

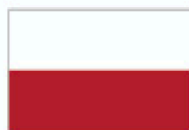
Efficiency determination of J-PET detector based on photon's scattering

S. Sharma

26.10.2019



European
Funds
Smart Growth



Republic
of Poland



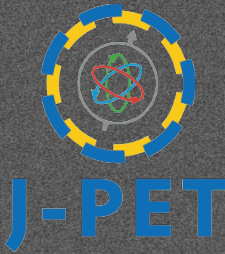
Foundation for
Polish Science

European Union
European Regional
Development Fund

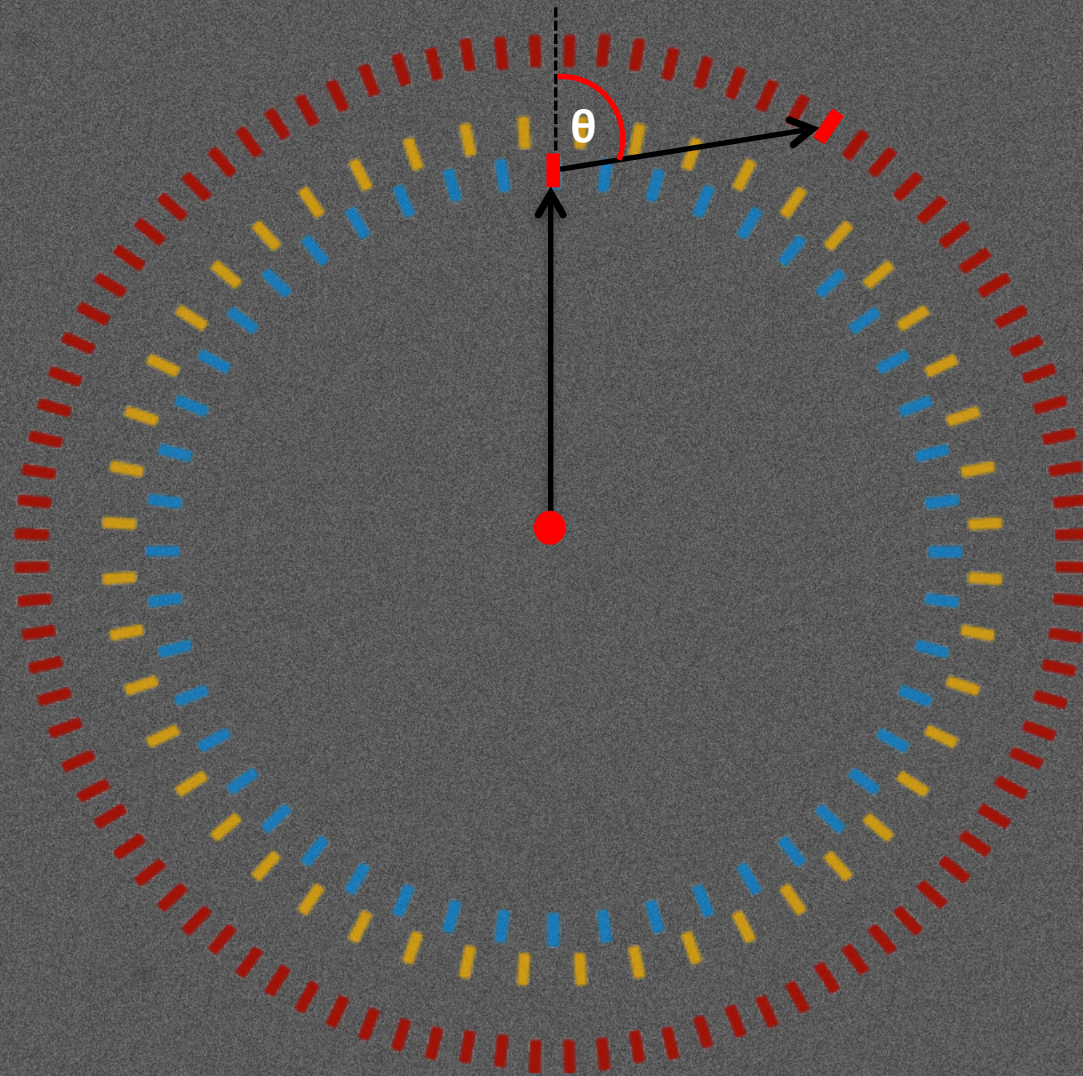




Outline



- Methodology
- Experimental set-up
- Monte-Carlo simulations (Geant4)
- Results



What we have :

- ✓ Hit positions of primary and scattered photon give access to the θ values

What is required :

- ▶ **Tagging of incident photon**
- ▶ **True scattering angles θ**
(proper association of scattered photon to its parent one)

Simulations-Geant4

Known incident photon's energy and scattering angles

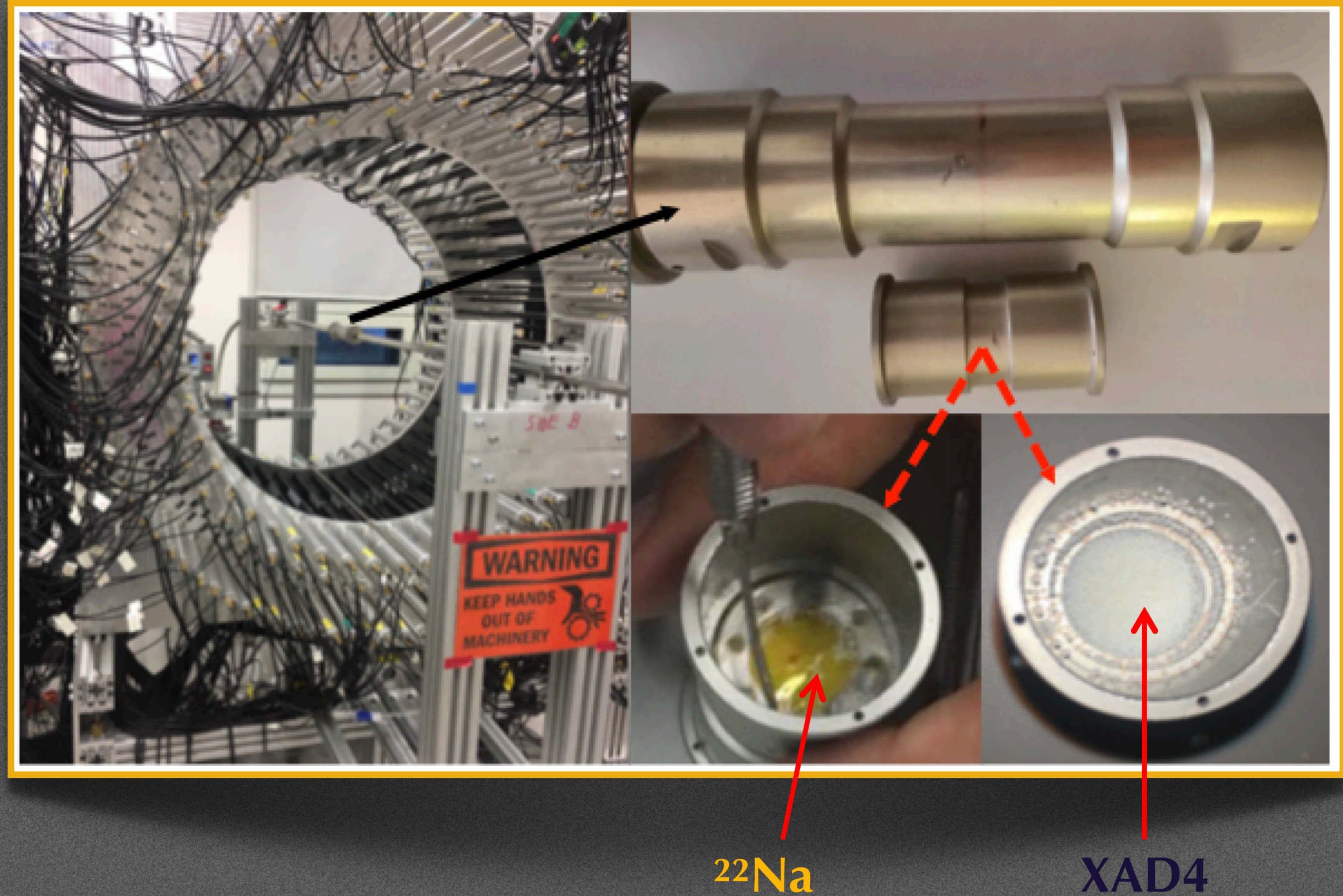


Experiment

Tagging the photon's incident energy and estimating the true scattering angles

Experimental set-up

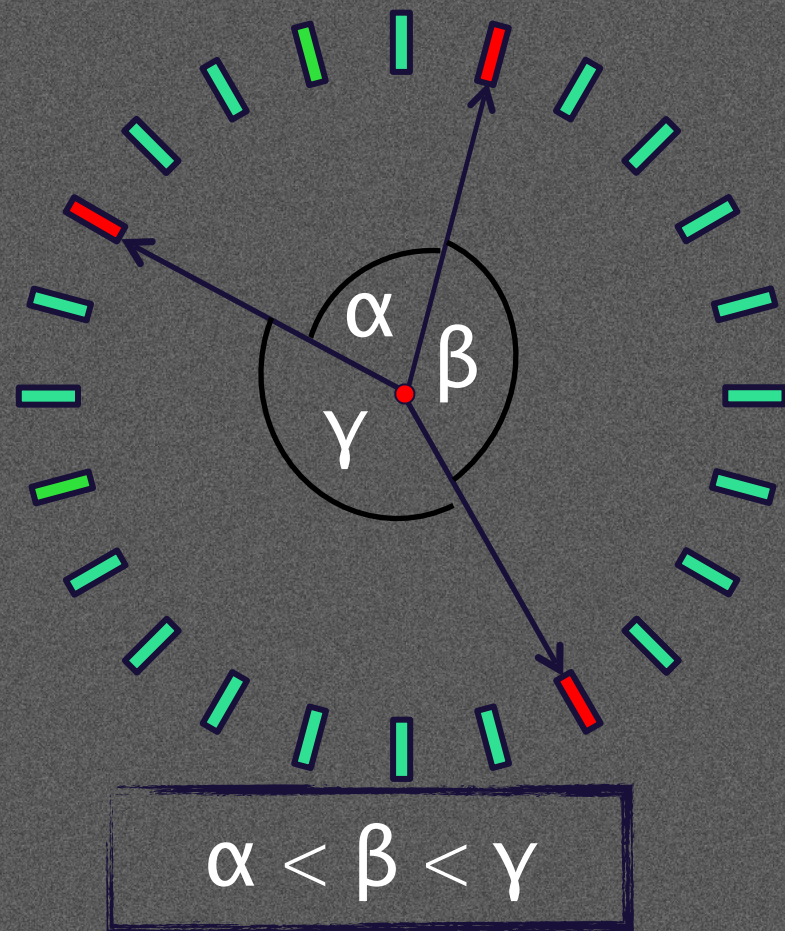
Small chamber in the center





Selection of photons of diff. energies : Events (3Hits ordered in time) were studied

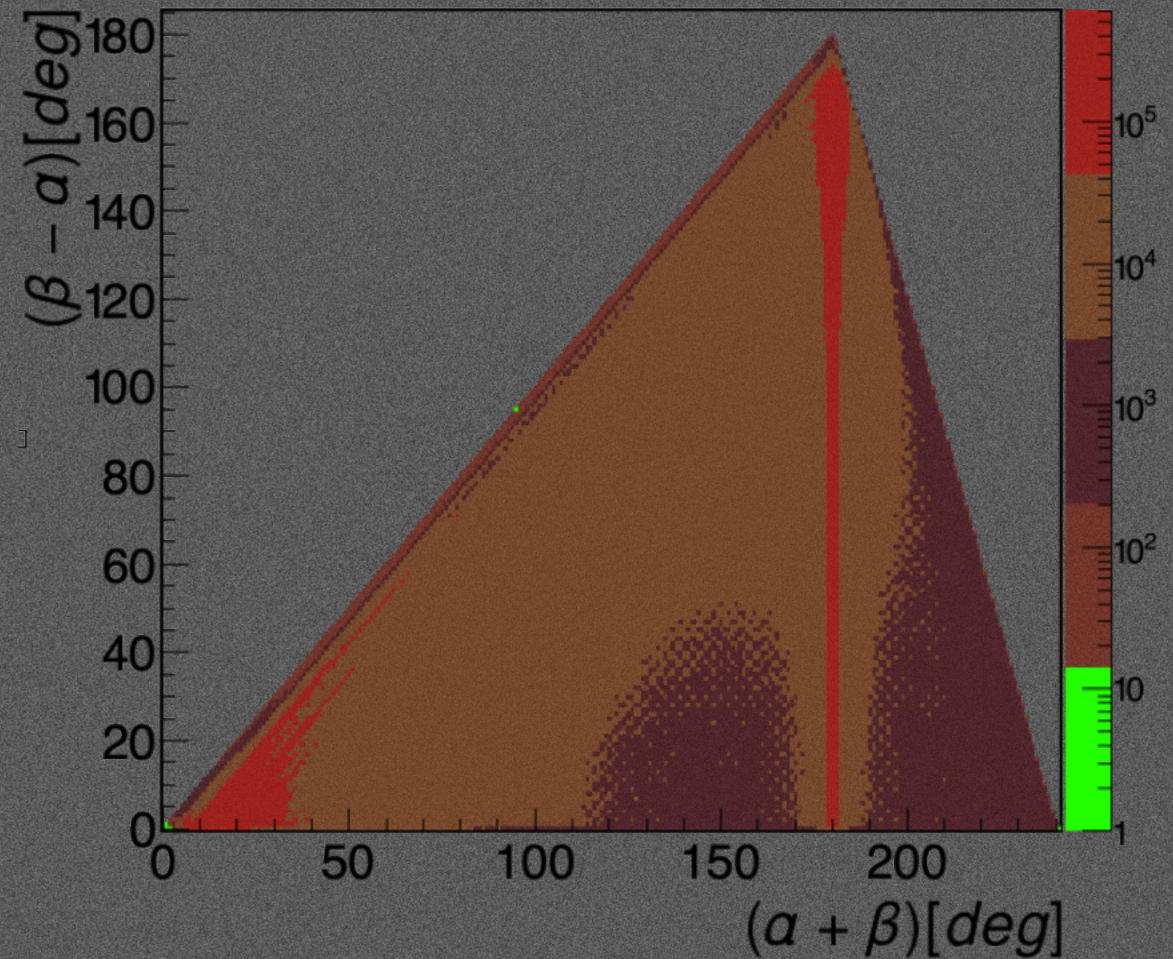
Angular correlations



Annihilation photons 511 keV

$$179 < (\alpha + \beta) < 181$$

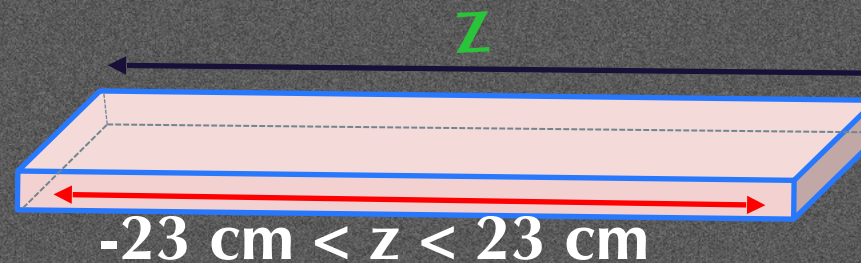
All 3 Hits are in different scintillators



Prompt photons 1275 keV

$$(\alpha + \beta) < 165 \ \&\& \ (\alpha + \beta) > 185$$

All 3 Hits are in different scintillators



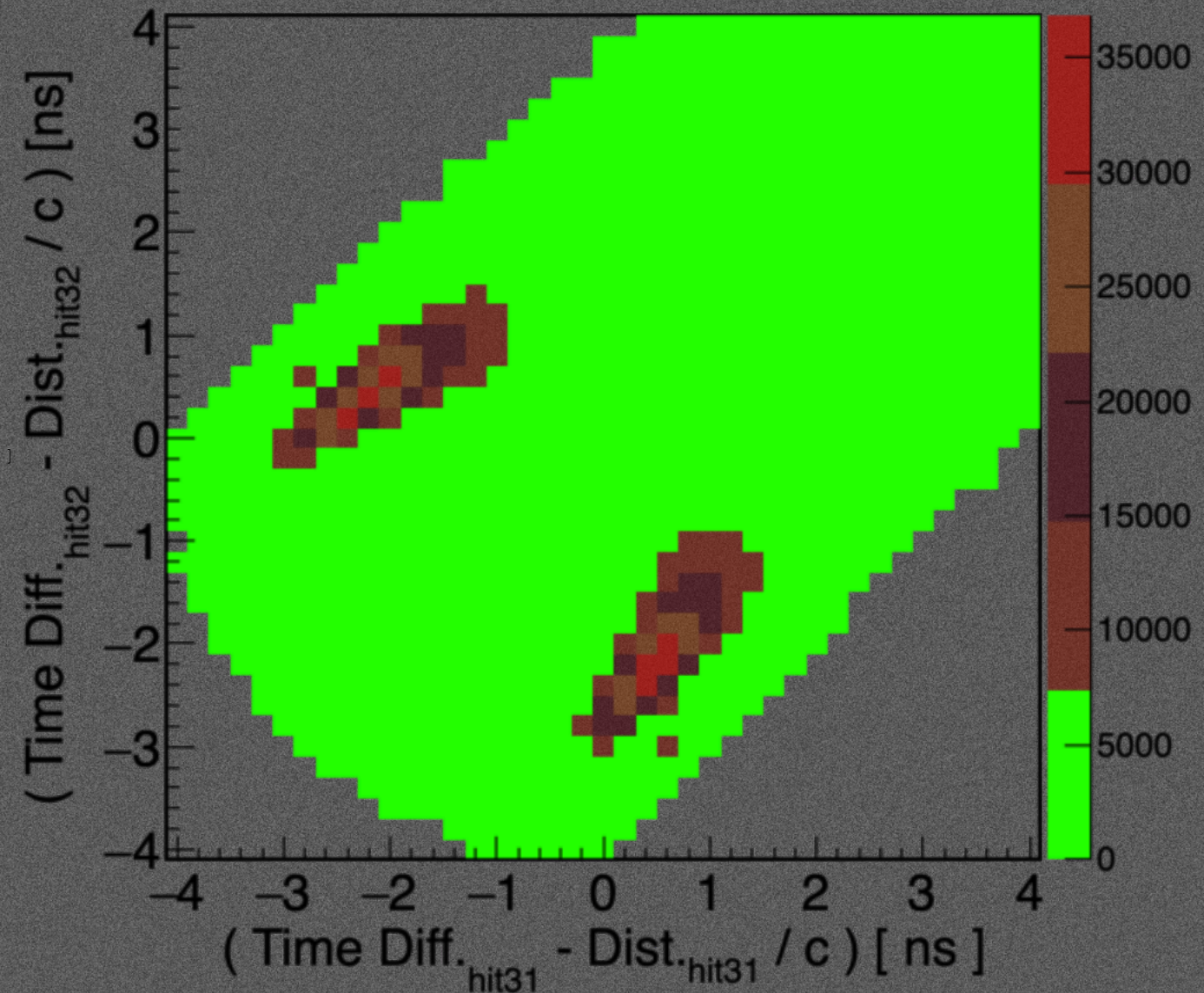
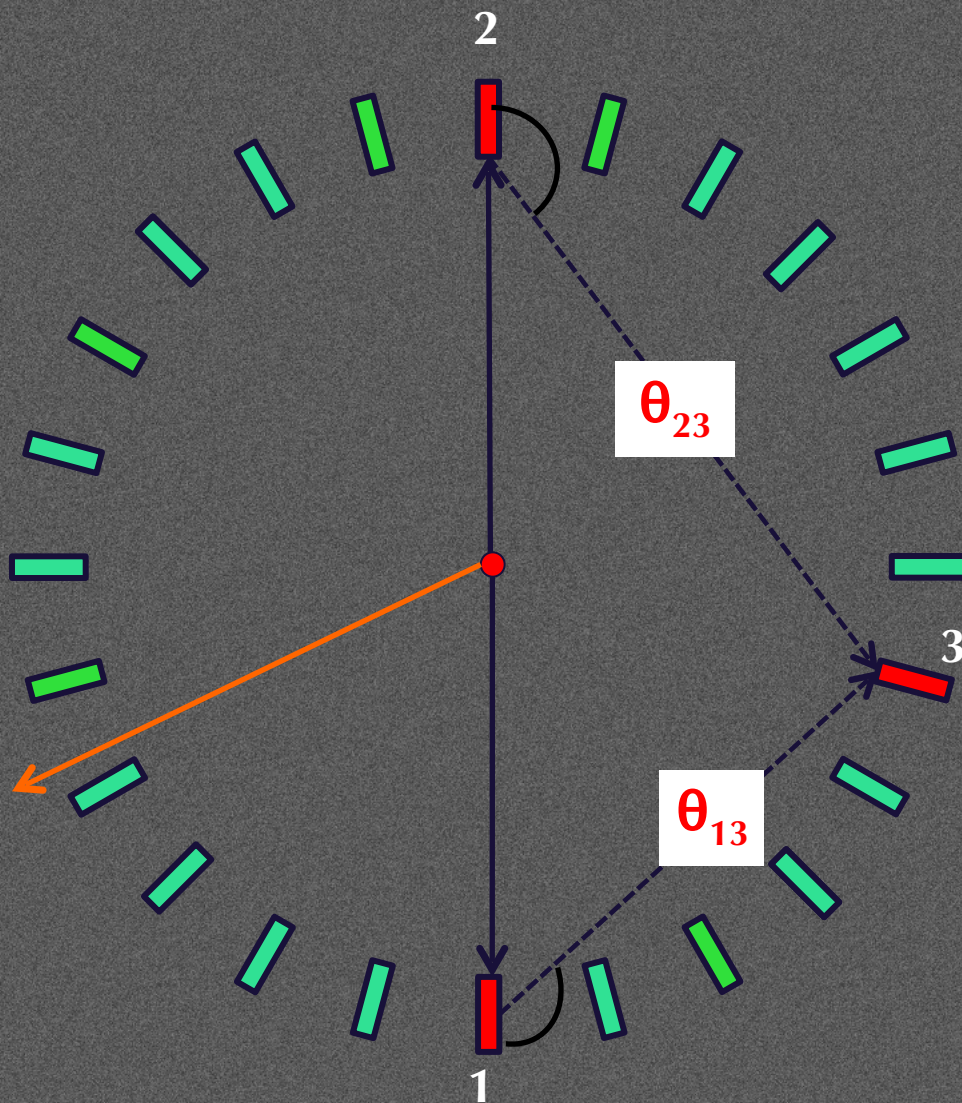


Measurement of 511 keV photon : (**Scatt. Ang / Edep**)

- ✓ 1, 2 Hits are Back-to-Back gamma
- ✓ 3RD Hit from the scattering of gamma either after Hit 1 or Hit2

For the assignment of scattered hit to its origin, scatter test(S) was applied:

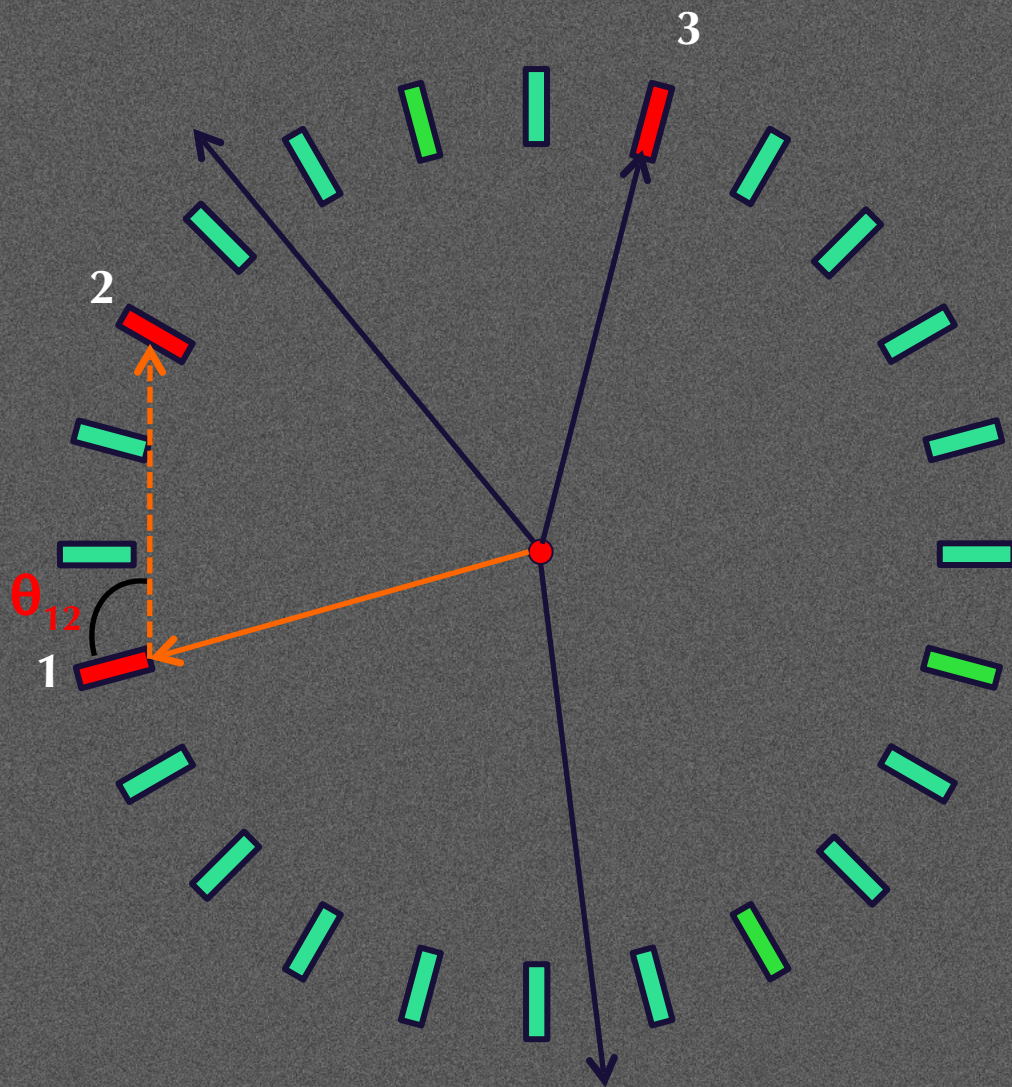
$$S = (time_{scatter} - time_{origin}) - Distance_{scatter-origin} / c$$





Measurement of 1275 keV photon : Scatt. Ang / Edep

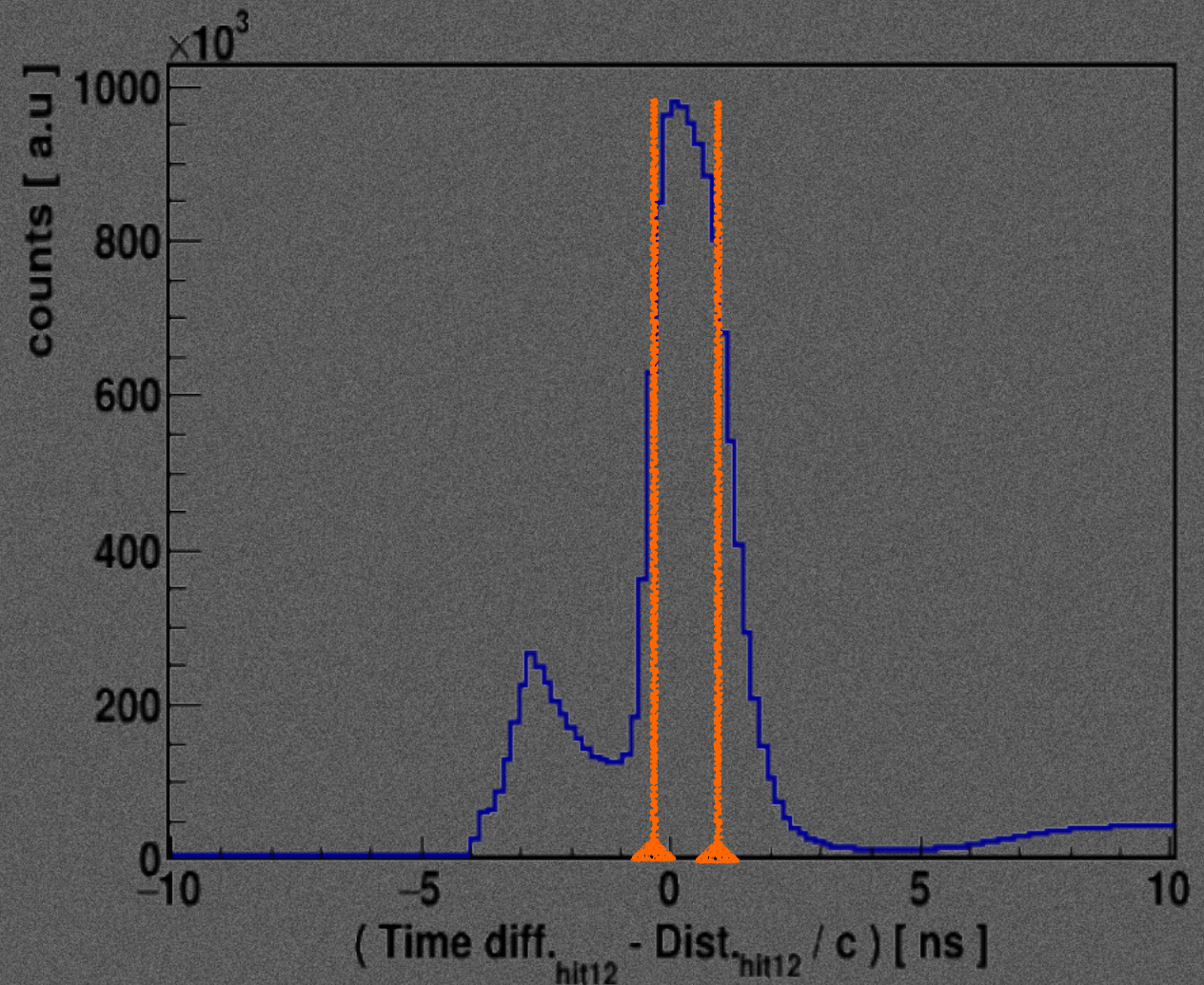
- * 1st Hit is prompt gamma
- * 2nd Hit from the scattering of prompt gamma



3rd hit is assumed as one of the annihilation gamma from oPs decay as the time difference b/w 1st hit and 3rd hit is in-between 10 – 100 ns

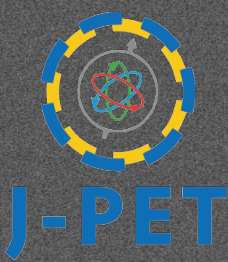
For the assignment of scattered hit to its origin, scatter test(S) was applied:

$$S = (time_{scatter} - time_{origin}) - Distance_{scatter-origin} / c$$

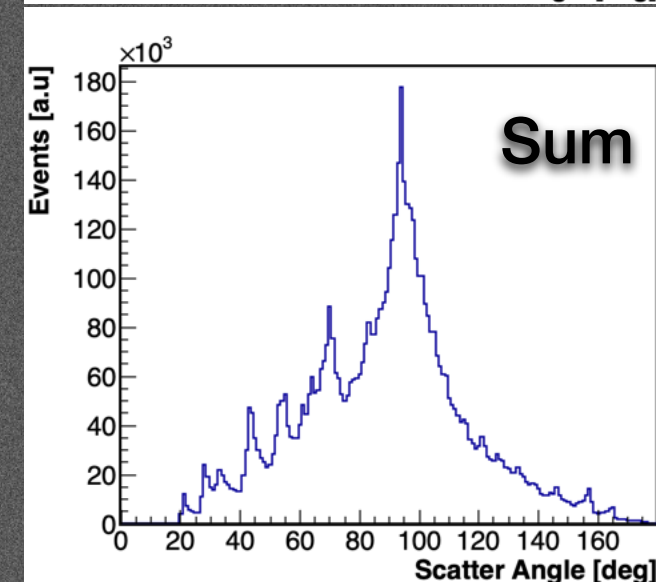
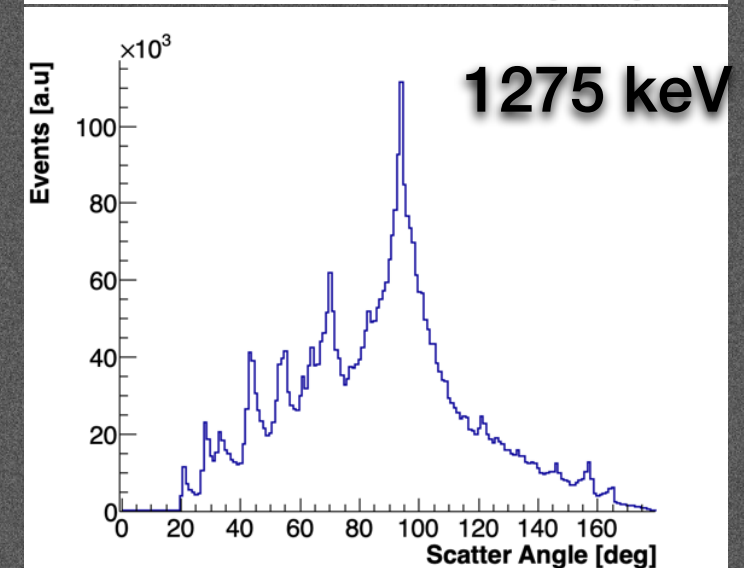
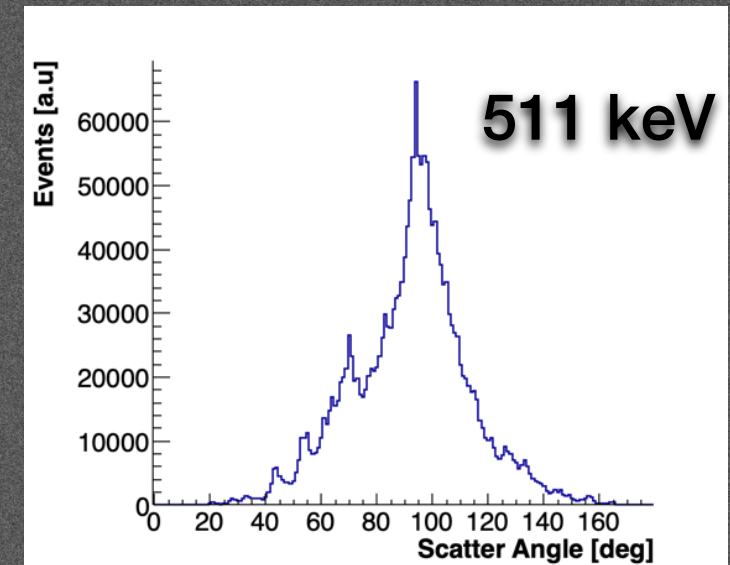




Scattering angles (Experimental)

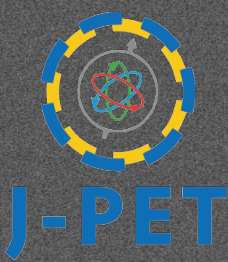


- ✓ **Event-wise** estimated scattering angles of 511 keV and 1275 keV photons.
- ✓ Using developed algorithm to **identify the** Photons (511 or 1275) and measured scattering angles allow to calculate the energy deposition.

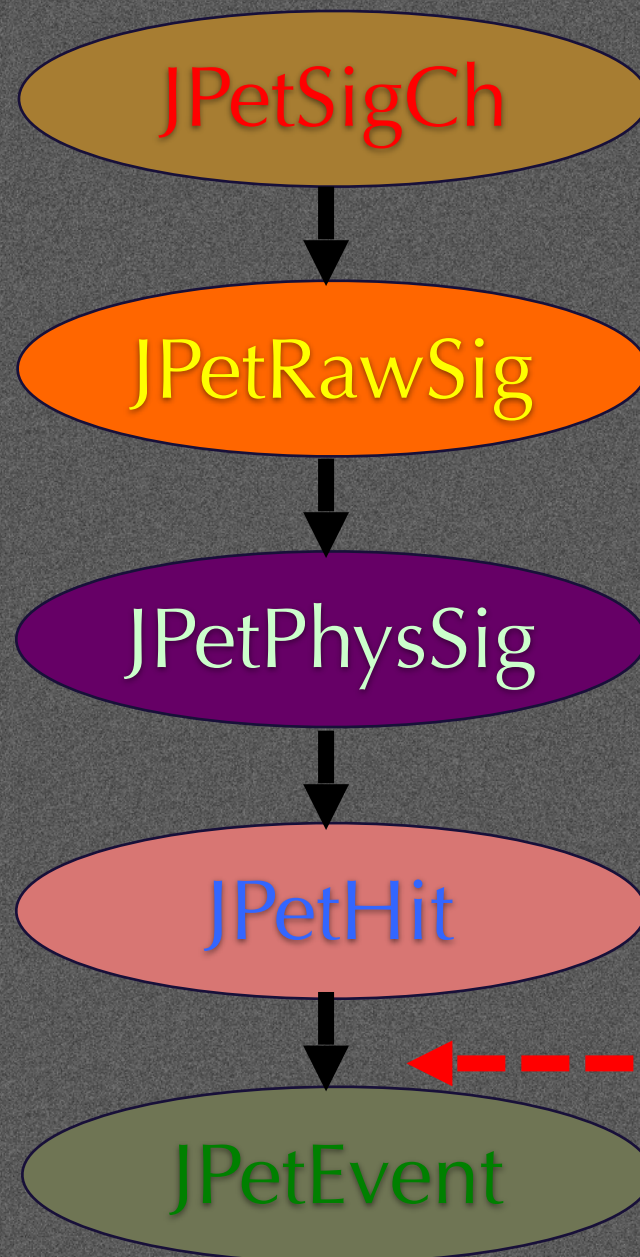




J-PET Analysis Framework : Open-source platform



Data Analysis



JPetTimeWindow

MC simulations

Dedicated simulation package



Source :

Photons beam, Ps decays,...

Relative angles and energy distributions of primary photons

(e.g., decay of Ps into Multi-photons)

Interaction of Gamma quanta : (**Comp. Scatt**)

hit – position , hit time, Scattering angle

Multiple-scattering

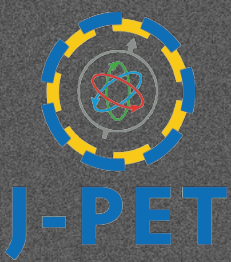
Geant4 –Parsar (empowered to introduce experimental resolution)

Bonus

Adjusted to utilize the multiple-threading feature

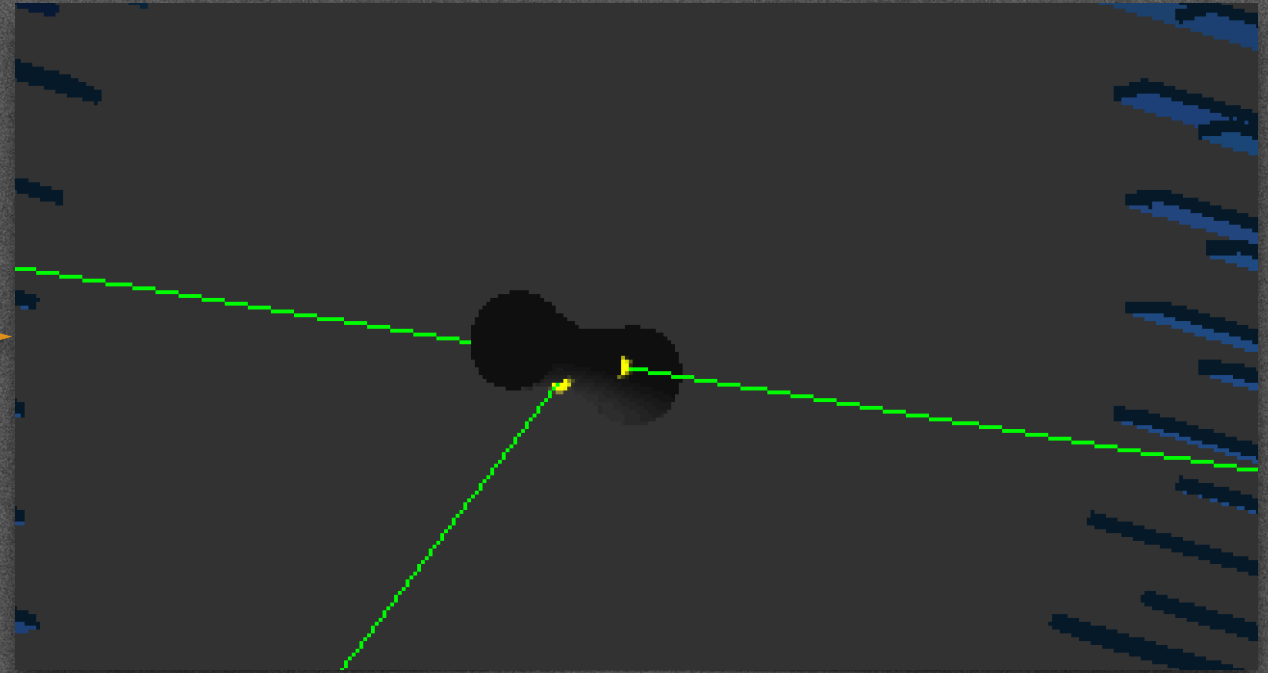
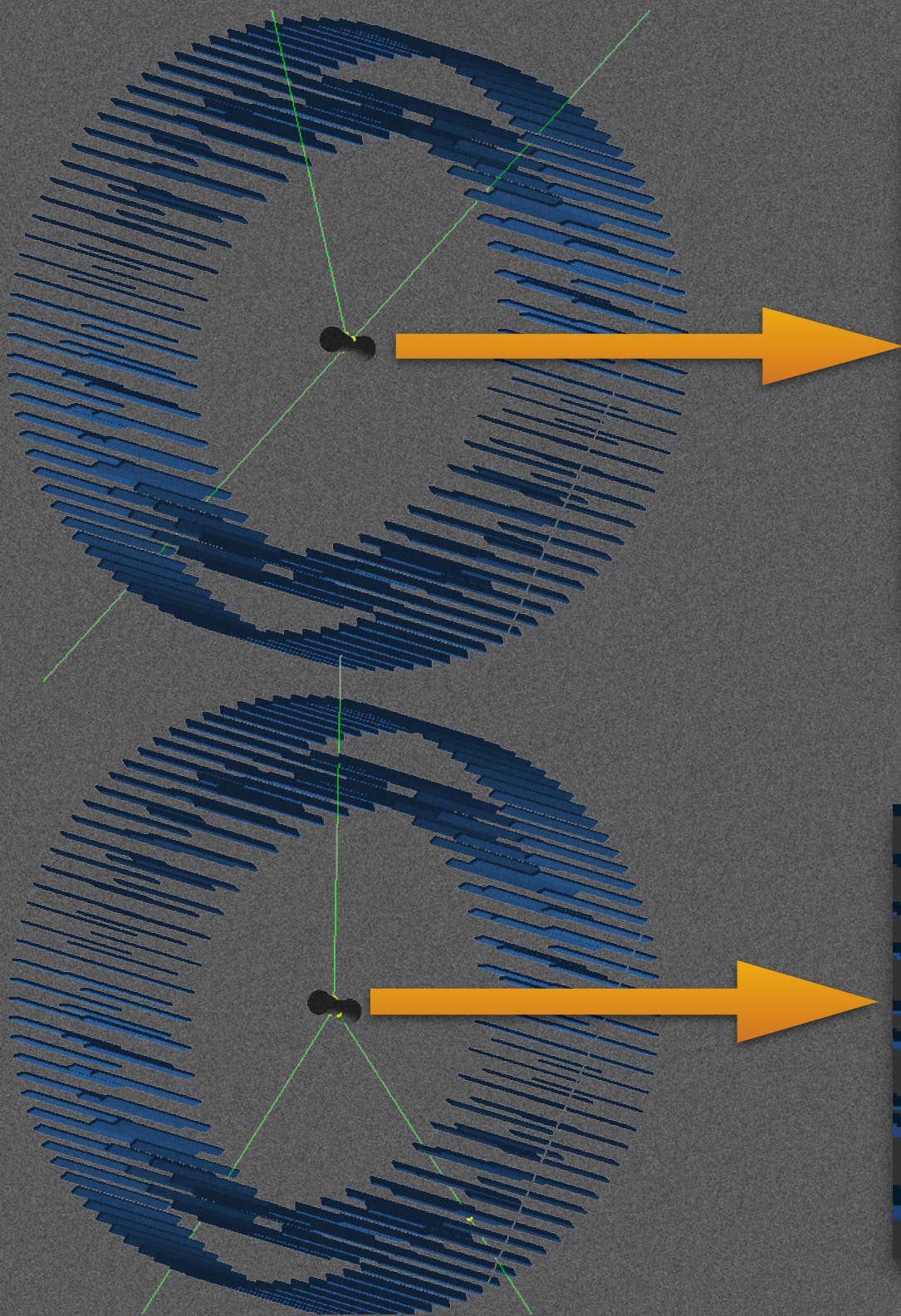


MC simulation : JPET - MC toolkit

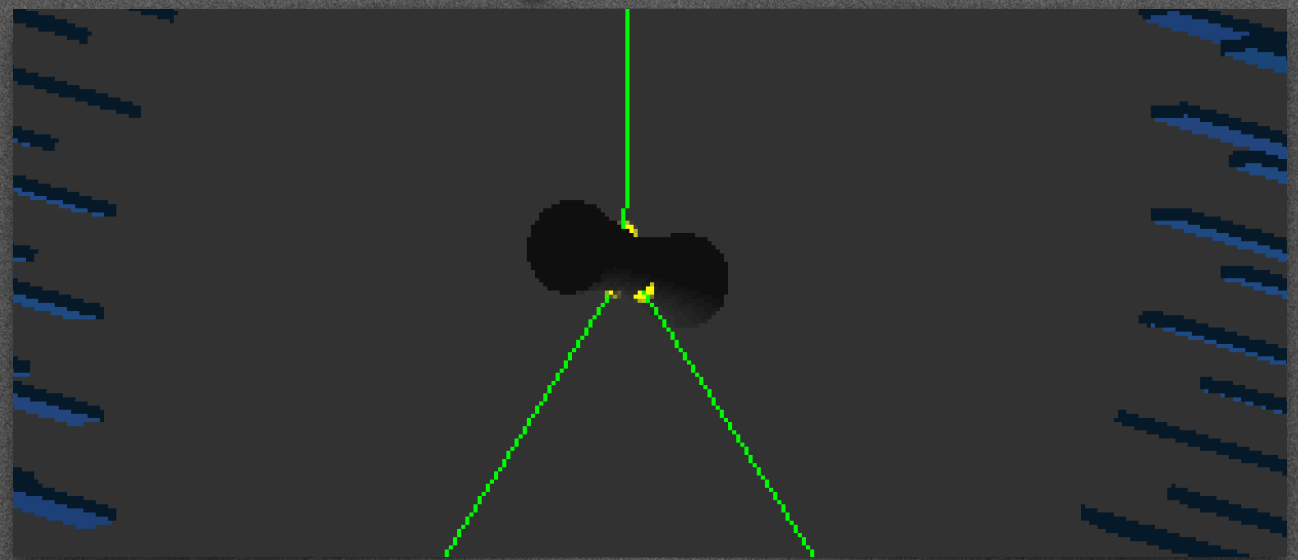


Simulated geometry: 3 hits event

(2 annihilation + 1 prompt)

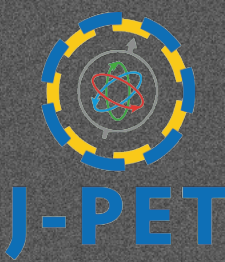


Scattering within chamber

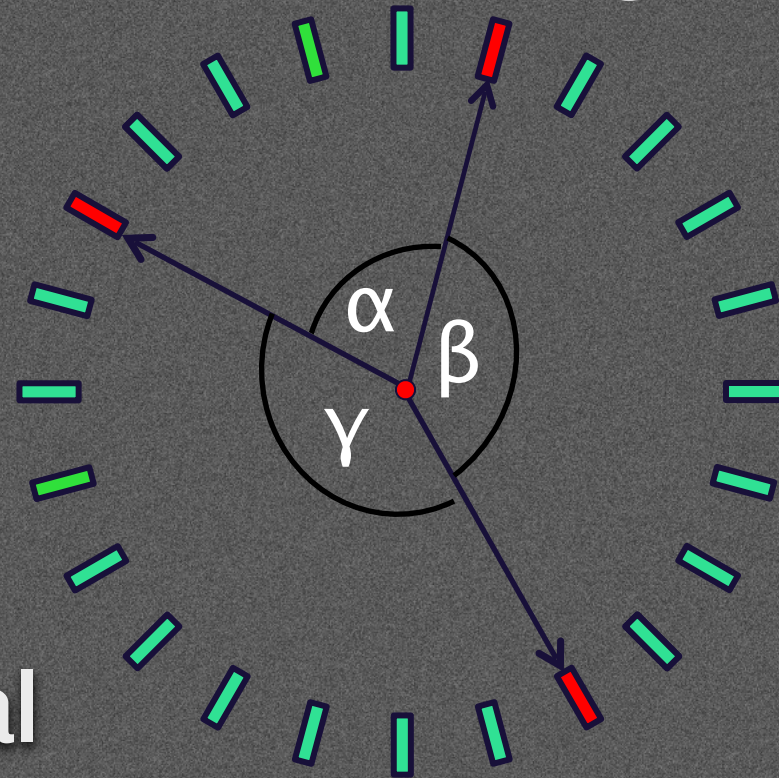




Angular correlation between 3 - Hits / photons

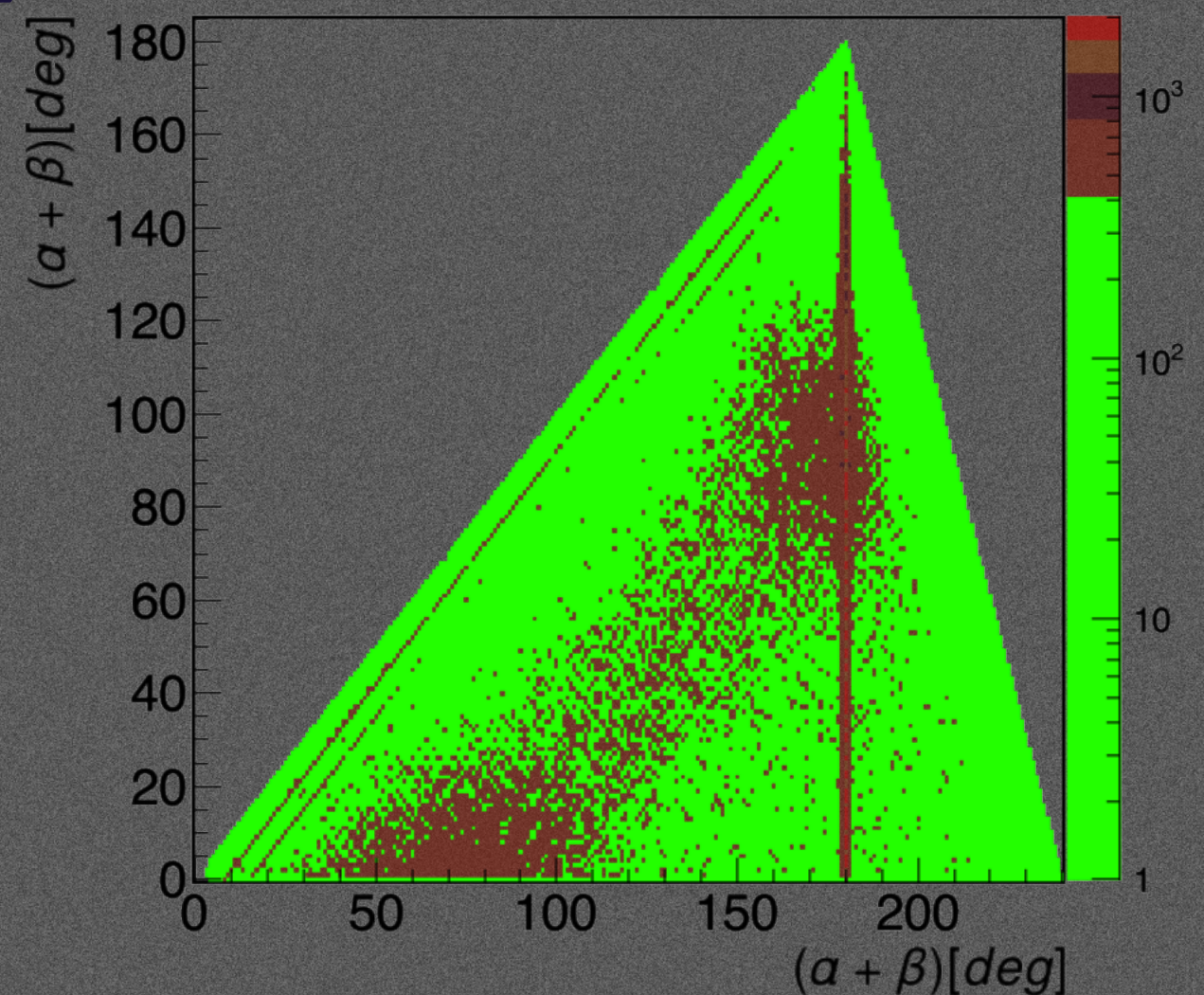
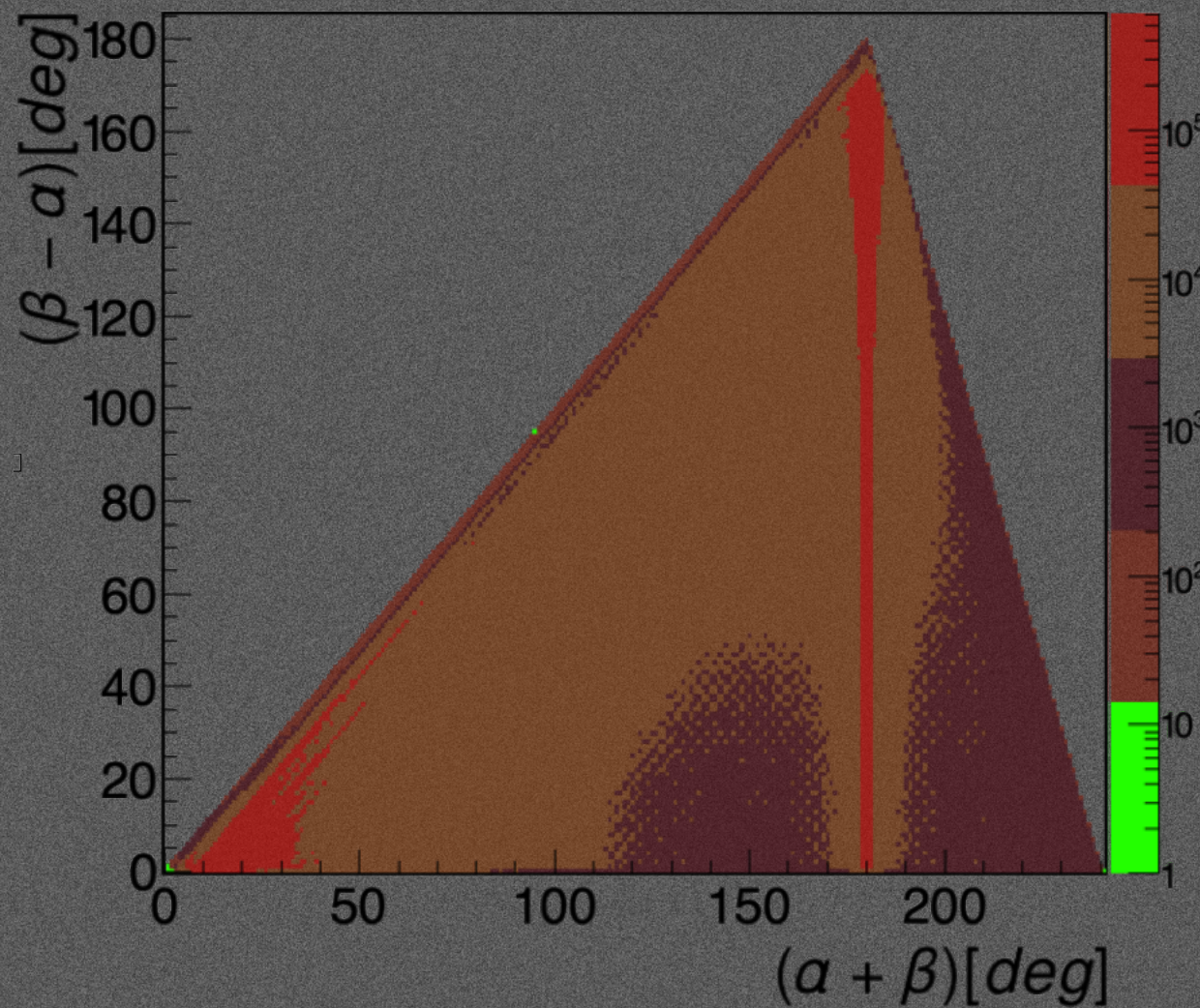


$$\alpha < \beta < \gamma$$



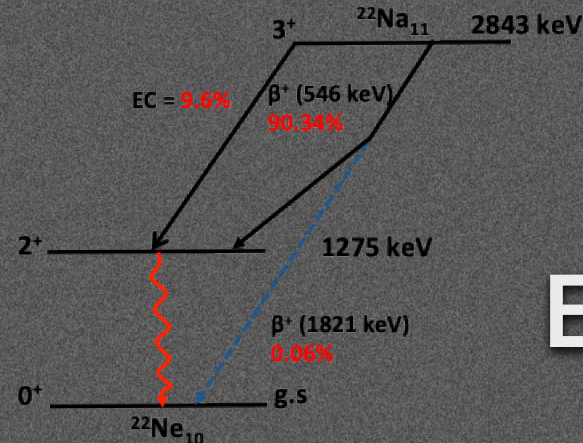
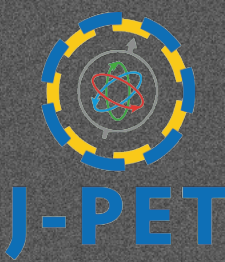
Experimental

Simulation





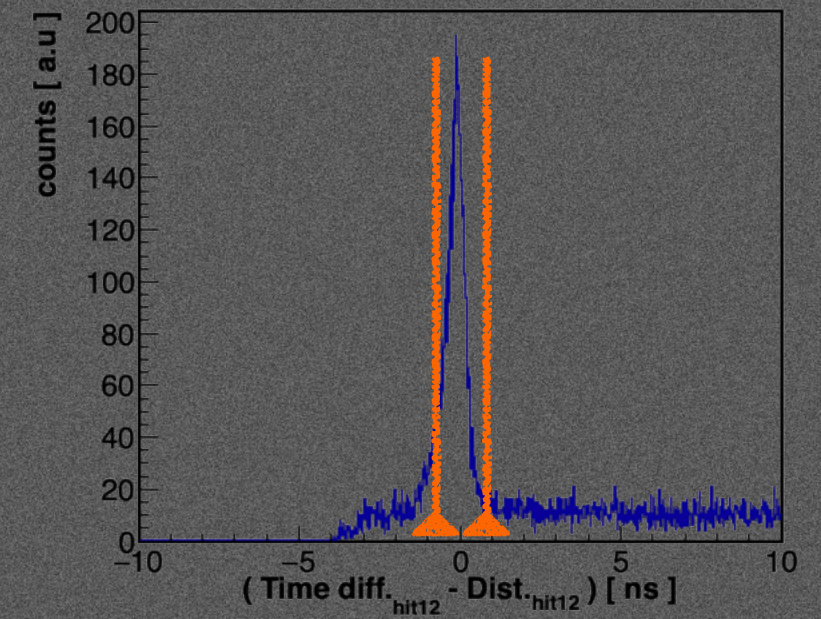
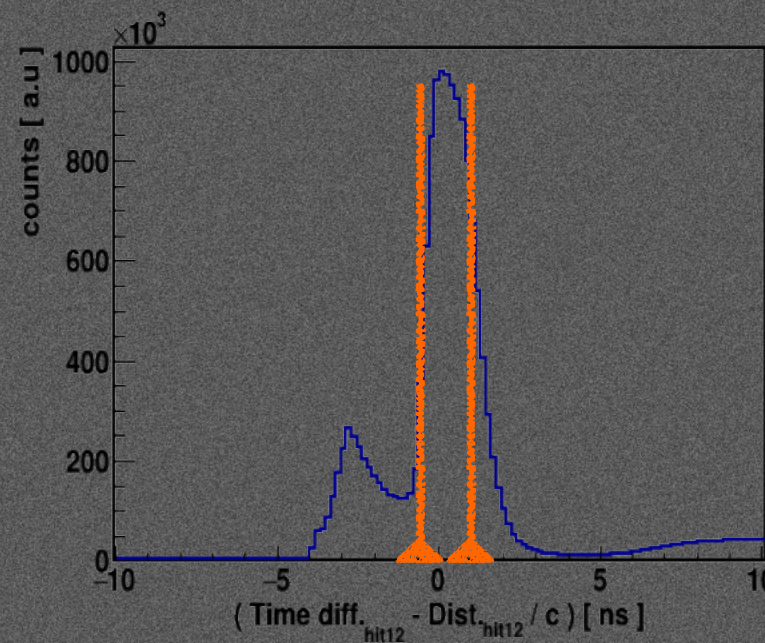
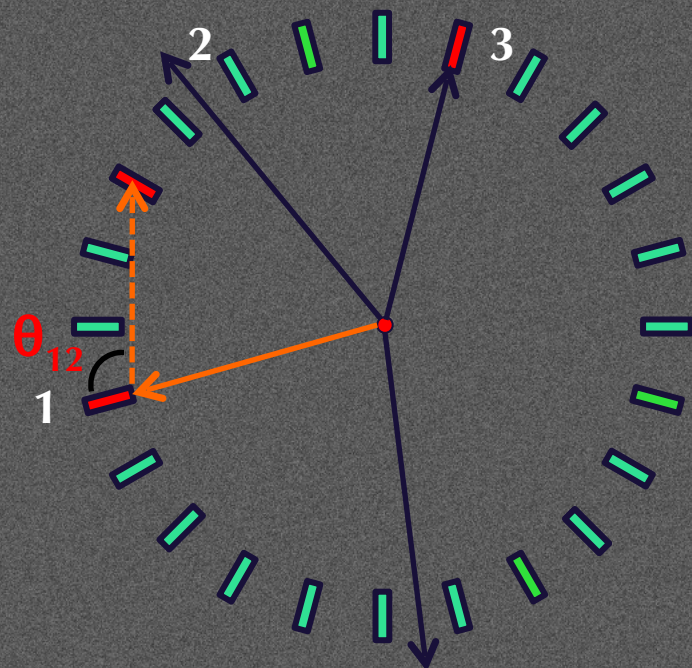
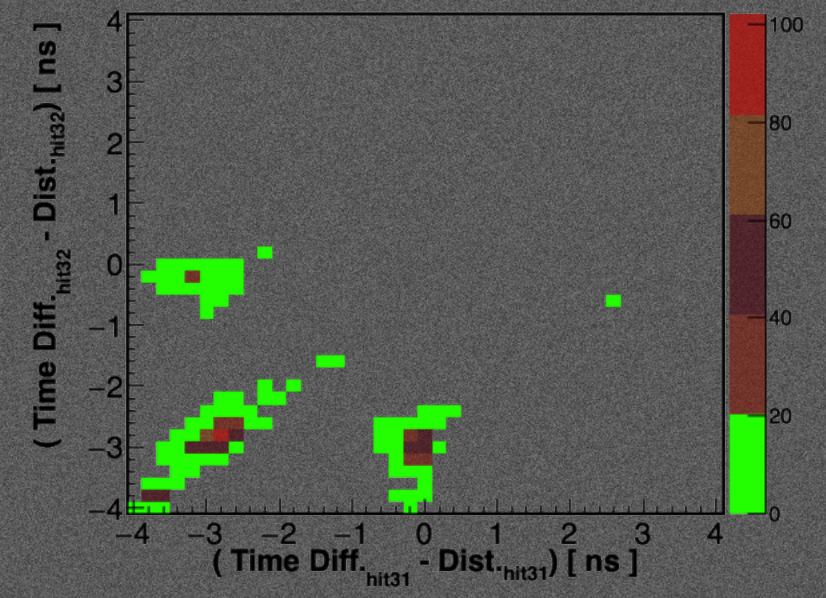
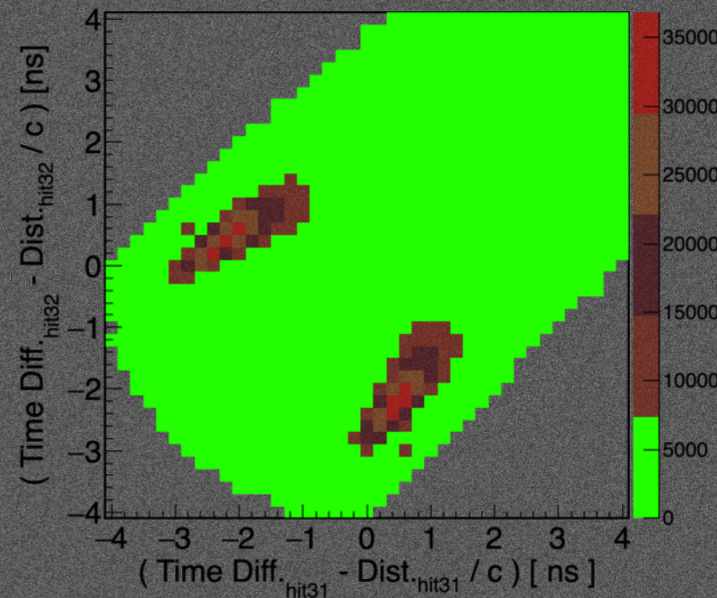
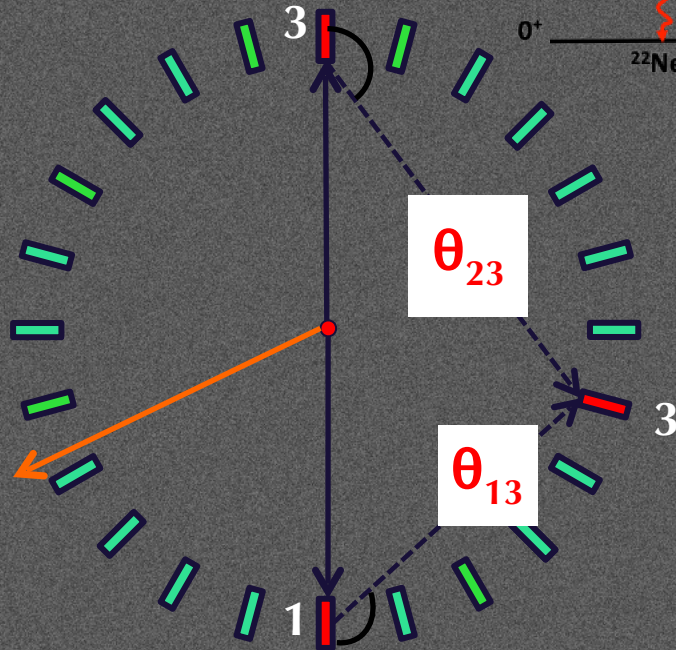
Scattering angles (511 keV and 1275)



$$S = (time_{scatter} - time_{origin}) - Distance_{scatter-origin} / c$$

Experimental

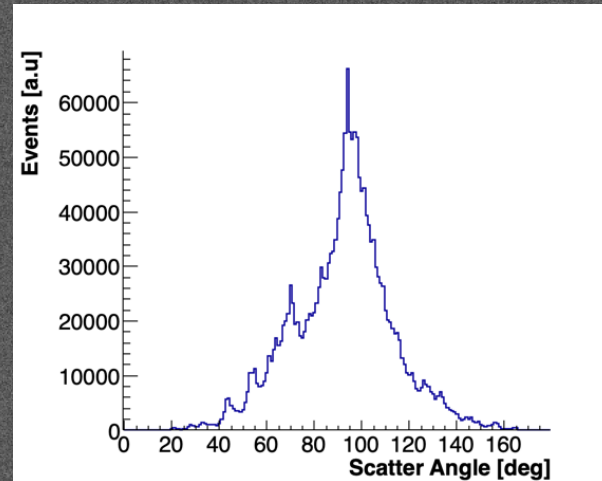
Simulations





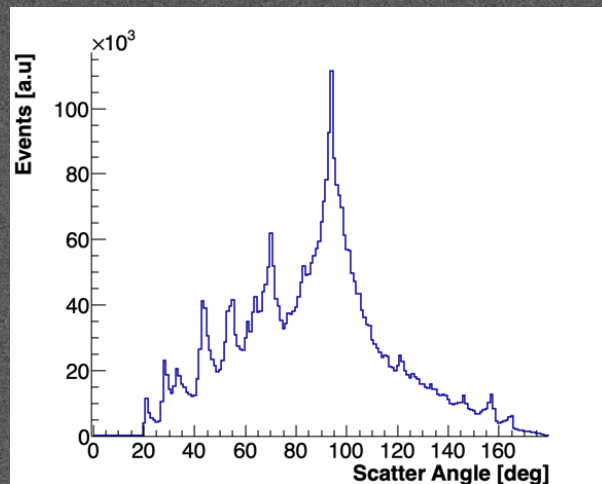
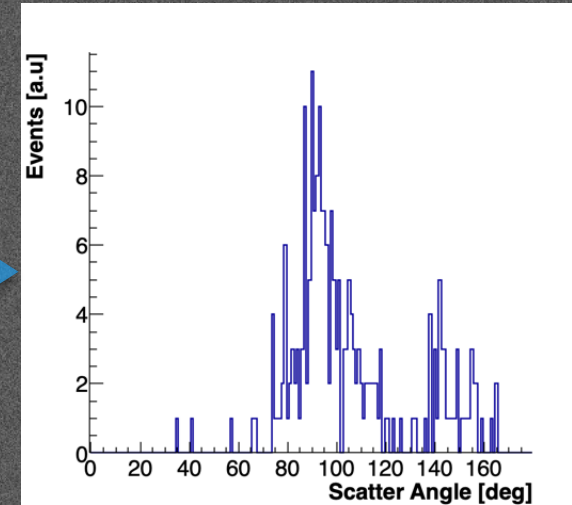
Data vs MC (Scattering angles)

Experimental

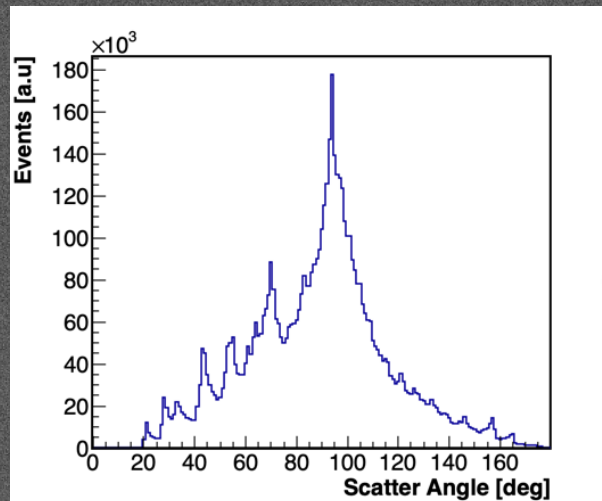
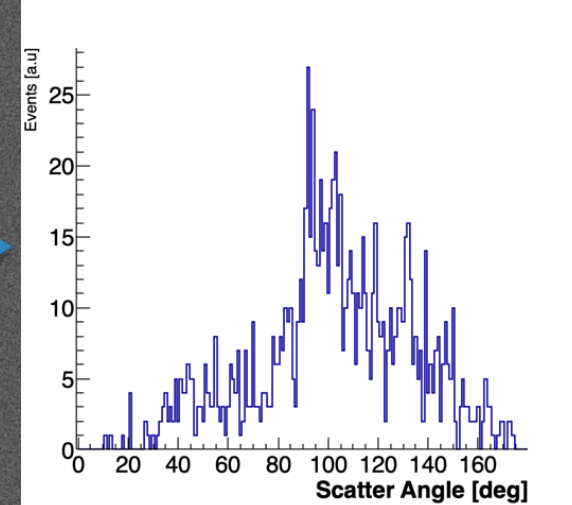


511 keV

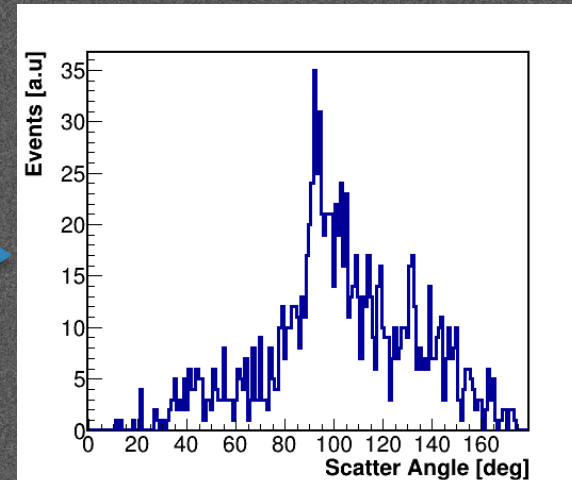
Simulation



1275 keV

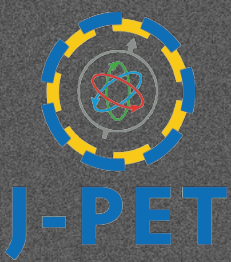


Sum



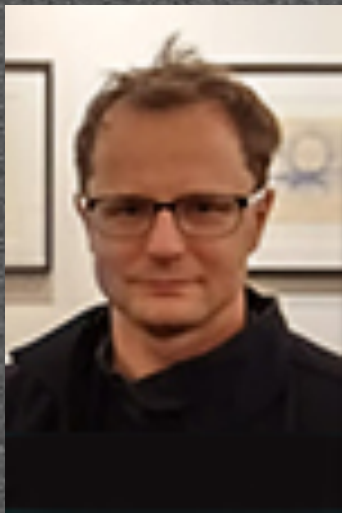


Summary and Future plans

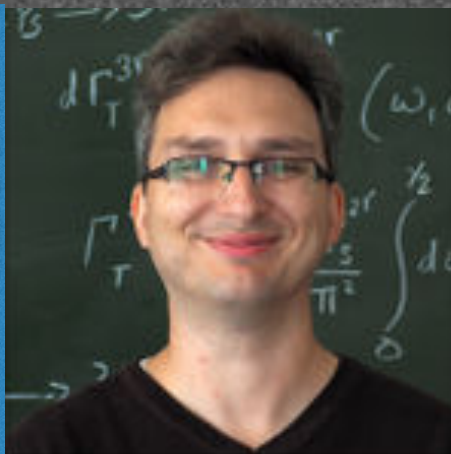


- ☑ The algorithm is developed to tag the photons of different energies emitting from different origins
- ☑ Scattering angles are measured for photons of two different energies : **511 keV** and **1275 keV**
- ☑ Tagged photons with known incident energies and their scattering information allow to estimate the energy deposition in event-wise manner
- ☑ Measured (experimental) and estimated (simulation) energy deposition allow to calculate the relative efficiency ϵ (energy deposition)
- 📌 More statistics (MC) and thorough investigations are needed.....
(Work in Progress)

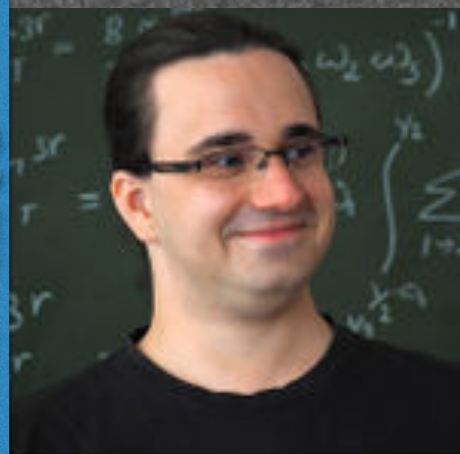
Thank you for your attention



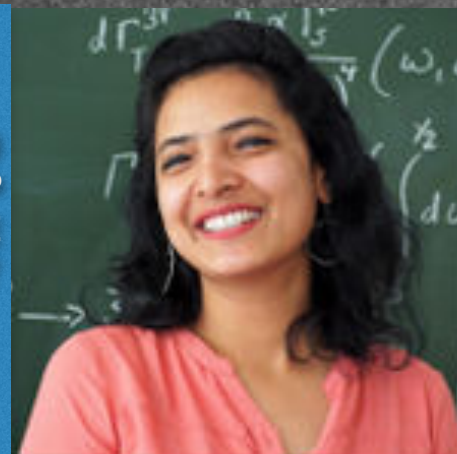
J PET



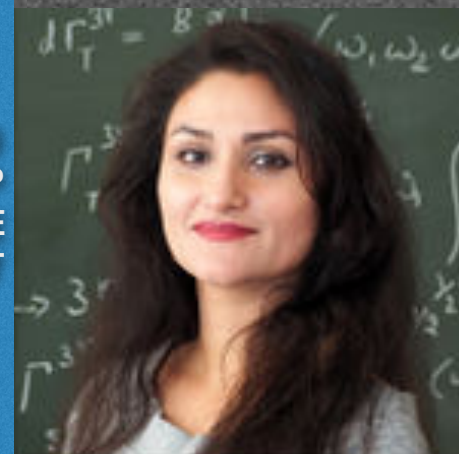
J PET



J PET



J PET



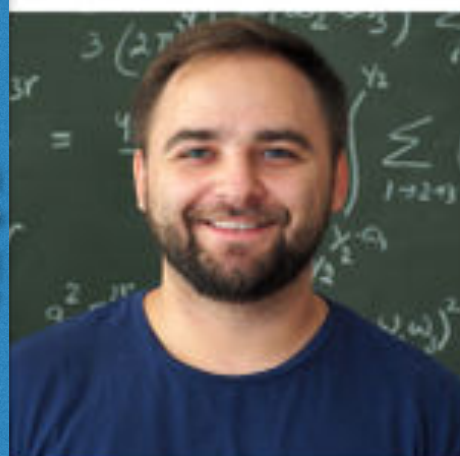
J PET



J PET



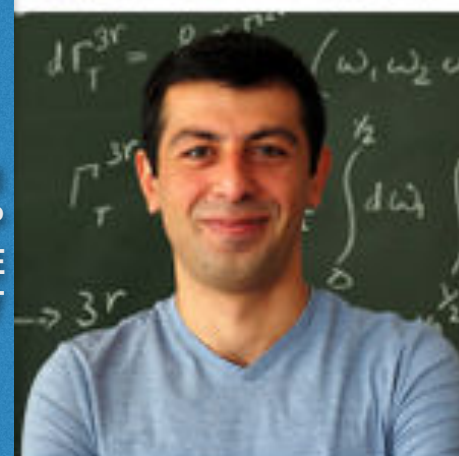
J PET



J PET



J PET



J PET



J PET



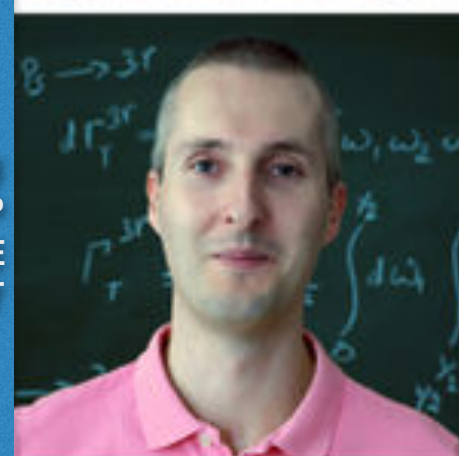
J PET



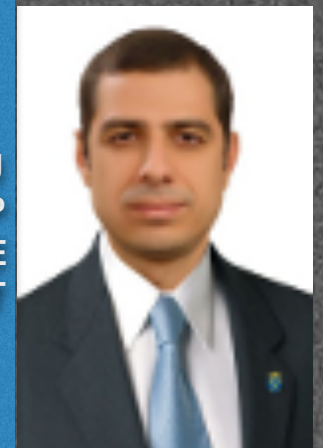
J PET



J PET



J PET



J PET



J PET



J PET



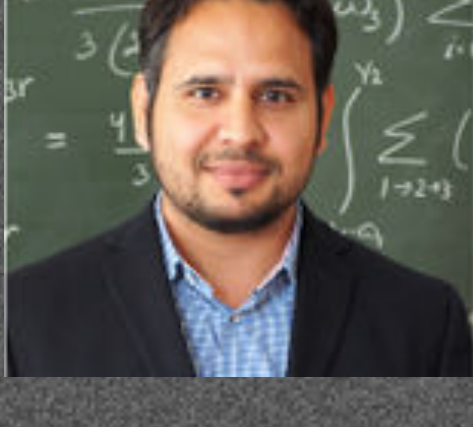
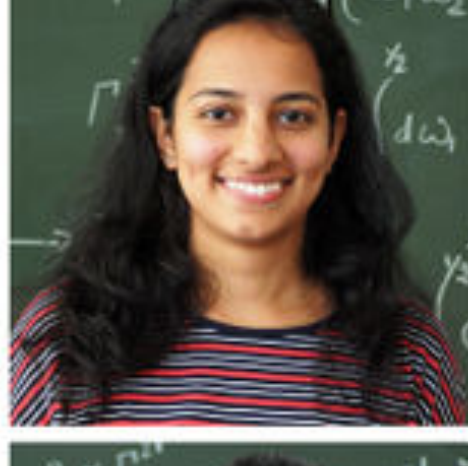
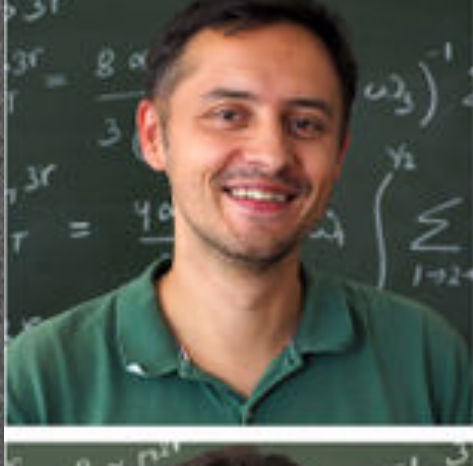
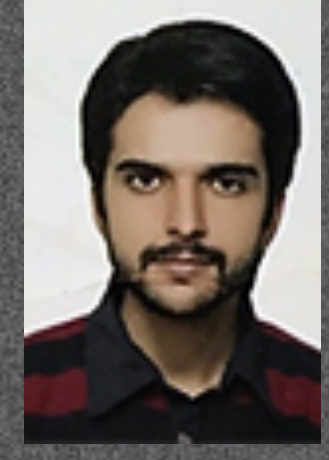
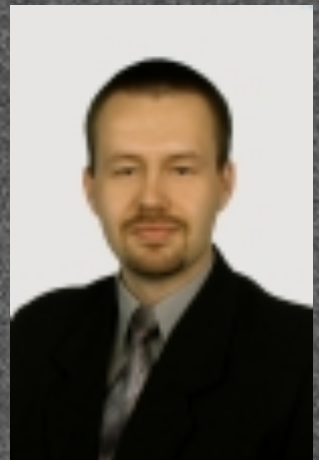
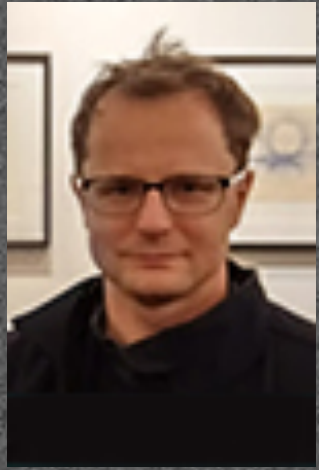
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