A Measurement of the Electron Compton Scattering Cross Section in the Jefferson Lab PrimEx Experiment

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On behalf of PrimEx Collaboration

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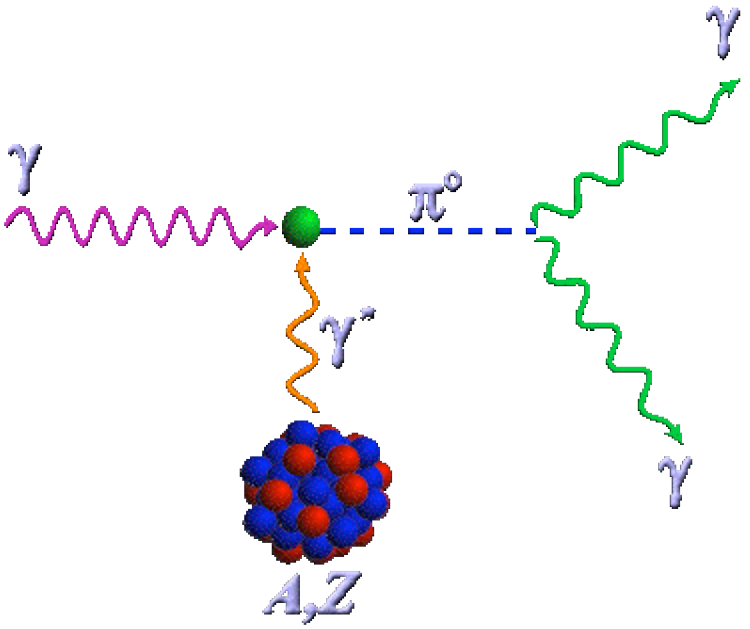
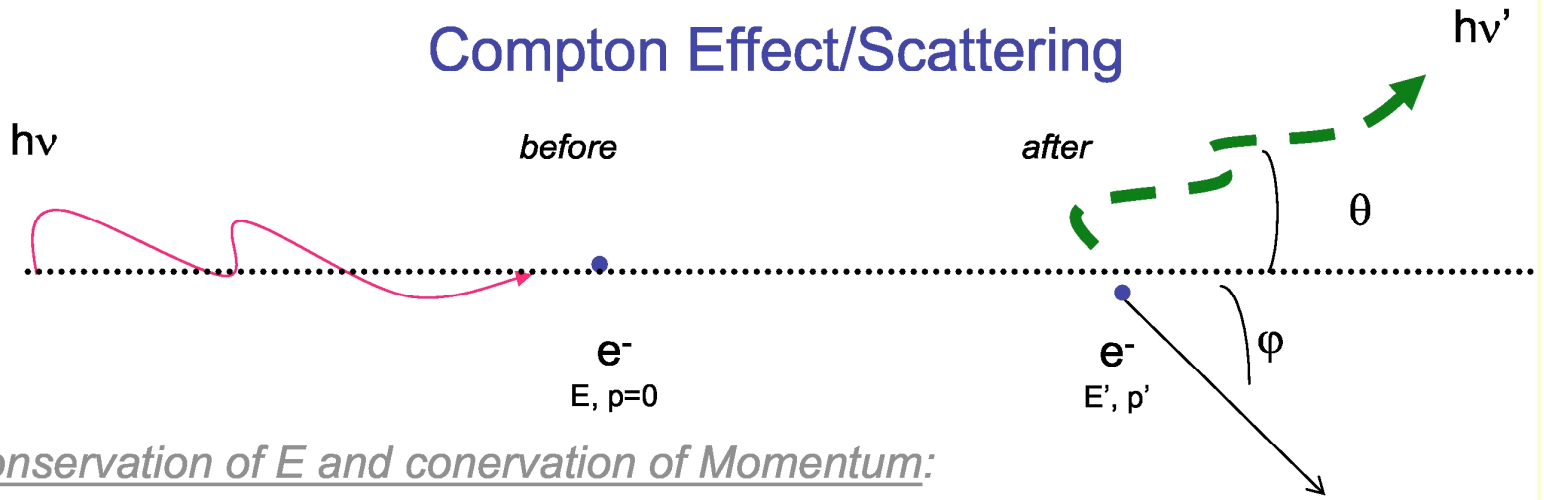
PrimEx Experiment

- The goal of the PrimEx Collaboration is to make a precision measurement of the absolute cross section for photoproduction of pions in the Coulomb field of a nucleus (Primakoff effect) and extract the neutral pion lifetime



- To achieve the desired precision for the lifetime measurement, the flux of tagged photons on the target must be known with precision of 1%.
- To verify the absolute normalization of the photon flux we measure the absolute cross-sections of well known electromagnetic processes such as Pair Production and the Compton Effect.

Compton Effect/Scattering



Conservation of E and conervation of Momentum:

The Klein-Nishina Formula (per electron)

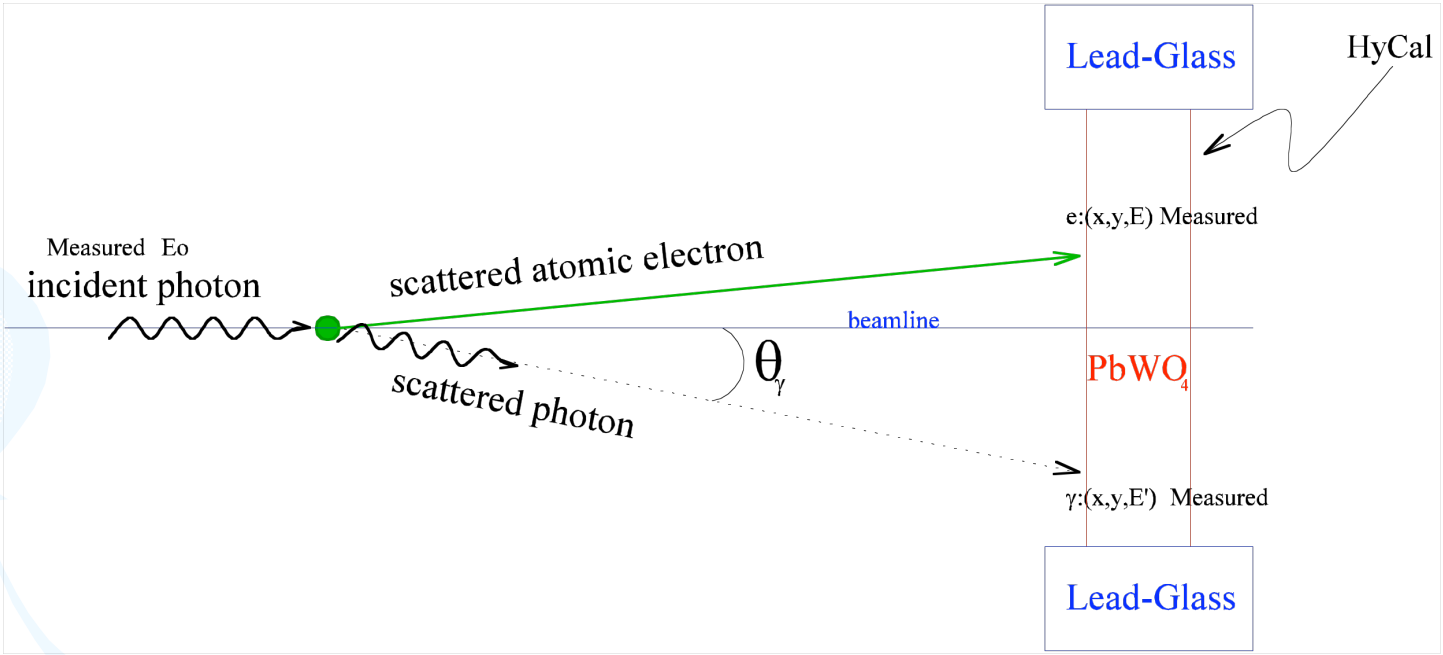
$$\frac{d_e\sigma}{d\Omega} = \frac{k^2e^4}{2m^2c^4}\left(\frac{\nu'}{\nu}\right)^2\left(\frac{\nu}{\nu'} + \frac{\nu'}{\nu} - (\sin\theta)^2\right)$$

$$h\nu' = \frac{h\nu}{1 + \left(\frac{h\nu}{mc^2}\right)(1-\cos\theta)}$$

Total Cross Section (per electron)

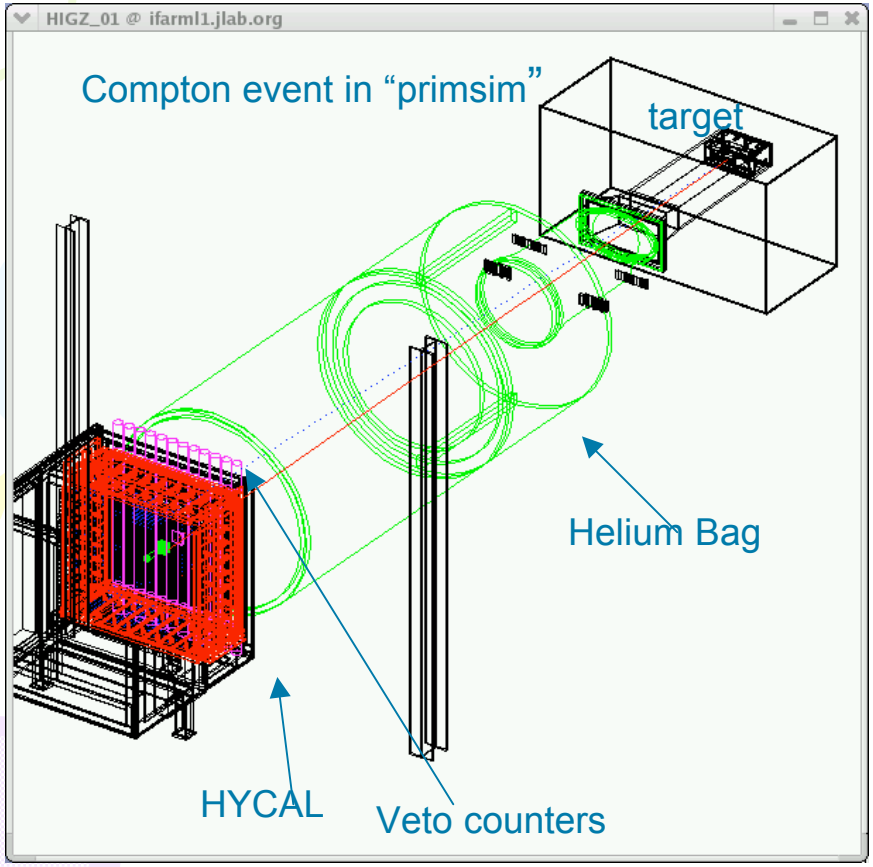
$$\sigma = 2\pi \oint_{4\pi} \frac{d_e\sigma}{d\Omega}(\sin\theta)d\theta$$

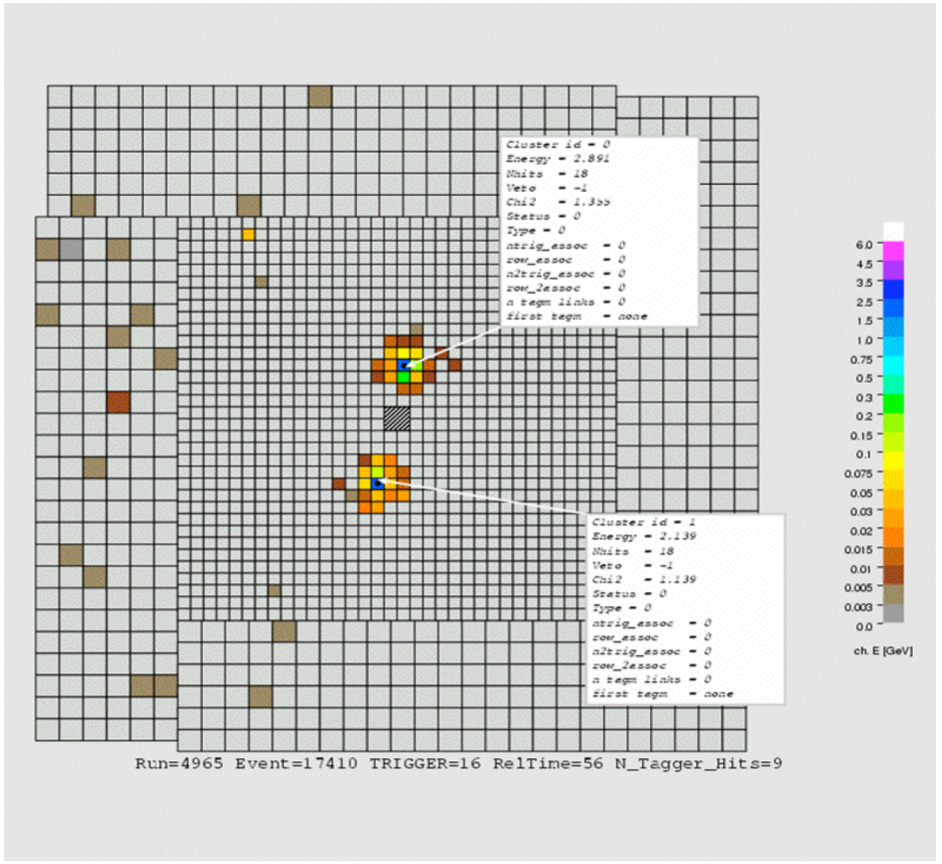
Experimental Setup



- Compton scattering at small angles
- Targets: 5 % r.l ^{12}C, 0.5 % r.l.^{9}Be
- What we measure:
  - Incident photon energy
  - Energy and position of the scattered particles

Compton Event





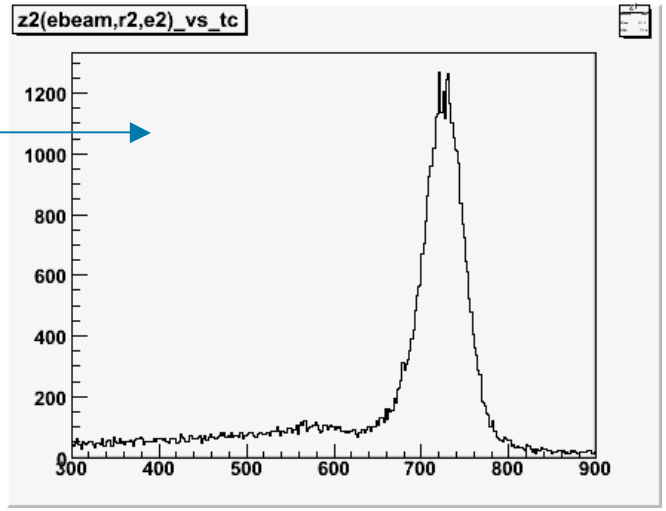
2 clusters are detected on the calorimeter

Event Selection (Be target)

Reconstruct the vertex of Compton reaction

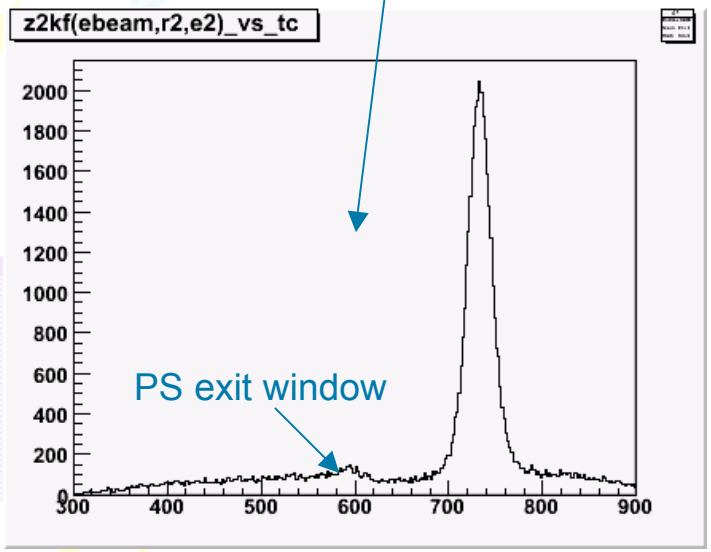
$Z=(x^2+y^2)^{0.5}[\gamma/(E/e-1)]^{0.5}$

- x,y: cluster coordinates
- E,e: beam,cluster energy
- γ: E/m_e

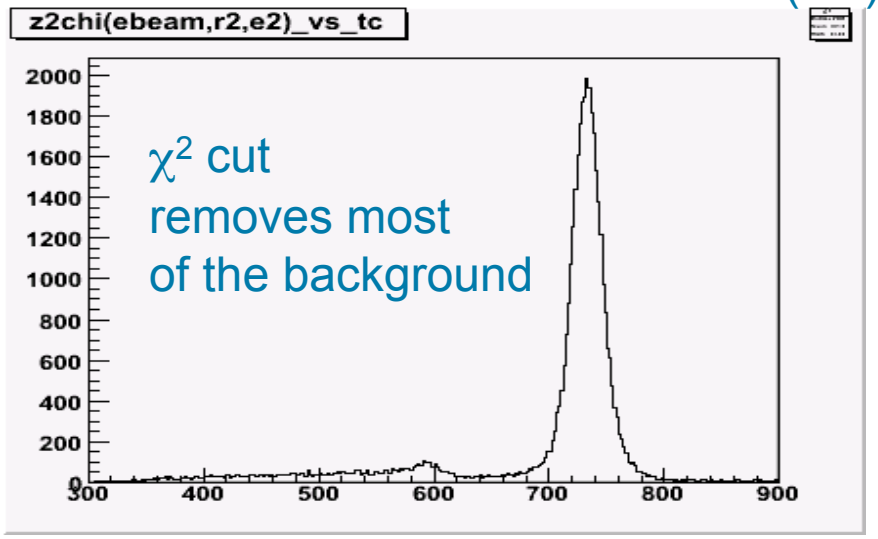


Apply kinematic constraints: E, p conservation

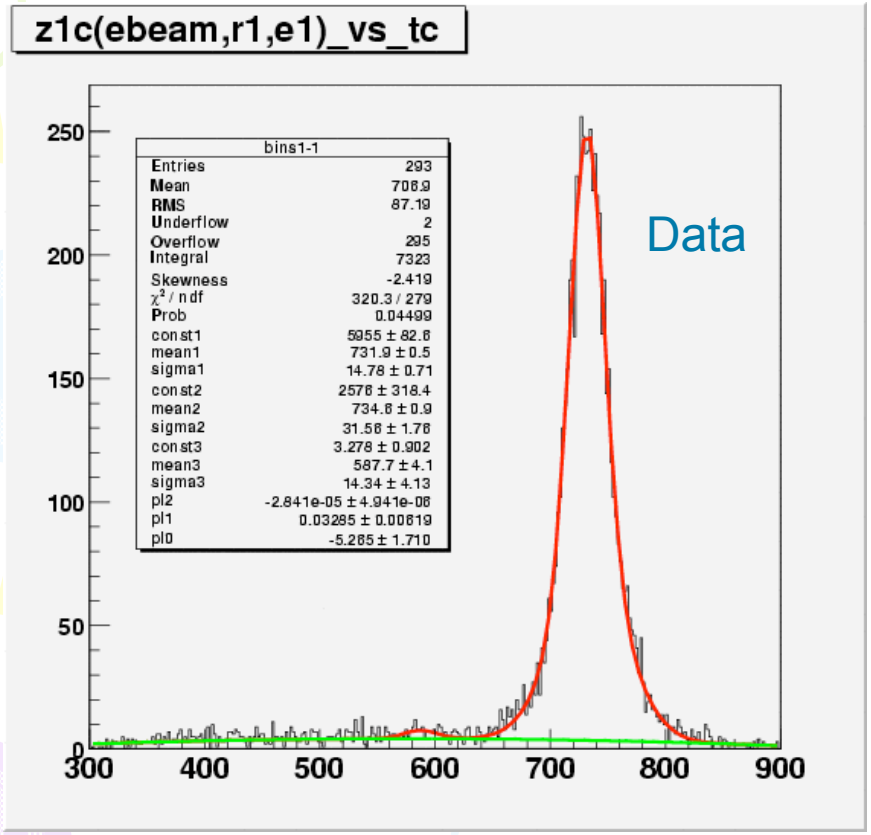
Reconstruct Z again

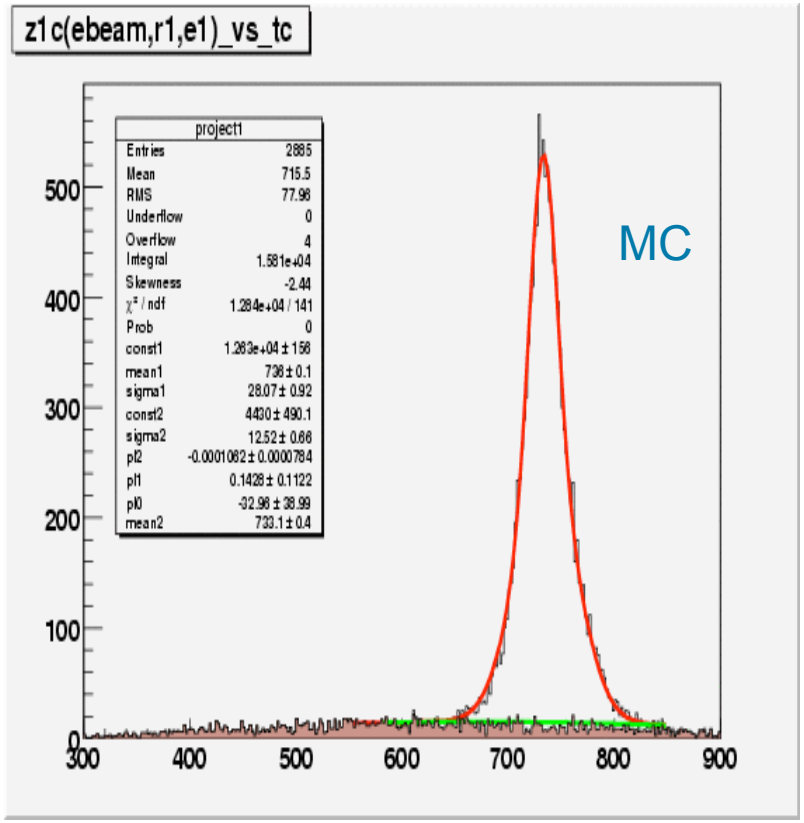


Z (cm)



Comparison with MC

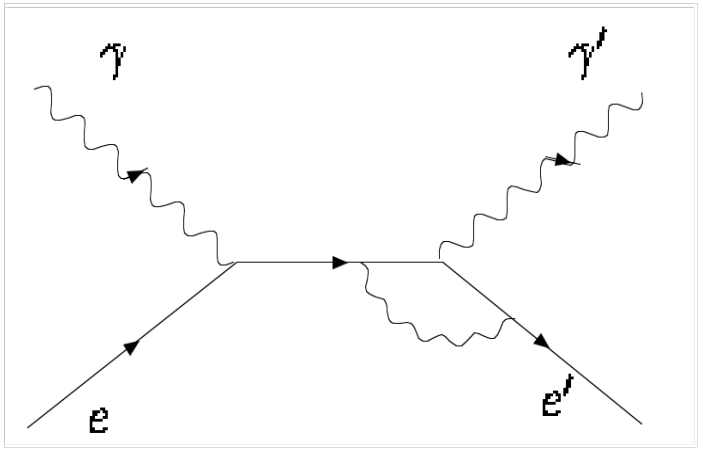




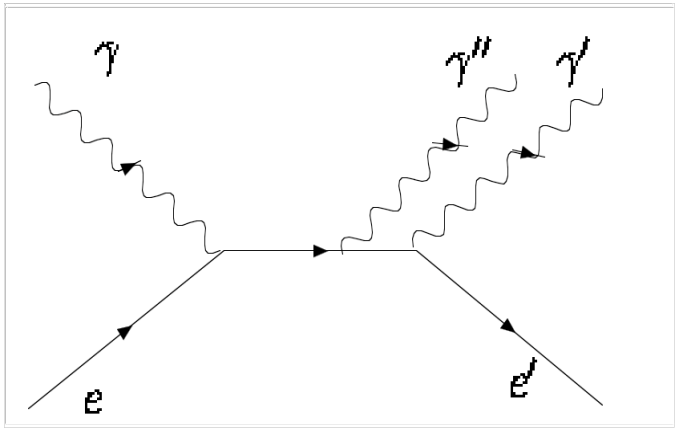
Background/Signal ~ 21 % (carbon), 27% (Be)

Radiative Corrections

- Virtual: possibility of emission and re-absorption of virtual photon by an electron during the scattering process

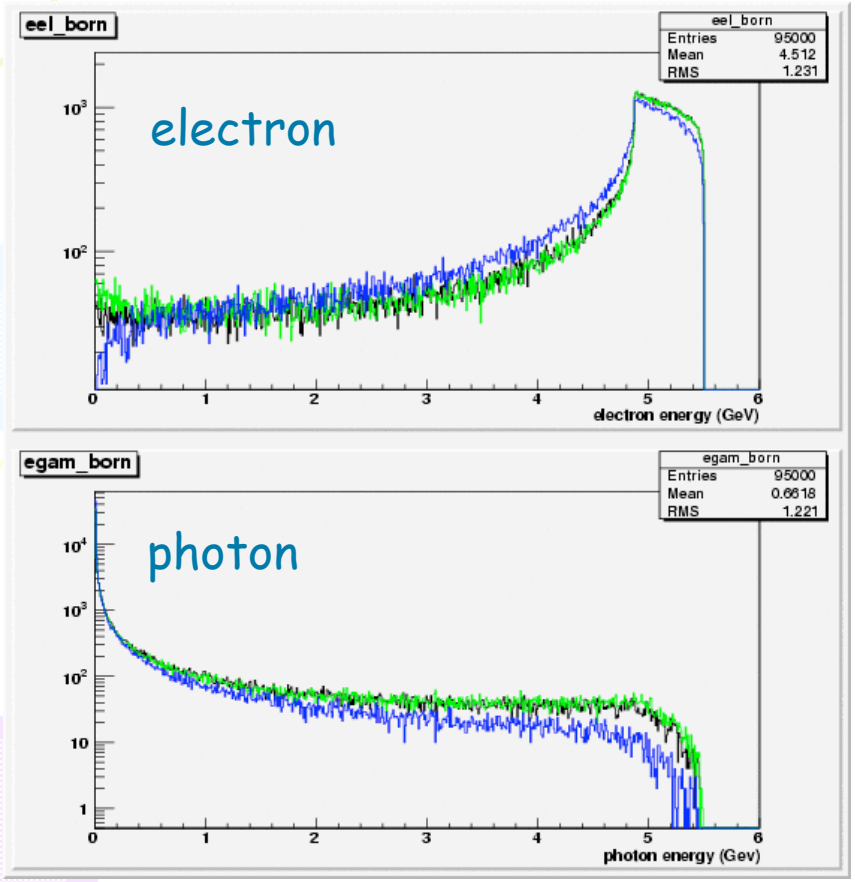


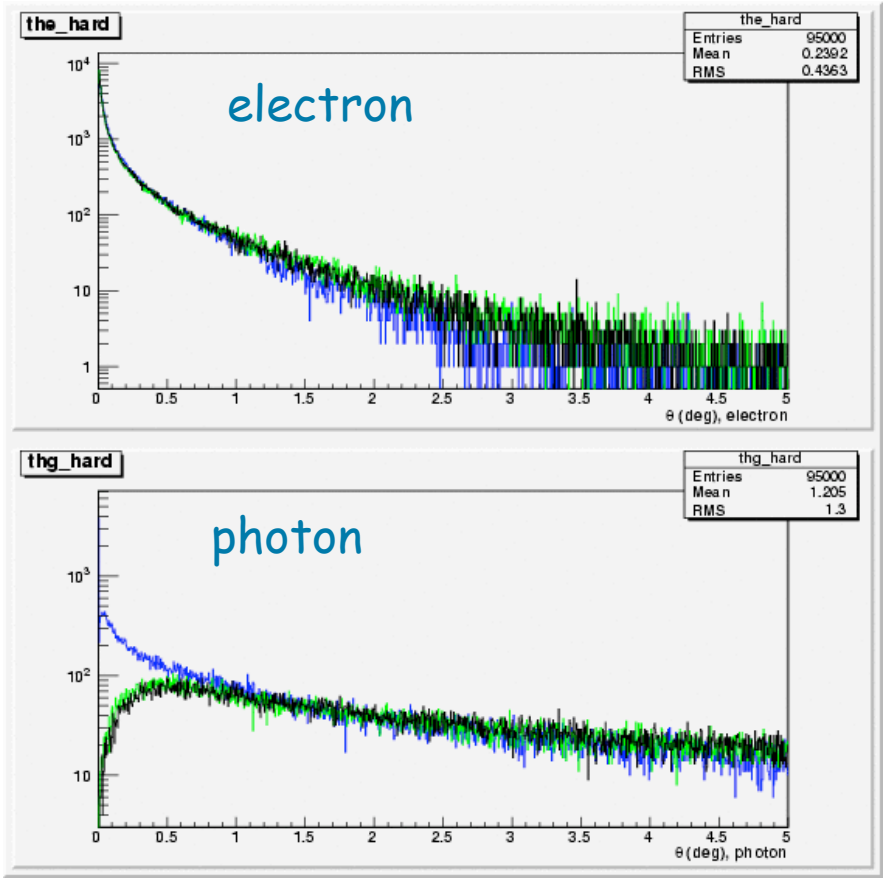
- Double Compton scattering
  - Soft: secondary photon of energy $k<<k_{max}$, not accessible to the experiment
  - Hard: secondary photon of energy $k>k_{max}$, accessible to the experiment



Implementing Radiative Corrections

Born vs Born+Soft-Virtual vs Double Compton Scattering

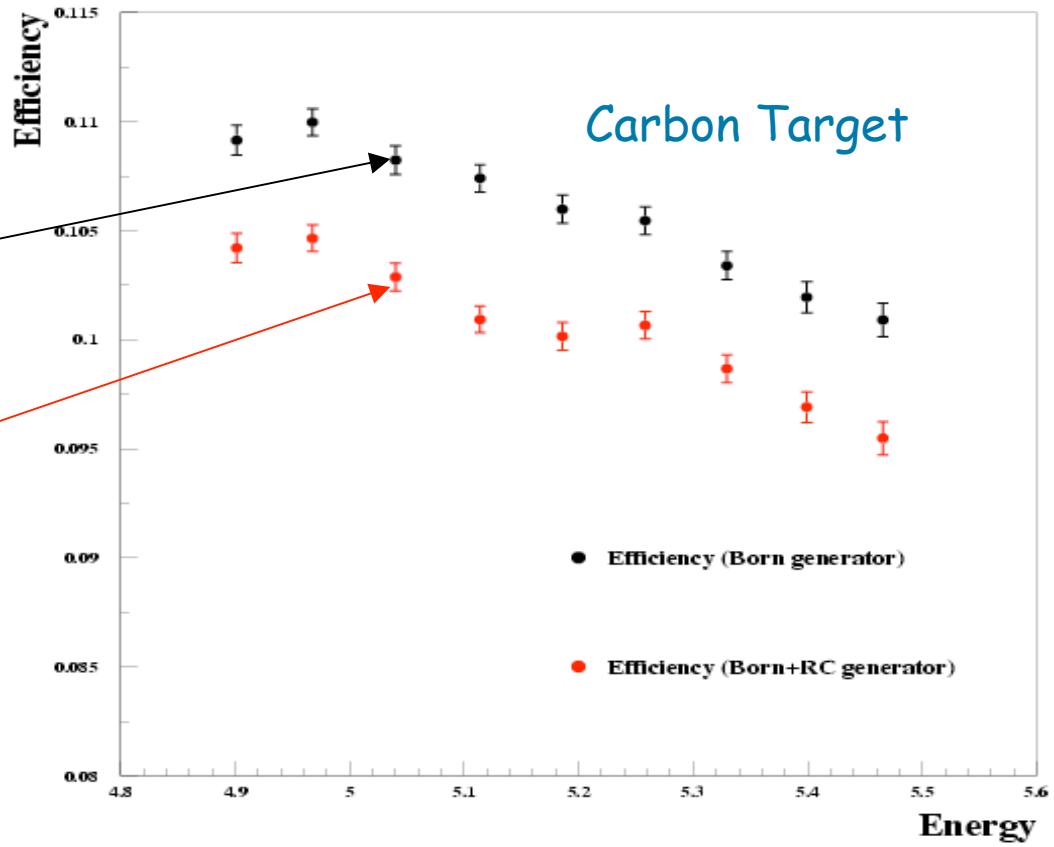




Scattered energy (GeV)

Scattering angle θ(deg)

Calculation of Efficiency



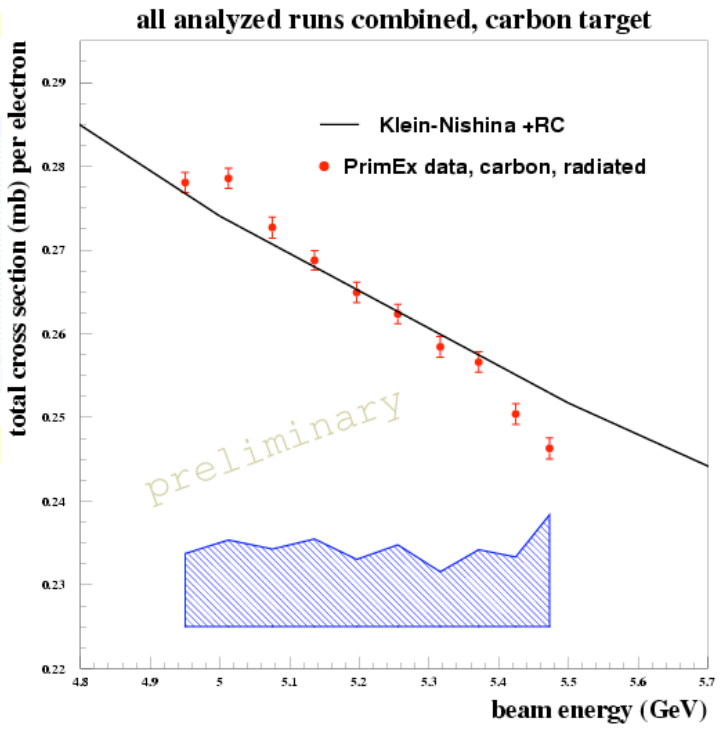
Born

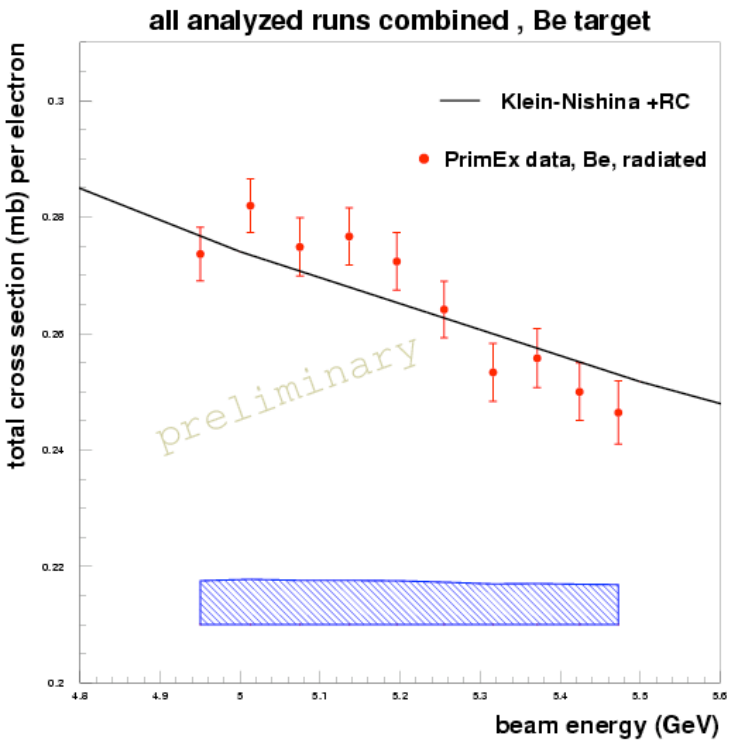
Born+RC

'Radiated' efficiency is ~ 5% smaller

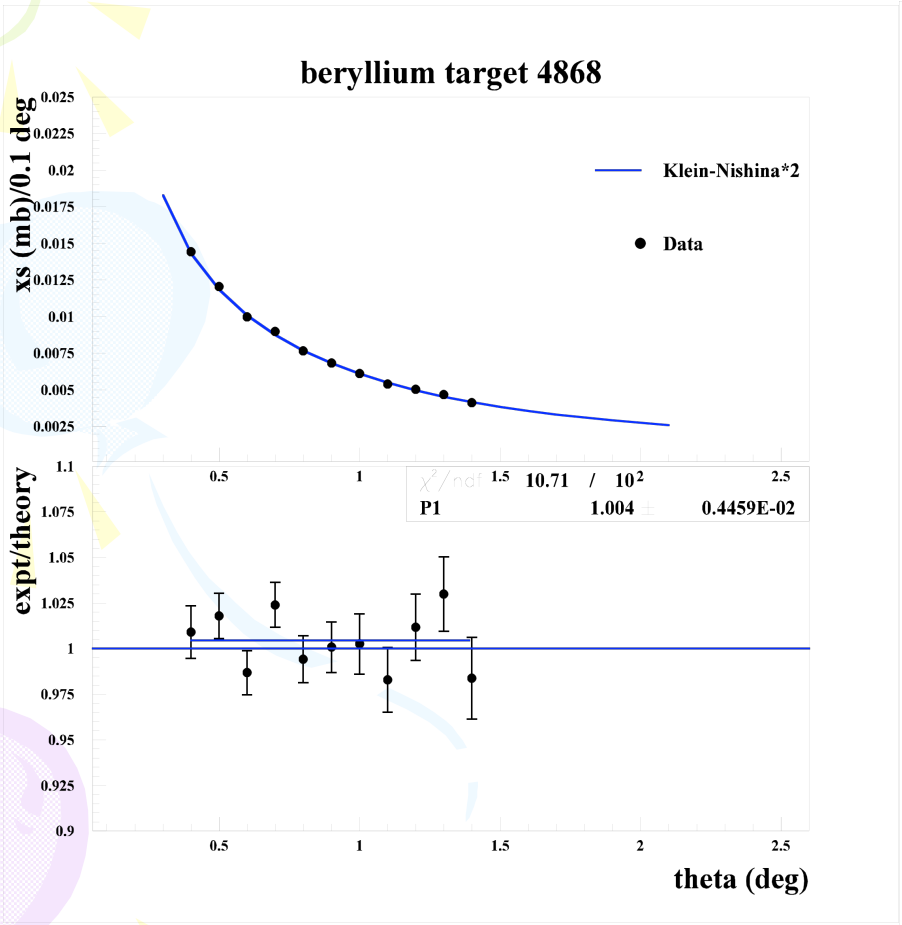
Total Cross Section

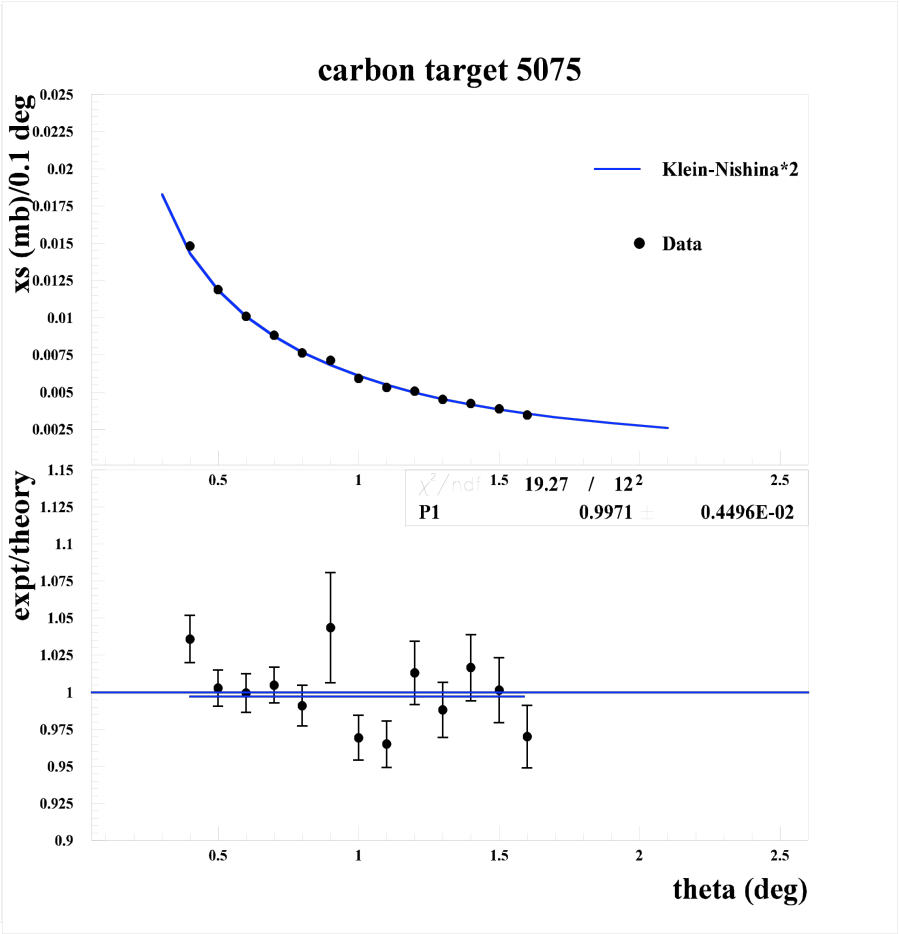
$\sigma_T = N/(L*F*A*\varepsilon)$





Differential Cross Section





Summary and Outlook

- Analysis of Compton scattering provides a useful tool for monitoring of experimental conditions
- Preliminary analysis of Double Arm Compton Cross Section is in good agreement with theory (within 1-2%)
- Work in progress:
  - Evaluation of systematic errors
  - Analysis of low energy data set (2-3 GeV)

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Extra Slides

Signatures of Compton Events