Primex note 32

A Compton simulation for PrimEx (V0.1)

A. Deur. deurpam@jlab.org

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Abstract

A simple Compton simulation is presented. The contain of the code and how to use it is described.

1 Description and Goal.

The program consists of a Compton event generator that produces events within a slightly bigger acceptance than the PrimEx Hycal detector. The position and geometry of Hycal (size, separation for the two regions, beam hole) as well as its energy and position resolution is hardwired at the beginning of the code. The initial photon energy E is randomly chosen using a bremsstrahlung (1/E) distribution. After generation of the Compton event at a random position within the target length, external photon radiations[1], ionization losses and multiple scattering are accounted for on the electron line. At the moment, only ^{4}He Carbon and scintillators are accounted for. The photon is assumed to propagate freely (no pair creations accounted for in the target, the Helium or in the veto of Hycal). The smearing of the photon or electron energies and positions as measured by Hycal is done according to the positions where they hit Hycal. The events is stored in an ntuple, whether or not the particle has hit Hycal.

The program is written in Fortran and output a paw ntuple.

The goal of this Monte Carlo simulation is to provide a fast, simple and robust simulation as a reference for the PrimEx Compton analysis. It is easy

[1] It is assumed that the recoiling electron is not subject to internal radiative corrections (Before being kicked, the electron is "far" away from the nucleus. One could question also the need of external radiative corrections since the emitted photons are mostly collinear to the electron line. Hence, they would hit Hycal in the same time and same place as the electron, which would produce a signal nearly identical as the one that would have been produced if the electron did not radiate. So, *a priori*, radiative corrections should not be implemented. However, the above is true for high energy photons. The bulk of the emitted photons are of very small energies and should be stopped by the matter between the vertex Hycal (Veto, Helium and part of the target). Hence, we included external radiation in the simulation. This reasoning may not hold for photons emitted in the scintillators, but the radiative corrections can be turned off and on in the scintillators to estimate the effect.

to modify and to update (e.g. with an additional physics generator). It should be more than sufficient to reach a few percent accuracy on the Compton cross section. Investigation of particular detector effects can be done separately using a specific (i.e. relatively simple) Geant simulation.

The author is available for support and help if explanation of upgrade are needed (A. Deur, (757) 269-7526, deurpam@jlab.org).

2 How to get it and use it ?

2.1 How to get it ?

The simulation is available under CVS in /group/primex/CVS_Repository/tools/compton_mc

2.2 How and where to compile it ?

The simulation can be compiled on a standard JLab Linux machine using the command: creer comptonmc

2.3 How to use it ?

2.3.1 input file

The input file is called compton_mc.inp. Although it is self explanatory, I describe below the input variables:

- Trials: Number of trials. On my 3.2 GHz laptop, it takes less than 15 s to run 300K events
- Inc. Energy: Electron Beam energy in GeV that will produce the secondary photon beam from a .3% radiator
- Tgt rad len. Target radiation length in unit of Xo (i.e. 5% usually)
- RC: Turn on (=1) or off (=0) the radiative, straggling and multiple scattering effects
- Tgt Mass: mass of the target nucleus in GeV
- A: A of the target nucleus
- Z: Z of the target nucleus
- Density: density of the target
- Xo: radiation length of the target matter

There is a line that is not read in the input file that recall the carbon mass, A, Z, density, and radiation length. You can add others if you use different targets.

2.3.2 run the code

Just type comptonmc. If you don't want the ntuple to be put in your current directory (space consuming), changed the path at the end of the code

(look for "call hropen (55,'bidon','compton.hbook','n',8190,irc)" and add the desired path in front of compton.hbook). Then, you have to recompile the code.

2.3.3 The output

The output is a paw ntuple. For *each* Compton scattering, *two* events are booked in the ntuple. The first one corresponds to the scattered photon. The next one corresponds to the recoiling electron. For ex. assuming that you are setting trial=1000, you produce an ntuple containing 2000 events. Each event, say for a photon (electron), actually also contains the variables of its associated electron (photon). There is a redundancy (we could divide by 2 the size of the ntuple) but it gives more freedom for analyzing the ntuple.

The ntuple contains the following variables:

- E: Incoming photon beam energy (GeV)
- Ep: Energy of the particle (GeV)
- theta: horizontal Cartesian scattering angle of the particle (degree)
- phi: vertical Cartesian scattering angle of the particle (degree)
- az: azimuthal scattering angle of the particle (degree)
- pol: polar scattering angle of the particle in degree (pol and az contain the same information as theta and phi. It is just another system)
- x: horizontal coordinate of the hit on Hycal, in cm
- y: vertical coordinate of the hit on Hycal, in cm
- xs: Compton cross section corresponding to the kinematics of the event (i.e. corresponding to the drawn E, phi and theta), in Barn. This is needed in particular to weight the histograms.
- flag: particle type: 1=photon, 2=electron. Note that if you don't flag your event, you end up with twice more events than expected since you get the associated particle (unless you have other cuts that somehow select the particle id).
- hit: hit=0: the particle is not in Hycal, hit=1: the particle is in the central Hycal, hit=2: the particle is in the outer region of Hycal
- Ep2: Same as Ep but for the corresponding particle (e.g. for the electron is flag=1)
- theta2: Same as theta but for the corresponding particle

- phi2 : Same as phi but for the corresponding particle
- az2: Same as haz but for the corresponding particle
- pol2: Same as pol but for the corresponding particle
- x2 : Same as x but for the corresponding particle
- y2 : Same as y but for the corresponding particle
- hit2: Same as hit but for the corresponding particle

2.4 Kumacs

There is two examples of kumacs in the package (compton.kumac and compton2.kumac).

The Compton events are generated with a uniform distribution, i.e. not following the peaked angular distribution expected from the Compton cross section. To account for this, a weight must be put when plotting a histogram. It is not possible to directly put both weights and cuts in the same time in a paw command line. However, this can be done using a Fortran file and in guise of weight. This is done for example in the above kumacs using in cutg.f

3 Examples of plots

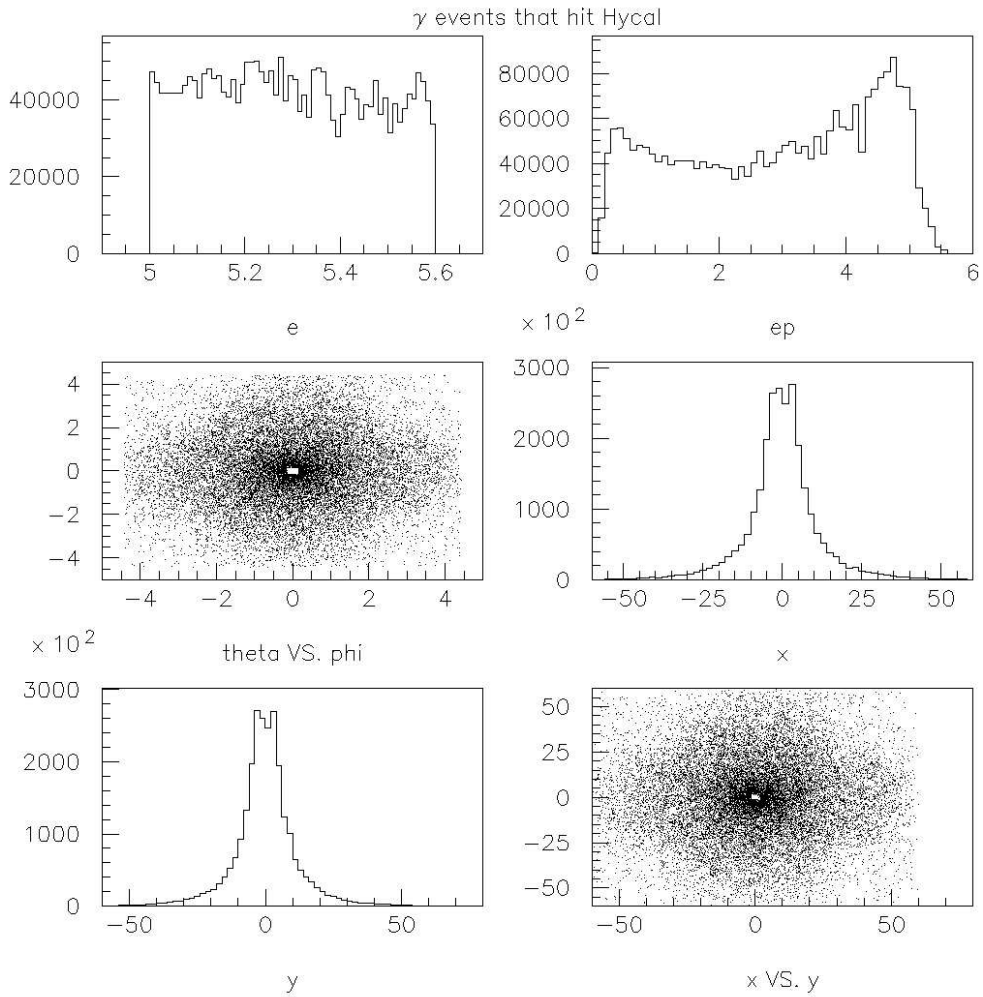

Fig.1. Photon variables plotted using compton. kumac, after cross-section weighting. The left top plot shows a selected part of the incoming photon energy spectrum (GeV). The right top plot shows the energy spectrum of the scattered photon (GeV). The middle left plot shows the photon angular distribution (Cartesian system, degree). The other plots show the x and y position of the photon on Hycal (cm).

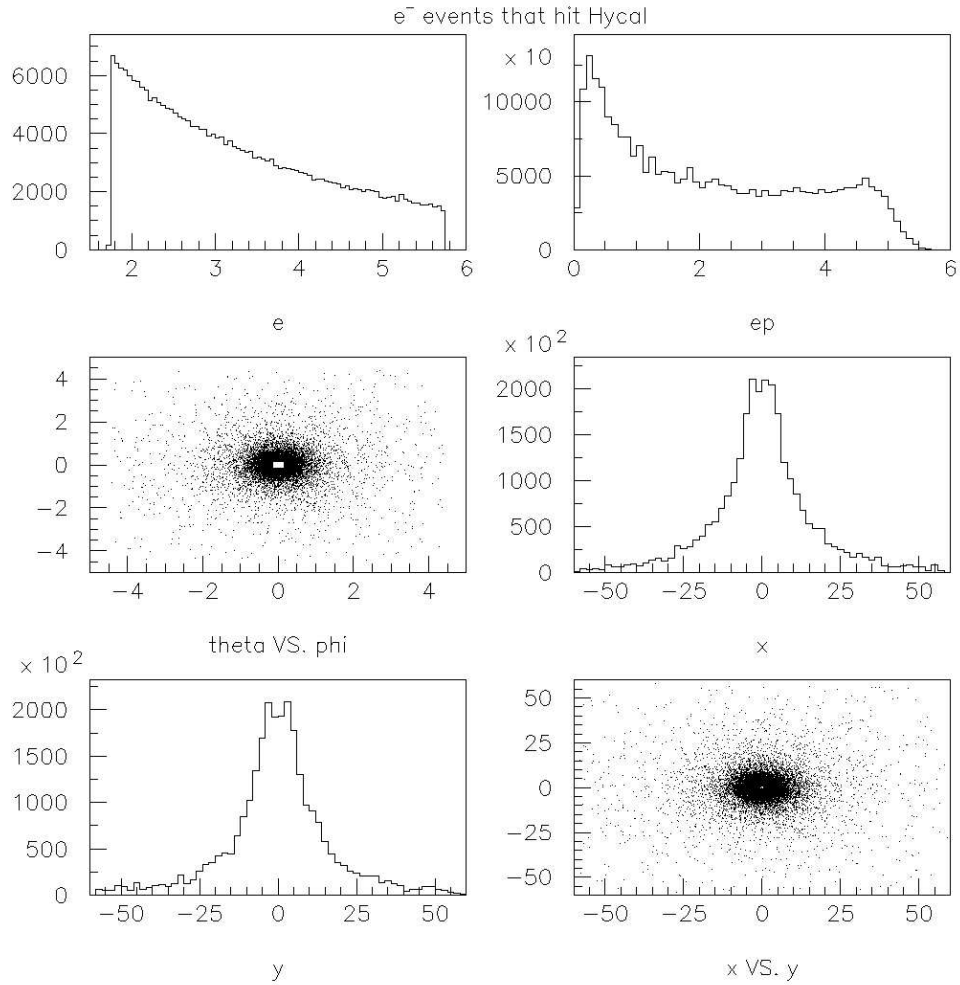

Fig.2. Same as figure 1 but for the electron. The top plot show the full bremsstrahlung spectrum.

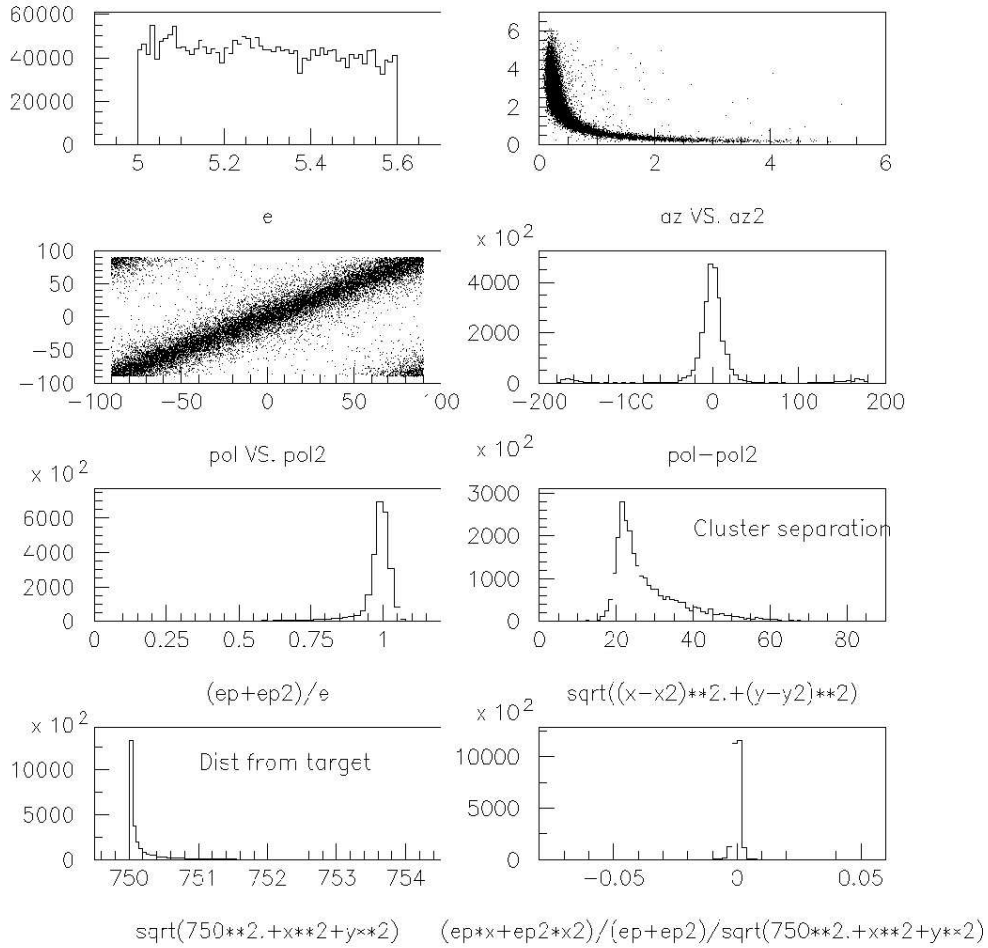

Fig.3. Photon and electron variables plotted using compton2. kumac, after cross-section weighting. The left top plot shows a selected part of the incoming photon energy spectrum. the right top plot shows the correlation between the azimuthal angle of the photon and the azimuthal angle of the electron. Next plot is the same but for polar angles. the Pol-Pol2 plot is the distribution of the difference between the polar angle of the electron and the polar angle of the photon. The (ep+ep2)/E plot gives the sum of the energy of the photon and electron normalized to the incoming photon energy.

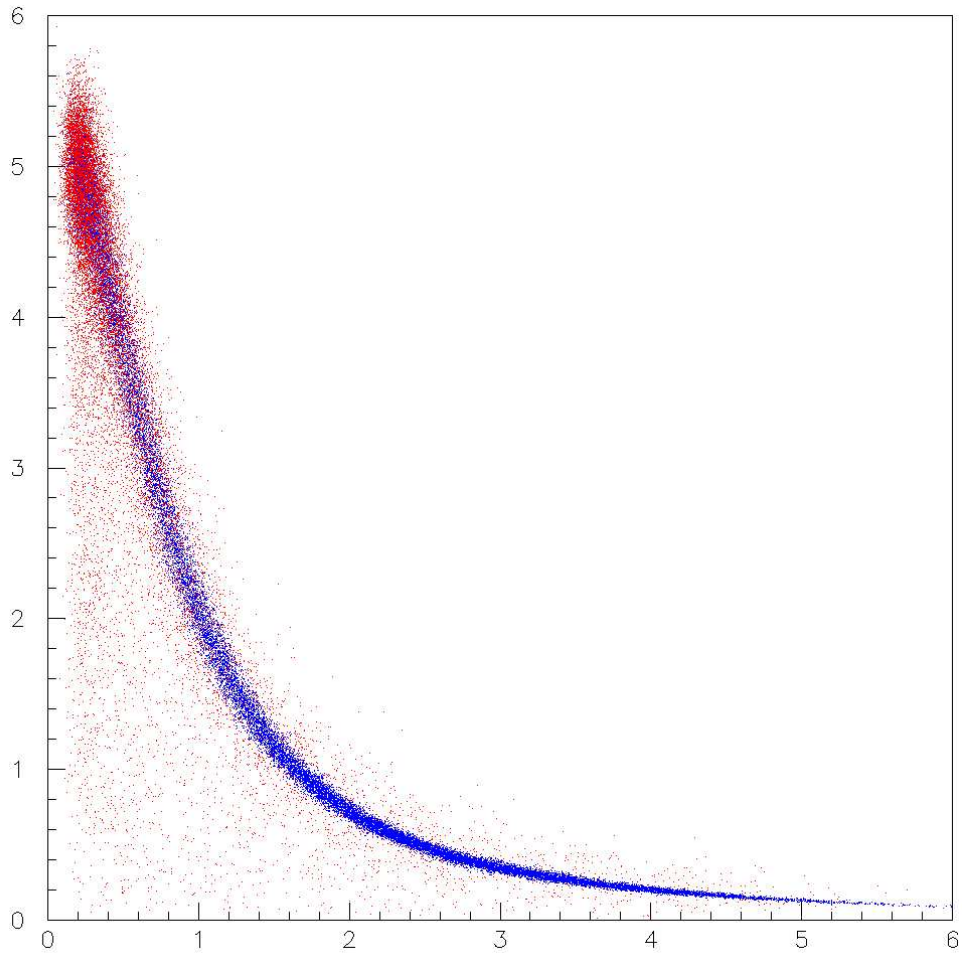

Fig.4. Particle energy (vertical scale, in GeV) vs its azimuthal angle (horizontal scale, degree). The blue dots identify a photon and the red dots are for the electrons. The radiative effects can be seen by the larger downward spread of the red dots. Ionizations losses pull the electron distribution downward.