Status of CICENNS Experiment

Xiang Xiao (Sun Yat-sen University)

肖翔（中山大学）

on behalf of the CICENNS Collaboration

October 25, 2025

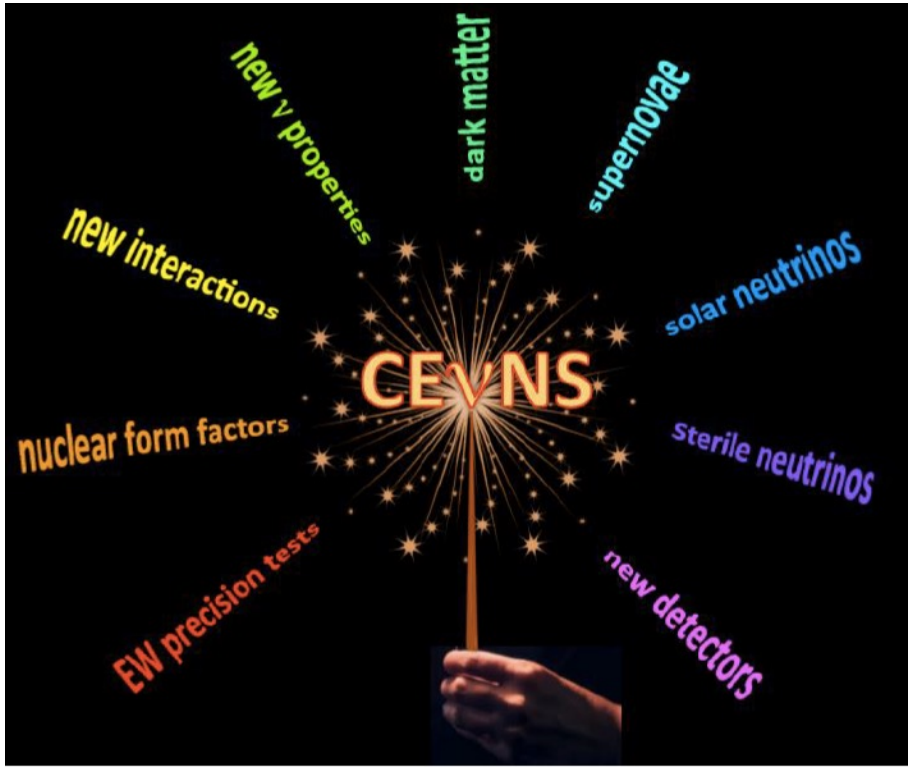
νSTEP @Beijing

CEvNS as a new probe

PHYSICAL REVIEW D VOLUME 9, NUMBER 5 1 MARCH 1974

Coherent effects of a weak neutral current

Daniel Z. Freedman†
National Accelerator Laboratory, Batavia, Illinois 60510
and Institute for Theoretical Physics, State University of New York, Stony Brook, New York 11790
(Received 15 October 1973; revised manuscript received 19 November 1973)



E. Lisi @Neutrino 2018

SCIENCE 357, no. 6356, 1123-1126 (2017)

134 ± 22 events observed with 308.1-day data

CICENNS experiment

- CICENNS: CsI detector for Coherent Elastic Neutrino Nucleus Scattering
- Development of a 300-kg CsI(Na) detector for precise CEvNS measurement from π decay-at-rest

Initiated in 2023

China + Korea, 4 institutions, ~20 collaborators

Technical Design Report for 300 kg CsI(Na) CEvNS Detector at CSNS

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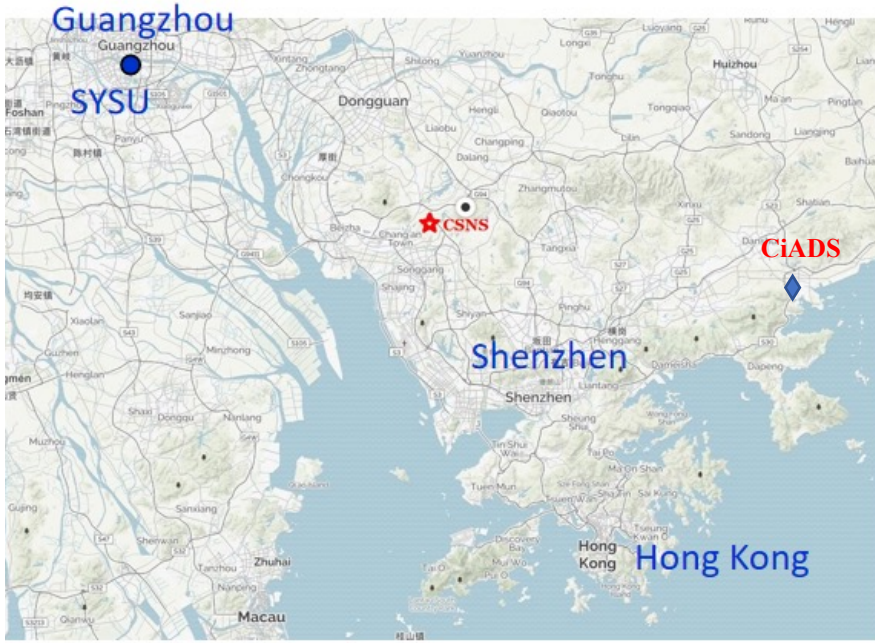
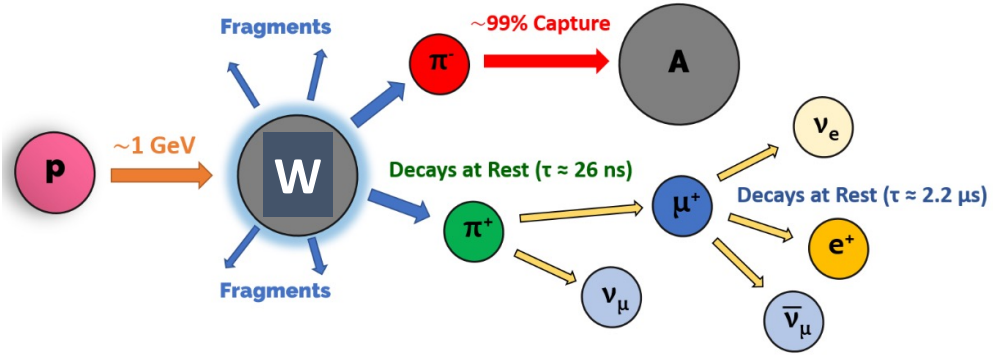
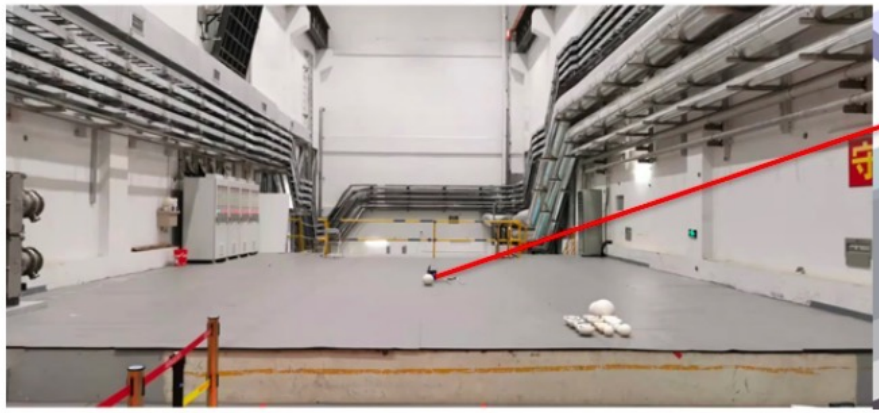
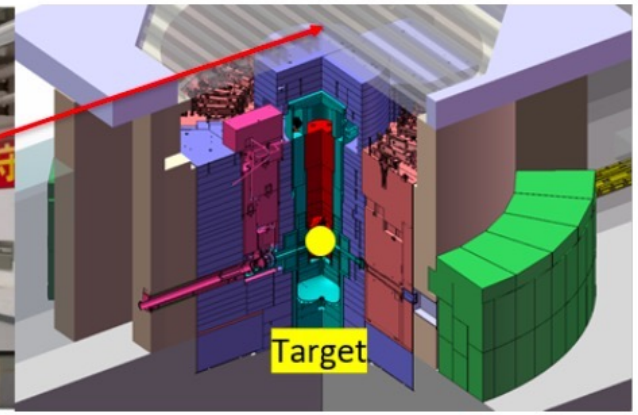
China Spallation Neutron Source (CSNS)





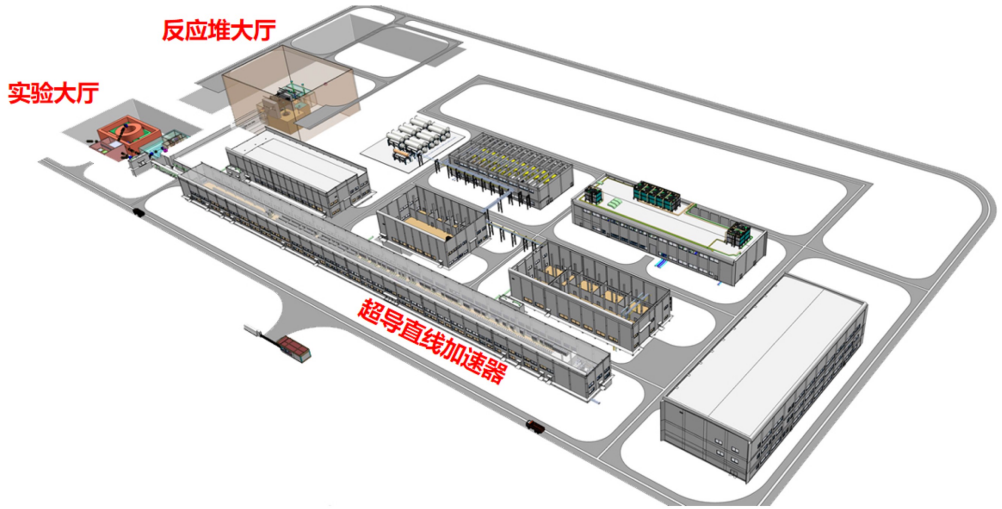




- 1.6 GeV proton beam
- 140 kW (→ 500 kW)
- 25 Hz repetition rate

Neutrino flux @10.5 m: $2\times10^{7}/cm^{2}/s$ (~40% of COHERENT)

China Initiative Accelerator-Driven System (CiADS)



	Power (MW)	Proton Energy (GeV)	Beam Type	Repetition Rate (Hz)
SNS	1.4 -> 2	1 -> 1.3	Pulse	60
J-PARC	0.6 -> 0.95	3	Pulse	25
CSNS	0.14 -> 0.5	1.6	Pulse	25
CiADS	0.3 -> 3	0.6	Continuous	

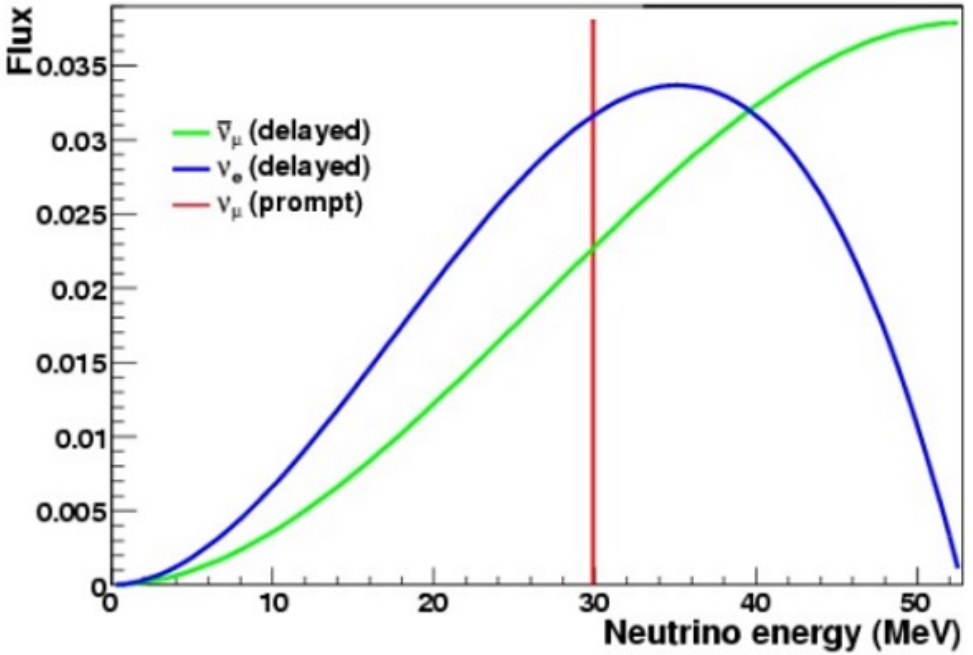
- Accelerator-driven sub-critical system to study the transmutation of spent fuel
- Continuous beam
- 600 MeV @300 kW (~2027) -> @3 MW (~2030)
- Possibly convert to pulsed beam

$$\pi^+ \rightarrow \mu^+ + \nu_\mu$$

2-body π⁺-decay: Prompt (26nsec)
Monochromatic: 29.9MeV ν_μ

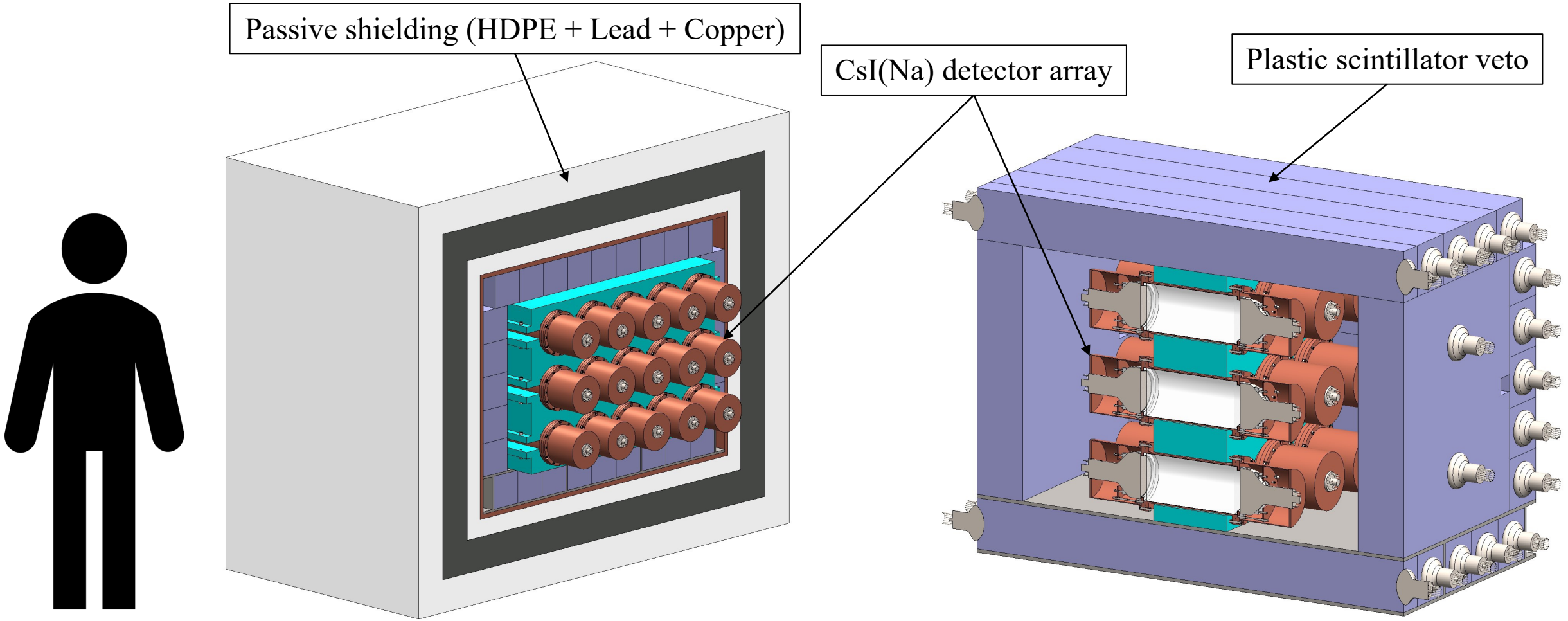
$$\mu^+ \rightarrow e^+ + \bar{\nu}_\mu + \nu_e$$

3-body μ⁻-decay:
Delayed (2.2μsec)
0-53MeV $\bar{\nu}_\mu$, ν_e

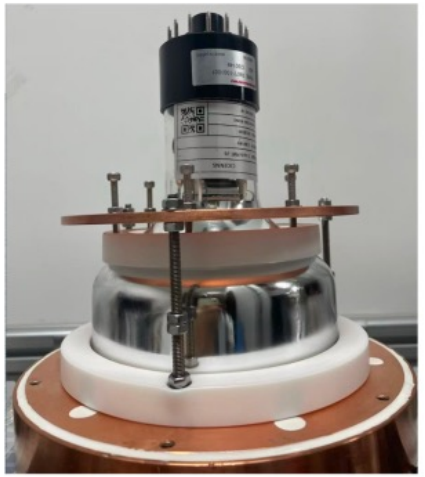


CICENNS overall design

Array of 15 CsI(Na) crystals, each with 20 kg, in total 300 kg target mass



CsI(Na) detector module



- 20-kg CsI(Na) × 15
- 14 cm (Dia.) × 28.7 cm (L) each
- Encapsulation: OFHC copper + PTFE foil + quartz window
- Two 5-inch Hamamatsu R877-100 PMTs in both sides, wrapped with permalloy foil
- 5 modules are completed and under tests, all the rest will be ready before end of this year

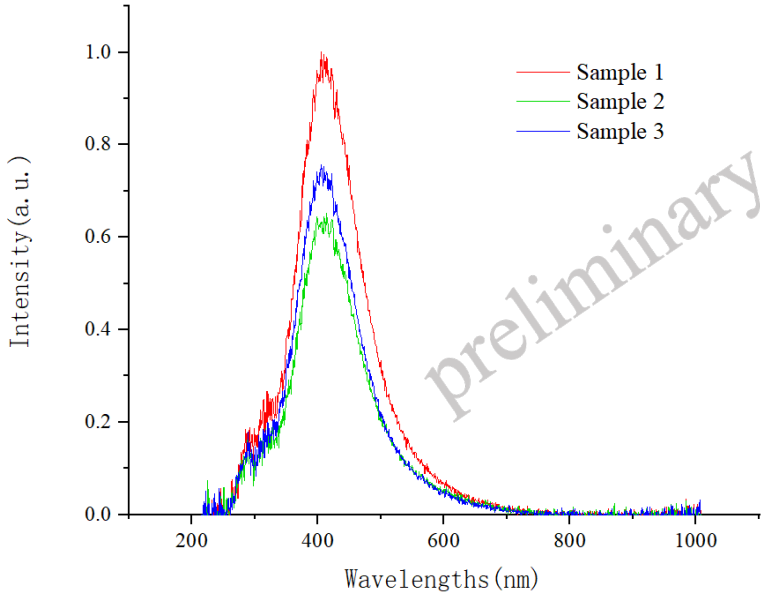
CsI(Na) crystal: radioactivity and optical performance

- Re-crystallization of CsI powder is applied, with a purification yield of ~57%
- Samples from grown CsI(Na) crystal, measured by ICP-MS and HPGe
- ^{87}Rb concentration of <1 ppb is achieved (×20 lower than COHERENT)

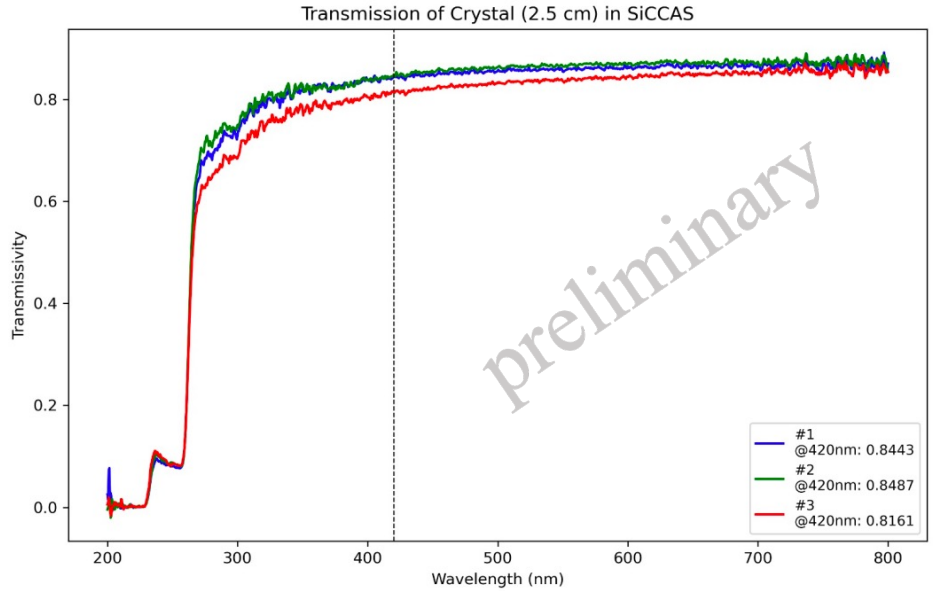
Isotopes	^{238}U (ppt)	^{232}Th (ppt)	^{87}Rb (ppb)	^{137}Cs (mBq/kg).	^{134}Cs (mBq/kg).
	63±25	14±5	0.77±0.04	2.27±2.22	23.1±3.0

CsI(Na) samples of 2.5 cm × 2.5 cm × 2.5 cm for optical tests

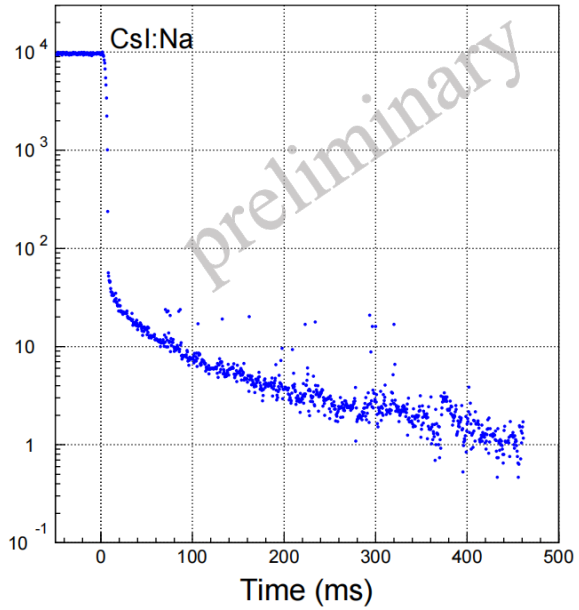
Emission spectrum: peak at ~420 nm



Transmittance (without correction of reflection) : ~84% @420 nm

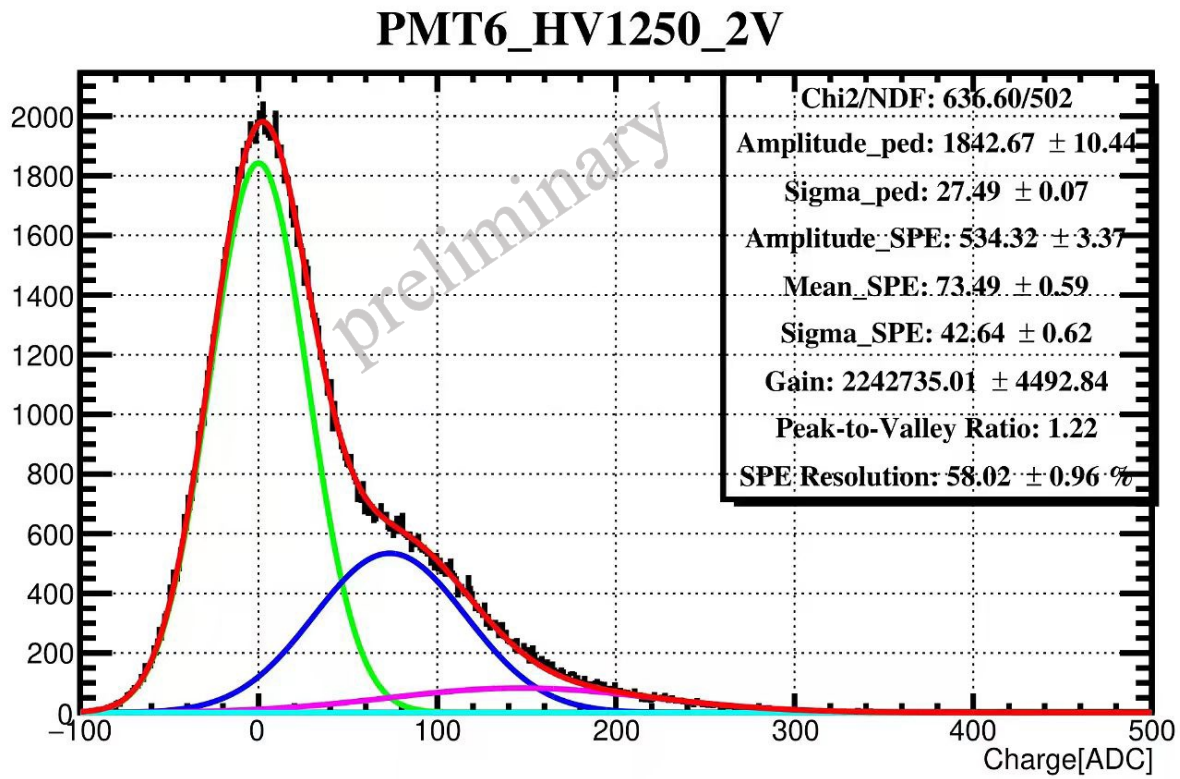


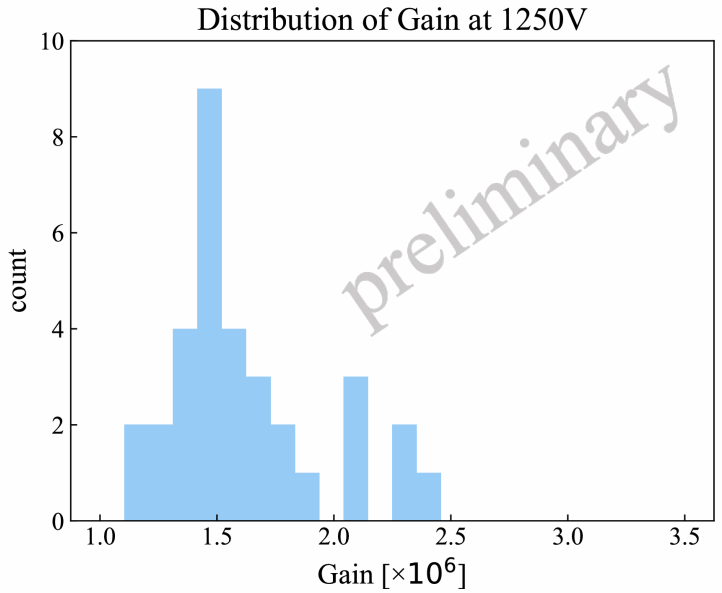
Afterglow rate: ~0.5% @6 ms and ~0.08% @100 ms

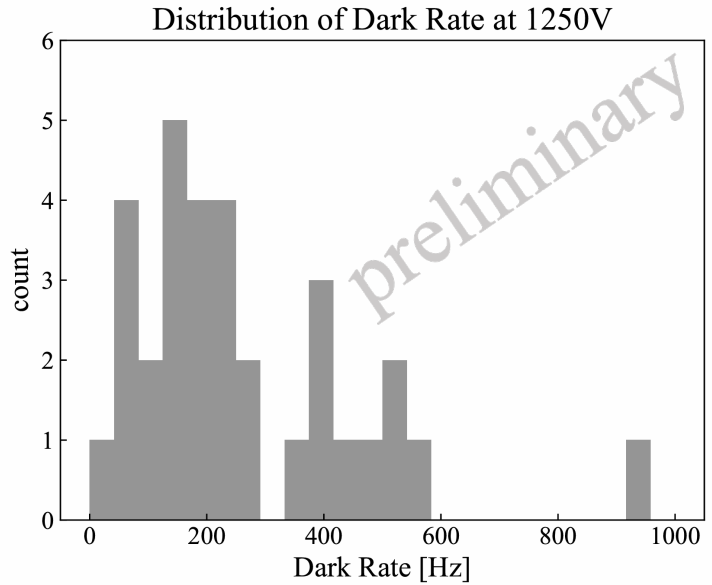


PMT characterization

- 32 5-inch PMTs purchased and tested in a dark box with LED
- Typical gain: ~1.5×10^6 @1250 V
- Typical dark count rate: ~300 Hz @1250 V

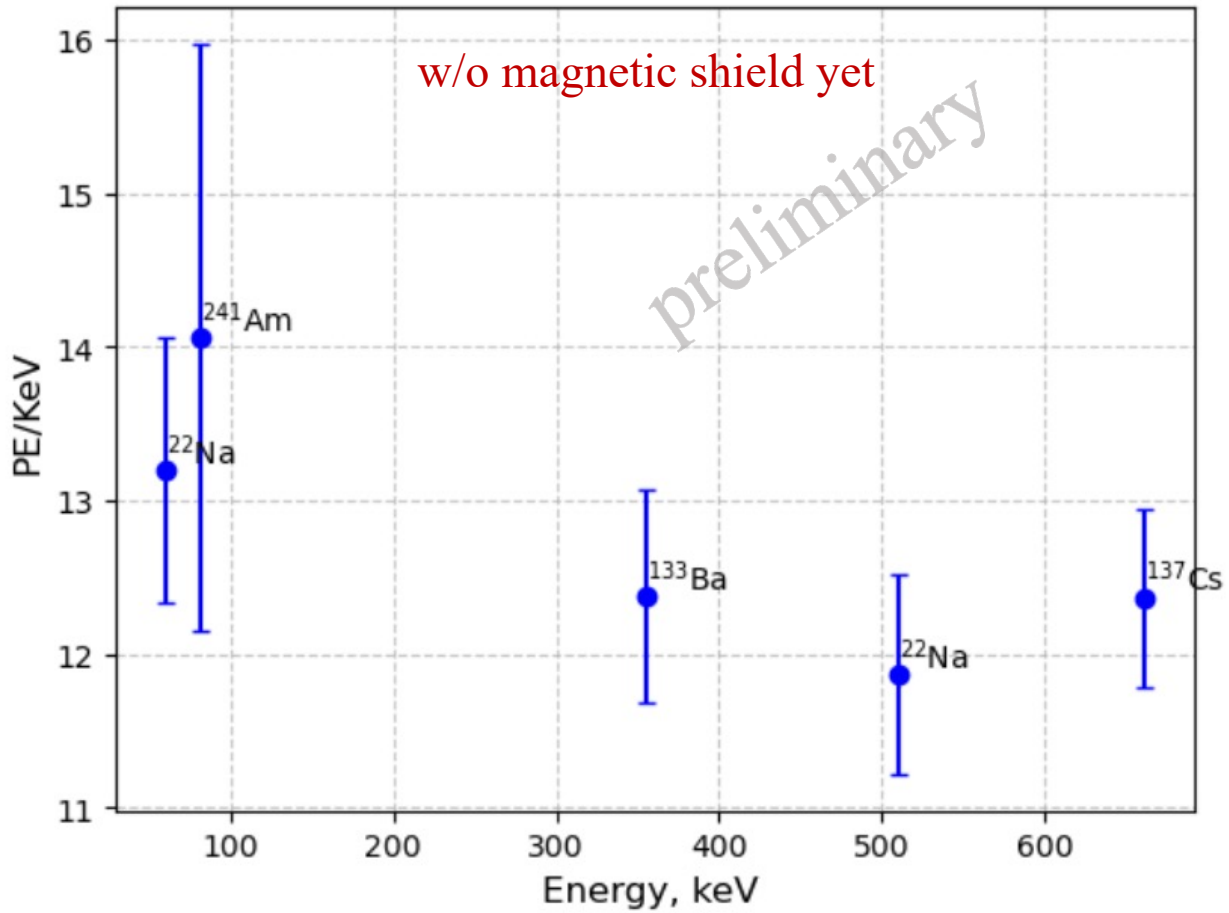




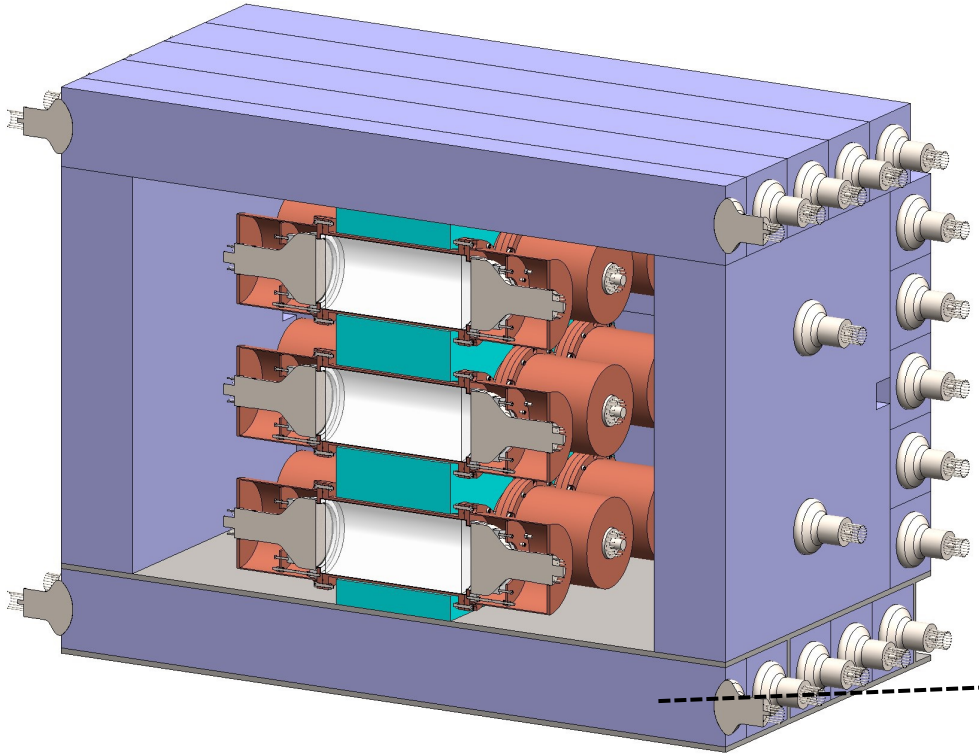


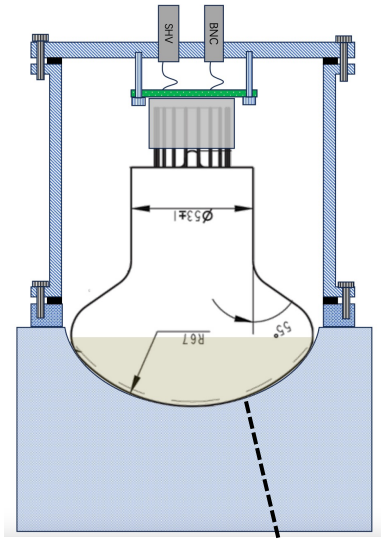
Energy calibration

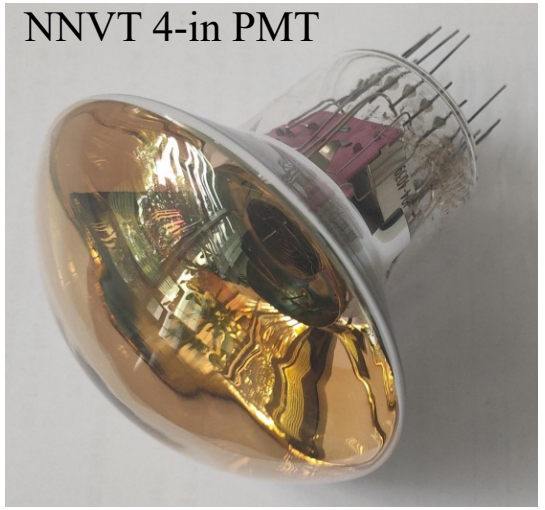
- Energy calibration of CsI(Na) detector with multiple gamma sources is on-going
- Optical coupling between PMT and quartz window is crucial!
- Magnetic shield for PMT is necessary

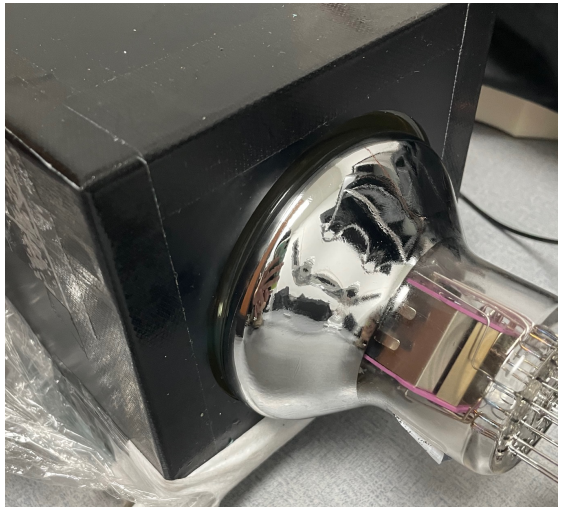


Plastic scintillator veto (PSV)





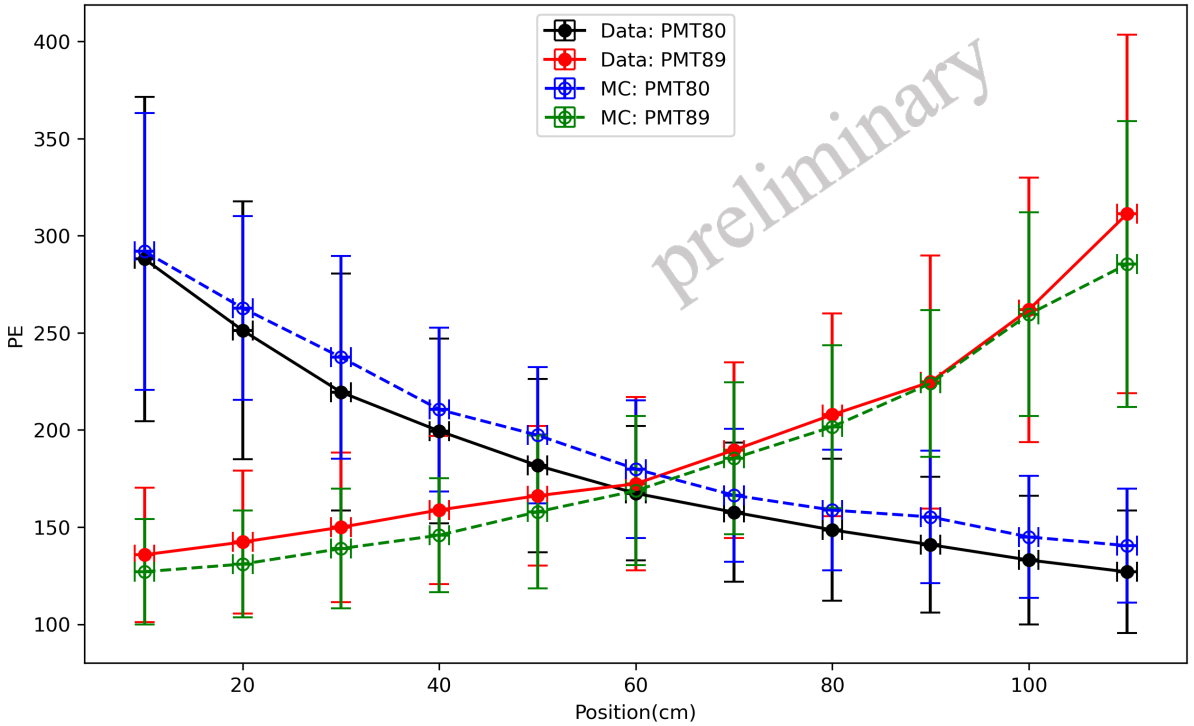




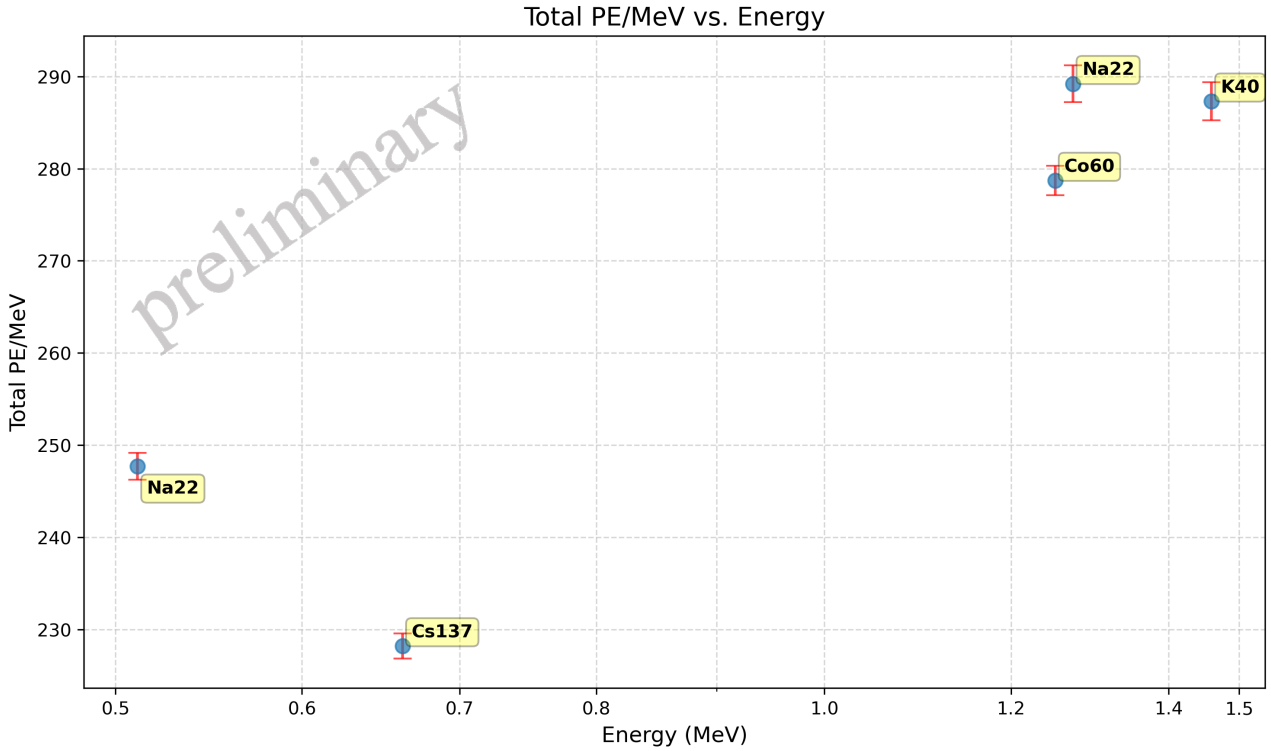
- Plastic scintillator × 32
- 15 cm × 15 cm × 120 cm strip, × 28
- 15 cm × 75 cm × 60 cm panel, × 4
- Two 4-inch N2041 PMTs attached in both sides
- Veto beam-related fast neutrons, as well as cosmic muons and gamma's

PSV strip: attenuation length and light yield

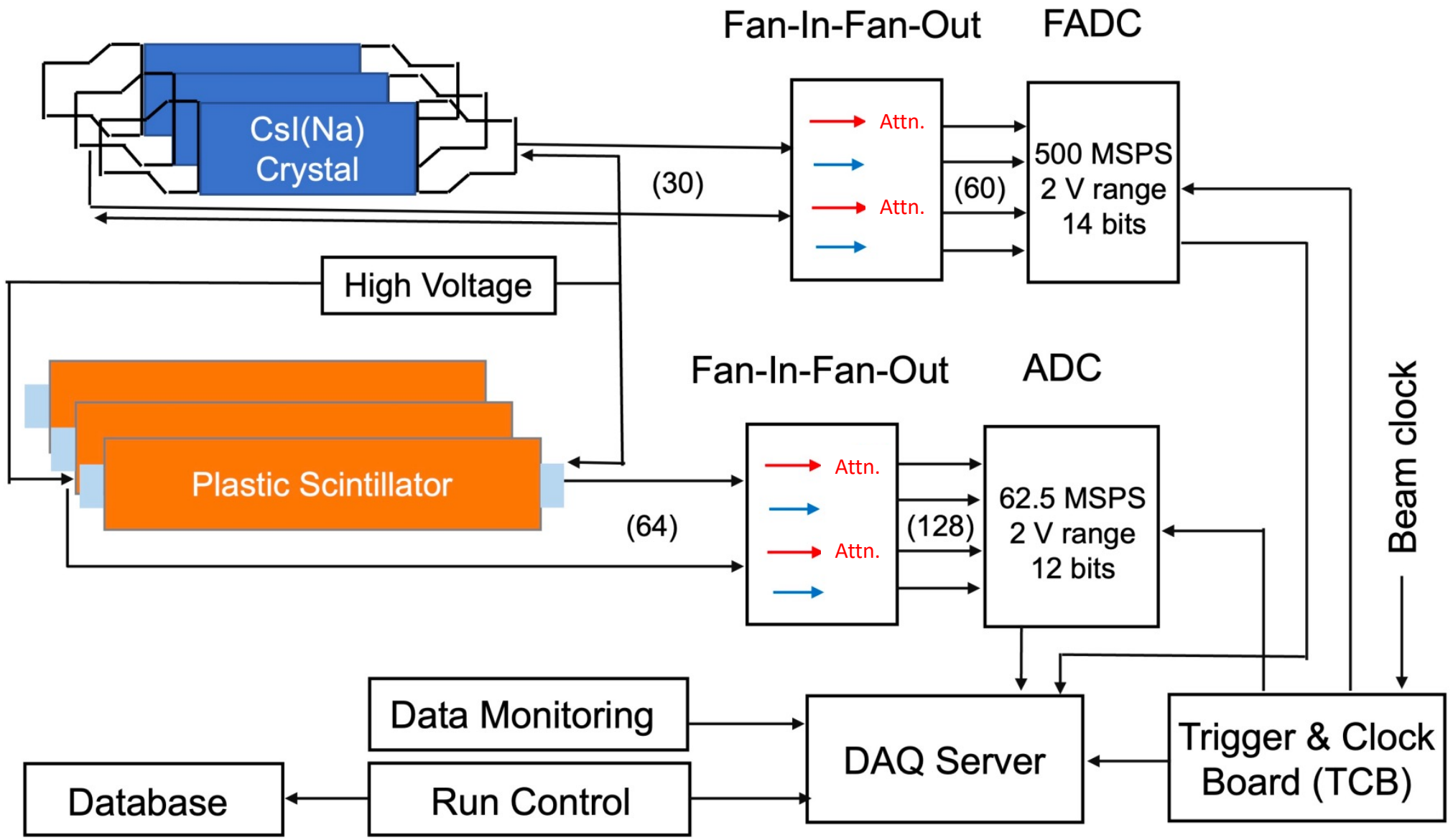
- Comparison between data and MC: attenuation length of PSV strip is estimated as ~2.3 m



- Light yield: ~260 PE/MeV @~1 MeVee, resulting in ~40 keVee threshold @10 PE
- Neutron calibration is planned



Readout scheme



Background

- **Beam related fast neutron**
- On-site measurement, joint effort from SYSU and UCAS
- Expected to be significantly reduced by PSV

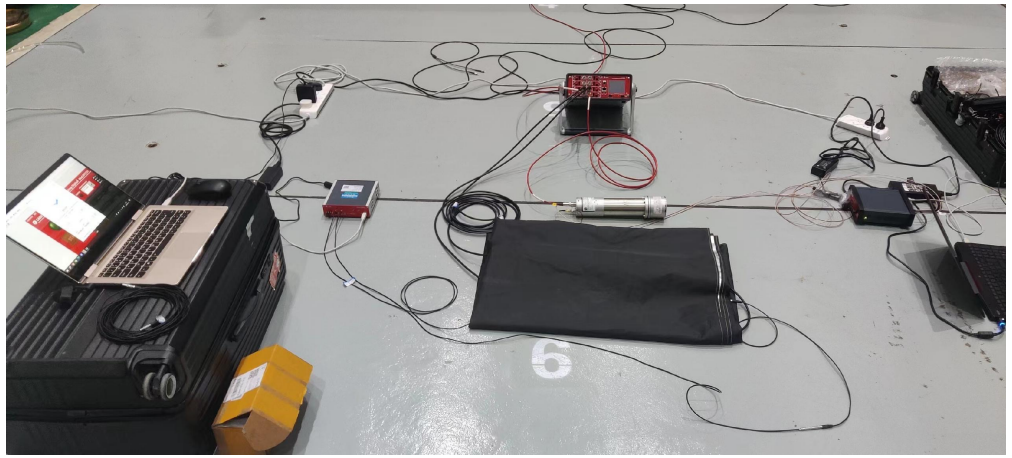
- **PMT dark-current noise**
- Two PMT coincidence is expected to reduce PMT dark-current noise by 3 orders of magnitude

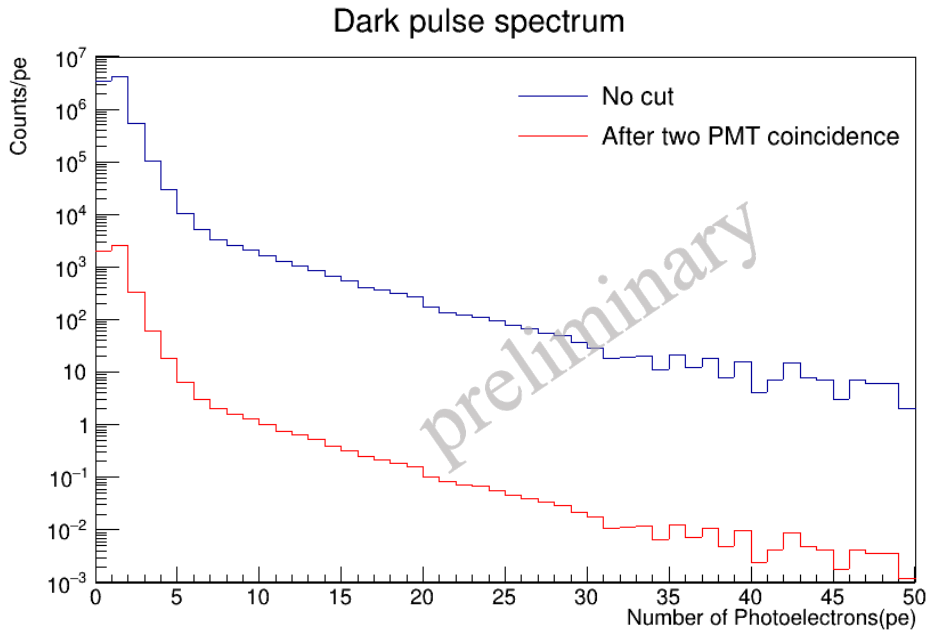
- **Radioactivity in detector materials**
- Low internal radioactivity in CsI(Na) crystal
- Background from PMTs and surrounding materials

- **Environmental radioactivity**
- Mostly attenuated by passive shielding

- **Cosmic muon induced background**
- Estimated to be negligible

Full Geant4-based MC on-going



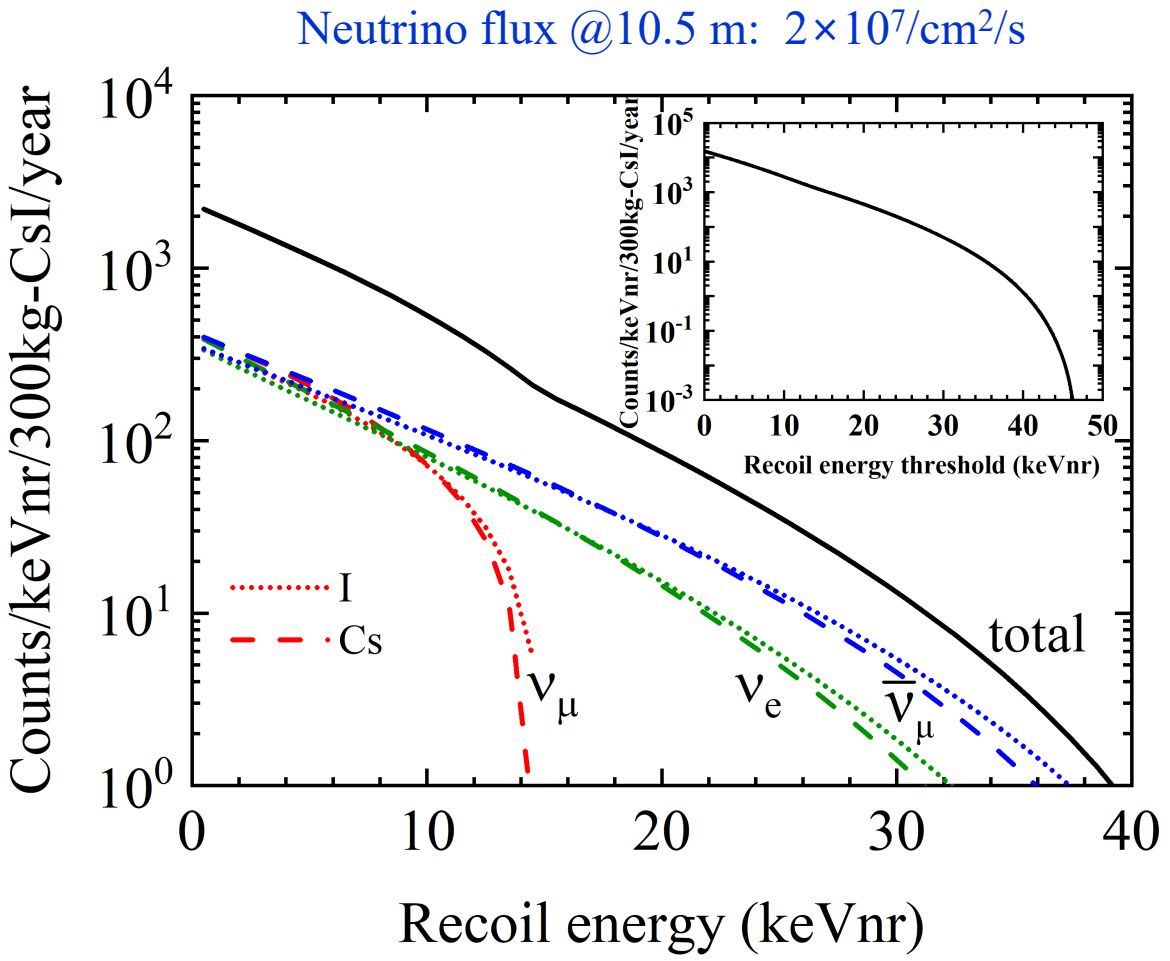


Expected CEνNS event at CSNS

- The maximum nuclear recoil energy is roughly 35 keVnr
- Expected CEνNS events from 300 kg CsI target in one year:

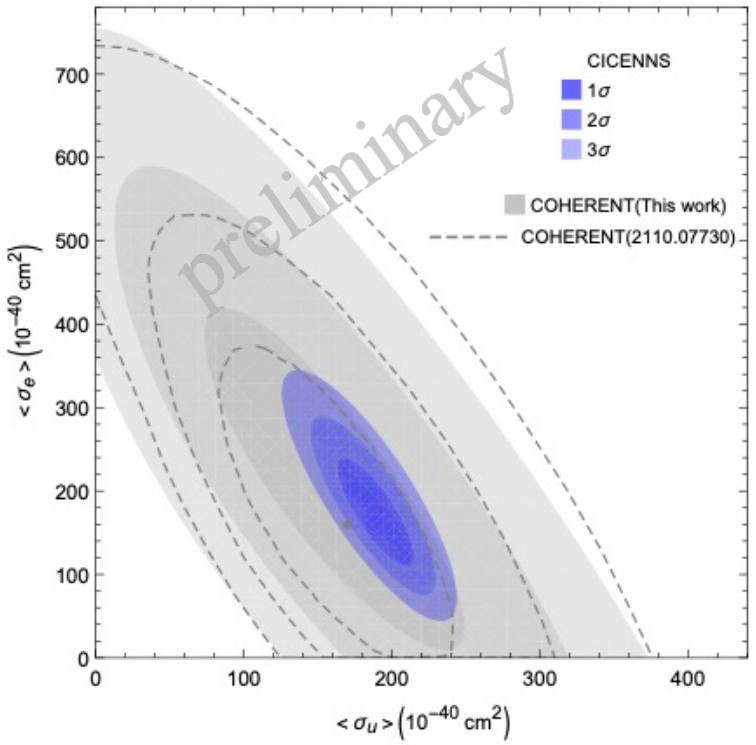
  ~5000 events at energy threshold of 5 keVnr

  ~6500 events at 3 keVnr

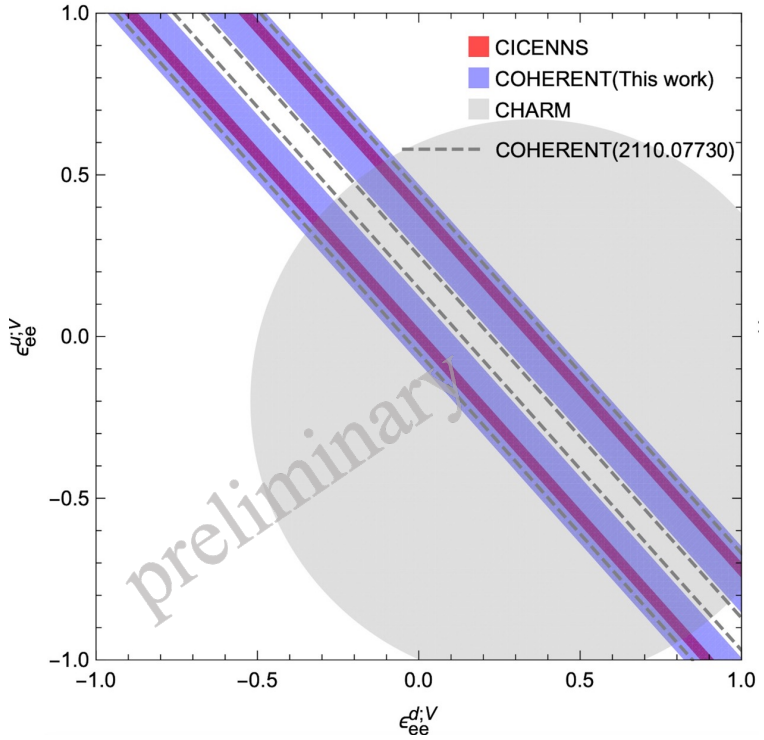


Some expected sensitivity with one-year data

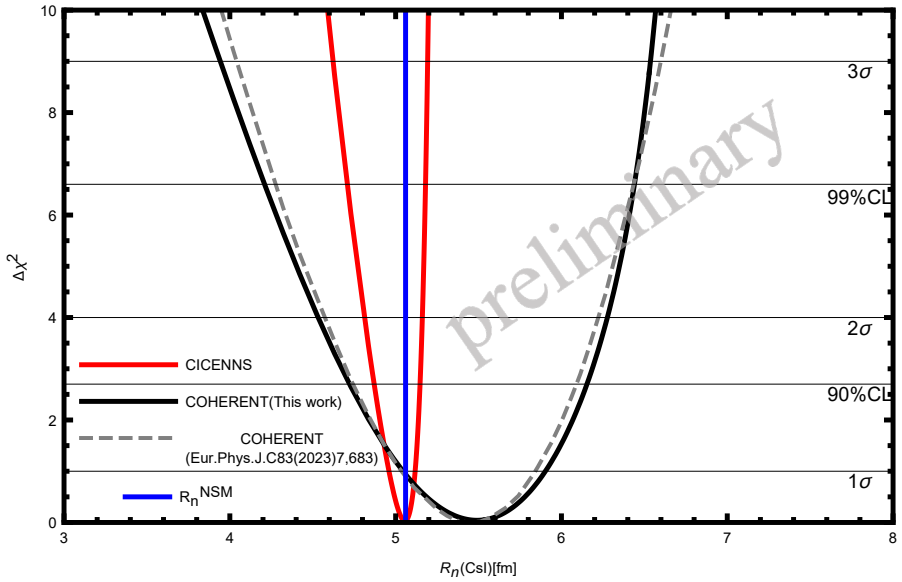
Flavored CEνNS cross section: 15% → 8%



Non-standard neutrino interaction



Mean radius of neutron distribution in nucleus: 8% → 2%



Timeline

2025

- Completion of CICENNS detector and performance check @SYSU
- Starting to deploy detector @CSNS

2026

- Completion of detector and shielding assembly @CSNS
- Commissioning
- Start data-taking

2027

- Continue data-taking
- Measurement of CsI(Na) quenching factor @SYSU
- Obtain physics results

2027+

- Move to CiADS?
- Cryogenic pure CsI?
- Different elements (e.g. NaI)?
- Scintillating bolometer?

Summary

- A 300-kg CsI(Na) crystal detector for CEνNS measurement at CSNS and CiADS has been proposed, and is being built now.
- Precise tests of SM at low momentum transfer and new physics search BSM are being pursued based on large statistics of CEνNS events.
- We are aiming to complete the construction and start data-taking in 2026.

Stay tuned and welcome to join this effort!

Thank you!