

Jagiellonian University In Kraków

Investigation of the DOI capable configuration in dealing with the parallax error in the Total-Body J-PET tomograph: A simulation study

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Positron Emission Tomography (PET)



Fig. 1: Schematic visualization of a patient inside PET scanner which is detecting only a fraction of the emitter gamma photons (red), while rest escapes without detection























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Total-Body PET scanners

Extended AFOV provides:

- Larger detection area
- Higher sensitivity
- Higher detection probability
- Shorter imaging time
- Improved lesion detectability

Reference: Meysam Dadgar, et al., Comparative studies of the sensitivity of sparse and full geometries of Total Body PET scanners build from crystals and plastic scintillators, preprint of manuscript for EJNMMI Physics.

> Fig. 2: (I) Schematic visualization of the Total-Body PET scanners based on the current technology and (II) geometrical configuration of the Total-Body PET scanners based on the J-PET technology.































J-PET technology



Fig. 3: Schematic visualization of the J-PET vs traditional scanners

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



























Total-Body J-PET scanners

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

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

























J-PET Collaboration, Jagiellonian University, Krakow, Poland



http://koza.if.uj.edu.pl/pet











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Oblique LORs in Total-Body PET scanners

Parallax error:

Such displacement propagates then to the line of response and as a consequence, causes incorrect annihilation position reconstruction



Fig. 5: Uknown depth of interaction of the oblique LORs which will give an incorrect annihilation photons and decreases quality of imaging















Unknown depth-of-interaction of the photons within the scintillators causes a shift in the hit position.











Mini-bar Configuration of J-PET detector 6x6x2000 mm 0.5 mm Gap between bars

















Standard Configuration of J-PET detector













DOI capable J-PET detector





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Standard Configuration of J-PET detector





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200 cm length of the phantoms and source















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athod	70 cm s	source	200 cm source		
ethou	Standard geometry	DOI geometry	Standard geometry	DOI ge	
SRB	36.711 ± 0.034 [%]	36.622 ± 0.034 [%]	35.896 ± 0.027 [%]	35.841 ±	
ie MC + Det. Scat.)	59.117 ± 0.053 [%]	59.010 ± 0.053 [%]	63.930 ± 0.062 [%]	64.026 ±	
ie MC . Scat)	54.855 ± 0.056 [%]	54.832 ± 0.056 [%]	60.917 ± 0.066 [%]	61.021 ±	



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Applying of acceptance angle cut

Acceptance angle is a maximum azimuthal angle for which the line of responses are still taken into image reconstruction



Reference: M. Dadgar, S. Parzych and F. Tayefi, "A Simulation Study to Estimate Optimum LOR Angular Acceptance for the Image Reconstruction with the Total Body J-PET," in MIUAOxford, UK, 2021, pp. 189–200.















Fig. 8: The red area represent the angle of all possible LOR as θ_{max} and blue area shows only those coincidences which has smaller or equal to the acceptance angle (θ_{AA})







Sensitivity Vs. Acceptance angle cut



Reference: M. Dadgar, S. Parzych and F. Tayefi, "A Simulation Study to Estimate Optimum LOR Angular Acceptance for the Image Reconstruction with the Total Body J-PET," in MIUAOxford, UK, 2021, pp. 189–200.



















Spatial resolution Vs. Acceptance angle

Spatial resolution

Spatial resolution is one of the most important characteristics of PET scanners, which determines the possible size of detectable lesions. One of the classic approaches to investigate the quality of spatial resolution utilizes a Point Spread Function (PSF). PSF is defined as a full width at half maximum of the either transverse or axial onedimensional projection of the slice of reconstructed image, which contains the radioactive source.



Reference: M. Dadgar, S. Parzych and F. Tayefi, "A Simulation Study to Estimate Optimum LOR Angular Acceptance for the Image Reconstruction with the Total Body J-PET," in MIUAOxford, UK, 2021, pp. 189–200.





















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Conclusion

V Parallax error has an undeniable destructive influence on axial resolution in Total-Body PET scanners oblique coincidences in image reconstruction. Acceptance angle improves axial resolution by the cost of reduction in the sensitivity. Minibar configuration, improves axial resolutions without any angle wise cut over the coincidences.

Reference: M. Dadgar, S. Parzych and F. Tayefi, "A Simulation Study to Estimate Optimum LOR Angular Acceptance for the Image Reconstruction with the Total Body J-PET," in MIUAOxford, UK, 2021, pp. 189–200.

















- If One of the approach is preselecting the coincidences by applying acceptance angle cut to remove contribution of



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KEYNOTE SPEAKERS



Prof. Abass Alavi University of Pennsylvania, USA



Prof. Catalina Curceanu National Laboratory of Frascati, Italy



Prof. Marco Durante GSI Darmstadt, Germany



Prof. Jonathan Heddle Malopolska Centre of Biotechnology, Poland



Prof. Leszek Królicki Medical University of Warsaw, Poland



Prof. Zdenka Kuncic University of Sydney, Australia



Prof. Paul Lecoq CERN, Switzerland



Prof. Craig Levin Stanford University, USA

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Prof. Taiga Yamaya QST, Japan

Prof. Sibylle Ziegler LMU Munich, Germany

Prof. Piotr Slomka Cedars-Sinai, Medicine, Los Angeles, USA



Prof. Guobao Wang University of California, Davis, USA

Prof. Georges El Fakhri Harvard Medical School, Boston, USA



- ► Clinical imaging

 - ► Total-body PET
 - Positronium in physics
 - Particle detection technologies







Thank you

Question/ comments?



FNP) Foundation for **Polish Science**

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