Development of a Compton gamma-ray camera with $LaBr_3$(Ce) pixellated arrays for medical imaging

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Contents

- Introduction
  - Electron Tracking Compton Camera (ETCC) for Medical imaging
- $LaBr_3$(Ce) array
  - Assembly of $LaBr_3$(Ce)
  - Measurement of a $LaBr_3$(Ce) array
- ETCC with $LaBr_3$(Ce) arrays
  - Setup
  - Imaging with the camera
- Summary

Medical imaging (functional image)

PET : E = 511keV
SPECT : E < 360keV

Narrow

Wide dynamic energy range

➢New radioactive tracer with new radioisotopes

It is possible that
we obtain various images:
anti-body, enzyme,
protein reaction

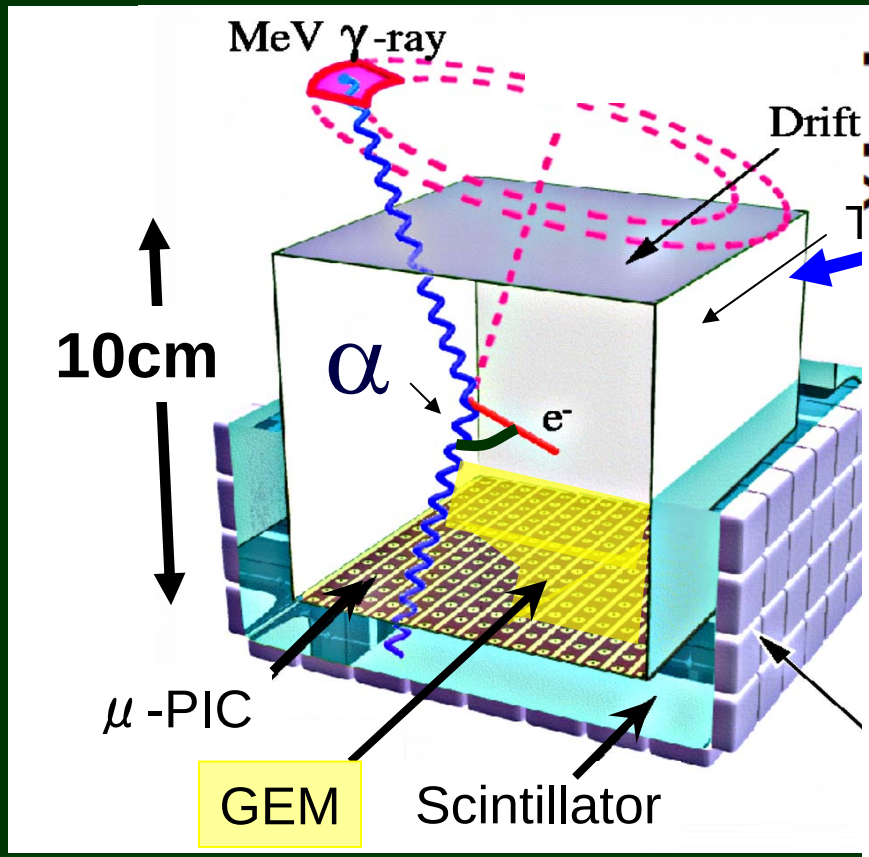
➢Multi-radioisotope Imaging With wide energy range

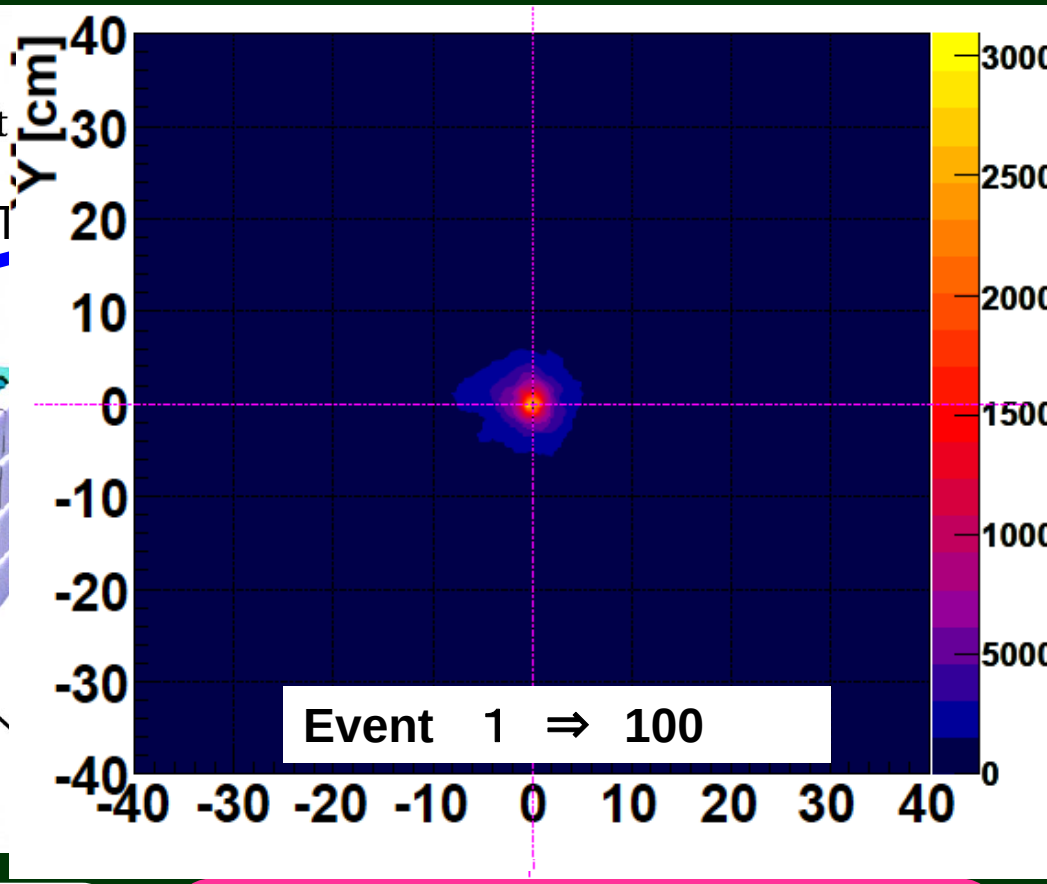
Simultaneous observation of some metabolisms and interactions

	^{139}Ce	^{133}Ba	^{131}I	^{198}Au	^{22}Na	^{18}F	^{54}Mn	^{65}Zn	^{60}Co
E [keV]	167	354	364	412	511 1275	511	835	1116	1173 1333

← SPECT PET

Electron Tracking Compton Camera





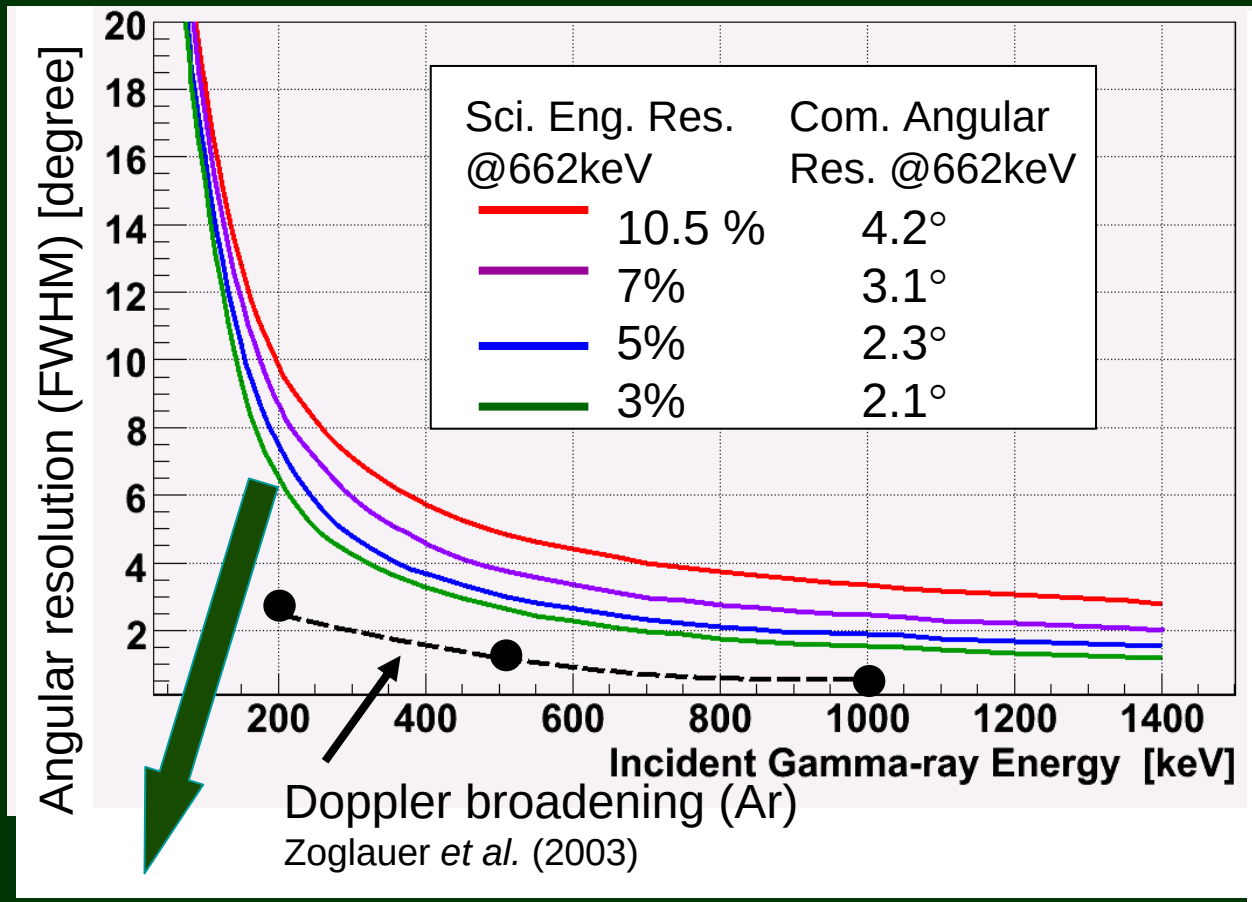
- Large FOV (~3str)
- Kinematical background rejection by comparison of two α angles

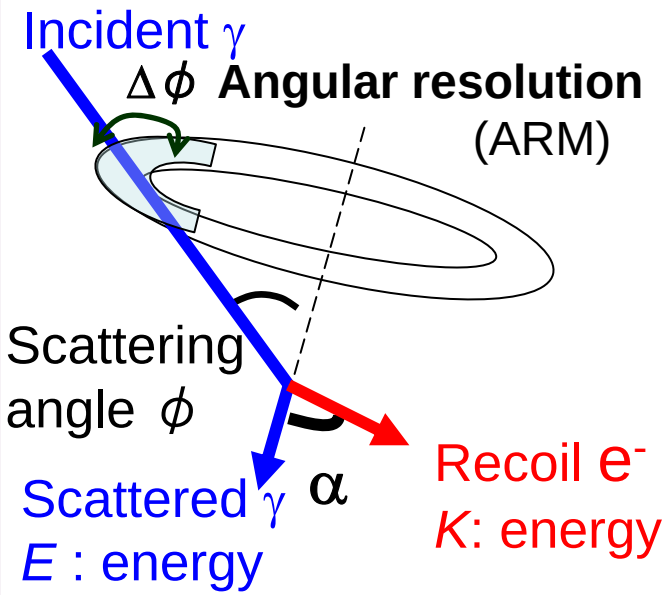
Reconstruct incident gamma ray event by event

Energy dynamic range: from 0.1 to ~1 MeV

To obtain a higher angular resolution

Angular resolution of the Compton camera depends on the energy resolution of scintillator





Calculated assuming
1, no error in position of Compton point
2, energy Res. of TPC : 30 % @ 22 keV

$$\cos\phi = 1 - \frac{m_e c^2}{(E+K)}\frac{K}{E}$$

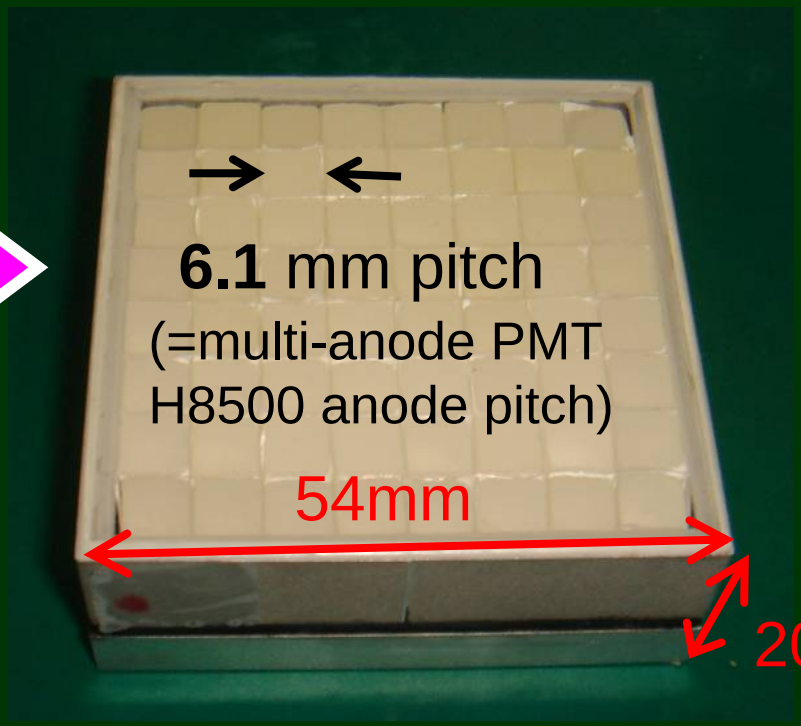
Eng. Res. (FWHM) of $LaBr_3$(Ce) : ~ 3 % @ 662 keV

Loef *et al*. (2001)

Assembly of $LaBr_3$(Ce) array

Using our technique, we cut 5.8×5.8×15.0mm^3 pixels out of two ϕ38×38 mm^3 $LaBr_3$ crystals and assembled an 8×8 array.

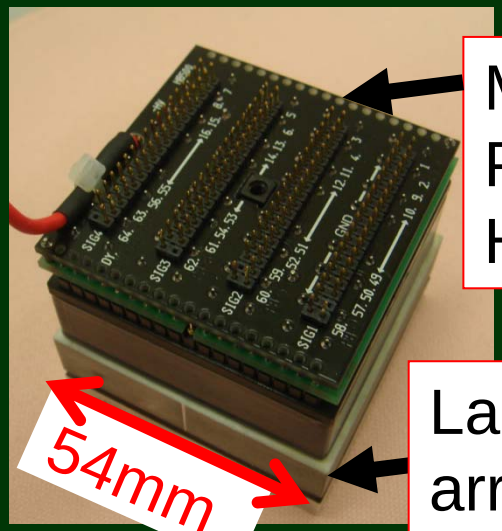
Saint-Gobain BrilLanCe380
Size: ϕ38×38mm^3
Eng. Res.: ~3 % (FWHM, @ 662 keV, using HPK R6231)



Effective area : 49 × 49 mm^2
(=PMT photocathode)
Glass window : Quartz (t 2.3 mm)
Hermetic package : Aluminum (t 0.5 mm)

1/2 attenuation length @662keV
$LaBr_3$ (Ce): 18 mm

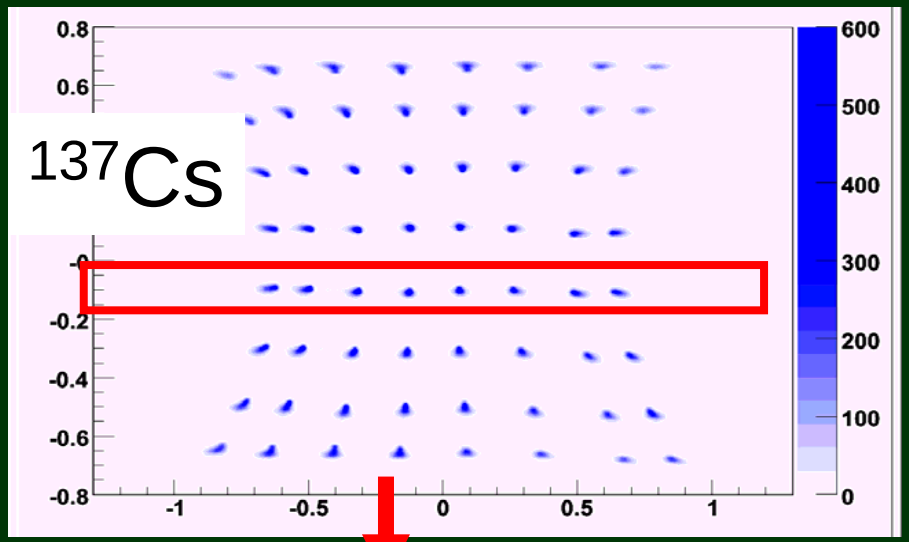
4ch readout with multi-anode PMT

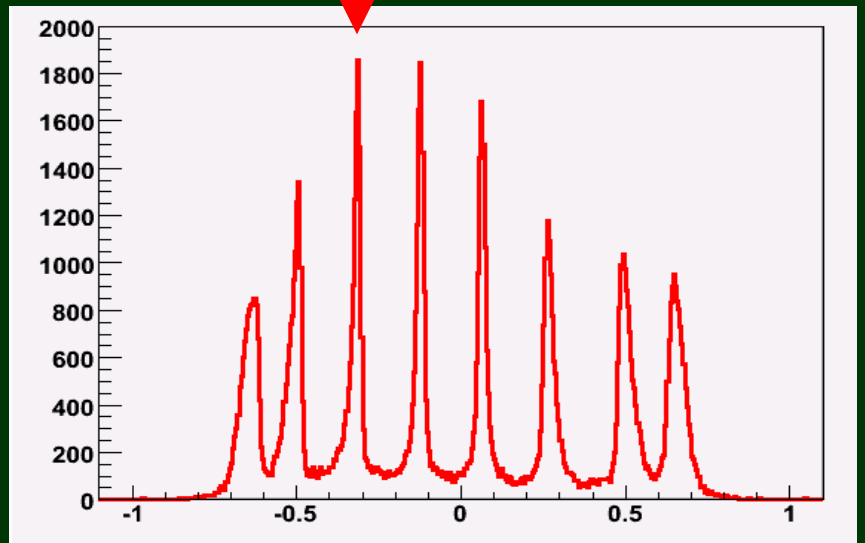


Multi-anode PMT HPK H8500

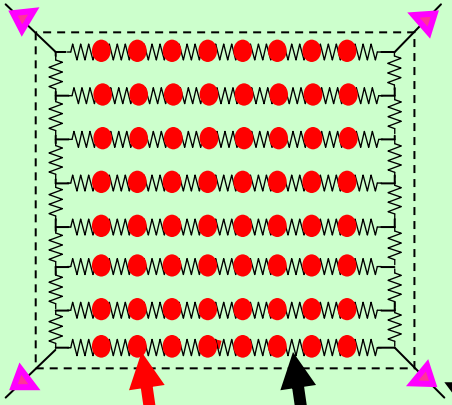
$LaBr_3$(Ce) array

- Flood field irradiation image using a Charge-division method





4ch readout with a resister chain



64 anodes of PMT

↓

4 ch output

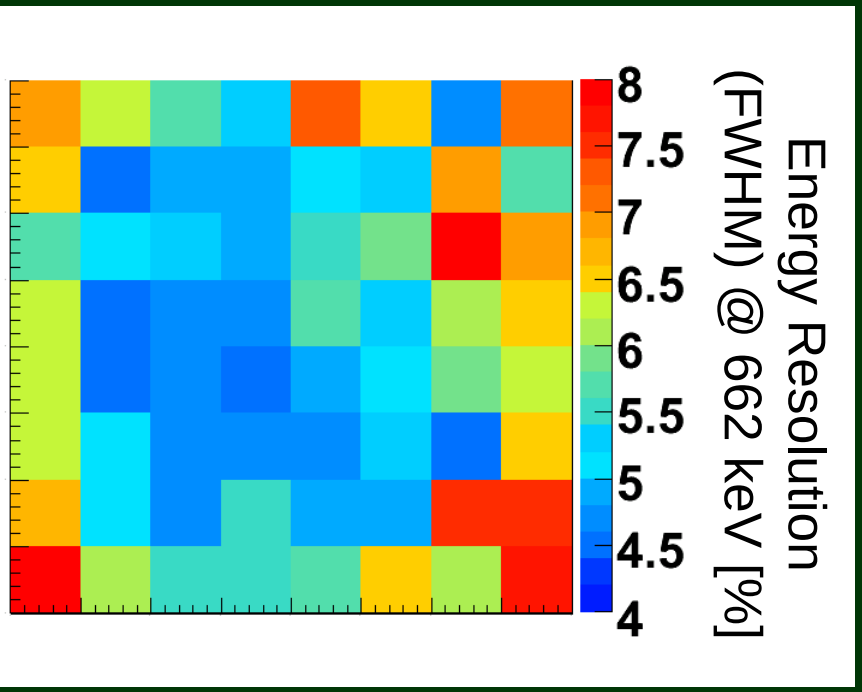
pre.AMP

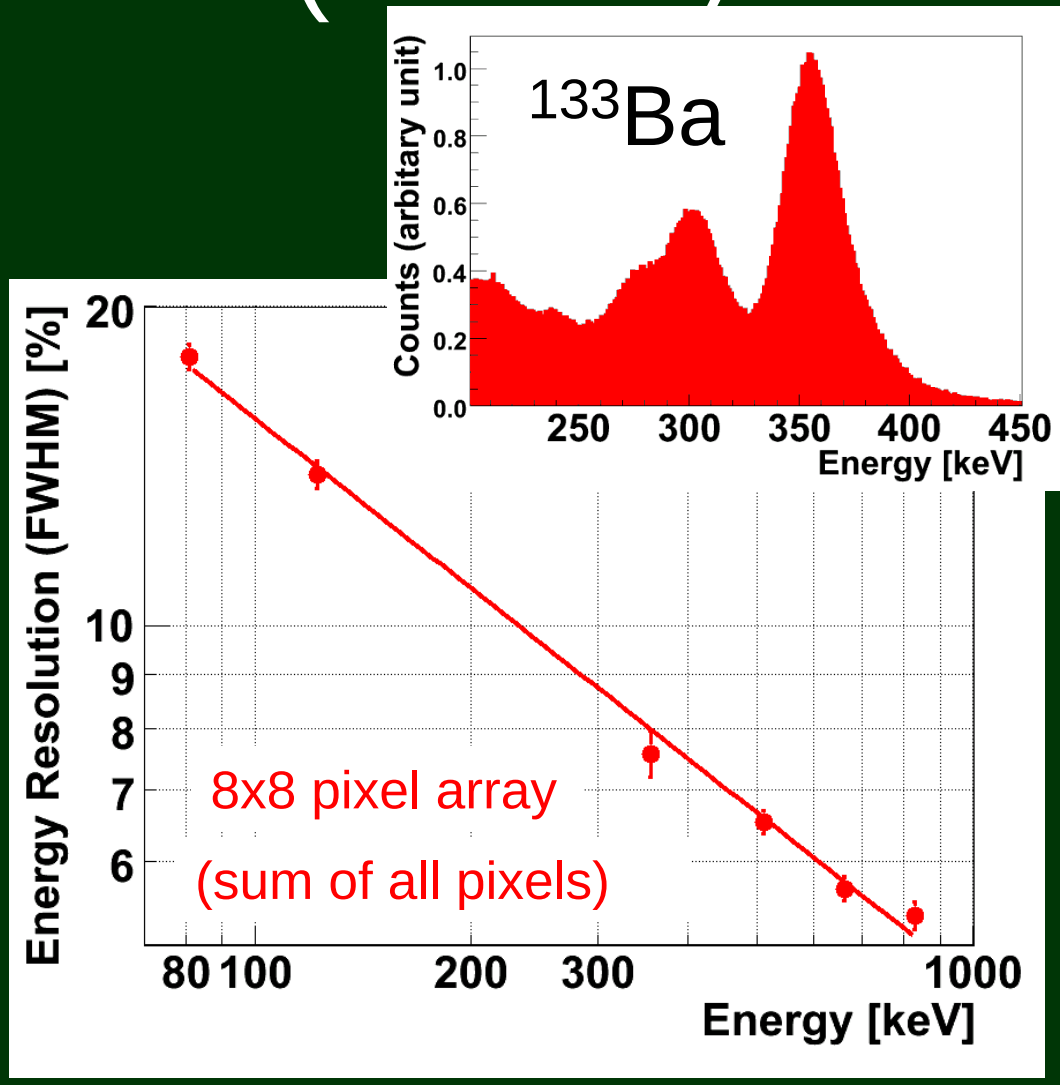
anode

R=100Ω

Energy resolution (FWHM)

Using Multi-anode PMT H8500

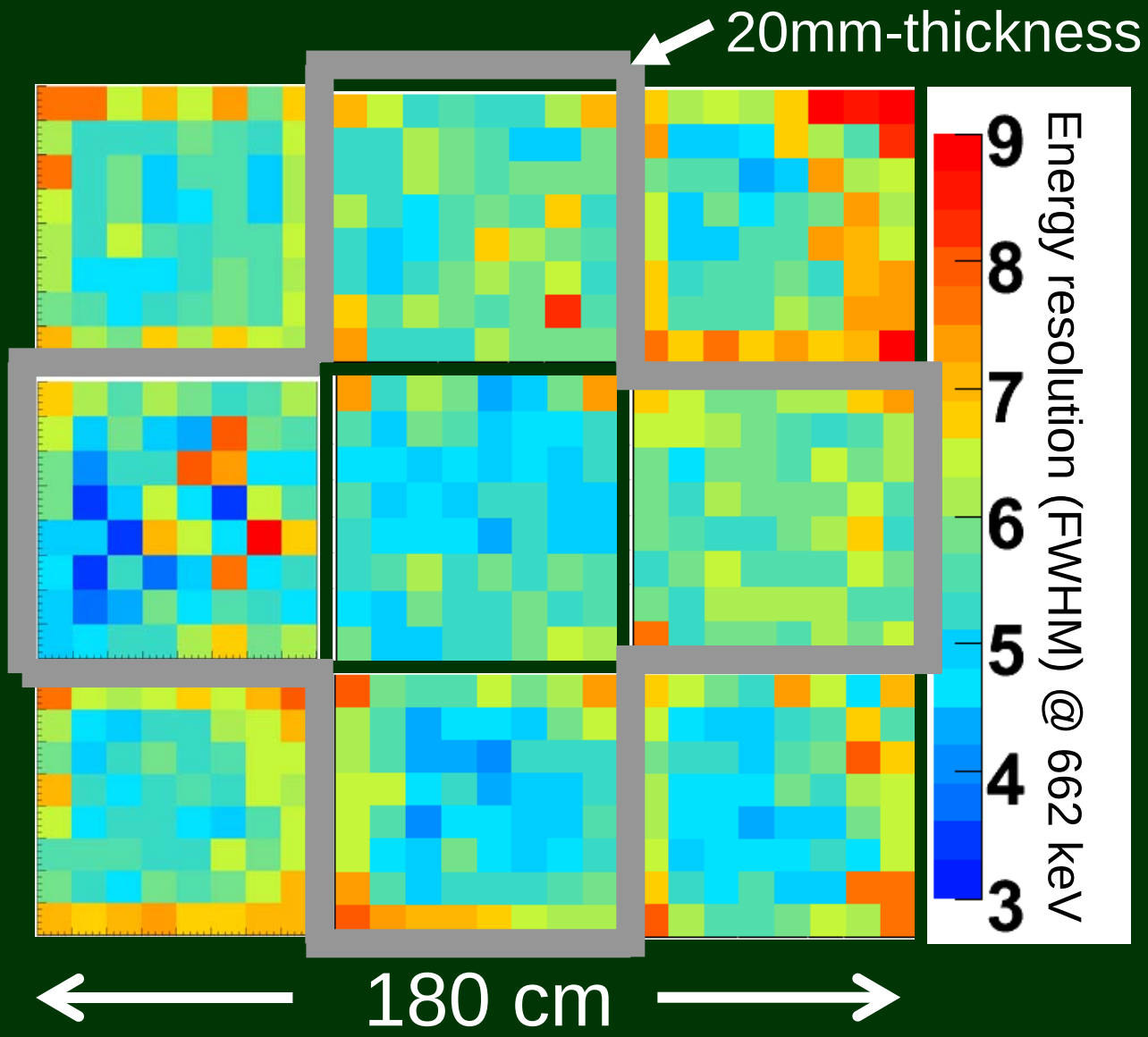




FWHM Eng. Res.
@ 662 keV
Ave. $\pm\sigma$: 5.8 $\pm$ 0.9%

FWHM(%)=
$(5.7\pm0.4)\times(E/662\text{keV})^{-0.53\pm0.01}$

9 arrays: Energy Resolutions (FWHM) @ 662keV



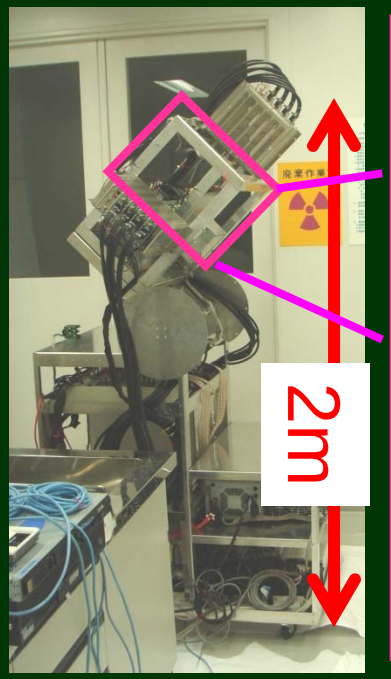
Eng. Res. (FWHM)
@ 662 keV
Ave. ± σ :

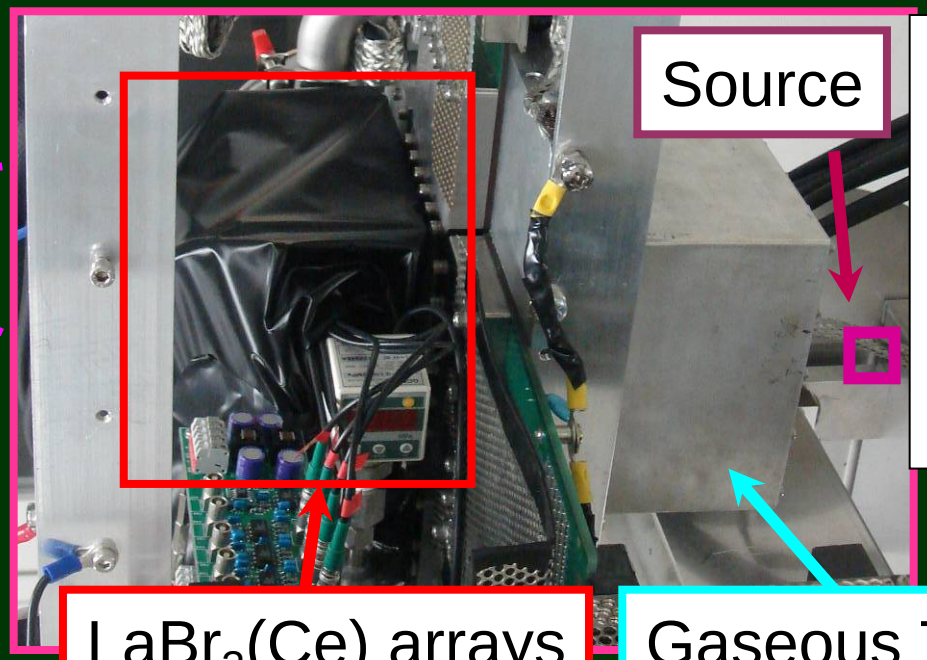
6.0 ± 1.0%
(15mm-thickness)

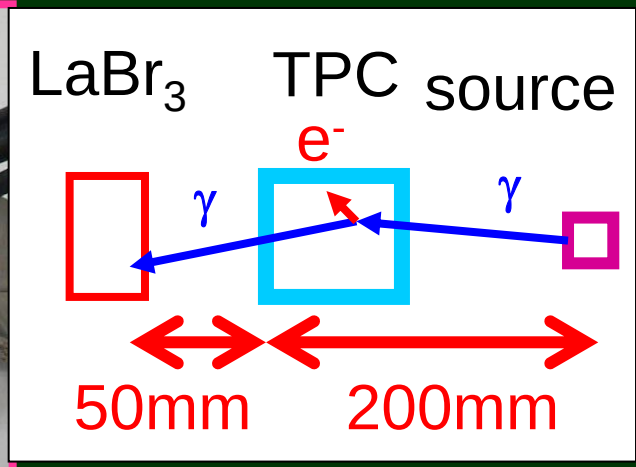
5.6 ± 0.8%
(20mm-thickness)

5.8±0.9%
(Total, 576 pixels)

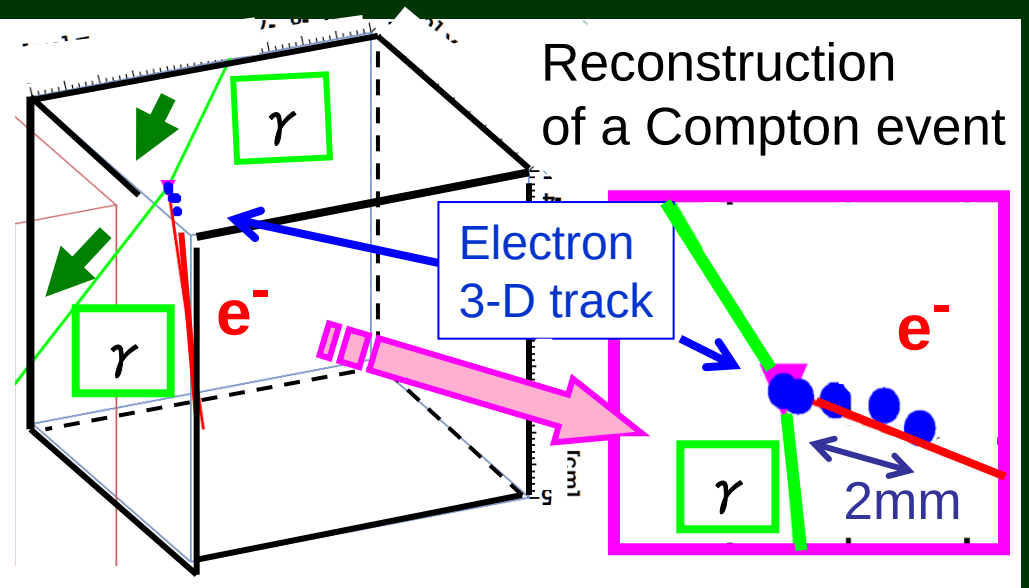
Setup of ETCC

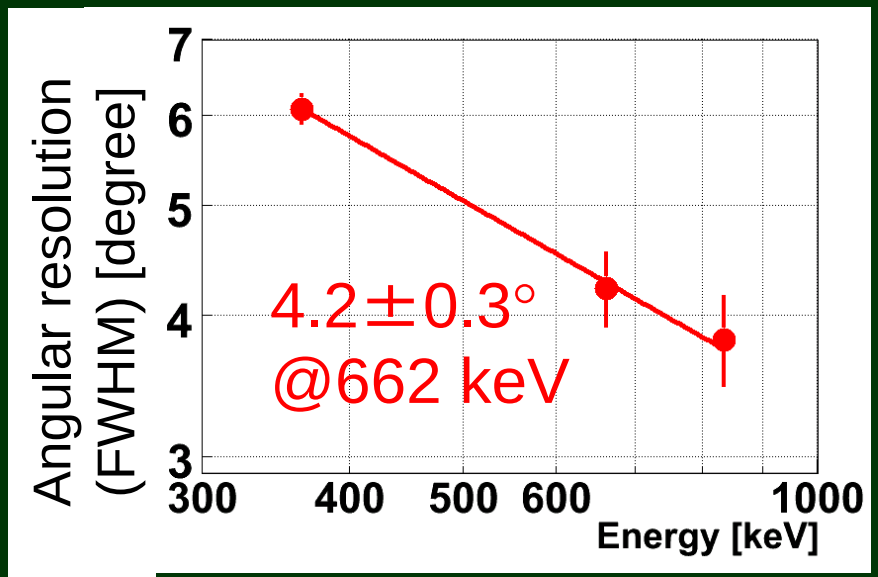






FOV: 400cm^2
@10cm from TPC
356keV, FWHM





Mouse imaging

^{131}I-MIBG (365keV)
Imaging (ETCC & CT)

$^{65}Zn^{2+}$ (1116keV)
Imaging (ETCC & photo)

^{131}I-MIBG (365keV) & ^{18}F-FDG (511keV) imaging

The clinical drugs ^{18}F-FDG (PET) and ^{131}I-MIBG (SPECT) can image the MRMT1 (mammary tumor) and PC12 (Pheochromocytoma)

Summary

- we assembled an 8×8 $LaBr_3$(Ce) pixel array.
  - Pixel size : 5.8 ×5.8 ×15 mm^3
    5.8 ×5.8 ×20 mm^3
  - Pixel pitch: 6.1mm (the same as that of the multi-anode PMT H8500)
- Dynamic energy range: 80 – about 1000 keV.
- Energy resolutions of the array with the MAPMT（FWHM、@662keV）.
  - 5.8 ± 0.9% (average of 9 arrays)
- Angular resolution of ETCC（FWHM、@662keV）.
  - 4.2 ± 0.3 deg.
- We observed mouse imaging:
  - High energy isotope : $^{65}Zn^{2+}$ (1116keV)
  - ^{131}I-MIBG (365keV) & ^{18}F-FDG (511keV) Simultaneously

감사합니다