

Direction-Sensitive Dark Matter Search --NEWAGE--

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

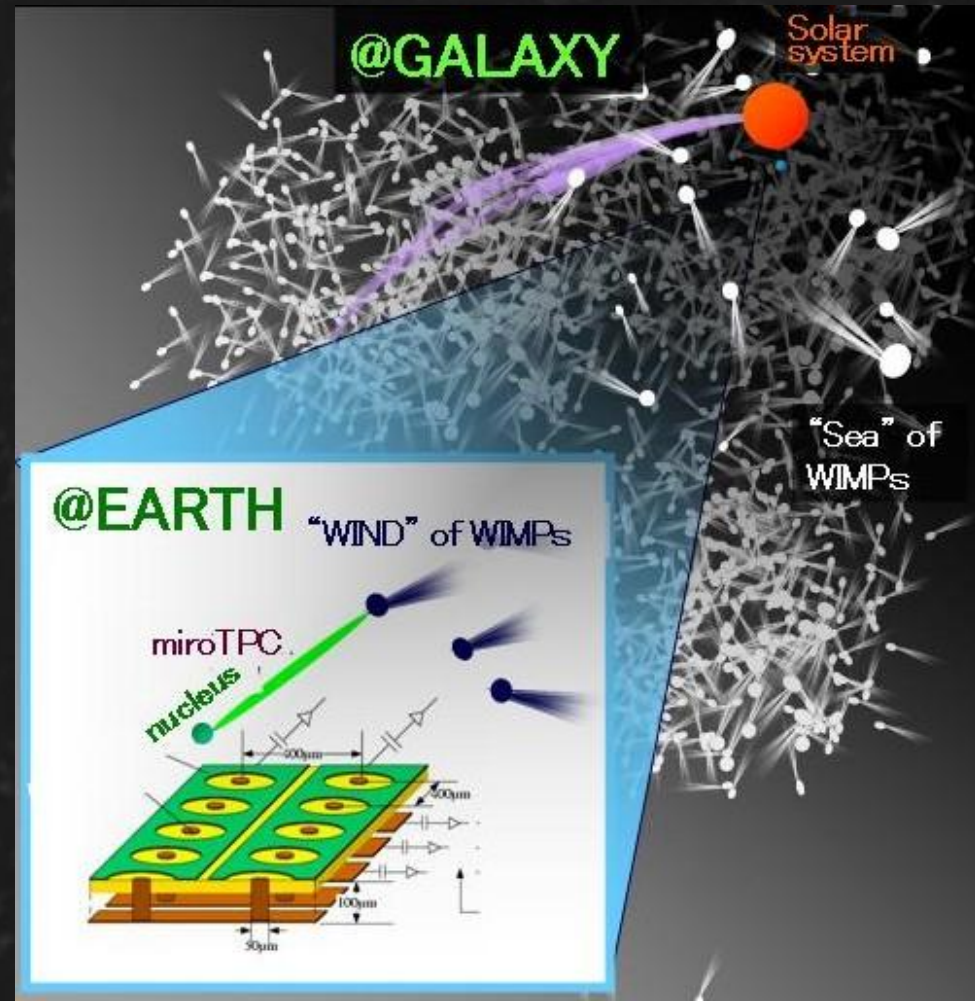
Kentaro Miuchi
(Kobe University)

with

K. Nakamura, A. Takada

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

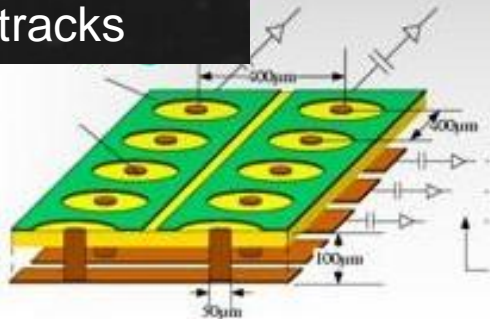
@EARTH

“WIND” of WIMPs

WIMP

$V_0 = 230$ km/s

low pressure gas
forward recoils
short tracks

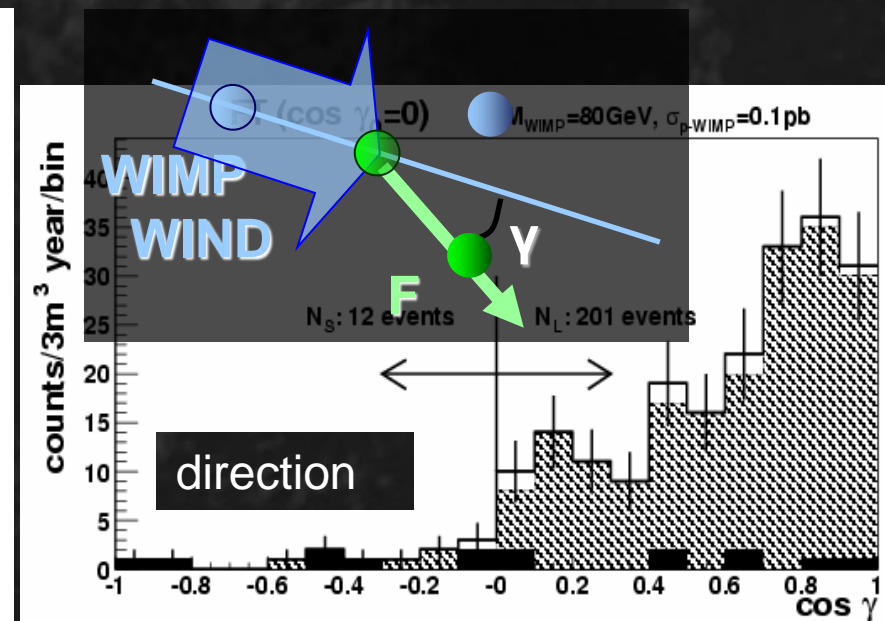
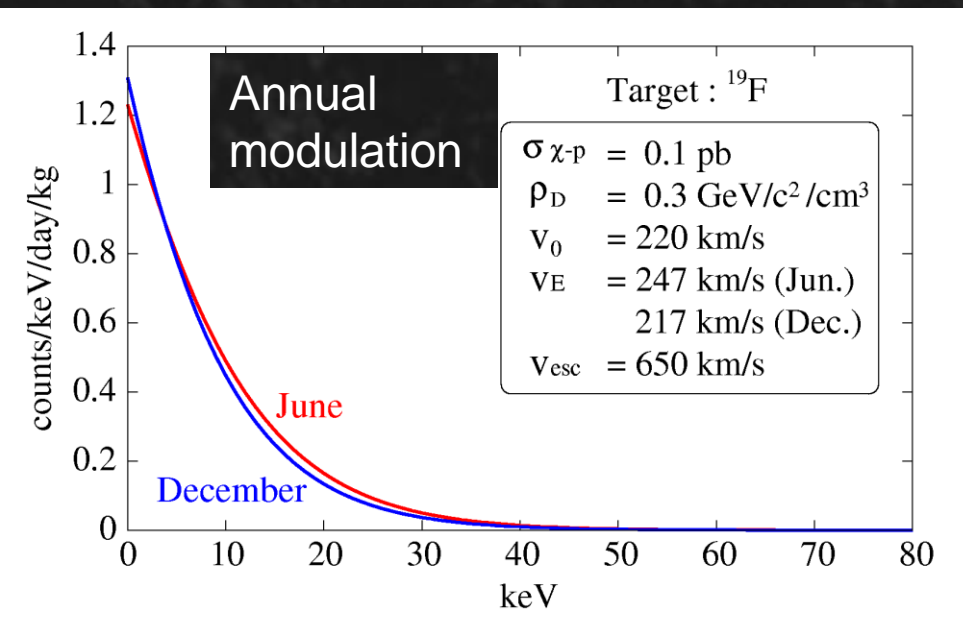


The WIMP-wind



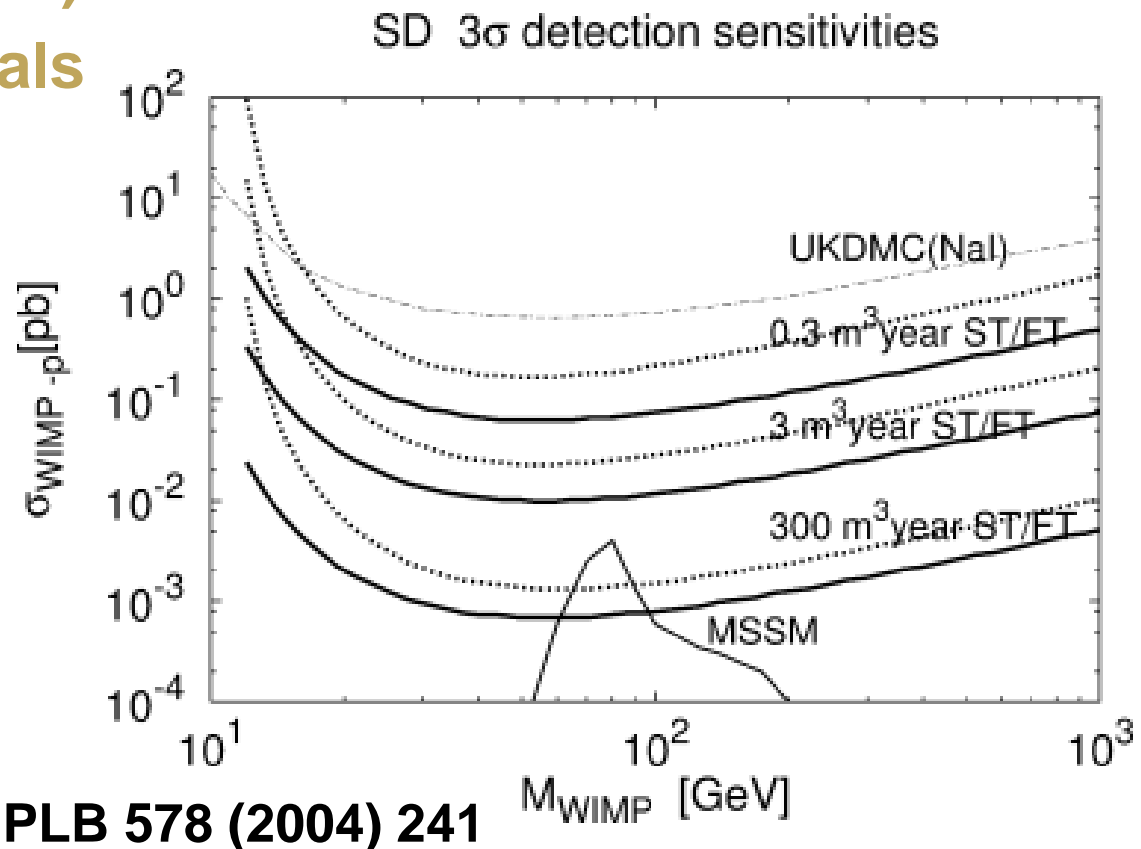
WHY “Direction-sensitive” ?

- 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 ($1\text{m}^3 \times N$) - radio-pure materials
- **CURRENT: pilot run**
 - CF_4 0.2 bar - $(0.3\text{m})^3$
 - normal materials



Methods

Methods (3D tracking device)

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

2012 JINST 7 C02023

TPC

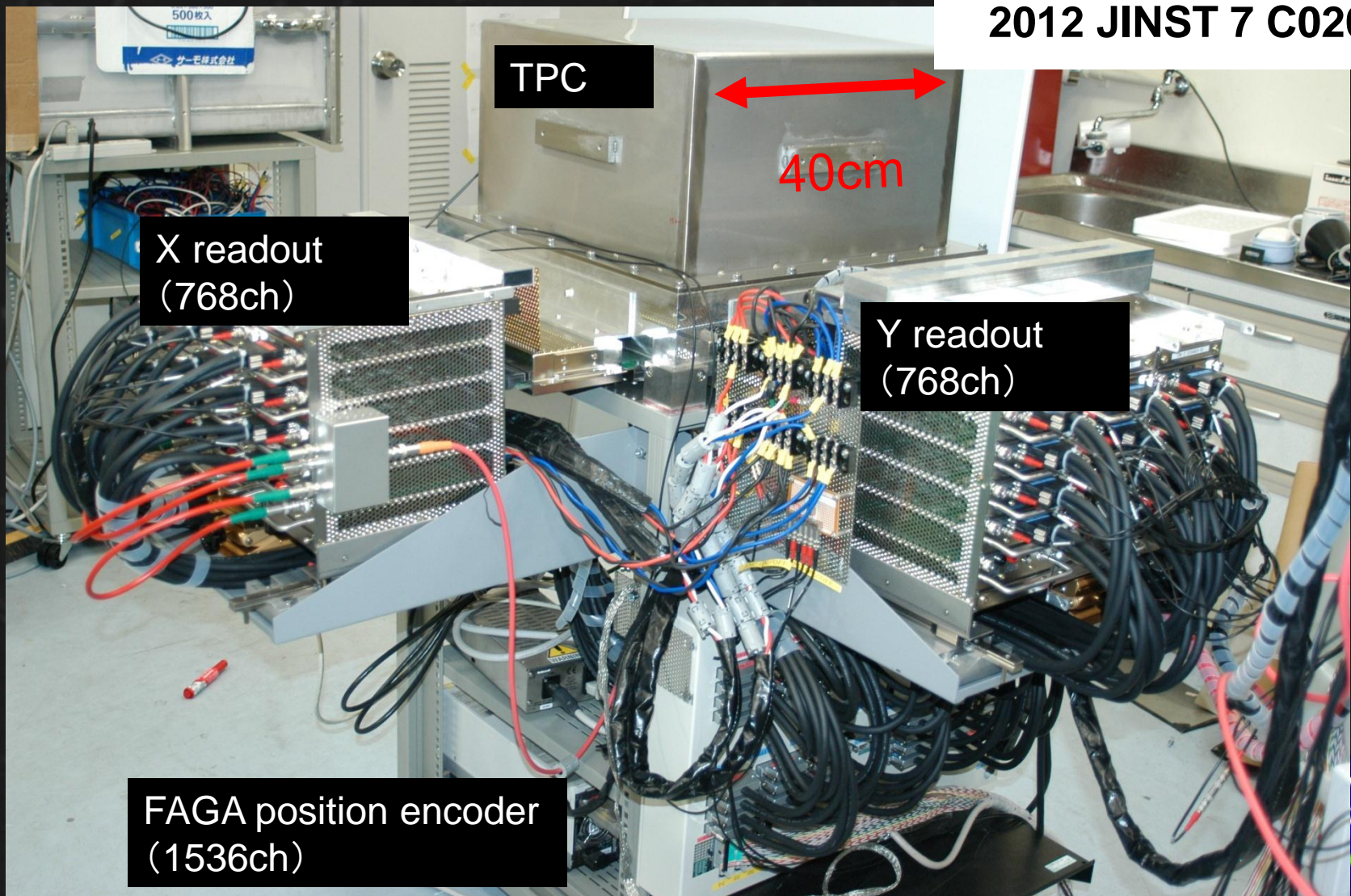
40cm

X readout
(768ch)

Y readout
(768ch)

FAGA position encoder
(1536ch)

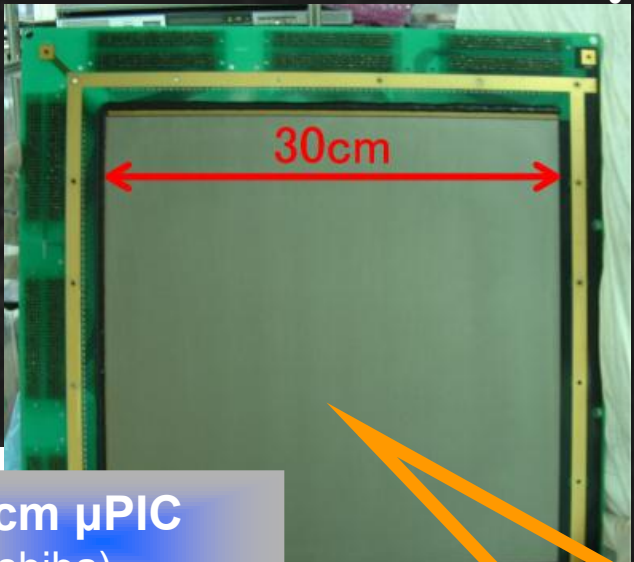
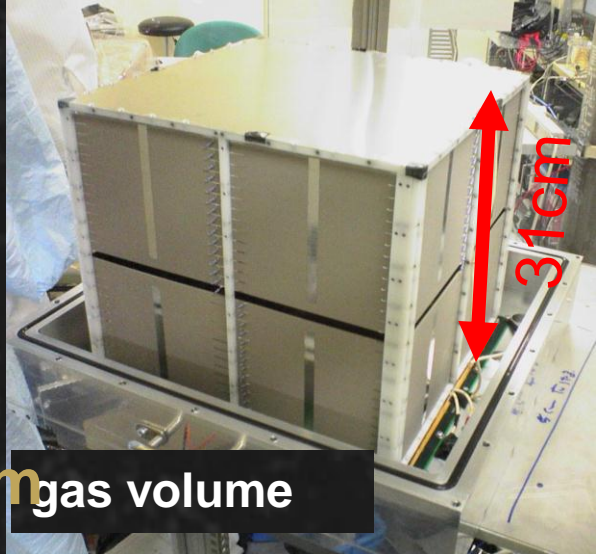
Highly Sensitive
MP-search
NEWAGE



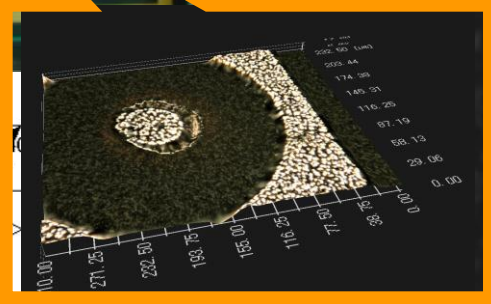
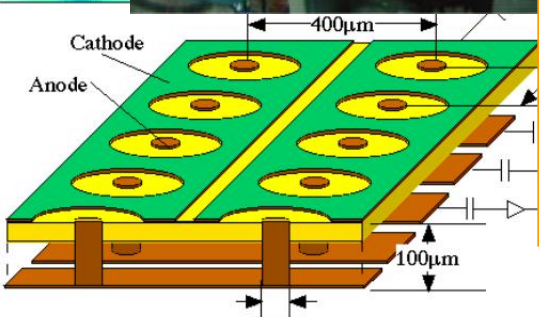
3D tracking device: microTPC

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

- 400 μ m pitch
- Gas volume
- 30 \times 30cm²
- DRIFT length 31cm

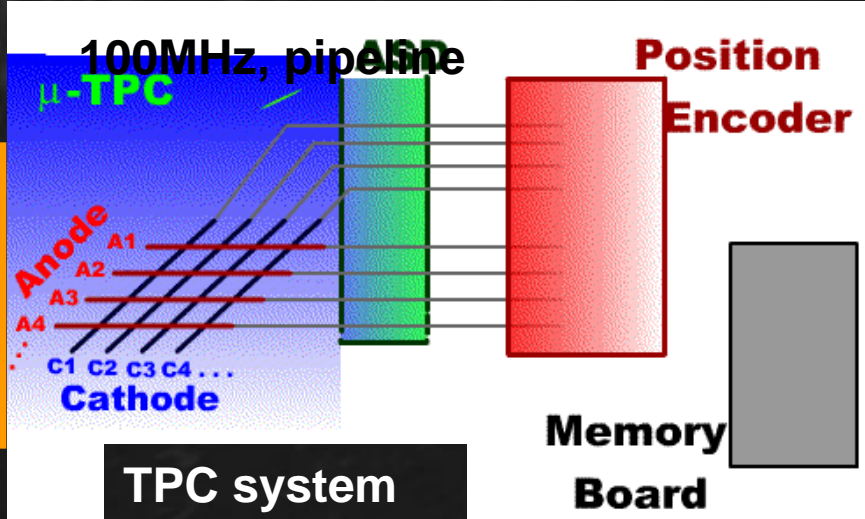


30cm μ PIC
(Toshiba)



Readout electronics

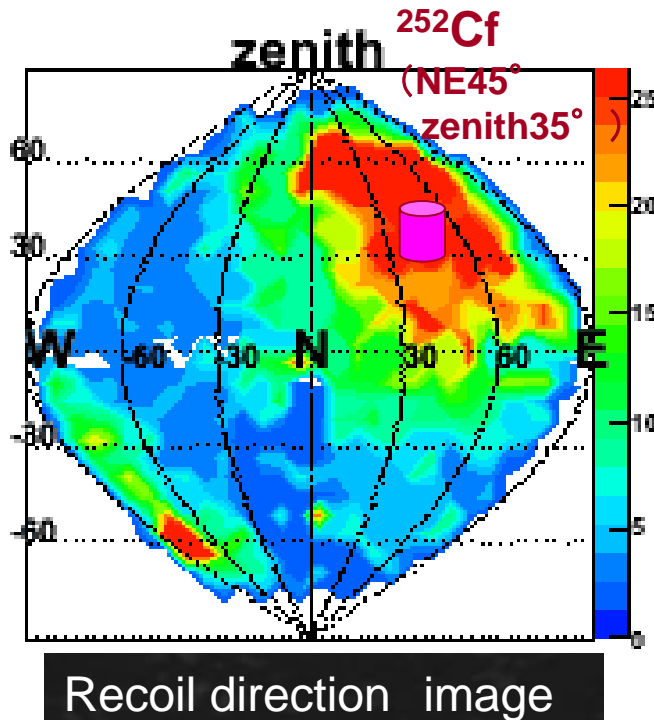
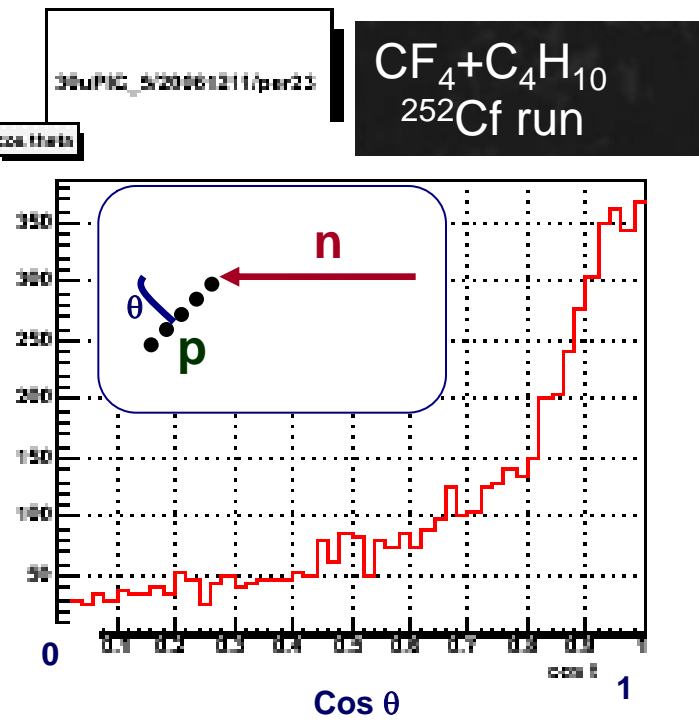
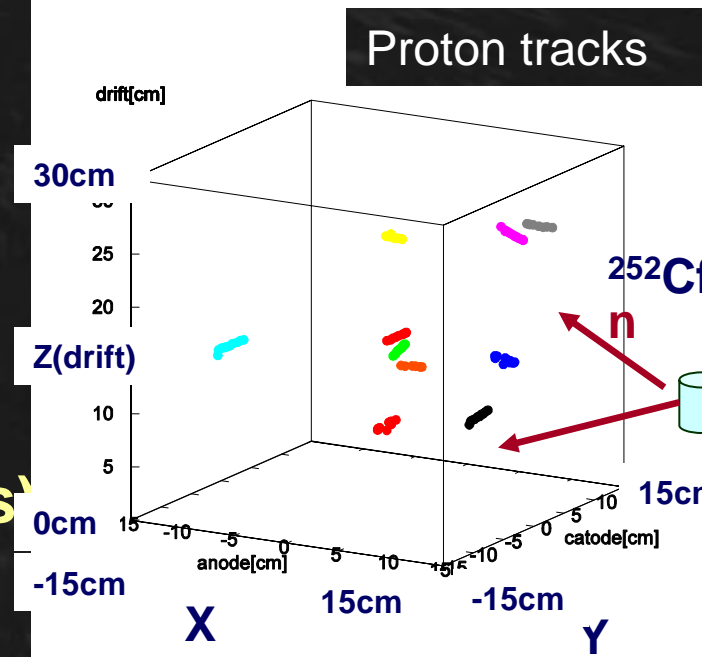
- Digital "3D-HIT" (track) +charge (energy)



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 WIMP \rightarrow F scatterings)



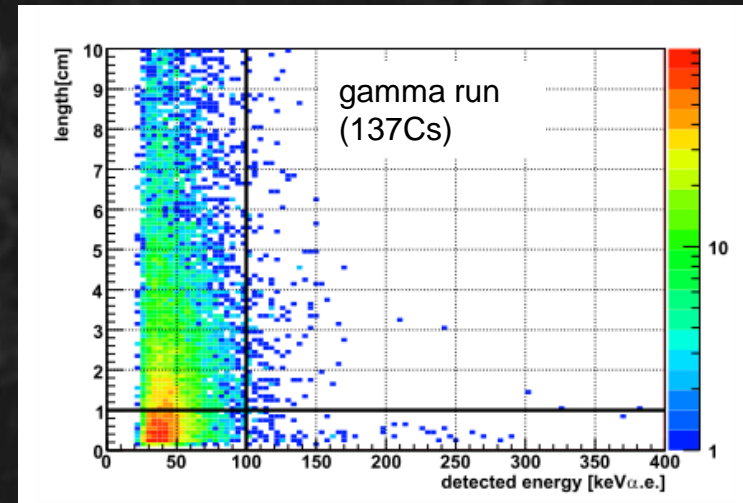
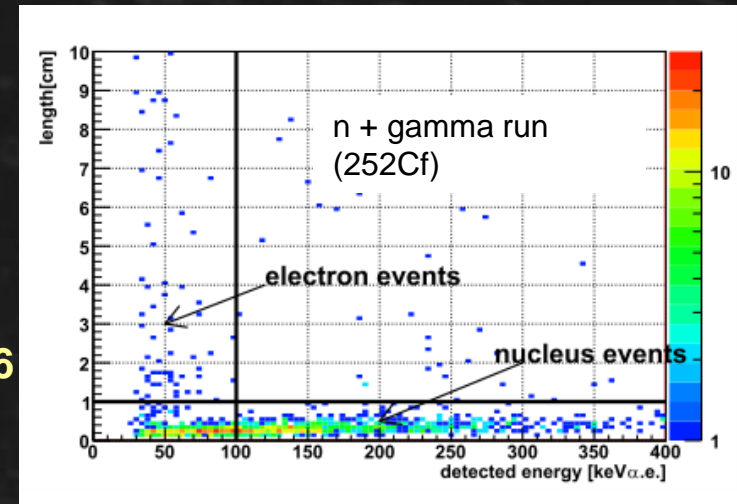
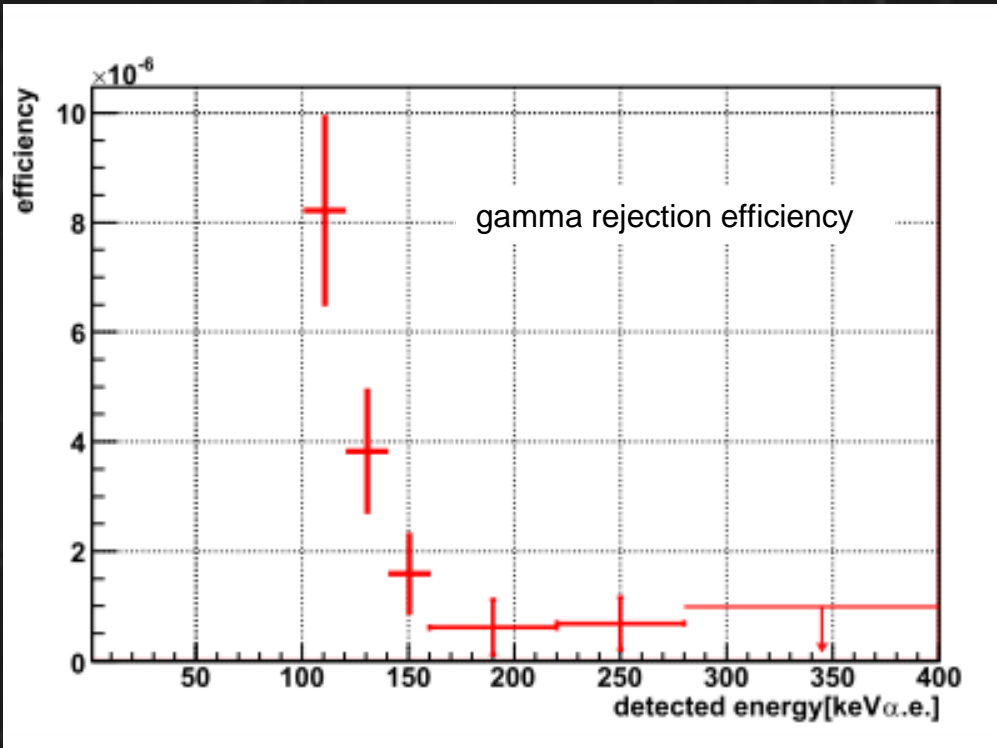
Direction Sensitive
WIMP-search
NEWAGE

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

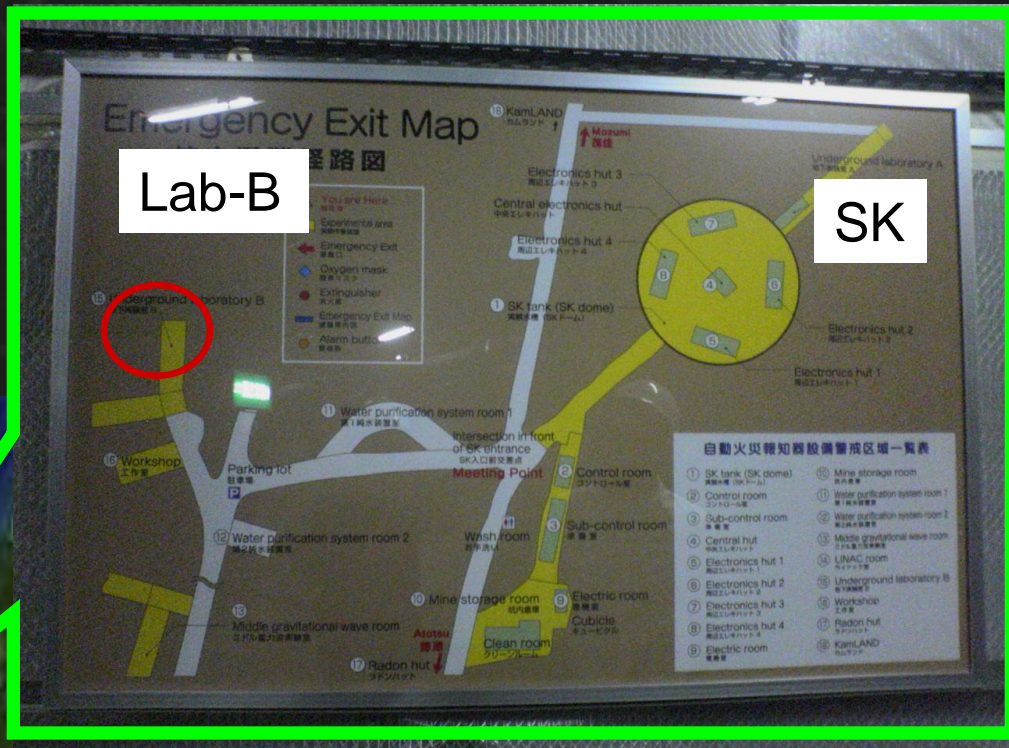


NEWAGE @ Kamioka

XMASS

- Kamioka mine
- 2700m w.e depth

- DM measurement
- Background Study



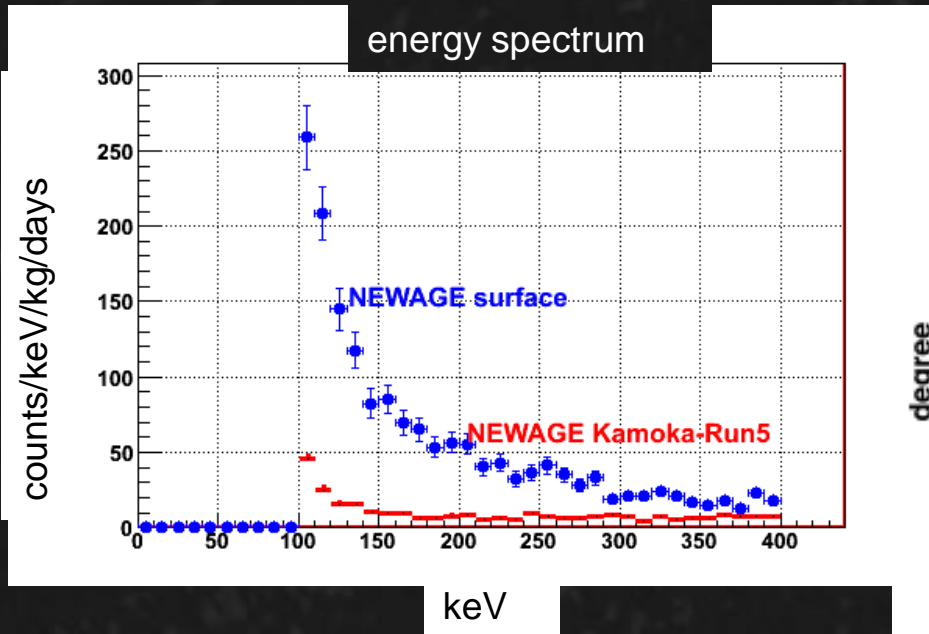
◆ RUN5: Detector

- 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
~55° (RMS)

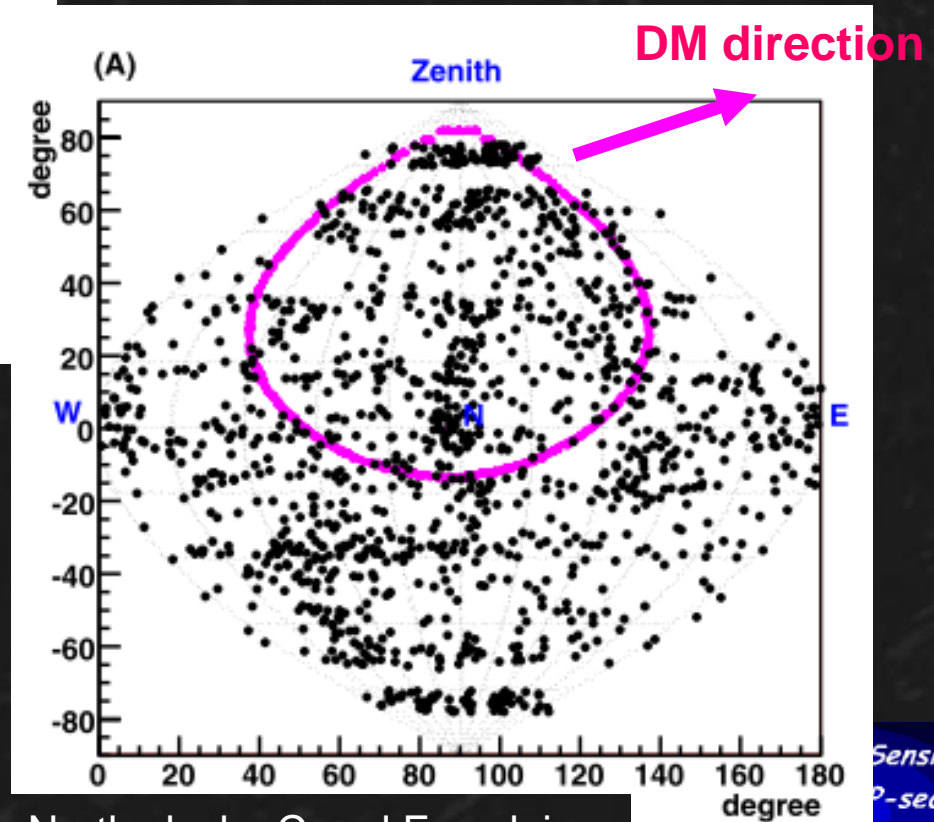


◆ RUN5 results①

● Energy spectrum 1/5 rate of the surface run



(PLB 686 (2010) 11)



North sky by C and F nuclei
(100-400keV)

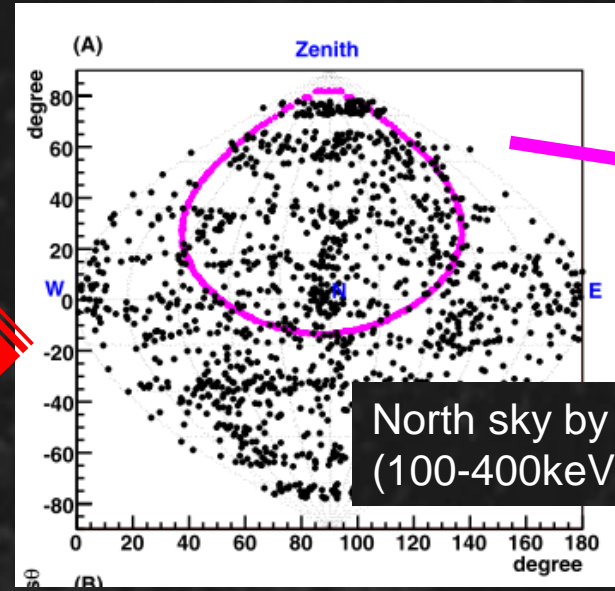
RUN5 results②

(PLB 686 (2010) 11)

The sky map

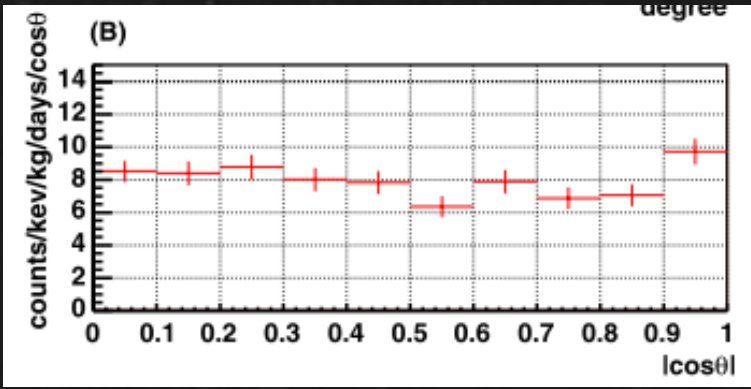
- > $\cos\theta$ distribution
- > upper limits

**new limits 5400pb
for 150GeV**



DM direction

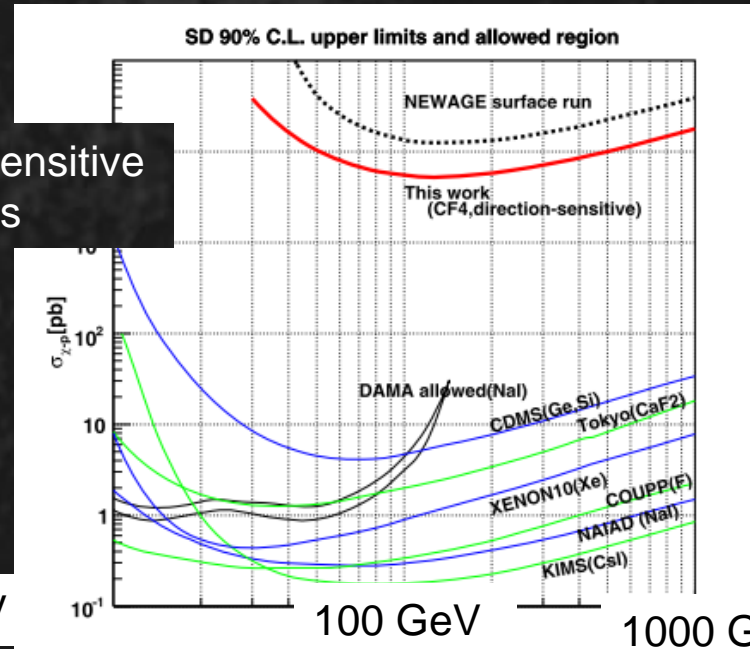
North sky by C and F nuclei (100-400keV)



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)

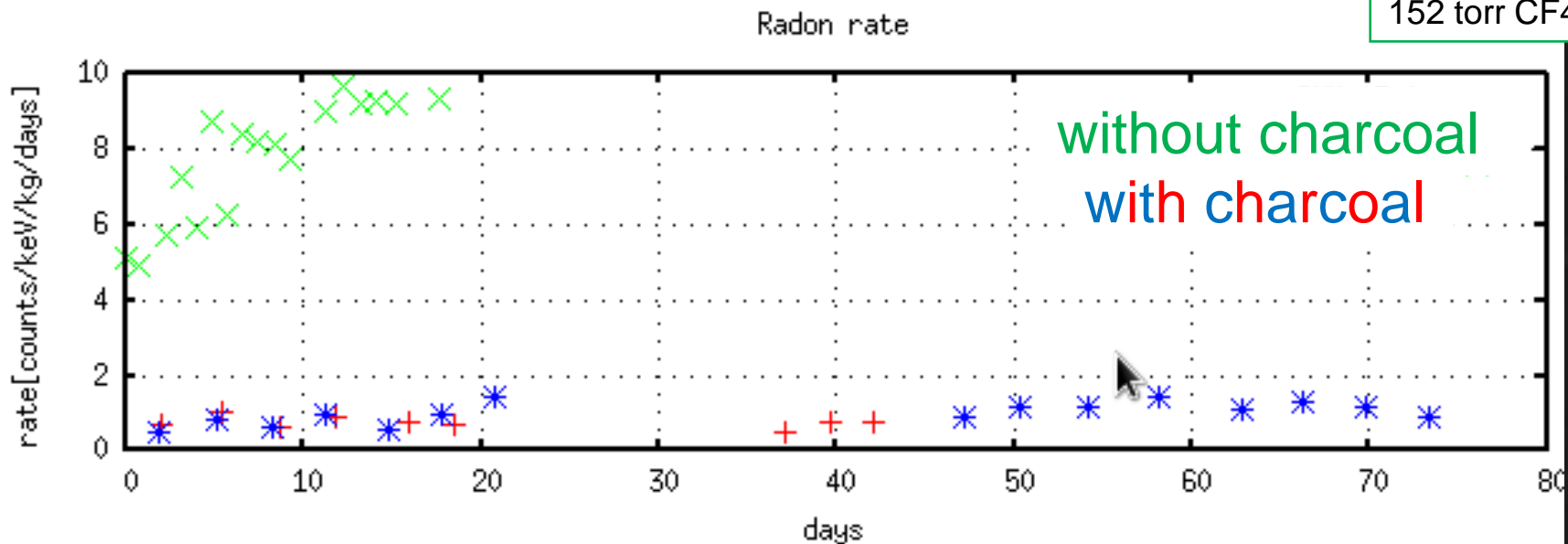
getter pump

(SAES GETTER C400-2DSK)

circulation

(Teflon bellows pump)

NEWAGE0.3a
152 torr CF₄ gas



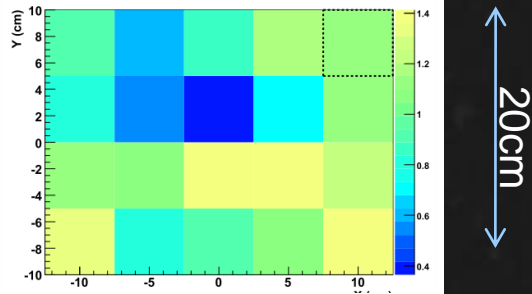
cf : $1\text{e}5\text{counts/kg/days} \sim 1\text{Bq/m}^3$

gamma: precise gain map

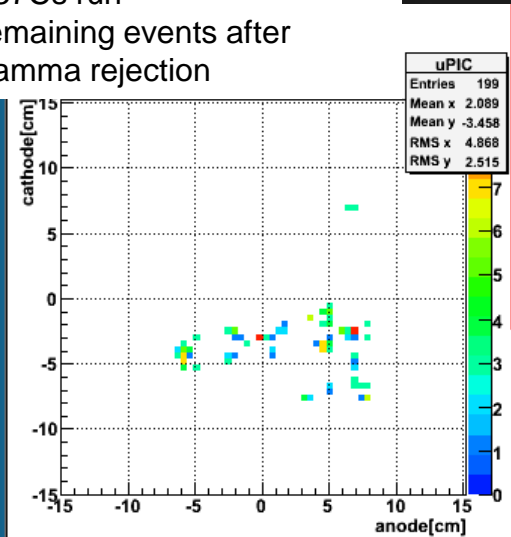
- gas gain is not uniform in $30 \times 30\text{cm}^2$

old gain map

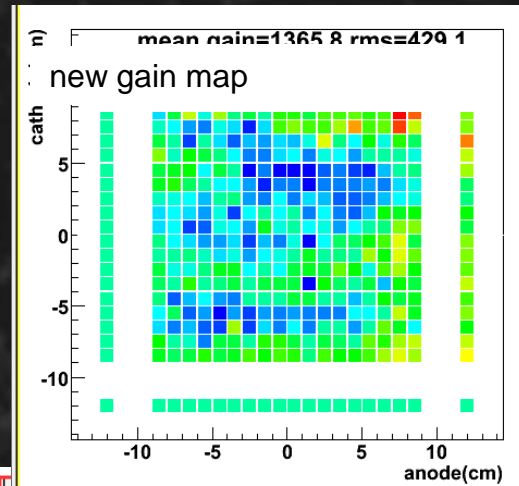
RUN5



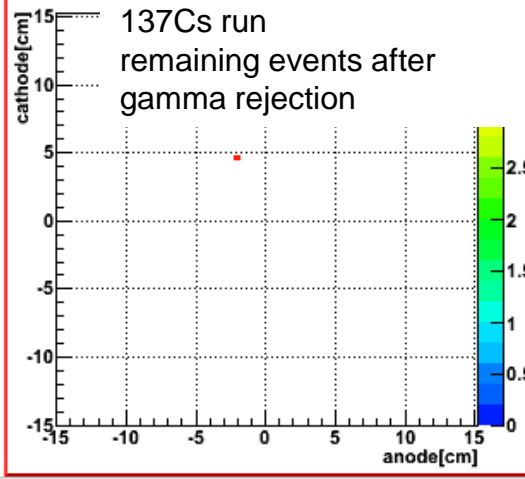
137Cs run
remaining events after
gamma rejection



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



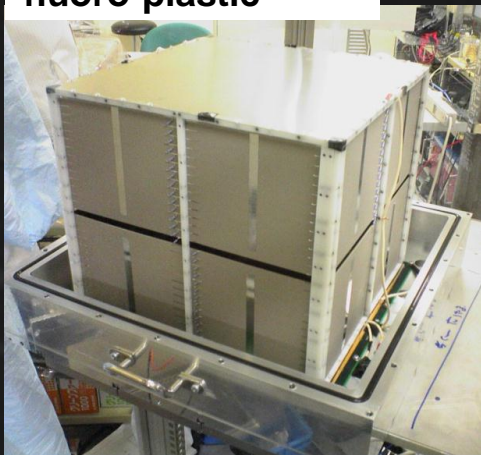
RUN13



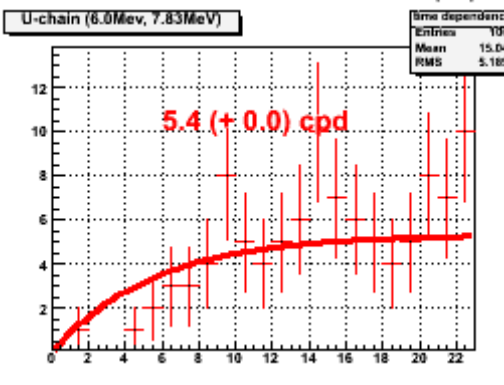
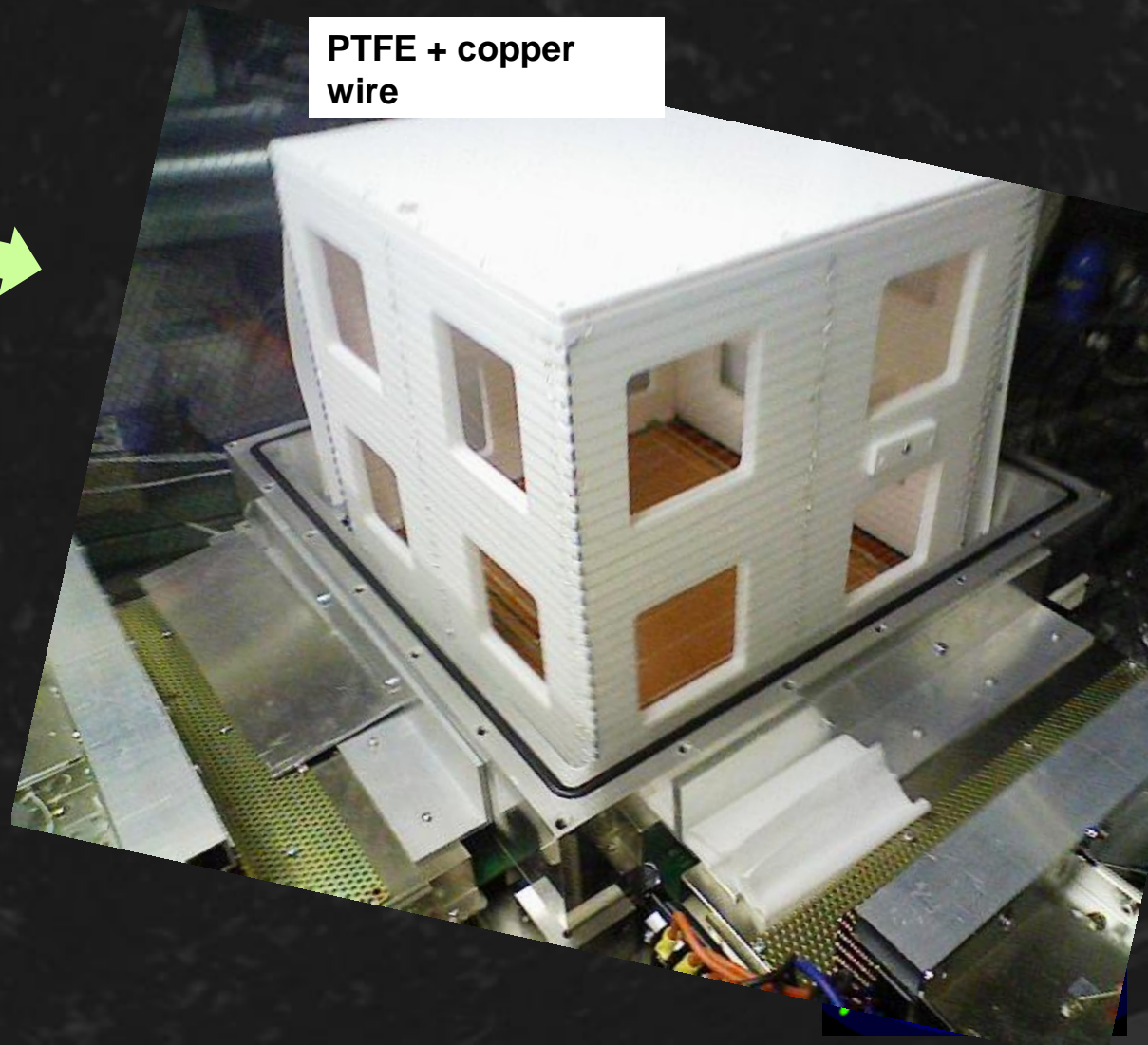
gamma rejection
 $1.0\text{e-}6 >$

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

glass-reinforced fluoro-plastic

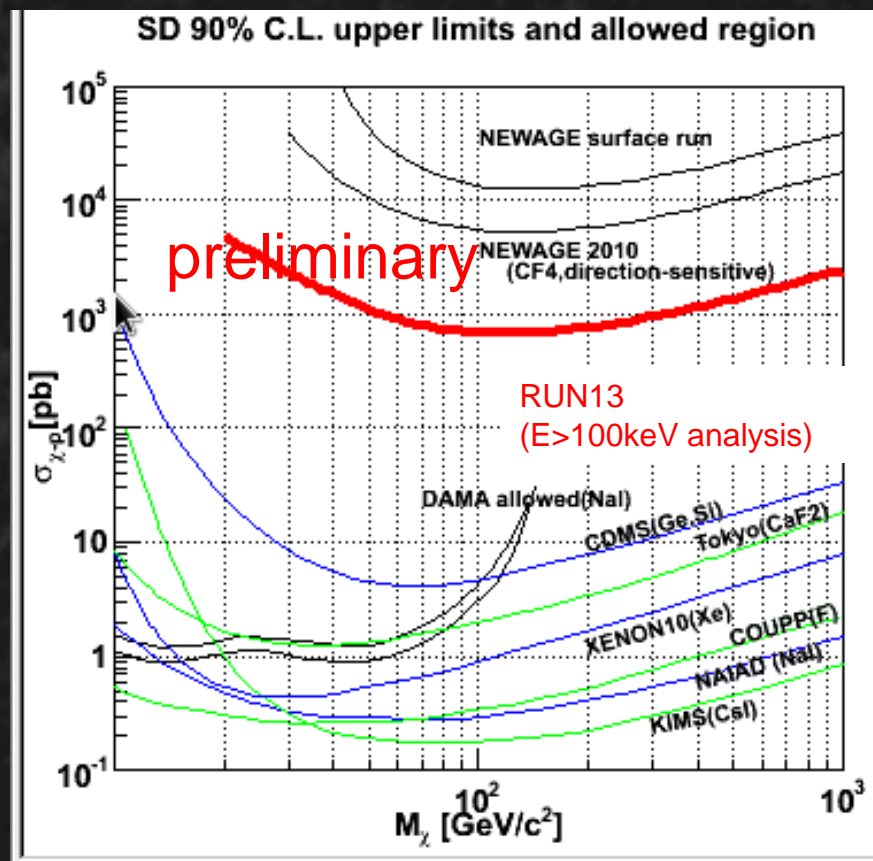
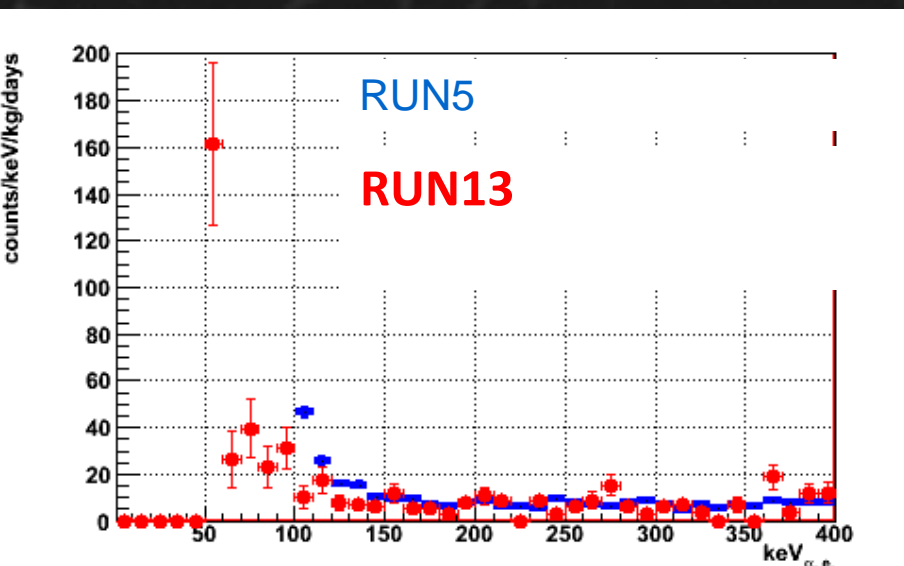


PTFE + copper wire



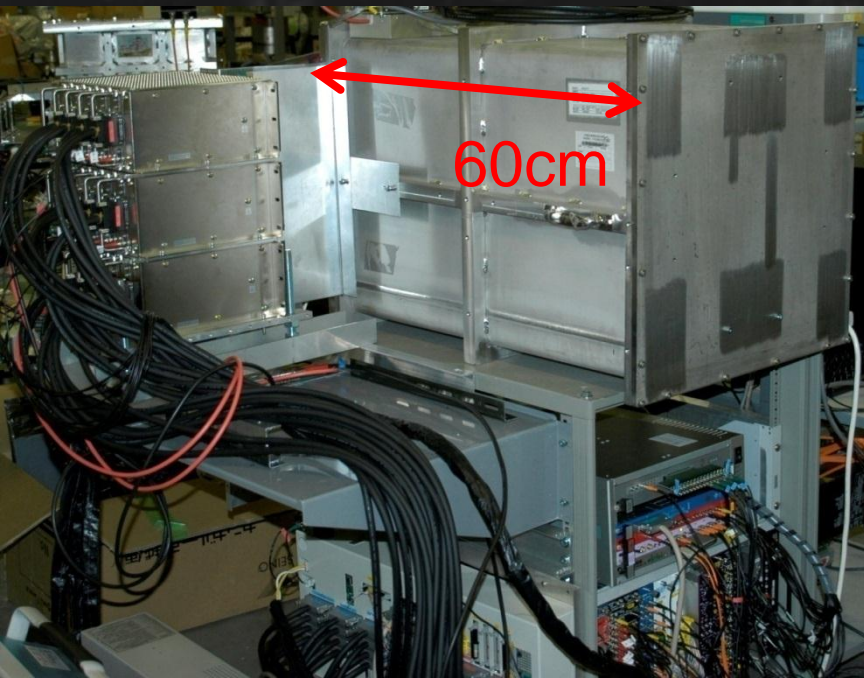
Results (preliminary)

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

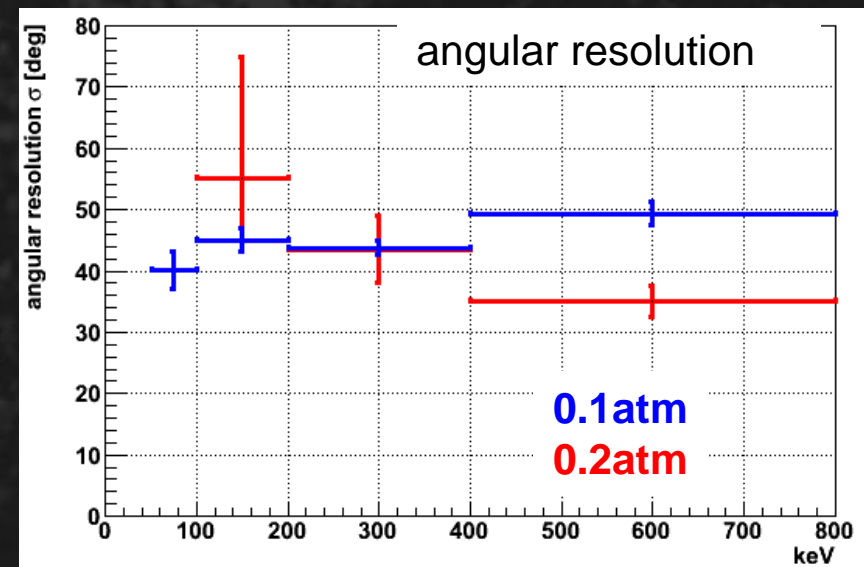


◆ To go further... (R&D in surface labo.)

- 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**