

MuSiC: a novel Multi Slit prompt gamma Camera for *in vivo* monitoring of proton therapy

Dr Andrea Gutierrez

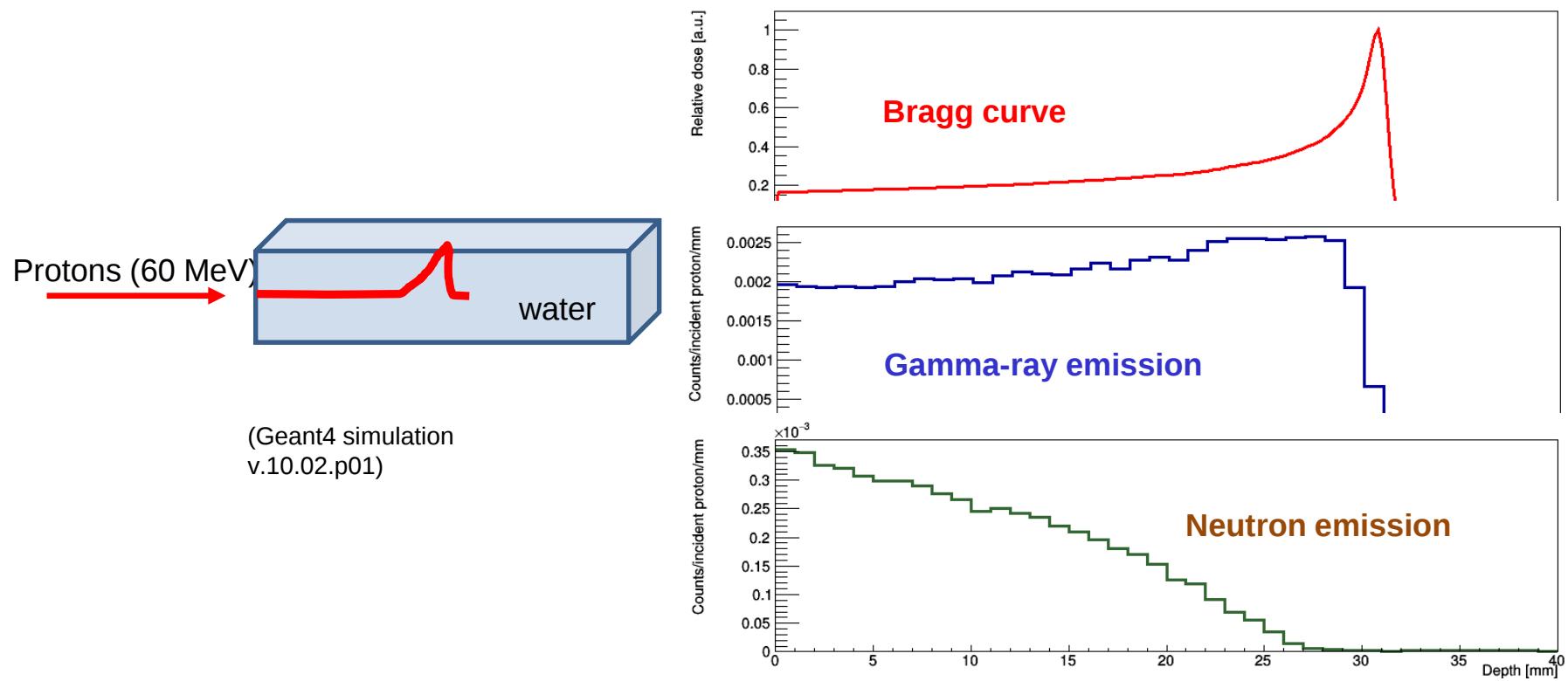
a.gutierrez@tudelft.nl

Medical Physics & Technology Department
Delft University of Technology

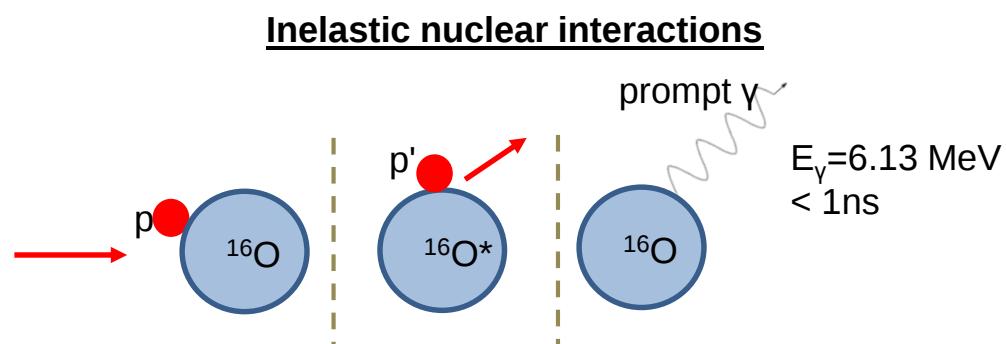
Outline

- Part 1: Development of a semiconductor Compton camera (previous project at University College London)
- Part 2: Optimisation of MuSiC, a novel Multi Slit gamma Camera (current project at TU Delft)

Generation of secondary particles during proton irradiation



Prompt gamma emission during proton irradiation

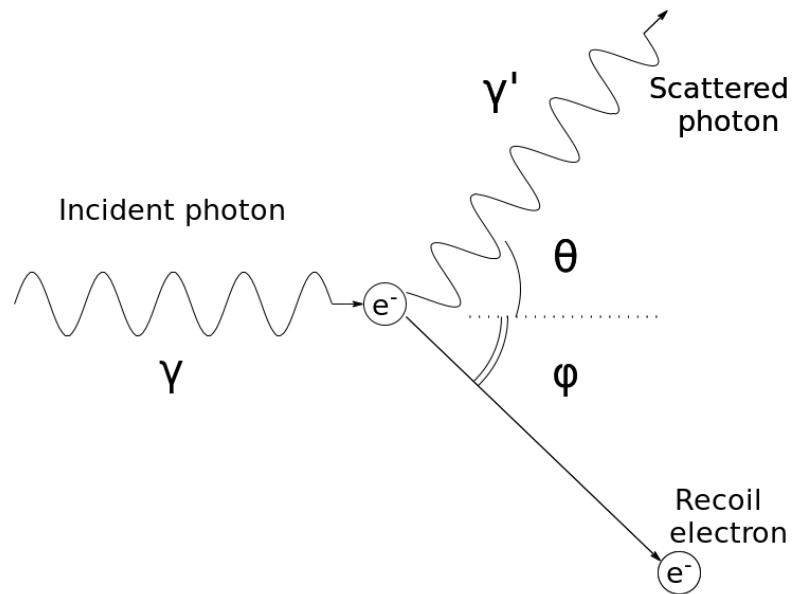


Target	Emitt.	$E_\gamma (\text{MeV})$
^{16}O	^{16}O	6.13
		6.92
		7.12
^{12}C	^{12}C	2.74
	^{15}N	4.44
		5.27
^{12}C	^{12}C	4.44
	^{11}C	2.00

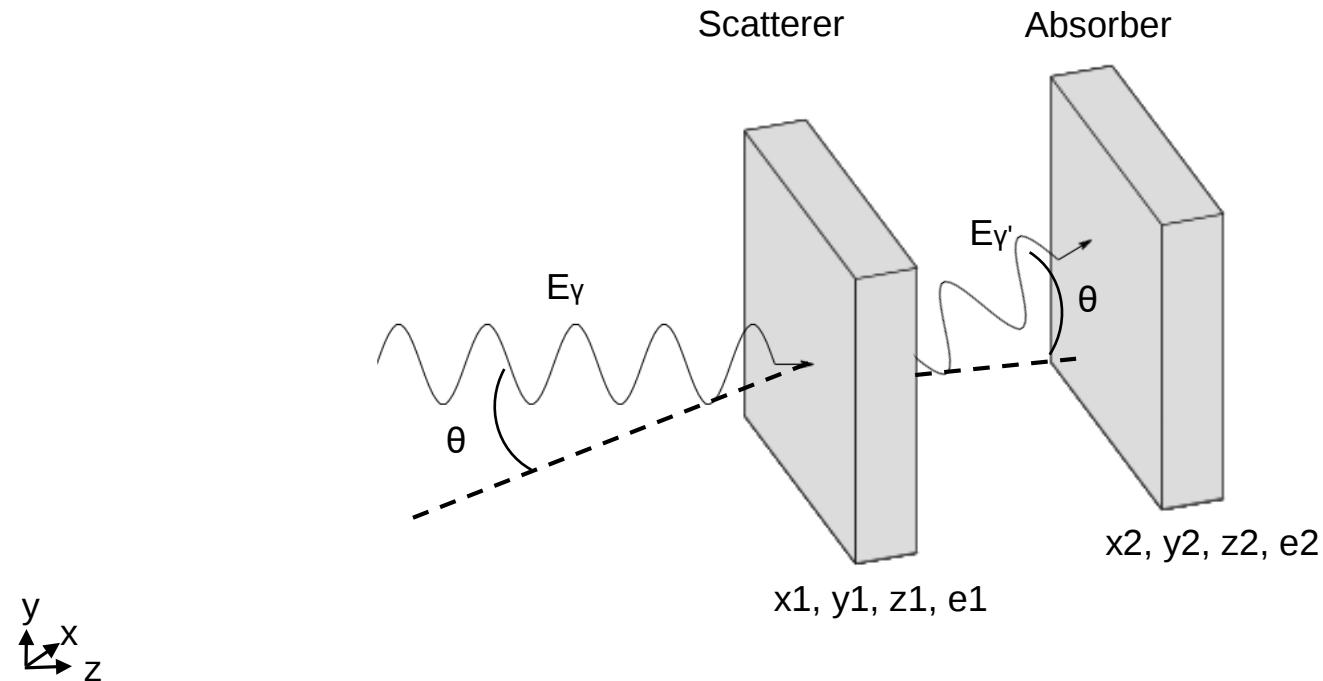
Compton scattering

Exploits Compton kinematics to:

- Track the origin of photons
- Energy spectrum



Compton camera

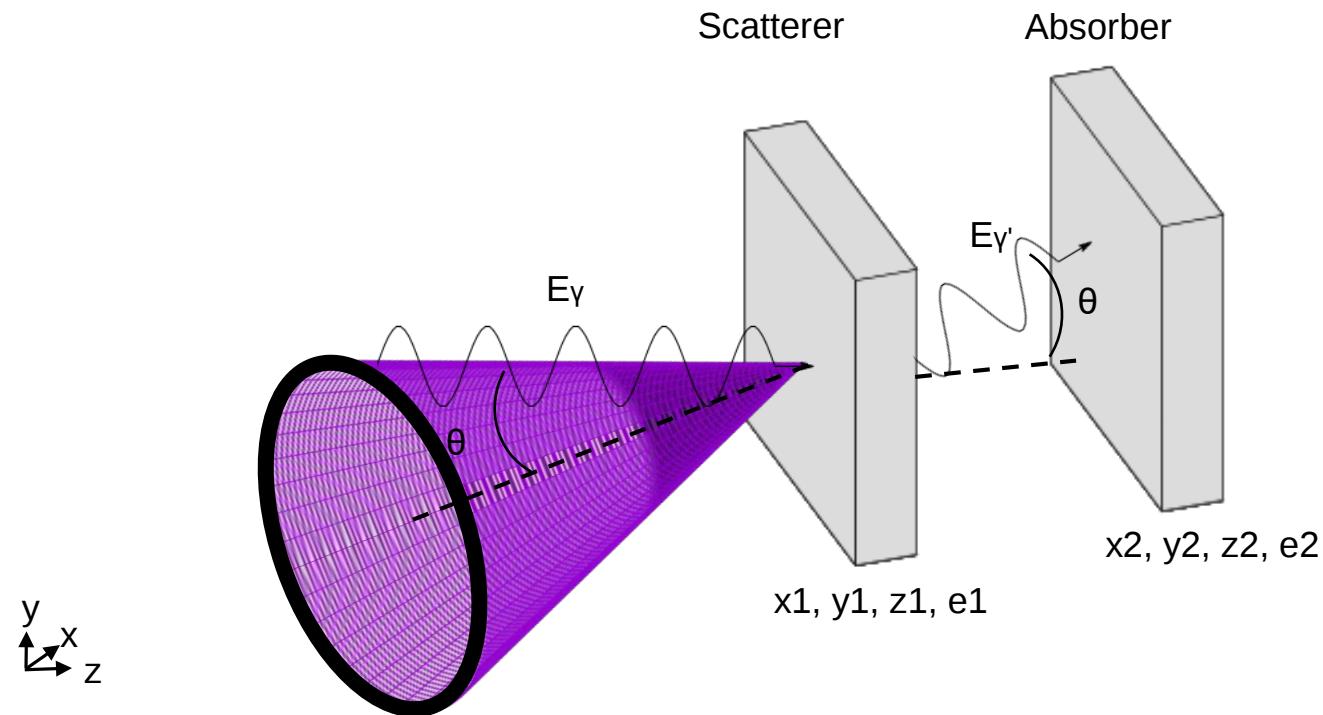


$$\cos \theta = 1 - m_e c^2 \left(\frac{1}{e_2} - \frac{1}{e_1 + e_2} \right)$$

$$E_\gamma = e_1 + e_2$$

$$E_{\gamma'} = e_2$$

Image reconstruction

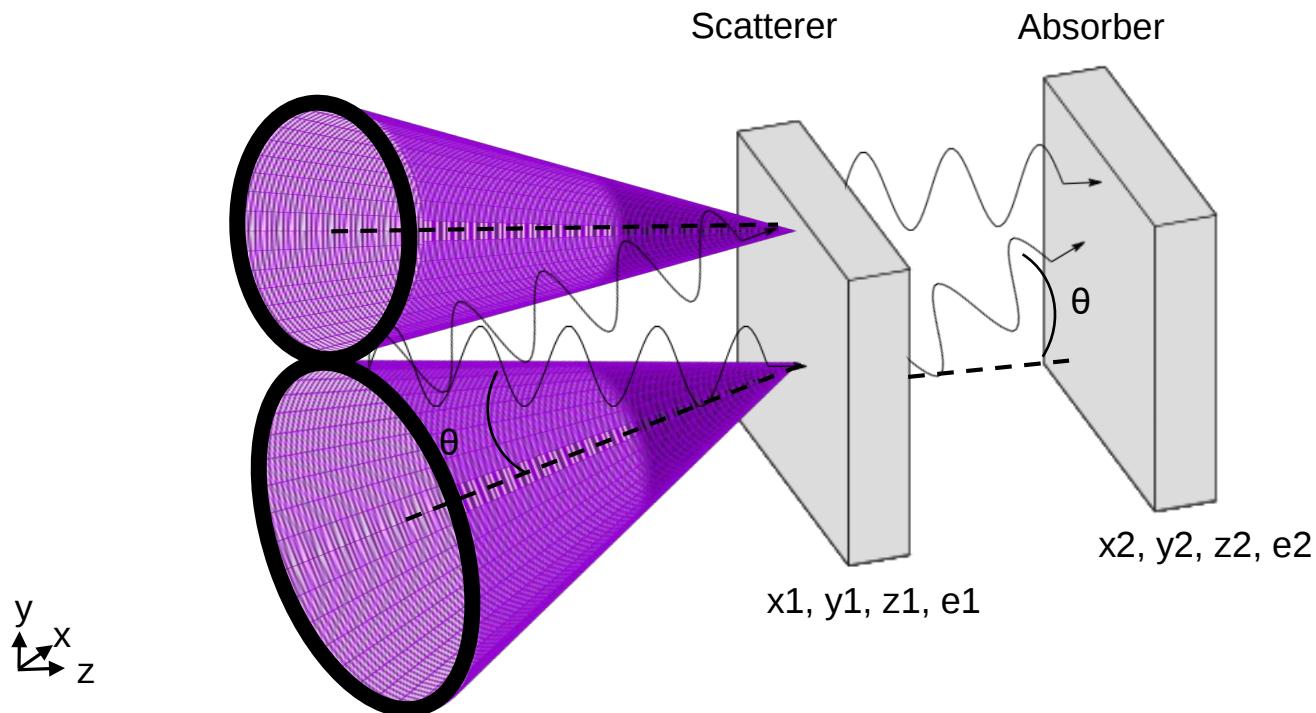


$$\cos \theta = 1 - m_e c^2 \left(\frac{1}{e_2} - \frac{1}{e_1 + e_2} \right)$$

$$E_\gamma = e_1 + e_2$$

$$E_{\gamma'} = e_2$$

Image reconstruction



$$\cos \theta = 1 - m_e c^2 \left(\frac{1}{e_2} - \frac{1}{e_1 + e_2} \right)$$

$$E_\gamma = e_1 + e_2$$

$$E_{\gamma'} = e_2$$

Image reconstruction: Simple back-projection

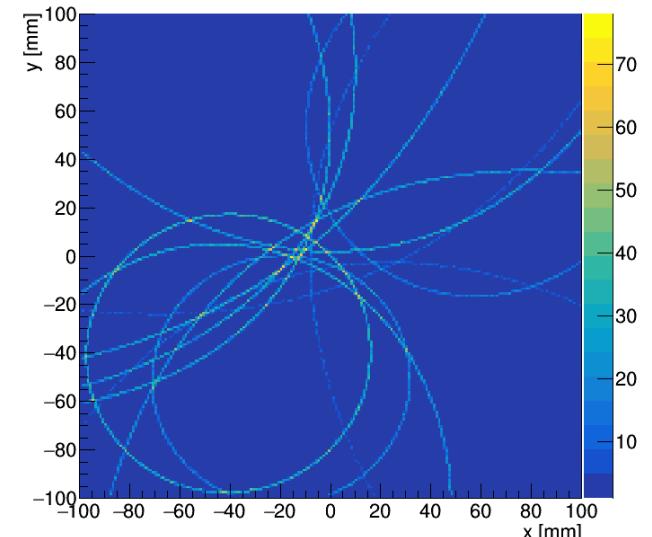
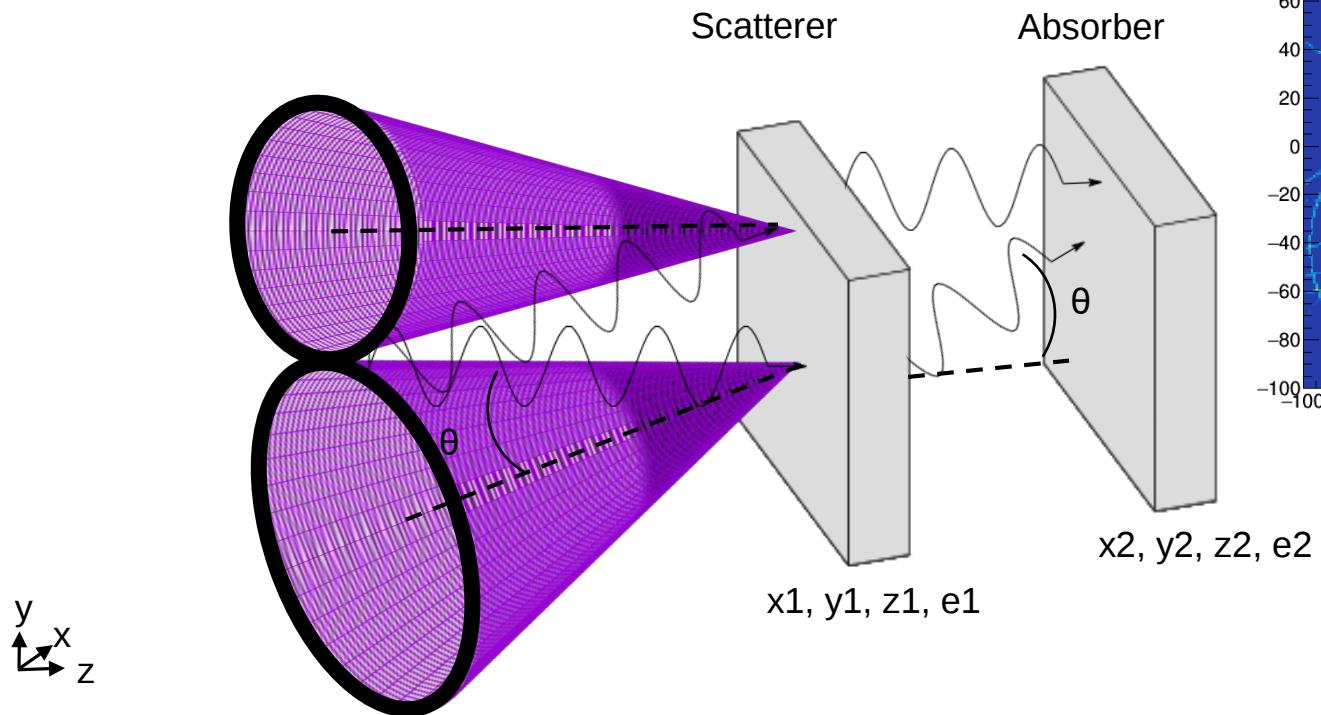
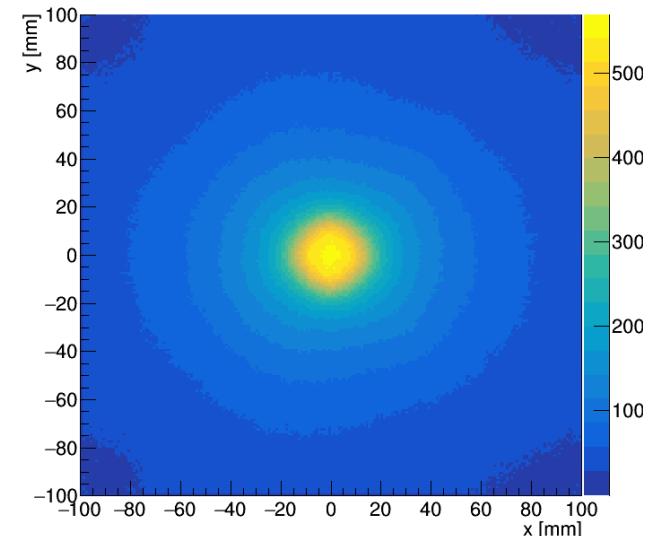
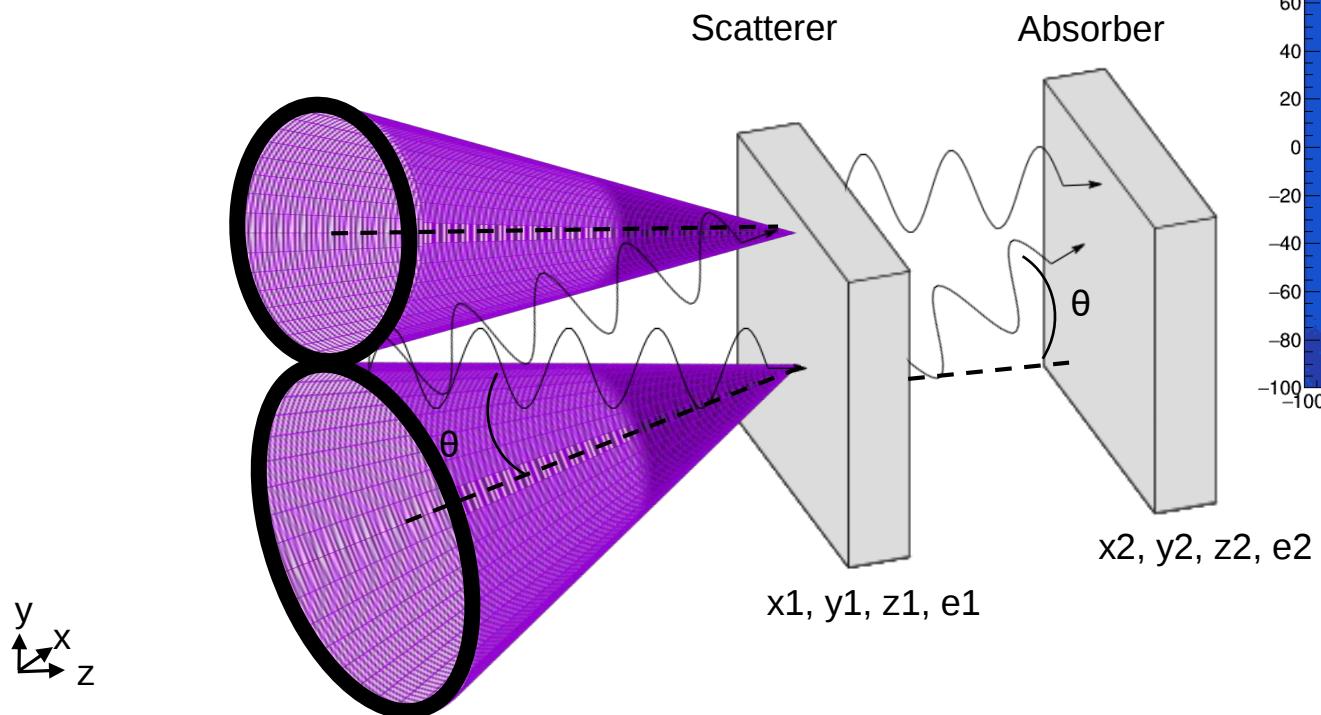
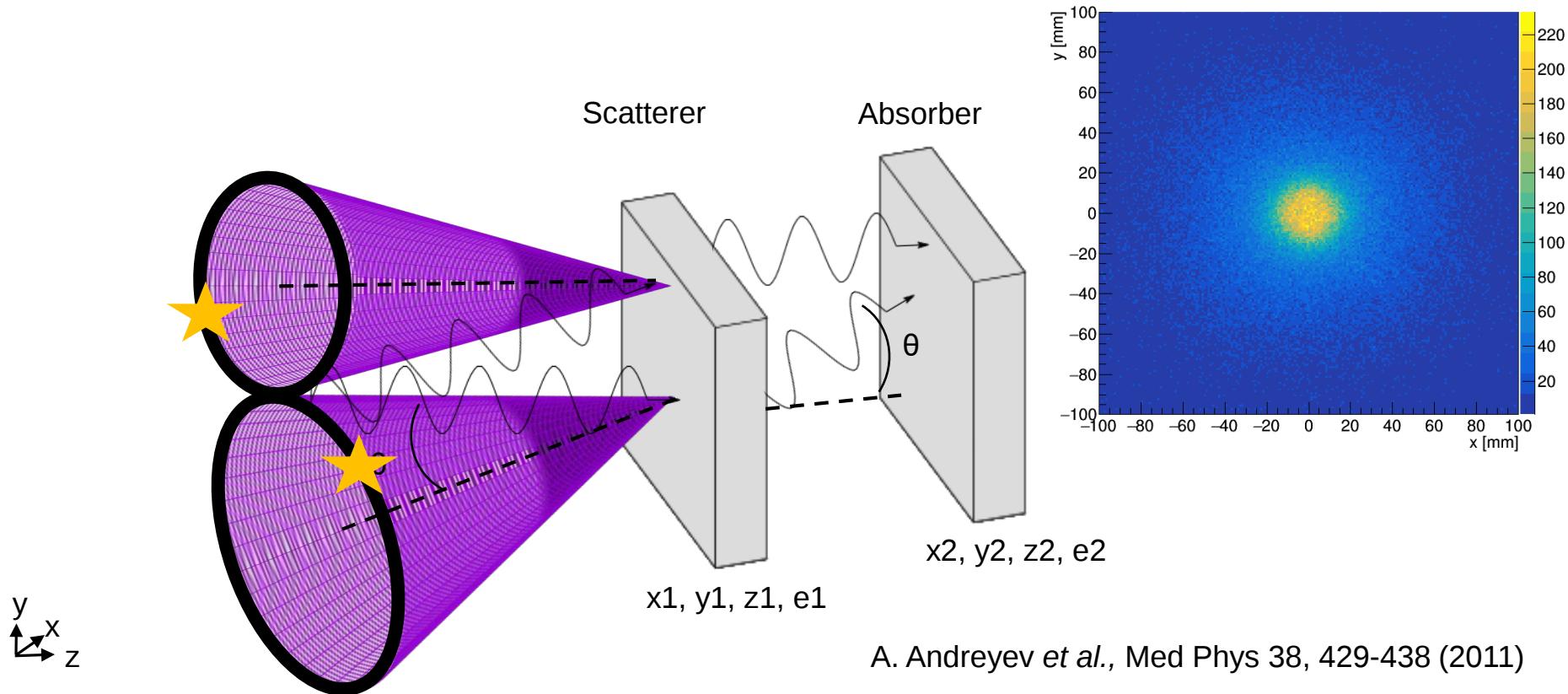


Image reconstruction: Simple back-projection

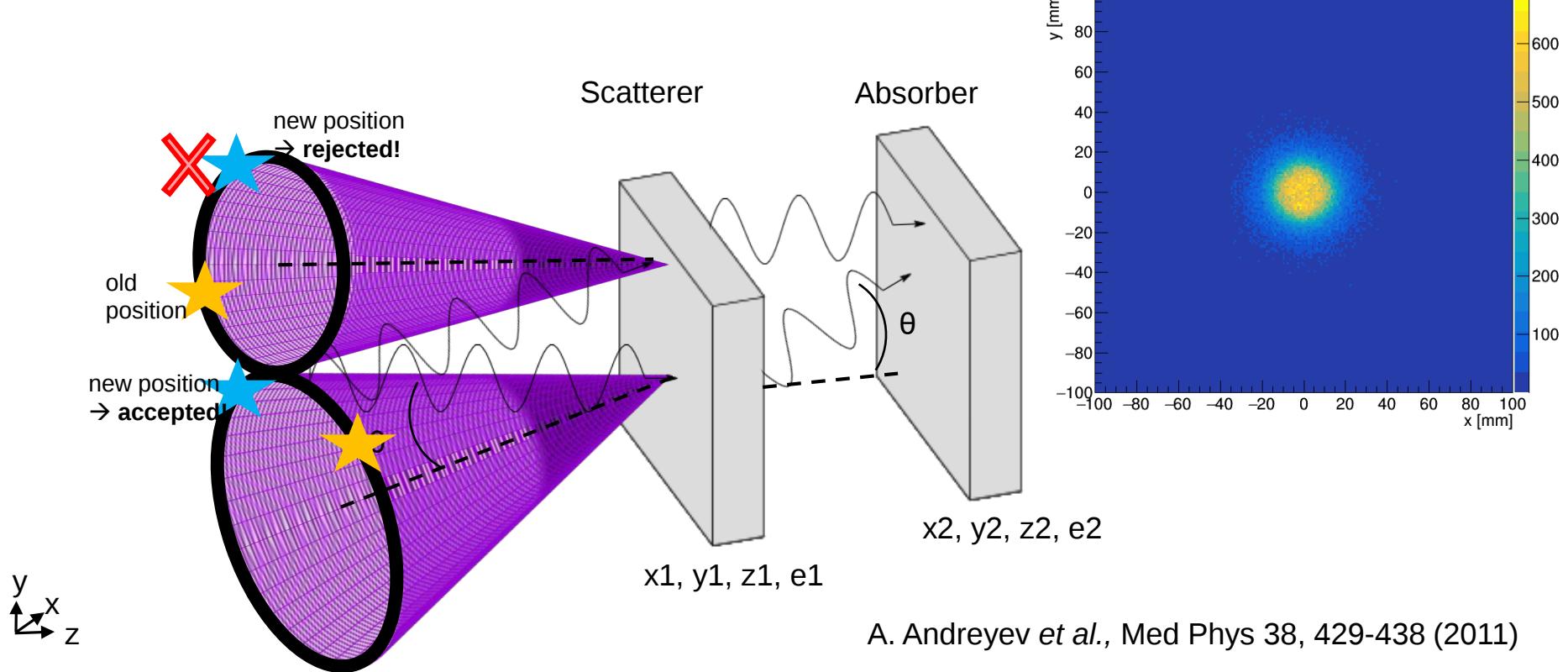


Iterative image reconstruction: Stochastic Origin Ensemble (SOE)



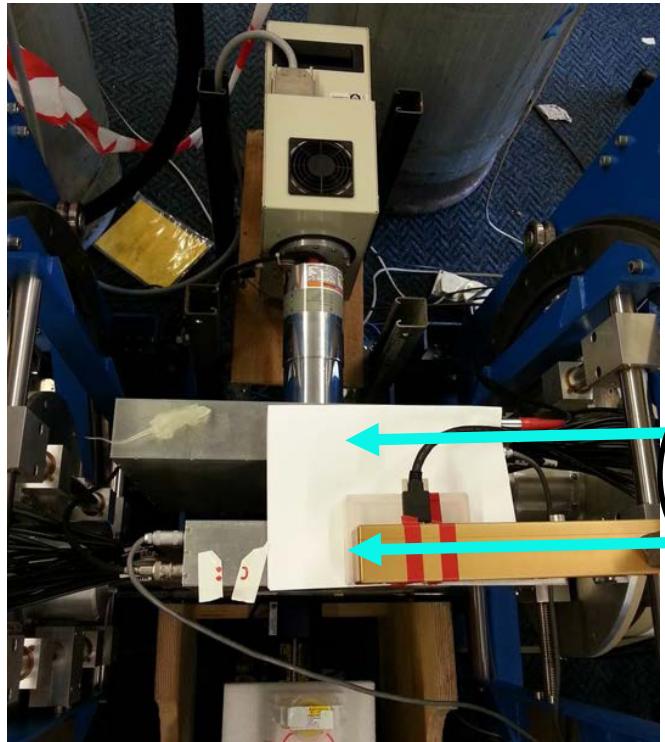
A. Andreyev *et al.*, Med Phys 38, 429-438 (2011)

Iterative image reconstruction: Stochastic Origin Ensemble (SOE)

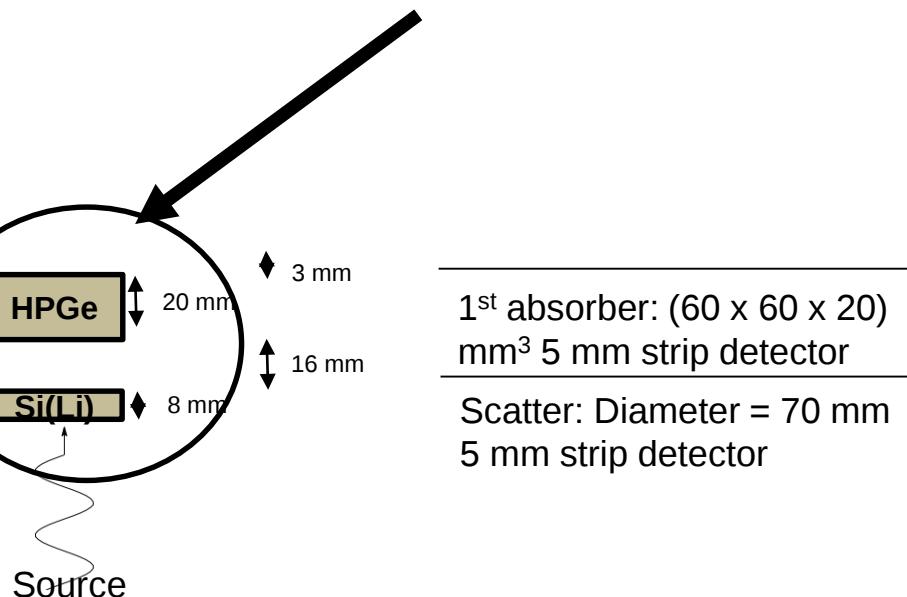


A. Andreyev *et al.*, Med Phys 38, 429-438 (2011)

Development of a semi-conductor camera for proton range verification



Courtesy of the University of Liverpool



Detector derived from ProSPECTus
L.J. Harkness et al. IEEE NSS/MIC conf. Proc.
(2009) 2452.

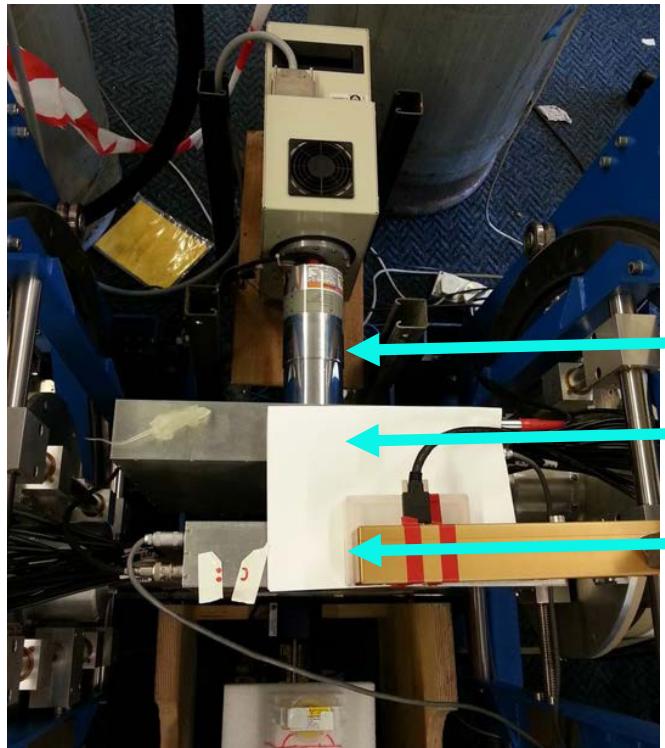
1st absorber: (60 x 60 x 20)
mm³ 5 mm strip detector

Scatter: Diameter = 70 mm
5 mm strip detector

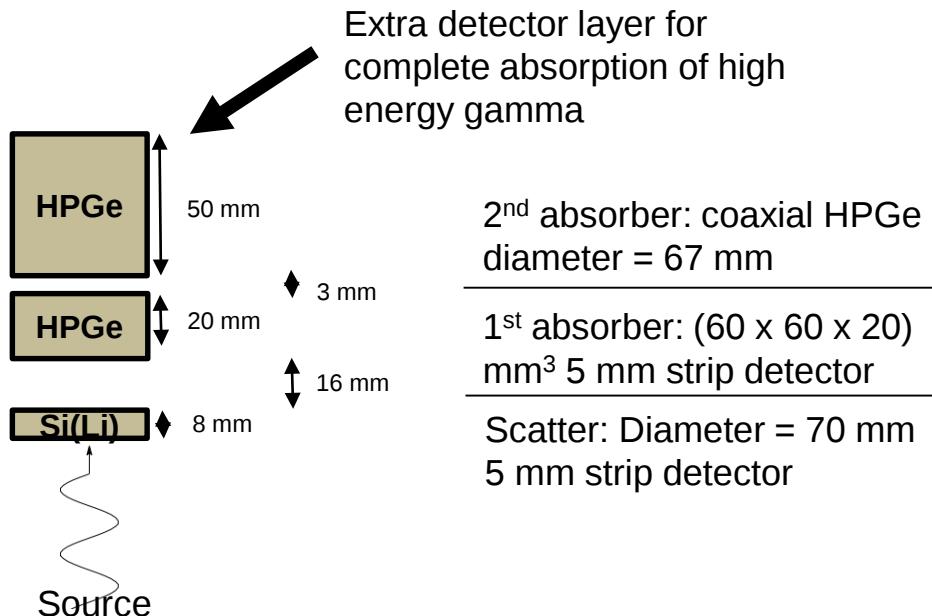
Development of a semi-conductor camera for proton range verification

Collaboration:

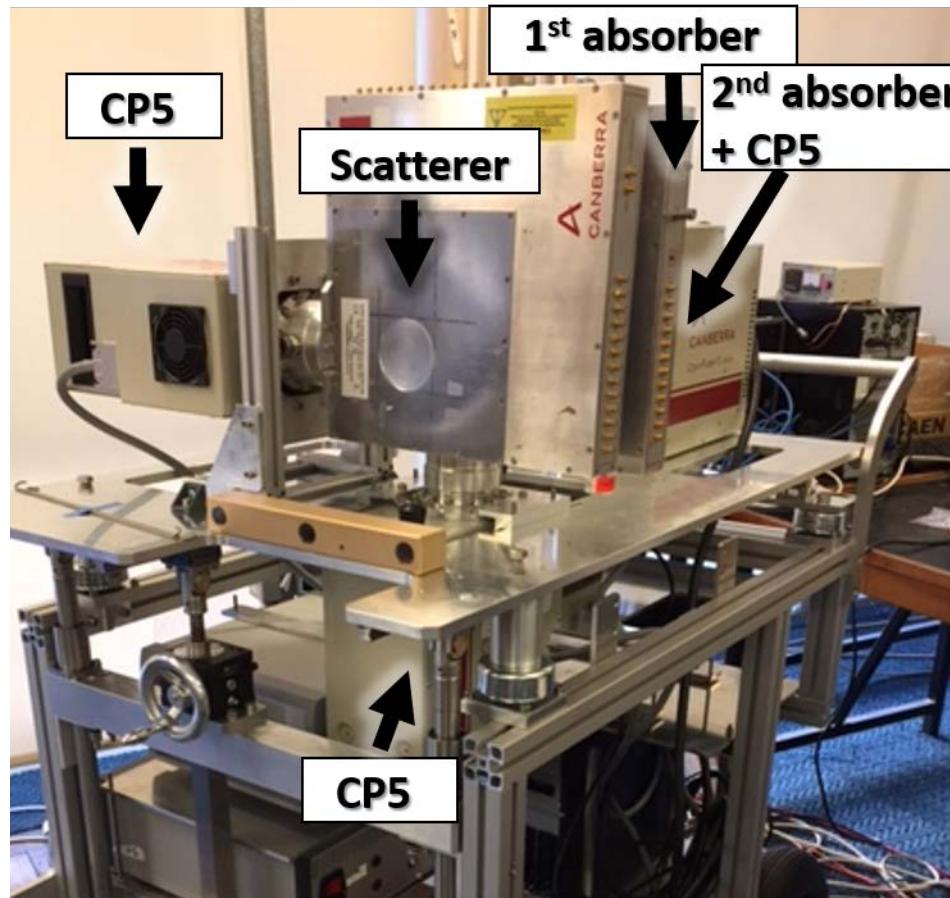
University College London
University of Liverpool
Royal Berkshire NHS Foundation Trust
The Clatterbridge Cancer centre NHS Foundation Trust



Courtesy of the University of Liverpool

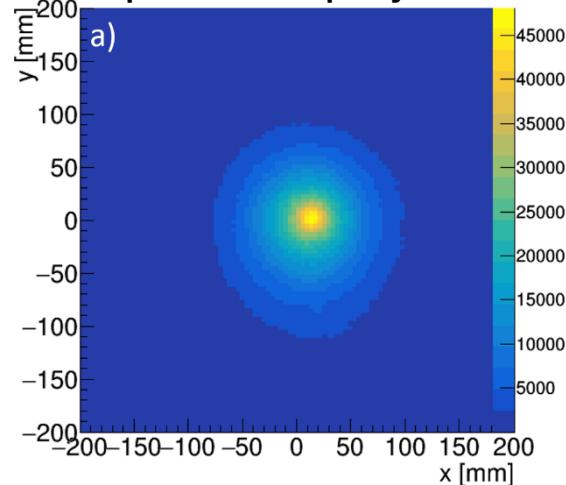


Development of a semi-conductor camera for proton range verification

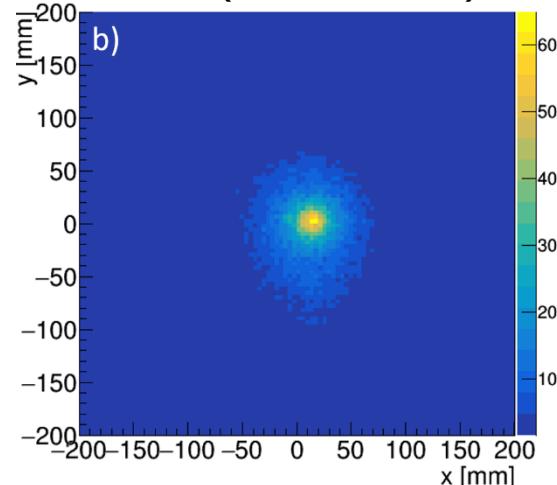


Experiments with ^{88}Y

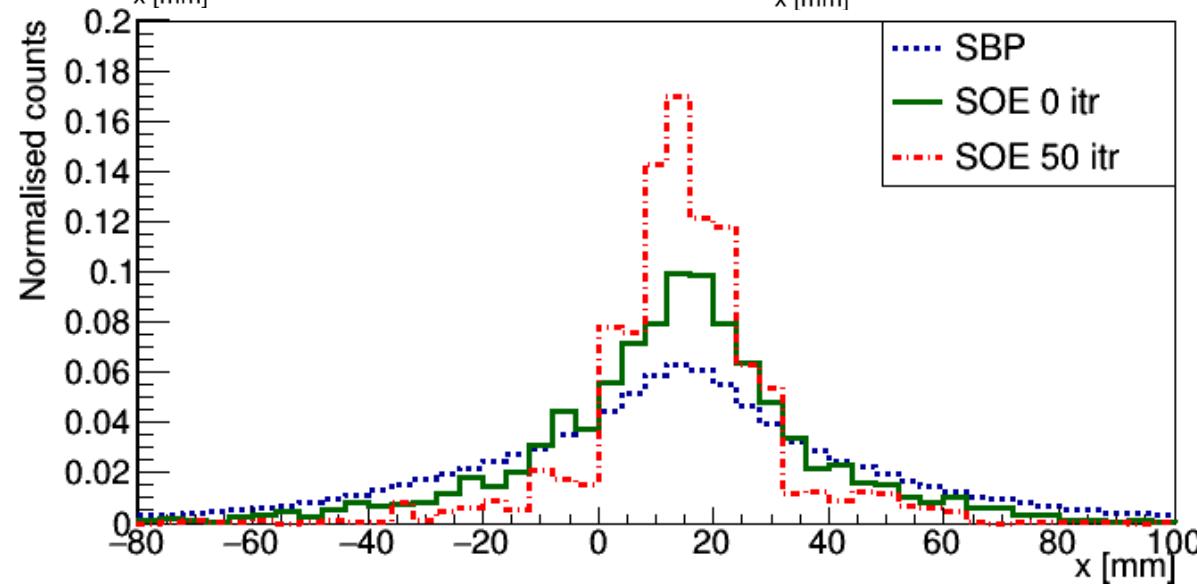
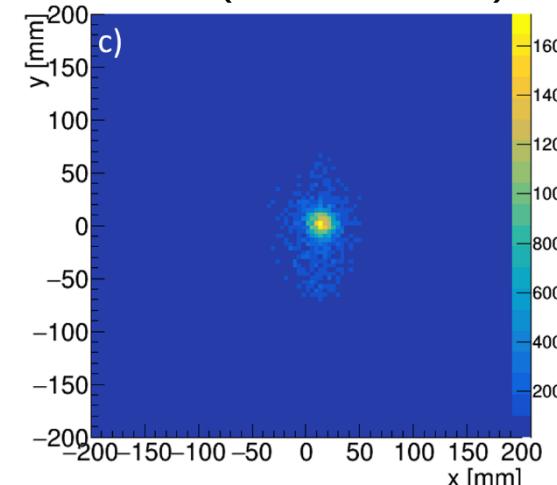
Simple Back-projection



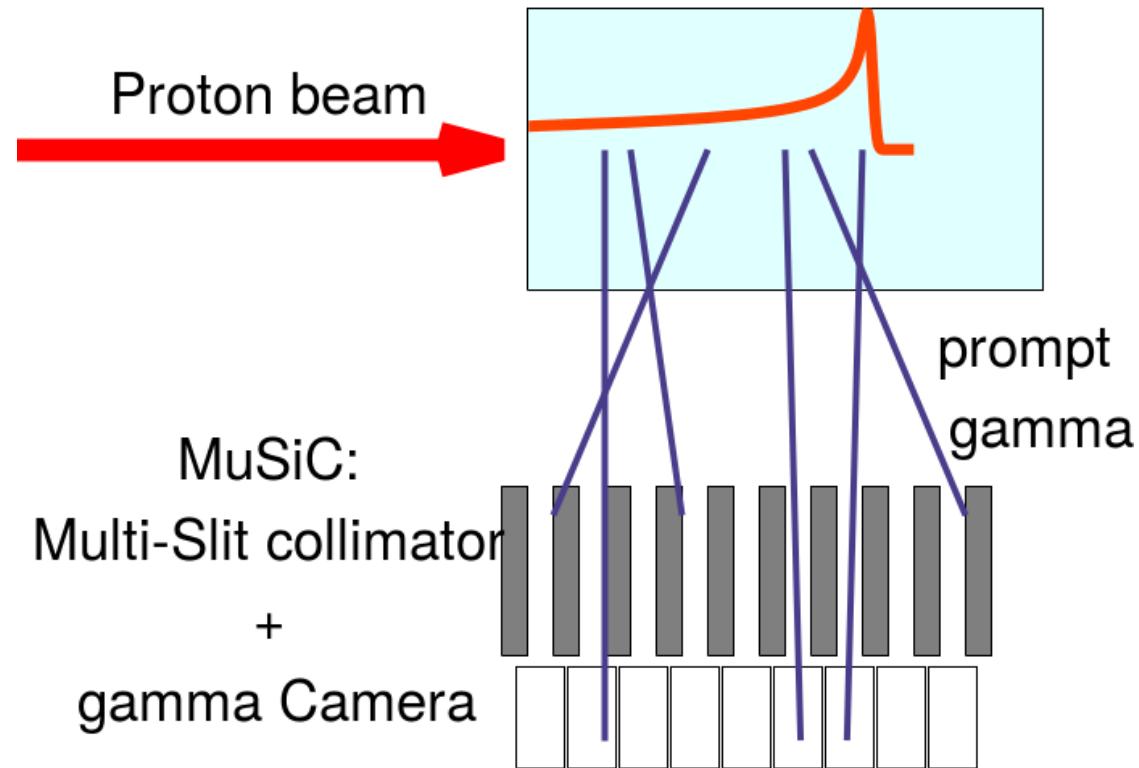
SOE (0 iterations)



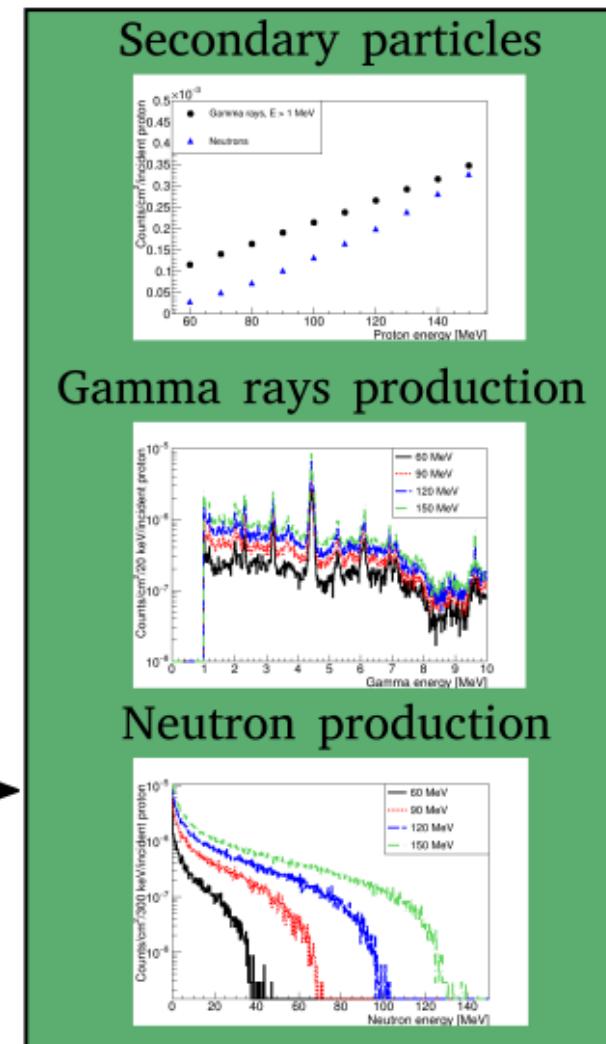
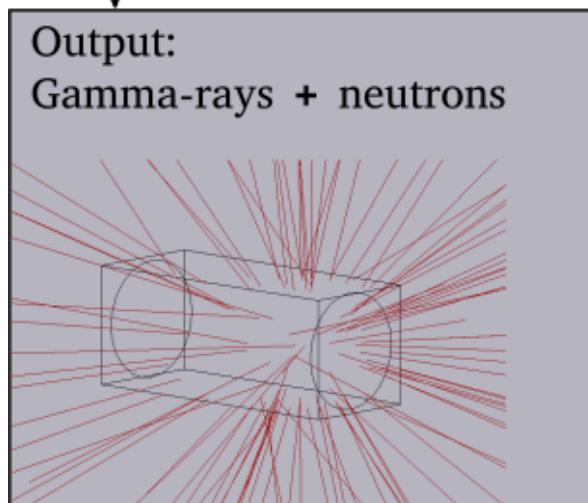
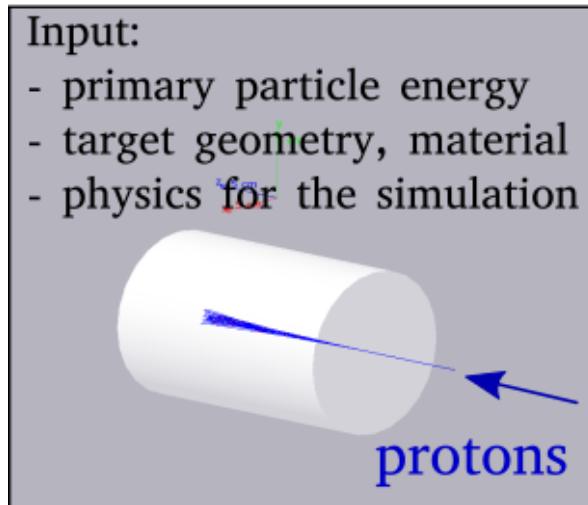
SOE (50 iterations)



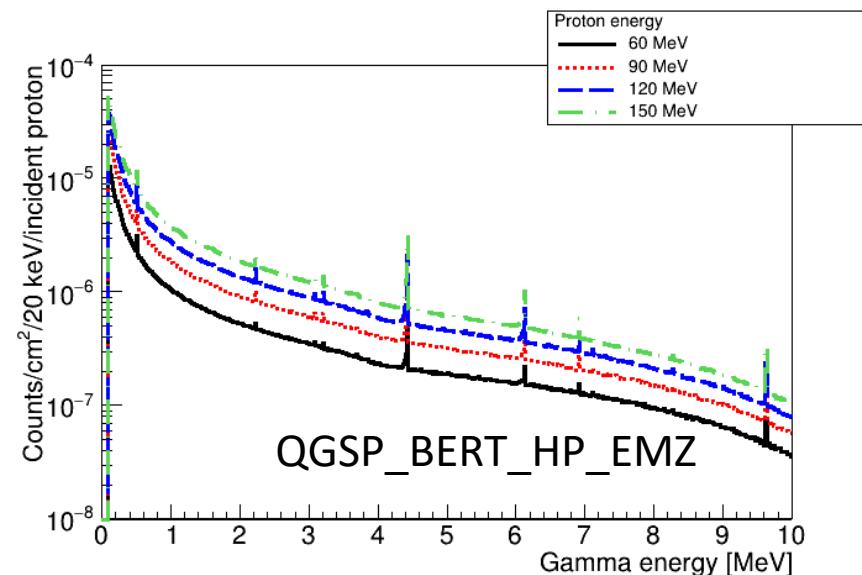
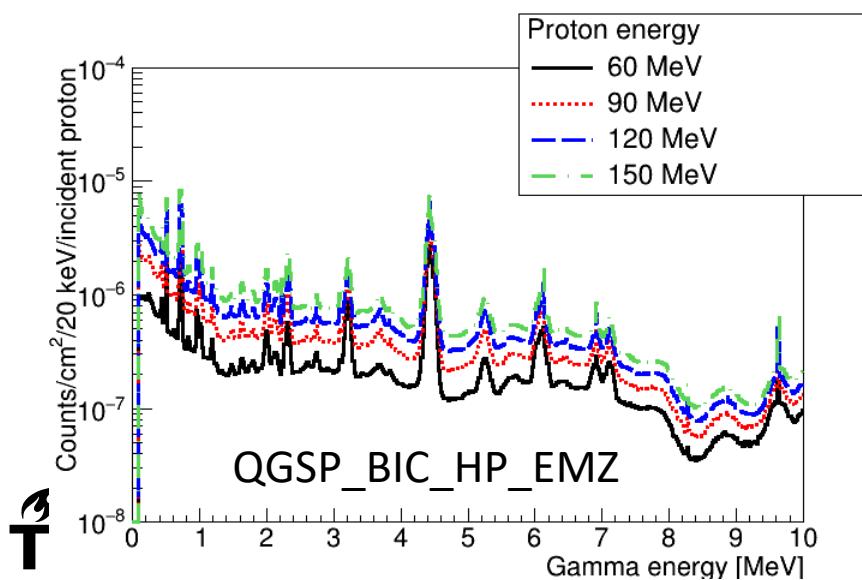
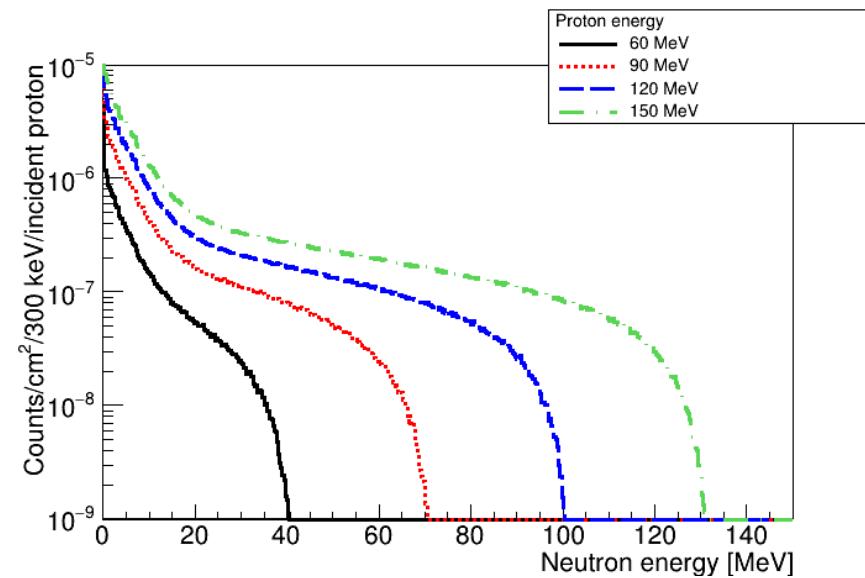
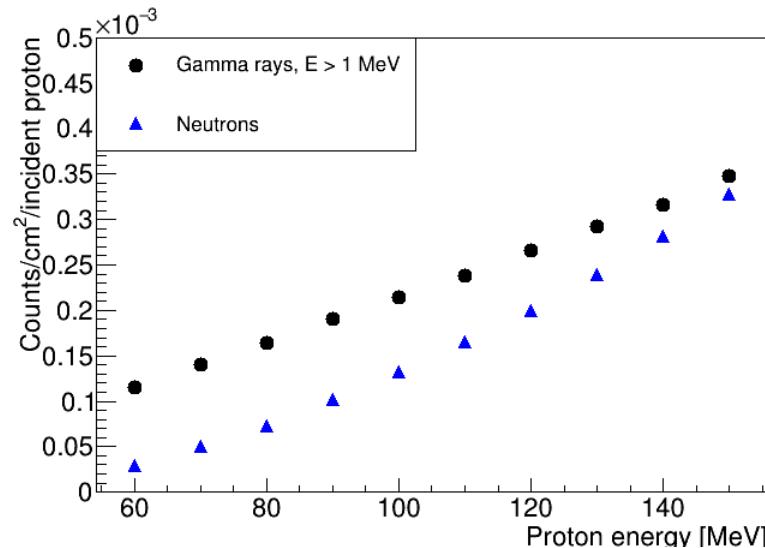
MuSiC: a novel Multi-Slit prompt gamma Camera for in vivo monitoring of proton therapy



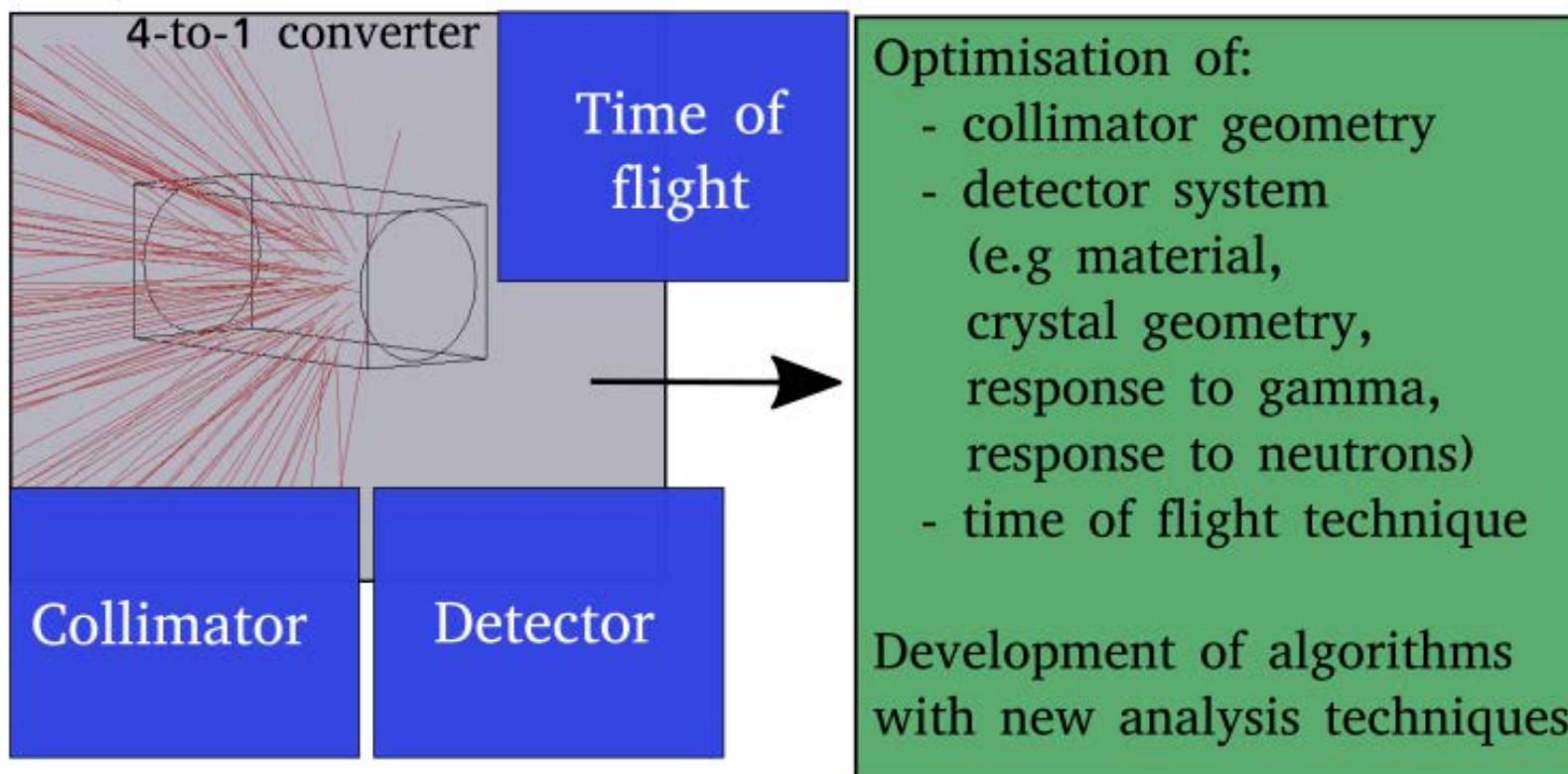
MuSiC Optimiser based on Geant4



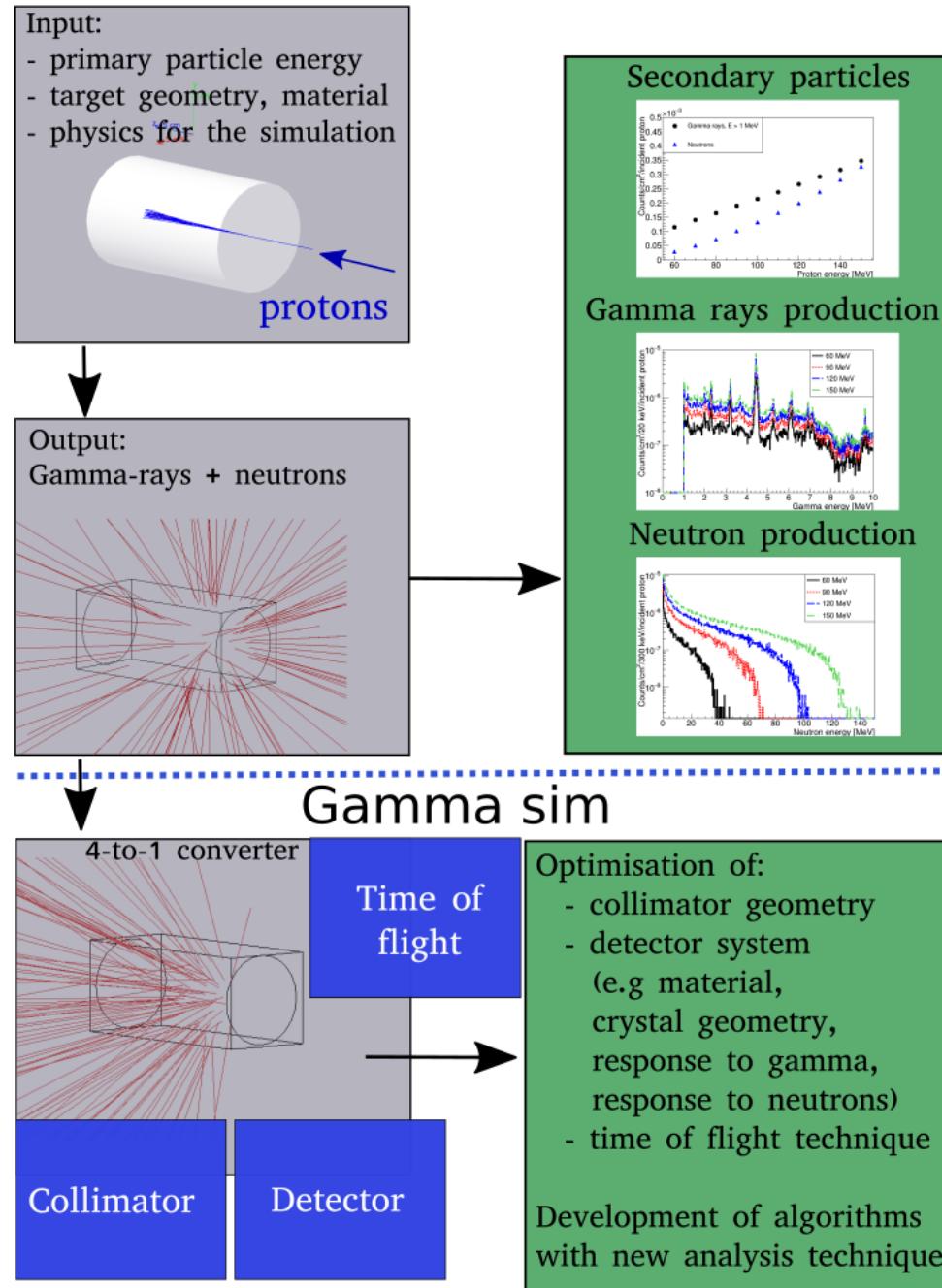
MuSiC Optimiser based on Geant4



MuSiC Optimiser based on Geant4



Proton sim



Thanks!

Acknowledgments:

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 707404.

