Isolpharm WPs Meeting

WP3: Activities and prospects

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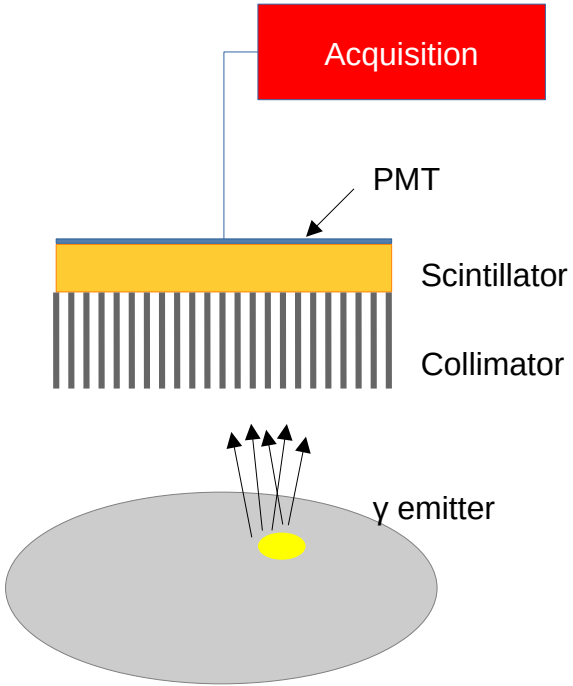
WP3 overview

- **Overall goal**
  - Build the prototype of a γ-camera, optimized for the Ag111 γ emission (342 keV)

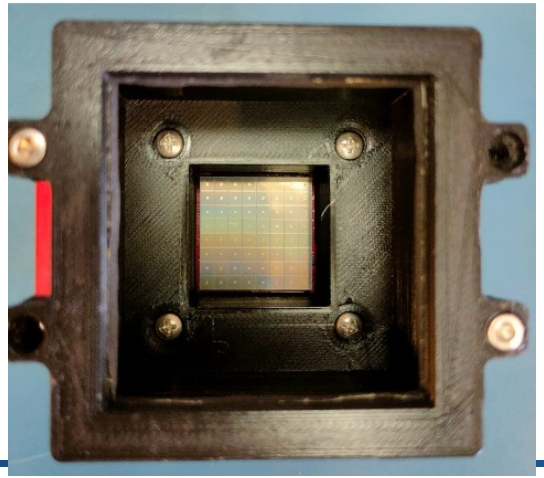
- **Targets for 2025**
  - Detector design optimization based on the experimental results obtained during 2024
  - Final assessment of the detector performance on Ag111.

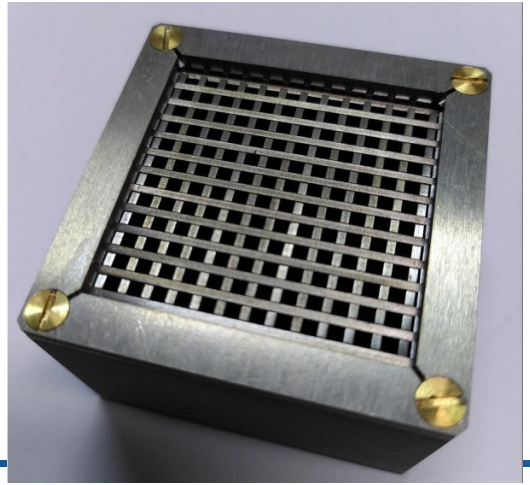


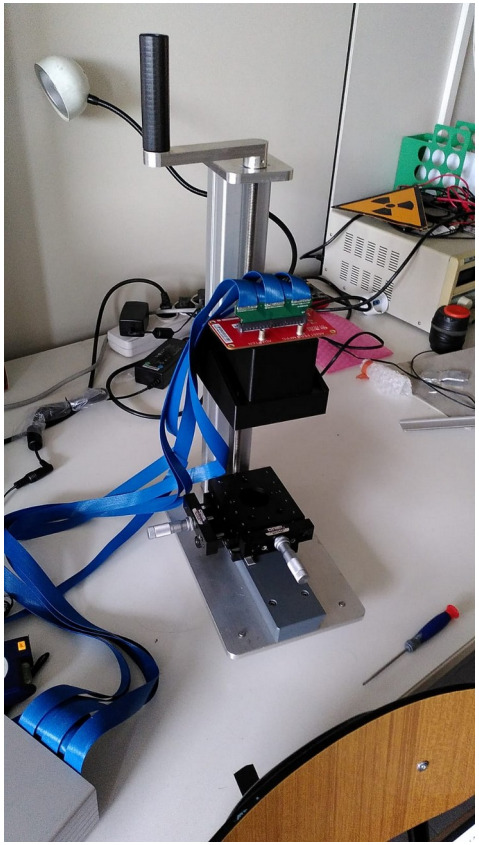
Collimator and support

- Two tungsten collimators with different septa thickness realized by the mechanical workshop in Bologna
  A) 1 mm septa - 2 mm holes - 3 cm length
  B) 1.6 mm septa - 2 mm holes - 3 cm length

- Light-tight support







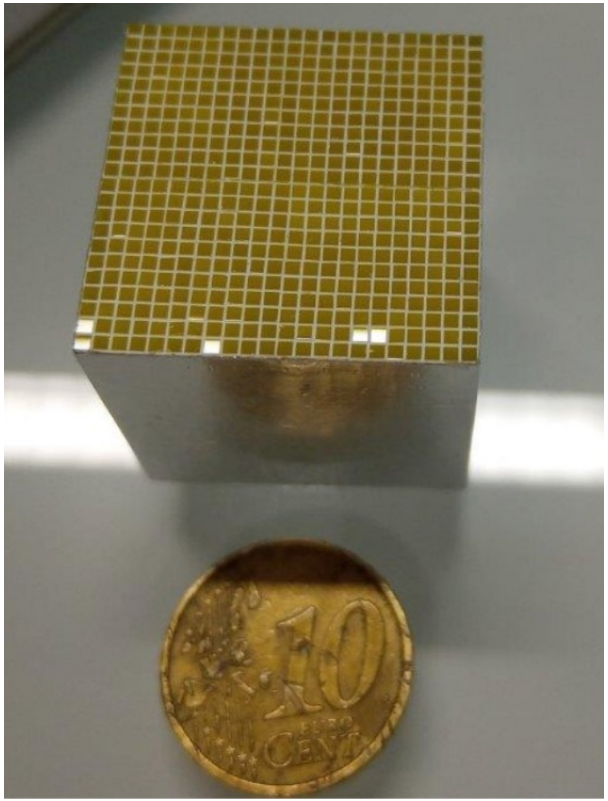
Scintillator

GAGG scintillator matrix

- 23x23x17 mm^3
- density: 6.7 g/cm^3
- λ range: 475-800 nm
- λ max: ~520 nm
- Decay time: 88 ns

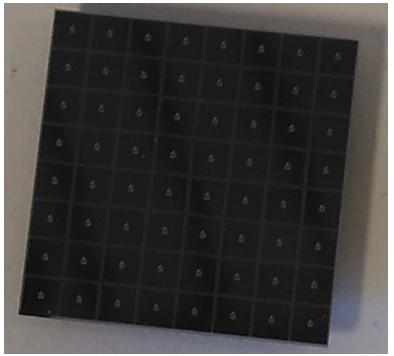
Two other GAGG scintillators used for performance tests and optimization

- 23x23x26 mm^3 array
- 27x27x17 mm^3 slab

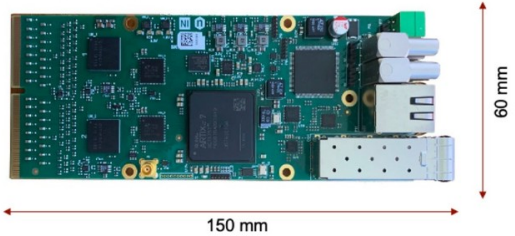


Readout

- Hamamatsu S14161-3050AS-08 SiPM matrix: 8x8 channels 3.2x3.2 mm^2
- CAEN FERS A5202 64-channels readout system (+connectors and flat cable, procured)



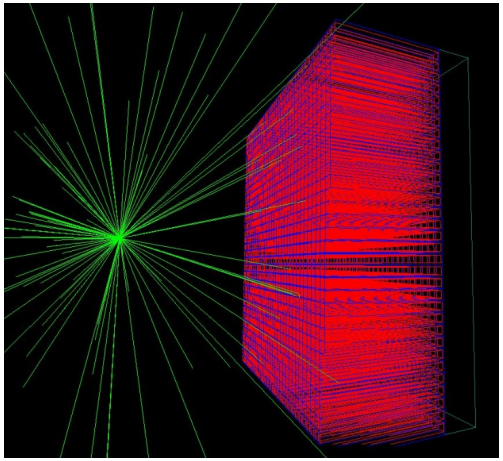
FERS: A5202



- Two Citiroc1A for reading out up to 64 SiPMs
- One (20 – 85V) HV power supply with temperature compensation
- Two 12-bit ADCs to measure the charge in all channels
- Timing measured with 64 TDCs implemented on FPGA (LSB = 500 ps)
- 2 High resolution TDCs (LSB = 50 ps)

Monte Carlo Simulation

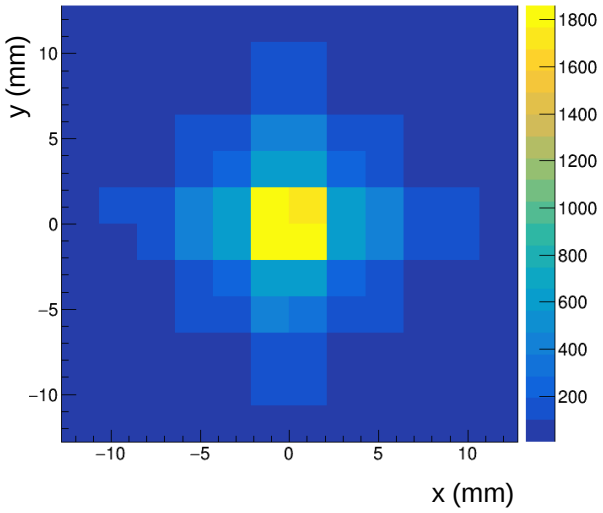
- Design of the γ-camera based on a Geant4 MC simulation
- Includes collimator, scintillator, propagation of optical photons
- Geometrical parameters can be easily modified from configuration files
- Simulation interfaced with batch system

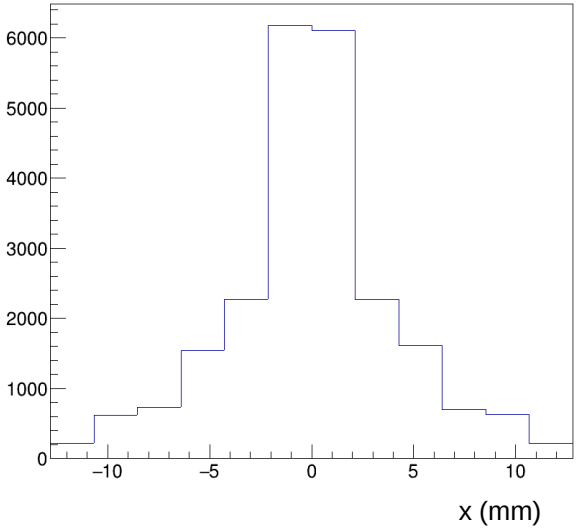


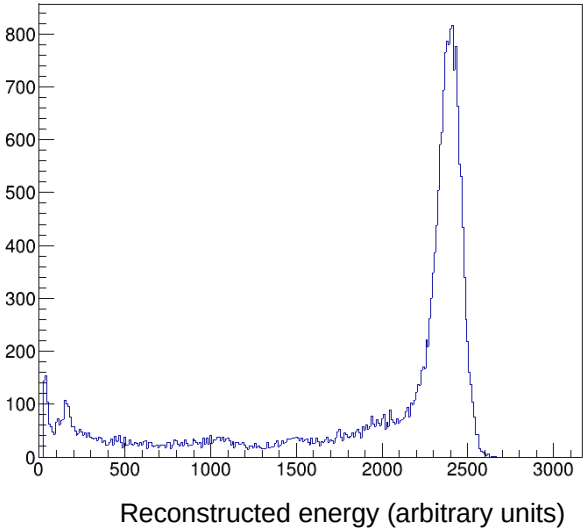
"Nominal" results obtained with:

- 100M events
- Gamma E = 342 keV
- Cylindrical source, radius = 2.0 mm
- Collim. length = 30 mm
- Septal thickness = 1.0 mm
- Hole size = 2.0 mm

Simulation results





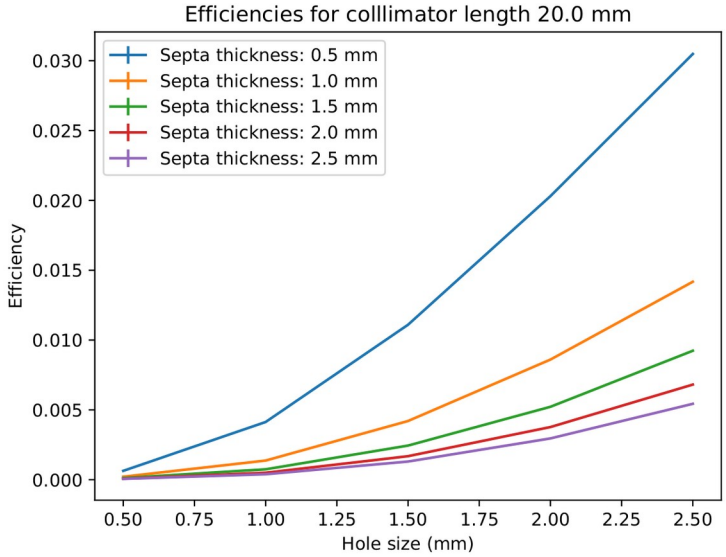


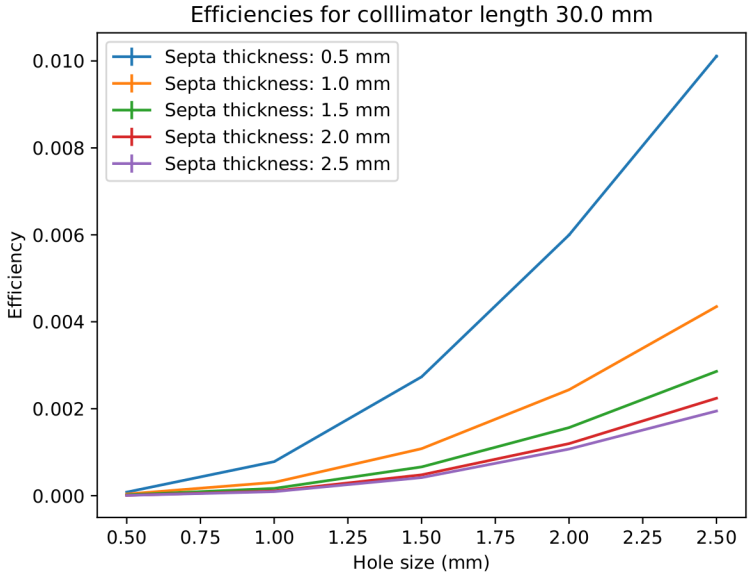
10^8 events generated, 24372 events observed → efficiency: $\epsilon = 2.4 \times 10^{-4}$

Simulation results

Detailed study of the performance possible after interfacing the simulation with the batch system:

- Collim. length = 20, 30 mm
- Septal thickness = 0.5, 1.0, 1.5, 2.0, 2.5 mm
- Hole size = 0.5, 1.0, 1.5, 2.0, 2.5 mm

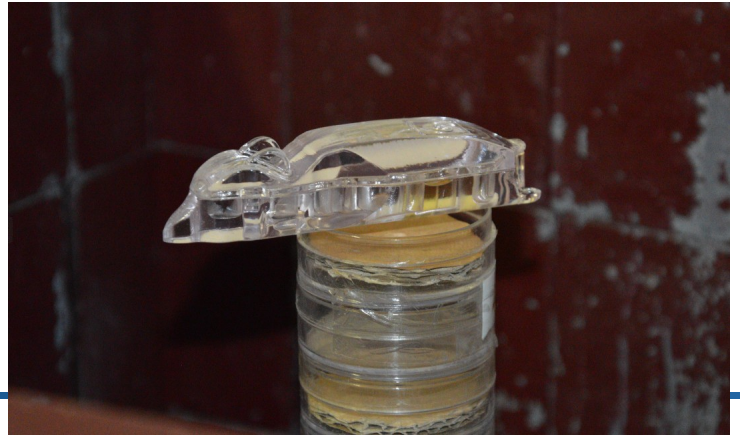




Tests with Ag111 (15/05/2025)

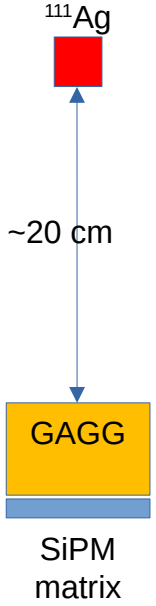
First set of tests of the γ-camera with Ag111 at LENA using 4 sources:

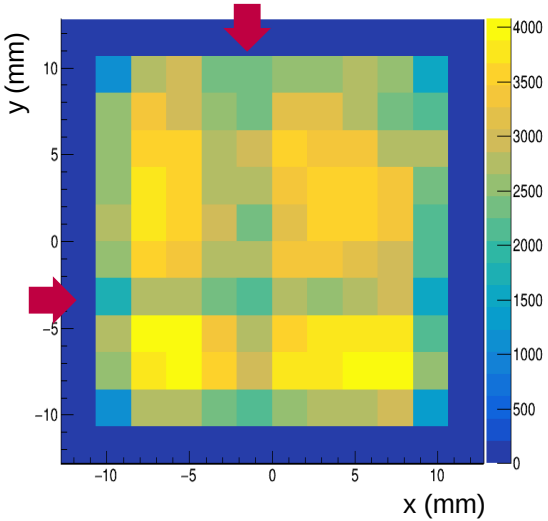
- Large vial, diameter = 12.5 mm, A = 18.6 MBq measured at 8:41 → A = 18.0 MBq at 14:15
- Small vial 1, diameter = 6.0 mm, A = 7.37 MBq measured at 13:51
- Small vial 2, diameter = 6.0 mm, A = 7.59 MBq measured at 13:42
- Mouse phantom:
  - Bladder: A = 2.31 MBq
  - Bladder + 2 kidneys: A = 7.69 MBq
  - Bladder + 2 kidneys + liver: A = 15.7 MBq

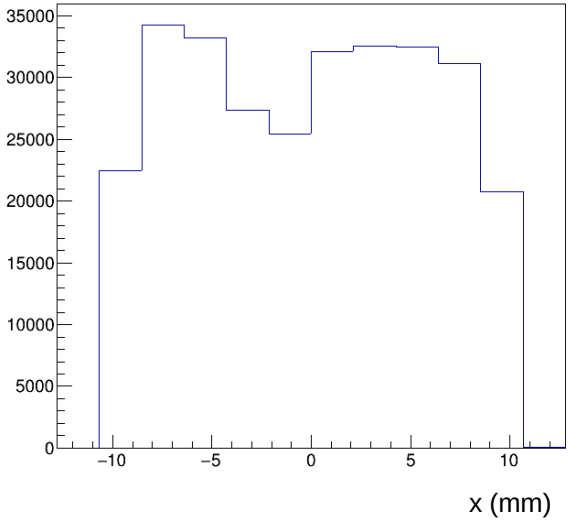


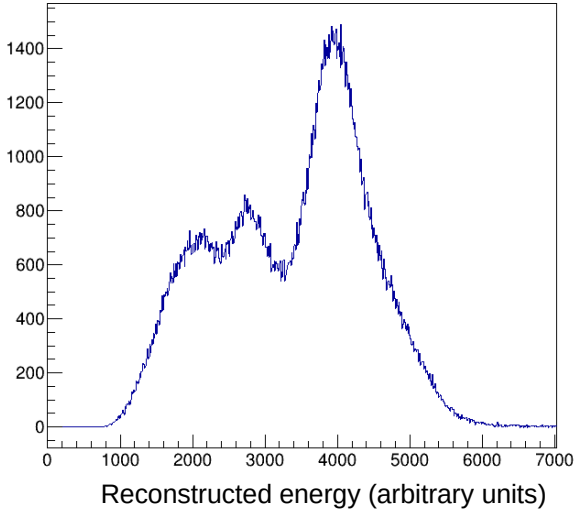
Without collimator

Possible reduced-efficiency regions
(Not observed in previous lab tests, to be further investigated)





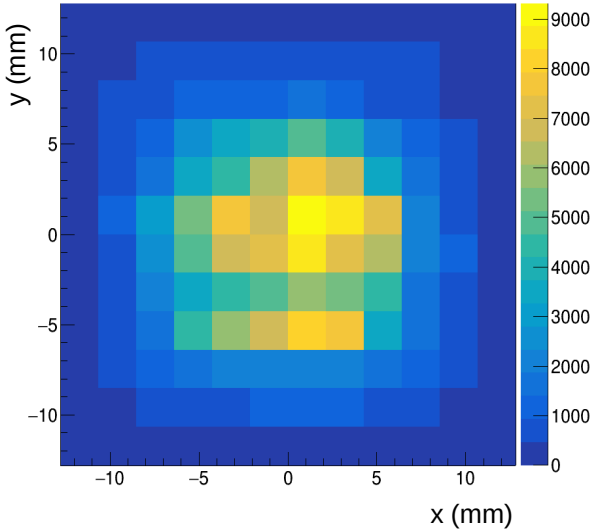


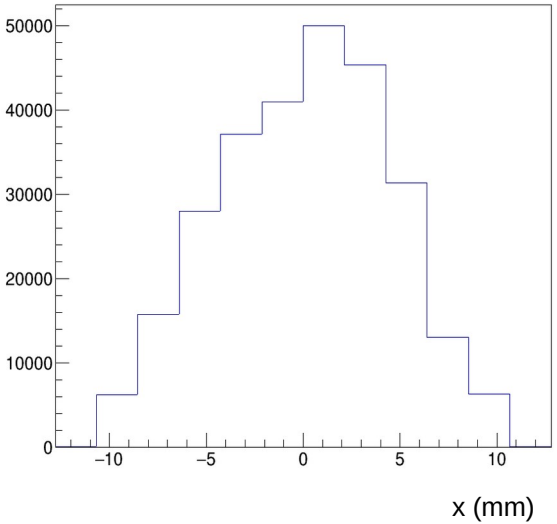


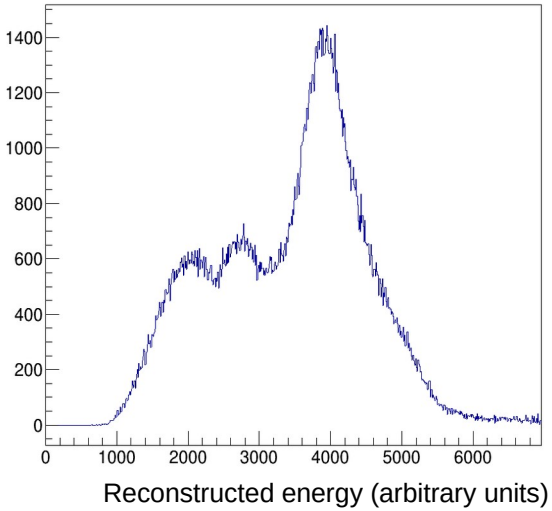
Plots after background subtraction

With collimator

Large vial in the center, diameter = 12.5 mm, A = 18.0 MBq

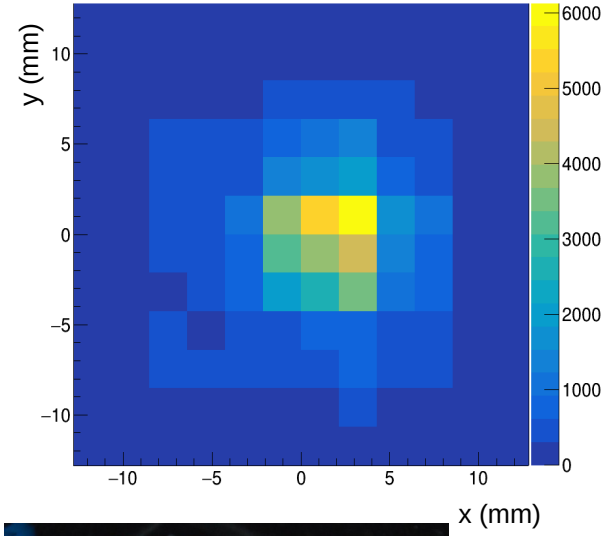


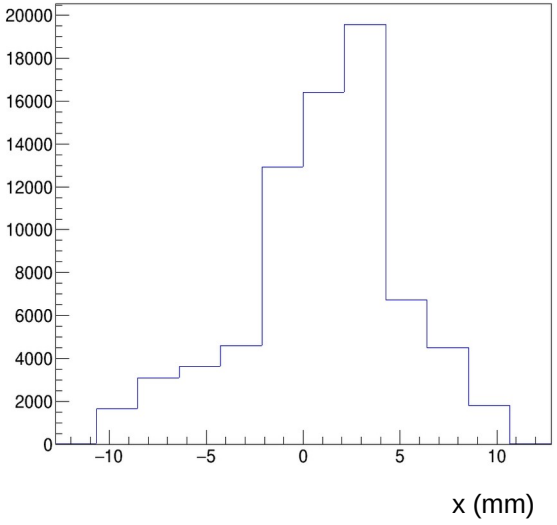


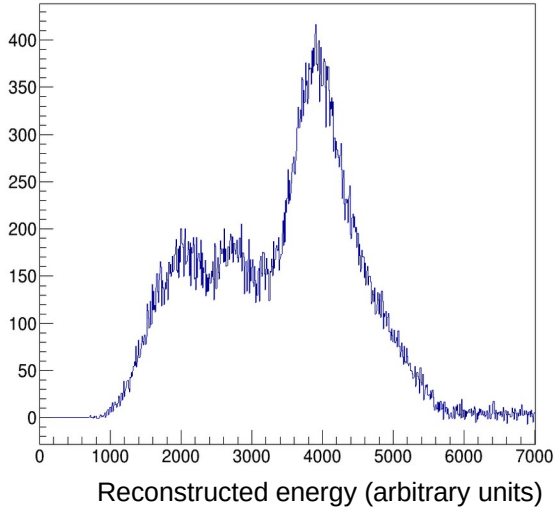


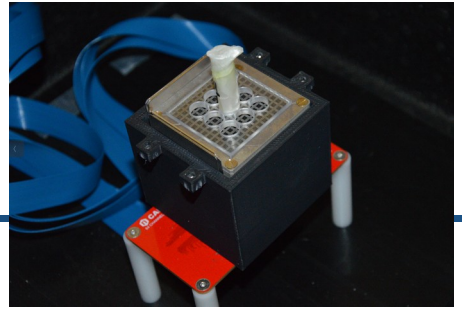
With collimator

Small vial 1 in the center, diameter = 6.0 mm, A = 7.37 MBq



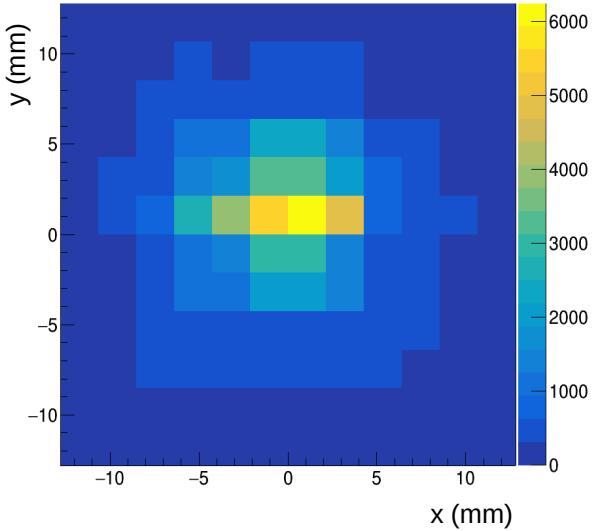


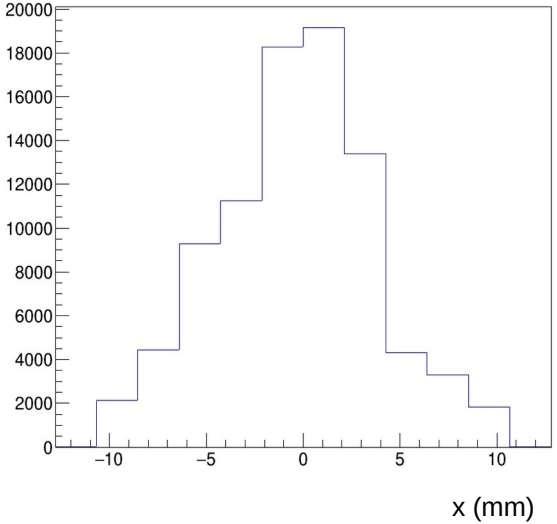


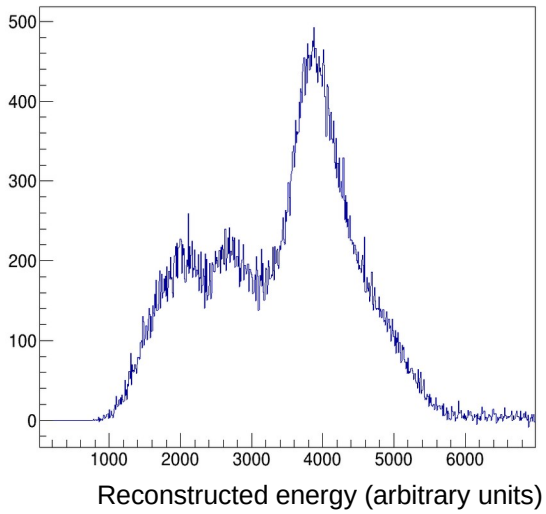


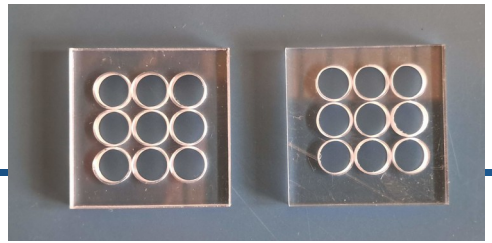
With collimator

Small vial 1 shifted by 1.5 mm in both x-y, diameter = 6.0 mm, A = 7.37 MBq

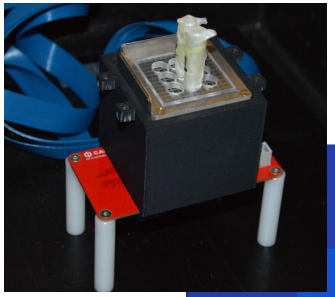




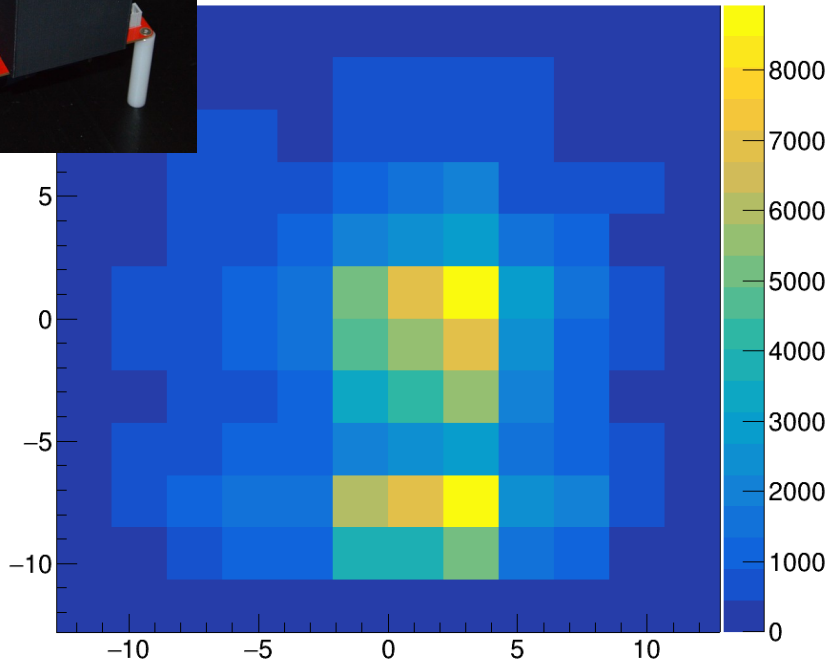


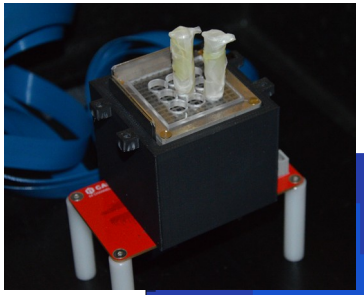


With collimator

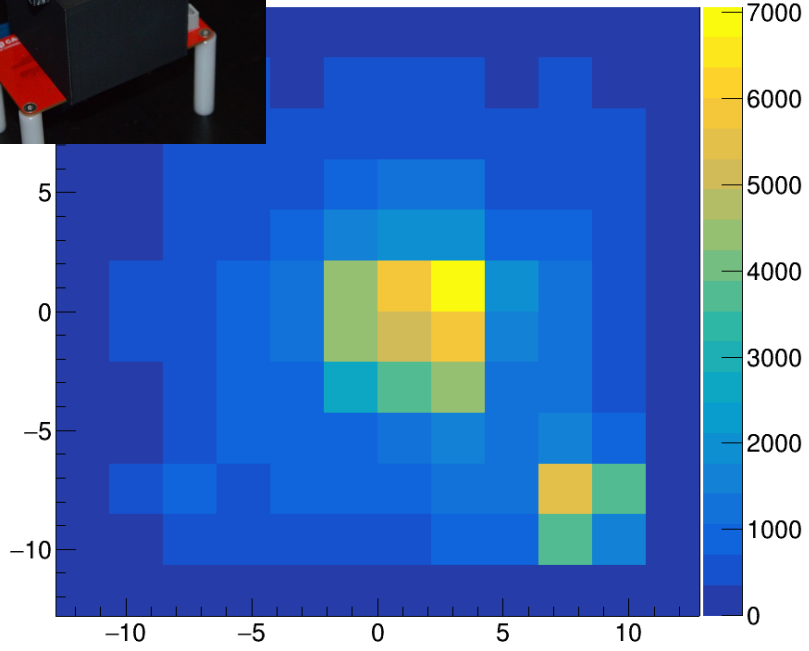


Small vial 2 → center
Small vial 1 → side





Small vial 2 → center
Small vial 1 → corner



Efficiency

$$N_{counts} = A \cdot time \cdot BR_{342\,keV} \cdot \epsilon$$

$$BR_{342\,keV} = 6.7\,\%$$

	N_{counts}	Time (s)	ϵ
Large vial - center	274k	1078	2.1×10^{-4}
Small vial 1 - center	74.9k	798	1.9×10^{-4}
Small vial 1 – shift 1.5 mm x-y	87.4k	941	1.9×10^{-4}

Disclaimer: many approximations in this efficiency calculation.
However the number looks reasonable

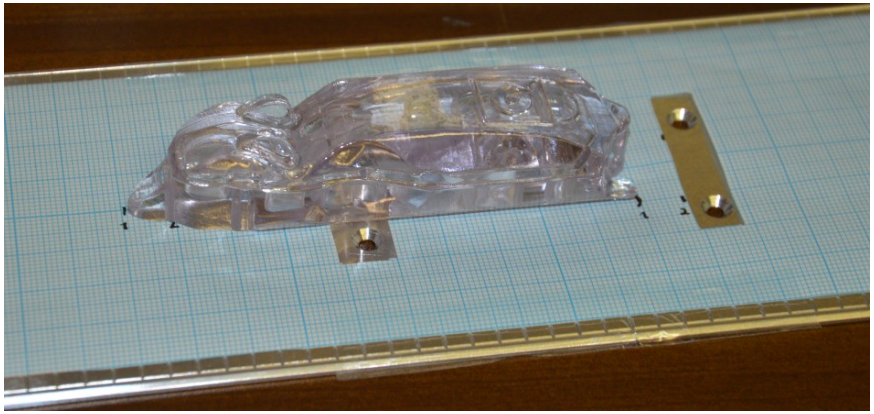
Tests with mouse phantom

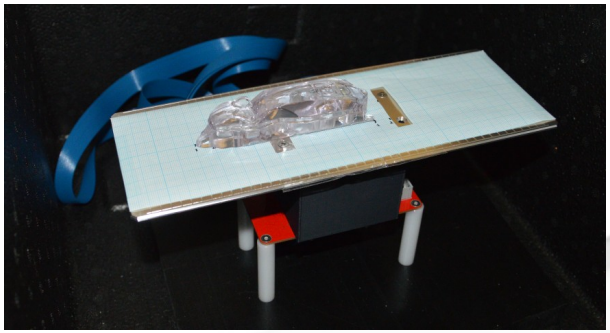
Test the capability to visualize mouse organs using a phantom (Bioemtech)

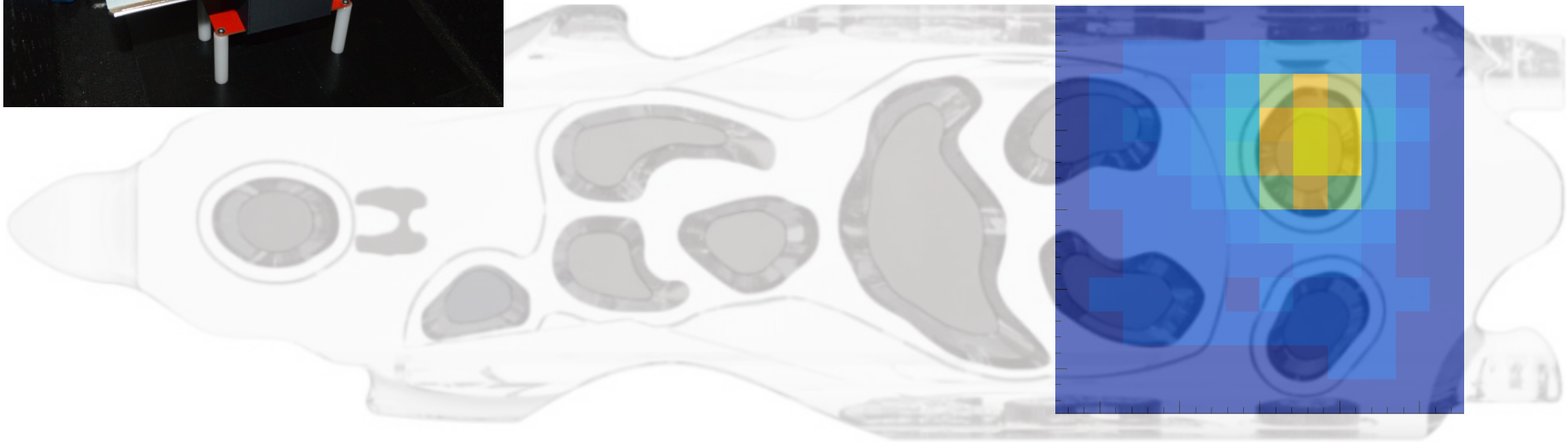
https://bioemtech.com/product/phantom/

Organs: bladder, kidneys, liver

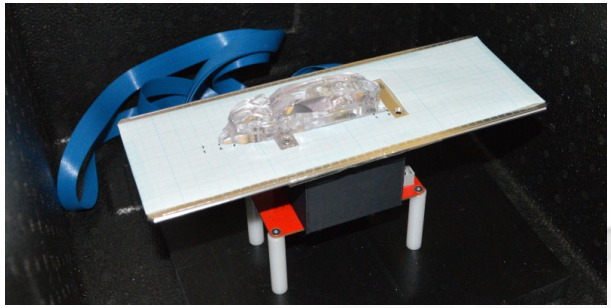
Acquisition time: 20 min (per organ)

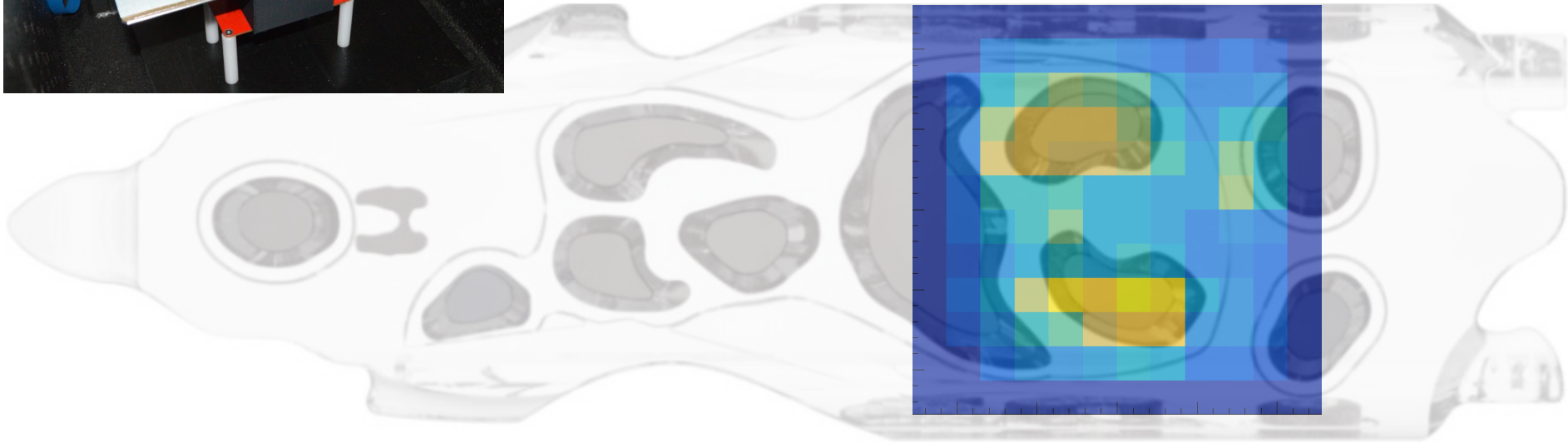




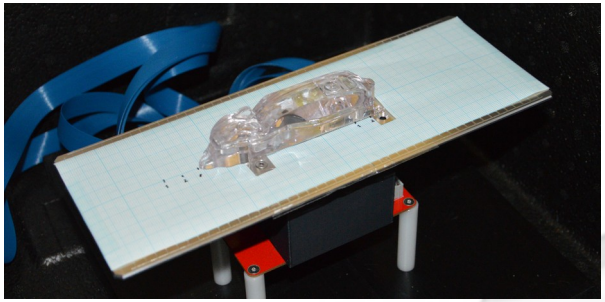


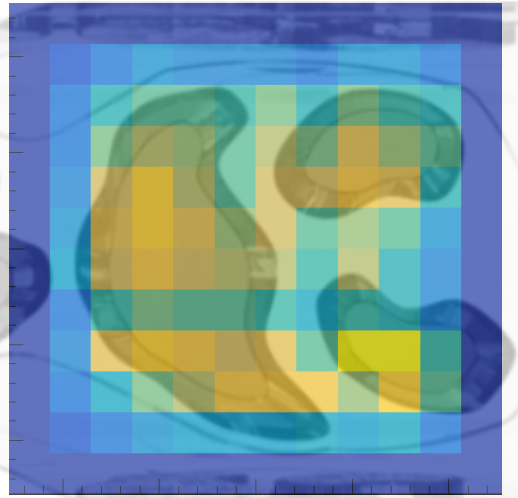
Bladder (2.31 MBq)
Reference position





Bladder + kidneys (7.69 MBq)
Shift: 9 mm





Bladder + kidneys + liver (15.7 MBq)
Shift: 17 mm

Summary and next steps

- **Goals for 2025 reached**
  - γ-camera prototype optimized
  - Tests with Ag111 done. Source activity 18.0 MBq (about 10x the activity available for the first tests done in 2024)

- **Next steps**
  - Finalize the data analysis
  - We may benefit from another data taking session after the summer, if possible
  - Paper in preparation

		Year 1				Year 2				Year 3				Notes
		M3	M6	M9	M12	M15	M18	M21	M24	M27	M30	M33	M36	Required for
	WP3 - γ-Imaging													
MS3.0	Sizing of the detector components according to the required spatial resolution	→	●											MS3.1, MS3.2
MS3.1	Preliminary Monte Carlo simulations for detector design	→	○		●									MS3.2
MS3.2	Planar imaging detector construction for Ag-111 γ detection					→	○		●					MS3.3
MS3.3	Characterization of the planar system for γ-imaging							→			●			MS3.4
MS3.4	γ-imaging test with Ag-111							→					●	