

NEWAGE

Kentaro Miuchi
KOBE University

7th SYMPOSIUM ON LARGE TPCs FOR LOW-ENERGY RARE
EVENT DETECTION

K. Nakamura⁽¹⁾, T.Tanimori⁽¹⁾, K.Kubo⁽¹⁾, A.Takada⁽¹⁾, H.Nishimura⁽¹⁾, J.D.Parker⁽¹⁾,
T.Mizumoto⁽¹⁾, Y.Mizumura⁽¹⁾, T.Sawano⁽¹⁾, Y.Matsuoka⁽¹⁾, S.Komura⁽¹⁾, Y.Yamaguchi⁽²⁾,
T.Hashimoto⁽²⁾, A.Takeda⁽³⁾, H.Sekiya⁽³⁾

(1) Kyoto university department of physics

(2) Kobe university department of physics

(3) ICRR

科研費
KAKENHI



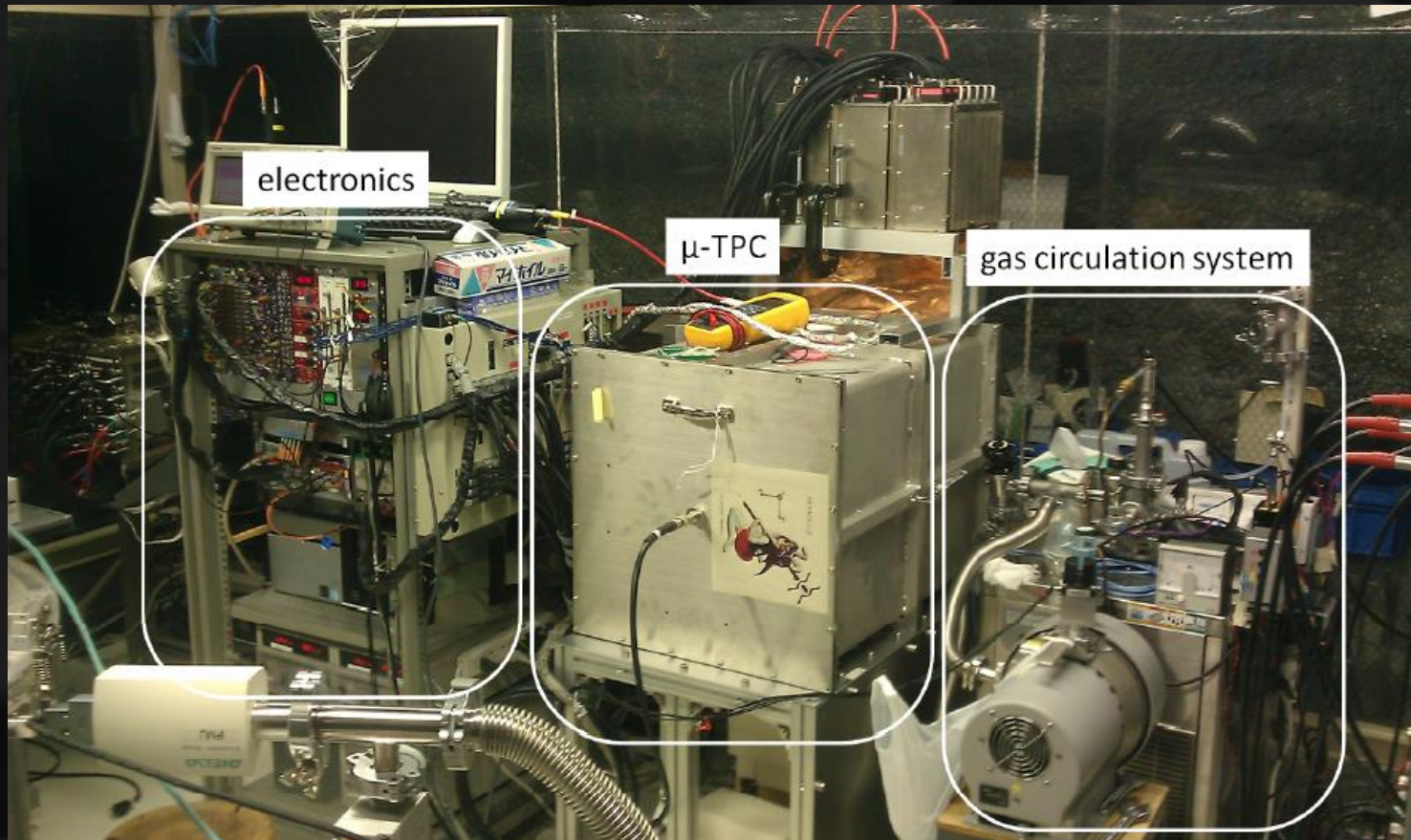
NEWAGE Overview

- ◆ **μ -PIC based TPC with electronics**
- ◆ **3-D tracks**

- ◆ **First direction-sensitive DM limits**
PLB654 (2007) 58
- ◆ **Underground results**
PLB686 (2010) 11
- ◆ **Phase for “low BG detector”**

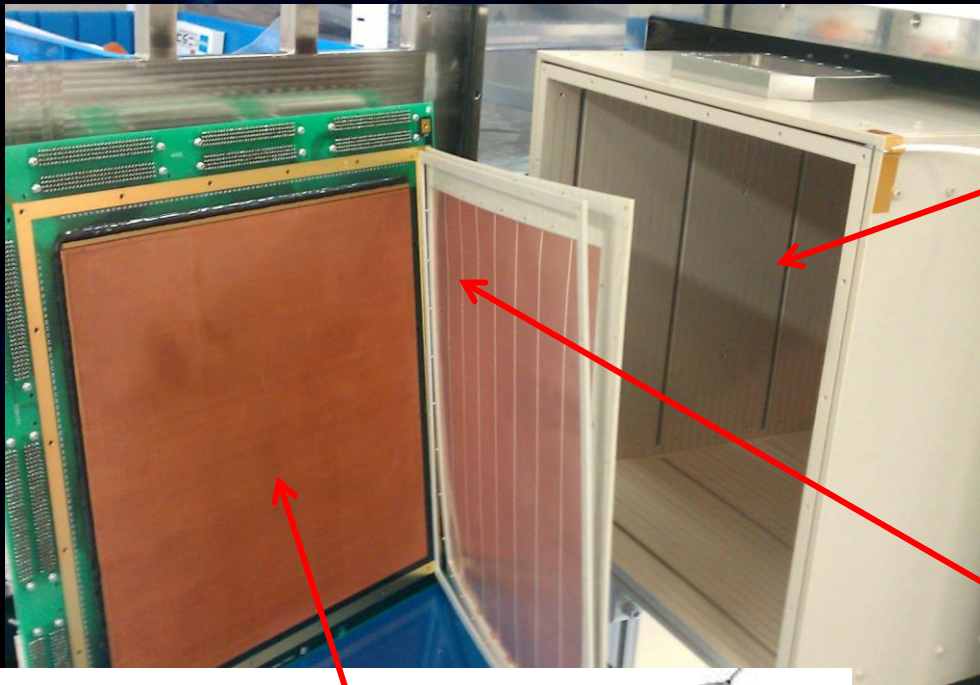
NEWAGE detector

- ◆ **NEWAGE-0.3b'**
- ◆ **Detection Volume: $31 \times 31 \times 41 \text{cm}^3$**
- ◆ **Gas: CF₄ at 0.1atm (50keVee threshold)**
- ◆ **Gas circulation system with cooled charcoal**

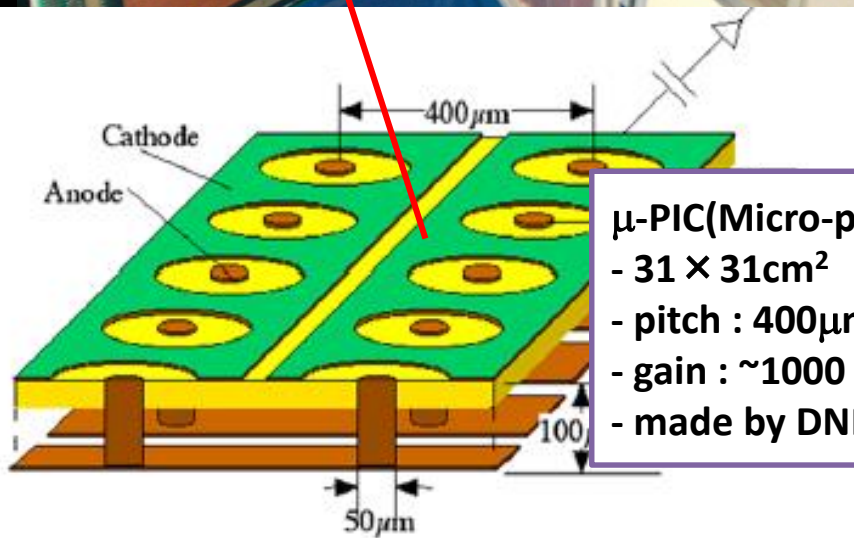


NEWAGE-0.3b' inside view

● Detection Volume: $30 \times 30 \times 41 \text{cm}^3$



Field cage
Drift length: 41cm
PEEK + copper wires



μ-PIC(Micro-pixel chamber)
- $31 \times 31 \text{cm}^2$
- pitch : $400 \mu\text{m}$
- gain : ~ 1000
- made by DNP, Japan

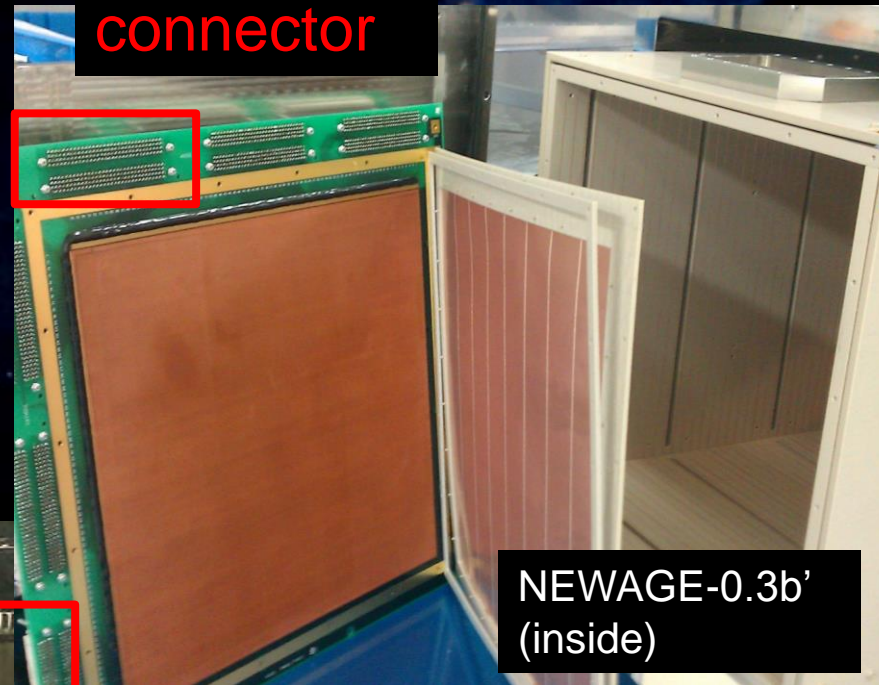


GEM
- $31 \times 32 \text{cm}^2$
- 8-segmented
- hole pitch : $140 \mu\text{m}$
- hole diameter: $70 \mu\text{m}$
- insulator : LCP $100 \mu\text{m}$
- gain : ~ 5
- made by Scienergy, Japan

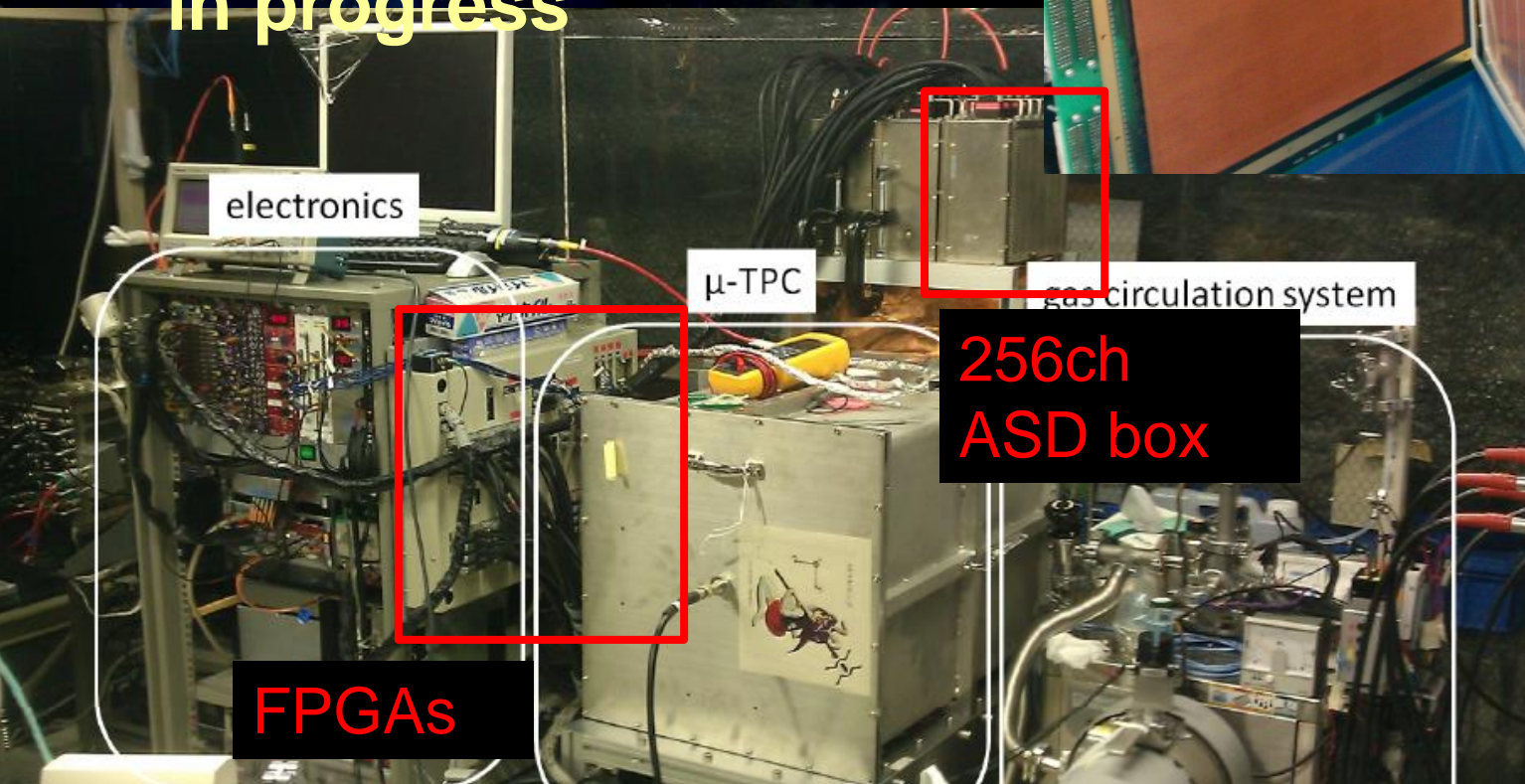
NEWAGE-0.3b' readouts

- μ -PIC is X-Y readout
- General purpose FPGA-based electronics since early 2000's.
- Updates are still in progress

256ch
connector



NEWAGE-0.3b'
(inside)



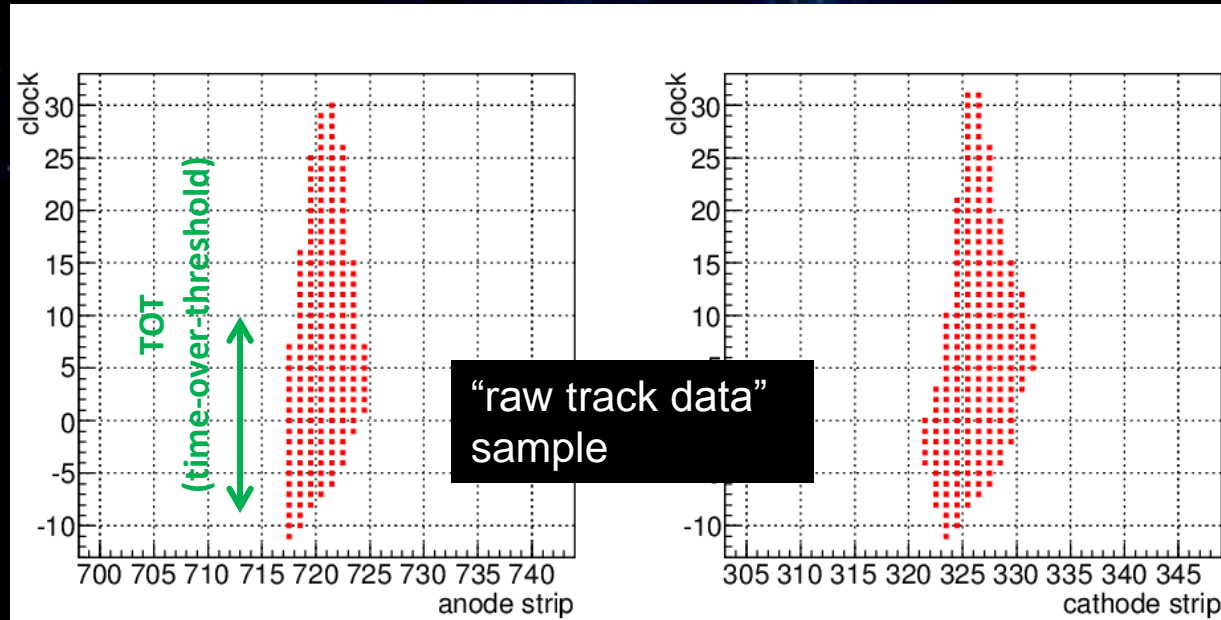
NEWAGE-0.3b' data

- TOT of every strip by FPGA (clock 100MHz)
⇒ 3D tracks, headtails in X,Y

+

- Summed waveforms by FADC (100MHz)
⇒ energy, headtails in Z

combined ⇒ PID, absolute z

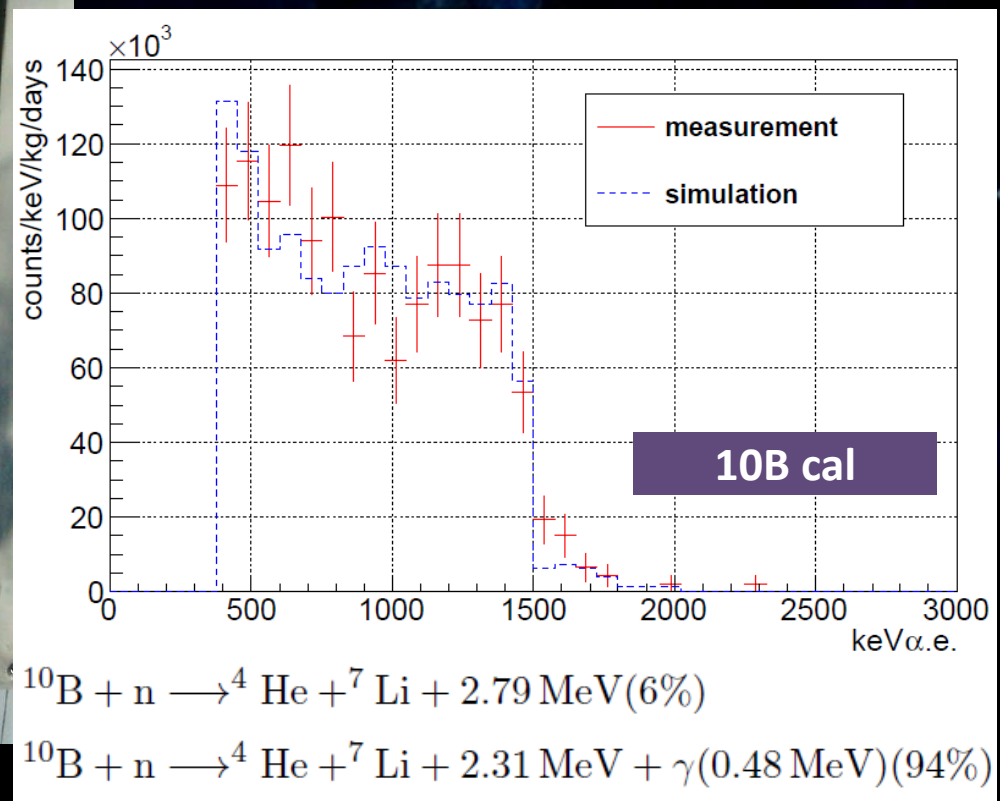
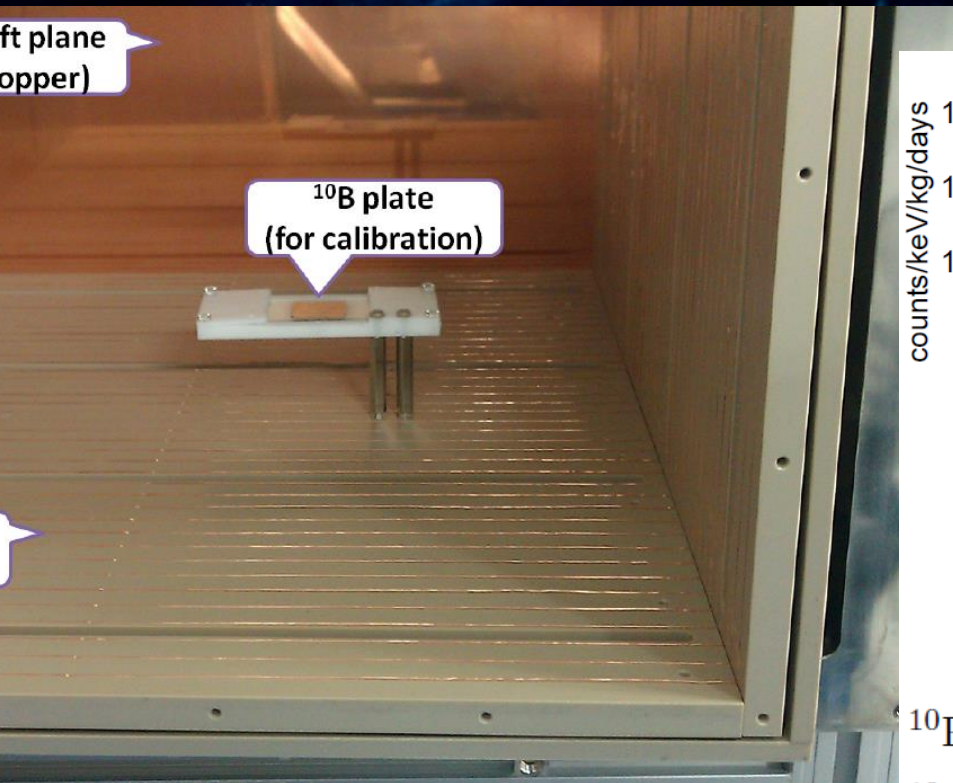


← **NEWAGE-0.3b' performance**

- **Energy threshold: 50keV**
- **Energy resolution:
20% (dominated by gain non-uniformity)**
- **Nuclear track detection efficiency: 40% @50keVee**
- **Gamma rejection $2.5E-5$ @50keVee**
- **angular resolution 40° @50keVee**

NEWAGE-0.3b' : calibration

- α 's from $^{10}\text{B}(n,\alpha)^7\text{Li}$ reaction
- ^{10}B plate stays in the TCP
- irradiated with thermalized neutrons

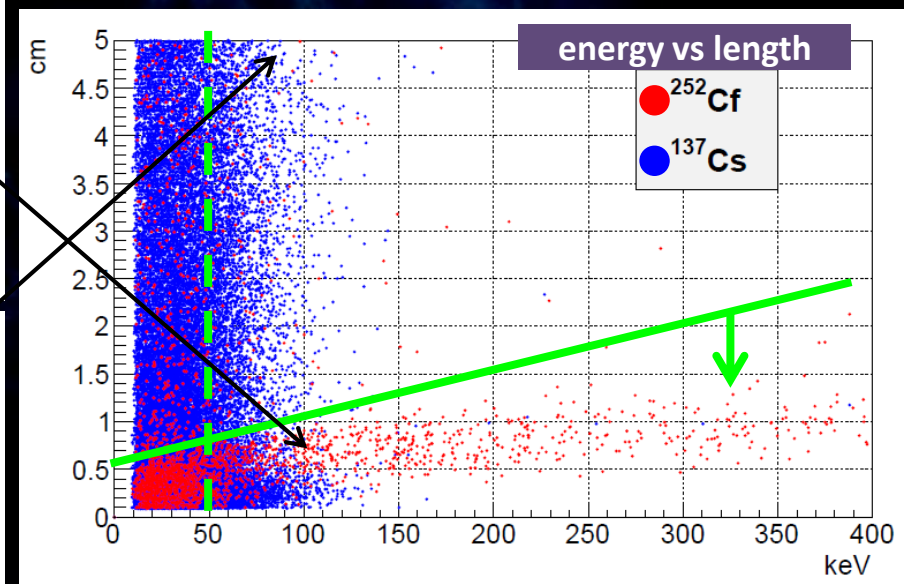
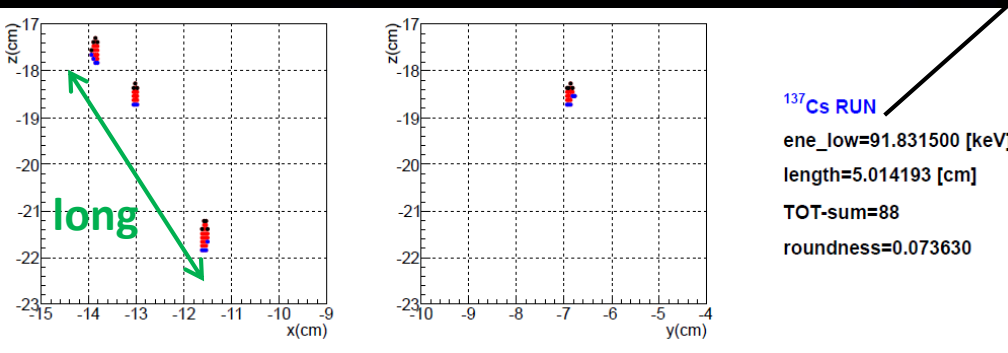
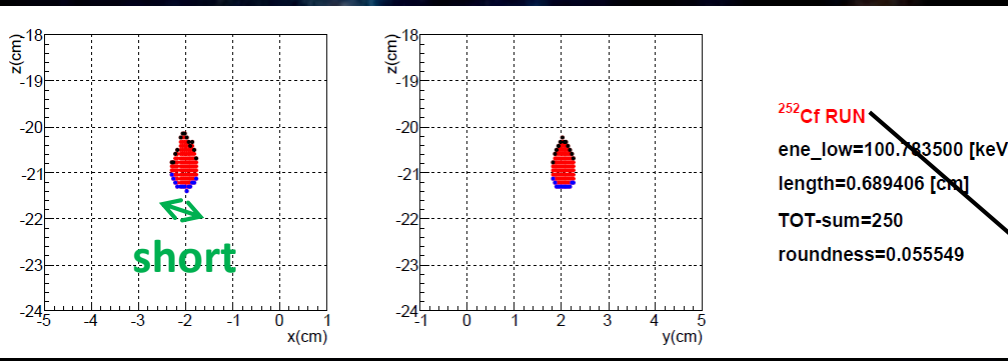


- linearity check: 1.5MeV+ 5.9keV, 6MeV

Event selection 1

length-cut (conventional gamma-ray cut)

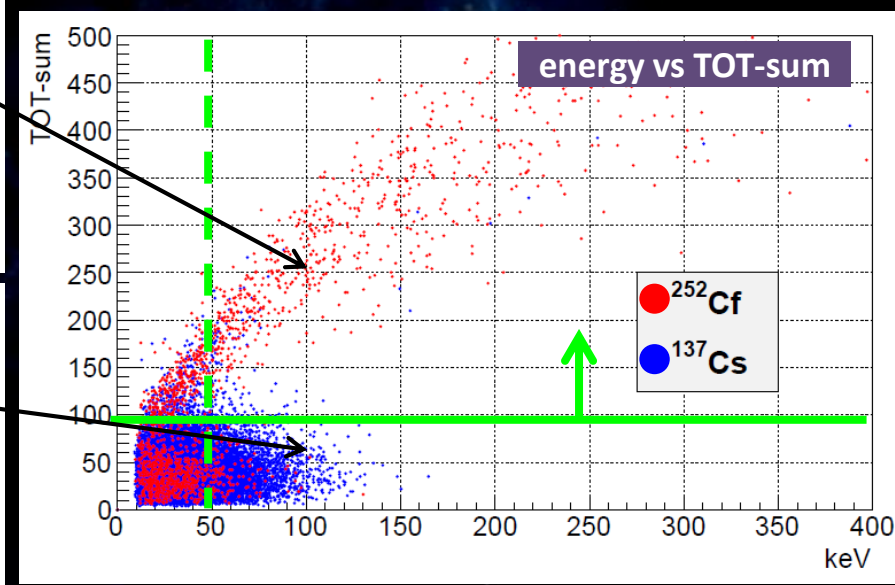
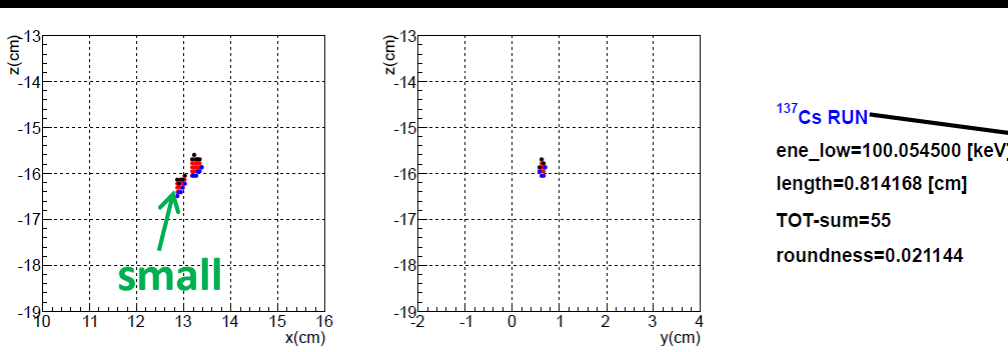
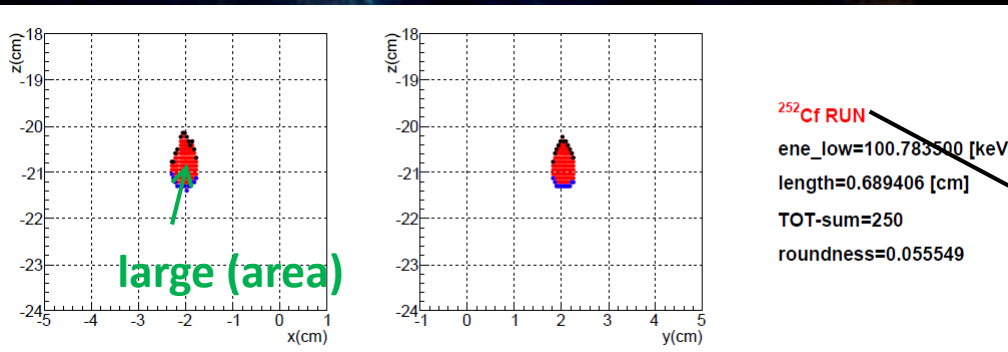
dE/dx : nuclear (^{252}Cf) > electron (^{137}Cs)
track length : electron > nuclear



Event selection 2

TOT-sum-cut (new gamma-ray cut)

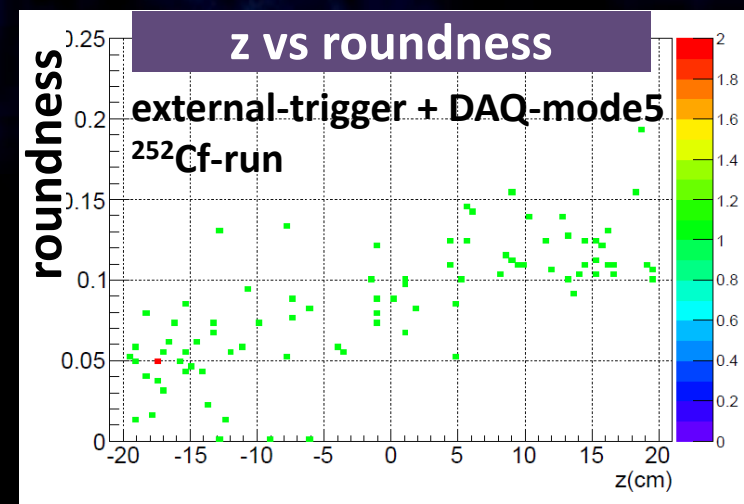
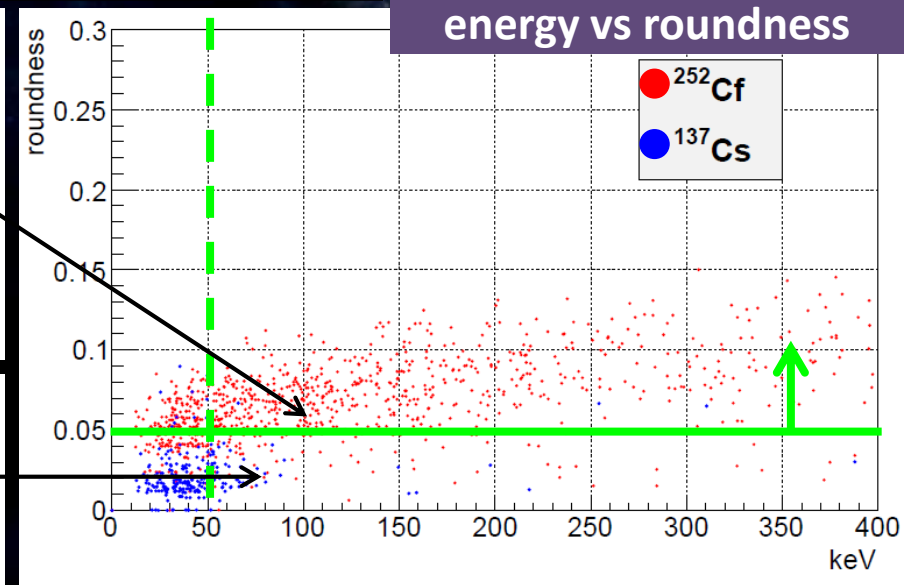
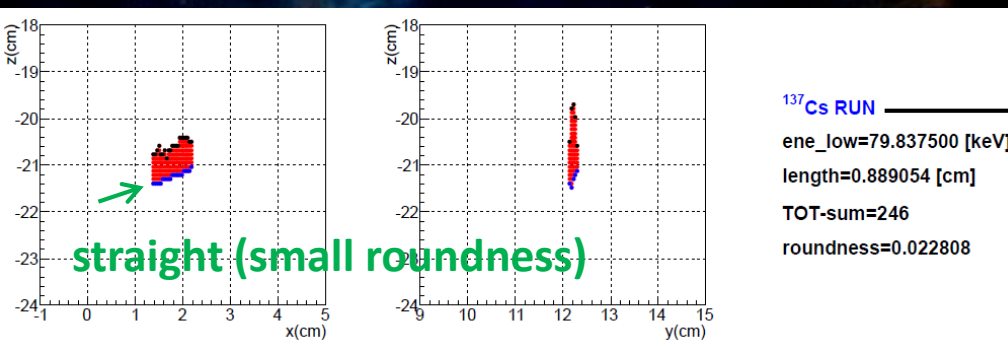
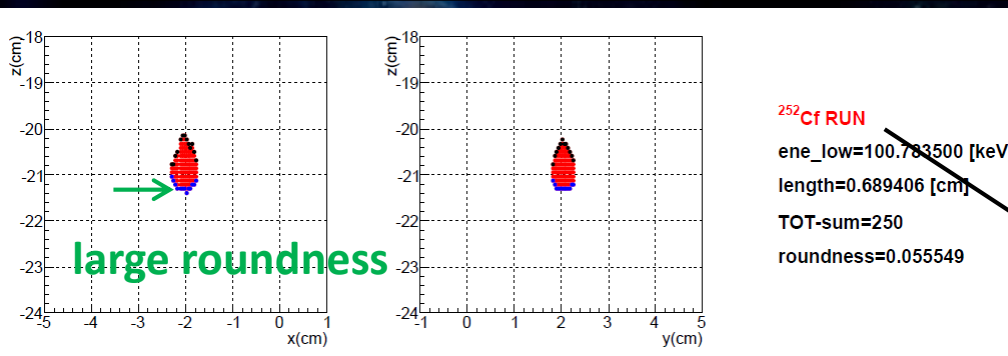
- Nuclear (^{252}Cf): TOT-sum is proportional to energy
- Electron (^{137}Cs): scratched track (small dE/dx)



Event selection 3

roundness-cut (third cut)

Remained ^{137}Cs events : straight track shape



Diffusion (drift distance) affects roundness !
(Almost all electron events are cut)
(Remained events are BG α from μ -PIC)
Roundness-cut works as “z-fiducial-cut”

Efficiency

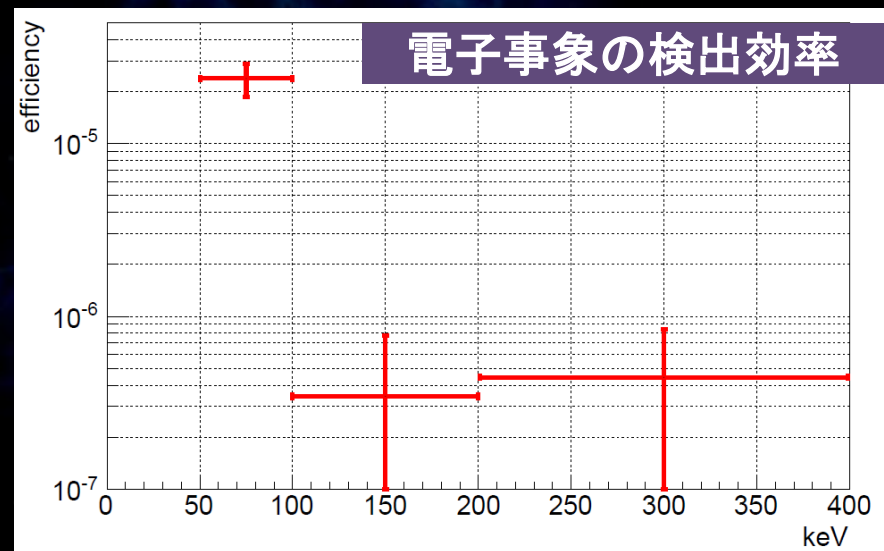
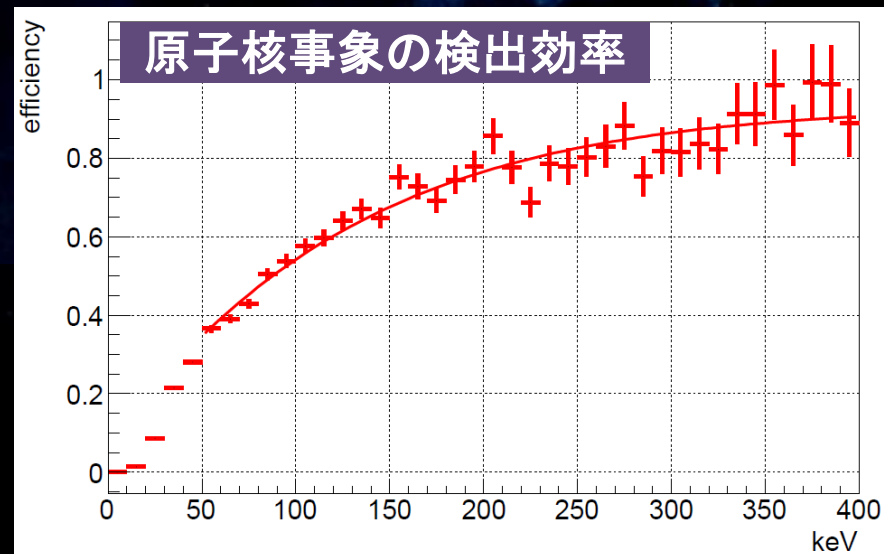
After all cut, compare to Geant4

- Nuclear (^{252}Cf neutron source)

Efficiency : 40% @ 50keV

- Electron (^{137}Cs γ source)

Rejection : 2.5×10^{-5} @ 50-100keV



NEWAGE underground run

RUN14

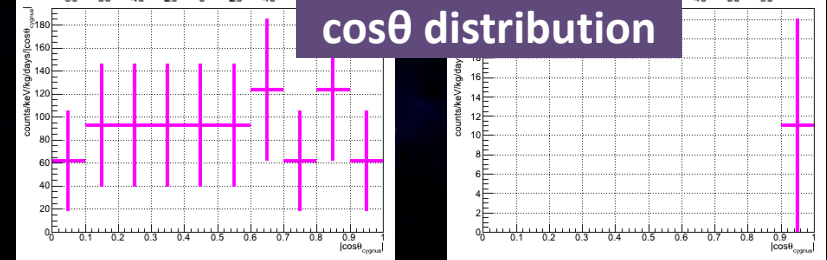
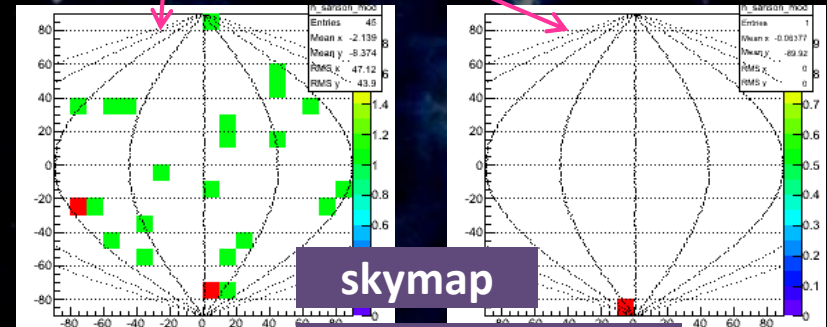
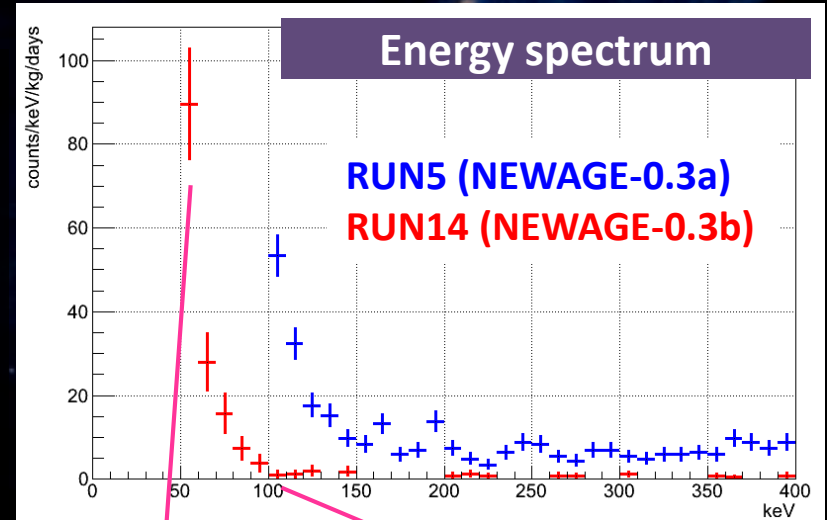
- period : 2013/7/20-8/11, 10/19-11/12
- live time : 31.6 days
- fiducial volume : $28 \times 24 \times 41 \text{cm}^3$
- mass : 10.36g
- exposure : 0.327 kg · days

• Energy spectrum

- Threshold : 100 => **50keV**
- BG rate : **1/10**@100keV

• Skymap, $\cos\theta$ distribution

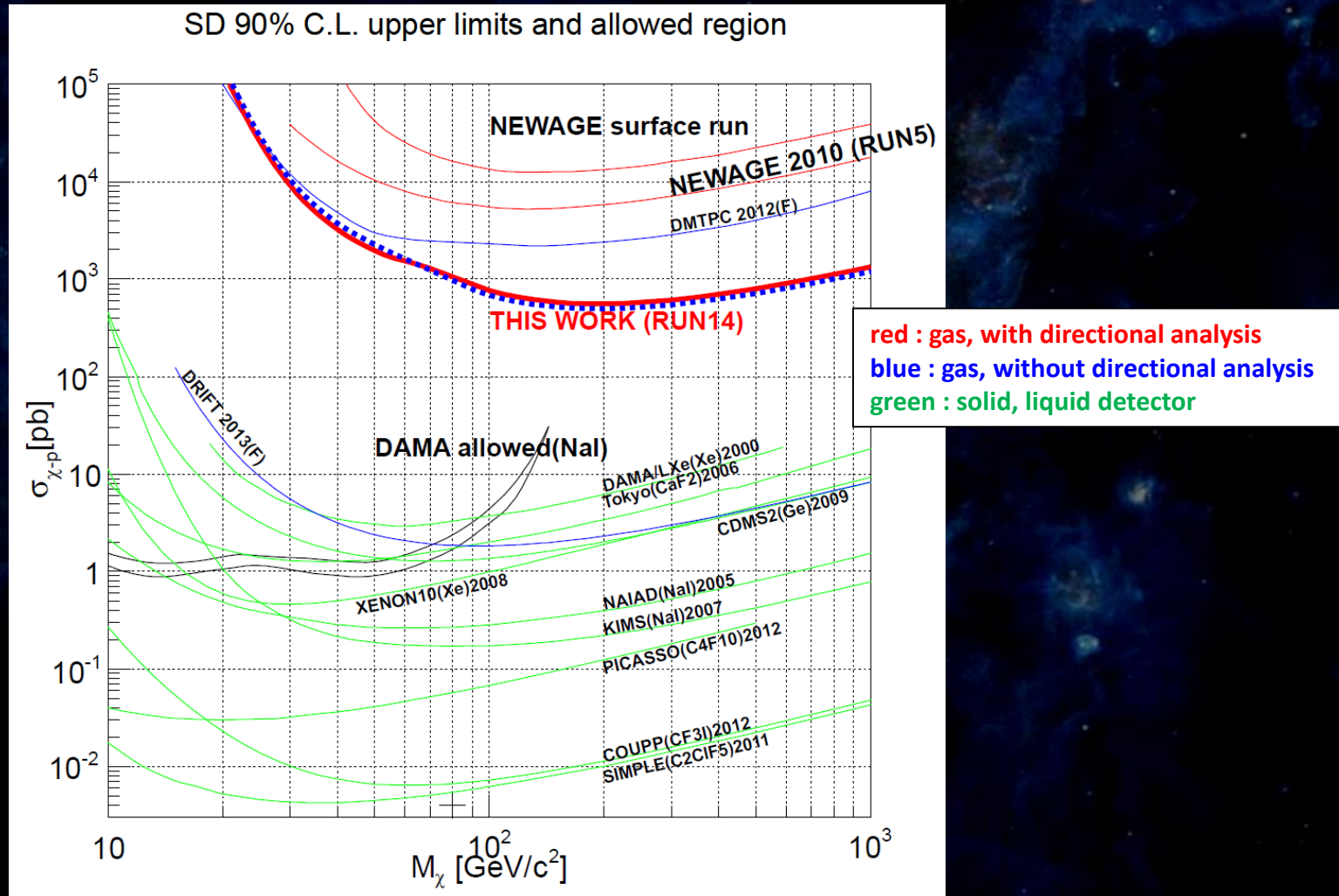
- Set limit by significant difference in 2-binned measured $\cos\theta$ and DM-wind simulated $\cos\theta$



50-60keV

100-110keV

Direction-sensitive limit

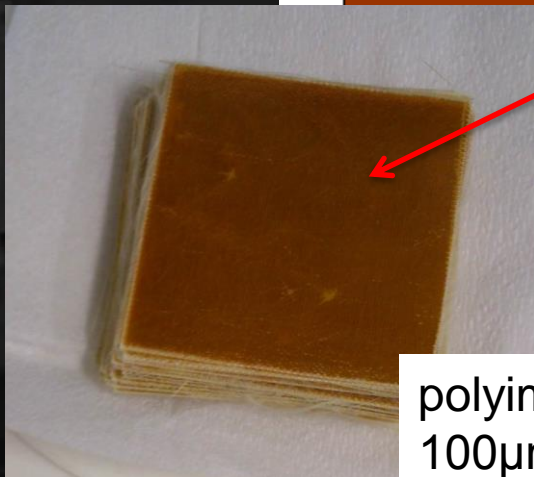
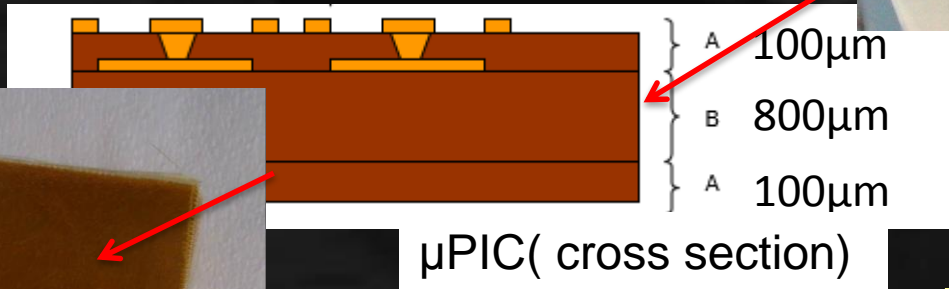
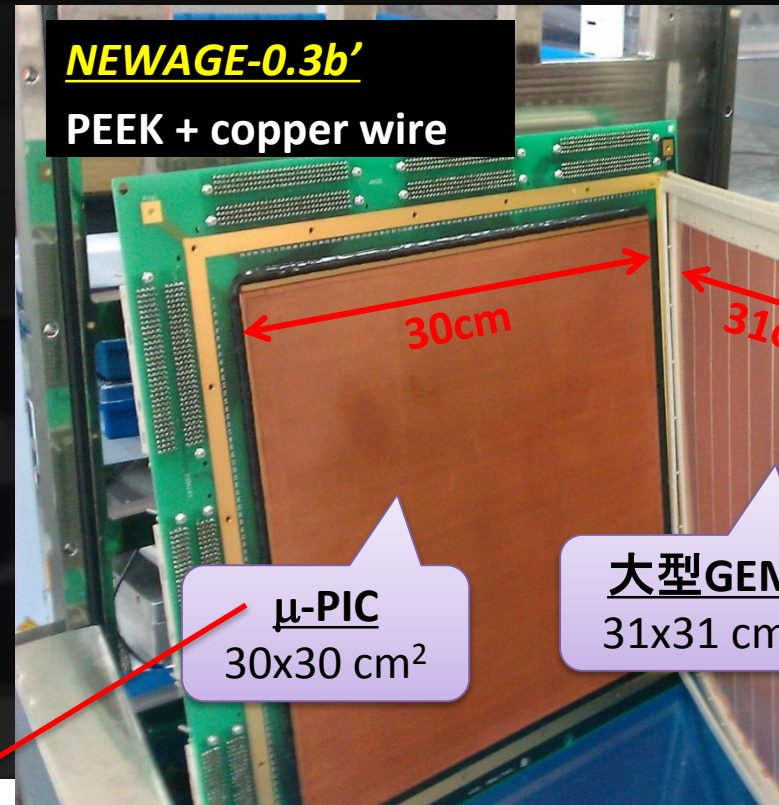


- Obtained limit : **557pb @200GeV**
(Best direction-sensitive limit)
- Improved one order of magnitude from previous RUN5

NEWAGE to low-BG

◆ BG sources

- BG source: α 's from polyimide for μ PIC
- U $0.4 \times 10^{-6} \text{g/g}$
Th $1.8 \times 10^{-6} \text{g/g}$
- Measured by Ge detectors



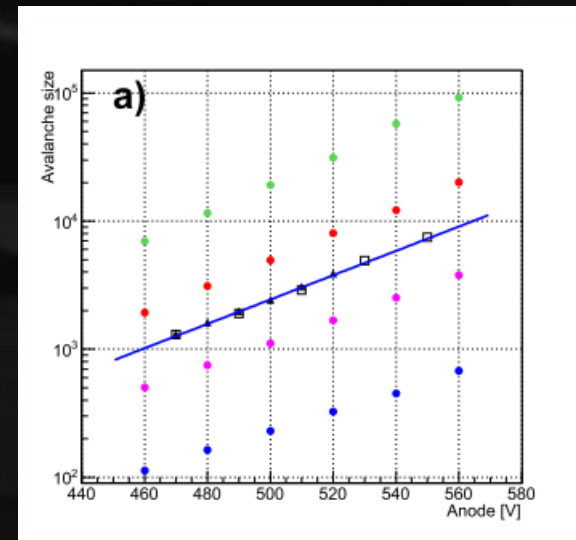
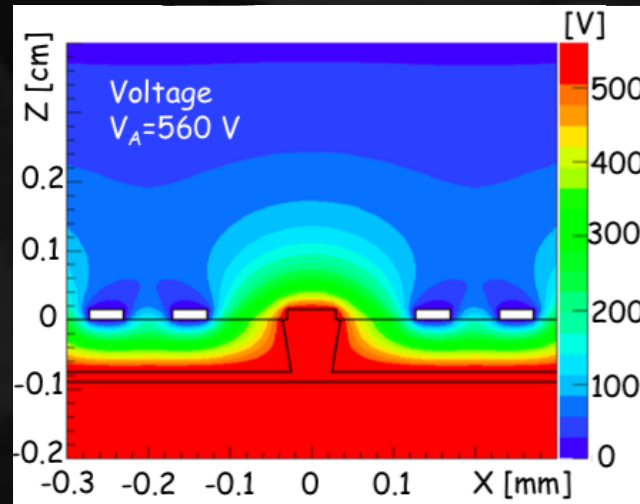
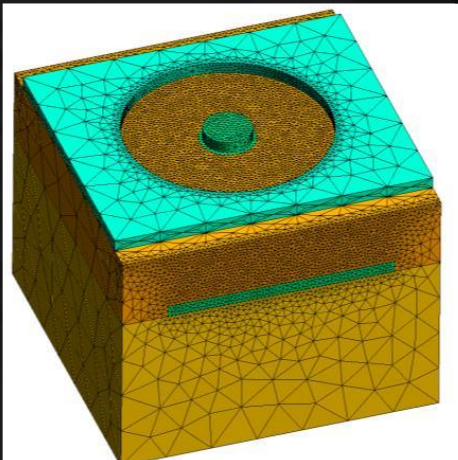
- low BG μ PIC development started

NEWAGE with Garfield++

μPIC 3D simulations with free softwares (Takada)

JINST8 (2013) C10023

- gmesh + elmer + garfiled
- For geometry designing, gas studies, electronics designing



SUMMARY

- ◆ μ -PIC based TPC with electronics
- ◆ 3-D tracks
- ◆ Phase for “low BG detector”