

# XENONnT @ LNGS & Kamioka



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at the Kyodo-Riyo Science Session  
2019.12.13

# Kyodo-Riyo: XENONnT Budget



approved for FY 2019:

**400 kJPY** for **travel** related to activities of the Japanese XENON collaborators from Nagoya, Kobe and The University of Tokyo at the Kamioka Observatory.

Japan has two major responsibilities within the XENON collaboration. We directly address two of the major obstacles to detecting heavy WIMPs via nuclear recoil (NR) in xenon detectors by providing our crucial technology and expertise for:

- 1.) The XENONnT Neutron Veto (nVeto):  
Our EGADS/SK-Gd water Cherenkov neutron detection technology was chosen by the collaboration.
- 2.) Liquid xenon (LXe) purification in XENONnT:  
Our XMASS expertise is expanded at the Kamioka Observatory and transferred to XENONnT.

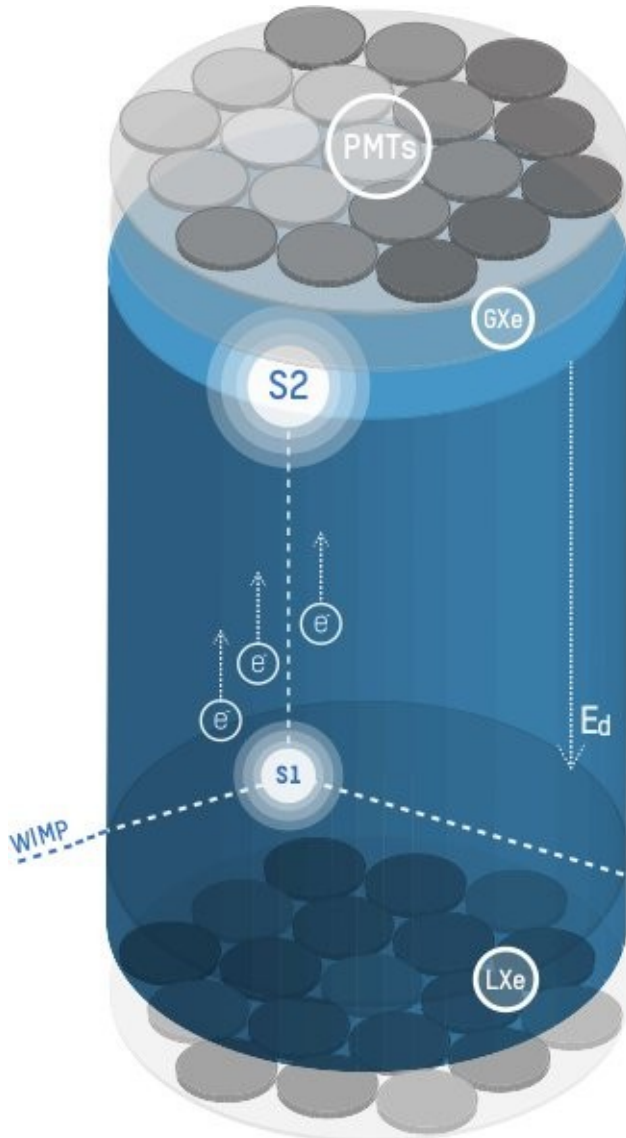
The allocated travel **funds for this FY are already used up...**

# Overview:



- Liquid xenon (LXe) & **Dark Matter (DM) direct detection:**  
Dual phase time projection chambers (TPCs) are the future
- The **XENONnT upgrade** of the successful XENON1T detector:  
our Japanese contribution to its physics reach
- Keeping Kamioka and Japan relevant for future DM searches:  
**Contribute** in the most successful collaboration in the field !!!
- Summary and Outlook:  
Kyodo-Riyo underpins Japanese impact and success,  
which provides a future for our young researchers

# XENON: Dual Phase LXe



## Dark Matter (DM) direct detection:

Weakly Interacting Massive Particle (WIMP) scattering on Xe nucleus

→ nuclear recoil (NR)

single phase detector: scintillation

e.g. **XMASS**: optimized for light collection, but very limited discrimination of NR vs. ER

dual phase TPC: scintillation + ionisation

- very good NR vs. ER discrimination !!!
- very good position resolution ( $e^-$  drift time)
- ← need to control electronegative impurities!

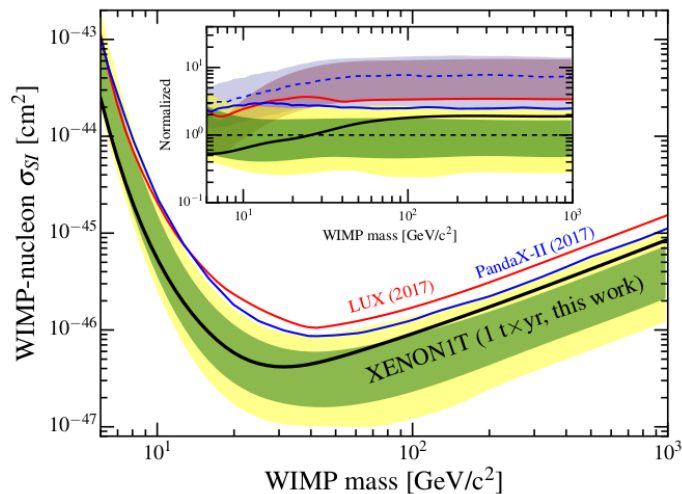
wikipedia rendering of dual phase TPC

acronyms: TPC = time projection chamber  
ER = electron recoil

# XENON1T: In Hall B @ LNGS



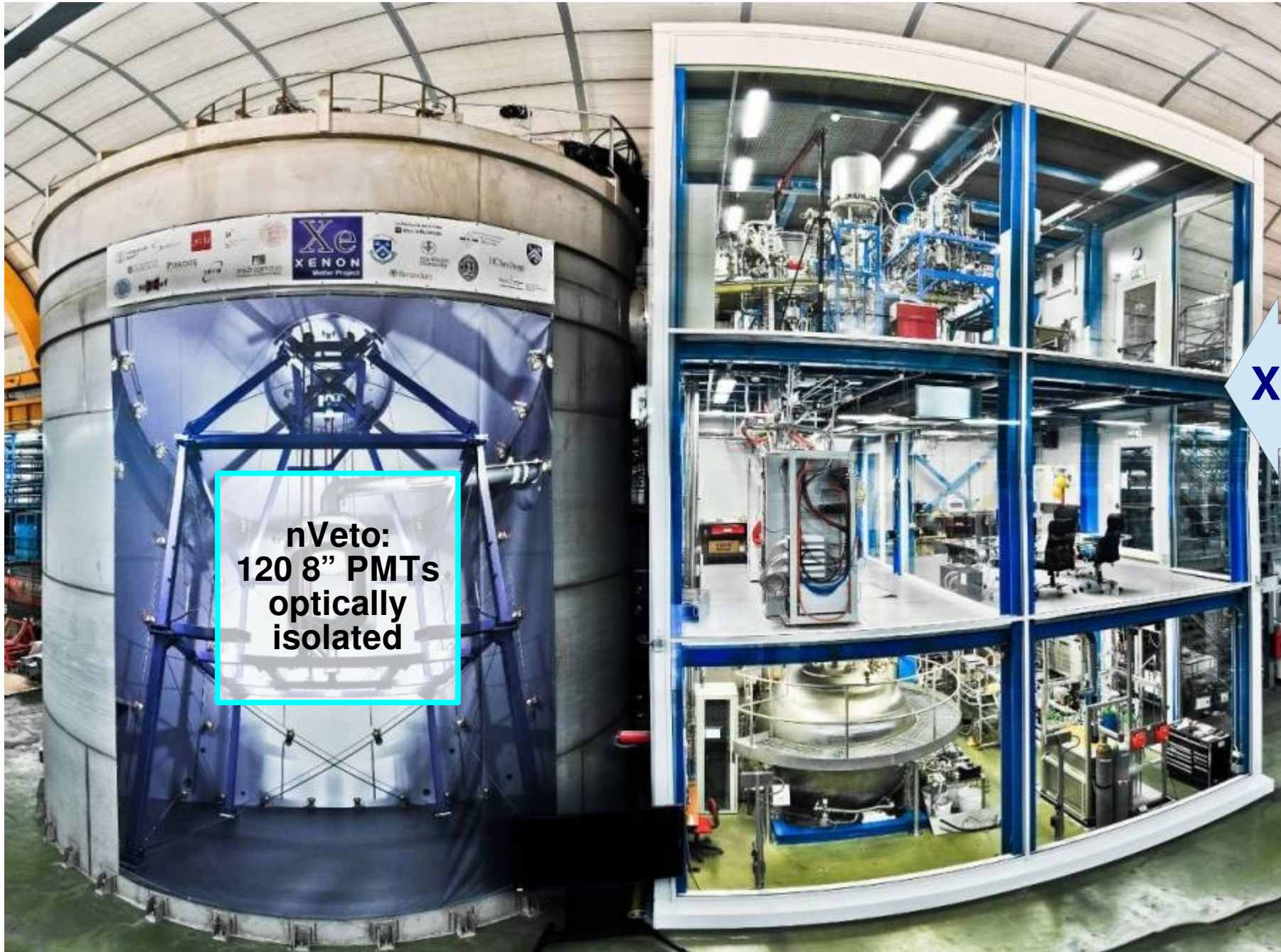
XENONnT  
will re-use  
many proven  
components  
and methods  
of  
XENON1T



← main physics result from XENON1T:  
**Phys. Rev. Lett. 121, 111302 (2018)**  
arXiv 1805.12562

XENONnT →  $\sim 10^{-48}$  cm<sup>2</sup>

# XENONnT (XnT): Starting Now



nVeto:  
120 8" PMTs  
optically  
isolated

Picture of:  
**XENON1T**  
reuse &  
upgrade:

↑  
proven &  
debugged:  
**XnT**  
early start!

# Backgrounds well understood:



given the **site** (Hall B, LNGS) and **experience with XENON1T**, the limiting **backgrounds in XnT** will be from detector materials:

- 1.)  $^{222}\text{Rn}$  emanation into the LXe:  
→ online Rn distillation: Xe100 technology, proven @ XENON1T
- 2.) **fast neutrons** from  $(\alpha, n)$  reactions in TPC materials:  
→ neutron veto (**nVeto**): **Kamioka technology**, proven @ EGADS

→ **Japan provides nVeto technology for XENONnT:**

- quantitative risk analysis is being concluded
- radio-isotope pure gadolinium sulfate
- crucial for **NR analysis: WIMP search !!!**

Our students (UT and Kobe), under guidance from their advisers and other senior Japanese team members, are **getting ready for data analysis**  
XMASS tradition: not only WIMP searches !!!

# Massive Targets: Liquid Purification

LXe purification of LXe from electronegative contaminants:

- **large volumes** mean **long electron drift**
- long drift requires ultra-low contaminant concentration (so that we do not lose ionization signal)

Two Kamioka efforts:

- testing of absorbents in LXe:
  - Masaki Yamashita proposed the best absorbent so far
  - currently being commissioned at XENONnT
- making and testing a “purity monitor”:
  - measures electron lifetime in the liquid
  - installed and commissioned at XENONnT



This effort is also future oriented:

a **Generation3** ~30 tonne LXe fiducial volume (50 tonne LXe total) absolutely needs extremely efficient liquid purification:

→ **Kamioka is further developing its XMASS expertise for G3 !!!**



# Summary and Outlook

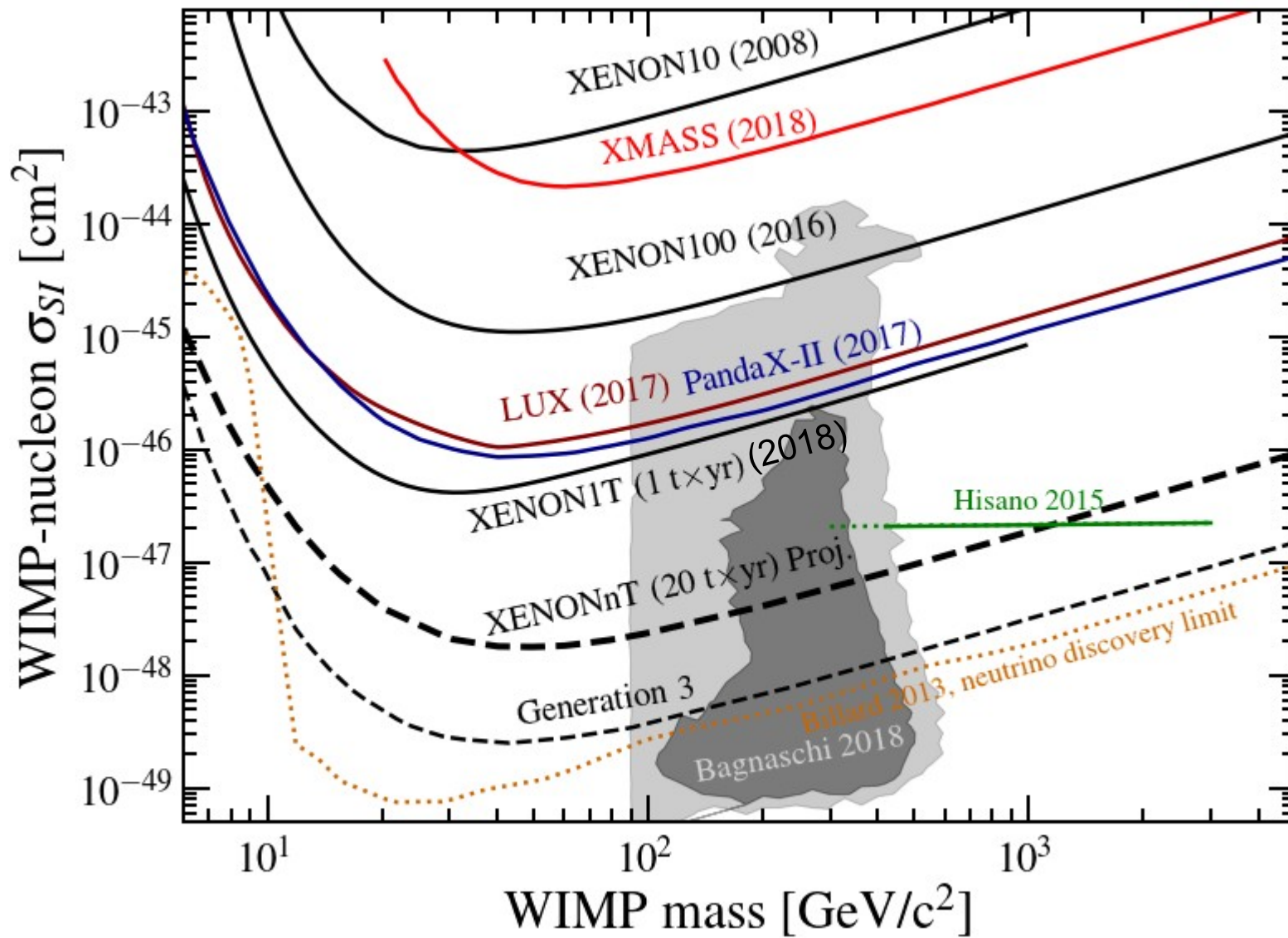


- XENON completes its upgrade from XENON1T to XENONnT
- Japan is part of **XENONnT**, contributing crucial Kamioka expertise:
  - SK-Gd/EGADS technology to veto fast neutrons at the LXe TPC
  - liquid purification technology originating from XMASS expertise
  - **analysis**: both our students and XENON benefit from XMASS !!!
- the Japanese XENONnT effort is an offshoot of XMASS:
  - it is largely based in Kamioka and wishes to continue to use Kamioka Observatory facilities below and above ground and XMASS equipment - as far as it is not otherwise used.
- XENONnT is a stepping stone to a future ~ 30 tonne LXe observatory:
  - stay connected with the international community and
  - develop the required new technologies

Kyodo-Riyo support is much appreciated for this Japanese contribution to direct Dark Matter detection, in particular WIMPs: It is our hope

to be the first to detect Dark Matter particles  
with **XENONnT!**

# Backup

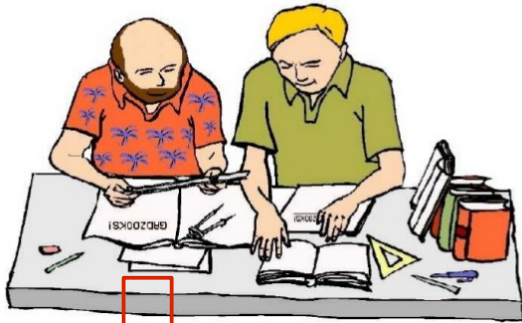


# SK-Gd Technology

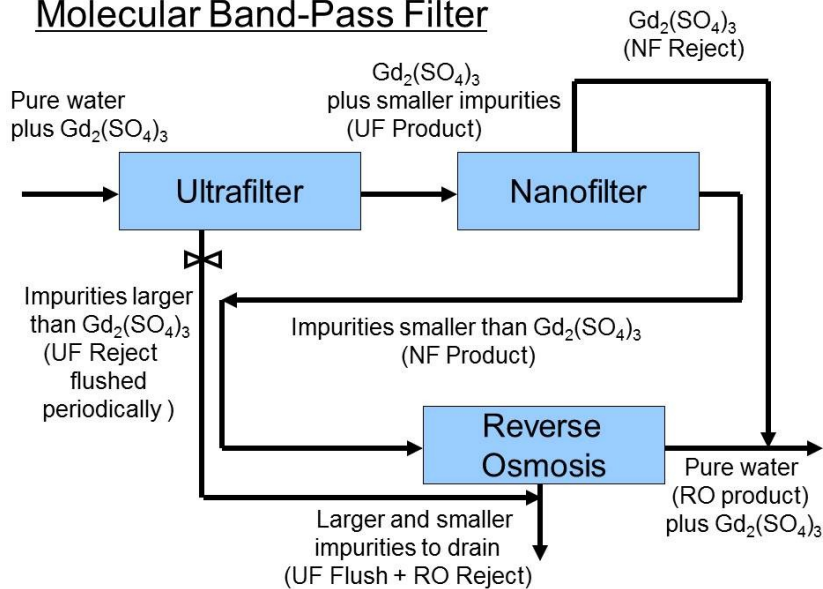
Gd-water idea (2004):  
Mark & John

implement, understand and improve the technology:

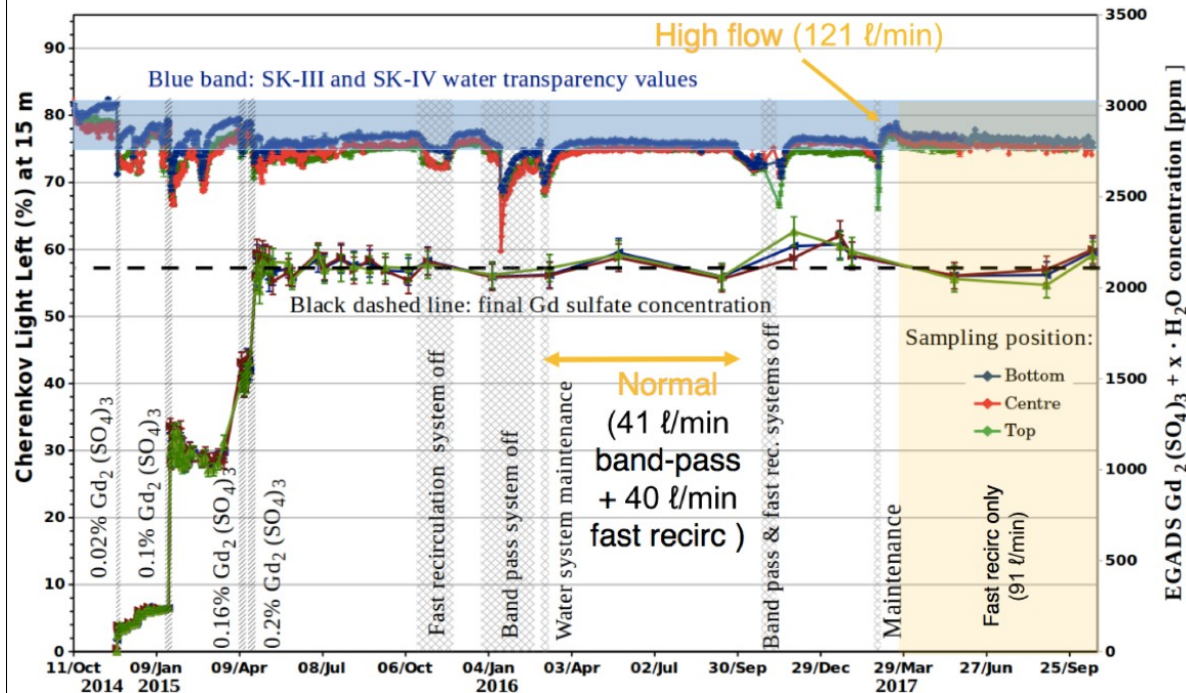
EGADS:



## Molecular Band-Pass Filter



Light @ 15 meters and Gd conc. in the 200-ton EGADS tank



After two and a half years at full Gd loading, during stable operations EGADS water transparency remains within the SK ultrapure range.

→ No detectable loss of Gd after more than 650 complete turnovers. ←

Slide credit: Mark Vagins

optimization different:

SK-Gd  
XENONnT

→ maximum transparency, huge volume  
→ maximum efficiency, small volume