

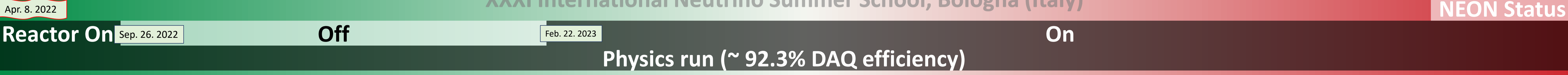
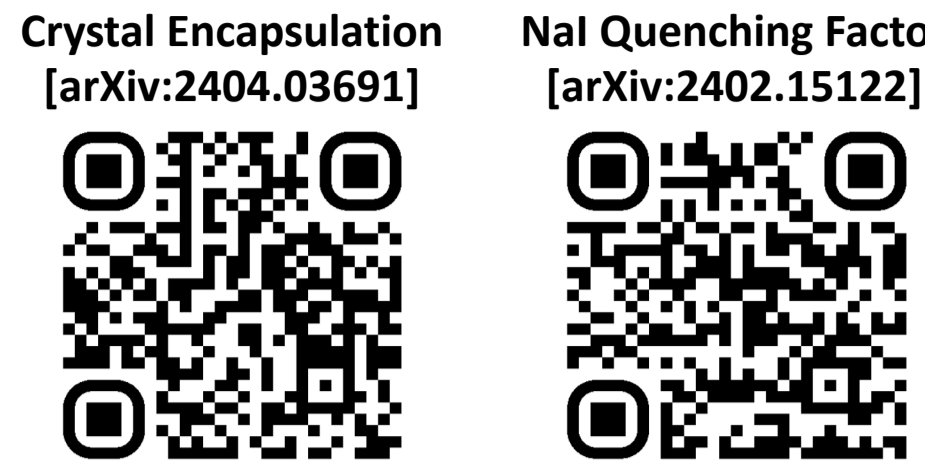
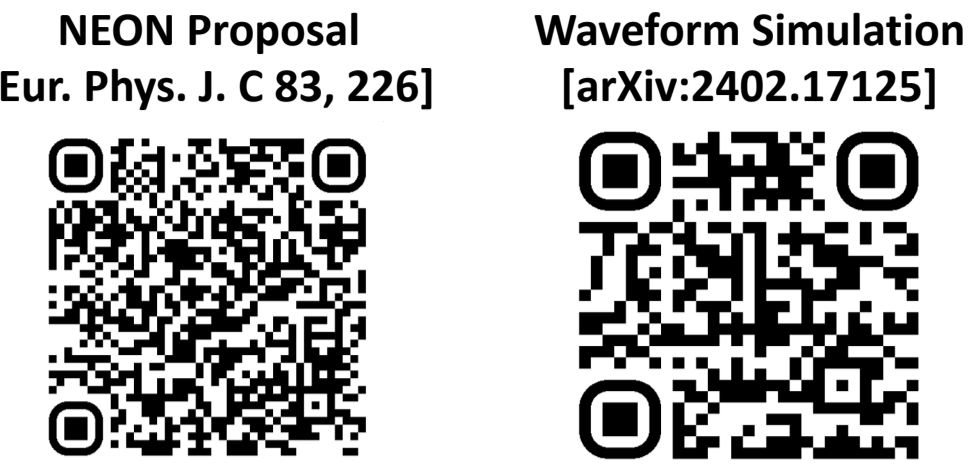
Status of Neutrino Elastic-scattering Observation with NaI(Tl) experiment

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XXXI International Neutrino Summer School, Bologna (Italy)

NEON Status



About the NEON experiment

Neutrino Elastic scattering Observation with NaI[NEON] is an experiment designed to detect coherent elastic neutrino-nucleus scattering[CEvNS] using reactor electron antineutrinos

CEvNS was predicted by Daniel Z. Freedman. [Phys. Rev. D 9, 1389] (1974)

- First measurement by the COHERENT collaboration using spallation neutron source. [Science 357, 1123-1126] (2017)
- First measurement of CEvNS on Argon by the COHERENT collaboration. [Phys. Rev. Lett. 126, 012002] (2021)
- Measuring CEvNS has not been achieved by reactor neutrino.

COHERENT Collaboration

Site: Hanbit Nuclear Power Plant Unit 6 Tendon gallery
23.7-m baseline & 20-m.w.e overburden
Reactor power: 2.815 GW_{th}
Neutrino($\bar{\nu}_e$) flux at NEON site: $8.1 \times 10^{12} \text{ cm}^{-2} \text{ s}^{-1}$

Neutrinos are produced in **beta decays** of fission fragments.

- Single flavor ($\bar{\nu}_e$, electron anti-neutrino)
- High flux: $10^{12} \sim 10^{13} \text{ v/cm}^2 \text{ s}$
- $E_\nu < 10 \text{ MeV} \rightarrow$ fully coherent regime
- Clean in background, active and passive shielding
- Recoil energy is less than **few keV**.
- Signal quenched \rightarrow Require **very low threshold**

Crystal Detector Performance

NaI(Tl) Crystals

- 6 NaI(Tl) detectors (total mass of 16.7 kg)
- Encapsulation R&D for increasing light yields[LY].
- ~15 PE/keV [COSINE-100]
- \rightarrow ~23 PE/keV [prototype encasing]
- \rightarrow ~23.7 PE/keV [DET-2]

| Detector | Mass (kg) | Size (inch, D x L) | Light yield w/o low gain (PEs/keV) | Light yield w/ low gain (PEs/keV) |
|----------|-----------|--------------------|------------------------------------|-----------------------------------|
| DET-1 | 1.67 | 3 X 4 | 22.0 ± 0.4 | 25.3 ± 0.6 |
| DET-2 | 3.34 | 3 X 8 | 25.6 ± 1.1 | 27.8 ± 1.4 |
| DET-3 | 1.65 | 3 X 4 | 21.8 ± 0.5 | 23.3 ± 0.9 |
| DET-4 | 3.34 | 3 X 8 | 23.7 ± 0.4 | 25.4 ± 0.7 |
| DET-5 | 3.35 | 3 X 8 | 22.4 ± 0.5 | 23.6 ± 0.8 |
| DET-6 | 3.35 | 3 X 8 | 25.0 ± 0.5 | 27.9 ± 0.7 |

- Enhancing LYs to lower the energy threshold.
- The crystals' LYs remained stable.

Data acquisition

Physics data taking since April 2022. Engineering run for (May 2021 ~ April 2022)

- 92.3% DAQ efficiency
- exposure : 11142.2 kg x day
- ON / OFF data : 523.2 / 144 days

Background Modeling

Sideband background data agrees well with Geant4 detector simulation.

Waveform Simulation

Waveform Simulation

- PMT gain
- DAQ Specification
- Trigger condition
- SPE shape
- SPE timing
- Probability

Event selection Status

The data is being analyzed by separating it into high and low energy regions

- BDT for high energy region ($\geq 0.6 \text{ keV}$)
- MLP for low energy region ($\geq 5 \text{ PEs}$)
- Variables: Time difference (Δt), Cluster charge, Charge asymmetry
- ~50% efficiency & 92~96% rejection
- 35% Efficiency
- Extraction of scintillation signals
- Chi-square formula
- 1% for exposure time σ_t
- Testing w/ multiple-hit events for bias check
- Extraction w/ single-hit events will be done soon

Light Dark Matter

- DM mass below few MeV/c²
- Massive gauge boson (vector portal)
- Dark photon mixes kinetically(ϵ) with Standard Model particles.
- LDM produced by dark photons provides strong constraints in the keV mass range.

Dark Sector Particle Search

Reactor Core

Experiment Site

- DM-e scattering
- ALPs (a) Decay
- ALPs (a) production

Axion-Like Particles

- Extension of the QCD axion
- Interacting with leptons from the SM and EM field
- Axion-Like Particle(ALP) searches in NEON cover "cosmological triangle".