

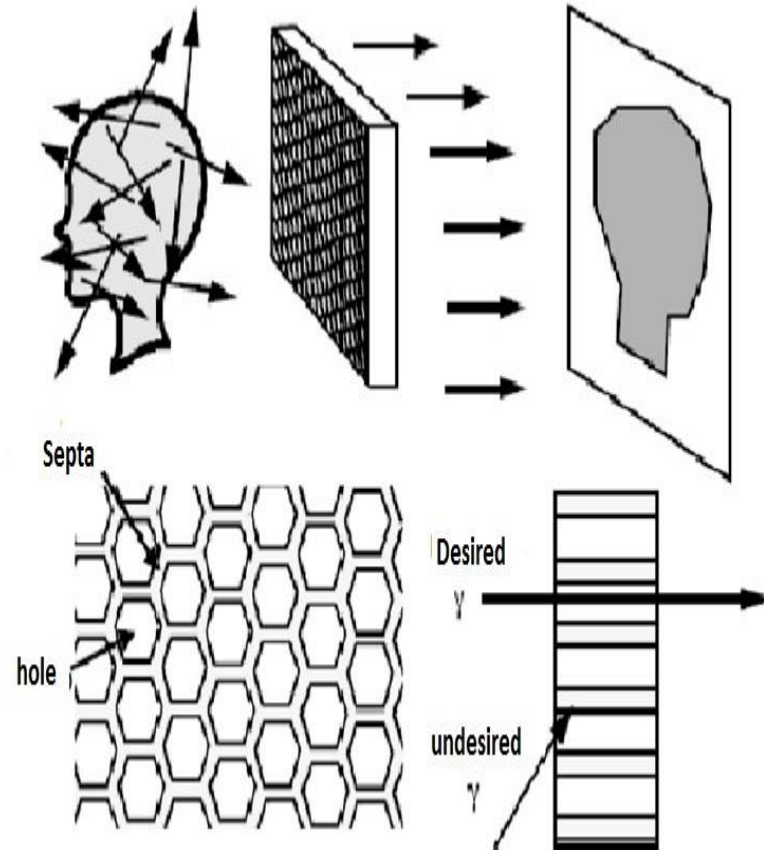
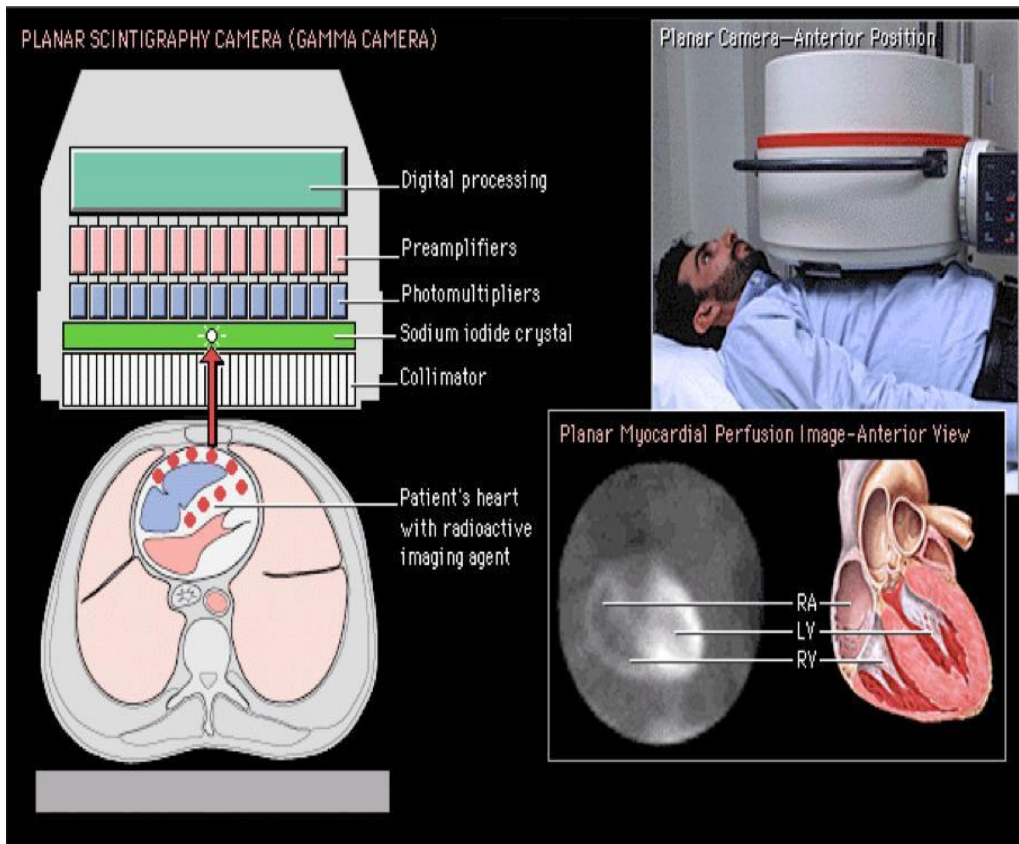
Suitability evaluation of GaAs(Cr) detectors with Medipix3 electronics for SPECT systems using Monte Carlo simulations

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Introduction

Operating diagram of traditional SPECT systems.



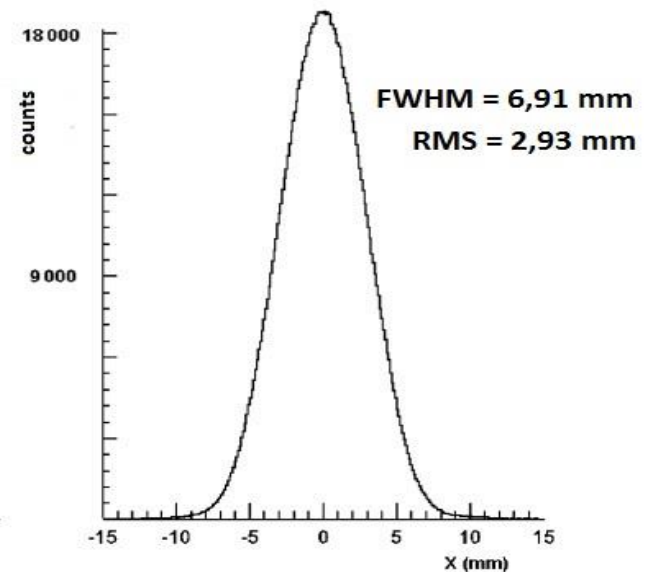
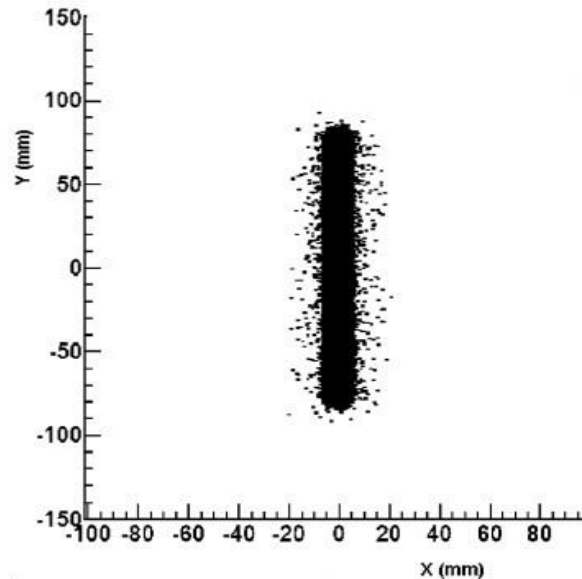
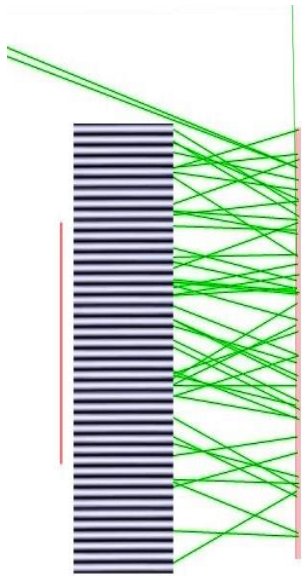
Introduction

Basic characteristics of the SPECT systems performance

Spatial resolution of the System:

$$R_{sys} = \sqrt{R_{det}^2 + R_{col}^2}$$

For our GaAs detector: $R_{sys} \approx R_{col}$



Introduction

Basic characteristics of the SPECT systems performance

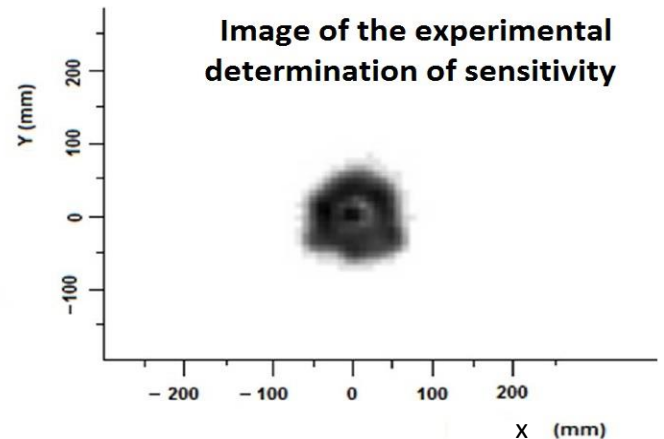
System sensitivity: *Detection efficiency of the entire system.*

Counts detected/Emitted by the source (%)

Rate of counts detected/Source activity (cpm/ μ Ci)

Strongly depends on:

- Size, thickness and material of the detector.
- Geometric efficiency of the used collimator.

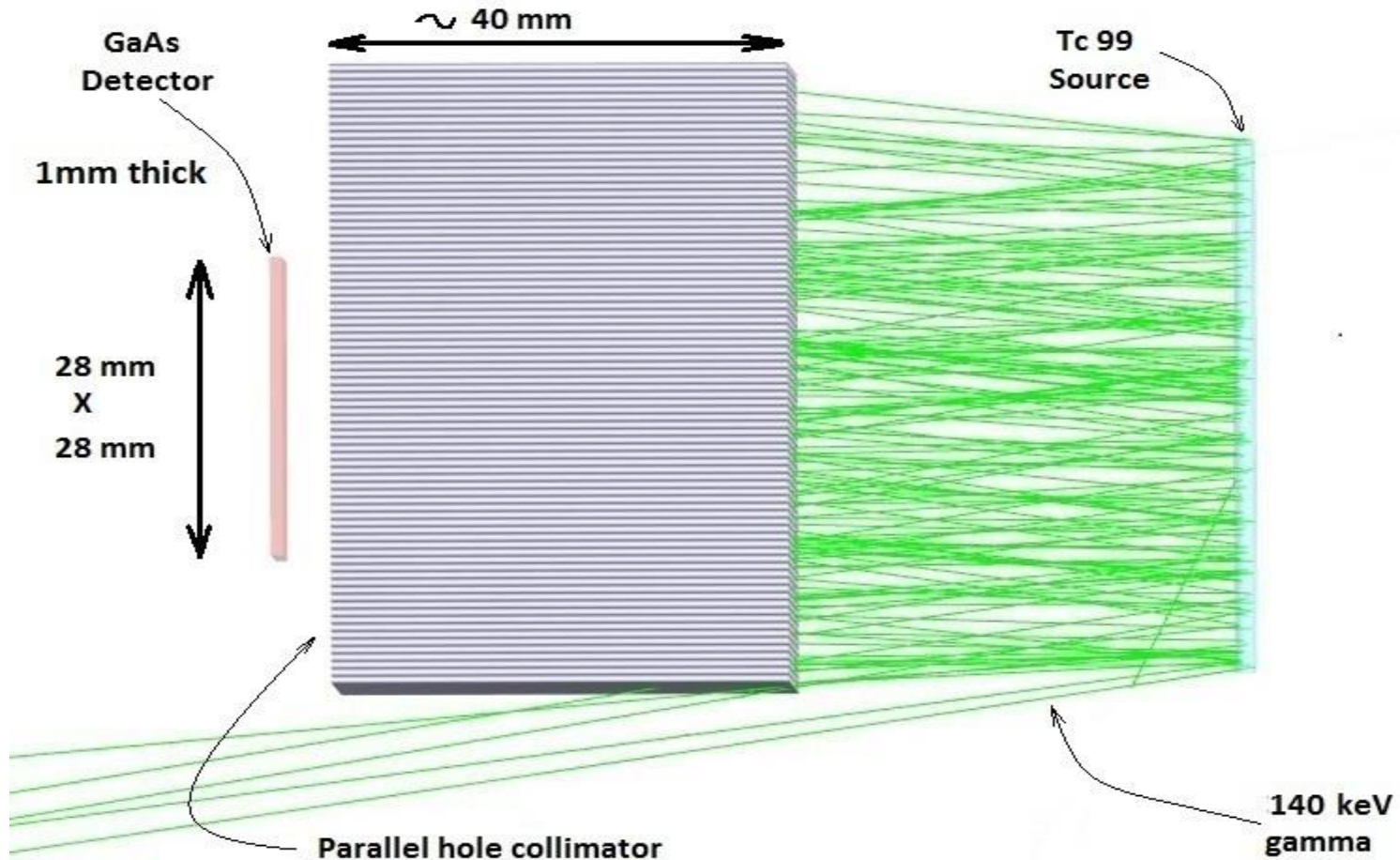


More than 60 cpm/ μ Ci are needed for clinical applications .

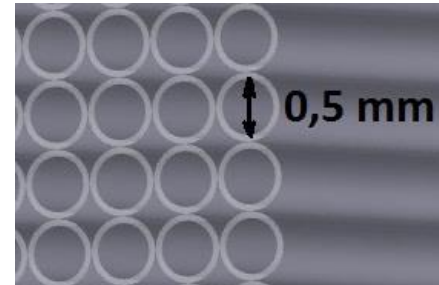
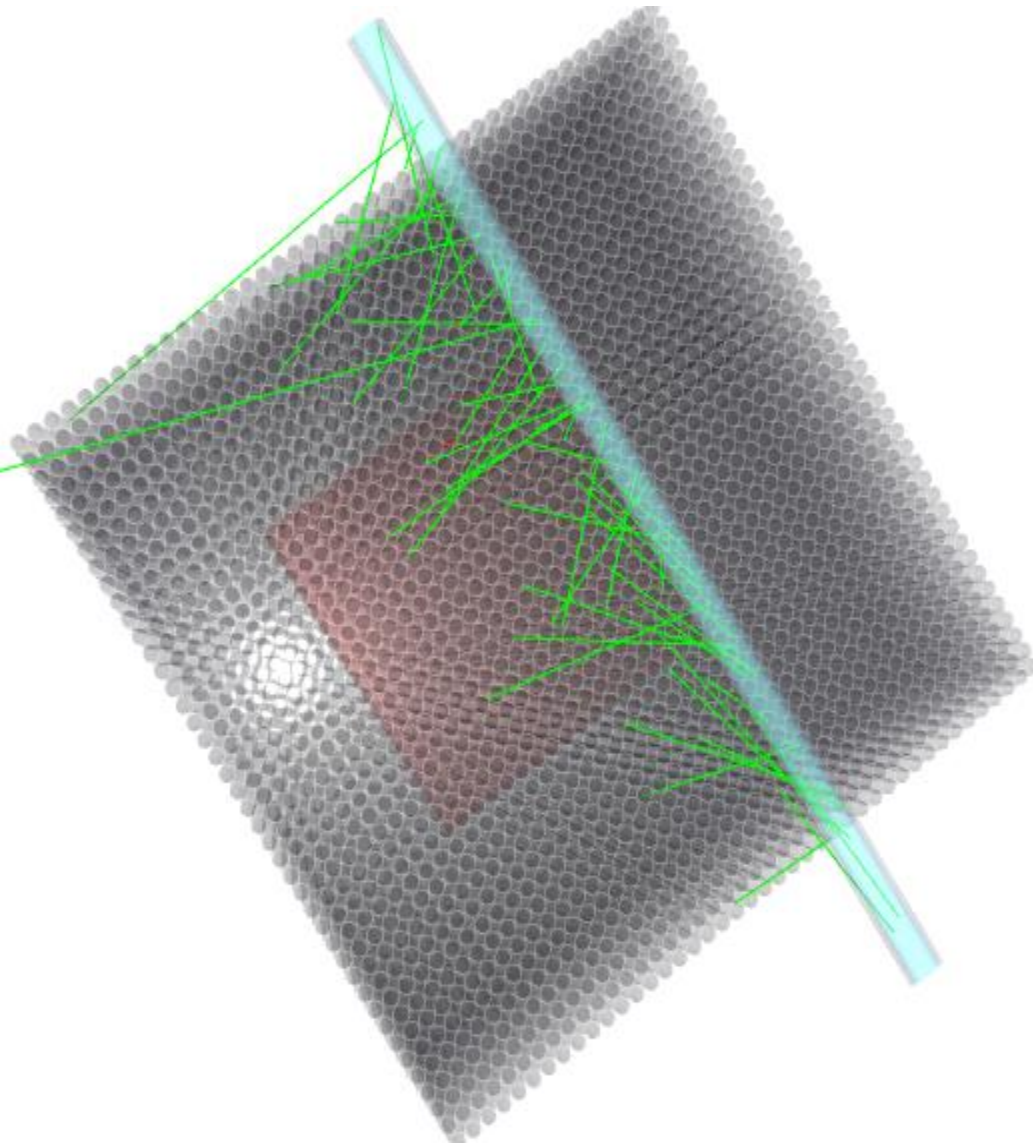
Main goals

- Study the development possibility of an ultra high-resolution (<1mm) SPECT system for small animals based on GaAs detector.
- Evaluate the advantages and the performance of using GaAs(Cr) detectors with Medipix3 electronics in clinical SPECT systems.

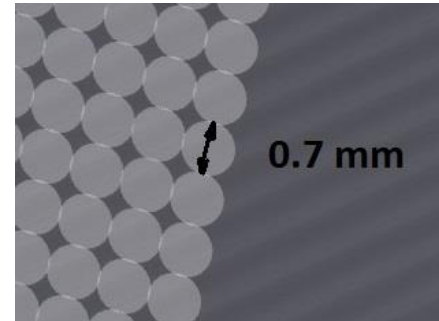
Parallel hole collimators (simulated geometry).



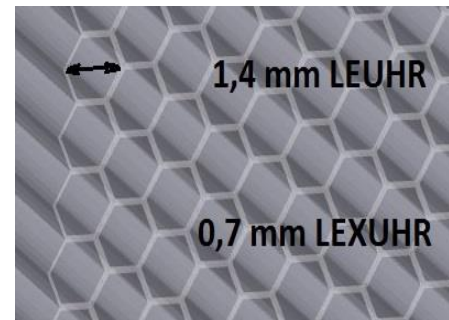
Parallel hole collimators (simulated geometry).



**Injection needles
(steel)**

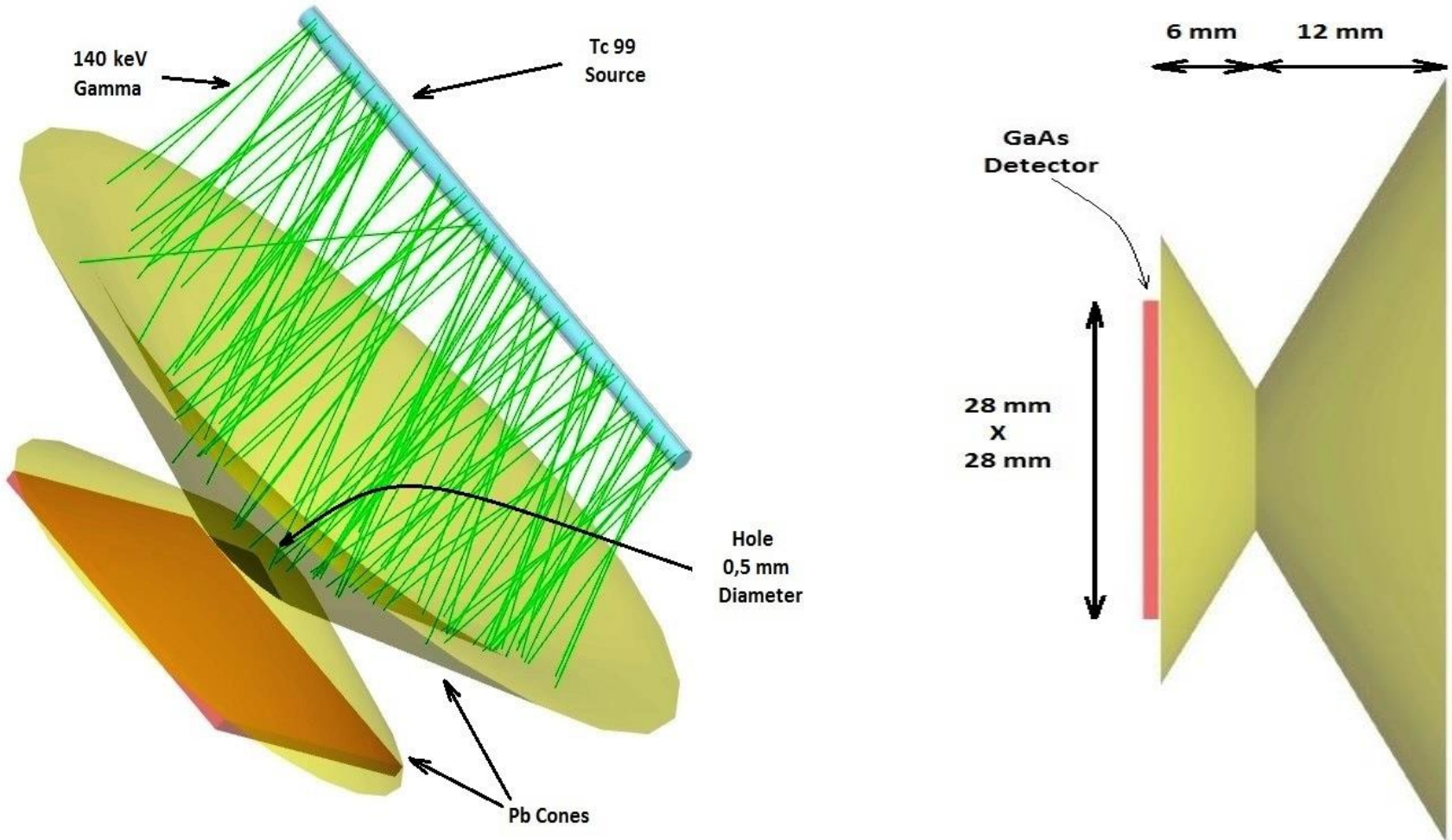


**Solid needles
(steel)**



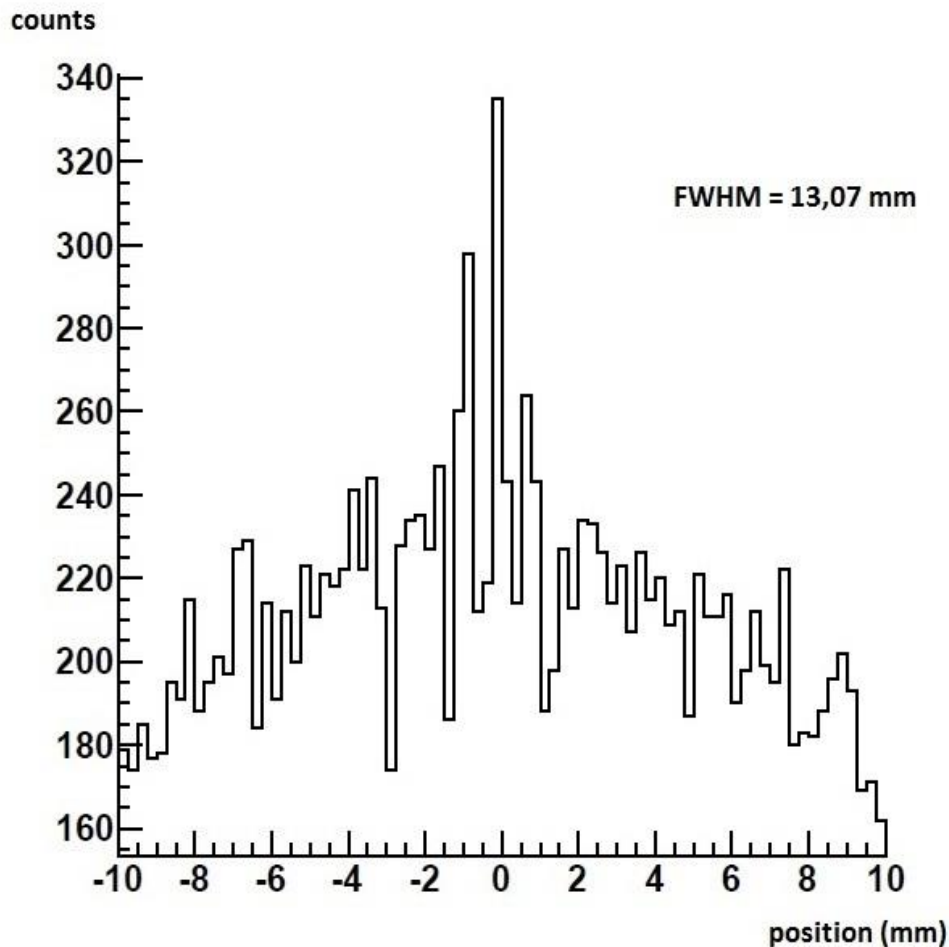
**Honeycomb
(led)**

Pinhole collimator (simulated geometry).

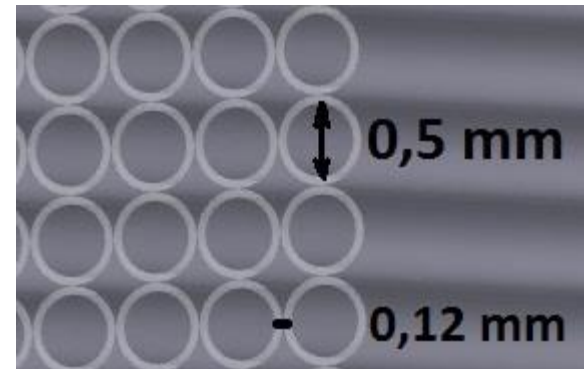


Results

Parallel hole collimators performance.



Injection needles
(steel)



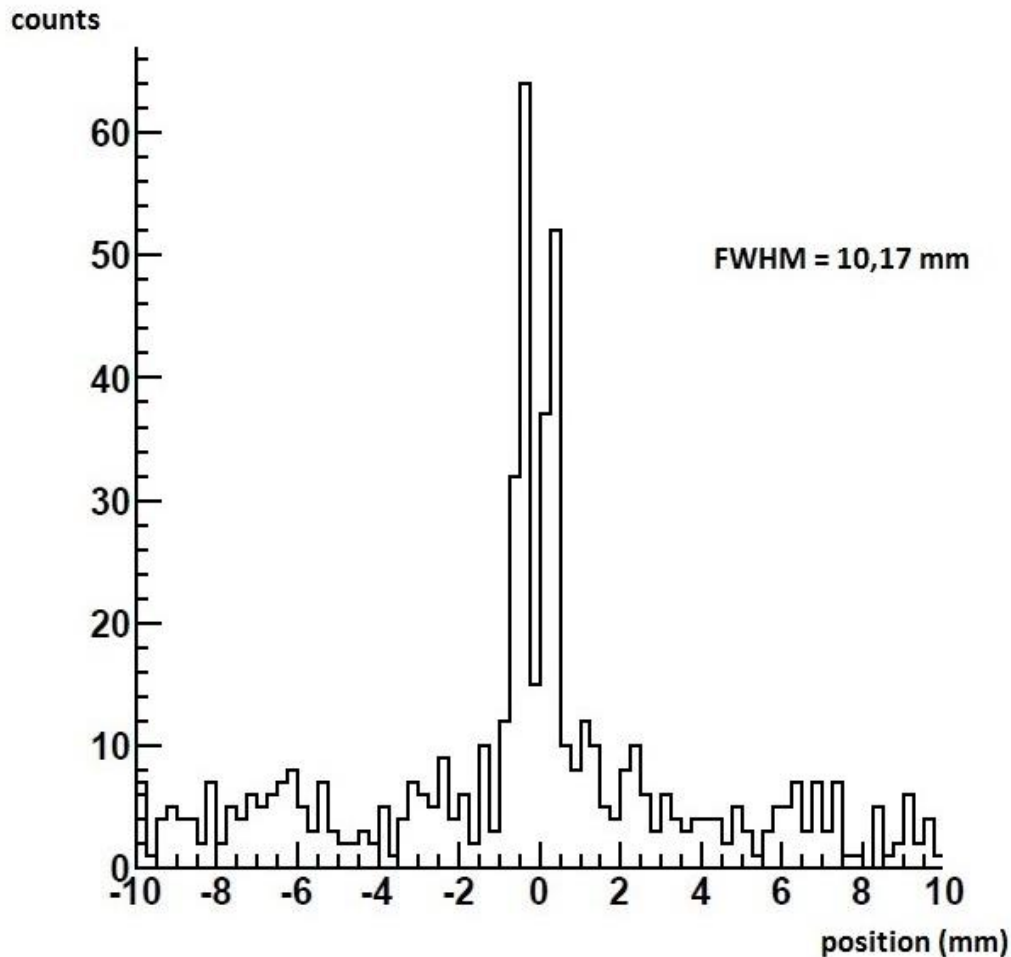
Sensitivity:

$3,87 \cdot 10^{-3} \%$

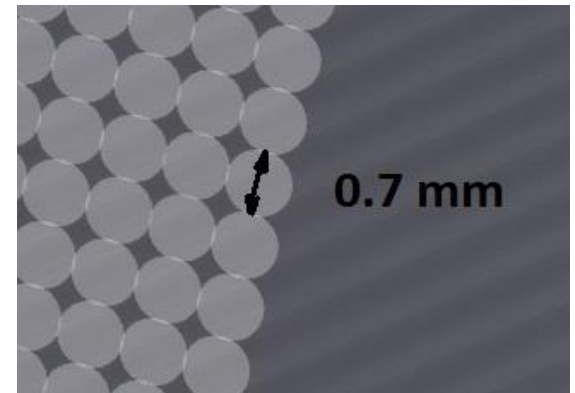
$8,59 \cdot 10^3$ cpm/ μ Ci

Results

Parallel hole collimators performance.



Solid needles (steel)



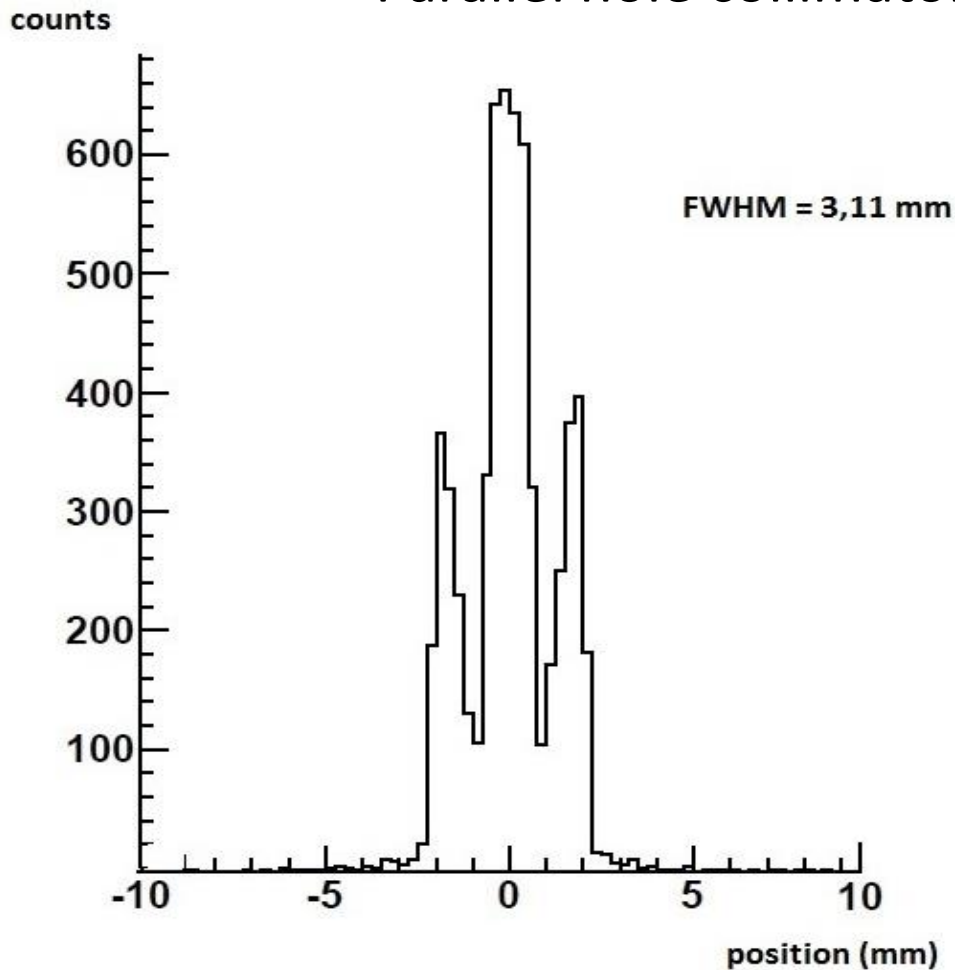
Sensitivity:

$3,69 \cdot 10^{-4}\%$

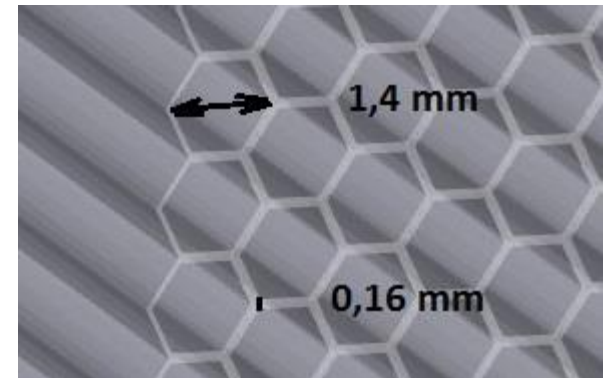
819 cpm/ μ Ci

Results

Parallel hole collimators performance.



**Honeycomb
LEUHR (lead)**



Sensitivity:

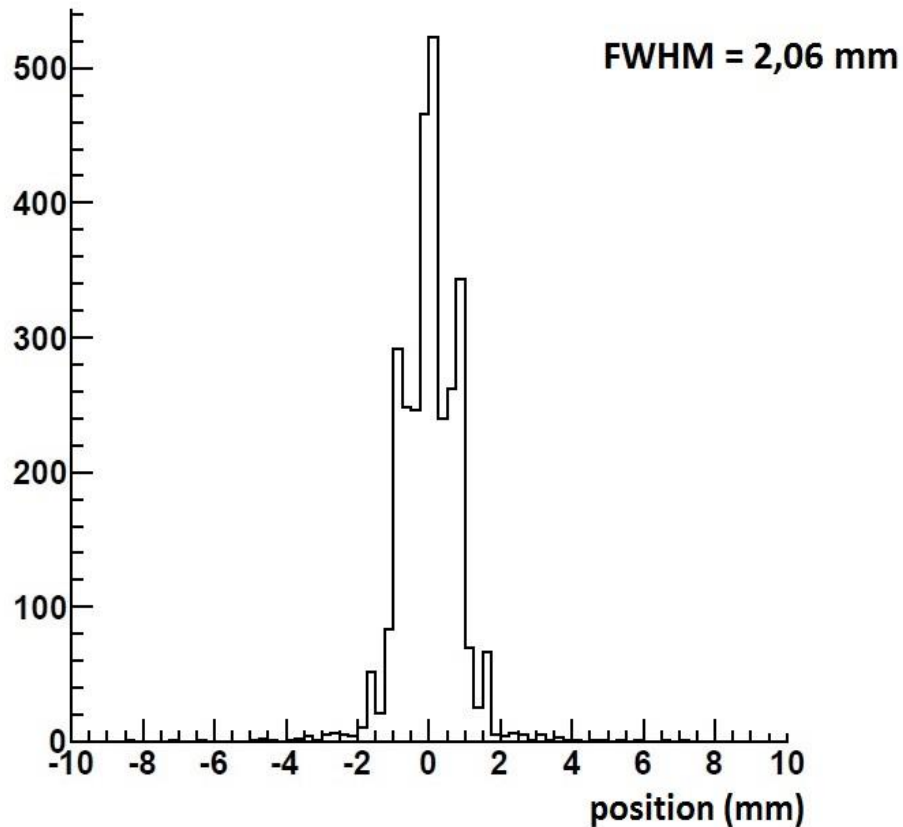
$3,09 \cdot 10^{-4}\%$

648 cpm/ μ Ci

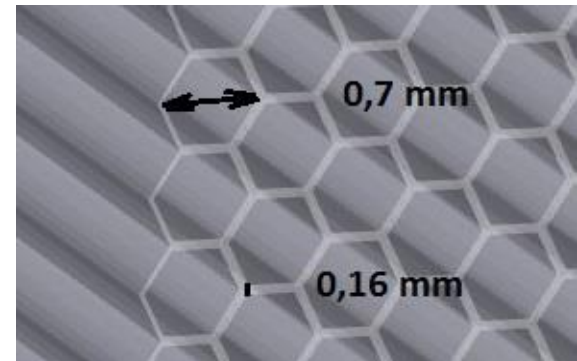
Results

Parallel hole collimators performance.

counts



**Honeycomb
LEXUHR (lead)**



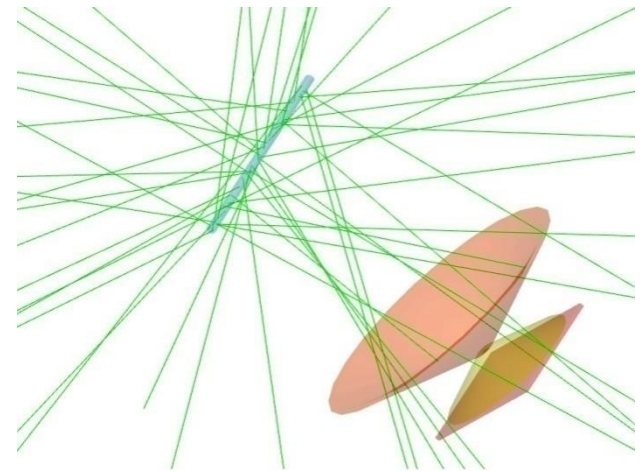
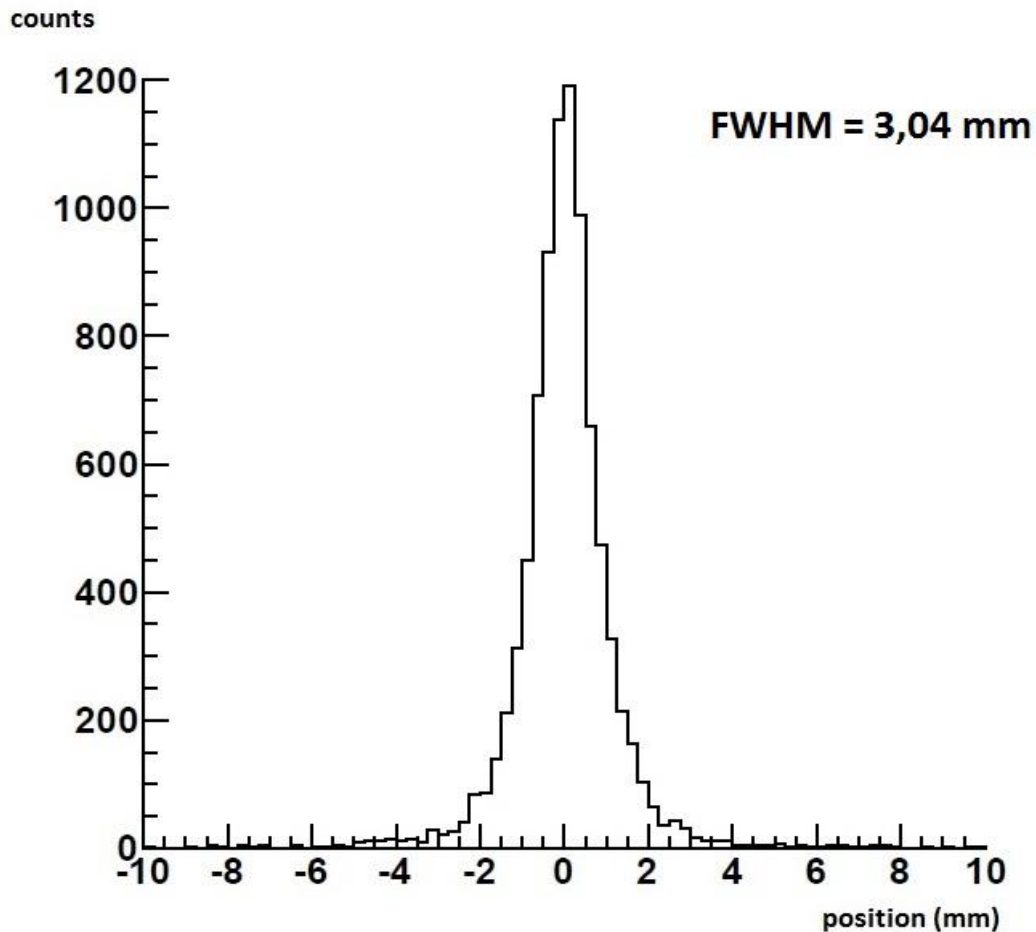
Sensitivity:

$8,54 \cdot 10^{-5}\%$

188 cpm/ μ Ci

Results

Pinhole collimator performance.



Sensitivity:

$7,82 \cdot 10^{-4}\%$

$1,74 \cdot 10^3$ cpm/ μ Ci

Results

Collimators performance.

Collimator	Resolution (mm)	Sensitivity (cpm/ μ Ci)
Injection needles	13,1	$8,59 \cdot 10^3$
Solid needles	10,2	819
Honeycomb <i>LEUHR</i>	3,11	685
Honeycomb <i>LEXUHR</i>	2,06	188
Pinhole	3,04	$1,74 \cdot 10^3$

- ❖ All values of spatial resolutions are higher than 1 mm.
- ❖ All values of sensitivity are higher than 60 cpm/ μ Ci.

Results

Evaluation of GaAs:Cr detector for clinical SPECT.

Comparison with a commercial clinical SPECT system

- **4 GaAs:Cr detectors in an 28x28 mm² array. Thickness 1mm.**

SPECT systems	Detector	Field of View (mm ²)	Resolution (mm)	Sensitivity (cpm/μCi)
Comercials (LEUHR)	NaI (TI)	550 X 450	6,5	100
Simulated (LEUHR)	GaAs:Cr	28 X 28	3,1	685

Results

Evaluation of GaAs:Cr detector for clinical SPECT.

Comparison with a commercial clinical SPECT system

- 9 GaAs:Cr detectors in an 42x42 mm² array. Thickness 1mm.
- Scanning area 126X126 mm², (9 positions) to increase field of view.
- The acquisition time is limited. Equivalent sensitivity higher than 60 cpm/μCi is required.

SPECT systems	Detector	Field of View (mm ²)	Resolution (mm)	Sensitivity (cpm/μCi)
Comercials (LEUHR)	NaI (TI)	550 X 450	6,5	100
Simulated (LEUHR)	GaAs:Cr	126 X 126	3,1	76,1

Conclusions

- The simulation results indicate that the construction of an ultra high-resolution (<1mm) SPECT system based on GaAs(Cr) detector is not possible with the use of the available collimator.
- The development of a clinical SPECT system based on GaAs(Cr) detector and Medipix3 electronics with about two times better spatial resolution than traditional systems is possible, demonstrated by the simulations.

Recommendations.

- 1) Continue the simulation studies including all geometrical details of the SPECT system based on GaAs(Cr) detector and Medipix3 electronics.**
- 2) Add all the electronic effects to get more accurate results.**
- 3) Carry on the simulation using phantom for performing tomographic images with the based in GaAs:Cr detector SPECT.**

Recommendations.

4) Simulate systems with pinhole collimators and large (360x360 mm²) detector, using the method of scanning the GaAs:Cr detectors. These systems have better resolution.

