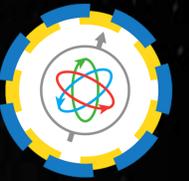




Developing positronium imaging technique for the liver phantom using modular J-PET

(A preliminary studies of the positronium lifetime for the multifocal gastric NET)

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On behalf of the J-PET collaboration



J-PET

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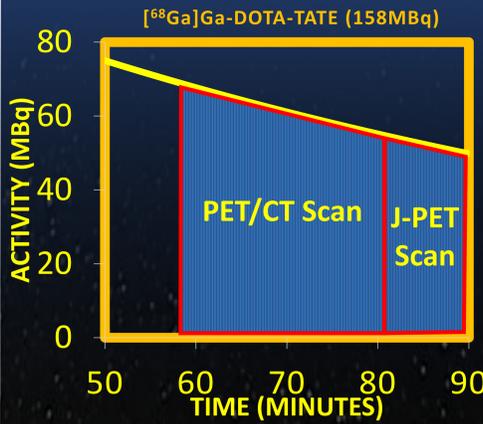
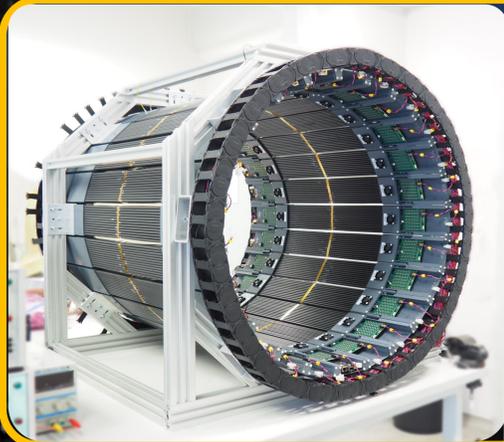
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Positronium imaging

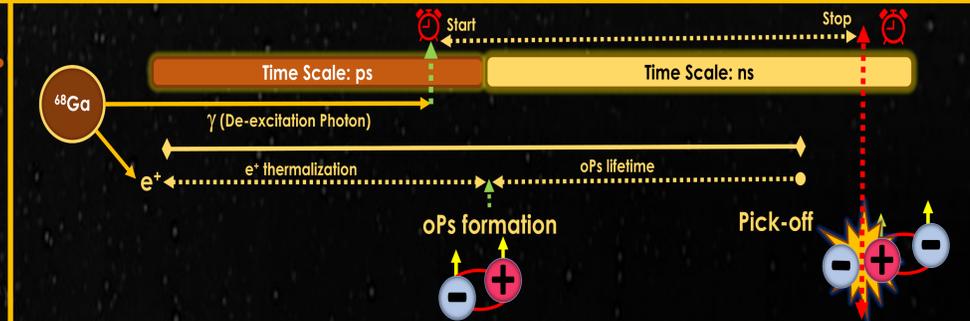
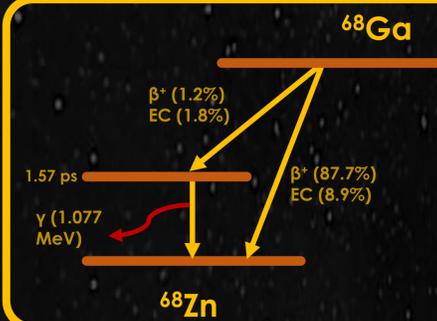
Positronium imaging is a novel technique which can be helpful in understanding the state of cancer^{1,2,3,4}. The positronium imaging technique was developed using a liver phantom with the modular J-PET detector^{3,4} and applied to a patient with a neuroendocrine tumor. The result shows the physiological accumulation of the radiopharmaceutical [⁶⁸Ga]Ga-DOTA-TATE in the liver, spleen and kidney of a 49-year-old female patient diagnosed with a multifocal gastric neuroendocrine neoplasm of the stomach. For the initial studies, the lifetime was estimated in the combined region of liver, spleen and kidney.

Key features

- 312 Plastic scintillators (24 modules)
- FPGA based DAQ⁵
- Multiphoton PET^{6,7}



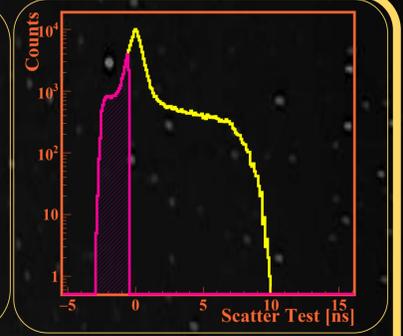
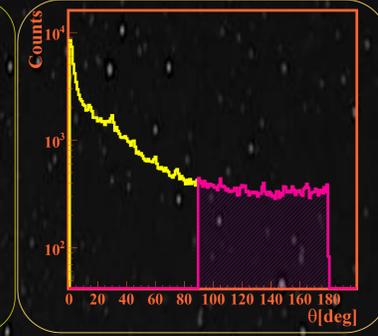
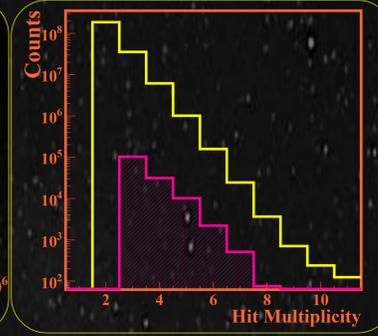
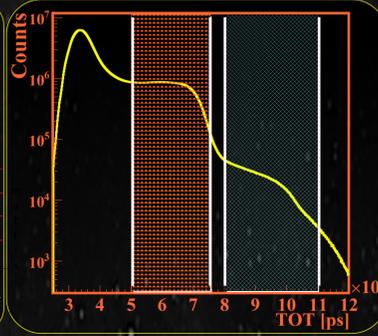
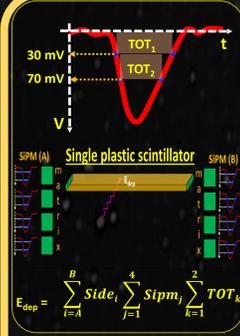
Positronium formation and lifetime estimation⁸



Registration of annihilation photons and prompt gamma⁹

Selection criteria :

- ✓ Annihilation and prompt selection based on TOT¹⁰. (measure of energy dep.)
- ✓ Events with 3 hits (2+1)
- ✓ Angular correlation b/w hits
- ✓ Scatter Test



TOT as a measure of energy [10]

In this context, the measure of energy deposition is represented by the Time-Over-Thresholds (TOT_{min}) values, which serves for photon identification. Orange and blue rectangular regions denote the respective ranges of TOT_{min} values utilized for selecting annihilation and de-excitation photons¹¹.

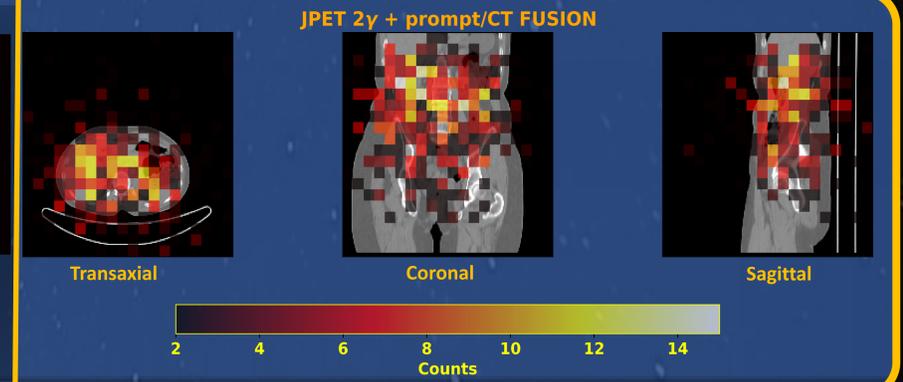
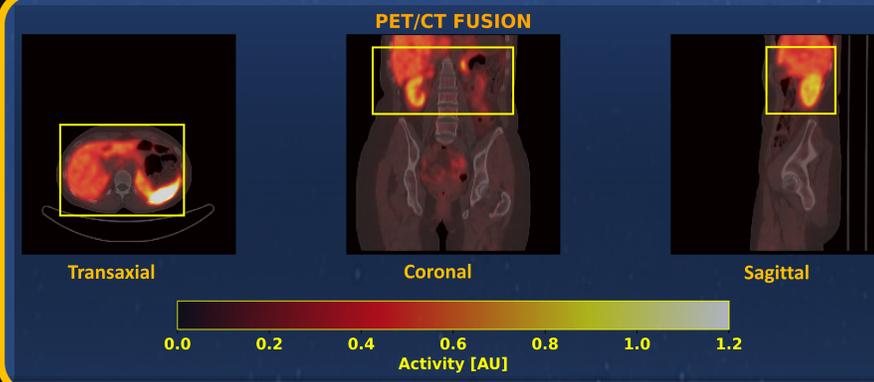
The histogram displays the distribution of hit multiplicities, with the pink shadow indicating observations in events featuring one identified de-excitation photon, two identified annihilation photons, and other potential hits categorized as scattered photons.

In the analysis, the relative angle between annihilation photons is restricted to the red range ($\theta > 90^\circ$), to restrict the FOV of the detector to avoid unwanted events.

Scatter test (ST) = $\Delta t - |r_1 - r_2| / c$
 Δt : Time difference between measured hit times (t_1 and t_2).
 $(r_1 - r_2)$: Distance between hit positions, (c) is the speed of light.

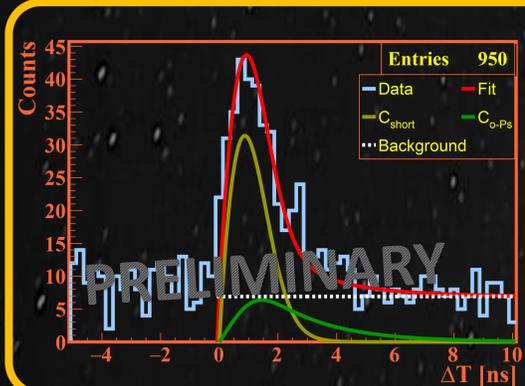
Preliminary Images

Siemens PET/CT images (left) and reconstructed images (2+1) using Modular J-PET



Preliminary Results

- ☐ Positronium imaging of NET using Modular J-PET.
- ☐ Density distribution selected for Ps lifetime is shown by region in yellow shape.
- ☐ Mean oPs lifetime and mean positron lifetime are estimated using PALS software¹².



τ_{o-Ps}	2.03 ns
\pm	± 0.58
τ_{mean}	1.55 ns

- ❖ C_{short} - Lifetime contribution from direct annihilation and p-Ps (Fixed lifetime with intensity 70%)³.
- ❖ C_{o-Ps} - lifetime contribution from the o-Ps decay (not fixed)
- ❖ Background is shown by dotted white line.

Acknowledgement

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