

TIME PROJECTION CHAMBER AND HIGH-ENERGY NEUTRON DETECTOR

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INTRODUCTION

Previous Experience and Current Activities

CURRENT RESEARCH ACTIVITIES

1. Time Projection Chamber : [LAMPS-TPC](#) at RAON, [HypTPC](#) at J-PARC, [sTPC](#) at KU
2. Neutron Detector : [LAMPS-n](#) at RAON, LEPS2 at SPring-8

Previous Experience

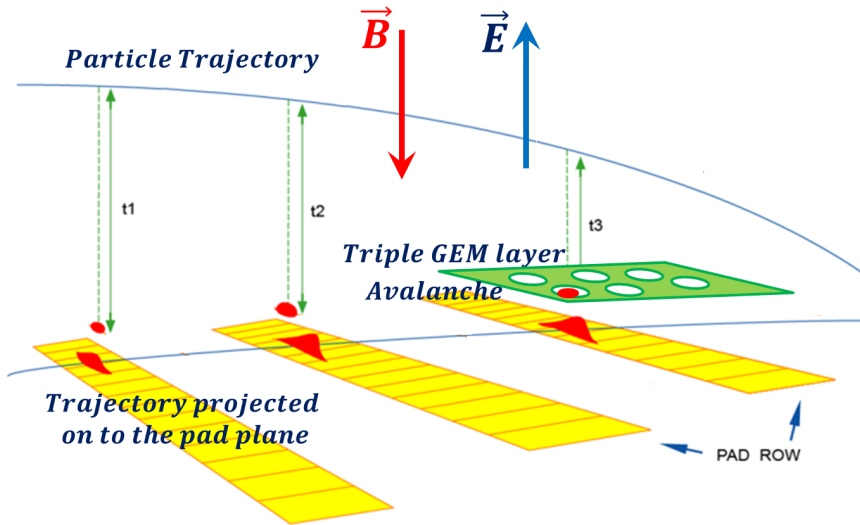
1. TPC : LEPS-TPC at SPring-8, pTPC at PNU
2. Neutron : LEPS at SPring-8



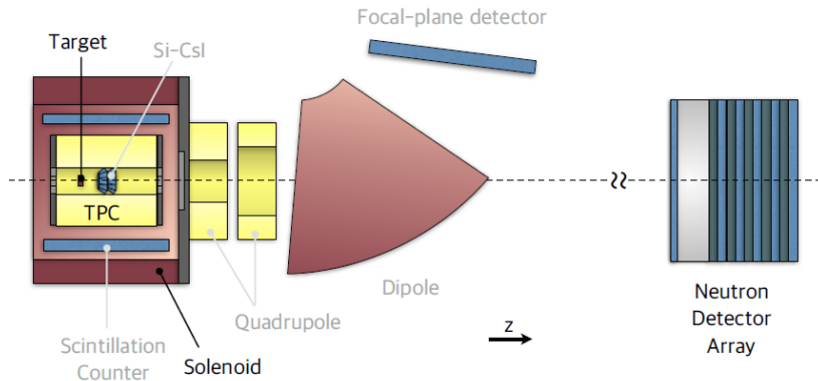
TIME PROJECTION CHAMBER



Operation Principle of Time Projection Chamber

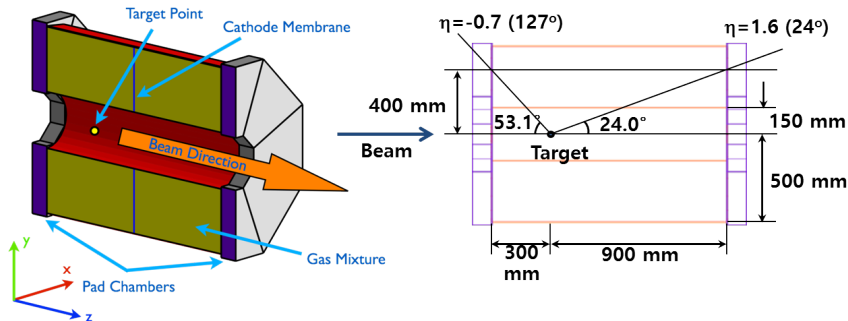


Large Acceptance Multi-Purpose Spectrometer (LAMPS)



- Nuclear Symmetry Energy
- Measuring π^+/π^- , n/p , and $^3\text{H}/^3\text{He}$ ratios from asymmetric isospin RI reactions such as $^{132}\text{Sn}+^{124}\text{Sn}$ at 250 MeV/u.

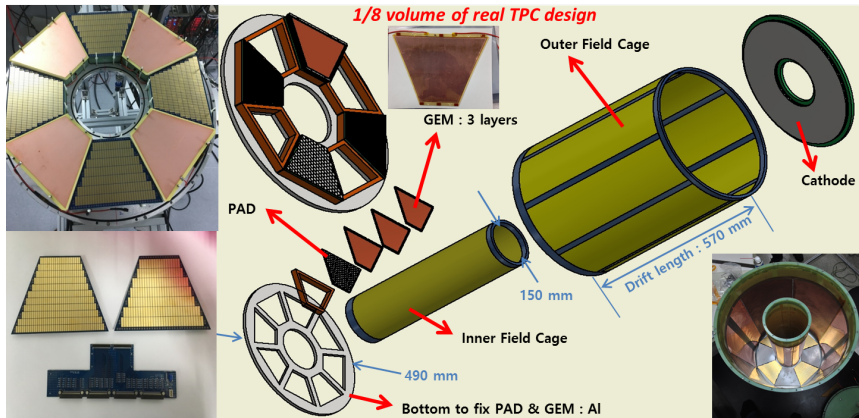
LAMPS Time Projection Chamber



- Central tracking device in a solenoid magnetic field.
- Momentum measurement and particle identification.
- Gas Electron Multiplier (GEM) for signal amplification.
- Front-end electronics (GET system).

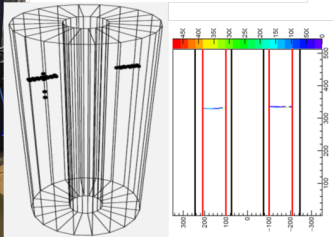
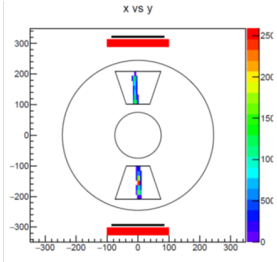
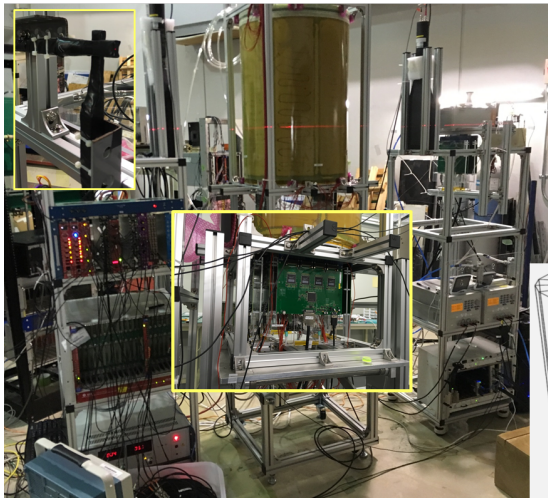


Prototype TPC for LAMPS



- 1/8 volume of the full-size TPC with four active sectors.

Beam Test of Prototype TPC at ELPH, Tohoku University

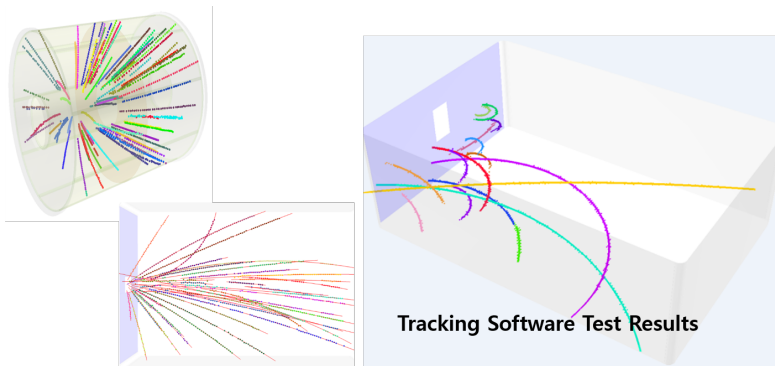


○ The LAMPS TPC prototype was exposed to 460-MeV



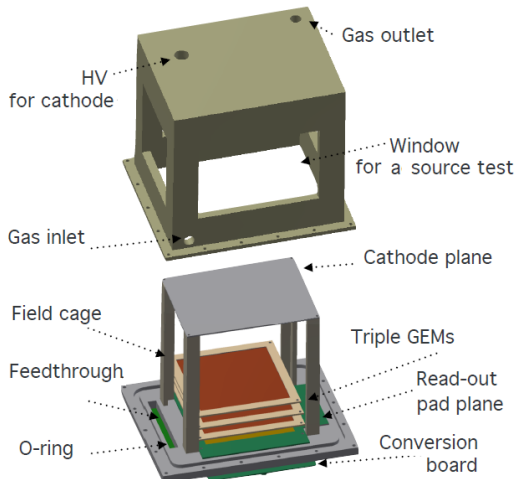
Progressive Track-Finding Software

- Progressive track-finding software finds more tracks.
- Effective for low momentum tracks and missing-hit tracks.



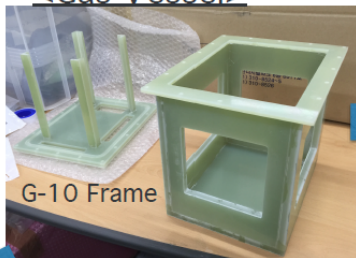
Small GEM TPC (sTPC) at KU

- A compact GEM TPC for a detection of low-energy recoil nuclei in nucleosynthesis reactions.
- Drift volume
 $10 \times 10 \times 15 \text{ cm}^3$
- Triple GEM structure ($50 \mu\text{m}$, $10 \times 10 \text{ cm}^2$)
- 256 readout anode pads



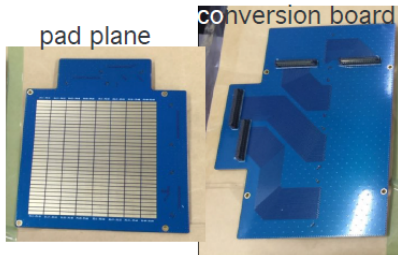
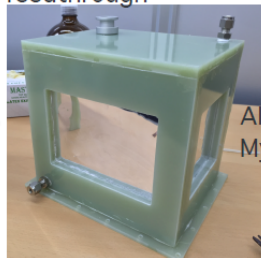
Prototype Assembly (sTPC)

<Gas Vessel>



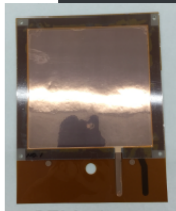
Cathode HV
feedthrough

Gas inlet/outlet

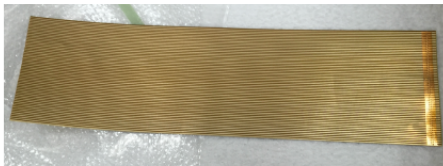


Prototype Assembly (sTPC)

<Drift & Amplification Region>



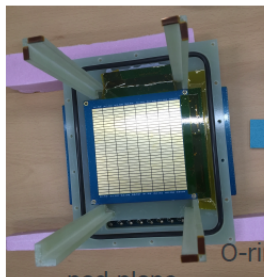
GEM sheet



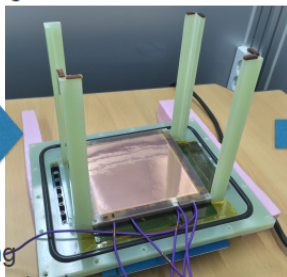
field cage



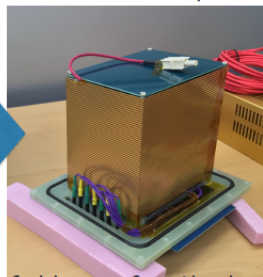
cathode plane



pad plane



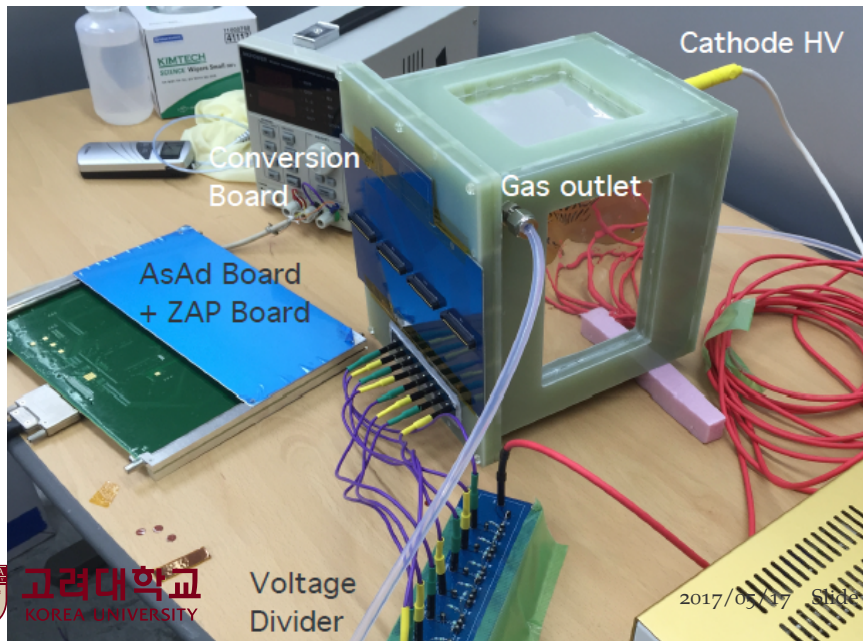
triple GEM



field cage & cathode

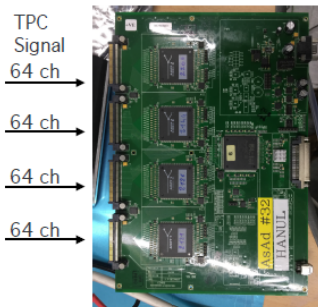


Prototype Test Setup (sTPC)



TPC DAQ System

AsAd(ASIC and ADC)



4 AGET chips

- Preamplifier(gain 120 fC-10 pC)
- Shaper(peaking time 50 ns- 1 us)
- Circular Buffer
(sampling rate 1 MHz-100 MHz)

R-CoBo

- Data Processing
- Network Transfer



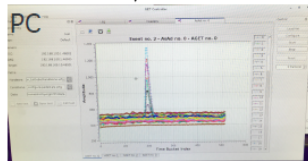
Data Transfer
(25 MHz)

Slow Control
Trigger

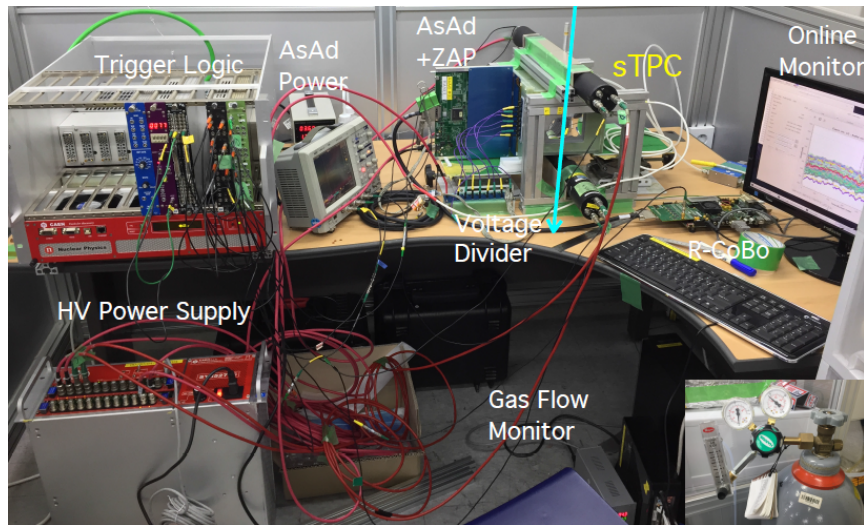
Data Transfer
(TCP/IP 1 Gbps)

Slow Control

GetController

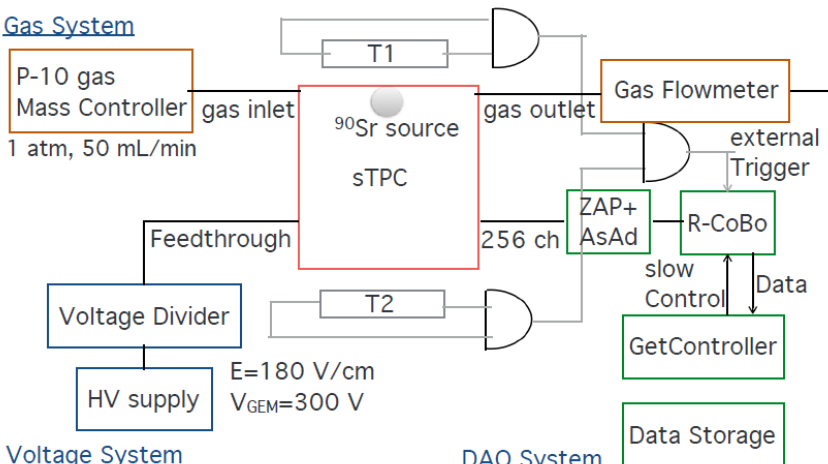


Cosmic-ray Test of sTPC

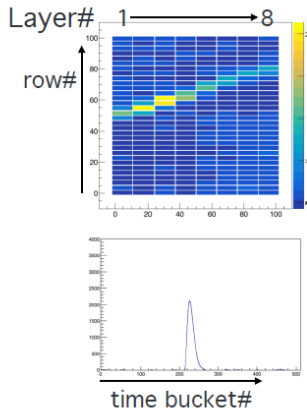
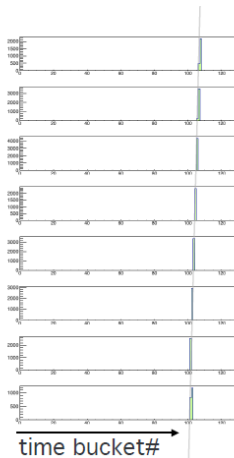
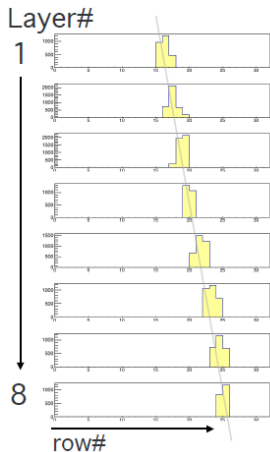


Cosmic-ray Test of sTPC

Gas System

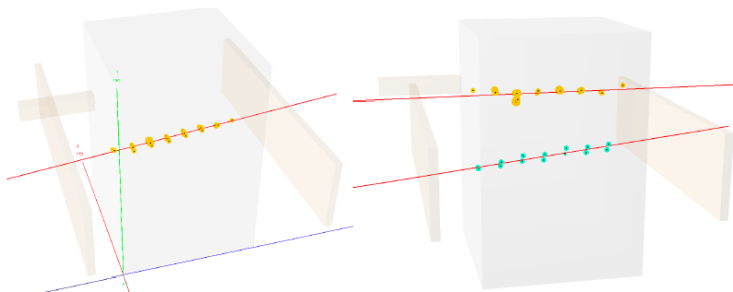
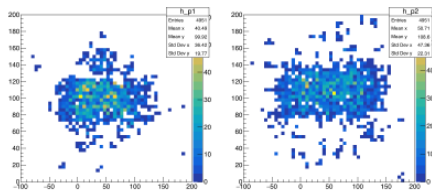


Track Finding in sTPC

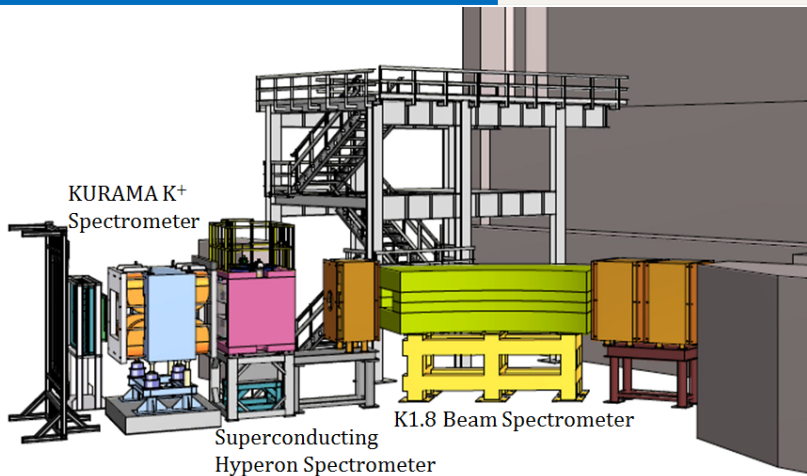


Track Reconstruction

- Cosmic-ray associated hits are recorded by trigger counters.



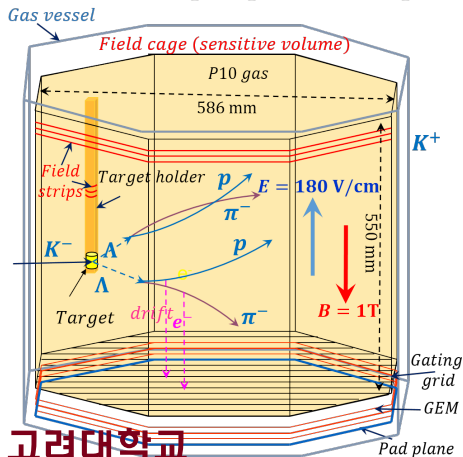
Hyperon Spectrometer at K1.8 Beam Line of J-PARC



- The Hyperon spectrometer consists of a time projection chamber (HypTPC) and the superconducting Helmholtz magnet.

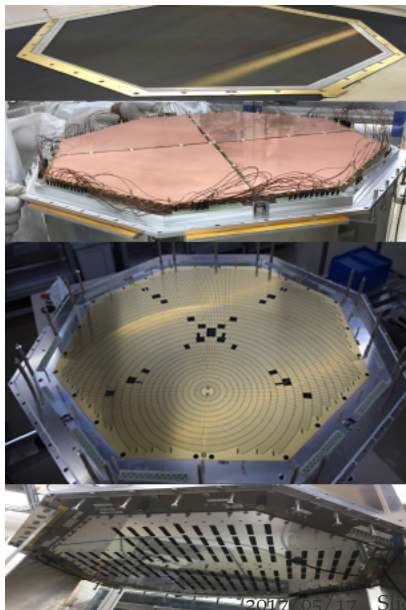
Time Projection Chamber for J-PARC E42 Experiment

- Octagonal prism field cage and a readout chamber consisting of a gating-grid, a triple GEM layer and a concentric pad plane (5768 pads)

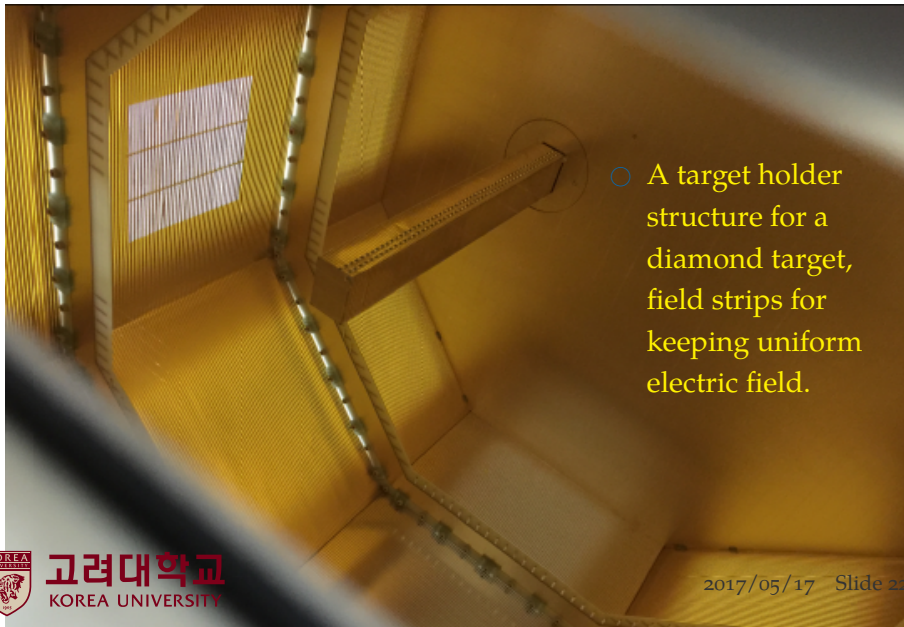


HypTPC Structure

- Four GEM ($250 \times 250 \text{ mm}^2$) sheets per layer
- Triple GEM layers ($100 \mu\text{m}$ (*top*) + $50 \mu\text{m}$ + $50 \mu\text{m}$)
- Gain $\sim 10^4$
- 10 inner pad rows with $2.1\text{-}2.7 \times 9 \text{ mm}^2$.
- 22 outer pad rows with $2.3\text{-}2.4 \times 12.5 \text{ mm}^2$.
- Position resolution $< 300 \mu\text{m}$
- $\Delta p/p = 1\text{-}3\%$ for π and p .

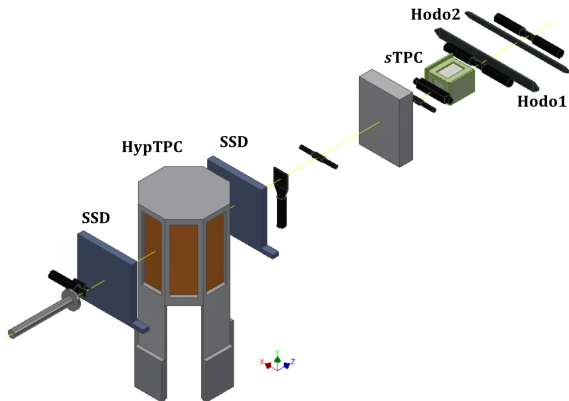


Inside the HypTPC



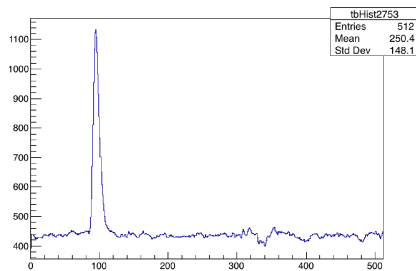
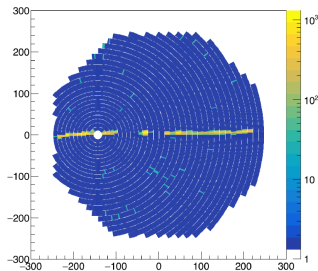
- A target holder structure for a diamond target, field strips for keeping uniform electric field.

First Beam Test with HypTPC at ELPH

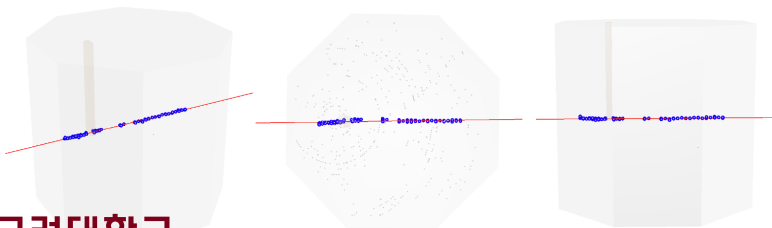


- A 460-MeV/c positron beam was exposed to HypTPC on November 7-9, 2016 at ELPH, Tohoku University.

Preliminary ELPH Test Results



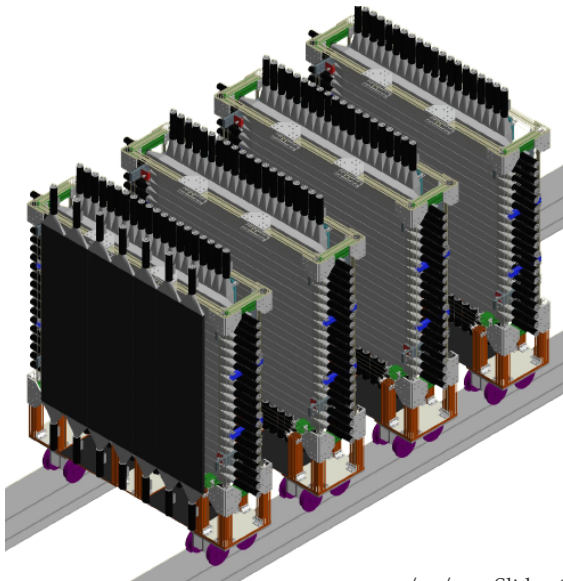
○ A positron beam track is clearly reconstructed.



NEUTRON DETECTOR FOR HIGH- ENERGY EXPERIMENTS

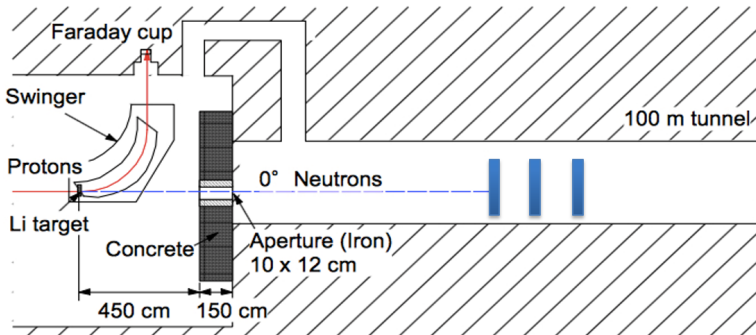
LAMPS Neutron Detector Array

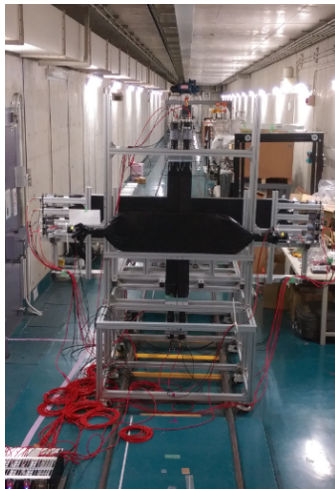
- Four movable stations.
- Each station has 40 neutron detectors.
- Charge veto counter with 20 thin plastic scintillators.



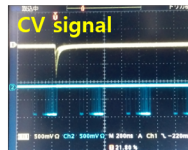
Beam Test at RCNP (E479)

- RCNP E479 Experiment (Approved in March 2016 and Performed in May 29, 2016).
- 65 MeV, 392 MeV protons on Li at N0 beam line.

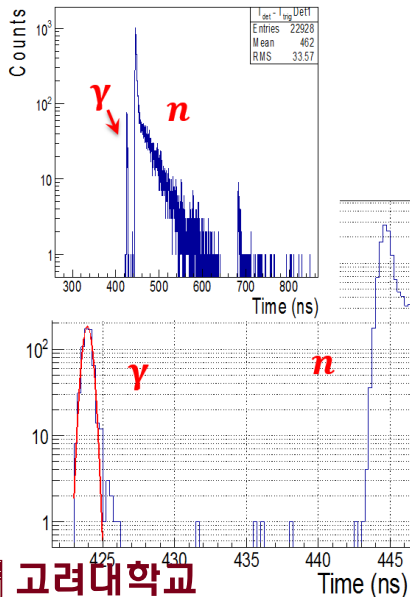




- $I_{\text{beam}} = 10 \text{ nA}$ and 1/9 chopping
- 2 stations and CV
- 1-m and 2-m long scintillators



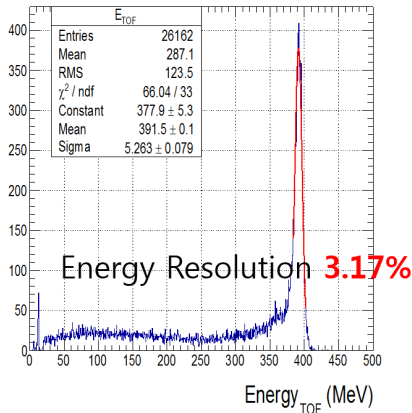
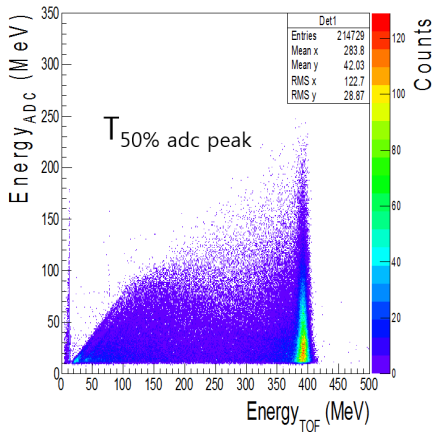
Time-of-Flight Spectrum



- 425 ns for γ arrival time
- Time-walk effect for neutrons from $\text{Li}(p, n)$ reaction at 392 MeV
- Leading-edge TDC value.



Neutron Energy Spectrum

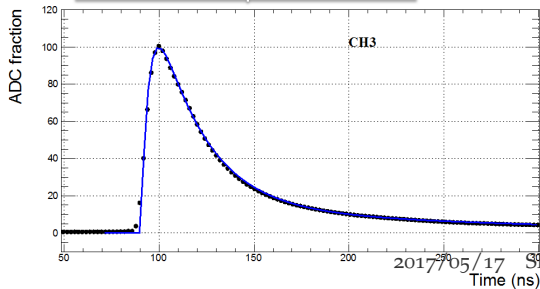
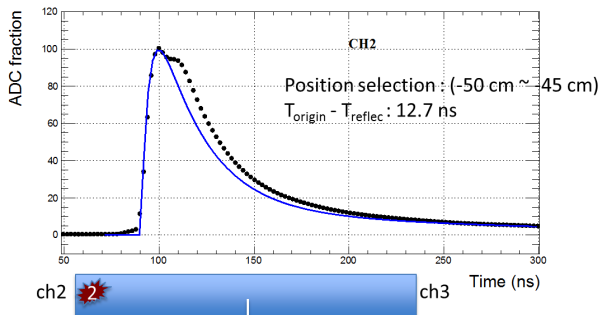


- Constant fraction (50%) timing with pulse-shape information from the IBS FADC/TDC module.



Pulse-Shape Analysis

- Neutron-associated hit much closer to CH₂.
- Reflected signal bounced back from CH₃ is overlaid as a delayed, attenuated signal.



Summary

- A compact TPC can be utilized to measure charged particles from **radioactive sources** and low-energy nuclei from **stellar nucleosynthesis reactions**.

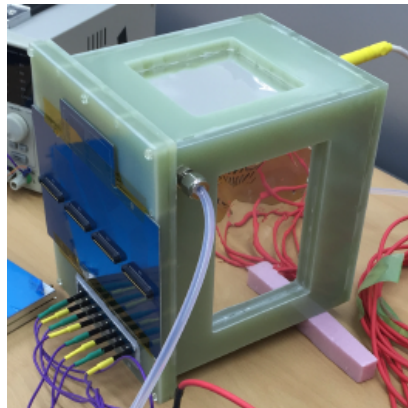


Photo of sTPC at KU