



NEON(Neutrino Elastic-scattering Observation with NaI(Tl)) Experiment

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On behalf of the NEON collaboration

CENTER FOR UNDERGROUND PHYSICS

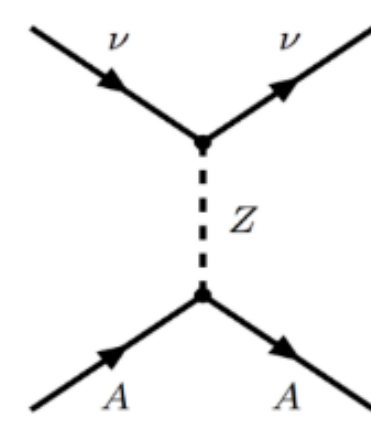


Abstract

NEON(Neutrino Elastic-scattering Observation with NaI(Tl)) aims an observation of a coherent elastic neutrino-nucleus scattering (CEvNS) using reactor electron antineutrino with NaI(Tl) crystal detectors at Hanbit nuclear power plant in Yeonggwang, South Korea. The NEON pilot detector consists of a 15 kg NaI(Tl) target mass which will be installed 24 meters from the reactor core. Currently, the detector was installed in Institute for Basic Science Headquarter(IFS HQ) basement with a shielding including 700 L liquid scintillator, 10 cm lead and 2.5 cm borated polyethylene, and 30 cm high density polyethylene. We are testing data stability and studying the NaI(Tl) crystal background and threshold. We are planning to install the detector in the reactor and run the experiment in this fall.

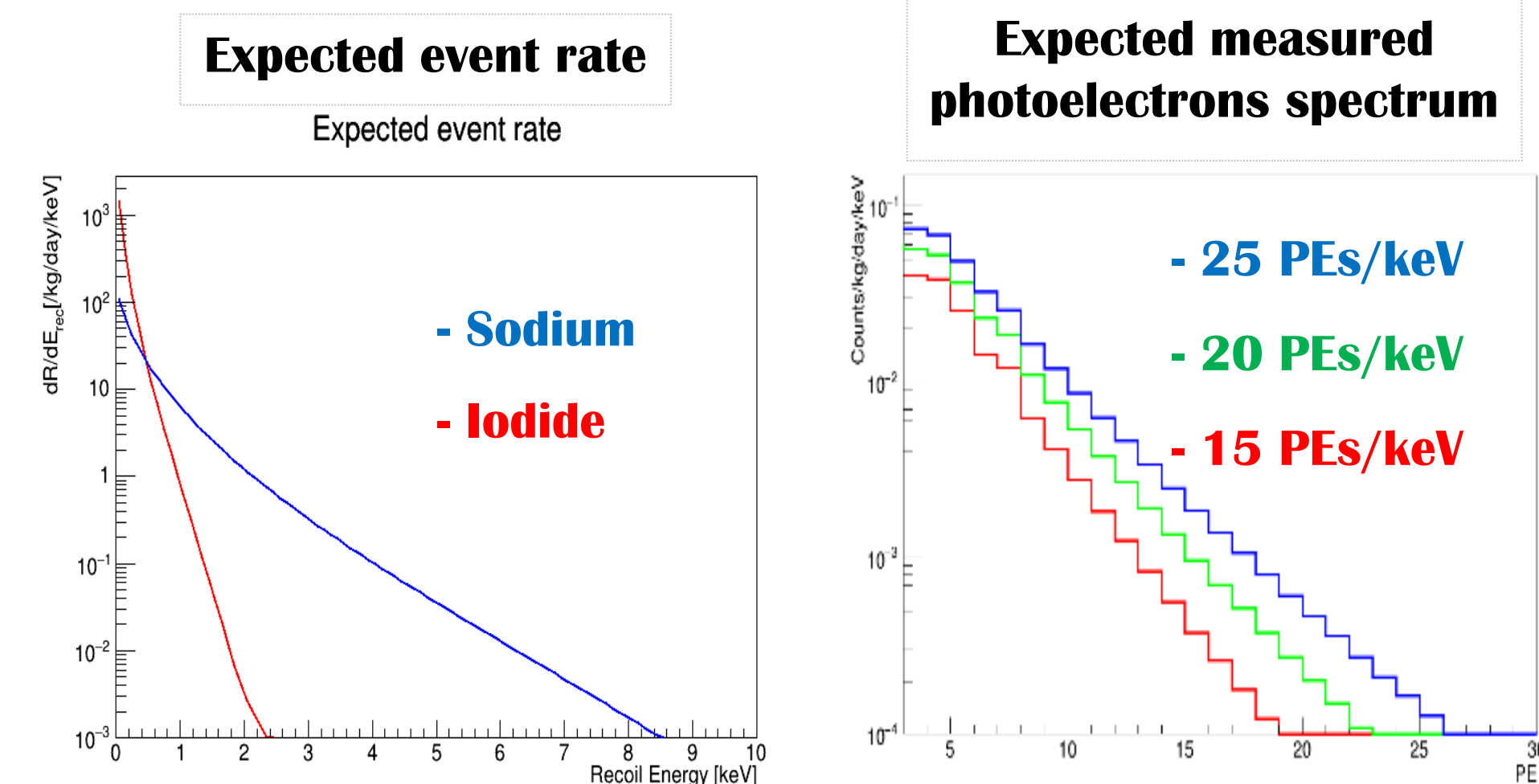
Motivation

- To observe coherent elastic neutrino-nucleus scattering for reactor neutrinos
- Study new physics
 - ✓ Neutrino magnetic moment
 - ✓ Neutrino non-standard interaction
- Reactor monitoring
- Neutrino-electron scattering



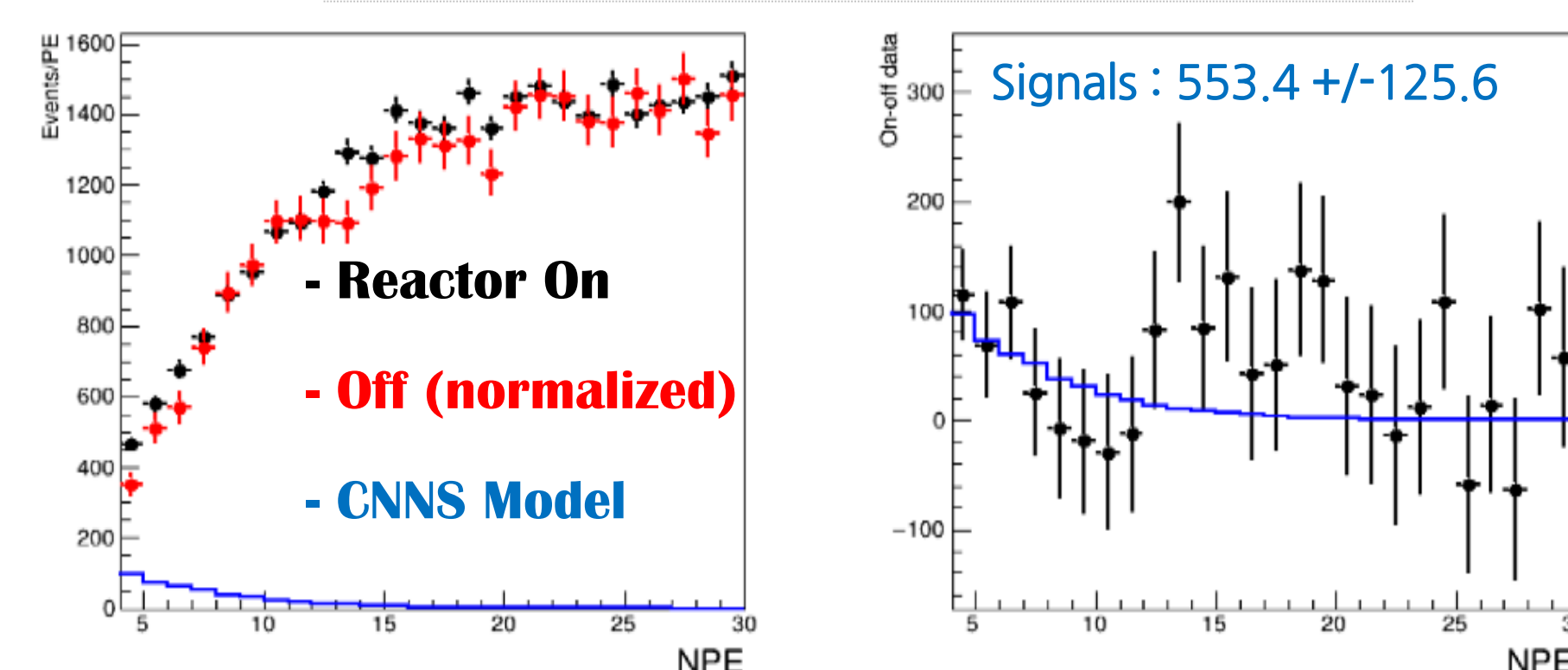
Sensitivity

$$\text{Event rate CEvNS: } \frac{dR}{dE_{rec}} = N_t \int_{\sqrt{E_{rec}M}}^{\infty} dE_{\nu} \Phi(E_{\nu}) \frac{d\sigma(E_{\nu}, E_{rec})}{dE_{rec}}$$



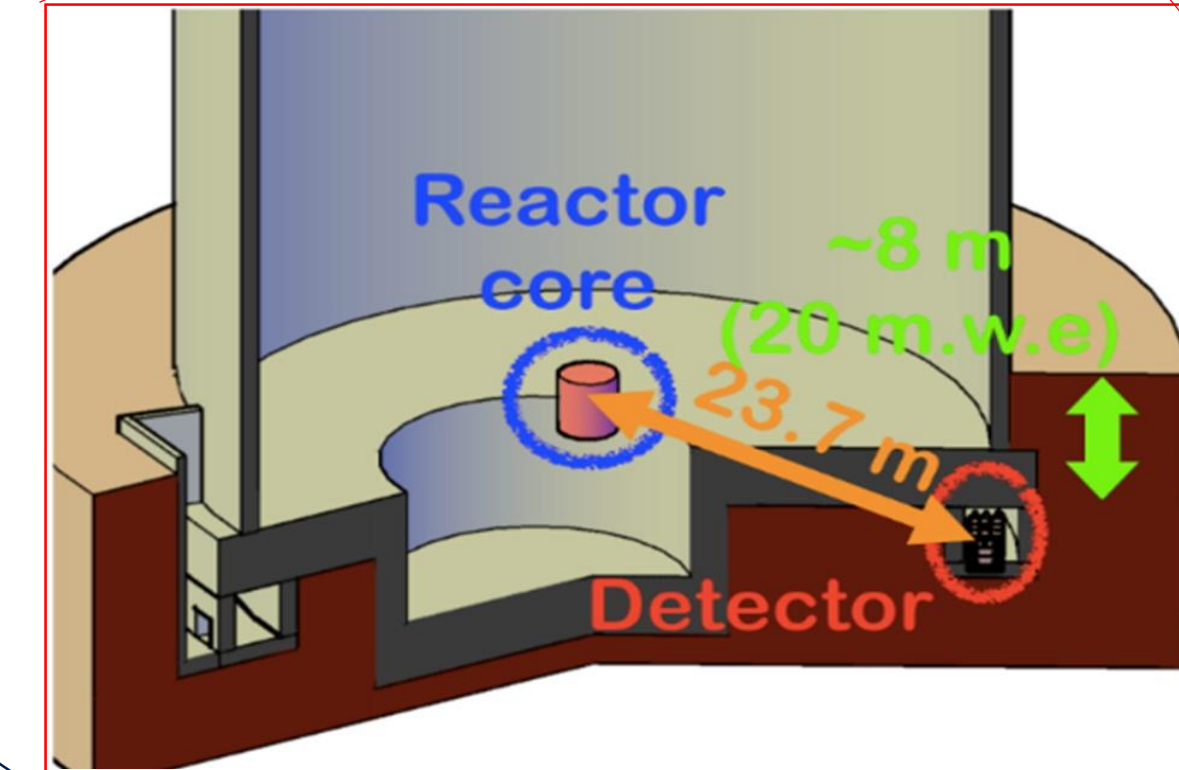
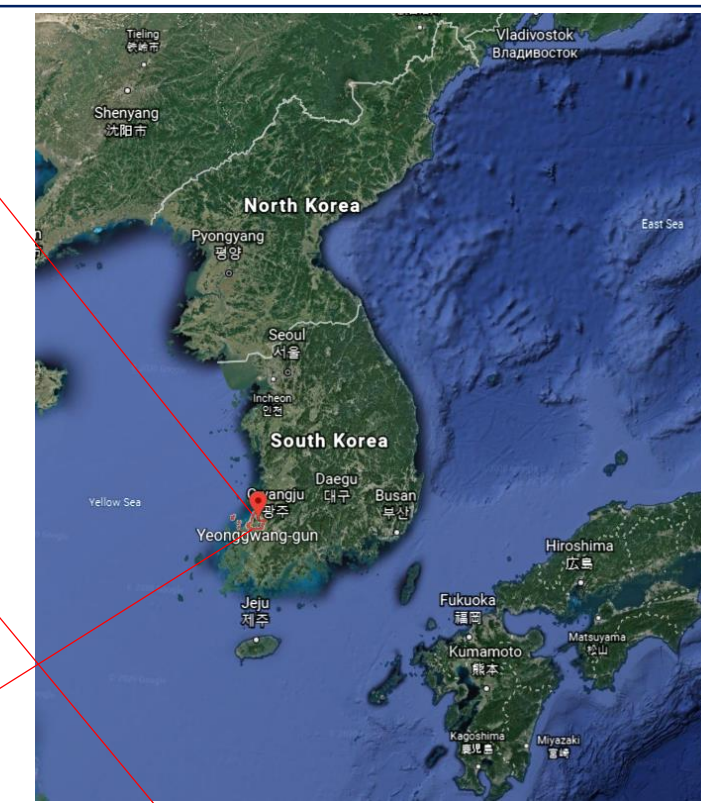
- Considering quenching factor, resolution and trigger efficiency of the COSINE-100 experiment to estimate measured photoelectrons spectrum
- The detector **light yield** is critical to detect CEvNS

An example of the pseudo experiment



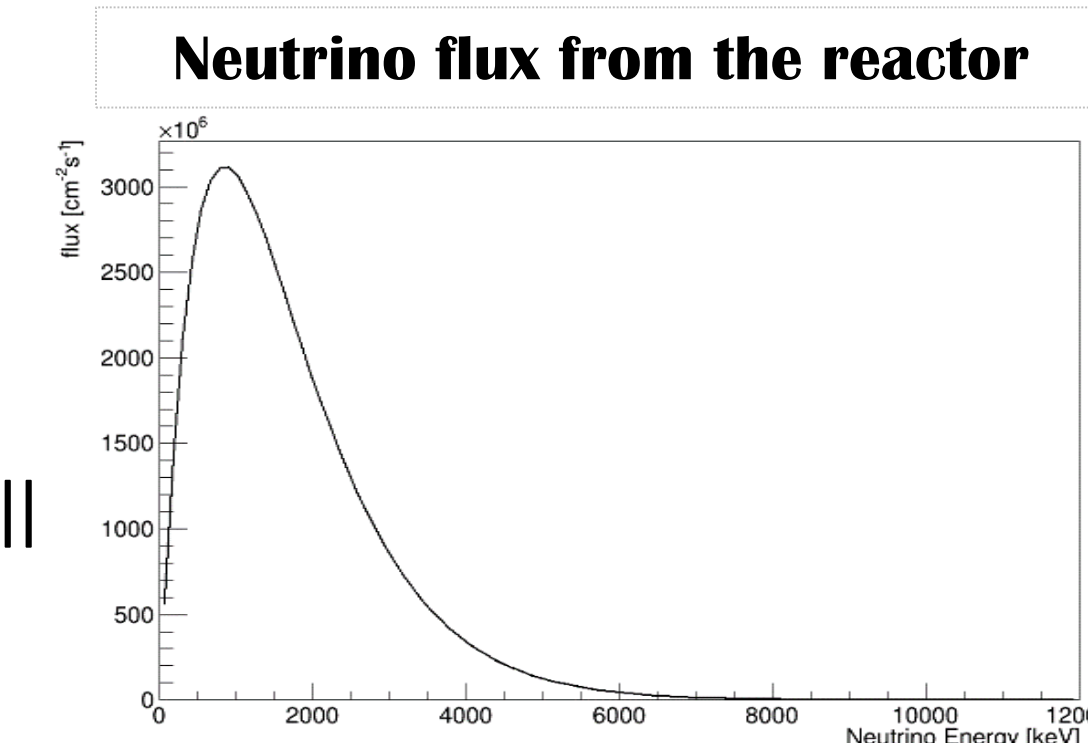
- Assumption for sensitivity study
 - ✓ ~10-counts/kg/day/keV (dru) flat background
 - ✓ 10-kg mass of detector
 - ✓ 365/100-days reactor-on/-off data
 - ✓ 25-photoelectrons/keV (Pes/keV) light yield
 - ✓ 4-PEs threshold
- Significance level: $4.5 \pm 0.7 \sigma$ (1000 iteration pseudo experiments)

Reactor



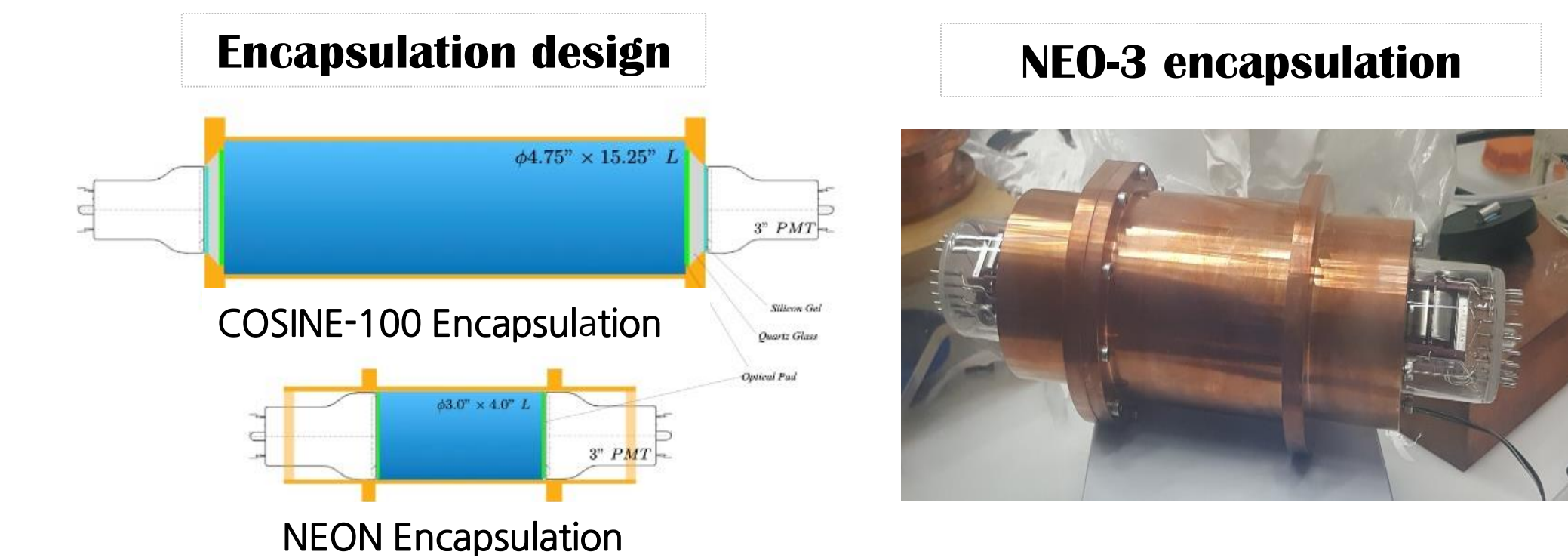
- ✓ Site is next to the NEOS experiment: understand environmental conditions well
- ✓ The experiment is scheduled to install in this fall

- Experiment site: Reactor Unit 6 Tendon gallery of Hanbit Nuclear Power Plant in Yeonggwang, South Korea
- Reactor power: 2.815 GW_{th}
- Distance from the reactor core: 23.7 m
- Overburden: 20 m.w.e
- Expected Neutrino flux at experiment site: $7.1 \times 10^{12} \text{ cm}^{-2} \text{ s}^{-1}$



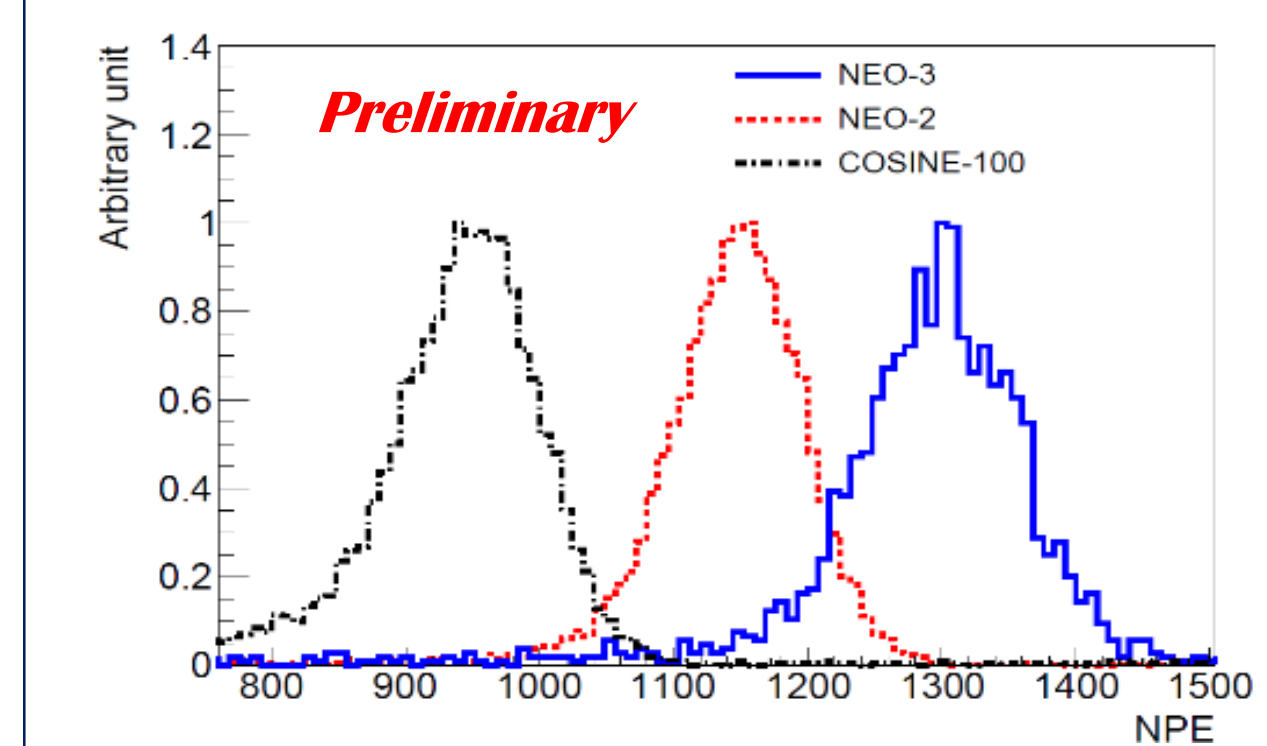
NaI(Tl) Detector R&D and Background Study

- A NaI(Tl) crystal should be encapsulated to block moisture



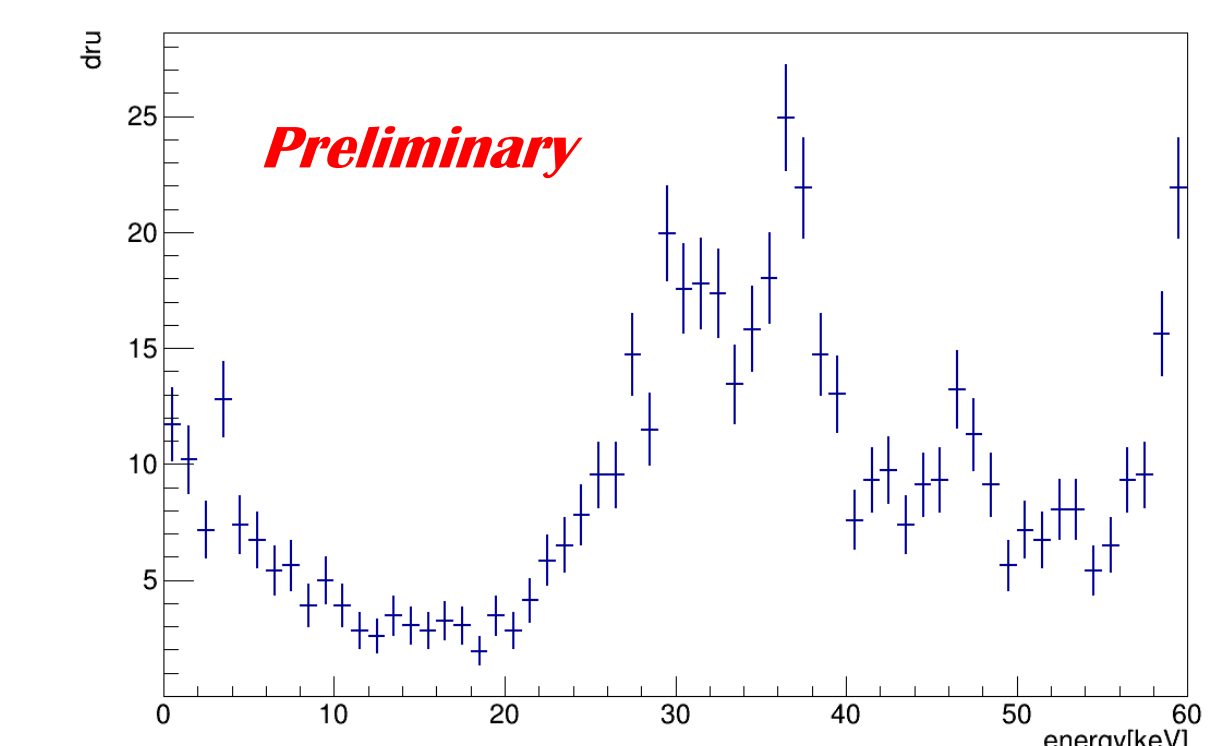
- We developed new encapsulation design to **reduce light loss**
 - ✓ Matched the crystal diameter size to the PMT size
 - ✓ Minimized material between the crystal and the PMT

NPE distribution at ²⁴¹Am gamma peak(59.54 keV)



- Compared to the COSINE crystal, **20~40 % Light yield improved!**

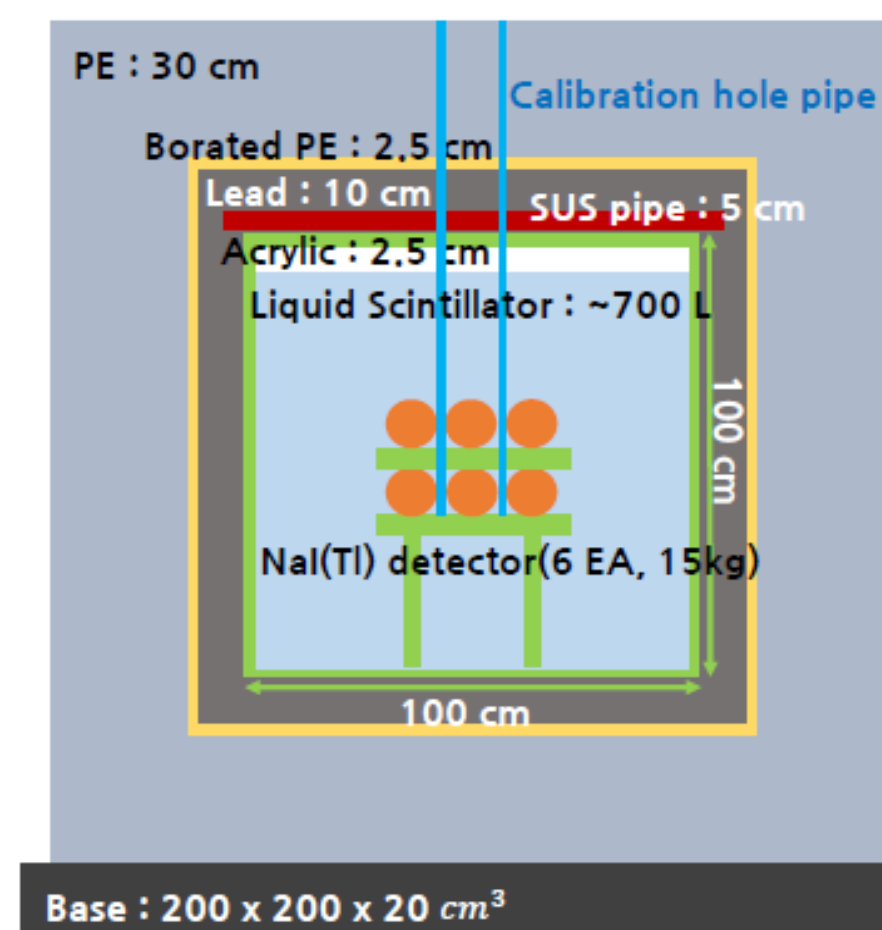
NEO-5 single background spectrum



- We took data at Institute of Basic Science Laboratory basement

- ✓ Tagging single events by Liquid scintillator
- ✓ Because of muon veto, trigger efficiency was considered: 64.6 %
- Background between 5-20 keV: **4 counts/day/kg/keV**

Shield design and Installation in Institute of Basic Science(IFS) Laboratory



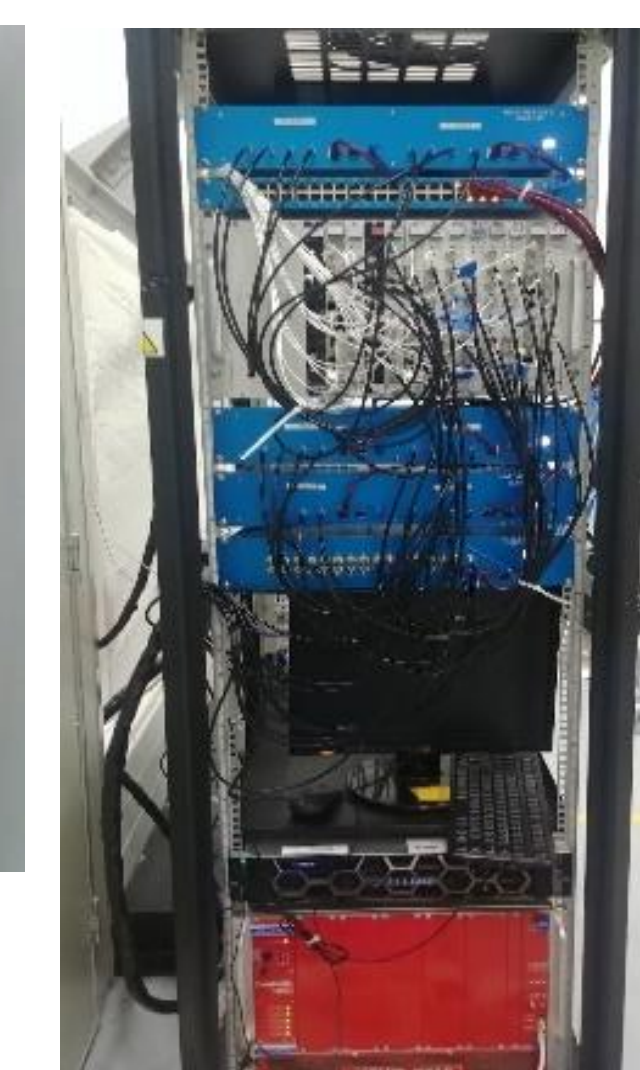
NEON shield design



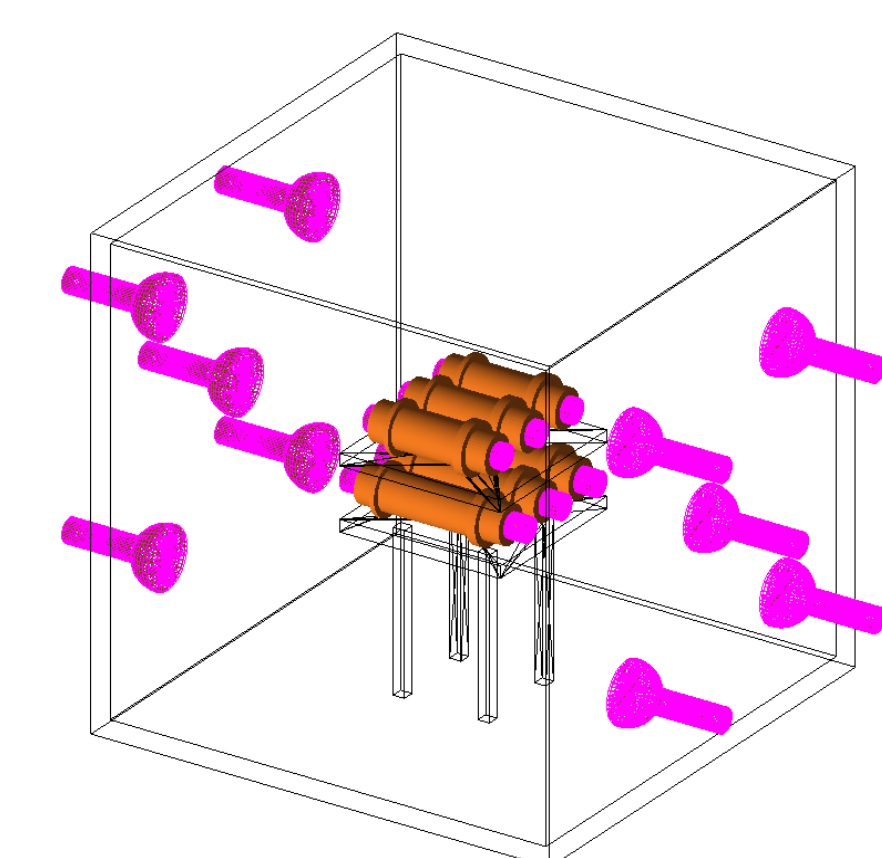
NaI(Tl) detectors in the acrylic box



NEON in IBS HQ basement



Data acquisition system



Simulation geometry

- Array of the NaI(Tl) detector(total 15 kg):
 - ✓ first floor: three crystals(dimension: 3" x 8", mass: 3.36 kg)
 - ✓ second floor: three crystals(dimension: 3" x 4", mass: 1.68 kg)
- Shielding material:
 - ✓ 700-L liquid scintillator(tagging multiple events with ten 5" PMTs)
 - ✓ 10 cm leads, 2.5 cm borated PE, 30 cm HDPE
- The data acquisition(DAQ) system is similar to the COSINE-100 experiment DAQ
- Dry run has begun at IBS Laboratory!
- Simulation study is ongoing

Reference

- [1] D.Z.Freedman, Phys. Rev. D 9 (1974) 1389.
- [2] COHERENT collaboration, Science 357 (2017) 1123.
- [3] COSINE-100 collaboration, Nature 564 (2018) 83.
- [4] COSINE-100 collaboration, Eur. Phys. J. C. 78 (2018) 107.
- [5] NEOS collaboration, Phys. Rev. Lett 118 (2017) 121802.