Imaging Performances of the DRAGO Gamma Camera

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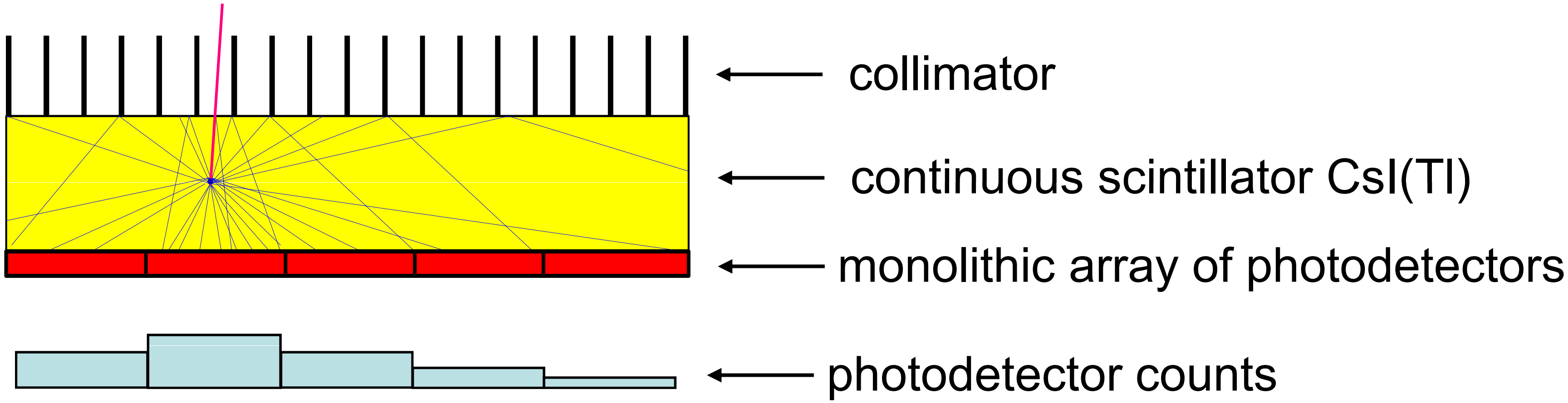
DRAGO is a small Gamma Camera based on SDDs



Main advantages (vs. pixellated detectors):

- spatial resolution (<mm) achieved with ~ 10 times larger photodetector pixel size

$\Rightarrow$1/100 readout channels needed for a given spatial resolution

- good detection efficiency, adjustable vs. energy with scintillator thickness

Main disadvantage

Poorer energy resolution, especially at low energy, due to the scintillator conversion (although new scintillators like $LaBr_3$ are reducing this gap) and to the electronics noise added by the several photodetectors used for the light readout

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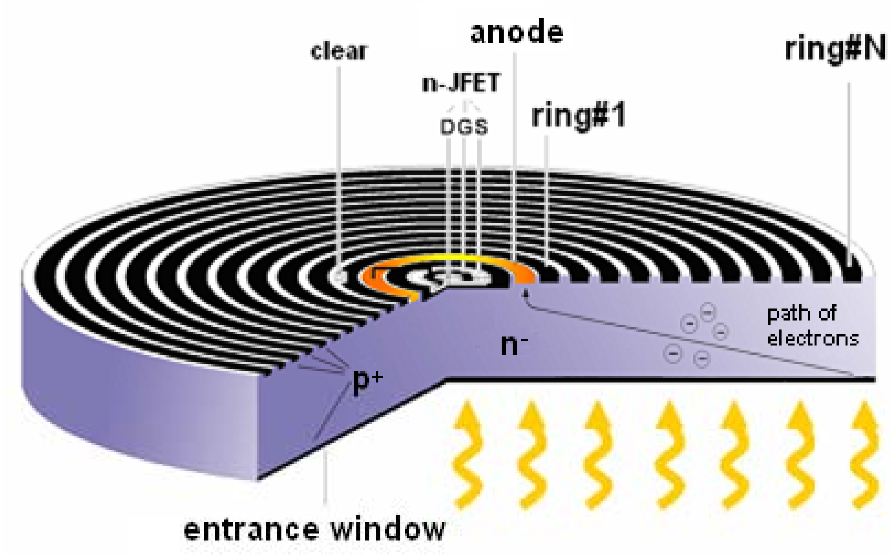
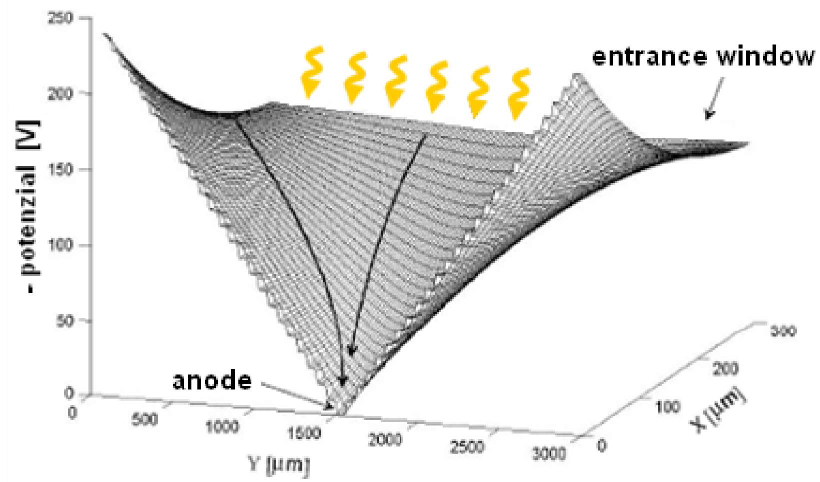
The Silicon Drift Detector (SDD) with on-chip JFET





- large light-induced signal level due to the high QE (ARC implemented)
- Poisson-limited spread of the light induced signals (no worsened by multiplication mechanism, as in PMT and APD)
- low electronics noise spread, to be kept lower than light statistical spread (leakage current < 1nA/cm^2 @RT and cooling)
- almost insensitive to bias/Temperature shifts, magnetic fields, ….

⇒ high spatial resolution (<1mm) achievable with a SDD Gamma Camera

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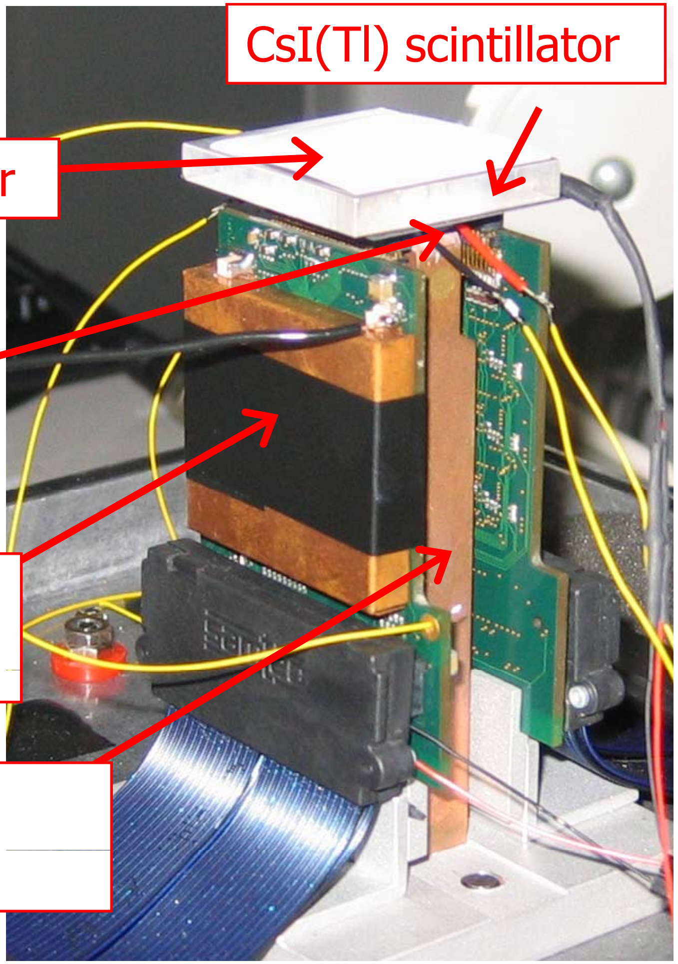
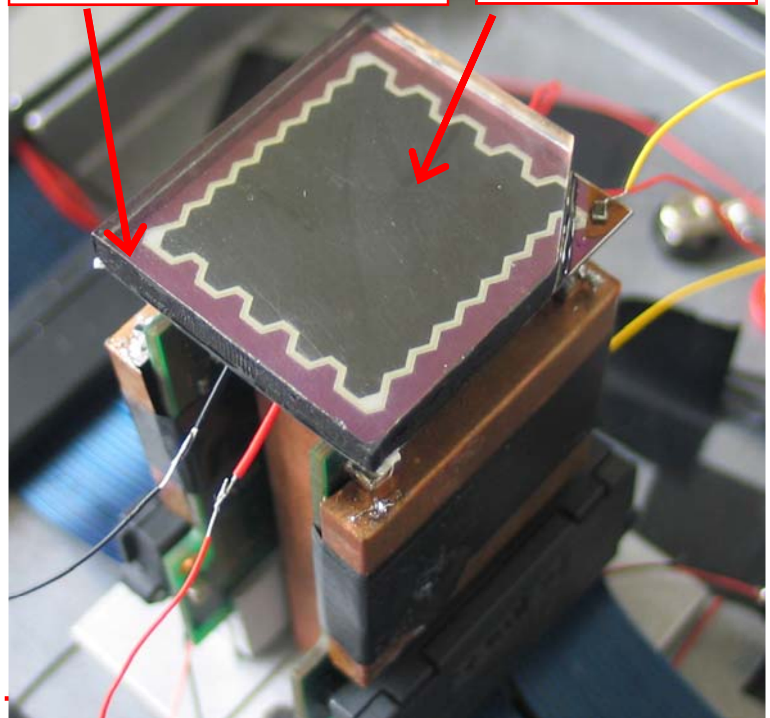
The DRAGO Gamma Camera

(DRift detector Array-based Gamma camera for Oncology)





- 77 SDD, 8.7 mm^2 each

  tot. active area = 6.7 cm^2

  CsI(Tl) thickness = 5mm

- leakage current ~300pA/cm^2 @RT

  (~80% @140keV)

- QE ~ 90% @ 565nm of CsI(Tl)

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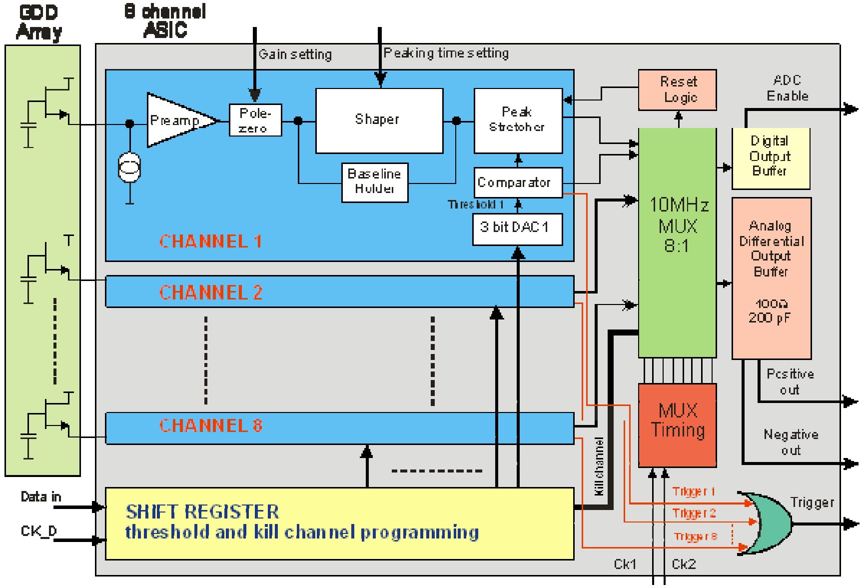
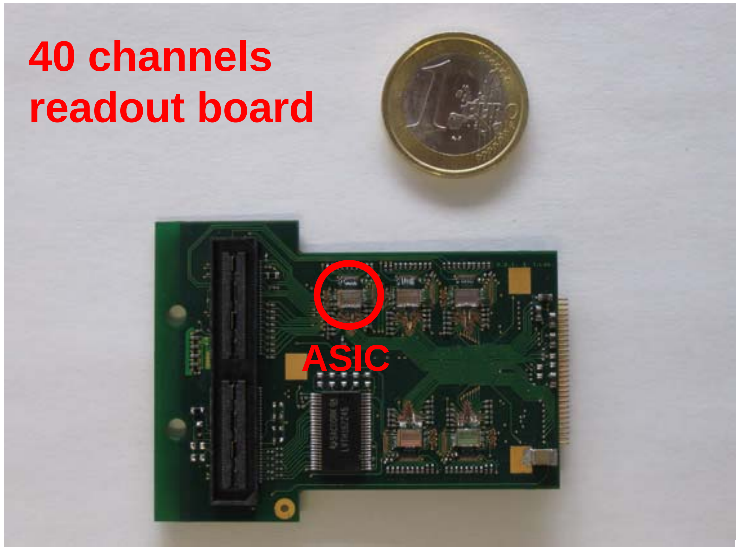
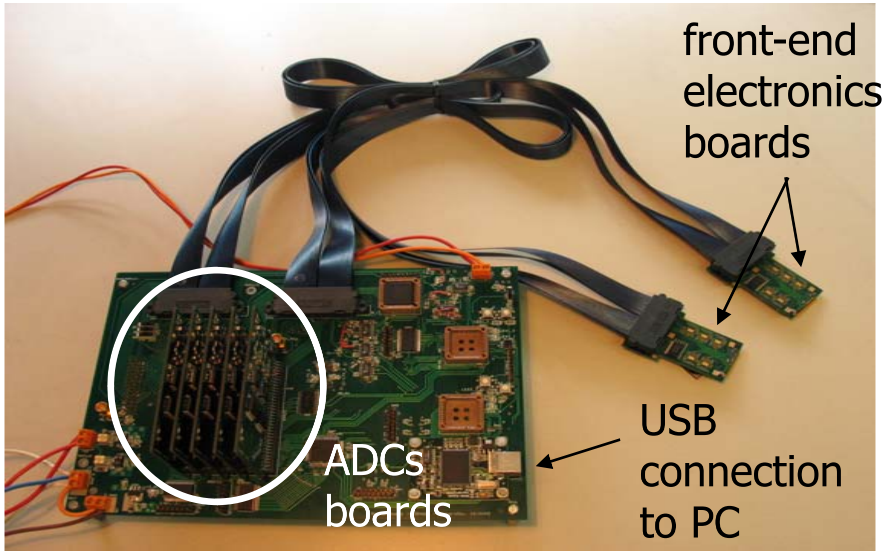
The readout electronics and the DAQ system







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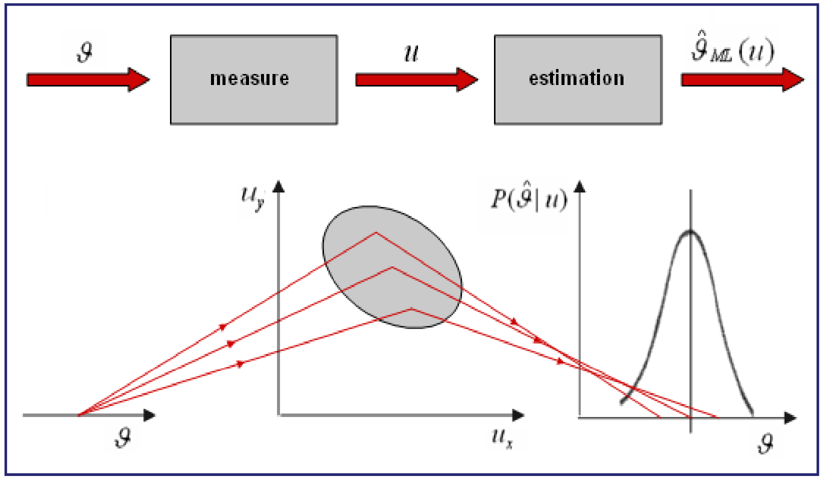
Event reconstruction using a Maximum-Likelihood (ML) algorithm



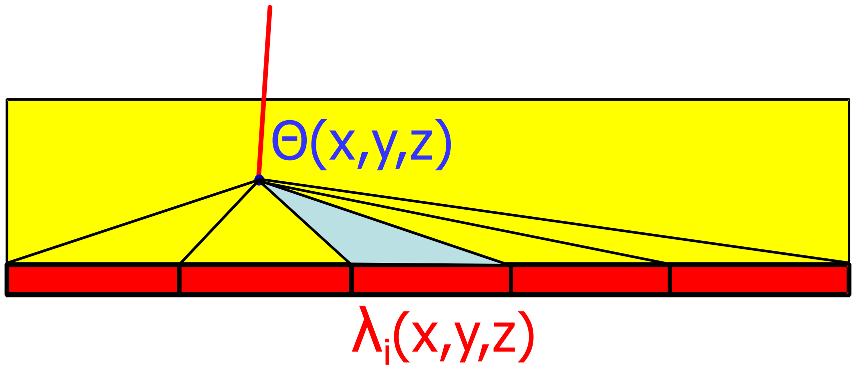
$\Theta(x,y,z)$: inter. point of gamma-event

u_i : measured counts collected by i_{th} photodetector

$\lambda_i = f(\Theta)$: mean response of the i_{th} photodetector

$P(\Theta|u)$: likelihood function

$$\hat{\vartheta}_{ML} = \arg_{MAX}\left[P(\hat{\vartheta}\,|\,u)\right] = \arg_{MAX}\left[\ln\left(\prod_i \frac{e^{-\lambda_i}\cdot\lambda_i^{u_i}}{u_i!}\right)\right]$$



Method:

$\lambda_i = f(\Theta)$ light mean response calculated employing a Montecarlo optical code (SCIDRA) without using experimental scanning to map the detector response

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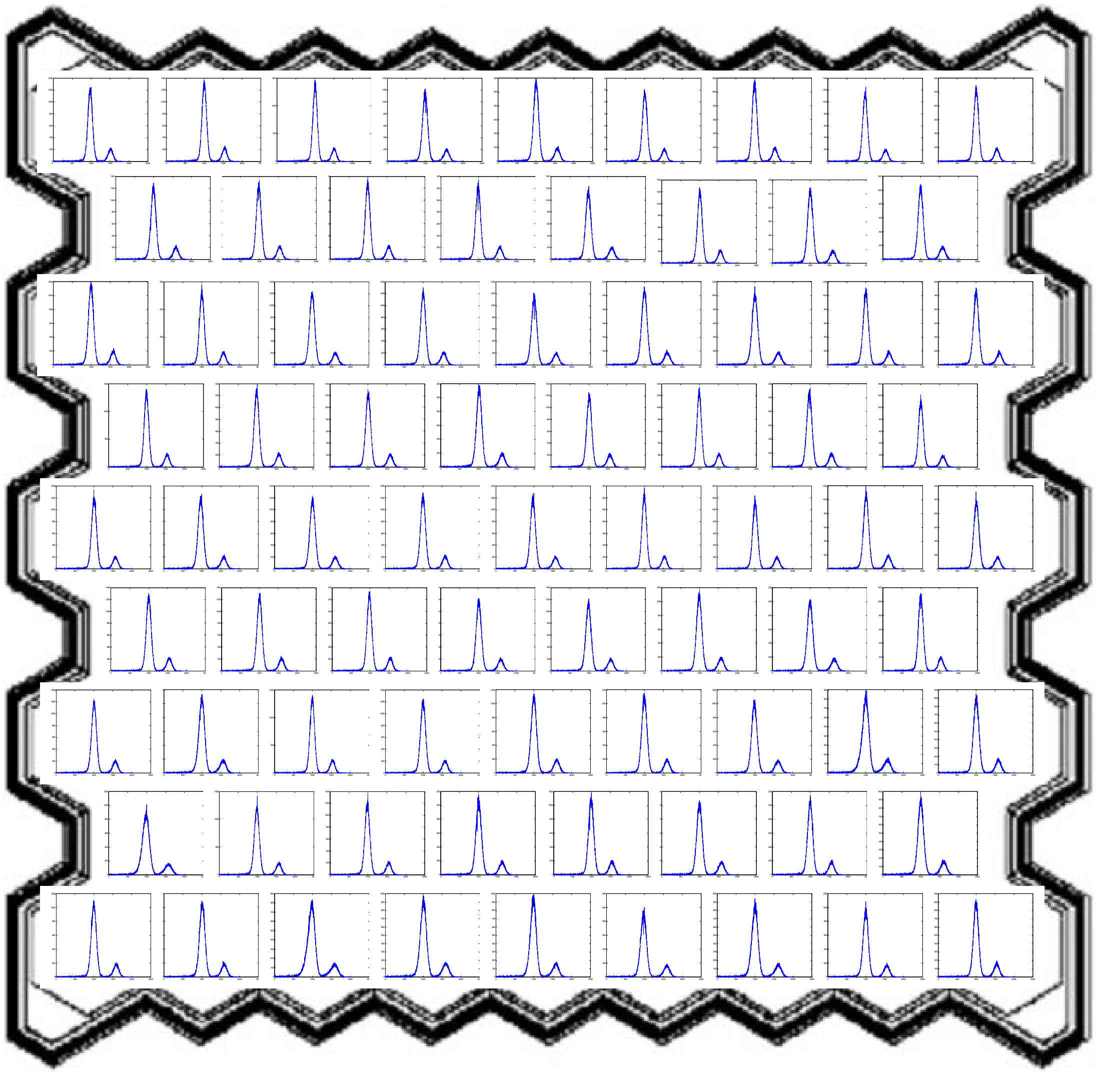
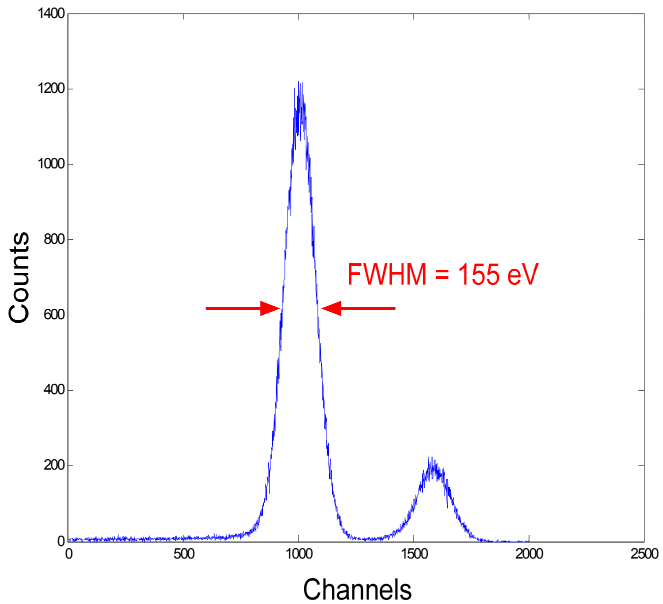
Electronics noise performances



- Direct interaction of ^{55}Fe X-rays (no scintillator)
- T = -13 °C
- Peaking time = 6 μs
- Bias common to all units



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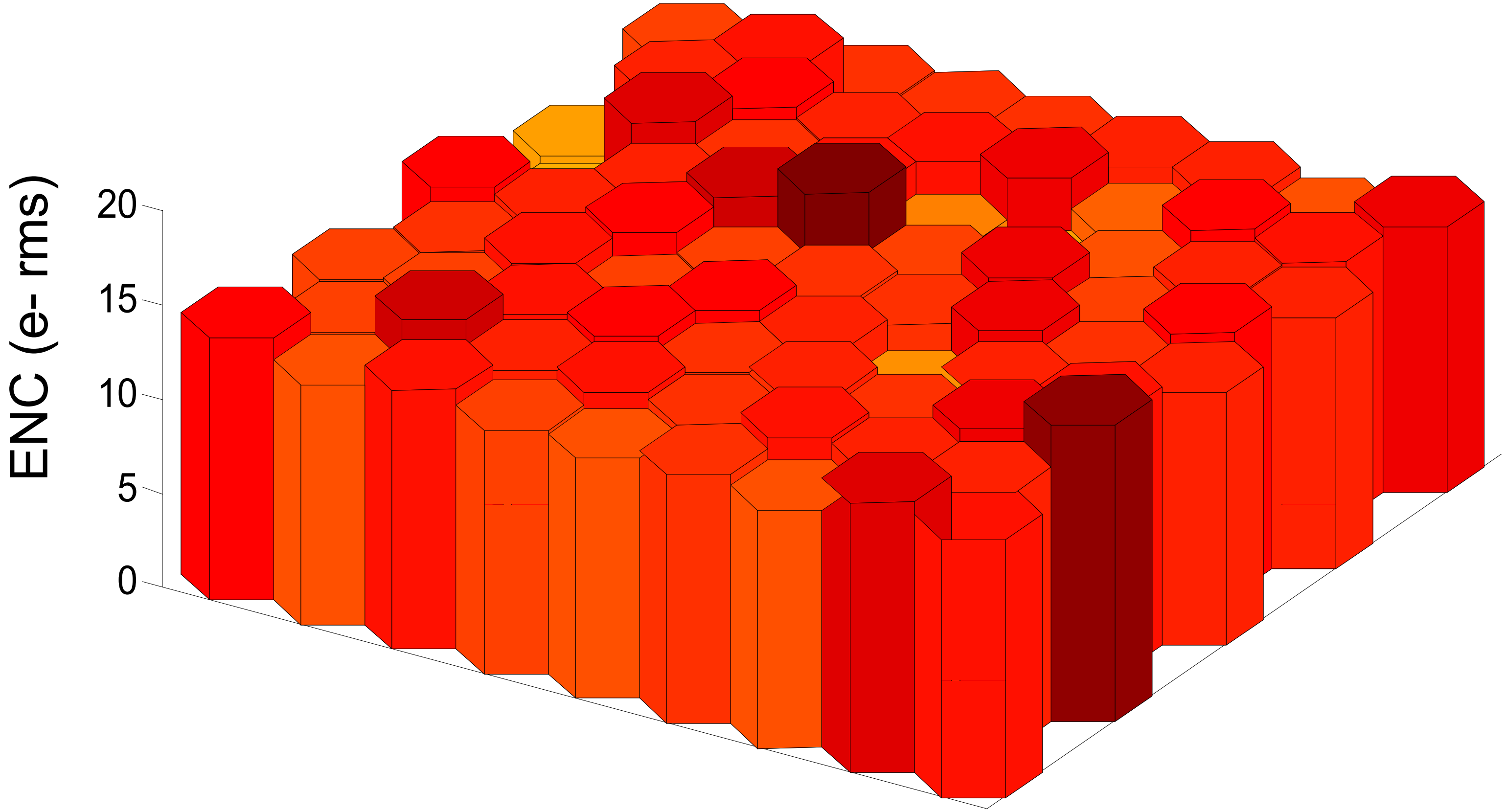
ENC distribution in the array



average noise = **13.4 e- rms**
(16.0 e- worse, 11.0 e- best)

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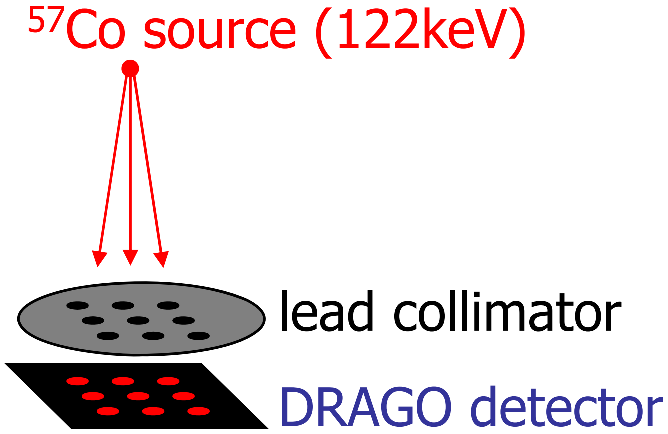
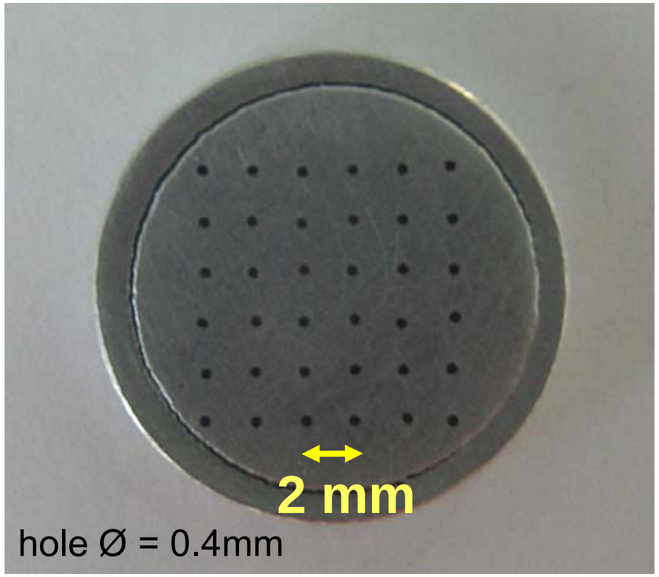
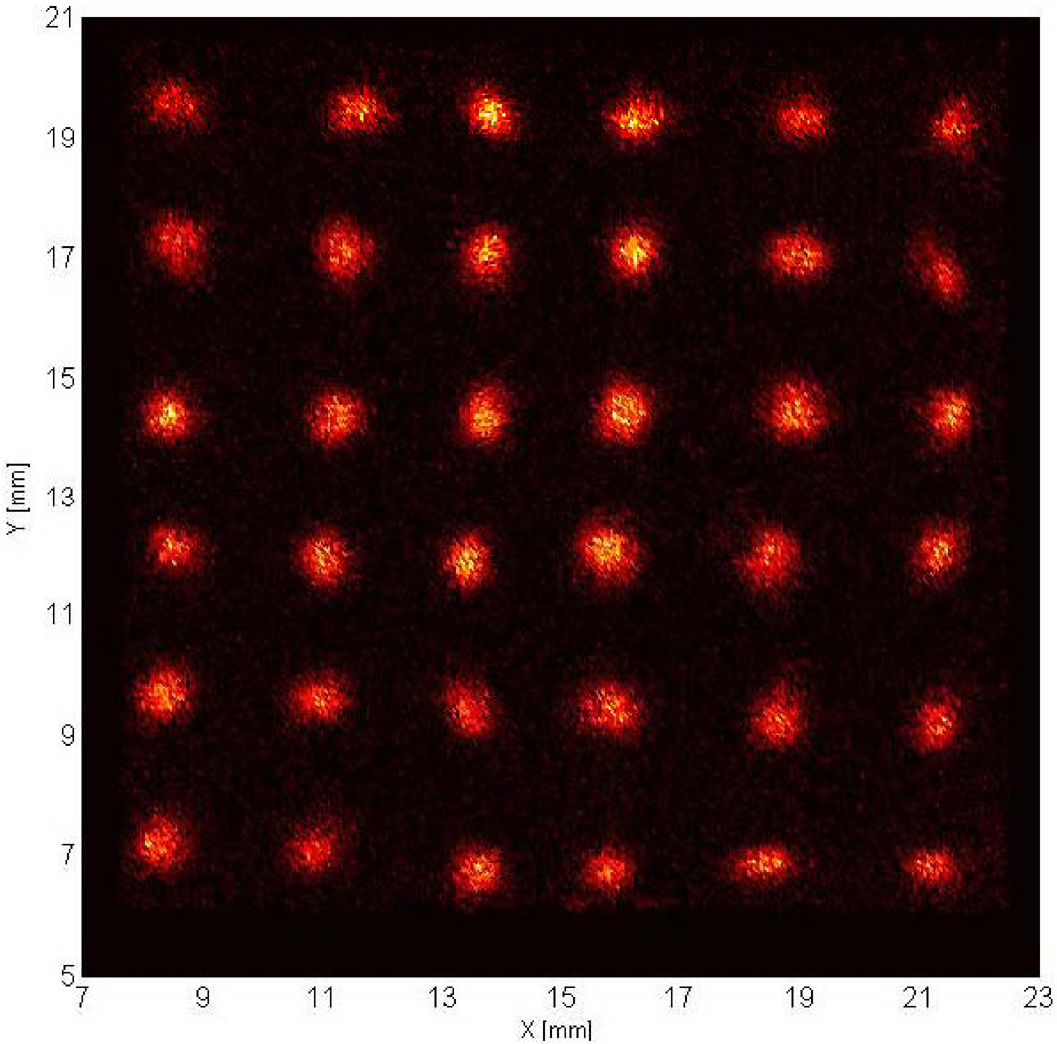
γ-ray measurements







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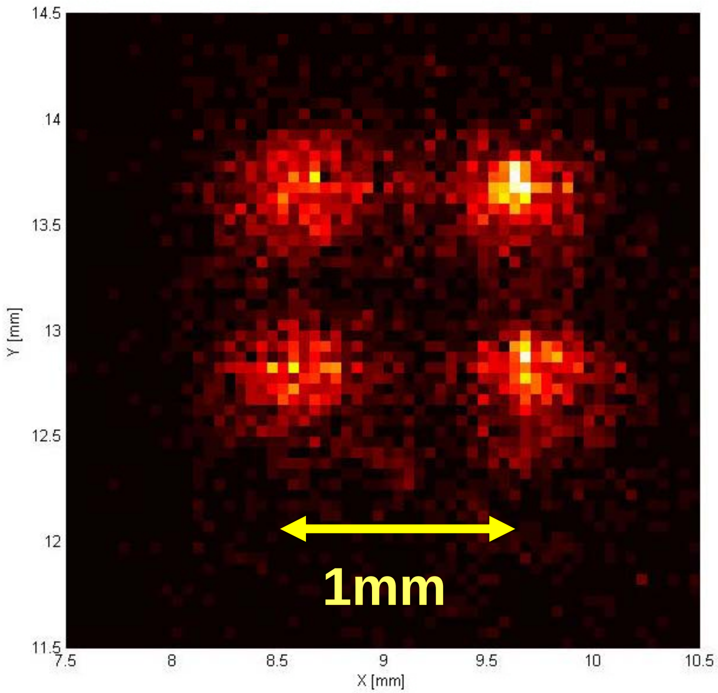
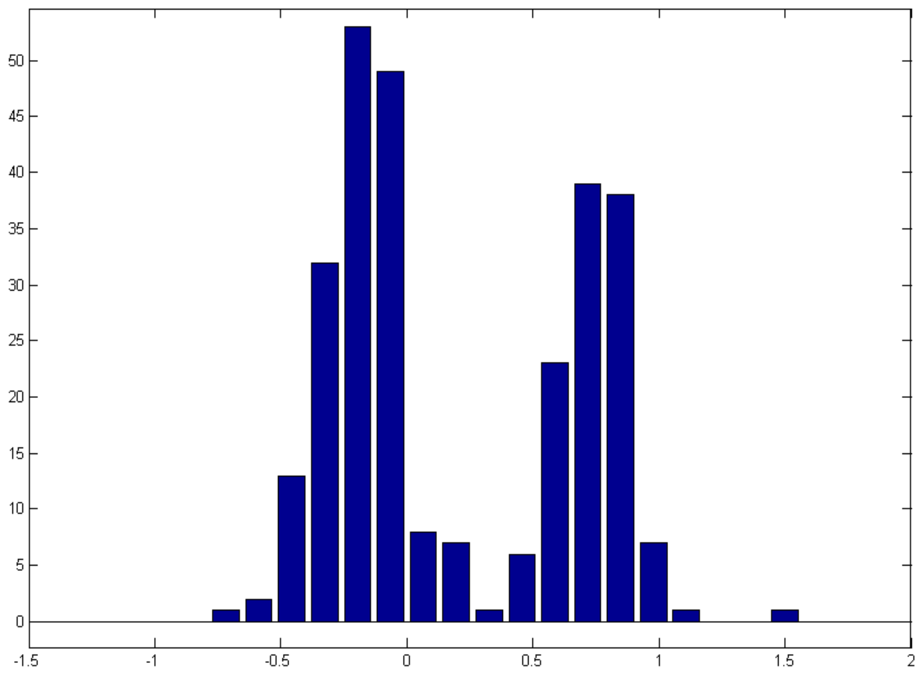
Spatial resolution





Ø collimator ~ 0.2 mm

Spatial resolution = 0.25 – 0.50 mm

(ref: 3.2mm SDD pixel size)

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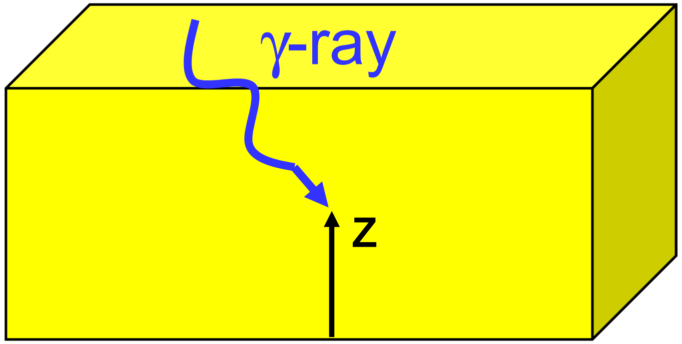
Depth-of-interaction (DOI) capability



Contemporary determination of the x,y,z coordinates of the point of interaction in the scintillator, with the ML method

Use of DOI information to improve imaging capabilities:

- more precise determination of x,y point coordinates thanks to z information (without using a light guide between scintillator and photodetector)
- correction of parallax errors for tilted radiation beams

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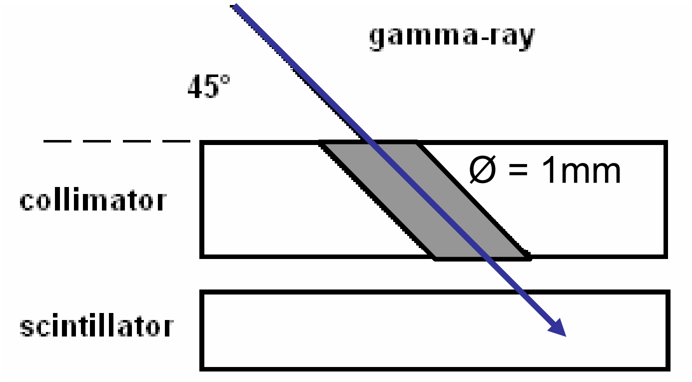
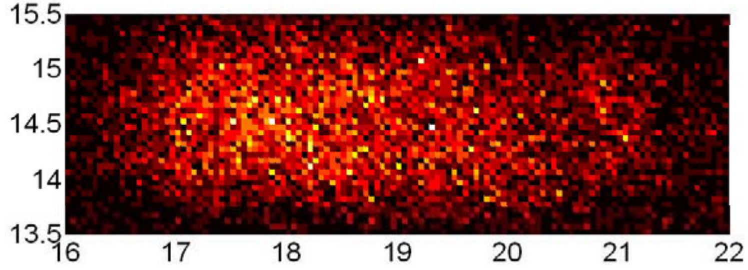
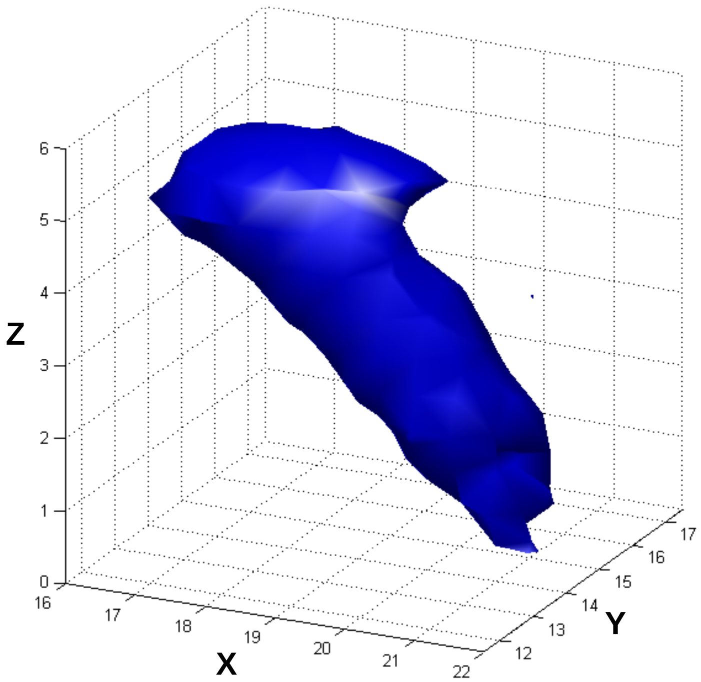
Verification of DOI capability by measuring a 45° tilted beam

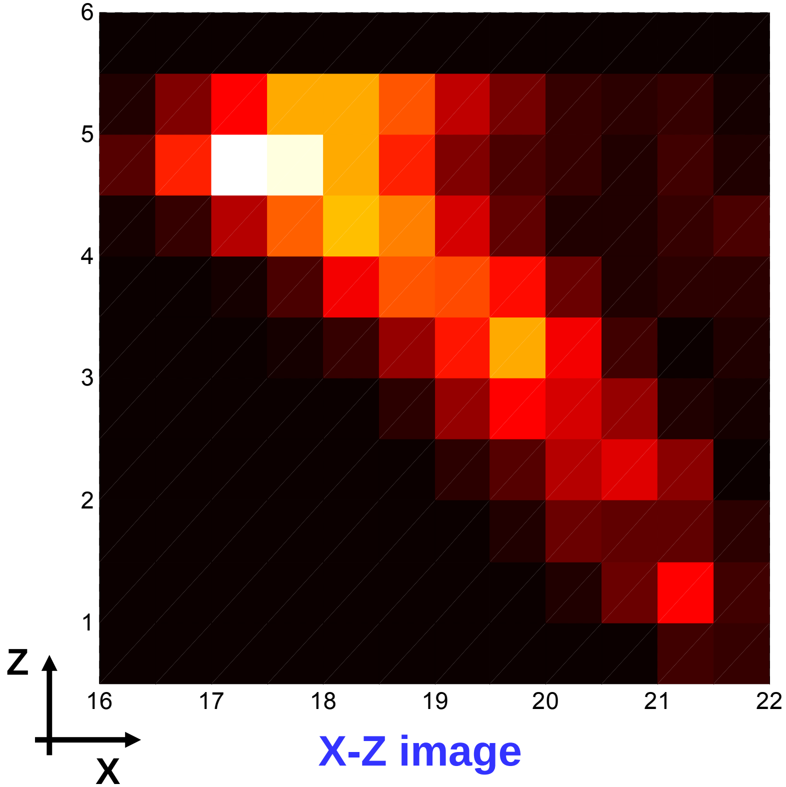




X-Y image



isosurface image



X-Z image

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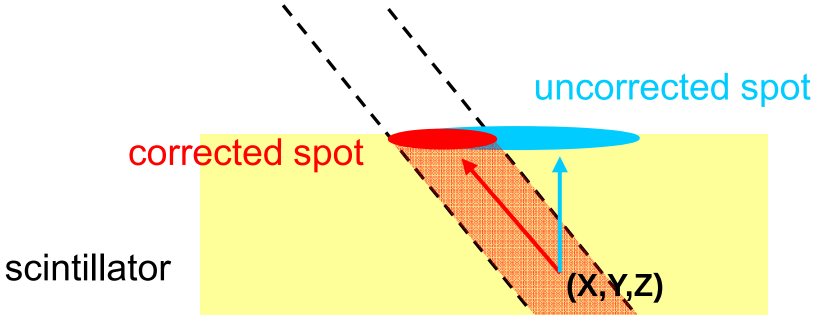
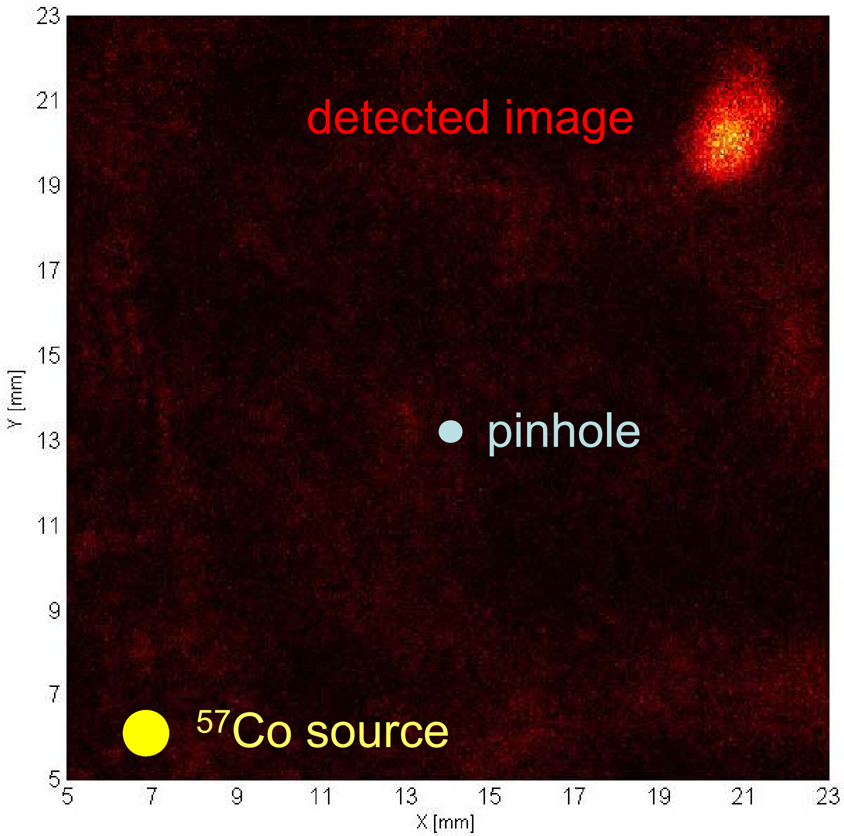
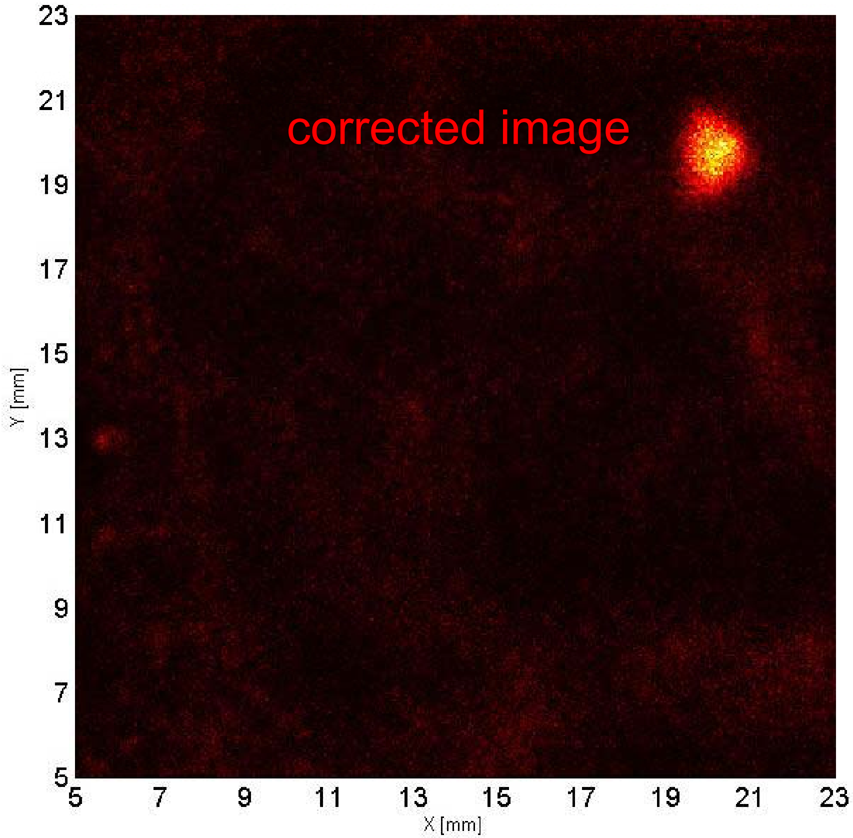


DOI used to correct parallax errors when detecting tilted radiation beams (e.g. with pinhole collimators)





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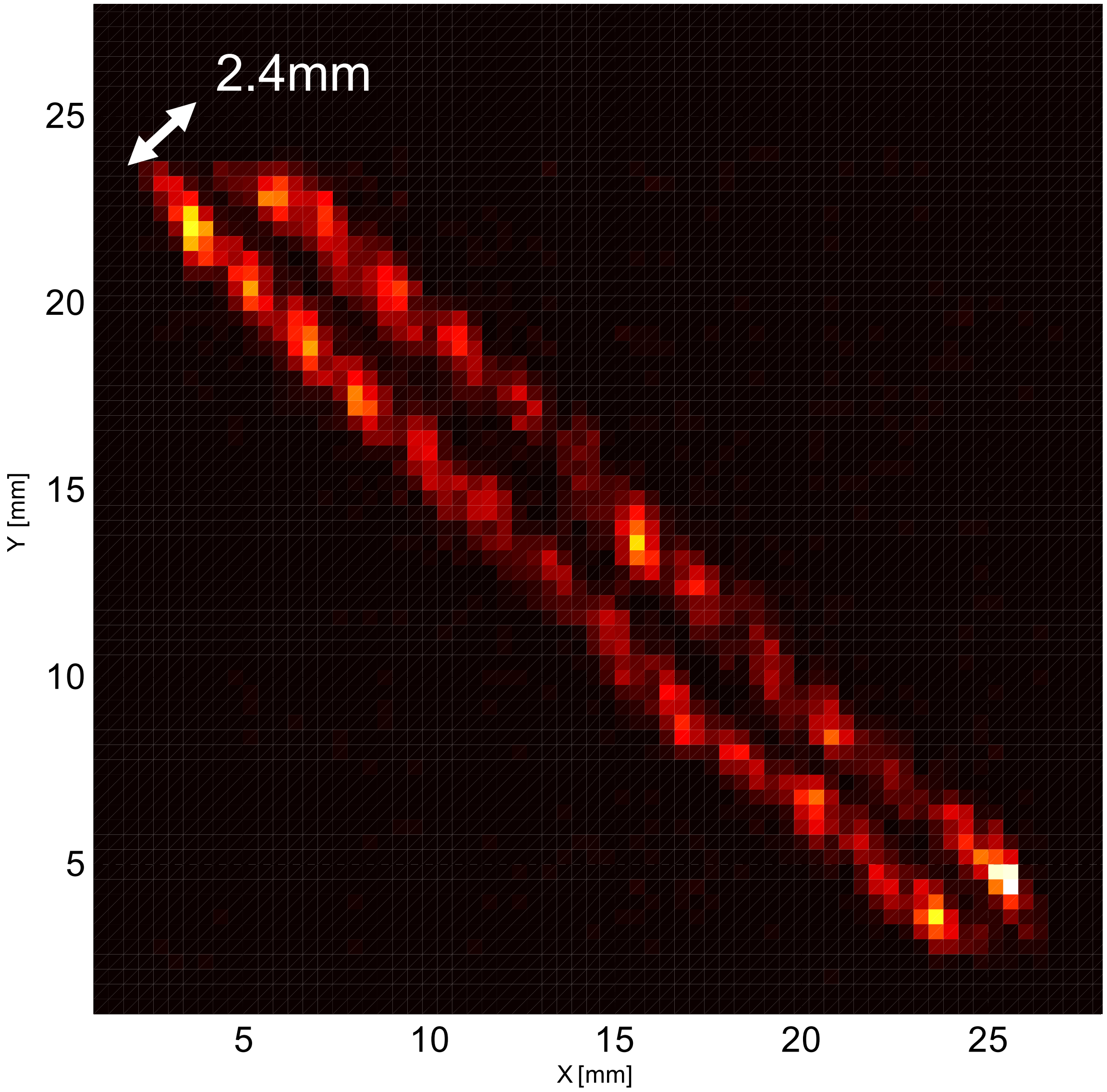

2 parallel capillaries
0.5mm wide each
2.4mm distance

parallel hole collimator with exagonal shaped holes, 0.6mm hole diameter, 0.15mm septa

^{99}Tc filled (140keV)
150µCi activity each
18min acq. time

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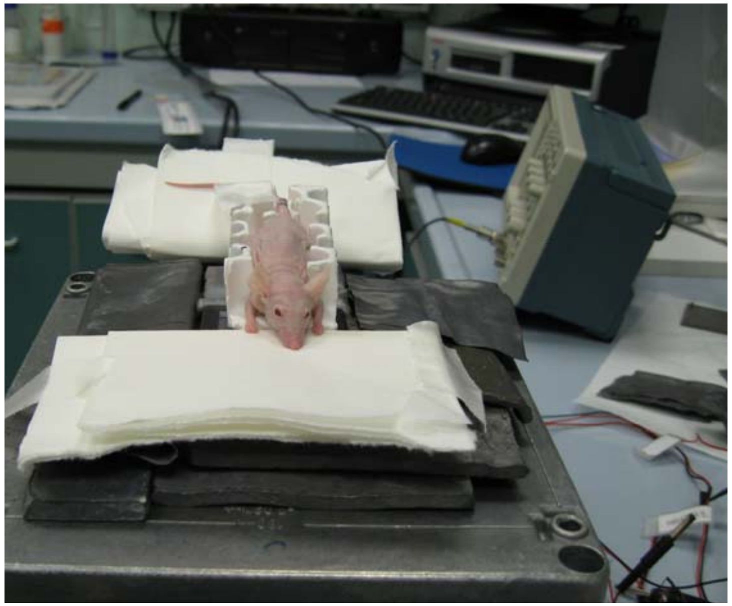
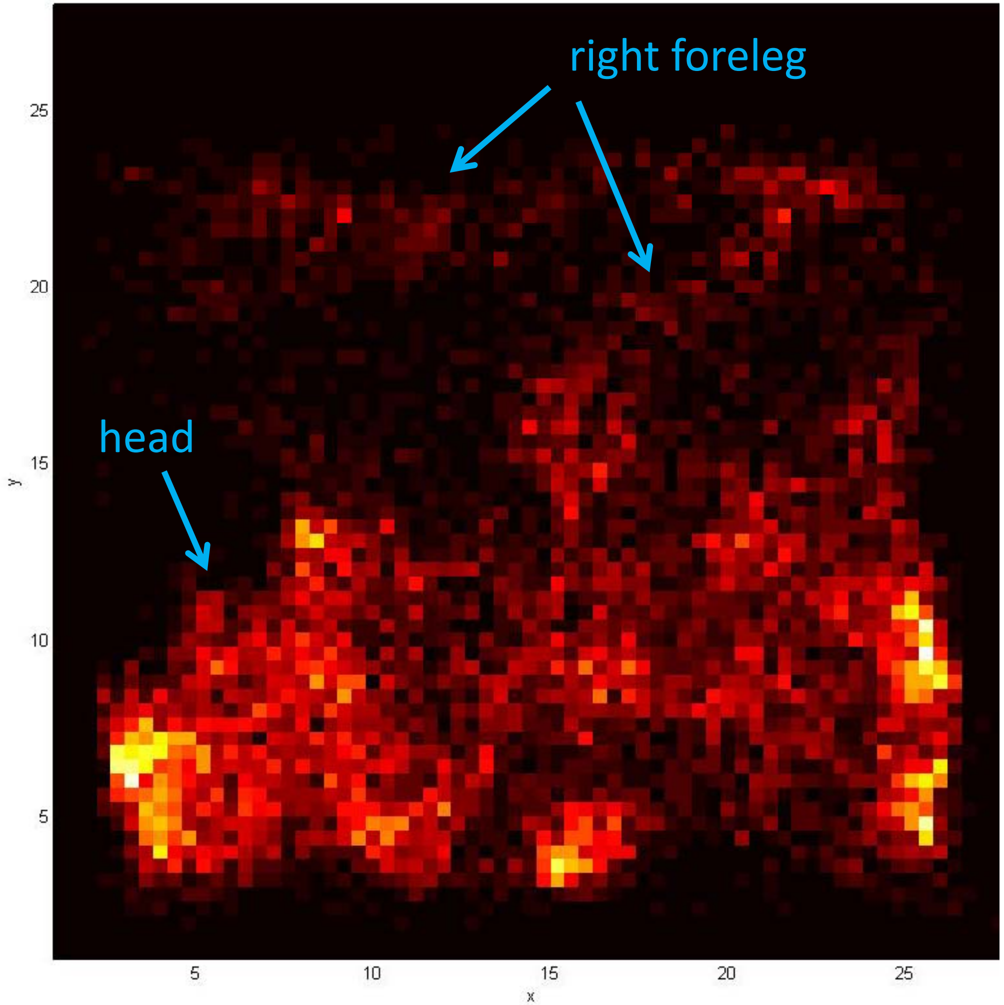
Preliminar *in vivo* planar scintigraphy of a mouse

[^{99}Tc] MDP
2.5mCi injected activity
2h. after injection,
10min acquisition time





Bones scintigraphy carried out at Hospital San Raffalele, Milano, Italy (thanks to: S.Belloli, R.Moresco, A.Pepe)

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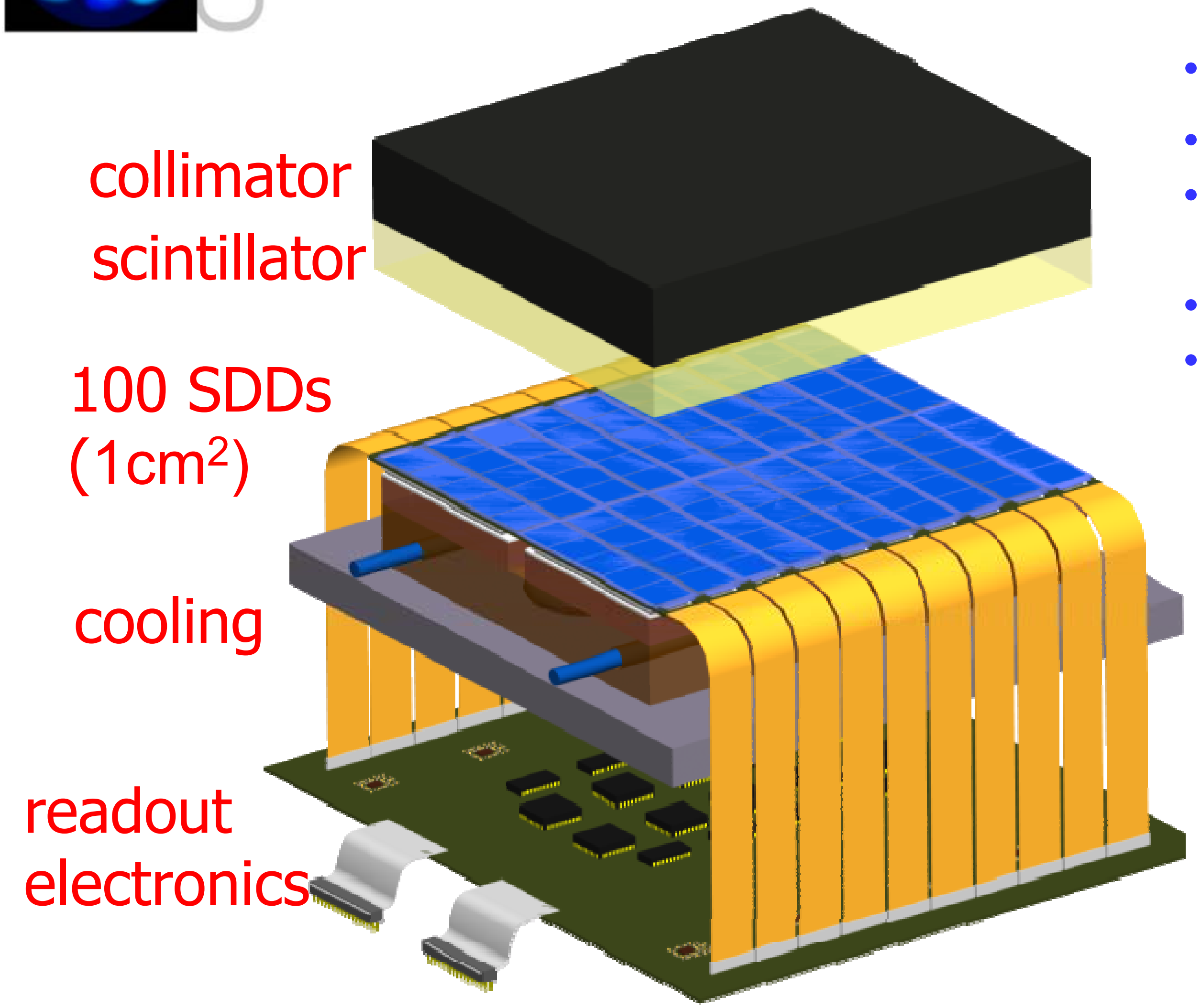
The HICAM project (EC)



- 10x10cm^2 FOV
- intrinsic resolution ~ 1mm
- energy resolution ~ 10% @140keV
- compactness
- compatibility with MRI

further info at:
www.hi-cam.org

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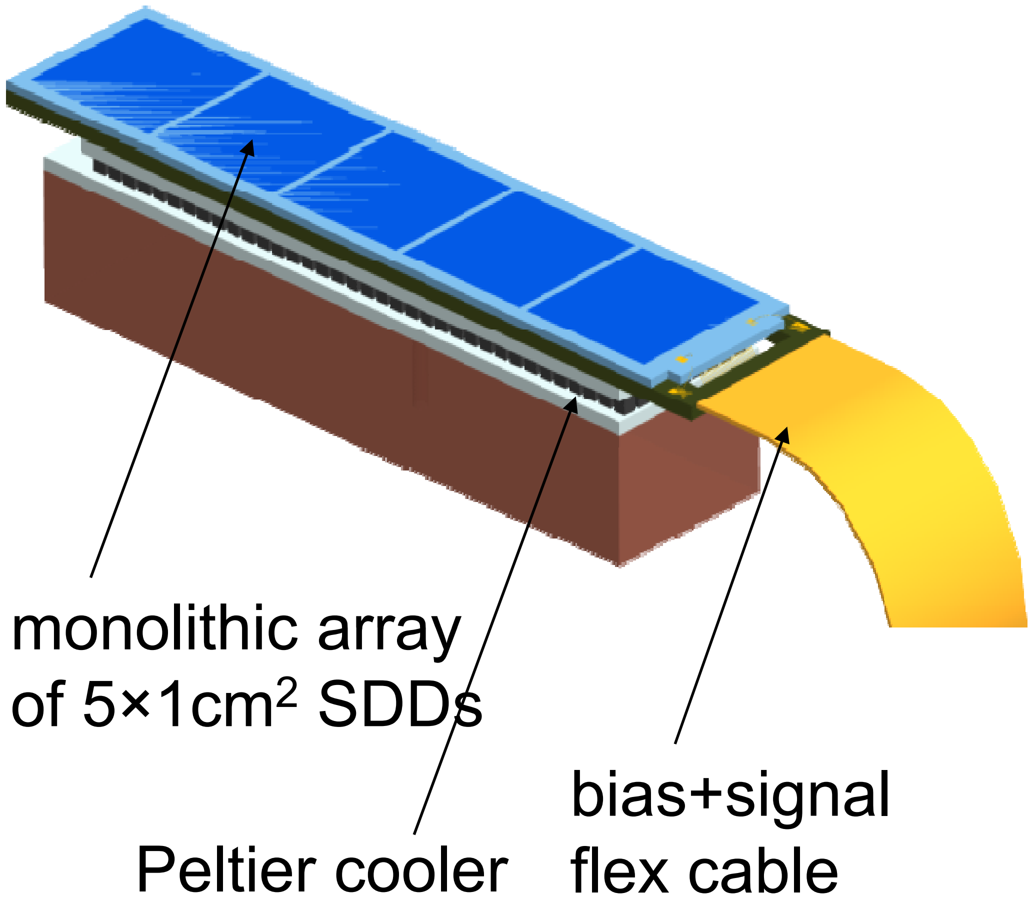

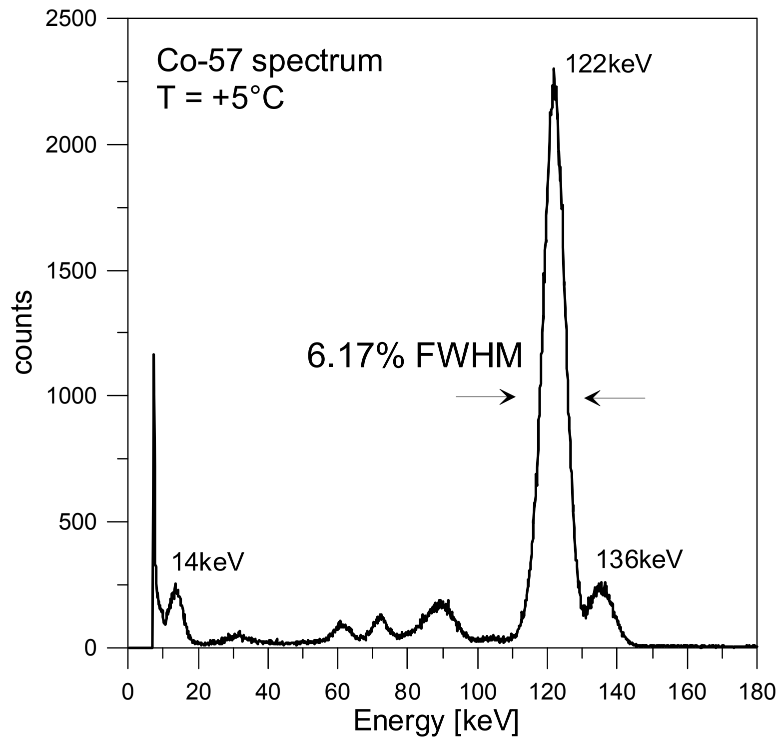

- single SDD with CsI(Tl)
- T = +5°C
- Gain = 53e-/keV
(80% of 65ph/keV of CsI)
- 12μs shap. time

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