A Study of Λ-N Scattering using the g12 experiment

CLAS Collaboration

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clas

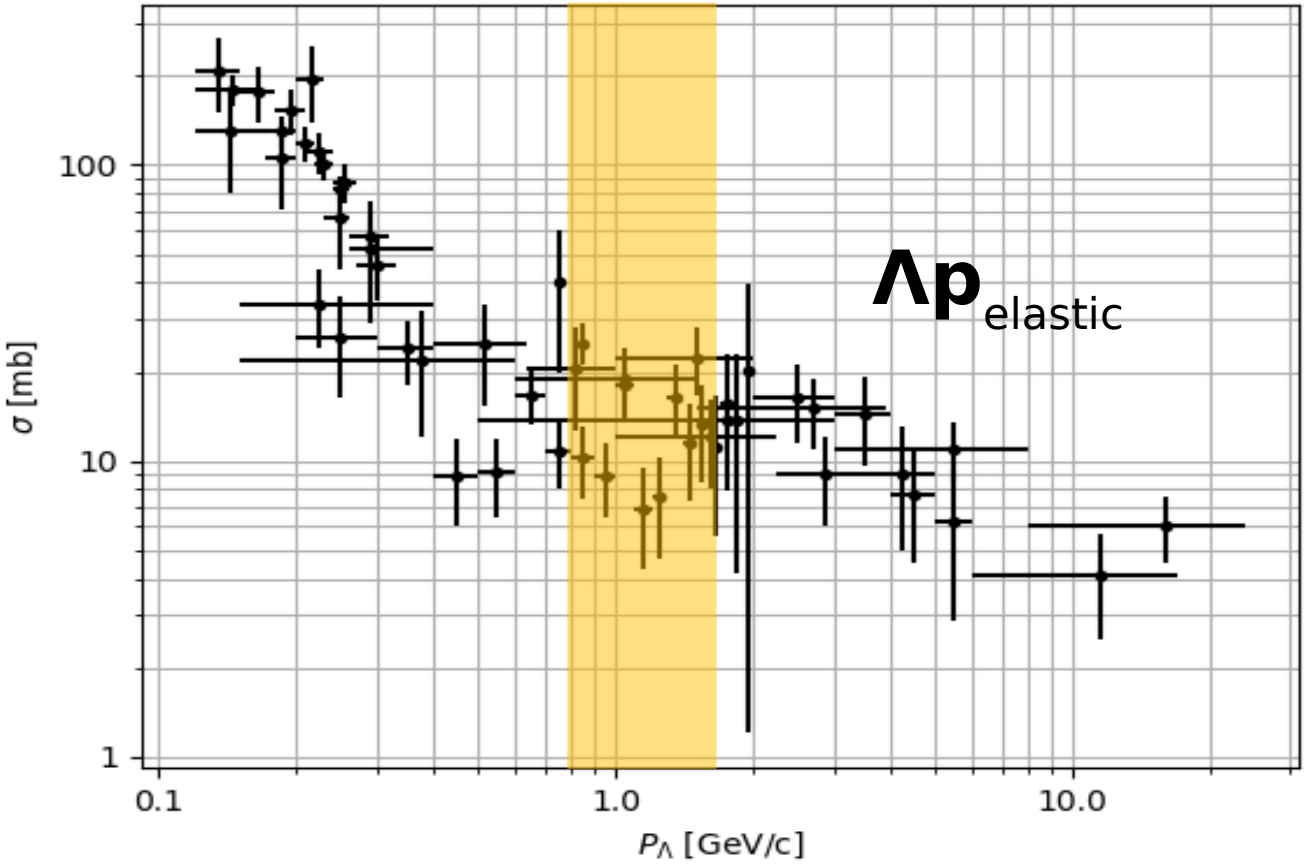
CEBAF Large Acceptance Spectrometer

Motivation

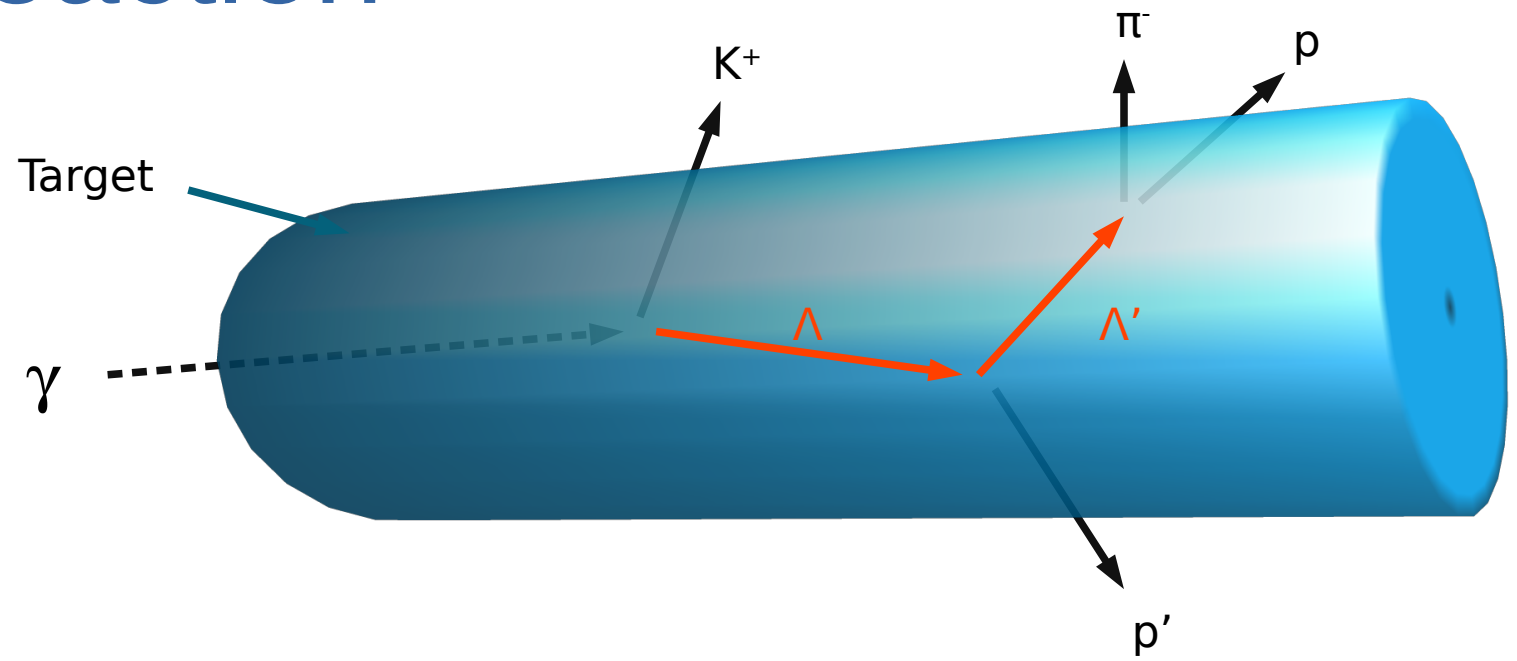
- Currently very little data for ΛN

  < 1300 events

- Entirely from Bubble Chamber
- ΛN scattering is important to understand the interior of neutron stars. (Haidenbauer and Meissner, PRC 72, 044005 (2005).)



Reaction

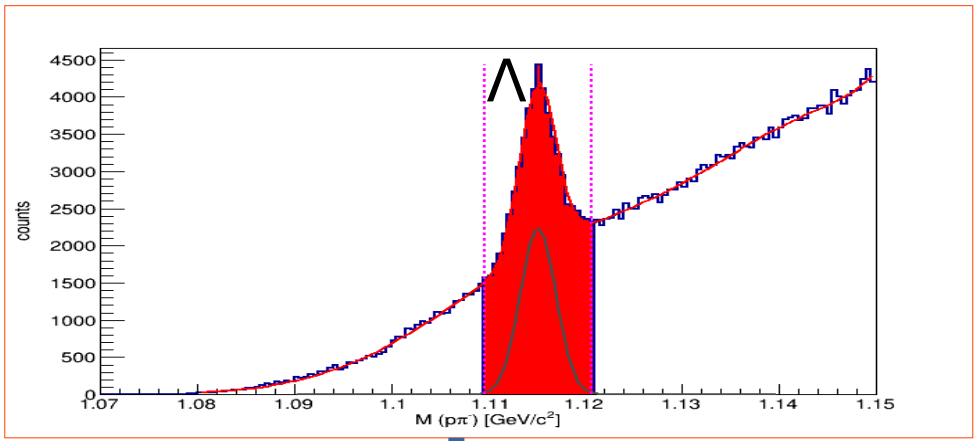


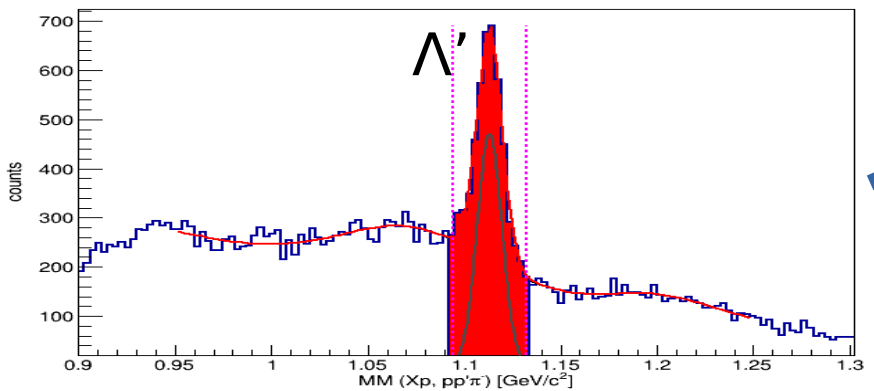
- Liquid Hydrogen Target
- p, p', π^- detected
- Λp scatter elastically

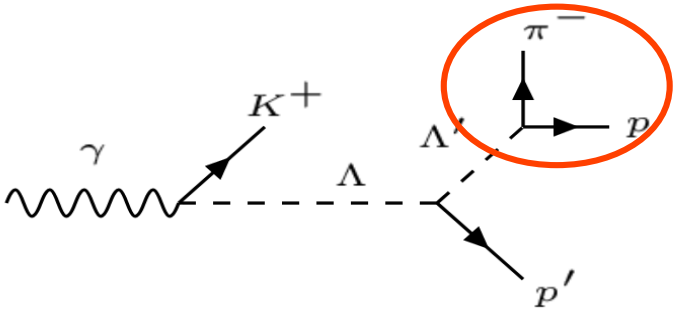
Analysis

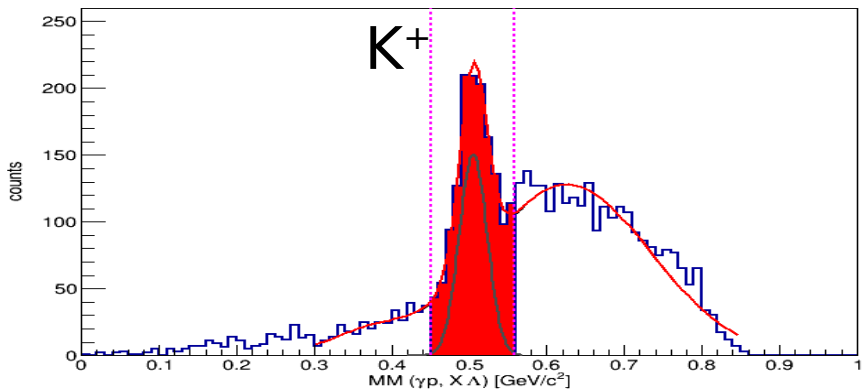
- All standard g12 procedural cuts and corrections are included
  - PID
  - Fiducial
  - Photon beam energy corrections
  - Efficiency corrections
  - Etc….

Data

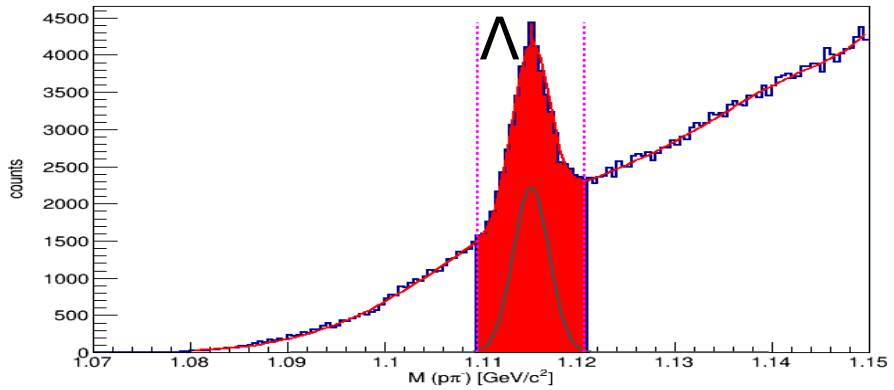

Λ
counts
M (pπ⁻) [GeV/c²]

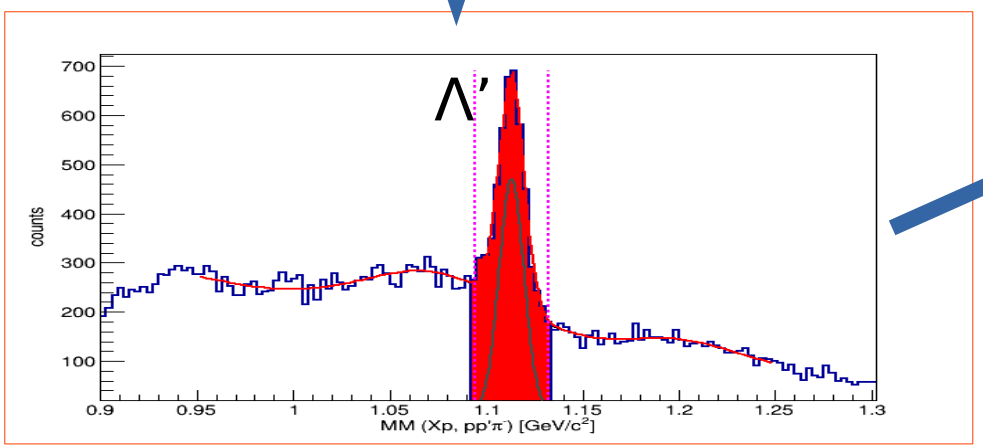

Λ'
counts
MM (Xp, pp'π⁻) [GeV/c²]

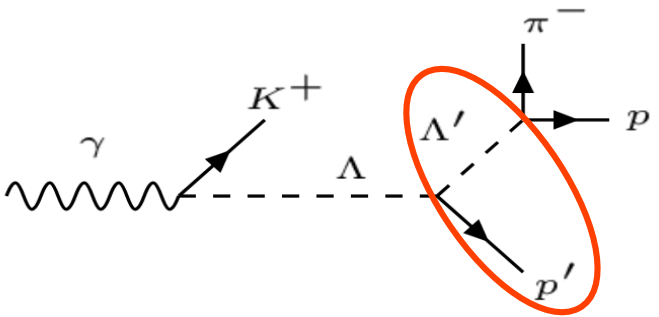

γ
K+
Λ
Λ'
π−
p
p'

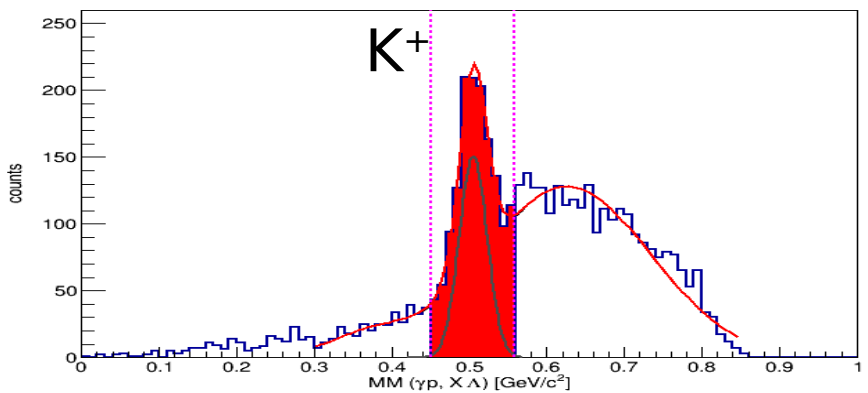

K+
counts
MM (γp, X Λ) [GeV/c²]

Data

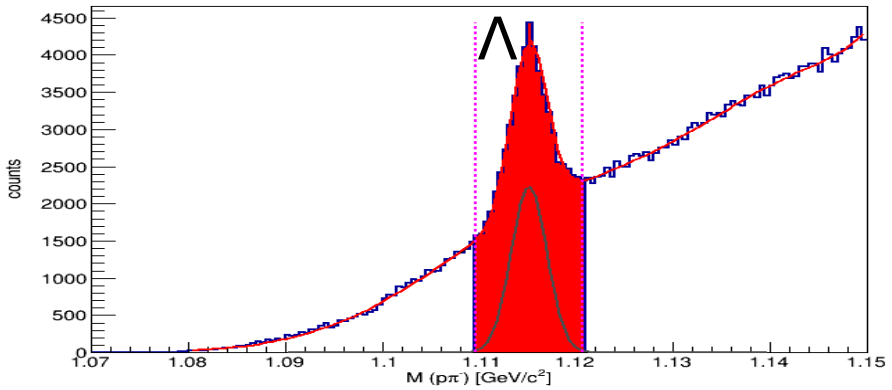

Λ
counts
M (pπ⁻) [GeV/c²]

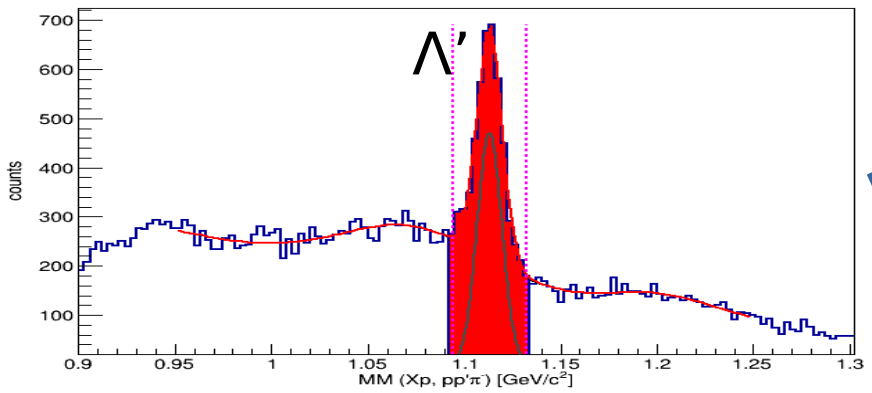

Λ'
counts
MM (Xp, pp'π⁻) [GeV/c²]

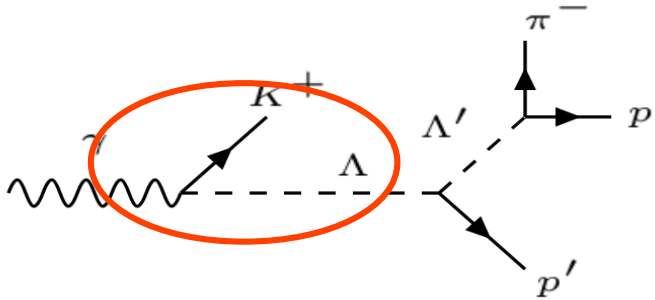

γ
K+
Λ
Λ'
π⁻
p
p'

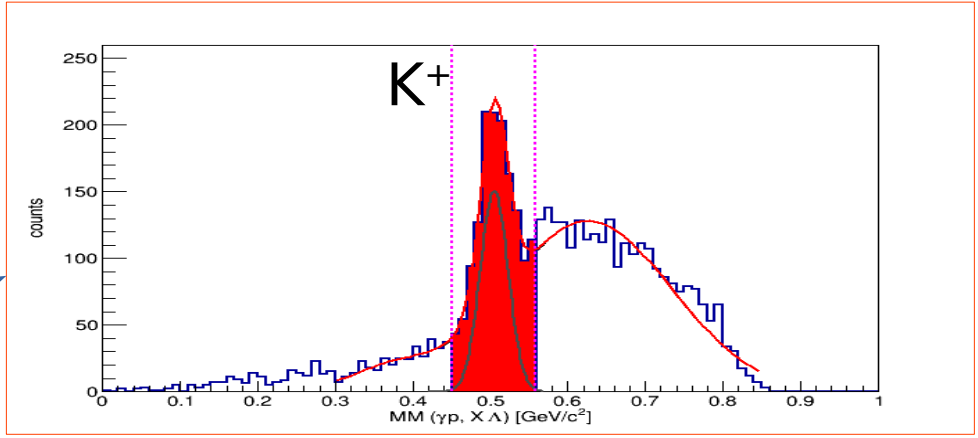

K+
counts
MM (γp, X Λ) [GeV/c²]

Data

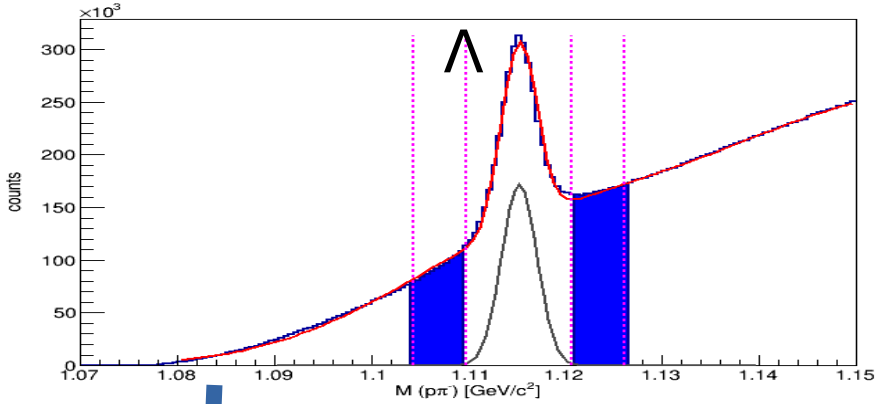

Λ
counts
M (pπ⁻) [GeV/c²]

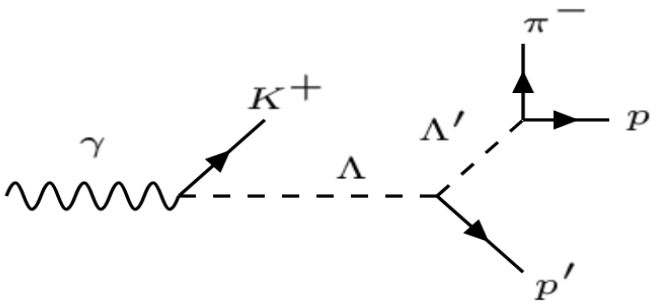

Λ'
counts
MM (Xp, pp'π⁻) [GeV/c²]

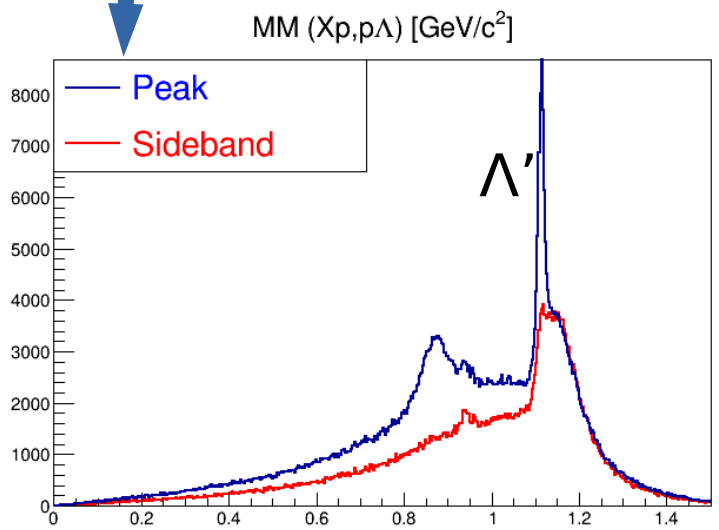

π⁻
K⁺
Λ'
p
Λ
p'

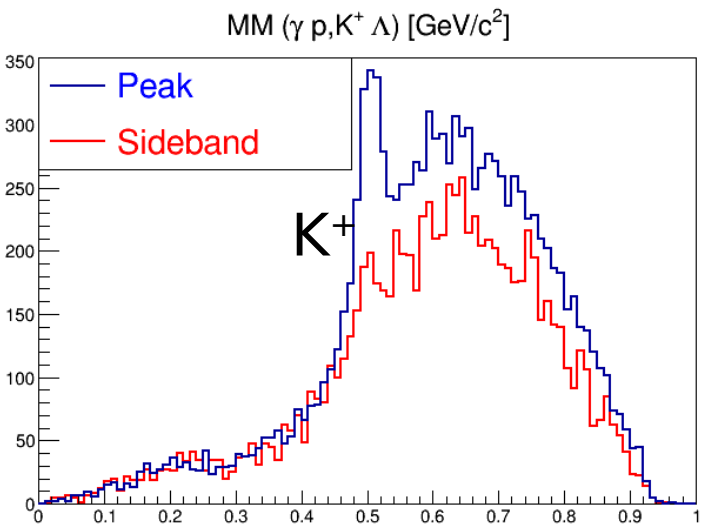

K+
counts
MM (γp, X Λ) [GeV/c²]

Sideband Subtraction

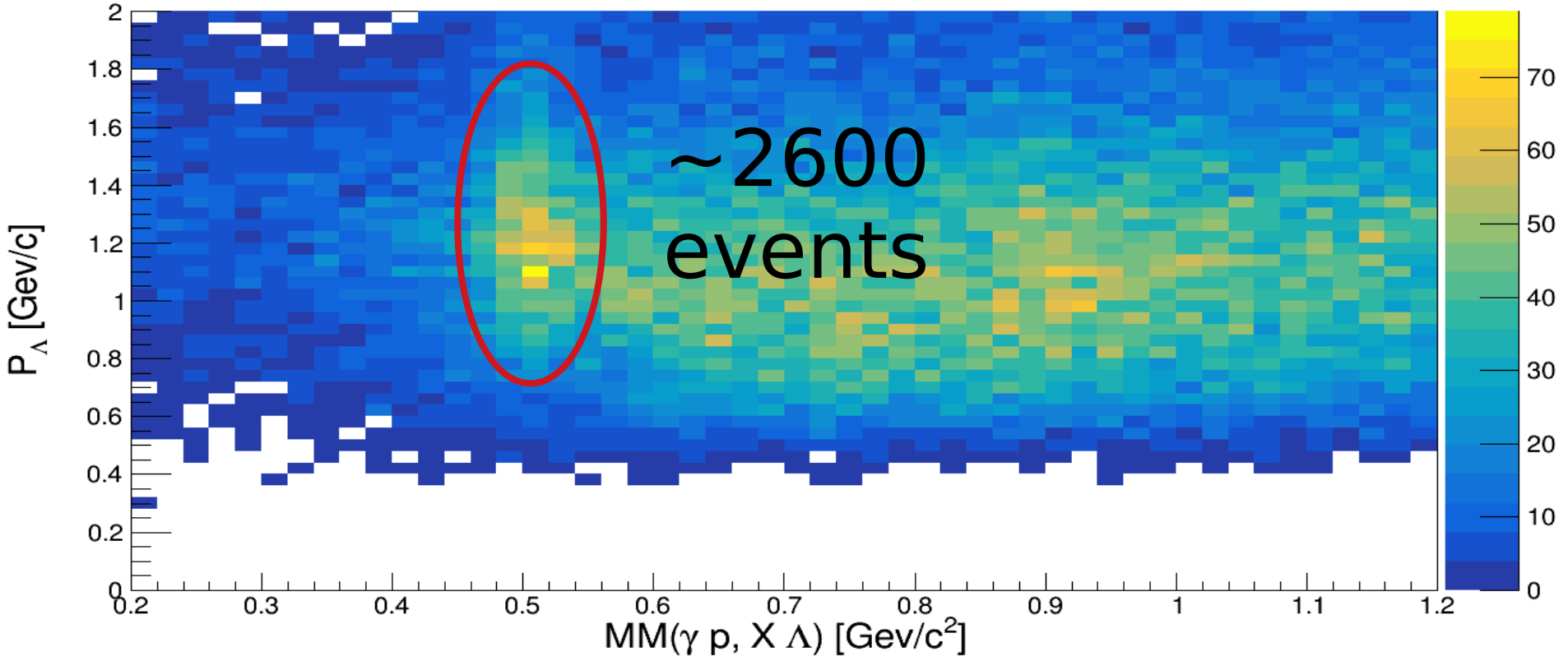




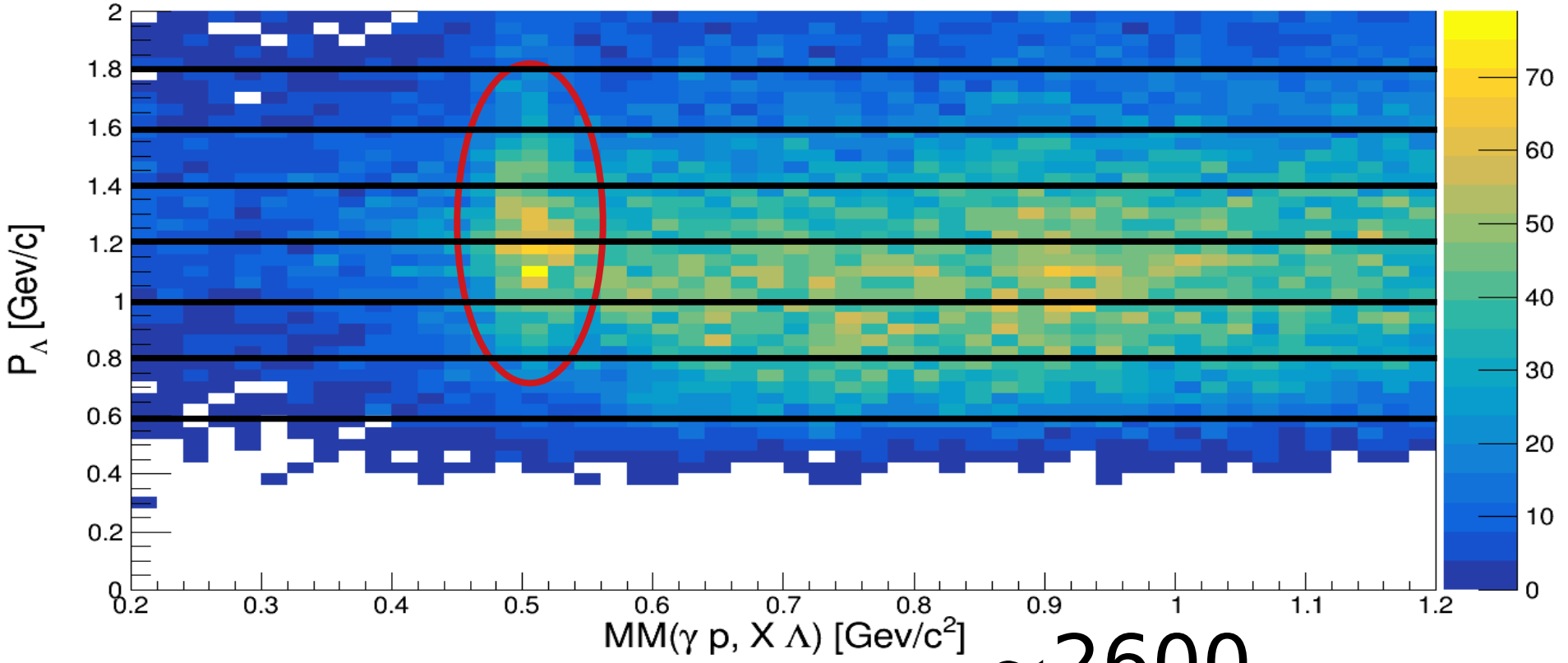




Yield

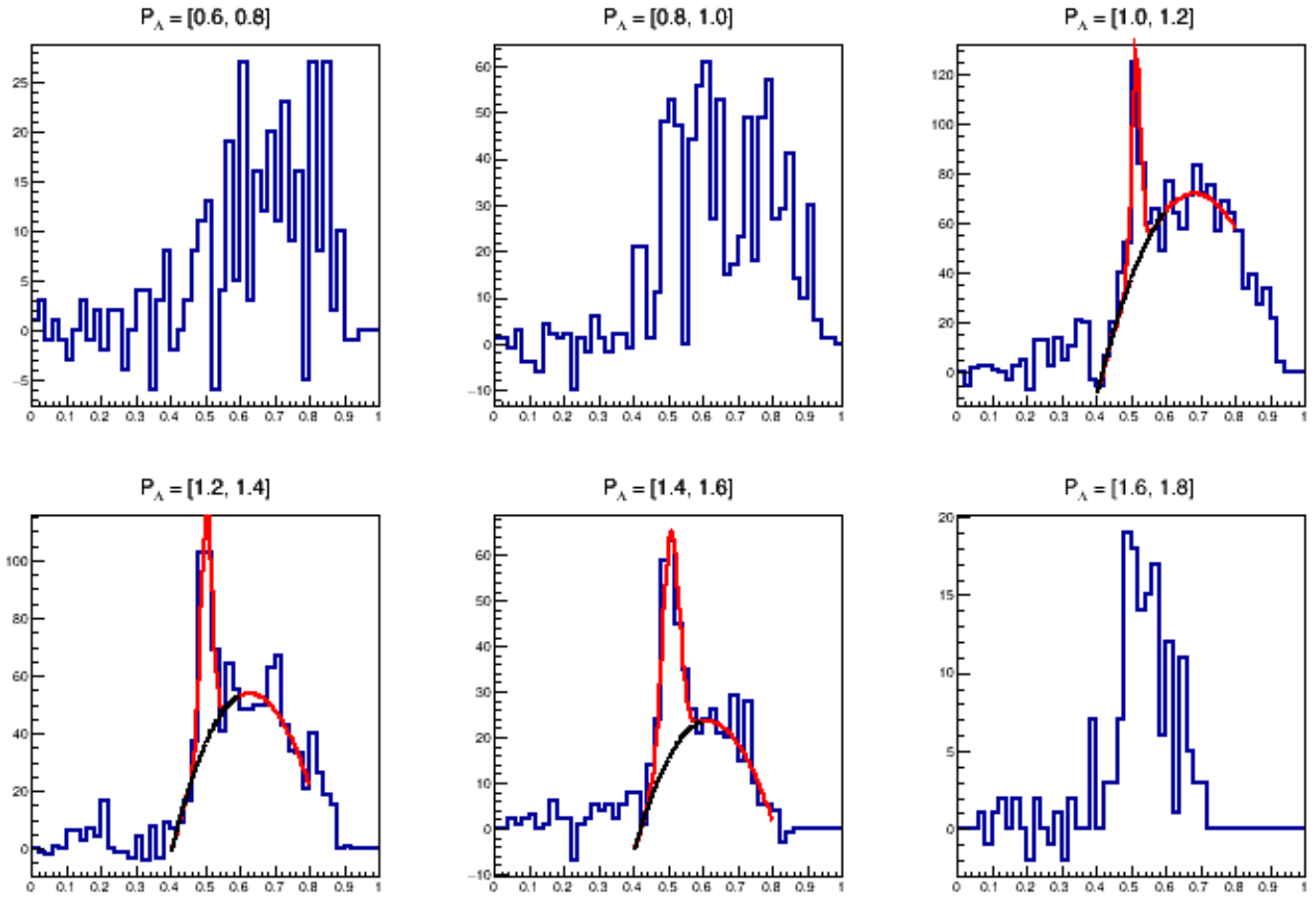

~2600
events
P_Λ [Gev/c]
MM(γ p, X Λ) [Gev/c^2]
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
0
10
20
30
40
50
60
70

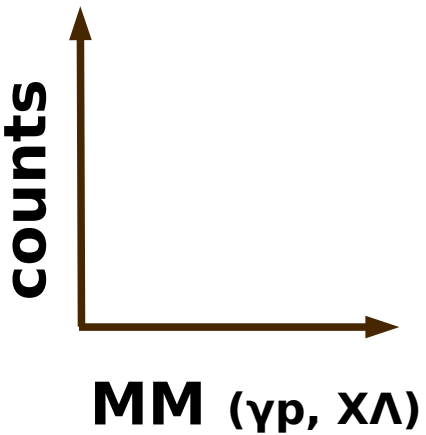
Yield



~2600 events

Yield

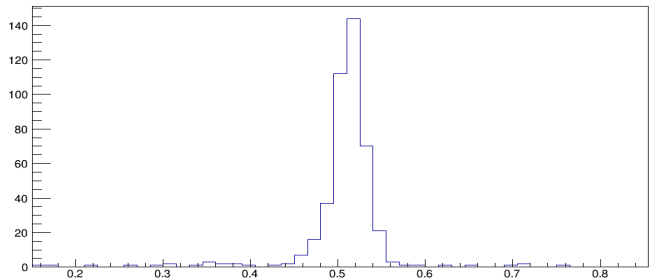

P_Λ = [0.6, 0.8]
P_Λ = [0.8, 1.0]
P_Λ = [1.0, 1.2]
P_Λ = [1.2, 1.4]
P_Λ = [1.4, 1.6]
P_Λ = [1.6, 1.8]


counts
MM (γp, XΛ)

Acceptance

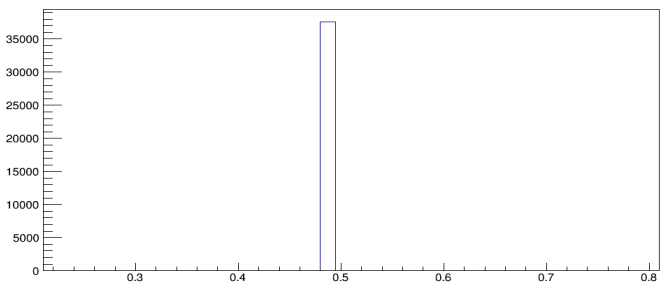
$$Acceptance = \frac{Accepted\ pp\pi^-}{Generated\ \Lambda p\ scattering}$$

Accepted Events:

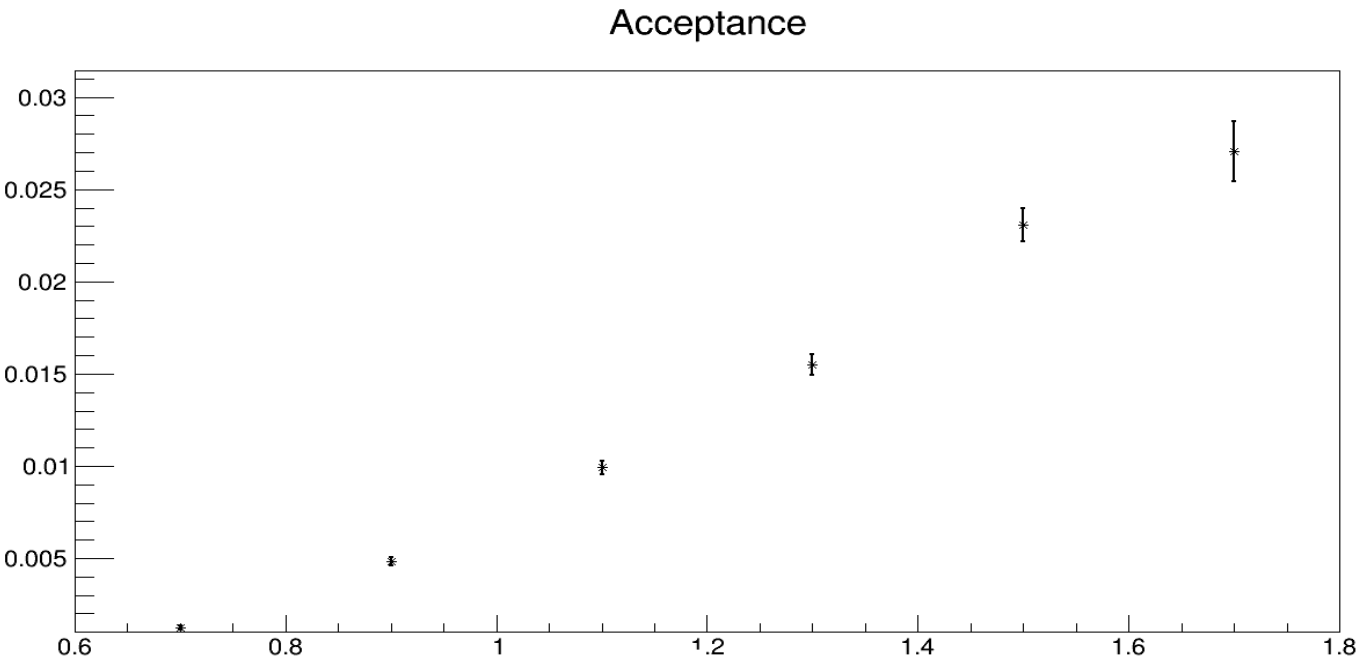


Missing Mass [GeV/c²]

Generate Events:



Missing Mass [GeV/c²]



Λ Momentum [GeV/c]

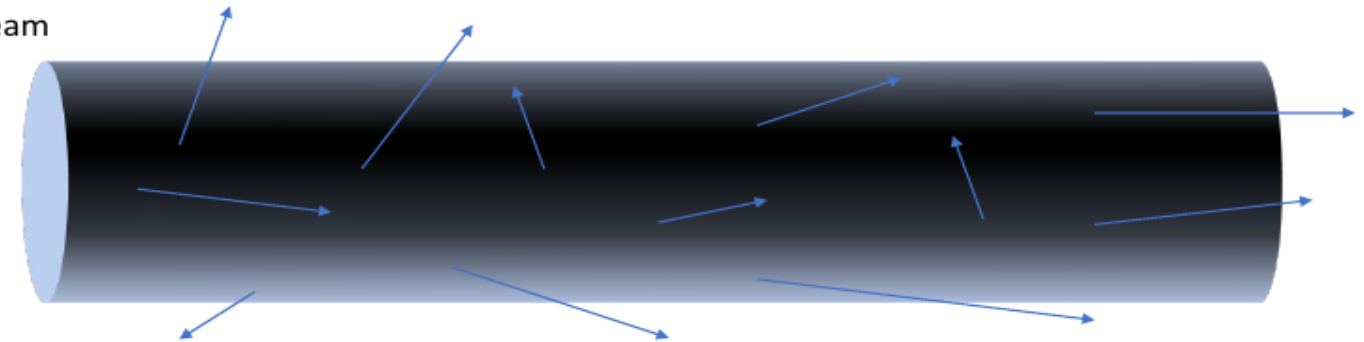
Luminosity

$$L_\Lambda(E_\Lambda) = \frac{\rho_T * N_A * l}{M} * N_\Lambda(E_\Lambda)$$

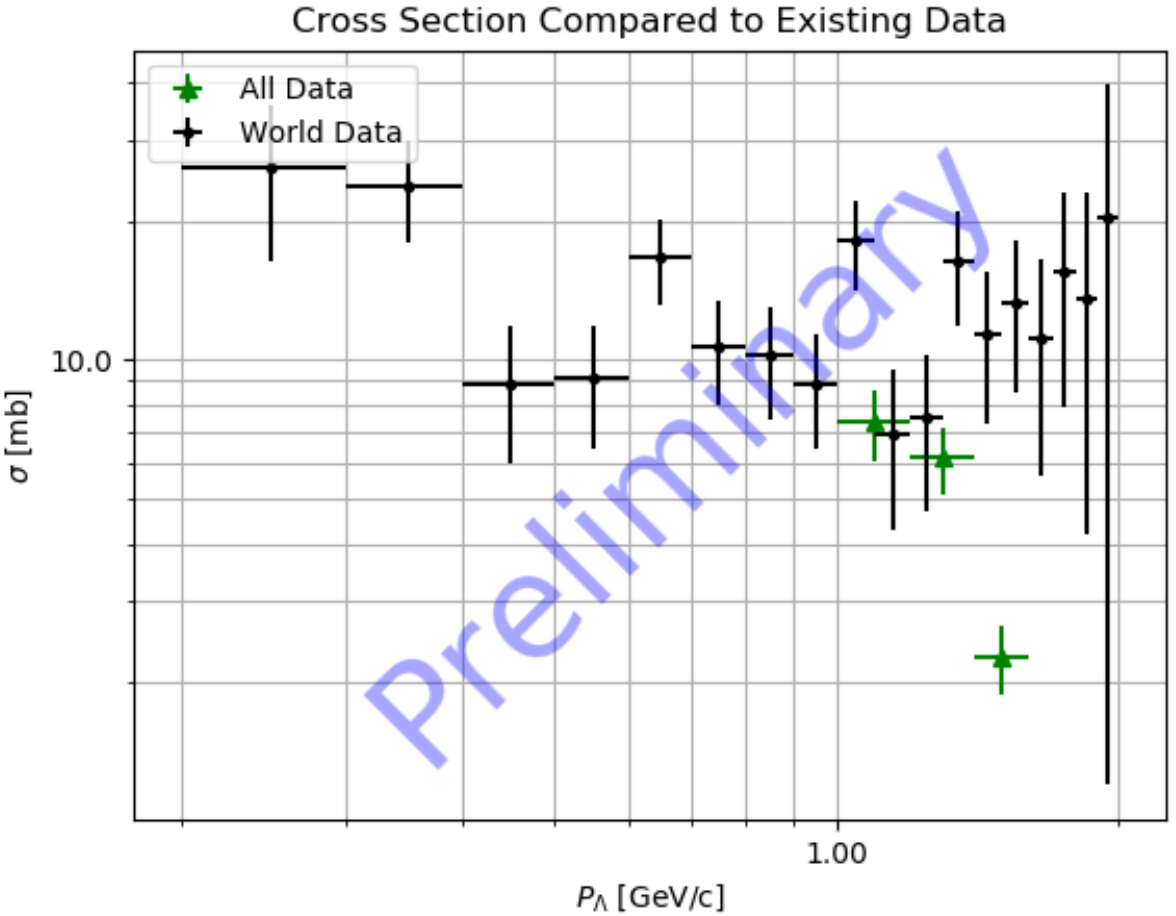
- ρ_T: density of the target
- N_A: Avogadro's number
- M: molar mass of Hydrogen
- l: travel distance of Λ
- $N_\Lambda(E_\Lambda)$: yield in a certain energy range

Photon Beam

Λ Beam



Preliminary Results

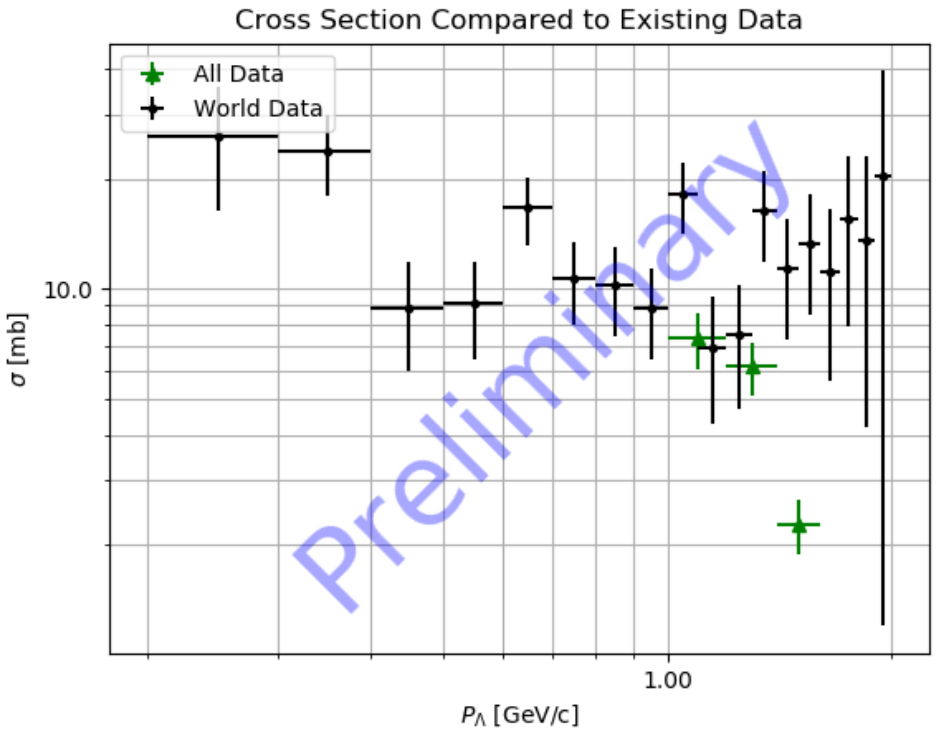


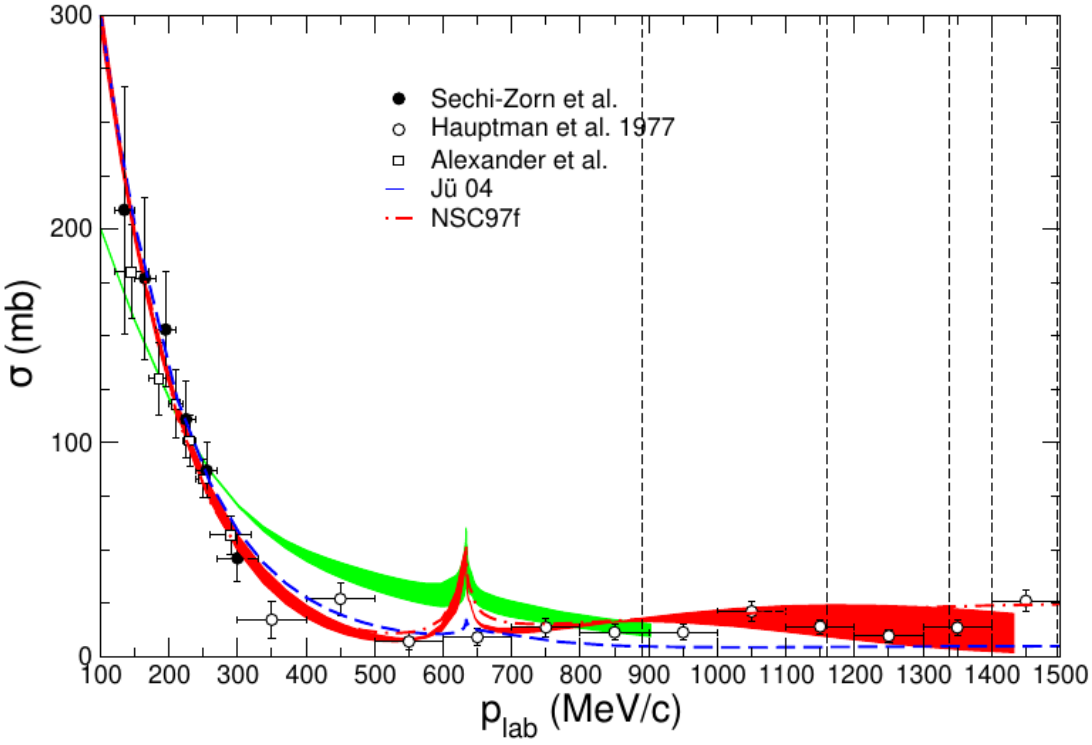
- Black: Existing data from Kadyk *et al.*
- Green: Measurements from this study.

- Our measurements trend lower than existing world data.

J.A. Kadijk, G. Alexander, J.H. Chan, P. Gaposchkin, and G. Trilling, Nucl. Phys. B27, 13 (1971)

Preliminary Results





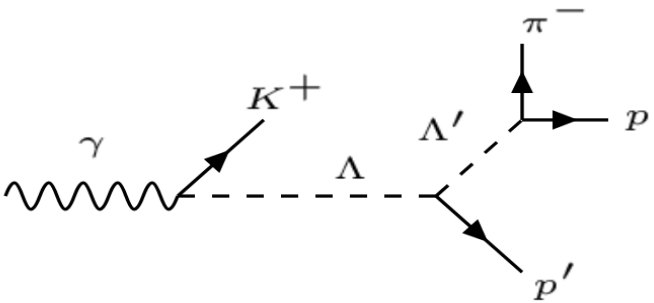
Theoretical prediction from Haidenbauer extended to our momentum range (unpublished).

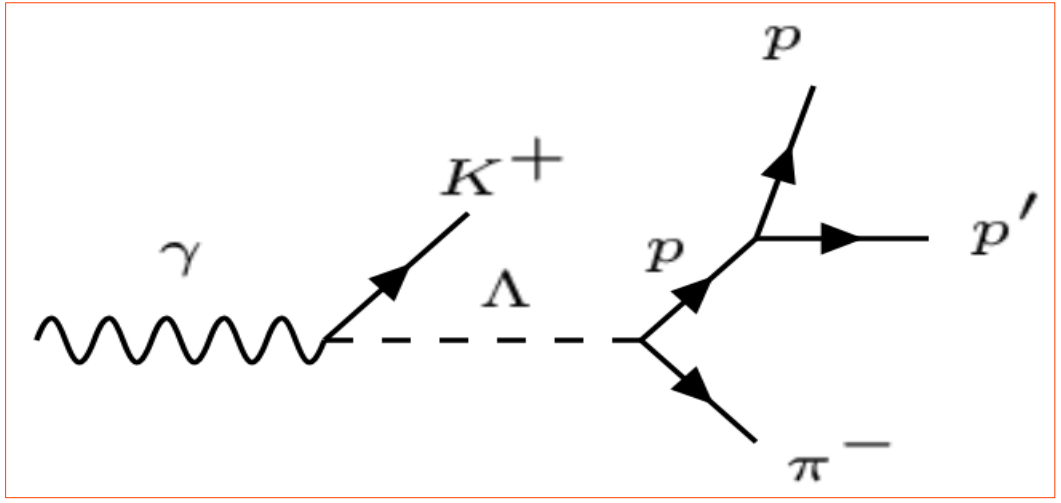
Systematics (Preliminary)

Cuts	Error (%)
Vertex	2.8
M (p π^-)	10.4
MM (Xp, Λp)	8.1
PID	0.2
pp events	8.7
Fit Function	12.0

Total Systematic: ~20%

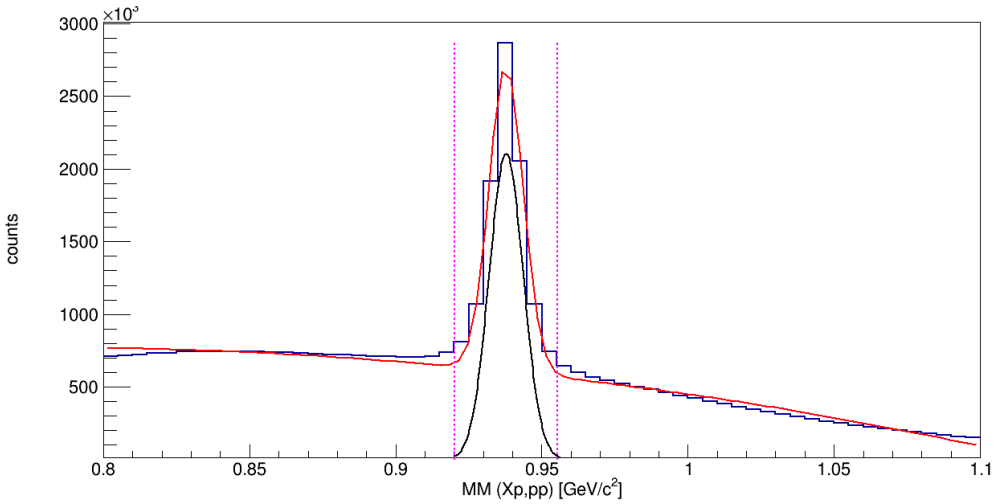
Why Low Cross Section? pp → pp scattering

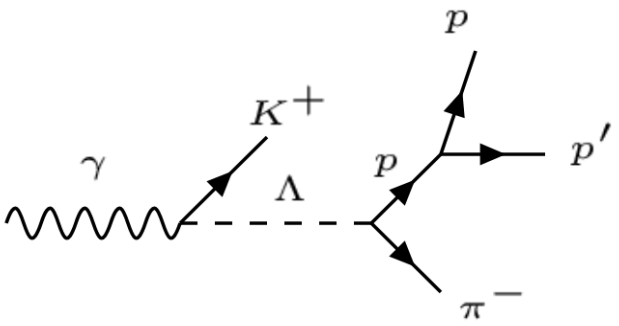


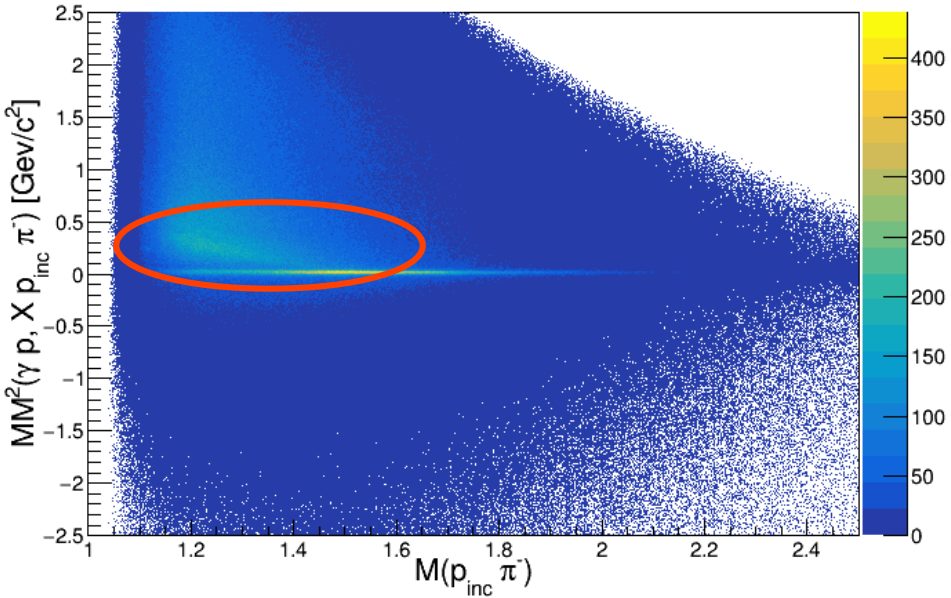


- pp → pp events can also result in the same final state.

pp → pp events



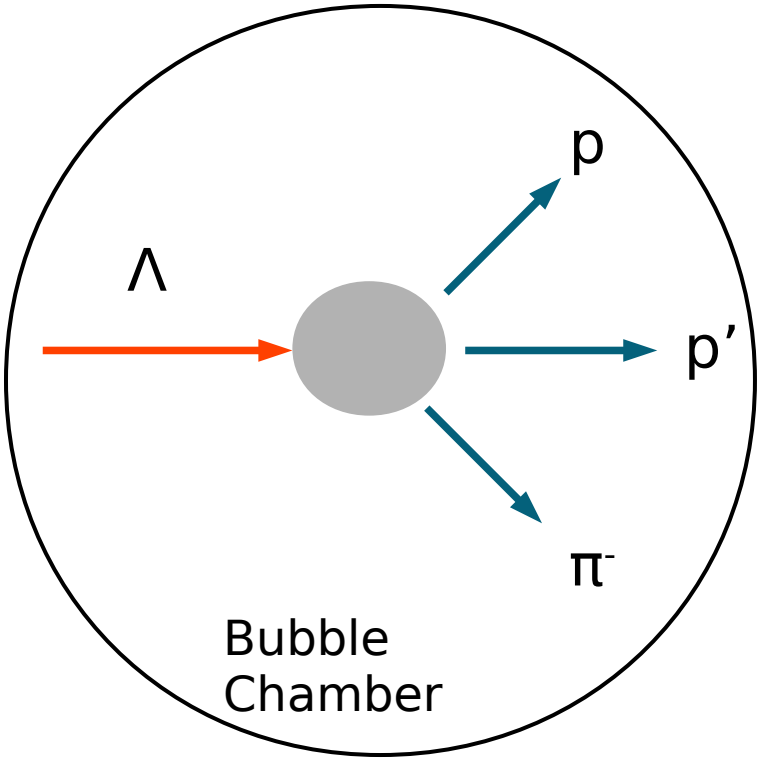


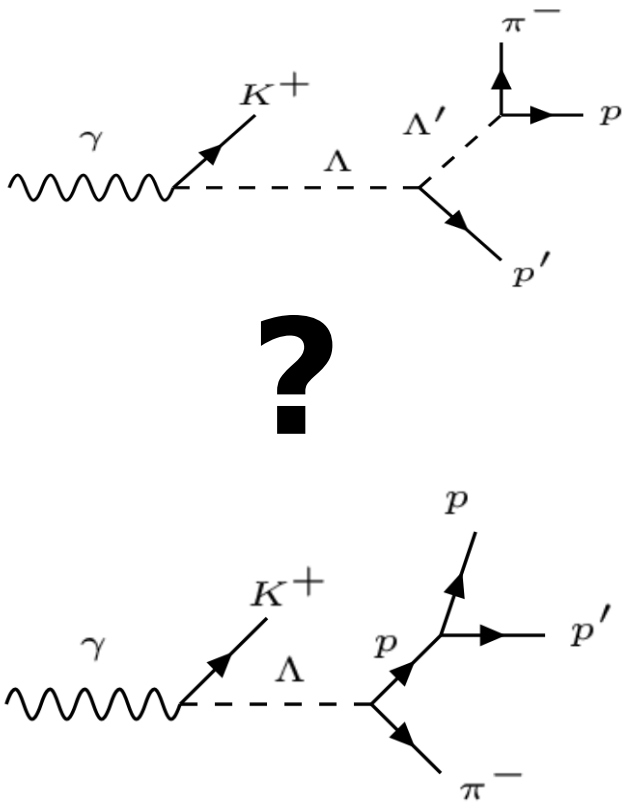


Events need to be removed for incident p events but not for incident π^-

~20% Effect

pp → pp events



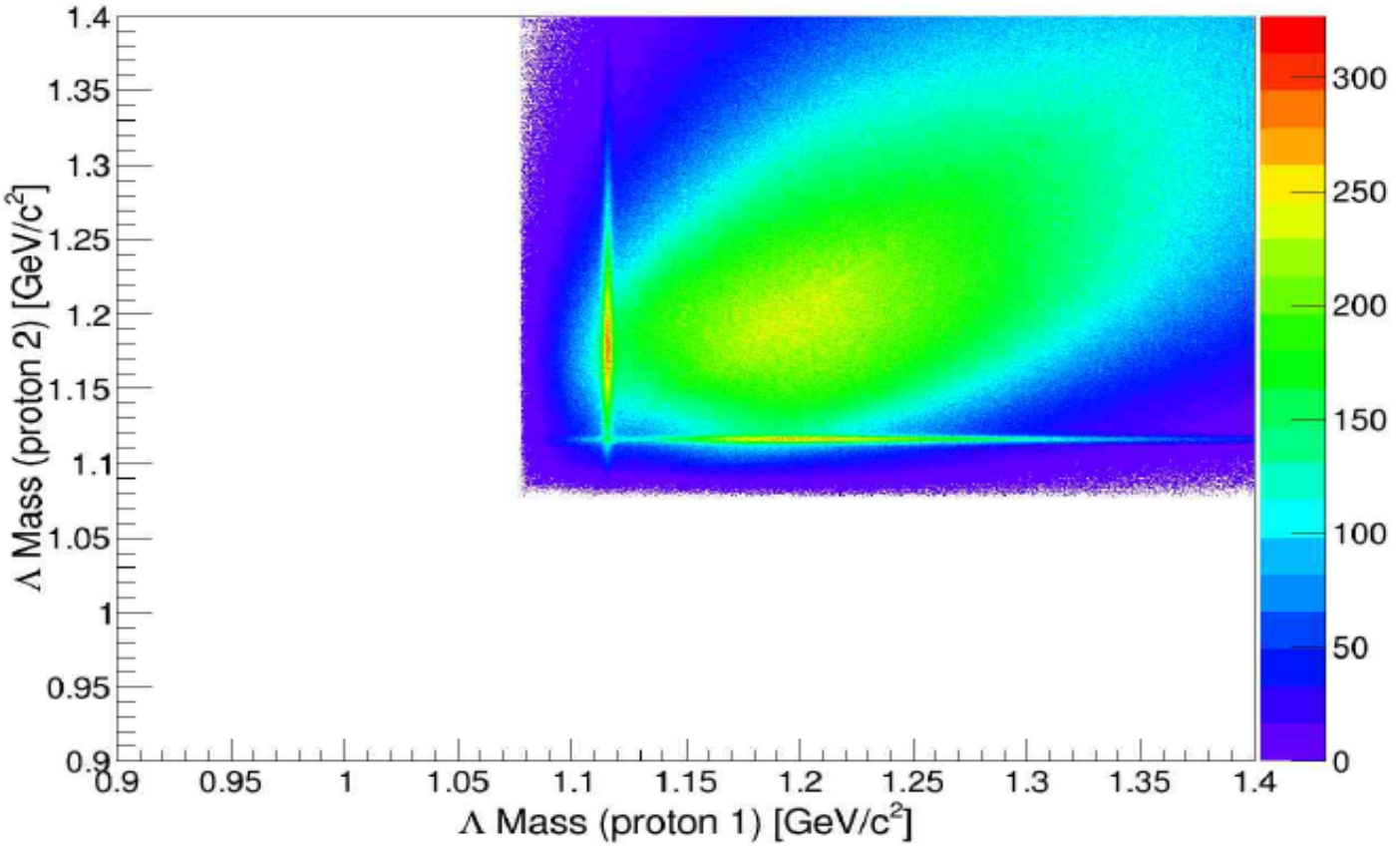


Summary

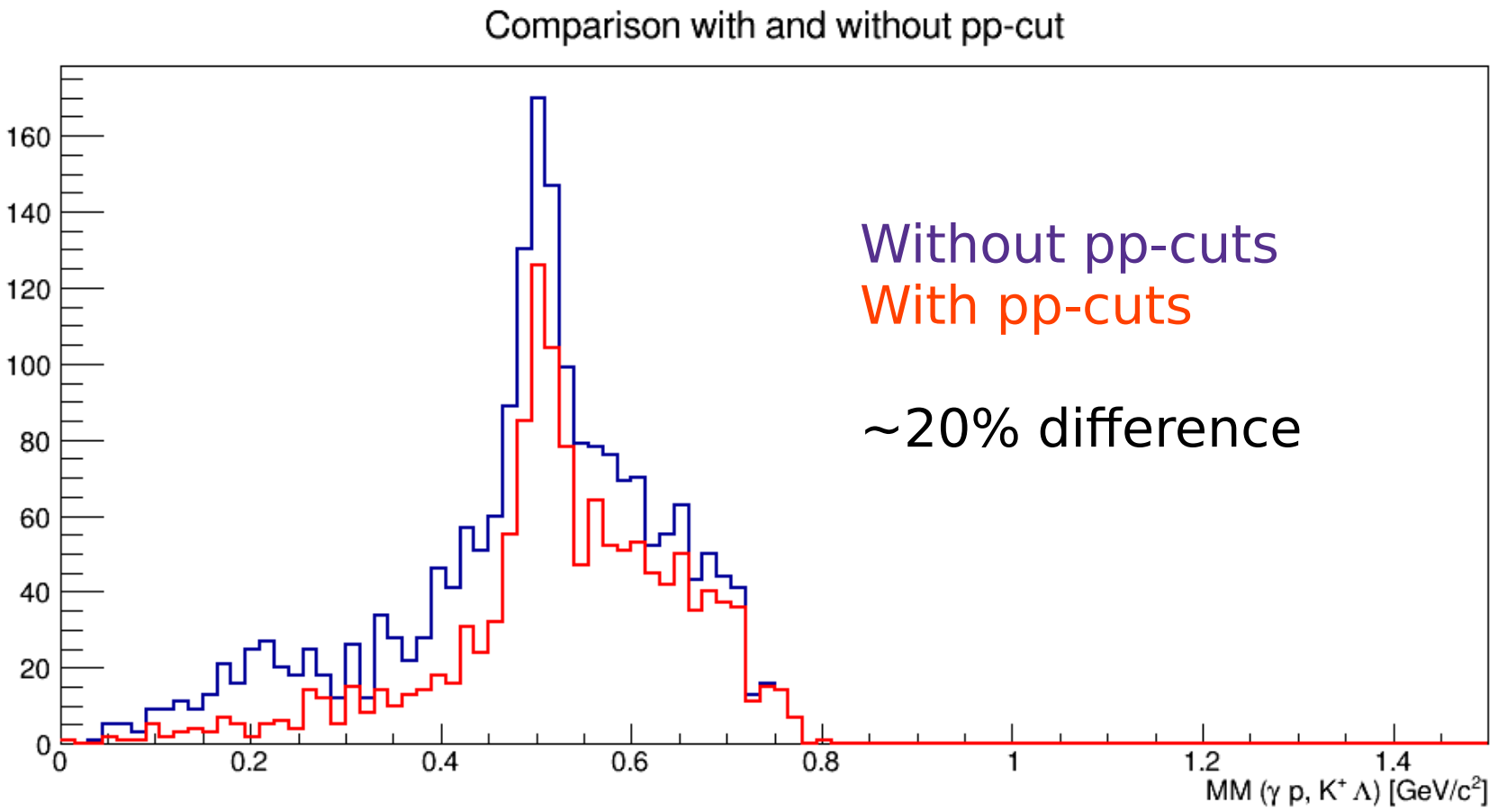
- Double the statistics as previous experiments
- Previous data could be excluding pp-scattering events
  - evidence to suggest that it does
- There is some agreement to theory but more work needs to be done.
- Results are still preliminary.

Extra Slides

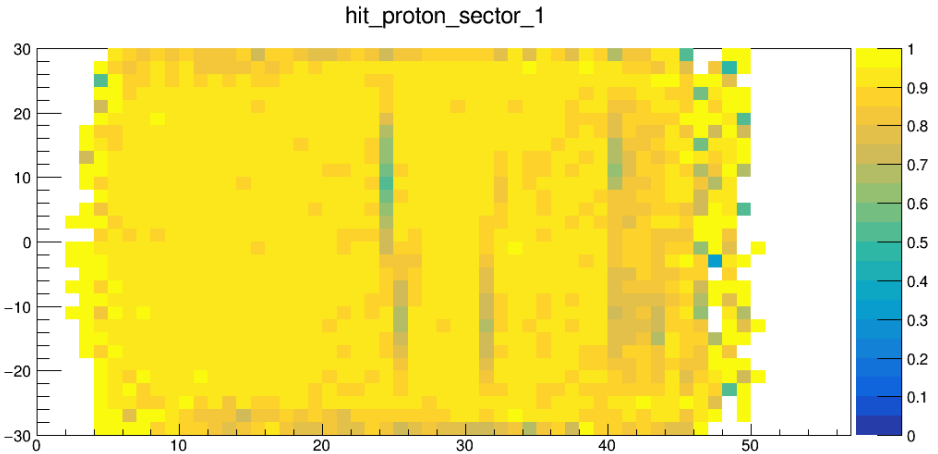
P1, P2

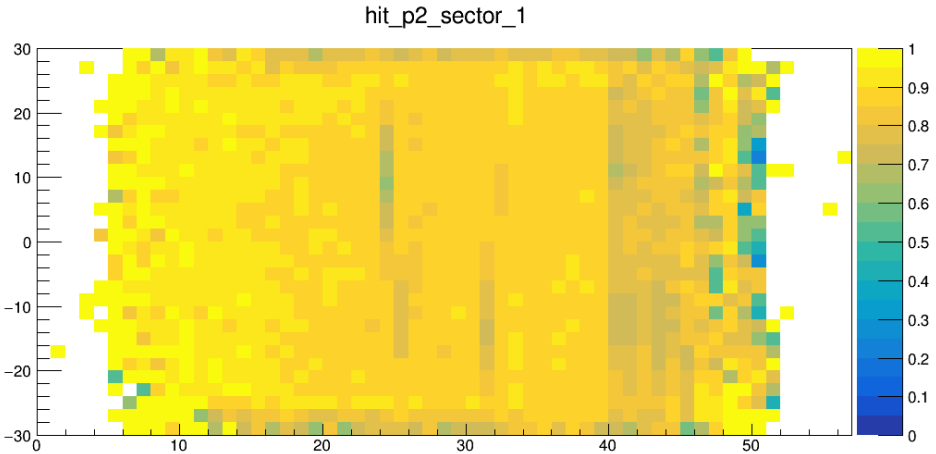

Λ Mass (proton 2) [GeV/c²]
Λ Mass (proton 1) [GeV/c²]
1.4
1.35
1.3
1.25
1.2
1.15
1.1
1.05
1
0.95
0.9
0.9
0.95
1
1.05
1.1
1.15
1.2
1.25
1.3
1.35
1.4
300
250
200
150
100
50
0

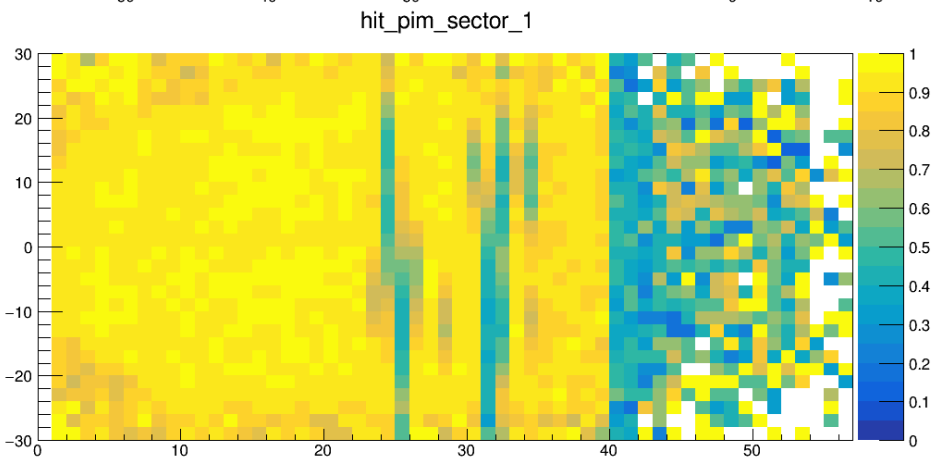
pp → pp events

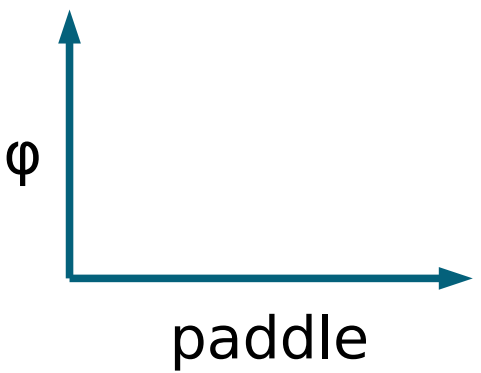

Comparison with and without pp-cut
160
140
120
100
80
60
40
20
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
MM (γ p, K⁺ Λ) [GeV/c²]
Without pp-cuts
With pp-cuts
~20% difference

Trigger Efficiency

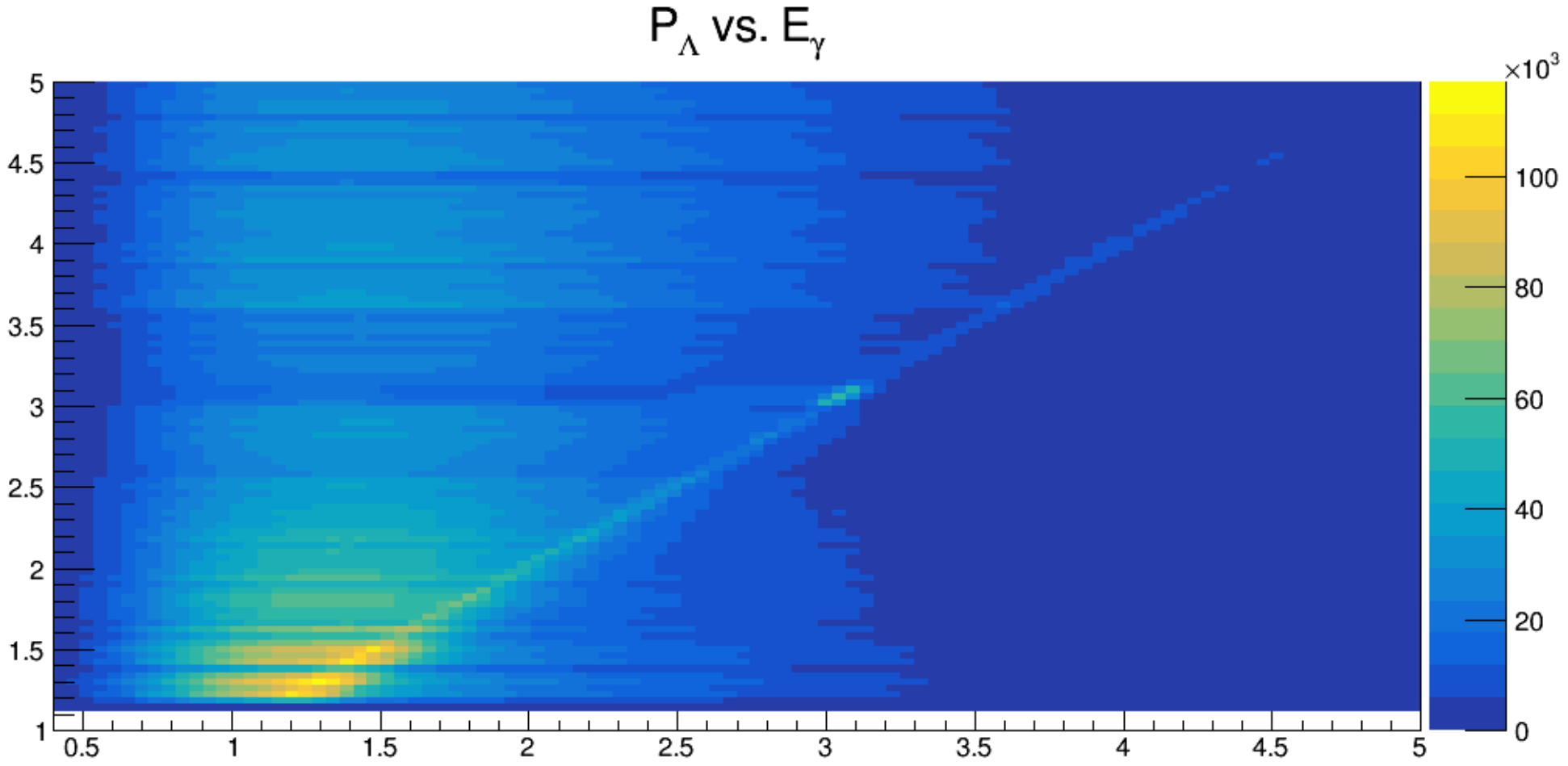






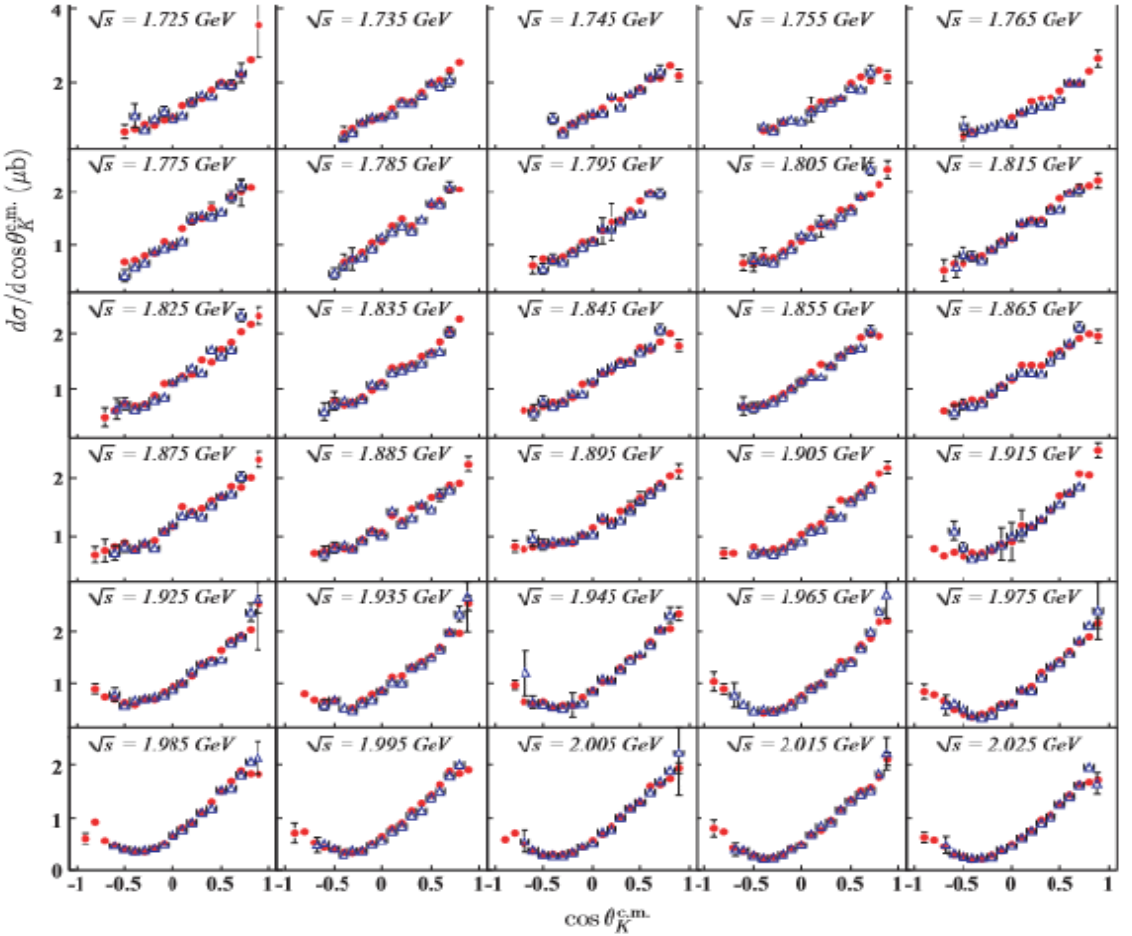


Momentum vs. Energy



$N_\Lambda(E_\Lambda)$

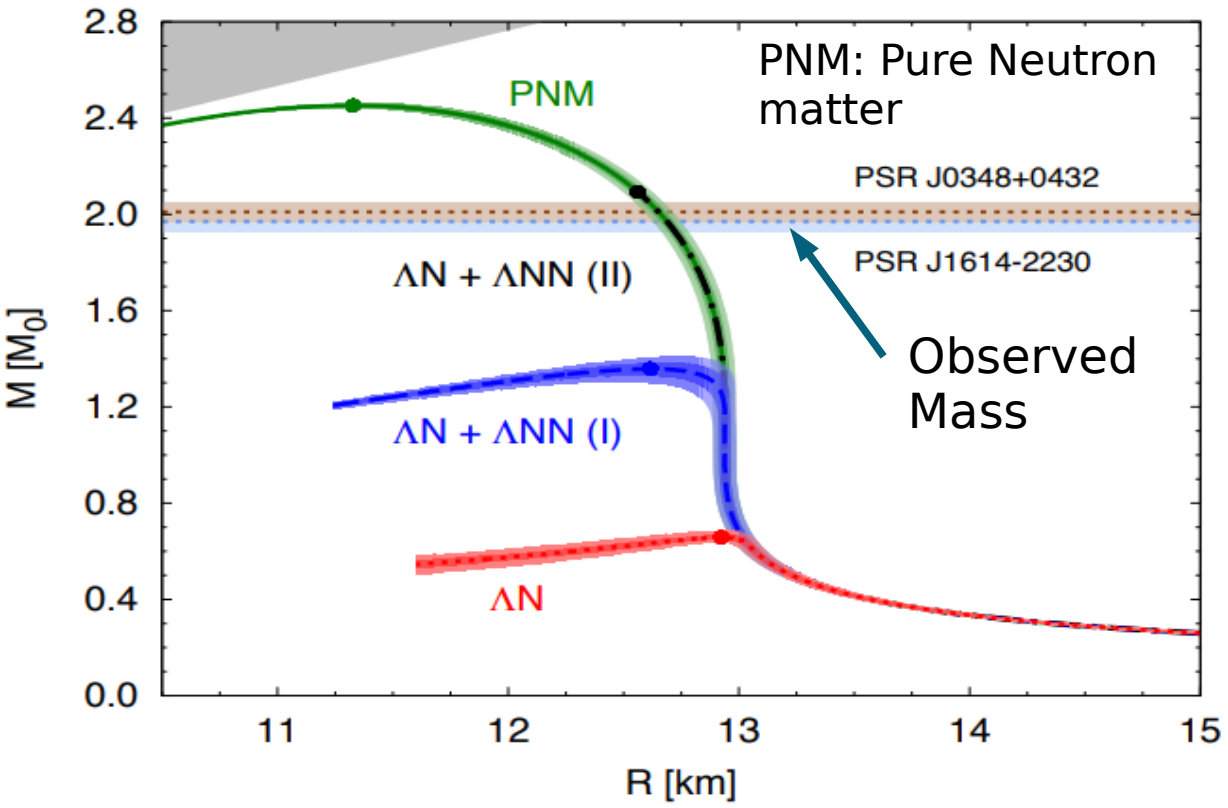
$$\frac{d\sigma}{d\Omega} = \frac{N_\Lambda}{2\pi * L_\gamma * \Delta\cos(\theta)}$$



M. E. McCracken *et al.* PHYSICAL REVIEW C 81, 025201 (2010)

Motivation - Hyperon Puzzle

- Hyperons may exist inside neutron stars
  - results in a softened Equation of State
- Better data for ΛN and ΛNN is needed



Diego Lonardoni, Alessandro Lovato, Stefano Gandolfi, and Francesco Ped-eriva. PRL, **114**, 092301 2015.