

NEWAGE

“direction-sensitive direct dark matter search”

Kentaro Miuchi
KOBE University

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

(1) Kobe university

(2) Kyoto university

(3) ICRR

Contents

Direction-sensitive DM search

NEWAGE

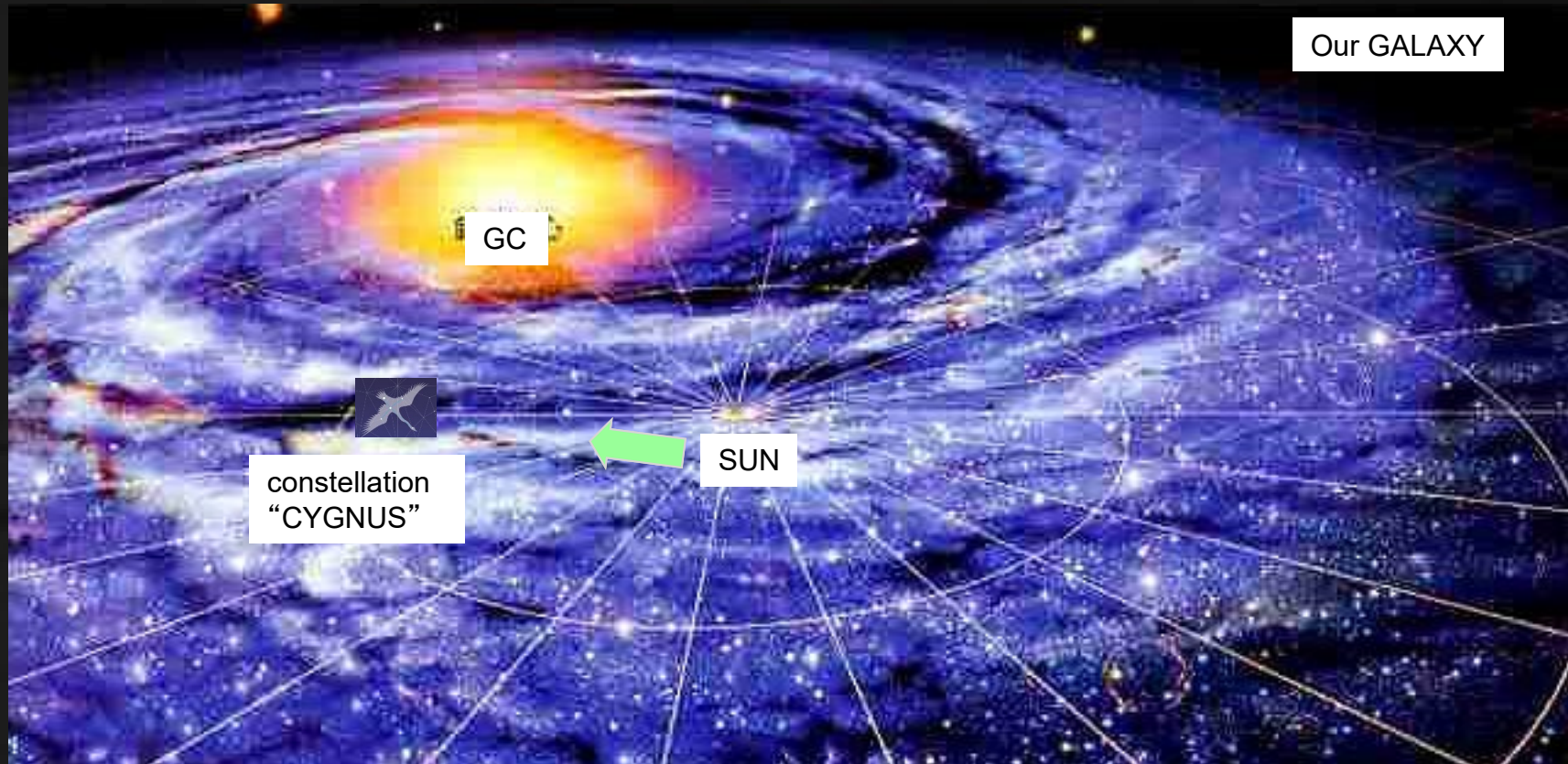
Underground results

Recent R&Ds

科研費
KAKENHI



Direction-Sensitive Dark Matter Search concept “CYGNUS”



WIMP-WIND from “CYGNUS”

“CYGNUS” concept

Direction-sensitive dark matter search
even below the “neutrino floor”

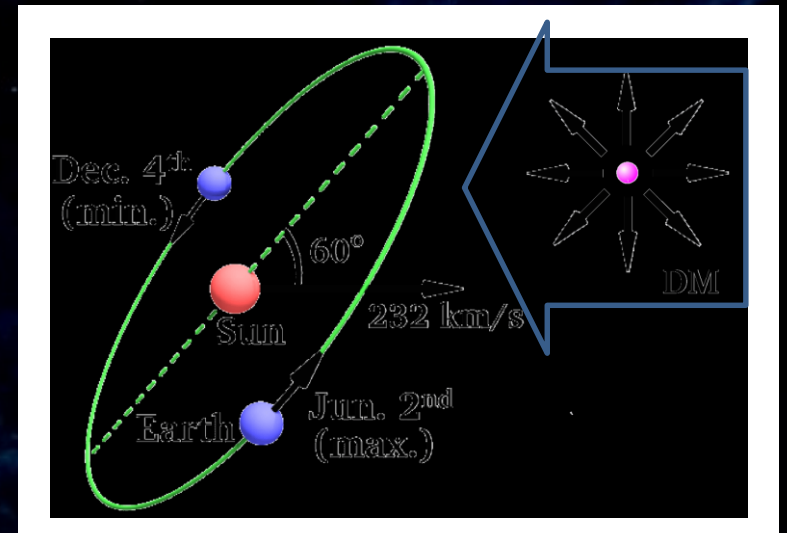
Clear detection of dark matter

DM precise study after detection

DM kinematics in the galaxy,

DM–nucleon interaction operators...

Difficulty: short track (a few mm >)

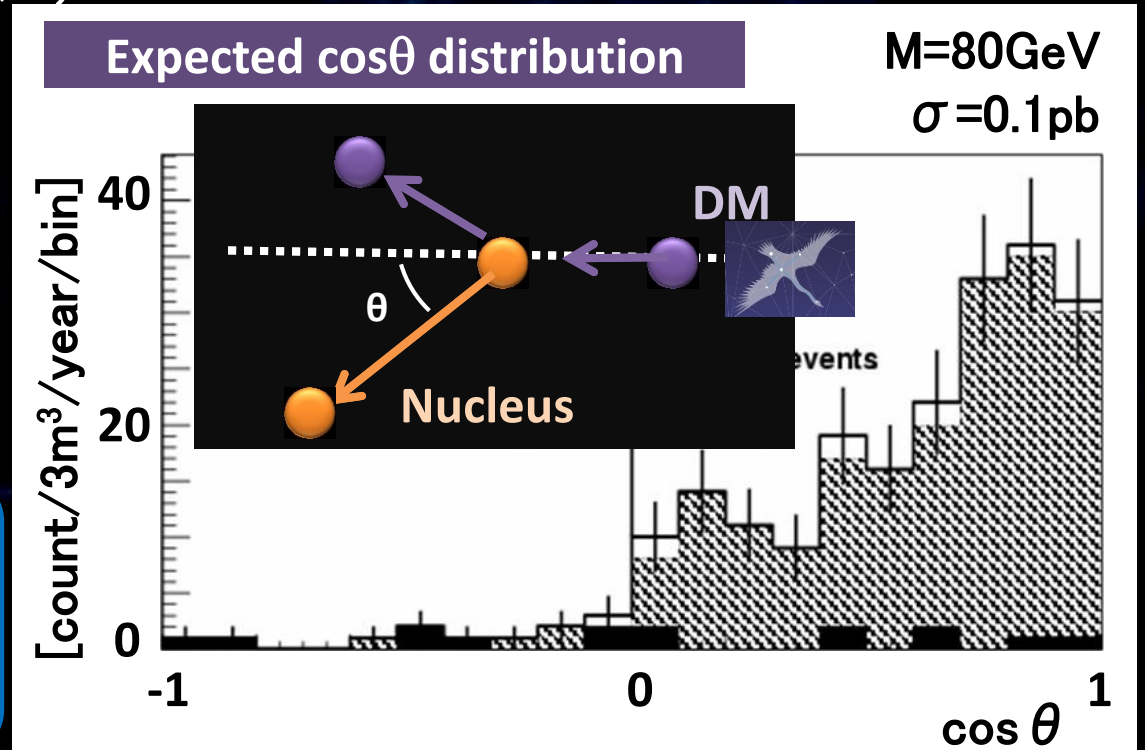


Gas TPC

- DRIFT
- NEWAGE MIMAC
- DM-TPC
- D3 NITEC

Solid/Liquid

- NEWS DCaNT
- ZnWO4 RED





NEWAGE

NEWAGE

New general WIMP search with an Advanced Gaseous tracker Experiment

μ-PIC(MPGD) based TPC

3-D tracks SKYMAP

CF4 gas for SD search

Proposal PLB 578 (2004) 241

First direction-sensitive limits

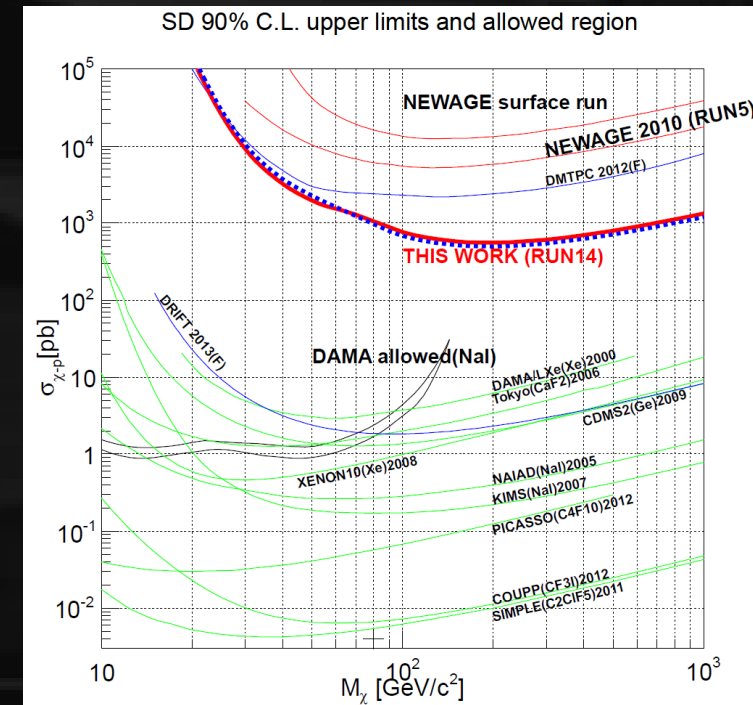
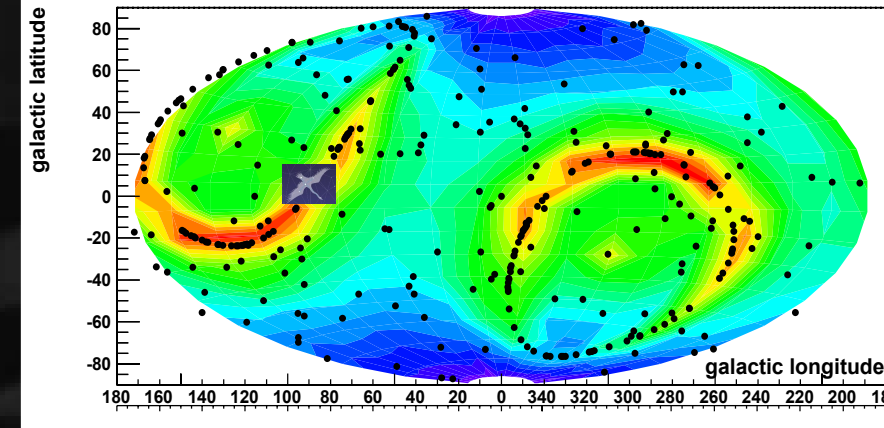
PLB654 (2007) 58

Underground results

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

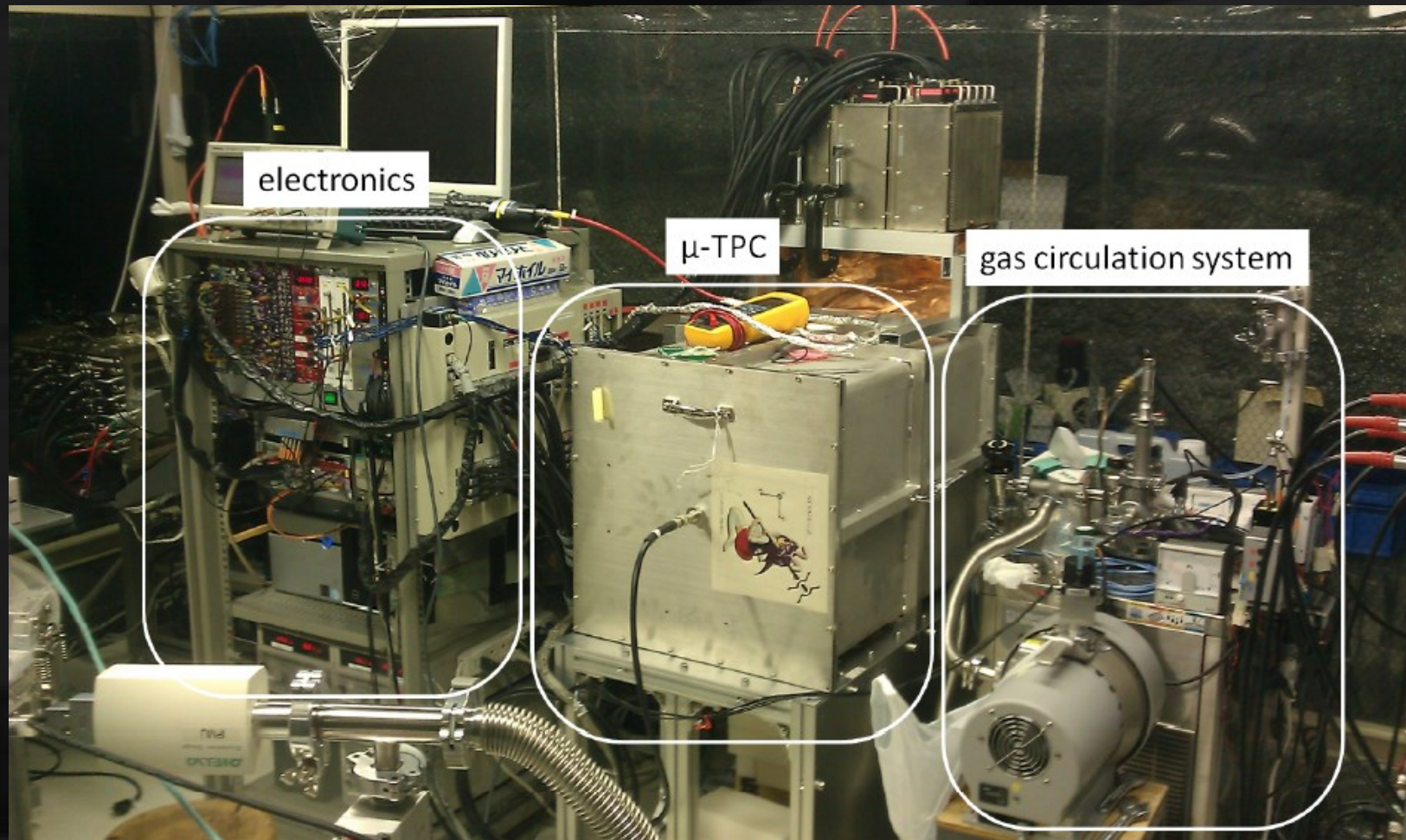
Phase for “low BG detector”

SKYMAP (measured DATA)



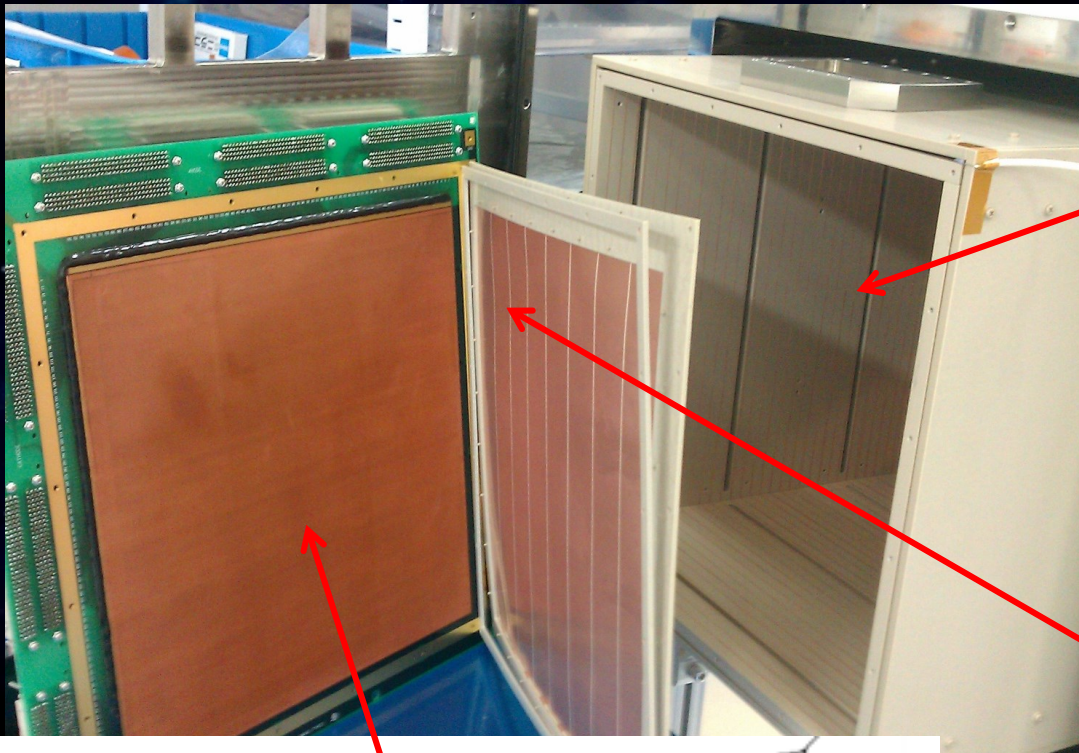
NEWAGE detector

- **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**

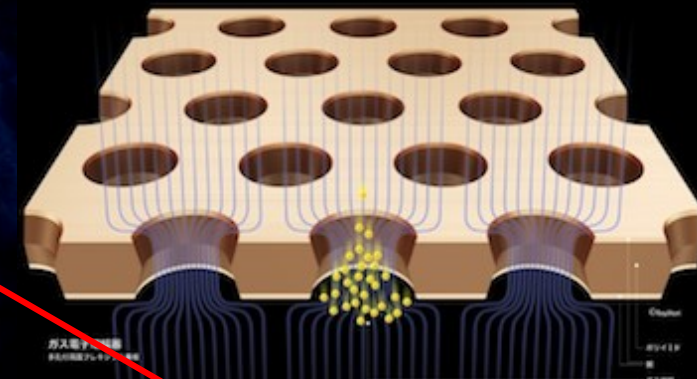


NEWAGE-0.3b' inside view

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

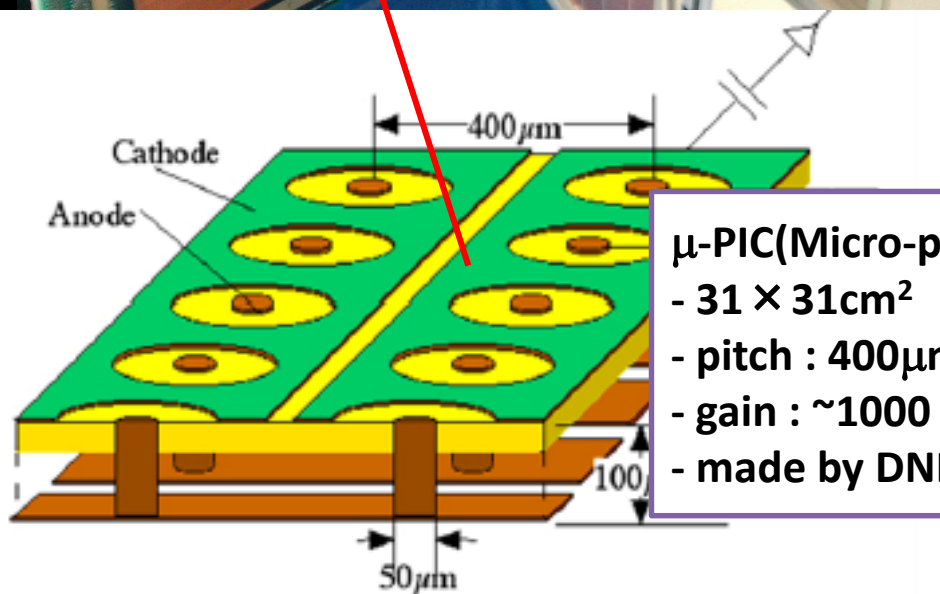


Field cage
Drift length: 41cm
PEEK + copper wires



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



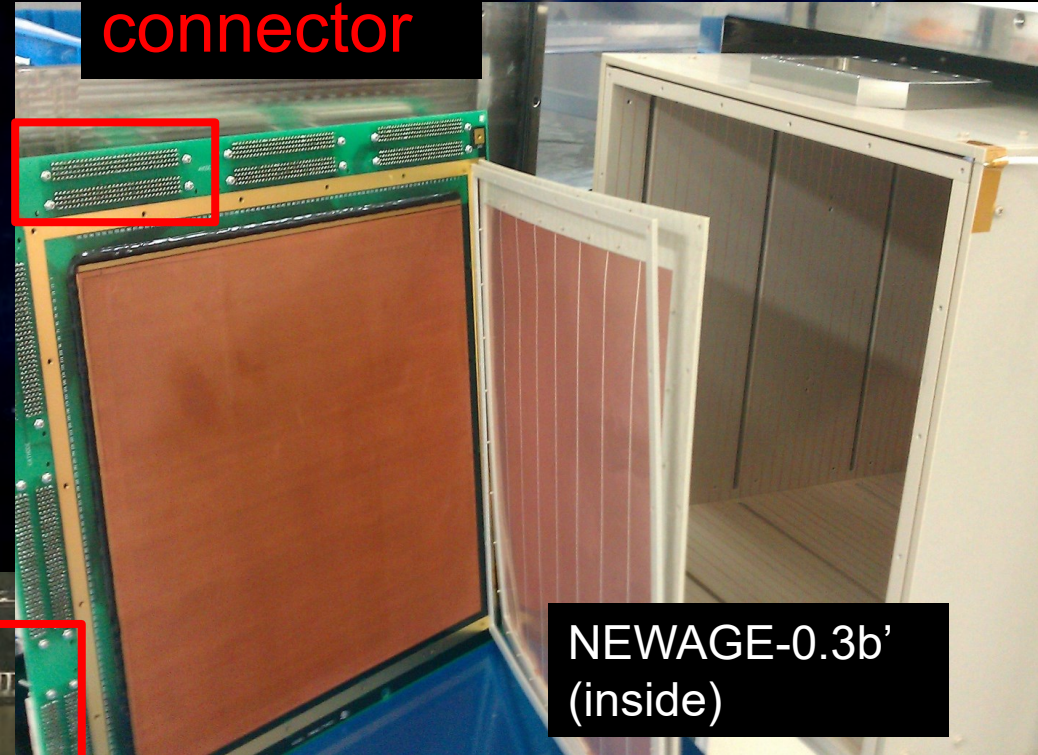
μ -PIC(Micro-pixel chamber)

- $31 \times 31 \text{cm}^2$
- pitch : $400 \mu\text{m}$
- gain : ~ 1000
- made by DNP, Japan

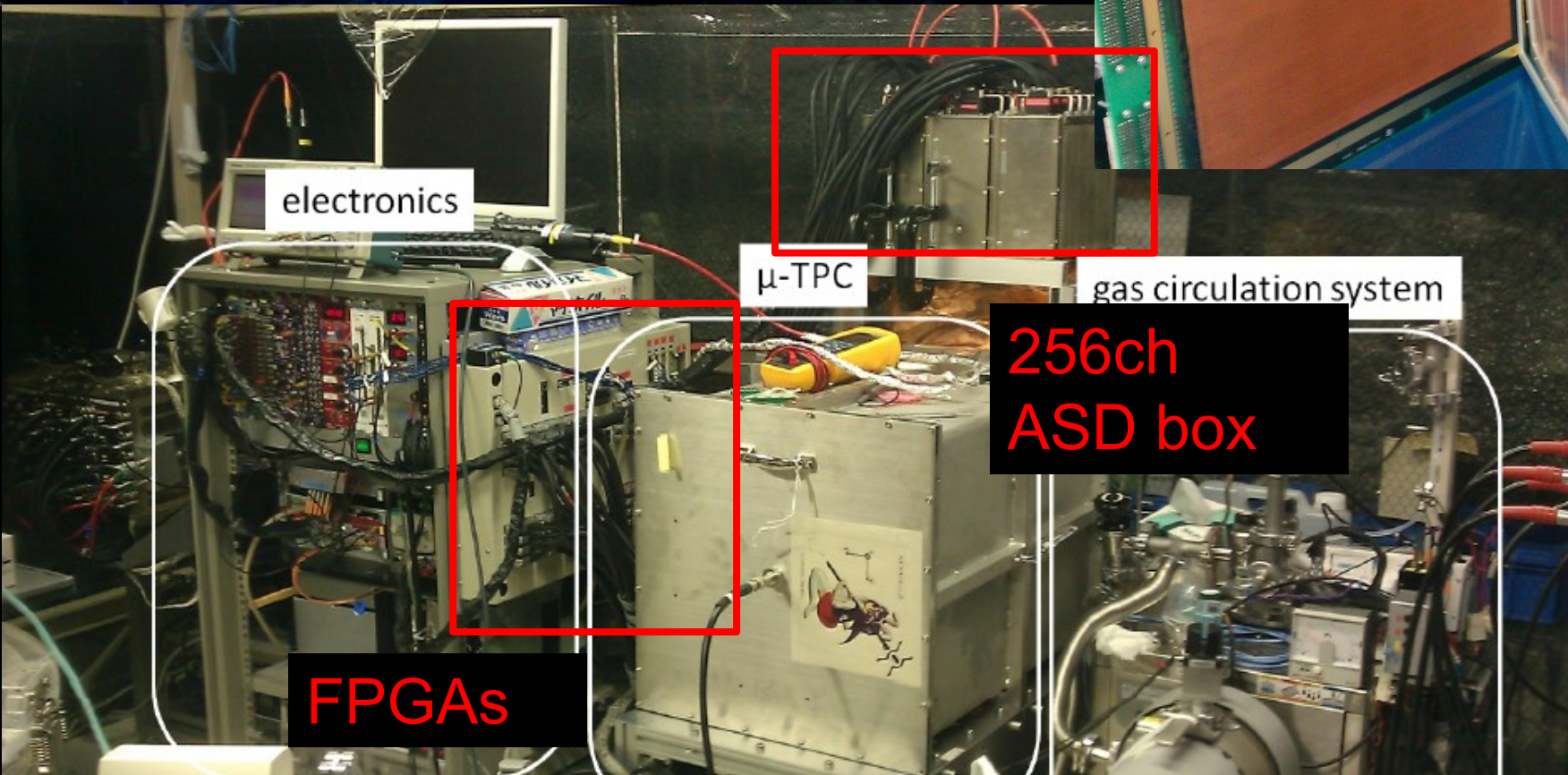
NEWAGE-0.3b' readouts

- μ -PIC is X-Y readout
- ALTAS TGC ADS chips
- General purpose FPGA-based electronics since early 2000's

256ch
connector



NEWAGE-0.3b'
(inside)



NEWAGE-0.3b' data

TOT of every strip by FPGA (clock 100MHz)

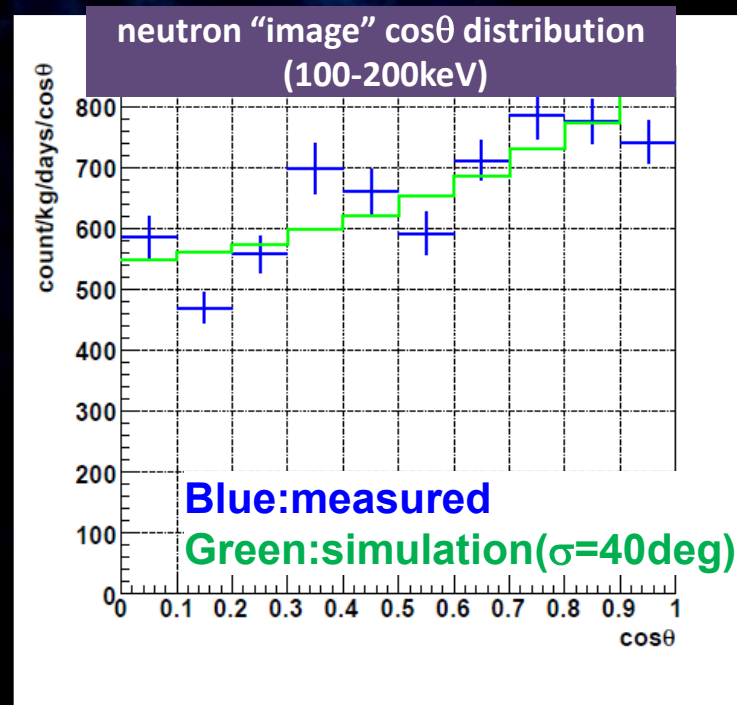
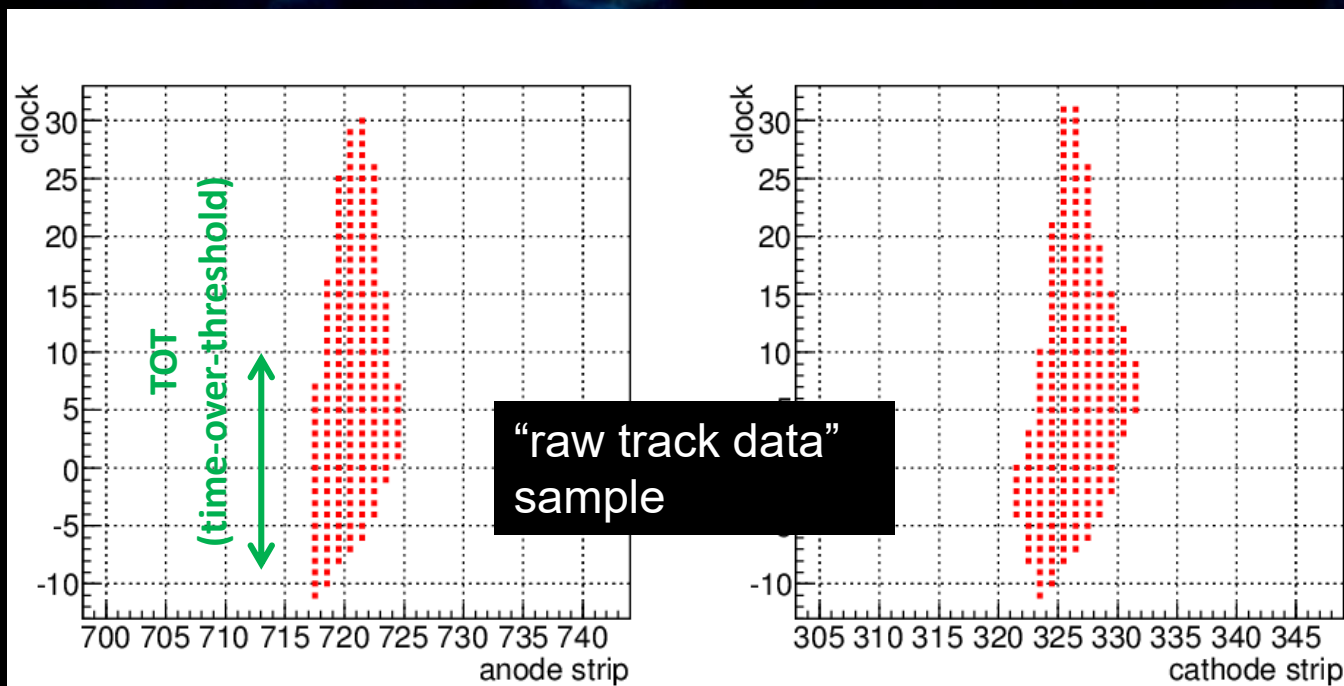
⇒ 3D tracks, headtails in X,Y

+

Summed waveforms by FADC (100MHz)

⇒ energy, headtails in Z

combined ⇒ PID, absolute z



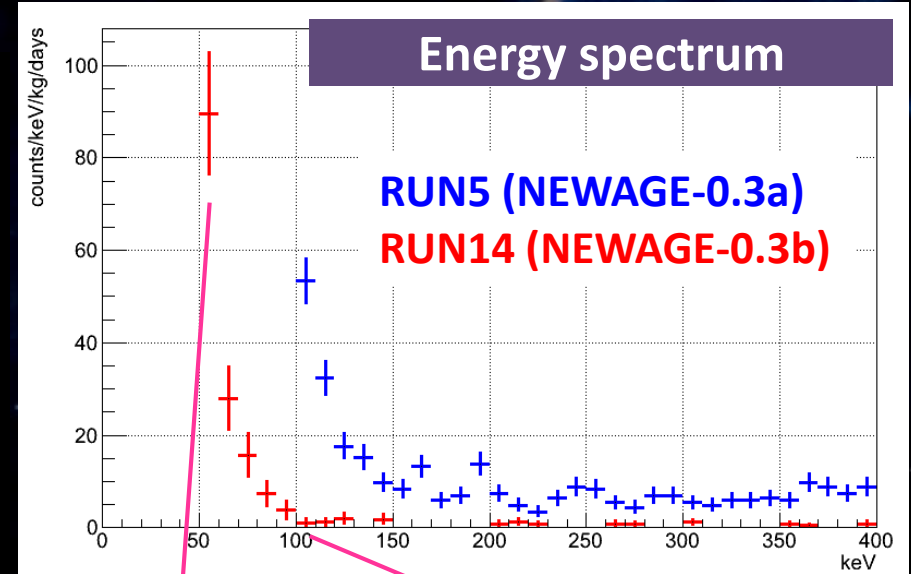


NEWAGE
Kamioka RUN14 results

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

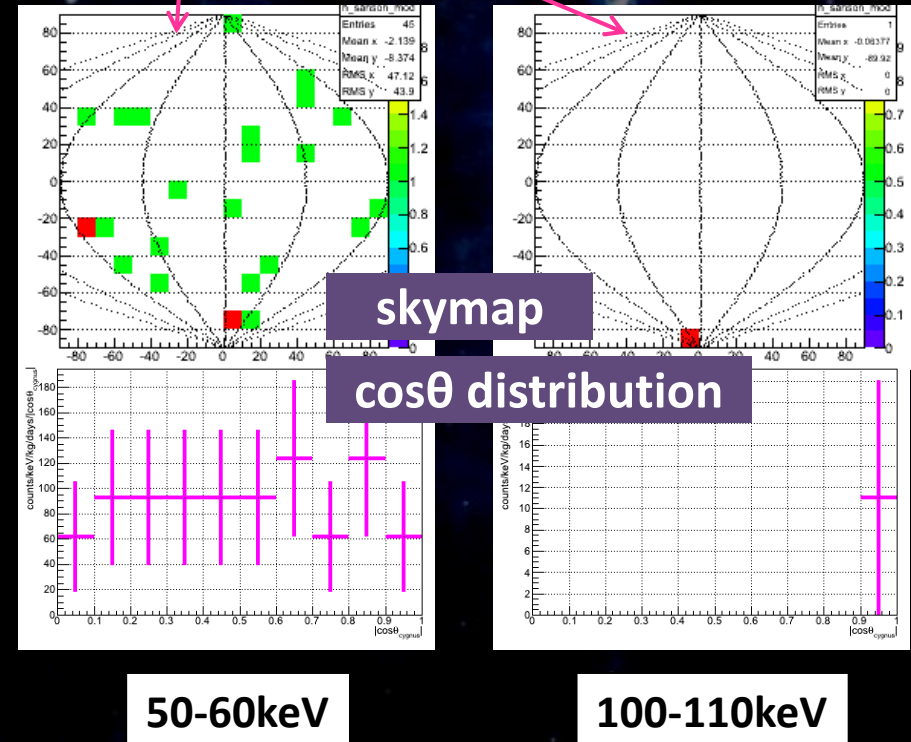


Energy spectrum

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

Skymap, $\cos\theta$ distribution

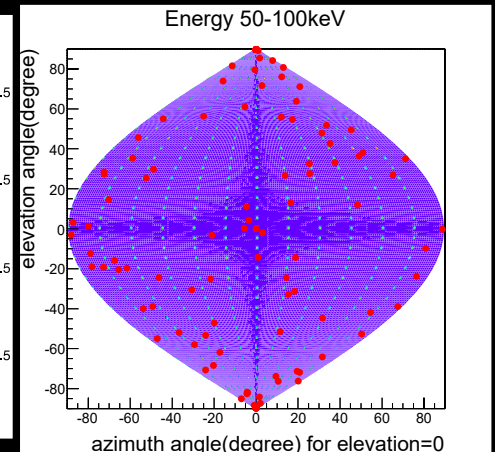
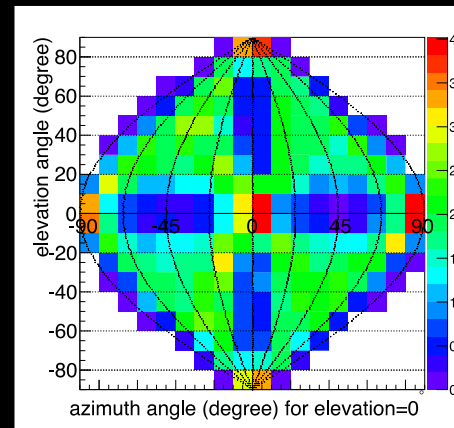
- Set limit by significant difference in 2-binned measured $\cos\theta$ and DM-wind simulated $\cos\theta$



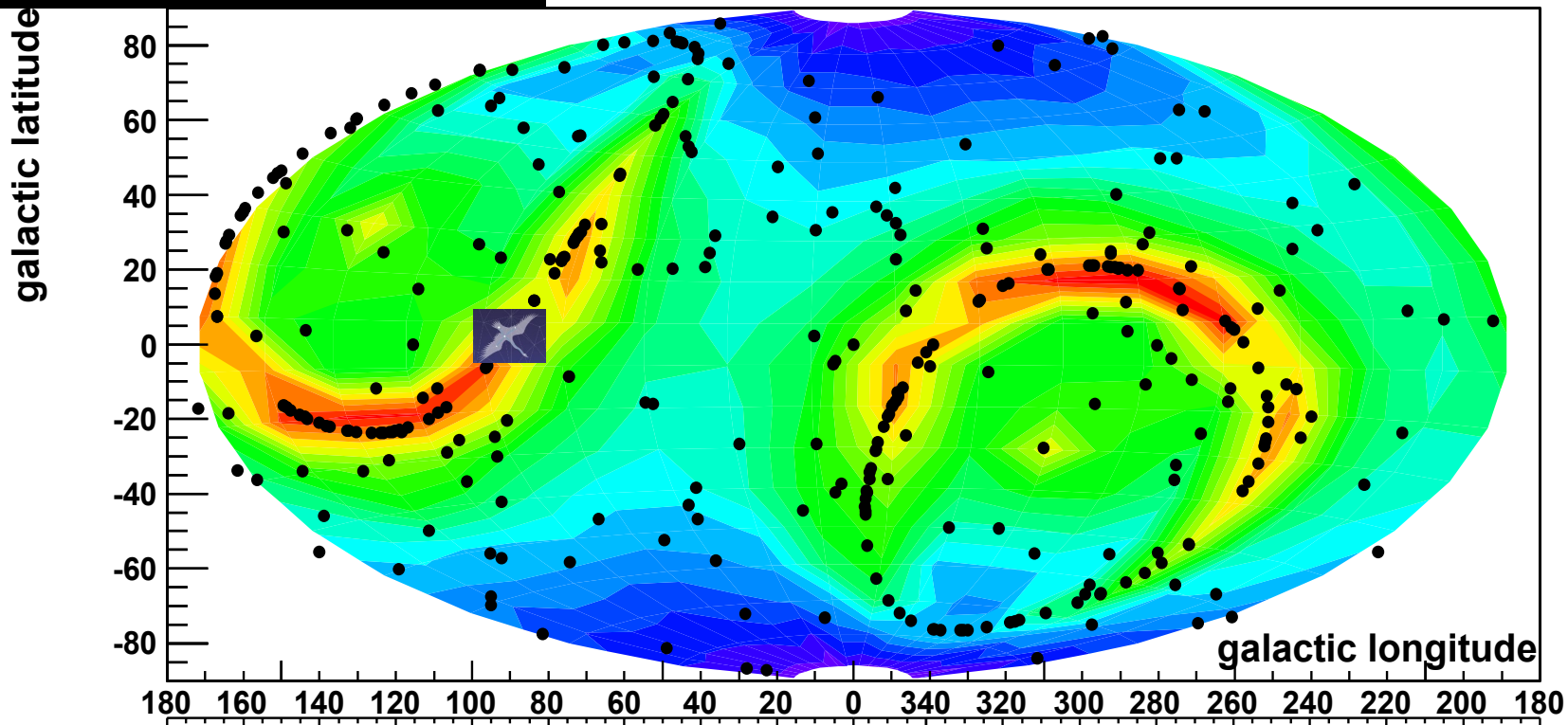
Galactic-plane sky-map

lab-coordinate

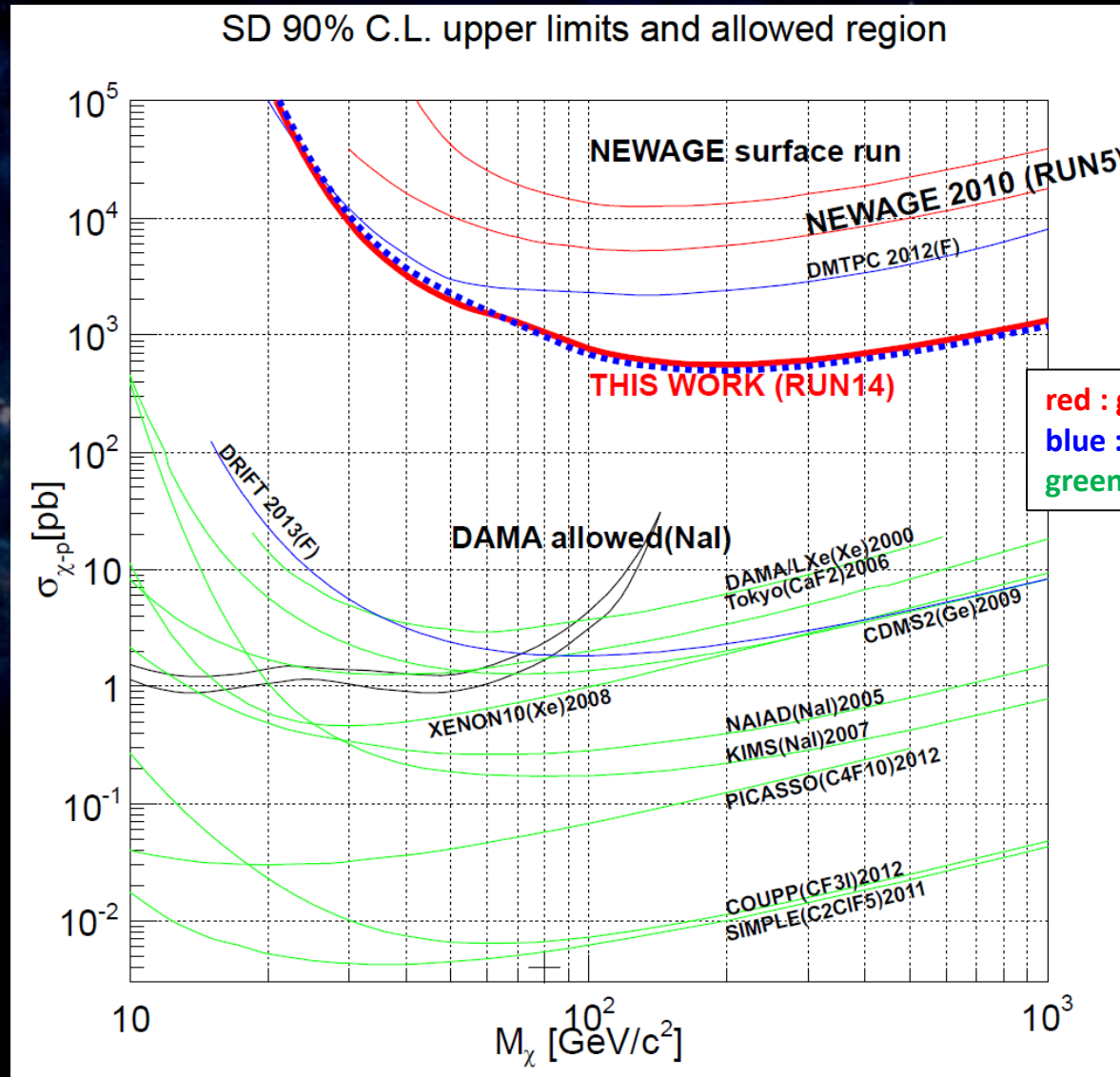
correlation with efficiency = consistent with isotropic



galactic coordinate



Direction-sensitive limit



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



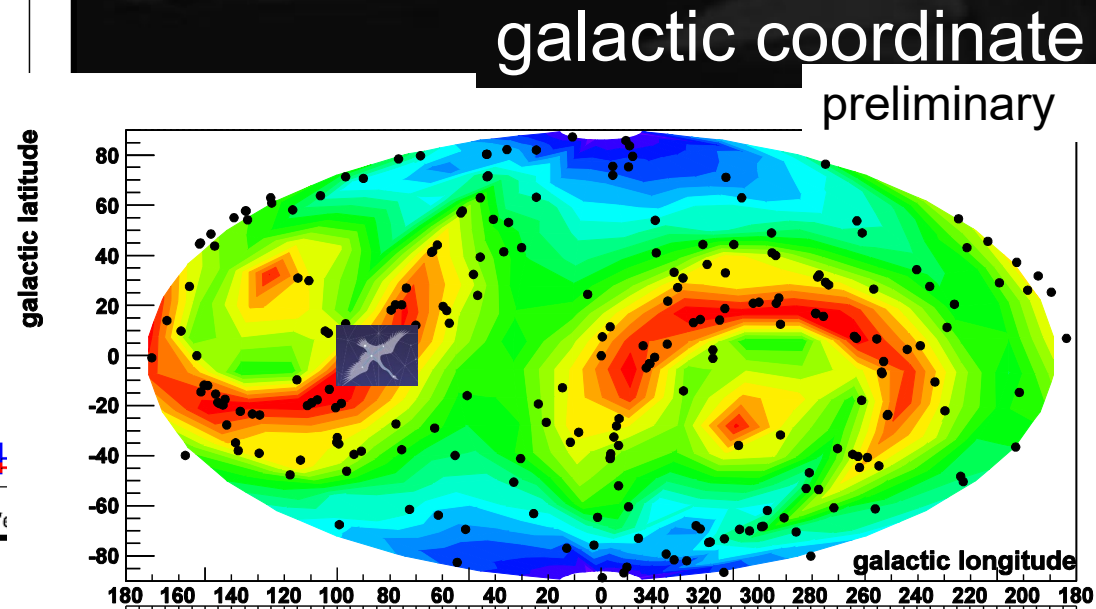
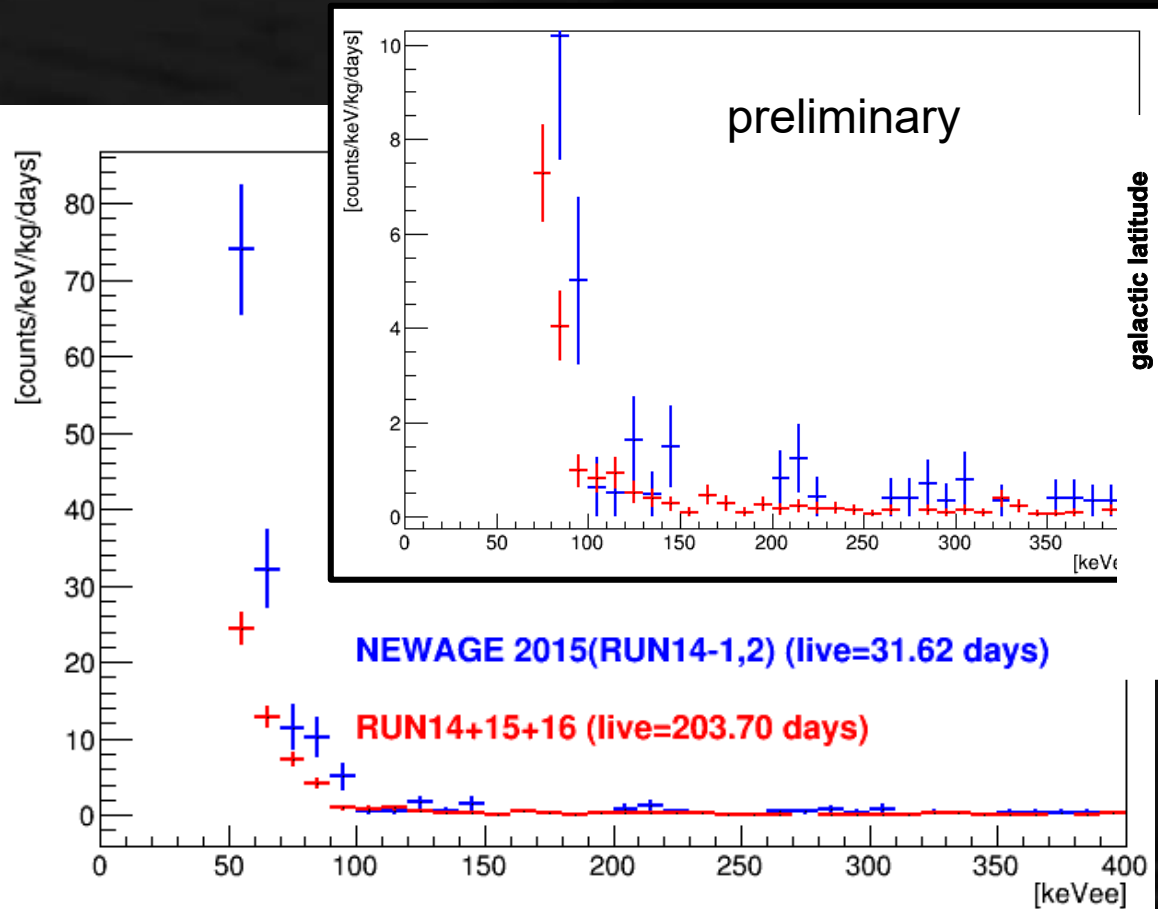
Recent R&Ds

Latest underground data

■ RUN14 (31.6days) + 172.08days

■ gamma-ray cut improvements

■ increased statistics



color: efficiency
dots: recoil events

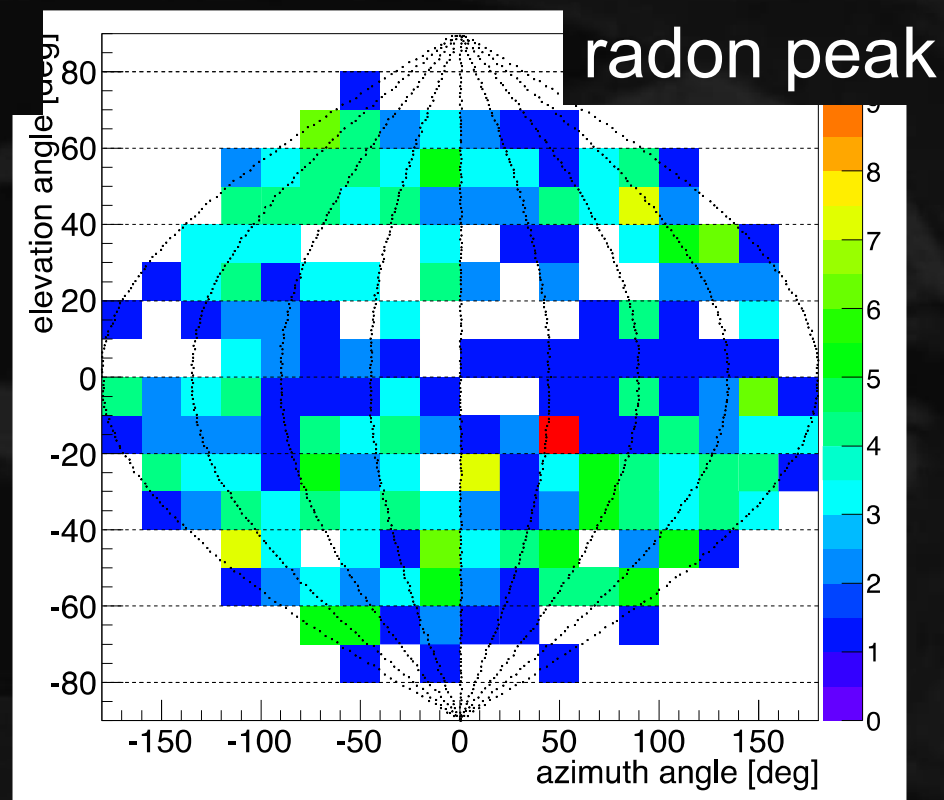
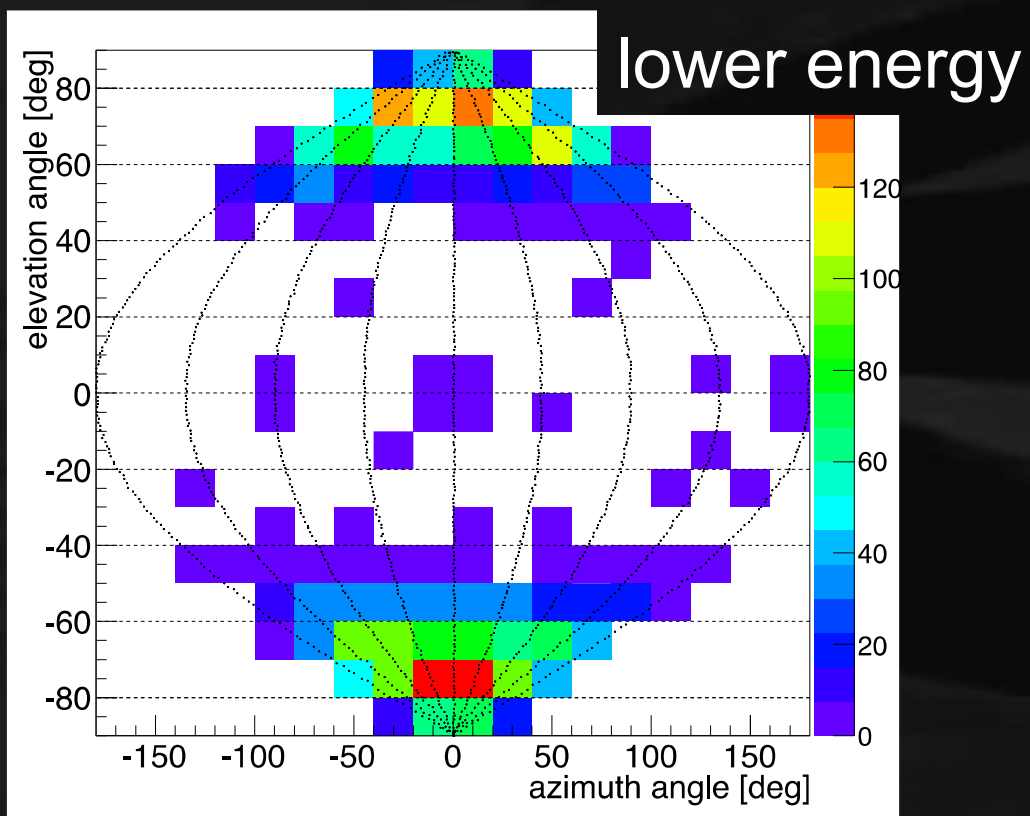
NEWAGE

BG study

Directionality helps!

SKYMAP @ detector coordinate

color: number of events



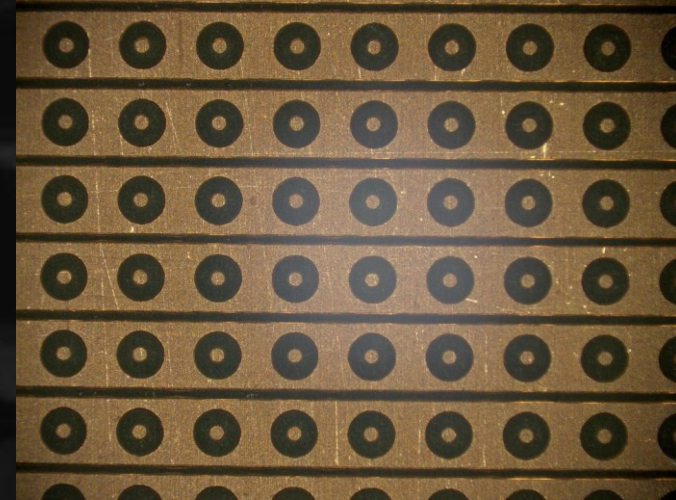
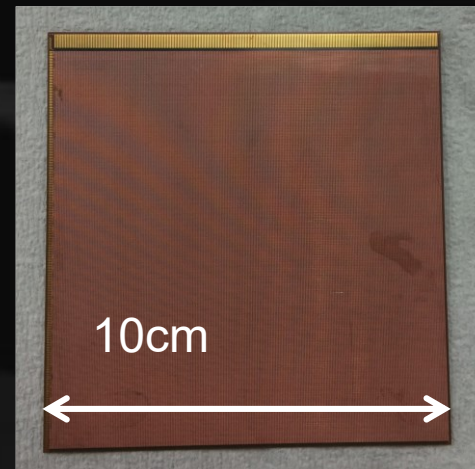
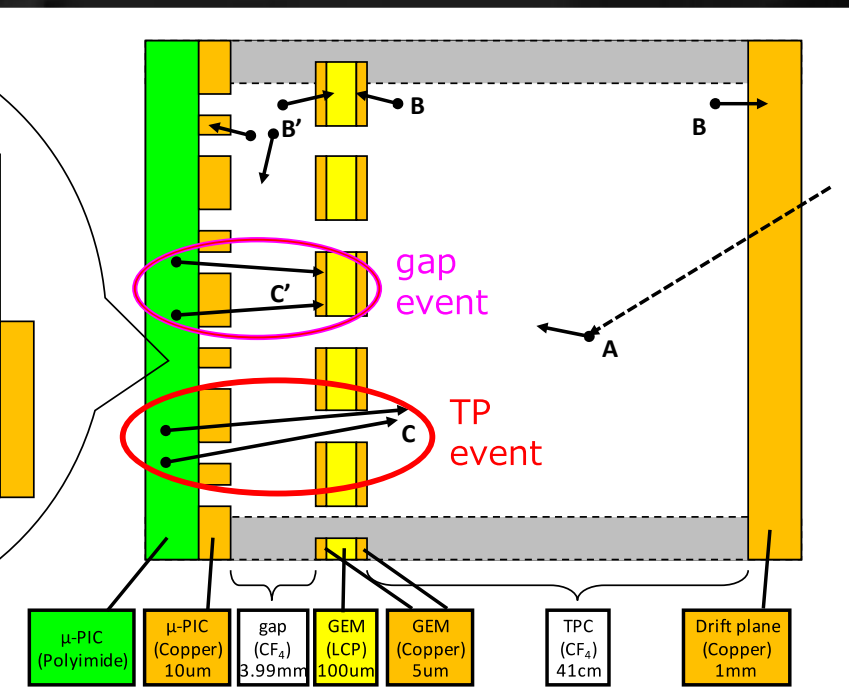
BG identified: upgoing events

Positive
Search

NEWAGE

Low BG R&Ds

- Largest BG source: alpha particle from μ -PIC
- Development of radio-pure(BG $\times 1/100$) μ -PIC:
10 \times 10 cm² μ -PIC was made and tested

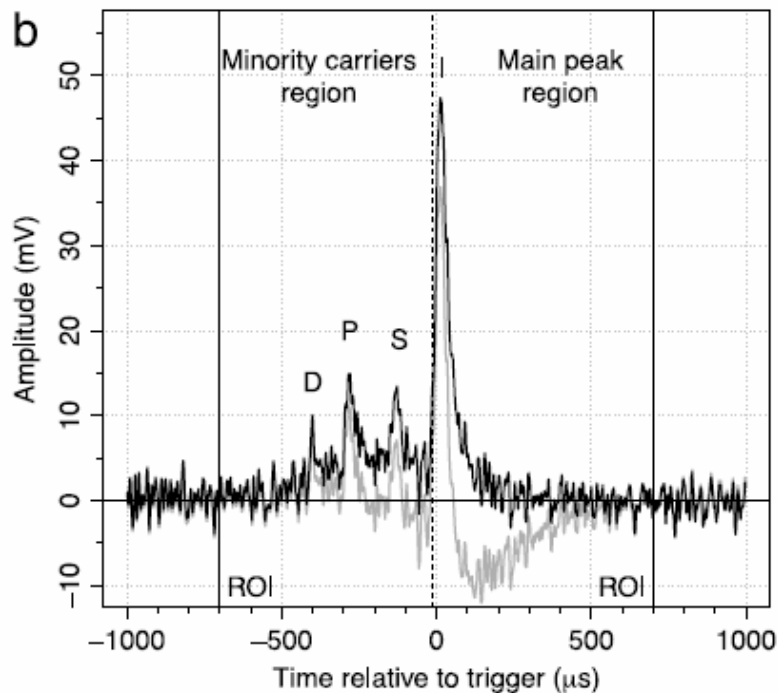


- FY2016: development of 30 \times 30 cm² μ -PIC
- FY2017~: underground run

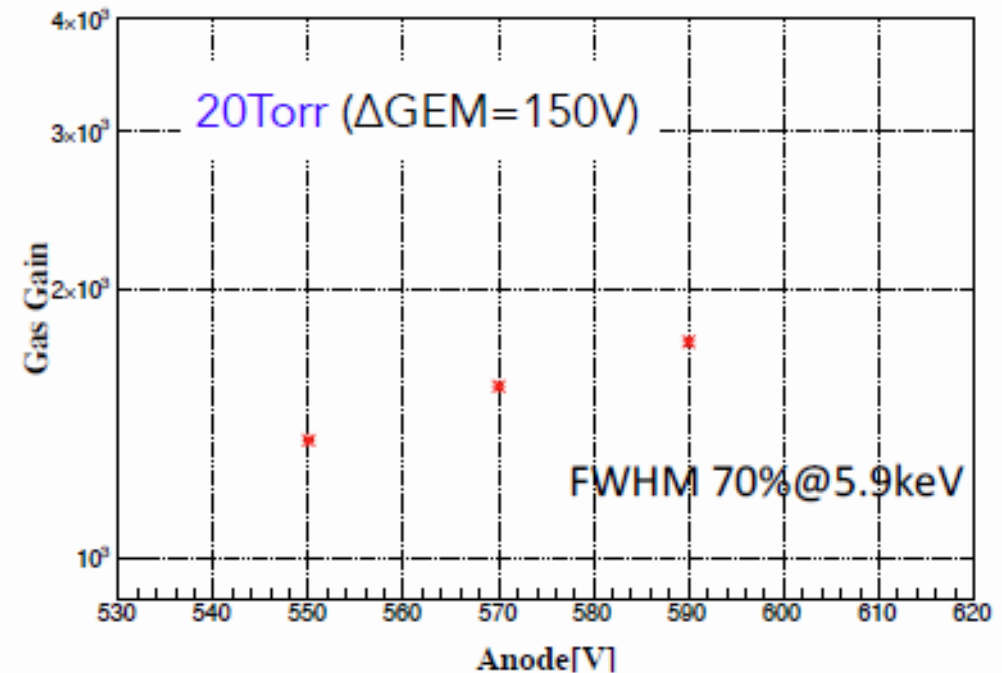
Z-fiducialization

- minority peaks “discovery” by DRIFT group
- SF₆ study for GEM+μPIC system
- wide dynamic-range ASIC development for

minority peaks (DRIFT group)



SF6 study (NEWAGE)



Summary

- **NEWAGE :**
 - direction sensitive with 3D track detection.
- **Sensitivity improvements are on-going.**