

# NEWAGE

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

Direction sensitive dark matter search

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K. Miuchi

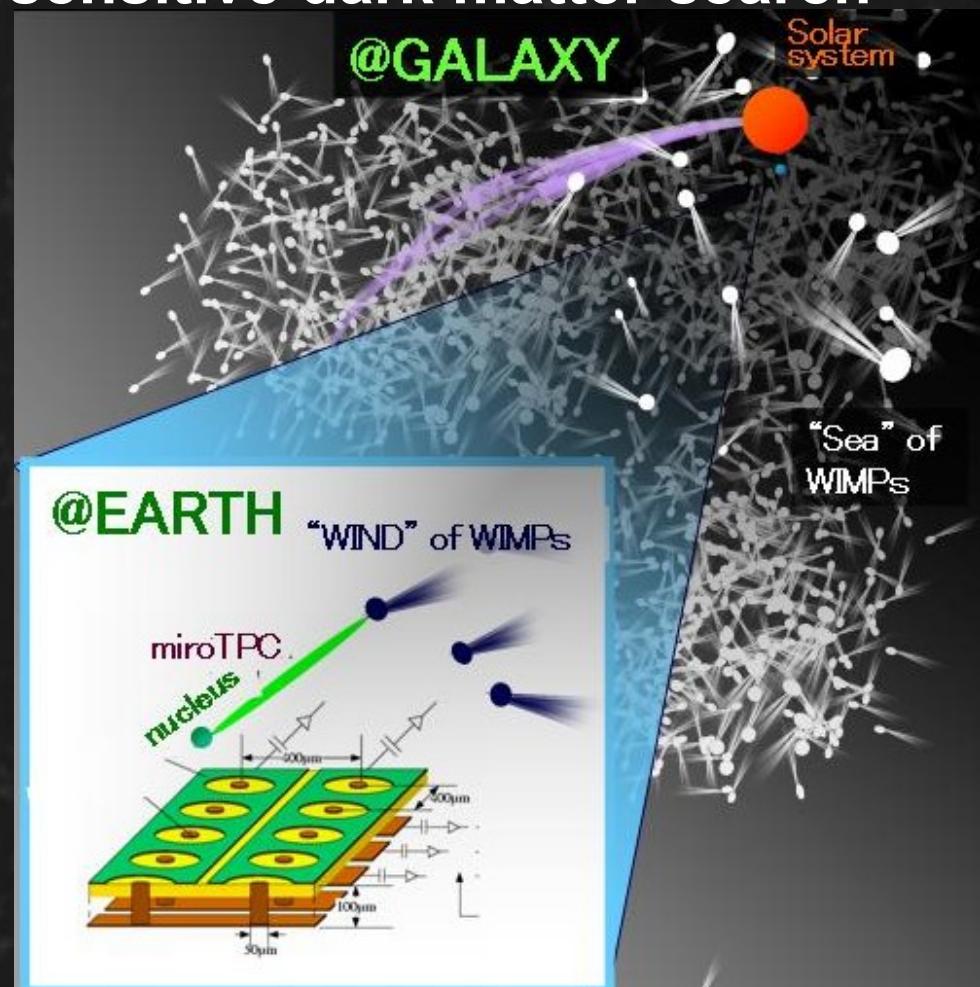
T. Tanimori, H. Kubo,

S. Kabuki, A. Takada,

K. Hattori, K. Ueno, S. Kurosawa,

T. Ida, S. Iwaki

A. Takeda (ICRR), H. Sekiya (ICRR)

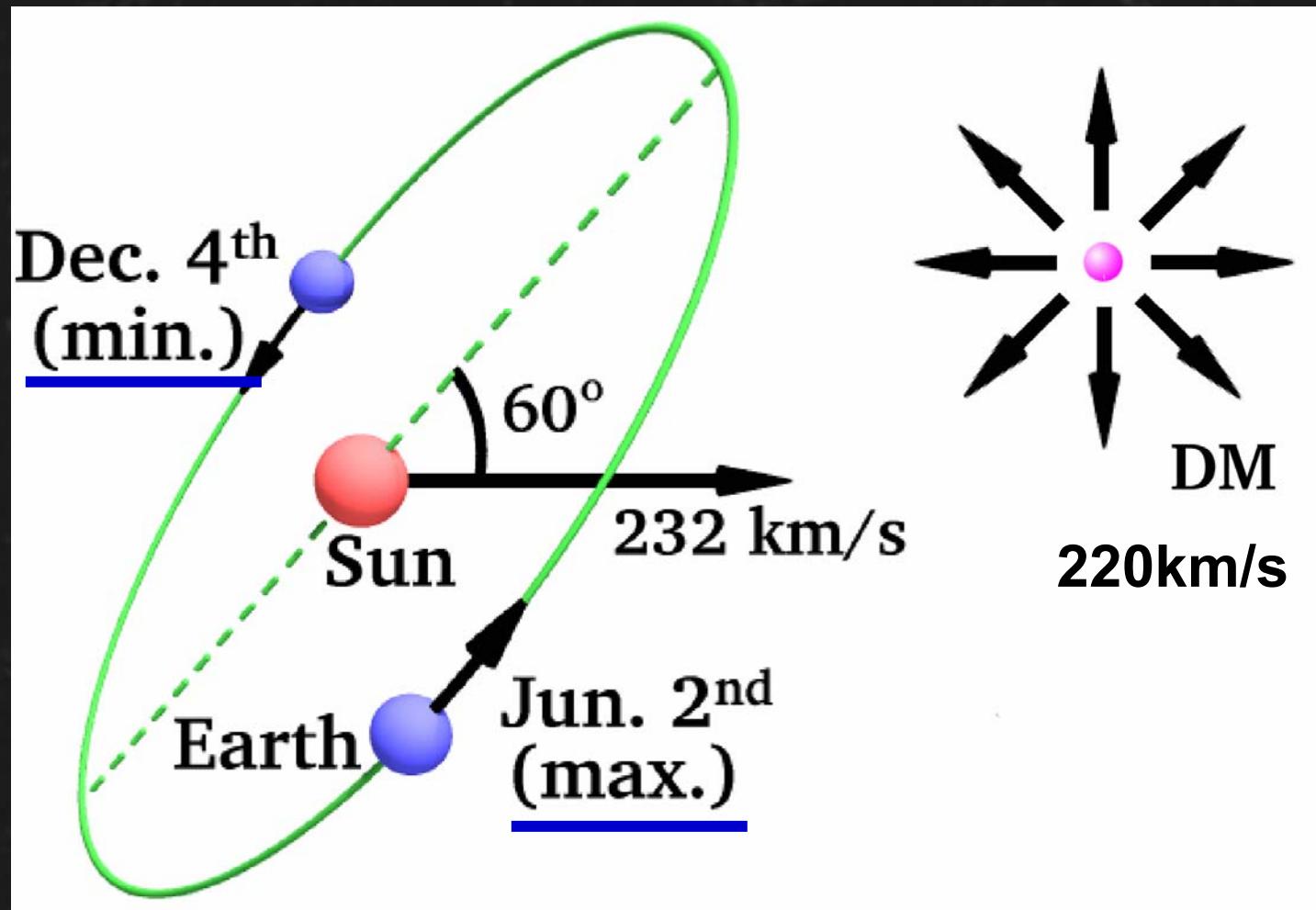


# OUTLINE

- ◆ Direction sensitive DM search
- ◆ 3D-Track Detector (Micro-TPC)
- ◆ Surface run result
- ◆ NEWAGE first run @Kamioka mine
- ◆ SUMMARY



# 1. Direction sensitive DM search “WIMP-wind” detection

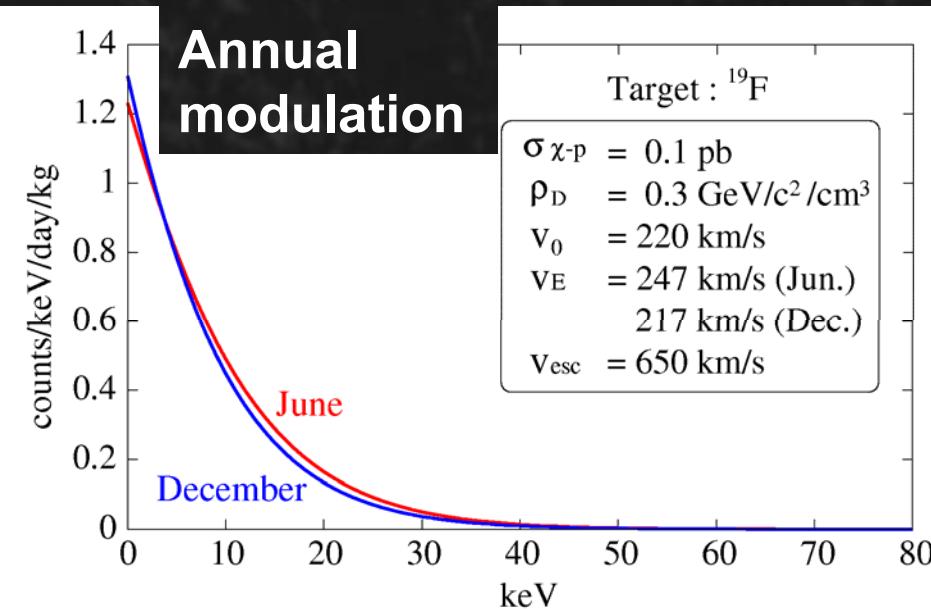


## ◆ WHY and How “Direction-sensitive” ?

- Large mass for exclusion (and indication)
- BUT Annual modulation is not enough...
- Direction-sensitive for detection

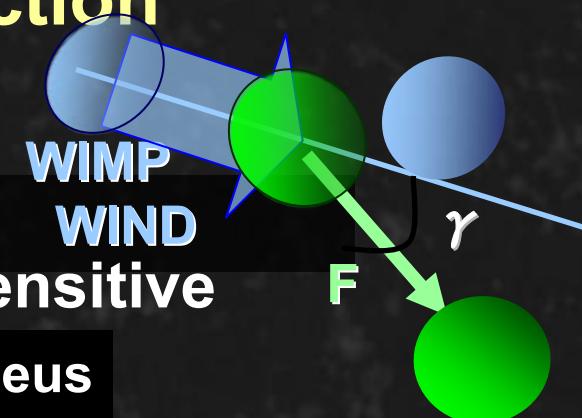
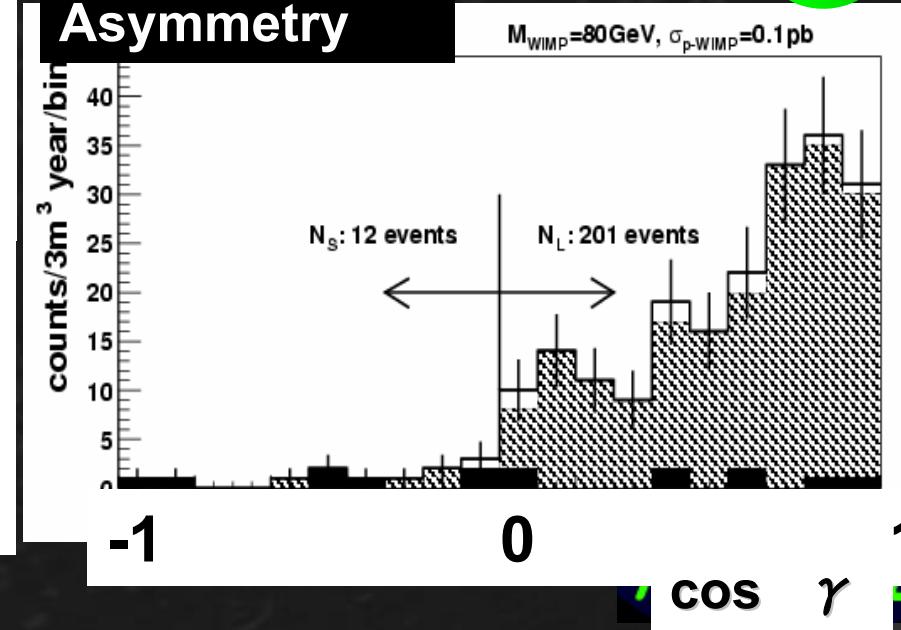
### Evidence of Dark Matter

#### Non-direction sensitive



#### Direction sensitive

#### Recoil nucleus Asymmetry



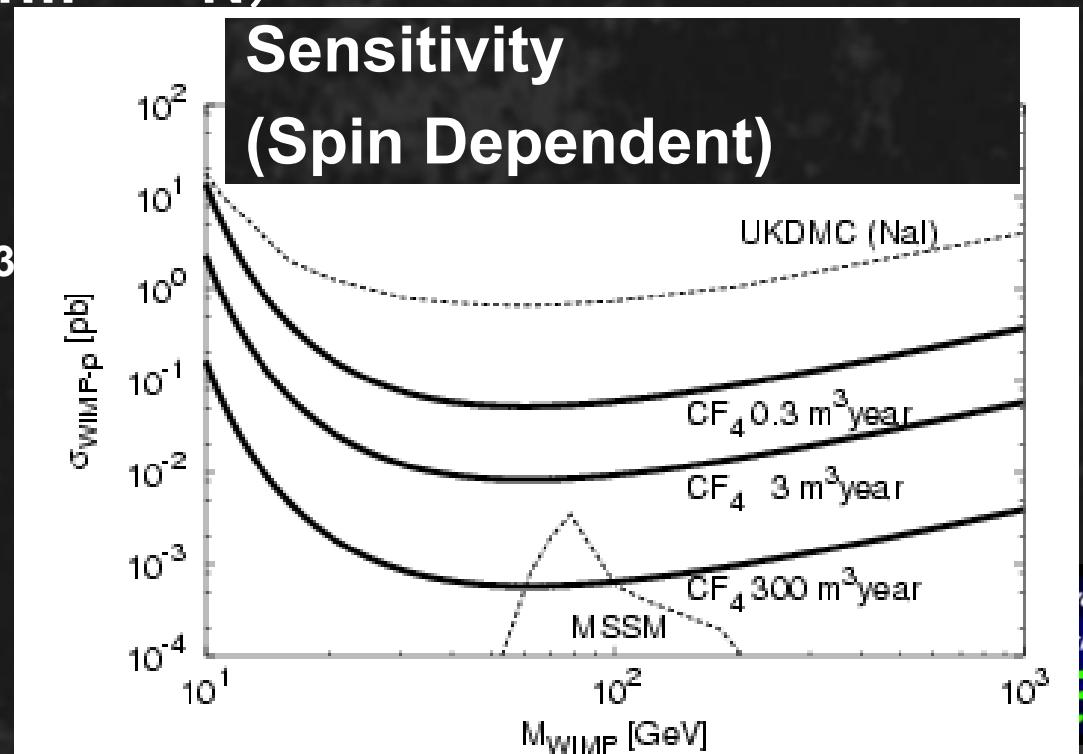
## ◆ Our Plan of direction sensitive DM search

- Gas target + 3D tracking device (next section)

- Tracking recoil nucleus
- Gamma rejection by  $dE/dx$

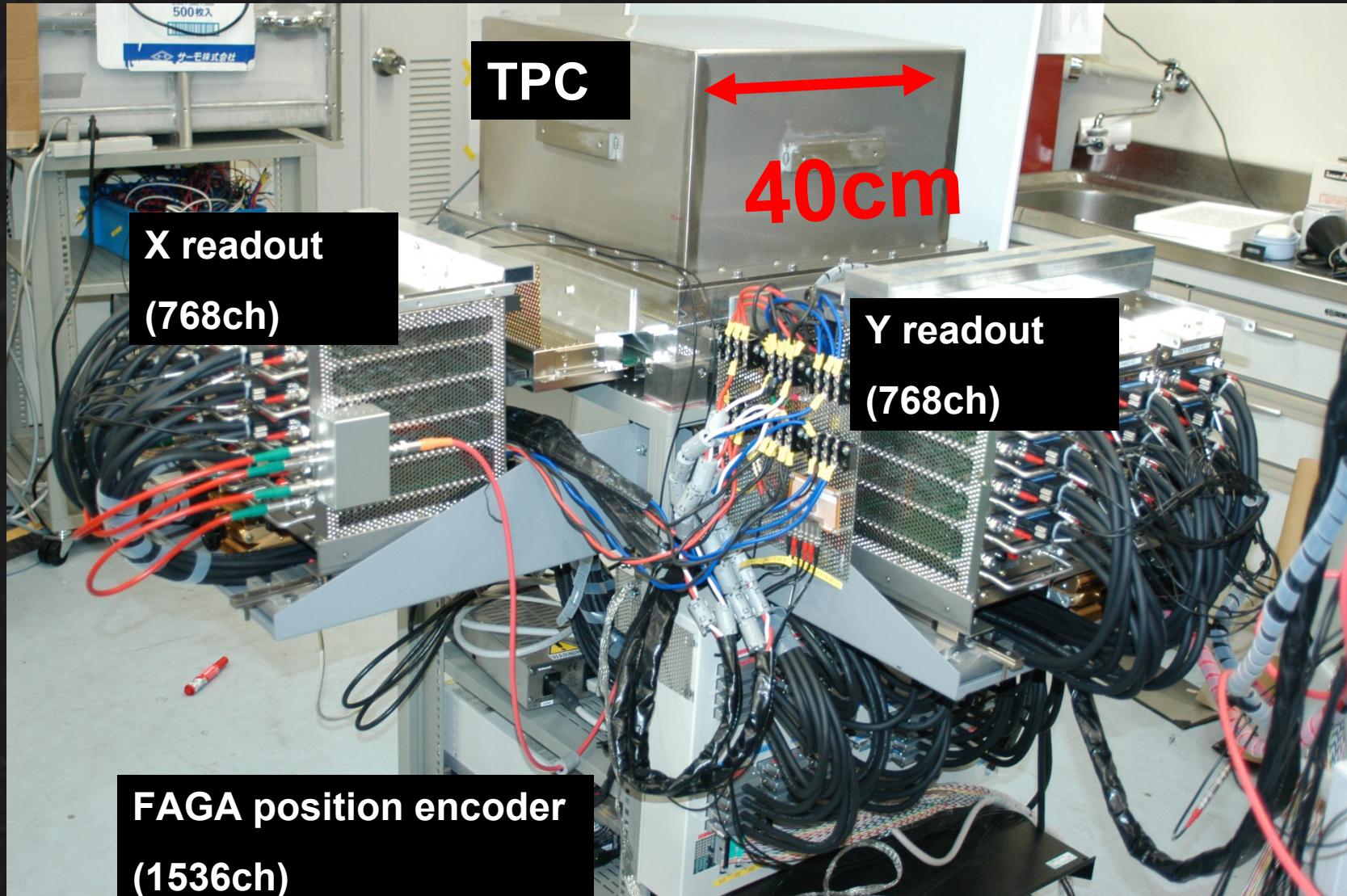
- Goal: Detect the WIMP-wind (2010~)
  - underground · low pressure (  $\text{CF}_4$  0.05 bar )
  - large volume ( $1\text{m}^3 \times N$ )

- CURRENT:
  - $\text{CF}_4$  0.2 bar
  - $23 \times 27 \times 30 \text{ cm}^3$



# 2 Detector micro-TPC (micro time projection chamber)

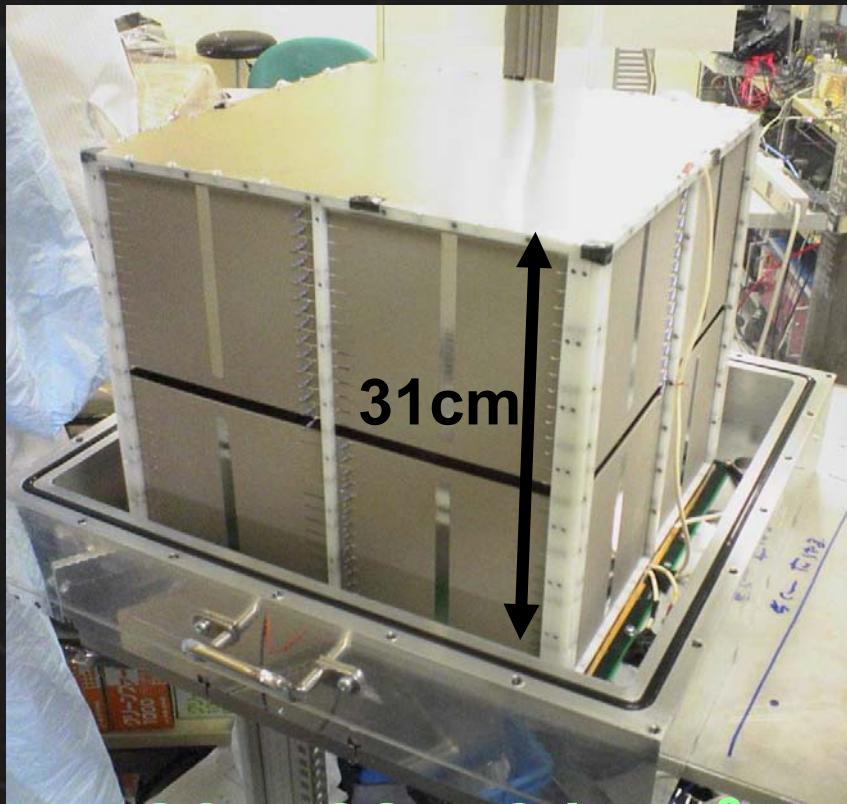
NIM A 576 (2007) 43 K.Miuchi et.al



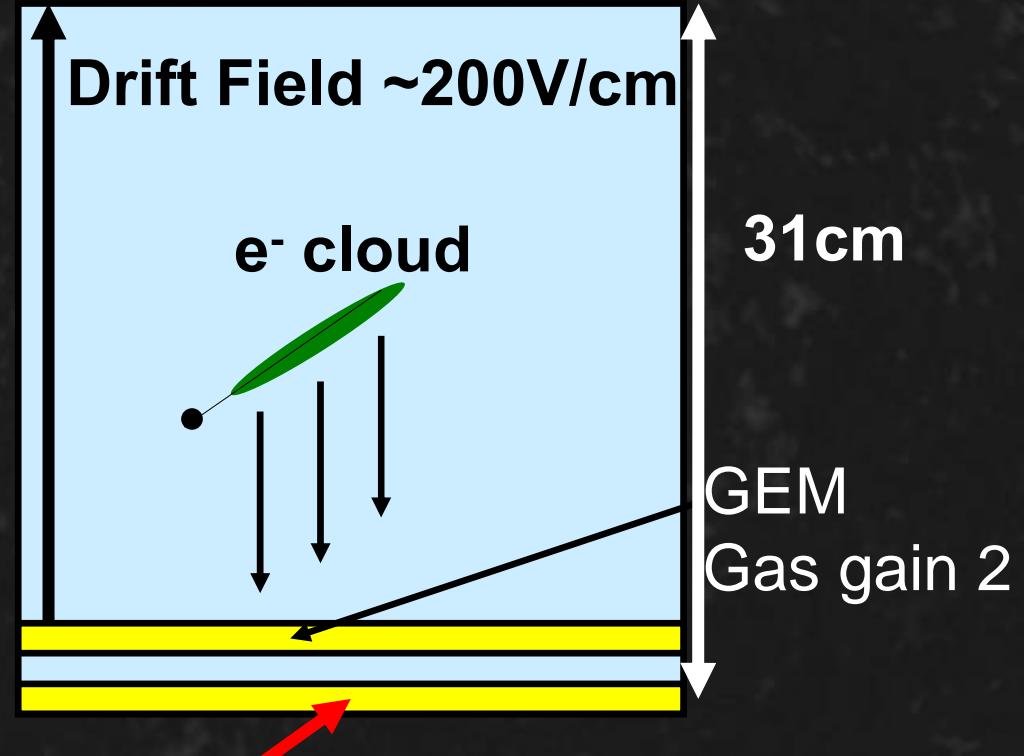
# micro-TPC principle

- **Gas volume**

- DRIFT length 31cm
- CF<sub>4</sub> 0.2bar gas, sealed



◆  $23 \times 28 \times 31\text{cm}^3$



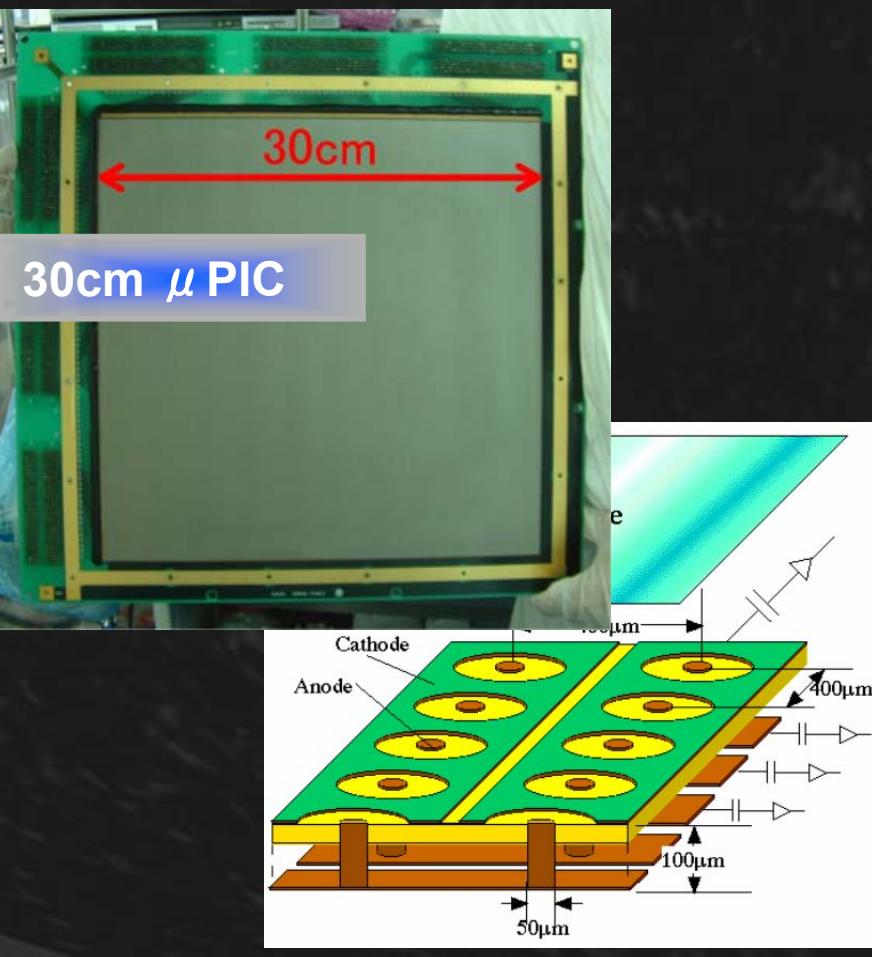
What's  $\mu$ -PIC?  
What's GEM?



## • $\mu$ -PIC (gas gain 2000)

- Micro pixel chamber
- 589,824 pixels  $400 \mu\text{m}$  pitch
- 768+768 readout

Takada et. al. NIM

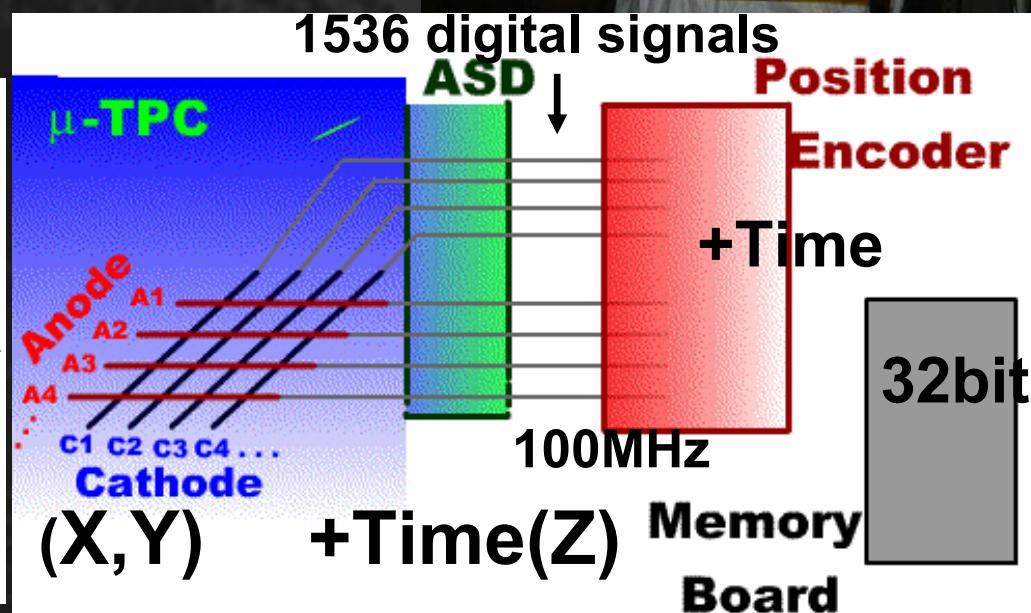


cf.F.Sauli

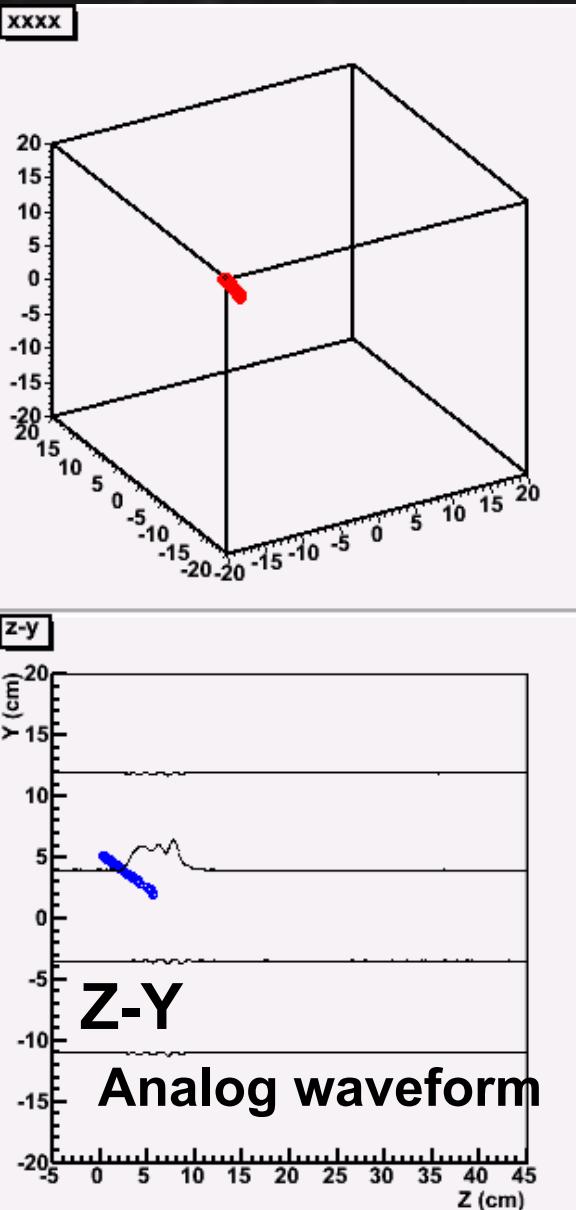
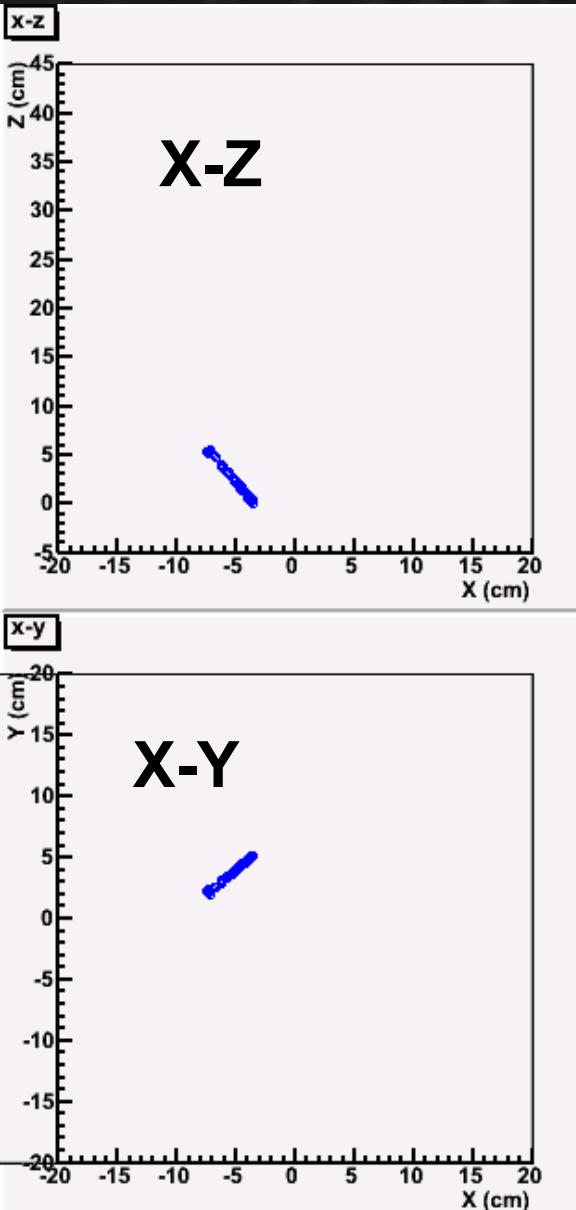
## • GEM (gas gain 1~2)

Gas electron multiplier

• 23cm × 28cm



# TPC performance tracking



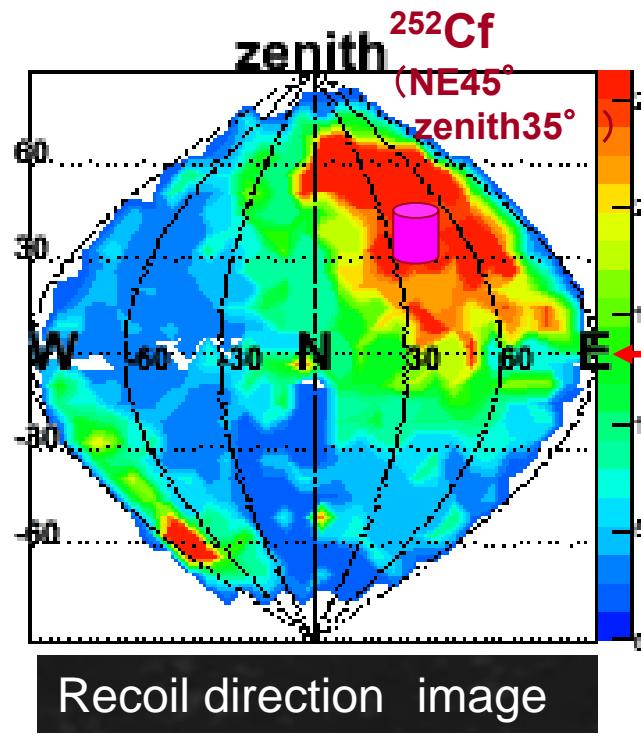
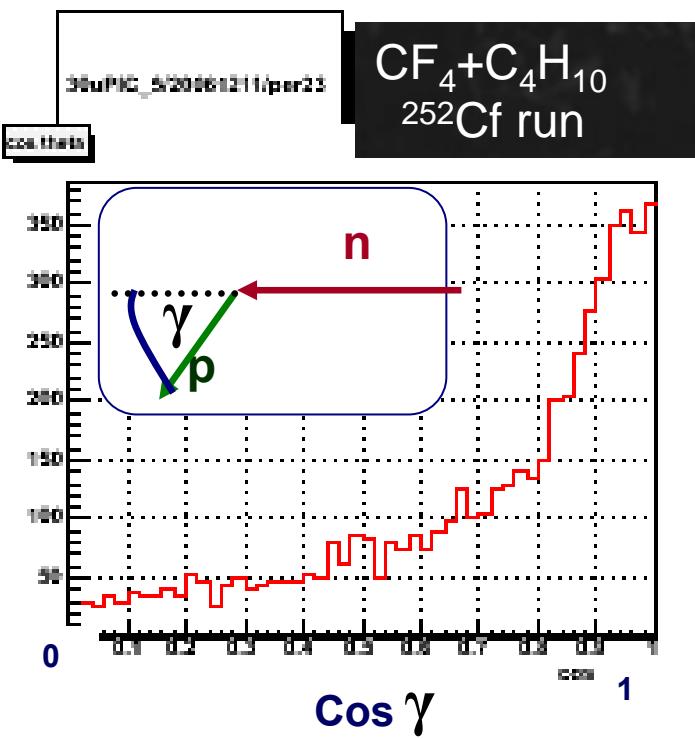
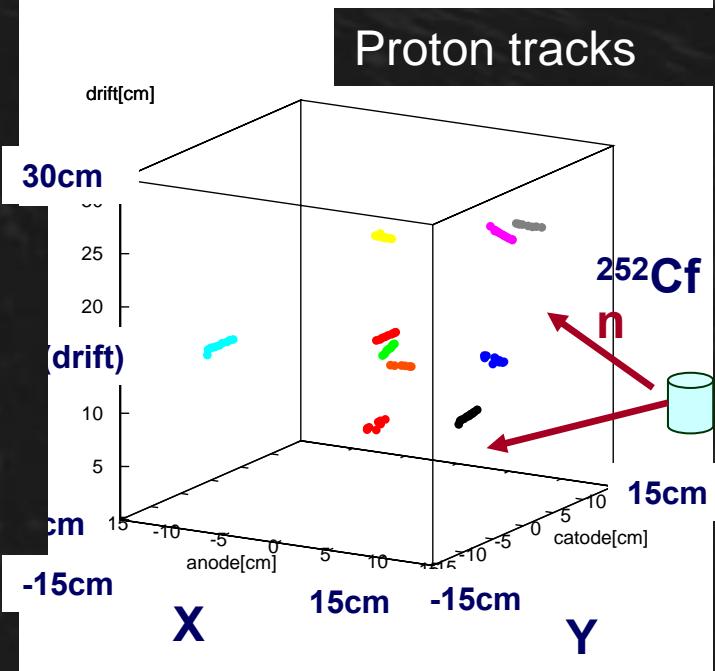
- **Example**  
Gas  $\text{CF}_4$  0.2bar  
Alpha-Particle Event  
Nhit=18  
Energy=6.5MeV  
Length=10.2cm

3D spatial resolution  
~  $800 \mu \text{m}$   
cf. F(100keV) run  $800 \mu \text{m}$

Detect both  
Track and Energy!

# TPC performance direction

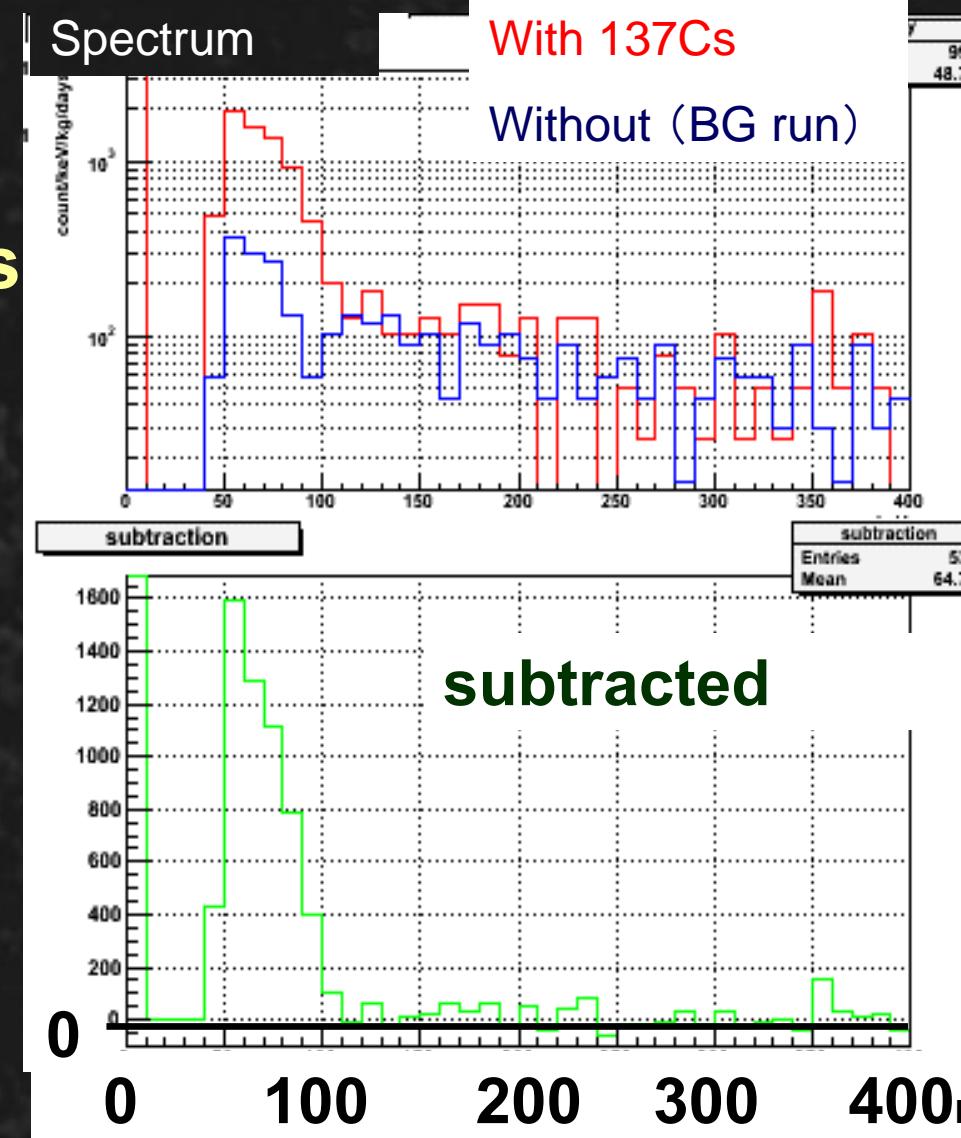
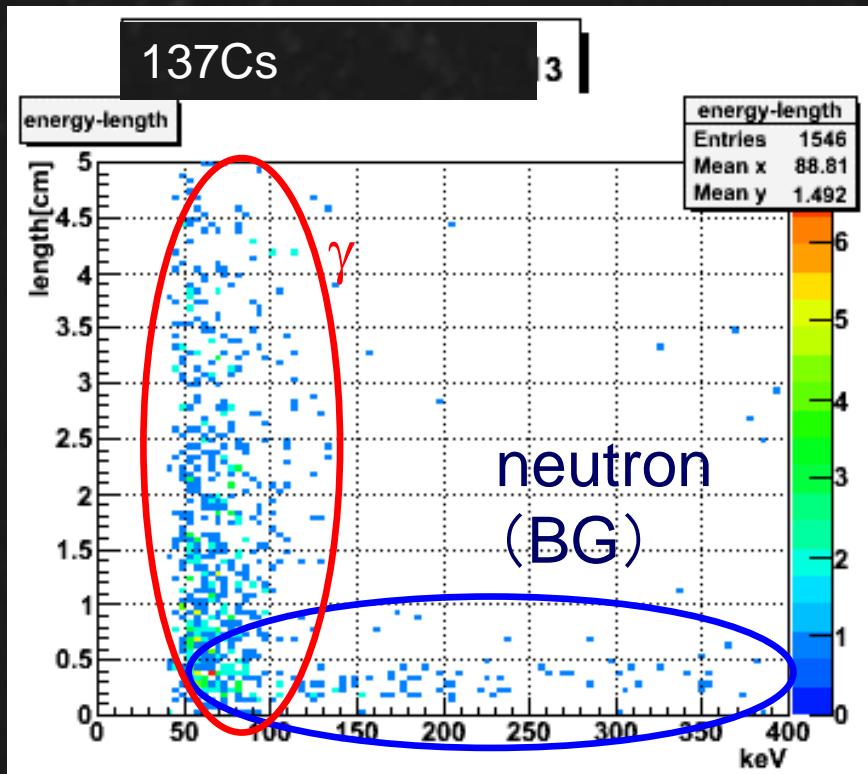
- $\text{CF}_4 + \text{C}_4\text{H}_{10}$  (9:1) 0.2bar
- Protons have longer tracks
- $n \rightarrow p$  forward scattering are seen  
(this is what we want to do with WIMP  $\rightarrow F$  scatterings)



Direction Sensitive  
WIMP-search  
**NEWAGE**

# TPC performance gamma-ray rejection

- gamma-rays from  $^{137}\text{Cs}$

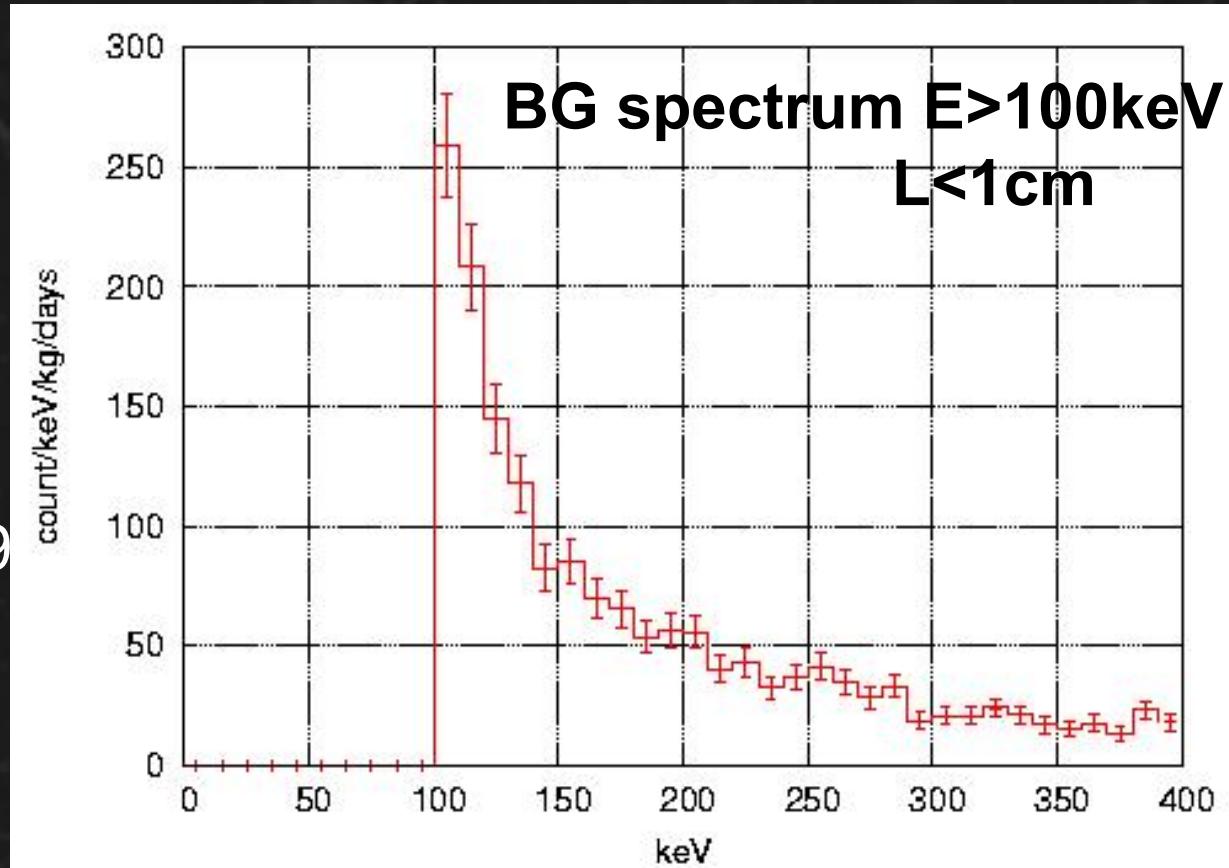


gamma efficiency  $< 2\text{e-}4$  (statistics limited)

$>100\text{keV}$

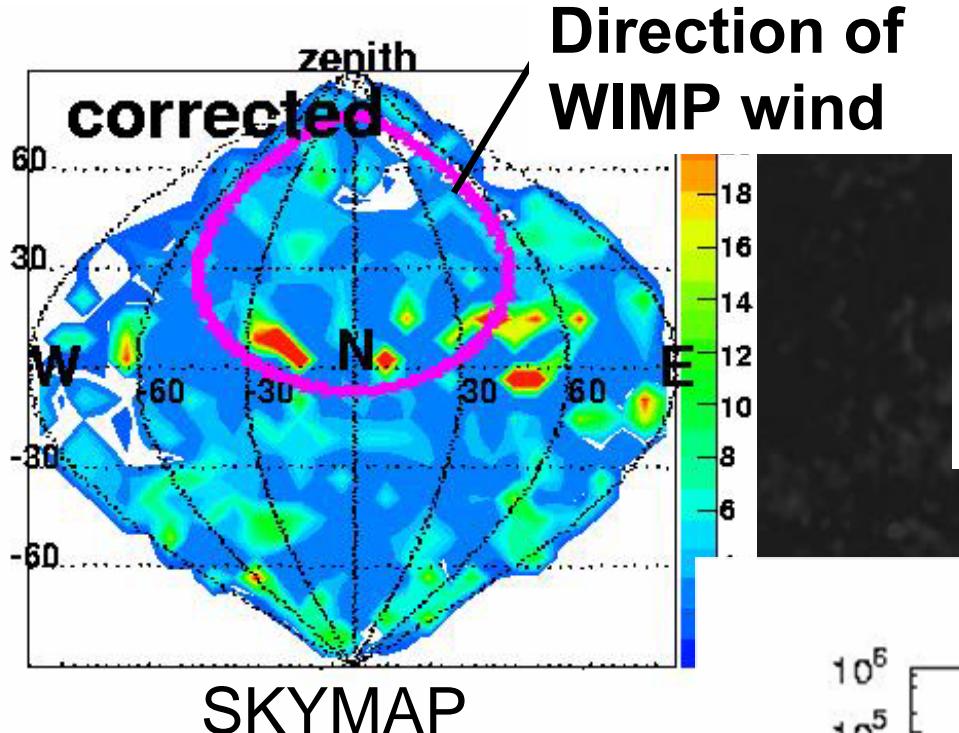
# 3 Surface Run

- 2006 Nov.1<sup>st</sup> ~ Nov.27<sup>th</sup>
- exposure 0.15 kg days
- @Kyoto university (N35.03 E135.783)

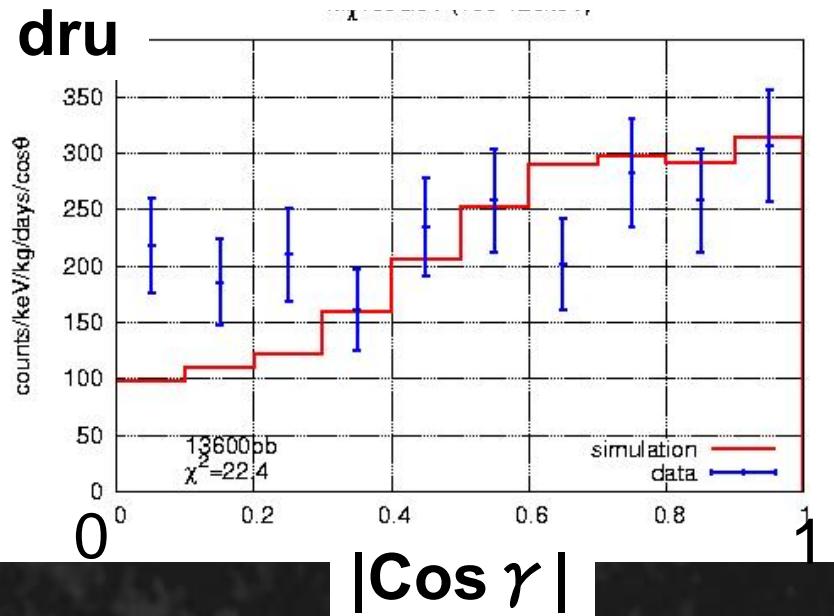


K.Miuchi et. al.  
To appear in PLB  
Preprint arXiv:0708.2529

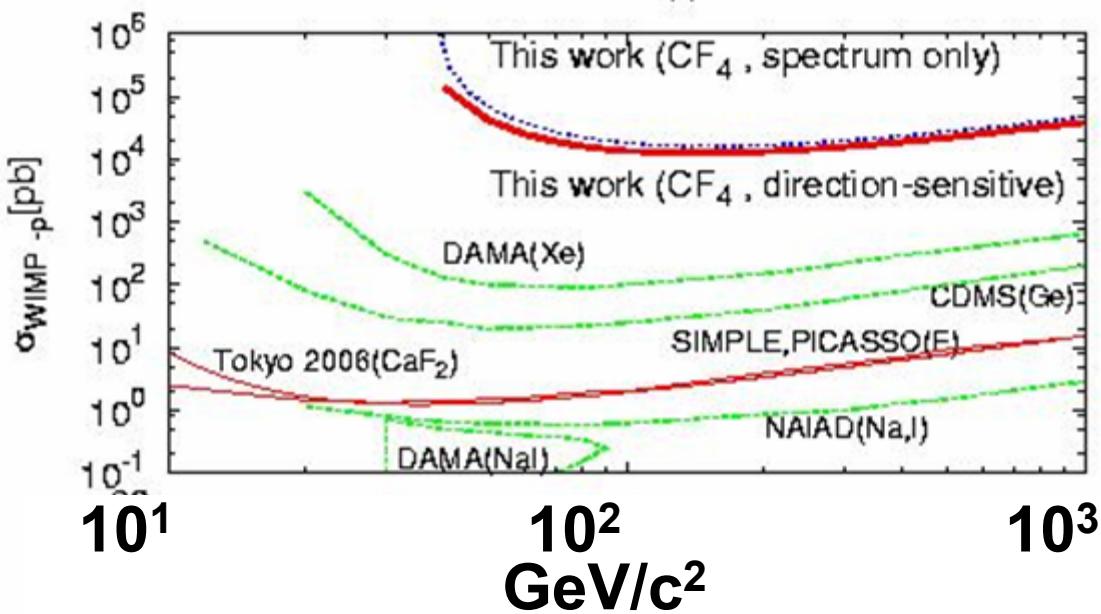
# 3 Surface Run



## Cos $\gamma$ distribution

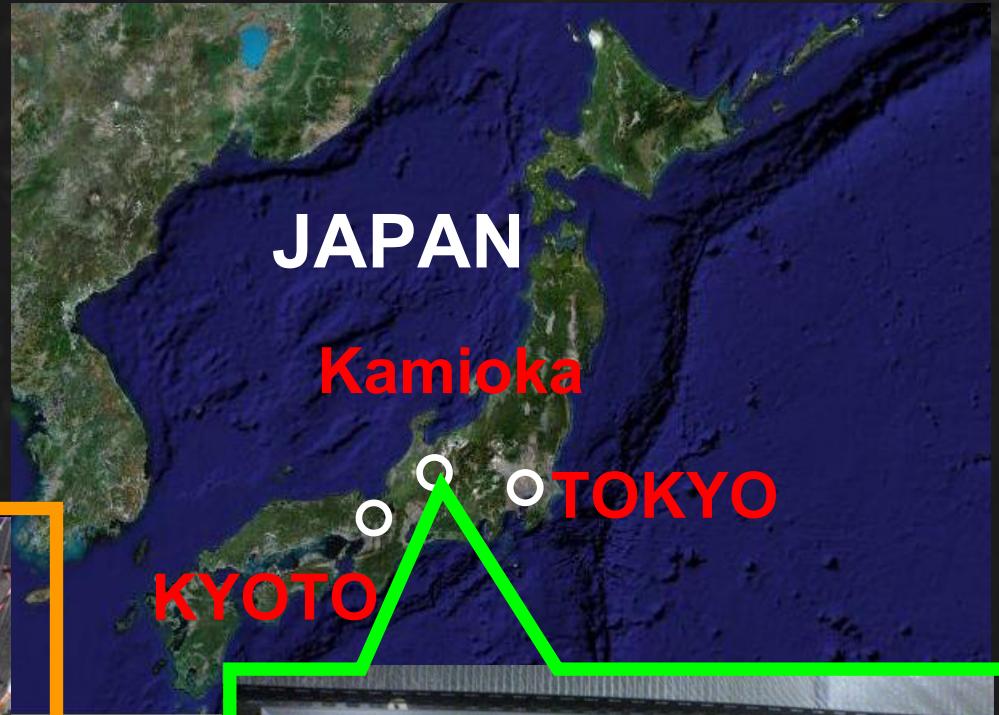
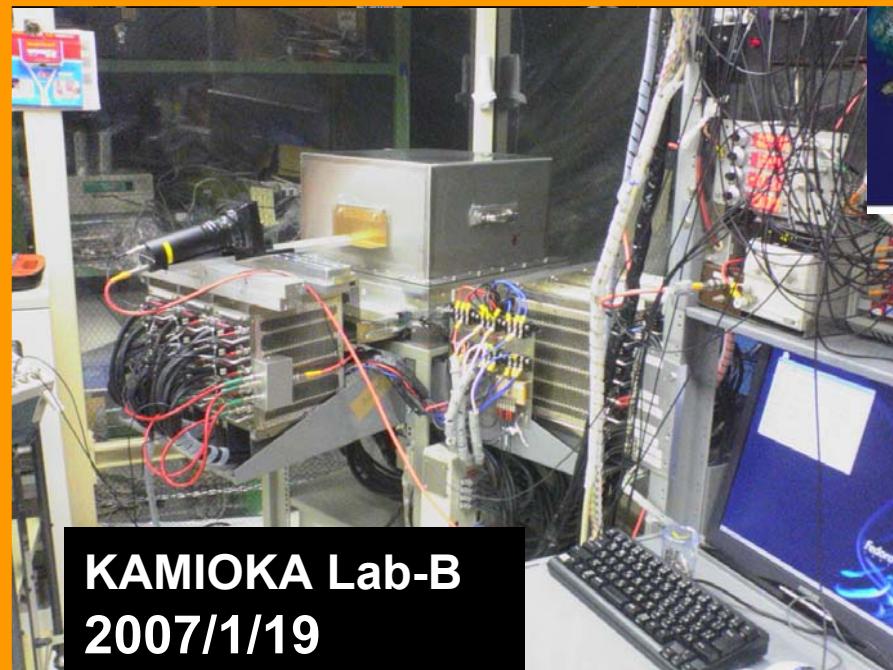


SD 90% C.L. upper limits



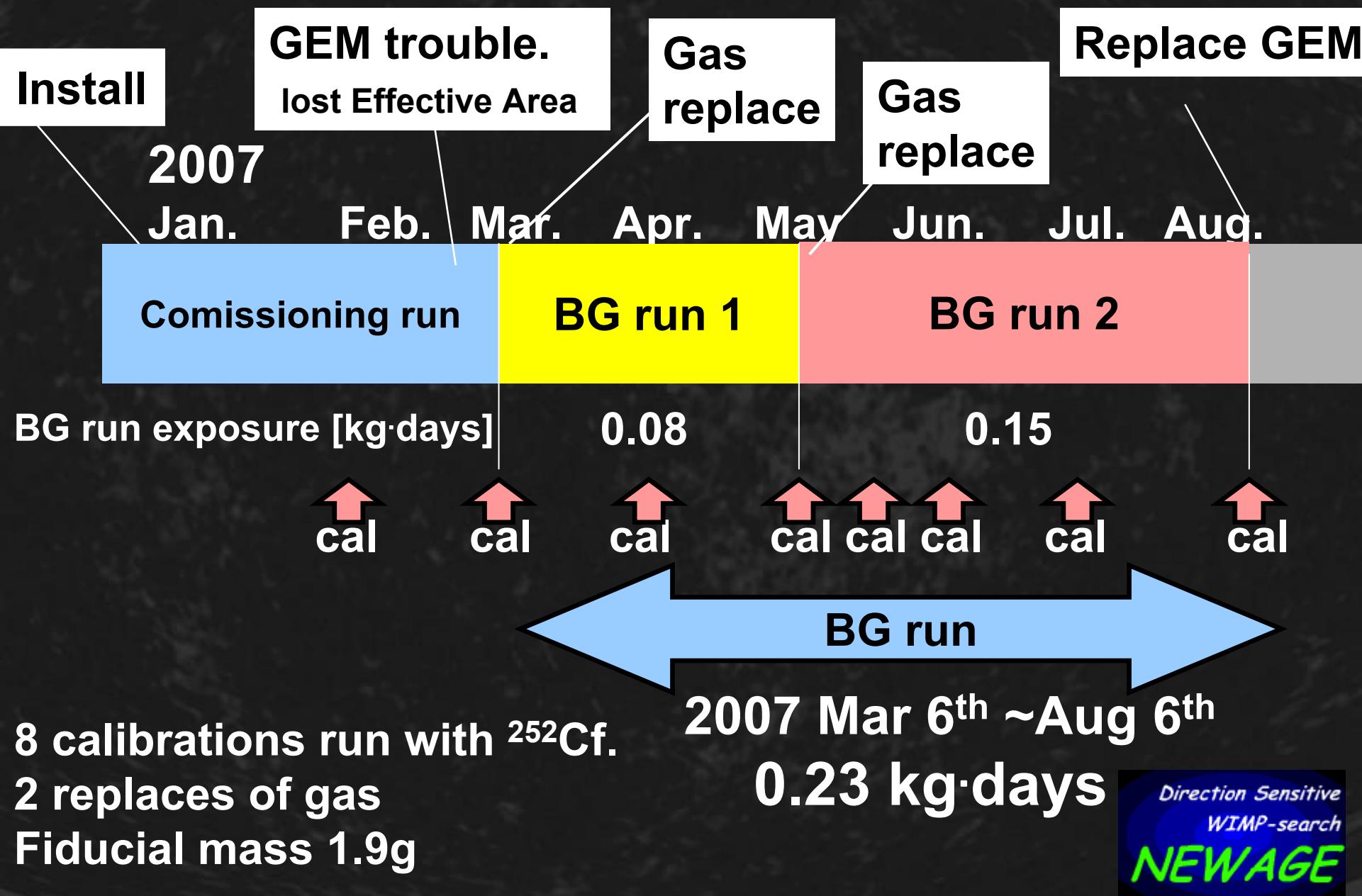
# 4 Underground run @Kamioka

- In Kamioka mine
- 2700m w.e depth
- $10^{-3}$  neutron (v.s surface)
- No shield
- Stable Operation
- Background Study

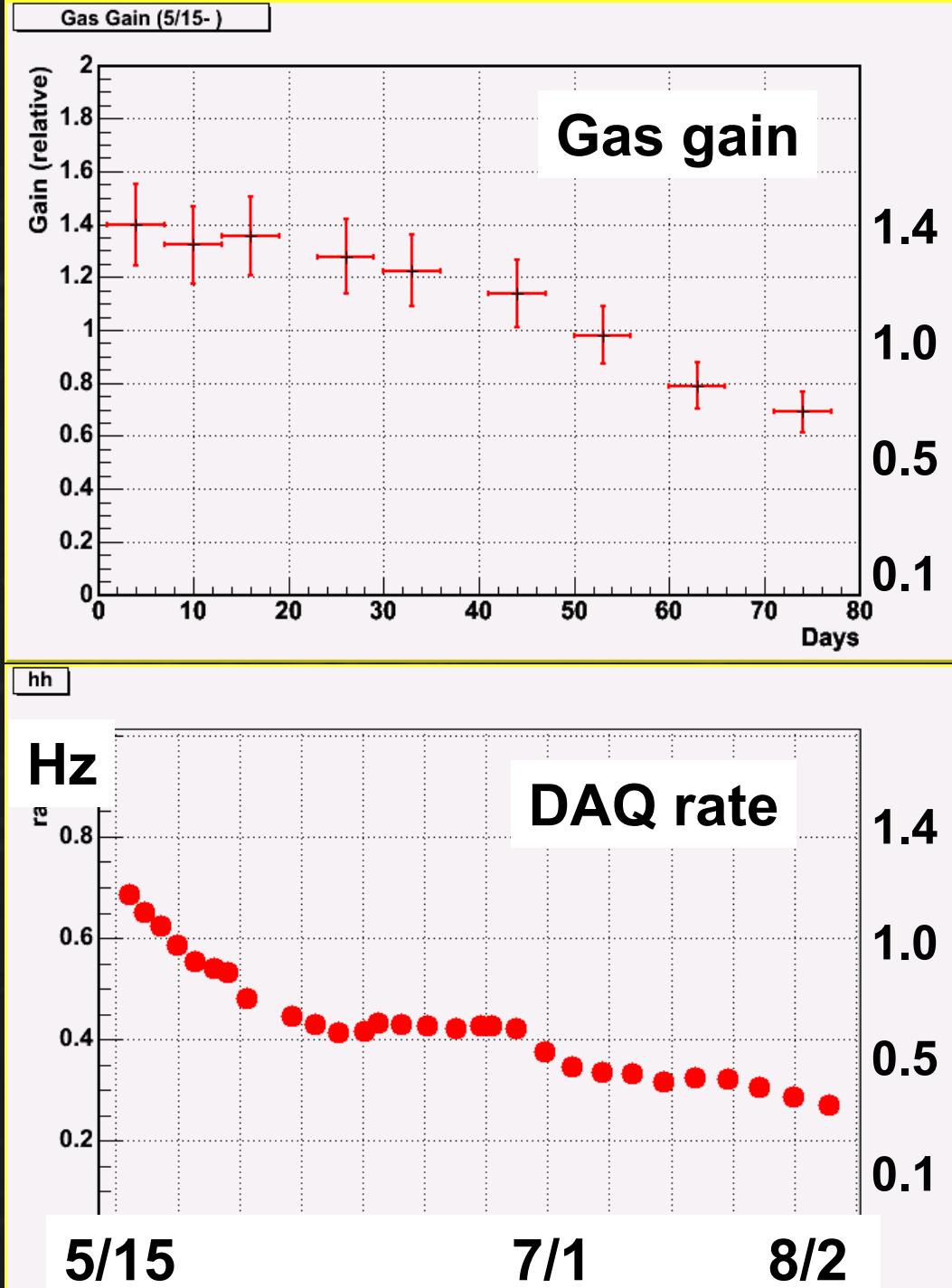


Super  
Kamiokande

# First operation report @Kamioka

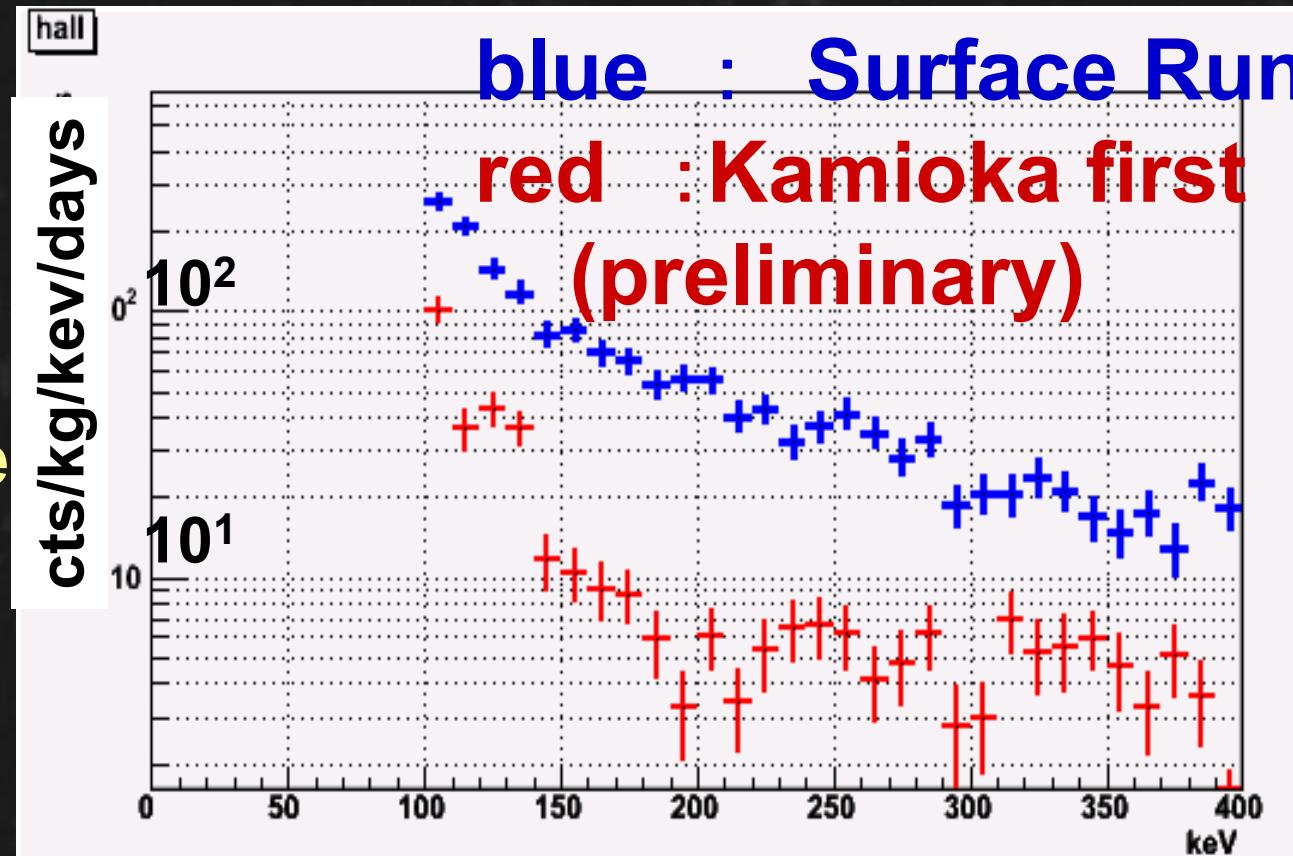


- ◆ Stability(BGrun2)
  - Gas gain &DAQ rate:
  - Slow decrease 10%~20% / month
  - correct by analysis
  - recover by replacing new gas



## ◆ Spectrum (preliminary)

- BGRUN1 + BGRUN2
- 0.23kg·days
- Length<1cm,  
 $E>100\text{keV}$
- BG decrease  
40% of surface  
@100keV



# Background Origin

- ◆ **Gamma-ray**

Rejection power ~ $10^{-4}$



Now checking

- ◆ **Neutron**

Surface : mine ~ 1: $10^{-3}$



- ◆ **alpha or heavy particle (Inside Chamber)**

- $^{222}\text{Rn}$  in U chain:
- U , Th in drift plane and GEM

now studying

## ◆ SUMMARY

- $\mu$  TPC (3D imaging device)
  - Gas: CF4: 0.2 bar
  - u-PIC + GEM sub mm

### • Result of Surface run

K.Miuchi et. al. to appear in PLB Preprint arXiv:0708.2529

### • underground run started

- Total exposure 0.23 kgday up to Aug.2007
- Event rate is 40% of surface run of @100keV
  - Now background study

## ◆ Future work

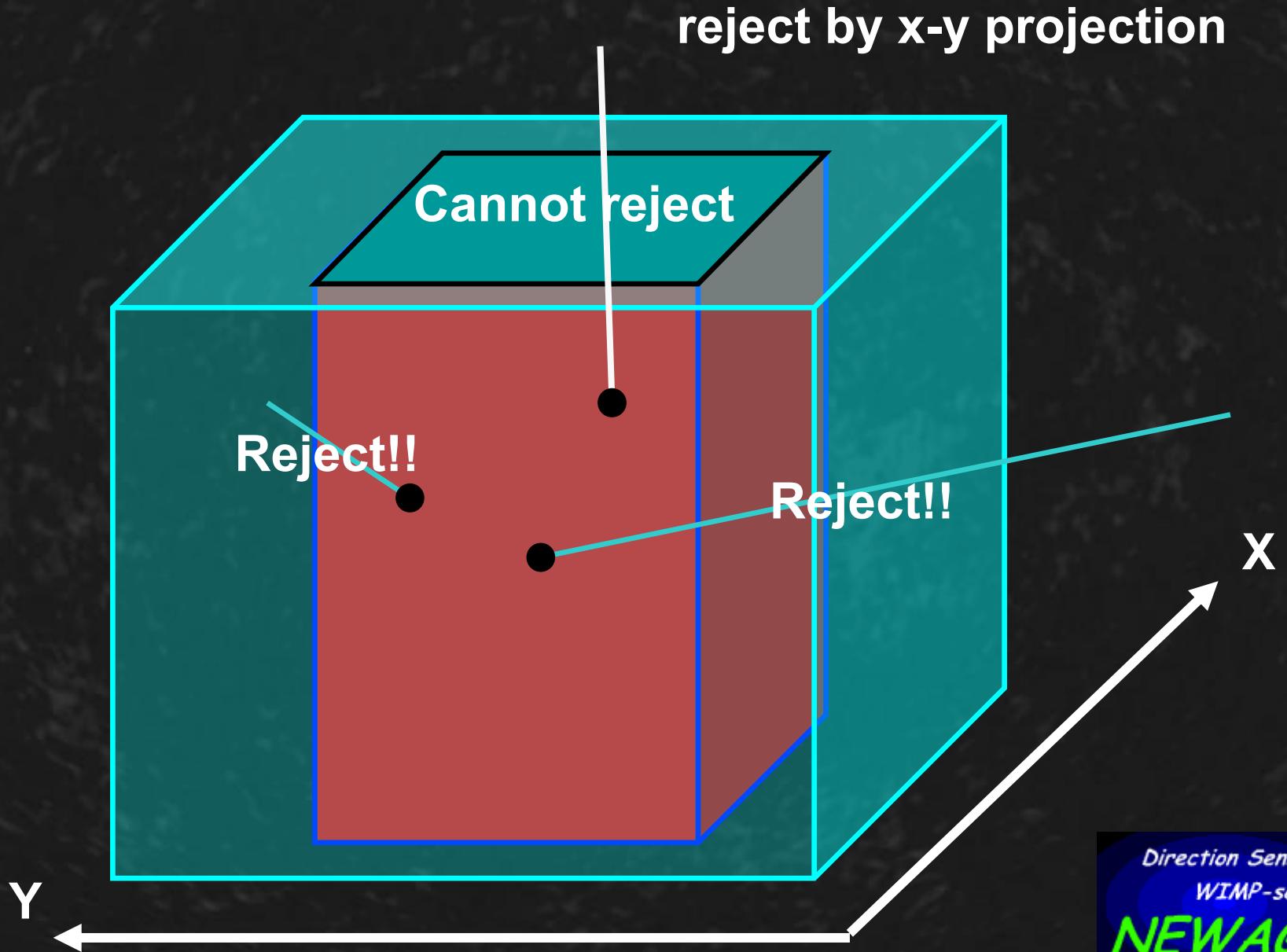
- Reduce Rn, U, Th in detector
- Larger Detector , low pressure
- Low background run



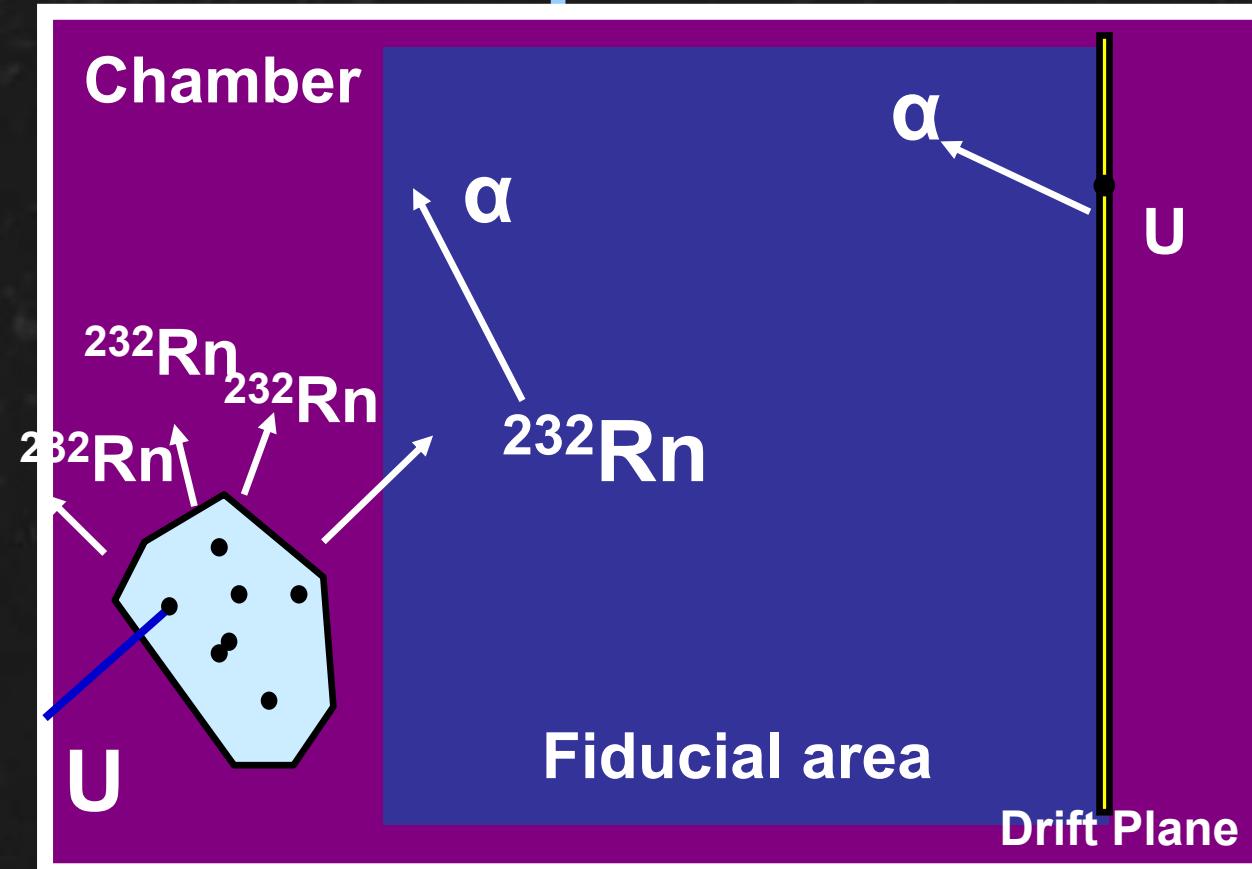
# Grazie !!



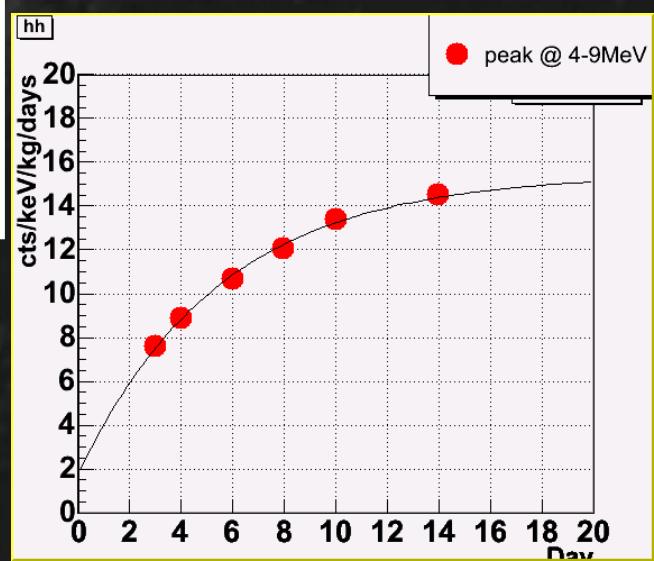
# Fiducial cut



# $^{222}\text{Rn}$ emanation and alpha from drift plane



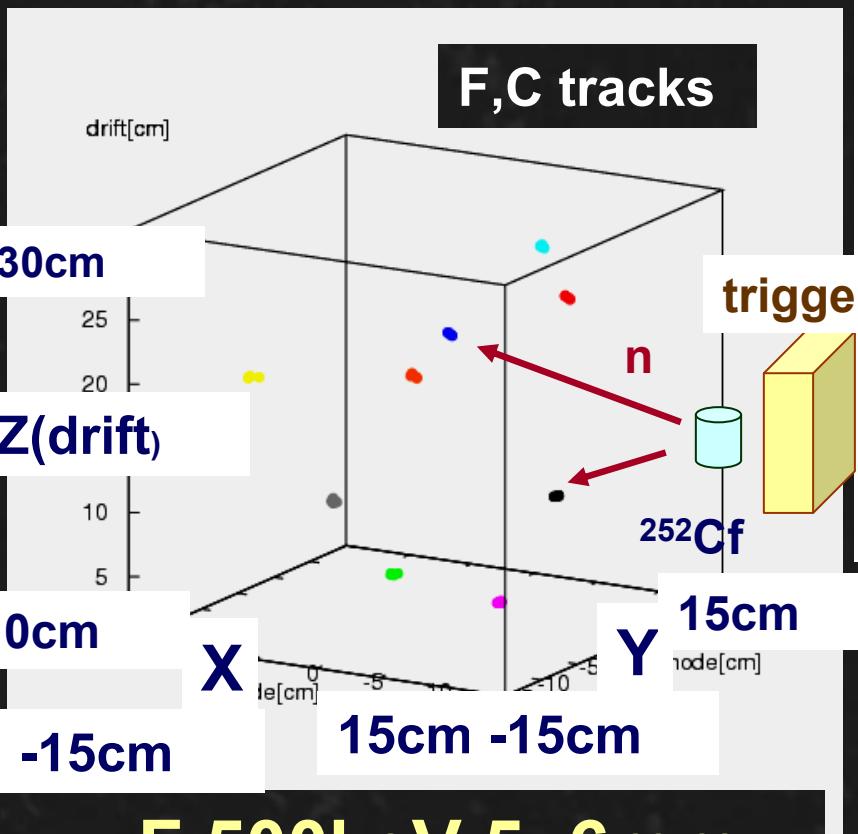
Increase of peak @ 6MeV  
With decay constant of Rn (3.8days)



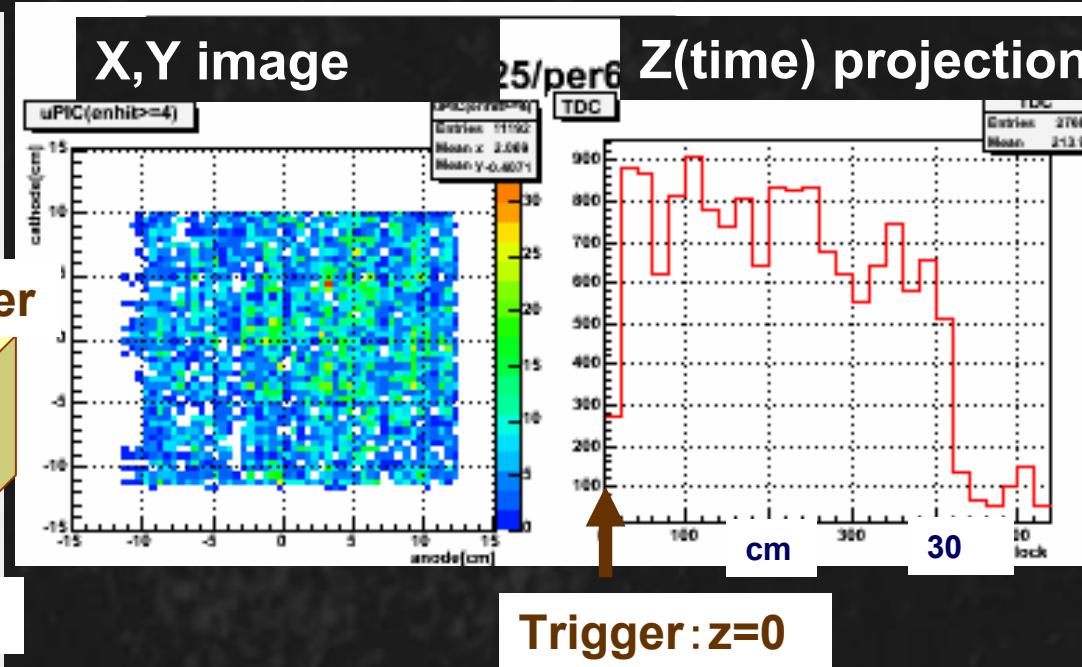
# ◆ TPC performance tracking

## • Neutron response

Preprints: physics/070118 K.Miuchi et.al



- F 500keV 5~6mm  
in 0.2atm  $\text{CF}_4$



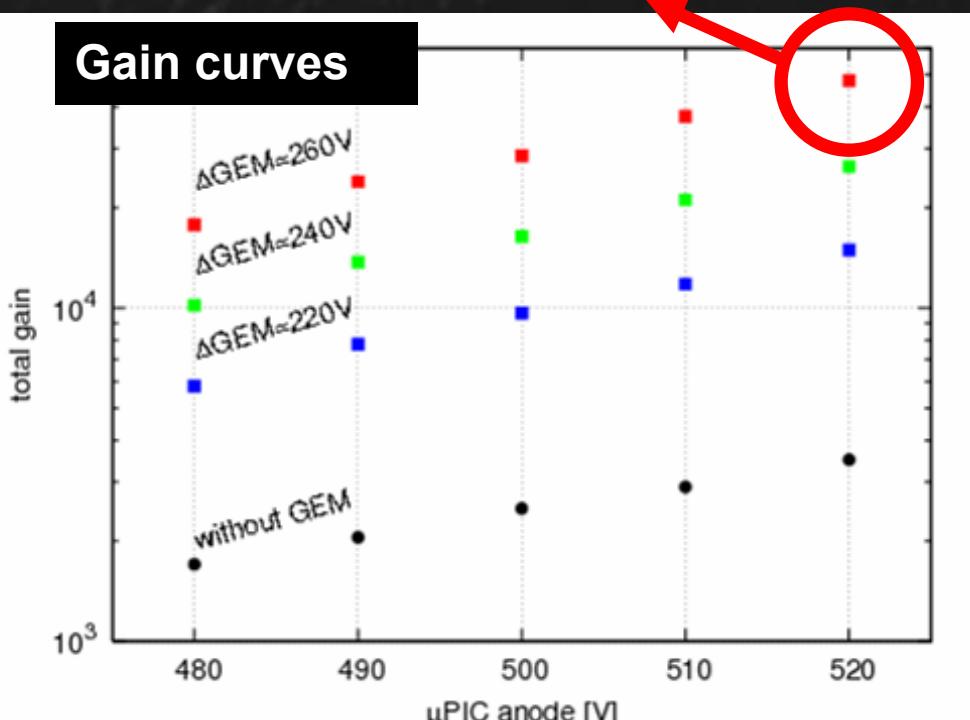
- Fiducial  $24 \times 21.5 \times 31\text{cm}^3$   
( $\text{CF}_4$  8.9g)  
FLAT response



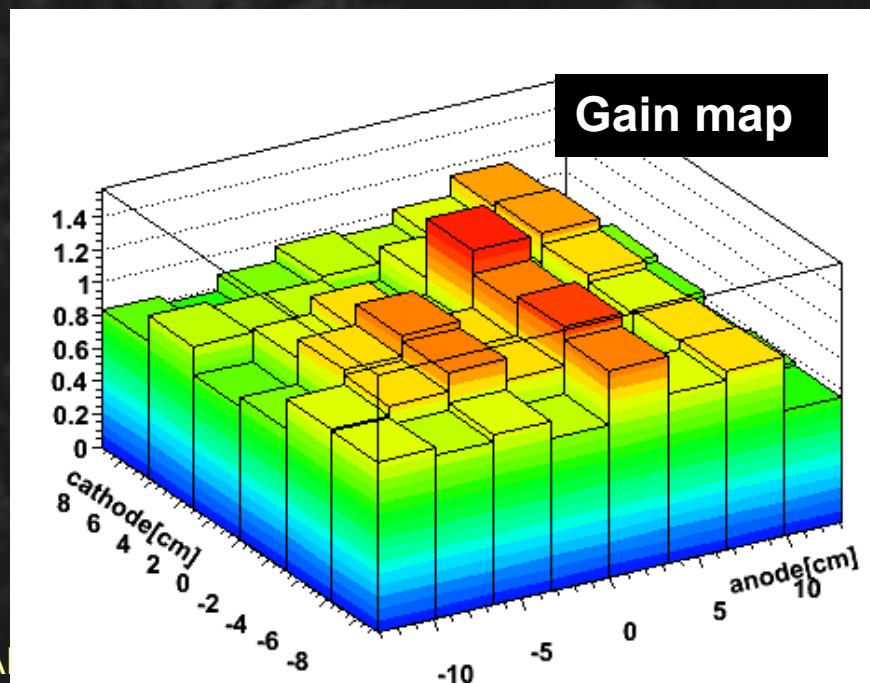
## ◆ TPC performance (with Ar+C<sub>2</sub>H<sub>6</sub> gas)

### ● Gas gains

- operation gain for MIPs ~50,000



- Gain uniformity
  - Maximum / minimum = 2.2



# Sensitivity to WIMPs



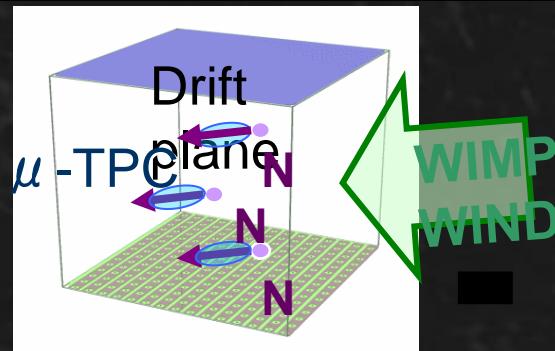
## Properties of $\mu$ TPC

Track length threshold : 3 mm

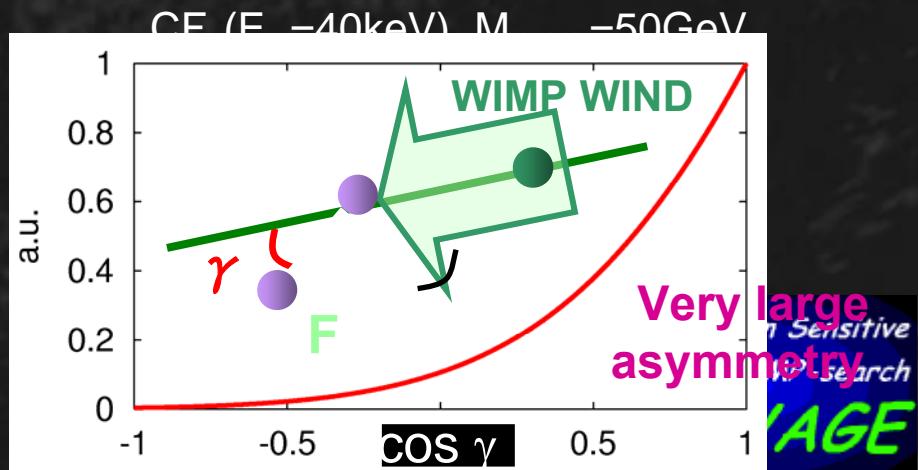
$dE/dx$  threshold : 10 keV/cm

with electron/nuclear recoil discrimination ability  
recoil direction sensitivity (Bragg curves)

gas	Pressure [Torr]	Density [g/m <sup>3</sup> ]
Xe	5	38
CF <sub>4</sub>	20	90



Need to study  
low-pressure  $\mu$ TPC

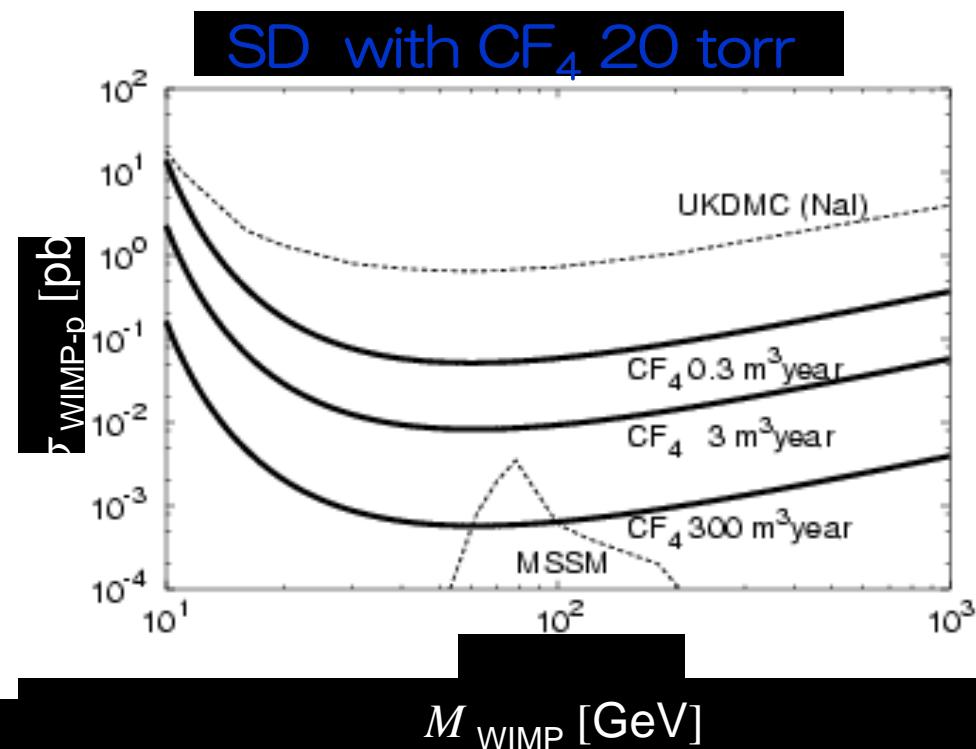
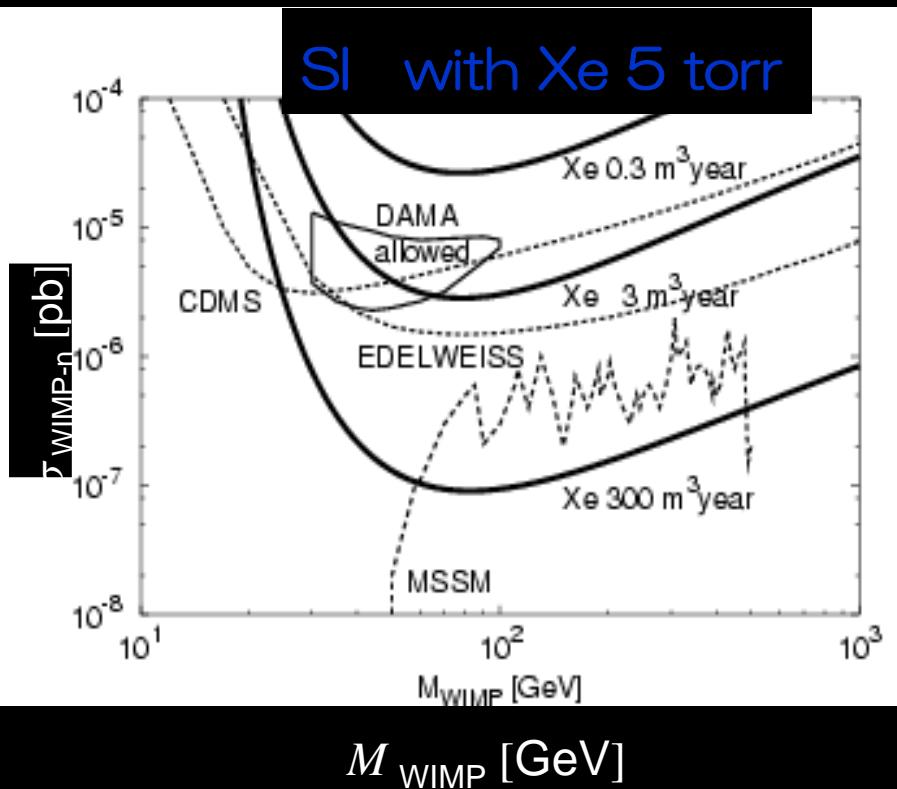


# Sensitivity to WIMPs



“Detection” by Forward/Backward  $3\sigma$  asymmetry

At Kamioka Observatory (1000 m.w.e)



0.3 m<sup>3</sup>year exposure reach the best sensitivity.

300 m<sup>3</sup>year exposure will test the MSSM prediction.

# 検出器応答

## ・ エネルギー校正

- ・ ガラスに蒸着した<sup>10</sup>B ( 厚さ $0.6\mu\text{m}$  )
- ・ ドリフトケージ内部にセット、外から<sup>252</sup>Cfの中性子を減速して照射
- ・  $^{10}\text{B}(\text{n},\alpha)^{7}\text{Li}$  反応 ( $Q=2.70\text{MeV}$     $1.8\text{MeV}$  for  $\alpha$ )
- ・ 原子核による校正、低エネルギーへの線形性は別途確認示す必要あり
- ・ 現状では、校正には6時間程度、見せれる絵には12時間程度かかっている

