Λ*(1520) Photoproduction on *Proton* and *Neutron*

from CLAS eg3 data set

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APS April 2010   2010/2/14

- Physics motivation
- Data analysis
- Preliminary results
- Summary and outlook

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Physics Motivation

Λ(1520) D_{03} **$I(J^P) = 0(3/2^-)$**

Mass *m* = 1519.5 ± 1.0 MeV **Full width Γ** = 15.6 ± 1.0 MeV

• **Λ***(1520) production mechanism is still poorly understood due to the lack of experimental data.

on the ***Proton***

1. two photoproduction measurements
   - [1] D. Barber *et al.*, Z. Phys. C **7**, 17 (1980)
   - [2] A. Boyarski et al., Phys. Lett. 34B, 547 (1971)
2. two electroproduction measurements
   - [3] T. Azemoon et al., Nucl. Phys. B95, 77 (1975)
   - [4] S. P. Barrow *et al.* (Clas Collaboration), Phys. Rev. C **64**, 044601 (2001).

on the ***Neutron,***

No published data

• Existing Data suggest dominance of t-channel processes and K* or K exchange.

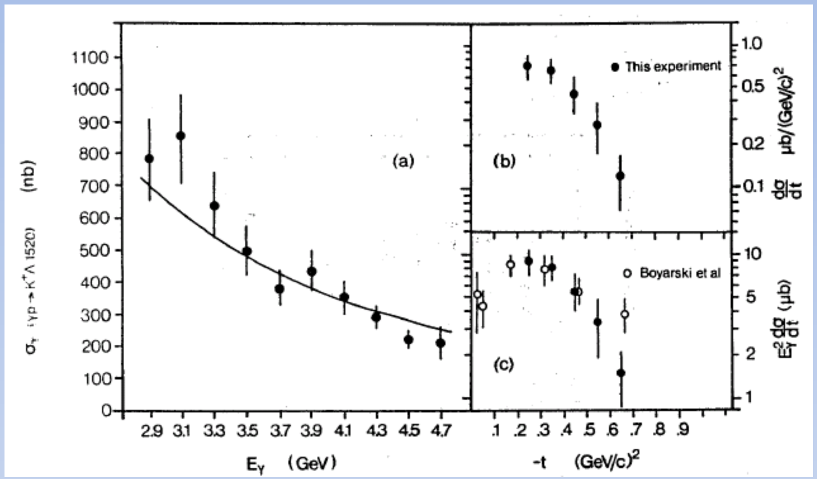
• Several model predictions for total and differential cross sections are available.

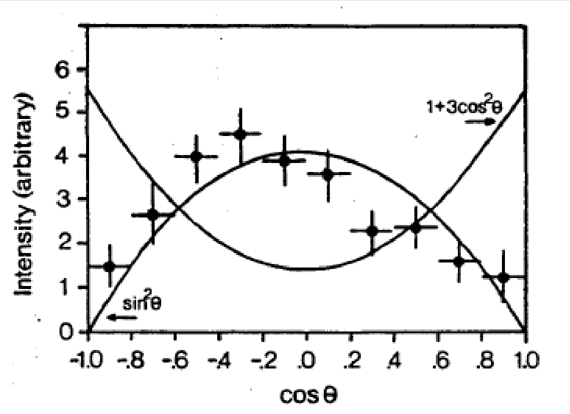
• Measurement of cross section and decay angular distribution can provide constraints on model prediction and insights into the production mechanism.

• Possible missing N* resonances decaying through strange channels.

Existing Data photoproduction

- Photoproduction measurements on the ***Proton*** were performed at SLAC and Daresbury
- Daresbury measured differential and total cross section as well as decay angular distribution in the energy range of 2.8-4.8 GeV
  - First look at the decay angular distribution showed dominance of $m_z=\pm 3/2$ spin projection
  - Limited statistics
- ***No data on Neutron yet***





Theoretical Result photoproduction

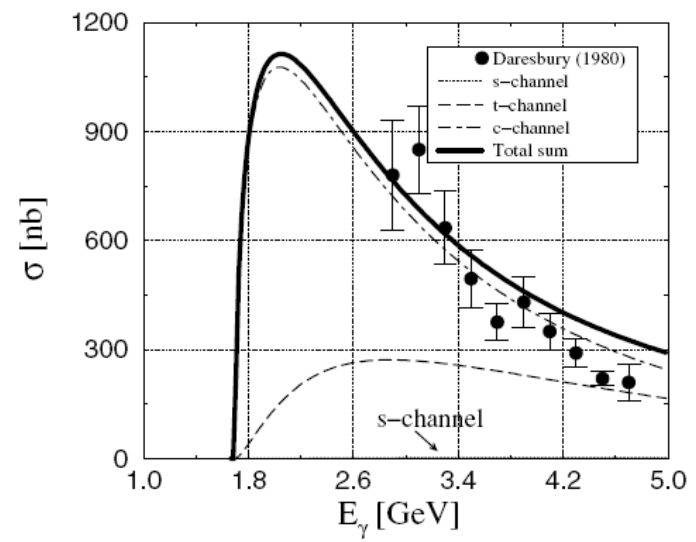


FIG. 3. The total cross sections for the proton target with the form factor F_1. The s-, t- and c-channel contributions are drawn separately. The experimental data are taken from Ref. [4]

Reactions	$\gamma p \to K^+\Lambda^*$		$\gamma n \to K^0\Lambda^*$
σ	$\sim 900\ nb$	>>	$\sim 30\ nb$

?

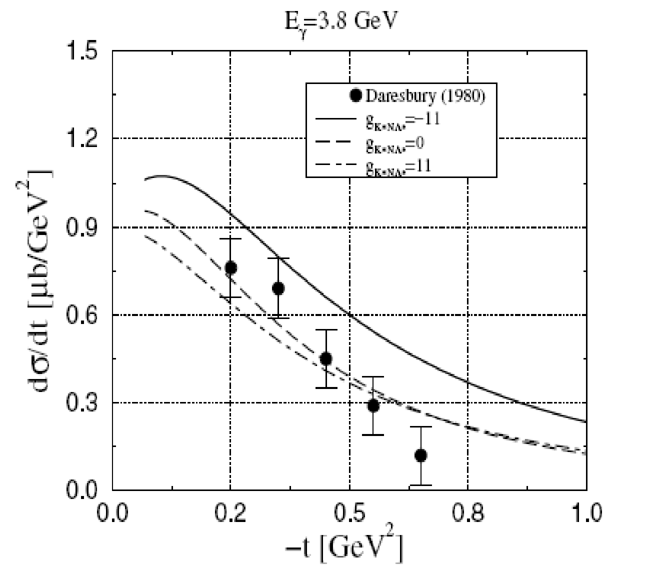


FIG. 5. The t-dependence for the proton target at $E_\gamma = 3.8$ GeV. We choose $(\kappa_{\Lambda^*}, X) = (0, 0)$. The experimental data are taken from Ref. [4]

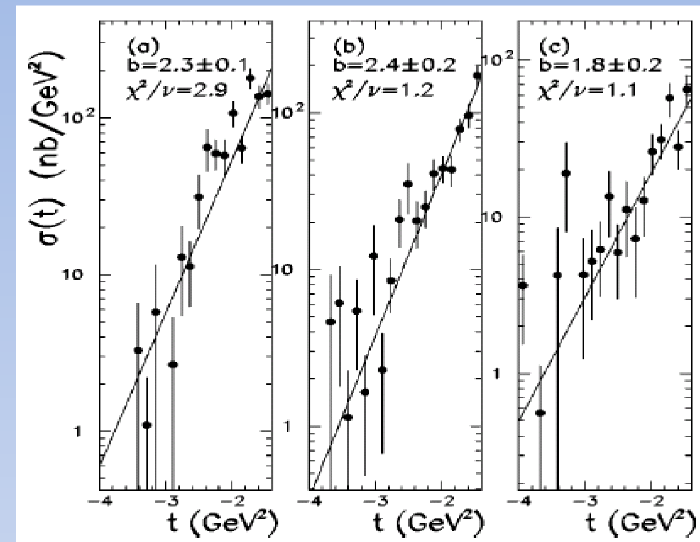
Proton

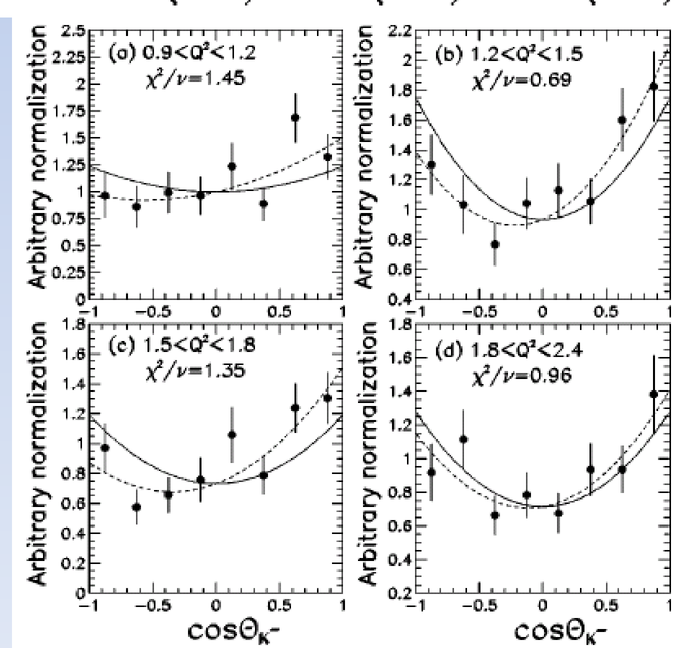
Comparing between data and theory

S. Nam et al. Phys. Rev. D 71, 114012 (2005)

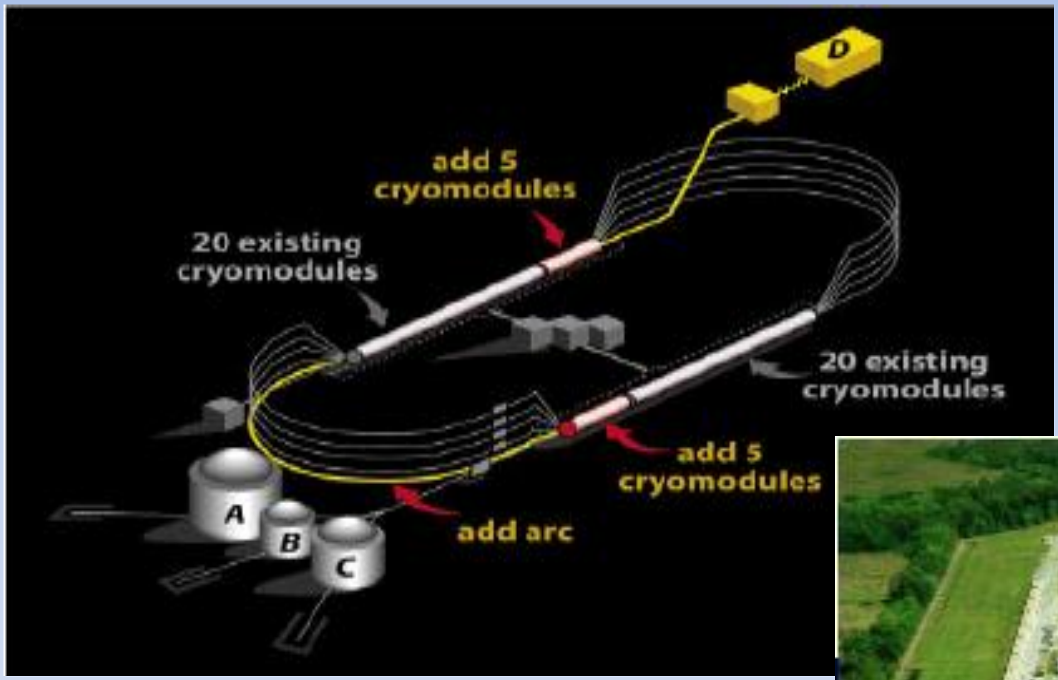
Existing Data electroproduction

- Electroproduction of Λ* off ***Proton*** has been studied at DESY and CLAS
- CLAS data (S. Barrow, e1c) showed
  - Dominance of t-channel process confirmed
  - Decay angular distribution showed significant contribution from $m_z=\pm 1/2$ spin projection

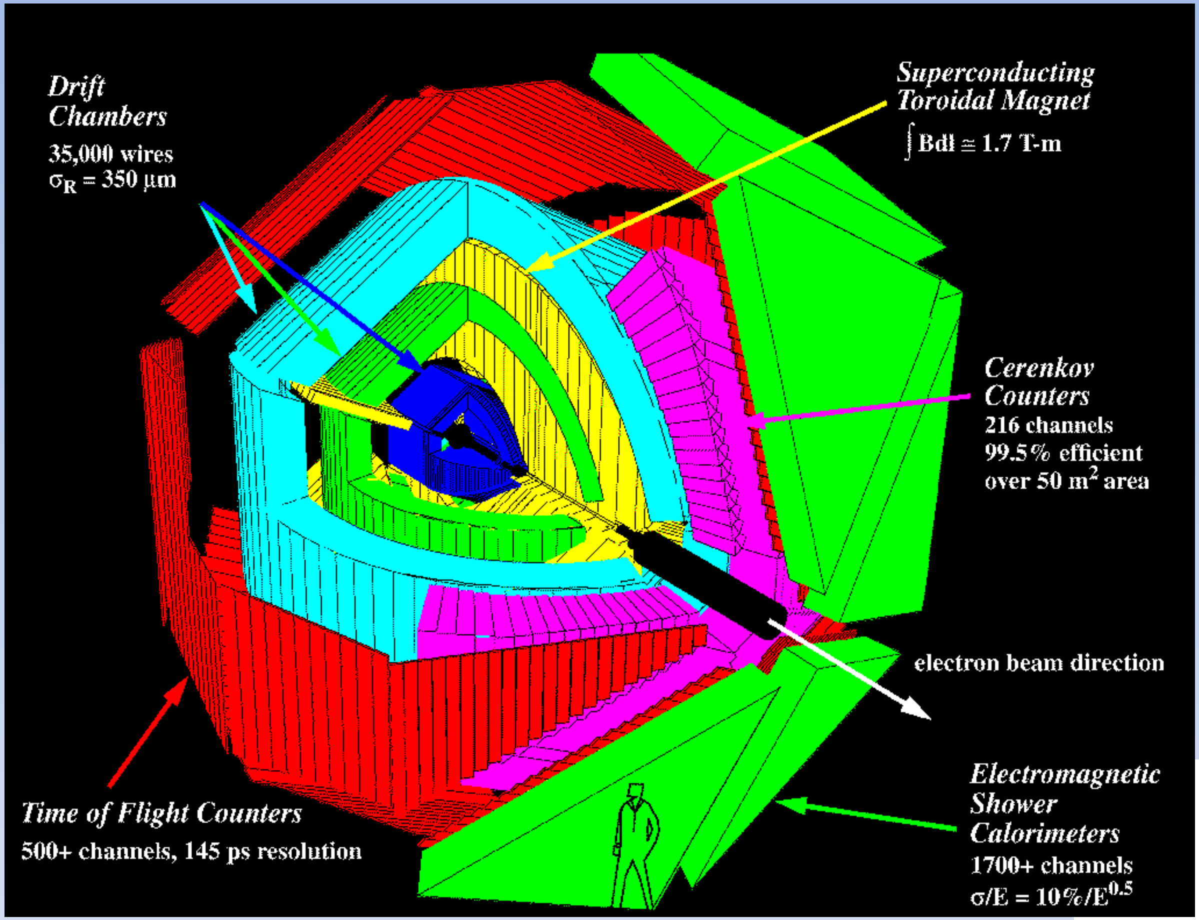


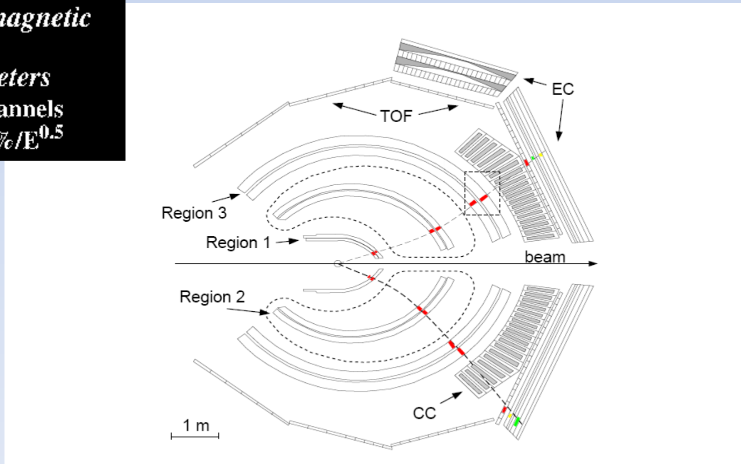


Jefferson Lab



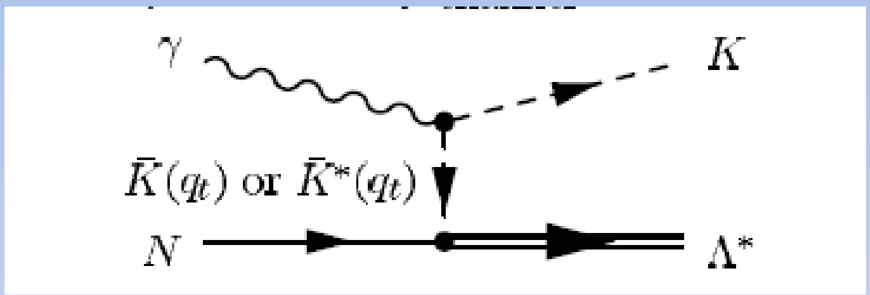
CLAS Detector





Reaction Channels

<u>deuteron target</u>



exclusive

$\gamma p(n) \rightarrow K^+ \Lambda^* (n)$ Proton

$\gamma n(p) \rightarrow K^0 \Lambda^* (p)$ Neutron

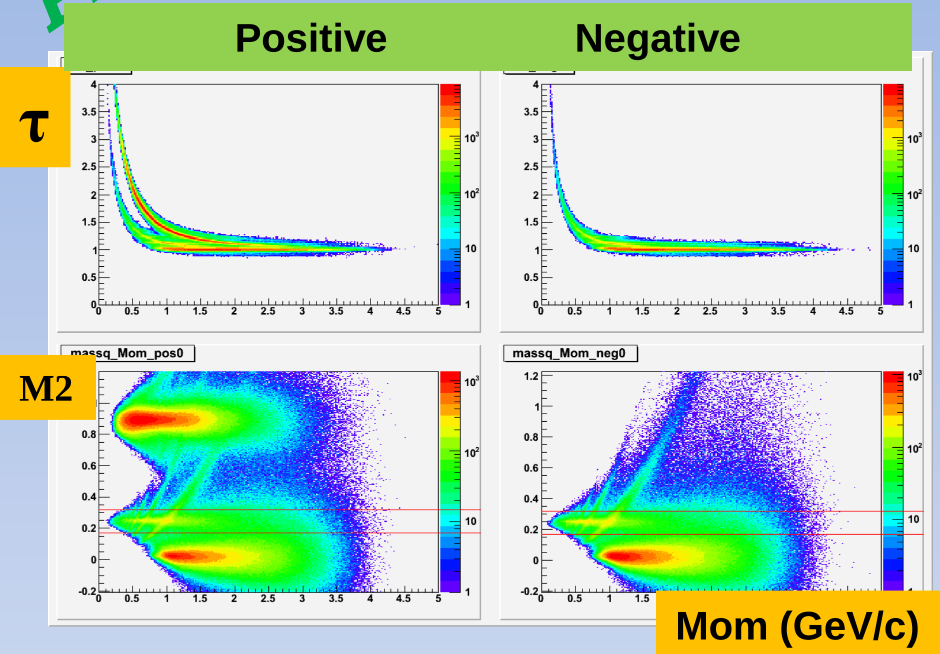
$(\Lambda^* \rightarrow p K^-$, $K^0 \rightarrow K^s \rightarrow \pi^+ \pi^-)$

eg3 run

- **Photon beam** electron beam 5.77 GeV, photon energy Tagger 1.15 < E < 5.5 GeV, 30 nA
- **Target** 40 cm upstream, LD2
- **Trigger** Tagger 4.5 < E < 5.5 GeV, STxTOF (3 sectors and prescaled 2 sectors), ST
- **Torus field** optimized to -1980 A, negative outbending
- **Run period** 12/06/2004 – 01/31/2005, 29 days of production on LD2 target
- **Data** 4.2 billion physics events, 32 TB raw data, average 2.7 tracks/event

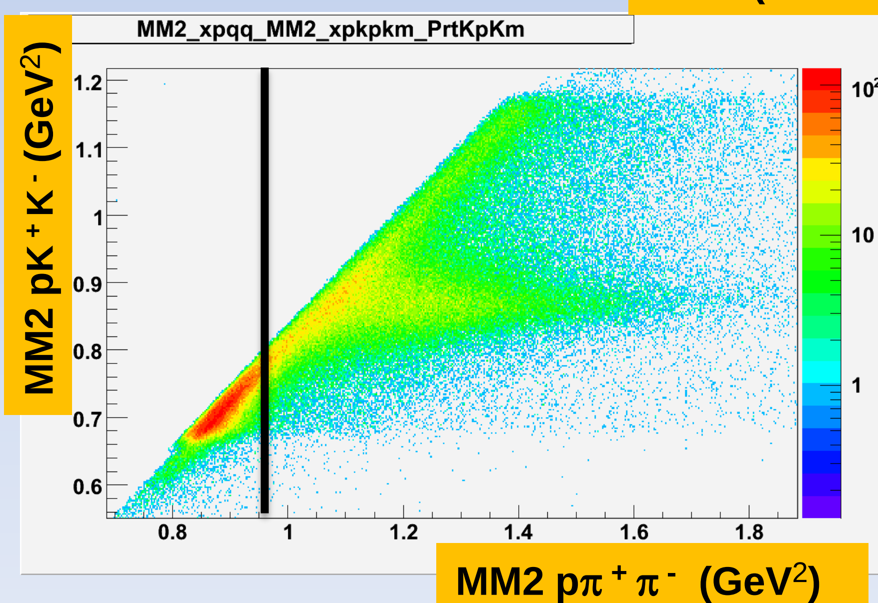
Event Selection

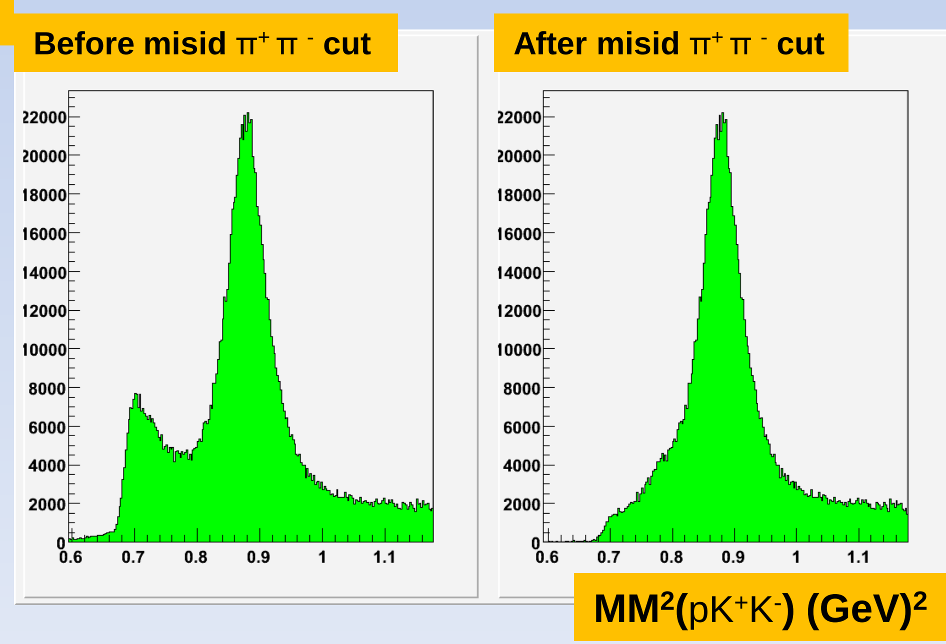
Proton



Particle timing after photon selected

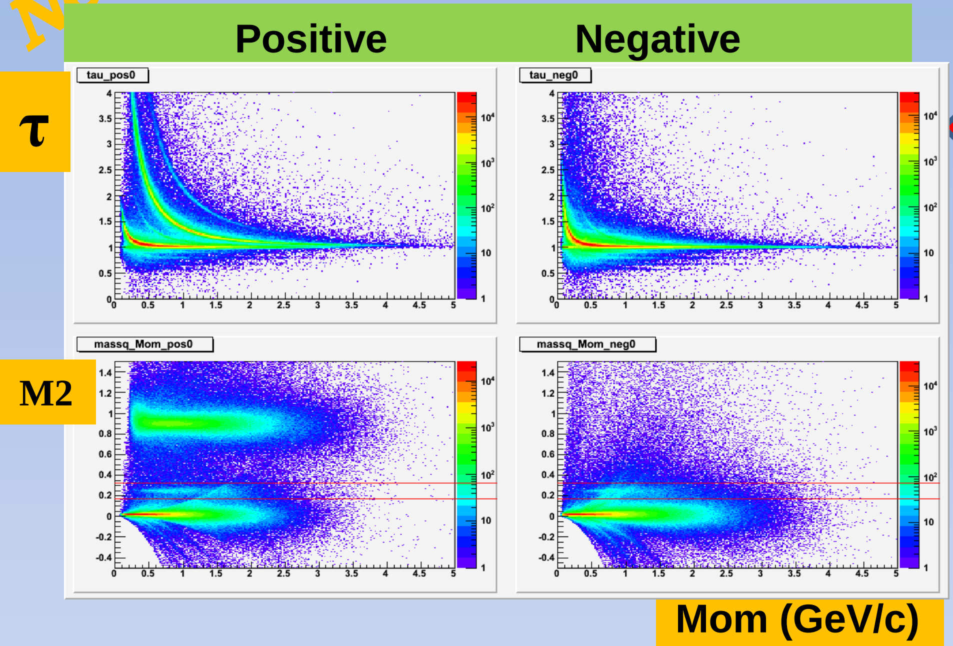
Cut Missidentified Pions



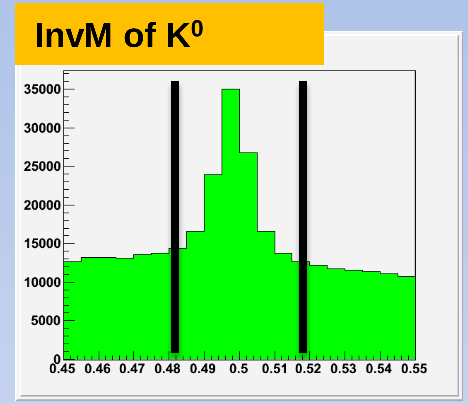


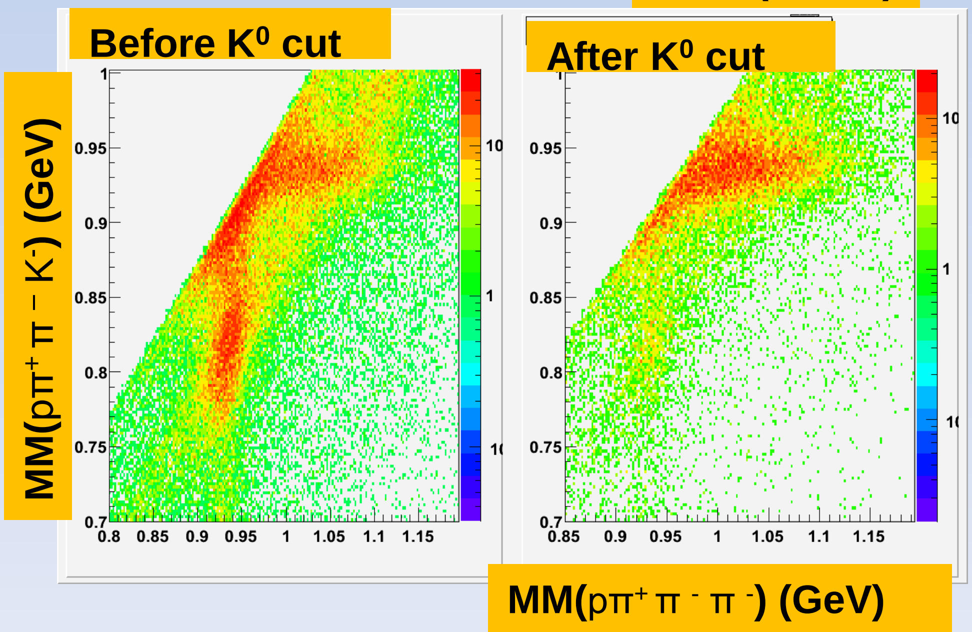
Neutron

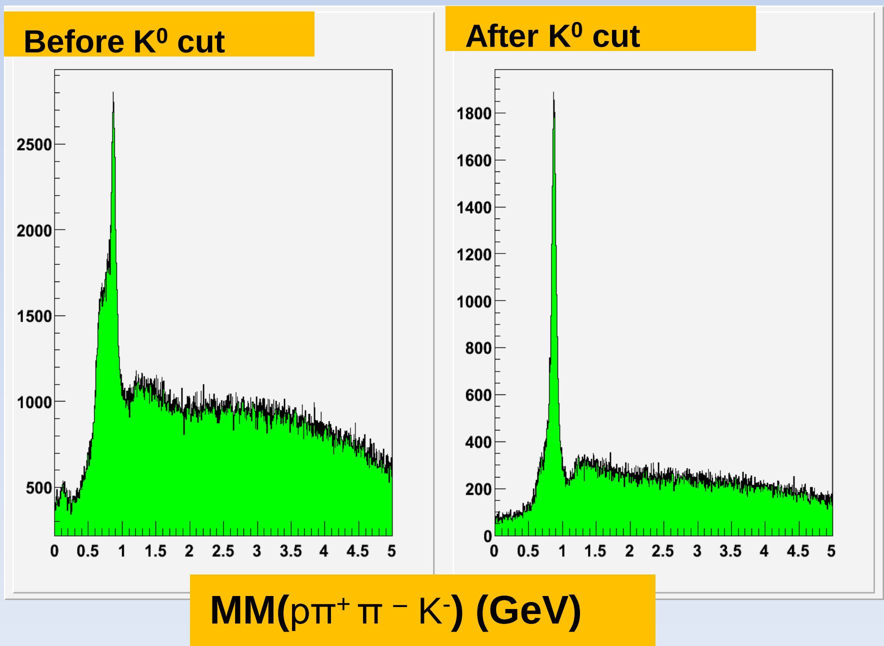
Event Selection



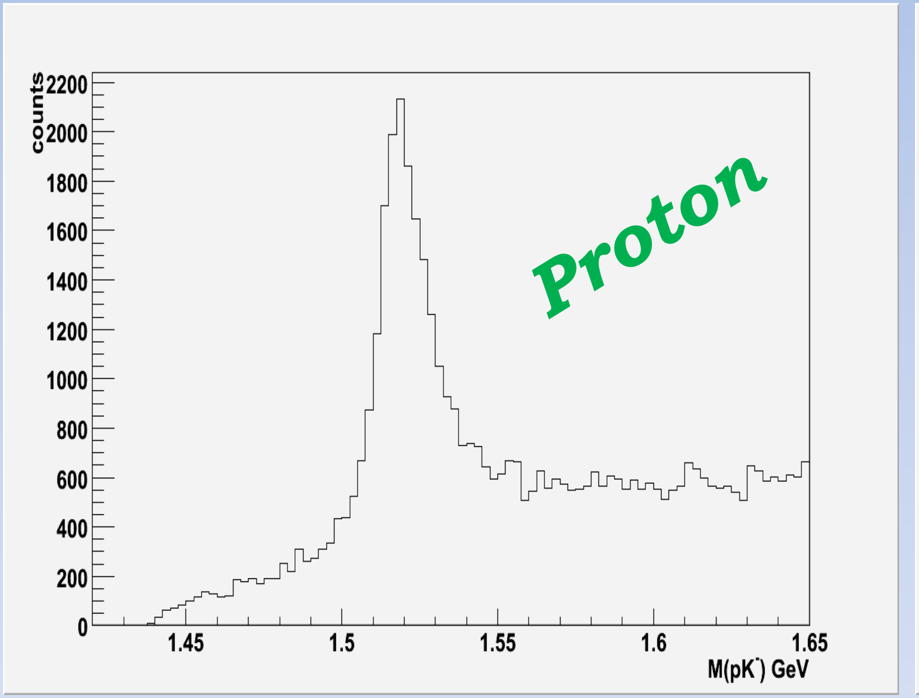
Particle timing after photon selected

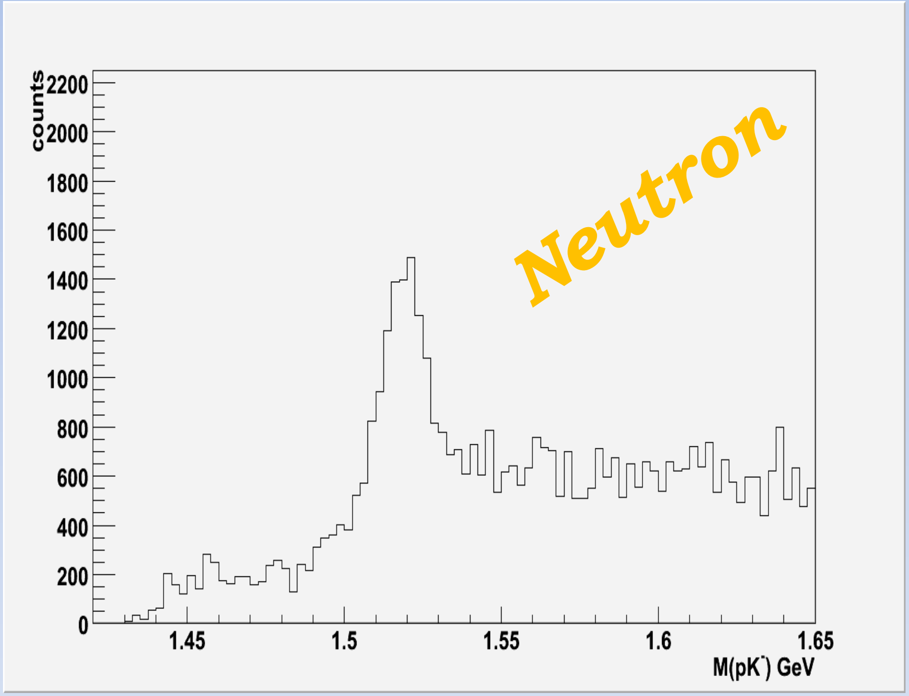






InvM of p K⁻

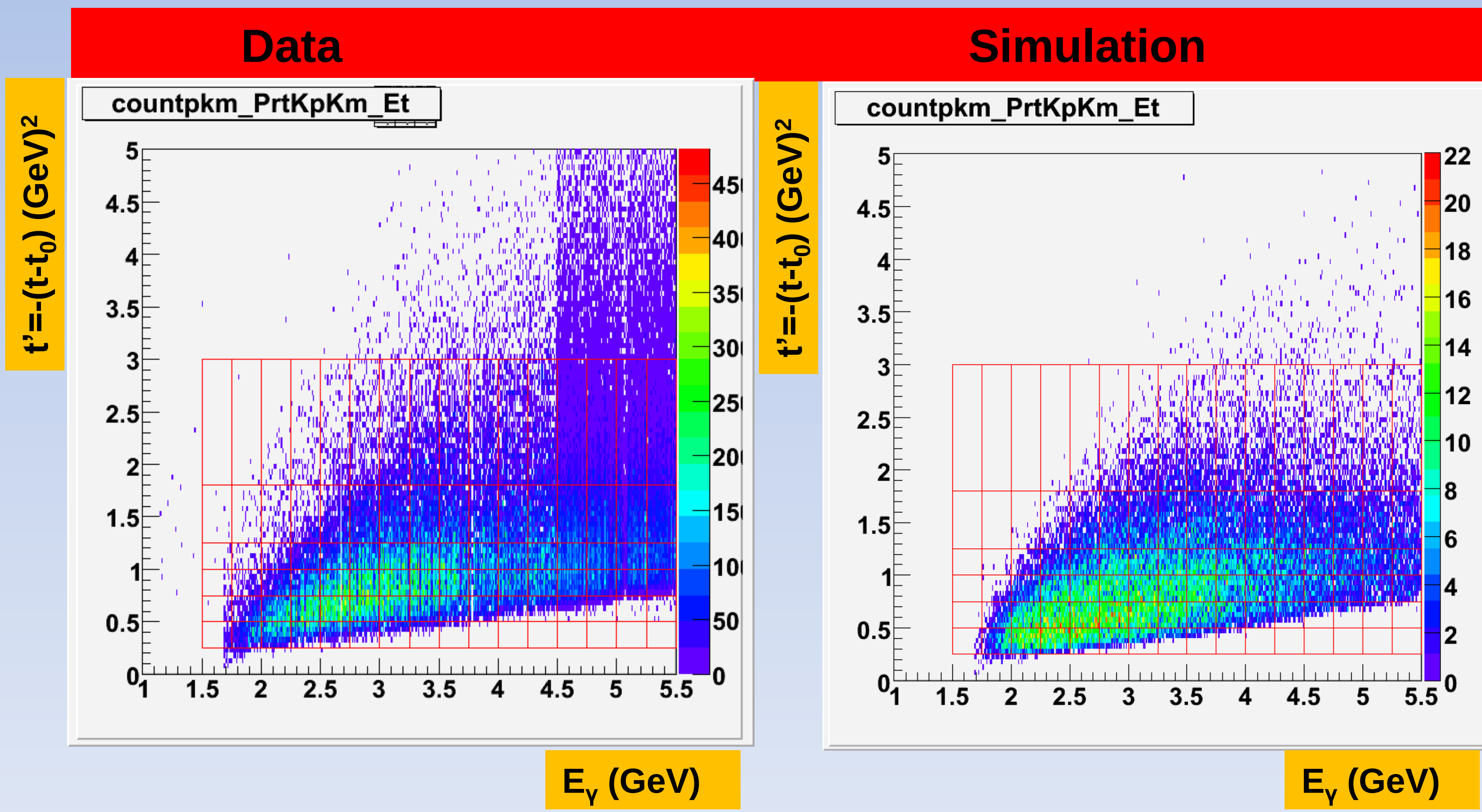

counts
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
1.45
1.5
1.55
1.6
1.65
M(pK⁻) GeV
Proton


counts
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
1.45
1.5
1.55
1.6
1.65
M(pK⁻) GeV
Neutron

Kinematic Distribution

$1.5 < E_\gamma < 5.5$ GeV
16 bins, bin width = 250MeV

$0.25 < t' < 3$ GeV^2
6 bins, bin width varies



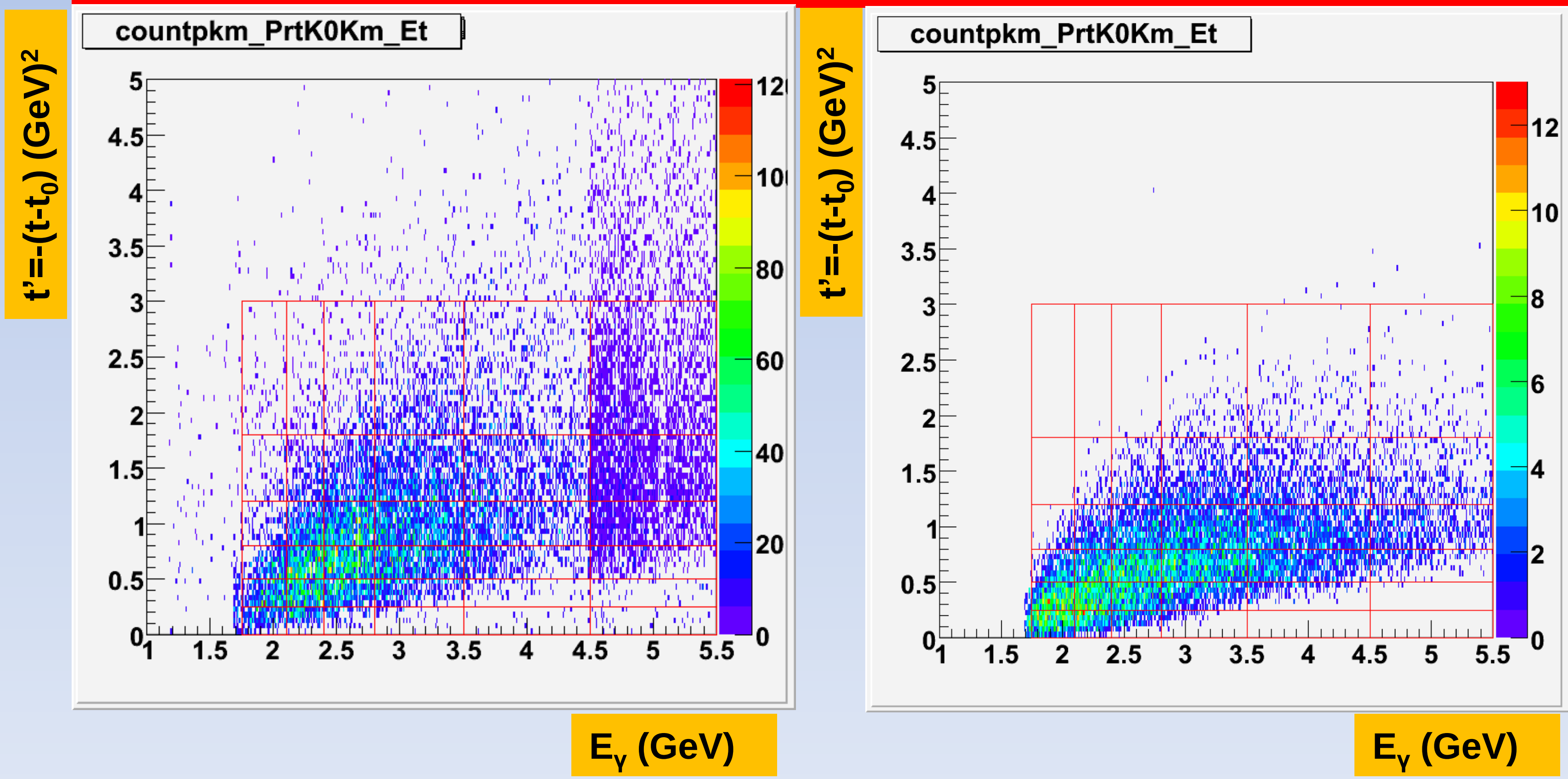
Kinematic Distribution

Neutron

$1.75 < E_\gamma < 5.5$ GeV
6 bins, bin width varies

$0. < t' < 3$ GeV^2
6 bins, bin width varies

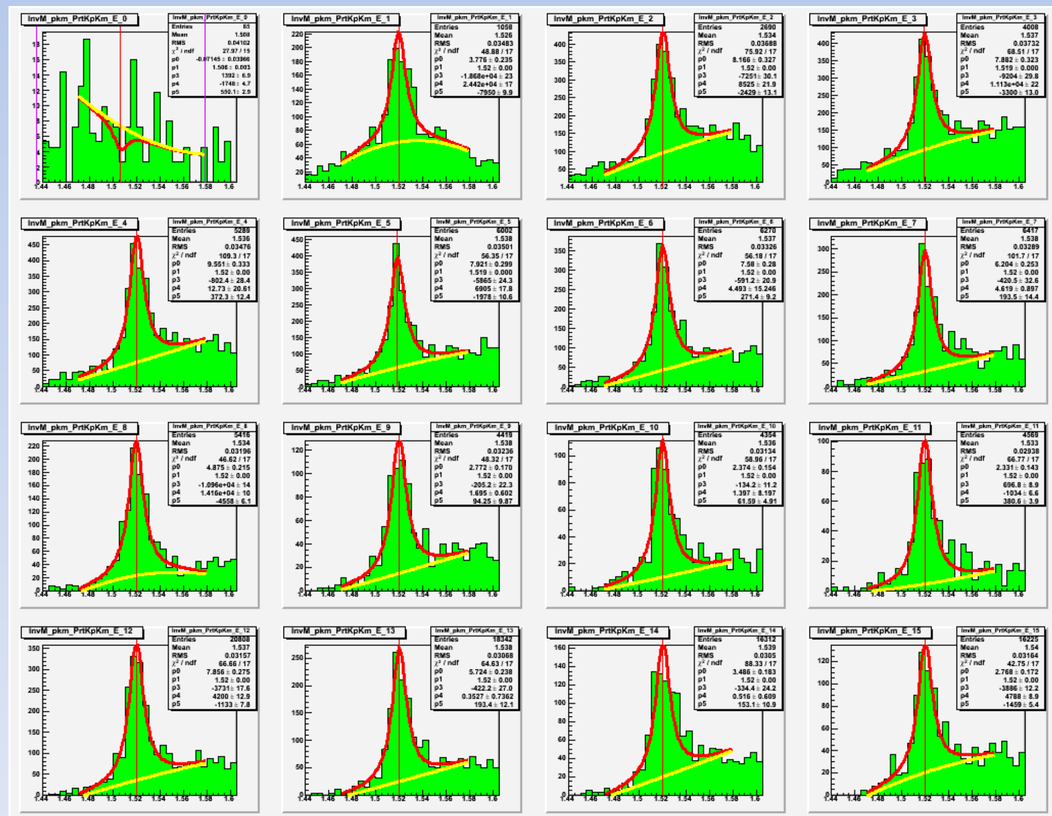
Data **Simulation**



Proton

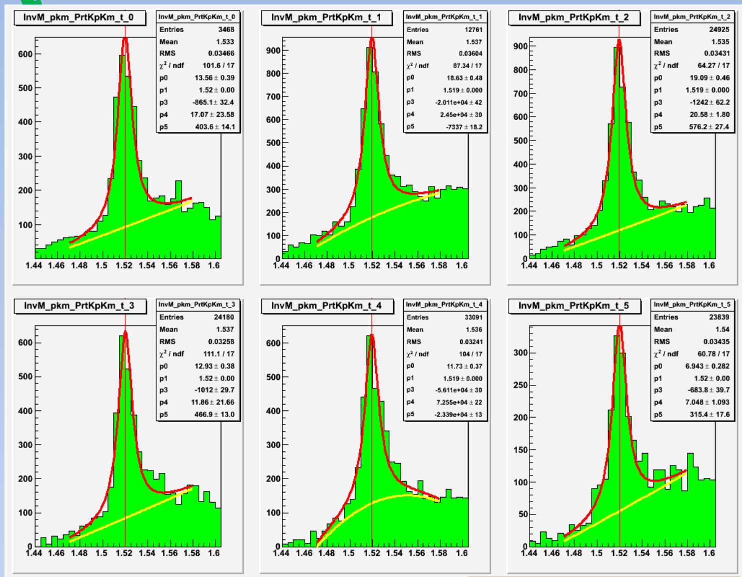
Yield Extraction (data)

$1.5 < E_\gamma < 5.5$ GeV
16 bins, bin width=250MeV



M(pK$^-$) GeV

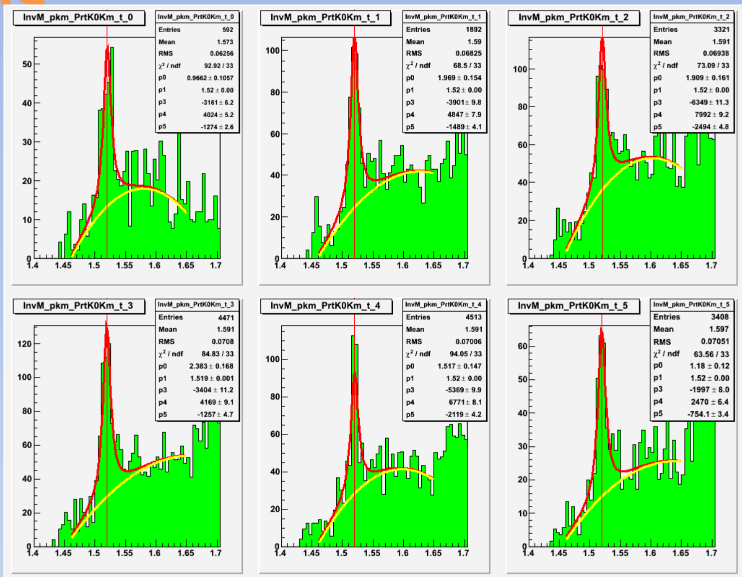
$0.25 < t' < 3$ GeV^2
6 bins, bin width varies



M(pK$^-$) GeV

Neutron

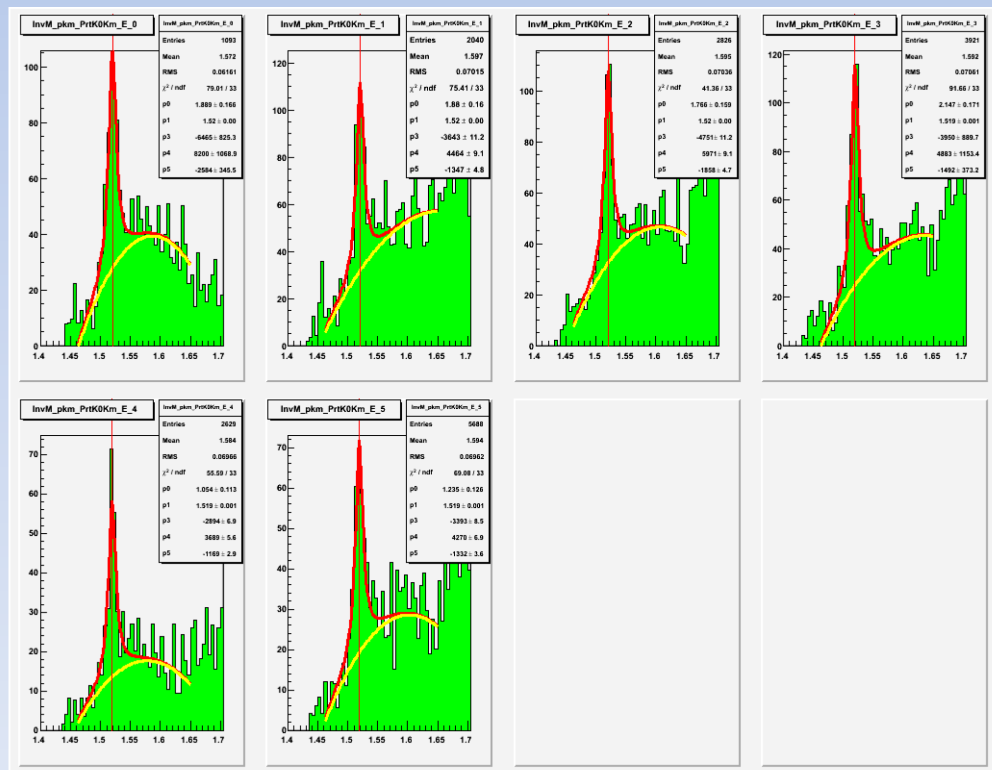
Yield Extraction (data)



M(pK$^-$) GeV

$1.75 < E_\gamma < 5.5$ GeV
6 bins, bin width varies

0. < t' < 3 GeV^2
6 bins, bin width varies



M(pK$^-$) GeV

Yield and Acceptance

Proton

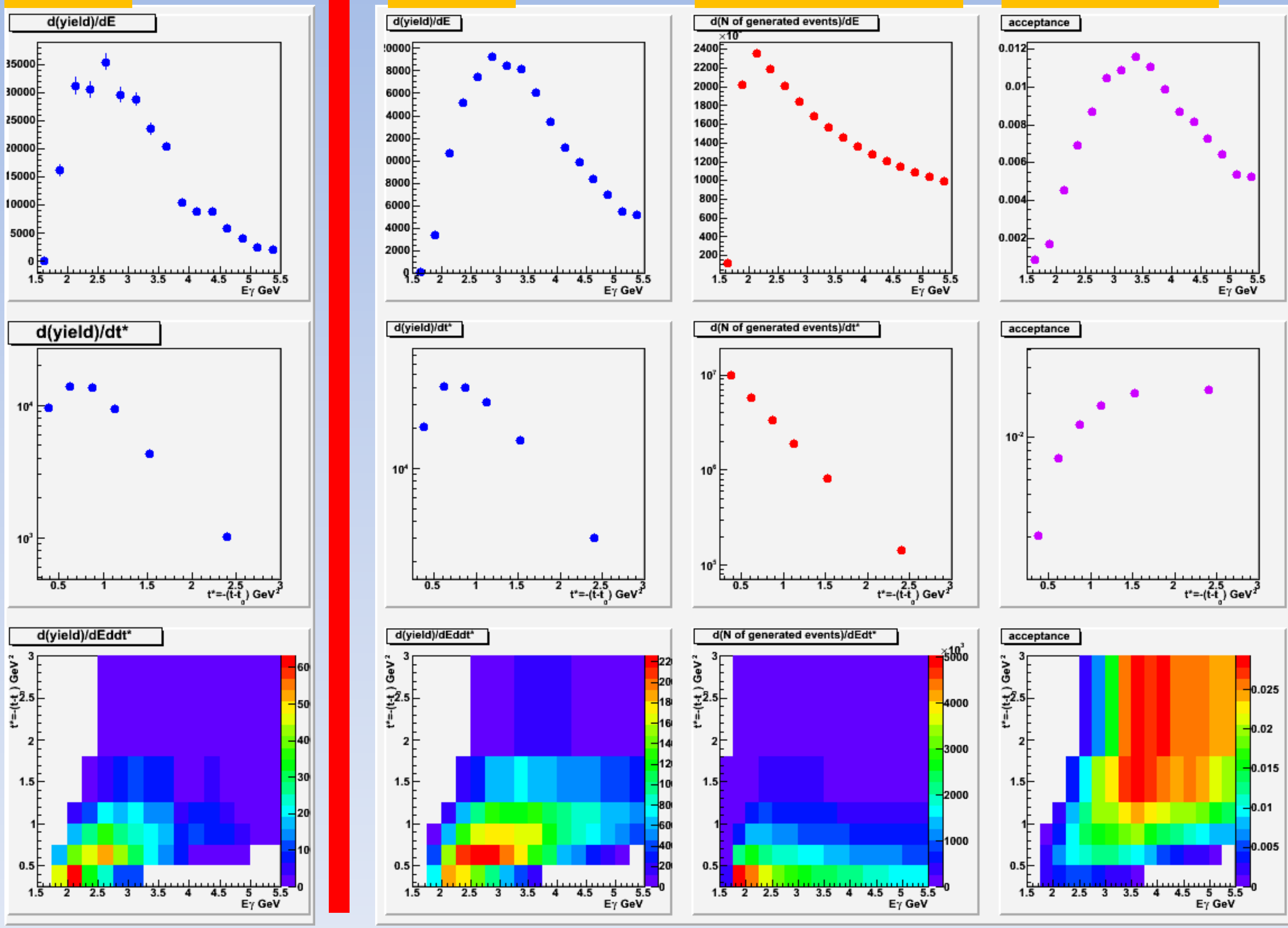
Data | Simulation

Yield | Yield | N of generated | Acceptance

$E\gamma$ bin

t' bin

$E\gamma$, t' bin



Yield and Acceptance

Neutron

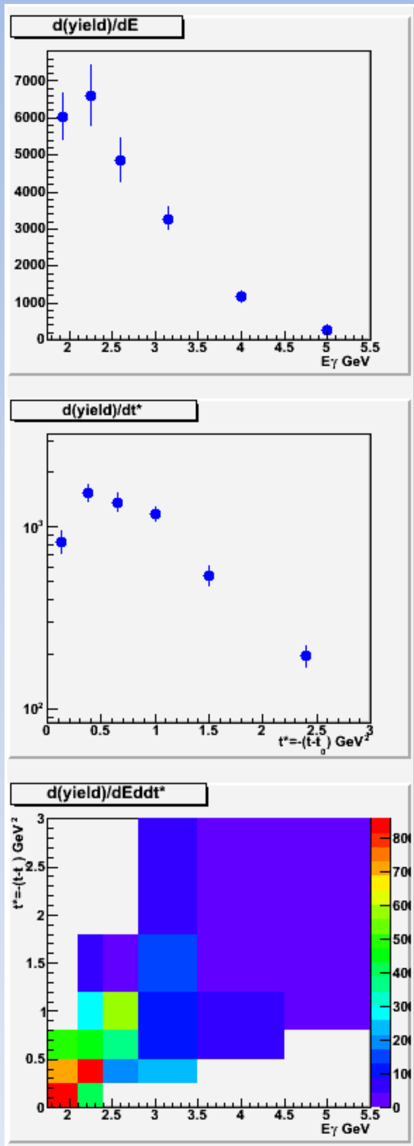
Data

Yield

Eγ bin

t' bin

Eγ, t' bin

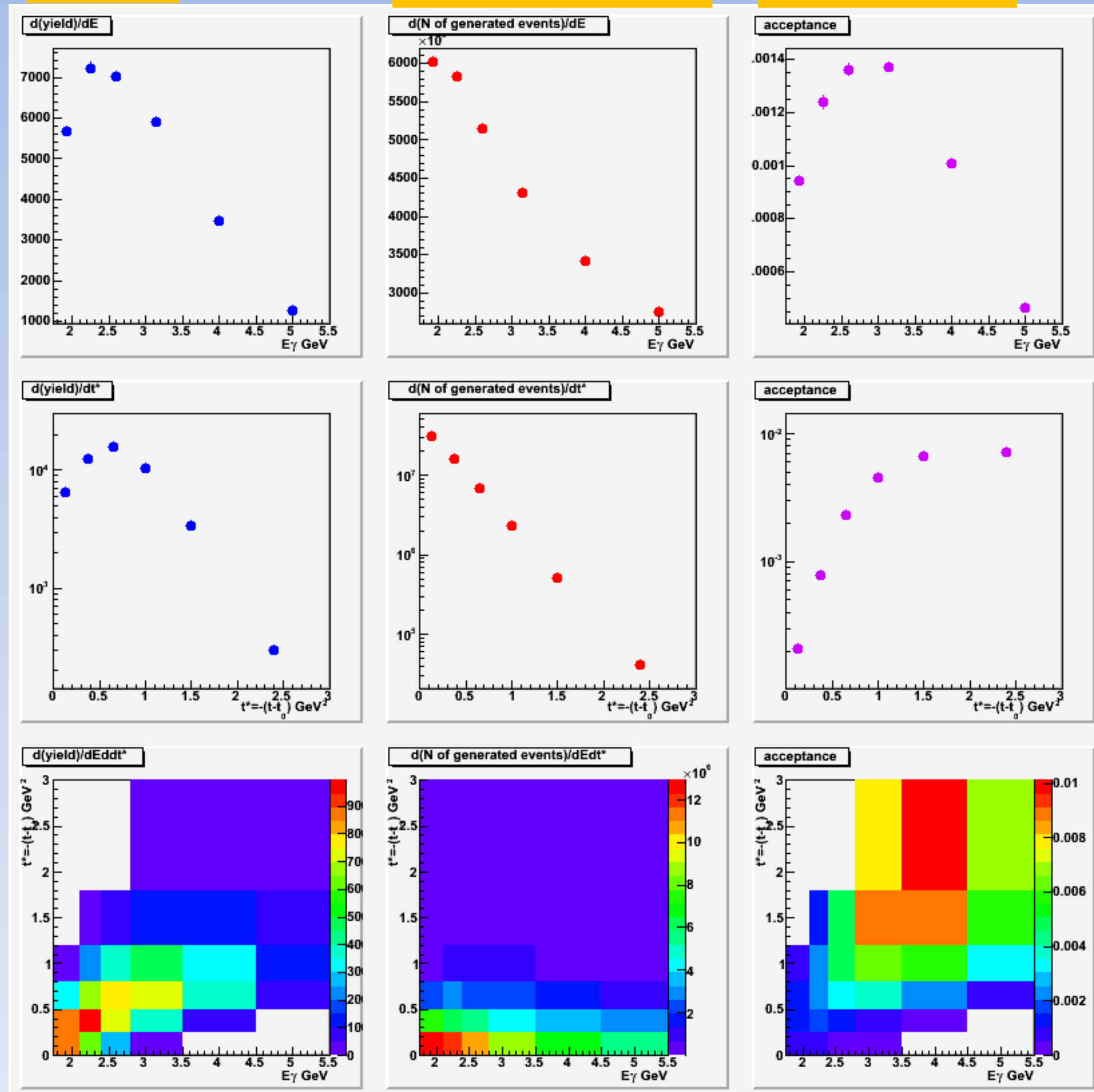


Simulation

Yield

N of generated

Acceptance



Differential Cross Section

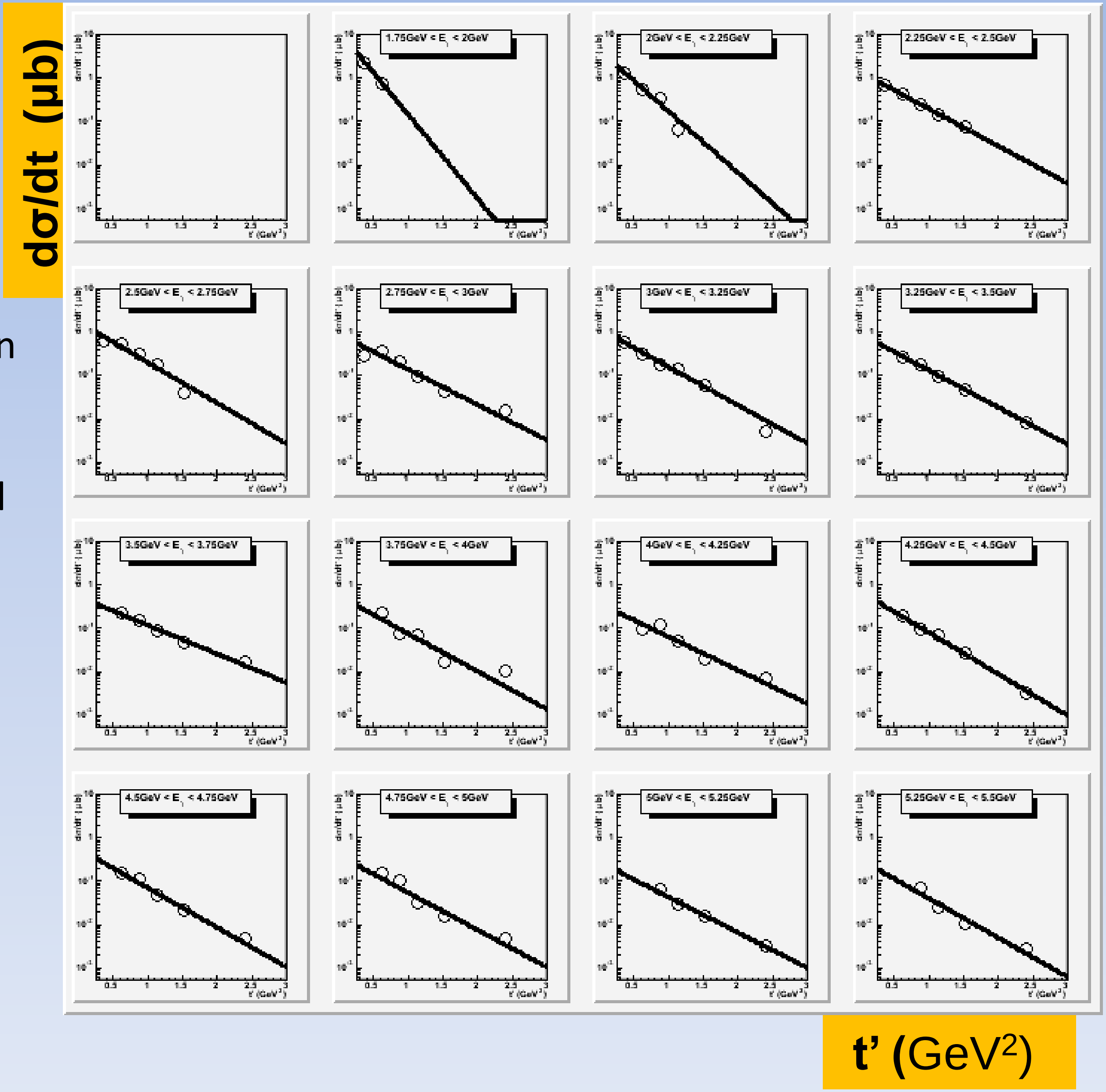
Proton

- $1.5 < E_\gamma < 5.5$ GeV
16 bins, bin width=250MeV

- Extrapolating to low t' with an exponential function

- Integrating over t' to get total cross section.

Preliminary,
stat error only



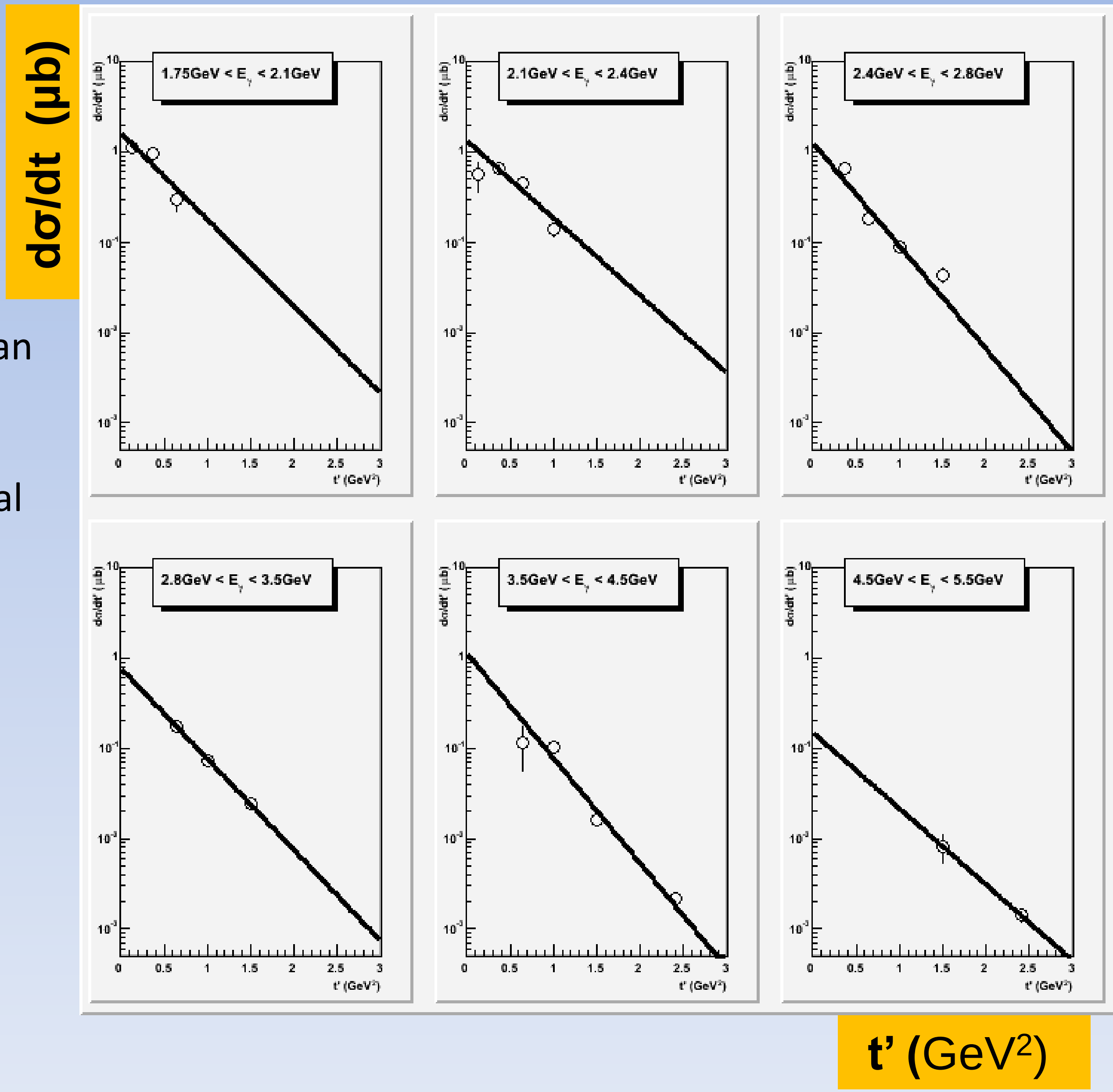
Neutron

Differential Cross Section

- 1.75 < E_γ < 5.5 GeV
6 bins, bin width varies

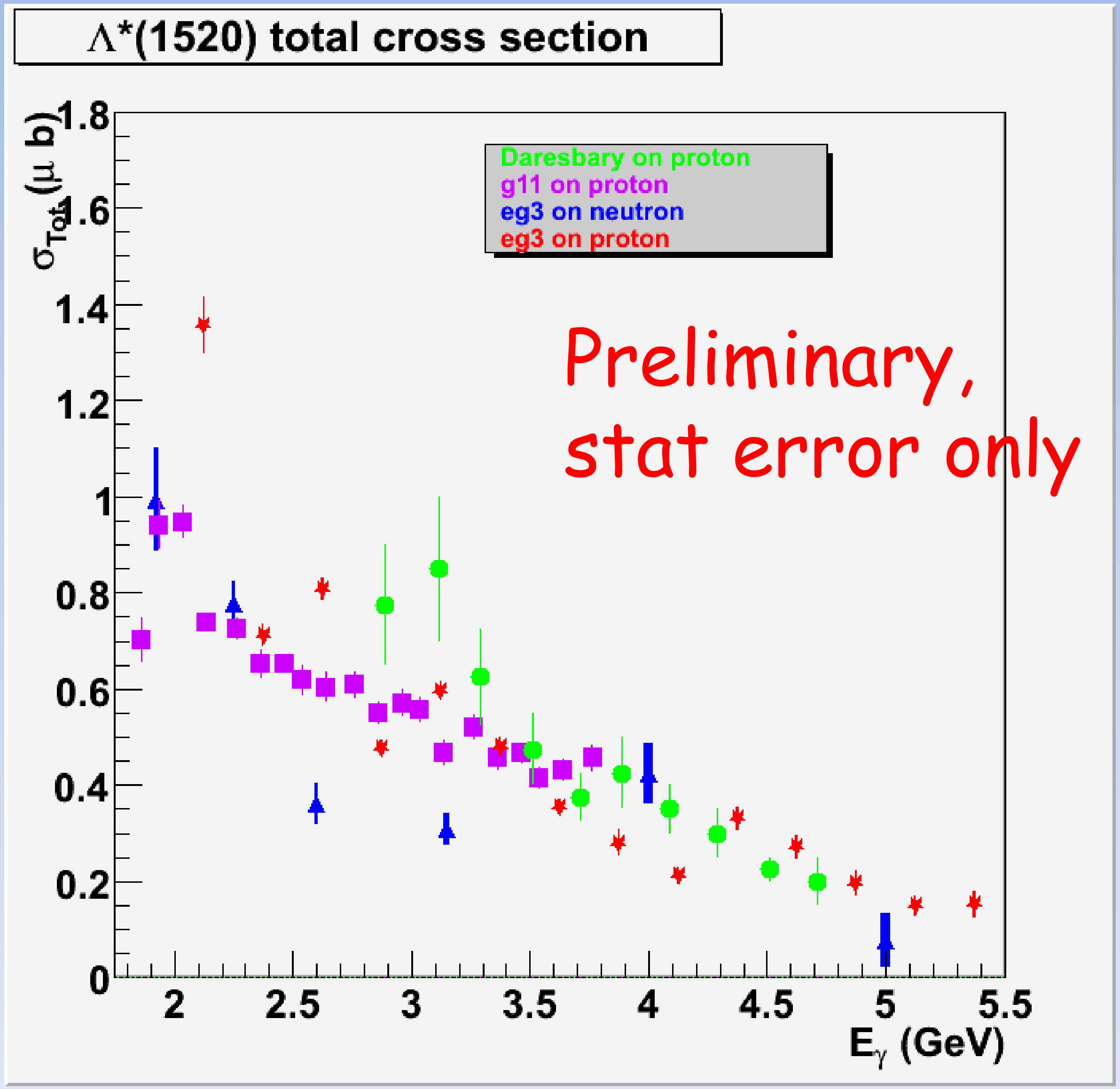
- Extrapolating to low t' with an exponential function

- Integrating over t' to get total cross section.

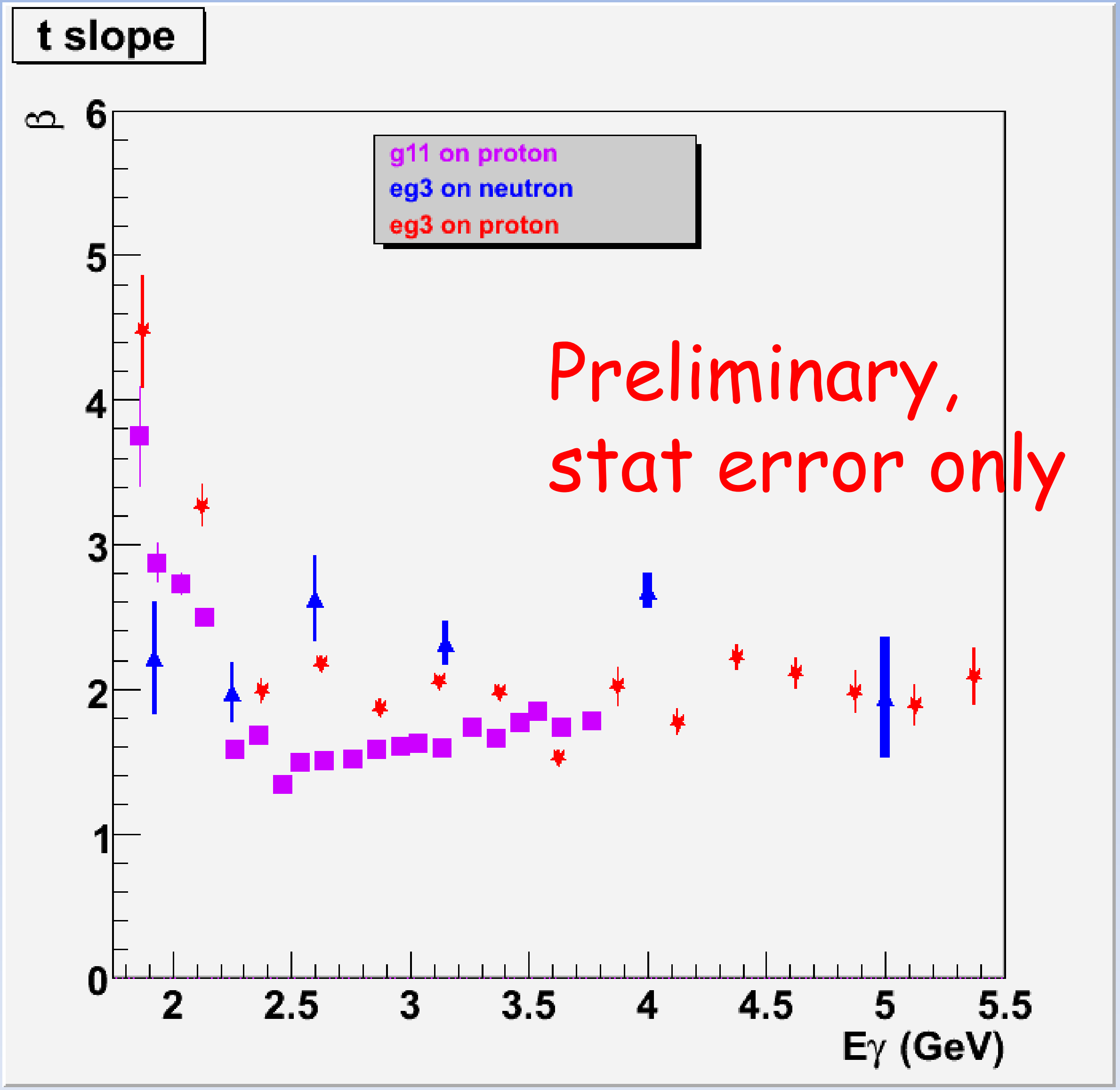


Preliminary,
stat error only

Total Cross Section



t-slope


t slope
β
6
5
4
3
2
1
0
2
2.5
3
3.5
4
4.5
5
5.5
Eγ (GeV)
g11 on proton
eg3 on neutron
eg3 on proton
Preliminary,
stat error only

Summary

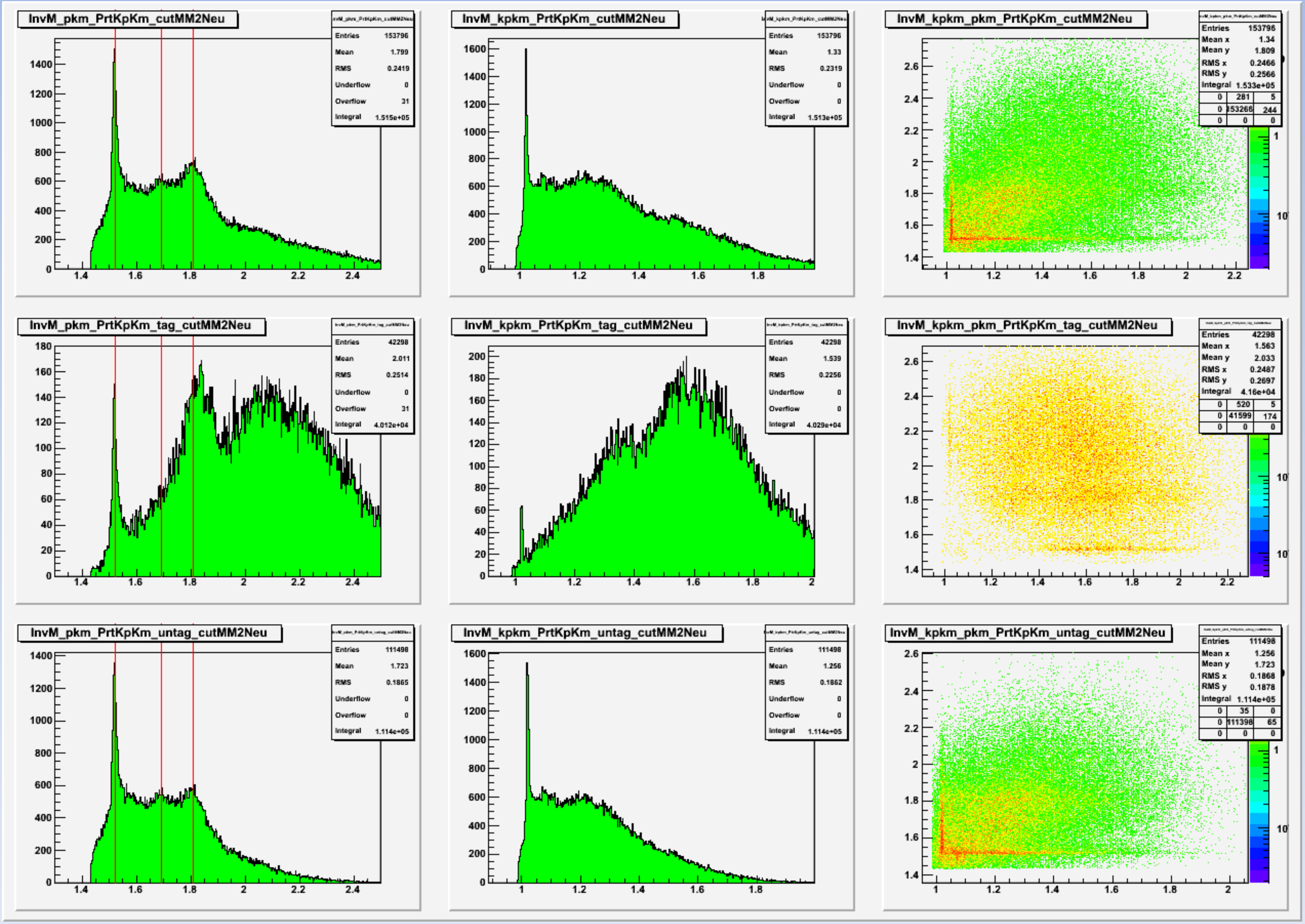
- The $\Lambda^*(1520)$ differential and total cross sections up to 5.5 GeV on the ***Proton*** are extracted. The total cross section is in good agreement with the the CLAS g11 run and Daresbury results.
- The $\Lambda^*(1520)$ differential and total cross sections on the ***Neutron*** are obtained for the first time. The total cross section is much larger than what the theory expected.

Outlook

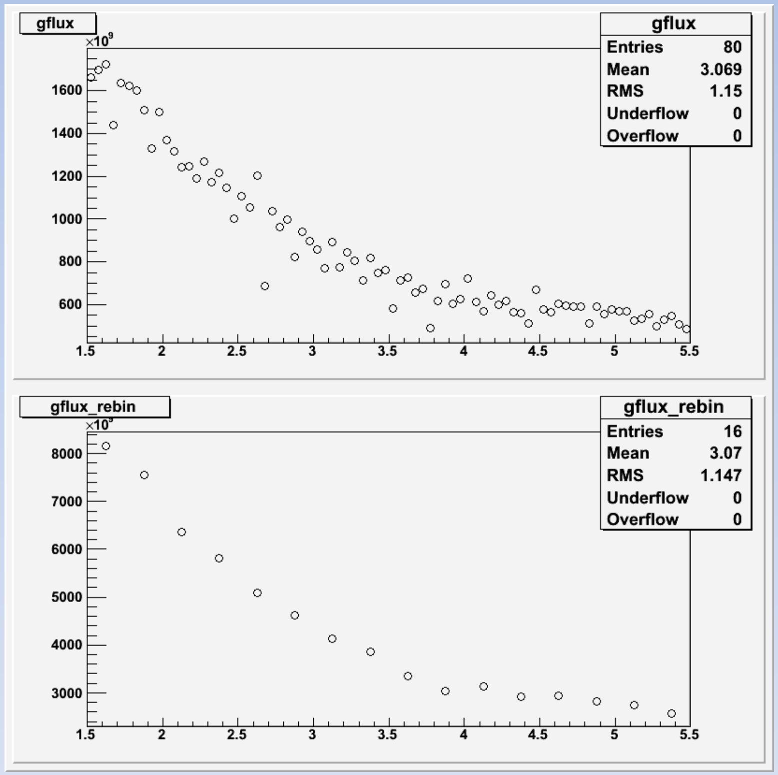
- Decay angle study
- systematics
- Look for possible missing N* resonances.

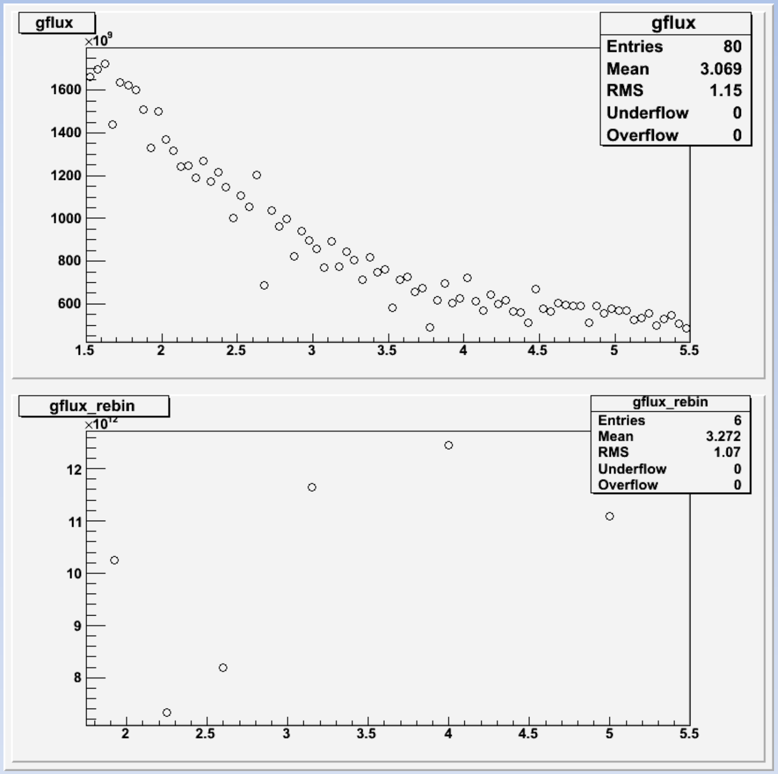
Back up

Phi and Lambda1520 interference

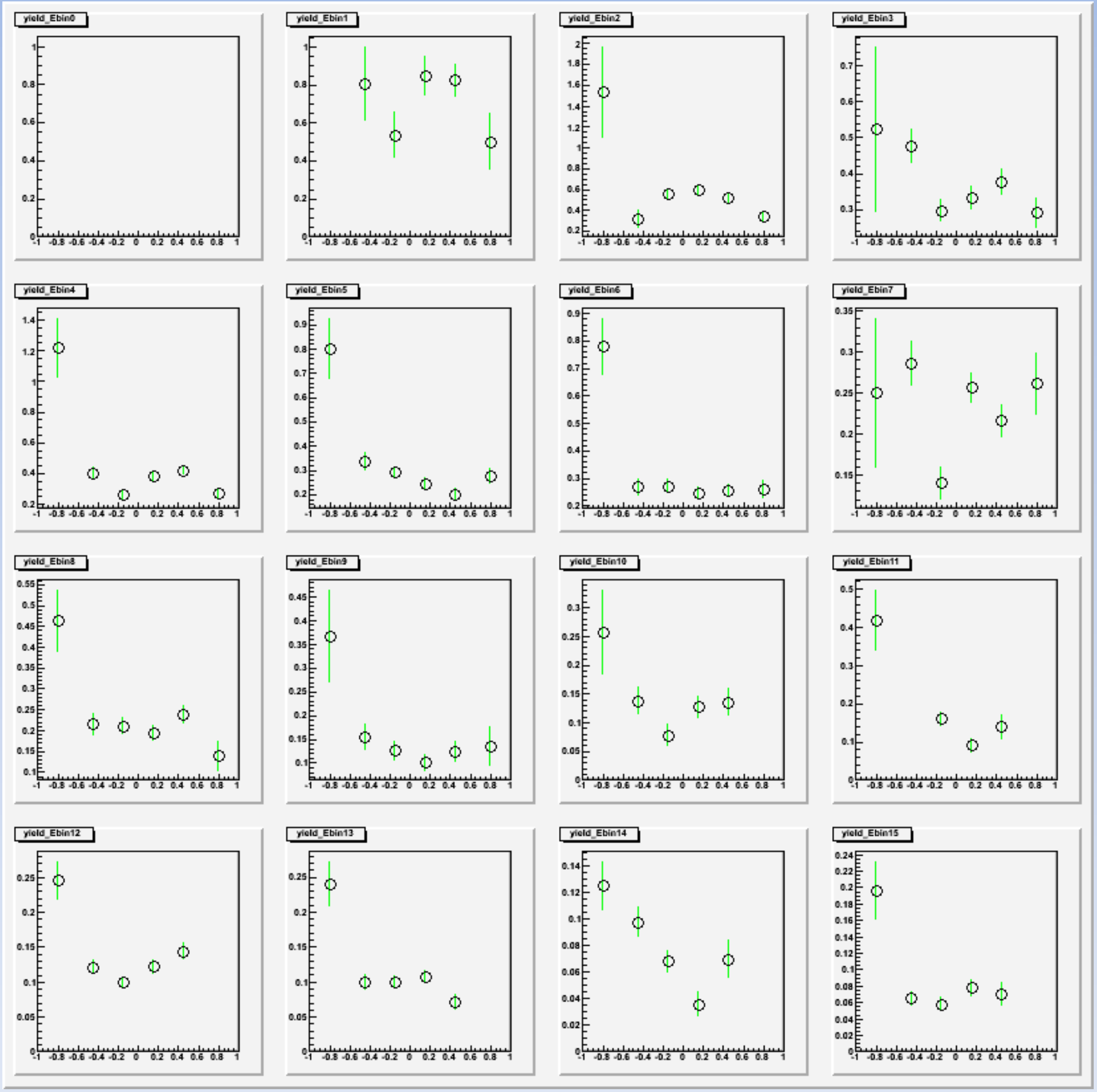


gflux


gflux
gflux
Entries 80
Mean 3.069
RMS 1.15
Underflow 0
Overflow 0
gflux_rebin
gflux_rebin
Entries 16
Mean 3.07
RMS 1.147
Underflow 0
Overflow 0


gflux
gflux
Entries 80
Mean 3.069
RMS 1.15
Underflow 0
Overflow 0
gflux_rebin
gflux_rebin
Entries 6
Mean 3.272
RMS 1.07
Underflow 0
Overflow 0

Decay angle



yield_Ebin0
yield_Ebin1
yield_Ebin2
yield_Ebin3
yield_Ebin4
yield_Ebin5
yield_Ebin6
yield_Ebin7
yield_Ebin8
yield_Ebin9
yield_Ebin10
yield_Ebin11
yield_Ebin12
yield_Ebin13
yield_Ebin14
yield_Ebin15