



CUSP Geant4 Toy Model n.1

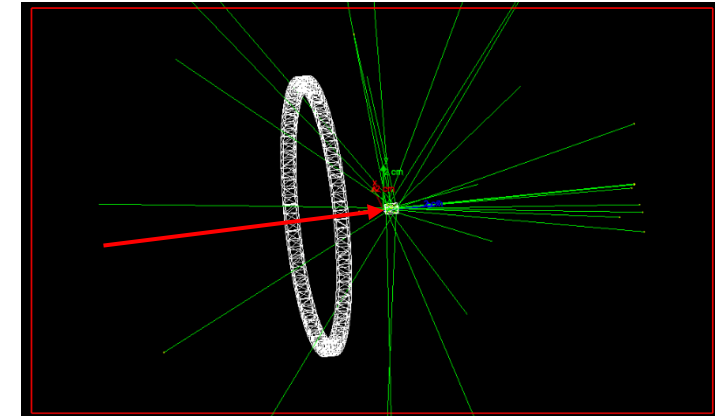
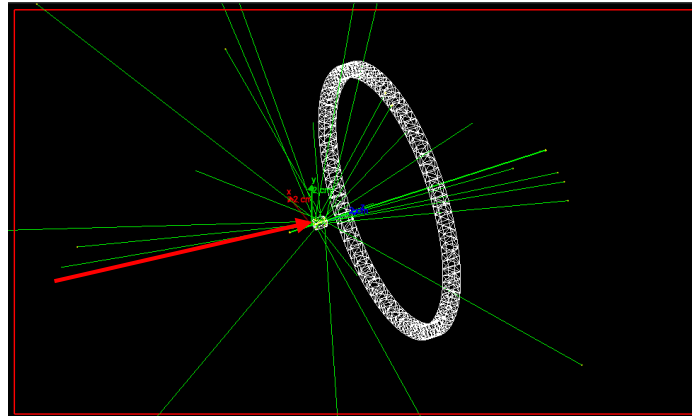
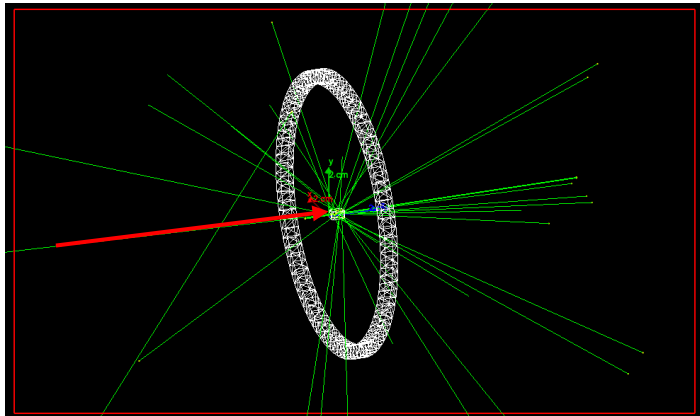
Sergio Fabiani

INAF-IAPS



Three toy model set-ups

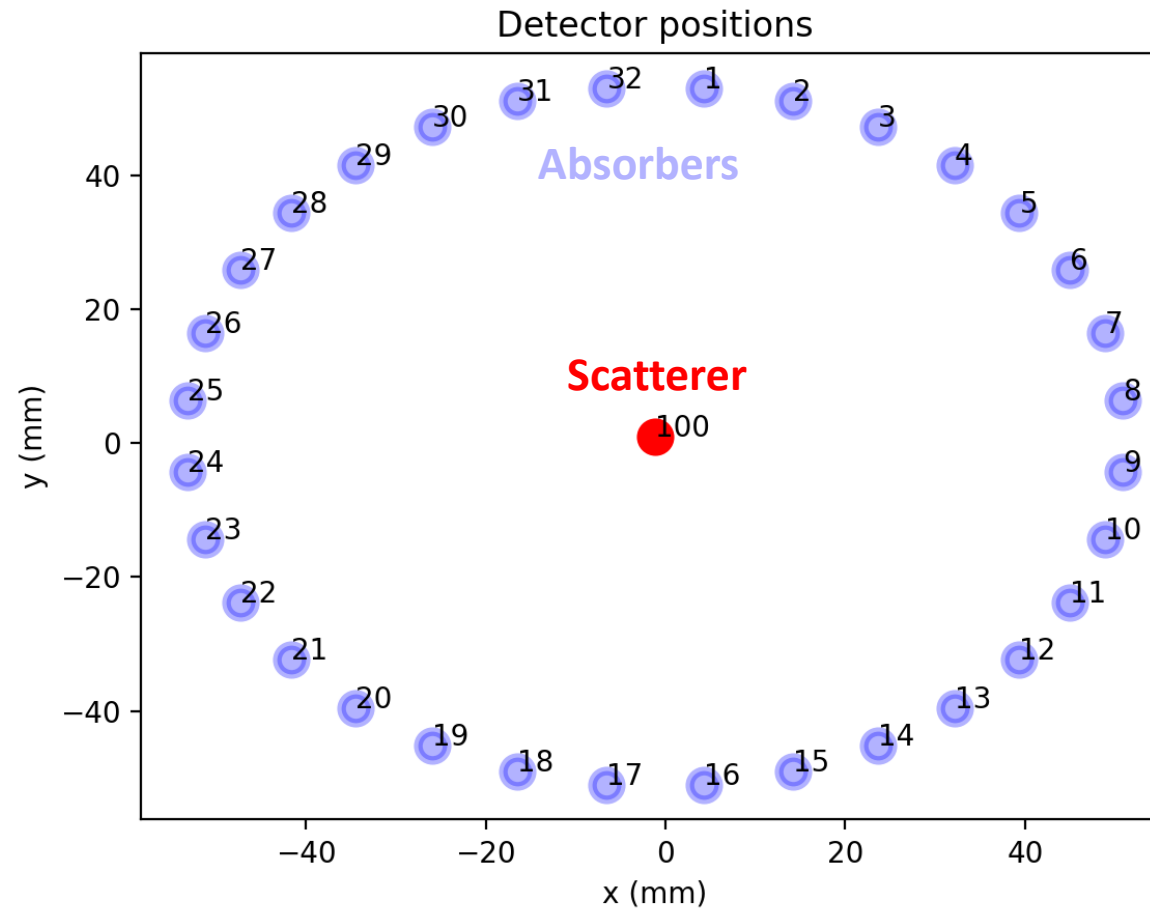
- **Scatterer:** cube 5 mm of side made of G4_PLASTIC_SC_VINYLTOLUENE (C and H)
- **Absorber:** ring with squared size 5 mm of side made of GAGG. Internal radius 50mm, external radius 55mm.
- v1
- 90° scattering
- v2
- forward scattering
- V3
- backward scattering



		centered	forward	backward
Energy (keV)		v1	v2	v3
20	tot evts	174097	174680	174420
	coinc	3185	3669	3853
60	tot evts	87896	87986	87965
	coinc	3219	4234	3464

- form factor suppresses the forward scattering
- larger energy more forward scattering

Element positions and label

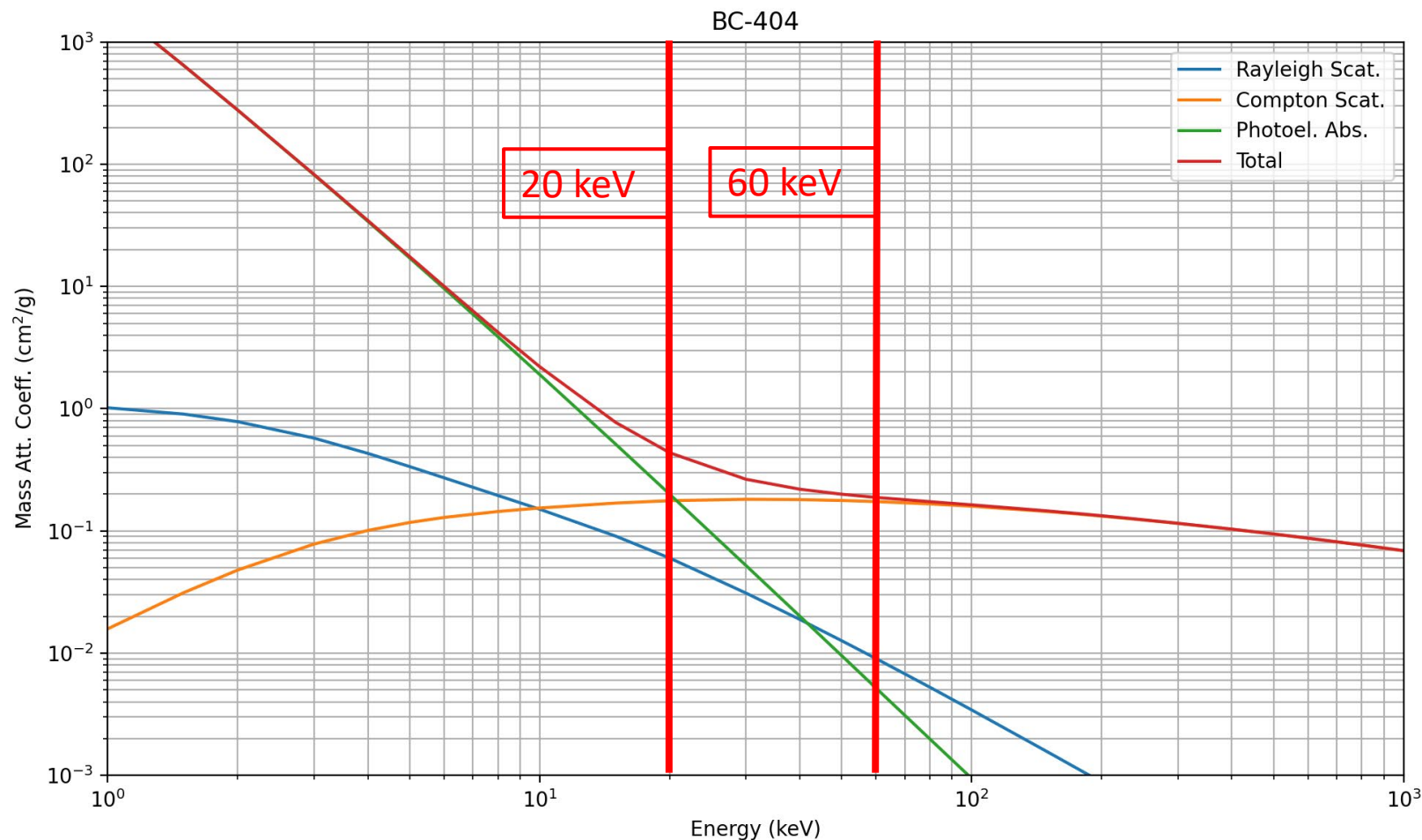


Order of event raws in fits file

- There are some coincidences whose first row (energy deposit listed) is in the absorber, then in the scatterer.
- Genat4 follows the secondaries each one until the end of its particle production, then goes back to follow other secondaries. Depending on which one is the first followed they are listed in the file.
 - This are good Compton scattering events: recoil electron energy deposition in the scatterer and photoelectric absorption in the absorber
- This example is v1 (90°), 20 keV incoming photon:
 - Coincidences scatterer → absorber are 607
 - Coincidences absorber → scatterer are 2578

	EventID	En_dep	Scint_ID	X_Primary	Y_Primary	Z_Primary	Theta_Primary	Phi_Primary	En_Primary	X_Detected	Y_Detected	Z_Detected
637	3617	19.212857	29	-0.090311	0.093011	-1.0	180.0	0.0	20.0	-34.492999	41.538246	2.838767
638	3619	1.374935	100	-0.098145	0.101620	-1.0	180.0	0.0	20.0	-1.158308	0.995162	2.838767

Cross sections



@ 20 keV:

- Compton ~ Photoelectric

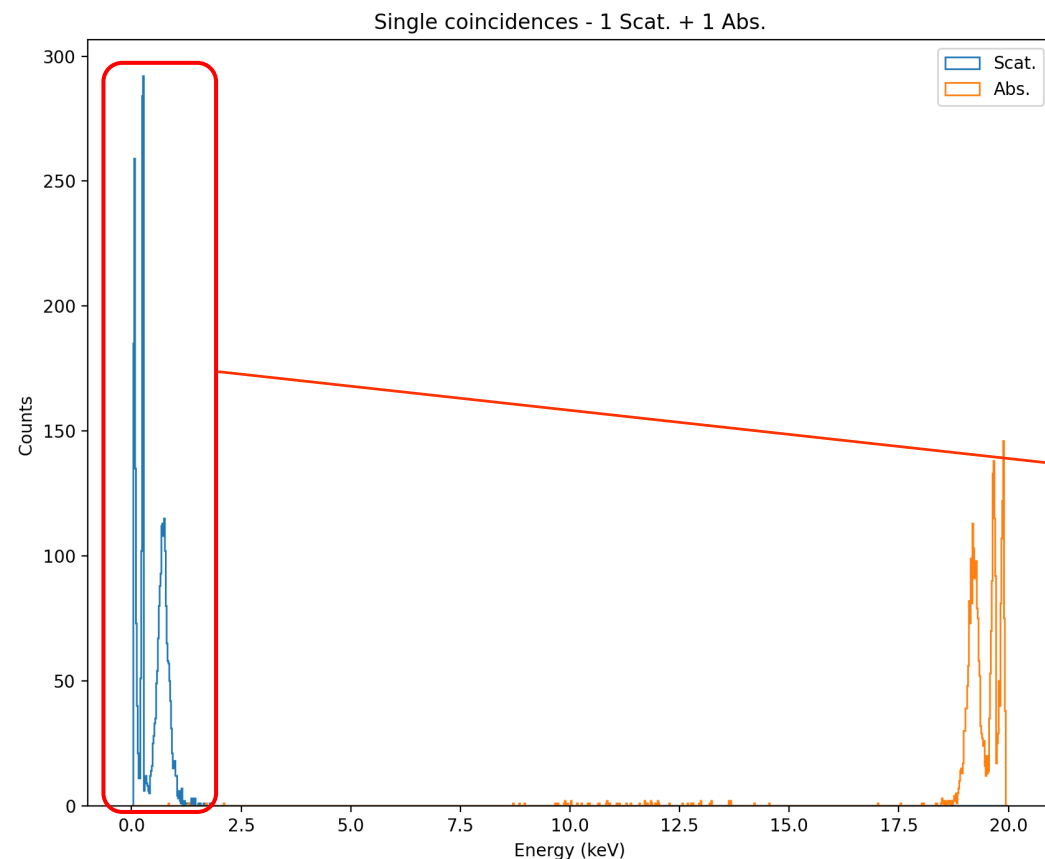
@ 60 keV:

- Compton ~ elastic x 11¹

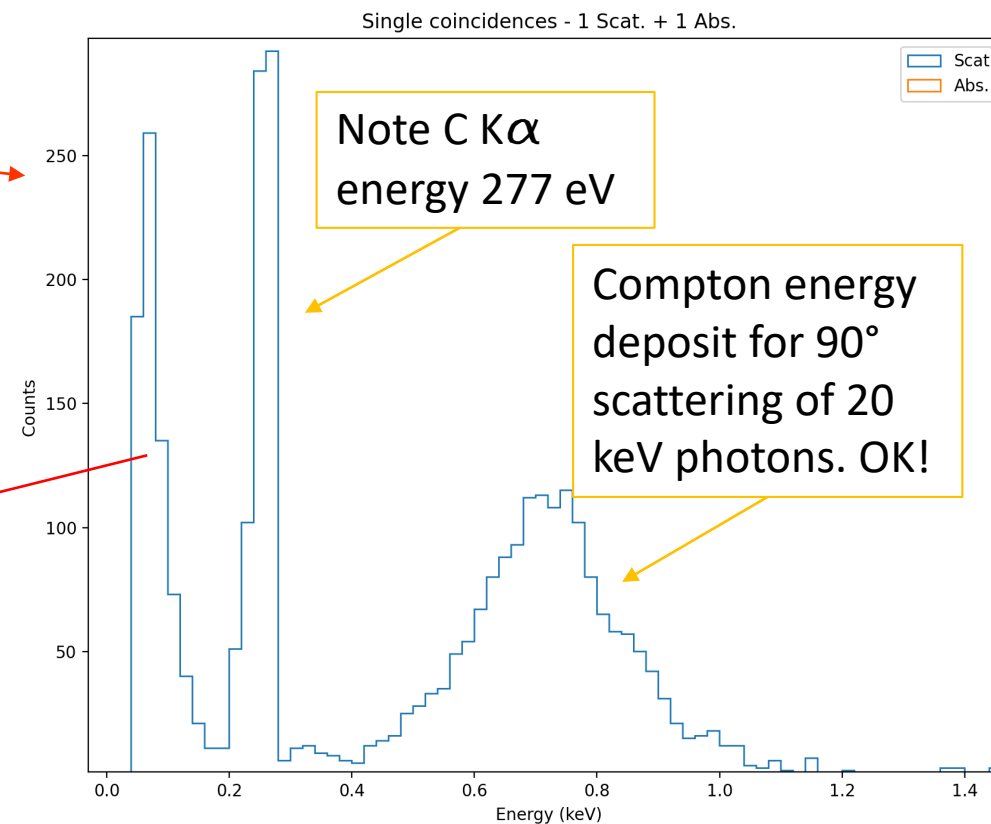
- Compton ~ photoel. x 15¹

v1, 90° scattering, 20 keV

- Energy deposits of coincidences scatterer+absorber for incoming photons at 20 keV
- 90° scattering

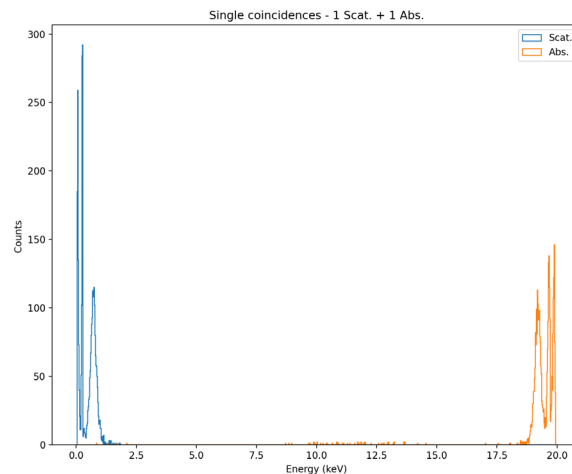
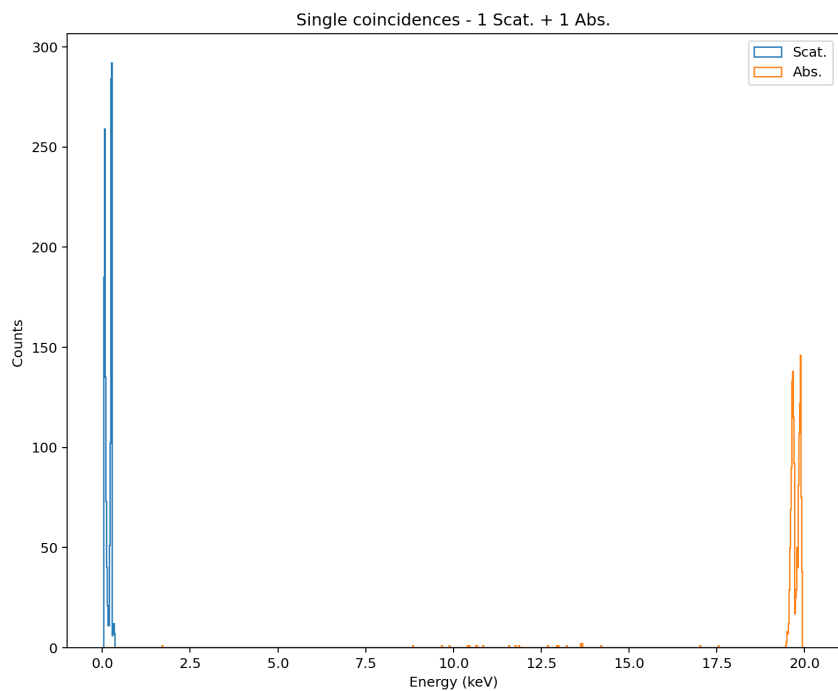


	EventID	En_dep	Scint_ID	X_Primary	Y_Primary	Z_Primary	Theta_Primary	Phi_Primary	En_Primary
61	341	19.831829	14	-0.105797	0.091695	-1.0	180.0	0.0	20.0
62	341	0.069480	100	-0.105797	0.091695	-1.0	180.0	0.0	20.0

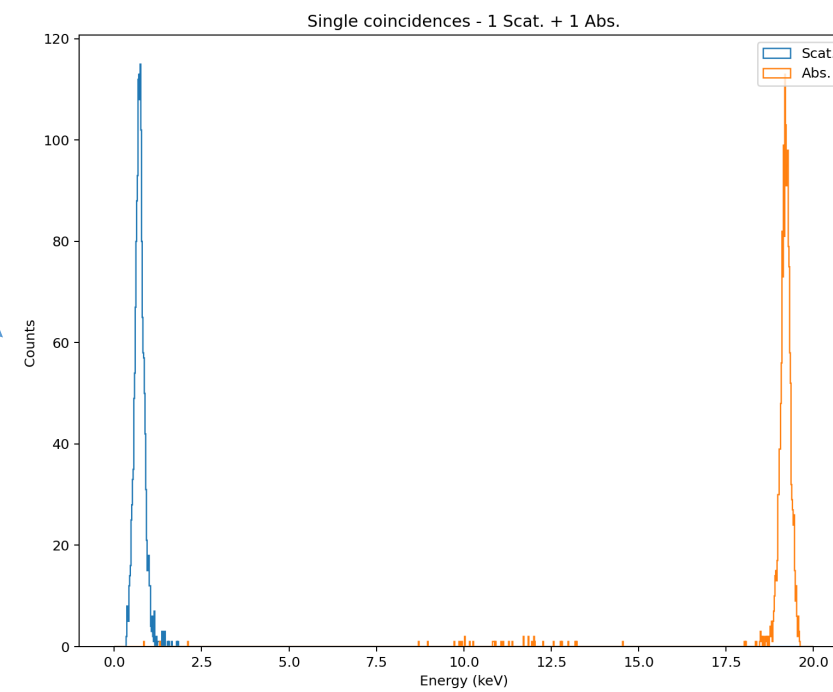


v1, 90° scattering, 20 keV

- Coincidences with energy deposit in scatterer below 0.35 keV
- 1500 events

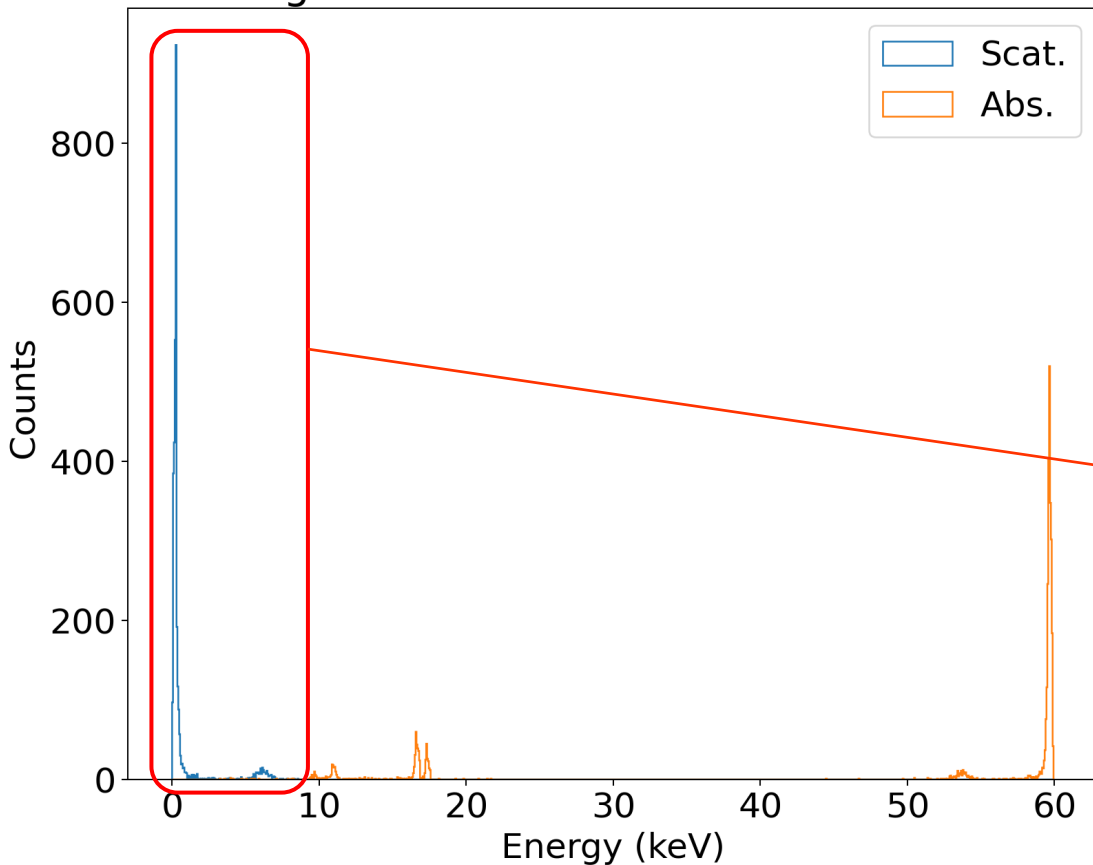


- Coincidences with energy deposit in scatterer above 0.35 keV
- 1685 events



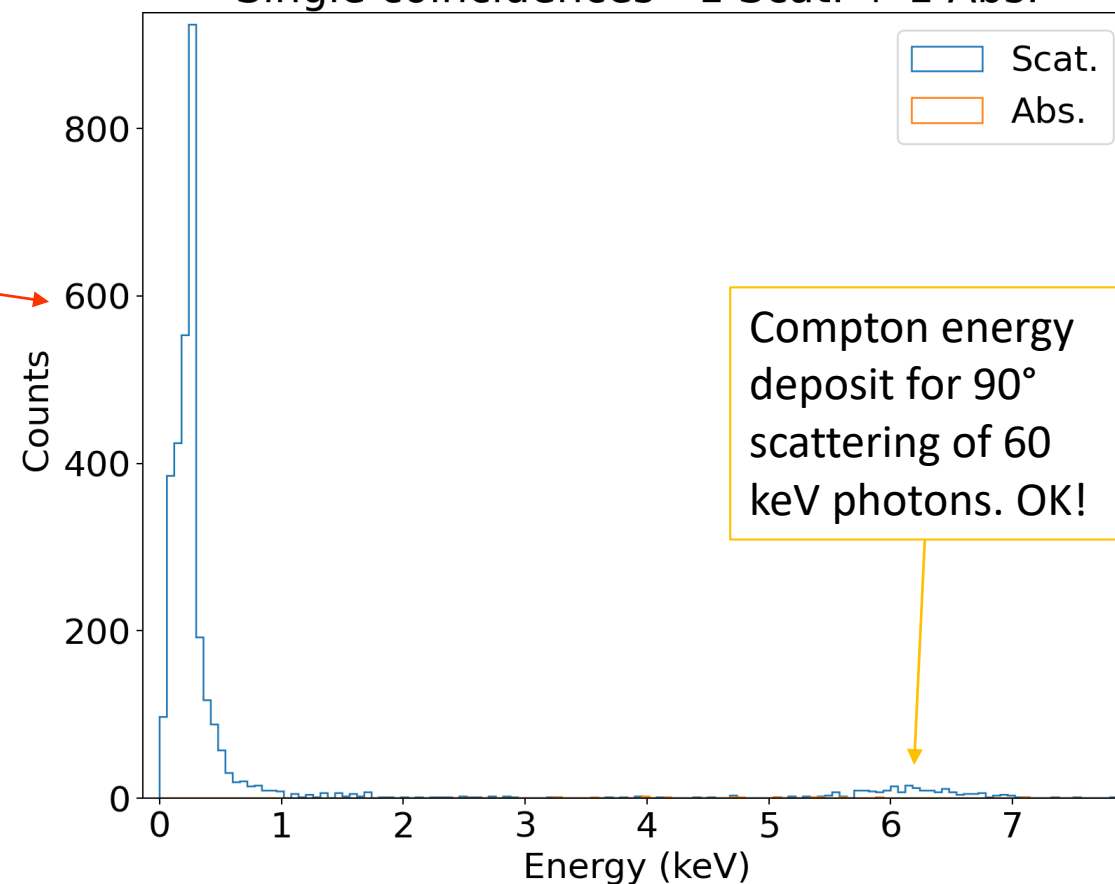
v1, 90° scattering, 60 keV

Single coincidences - 1 Scat. + 1 Abs.



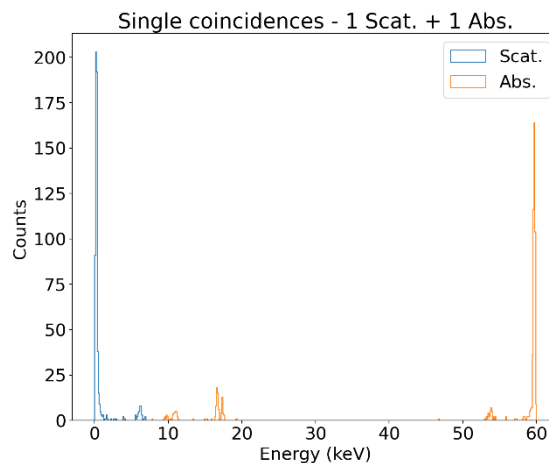
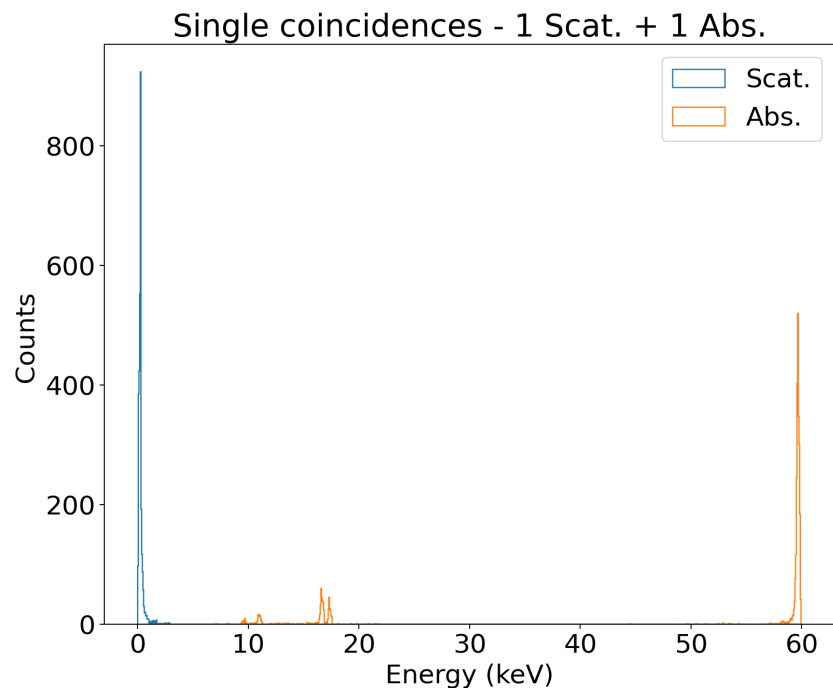
- Energy deposits of coincidences scatterer+absorber for incoming photons at 60 keV
- 90° scattering

Single coincidences - 1 Scat. + 1 Abs.

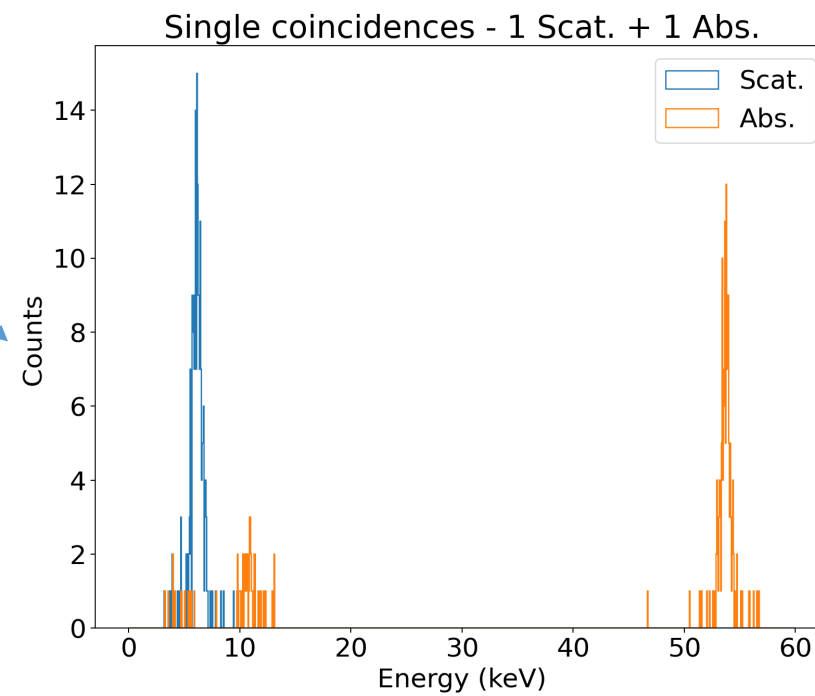


v1, 90° scattering, 60 keV

- Coincidences with energy deposit in scatterer below 3 keV
- 3016 events

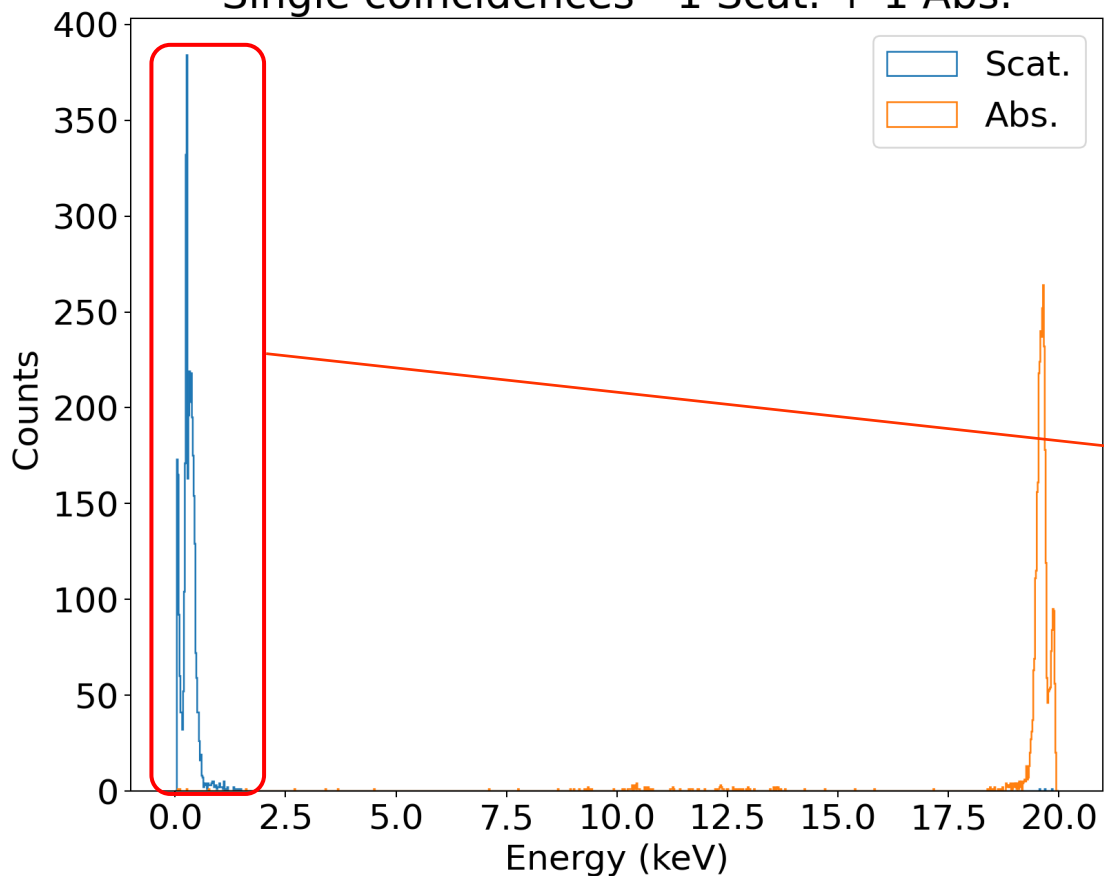


- Coincidences with energy deposit in scatterer above 3 keV
- 203 events



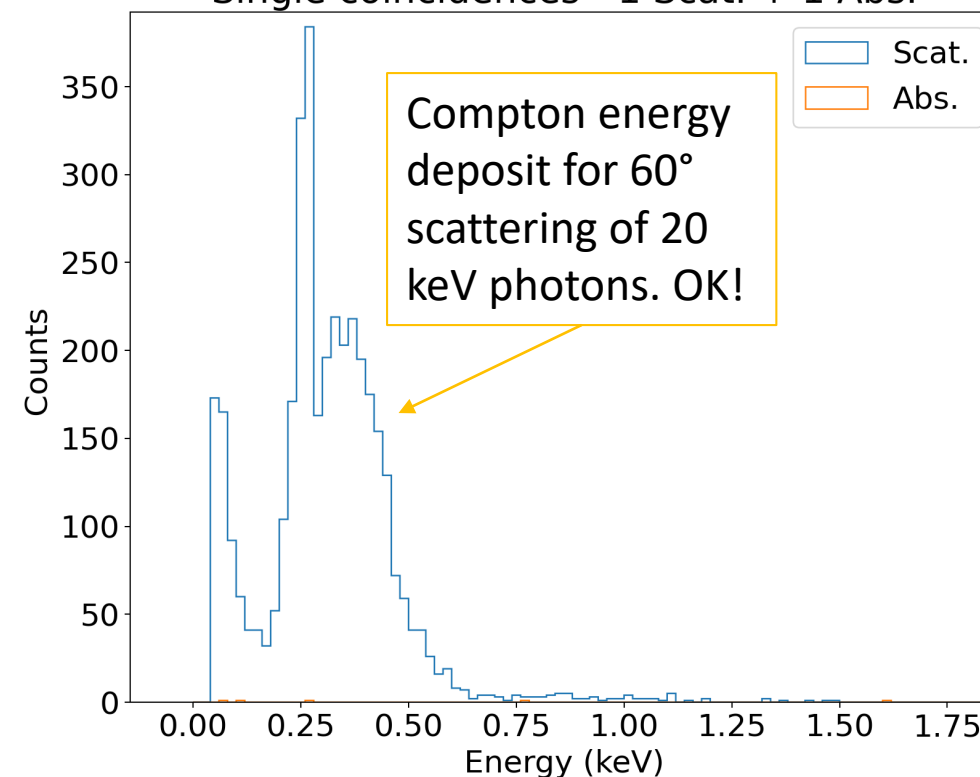
v2, 60° scattering, 20 keV

Single coincidences - 1 Scat. + 1 Abs.



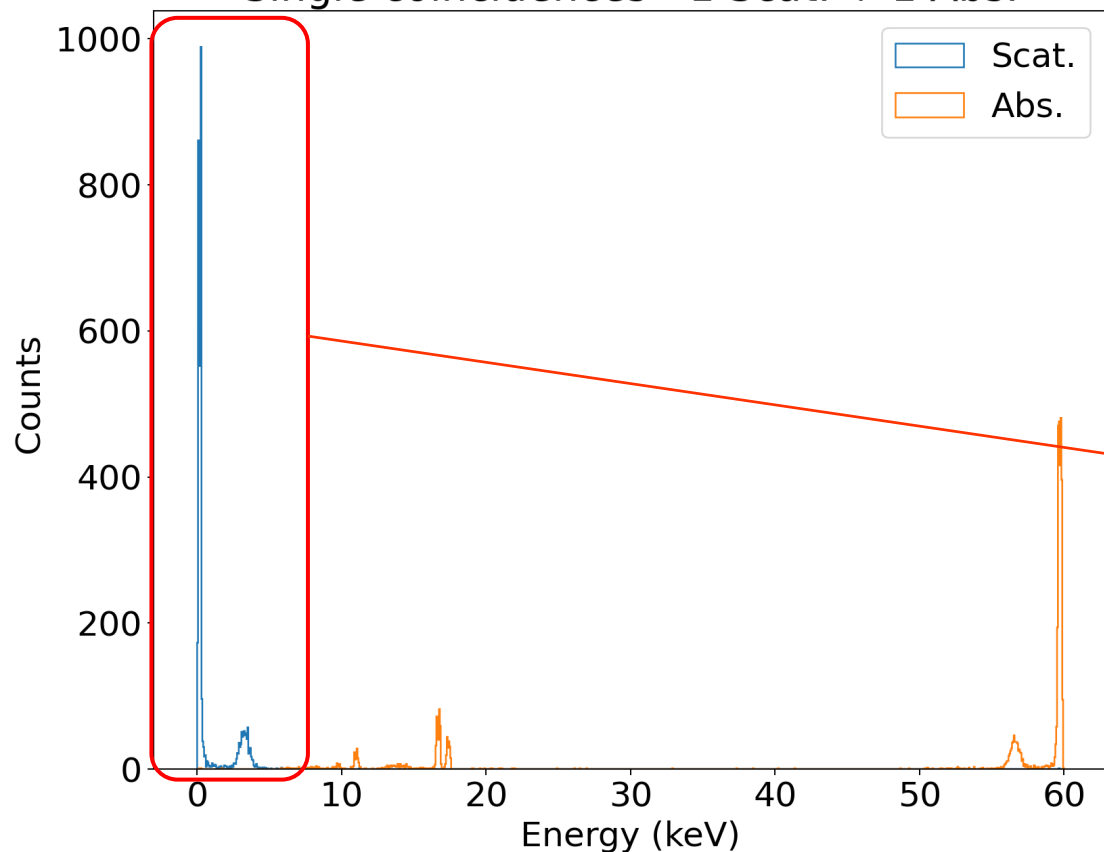
- Energy deposits of coincidences scatterer+absorber for incoming photons at 20 keV
- 60° scattering

Single coincidences - 1 Scat. + 1 Abs.

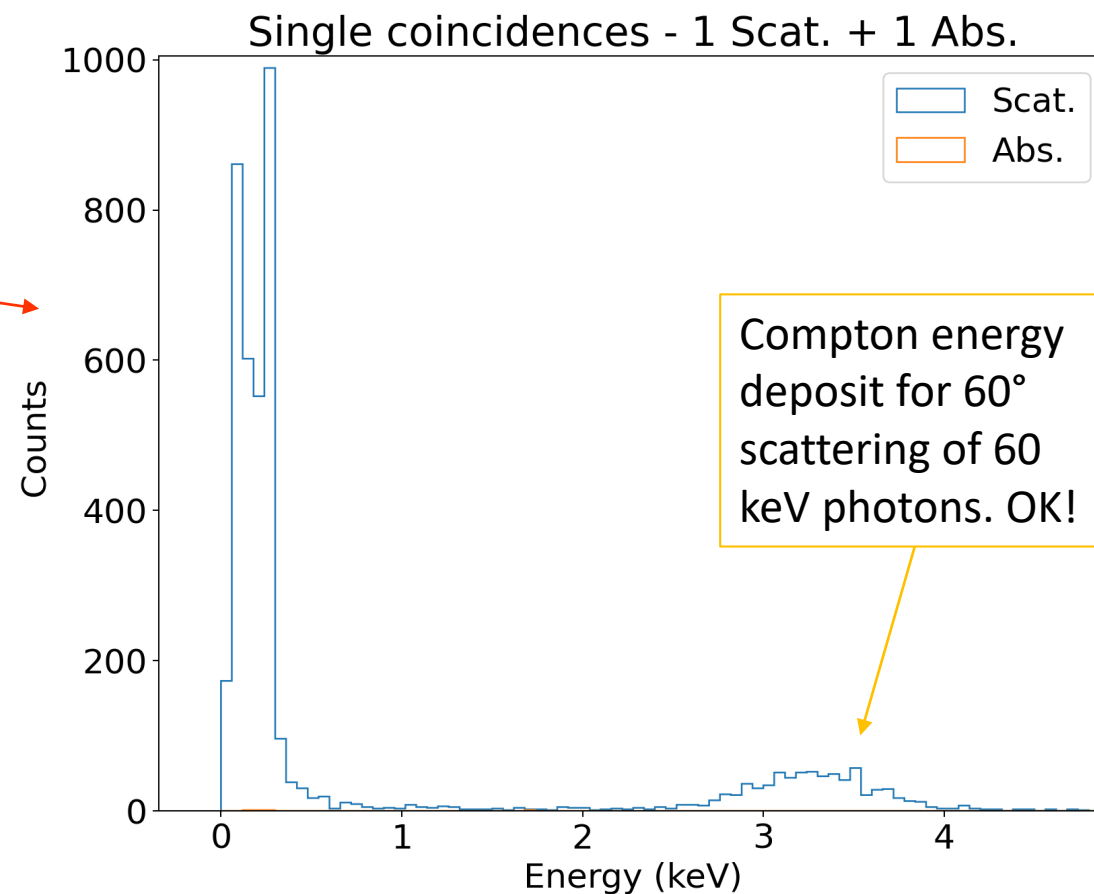


v2, 60° scattering, 60 keV

Single coincidences - 1 Scat. + 1 Abs.

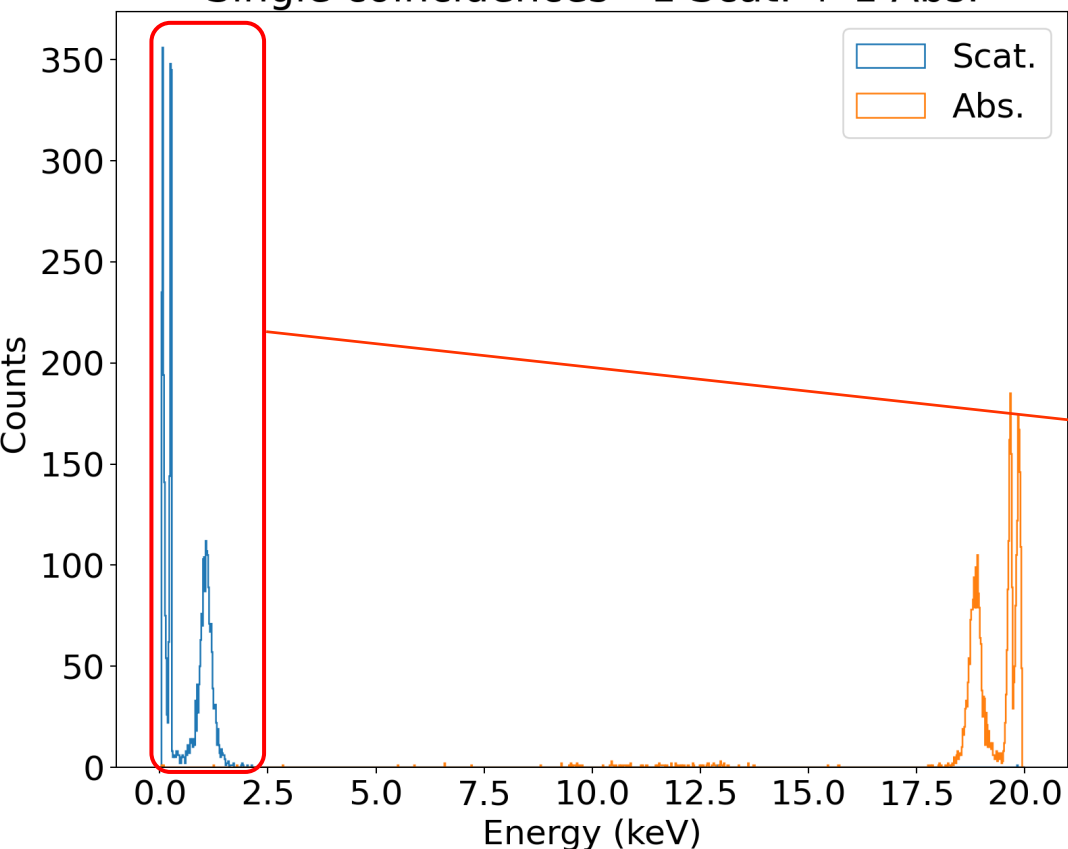


- Energy deposits of coincidences scatterer+absorber for incoming photons at 60 keV
- 90° scattering



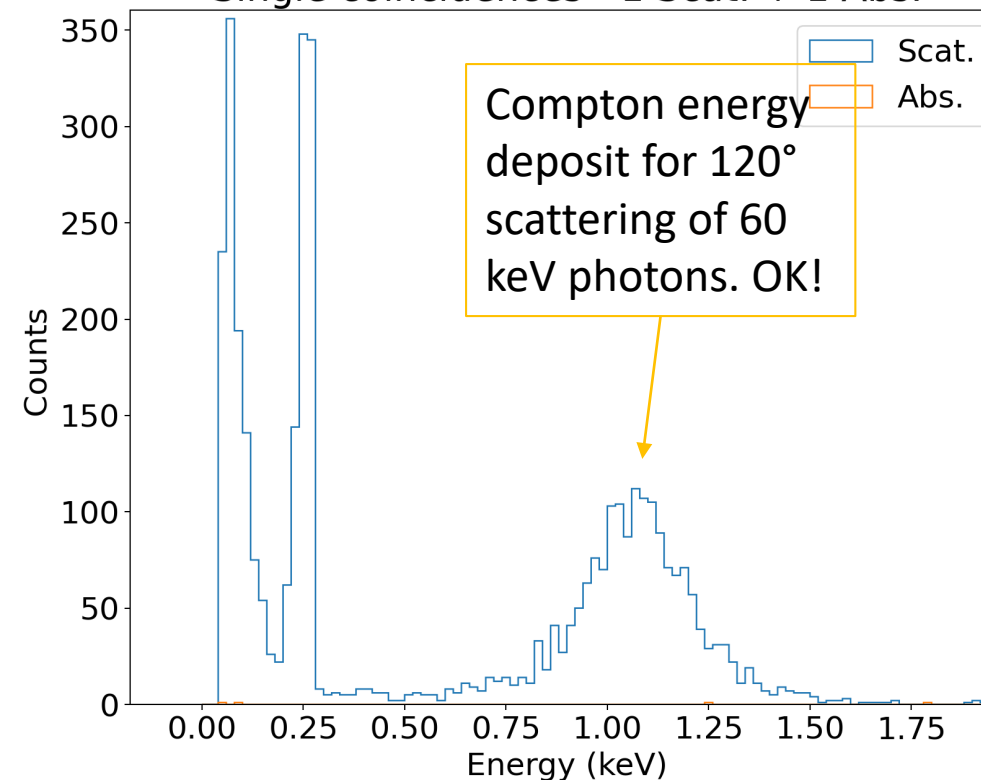
v3, 120° scattering, 20 keV

Single coincidences - 1 Scat. + 1 Abs.



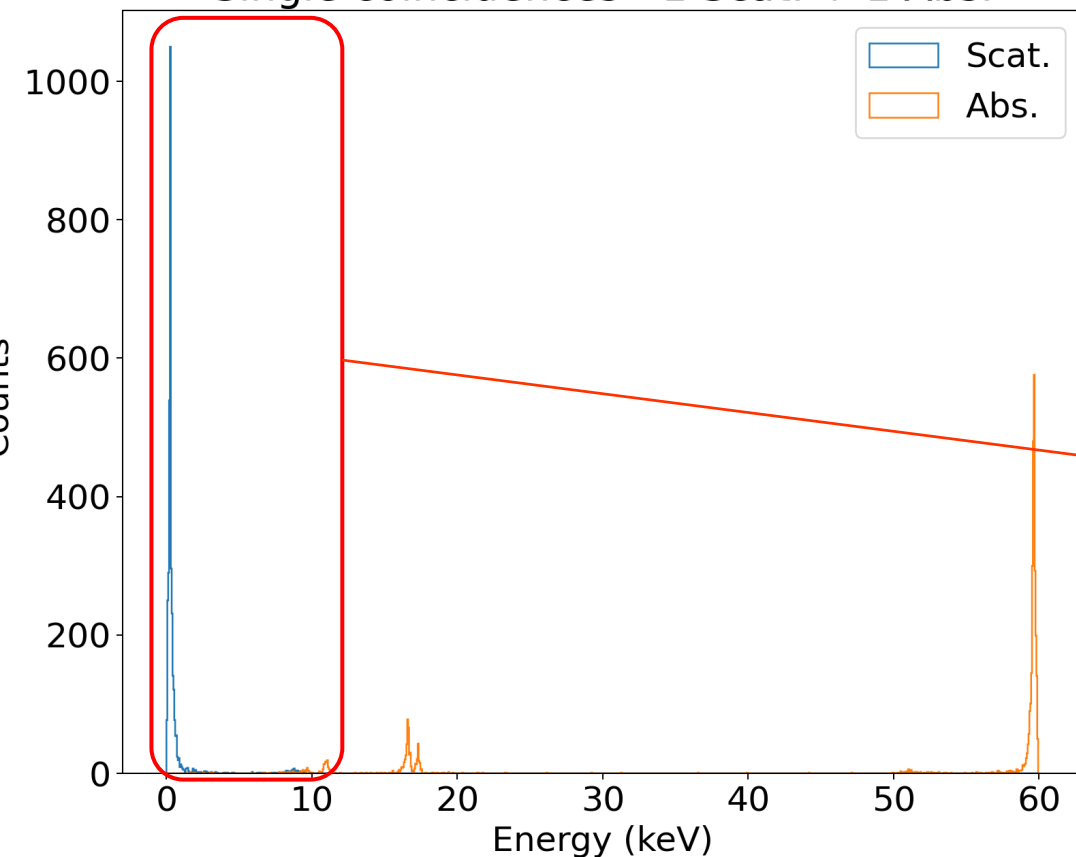
- Energy deposits of coincidences scatterer+absorber for incoming photons at 20 keV
- 120° scattering

Single coincidences - 1 Scat. + 1 Abs.



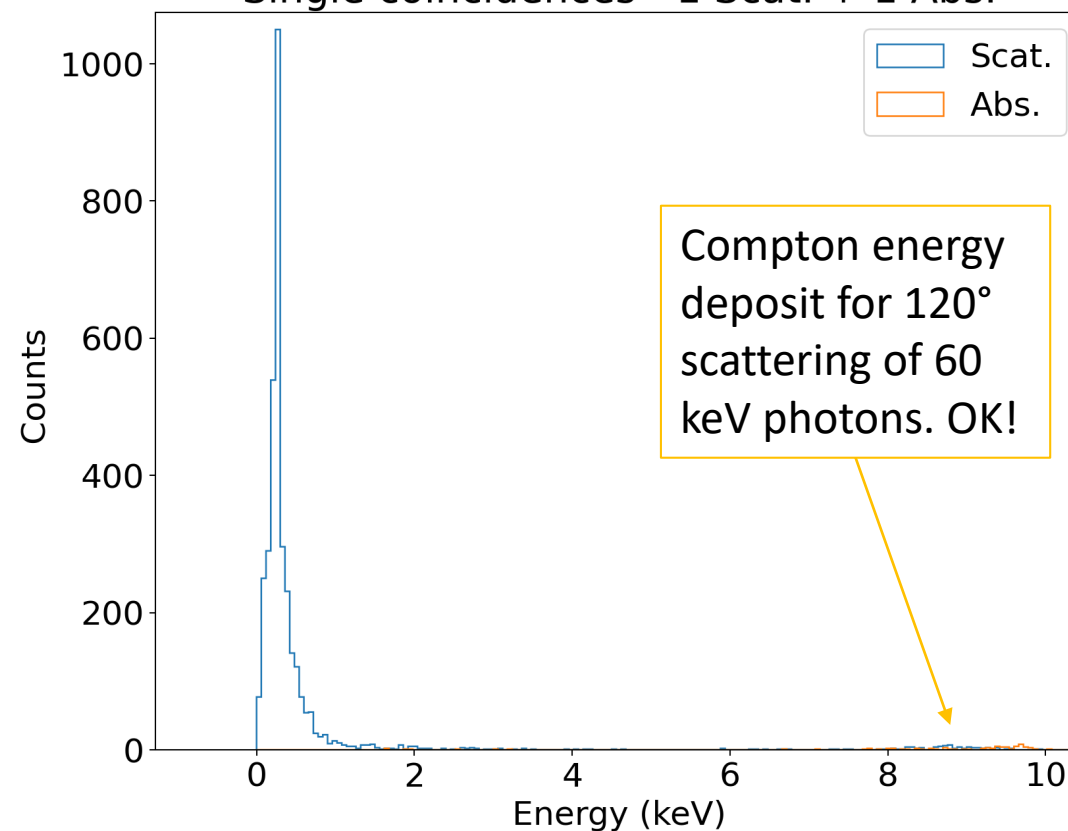
v3, 120° scattering, 60 keV

Single coincidences - 1 Scat. + 1 Abs.



- Energy deposits of coincidences scatterer+absorber for incoming photons at 60 keV
- 120° scattering

Single coincidences - 1 Scat. + 1 Abs.





Energy deposits of coincidences

- The Compton energy deposit in the scatterers (about 0.2 keV in average) is smaller than expected (there should be a significant fraction of 2-5 keV events)
- The 60 keV photons scattered at 15 deg deposit about 0.24 keV. Too much forward folded wrt energy?

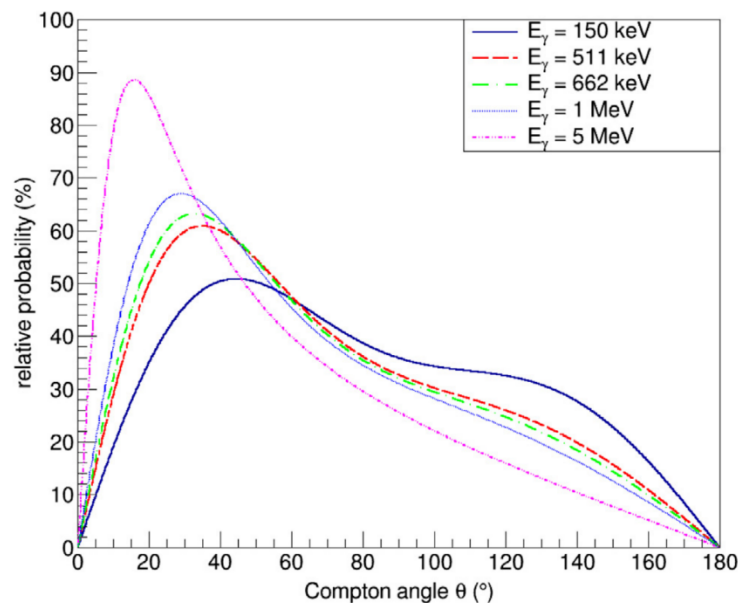
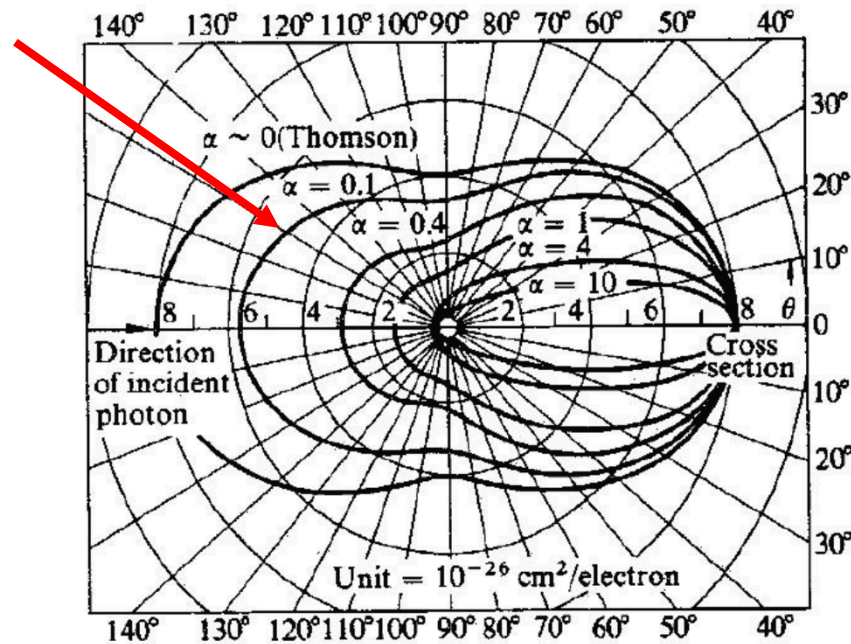


Fig. 2. Relative scattering probability as a function of the Compton angle for a series of γ -ray energies between 150 keV and 5 MeV.



$$\alpha = 60 \text{ keV} / 511 \text{ keV} = 0.12$$

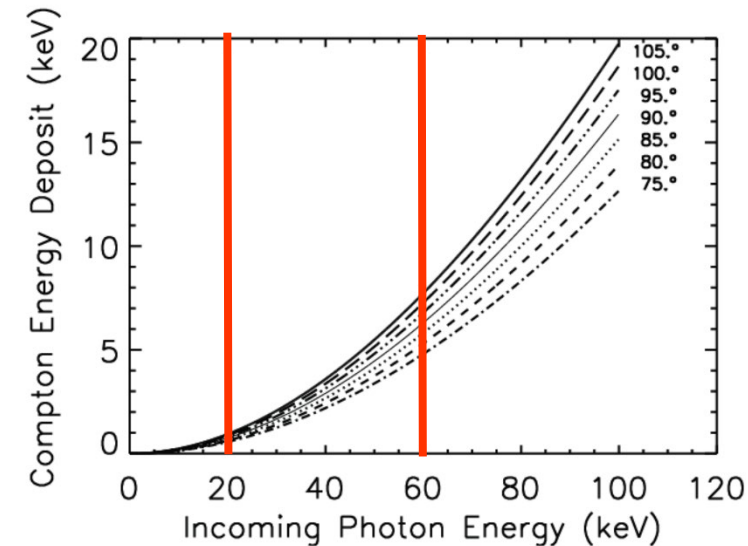


Figure 2.12: Compton scattering cross-section per unit solid angle as a function of θ and $\alpha = \frac{E}{mc^2}$. The cross-section decreases with increasing the scattering angle θ and for high values of α the fall-off occurs rapidly (Davisson & Evans, 1952).

- G4 checks to do:
 - Verify Physics List version
 - Verify materials in the mass model
 - Verify if some particoular cuts are applied
 - Verify other possible source of errors (generation of energy, writing of energy etc.)
 - Take some screenshots of the visualization of a simple simulation with a narrow pencil beam unpolarized centered on a scatterer bar at the corner. If angular distribuion is so wrong we should see by eye a significant forward folding of scattered events
 - Simulate a toy model with a segmented ring (5 mm of height) around a central small scatterer (take also some screenshot of the visualization of the simulation)
- G4 improvements for file format (I'm proposing, not discussed at the meeting):
 - Include the polarization state in the header of the fits file
 - Include the version of the mass model in the header of the fits file