Preliminary Monte Carlo study of Modular J-PET

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Modular Jagiellonian Positron Emission Tomograph

- Latest prototype of the J-PET Collaboration [1].
- Cost-effective enabling of multi photon and positronium imaging [2].
- Consists of 24 modules which are arranged in regular 24-sided polygon circumscribing a circle with the diameter of 73.9 cm [3-4].
- Each module is built out of 13 scintillator strips placed next to each other, read out on both ends by SiPM.
- The study has been carried on by GATE software [5] according to NEMA_NU_2 2018.

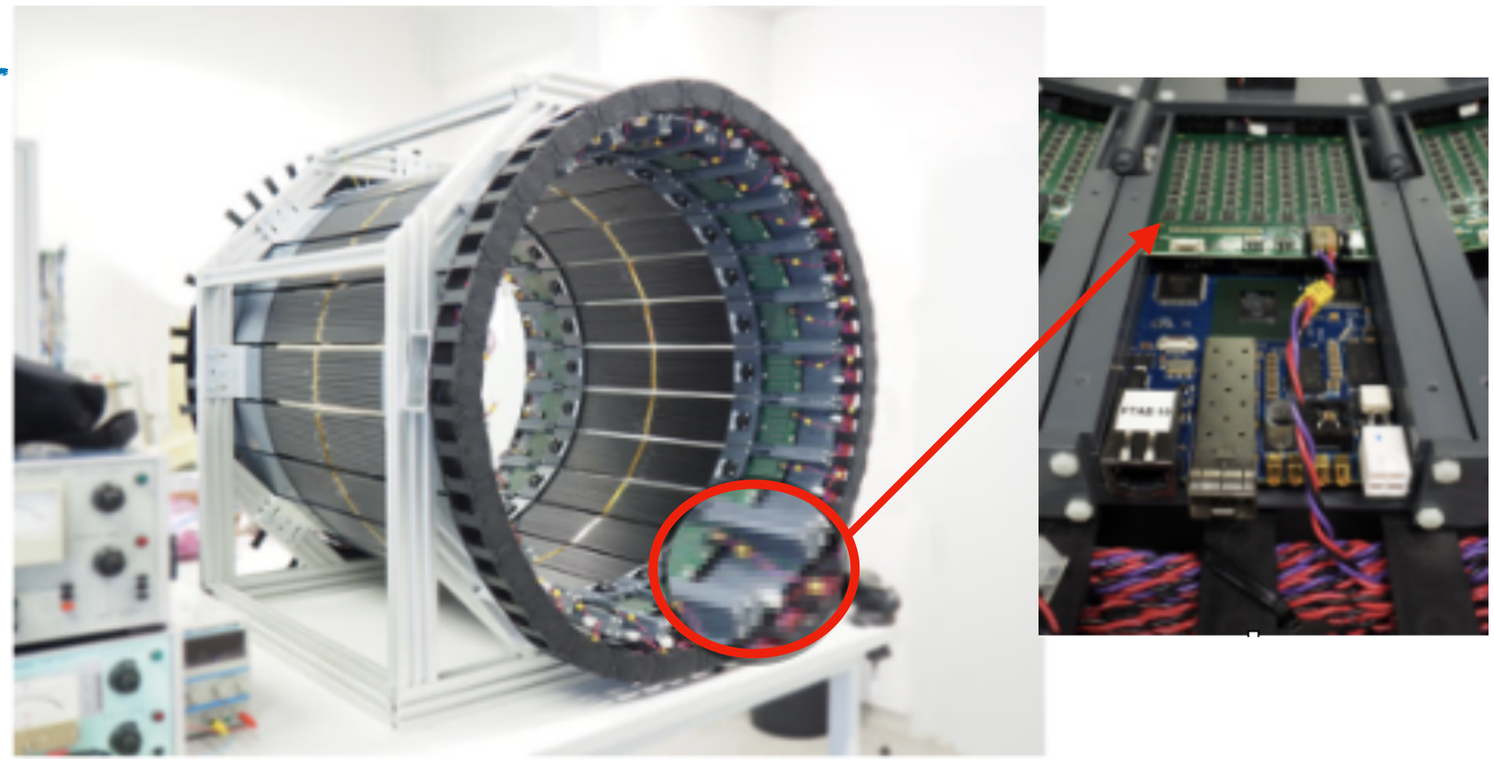

Fig 1: (Left)Modular J-PET after mechanical assembly, (Right) Power supply board (green) providing voltage to each SiPM separately and TDC board (blue) converting analog signals to digital ones, by measuring the Time of analog signal crossing at two selected constant thresholds.

Sensitivity

To estimate the sensitivity of scanner

- 70 cm Line source
- Diameter of source is 1mm
- Source is in the center of scanner
- The activity of source is 1MBq
- Back-to-back gamma photons

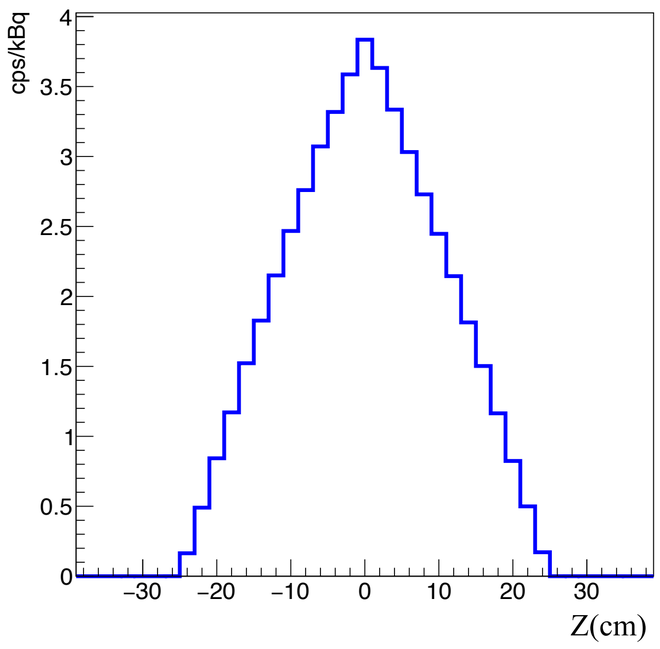

Fig 2: Axial sensitivity profile

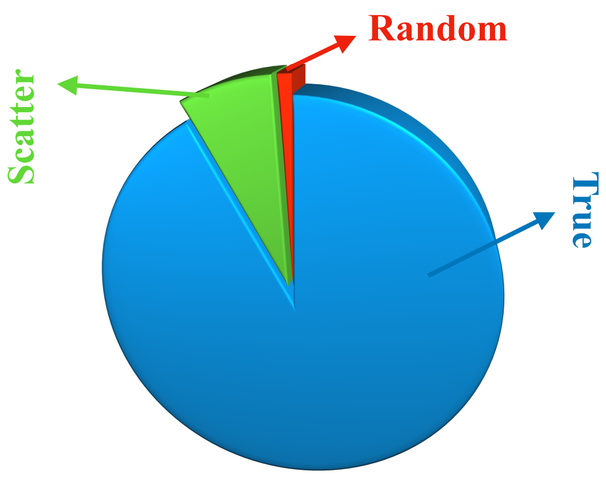

Fig3: Different types of coincidences for sensitivity measurement. The random coincidence rate is 1.1% of true rate.

Scatter Fraction

The Scatter Fraction was calculated based on SSRB algorithms. True, scatter, and random coincidence rates were extracted from the re-binned sinograms.

Phantom simulation:

- Cylinder phantom composed of polyethylene with specific gravity of 0.96 ± 0.01 g/cm^3
- Diameter of source is 203 ± 3 mm
- Length of source is700 ± 5 mm
- Position of source(mm) is (0, -45, 0)

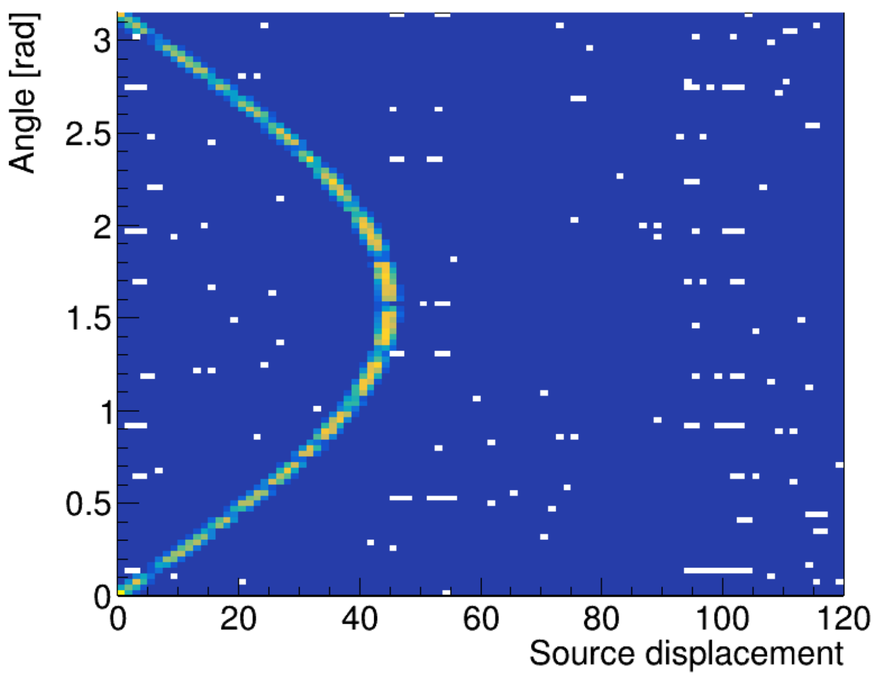

Fig 4: The sinogram for a whole scanner

Source Distribution:

- Line source
- Diameter of source is 3.2 mm
- Position of source (mm) is (0, -45, 0)
- The activity of source is 1 MBq
- Back to back gamma photons

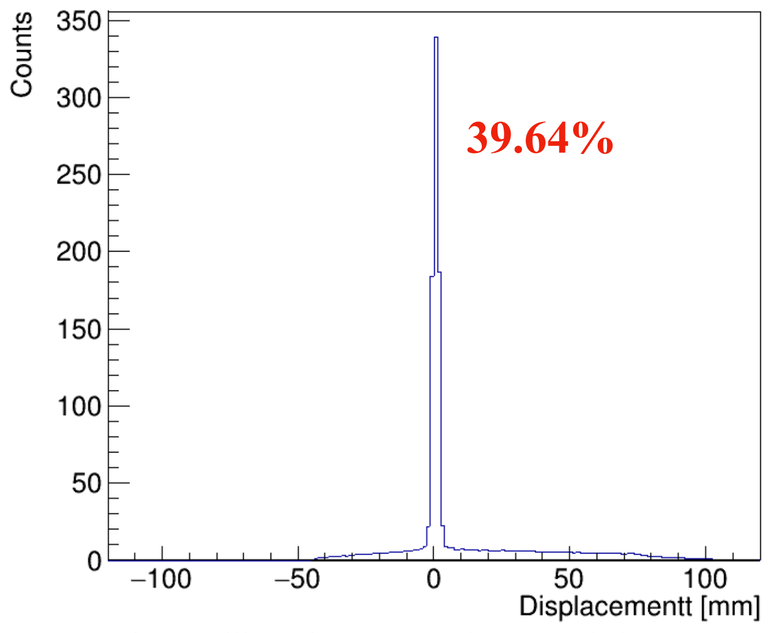

Fig 5: Alligned to zero and summed sinogram

Conclusion

Table: Results of Modular J-PET in comparison with traditional PET scan according to NEMA-NU2-2018.

Feature/Scanner	First J-PET prototype	Modular J-PET	GE Discovery	Philips Biograph MCT Flow
AFOV(cm)	50	50	15.7	21.8
Peak Sensitivity in the center (cps/KBq)	5	4	0.45	0.17
Scatter Fraction(%)	35.8	39.6	40.2	33.5
Time window (ns)	3	3	0.38	4.066
Energy window (KeV)	200-380	>200	425-650	435-650

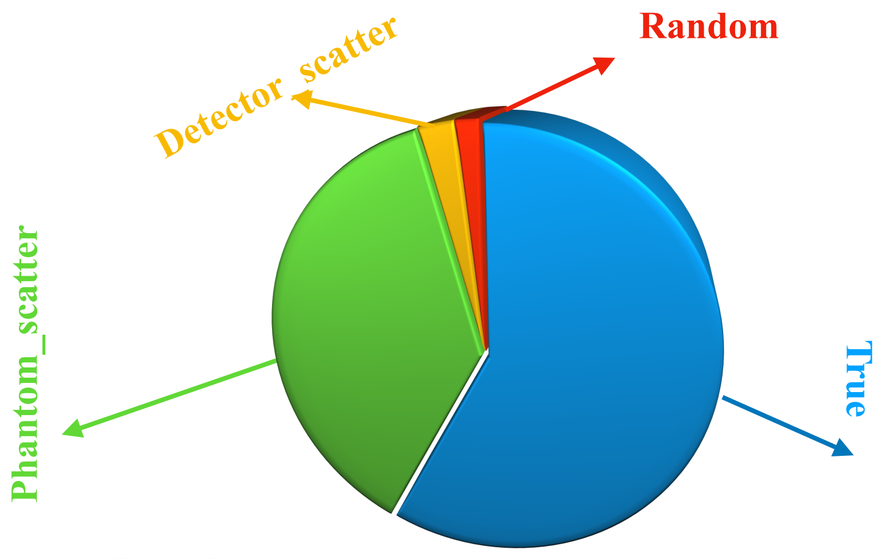

Fig 6: Different types of coincidences for scatter fraction measurement. The randoms to true ratio is 0.02%

Reference

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[3] M. Dadgar, P. Kowalski, Acta Physica Polonica B, vol. 51, pp. 309--311, 2020.
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Please see https://koza.if.uj.edu.pl for more information about J-PET technology.