tonne·yr exposure

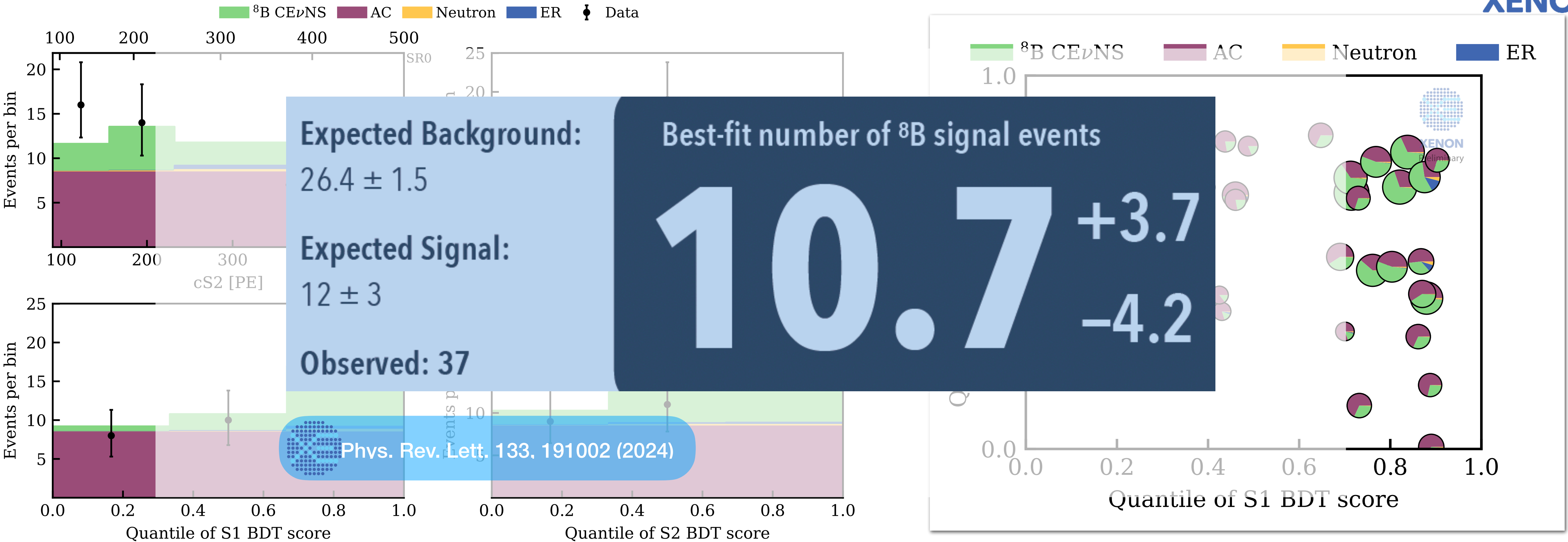


Analysis in 4D parameter space to enhance the discovery power

Results

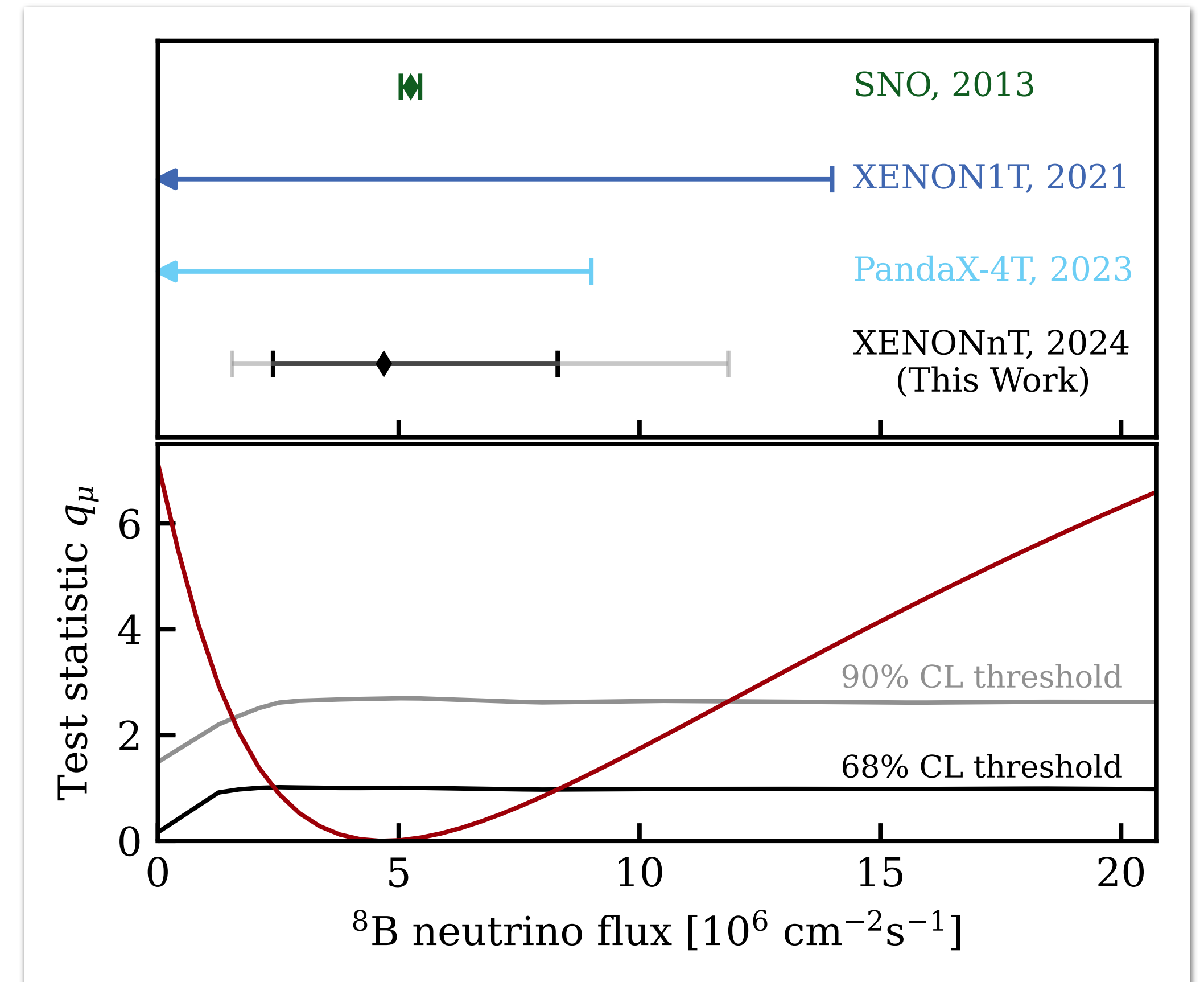


Results



First measurement of Solar ^8B CEvNS

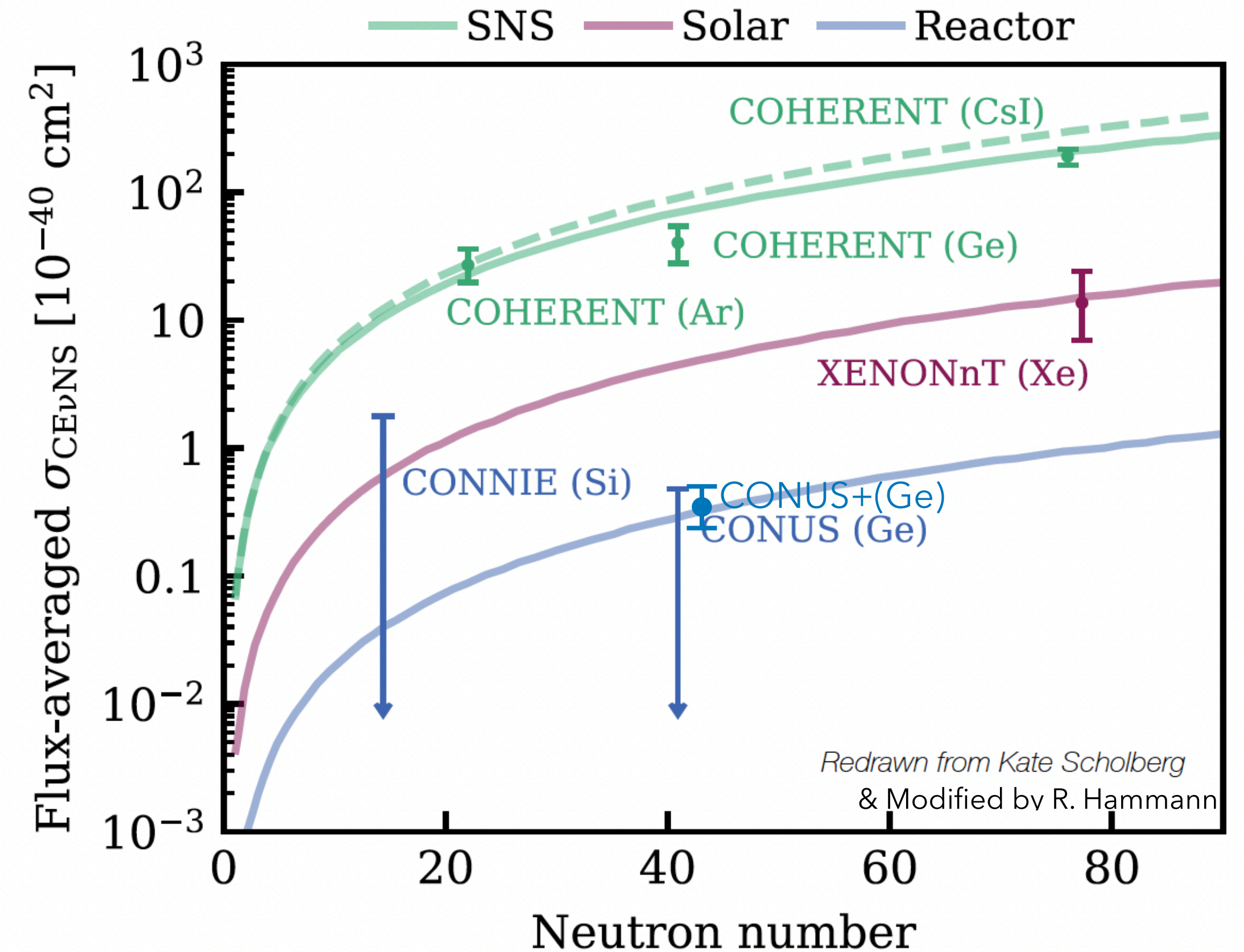
- Discovery significance: **2.73 σ** (1/300 chance to be background only)
- Measured ^8B flux: $(4.7^{+3.6}_{-2.3}) \times 10^6 \text{cm}^{-2}\text{s}^{-1}$
- Fix flux $\rightarrow$ First **measurement of** CEvNS on **Xe target**
- **5 σ discovery** & precision measurement in reach for XENONnT with future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



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

First measurement of Solar ^8B CE ν NS

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



XENONnT: The Smallest

Solar Neutrino Detector

Super-Kamiokande
(50 kt)

KamLAND
(1000 t)

SNO
(1000 t)

Borexino
(270 t)

XENONnT: The Smallest

Solar Neutrino Detector

Super-Kamiokande
(50 kt)

KamLAND
(1000 t)

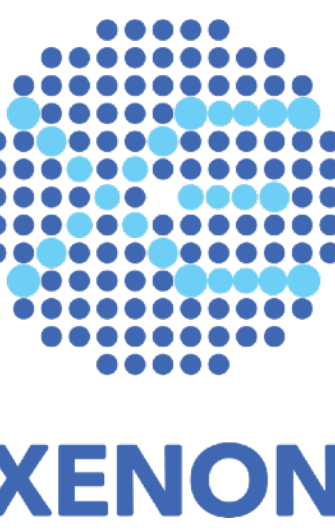
SNO
(1000 t)

Borexino
(270 t)

XENONnT
(5.9 t)



Search for Light WIMPs in the neutrino fog



Search for Light Dark Matter with XENONnT

Aug 27, 2025, 4:00 PM

20m

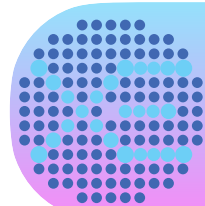
Conference Room F2-R1

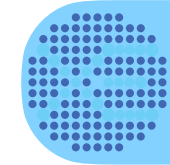
Speaker

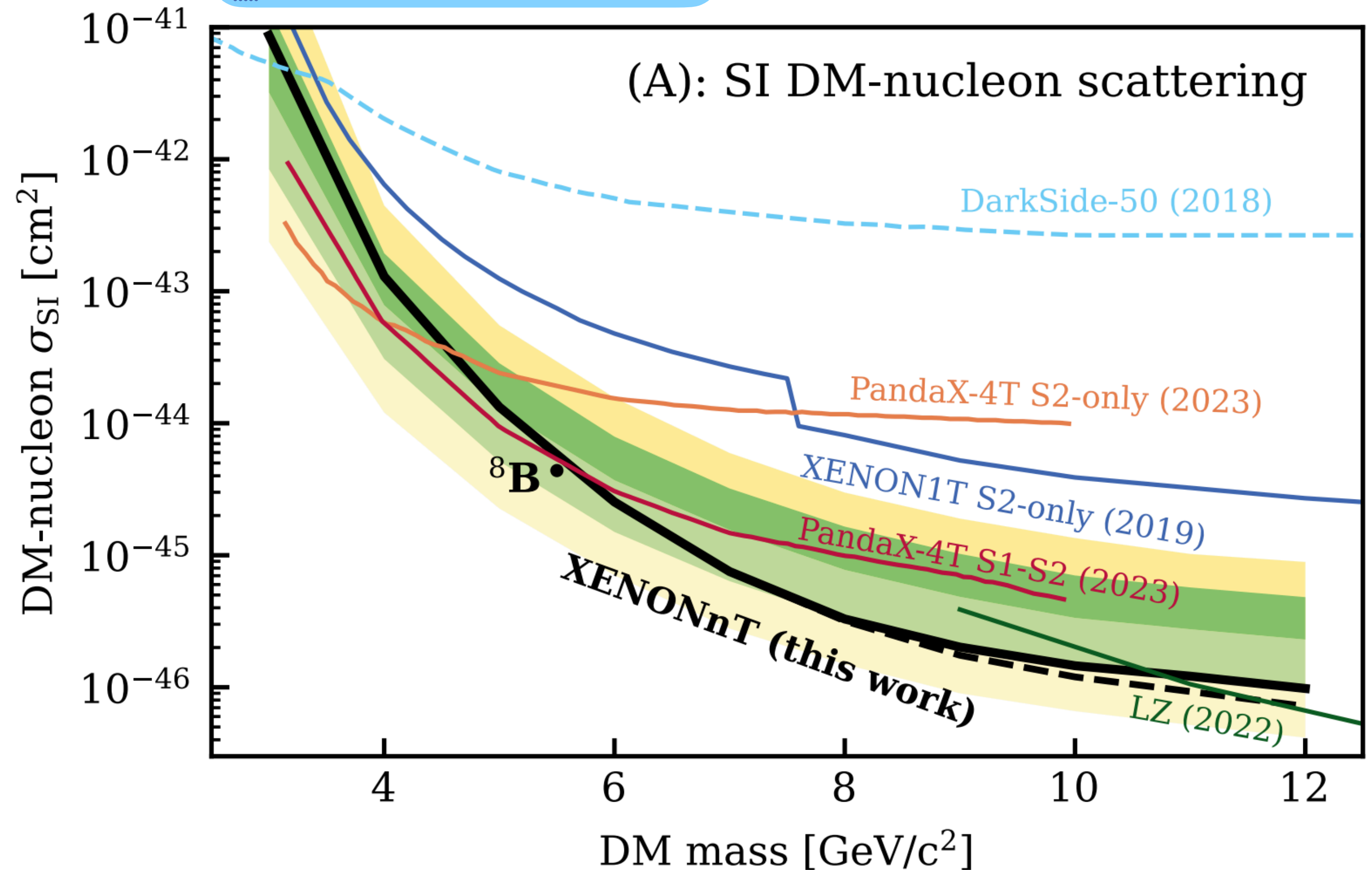
Shenyang

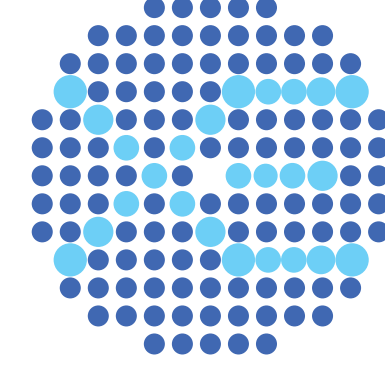
dedicated talk Aug 27 by Shenyang

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

 Check out our [Data Release!](#)

 Phys. Rev. Lett. 134,111802





XENON

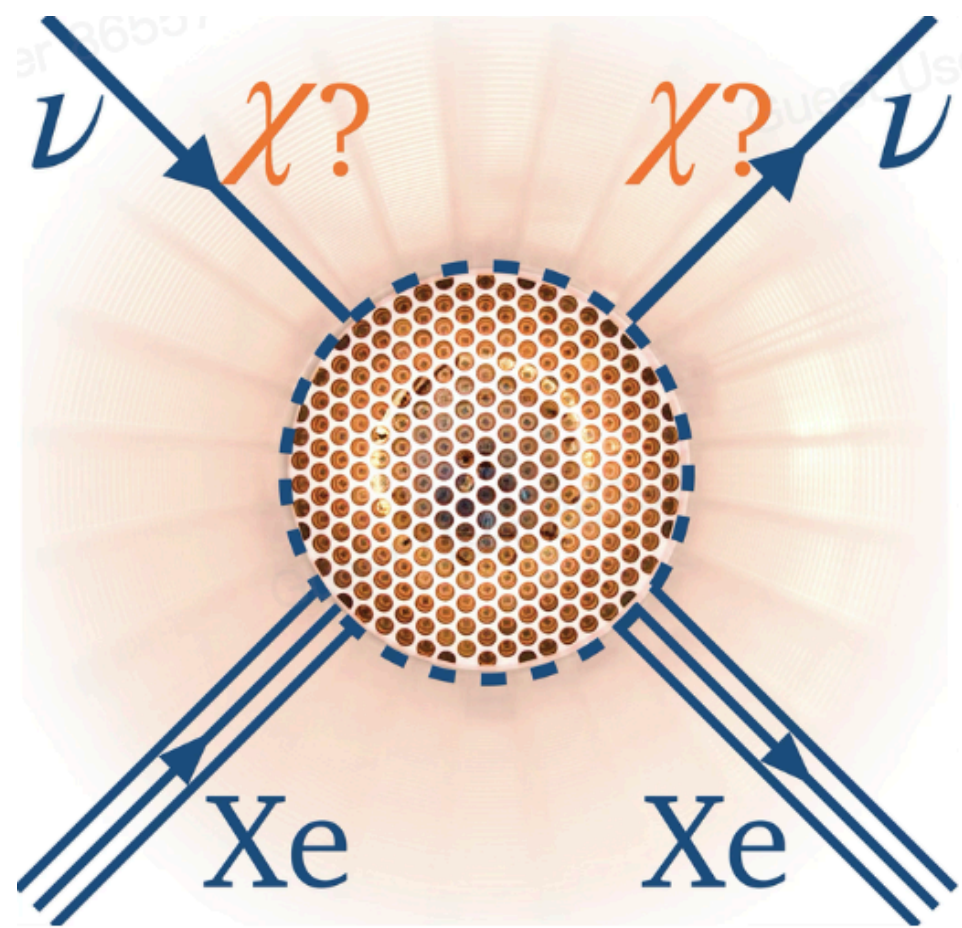


清华大学
Tsinghua University



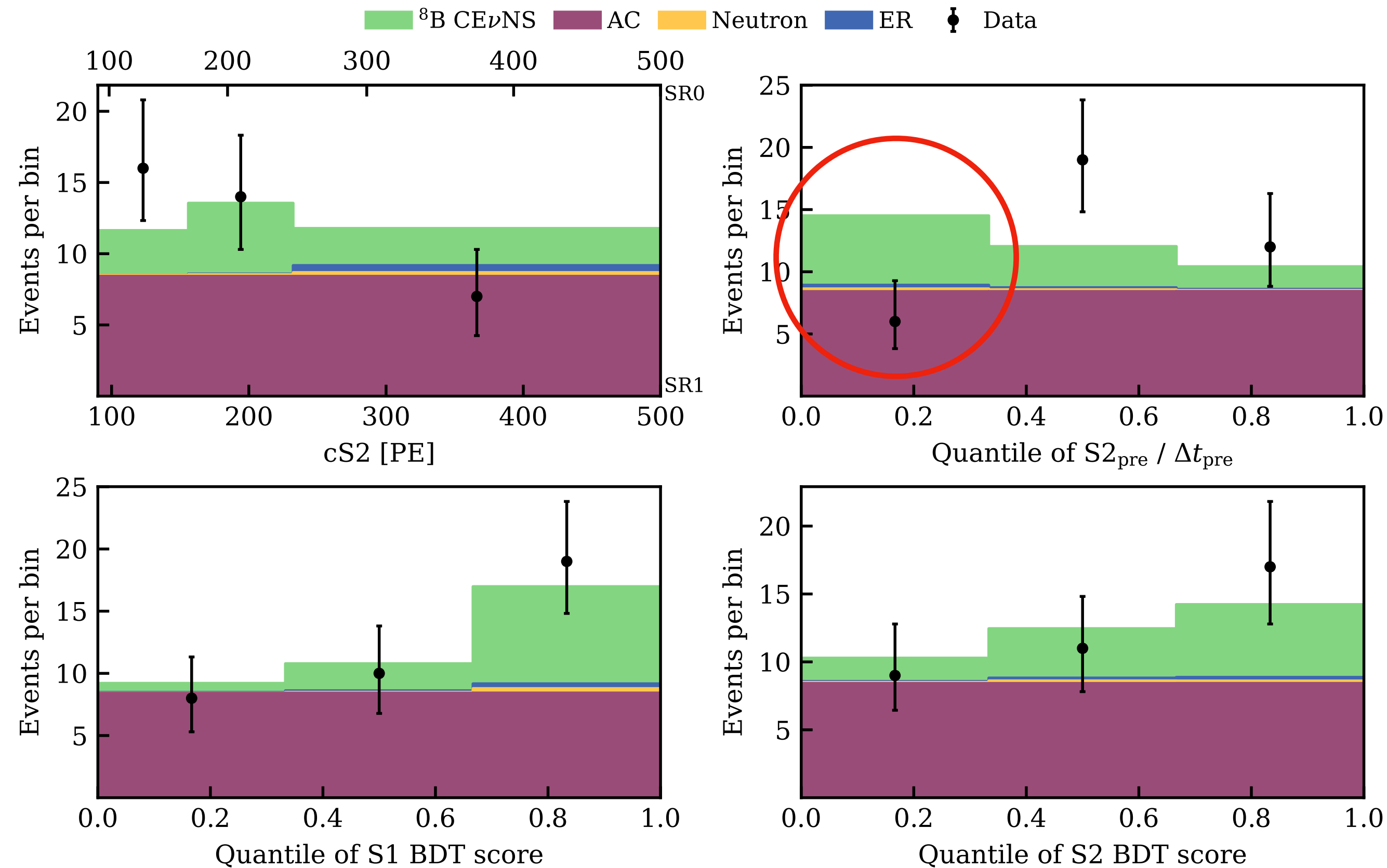
Thanks for your attention!

lkx21@mails.tsinghua.edu.cn



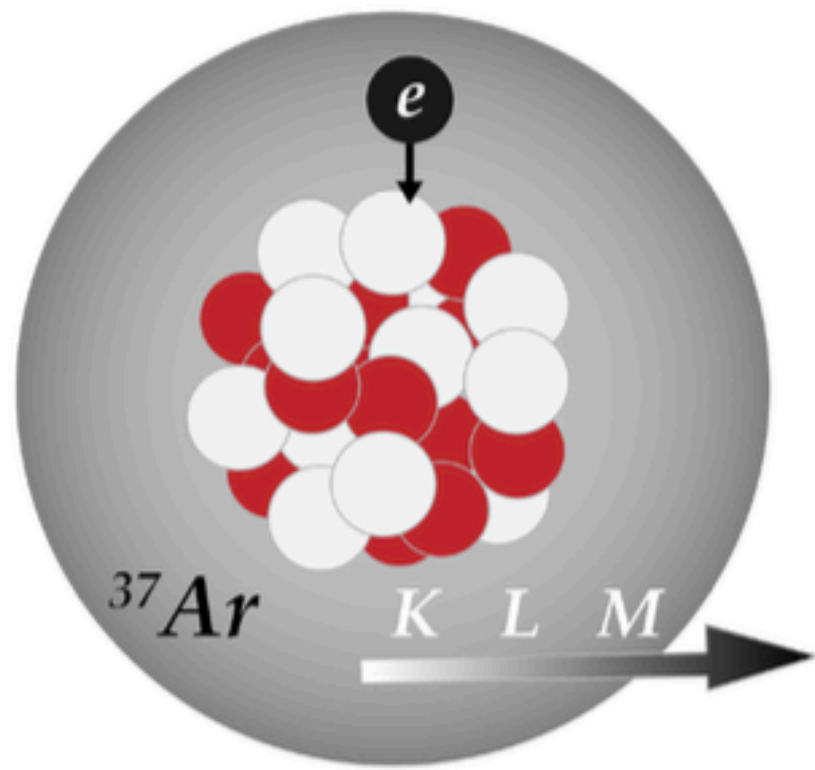
Backup

S2 Time Shadow

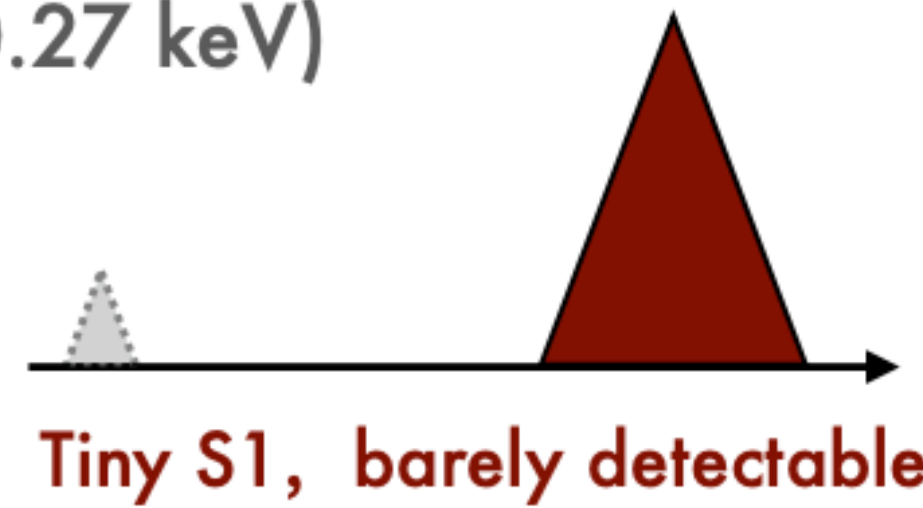


- We checked the impact of dropping the S2 time shadow from the likelihood and found:
 - The observed discovery significance would increase from 2.73σ to 3.22σ
 - The best-fit B8 flux would be $\sim 25\%$ higher

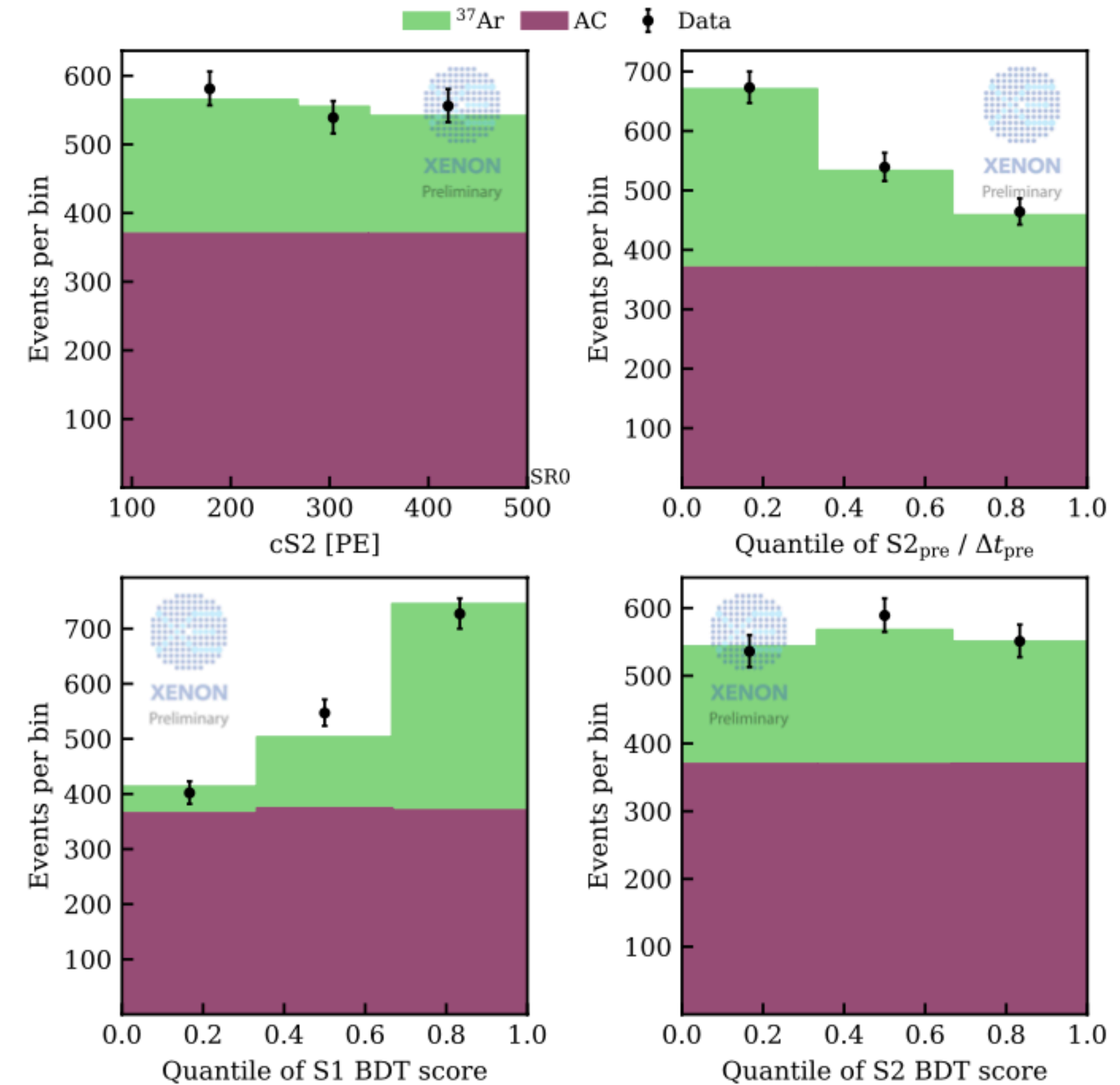
Rehearsal: Search for the Ar-37 L-shell EC (0.27 keV ER)



L-shell Electron Capture
(0.27 keV)



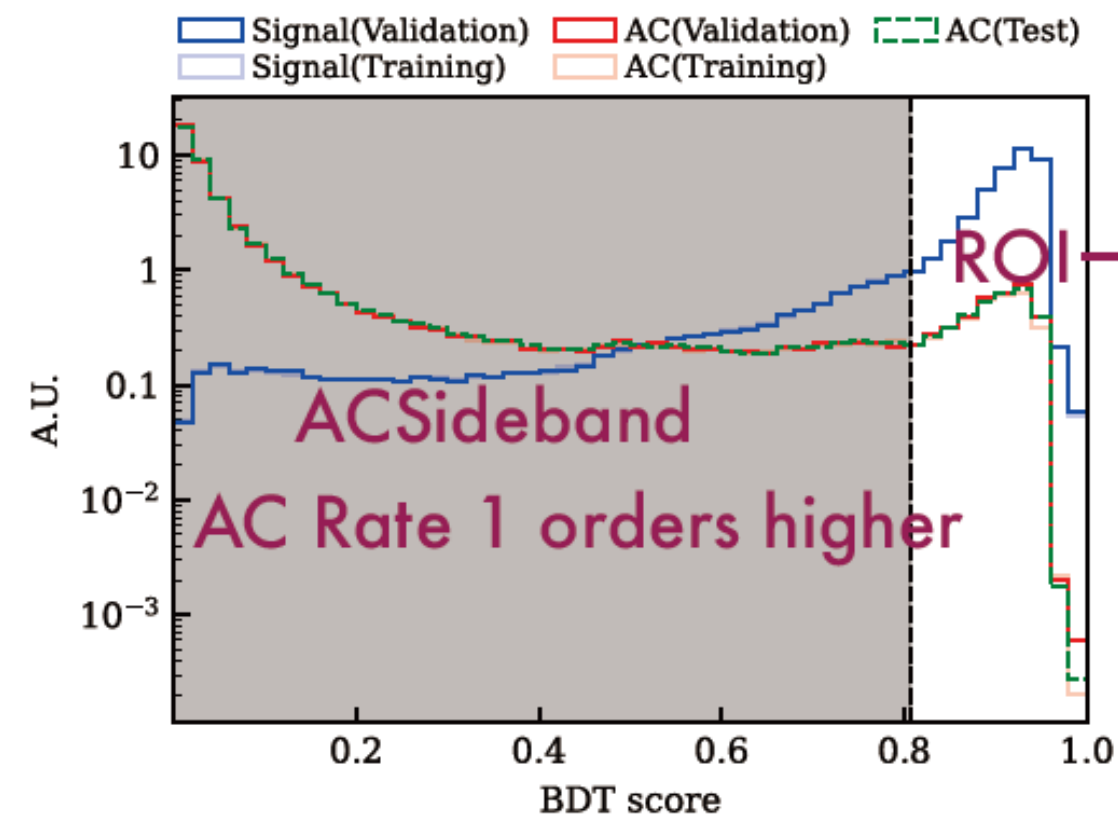
- Validate the AC model method
- Test the 4-dimension inference framework
- Predict 1062 ± 53 AC, observe 1676 events



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	/

