

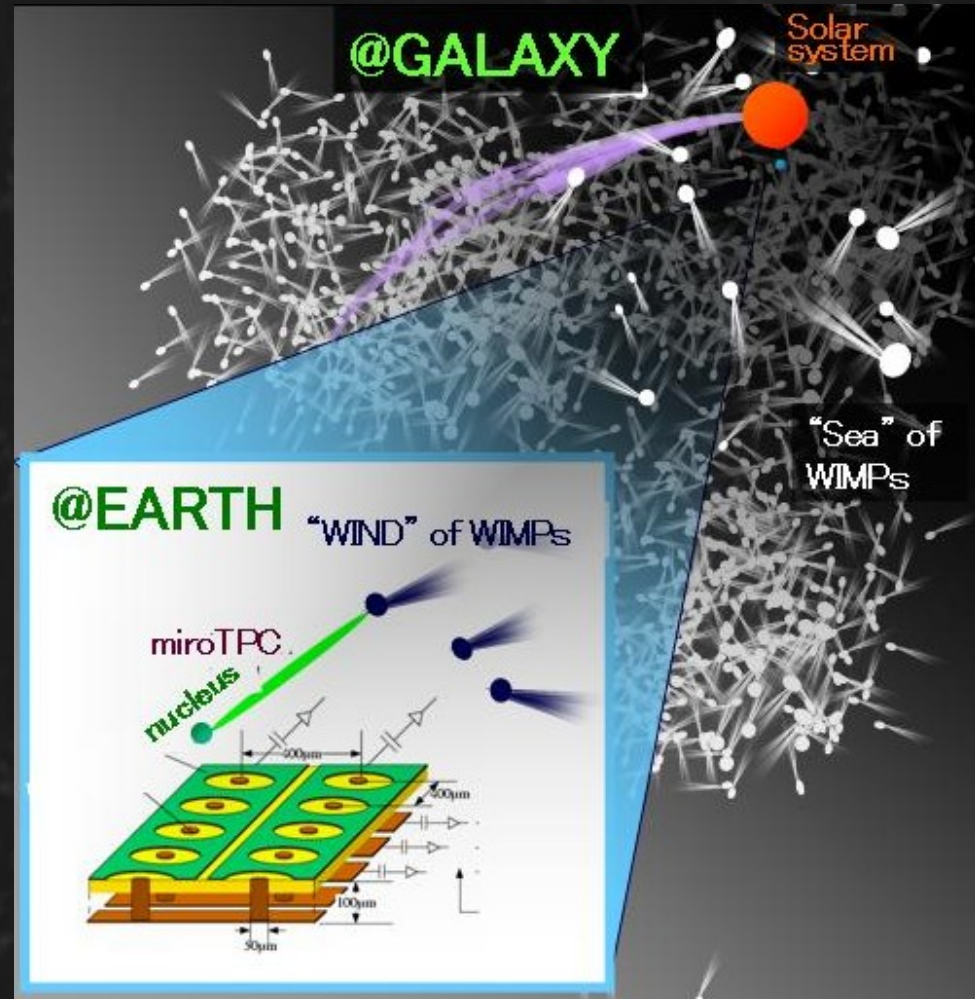
Direction-Sensitive Dark Matter Search --NEWAGE--

(New generation WIMP search
with an advanced gaseous tracker experiment)

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with

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, T. Tanimori, H. Kubo, H. Nishimura
A. Takeda, H. Sekiya



OUTLINE

- ◆ Motivation
- ◆ Methods
- ◆ 1st underground result
- ◆ Latest activities
- ◆ Summary

Motivation

1. Motivation

“WIMP-wind” detection

PLB 578 (2004) 241

@GALAXY

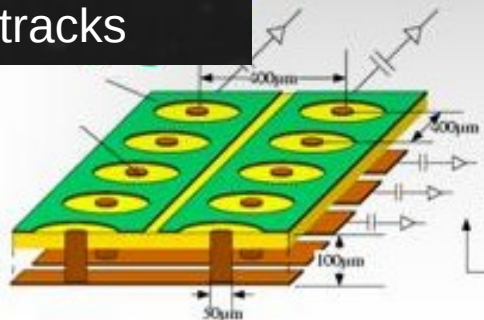
SOLAR SYSTEM
220 km/s

WIMP
 $V_0 = 230$ km/s

@EARTH

“WIND” of WIMPs

low pressure gas
forward recoils
short tracks

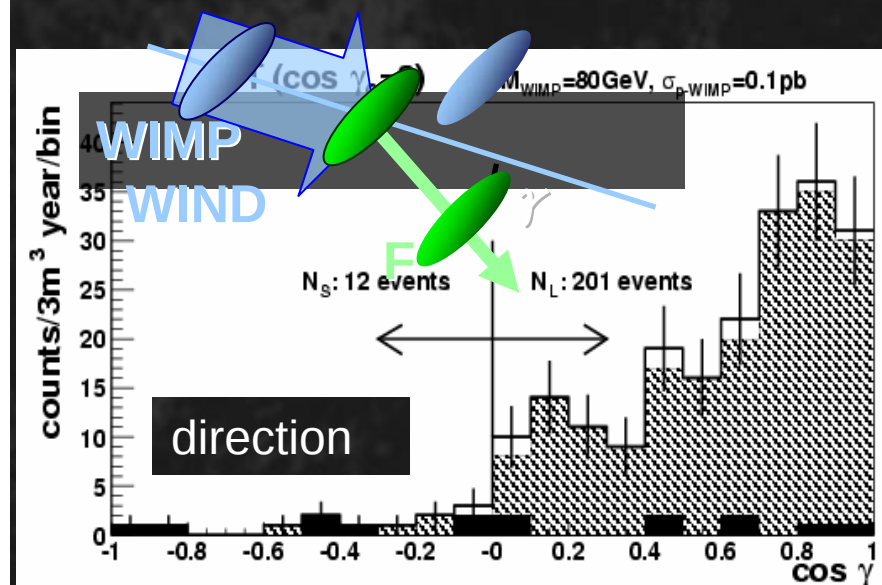
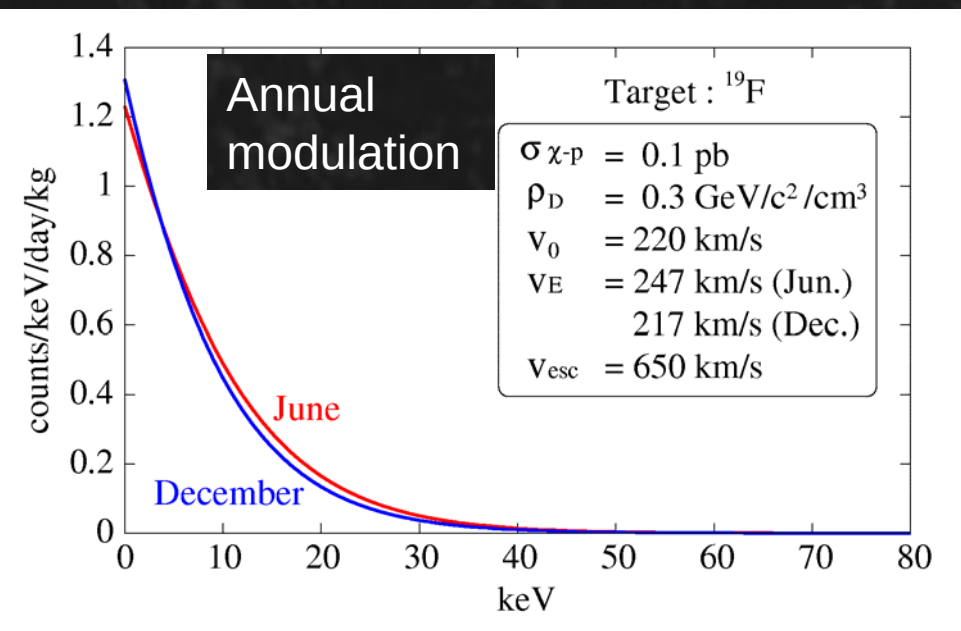


The WIMP-wind

Direction Sensitive
WIMP-search
NEWAGE

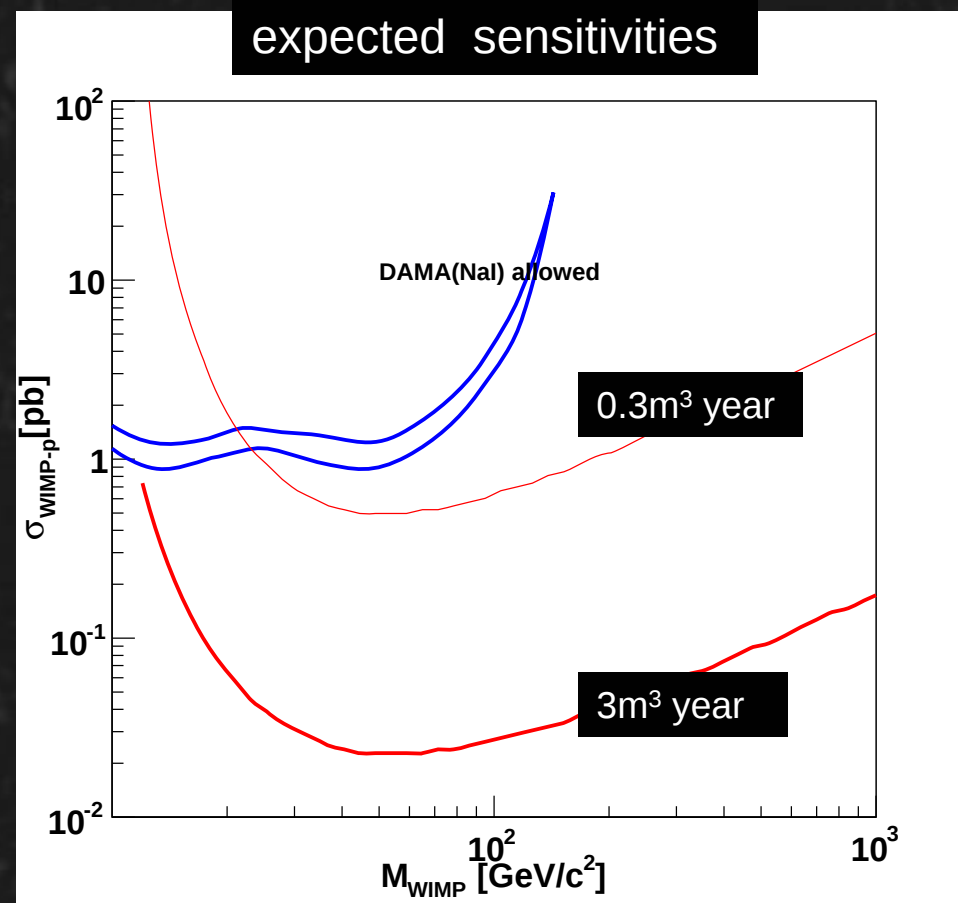
◆ WHY “Direction-sensitive” ?

- Large mass for exclusion (and indication)
- BUT Annual modulation is not enough...
- Direction-sensitive for a concrete evidence and further study of halo dark matter



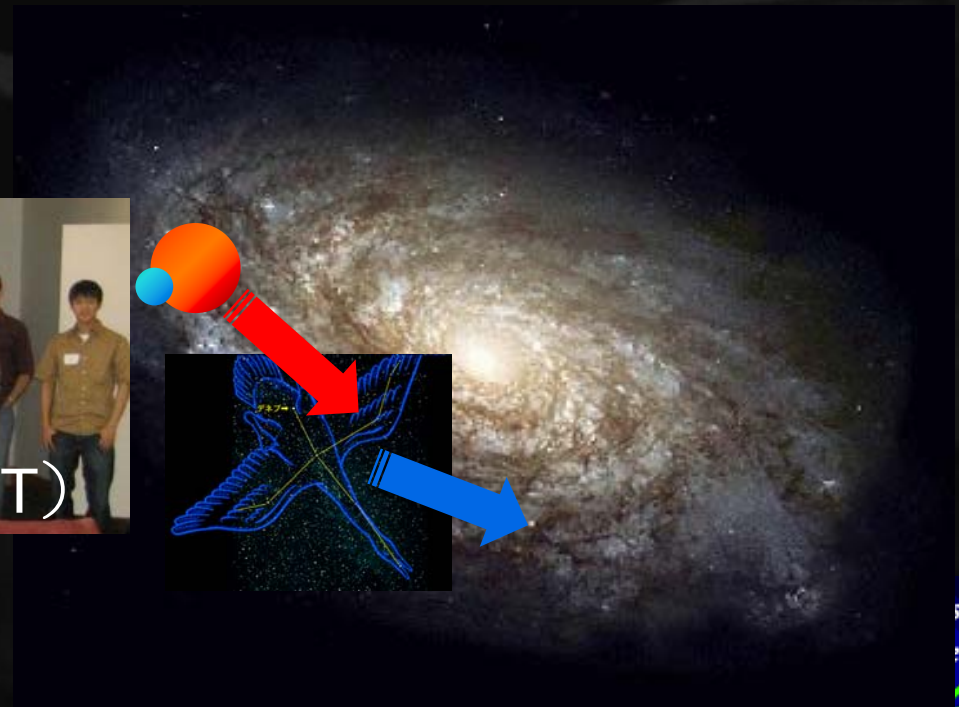
Expected Sensitivities

- **Goal: Detect the WIMP-wind**
 - low pressure (CF_4 0.05 bar)
 - large volume ($1\text{m}^3 \times \text{N}$)
 - radio-pure materials
- **CURRENT: pilot run**
 - CF_4 0.2 bar
 - $(0.3\text{m})^3$
 - normal materials

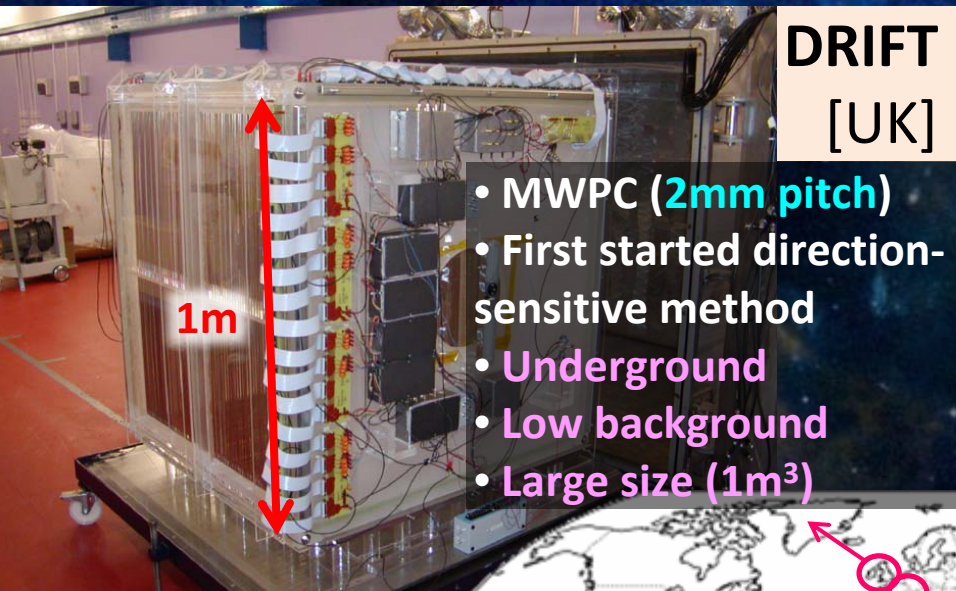


Community : CYGNUS

- ◆ direction-sensitive DM search workshop
 - 2007(UK)
 - 2009(US)
 - 2011(France)
 - 2013(Japan)

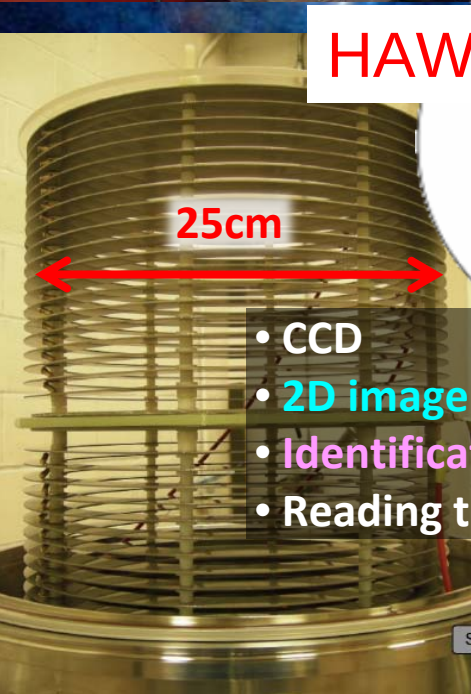
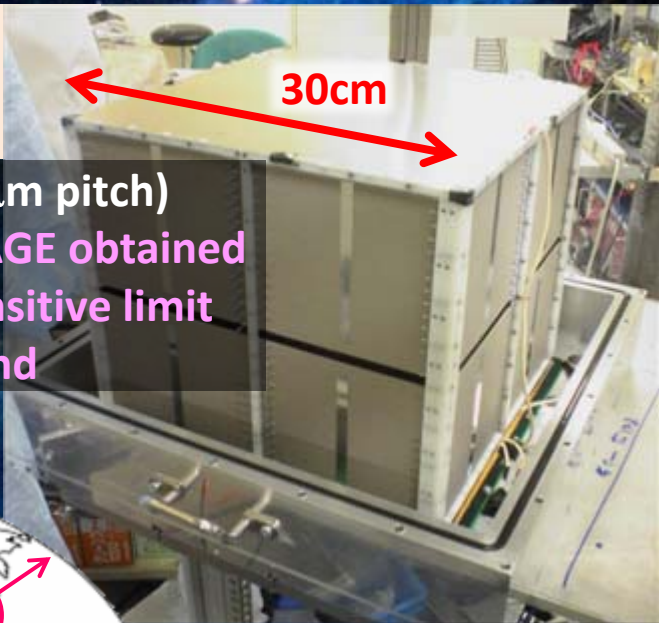


Direction-sensitive DM search



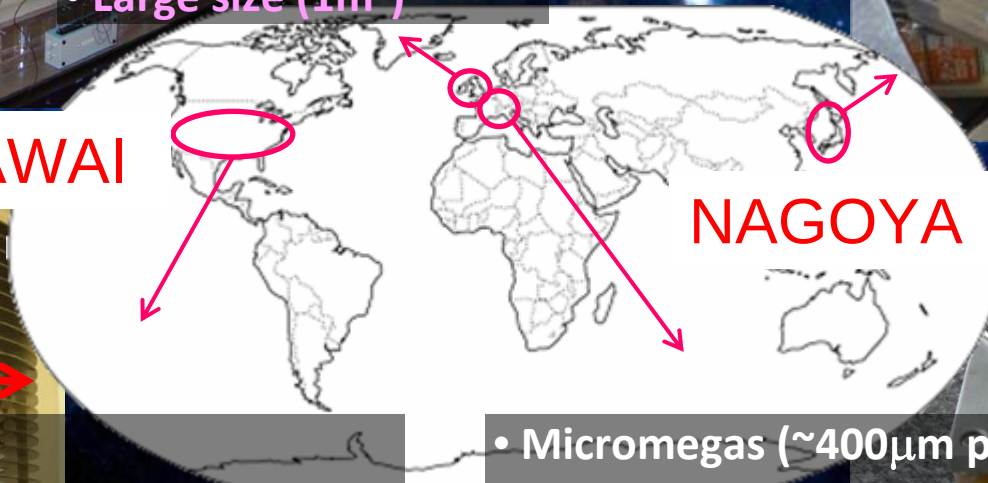
NEWAGE
[Japan]

- μ -PIC (400 μ m pitch)
- Only NEWAGE obtained direction-sensitive limit
- Underground



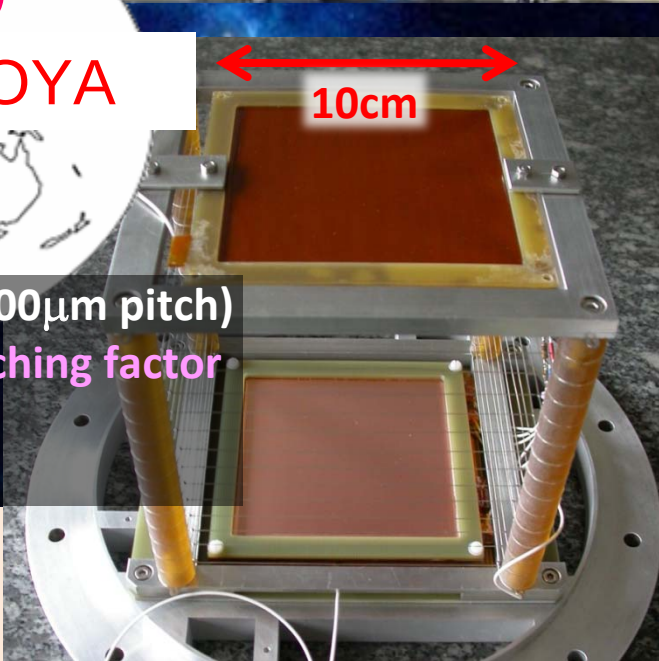
- CCD
- 2D image
- Identification of head-tail
- Reading to underground

DMTPC
[USA]



- Micromegas (~400 μ m pitch)
- Measured quenching factor in detail
- R&D at surface

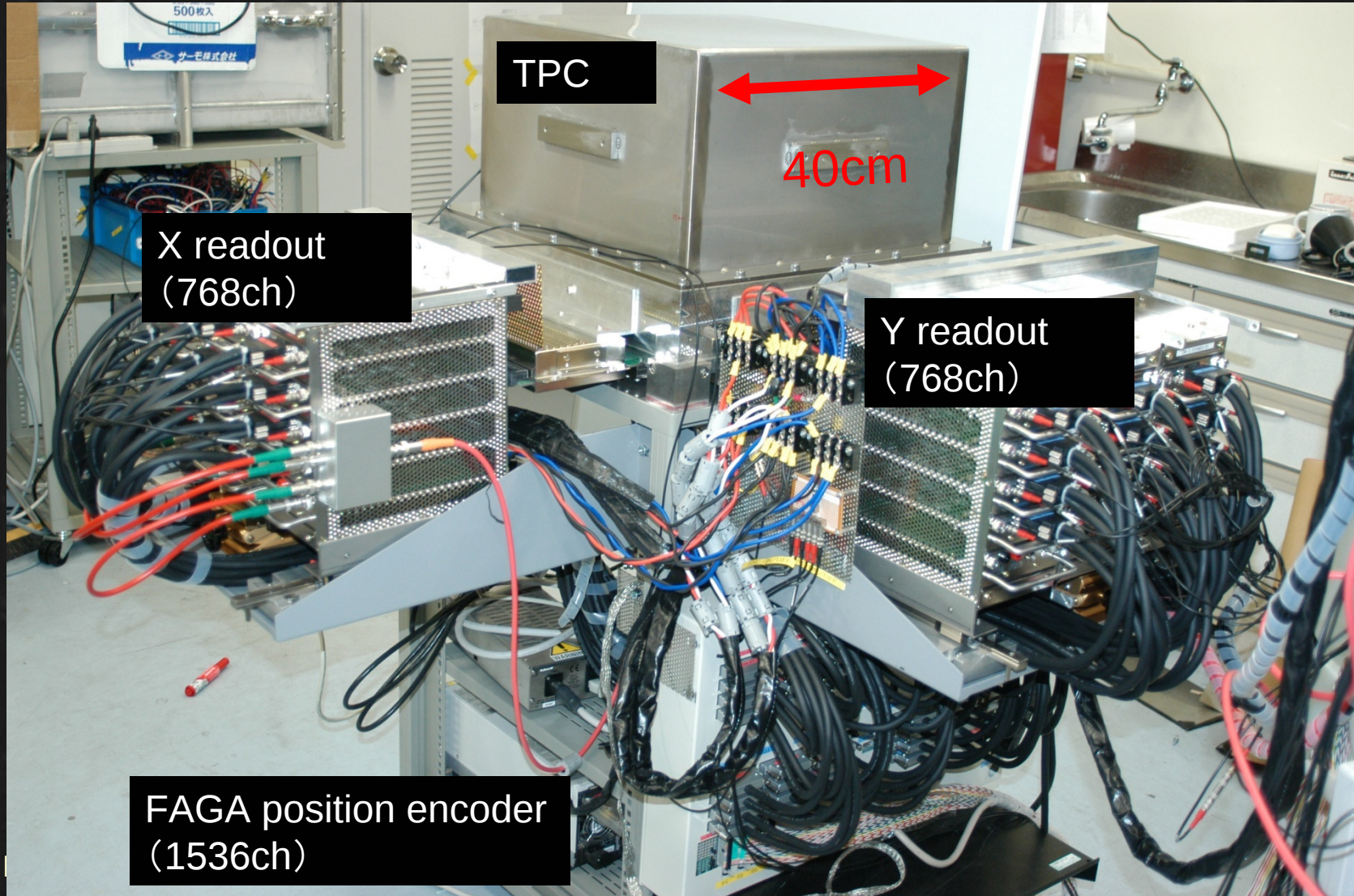
MIMAC
[France]



Methods

Methods (3D tracking device)

- ◆ NEWAGE-0.3a : $23 \times 28 \times 31\text{cm}^3$



3D tracking device: microTPC

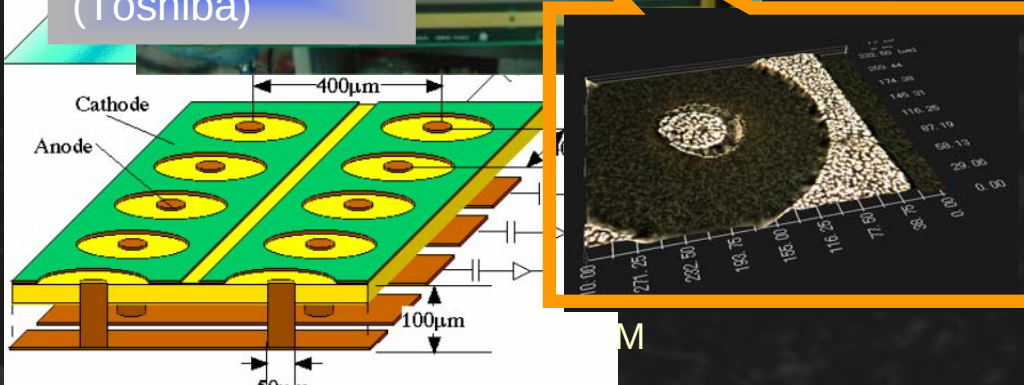
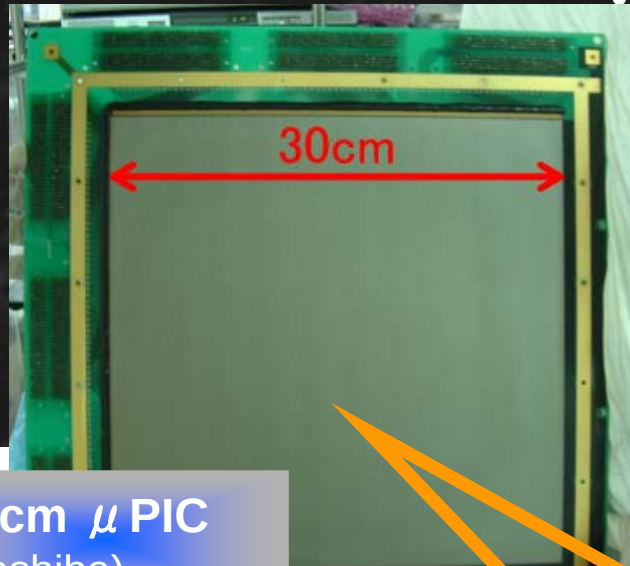
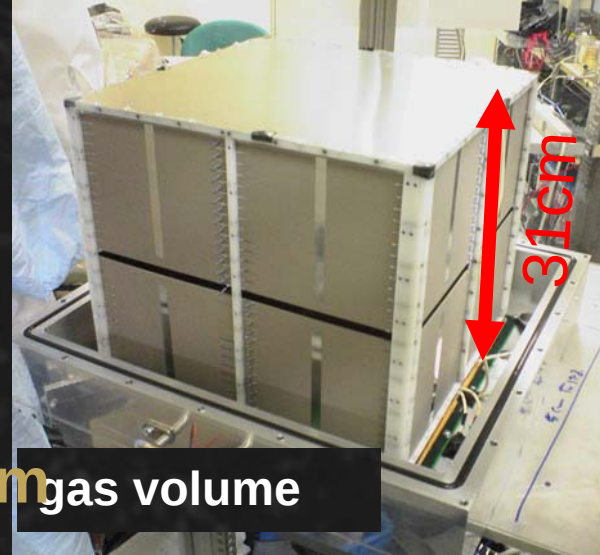
2D imaging device: μ -PIC (gas gain 5000)

- 400mm pitch

- $30 \times 30\text{cm}^2$

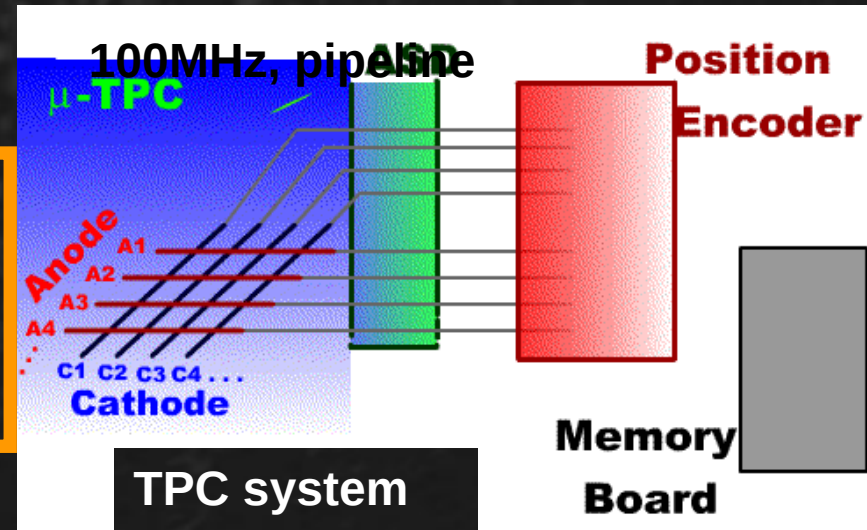
- Gas volume

- DRIFT length 31cm



Readout electronics

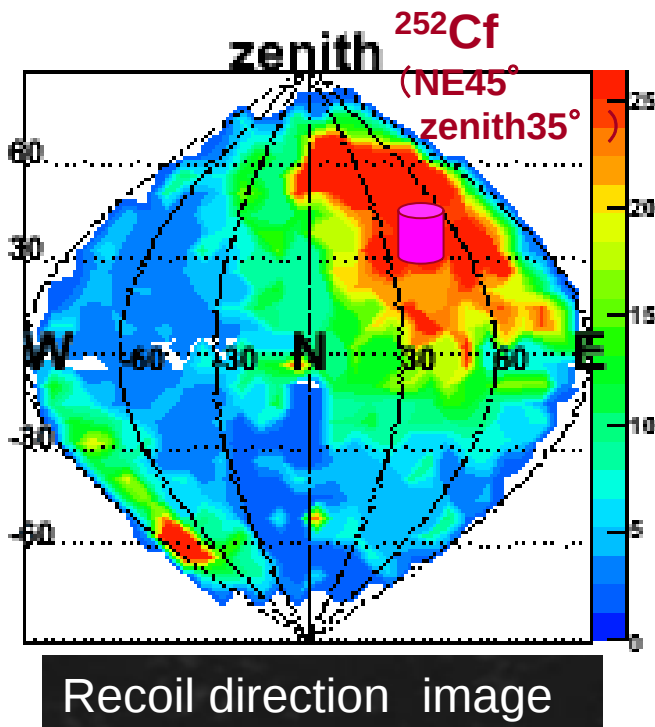
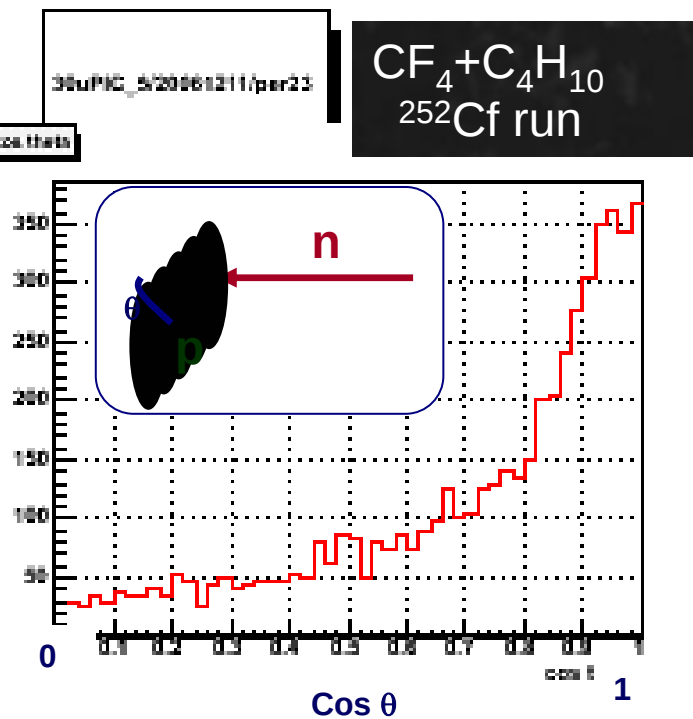
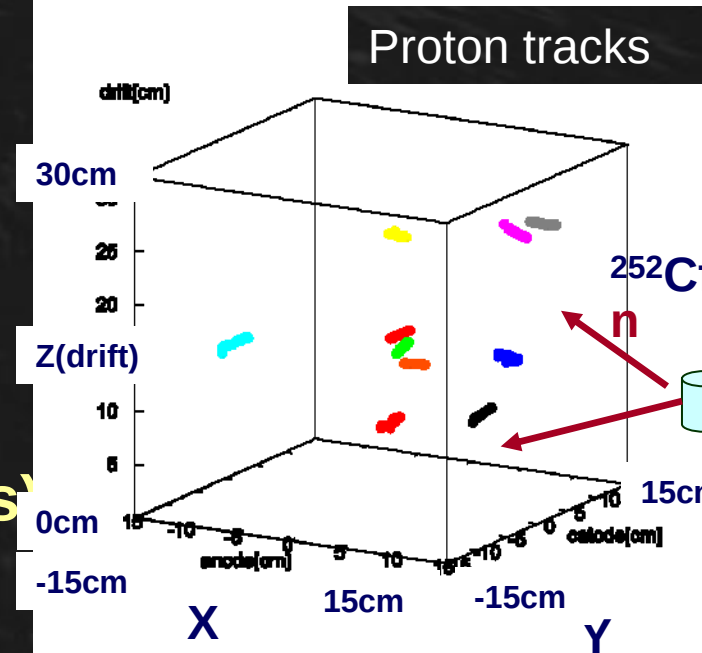
- Digital "3D-HIT" (track)
+charge (energy)



TPC Performance

① nuclear tracking

- $\text{CF}_4 + \text{C}_4\text{H}_{10}$ (9:1) 0.2 atm
- $n \rightarrow p$ forward scattering (emulation of $\text{WIMP} \rightarrow \text{F}$ scatterings)

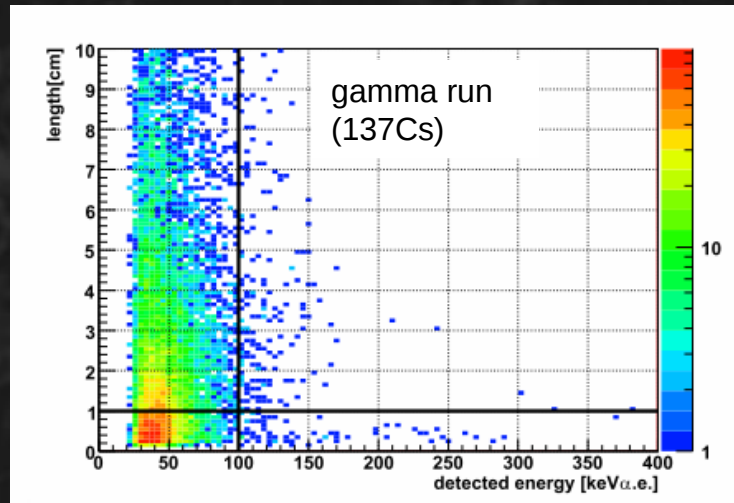
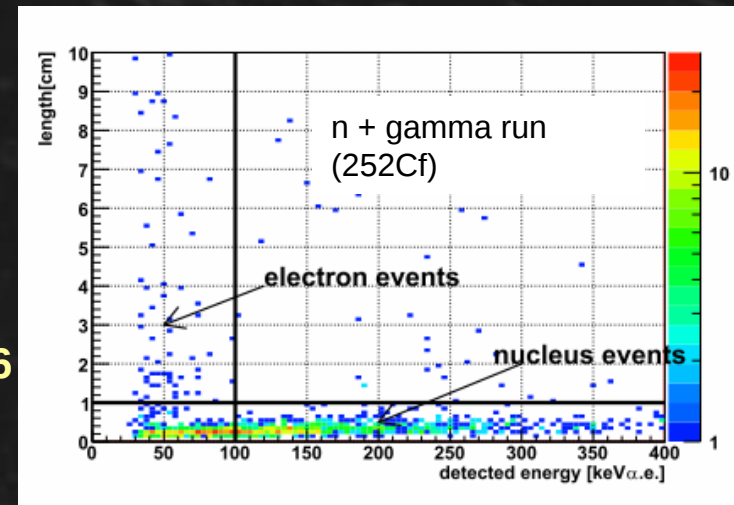
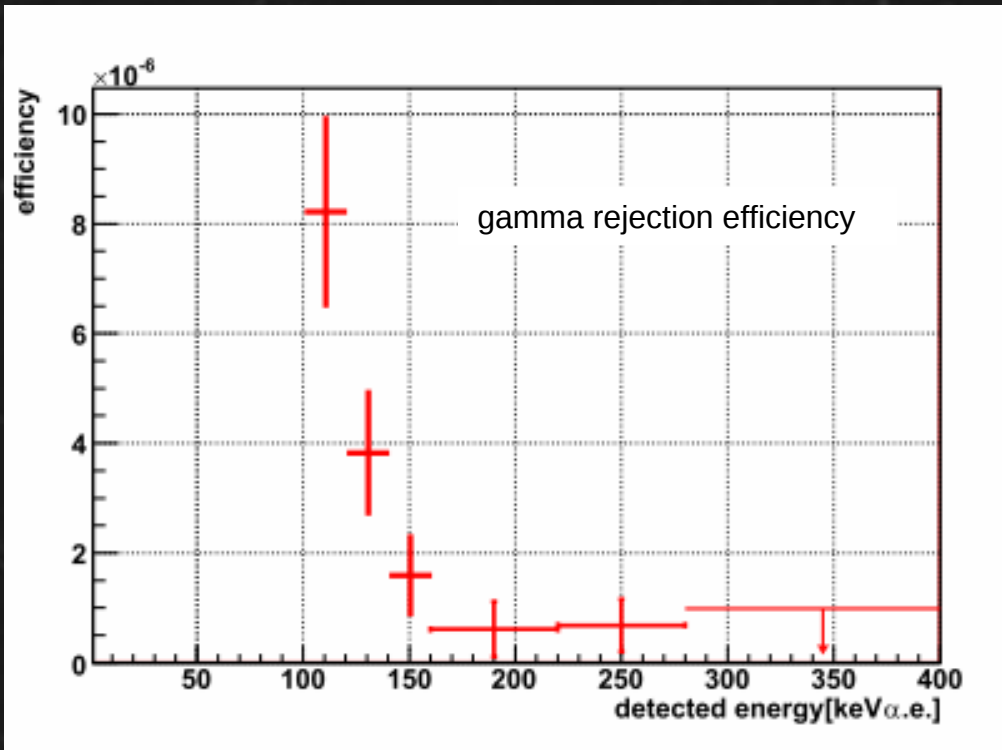


Direction Sensitive
WIMP-search
NEWAGE

TPC Performance

② gamma rejection

- energy vs length cut
- gamma rejection efficiency[†] 8.1×10^{-6}



[†] gamma rejection efficiency=electron detection efficiency

1st underground result =NEWAGE-0.3a Kamioka Run5

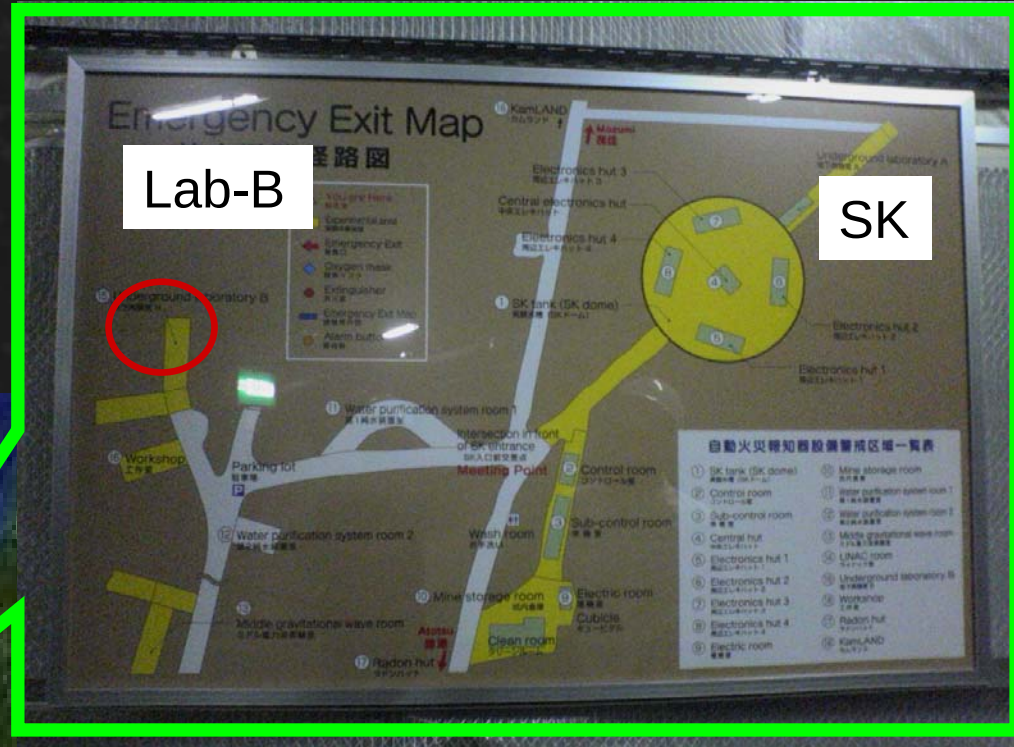
K.Miuchi+
PLB2010(686)11

NEWAGE @ Kamioka

XMASS

- Kamioka mine
- 2700m w.e depth

- DM measurement
- Background Study



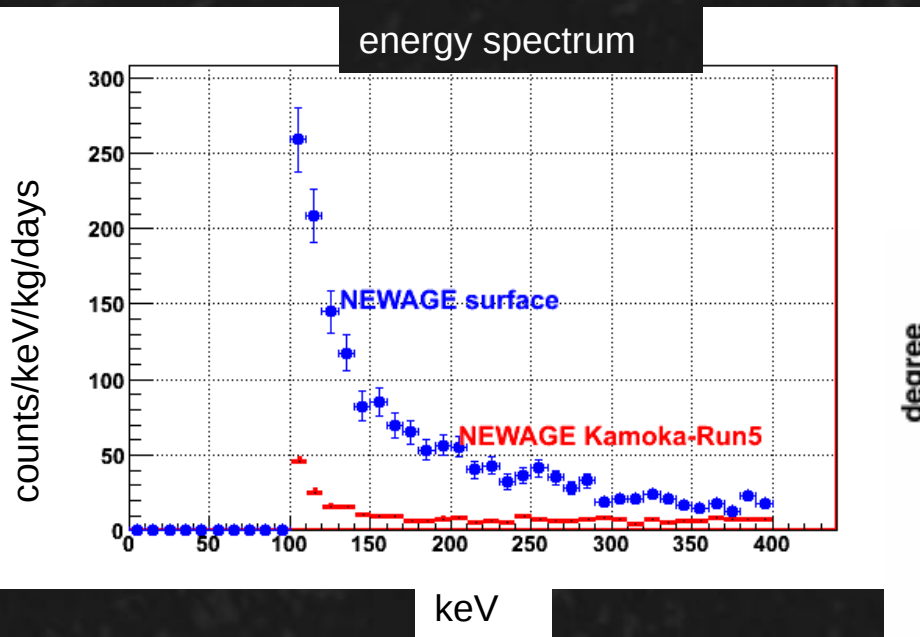
◆ RUN5: Detector

- Target gas: CF_4 0.2atm (0.0115kg)
- Exposure: 0.524 kg·days
(Sep. 2008 - Dec. 2008)
- Energy resolution
70%@100keV(FWHM)
- Position resolution
800 μm (rms)
- angular resolution
 $\sim 55^\circ$ (RMS)

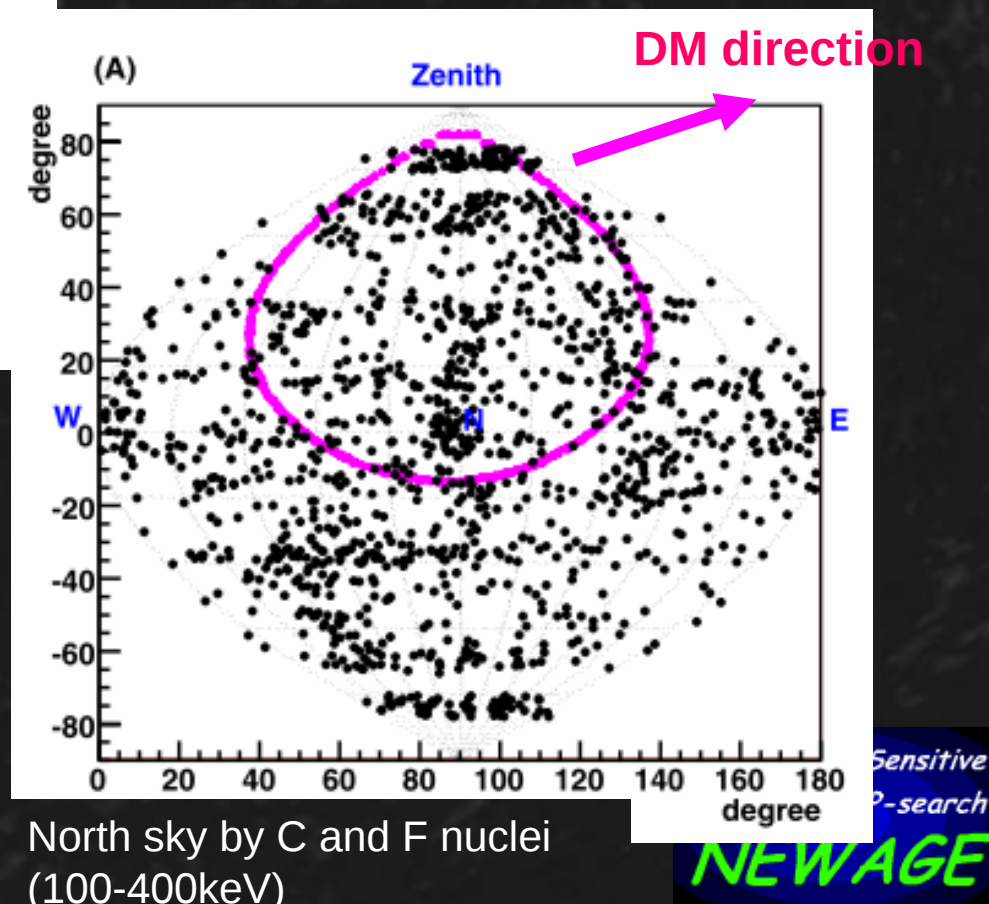


◆ RUN5 results①

● Energy spectrum 1/5 rate of the surface run



(PLB 686 (2010) 11)



◆ RUN5 results②

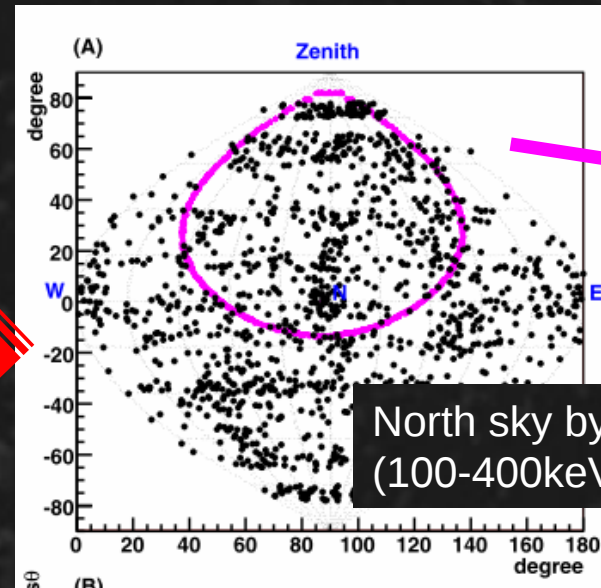
● The sky map

--> $\cos\theta$ distribution

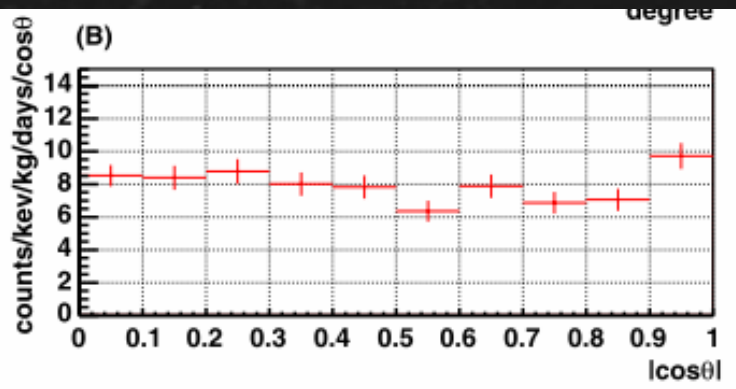
--> upper limits

new limits 5400pb
for 150GeV

(PLB 686 (2010) 11)

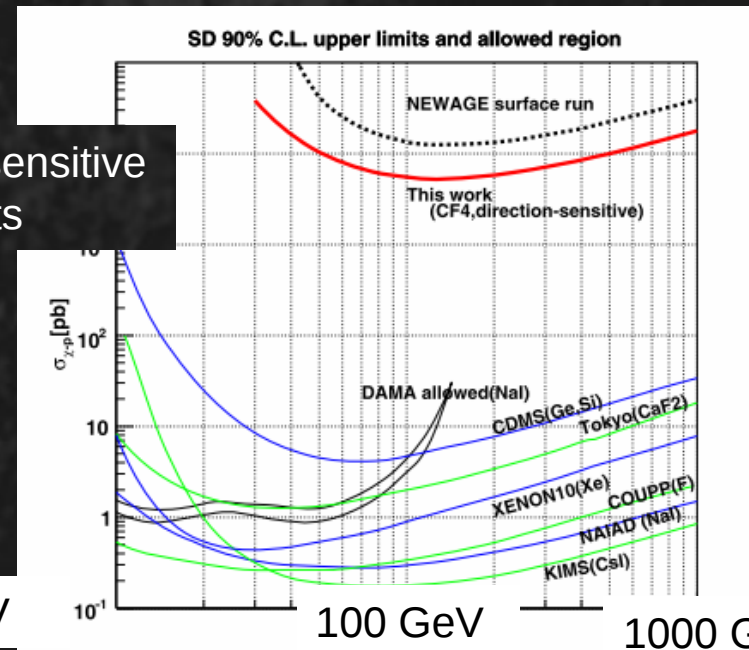


DM direction



Cos θ distribution
(100-400keV)

direction-sensitive
upper limits



Recent activities

- ◆ Sensitivity improvement
(underground updates)
- ◆ To go further
(surface R&Ds)

◆ Sensitivity improvement

- radon gas
 - gamma rays
 - α particles
 - DAQ upgrade
- } $\Rightarrow$ low background aiming 1/10
- $\Rightarrow$ low threshold

● Kamioka RUN-13

TODAY

- RUN13-1 : 2012 Jan. 23 – March 8
- RUN13-2 : 2012 March 8 – May 24
- RUN13-3 : 2012 May28-

Radon: charcoal

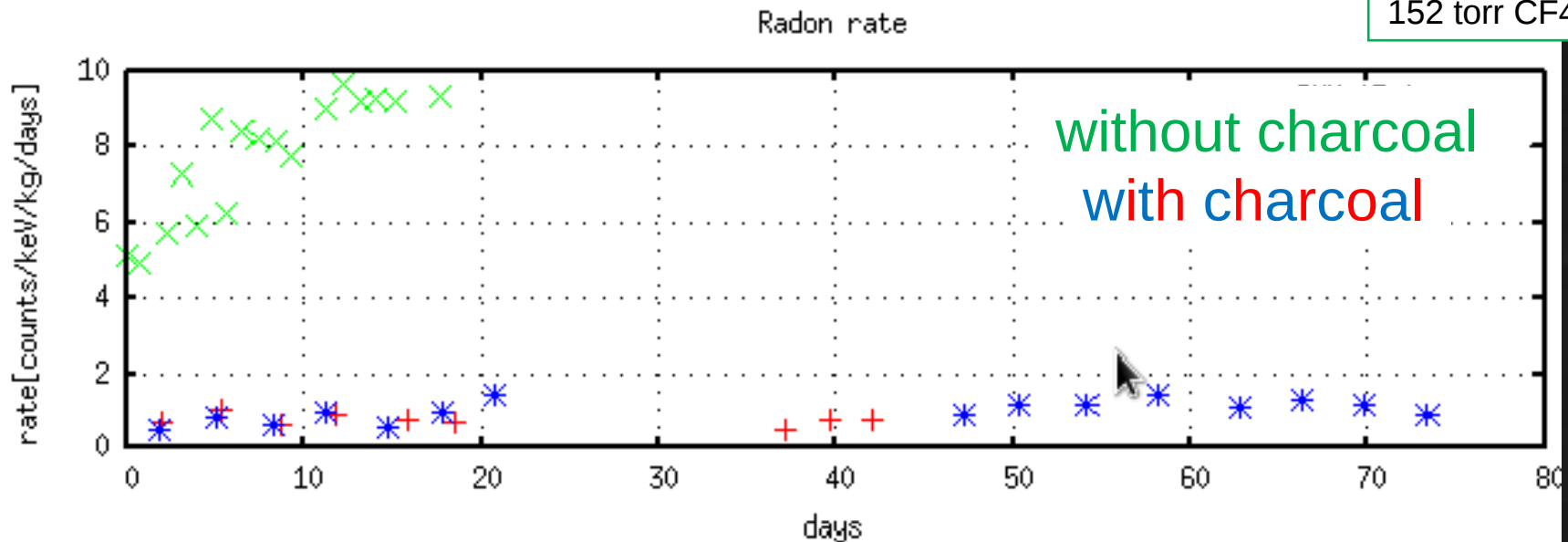
- gas circulation system
- monitor radon rate ($\sim 6\text{MeV}$)
- radon rate $\sim 1/10$ after day 10

charcoal filter $\sim 100\text{g}$
(TSURUMICOAL 2GS)

getter pump
(SAES GETTER C400-2DSK)

circulation
(Teflon bellows pump)

NEWAGE0.3a
152 torr CF_4 gas



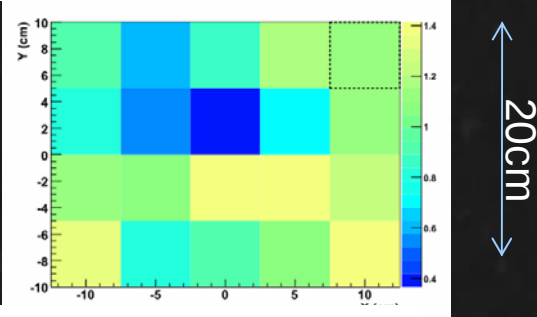
cf: $1\text{e}5\text{counts/kg/days} \sim 1\text{Bq/m}^3$

gamma: precise gain map

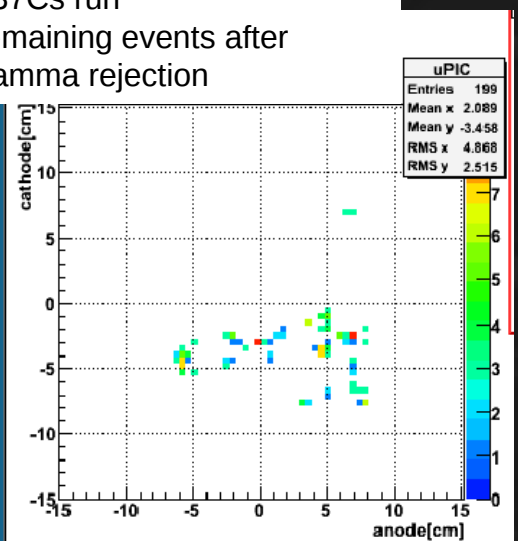
- gas gain is not uniform in $30 \times 30\text{cm}^2$

old gain map

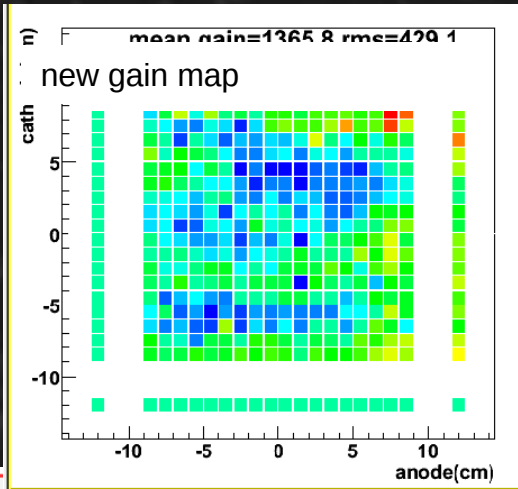
RUN5



137Cs run
remaining events after
gamma rejection

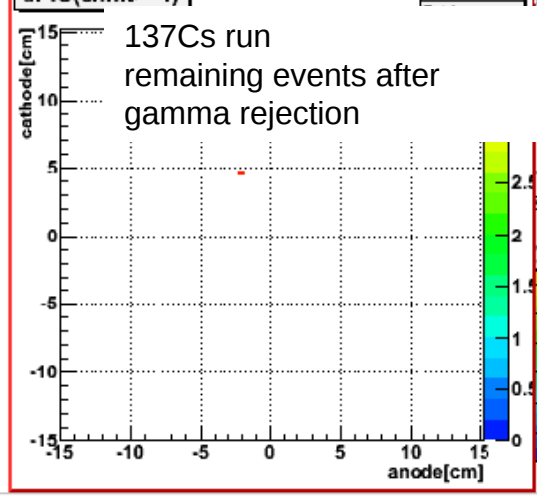


gamma rejection
 $8.1\text{e-}6$



RUN13

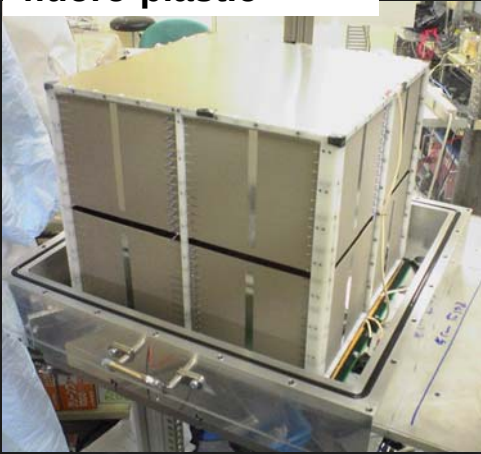
137Cs run
remaining events after
gamma rejection



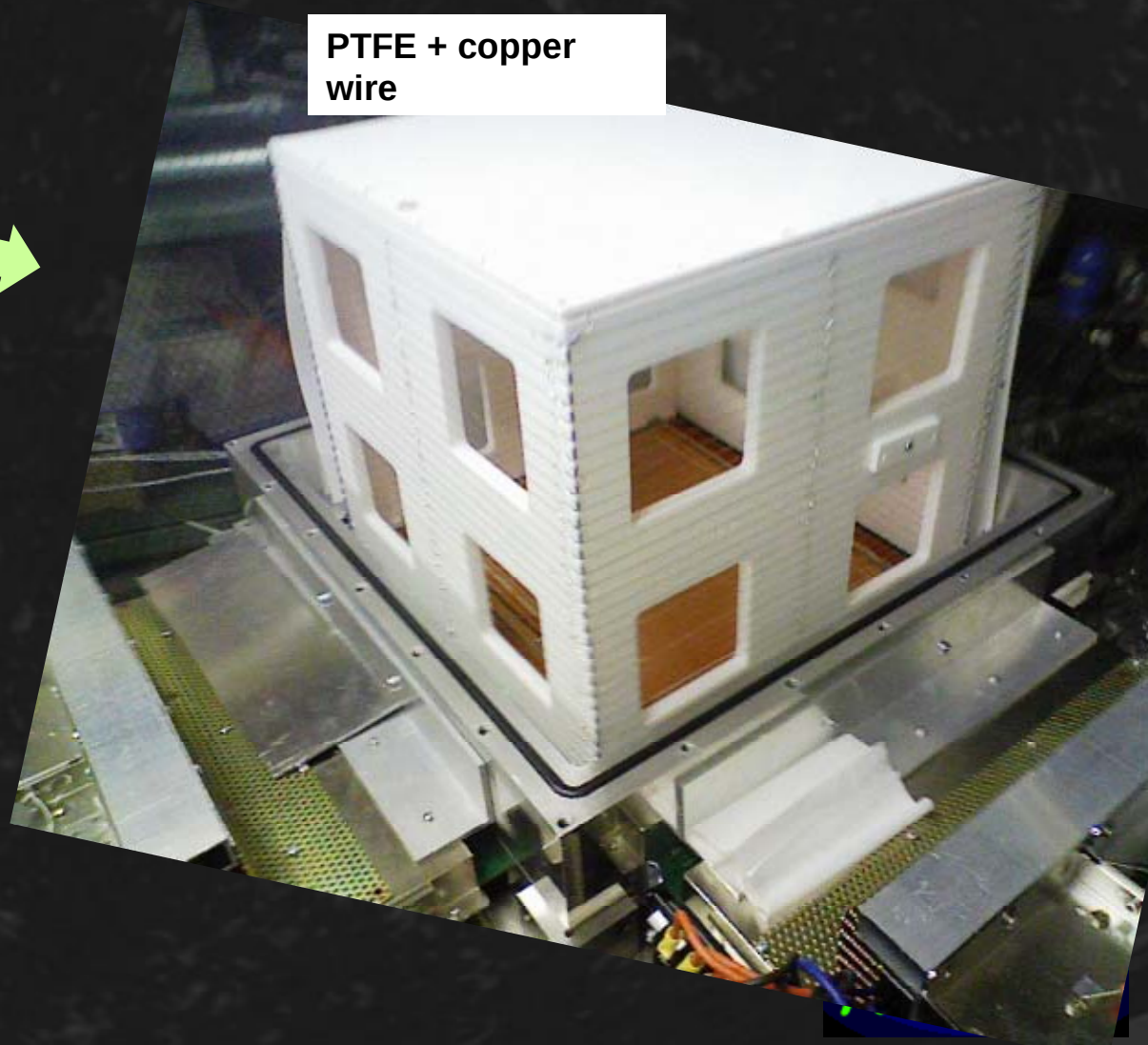
gamma rejection
 $1.0\text{e-}6>$

radon, gamma, alpha: "clean" materials to $<1/10$ radon emanation level

glass-reinforced
fluoro-plastic



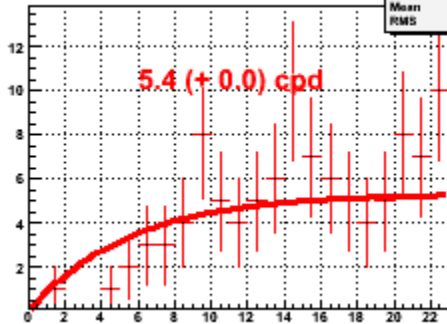
PTFE + copper
wire



U-chain (6.0MeV, 7.83MeV)

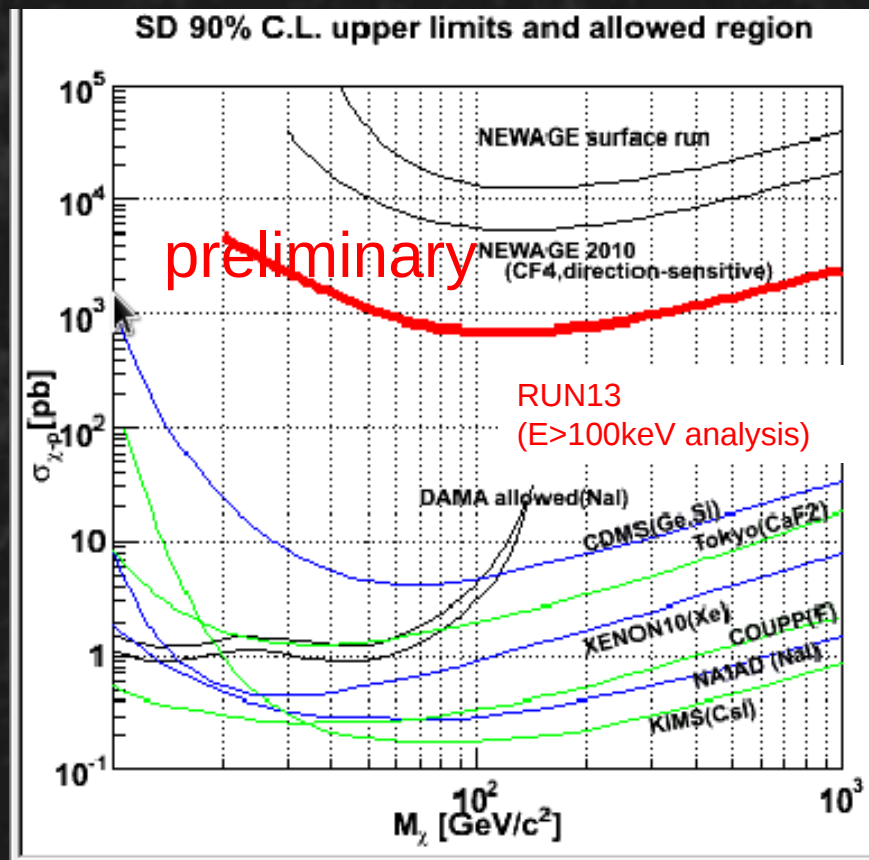
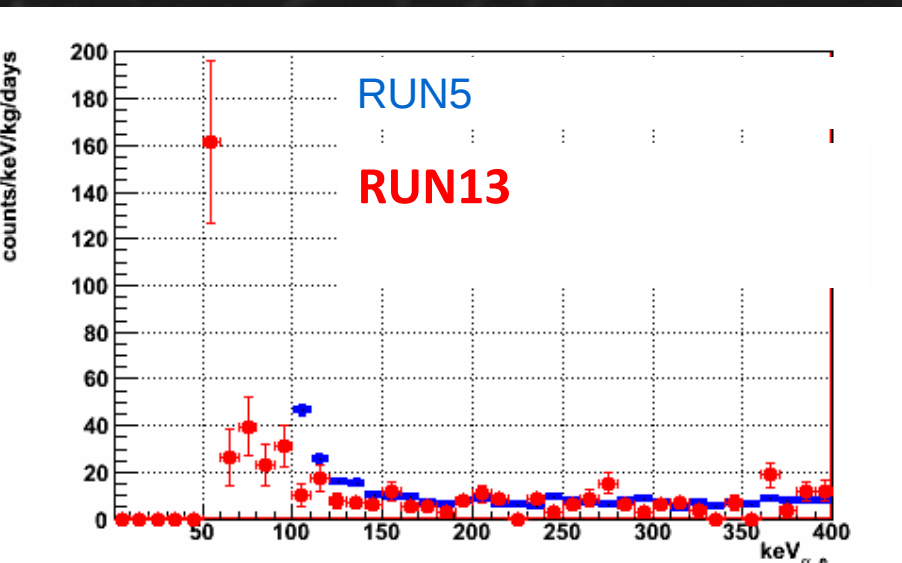
time dependence
Entries 1000
Mean 15.04
RMS 5.189

5.4 (+ 0.0) cpd



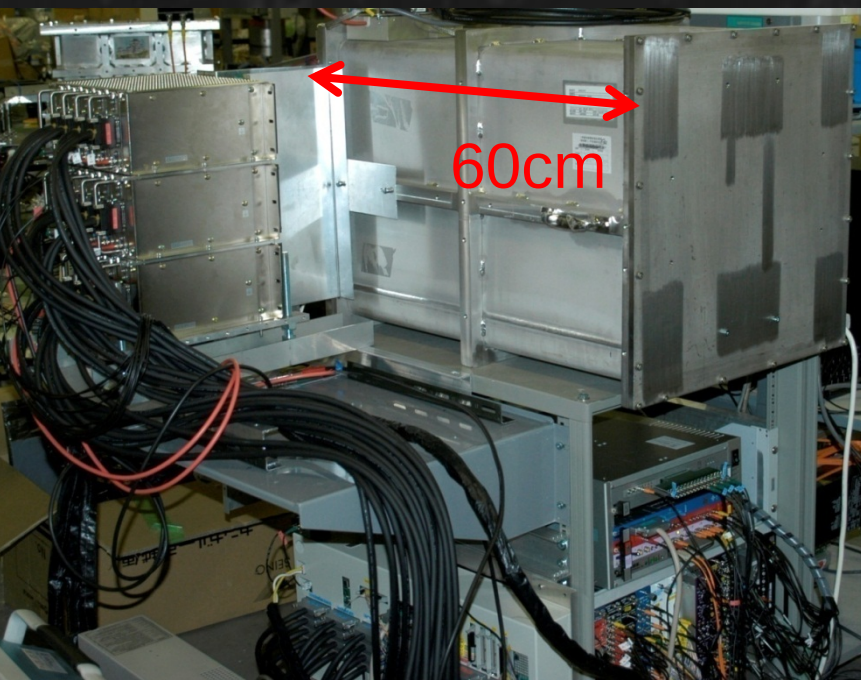
Results(preliminary)

- exposure 0.140kg·days
- spectrum threshold 100keV $\Rightarrow$ 50keV
- rate: $\sim 1/5$ at 100keV
- direction-sensitive analysis: on-going

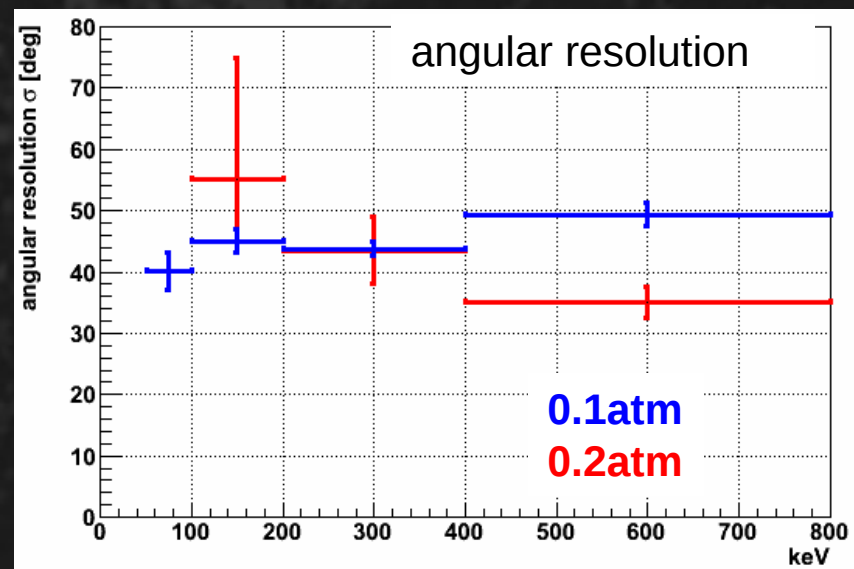


◆ To go further... (R&D in surface labo.)

- NEWAGE-0.3b detection volume $31 \times 31 \times 50 \text{cm}^3$
- Cold charcoal
- $0.2 \text{atm} \Rightarrow 0.1 \text{atm}$ CF_4 gas for lower threshold



K.Nakamura
2012 JINST 7 C02023



SUMMARY

- ◆ **NEWAGE: direction-sensitive DM exp.**
- ◆ **1st underground run:
updated direction-sensitive results**
- ◆ **underground and surface R&Ds are on-going**