



Recent Results from XENONnT

Searching for Dark Matter and Neutrinos

Sana Ouahada¹, on behalf of the XENON collaboration

¹University of Zurich

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- Stepping into the neutrino fog
- Background
- Measurement of the solar ^8B CE ν NS

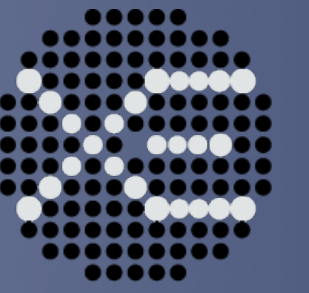
Summary and Outlook



The XENON experiment



The XENON program



The dark matter project at Laboratori Nazionali del Gran Sasso (LNGS)

200+ scientists

30 institutions

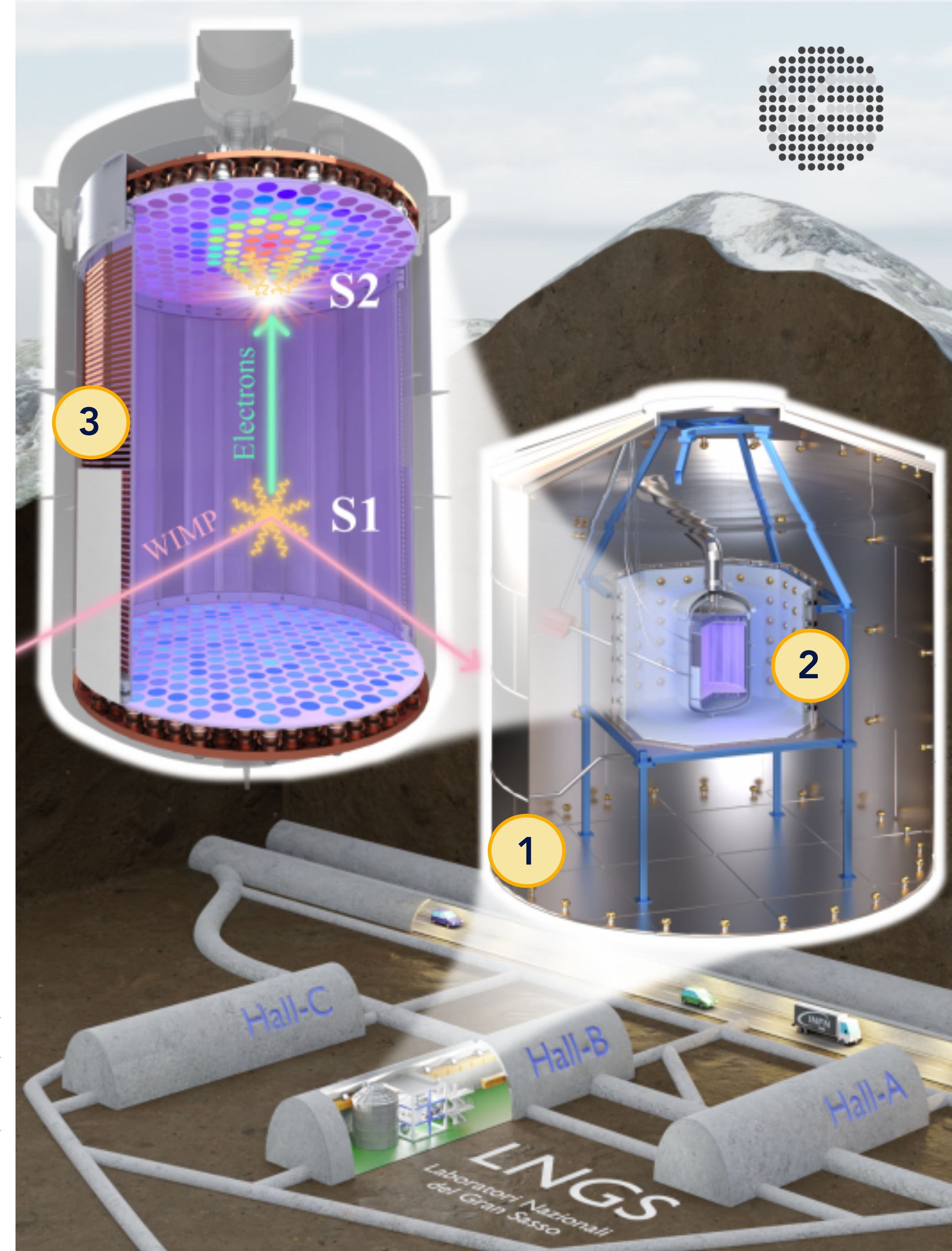
12 countries



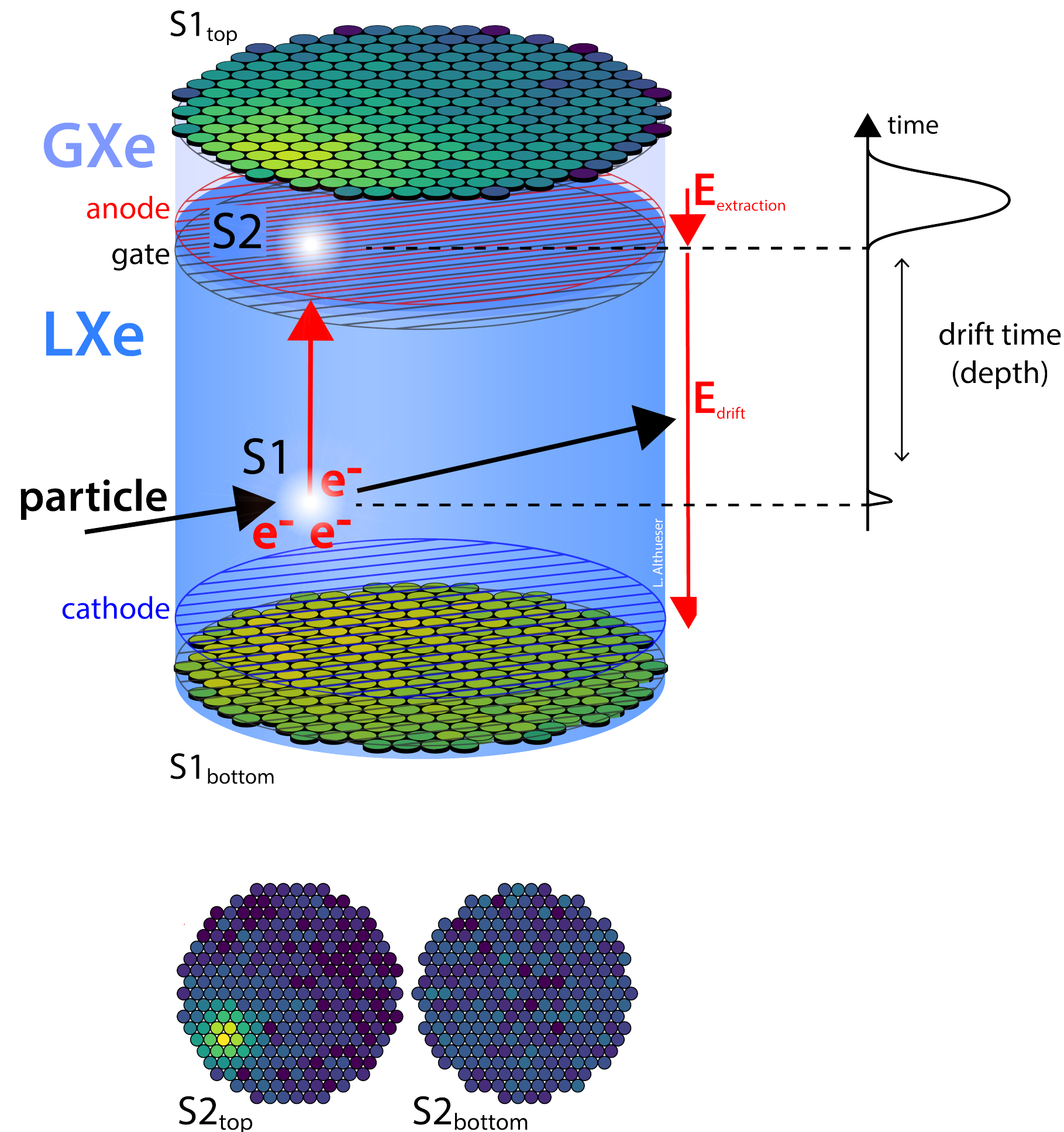
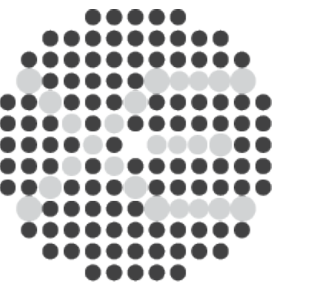
The XENON program

Nested detectors

- 1 Cherenkov muon veto (MV)** JINST 9, P11006 (2014) 700 tonnes Gd-loaded water tank
 - 10 m x 10 m
 - 84 PMTs
- 2 Cherenkov neutron veto (NV)** Eur. Phys. J. C 85 (2025) 695
 - Optically separated from MV
 - 120 PMTs
 - Neutron capture times: $\sim 75 \mu\text{s}$ vs $\sim 200 \mu\text{s}$ in pure water capture
- 3 Liquid Xenon (LXe) time projection chamber (TPC)** Eur. Phys. J. C 84, 784 (2024)
 - 5.9 tonnes active LXe mass (8.5 tonnes in total)
 - 494 PMTs
 - 1.5 m x 1.3 m (drift length x diameter)
 - 23 V/cm operating drift field



The dual-phase TPC



Signal detection

- S1 from prompt scintillation light in LXe
- S2 from ionization electrons in gas xenon (GXe)

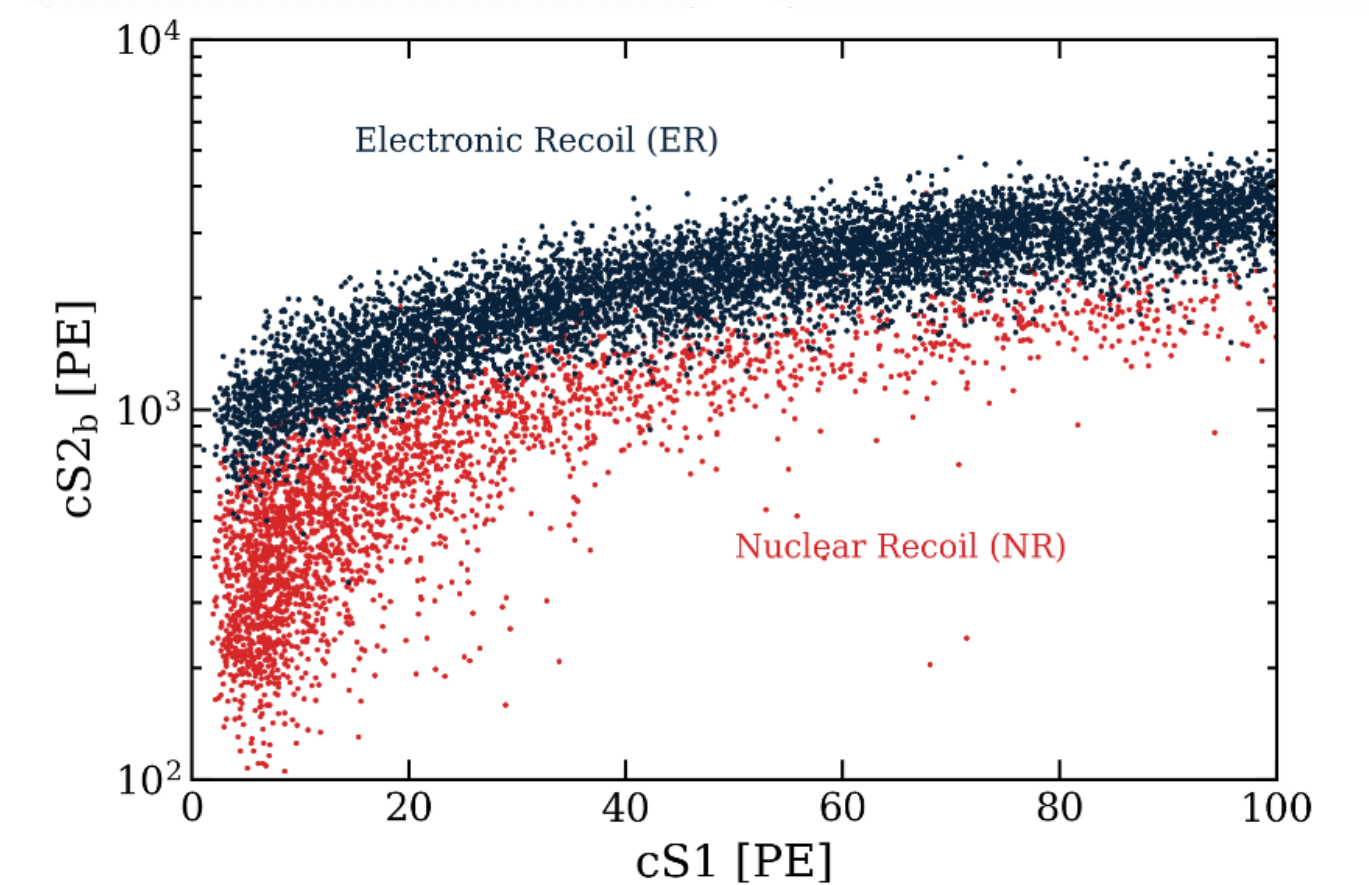
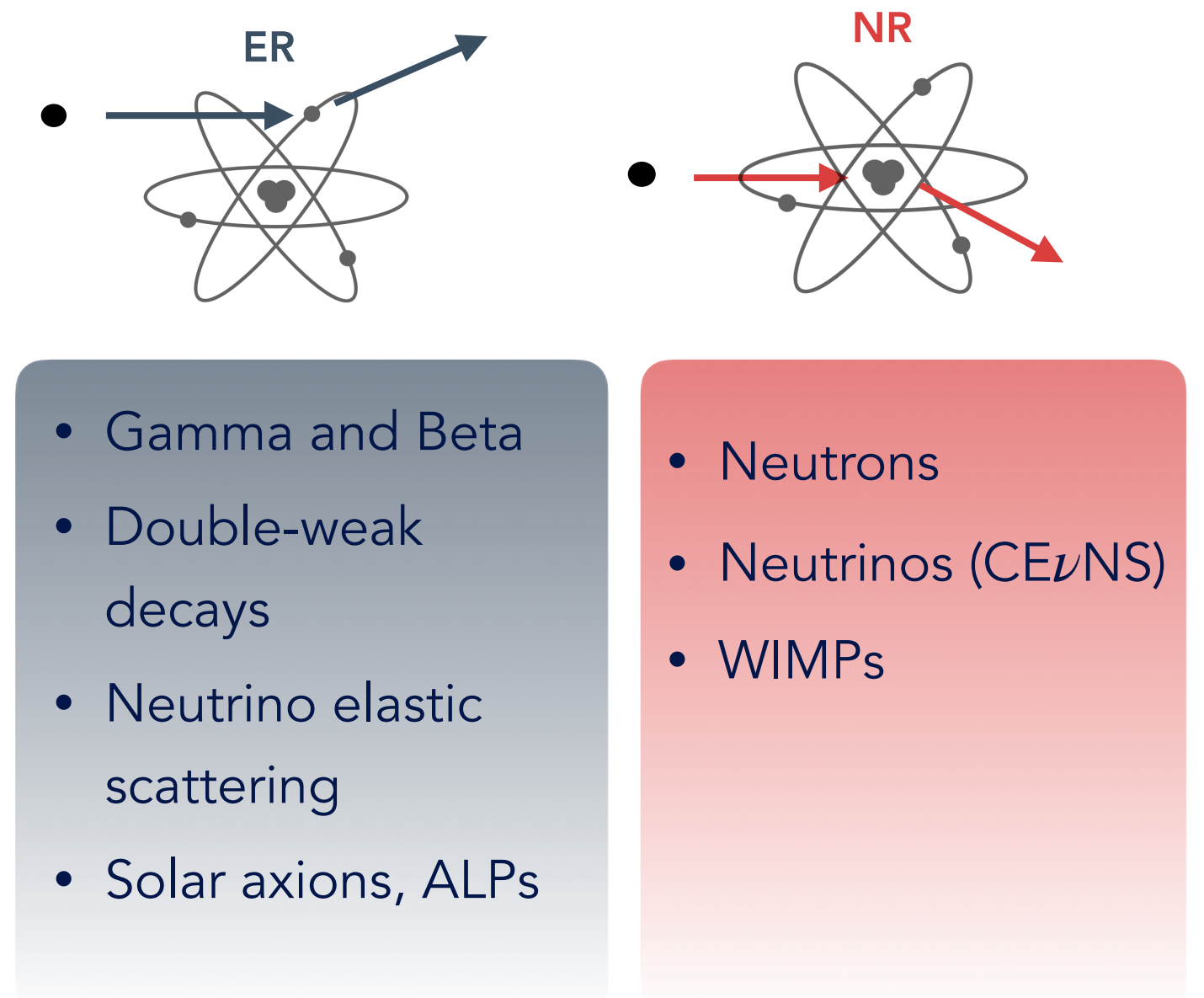
Signal and energy reconstruction

- $x - y$ from S2 hit pattern
- z from S1-S2 delay time
- Energy from combined S1 and S2 signals:

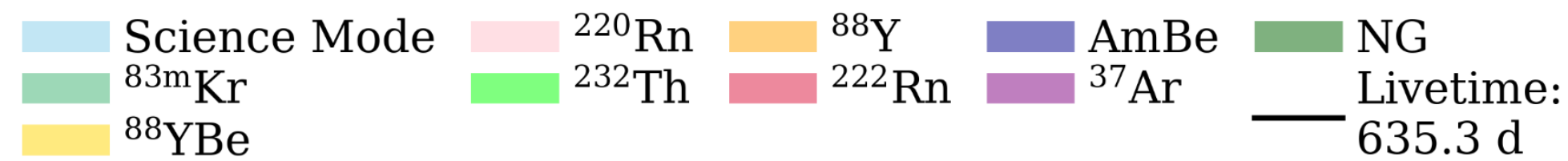
$$E \propto \left(\frac{S_1}{g_1} + \frac{S_2}{g_2} \right)$$

Signal discrimination

- Ratio S2/S1 to discriminate between nuclear recoils (NR) and electronic recoils (ER)



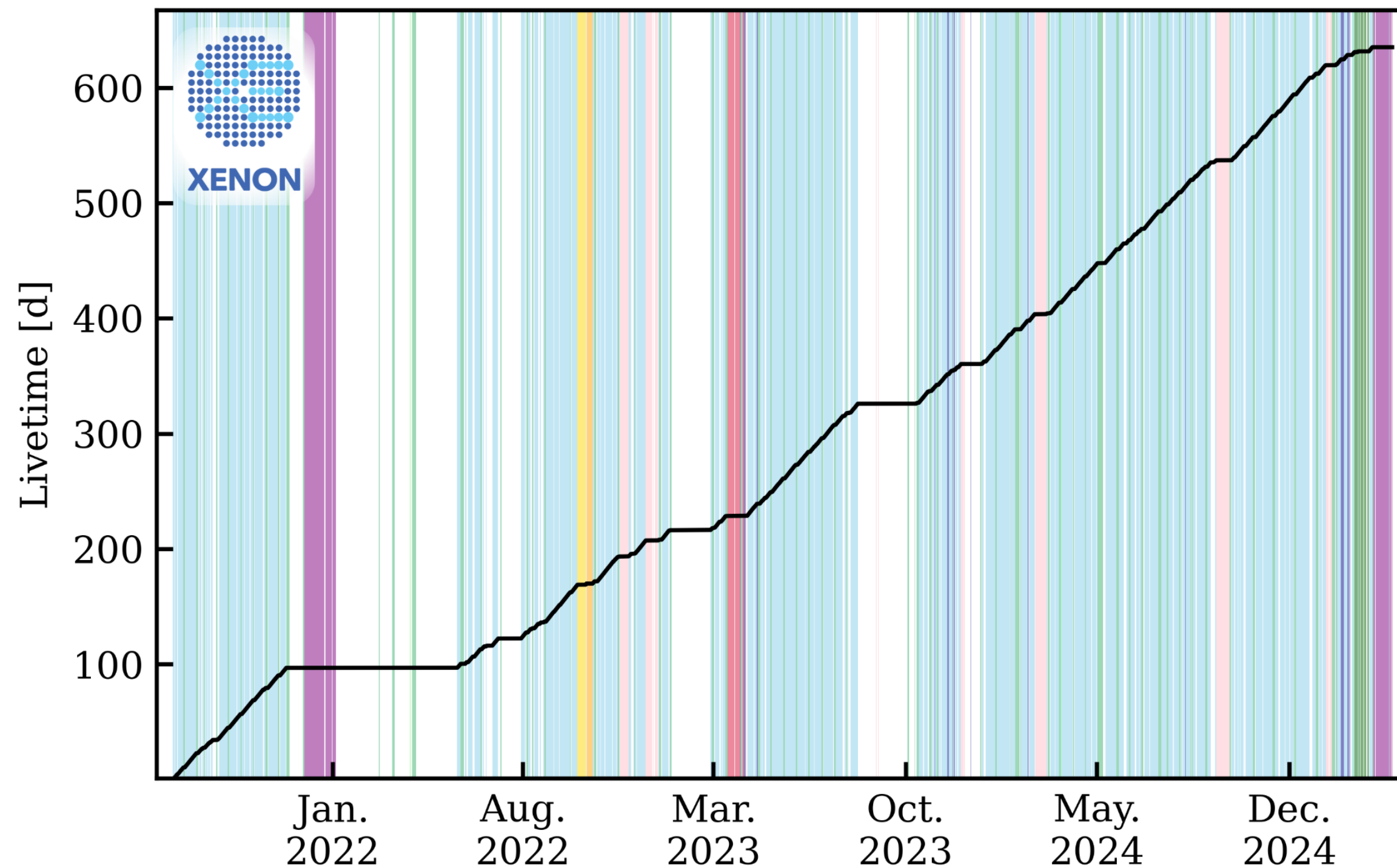
XENONnT science data



SR0
108 days

SR1
209 days

SR2
319 days



Fiducial mass

~4 tonnes

Exposure

~ 6.7 tonnes · year

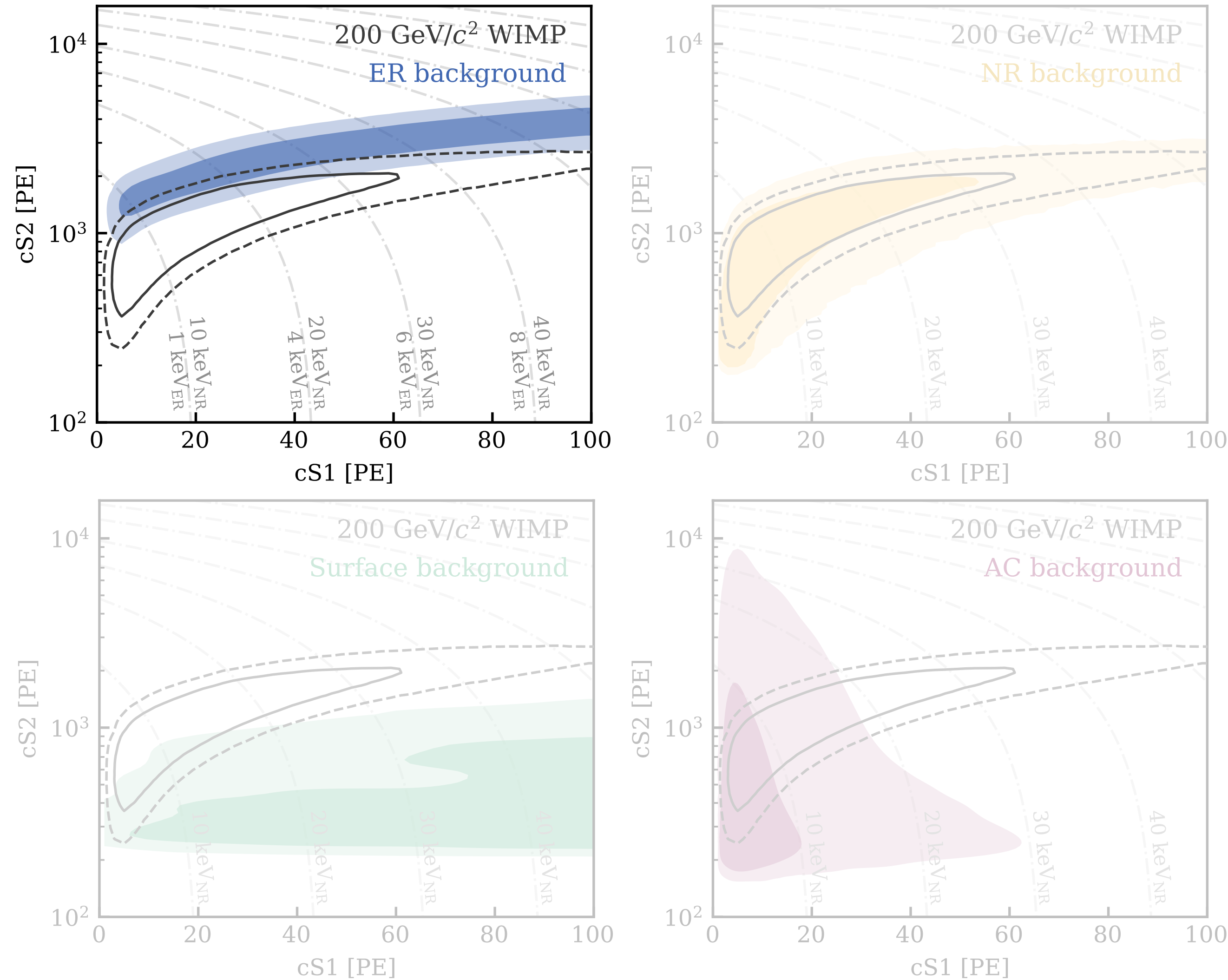
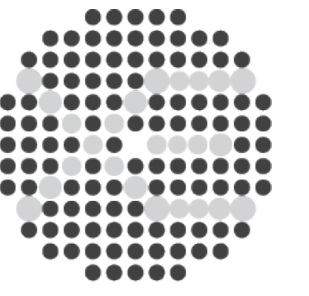
DM and neutrino search results so far

- SR0
 - Searches of new physics in ER
 - WIMP search in NR
- SR0 + SR1
 - First indication of solar ^8B neutrinos
 - First search of light DM in neutrino fog
 - WIMP search
- SR0+ SR1 + SR2
 - Measurement of solar ^8B neutrinos
 - Light DM search



WIMP search

Background model



Electronic recoil (ER)

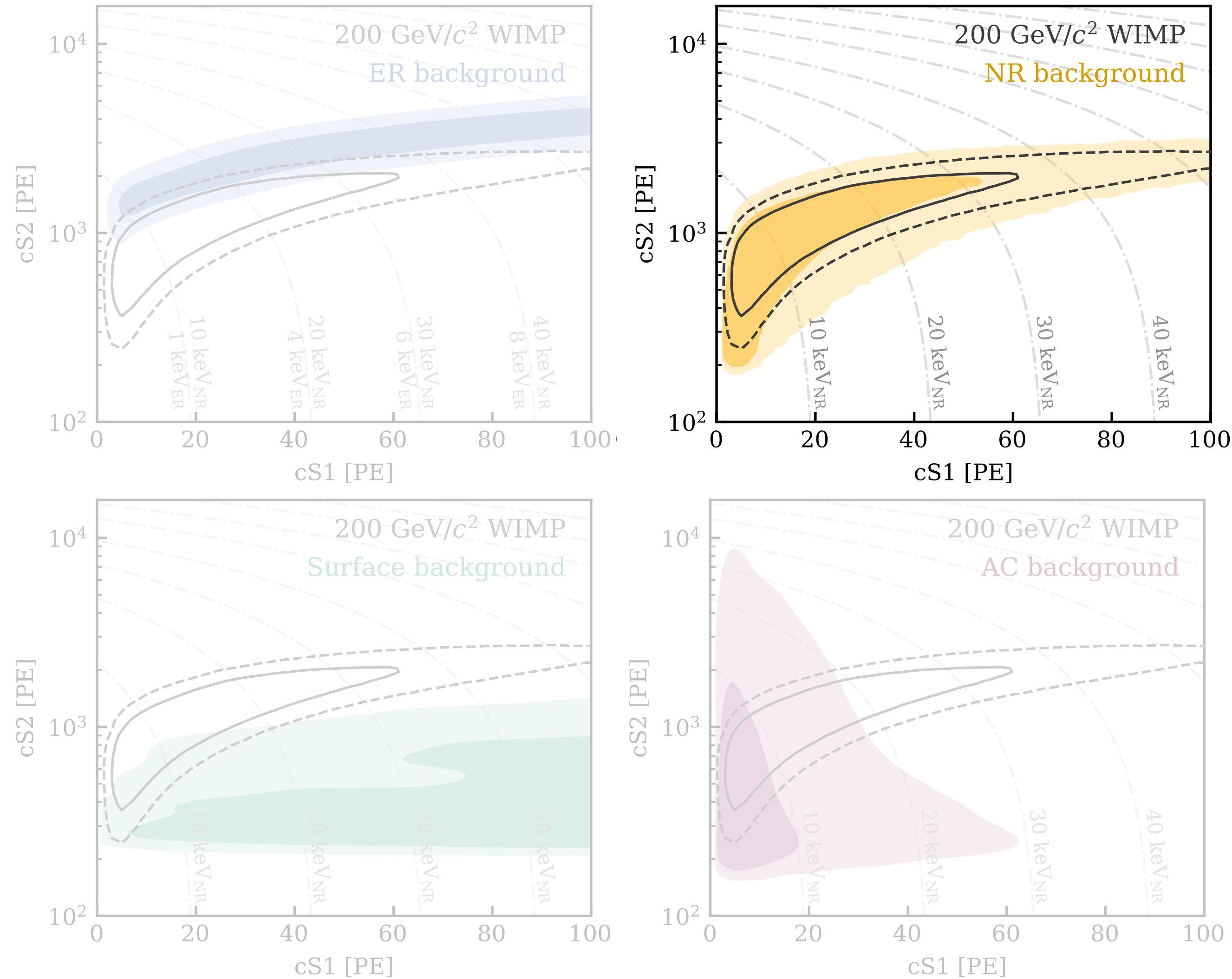
- Continuous β -spectrum of ^{214}Pb at low energies
- ^{85}Kr β -decays
- Solar ν -e scattering
- Double-weak decays of xenon isotopes

Shape constrained by ^{220}Rn calibration data

*"c" before S1/S2 stands for "corrected"

Analysis paper: PRD 111, 062006 (2025)

Background model



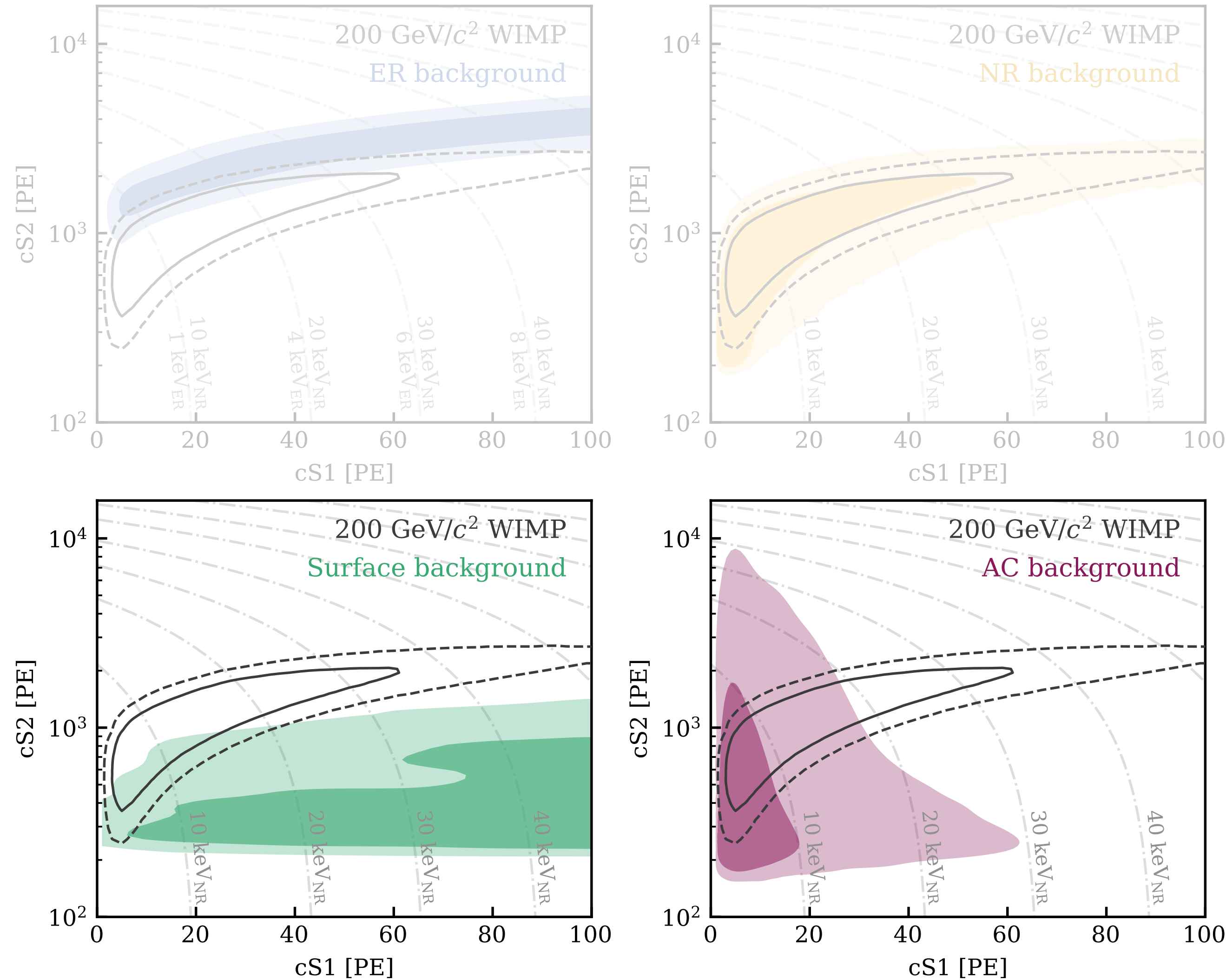
Nuclear recoil (NR)

- Radiogenic neutrons from detector materials
- $CE\nu NS$ events in region of interest (ROI)

Constrained by sideband of multi-scatter events and single-scatter events tagged by n-Veto

Analysis paper: PRD 111, 062006 (2025)

Background model



Surface events

- ^{214}Pb rate from PTFE walls

Reduced by volume fiducialization

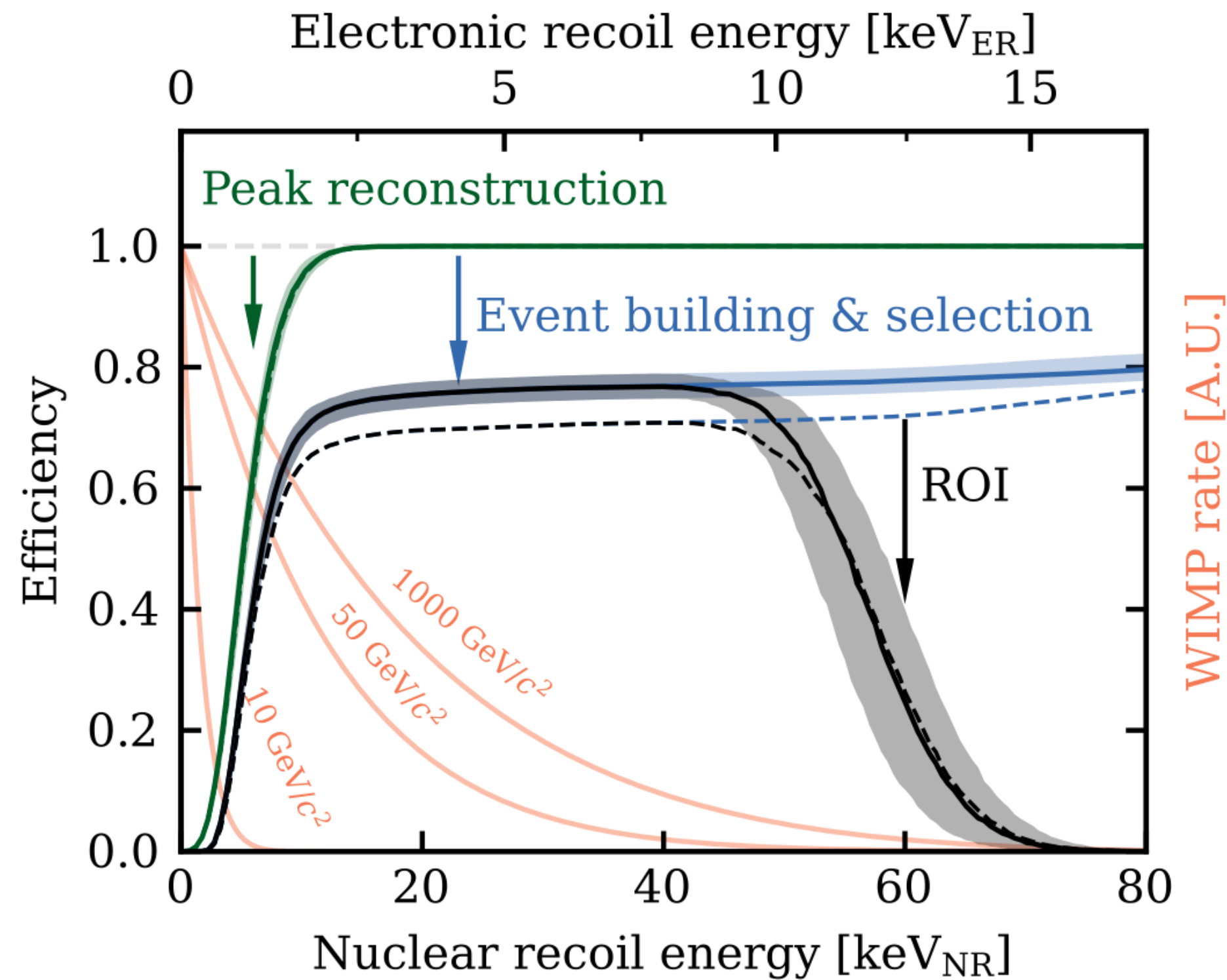
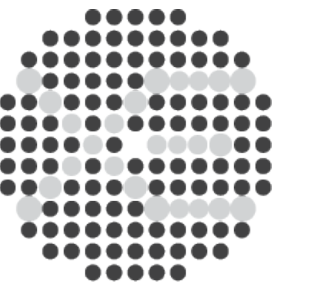
Accidental coincidences (AC)

- Incorrectly paired S1 and S2 signals
- Modeled using data-driven methods

Suppressed by ML-based data selection

Analysis paper: PRD 111, 062006 (2025)

Signal reconstruction



Efficiency vs recoil energy for SR1a (dashed) and SR1b (solid); orange curves show example WIMP spectra

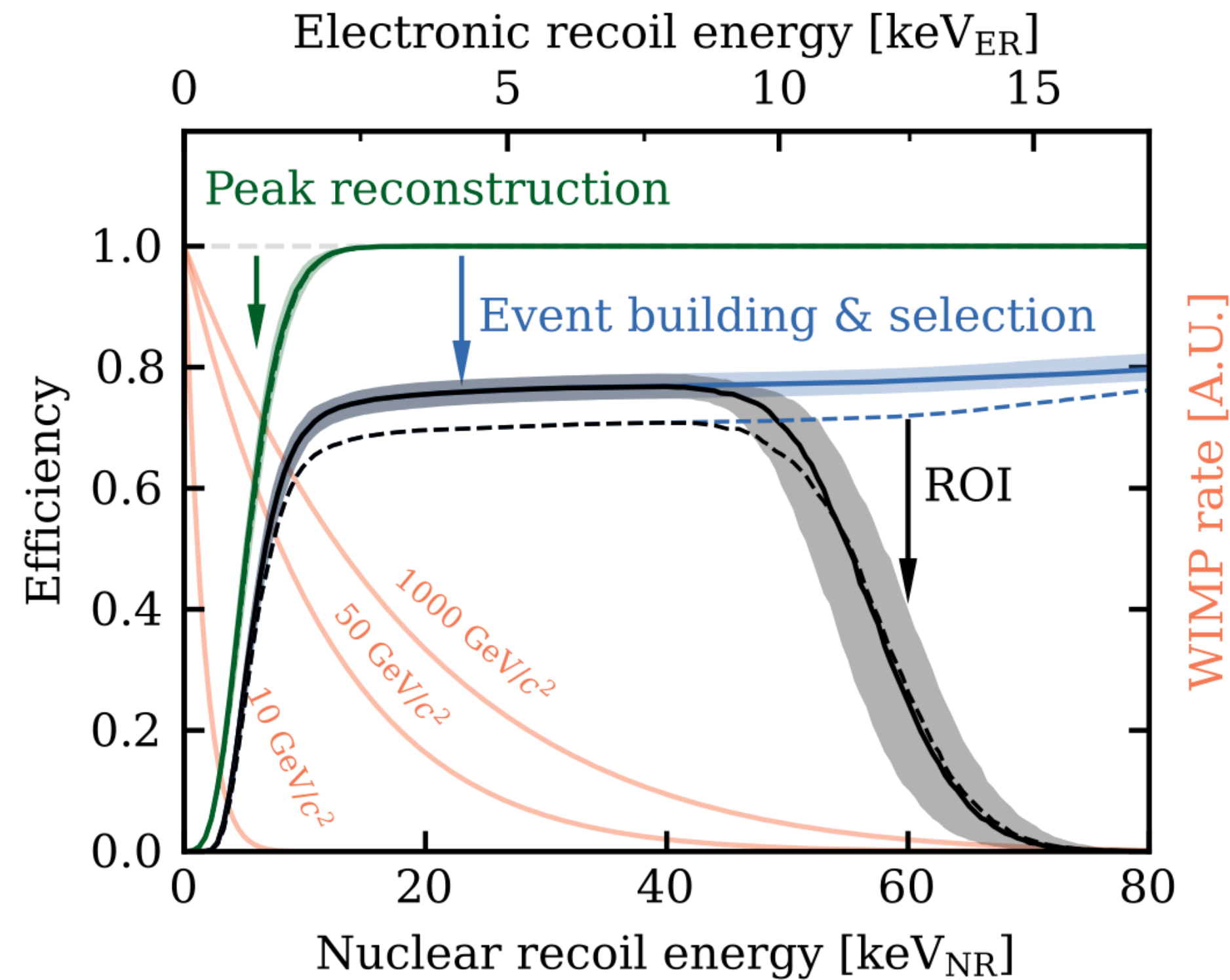
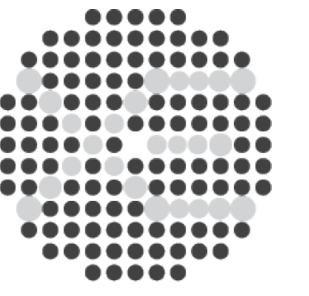
Event building and selection
Build S1+S2 pairs; reject AC via GBDT; apply quality cuts

Peak reconstruction
S1 threshold: 3-PMT coincidence

ROI
 $cS1 < 100$ PE
 $cS2 \in [10^{2.1}, 10^{4.1}]$ PE

WIMP search paper: PRL 135, 221003

Signal reconstruction



Efficiency vs recoil energy for SR1a (dashed) and SR1b (solid); orange curves show example WIMP spectra

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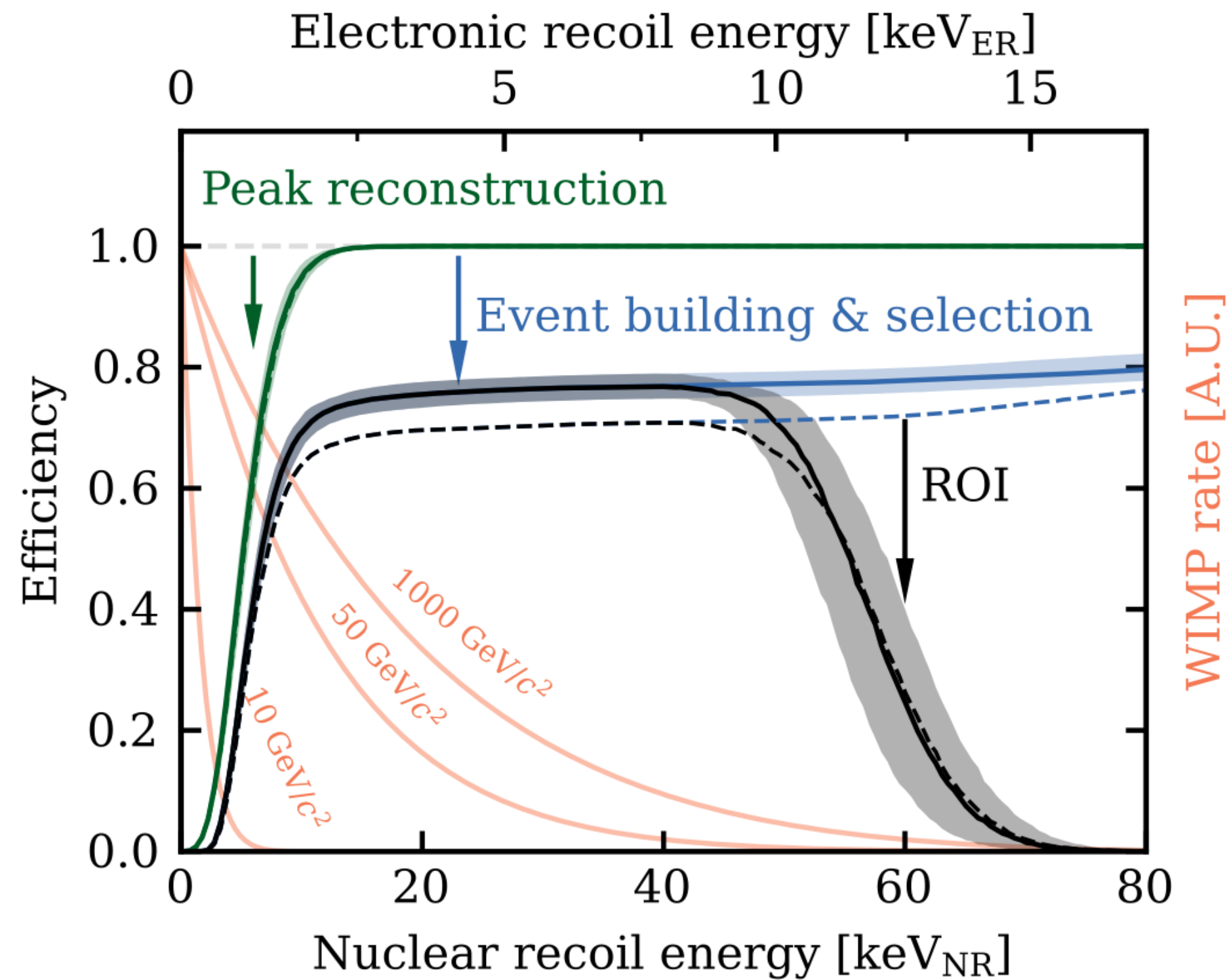
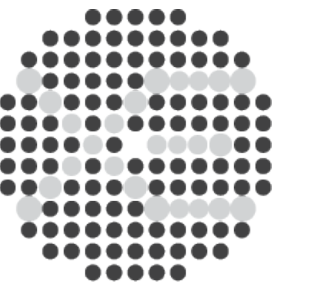
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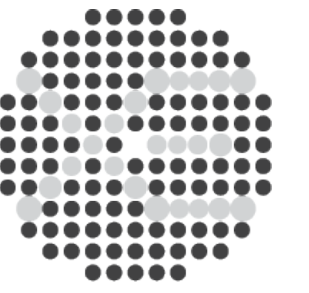
Peak reconstruction
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WIMP results



Total exposure

3.1 tonnes · year

Science data

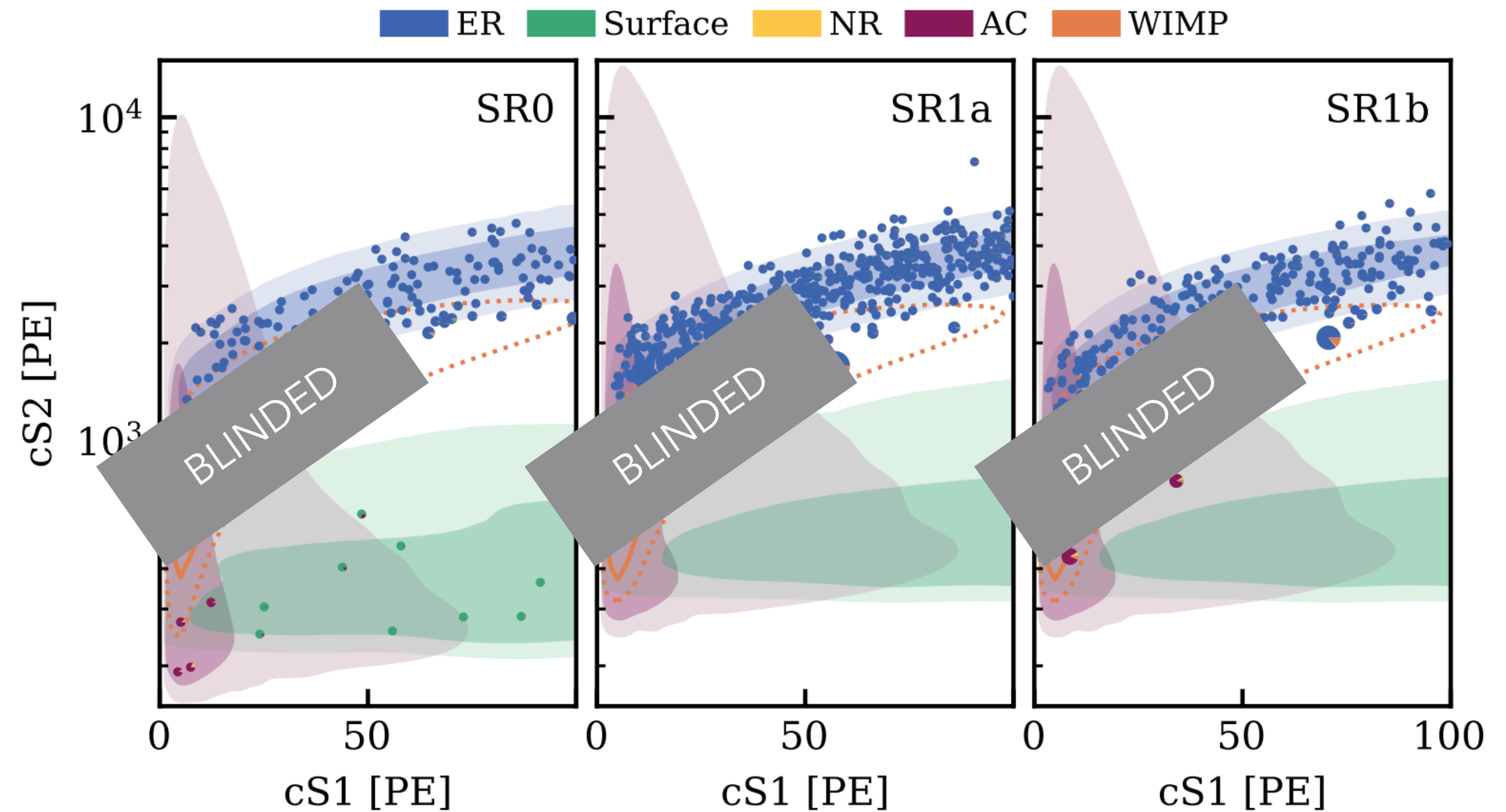
- SR0 : re-analyzed
 - Updated background model
 - Unblinded data kept untouched
- SR1 :
 - Blind analysis in WIMP ROI

66.6 days

- High rates of ^{85}Kr and ^{37}Ar
- ^3H background

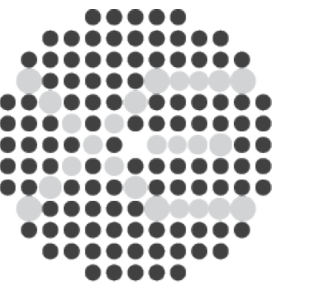
119.9 days

- ER rate back to SR0 level
- ^3H component remains



WIMP search paper: PRL 135, 221003

WIMP results



Total exposure

3.1 tonnes · year

Science data

- SR0 : re-analyzed
 - Updated background model
 - Unblinded data kept untouched
- SR1 :
 - Blind analysis in WIMP ROI

Observed events

45 events in the blinded region
No significant excess over background

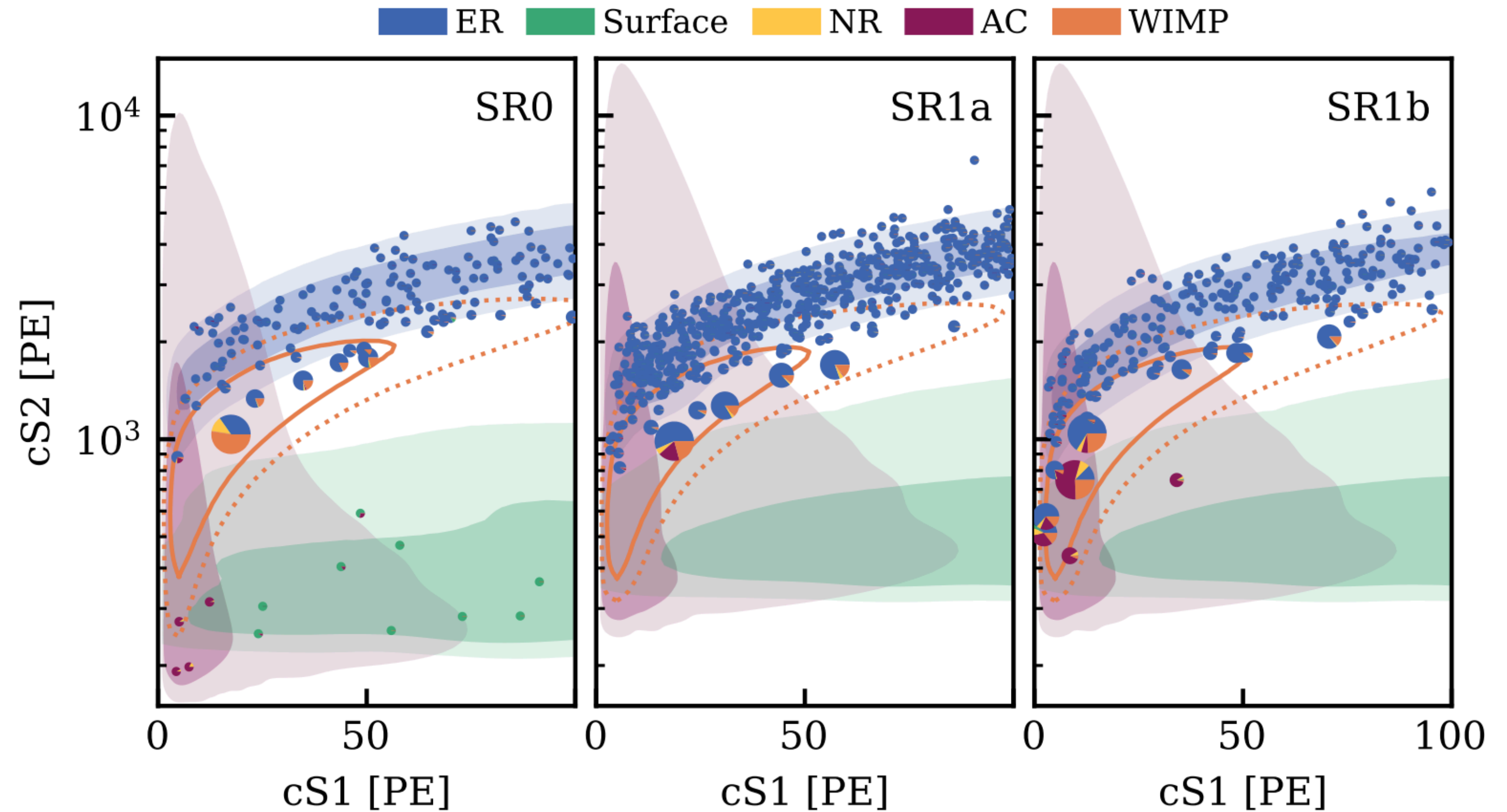
PRL 135, 221003

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- High rates of ^{85}Kr and ^{37}Ar
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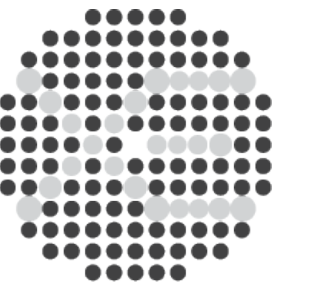
119.9 days

- ER rare back to SR0 level
- ^3H component remains



The pie charts represent a fraction of the best-fit model w/ 200 GeV/c² WIMP evaluated at the position of the event

WIMP results



Total exposure

3.1 tonnes · year

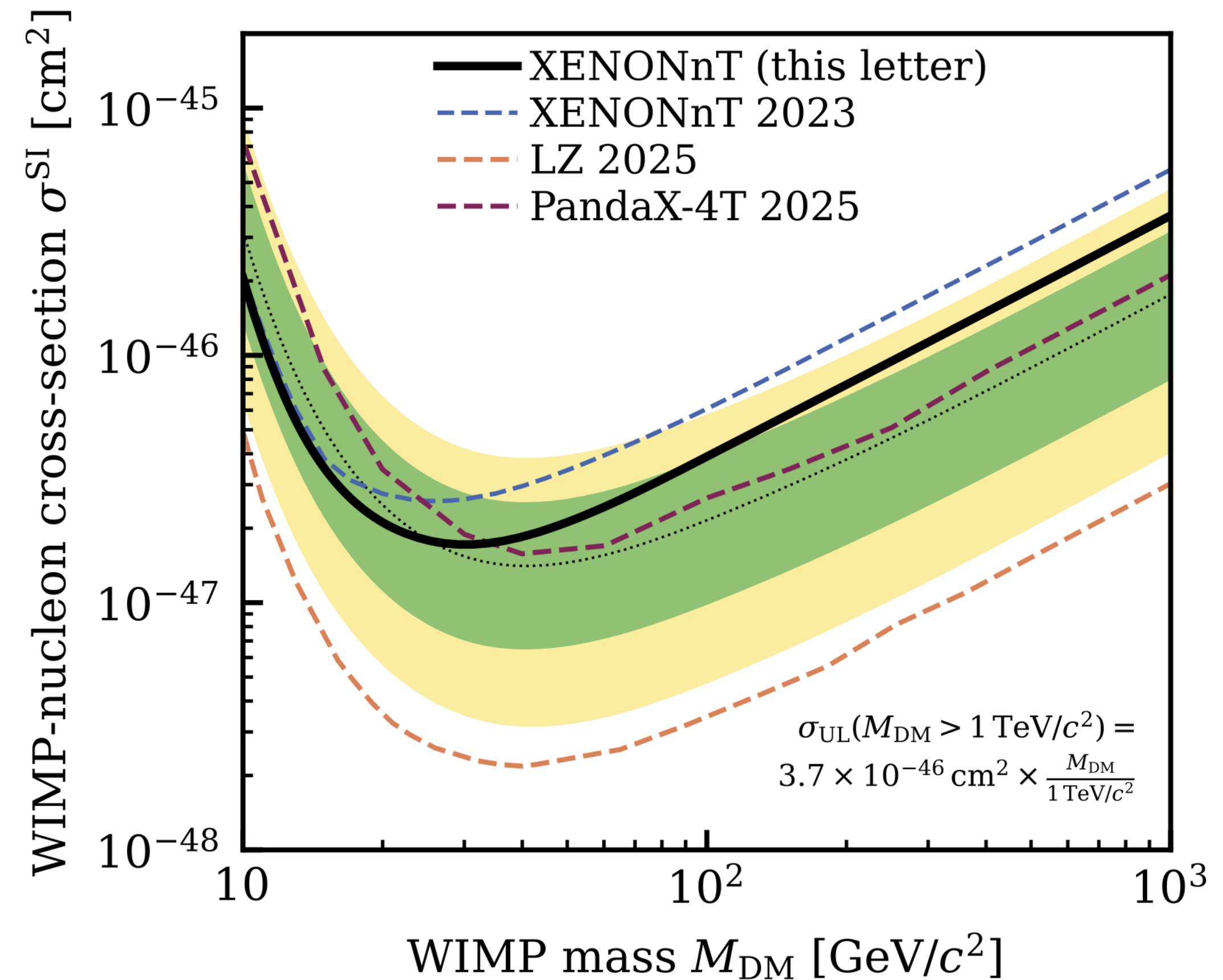
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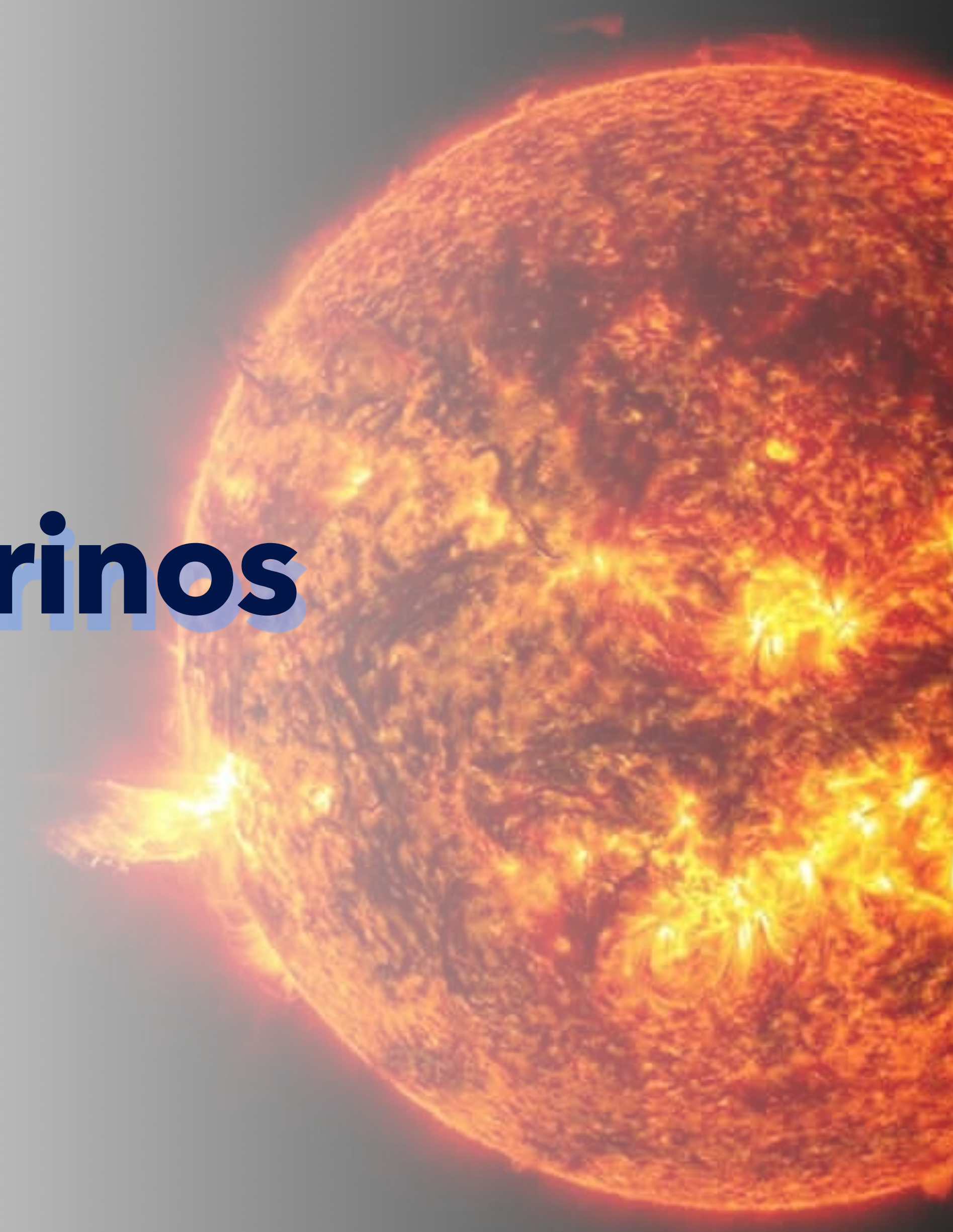
New exclusion limit on WIMP-nucleon SI cross-section at

$1.7 \cdot 10^{-47} \text{ cm}^2$ for $m_\chi = 30 \text{ GeV}/c^2$

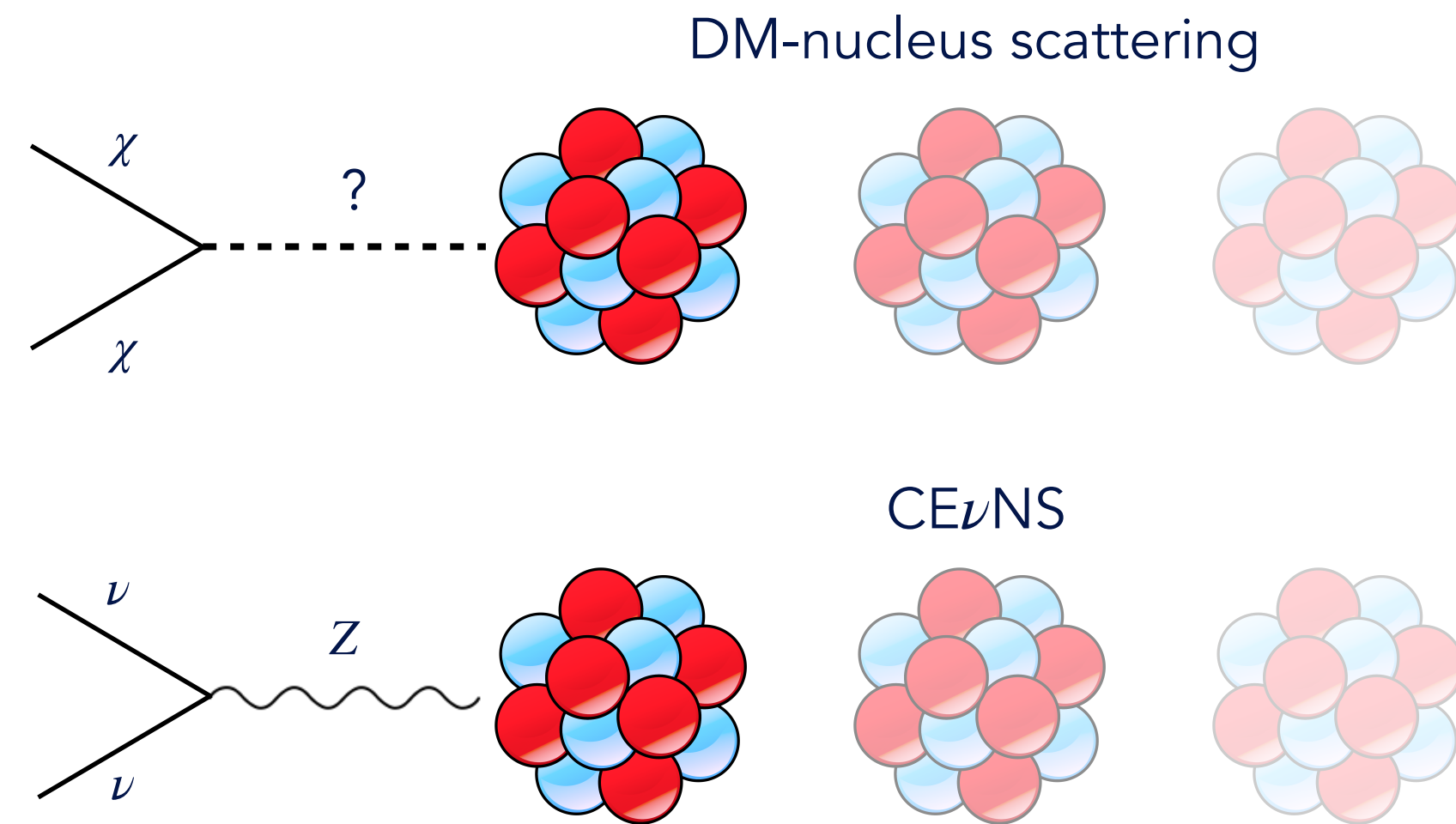
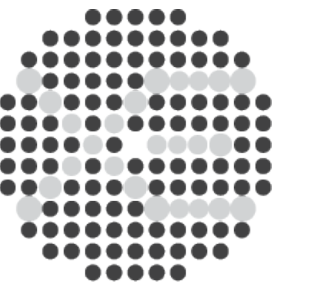
PRL 135, 221003



^8B solar neutrinos



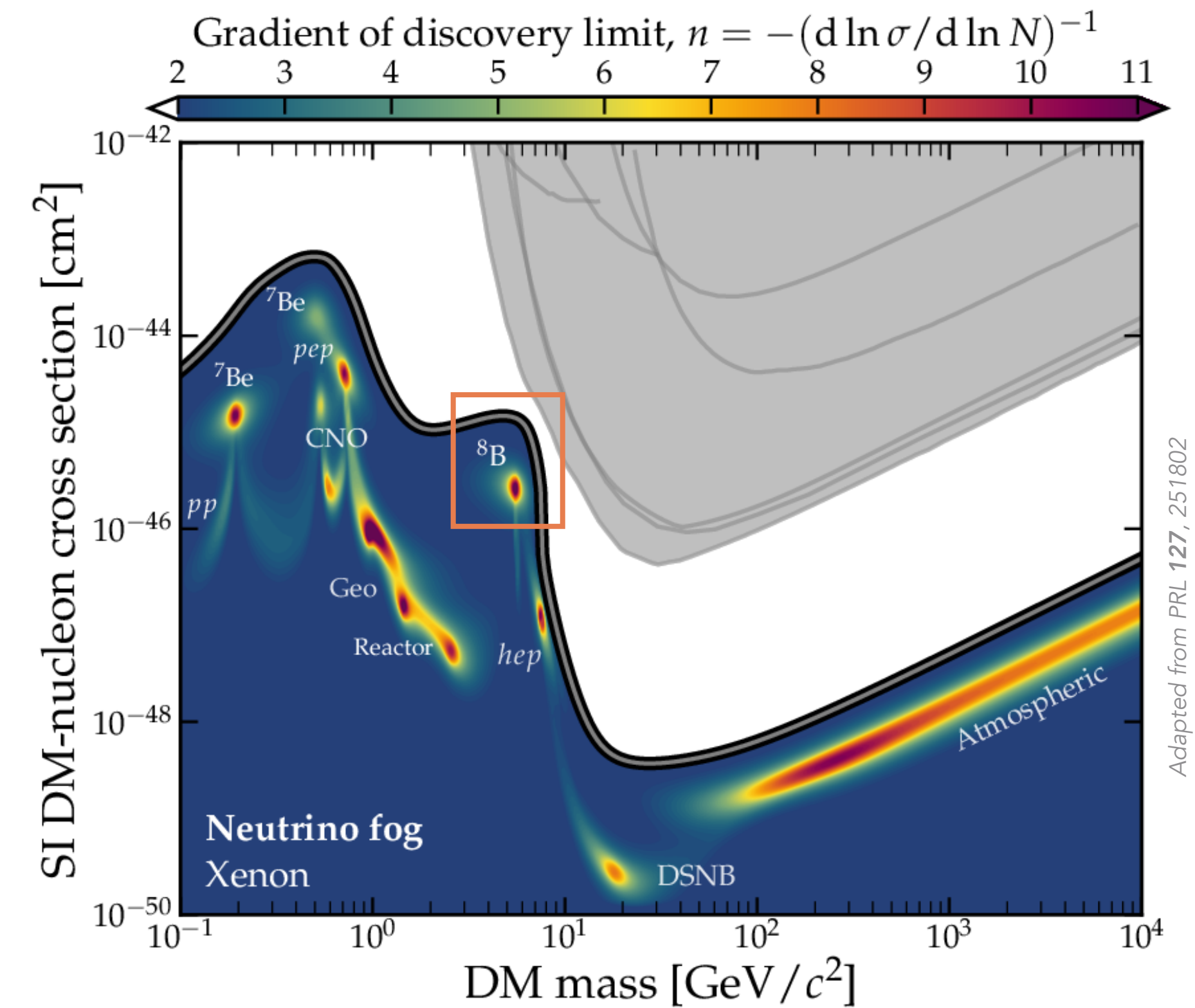
Stepping into the neutrino fog



CEvNS signal

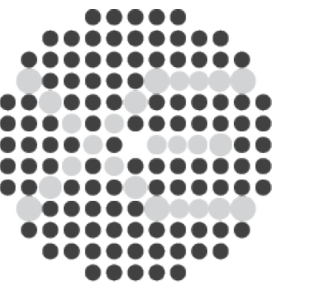
Coherent Elastic Neutrino-Nucleus Scattering

- SM process: predicted in 1974, observed by COHERENT in 2017
- Coherent enhancement gives $\sigma \propto N^2$, but only at low momentum transfer \rightarrow ^8B CEvNS typical recoil energy < 1.5 keV
- Produces single-scatter nuclear recoils that **mimic a WIMP signal**
 \rightarrow irreducible "neutrino fog"



Color shows how much the fog slows sensitivity gains with exposure

Stepping into the neutrino fog

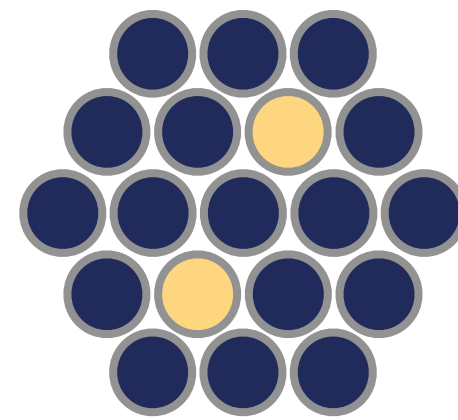


Datasets

- SR0 + SR1 + SR2 - total livetime of 603 days
- Total exposure: 6.77 tonnes · year
- SR0 and SR1 unchanged; SR2 combined with same drift field and stable conditions

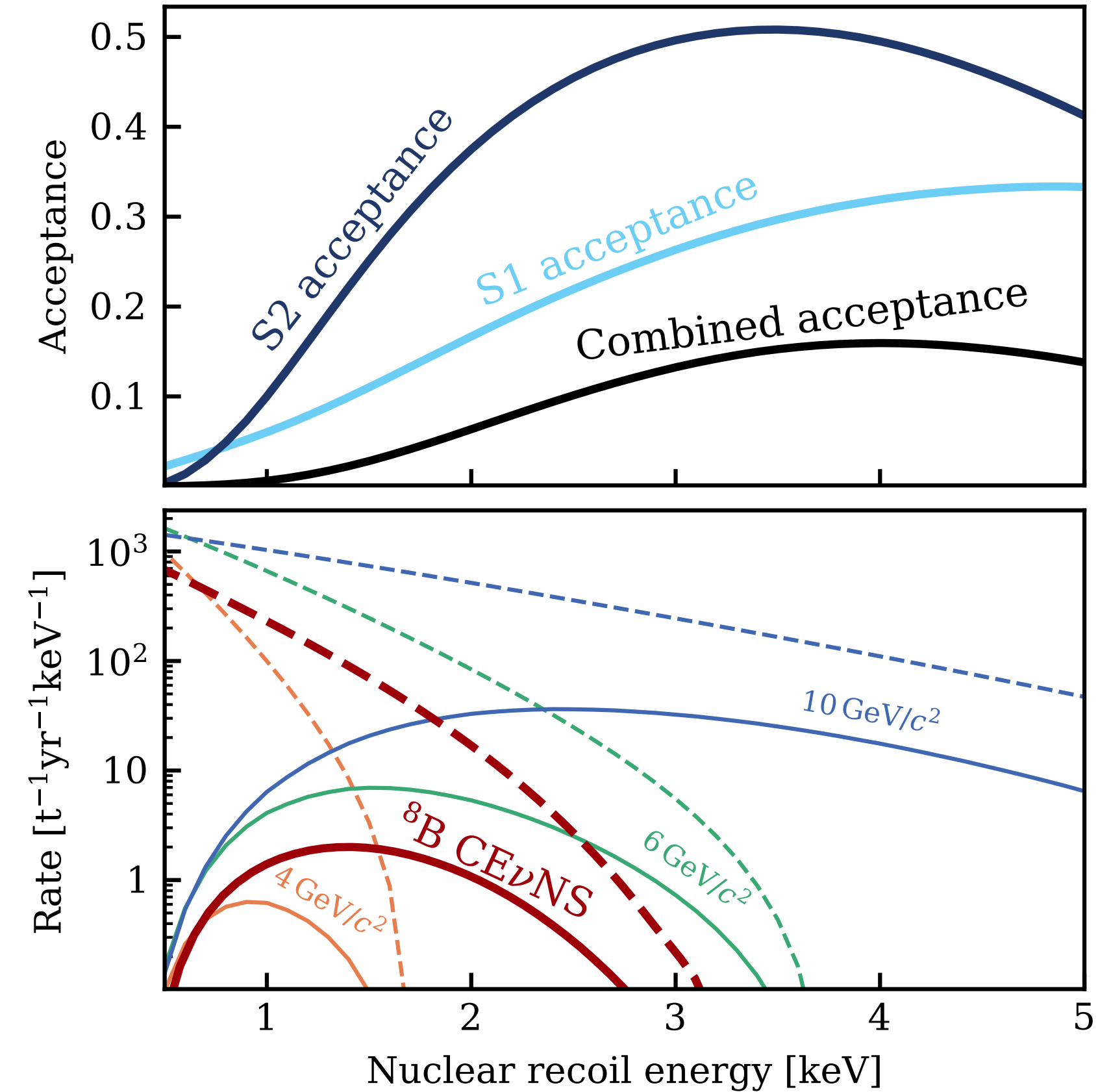
Lowering the threshold

2-fold instead of 3-fold detection
→ lower energy ROI



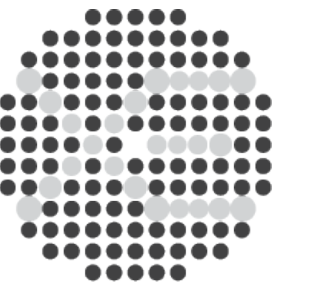
Precisely model

Low energy NRs + AC background



Top: Low-energy NR acceptance, exposure-weighted over the three SRs. **Bottom:** Expected ⁸B CEvNS and SI WIMP spectra, with (solid) and without (dashed) acceptance.

Measurement of solar ^8B CE ν NS



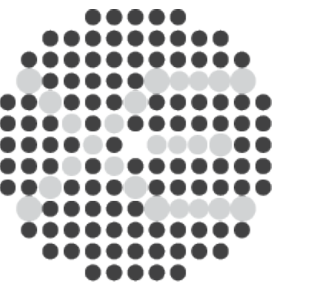
Signal and background predictions

Component	Expectation
AC (SR0)	7.5 ± 0.7
AC (SR1)	17.8 ± 1.0
AC (SR2)	14.9 ± 0.7
ER	1.2 ± 1.2
Neutron	$0.8^{+0.4}_{-0.5}$
Total background	$42.1^{+1.9}_{-1.7}$
^8B (SR0)	$3.2^{+1.0}_{-0.9}$
^8B (SR1)	$5.9^{+1.9}_{-1.6}$
^8B (SR2)	$7.2^{+2.3}_{-1.9}$
Total ^8B	16^{+5}_{-4}
Total observed	

How we test it

- 4 observables: $cS2$, $S2_{\text{pre}}/\Delta t_{\text{pre}}$, S1 BDT, S2 BDT
- 3 bins each \rightarrow 81-bin extended likelihood fit, AC-flat binning
- Blinded ROI
- Goodness-of fit tests fixed before unblinding

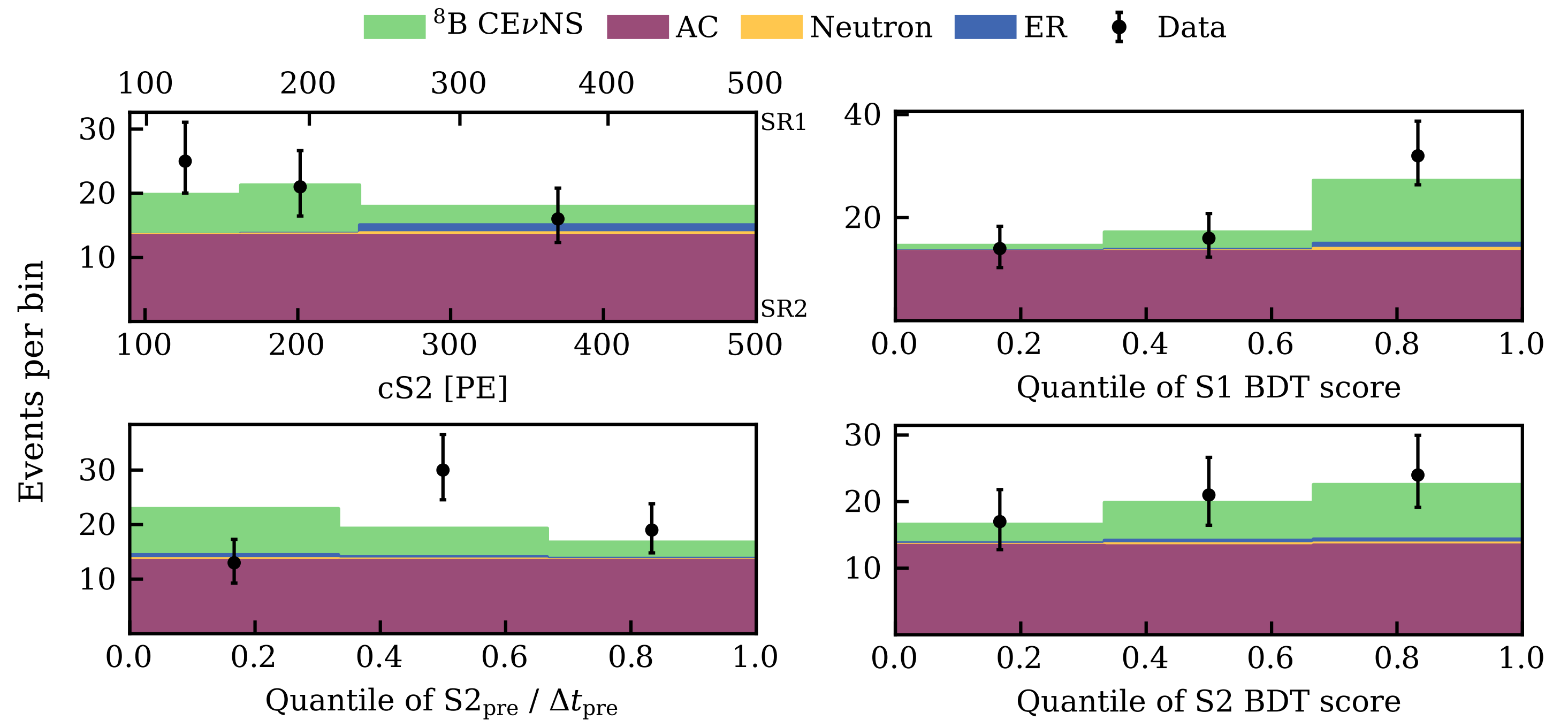
Measurement of solar ^8B CE ν NS



Signal and background predictions

Component	Expectation	Best-fit
AC (SR0)	7.5 ± 0.7	7.4 ± 0.7
AC (SR1)	17.8 ± 1.0	17.9 ± 1.0
AC (SR2)	14.9 ± 0.7	14.9 ± 0.7
ER	1.2 ± 1.2	1.4 ± 1.1
Neutron	$0.8^{+0.4}_{-0.5}$	0.8 ± 0.4
Total background	$42.1^{+1.9}_{-1.7}$	42.4 ± 1.9
^8B (SR0)	$3.2^{+1.0}_{-0.9}$	3.3 ± 1.0
^8B (SR1)	$5.9^{+1.9}_{-1.6}$	$6.1^{+1.7}_{-1.9}$
^8B (SR2)	$7.2^{+2.3}_{-1.9}$	$7.3^{+2.1}_{-2.3}$
Total ^8B	16^{+5}_{-4}	17 ± 5

Total observed: 9 (SR0) + 28 (SR1) + 25 (SR2) = 62



[arXiv:2604.06002](https://arxiv.org/abs/2604.06002)

3.3 σ observation of solar ^8B CE ν NS, with a measured ^8B neutrino flux of $(5^{+3}_{-2}) \times 10^6 \text{ cm}^{-2} \text{ s}^{-1}$

Conclusion and outlook

Results

- **WIMPs:** no excess over background, new exclusion limit at $1.7 \cdot 10^{-47} \text{ cm}^2$ for $m_\chi = 30 \text{ GeV}/c^2$
- **$^8\text{B CE}\nu\text{NS}$:** first multi-SR measurement at 3.3σ rejection of background-only hypothesis
- The neutrino fog is now signal, not just background

Outlook

- XENONnT recommissioned after **electrode upgrade** → higher fields, better background suppression
- Ongoing: SR0+1+2 WIMP search
- **XLZD:** next-generation LXe TPC, target mass up to ~60 t



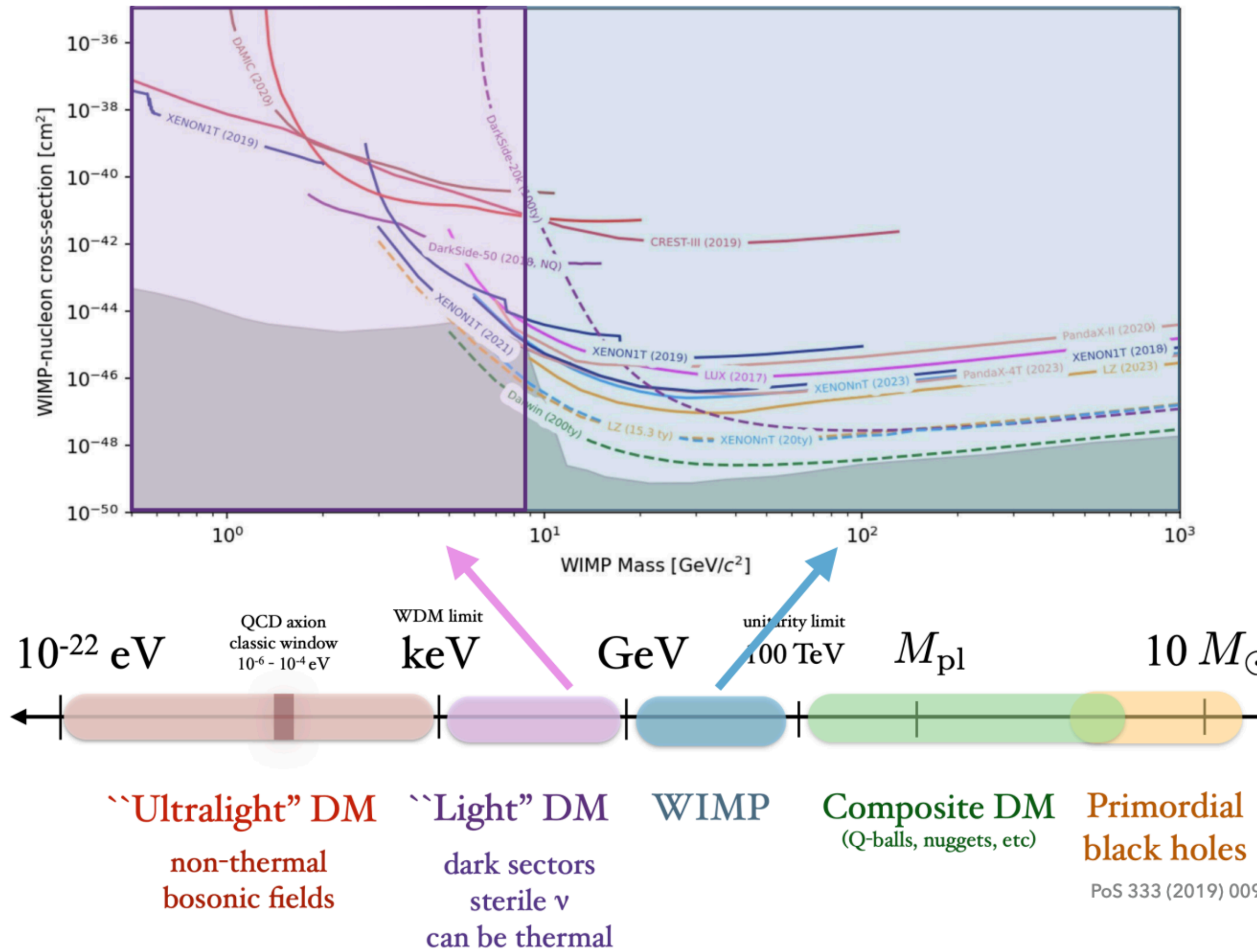
xenonexperiment.org



@xenon_experiment

Backup slides

Regions of interest



WIMP results

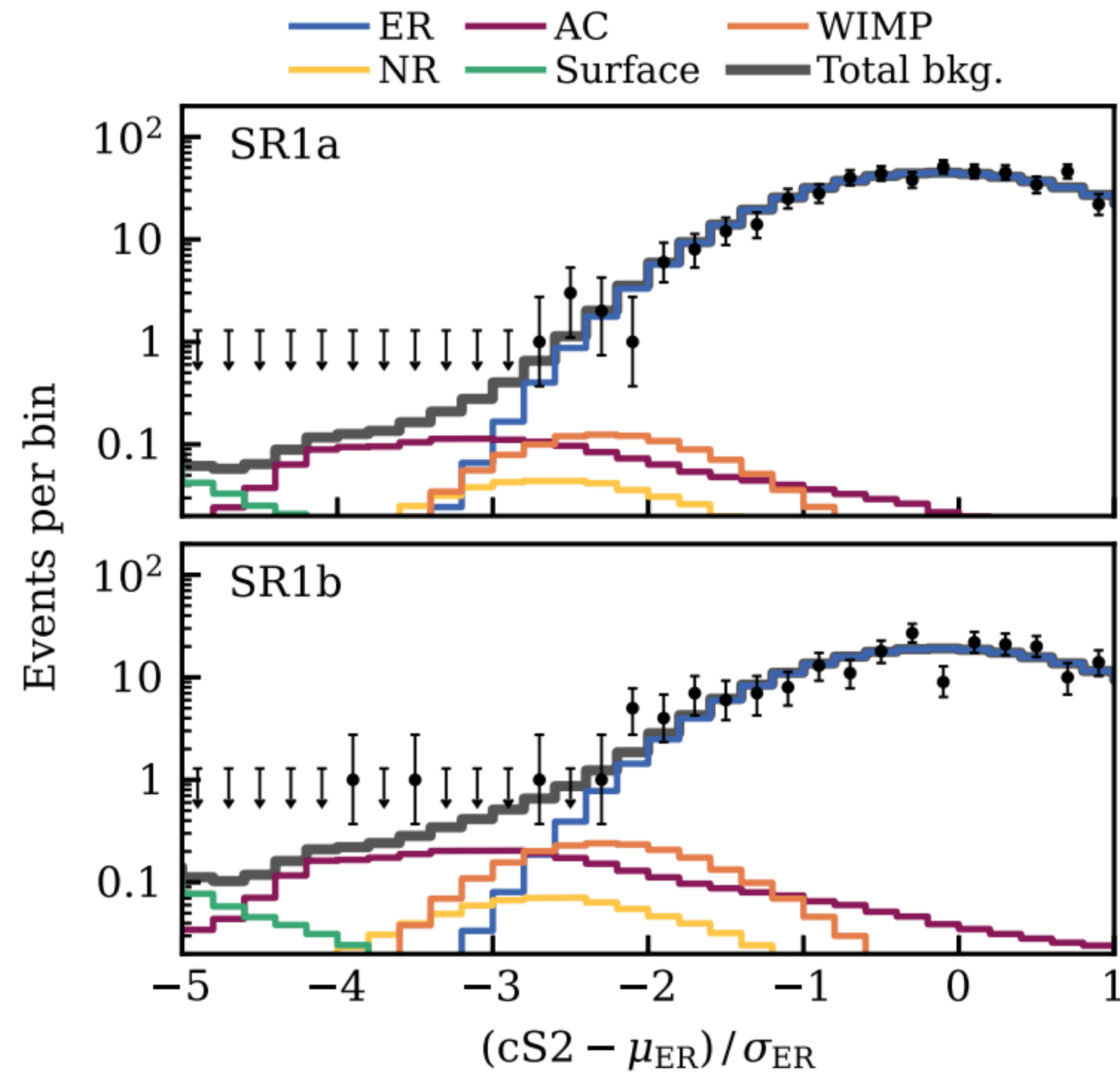
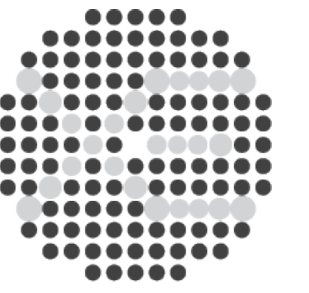


FIG. 3. Distribution in $cS2$ of the observed data and the best-fit model including an unconstrained $200 \text{ GeV}/c^2$ SI WIMP component in SR1a (top) and SR1b (bottom). The $cS2$ is normalized by subtracting the median μ_{ER} and dividing by the standard deviation σ_{ER} of the ER distribution along $cS1$. The gray histogram represents the total background expectation. Black dots represent observed event counts, while triangles mark bins with zero events, both with Poisson confidence intervals.

[PRL 135, 221003](#)

CEvNS Background



AC background

- AC dominate the background at low thresholds
- Isolated signals are mostly delayed S1s/S2s following high-energy interactions (material radioactivity γ 's)

Suppression

- **S2 Time Shadow** : veto signals correlated with a preceding high-energy event
- **S1 & S2 BDTs** : waveform ML separating CEvNS from AC
→ AC rates: **430** → **~15**
- Residual AC handled in the likelihood fit

