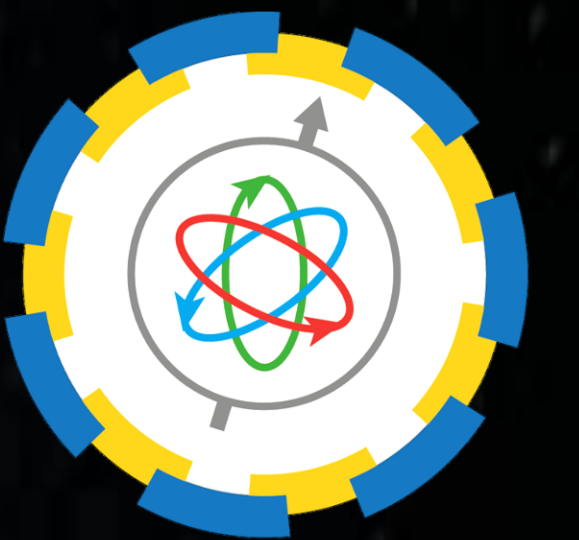




# Positronium as a biomarker for neuroendocrine tumor



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On behalf of the J-PET collaboration

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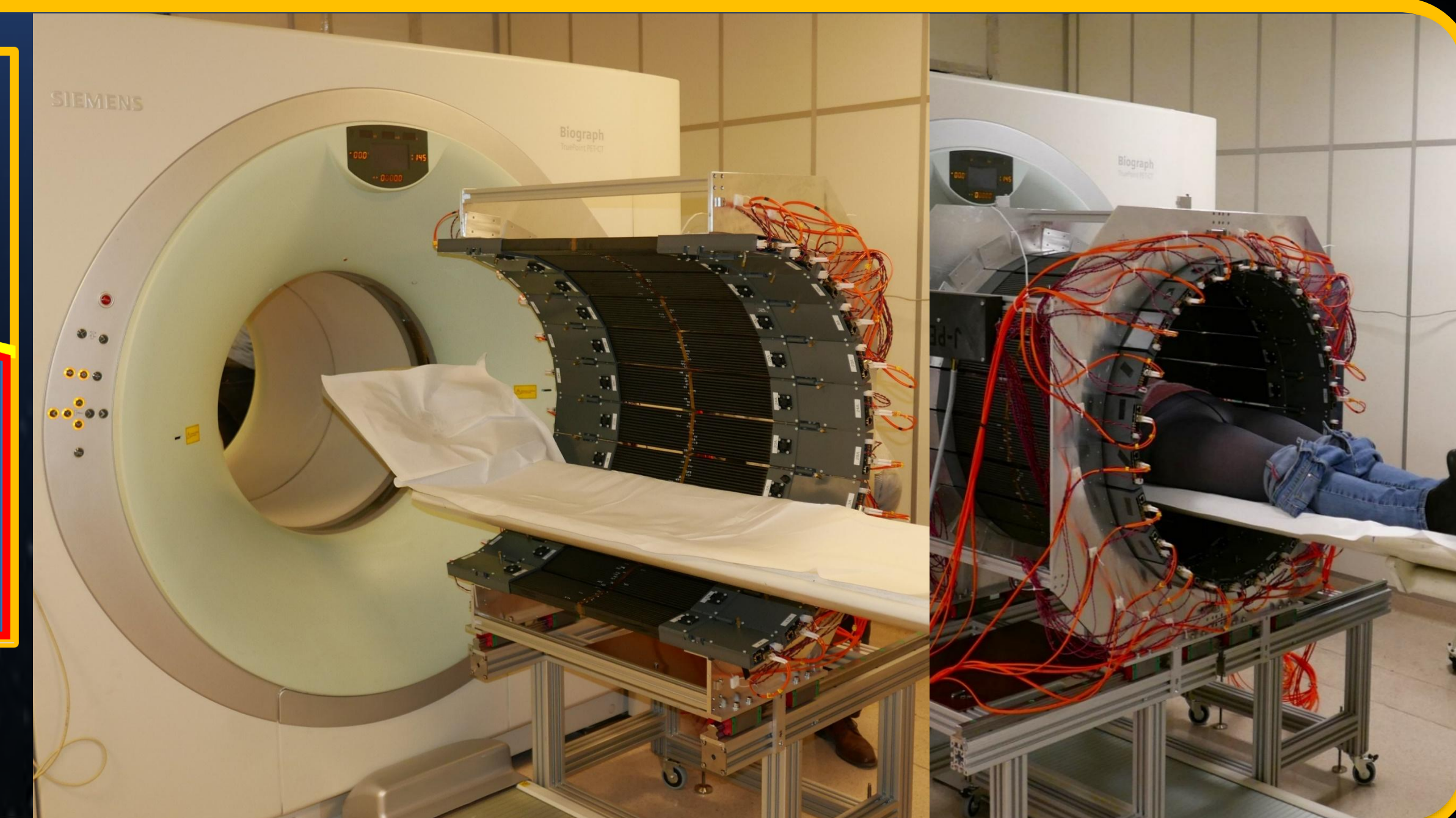
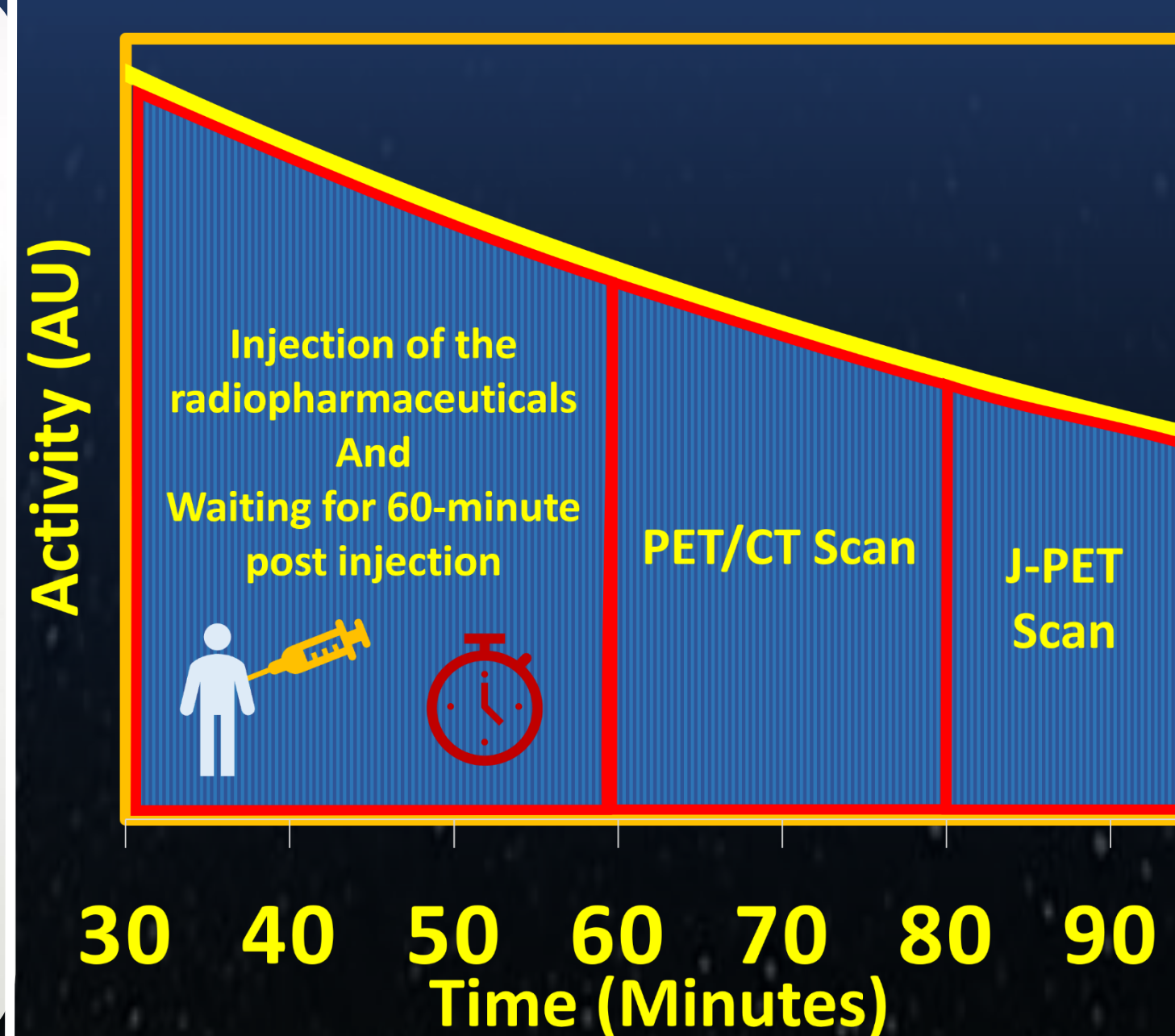
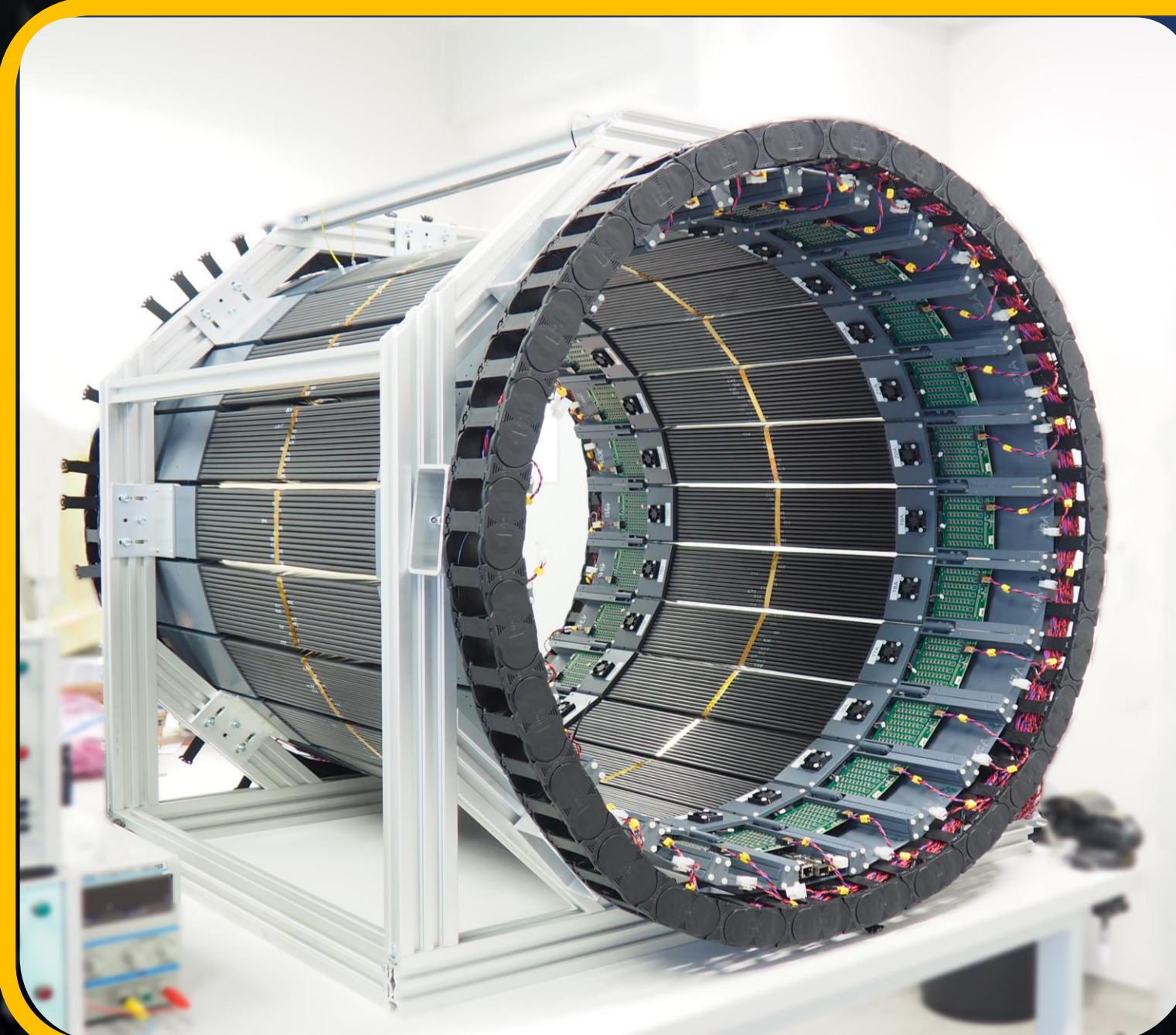
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## Positronium imaging

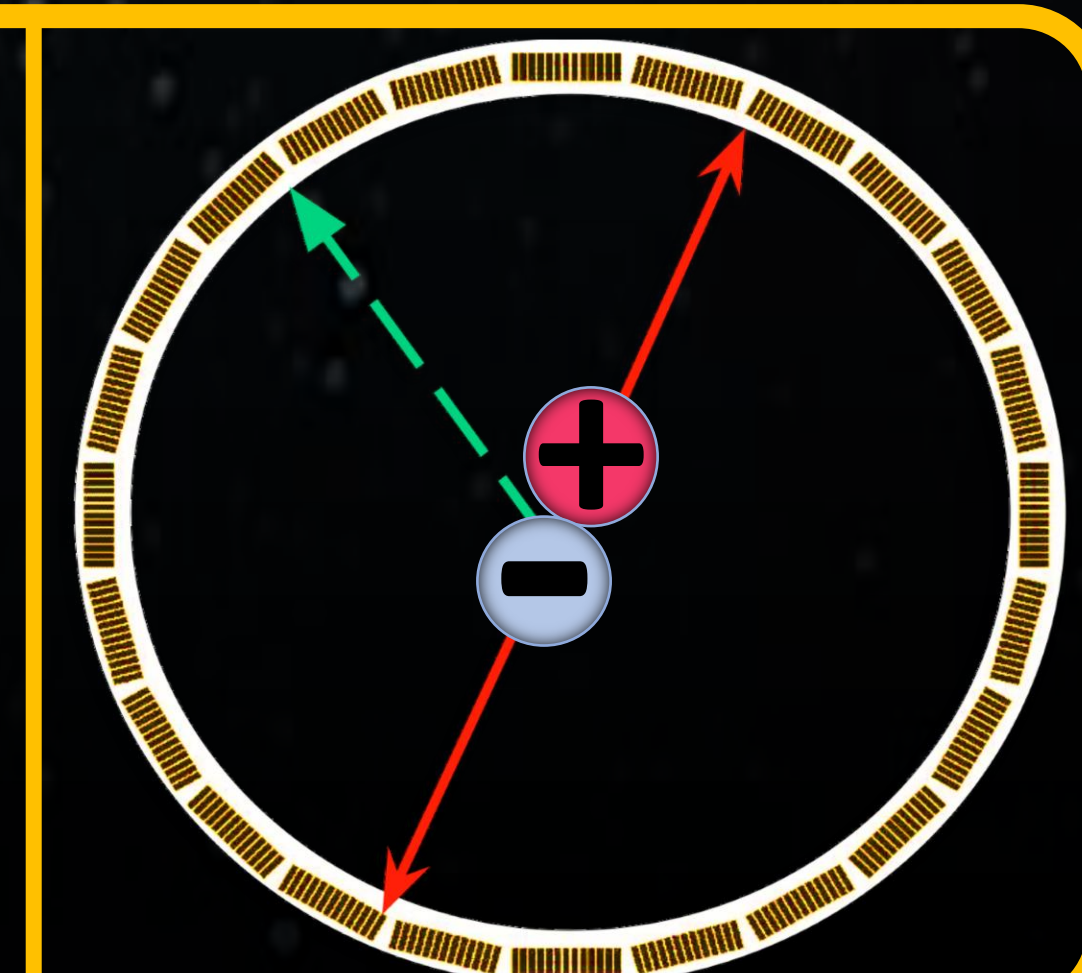
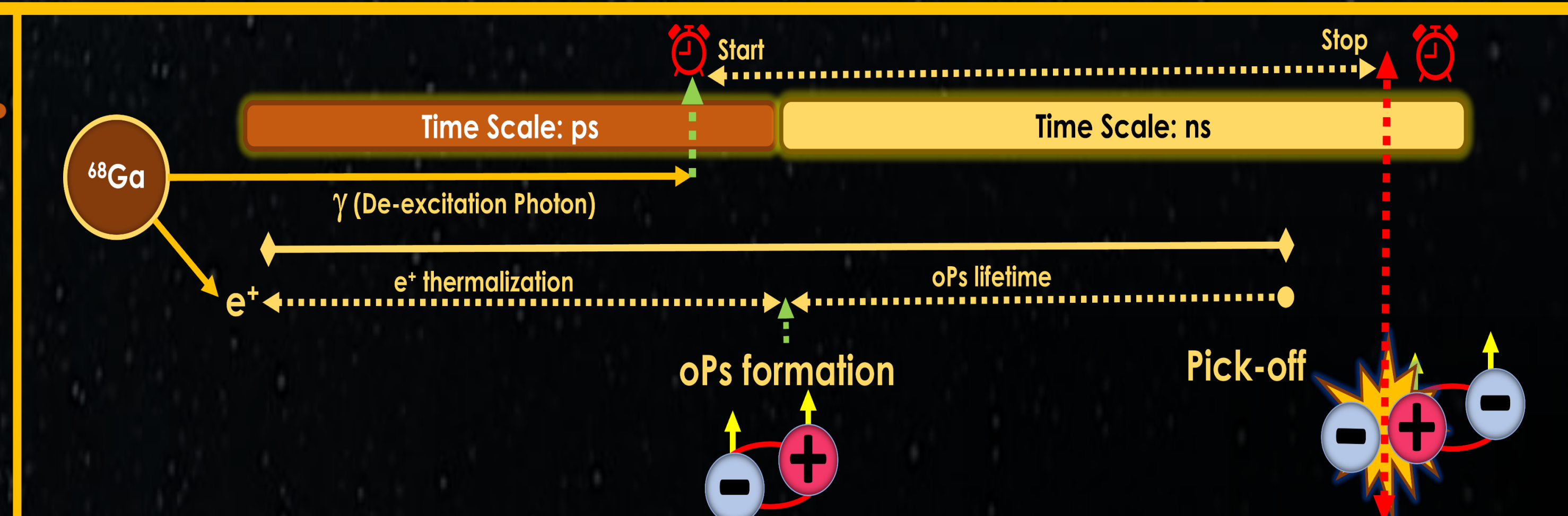
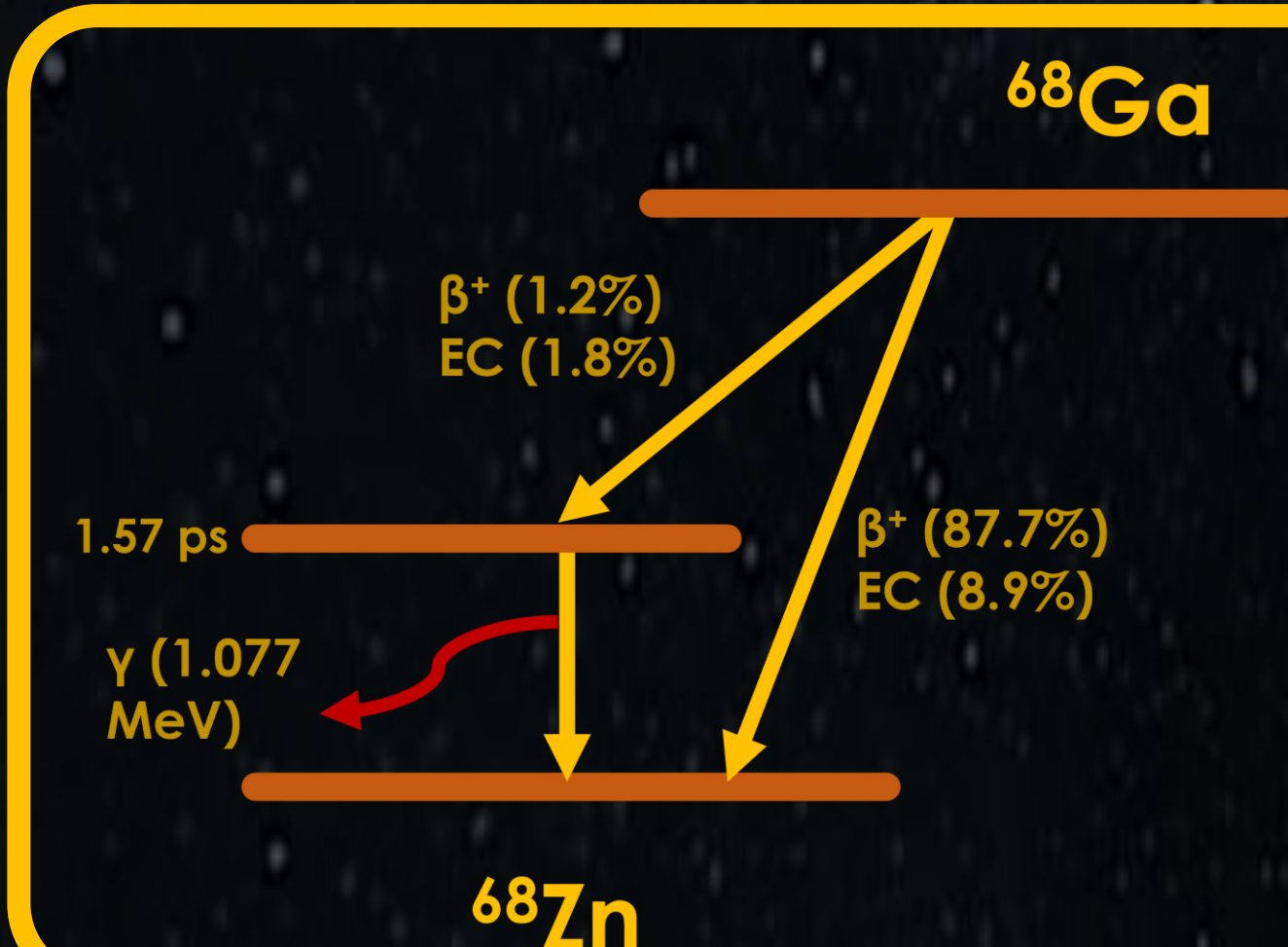
Positronium imaging is a novel technique with potential applications in cancer assessment<sup>1,2,3,4</sup>. Recently, the first positronium imaging with human brain was demonstrated using the modular J-PET detector<sup>3</sup>. Neuroendocrine tumors (NETs) are characterized by the overexpression of somatostatin receptors, and their evaluation is commonly performed using <sup>68</sup>Ga-labeled somatostatin analogs. In this study, we demonstrated positronium imaging with two patients—one healthy and one with diagnosed NET in the liver and administered with Ga-DOTATATE. We present the preliminary ortho-positronium lifetime and mean positron lifetime estimated from the liver, spleen, and other regions to investigate its correlation.

### Key features

- 312 Plastic scintillators (24 modules)
- FPGA based DAQ<sup>5</sup>
- Multiphoton PET<sup>6,7</sup>



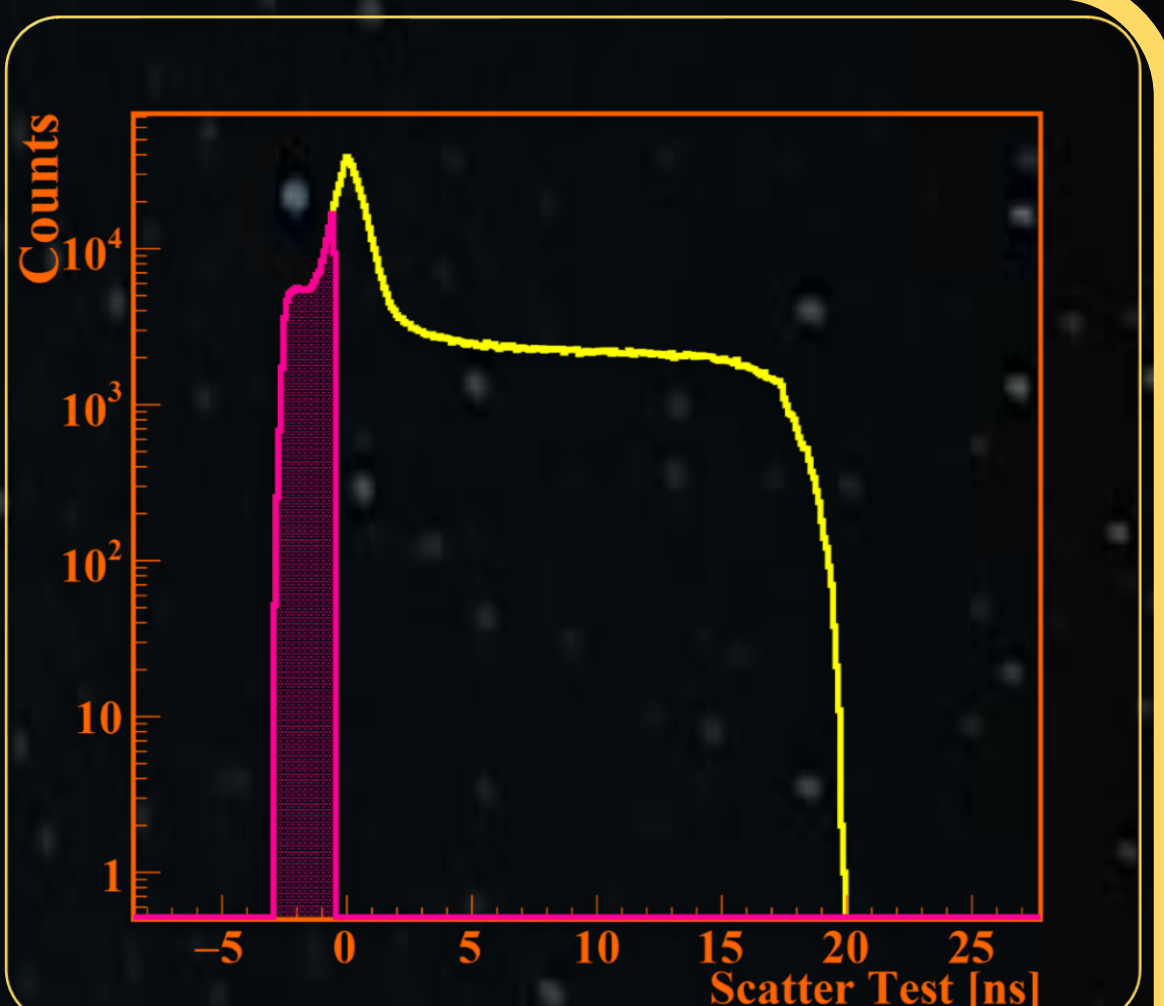
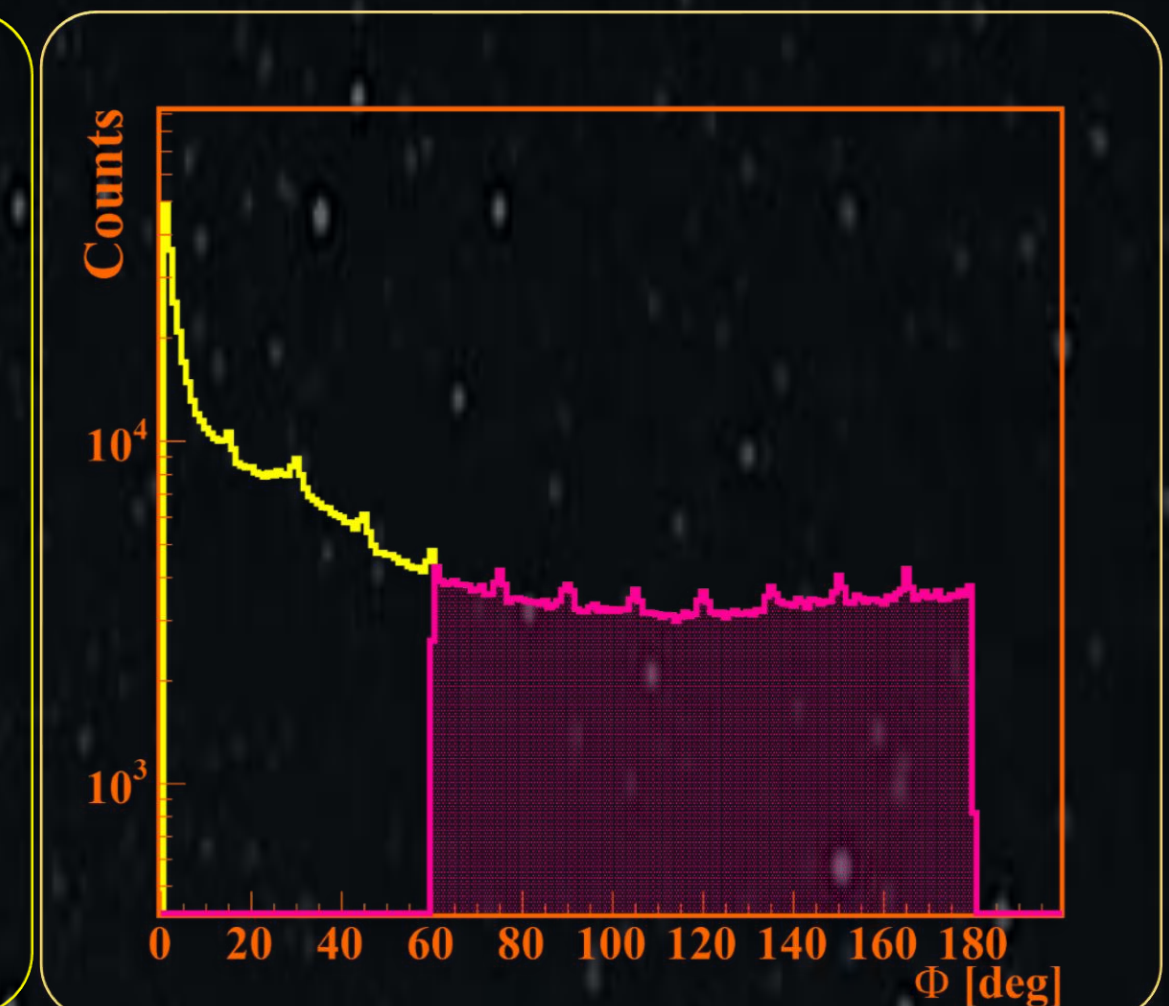
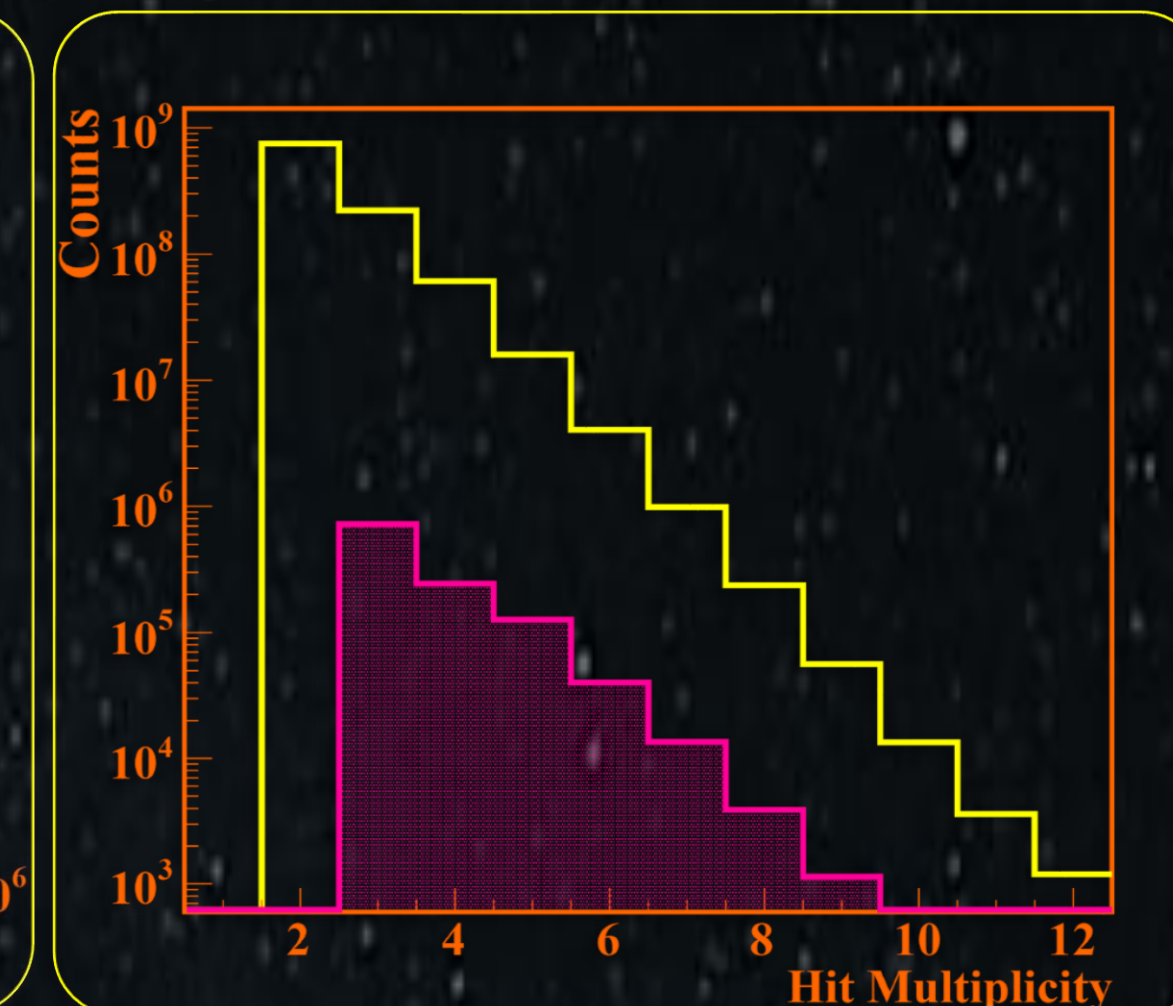
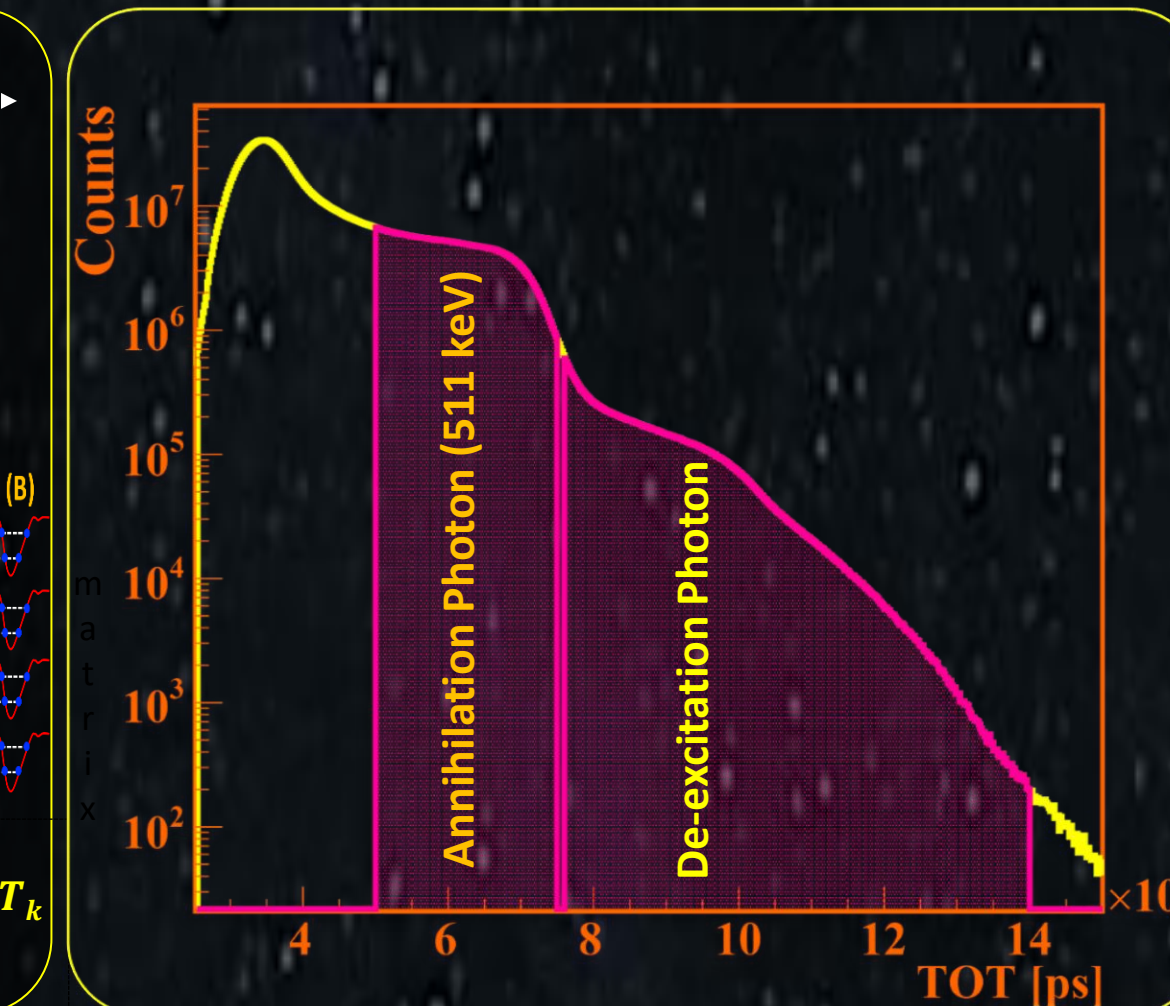
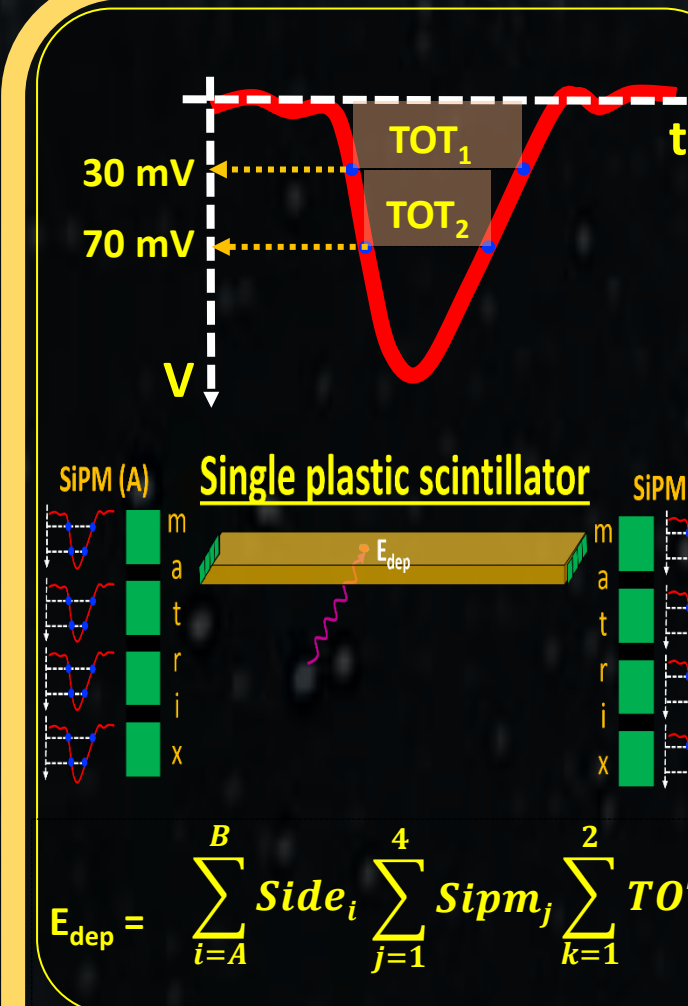
### Positronium formation and lifetime estimation<sup>8</sup>



### Registration of annihilation photons and prompt gamma<sup>9</sup>

#### Selection criteria :

- ✓ Annihilation and prompt selection based on TOT<sup>10</sup>. (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<sub>me</sub>) values, which serves for photon identification. Pink shadowed regions denotes the respective ranges of TOT<sub>me</sub> values utilized for selecting annihilation (511 keV) and de-excitation photons<sup>11</sup>.

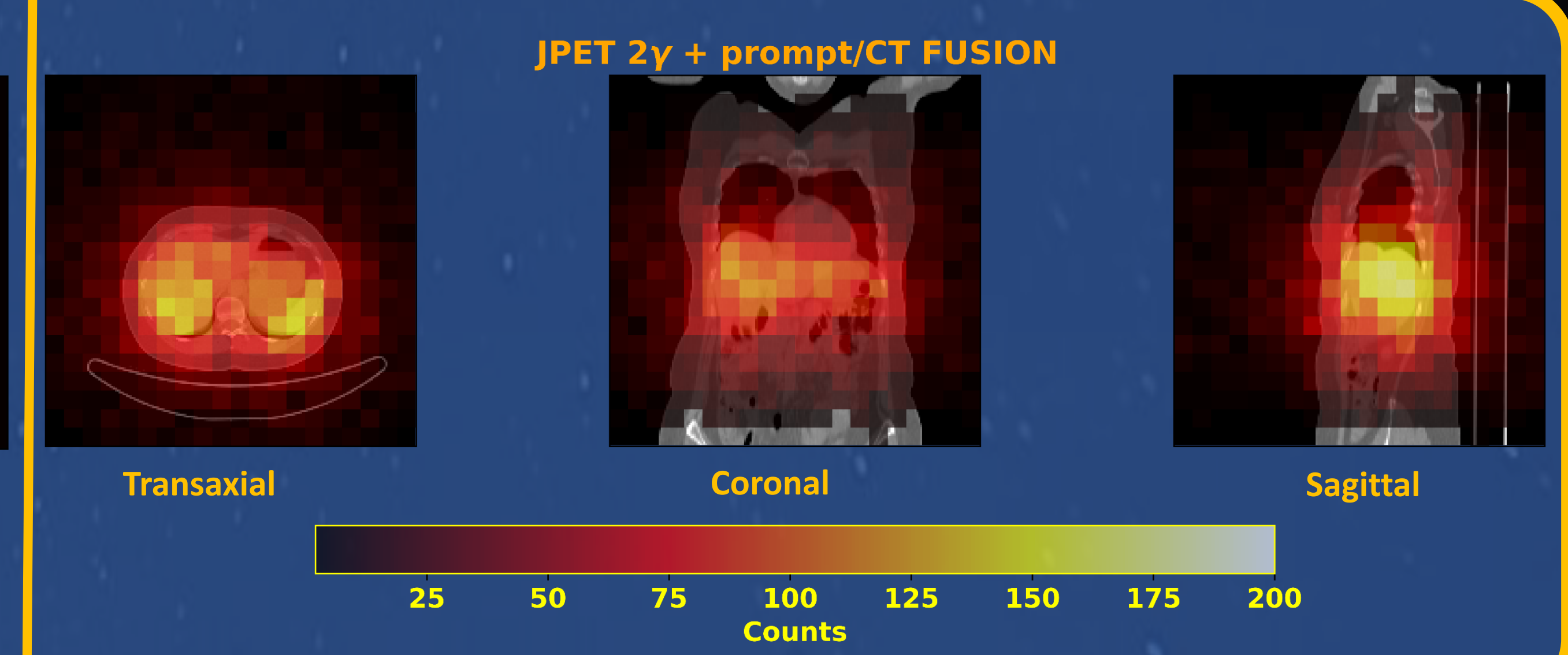
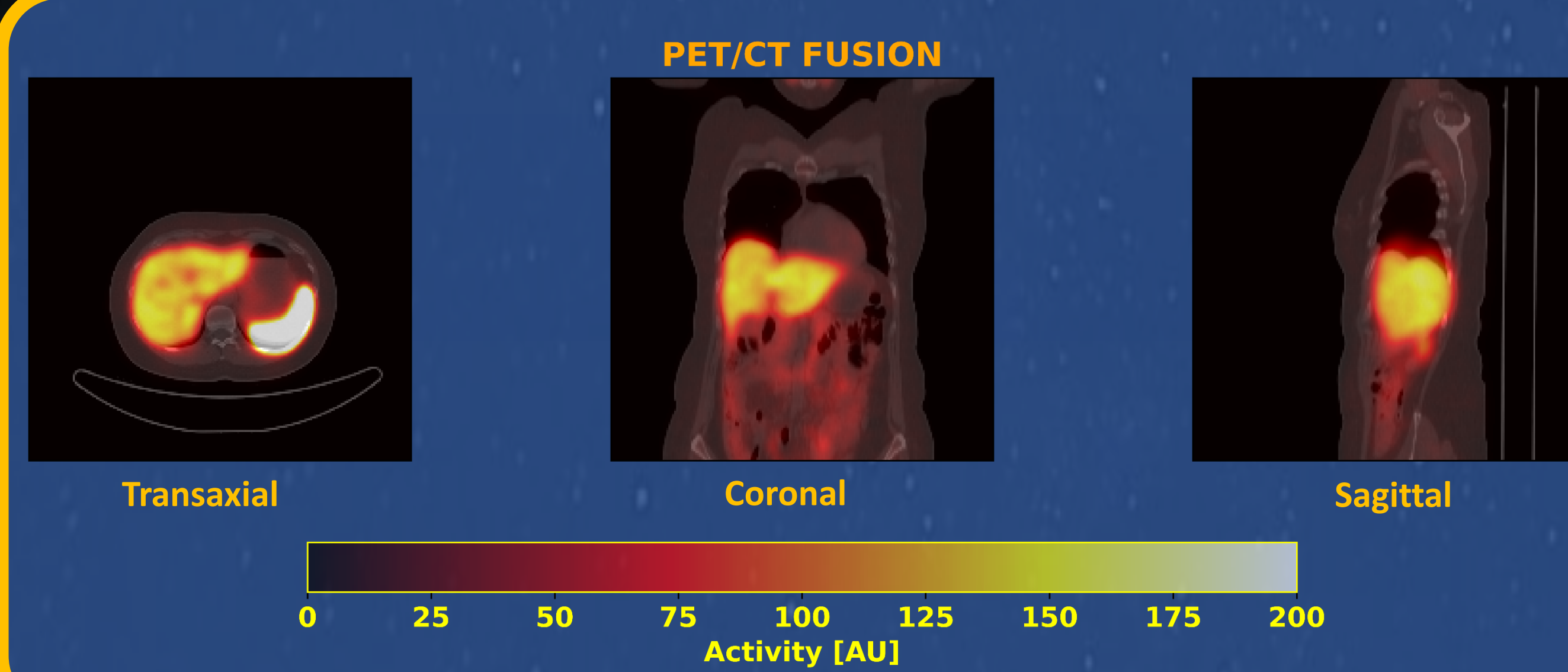
The histogram displays the distribution of hit multiplicities, with the pink shadow indicating observations in events featuring one identified de-excitation photon, two identified annihilation photons, and other potential hits categorized as scattered photons.

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

Scatter test (ST) =  $\Delta t - |r_1 - r_2| / c$   
 $\Delta t$  : 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.

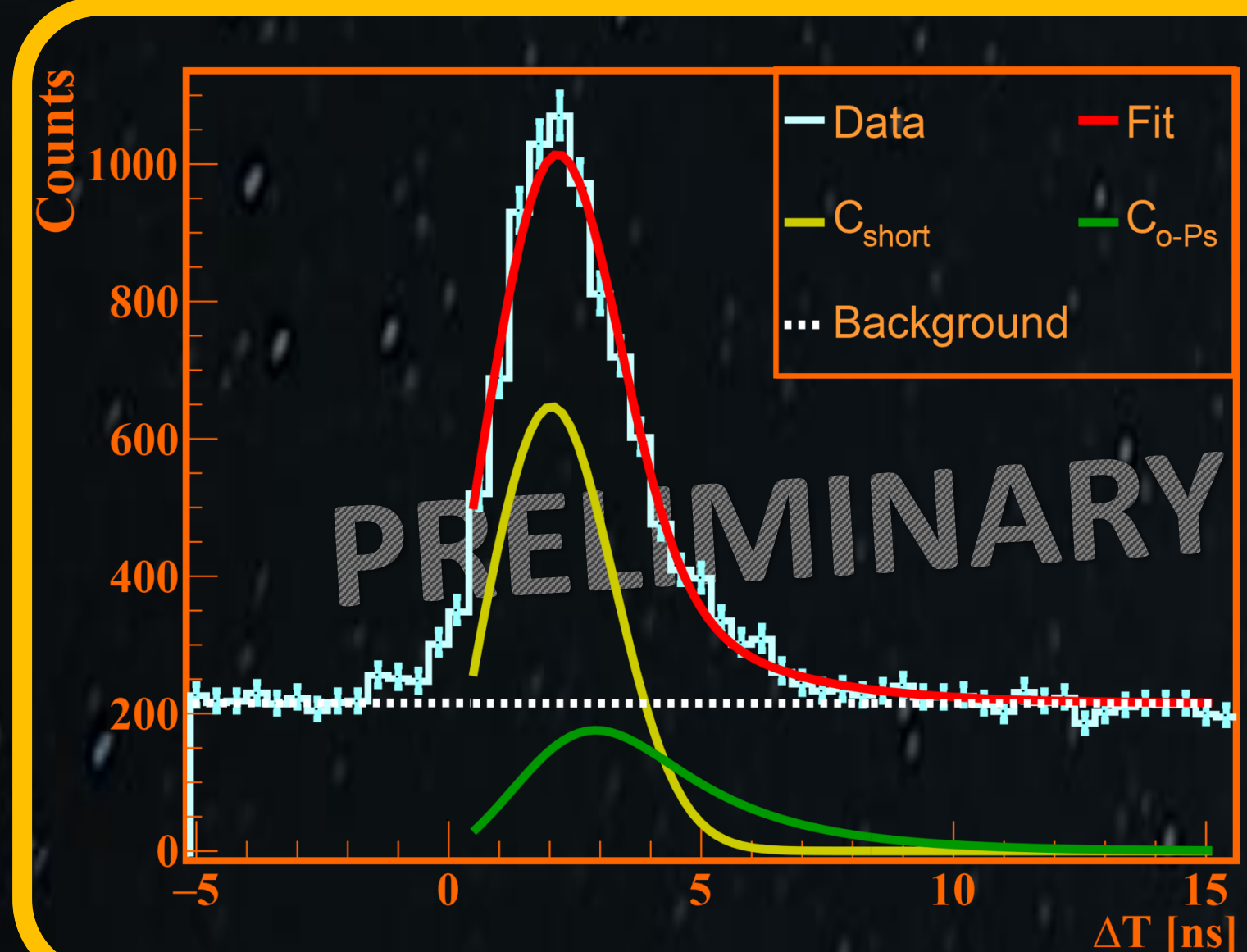
### Preliminary Images

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



### Preliminary Results

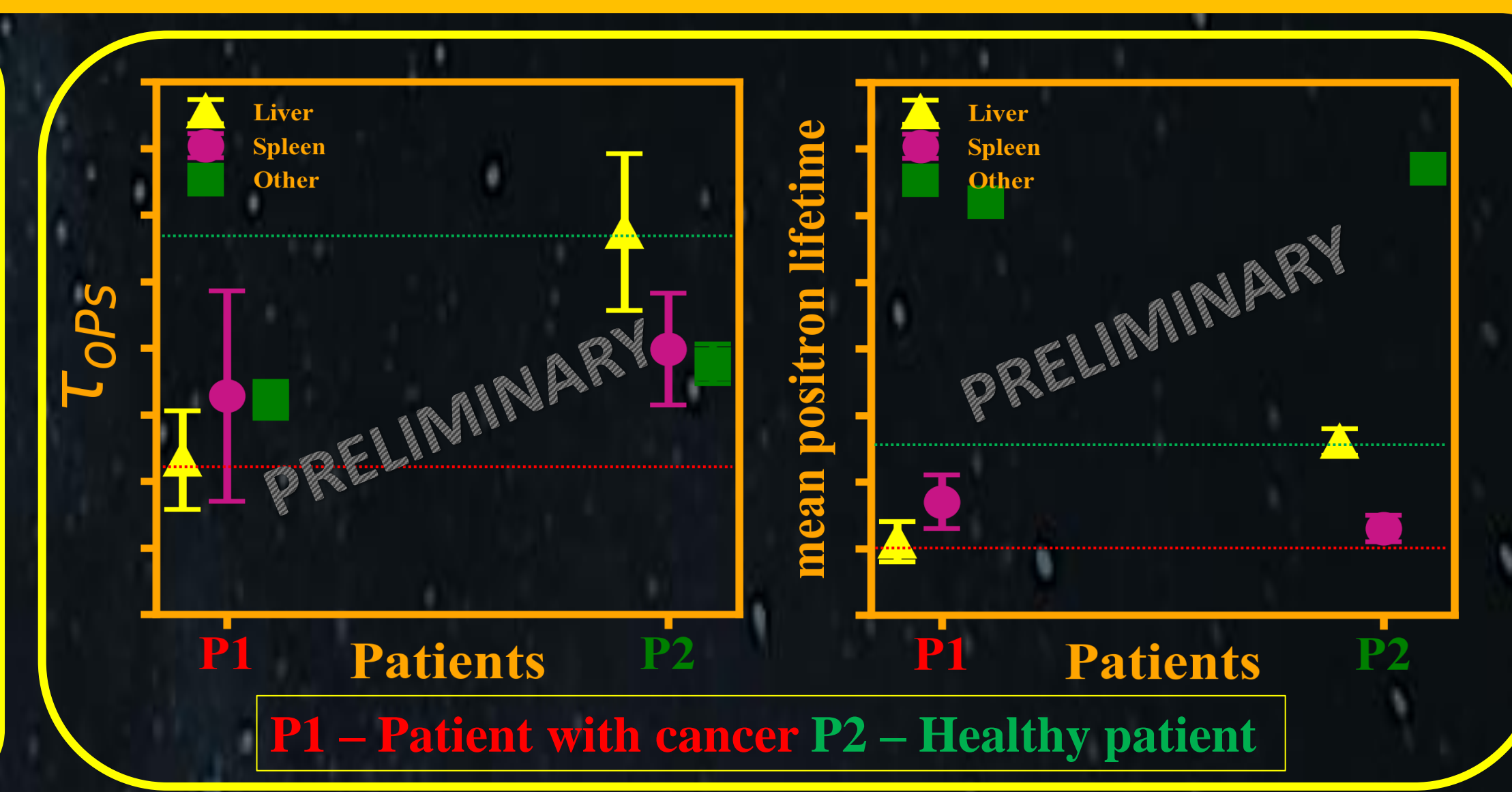
- Exemplary positron lifetime spectra, and deconvoluting the different lifetime components.
- The preliminary results shows that the o-Ps lifetime and mean positron lifetime in liver in patient with cancer is lower than the healthy patient.



✱  $C_{short}$  - Lifetime contribution from direct annihilation and p-Ps (Fixed lifetime with intensity 70%)<sup>3</sup>.

✱  $C_{o-Ps}$  - lifetime contribution from the o-Ps decay (not fixed)

✱ Background is shown by dotted white line.



### Acknowledgement

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