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Status report of E27 Pilot run analysis

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E27 Collaboration

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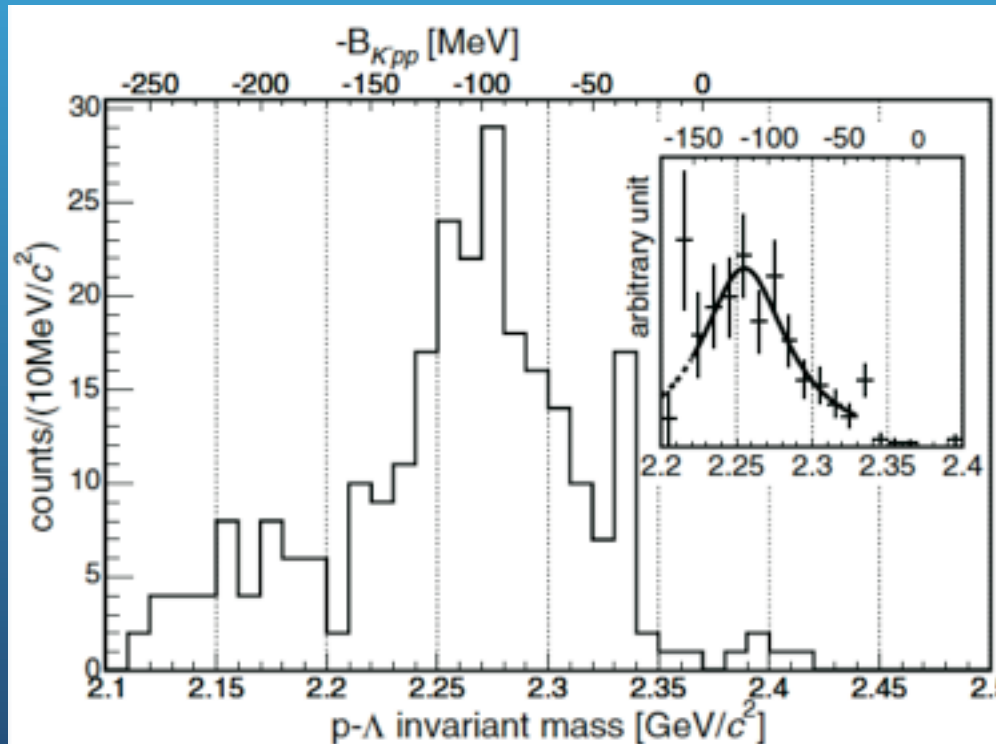
K^-pp : experiments

- FINUDA; First evidence of K^-pp
 - Back-to-back Λ - p pairs in Stopped K^- absorption on ${}^6,7\text{Li}+{}^{12}\text{C}$

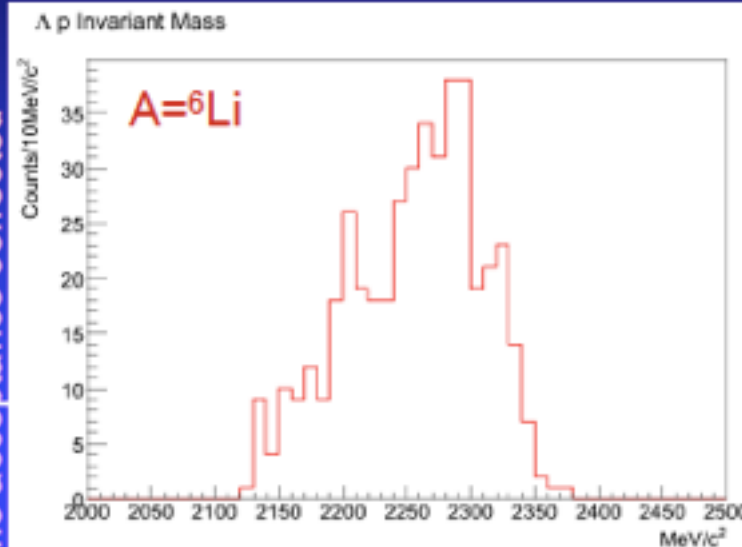
$B=115+6/-5$ MeV

$\Gamma=67+14/-11$ MeV

M. Agnello *et al.*,
PRL 94 (2005) 212303.

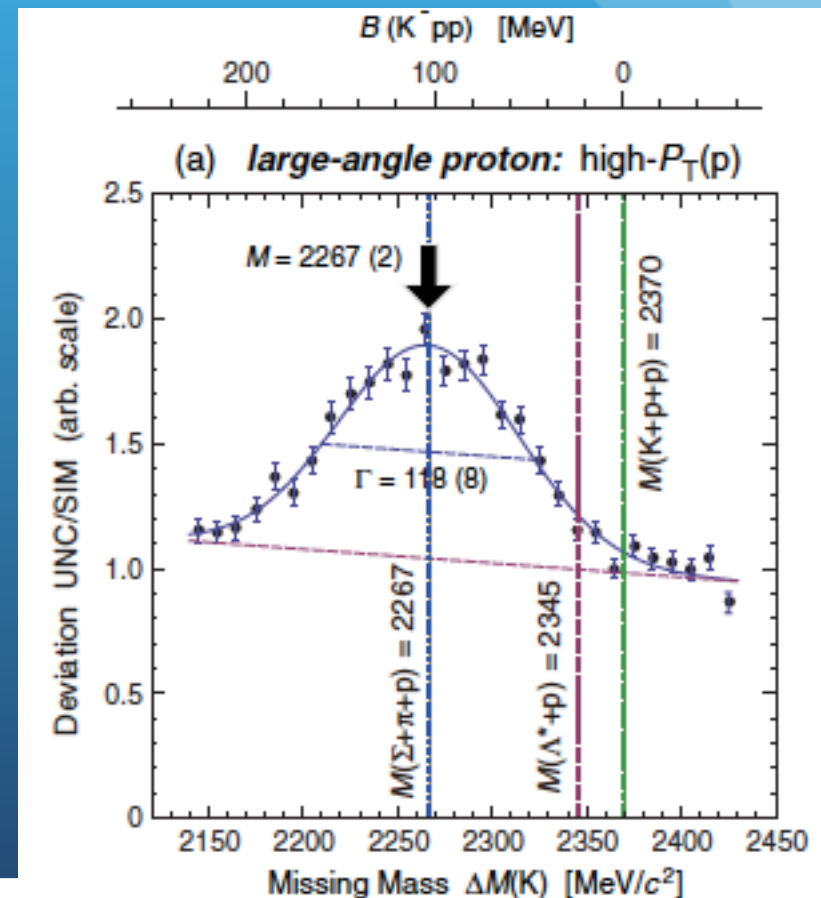


no acceptance corrected



- DISTO
 - $pp \rightarrow K^+ + X$ @ $T_p = 2.85$ GeV
 - $X \rightarrow \Lambda p$
 - $M_x = 2267 \pm 3 \pm 5$ MeV
 - $\Gamma_x = 118 \pm 8 \pm 10$ MeV

T. Yamazaki et al., PRL
104(2010) 132502.



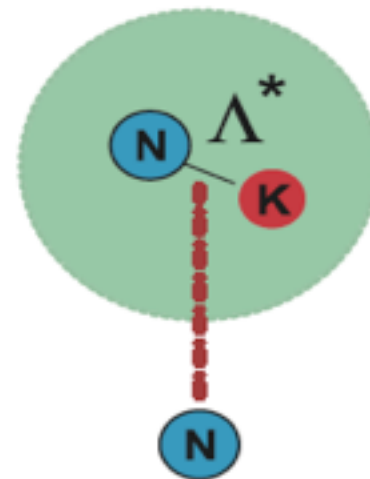
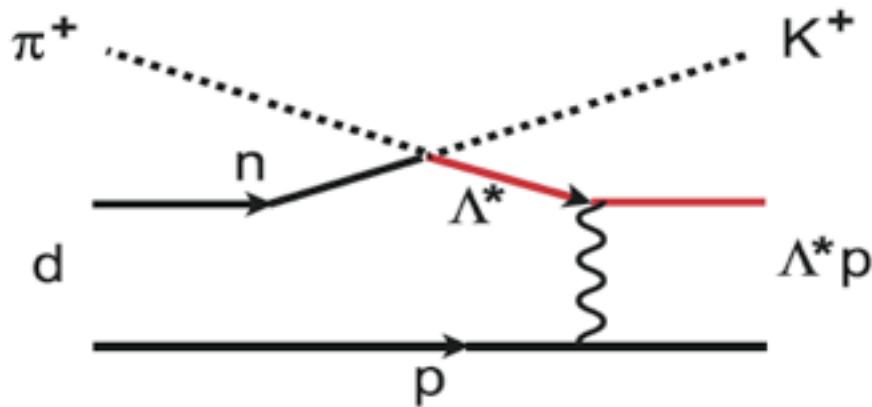
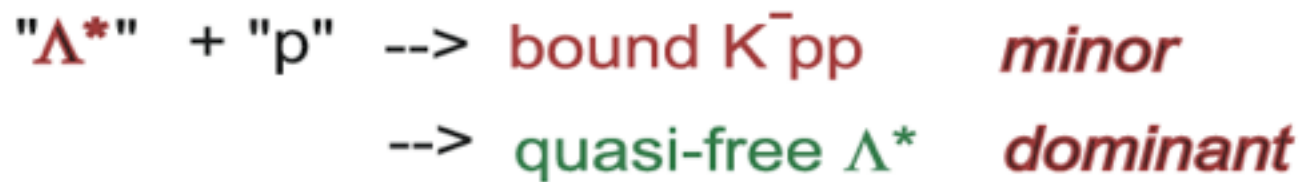
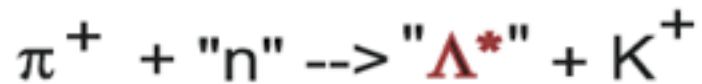
K - pp : theoretical status

Methods	Binding Energy (MeV)	Width (MeV)
Shevchenko, Gal, Mares	50 - 70	~100
Ikeda and Sato Faddeev	60 - 95	45 - 80
Yamazaki and Akaishi Variational (ATMS)	48	61
Dote, Hyodo, Weise Variational (AMD)	20 ± 3	40 - 70

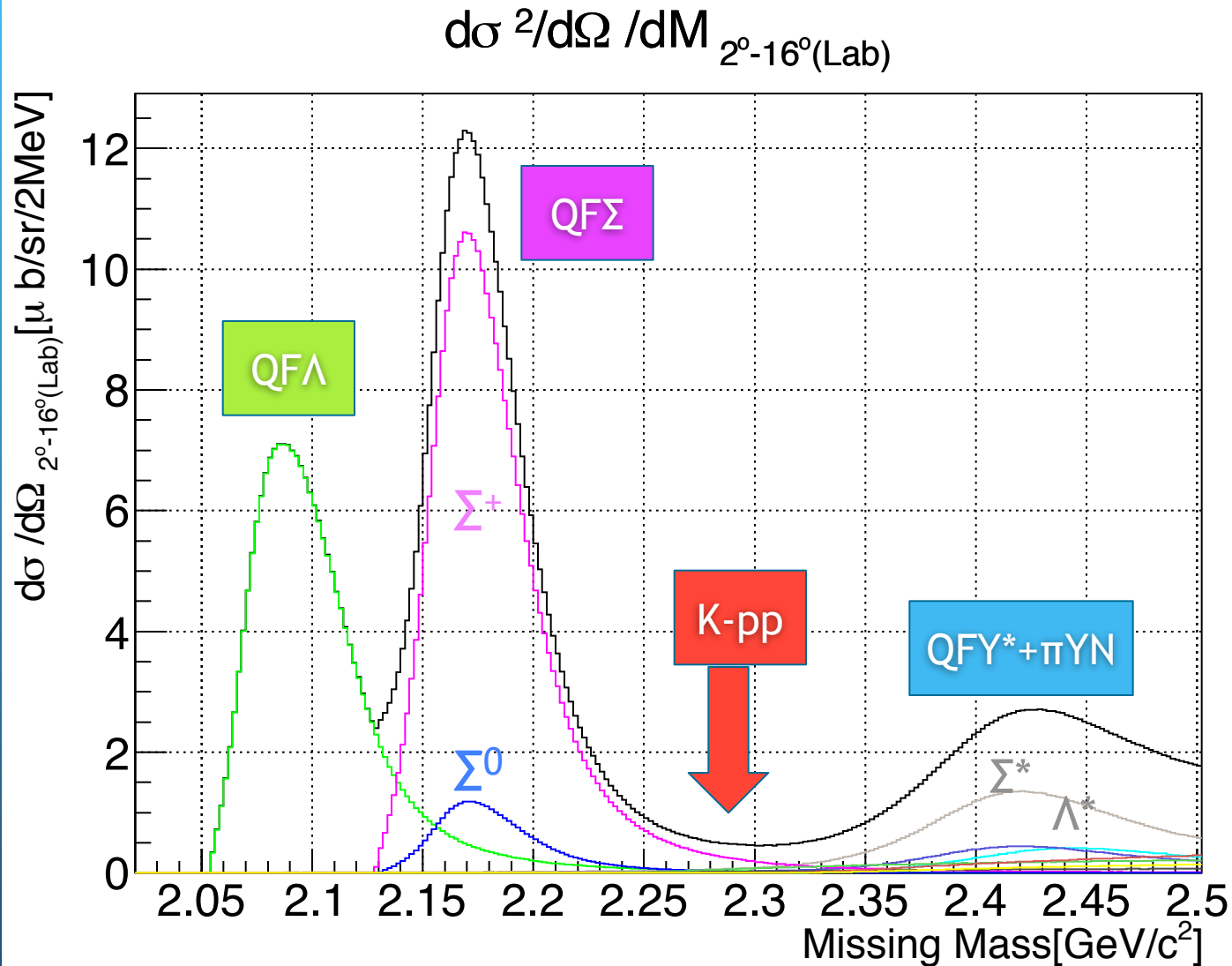
- *K - pp should exist as a bound state.*
 - Deep or Shallow ??
 - Width could be 40 - 100 MeV
- $\Lambda(1405)$ - p bound state ? (Arai, Oka, and Yasui)
- FSI effects ? (Magas, Oset, Ramos, Toki)

$d(\pi^+, K^+)$ reaction

Yamazaki & Akaishi, Phys. Rev. C76 (2007) 045201.

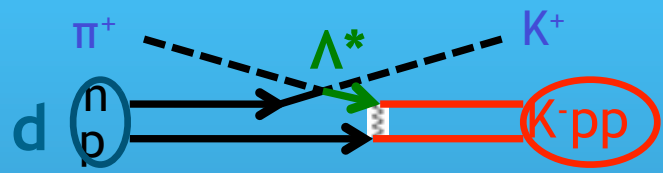


$d(\pi^+, K^+)$ inclusive spectrum; in simulation



E27: Search for “K⁻pp” bound state in the d(π⁺,K⁺)X reaction

- “K⁻pp” is produced through Λ* doorway in the d(π⁺,K⁺) reaction



- Semi-exclusive measurement by Range Counter Array (RCA) in order to suppress quasi-free B.G.

- K⁻pp → Λ p₁, Λ → p₂ π⁻
- K⁻pp → Σ⁰ p₁, Σ⁰ → (Λγ) → p₂ π⁻ γ
- π⁺d → Λ* K⁺ p_{1s}, Λ* → Σ π, Σ⁺ → p₂ π⁰

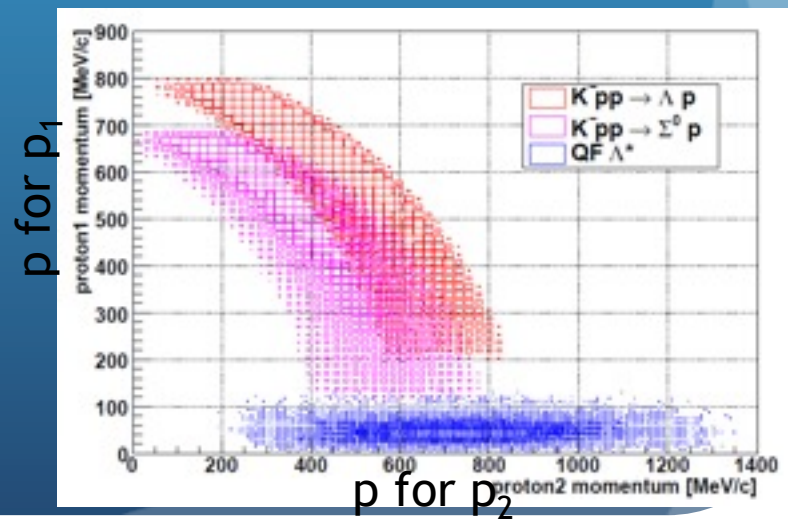
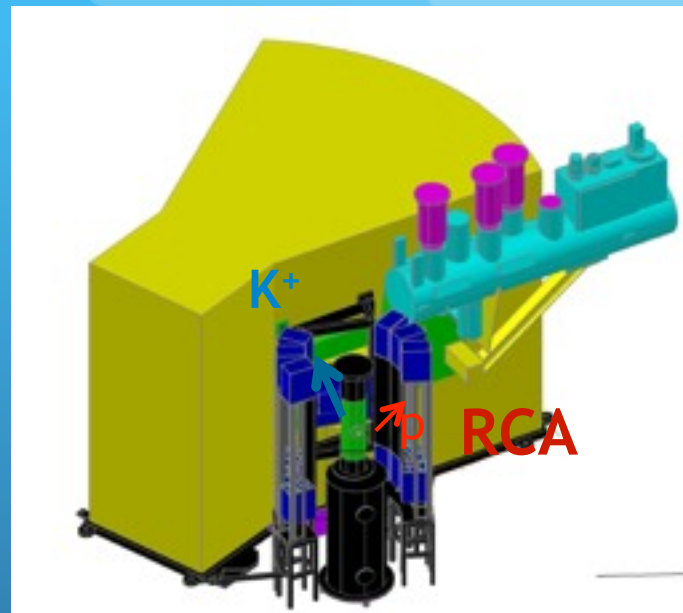
- Original Proposal: 5M/spill beam

- 6x10⁴ Λ* /day

Assuming 1% trapping probability

- 600 bound states/day (inclusive)
- ~300 events/40 days (exclusive)

with ε_{RCA} ~14% for two protons

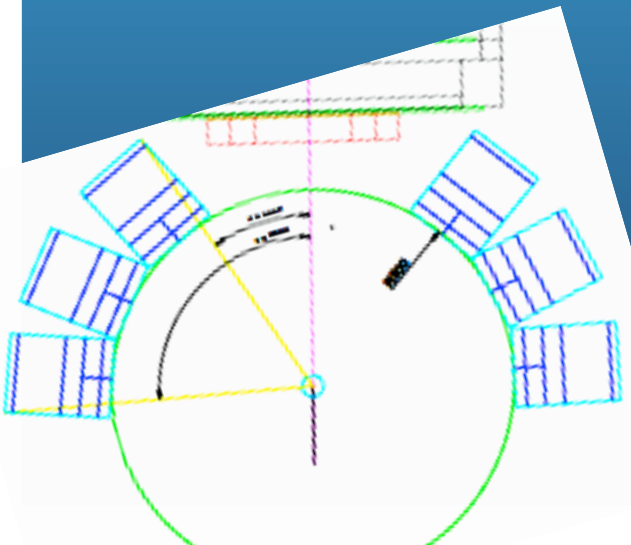
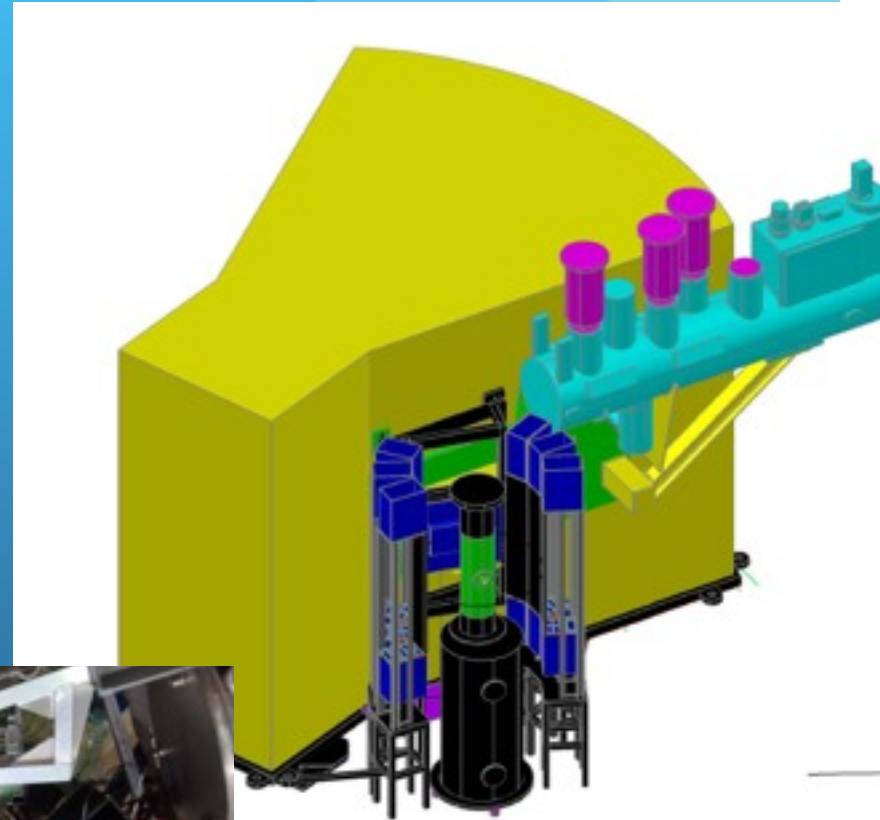


E27: Goal in a pilot run

- Inclusive $d(\pi^+, K^+)X$ spectrum @ $2.2 < M_X < 2.5 \text{ GeV}/c^2$.
 - The first measurement of this reaction and this missing mass region.
 - To evaluate the maximum value of the cross section, and to understand the background shapes.
 - $p(\pi^+, K^+)X$ → contribution of “p” in “d”
- Check the feasibility of coincidence measurement
 - One proton tag/Two proton tag
- Data Taking in **June, 2012** 3M π^+ /spill
 - Calibrations etc. ; 2 days @ 5 kW
 - $p(\pi^+, K^+)$ @ 1.7 GeV/c ; 0.6 days
 - $d(\pi^+, K^+)$ @ 1.7 GeV/c ; **7.6 days**

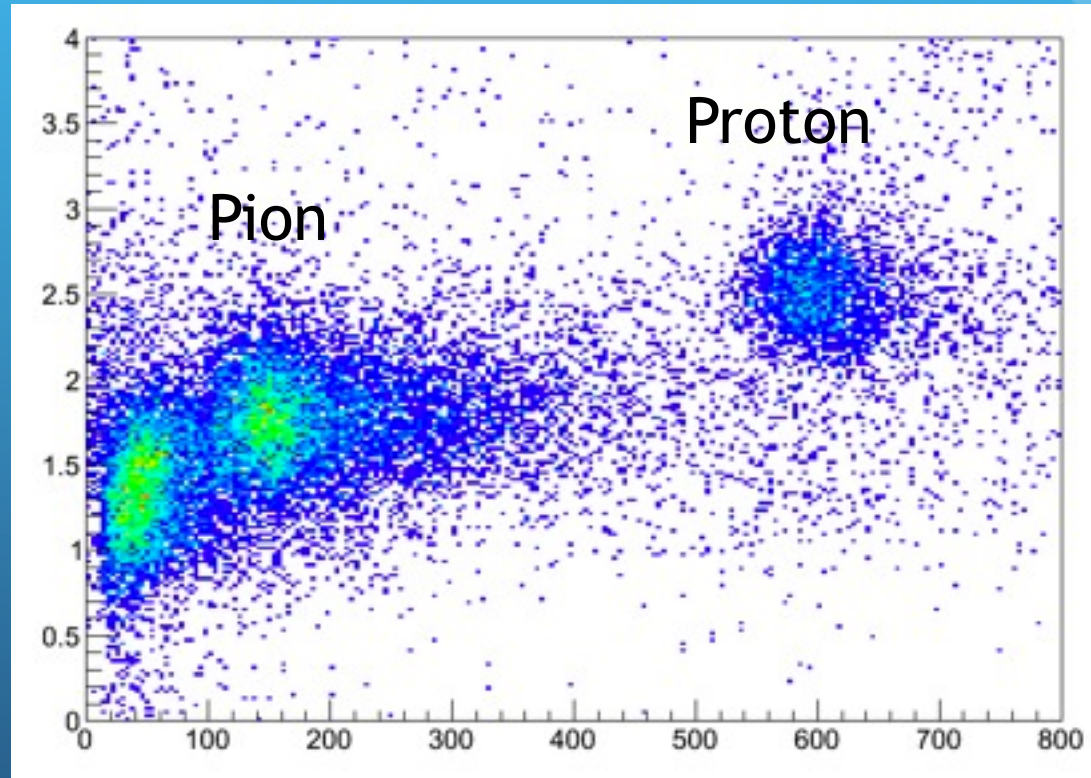
Range Counter System for E27

- 5 layers (1+2+2+5+2cm) of plastic scinti.
- 39 - 122 degrees (L+R)
- 50 cm TOF



Particle Identification in Range Counter

$1/B$



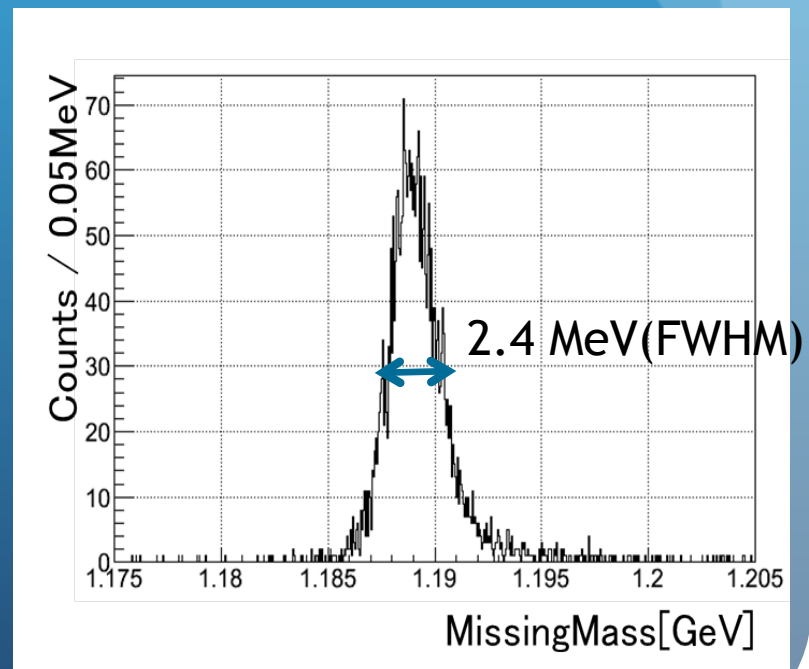
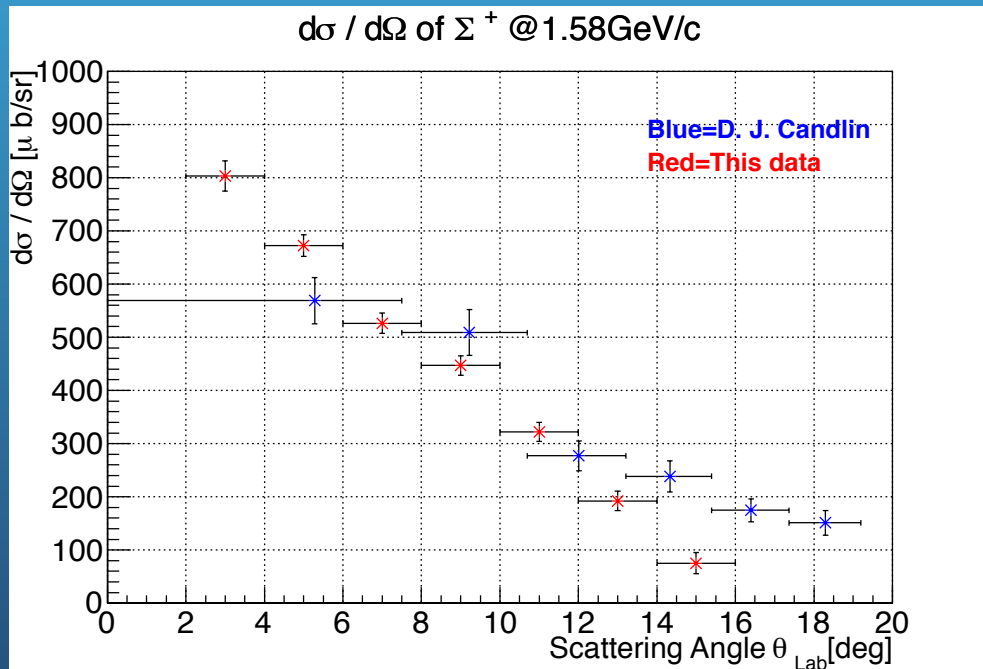
Range Information

Spectrometer performance

• $p(\pi^+, K^+)\Sigma^+$ @1.58 GeV/c [LH₂Target]

~ Energy Calibration & Cross section normalization

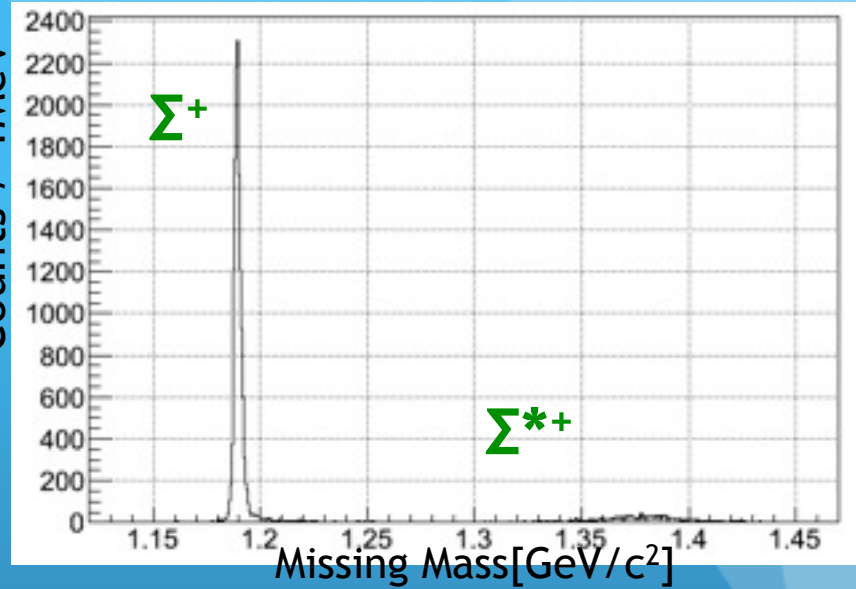
- Resolution ; $\Delta M \sim 2.41\text{MeV}(\text{FWHM})$
- Mean ; $1188.98 \pm 0.03 \text{ MeV}$ (PDG = 1189.37MeV)



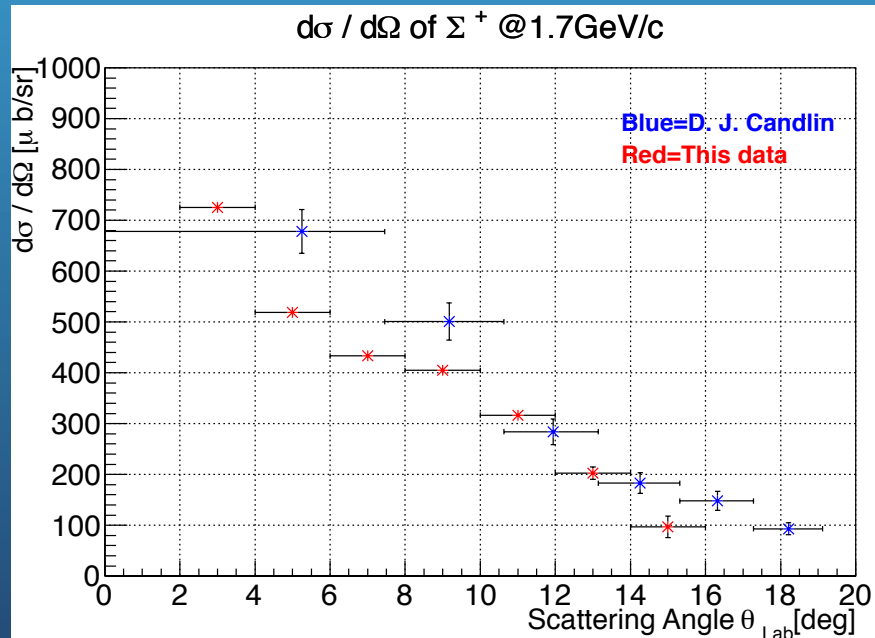
$p(\pi^+, K^+)1.7\text{GeV}/c$

- Σ^+ production
 - $\Delta M = 3.2\text{MeV}(\text{FWHM})$
 - $\text{Mass} = 1188.92\text{MeV}$
- $\Sigma^+(1385)$ production

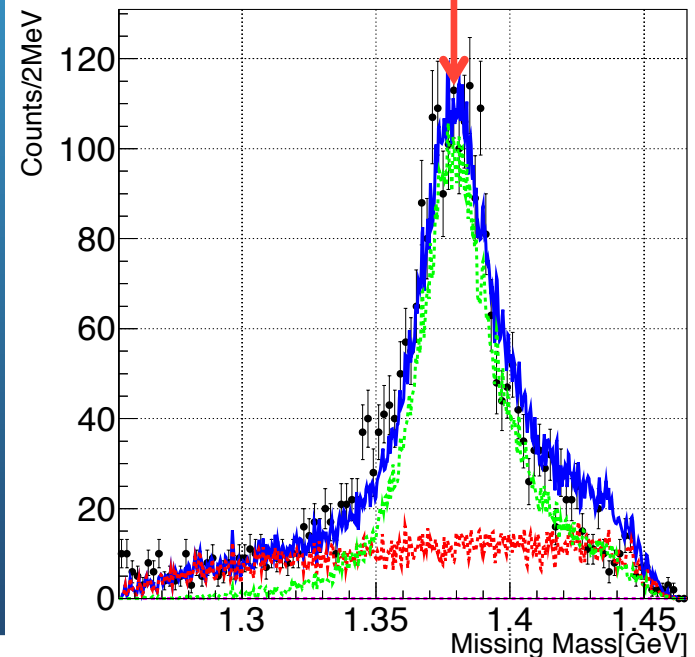
Counts / 1MeV



$p(\pi^+, K^+)\Sigma^+ @1.7\text{GeV}/c$

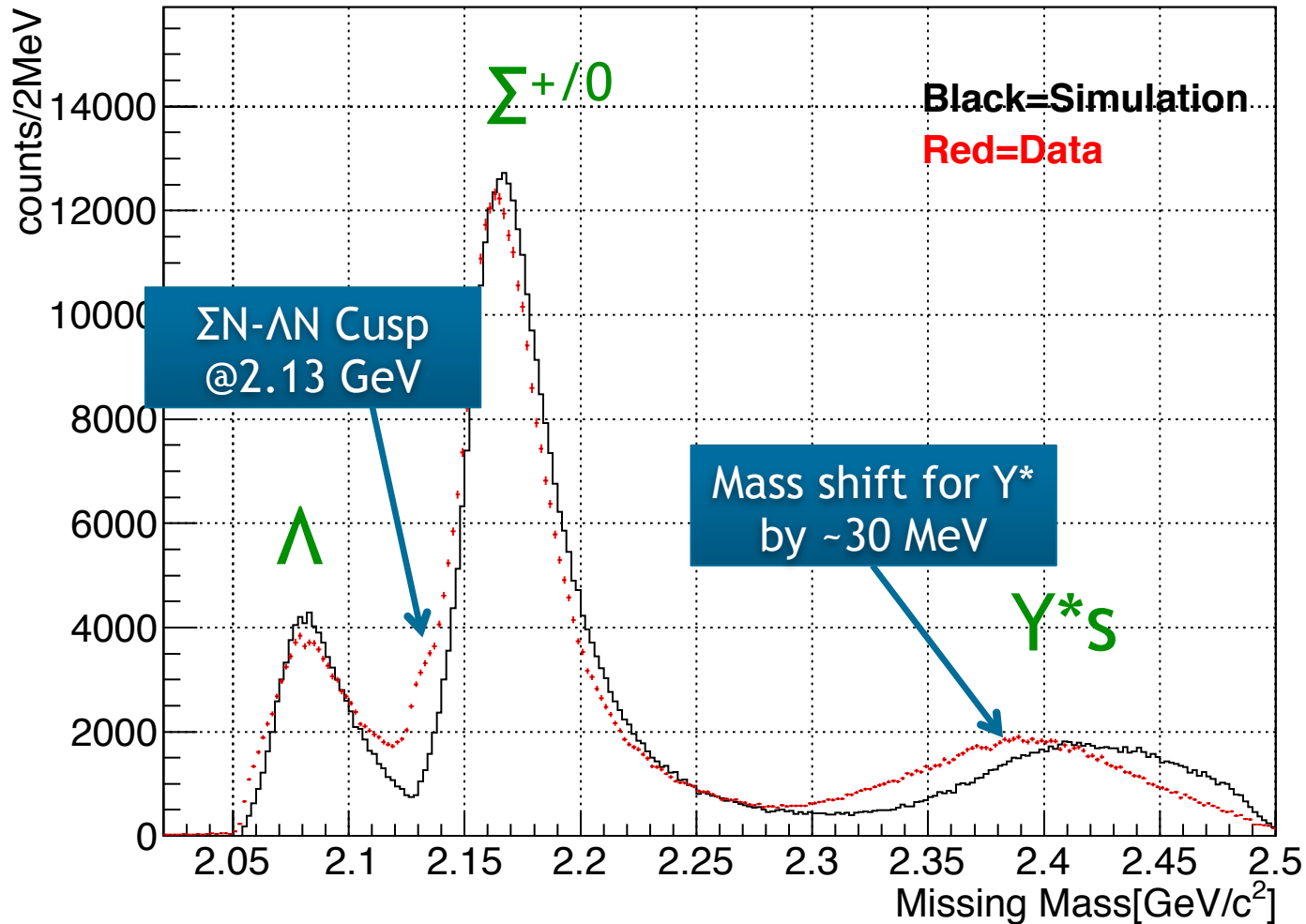


$\Sigma(1385)^+$ fit ($\chi^2=2.514970$)

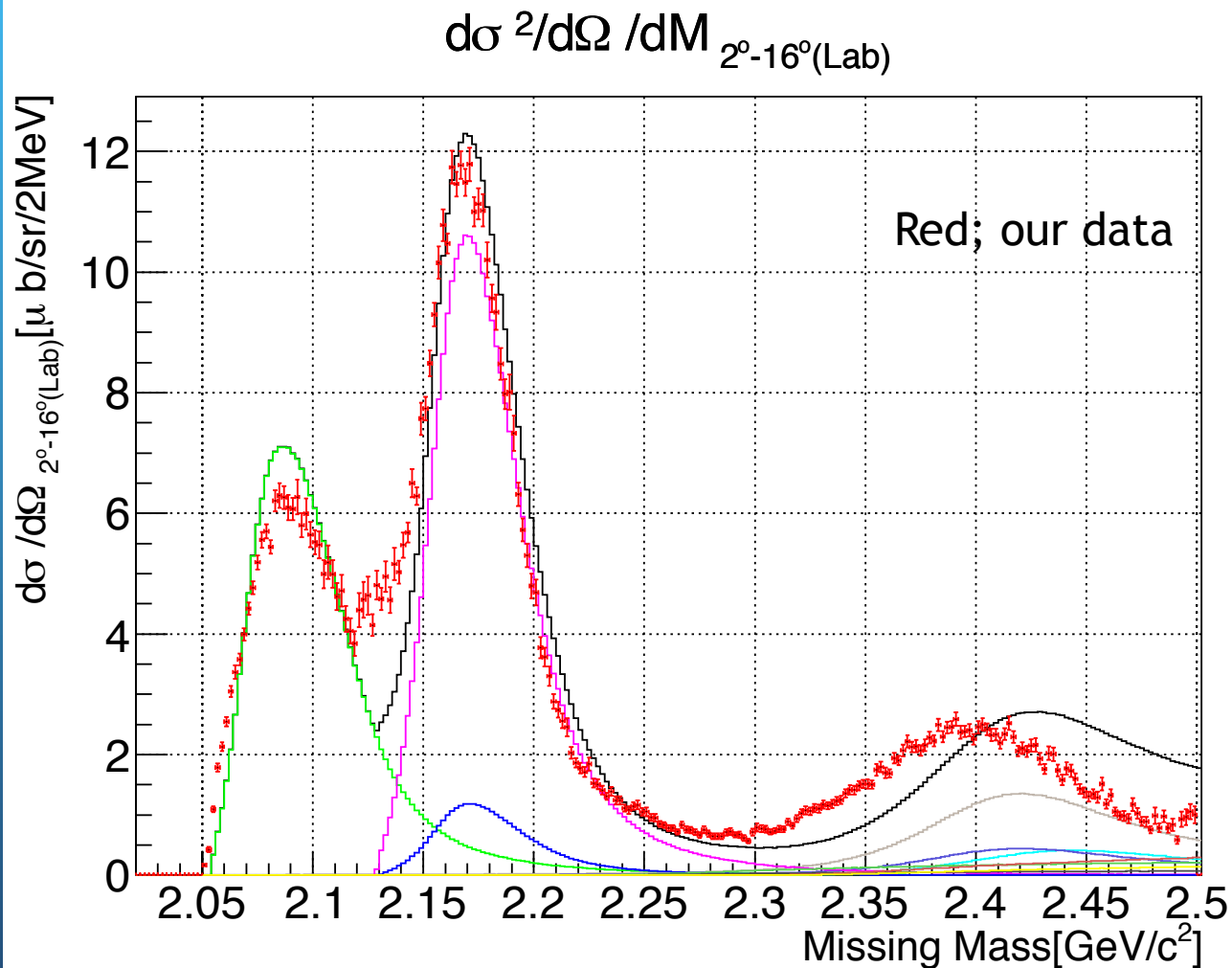


$d(\pi^+, K^+) @ 1.7 \text{ GeV}/c$

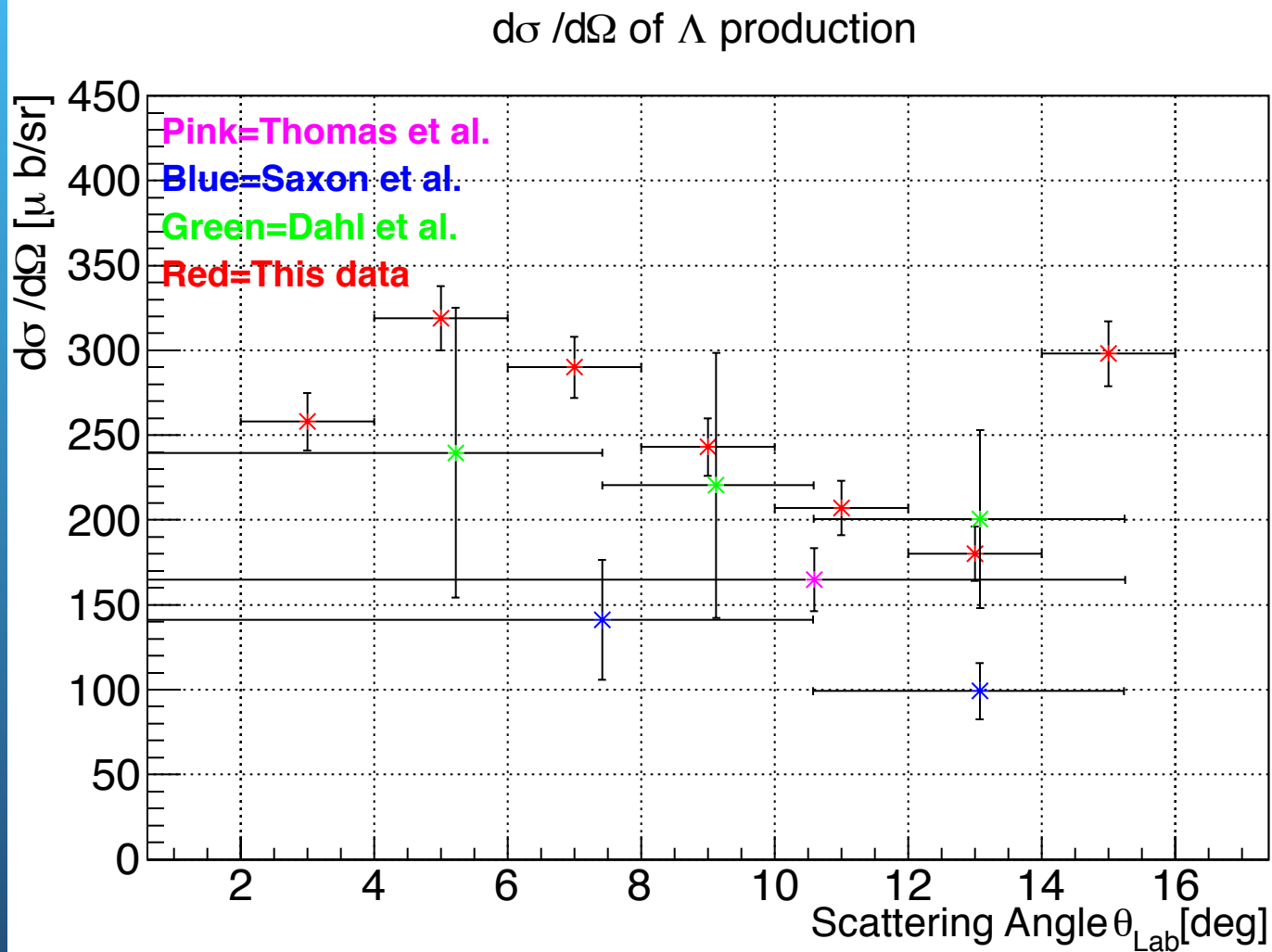
Missing Mass ($\theta_{\pi K(\text{Lab})} = 2^\circ - 16^\circ$)



$d(\pi^+, K^+) @ 1.7\text{GeV}/c$ differential cross section

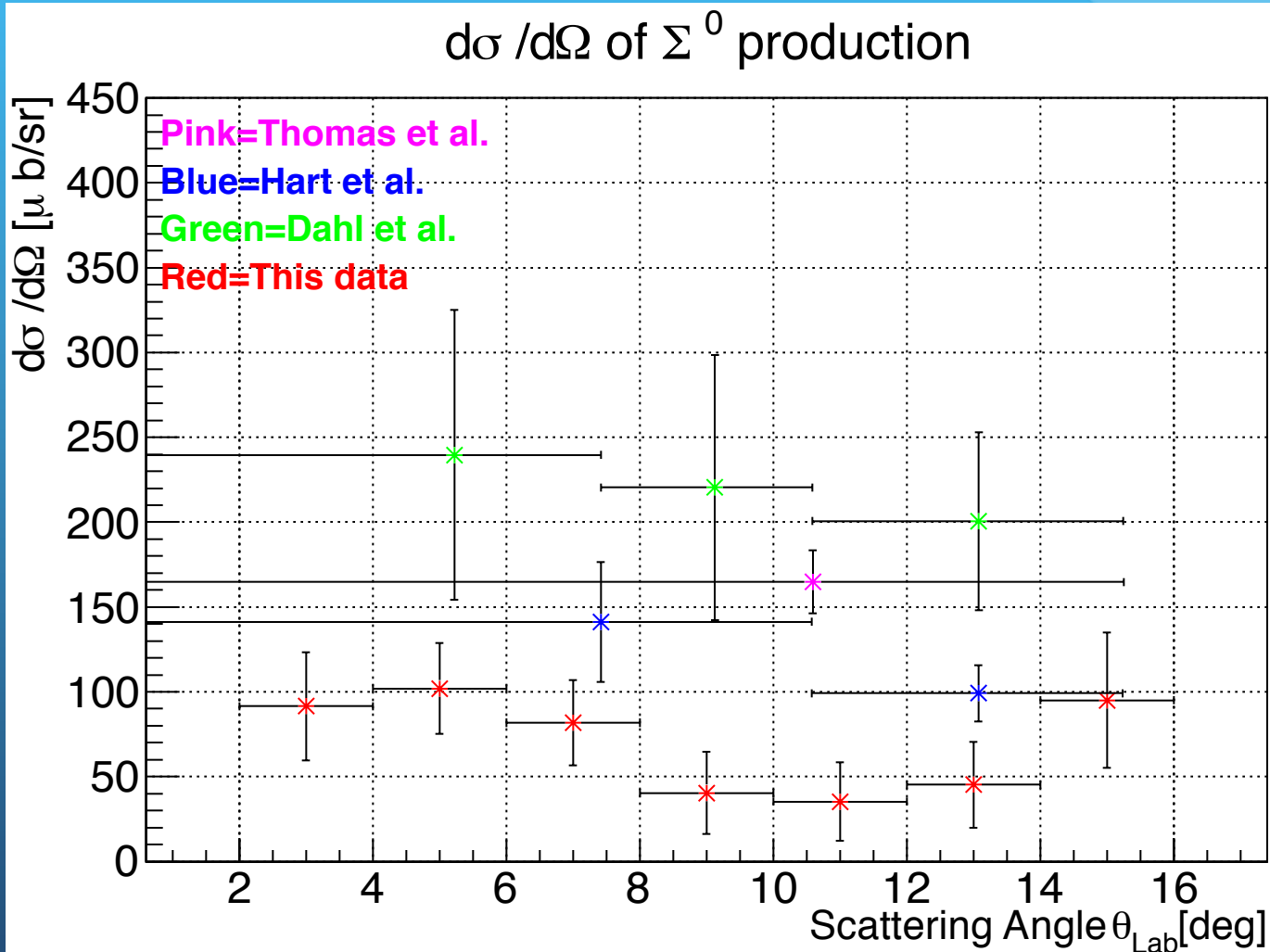


$\pi^+n \rightarrow K^+\Lambda$ at 1.7 GeV/c

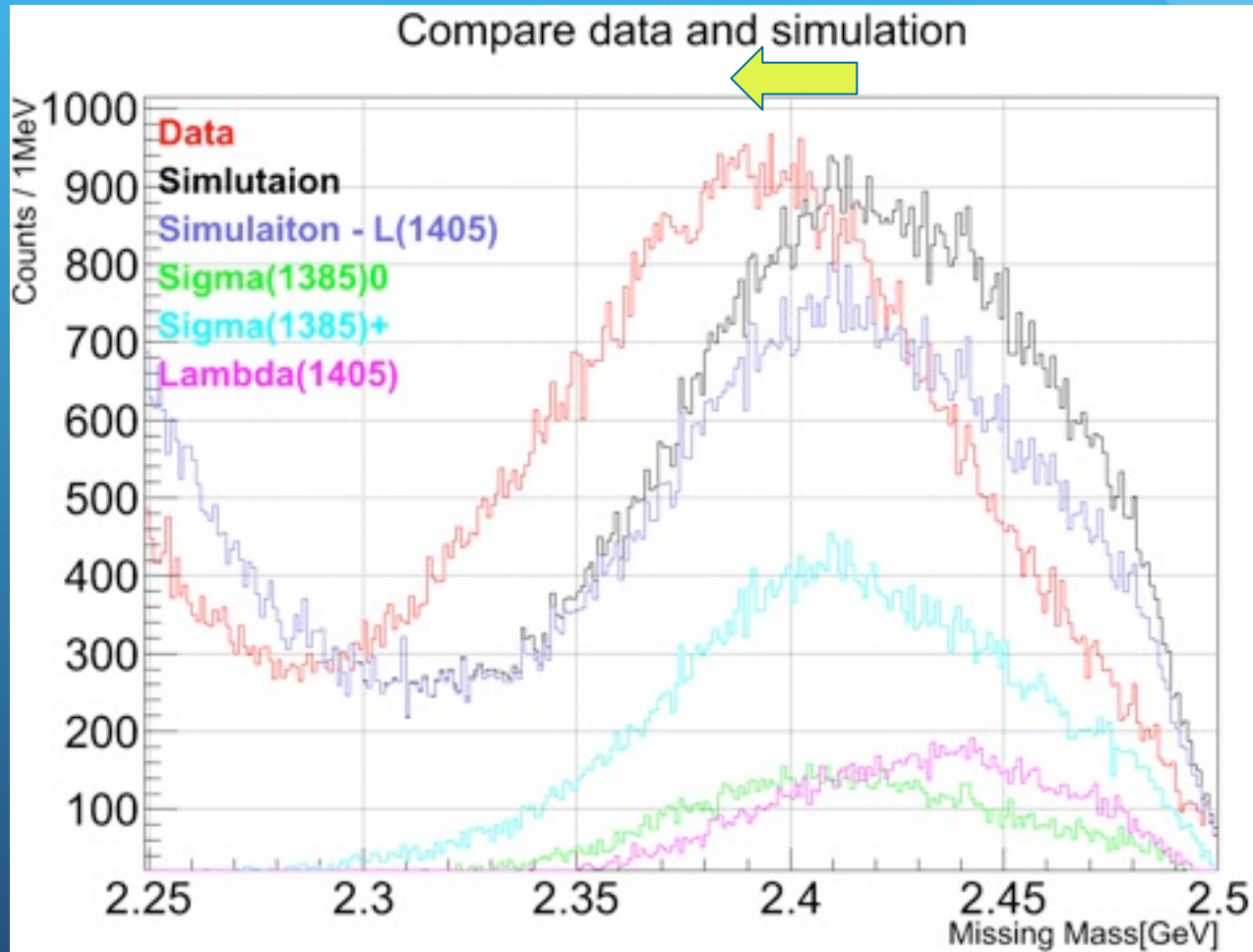


$\pi^+n \rightarrow K^+\Sigma^0$ at 1.7 GeV/c

- $\pi^+d \rightarrow \Sigma^{+0}K^+ - \pi^+p \rightarrow \Sigma^+K^+$



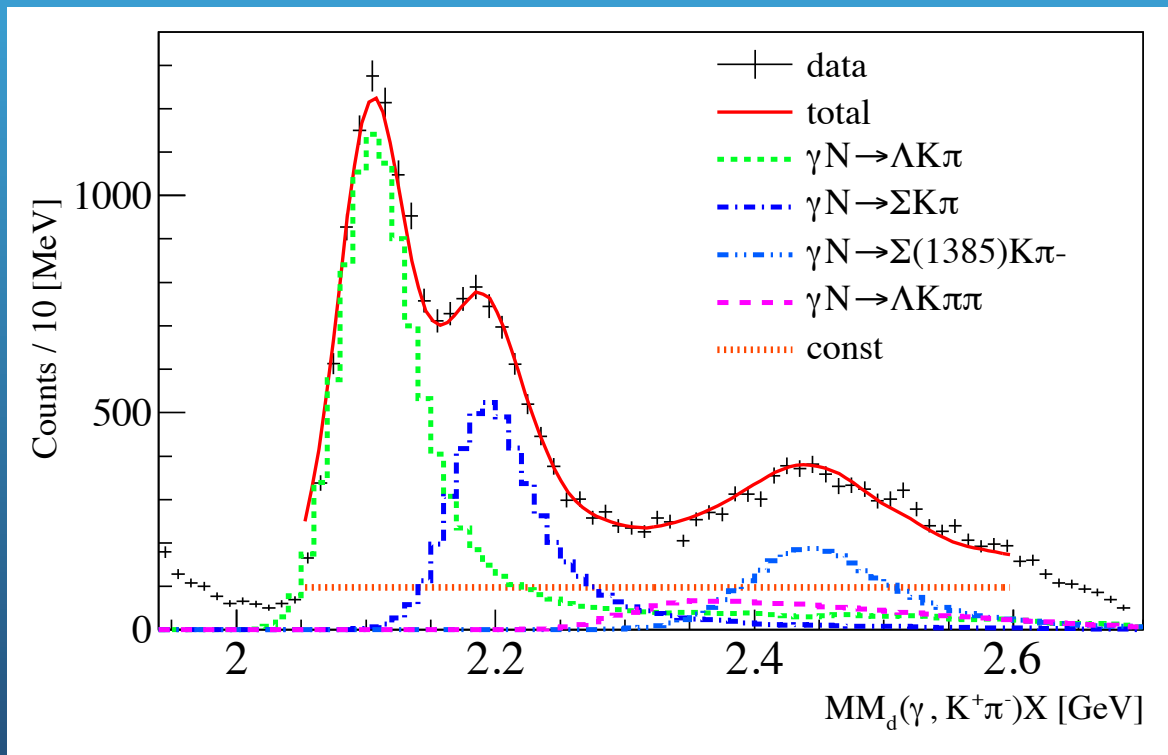
Y^* region; mass shift by ~ 30 MeV ??



$d(\gamma, K^+\pi^-)Y^*$ @1.5-2.4 GeV

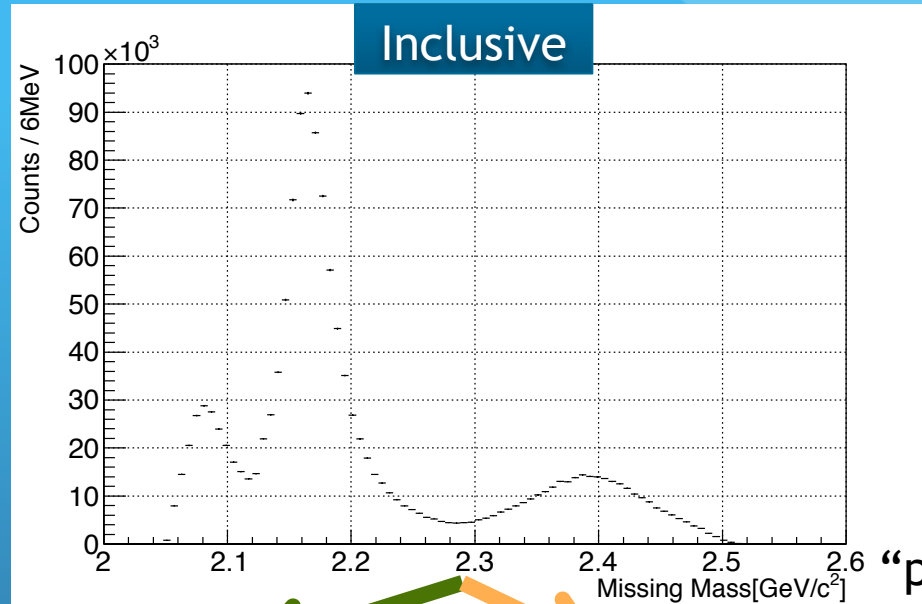
- SPring-8 LEPS
 - No mass shift for $\Sigma(1385)$

arXiv:1306.5320

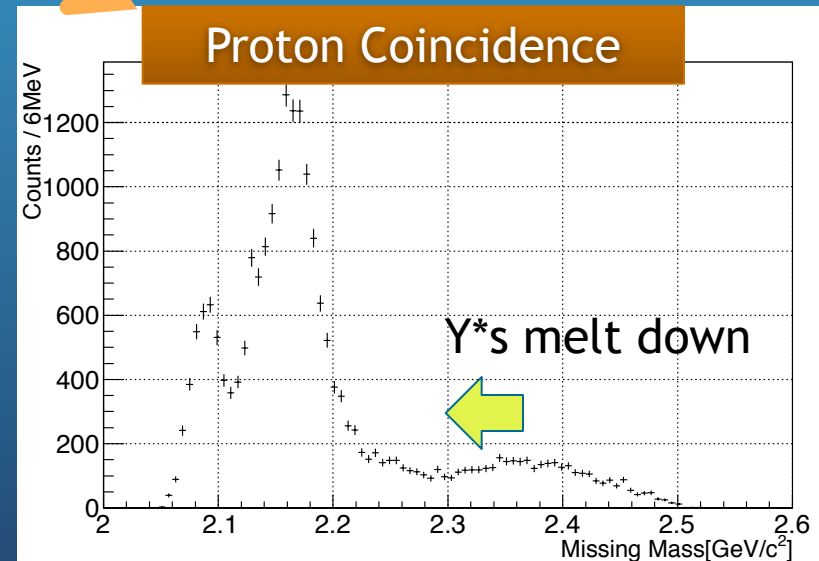
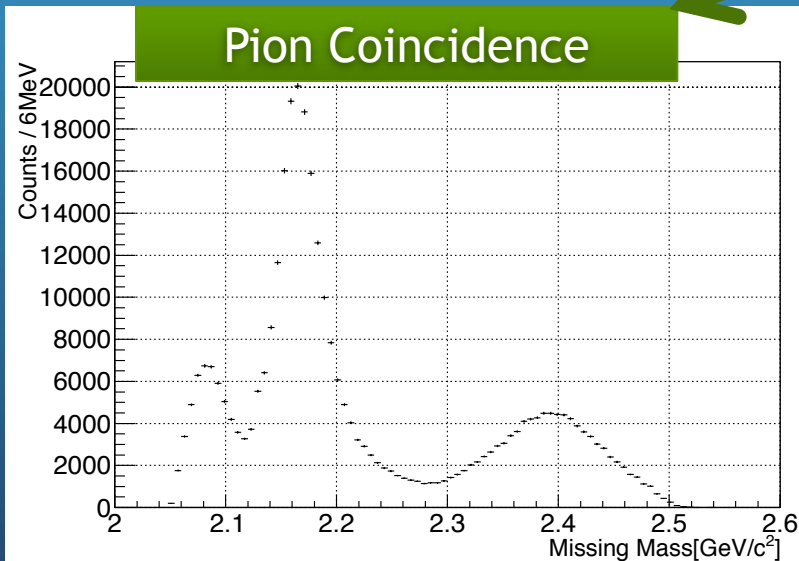


Coincidence study

“pion”= π or
slow p

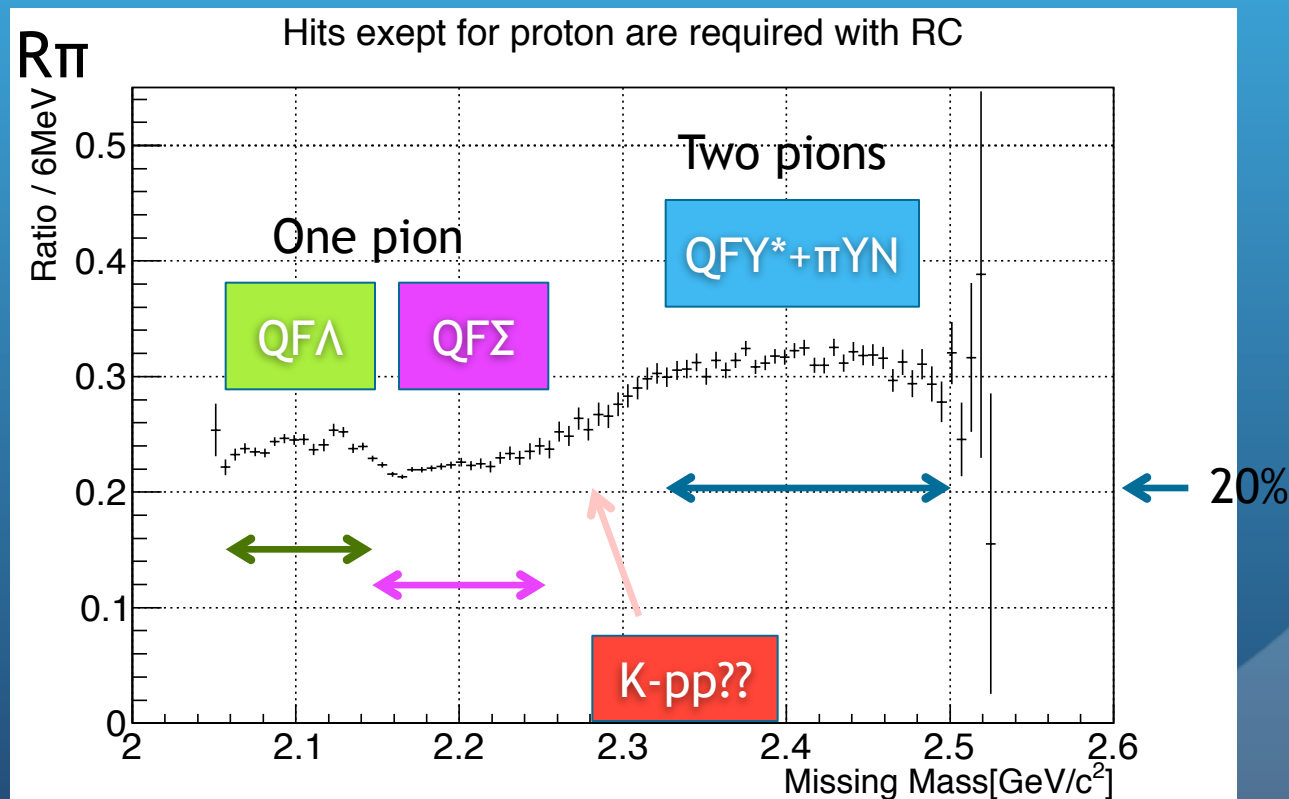


“proton”=p>280 MeV/c

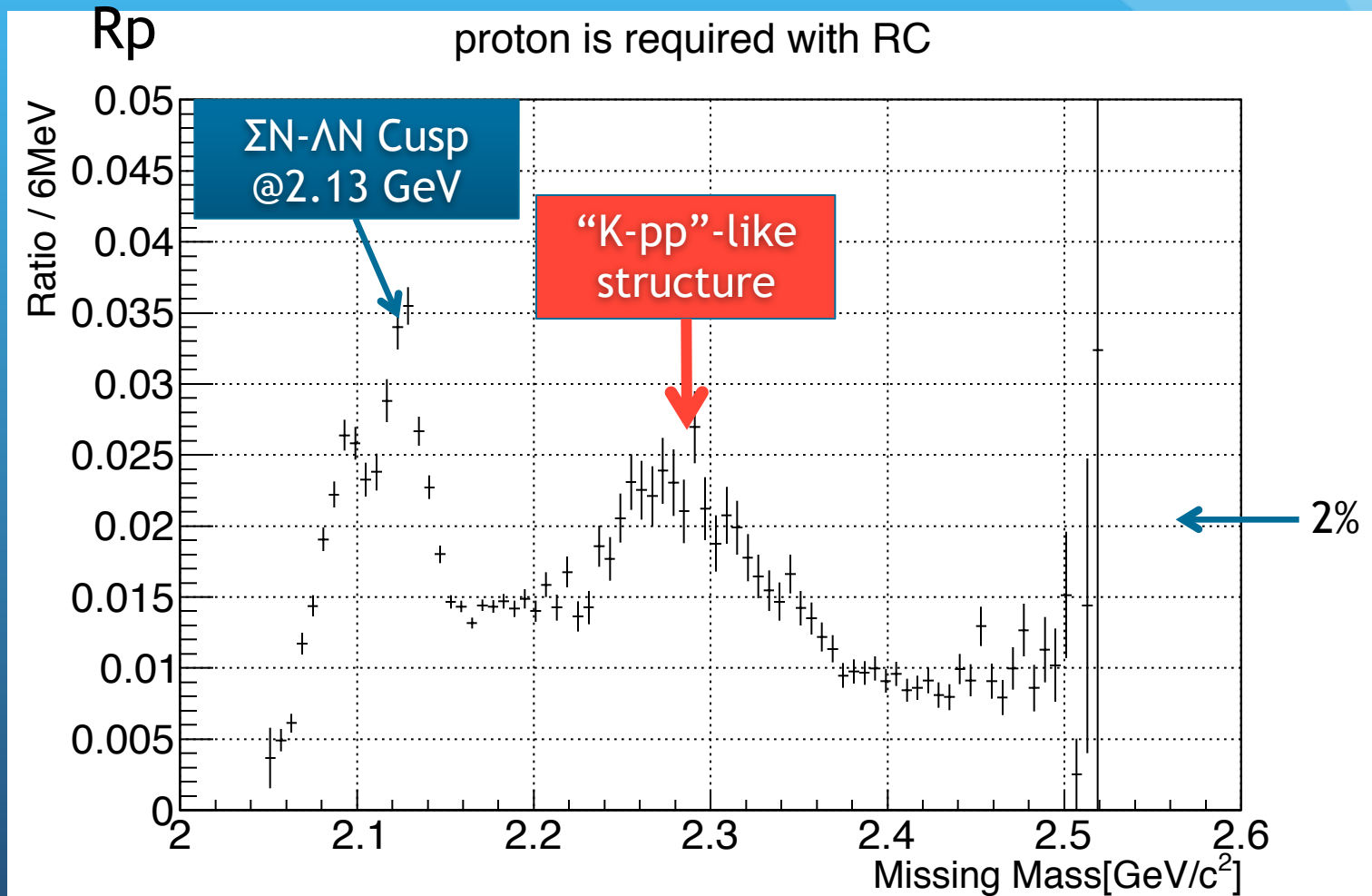


Pion Coincidence Rate

- $R_{\pi} = (\text{Pion coincidence spectrum}) / (\text{Inclusive spectrum})$
- $R_{\pi} \propto (\pi \text{ emission BR}) \times (\pi \text{ detection efficiency})$



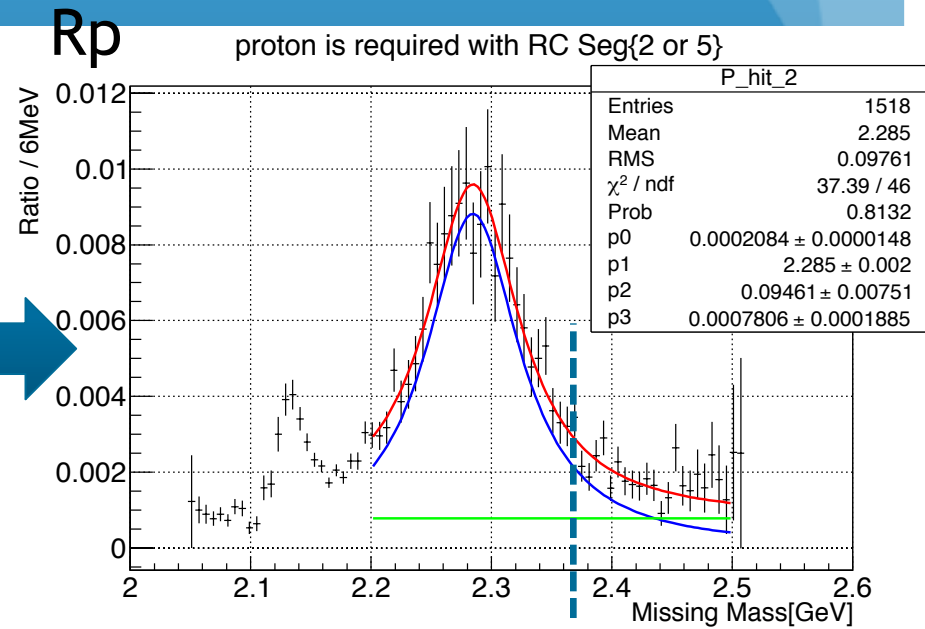
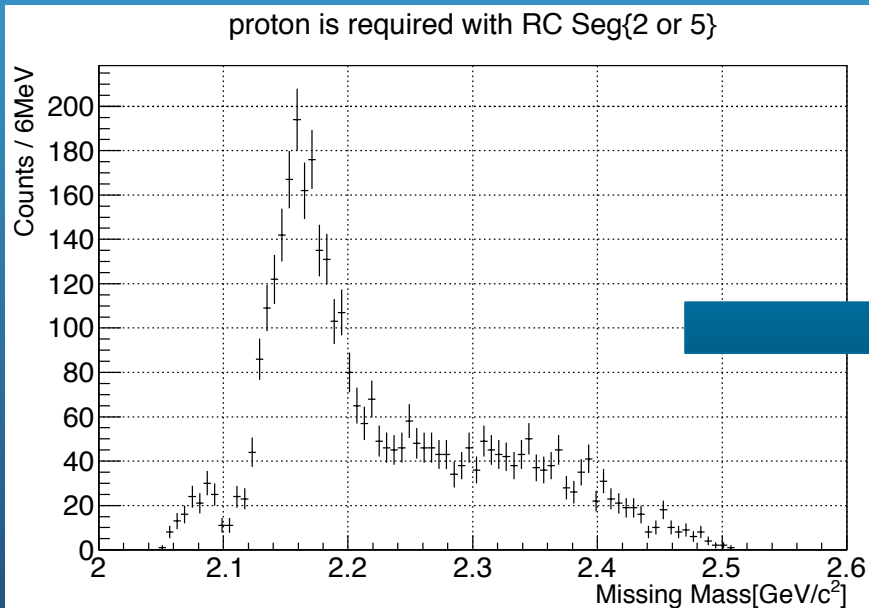
Proton Coincidence Rate



Proton Coincidence in the middle of RCs

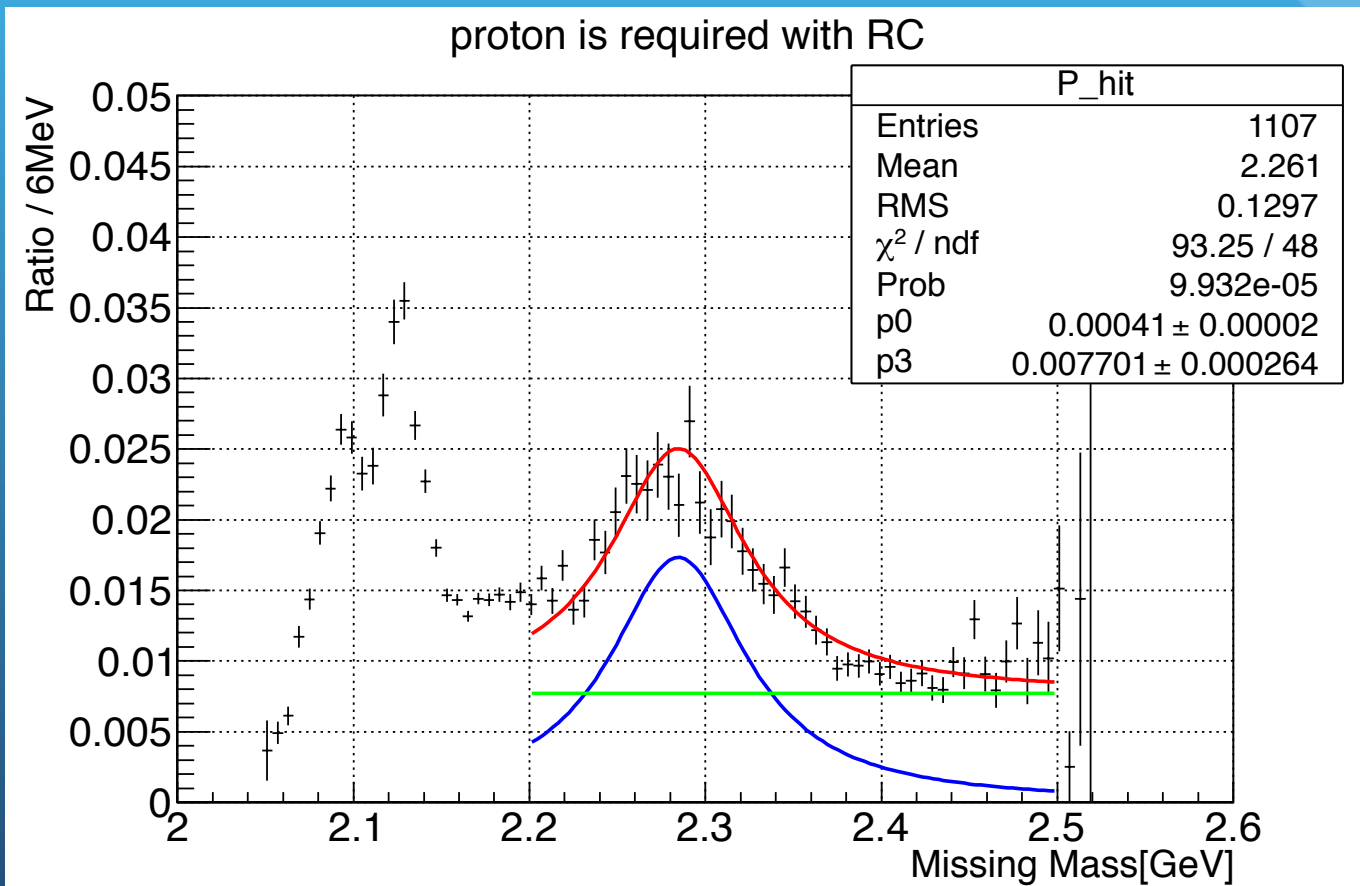
- RC: #3 #2 #1 #4 #5 #6
- Better S/N

- “K-pp”-like structure ; $2.285 \text{ GeV}/c^2$, $\Gamma \sim 95 \text{ MeV}$



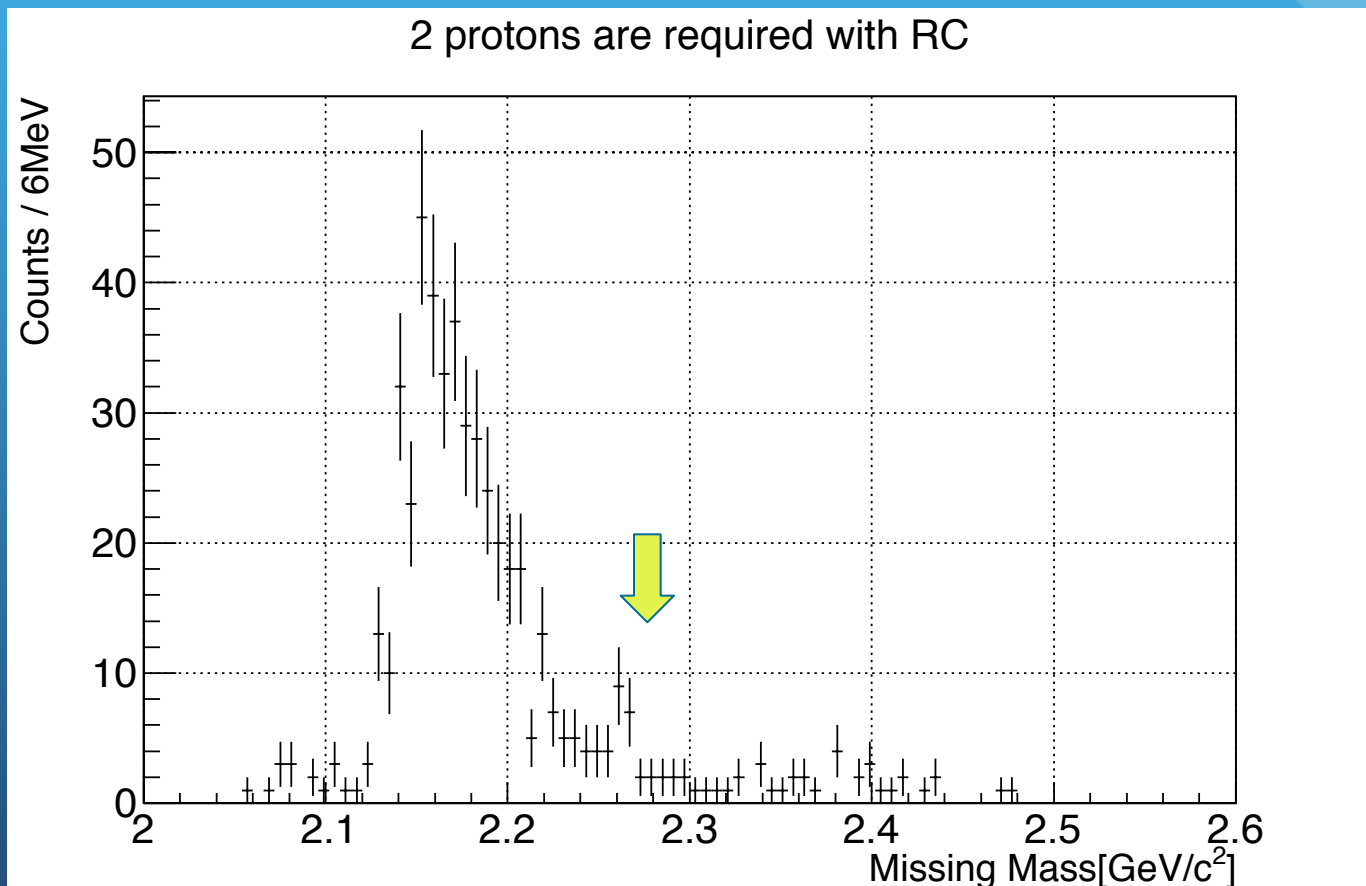
K-pp threshold

Same mass and width for “K-pp”-like structure



Two proton tagged spectrum

- Excess is observed at “K-pp”-like structure, but the coincidence rate is very low.



Summary

- We believe we have caught **a signal of the “K-pp”-like structure** in one-proton tagged spectrum.
- **“K-pp”-like structure**
 - Mass = $2.285 \text{ GeV}/c^2$ ($\sim 85 \text{ MeV}$ binding from the K-pp threshold)
 - $S=-1$, $B=2$ (?, non-quasifree)
- Need careful studies on detector efficiencies to get final results.
- Inclusive (π^+ , K^+) spectra are almost finalized.
 - For deuteron,
 - A cusp structure due to $\Sigma^+n-\Lambda p(^3S_1-^3D_1, I=1/2)$ coupling is observed.
 - Significant mass shift by $\sim 30 \text{ MeV}$ is observed for Y^* .