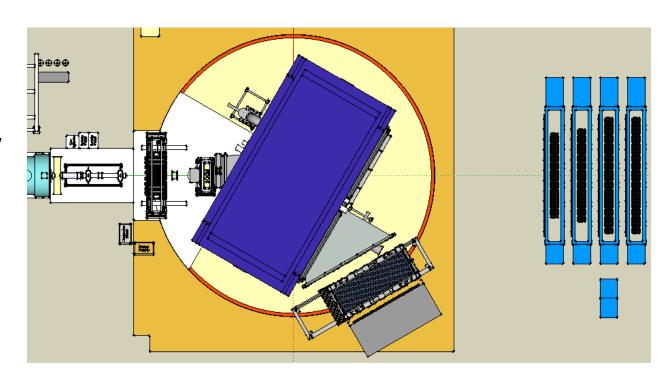
# Plastic scintillator arrays at SAMURAI

Y. Kondo (Tokyo Institute of Technology)

# Plastic scintillator arrays at SAMURAI

- 4 wall setup of NEBULA is now available
- There are many plans of neutron detector arrays
  - -HIME, NEOLITH, LAMPS neutron detector, PKU-AMDA, MNEUT

 Optimization is necessary Improve productivity of SAMURAI collaboration



### **HIME AT SAMURAI**



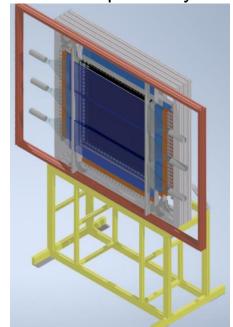
- Improved neutron-detection granularity:
- HIME High-resolution detector for Multi-neutron Events
- Modular plastic-scintillator (EJ-200) based array
- Dimensions: 100 (length) x 4 (width) x 2 (depth) cm<sup>3</sup>
- Full detector (HIME+):
  - → active area ~100x100 cm<sup>2</sup>
  - → 24 bars per layer
  - → 720 channels in total
  - → two separate detector walls with:
  - → 4 (existing layers) and 11 (being built at TU Darmstadt) layers (30 cm thick)
- Readout: padiwa4 + TRB3 (GSI)
  - → internal time precision ~20 ps
  - → expected time resolution (not measured yet) ≤100 ps (rms)

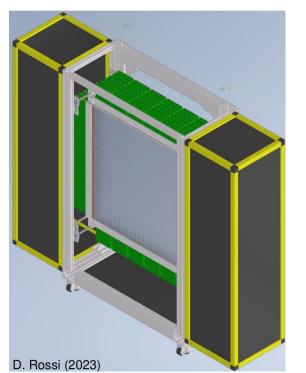


#### **HIME CURRENT STATUS**



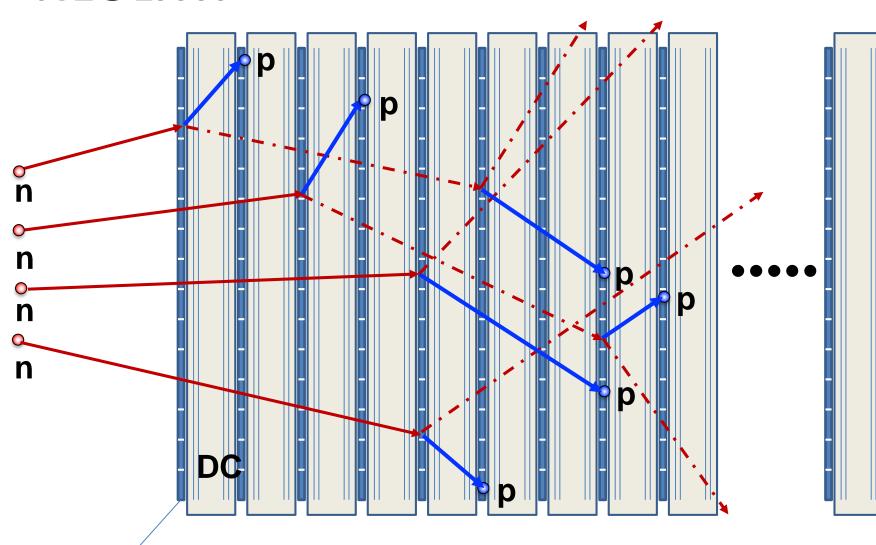
- Planes 1-3 assembled in March 2024
- Plane 4 incomplete (missing 8 bars + PMTs)
  - → to be completed in 2024 (components ordered and received TiTech)
- Planes 1-3 used successfully in Spring 24 beamtine
- (Spirit-TPC experiment, June 2024)
- Planes 5-15 being assembled at TU Darmstadt
  - → to be completed by the end of 2024 and shipped to Japan





HIME at Spring 24 beamtime

## **NEOLITH**



tracking of secondary protons

better crosstalk handling better position resolution  $\rightarrow$  good Erel resolution ( $\sigma_{Exn} = 30-70$ keV for multi-n system)

Schedule plan

2024Apr: start KAKENHI period

2025Mar: first layer

..

2028Mar: full setup

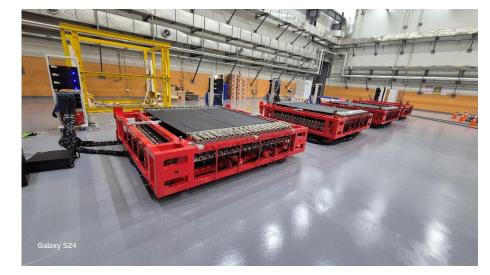
2029Mar end of KAKENHI period

Plastic Scintillator (optimized size is under investigation) 15 modules x20 Layers

## LAMPS Neutron detector

Prepared by Sunji Kim, Jongwon Lee, Byungsik Hong

- Frame Size: ~3m(vertical) x ~4m(Horizontal) x ~0.8m
- Detection area: 2m x 2m
- Total 160 **10x10x200 cm<sup>3</sup>** scintillator for neutron detection
- Total 80 10x1x200 cm<sup>3</sup> scintillator for charged particle VETO
- 480 H7195 PMT in mu-metal shield (removable)
- Total 4 layer (80 cm thick in total)
  - In a single layer: 20 veto array(x) -- 20 neutron array(x) -- 20 neutron array(y)
- DAQ electronics
  - Single LTE (LAMPS Trigger Electronics)
    - Global trigger controller
    - Clock generation & sync. between 4 FADC crates(up to 8 crates, <40ps)</li>
    - Recording incoming (trigger) signal timing & count (2.8e8 sec, 8 ns precision, 4.3e9 counts)
    - Self trigger with multiplicity, hit pattern.
    - Top trigger rate: 500 kHz, 2us interval.
  - 4 TCB (Trigger Control Boards)
    - Handle up to 80 FADC boards.
    - Local trigger setting in single boards (4 channel hit pattern)
    - External trigger.
  - 500Msps Flash ADC x 480 channels (120 boards)
    - Data transfer rate: 5Gbps/boards using USB3(implemented) or SFP(planned)
    - On board memory: 4GB / boards
    - Recording length: 128 ns 32 us
    - Dynamic range: 2V(-2V~2V offset adjustable, 12 bit, 0.5mV/1bit)



(FYI, LAMPS (Large Acceptance Multi-Purpose **S**pectrometer) is a spectrometer at the end of the high-energy beamline of RAON.)







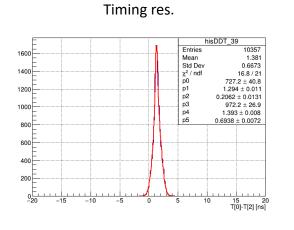


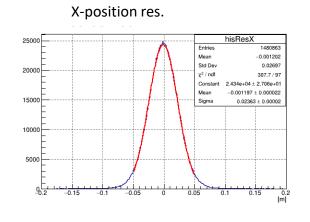


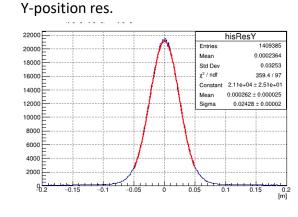


## **Performance & Schedule**

- Resolutions (FWHM) (Cosmic-ray measurement)
  - Position resolution: 4.5 cm(x array), 4.7 cm (y array)
  - Timing resolution : 301 ps ( $\sigma$ =128 ps)

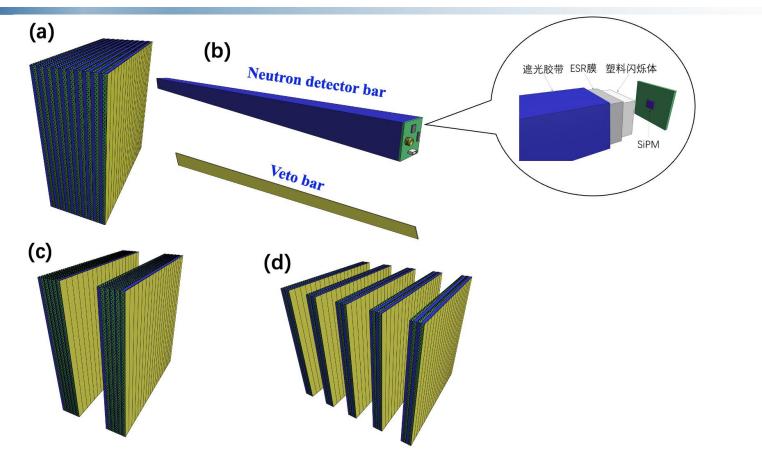






- Position/Timing resolution measurement for the veto array ongoing
- DAQ development ongoing for integration with another system
- Completion of administrative paperwork by August
- LAMPS neutron detector will be transported to RIKEN
  - Shipping & Installation: ~4 month
  - Schedule and budget discussion needed
  - Manpower: more than 3 needed

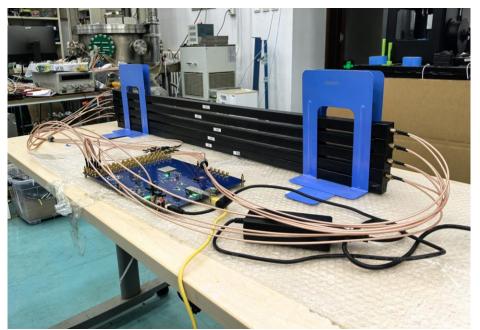
### **Overview of PKU-AMDA**

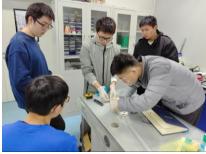


- ➤ Multi-layer of BC408 scintillator modules (tentatively, 10 double planes)
- ➤ Total size: ~200cm\*200cm\*80cm
- ➤ Light readout: SiPM (Hamamatsu)
- ➤ ASIC-based readout electronics: operational (upgrading)

### Prototype and schedule plan

#### Construction and test of a prototype array at PKU (2022~)









 $\triangleright$  Preliminary test results using cosmic ray:  $\sigma_t \sim 150$  ps

### **Tentative plan**

- > Funding application for the full array: in progress
- ➤ Demonstrator (~300 modules): available from ~ 2026/Spring

MNEUT Designed for (p,pn) measurement for RIBF16 (T. Kobayashi) -> SAMURAI75R1 (Y. Matsuda, T. Nakamura) 0

#### MNEUT-L

- 1 bar: 6.5(H) x 10(D) x 200(V) cm<sup>3</sup>
- Effective area: 104 x 200 cm<sup>2</sup>
- 40 cm thick in total (16 bars x 4 layers)

#### MNEUT-S (lying in the SAMURAI area)

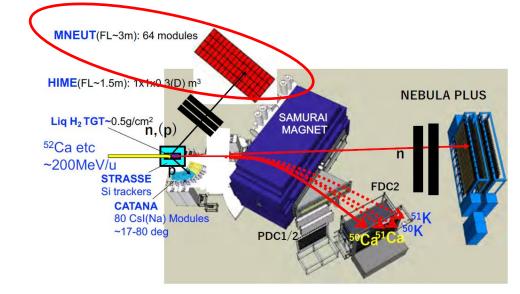
- 1 bar: 6(H) x 6(D) x 110(V) cm<sup>3</sup>
- Effective area: 100 x 96 cm<sup>2</sup>
- 24 cm thick in total (16 bars x 4 layers)

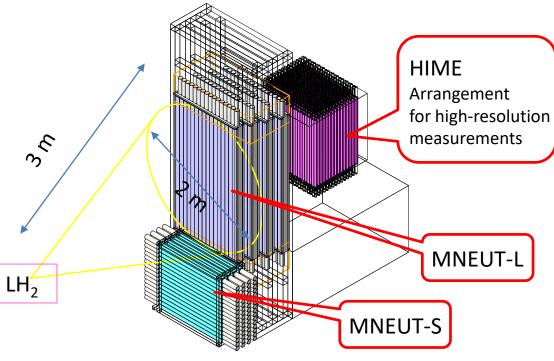
#### Current status

- \* Budget: MEXT/JSPS KAKENHI 2024-2028
- \* Re-assembly of MNEUT-S at KONAN Univ.
- \* No VME QDCs and TDCs. [128ch for L, 128ch for S] (They are originally CAMAC readouts.)

#### Schedule plan

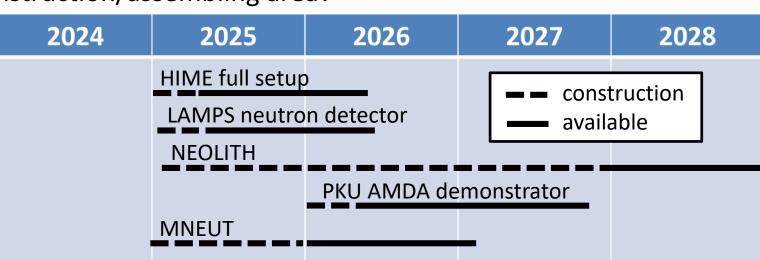
- 2024 Design of the stands and magnetic shields
- 2025 Construction & Signal check
- 2025- Experiment with STRASSE and HIME

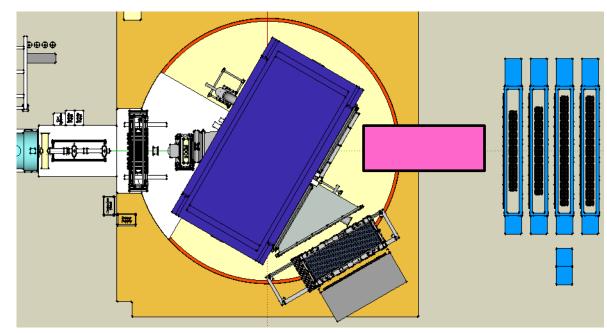




# How to optimize/manage the setup?

- LAMPS neutron detector will come to RIKEN
  → What is the optimized setup?
- NEOLITH will fully occupy the 0-deg area before NEBULA, others cannot be placed
  - How much time needed for installation/replacement?
  - → related to beam time allocation
- Enough construction/assembling area?

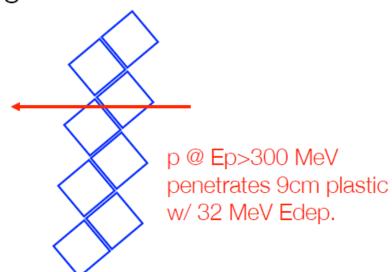






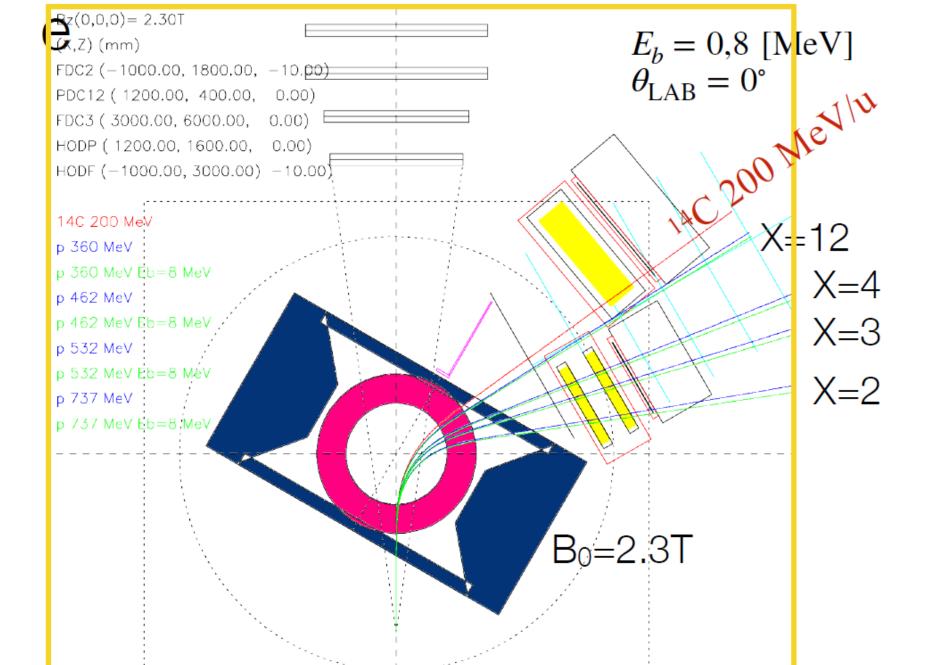


- Compatible w/ Short NEUT which was used in RIPS facility
- 6 ×6 ×100 [cm<sup>3</sup>]
  45° twisted against SAMURAI focal plane
- 16 modules, 32ch readout / 1 HODXXX
- Proton @ 300 MeV penetrates 9cm plastic
- by hitting 2 modules at least



slide shown by H. Otsu in SM WS2023

p @ Ep>300 MeV



slide shown by H. Otsu in SM WS2023

## **Summary**

- Many plastic scintillator arrays are planned at SAMURAI
  - HIME, NEOLITH, LAMPS neutron detector, PKU-AMDA, MNEUT

- What is the optimized setup?
  - $-\rightarrow$  need to start the discussion
  - Working group
    - Y. Kondo, S. Koyama, S. Huang, somebody from IBS, TU Darmstadt