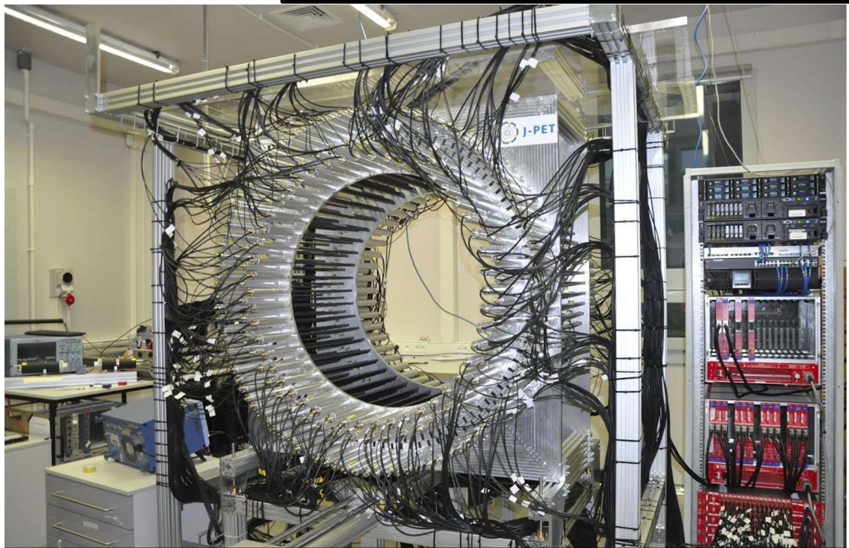
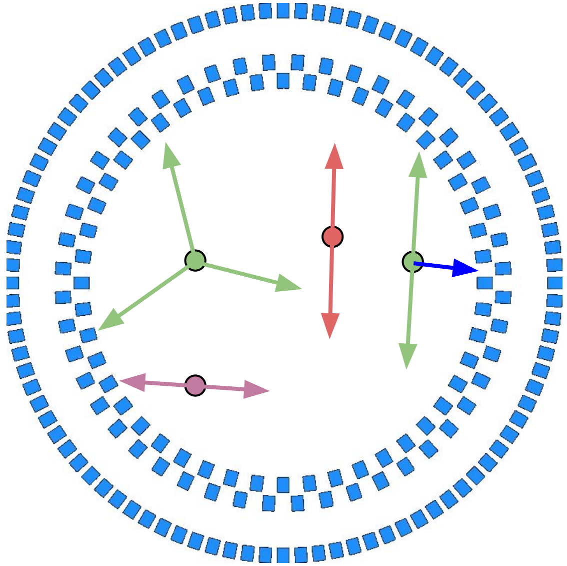
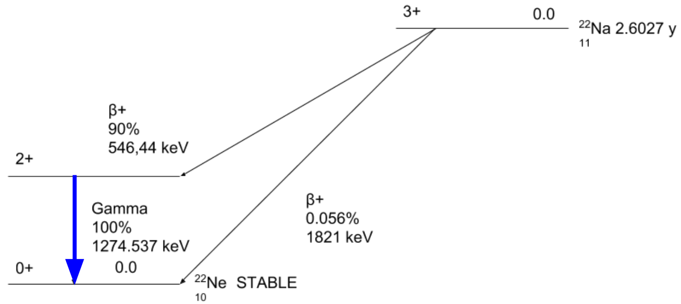
J-PET a novel approach to multi-gamma detector

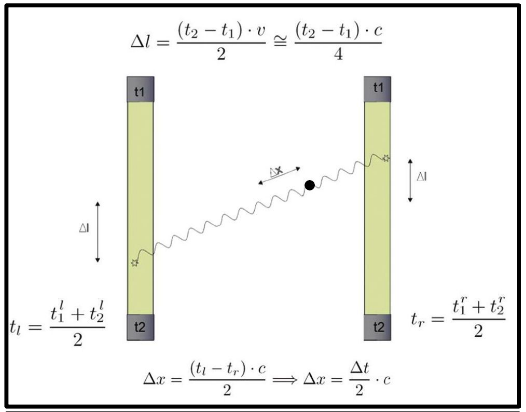
Background

J-PET is a novel technology which employs a new approach to annihilation gamma detection. Utilization of plastic scintillators coupled with fast photomultipliers and triggerless data acquisition system forms the core of its unique design. The system is able to process signals from two, three and two + prompt decay channels of beta+ radioactive isotopes, thus making the multi-gamma detection possible.







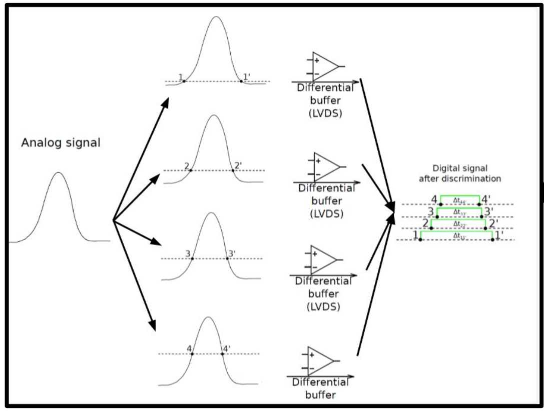


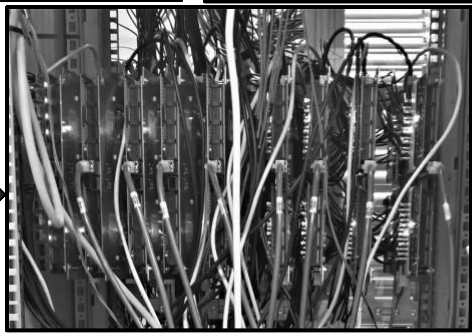
Methods

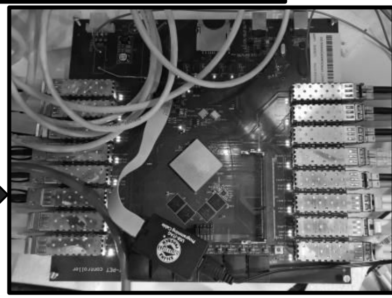
First full scale prototype J-PET scanner. It consists of 192 plastic scintillators with dimensions 500 x 19 x 7 mm^2. Each scintillator is read out from both sides by vacuum tube photomultiplier.

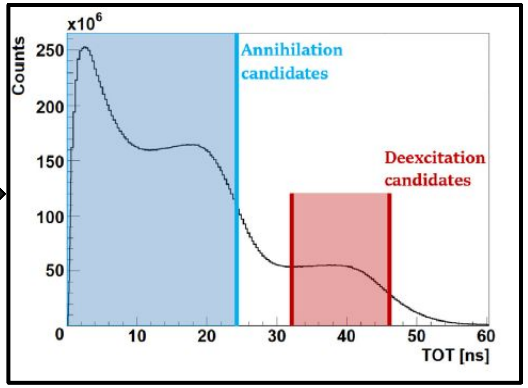
e+e- o-Ps e+e- p-Ps e+e- direct

See K. Dulski and A. Gajos posters for Ps lifetime and 3 ɣ imaging









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Commissioning of 50 cm AFOV modular plastic J-PET scanner

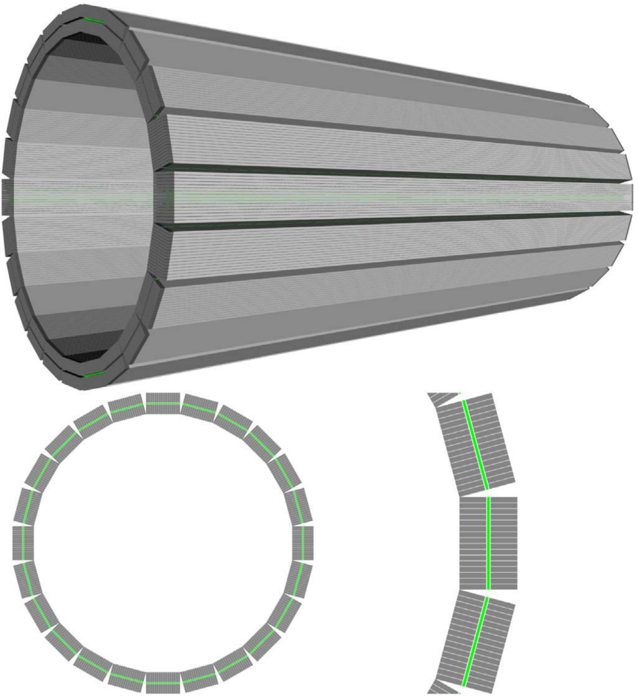


Fig. 3. Visualisation of the simulated 2-layer 24-module 2 m long TB-J-PET scanner. Scintillator strips are marked in gray and WLS strips in green. Upper panel indicates the perspective view of the TB-J-PET scanner and lower panel shows the transverse cross sections: full (L) and zoomed (R).

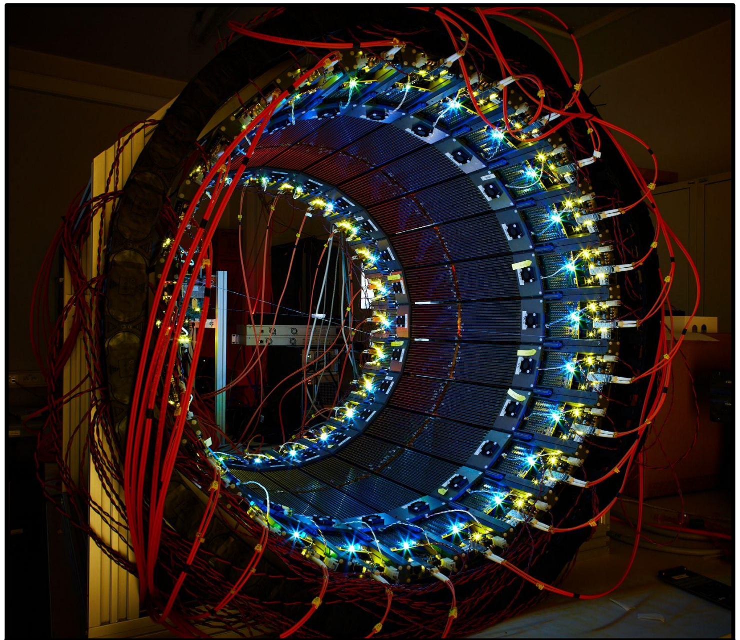


Fig. 2 The system is composed of 24 modules, each is build out of 50 cm long 13 scintillator strips, read out by a SiPM matrix.

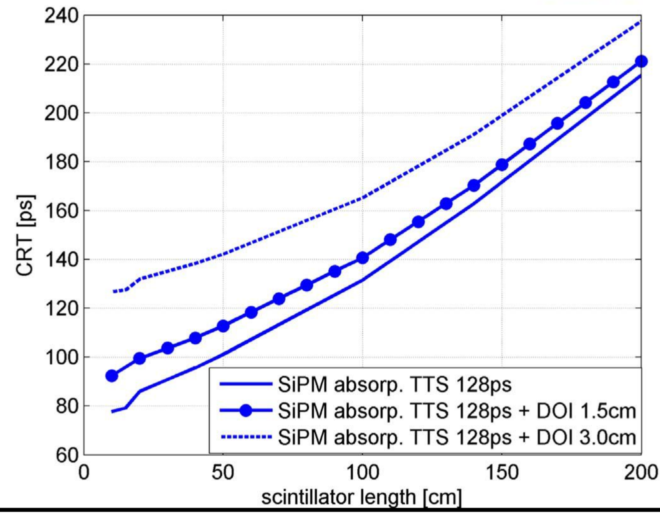
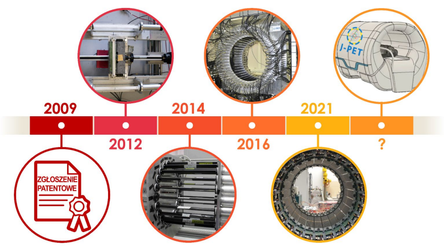


Fig. 4 CRT values as a function of the AFOV expected while using BC-408 scintillator. Values obtained for the radial thickness of 1.5 cm and 3.0 cm, in the case of unknown DOI, are indicated by a solid line with dots and a dotted line, respectively. The result for ideal case with a known DOI is shown by a solid line.



VERY PRELIMINARY RESULTS!

CRT = (753 ± 4) ps
XY (FWHM) = (5±1) mm
Z (FWHM) = (40 ± 4) mm

Simulated for TB J-PET

CRT = 240 ps
XY (FWHM) ~ 5 mm
Z (FWHM) ~ 4 - 8 mm

Ref: Phys. Med. Biol. 66 (2021) 175015

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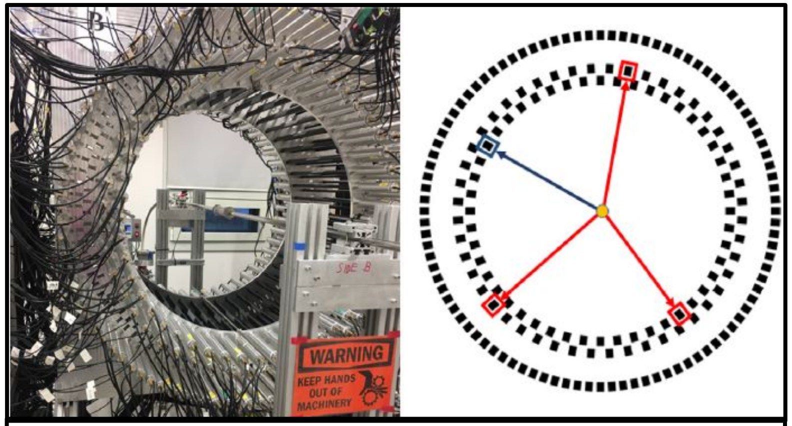

Fig. 5 (left) Photograph of the prototype of the J-PET detector with the annihilation chamber placed in the centre of the detector with a pipe installed on the detector axis. (right) Schematic cross section of the J-PET detector. Black rectangles indicate the cross section of scintillator strips arranged in three concentric cylindrical layers. The arrows indicate annihilation photons (red) from ortho-positronium and the de-excitation photon (blue) emitted by the 22Na source located at the centre of the detector.

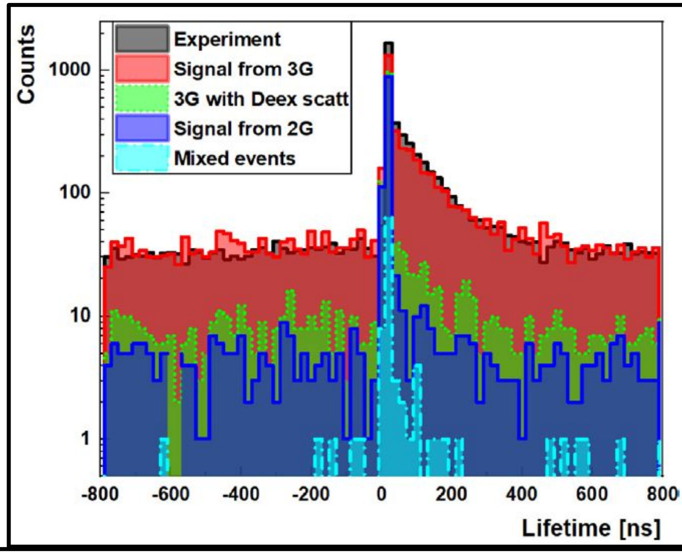

Fig 6. Comparison of the positron lifetime spectrum between the experiment (black line) and the simulations. Simulation spectrum was divided into different components with different origins: annihilations of positron–electron into 3 photons (red line), events in which one or more annihilation hit was coming from the scattering of the deexcitation photon (green line), annihilations of positron–electron into 2 photons with scattering of the deexcitation photon (blue line), and the mix of the different decays and more complicated scatterings containing secondary particles (cyan line).

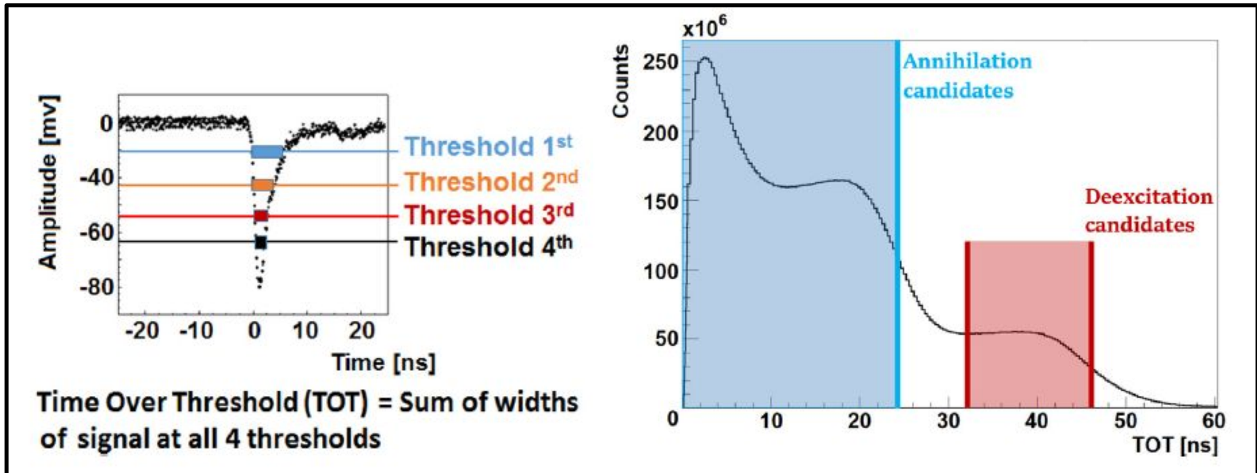

Fig 7. (Left panel) Pictorial definition of the Time-Over-Threshold (TOT) of the signal measured in the J-PET detector. TOT is a sum of signal widths in the time domain, over four preset voltage levels. (Right panel) Distribution of the TOT values measured by means of the J-PET detector. Categorization of the hit is based on the TOT value. In the analysis, the annihilation candidate is defined when TOT value is less than 24 ns. De-excitation candidates corresponds to the TOT greater than 32 ns and smaller than 46 ns.

Ref: NIM in Phys. Res., A 1008 (2021) 165452