



Universität
Münster



XENON

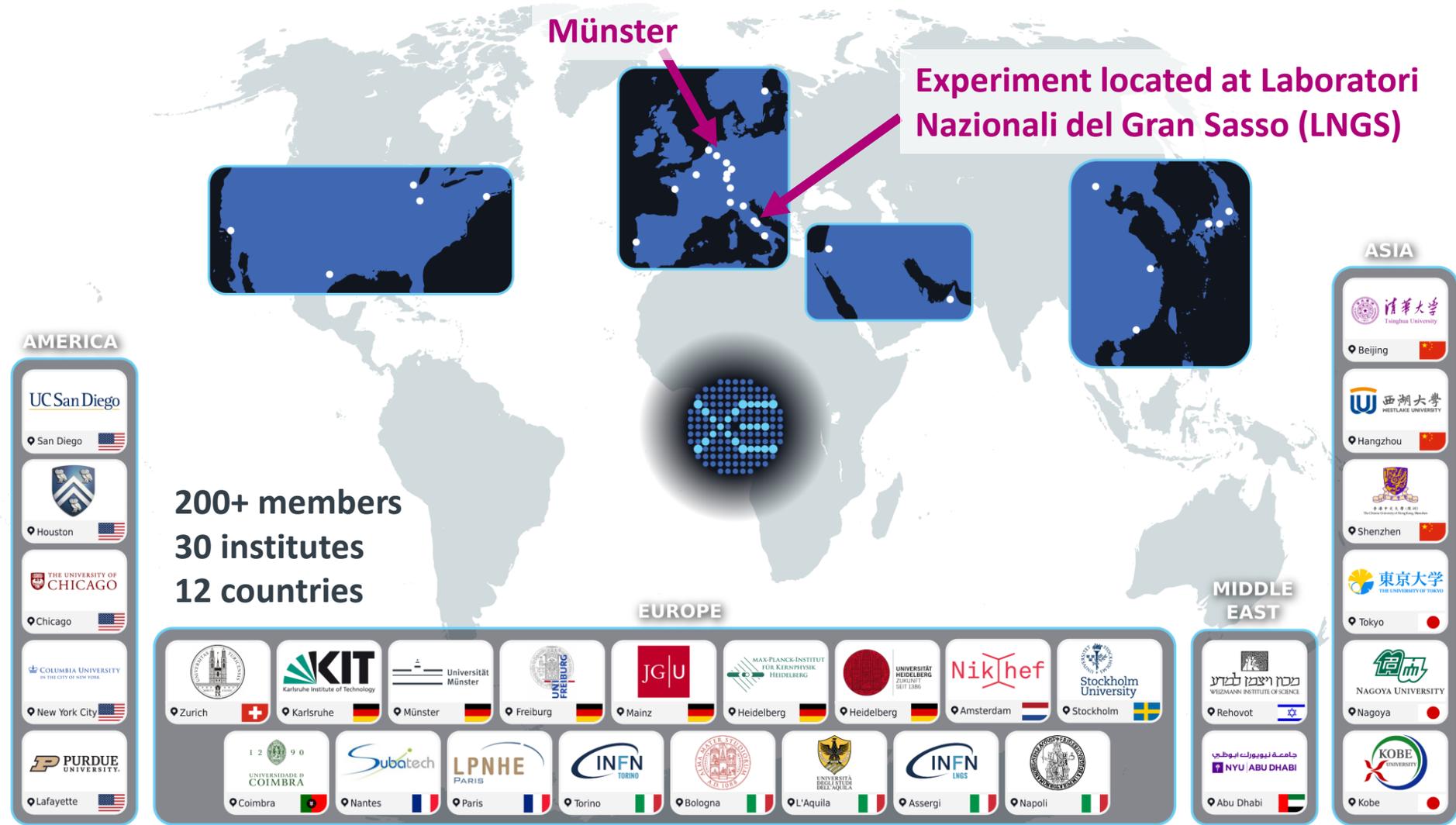
The first measurement of coherent elastic neutrino-nucleus scattering of solar ^8B neutrinos in the XENONnT experiment

Daniel Wenz on behalf of the XENON collaboration
(dwenz@uni-muenster.de)



Bundesministerium
für Bildung
und Forschung

The XENON collaboration

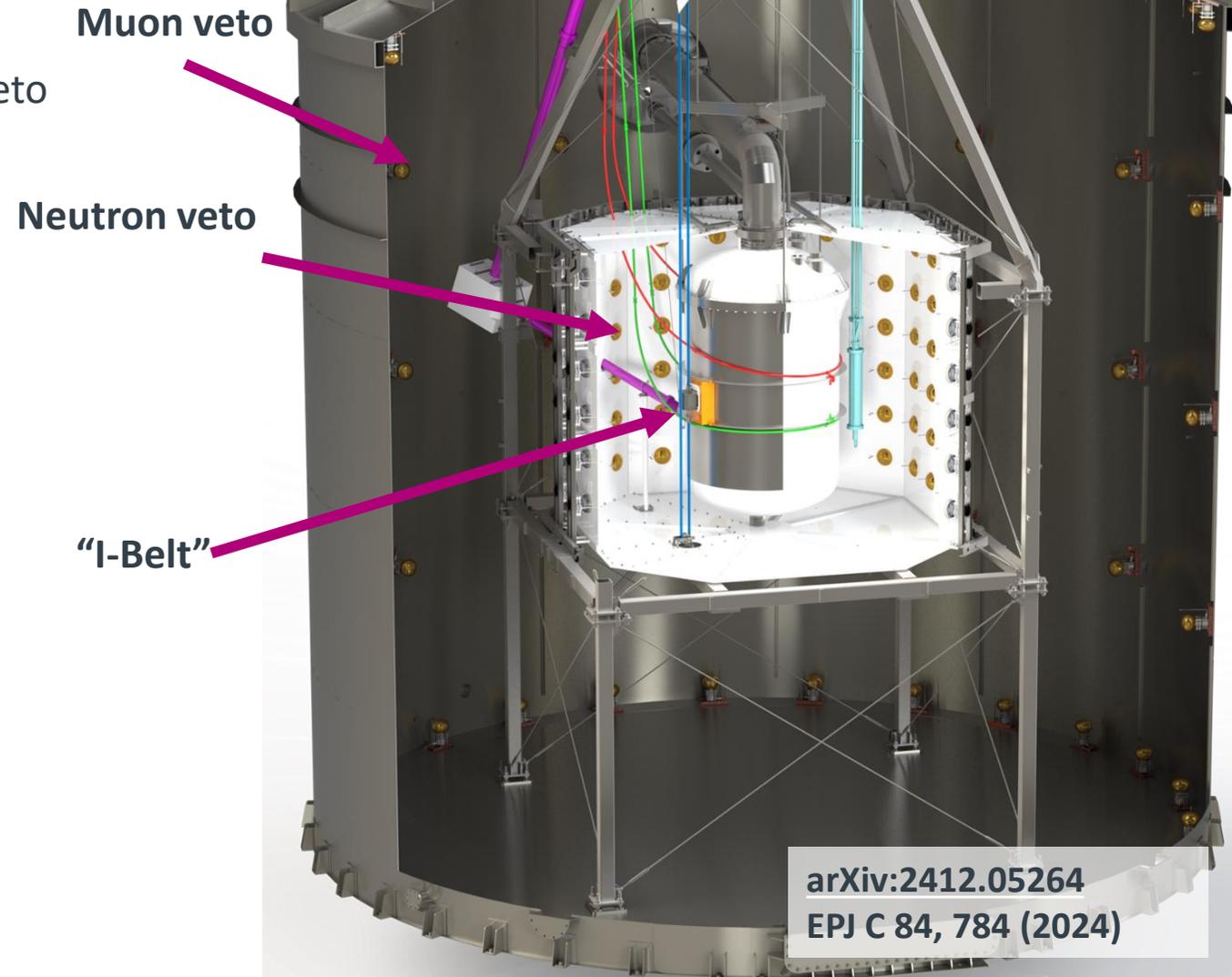


The XENONnT Experiment



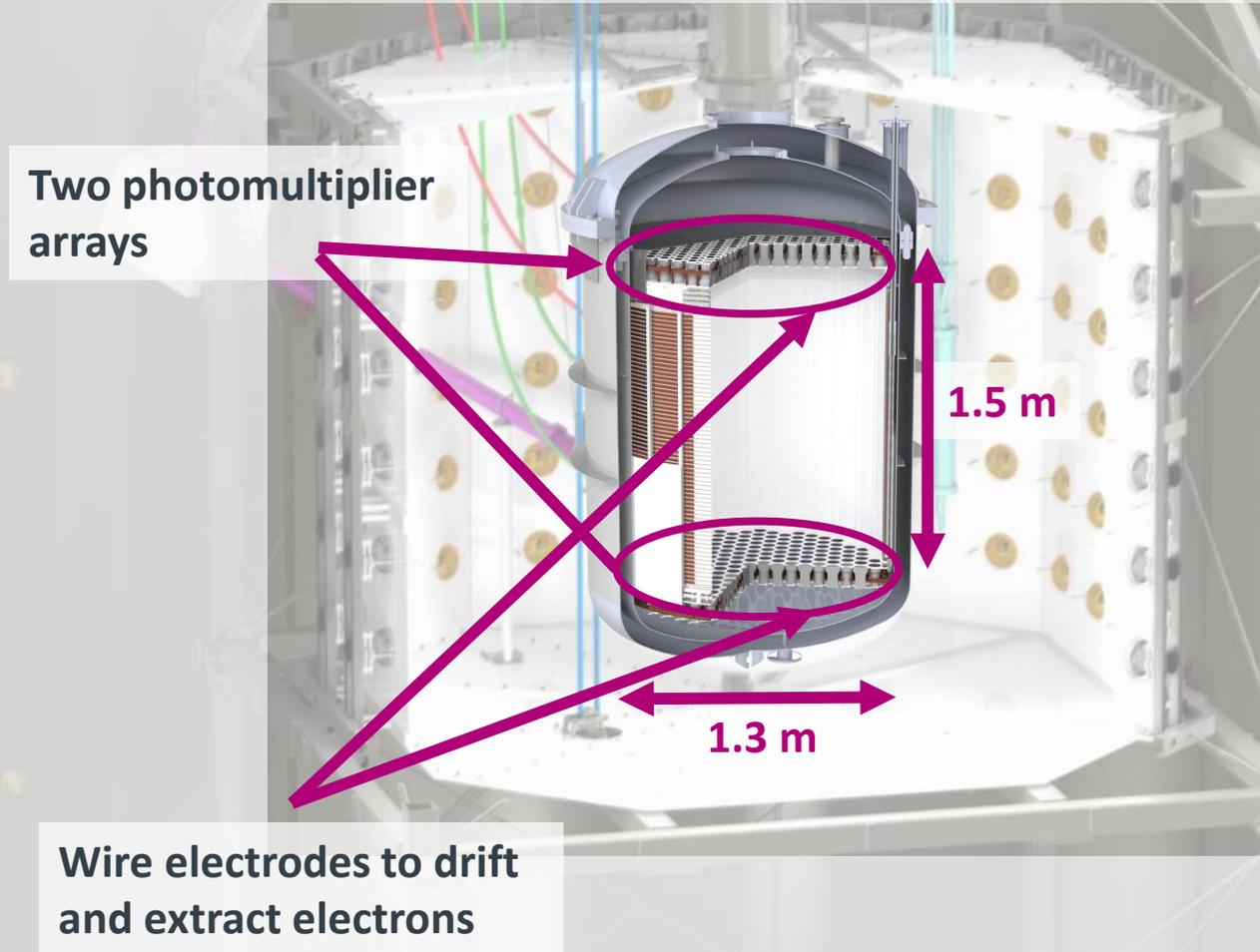
The XENONnT Experiment

- Nested detector system:
 - Gd loaded water Cherenkov muon and neutron veto



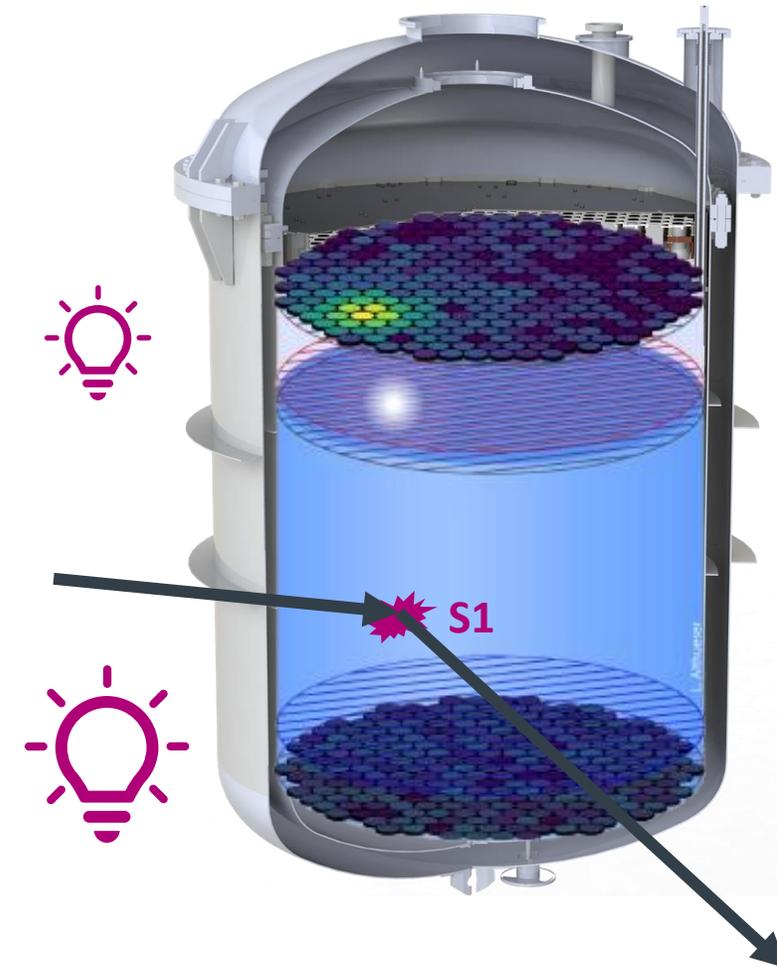
The XENONnT Experiment

- Nested detector system:
 - Gd loaded water Cherenkov muon and neutron veto
 - Liquid xenon (LXe) time projection chamber (TPC)
 - Target volume of 5.9 tonnes



The XENONnT Experiment

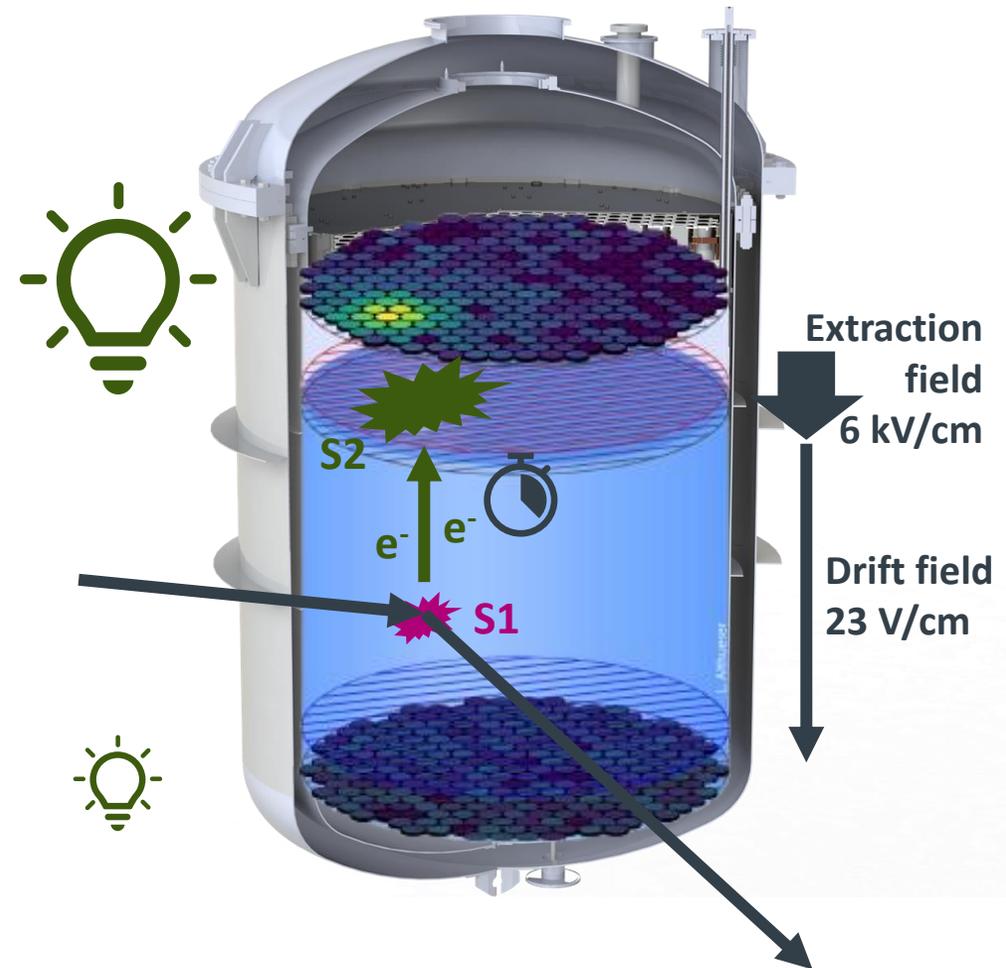
- Nested detector system:
 - Gd loaded water Cherenkov muon and neutron veto
 - Liquid xenon (LXe) time projection chamber (TPC)
 - Target volume of 5.9 tonnes
- Particle interaction produces...
 - ...scintillation photons (S1) and...



Phys. Rev. D 111, 062006 (2025)
arXiv:2406.13638 (submitted)

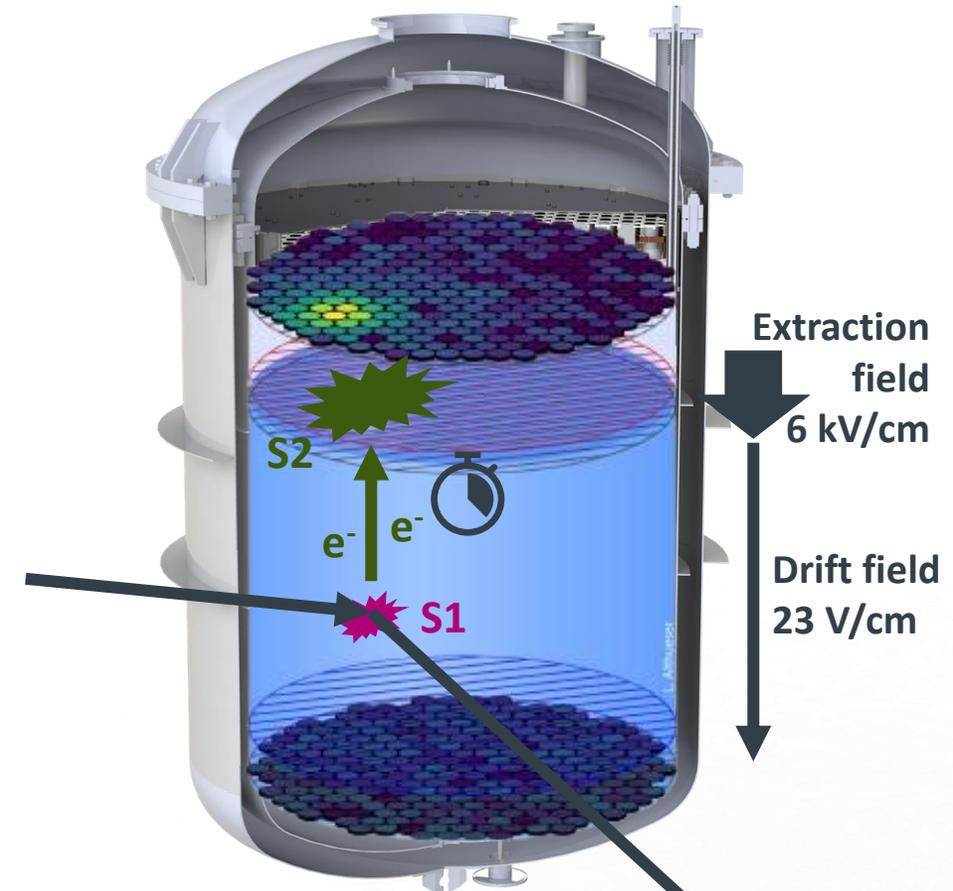
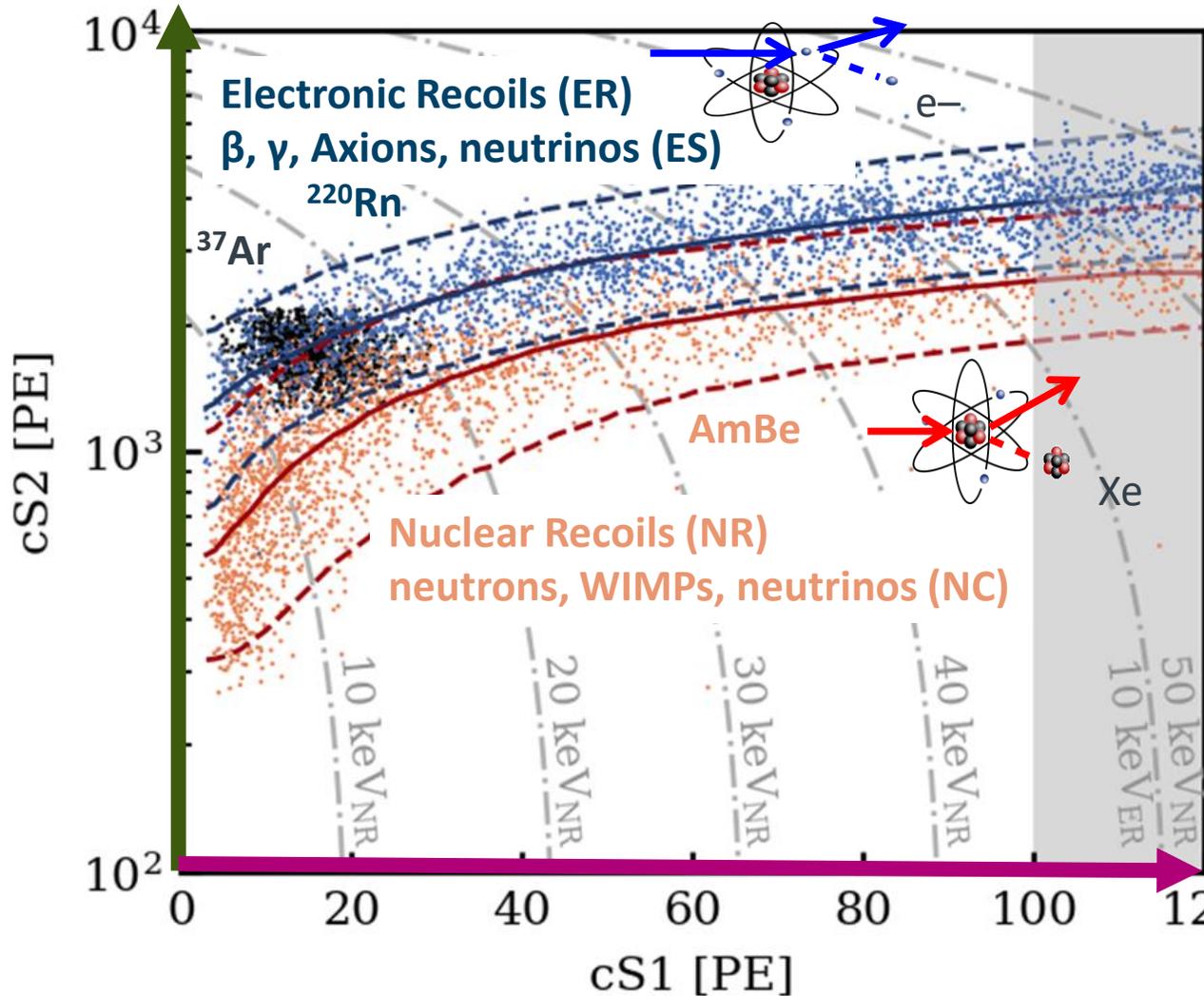
The XENONnT Experiment

- Nested detector system:
 - Gd loaded water Cherenkov muon and neutron veto
 - Liquid xenon (LXe) time projection chamber (TPC)
 - Target volume of 5.9 tonnes
- Particle interaction produces...
 - ...scintillation photons (S1) and...
 - ... electrons which are drifted to produce second scintillation signal (S2)



Phys. Rev. D 111, 062006 (2025)
arXiv:2406.13638 (submitted)

The XENONnT Experiment



JINST 18, P11009 (2023)

EPJ C 83, 542 (2023)

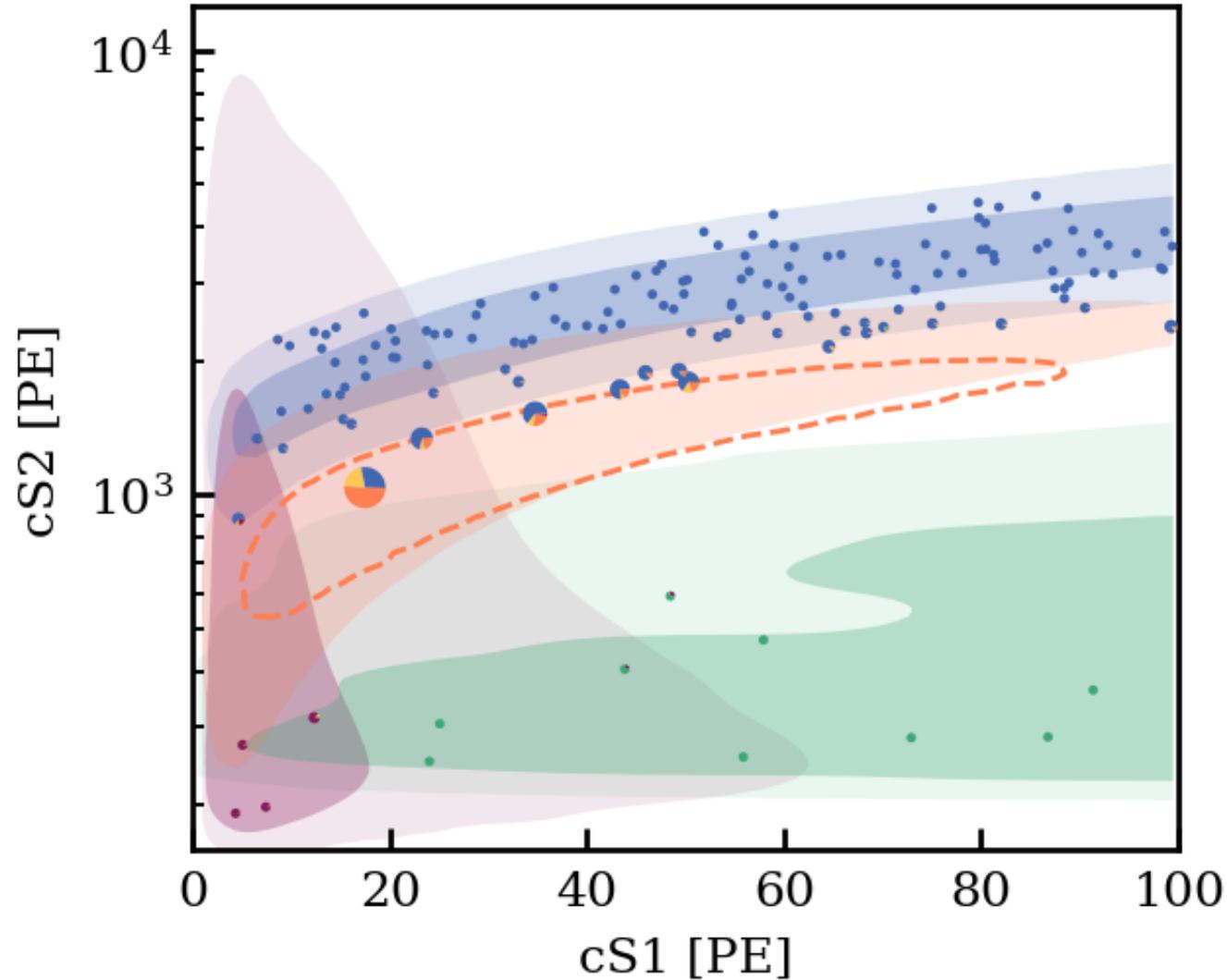
PRL 131, 041003 (2023)

Phys. Rev. D 111, 062006 (2025)

arXiv:2406.13638 (submitted)

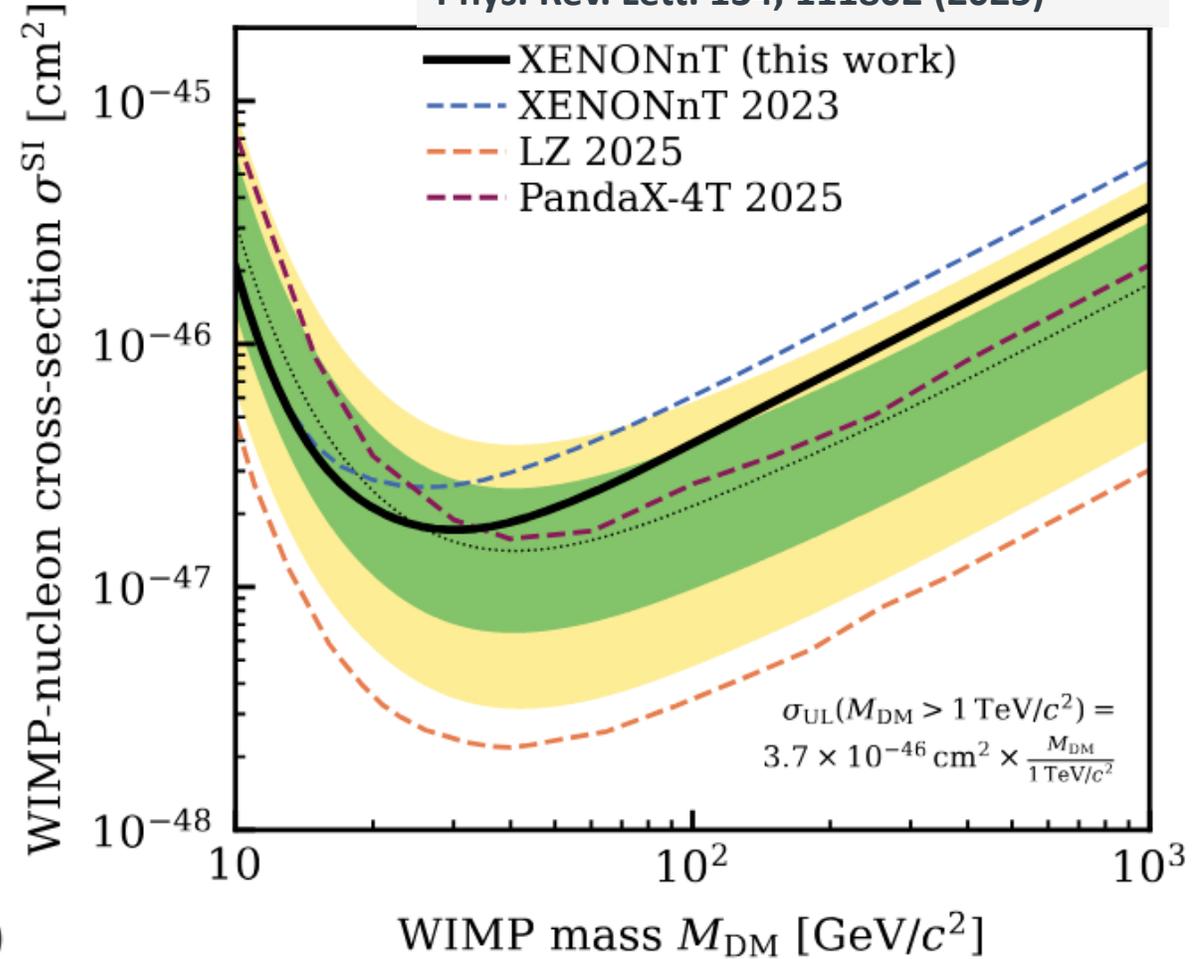
The XENONnT Experiment

ER Wall Neutron AC WIMP



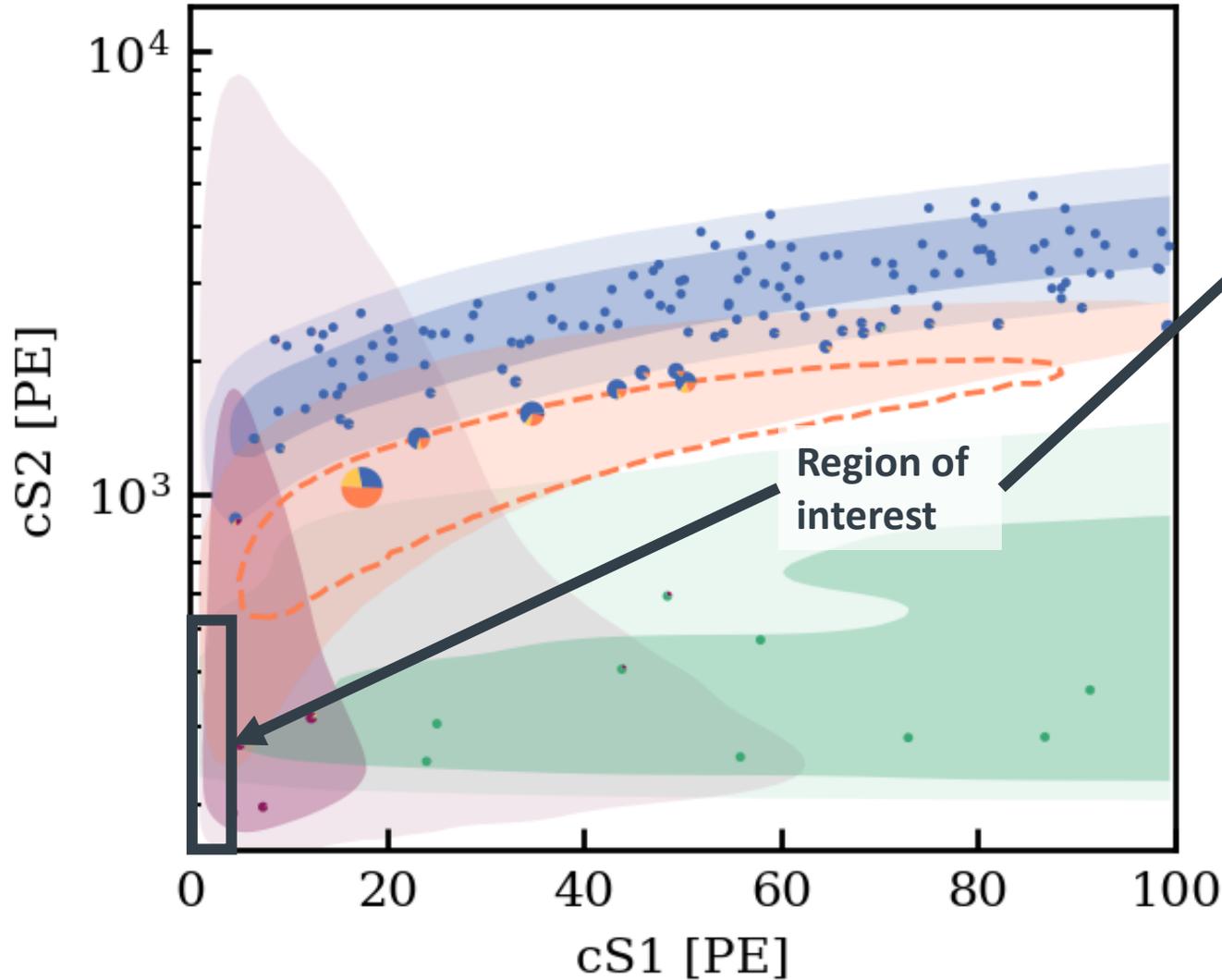
WIMP results 3.1 tonne x year exposure:
arxiv:2502.18005

WIMP search inside the neutrino fog:
Phys. Rev. Lett. 134, 111802 (2025)

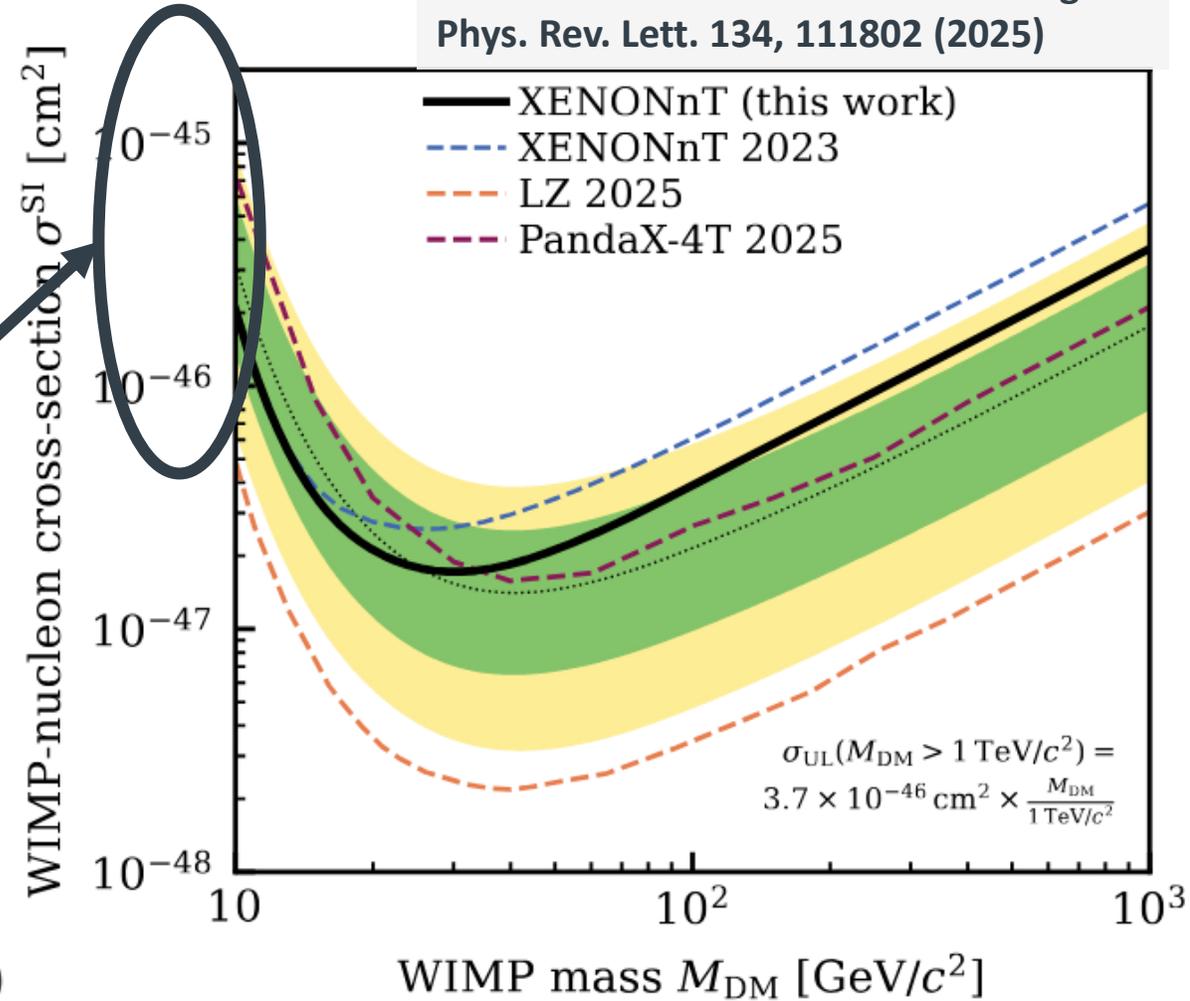


The XENONnT Experiment

ER Wall Neutron AC WIMP

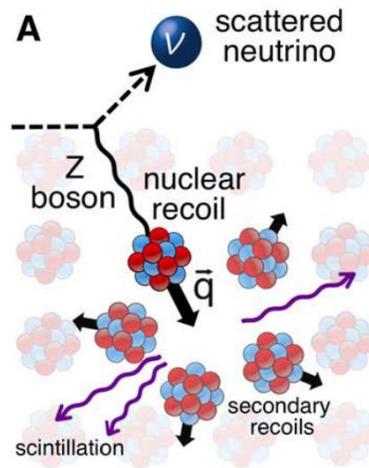
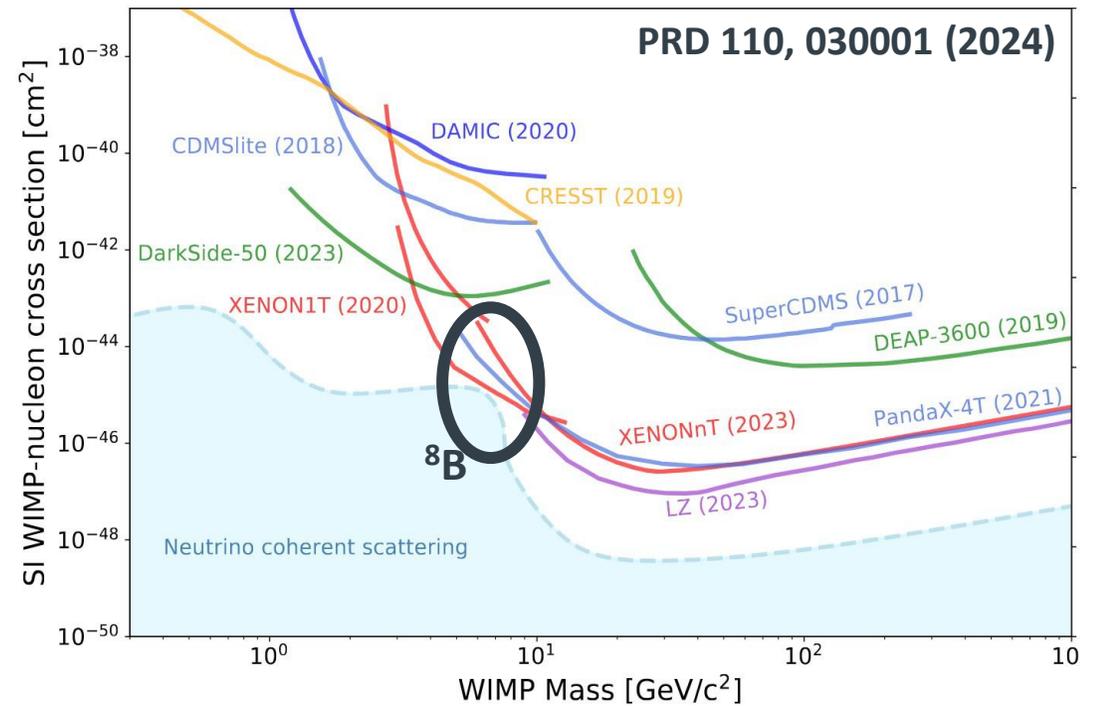


WIMP results 3.1 tonne x year exposure:
 arxiv:2502.18005
 WIMP search inside the neutrino fog:
 Phys. Rev. Lett. 134, 111802 (2025)

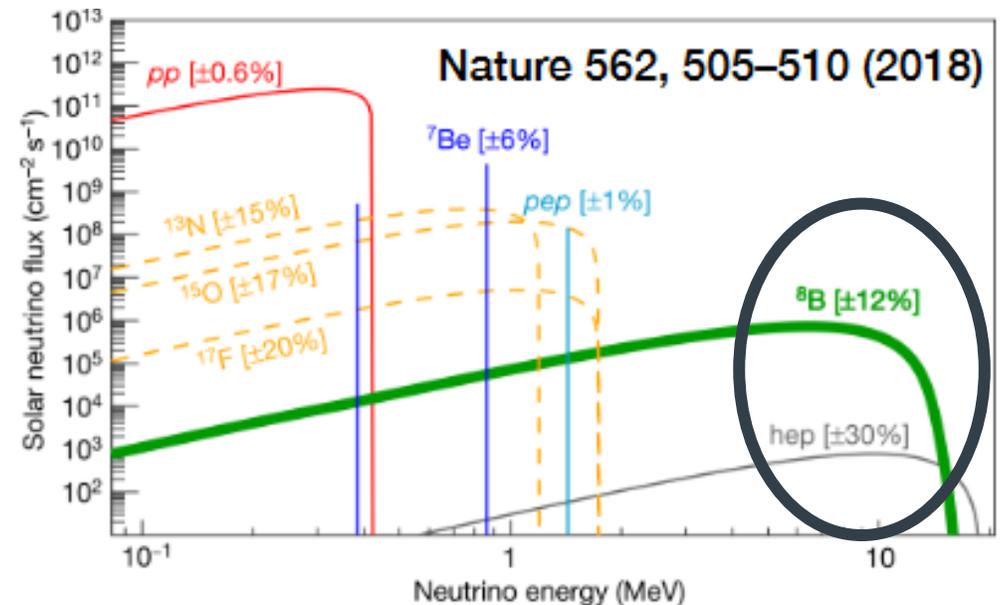


Dark matter, what else?

- Coherent elastic neutrino nucleus scattering (CEvNS)
 - Low momentum transfer, “see” nucleus as a whole
 - ➔ $\sigma \propto N^2 \propto 6400$ for Xenon
 - “Large” cross section compared to e.g. neutrino-electron scattering
- Downside: Mimics signal of 6 GeV/c² WIMPs



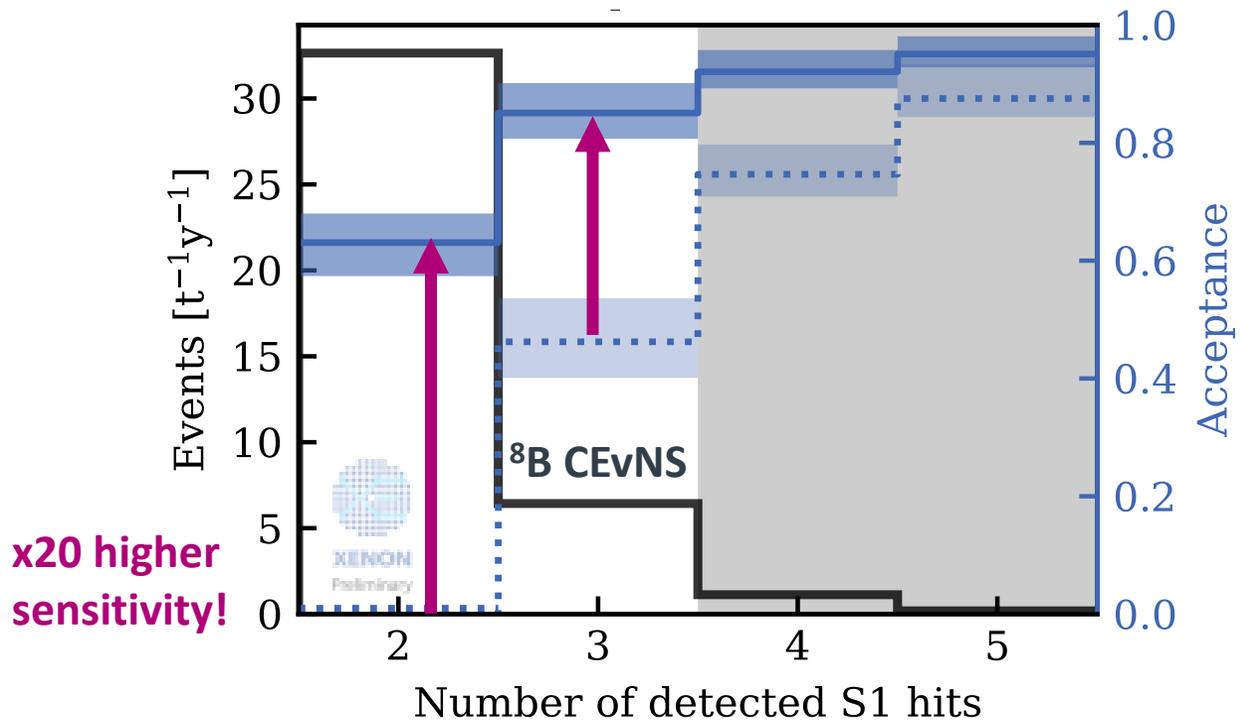
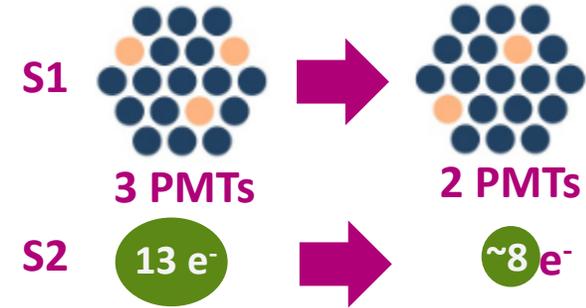
COHERENT, Science 357 (2017)



Coherent elastic neutrino-nucleus scattering

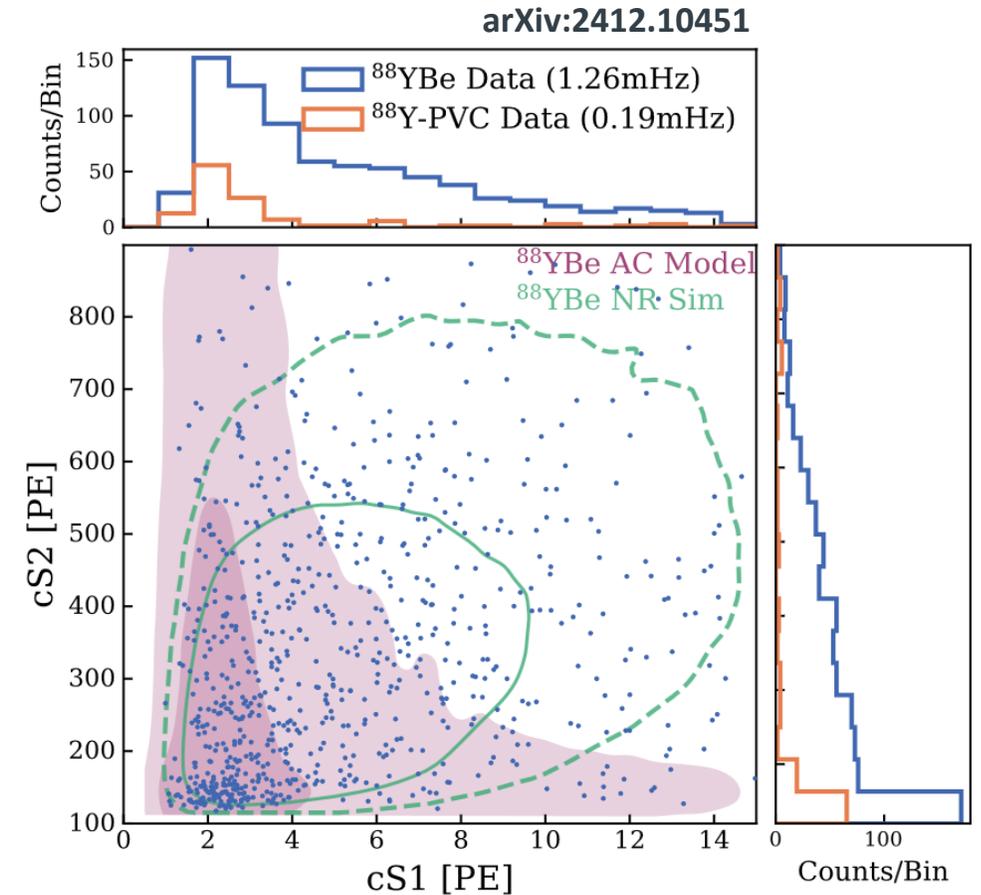
- **Blind analysis** with 3.5 tonne x year exposure
(SR0: 108.0 d. SR1: 208.5 d, 4 tonne fiducial volume)
- Signal at edge of the detector threshold
 - Lower threshold to increase sensitivity!

➡ Lowering the threshold comes at a cost



Coherent elastic neutrino-nucleus scattering

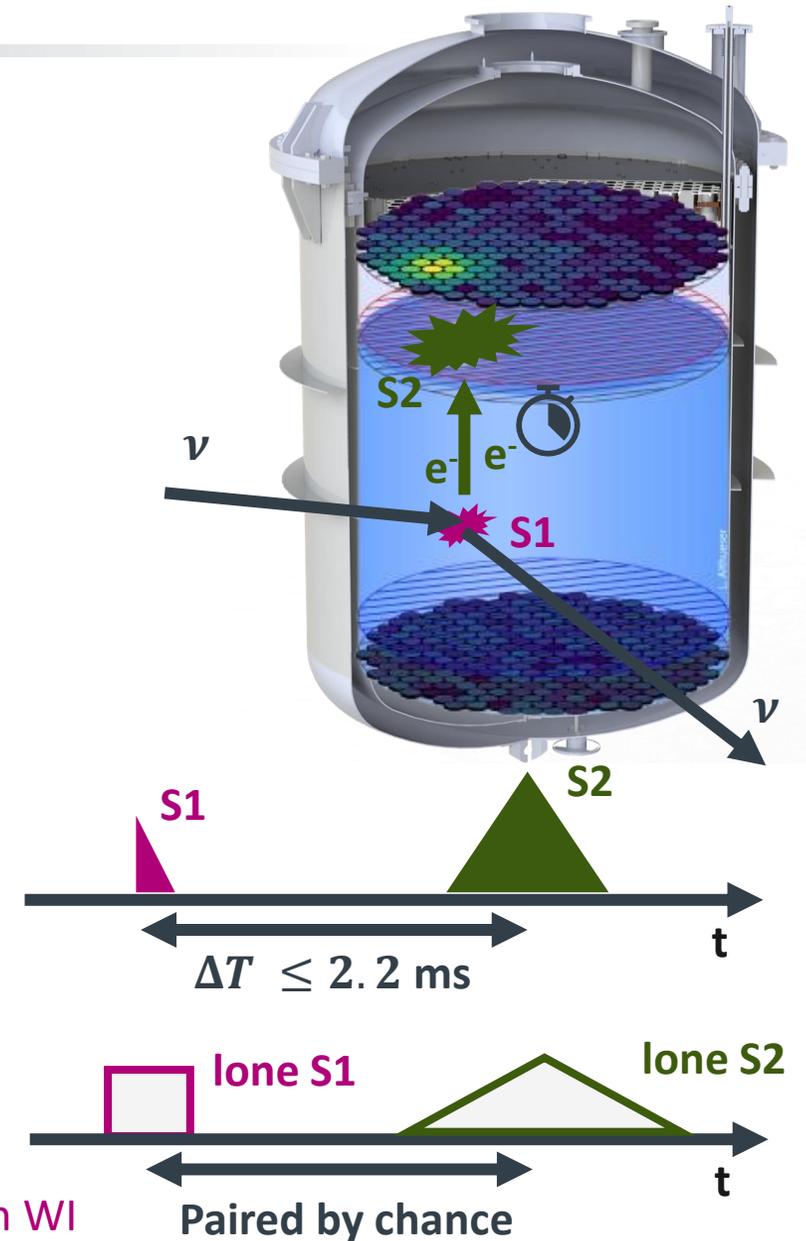
- Blind analysis with 3.5 tonne x year exposure (SR0: 108.0 d. SR1: 208.5 d, 4 tonne fiducial volume)
- Signal at edge of the detector threshold
 - Lower threshold to increase sensitivity!
- Requires extra low energy calibration of detector response.
 - Use **YBe** photo neutron source ($\gamma + {}^9\text{Be} \rightarrow n + {}^8\text{Be}$)
 - Very low kinetic energy of 152 keV
 - Neutrons **on with ${}^{88}\text{YBe}$**
 - Neutrons **off with Y-PVC** to quantify AC background
- **Light** and **charge** yield (and uncertainties) from best fit of NESTv2.3 yield model



Background

- Main background: accidental coincidences (AC) of...
 - ... lone S1s mostly due to PMT dark counts.
 - ... lone S2s formed by single electron pile up.
- Raw AC rate about 400 events per day

➔ **130.000 AC events in total**



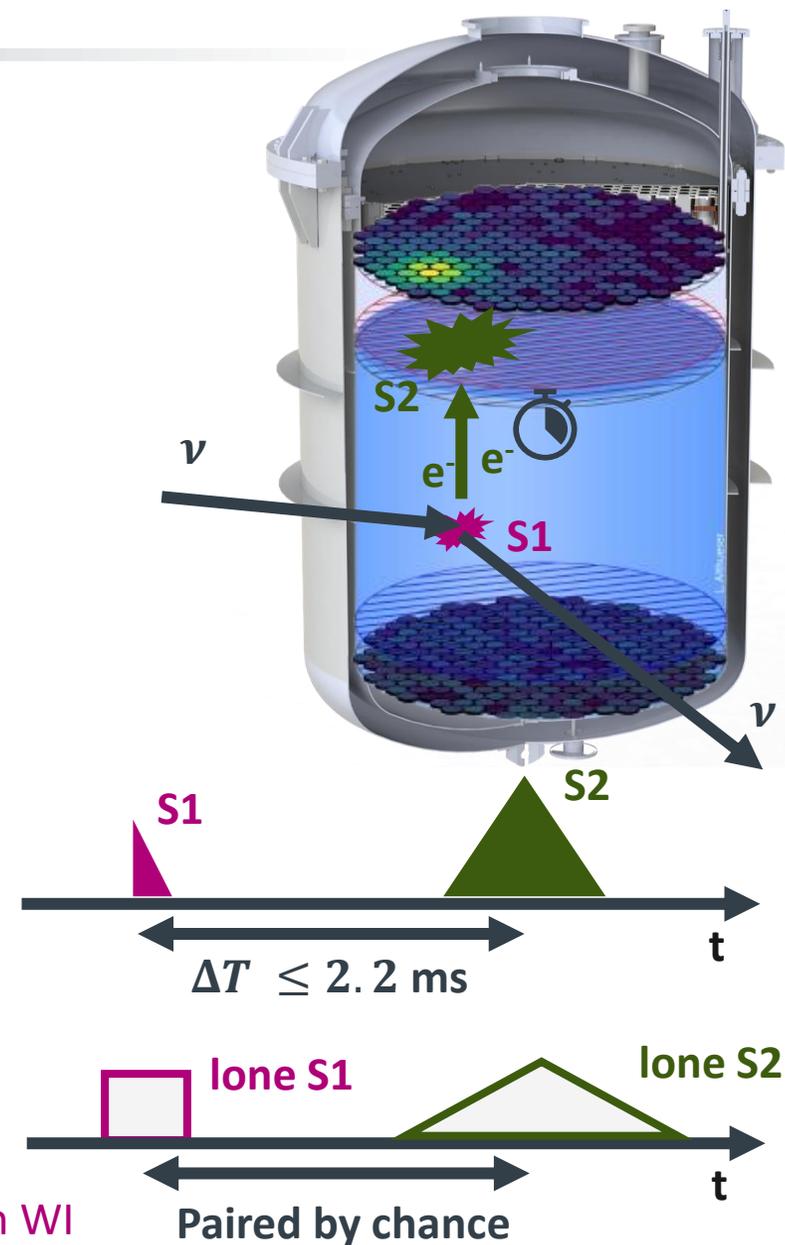
Background

- Main background: accidental coincidences (AC) of...
 - ... lone S1s mostly due to PMT dark counts.
 - ... lone S2s formed by single electron pile up.
 - Raw AC rate about 400 events per day
- ➔ 130.000 AC events in total
- After applying quality selections:



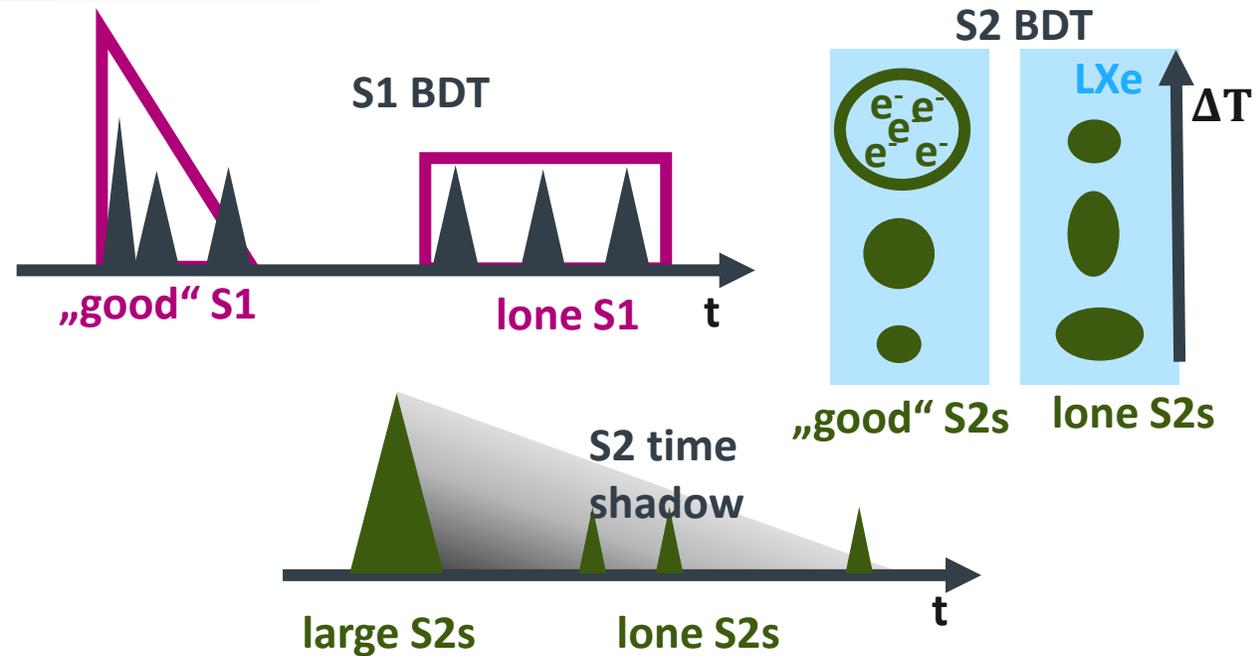
Daniel Wenz

CIPANP conference 2025, Madison WI



Background

- Use signal topology and machine learning techniques to remove AC events.
- S1 and S2 boosted decision trees discriminating lone S1 and lone S2s by signal shape
- Quality cuts using spatial and time information
- Validation and uncertainty estimate of AC rate from AC rich side band



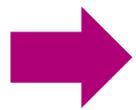
Background

- Use signal topology and machine learning techniques to remove AC events.
 - S1 and S2 boosted decision trees discriminating lone S1 and lone S2s by signal shape
 - Quality cuts using spatial and time information
- Validation and uncertainty estimate of AC rate from AC rich side band
- Validation of background and inference model using ^{37}Ar side band:
 - L-shell electron capture of ^{37}Ar (0.27 keV)
 - Lowest monoenergetic light yield measurement in LXe!
(publication under preparation)



Signal

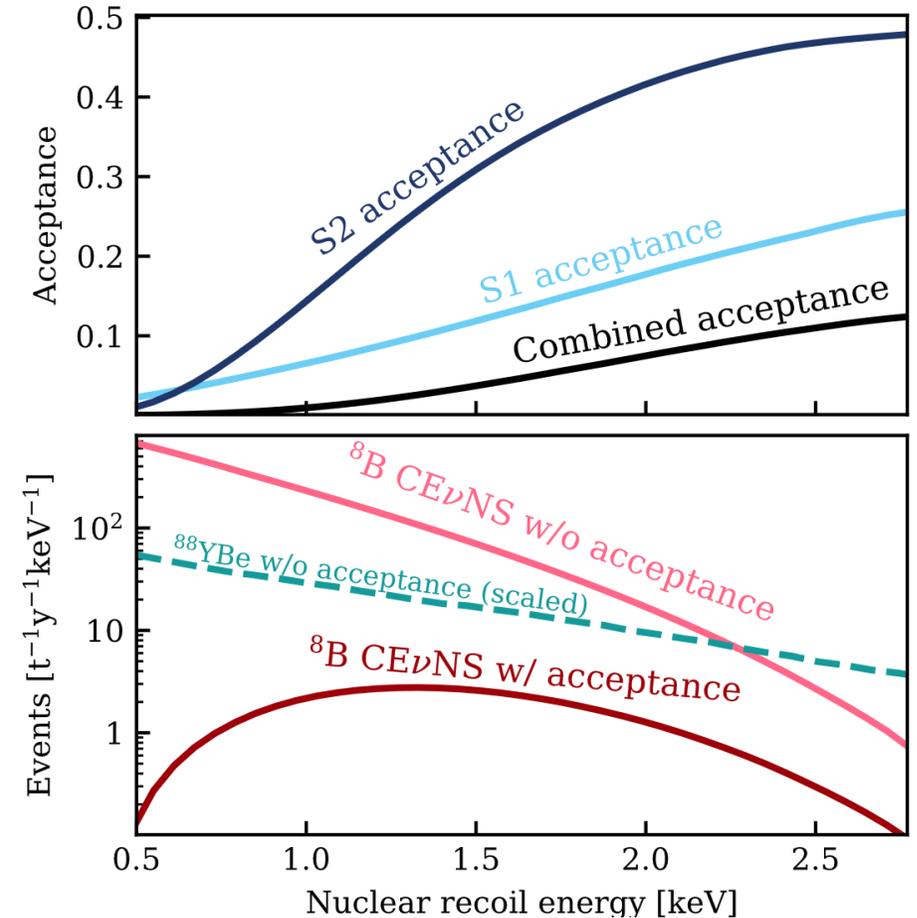
- Signal model based on
 - Solar model + SNO ^8B flux measurement
 - CE ν NS cross section on xenon using standard model



about 12 ^8B events expected

(0.2 evts/(tonne x year))

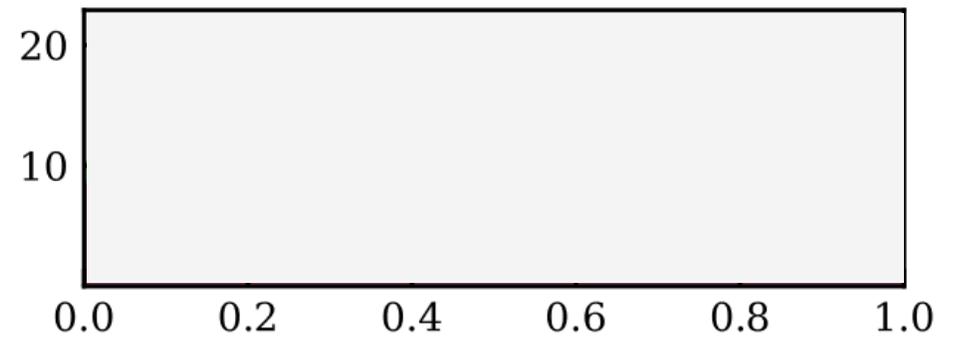
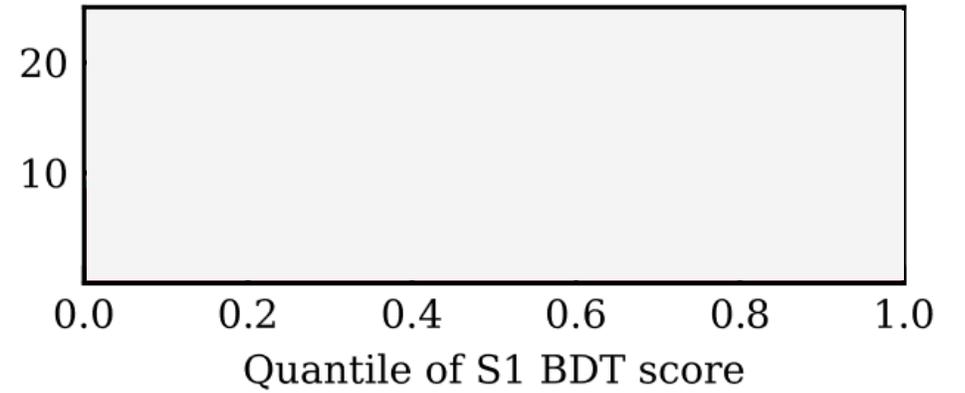
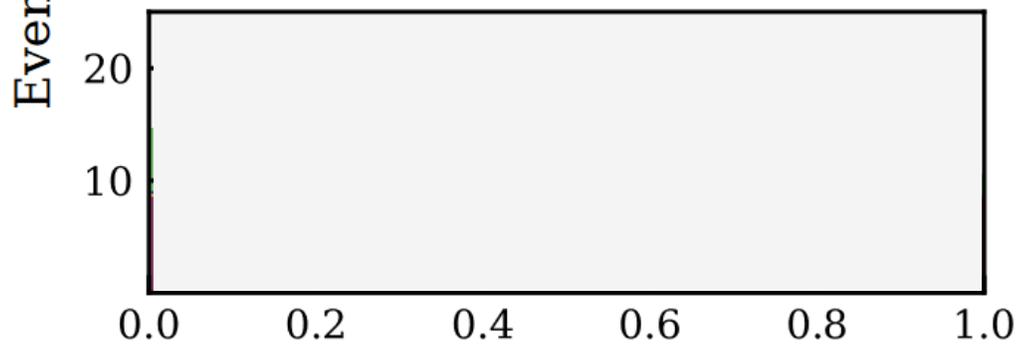
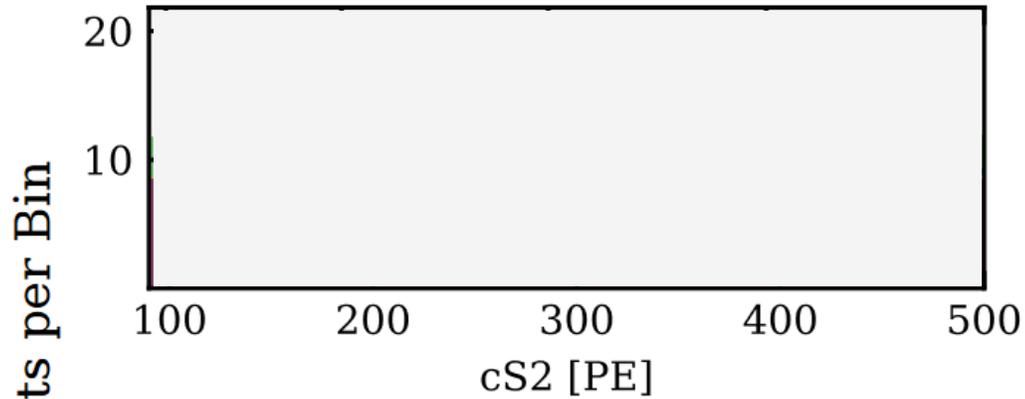
(keep in mind the expected AC background is about 26 events and 130.000 before quality cuts)



Analysis dimensions and result

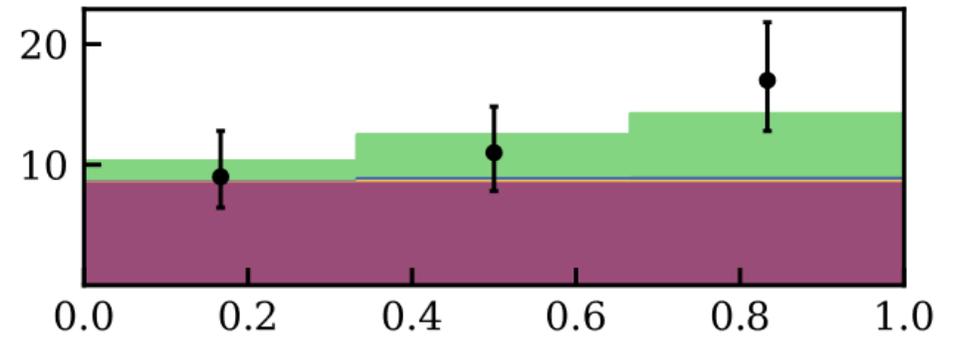
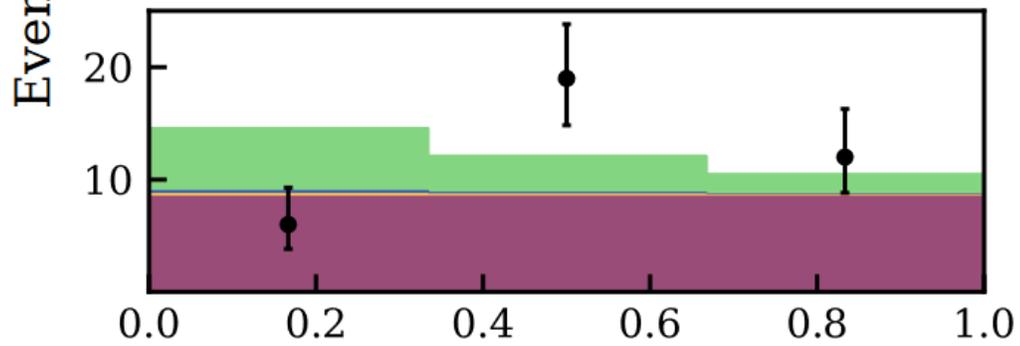
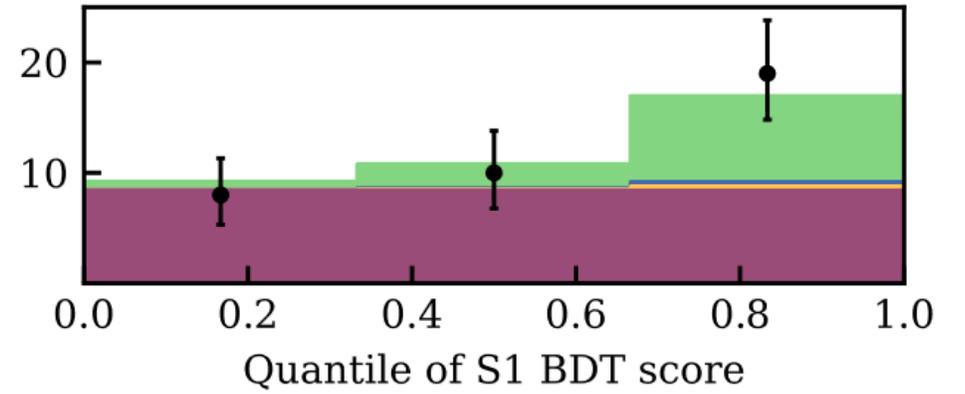
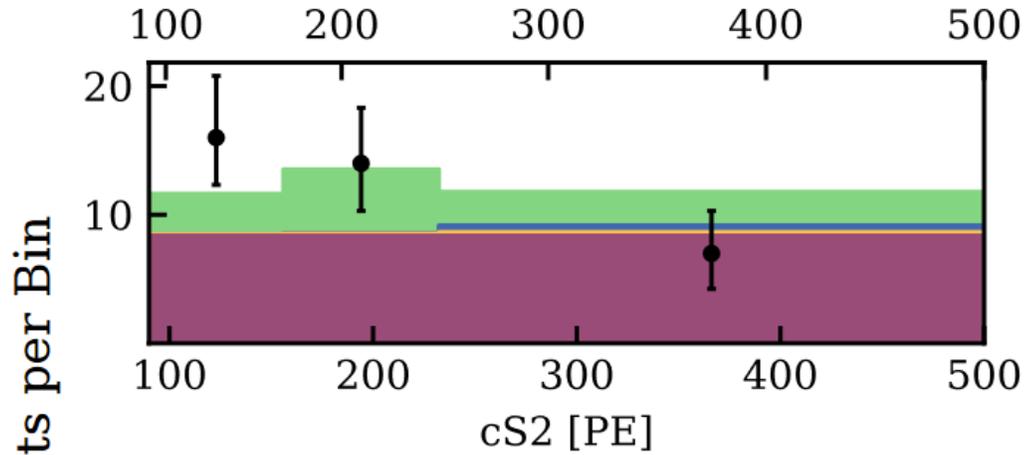
■ $^8\text{B CE}\nu\text{NS}$ ■ AC ■ Neutron ■ ER ■ Data

100 200 300 400 500

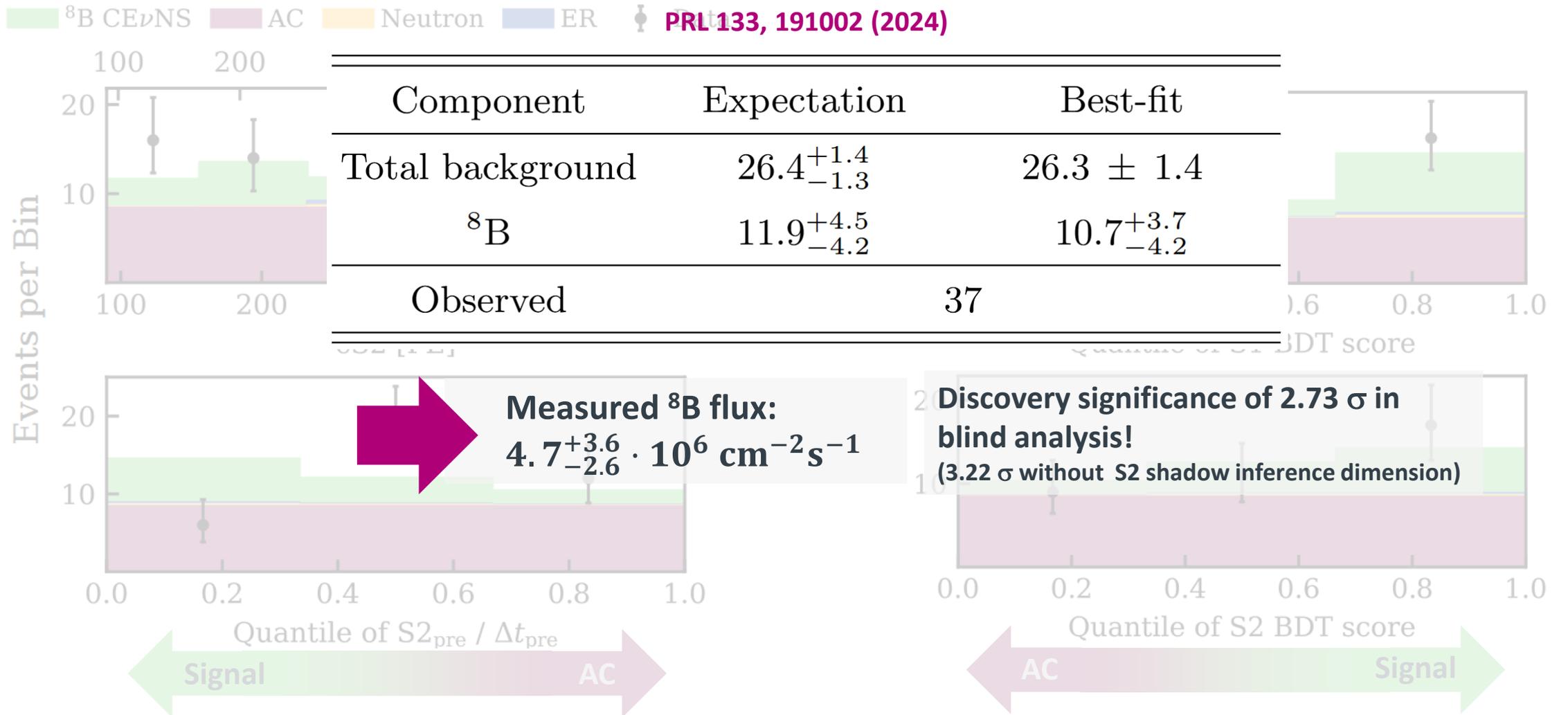


Analysis dimensions and result

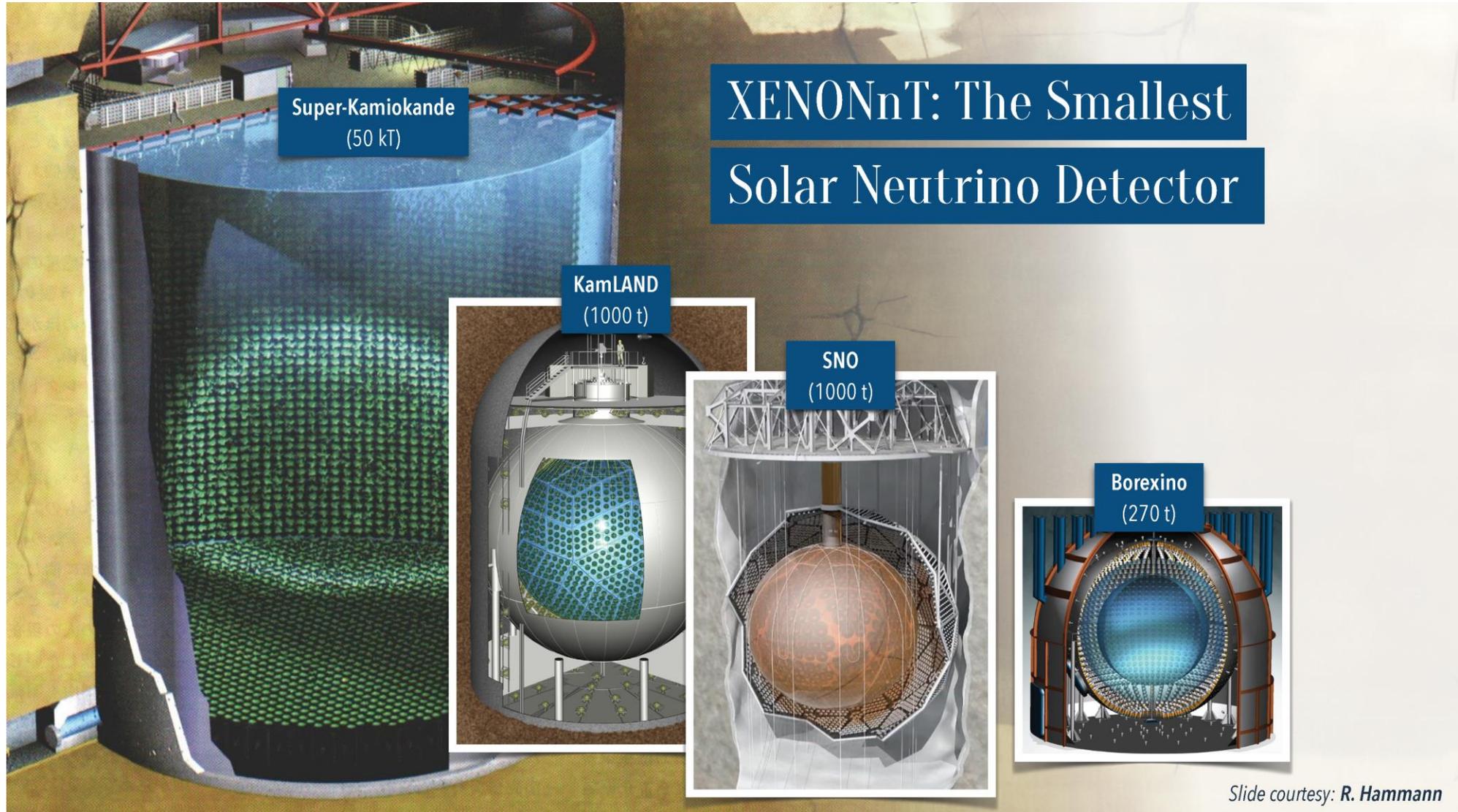
■ $^8\text{B CE}\nu\text{NS}$
■ AC
 ■ Neutron
 ■ ER
 ● Data



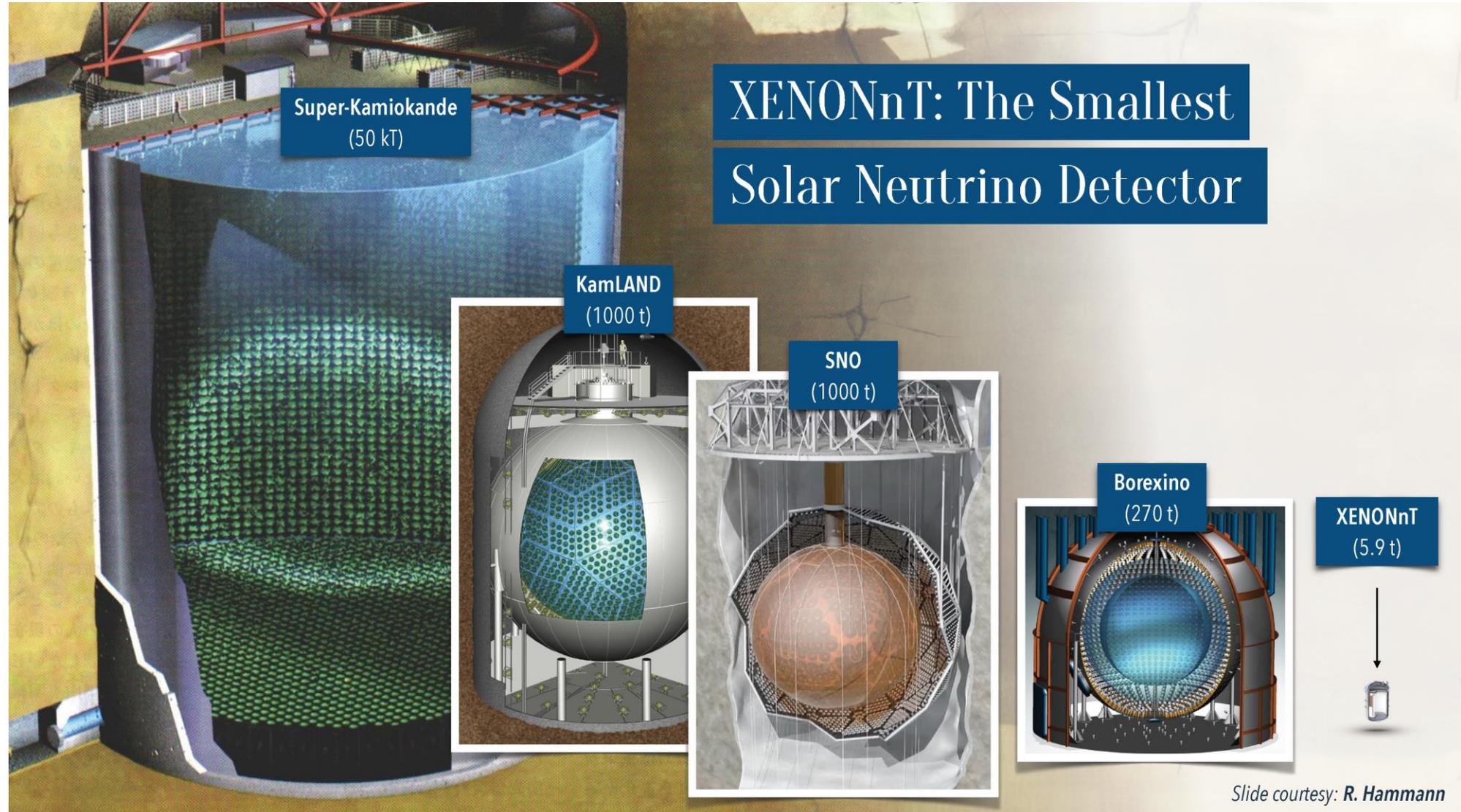
Analysis dimensions and result



Result CEvNS

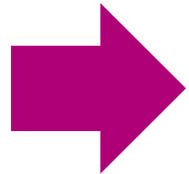


Result CEvNS



First measurement of ^8B CEvNS

- First observation of solar neutrinos via CEvNS!
- First observation of CEvNS in xenon!
- First adventure into the neutrino fog!
- First measurement of nuclear recoils via a coherent weak elastic interaction!
- 5 sigma measurement of CEvNS in reach of the science program of XENONnT



PRL 133, 191002 (2024)

