# Compton Scattering and Pion Photoproduction Event Generator

*Designed for use with the MAMI A2 Geant4 Simulation*

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## 1 Relevant Files

- BaseGen.h → The base generator class
- BasePart.h → The base particle class
- CompGen.h → The Compton generator class
- EventGen.cxx → The main generator code
- Makefile
- out/ → The directory for all output files
- par/Comp* → The Compton parameter files
- par/Pi0P* → The neutral pion photoproduction parameter files
- par/PiPN* → The charged pion photoproduction parameter files
- physics.h → Various physical constants
- Pi0PGen.h → The neutral pion photoproduction generator class
- PiPNGen.h → The charged pion photoproduction generator class
- readme.pdf → This file
- version.txt → Details updates to this generator

# 2 To Compile

Type 'make' from within this main directory (EventGen).

# 3 To Run

Type './EventGen' from within this main directory, and follow the prompts to select the desired conditions.

# 4 Selections

## 4.1 Processes

- Comp ($\gamma\, p \rightarrow \gamma\, p$)
- Pi0P ($\gamma\, p \rightarrow \pi_0\, p$)
- PiPN ($\gamma\, p \rightarrow \pi_+\, n$)

## 4.2 Type

- Normal
- Incoherent
- Coherent

## 4.3 Weighting

- Isotropic (in CM frame)
- For Comp - Dispersion (Pasquini)
- For Pi0P/PiPN - DMT, MAID (MD07), SAID (SN11 and SP09)

## 4.4 Target

- For Normal - proton
- For Incoherent - 12C (16O in progress)
- For Coherent - 3He, 4He, 12C, 16O

### 4.5 Beam Polarization ($P_B$)

- Unpolarized $\rightarrow P_B^{\mathrm{lin}} = 0$, $P_B^{\mathrm{cir}} = 0$, $\phi_B = 0$
- Linear $\rightarrow 0 \leq P_B^{\mathrm{lin}} \leq 1$, $P_B^{\mathrm{cir}} = 0$, $-180 \leq \phi_B \leq 180$
- Circular $\rightarrow P_B^{\mathrm{lin}} = 0$, $-1 \leq P_B^{\mathrm{cir}} \leq 1$, $\phi_B = 0$

### 4.6 Target Polarization ($P_T$)

- Unpolarized $\rightarrow P_T^{\mathrm{tran}} = 0$, $P_T^{\mathrm{long}} = 0$, $\phi_T = 0$
- Transverse $\rightarrow -1 \leq P_T^{\mathrm{tran}} \leq 1$, $P_T^{\mathrm{long}} = 0$, $-180 \leq \phi_T \leq 180$
- Longitudinal $\rightarrow P_T^{\mathrm{tran}} = 0$, $-1 \leq P_T^{\mathrm{long}} \leq 1$, $\phi_T = 0$

### 4.7 Beam Energy

- For Compton - 80 – 450 MeV, in 5 MeV steps
- For Pi0P - 145 – 450 MeV, in 5 MeV steps
- For PiPN - 155 – 450 MeV, in 5 MeV steps

### 4.8 Number of Events

## 5 Parameter Files

For Normal and Incoherent reactions, parameter files are read in from the 'par' subdirectory, which is what causes the restriction on the energy step. (NOTE: If a finer step size, or a different Pi0P/PiPN solution, is required please contact me and I can provide the appropriate files)

Description of columns in parameter files (using the observables nomenclature of: L.S. Barker, A. Donnachie, J.K. Storrow, Nucl. Phys. B 95 (1975) 347)

- Angle $\rightarrow$ lab for Compton, cm for Pi0P/PiPN
- $\left(\frac{d\sigma}{d\omega}\right)_{\mathrm{unp}} \rightarrow$ unpolarized cross section, also written as DSG, in units of nb for Compton or $\mu$b for Pi0P/PiPN
- $\Sigma \rightarrow$ beam asymmetry, equal to $-\Sigma_3$ for Compton, also written as S
- T $\rightarrow$ transverse target asymmetry observed in plane transverse to target polarization, equal to zero for Compton
- P $\rightarrow$ linear beam/transverse target asymmetry observed in plane transverse to target polarization, currently equal to zero for Compton

- G $\rightarrow$linear beam/longitudinal target asymmetry, currently equal to zero for Compton
- H $\rightarrow$linear beam/transverse target asymmetry observed in plane of target polarization, currently equal to zero for Compton
- E $\rightarrow$circular beam/longitudinal target asymmetry, equal to $-\Sigma_{2z}$ for Compton
- F $\rightarrow$ circular beam/transverse target asymmetry observed in plane of target polarization, equal to $\Sigma_{2x}$ for Compton

$$\frac{d\sigma}{d\omega} = \left(\frac{d\sigma}{d\omega}\right)_{\text{unp}} \Big\{ 1 - P_B^{\text{lin}}\,\Sigma\cos 2\phi + P_x\left[P_B^{\text{cir}}F - P_B^{\text{lin}}H\sin 2\phi\right] \\ + P_y\left[T - P_B^{\text{lin}}P\cos 2\phi\right] - P_z\left[P_B^{\text{cir}}E - P_B^{\text{lin}}G\sin 2\phi\right] \Big\}$$

where $\phi = \phi_B - \phi_\pi$, the azimuthal angle between the plane of linear beam polarization (along the electric field) and the pion. Since:

$$P_x = P_T^{\text{tran}}\cos\phi \\ P_y = P_T^{\text{tran}}\sin\phi \\ P_z = P_T^{\text{long}}$$

where $\phi = \phi_T - \phi_\pi$, the azimuthal angle between the direction of transverse polarization and the pion.

$$\frac{d\sigma}{d\omega} = \left(\frac{d\sigma}{d\omega}\right)_{\text{unp}} \Big\{ 1 - P_B^{\text{lin}}\,\Sigma\cos 2(\phi_B - \phi) \\ + P_T^{\text{tran}}\cos\left(\phi_T - \phi\right)\left[P_B^{\text{cir}}F - P_B^{\text{lin}}H\sin 2(\phi_B - \phi)\right] \\ + P_T^{\text{tran}}\sin\left(\phi_T - \phi\right)\left[T - P_B^{\text{lin}}P\cos 2(\phi_B - \phi)\right] \\ - P_T^{\text{long}}\left[P_B^{\text{cir}}E - P_B^{\text{lin}}G\sin 2(\phi_B - \phi)\right] \Big\}$$

For Coherent reactions, cross sections are produced using a method provided by R. Miskimen.

# 6 Output

Three root files are produced as output in the 'out' sub-directory. 'hist.root' contains histograms for testing, energy and angular distributions, etc. 'tree.root' is a tree file with the Lorentz vectors of the resulting particles for more detailed testing. 'ntpl.root' is then the ntuple for use in the A2 Geant4 simulation.