Measurement of Compton scattering cross section at a few GeV energy

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for the PrimEx-II collaboration

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Outline

- ***Physics Motivation***
- ***Experimental Setup***
- ***Event Selection***
- ***Cross Section Extraction***
- ***Summary***

Physics Motivation

Electron Compton scattering is one of the most fundamental and the best theoreti cally known reaction in QED.

1. Leading order (Figure 1) :

The lowest order Compton scattering diagrams were first calculated by Klein and Nishina in 1929.

The Klein-Nishina formula :

$$\frac{d\sigma}{d\Omega} = \frac{r_e^2}{2}\left(\frac{E'}{E_0}\right)^2\left[\frac{E'}{E_0} + \frac{E_0}{E'} - \sin^2\theta_\gamma\right]$$

2.Higher order corrections (Figure2 and 3) :

Include radiative corrections and double Compton scattering.

[L. M. Brown and R. P. Feynman, Phys. Rev. 85,231 *(1952)*.]

Compton scattering in a few GeV electron energy has not been measured experi mentally.

In this experiment:

- ✓ Precision measurement of Compton scattering in a few GeV electron energy.
- ✓ Validate systematic error for π^0 lifetime measurement (PrimEx-II) .

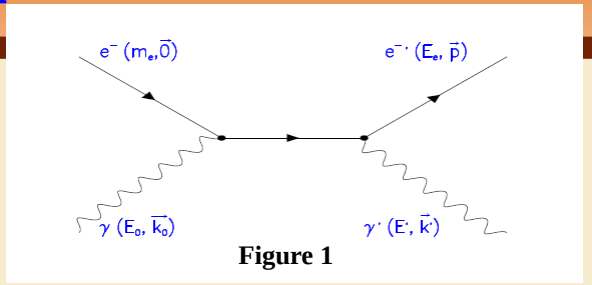


Figure 1

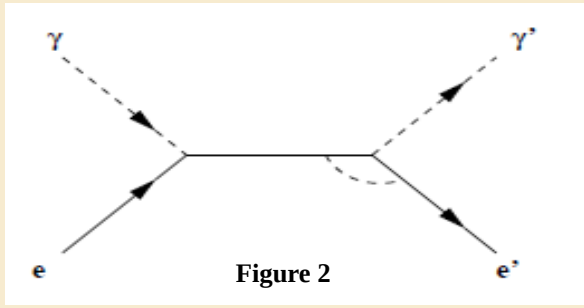


Figure 2

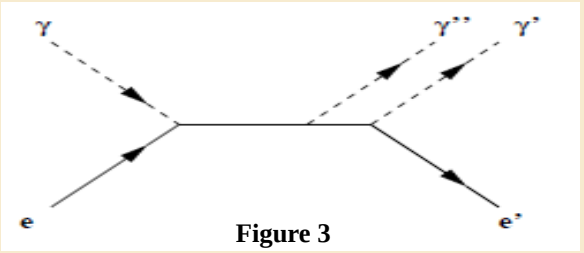
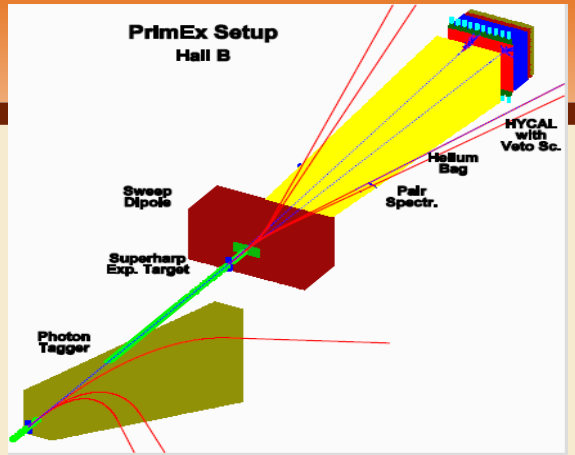


Figure 3

Experimental Set up

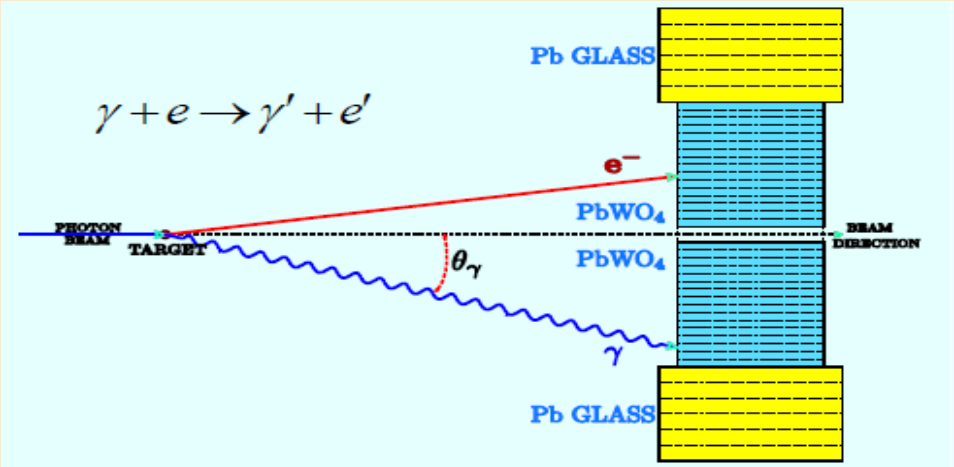


Includes :

1. Targets : Carbon-I(5% r.l.),Carbon-II(8% r.l.),Silicon(10% r.l.)
2. Hall B Photon Tagger
3. Hybrid electro-magnetic calorimeter (HyCal)
   - ✓ Energy resolution : ~ 2.5% at 1GeV
   - ✓ Position resolution : ~ 2 mm at 1GeV

Measured:

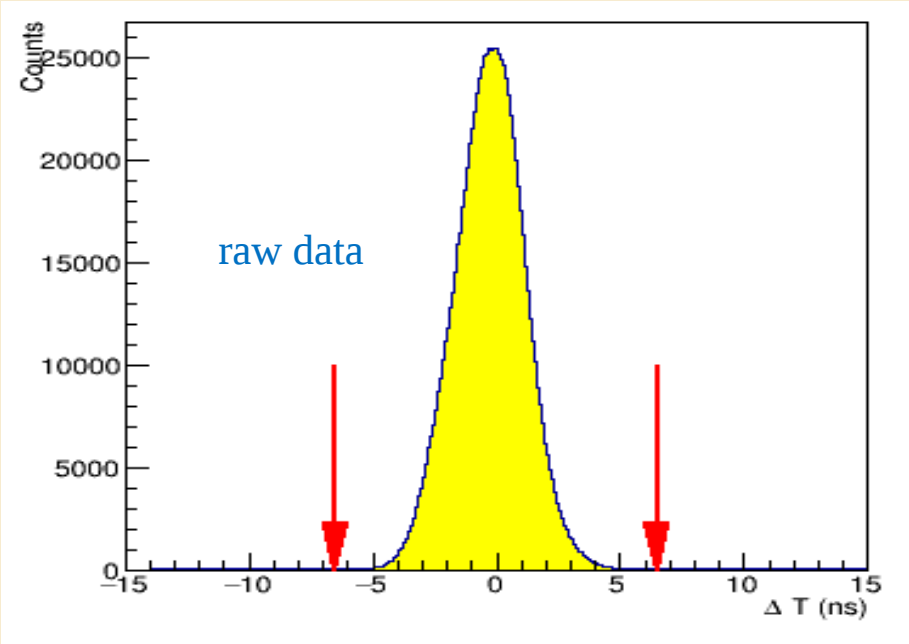
1. Tagged photon beam energy
2. Cluster's energies
3. Cluster's positions



Event Selection

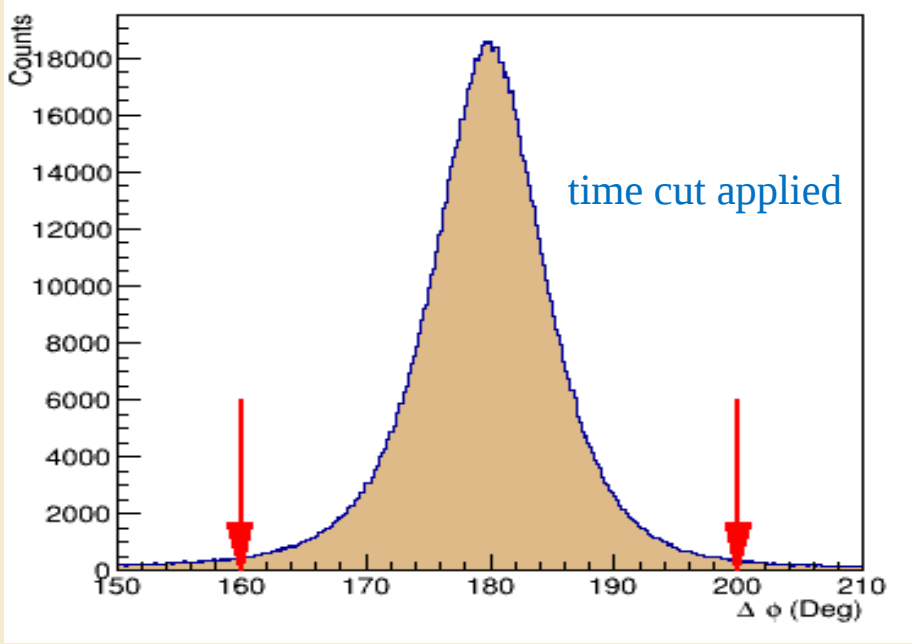
Time Difference (±6.5ns) :

Time difference betwwen HyCal and Tagger



Azimuthal Angle Difference (±20deg) :

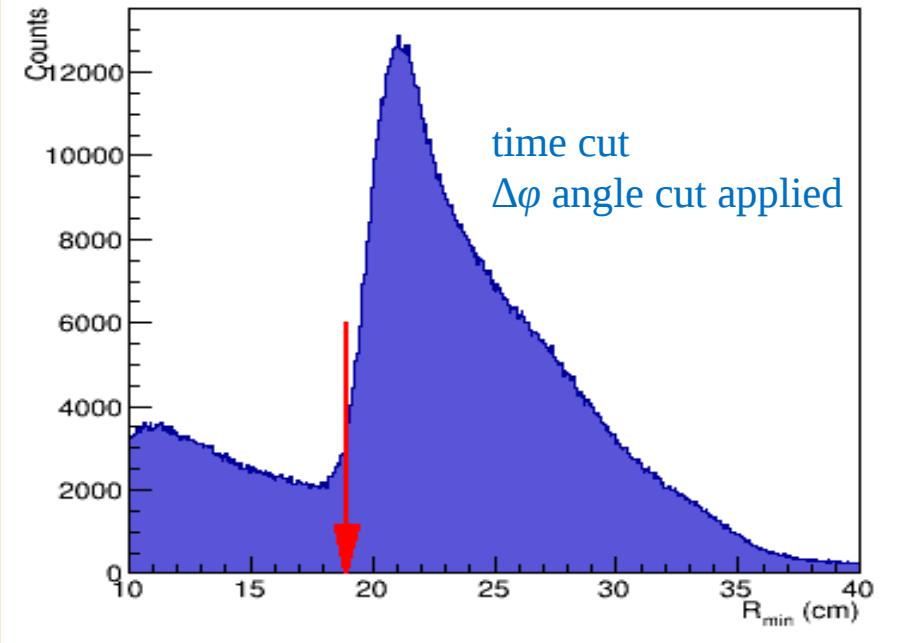
Δφ angle between two clusters in HyCal plane



Event Selection

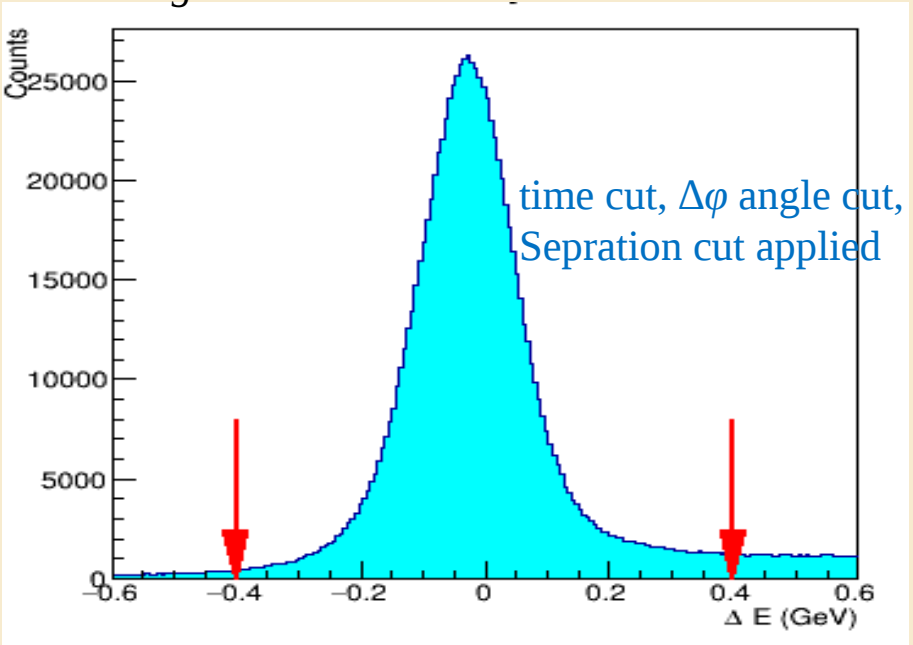
Cluster Separation (19cm) :

Cluster Seperation , distance between two cluster s



Elasticity (-0.4 ~ 0.4 GeV) :

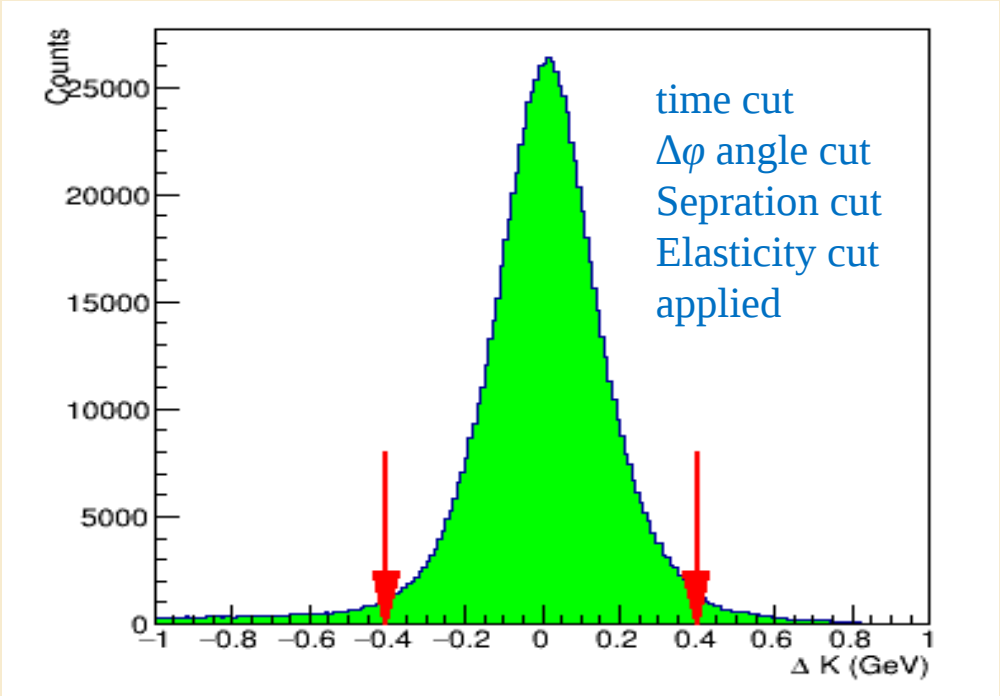
Elasticity = Photon beam energy - Sum of clust ers energies



Event Selection

Kinematic Energy Difference (-0.4 ~ 0.4 GeV) :

Kinematic energy difference =
Sum of calculated cluster energies using Compton kinematics
- Sum of measured cluster energies



Yield Extraction

Yield

= Data – e+e- simulation - accidentals

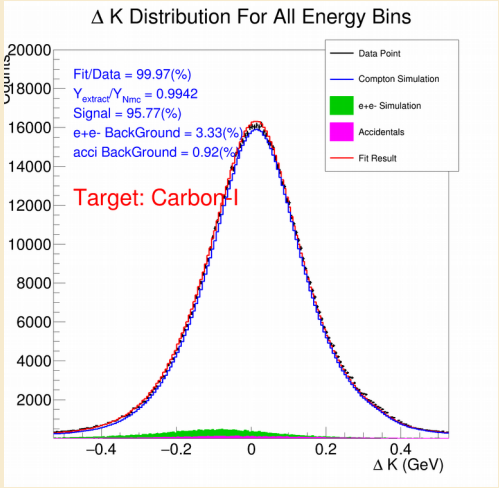
accidentals = estimated accidental coincidences

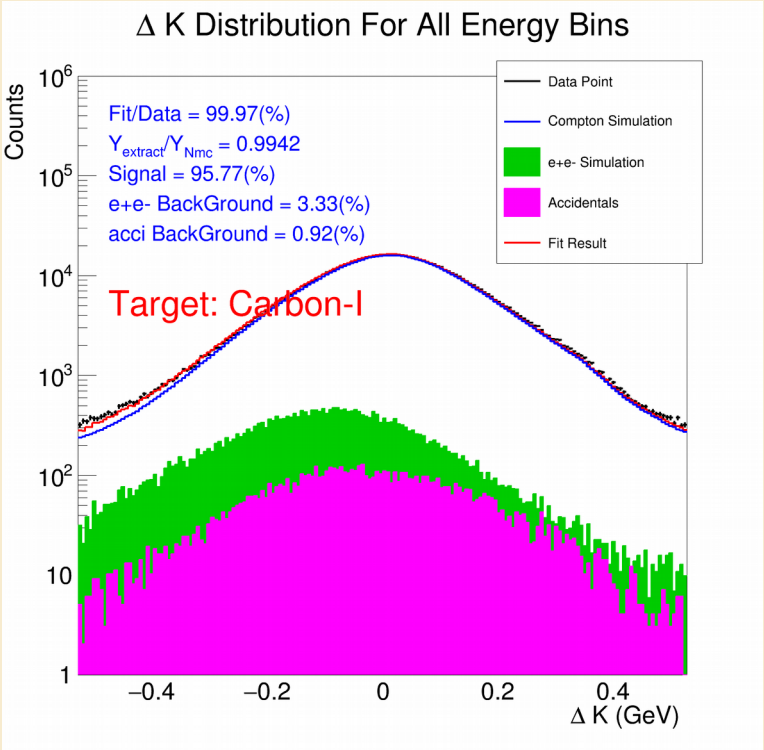
(using events in the tails of the time difference distribution)

Fit result

= e+e- + Compton simulation fit to data

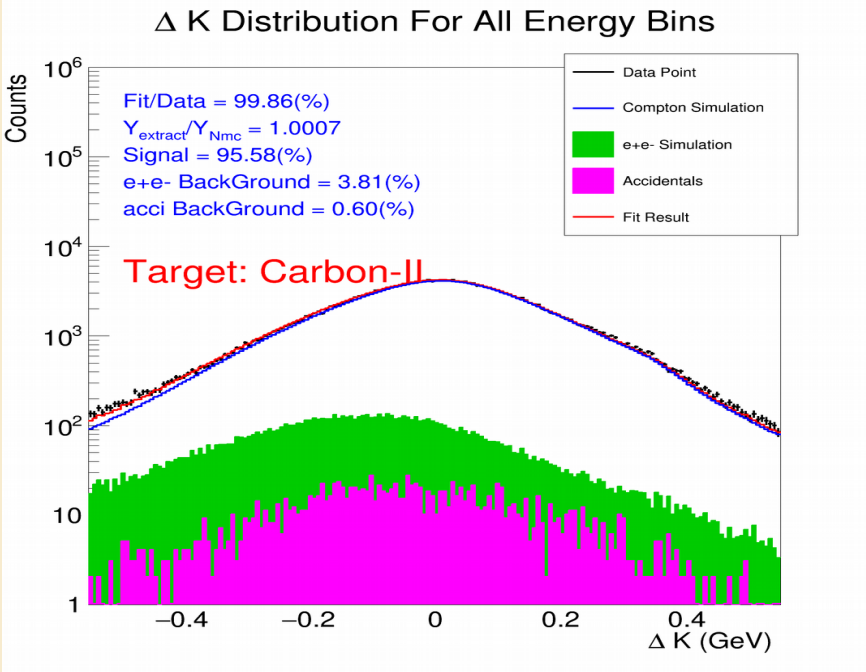
Carbon-I : Carbon(5% r.l.)

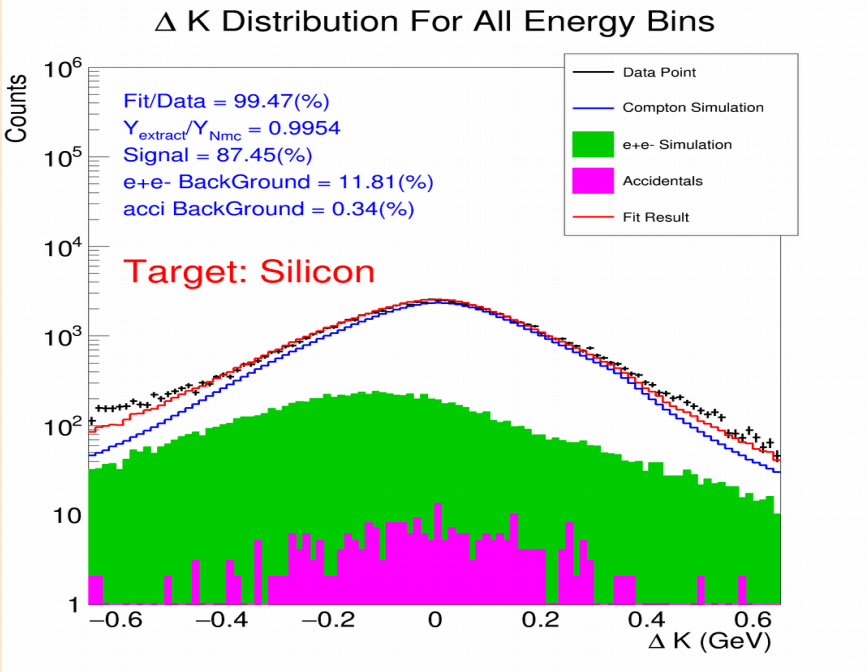




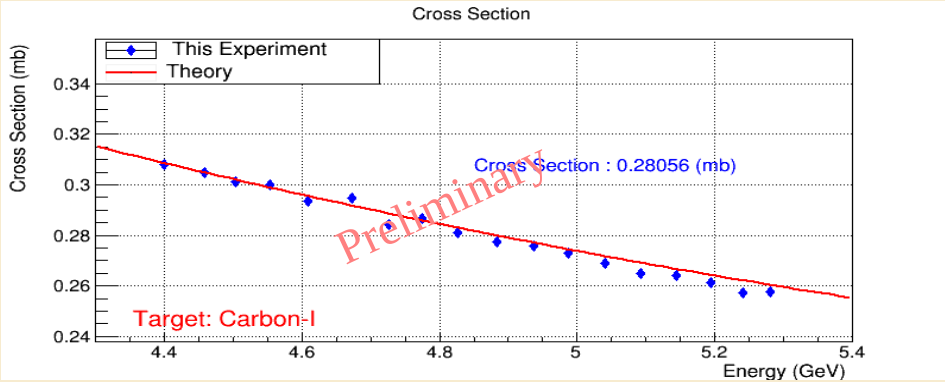
Yield Extraction

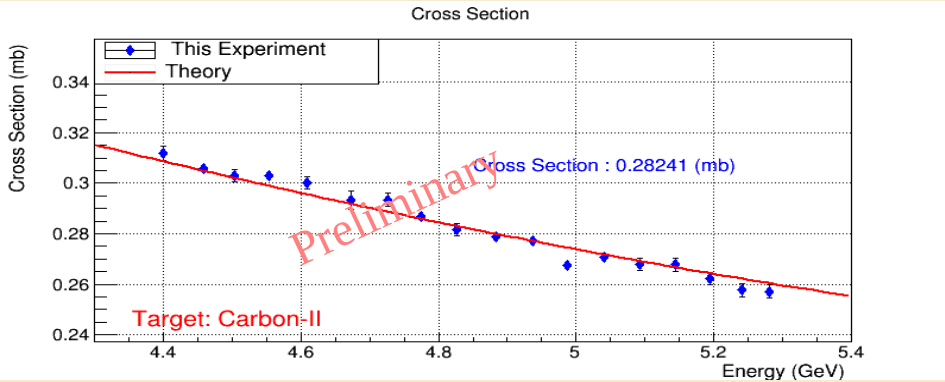
Yield from Carbon-II(8% r.l.) and Silicon using the same method as in previous slides

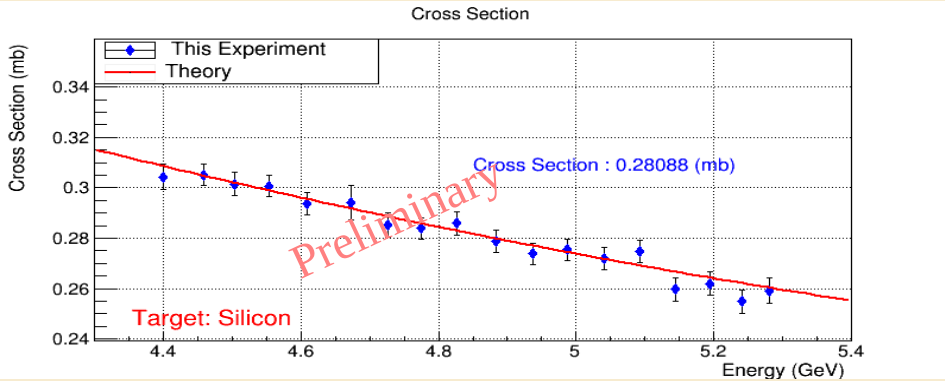




Cross Sections as Function of Energies





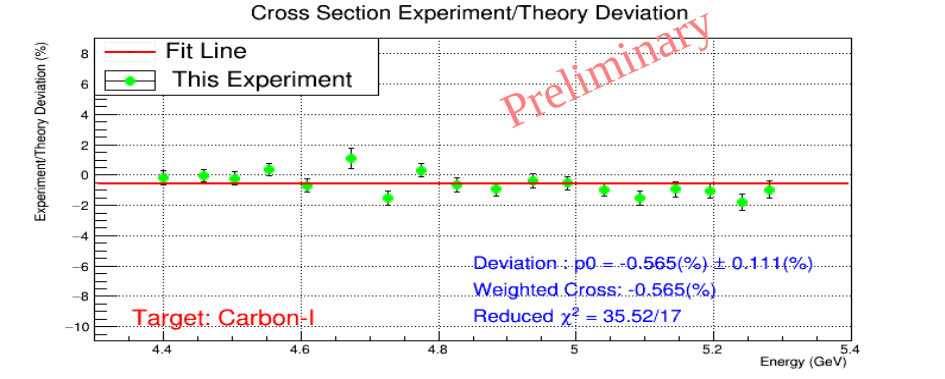


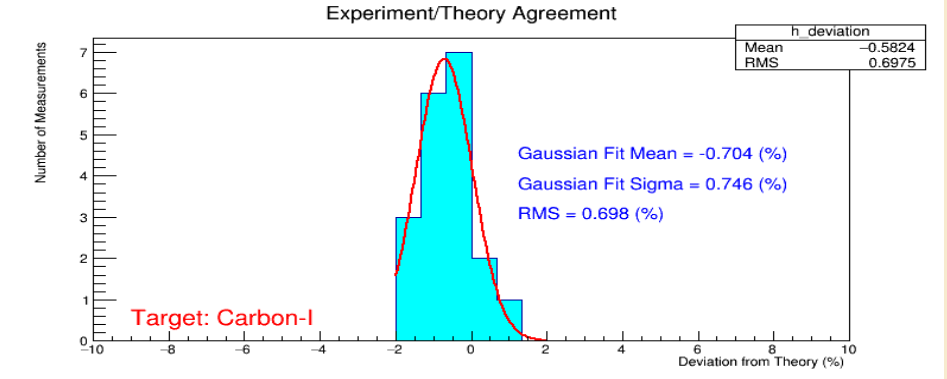
Cross section

= Yield / (Photon Flux×N_{Target}×Acceptance)

♦ Statistical uncertainty only

Experiment/Theory Deviation

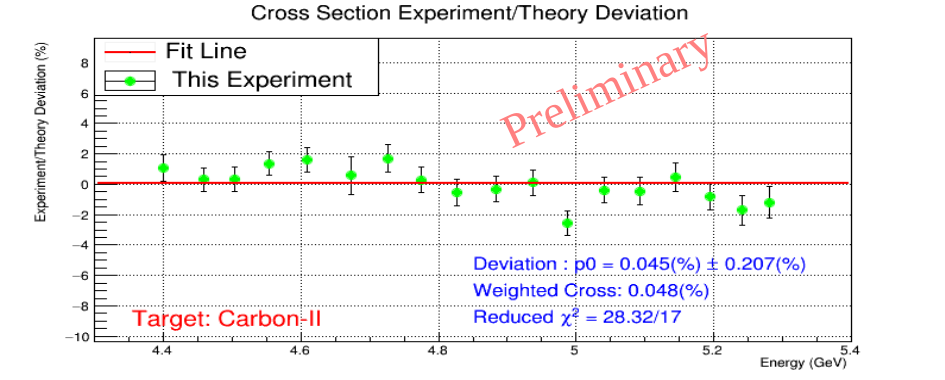


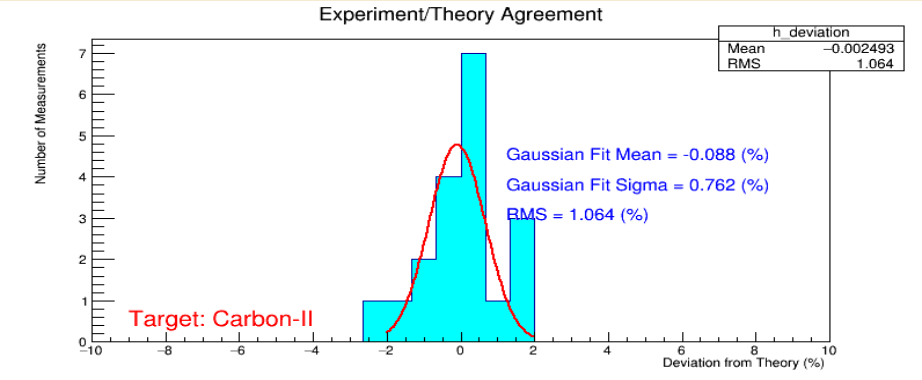


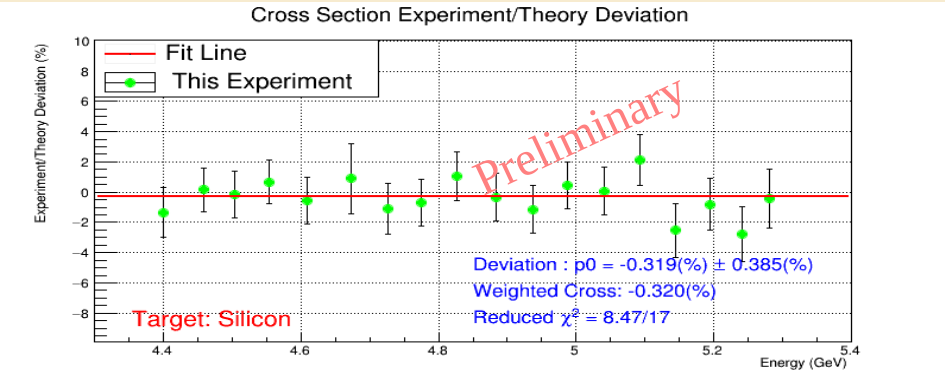
Deviation = Experiment/Theory - 1

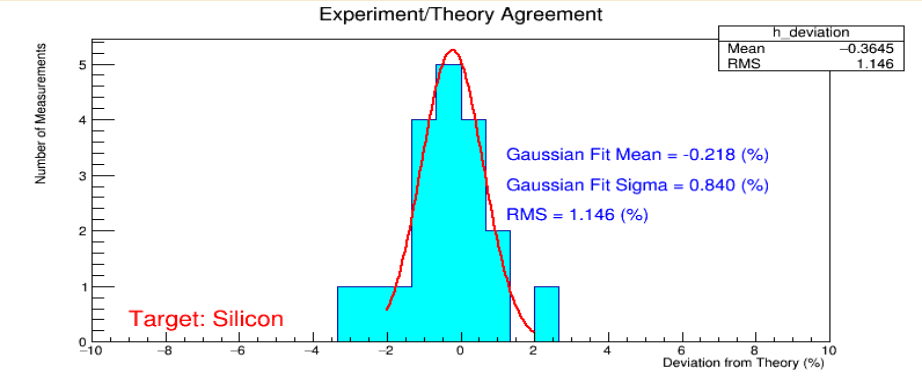
- Statistical uncertainty only

Experiment/Theory Deviation



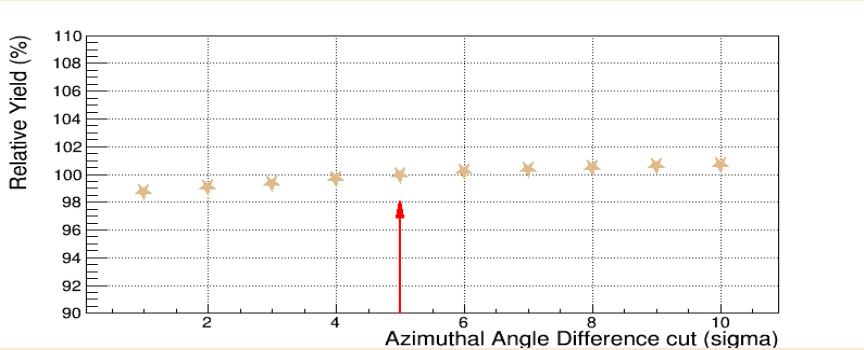


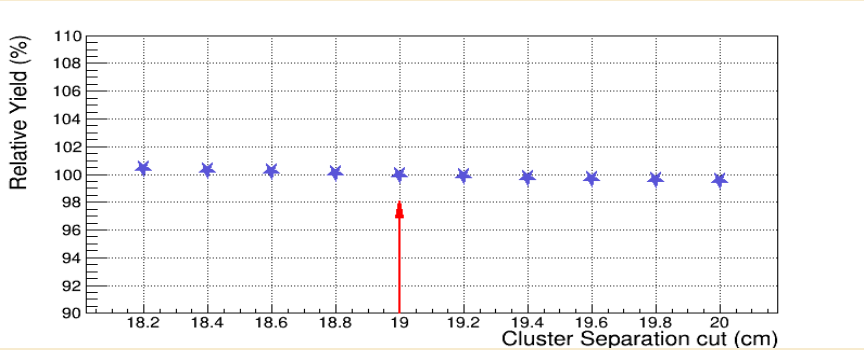


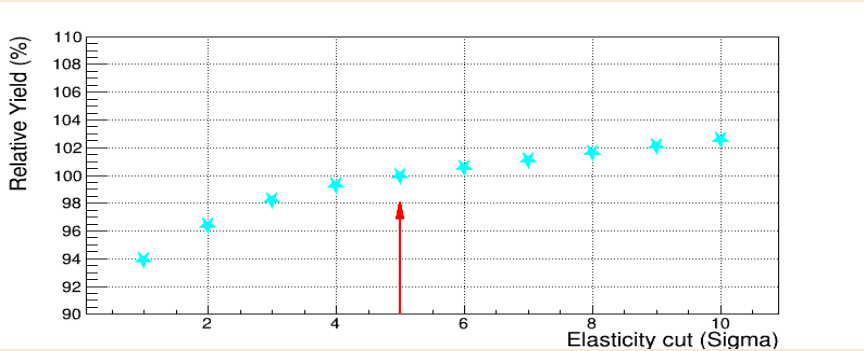


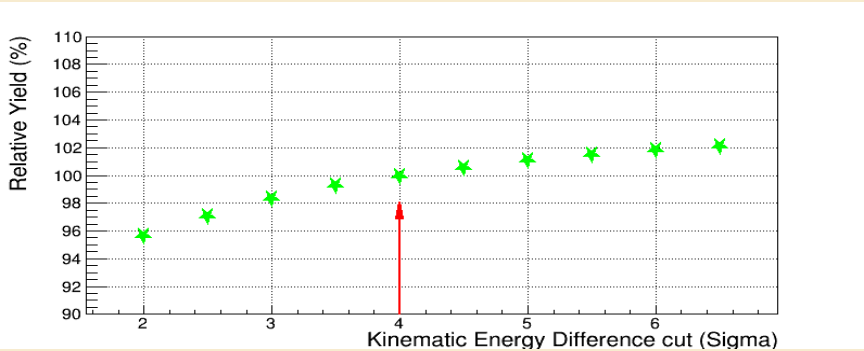
Systematic Study of Cuts Stability

All differences in yield relative to the final result









Systematic Uncertainties

All values are in %

Target	*Carbon-I*	*Carbon-II*	*Silicon*
Event selection	*0.68*	*0.88*	*0.54*
Signal/Background separation	*0.17*	*0.19*	*0.87*
Acceptance	*0.25*	*0.25*	*0.25*
Photon beam flux	*0.82*	*0.82*	*0.82*
Target	*0.02*	*0.04*	*0.35*
Total Syst.	*1.22*	*1.34*	*1.79*

Integrated Cross Sections

Target	*Energy (GeV)*	*Cross Section (mb)*	*Theory (mb)*	*Deviation (%)*	*Syst. Error (%)*	*Stat. Error (%)*	*Total Error (%)*
Carbon-I	*4.84*	*0.2806*	*0.2822*	*-0.57*	*+/- 1.22*	*+/- 0.11*	*+/- 1.22*
Carbon-II	*4.84*	*0.2824*	*0.2822*	*0.19*	*+/- 1.34*	*+/- 0.21*	*+/- 1.36*
Silicon	*4.84*	*0.2809*	*0.2822*	*-0.46*	*+/- 1.79*	*+/- 0.39*	*+/- 1.83*

Summary

- Compton scattering is one of the fundamental reactions in QED.
- The Compton cross sections for the energy range of 4.4-5.3 GeV were measured with precision of 2% for the first time.
- The Compton results validated that the systematic uncertainties of the PrimEx-II experiment for the pi0 lifetime measurement were controlled at level of 2%.
- Extracted cross sections are in a good agreement with the theory prediction.