Performance test of a gaseous TPC with neutron beam for the detection of Migdal effect

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on behalf of the MIRACLUE collaboration

1. Introduction

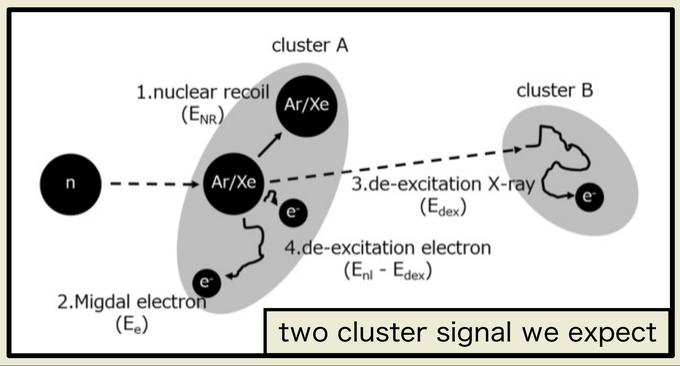
- Migdal effect is recently attracting in context of light dark matter search.
- The Migdal effect is a phenomenon in which ionization and excitation occur with low probability as a rapid motion of nucleus.

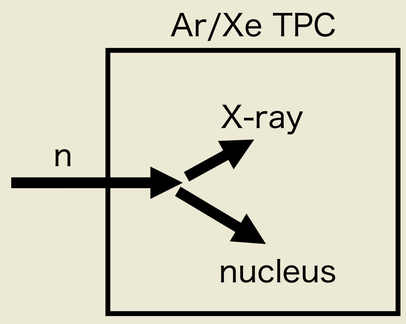
2. MIRACLUE Experiment

- Our experiment aims to detect Migdal effect in nuclear recoil which has not been detected yet.
- We aim to detect 2 cluster signal of Migdal effect using neutron beam.

Detector

- Gaseous TPC
- Argon (Kobe) / Xenon (Tohoku)





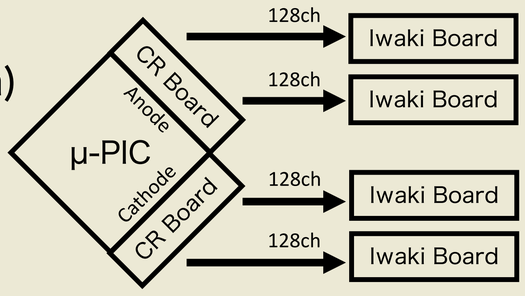
3. DAQ for Gaseous TPC

Overview

- A gaseous TPC (Ar : C_2H_6 = 9 : 1)
- Detection volume: 10×10×8 cm^3

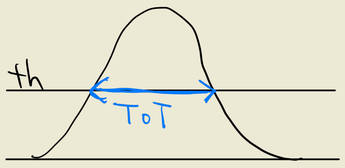
Readout

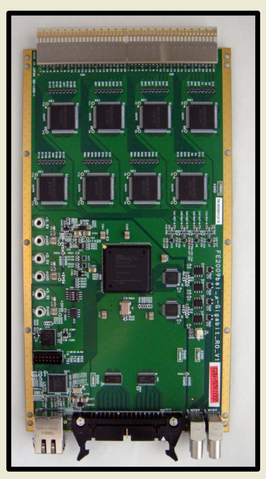
- μ-PIC (2D strip, 400 μm pitch)
- Gigabit Iwaki Board

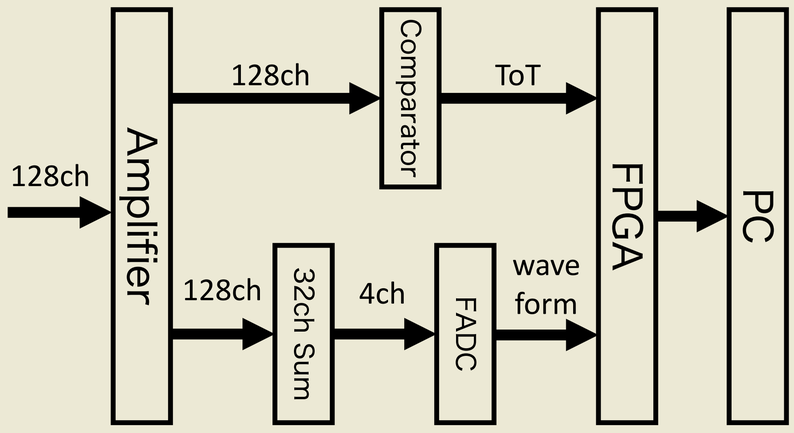


Gigabit Iwaki Board

- 128 channel analog input
- ToT (Time over Threshold) and FADC output
- comparator: 100MHz sampling
- FADC: 50MHz sampling
- output waveform as 32ch sum

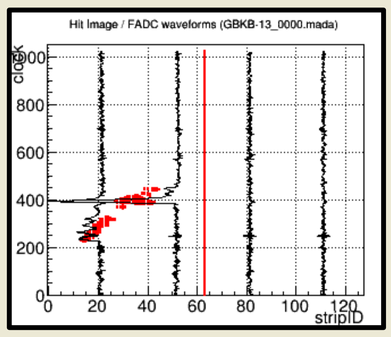






One Event Example

- Cathode side output
- Strip ID vs clock
- Red Point : ToT
- Black curve : 32ch sum waveform

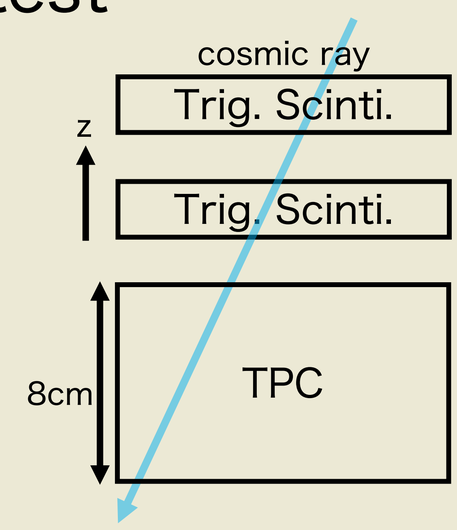


4. TPC performance test

- 2022/04/11~13 @AIST

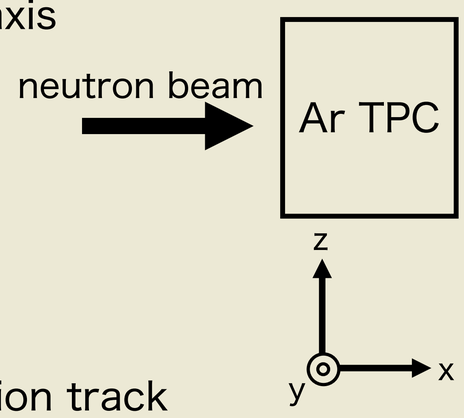
Cosmic ray run

- Trigger: 2 scintillator coincidence
- 766 events / 3 hours
- For energy calibration and drift velocity measurement



Neutron beam run

- 565 keV neutron beam
- Beam direction is parallel to x-axis
- Self trigger
- 4528 events / 20 minutes



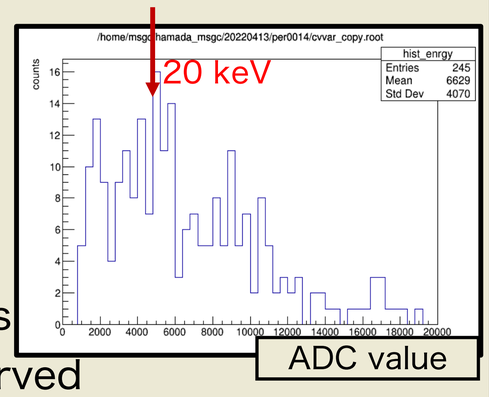
Trouble

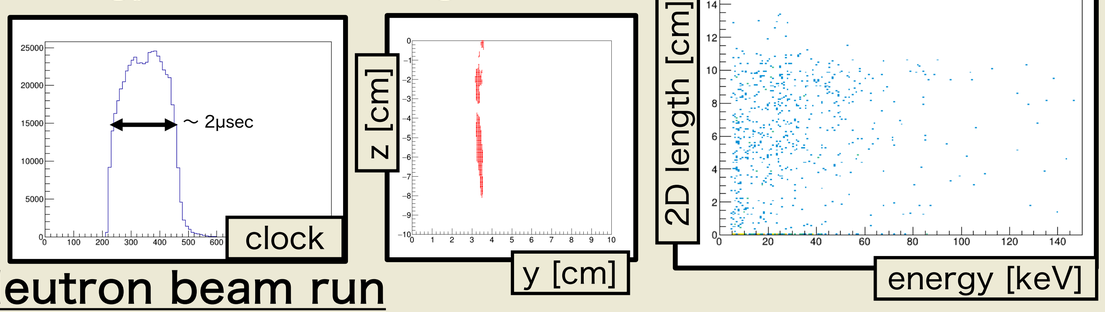
- We used 1 / 4 Iwaki board cause of its ASIC malfunction
- We can only see YZ 2D projection track

5. Results

Cosmic ray run

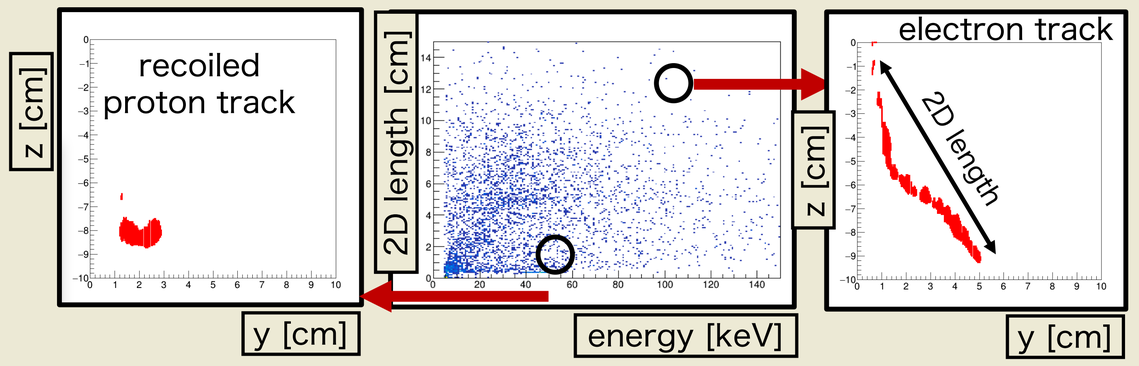
- energy deposit distribution
- ADC value ~ 4000 is 20 keV
- Calculated drift velocity ~ 5μm/s
- Cosmic muon tracks were observed
- energy vs “YZ 2D length”





Neutron beam run

- energy vs YZ 2D length
- YZ projection tracks
- Electron track(gamma BG), proton track (n recoil) was observed



6. Summary and Prospect

- The TPC worked in neutron beam test
- A large number of gamma ray BG events were observed
- We could see about 5 keV signal
- For Migdal effect, we must see less than 5keV signal
- Migdal effect is low probability, we will design 30×30×20 cm^3 TPC and its DAQ

Reference

2020 Kiseki D. Nakamura, Detection capability of Migdal effect for argon and xenon nuclei with position sensitive gaseous detectors (DOI: 10.1093/ptep/0000000000)