Photo-production of $\pi^+\pi^-\pi^0$ using CLAS-g12 at Jefferson Laboratory

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CLAS Collaboration Meeting June 2017

06/15/2017

Outline

- CLAS-g12 Experiment
- Background & Motivation
- Data Analysis
- Preliminary Result
- Summary and Outlook

CLAS-g12 Experiment

The Beauty of CLAS-g12 :

- High Energy
- High Statistics/Luminosity
- Serve as the “bridge” between the low energy and the new upgraded energy at JLAB.
- The g12 run group have an approved common analysis procedure.

g12 Experiment :

Electron Energy	5.7 GeV
Electron Degree of Polarization	67.2 %
Tagged Photon Energy	1.1 – 5.45 GeV
Target Material	Liquid Hydrogen
Target Polarization	Unpolarized
Photon Polarization	Circular

Background & Motivation

- We have analyzed $\gamma p \rightarrow p\pi^+\pi^-(\pi^0)$ channel based on approved g12 analysis notes :
  a. g12-specific corrections.
  b. photon flux calculation.
  c. TOF and Fiducial cut.
  d. Monte Carlo parameter
  e. Kinematic fitting parameter
  f. And many more..
- We then analyzed three dominant reactions that contribute to the $\gamma p \rightarrow p\pi^+\pi^-(\pi^0)$ channel :
  a. $\gamma p \rightarrow p\omega$
  b. $\gamma p \rightarrow p\eta$
  c. $\gamma p \rightarrow K^0\Sigma^+$

Physics Motivation

$\gamma p \to p\omega$	$\gamma p \to K^0\Sigma^+$	$\gamma p \to p\eta$
High statistic isospin filter -> Benchmark measurement	Assess the validity of SU(3) quark model in describing resonance decay	Assess the validity of SU(3) quark model in describing resonance decay
Missing baryon resonance study through vector meson photo production	The strangeness production study through Isospin related channel	Testing the model of η photo production at higher energy using FESR by JPAC
	Missing baryon resonances study	
	There have been many attempts to measure the $\gamma p \to K^0\Sigma^+$ cross section (not yet published)	

Data Analysis

- Signal-Background separation using Q-factor methods
  a. Locating the peak
  b. Define kinematic distance to find nearest neighbor
  c. Fit using signal and background pdf
  d. Determine the signal/background fraction and Q-value
- Normalization
  a. Detector Acceptance (Monte Carlo simulation)
  b. Photon flux normalization
  c. Trigger simulation
  d. Multiple photon correction

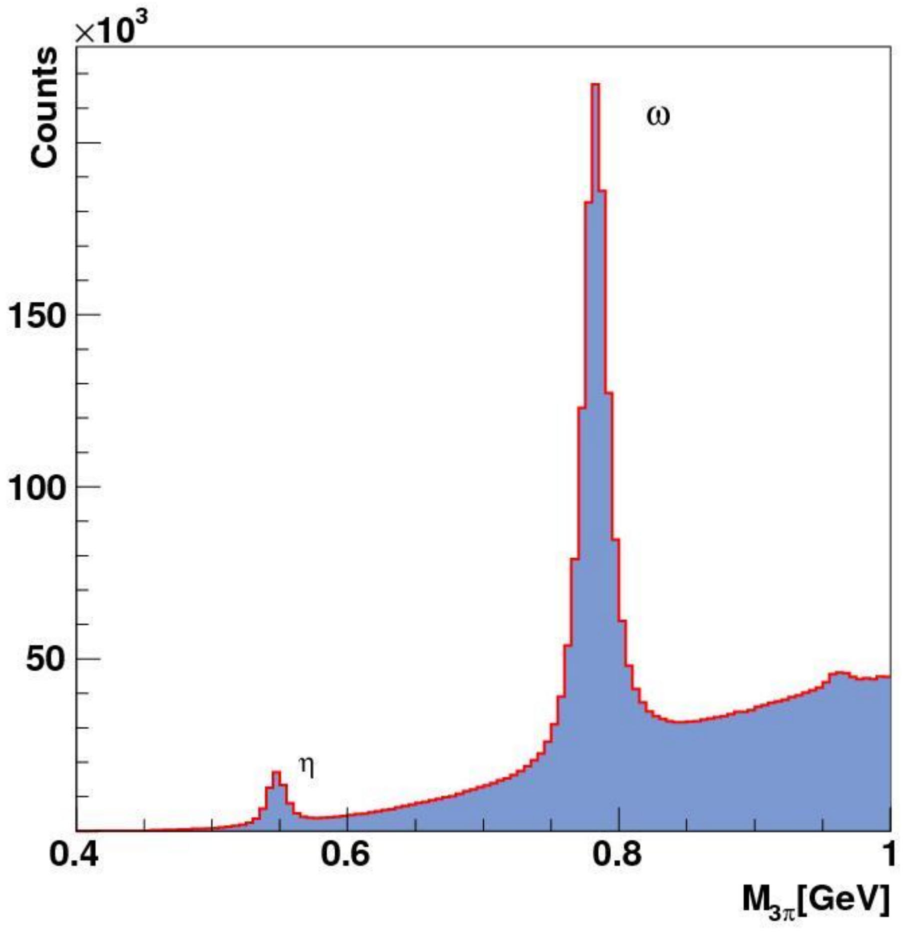
Locating the peak/coordinate reference

Since $\eta/\omega \rightarrow \pi^+\pi^-\pi^0$,we use the $M_{3\pi}$ as the coordinate reference for the $\gamma p \rightarrow p\eta/\omega$ channel.

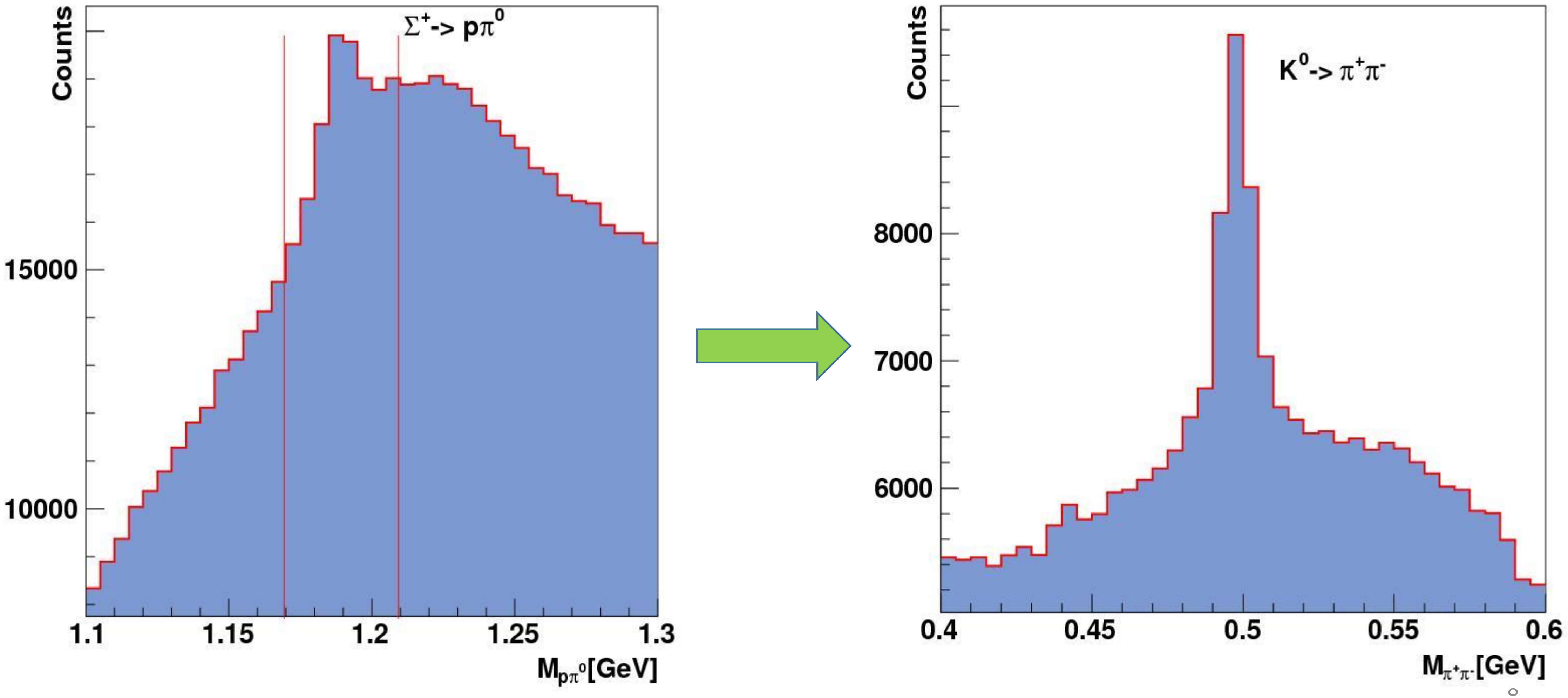
Since $\gamma p \rightarrow K^0\Sigma^+$ → $\Sigma^+ \rightarrow p\,\pi^0$

→ $K^0 \rightarrow \pi^+\pi^-$

We use the $M_{\pi\pi}$ as the coordinate reference for the $\gamma p \rightarrow K^0\Sigma^+$ channel after applying a cut on sigma region.



Locating the peak/coordinate reference

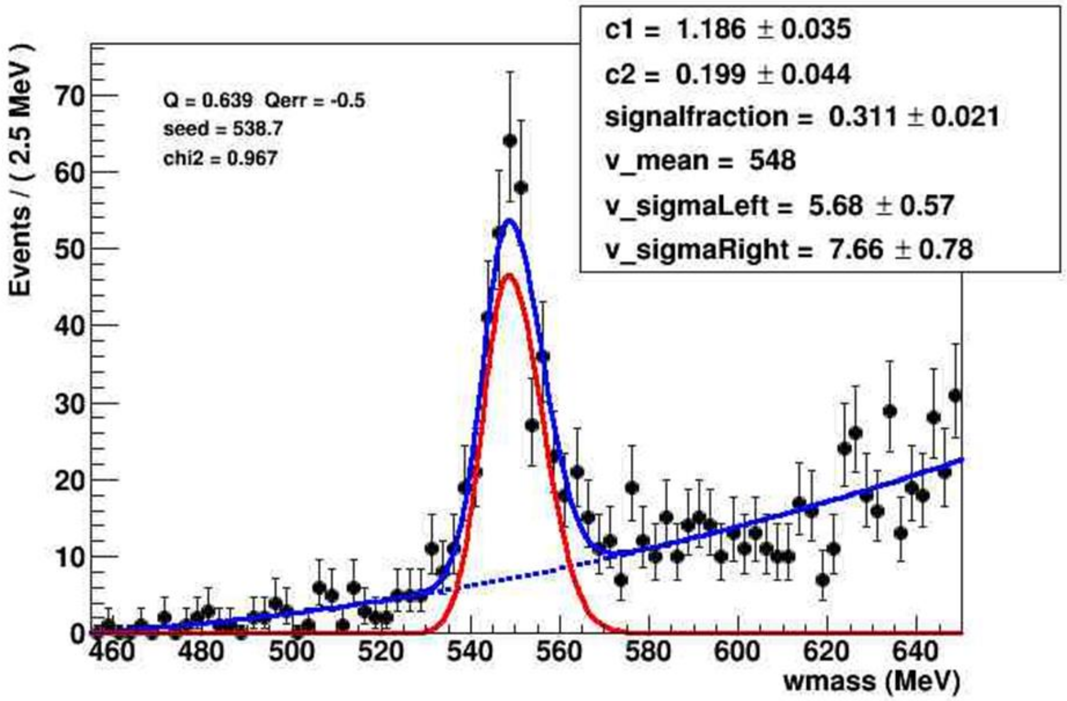


Q-factor methods

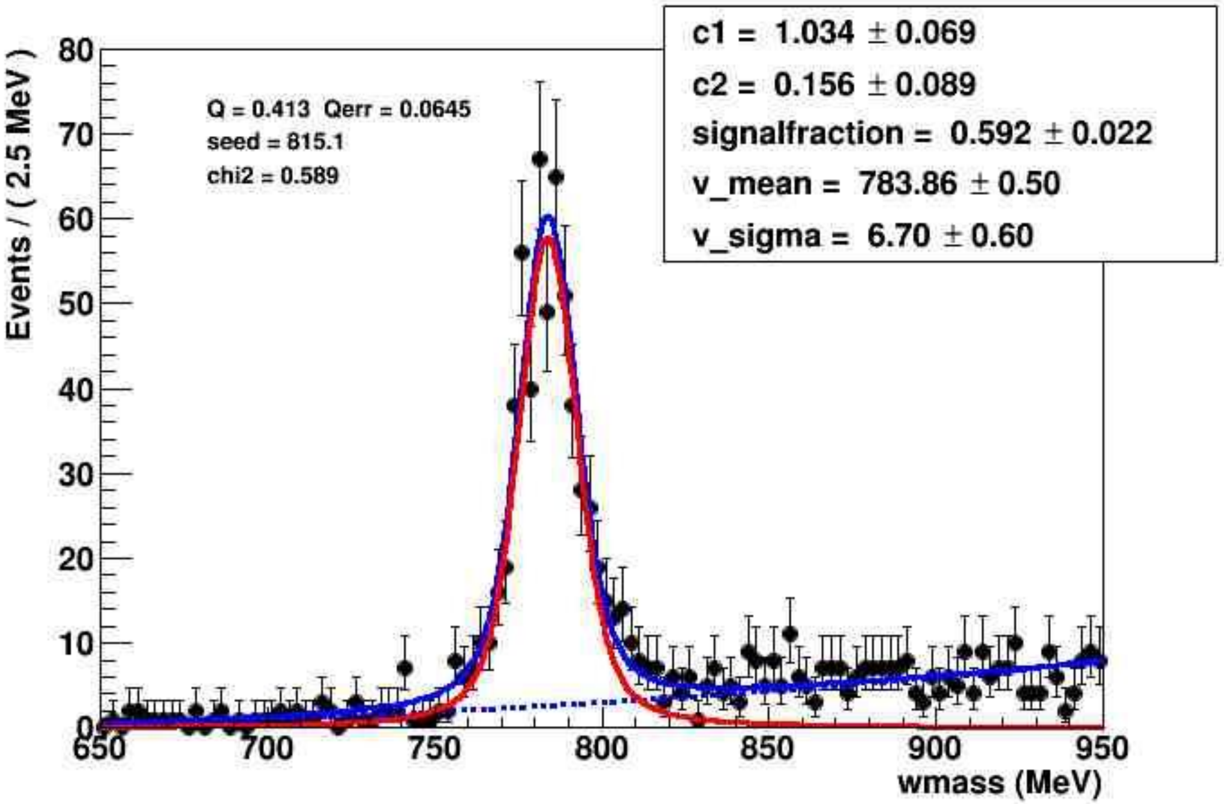
	$\gamma p \to p\omega$	$\gamma p \to p\eta$	$\gamma p \to K^0\Sigma^+$
Kinematic distance	$cos\theta^{\omega}_{c.m}$	$cos\theta^{\eta}_{c.m}$	$cos\theta^{K^0}_{c.m}$
	$cos\theta_{HEL}$	$cos\theta_{HEL}$	$cos\theta_{HEL}$
	φ_{HEL}	φ_{HEL}	φ_{HEL}
	λ	λ	E_γ
	φ_{Lab}	φ_{Lab}	φ_{Lab}
			$cos\theta_{K\Sigma}$
Number of neighbor	1000	1000	300
Signal pdf	Voigt function	Bifurcated gaussian	Gaussian
Background pdf	2^{rd} order Chebyshev polynomial	2^{rd} order Chebyshev polynomial	2^{rd} order Chebyshev polynomial

Notes : λ is a property of a vector meson. It is proportional to the decay amplitude and a function of pion momentum and kinetic energy.

Q-factor methods : Fit example

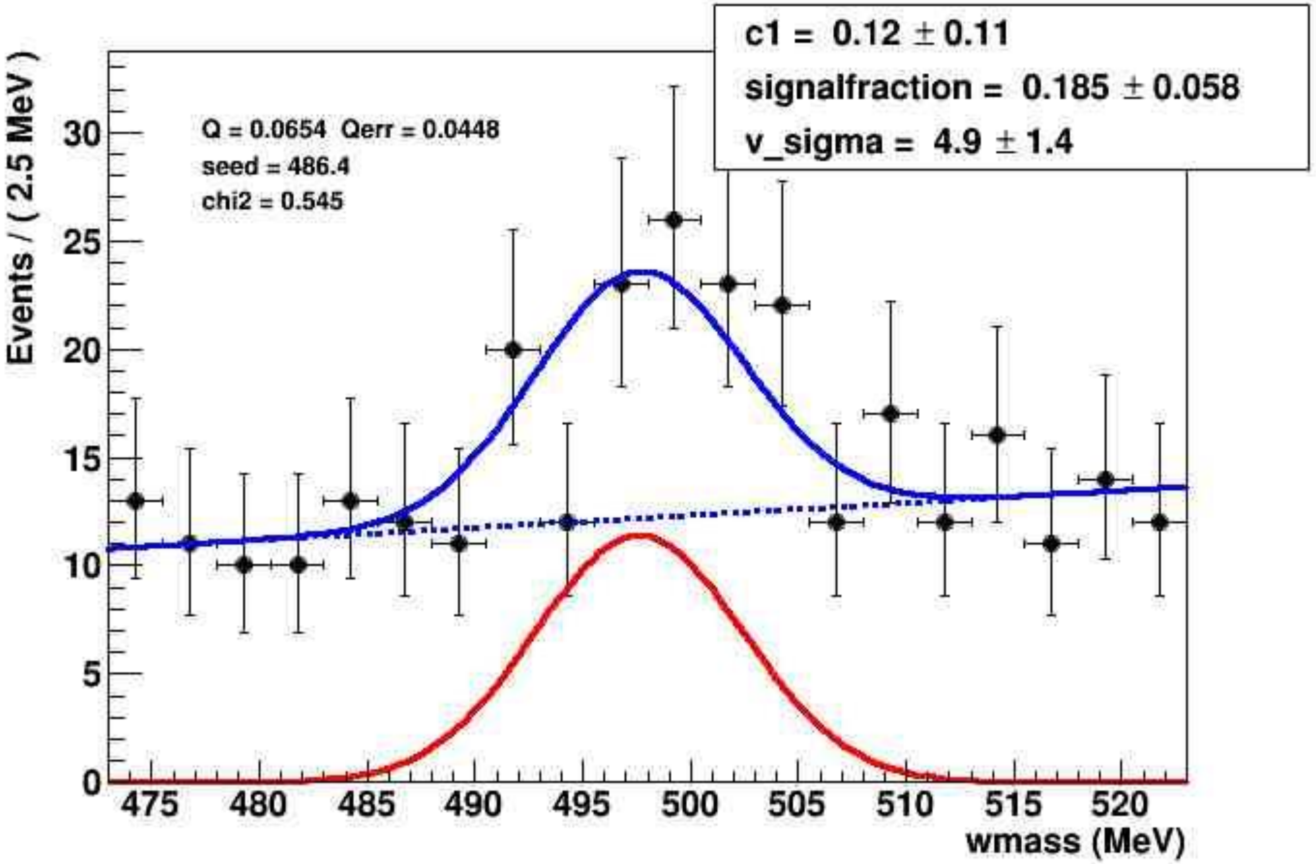


Fit example for an η event.



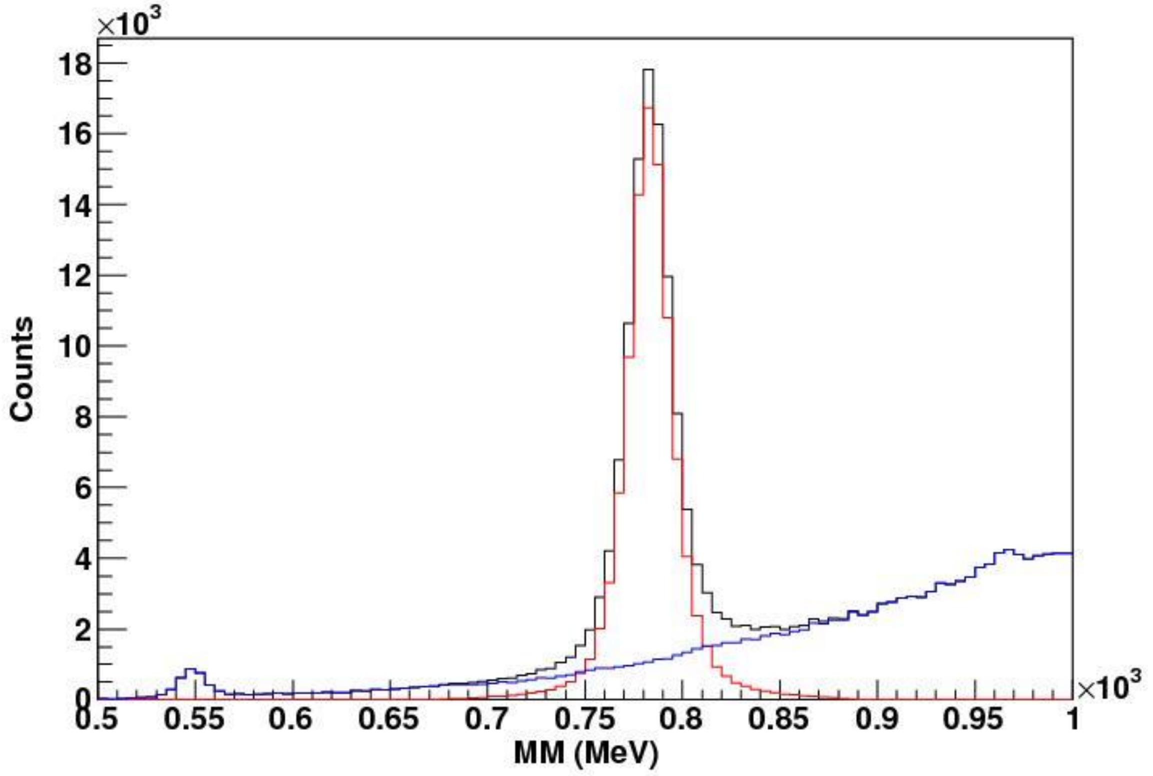
Fit example for an ω event.

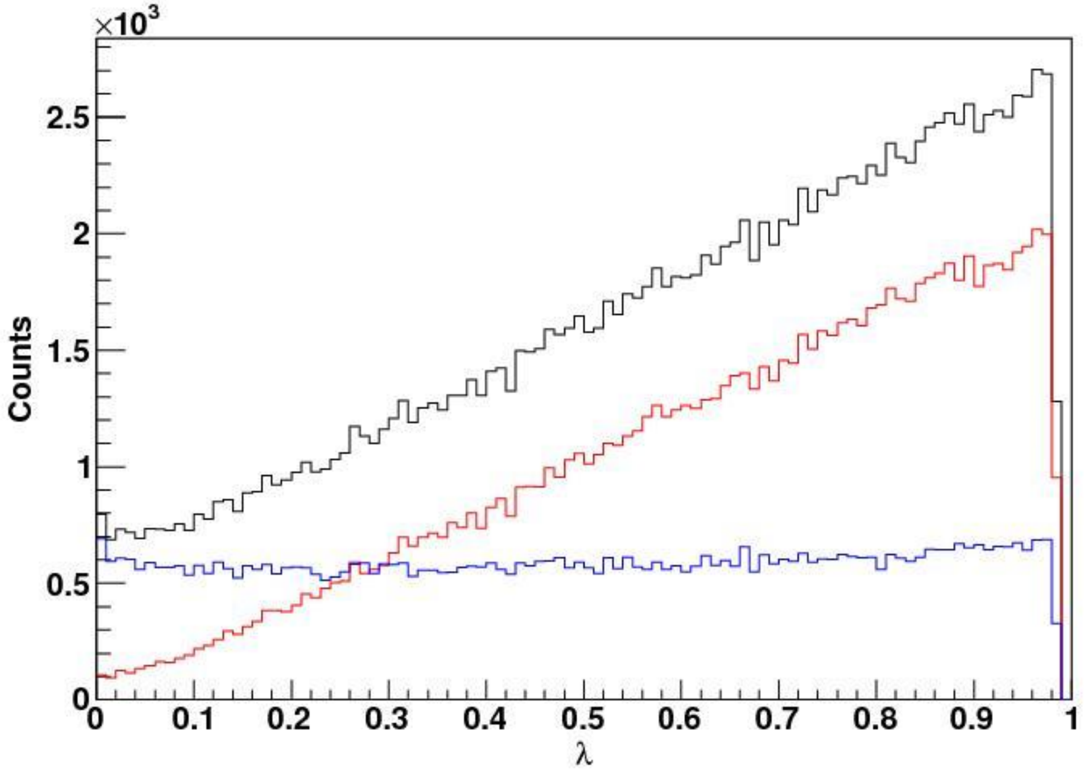
Q-factor methods : Fit example



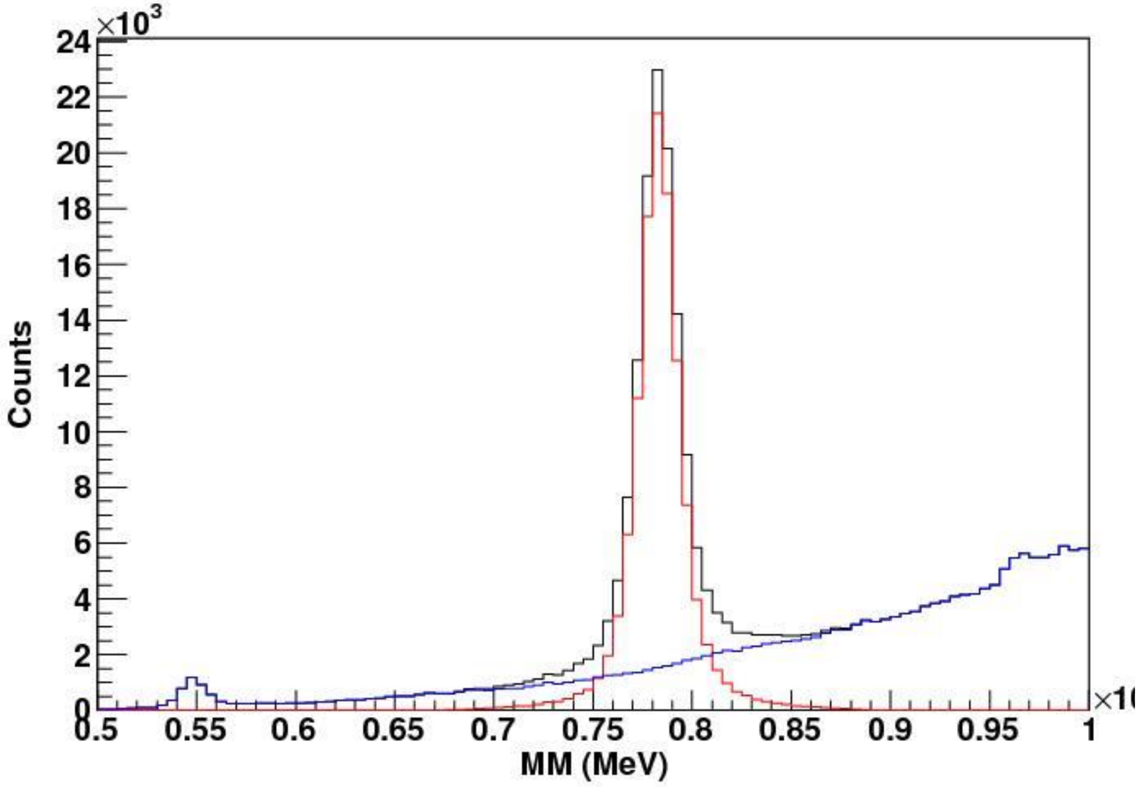
Fit example for a K^0 event.

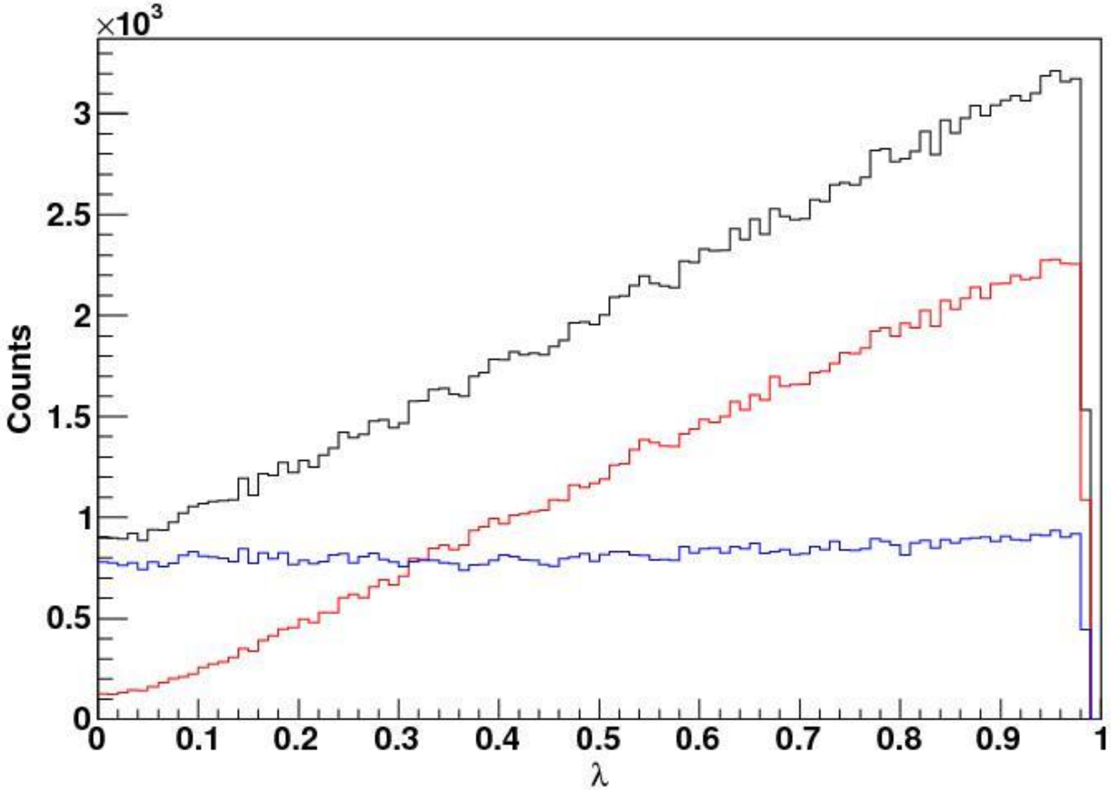
Q-factor methods : result for ω ($E_\gamma = 2.125\ GeV$)



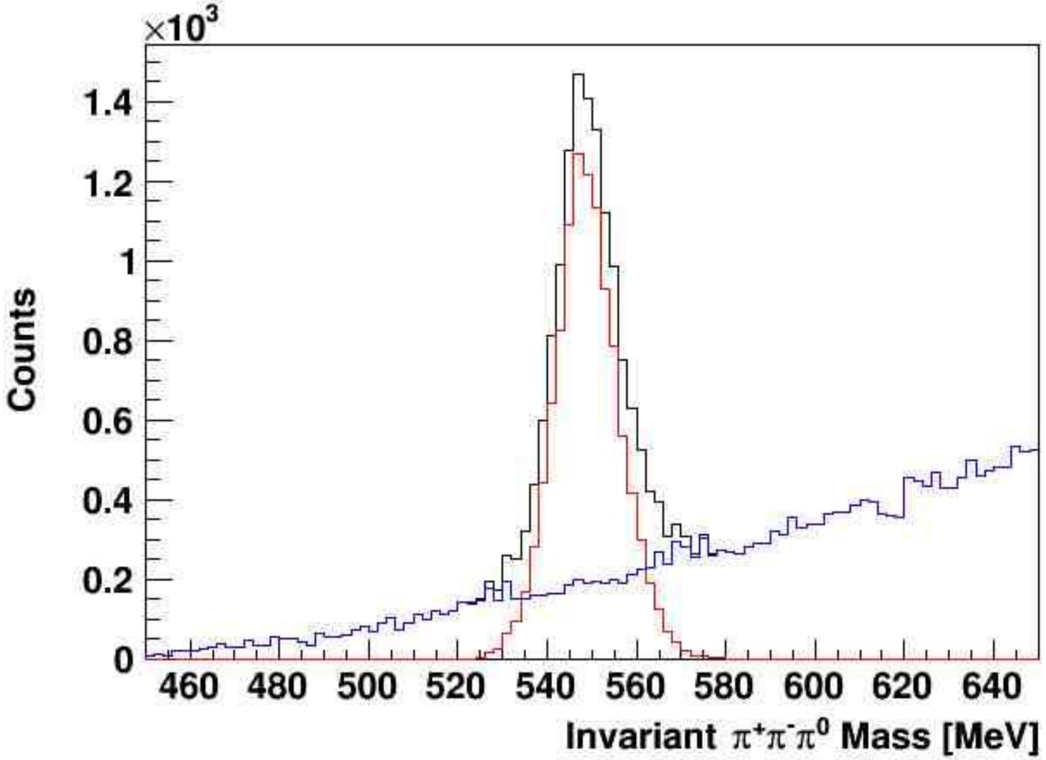


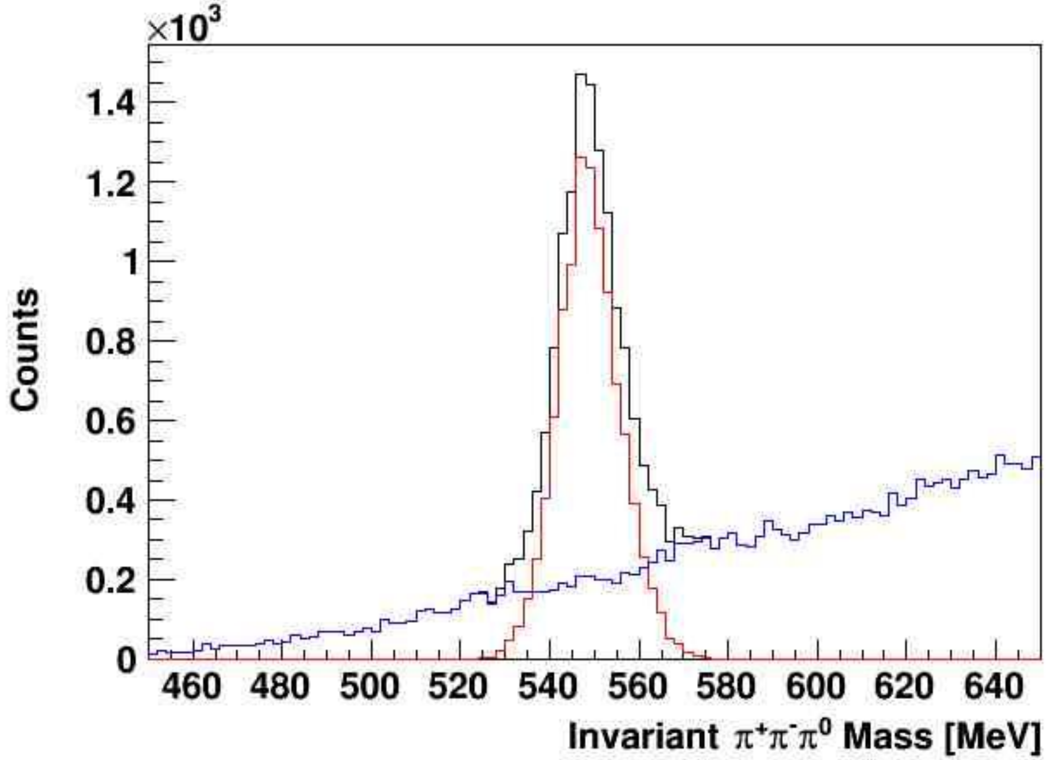
Q-factor methods : result for ω ($E_\gamma = 1.925\ GeV$)





Data Analysis : Q-factor result for η ($E_\gamma = 1.85\ GeV$ & $2.05\ GeV$)





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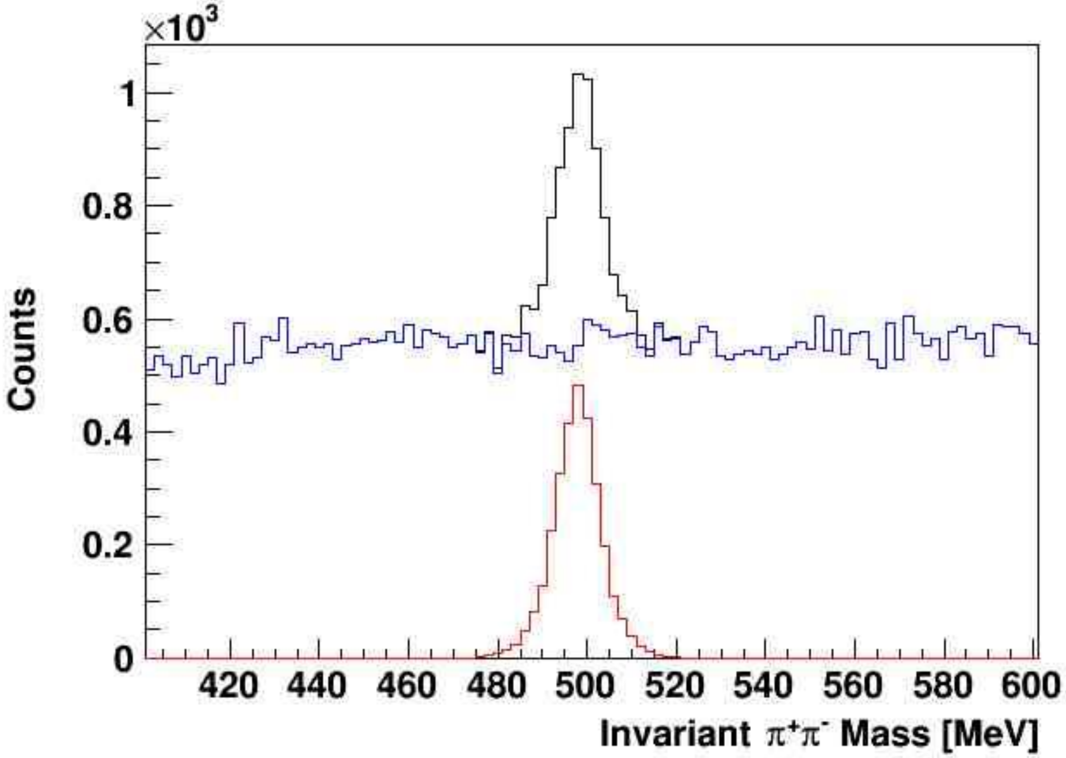
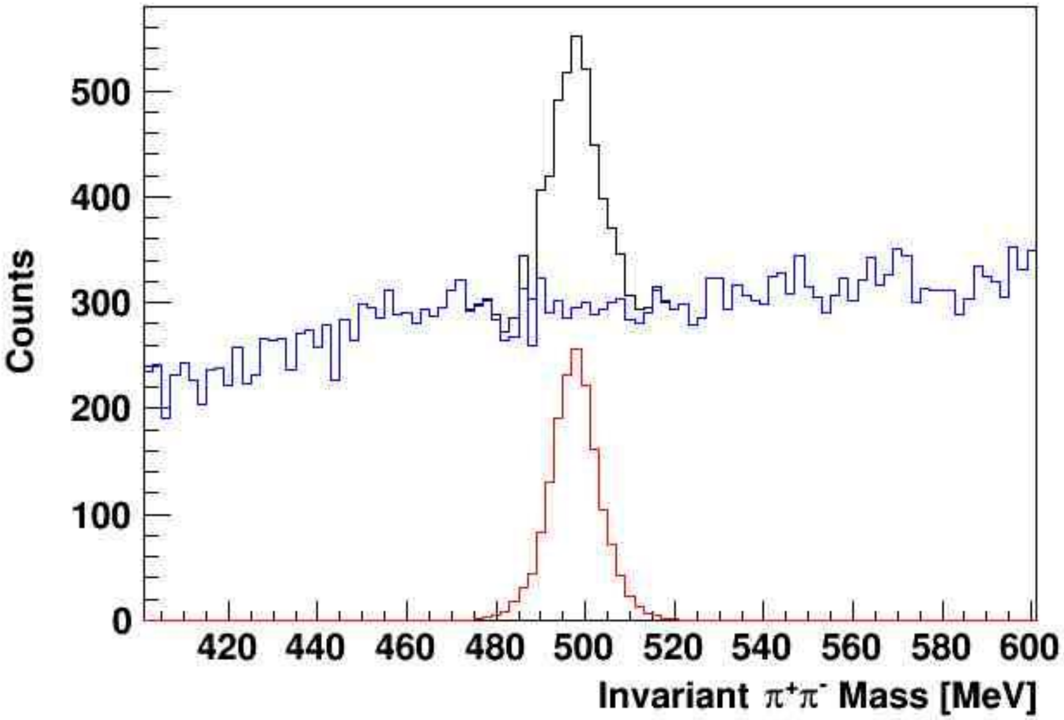
Data Analysis : Q-factor result for K^0 (E_γ =1.95 GeV & 2.35 GeV)





Data Analysis : Differential Cross section

- Differential cross section is the number of events (sum over Q-value) normalized by photon flux, target factor and branching ratio.

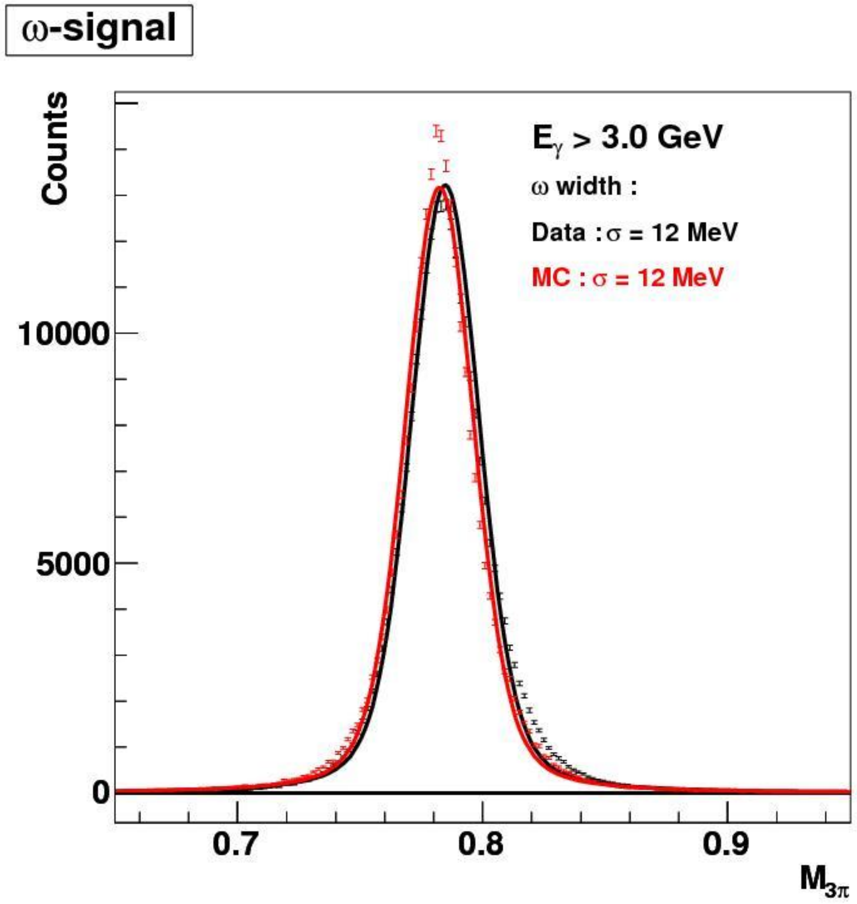
$$\frac{\mathrm{d}\sigma}{\mathrm{d}\Omega} = \frac{N_{\text{reaction}}}{A_{\text{reaction}}} \frac{1}{N_\gamma\, \rho_{\text{target}}} \frac{1}{\Delta\Omega} \frac{1}{BR},$$

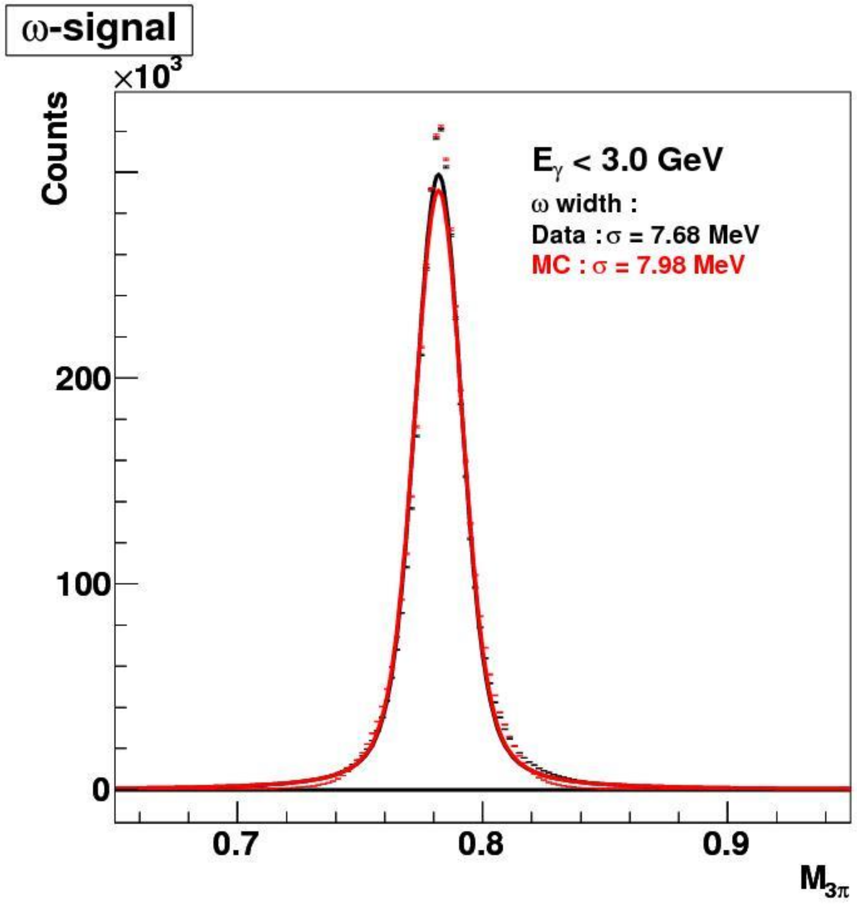
where

ρ_{target} :	target area density
N_{reaction} :	number of reconstructed data events in an $(E_\gamma, \cos\theta_{\text{c.m.}})$ bin
N_γ :	number of photons in an E_γ bin (photon flux)
A_{reaction} :	acceptance in an $(E_\gamma, \cos\theta_{\text{c.m.}})$ bin
$\Delta\Omega$:	solid-angle interval $\Delta\Omega = 2\pi\, \Delta\cos(\theta_{\text{c.m.}})$
BR :	decay branching fraction.

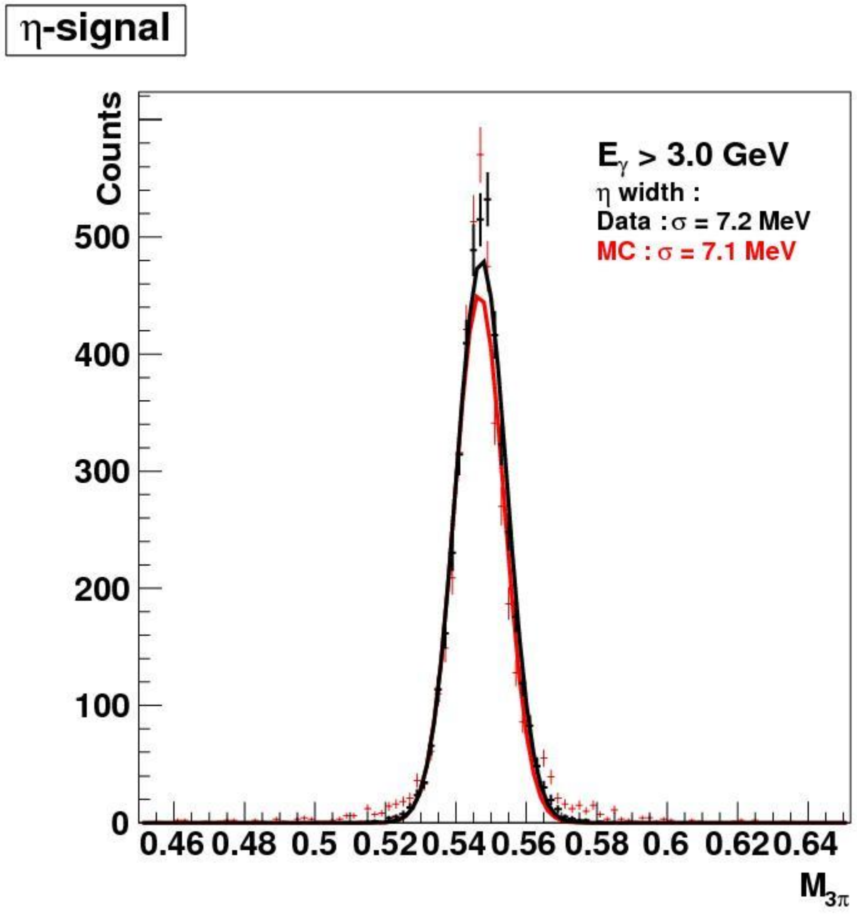
- The detector acceptance correction derived using Geant based Monte Carlo simulation.
- The next slide show how good are the Monte Carlo events mimic the detector resolution.
- Other corrections : Multiple photon correction and trigger simulation will be presented on the next opportunity.

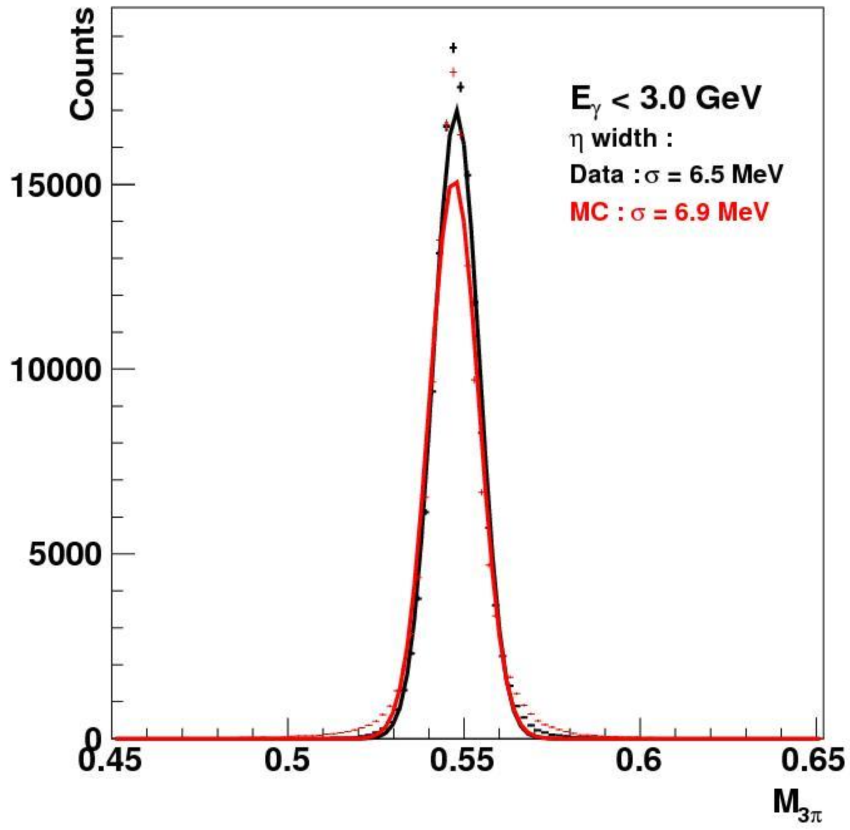
Data Analysis : ω Monte Carlo



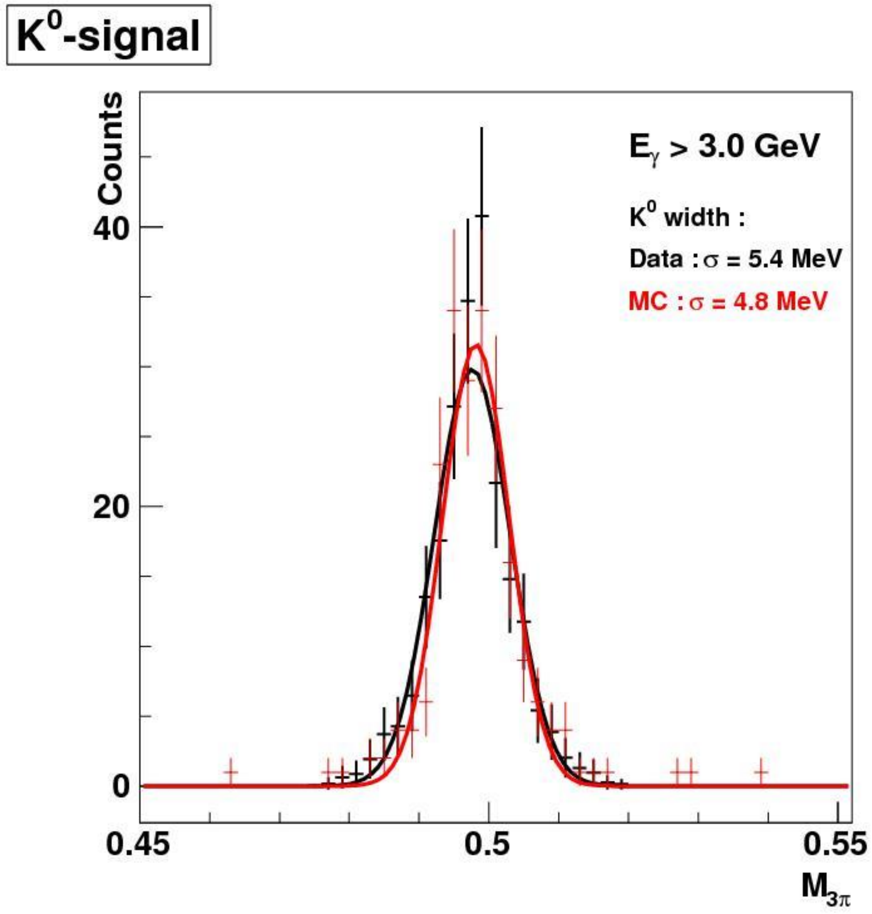


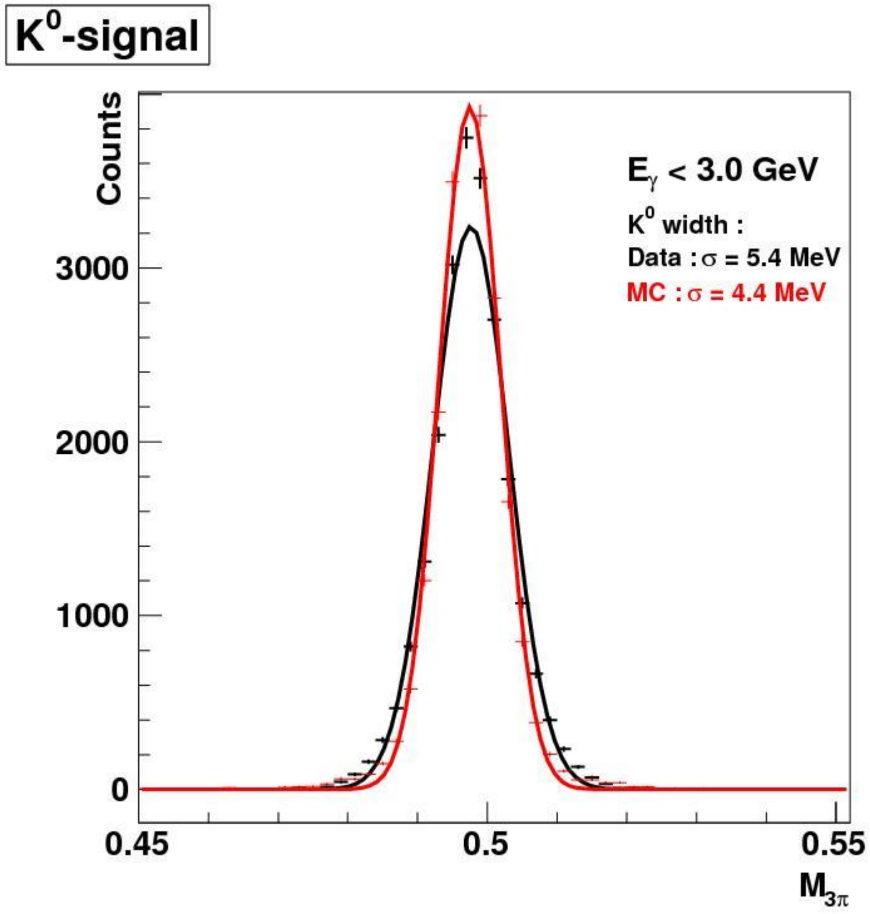
Data Analysis : η Monte Carlo



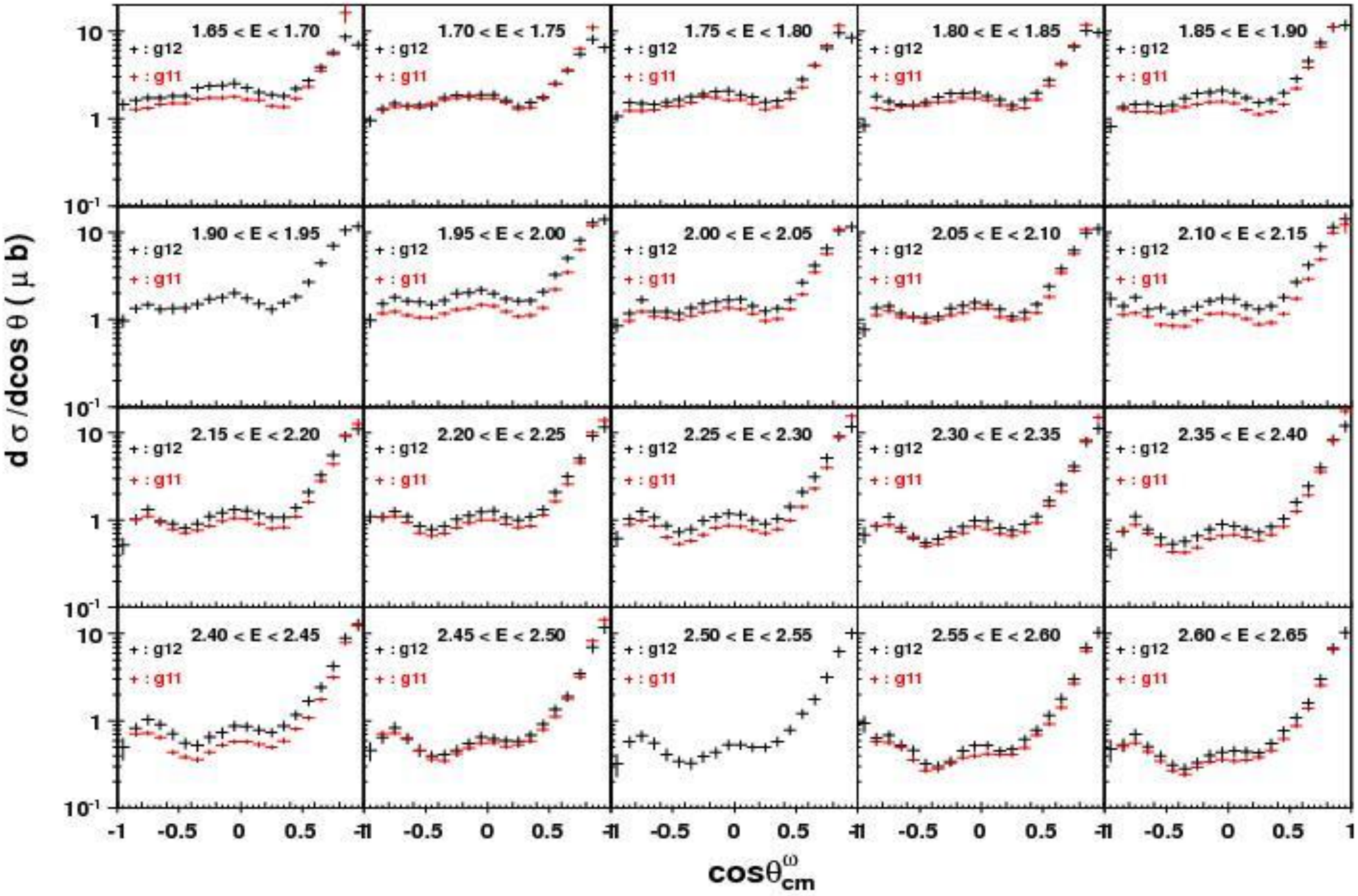


Data Analysis : K^0 Monte Carlo



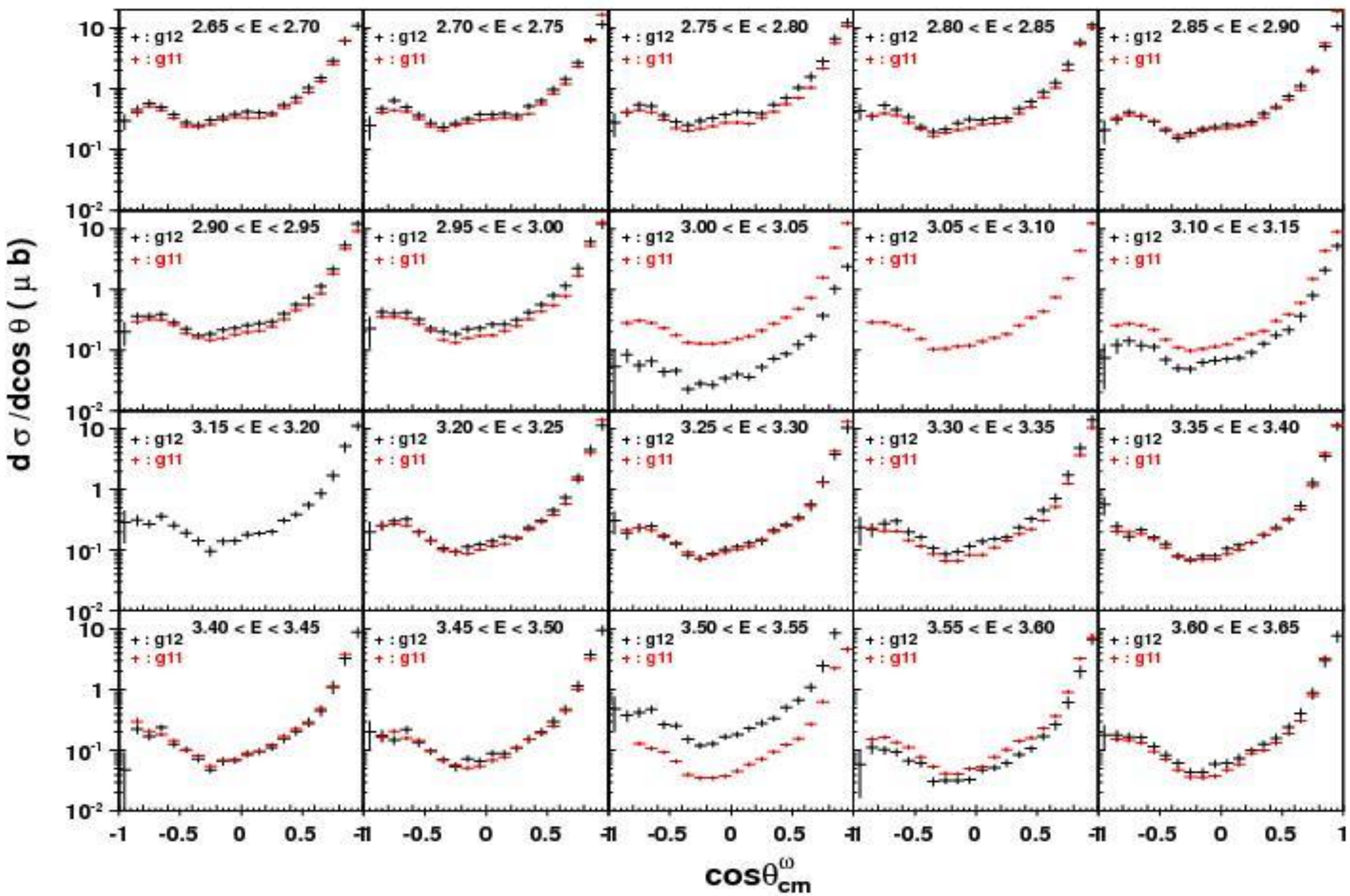


Preliminary result : Differential Cross Section of γp -> pω



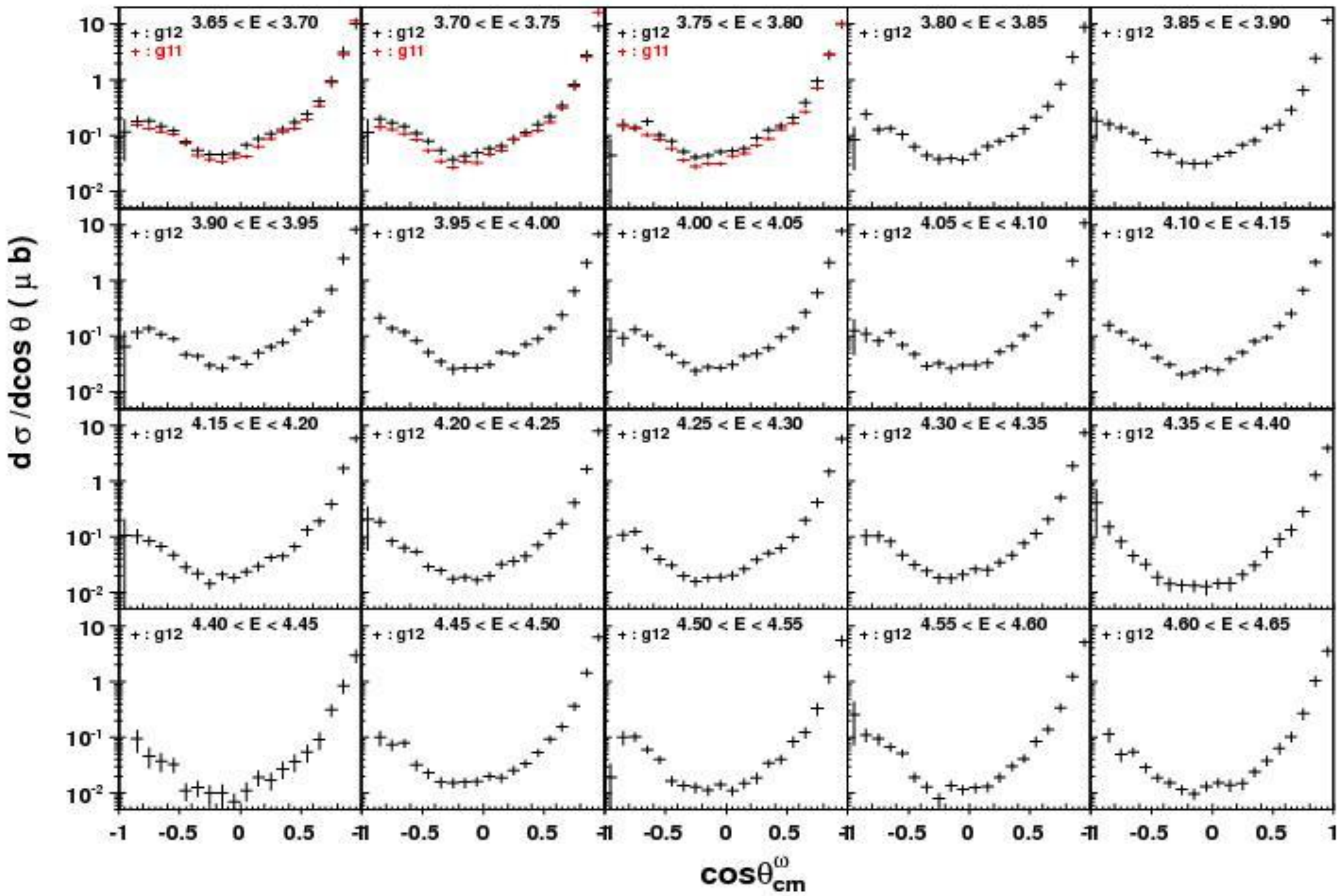
Some energy bins show that the g12 cross section look slightly higher due to the binning effect.

Preliminary result : Differential Cross Section of γp -> pω

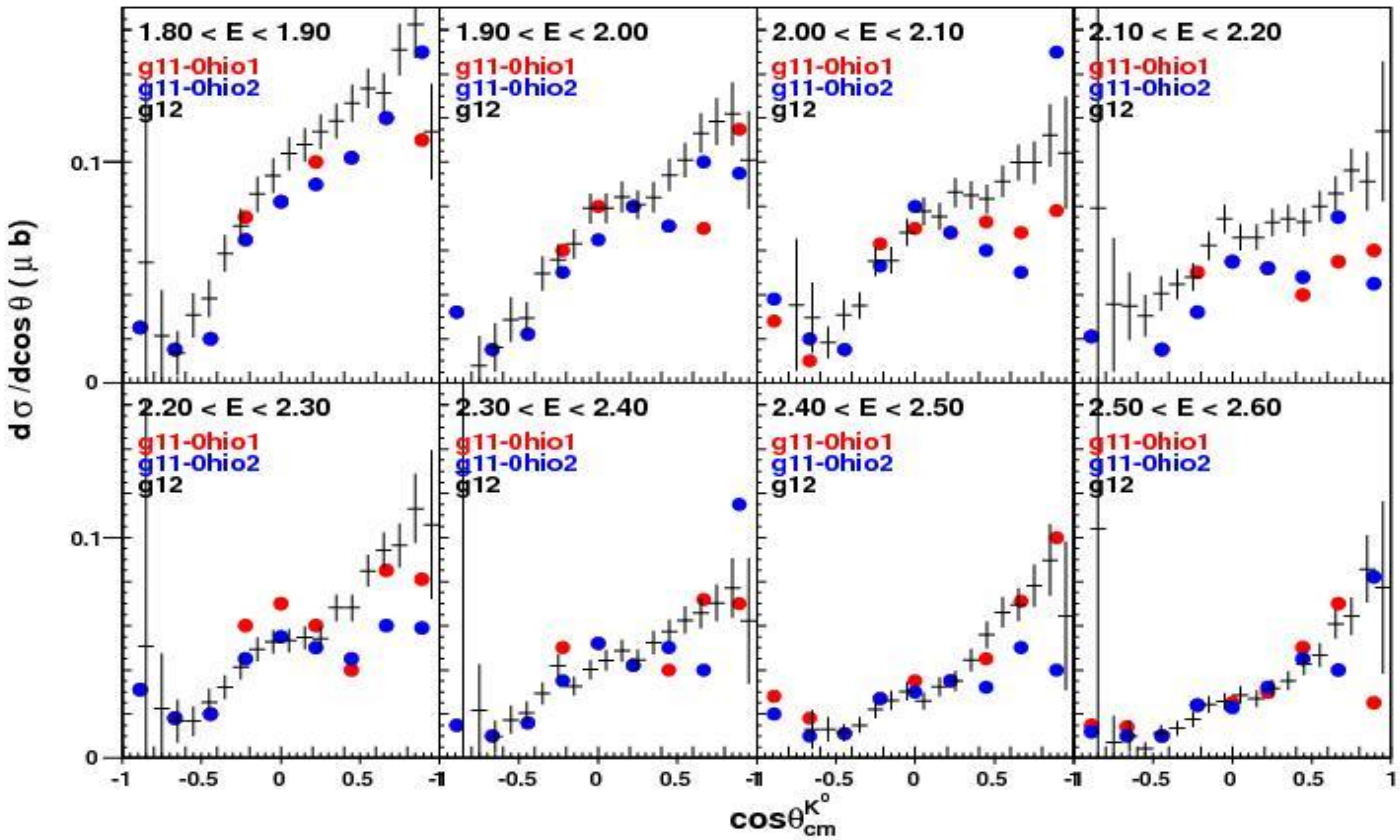


Notes : g12 has tagger problem around 3.0 GeV and 3.5 GeV

Preliminary result : Differential Cross Section of γp -> pω

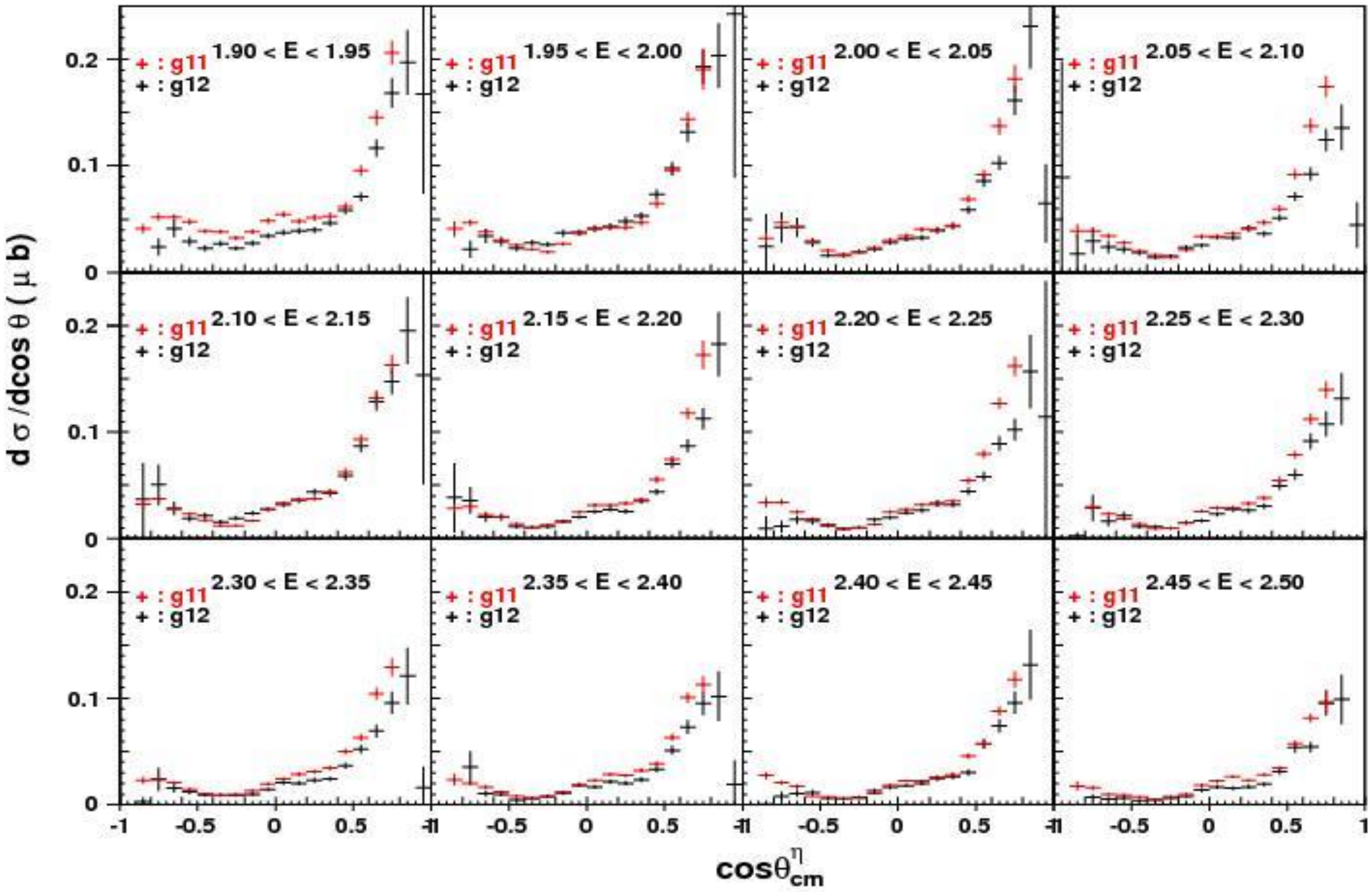


Preliminary result : Differential Cross Section of γp -> $K^0\Sigma^+$



Notes : g11-Ohio analysis (Wei Tang) was performed using two methods.

Preliminary result : Differential Cross Section of γp -> pη



Notes : The statistical error bars are dominated by the statistic of the Monte Carlo events. We are working to increase the number of the Monte Carlo events.

Summary & Outlook

- We have measured the differential cross section of $\gamma p \to p\omega/\eta/ K^0\Sigma^+$ from g12. The result are in fair agreement with previous measurement from g11.

Channel	Average ratio of g12/g11	g11 data
$\gamma p \to p\omega$	1.14	Mike Williams
$\gamma p \to p\eta$	Still Finalize	Mike Williams
$\gamma p \to K^0\Sigma^+$	1.1 – 1.2	Wei Tang

Summary & Outlook

- The Ongoing research using CLAS data in our group :

Run	Channel	Observable	Status	PIC
FROST	$\gamma p \to p\omega$	E	Wide Collaboration review	Zulkaida Akbar
FROST	$\gamma p \to p\omega$	Σ	Paper review	Priyashree Roy
g12	$\gamma p \to p\omega$	Cross section	Analysis note in preparation	Zulkaida Akbar
g12	$\gamma p \to p\eta$	Cross section	Analysis note in preparation	Zulkaida Akbar
g12	$\gamma p \to K^0\Sigma^+$	Cross section	Analysis note in preparation	Kyle Romines/Zulkaida Akbar
g12	$\gamma p \to p\varphi$	Cross section	Starting	Tianqi hu/Benjamin Gibson
g12	$\gamma p \to p\omega$	SDME	Paused	Chris Zeoli/Zulkaida Akbar
g12	$\gamma p \to p\pi^+\pi^-$	Cross section & Polarization observable	Will start in Fall	Zulkaida Akbar

Thank You