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Embrace scientists
translate ideas
into outcomes

A “GATE” in silico evaluation of the γ-eye preclinical system, for imaging alpha and beta radiopharmaceuticals

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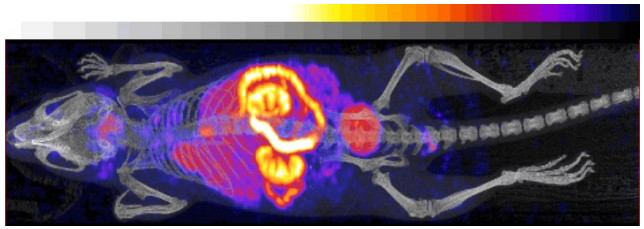
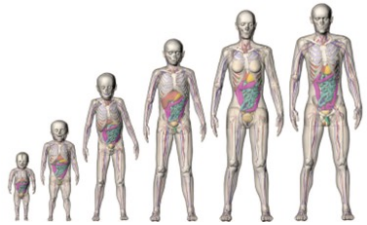
BIOEMTECH activities

BIOEMTECH develops and offers innovative solutions in pharmaceutical, medical physics and biotechnology research.

We focus on **molecular imaging, dosimetry & biomedical engineering**:

- ✓Design and construction of preclinical imaging devices
- ✓Performance of preclinical imaging services in our certified laboratories
- ✓Computational solutions using MC simulations & AI techniques





“eyes” imaging devices

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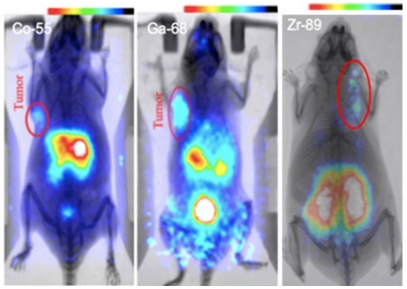
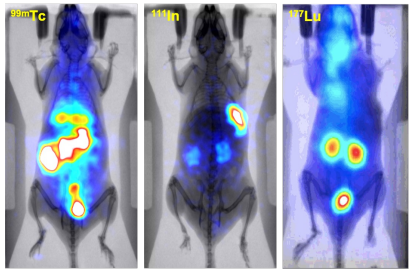
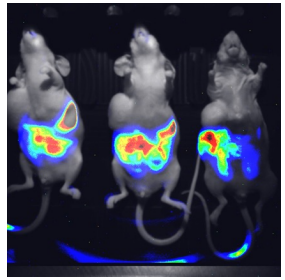
Model name	β-eye	γ-eye	ϕ-eye
What it detects	High energy photons (511keV)	Low energy photons (<250keV)	Light from fluorescent dyes
Special Features	• Imaging of radiolabeled SPECT compounds • Whole body real-time scanning • Organs/Tumors, functional info • Small form factor • Plug & Play • Data analysis tool	• Imaging of radiolabeled PET compounds • Whole body real-time scanning • Organs/Tumors, functional info • Small form factor • Plug & Play • Data analysis tool	• Imaging of chromophores and fluorescent compounds • Whole body real-time scanning • Organs/Tumors, functional info • Small form factor • Plug & Play • Data analysis tool
Suitable for studies	Oncology, lungs, kidneys, bones, brain, nanomedicine	Oncology, lungs, kidneys, bones, brain, nanomedicine	Oncology, nanomedicine







Background and scope of the study

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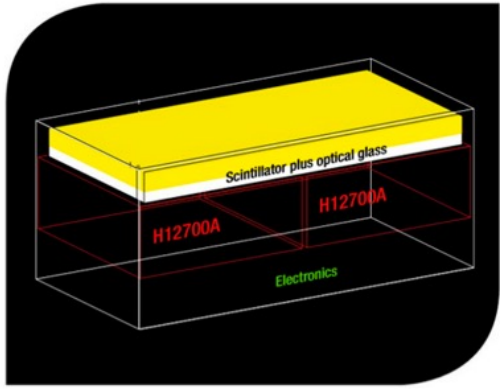
BIOEMTECH is an official member of **OpenGATE Collaboration**

www.opengatecollaboration.org

GATE

- ✓The goal of the study is to investigate technical characteristics of the *γ-eye*^{TM} system to image novel compounds based on alpha and beta emitters (i.e ^{225}Ac, ^{212}Pb, ^{203}Pb, ^{177}Lu).
- ✓Our study is based on a previously validated model of the standard *γ-eye*^{TM} in GATE.
- ✓The first version of *γ-eye*^{TM} was standardized for more conventional SPECT radiotracers (^{99m}Tc,^{111}In, ^{67}Ga, ^{131}I).



R. Ricci et al. Crystals 2019

Technical characteristics / GATE model

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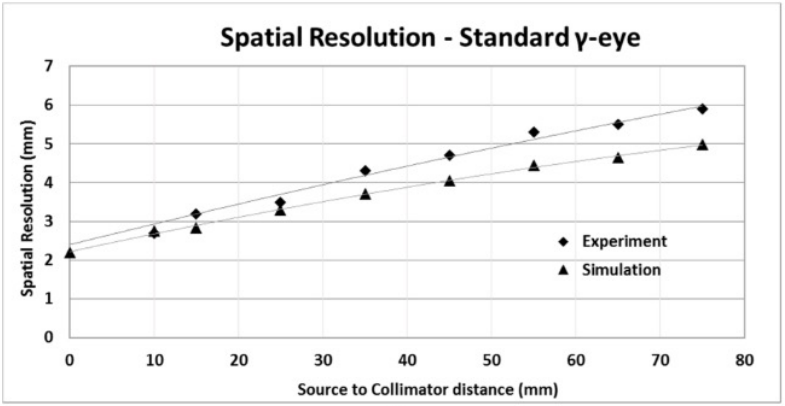
- ✓ **Detector CsI:Na**:
  29x58 pixelated crystals 1.5x1.5x6 mm^3 (1.7 mm pitch)

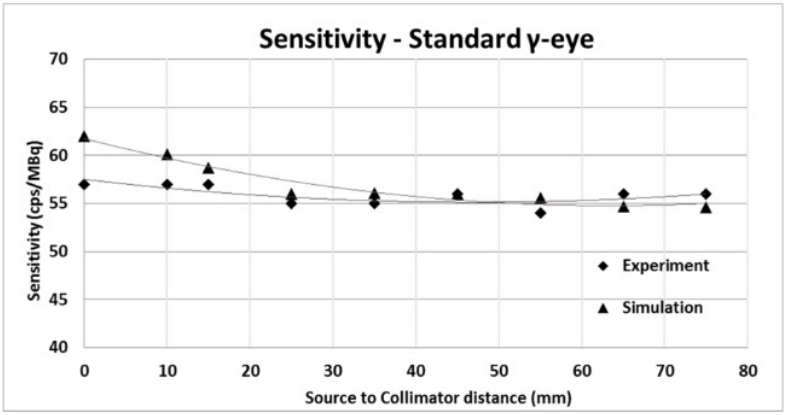
- ✓ **Collimator Pb:**
  Parallel hexagonal holes
  Diameter = 1.2 mm (0.15 mm septa)
  Thickness = 27 mm

- ✓ **PSPMTs**:
  48.5x48.5x32.5 mm^3

Properties	γ-eye
Useful Field of View (UFoV)	48 mm × 98 mm
Sensitivity @ ±20% energy window	56 cps/MBq
Spatial resolution	2.2 mm @ 0 mm
Energy resolution	24.5% @ 140 keV



(a)



Technical characteristics / GATE model

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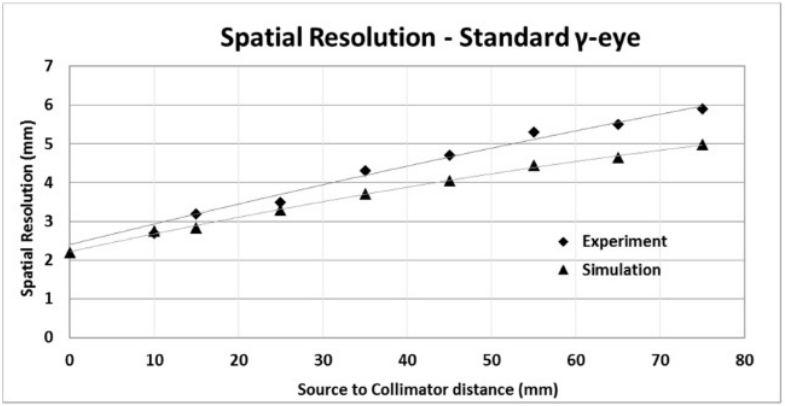
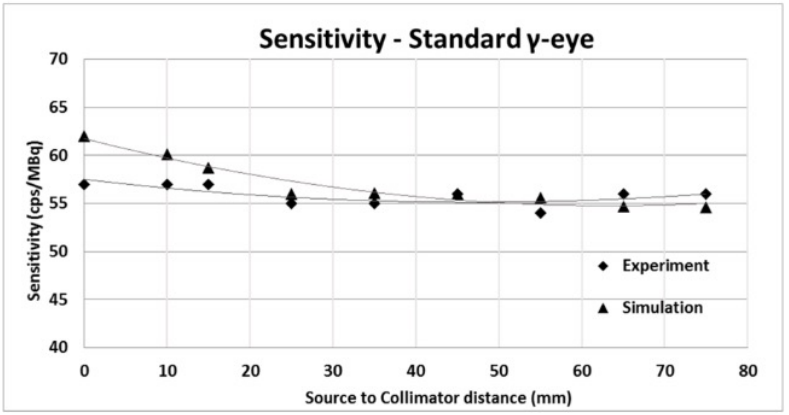
GATE general parameters

- ✓ GATE version: 9.1 (running in HPC)
- ✓ Physics model : emstandard opt3
- ✓ Source : “ion” source

Properties	γ-eye
Useful Field of View (UFoV)	48 mm × 98 mm
Sensitivity @ ±20% energy window	56 cps/MBq
Spatial resolution	2.2 mm @ 0 mm
Energy resolution	24.5% @ 140 keV



(a)



γ-eye towards ^{212}Pb

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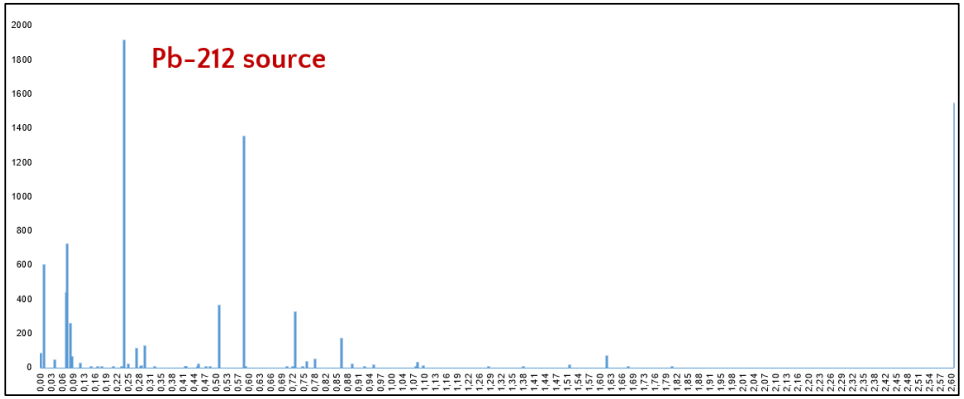
- ✓ **Variable collimator:**
  - ✓ M=Tungsten, D=1.2mm, 1.5mm & 2mm, S=0.5, H=30mm
- ✓ **Constant crystal scintillator height:**
  - ✓ CsI(Na) 29 × 58 pixels array (1.5x1.5mm^2 and H = 6mm).
- ✓ **Different phantoms tested:**
  - ✓ Vials filled with 100μCi @ 11mm distance from collimator.
- ✓ **Methodology:**
  - ✓ Investigate different energy windows (EW).
  - ✓ Apply scatter correction based on specified EW.



Vials study ^{212}Pb

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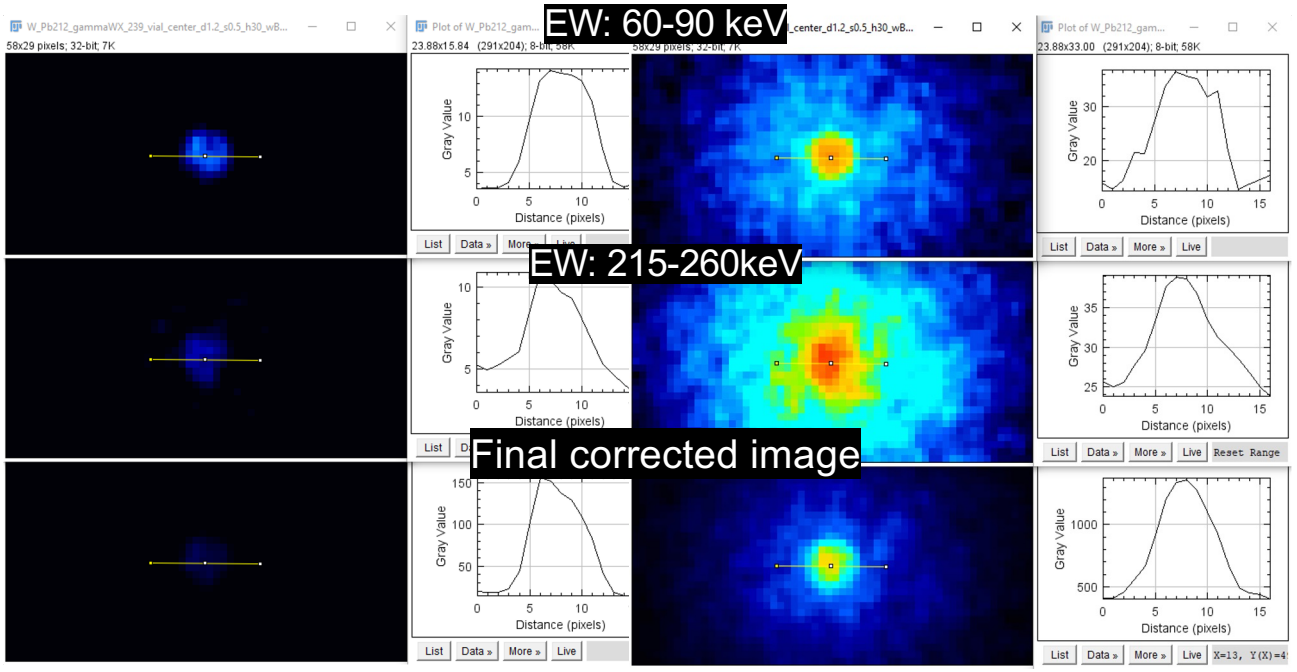
D = 1.2mm, S=0.5mm, H=30mm, CsI(Na)=6mm



Un-scattered photons **Total counts**

Vials study ^{212}Pb

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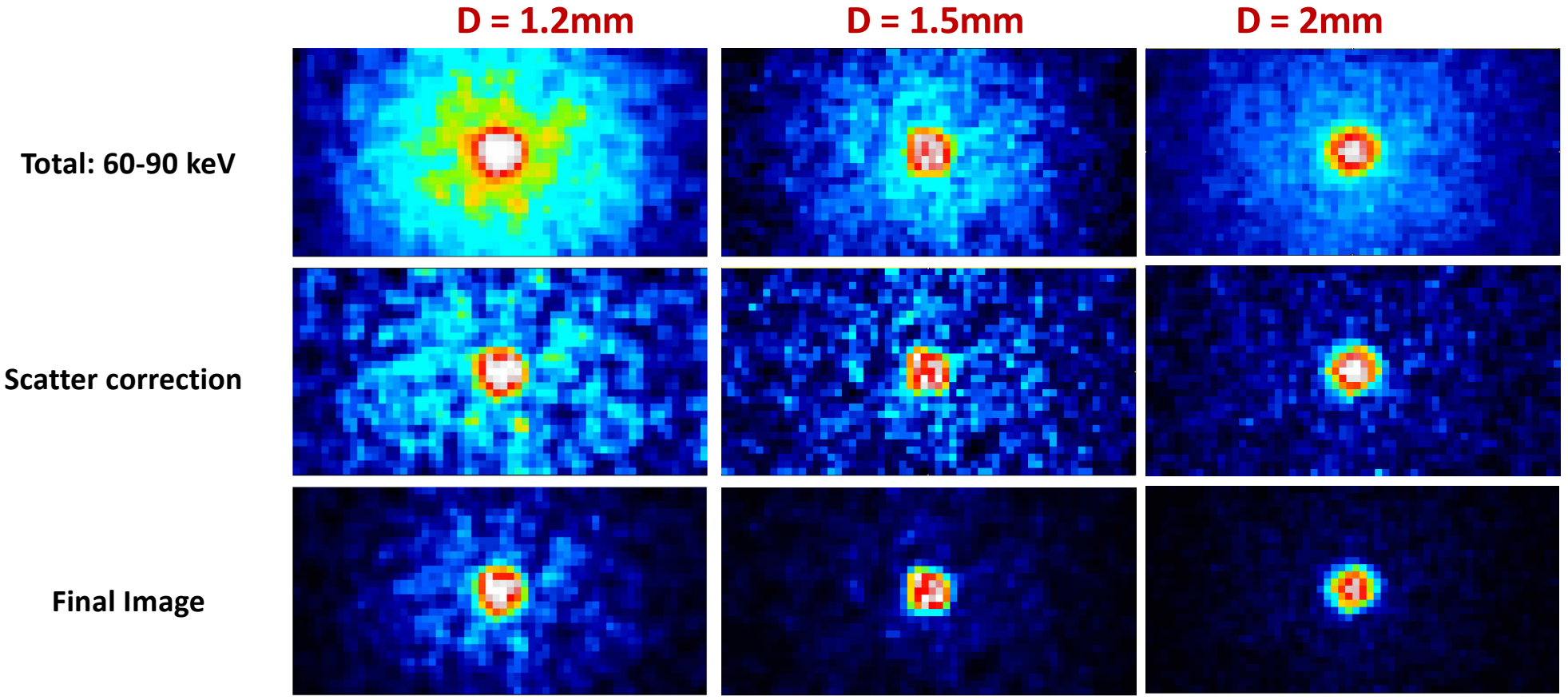

Vials study ^{212}Pb: Simulation vs Experiment

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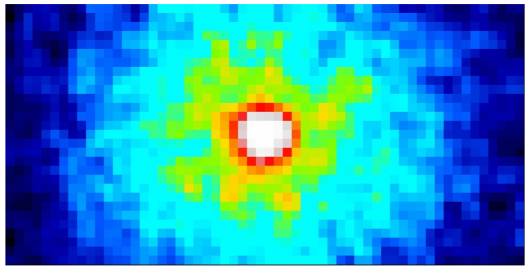
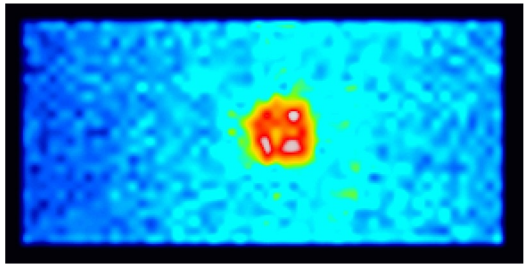
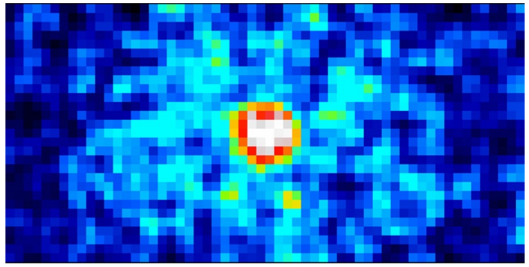
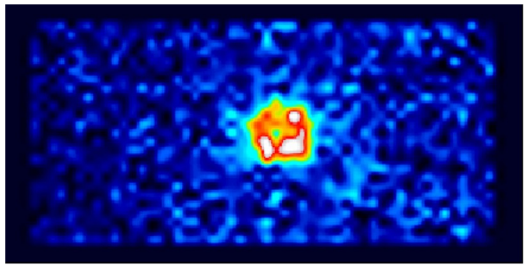
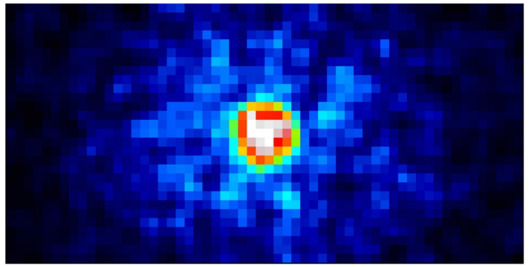
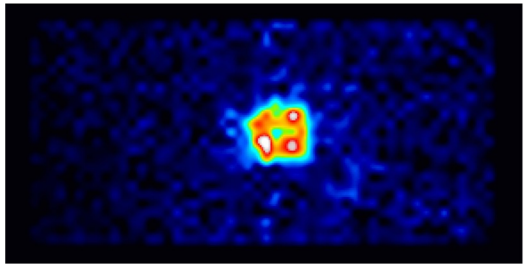
	Simulation	Experiment
Total: 60-90 keV		
Scatter correction		
Final Image		

γ-eye towards ^{212}Pb

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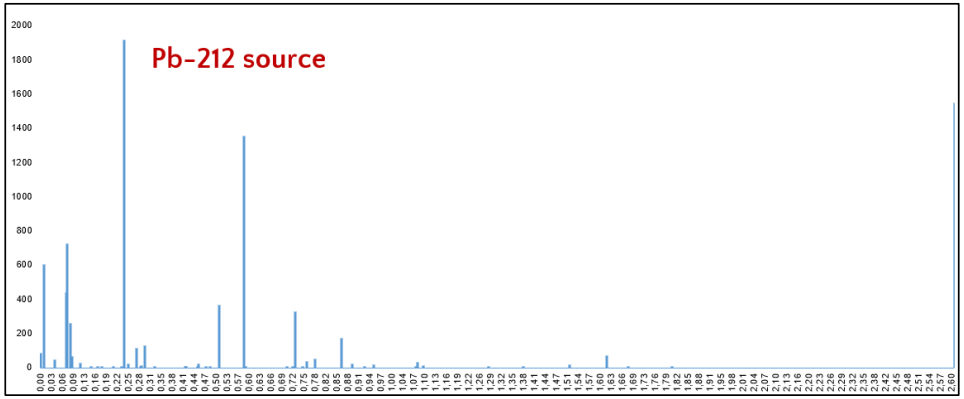
- ✓ **Constant collimator:**
  - ✓ M=Tungsten, D=2mm, S=0.5, H=30mm
- ✓ **Variable crystal scintillator height:**
  - ✓ CsI(Na) 29 × 58 pixels array
    (1.5x1.5mm^2 and H = 3mm, 6mm and 10mm).



- ✓ **Different phantoms tested:**
  - ✓ Mouse phantom @ 11mm distance from collimator
    (Activities: Liver 4μCi , Kidneys 7μCi, Bladder 1μCi, Upper tumor 0.2μCi & 1μCi).

- ✓ **Methodology:**
  - ✓ Investigate different energy windows (EW).
  - ✓ Apply scatter correction based on specified EW.

Mouse phantom ^{212}Pb

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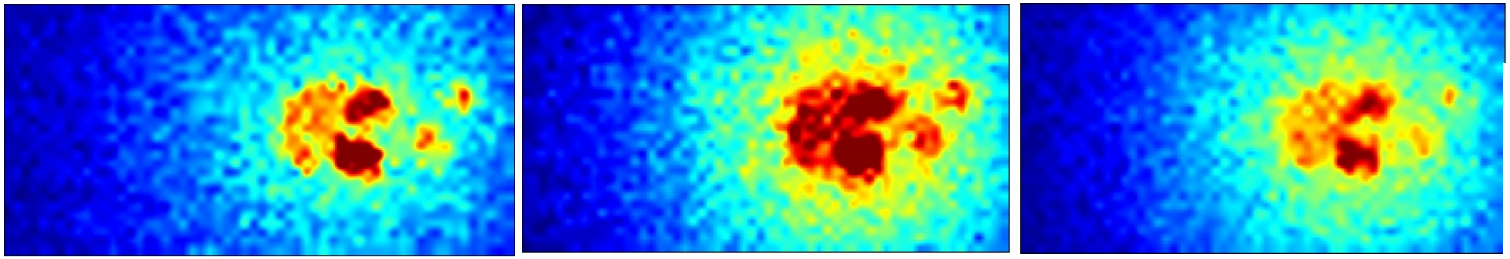
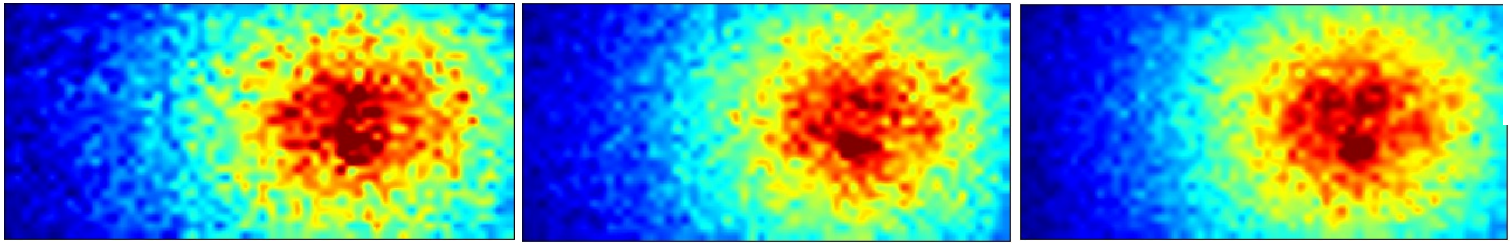
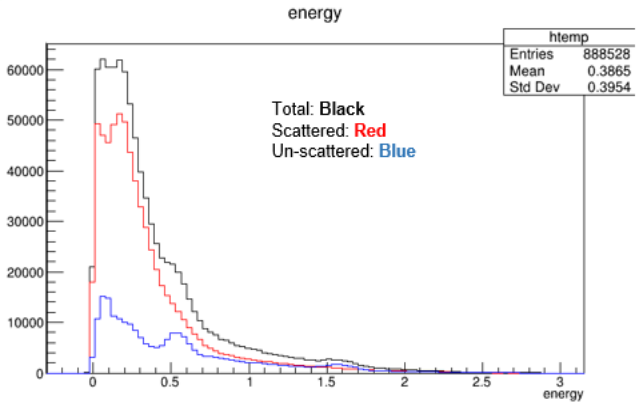
CsI(Na) 3mm **CsI(Na) 6mm** **CsI(Na) 10mm**

Total counts: EW = 60-90 keV



Total counts: EW = 215-260 keV





Mouse phantom ^{212}Pb

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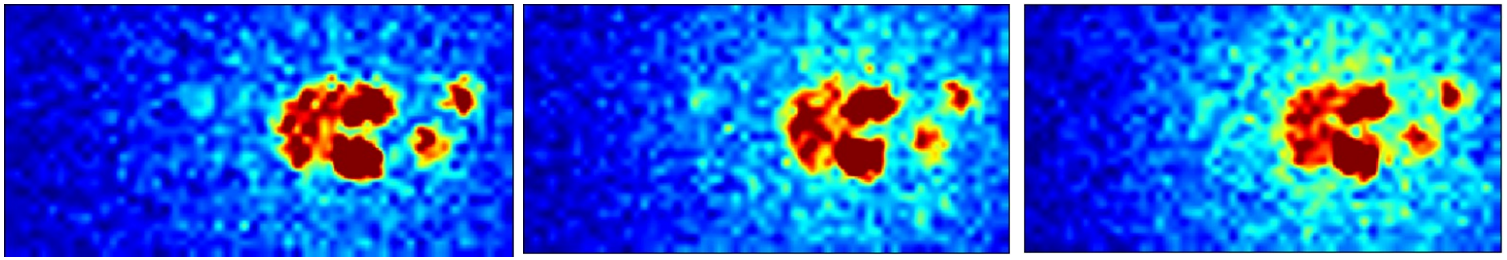
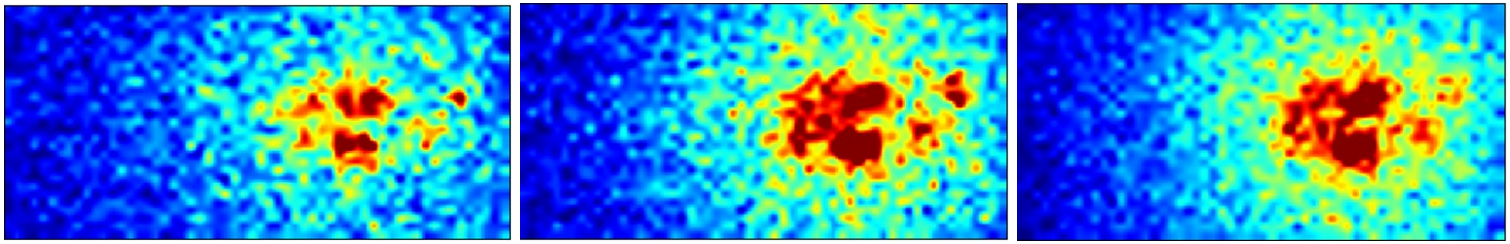
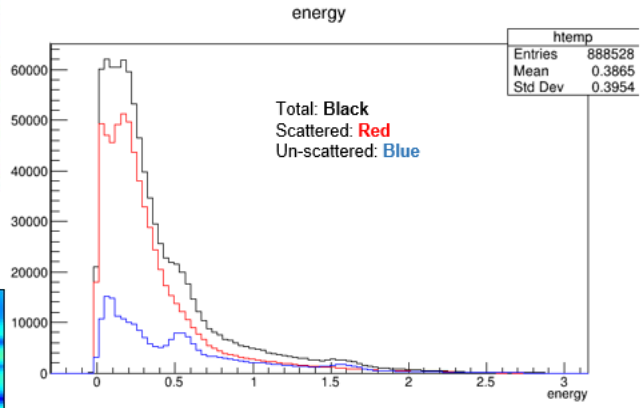
CsI(Na) 3mm **CsI(Na) 6mm** **CsI(Na) 10mm**

Un-scattered: EW = 60-90 keV



Un-scattered: EW = 215-260 keV





Mouse study ^{212}Pb: Simulation vs Experiment

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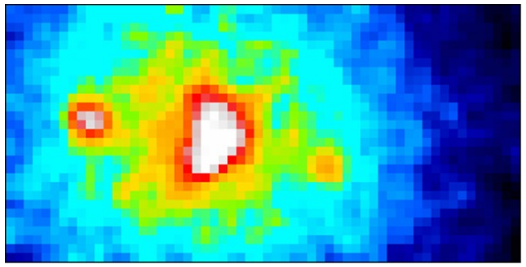
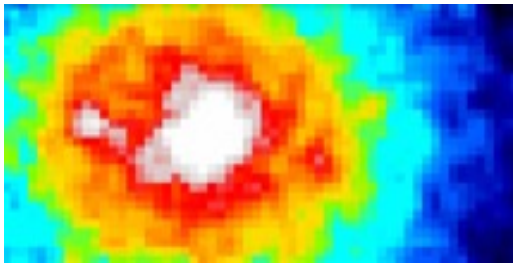
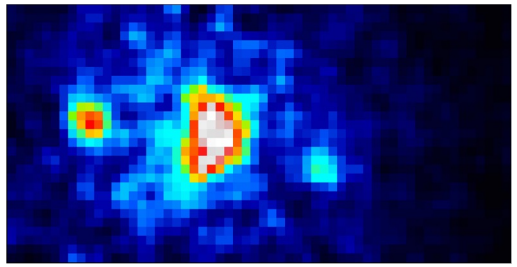
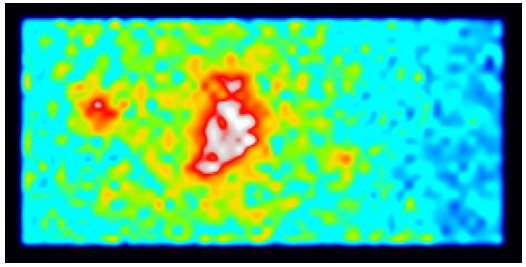
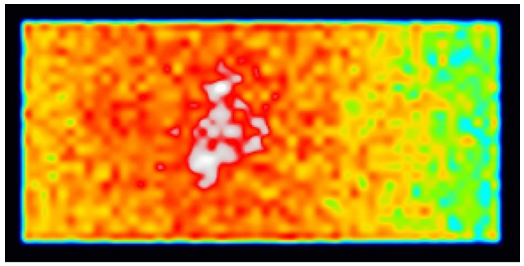
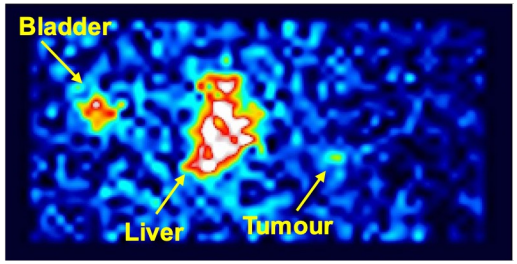
	Total: 60-90 keV	Total: 215-260keV	Final Image
Simulation			
Experiment			

γ-eye towards ^{225}Ac

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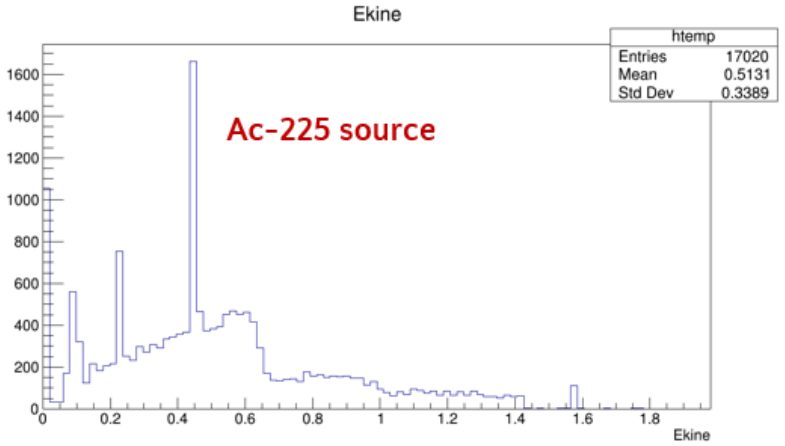
- ✓ **Variable collimator:**
  - ✓ D=2mm, 3mm & 3.5mm, S=0.5mm & 1.5mm, H=30mm
- ✓ **Variable crystal scintillator height:**
  - ✓ CsI(Na) 29 × 58 pixels array (1.5x1.5mm^2 and H = 6mm).
- ✓ **Different phantoms tested:**
  - ✓ Vial filled with 10μCi @ 11mm distance from collimator.
  - ✓ Mouse phantom @ 11mm distance from collimator
    (Activities: Liver 4μCi , Kidneys 7μCi, Bladder 1μCi, Upper tumor 0.2μCi & 1μCi).



Phantoms studies: ^{225}Ac

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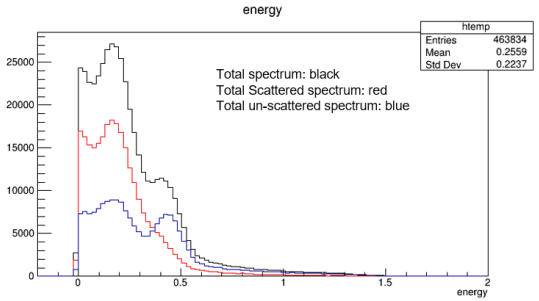
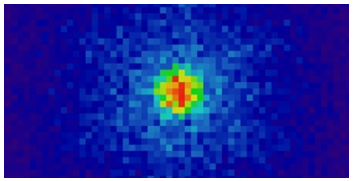
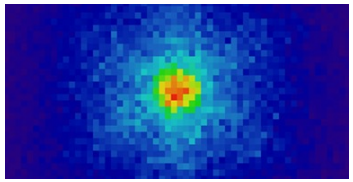
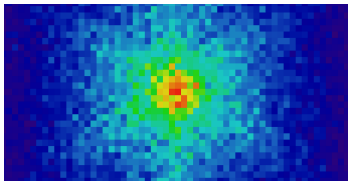
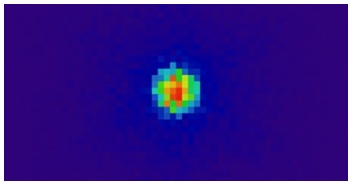
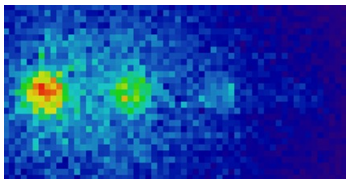
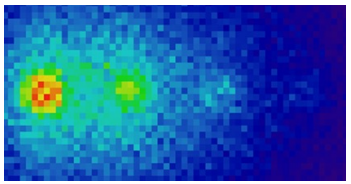
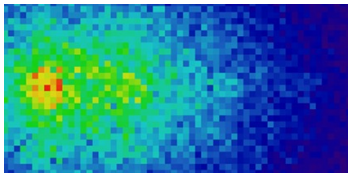
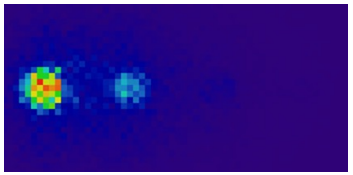
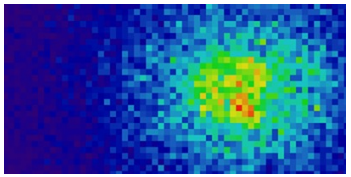
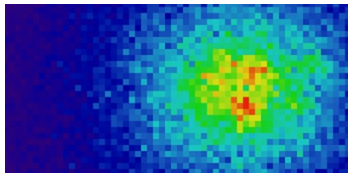
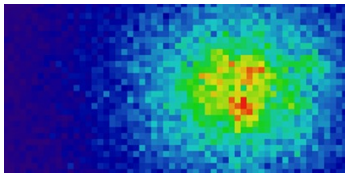
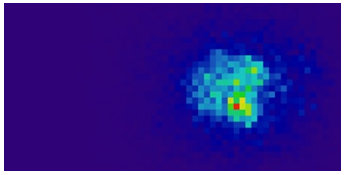


D=2mm, S=0.5mm, H=30mm, CsI(Na) 6mm

	EW: 86keV ±20%	EW: 218keV ±20%	EW: 440keV ±20%	Final Image
1 vial: 10 µCi				
4 vials: 2, 4, 8, 16 µCi				
Mouse phantom				

Comparison of spectra: ^{225}Ac

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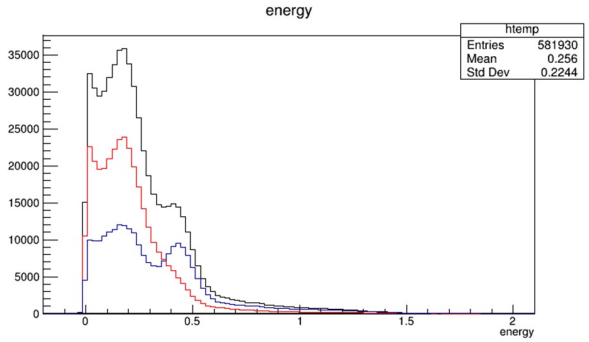
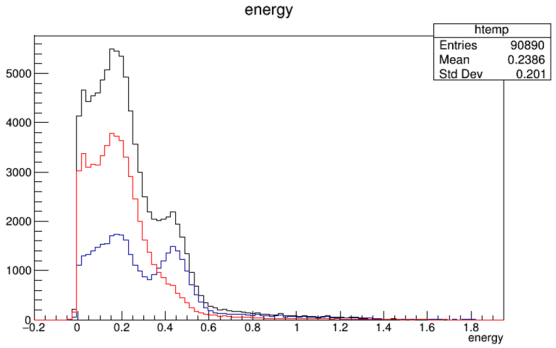
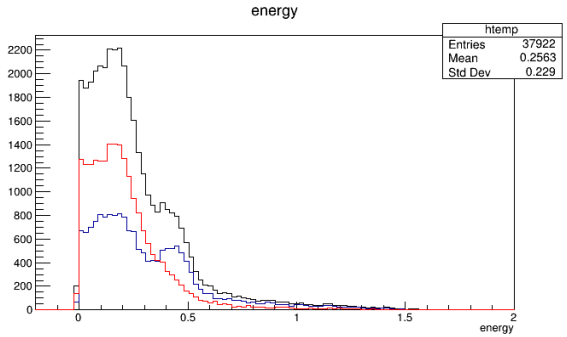
D=2mm, S=0.5mm,H=30mm



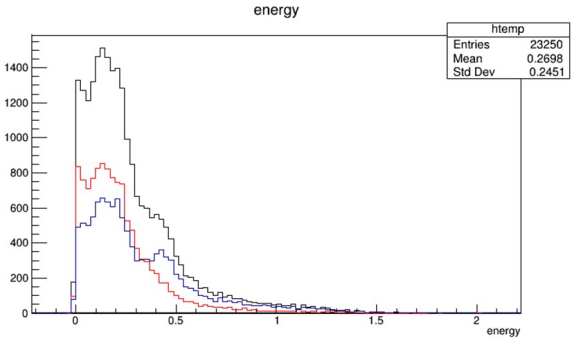
D=3mm, S=0.5mm, H=30mm



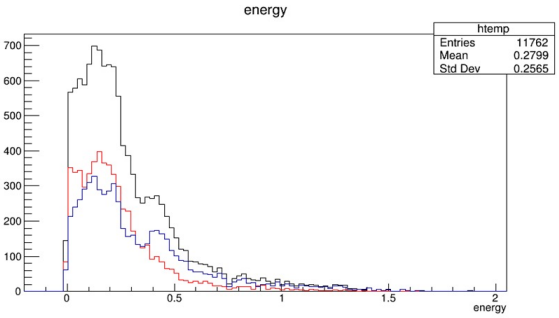
D=3mm, S=1mm, H=30mm



D=3mm, S=1.5mm,H=30mm



D=3mm, S=1mm, H=45mm



Black: Total

Red: Scattered

Blue: Un-scattered

^{225}Ac imaging: Simulations vs Experiment

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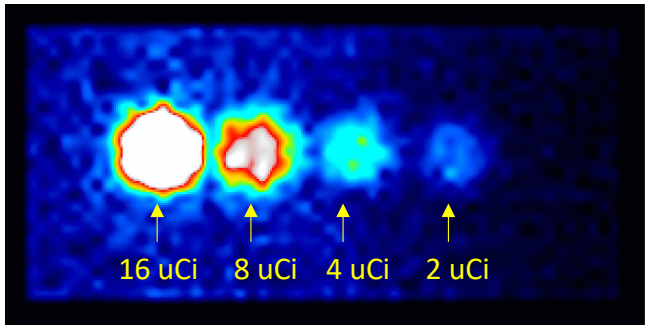
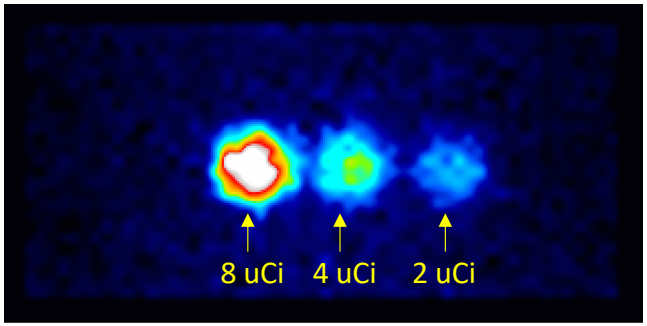
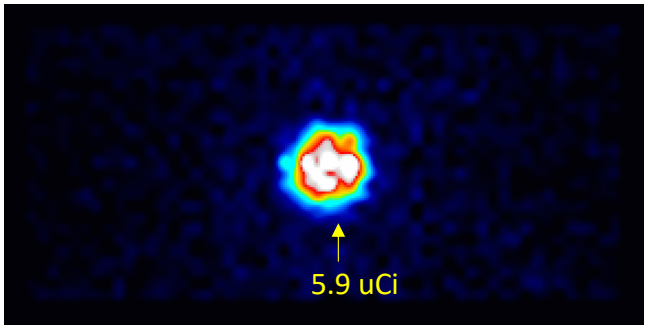
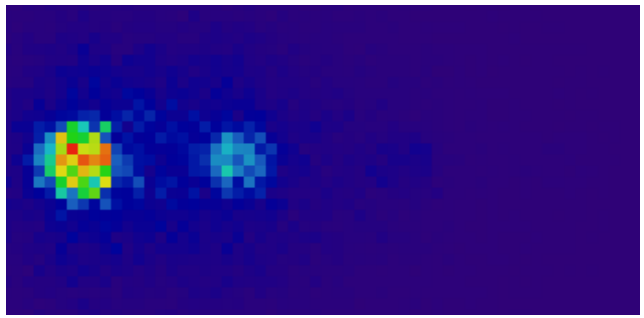
Experiment time: 20 min: 4 vials: 16, 8, 4, 2 µCi / 500 µl & 1 vial 5.9 µCi / 500 µl

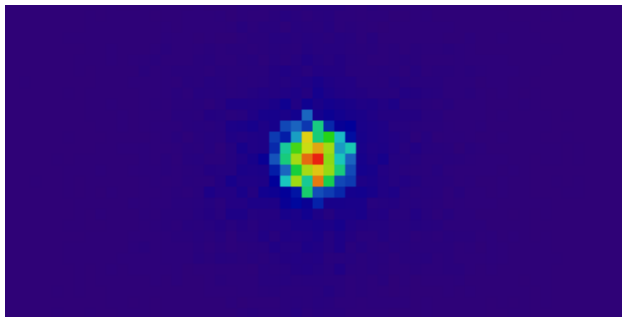






GATE simulation data





Outcome: GATE MC sims for R&D of "eyes"

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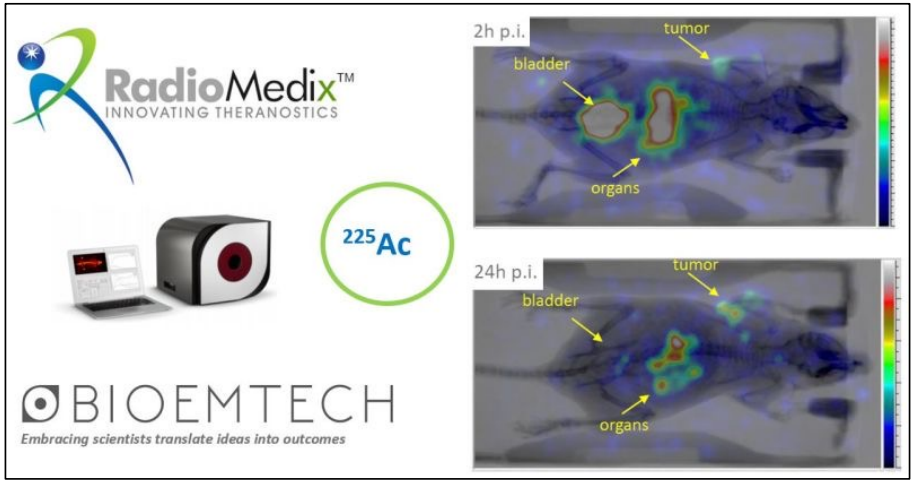
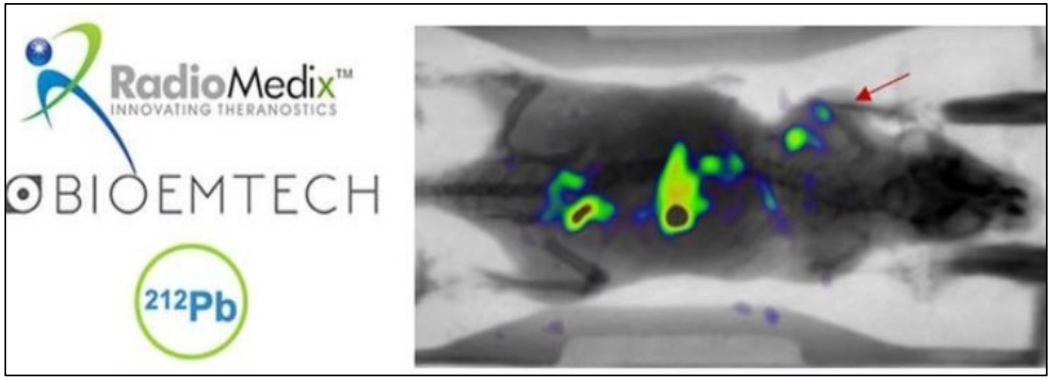
- ✓GATE is a reliable tool for studying NM imaging systems.
  (Design, collimator's characteristics, crystals' efficiency etc.)
- ✓Novel radiopharmaceuticals can be studied for optimizing imaging protocols.
  - ✓ Both ^{225}Ac and ^{212}Pb have tested in γ-eye^{TM} system by RadioMedix.

GATE





Other radioisotopes studied in GATE & applied in γ-eye

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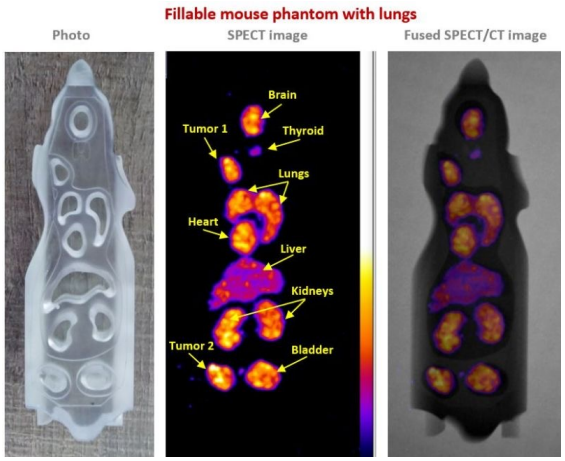
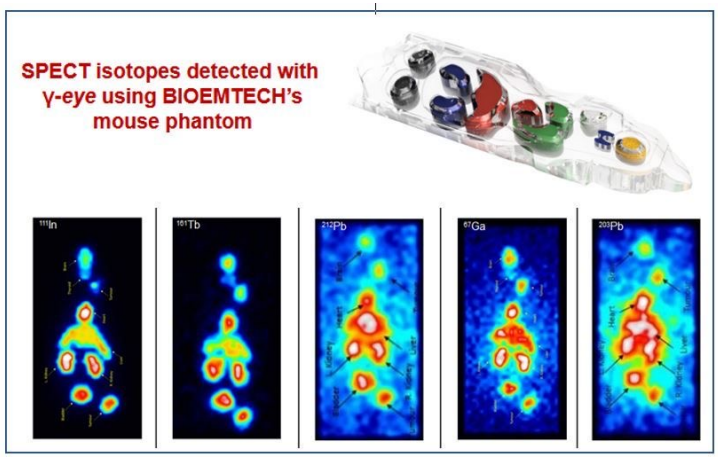
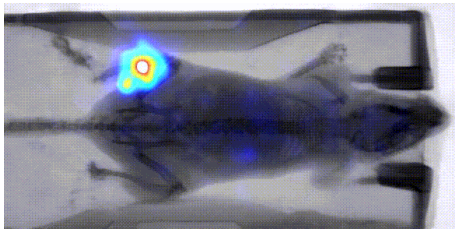


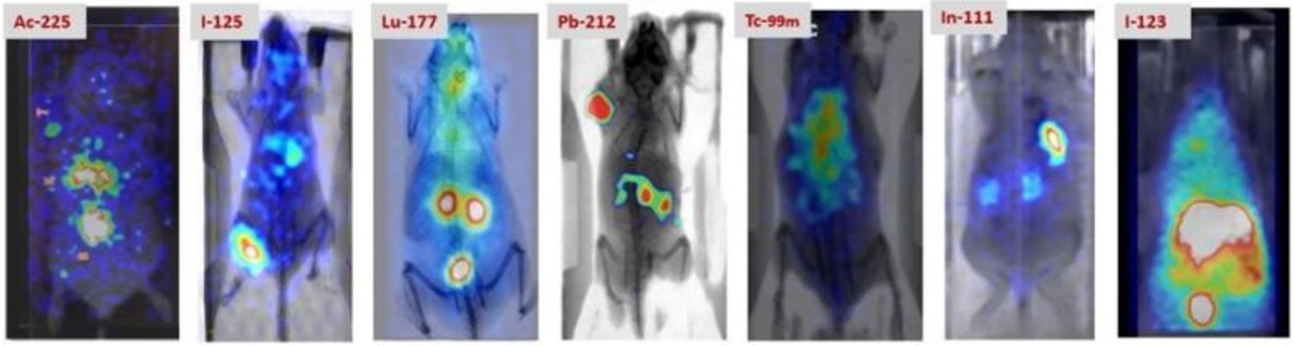
^{177}Lu





^{125}I

GATE



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Thank you

GATE