

Research and Development for XENONnT and future Dark Matter Searches



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2023.02.21

ICRR Inter-University Research Program meeting
for nT-JP in the XENON collaboration

Kyodo-Riyo Support for nT-JP



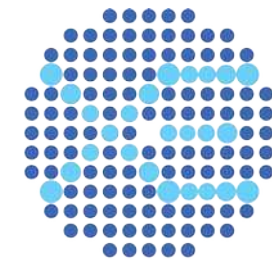
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Our Kyodo-Riyo grants are for travel to/from Kamioka to coordinate and advance our research by in-person meetings and Nagoya and Kobe University's personnel to use and work in labs at the Kamioka Observatory, in particular Lab-C (XMASS equipment):

- 2020 300,000 → fully carried over as COVID-19 prevented meetings
- 2021 +300,000 → 30,000 spent for Nagoya PD help with ^3H measurements in Lab C at Kamioka.
- 2022 570,000 ← carried over from both previous years:
no additional funds requested.
used 254,480 JPY so far this current FY:
4x PD from Nagoya to Kamioka/Lab C for ^3H studies
2x senior scientists from Kamioka to Kashiwa (this event)
plan to use ~90,000 JPY more before April (2 people to Kashiwa)
carrying over no longer possible: all that remains to be returned.

Requested new travel funds for in-person collaboration at Kamioka on XENONnT data analysis and XLZD development efforts.

nT-JP and the XENON collaboration



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- K. Martens
- M. Yamashita
- K. Bui
- S. Moriyama
- A. Takeda
- K. Abe
- Y. Kaminaga
- Y. Itow
- S. Kazama
- M. Kobayashi
- K. Miuchi
- Y. Maeda

12 countries, 27 institutions
> 180 people:



Our **Japanese** (Kamioka) expertise:

XMASS

liquid phase Xe purification

→ 15 ms electron lifetime

EGADS/Super-Kamiokande Gd:
water Cherenkov neutron tagging



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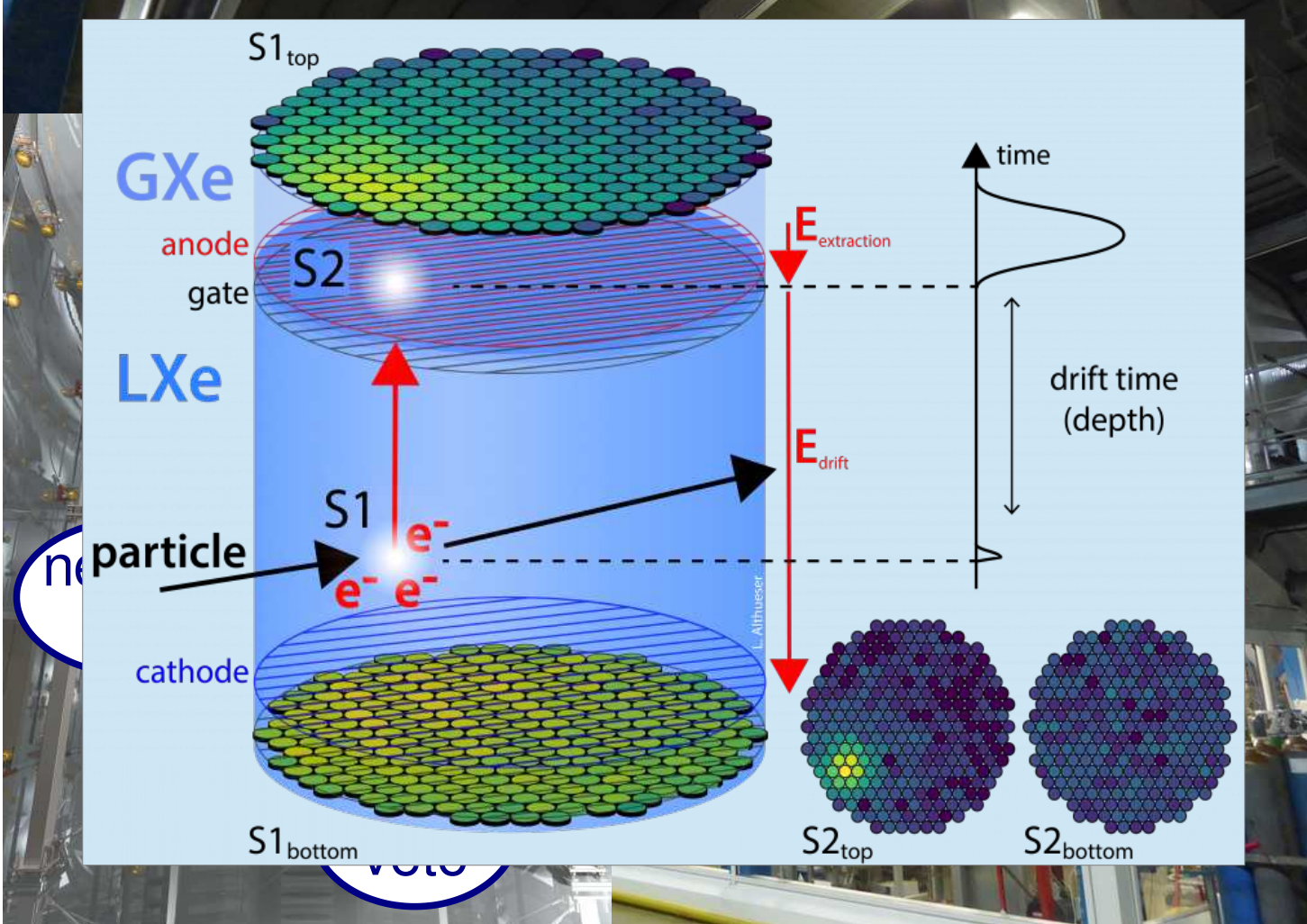
The XENONnT Experiment

Physics targets:

- direct detection of Dark Matter particles
- solar neutrino measurements
- nuclear physics of Xe nuclei
- Supernova neutrino detection via CEvNS

Detector components:

- Liquid xenon TPC
- Gd-water neutron veto
- muon veto
- custom purification equipment:



- Gd water neutron veto (EGADS/SK technology) NIM A 959 163549 (2020)
- Kr distillation column (XMASS technology) Astropart. Phys. 31, 290 (2009)
- Rn distillation column (XENON technology) EPJC 82, 1104 (2022)
- ultra clean, low-Rn liquid xenon pump (XENON technology) JINST 16 P09011 (2021)
- Xe liquid phase purification (XENON technology) EPJC 82, 860 (2022)

... plenty more work to be done also here in Japan for XLZD...

XENONnT: Lowest Background for Electron Recoil Searches



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Thanks to the aforementioned efforts:
XENONnT has the cleanest LXe target

of the current generation of LXe TPCs!

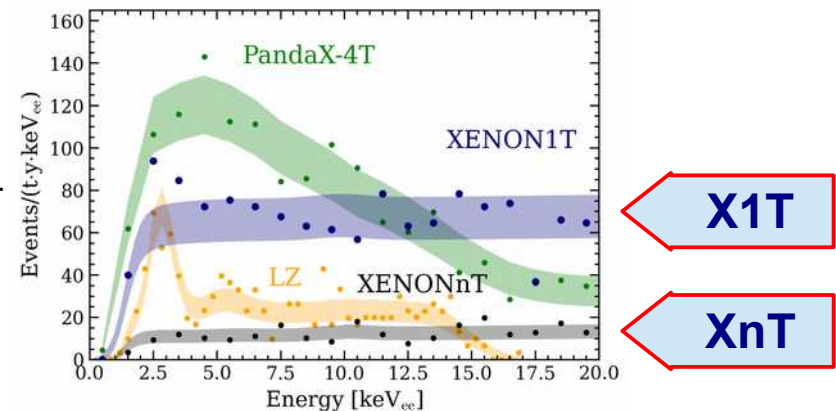
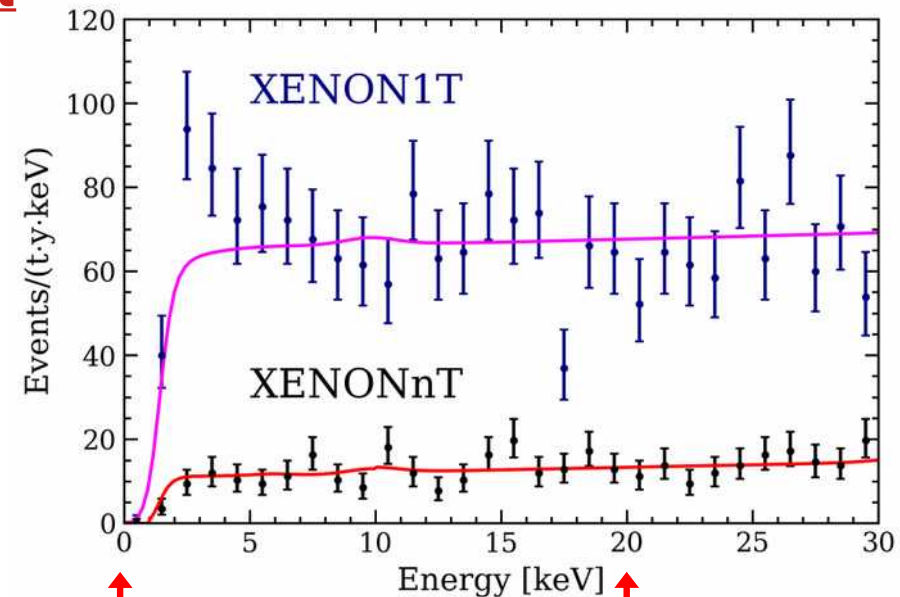
→ lowest threshold, highest sensitivity !!!

What about Nuclear Recoils (NR)?

→ **Kamioka Gd technology** with a twist:
replace photocathode coverage
by reflective detector lining
→ **XENONnT neutron veto**

Last year's XENON publications:

1. Application and modeling of an online distillation method to reduce krypton and argon in XENON1T, PTEP 053H01 (2022)
2. Emission of single and few electrons in XENON1T and limits on light dark matter, PRD 106 022001 (2022)
3. Double-weak decays of ^{124}Xe and ^{136}Xe in the XENON1T and XENONnT experiments, PRC 106 024328 (2022)
4. Search for New Physics in Electronic Recoil Data from XENONnT, PRL 129 161805 (2022)
5. An approximate likelihood for nuclear recoil searches with XENON1T data, EPJC 82:989 (2022)



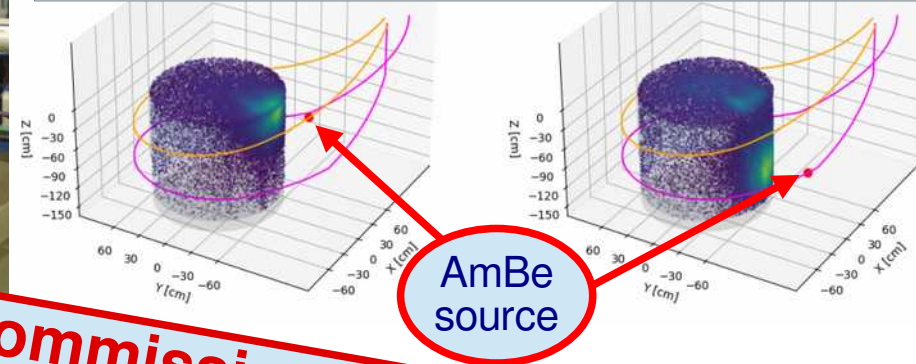
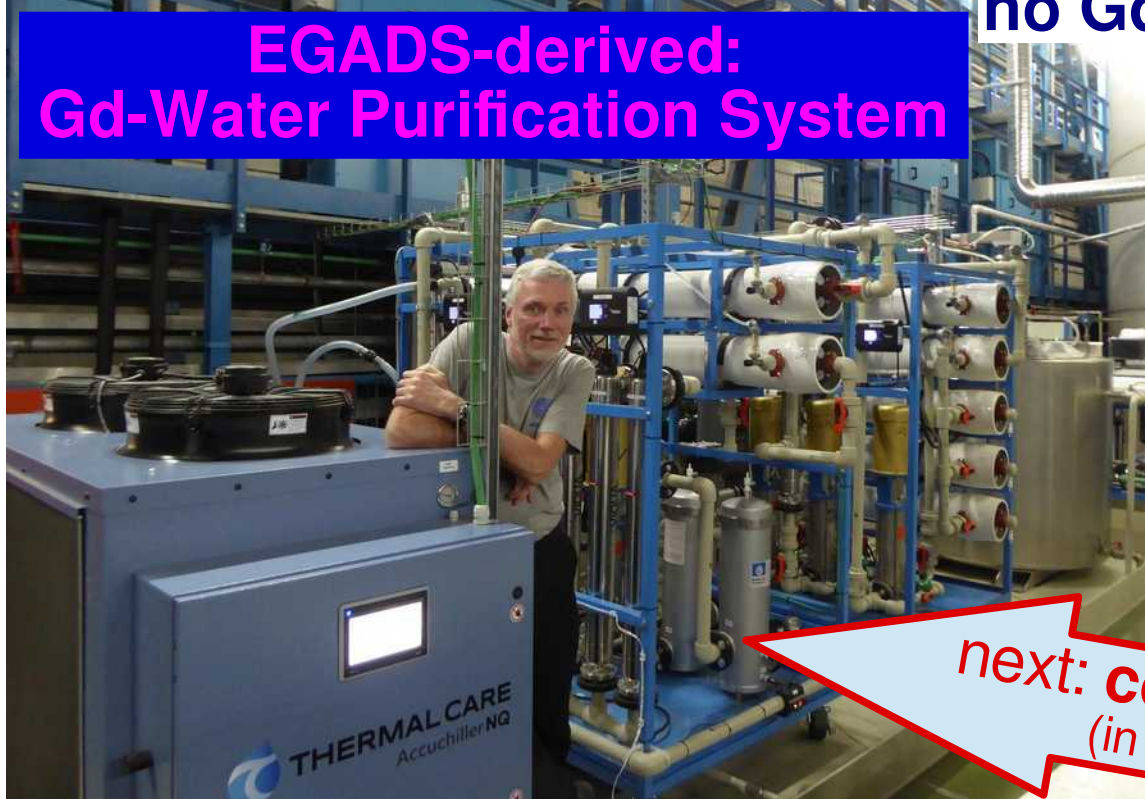
Japan @ XENONnT



nT-JP & neutron veto: 700 ton veto pure water: **OK**, but:
no Gd-sulfate introduced yet. **XENON**

**EGADS-derived:
Gd-Water Purification System**

XENONnT neutron veto:
**pure water = H(n, γ) 2.2 MeV
neutron tagging efficiency:
~68%**



next: commissioning w/Gd-sulfate
(in closed loop, without 700 ton tank)

nT-JP & liquid xenon purification:

- impurity absorber ← tested and suggested absorber
- purity monitor ← delivered and installed by us
- purity monitoring ← service provided by us

XLZD (DARWIN): The Future



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Agreement to build a next generation liquid xenon TPC together:
XENON, LUX-ZEPLIN, and interested researchers
founded the “**XLZD Consortium**”



at the “**DARWIN/XENON + LUX ZEPLIN Summer Meeting 2022**”
@ KIT in Karlsruhe, Germany, after having signed the
“*Memorandum of Understanding towards a Next-Generation Liquid Xenon Experiment*”
a year earlier, in July 2021.

Let us here in Japan make a strong contribution to this world-wide effort!

Community whitepaper: J. Phys. G 50 013001 (2022), arXiv: 2203.02309

Conclusions



- XENONnT is taking science data and producing results:
 - longest electron lifetime in the field !
 - lowest ER background in the field !!
 - *nT-JP is thankful for Kyodo-Riyo support !!!*
- XLZD is coming together to push beyond XENONnT & LZ:
 - Dark Matter measurement or detection ?
 - precision neutrino physics with astrophysical neutrinos.
 - new technologies to scale achieved purity and performance!
 - 未来の学術構想 submitted by Kavli IPMU director Hirosi Ooguri, with recommendations from CRC and SCJ astrophysics
 - opportunity for new Japanese groups to join → see G3C



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Backup

LZ/XnT Notes



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	fiducial volume	drift field [V/cm]	max. drift time [ms]	e ⁻ lifetime [ms]
LZ NR (2207.03764):	5.5 t	193	0.95	5-8 ms
XnT ER (PRL 2022):	5.9 t	23	2.2	>10 ms



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