Development of Data Acquisition (DAQ) Software for CICENNS Detector

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On behalf of CICENNS Collaboration

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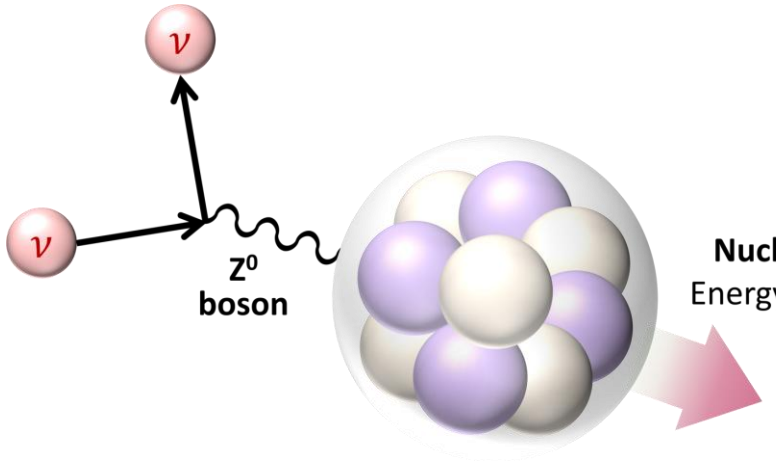
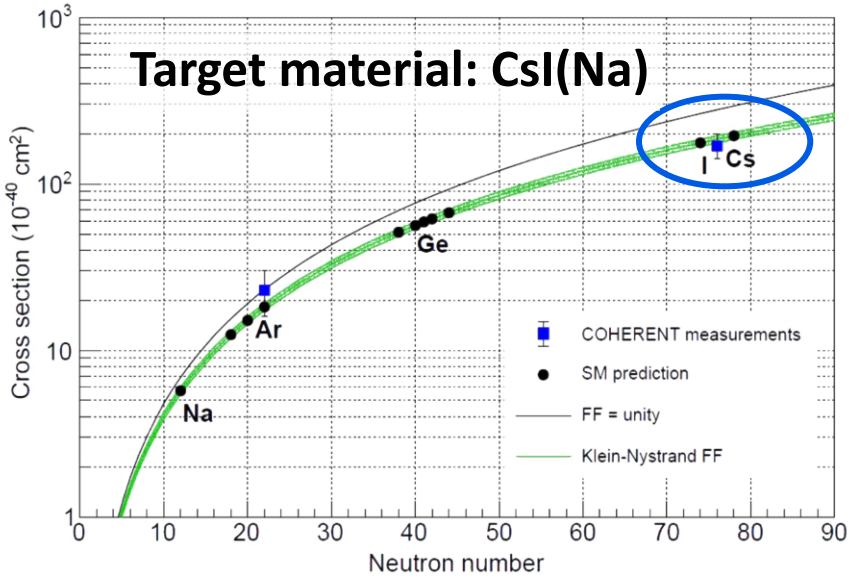
CEνNS process

Coherent Elastic Neutrino-Nucleus Scattering

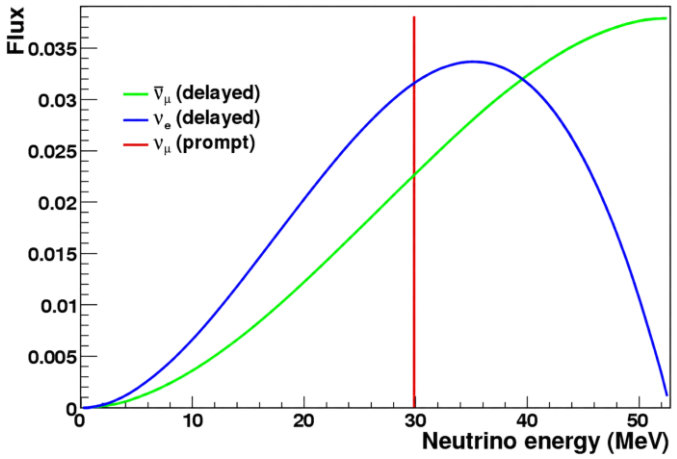


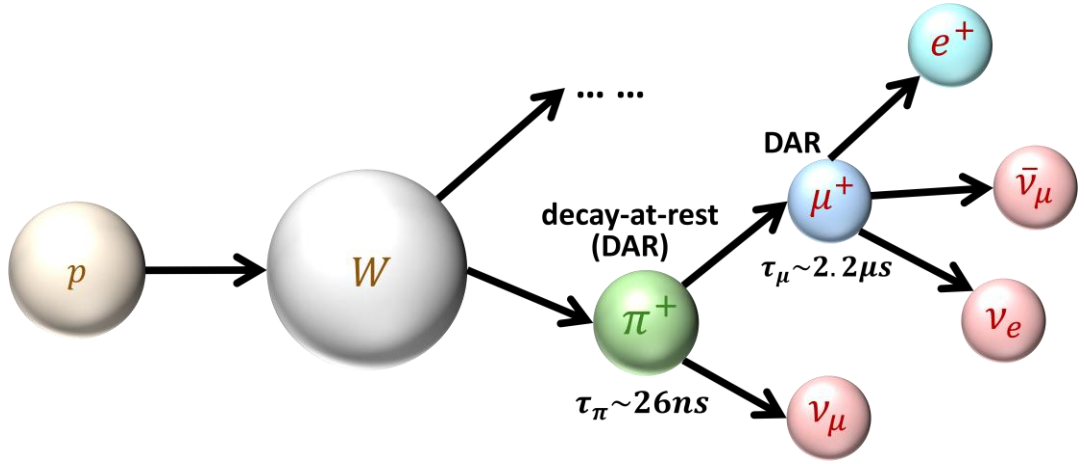
$$qR < 1$$
$$\sigma \sim N^2$$

Nuclear Recoil
Energy: O(10 keV)



Neutrino source: China Spallation Neutron Source (CSNS)





- **π/μ decay-at-rest neutrino source**
- **Detector location:** 10.5m above the target
- **Neutrino flux at 10.5m:** $6.71 \times 10^6\ cm^2/s/flavor$
- **Pulsed beam:** 25Hz

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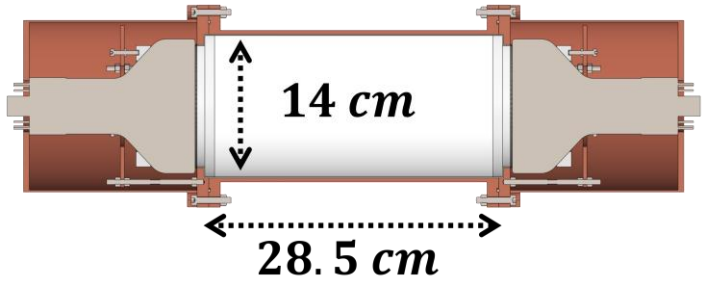
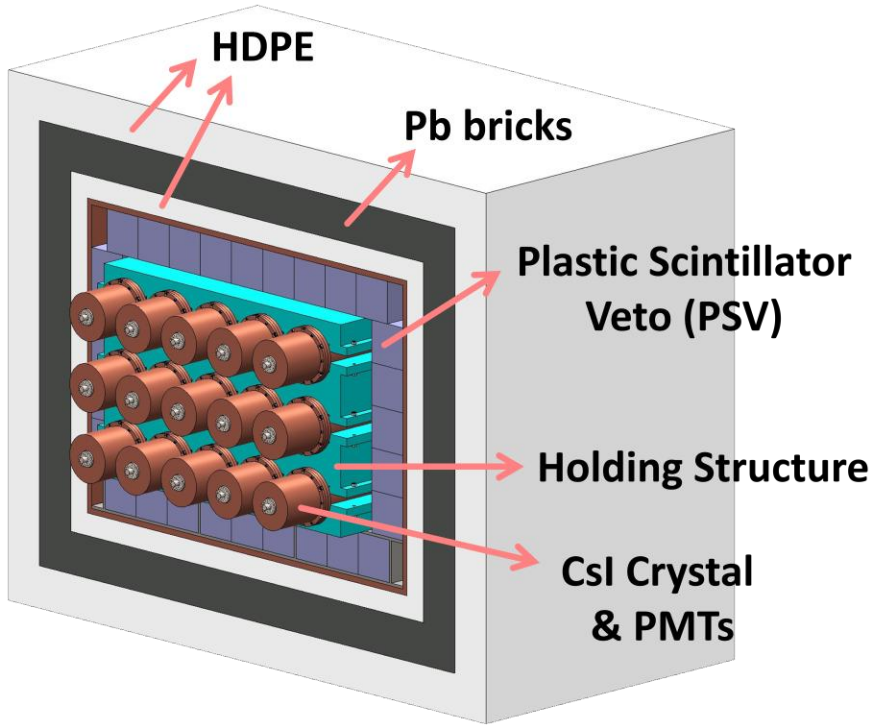
CICENNS DAQ requirement

CICENNS: 300 kg CsI(Na) Detector for CEνNS

July 16th | 分会V | 8:30 黄振秀



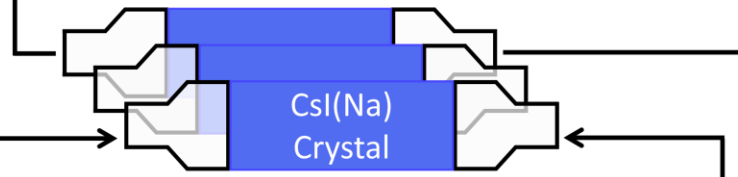


- **Target:** 15 CsI(Na) crystal modules
- **Active veto:** PSV array of 32 modules
- **Passive shielding:** Pb/Fe/HDPE
- **Readout:** dual-ended PMTs on crystal and PSV

DAQ requirements

- **Multi-digitizer waveform acquisition**
- **Synchronized timing across 8 digitizers**
- **Dual-range digitization for PSV**
- **Long acquisition window:** 360–400 μs
- **Detector-level online reconstruction and monitoring**

Multi-digitizer readout architecture



(30)

High Voltage

(64)

Fan-In-
Fan-Out

(128)

4x DT5730

500 MSPS
0.5V range
14 bits

4x DT5740

62.5 MSPS
2/10 V range
12 bits

Optical link

Optical Link

25Hz
Beam Trigger

Clock Generator

Monitoring Workstation

Run controller

Monitoring

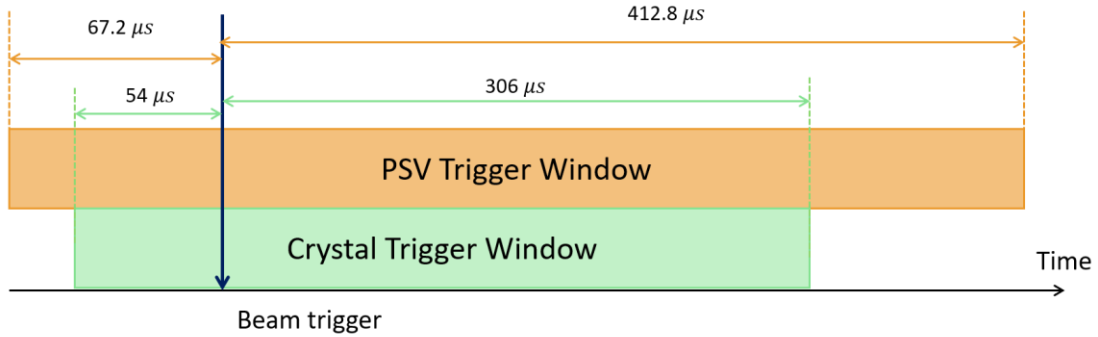
Trigger linking
Online reconstruction
↓
Database

Processing server

Readout
Workstation

Readout architecture

Trigger timing (under beam trigger mode)



- **Commissioning mode:** common external beam trigger
- **Other trigger modes:**
  - beam gate + local self-trigger
  - cosmic ray mode with coincidence trigger logic

- **Parallel readout from all DTs** (4x DT5730SB, 2x DT5740C, 2x DT5740D) **preserves data stream of each board.**
- **Long acquisition window (physics requirement vs. readout bandwidth):**
  - **Crystal:** 360 μs per beam → ~75MB/s per DT5730SB
  - **PSV:** 480 μs per beam → ~35MB/s per DT5740C/D

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Cross-board trigger association

Local ID of each FADC ≠ global trigger identity:

Global trigger ID: common software-assigned ID for records associated with the same beam timing reference

- **Data loss/missing record**
- **Complicated trigger strategy** (beam as gate + threshold as self trigger)

	Trigger A	Trigger B	Trigger C
FADC 0	1000	1001	1002
FADC 1	1000	---	1001
FADC 2	1000	1001	1002

FADC 0 local #1001 ≠ FADC 1 local #1001 !

Trigger linking

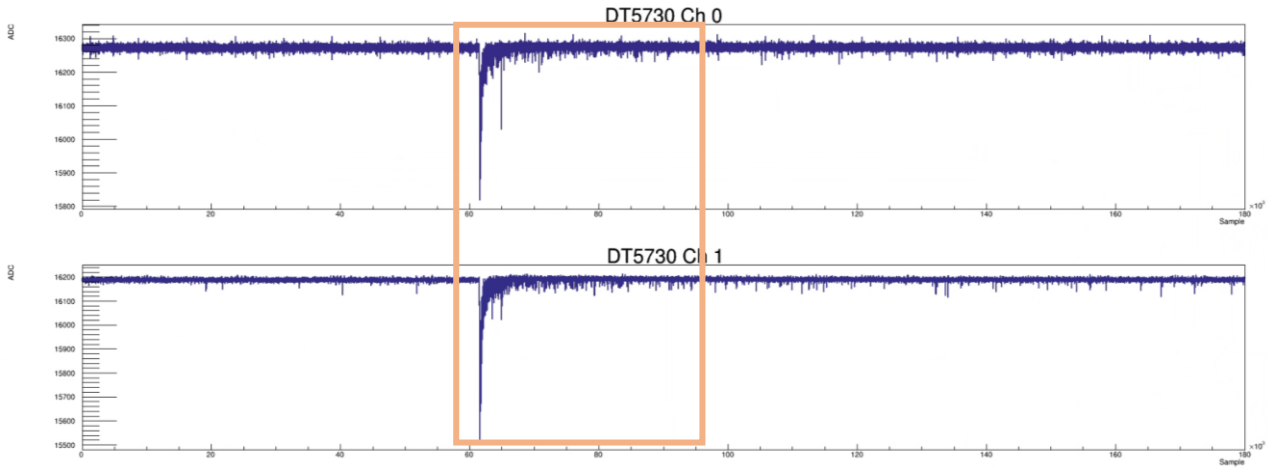
- Multi-board triggers are associated using trigger time tag
- Establishing a global trigger ID
- Data loss check while associating triggers

Status
- Implemented
- Used in current DAQ pipeline
- Extended to gate + self-trigger acquisition

Multi-level Online DQM

Online waveform reconstruction

- Pulse finding
- Charge integration
- Intra-detector coincidence
- Preliminary time-based event building



Pulse coincidence between dual-ended PMTs on one crystal.

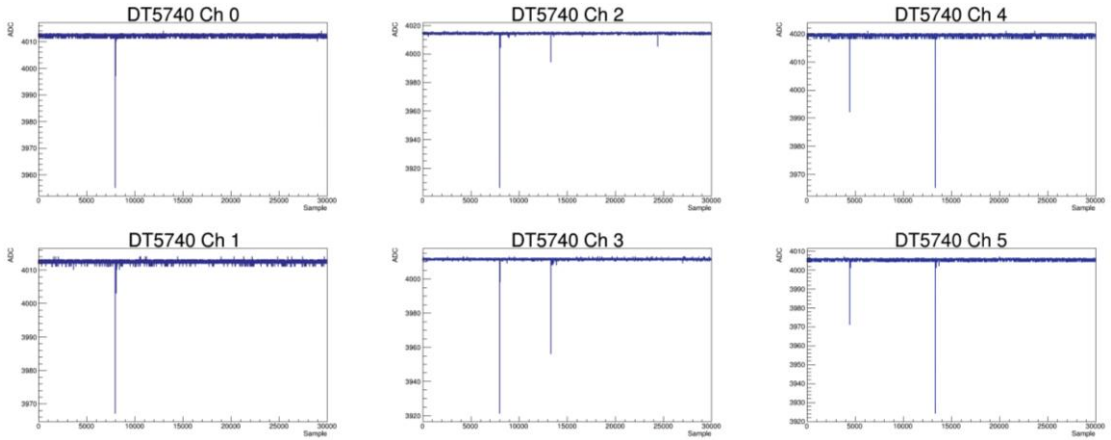
Raw data
Waveform Baseline average Baseline RMS

Reconstructed data
Hit map Integrated charge Event display

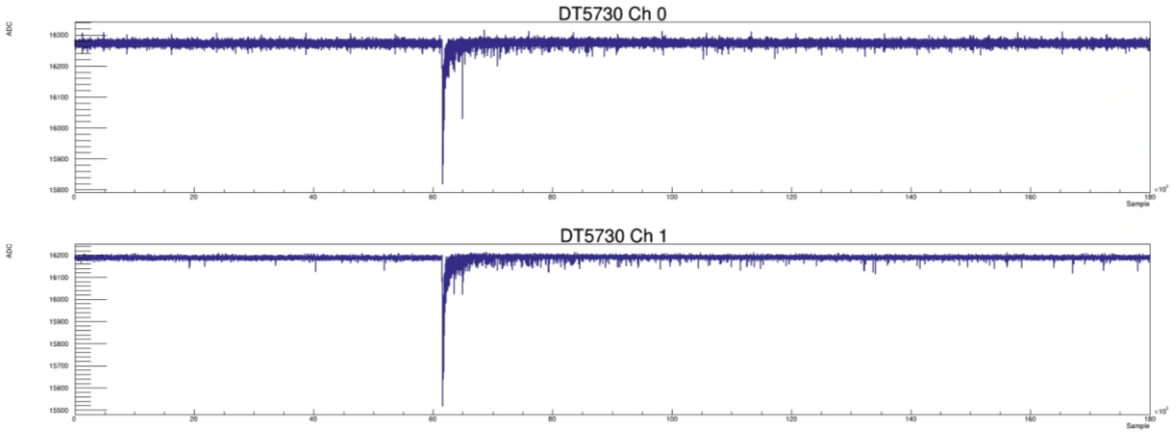
Slow control (under development)
Temperature, Humidity HV value Site status

Examples of online monitoring

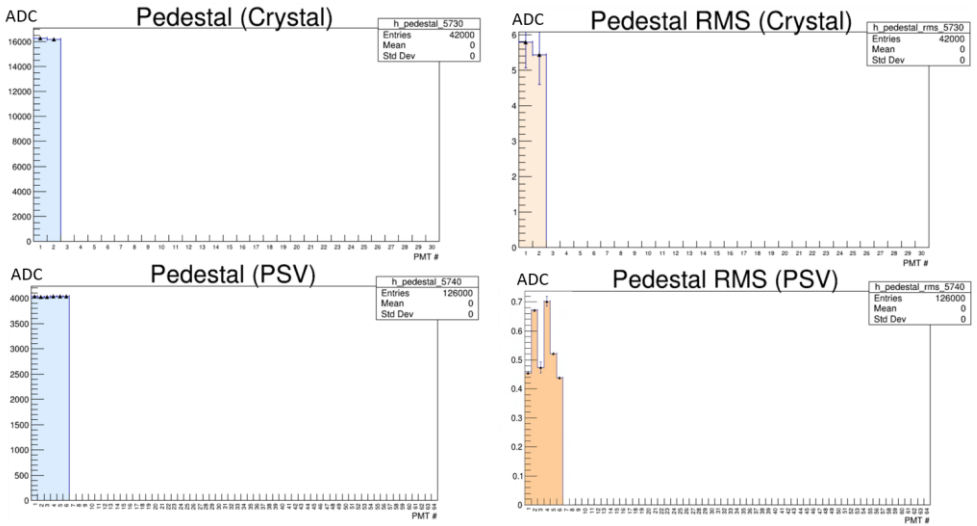
Waveform display of PSV



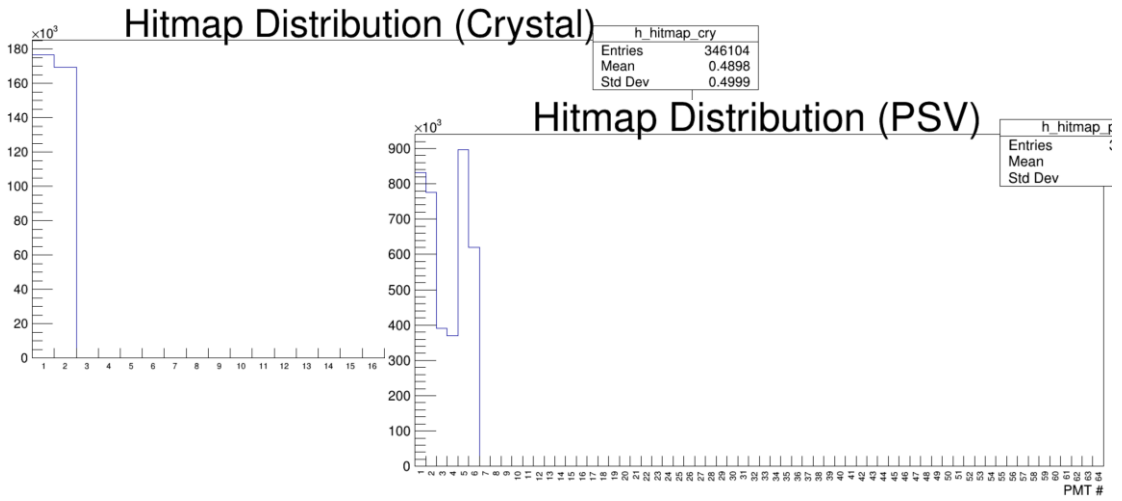
Waveform display of crystal



Pedestal information



Number of hits distribution



Monitoring examples are from partial-detector commissioning tests.

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Current status & summary

Components	Status
Parallel multi-digitizer acquisition 8 CAEN FADCs with long-window waveform acquisition	✓ **Operational**
Cross-board trigger association Board-local streams → global trigger identity	✓ **Operational**
Online reconstruction & multi-level DQM Raw waveforms → detector-level observables	✓ **Operational, expanding** • Slow-control integration under development

- A complete software chain from independent digitizer streams to globally associated and reconstructed detector data has been established.

Thank you for listening.

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