Photoproduction of $K^0 \Sigma^+$ with CLAS

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for the CLAS Collaboration

Physics Motivation

Photoproduction of associated strangeness :

Channels:

significant data exist:
$\gamma p \rightarrow K^+ \Lambda$
$\gamma p \rightarrow K^+ \Sigma^0$

more data required to test theoretical predictions:
$\gamma p \rightarrow K^0 \Sigma^+$ (this analysis)
$\gamma n \rightarrow K^+ \Sigma^-$

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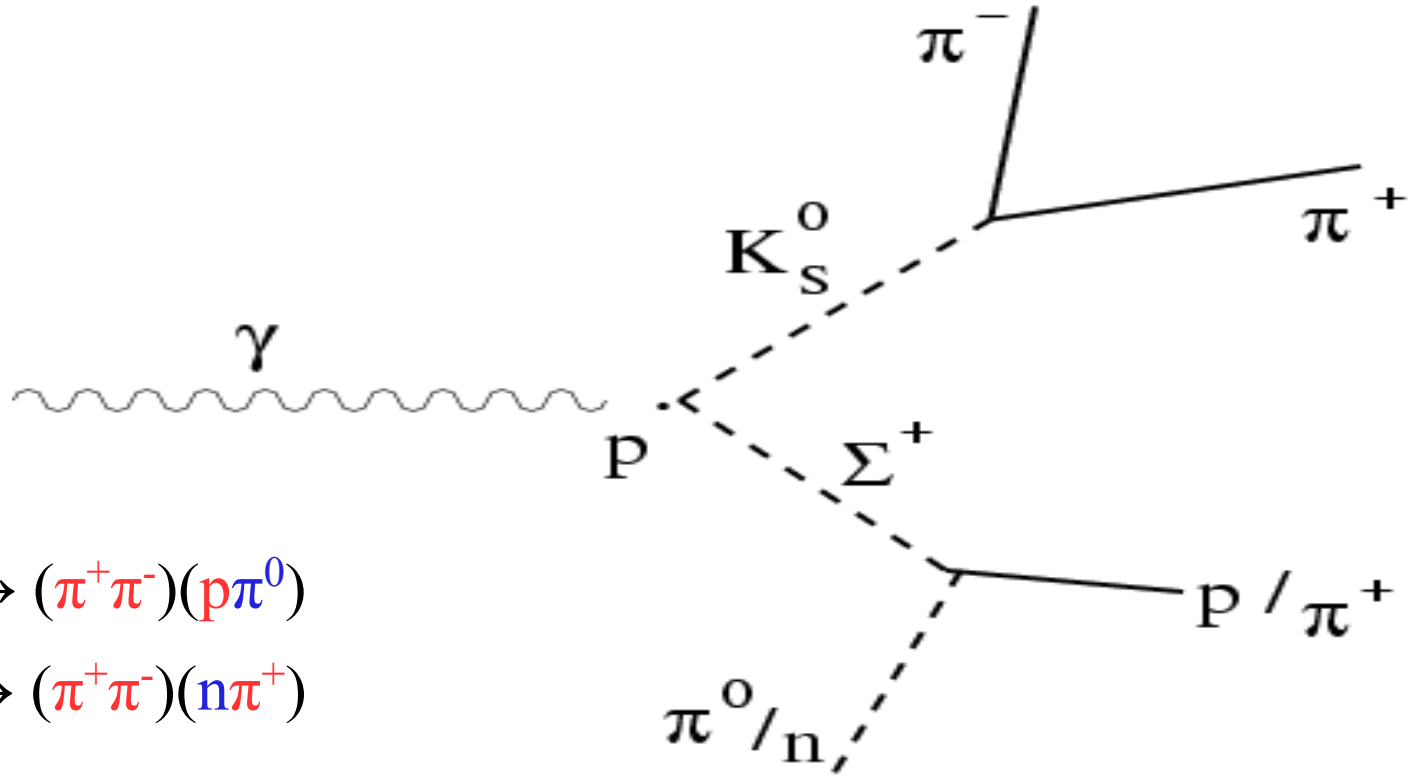
→couplings in SU(3)

$$G_{K^+\Sigma^0 p} = -G_{K^0\Sigma^0 n} = \frac{1}{\sqrt{2}} G_{K^0\Sigma^+ p} = \frac{1}{\sqrt{2}} G_{K^+\Sigma^- n}$$

$$G_{K^+\Sigma^0\Delta^0} = -\sqrt{2} G_{K^0\Sigma^+\Delta^+} = G_{K^0\Sigma^0\Delta^0} = \sqrt{2} G_{K^0\Sigma^-\Delta^0}$$



$\gamma p \rightarrow K^0\Sigma^+ \rightarrow (\pi^+\pi^-)(p\pi^0)$

$\gamma p \rightarrow K^0\Sigma^+ \rightarrow (\pi^+\pi^-)(n\pi^+)$

$|K^0> = 1/\sqrt{2}\ \{\ |K^0_L> + |K^0_S>\ \}$

$K^0_S \rightarrow \pi^+\pi^-$ (68.6 % branching ratio)

$\rightarrow \pi^0\pi^0$ (31.4 % branching ratio)

$\Sigma^+ \rightarrow p\pi^0$ (51.6 % branching ratio)

$\rightarrow n\pi^+$ (48.3 % branching ratio)

Threshold energy
1.047 GeV

Experimental Data

Run period g1c: October-November, 1999

2.445 GeV beam energy data set 10^9 triggers

Identified events:

4900 events for $\gamma p \rightarrow K^0\Sigma^+ \rightarrow (\pi^+\pi^-)(p\pi^0)$

2700 events for $\gamma p \rightarrow K^0\Sigma^+ \rightarrow (\pi^+\pi^-)(n\pi^+)$

3.115 GeV beam energy data set 2.6×10^9 triggers

Identified events:

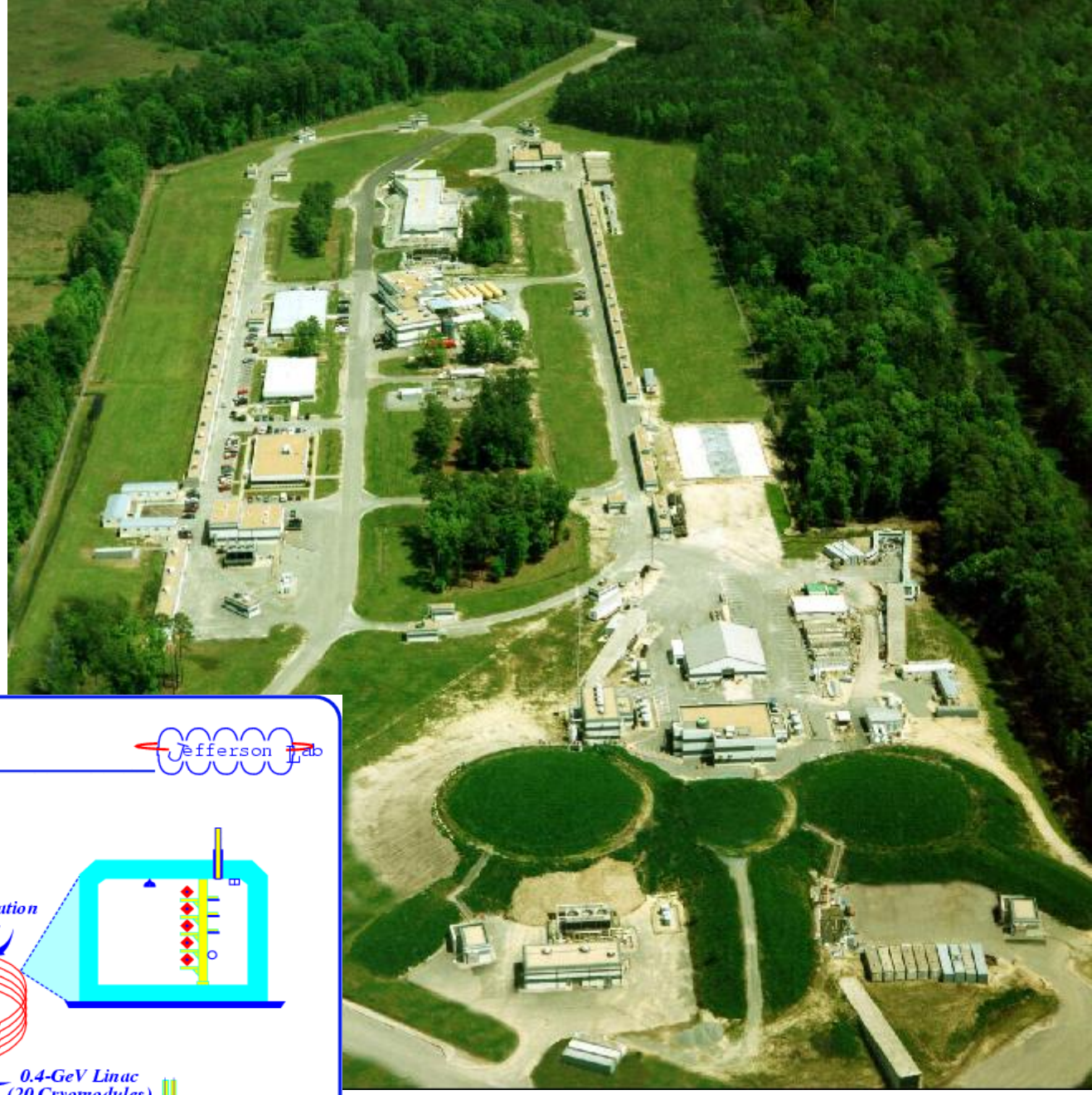
6000 events for $\gamma p \rightarrow K^0\Sigma^+ \rightarrow (\pi^+\pi^-)(p\pi^0)$

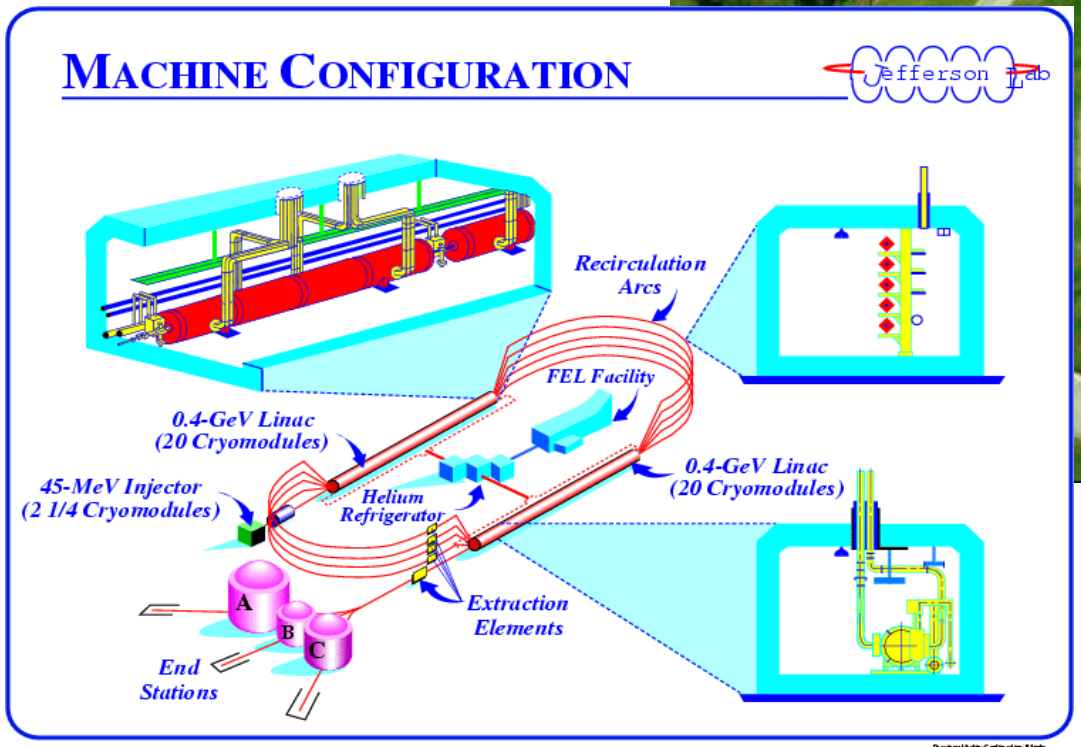
3900 events for $\gamma p \rightarrow K^0\Sigma^+ \rightarrow (\pi^+\pi^-)(n\pi^+)$

Events from previous experiments:

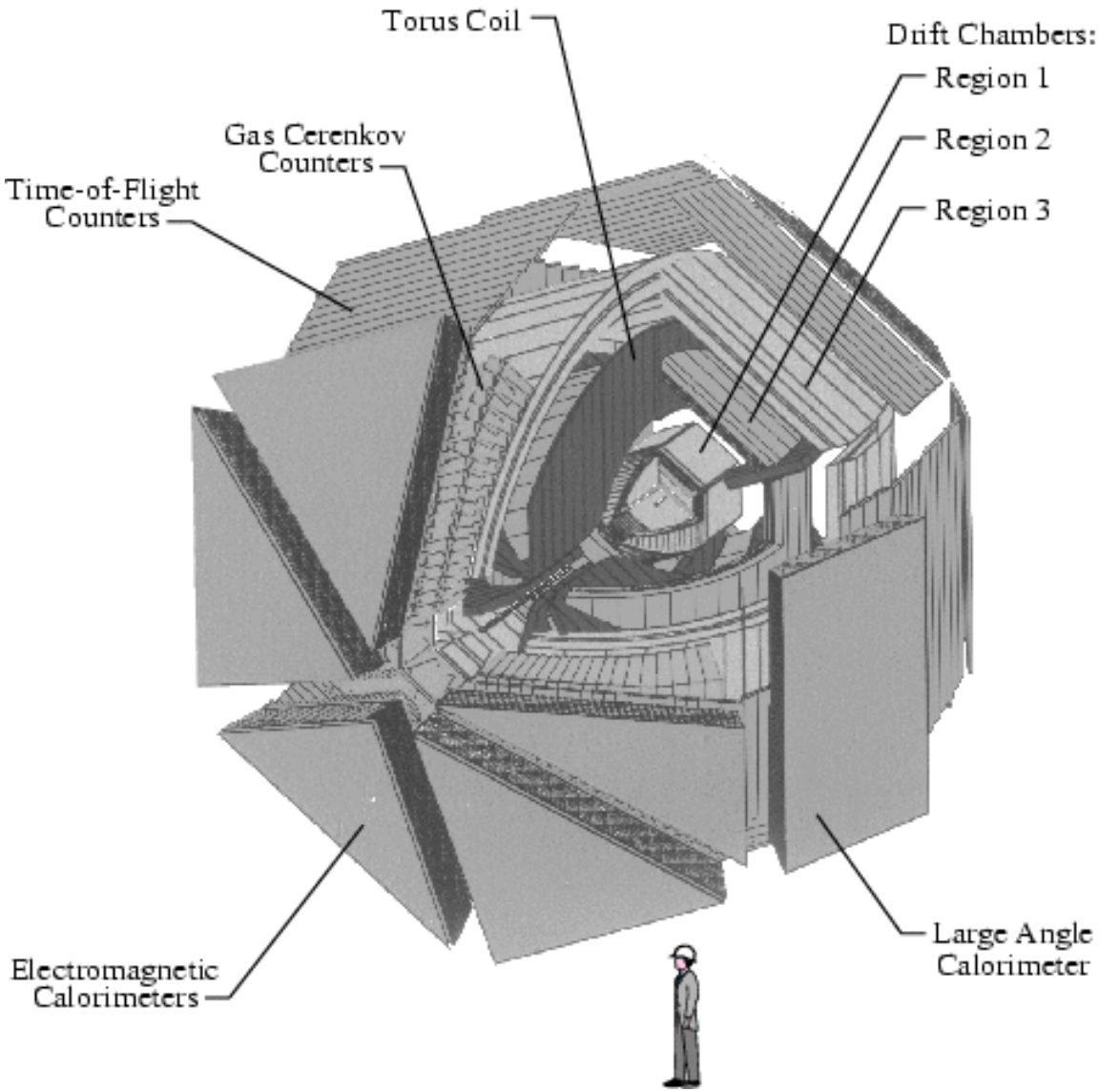
ABBHHM (1969)	18 events
SAPHIR(1999)	405 events

Jefferson Lab
Newport News, VA

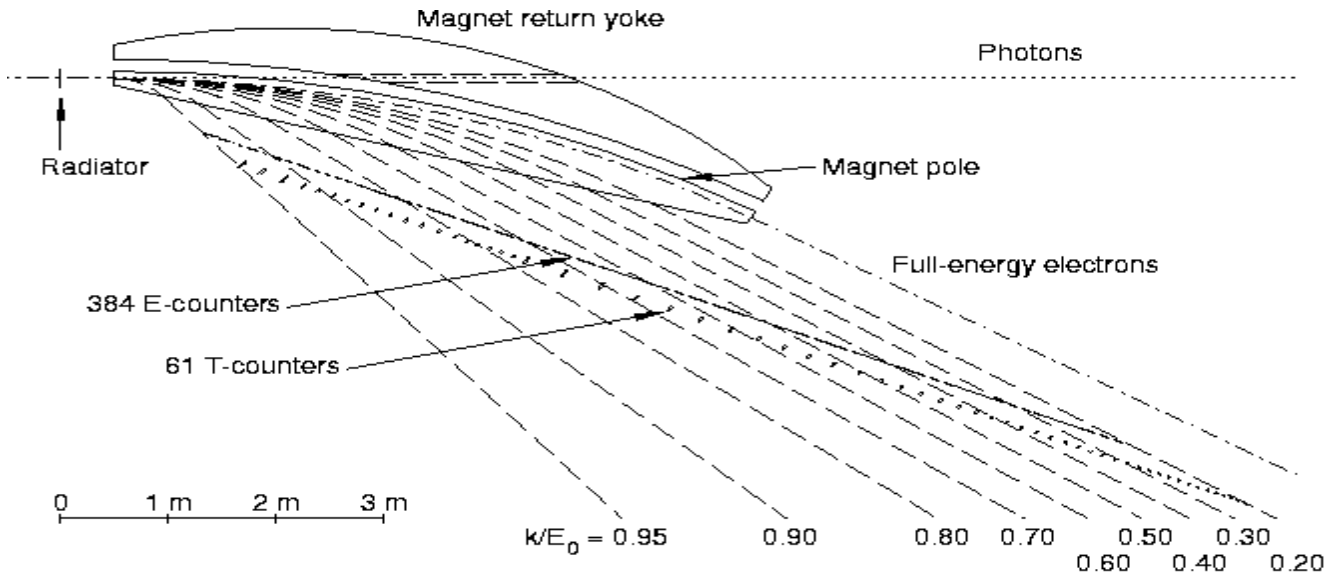


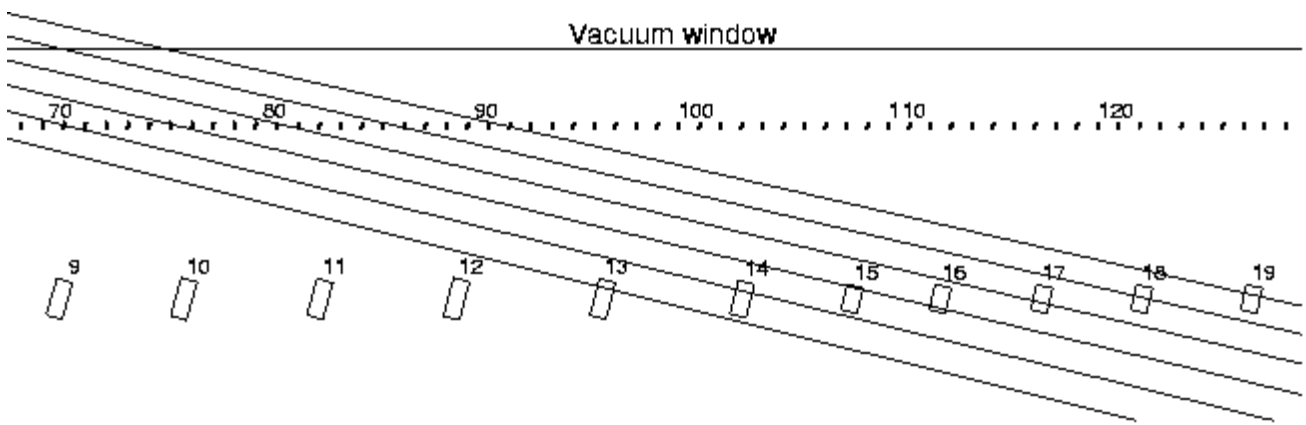


CLAS (CEBAF Large Acceptance Spectrometer)

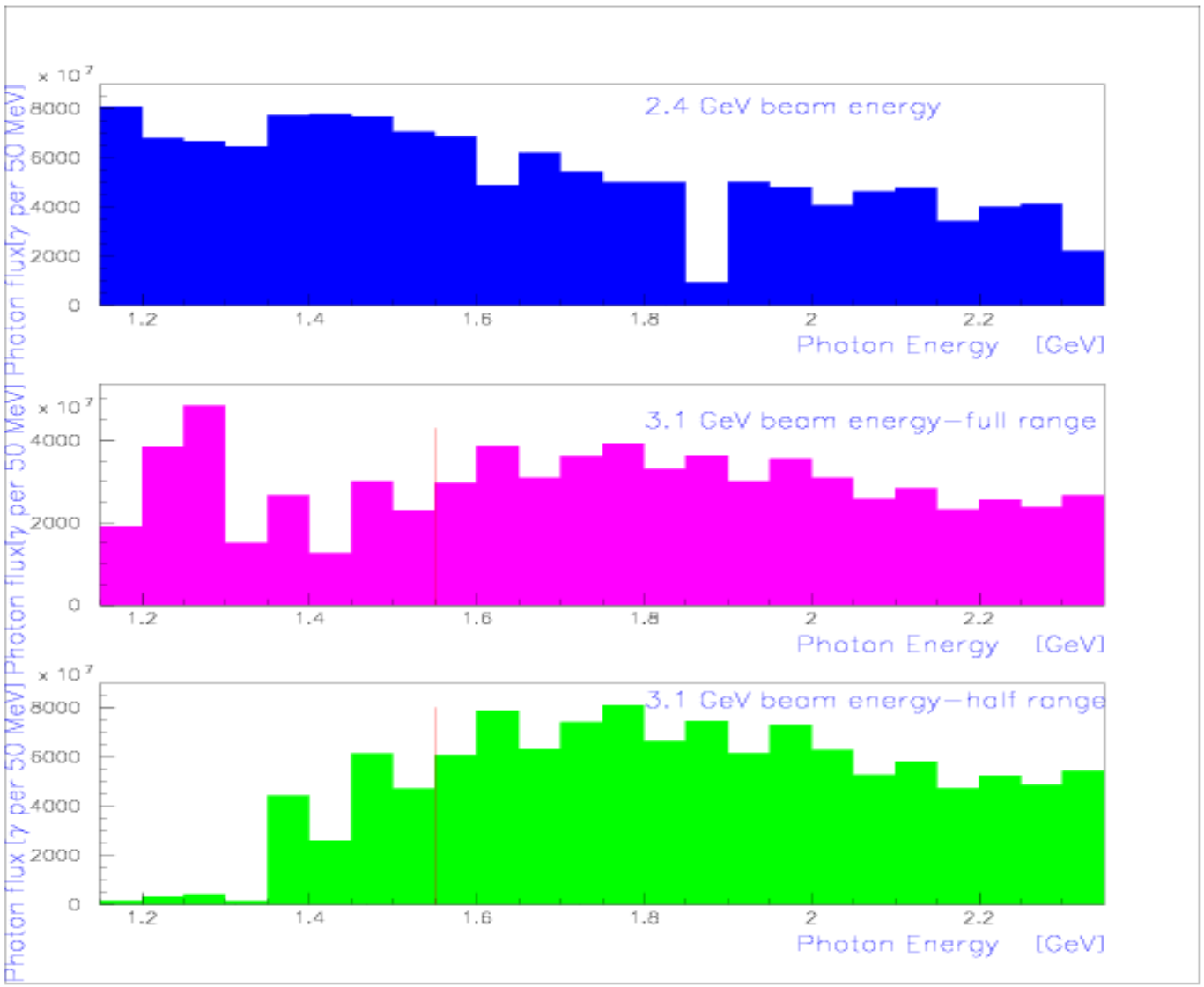


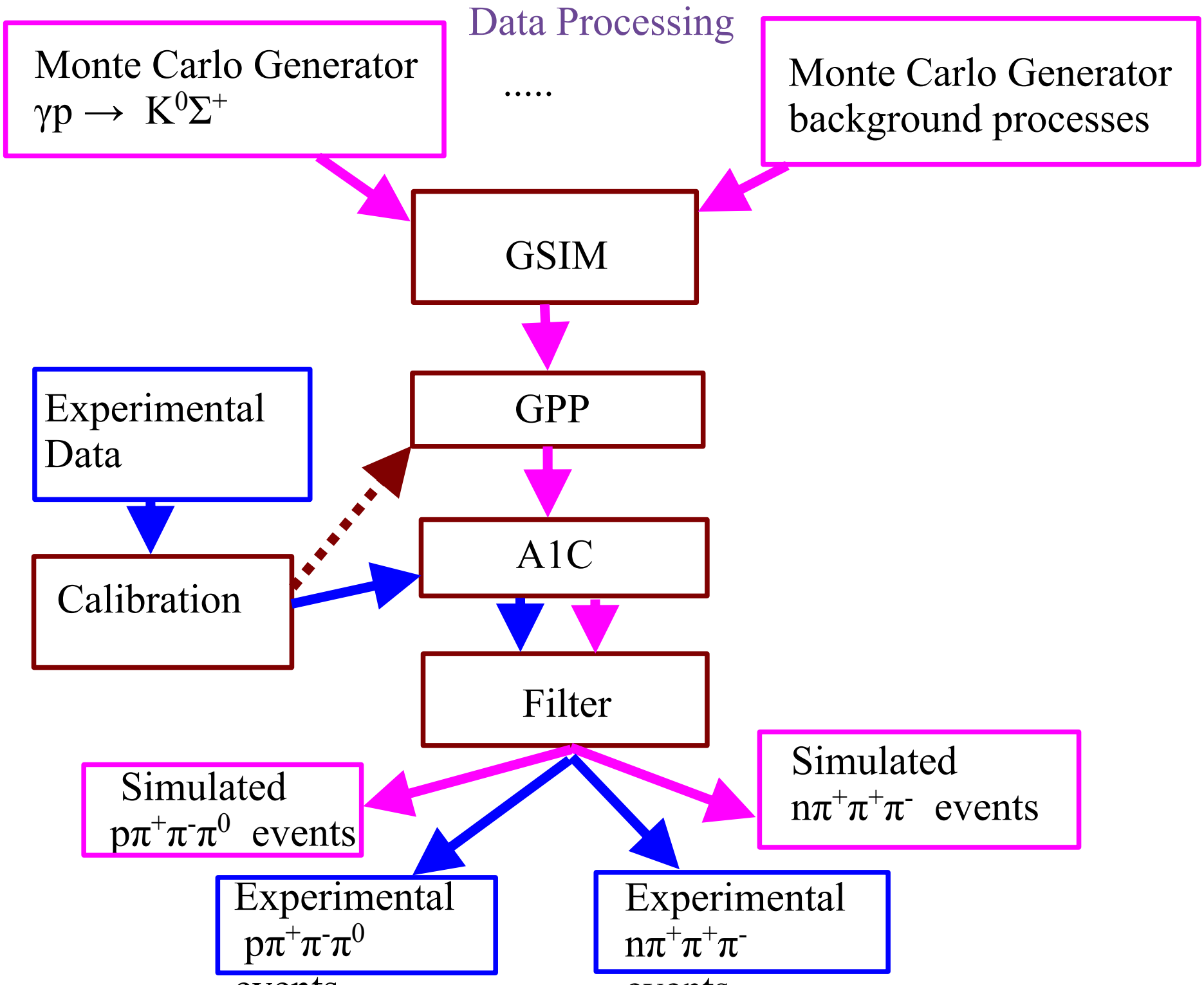
Photon tagger

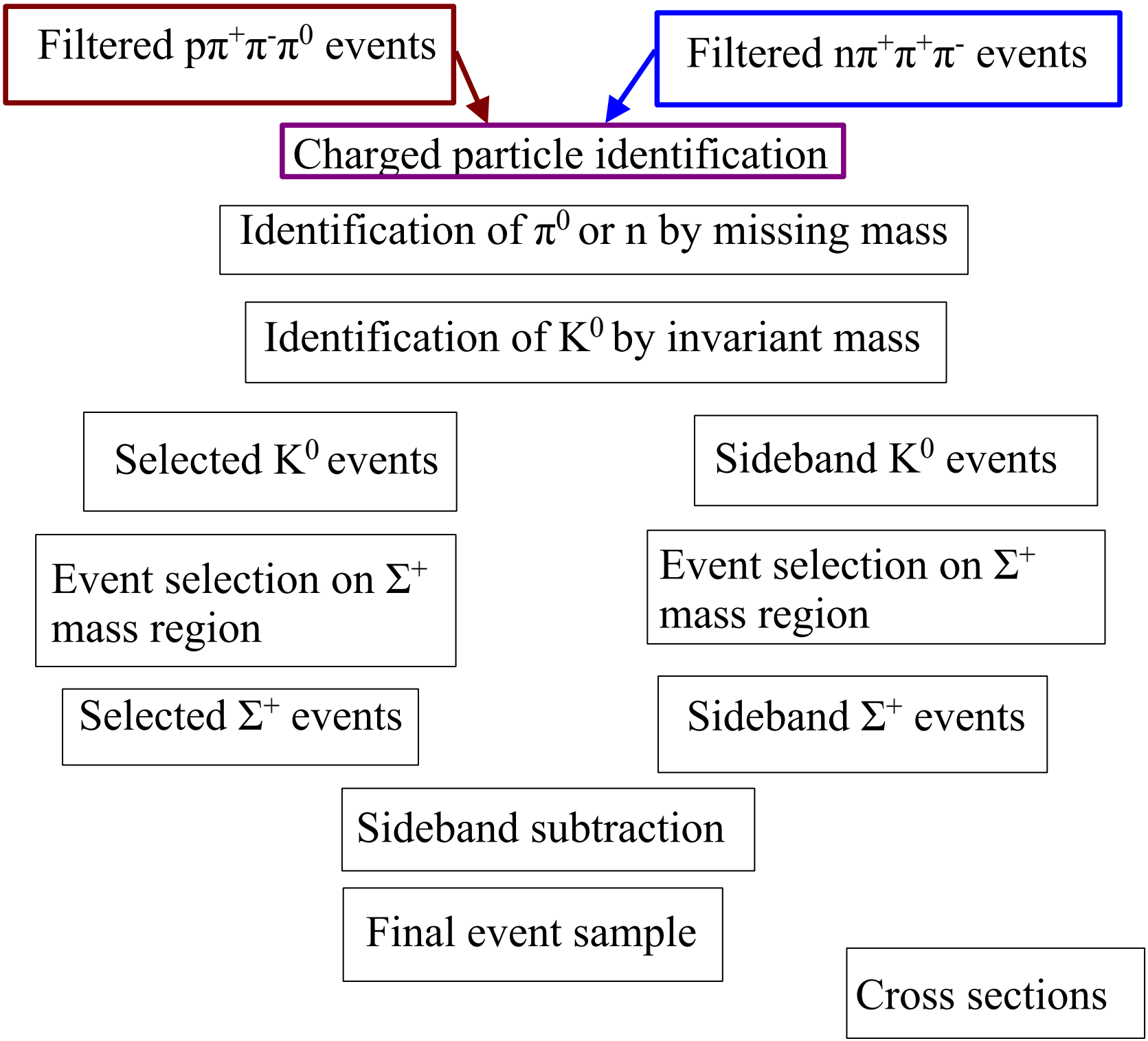


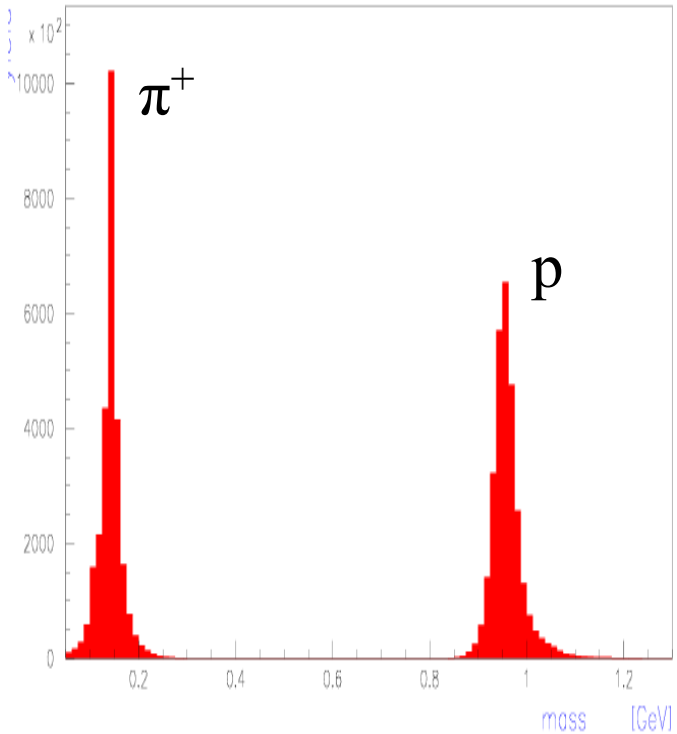


Photon Flux
(flux per tagger E-counter)

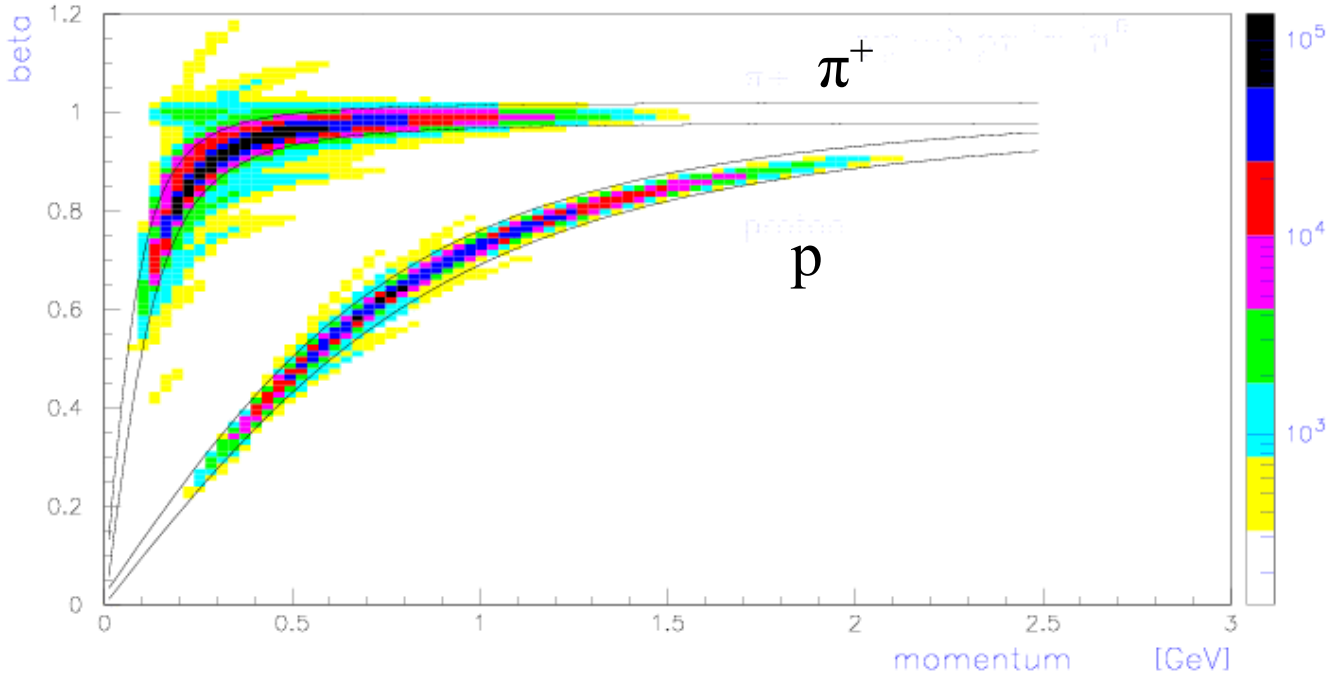



Data Processing
Monte Carlo Generator
γp → K⁰Σ⁺
.....
Monte Carlo Generator
background processes
GSIM
GPP
Experimental
Data
Calibration
A1C
Filter
Simulated
pπ⁺π⁻π⁰ events
Simulated
nπ⁺π⁺π⁻ events
Experimental
pπ⁺π⁻π⁰
Experimental
nπ⁺π⁺π⁻

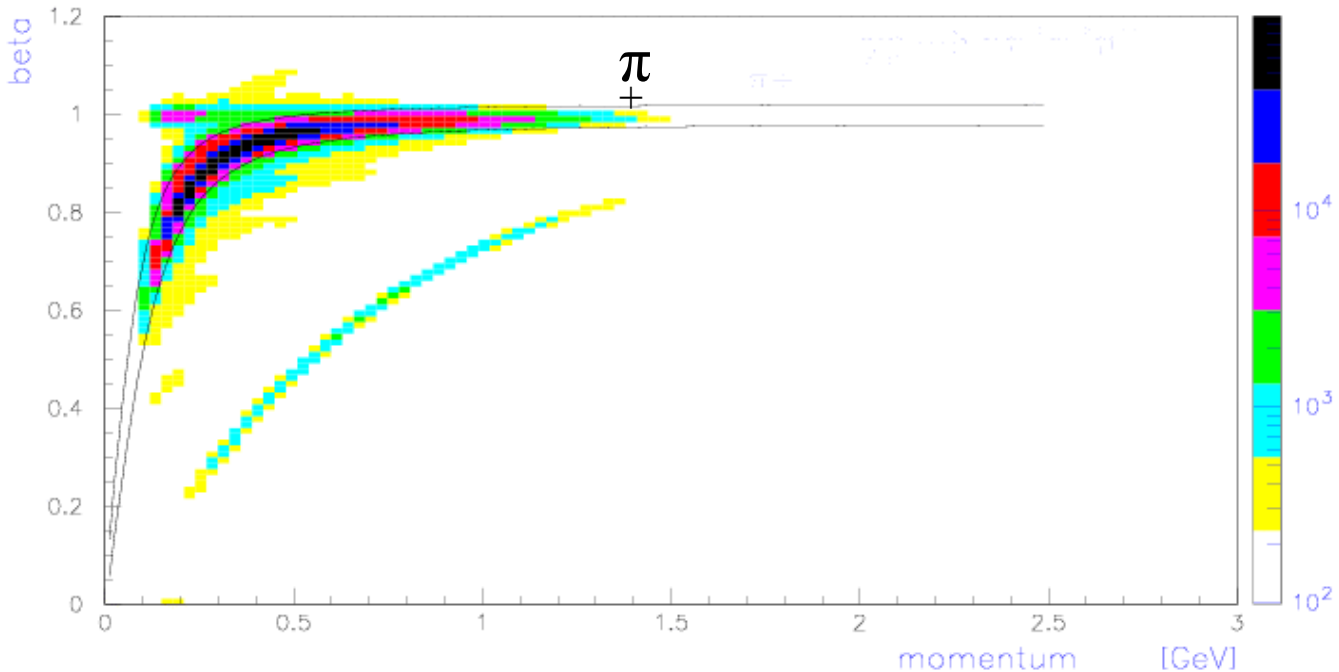

Filtered $p\pi^+\pi^-\pi^0$ events
Filtered $n\pi^+\pi^+\pi^-$ events
Charged particle identification
Identification of π^0 or n by missing mass
Identification of K^0 by invariant mass
Selected K^0 events
Sideband K^0 events
Event selection on Σ^+ mass region
Event selection on Σ^+ mass region
Selected Σ^+ events
Sideband Σ^+ events
Sideband subtraction
Final event sample
Cross sections



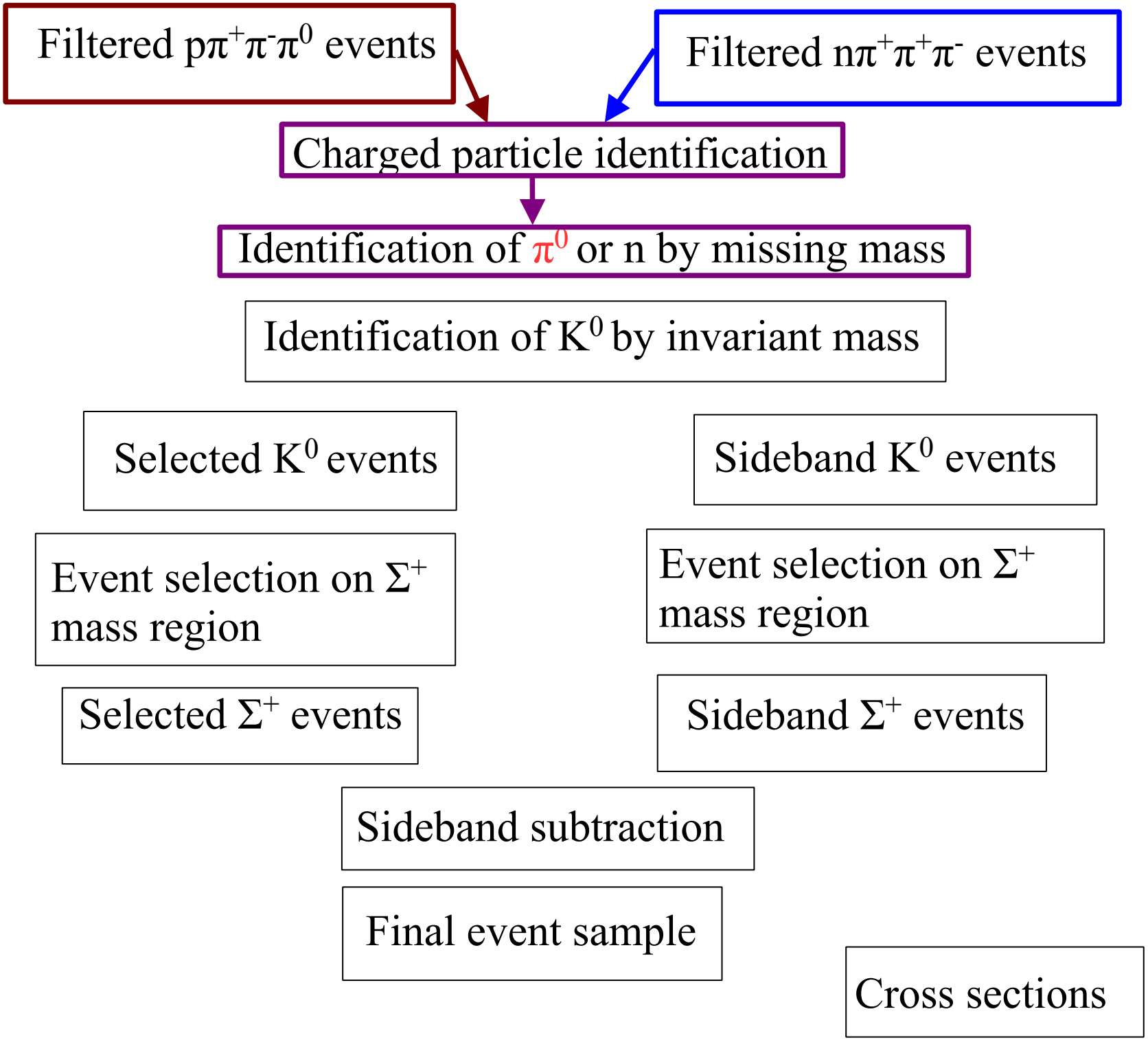
$\gamma p \rightarrow K^0\Sigma^+ \rightarrow (\pi^+\pi^-)(p\pi^0)$



$\gamma p \rightarrow K^0\Sigma^+ \rightarrow (\pi^+\pi^-)(n\pi^+)$



Charged particle identification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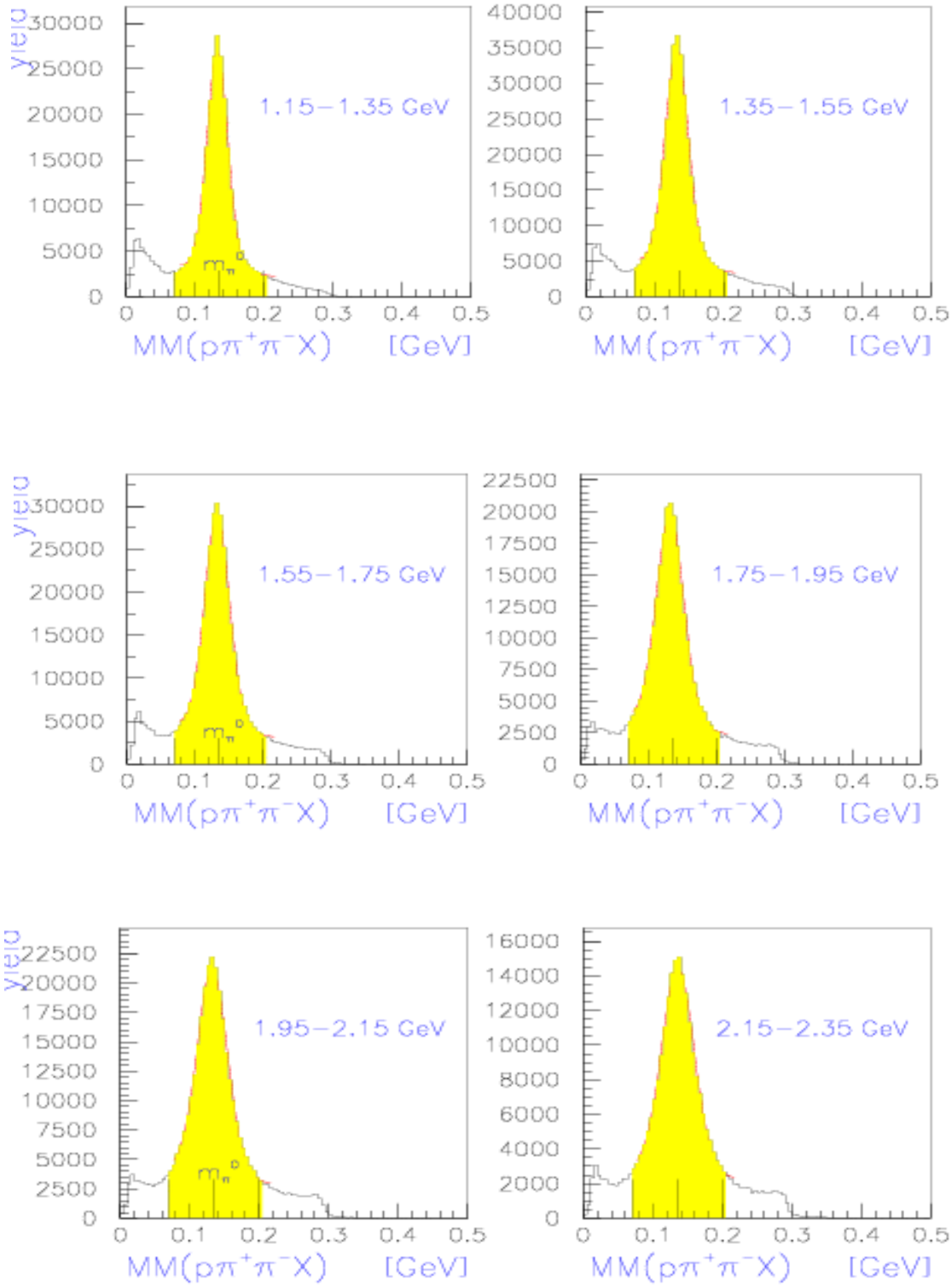
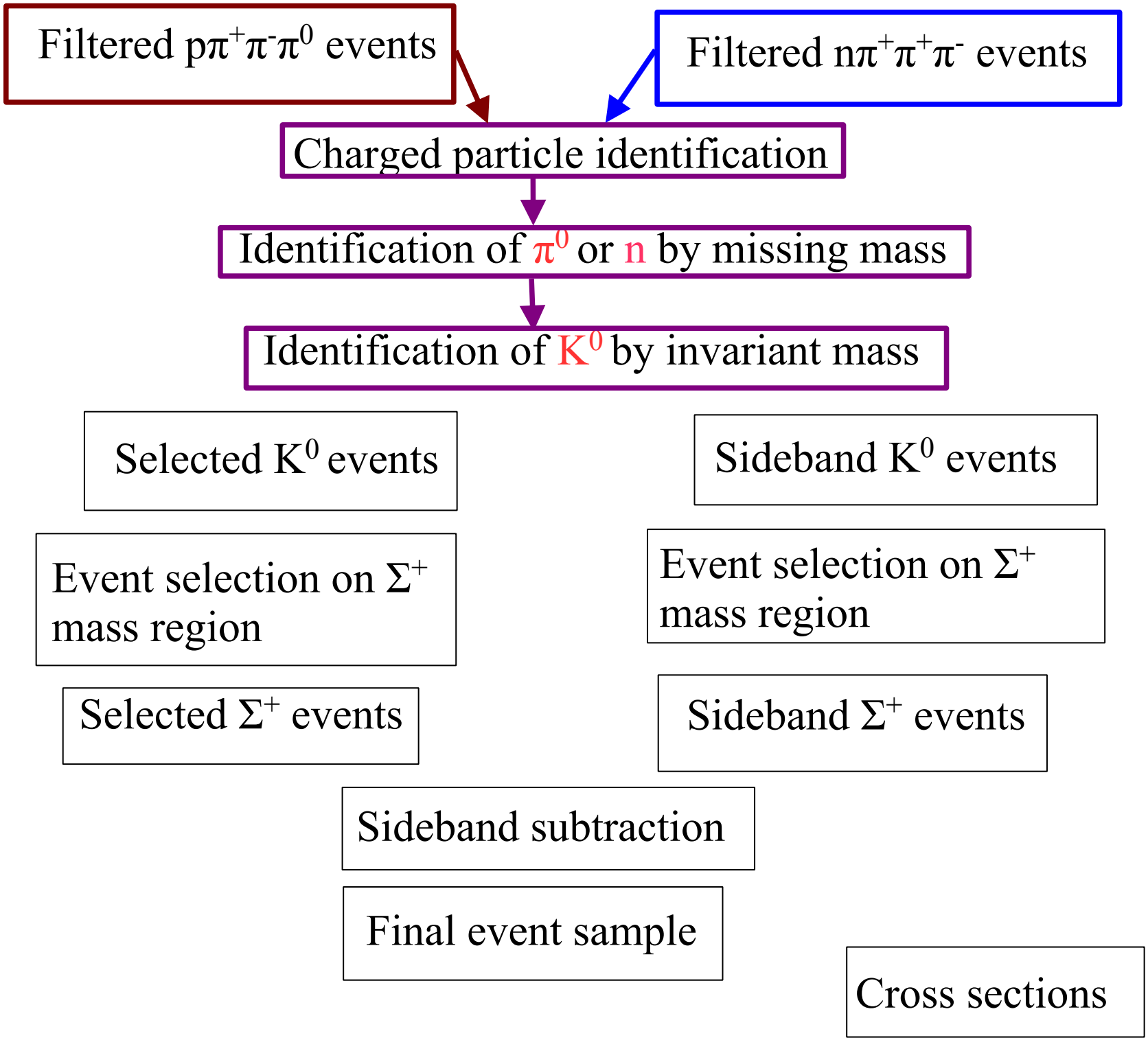
Identification of π^0 by missing mass

$$\gamma p \rightarrow K^0\Sigma^+ \rightarrow (\pi^+\pi^-)(p\pi^0)$$

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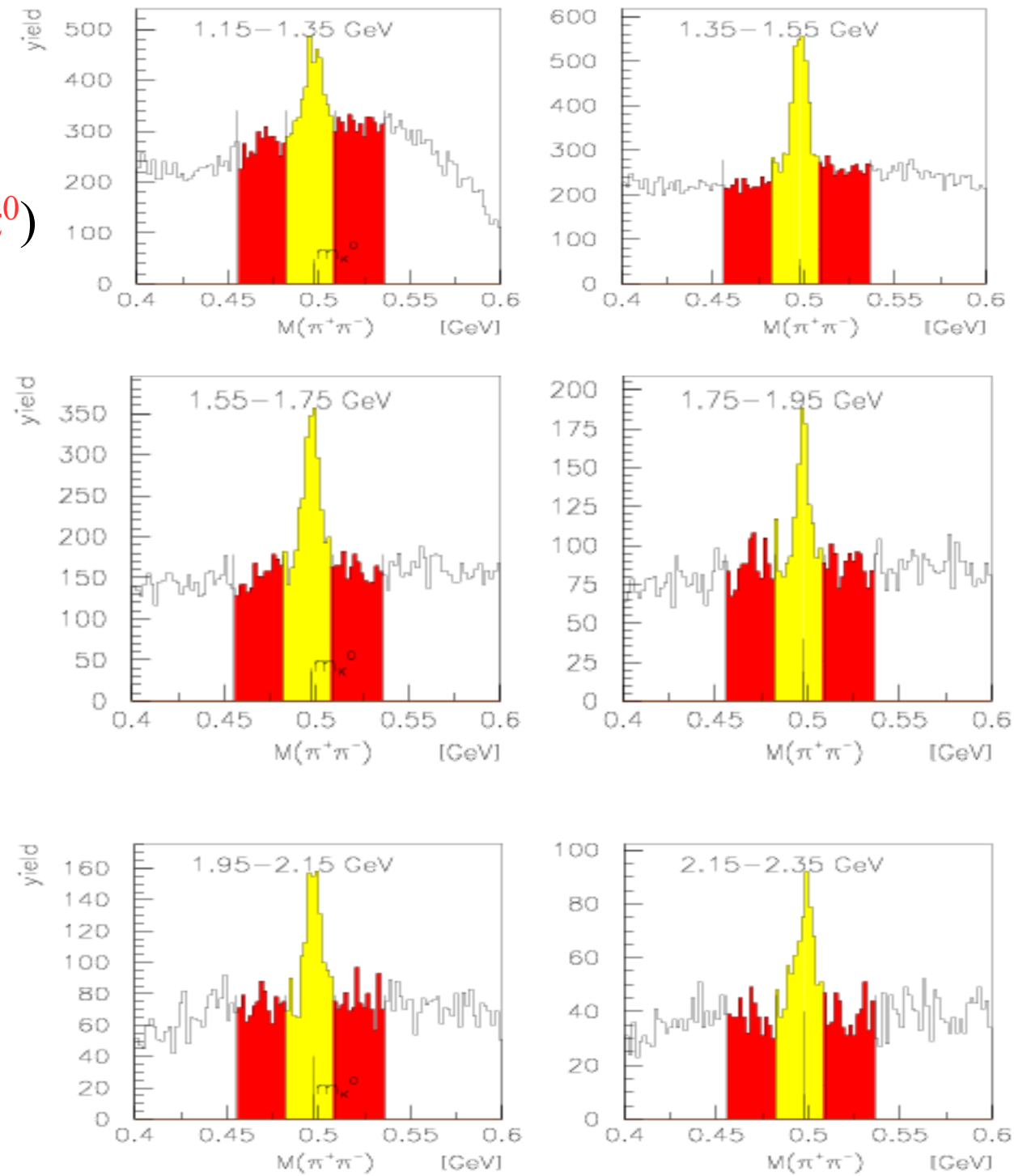
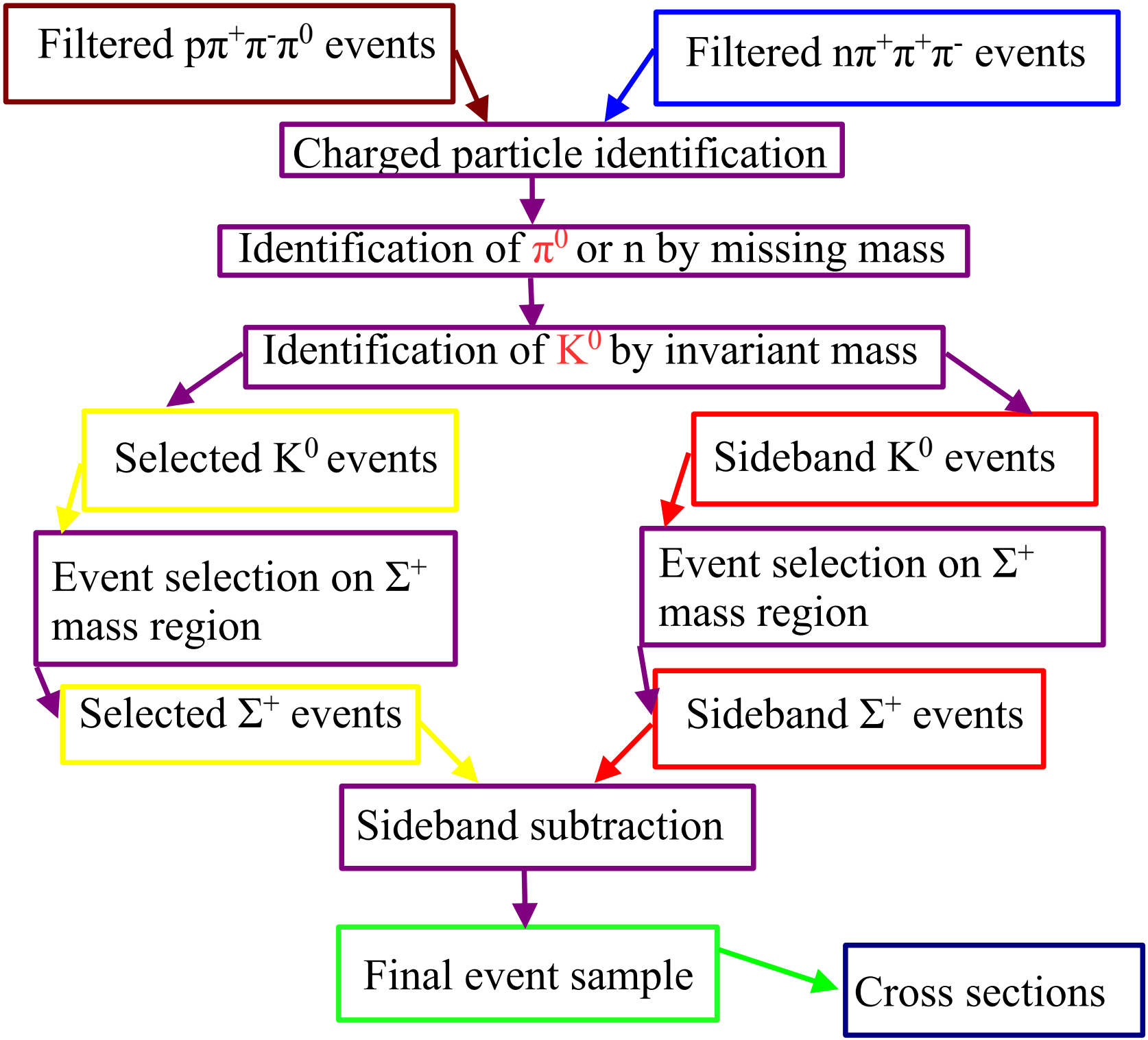
Identification of K^0 by invariant mass

$\gamma p \rightarrow K^0\Sigma^+ \rightarrow (\pi^+\pi^-)(p\pi^0)$

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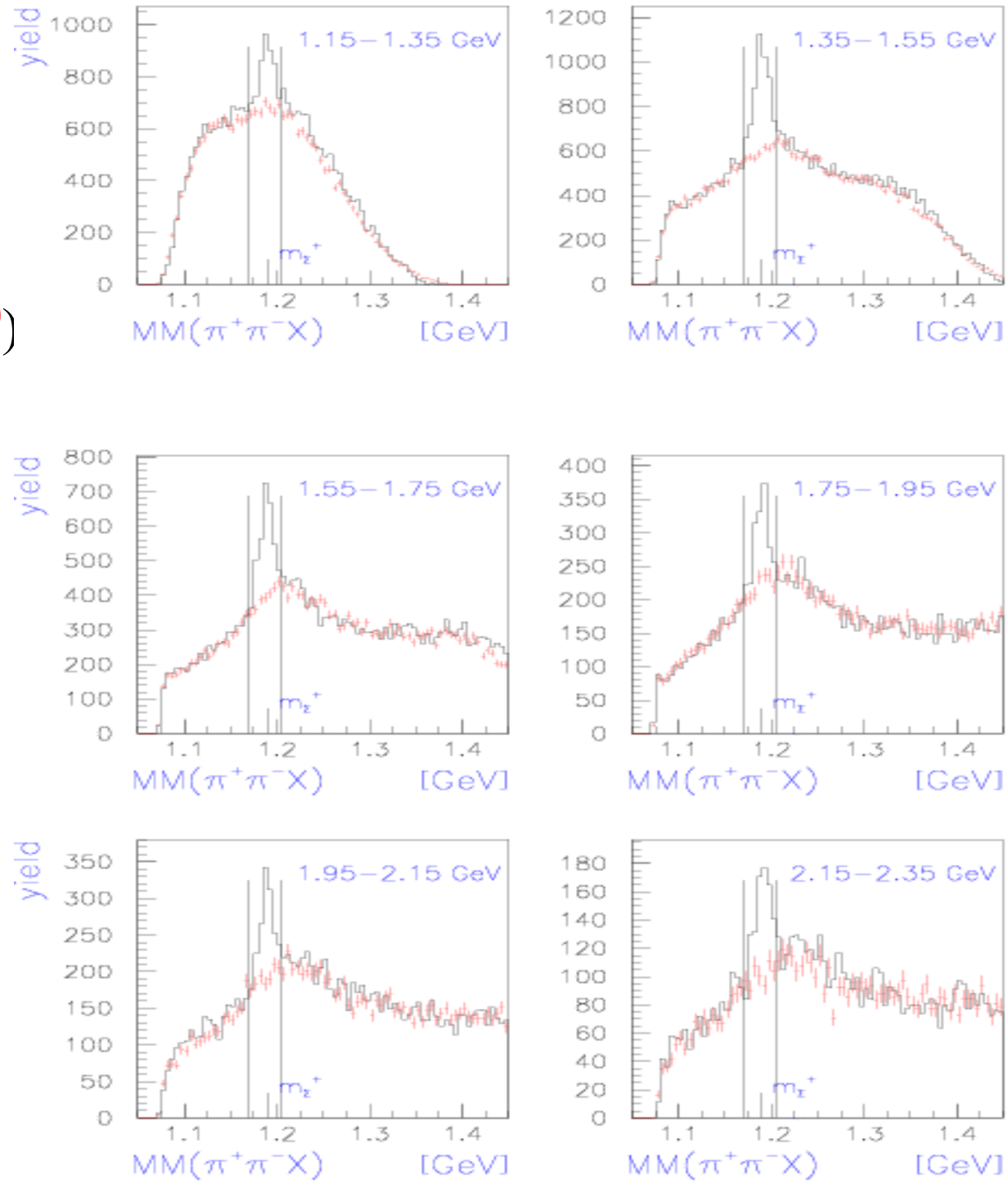
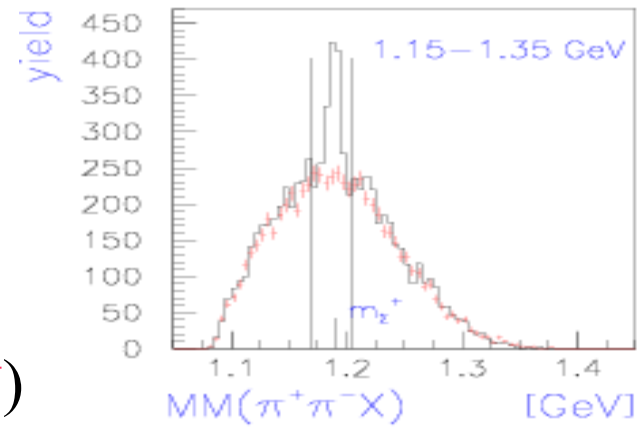
Identification of Σ^+ by missing mass
(for $\Sigma^+ \rightarrow p\pi^0$)

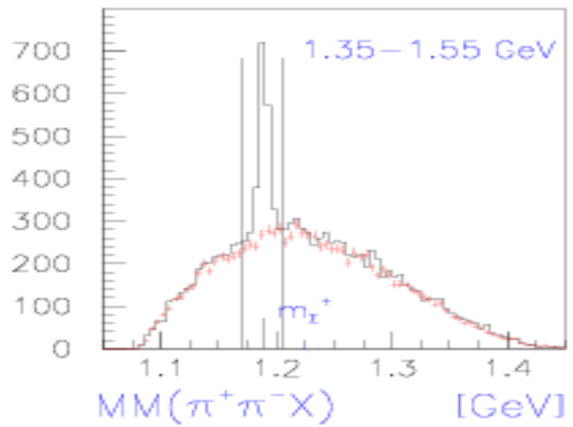
$\gamma p \rightarrow K^0\Sigma^+ \rightarrow (\pi^+\pi^-)(p\pi^0)$

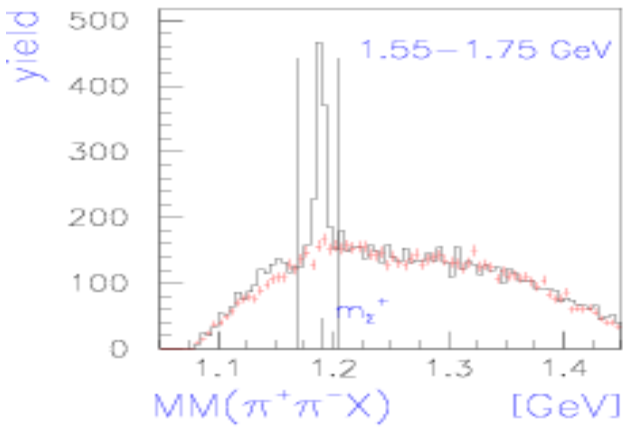


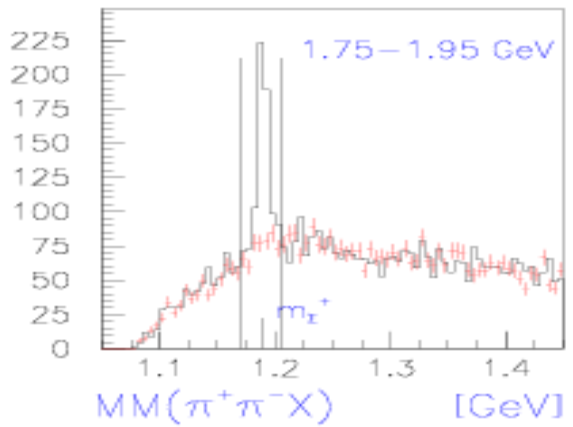
Identification of Σ^+ by missing mass
(for $\Sigma^+ \rightarrow n\pi^+$)

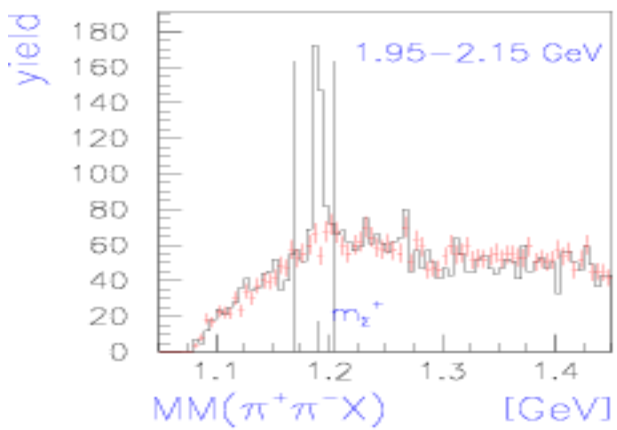
$\gamma p \rightarrow K^0\Sigma^+ \rightarrow (\pi^+\pi^-)(n\pi^+)$

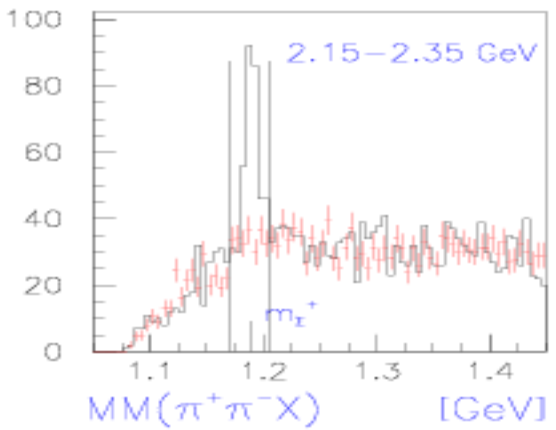








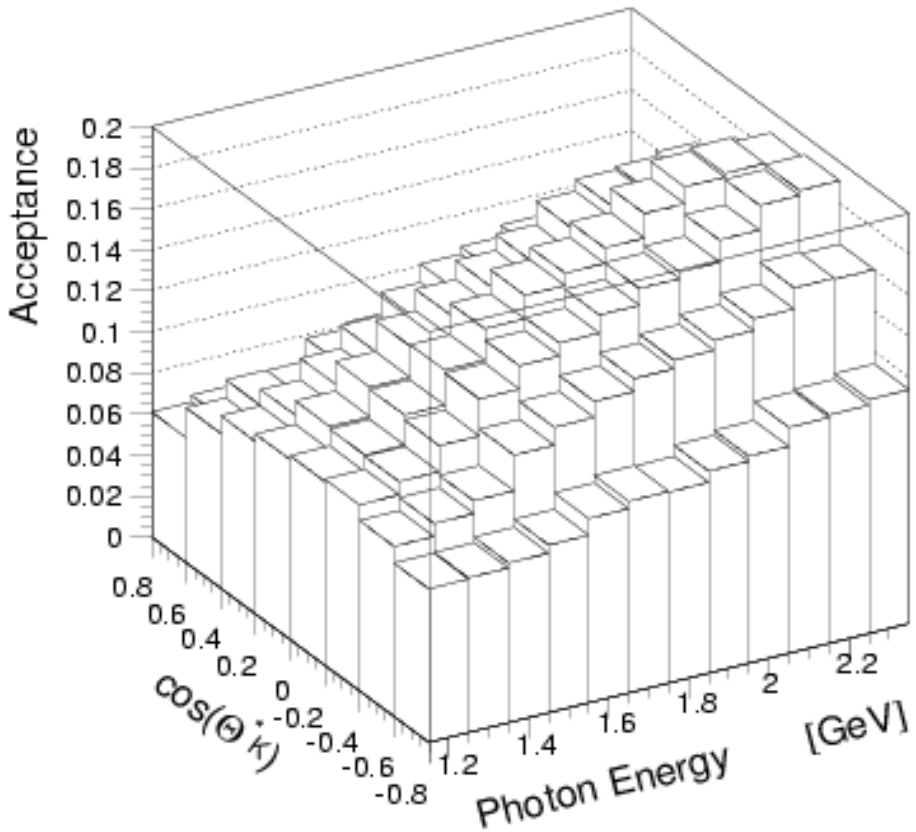


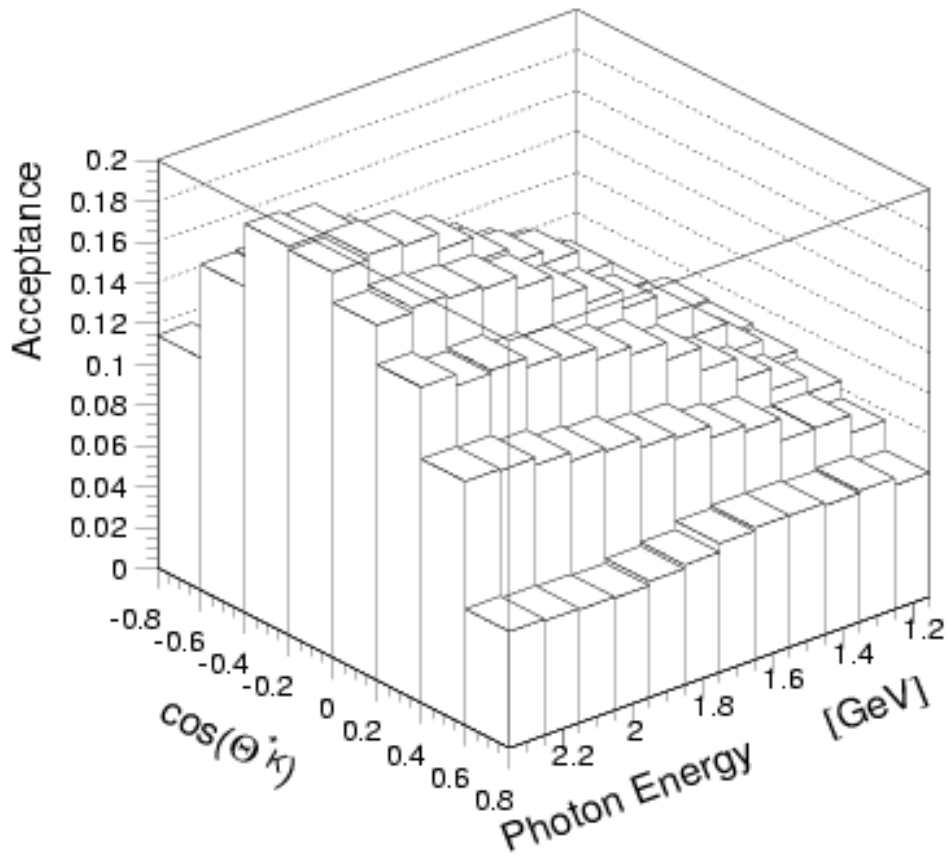


A

Acceptance

$\gamma p \rightarrow K^0\Sigma^+ \rightarrow (\pi^+\pi^-)(p\pi^0)$





Desired process:

$\gamma p \rightarrow K^0\Sigma^+ \rightarrow (\pi^+\pi^-)(p\pi^0)$

Background processes which can pass our event selection criteria and contaminate the data:

$\gamma p \rightarrow \pi^+\pi^- p\pi^0$ (phase space)

$\gamma p \rightarrow p\omega \rightarrow \pi^+\pi^- p\pi^0$

$\gamma p \rightarrow \Delta^+\rho^0 \rightarrow \pi^+\pi^- p\pi^0$

These backgrounds are almost completely eliminated from our final event sample by our event selection criteria.

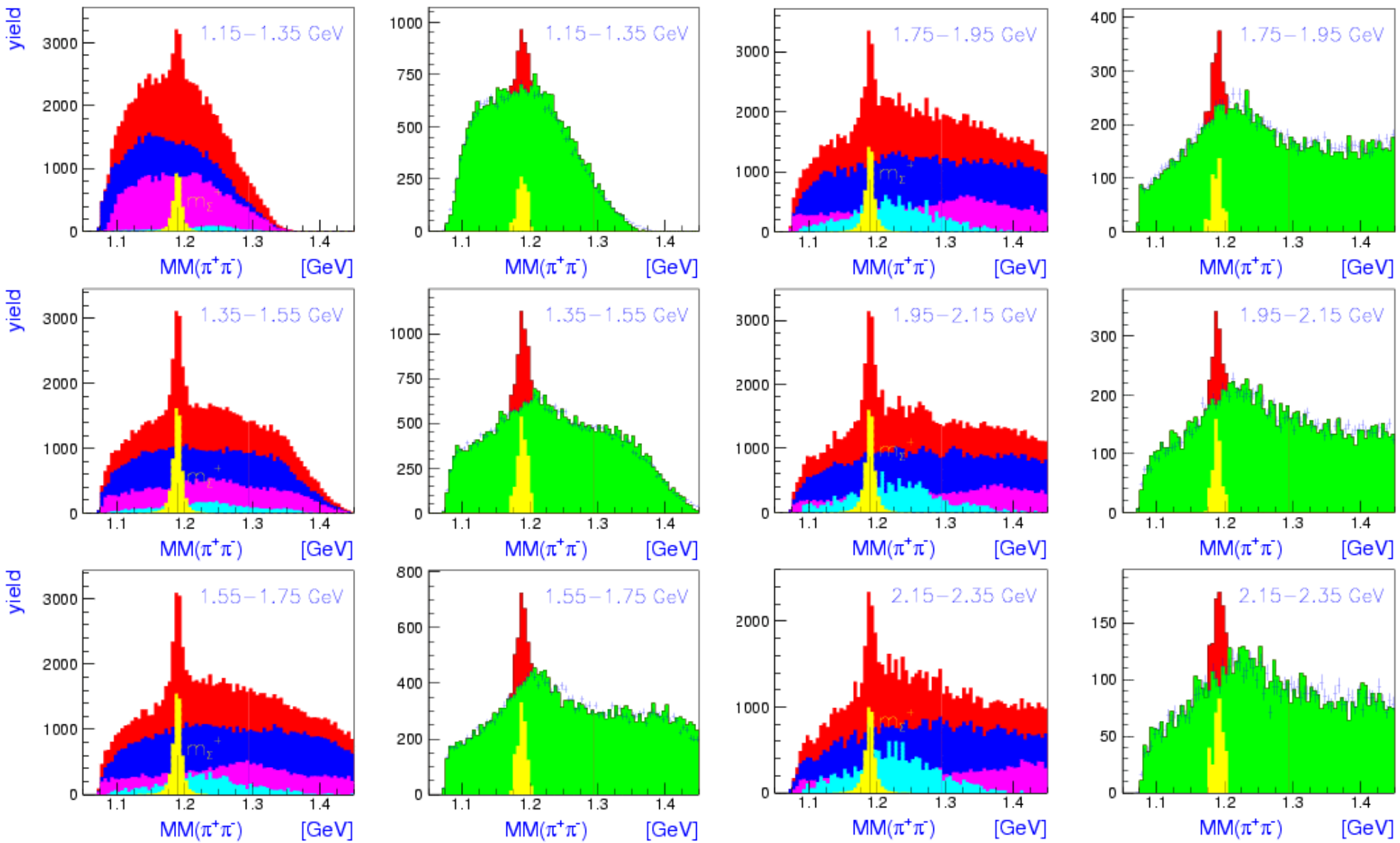
$\gamma p \rightarrow K^0\Sigma^+ \rightarrow (\pi^+\pi^-)(p\pi^0)$

Simulated processes

Experimental data

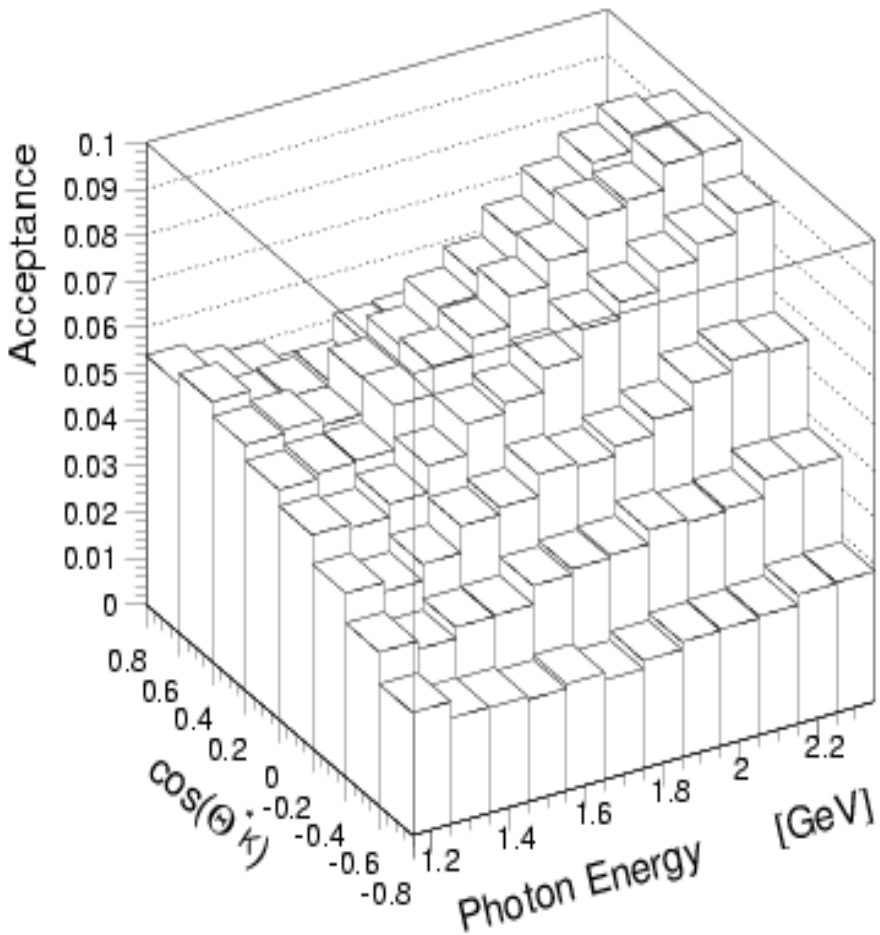
Simulated processes

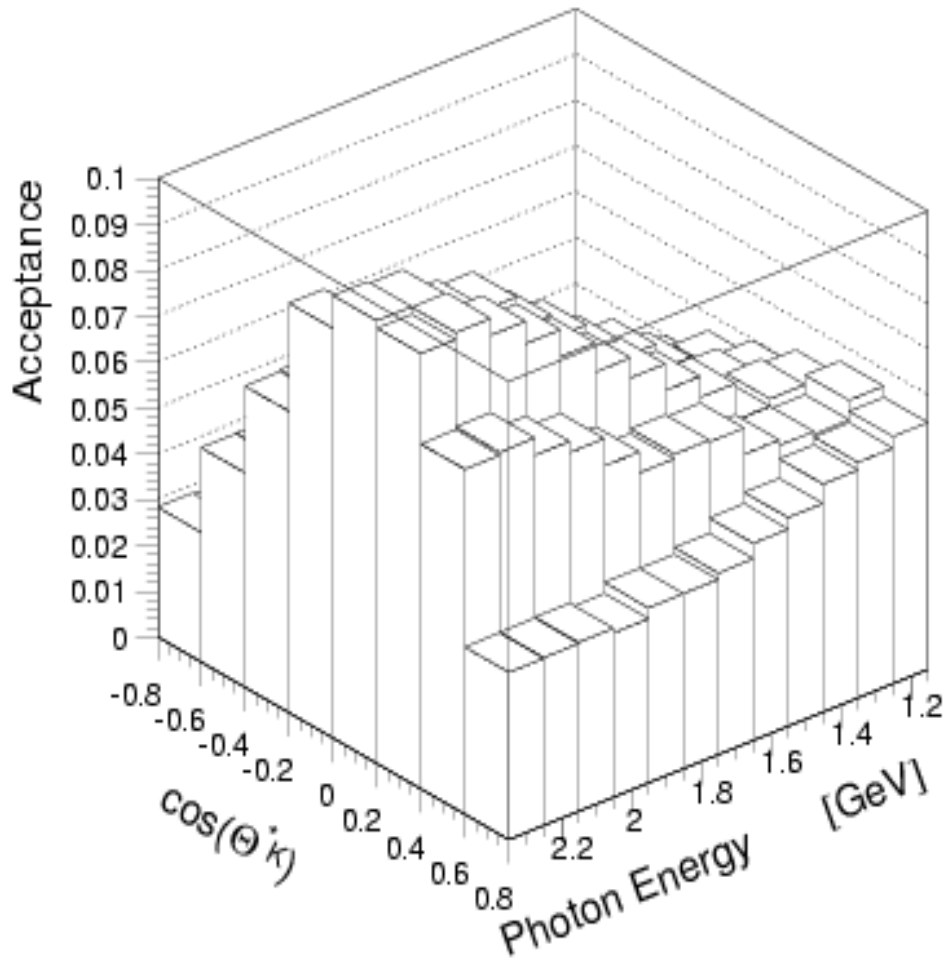
Experimental data



Acceptance

$\gamma p \rightarrow K^0\Sigma^+ \rightarrow (\pi^+\pi^-)(n\pi^+)$





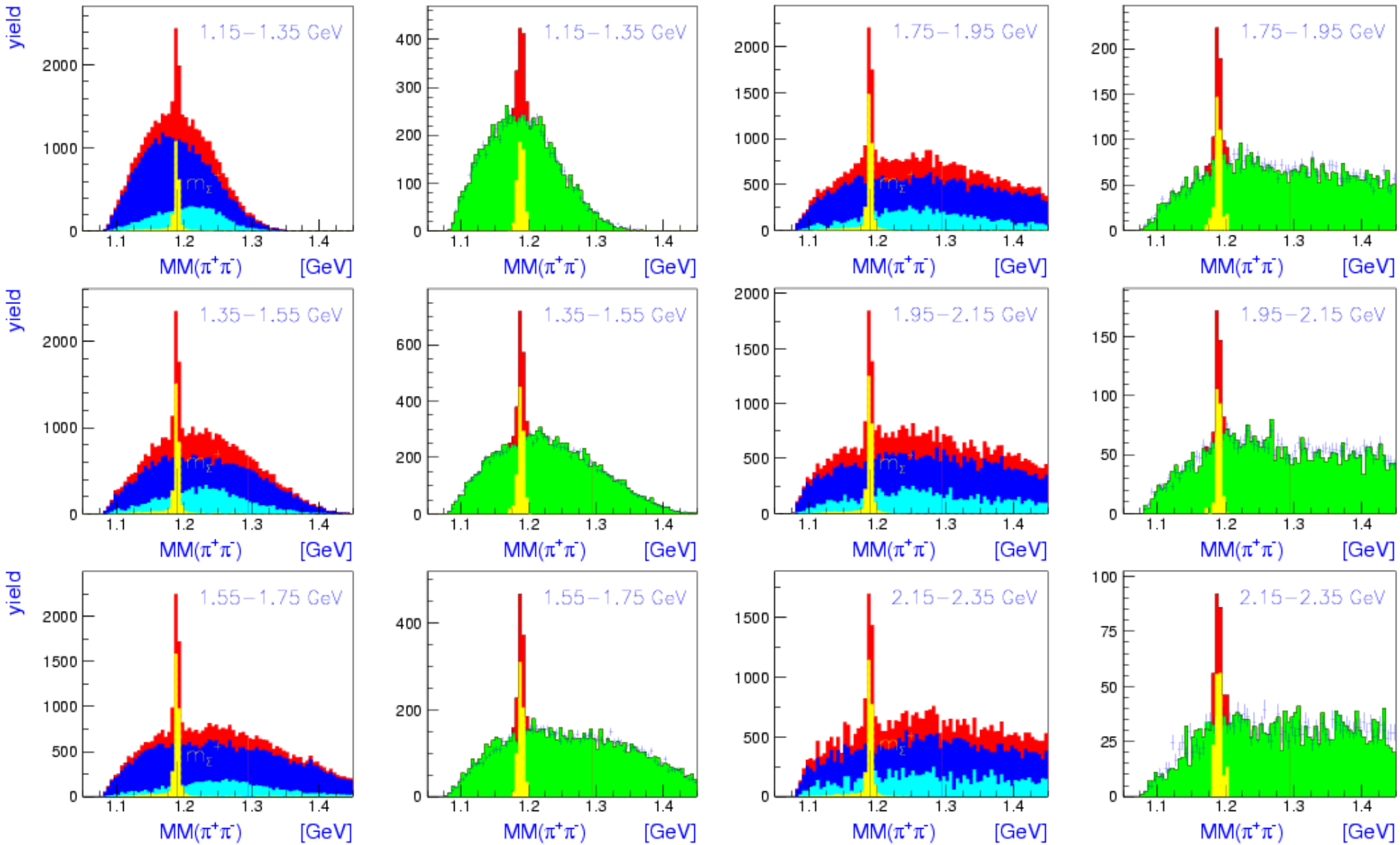
$$\gamma p \rightarrow K^0\Sigma^+ \rightarrow (\pi^+\pi^-)(n\pi^+)$$

Simulated processes

Experimental data

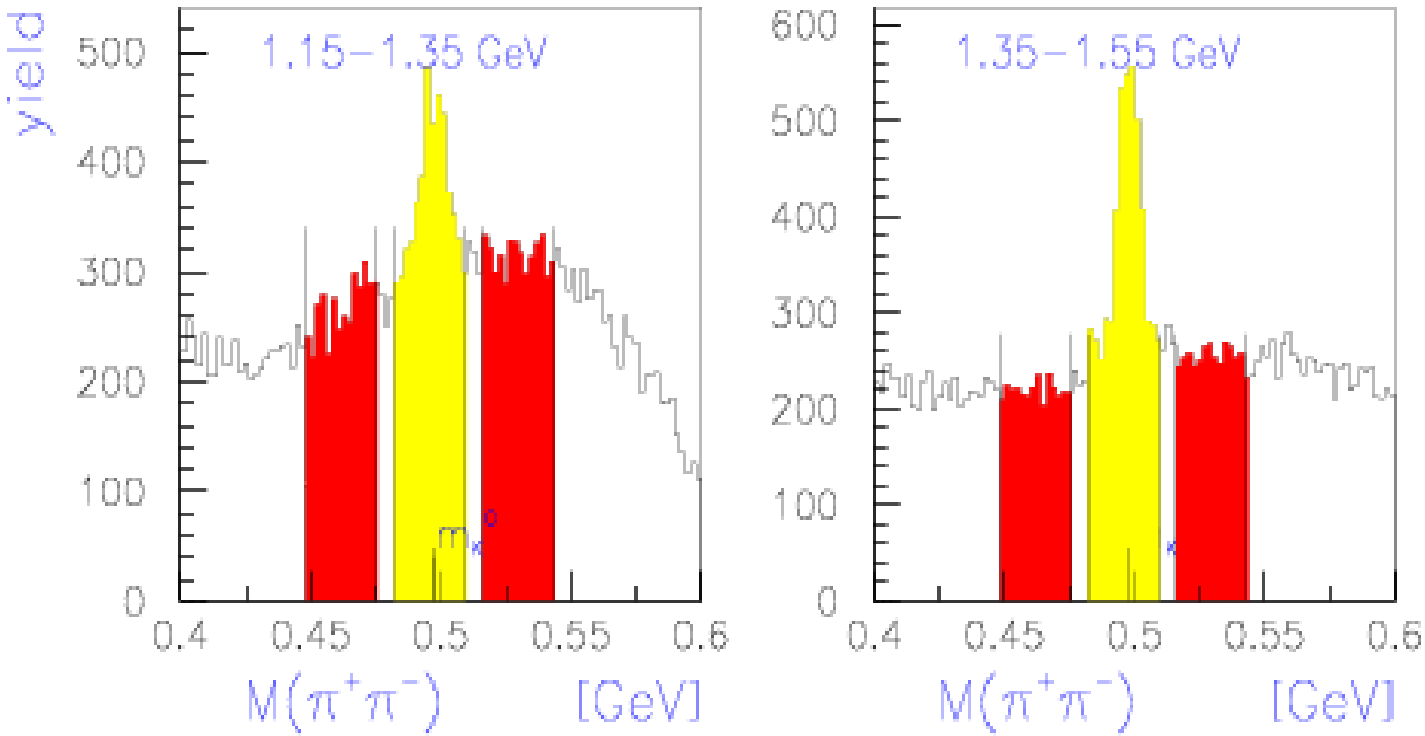
Simulated processes

Experimental data



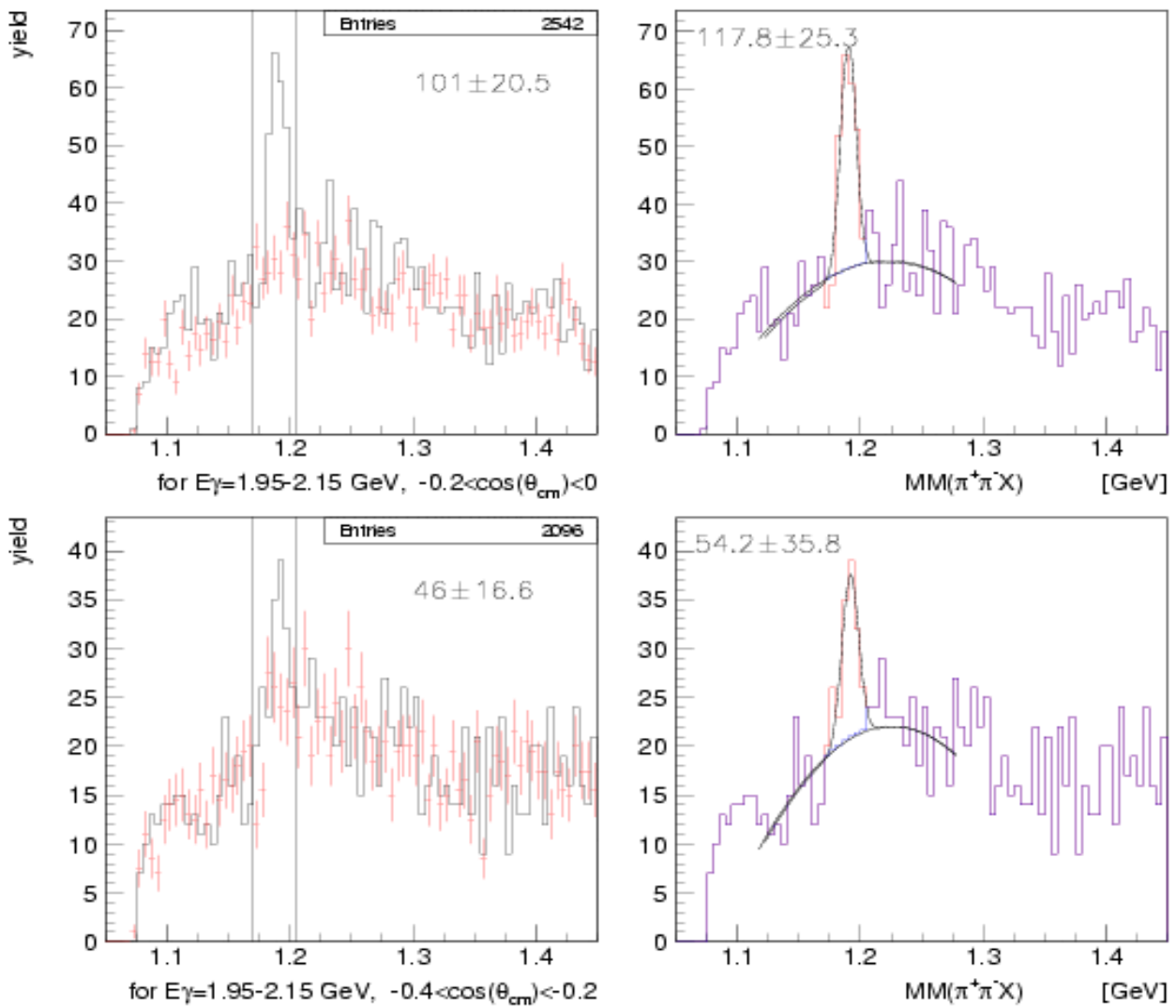
Systematic Errors

Non-contiguous regions of selected and sideband events

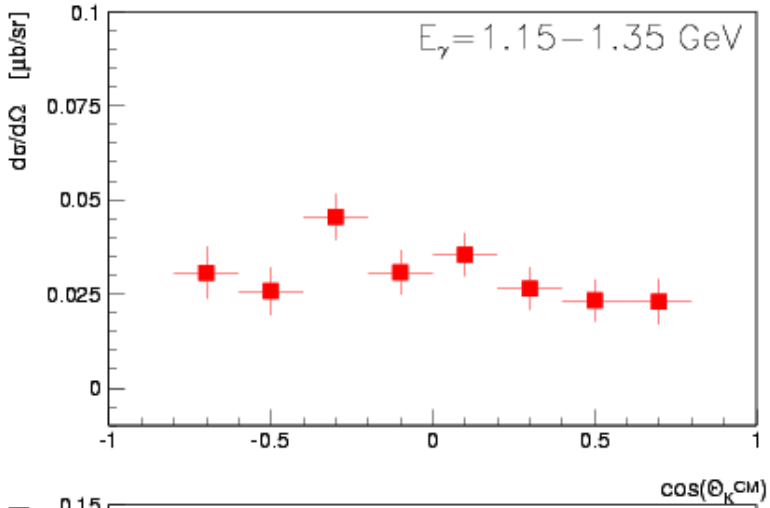


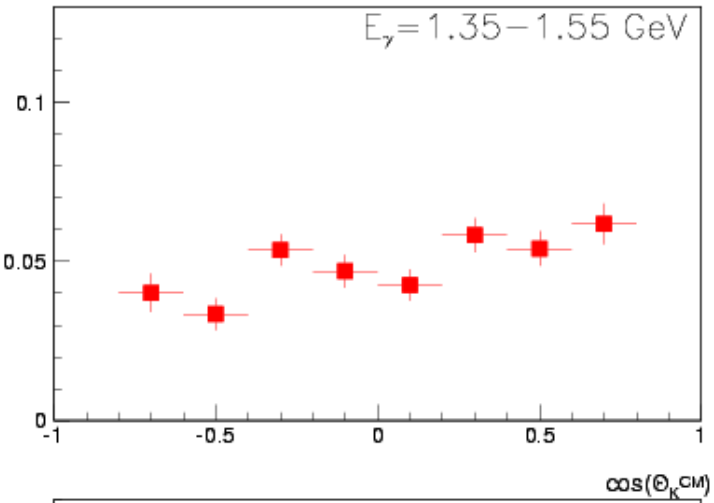
Photon Energy (GeV)	Statistical Error	Systematic Error
1.15-1.35	27%	11%
1.35-1.55	14%	6%
1.55-1.75	15%	6%
1.75-1.95	38%	7%
1.95-2.15	29%	7%
2.15-2.35	42%	10%

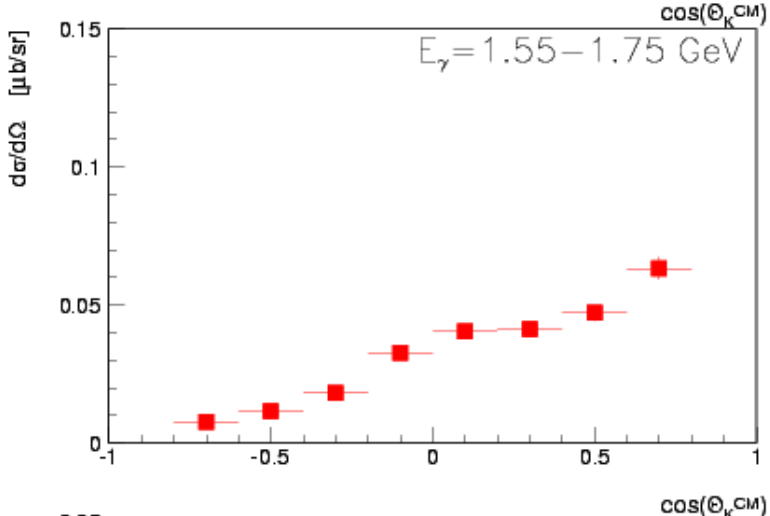
Sideband subtraction versus Gaussian fit

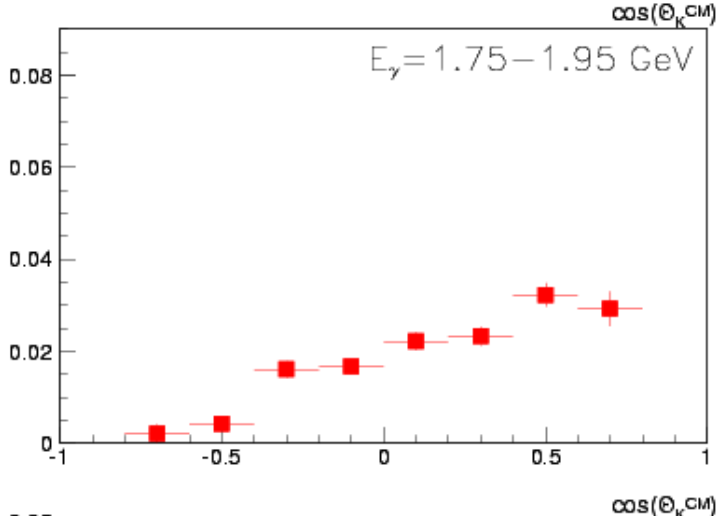


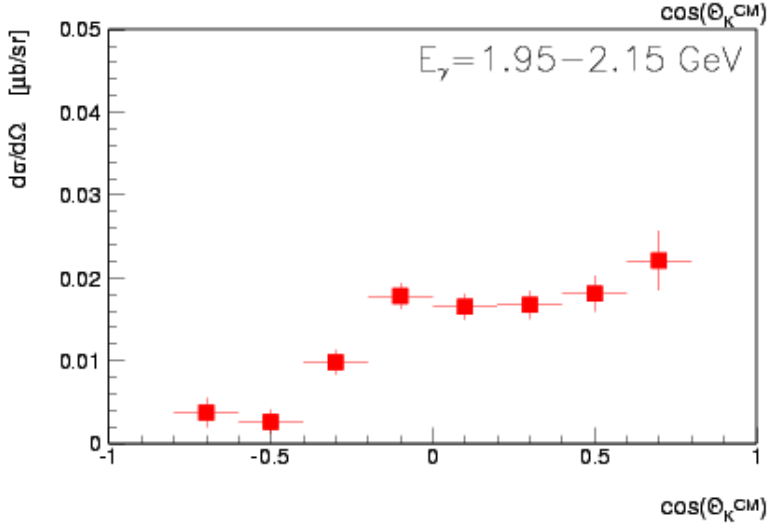
Differential cross sections

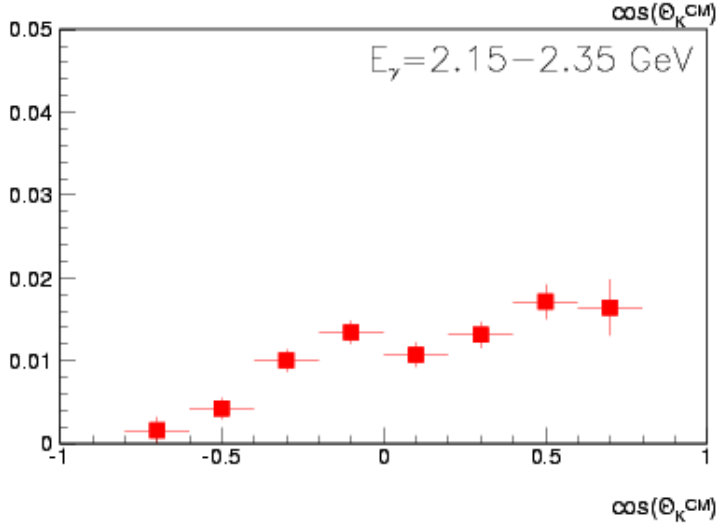




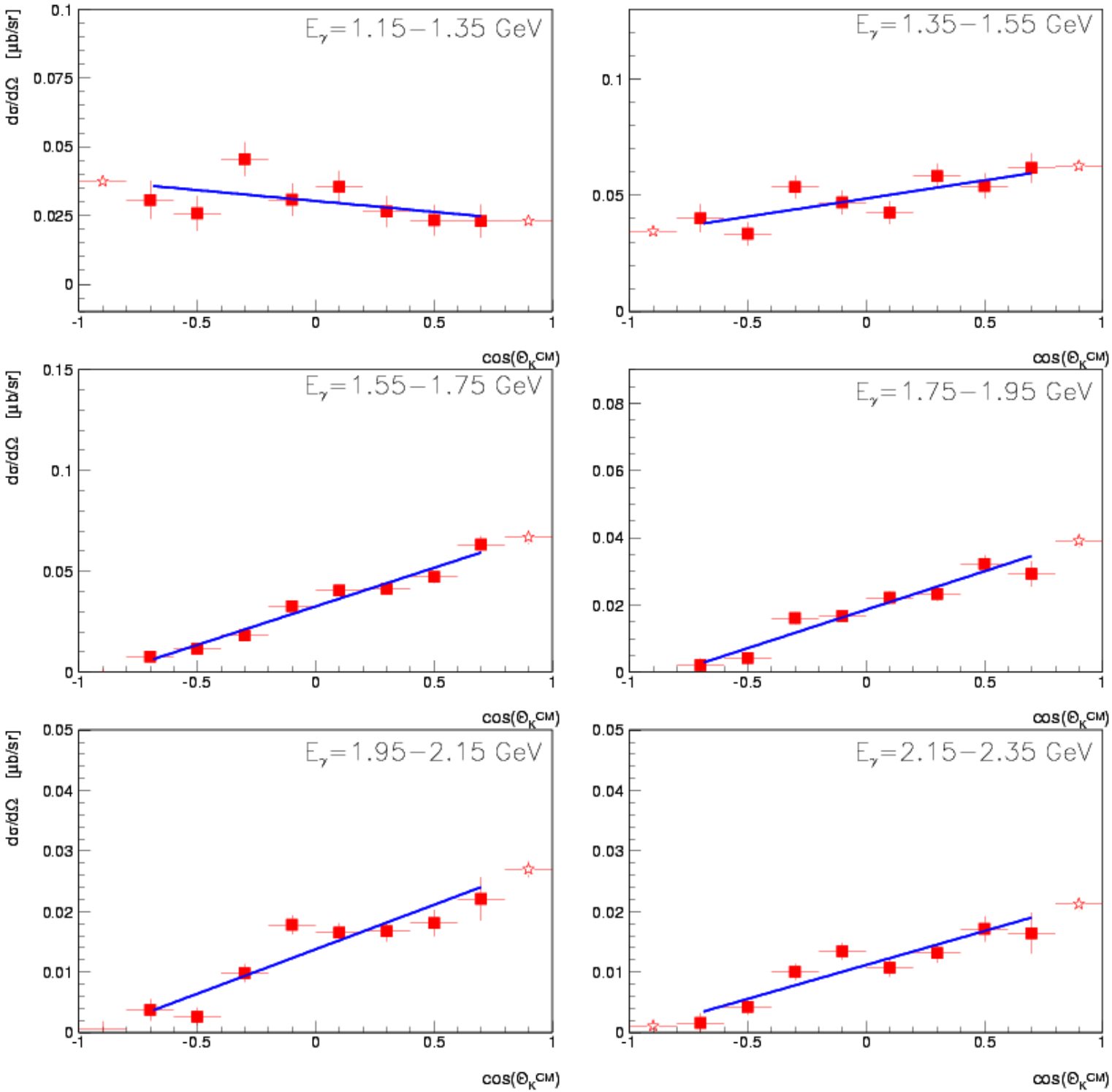




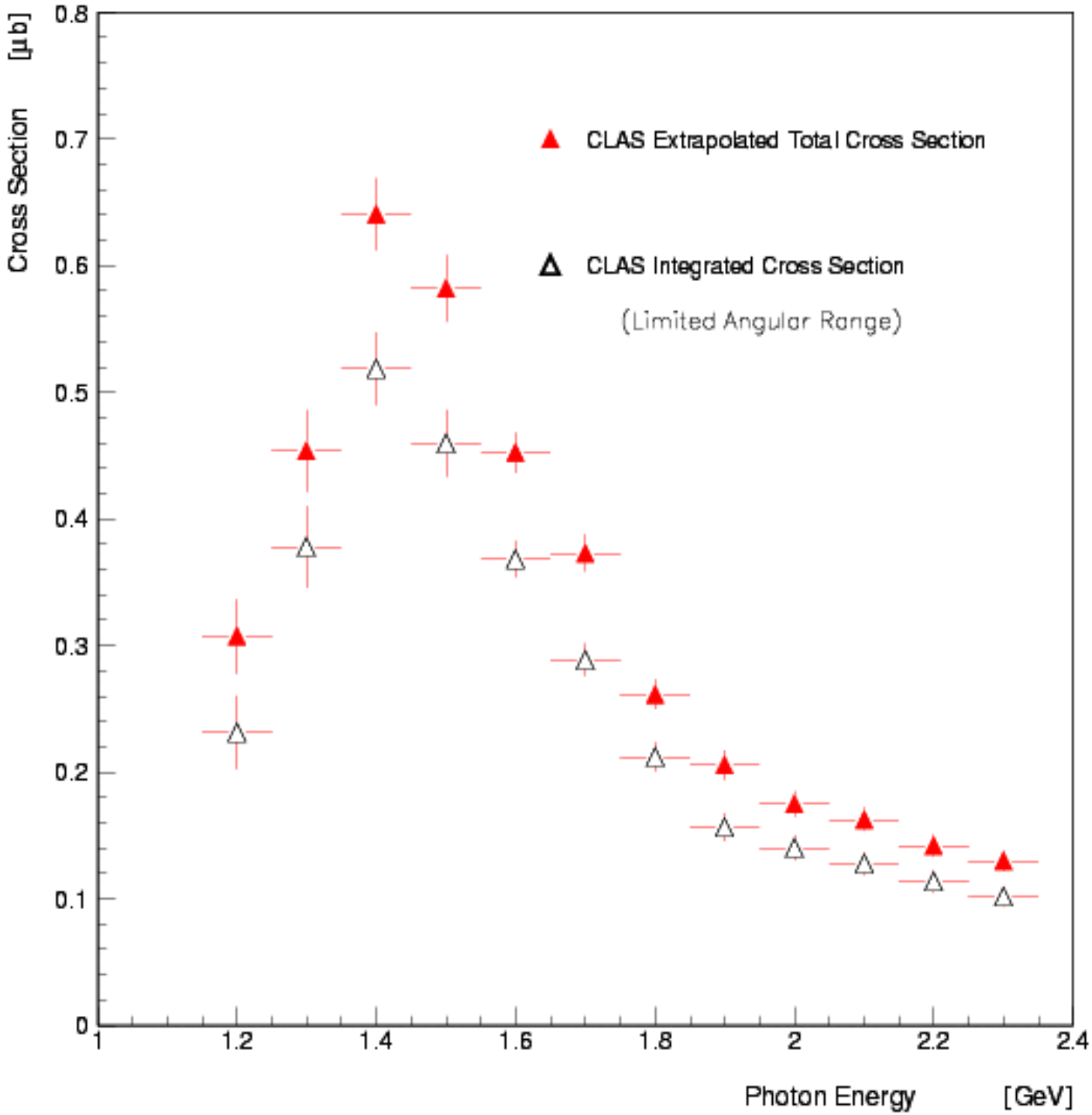




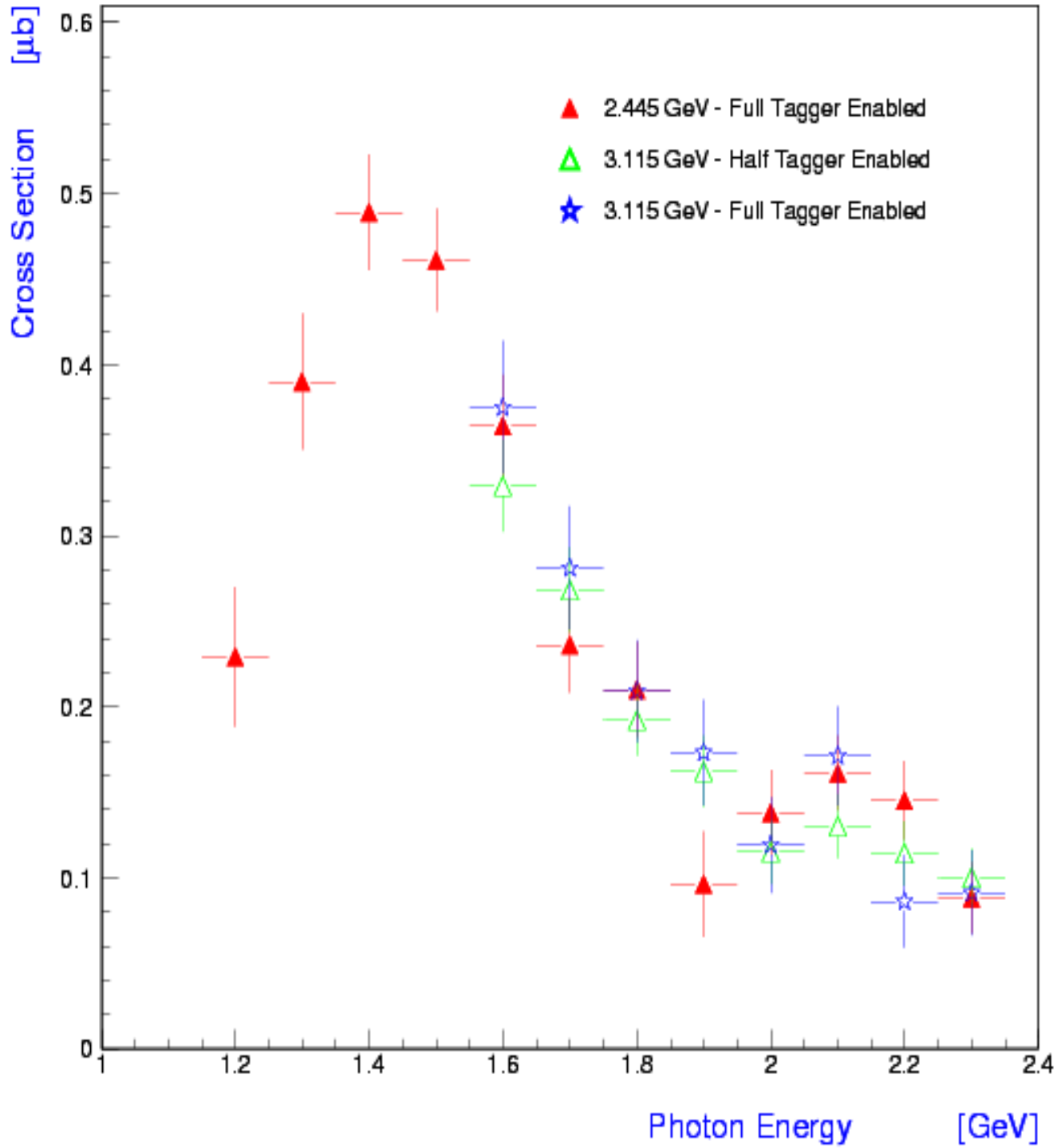
Extrapolation for missing angular regions



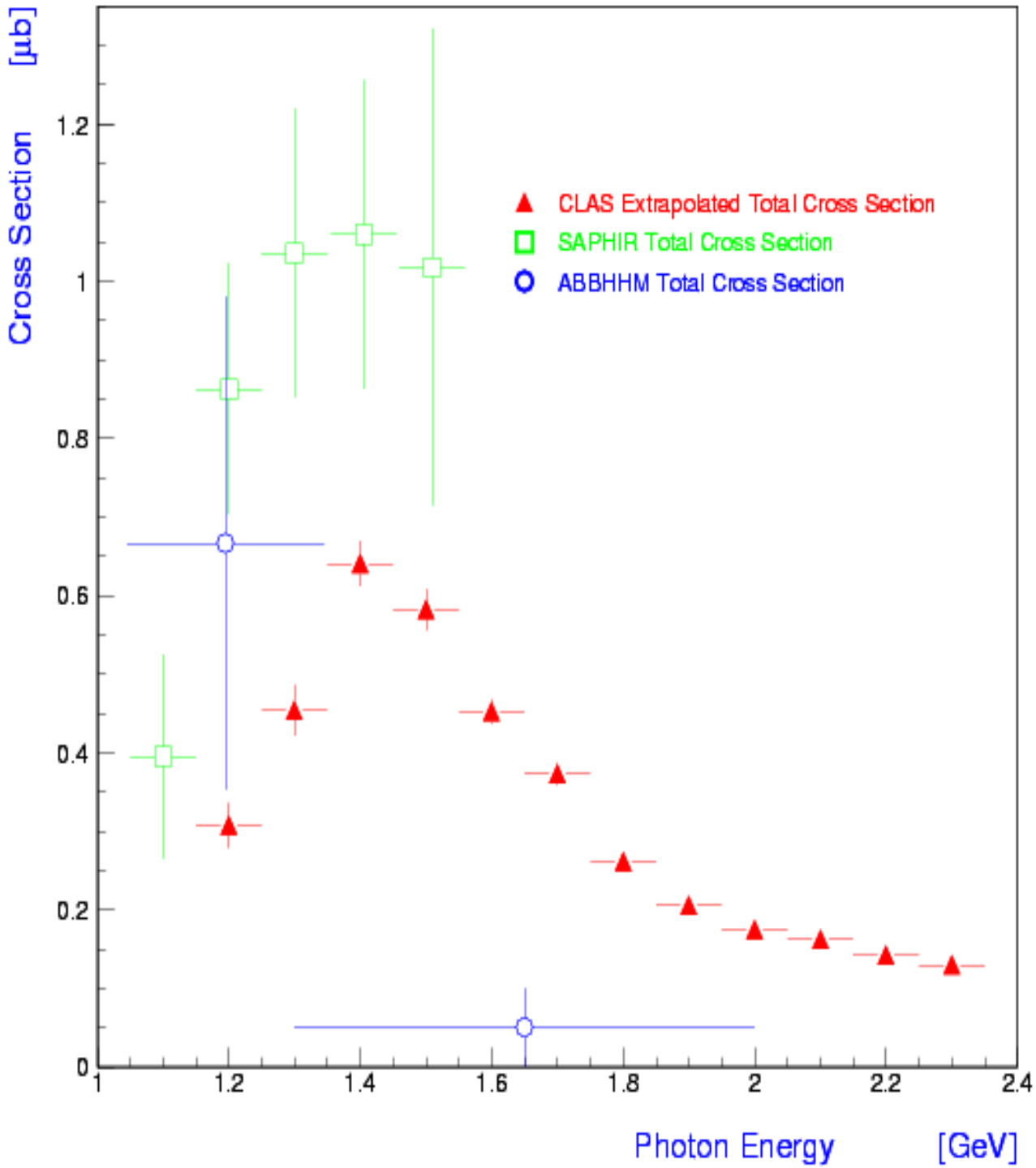
Integrated and extrapolated cross sections



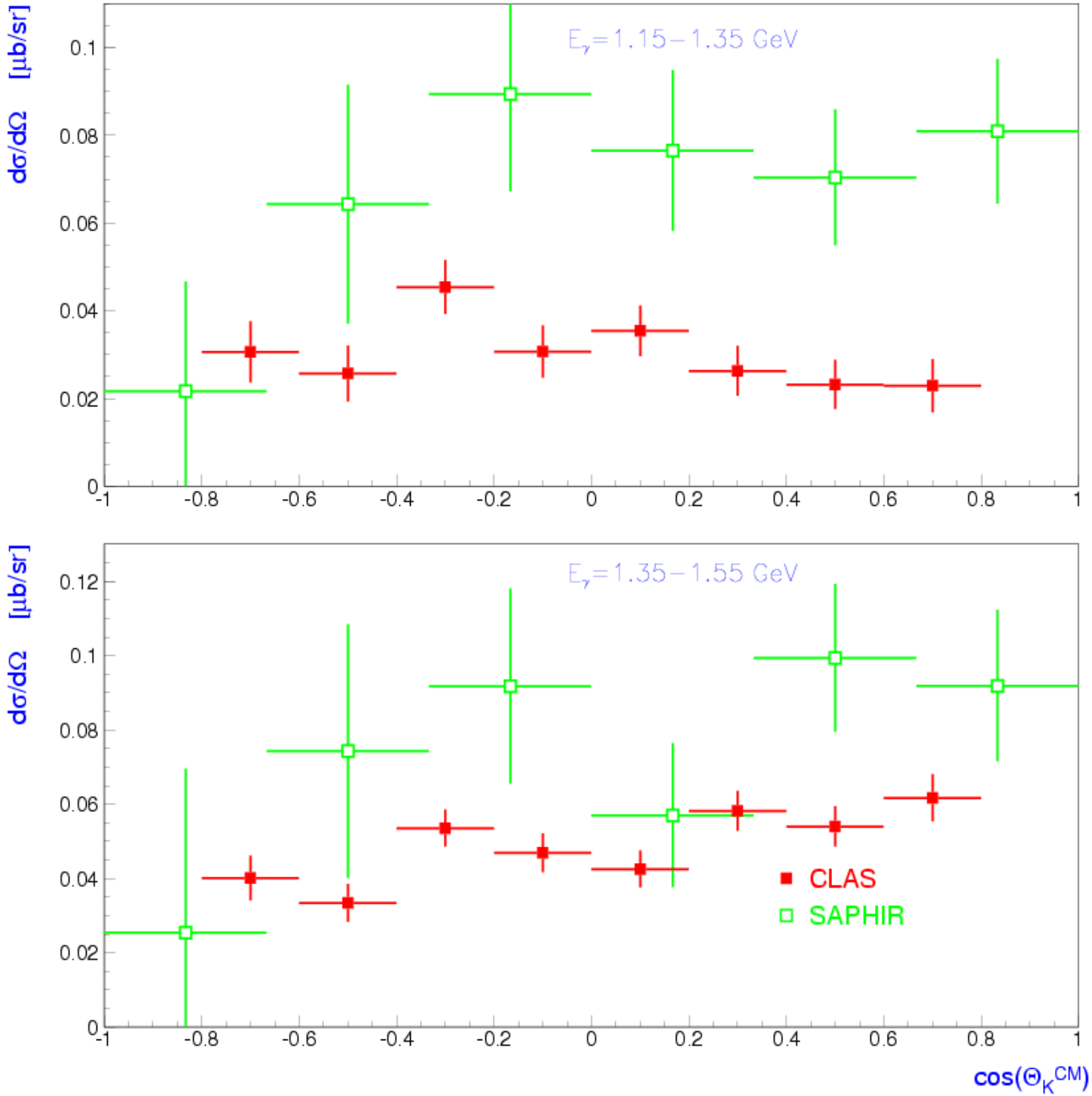
Integrated Cross Sections for $\gamma p \rightarrow K^0\Sigma^+ \rightarrow (\pi^+\pi^-)(p\pi^0)$ for the three data sets

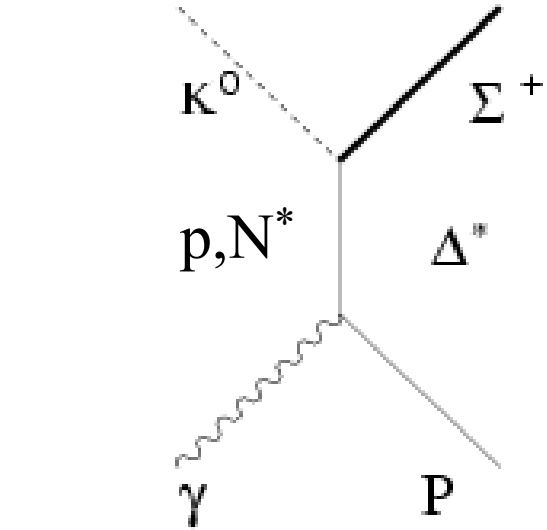


Total cross section comparison with ABBHHM and SAPHIR results

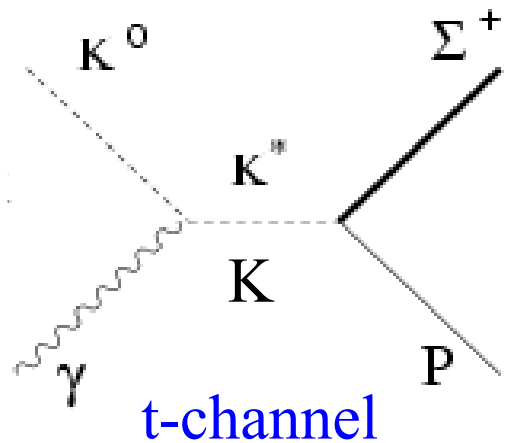


Differential cross section comparison with SAPHIR results

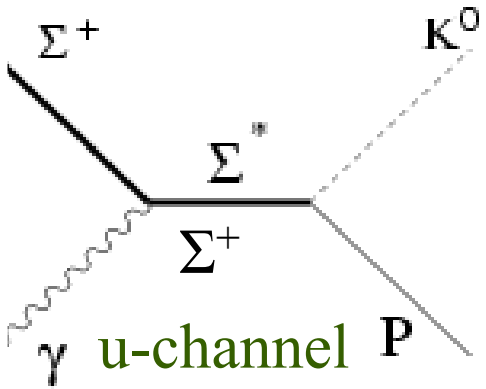




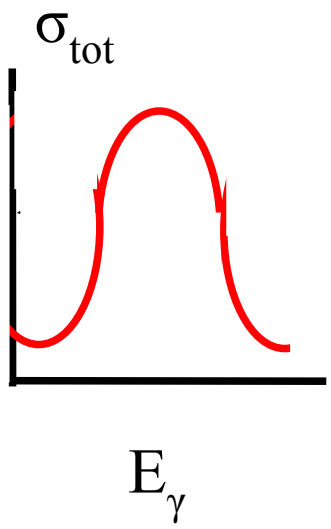
s-channel

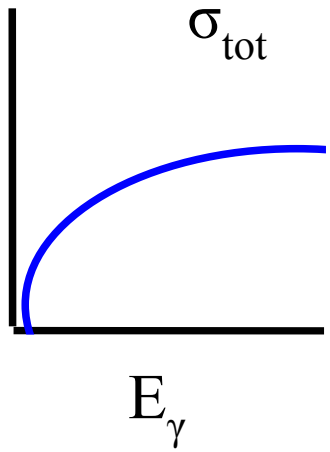


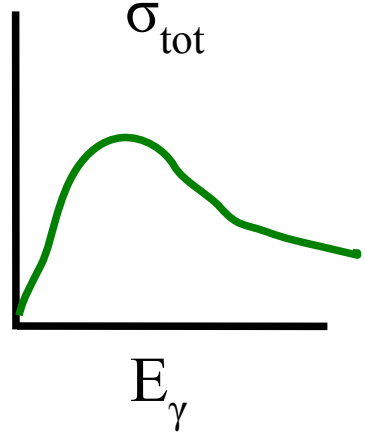
t-channel

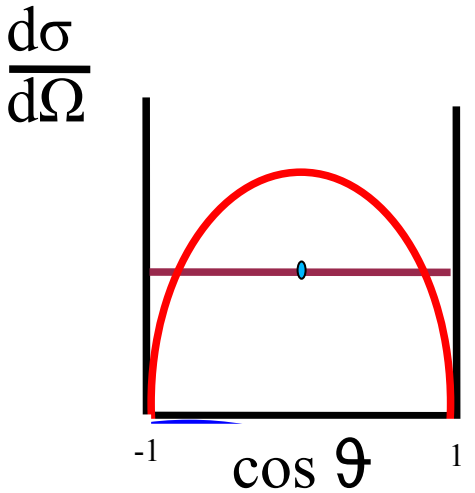


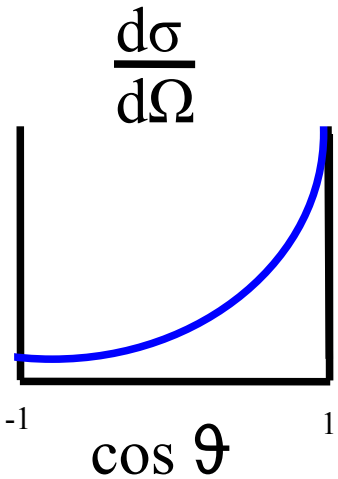
u-channel

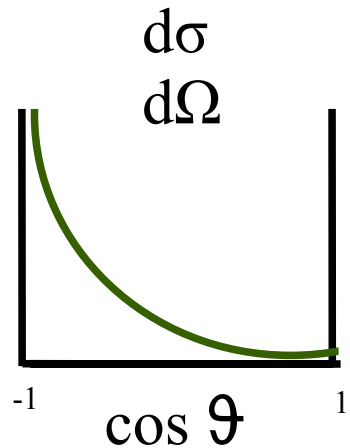




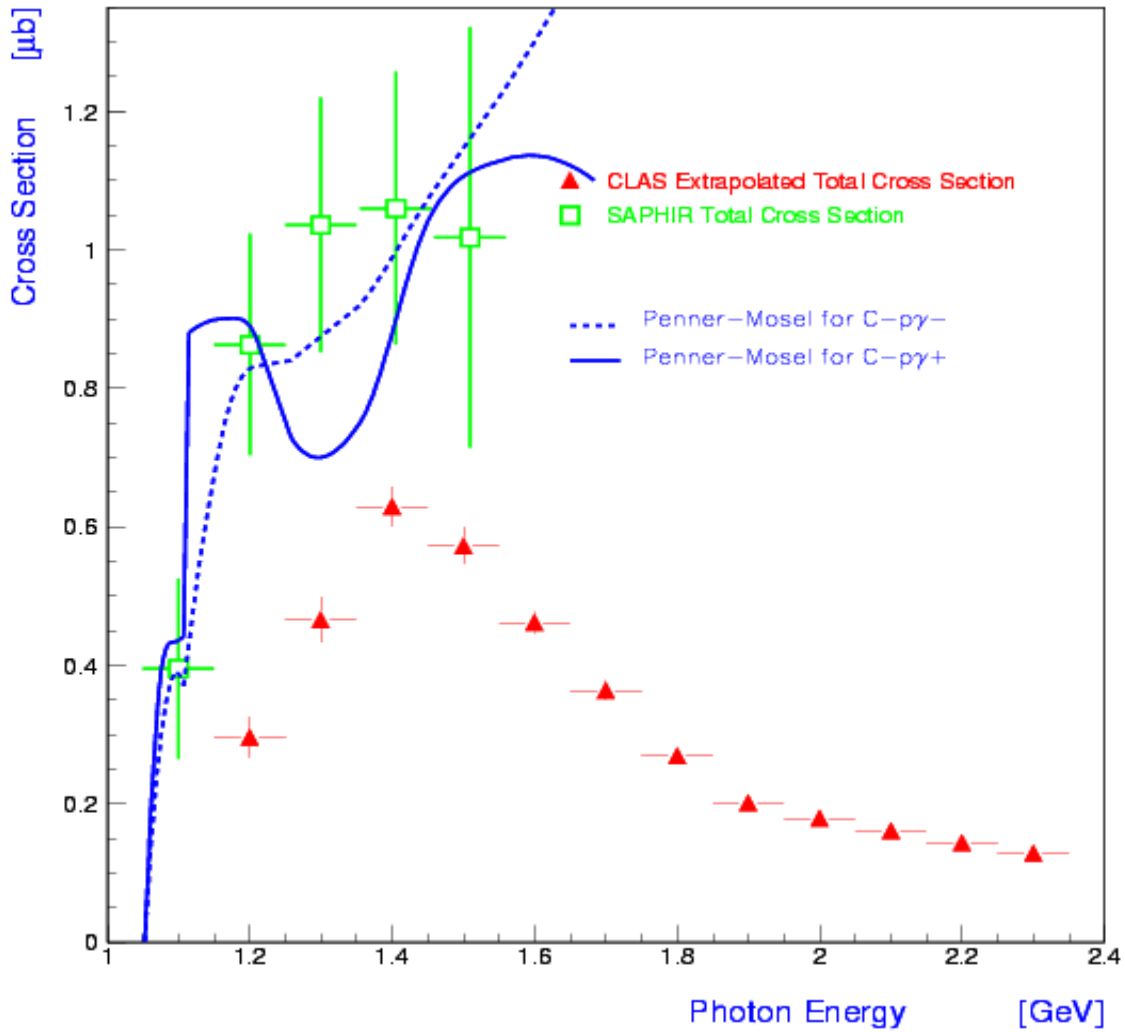






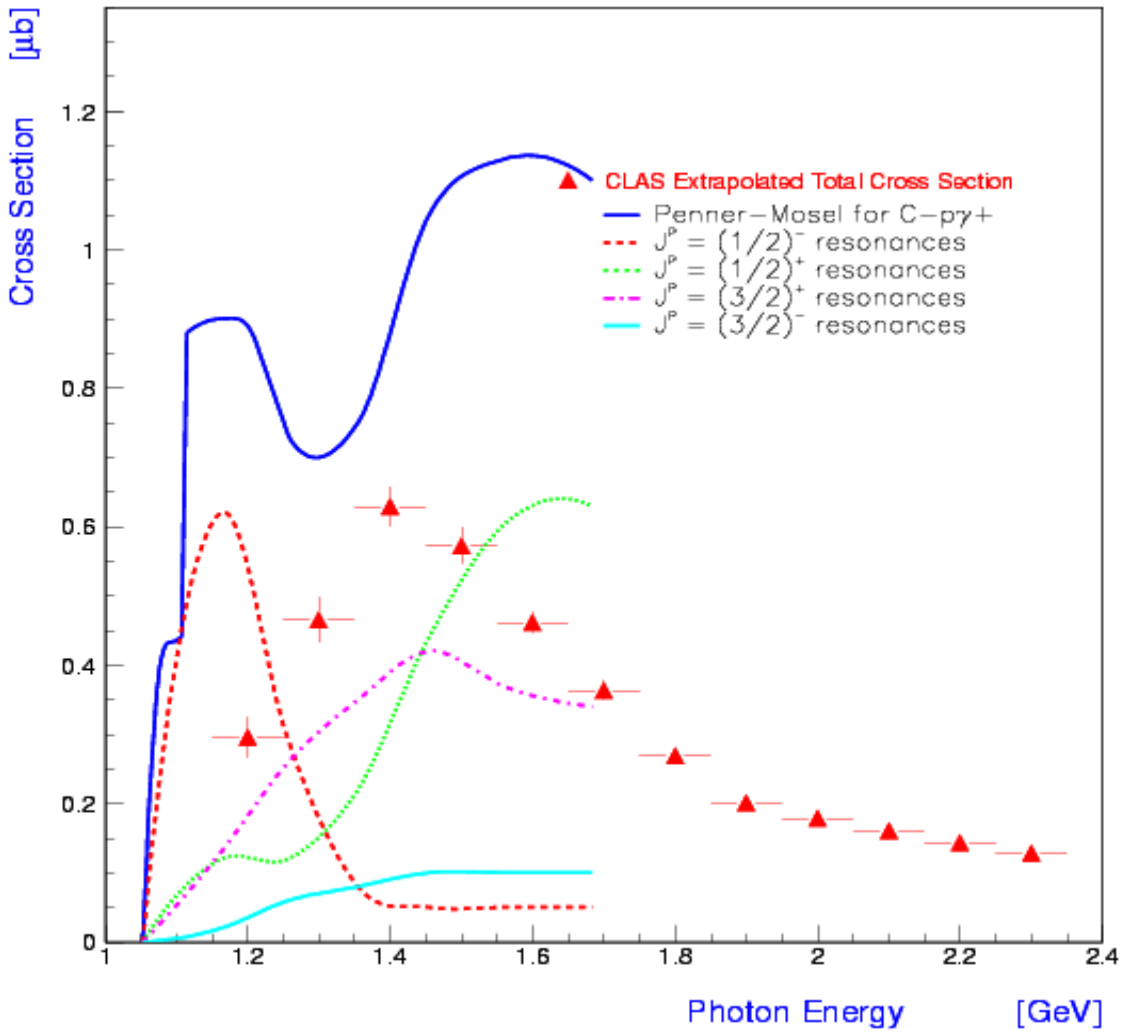


Comparison with Coupled Channel model by Penner & Mosel



Phys. Rev. 66, 055212 (2002)

Comparison with Coupled Channel model by Penner & Mosel



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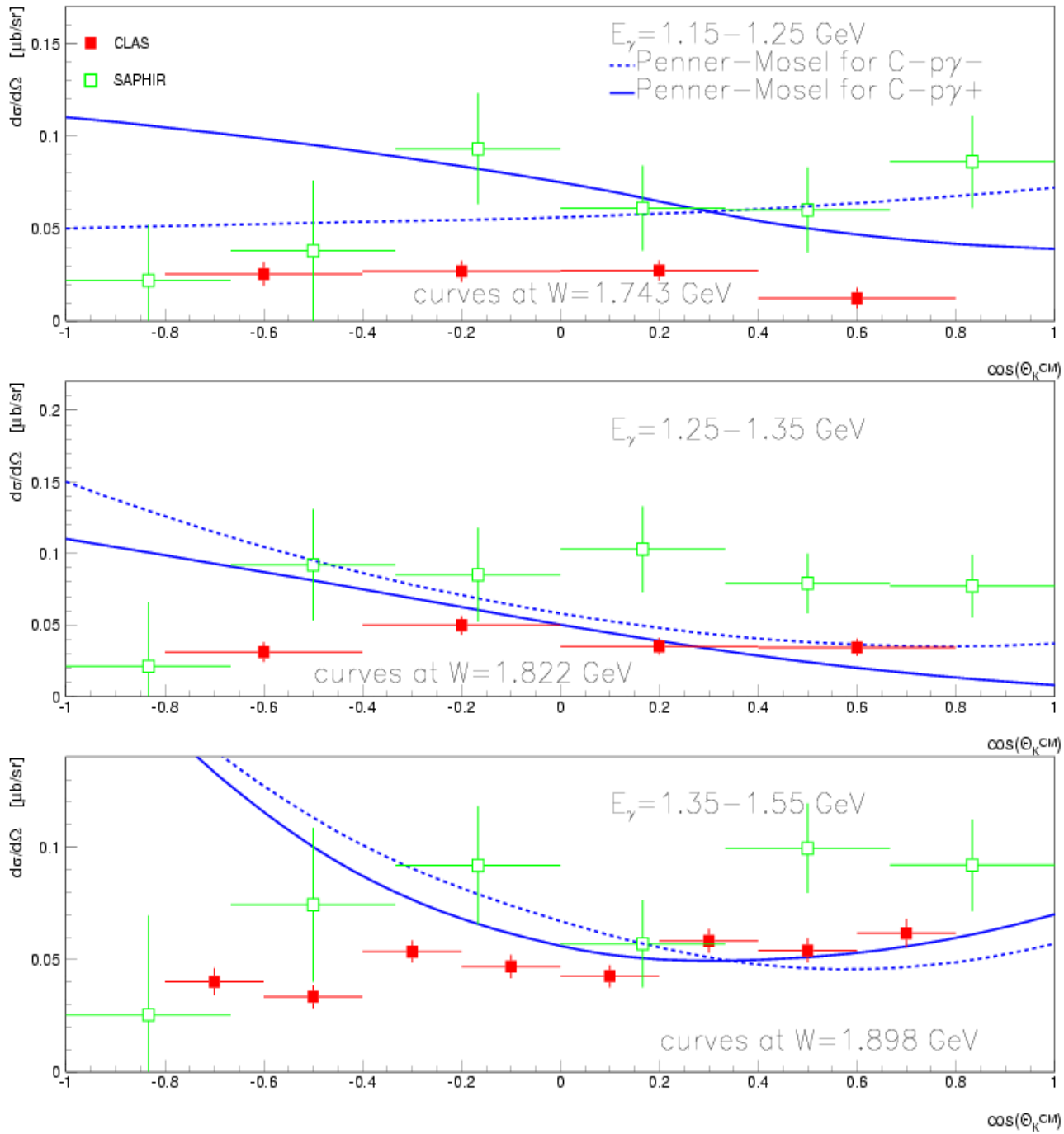
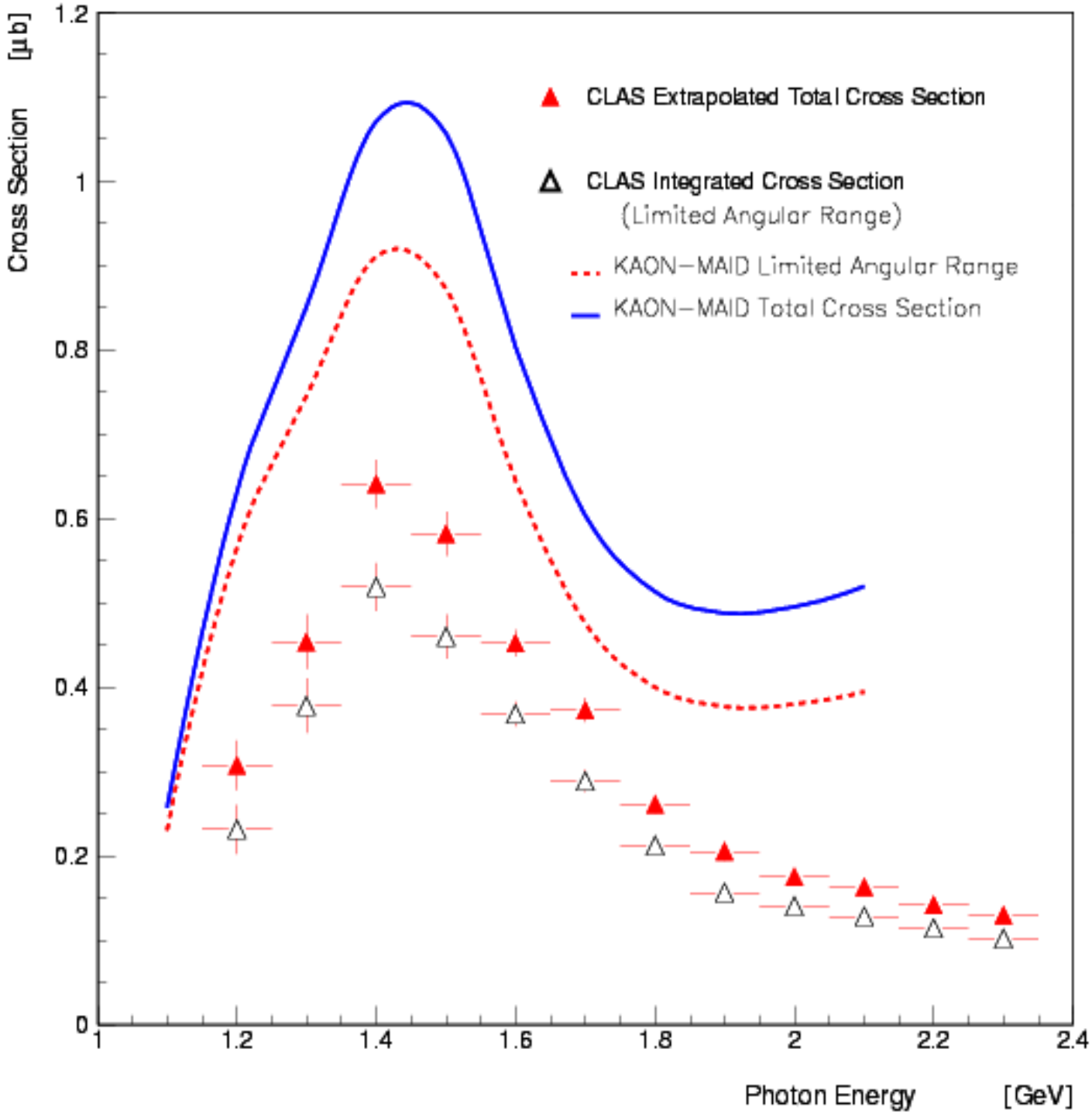
Comparison with Coupled Channel model by Penner & Mosel

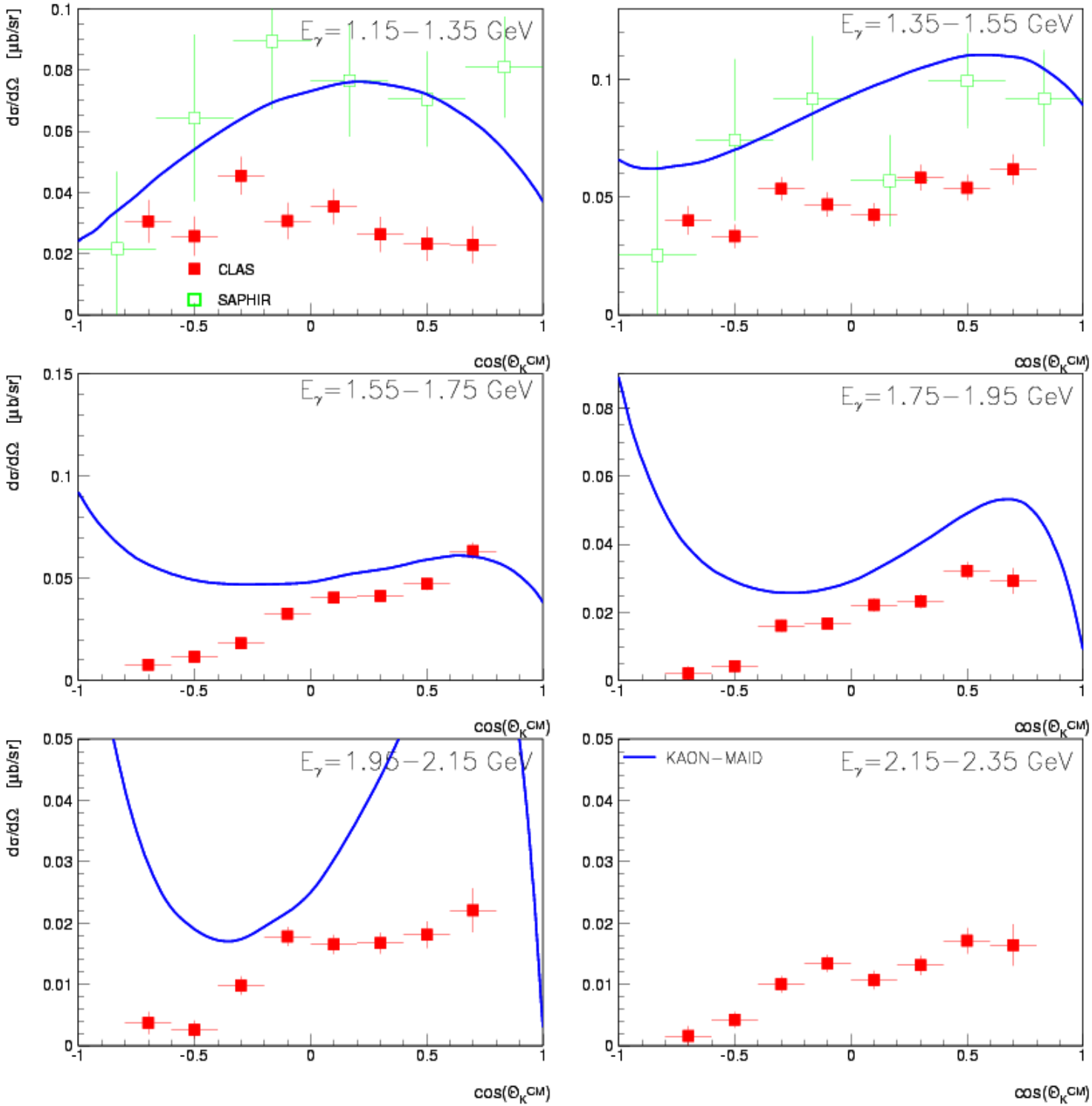
(diff. Xsection)



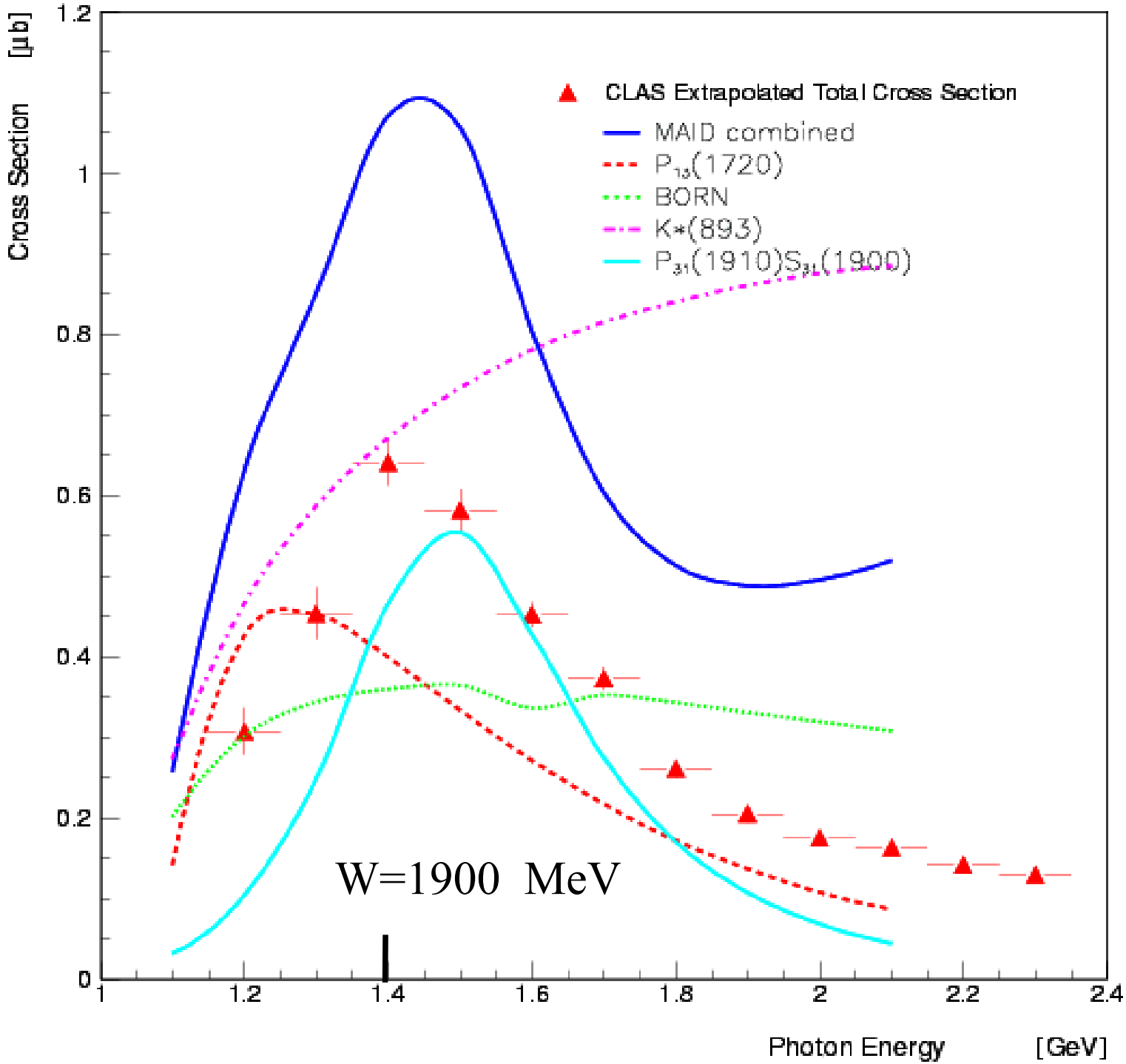
Comparison with KAON-MAID predictions



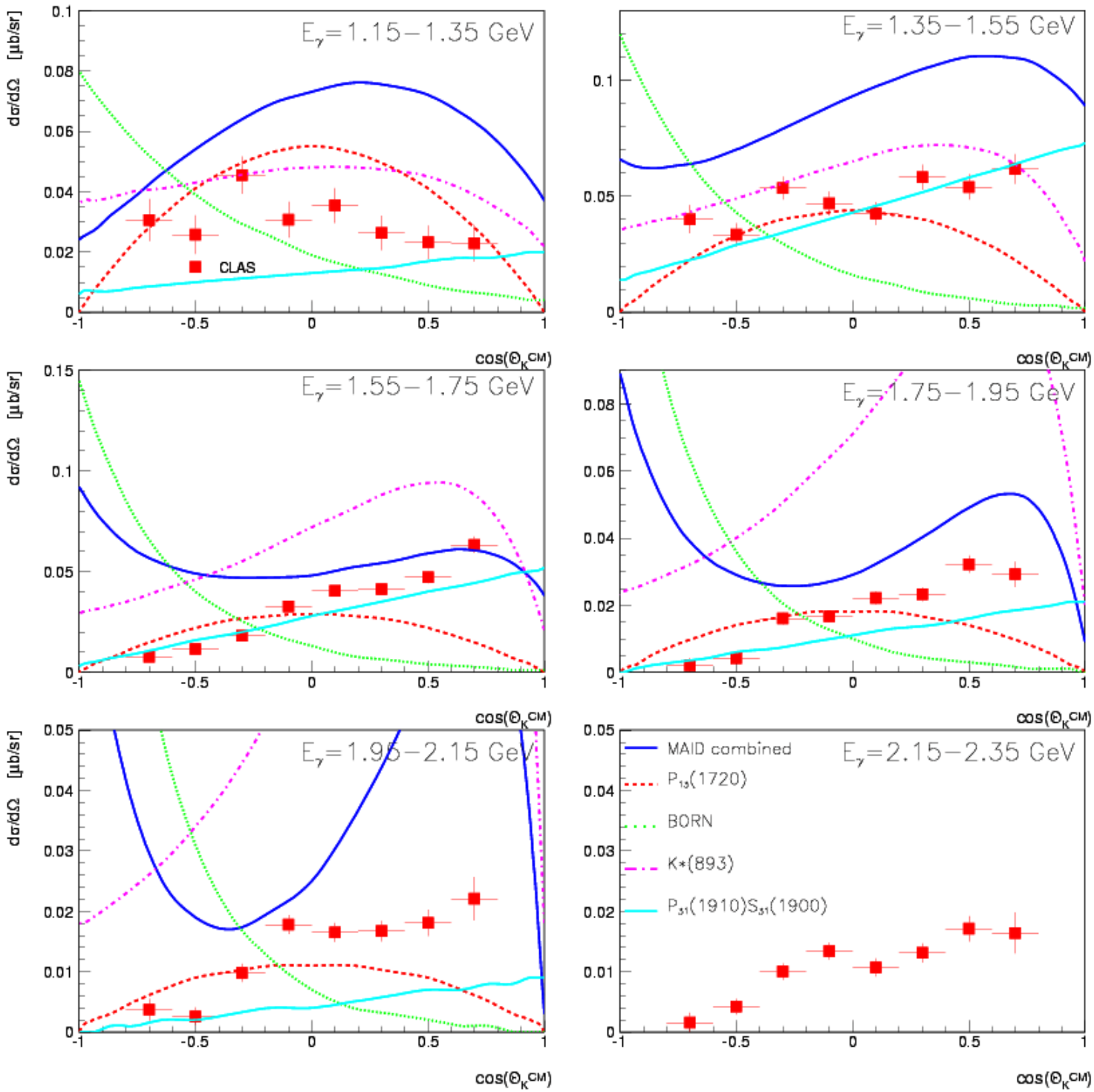
Differential cross sections compared with KAON-MAID predictions



Partial wave decomposition for total cross section (KAON-MAID)



Partial wave decompositions for differential cross sections (KAON-MAID)



Conclusions

- our results for $\gamma p \rightarrow K^0\Sigma^+$ in the range $1.15<E_\gamma<2.35$ GeV greatly expand upon existing data.

- at E_γ <1.55 GeV where previous data existed, our data are similar in shape for total cross section, but lower in magnitude than previous data and the KAON-MAID isobar model.

- for E_γ >1.55 GeV our data differ from KAON-MAID predictions. Our data suggest decreasing the t- and u-channel Born terms.

- future experimental data will refine these results:
  - recoil asymmetry (CLAS-g1c and CLAS-g8b)
  - photon beam asymmetry (CLAS-g8b)
  - target asymmetry (E02-112)
  - beam-recoil and target-recoil polarization (E02-112)