



Towards improving the sensitivity of testing CPT symmetry in positronium decays with the Modular J-PET detector



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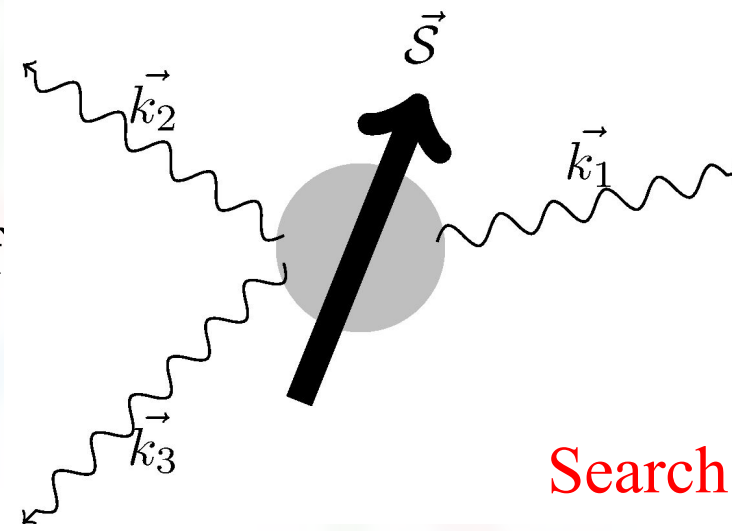
Center for Theranostics, Jagiellonian University, Krakow, Poland

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Motivation

- To perform Fundamental research with J-PET detector in positronium annihilations [1,2]
- Search for discrete symmetry violation in 3γ annihilation of ortho-positronium (3S_1)
- **CPT symmetry test** using the angular correlations between spin and decay plane of o-Ps $\rightarrow 3\gamma$ [3]
- $\langle O_{CPT}^{(-)} \rangle \stackrel{?}{=} 0$



Gamma sphere detector
 $C_{CPT} \sim 10^{-3}$ [4]
(previous best measurement)

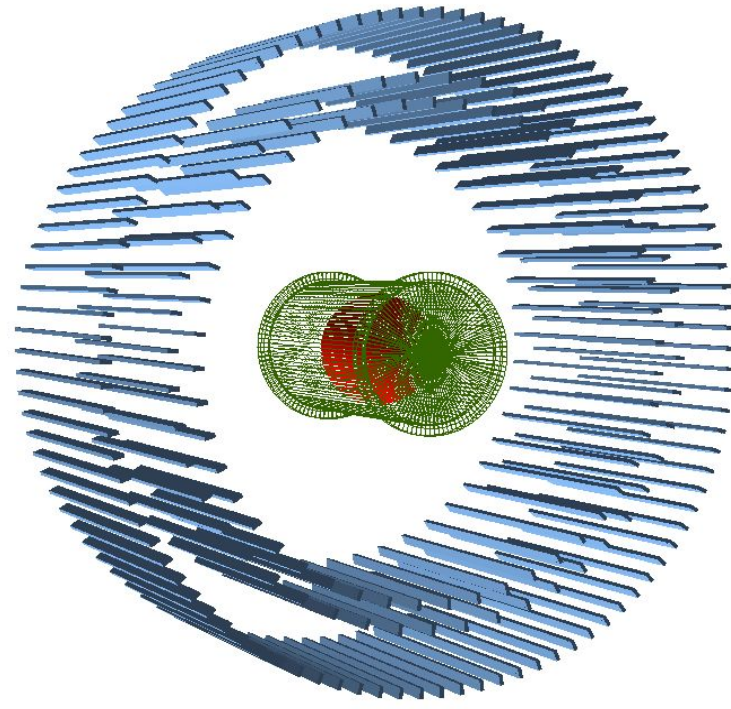
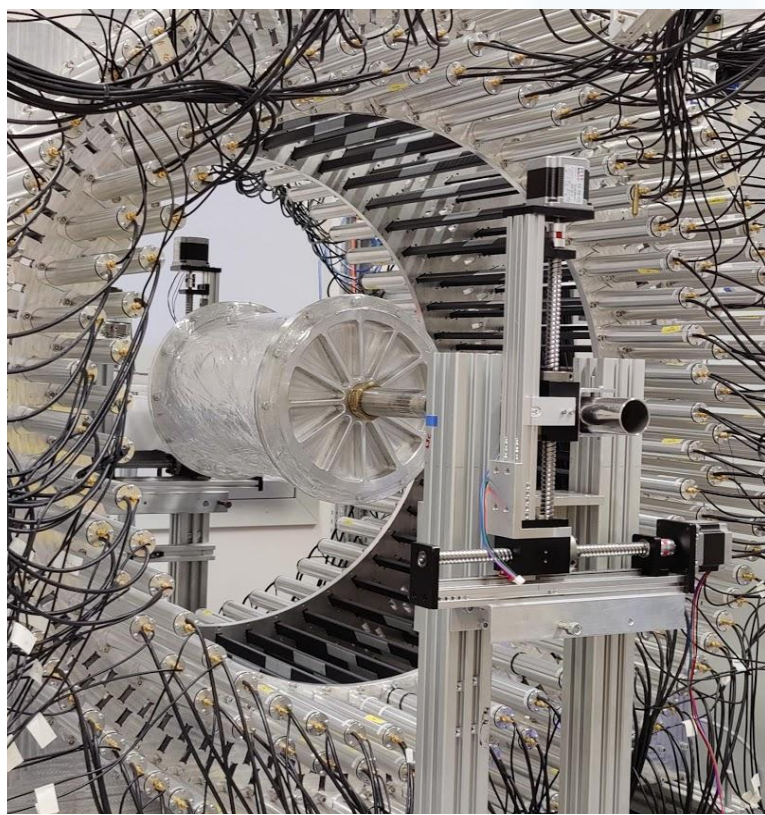
Operators	C	P	T	CP	CPT
$\vec{S} \cdot \vec{k}_1$	+	-	+	-	-
$\vec{S} \cdot (\vec{k}_1 \times \vec{k}_2)$	+	+	-	+	-
$(\vec{S} \cdot \vec{k}_1)(\vec{S} \cdot (\vec{k}_1 \times \vec{k}_2))$	+	-	-	-	+

$$|\vec{k}_1| > |\vec{k}_2| > |\vec{k}_3|$$

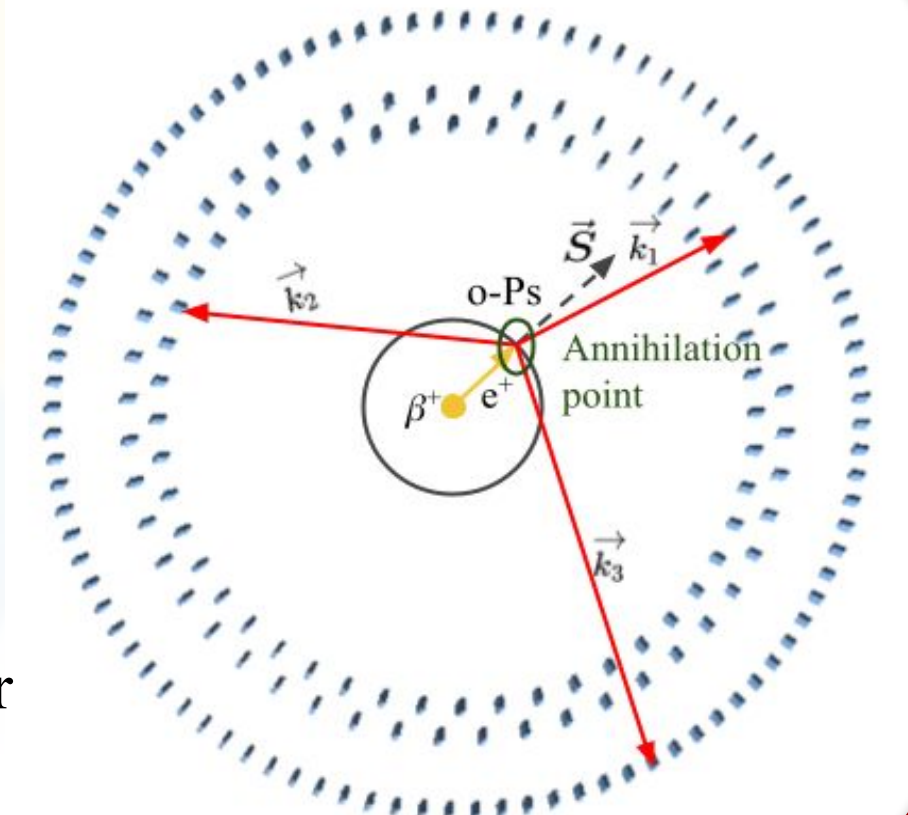
Search for CPT violation in Ps decays

➔ **J-PET detector**
 $C_{CPT} \sim 10^{-4}$ [5]

CPT odd operator study with J-PET



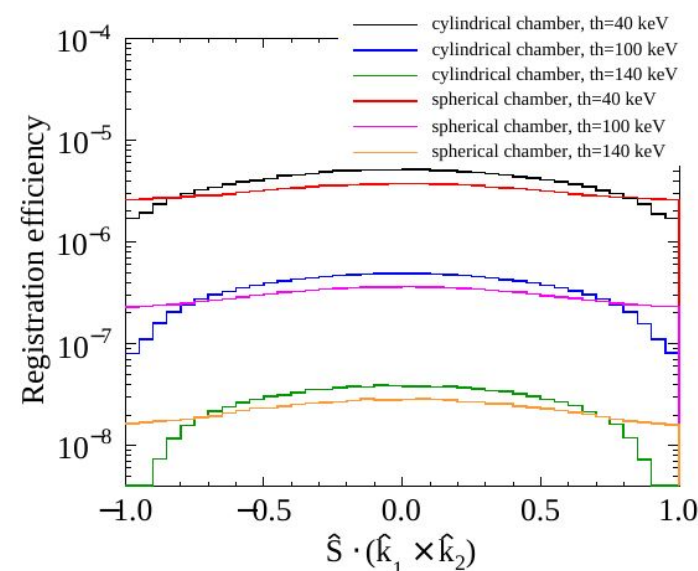
- Use of **annihilation chamber** for Ps production.
- Trilateration method: reconstruct o-Ps annihilation point [6]
- **Spin** of o-Ps is estimated event by event
- $\vec{S} \cdot (\vec{k}_1 \times \vec{k}_2)$: CPT- violation sensitive operator



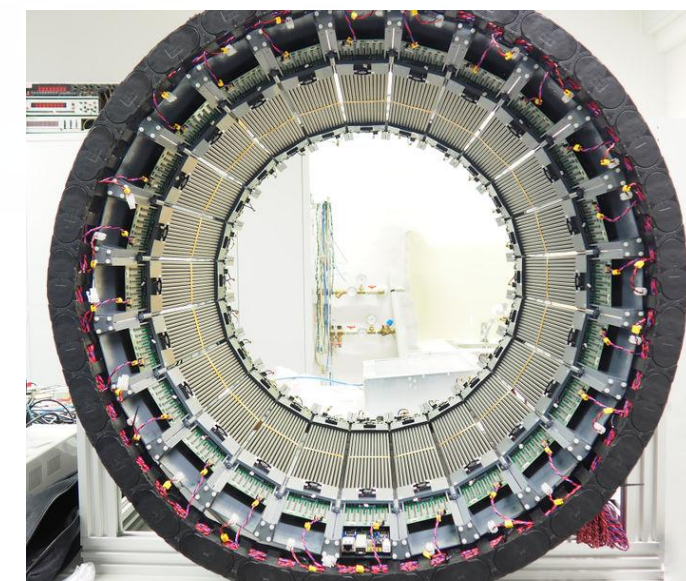
Talk by E. Czerwiński on 14 July

- **Spherical annihilation chamber:** to increase positronium formation

Total Efficiency of registration of o-Ps events in J-PET based on MC simulation [7]



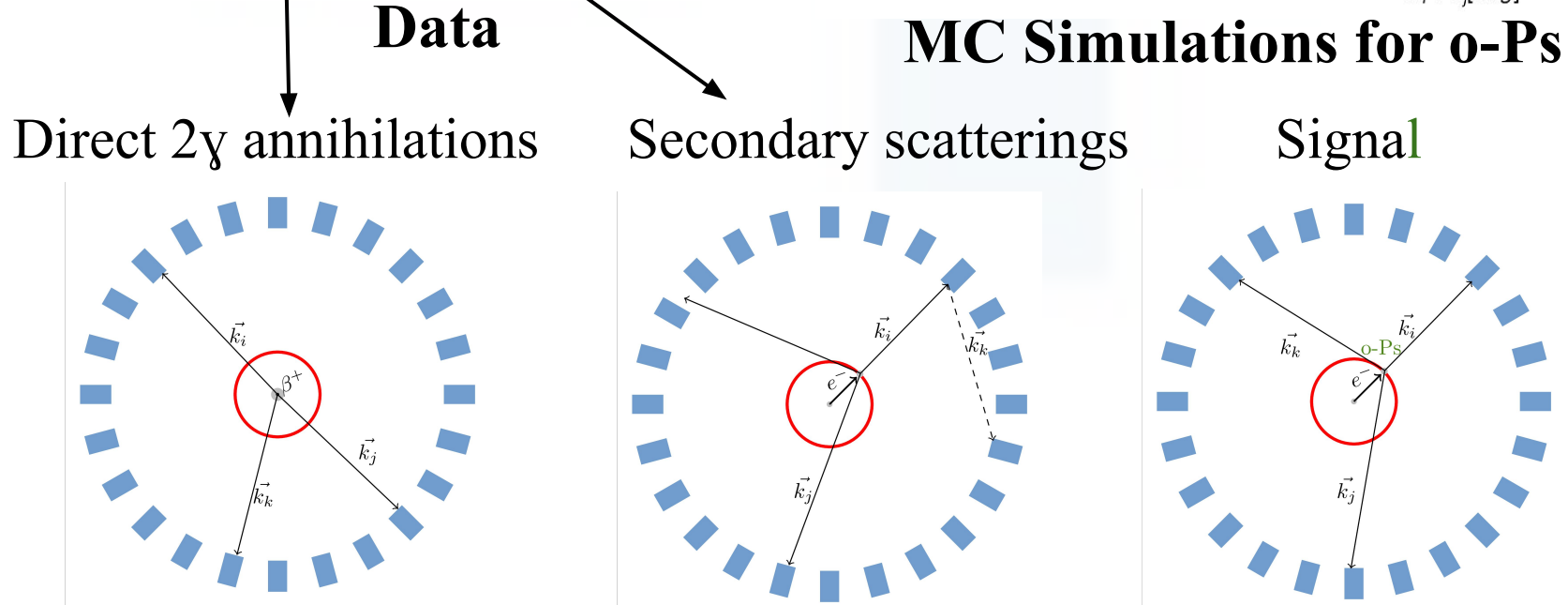
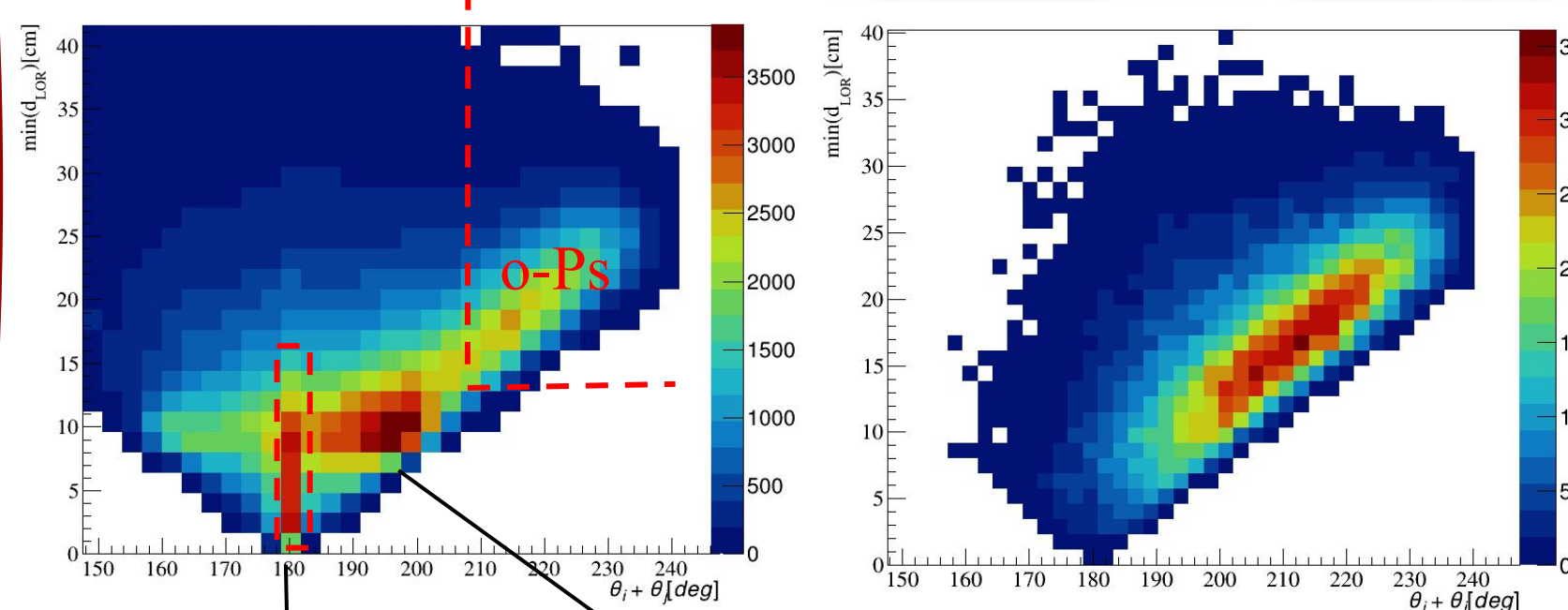
- **Modular J-PET:** 24 modules of densely packed plastic scintillators with SiPM readout.



- Increase the detection efficiency for registration of annihilation photons from Ps

Improving the sensitivity for CPT symmetry test to 10^{-5}

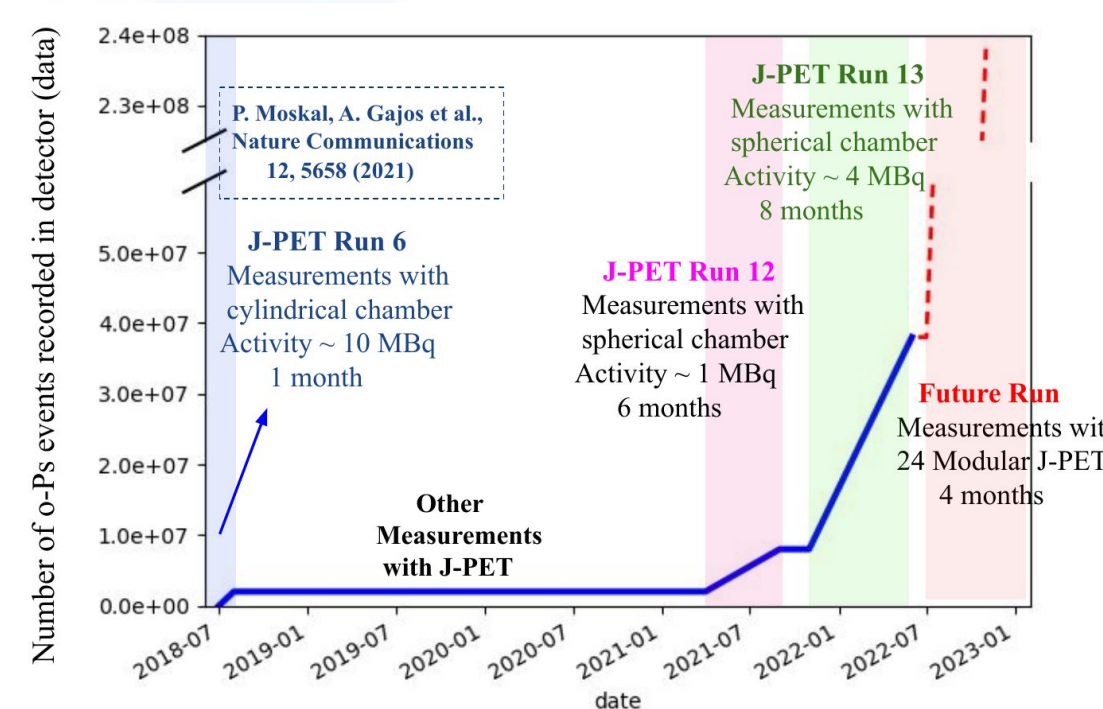
Studies with spherical vacuum chamber + J-PET detector



- Reconfigured in to multiple layers, hence making it a portable device

Efficiency ~ 28 w.r.t present J-PET

Efficiency ~ 112 w.r.t present J-PET



Efficiency ~ 17 w.r.t present J-PET

BiBliography

- [1] P. Moskal et al., Acta Phys. Polon. B 47 (2016) 509
- [2] P. Moskal et al., NIM 2014, 764, 317–321
- [3] W. Bernreuther et al., Z. Phys. C 41, 143 (1988)
- [4] P.A. Vetter et al., Phys. Rev. Lett. 91, 2003 263401
- [5] P. Moskal et al., Nat. Commun. 12, 5658 (2021)
- [6] A. Gajos et al., NIM A 2016, 819, 54
- [7] A. Gajos, Symmetry 2020, 12(8), 1268