National and Kapodistrian University of Athens
Department of Physics
Nuclear & Particle Physics Section

The Compton Camera in the γ-Ray Imaging

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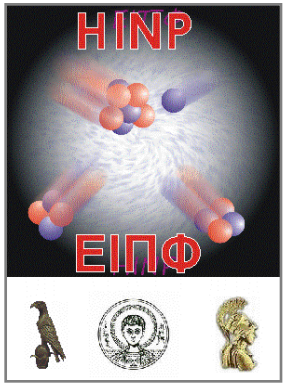
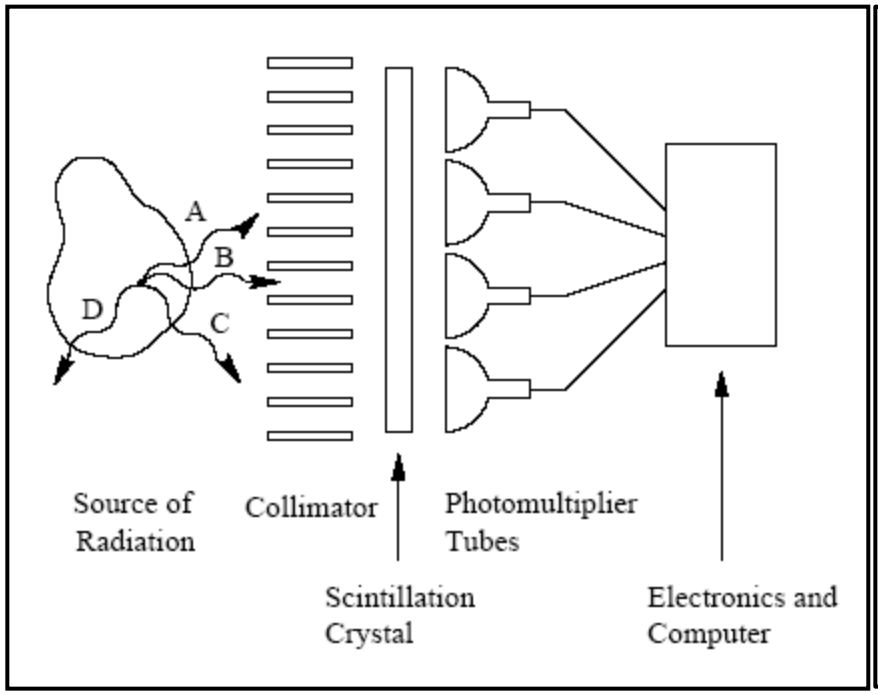
1st One Day Workshop on
New Aspects and Perspectives in Nuclear Physics
8th of September, 2012
Ioannina, Greece

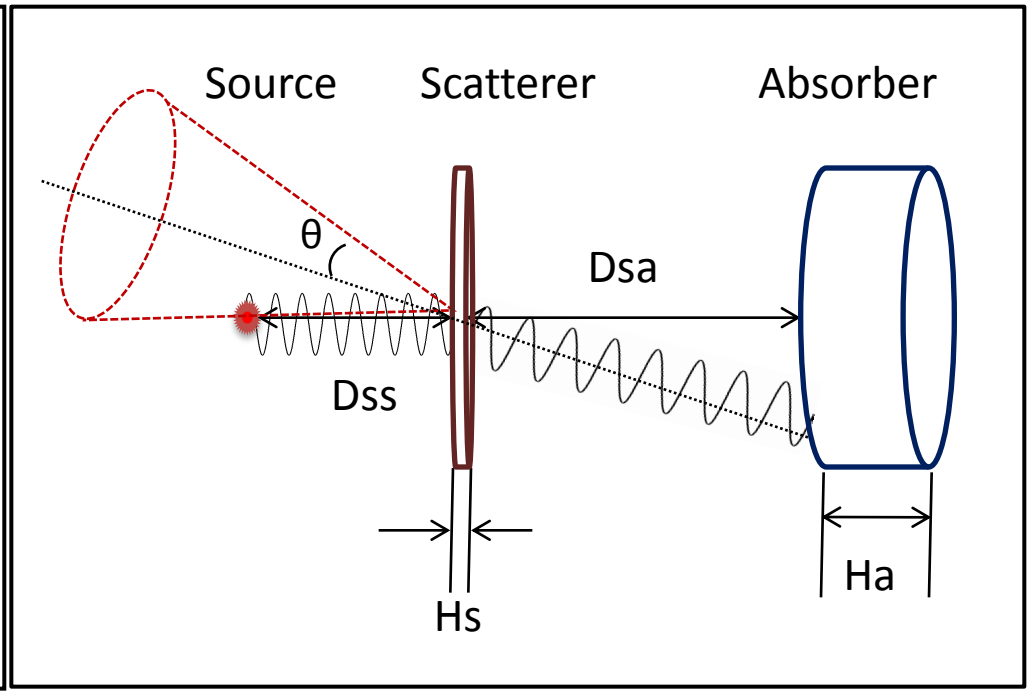


From the Anger Camera to the Compton Camera

γ-Camera



Compton Camera

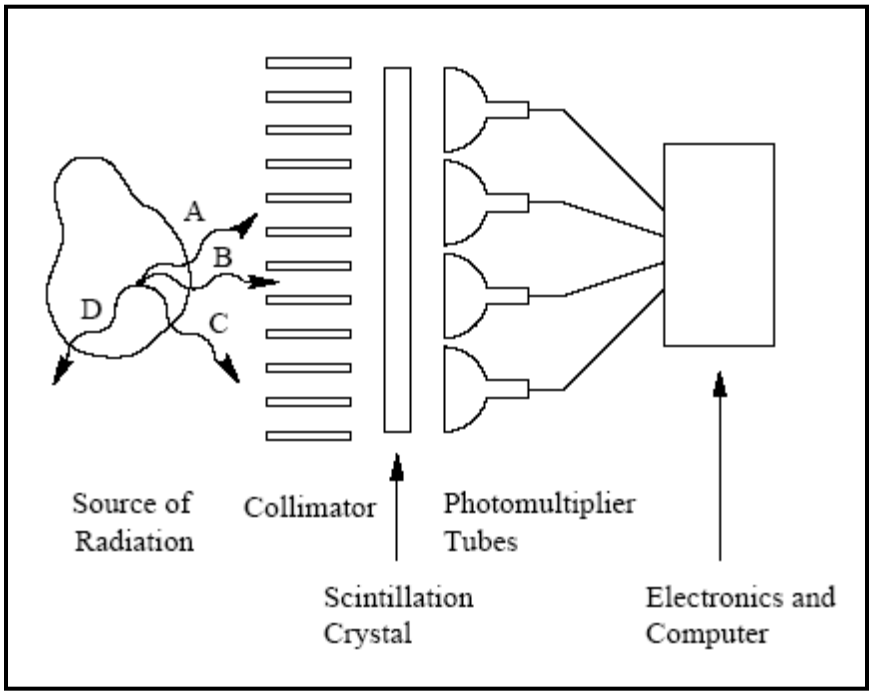


Advantages of the Compton Camera

- Higher sensitivity
- Lower dose than conventional γ-Camera systems

Angers' Camera Components

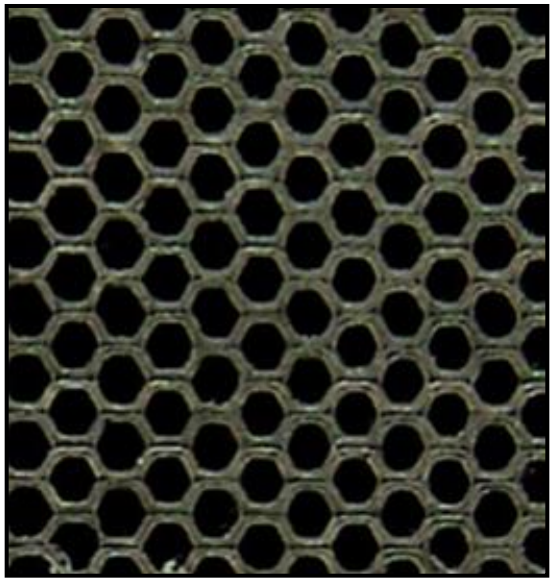
- Collimator
- Scintillation Crystal
- Photomultiplier
- Amplification System
- Read Out System (Position and Energy Reconstruction)



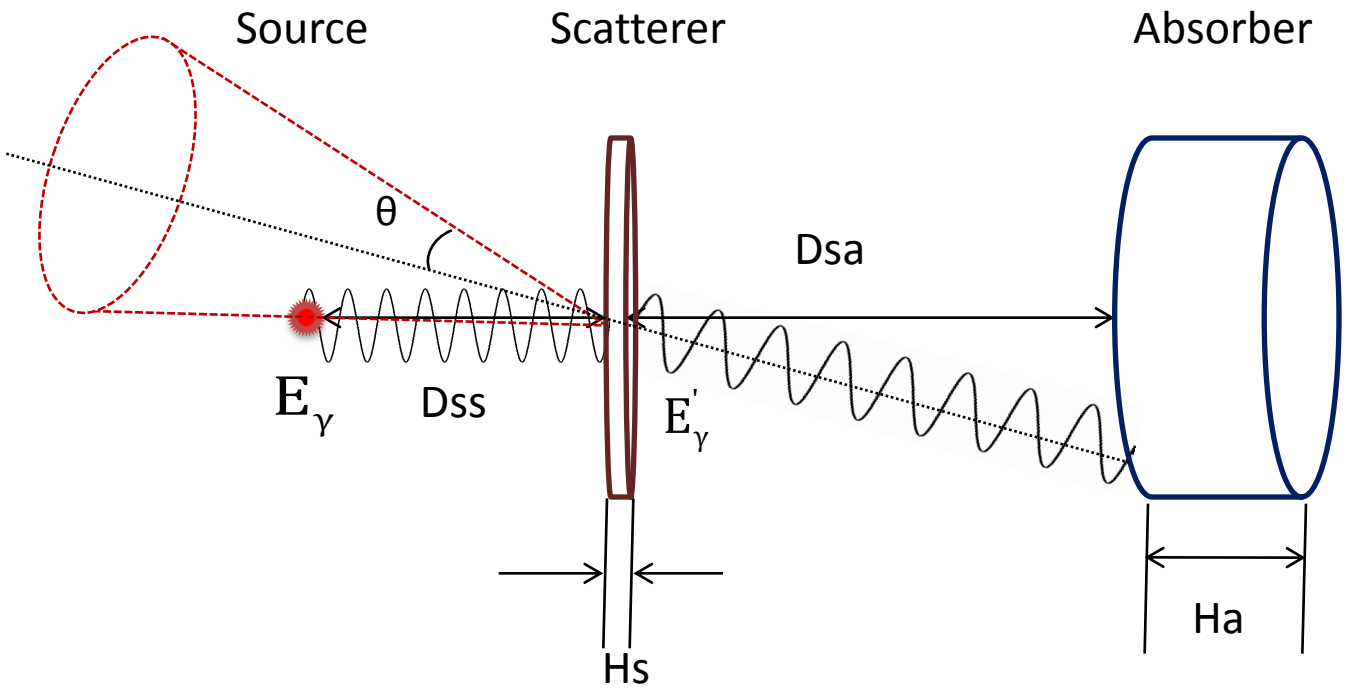
Angers' Camera shows:

- High radiation dose
- Poor sensitivity

Collimator

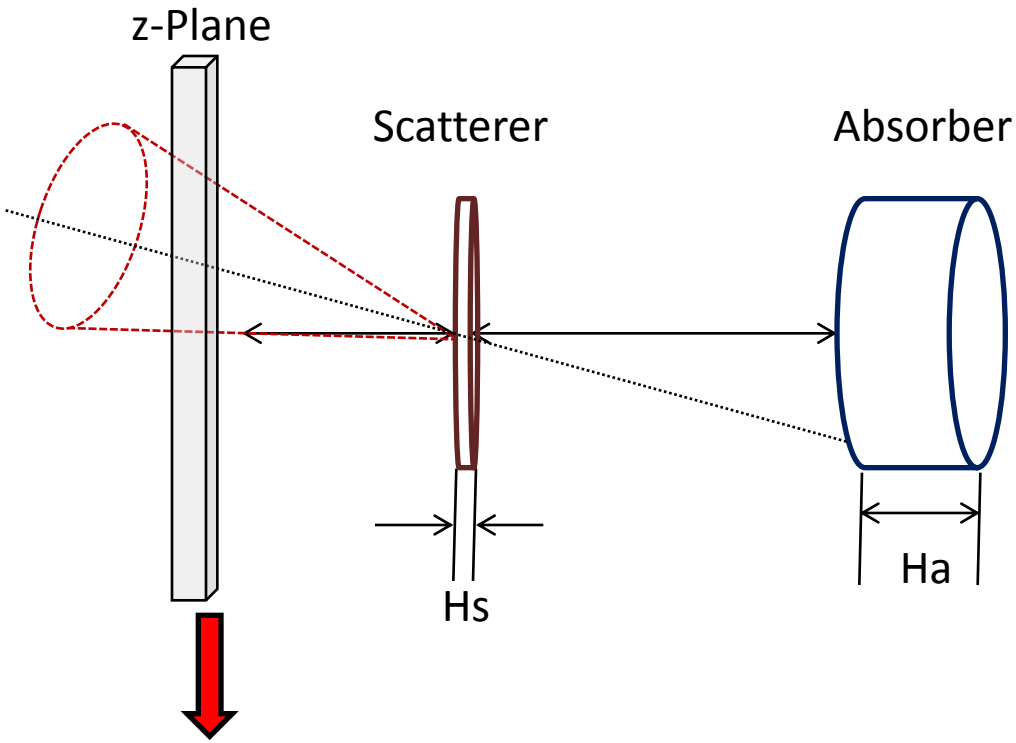


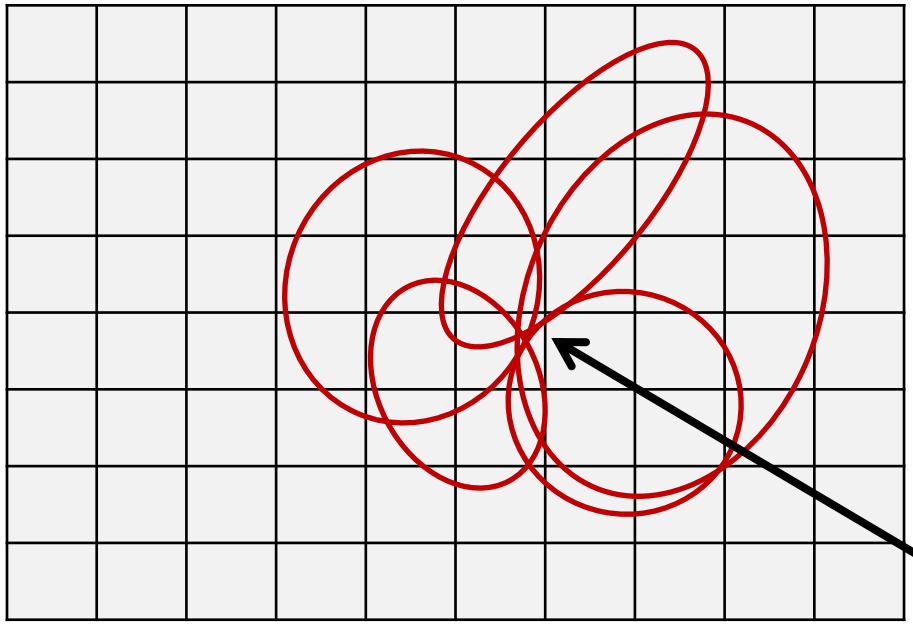
Compton Camera Principle



The initial photon of the source is scattered on the first detector and then absorbed in the second one. A conical surface is formed using the interaction locations and the energies calculated.

$$\cos\theta = 1 + m_0 c^2 \left(\frac{1}{E_\gamma} - \frac{1}{E'_\gamma} \right)$$

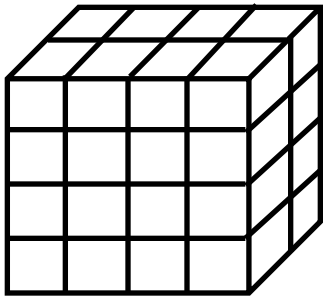




Location of the source

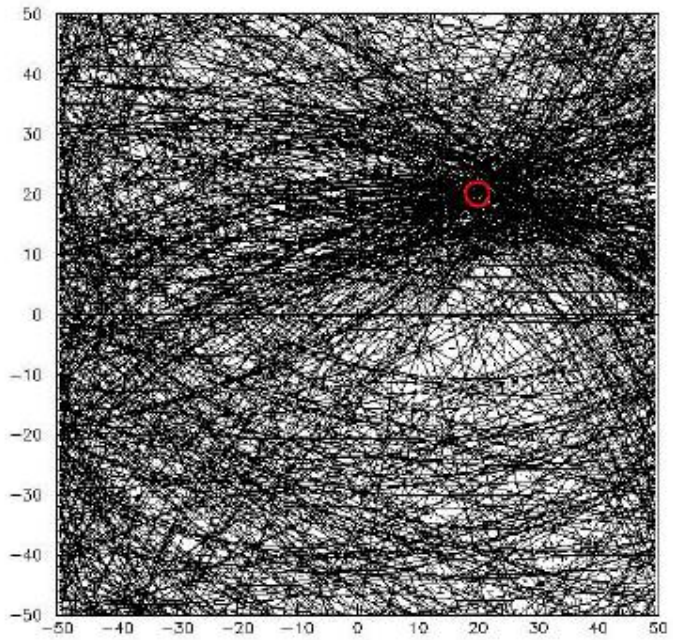
• A plane is placed vertically to the systems' axis and it is segmented into pixels.

• It is moved forward and backward, forming a voxel.

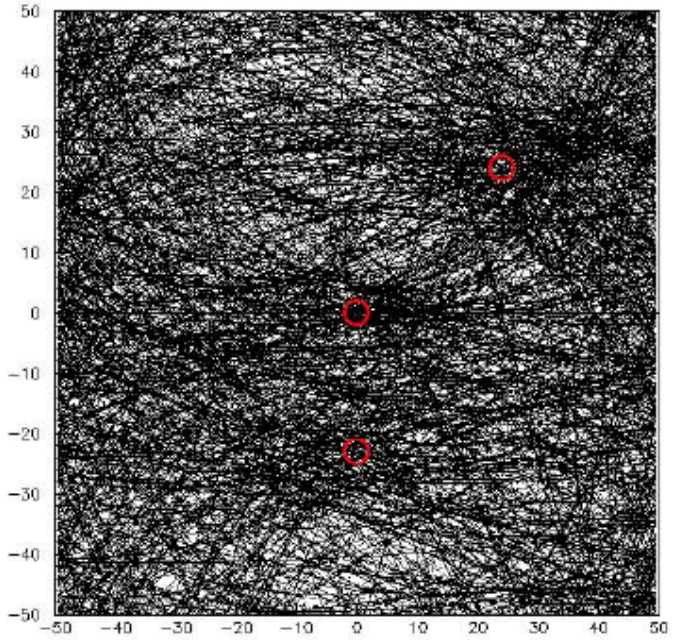


• The density of its pixel, because of the overlap of the plane with the cones, is measured.

1-Point Source



3-Point Sources

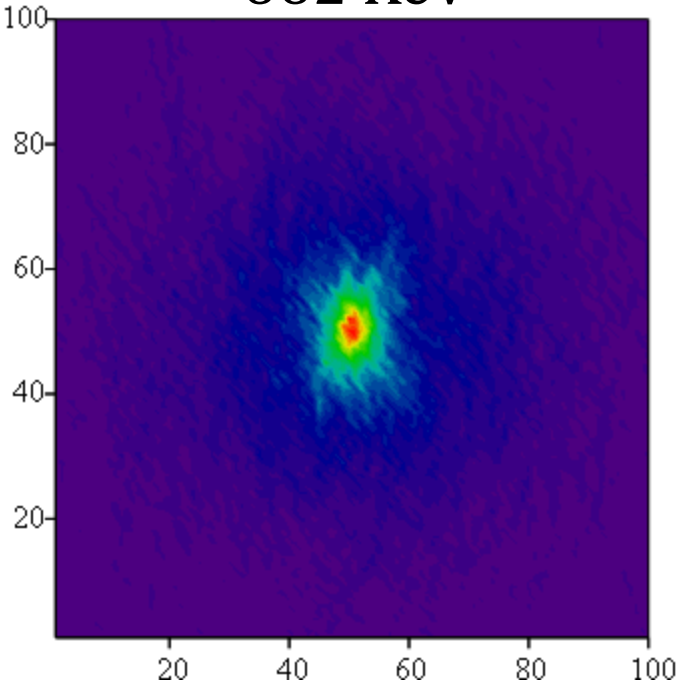


Advantages of the Compton Camera

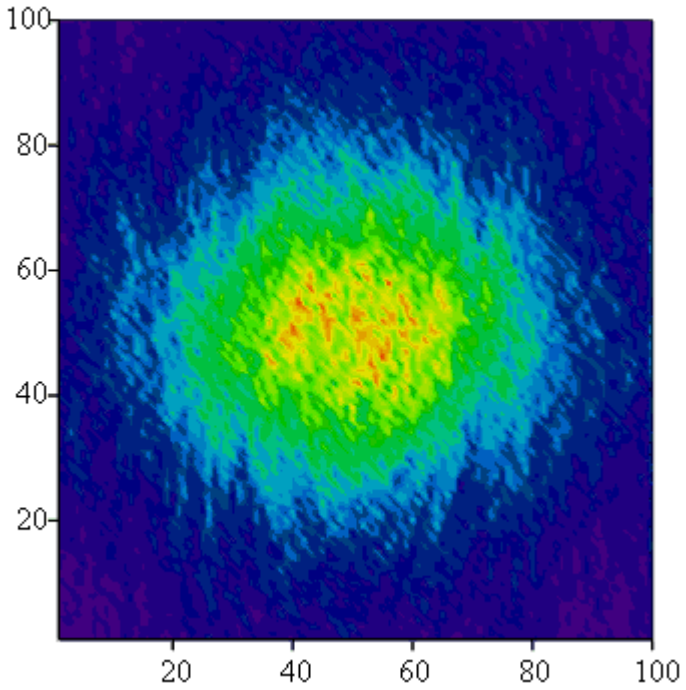
- Uses electronic collimation
- Reconstructs a wide range of energy radiation
- Provides high sensitivity
- Reduces the patient dose

Energy Dependance

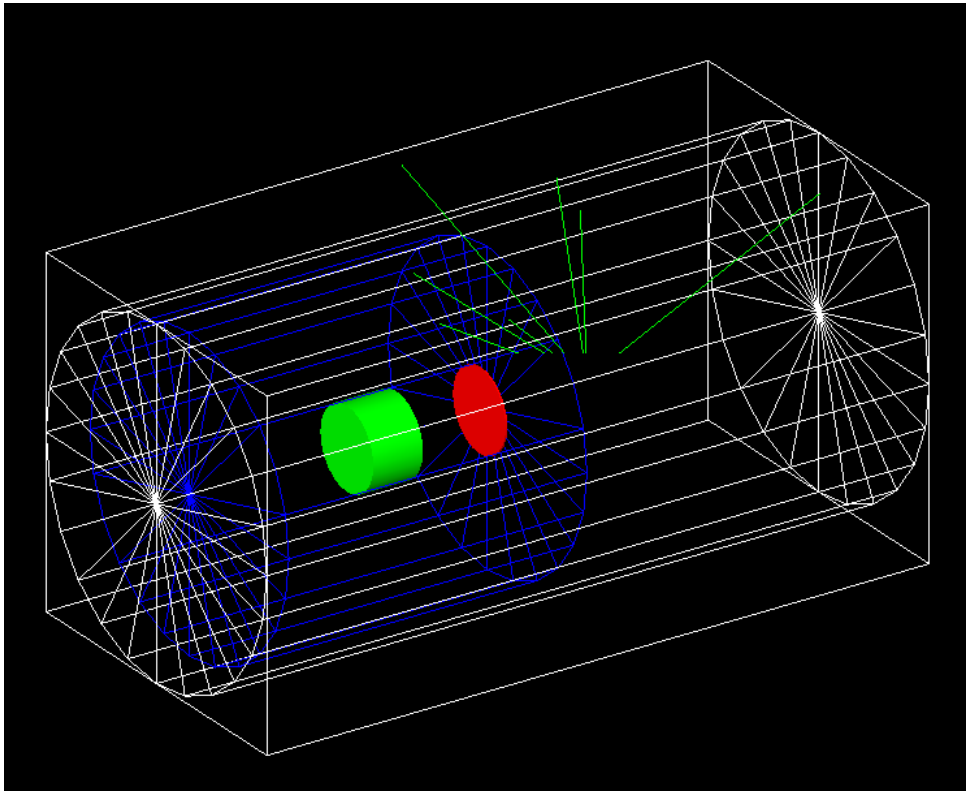
^{137}Cs Point Source
662 KeV



^{99m}Tc Point Source
140 KeV



The density of all pixels can show the location and the geometrical characteristics of the radiation distribution.



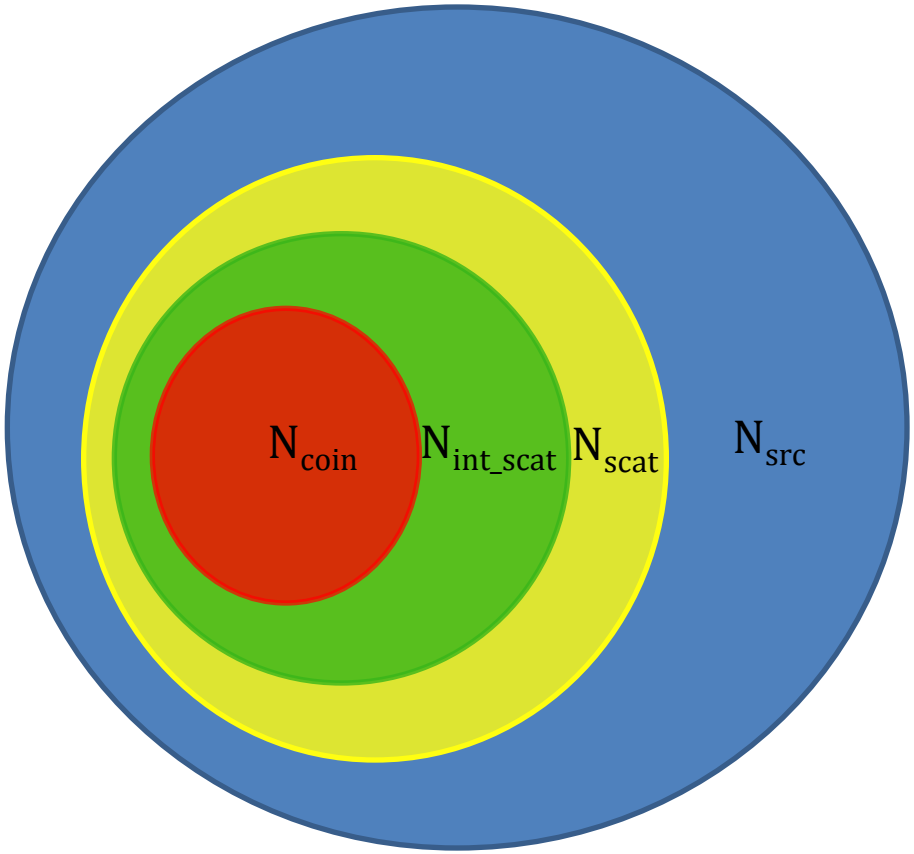
The performance of a Compton Camera is studied through GEANT4/GATE simulations for various geometrical characteristics.

N_{src} : Number of source emitted photons

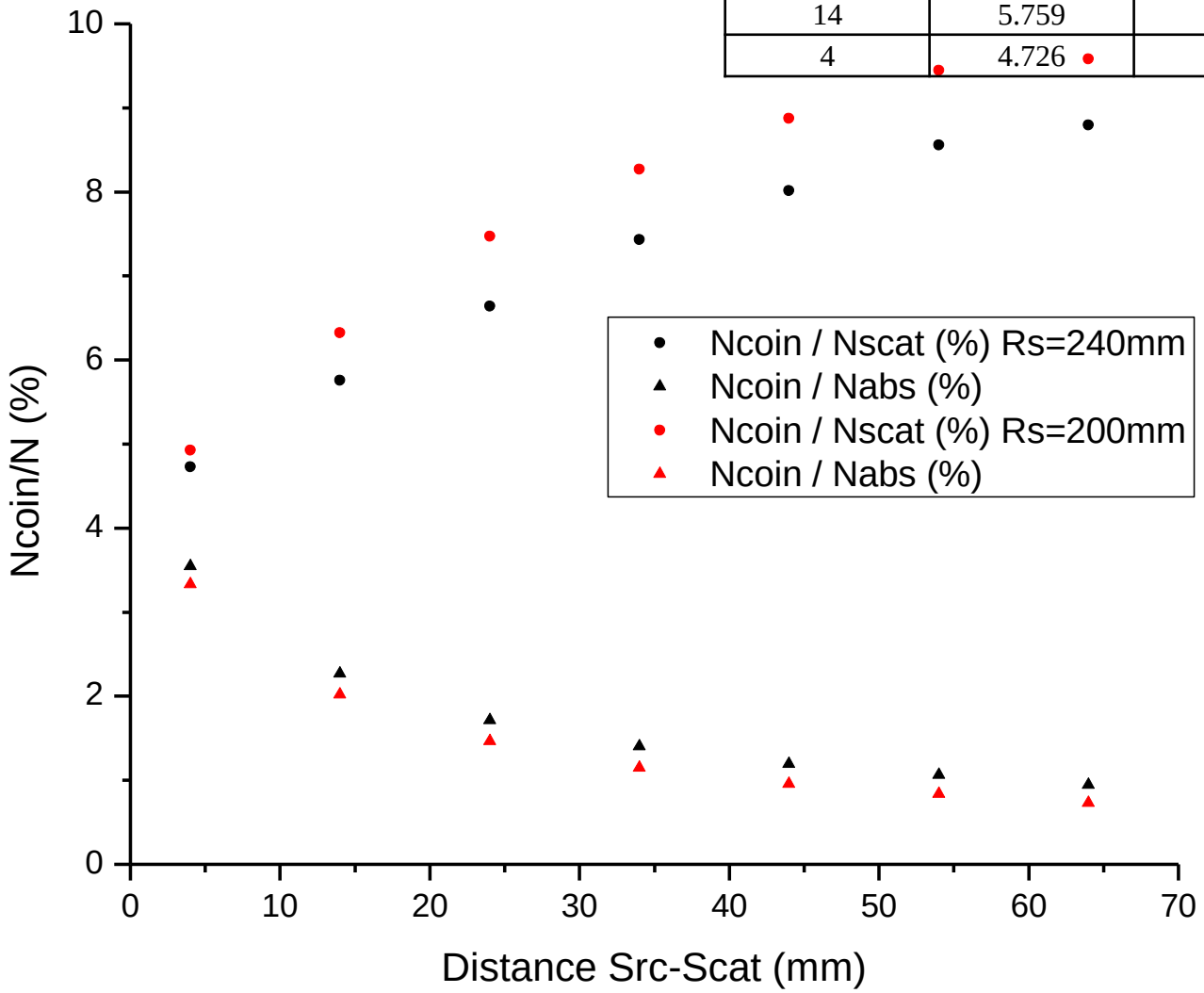
N_{scat} : Number of photons reached scatterer

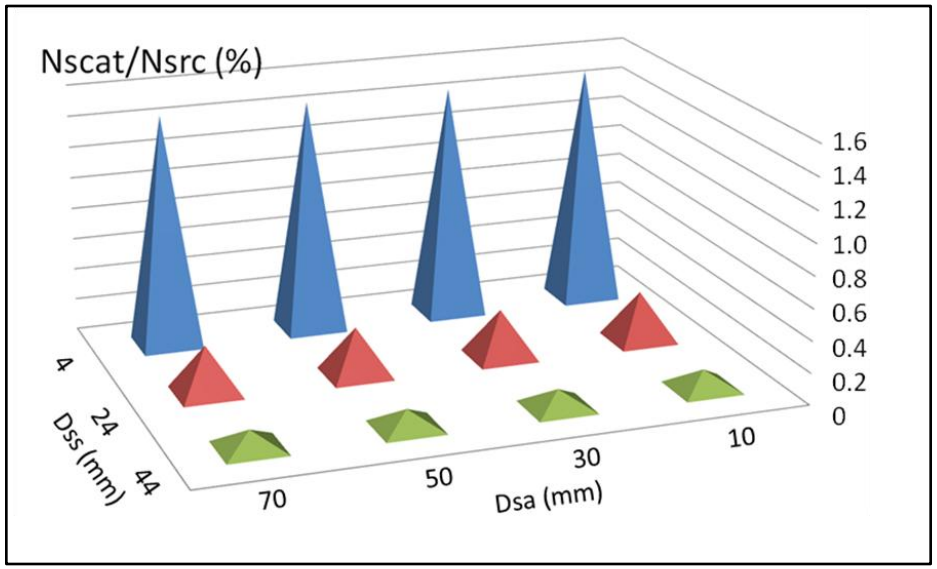
N_{int_scat} : Photons interacted with scatterer

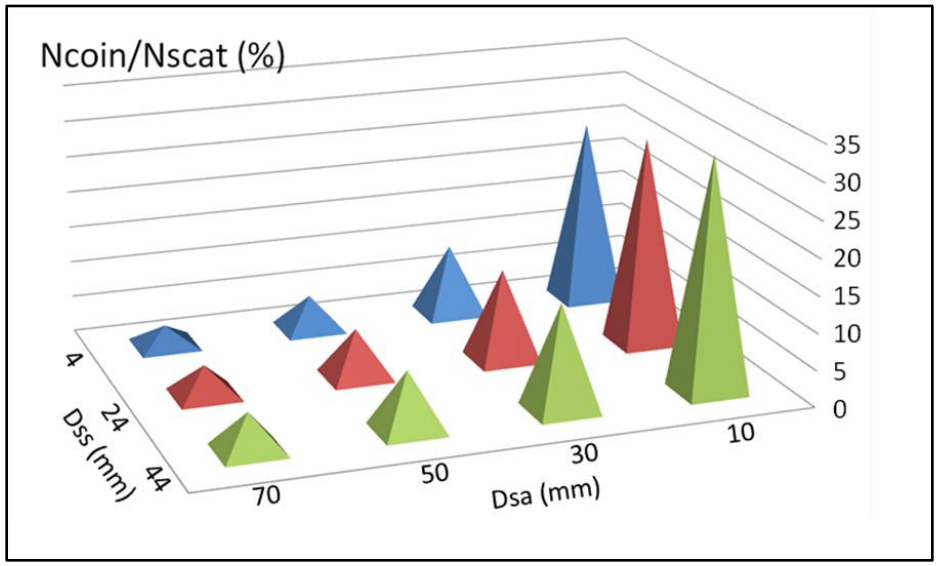
N_{coin} : Number of detected coincidences



Distance Src-Scat (mm)	Rs=240mm		Rs=200mm	
	Ncoin / Nscat (%)	Ncoin / Nabs (%)	Ncoin / Nscat (%)	Ncoin / Nabs (%)
64	8.796	0.945	9.580	0.731
54	8.559	1.063	9.447	0.835
44	8.015	1.194	8.877	0.956
34	7.433	1.402	8.267	1.149
24	6.641	1.712	7.469	1.466
14	5.759	2.269	6.323	2.020
4	4.726	3.546	4.928	3.330

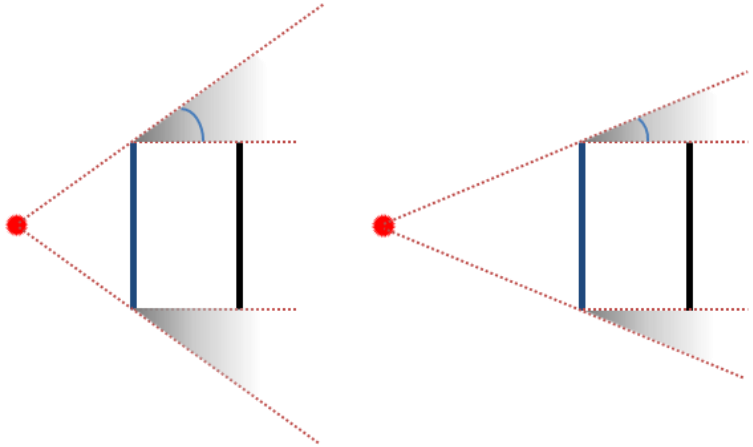






The detected efficiency for the events reached the scatterer after being emitted from the source.

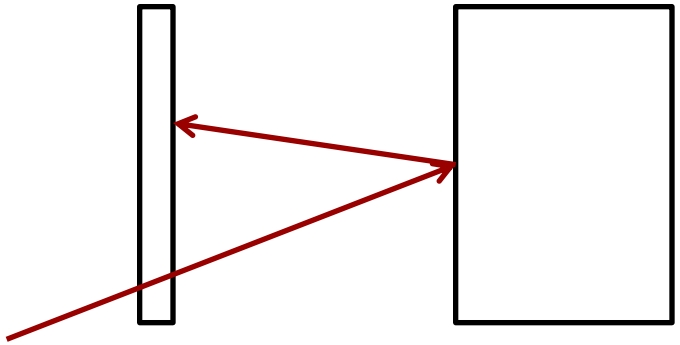
The coincidence efficiency with respect to the events detected on the scatterer with a radius Rs=24mm.



The geometrical characteristics affect the systems' efficiency.

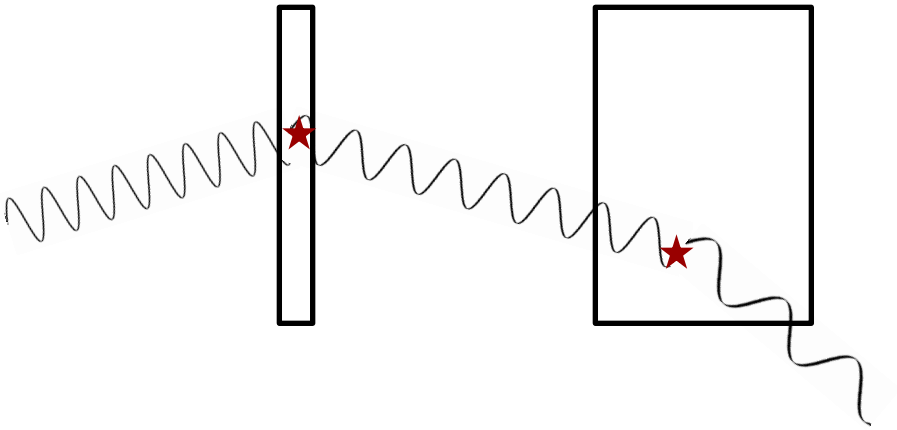
Physical Background

- False Coincidences



- Missing Energy

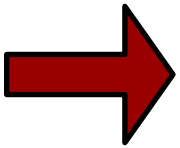
$$E_1 + E_2 < E_\gamma$$



Results in

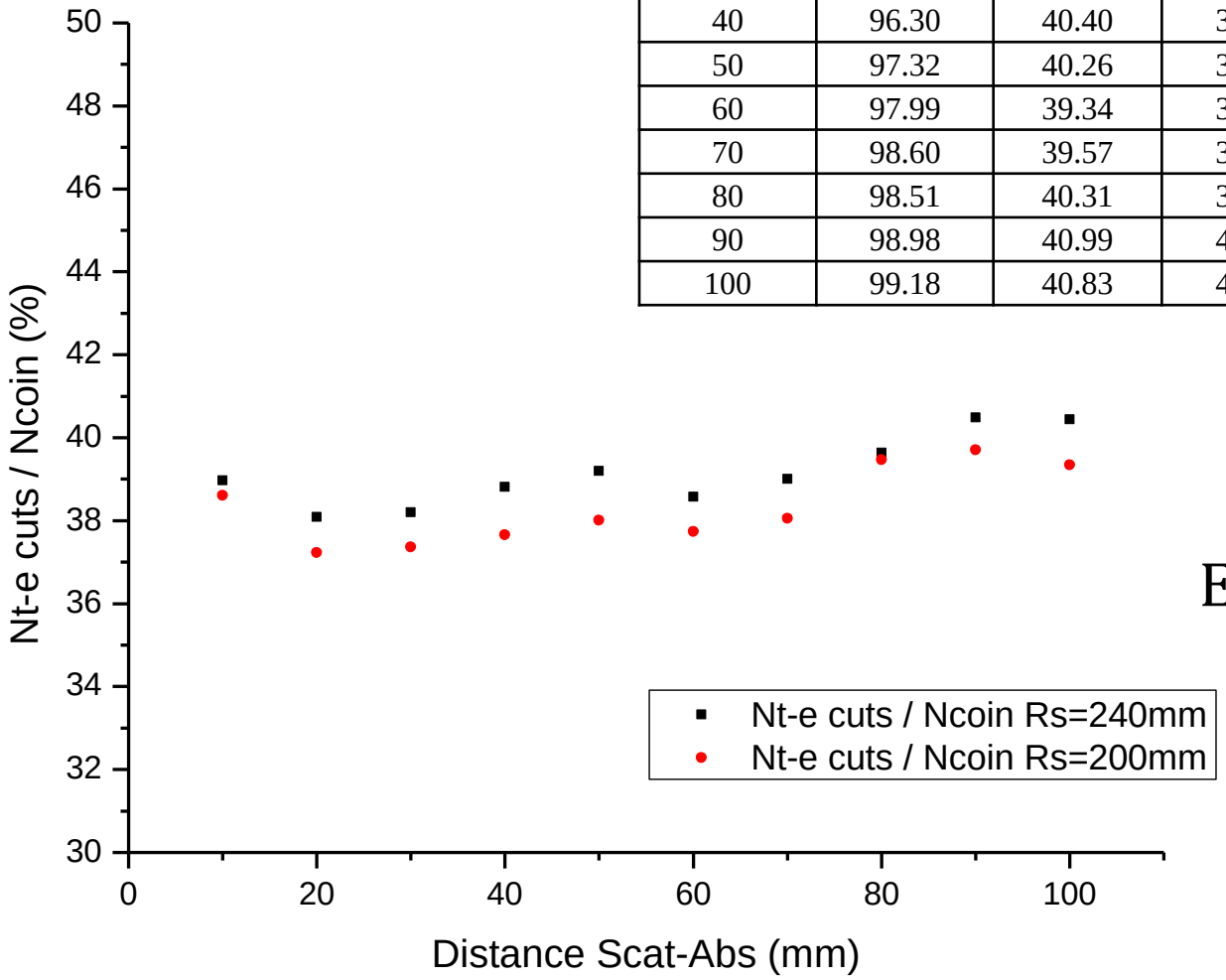
Wrong Reconstruction

$$\left|\cos\theta\right| > 1$$



EFFICIENCY ~ 40%

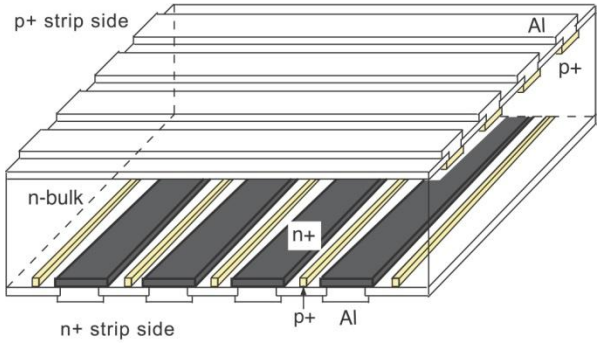
Dist. Scat – Abs (mm)	Rs=240mm			Rs=200mm		
	Ncoin(time)/ Ncoin (%)	Ncoin (energy cut 30%) / Ncoin (%)	Ncoin (t-e cuts) / Ncoin (%)	Ncoin(time) / Ncoin (%)	Ncoin (energy cut 30%) / Ncoin (%)	Ncoin(t-e cuts) / Ncoin (%)
10	88.50	43.89	38.97	89.72	43.12	38.60
20	92.57	41.18	38.08	93.43	40.05	37.23
30	94.88	40.33	38.20	95.67	39.19	37.37
40	96.30	40.40	38.81	96.81	39.03	37.65
50	97.32	40.26	39.19	97.68	38.91	38.01
60	97.99	39.34	38.57	98.29	38.47	37.74
70	98.60	39.57	39.00	98.70	38.56	38.05
80	98.51	40.31	39.64	98.95	39.91	39.47
90	98.98	40.99	40.48	99.01	40.23	39.71
100	99.18	40.83	40.44	99.13	39.76	39.35



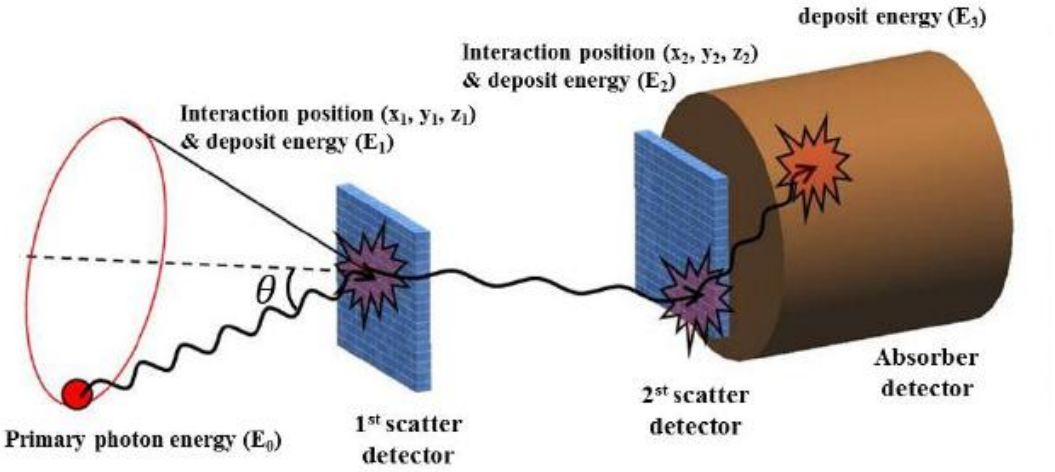
EFFICIENCY ~ 40%

Future Plans

- As a first detector use a Double Sided Silicon Detector (DSSD)



- Replace the first detector with two scatterers




Thank You