Status and Prospect of the RELICS Experiment

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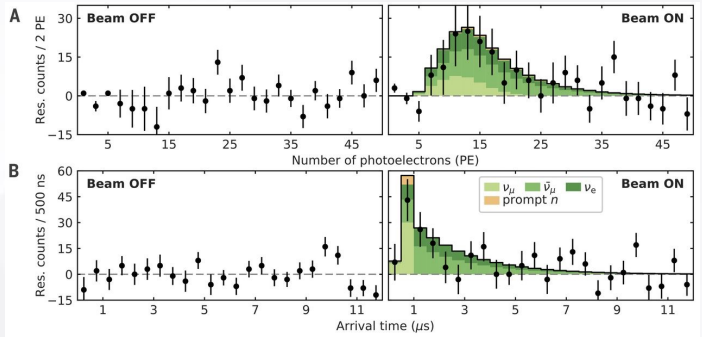
(On behalf of RELICS collaboration)

University of Science and Technology of China

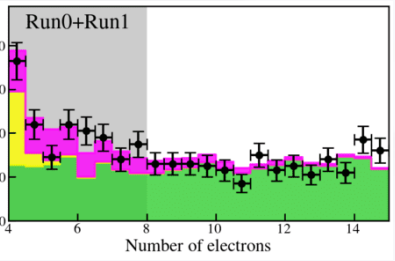
TeVPA2026 @ Tendo, 2026.09.02

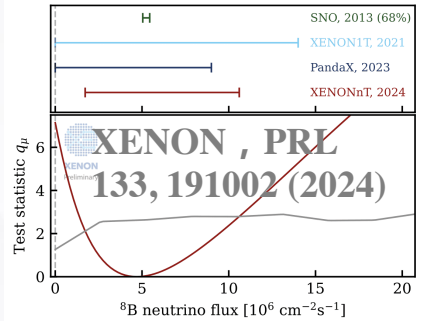
Xe for reactor CEνNS

COHERENT, Science 357: 1123 (2017)



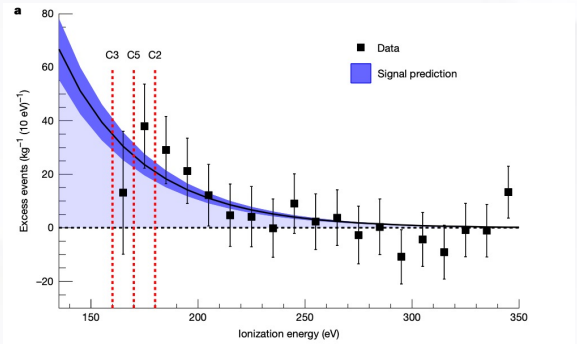
PandaX, PRL 133, 191001 (2024)

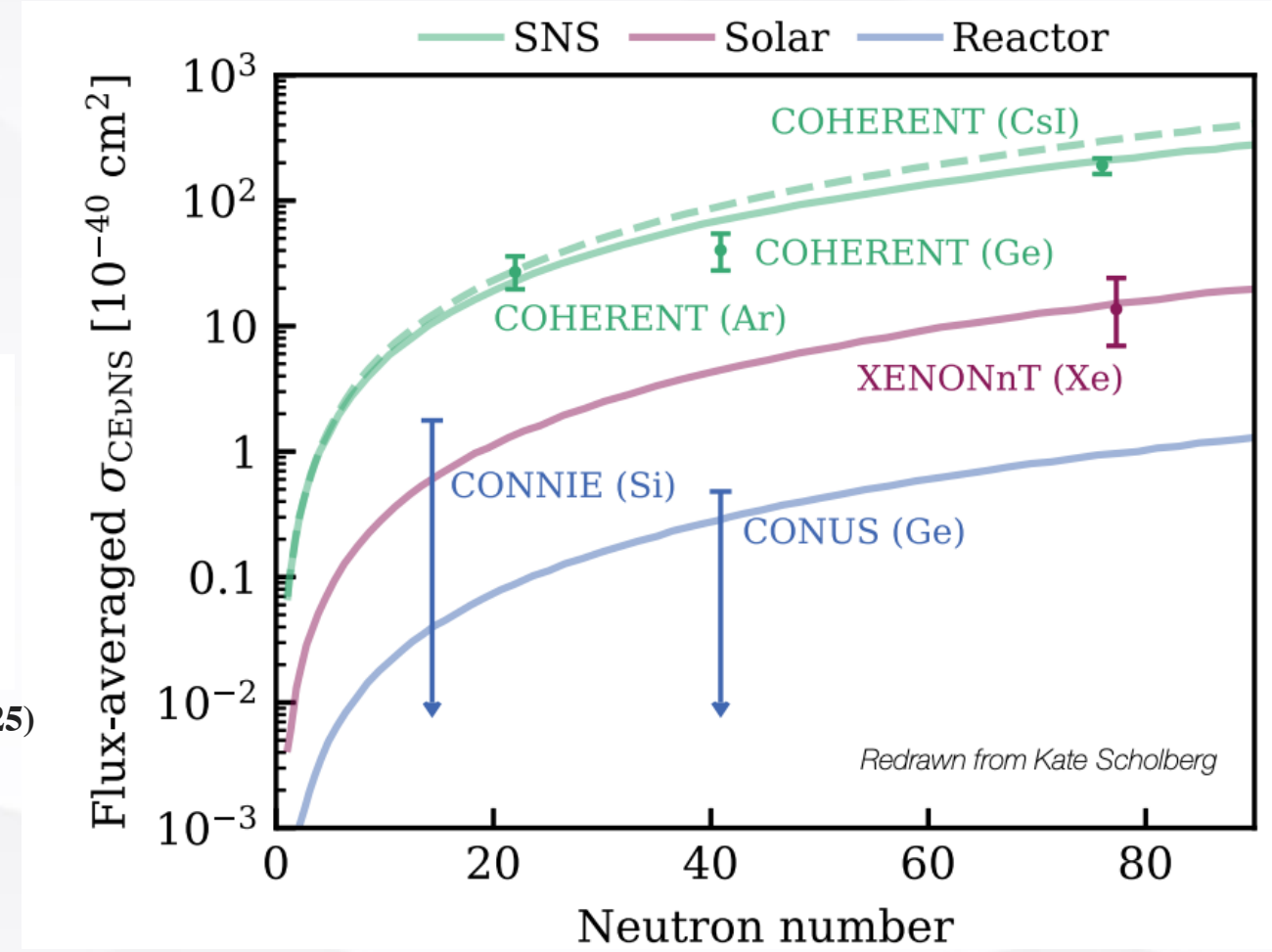


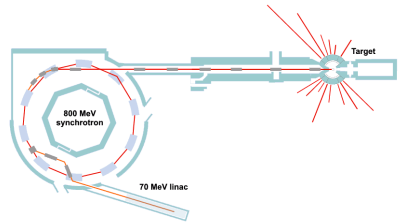


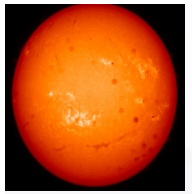
XENON , PRL 133, 191002 (2024)

CONUS+ , Nature **volume 643, pages1229–1233 (2025)**



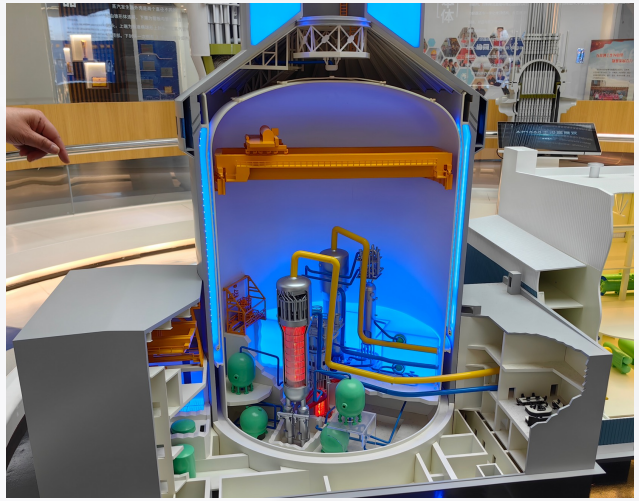






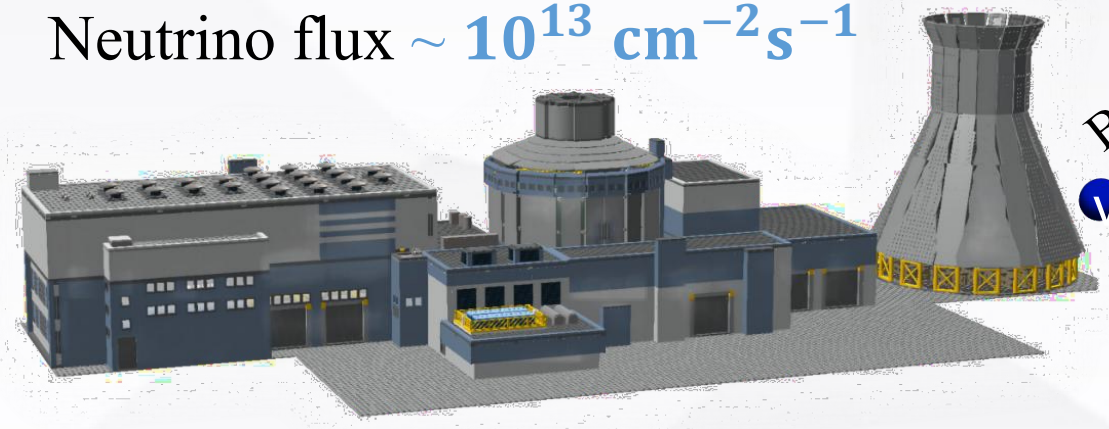
RELICS experiment

Taizhou, Zhejiang, China

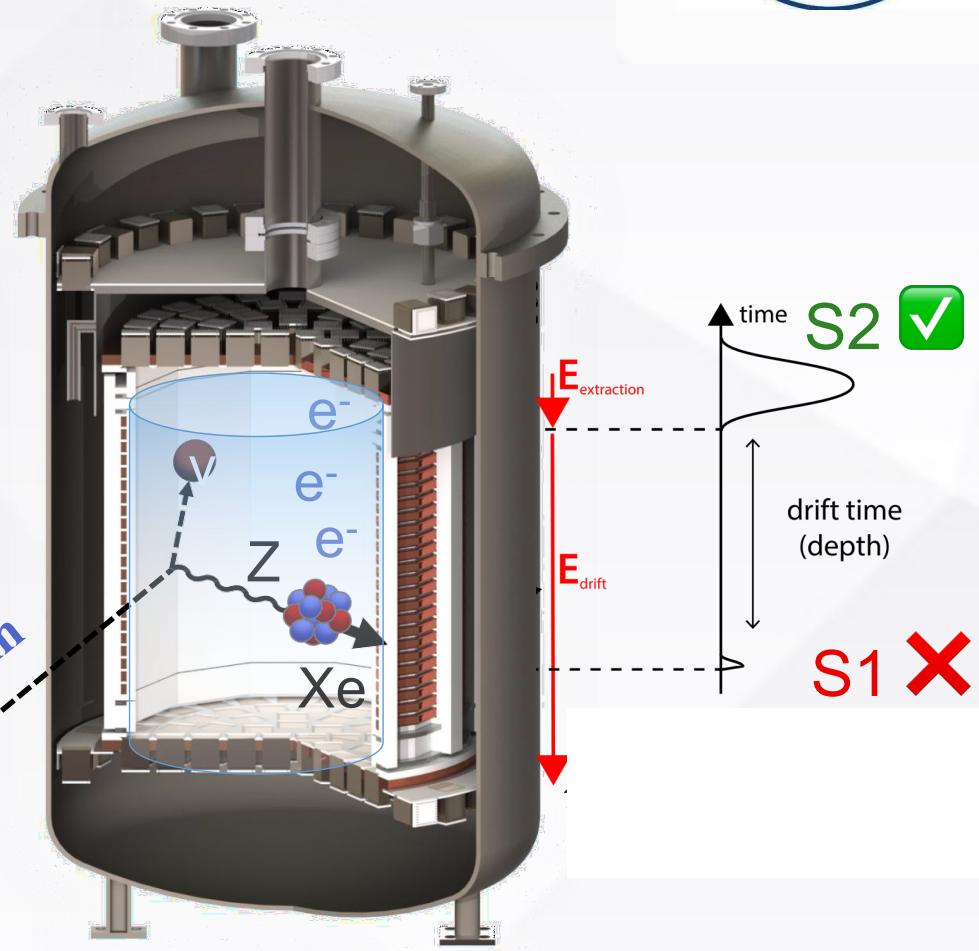


AP1000 thermal power ~ 3GW

Neutrino flux ~ $10^{13}\ cm^{-2}s^{-1}$



Baseline ~25m

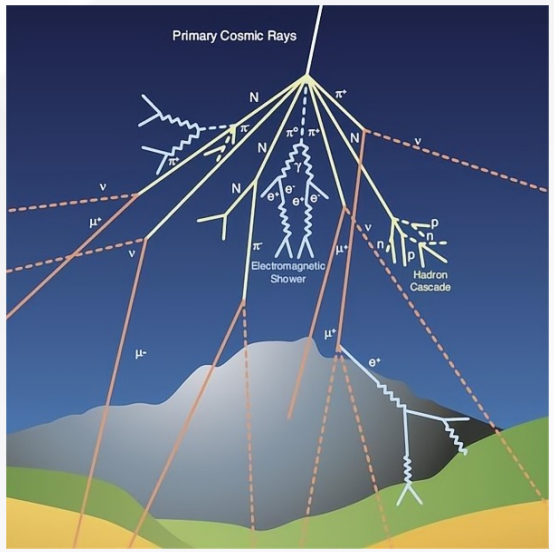


13.7eV = **0.1** S1 or **25** S2

Reactor neutrino <1.3 keV_{nr}

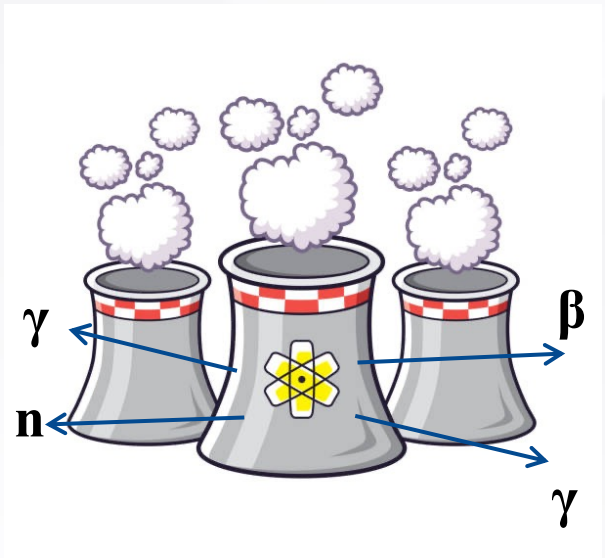
Background Components

Cosmic Ray Particles



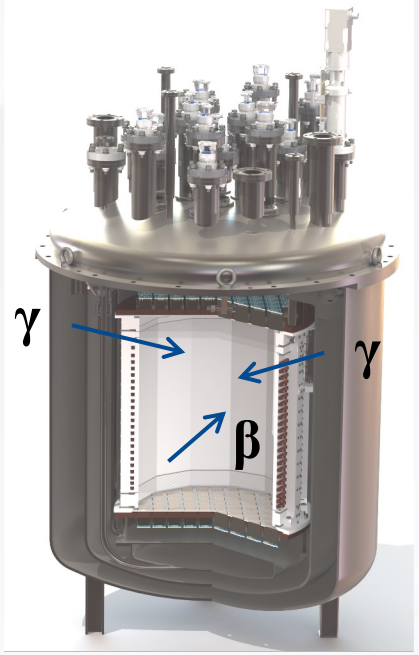
- Cosmic μ
- Cosmic neutron
- Others…

Reactor



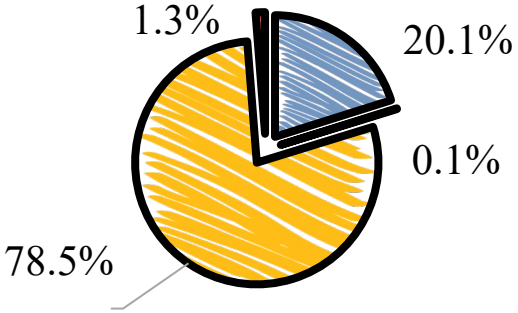
- Reactor Neutron
- Reactor γ
- Others…

Detector Material



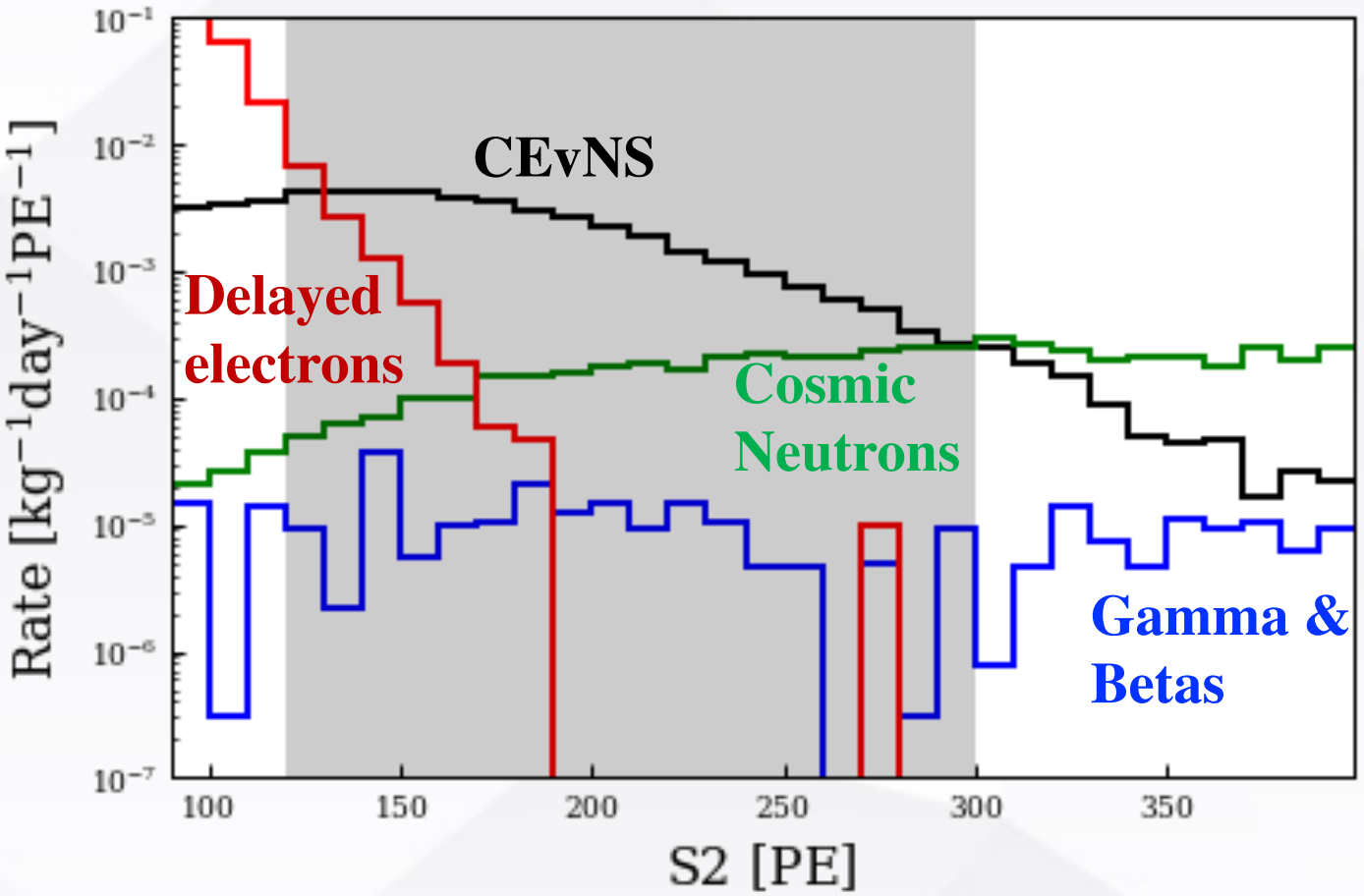
- Material γ, β
- Others…

Background ratio



- cosmic ray neutron 20.1%
- muon induced neutron 0.1%
- delayed electron 78.5%
- cosmic & meterial 1.3%

Signal and Background Expectation



OPEN ACCESS

PDF

Reactor neutrino liquid xenon coherent elastic scattering experiment

Chang Cai[1], Guocai Chen[2], Jiangyu Chen[3], Rundong Fang[4], Fei Gao[1,*], Xiaoran Guo[5,6], Jiheng Guo[4], Tingyi He[7,//], Chengjie Jia[1,‡] *et al.* (RELICS Collaboration)

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Phys. Rev. D **110**, 072011 – **Published 18 October, 2024**

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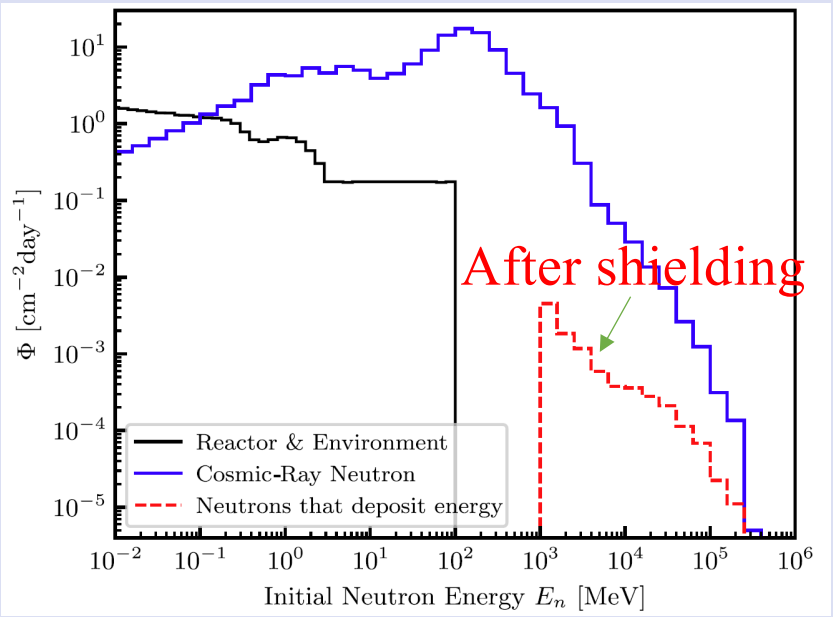
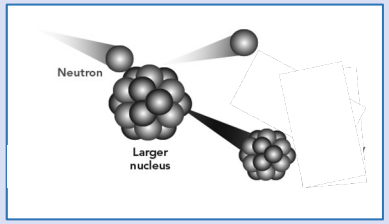
DOI: https://doi.org/10.1103/PhysRevD.110.072011

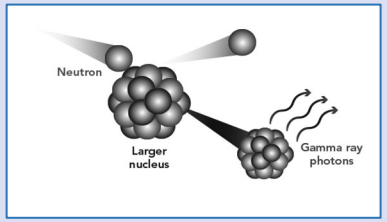
	Events/$(32kg \cdot year)$
Total background	1687.8
CR neutron	339.9
μ-induced neutron	1.7
Beta, gamma	21.1
Delayed electron	1325.1
CEvNS	4639.7

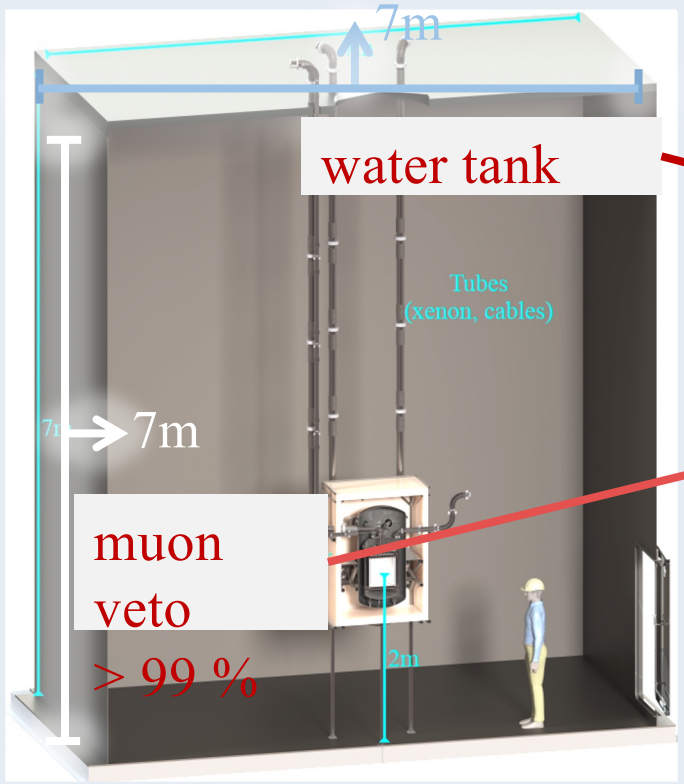
NR Background



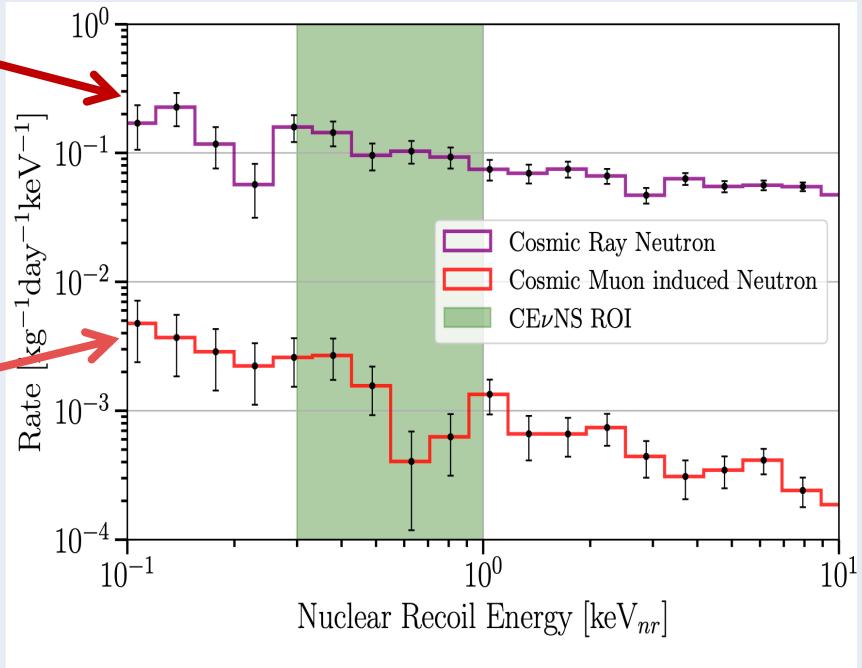
- Cosmic-Ray neutron
- Reactor & Environment neutron







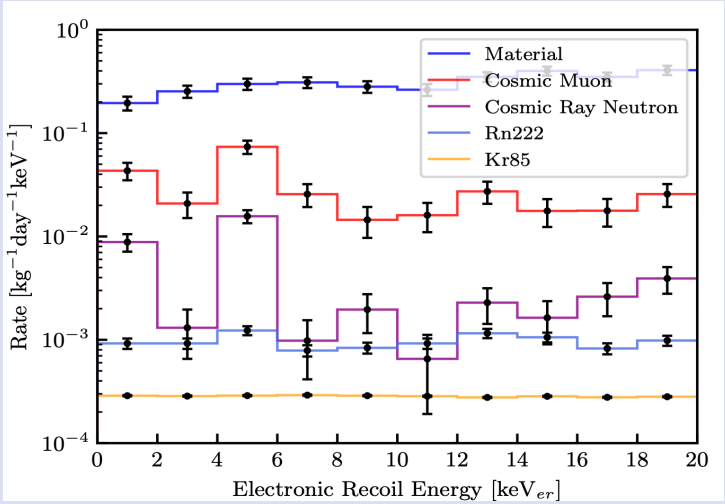
Phys. Rev. D 110, 072011 (2024)



NR Background:

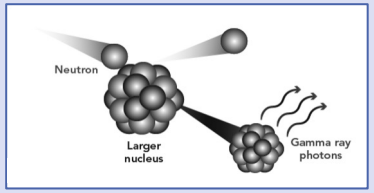
- **$(7.7 \pm 0.7) \times 10^{-2}$ kg^{-1}·day^{-1} in [0.3 ,1] keV$_{NR}$**
- **Dominated by cosmic ray neutron**

ER background



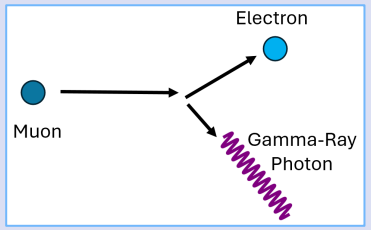
-- Cosmic Ray neutron

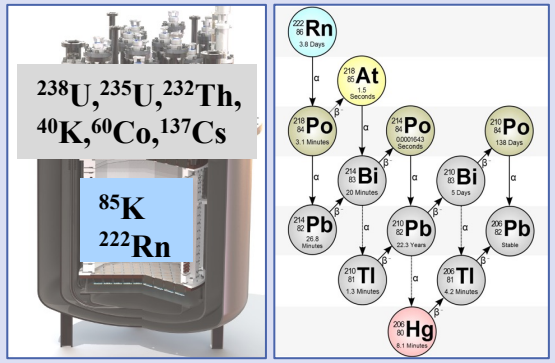
-- Material

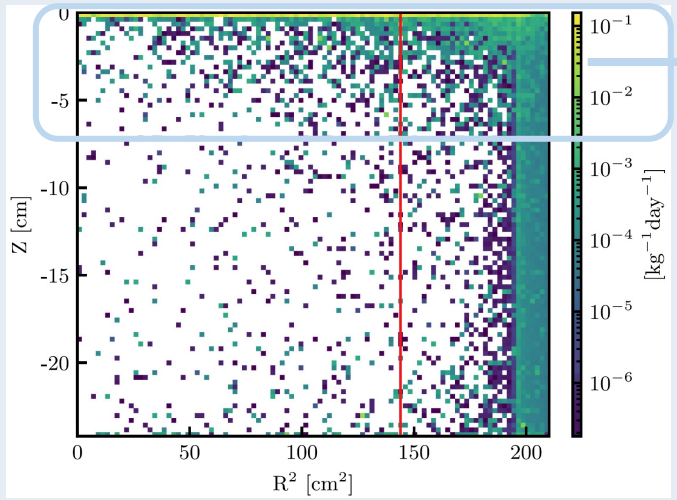


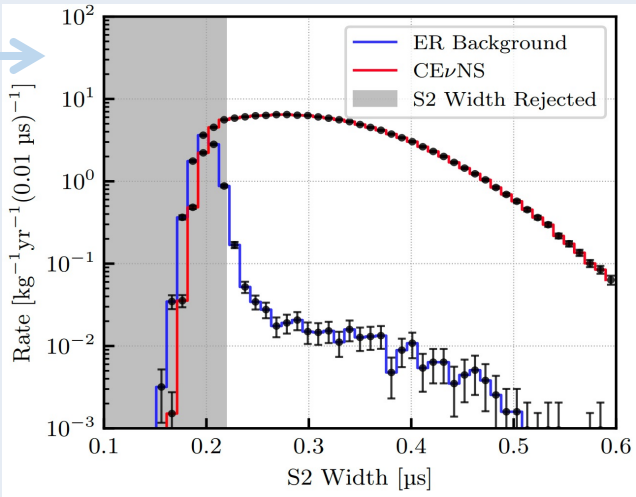
LXe intrinsic -- Rn222 -- Kr85

-- Cosmic Muon









Fiducial Volume: **S2 only --- No Z position**

R < 12 cm

Edge

> 95% efficiency

ER Background:

- **$(3.10 \pm 0.10) \times 10^{-1}$ kg^{-1}·day^{-1}·keV^{-1} average in [0,20] keV$_{ER}$ before S2 width cut**

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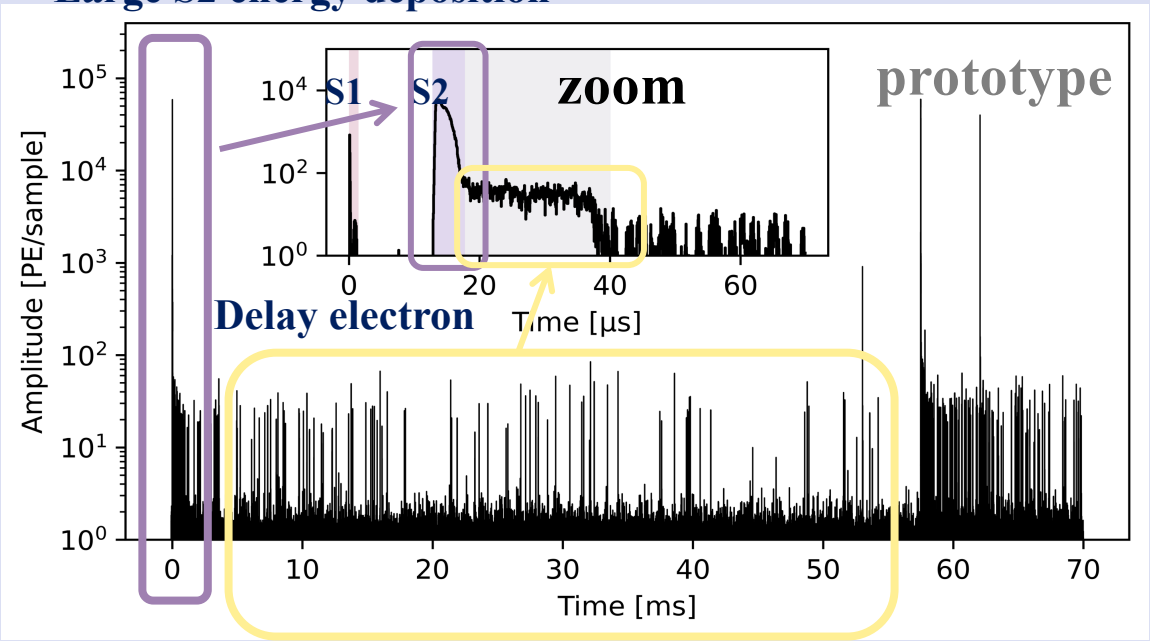
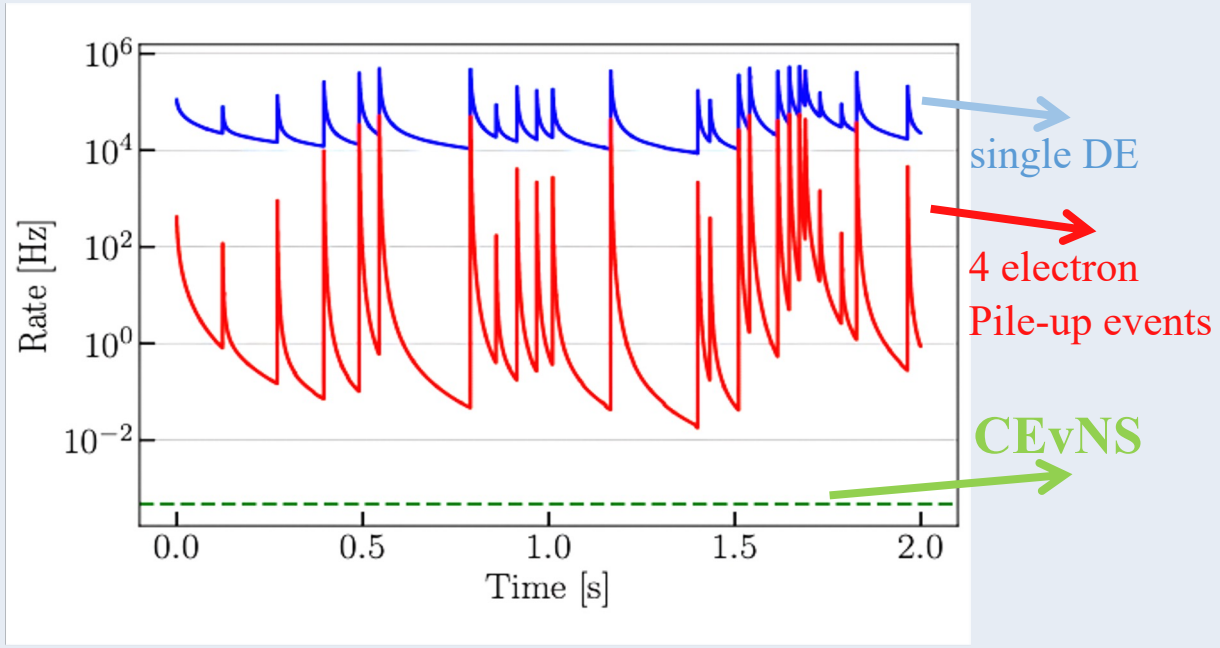
Delayed electron background

Large S2 energy deposition



Delayed electron sources:

- Observed by large LXeTPCs experiments and prototypes
- Emission of electron following large energy deposition
- Pile-up of single electrons distorts the physical signal



Delayed electron background:

- ~10 Hz muon flux
- Pile-up DE events rate higher than CEvNS events

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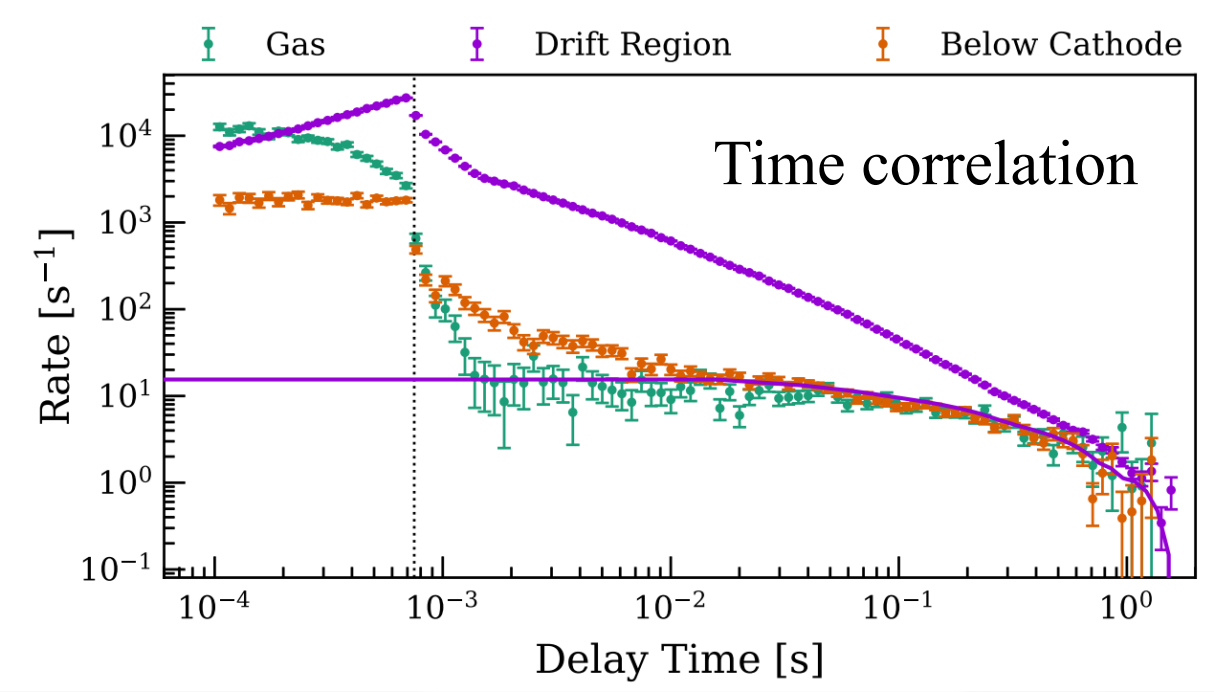
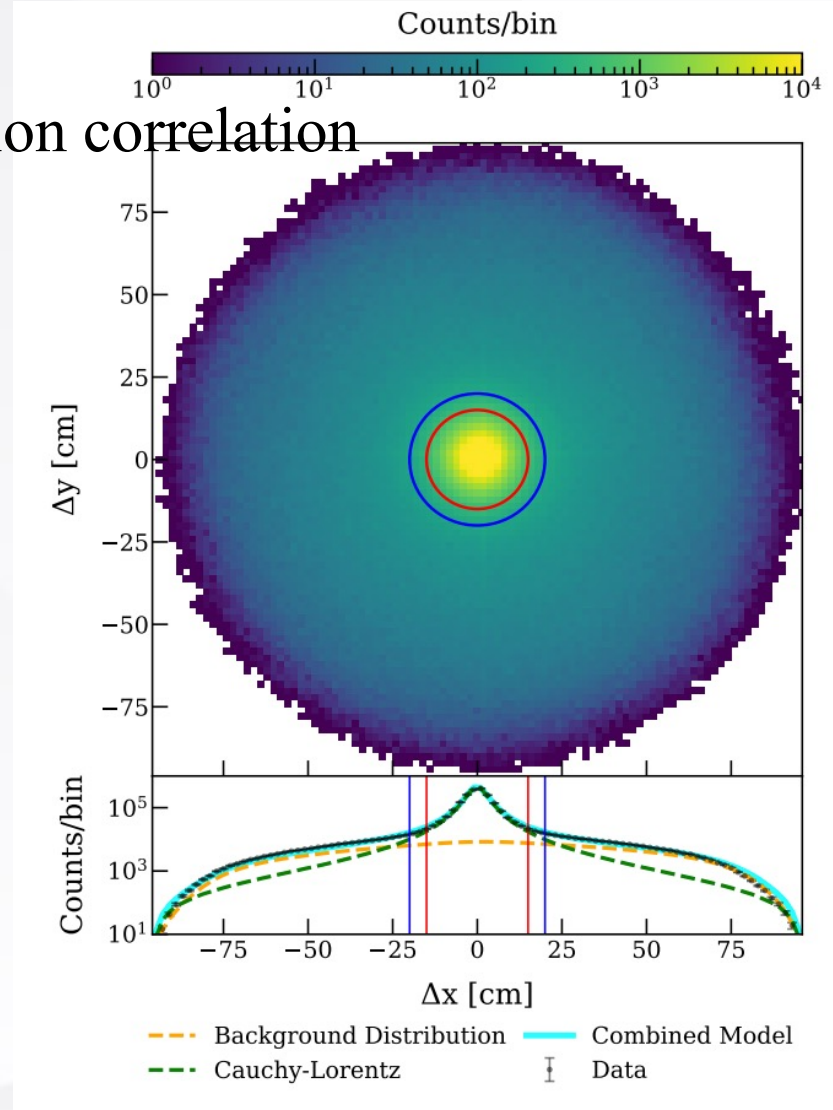
Features of DE

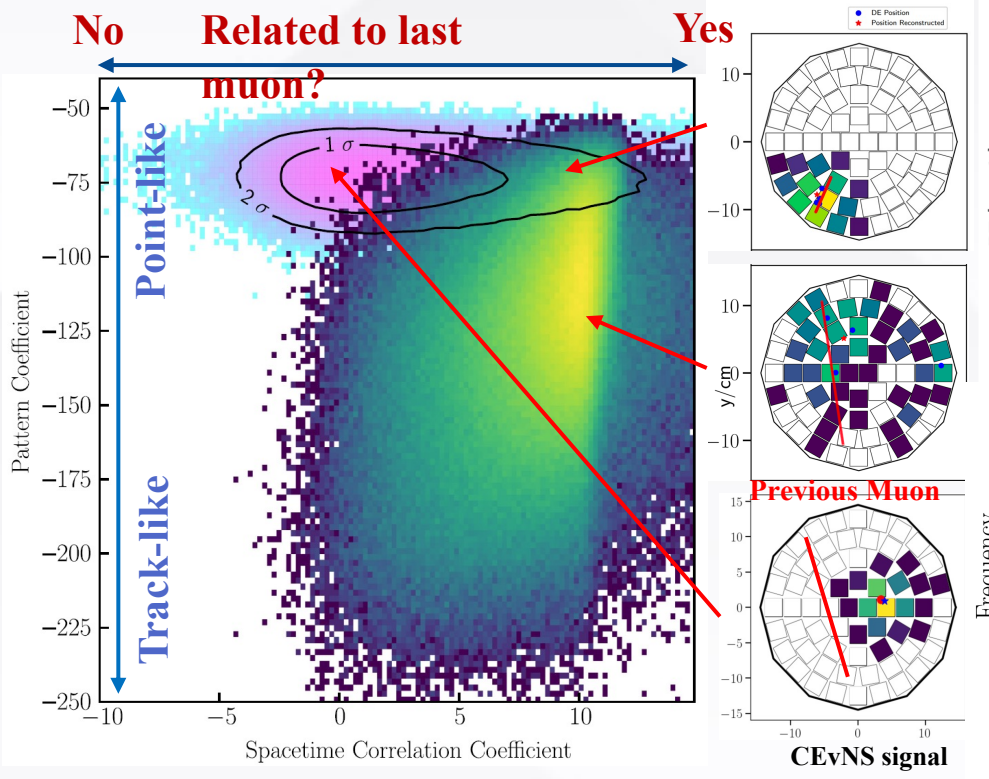


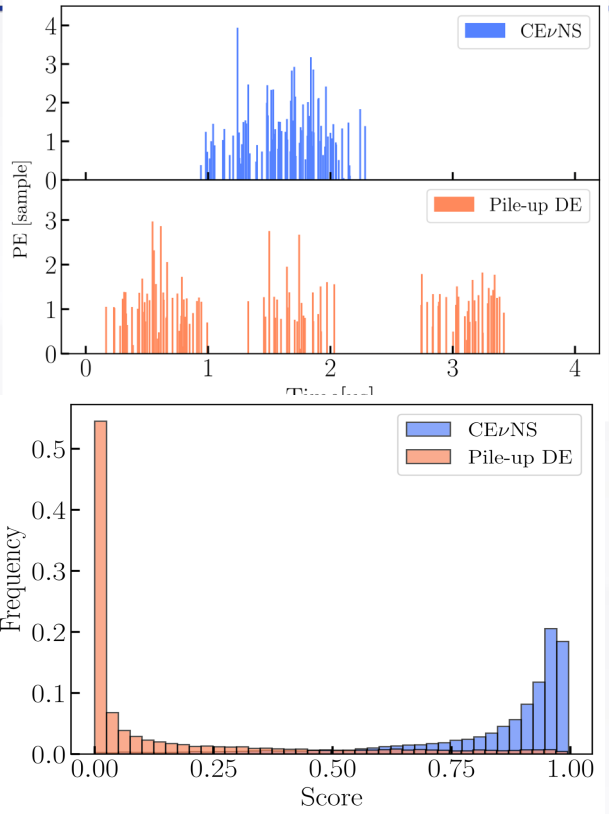


- Delayed electrons studied in large LXeTPCs
- Time correlation
- Position correlation

XENON collaboration, arXiv: 2112.12116

DE Suppression





	Signal Acceptance	Background Remaining
Pattern + Correlation	~52%	~0.01%
Waveform	~80%	~10%

4-5 orders total

Pattern + Correlation selection:

- CEvNS : Closer to single - point events.
- DE: More linked to the preceding muon track.

Waveform selection:

- CEvNS : clustered
- DE: dispersed

Need:

- Full muon track information
- DE suppression with material

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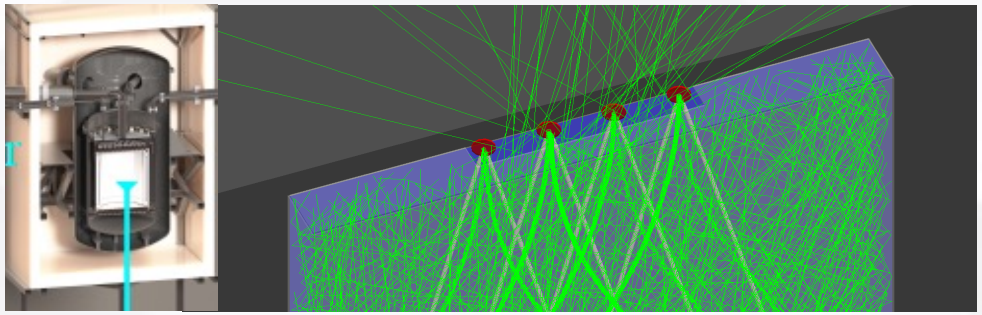
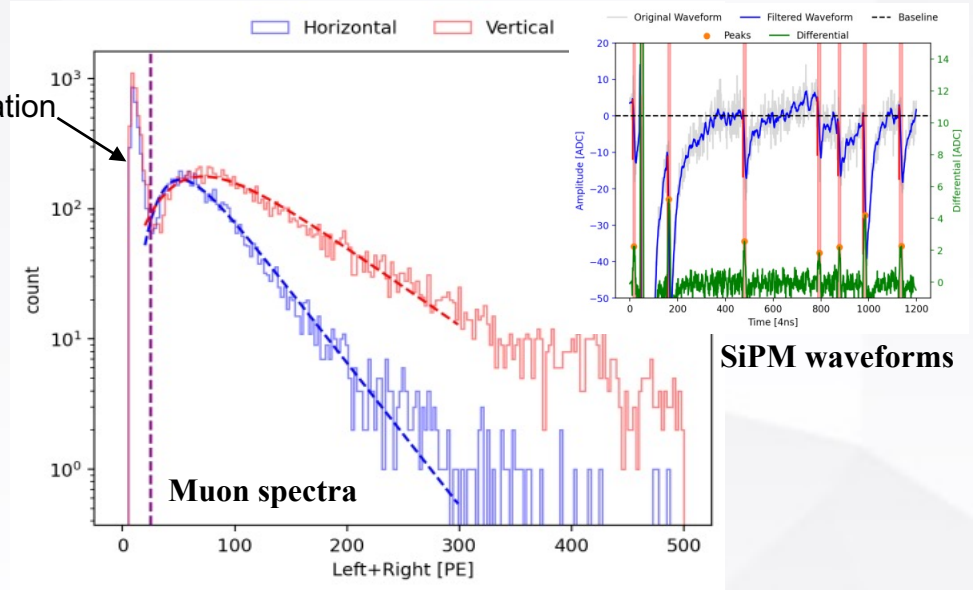
Cosmic muon detection

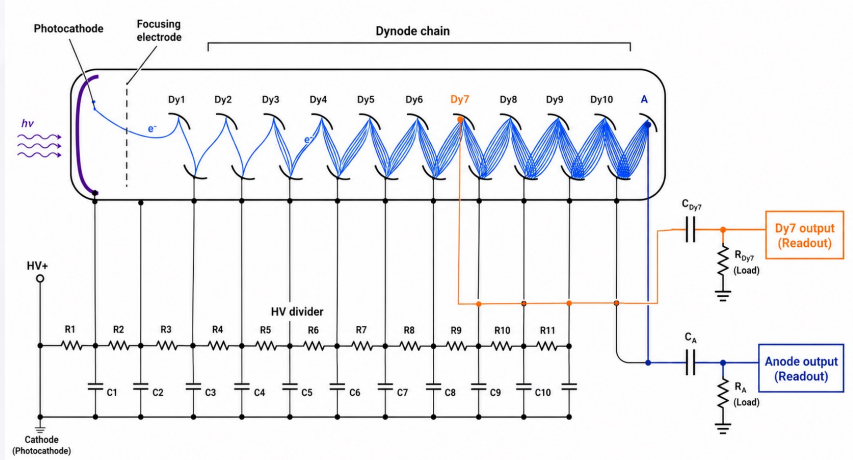
Path 1: Muon Active Veto Boards

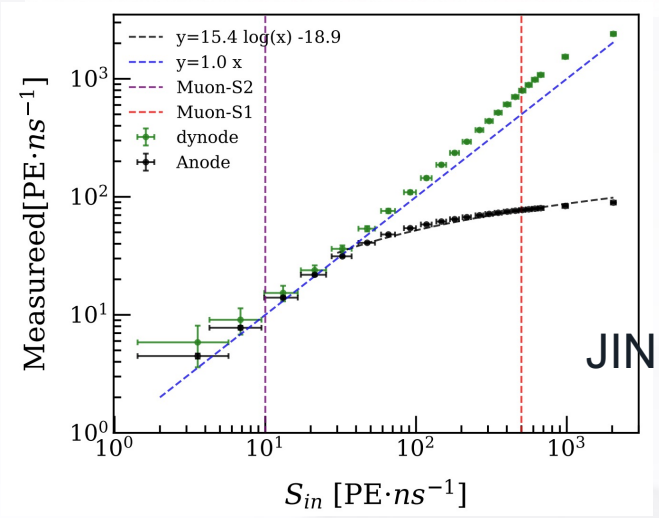




Plastic scintillator bars w/ SiPM to tag muons

Path 2: PMT Dynode Readout Extension





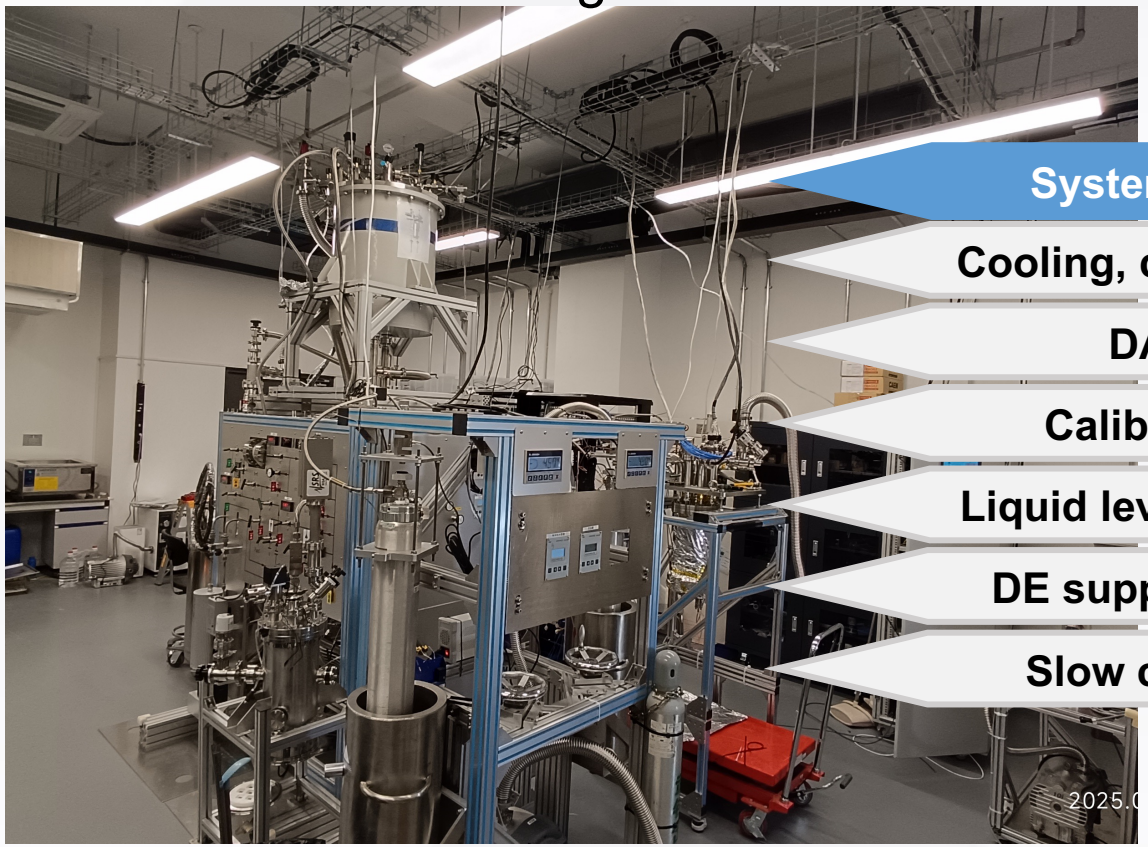
JINST 21, P02039 (2026)

Range: keV → MeV

Dynode recovers otherwise **saturated** anode signal

RELICS prototype

Tsinghua



Westlake

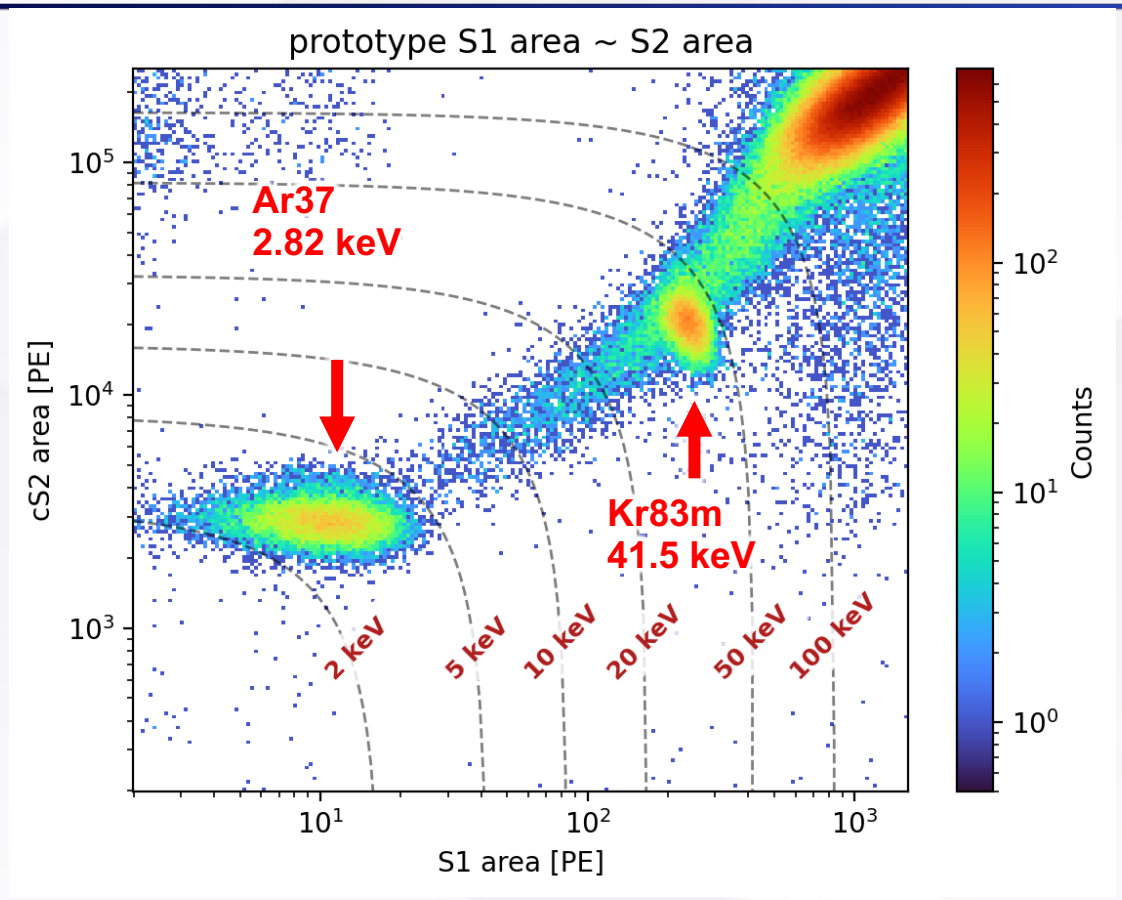
- System R&D
- Cooling, circulation
- DAQ
- Calibration
- Liquid level control
- DE suppression
- Slow control

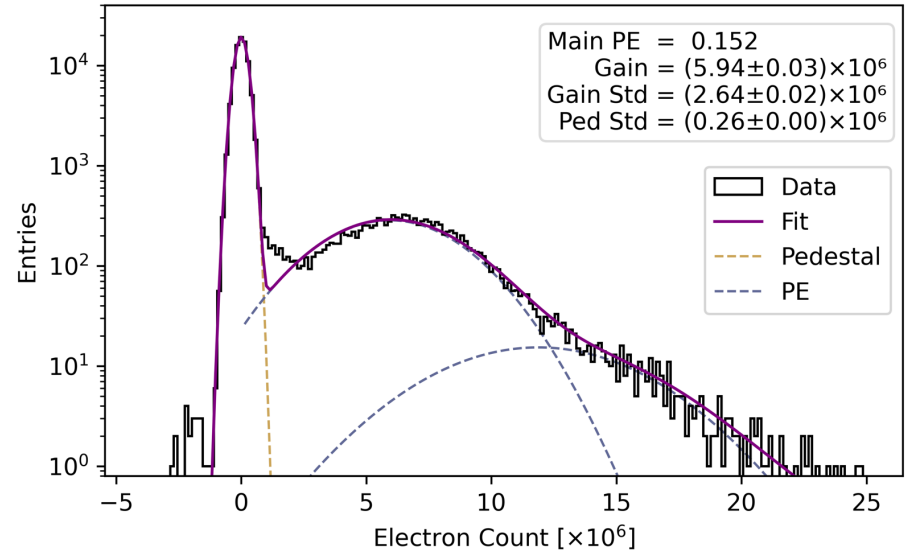
NST 37(1), 14 (2025)
Eur. Phys. J. C 86, 348 (2026)
arXiv:2604.12572

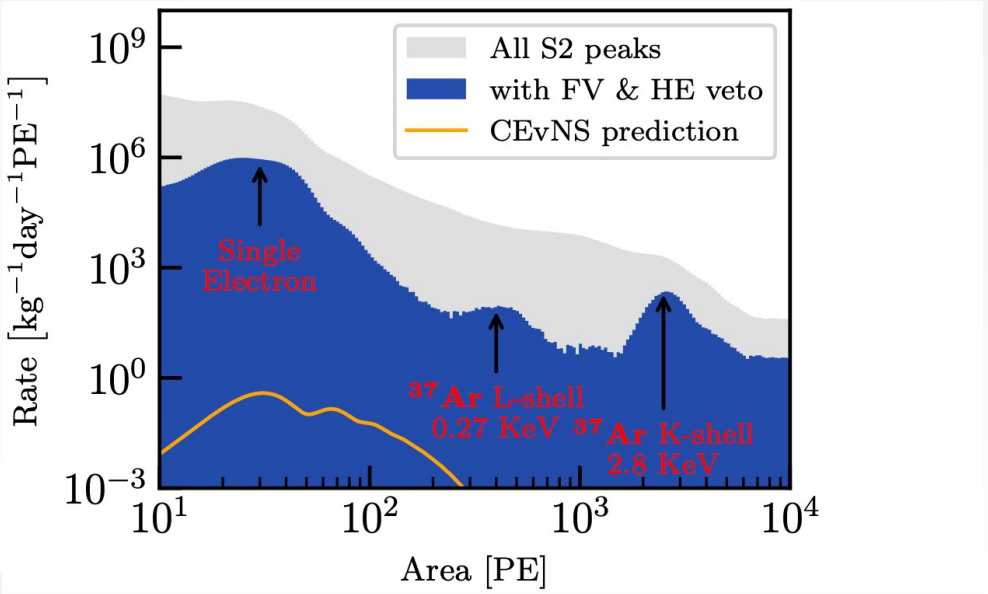
Test and optimize sub-systems
Establish data analysis pipeline

JINST 21, P02039 (2026)

Energy threshold and DE suppression







Single electrons are detected with high efficiency
DE background can be suppressed via HE veto

NST 37(1), 14 (2025)
Eur. Phys. J. C 86, 348 (2026)

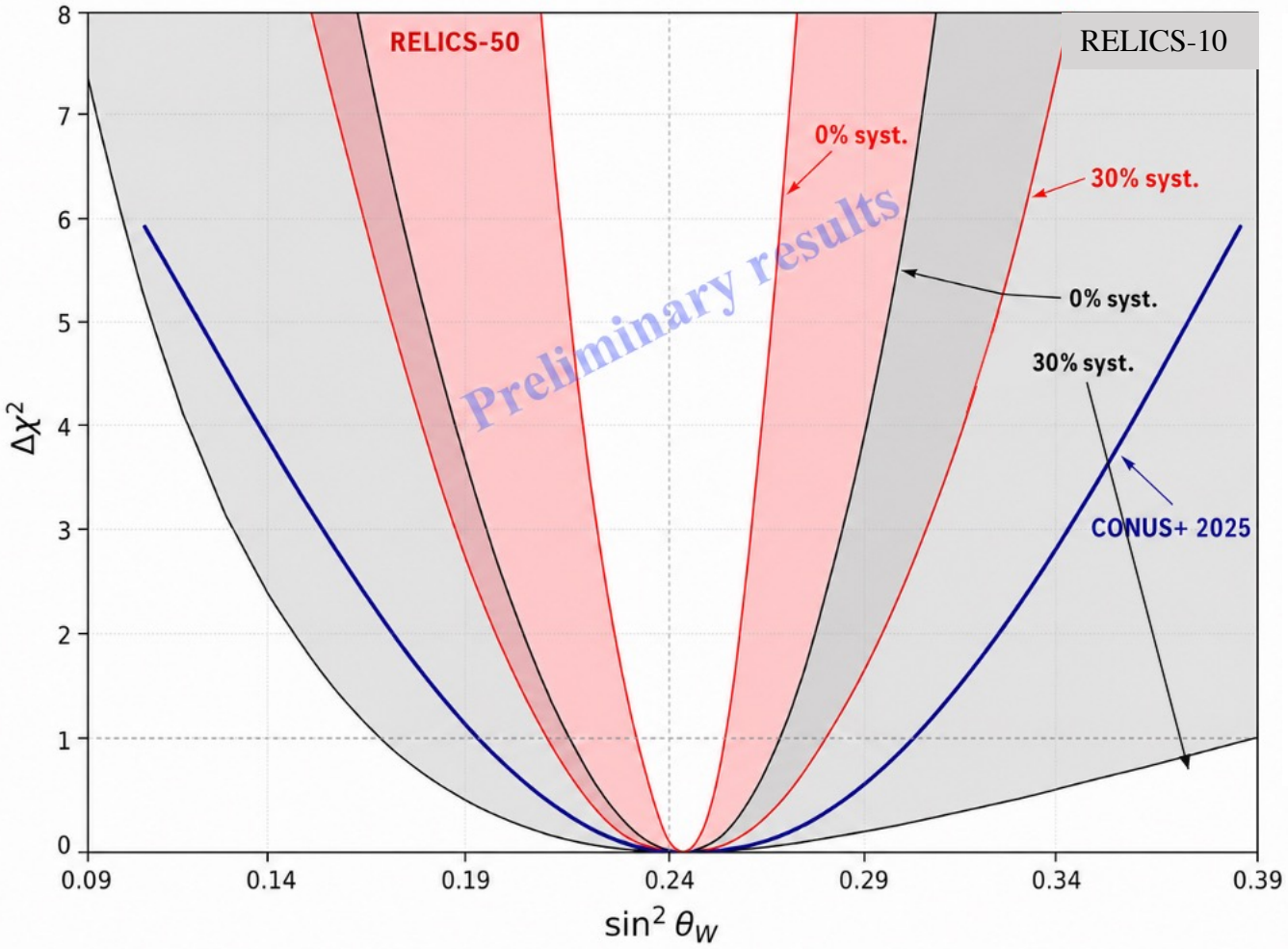
First step: RELICS-10

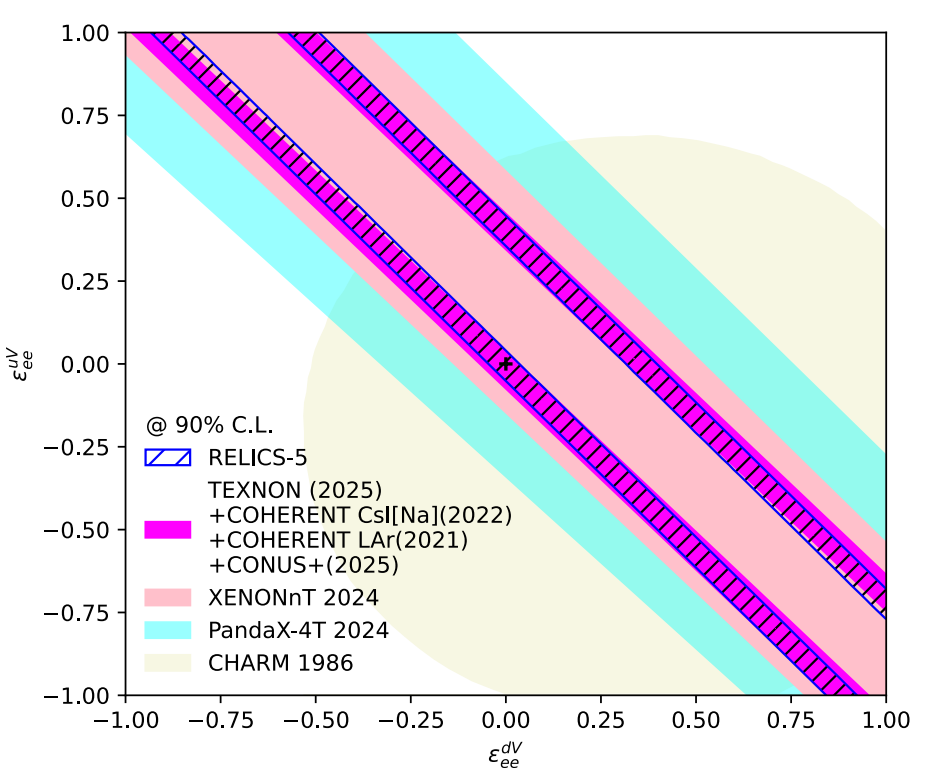
Increased background ➡️ smaller detector

	Events / (5 kg·year)
CEvNS	4640 x 0.15 ~ 720
Cosmic Ray Neutron	340 x3 ~ 1000
Muon Induced Neutron	2 x 1 ~ 2
ER	21 x 5 ~100
DE Pile-ups	1325 x 0.33 ~ 440

Sanmen 2027

Physics potential for RELICS-10





RELICS-10 is competitive in CEvNS physics

Timeline

Tsinghua

Westlake

Reactor

PROTOTYPE | RELICS-10 | RELICS-50

2024 2025 2026 2027 2028 2029

Subsystem R&D | Commissioning | Next step

Summary

- RELICS aims to measure reactor CEvNS using a **liquid-xenon TPC**.
- RELICS **prototypes** and **subsystems** were built to demonstrate the **feasibility** of the detector concept.
- **RELICS-10** will commission in **2026**, and target CEvNS detection in **2027**.

Backup