

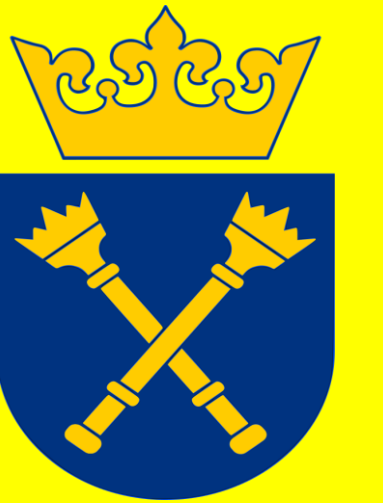
Time over Threshold (TOT) as a measure of Energy deposition by gamma quanta in plastic scintillator used in J-PET



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Abstract

The Jagiellonian Positron Emission Tomograph (J-PET) is one of its kind based on the organic scintillators developed at Jagiellonian University in Krakow. The organic scintillators are hydrocarbon compounds, therefore, the gamma quanta interact predominantly via the Compton effect. The energy loss of incident photon in scintillator varies with scattering angle of outgoing photon. In this study, we present a method to establish a relationship between the energy deposited by incoming gamma quanta in plastic scintillator and sum of the Time Over Threshold (TOT) spectra estimated from the signals measured from scintillator by using photomultiplier tubes and associated electronics. Such a study is also of utmost importance to distinguish the origin of photons i.e., either annihilation or de-excitation process.

Introduction

- The Jagiellonian Positron Emission Tomograph (J-PET) is built out of axially arranged plastic scintillator strips forming a cylinder [1].
- The light signals produced in scintillators are converted to electrical pulses by photomultipliers placed at opposite ends of each strip [2].
- The pulses are probed in the voltage domain by a newly developed electronics [1,3] and are collected by the novel trigger-less and reconfigurable data acquisition system [4,5].

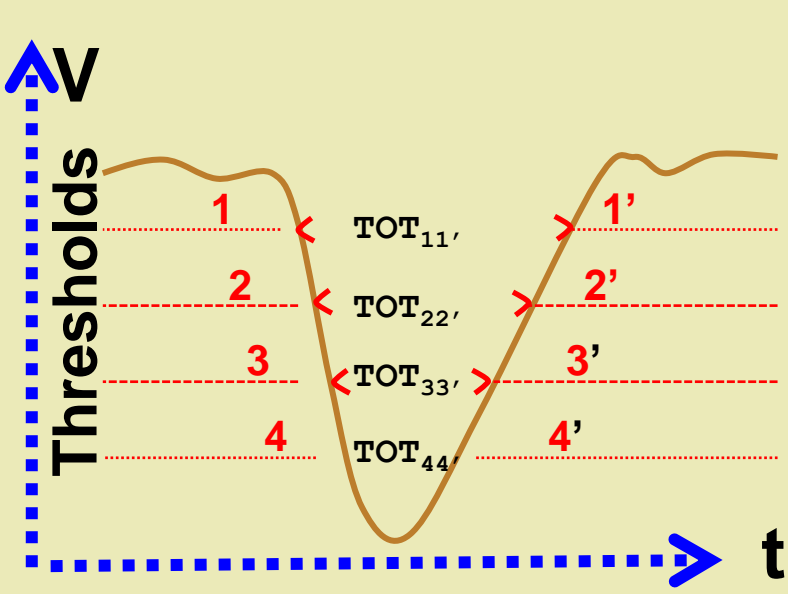
Data Analysis

Signal from individual PMT

Analog Signal

Four thresholds are applied on signal

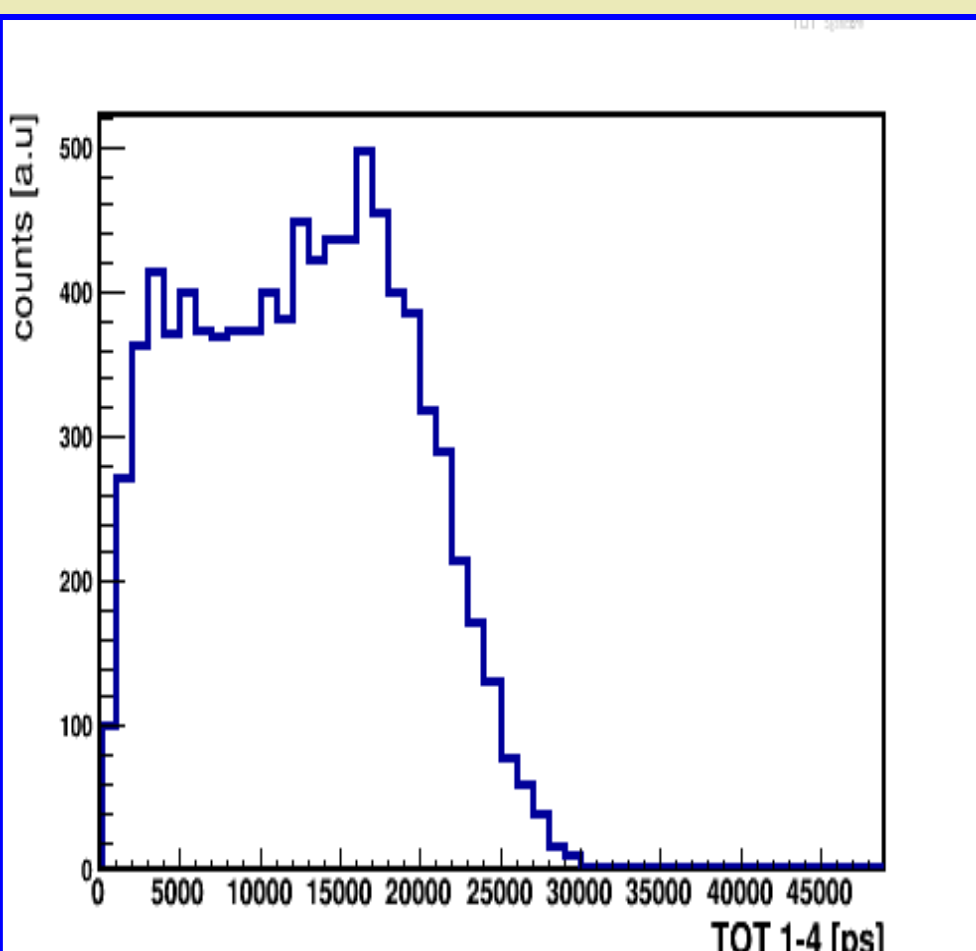
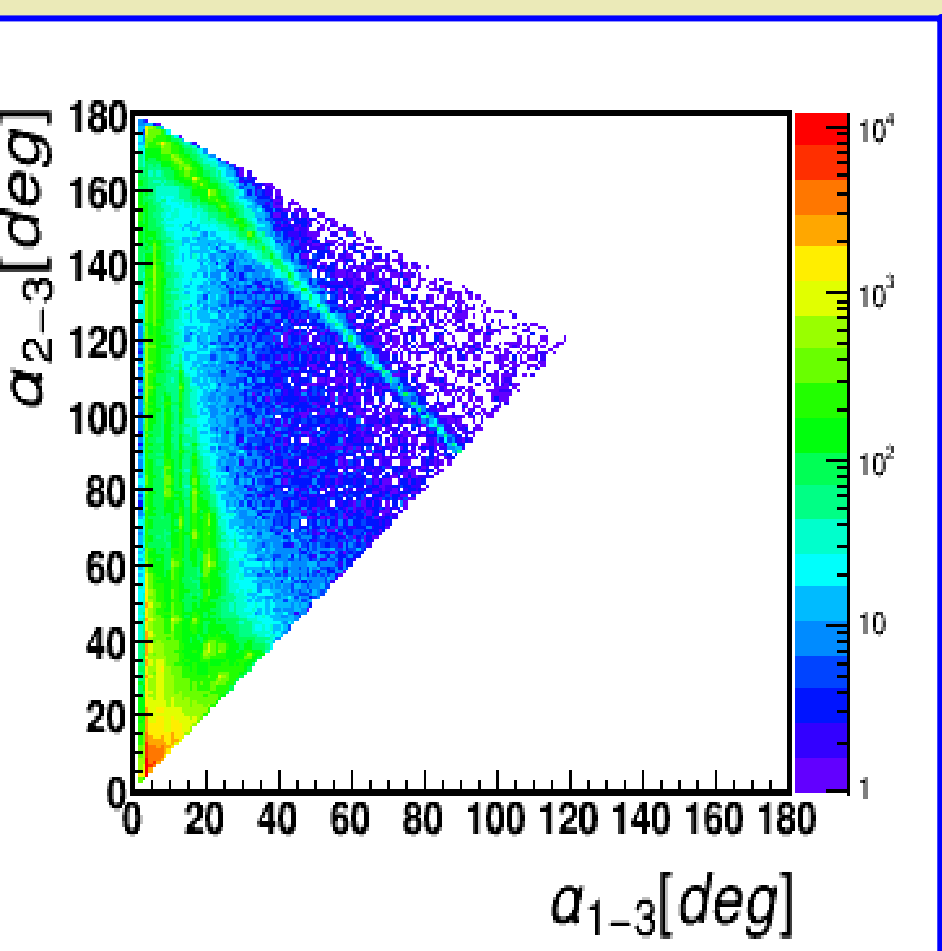
Four TOT values, Where TOT: Represents the Time difference between the leading and trailing edge of the signal at a fixed threshold.



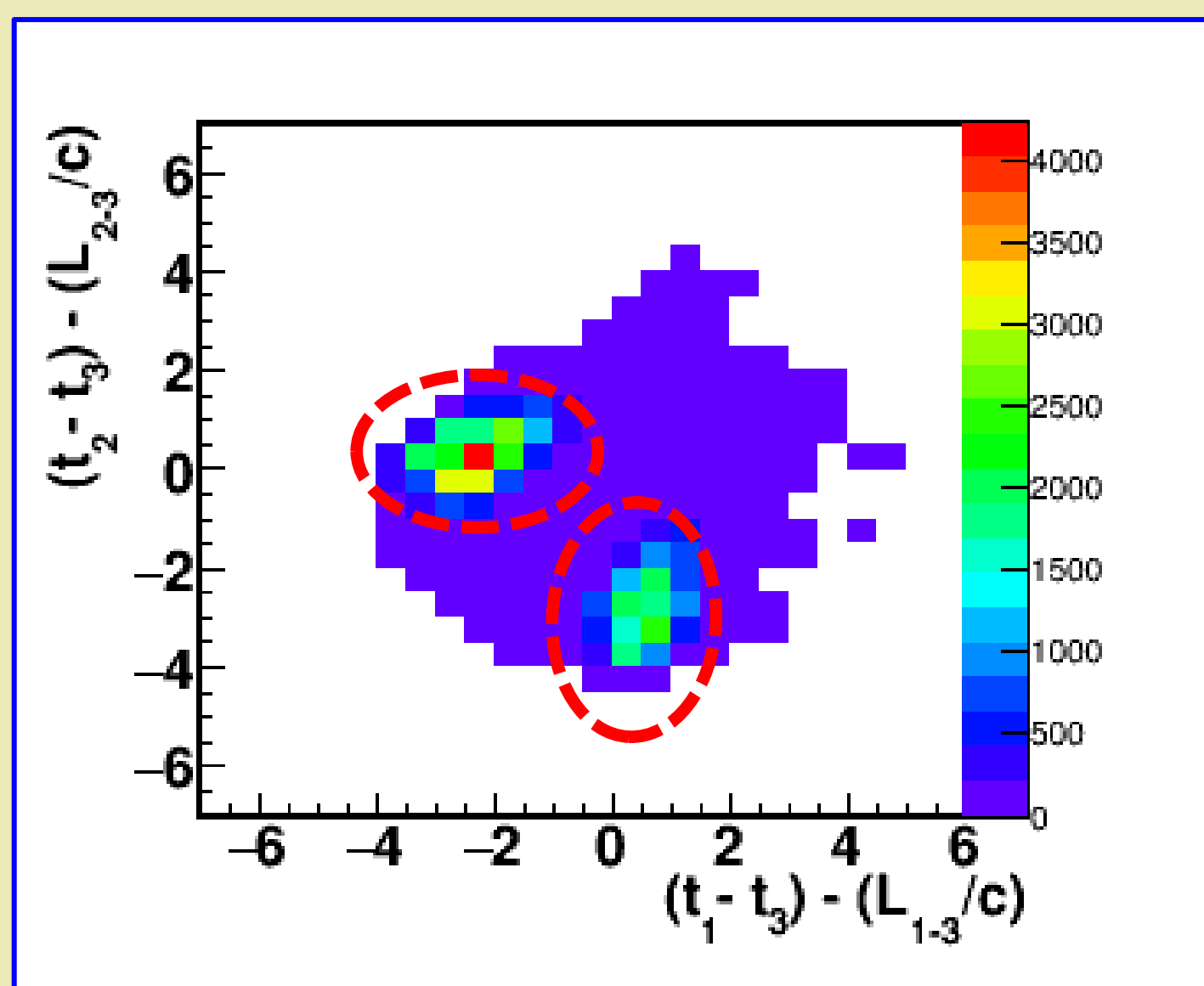
$$TOT_{SUM} = \Delta t_{11'} + \Delta t_{22'} + \Delta t_{33'} + \Delta t_{44'}$$

3-HIT angles

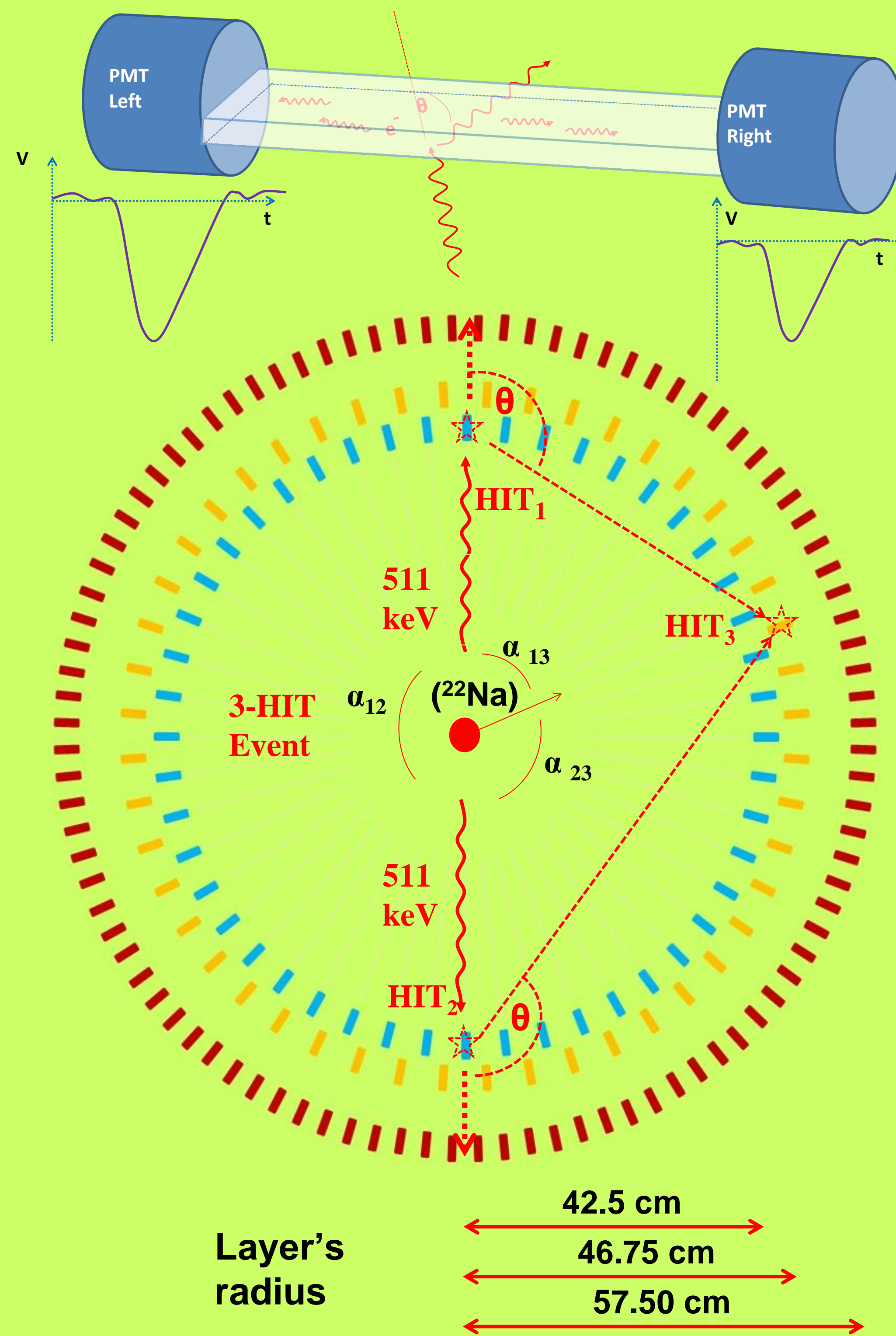
TOT for back-to-back hit



Criteria used to tag the origin of third hit



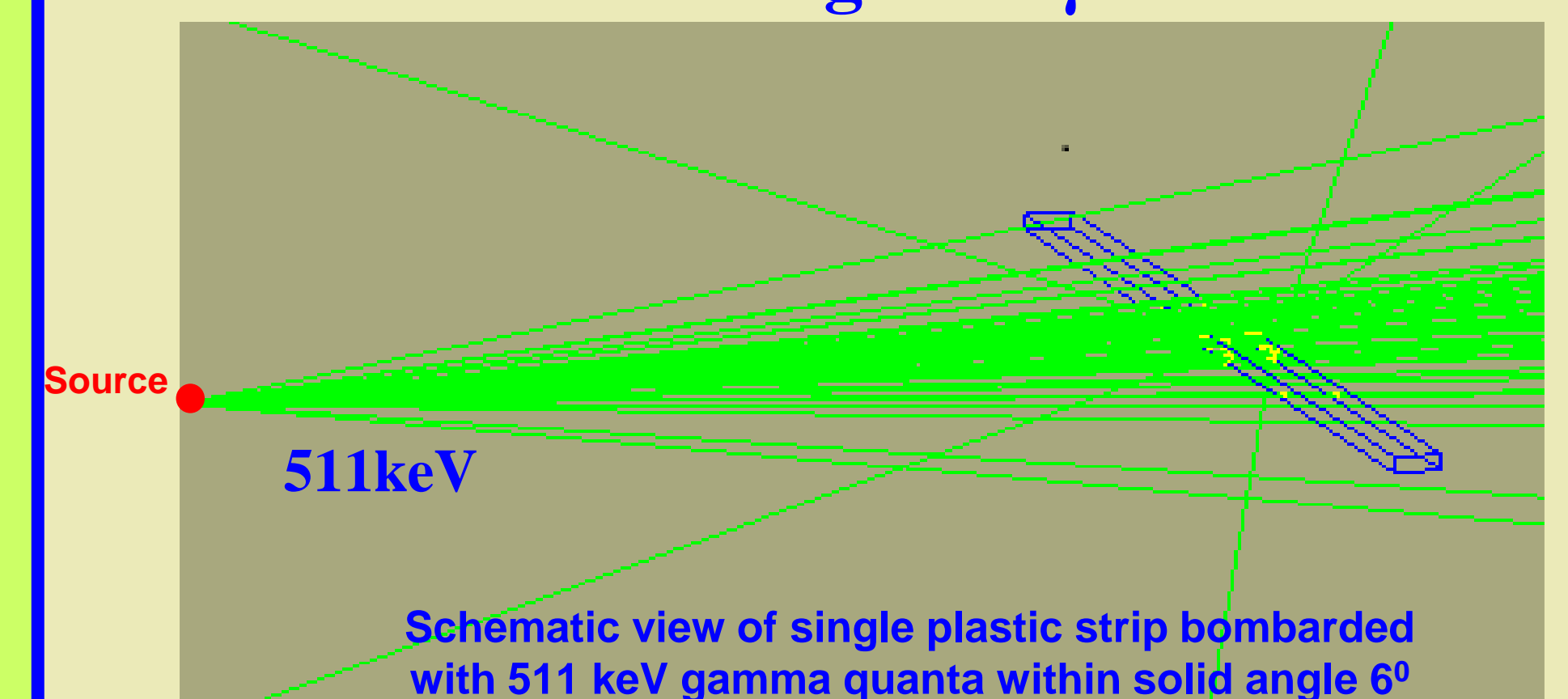
J-PET MODULE : 500 X 19 X 7 mm³



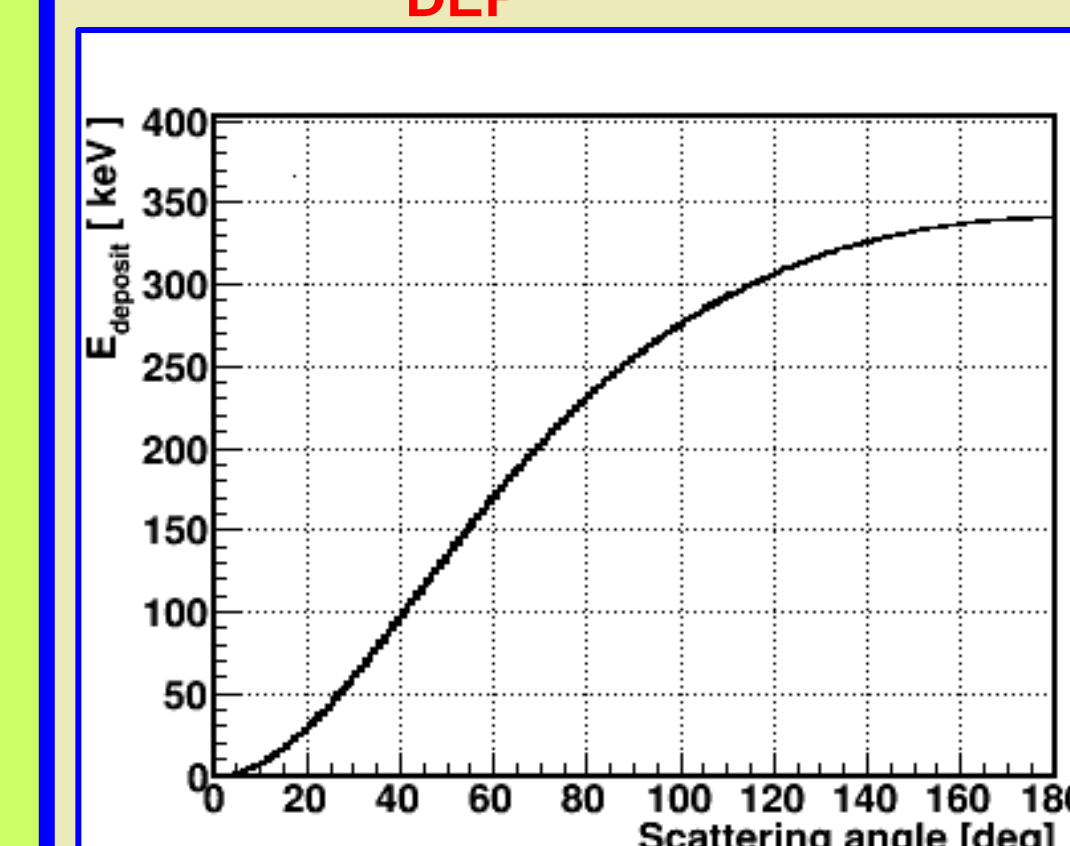
Jagiellonian – Positron Emission Tomograph

Theoretical Foundation

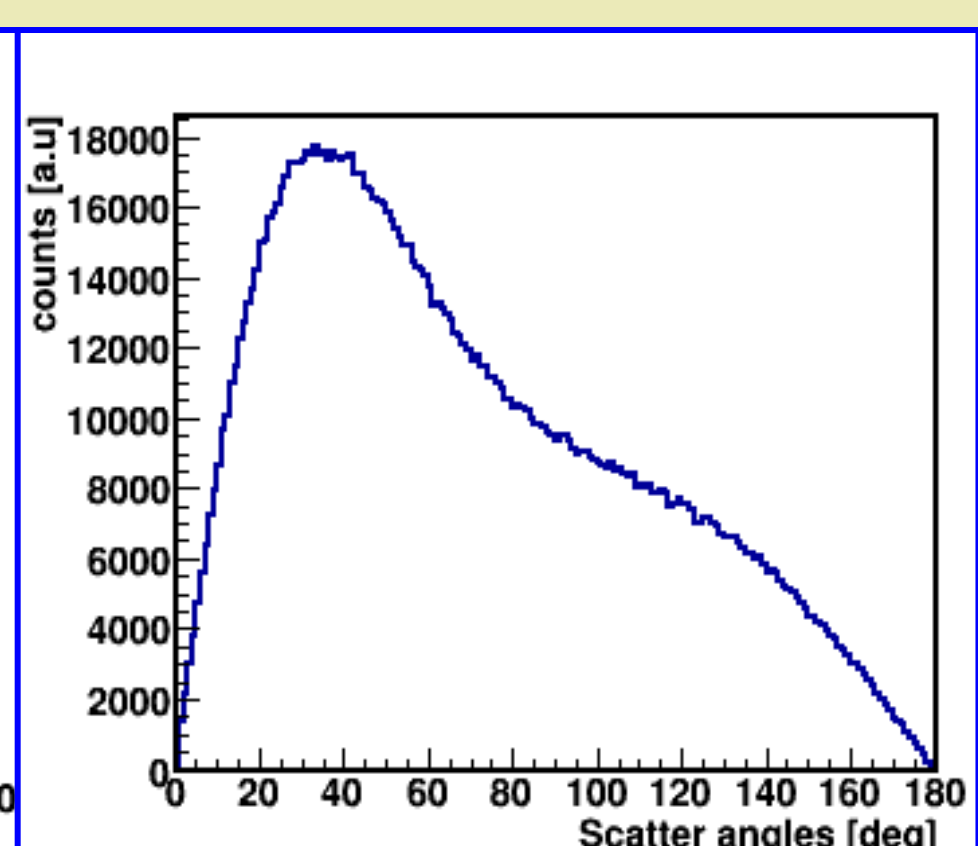
Geant4 simulations using single J-PET module for scatterings of $E_\gamma = 511 \text{ keV}$:



E_{DEP} VS θ_{scatt}



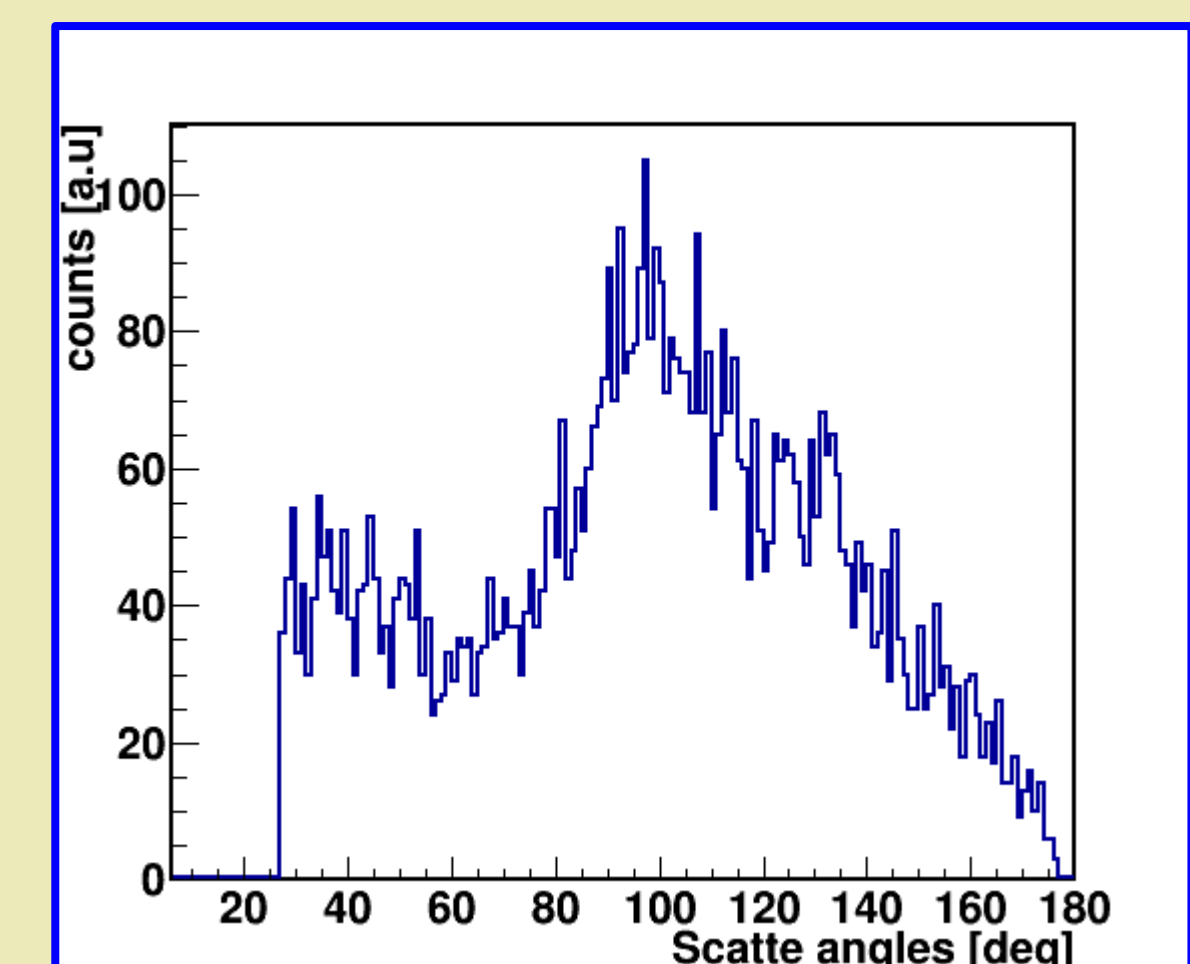
θ_{scatt}



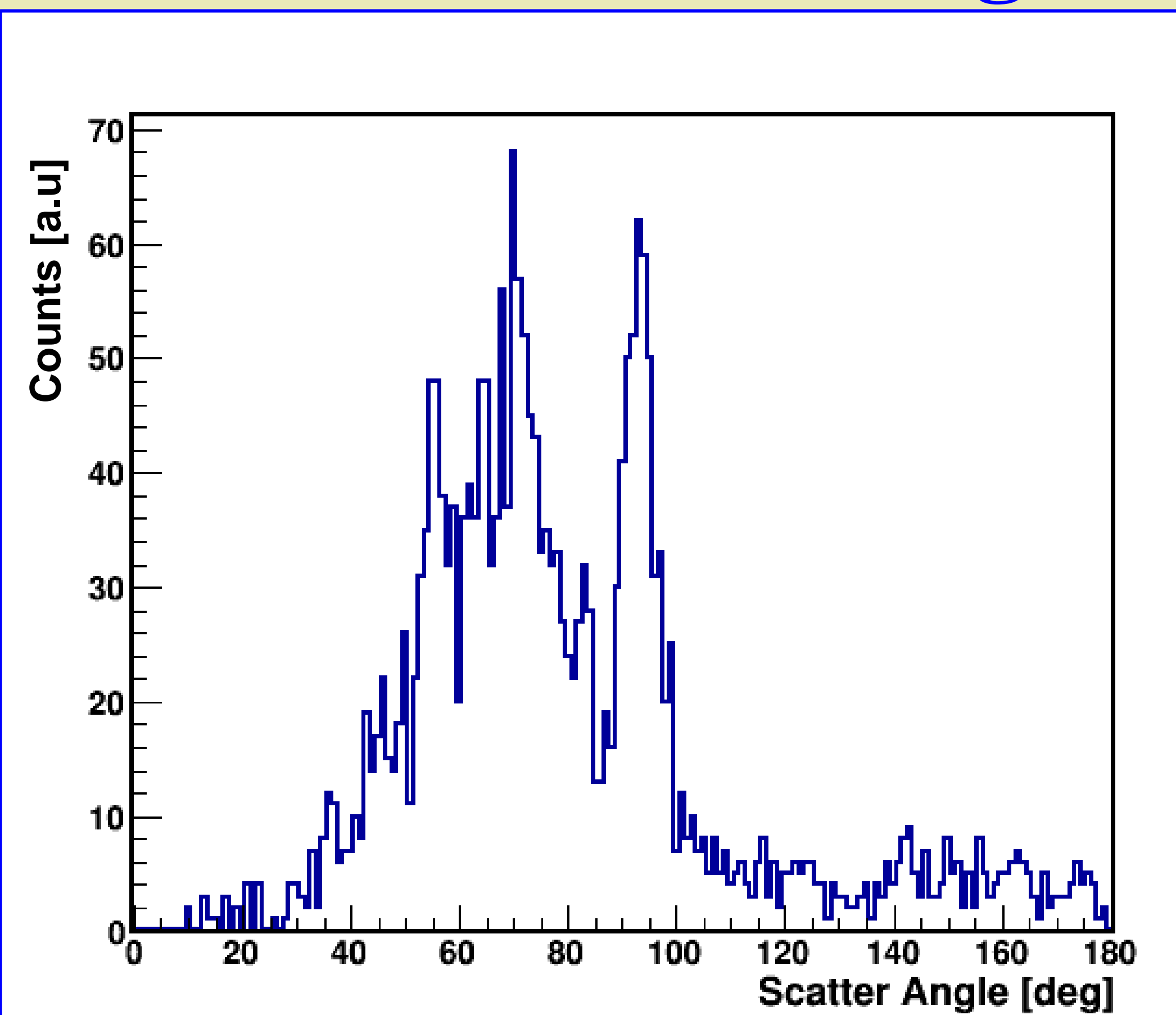
Full barrel Geant4 simulations to study the geometry effect on θ_{scatt} of $E_\gamma = 511 \text{ keV}$

Energy Cut :

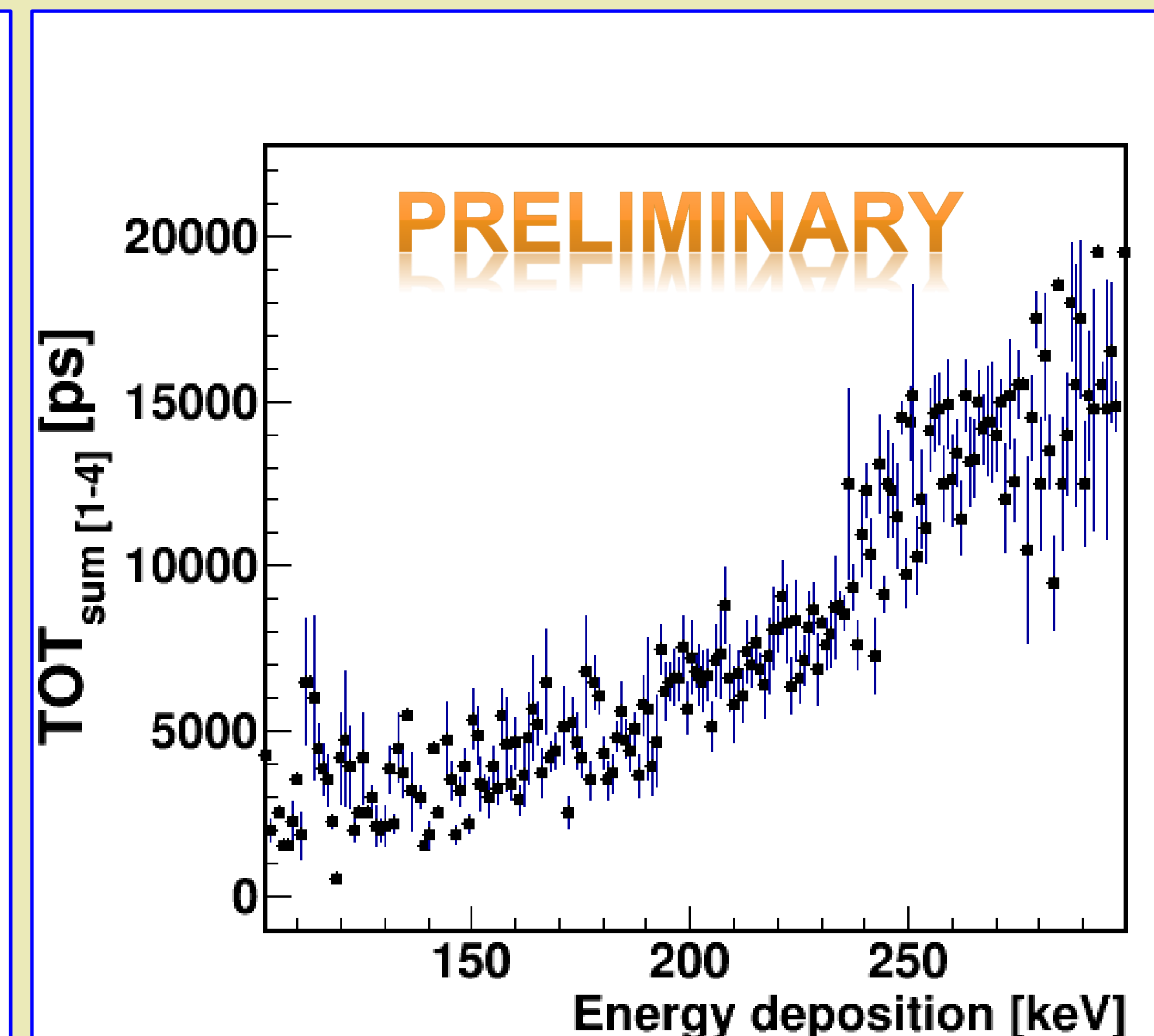
$E_{DEP} > 50 \text{ keV}$



Measured scatter angle



Result



Summary

- Preliminary relationship between measured TOT and energy deposition in plastic scintillators using 511 keV gammas was established.
- TOT values increase with deposited energy.
- Geant4 simulations were performed with single J-PET module to study energy deposition at various scattering angles.
- Significant geometry effects were observed in the scatterings of gamma quanta.

References:

- [1] 18 Patent Applications, <http://koza.if.uj.edu.pl/patents/>.
- [2] P. Moskal et al., Nucl. Inst. and Meth. A 764 (2014) 317.
- [3] M. Palka et al., Bio Algorithms and Med-Systems 10 (2014) 41.

- [4] G. Korcyl et al., Bio-Algorithms and Med-Systems 10(2014) 37.
- [5] M. Palka et al., Journal of Instrumentation 12 (2017) P08001