Reactor Short Baseline Neutrino Experiment in Korea

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On behalf of NEOS Collaboration
Centre for Underground Physics, Institute for Basic Science

Introduction

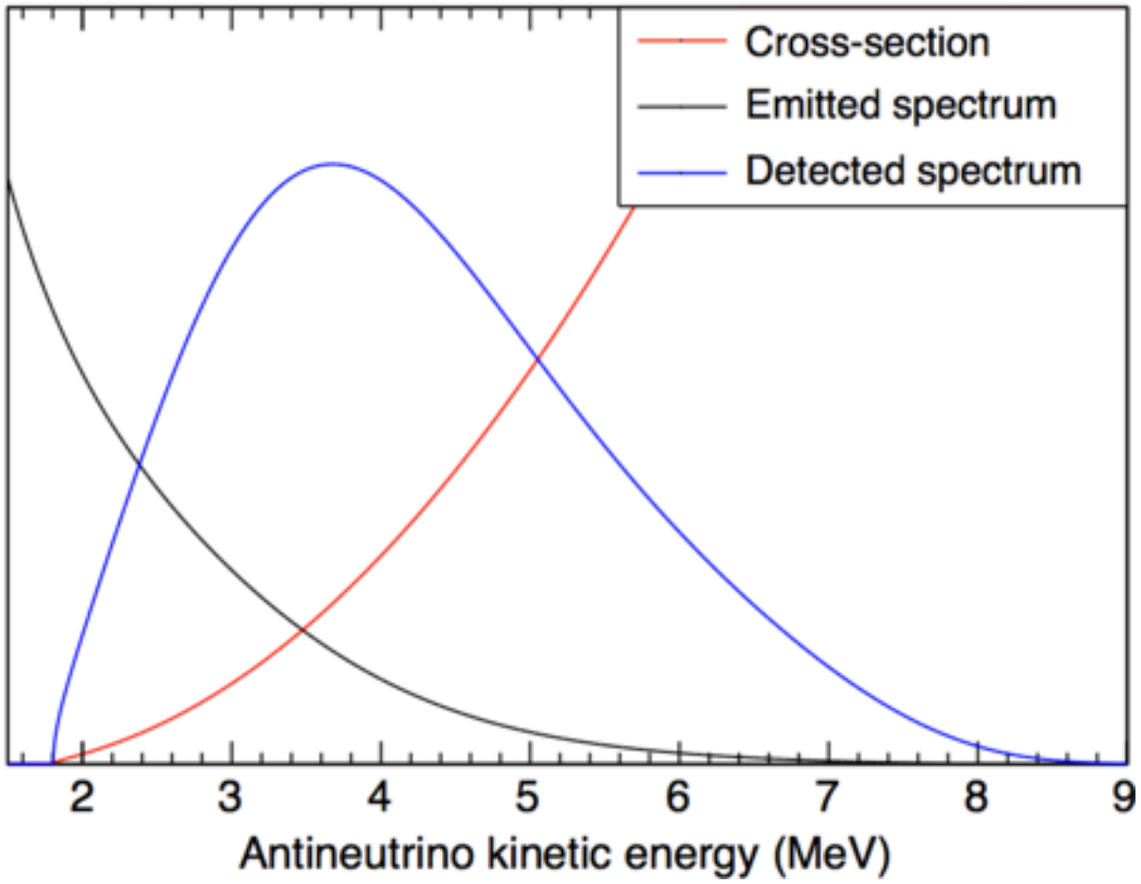
- **N**eutrino **E**xperiment for **O**scillation at **S**hort baseline (previously introduced as Hanaro)
- Updates since Applied Antineutrino Physics 2014:
  — Experimental site determined,
  — Main detector design finalized, under construction.
- Data taking starts in two month!
- Today's focus mainly on preparation of the experiment.

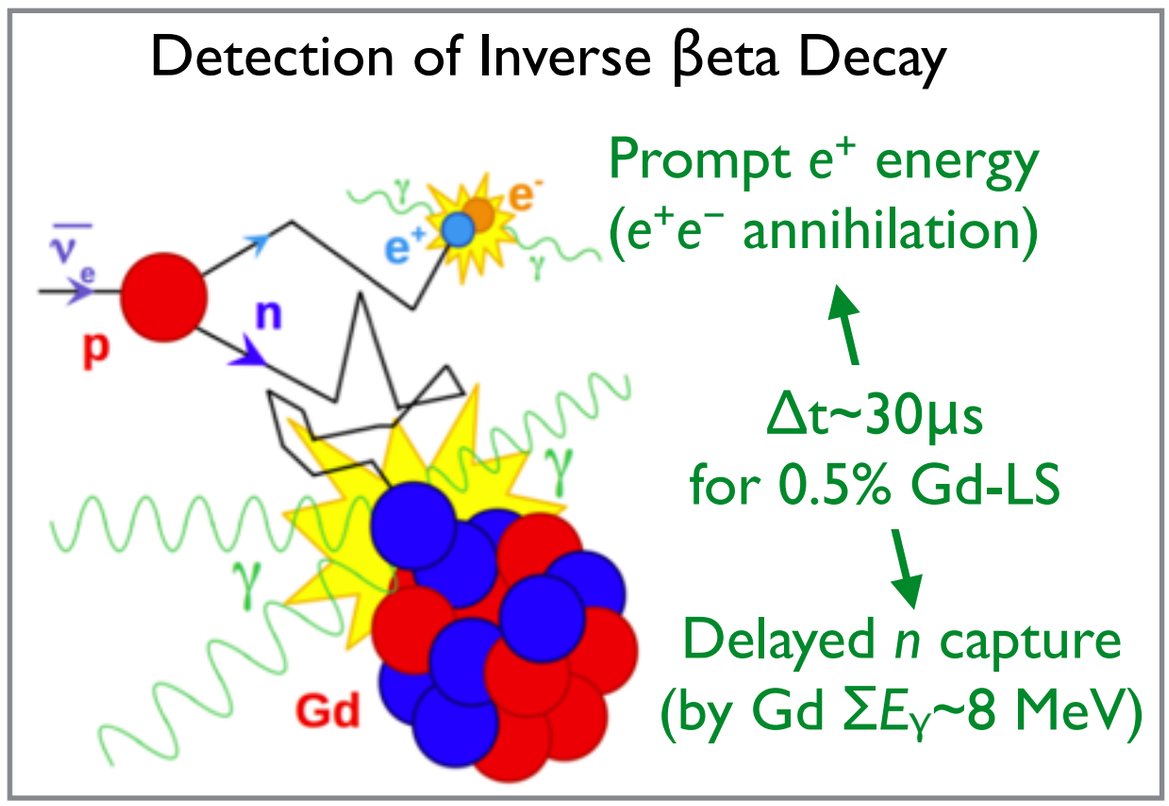
Reactor $\bar{\nu}_e$ and Detection

- Nuclear fission: β-decays from ^{235}U, ^{239}Pu, ^{241}Pu, ^{238}U, … :

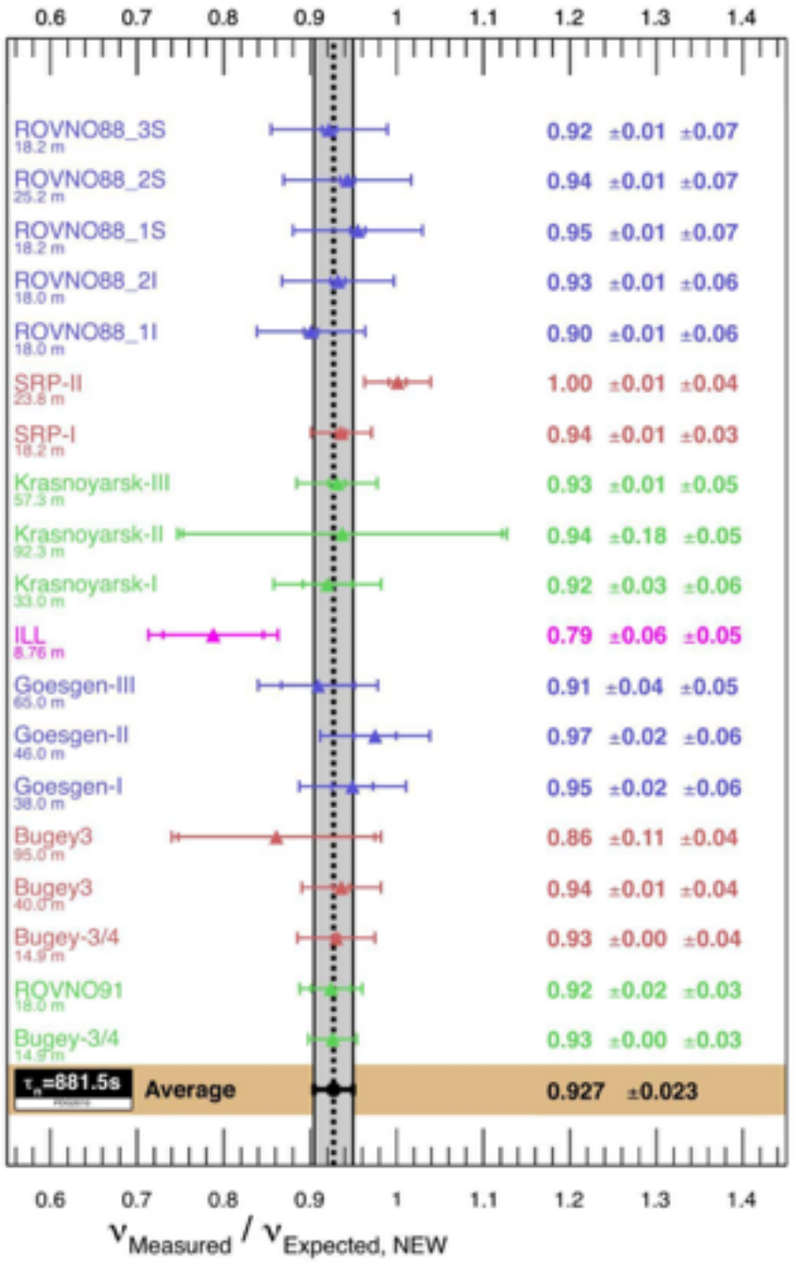
$$n \rightarrow p + e^- + \bar{\nu}_e$$

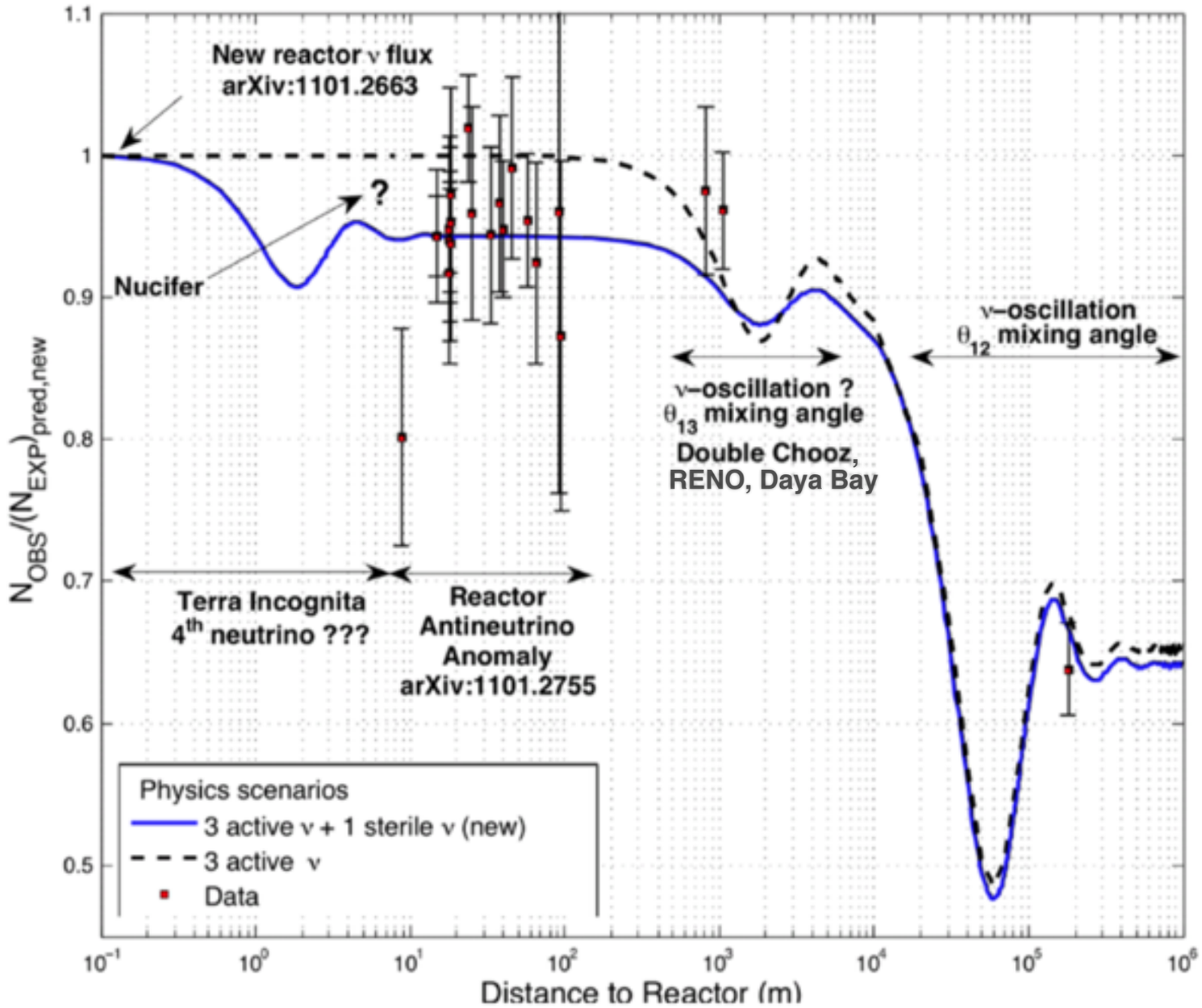
- Detection using Inverse β-Decay : $\bar{\nu}_e + p \rightarrow e^+ + n$
- From 1 GW_{th} nuclear reactor, ~2×10^{20} $\bar{\nu}_e$ per second.
- $\bar{\nu}_e$ at short baseline : particle physics & safeguard purpose





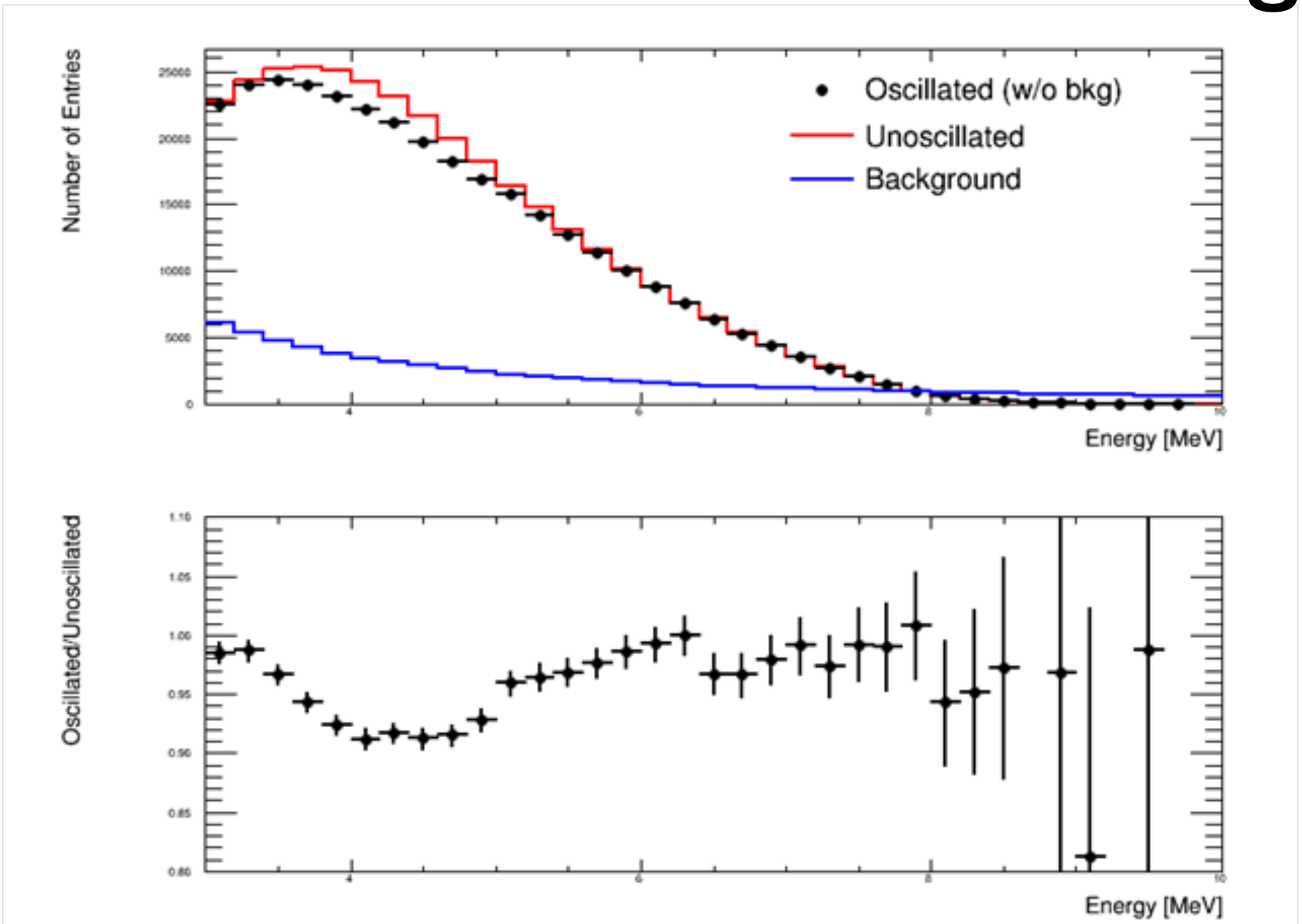
Reactor Anomaly & Sterile ν





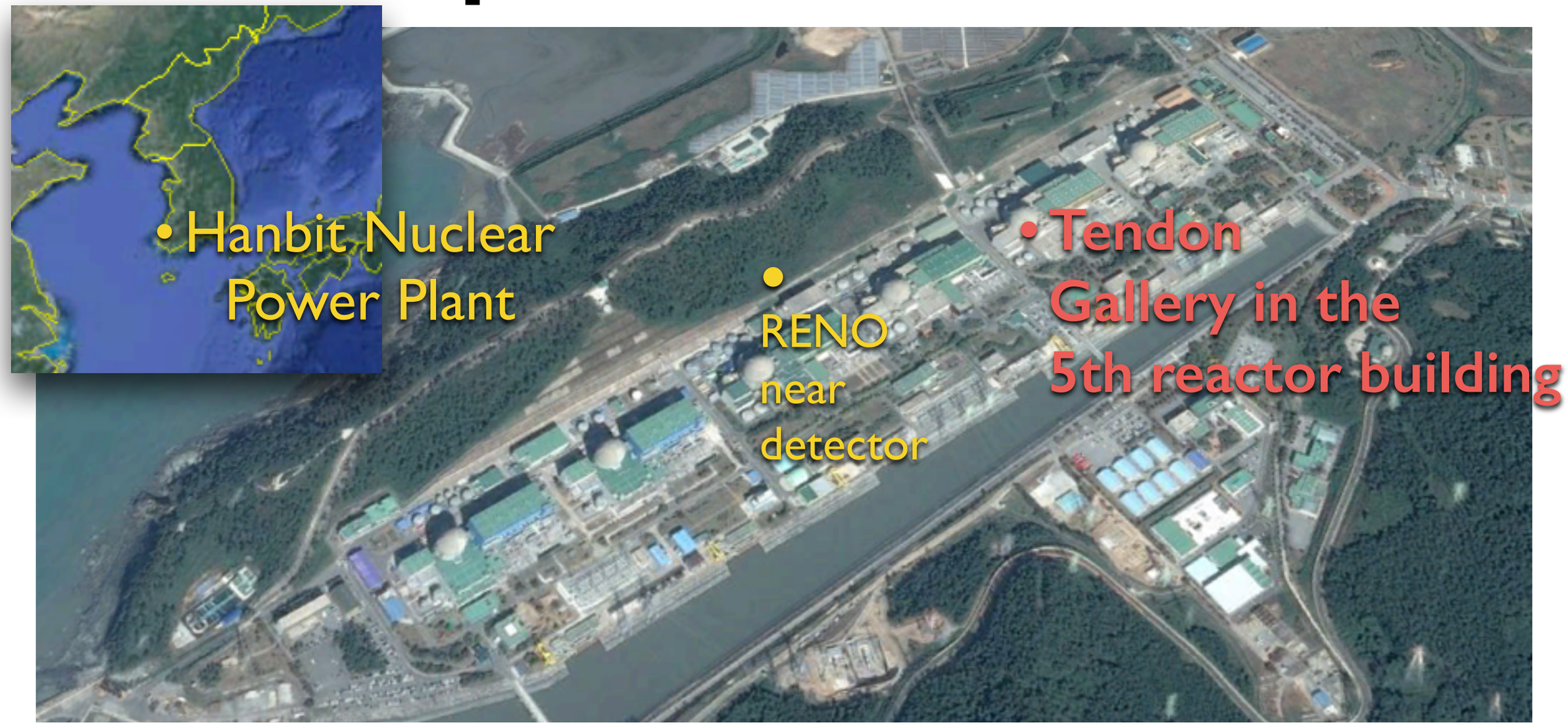
$$P_{ee} \sim 1 - \sin^2(2\theta)\,\sin^2[1.27\ \Delta m^2\ (\mathrm{eV}^2)\ L\ (\mathrm{m})\ /\ E\ (\mathrm{MeV})]$$

Oscillation In Terms of Energy



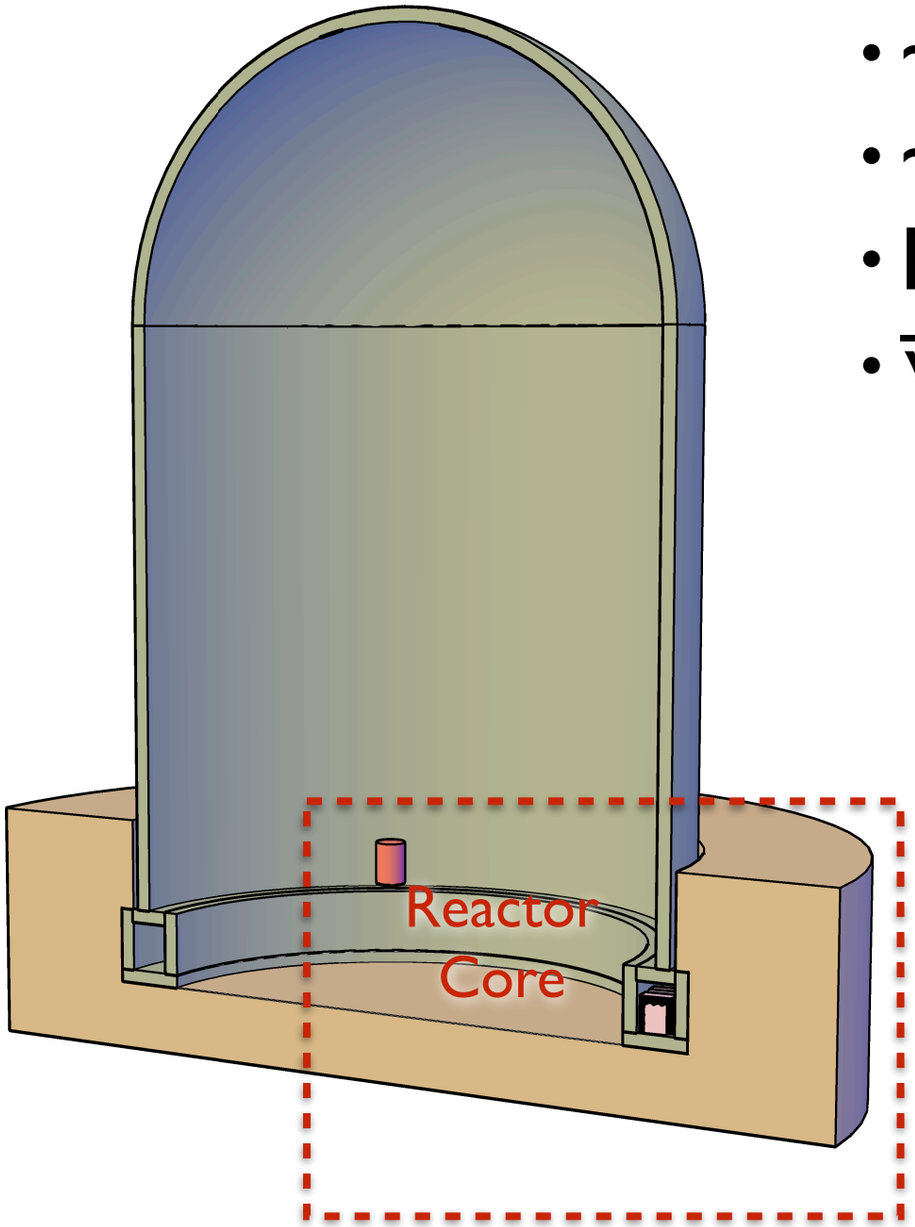
$\Delta m_{14}^2 = 0.6\ \mathrm{eV}^2$, $\sin^2 2\theta = 0.1$, $L \sim 26$ m

Experimental Site

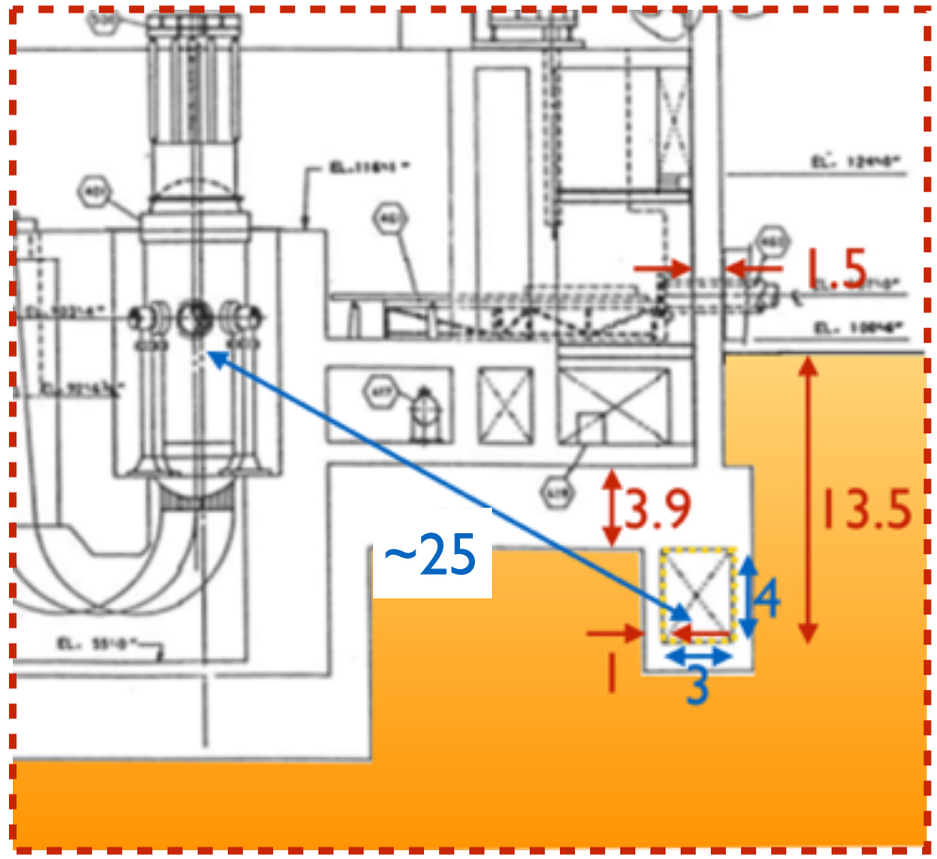


Candidate	Baseline (m)	Thermal Power (W)	Overburden (m.w.e.)	Expected S / B	Consideration
Hanaro	6	30 M	0~	<0.2	off during 2015
Kijang	5	15 M	~23	>~1?	After 2017
Hanbit	25	2.8 G	15~30	5	Commercial

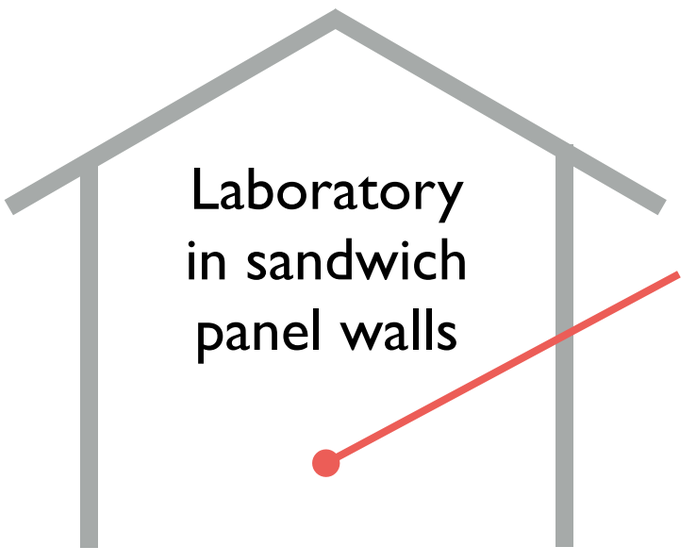
Tendon Gallery at Hanbit



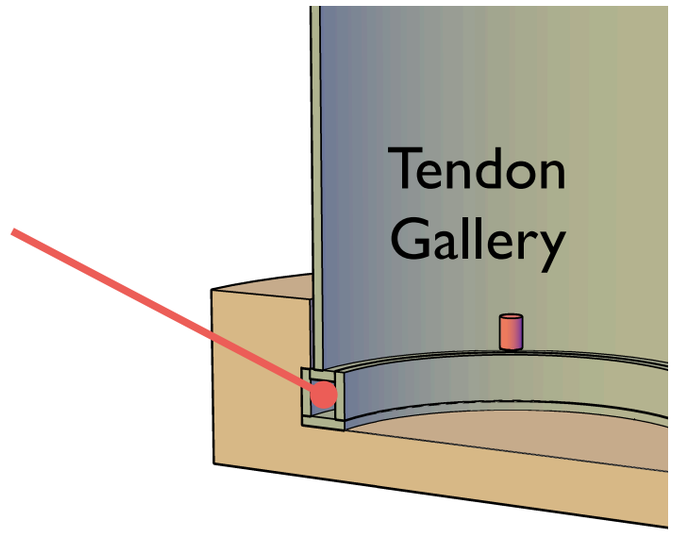
- ~25 m from 2.8 GW_{th} reactor
- ~10 m concrete overburden
- Expected signal / background >~5
- $\overline{\nu}_e$ event : ~1000 / day (1 ton LS)

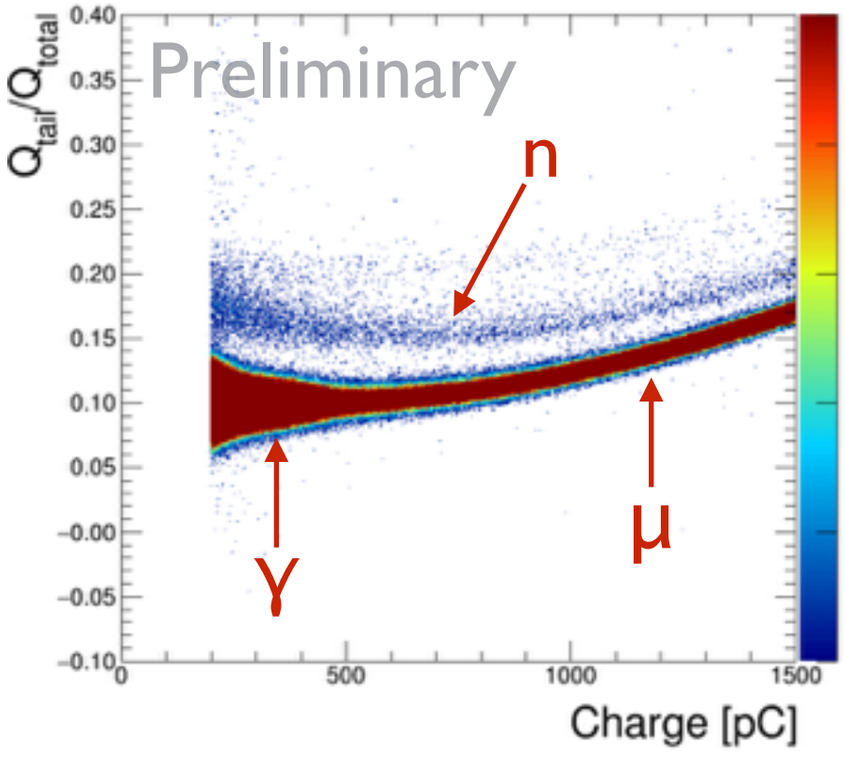


Background in Tendon Gallery

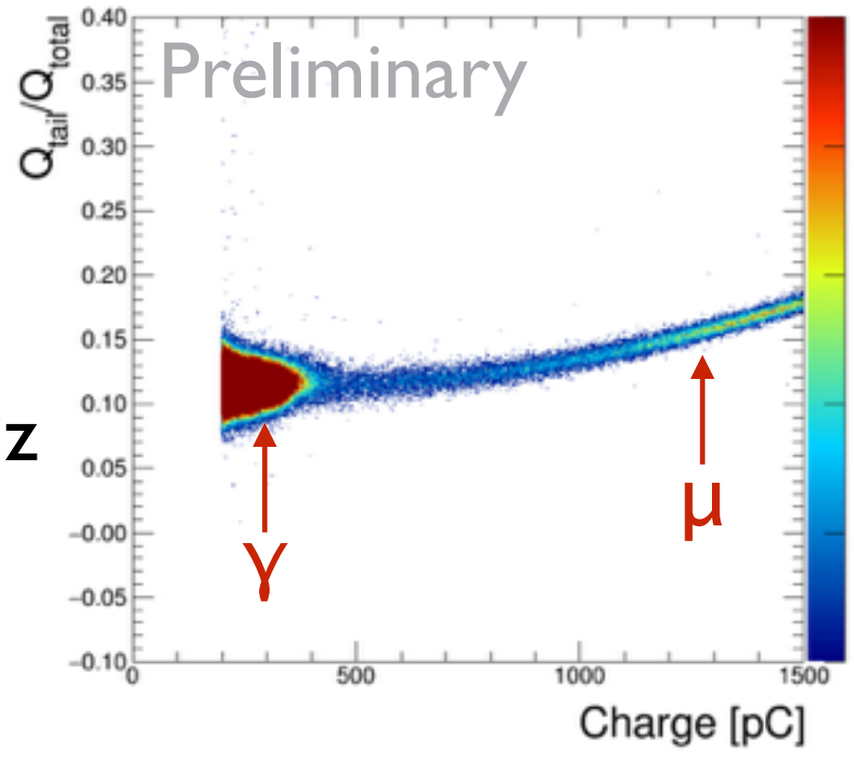


UG-F 700 mL + R877-100 (5”)

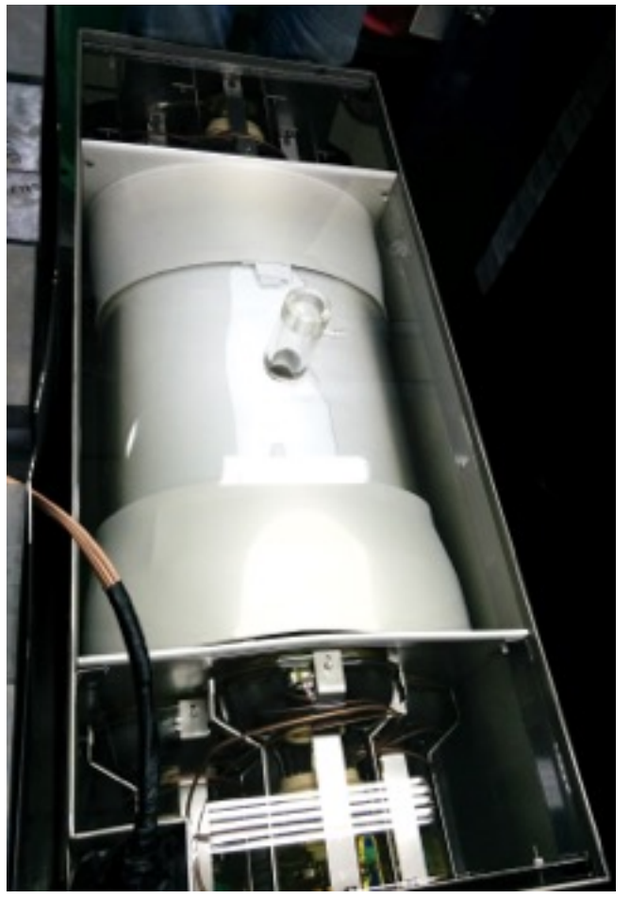


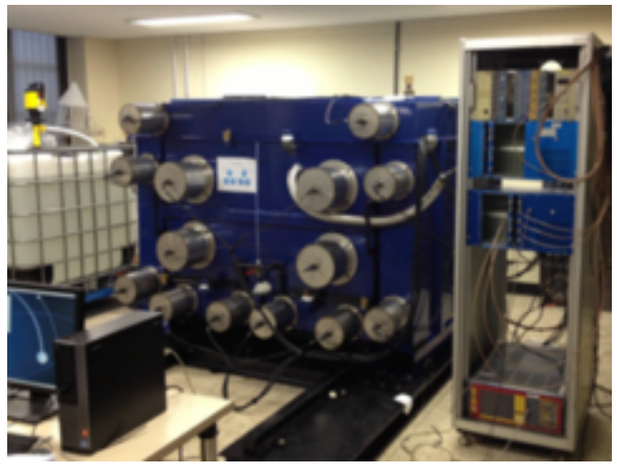


- Trigger rate:
  78Hz *vs* 90Hz
- Neutron rate:
  0.025Hz *vs* <0.001 Hz

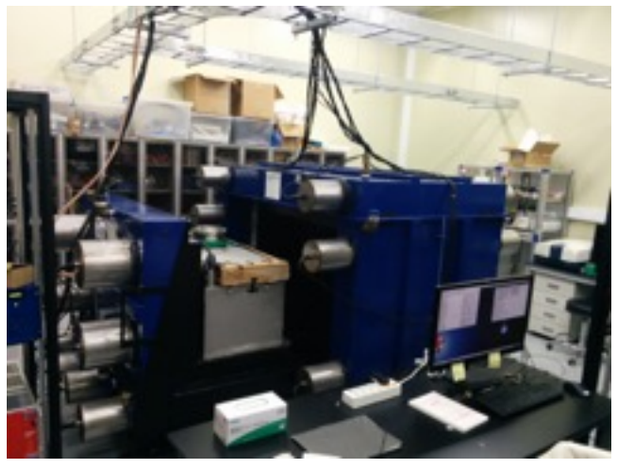


Study with Prototype





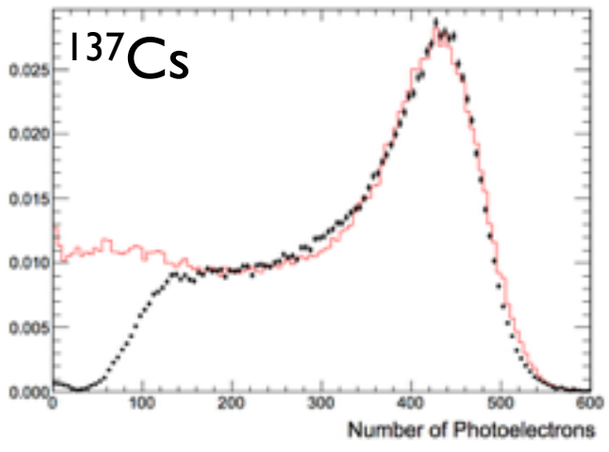
Sejong University

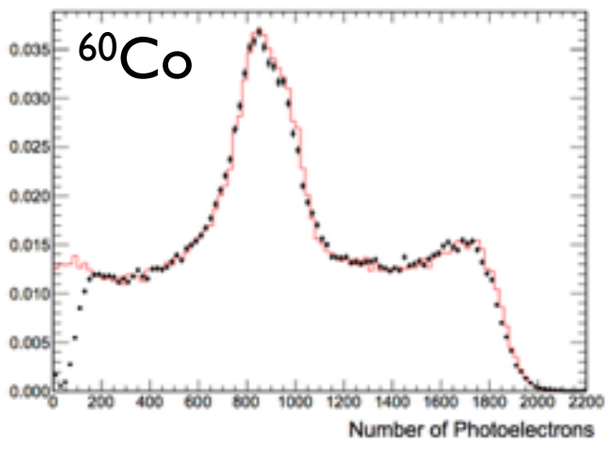


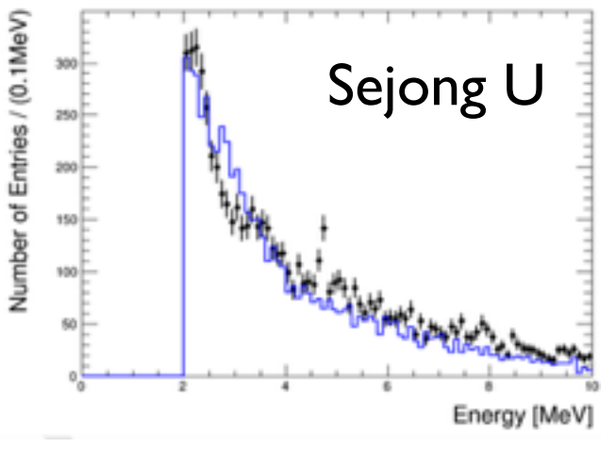
CUP Lab in Daejeon

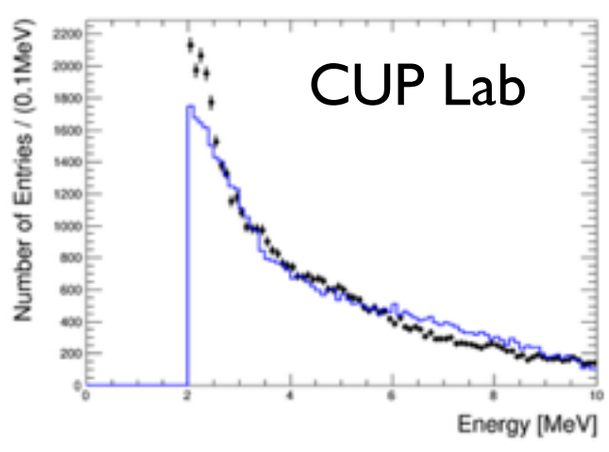
Hanaro Reactor

- 50L 0.5% Gd-LS in acrylic cylinder seen by 6 R5912.
- 4π LS μ-veto and 10 cm Pb shield.
- DAQ / calibrations / background & shielding / MC.





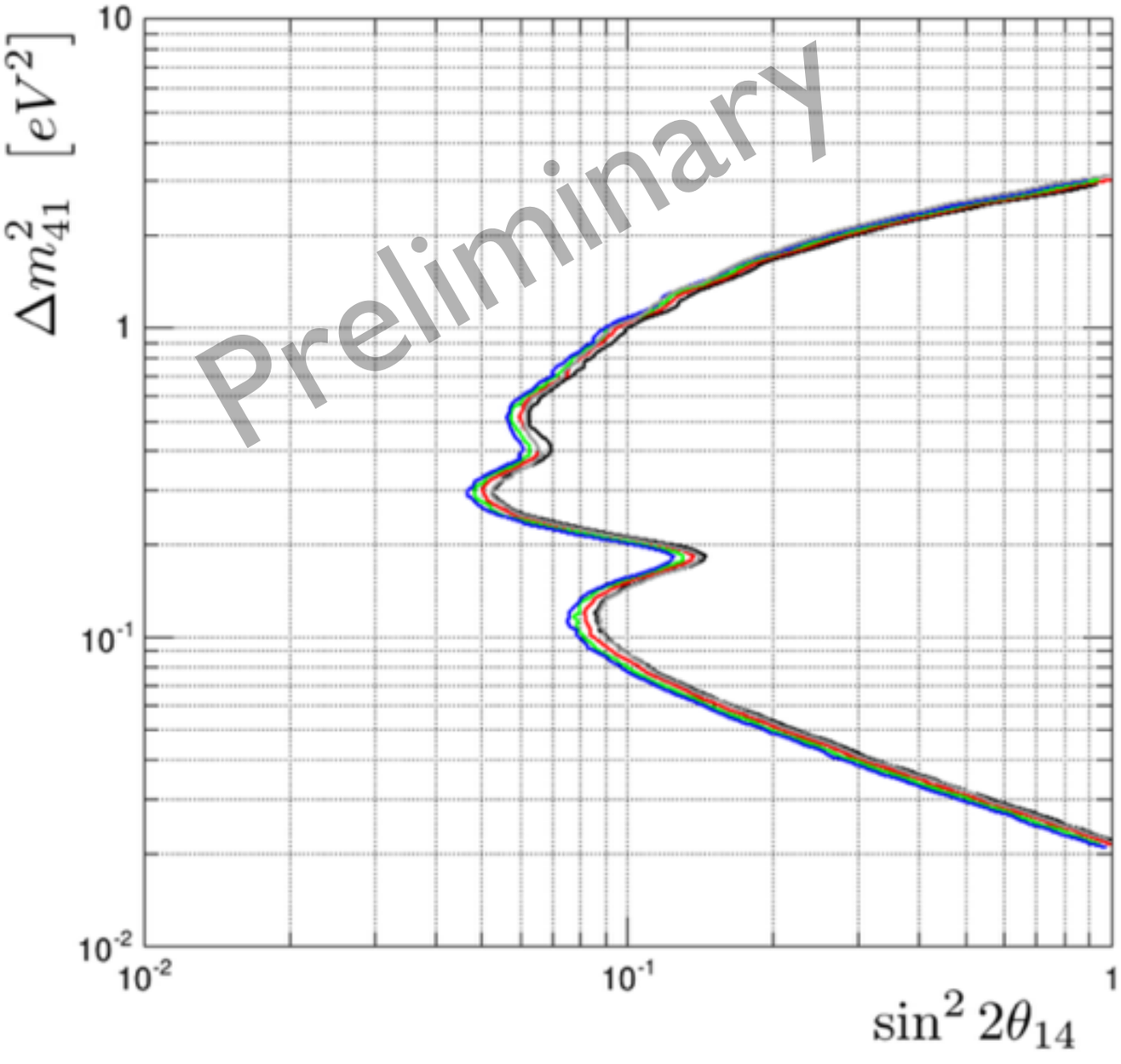




Main Detector Design Principle

- Large enough to collect $\overline{\nu}_e$ events efficiently,
- Small enough to fit in a limited space in the tendon gallery: 3m width x 4m height,
- Energy resolution — minimizing the loss of scintillation γ.
  → phototube configuration, reflecting material,…
- Light / radioactive source calibrations
- Considering active/passive shielding for μ, γ, *n*,…

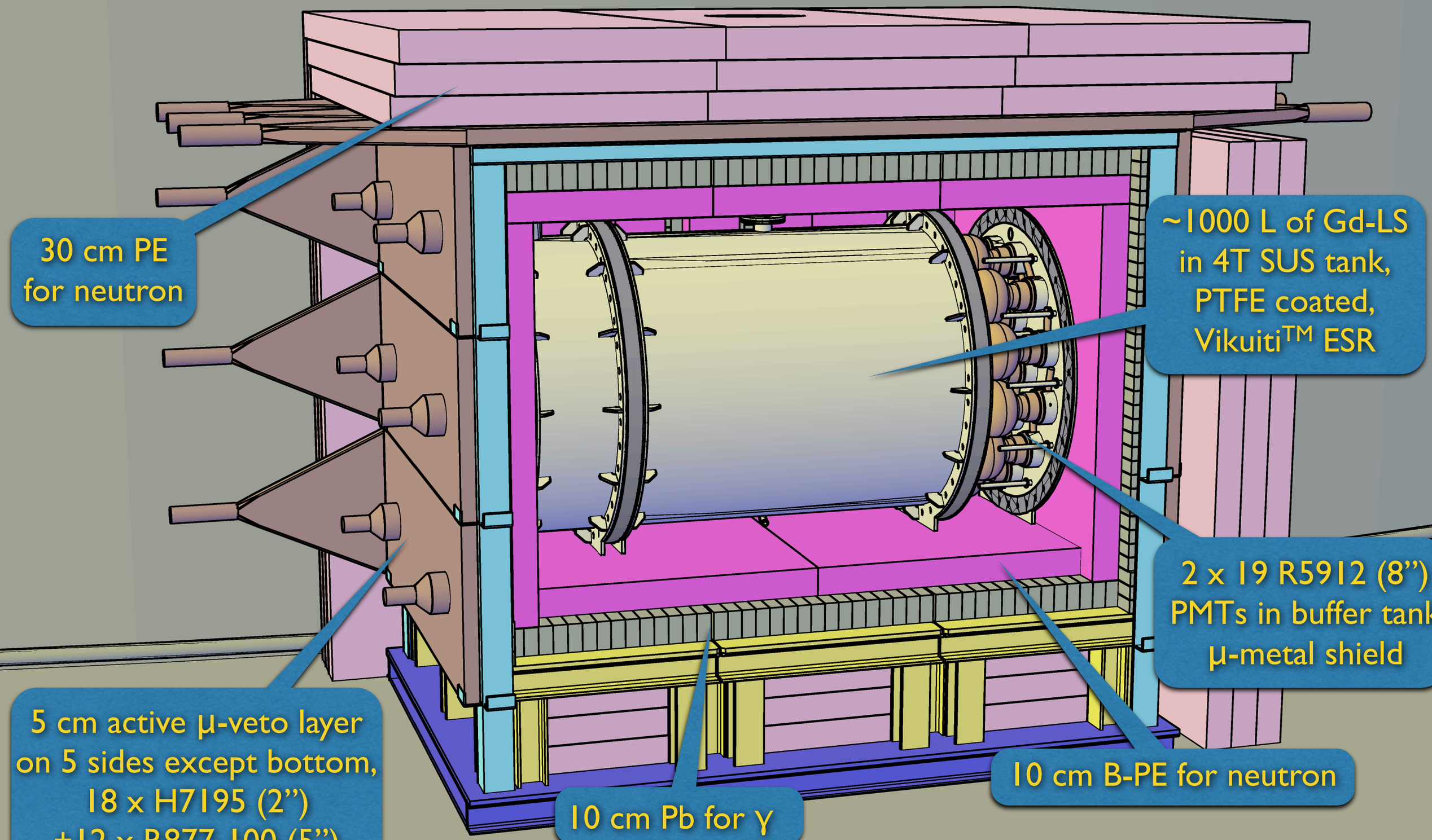
Design and Sensitivity



0.5 years data / 95% C.L.

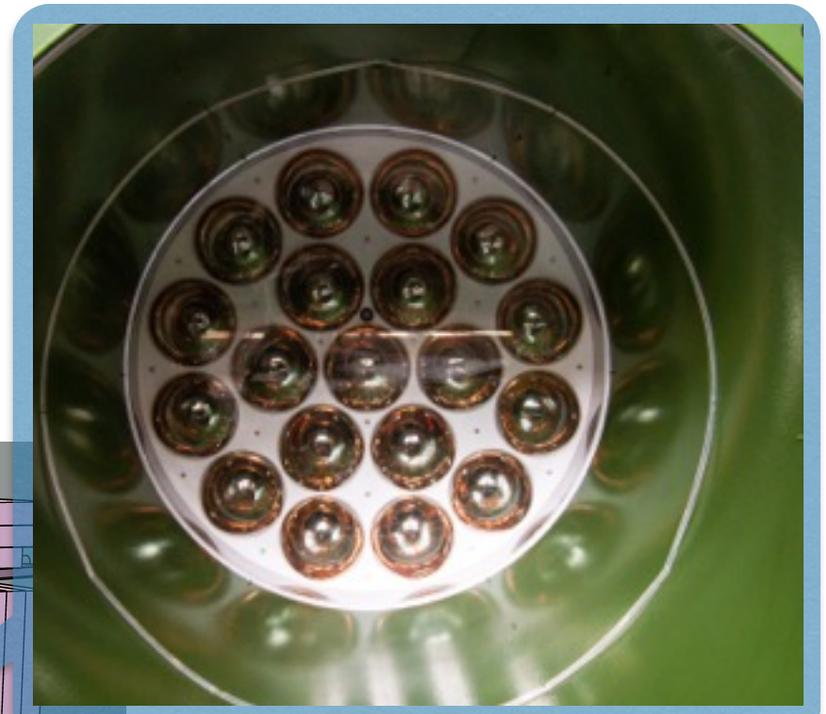
Radius (cm)	Length (cm)	γ-catcher thickness
42.5	100	0
42.5	100	15 cm
47.5	100	0
52.5	100	0
52.0	120	0

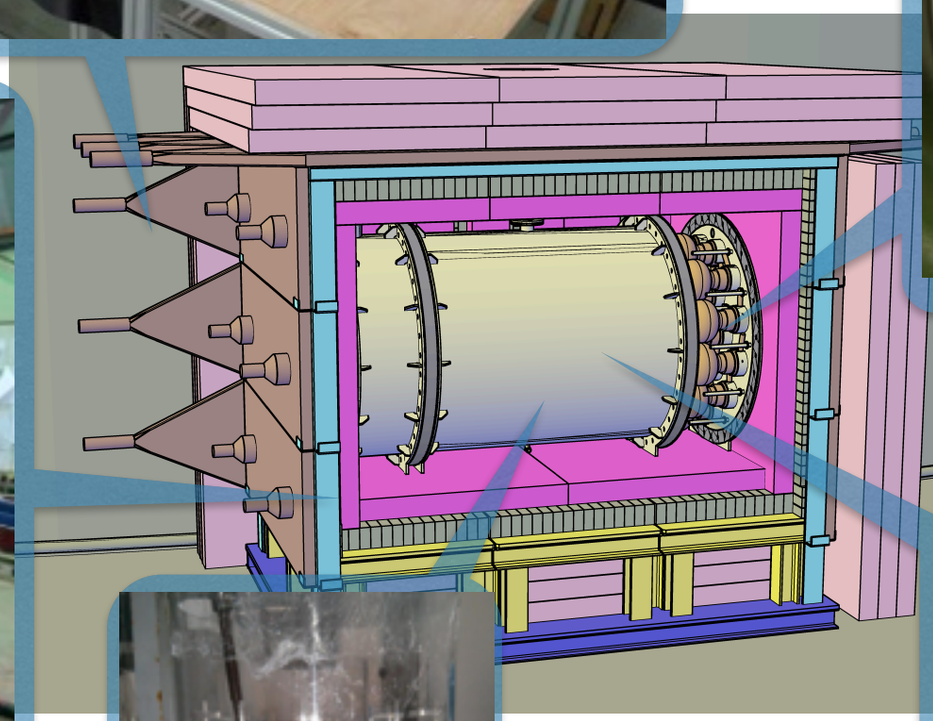
NEOS Main Detector



Main Detector Under Construction

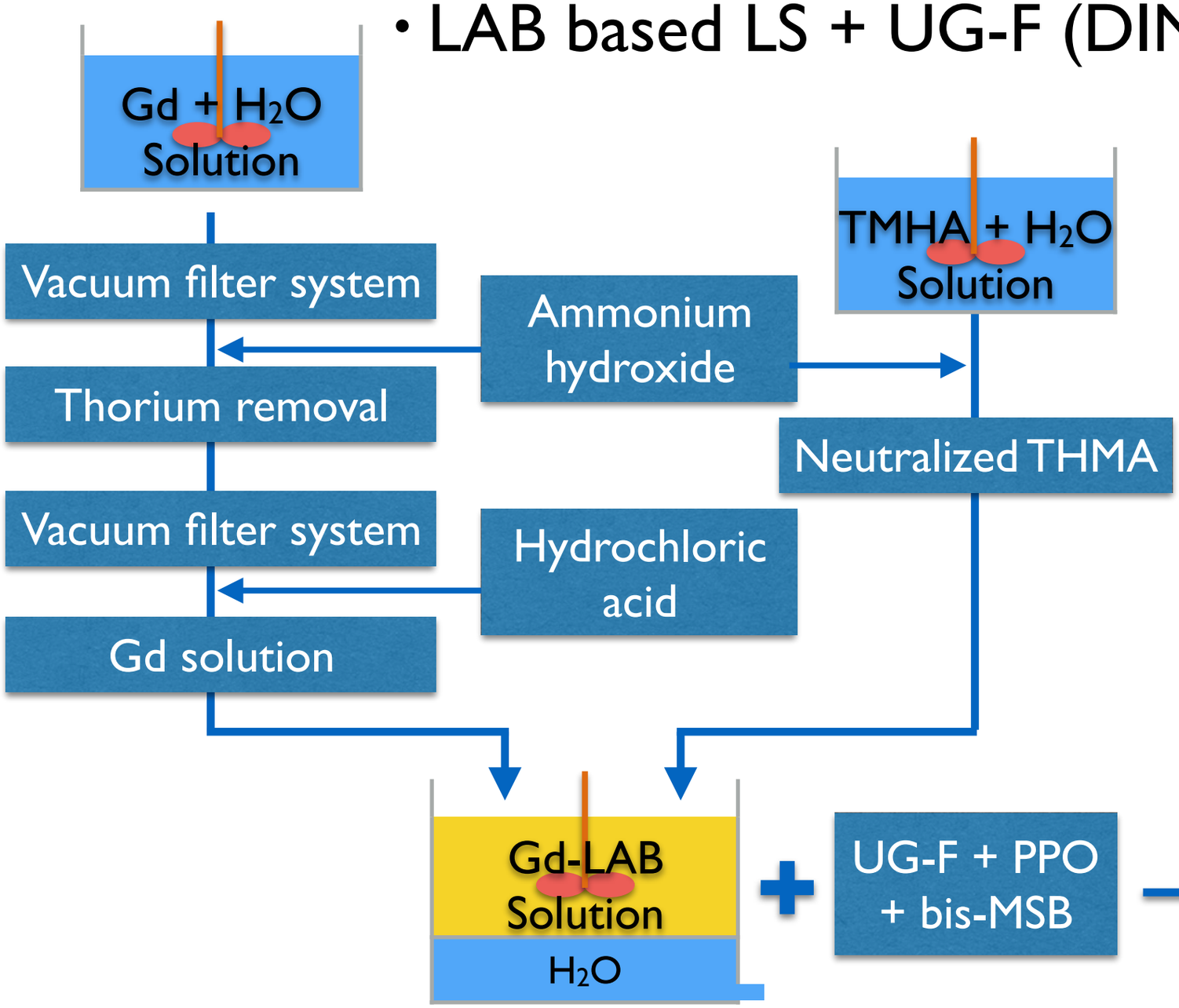
@ Korea Atomic Energy Research Institute

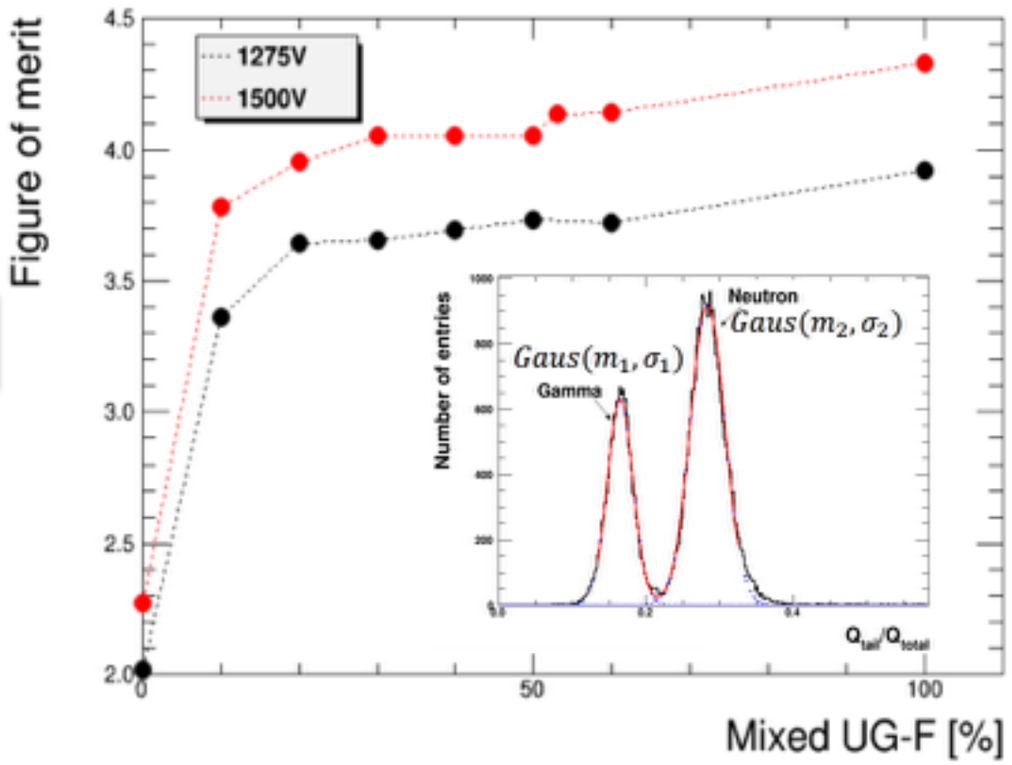




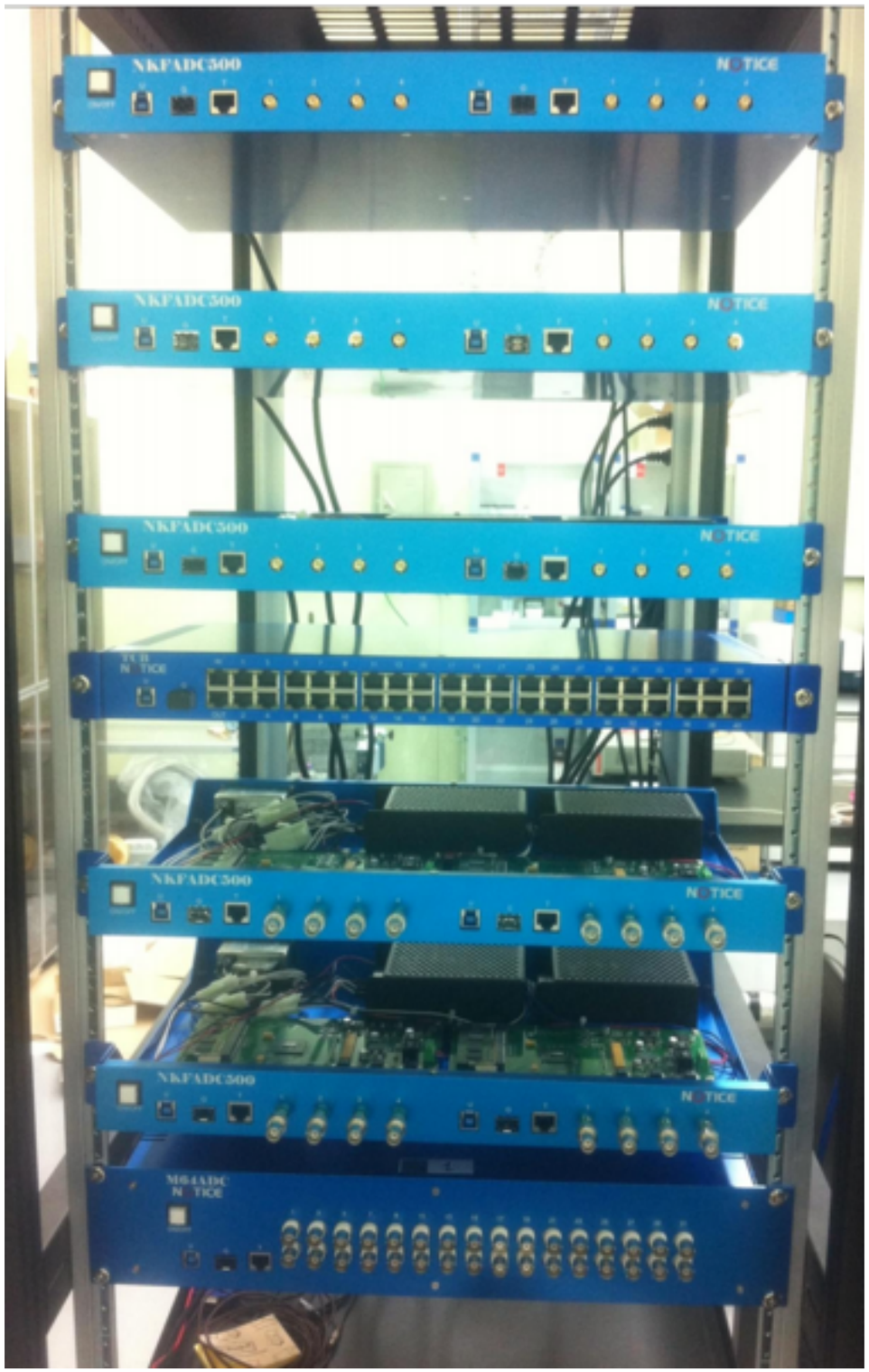
Liquid Scintillator

- 1020 litres of 0.5% Gd LS for the main detector
- LAB based LS + UG-F (DIN) → Better PSD than ever





Data AcQuisition



- 38 channels for the main detector:
  - 500 MHz FADCs for waveform analysis (PSD)
  - Multiplicity trigger for main event
  - Independent pedestal monitoring

- 30 channels for the muon veto detector:
  - Veto purpose only, 64 MHz FADC

- One trigger board controls synchronisation

- Estimated data size :
  ~600 Gbytes / day / kHz

NEOS Collaboration

Hongjoo Kim, Jooyoung Lee,
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Kyungkwang Joo, Ba Ro Kim, Seoung Chan Kim,
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Jinyu Kim, Kyungju Ma, Yeongduk Kim,
Eun-ju Jeon, Jaison Lee, Jeong-Yeon Lee, Moo-hyun Lee,
Yoomin Oh, Hyangkyu Park, Kang-sun Park,
Gwang-Min Sun, Boyoung Han, Hyunseo Park

Summary & Schedule

- Reactor $\overline{\nu}_e$ experiment at a short baseline may provide a solution for the reactor anomaly, and verify the existence of a sterile neutrino.
- For NEOS experiment, the detector of 1000 L Gd-LS is under construction and commissioning.
- Data taking will be started from this summer, in the tendon gallery of Hanbit nuclear reactor.

~Jul 2015	Aug~Sep 2015	Oct 2015~Mar 2016 ~ …
Detector Construction & Commissioning & Installation on site	Reactor Overhaul Maintanance	Reactor On
	Reactor Off data	Reactor On Data