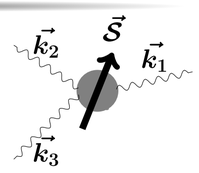
CPT symmetry test in positronium annihilations with the J-PET detector

Neha Chug*, On behalf of the J-PET collaboration, *Jagiellonian University, Krakow, Poland

Motivation

To search for discrete symmetry violation in 3γ annihilation of ortho-positronium ($^3S_1$).



CPT symmetry test in o-Ps→3γ decay [2]

Operators	C	P	T	CP	CPT
$\vec{S}\cdot\vec{k_1}$	+	-	+	-	-
$\vec{S}\cdot(\vec{k_1}\times\vec{k_2})$	+	+	-	+	-
$(\vec{S}\cdot\vec{k_1})(\vec{S}\cdot(\vec{k_1}\times\vec{k_2}))$	+	-	-	-	+

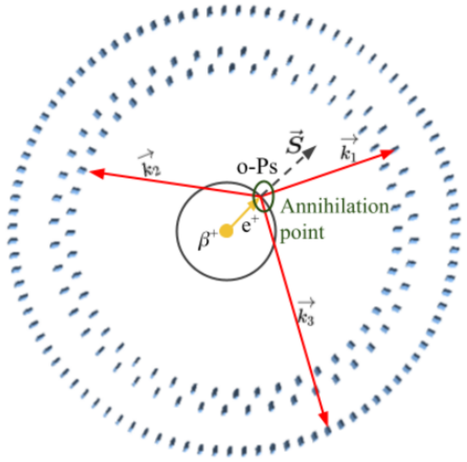
$$|\vec{k_1}| > |\vec{k_2}| > |\vec{k_3}|$$

(Talk by W. Krzemień on 8 Sept, Contrib No. 372)

- $< O_{CPT}^{(-)} > \stackrel{?}{=} 0$
- Gammasphere detector: search for CPT violation; Reached a sensitivity of $C_{CPT} \sim 10^{-3}$ [1]

CPT odd operator study with J-PET

- Trilateration method: reconstruct o-Ps annihilation point [4]
- Spin of o-Ps is estimated event by event
- $\vec{S}\cdot(\vec{k_1}\times\vec{k_2})$: CPT- violation sensitive operator [5]



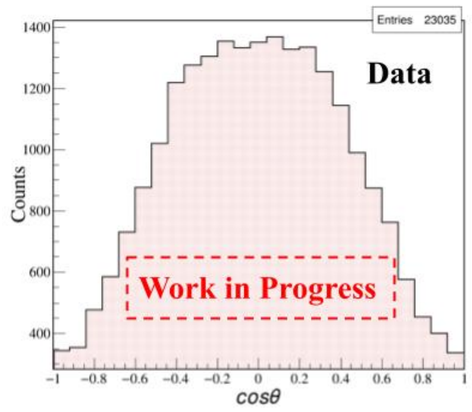
$$O_{CPT} = \hat{S}\cdot\frac{(\vec{k_1}\times\vec{k_2})}{|\vec{k_1}\times\vec{k_2}|} = cos\theta$$

$$C_{CPT} = \frac{<O_{CPT}>}{P}$$

P : average polarization of o-Ps (analyzing power)

C_{CPT}: amplitude of CPT violating effect

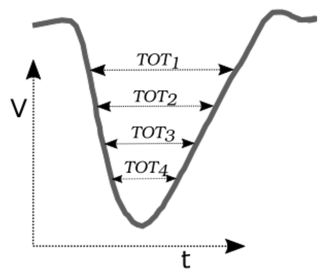
Result/Discussion



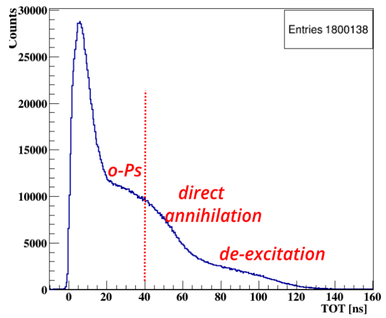
Identification of o-Ps→3γ events

Time Over Threshold

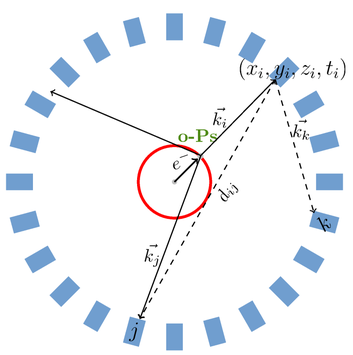
- Measure of energy deposited by a photon in the scintillator.
- Approach to identify prompt and annihilation photon.



$$\sum_{i=1}^{4} TOT_i$$

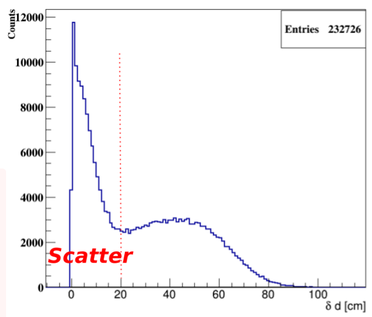


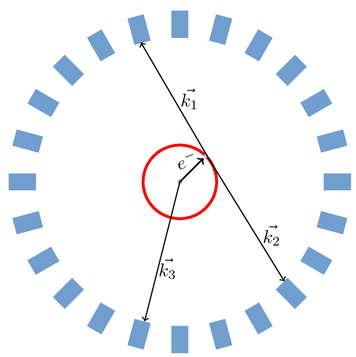
Mimicked 3γ events



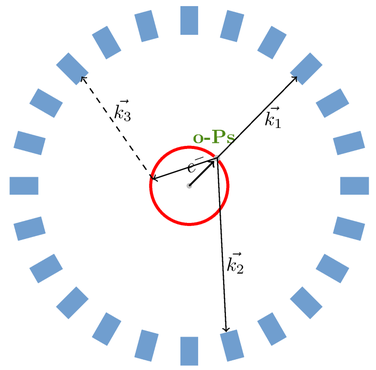
Scatter Test

$$\delta_{ij} = |d_{ij} - c\Delta t_{ij}| \sim 0$$



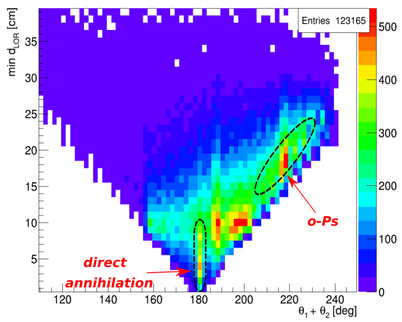


Direct 2γ annihilations

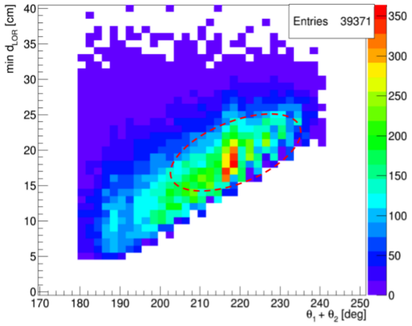


Scatterings inside chamber

Data

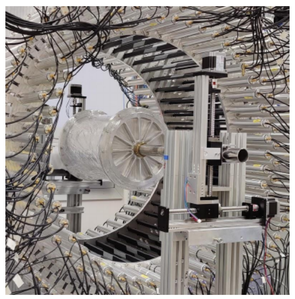


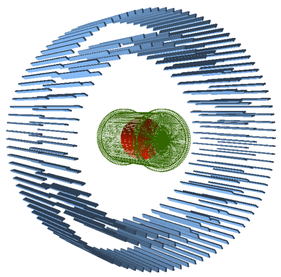
MC Simulations for o-Ps



J-PET detector

Jagiellonian Positron Emission Tomograph





192 plastic scintillators [3]

Spherical annihilation chamber + porous silica

(Talk by Prof. P. Moskal, Contribution No. 373)

References

[1] P.A. Vetter *et al.*, Phys. Rev. Lett. 91, 2003 263401.
[2] W. Bernreuther *et al.*, Z. Phys. C 41, 143 (1988).
[3] P. Moskal *et al.*, NIM 2014, 764, 317–321.
[4] A. Gajos *et al.*, NIM A 2016, 819, 54.
[5] P. Moskal *et al.*, Acta Phys. Polon. B 47 (2016) 509.

Acknowledgement

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