

# Multi-Messenger Astronomy at



Mark Vagins

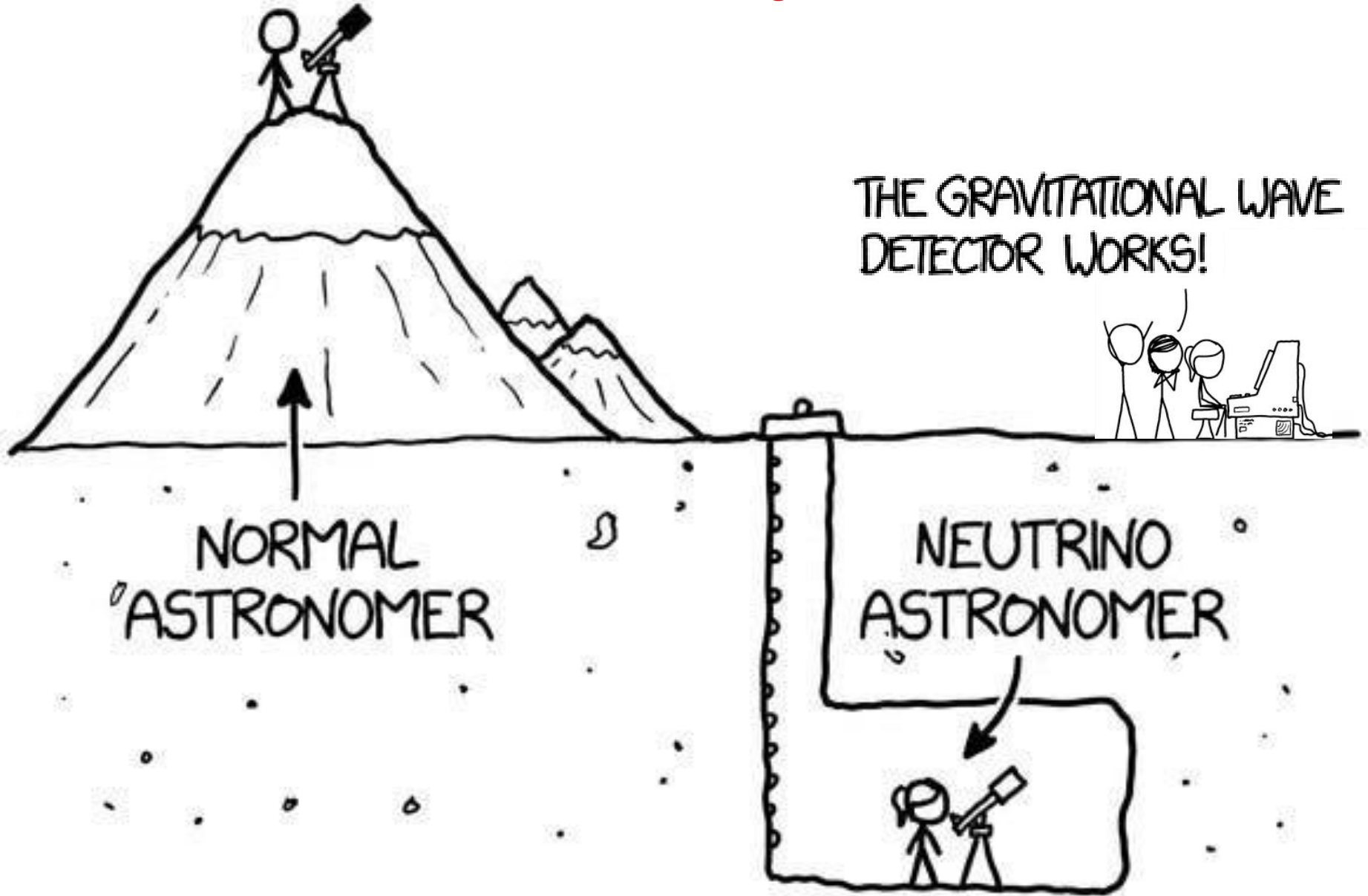
Kavli IPMU, UTokyo

Next-generation Neutrino Science and  
Multi-messenger Astronomy Organization Symposium

Kashiwa

November 1, 2023

*This meeting in a nutshell...*



As of this morning, Kavli IPMU has a new Director:

**Jun'ichi Yokoyama**

**Yokoyama-san is also the Director of the Research Center for the Early Universe (RESCEU) at the University of Tokyo. He is an expert in gravity and cosmology, and served as the chair of the KAGRA Scientific Congress for the past two years.**



# Kavli IPMU's optical/IR role for multi-messenger astronomy

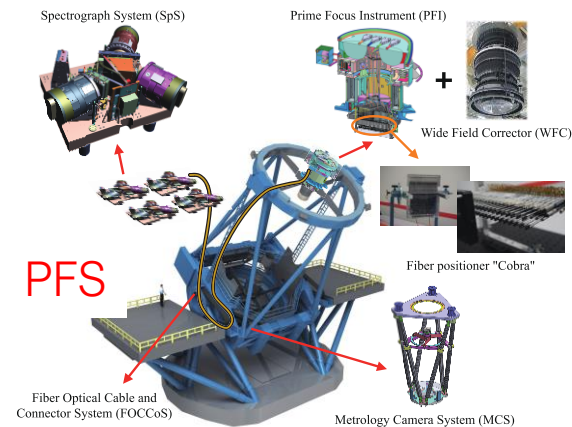
- Kavli IPMU is a leading institute of Subaru Hyper Suprime-Cam (HSC; imaging) and Prime Focus Spectrograph (PFS: spectroscopy) projects
- HSC/PFS are powerful instruments for a follow-up observation of transients (e.g. identifying GW counterparts)
- PFS is unique among other 8m-class tels
  - About 2400 fibers, 8.2m large aperture, wide field-of-view
  - Reconfigurable of fibers within ~2min
  - Now in the commissioning phase, and envision to start the operation in mid 2024
- Some of us are full members of the US-led RO LSST (imaging)



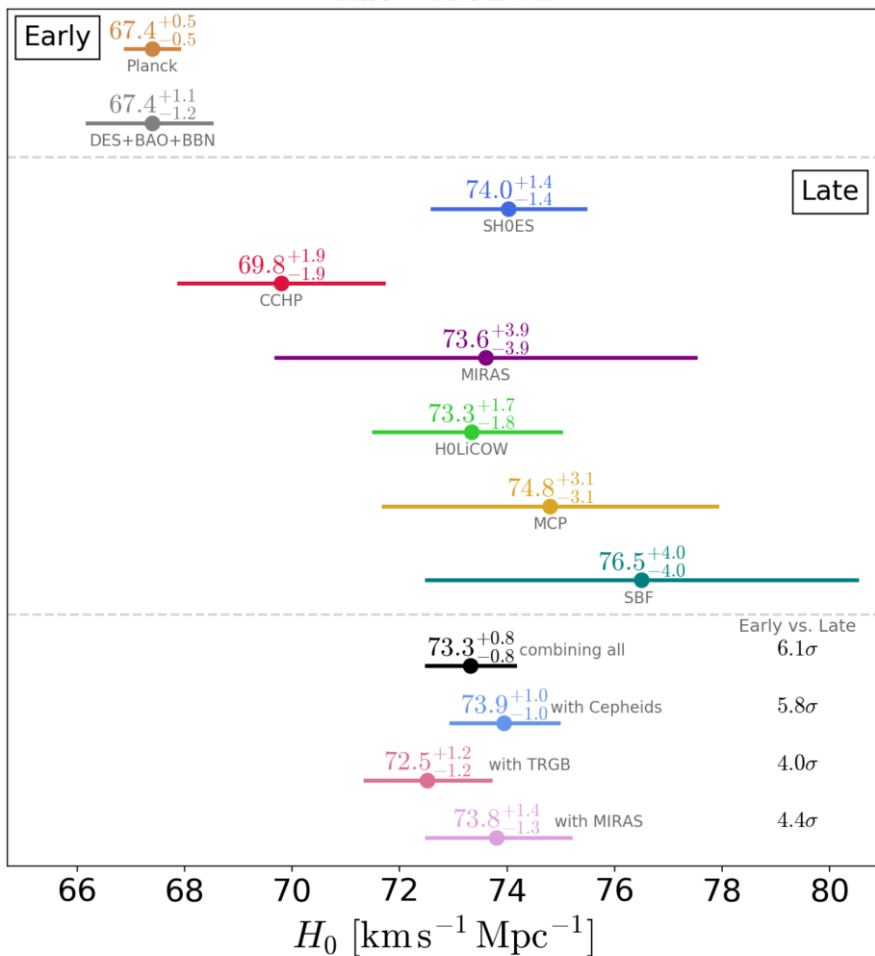
8.2m Subaru tel.  
(NAOJ)



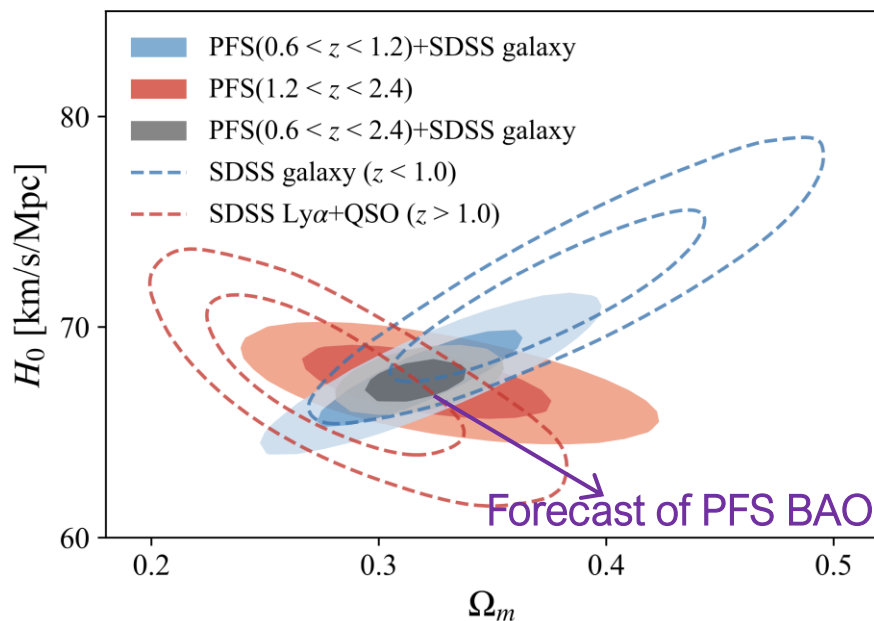
HSC



flat –  $\Lambda$ CDM



- “Hubble tension” might be a hint of  $\Lambda$ CDM breakdown – a new physics? e.g., early-dark energy
- Subaru PFS wide-field survey of emission-line galaxies can give an independent test of the Hubble tension from the BAO measurements, over  $0.6 < z < 2.4$
- PFS BAO is very complementary to GW standard siren
- Profs. Yokoyama and Sasaki for GW/GR physics



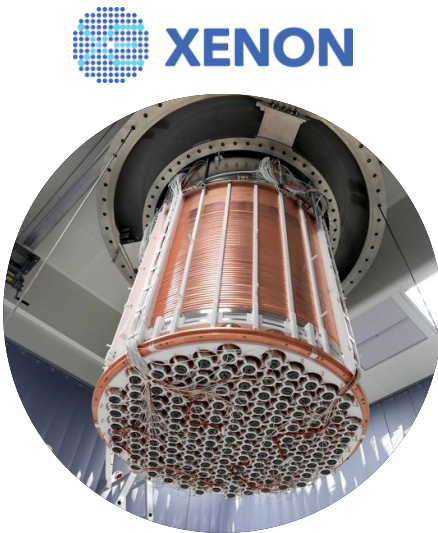
## XENONnT & DARWIN/XLZD:

Dark Matter detectors also record SN neutrino bursts

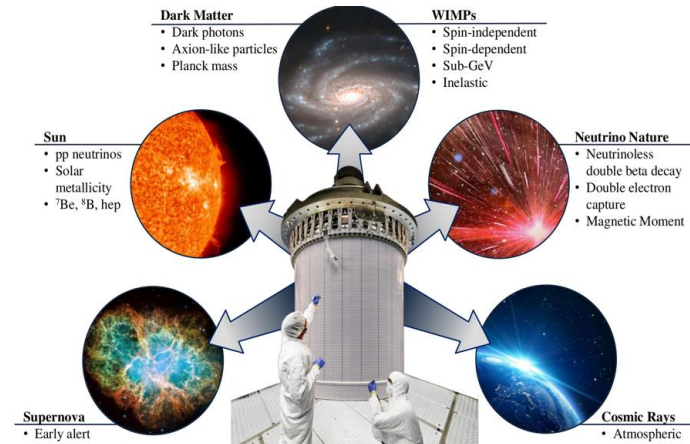
Kai Martens

Masaki Yamashita

*Large Liquid Xenon Detector in the underground laboratory*



The future: DARWIN / XLZD



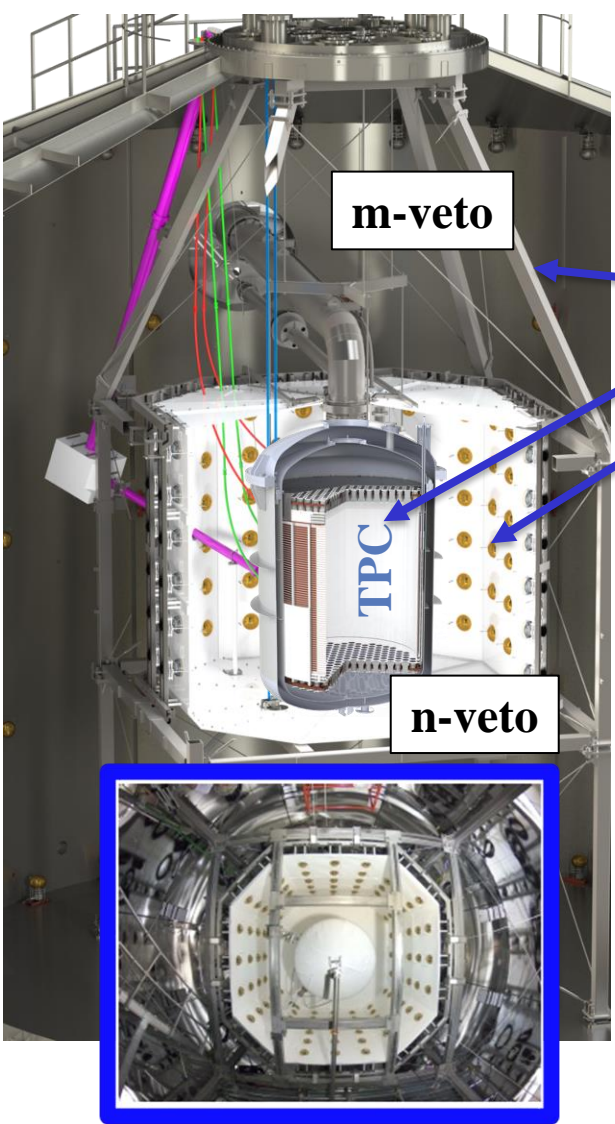
### XENONnT:

one of the most sensitive **WIMP** dark matter detectors

- ongoing experiment, located at LNGS in Italy
- **5.9 t liquid xenon** target

### DARWIN/XLZD:

Ultimate detector with **50 t** or more for **Multi-purpose rare-event search** in 2030's



# XENONnT: 3 detectors

## Xe Time Projection Chamber

- 5.9 t LXe target (WIMP detector)

## Neutron and muon Veto Systems: Cherenkov Detectors

- 700 t water tank

- 84 (120) PMTs in nVETO ( $\mu$ VETO)

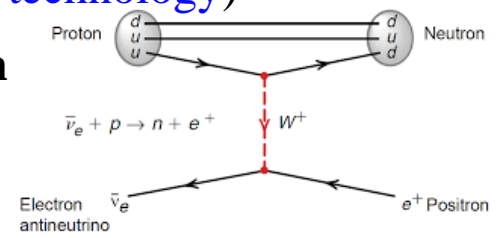
### n-veto

- Highly reflective ePTFE and ultra-pure water to maximize light-collection efficiency

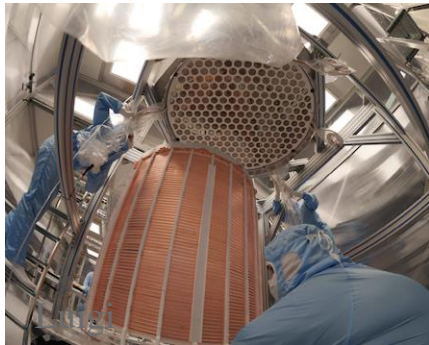
- Tag neutrons through the neutron capture on hydrogen which releases a 2.22 MeV  $\gamma$ -ray

Plan to introduce Gd in the water  
(EGADS, SK-Gd technology)

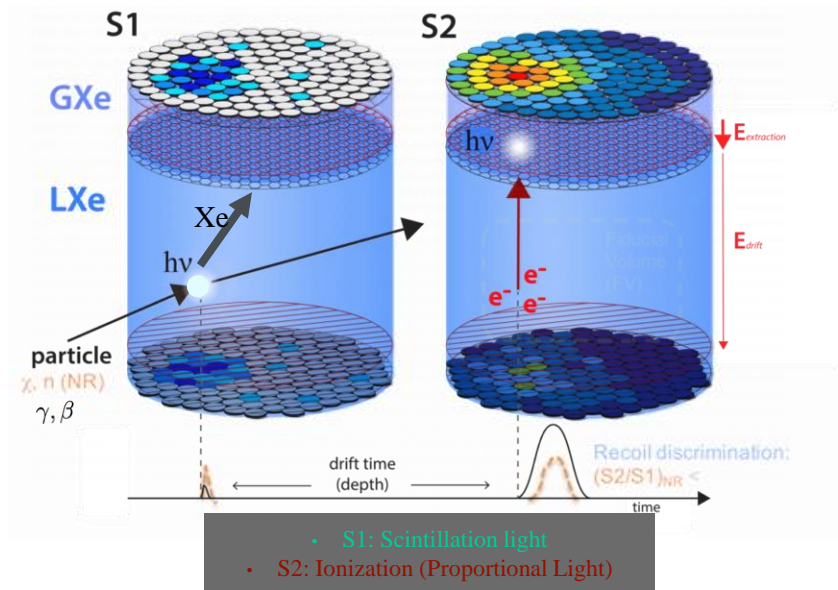
## Supernova Neutrino Detection through inverse-beta decay channel



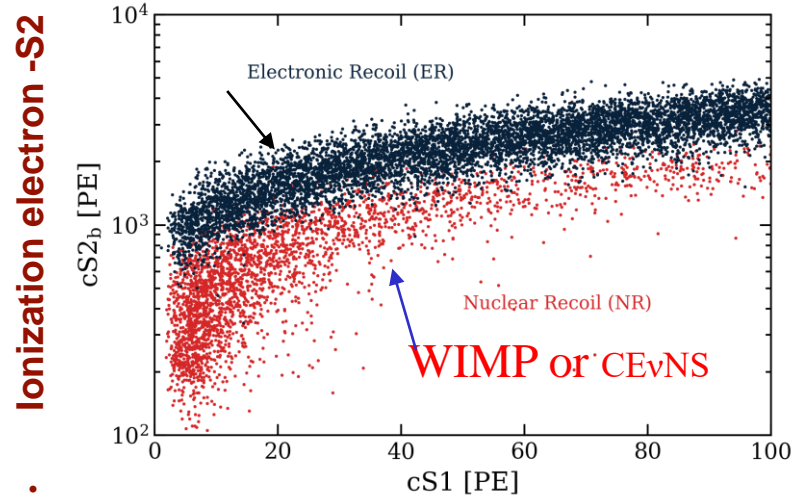
# How can we detect SN neutrinos with a Dark Matter Detector?



- Signal from Scintillation Light(S1) and Charge (S2)
- 3D Position Reconstruction: x-y (S2) and z (drift time)
- Identify multiple site events: Compton Scattering, Neutron
- Particle identification: the nuclear recoil signal (WIMP) and CEvNS from electronic recoil ( $\gamma$ ,  $\beta$  rays) with S2/S1 ratio ( $> 99\%$ )



## Solar $\nu$ (e-scatter) and Background



- Scintillation light - S1

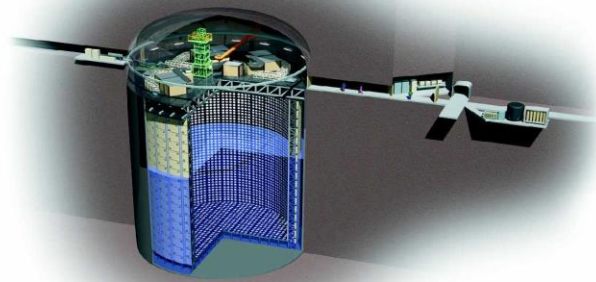


# Neutrinos at Kavli IPMU and the WC Gadolinium Pipeline

[Beacom and Vagins, *Phys. Rev. Lett.*, **93**:171101, 2004]  
(560 citations as of today)

EGADS  
(200 tons)

↓ 2020

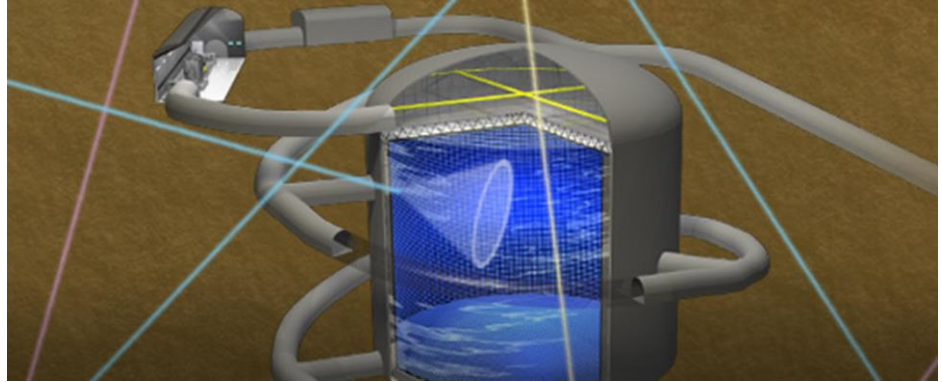


Super-K  
(50 ktons)

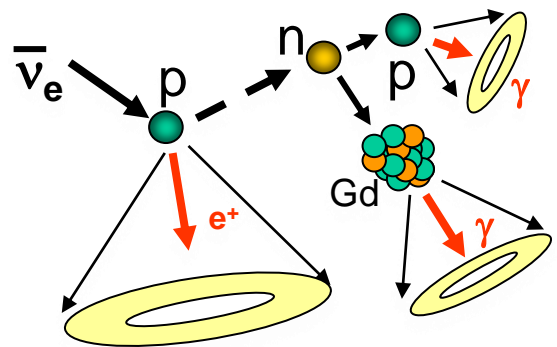
EGADS and Super-K are now both Gd-loaded in Japan, along with ANNIE at Fermilab (US) and the veto region of XENONnT in Gran Sasso (Italy). Other projects using this Kavli IPMU/ICRR tech are under construction at CERN (EU) and Boulby (UK).



↓ 203x (hopefully!)



Hyper-K  
(258 ktons)



Main 200-ton Water Tank  
(224 50-cm PMT's + 16 HK test tubes)

**EGADS  
Laboratory  
in Kamioka**

15-ton Gadolinium  
Pre-treatment  
Mixing Tank

Selective Water+Gd  
Filtration System

**Worldwide, over ¥十五億 (not counting salaries) has been spent developing and proving the viability of the Gd-in-water concept.**

With an R&D program of mostly long-duration tests, EGADS also functions as a dedicated, Gd-loaded SN detector. Its realtime alerts are open to the public.

~90,000  $\nu$  events  
@ Betelgeuse

~40  $\nu$  events  
@ G.C.

EGADS is now the lowest latency SN neutrino detector in the world.  
We'll send out an announcement within **a few seconds** of a MW SN neutrino burst's arrival!

<https://www-sk.icrr.u-tokyo.ac.jp/~egofl/>

EGADS/HEIMDALL

https://www-sk.icrr.u-tokyo.ac.jp/~egofl/

# 200-ton EGADS/HEIMDALL Galactic Supernova Monitor

Page loading time (local time):	Wednesday, 1 November 2023 01:21:10
HEIMDALL status update time (JST):	Wednesday, 1 November 2023 01:21:06

## Status: No supernova detected

Page loading time should be ~ 2 seconds  
HEIMDALL update time should be < 2 minutes  
(In case of supernova alarm will fired within < 10 seconds from the burst onset)

A prompt email is sent as soon as a supernova is detected.  
More information is sent by email within about less than 30 minutes.  
If you want to receive them or have questions/suggestions send an email to: [martillu\\_at\\_suketto.icrr.u-tokyo.ac.jp](mailto:martillu_at_suketto.icrr.u-tokyo.ac.jp)

Sound Test

Sorry, but there was no Milky Way supernova while I was preparing my talk this morning.

So, thank you  
for having me  
here today.

Let's keep  
watching the  
skies together!

