The development of the QETIR image reconstruction software for the Total-Body J-PET application

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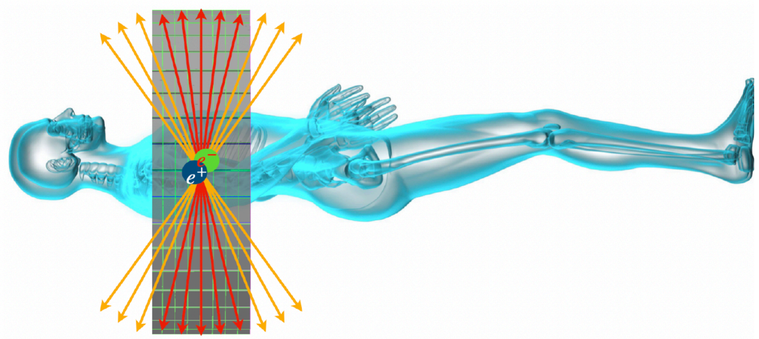
Outline

- ☑ PET scan to Total-Body PET
- ☑ J-PET technology
- ☑ QETIR image reconstruction
- ☑ J-PET configurations in QETIR

☆ The aim:
Implementation of J-PET configuration in QETIR image reconstruction software

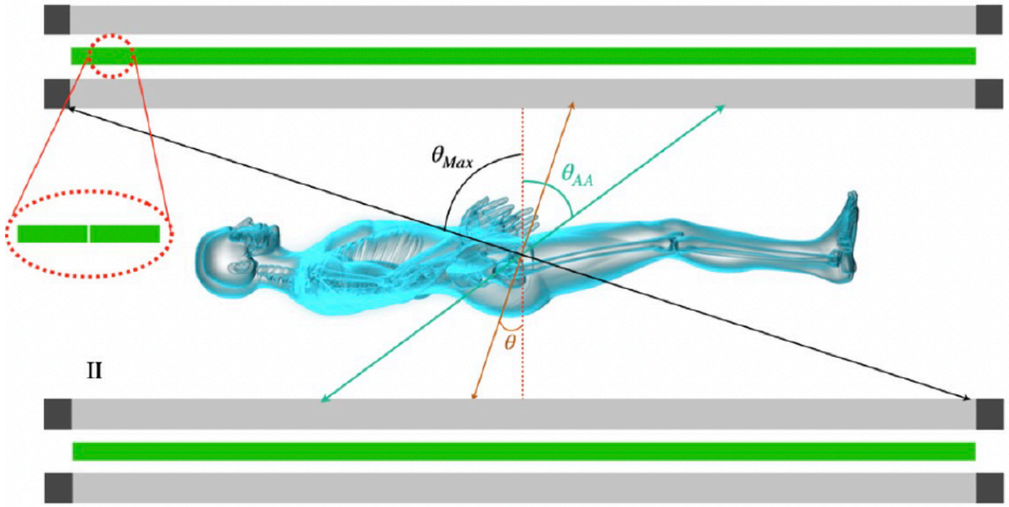
Positron Emission Tomography (PET)

Current clinical PET



- Limited axial coverage
- Longer imaging time
- Multi-bed positioning
- The higher dose of patient

Total-Body PET



- Larger axial coverage
- Shorter imaging time
- Single-bed positioning
- Low dose imaging
- Higher sensitivity
- Improvement in the lesion detectability

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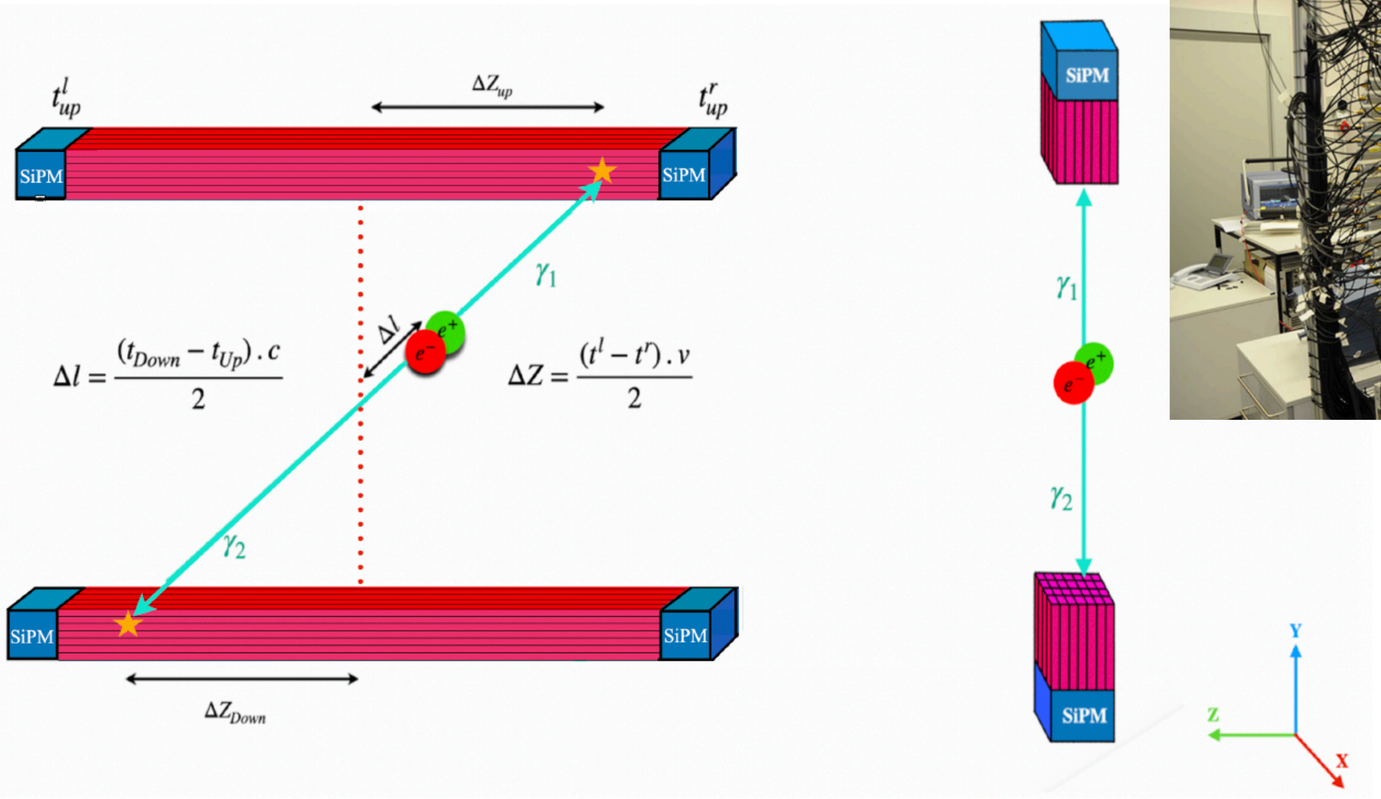
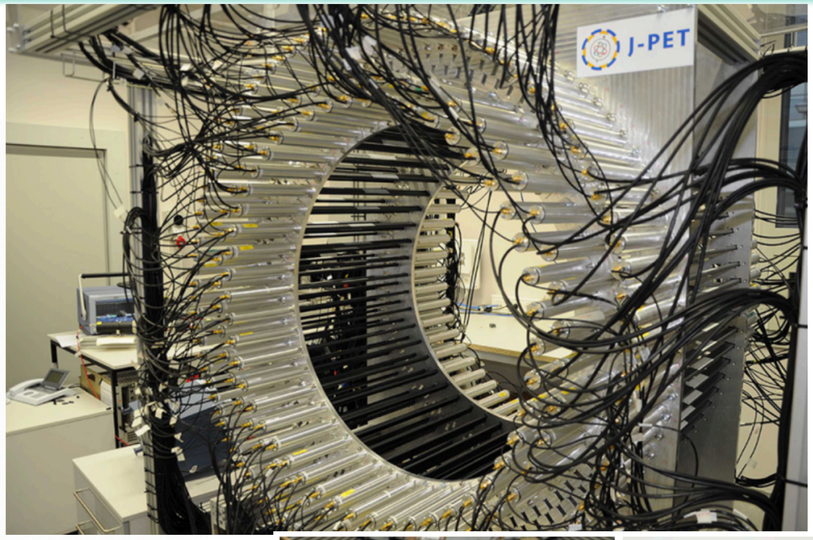
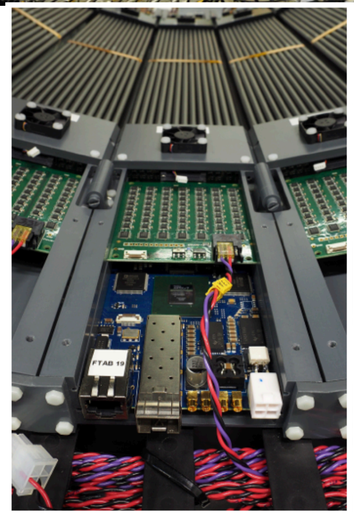
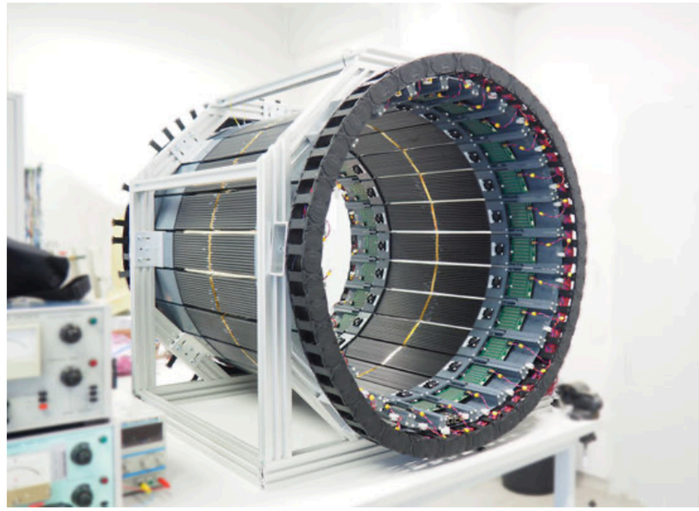
J-PET technology









Reference: Meysam Dadgar, et al., Investigation of novel preclinical Total Body PET designed with J-PET technology: A simulation study, preprint of the manuscript for IEEE TNS.

Total-Body J-PET scanners

- Scintillator material – plastic (EJ230, Eljen Technology)
- Axial arrangement
- Silicon photomultiplier (SiPM) readout at both ends

} Cost-efficient long field of view PET system

- 200 cm AFOV
- 79 cm diameter
- 2 layers × 24 modules × 16 scintillators

Challenges in the image reconstructions

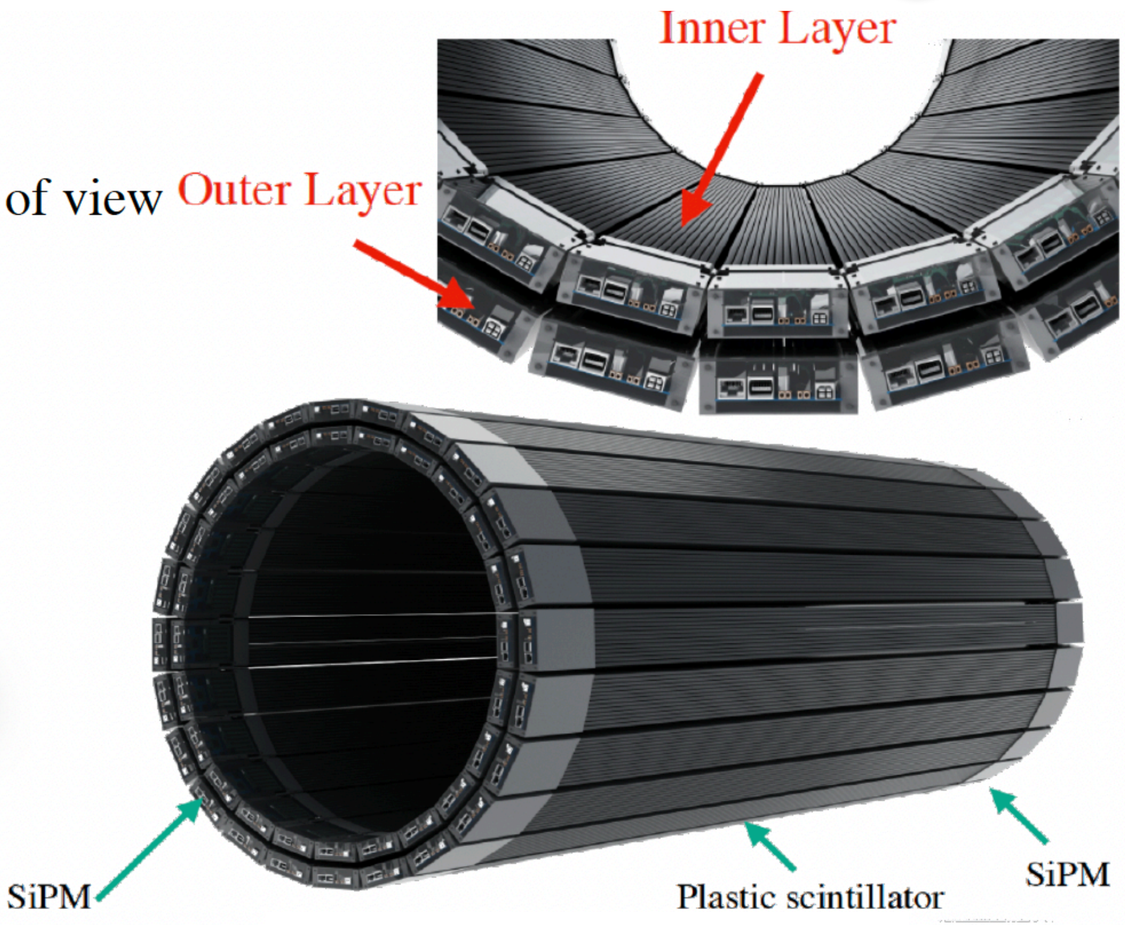


Fig. 4: 3D rendered images of Total-Body J-PET

QETIR image reconstruction software

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+                                                     +
+                   WELCOME TO QETIR                  +
+                                                     +
+   Emission Tomography Iterative Reconstructor       +
+++++++++++++++++++++++++++++++++++++++++++++++++++++++

Usage:

QETIR <function> <configuration file>
          |
          |--> sensmap    : generate geometrical PET sensitivity map by
          |                 backprojection of each LOR into image space.
          |
          |--> MLP        : Most Likely Position based on TOF;
          |                 place each event in most likely voxel.
          |
          |--> FBP        : Filtered BackProjection
          |
          |--> recon      : Iterative MLEM/OSEM PET image reconstruction
          |
          |--> attrecon   : Iterative MLTR/MLAA/MLAA+ PET attenuation reconstruction
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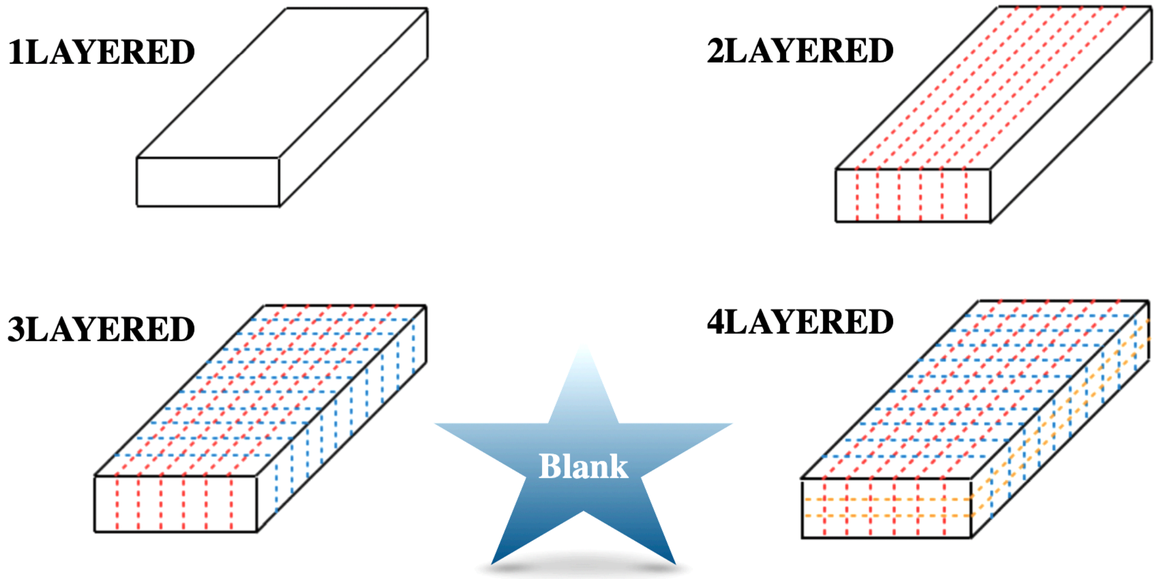
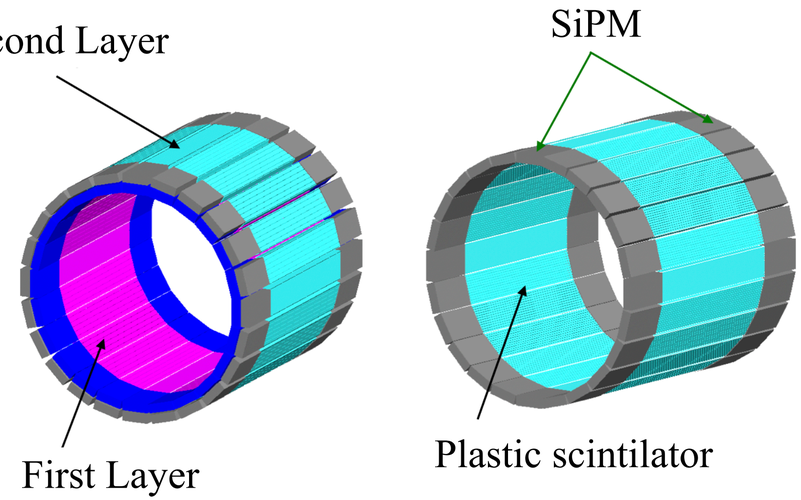


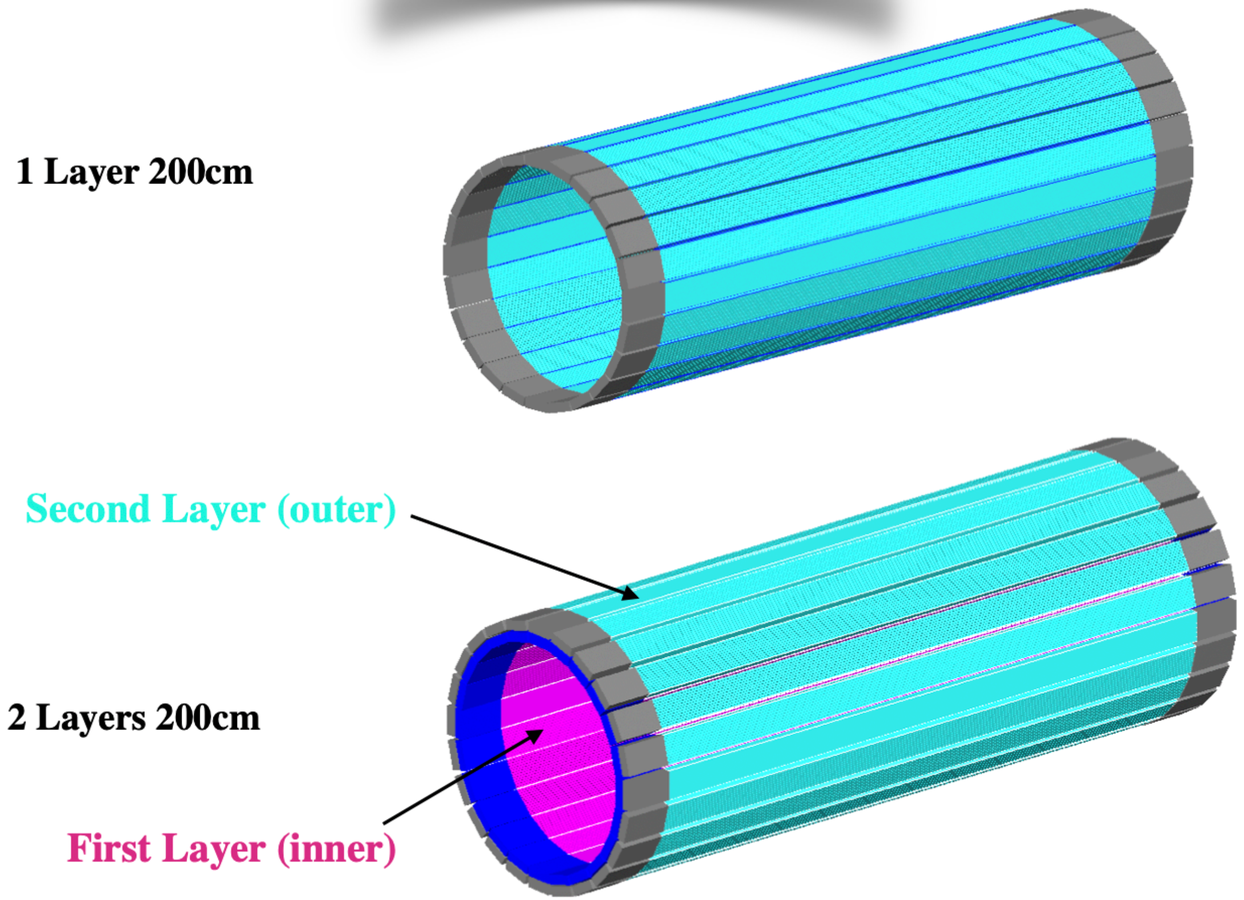
Pet image reconstruction software qetir. Universiteit Gent. (2021, January 12). Retrieved July 2, 2022, from https://www.ugent.be/ea/ibitech/en/research/medisip/software-lab/software-lab13.htm.

J-PET tomographs in QETIR

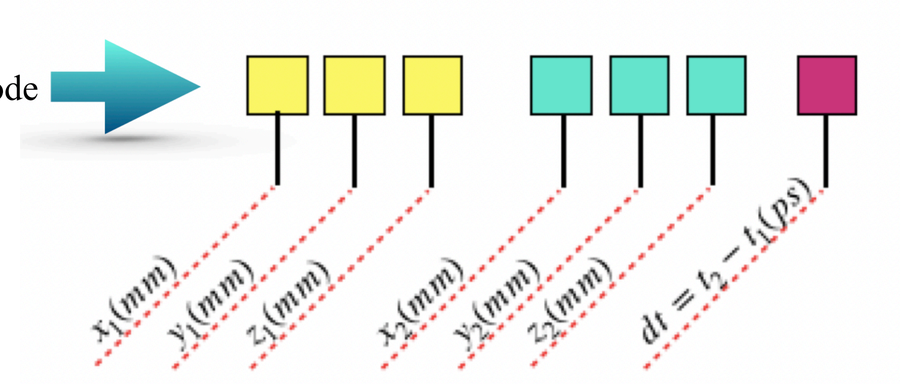
24 Modular J-PET with 50cm AFOV

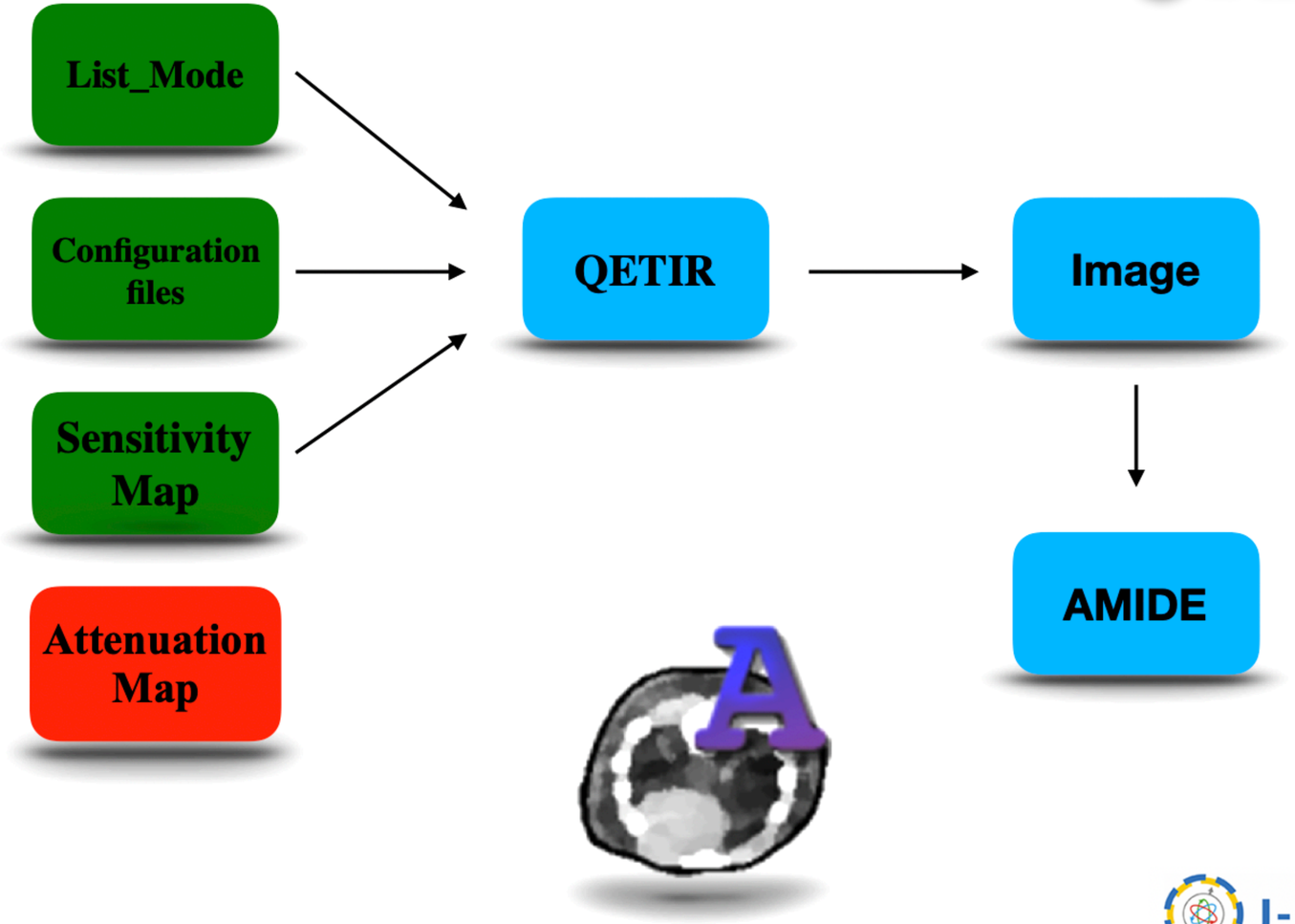


TB J-PET with 200 cm AFOV

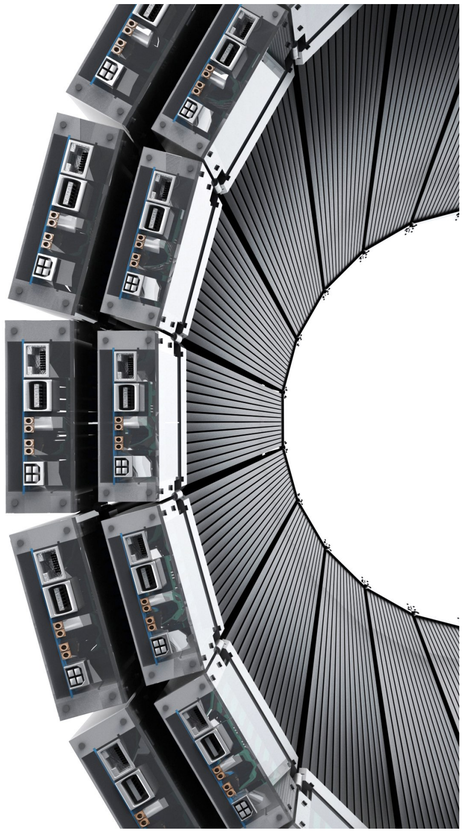


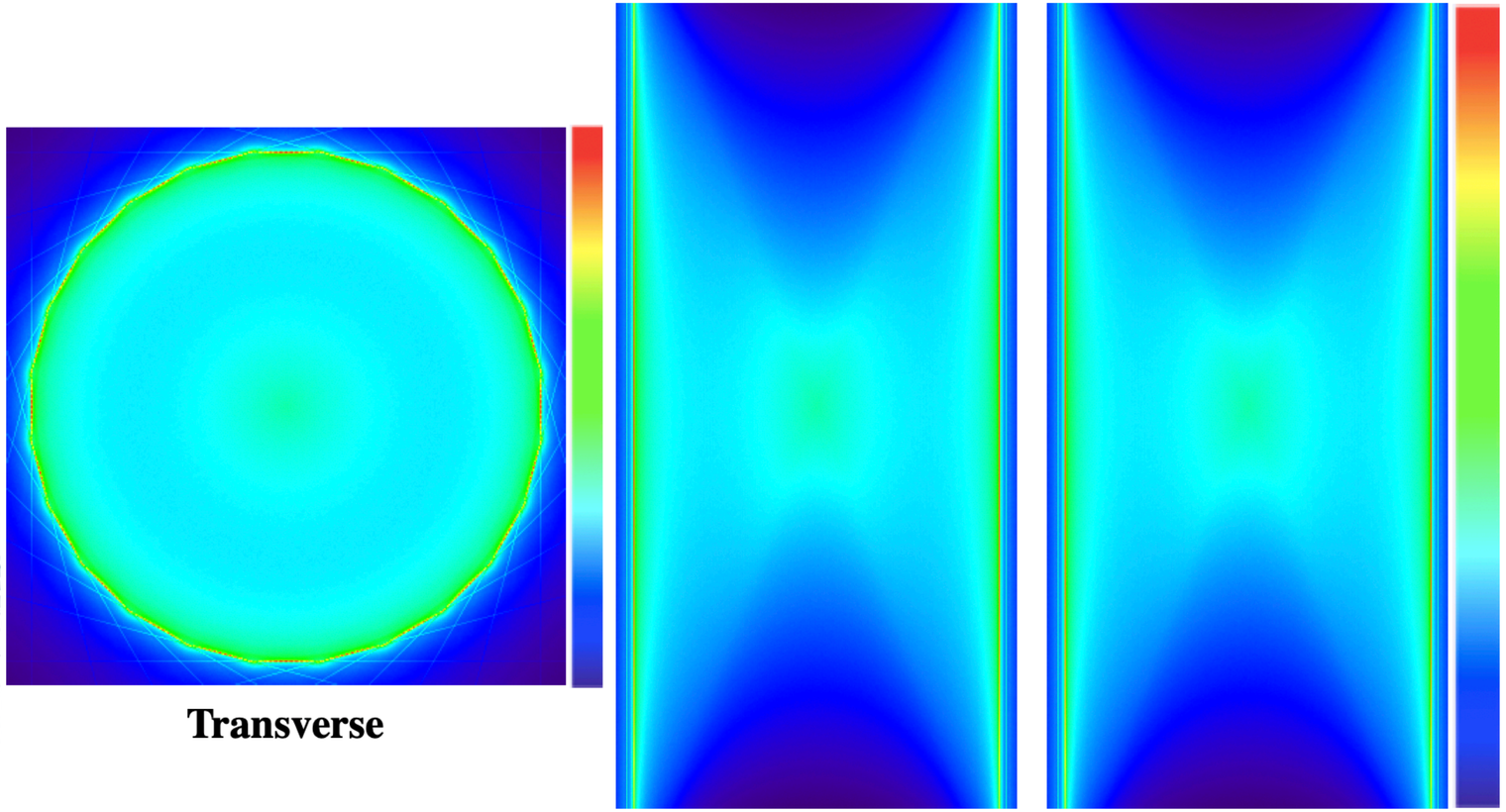
Roadmap of QETIR





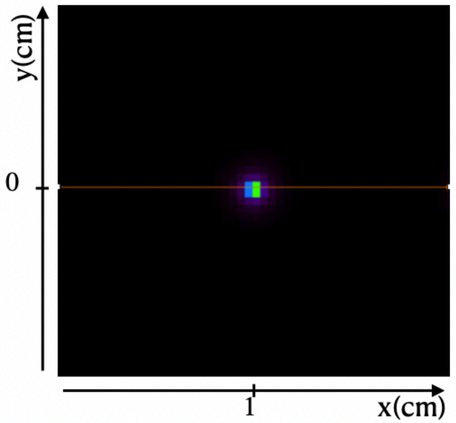
Outline



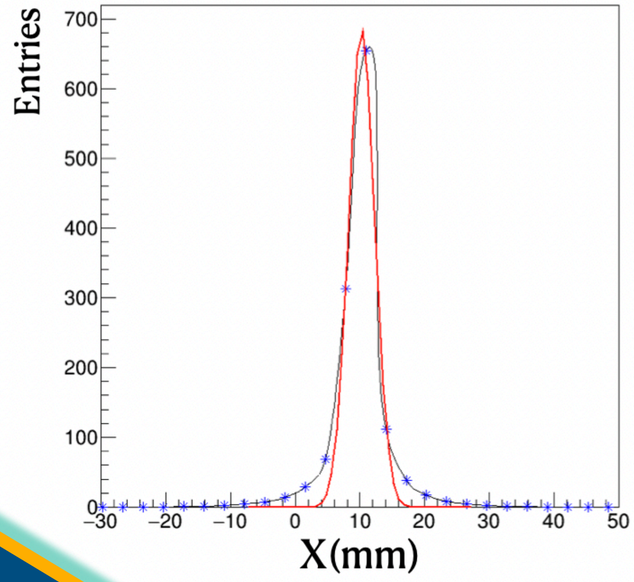


An exemplary sensitivity map of TB J-PET generated by QETIR software

Comparision of the results



Radial_FWHM_1,0,0

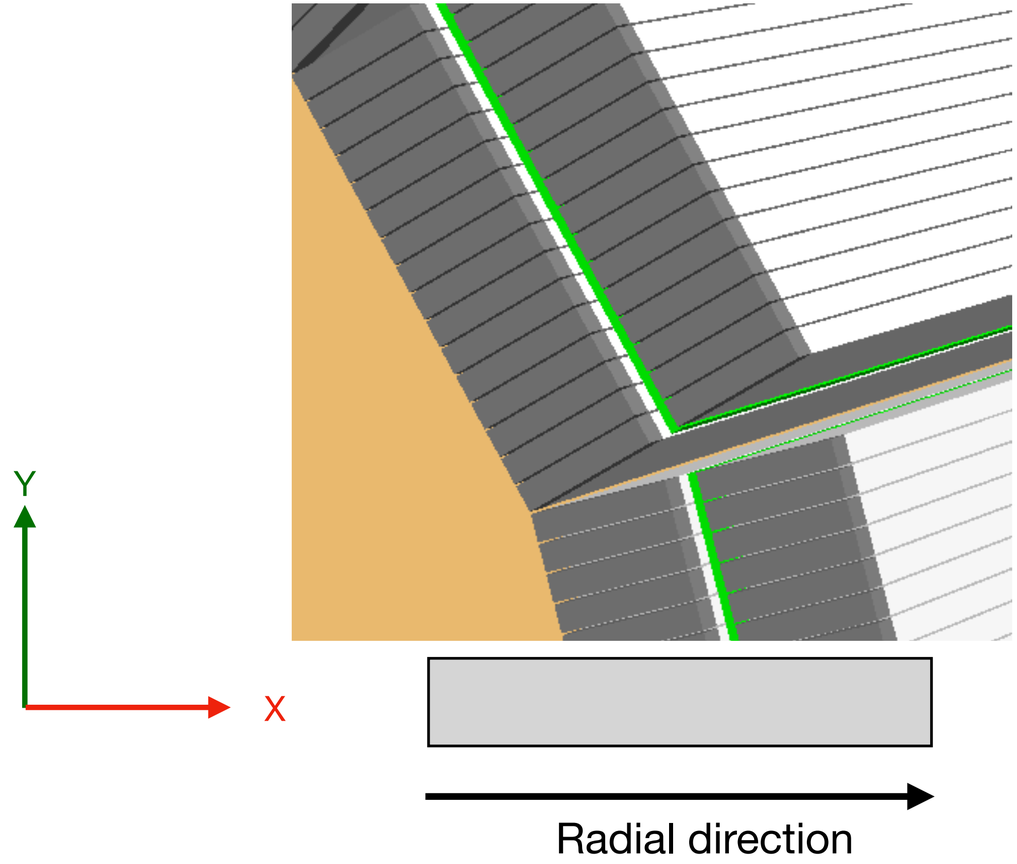


1 st Iteration	$FBP_{radial-FWHM}$	$MLEM_{radial-FWHM]}$	$FBP_{tang-FWHM}$	$MLEM_{tang-FWHM}$	$FBP_{axial-FWHM}$	$MLEM_{axial-FWHM}$
(10,0,0)	3.7	3.54 ± 0.11	3.3	2.96 ± 0.07	4.9	3.35 ± 0.06
(100,0,0)	3.4	3.36 ± 0.11	3.2	3.14 ± 0.07	4.5	3.35 ± 0.06
(200,0,0)	3.7	2.66 ± 0.11	3.4	3.14 ± 0.07	4.7	3.30 ± 0.06
(10,0,750)	4.2	4.23 ± 0.07	3.7	3.65 ± 0.04	5.9	3.48 ± 0.07
(100,0,750)	3.8	4.27 ± 0.07	3.7	3.36 ± 0.04	5.6	3.60 ± 0.07
(200,0,750)	4.0	3.79 ± 0.07	3.9	3.51 ± 0.03	5.6	3.65 ± 0.07

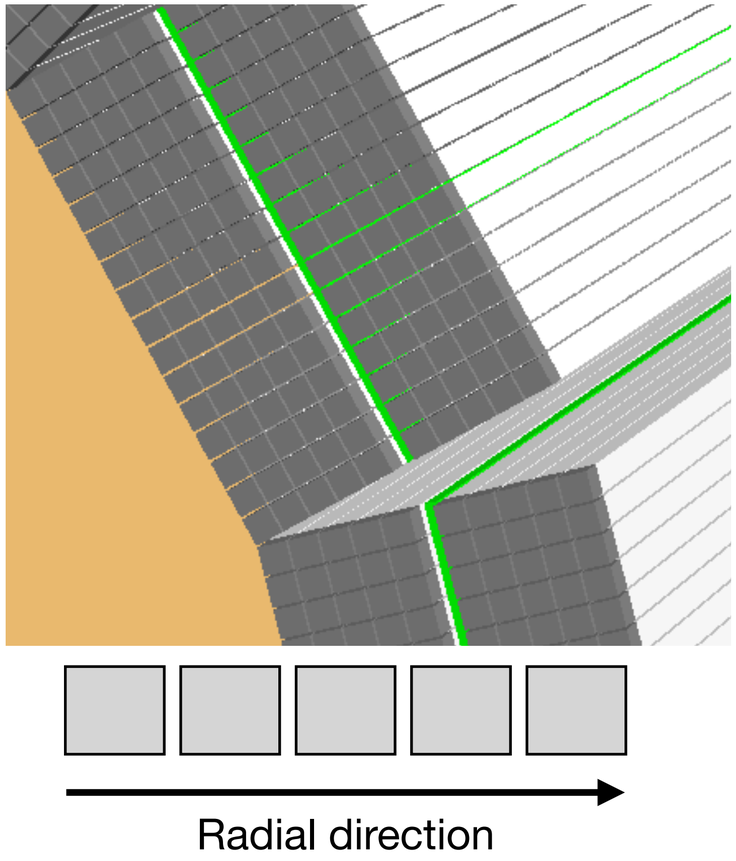
All the Values are in mm

Mini-Bar (matrix array) detector configuration

Standard Configuration of J-PET detector



DOI capable J-PET detector



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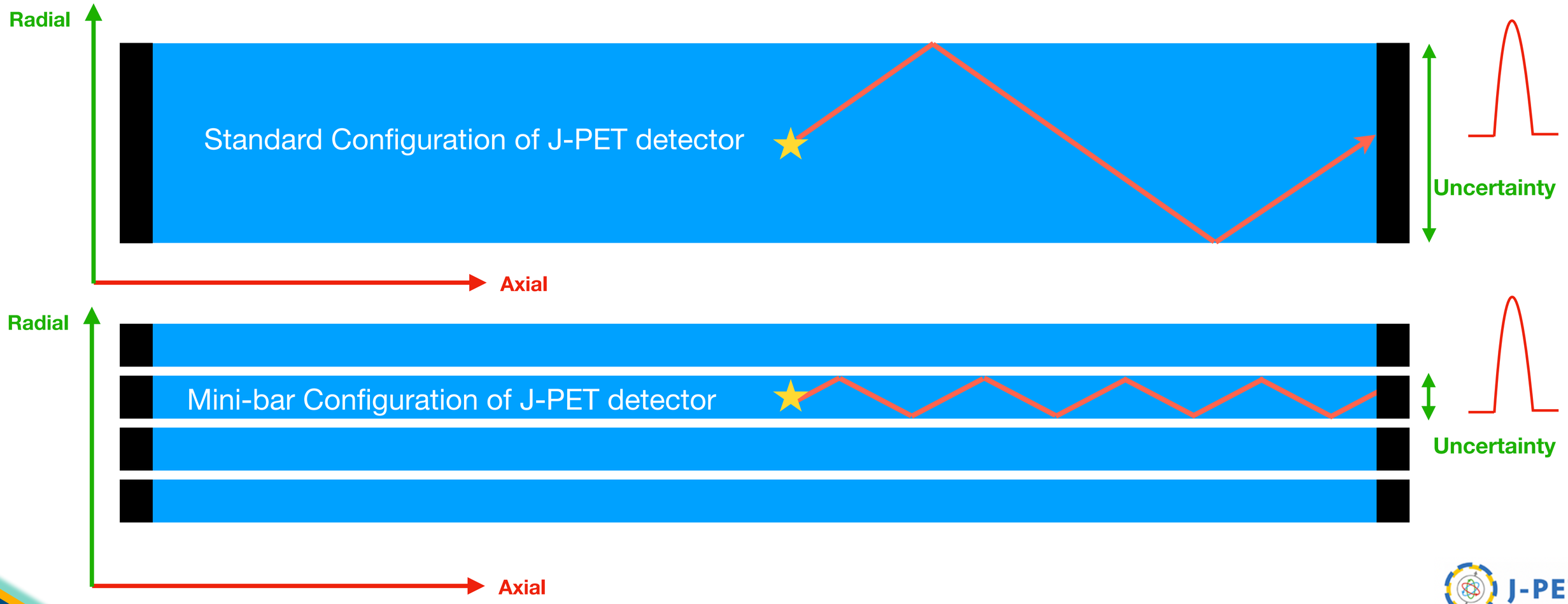

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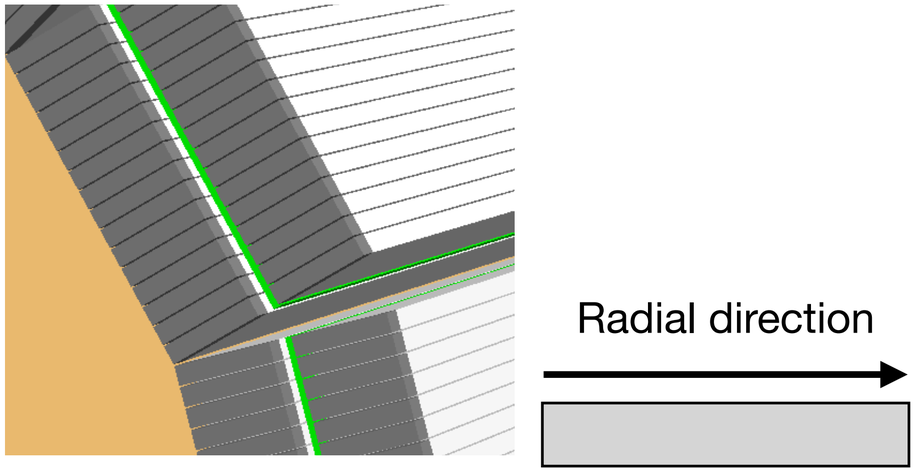
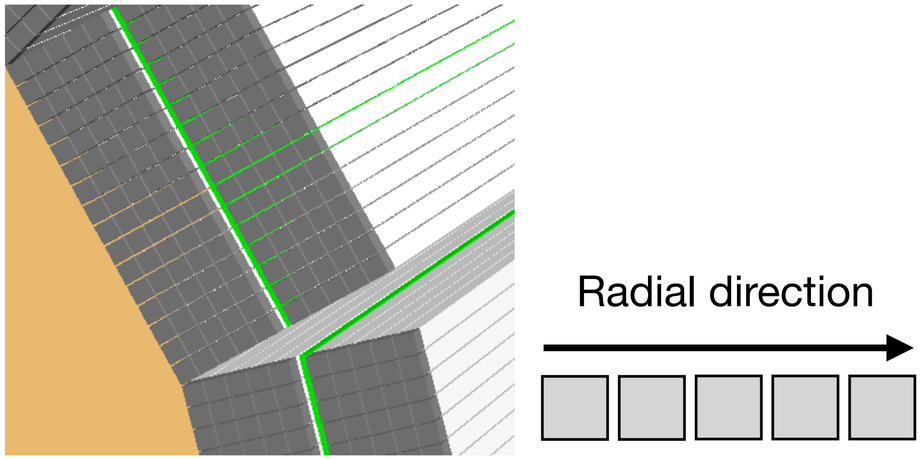
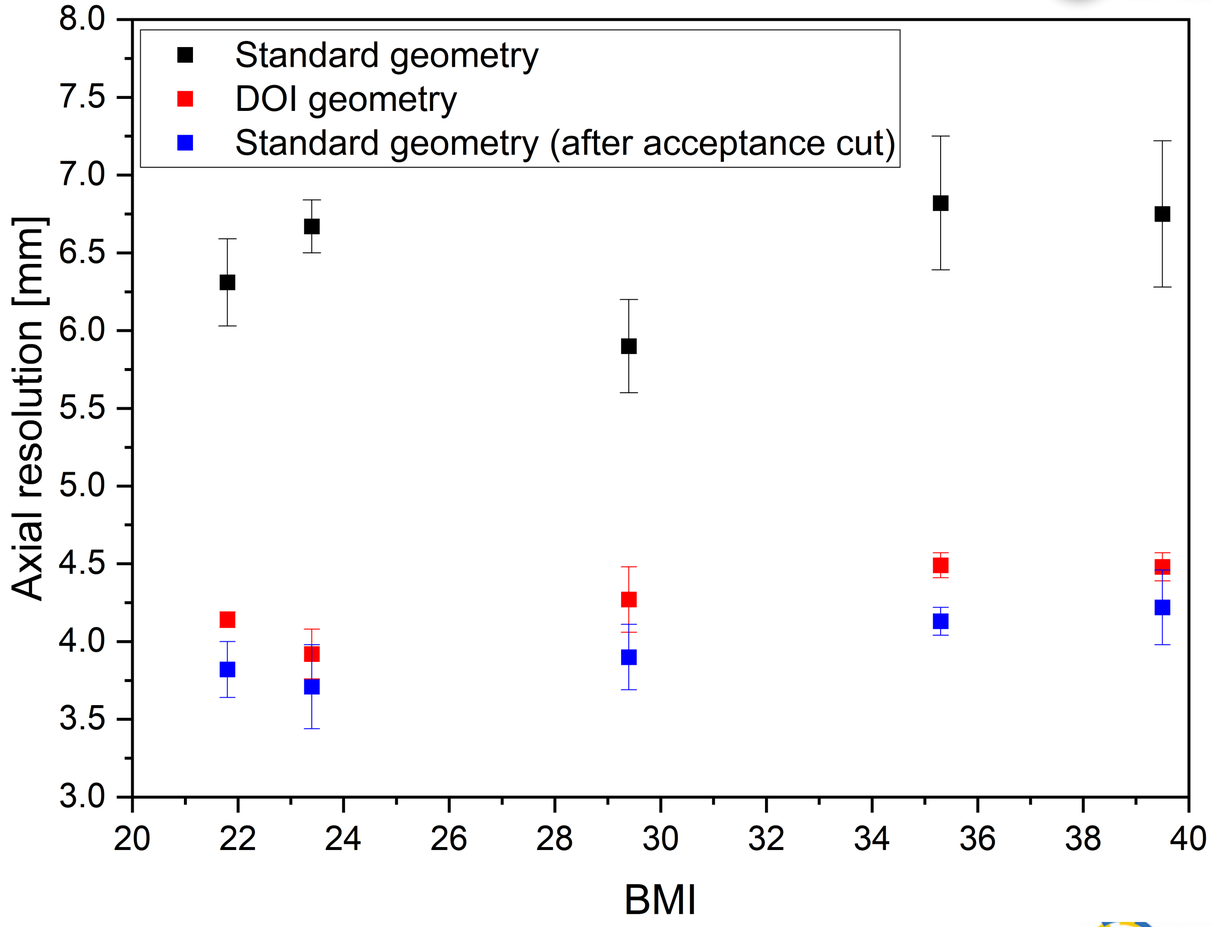
Mini-Bar (matrix array) detector configuration

Standard Configuration of J-PET detector



DOI capable J-PET detector





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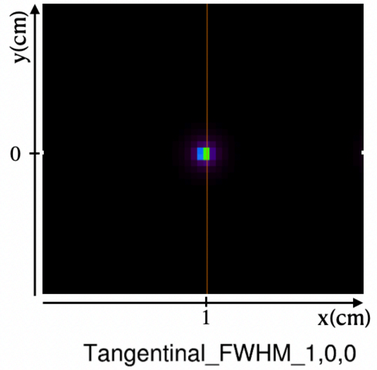
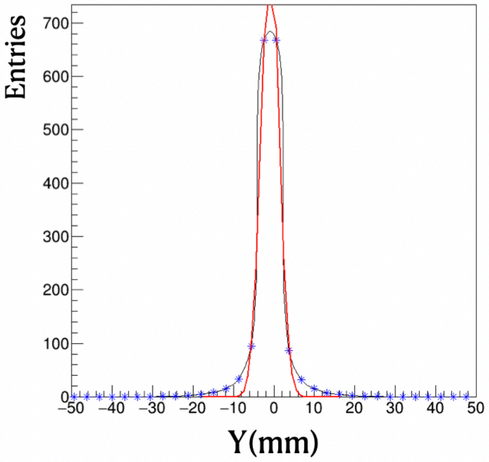
Exemplary results by QETIR

Studies	FWHM		
	Radial	Tangential	Axial
Small Animal J-PET	1.80±0.10 mm	1.70±0.02 mm	3.09±0.03
Acceptance Angle in TB J-PET	3.27±0.31 mm	3.36±0.18 mm	4.43±0.5 mm
DOI capable TB J-PET	-	-	4.3±0.10 mm





1. M. Dadgar, S. Parzych and F. Tayefi Ardebili, “A Simulation Study to Estimate Optimum LOR Angular Acceptance for the Image Reconstruction with the Total-Body J-PET,” Lecture Notes in Computer Science 12722 (2021) 189-200.
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3. M. Dadgar, P. Kowalski, “Gate simulation study of the 24-module J-PET scanner: data analysis and image reconstruction” Acta Phys. Pol. B 51 (2020) 309.
4. M. Dadgar, S. Parzych, F. Tayefi Ardebili, et al. “Investigation of novel preclinical Total Body PET designed with J-PET technology: A simulation study”,
5. M. Dadgar, S. Parzych, F. Tayefi, S.Vandenberghe, P. Moskal “Introduction of the DOI capable Total-Body J-PET: a simulation study” SNMMI 2022 Anual Metting, Vancouver. Canada, Jun 2022.
6. M. Dadgar, S. Parzych, F. Tayefi, S.Vandenberghe, P. Moskal, “ A simulation study to estimate optimum energy window criterion for data acquisition in Total-Body J-PET. MCSB, Krakow, Poland May 2021.

Conclusion

- Large AFOV and multi-layer configuration as the main challenges in Total-Body J-PET image reconstruction.
- QETIR is stand-alone software that can generate a sensitivity map very fast.
- The flexibility of software in various configurations from preclinical grade to Total-Body J-PET.

Acknowledgment

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Quastions?