First observation of the positronium atoms with the J-PET detector

K. Dulski[1], on behalf of the J-PET collaboration

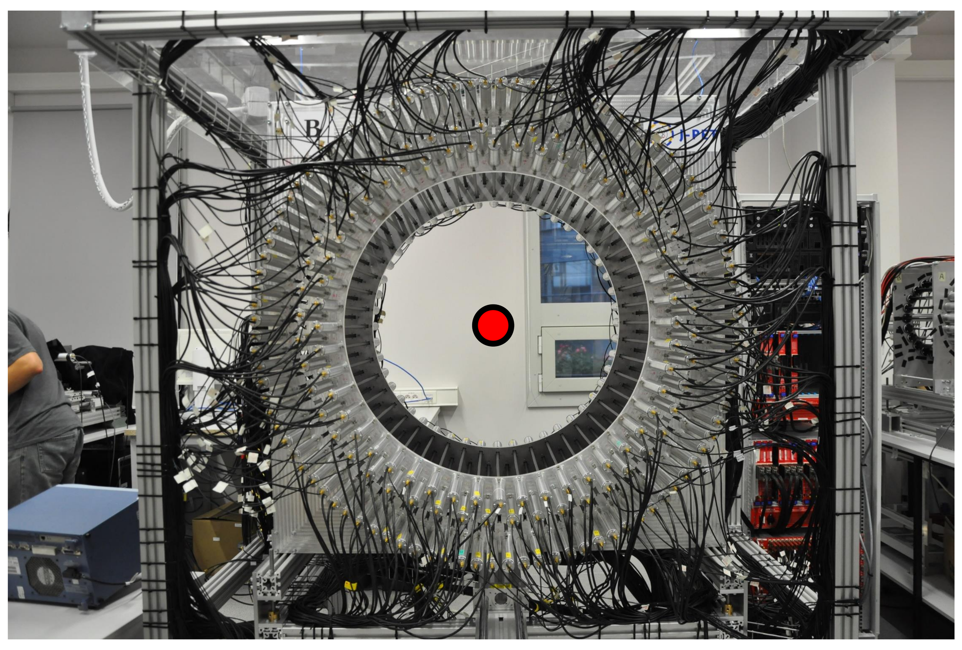
[1]M. Smoluchowski Institute of Physics, Jagiellonian University, Lojasiewicza 11, 30-348 Cracow

Email: kamil.dulski@doctoral.uj.edu.pl

Abstract

Jagiellonian Positron Emission Tomograph (J-PET) is a first PET device built from plastic scintillators [1-4]. As a detector optimised for the registration of photons from the positron-electron annihilation it is also used for the studies of decays of positronium atoms [5-7]. In this poster we present: (i) results of the commissioning of the J-PET detector, (ii) methods of the data selection and analysis, and (iii) first lifetime spectra of positronium (produced in the porous polymer [8]) measured with the J-PET detector.

J-PET detector

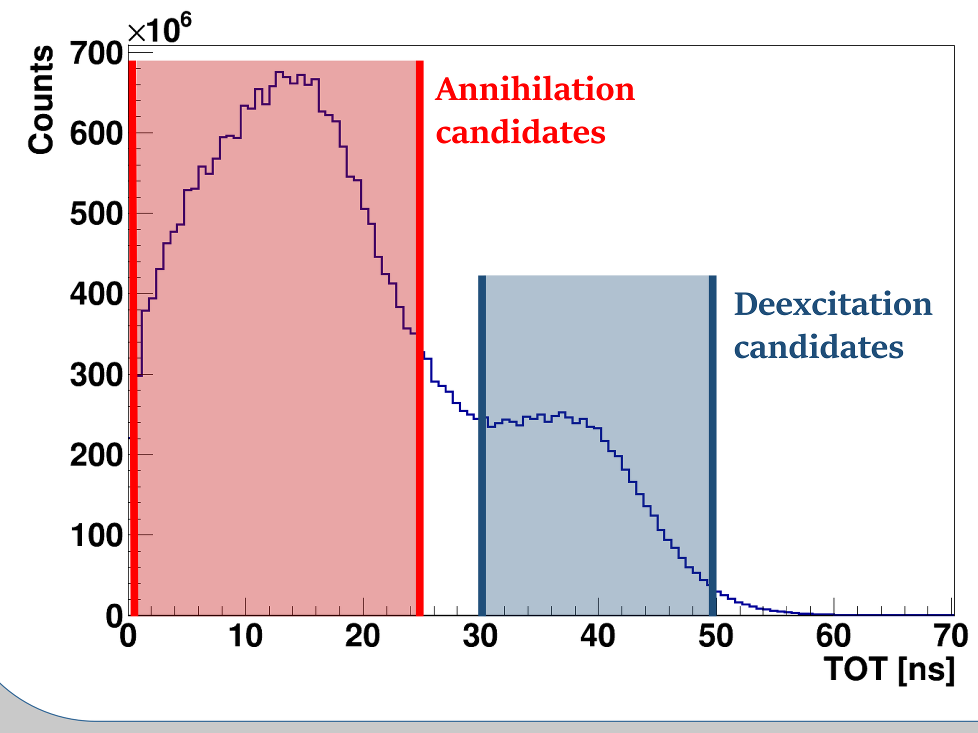


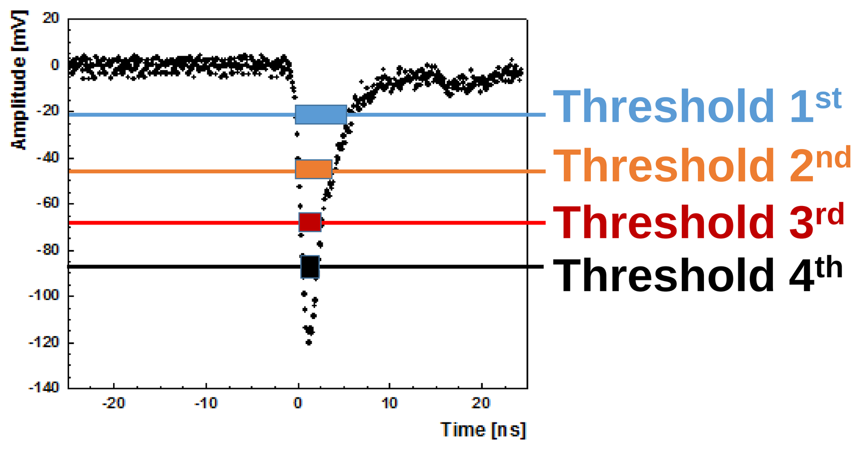
Picture of the J-PET detector. ^{22}Na source ● in Kapton foil was placed inside the center of the detector. Source was surrounded with porous polymer XAD4[8] ○ in vacuum.

$$^{22}Na \rightarrow {}^{22}Ne^{*} + e^{+} + \nu_e$$

$$^{22}Ne^{*} \rightarrow {}^{22}Ne + \gamma_{1274\ keV}$$

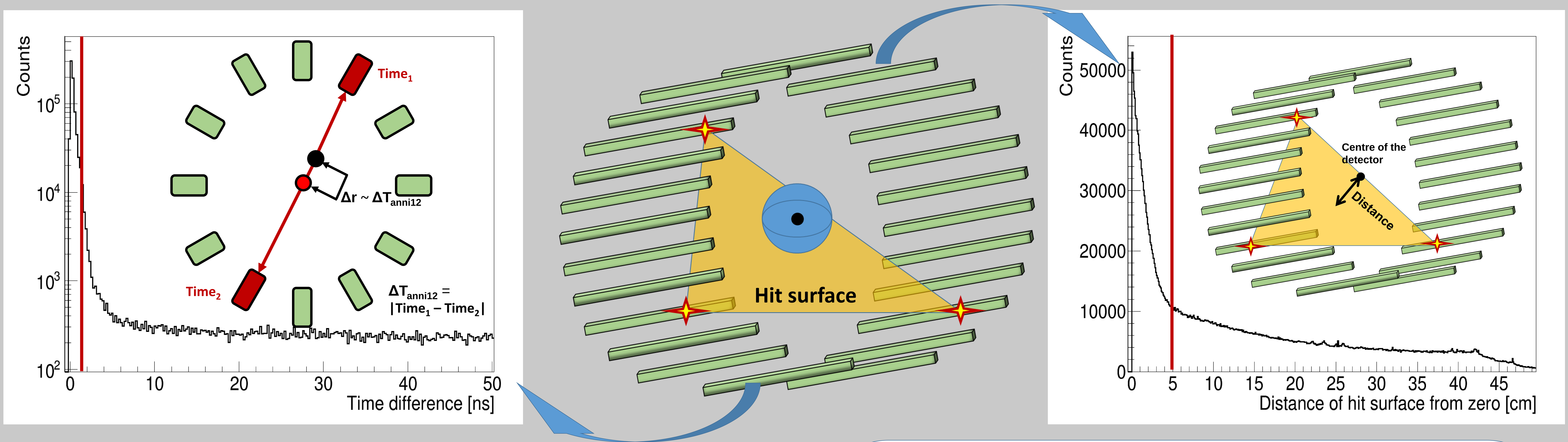
TOT as a measure of energy loss



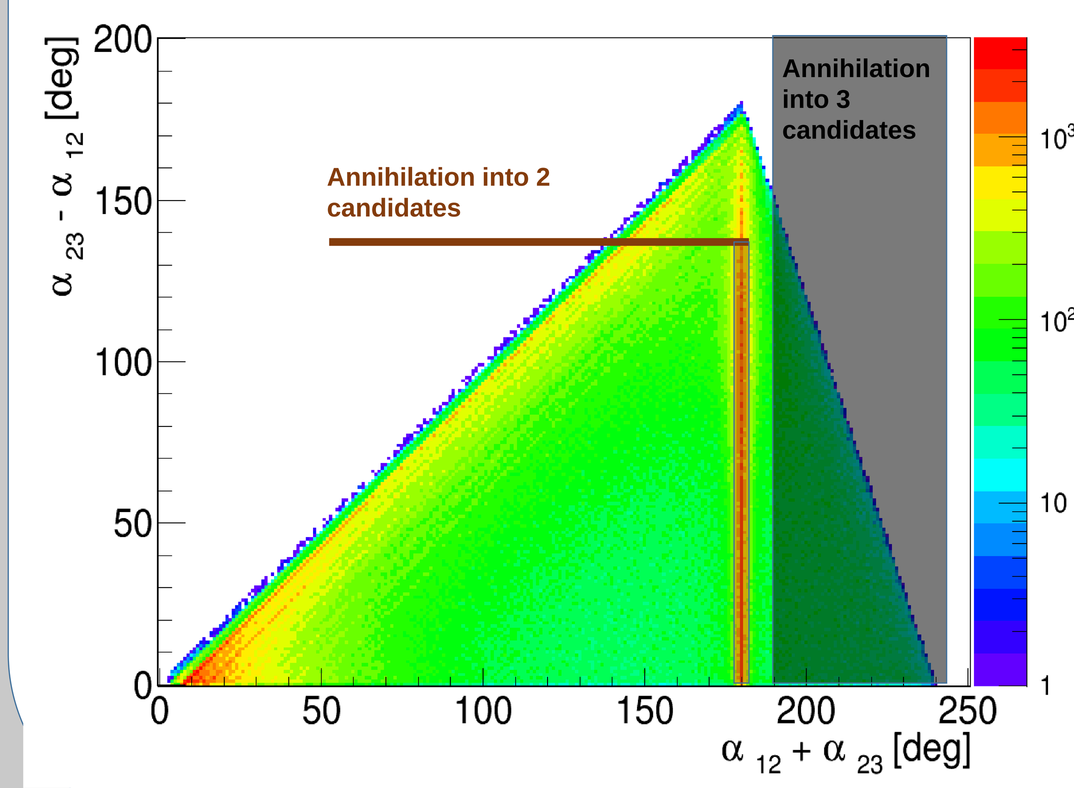


TOT_{hit} =

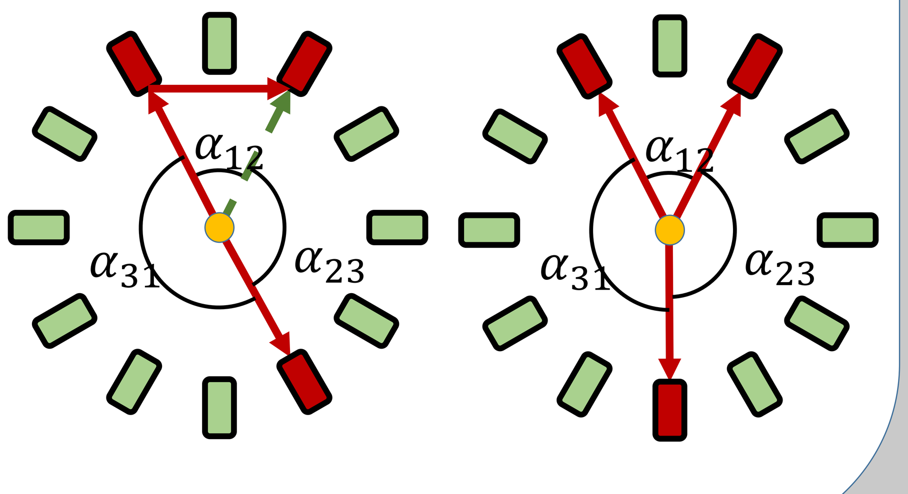
Time Over Threshold (TOT) = Sum of widths of signal at all 4 thresholds



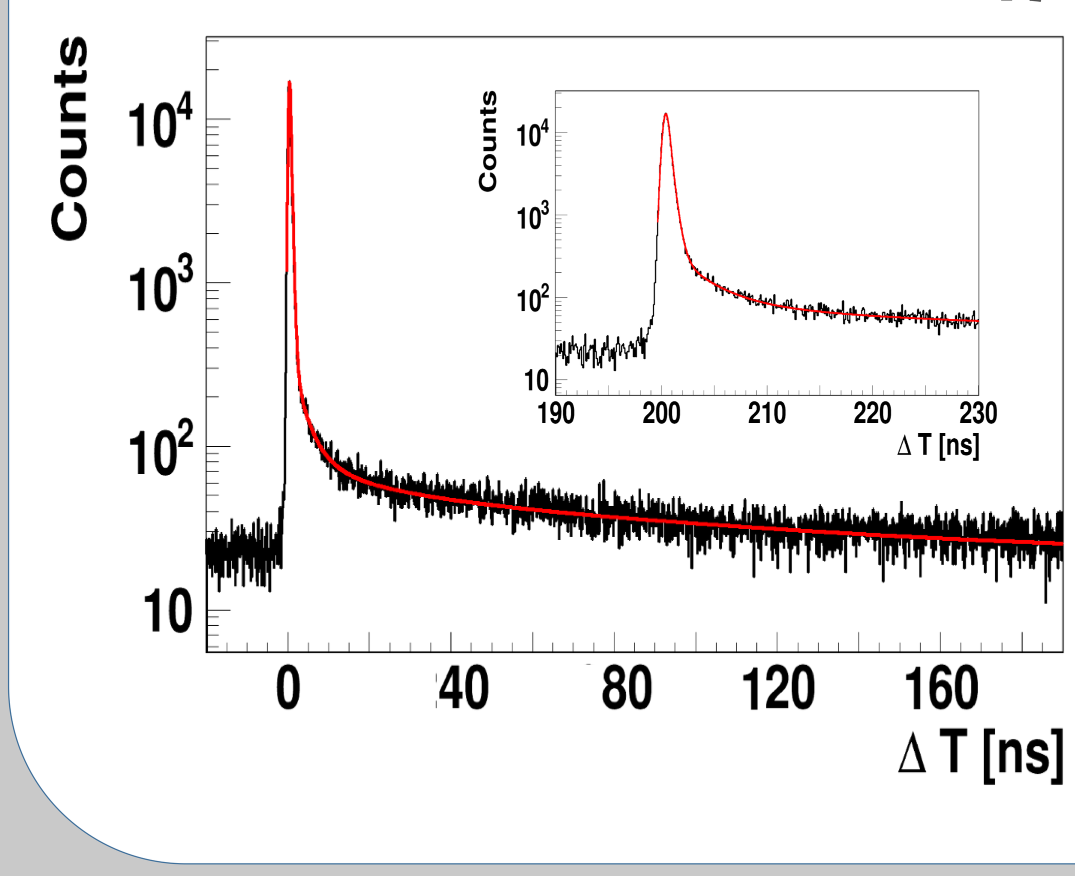
Annihilation types distinction



Selection of different types of annihilation decay is done based on geometry of potential positroinum decay



Positronium Lifetime Distribution – Annihilation into 2 gamma quanta



	PAv 9]	[8]
Lifetime for 1 Component [ns]	2.88 (25)	2.45 (25)
Intensity for 1 Component in percent	4.52 (31)	3.3 (0.6)
Lifetime for 2 Component [ns]	10.90 (93)	10.2 (0.6)
Intensity for 2 Component in percent	2.53 (36)	2.8 (0.5)
Lifetime for 3 Component [ns]	90.9 (2.4)	90.8 (1.2)
Intensity for 3 Component in percent	18.29 (53)	40.4 (0.4)
Lifetime for p-PS Component - fixed	*0.125*	
Intensity for p-PS Component in percent	20.1 (2.1)	
Sigma for 1 Gauss [ns]	0.275 (19)	
FWHM for 1 Gauss [ns]	0.647 (45)	
Fraction for 1 Gauss	0.23 (02)	
Sigma for 2 Gauss [ns]	0.242 (04)	
FWHM for 2 Gauss [ns]	0.571 (10)	
Fraction for 2 Gauss	0.77 (03)	

Summary

The Jagiellonian Positron Emission Tomograph (J-PET) is optimized for the detection of photons from the electron–positron annihilation with high time and angular resolutions. Selection procedure for analysis of J-PET data provides the opportunity to study different types of decay of positronium, creating a possibility to conduct research in the fundamental physics field as well as in the material sciences.

Acknowledgment

We acknowledge suport by the the Foundation for Polish Science through the MPD and TEAM/2017-4/39 programmes, the National Science Centre through the grant No. 2016/21/B/ST2/01222, 2017/25/N/NZ1/00861, the Ministry for Science and Higher Education through grants no. 6673/IA/SP/2016, 7150/E-338/SPUB/2017/1, 7150/E-338/M/2017 and 7150/E-338/M/2018

Bibliography

[1] P. Moskal et al., Nucl. Instr. and Meth. **A764** 317, (2014)
[2] P. Moskal et al., Nucl. Instr. and Meth. **A775** 54, (2015)
[3] P. Moskal et al., Phys. Med. Biol. **61** 2025, (2016)
[4] Sz. Niedzwiecki et al., Acta Phys. Polon. **B48** 1567, (2017)
[5] P. Moskal et al., Acta Phys. Polon. **B47** 509, (2016)
[6] A. Gajos et al., Nucl. Instr. and Meth. **A819** 54, (2016)
[7] D. Kaminska et al. Eur. Phys. J C 76, (2016)
[8] B. Jasinska et al., Acta Phys. Polon. B47 453, (2016)
[9] K. Dulski et al., Hyperfine Interactions, (2018)