

Probing Inelastic Higgsino Dark Matter at High Recoil Energies with XENONnT

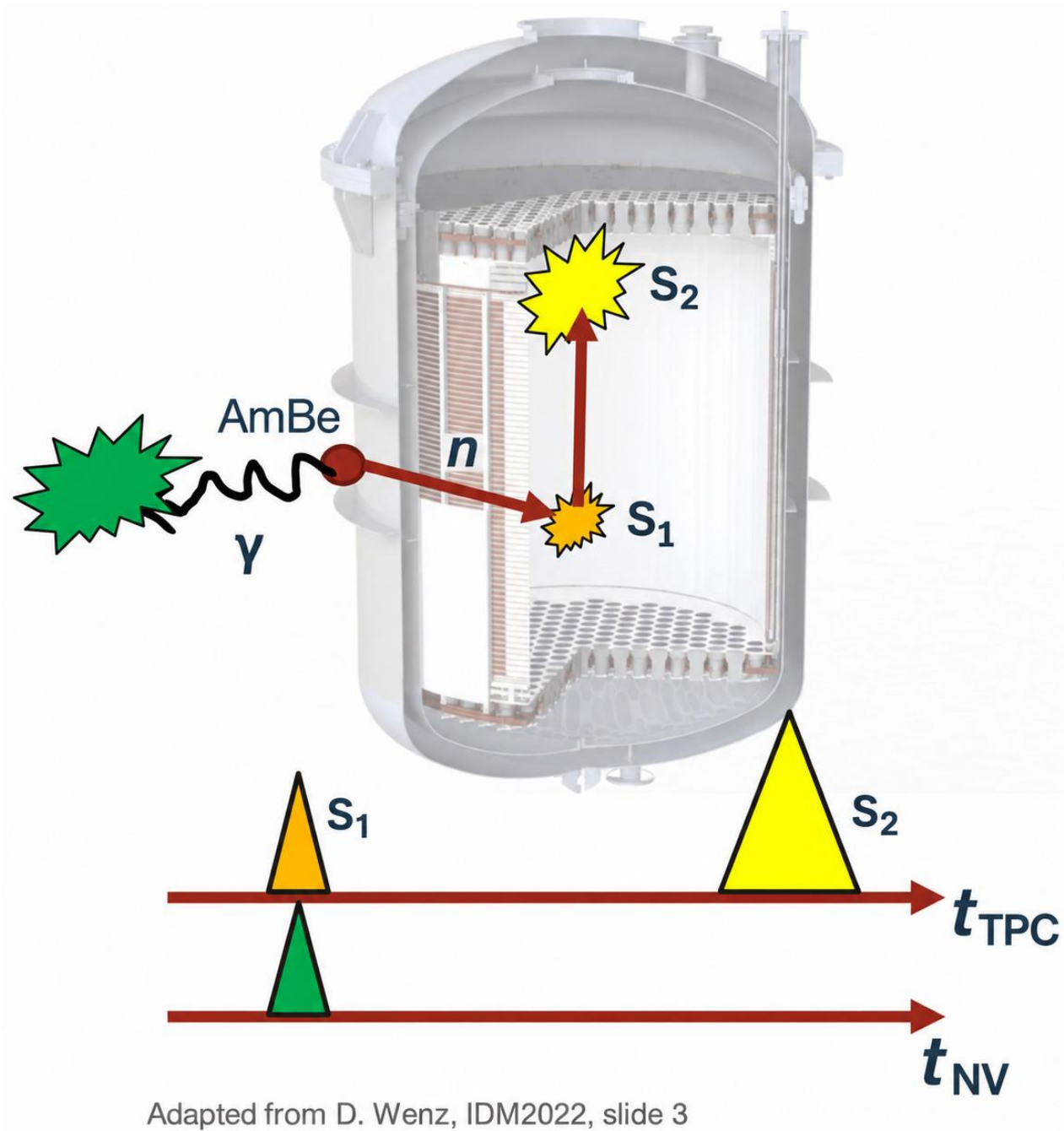
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UGRP2026 · 28–30 September 2026

1 XENONnT and AmBe tagging

5.9 t liquid xenon (LXe) in a dual-phase TPC at LNGS (Eur. Phys. J. C 84, 784 (2024)).

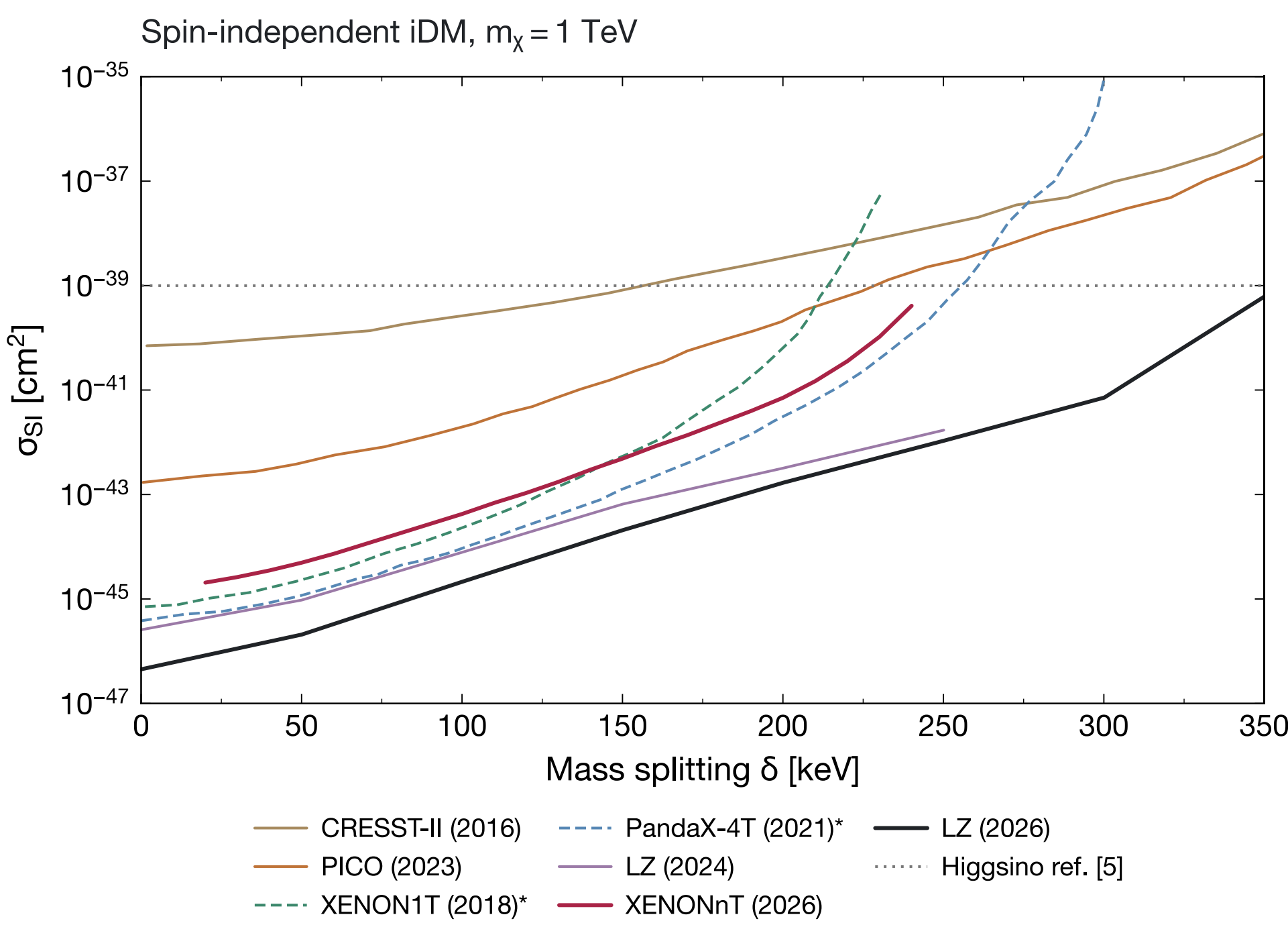


S1: prompt scintillation.
S2: drifted electrons generate light in gas.
S1–S2 timing and the S2 pattern give 3D position.
S2/S1 statistically separates nuclear (NR) and electronic recoils (ER).

The water neutron veto (NV) surrounds the sealed cryostat. Green pulse: prompt AmBe γ tag.

Adapted: D. Wenz, IDM2022, slide 3. NV omitted. Timing schematic.
NV: Eur. Phys. J. C 85, 695 (2025). Principle: Di Gangi, Universe 7, 313 (2021).

3 Public SI-iDM baseline



Higgsino ref. [5]: Phys. Rev. D 111, 055030 (2025).
XENONnT / LZ 2026 curves: collaboration preprints.
Scalar SI. LZ: upper edge of the observed two-sided 90% CL interval.
Other experimental curves: 90% CL upper bounds.
* PICO reinterpretations of XENON1T and PandaX-4T.

XENONnT SR1: 2.1 tonne-year, $cS1 \leq 100 \text{ PE}$.
LZ extends the NR window to $\approx 270 \text{ keV}_{nr}$.

5 Signal calibration

AmBe fits constrain NR light/charge yields and fluctuations for high-recoil iDM templates.

AmBe source and timing

α from ^{241}Am (Eur. Phys. J. C 85, 695 (2025)).

$\alpha + {}^9\text{Be} \rightarrow n + {}^{12}\text{C}$

No prompt 4.44 MeV γ tag

$\alpha + {}^9\text{Be} \rightarrow n + {}^{12}\text{C}^*$

${}^{12}\text{C}^* \rightarrow {}^{12}\text{C} + \gamma (4.44 \text{ MeV})$

Colour: γ -to-S1 delay

$\Delta t = t_{S1,TPC} - t_{\gamma,NV} \text{ [ns]}$

GPS-synchronized pulse centre times.
Positive Δt means the TPC S1 follows the source γ . Drift and neutron capture are separate delays.

Below the AmBe NR band

Multiple scatters can add S1 with little S2 in charge-insensitive regions, lowering S2/S1. Mispairing may contribute. Origins remain unresolved.

7 Planned analysis tasks

Selection and efficiencies

Runs, ROI and cut efficiencies
Blinding strategy

Response and background models (parallel)

iDM / NR / ER fits and ${}^{129}\text{Xe}$ NR+ER templates
Background spectra and rates

Joint fit and systematics

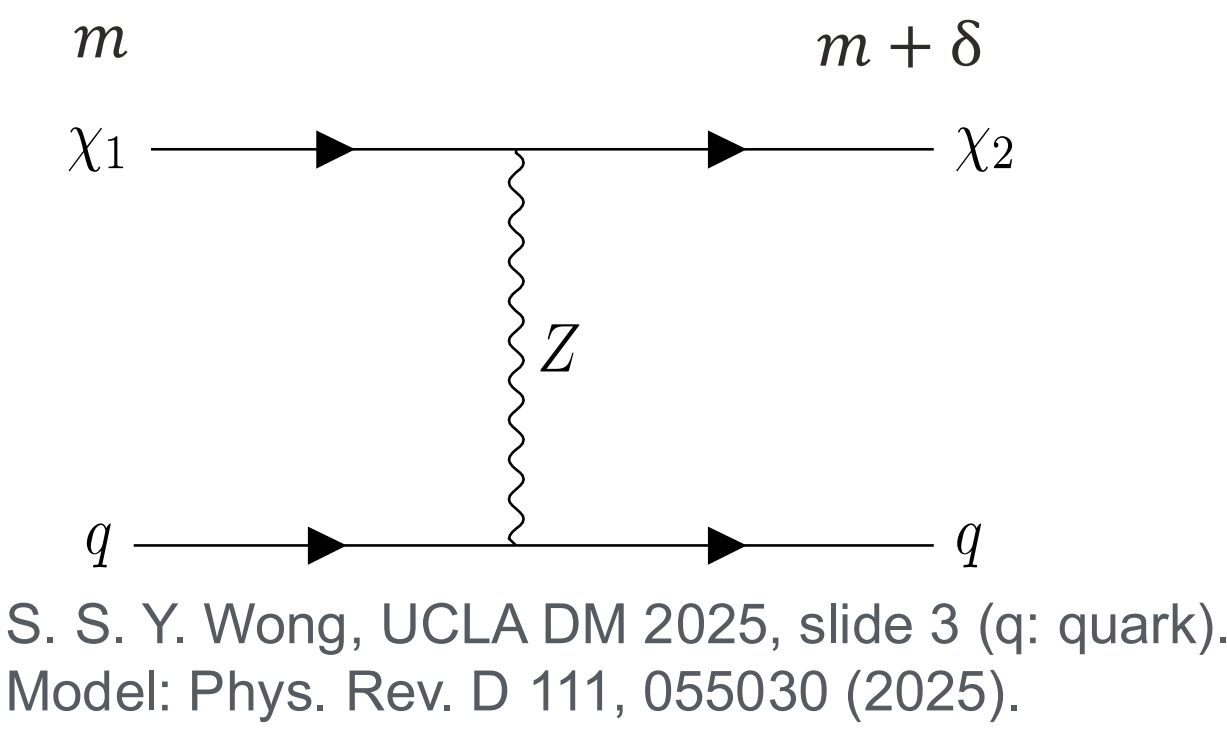
Signal + background fit
Systematics and mismodeling

Validation and inference

Closure / goodness of fit
Review + unblinding approval
Statistical inference

2 Inelastic Higgsino dark matter

Higgsinos scatter to a degenerate heavier state via Z exchange. Thermal benchmark: $m_\chi \approx 1.1 \text{ TeV}$. Larger δ favors high recoils beyond standard WIMP selections, motivating an independent search.

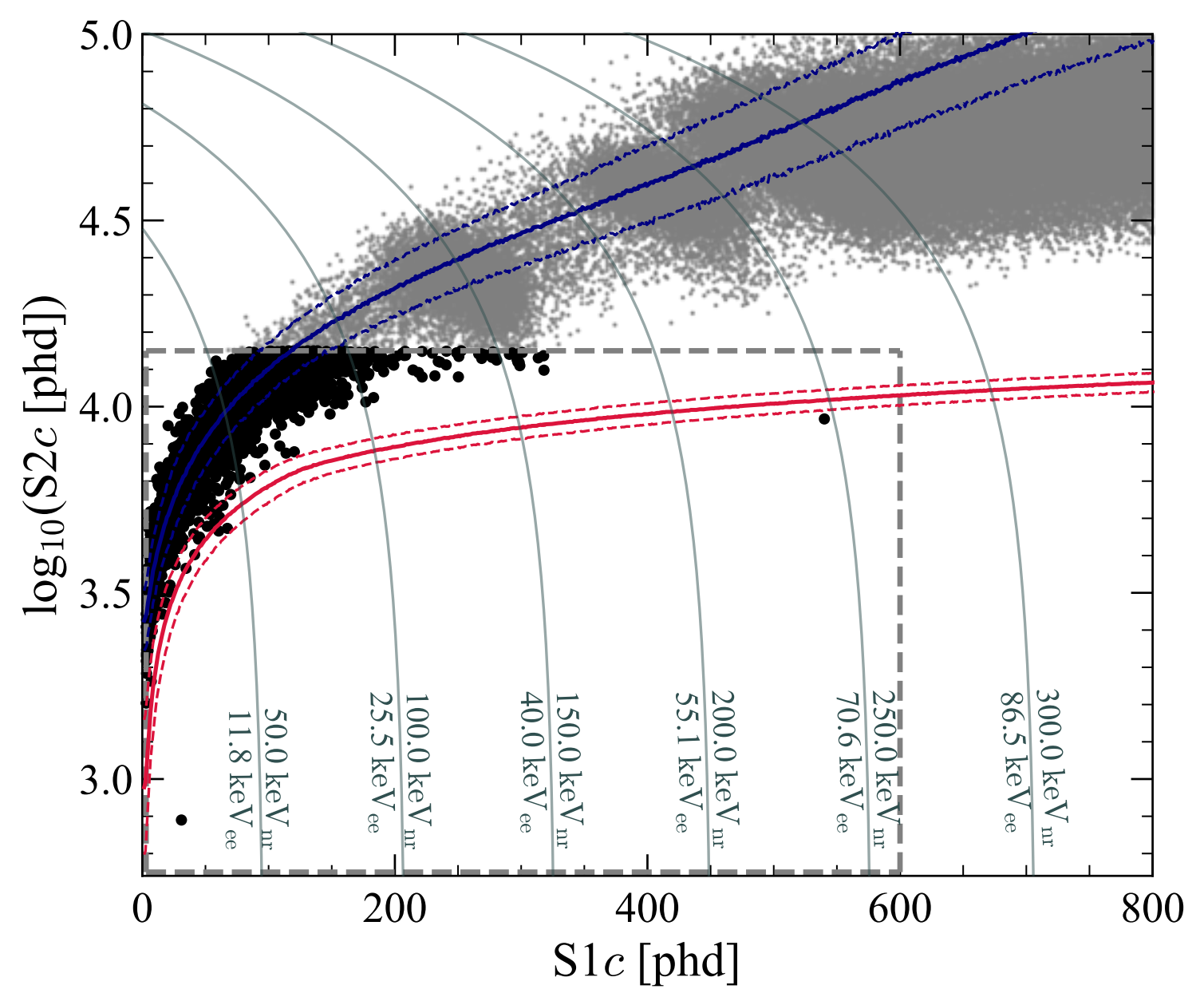


$$\chi_1 + \text{Xe} \rightarrow \chi_2 + \text{Xe}$$

$$\delta = m_{\chi_2} - m_{\chi_1} > 0$$

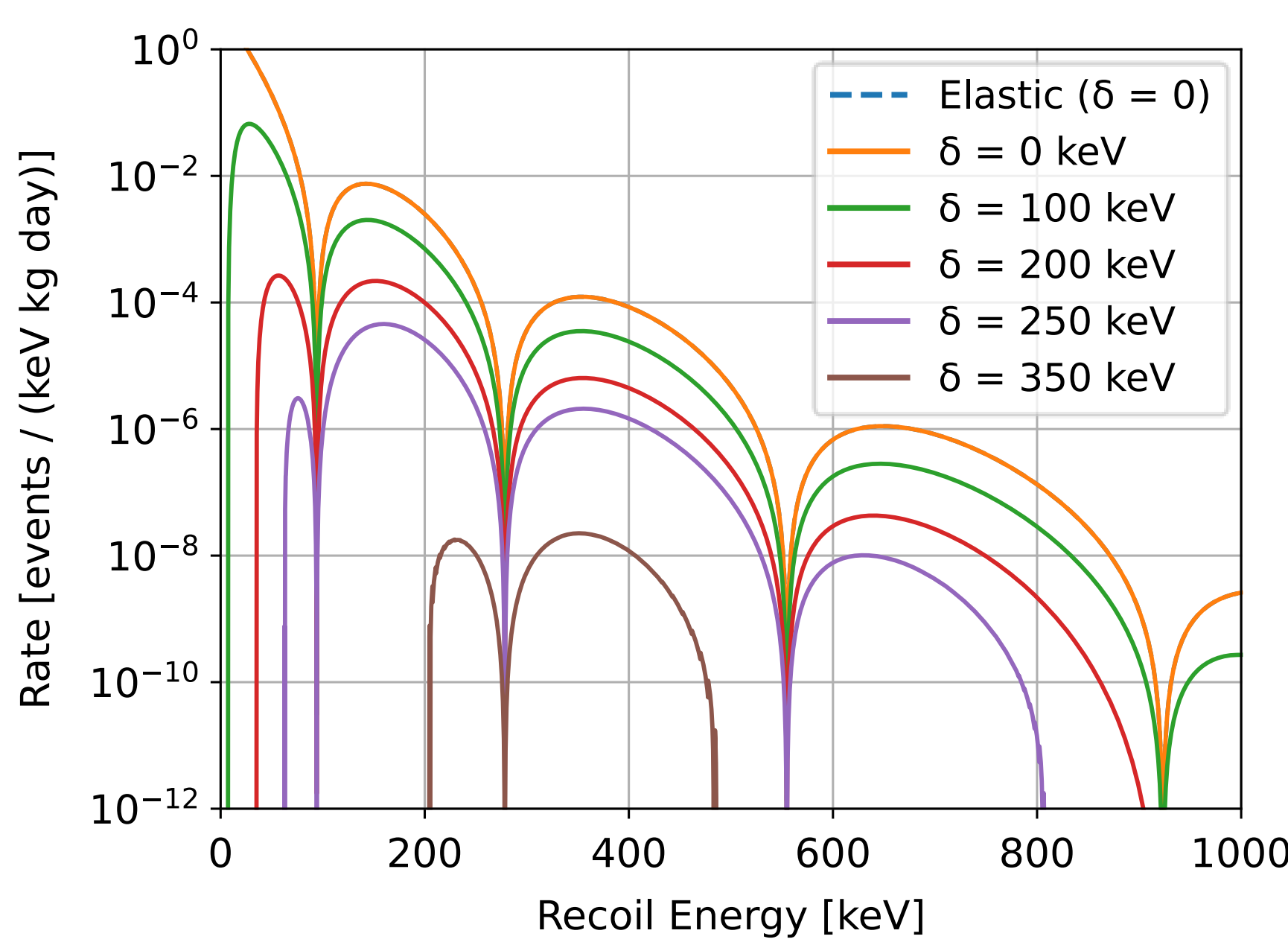
$$v_{\min}(E_R) = \frac{1}{\sqrt{2m_N E_R}} \left| \frac{m_N E_R}{\mu_{\chi N}} + \delta \right|$$

$v_{\min}$: speed threshold for recoil E_R .
 $\mu_{\chi N}$: DM–nucleus reduced mass. Natural units.



NR-compatible: $248 \pm 23_{\text{stat}} \pm 23_{\text{sys}} \text{ keV}_{nr}$.
2.6 σ global tension with background-only.
No DM discovery. Dashed box: expanded ROI.
LZ Collaboration preprint (2026), Fig. 4.

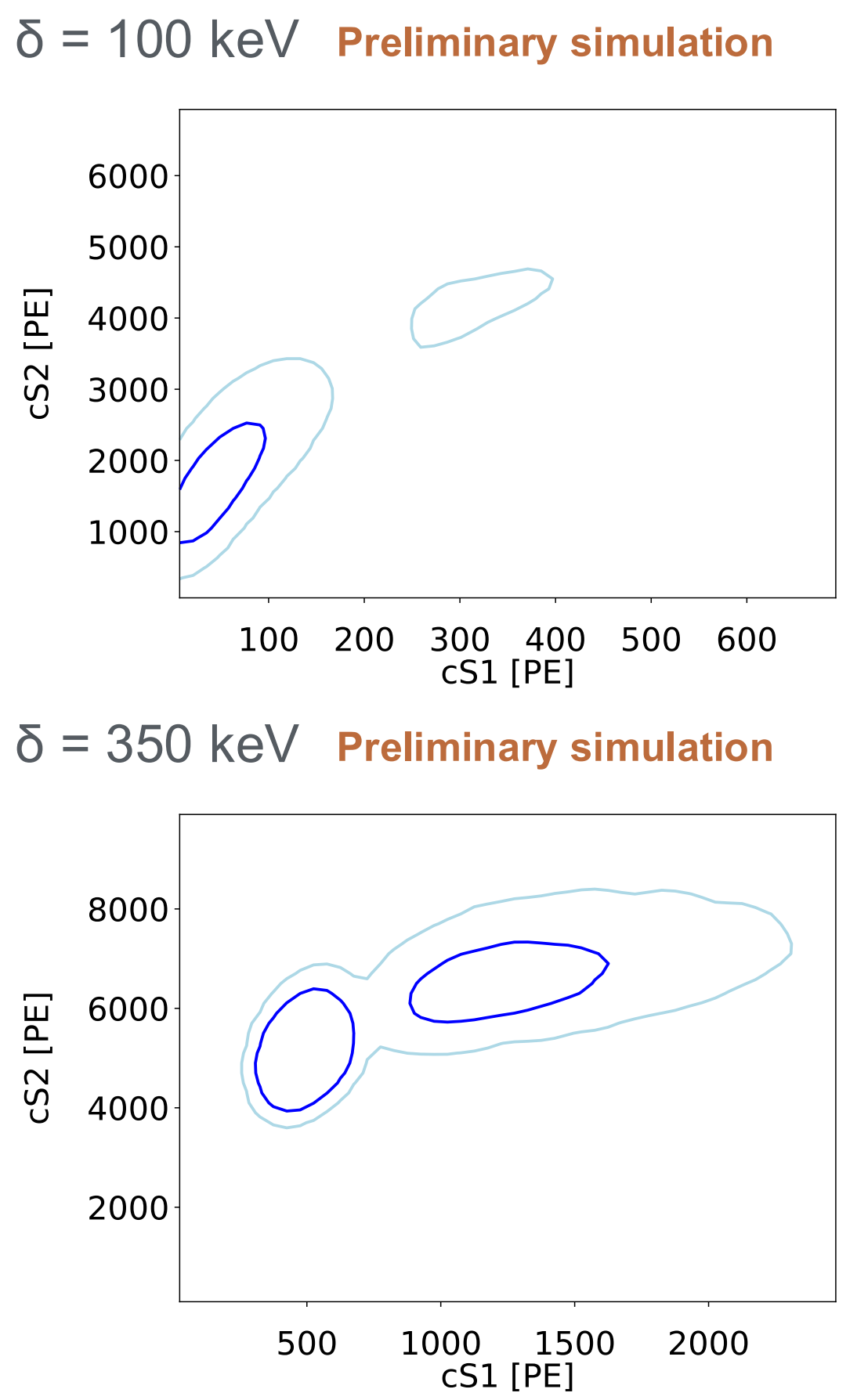
4 Signal prediction in detector space



$m_\chi = 1.1 \text{ TeV}$, $\sigma = 10^{-39} \text{ cm}^2$.
 $\delta = 350 \text{ keV}$ favors high E_R [keV_{nr}].

A detector-response simulation maps recoil energy to $cS1$ – $cS2$ using LXe light/charge yields, detector gains and selection efficiencies.

Response model: Phys. Rev. D 111, 103040 (2025).

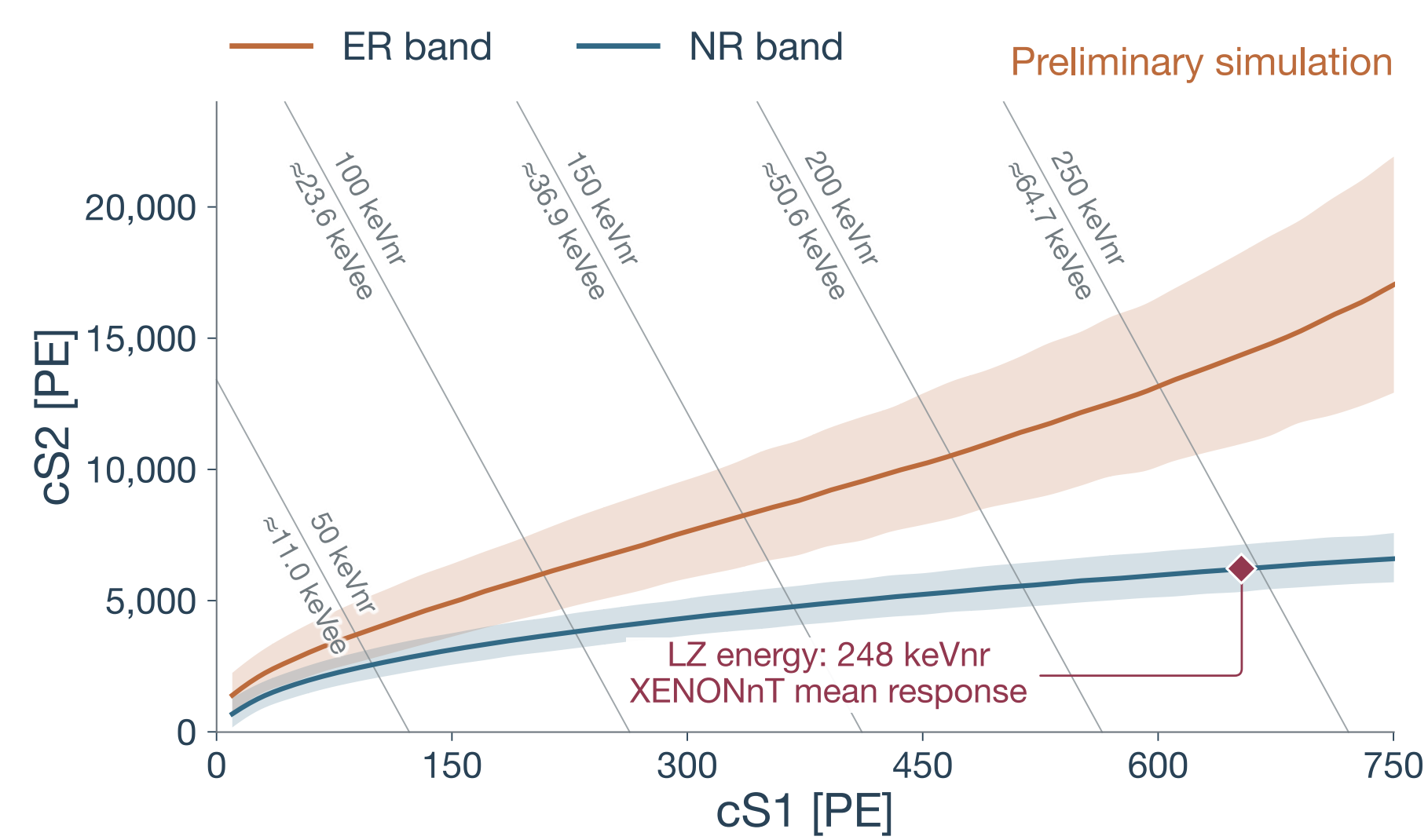


Illustrative 68% / 95% signal contours.
 $cS1/cS2$: corrected areas [PE].
Note the different axis ranges.

6 Background modeling

${}^{220}\text{Rn}$ calibration constrains ER recombination and leakage into the NR signal region.

ER and NR response



NEST: 23 V/cm, (Front. Detect. Sci. Technol. 2, 1480975 (2024)).
Lines: medians. Shading: central 90% event range.
Grey: approximate combined-energy guides.
Diamond: simulated mean at LZ's 248 keV_{nr}.

Background components

β/γ , ${}^{124}\text{Xe}$ 2vECEC and ${}^{136}\text{Xe}$ 2v $\beta\beta$ spectra/rates, plus neutrons, accidental S1–S2 pairs and charge-loss events.

Models: Phys. Rev. D 111, 103040 (2025); Phys. Rev. Lett. 129, 161805 (2022).

Indicative sequence, not a duration scale.