

CsI(Na) Detector for CICEENNS Experiment and Neutron Background Measurement at the CSNS

CICEENNS实验晶体探测器研制进展与 CSNS靶站快中子本底测量

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CICEENNS Collaboration

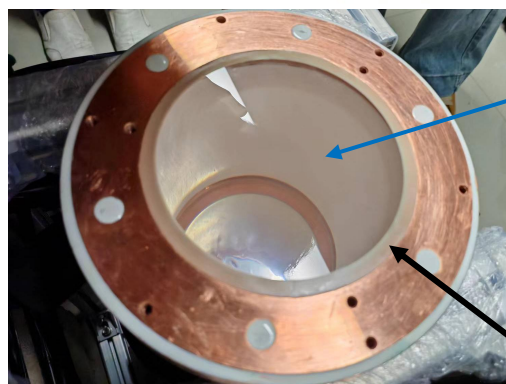
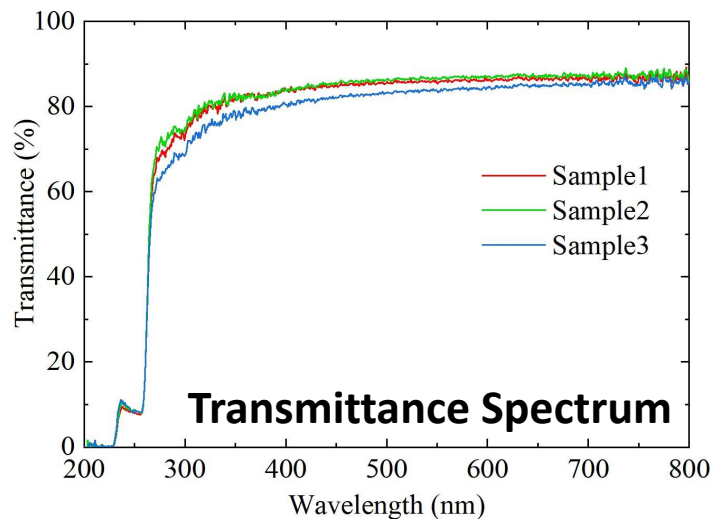
2026 年 7 月

广州·白云

CICENNS Detector Structure

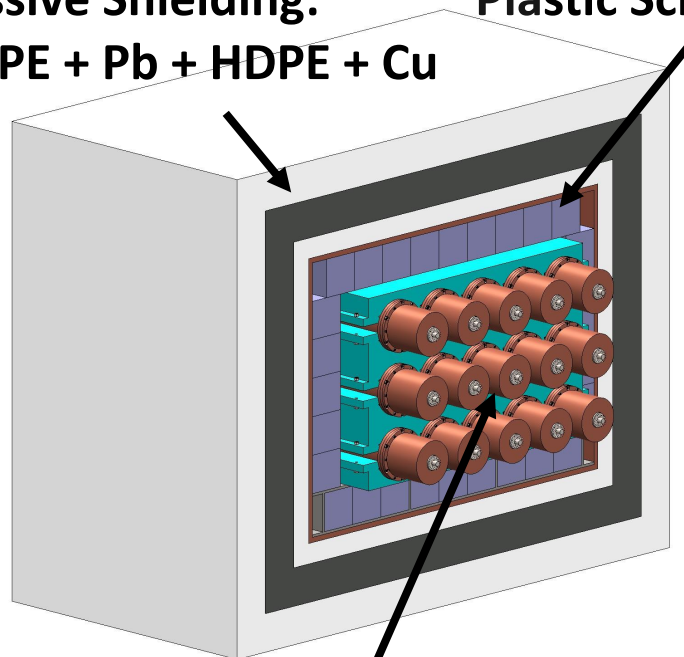


Spectrophotometer, SYSU



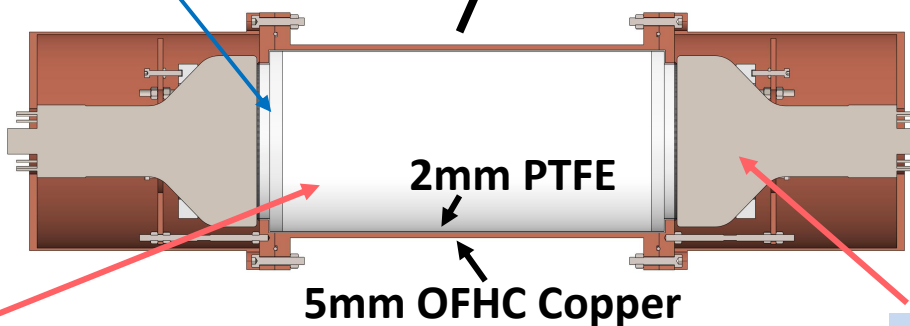
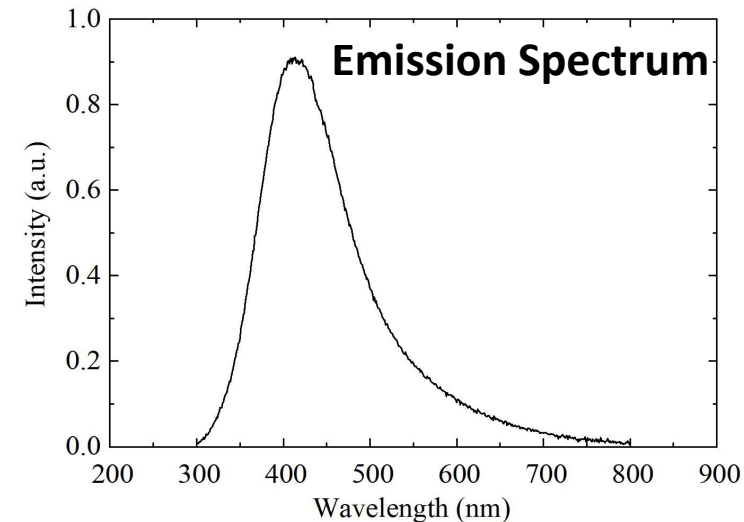
20 kg CsI(Na) Crystal
14 cm (Φ) × 28.7 cm

Passive Shielding:
HDPE + Pb + HDPE + Cu



Plastic Scintillator Veto

SICCAS

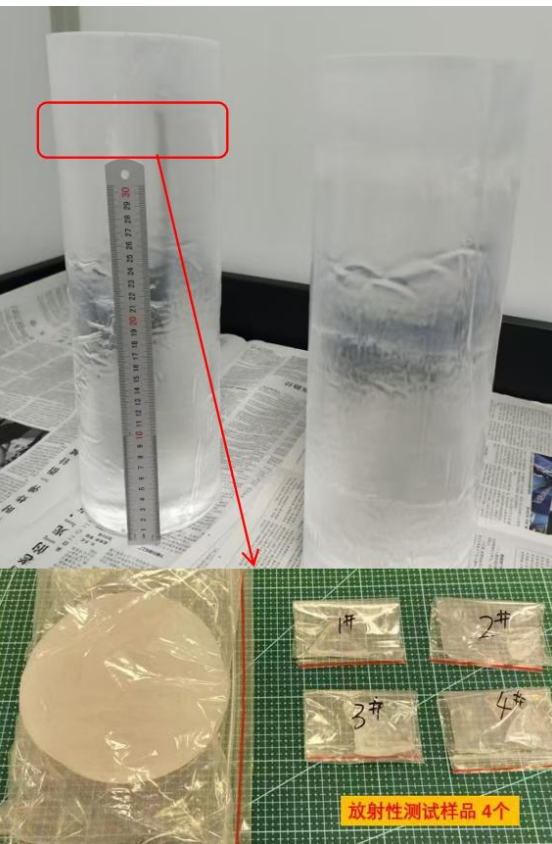
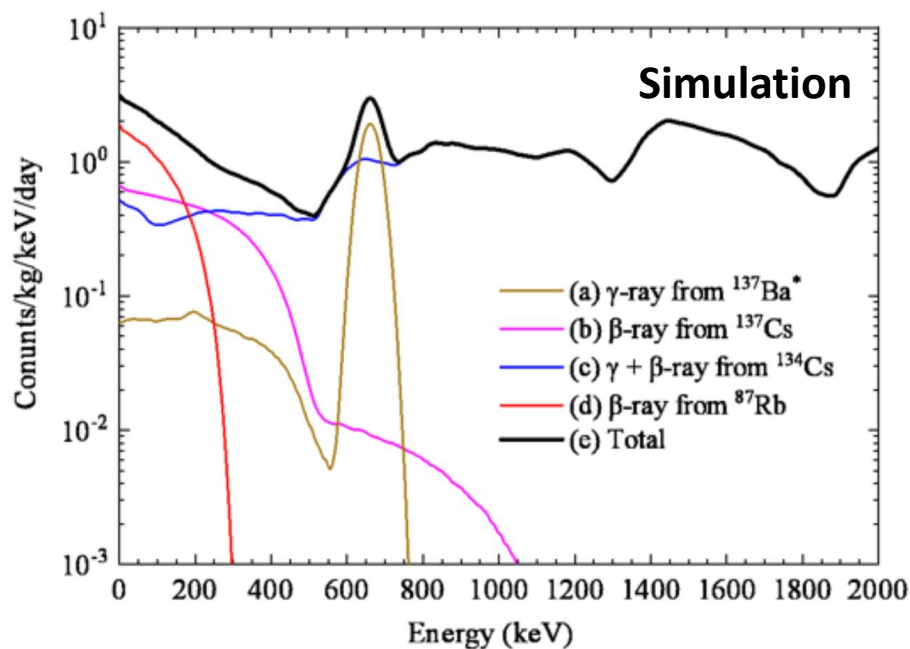


5-inch PMT

Hamamatsu
R877-100 PMTs
(super-bialkali)

Internal Radioactivity of Crystal

- The dominant background below ~ 100 keV is from ^{87}Rb .
- Screened cesium salt and crystal powder purification.
- Essential for achieving an energy threshold of ~ 4 keVnr.



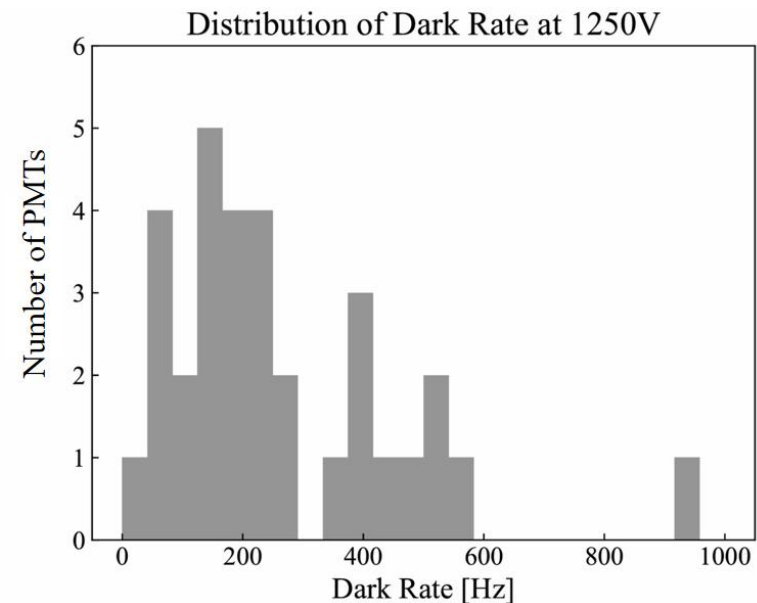
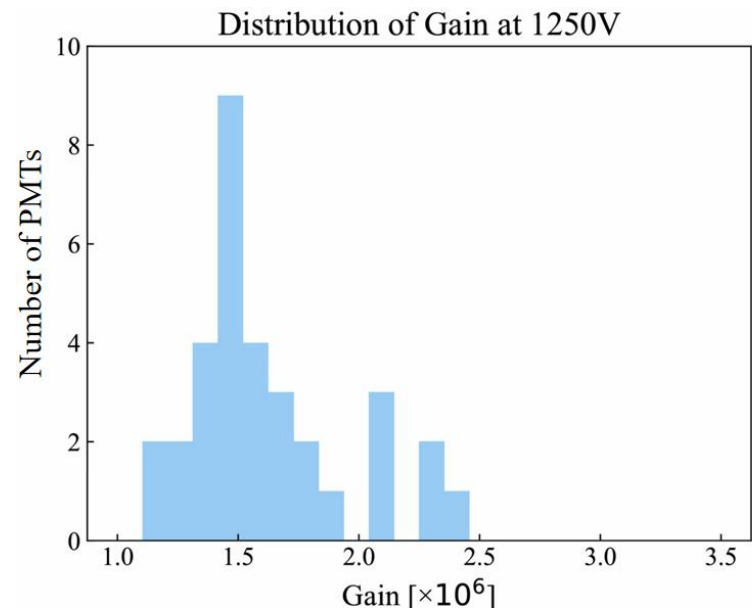
Isotopes	^{87}Rb (ppb)	^{238}U (ppt)	^{232}Th (ppt)	^{137}Cs (mBq/kg)	^{134}Cs (mBq/kg)
COHERENT	~ 20	< 1000	< 1000	28 ± 3	26 ± 2
CICENNS	0.77 ± 0.04	63 ± 25	14 ± 5	2.27 ± 2.22	23.1 ± 3.0

Radiopurity Measured by ICP-MS (PKU) and HPGe (PandaX).

PMT Calibration



PMT SPE Calibration

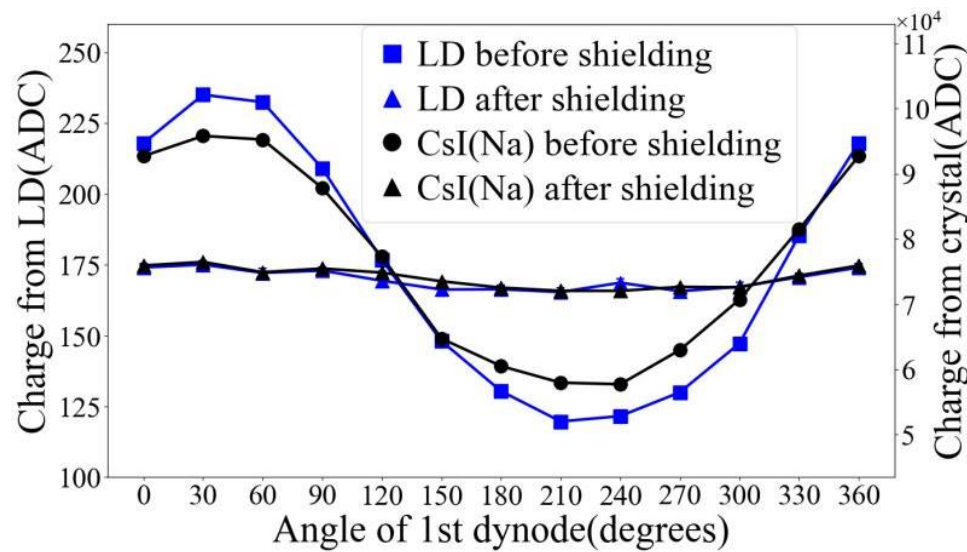


Testing with Magnet Shielding



Copper Hat

Mu metal



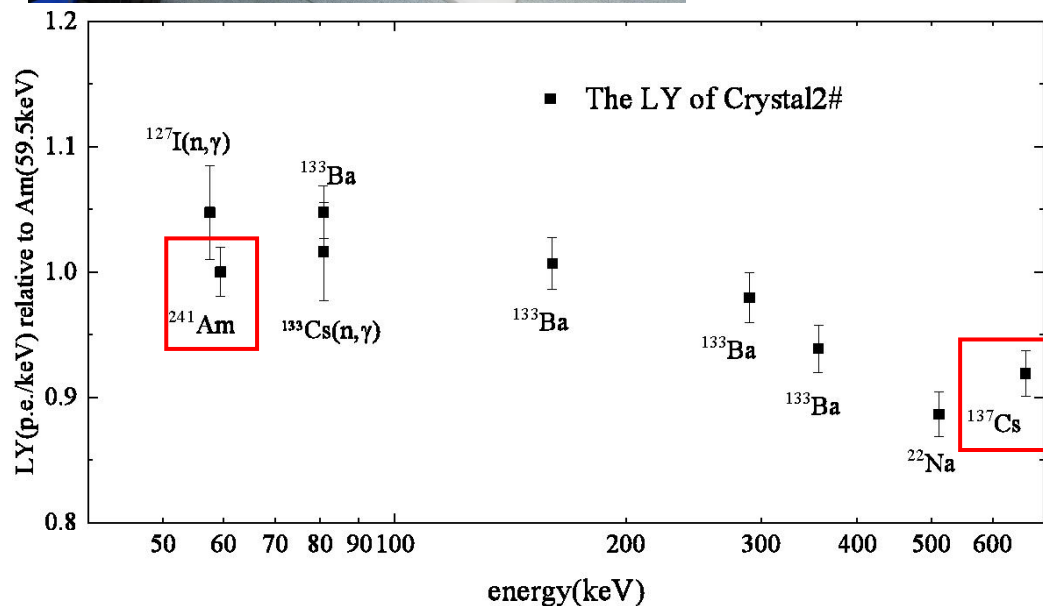
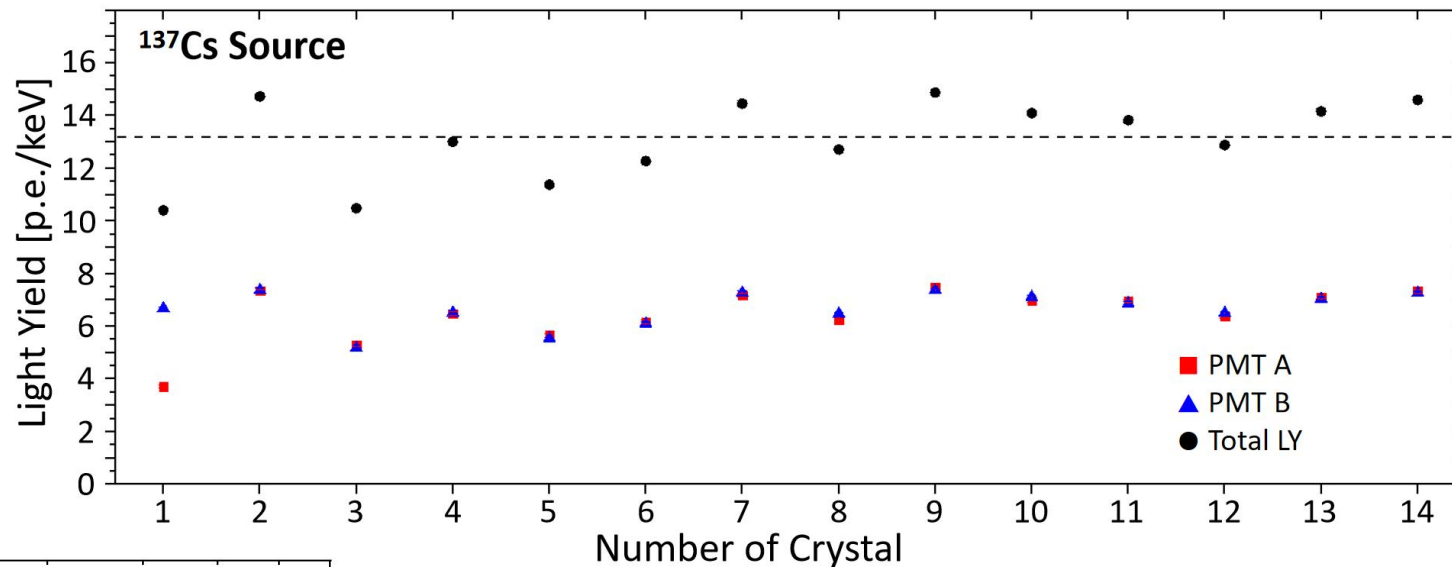
QE: 30.7~40.3%
Mean value: 37% @ 420nm

- Gain calibration
- Dark rate testing
- Effect of geomagnetic field and strategies

Crystal Energy Calibration



Crystal Energy Calibration Setting



- Light yield measurement with ^{137}Cs and ^{241}Am for every crystal
- Mean value: **13.2 p.e./keV**
- Energy Calibration with ^{133}Ba , ^{22}Na , ^{60}Co et.al.

Crystal Position Scanning

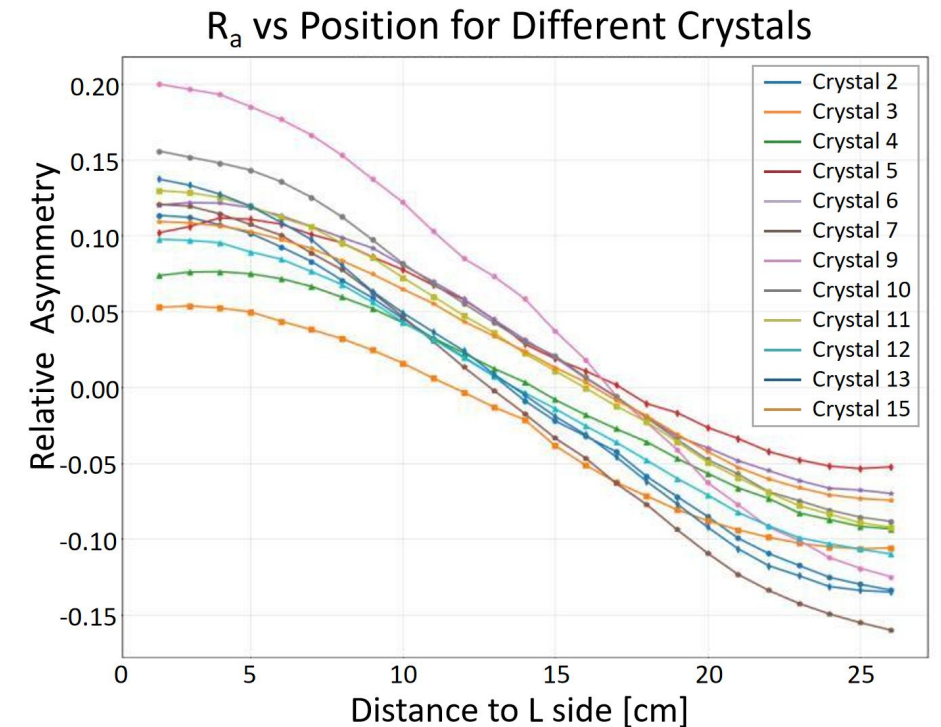
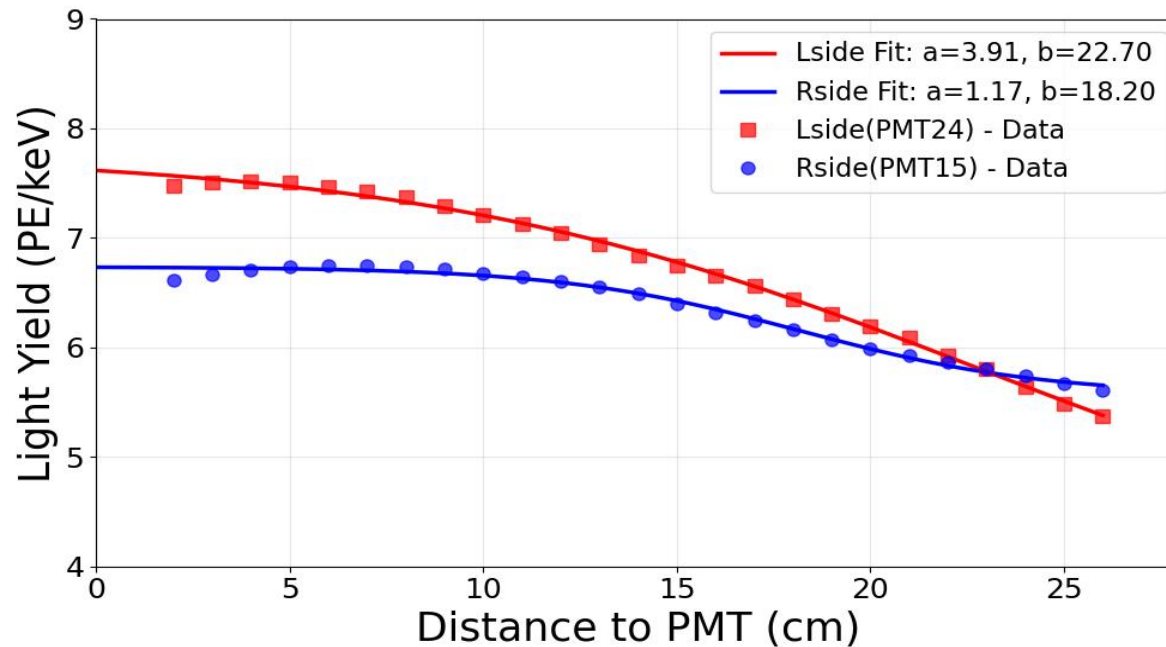


- **Crystal anisotropy: Position scanning**

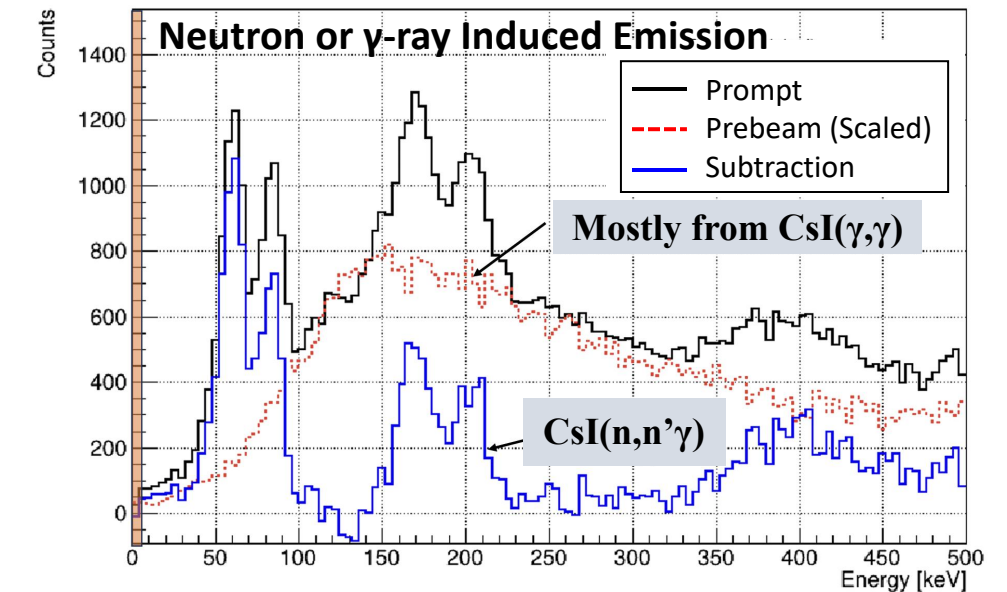
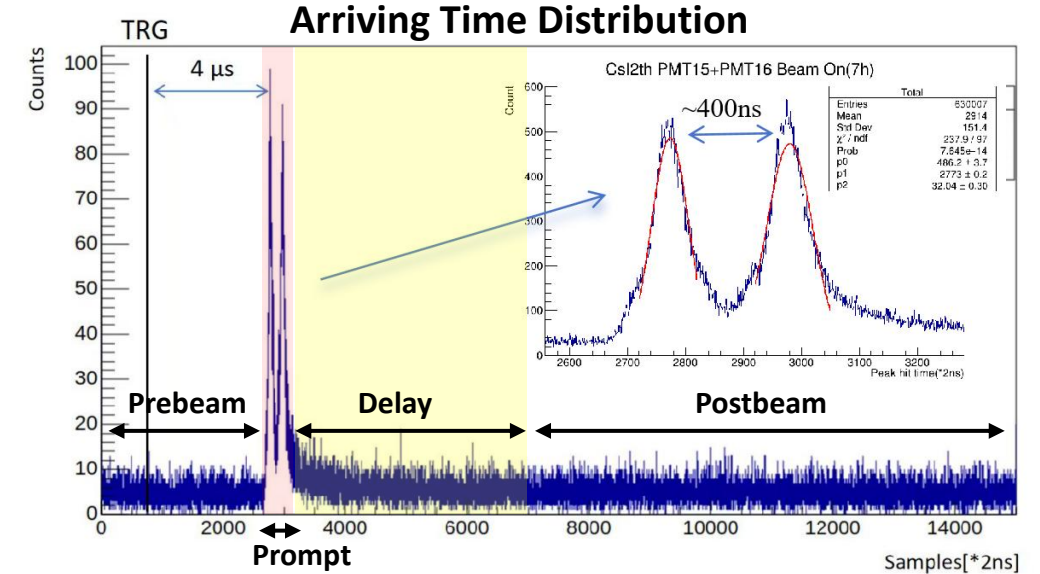
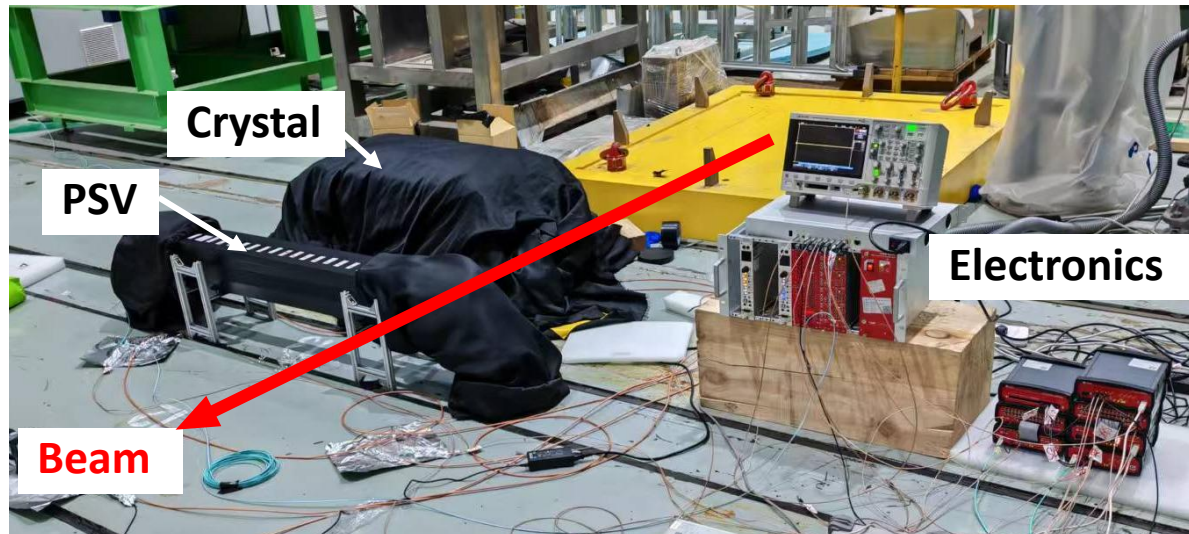
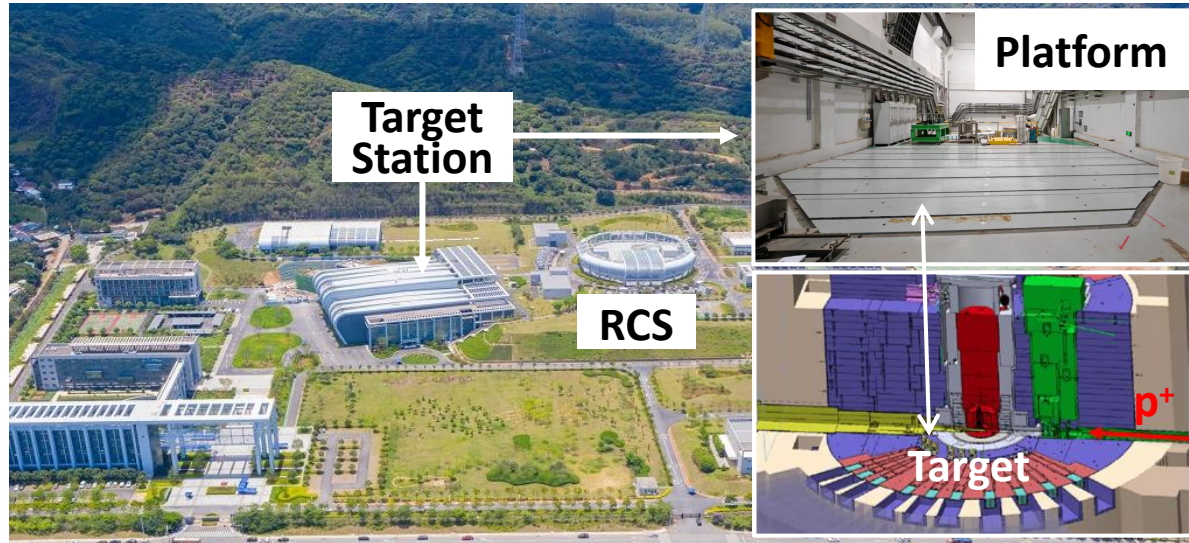
Fitting function: Four-Parameter Logistic

$$LY = \frac{a}{1 + e^{\frac{\text{Distance}-b}{c}}} + d$$

- **Axial position reconstruction**



Crystal Measurement in CSNS

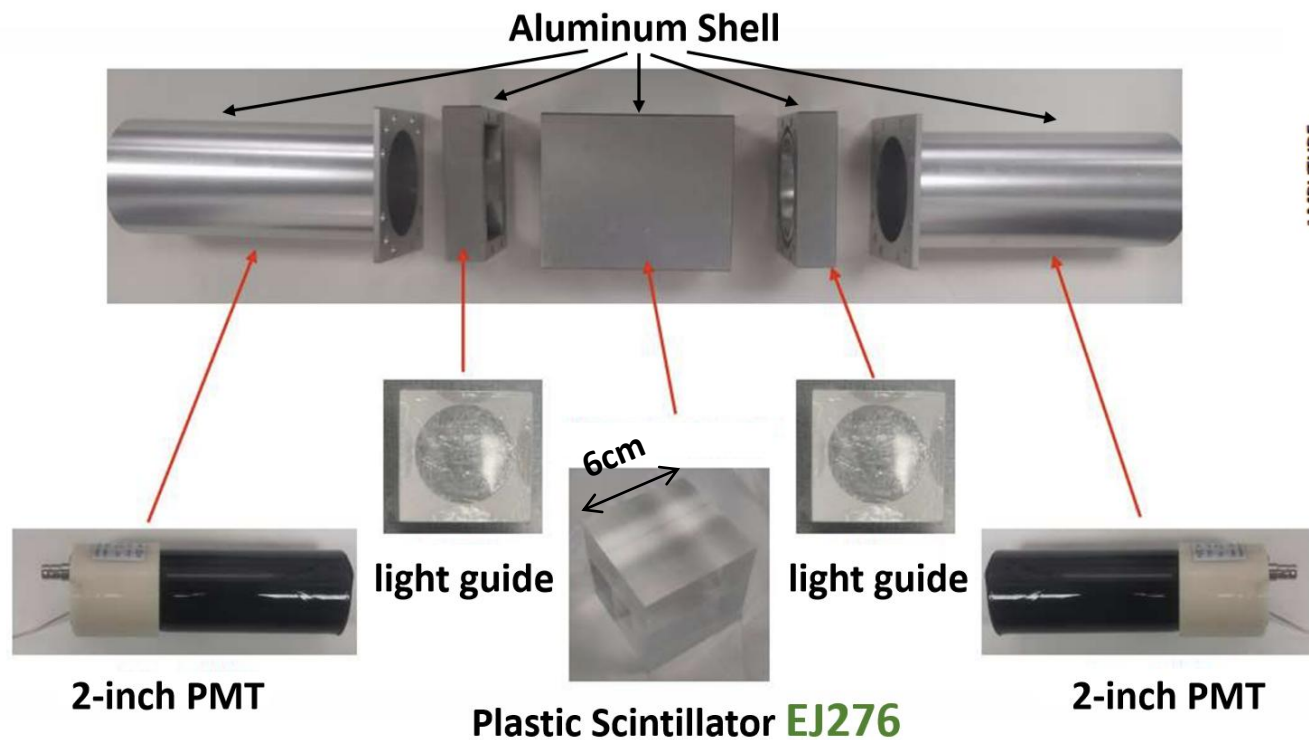


- 4 times measurement in CSNS.
- Above one month data taking in total.
- Different shieldings and settings.

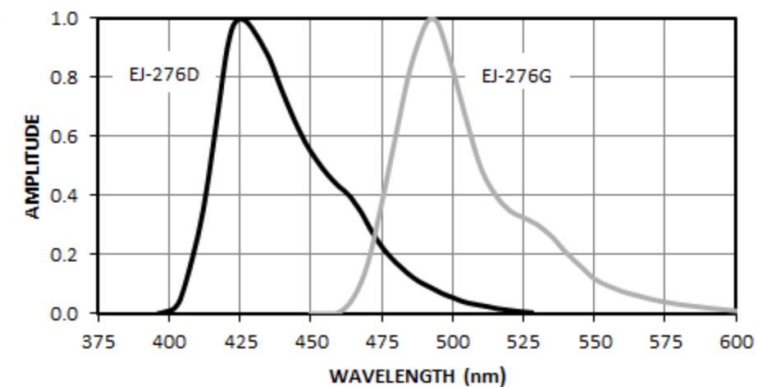


Motivation of Neutron Measurement

- ~ 10 keV CEvNS $\rightarrow$ Stringent background rejection
- Beam-Target $\rightarrow$ Fast-neutrons
- Fast-n recoil mimics CEvNS signal $\rightarrow$ *Indistinguishable Background*
- Neutron background measurement in CSNS



EJ-276D & EJ-276G EMISSION SPECTRUM [https://eljentechnology.com/]



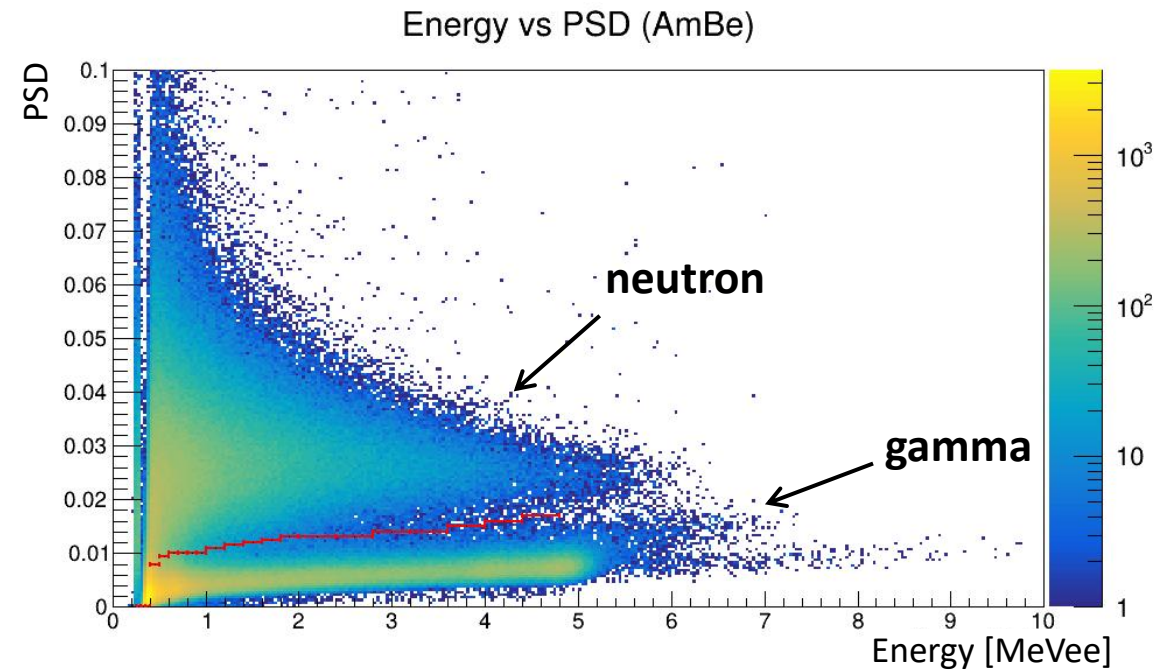
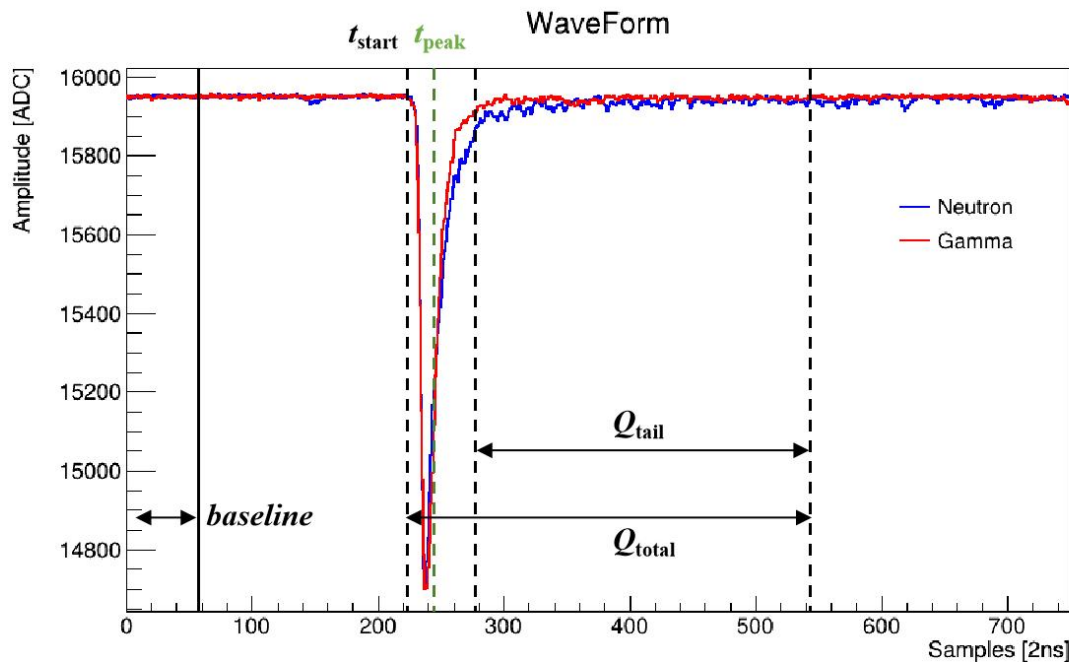
- Non-hygroscopic and physical hardness
- Long-term stability of scintillation and optical characteristics
- Basic PSD properties comparable to the best liquid scintillators

Energy and PSD Calibration

Source	Energy[MeV]	LightYield[p.e./MeV]	Resolution[%]
Na ²²	0.511	700.59 ± 9.67	17.87
Cs ¹³⁷	0.662	792.75 ± 10.94	12.24
Co ⁶⁰	1.17	961.79 ± 13.27	8.32
Na ²²	1.27	988.58 ± 13.64	7.96
Co ⁶⁰	1.33	1000.45 ± 13.81	6.24
K ⁴⁰	1.46	1016.03 ± 14.02	6.71

- $^{241}\text{Am} \rightarrow ^{237}\text{Np} + \alpha$; $^9\text{Be} + \alpha \rightarrow ^{12}\text{C} + \text{n}$
- Average energy of neutron spectrum: 4.5MeV
- Gamma ray from excited ^{12}C : 4.44MeV

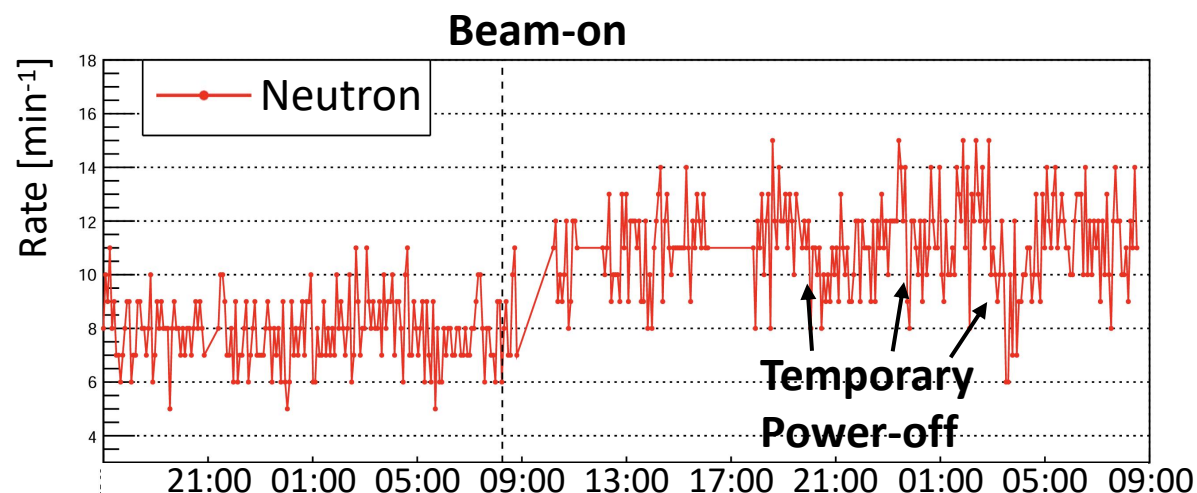
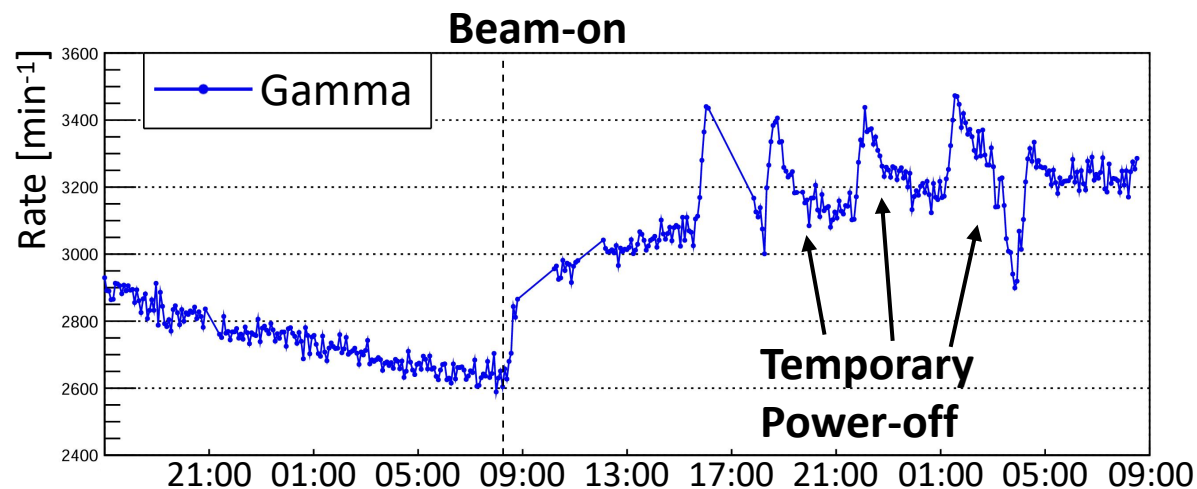
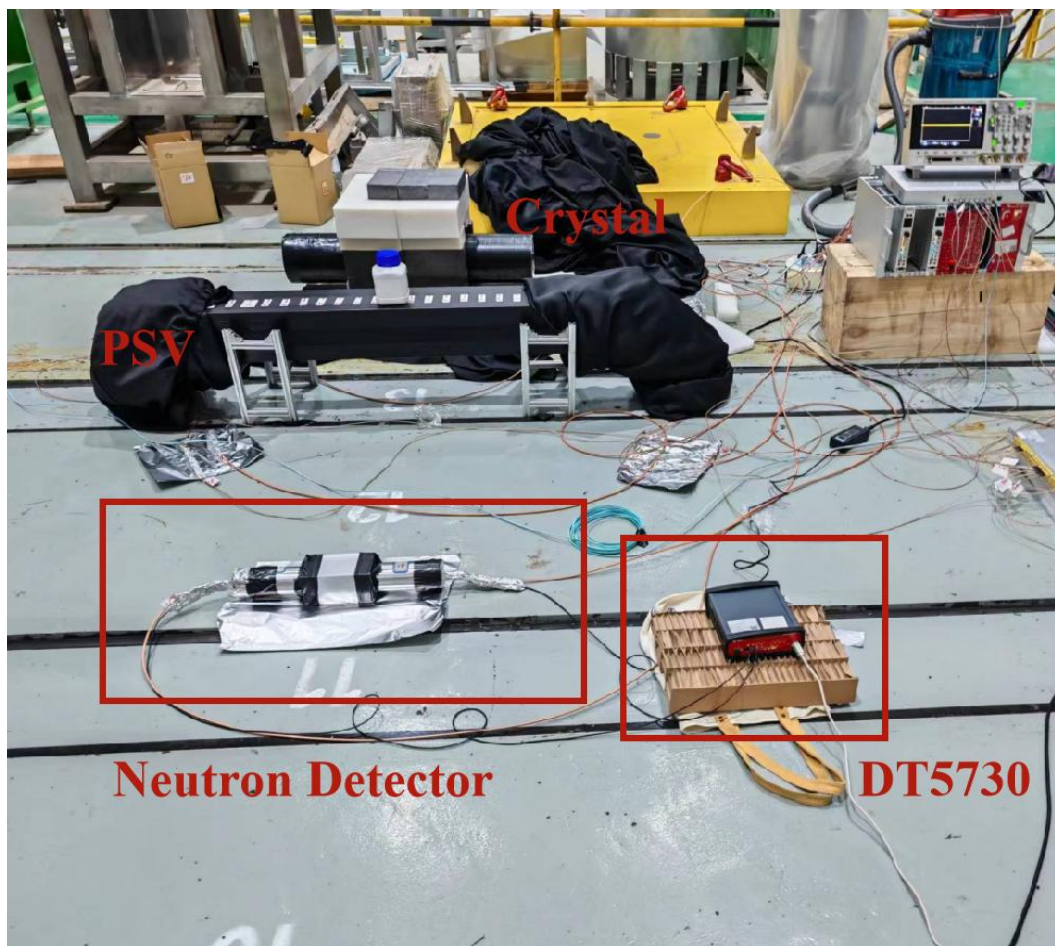
$$f_{\text{PSD}} = \frac{Q_{\text{tail}}(t_{\text{peak}} + 60\text{ns} < t < t_{\text{peak}} + 600\text{ns})}{Q_{\text{total}}(t_{\text{start}} < t < t_{\text{peak}} + 600\text{ns})}$$

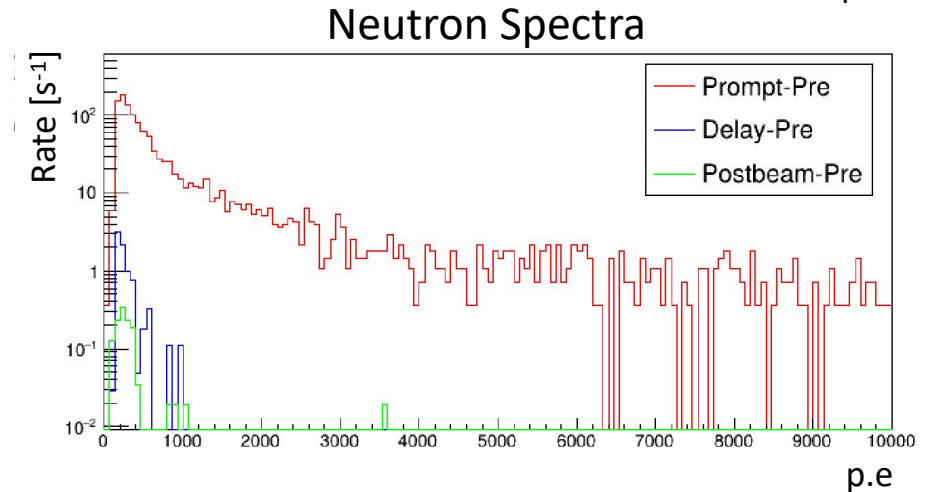
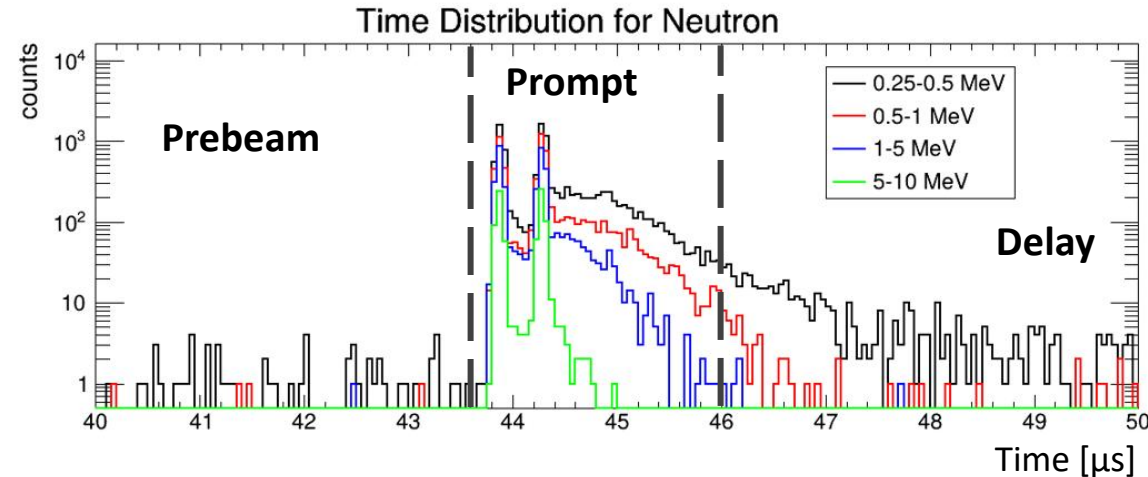


Event Rate Variation after Beam-on



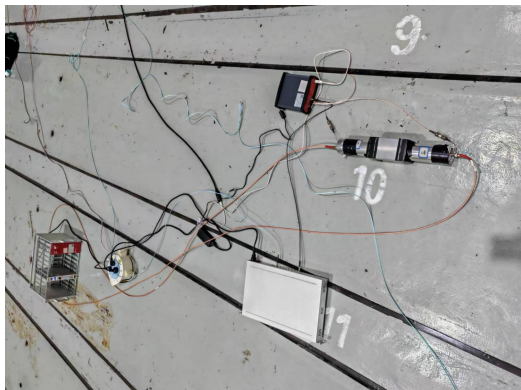
- Detector setting and functional verification.



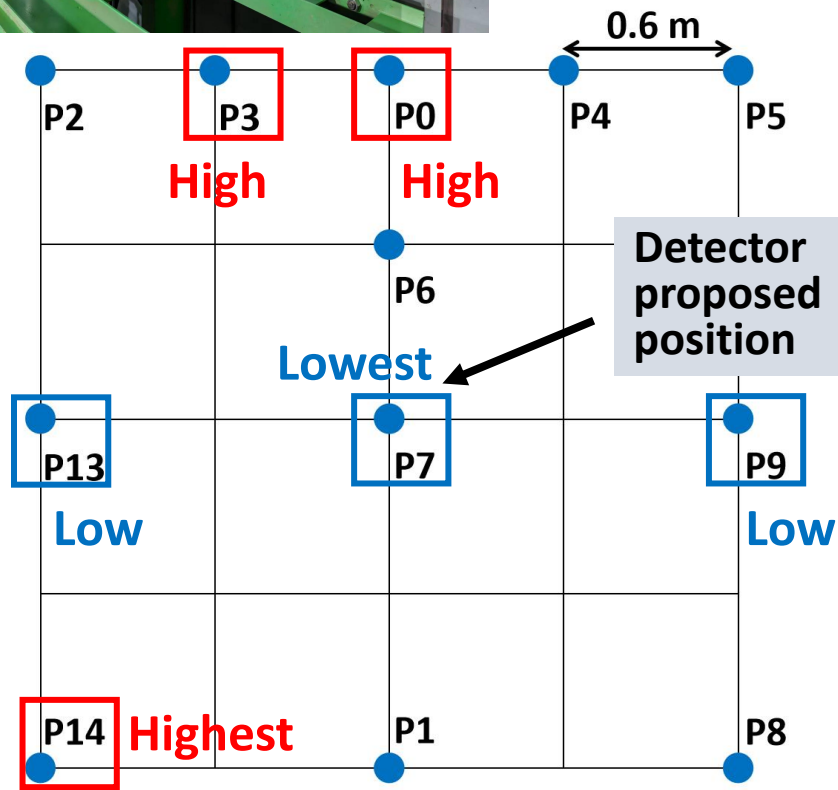
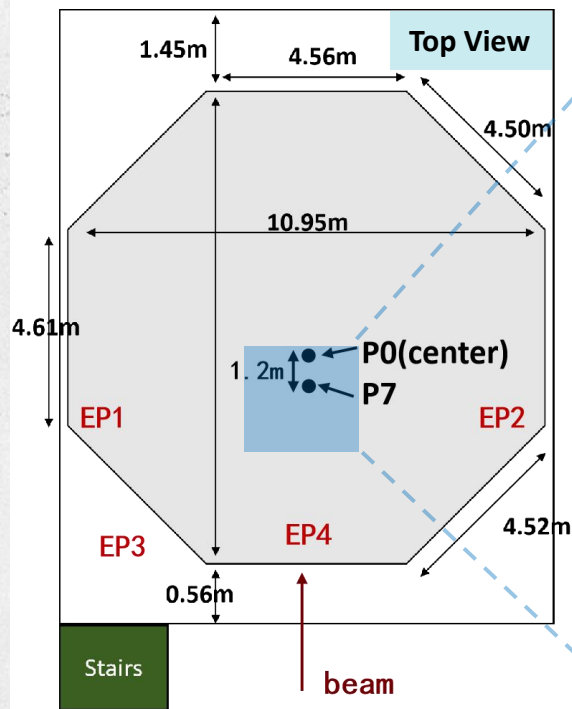


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Event Rate Position Distribution on Platform



- The count rate increases in the downstream direction.
- P7 exhibits the **lowest** event rate.
- Target shielding inhomogeneity.



	γ Rate[/s]	n Rate[/s]
P0	2328.7 ± 62.1	1675.5 ± 52.9
P7	1249.8 ± 55.9	674.1 ± 41.3
P14	3487.7 ± 145.8	2521.1 ± 125.5
EP1	3666.0 ± 145.4	2445.0 ± 119.7
EP2	4272.4 ± 205.3	3017.8 ± 173.9
EP3	2212.3 ± 116.5	1268.9 ± 88.6
EP4	2452.3 ± 101.1	1423.6 ± 77.6

Summary & Outlook

➤ CsI(Na) Crystal

- Preliminary calibration and measurement has been completed.

➤ Neutron Detector

- γ -ray and neutron performance on CSNS target platform.
- Lowest flux position (P7) from current results.

➤ Optimization

- Waveform reconstruction algorithms modification.
- Simulation for beam-induced neutron spectra.

➤ Future Measurement

- Neutron calibration for both crystals and PSD detector.
- Data taking is scheduled to commence by the end of 2026.





谢谢！
Thank you for listening!