See E. Aprile et al., EPJC 85, 695 (2025) for the details in SRO pure water phase.

XENONnT

XENC

Dark matter direct search

GXe LXe

TAUP2025, Xichan

ER calibration(220Rn)_

NR calibration cS1 [PE]

w/ 5.9t Liq. Xe active target

Dual-phase Xe TPC

- scintillation signal (S1)
- ionization signal (S2)

Background suppression

- Self shielding by Liq. Xe
- Fiducial volume cut by 3D position reconstruction
 - x, y : S2 hit pattern
 - : S1-S2 time difference
- Discrimination of Electronic recoil (ER) and Nuclear recoil (NR) by S2/S1



Neutron Veto

Muon Veto

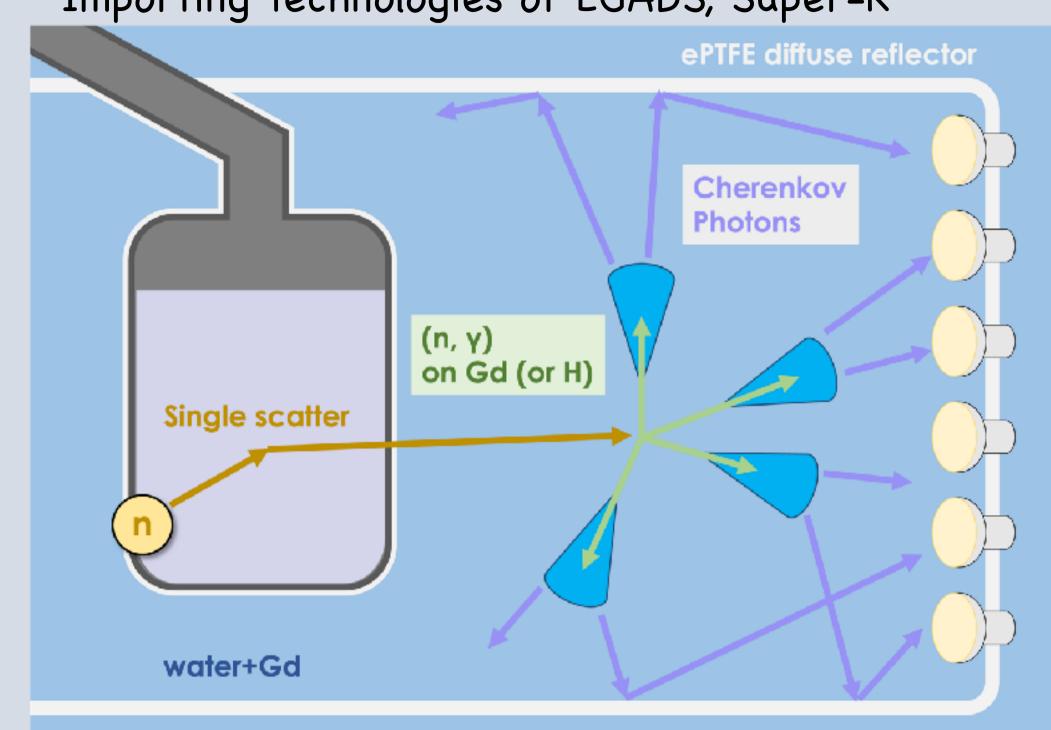
NR event by neutron is indistinguishable from WIMPs signal → tagged by Gd-water Cherenkov detector (Neutron Veto)

on behalf of the XENON collaboration

email: myoshida@km.icrr.u-tokyo.ac.jp

Masashi Yoshida, The University of Tokyo ICRR

Importing technologies of EGADS, Super-K

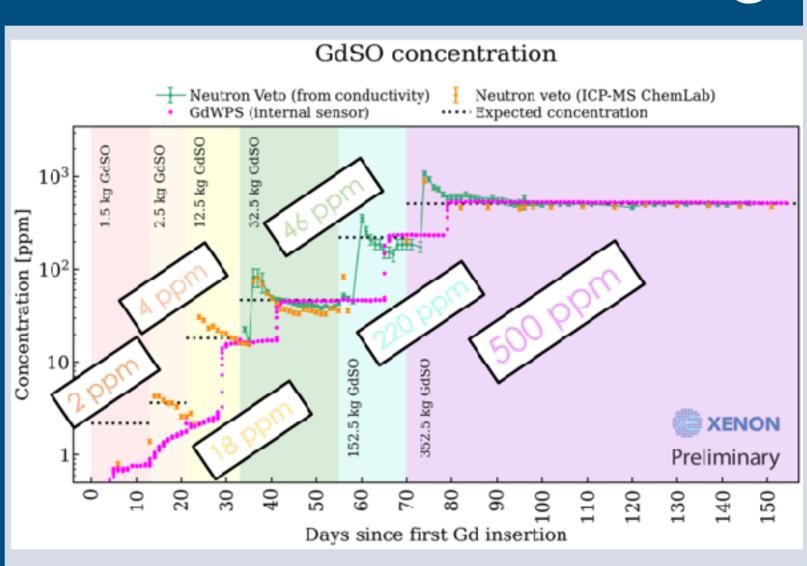


Gd concentration

start w/ 0% \rightarrow current: 0.02% \rightarrow qoal: 0.2%

Nanofilter

Gadolinium Loading



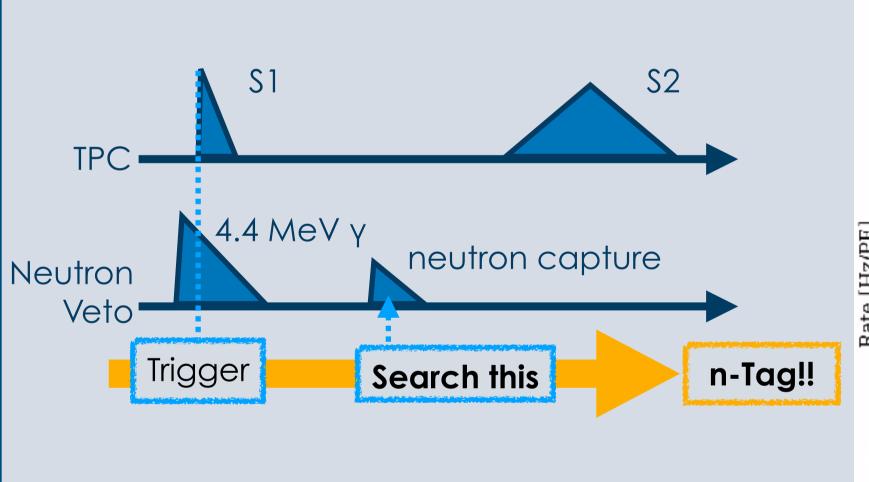
- Gd-loading started in the fall of 2023.

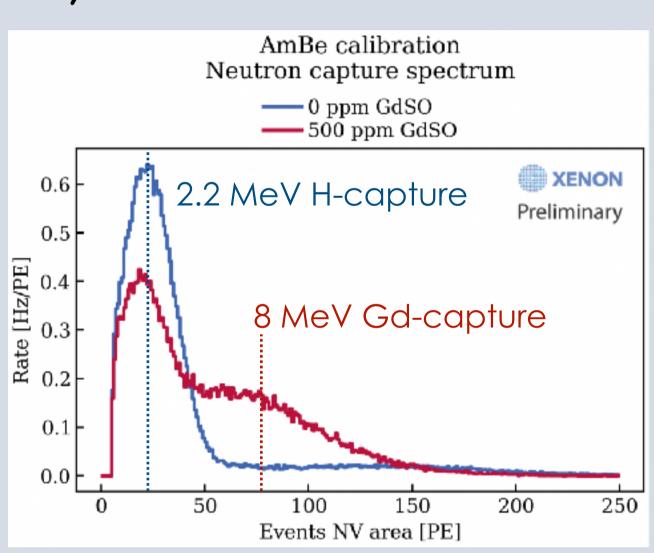
- to improve the neutron tagging efficiency
- riangleright currently up to 500 ppm (350 kg) of Gd₂(SO₄)₃·8H₂O in total (corresponds to 0.02% Gd)
- Monitoring the Gd concentration by mass spectrometry and conductivity measurements
- Continuous removal of impurities without removing Gd
- Nanofiltration: separate Gd rich and Gd depleted lines
- ► De-Ionization : remove ions in Gd depleted line
- Technologies from EGADS[1]

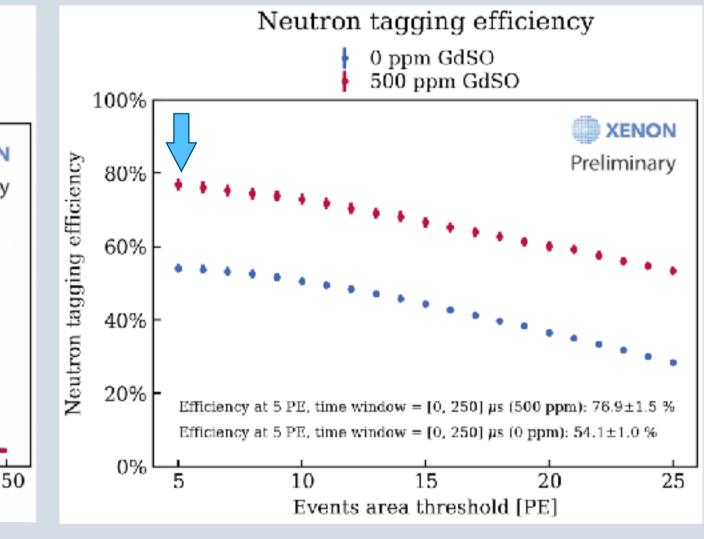
[1] L. Marti et al., NIMA **959**, 163549 (2020)

n-Tag efficiency

Neutron tagging efficiency has to be measured in advance to estimate neutron background rate. Calibration by Ambe neutron source: 3-5 MeV neutron + 4.4 MeV gamma







n-tagged events in SRO (first ~100 days) SRO neutron events

tagged multiple scatter

tagged single scatter

WIMP search data

Gd depleted

Gd rich

De-Ionizer

- ✓ 4 events tagged as neutrons
 - single scatter: 1, multiple scatter: 3)
- ✓ NR background model is validated with n-tagged events

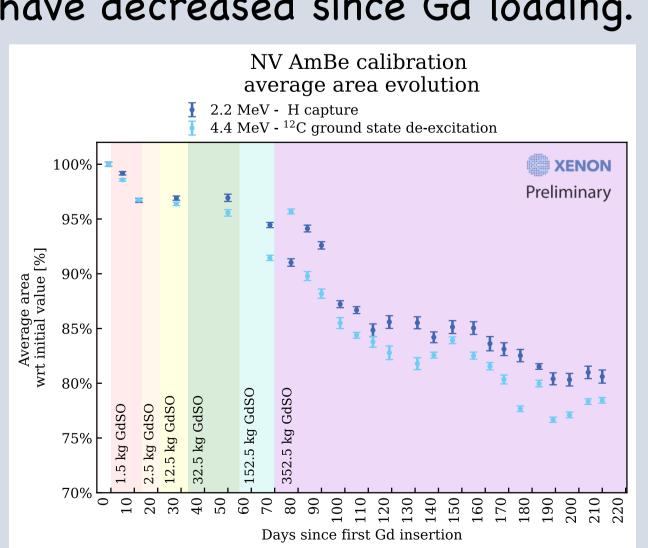
- Multi-PMT coincidence to reduce accidental coincidence

- Low PE threshold to tag 2.2 MeV H-capture
- \rightarrow > 5 PMT coincidence & > 5 PE & < 250 μ s time difference with TPC S1

n-tag efficiency: 53% (pure water) \rightarrow 77% (0.02% Gd): factor ~2 reduction of neutron background! expecting ~90% at 0.2% Gd

Optical property

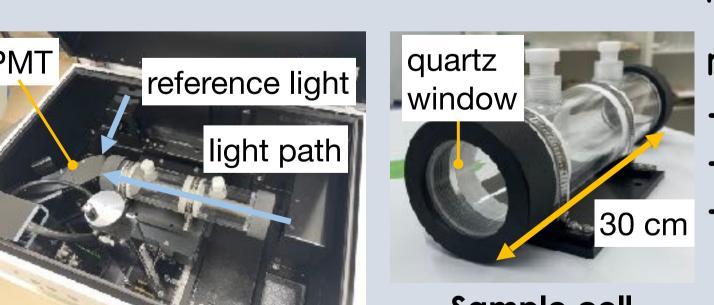
Light collection efficiency in nVeto have decreased since Gd loading.



Though n-Tag efficiency loss is not significant (2-3%), it is important to understand the cause to increase Gd concentration.

- absorption by water?
- reflectivity loss of ePTFE?

Direct measurement of light absorption by Absorption water with UV-Vis. Spectrophotometry



measured samples nVeto water - 0.02% Gd

- O(10) ppb metal ion

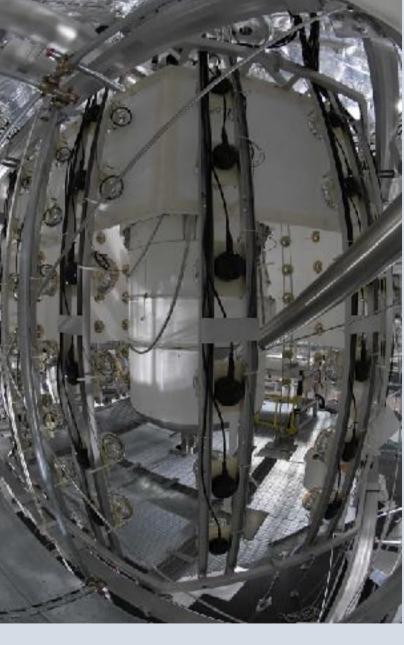
Sample cell

Spectrophotometer: Shimadzu UV-2600i $T_{\text{sample}} = T_{\text{purewater}} \times \exp(-\alpha L)$ NV GdWater 14.01.2025 --- 0.02% Gd³+ 0.20--- 0.9 ppb Fe^{b +} 0.15 E 0.10 Preliminary. 0.05 350 wave length [nm]

- ✓ Additional absorption consistent with 0.9 ppb Fe³⁺
- ✓ Absorption by Fe³+ only explained ~15% of light loss.

Reflectivity

Neutron veto is temporarily dismounted during the ongoing TPC upgrade.





- ✓ Some trace of reddish material (likely iron rust) is found on ePTFE.
 - → leads to less reflectivity
- Easily removed by wiping with pure water.
- ✓ Sufficient recovery of reflectivity was confirmed with the spectrophotometer.

Summary

- ✓ XENONnT utilizes Gd-loaded water Cherenkov detector for the Neutron Veto detector.
- ✓ The Neutron Veto plays a significant role in XENONnT to tag and to estimate neutron background.
- ✓ Neutron tagging efficiency of 77% is achieved with 0.02% Gd concentration.
- Decrease in light collection due to rust deposited on the ePTFE panels. Reflectivity recovered via wiping during the current upgrade phase.