NEWAGE

-- First experiment with a micro-patterned gaseous detector --

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

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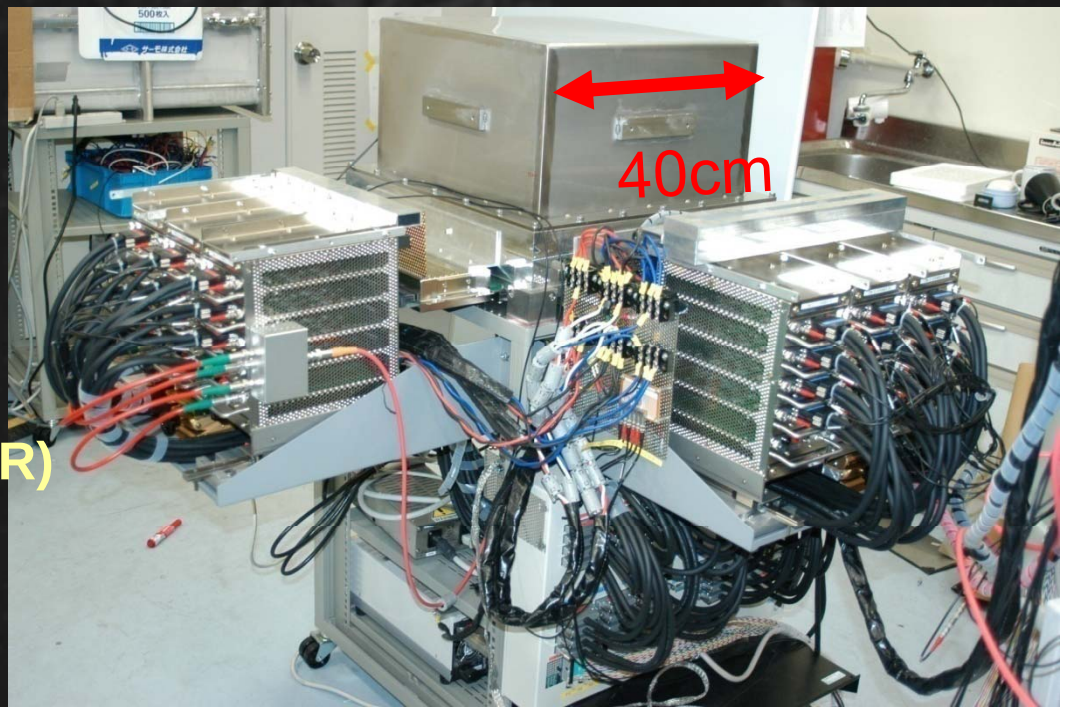
A. Takeda (ICRR), H. Sekiya (ICRR)



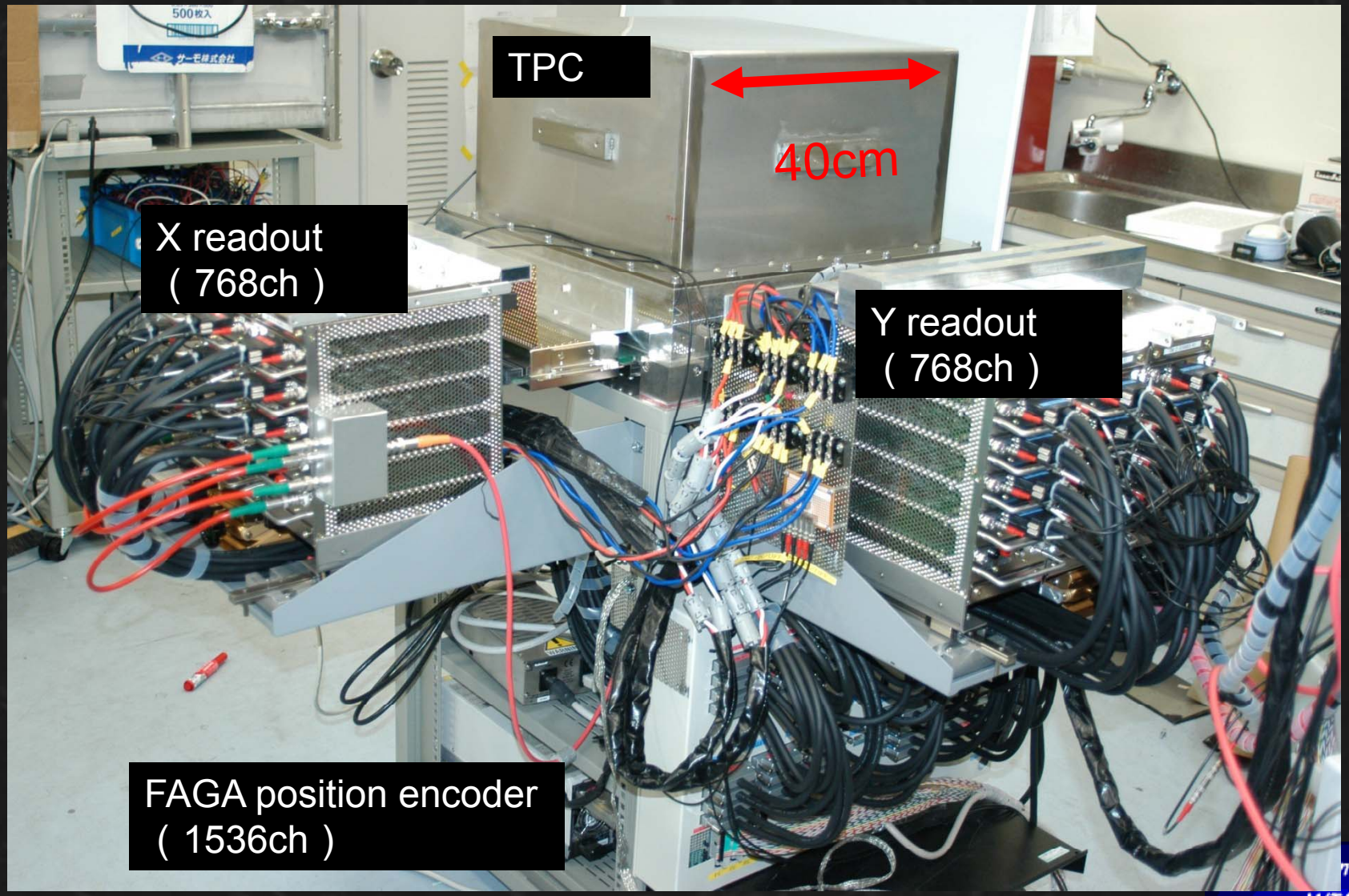
OUTLINE

- Detector
  - μ-PIC
  - Readout system
  - Response
- NEWAGE surface run
  - Direction-sensitive analysis
- FUTURE PLANS
  - Scaling up
  - Background

Direction Sensitive WIMP-search NEWAGE

1 . Detector

physics/0701085 K.Miuchi et.al



n Sensitive
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NEWAGE

OUTLINE

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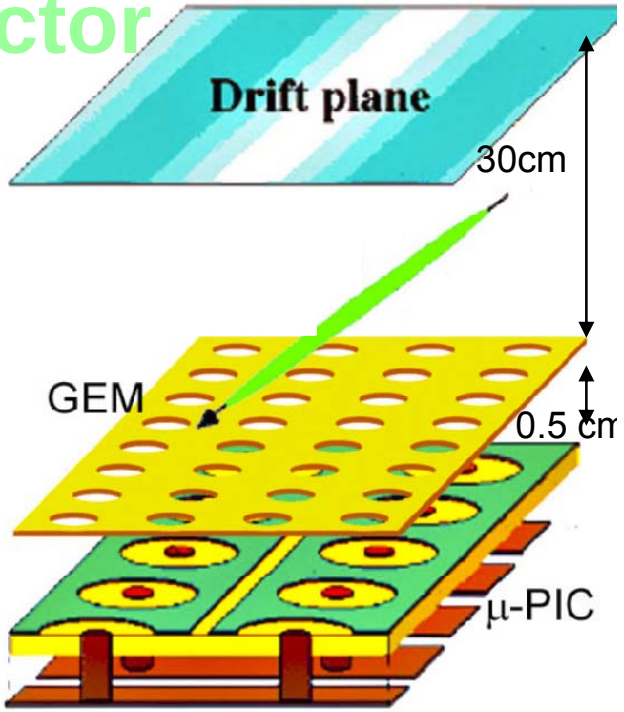
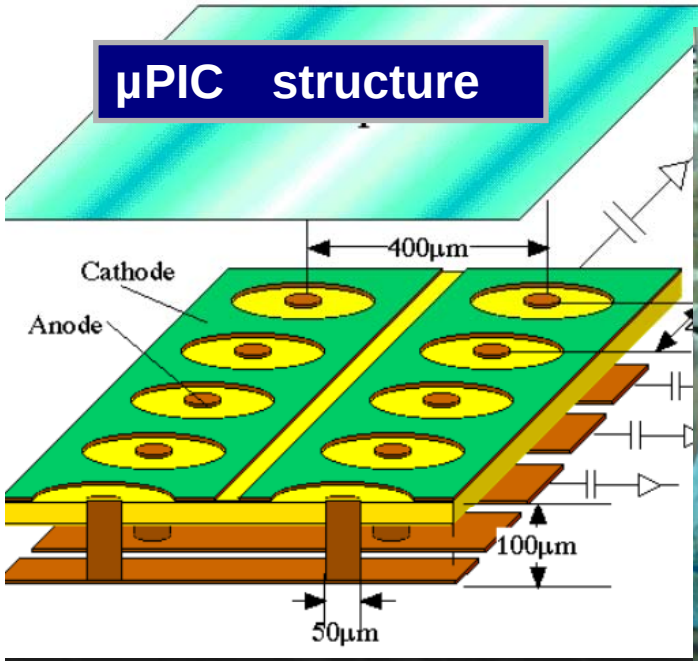
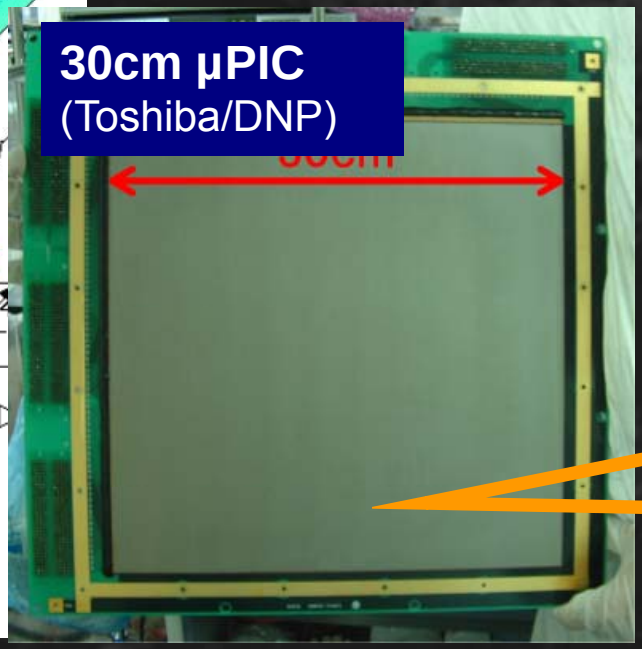
Direction Sensitive WIMP-search NEWAGE

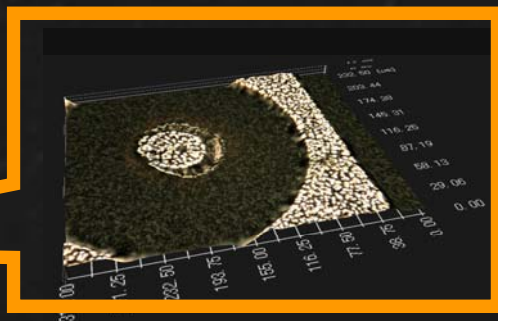
Micro-patterned gaseous detector

- μ-PIC (30*30cm²)
  - Gas amplification + readout
  - 400μm pitch
  - 589824 pixels
  - 768+768 readouts
  - Gas gain ~1000 with 0.2bar CF_4









NEWAGE

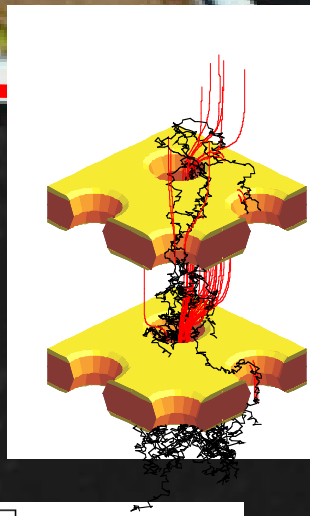
μ-PIC characteristics

Propaganda–like characteristics	actually…
High gain	
Maintenance in long-term operation	
Mechanically robust	
Large area	
Cheap	PCB technology

- **personal comment**
  - **We had μ-PIC so we used it.**
    Maybe this is not the best device for DM search…

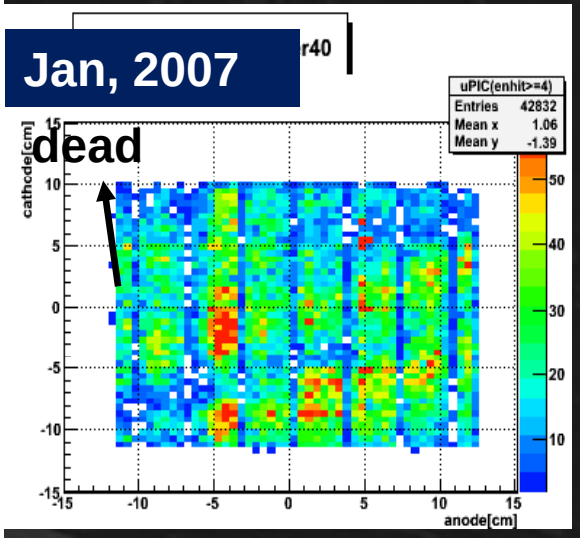
- **GEM (23*28cm^2)**
  - Pre-amplifier (temporally use)
  - Segmented to 8 strips
  - 140μm pitch 70μm diameter
  - Gas gain ~3 with 0.2bar CF_4

Large area GEM
(scienergy)

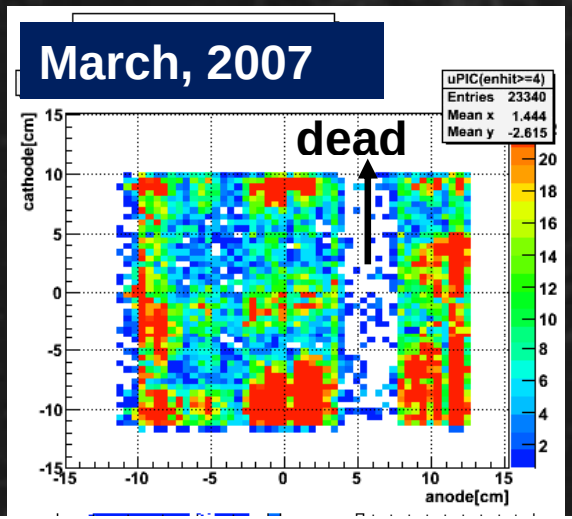


- **"Dead-segment" problem of GEM**
  - Spark -> get conductive
    -> no gas multiplication -> dead segment

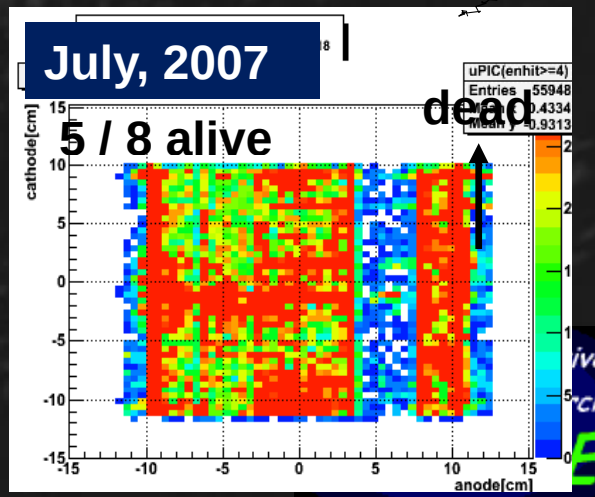
Jan, 2007



March, 2007

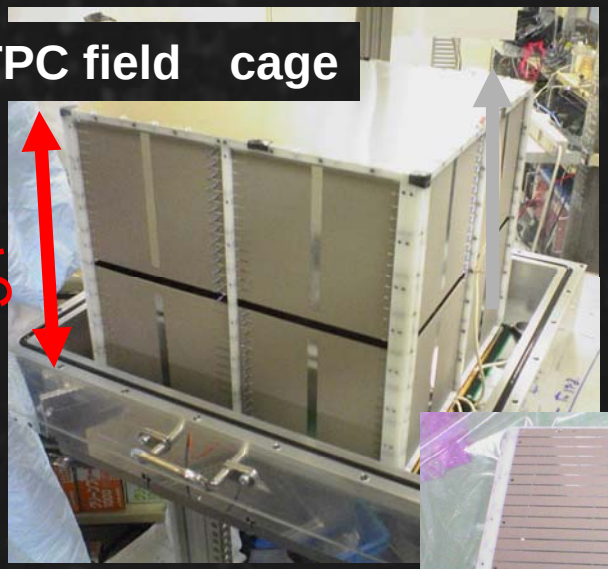


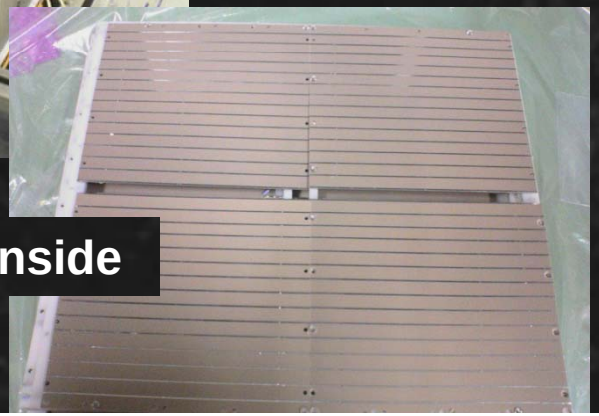
July, 2007

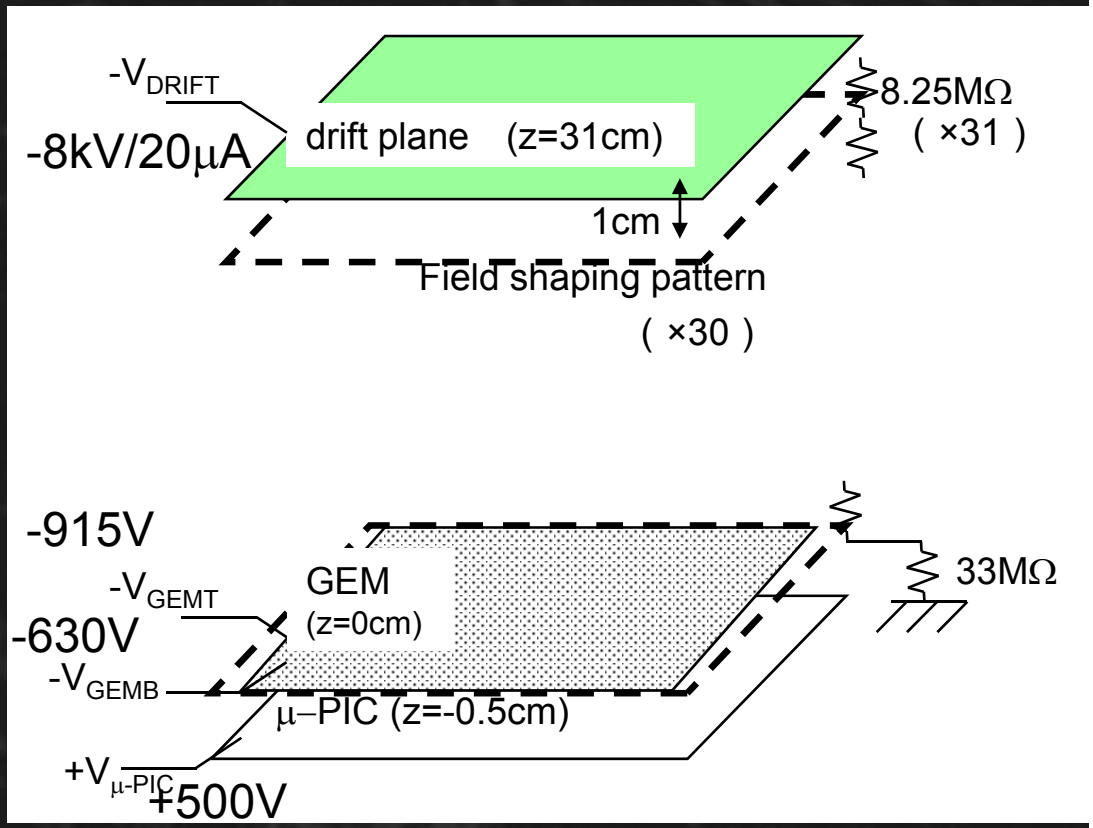


TPC system

- Gas volume
  - DRIFT length 31cm
  - CF_4 0.2bar gas
  - sealed operation with a getter pump







Direction Sensitive WIMP-search NEWAGE

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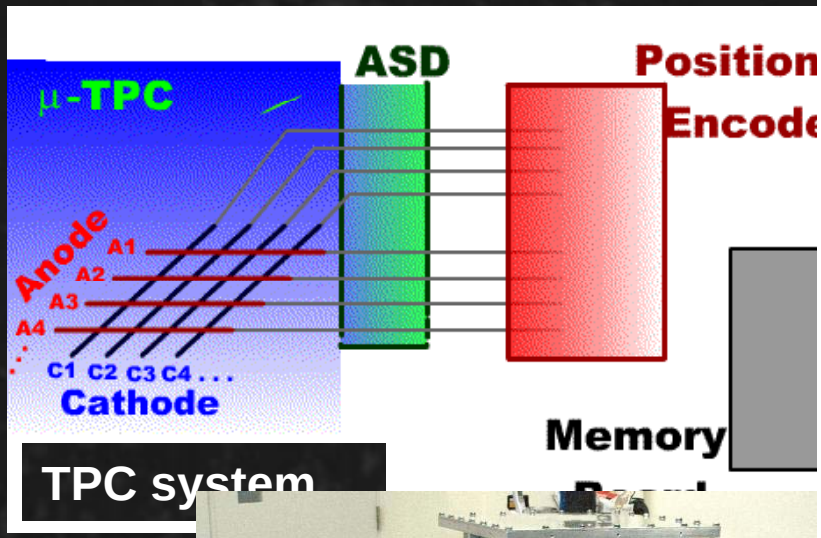
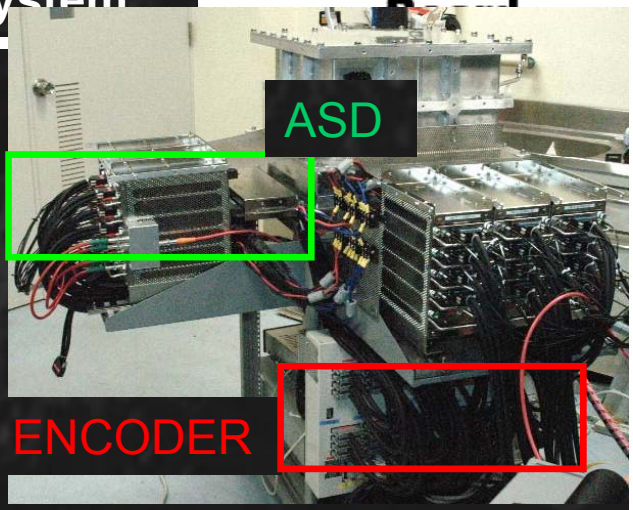
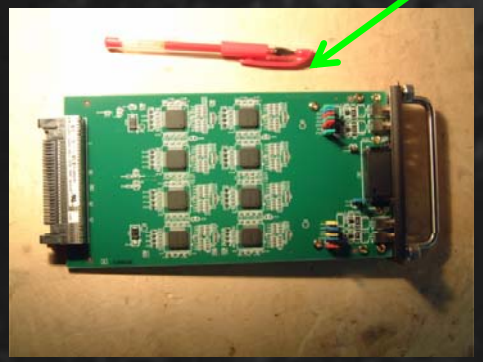
Readout electronics

- **DIGITAL : Tracking**
  - 768 anode + 768 cathode
  - Digital (LVDS) signals at ASD
  - (X,Y,T) at the position encoder
  - 100MHz pipeline
- **ANALOG : energy**
  - 768 cathode –sum--> 2ch
- **DATA size**
  - 16k byte /event
  - ~ 20Gbyte /month @0.5Hz

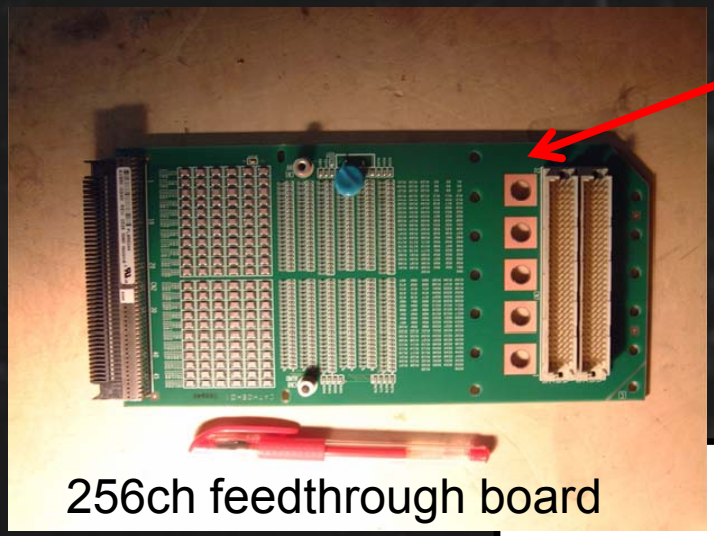


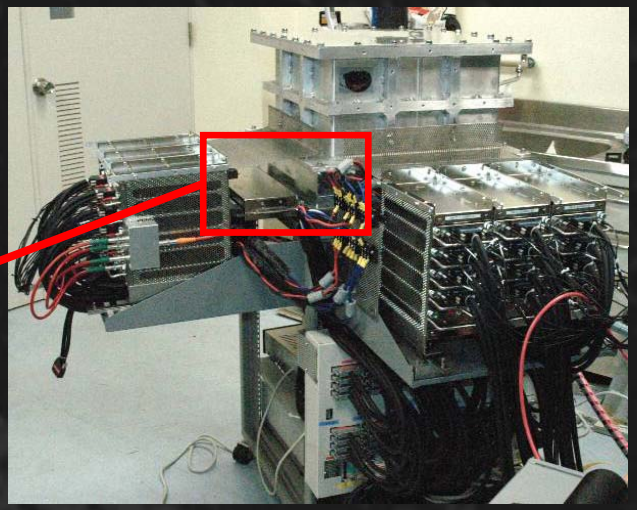


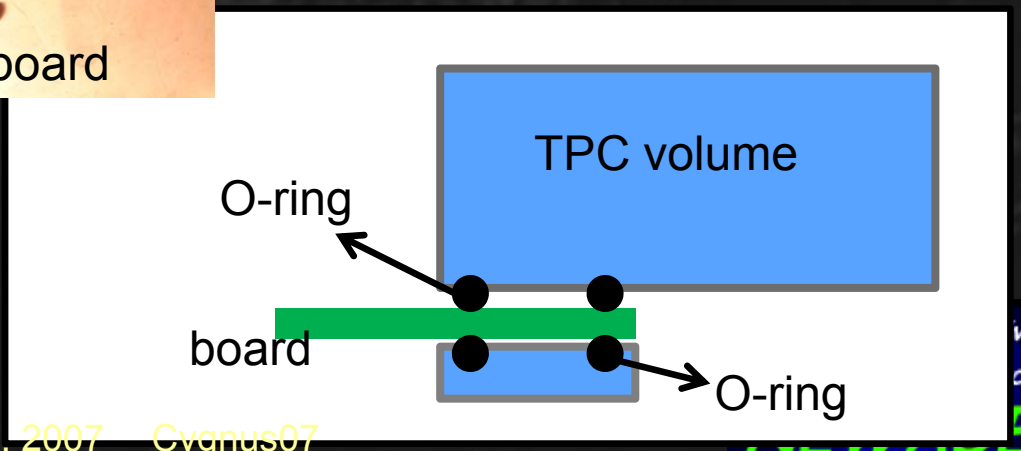


Direction Sensitive WIMP-search NEWAGE

- **1500ch feedthrough**
  - feedthrough board
  - everything is out of the vessel
  - easy to maintain
  - keep the gas purity


256ch feedthrough board





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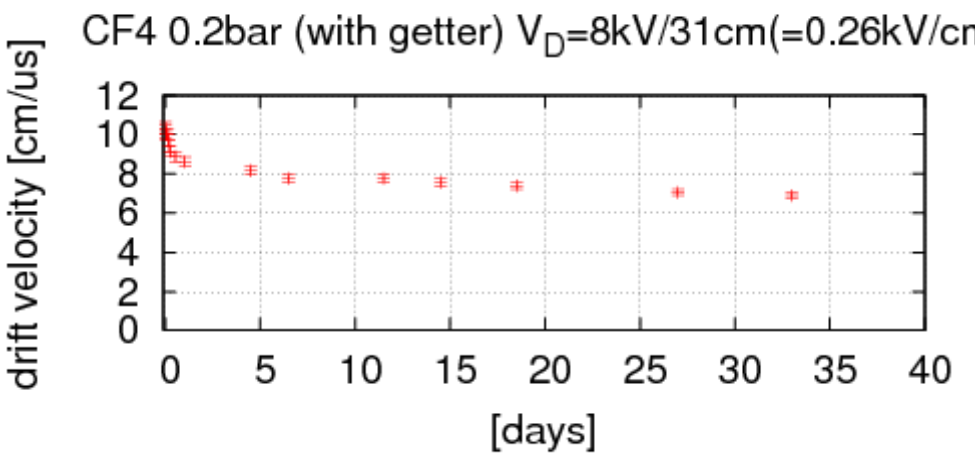
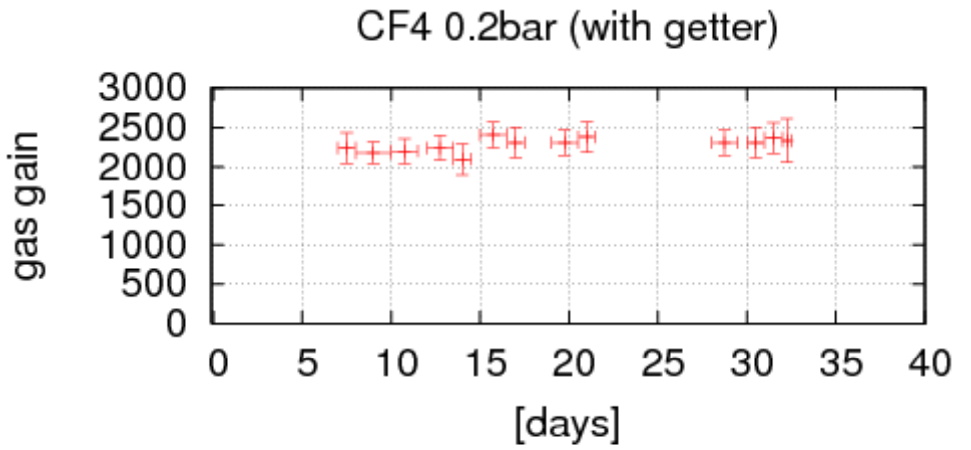
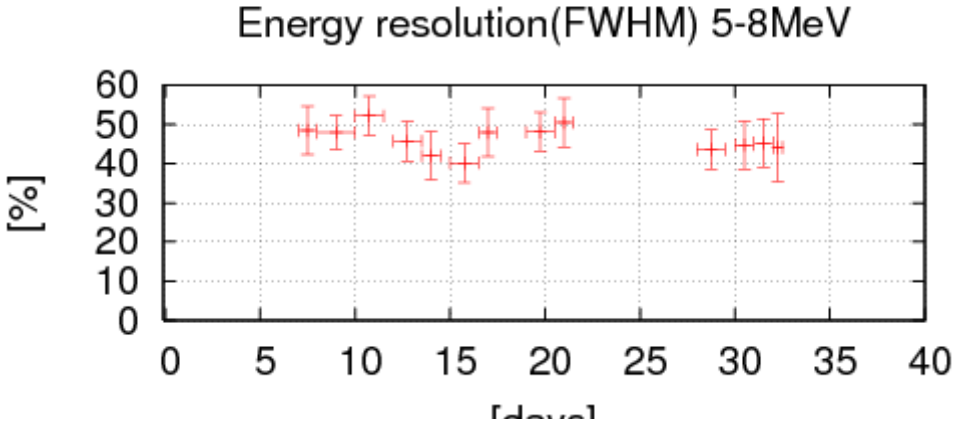
Response

Stability monitoring

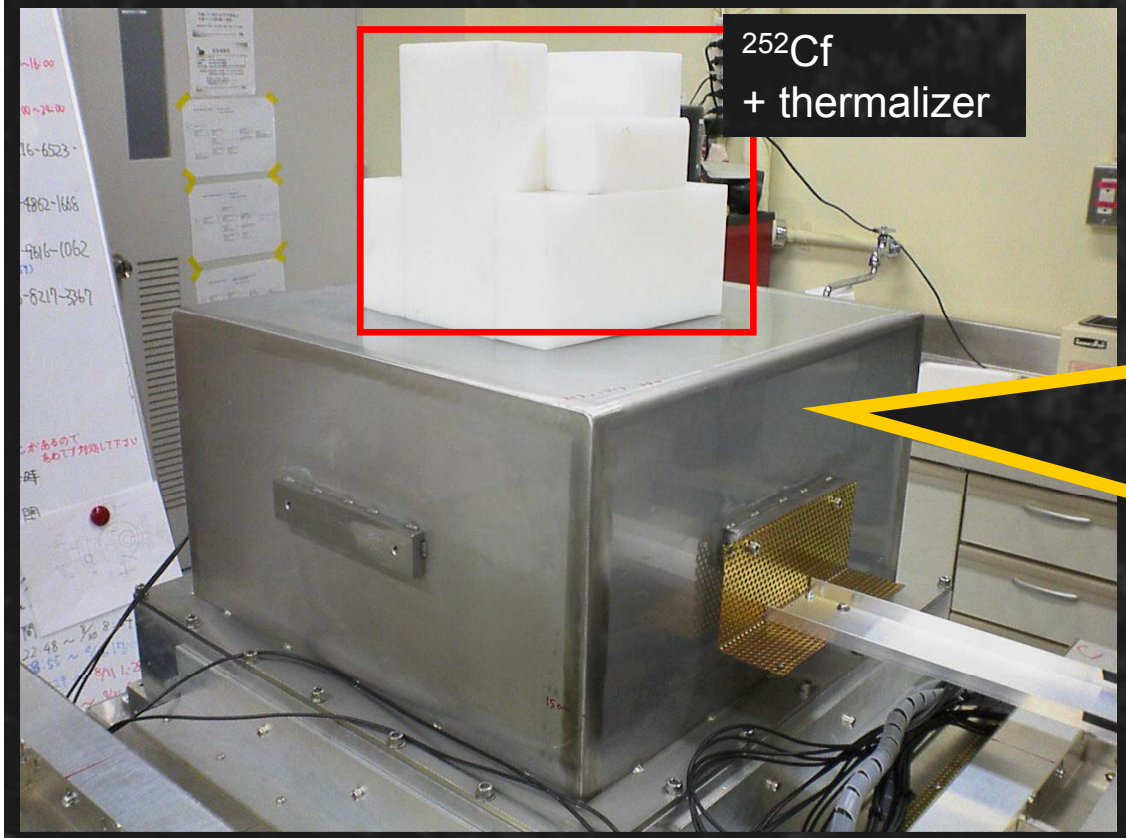
- drift velocity
  12% decrease in day 2~30
- gas gain
  2300 +-4%rms
- energy resolution
  46% -+ 6.4%rms
- three parameters
  : acceptable

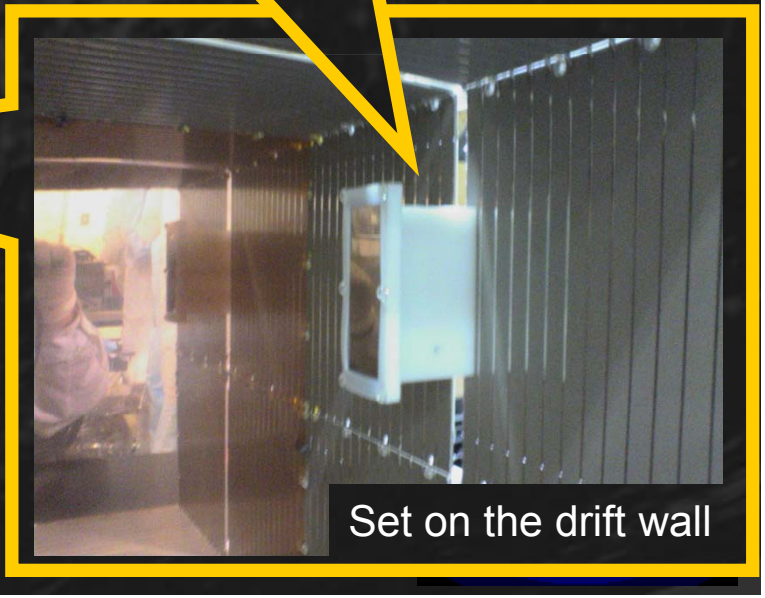






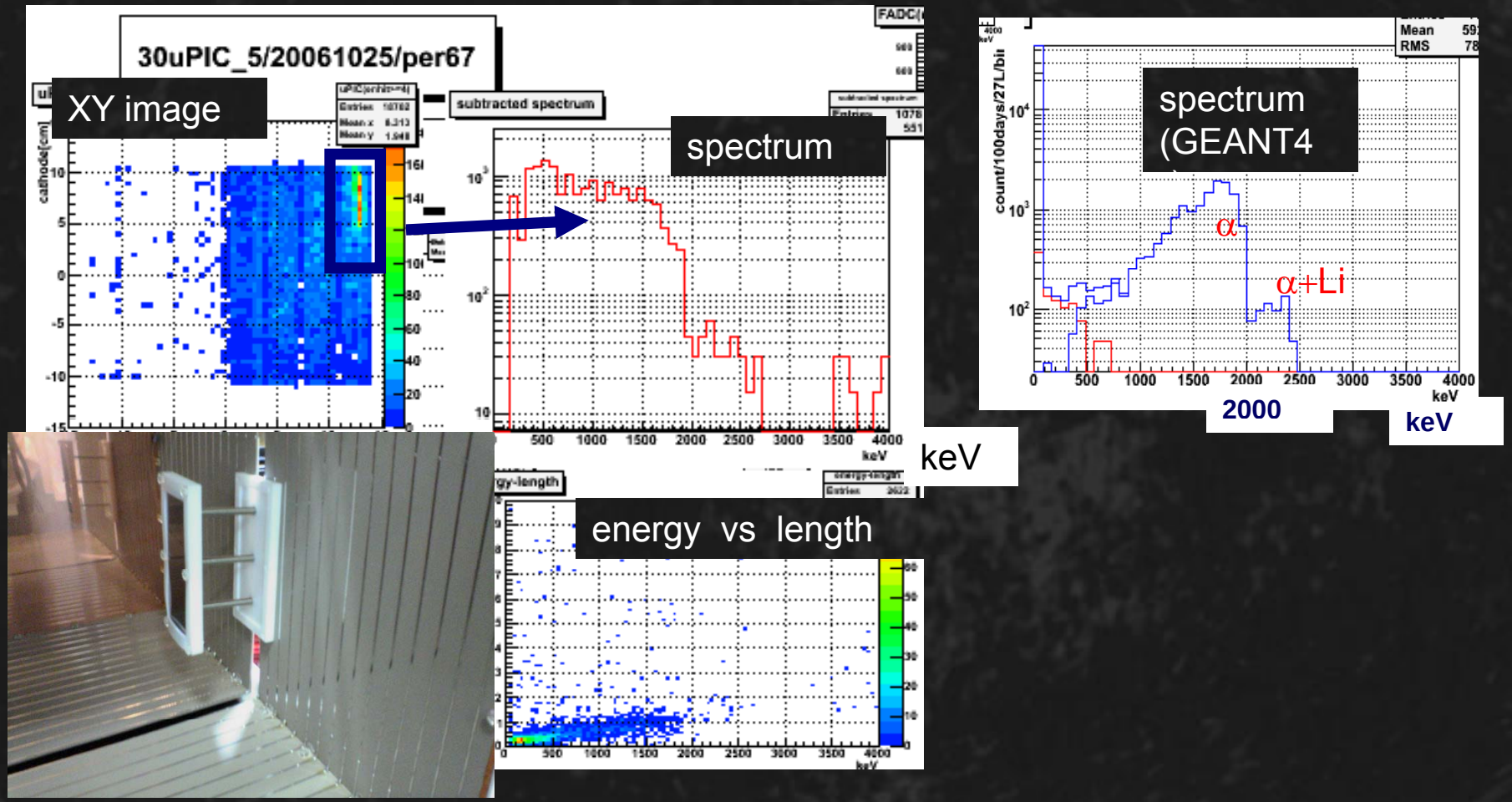
- **Calibration / gain monitor**
  - Heavy ion (not a γ source)
  - On / off from outside
  - $^{10}B(n,\alpha)^{7}Li$ reaction
    (Q=2.70MeV 1.8MeV for α)





Calibration / gain monitor

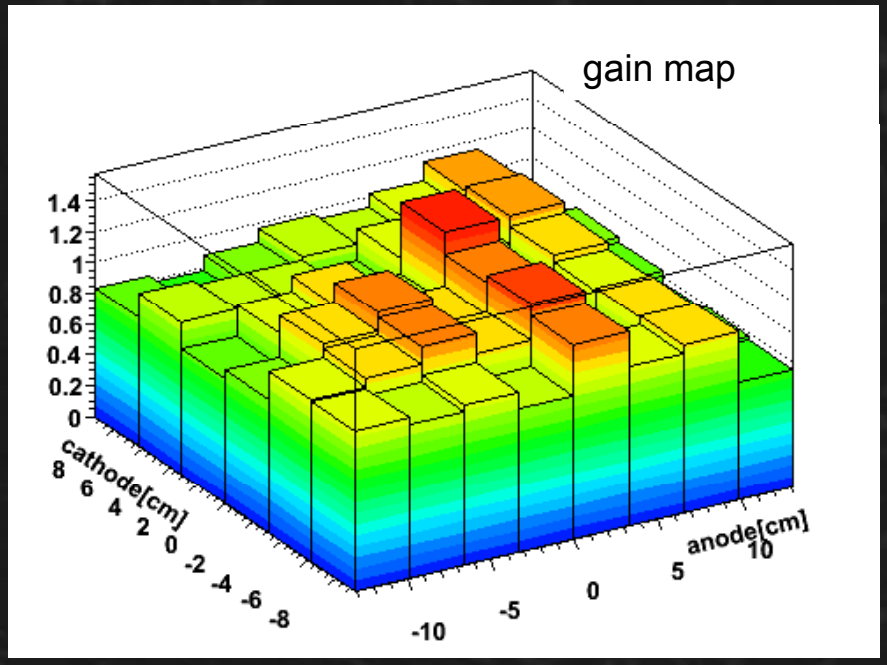
- typical results

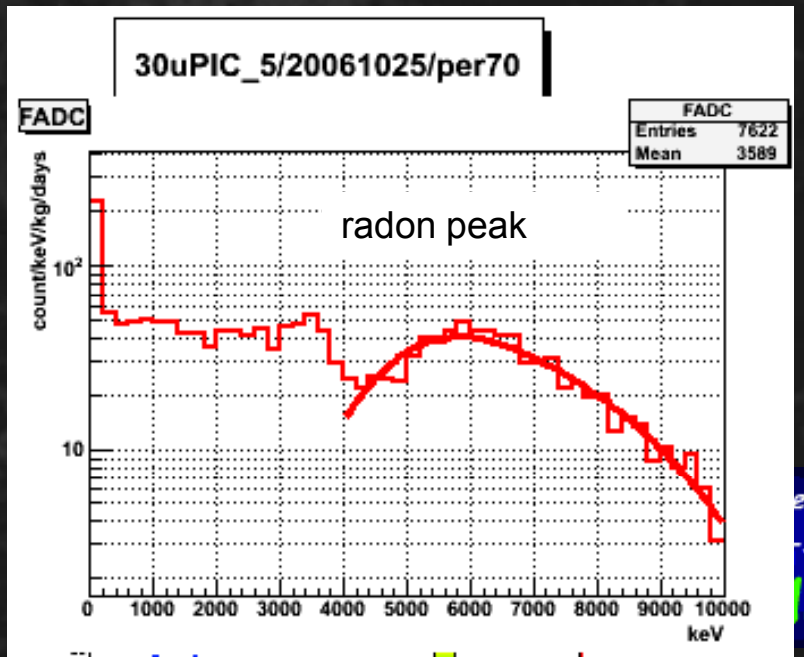


- @DM energy region (~100keV):
  - extrapolation by energy-length correlations
  - direct measurement method is being investigated

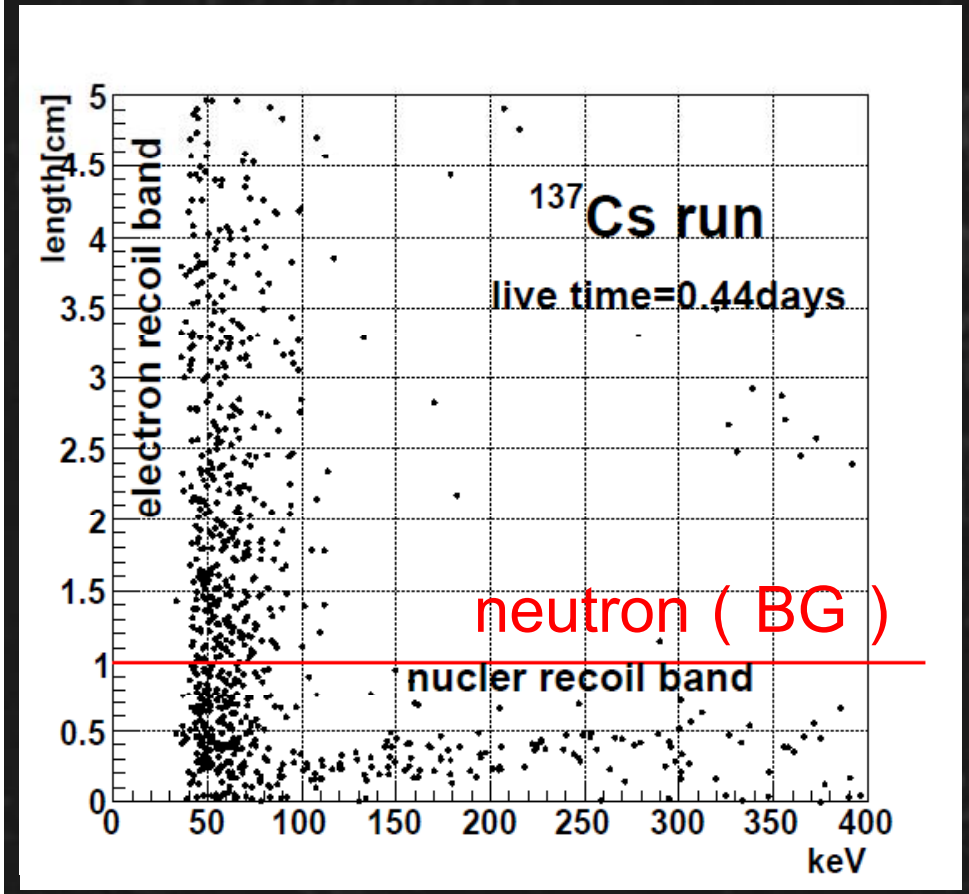
- **energy resolution**
  - Radon peak （5-8MeV） 40％FWHM
  - due to the gain inhomogeneity of the μ-PIC

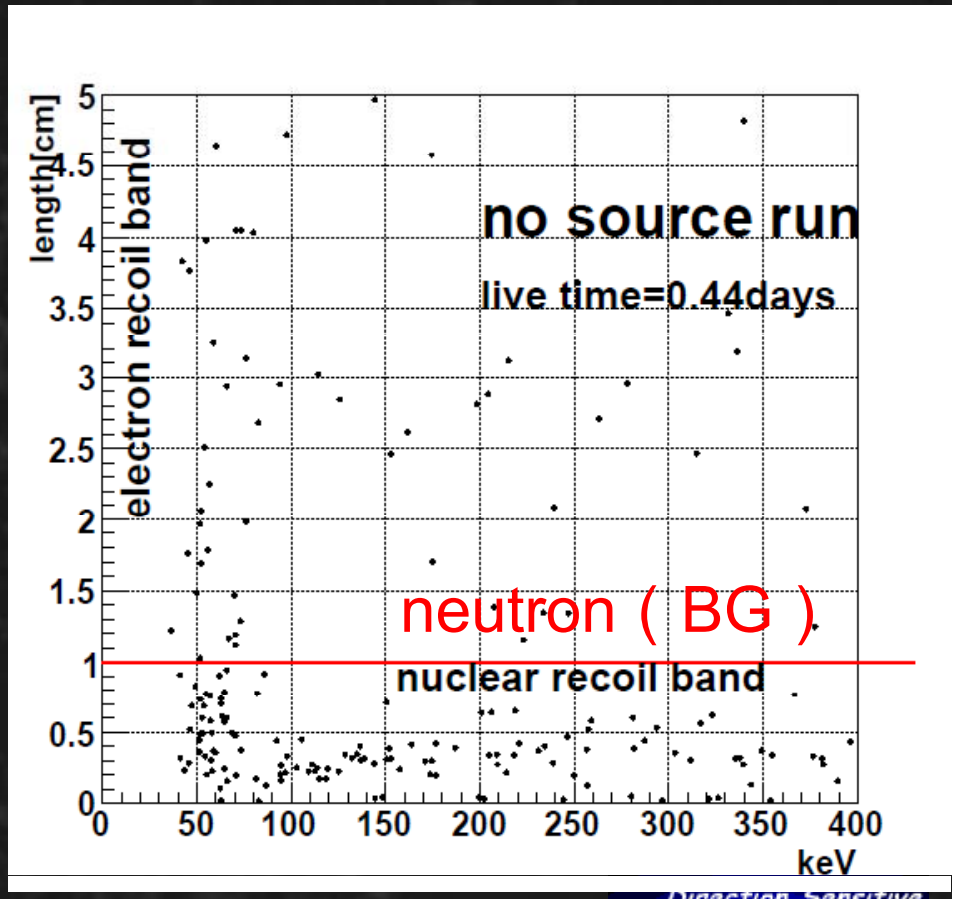
  - low energy: measurement with Ar-based gas : 60％FWHM@60keV
  - statistics restricted
  - extraporation with
    W value, num of electron 60×sqrt((54/26)×(60/100))
    = 70％FWHM @100keV
    60%@59.5keV
  - direct measurement is needed.





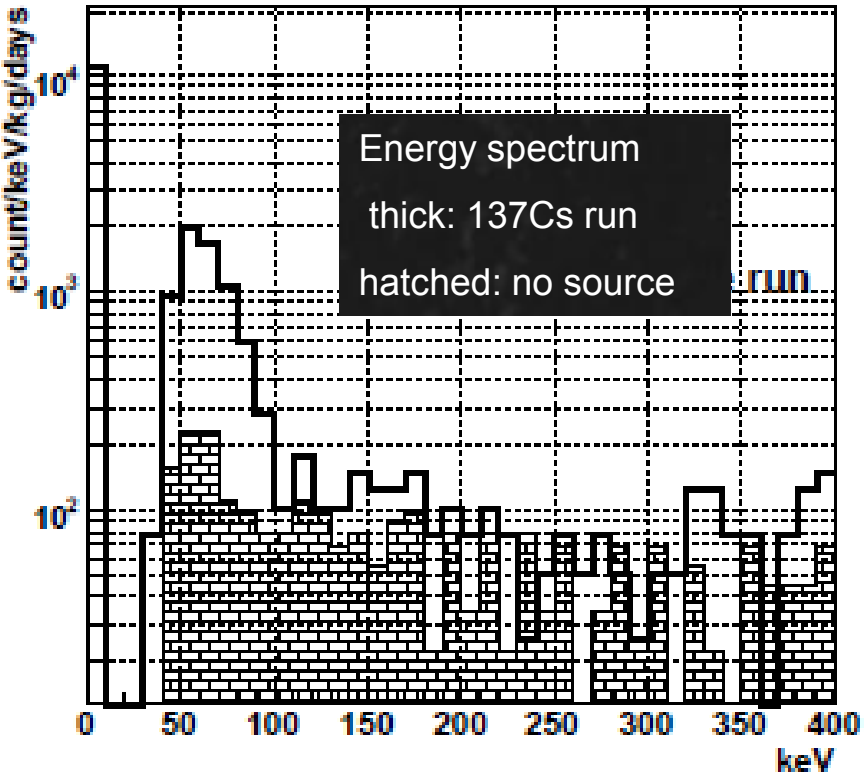
- **gamma-ray rejection**
  - **energy-length correlation**
  - **gamma-rays from ^{137}Cs**

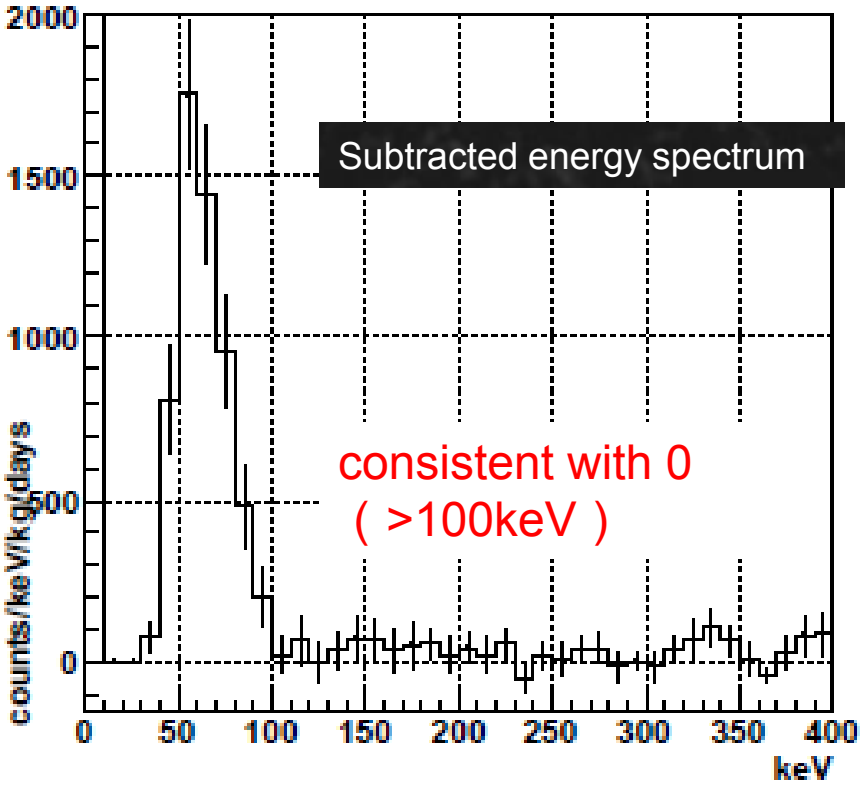




Direction Sensitive WIMP-search NEWAGE

- **gamma-ray rejection**
  - **spectrum, BG subtraction**

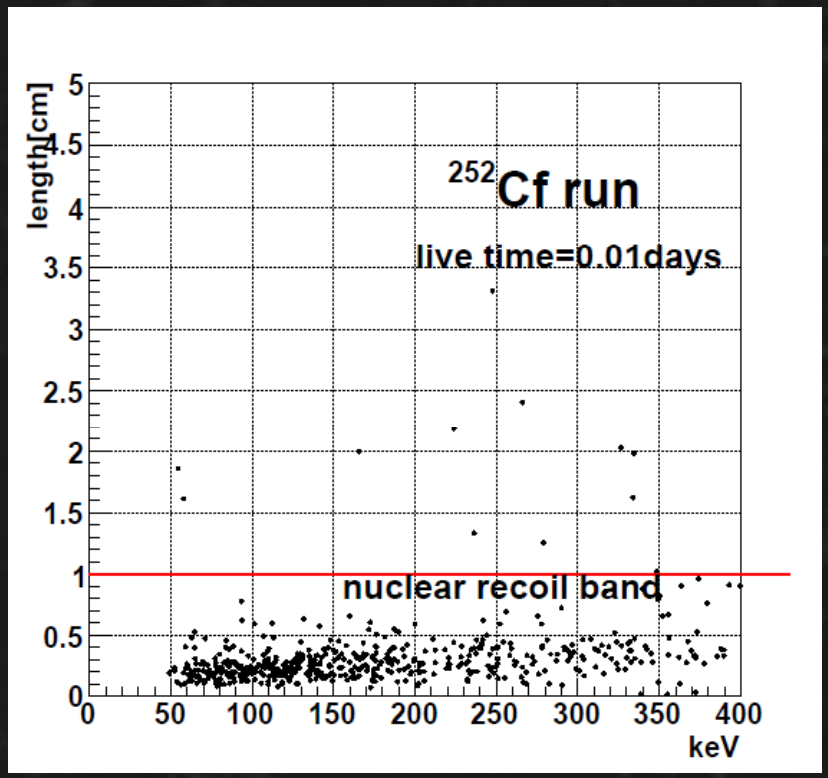


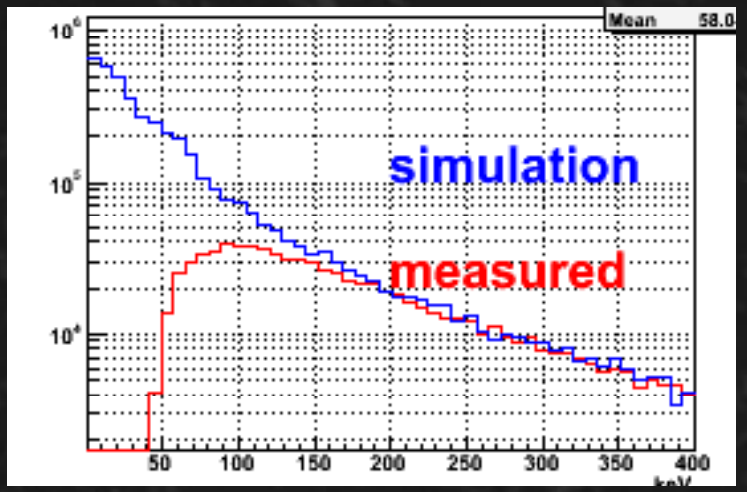


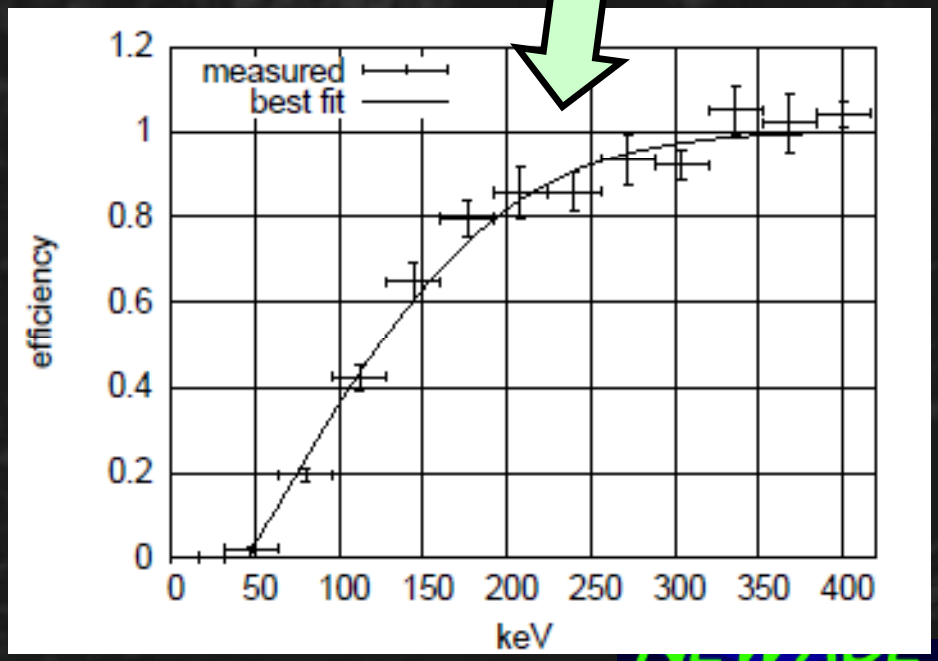
- **gamma rejection (=efficiency to electron tracks)**
  < 2e-4 (statistics limited)

nuclear detection efficiency

- neutrons from ^{252}Cf





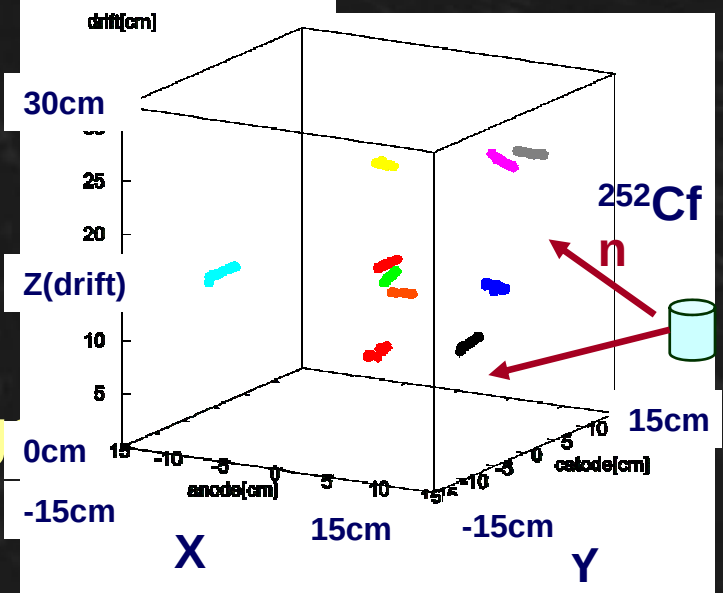


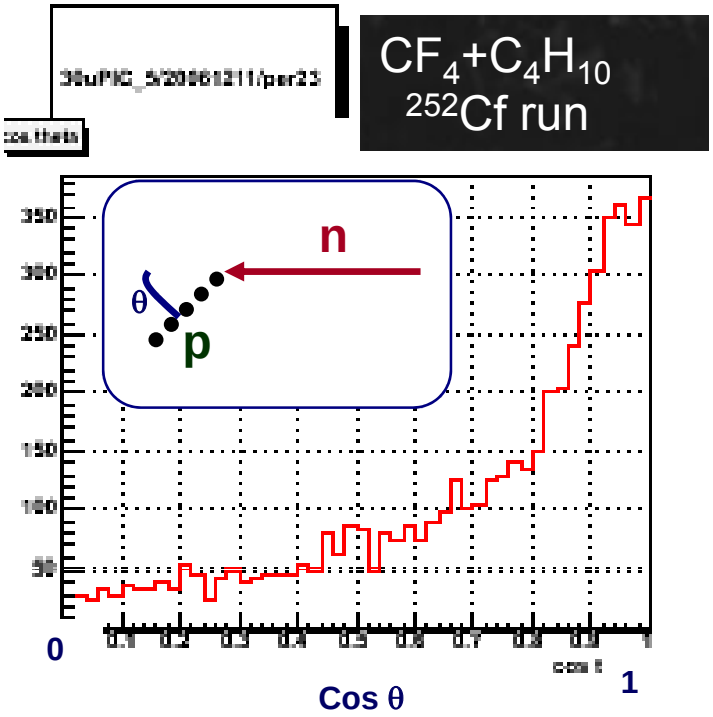
- 0.4 @ 100keV

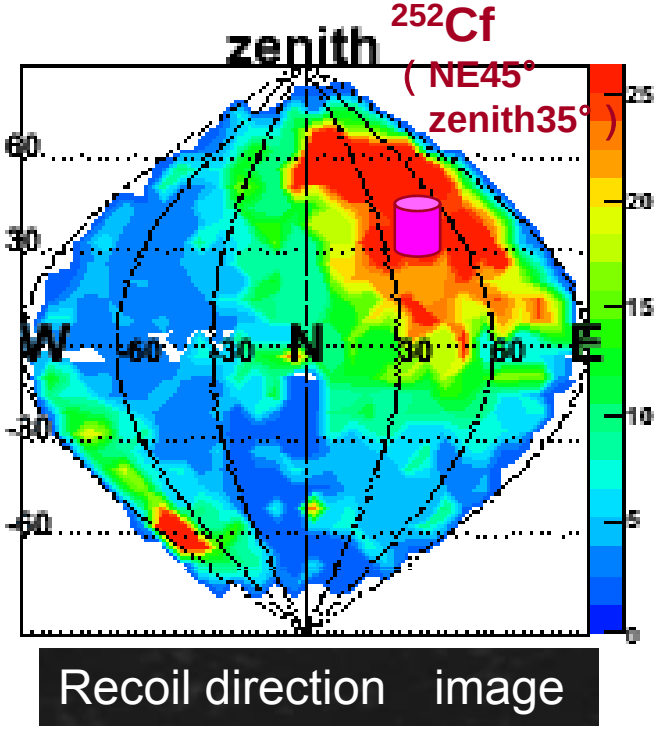
nuclear tracking, imaging demonstration

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

Proton tracks







Recoil direction image

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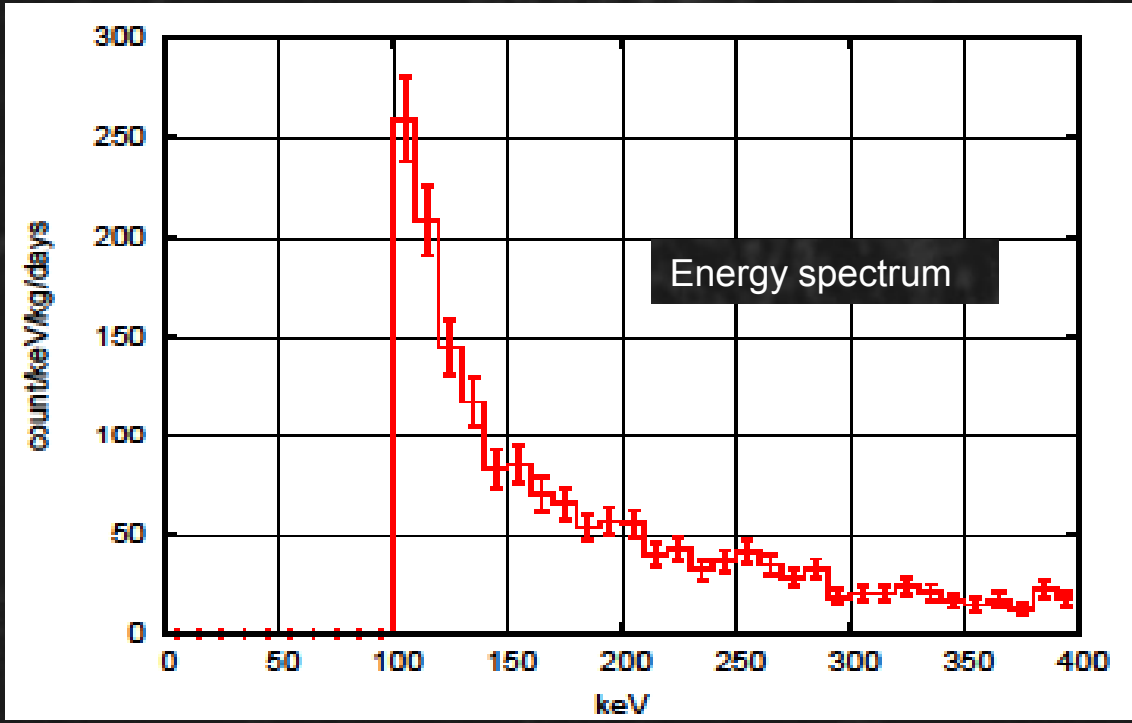
Surface run

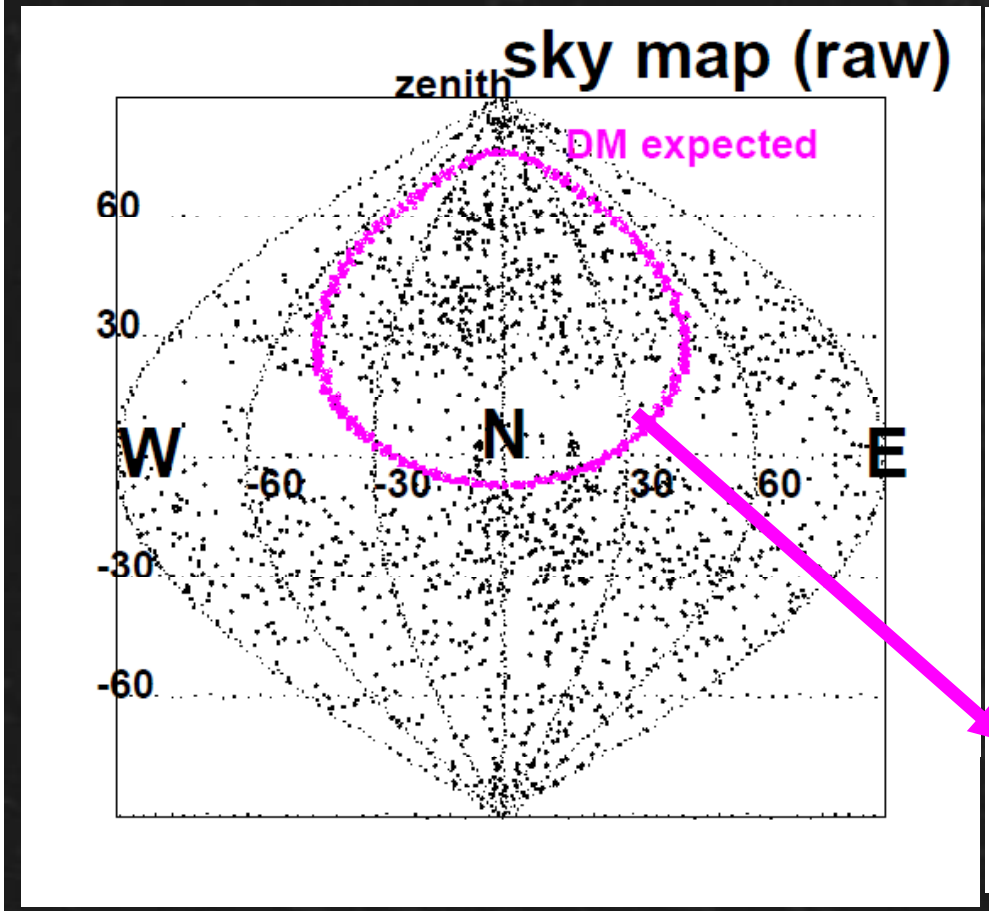
- 2006 Nov.1st ~ Nov.27th
- exposure 0.15 kg days (=0.0089kg ×16.7days)
- @Kyoto university (N35.03　E135.783)
- Energy spectrum (conventional method)

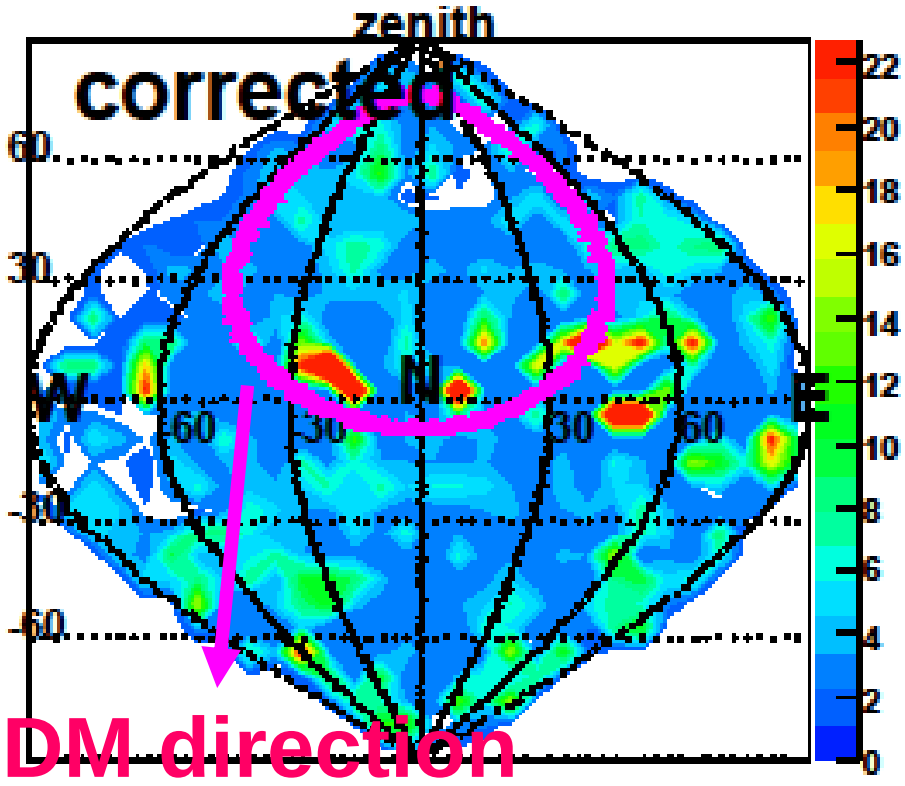


Direction Sensitive WIMP-search NEWAGE

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

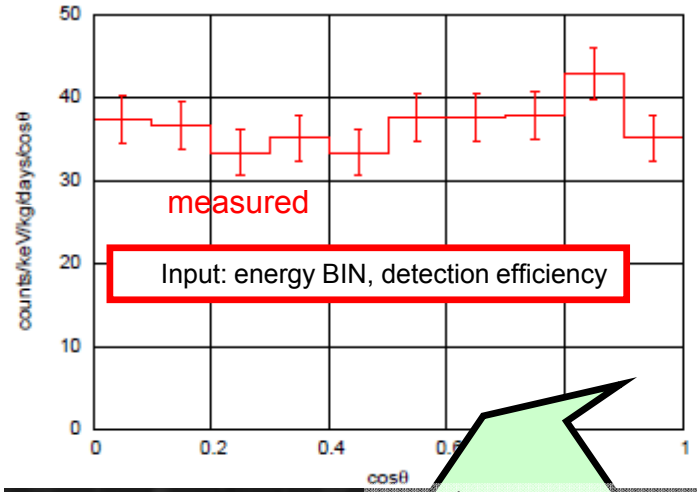
North sky view seen by C and F nuclei
(100-400keV)





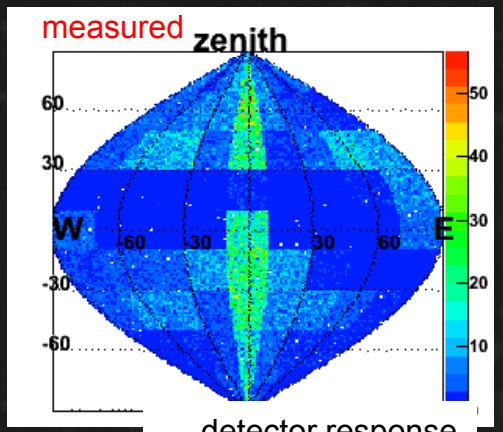
DM direction

DATA



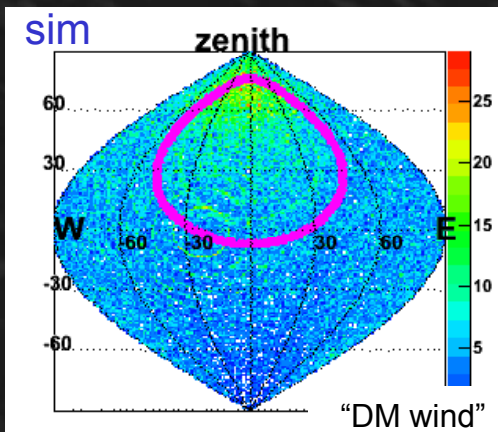
Input: energy BIN, detection efficiency

simlation



detector response

×



"DM wind"

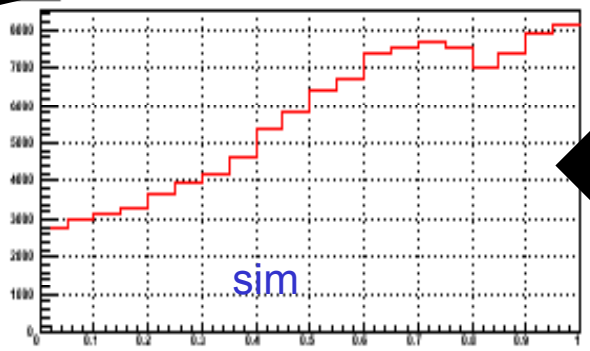
Input: E resolution, angular resolution, WIMP mass, energy BIN

comparison

=

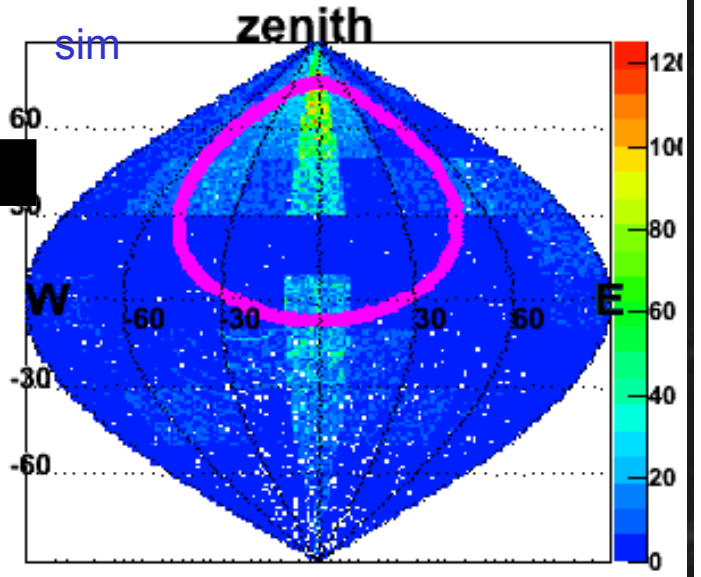
cross section

For given WIMP mass, energy bin



Expected cosθ distribution (DM)

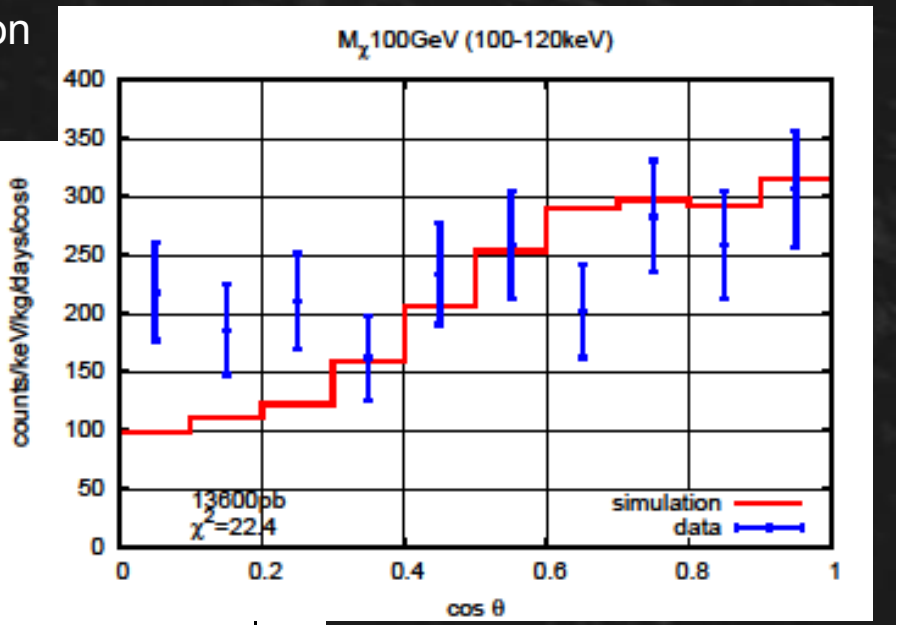
given WIMP mass, energyBIN



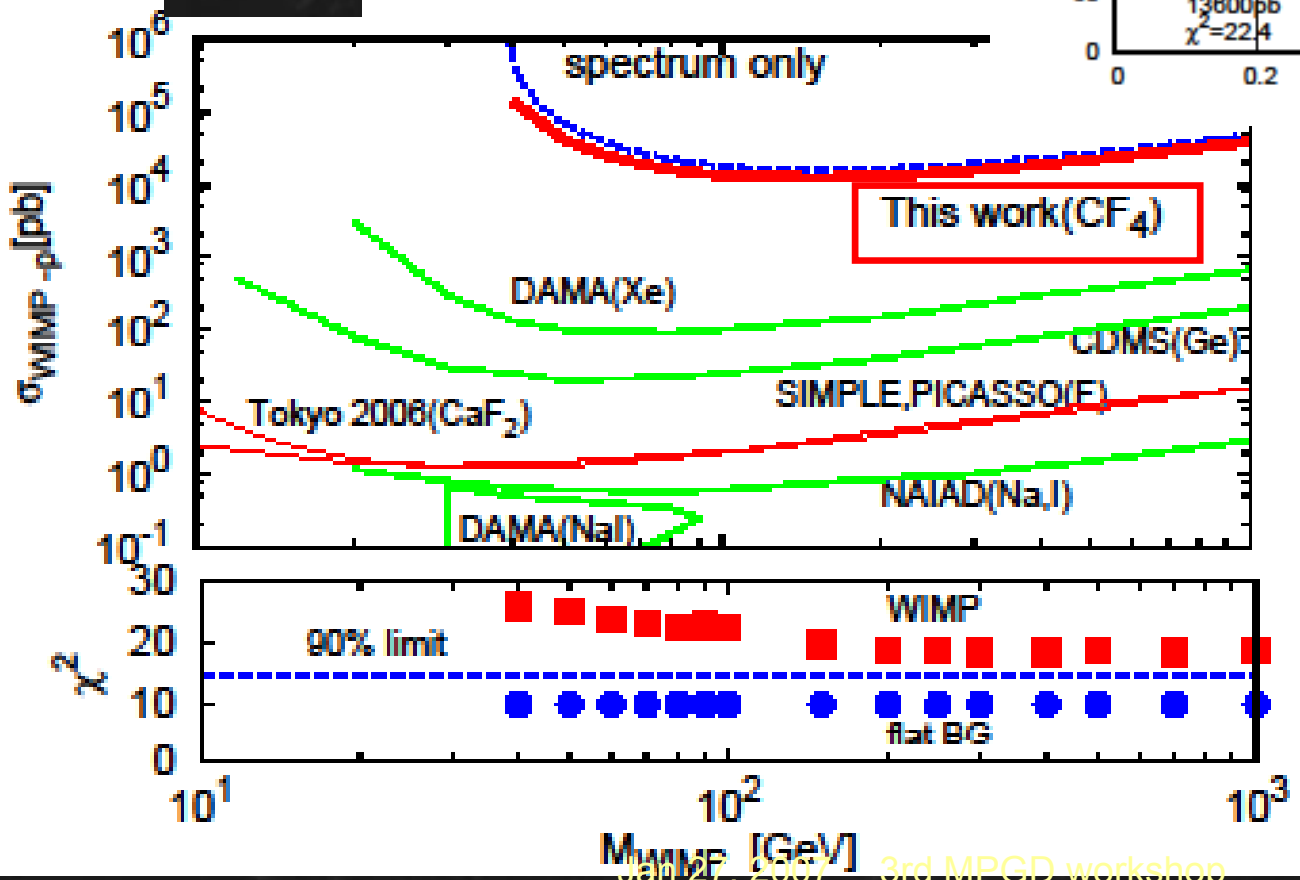
Expected "DM wind"

- **Results**
  - **DM signals are rejected by X^2 tests**
  - **…while the distribution was consistent with a flat distribution**

Cosθ distribution (100-400keV)



DM limit



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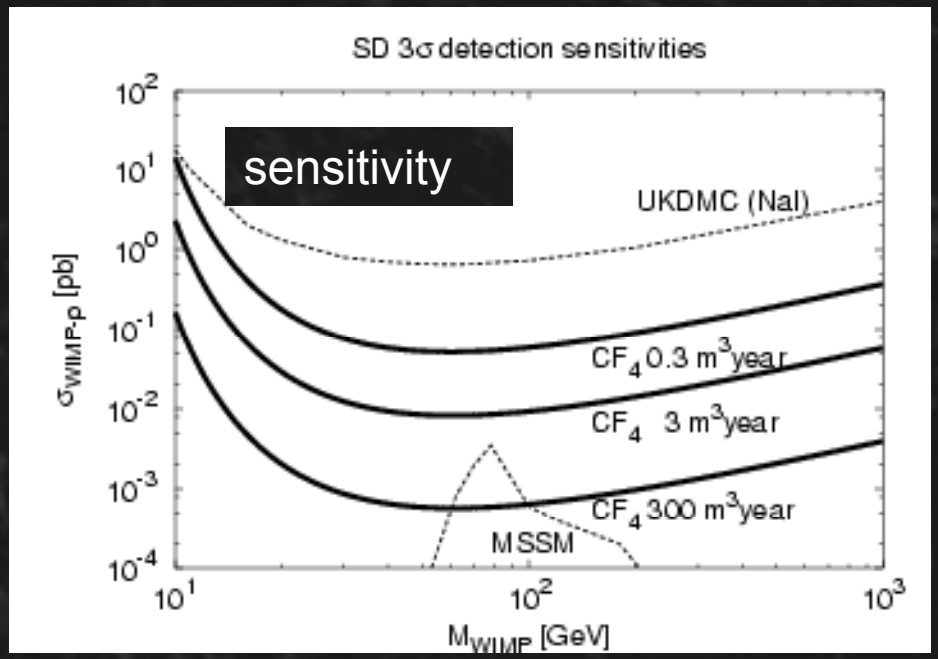
Future plans

- ultimate plan is 100m^3

STEP 1

- 30cm^2*4pcs
  funded 2007-2009
  - simple scaling-up based on the existing μ-PIC
  - low BG materials
  - to improve the sensitivity



STEP 2

- R&Ds for 1m^3 TPC with MPGD readout
  - get ready for the ultimate version
  - 30cm^2 unit is maybe too small

strategy 1: • 50cm^2 μ-PIC and scaling-up of the electronics

strategy 2: • other MPGD + TIMEPIX-like ASIC (discussion with KEK started)

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- **very near future plans**
  - **operation with 0.05 bar CF_4**
  - **longer (50cm) drift**
  - **SI-sensitive gas**

  - **underground run at Kamioka since Jan, 2007**

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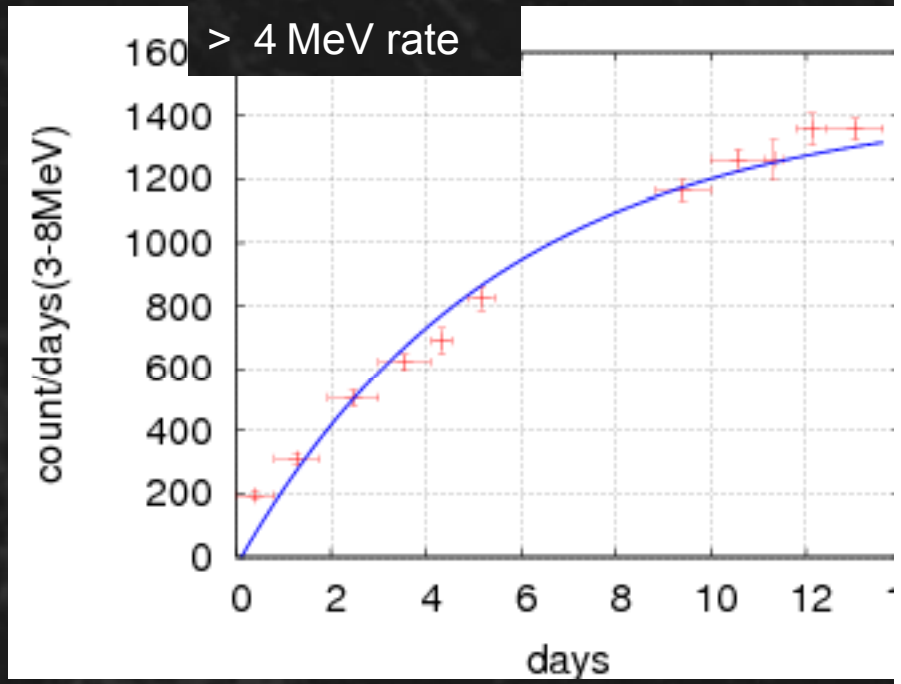
BG studies (very preliminary)

- **radon**
  - time dependence is seen > 4MeV
  - lower energy : being studied



- **alpha**
  - hard to PID by energy-length below 1MeV
  - from drift plane, GEM

- **gamma-ray**
  - well-rejected >100keV
  - DM run can be performed with ^{137}Cs existence

- **neutron**
  - underground run : just started

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- **SUMMARY**
  - **μTPC：30cm cube in operation**
  - **direction-sensitive method works!**
  - **NEWAGE：underground run just started**

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