NEMA Phantom Characteristics of Simultaneous Double Isotope Imaging With J-PET Using 55Co + 18F And 52Mn + 18F Isotopes

Ermias Y. Beyene, P. Moskal and E. Stepien on behalf of J-PET collaboration

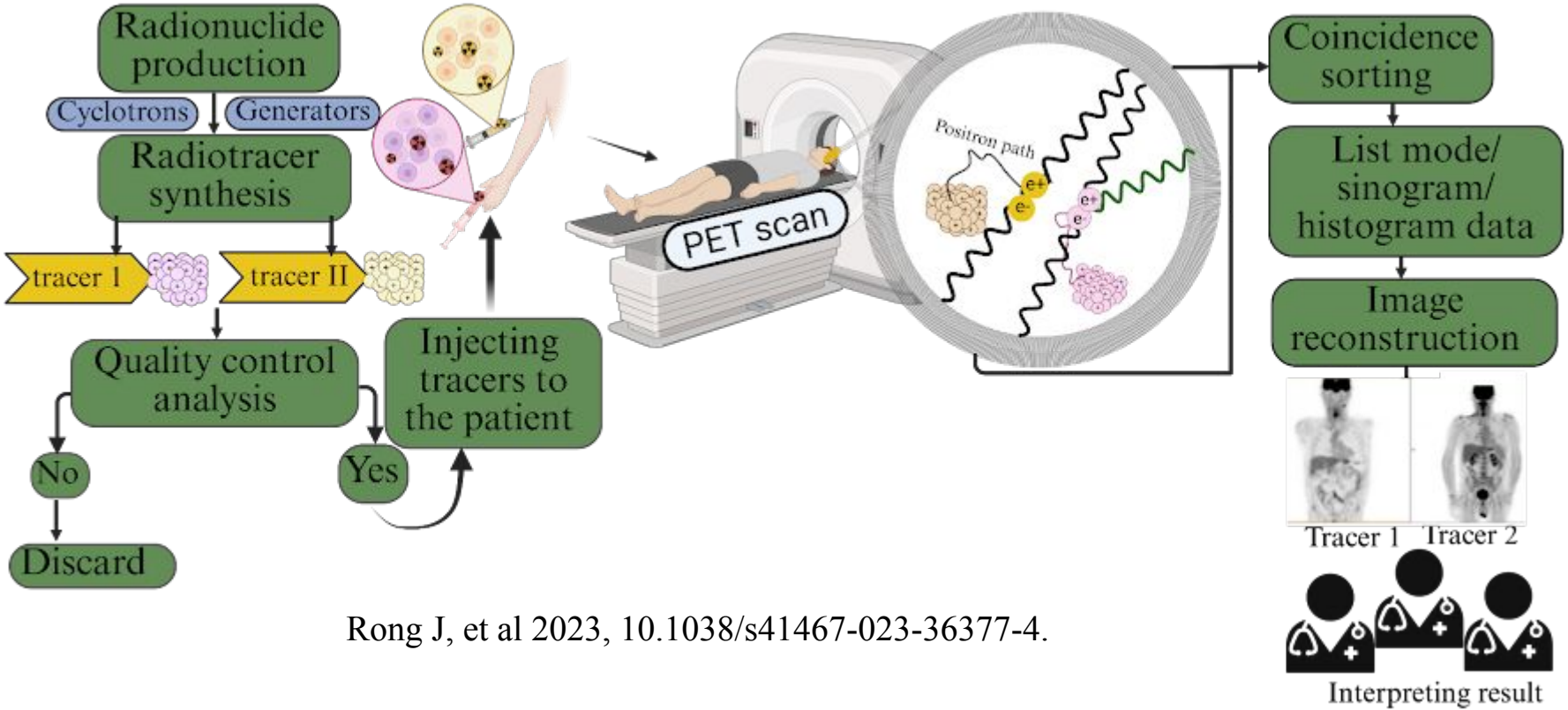


Outlines

- Introduction to PET
- Double isotope imaging principes with J-PET
- Measurements conducted with NEMA phantom
- Results

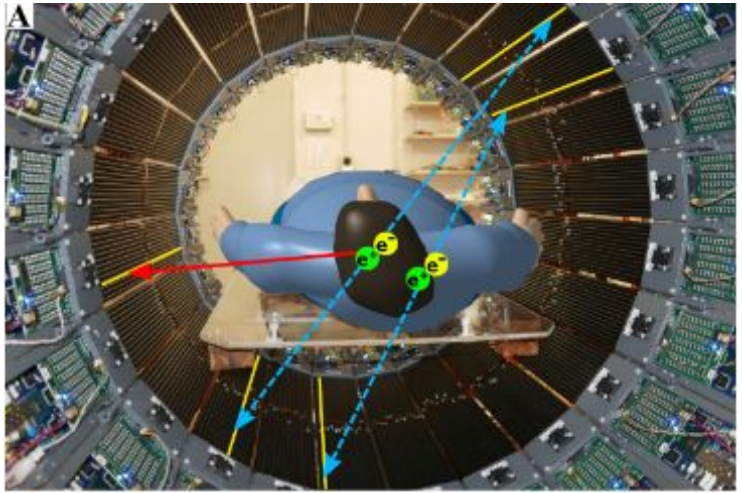
Basic principles of PET

- **Positron emission Tomography (PET) is a powerful imaging modality**



Rong J, et al 2023, 10.1038/s41467-023-36377-4.

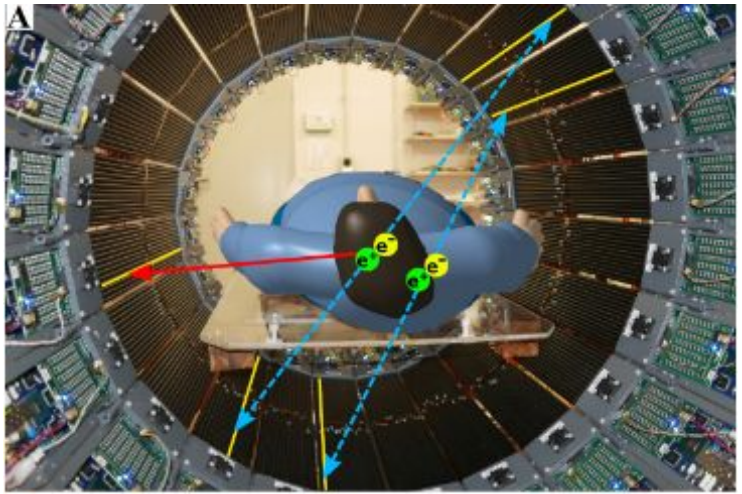
Overview of key points of double-isotope imaging



Overview of key points of double-isotope imaging

Advantages:

- Multiple scans simultaneously
- Enhanced information beyond a single scan
- Enhanced diagnostic accuracy



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How it is Done:

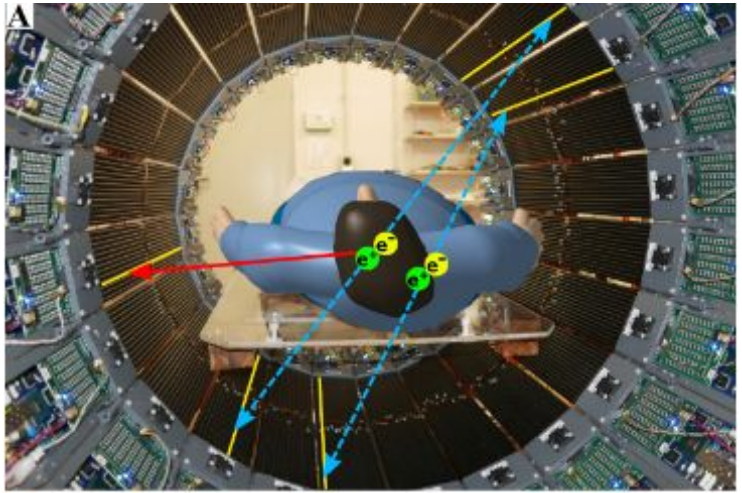
Sequential vs. simultaneous imaging

Sequential

- One after the other
- Needs to wait for the first tracer to wash out
- Physiological changes may occur
- Reduces patient comfort

Simultaneous

- Simultaneous imaging at real time
- Needs careful for isotope selection
- Pure beta & beta + gamma emitters
- Minimizes physiological variability
- Minimized patient discomfort, scan time
- Better correlation in co localization studies



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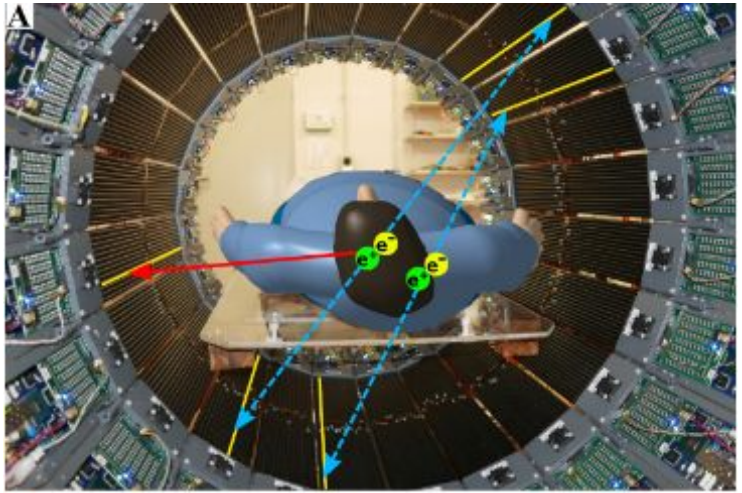
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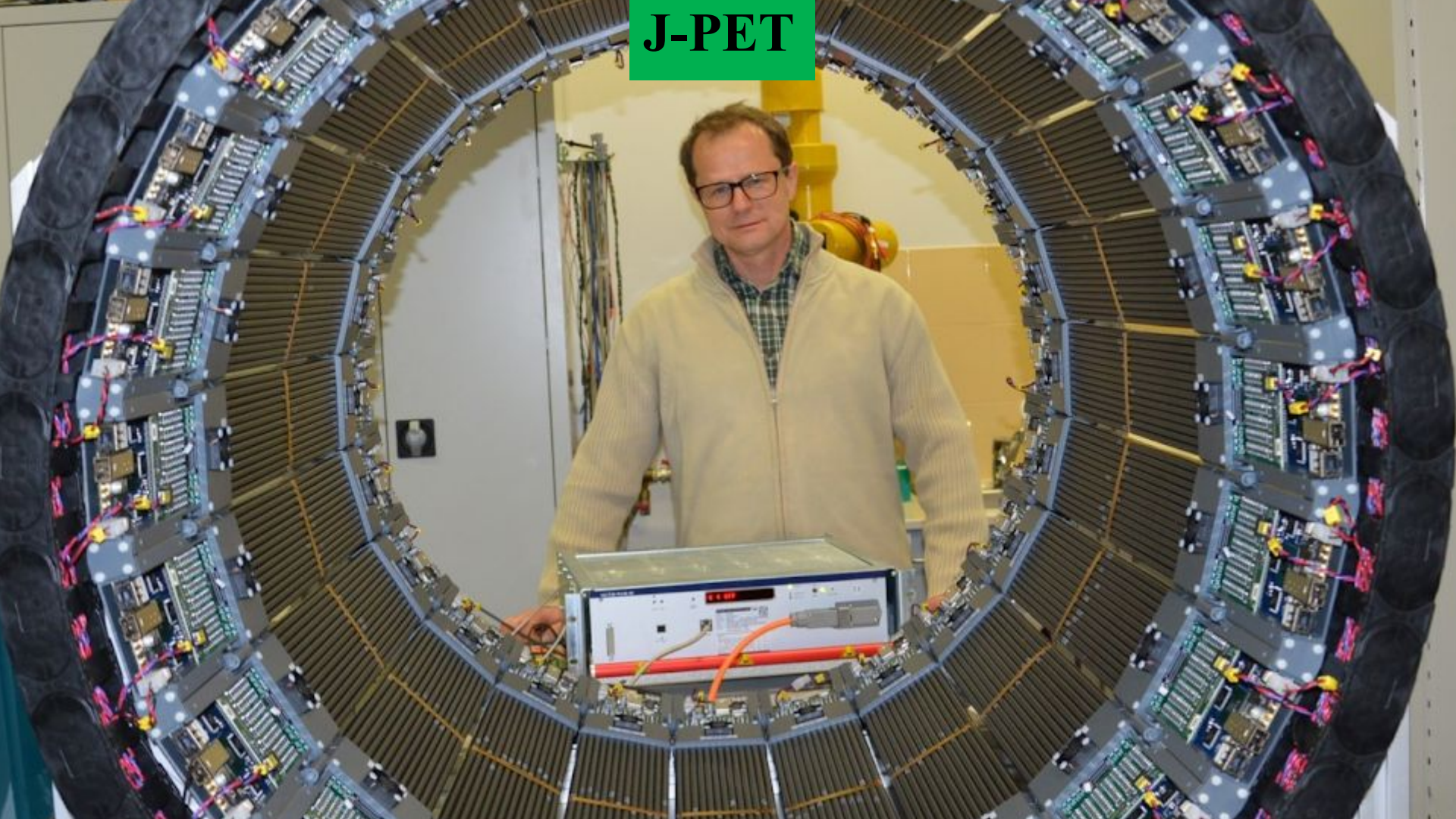
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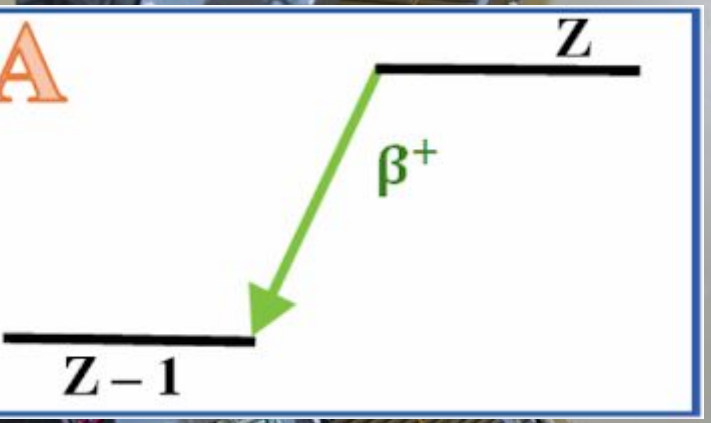
J-PET scanner:

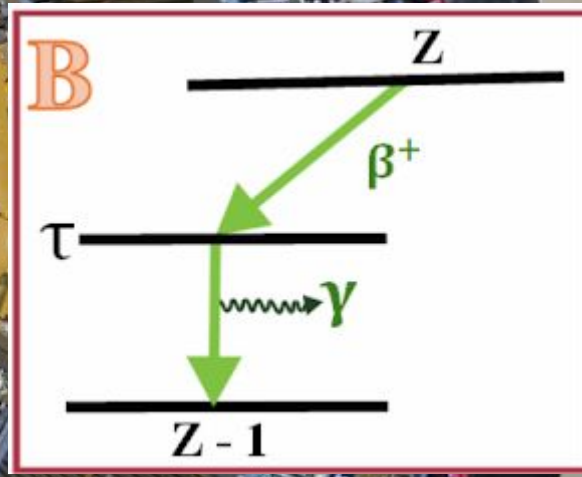
- Detection of annihilation and prompt gammas



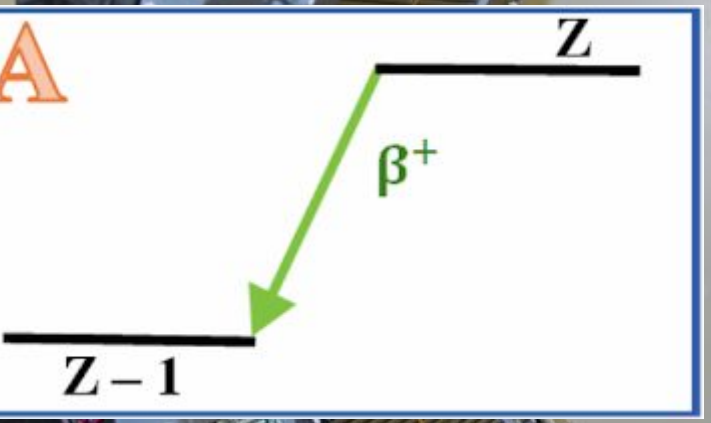

J-PET

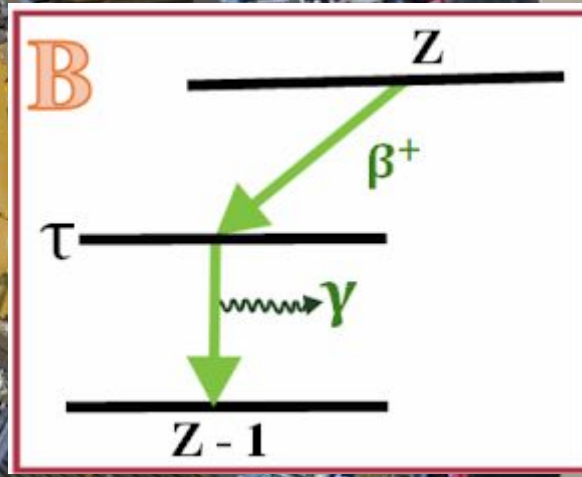
J-PET





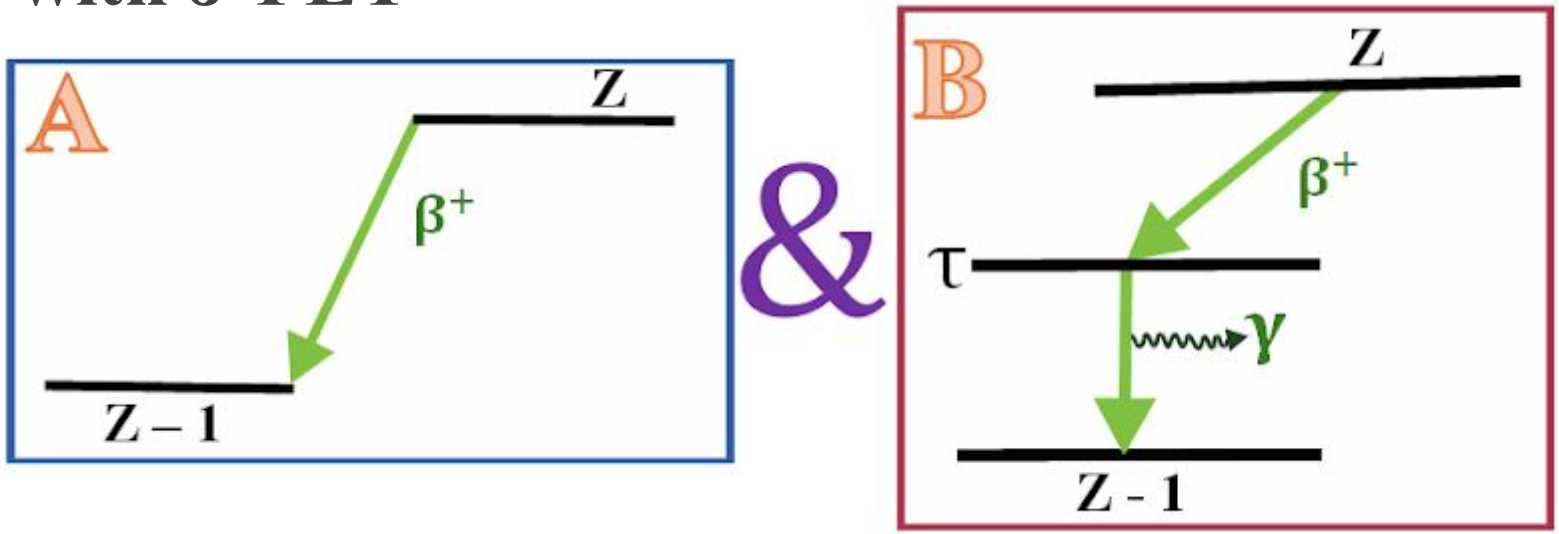
J-PET



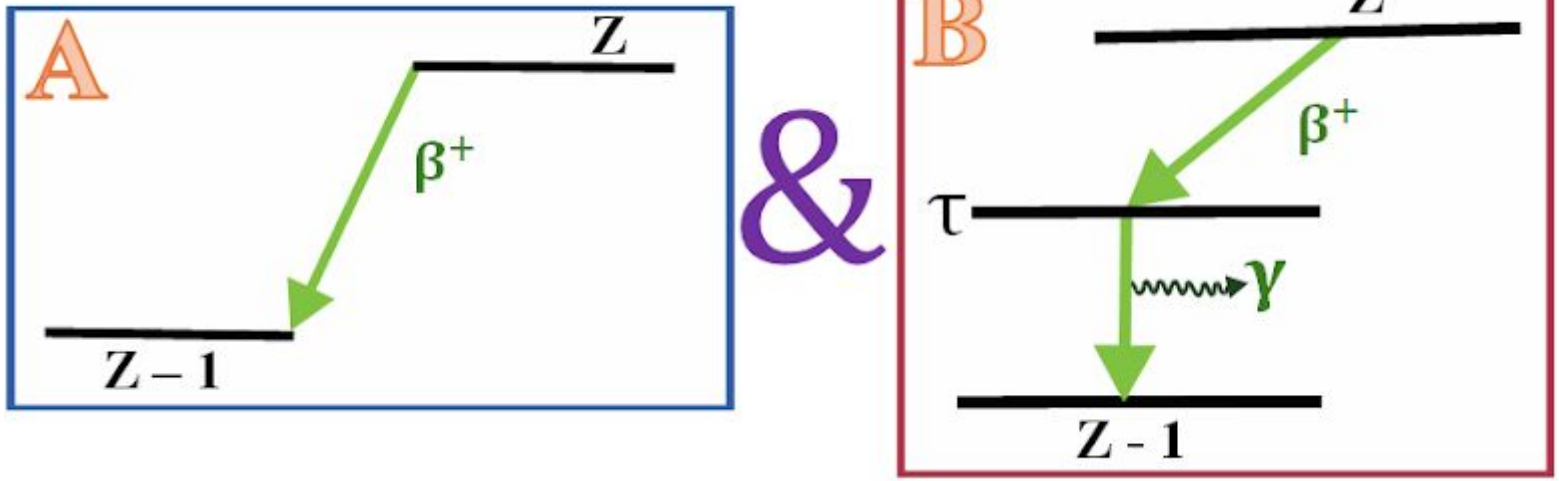


- Trigger less DAQ
- Multi-photon detection capability

… with J-PET



… with J-PET

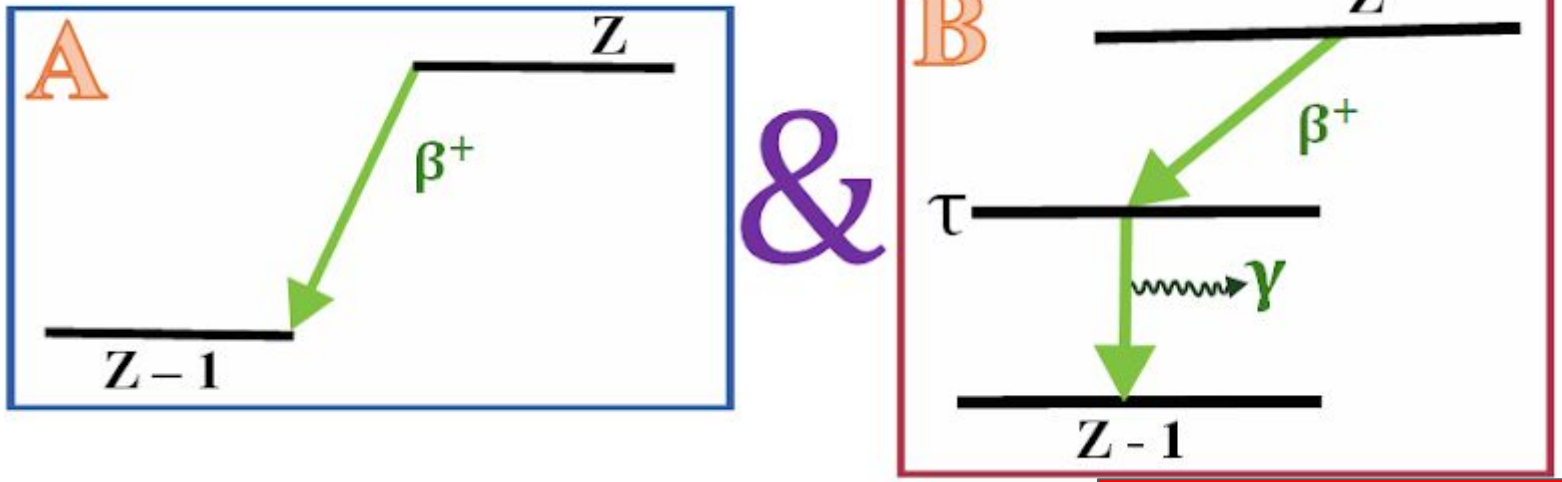


2gamma event selection and reconstruction

Image of two isotopes

Isotope A + Isotope B

… with J-PET



2gamma event selection and reconstruction

Image of two isotopes

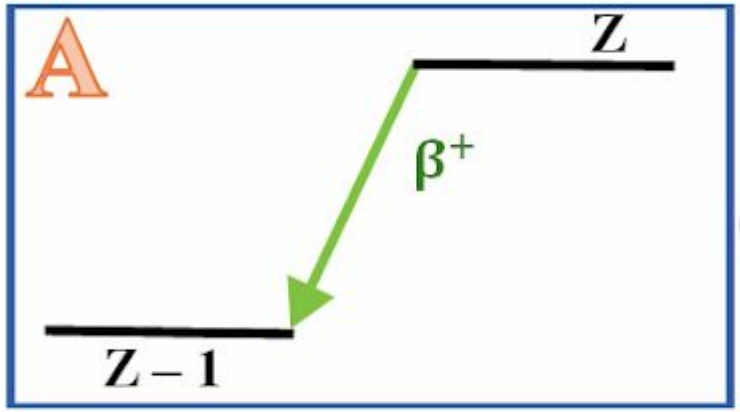
Isotope A + Isotope B

2gamma + prompt event event selection and reconstruction

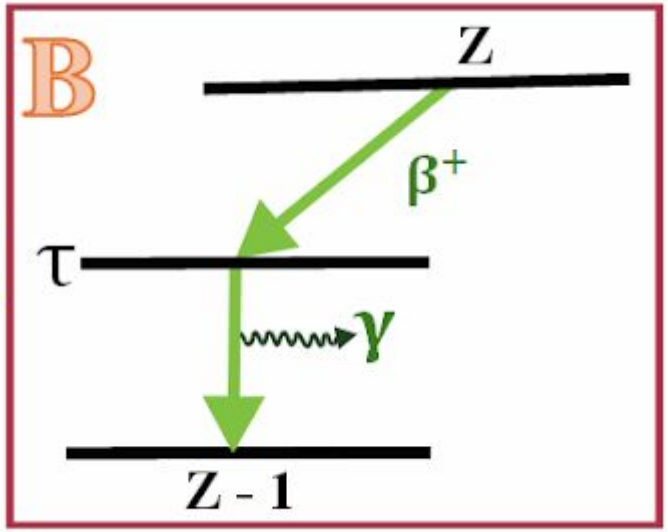
Image of beta + gamma emitter

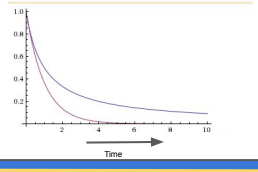
Isotope B

… with J-PET



&





2gamma event selection and reconstruction

Image of two isotopes

Isotope A + Isotope B

2gamma - Ɛ * (2gamma + prompt)

Image of pure beta emitter

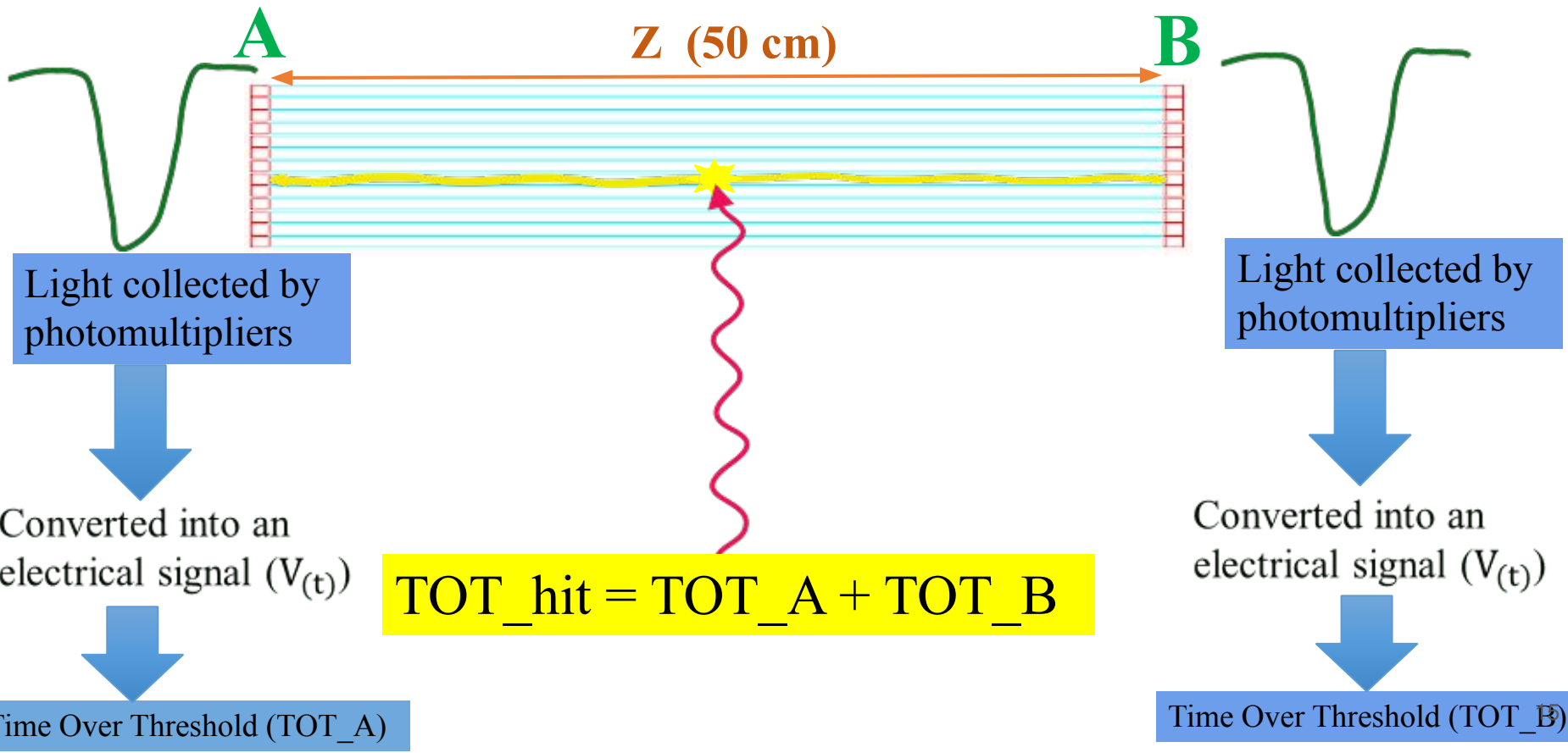
Isotope A

2gamma + prompt event event selection and reconstruction

Image of beta + gamma emitter

Isotope B

J-PET acquisition



Isotopes

44Sc + 18F
55Co + 18F
52Mn + 18F

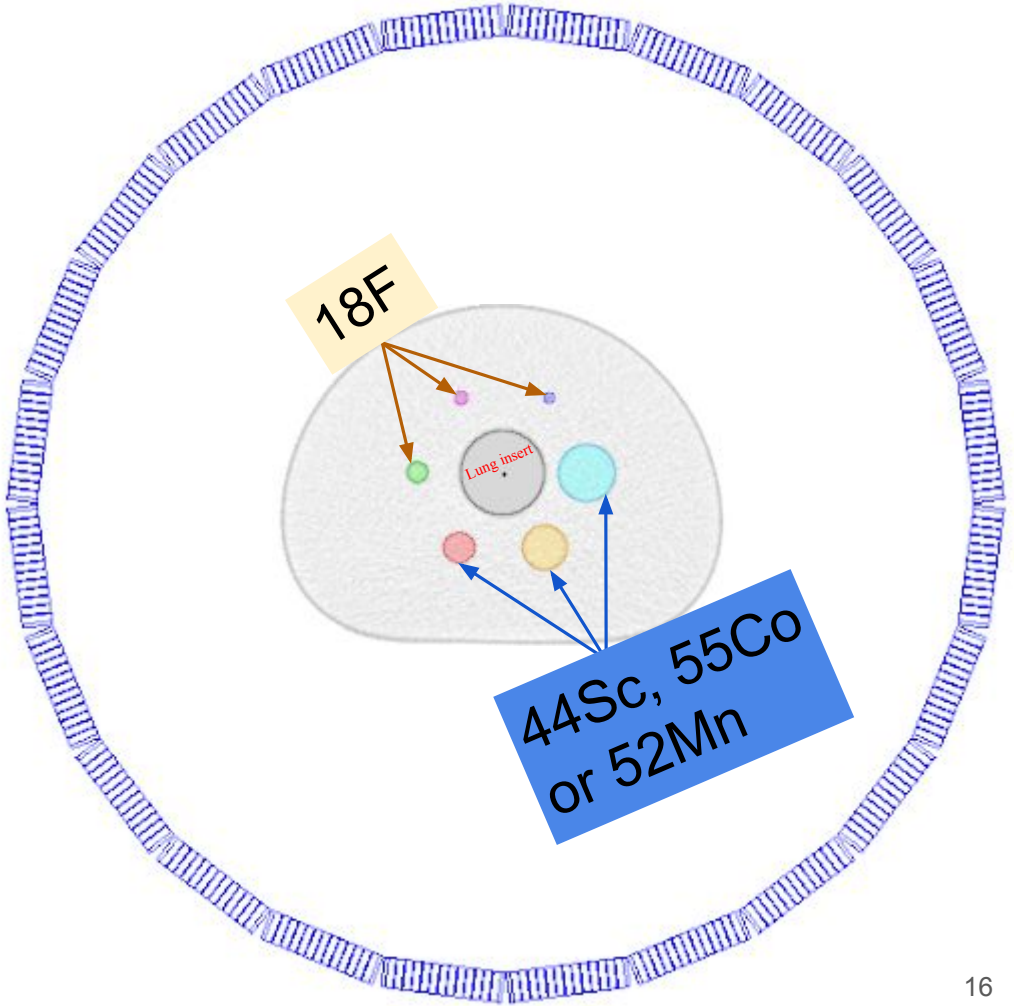


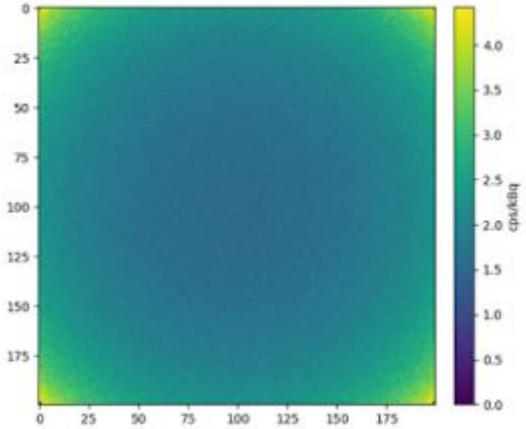
Table of isotopes

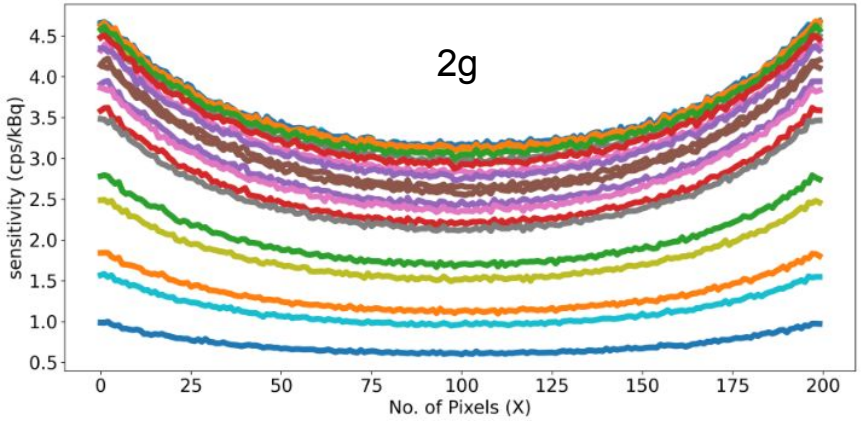
Isot.	HL	β+ (%)	γ_P (MeV & %)	β+ γ_P	Y_((β+ γ))/β+	ε_γp/ε_((γ_511))
^{18}F	110 min	97	---	---	---	---
^{44}Sc	3.97 hr.	94	1.157 (100.0)	100.0	100	0.56
^{55}Co	17.53 hr.	57	0.477 (20) 0.931 (75) 1.316 (7.1) 1.409 (17)	13 59 3.5 11	17.8 77.7 3.8 10.7	1.02 0.63 0.57 0.51
^{52}Mn	5.6 da.	29	0.744 (90) 0.936 (94) 1.434 (100)	100	100	0.72 0.62 0.50

Beyene et al, poster

Sensitivity maps

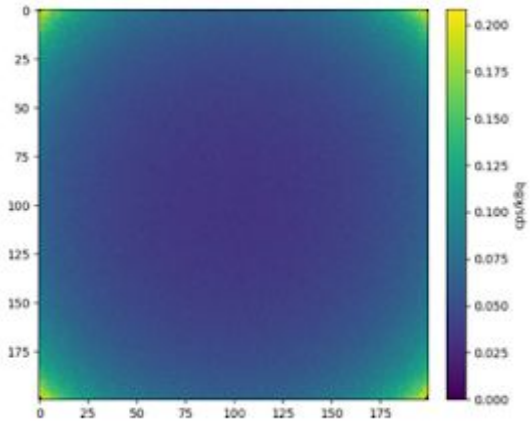
2g

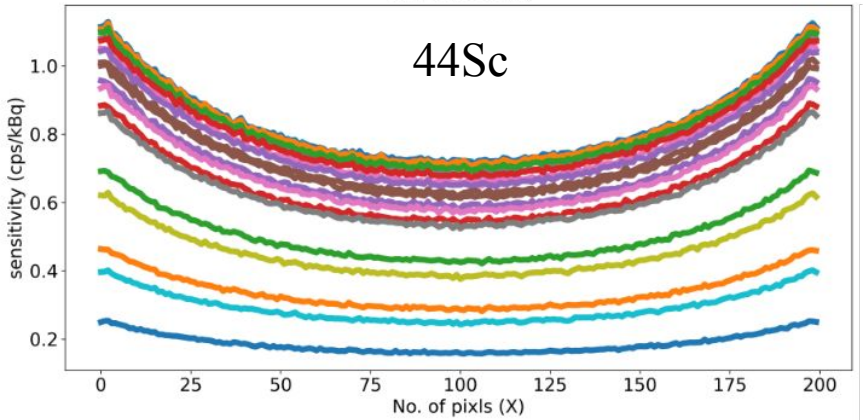




2g + g_p.

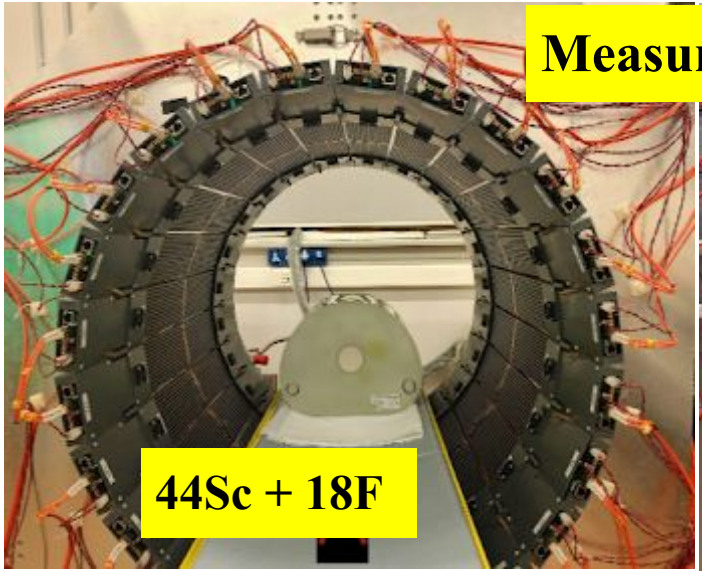
44Sc

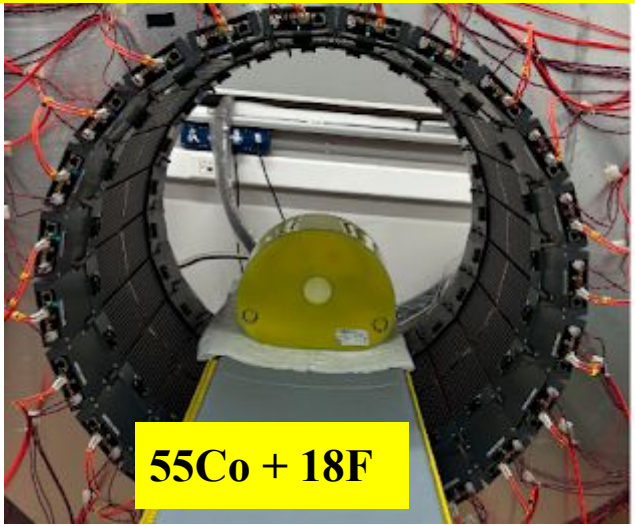


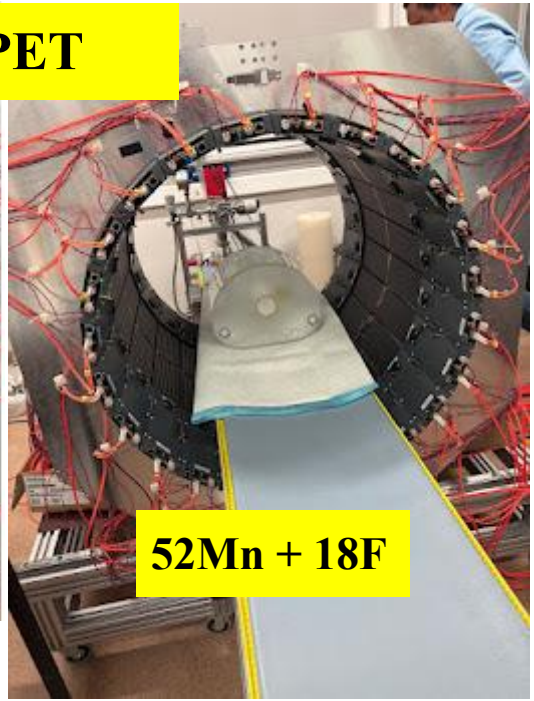


Beyene et al, poster (55Co and 52Mn)

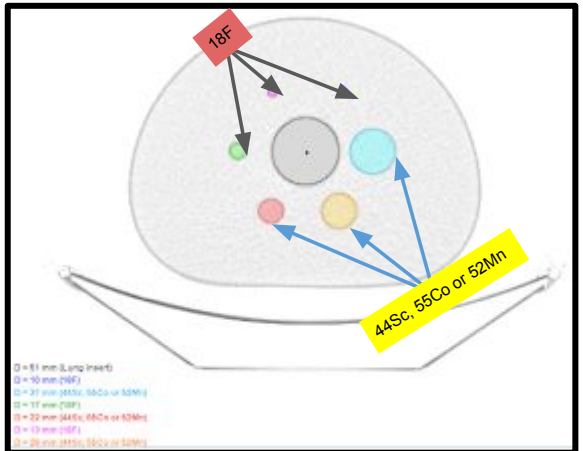
Measurements conducted with J-PET



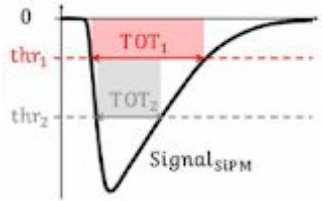




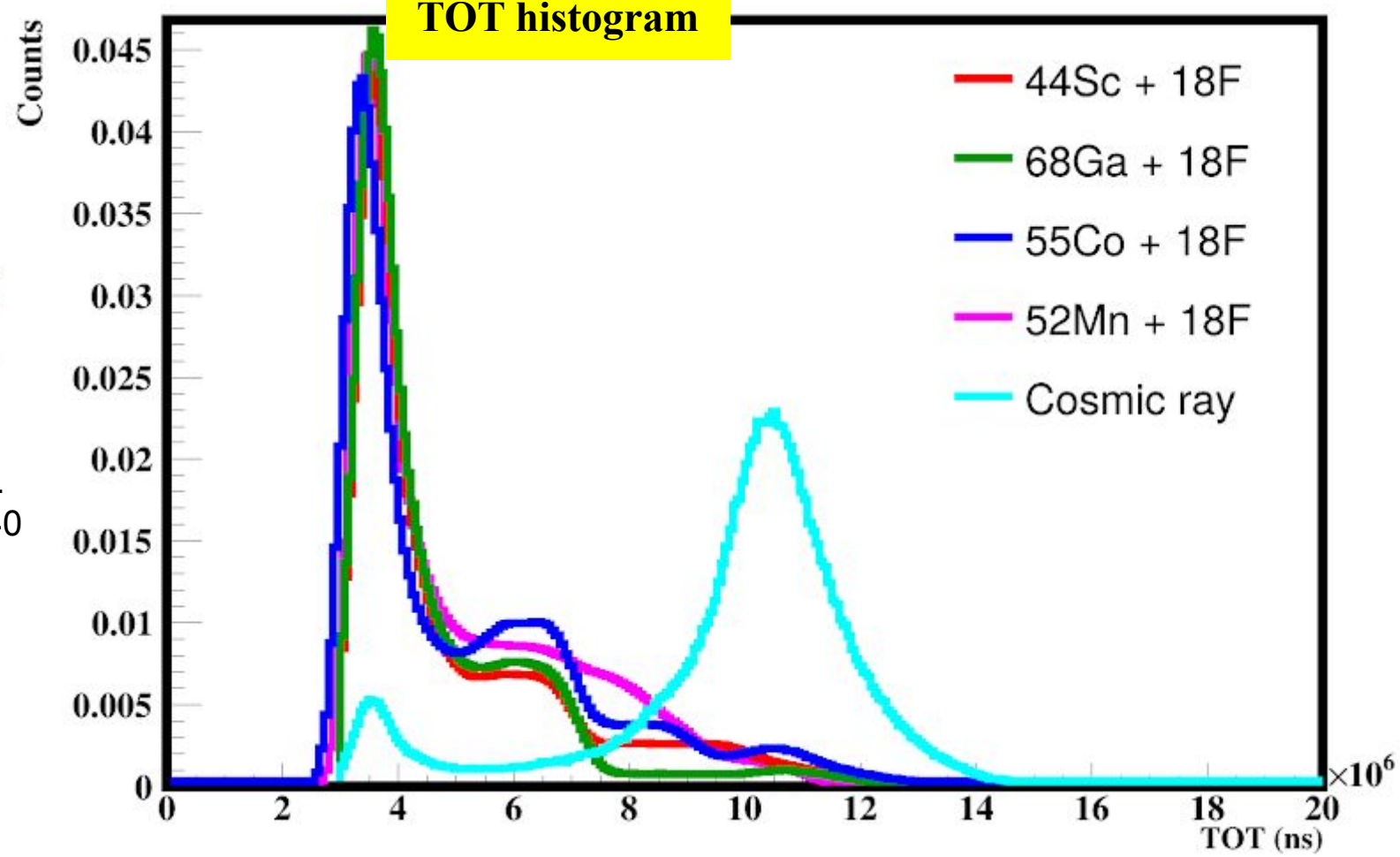




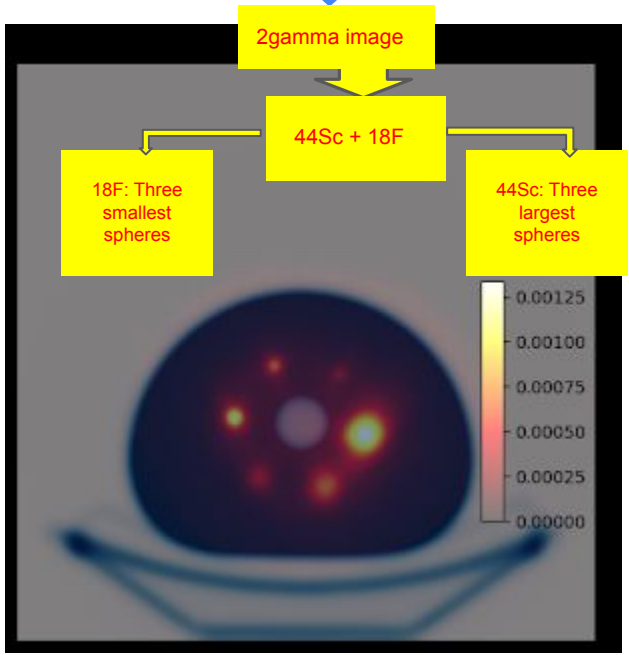
TOT histogram



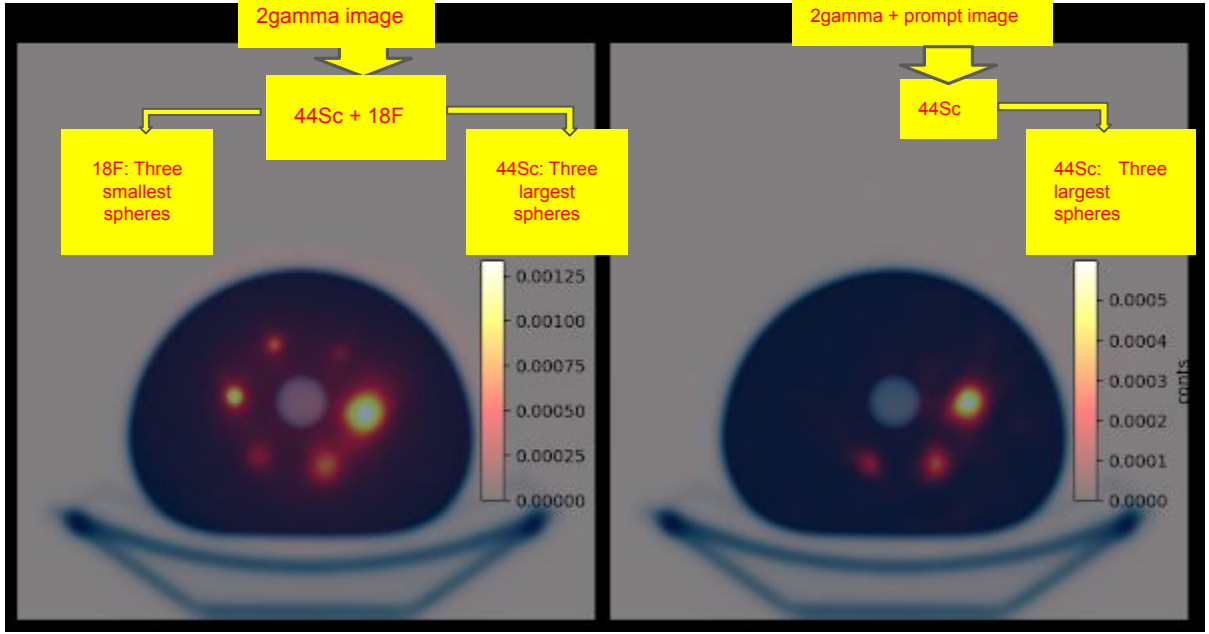
Moskal et al., Sci. Adv. 10, eadp2840 (2024)



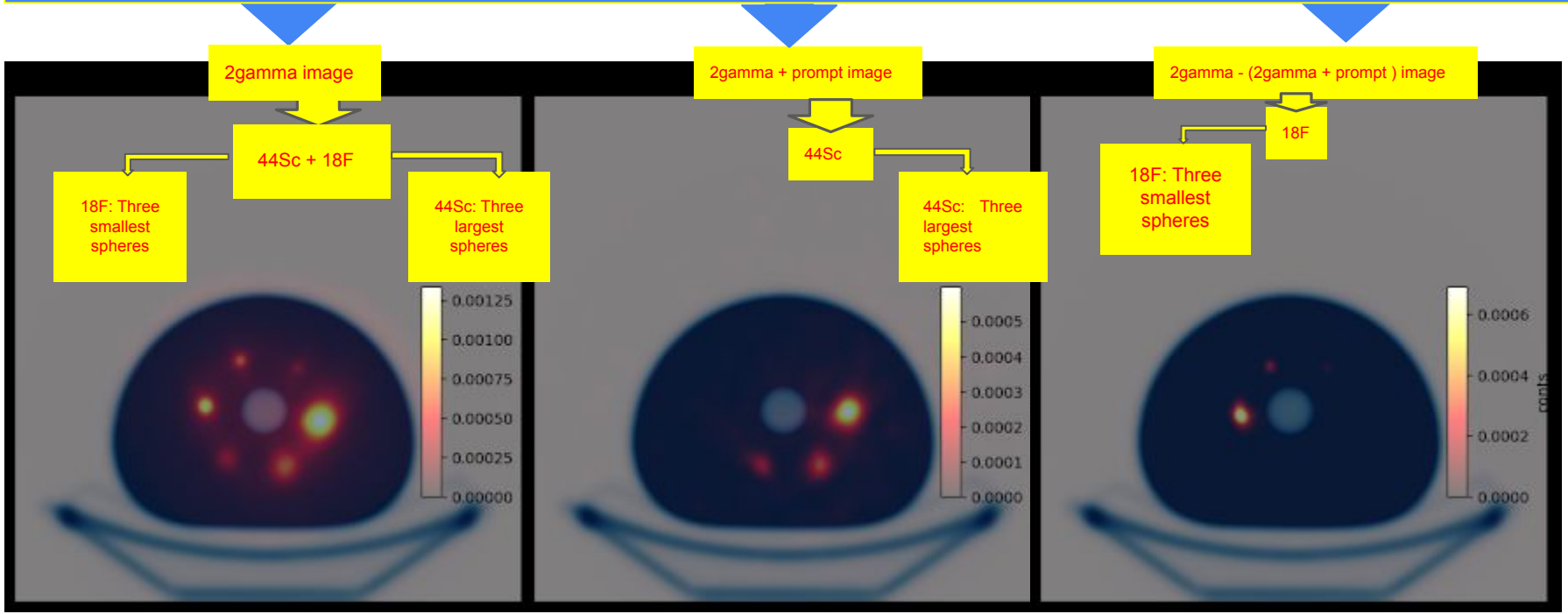
44Sc + 18F Measurement



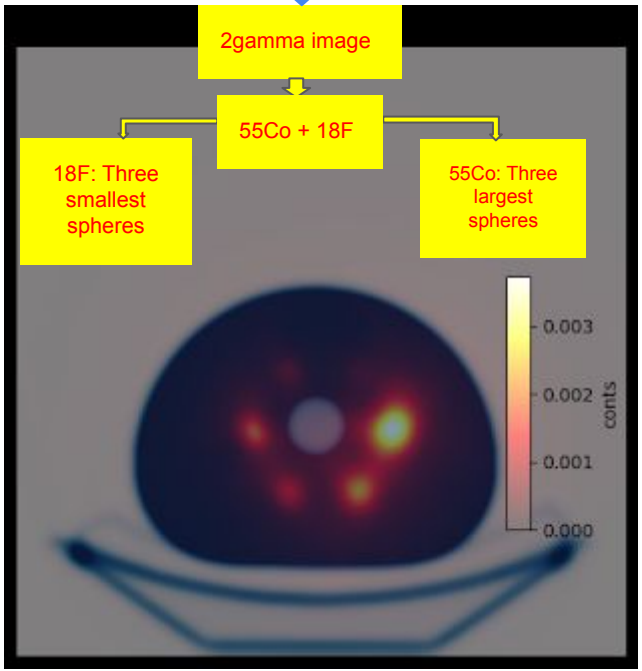
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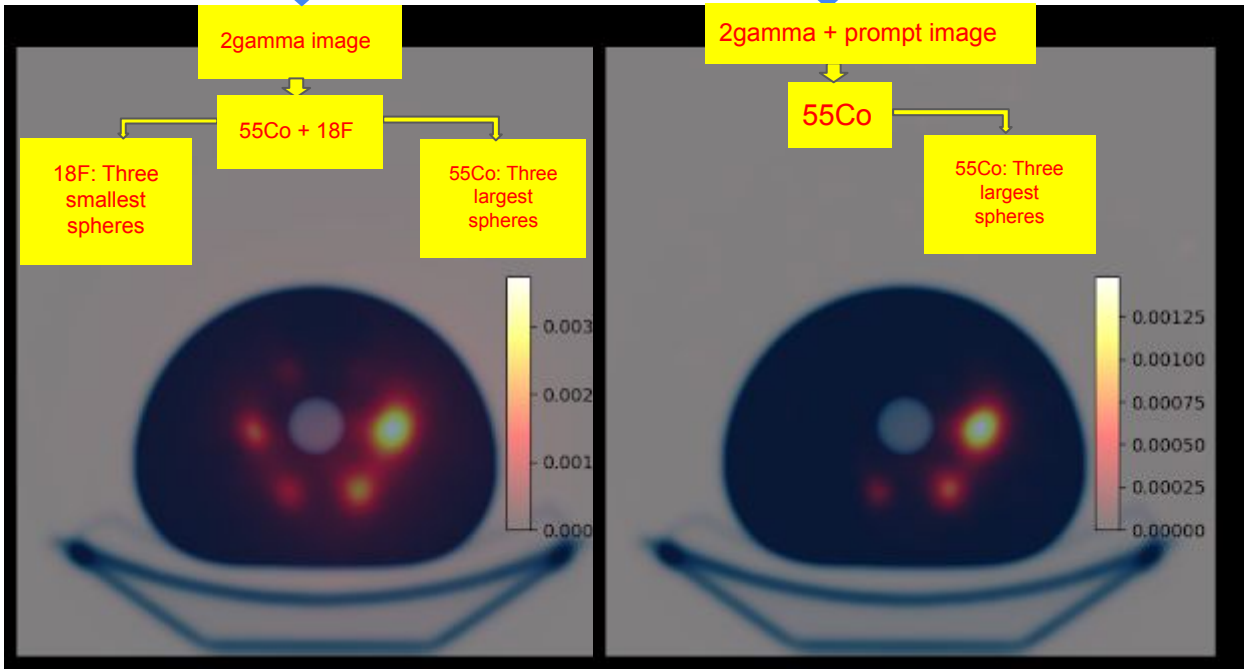
44Sc + 18F Measurement



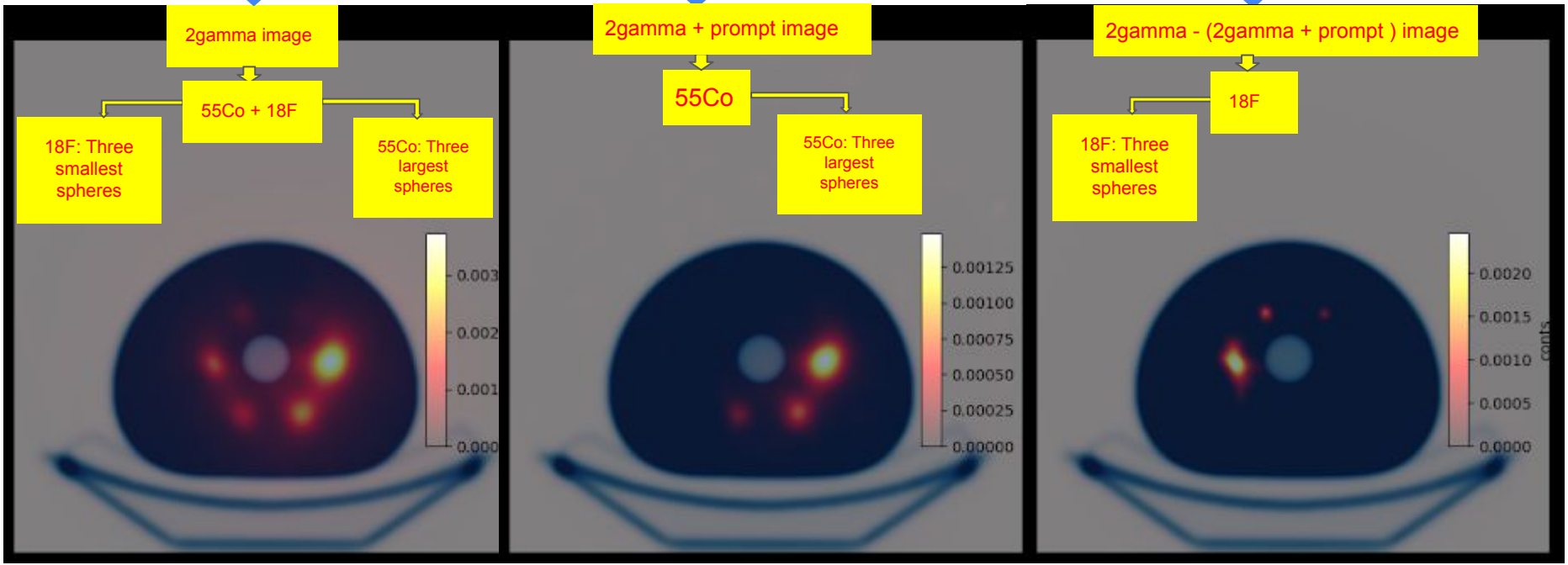
55Co + 18F Measurement



55Co + 18F Measurement



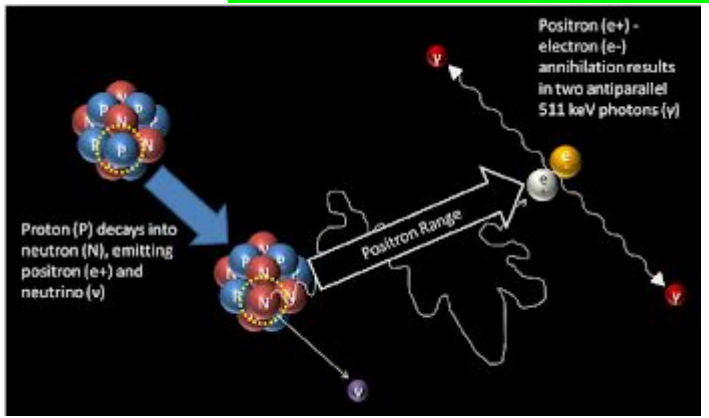
55Co + 18F Measurement



My comment

My comment (PET -> PGET)

My comment (PET -> PGET)



Radioisotope/tracer

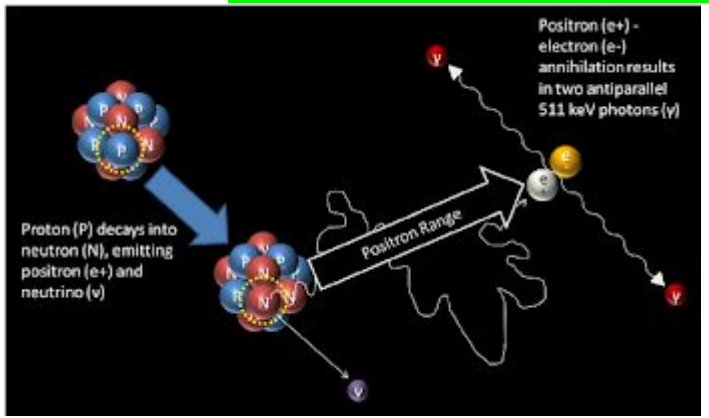
Positron emitted

Annihilated by the electron

Emitting gamma

P E T

My comment (PET -> PGET)



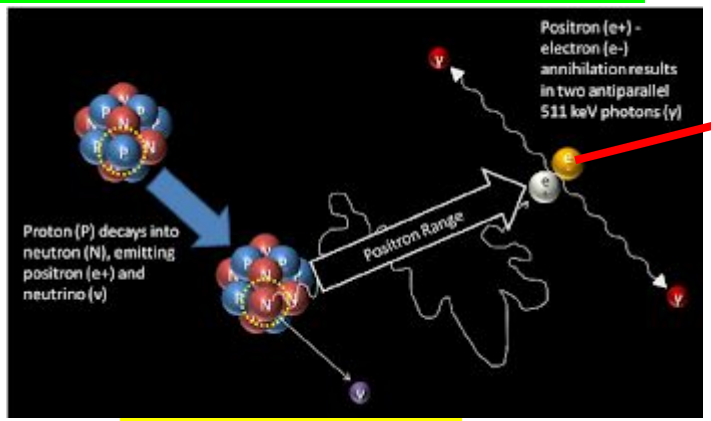
Radioisotope/tracer

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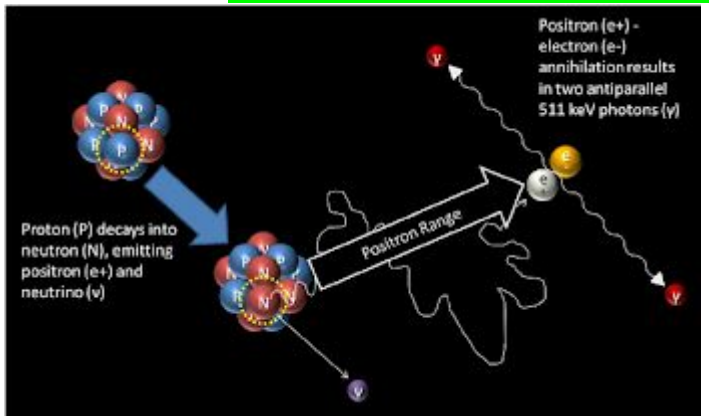
Radioisotope/tracer

Positron emitted + **prompt gamma**

Annihilated by the electron

Emitting annihilation gamma + **prompt gamma**

My comment (PET -> PGET)



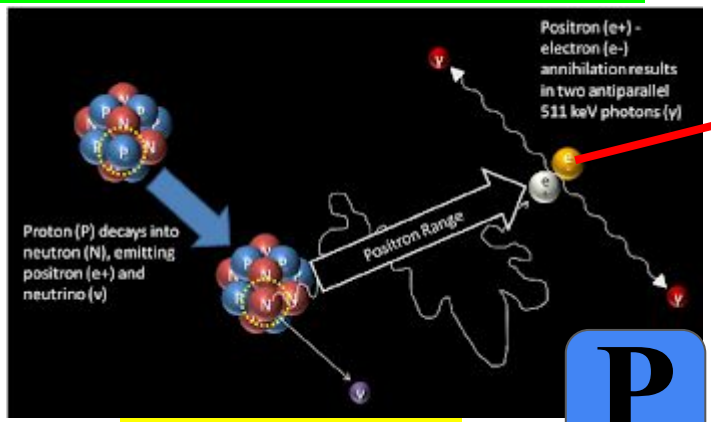
Radioisotope/tracer

Positron emitted

Annihilated by the electron

Emitting gamma

P E T



Radioisotope/tracer

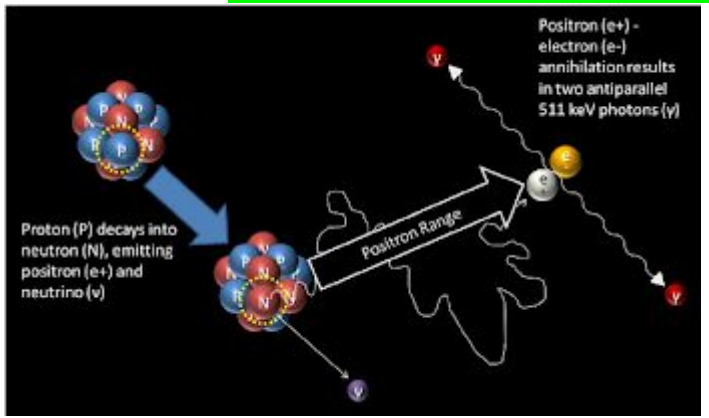
Positron emitted + **prompt gamma**

Annihilated by the electron

Emitting annihilation gamma + **prompt gamma**

P G E T

My comment (PET -> PGET)



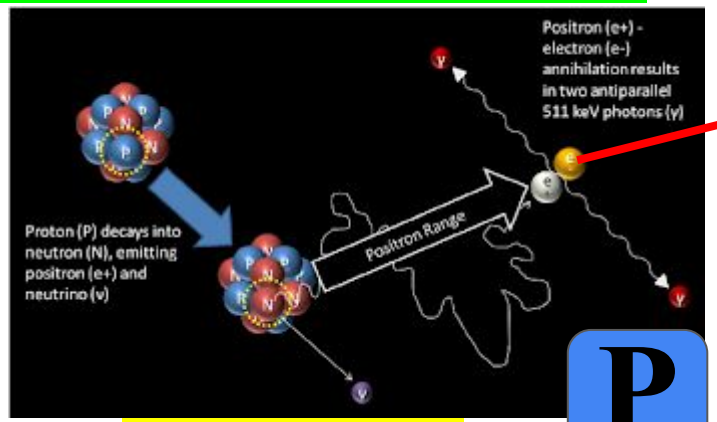
Radioisotope/tracer

Positron emitted

Annihilated by the electron

Emitting gamma

PET



Radioisotope/tracer

Positron emitted + **prompt gamma**

Annihilated by the electron

Emitting annihilation gamma + **prompt gamma**

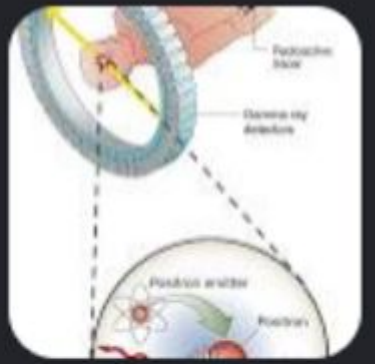
PGET

Positron Gamma Emission Tomography (PGET)

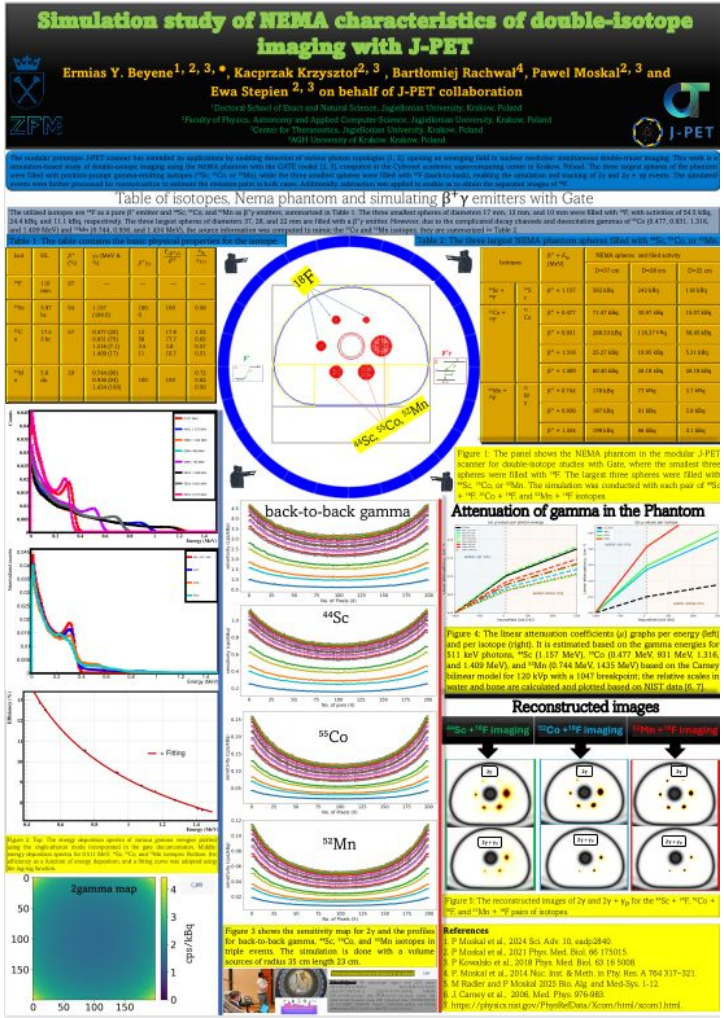


Positron Gamma Emission Tomography (PGET)

There is no medical imaging system known as Positron Gamma Emission Tomography (PGET).



Medical systems that use positrons and gamma rays are simply called **PET (Positron Emission Tomography)** scans. During a PET scan, a patient is injected with a radioactive tracer. As the tracer decays, it emits positrons. These positrons collide with electrons in the body, causing an annihilation event that simultaneously emits **two gamma rays** in opposite directions. The PET scanner detects these gamma rays to map cellular and metabolic activity. Wikipedia +4


Simulation study of NEMA characteristics of double-isotope imaging with J-PET
Ermias Y. Beyene[1, 2, 3, *], Kacprzak Krzysztof[2, 3], Bartłomiej Rachwał[4], Pawel Moskal[2, 3] and Ewa Stepien[2, 3] on behalf of J-PET collaboration
[1]Doctoral School of Exact and Natural Science, Jagiellonian University, Krakow, Poland
[2]Faculty of Physics, Astronomy and Applied Computer Science, Jagiellonian University, Krakow, Poland
[3]Center for Theranostics, Jagiellonian University, Krakow, Poland
[4]AGH University of Krakow, Krakow, Poland
Table of isotopes, Nema phantom and simulating β+γ emitters with Gate
Table 1: The table contains the basic physical properties for the isotope.
Table 2: The three largest NEMA phantom spheres filled with
Figure 1: The panel shows the NEMA phantom in the modular J-PET
scanner for double-isotope studies with Gate, where the smallest three
spheres were filled with
Figure 2: Top: The energy deposition spectra of various gamma energies plotted
Figure 3 shows the sensitivity map for 2γ and the profiles
for back-to-back gamma.
back-to-back gamma
Attenuation of gamma in the Phantom
Figure 4: The linear attenuation coefficients (μ) graphs per energy (left)
and per isotope (right). It is estimated based on the gamma energies for
Reconstructed images
Figure 5: The reconstructed images of 2γ and 2γ + γp for the
References
1. P Moskal et al., 2024 Sci. Adv. 10, eadp2840.
2. P Moskal et al., 2021 Phys. Med. Biol. 66 175015.
3. P Kowalski et al., 2018 Phys. Med. Biol. 63 16 5008.
4. P. Moskal et al., 2014 Nuc. Inst. & Meth. in Phy. Res. A 764 317–321.
5. M Rädler and P Moskal 2025 Bio. Alg. and Med-Sys. 1-12.
6. J. Carney et al., 2006. Med. Phys. 976-983.
7. https://physics.nist.gov/PhysRefData/Xcom/html/xcom1.html.

Thank You

