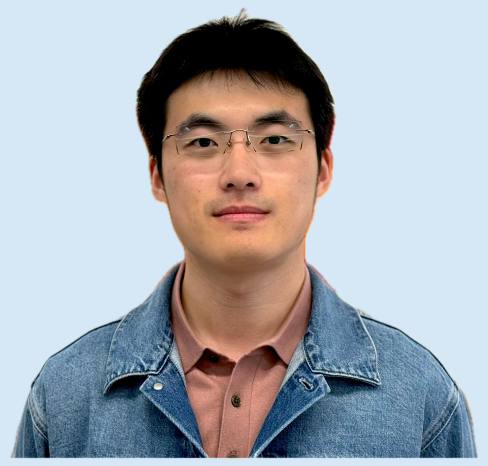
Measurement of Solar ^{8}B Neutrino CEνNS with XENONnT

Dacheng Xu (dacheng.xu@columbia.edu) on behalf of the XENON Collaboration

Physics Department, Columbia University, New York, NY 10027, USA

Neutrino 2026: XXXII International Conference on Neutrino Physics and Astrophysics



arXiv: [1] 2604.06002

XENONnT homepage

Online poster

Neutrino Fog in Dark Matter Detection

Dark matter (DM) accounts for more than 25% of the critical density in the universe [2], but its particle nature remains elusive.

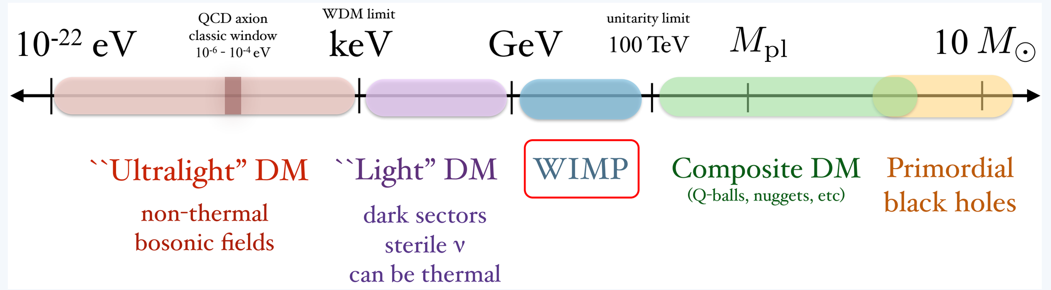


Fig. 1 The mass of DM candidates [3]. Weakly interacting massive particles (WIMPs) are particularly well-motivated [4].

However, as direct detections become more sensitive, they will eventually encounter an irreducible background from coherent elastic neutrino–nucleus scattering (CEνNS) of neutrinos, known as the "neutrino fog" [5].

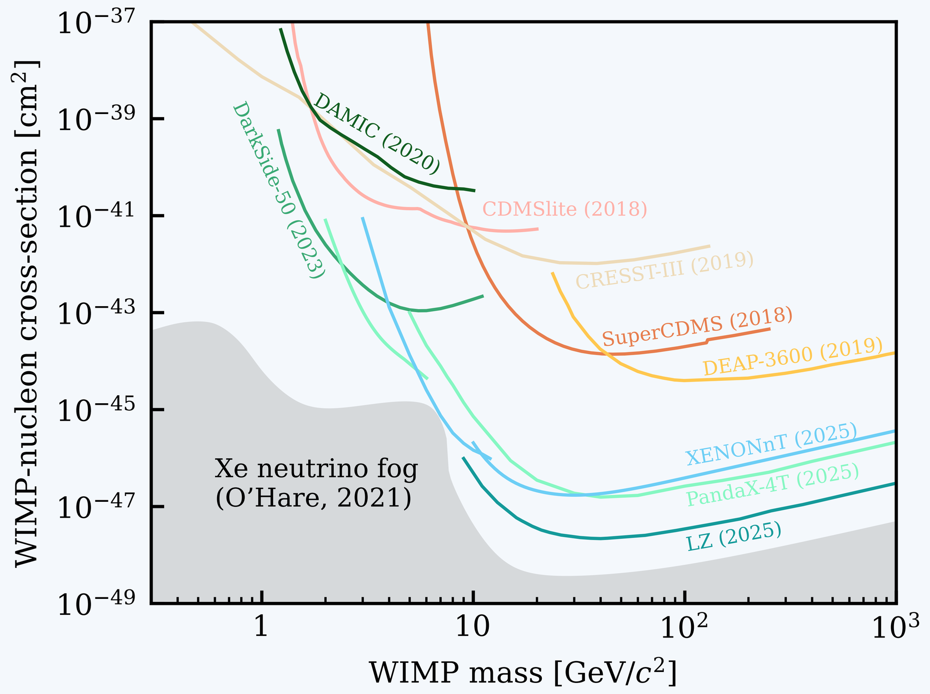


Fig. 2 90% CL upper limits on the spin-independent (SI) WIMP–nucleon cross section [2]. The nuclear recoil (NR) spectra of solar ^{8}B CEνNS closely resembles that of $\mathcal{O}(5)$GeV/c^2 WIMPs, see Fig. 5, diminishing the sensitivity of DM searches.

This poster presents the search for ^{8}B CEνNS in XENONnT using the first three science runs (SRs) with a total exposure of 6.77 t$\times$yr.

XENONnT Experiment

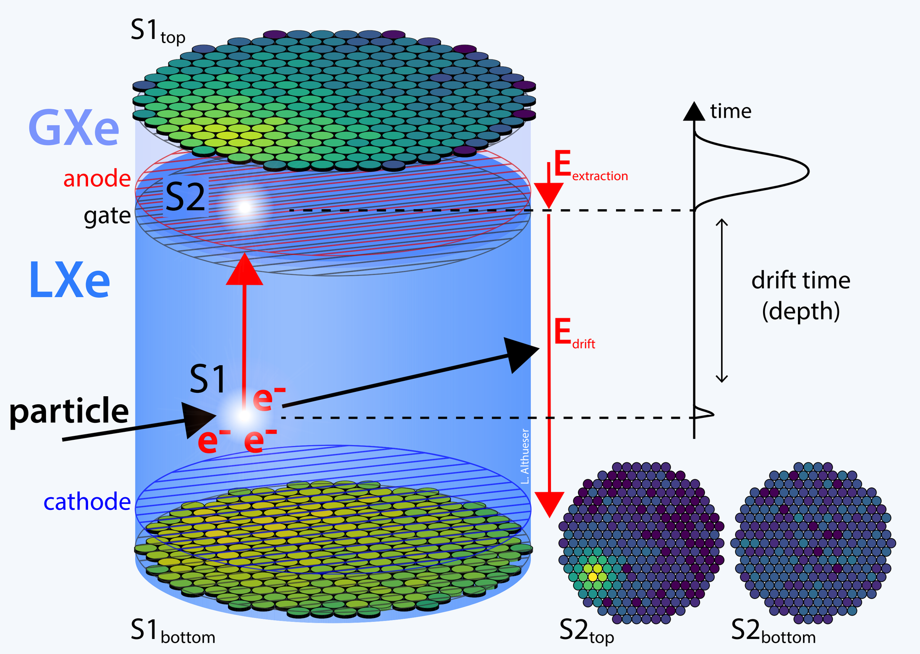
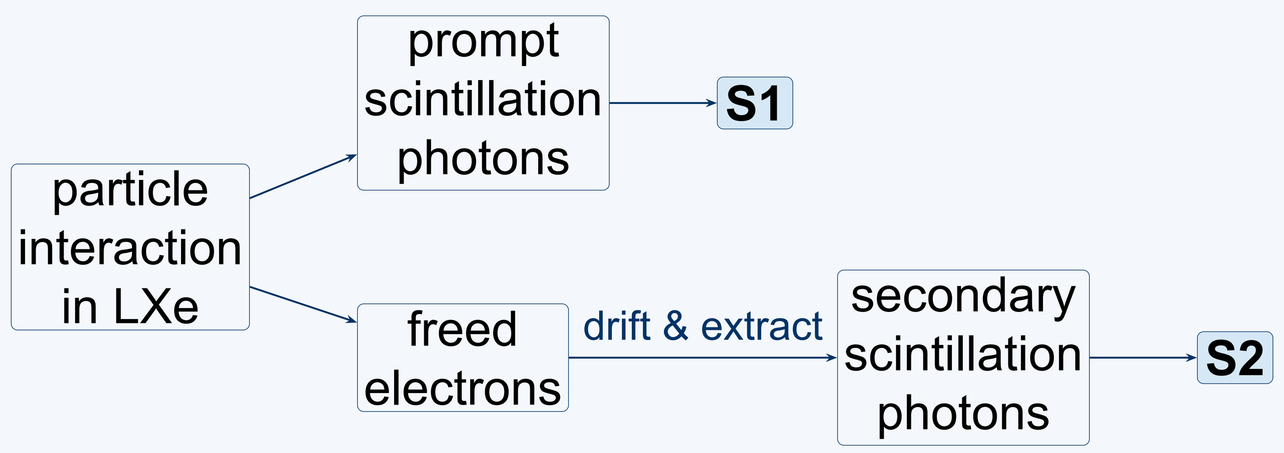


Fig. 3 XENONnT [6] working principle.

- @ INFN LNGS, Italy
- Dual-phase time projection chamber (TPC) with 5.9 t of liquid xenon (LXe)
- (X, Y, Z) position reconstruction via light (S1) and charge (S2)
- S1/S2 ratio depends on particle type



Solar ^{8}B Neutrino CEνNS Signal

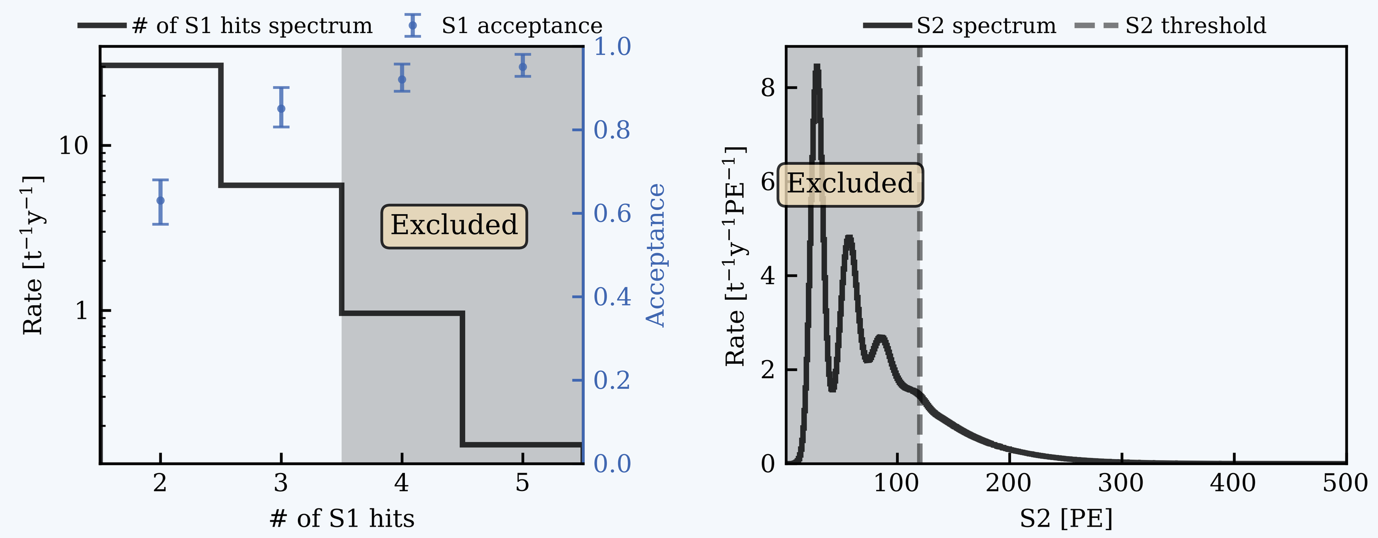


Fig. 4 Because of the low-energy nature of the recoils, S1 with 2 or 3 triggered PMTs and S2 between 120 and 500 PE (about 4 and 18 extracted electrons) are selected as the region of interest (ROI) of the ^{8}B CEνNS signal.

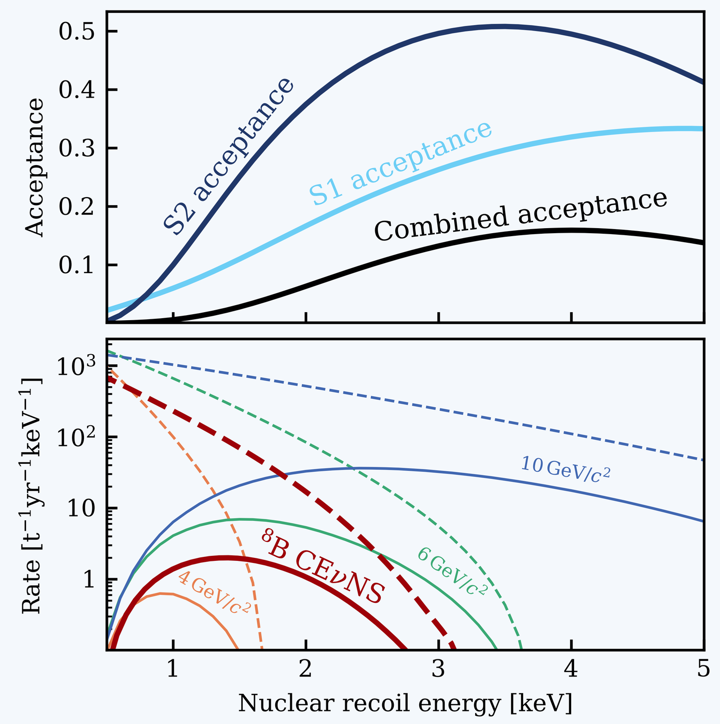


Fig. 5 Top: Acceptance of low-energy NR. Bottom: Energy spectra of ^{8}B CEνNS and SI WIMPs. Solid (dashed) lines show spectra with (without) acceptance. An SI WIMP–nucleon cross section of 10^{-44} cm^2 is assumed for the WIMP spectra.

Under optimized event selection and background mitigation, the expected number of ^{8}B CEνNS events in the ROI is 16^{+5}_{-4}.

Background Suppression and Estimation

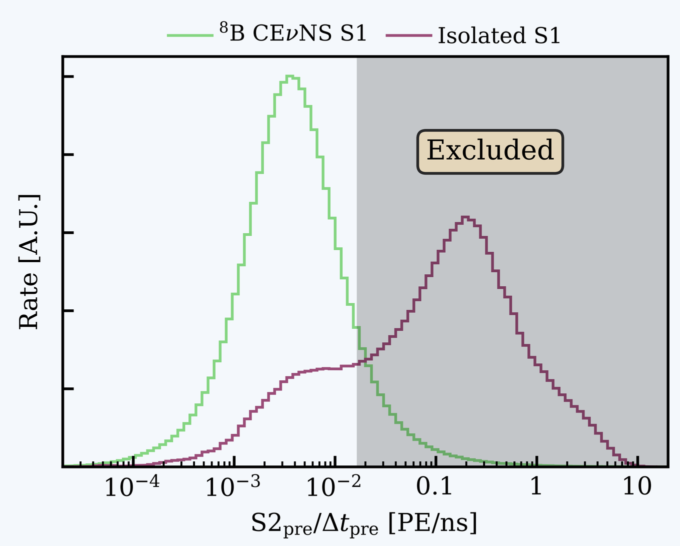


Fig. 6 S2$_{\text{pre}}/\Delta t_{\text{pre}}$ comparison.

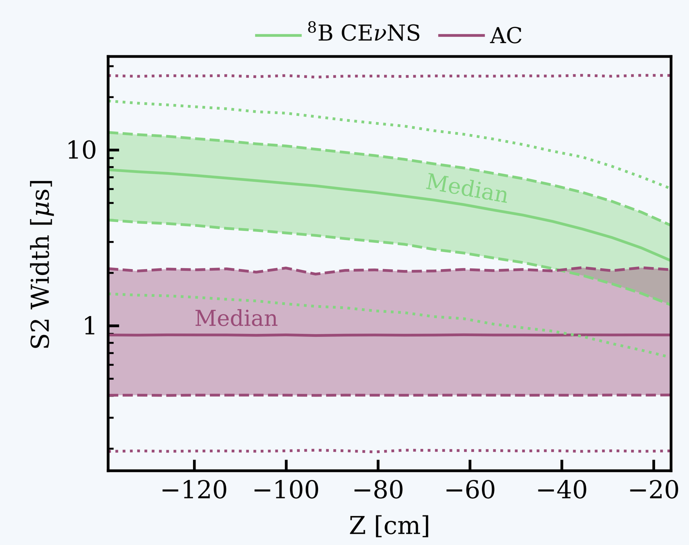


Fig. 7 S2 width correlation.

The background is dominated by accidental coincidence (AC) events, arising from random pairing of "isolated" S1 and S2. There are many methods to suppress this background by a factor of $\mathcal{O}(3000)$, including:

1. Removing S1s and S2s that are correlated with high-energy interactions in time (S2$_{\text{pre}}/\Delta t_{\text{pre}}$ is also used in inference) and space
2. A boosted decision tree (BDT) exploiting that the ^{8}B S2 width grows with electron depth, unlike that of the AC background

The expected number of background events in the ROI is $42.1^{+1.9}_{-1.7}$.

Inference and Results

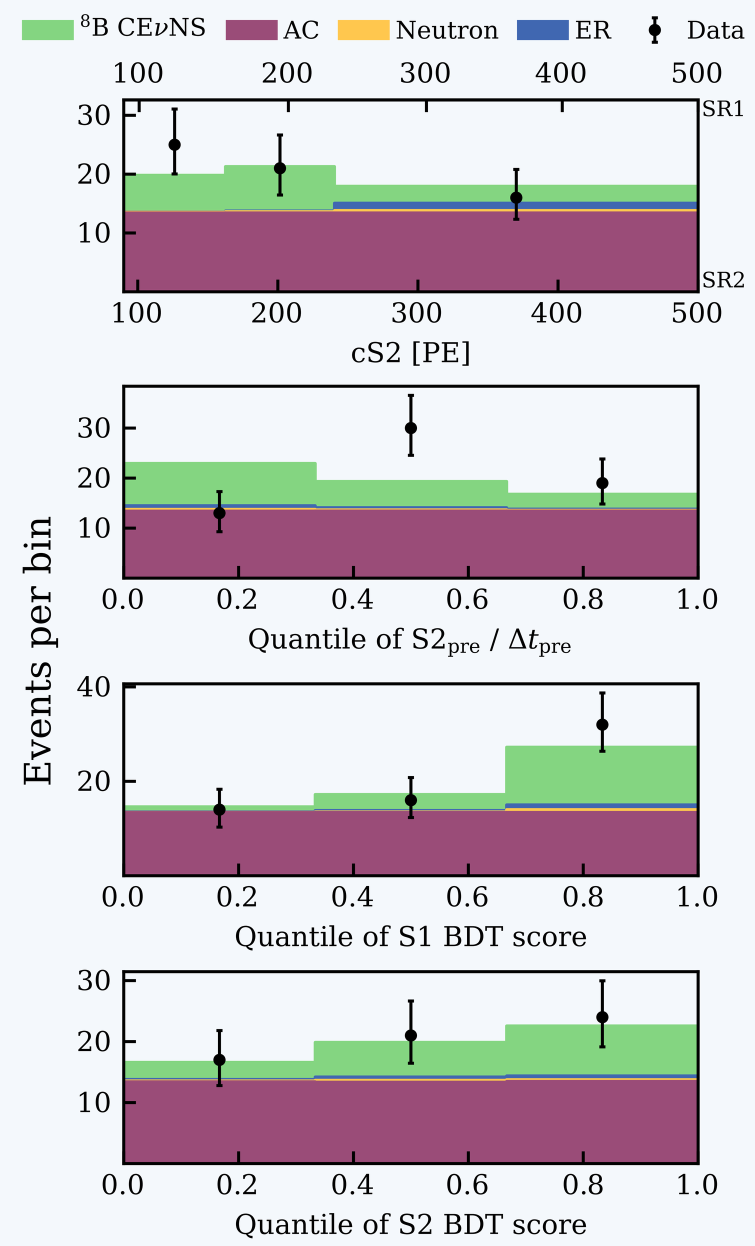


Fig. 8 Best-fit distributions compared to data in the projected analysis dimensions: corrected S2, S2$_{\text{pre}}/\Delta t_{\text{pre}}$, S1 and S2 BDT scores.

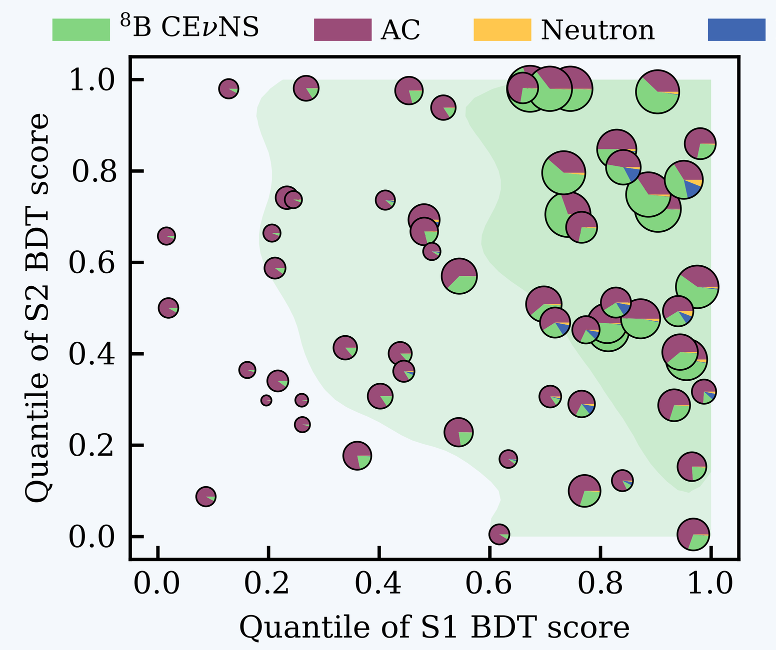


Fig. 9 Pie-chart representation of the dataset in the S1 and S2 BDT score plane.

- After unblinding, 62 events are observed
- Binned profile likelihood ratio test:
  - Solar ^{8}B neutrino discovery significance: 3.3σ
  - Solar ^{8}B neutrino flux is $(5^{+3}_{-2}) \times 10^6$ cm^{-2}s^{-1} (assuming the Standard Model prediction for the CEνNS cross section)
  - Various beyond the Standard Model neutrino interactions are constrained

Conclusion

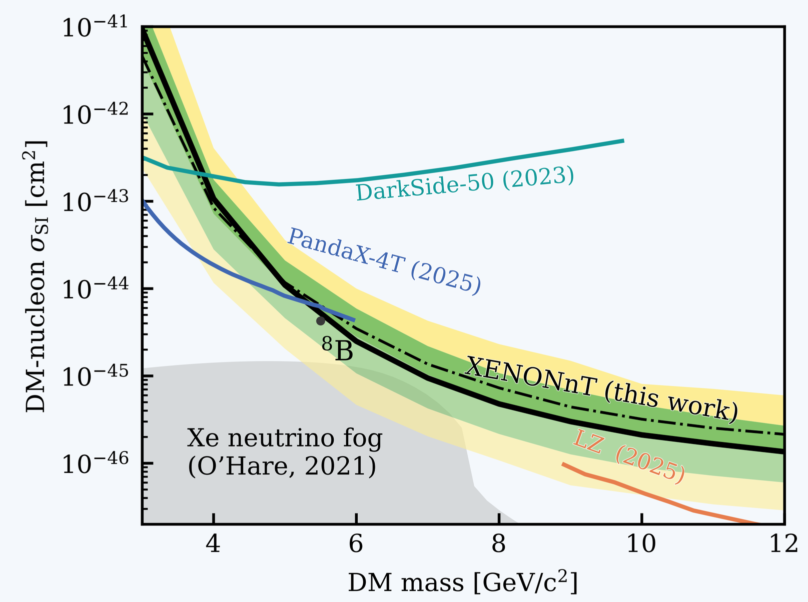


Fig. 10 90% CL upper limit (black line) on SI WIMP–nucleon interaction (^{8}B CEνNS as background).

The results inspire future DM searches using new methods, and demonstrate the versatility of the LXe TPC as a probe for low-energy neutrino measurements and new-physics searches.

References

[1] E. Aprile *et al.*, "Probing the Solar ^{8}B Neutrino Fog with XENONnT", 2026. **arXiv:2604.06002**.

[2] F. Takahashi *et al.*, "Review of Particle Physics", 2026.

[3] T. Lin, "Dark matter models and direct detection", 2019.

[4] M. W. Goodman and E. Witten, "Detectability of Certain Dark Matter Candidates", 1985.

[5] C. A. J. O'Hare, "New Definition of the Neutrino Floor for Direct Dark Matter Searches", 2021.

[6] E. Aprile *et al.*, "The XENONnT dark matter experiment", 2024.