

Results of directional dark matter search from the **NEWAGE** experiment

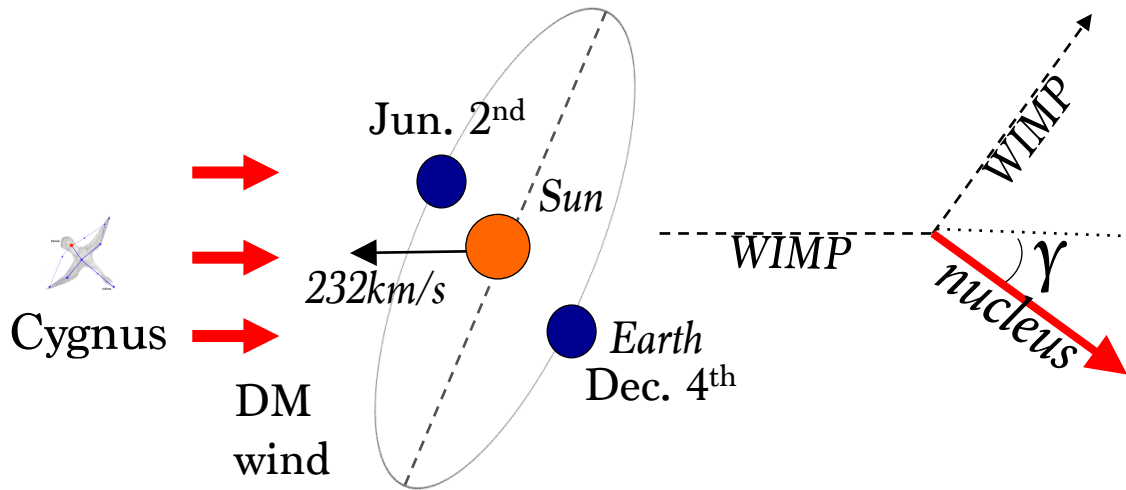
Tomonori Ikeda

Kentaro Miuchi, Hirohisa Ishiura, Takuma Nakamura, Takuya Shimada, Kiseki Nakamura

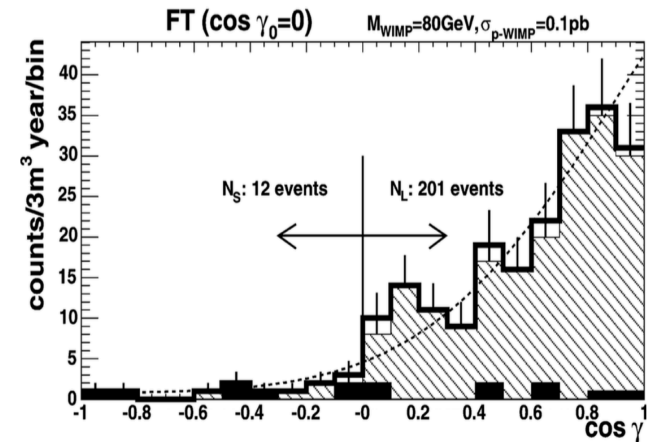
Kobe University

Introduction

Directional sensitive WIMP-search



Expected cosy distribution

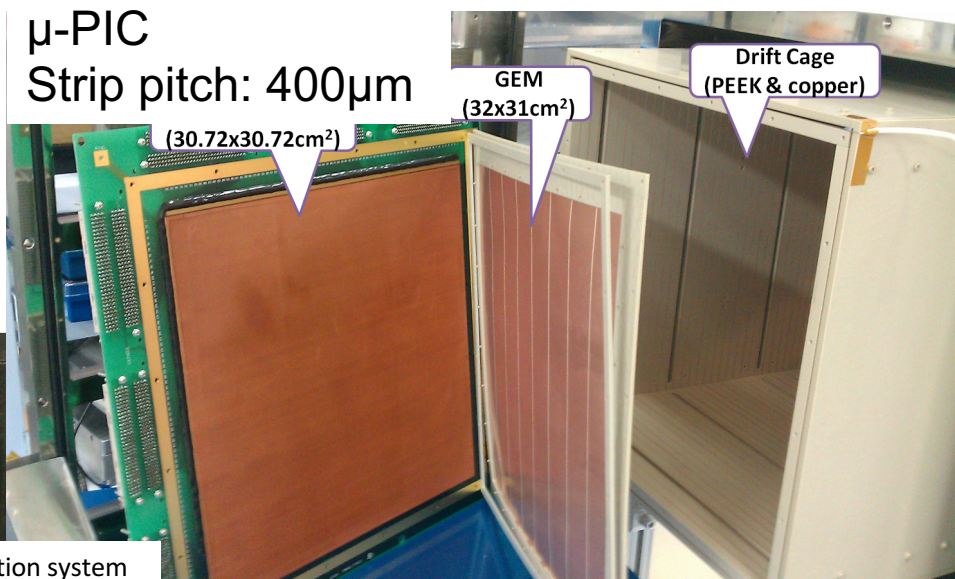
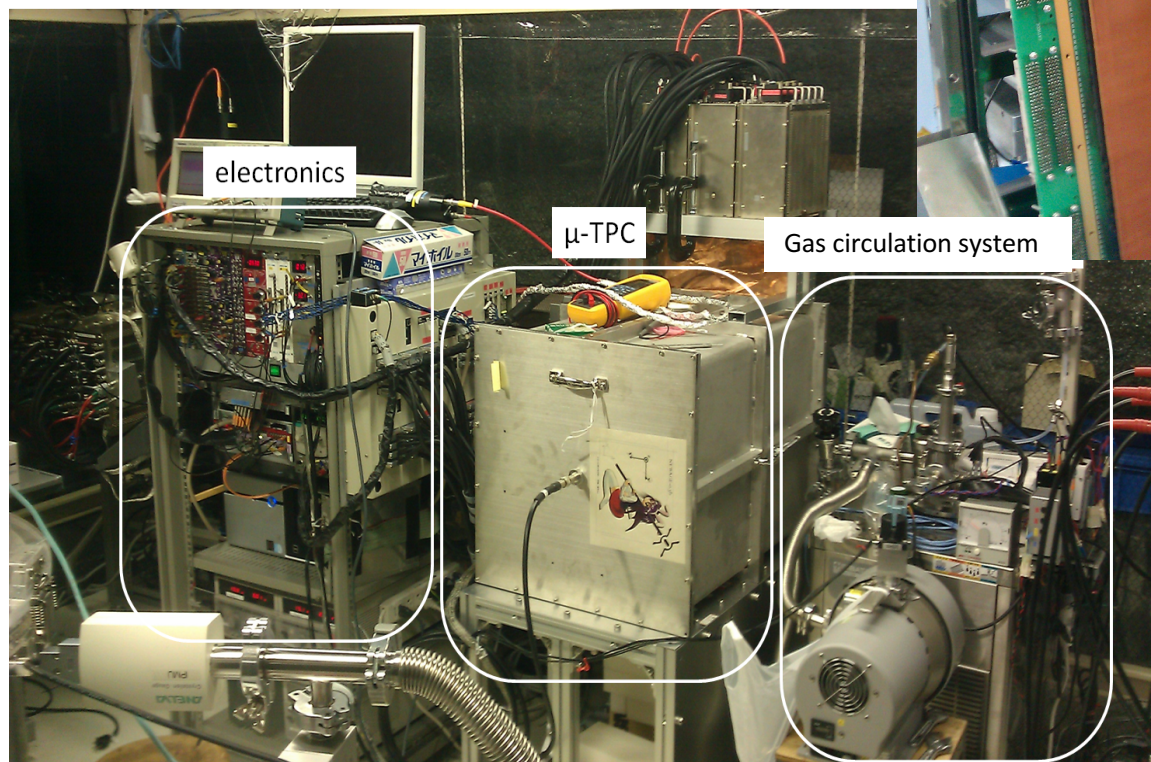


PLB578 (2004) 241–246

- Solar system moves to cygnus
 - WIMP flux has **anisotropic** distribution
- Target Nuclear is scattered with WIMP
 - Angular distribution of recoil nucleus has anisotropy
- Anisotropic angular distribution is a strong signature of WIMP

NEWAGE Experiment

- Challenge: very short recoil track
 - Low pressure gas TPC
 - Micro pattern gas detector μ -PIC

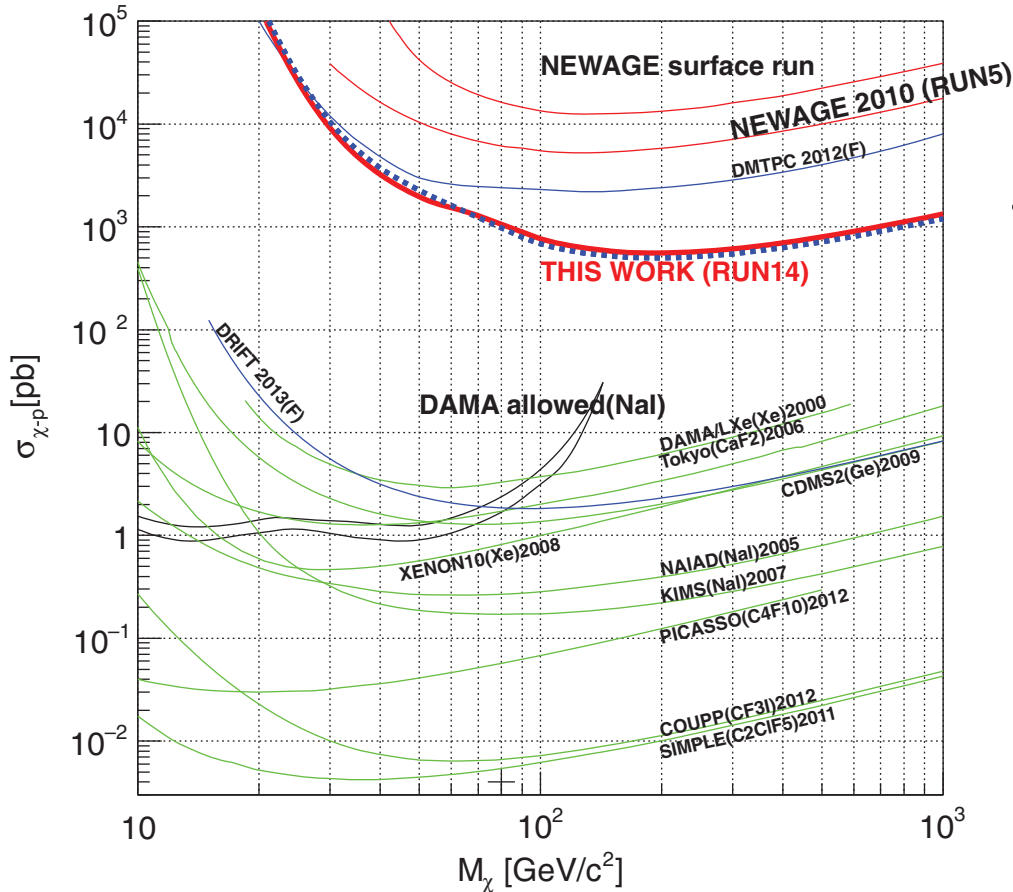


- Detection Volume: $31 \times 31 \times 41 \text{cm}^3$
- Gas: CF_4 at 76Torr (50 keVee threshold)
- Gas circulation system with cooled charcoal
- Installed in Kamioka Laboratory

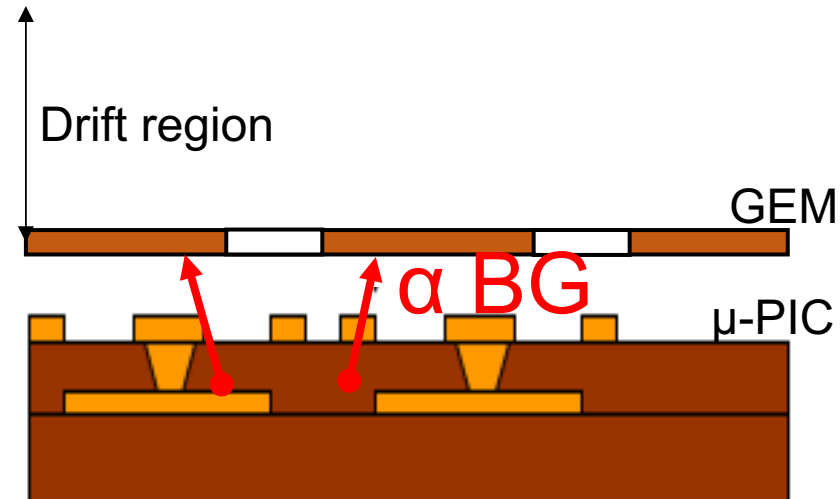
Previous results

PTEP 2015, 043F01

SD 90% C.L. upper limits and allowed region



- Obtained limit : 557pb @200GeV (Best direction-sensitivie limit)
- Main background : Alpha particles in μ PIC mateiral



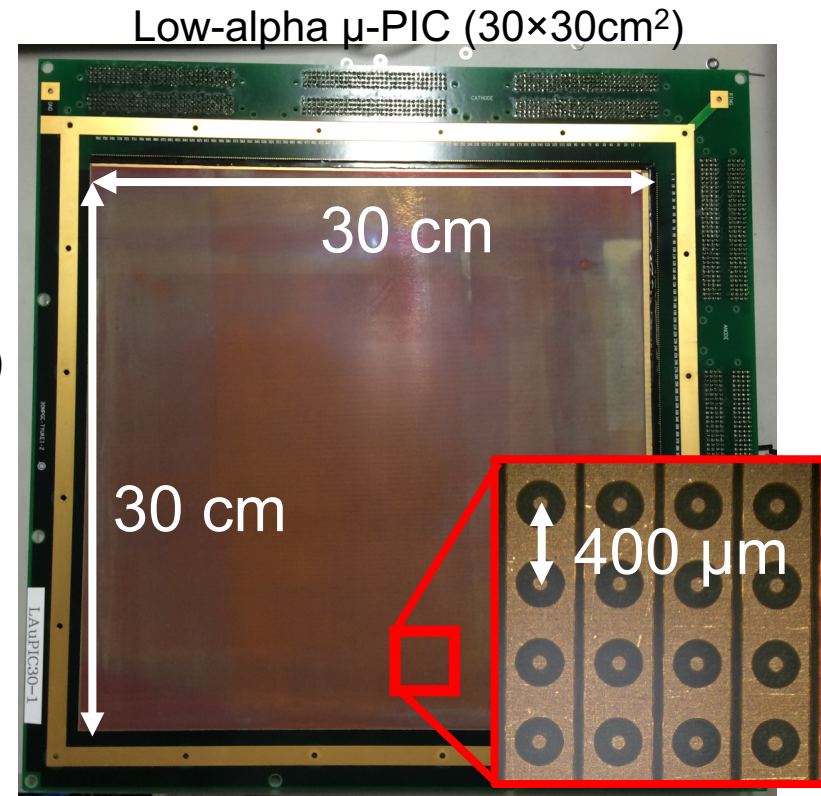
Low background gas detector

- Development of μ -PIC with low radioactive materials (**Low-alpha μ -PIC**)
work by Dai Nippon Printing Co., Ltd
- Main background of previous results: **surface alpha from μ -PIC**
 - Replace of surface material to low radioactive material

	^{238}U [ppm]	^{232}Th [ppm]
Standard material (PI+glass cloth)	0.39 ± 0.01	1.81 ± 0.04
New material (PI+epoxy)	$< 2.98 \times 10^{-3}$	$< 6.77 \times 10^{-3}$

work by K. Ichimura (XMASS), K. Abe (XMASS)

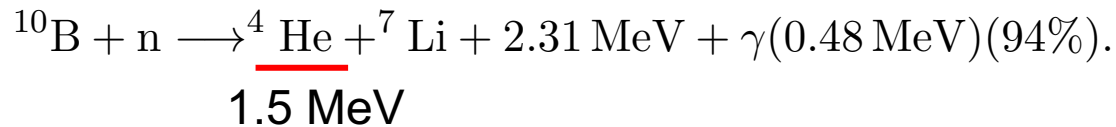
- Gas gain is almost the same as standard μ -PIC
- Physics run started in 2018



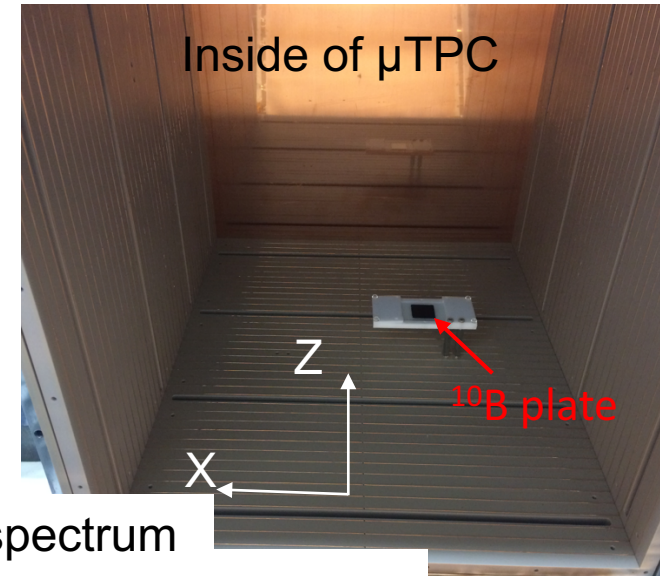
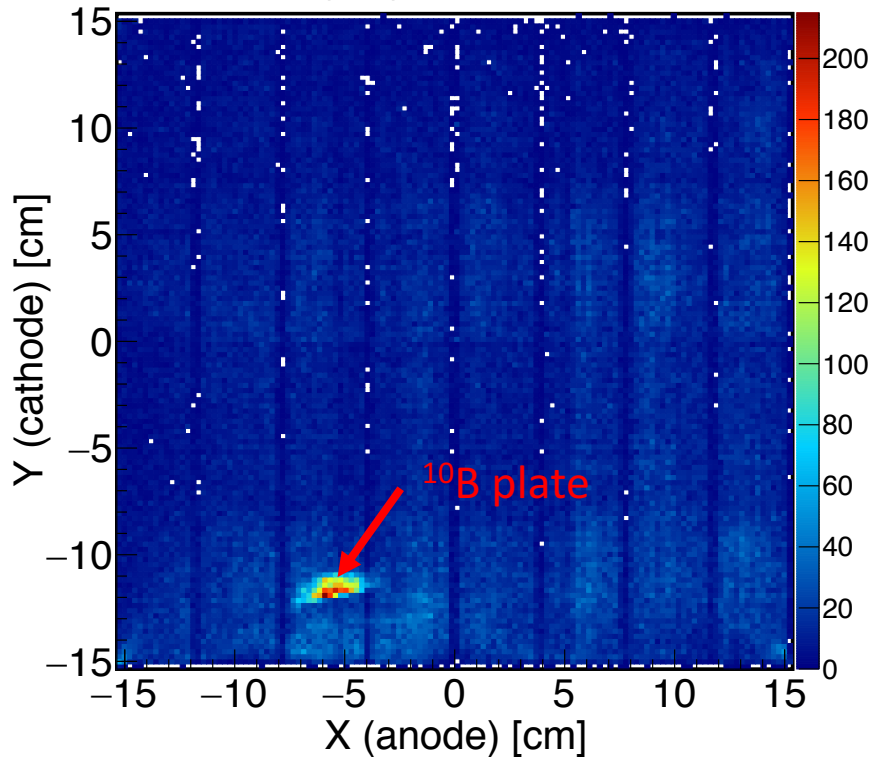
Detector performance

Energy calibration

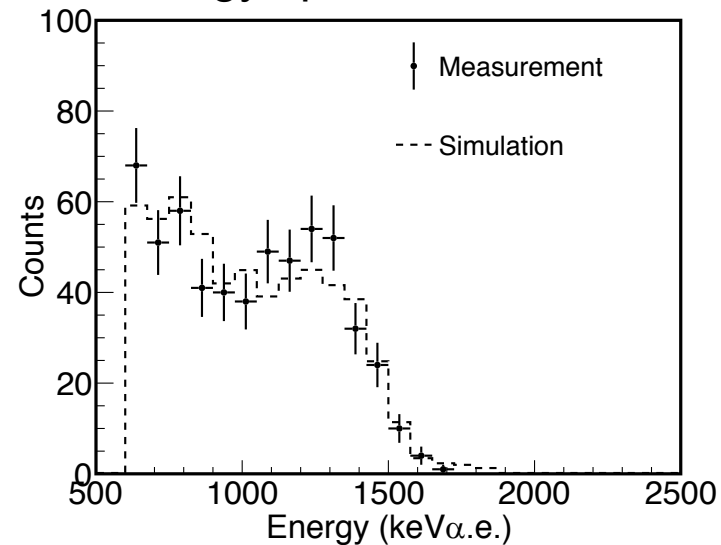
- Thermal neutron capture of ^{10}B



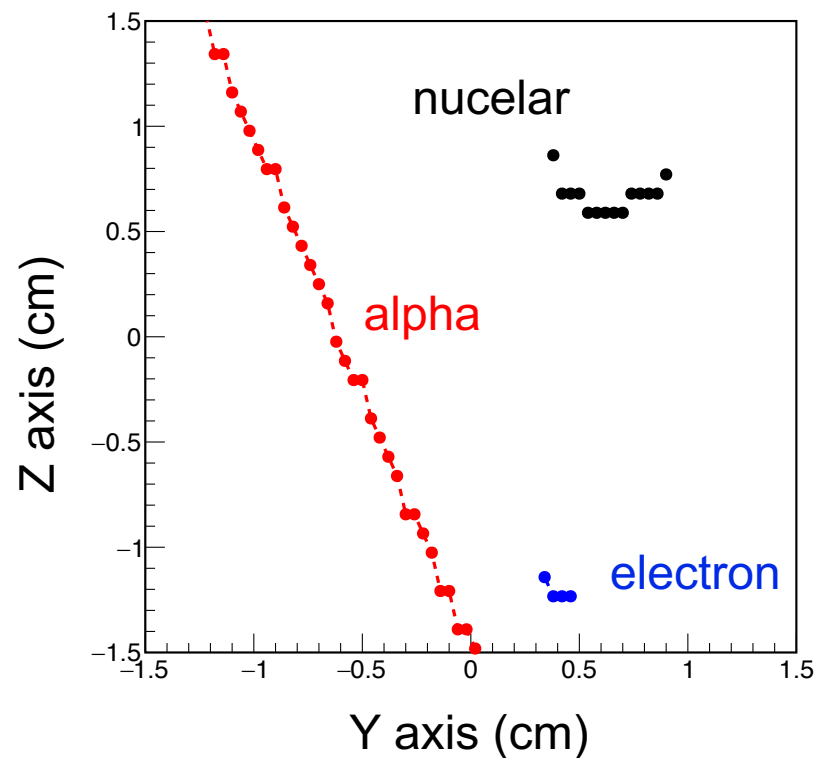
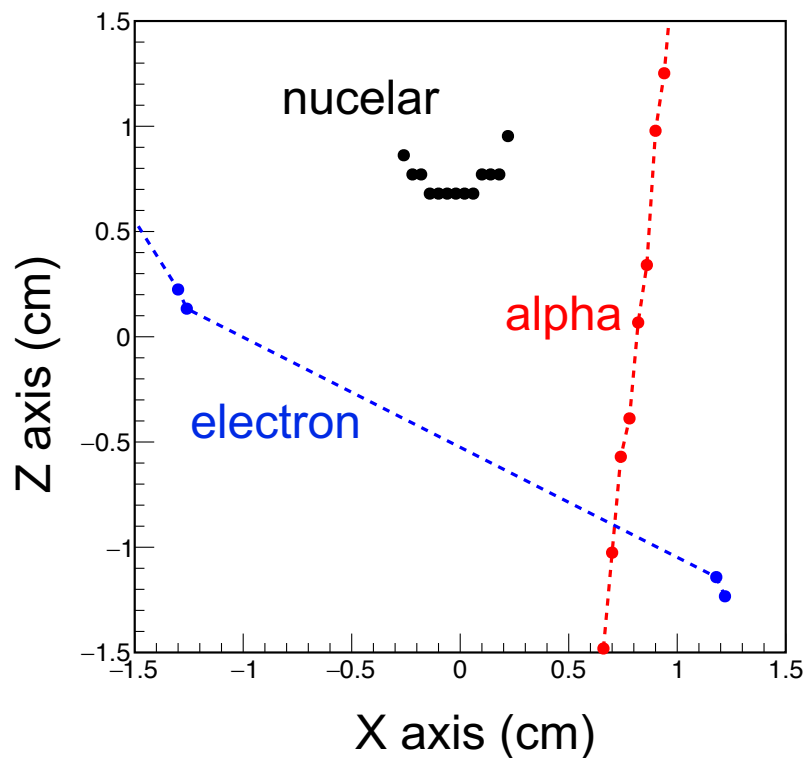
Imaging of ^{10}B plate



Energy spectrum



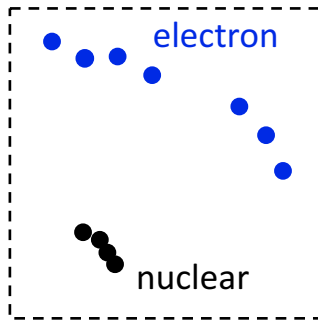
Particle tracks



Event selection

Two event selections for rejection of electron event.

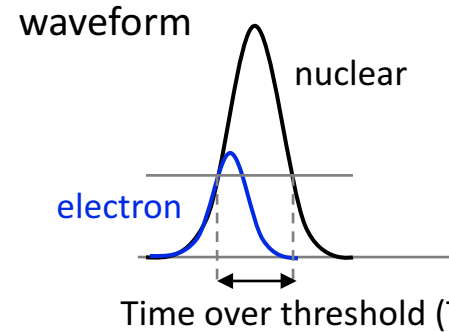
- Energy-Length cut



Track length of electron is **long**

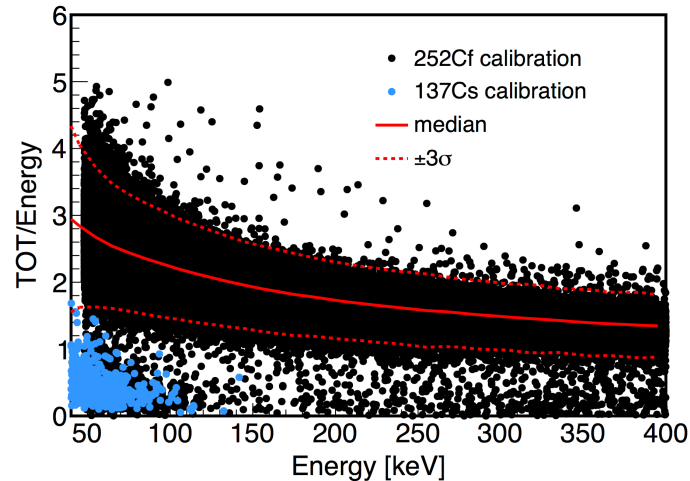
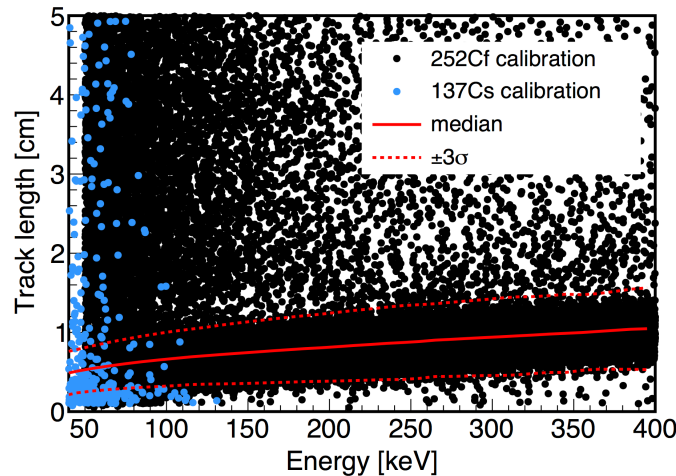
Track length of nuclear is **short**

- TOT-Energy cut



Electron has **small dE/dx**

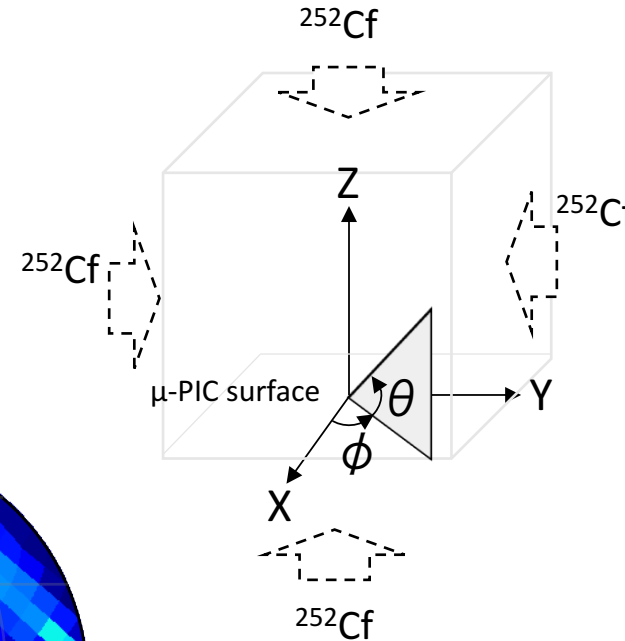
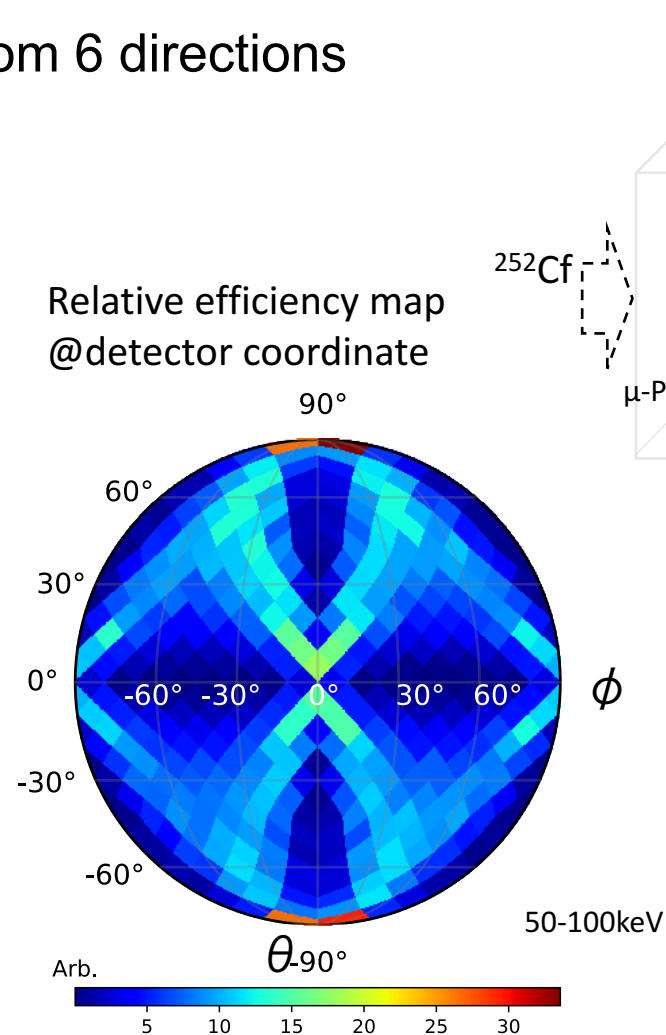
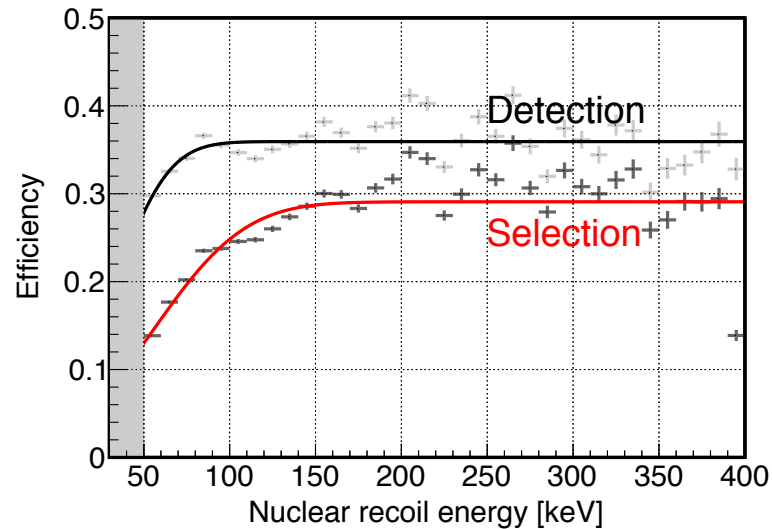
Nuclear has **large dE/dx**



- Inside of red dot lines was selected as nuclear event

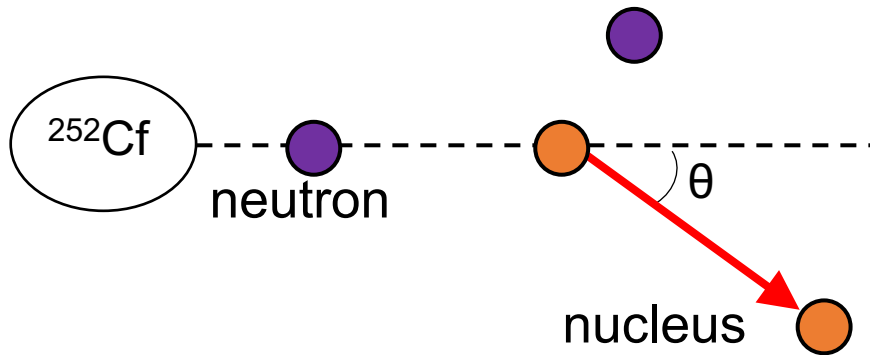
Detection efficiency

- Irradiate with fast neutrons from 6 directions
- Nuclear detection efficiency:
14% @50-60keV
- Electron detection efficiency
 5.9×10^{-6} @50-60keV

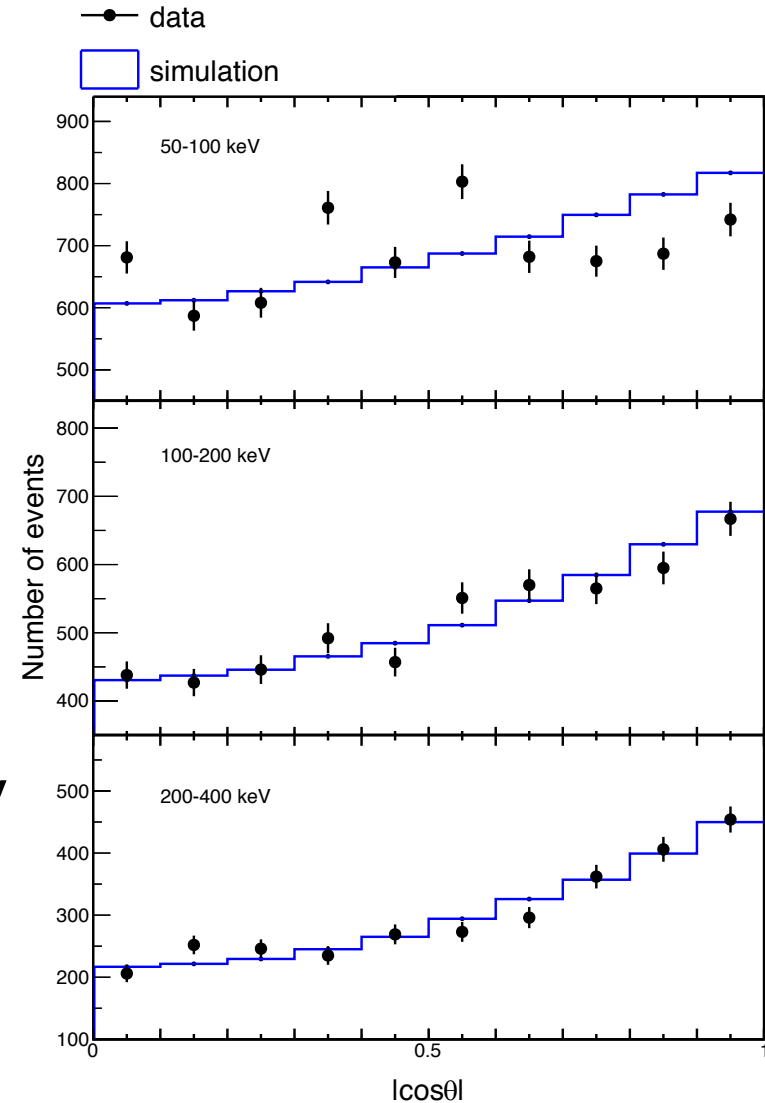


Angular resolution

- Angular resolution was measured by ^{252}Cf neutron source



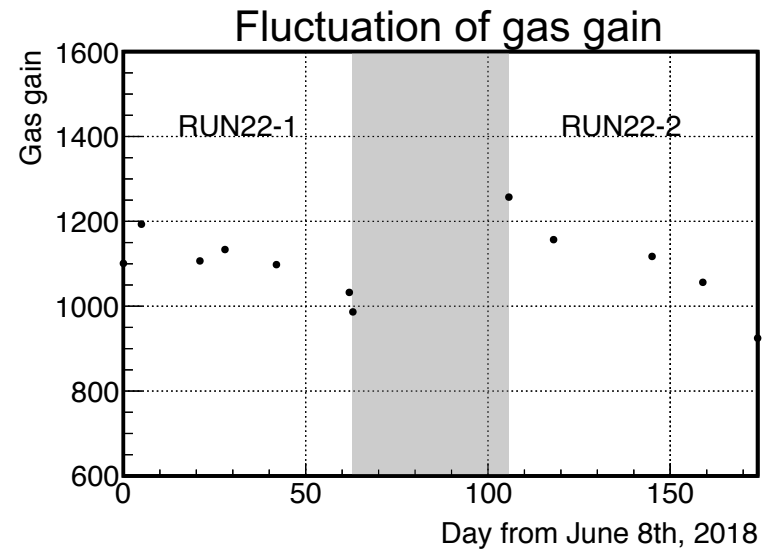
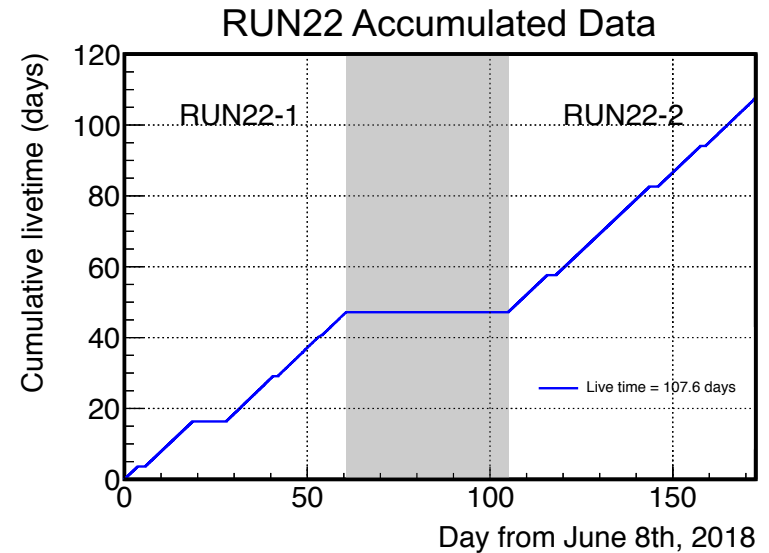
- Angular resolution:
 49.3 ± 6.5 degree @50-100 keV



Physics results

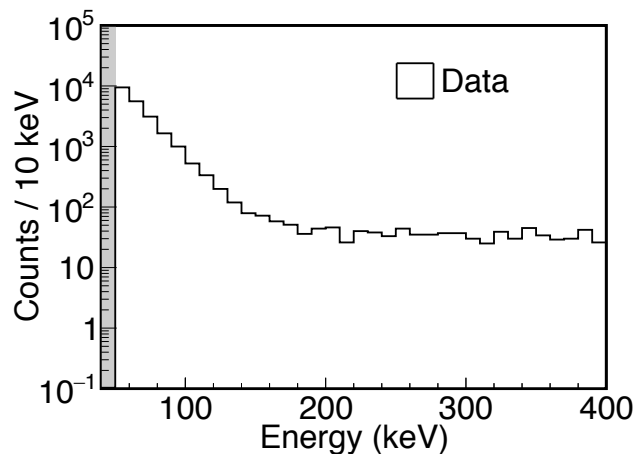
RUN22

- RUN22
 - **First data using Low-alpha μ -PIC**
- Exposure:
 - RUN22-1 June 2018 0.49 kg · days
 - RUN22-2 Sept. 2018 0.63 kg · days
- Calibrate every 2 weeks
 - Energy scale
 - Energy resolution
 - Detection efficiency

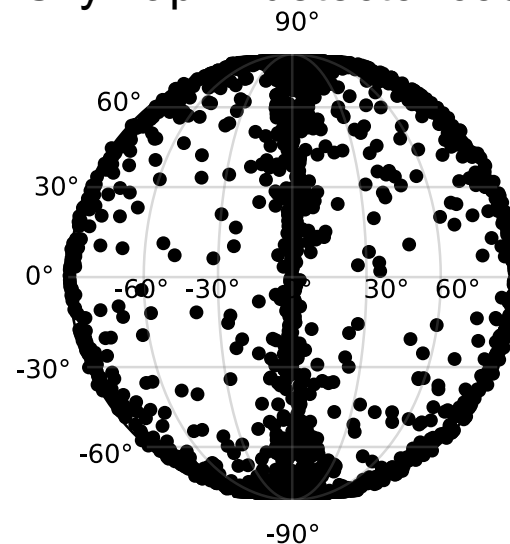


Data before event selections

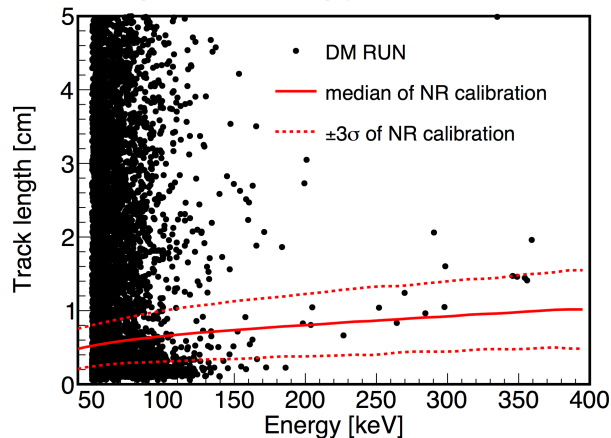
Energy spectrum



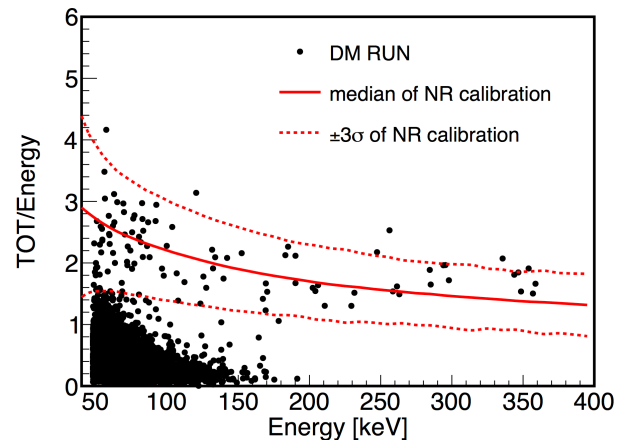
Skymap in detector coordinate



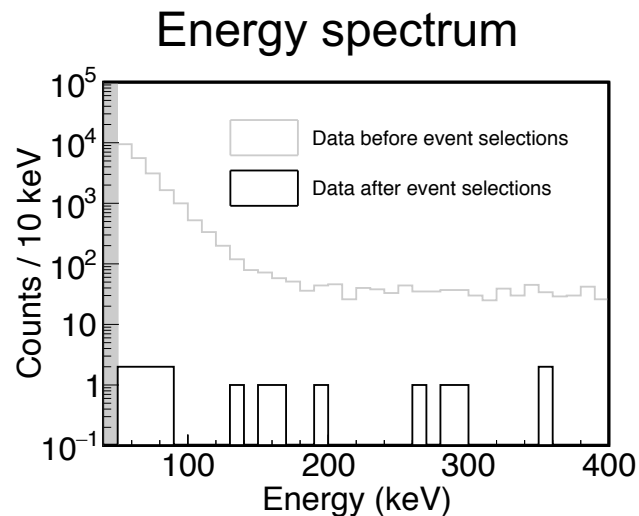
Length-Energy distribution



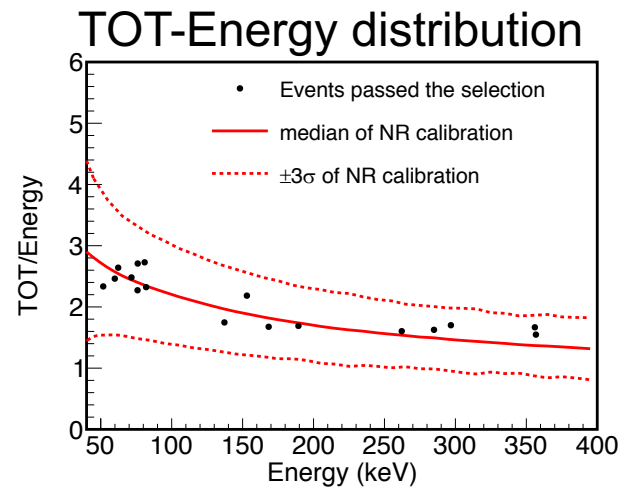
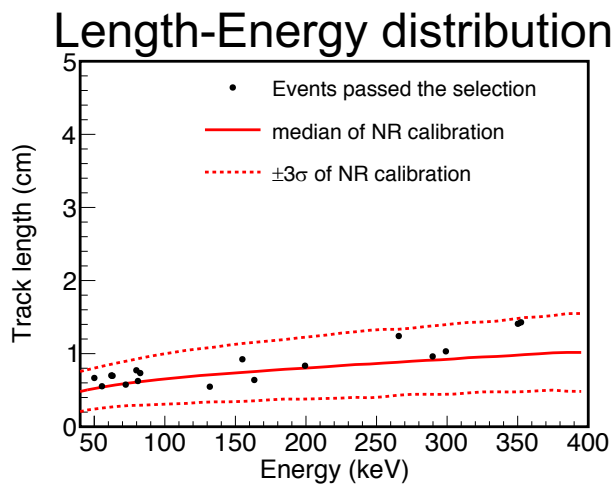
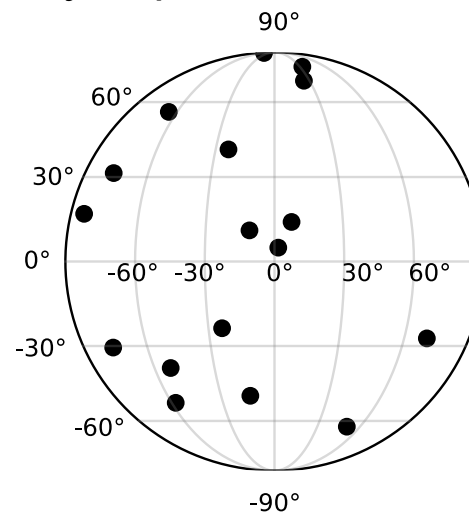
TOT-Energy distribution



Data after event selections

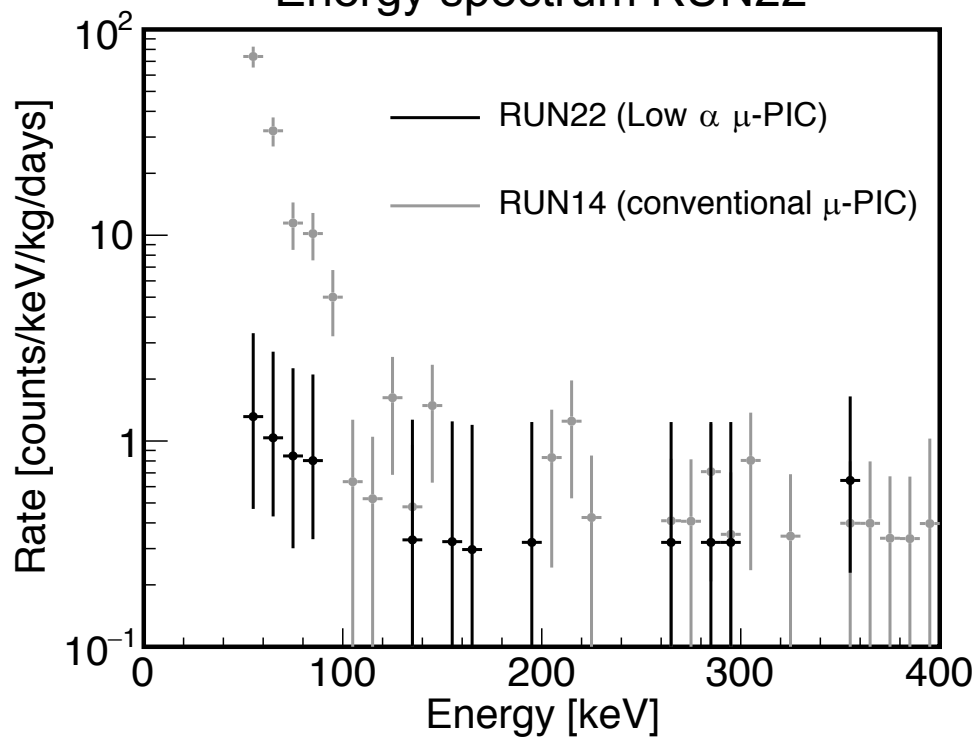


Skymap in detector coordinate

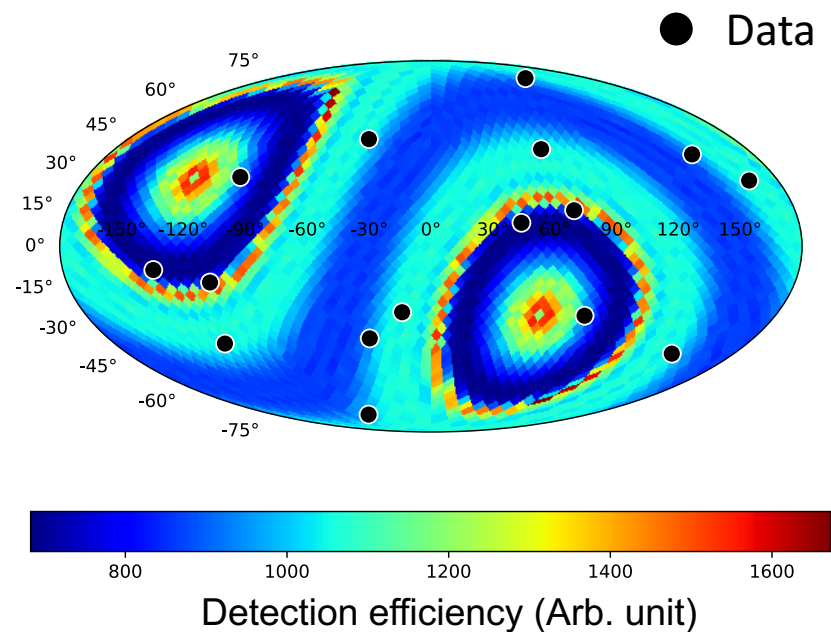


Data after event selections

Energy spectrum RUN22



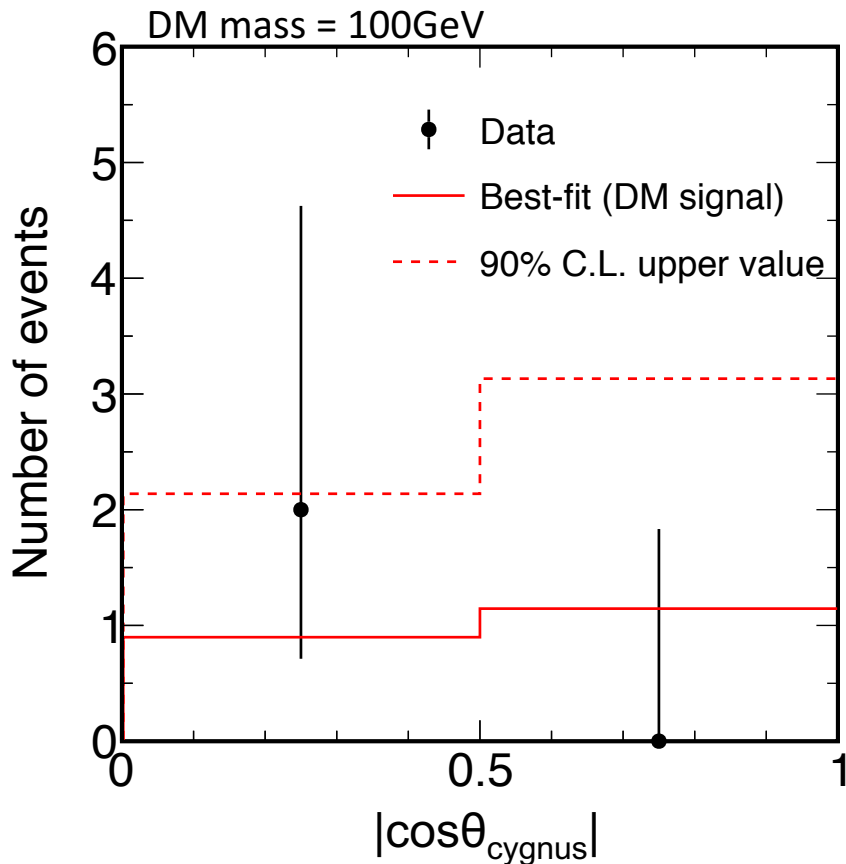
Skymap in galactic coordinate



- Main background @50-100 keV: Alpha particles in μ PIC material
 - Successful in reduction due to Low-alpha μ -PIC

The directional analysis

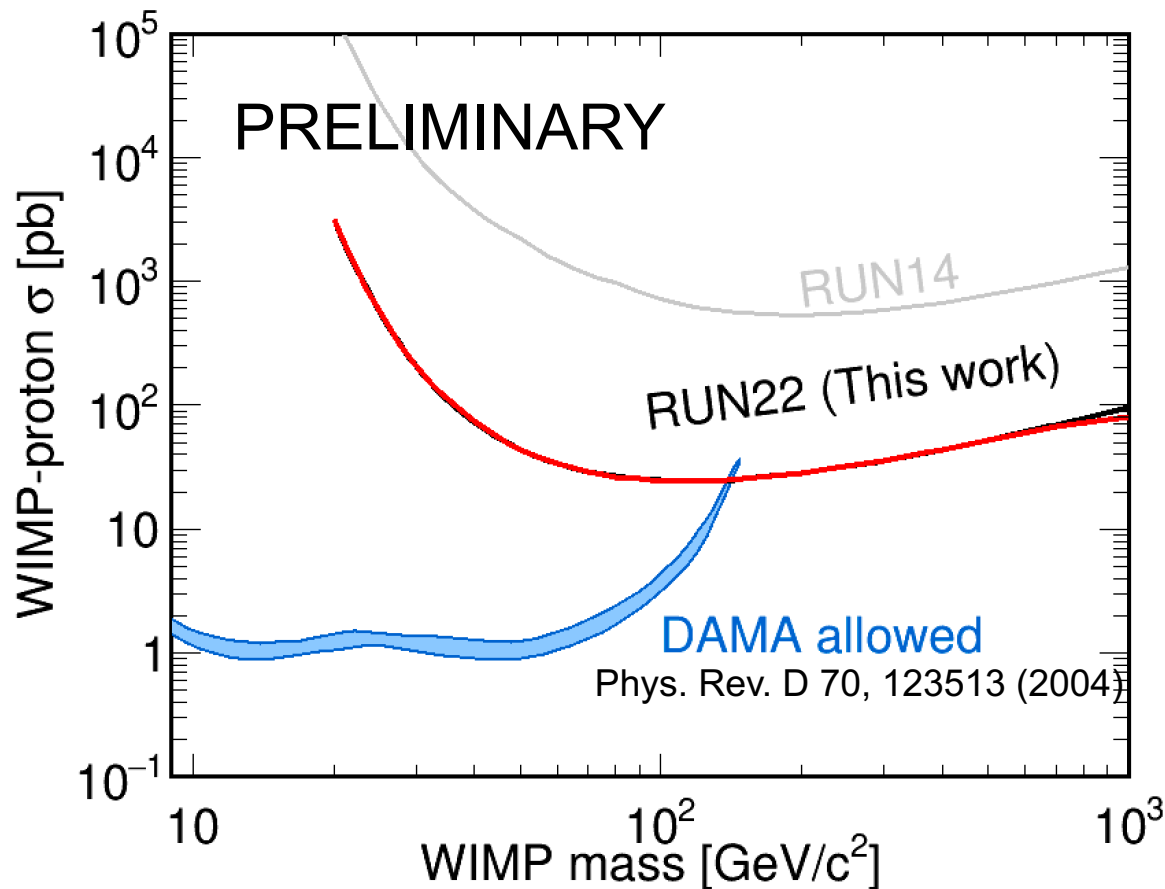
- Region of interest: 50 to 60 keV
- Observed events in ROI: 2 events



- Using a binned likelihood-ratio method
- Expected anisotropic ratio
 $29.9^{+17.6}_{-10.6} \%$
- Low statistic (high statistic error)
 - Observation is consistent to the isotropic BG model
 - The 90% C.L. limit of SD cross section (including systematics)
24.5 pb @ 100 GeV

The result of a directional method

The 90% C.L. upper limit of SD cross section



- The sensitivity was improved by about 50 times comparing with previous results

Background study

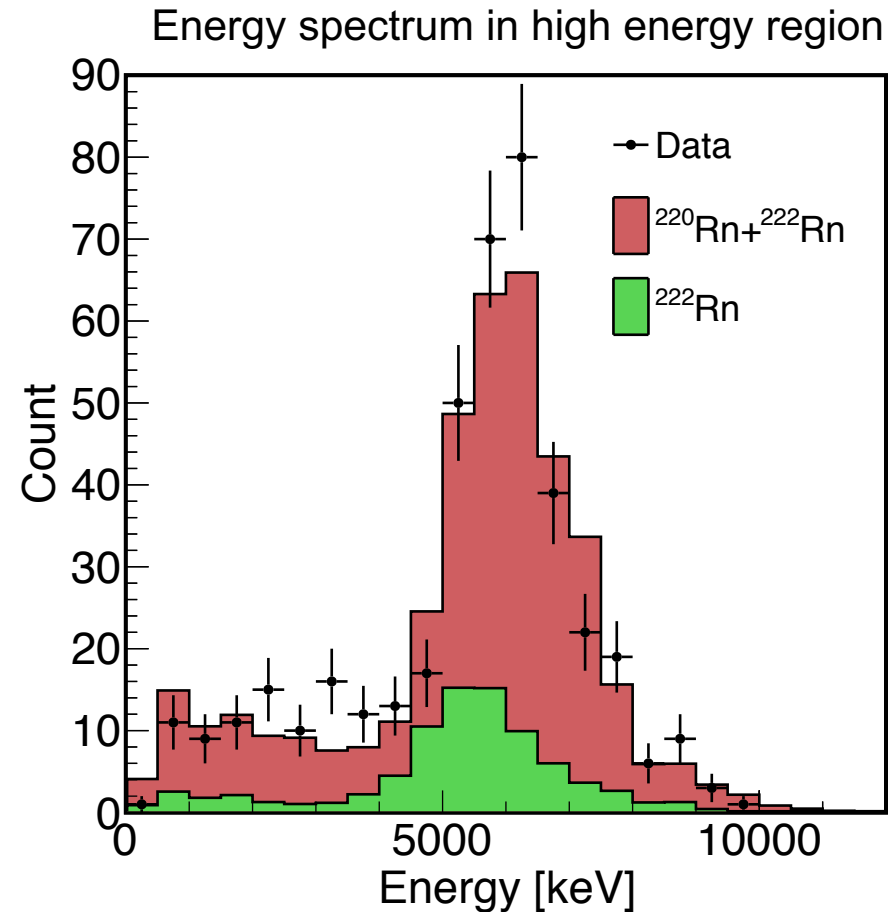
Radon background

- Alpha particles from Rn^{220} and Rn^{222} was observed in high energy region

Energy of α (MeV)	U-chain		
	^{222}Rn	^{218}Po	^{214}Po
5.490	6.003	7.687	

Th-chain			
^{220}Rn	^{216}Po	^{212}Bi	^{212}Po
6.288	6.779	6.051	8.785

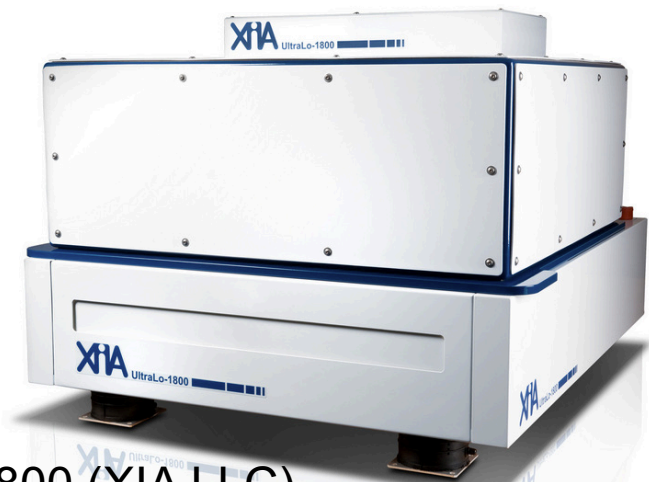
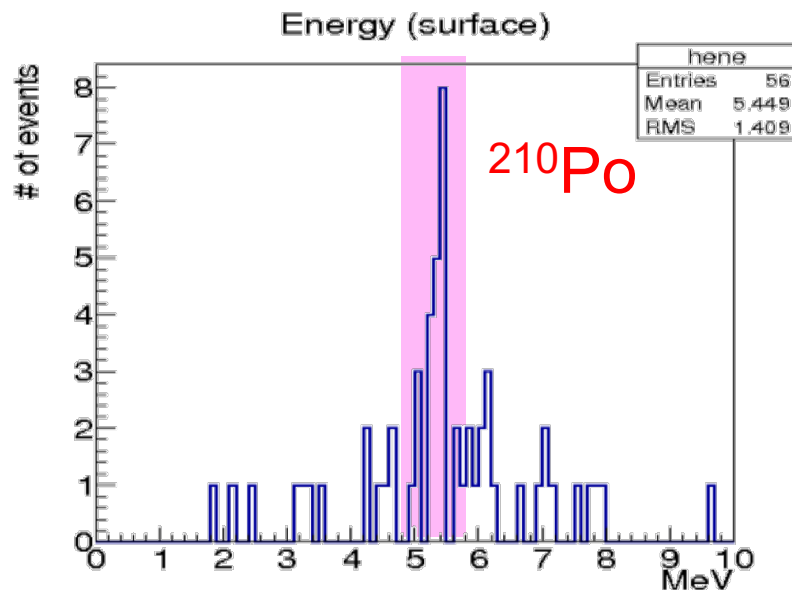
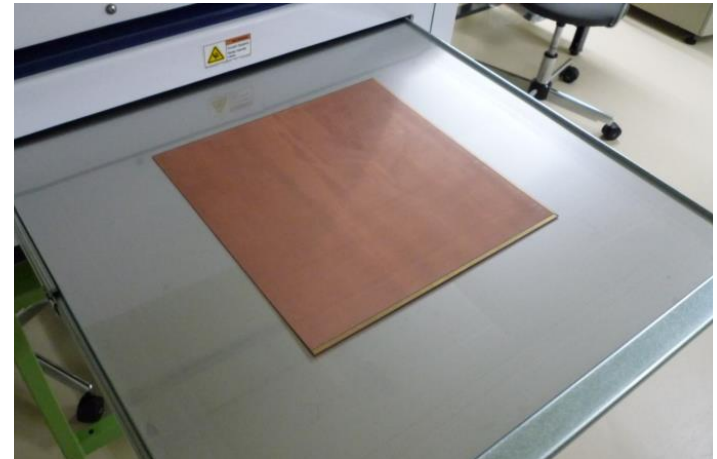
- Simulated the radon BG by Geant4
- Estimated amount of Rn
 - ^{220}Rn 4.5 mBq/m³
 - ^{222}Rn 1.0 mBq/m³



Surface alpha background

- A surface alpha of Low- α μ -PIC was measured by Ultra-Lo 1800 (XIA LLC)
 - Observed ^{210}Po peak
 - $(2.35 \pm 0.48) \times 10^{-4} \alpha/\text{cm}^2/\text{hr}$.

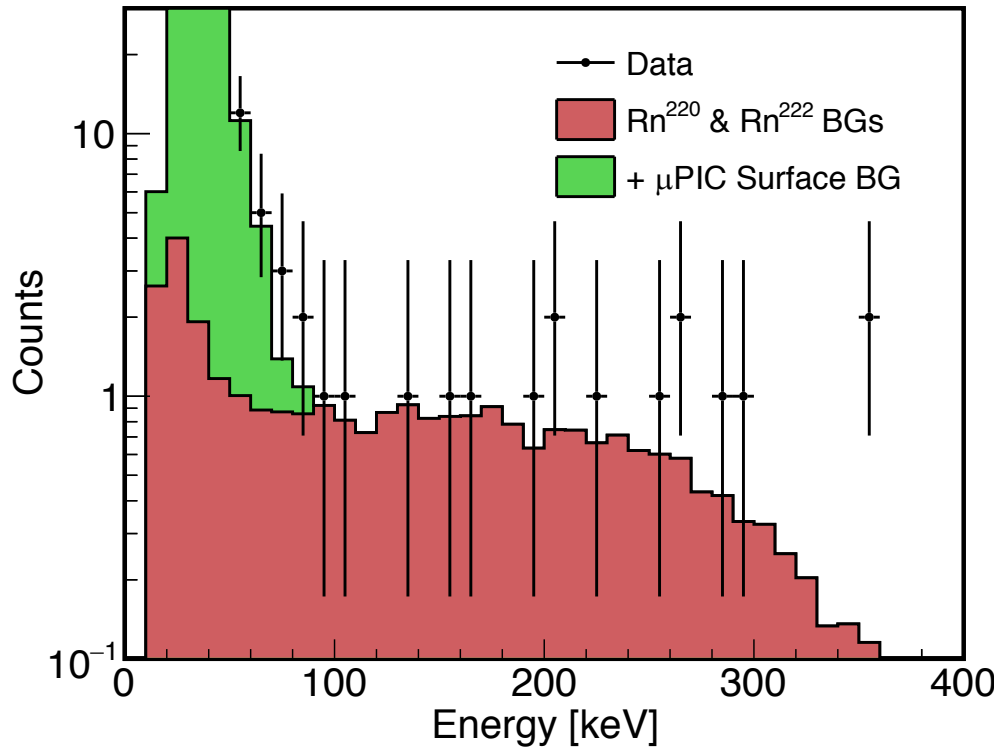
Worked by K.Kobayashi (XMASS)



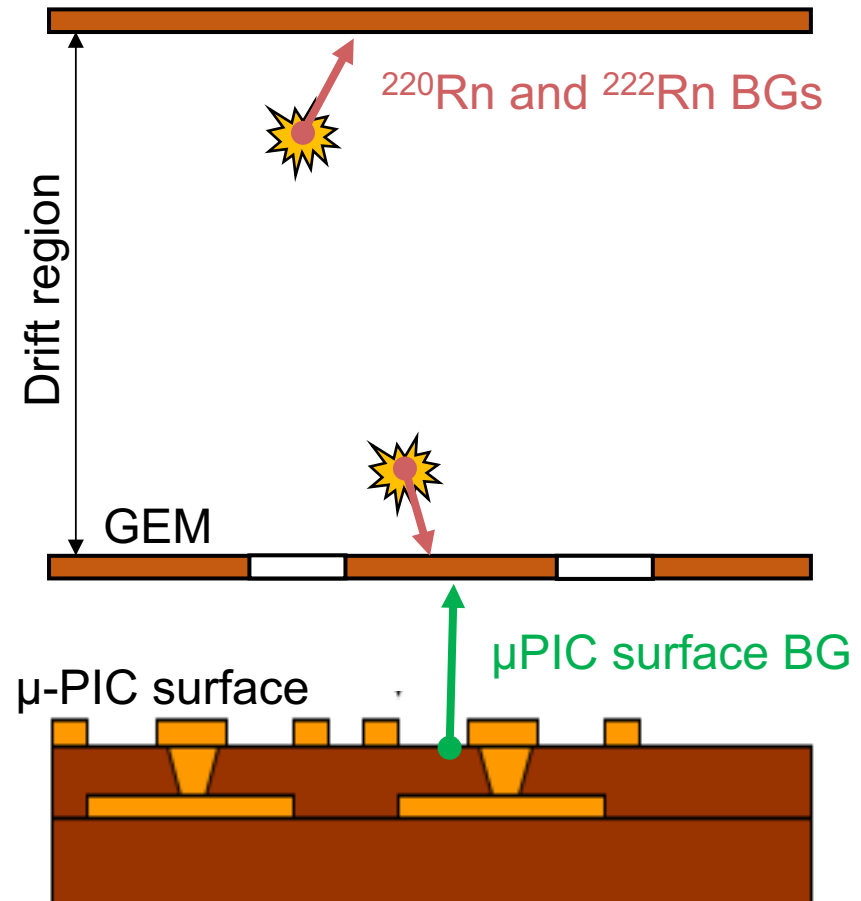
Ultra-Lo 1800 (XIA LLC)

Summary of background

Simulation results of Rn and surface alpha BGs



- **Main background in 50-100 keV region : a surface alpha of Low- α μ -PIC**



Summary



- NEWAGE is directional dark matter search using gas detector
- Low background gas detector (Low- α μ -PIC) was developed
- RUN22 data taking and analysis
- Reach the sensitivity of 24.5pb @100GeV with directional method
- Main background in ROI is surface alpha of Low- α μ -PIC
- Continued R&D for search of DAMA region

Thank you!