

# An Electron-Tracking Compton Imaging Camera Based on a Gaseous TPC and a Scintillation Camera

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- Our plan (SMILE ~ balloon experiment) and requirement

## ➤ Performance of ETCC based on 30cm X 30cm X 15cm TPC and Scintillation camera

## ➤ Development of (30cm)<sup>3</sup> ETCC

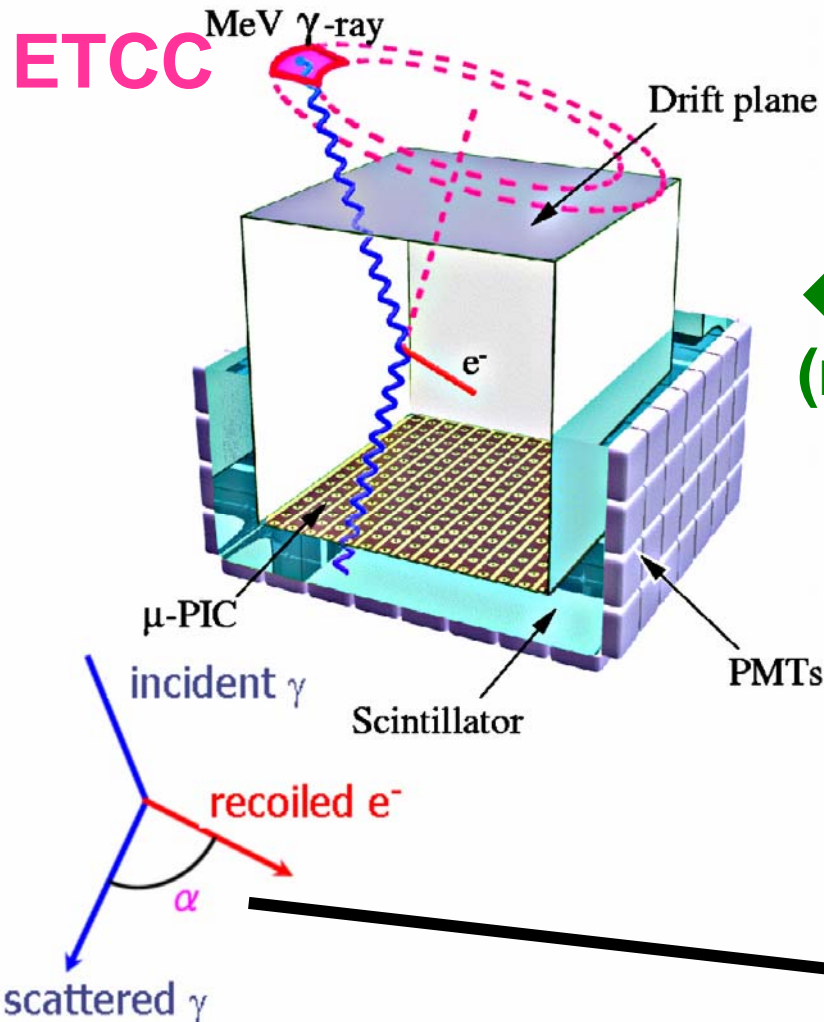
## ➤ Summary and Future work

# Electron Tracking Compton Camera (ETCC)

Sub MeV ~ MeV gamma-ray  
imaging for...

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

See S. Kabuki's poster(M18-110)



## ◆ gaseous TPC

(Time projection chamber based on  $\mu$ -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  $\Rightarrow$  direction + energy
- Large FOV ( $\sim 3$ str)
- Kinematical background rejection

# Gaseous TPC

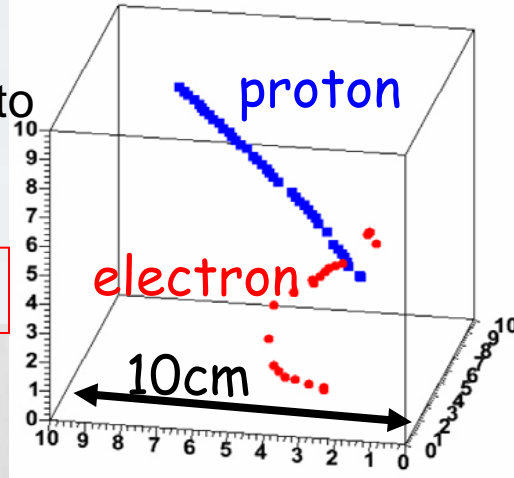
for recoil electron

2D readout ( $\mu$ PIC 400 $\mu$ m pitch)  
+ Drift time (100MHz)  
>3D tracking and energy

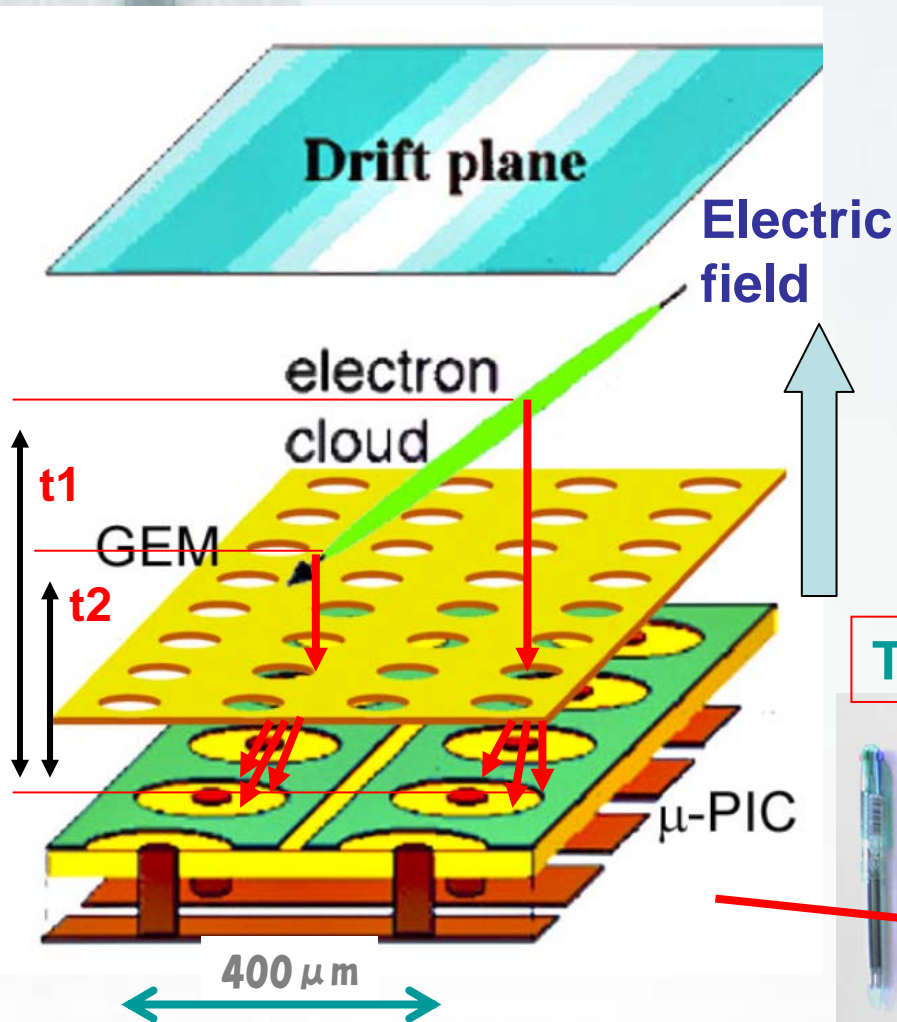
- Volume : 10cm x 10cm x 15cm (prototype)
- Position resolution : 400  $\mu$ m
- Stable gas gain : ~ 35000 ( $\mu$ PIC ~ 3500, GEM ~ 10)

Using as pre-amplifier to obtain stable high gain

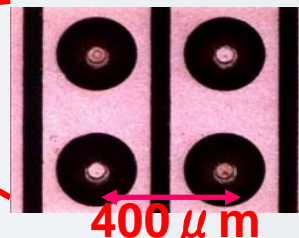
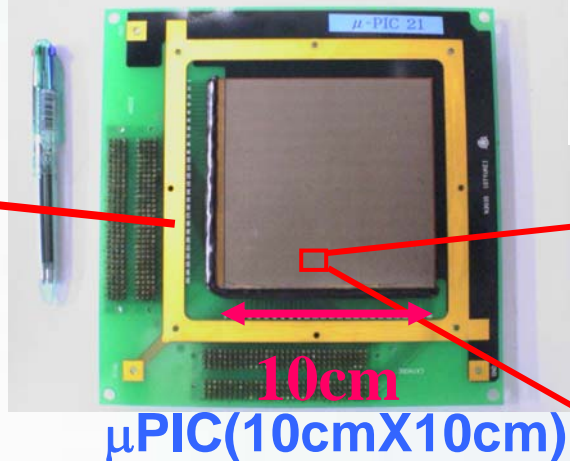
T. Tanimori (MP4-1)



Example of 3D-track



Schematic view of gaseous TPC



# Scintillation Camera

for scattered gamma ray

## Scintillation camera (Multi Anode PMT + Pixel Scintillator Array)

Scintillator : GSO(Ce)

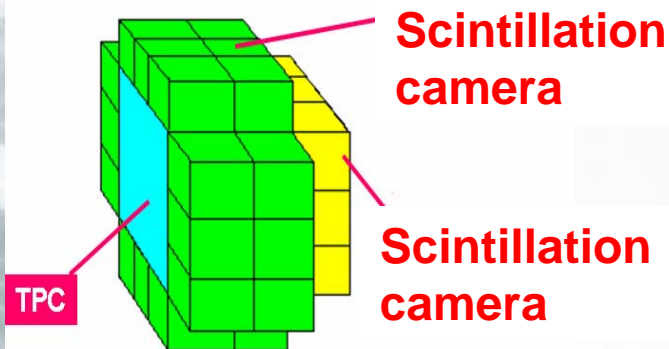
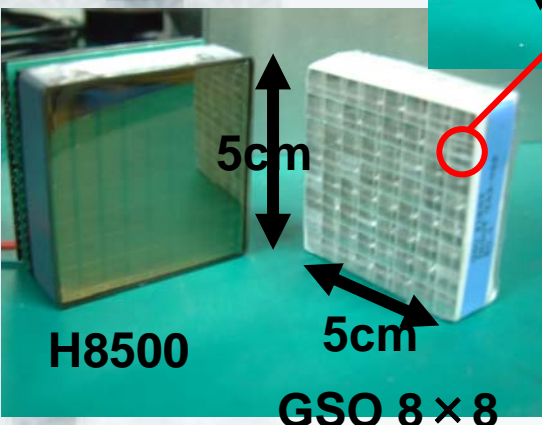
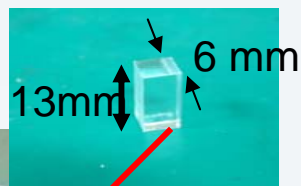
Photon sensor : H8500 (HPK)

Position resolution : 6mm (proto type)

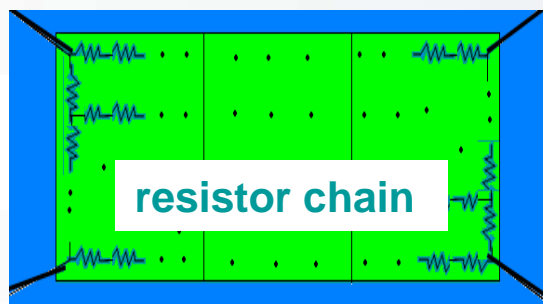
Energy resolution : ~11%(FWHM) @ 662keV

## Readout system

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

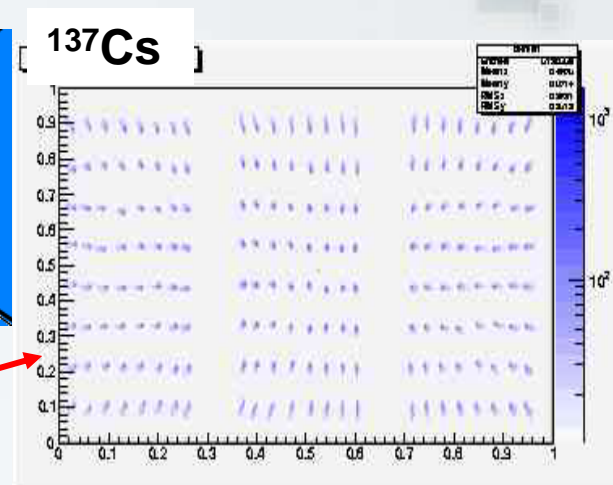


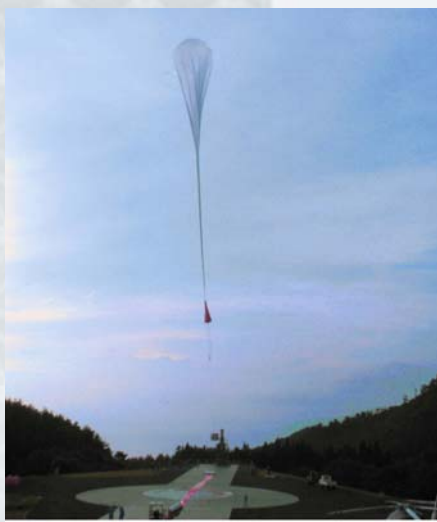
Scintillation camera (prototype)



Position imaging map

Center of gravity of 4 outputs





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

## SMILE-1

(10cm)<sup>3</sup> ETCC (prototype) @ Sanriku, Japan

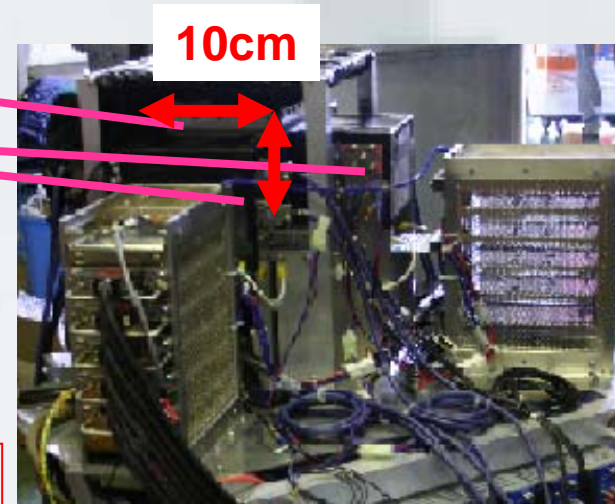
1st September 2006 launch  
Gaseous TPC

**33** Scintillation cameras

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

**SMILE-1 has been successful!**

**See A.Takada's talk (N59-8)**



Next step

## SMILE-2

• Observation of bright Object (Crab or Cyg X-1)  
(10cm)<sup>3</sup> ETCC → Detection efficiency is not good.

**We need the larger ETCC, and have developed that!**

1<sup>st</sup> step : 30 x 30 x 15cm<sup>3</sup> TPC with 6 x 6 scintillation camera

2<sup>nd</sup> step : (30 cm)<sup>3</sup> TPC with 6 x 6 + 6 x 3 x 4 scinti. camera

# 1<sup>st</sup> step : $30 \times 30 \times 15\text{cm}^3$ ETCC

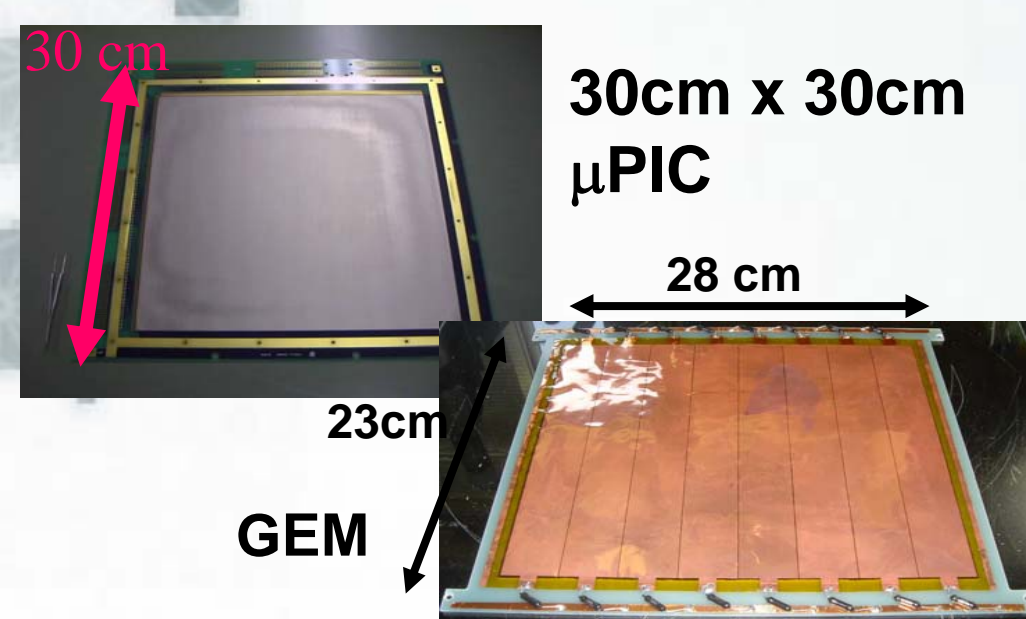
We have developed larger ETCC based on 30cm x 30cm x 15cm TPC and 6 x 6 scintillation cameras which consists of 3mm pitch 256 pixels.

## **gaseous TPC**

- volume :  $30 \times 30 \times 15 \text{ cm}^3$
- gas : Ar 90% + C<sub>2</sub>H<sub>6</sub> 10%  
1atm
- drift velocity : 3.8 cm/  $\mu$  sec
- gain :  $\sim 30000$
- energy resolution : 50% @ 32keV
- position resolution: 400  $\mu$  m

## **scintillation camera**

- number of pixels : 9216
- pixel size :  $3 \times 3 \times 13\text{mm}^3$
- energy resolution : 10.7% (@662keV, FWHM)
- position resolution: 3mm
- **not using the outer circumferencial pixels**



# 1<sup>st</sup> step : $30 \times 30 \times 15\text{cm}^3$ ETCC

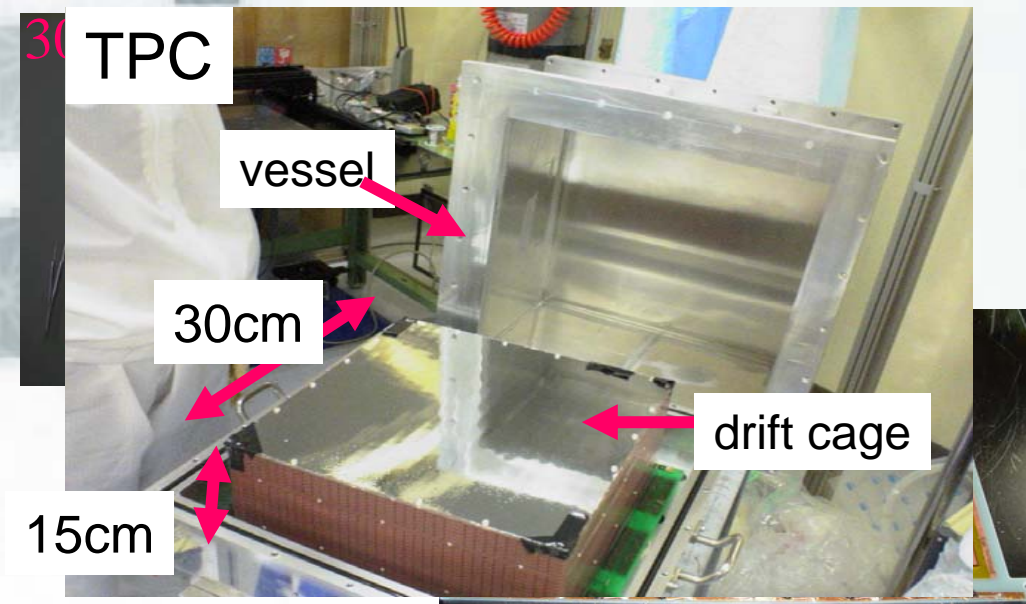
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## **scintillation camera**

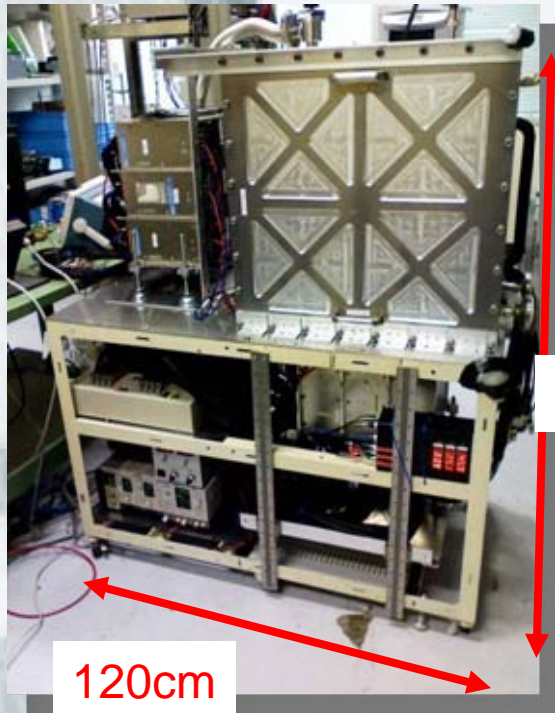
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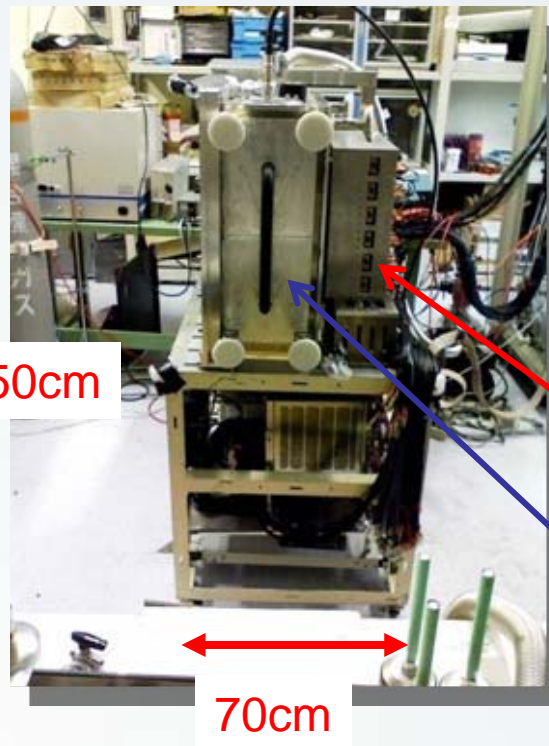


# 30 × 30 × 15cm<sup>3</sup> ETCC

## Front view



## Side view



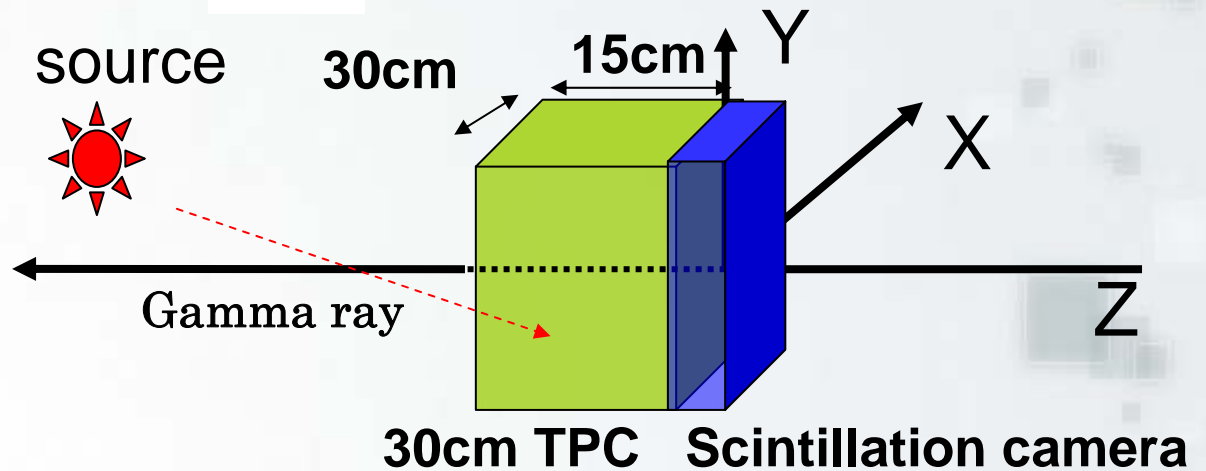
30 × 30 × 15cm<sup>3</sup> ETCC

Size (Camera)

120 × 70 × 150cm<sup>3</sup>

Scintillation Camera  
TPC

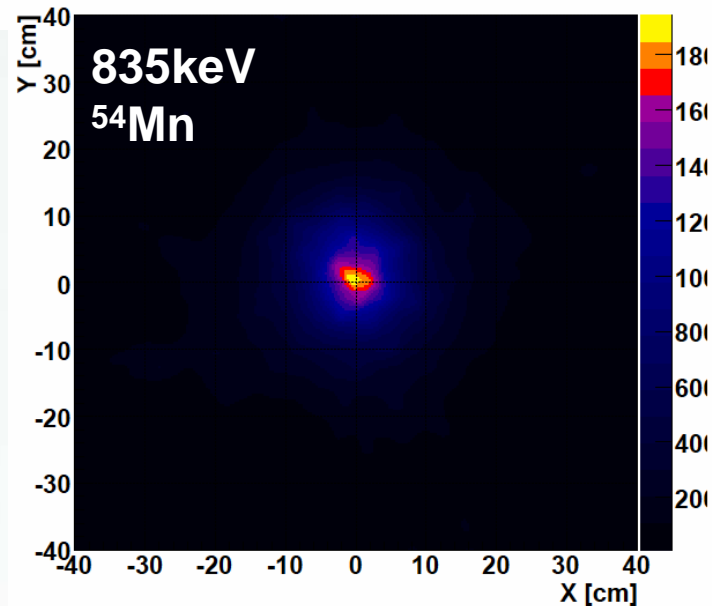
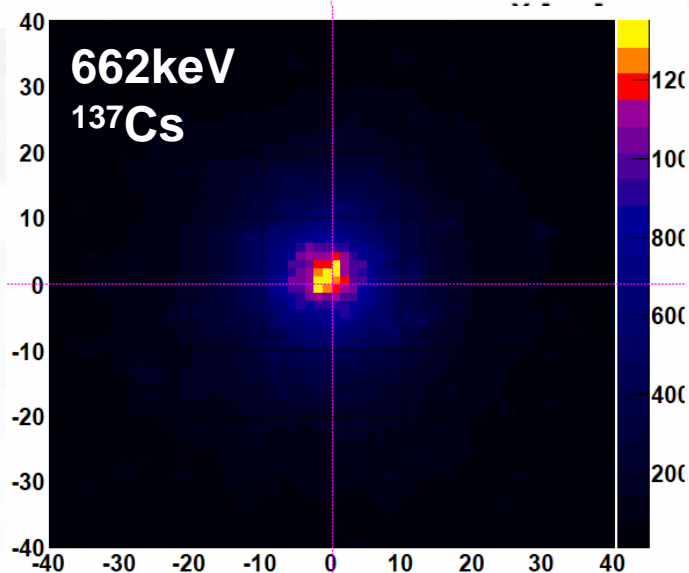
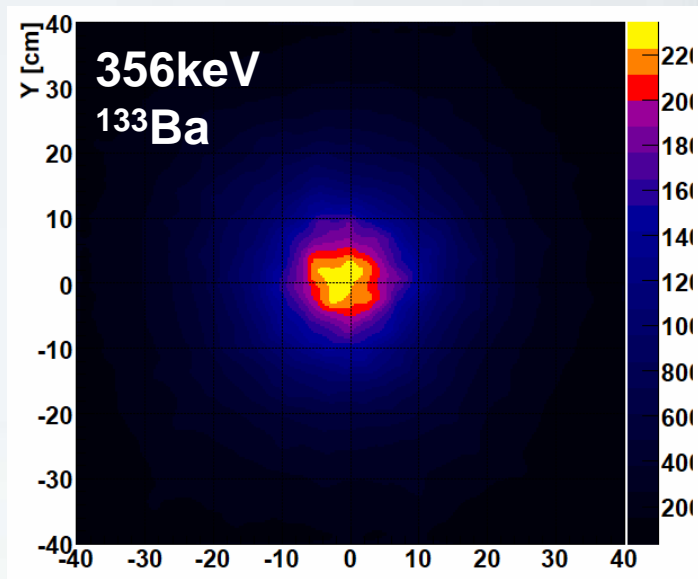
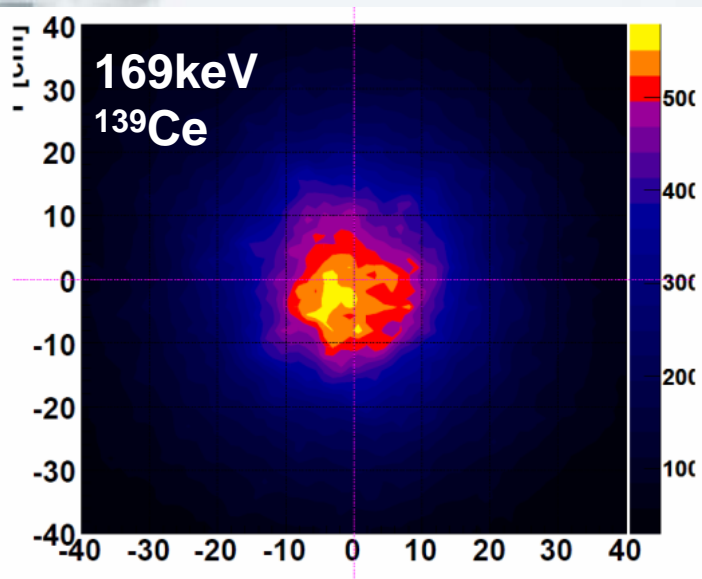
## Experimental setup



# Point Source Images

preliminary!

Source position  $:(x,y,z)=(0,0,37\text{cm})$ , 1MBq



# 2 point sources

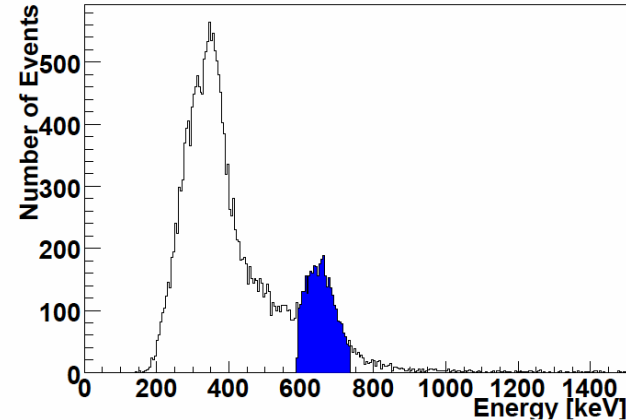
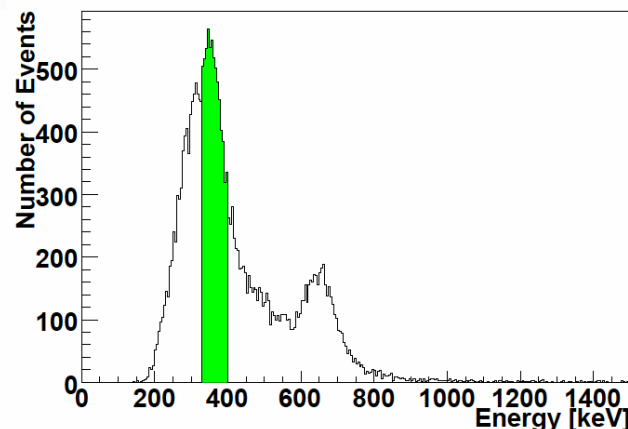
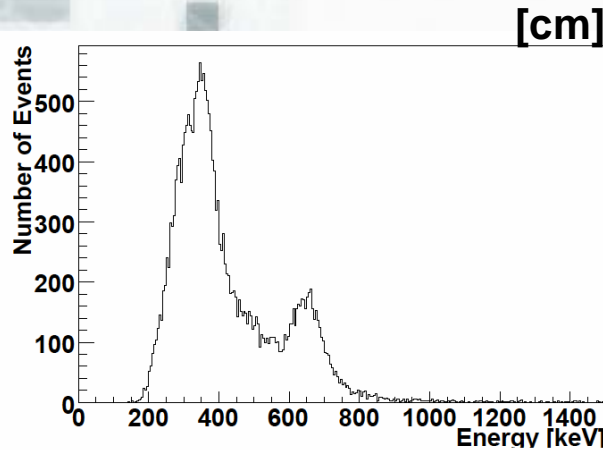
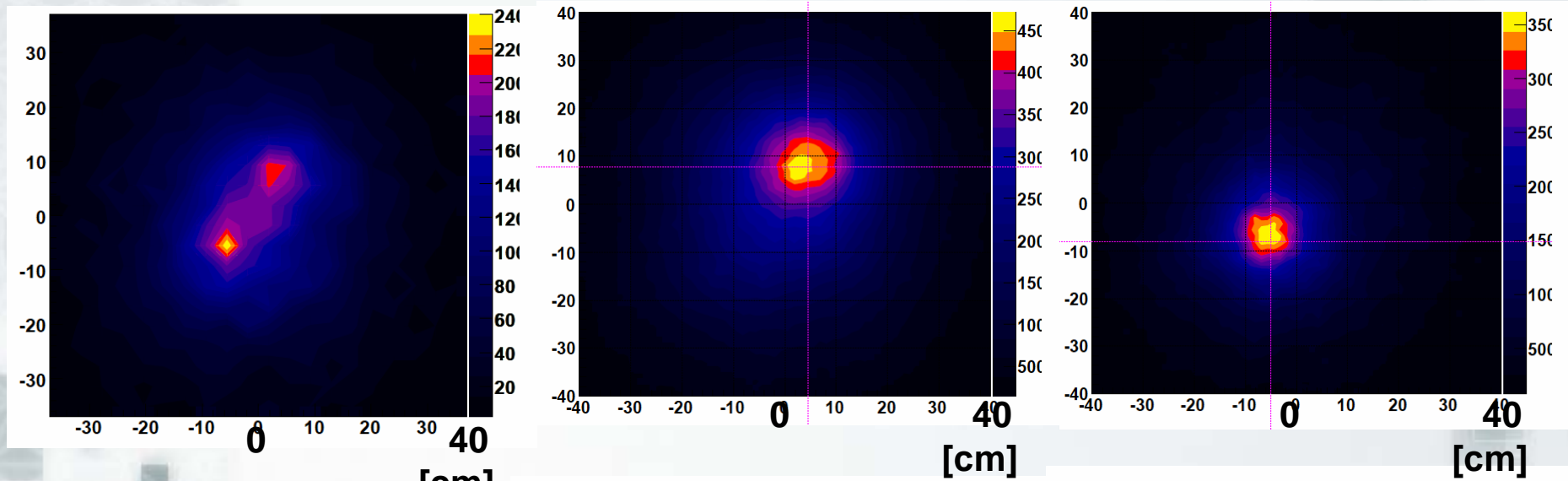
Preliminary!

356keV(5,8,38) & 662keV(-5,-8,38)

All data

300-400keV

600-750keV

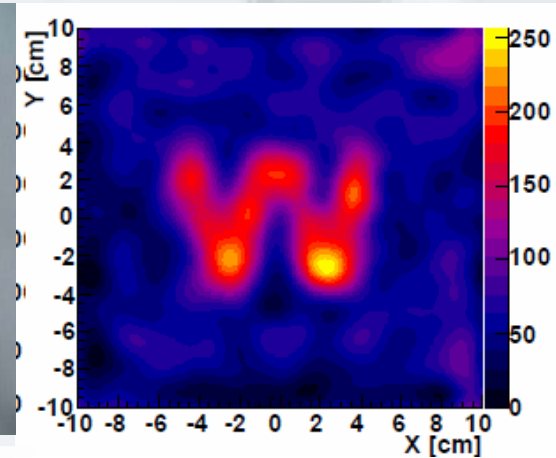


# Furthermore ...

For example, using **prototype (10cm)<sup>3</sup> camera**, we can obtain following images.

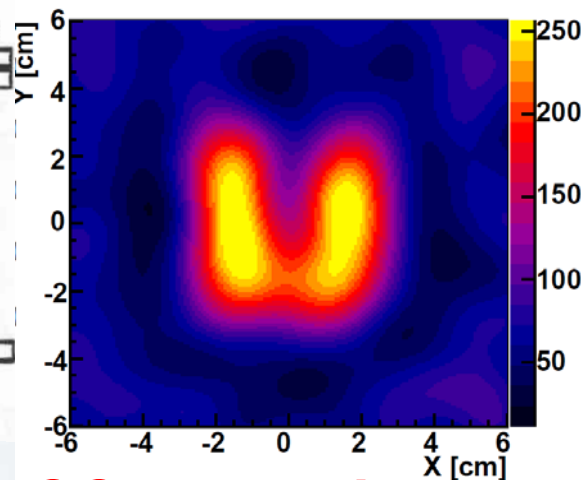
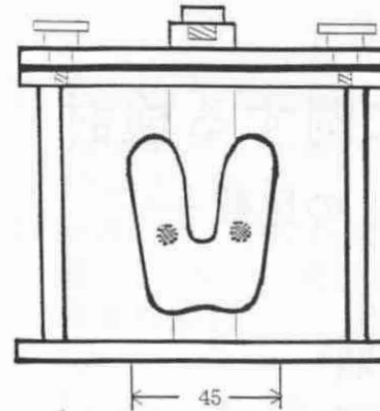
## Shape of “W”

I-131 365 keV 1.MBq 70h  
(0,0,-20cm)



## Thyroid phantom

I-131 365 keV  
1.MBq 40h  
(0,0,-20cm)

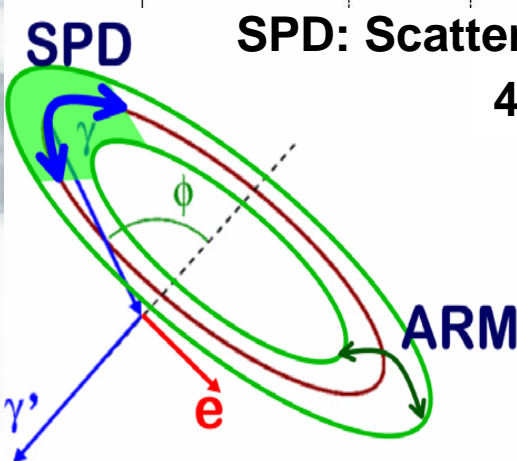
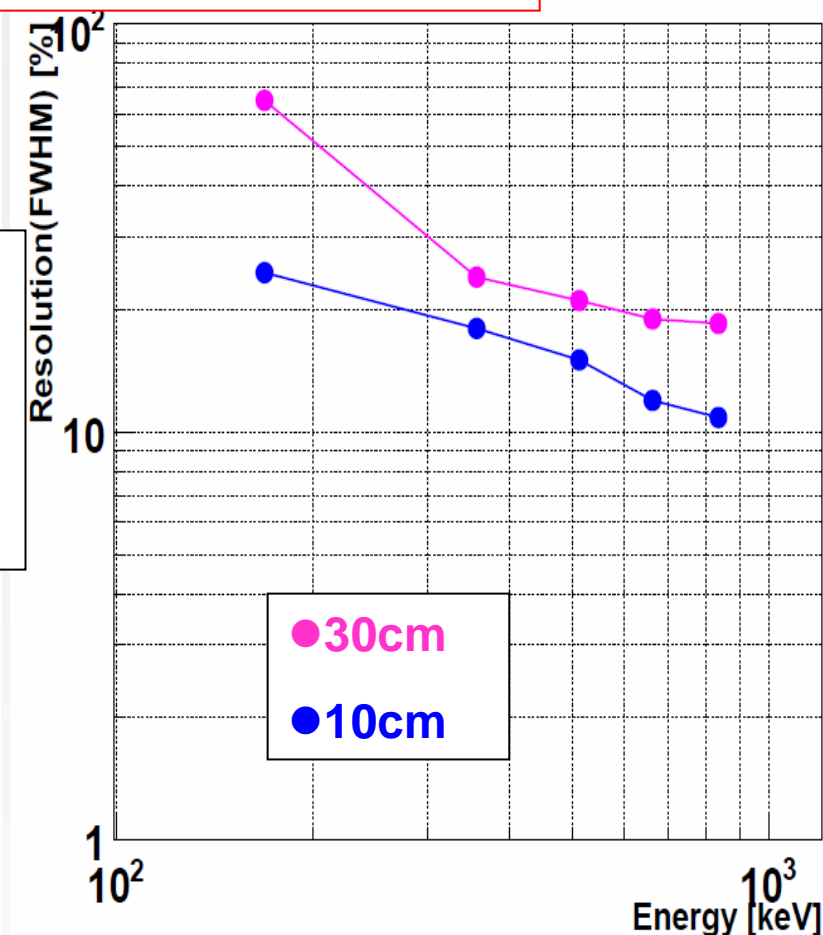
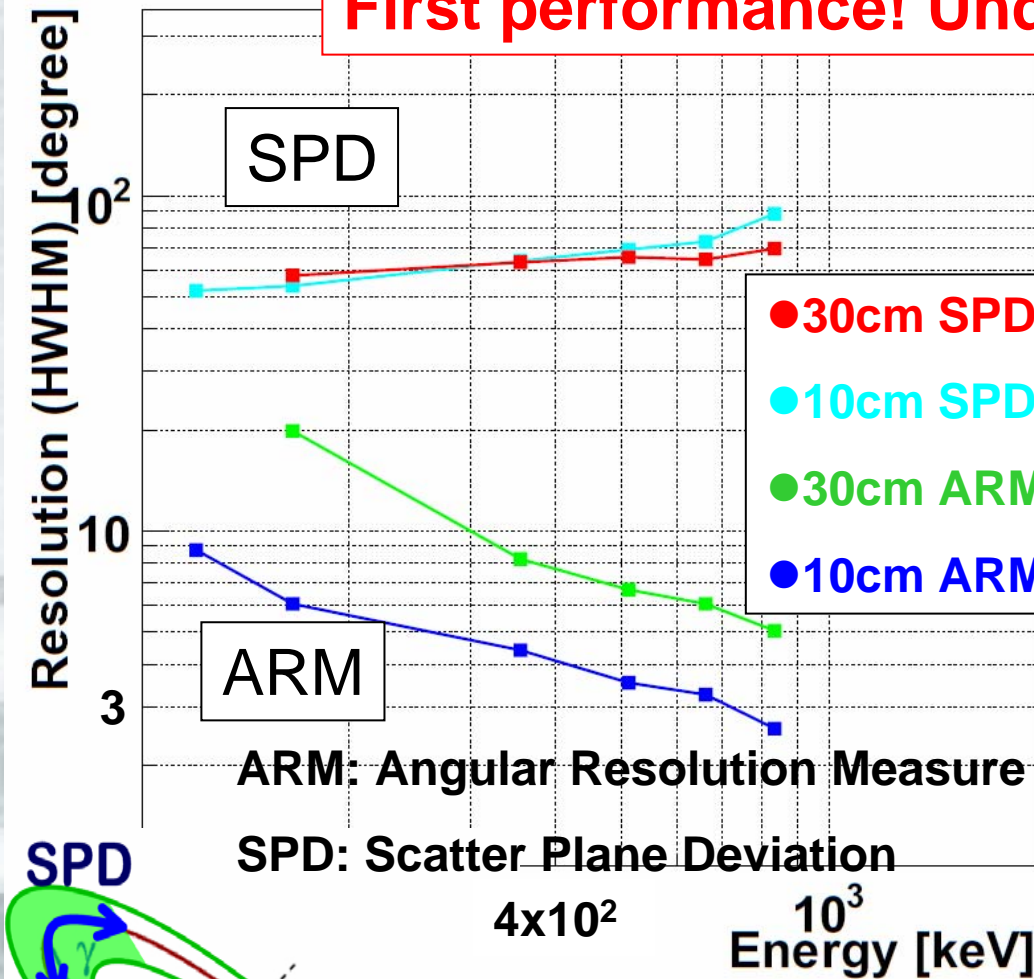


**Now, we are improving the larger ETCC to obtain images like these.**

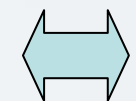
# Angular Resolution

# Energy Resolution

**First performance! Under improvement!**



**ARM : 6.1[degree](HWHM)**  
**SPD : 64.5[degree](HWHM)**  
**Energy resolution : 18.0%(FWHM)**  
**@662keV**

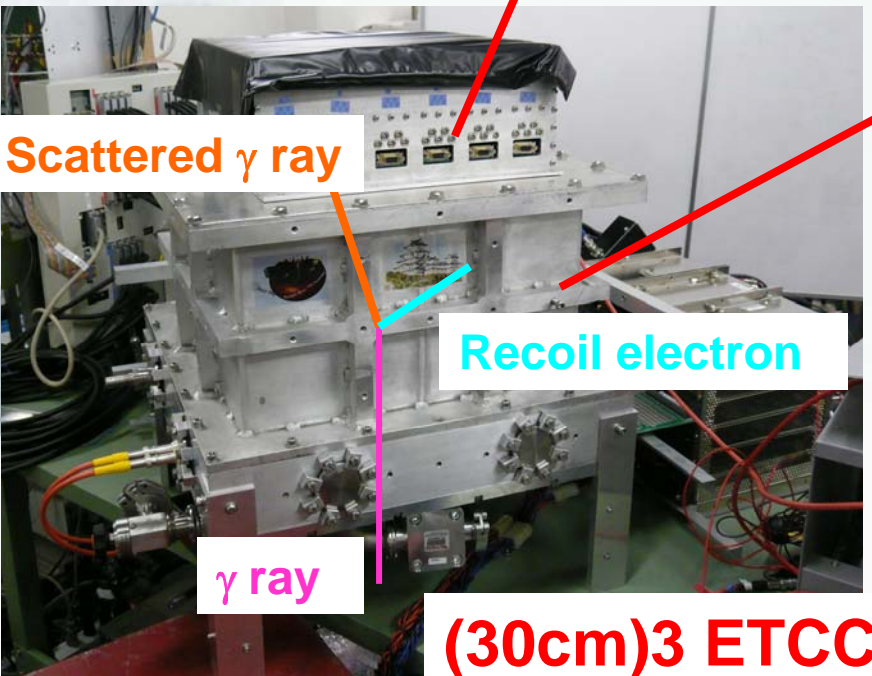
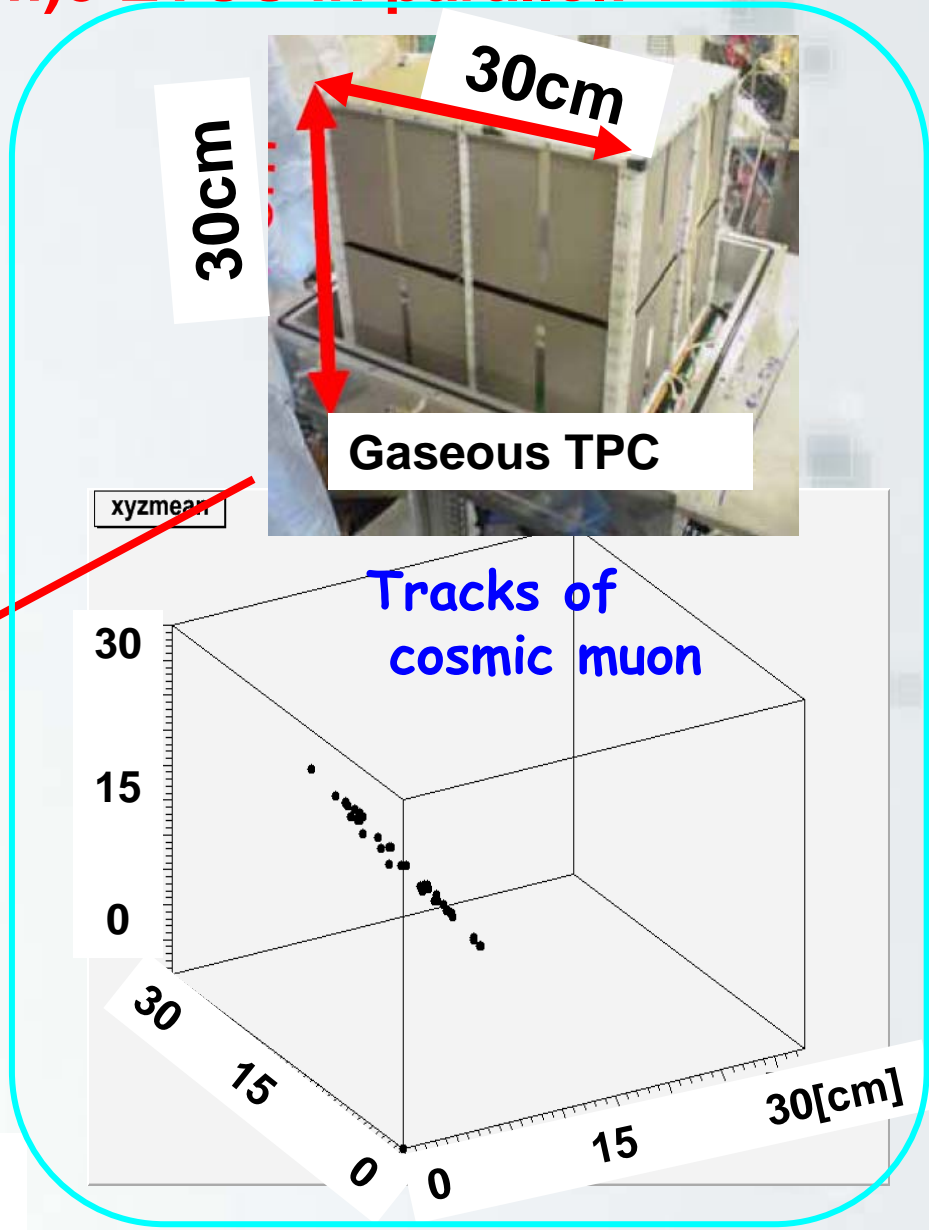
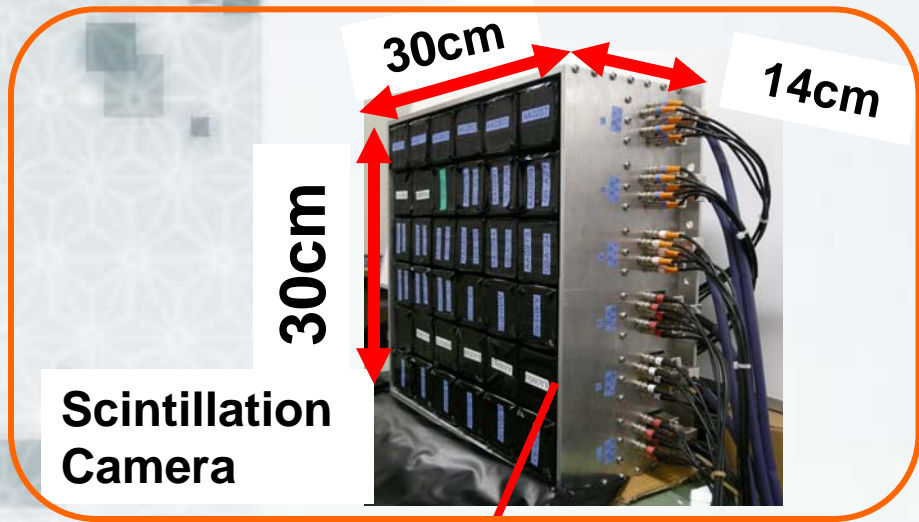


**3.0[deg]**  
**65.0[deg]**  
**12.0%**

**Prototype(10cm)**

# 2<sup>nd</sup> step: (30cm)<sup>3</sup> ETCC

We are developing (30cm)<sup>3</sup> ETCC in parallel!



# 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 efficiency.
- **ETCC based on 30cm X 30cm X 15cm TPC and 6 X 6 GSO Scintillation camera**
  - We have developed larger ETCC. At the 1<sup>st</sup> step, we made 30 x 30 x 15 cm<sup>3</sup> ETCC and tested that.
  - ARM: 6.1[deg](HWHM), SPD:64.5[deg](HWHM), Energy resolution:18.0%(FWHM) @662keV
- **ETCC based on 30cm X 30cm X 30cm TPC and 6 X 6 + 6X 3X4 scintillation Camera**
  - At the 2<sup>nd</sup> step, we started to develop 30x30x30cm<sup>3</sup> ETCC in parallel.

# Future work

- Tune up the 30cm X 30cm X 15cm ETCC
- Set the 30cm X 30cm X 30cm ETCC up
- Construct the ETCC with high efficiency and good performances





**Thank you!**