NEWAGE

-- A direction-sensitive dark matter search

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@GALAXY Solar system

@EARTH "WIND" of WIMPs

microTPC

nucleus

"Sea" of WIMPs

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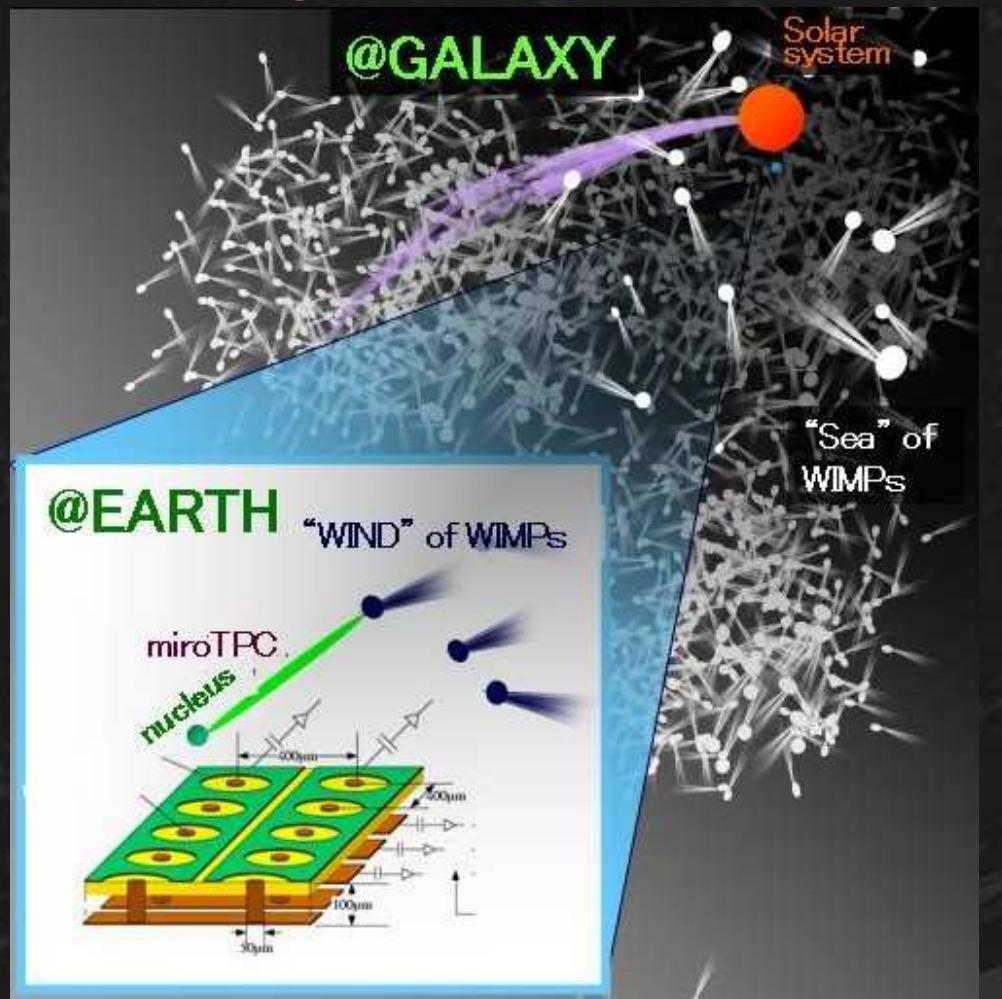
OUTLINE

- **Direction sensitive DM search**
- **Micro-TPC**
- **NEWAGE surface run**
- **FUTURE PLANS & SUMMARY**

# 1. Direction sensitive DM search "WIMP-wind" detection

PLB 578 (2004) 241

@GALAXY

SOLAR SYSTEM
220 km/s

WIMP
V0 =230 km/s

@EARTH "WIND" of WIMPs

miroTPC

nucleus

The WIMP-wind

Direction Sensitive
WIMP-search
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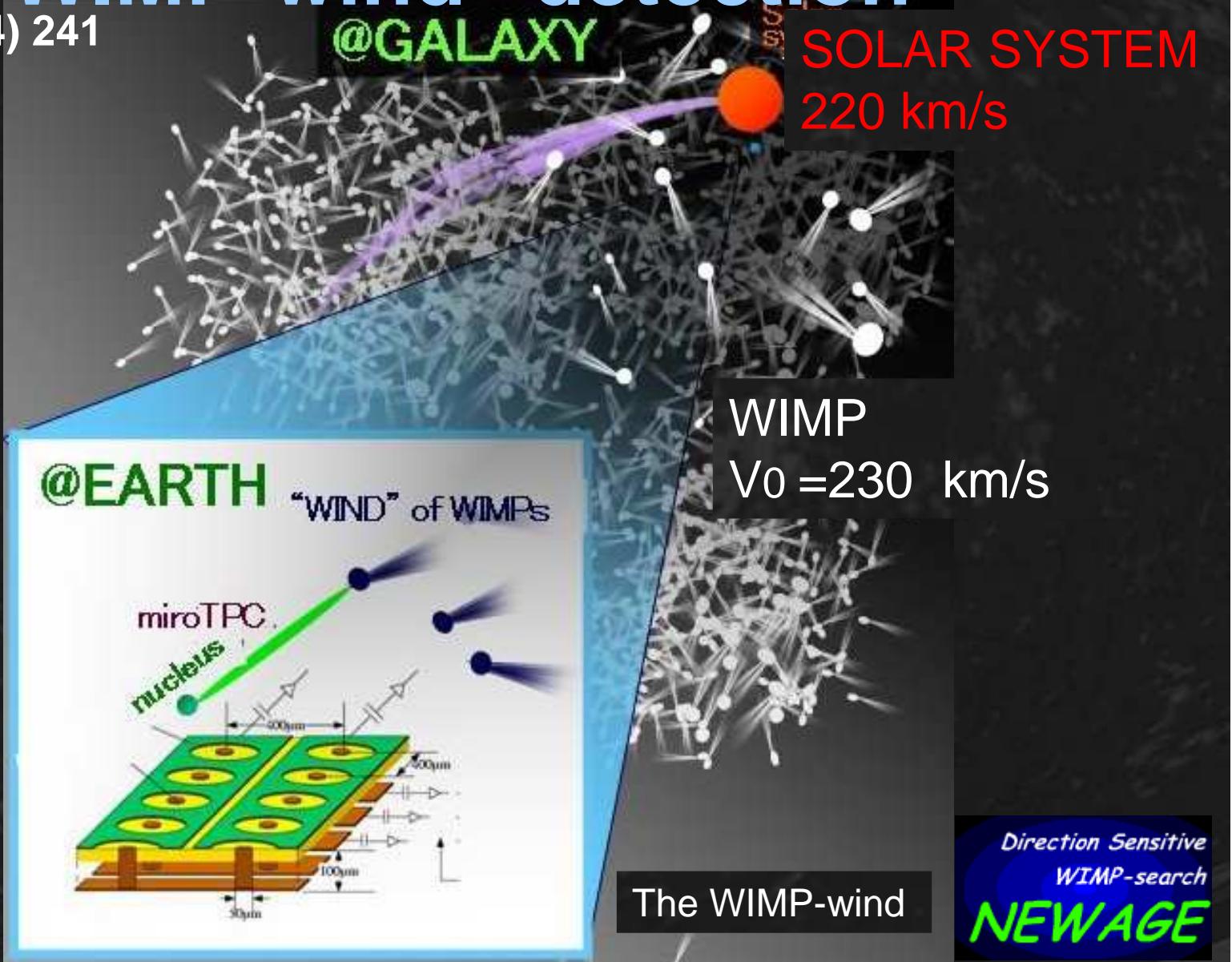
WHY "Direction-sensitive" ?

- **Large mass for exclusion** (and indication)

- **BUT Annual modulation is not enough…**
- **Direction-sensitive for detection**

Annual modulation

Target : ^{19}F

$\sigma_{\chi\text{-}p}$ = 0.1 pb
ρ_D = 0.3 GeV/c^2 /cm^3
v_0 = 220 km/s
v_E = 247 km/s (Jun.)
           217 km/s (Dec.)
v_{esc} = 650 km/s

June

December

WIMP WIND

direction

M_{WIMP}=80GeV, $\sigma_{\chi\text{-}WIMP}$=0.1pb

N_B: 12 events N_L: 201 events

F

γ

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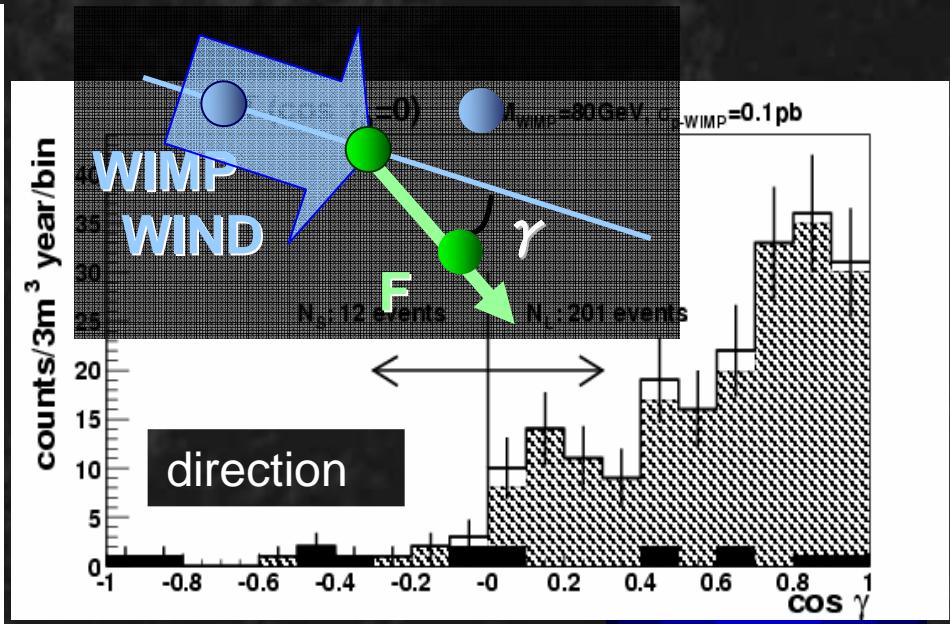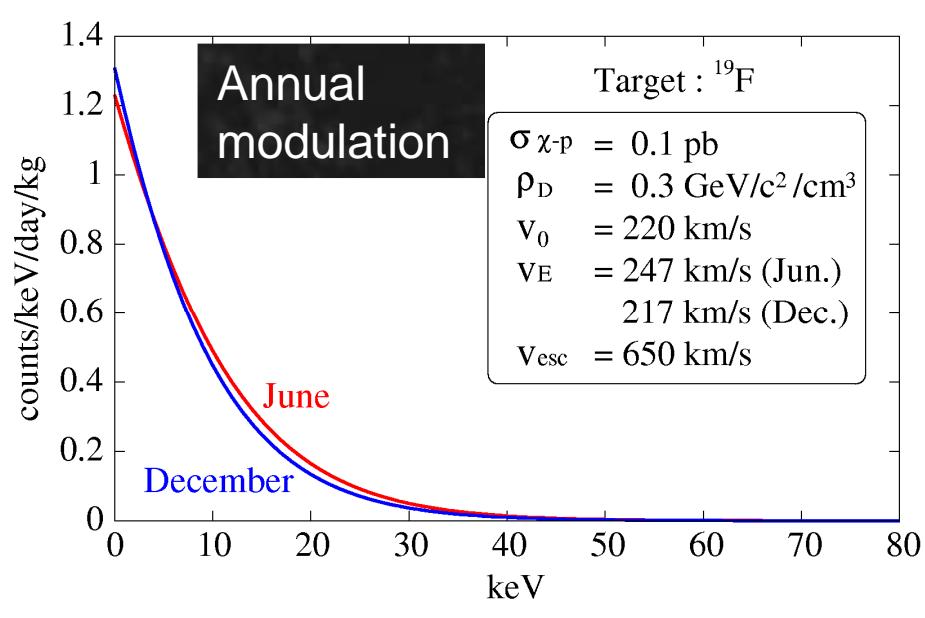
Sensitivities

Goal: Detect the WIMP-wind （2010~）

- underground・low pressure (CF_4 0.05 bar)・large volume （1m³ × N）

CURRENT:

- surface・CF_4 0.2 atm ・30cm cube

SD 3σ detection sensitivities

sensitivity

UKDMC (NaI)

CF_4 0.3 m³year

CF_4 3 m³year

CF_4 300 m³year

MSSM

σ_{WIMP-p} [pb]

M_{WIMP} [GeV]
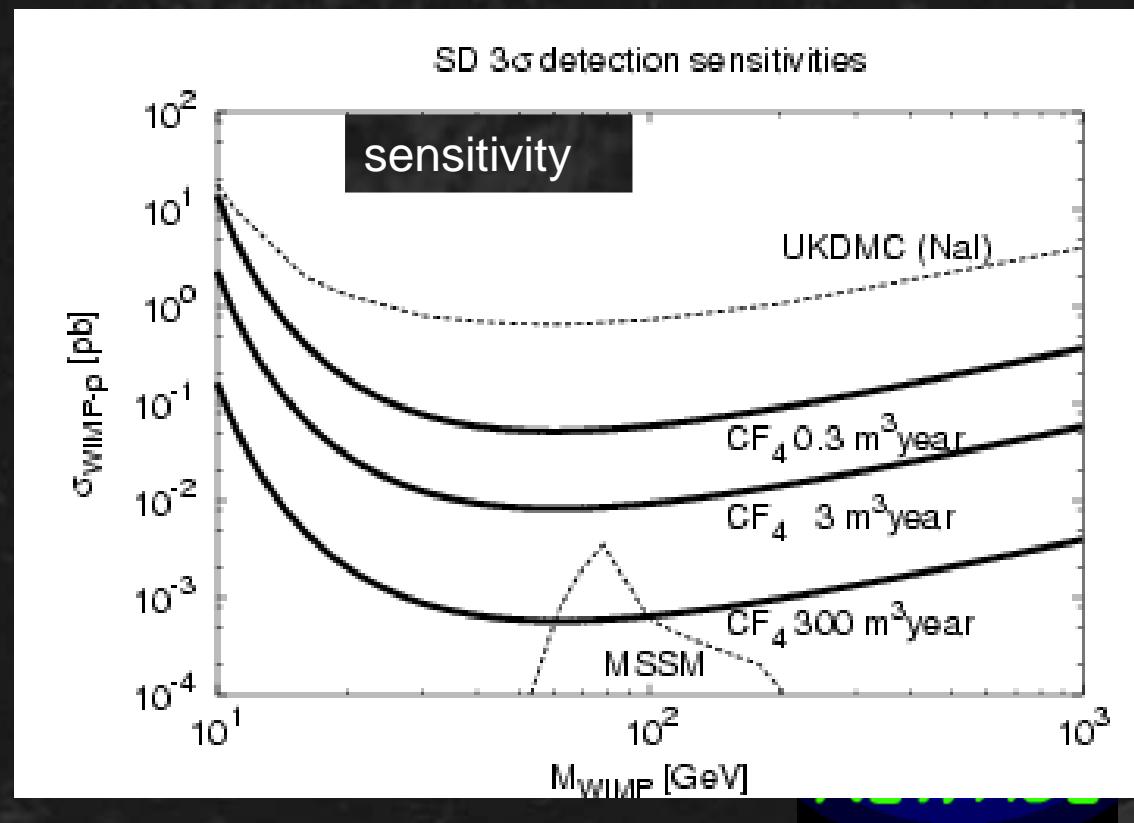
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2 micro-TPC (3D tracking device)

- $23 \times 28 \times 31 cm^3$
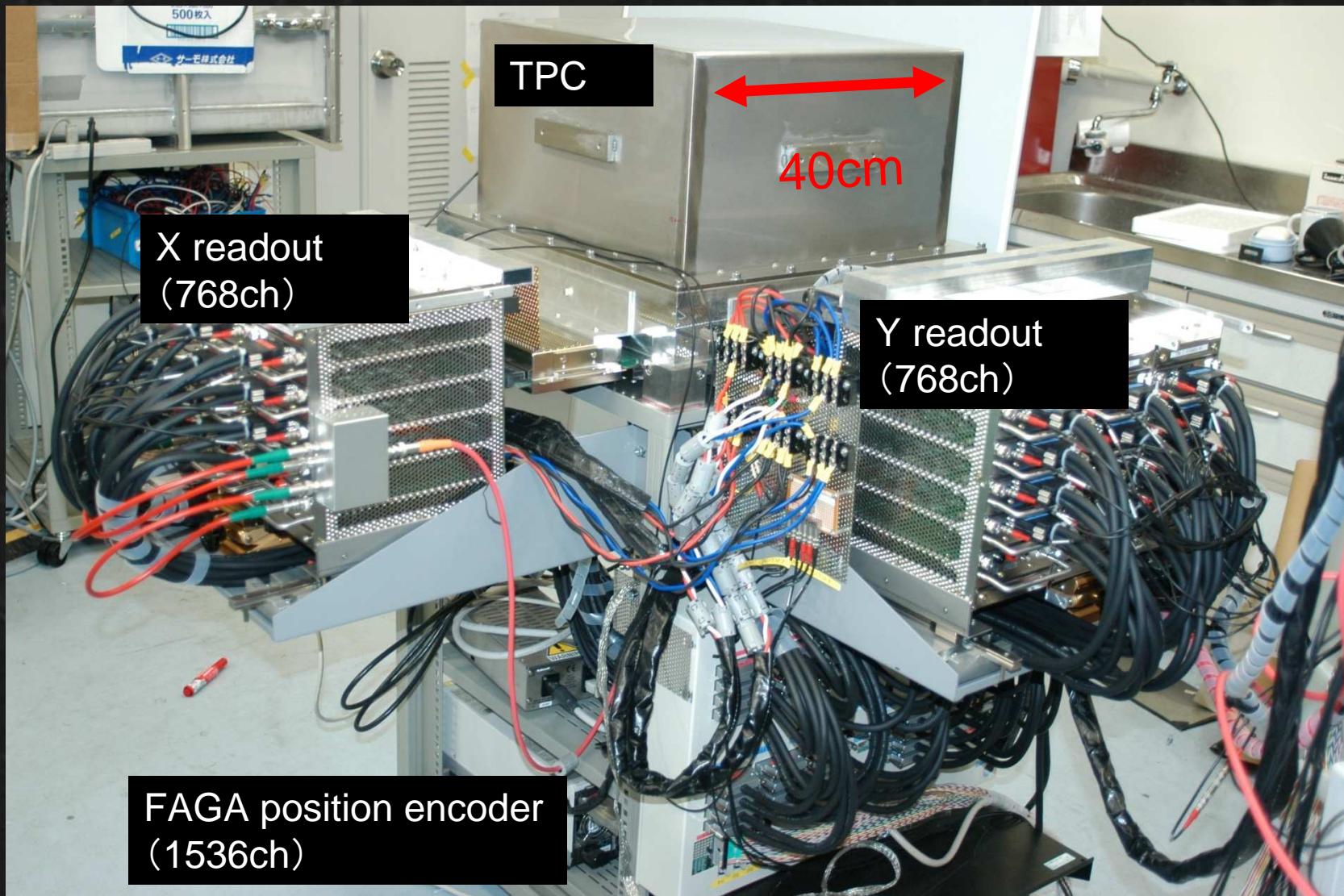
2D imaging device
Takada et. Al. PSD7

TPC

Particle tracks

e

GEM

μ–PIC

30cm

5mm

μ-PIC (gas gain 5000)

- **400mm pitch**
- **589824 pixels**
- **768+768 readout**

30cm

30cm μ PIC
(Toshiba)
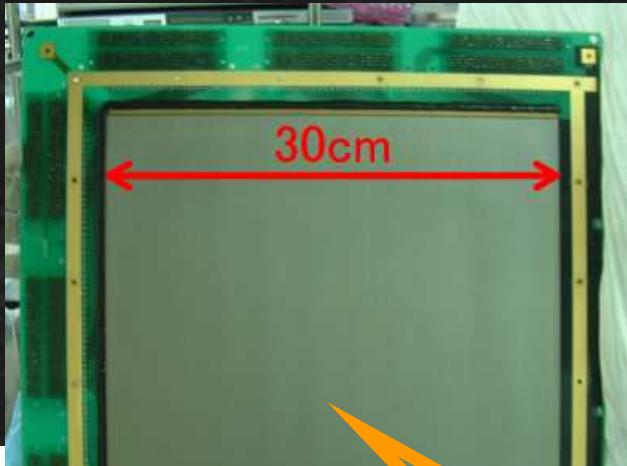
Cathode
Anode
400μm
100μm
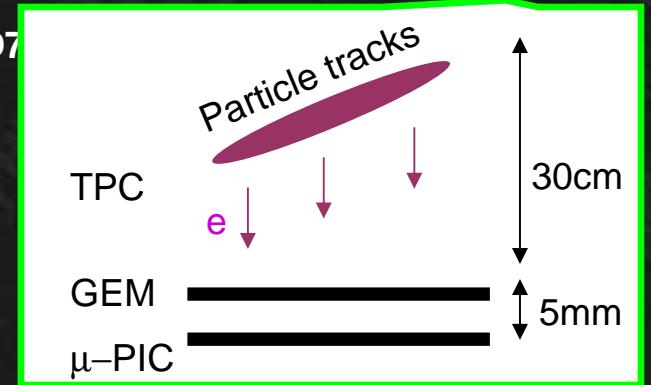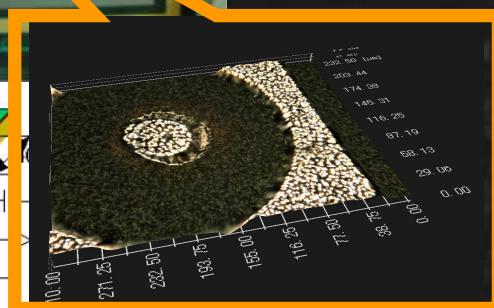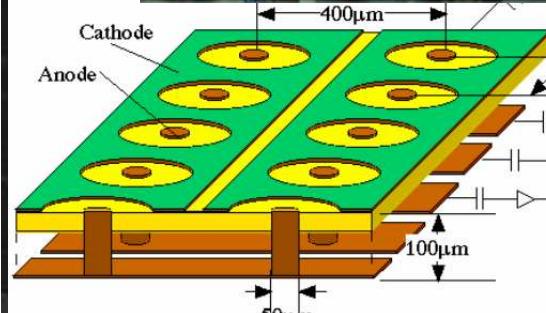
GEM (gas gain 10)

140mm pitch

70mm diameter

Large area GEM
(scienergy)

28cm

23cm

WIMP-search

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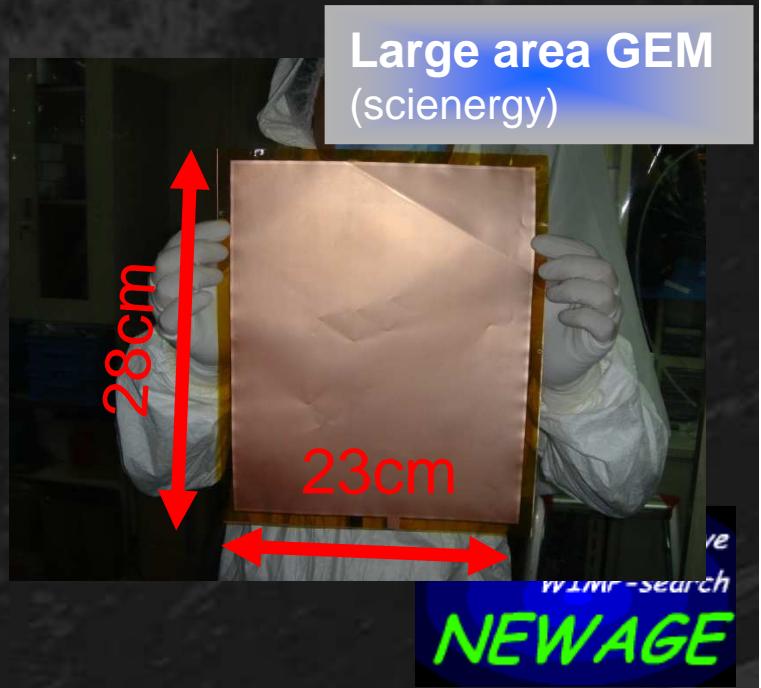
TPC system

Gas volume

- DRIFT length 31cm
- CF_4 0.2bar gas

gas volume

31cm

ASD
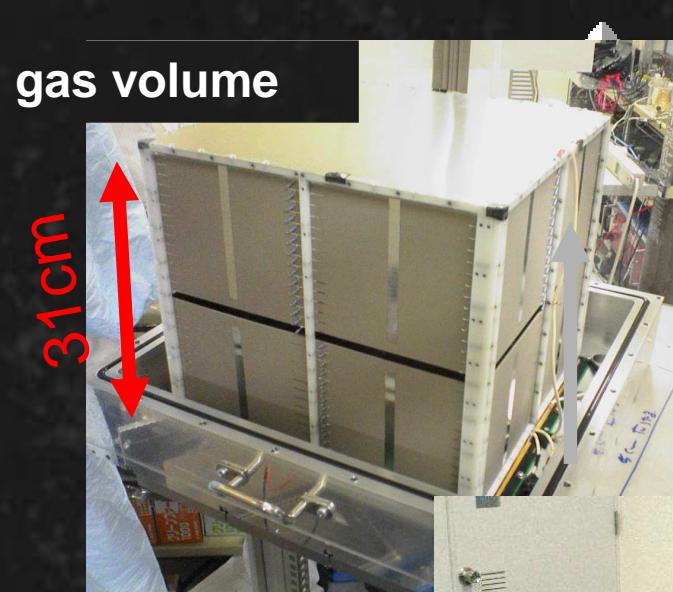
ENCODER

# Readout electronics

- 768 anode + 768 cathode
- Digital (LVDS) signals at ASD
- (X,Y,T) at the position encoder

for tracking

TPC system

ASD

Position Encoder

Anode A1 A2 A3 A4
C1 C2 C3 C4 ...
Cathode

100MHz, pipeline

Memory Board

+
**Summed analog signal**

Direction Sensitive

for energy

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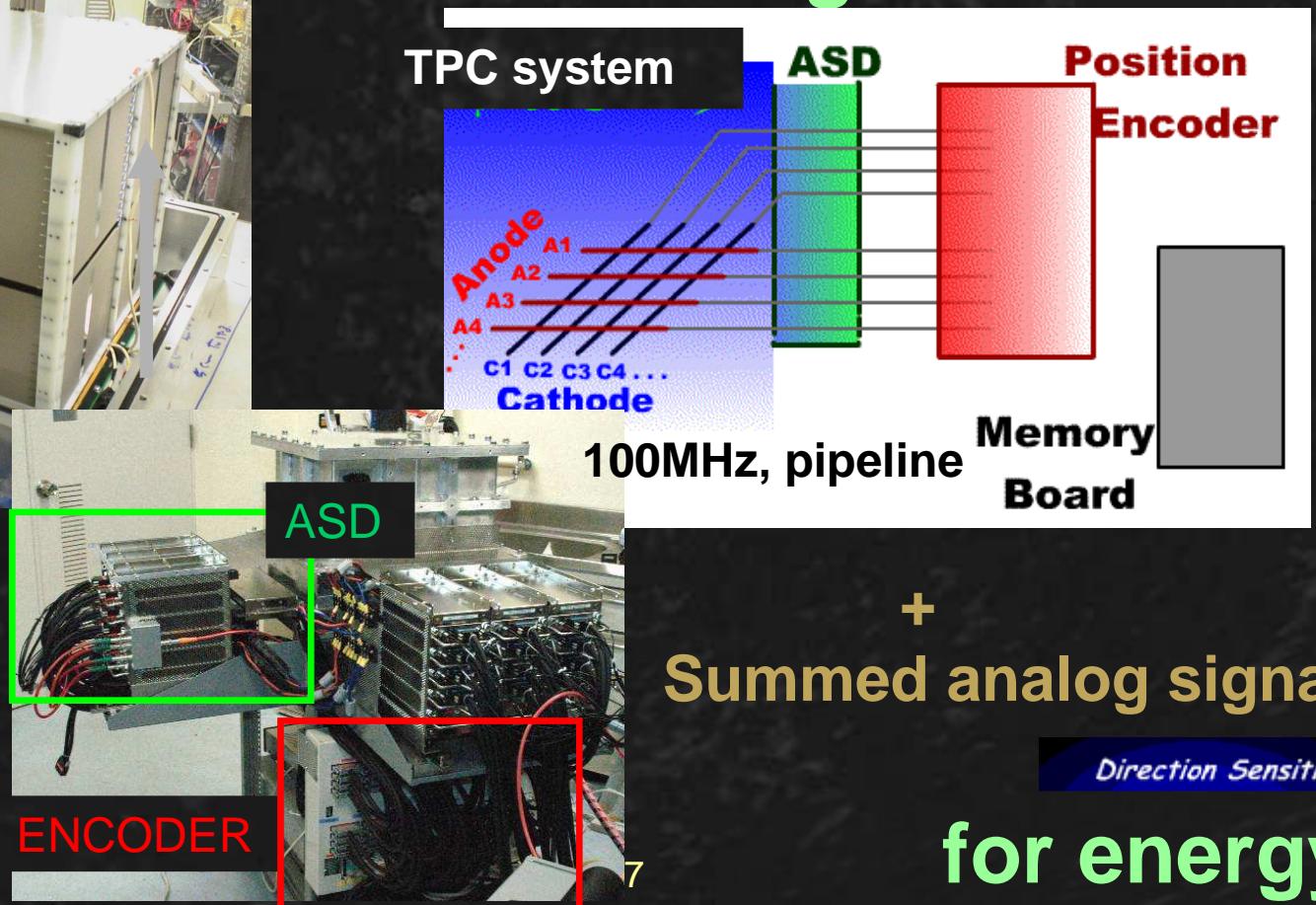
TPC performance 1: nuclear tracks, imaging

- $CF_4+C_4H_{10}$ (9:1) 0.2 atm
- n -> p forward scattering
  (emulation of WIMP -> F scattering

Proton tracks

drift[cm]

30cm

25

20

Z(drift)

10

5

0cm

-15cm

X   15cm   -15cm   Y

^{252}Cf

n

15cm

$CF_4+C_4H_{10}$
^{252}Cf run

n

θ

p

Cos θ

zenith ^{252}Cf
(NE45°
zenith35°
)

60

30

W   -60   -30   N   30   60   E

-30

-50

Recoil direction image
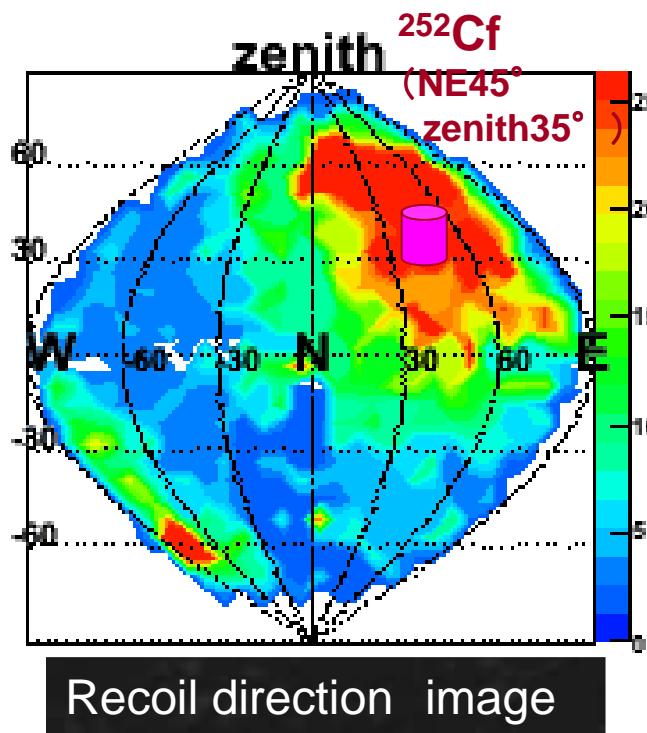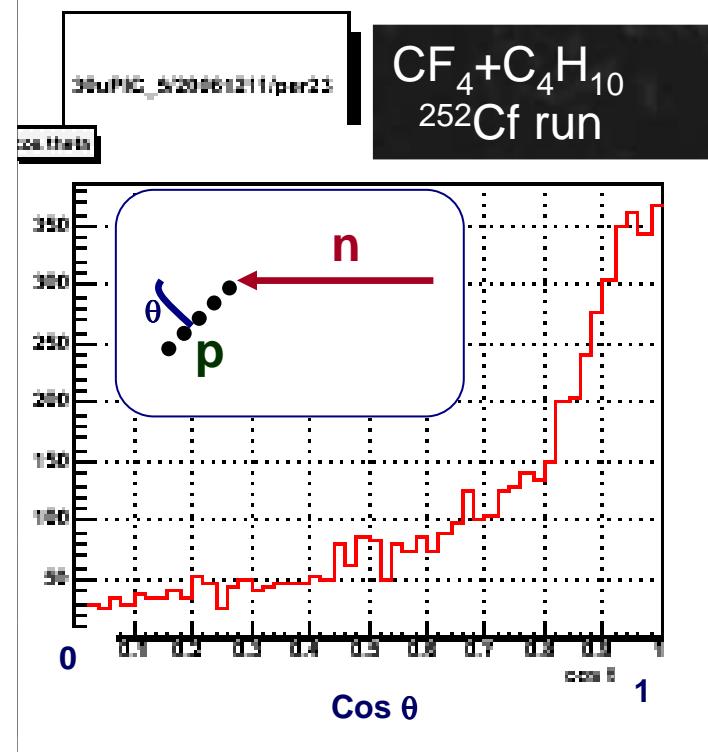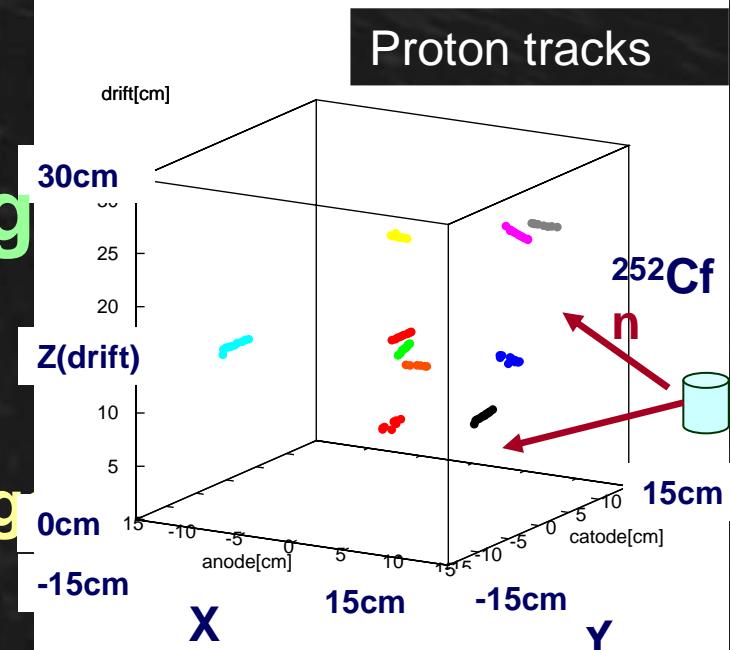
Direction Sensitive
WIMP-search
NEWAGE

# TPC performance 2: gamma-ray rejection

- energy length correlation
- gamma-rays from ^{137}Cs

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NEWAGE
Direction Sensitive WIMP-search
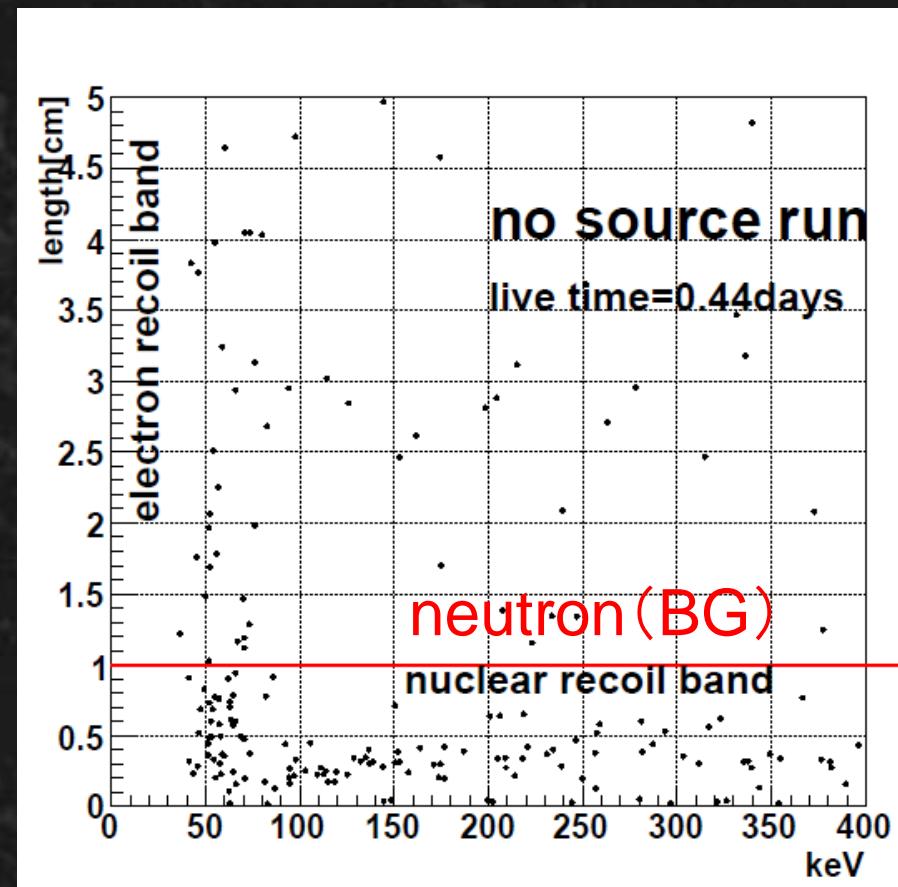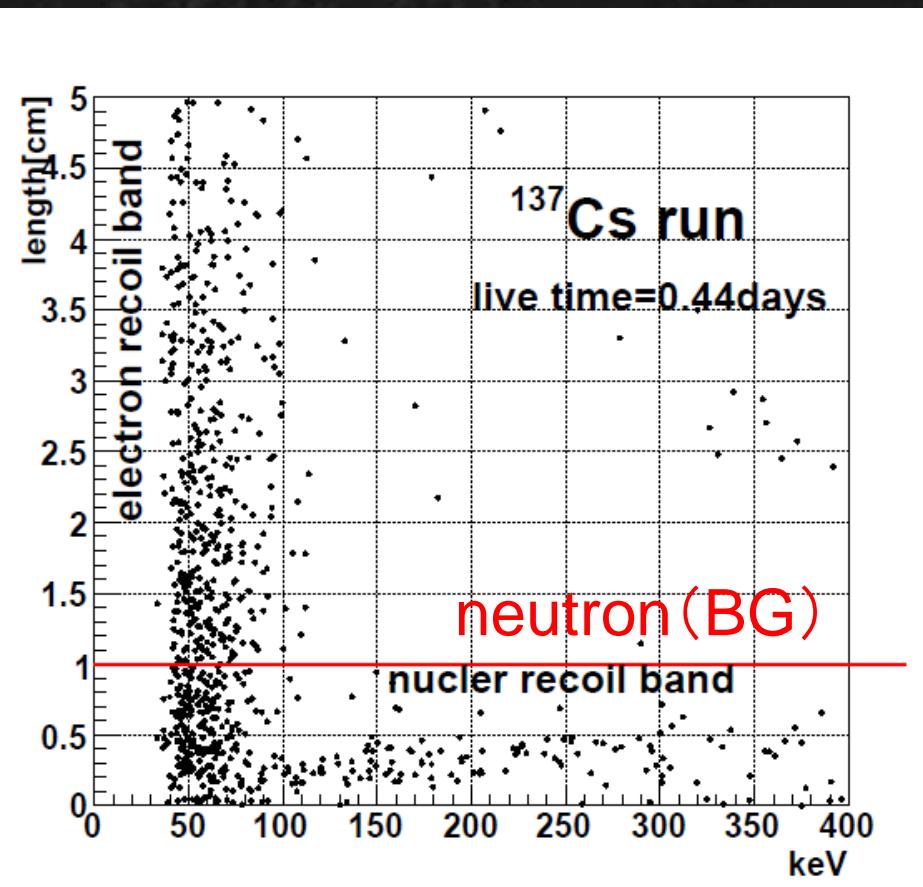
gamma-ray rejection（continued）

- **spectrum, BG subtrucction**

Energy spectrum

thick: 137Cs run

hatched: no source

Subtracted energy spectrum

consistent with 0
（>100keV）
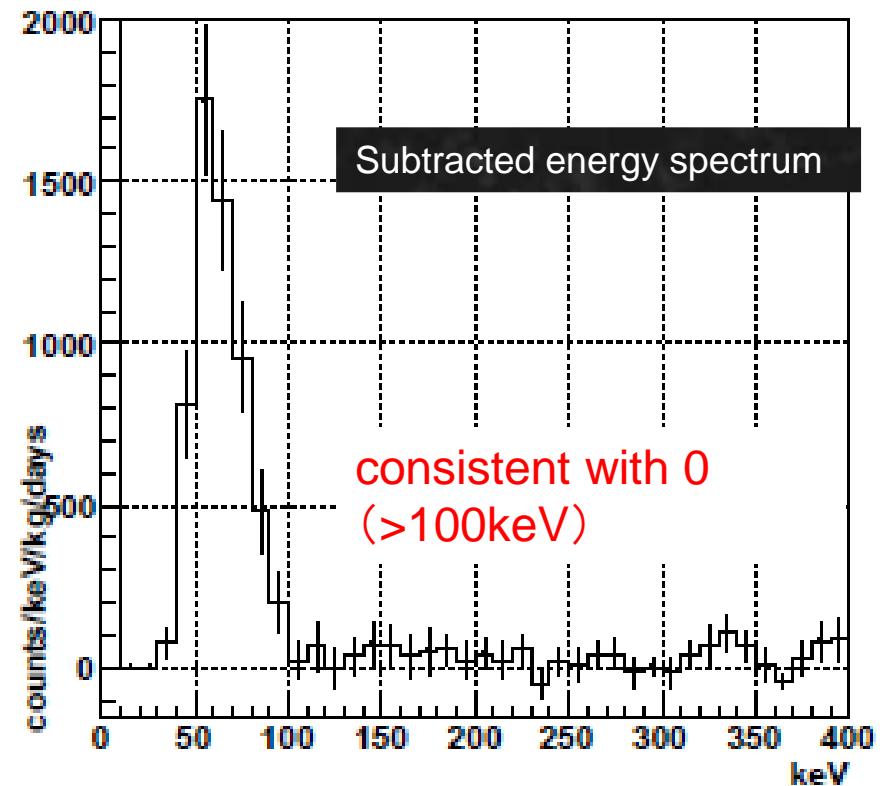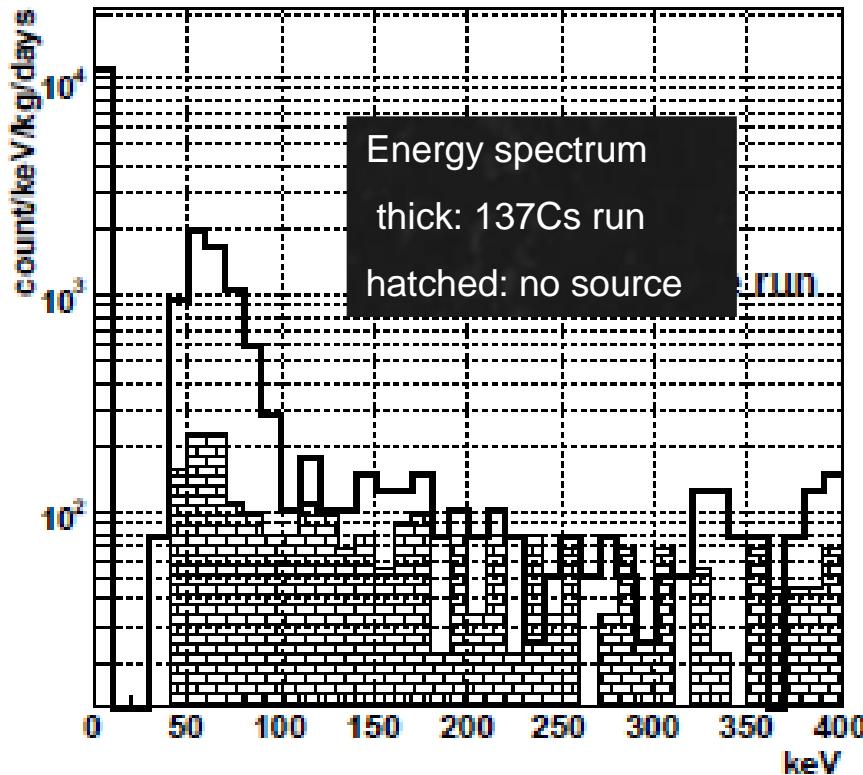
- **gamma rejection ＜ 2e-4 （statistics limited）**

WIMP-search
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TPC performance: nuclear track efficiency

- **neutrons from ^{252}Cf**
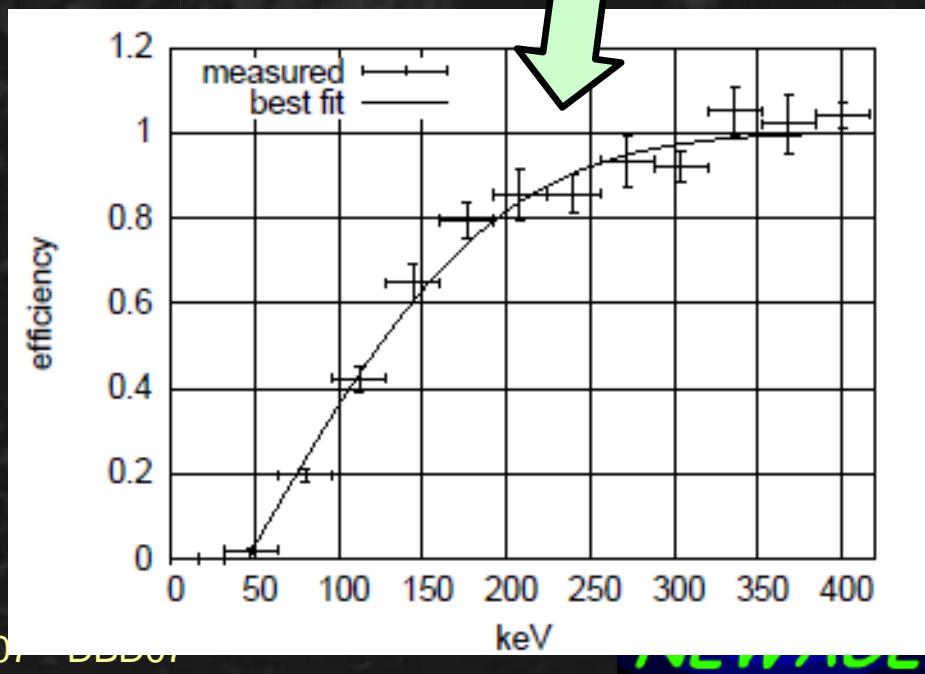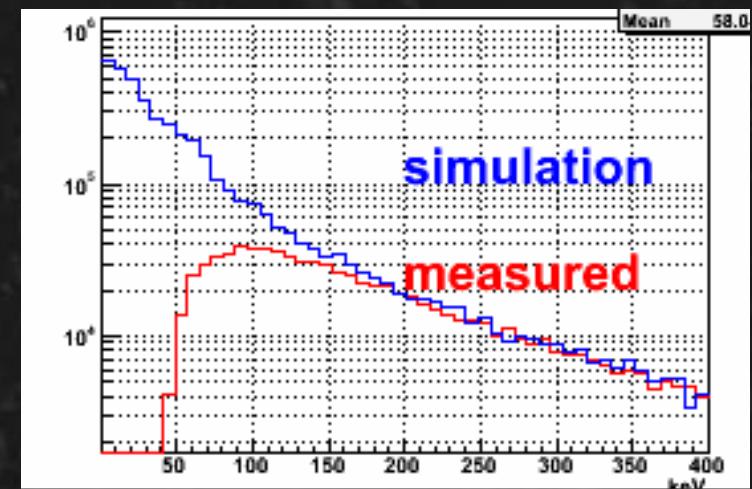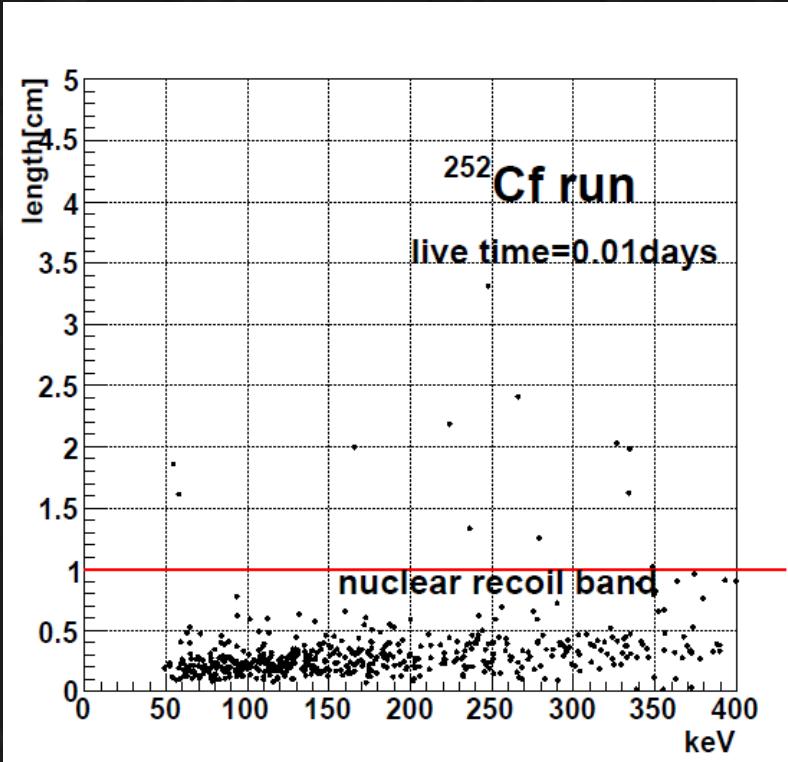
- ## 0.4 @ 100keV

3 Surface run

Surface run①

- 2006 Nov.1st ~ Nov.27th
- exposure 0.15 kg days (=0.0089kg ×16.7days)
- @Kyoto university (N35.03 E135.783)
- Energy spectrum（conventional method）

Energy spectrum

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Direction Sensitive
WIMP-search
NEWAGE
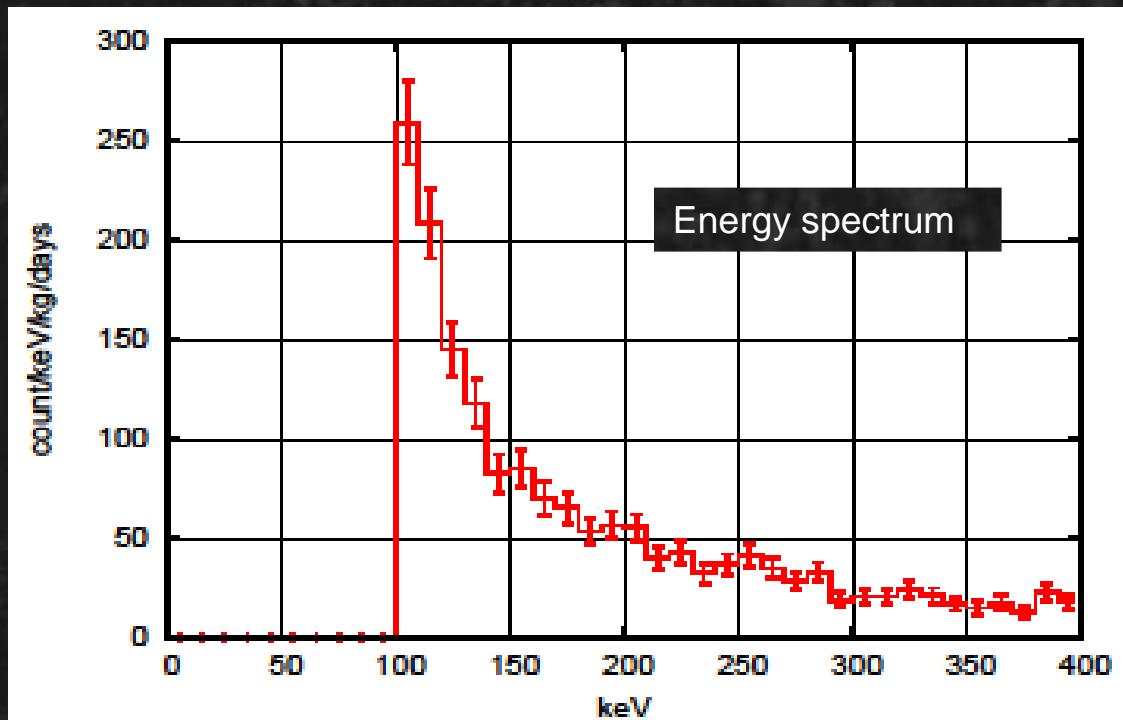
Surface run ②

- **The sky map (by nuclear recoil tracks)**
- **flat neutron background is seen**

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

DM direction

Direction Sensitive
WIMP-search
NEWAGE
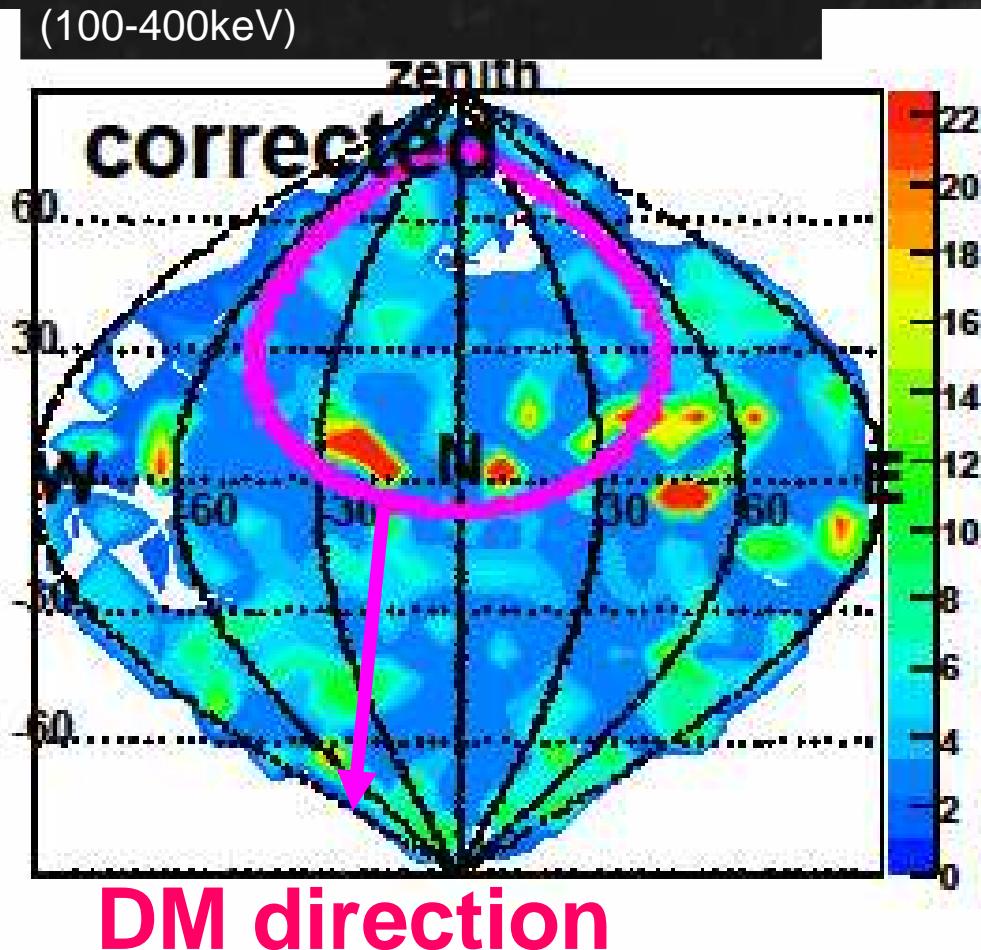
Surface run ③

- **Cos θ distribution**
- **consistent with a flat distribution**

M_χ 100GeV (100–120keV)

Cosθ分布
(100-400keV)

13600pb
χ²=22.4

simulation
data

DM limit

SD 90% upper limits

spectrum only

This work(CF₄)

DAMA(Xe)

CDMS(Ge)

SIMPLE,PICASSO(F)

Tokyo 2006(CaF₂)

NAIAD(Na,I)

DAMA(Na,I)

WE ARE HERE

- **First step to the NEWAGE**
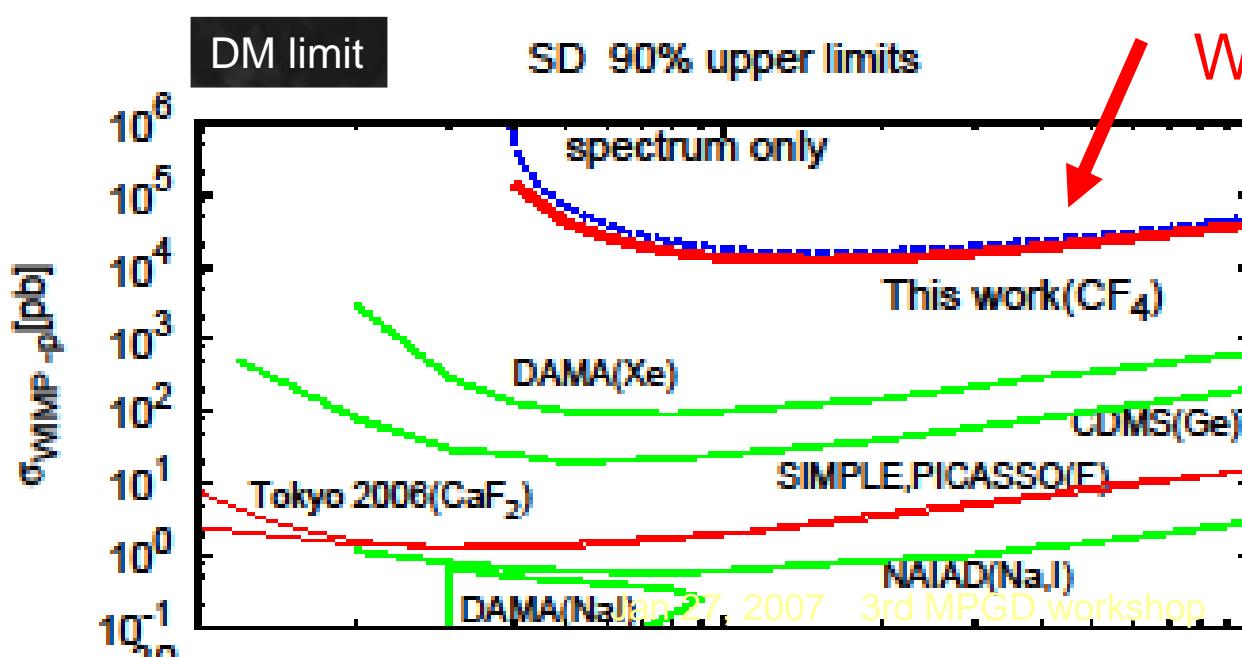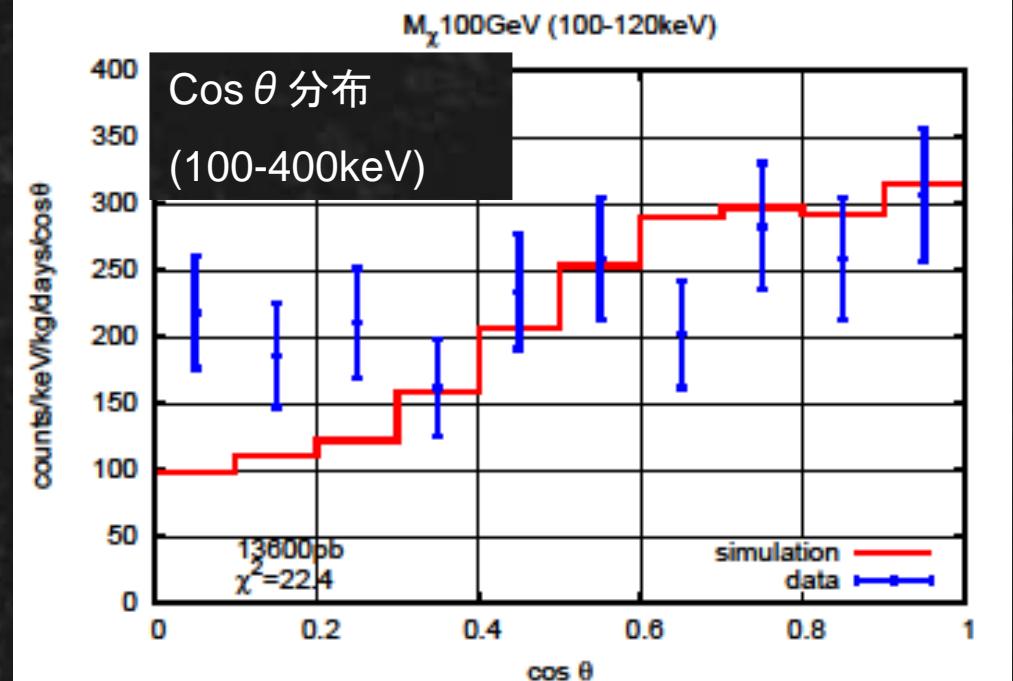
Direction Sensitive
WIMP-search
NEWAGE

4 Next step...

✦ Go underground

- ● JUST started

Kamioka

Kyoto

Osaka

KAMIOKA LAB-B
2007/1/19

Emergency Exit Map
坑内避難経路図
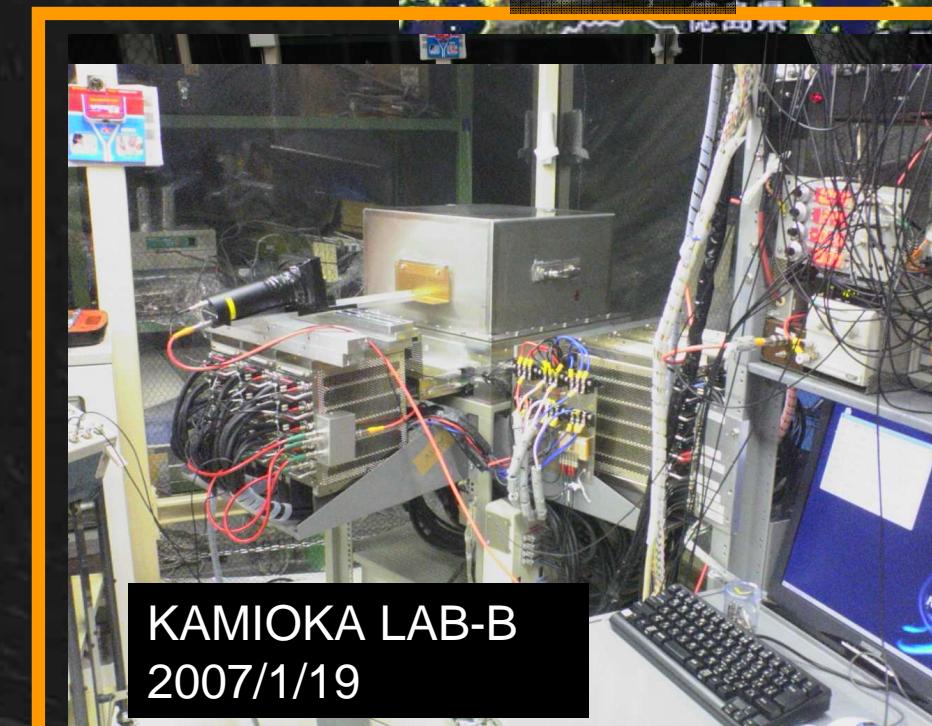
SUMMARY

- μ TPC：30cm cube in operation

- direction-sensitive method works!

- NEWAGE：underground run just started

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Direction Sensitive
WIMP-search
NEWAGE