Status of Neutrino Elastic-scattering Observation with NaI(Tl) experiment (NEON)

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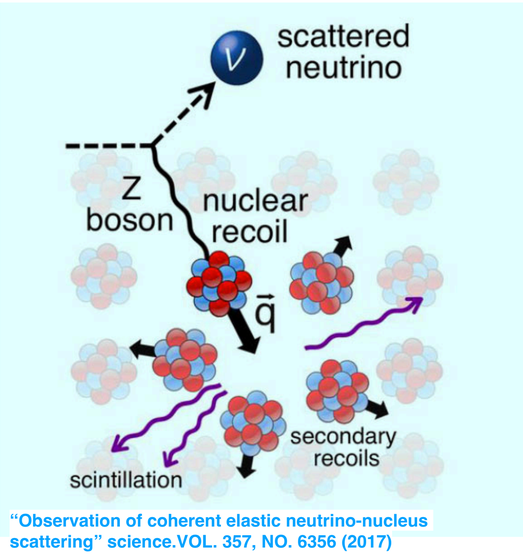
On behalf of the NEON collaboration

ICHEP 2022 Meeting

Motivation

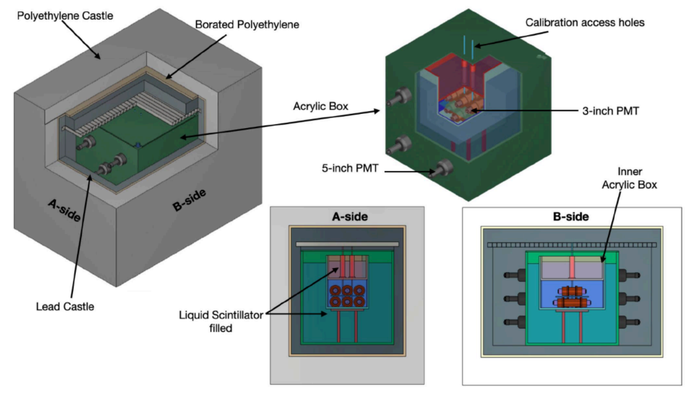


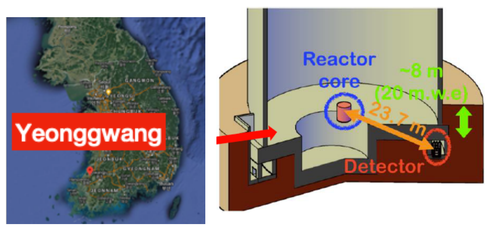
"Observation of coherent elastic neutrino-nucleus scattering" science.VOL. 357, NO. 6356 (2017)

- Coherent elastic neutrino-nucleus scattering (CEvNS) has garnered the attention of particle physicists to complete the standard model picture.
- The COHERENT experiment explores CEvNS using a spallation neutron source with energies of ~ 30 MeV.
- However, such success has not been achieved using other neutrino sources such as reactor.
- In particular, the reactor neutrinos have an energy few MeV, producing visible recoil energy less than 0.5 keV.

Neutrino Elastic scattering Observation with NaI (NEON) is an experiment that aims to observe CEvNS from the reactor anti-electron neutrinos using low threshold.

NEON Experiment



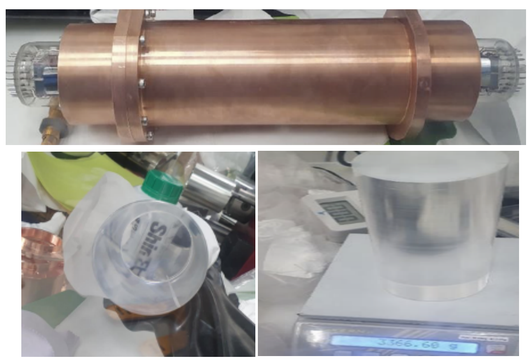


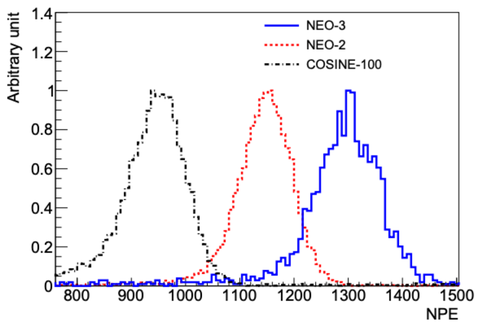
Neutrino($\overline{\nu_e}$) flux at NEON site :
7.1×10^{12} cm^{-2}s^{-1}

- The NEON detector was installed at November 2020 in the tendon gallery of reactor unit 6 of the Hanbit Nuclear Power Complex in Yeounggwang, Korea.
- From outside in ward, the 4 shielding layers are polyethylene castle, borated polyethylene board, lead castle, and a Linear Alkyl-Benzene (LAB)-based liquid scintillator(LS).
- The six NaI(Tl) crystal assemblies are placed in an acrylic box to avoid direct contact with LS.

NEON Detector

Improving the light collection using a new NaI(Tl)crystal encapsulation." Nucl. Instrum. Meth. A 981 (2020)

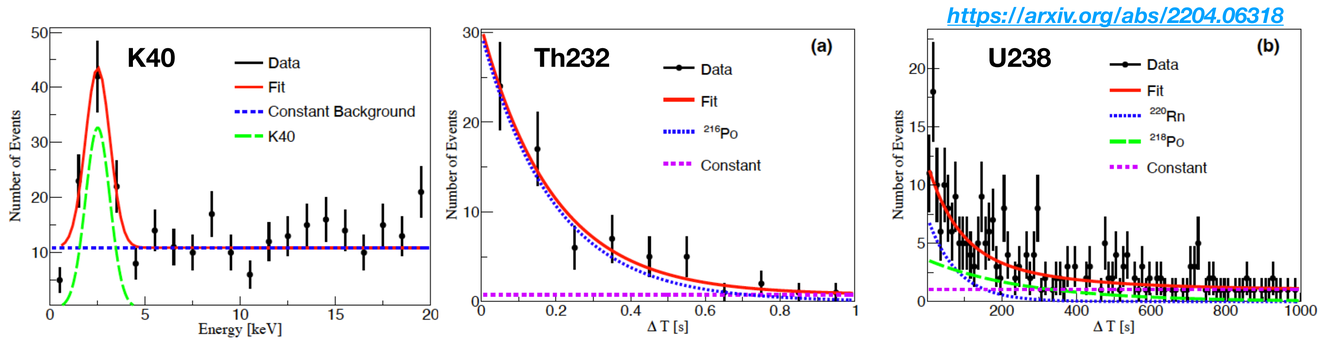




- For the low-threshold detector, new detector encapsulation technique was developed.
- We can increase light yield by no quartz window design for the encapsulation.
- With new design of detector encapsulation, NEON achieve about 22 NPE/keV light yield.
- 5NPE ~ 0.2keV threshold

NEON background understanding

https://arxiv.org/abs/2204.06318



Crystal	Mass (kg)	Size (inch, D × L)	^{nat}K (ppb)	α Rate (mBq/kg)	^{210}Pb (mBq/kg)	^{216}Po(^{232}Th chain) (μBq/kg)	^{218}Po(^{238}U chain) (μBq/kg)	Light yield (NPE/keV)
NEO-1	1.62	3 × 4	50±20	2.16±0.02	1.89±0.26	1.6±0.7	10.6±4.2	20.5±0.9
NEO-2	1.67	3 × 4	137±28	7.78±0.03	7.46±0.73	<59.8	<57.2	19.3±0.9
NEO-3	1.67	3 × 4	46±20	0.56±0.01	0.53±0.13	<3.6	<11.2	21.8±0.9
NEO-4	3.35	3 × 8	22±11	0.76±0.01	0.69±0.18	1.6±0.8	<3.3	22.4±1.0
NEO-5	3.35	3 × 8	<29	0.76±0.01	0.68±0.17	1.6±0.5	2.9±1.6	21.8±0.9
NEO-6	1.65	3 × 4	<38	0.94±0.01	0.88±0.21	5.8±1.3	11.0±3.3	21.7±1.0
COSINE-100(C6)	12.5	4.8 × 11.8	17±3	1.52±0.04	1.46±0.07	2.5±0.8	< 0.25	14.6±1.5

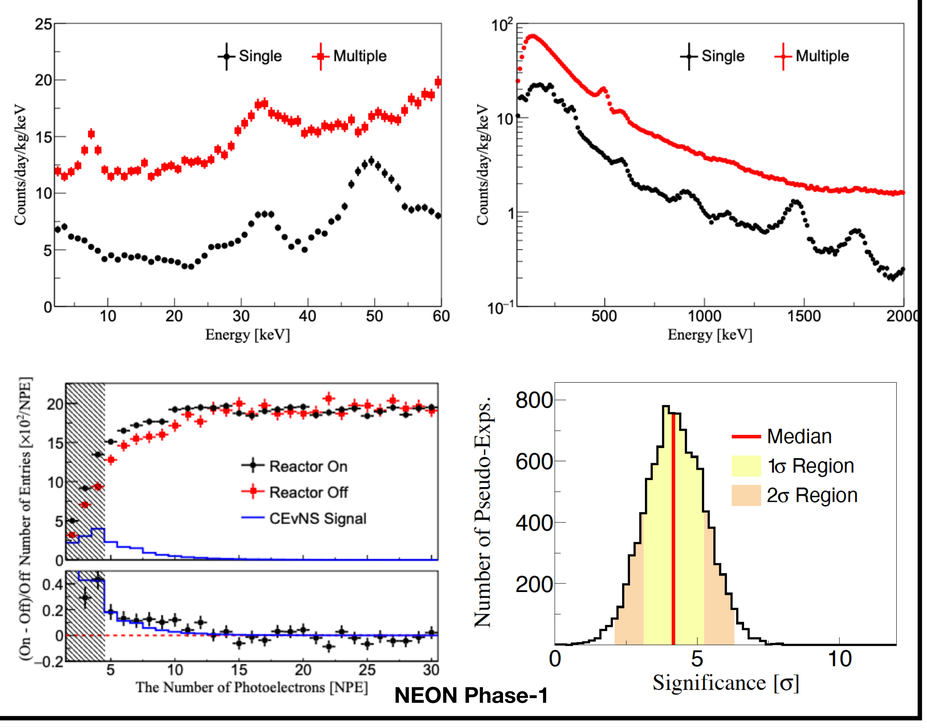
Achieved a better quality crystal than COSINE100 ones.

NEON Detector performance

Simulation assuming sensitivity :

- **6 counts/day/kg/keV (DRU) flat bkg**
- **22 PEs/keV light yield**
- **0.2 keV threshold**
- **13.5 kg detector mass**
- **1 year reactor on data**
- **100 days reactor off datas**

Assumed Significance : 4.2+/-1.0 σ

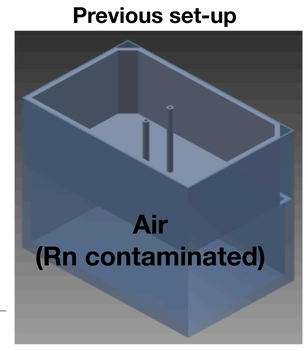


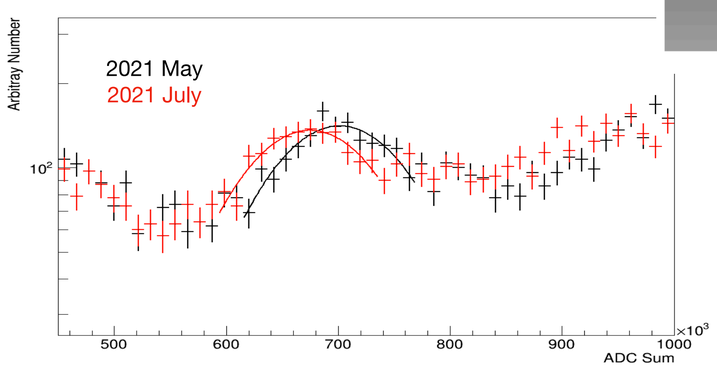
NEON Phase-1

Upgrade to NEON Phase 2

- We have problems because we were using Acrylic table to avoid LS leak in the detector.
- Problem 1 : Rn contamination on acrylic box
  -> **More background**
- Problem 2 : Air leak in detector encapsulation
  -> **Gain drop (decrease light yield)**

Previous set-up

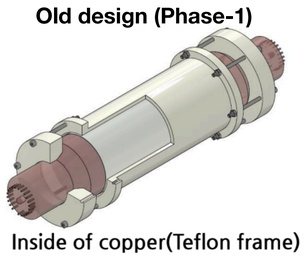




-> Improved the detector encapsulations

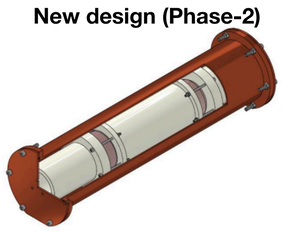
NEON Phase-2 Energy spectrum

Old design (Phase-1)

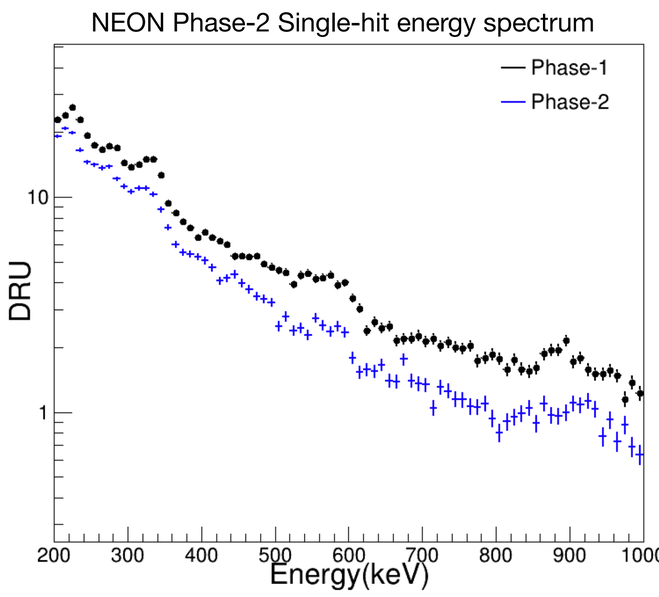


Inside of copper(Teflon frame)

New design (Phase-2)

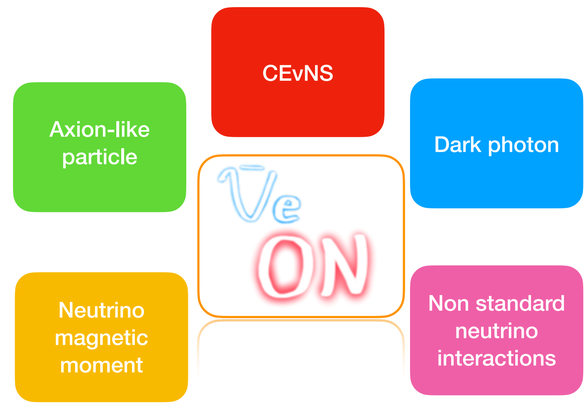


Copper shield with crystal



- No gain drop was observed in a month of measurement.
- Less background from Rn contamination was observed in NEON Phase-2 high energy spectrum.
- **Background modeling** and **event selection** are in progress.

Physics at NEON and Summary



- The NEON experiment started reactor-off data collection at Nov/2020 and reactor-on data at May/2021.
- We restart operation with improved detector encapsulation since April/7th.
- In addition to CEvNS, NEON is preparing various new physics searches : **Axion-like particle, Dark photon, Neutrino magnetic moment, Non standard neutrino interactions.**