NEWAGE

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PTEP (2015) 043F01s
R&D status

科研費 KAKENHI

Direction-Sensitive WIMP-search NEWAGE

Japanese Underground Activities

"Revealing the history of the universe with underground particle and nuclear research"

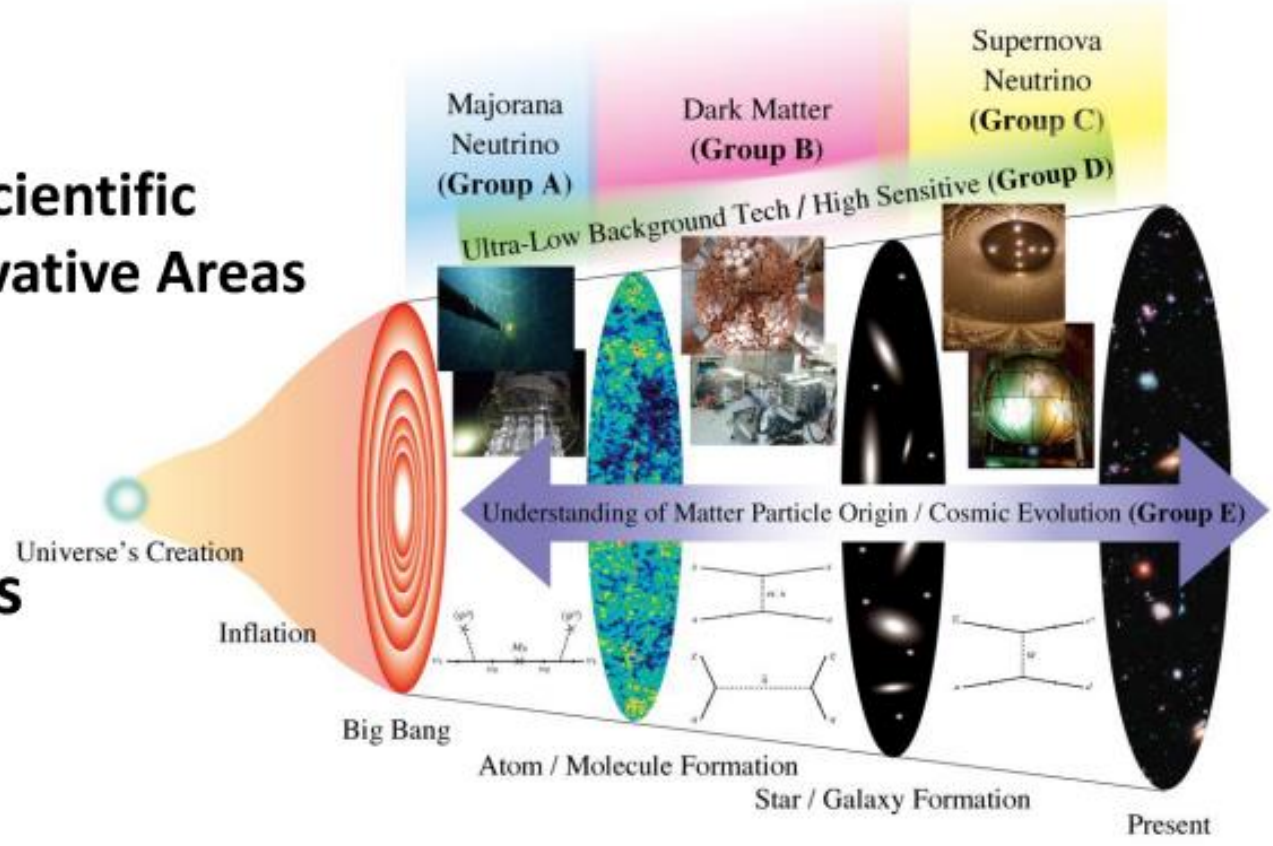
科研費 KAKENHI

Takeuchi @NDM2014

http://www.lowbg.org/ugnd/

Cooperate among underground experiments, theorists, & low-BG researchers to achieve technical and scientific synergies.

- **MEXT KAKENHI**
  - **Grant-in-Aid for Scientific Research on Innovative Areas**
- **JFY 2014 - 2018**
- **~10 million US$**
- **5 research groups**
- **~70 researchers**



"Revealing the history of the universe with underground particle and nuclear research"

科研費 KAKENHI

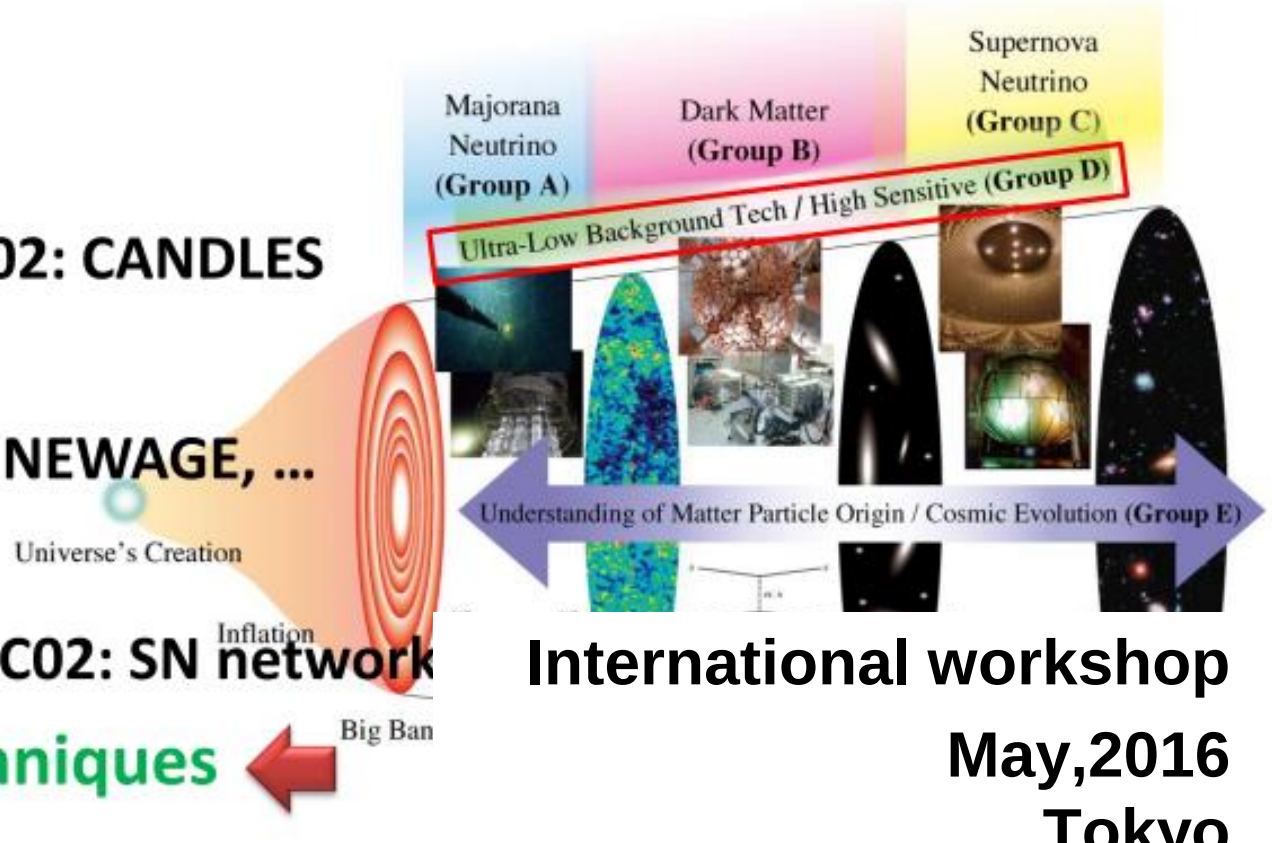
Takeuchi @NDM2014

http://www.lowbg.org/ugnd/

Cooperate among underground experiments, theorists, & low-BG researchers to achieve technical and scientific synergies.

Research groups:

- **A: Majorana ν**
  - A01: KamLAND, A02: CANDLES
- **B: Dark matter**
  - B01: XMASS, B02: NEWAGE, …
- **C: Supernova ν**
  - C01: GADZOOKS!, C02: SN network
- **D01: Low BG techniques**
- **E01: Theory**



International workshop

May,2016

Tokyo

Kobe University's activity

- **JSPS "Brain circulation program"**
  (Program for Advancing Strategic International Networks to Accelerate the Circulation of Talented Researchers)
  - **Micro-Patterned Gas Detector and Direction-Sensitive Dark Matter**
  - **We can invite "young" staff researchers. Dan, Neil, James and Sven**
  - **We can invite some more in 2015, 2016.**

NEWAGE

NEWAGE

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

- Proposal

  PLB 578 (2004) 241-246

- First direction-sensitive DM limits

  PLB654 (2007) 58

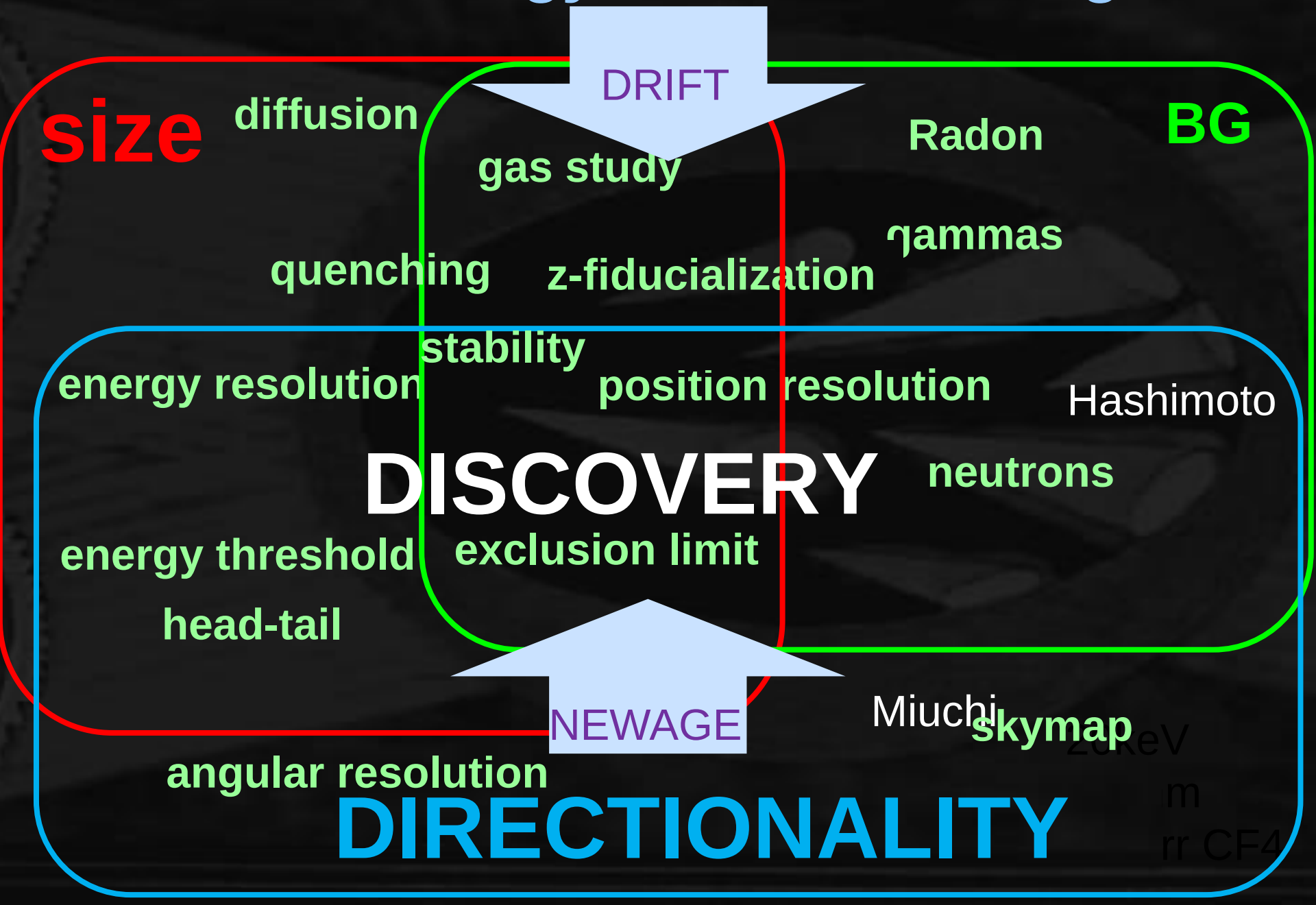
CYGNUS 07

- Underground results

  PLB686 (2010) 11, PTEP (2015) 043F01s

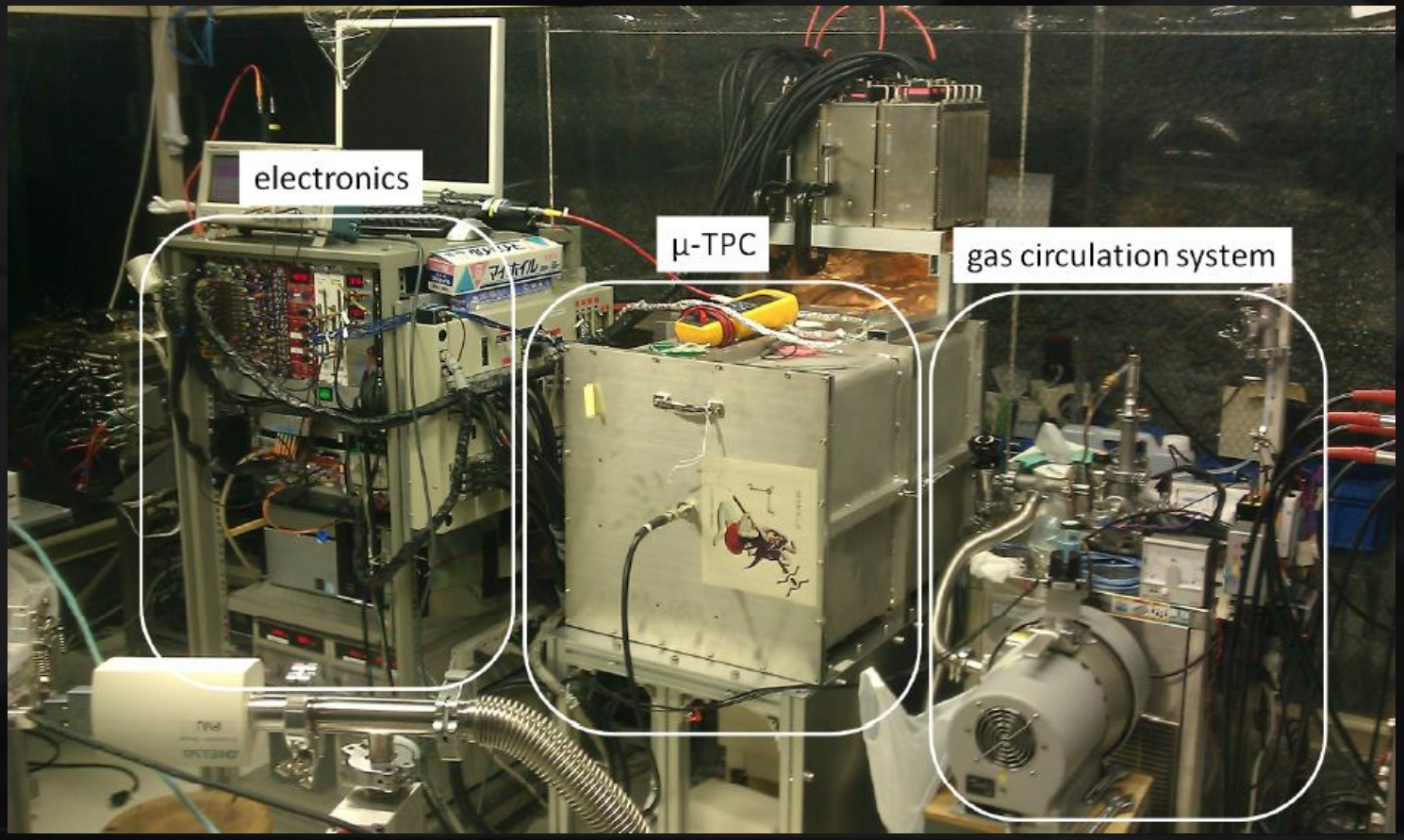
- Phase for “low BG detector”

NEWAGE strategy since its new ages



NEWAGE detector

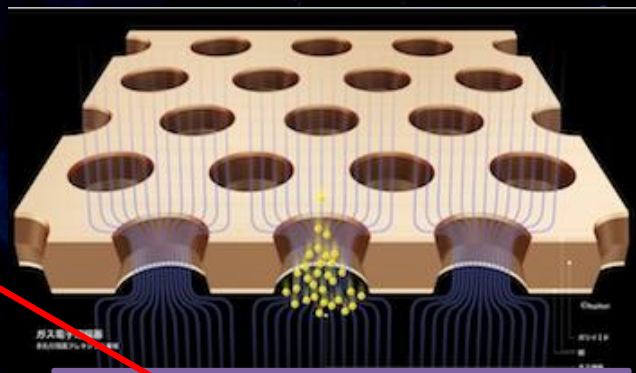
- NEWAGE-0.3b’
- Detection Volume: 31×31×41cm^3
- Gas: CF4 at 0.1atm (50keVee threshold)
- Gas circulation system with cooled charcoal

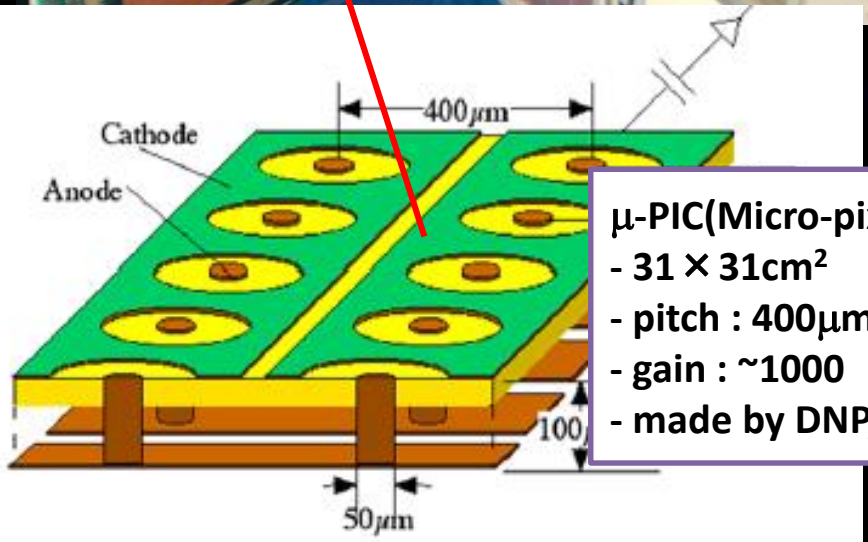


NEWAGE-0.3b' inside view

- Detection Volume: 30×30×41cm^3

Field cage
Drift length: 41cm
PEEK + copper wires



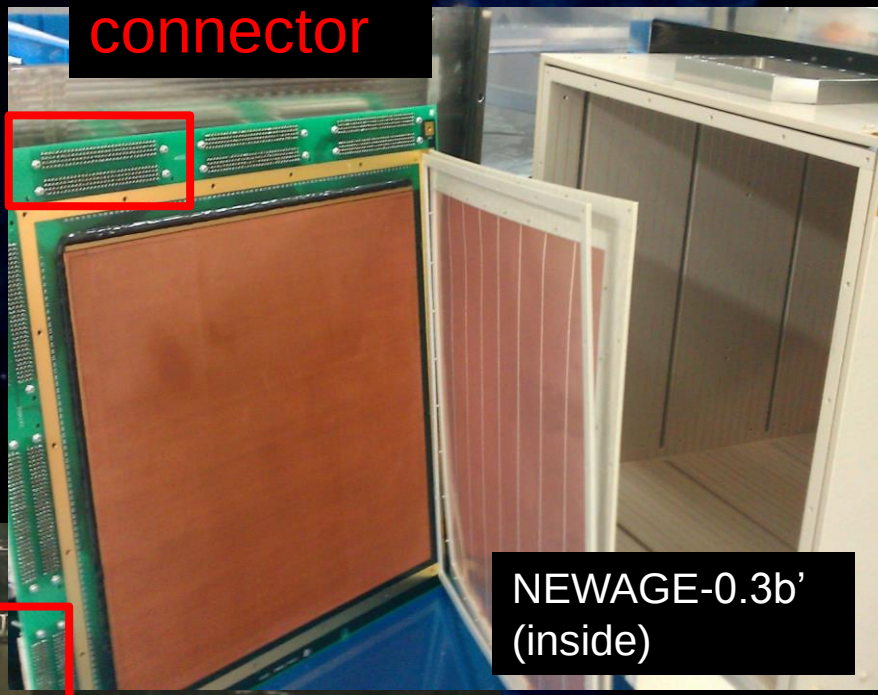


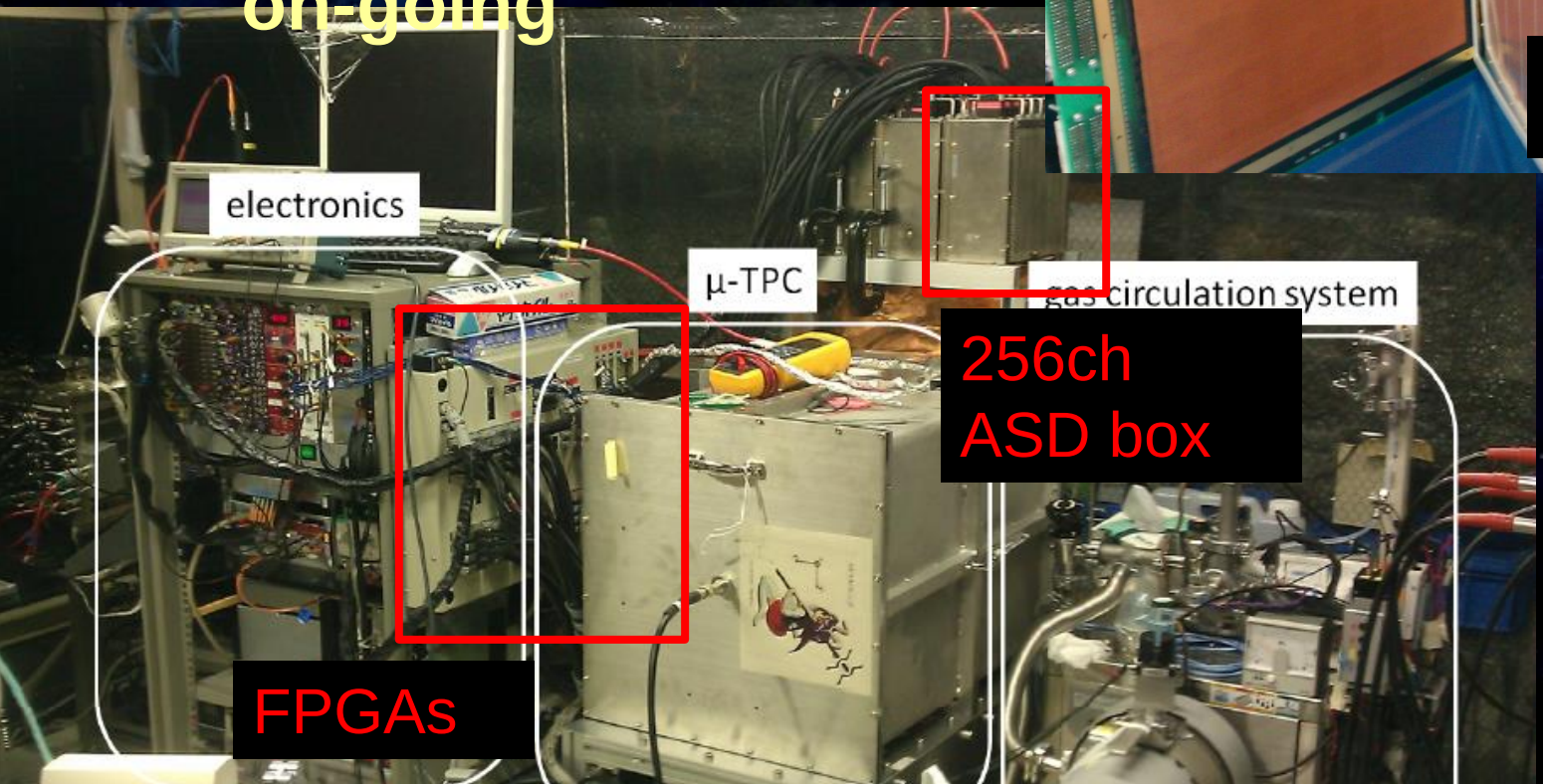
μ-PIC(Micro-pixel chamber)
- 31×31cm^2
- pitch : 400μm
- gain : ~1000
- made by DNP, Japan

GEM
- 31×32 cm^2
- 8-segmented
- hole pitch : 140μm
- hole diameter: 70μm
- insulator : LCP 100μm
- 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 always on-going





NEWAGE-0.3b' data

- TOT of every strip by FPGA (clock 100MHz)

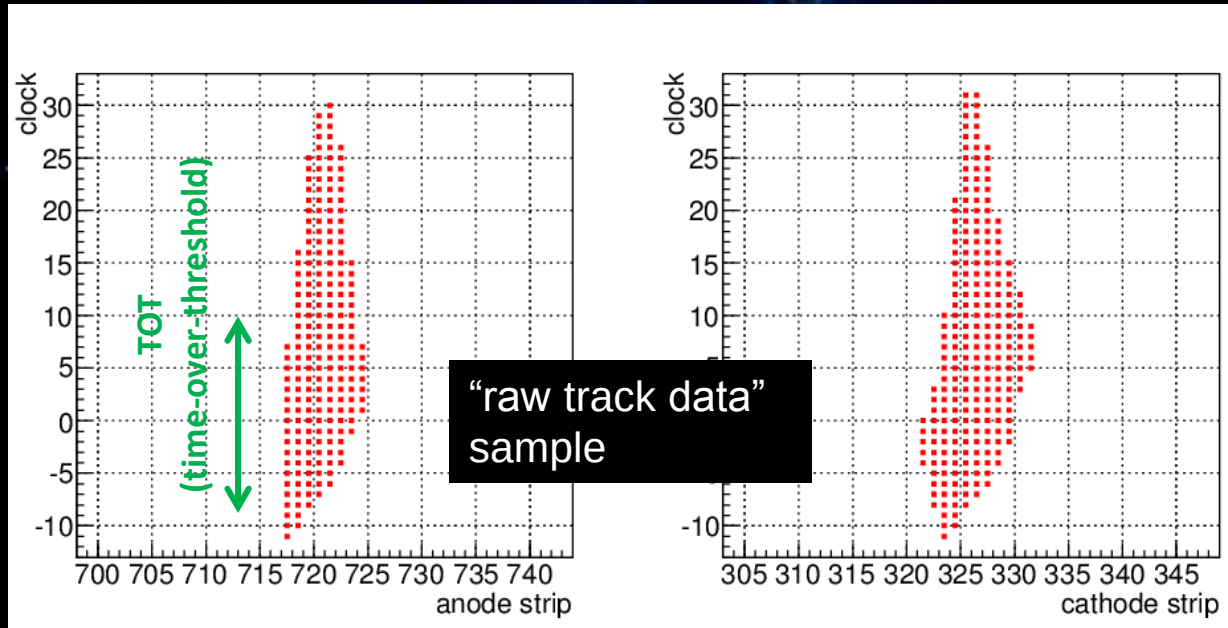
  ⇒3D tracks, headtails in X,Y

  +

- Summed waveforms by FADC (100MHz)

  ⇒energy, headtails in Z

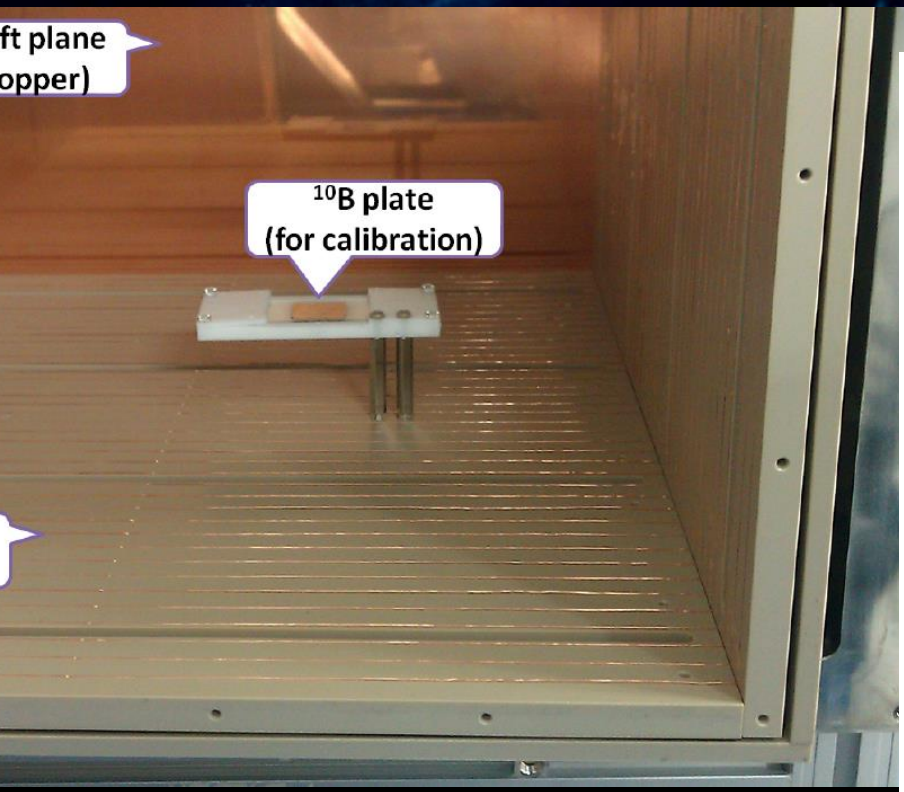
combined ⇒ PID, absolute z

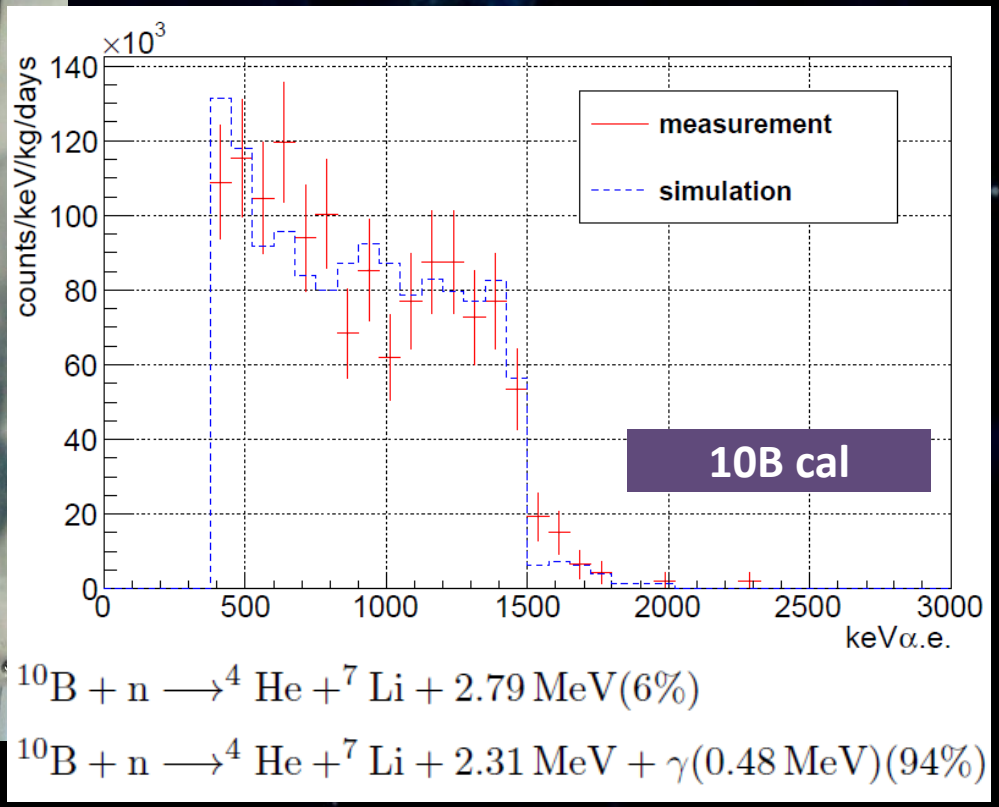


- **NEWAGE-0.3b’ performance**
  - **Energy threshold: 50keV**
  - **Energy resolution:**
    20% (dominated by gain non-uniformity)
  - **Nuclear track detection efficiency: 40% @50keVe**
  - **Gamma rejection 2.5E-5@50keVee**
  - **angular resolution 40˚ @50keVee**

NEWAGE-0.3b' : calibration

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





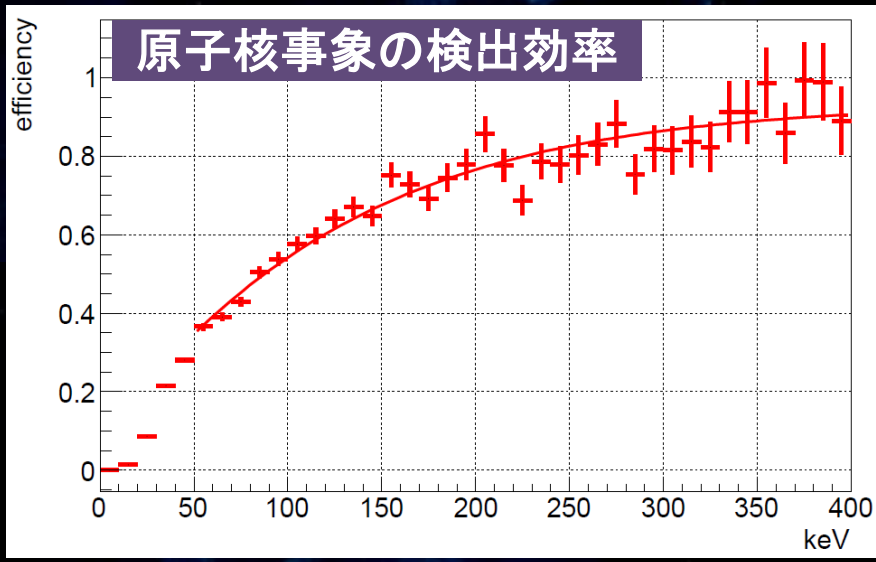
- linearity check: 1.5MeV+ 5.9keV, 6MeV

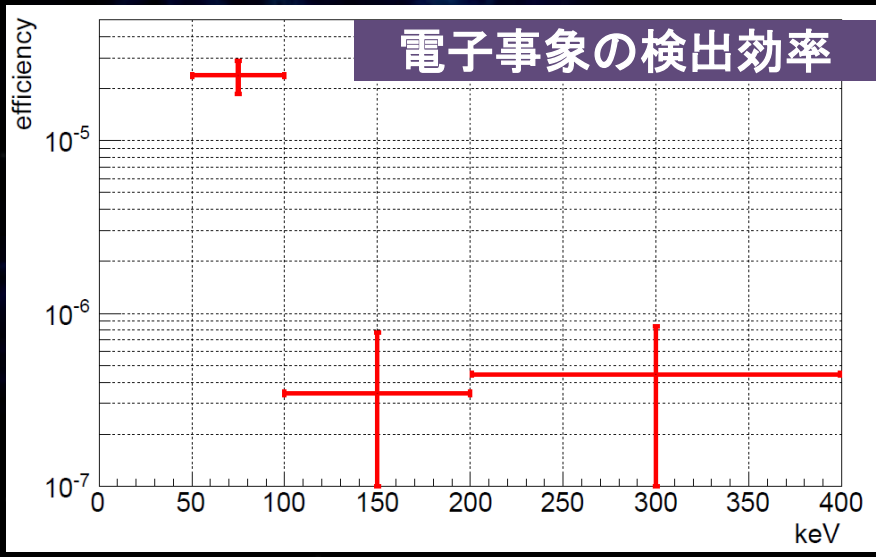
Efficiency

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



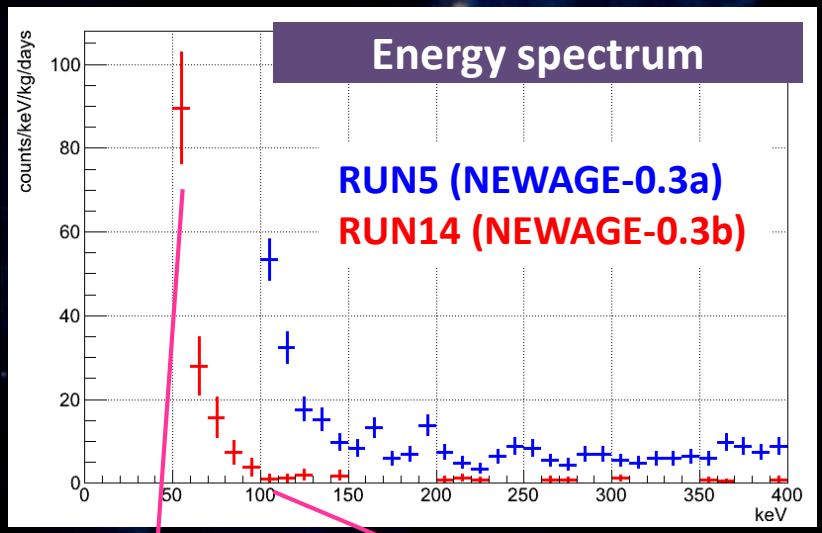


NEWAGE
Kamioka RUN14 results

NEWAGE underground run

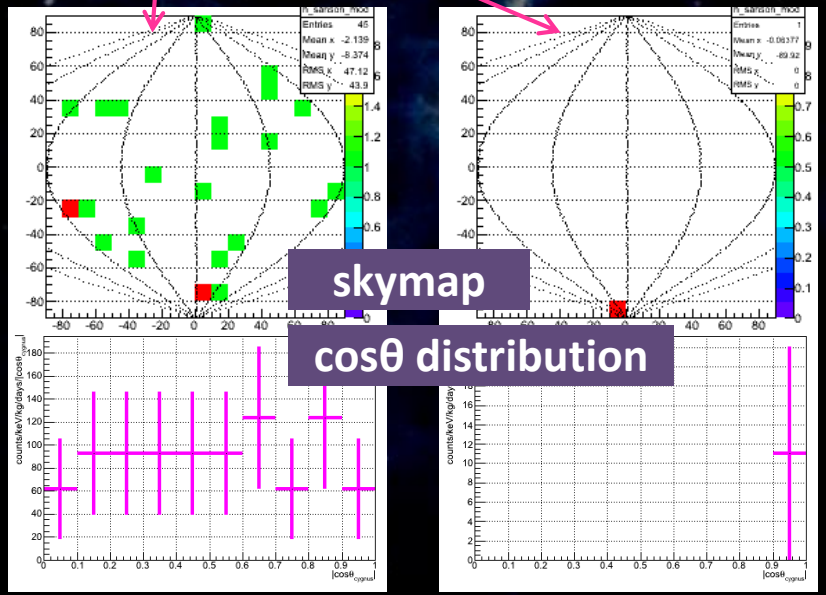
RUN14

- period : 2013/7/20-8/11, 10/19-11/12
- live time : 31.6 days
- fiducial volume : 28x24x41cm^3
- mass : 10.36g
- exposure : 0.327 kg･days

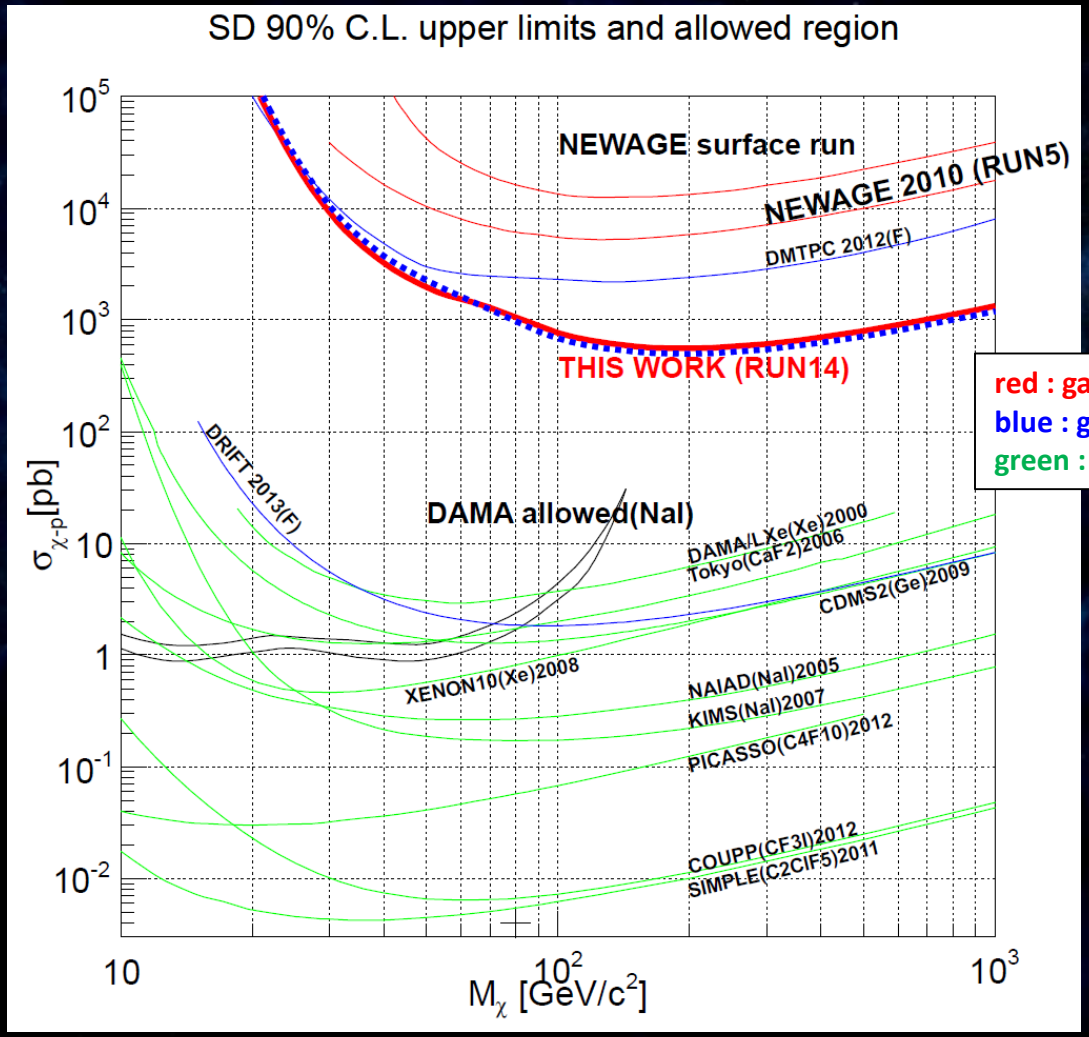


- *Energy spectrum*
  - Threshold : 100 => **50keV**
  - BG rate : **1/10**@100keV

- *Skymap, cosθ distribution*
  - Set limit by significant difference in 2-binned measured cosθ and DM-wind simulated cosθ



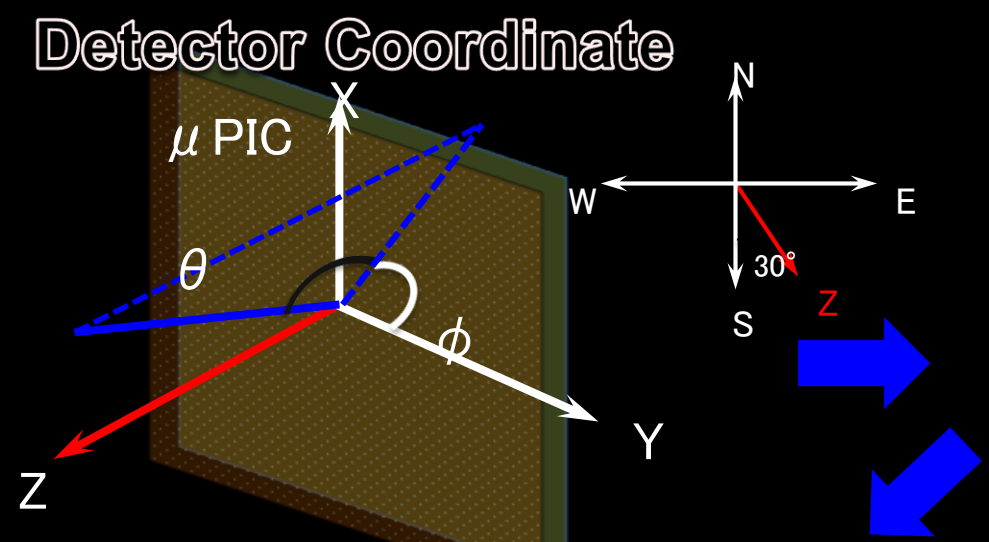
Direction-sensitive limit

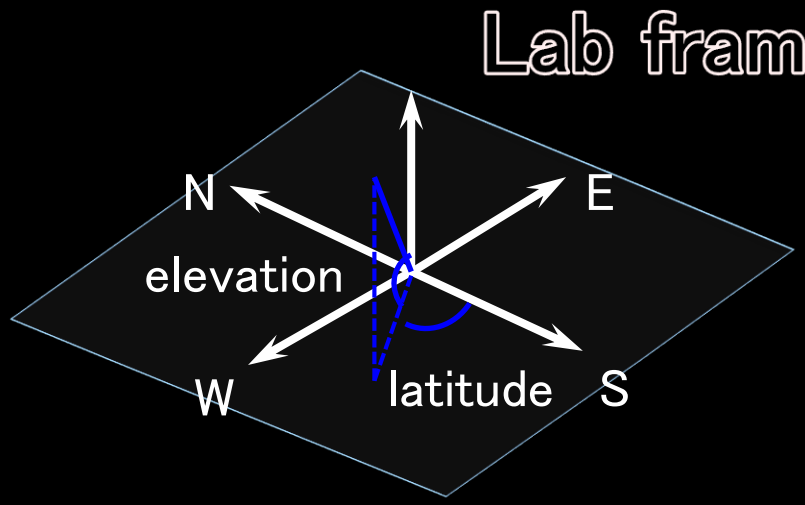


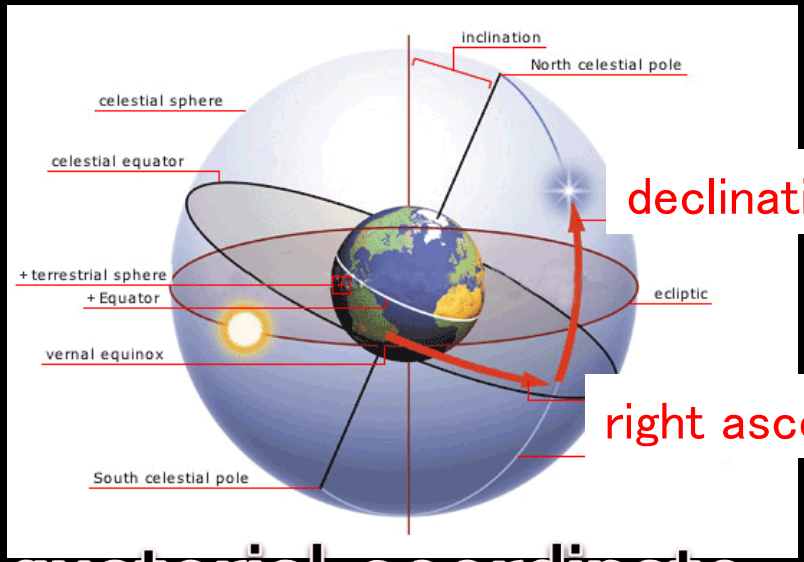
- Obtained limit : 557pb @200GeV
  (Best direction-sensitive limit)
- Improved one order of magnitude from previous RUN5

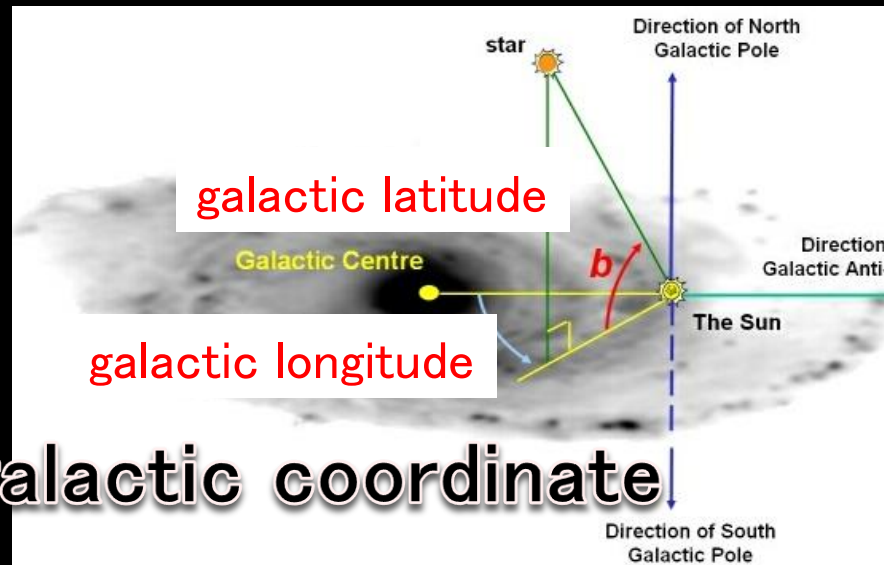
Galactic-plane sky-map

Demonstration for direction sensitivity





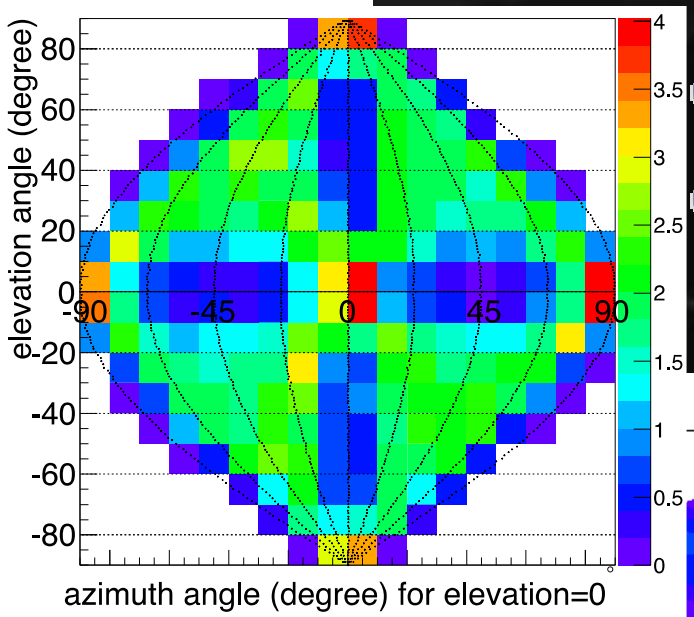




Detection efficiency in Galactic-coordinate

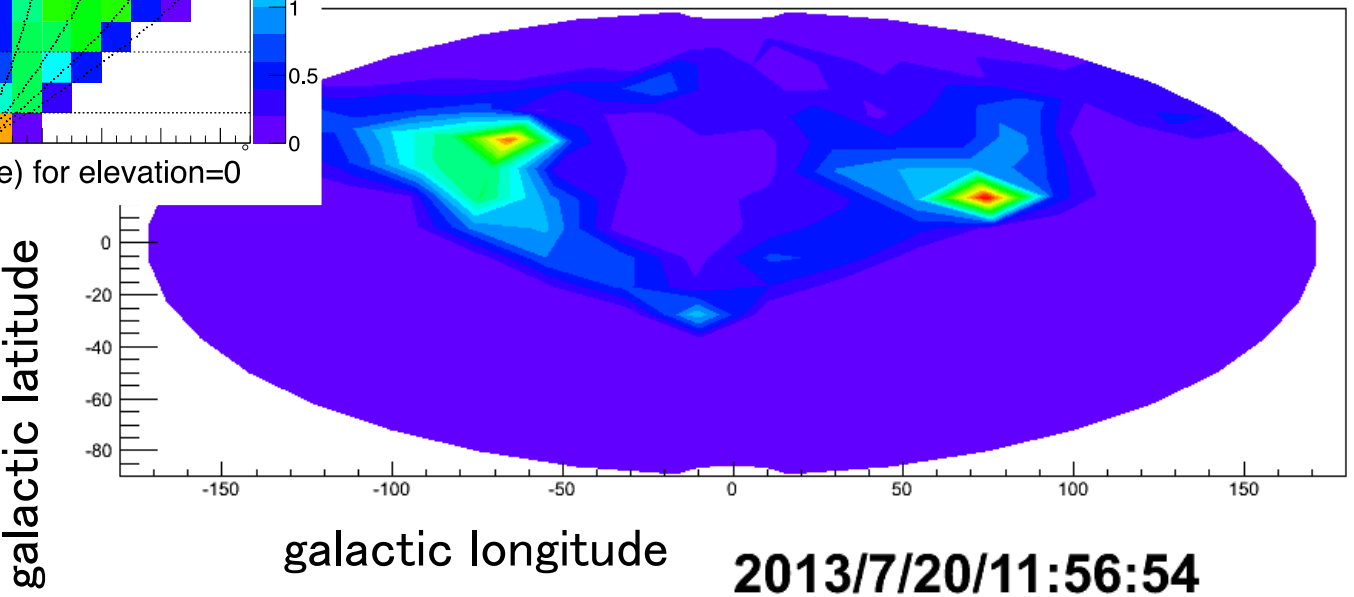
- Time variation of the efficiency map in the galactic coordinate

lab-coordinate



- auto-scanning is demonstrated
- "vertical" and "horizontal" detectors would be needed

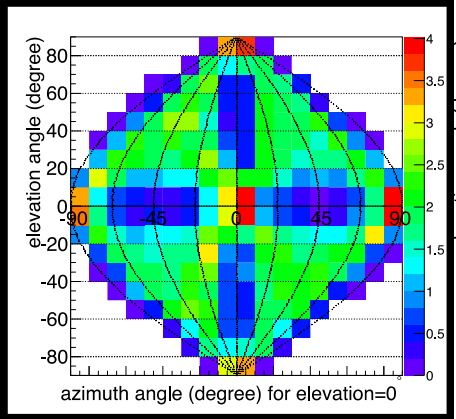
galactic coordinate

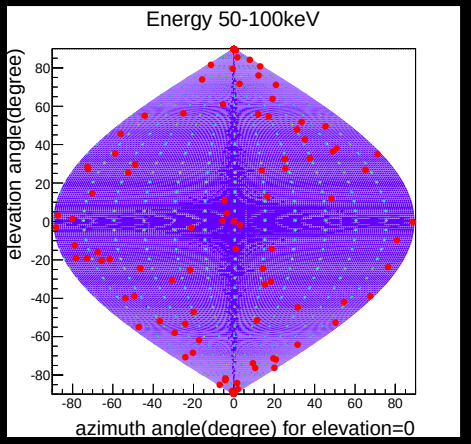


Galactic-plane sky-map

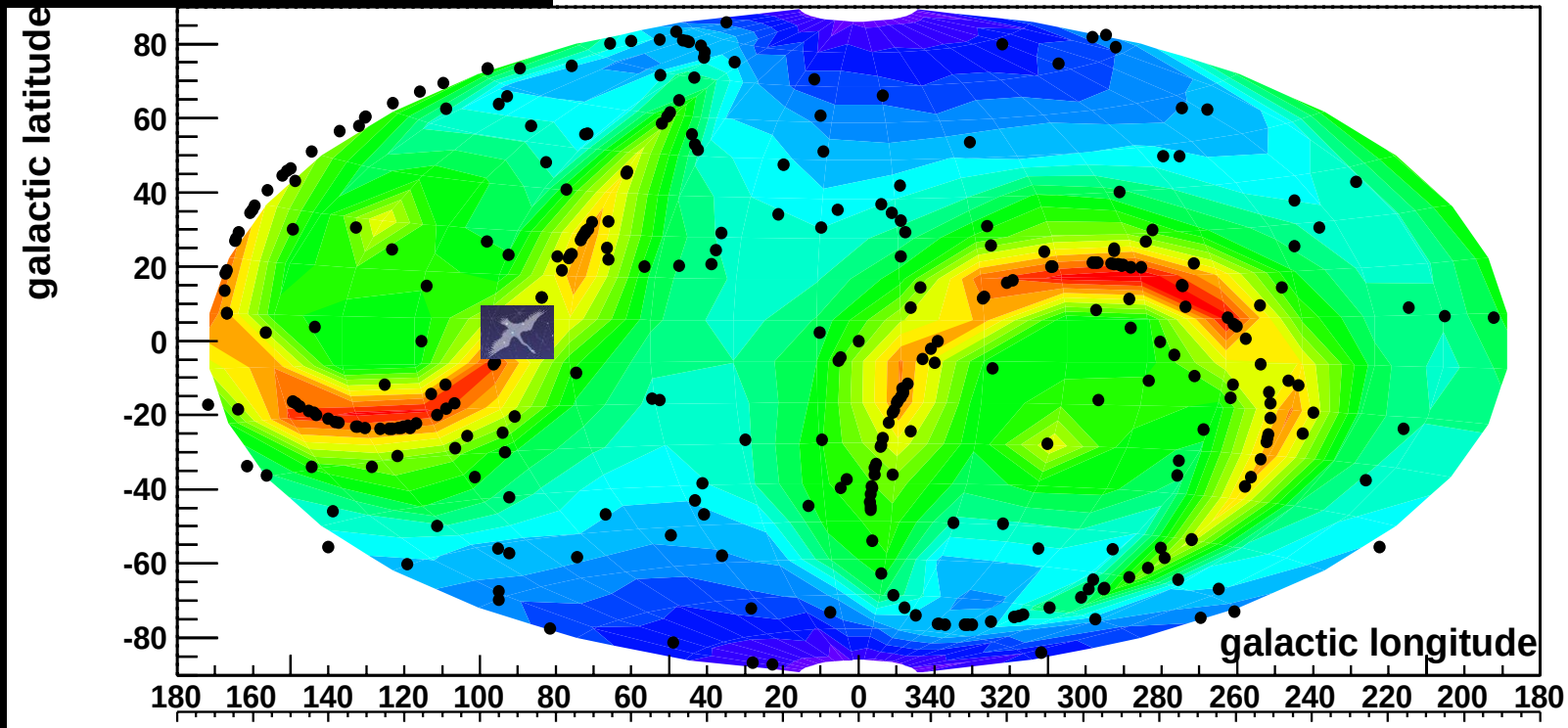
lab-coordinate

- correlation with efficiency = consistent with isotropic





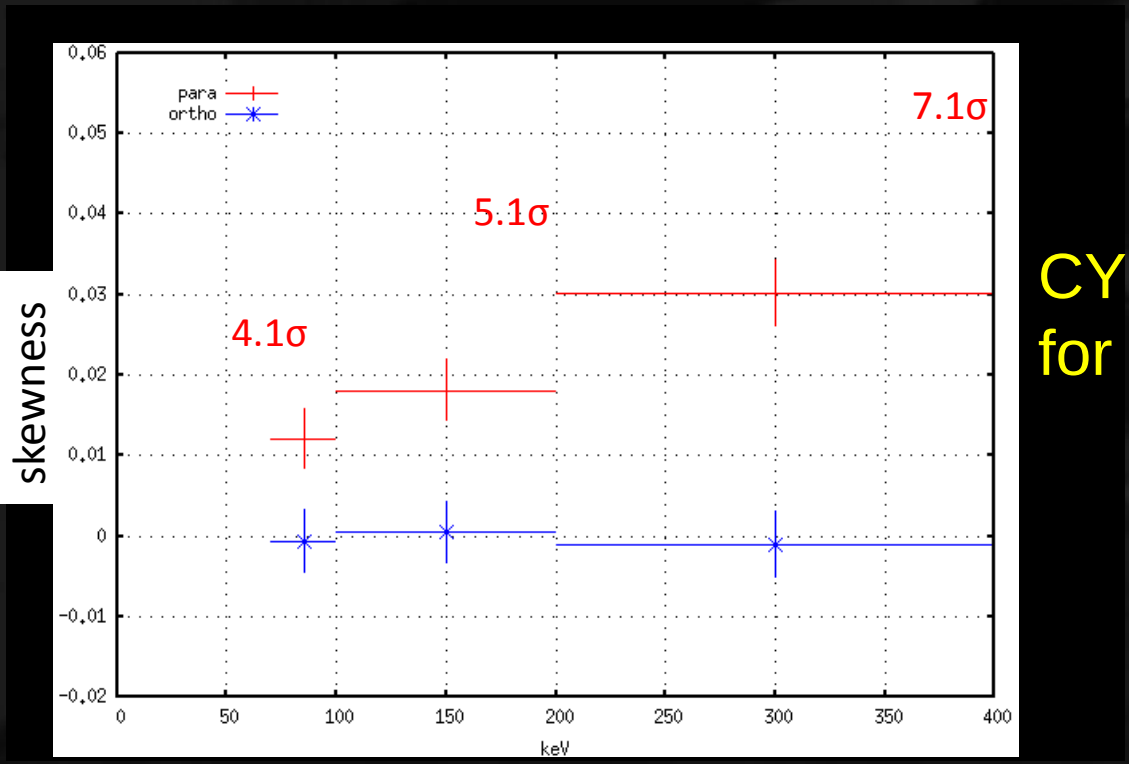
galactic coordinate



NEWAGE
R&Ds

Head/tail study

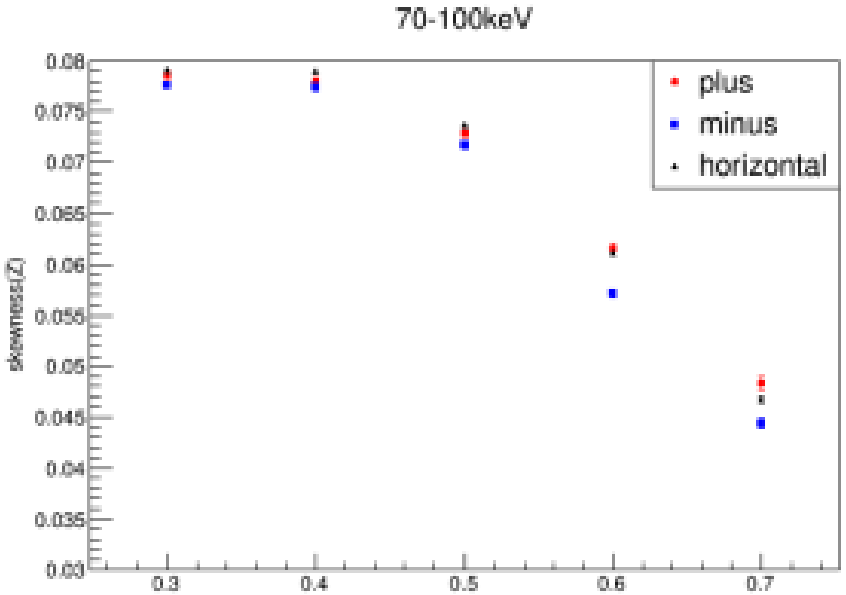
- Head tail in X-Y plane by Cygnus 2013
- Head tail in Z-axis <- NEW



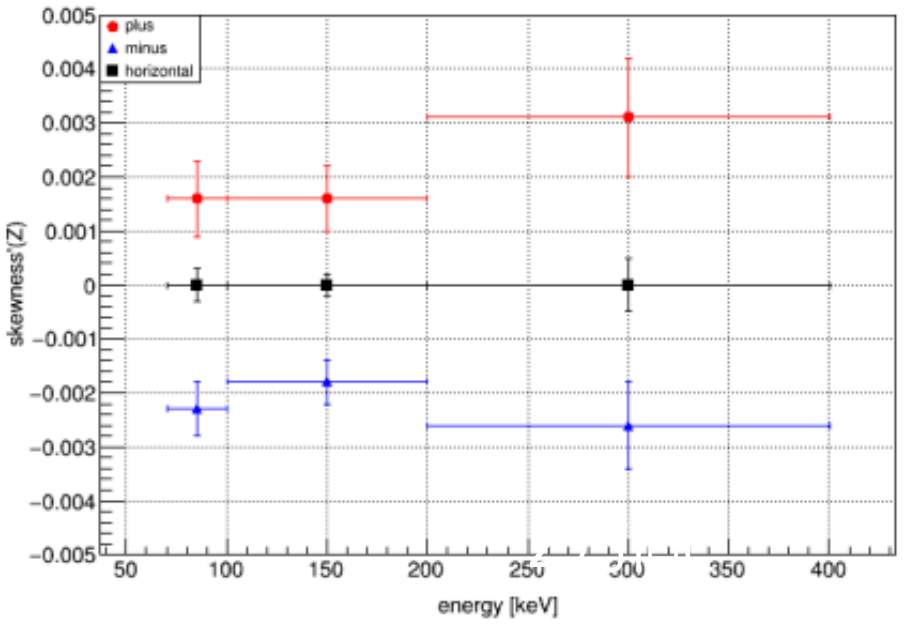
CYGNUS2013
for X-Y plane

Direction Sensitive
WIMP-search
NEWAGE

- **Head tail in Z-axis**
  - skewness in FADC signal



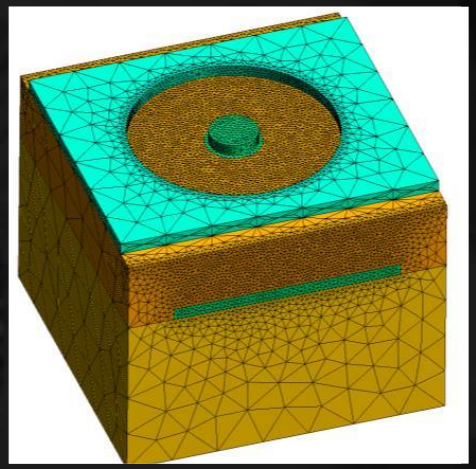
analysis threshold relative to the pulse peak

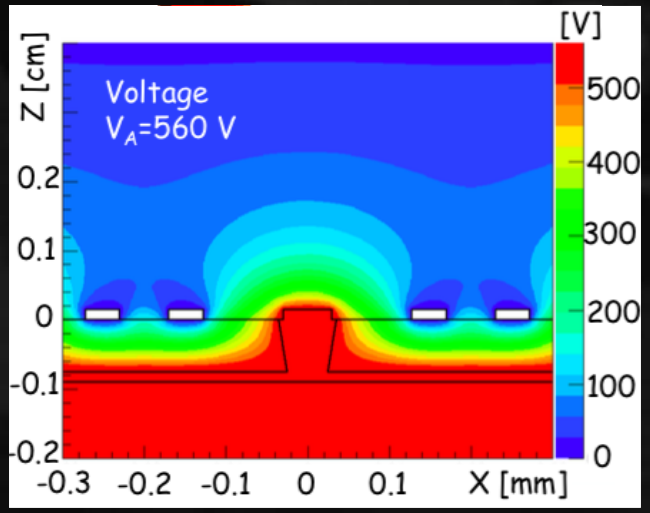


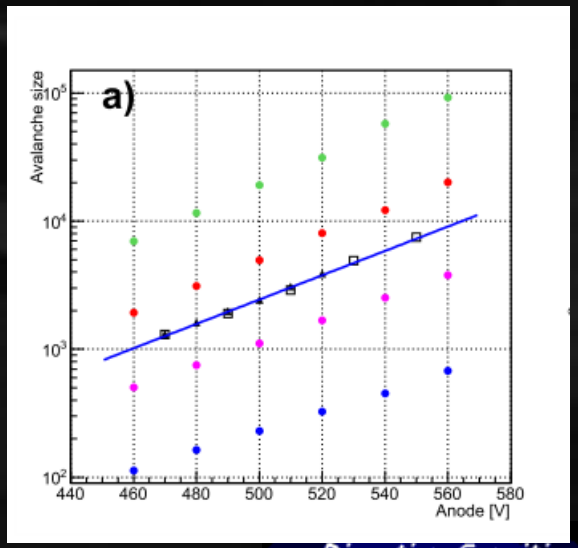
- **Though discrimination is still primitive,**
  - irradiation is not ideal
  - analysis is not optimized
- **We are ready to detect 3-D vector-like tracks.**

NEWAGE with Garfield++

- **μPIC 3D simulations with free softwares (Takada)** JINST8 (2013) C10023
  - **gmesh + elmer + garfiled**
  - **For geometry designing, gas studies, electronics designing**





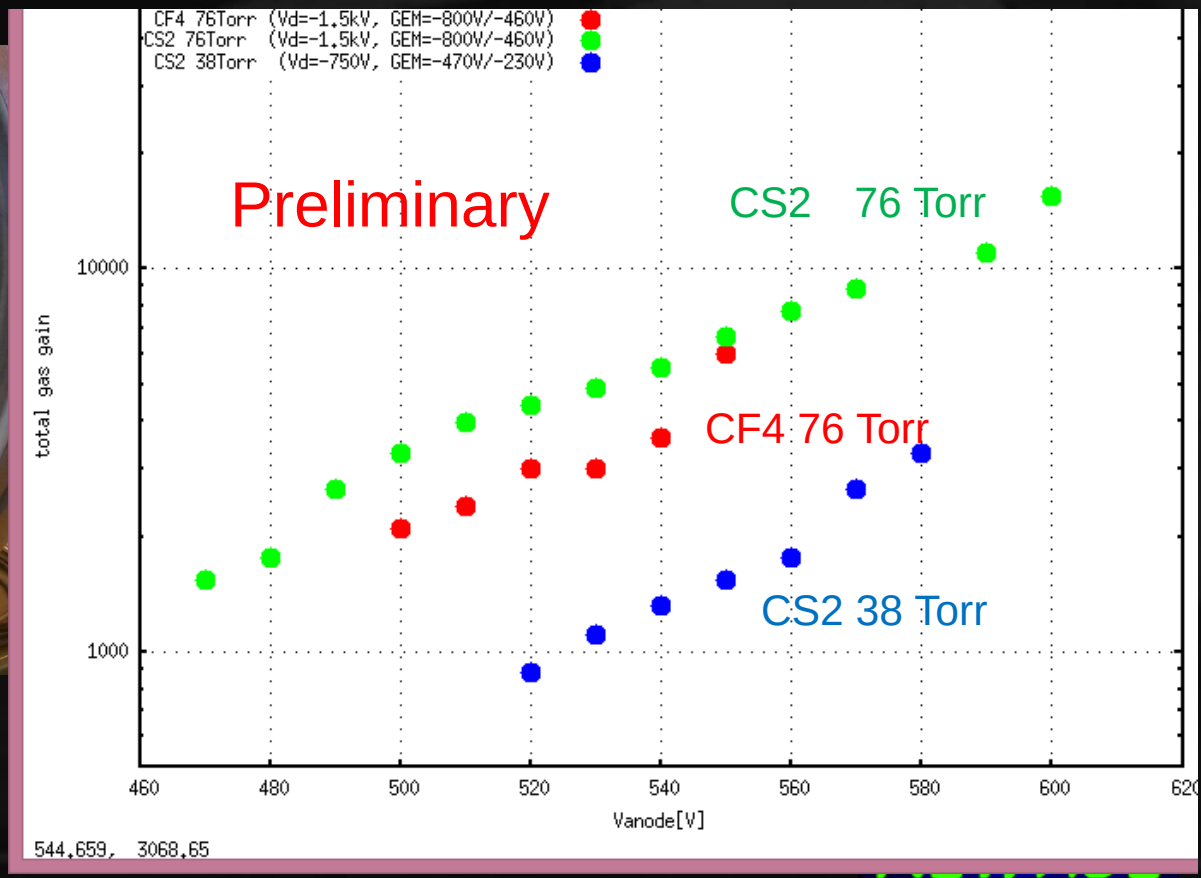


Direction Sensitive WIMP-search NEWAGE

NEWAGE with DRIFT

- **μ-PIC test with CS_2 gas**
  - **@ Occidental college**
  - **promising results!**

μ-PIC



SUMMARY

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

- Phase for “low BG detector”