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"Performance assessment of the Albira tri-modal pre-clinical SPECT system"

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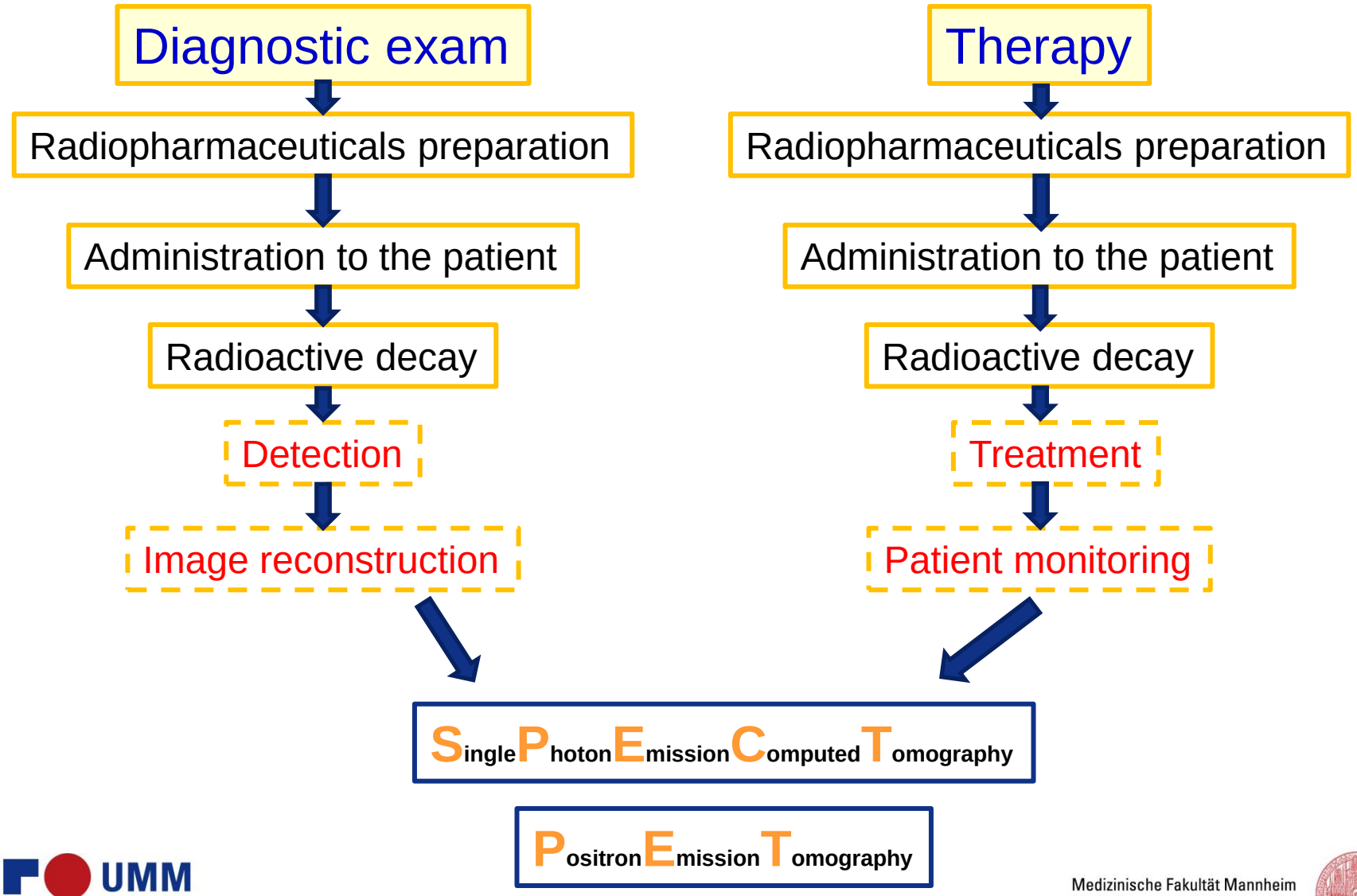
Outline

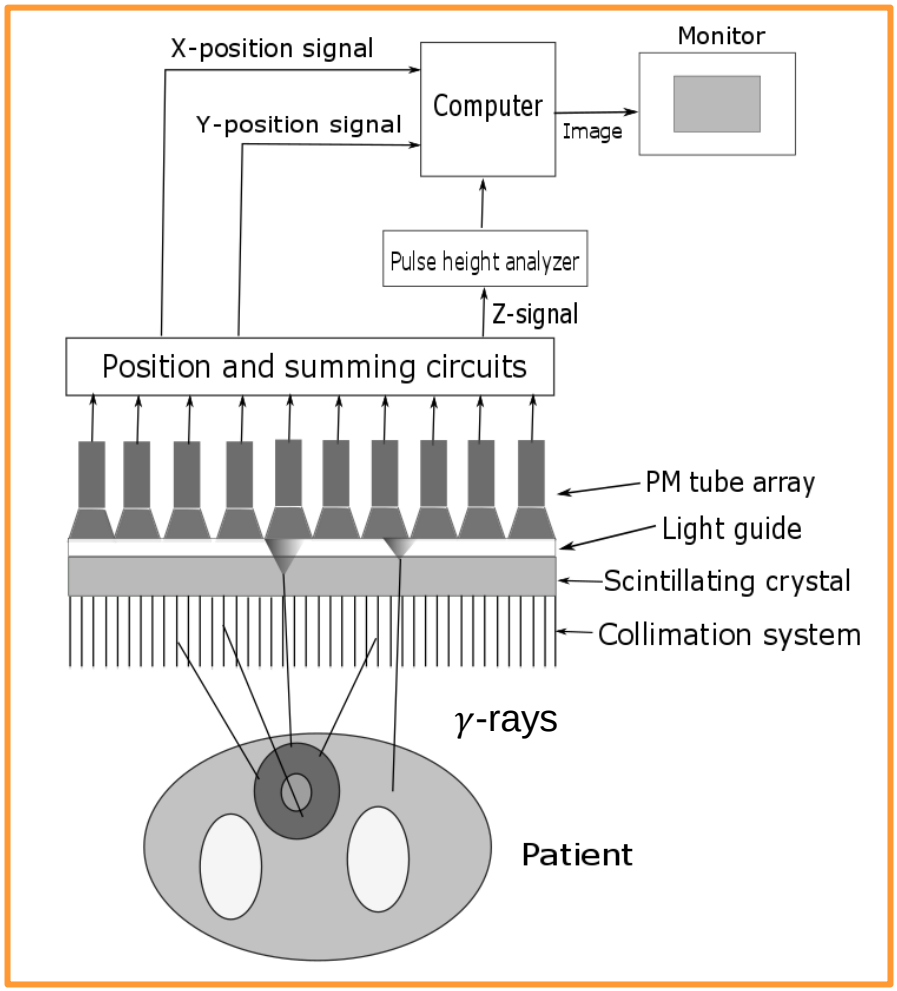
- Introduction
- Motivation
- Aim
- Material
- Methods
- Results
- Conclusions

Introduction: Nuclear Medicine

Radiopharmaceuticals: specific biological molecules labeled with medical radionuclides.

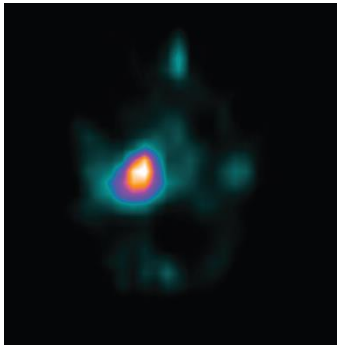


Introduction: Gamma Camera



[S. R. Cherry et al. *Physics in nuclear Medicine*. Elsevier, fourth edition, 2012]

A SPECT system
[www.healthcare.siemens.com].



A brain SPECT image

[S. R. Cherry et al. *Physics in nuclear Medicine*. Elsevier, fourth edition, 2012].

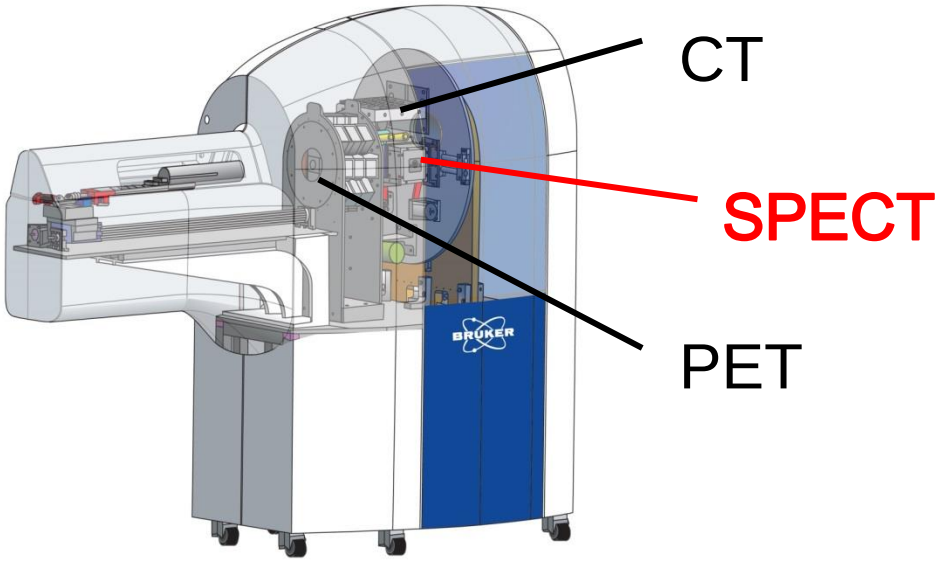
Motivation

Commissioning of the Albira tri-modal pre-clinical tomograph.

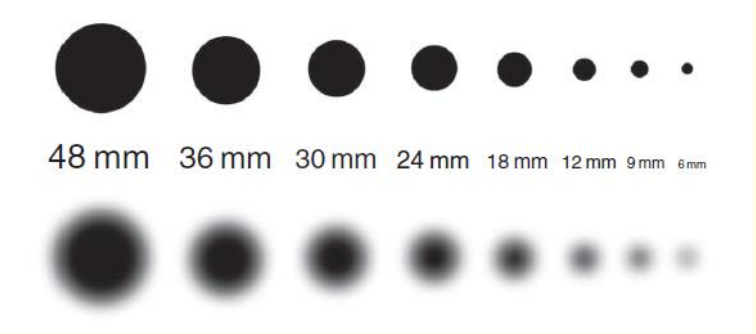
Accuracy of the obtained data.

Comparison between different devices.

Prerequisite for quantitative measurement of small animal *radio-pharmacokinetics*.



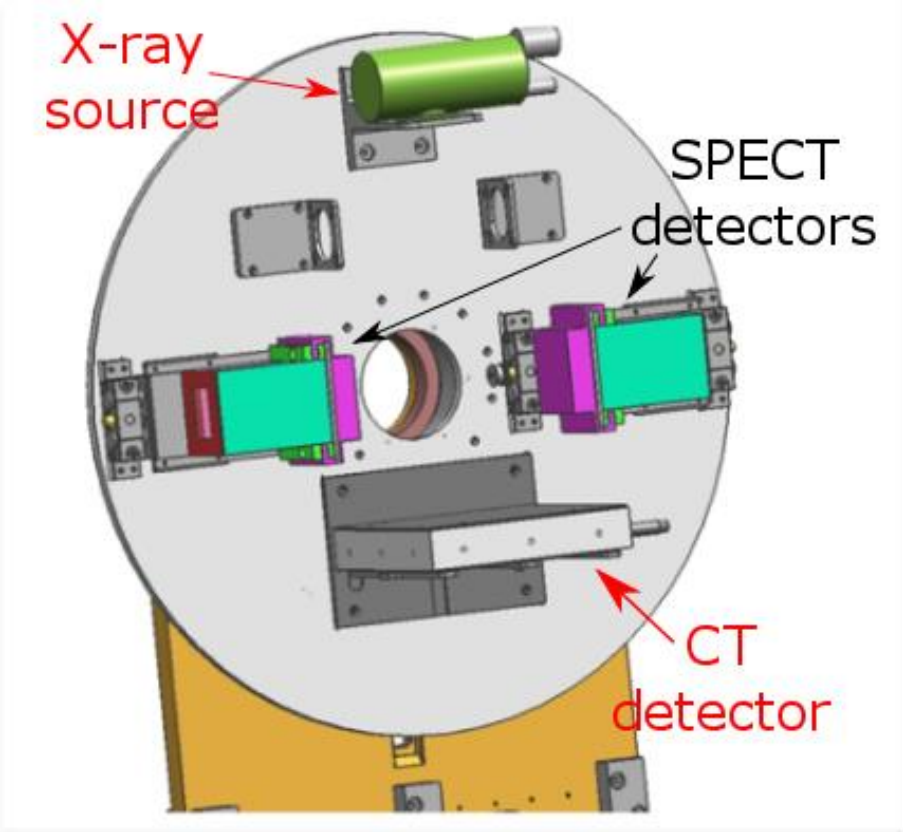
Aim: evaluation of the following parameters

Sensitivity	The number of *counts per second (cps)* detected for a given amount of activity.
Count rate linearity	The response of the device in terms of *cps* plotted as a function of the injected activity.
Spatial resolution	Measurement of the smallest detail that an image allows to distinguish.
Partial-volume Effect (PVE) and Recovery Coefficient (RC)	Difference between the pixel intensities and the true radioactivity. 

^{99m}Tc

γ Energy	0.141 MeV
Half-life	6.02 hours
Branching ratio	89.1 %

Material: SPECT sub-system



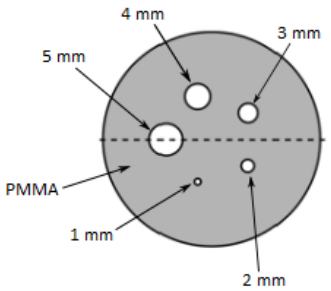
Collimation system	Single PinHole (SPH)	Multi PinHole (MPH) (5 holes)
Projections number	60	
Field Of View (FOV) (mm)	80	
Algorithm	Ordered-Subset Expectation-Maximization (OSEM)	
Subsets number	5	15
Pixel unit	cps/voxel	
Voxel size (mm)	0.85	1.00

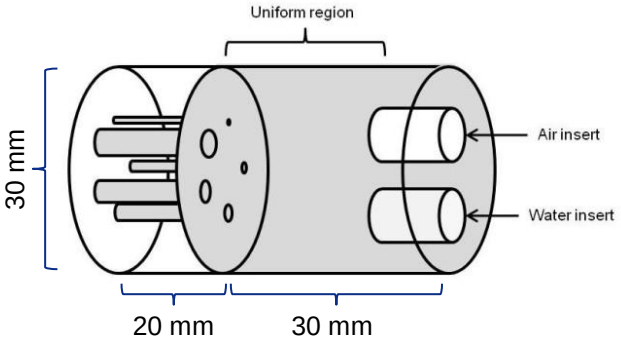
FOV: area under study.
Voxel: the three dimensional array of the image elements.

Material: phantoms

National Electrical Manufacturers Association (NEMA) NU 4-2008 image quality phantom

[NEMA NU 4-2008 image quality phantom].



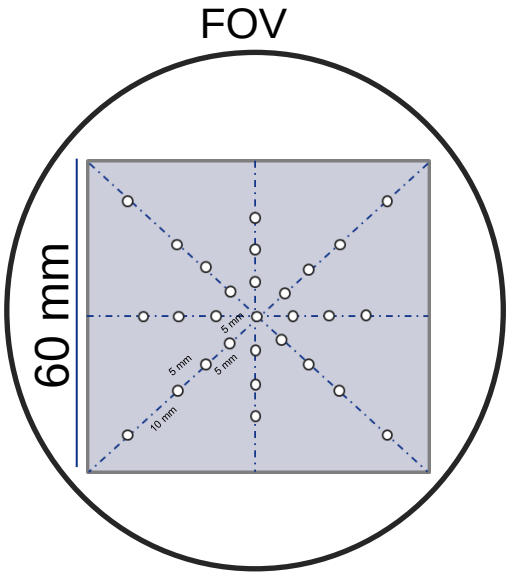


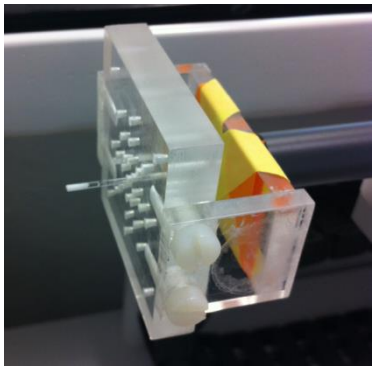
Anizan et al. EJNMMI Research 2012 2:7

Point source phantom developed in-house

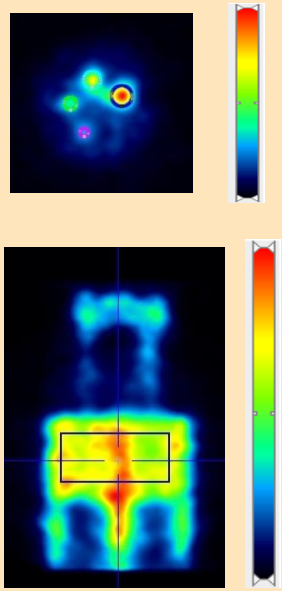
Source dimensions

$$\emptyset_x = (1.2 \pm 0.2)\ mm$$
$$\emptyset_y = (1.2 \pm 0.2)\ mm$$
$$z = (2.0 \pm 0.2)\ mm$$





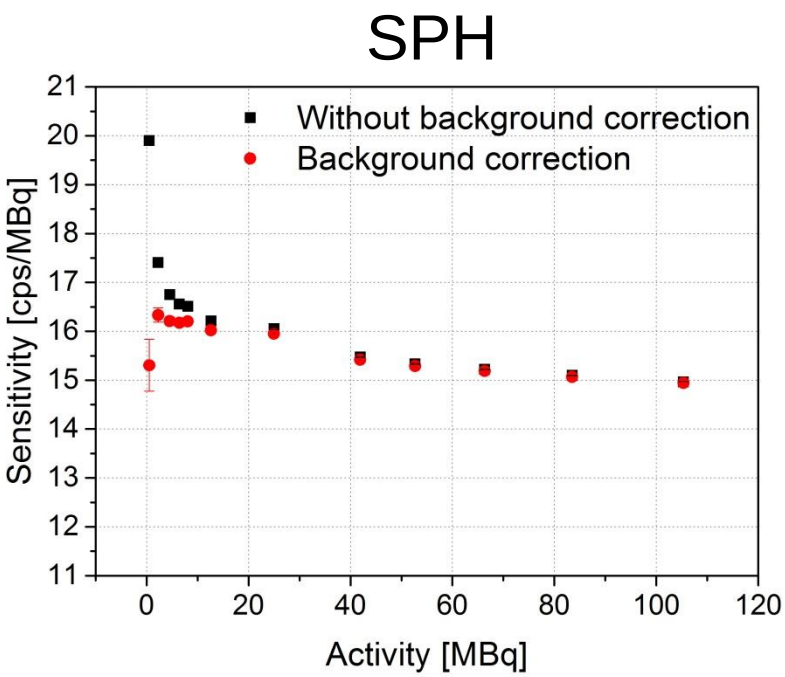
[Point source phantom developed in-house].

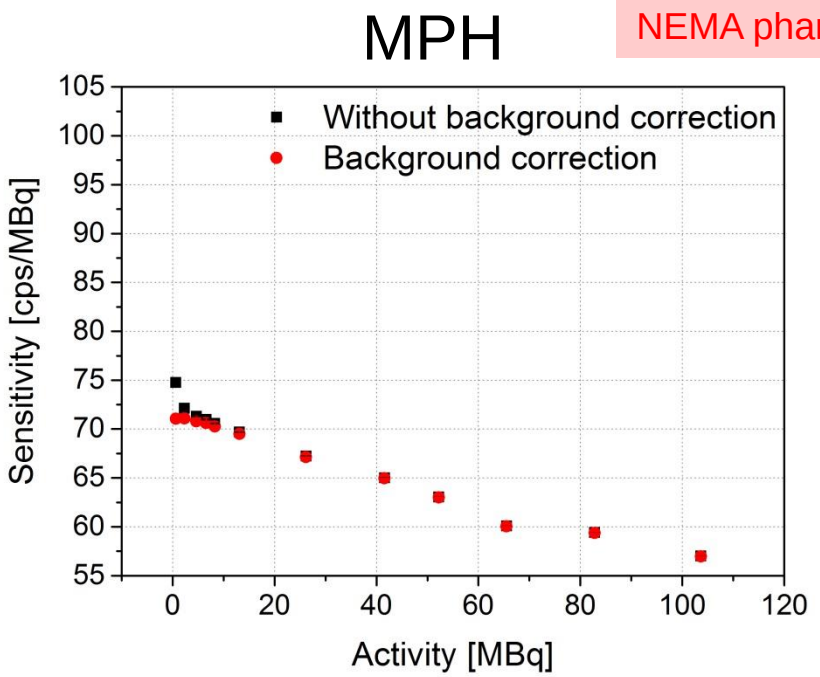
Parameter	Method	Phantom
Sensitivity	$\text{Sensitivity} = \frac{\text{cps} - \text{background}}{\text{A [MBq]}}$	• NEMA • Point source
Count rate linearity	cps vs activity	• NEMA
Spatial Resolution	FWHM: 3D fit function	• Point source
Recovery Coefficient	$\text{RC} = \frac{\text{apparent activity}}{\text{uniform region activity}}$	• NEMA 

Results

Sensitivity

NEMA phantom





Point source phantom

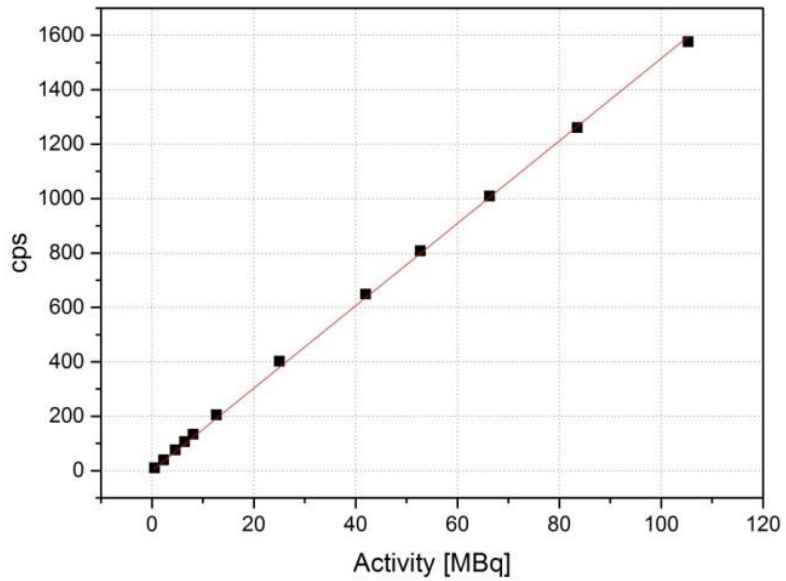
SPH (cps/MBq)	MPH (cps/MBq)
23.1 ± 0.3	105.6 ± 5.5

$0.396\ \mathrm{MBq}/\mu l$ SPH
$0.130\ \mathrm{MBq}/\mu l$ MPH

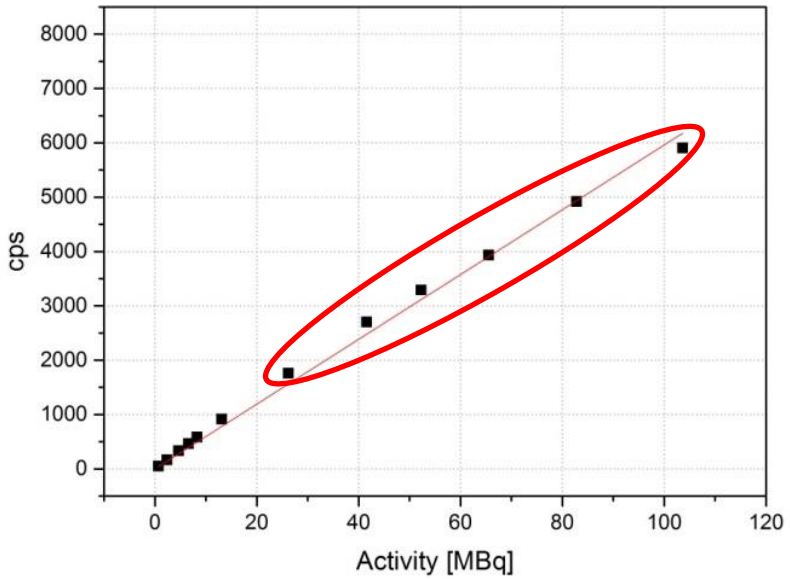
Results

Count rate linearity

SPH



MPH



	SPH	MPH
s (cps/MBq)	14.96 ± 0.07	57.74 ± 1.02
B (cps)	12.8 ± 3.4	125 ± 49

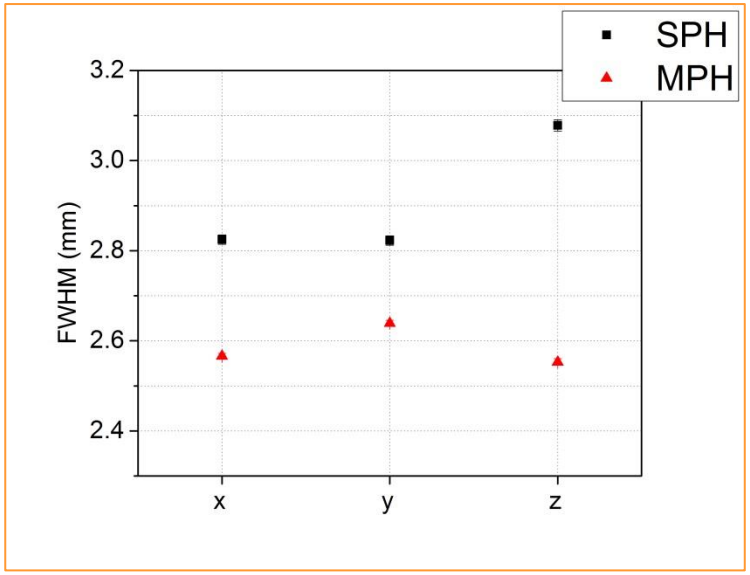
$$y = s \cdot x + B$$

s system sensitivity
B background cps

Results

Spatial resolution

Point source phantom



SPH (mm)			MPH (mm)		
x	y	z	x	y	z
2.82 ± 0.01	2.82 ± 0.01	3.08 ± 0.01	2.57 ± 0.01	2.64 ± 0.01	2.55 ± 0.01

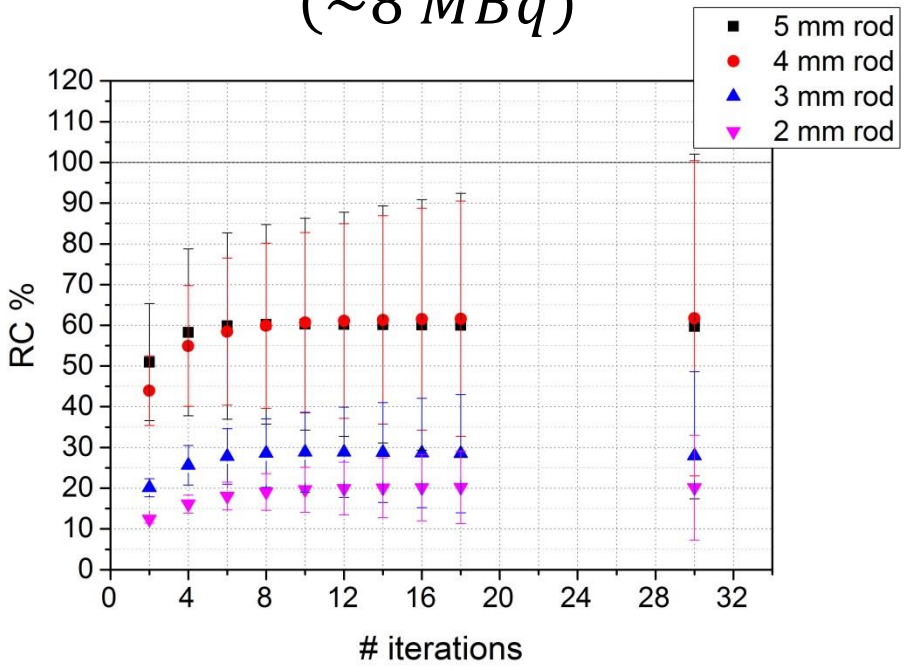
The MPH collimation system presents a better spatial resolution.

Results

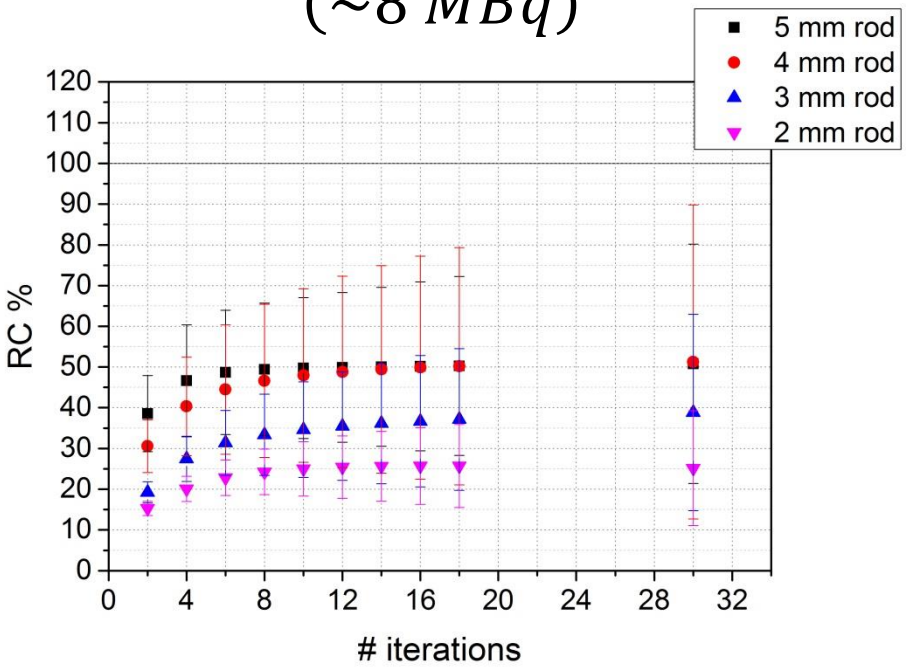
PVE and RC

NEMA phantom

SPH
$(\sim 8\ MBq)$



MPH
$(\sim 8\ MBq)$



- RCs lower than 100 %.
- Convergence at 12 iterations.
- The larger the diameter the higher the RC since the smaller the PVE.

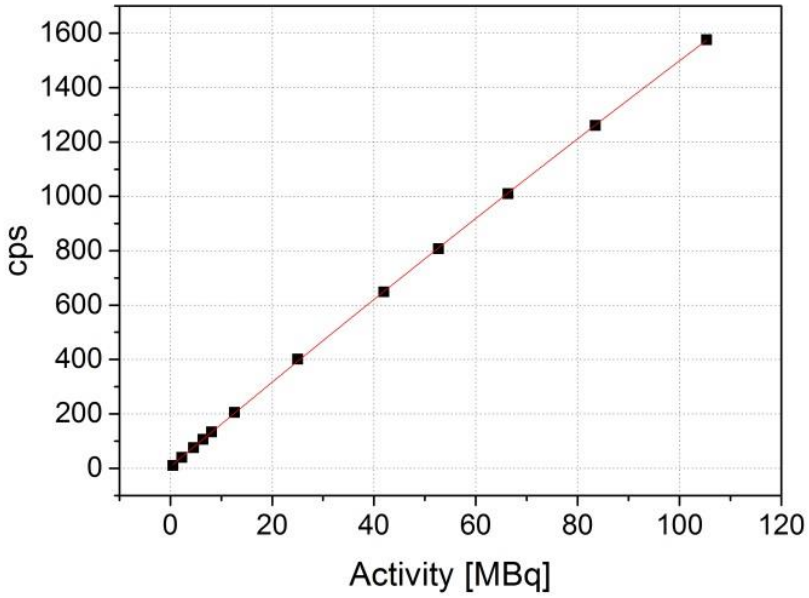
Conclusions

- The sensitivity to a point source is in the same range of other investigated studies.
- The sensitivity of the system is about five times larger for the MPH with respect to the SPH, as expected.
- The spatial resolution for the MPH results better than the spatial resolution evaluated for the SPH collimation system.
- Quantitative data are obtained by reconstructing the image with 12 iterations. 2 iterations are enough for a visual image interpretation.
- New radiotracers will be tested and validated.

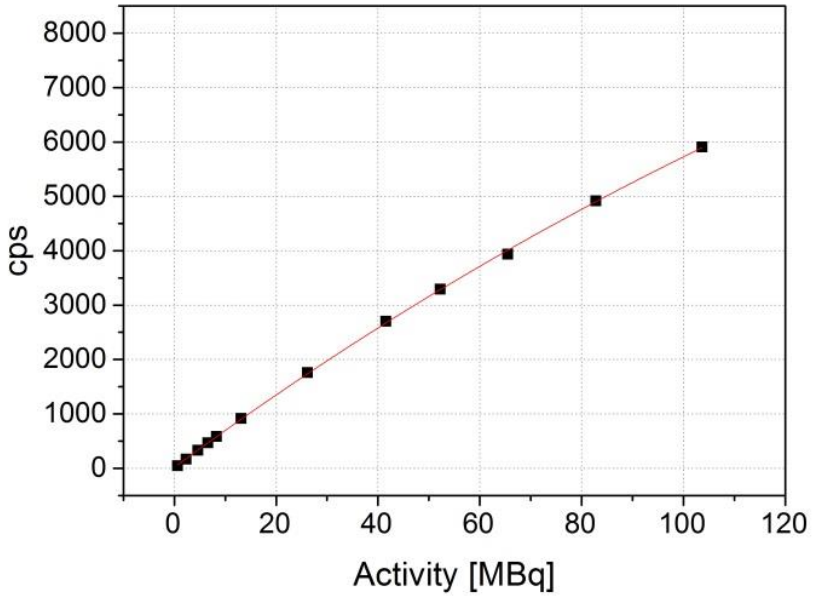
Back up

Count rate linearity

SPH



MPH



	SPH	MPH
s (cps/MBq)	15.68 ± 0.11	69.18 ± 1.00
b (MBq)	0.38 ± 0.12	0.25 ± 0.23
τ (1/MBq)	$(4.9 \pm 0.7) \cdot 10^{-4}$	$(19.1 \pm 1.5) \cdot 10^{-4}$

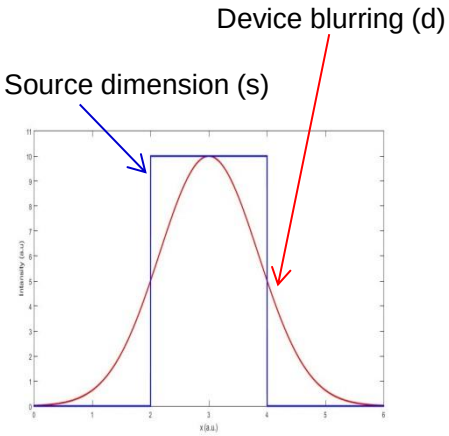
$$y = s \cdot (x + b) \cdot e^{-(x+b)\cdot\tau}$$

s system sensitivity
b background activity
τ constant related to the deadtime

Spatial resolution

Three dimensional fit

Gaussian function convolved with the source dimensions



$$FWHM = 2 \cdot \sqrt{2 \cdot \ln(2)} \cdot \sigma \cdot p$$

σ standard deviation
p pixel size

Source dimensions
$\emptyset_x = (1.2 \pm 0.2)\ mm$
$\emptyset_y = (1.2 \pm 0.2)\ mm$
$z = (2.0 \pm 0.2)\ mm$

$$f_1(x,y,z) =$$
$$A \cdot \left(erf\left(\frac{x-(b_x - r_x)}{\sqrt{2}\cdot\sigma_x}\right) - erf\left(\frac{x-(b_x + r_x)}{\sqrt{2}\cdot\sigma_x}\right)\right) \cdot \left(erf\left(\frac{y-(b_y - r_y)}{\sqrt{2}\cdot\sigma_y}\right) - erf\left(\frac{y-(b_y + r_y)}{\sqrt{2}\cdot\sigma_y}\right)\right) \cdot \left(erf\left(\frac{z-(b_z - r_z)}{\sqrt{2}\cdot\sigma_z}\right) - erf\left(\frac{z-(b_z + r_z)}{\sqrt{2}\cdot\sigma_z}\right)\right)$$