A Study of Λ-N Scattering using the CLAS Detector

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clas

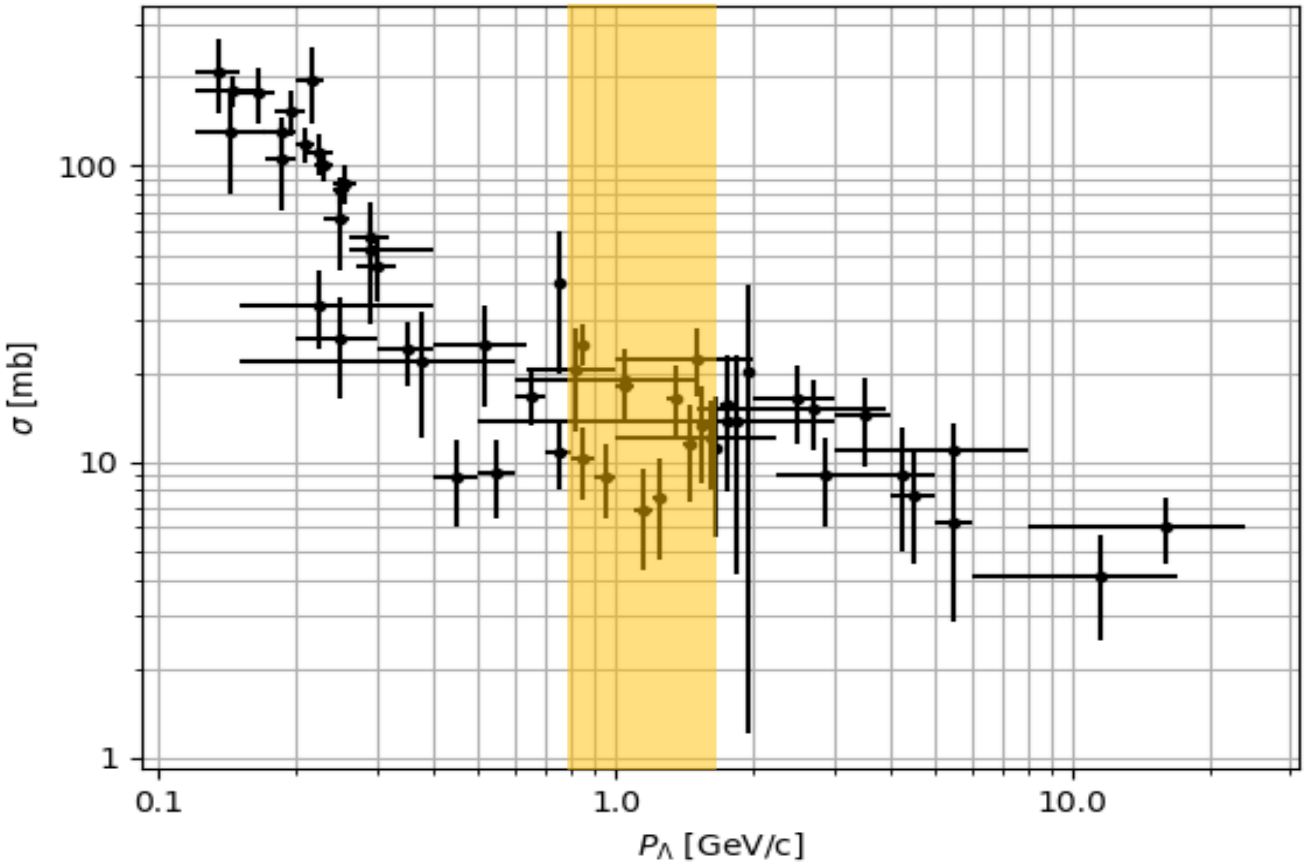
CEBAF Large Acceptance Spectrometer

Motivation

- Currently very little data for ΛN

  < 1300 events

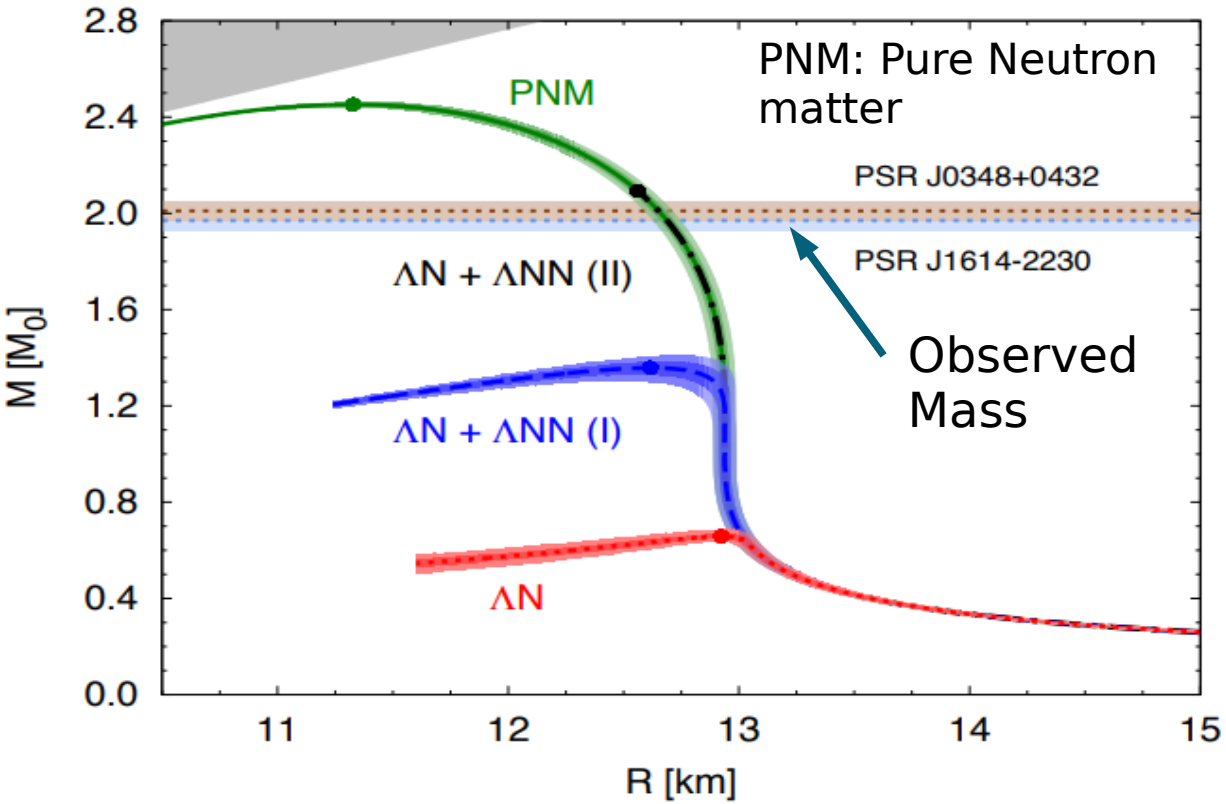
- Entirely from Bubble Chamber
- SU(3) suggests a relationship between NN and ΛN interactions.
  - we need more data because we can't use pure SU(3)



Motivation - Hyperon Puzzle

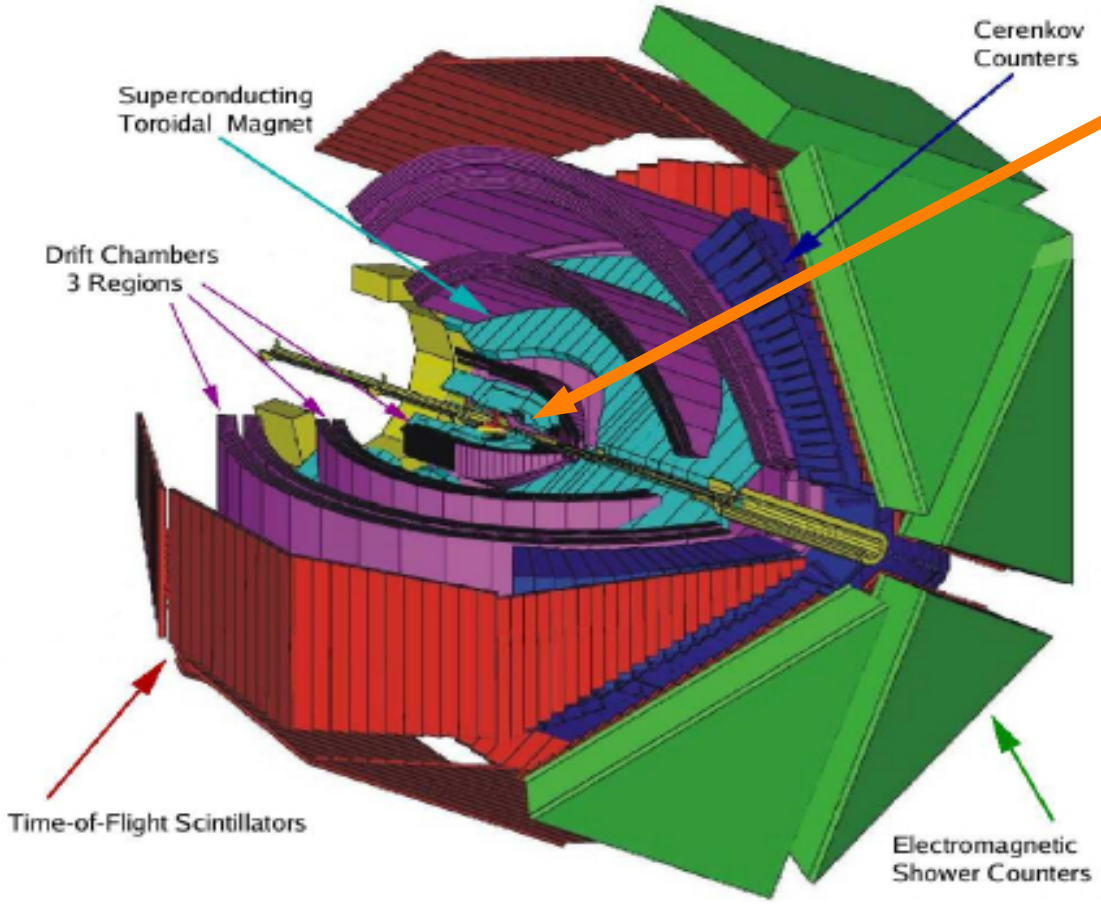
- Hyperons may exist inside neutron stars
  - results in a softened Equation of State

- "*We conclude that stronger constraints on the hyperon-neutron force are necessary in order to properly assess the role of hyperons in neutron stars.*"



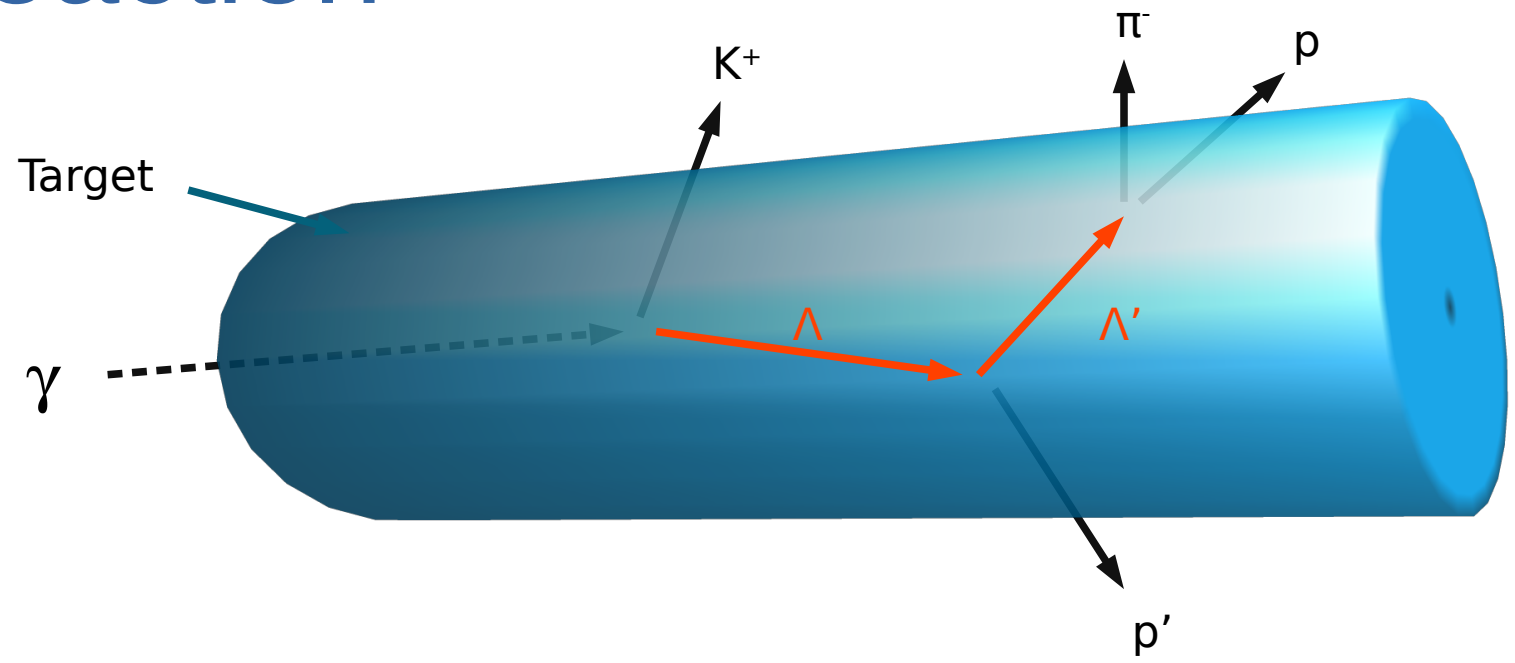
Diego Lonardoni, Alessandro Lovato, Stefano Gandolfi, and Francesco Ped-eriva. PRL, **114**, 092301 2015.

CLAS Detector



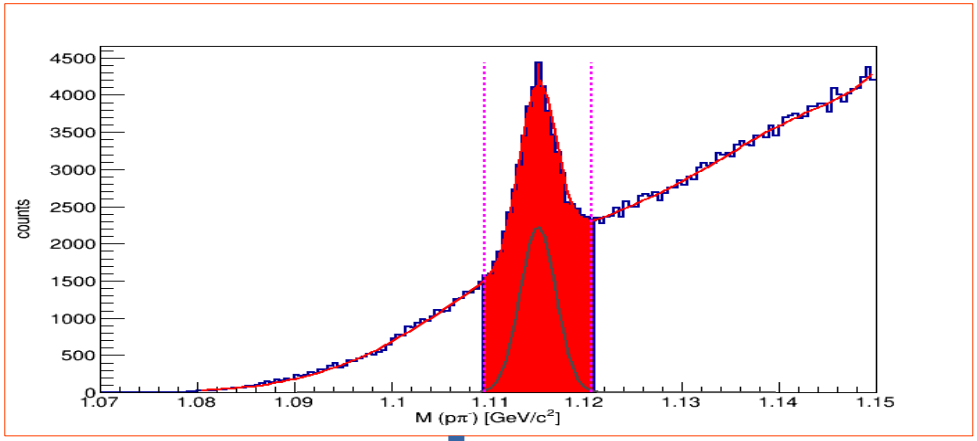
- LH_2 target
- Length: 40 cm
- Width: 4 cm
- -90 cm from center of detector

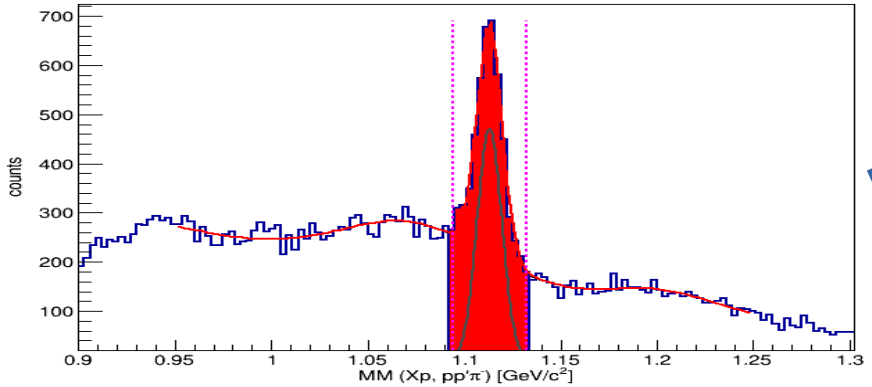
Reaction

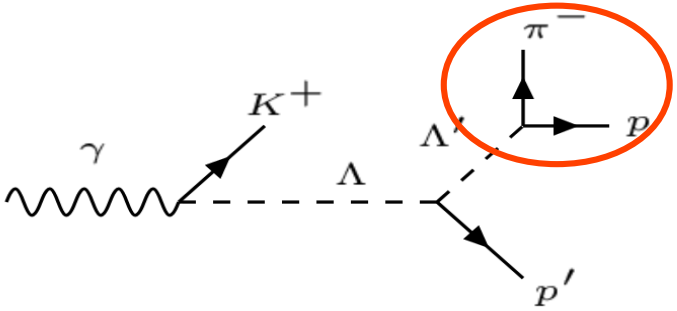


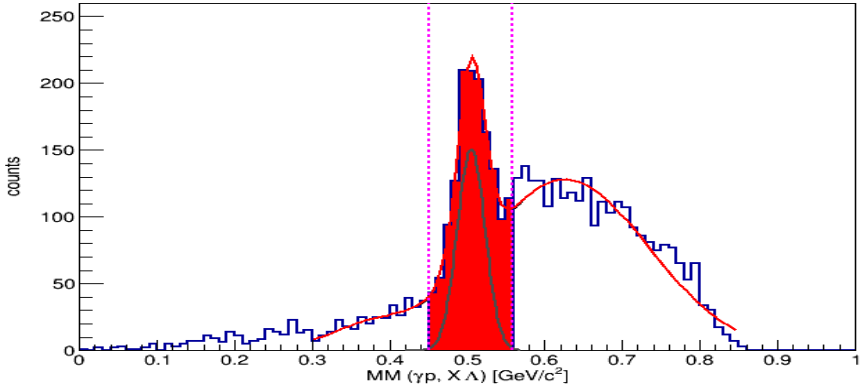
- Liquid Hydrogen Target
- p, p', π^- detected
- Λp scatter elastically

Data

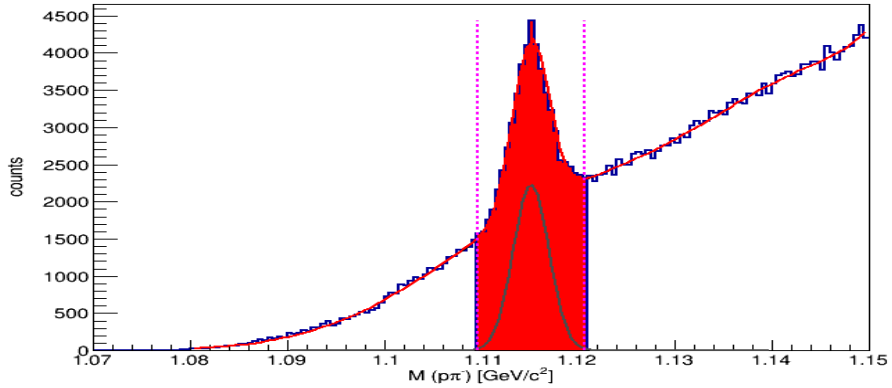

counts
M (pπ⁻) [GeV/c²]

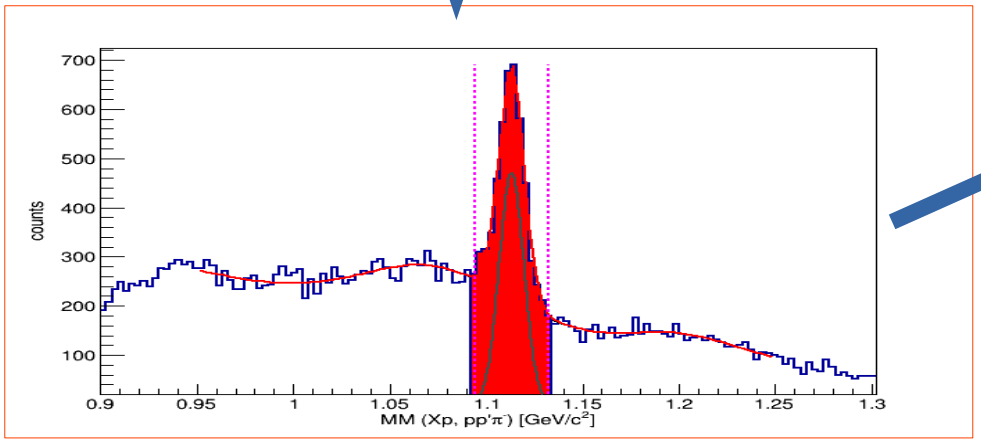

counts
MM (Xp, pp'π⁻) [GeV/c²]

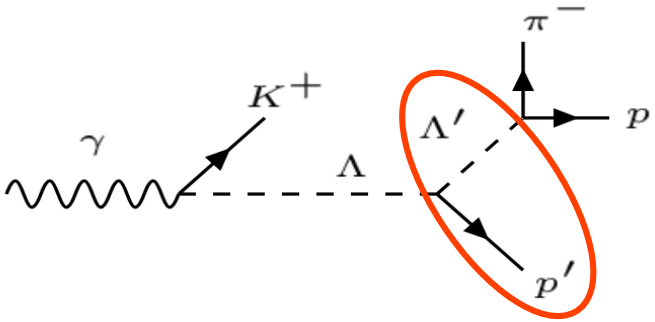

γ
K⁺
Λ
Λ'
π⁻
p
p'

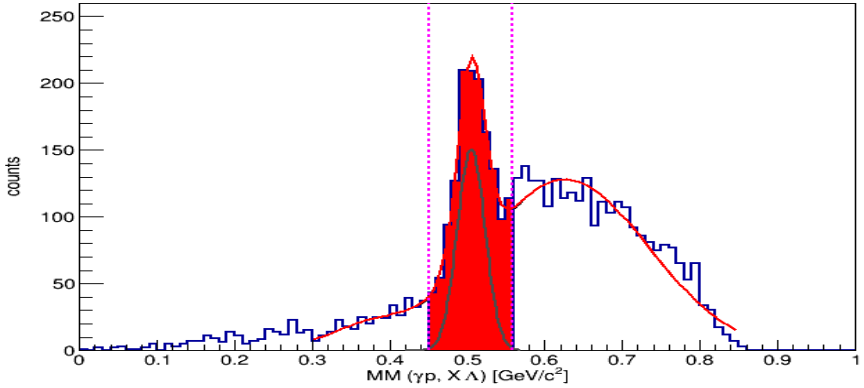

counts
MM (γp, X Λ) [GeV/c²]

Data

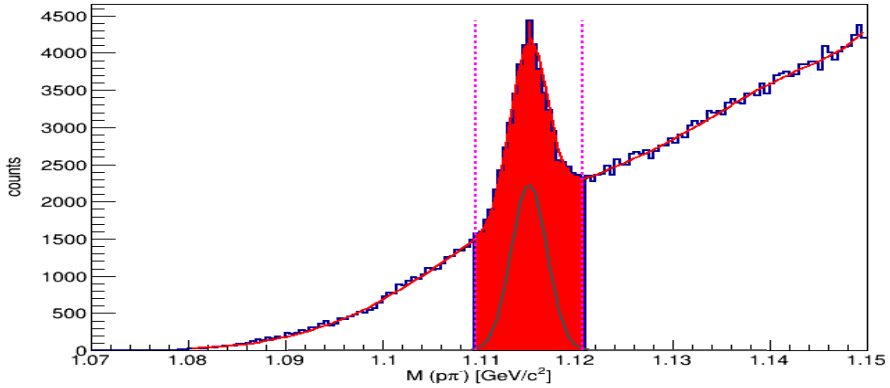

counts
M (pπ⁻) [GeV/c²]

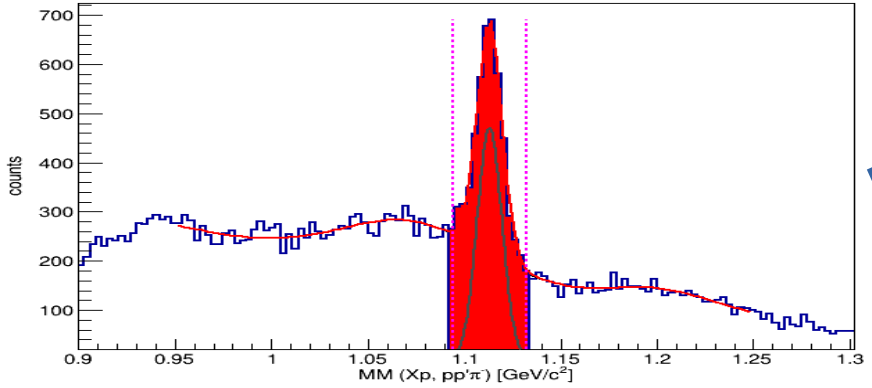

counts
MM (Xp, pp'π⁻) [GeV/c²]

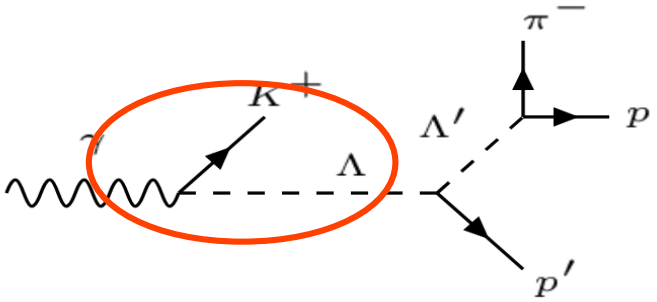

π^-
K^+
γ
Λ'
p
Λ
p'

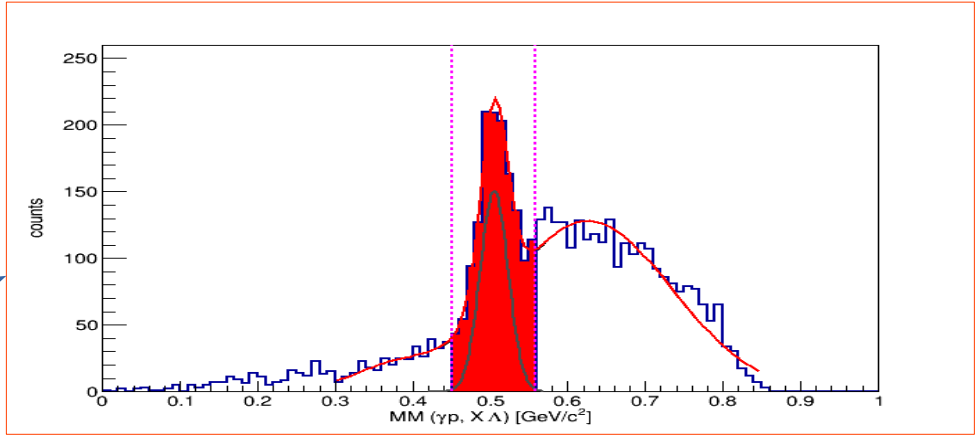

counts
MM (γp, X Λ) [GeV/c²]

Data


counts
M (pπ⁻) [GeV/c²]


counts
MM (Xp, pp'π⁻) [GeV/c²]


π⁻
K⁺
Λ′
p
Λ
p′


counts
MM (γp, X Λ) [GeV/c²]

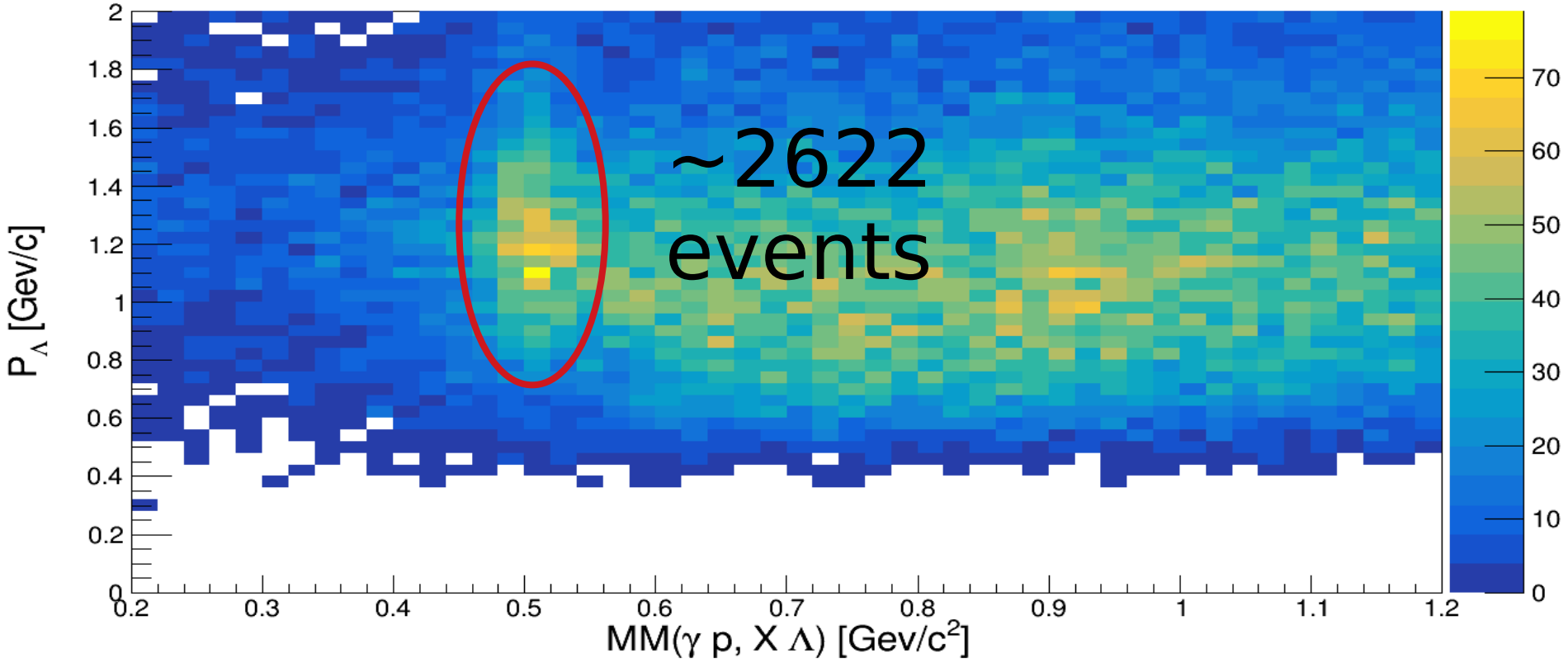
Cross Section

$$\frac{d\sigma}{dcos(\theta)}(E) = \frac{Y}{A * \mathcal{L} * \mathrm{b.r.} * \Delta\cos(\theta)}$$

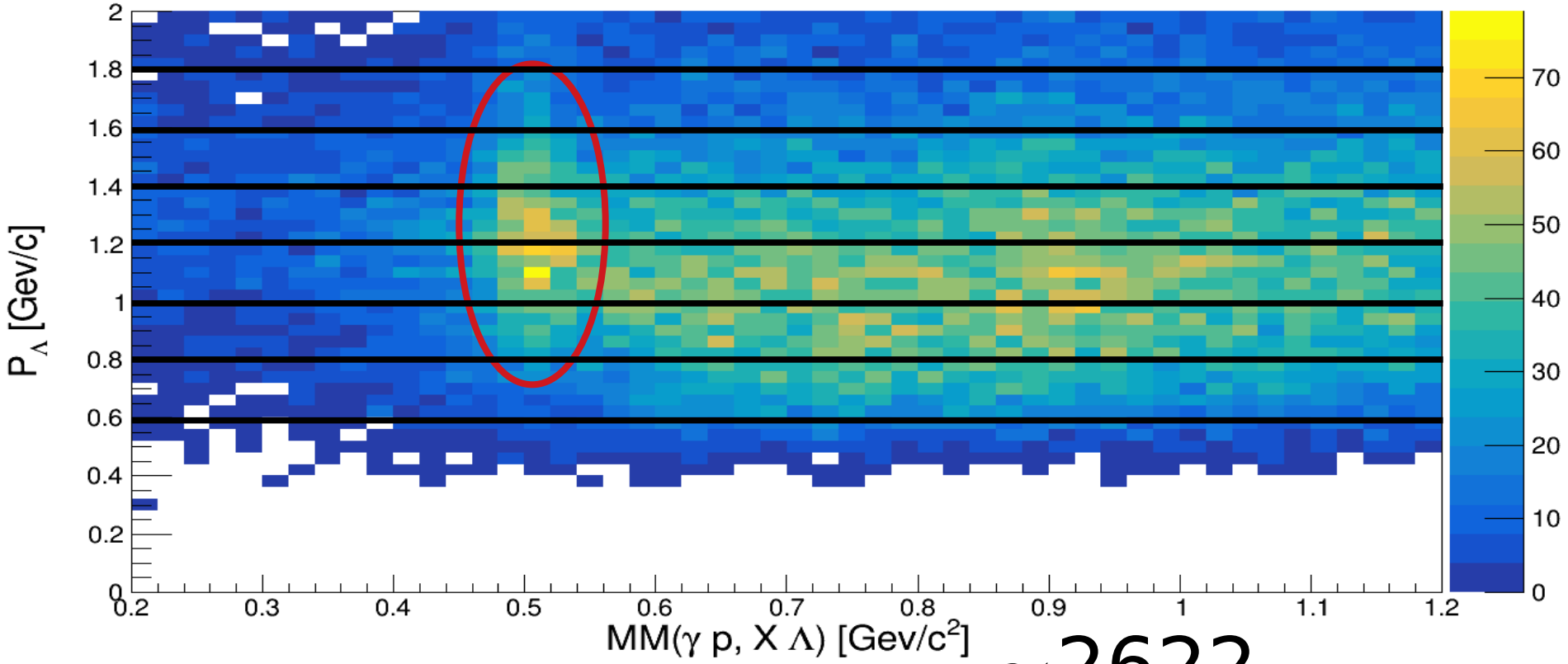
Y: Yield
A: Acceptance
$\mathcal{L}$: Luminosity
b.r: Branching ratio (for $p\pi^-$)

$\frac{d\sigma}{dcos(\theta)}(E)$: Energy dependent cross section

Yield

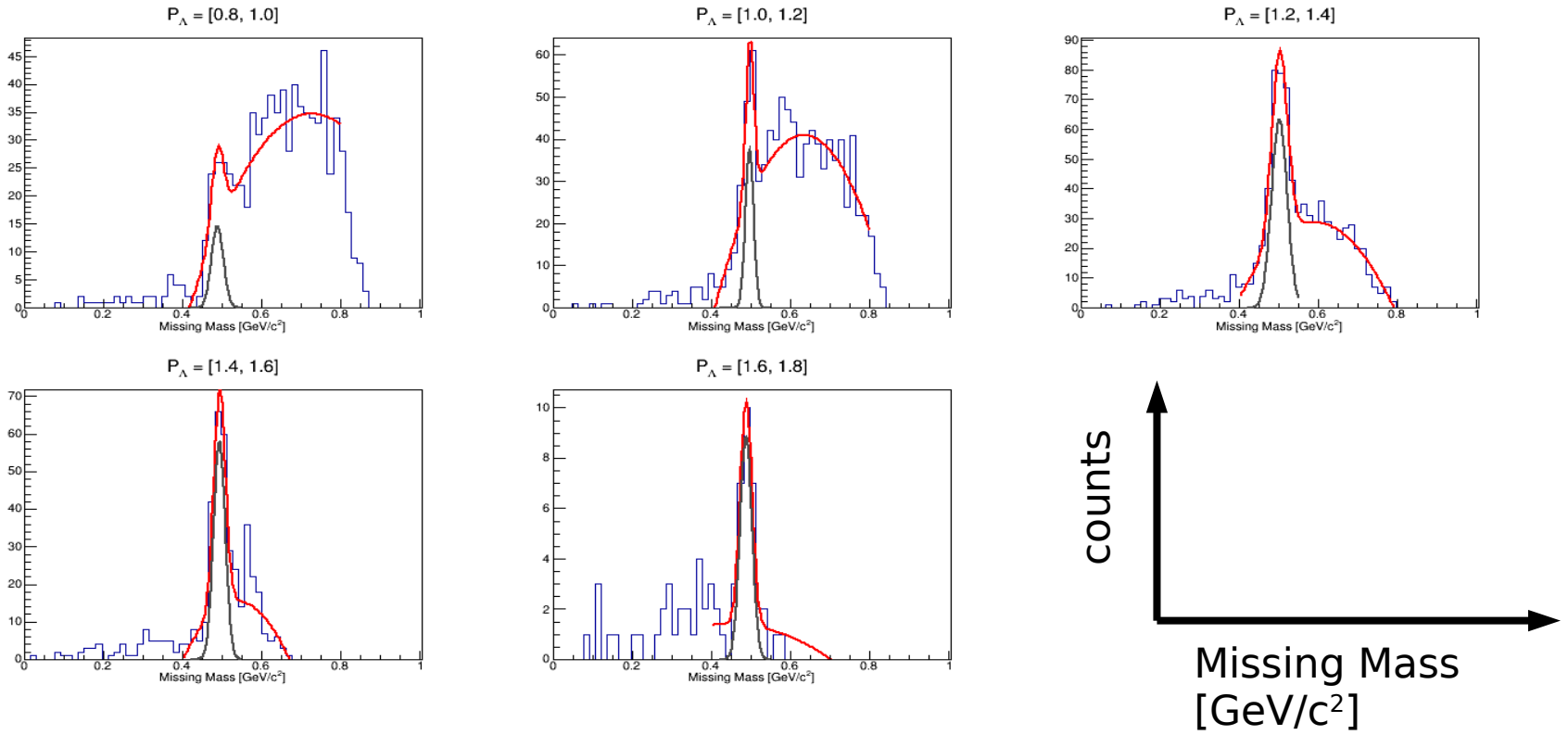

~2622
events
P_Λ [Gev/c]
MM(γ p, X Λ) [Gev/c^2]
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
0
10
20
30
40
50
60
70

Yield



~2622 events

Yields

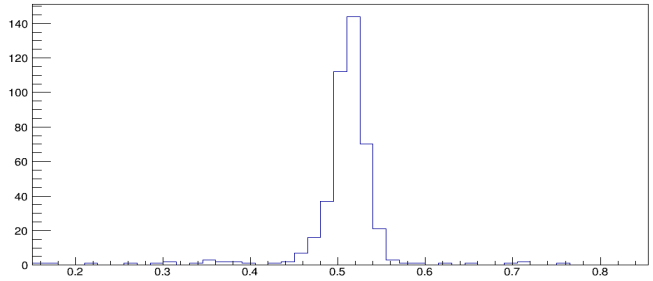


- Yield is taken from Missing Mass (K+ peak)
- Binned in Λ Momentum

Acceptance

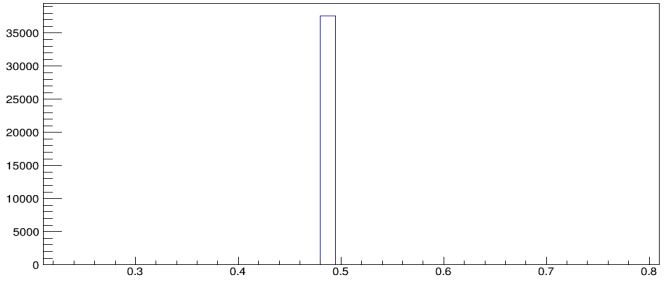
$$Acceptance = \frac{Accepted\ pp\pi^-}{Generated\ \Lambda p\ scattering}$$

Accepted Events:



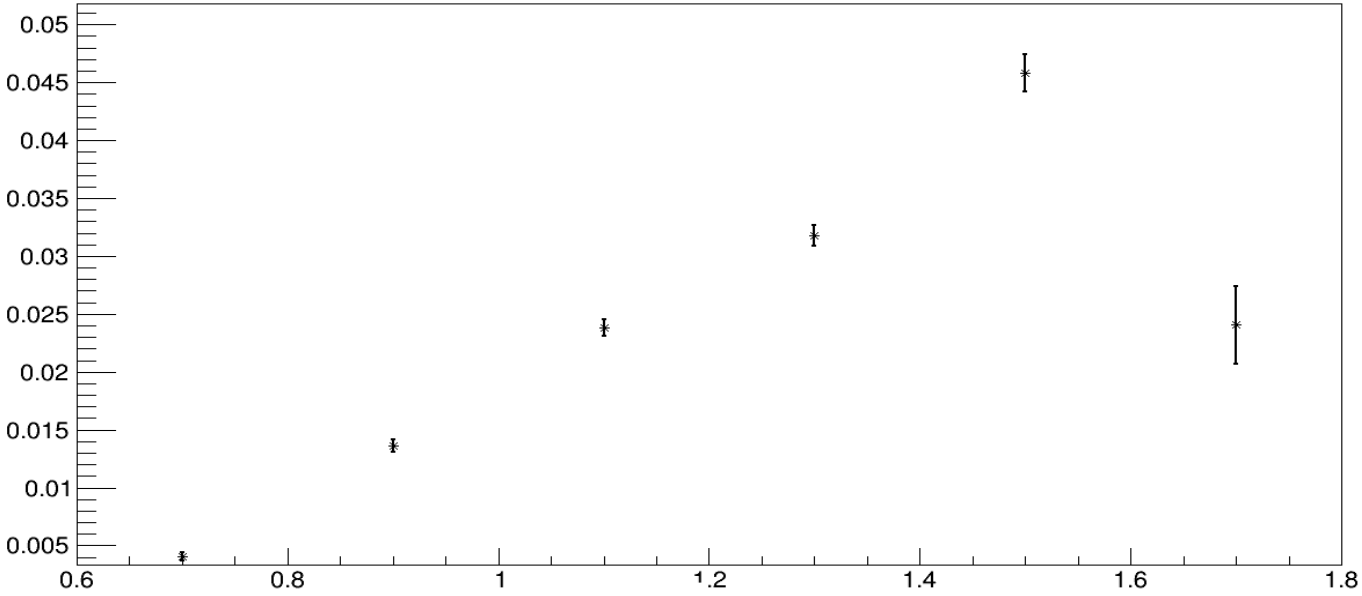
Missing Mass [GeV/c²]

Generate Events:



Missing Mass [GeV/c²]

Acceptance (E_γ [1.2,1.6])



Missing Mass [GeV/c²]

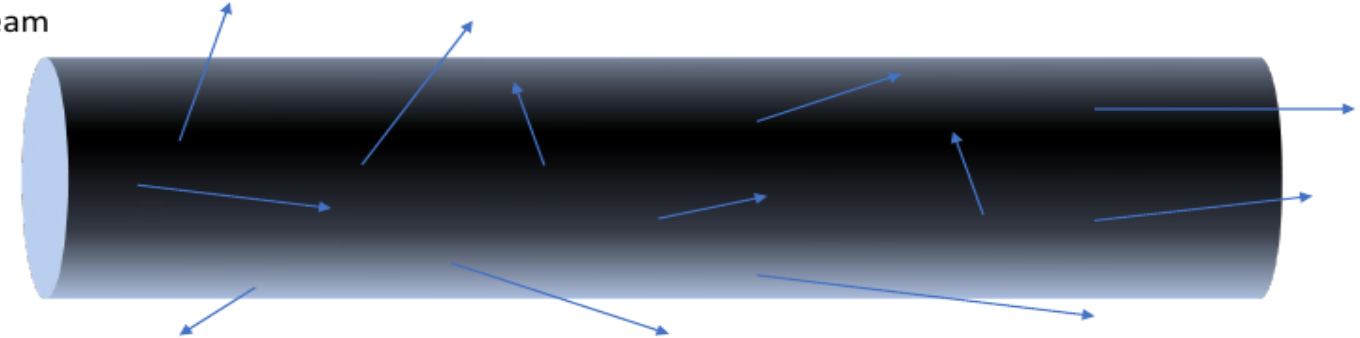
Luminosity

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

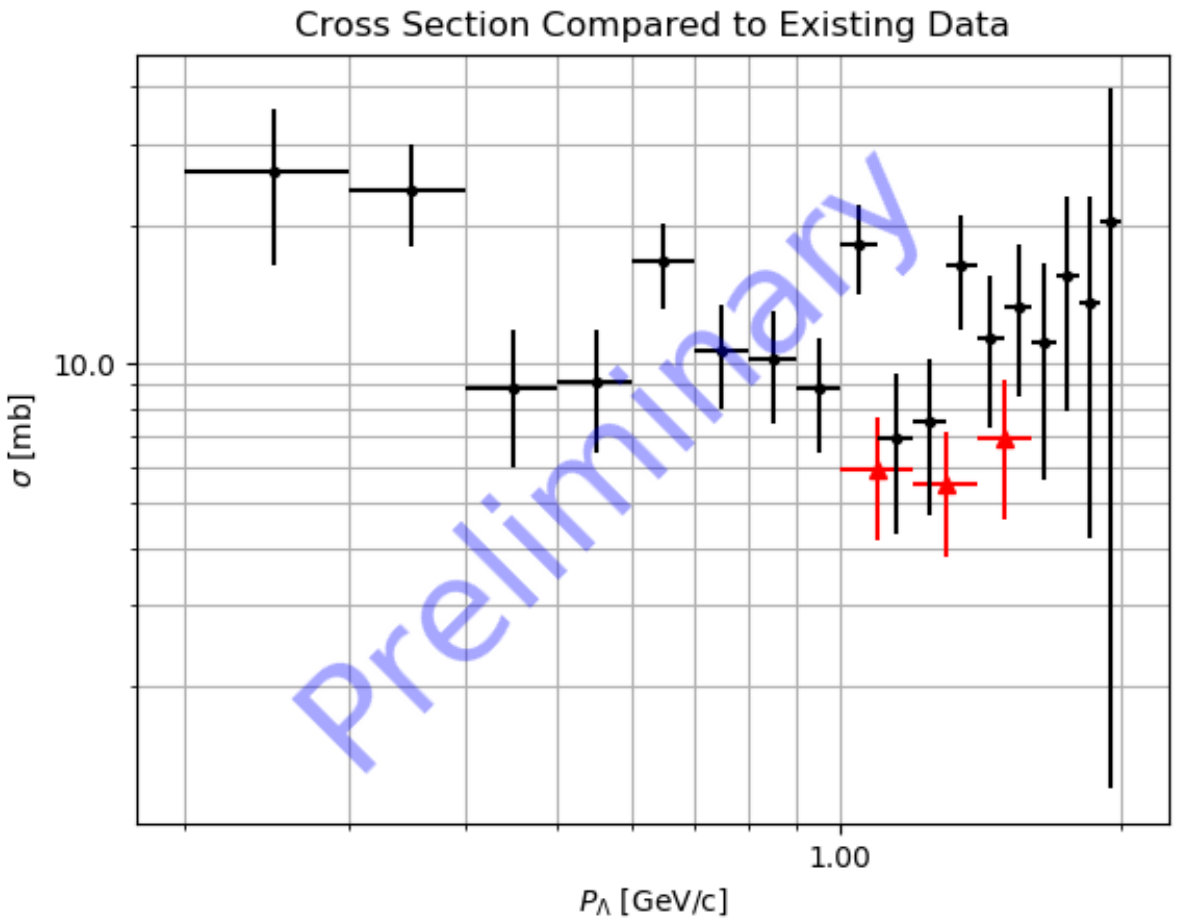
- ρ_T: density of the target
- N_A: Avogadro's number
- M: molar mass of Hydrogen
- l: travel distance of Λ
- $N_\Lambda(E_\Lambda)$: yield in a certain energy range

Photon Beam

Λ Beam



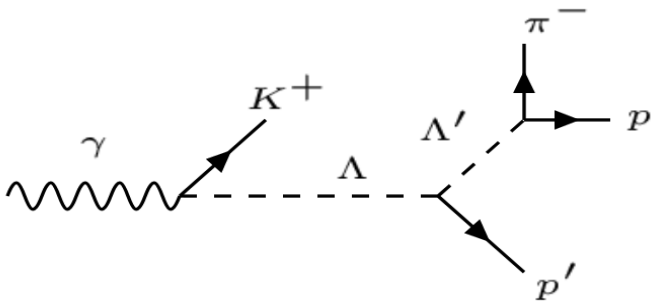
Preliminary Results

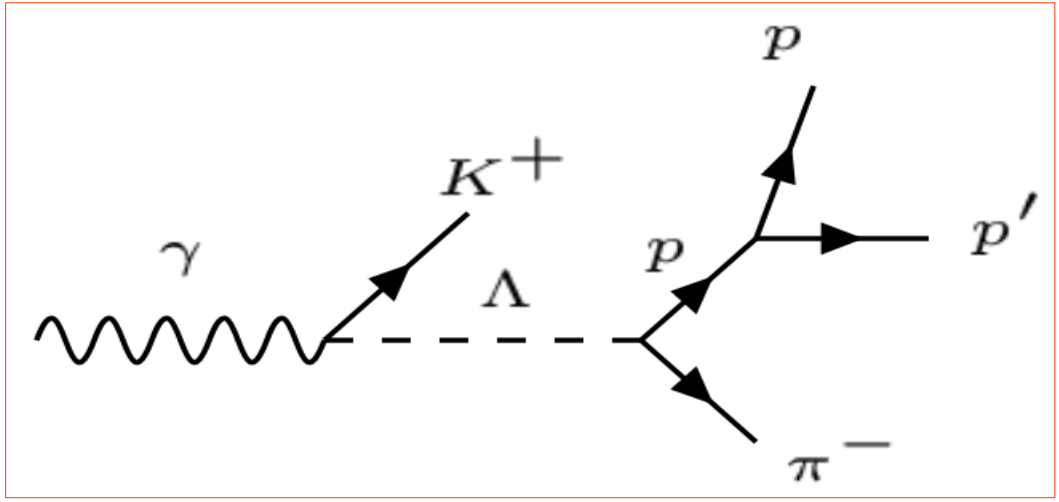


- Black: Existing data from
- Red: Measurements from this study (~30% of total data set)

Questions?

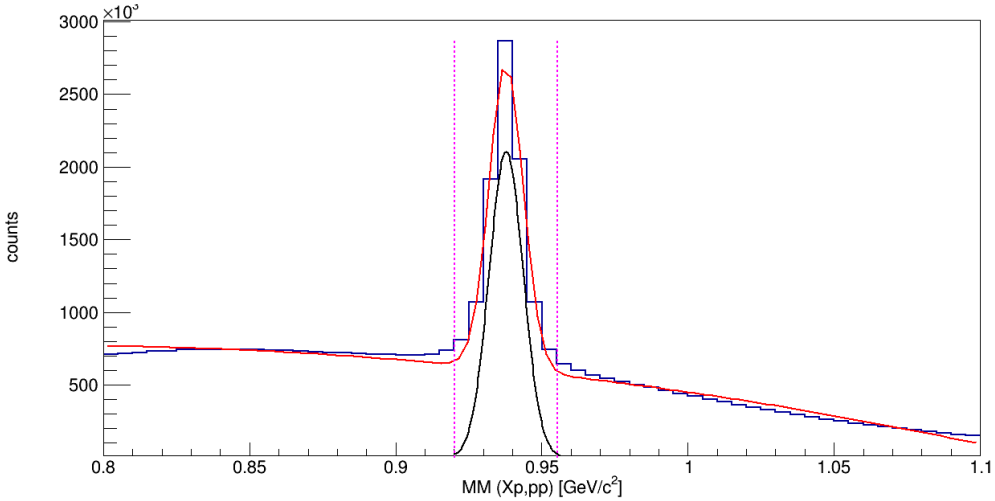
pp → pp events

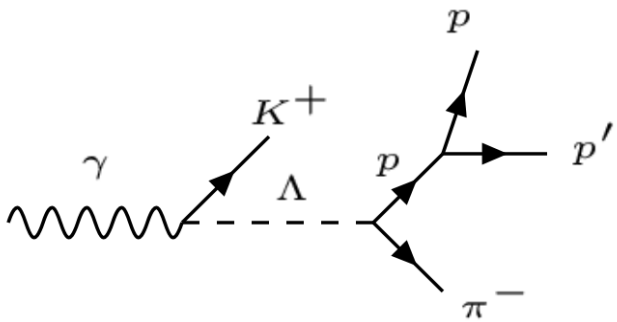


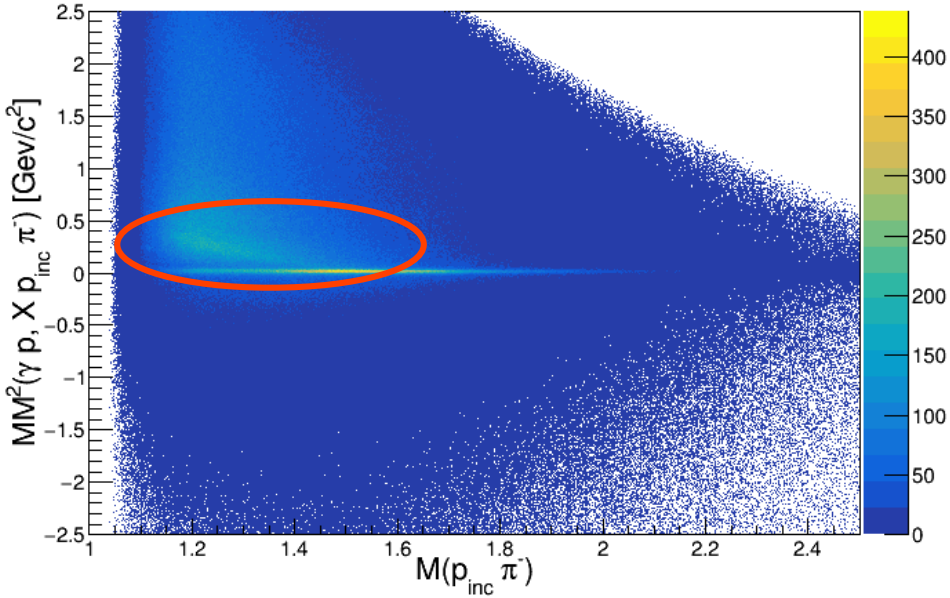


- pp → pp events can also result in the same final state.

pp → pp events

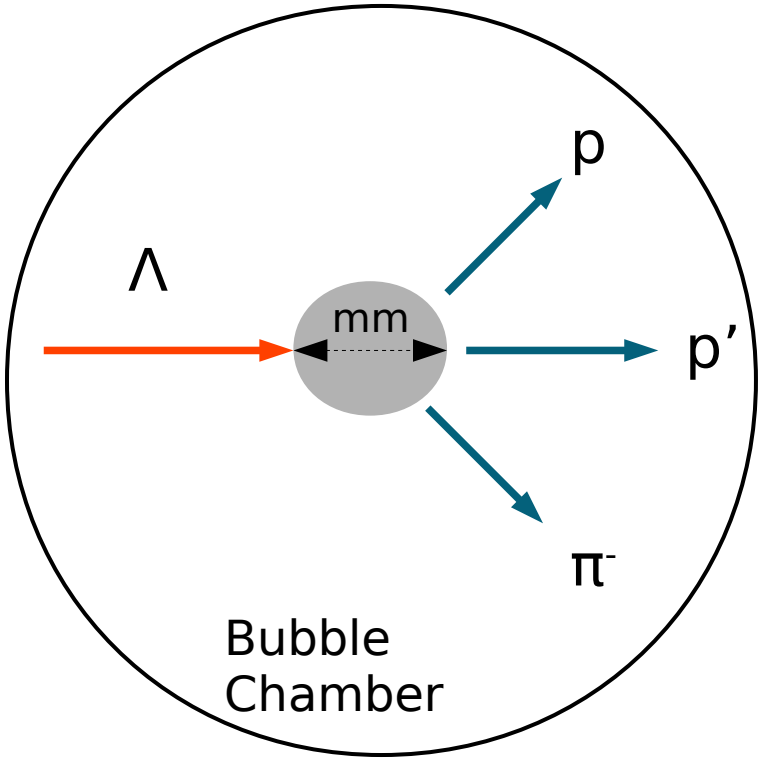


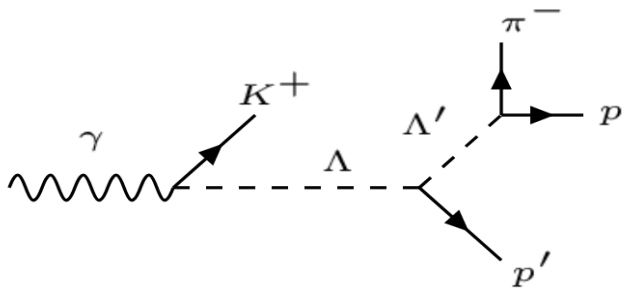


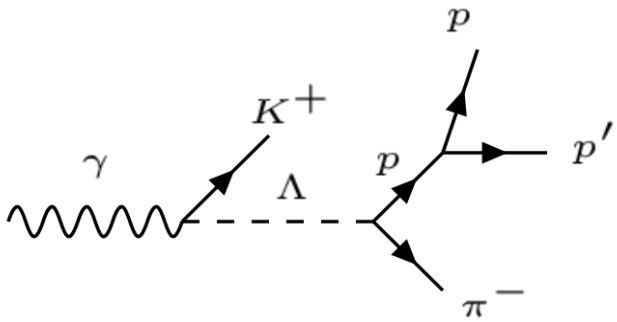


Events need to be removed for incident p events but not for incident π^-

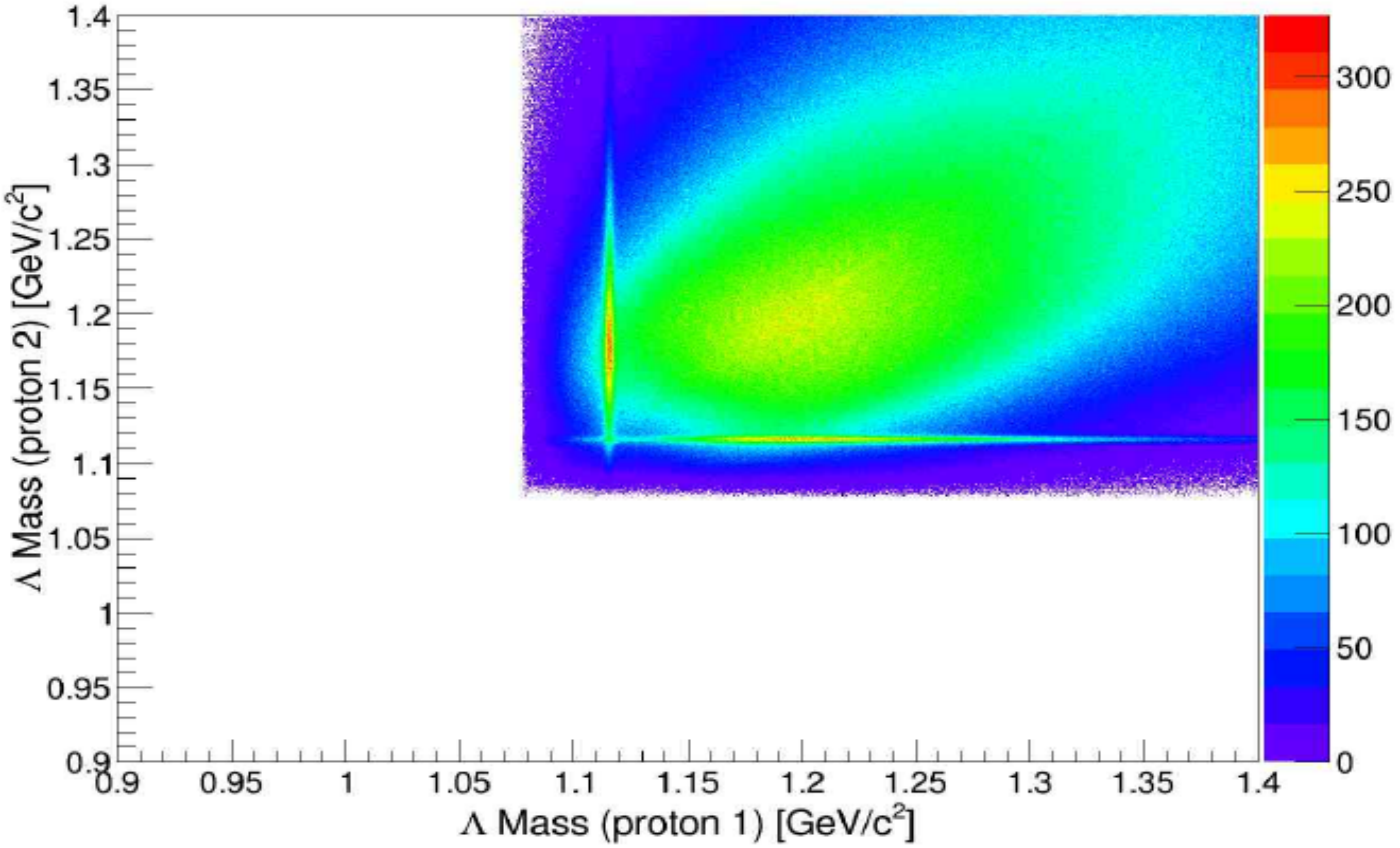
pp → pp events


Λ
mm
p
p'
π-
Bubble
Chamber


π^-
K^+
Λ'
p
γ
Λ
p'


p
K^+
p'
γ
p
Λ
π^-

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

θ Distribution