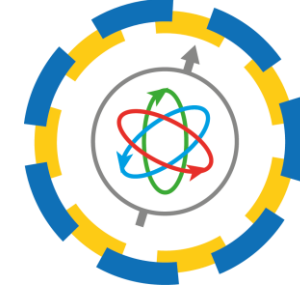




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J-PET

# Reconstruction of photon's interaction position within plastic scintillator based on the WLS strips readout for the Total-Body J-PET

**Szymon Parzych** on behalf of the J-PET Collaboration

Faculty of Physics, Astronomy, and Applied Computer Science, Jagiellonian University, Łojasiewicza  
11, 30-348 Kraków, Poland

Total Body Jagiellonian-PET Laboratory, Jagiellonian University, Kraków, Poland  
Center for Theranostics, Jagiellonian University, Poland

**4<sup>th</sup> Jagiellonian Symposium**  
**on Advances in Particle Physics and Medicine**  
**Kraków, 13.07.2022**



Republic  
of Poland



Foundation for  
Polish Science

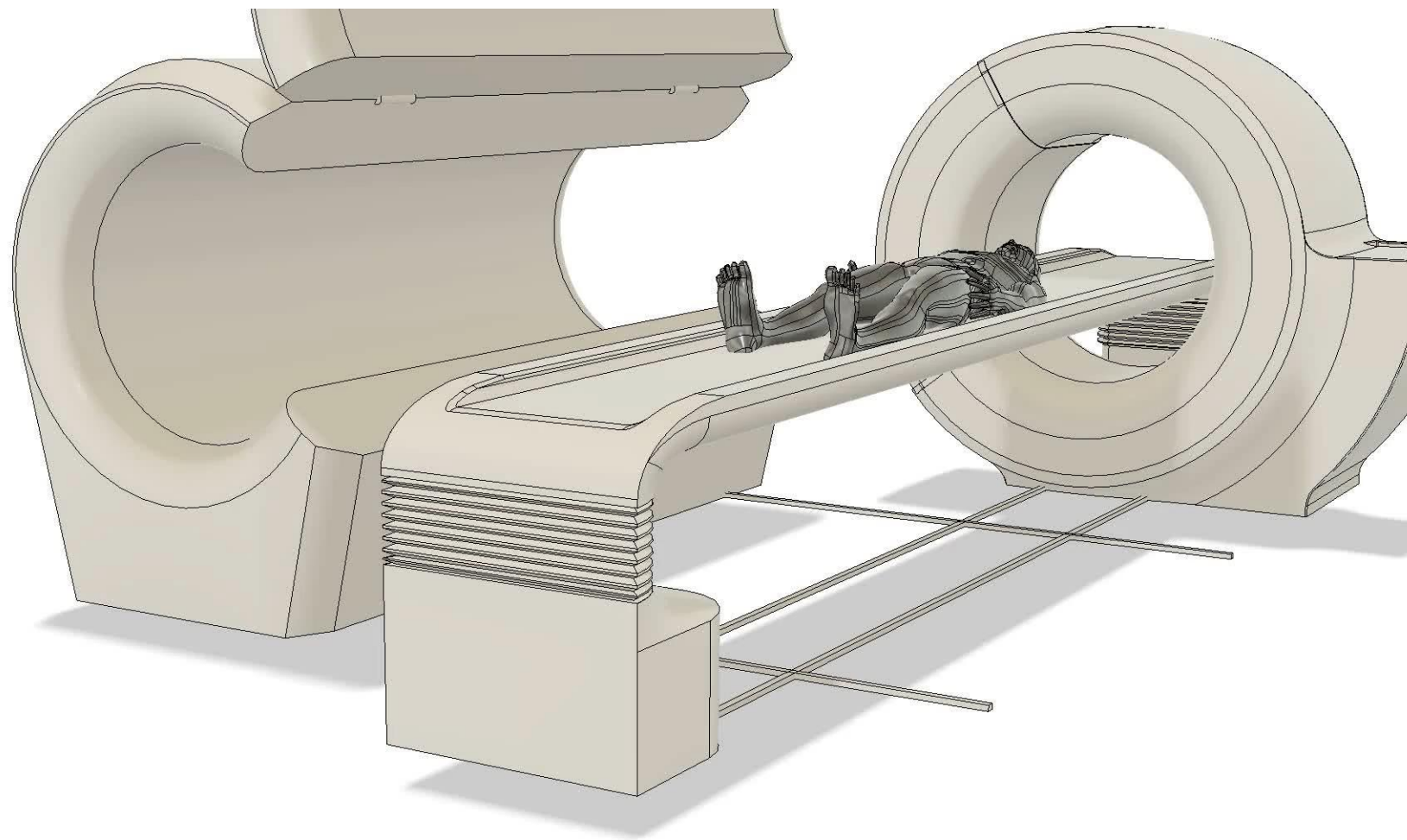
European Union  
European Regional  
Development Fund



# Total-Body J-PET from plastic scintillators



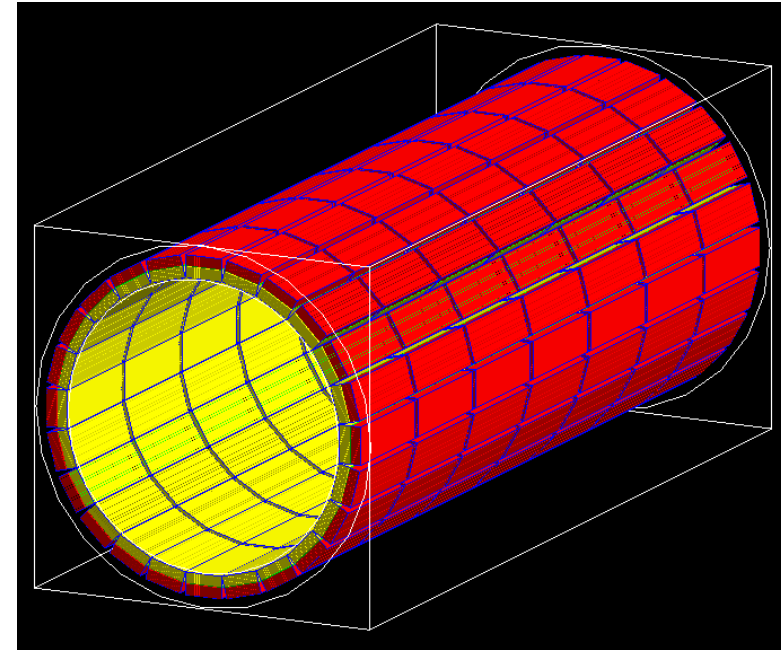
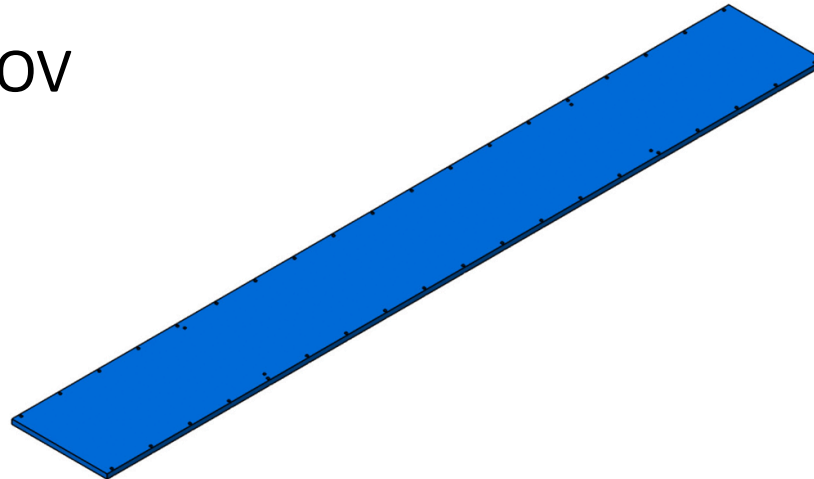
# Total-Body J-PET from plastic scintillators



# Total-Body J-PET from plastic scintillators

## Total-Body J-PET:

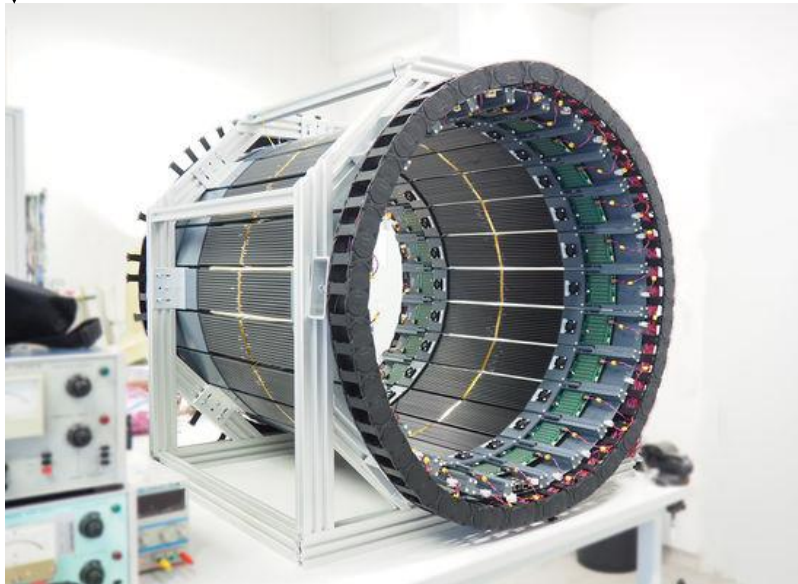
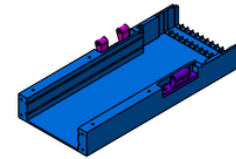
- 16 ( $6 \times 30 \text{ mm}^2$ ) plastic scintillator strips per layer
- 2 layers per module
- 1 layer of (dimensions) wavelength-shifting (WLS) strips per module
- 24 modules per ring
- 7 rings each of 33 cm AFOV
- 2 cm gap between rings
- Total AFOV = 243 cm



# On a way to the Total-Body J-PET

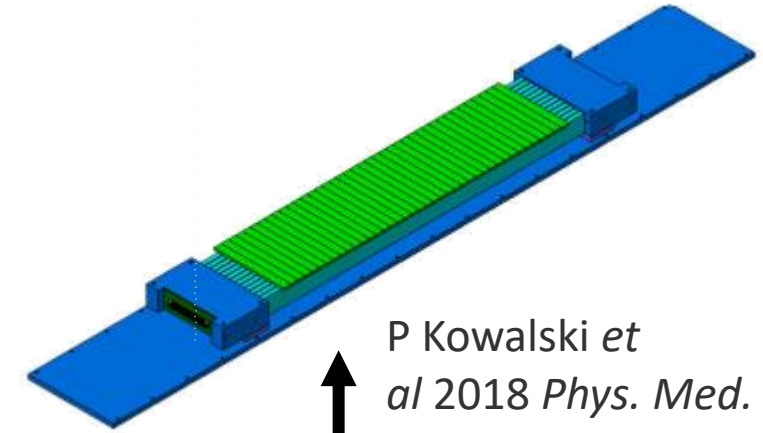
Currently commissioned J-PET:

- 13 ( $6 \times 24 \text{ mm}^2$ ) scintillators per layer
- 1 layer per module
- 24 modules per ring
- 1 ring of 50 cm AFOV



Simulated J-PET:

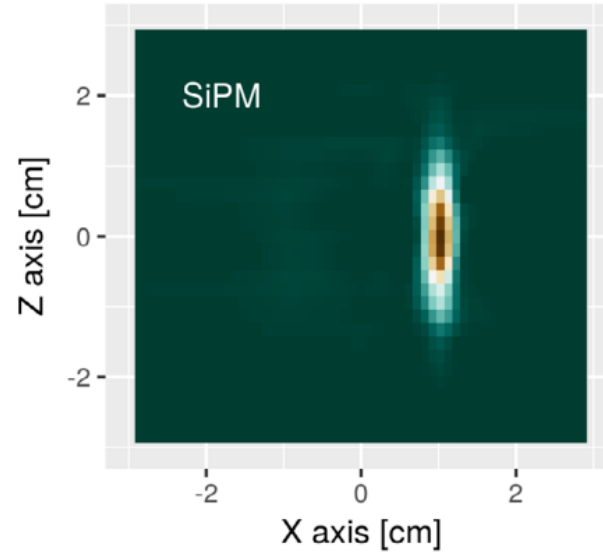
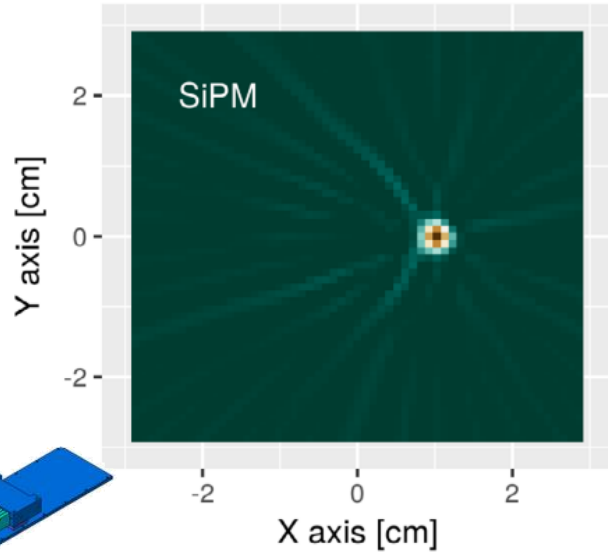
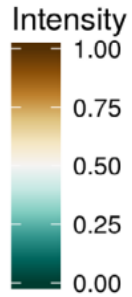
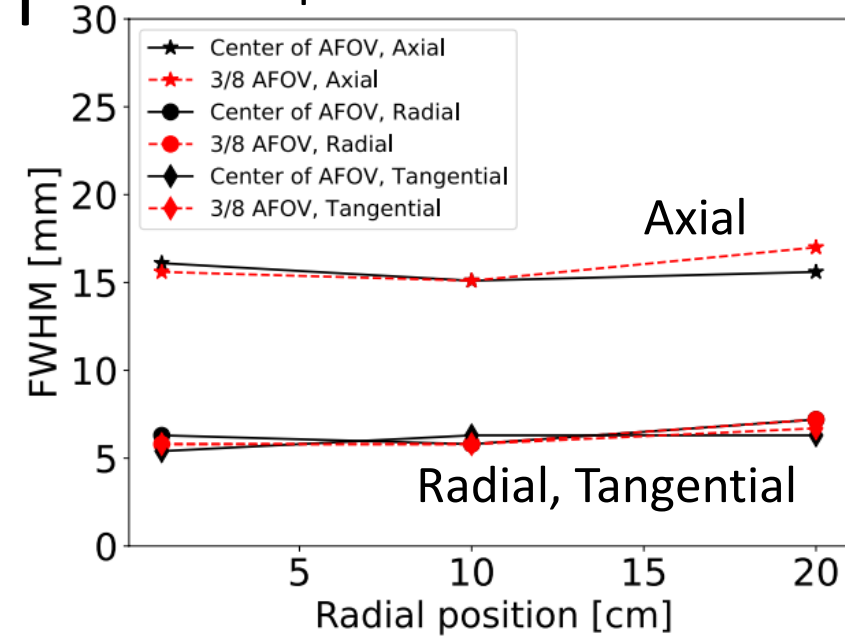
- $7 \times 20 \text{ mm}^2$  scintillators per layer
- 1 layer per module
- 1 layer of WLS per module
- 24 modules per ring
- 1 ring of 50 cm AFOV



P Kowalski *et al* 2018 *Phys. Med. Biol.* **63** 165008

# On a way to the Total-Body J-PET

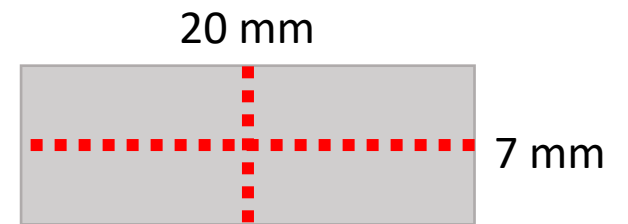
Spatial resolution expressed as FWHM of PSF



Hit axial position (along the strip) with resolution of 22 mm

Nucl. Instr. and Meth. A 764 (2014) 317-321

*z'* information NOT used  
DOI NOT used



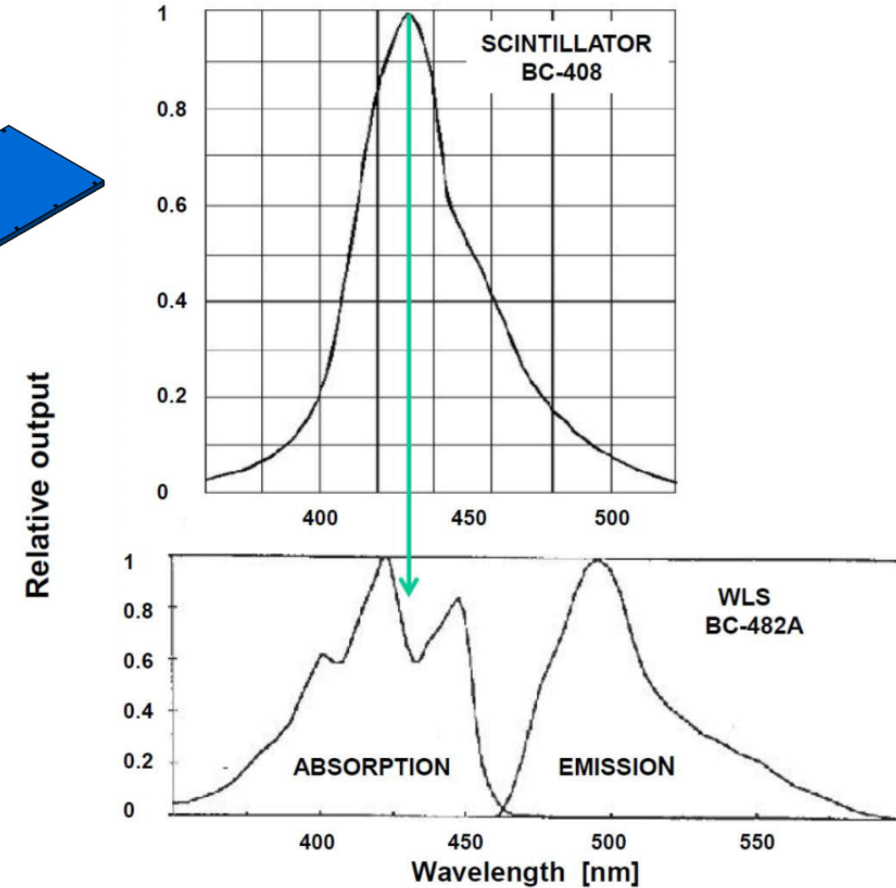
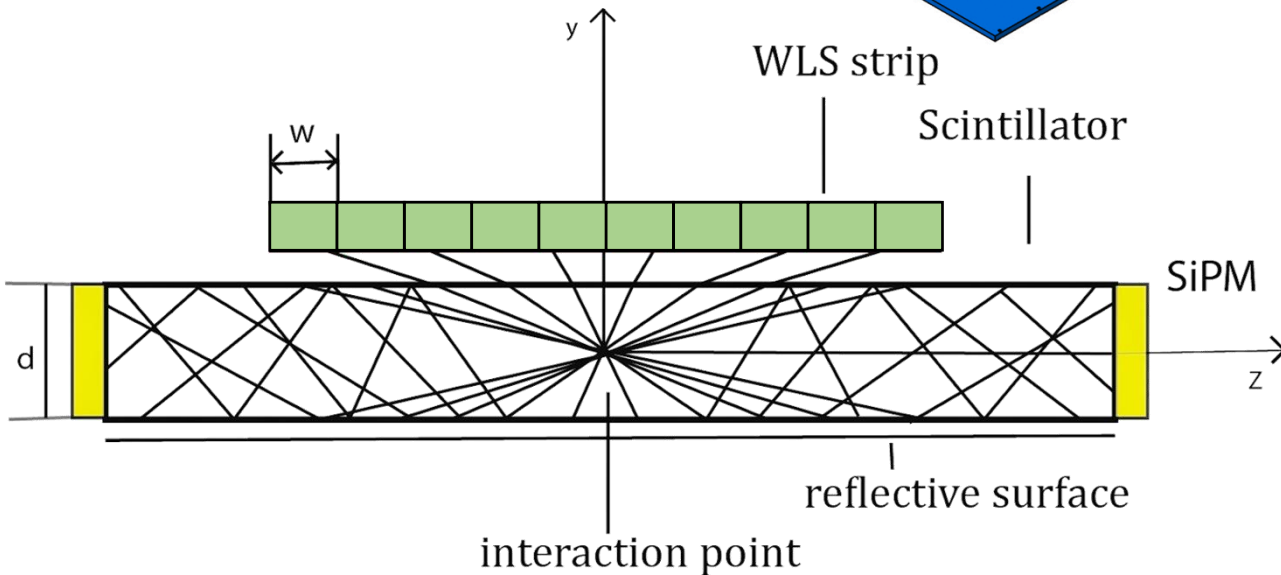
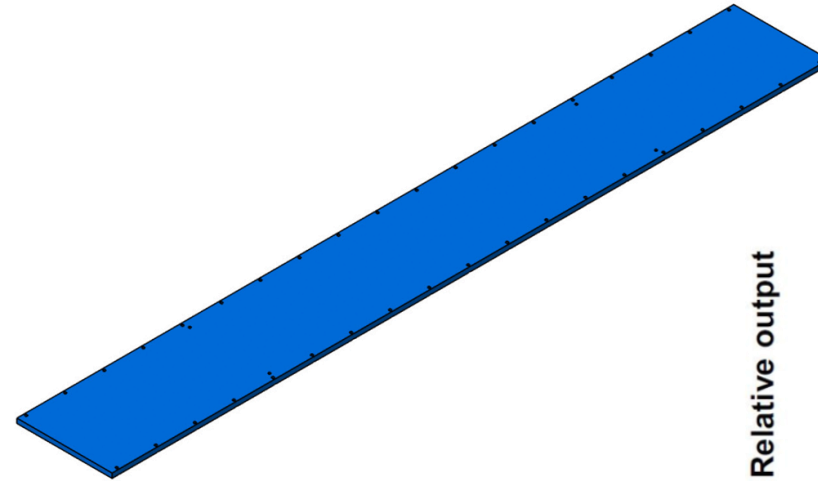
Hit transaxial position estimated as center of the scintillator in the transaxial cross section

Simulated J-PET:

- 7×20 mm<sup>2</sup> scintillators per layer
- 1 layer per module
- 1 layer of WLS per module
- 24 modules per ring
- 1 ring of 50 cm AFOV

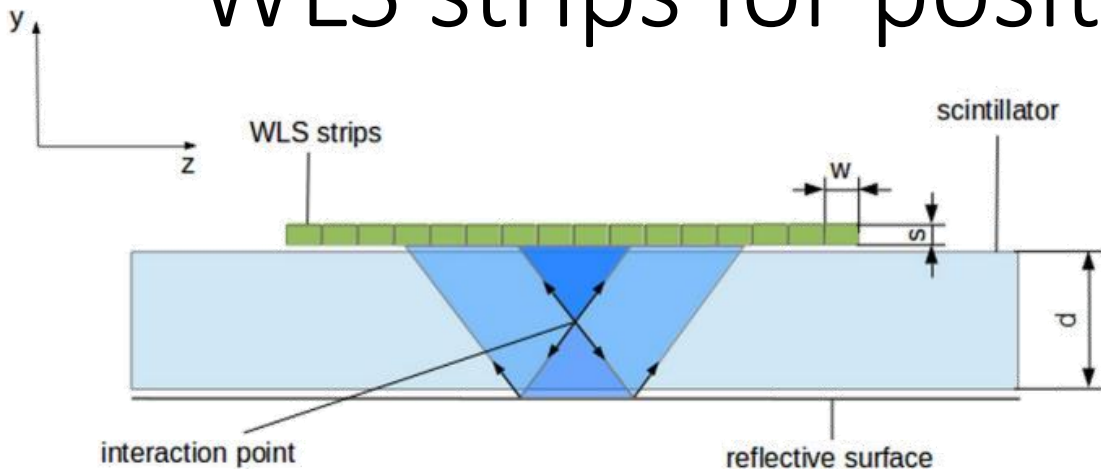
# WLS strips for position determination

Utilization of an array of parallel WLS strips oriented perpendicularly to the scintillator strips

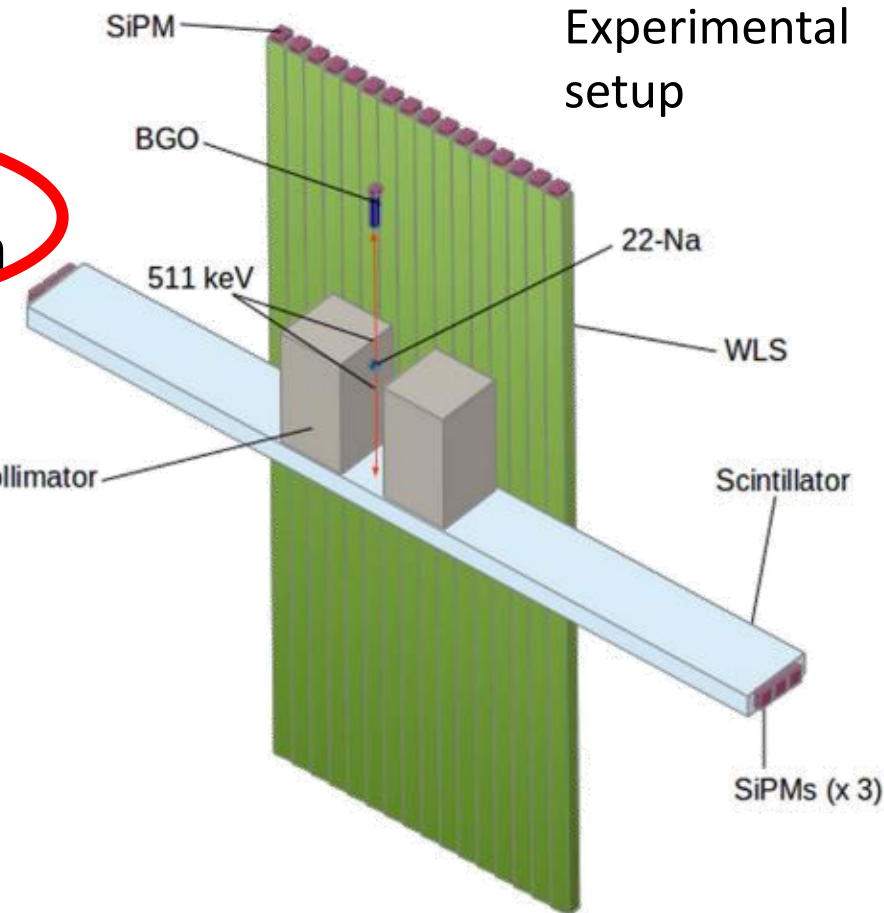
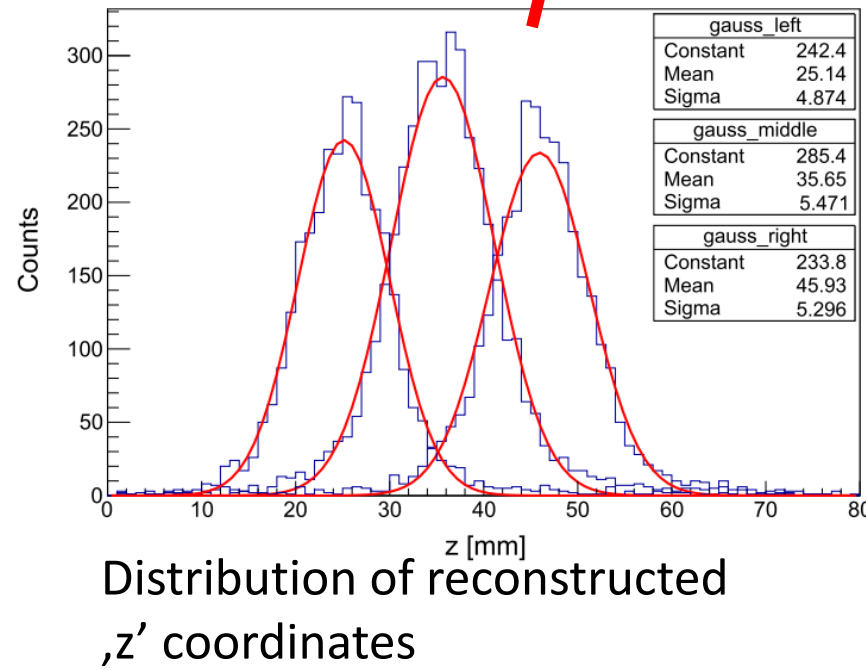
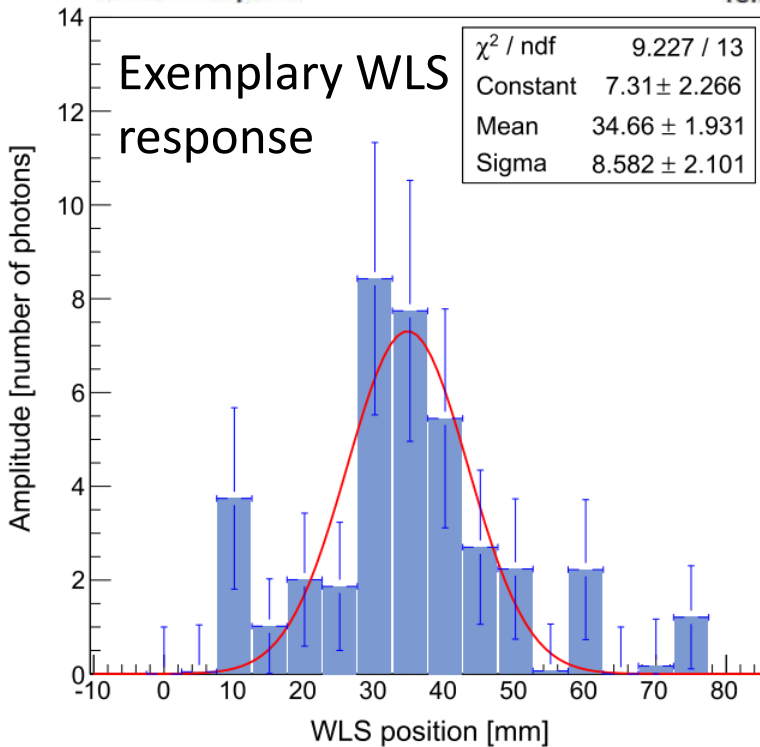


Bio-Algorithms and Med-Systems  
10 (2014) 59

# WLS strips for position determination



**$z'$  resolution of FWHM = 11.8 mm**

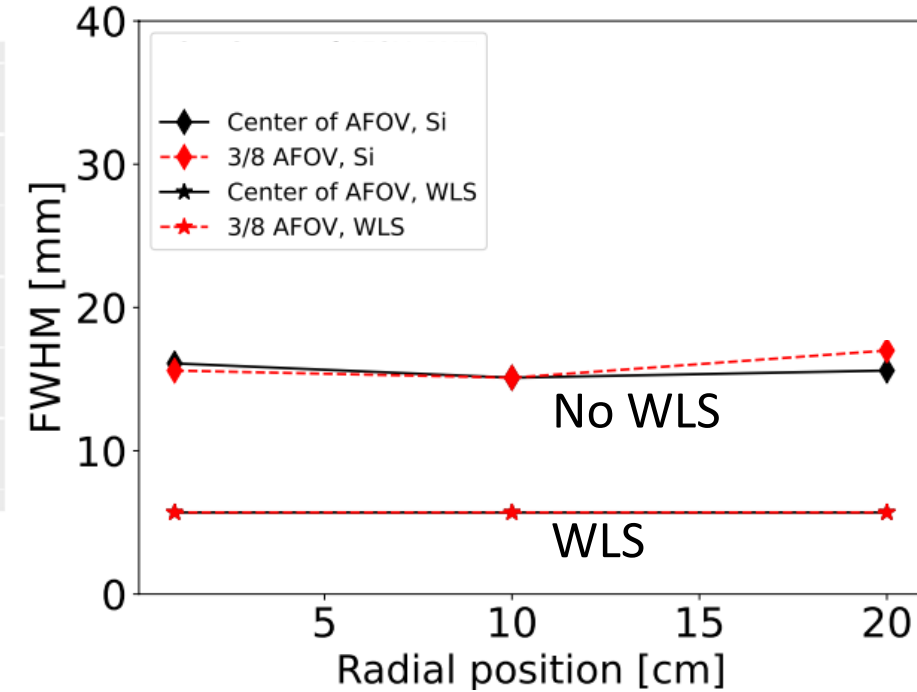
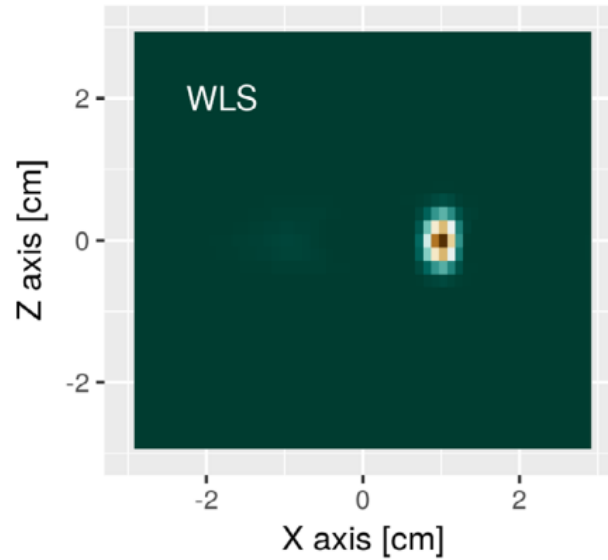
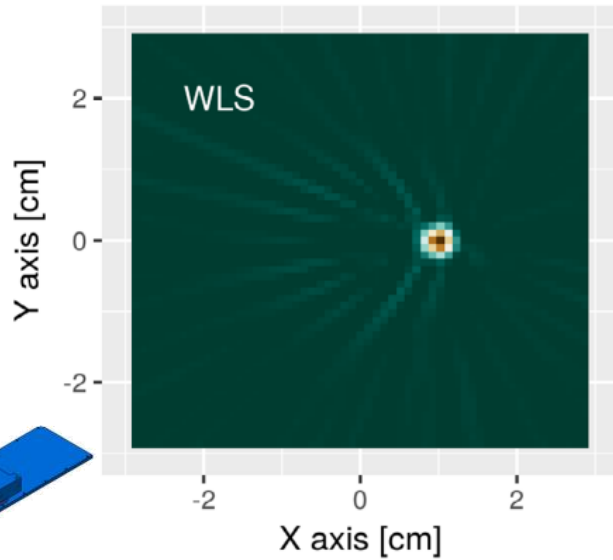
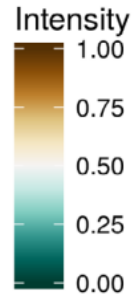


- $300 \times 19 \times 5 \text{ mm}^3$  BC-420 scintillator strip
- 16 BC-482A WLS strips ( $5 \times 3 \times 100 \text{ mm}^3$ )



# On a way to the Total-Body J-PET

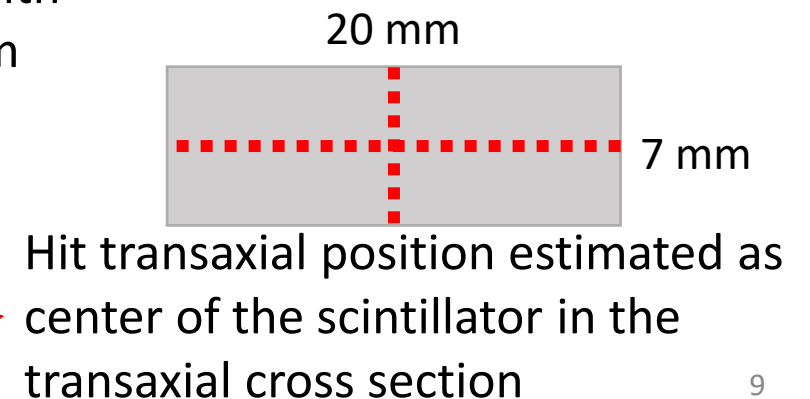
**Axial** resolution expressed as FWHM of PSF



Hit axial position (along the strip) with resolution of 5 mm

P Kowalski et al 2018 Phys. Med. Biol. 63 165008

**,z' information IS used  
DOI NOT used**



Simulated J-PET:

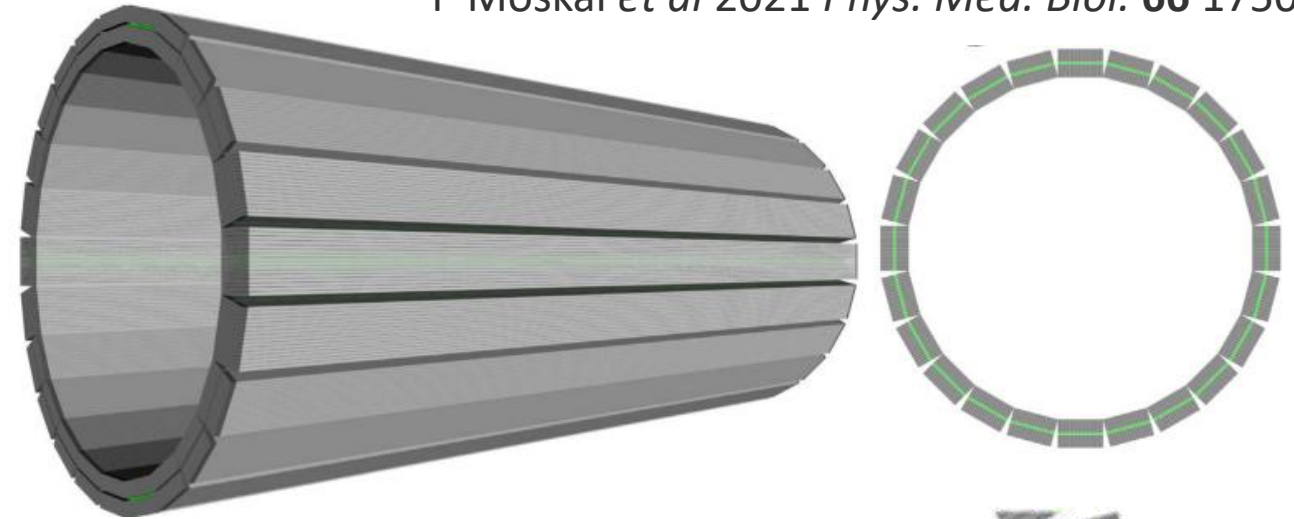
- 7×20 mm<sup>2</sup> scintillators per layer
- 1 layer per module
- 1 layer of WLS per module
- 24 modules per ring
- 1 ring of 50 cm AFOV

# On a way to the Total-Body J-PET

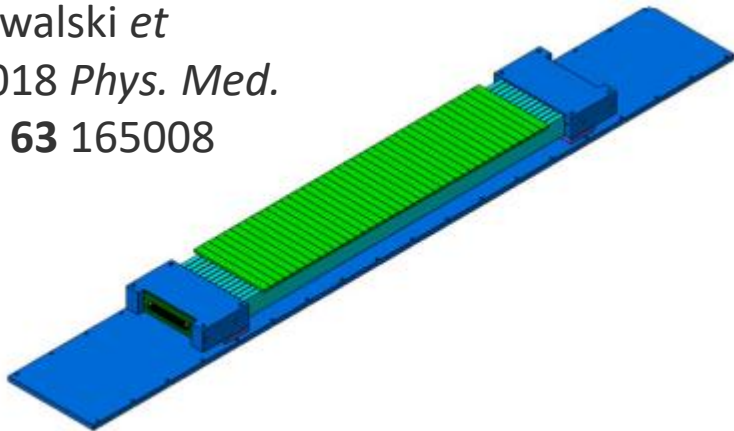
P Moskal *et al* 2021 *Phys. Med. Biol.* **66** 175015

## Simulated J-PET:

- 7×20 mm<sup>2</sup> scintillators per layer
- 1 layer per module
- 1 layer of WLS per module
- 24 modules per ring
- 1 ring of 50 cm AFOV

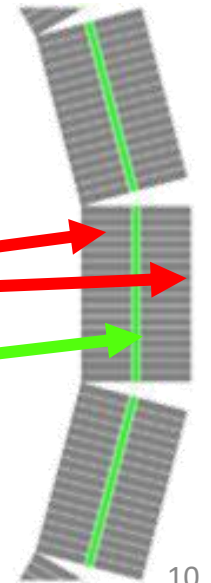


P Kowalski *et al* 2018 *Phys. Med. Biol.* **63** 165008



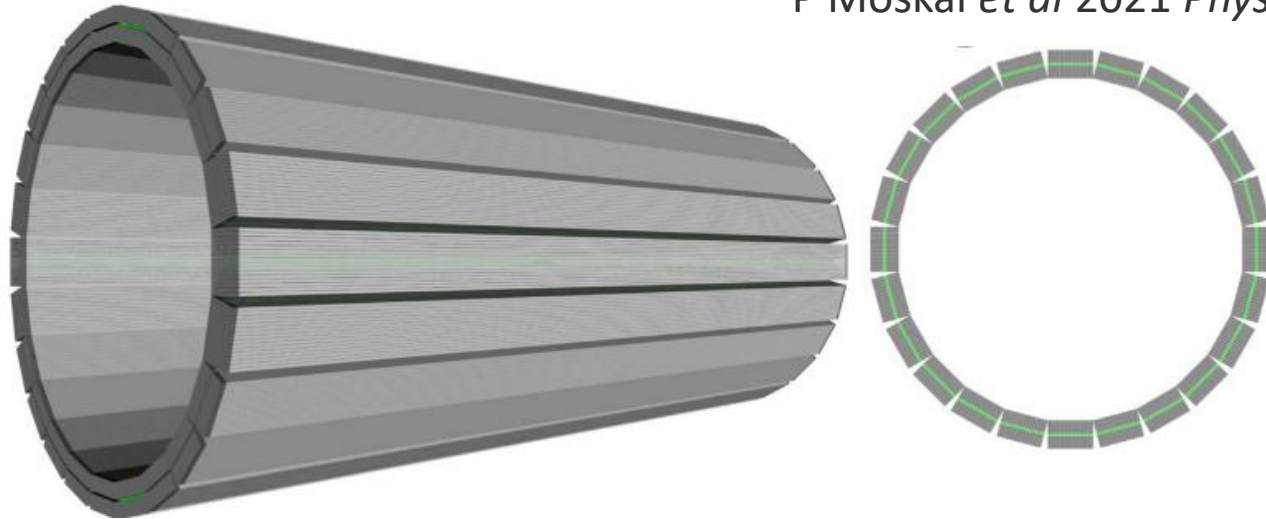
## Simulated Total-Body J-PET:

- 16 (6×30 mm<sup>2</sup>) scintillators per layer
- 2 layer per module
- 1 layer of WLS per module
- 24 modules per ring
- 1 ring of 200 cm AFOV



# On a way to the Total-Body J-PET

P Moskal *et al* 2021 *Phys. Med. Biol.* 66 175015



Simulated Total-Body J-PET:

- 16 (6×30 mm<sup>2</sup>) scintillators per layer
- 2 layer per module
- 1 layer of WLS per module
- 24 modules per ring
- 1 ring of 200 cm AFOV

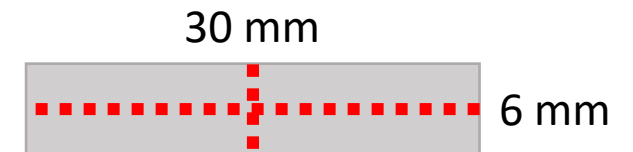
Hit axial position  
(along the strip) with  
resolution of 5 mm

P Kowalski *et al* 2018 *Phys.*  
*Med. Biol.* 63 165008

,z' information IS used  
DOI NOT used

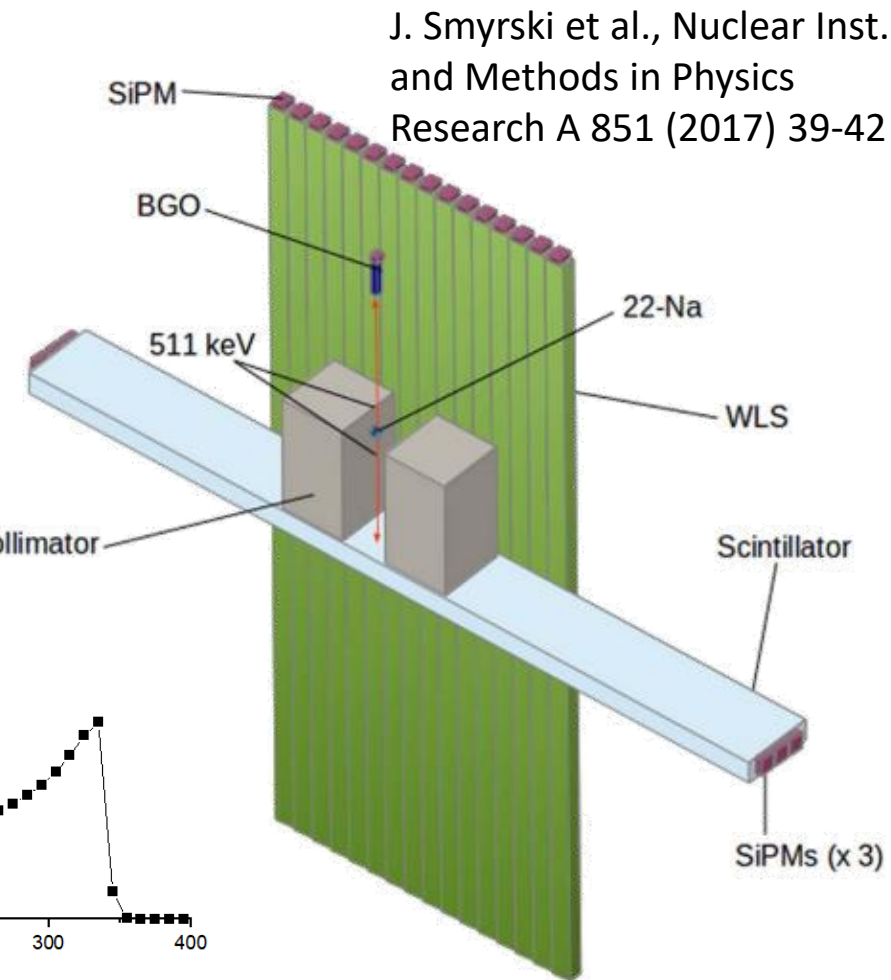
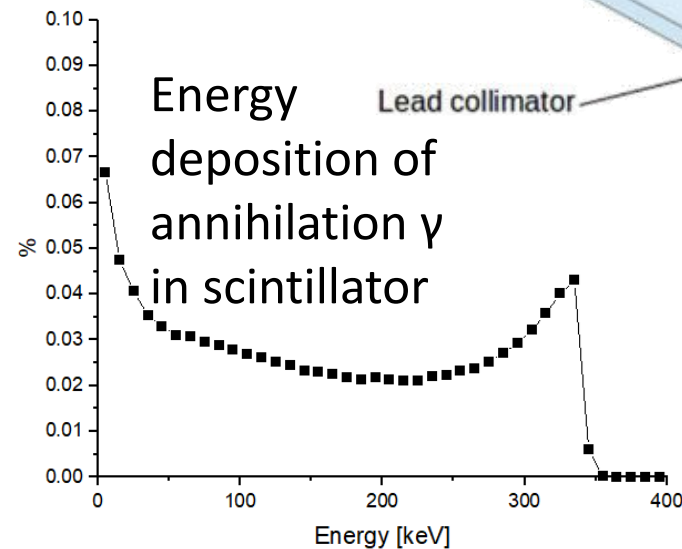
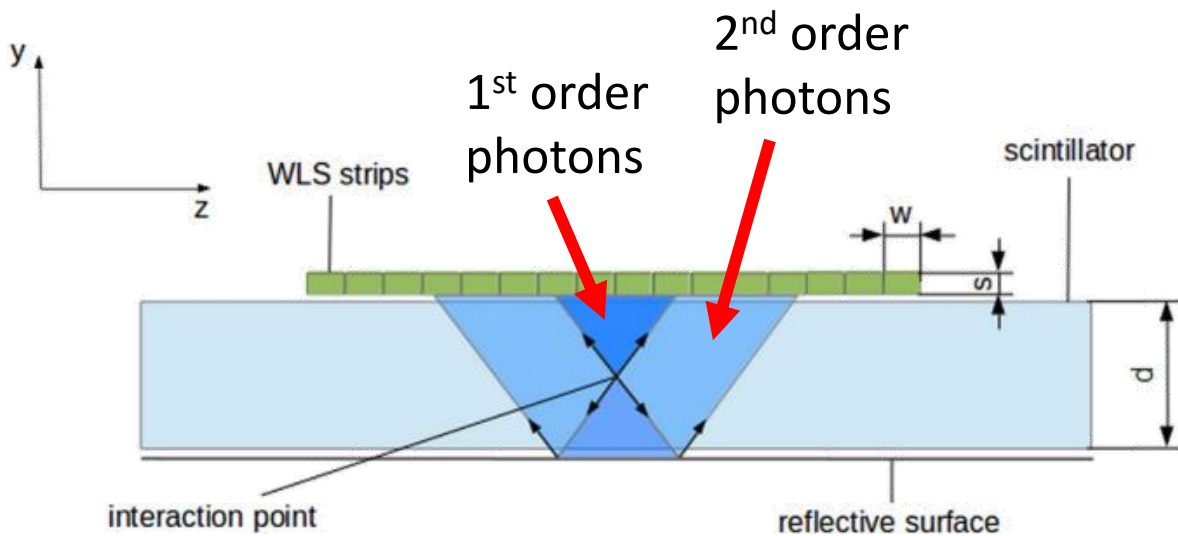
Spatial resolution	FWHM [mm]
Radial	4.8
Tangential	4.8
Axial	7.8

Spatial resolution expressed  
as FWHM of PSF



Hit transaxial position estimated as  
center of the scintillator in the  
transaxial cross section

# Simulation of WLS response



In order to take into account some WLS, geometry and SiPM effect, a number of efficiencies has been added:

- 0.96 - fraction of photons passing the interface air-WLS
- 0.75 - fraction of photons absorbed in WLS
- 0.86 - fluorescence efficiency of WLS

- 0.28 - fraction of confined photons propagating towards one end of a WLS strip
- 0.60 - coverage of WLS face with SiPM
- 0.62 - SiPM fill factor
- 0.35 - photon detection efficiency at 500 nm

# Validation of the simulation method

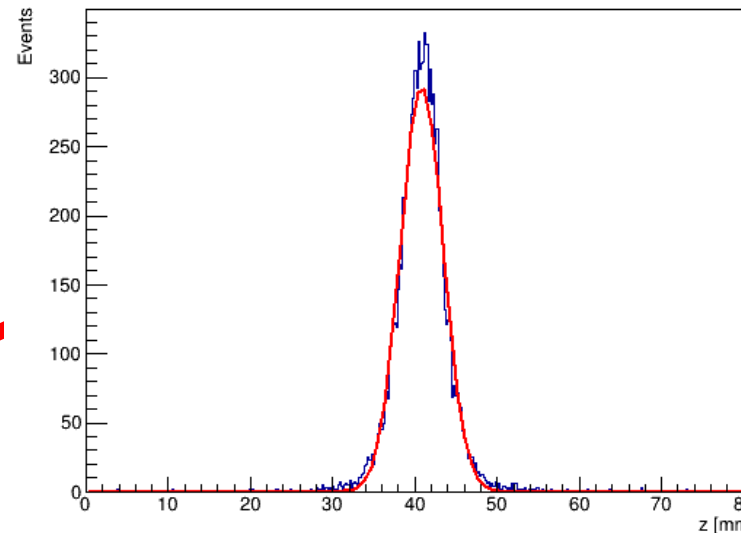
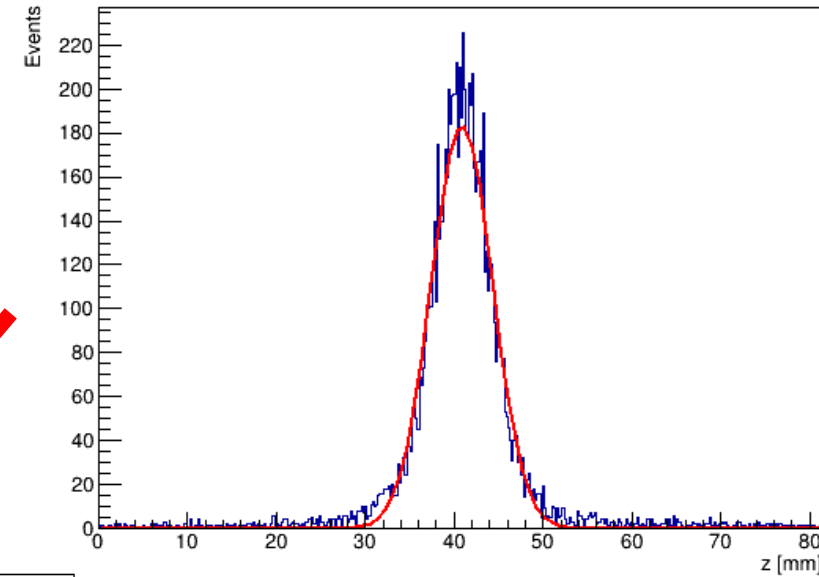
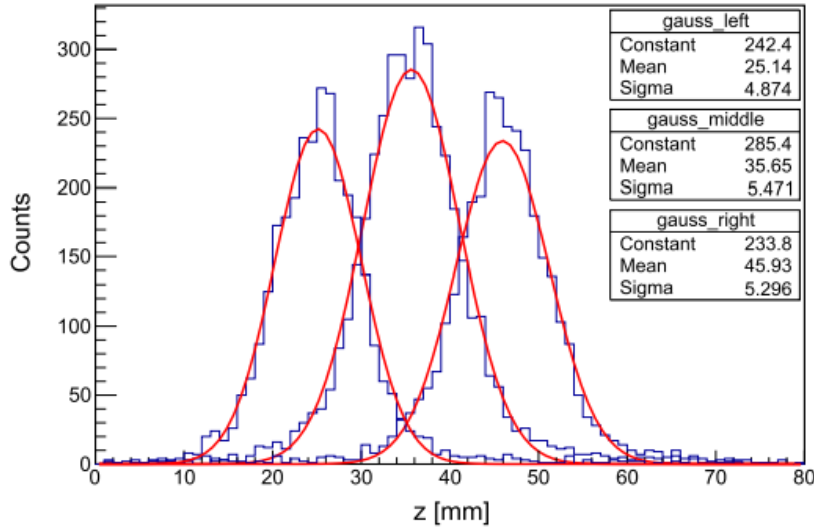
## Article

J. Smyrski et al., Nuclear Inst. and Methods in Physics Research A 851 (2017) 39-42

**FWHM  $\approx$  11.8 mm**

## Simulation

**FWHM = 8.2 mm**



**Simulation with energy threshold**

**FWHM = 6.1 mm**

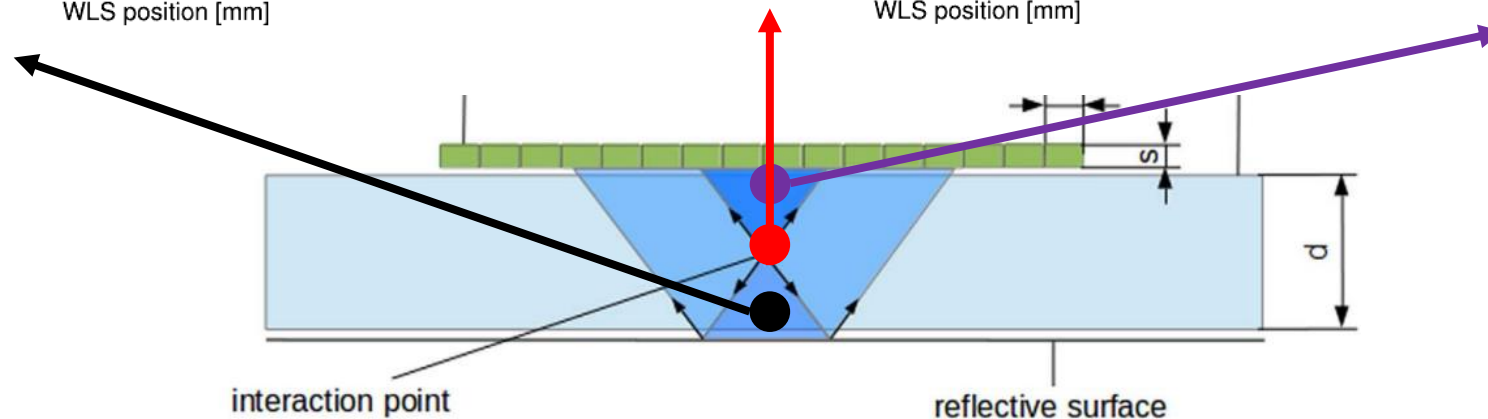
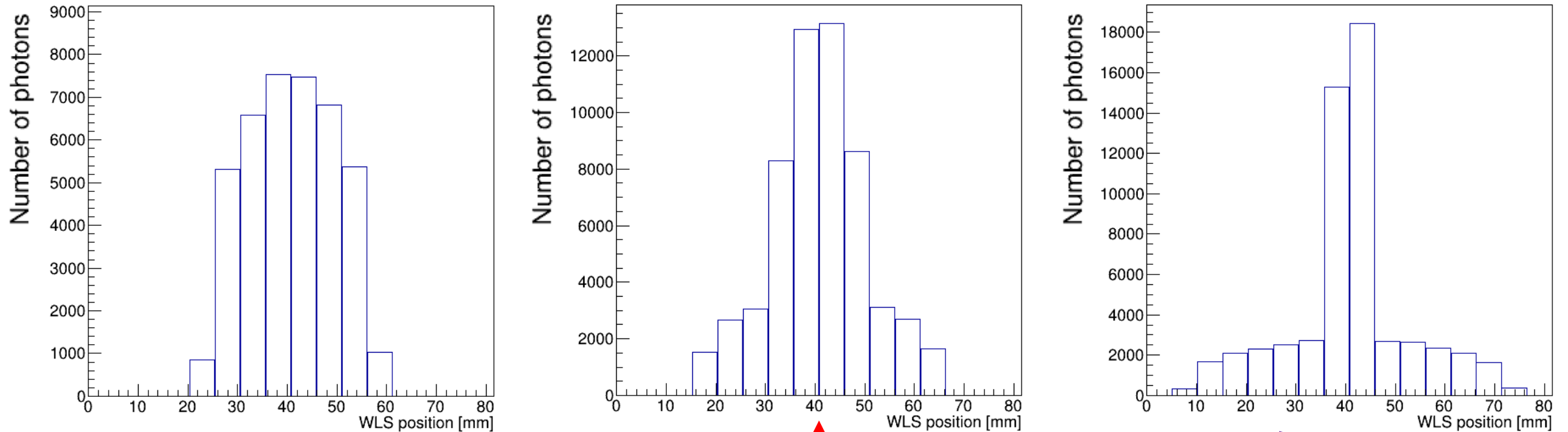
Hit axial position (along the strip) with resolution of 5 mm

P Moskal *et al* 2021 *Phys. Med. Biol.* **66** 175015

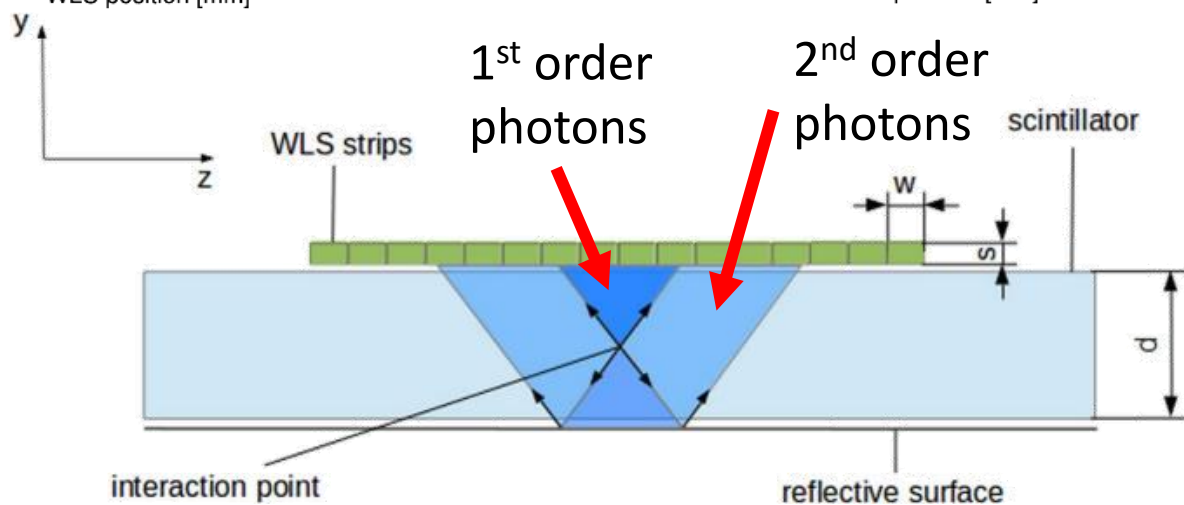
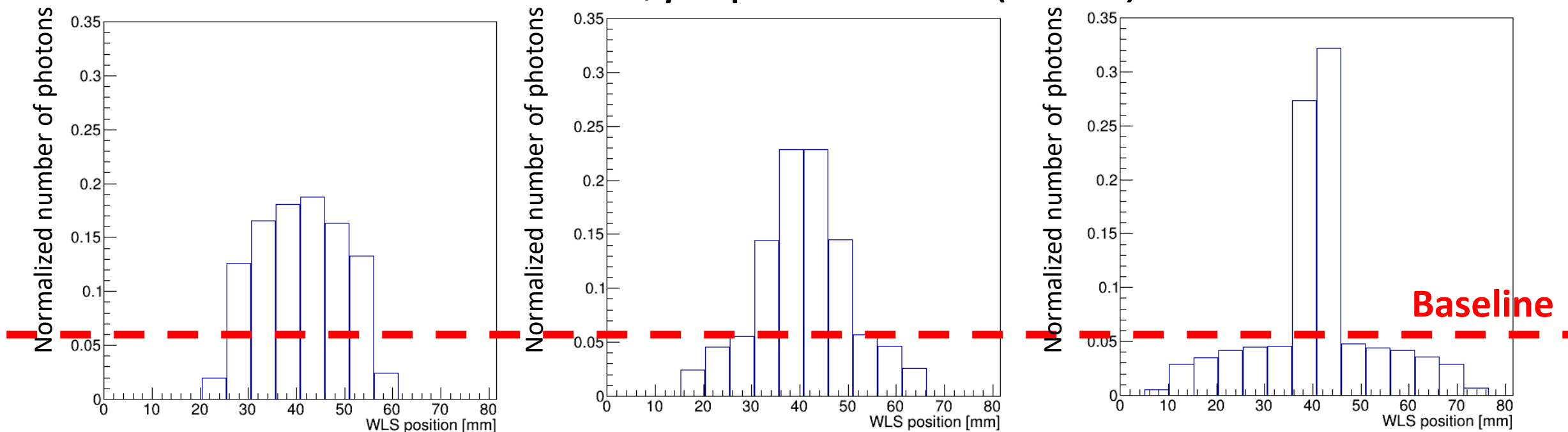
Spatial resolution	FWHM [mm]
Radial	4.8
Tangential	4.8
Axial	7.8

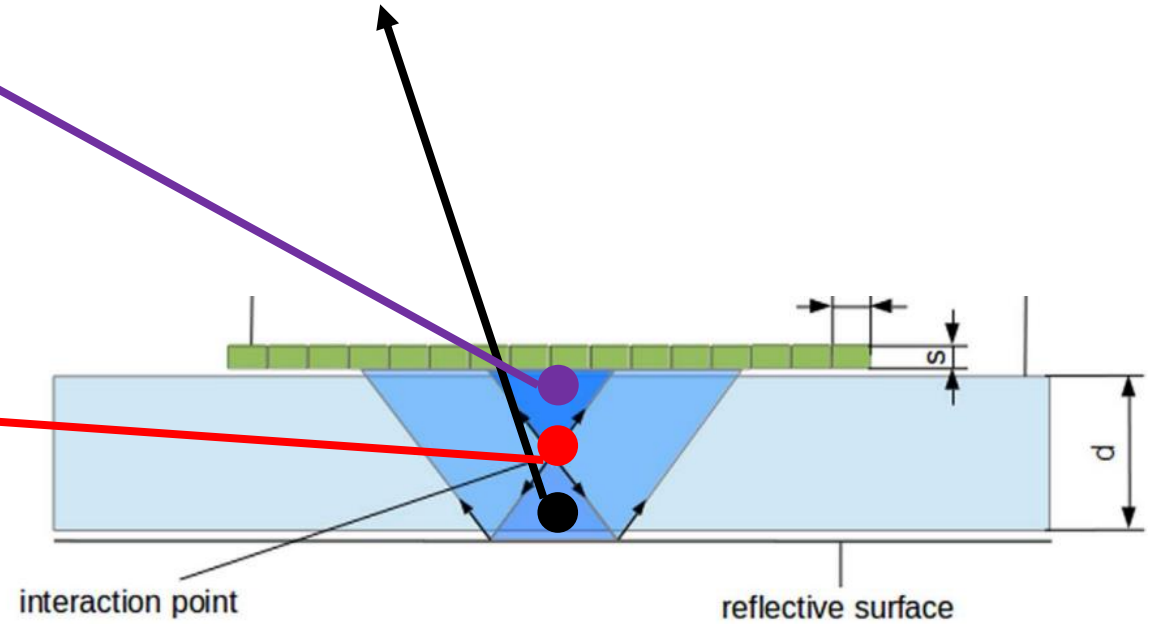
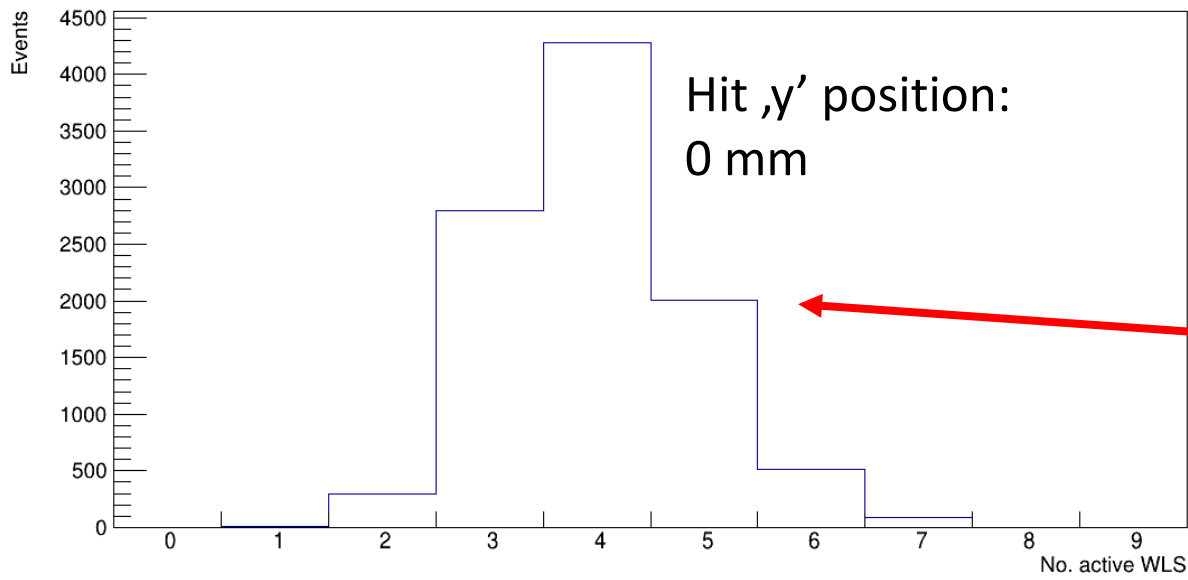
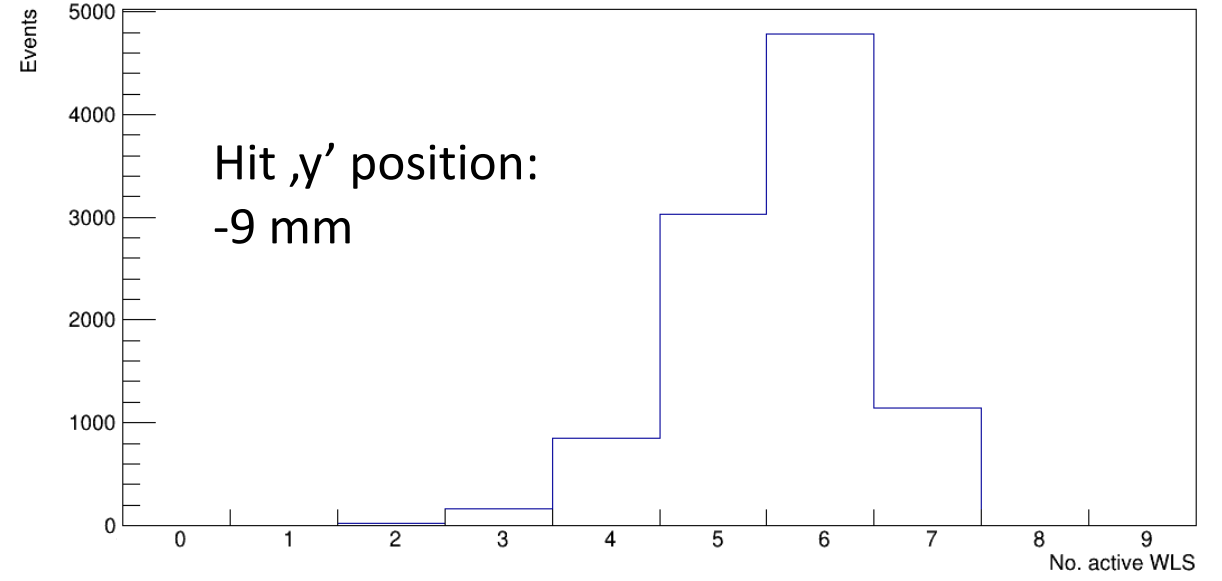
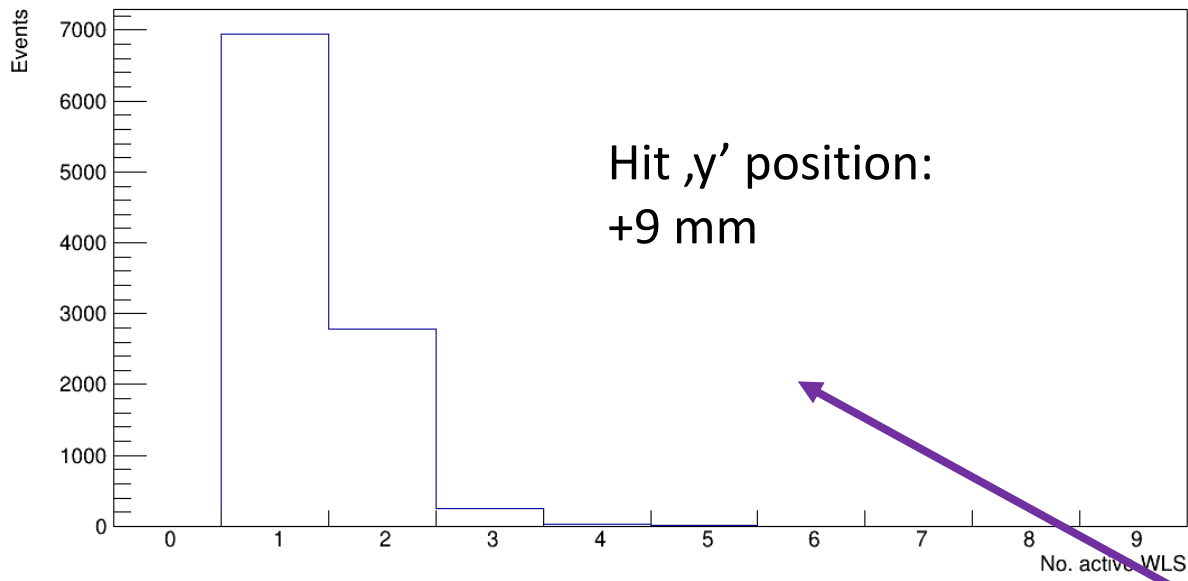
# Reconstruction of $y'$ position (DOI)

1000 annihilation photons interactions



# Reconstruction of $y'$ position (DOI)

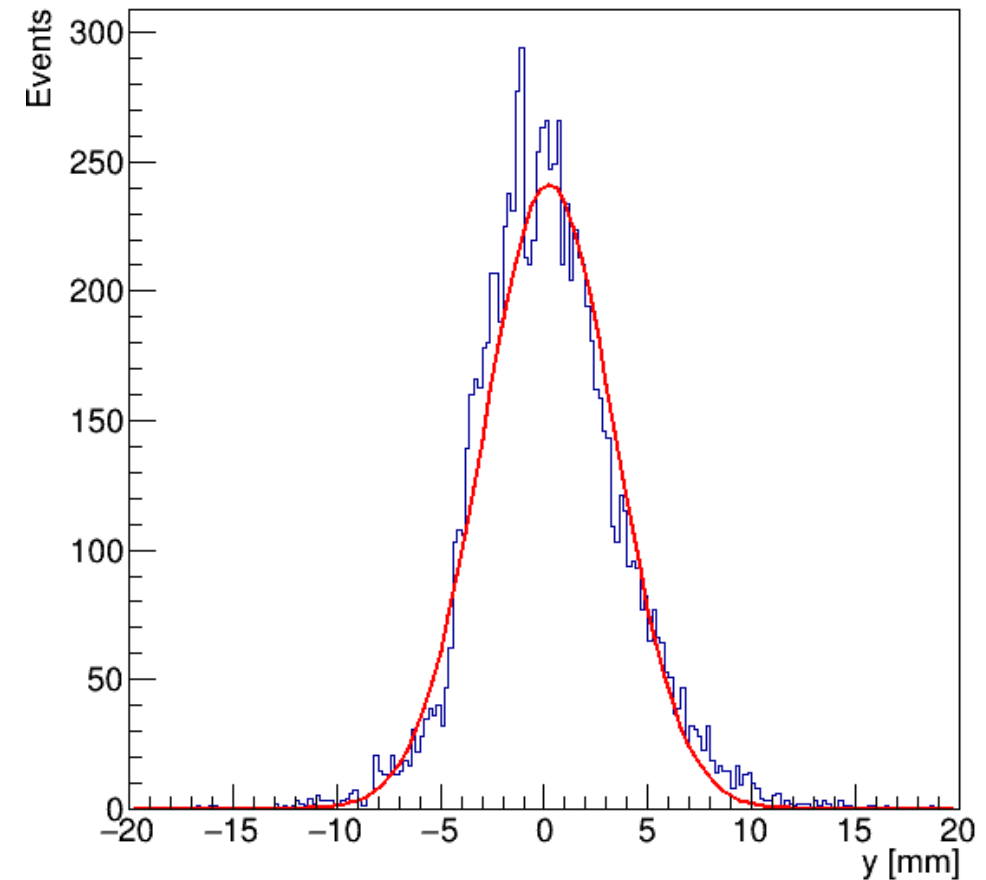
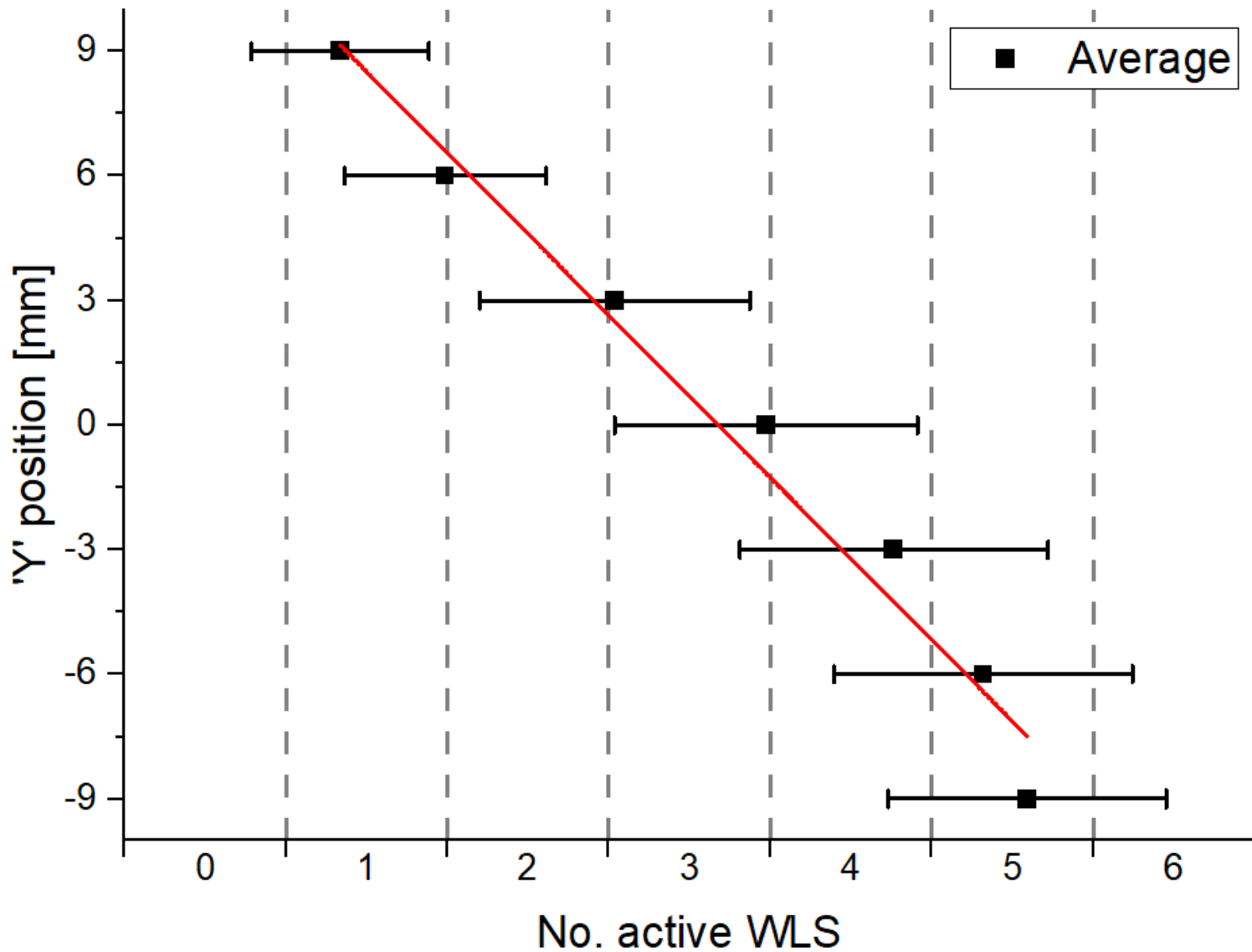






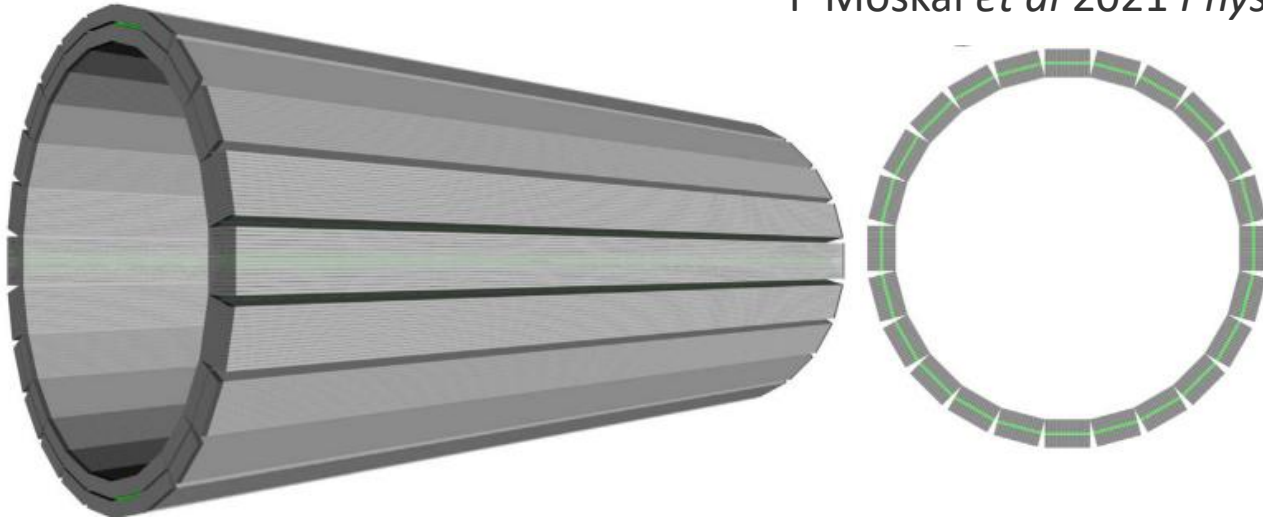
Reconstruction of  $y'$  position (DOI)

'y' - recon. 'y'



# On a way to the Total-Body J-PET

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Simulated Total-Body J-PET:

- 16 (6×30 mm<sup>2</sup>) scintillators per layer
- 2 layer per module
- 1 layer of WLS per module
- 24 modules per ring
- 1 ring of 200 cm AFOV

Hit axial position  
(along the strip) with  
resolution of 5 mm

P Kowalski *et al* 2018 *Phys.*  
*Med. Biol.* 63 165008

,z' information IS used  
DOI IS used

Spatial resolution	FWHM [mm]
Radial	3.3
Tangential	3.7
Axial	4.9

Spatial resolution expressed  
as FWHM of PSF



Hit transaxial true position is known

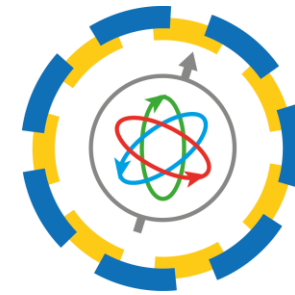
# Acknowledgements

The abovementioned work is presented on behalf of the J-PET Collaboration. This work was supported by the TEAM POIR.04.04.00-00-4204/17 program, the NCN grant no. 2021/42/A/ST2/00423 and the SciMat and qLife Priority Research Areas budget under the program Excellence Initiative - Research University at the Jagiellonian University. The study was funded by “Laboratories of the Youth” as part of the “Excellence Initiative - Research University” program at the Jagiellonian University in Kraków. The study was funded by “Research support module” as part of the “Excellence Initiative - Research University” program at the Jagiellonian University in Kraków.





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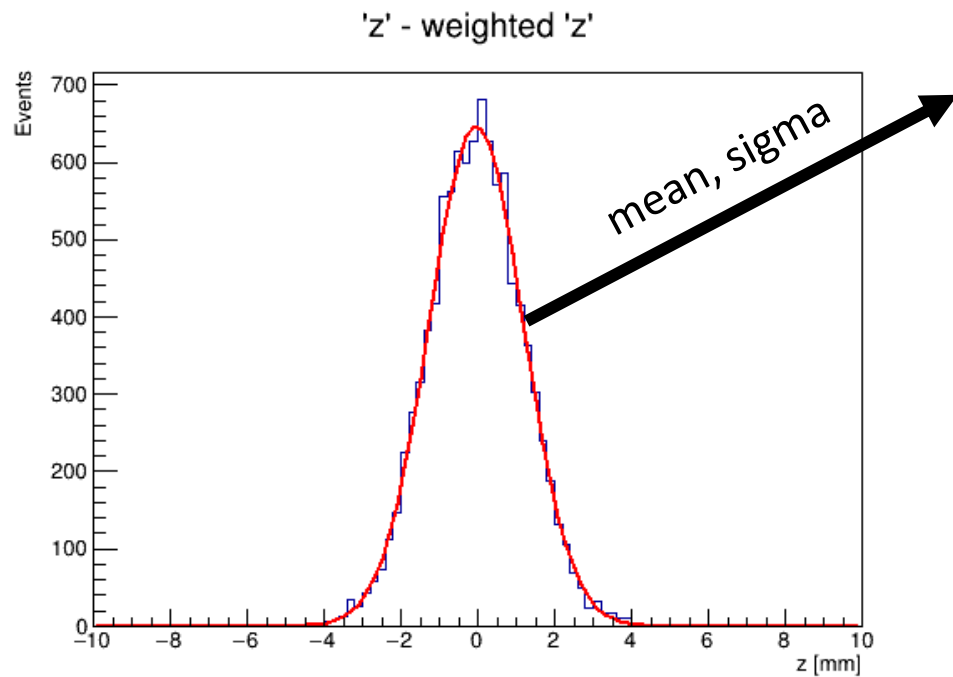


**J-PET**

Thank you for your attention

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# Reconstruction of ,z' position



Distribution of real ,z' coordinates  
- reconstructed ,z' coordinates

