

Keyvan Tayefi Ardebili, Szymon Niedźwiecki, Paweł Moskal 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

Abstract

Total-Body PET scanner due to the larger detection area, provides high sensitivity which plays a key role in the overall performance of the tomographs. A new generation of Total-Body PET scanners based on plastic scintillators is being developed by J-PET collaboration. One of the approaches in the development of the Total-Body J-PET is the ring wise configuration [1, 2]. The main aim of this study is to investigate the sensitivity of Total-Body J-PET for different numbers of rings with axial field of views (AFOVs) of 243 cm.

Total Body Jagiellonian Positron Emission Tomograph

- A new generation of Total-Body PET scanners based on plastic scintillators is being developed by the J-PET collaboration [1].
- One of the designs of the total body J-PET scanner comprises of 7 rings with 33 cm length and 89.2 cm diameter (see Fig 1).
- Each ring consists of 24 modules.
- Each module is built out of 3 Layers.
- First and third layer is build out of 16 scintillator strips placed next to each other, read out on both ends by SiPMs.
- Second layer build of 50 wavelength shifter (WLS) fibers.
- The study has been carried on by Gate software [2] according to NEMA_NU_2 2018 [3].

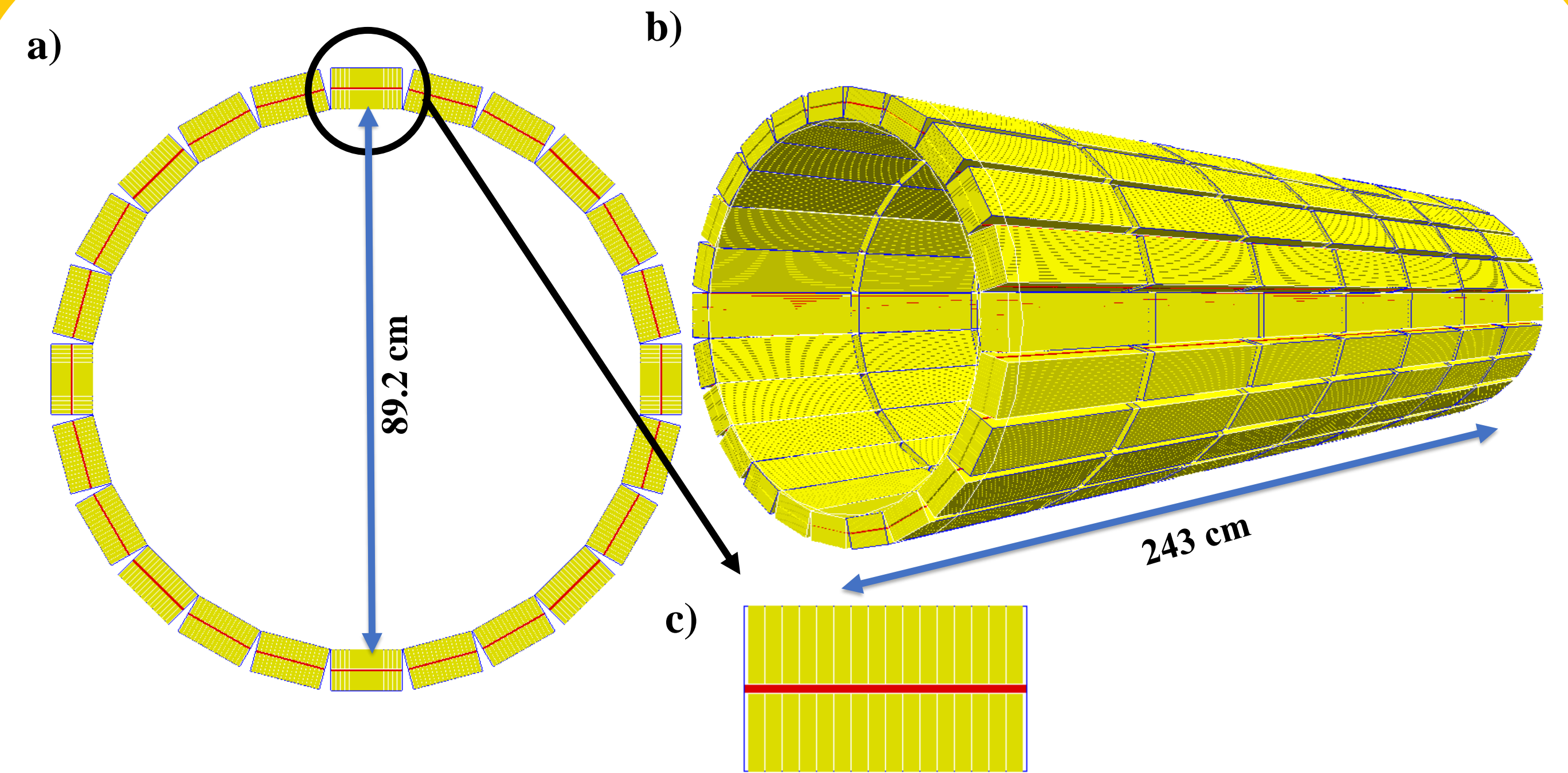


Fig 1. Schematic view of simulated Total Body J-PET. A) Shows the front view of the scanner, with the 89.2 cm diameter detection ring consisting of 24 modules. B) The scanner consists of 7 detection rings with a length of 33 cm and a 2 cm gap between the rings for a total AFOV of 243 cm. C) Each module consists of 2 layers with a total of 32 strips of plastic scintillators (30 mm×6 mm×330 mm) (yellow strips in the picture) and additional 50 fiber strips (3 mm×108.15 mm×6 mm) called WLS (red strips in the picture).

Sensitivity

✓ **The sensitivity of a PET is expressed as the rate in counts per second that true coincidence events are detected for a given source strength.**

✓ According to the NEMA-NU-2018 for the scanner less than 65 cm we can use a line source with the length of 70 cm and for the scanner more than 65 cm we can use the bigger line source.

1 ring (33 cm)

- 70 cm Line source
- The diameter of the source is 1 mm
- The activity of the source is 1 MBq
- Back-to-back gamma photons

✓ The source at (0, 0, 0) mm

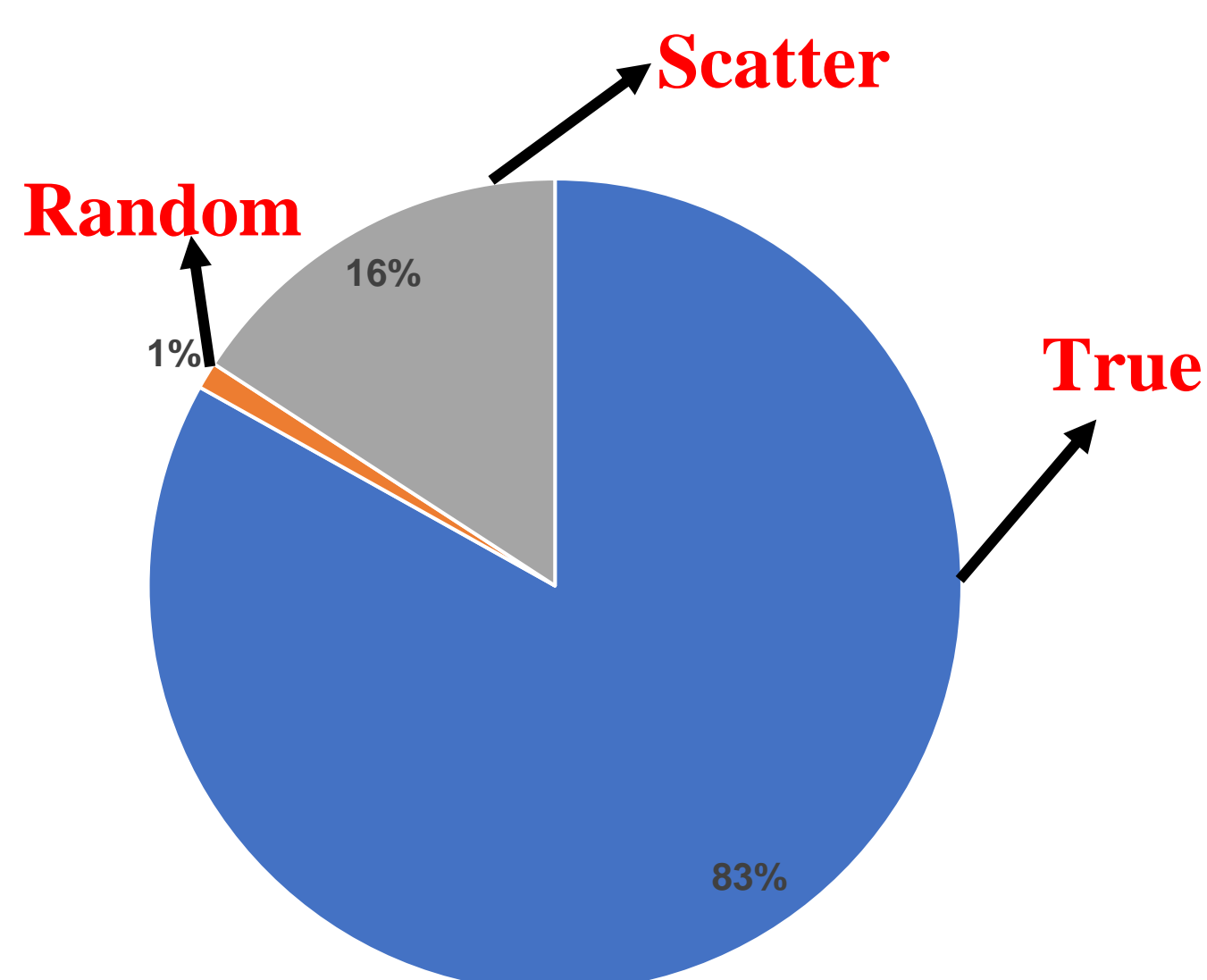


Fig 2. Types of coincidences for 1 ring sensitivity measurement with the source in the center of the scanner. The random coincidence rate is 1.06% of the total rate.

✓ The source at (0, 100, 0) mm

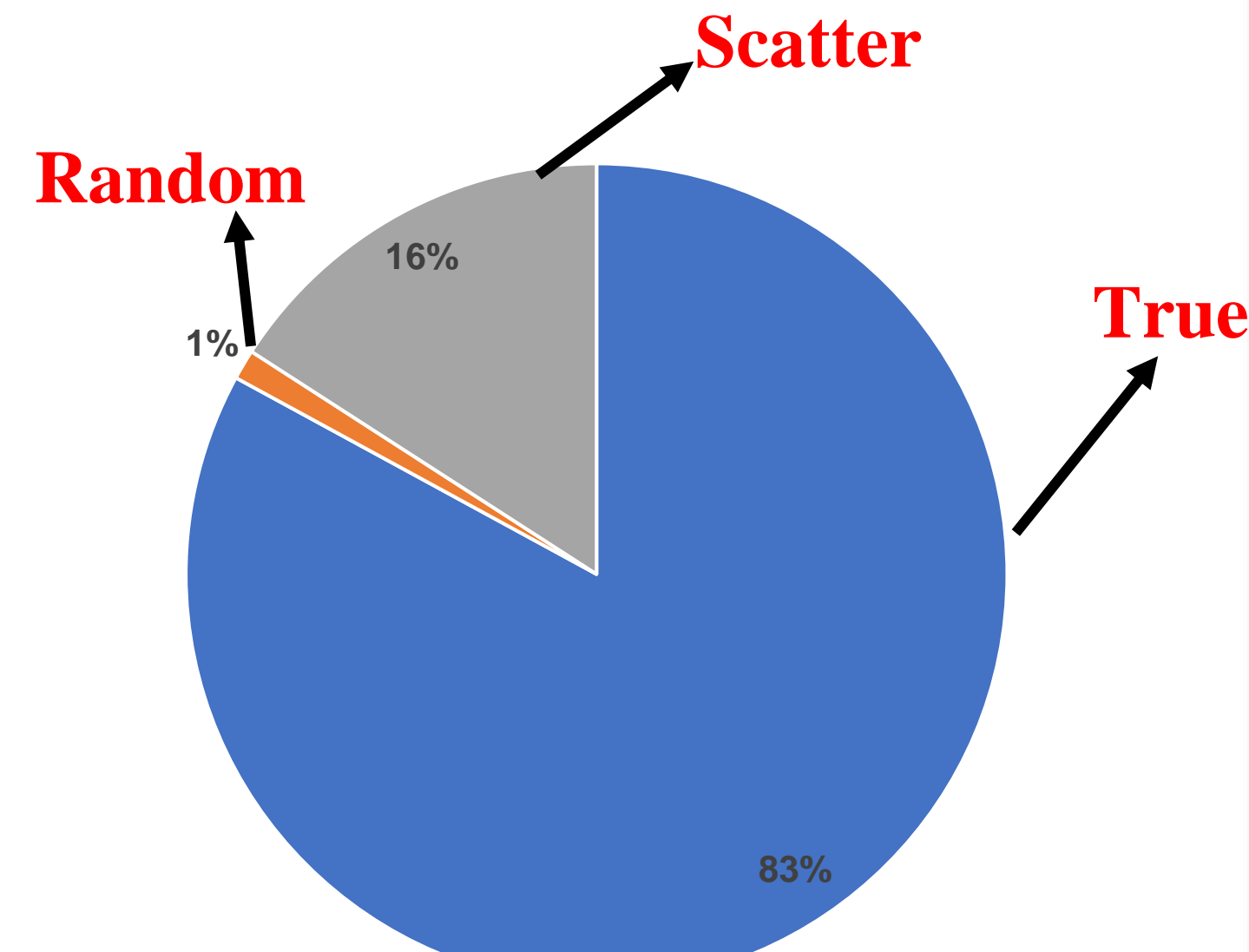


Fig 3. Types of coincidences for 1 ring sensitivity measurement with the source in the 10 cm offset of the scanner. The random coincidence rate is 1.18% of the total rate.

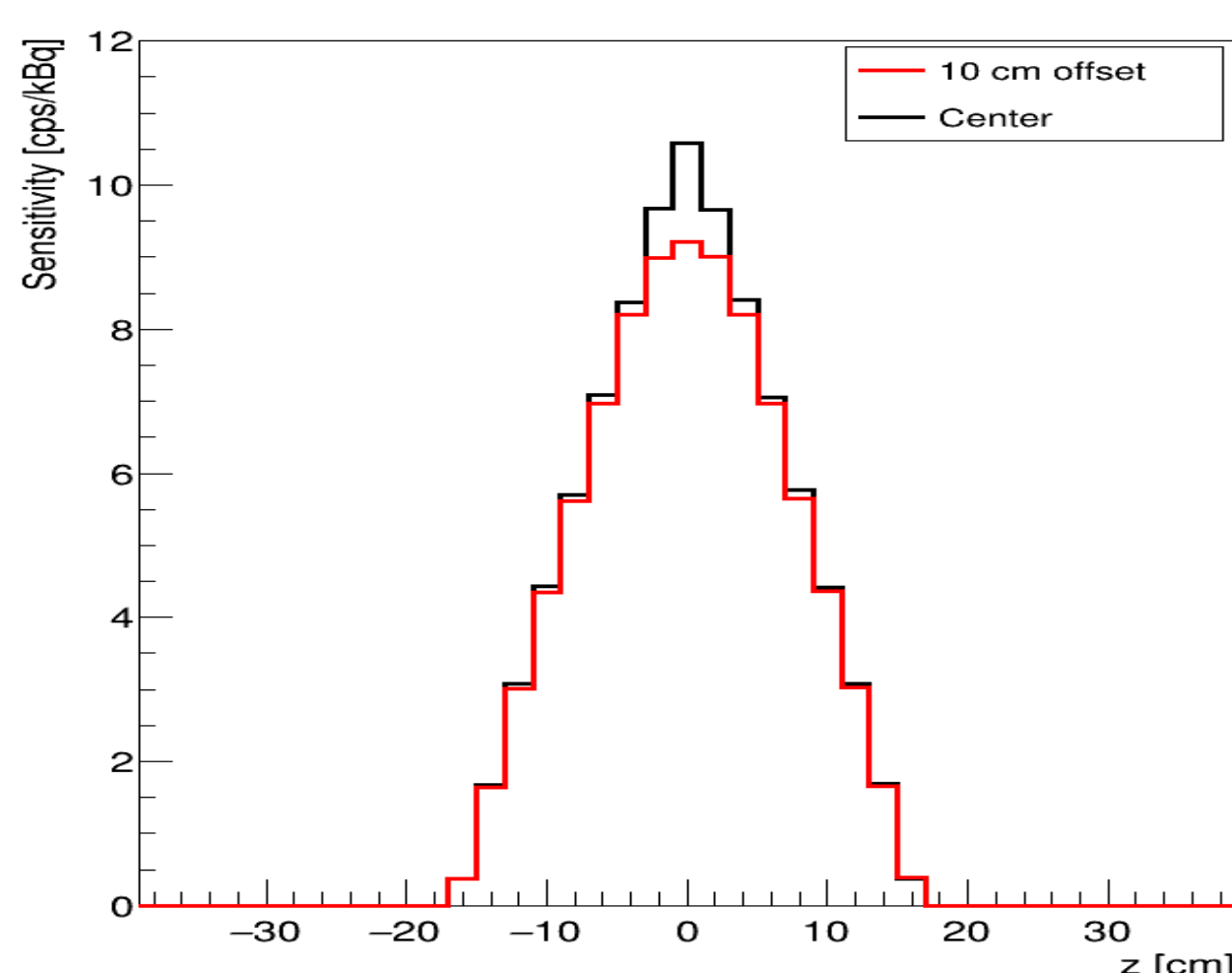


Fig 6. Axial sensitivity profile for 1 ring of the Total Body J-PET

7 rings (243 cm)

- 261.7 cm Line source
- The diameter of the source is 1 mm
- The activity of the source is 1 MBq
- Back-to-back gamma photons

✓ The source at (0, 0, 0) mm

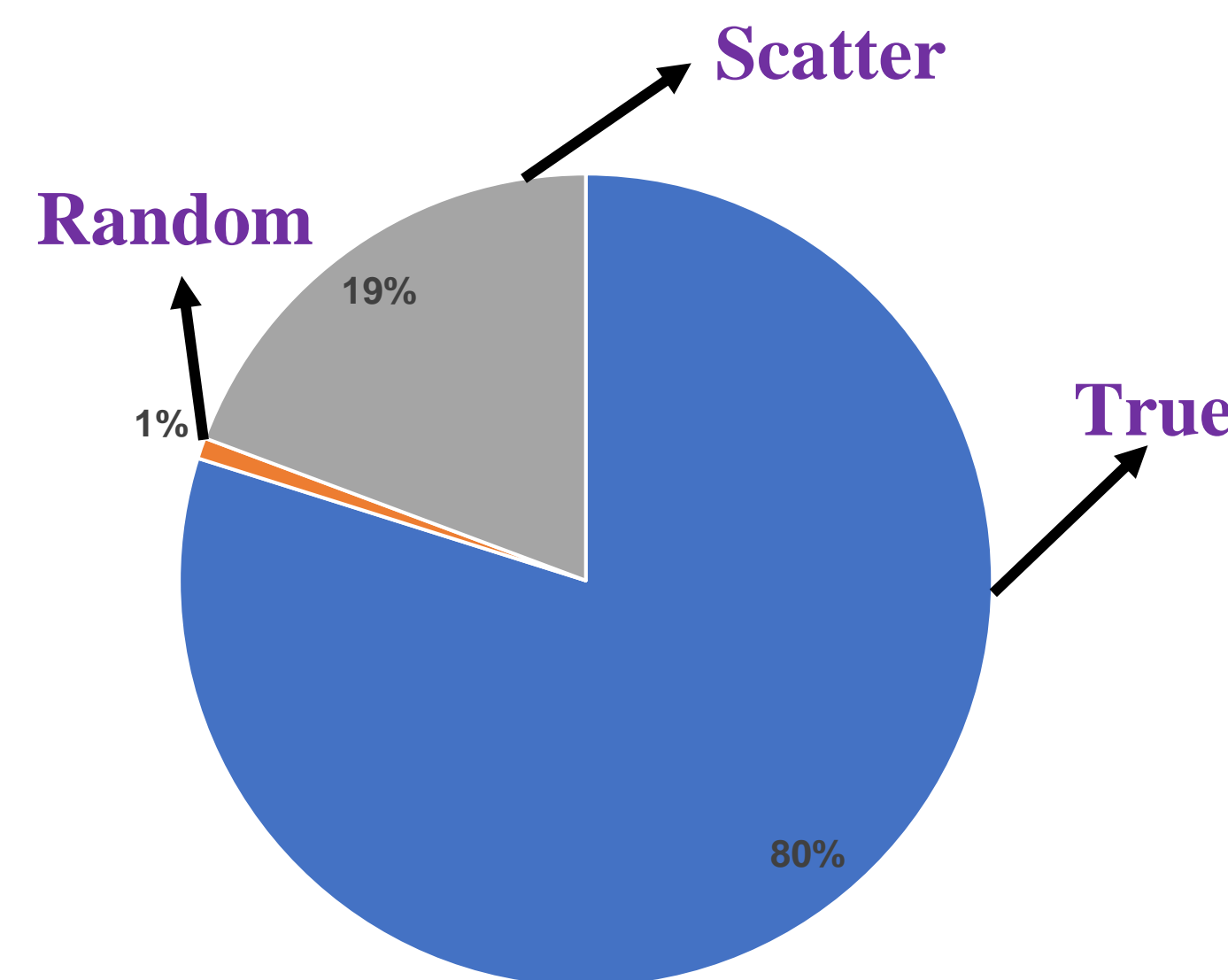


Fig 4. Types of coincidences for 7 rings sensitivity measurement with the source in the center of the scanner. The random coincidence rate is 0.8% of the total rate.

✓ The source at (0, 100, 0) mm

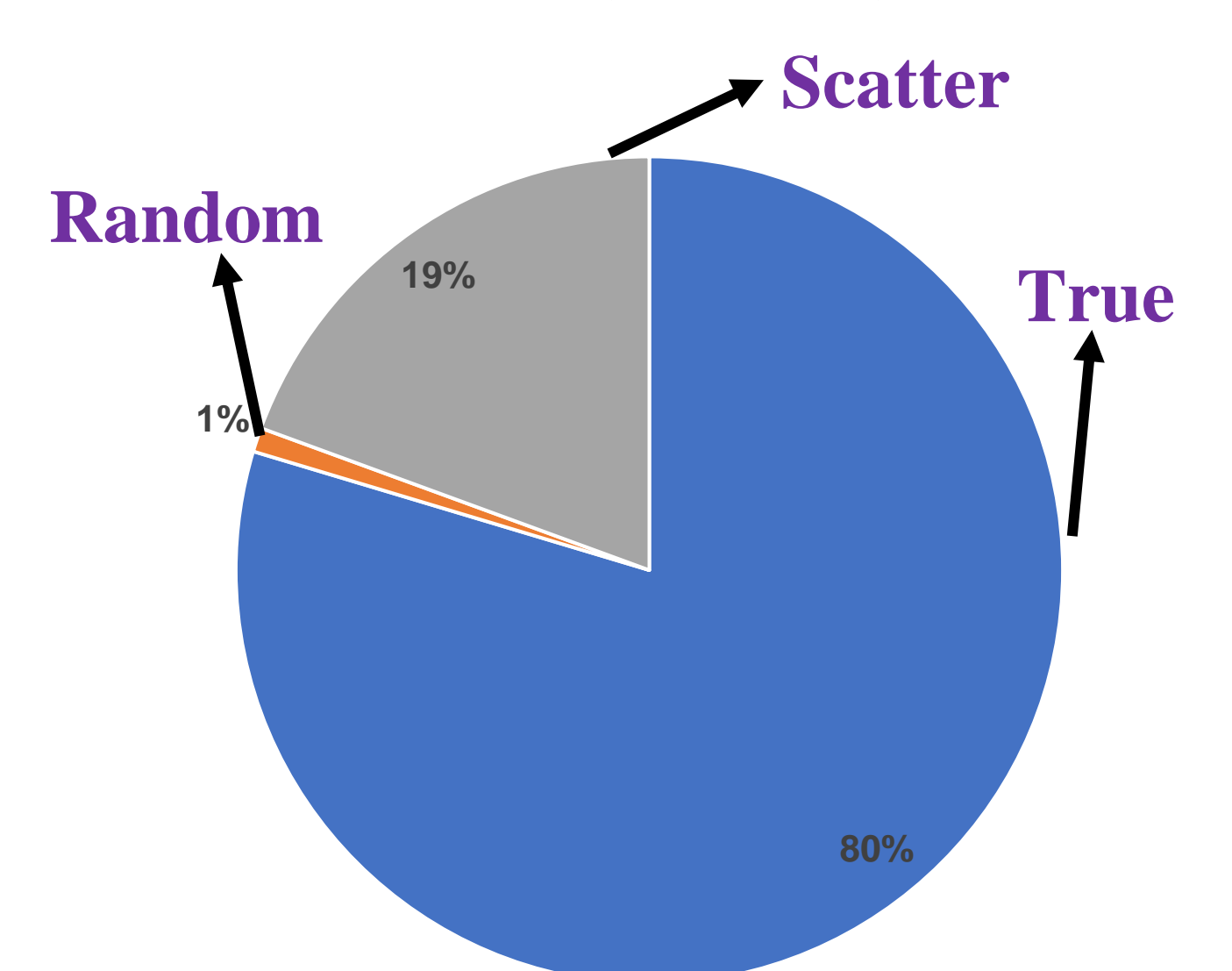


Fig 5. Types of coincidences for 7 rings sensitivity measurement with the source in the 10 cm offset of the scanner. The random coincidence rate is 0.9% of the total rate.

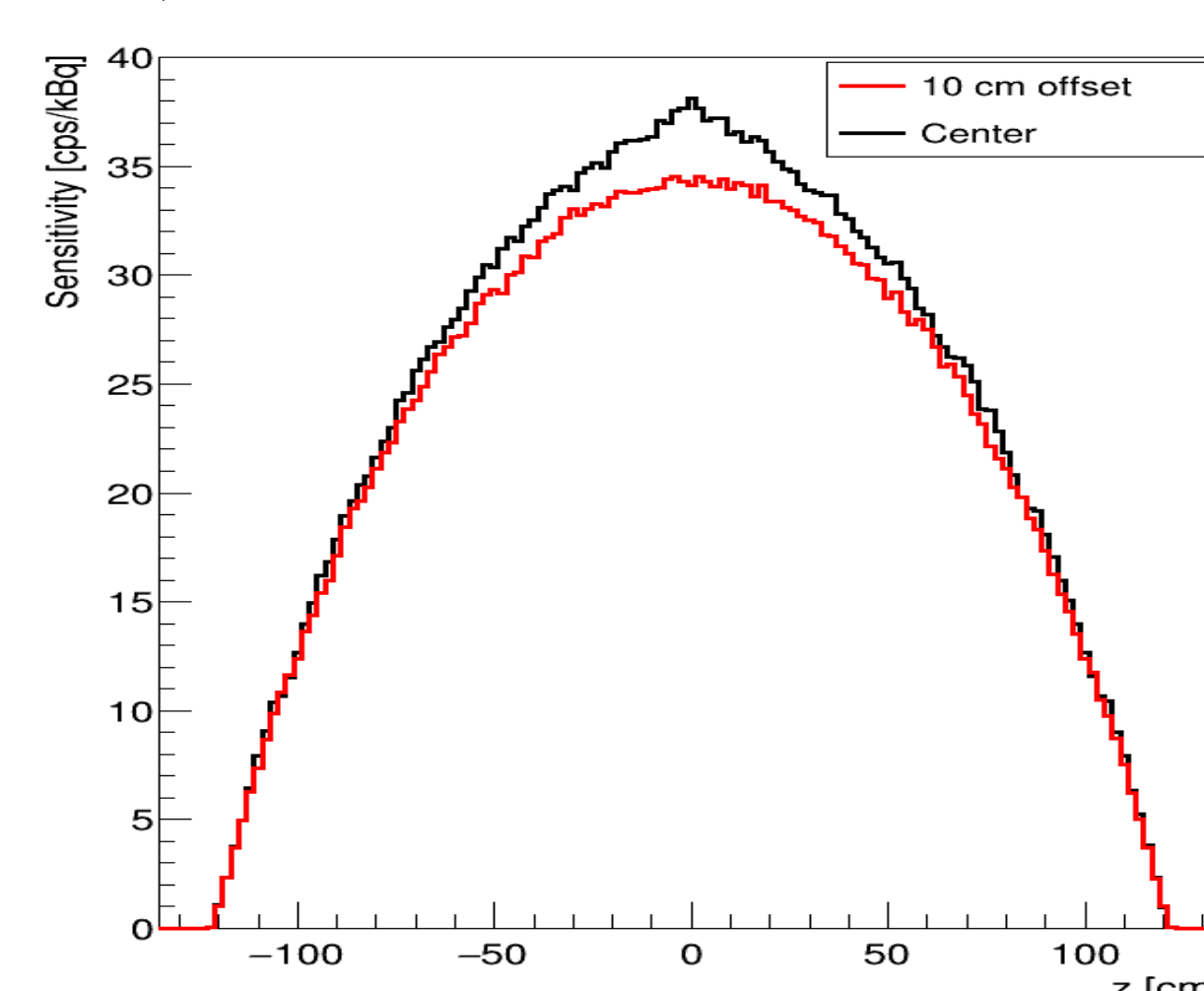


Fig 7. Axial sensitivity profile for 7 rings of the Total Body J-PET

Simulation is done with Gate V9

Conclusion

Table 1. Result of TB-JPET in comparison with traditional PET scan

	1 ring of Total Body J-PET (Simulation)	7 rings of Total Body J-PET (Simulation)	uExplorer [4] (Experimental)	uExplorer [4] (Experimental)
Scintillator	BC-408	BC-408	LYSO	LYSO
Number of modules	24	24	24	24
Number of rings	1	7	8	8
Ring diameter(cm)	89.2	89.2	78.6	78.6
AFOV (cm)	33	243	194	194
Time window (ns)	3	3	4.5	4.5
Source	Gama back to back	Gama back to back	¹⁸ F	¹⁸ F
Activity (MBq)	1	1	4	4
Energy window (keV)	> 200	> 200	430-645	430-645
Sensitivity in the center (cps/kBq)	10.5	38	174	147
Length of line source (cm)	70	261.7	70	170

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References

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