Compton Imaging Camera Using an Electron-Tracking Gaseous TPC and a Scintillation Camera

Kazuki Ueno[1]

K. Hattori[1], C. Ida[1], S. Iwaki[1], S. Kabuki[1], H. Kubo[1], S. Kurosawa[1], K. Miuchi[1], H. Nishimura[1], Y. Okada[1], A. Takada[2], M. Takahashi[1], T. Tanimori[1], K. Tsuchiya[1]

[1]Dept. of Physics, Graduate school of Science, Kyoto University, Kyoto, Japan
[2]ISAS/JAXA, Japan

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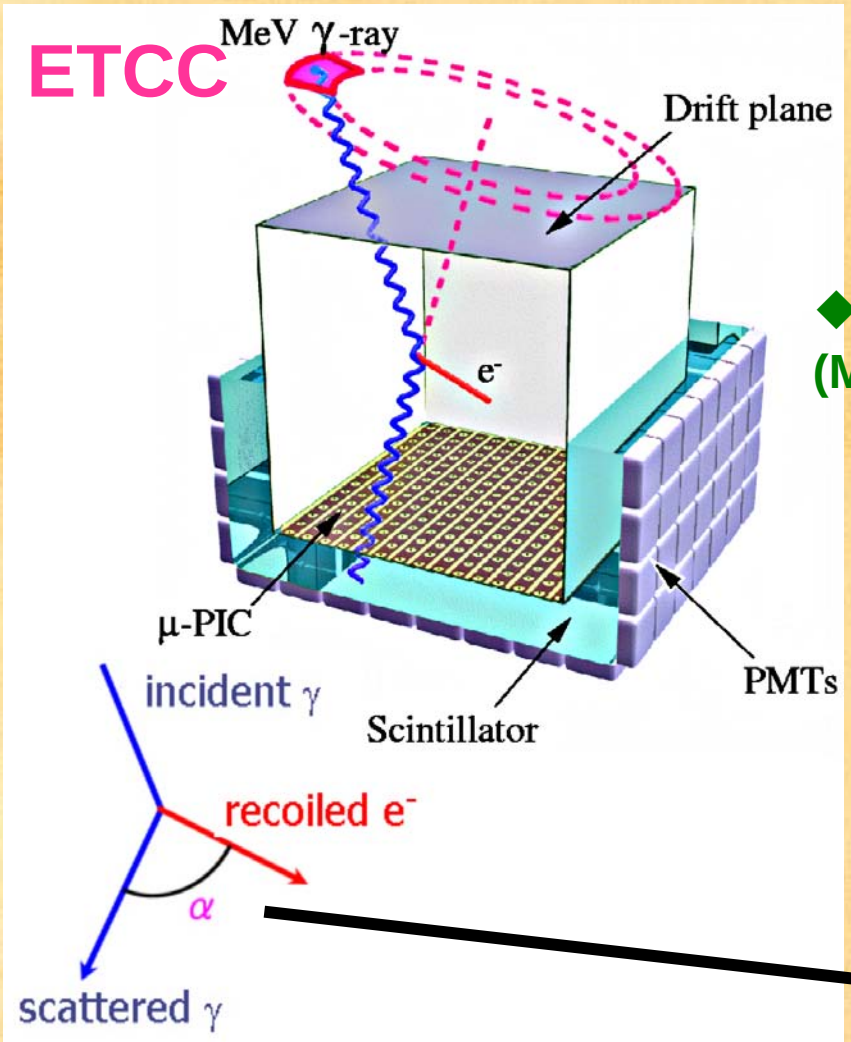
- **Summary and Future work**

Electron Tracking Compton Camera (ETCC)

Sub MeV ~ MeV gamma-ray imaging for…

- Astronomy (balloon experiment, SMILE)
- Application → Medical Imaging

See S. Kabuki's poster(M06-199)



◆ gaseous TPC

(Time projection chamber based on μ-PIC as readout system)

→ **Track** and **energy** of recoil electron

◆ Scintillation camera

(Multi Anode PMT+Pixelated Scintillator Array)

→ **position** and **energy** of scattered gamma-ray

Reconstruct incident gamma-ray event by event

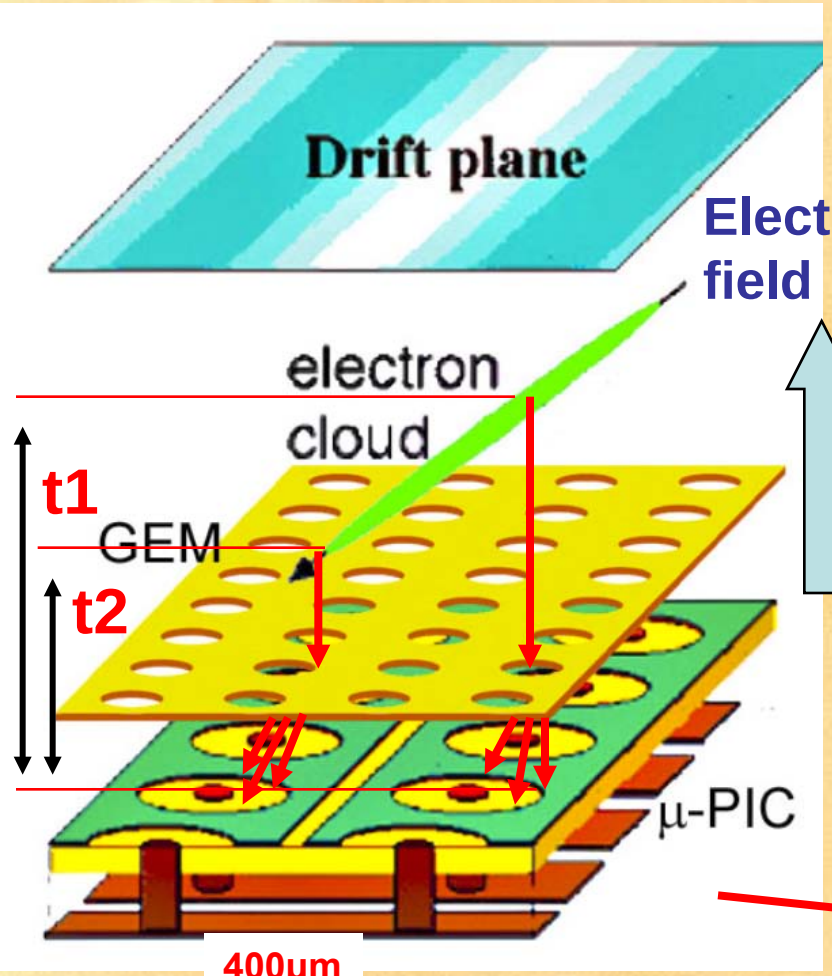
- 1 photon ⇒ direction + energy
- Large FOV (~3str)
- Kinematical background rejection

Gaseous TPC

for recoil electron

2D readout (μPIC 400μm pitch)
+ Drift time (100MHz)
>3D tracking and energy

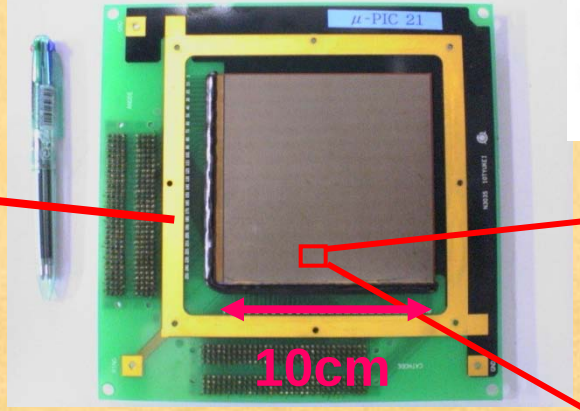
- **Volume : 10cm x 10cm x 15cm (prototype)**
- **Position resolution : 400 mm**
- **Stable gas gain : ~ 35000 (μPIC ~ 3500, GEM ~ 10)**



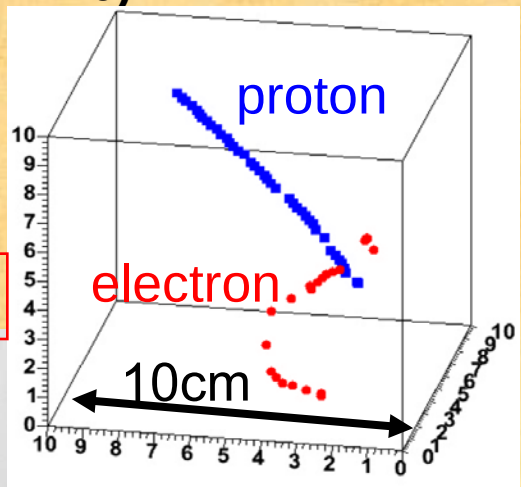
Schematic view of gaseous TPC

Using as pre-amplifier to obtain stable high gain

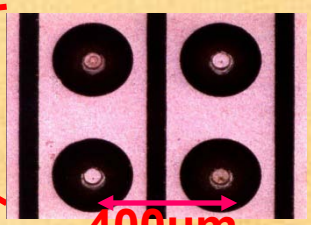
T. Tanimori (CC2-1)



μPIC(10cmX10cm)

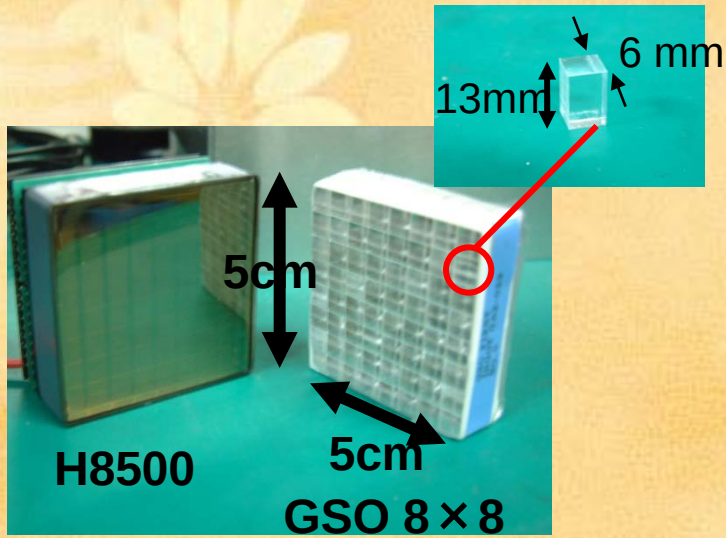


Example of 3D-track



Scintillation Camera

for scattered gamma ray



Scintillation camera (Multi Anode PMT + Pixel Scintillator Array)

Scintillator : GSO(Ce)

Photon sensor : H8500 (HPK)

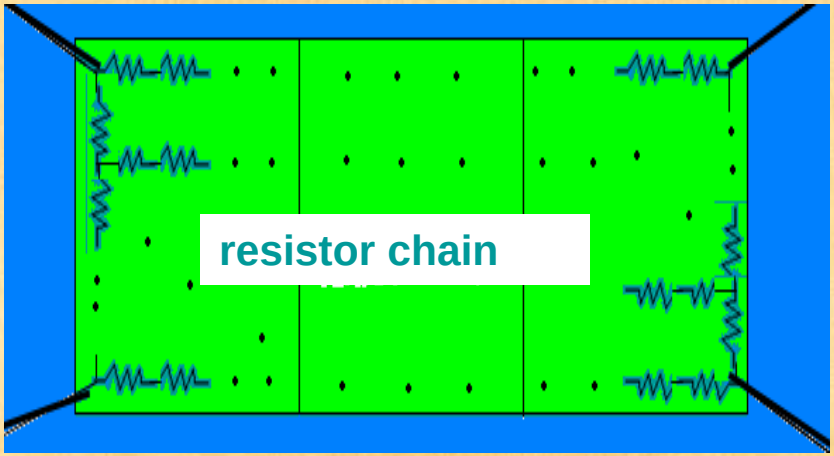
Position resolution : 6mm (proto type)

Energy resolution : ~11%(FWHM) @ 662keV

H. Kubo (N02-367)

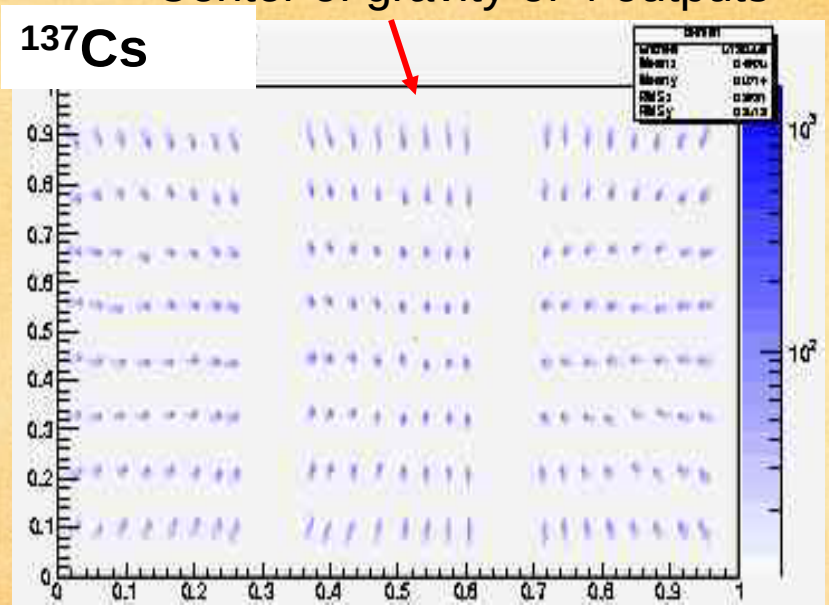
Readout system

4 channels readout with resistive chain to 192 pixels (3 PMTs) (H. Sekiya et al., NIM, 2006)



Position imaging map

Center of gravity of 4 outputs



SMILE *Sub-MeV gamma-ray Imaging Loaded-on-balloon Experiment*

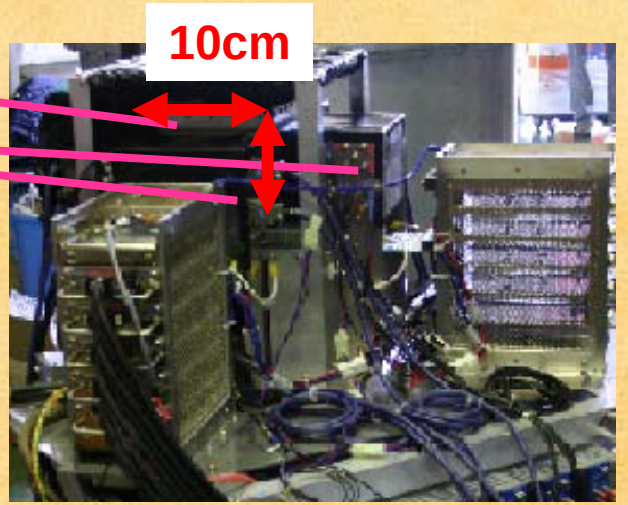
SMILE-1

(10cm)^3 ETCC (prototype)@ Sanriku, Japan

1st September 2006 launch

Gaseous TPC

33 Scintillation cameras



- Operation test of our Compton Camera @ 35km
- Diffuse cosmic and atmospheric gamma-ray measurement

SMILE-1 has been successful!

A.Takada et al. 2007 IEEE Conf. Rec.

Next step **SMILE-2**

- Observation of bright Object (Crab or Cyg X-1)

(10cm)^3 ETCC ⟶ Effective area is not good.

We need the larger ETCC !

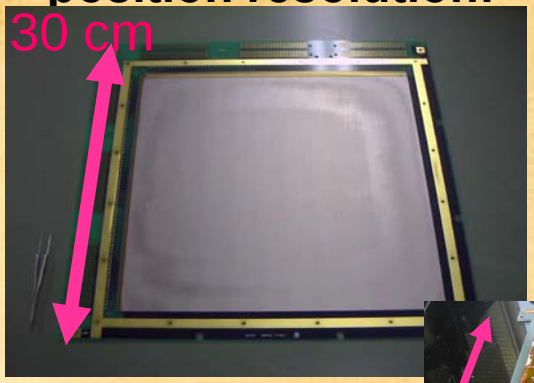
(30 cm)^3 TPC with 6 x 6 scintillation cameras.

30×30×30cm³ ETCC

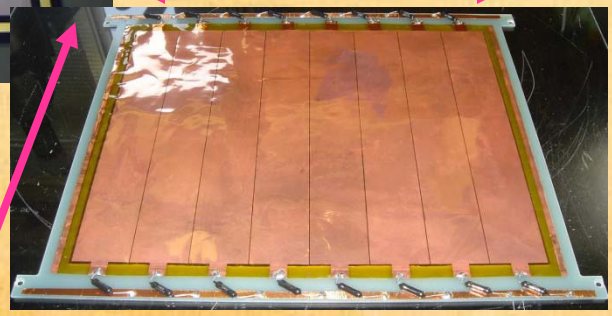
We are developing a larger ETCC based on the 30cm ×30cm×30cm TPC and 6 x 6 scintillation cameras.

gaseous TPC

- volume : 30×30×30 cm³
- gas : Ar 90% + $C_2H_6$10% 1atm
- drift velocity : 4 cm/μsec
- gain : ～30000
- energy resolution : 46%@32keV
- position resolution: 400μm



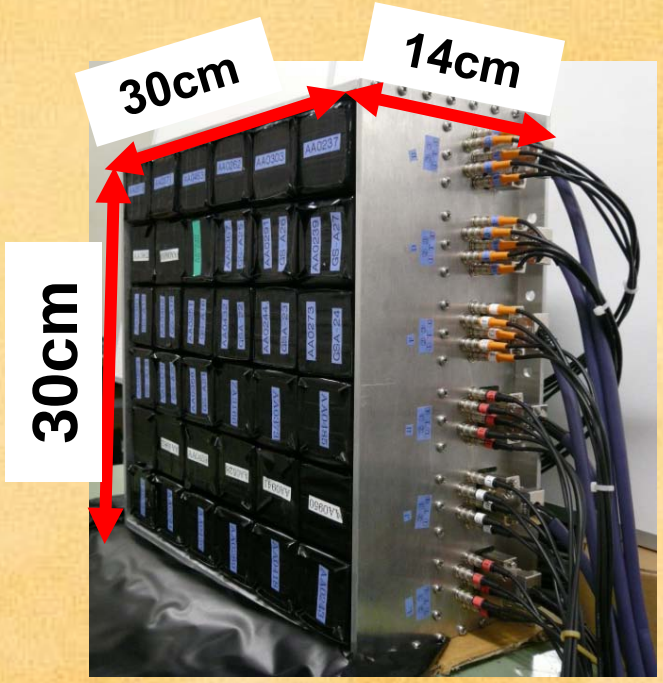
30cm x 30cm μPIC



GEM

scintillation camera

- number of pixels : 2304
- Crystal : GSO(Ce)
- pixel size : 6×6×13mm³
- energy resolution : 10.9% (@662keV, FWHM)
- position resolution : 6mm



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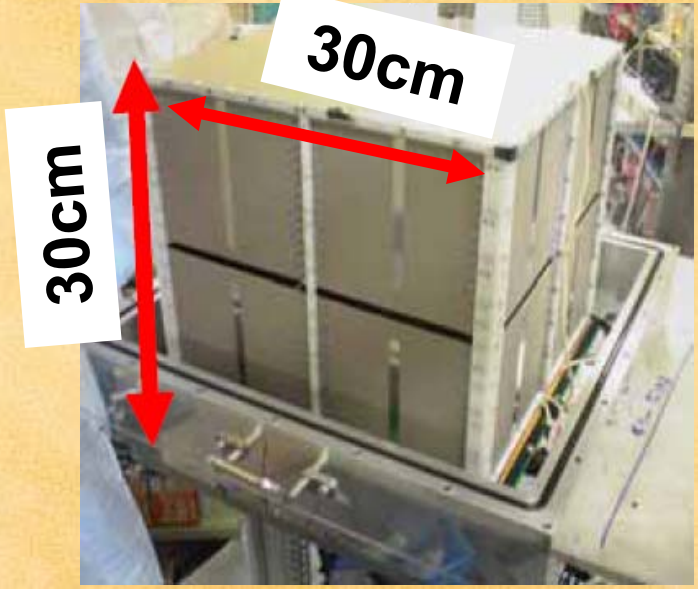

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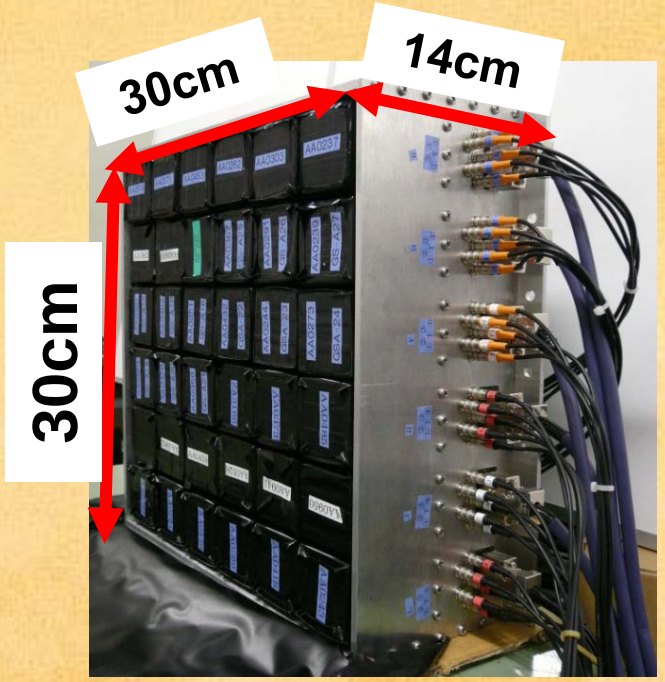
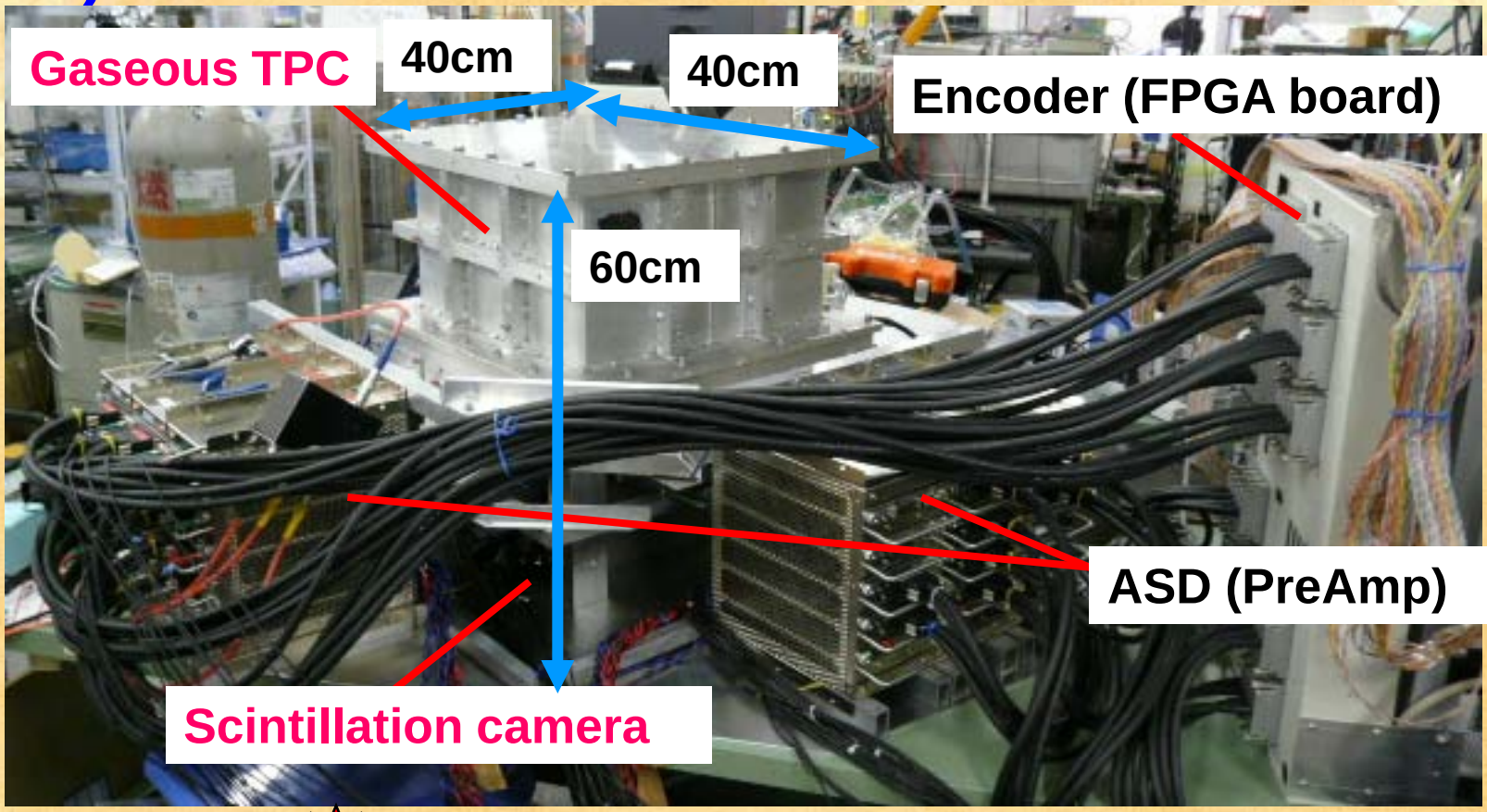
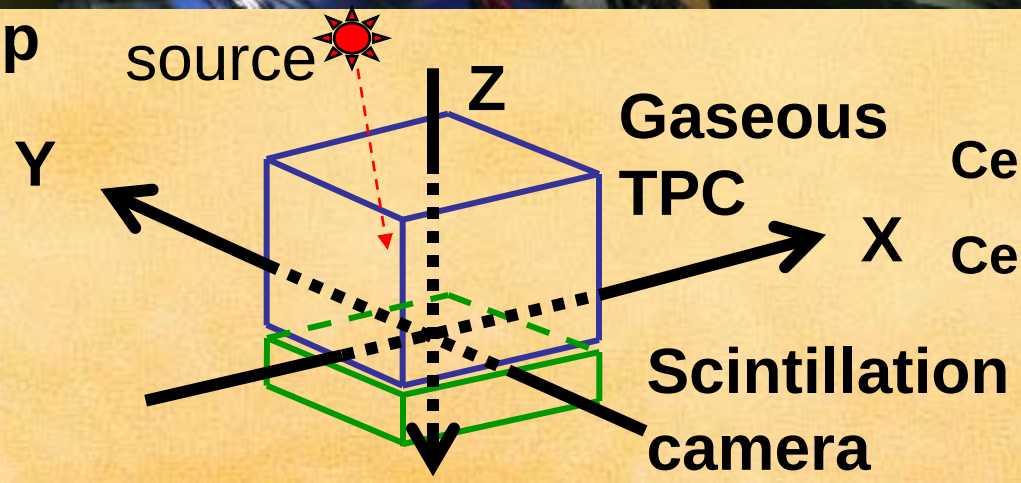


$(30cm)^3$ETCC



Setup



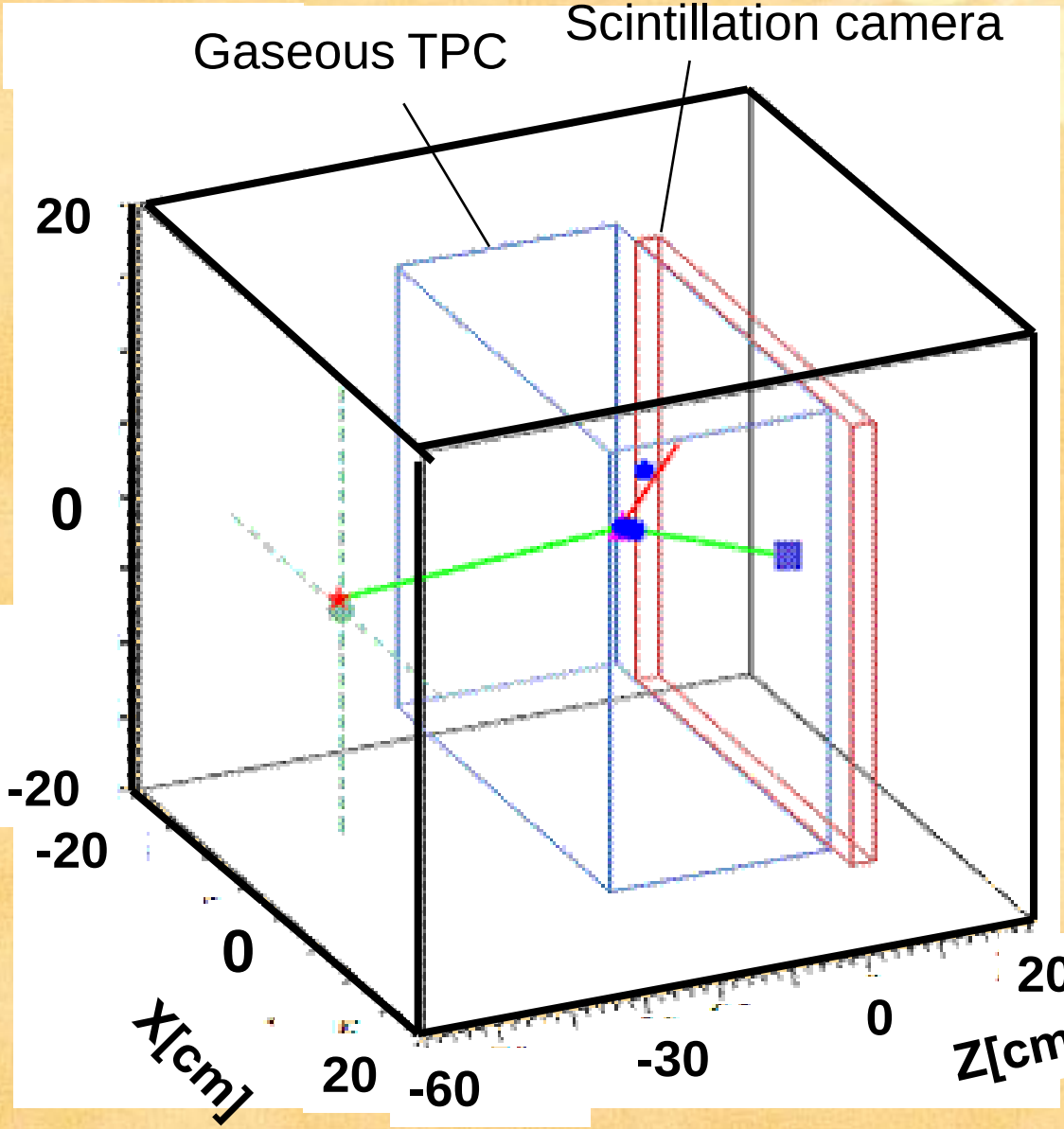
Center of μPIC :(0,0,0)

Center of Scinti. :(-3.3, 0.2, 5.7)

Typical Compton event

^{137}Cs (662keV)

(X,Y,Z)=(0,0,-52cm)



: source position

: reconstructed

: Compton point

: Scinti hit

: electron hit

: reconstructed gamma

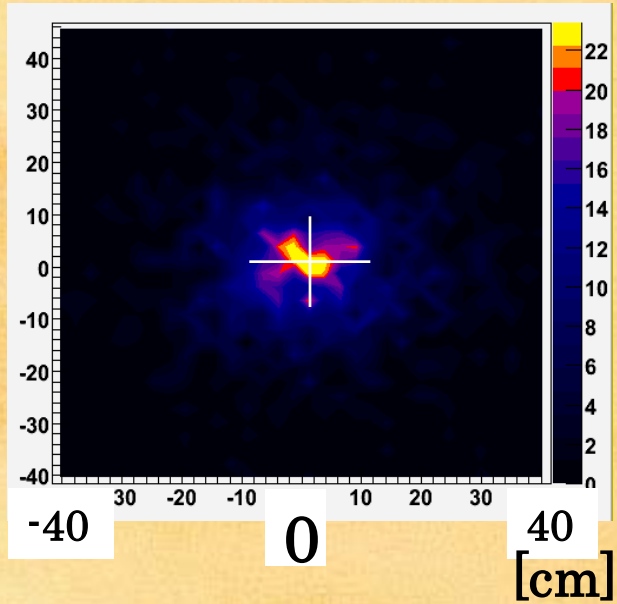
: scattered gamma

: recoil electron

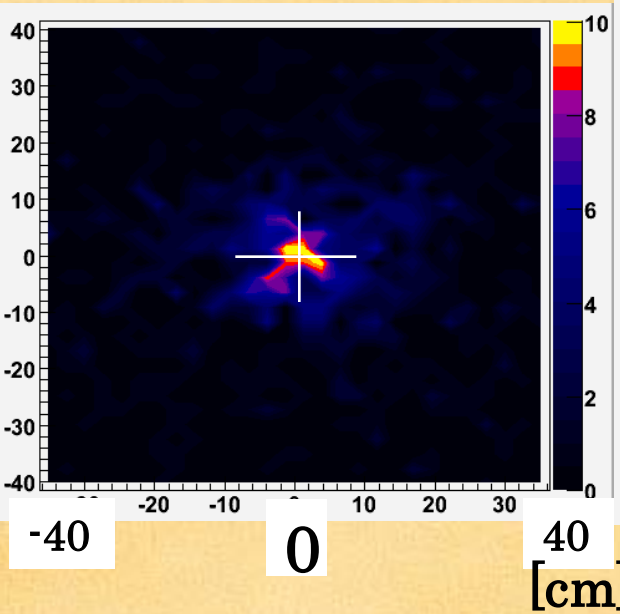
Reconstructed energy 620-700keV

Point source Imaging (preliminary)

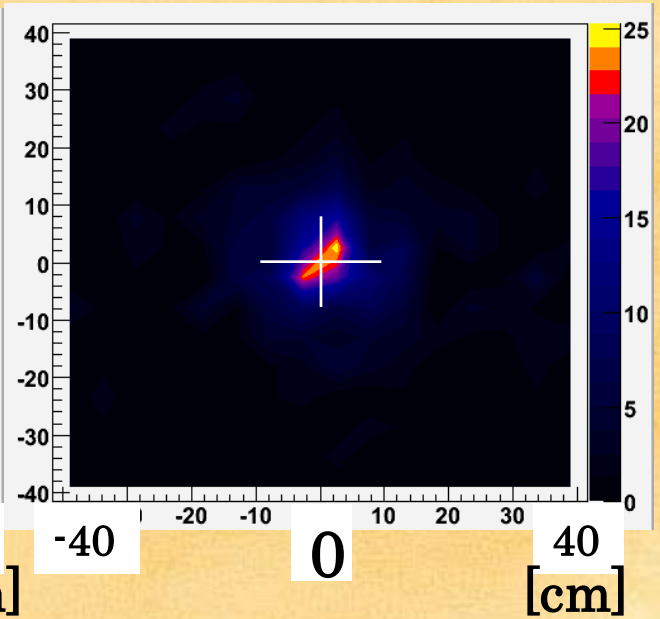
Source position (X,Y,Z)=(0,0,-52cm) 1MBq



356keV
^{133}Ba
Events : 2884
(309-403keV)



662keV
^{137}Cs
Events : 992
(605-719keV)

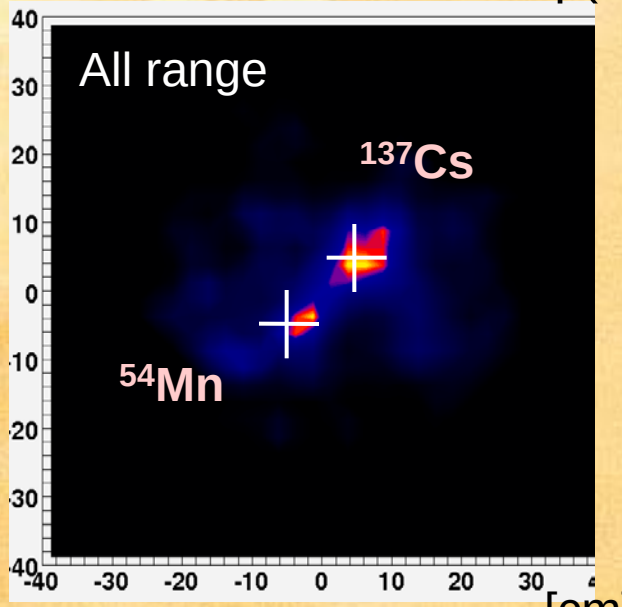


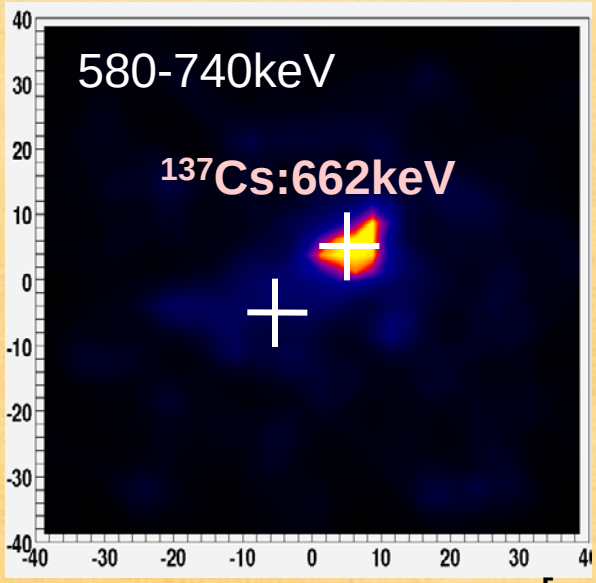
835keV
^{54}Mn
Events : 515
(770-900keV)

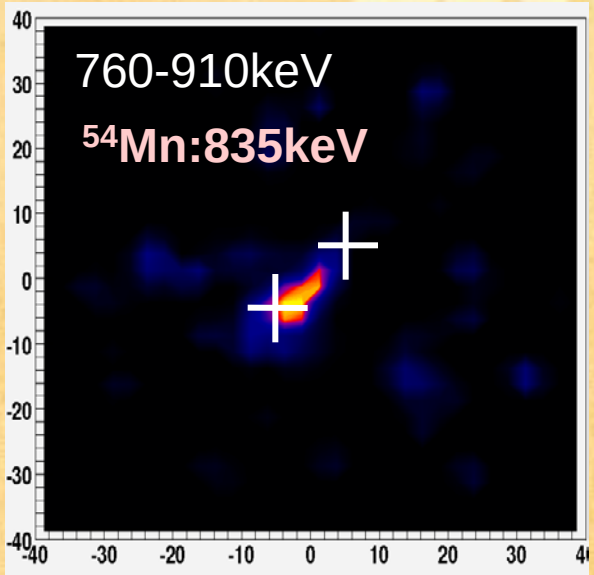
2 point sources (preliminary)

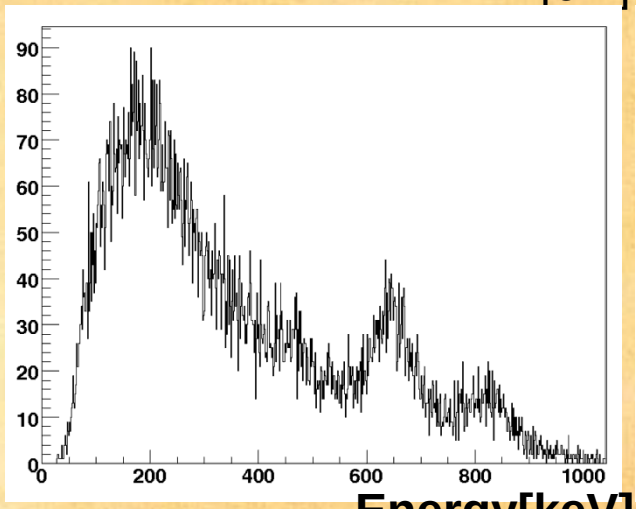
^{137}Cs : 662keV, 1MBq (X,Y,Z)= (-5,-5,-58)

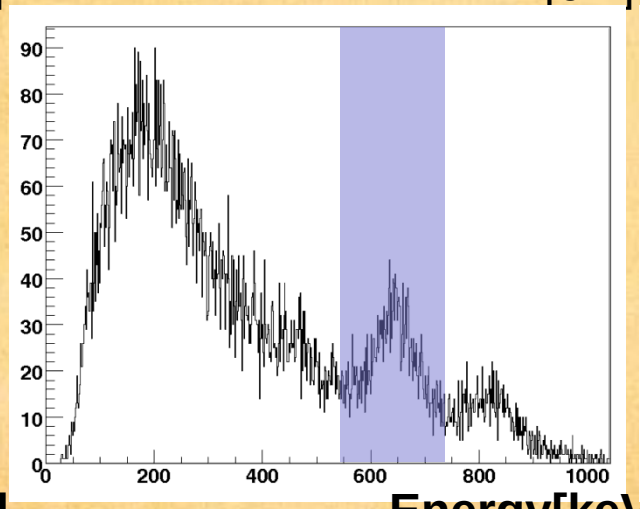
^{54}Mn : 835keV, 1MBq (X,Y,Z)= (5,5,-58)

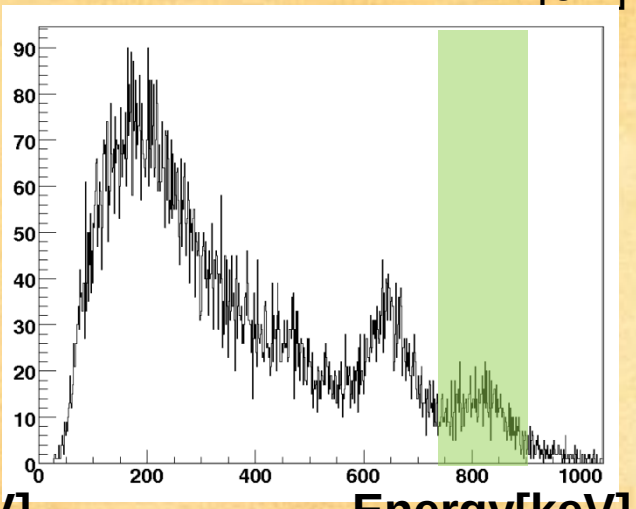






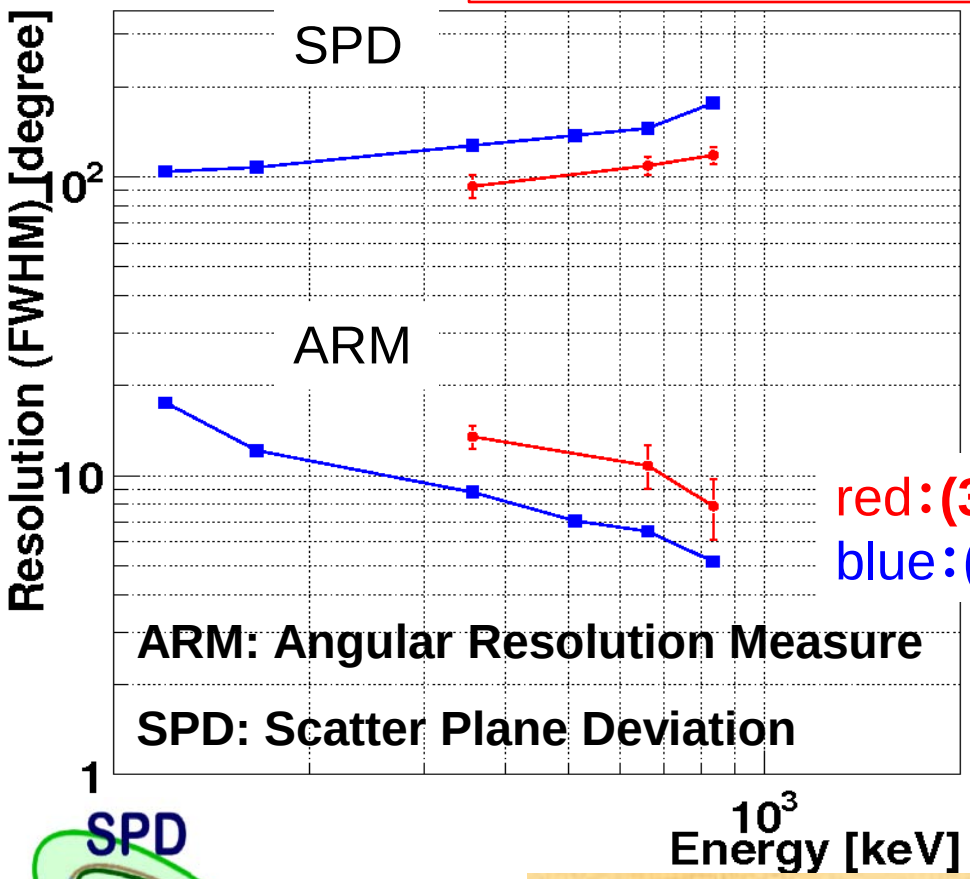


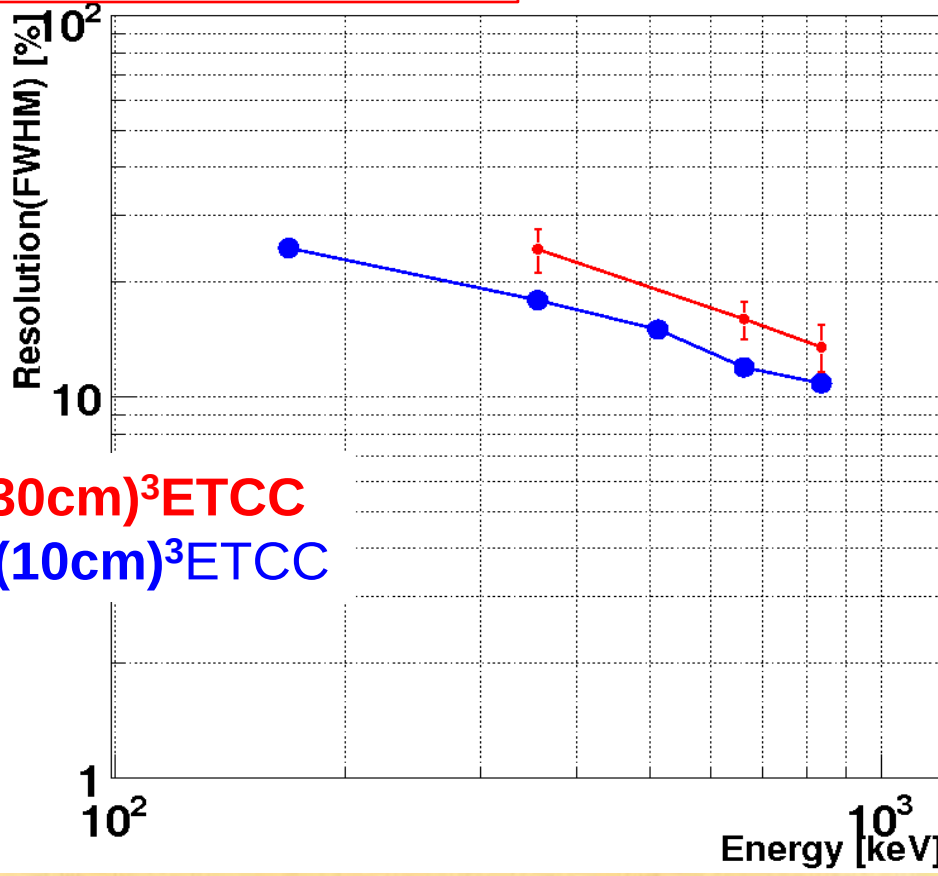




Angular resolution, Energy resolution

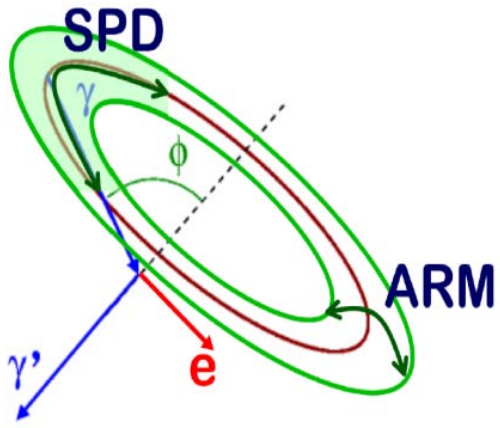
(Preliminary! Under improvement)





red : **(30cm)^{3}ETCC**

blue : **(10cm)^3**ETCC



SPD: 109[deg]	130[deg]
ARM: 10.8[deg]	6.6[deg]
ΔE/E: 16.0% (FWHM) @662keV	12.0%

(10cm)^{3}ETCC

Summary

- Sub MeV gamma-ray imaging detector, ETCC
  - We have developed the MeV gamma-ray imaging detector with using Compton scattering, ETCC, for the balloon experiment, SMILE.
  - SMILE-1 has been successful.
  - For SMILE-2, we need the larger ETCC in order to improve effective area.
- ETCC based on 30cm X 30cm X 30cm TPC and 6 X 6 GSO Scintillation camera
  - We have developed the $(30cm)^3$ ETCC and tested that.
  - Imaging has been successful.
  - ARM: 10.8[deg](FWHM), SPD:109[deg](FWHM), Energy resolution:16.0%(FWHM) @662keV

Future work

- Tune up the 30cm X 30cm X 30cm ETCC

  achieve close to the performances of $(10cm)^3$ ETCC

- Construct the ETCC with higher efficiency and better performances

Thank you for your attention!!