J-PARC E15実験における $\pi\Sigma$N崩壊チャンネルを用いた K^{bar}NN束縛状態の研究

Search for the K^{bar}NN bound state via $\pi\Sigma$N decay channel at J-PARC E15

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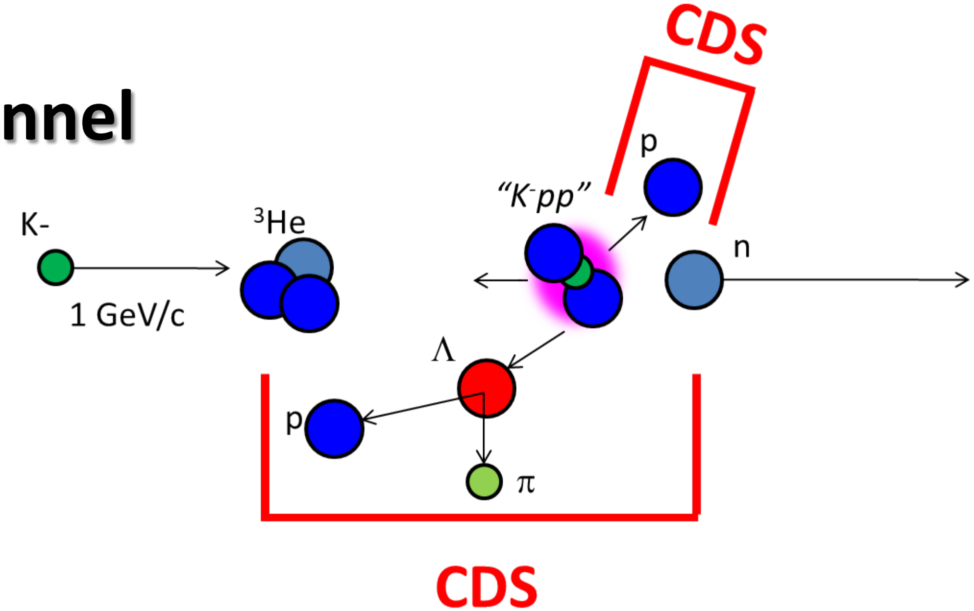
日本物理学会第73回年次大会 @ 東京理科大学 2018, 3/22

Outline of the Talk

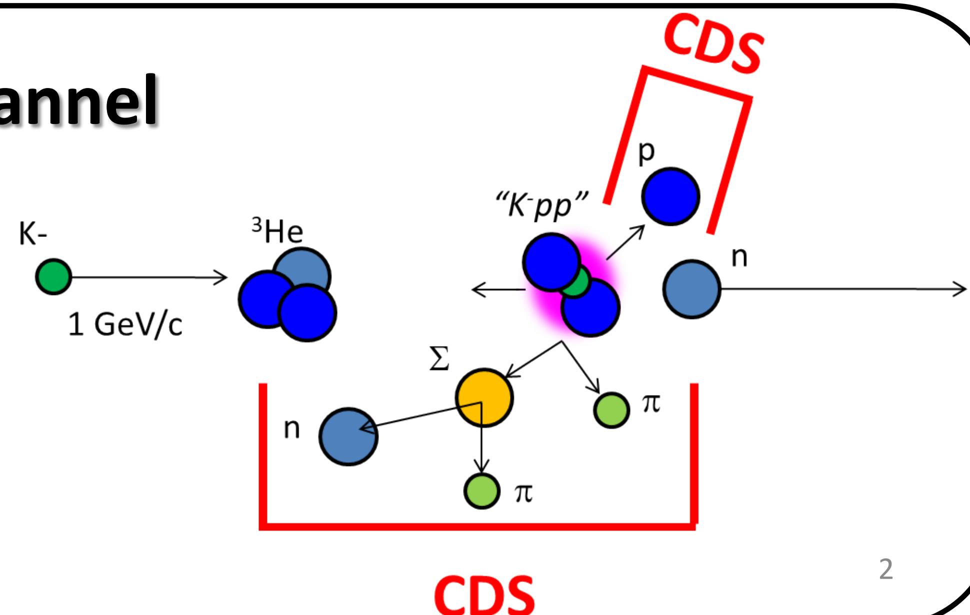
1. $K^{bar}NN$ search via Λp channel

→ Non-mesonic channel



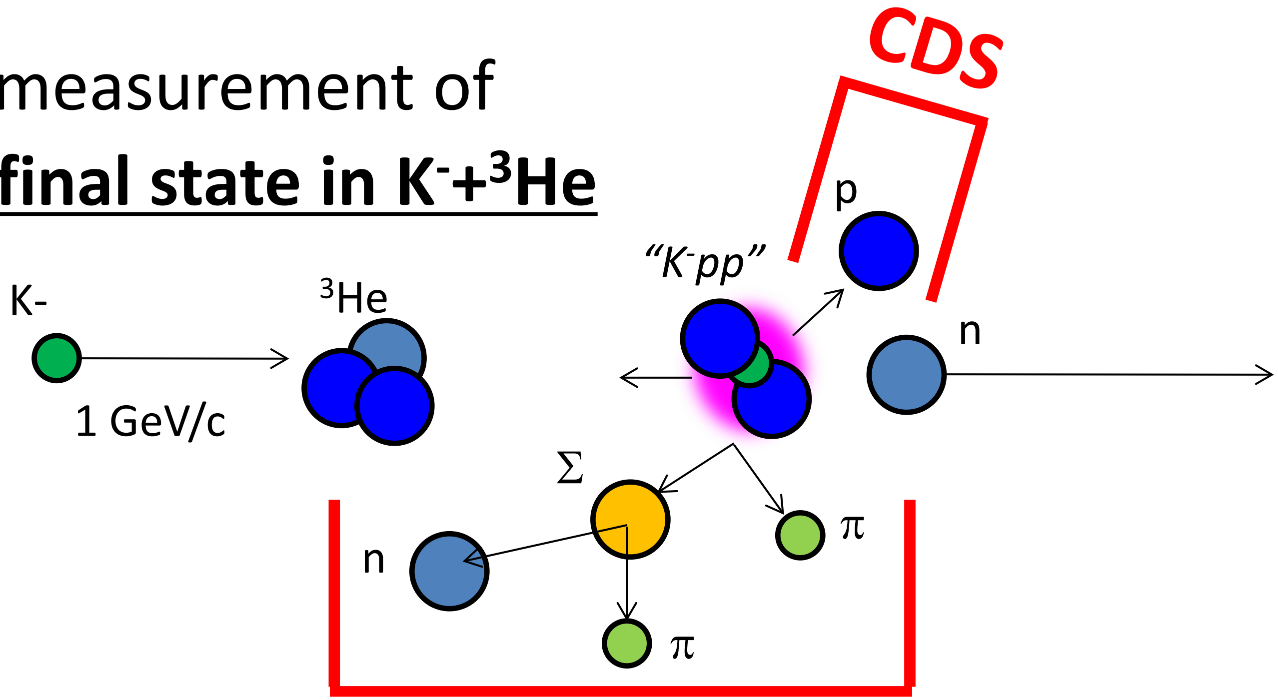
2. $K^{bar}NN$ search via $\pi\Sigma p$ channel

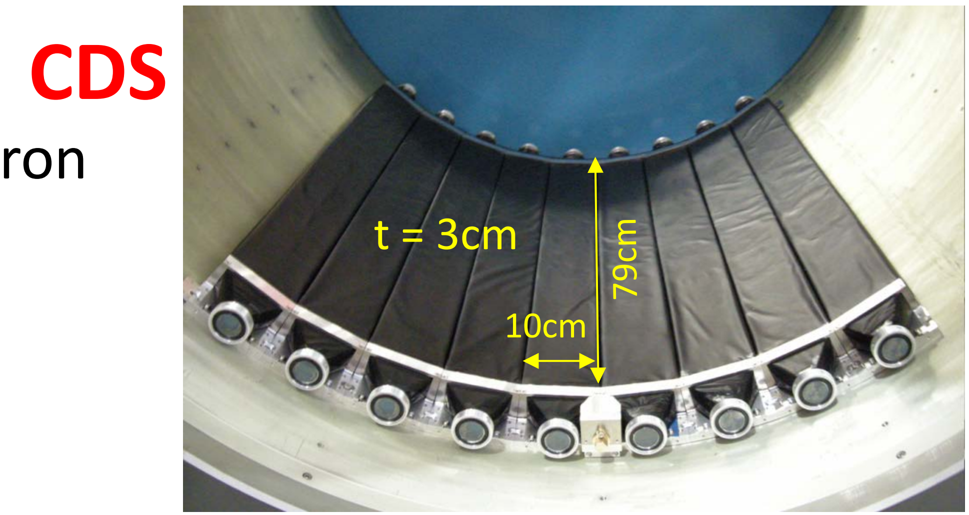
→ Mesonic channel



$K^- \, {}^3He \rightarrow \pi\Sigma pn$ @ E15

- Exclusive measurement of
  <u>$\pi^{\pm}\Sigma^{\mp}pn$ final state in $K^- + {}^3He$</u>





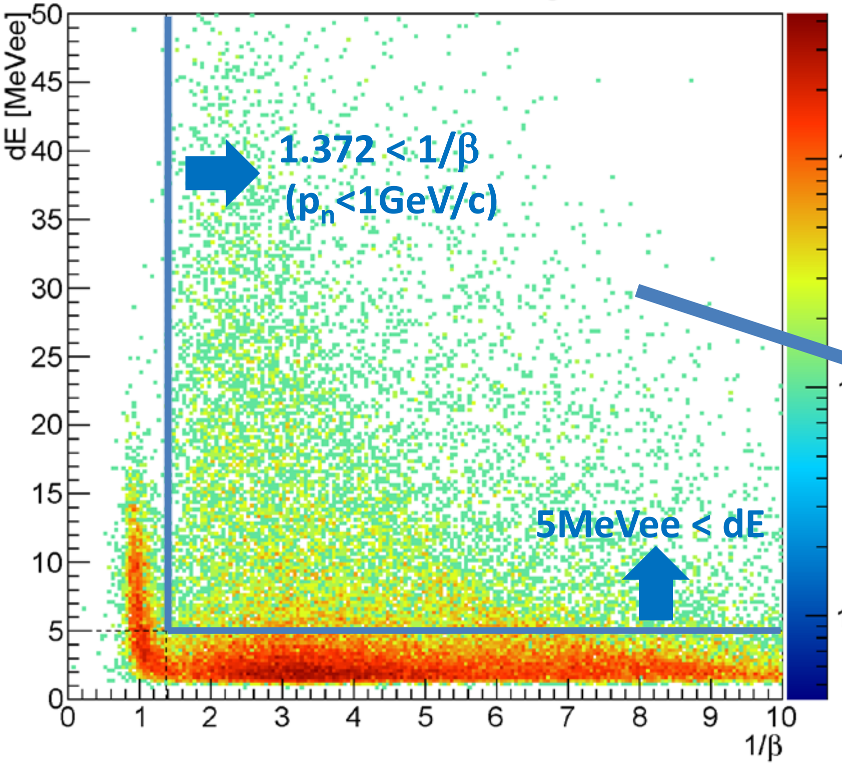
- **<u>Experimental challenge</u>** of neutron detection with thin scintillation counter (t=3cm)

n detection efficiency ~ 3%

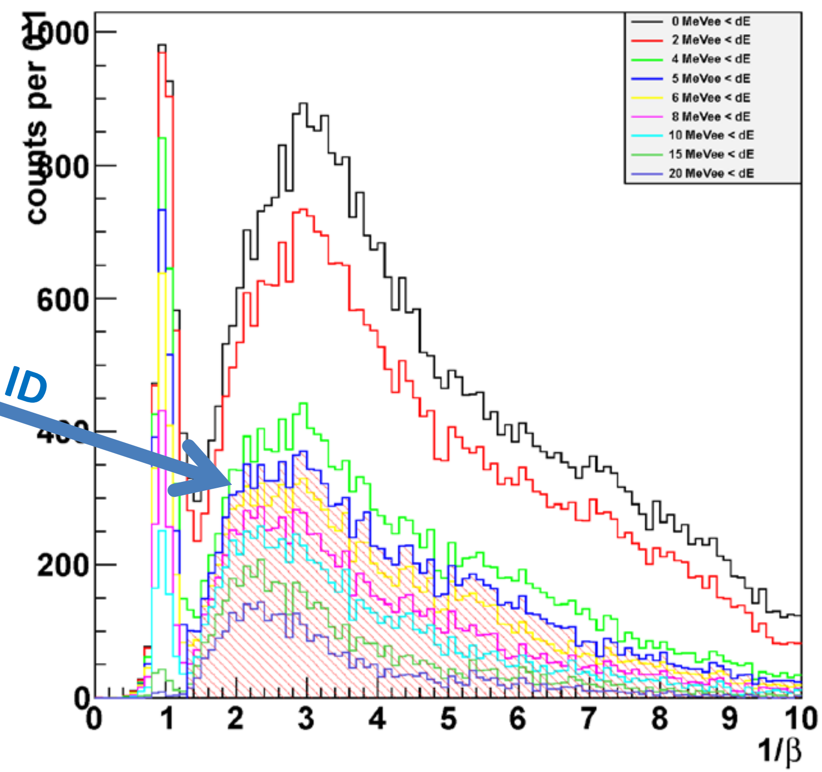
Neutron ID with CDS

- $\pi^+\pi^-p$ events (3 tracks) in CDS with 4 CDH hits are selected
- a CDH hit with CDC-veto (outer-layer) is applied to identify the "neutral hit"

dE vs. 1/β



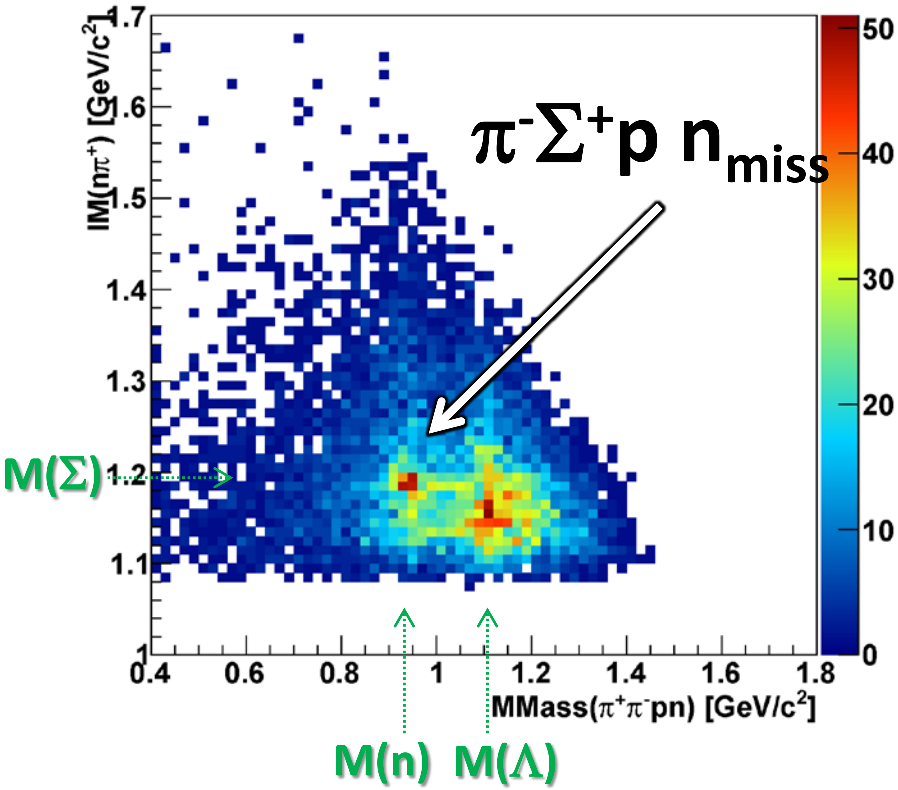
dE-cut dependence



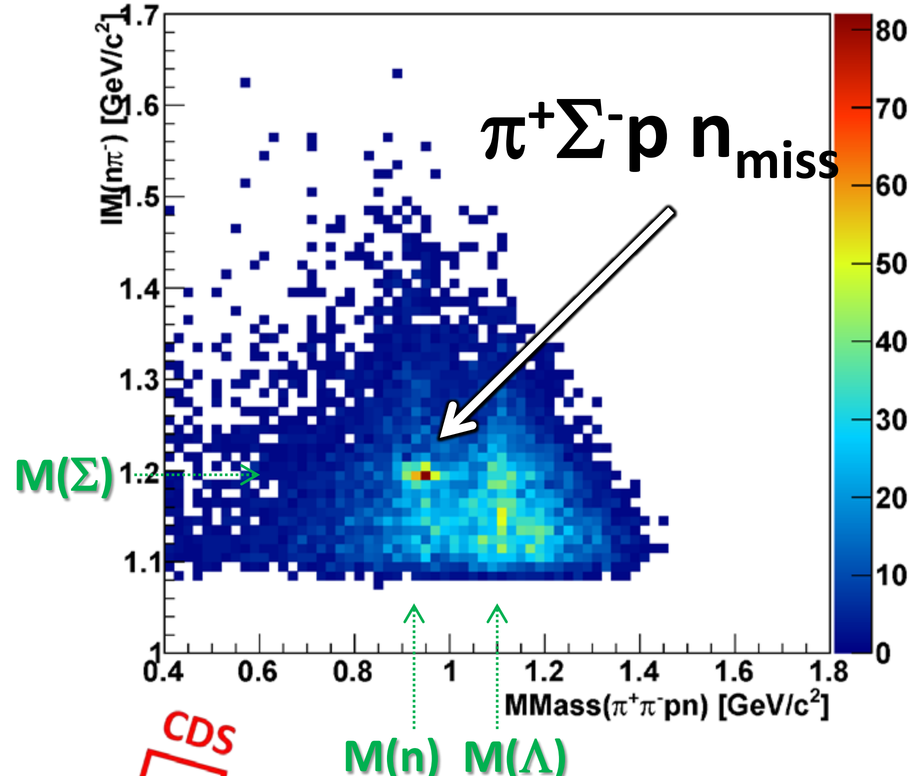
Neutron can be identified with CDS

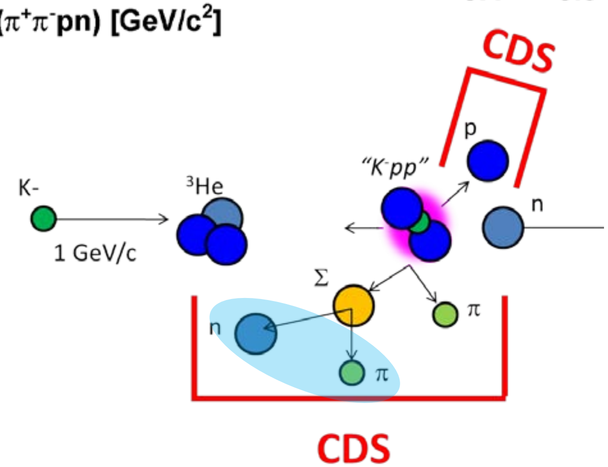
$\pi\Sigma pn$ Events

$IM(n\pi^+)$ vs $MM(\pi^+\pi^- pn)$

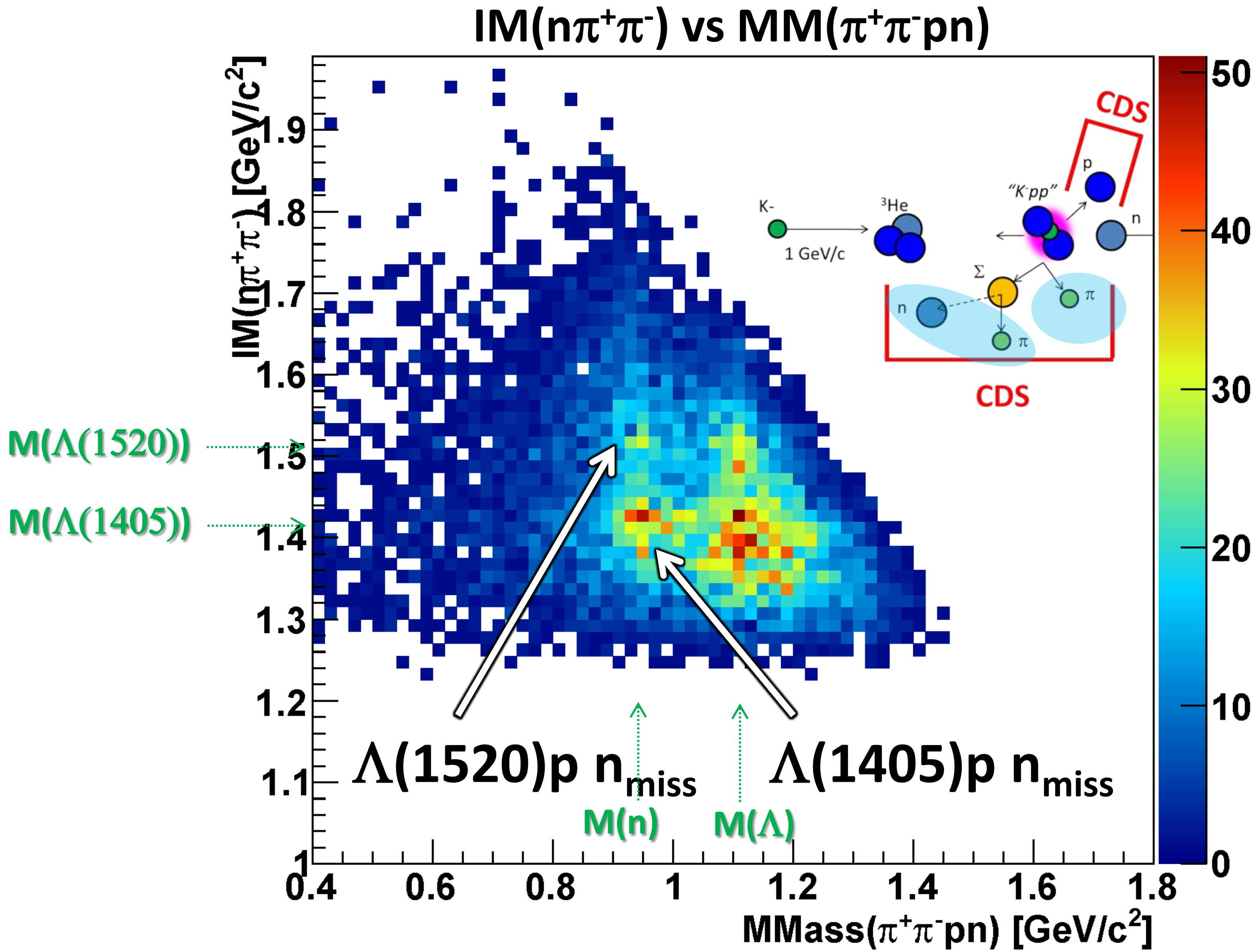


$IM(n\pi^-)$ vs $MM(\pi^+\pi^- pn)$



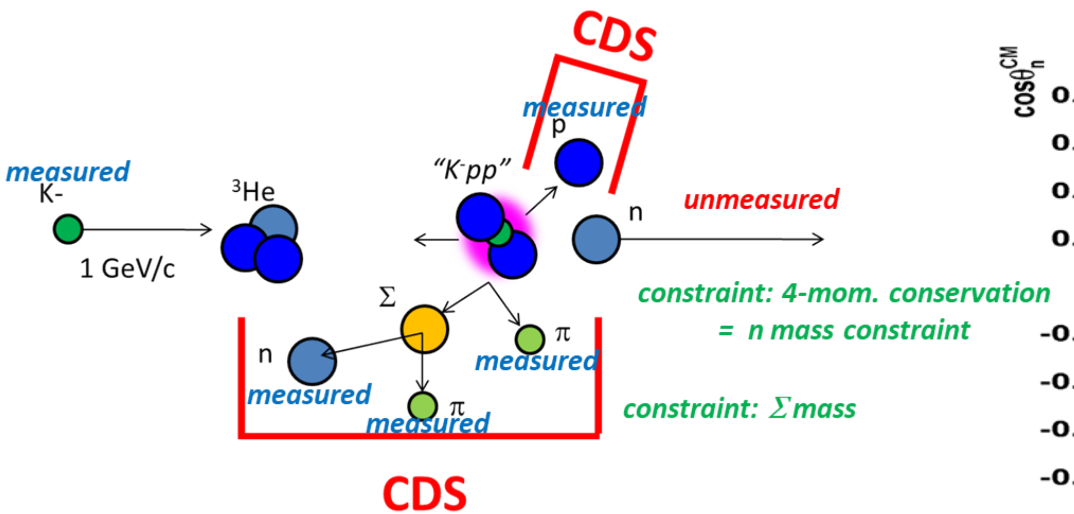


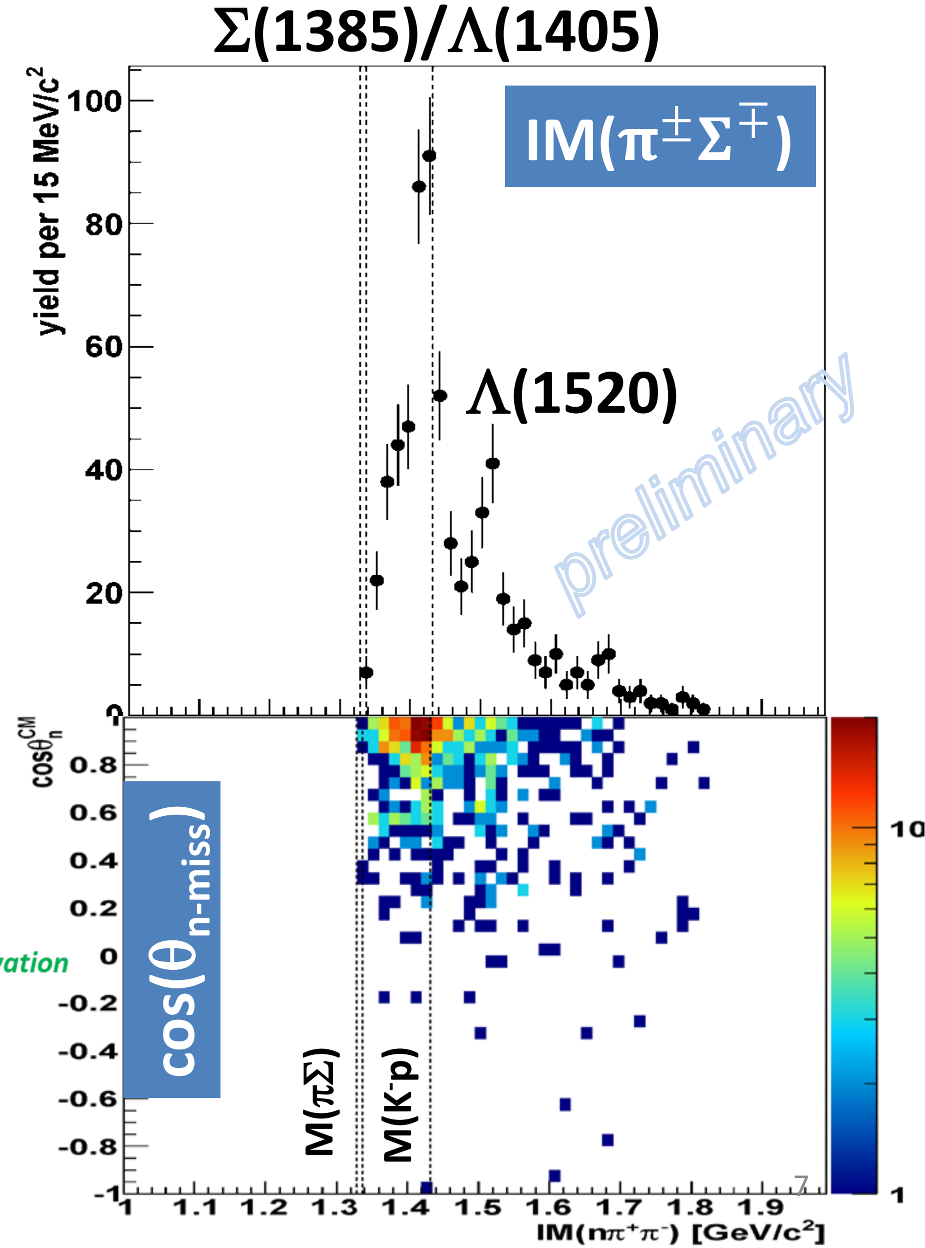
Λ^*pn Events



Y* in $\pi^{\pm}\Sigma^{\mp}$ p n_{miss}

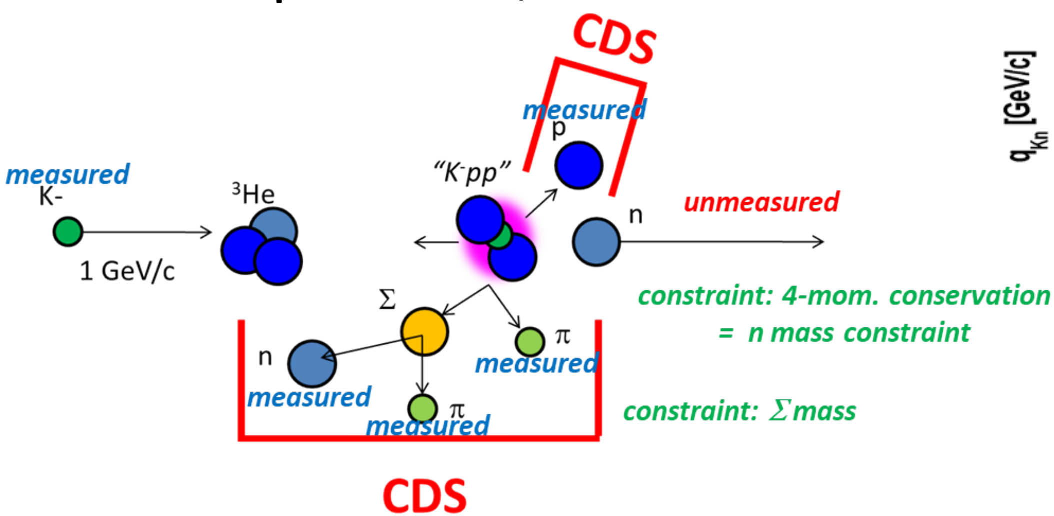
- $\pi^{\pm}\Sigma^{\mp}$ events are separated using kinematical refit
  - Constraints:
    - M(Σ→nπ)
    - 4-momentum conservation
  - Event selection by χ^2 probability (0.01<p)

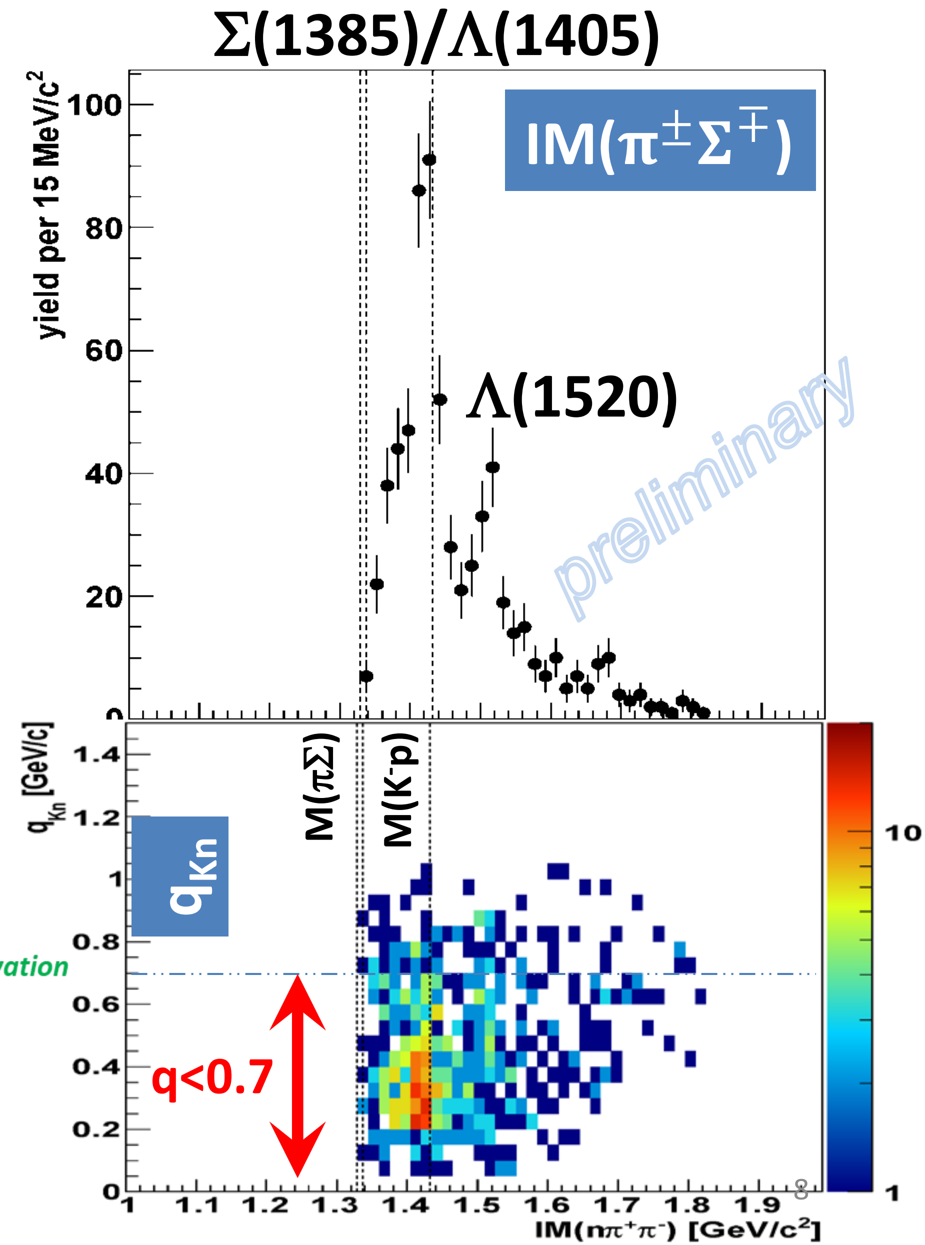




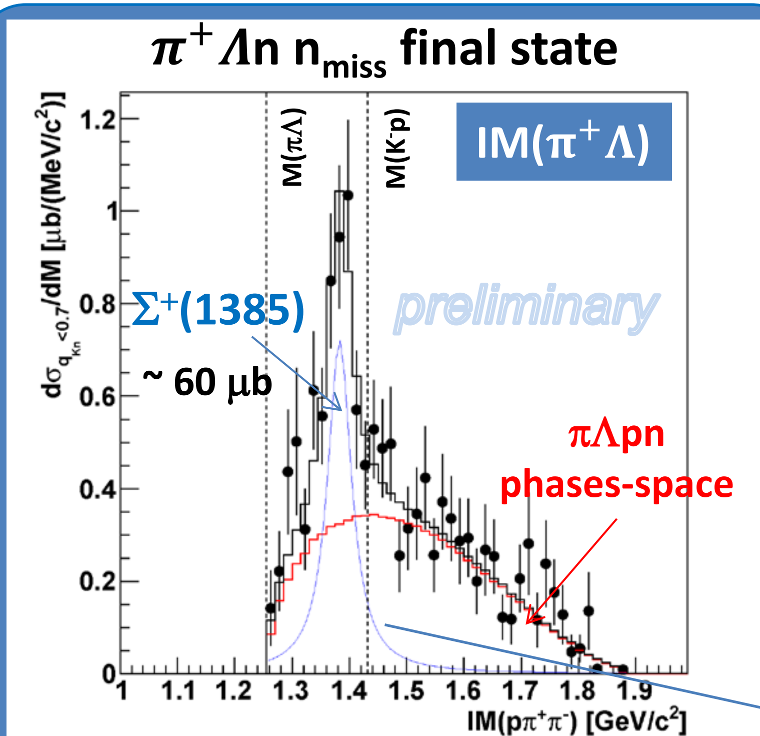
Y^* in $\pi^\pm\Sigma^\mp p\, n_{miss}$

- **To compare "K^-pp" and Λ^* production CS's, we select q<0.7 GeV/c region**
  - Both of "K^-pp" and Λ^* signals are seen in q<0.7 GeV/c
  - $\pi\Sigma$(p) acceptance is limited in q>0.7 GeV/c





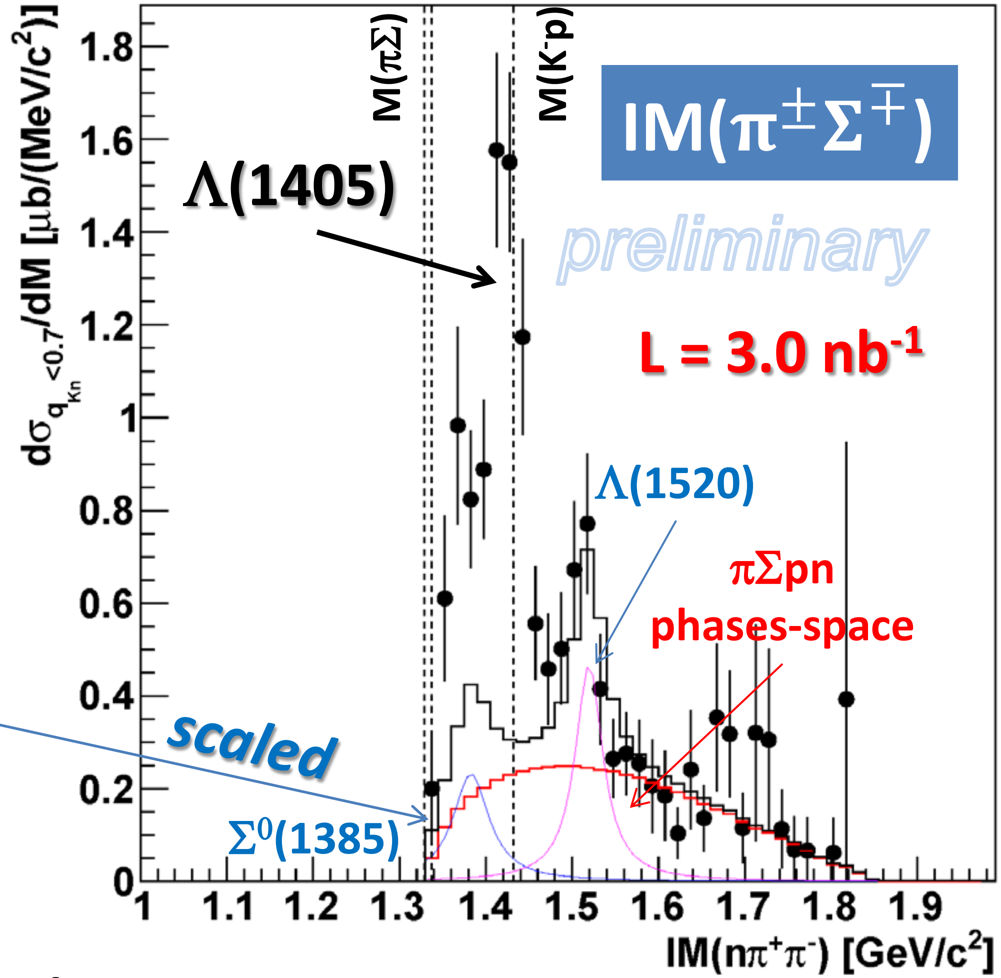
Y^* CS in q<0.7 GeV/c



we assume $\Sigma^0(1385)$ CS at 1.0 GeV/c to be:

$\sigma(\Sigma^{*0}) = 2.3 \times \sigma(\Sigma^{*+})$

by considering reaction combination in $K^-{}^3He$

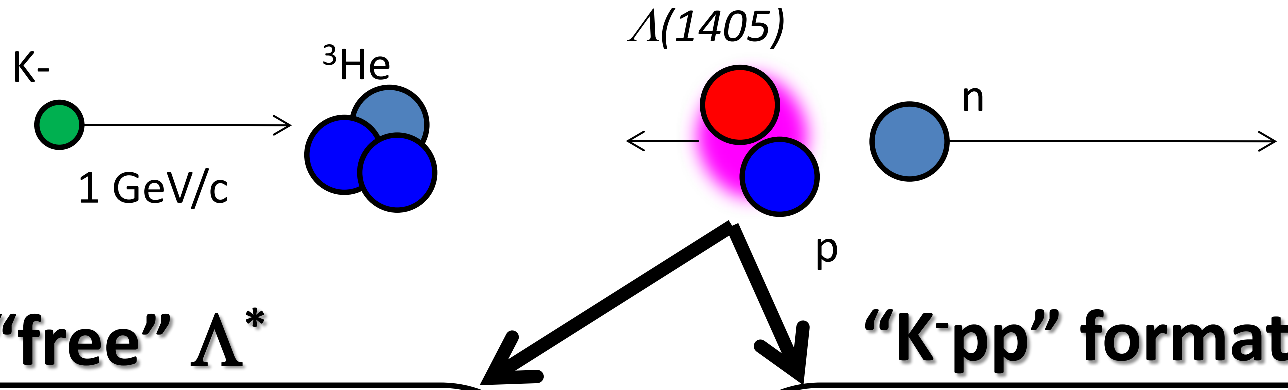


$K^- + {}^3He \rightarrow$ **$\Sigma^0(1385)$** + p + n: ~ 140 μb

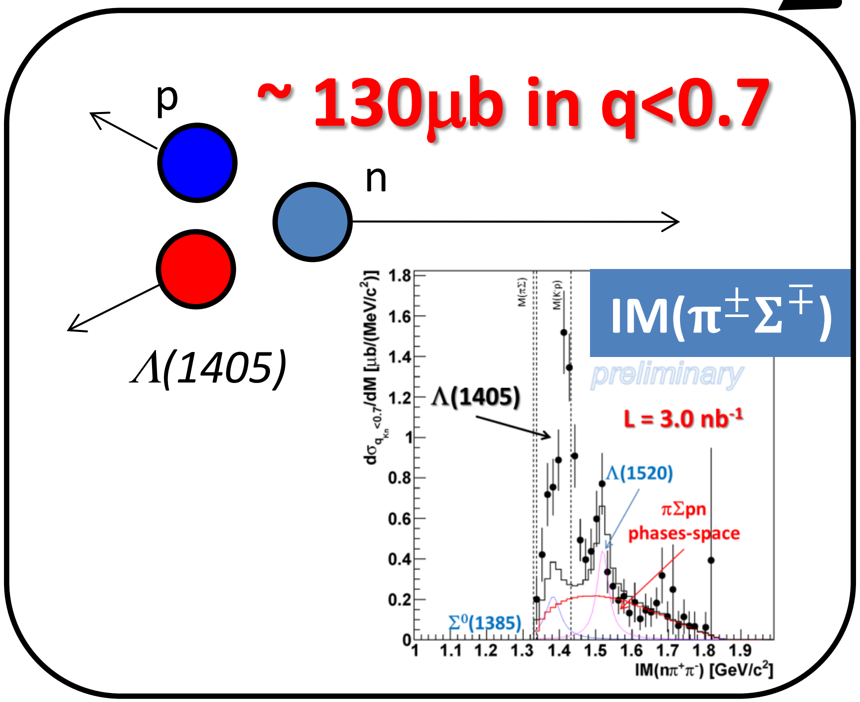
$K^- + {}^3He \rightarrow$ **Λ(1405)** + p + n: ~ 130 μb

$K^- + {}^3He \rightarrow$ **Λ(1520)** + p + n: ~ 70 μb

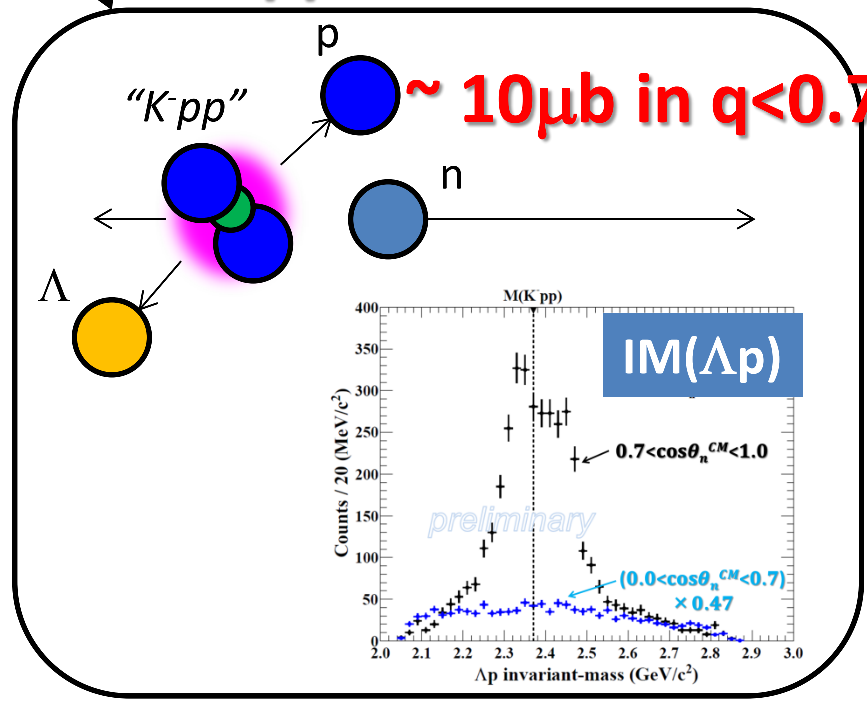
Production of Λ^* and "K⁻pp"



"free" Λ^*

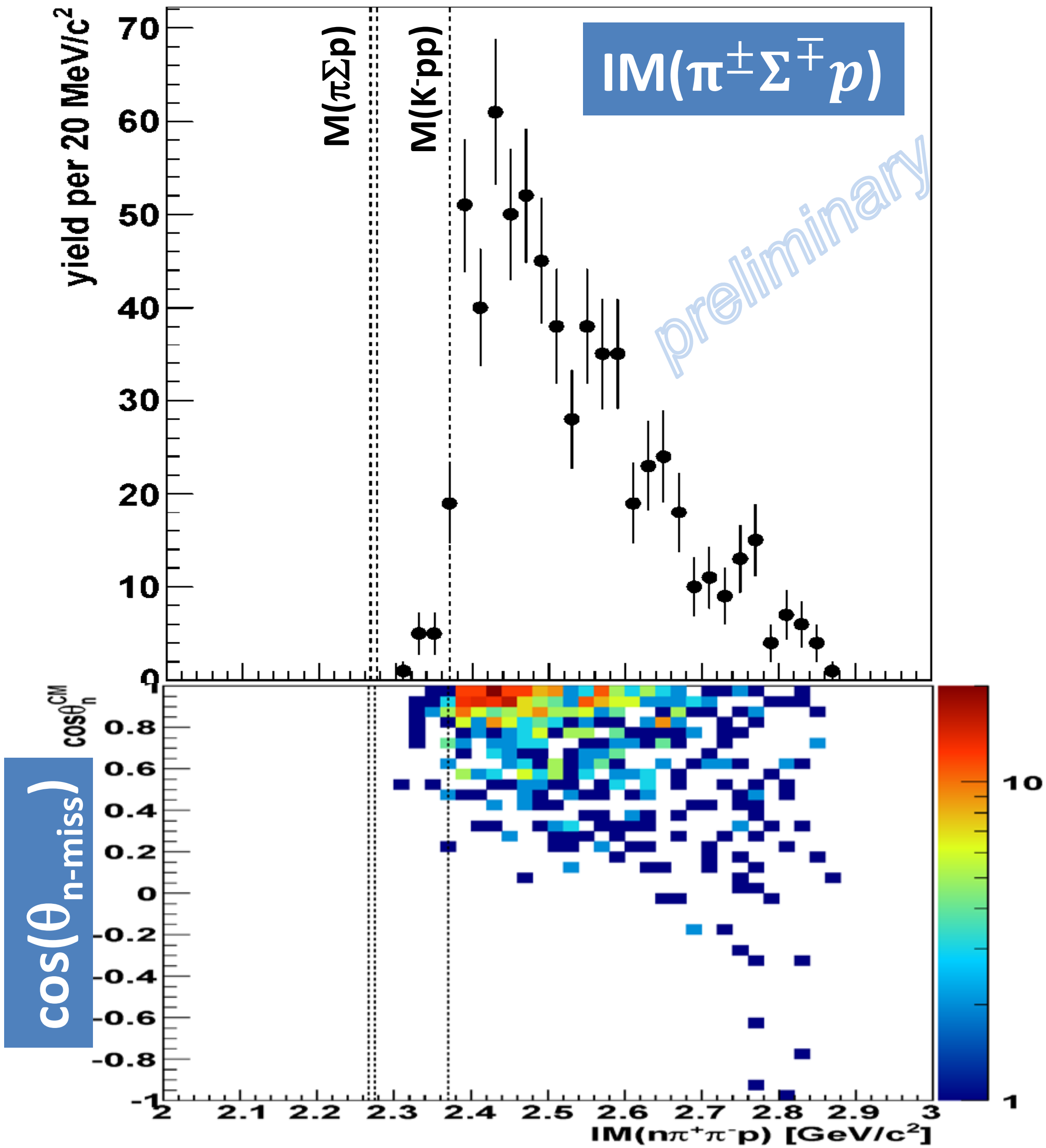


"K⁻pp" formation

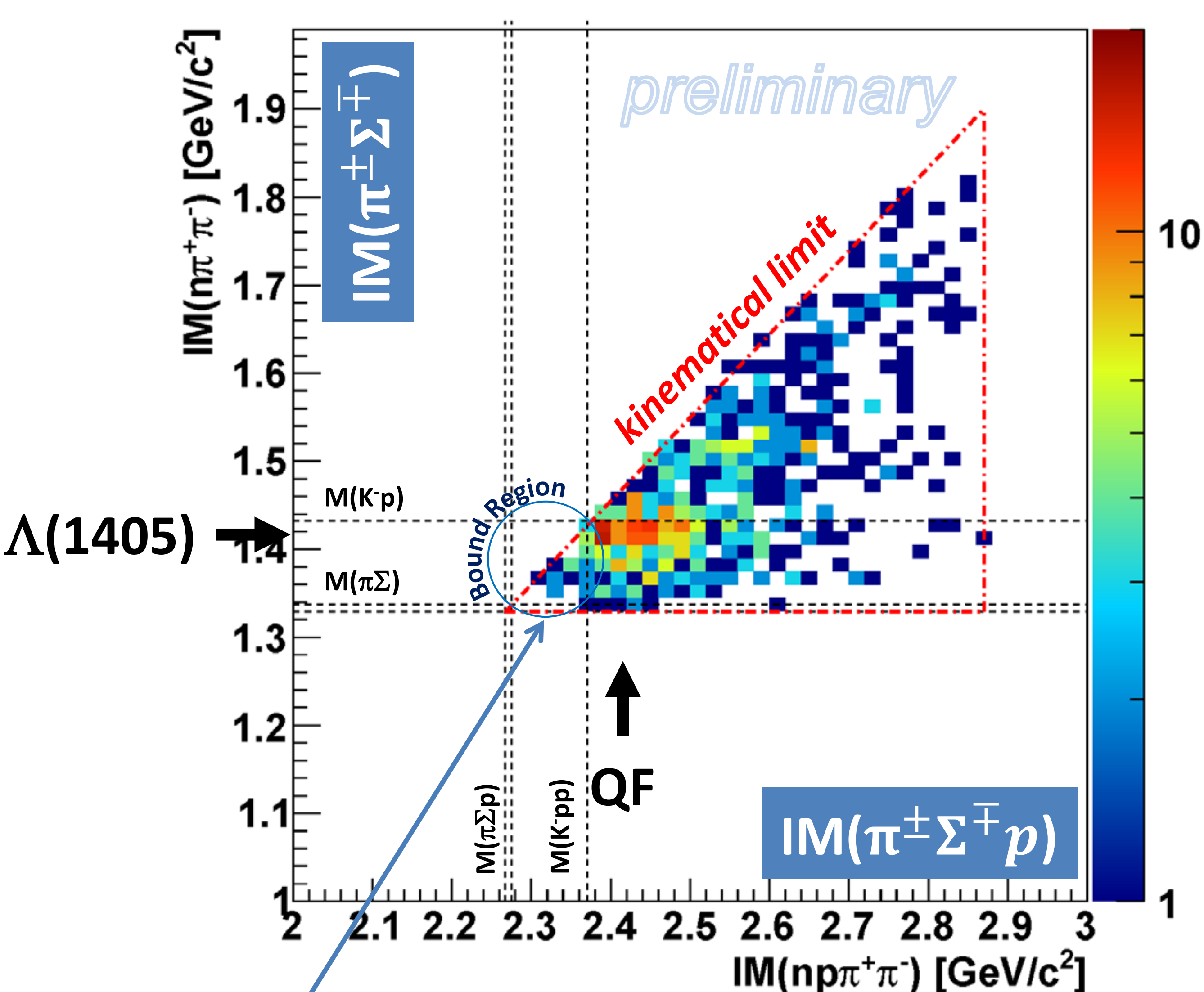


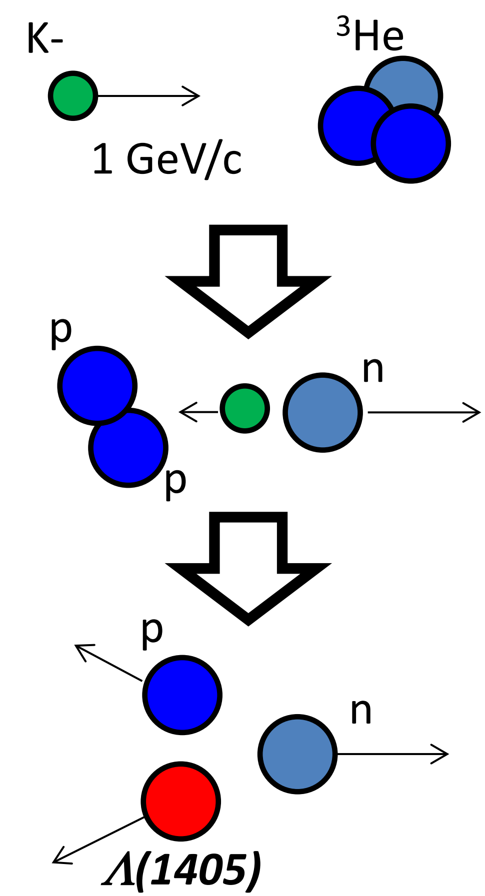
Large CS of Λ^* compared to "K⁻pp"

"K⁻pp" Search in $\pi^{\pm}\Sigma^{\mp}p\ n_{miss}$



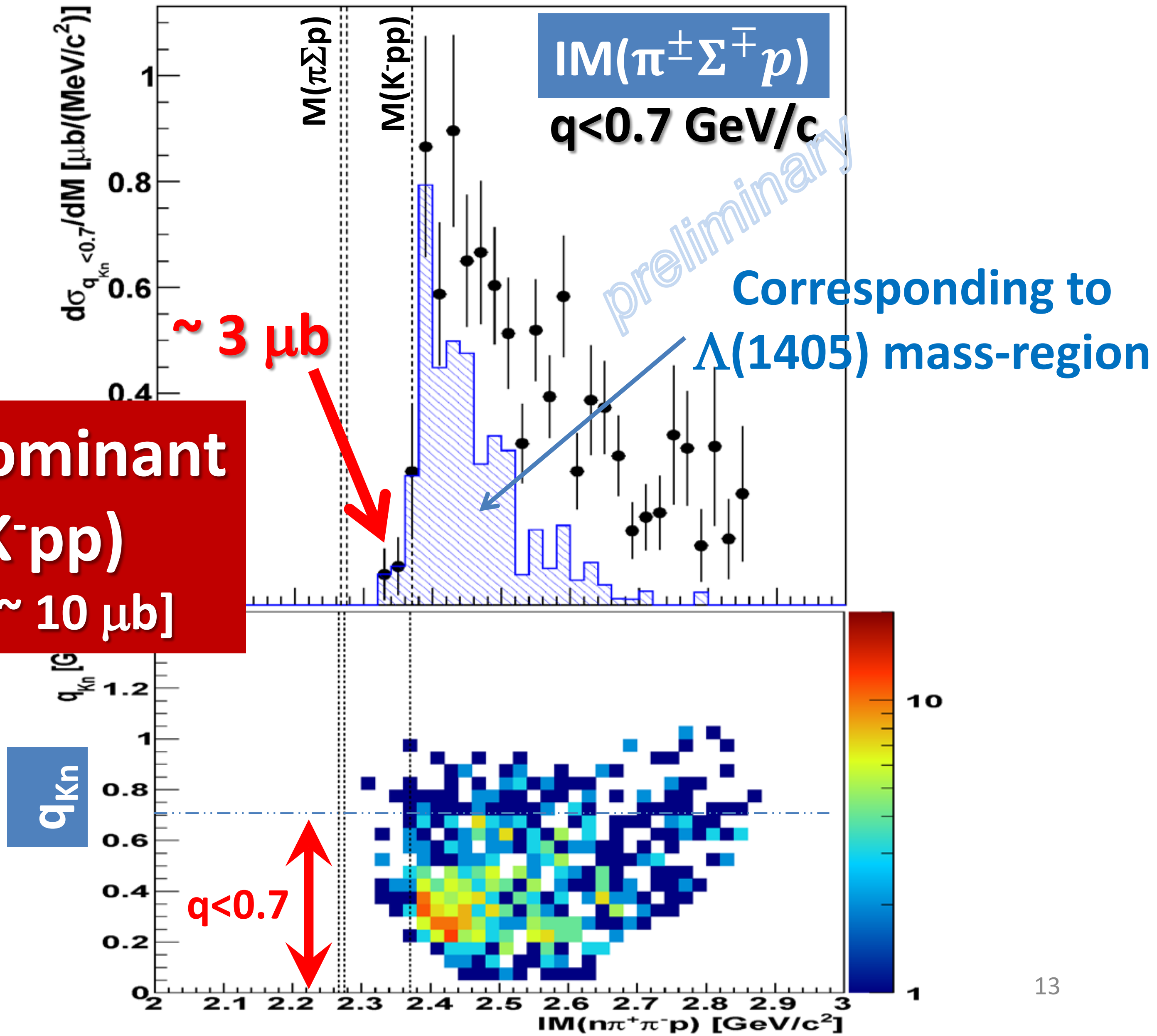
$\mathrm{IM}(\pi^{\pm}\Sigma^{\mp})$ vs. $\mathrm{IM}(\pi^{\pm}\Sigma^{\mp}p)$





Small phase-space of "K⁻pp"→πΣN

"K⁻pp" Search in $\pi^{\pm}\Sigma^{\mp}p\ n_{miss}$

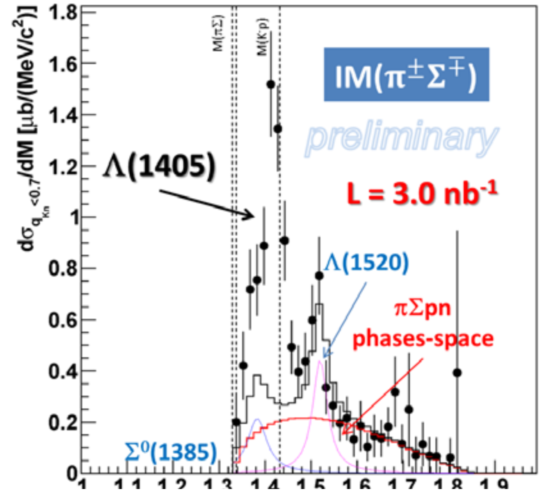


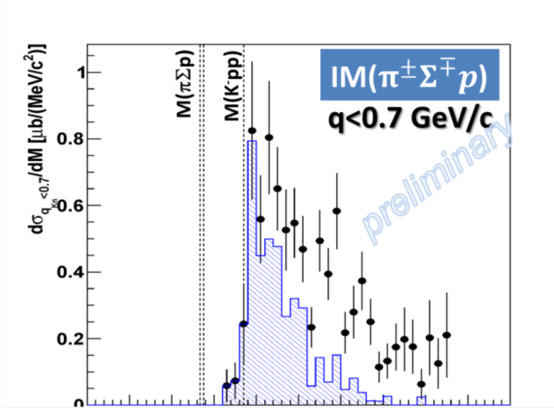
Λp decay is dominant below M(K⁻pp)

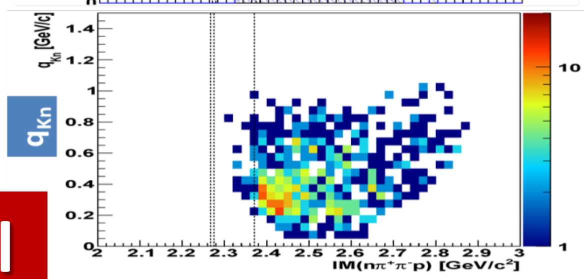
[σ("K⁻pp"→Λp) ~ 10 μb]

Summary

- **$\Lambda(1405)$ is clearly observed in $\pi^{\pm}\Sigma^{\mp}p\ n_{miss}$ final state**
  - ~ 130 μb in q_{Kn}<0.7 GeV/c
    - Large CS compared to "$K^-pp \rightarrow \Lambda p$"
- **Weak structure below the K^-pp threshold is seen in $IM(\pi^{\pm}\Sigma^{\mp}p)$**
  - ~ 3 μb in q_{Kn}<0.7 GeV/c
    - Λp decay is dominant below M(K-pp)



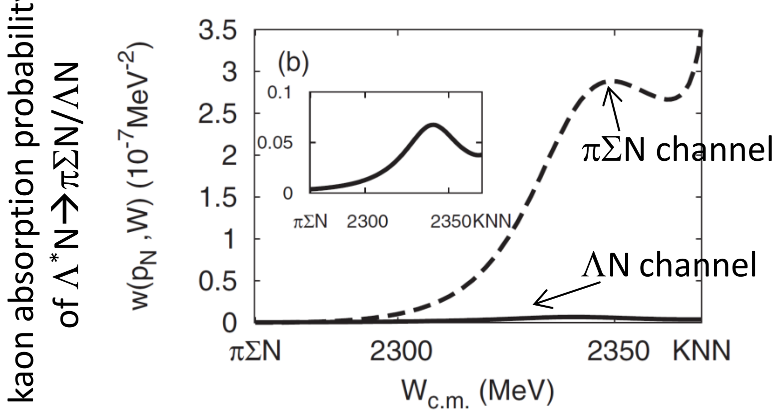




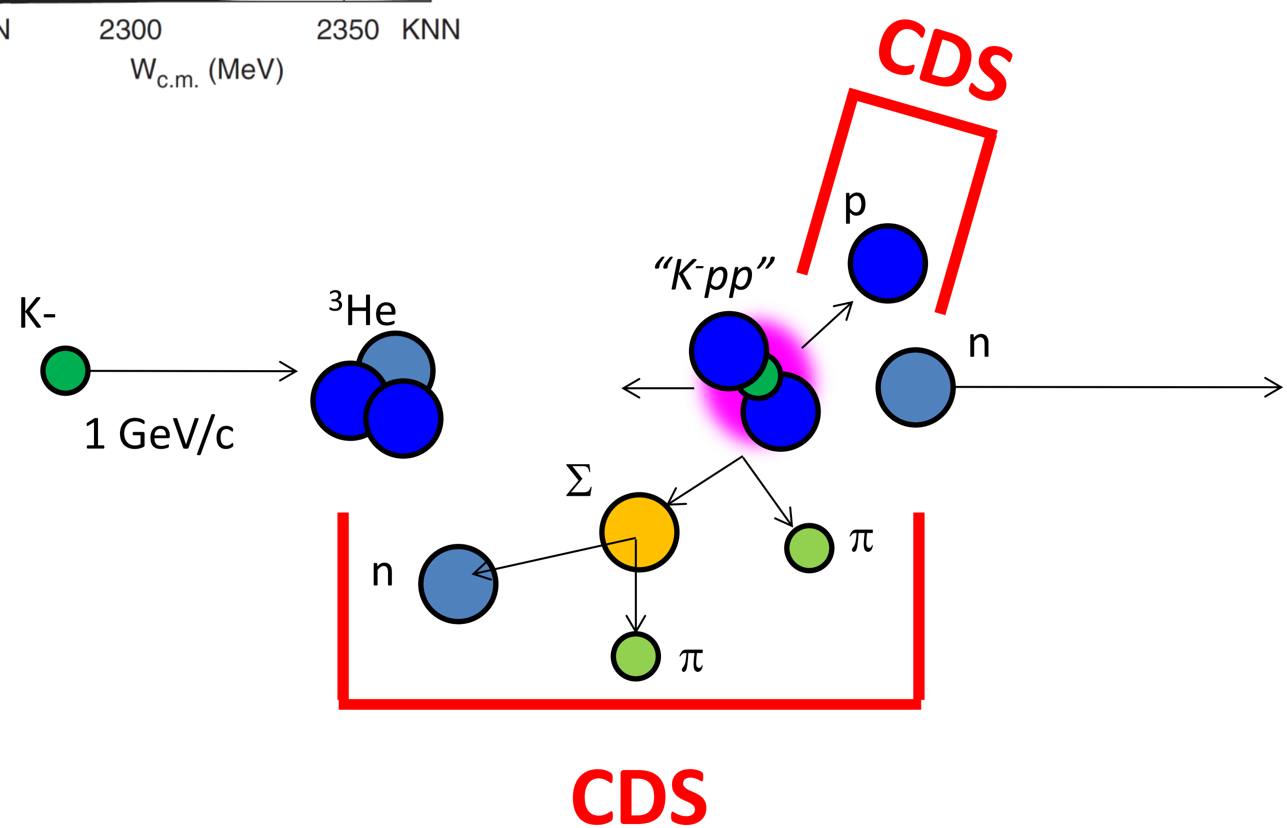
need further investigation of $\pi\Sigma N$ channel

"K⁻pp"→πΣN Decay Channel

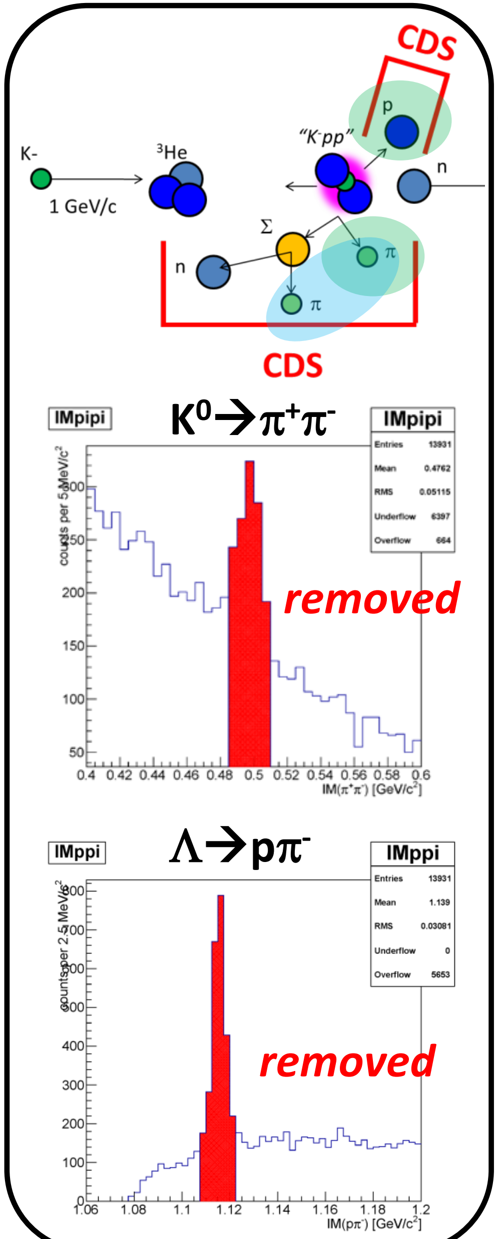
S.Ohnish et al.,PRC88(2013)025204



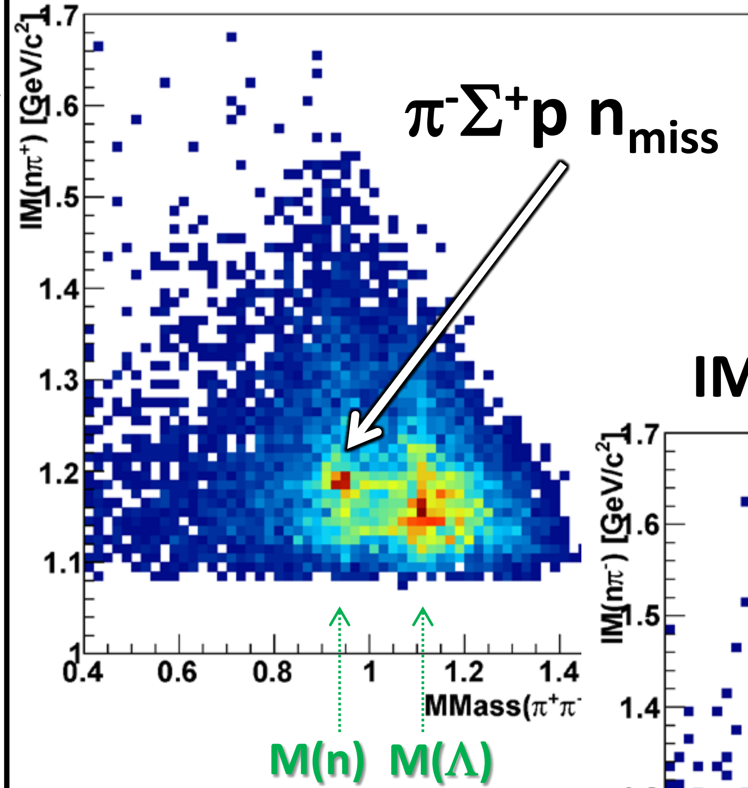
Theoretically,
πΣN decay is expected to be the dominant channel

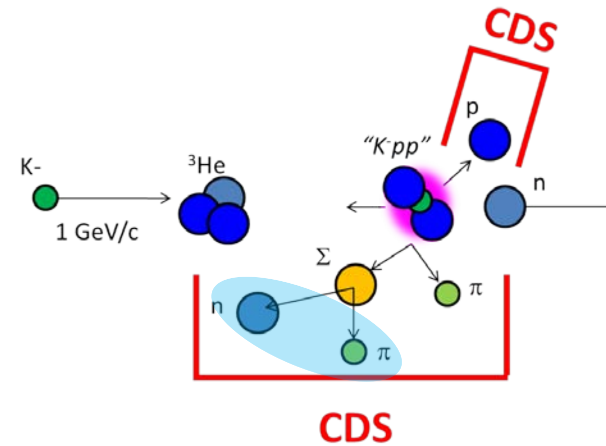


$\pi\Sigma pn$ Events

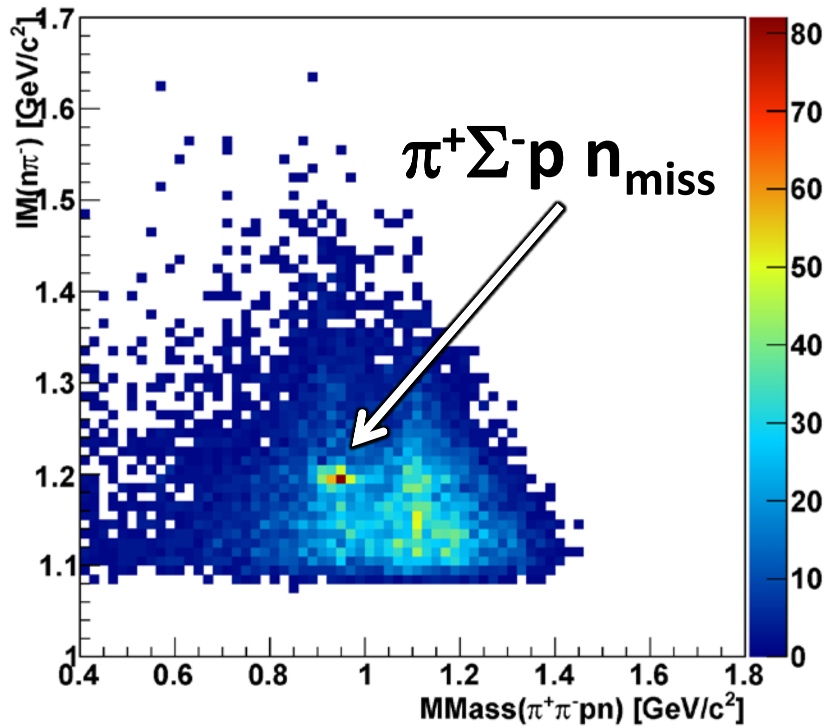


IM($n\pi^+$) vs MM($\pi^+\pi^-pn$)





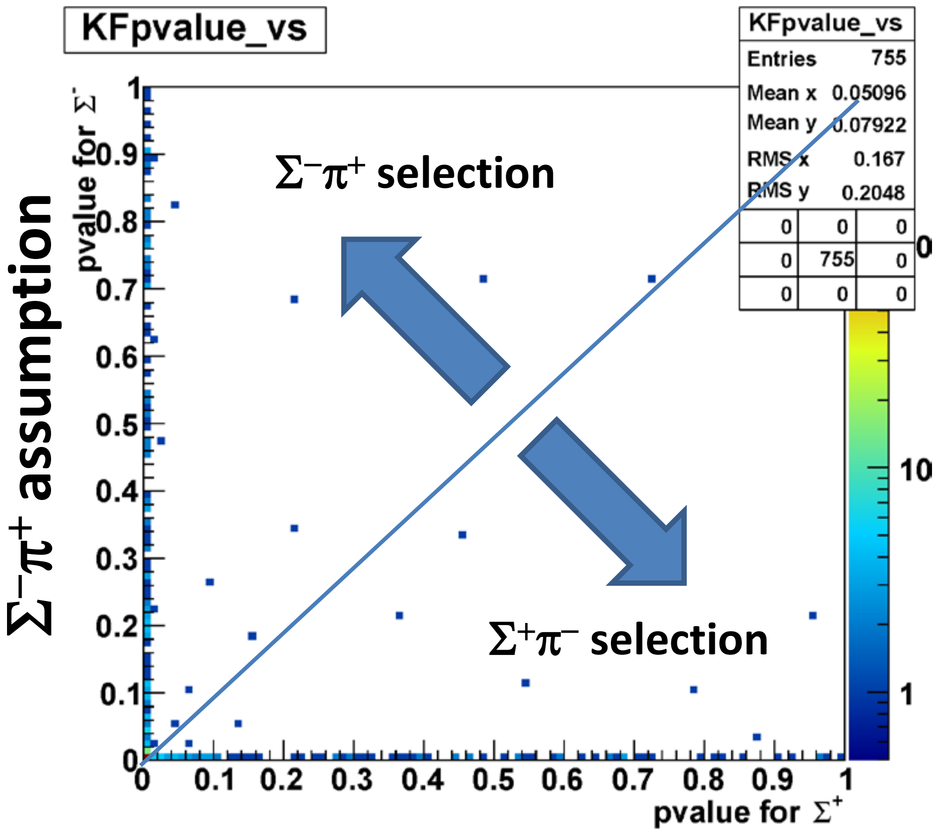
IM($n\pi^-$) vs MM($\pi^+\pi^-pn$)



Event Selection by χ^2 Probability

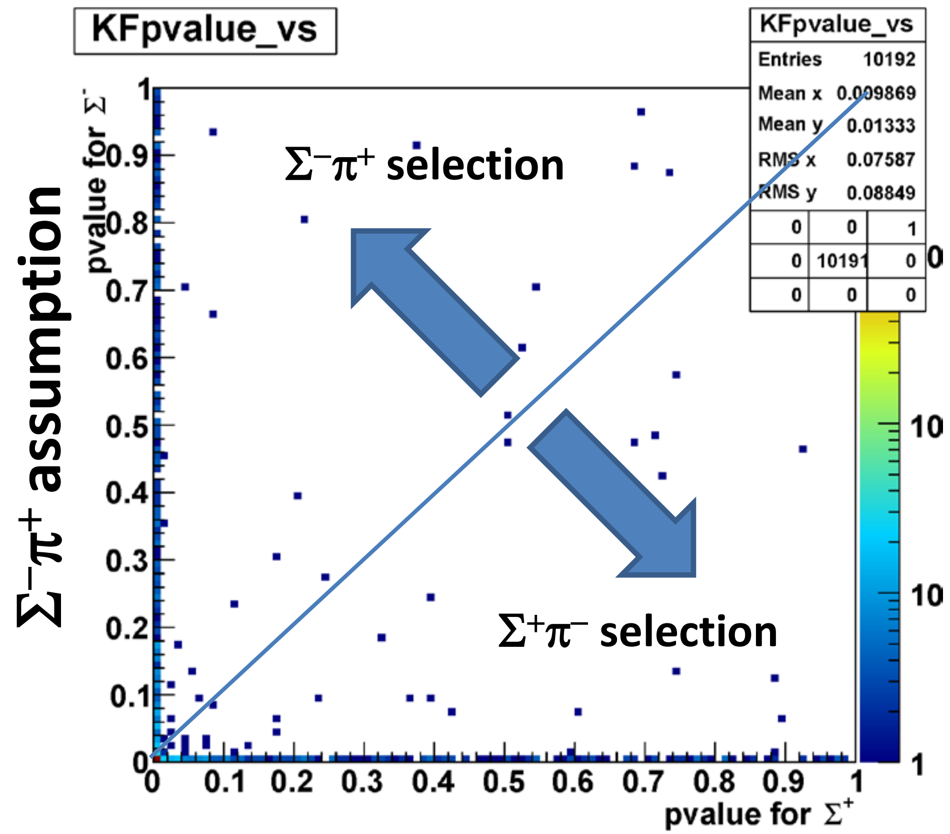
MC

[4-body PS $K^- + {}^3He \rightarrow \pi^{\mp} \Sigma^{\pm}$ p n]



$\Sigma^+\pi^-$ assumption

data



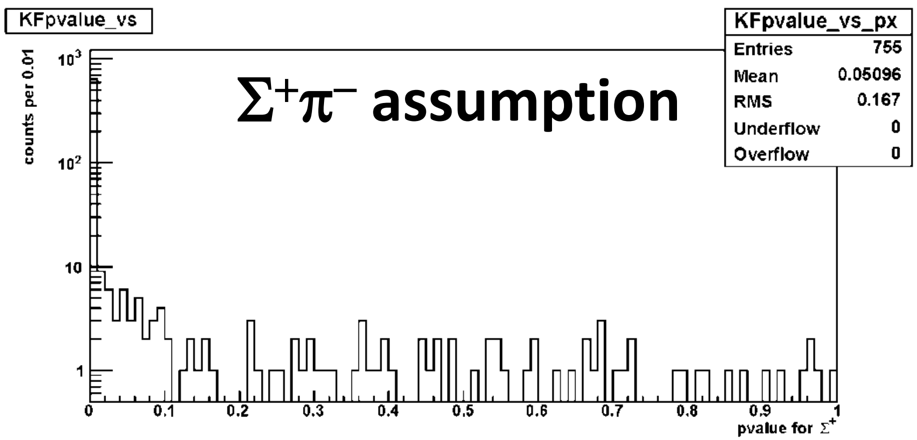
$\Sigma^+\pi^-$ assumption

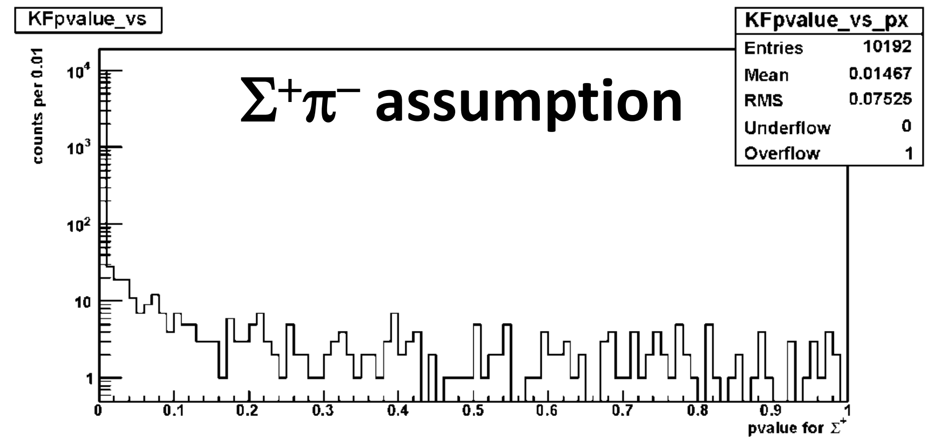
Event Selection by χ^2 Probability

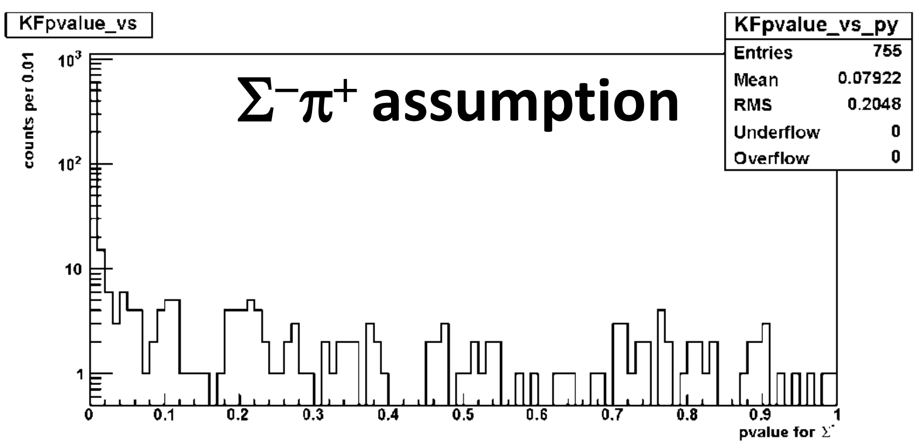
MC

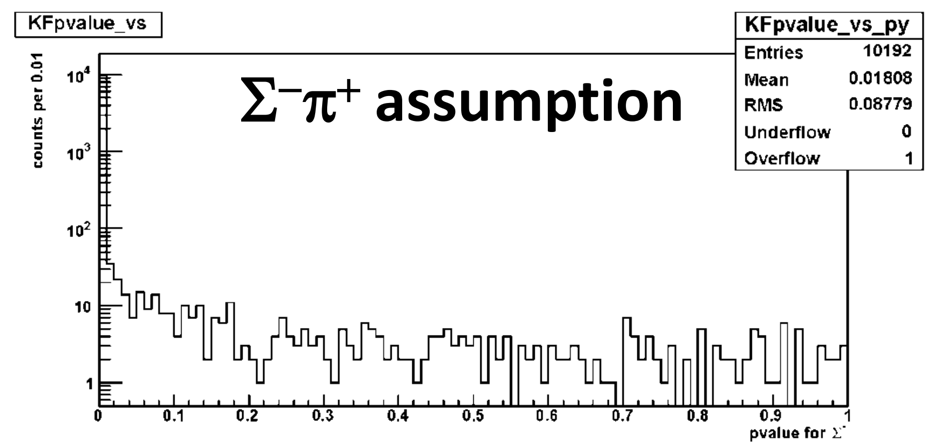
[4-body PS $K^-+{}^3He \rightarrow \pi^{\mp}\,\Sigma^{\pm}$ p n]

data







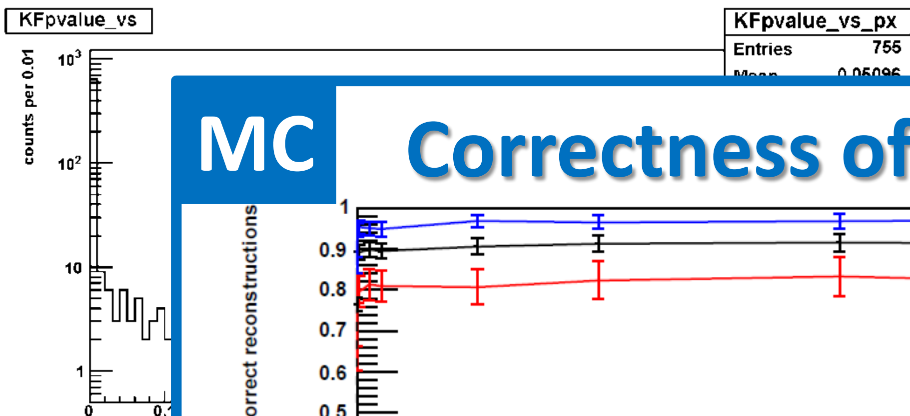


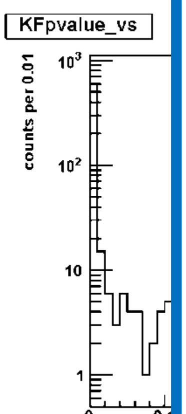
Event Selection by χ^2 Probability

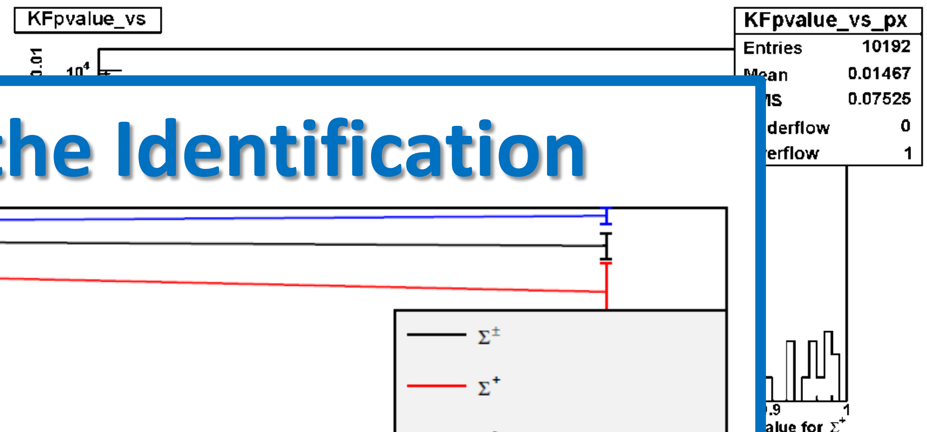
MC

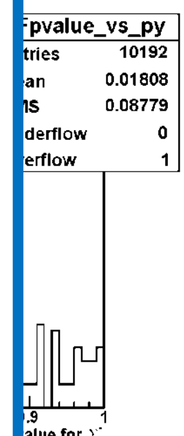
[4-body PS $K^- + {}^3He \rightarrow \pi^\mp \Sigma^\pm p\, n$]

data

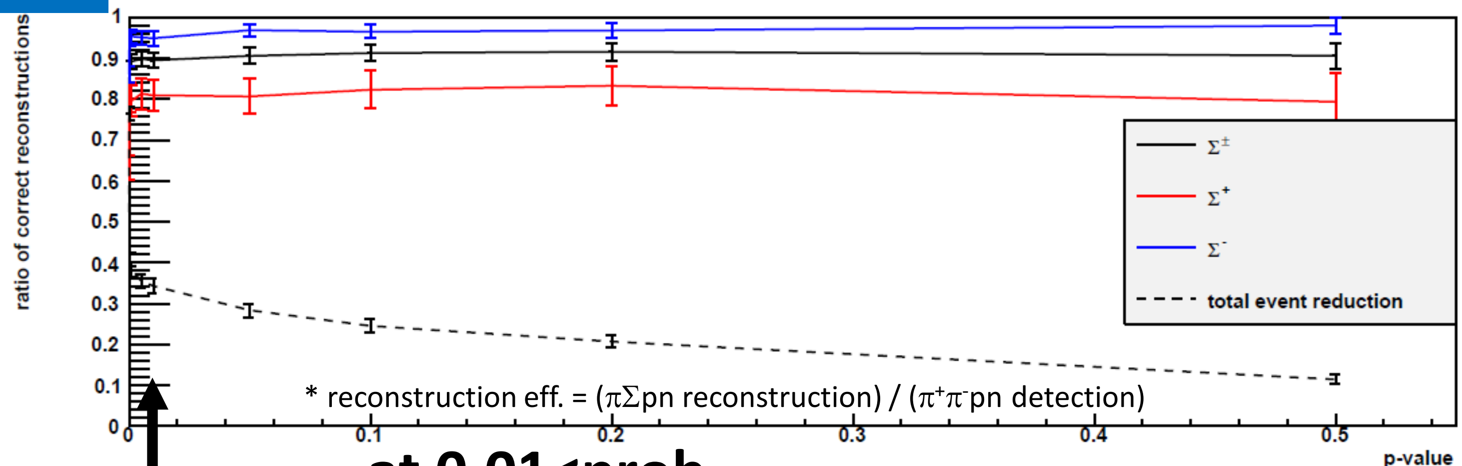








MC Correctness of the Identification



at 0.01<prob.

$\Sigma^+\pi^-$ assumption = 81.0%

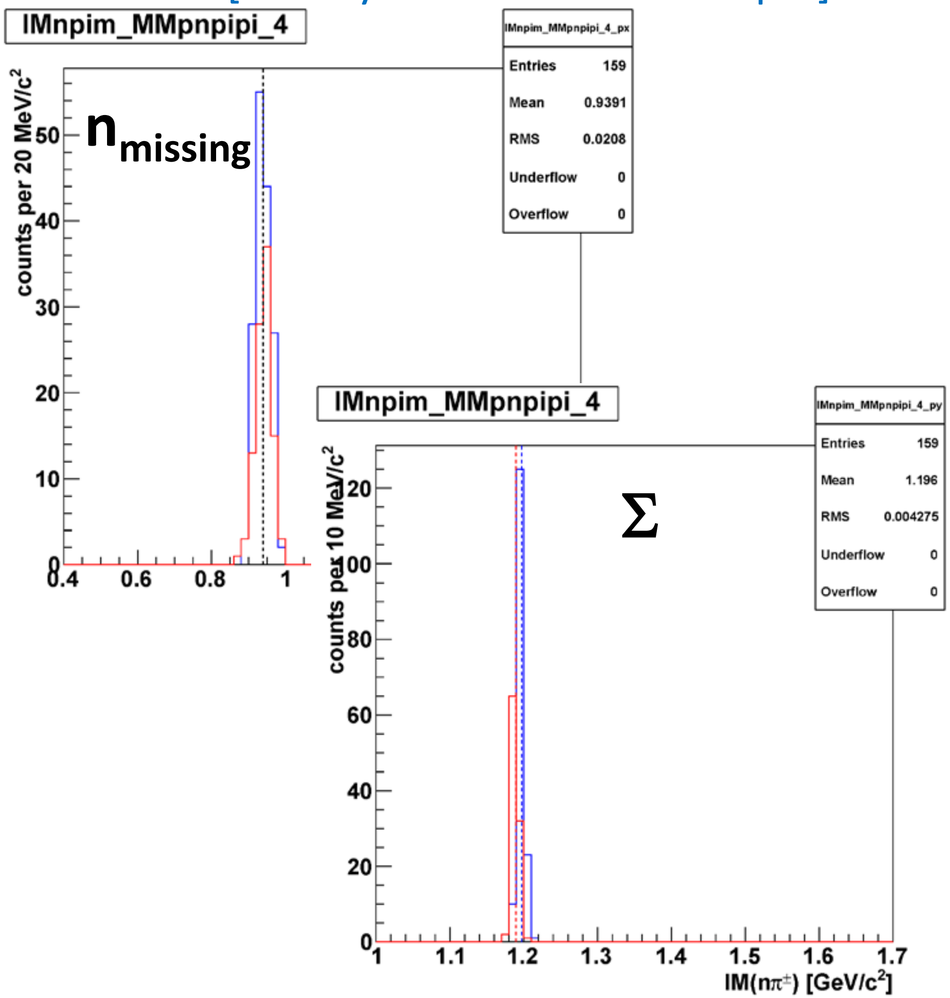
$\Sigma^-\pi^+$ assumption = 95.0%

$\Sigma^\pm\pi^\mp$ total = 89.6%

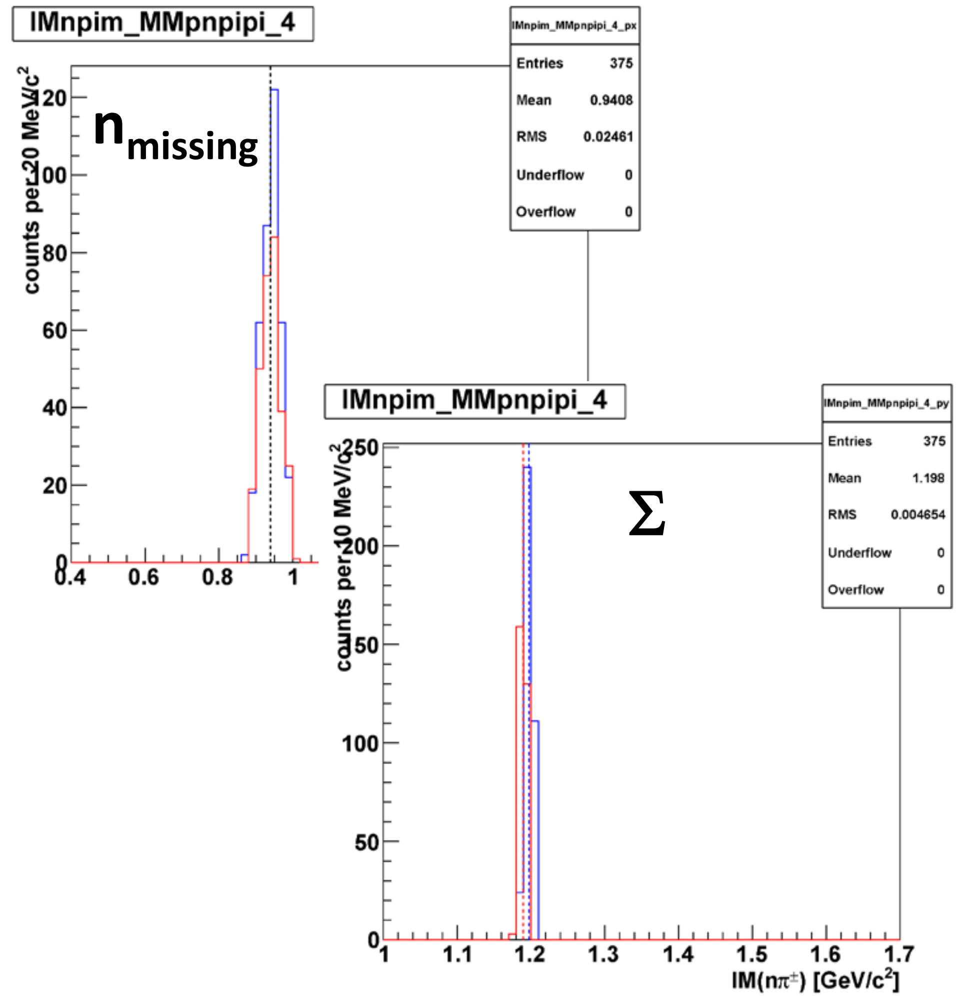
$n_{missing}$ and Σ Selection [0.01< p-value]

MC

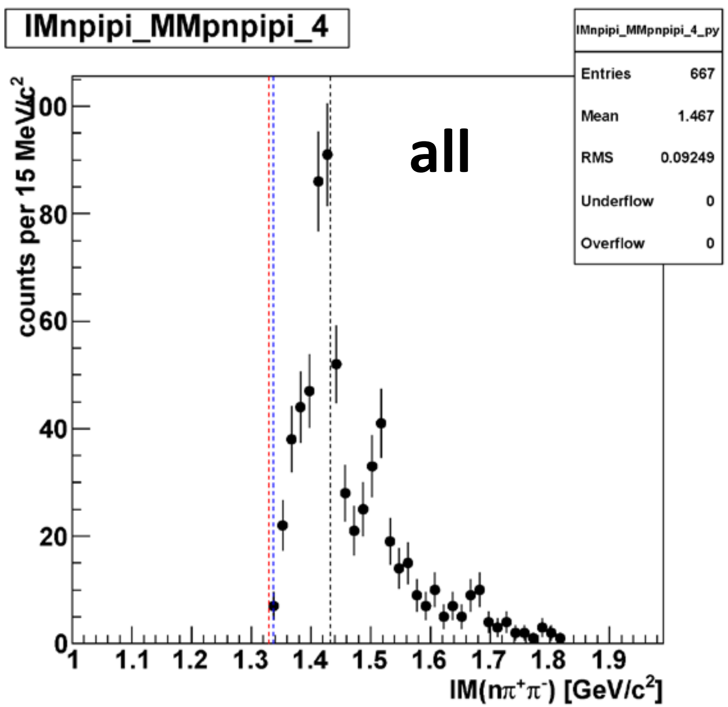
[4-body PS $K^{-}+^{3}He \rightarrow \pi^{\mp}\ \Sigma^{\pm}$ p n]

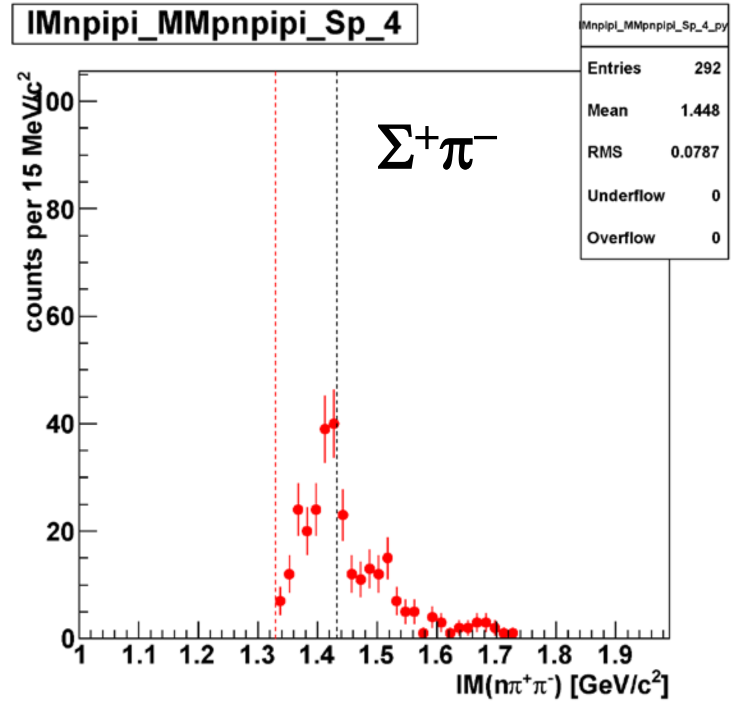


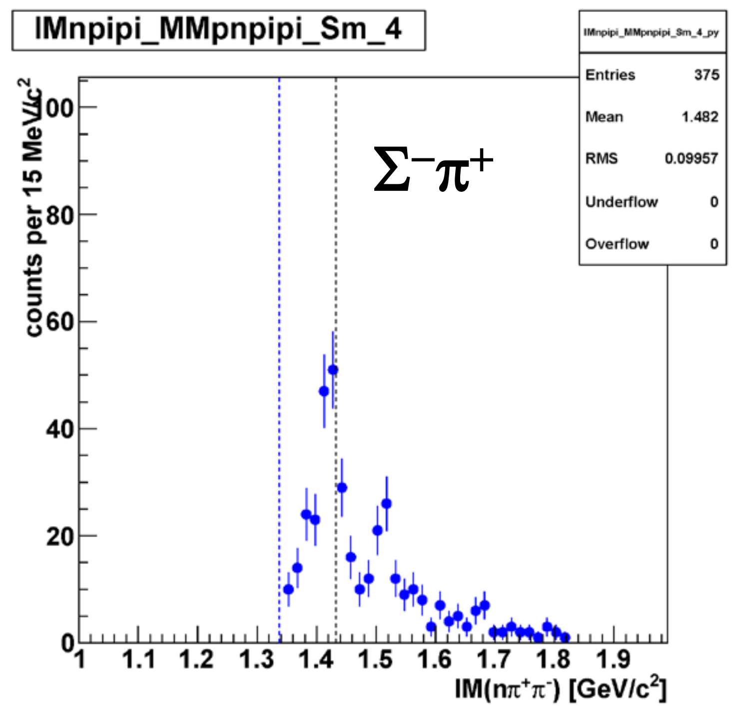
data



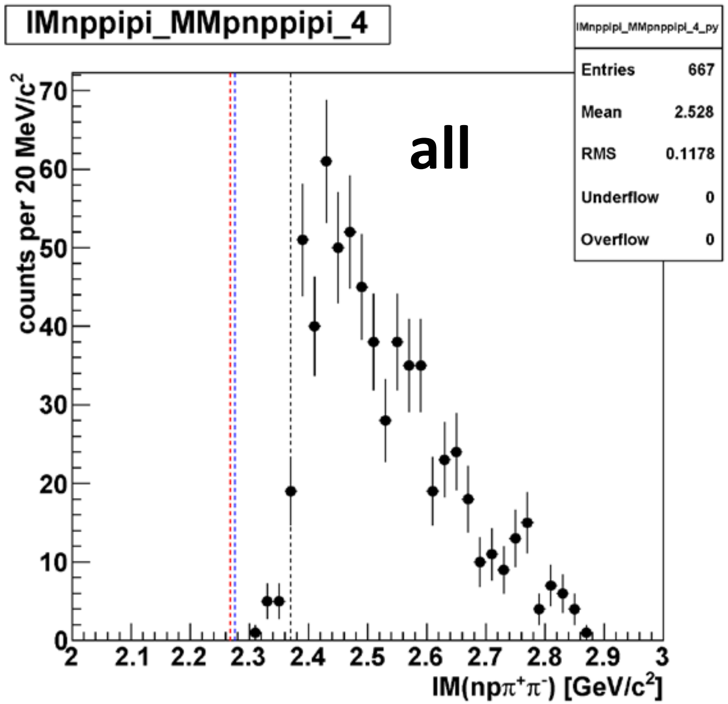
$\pi^-\Sigma^+$ and $\pi^+\Sigma^-$

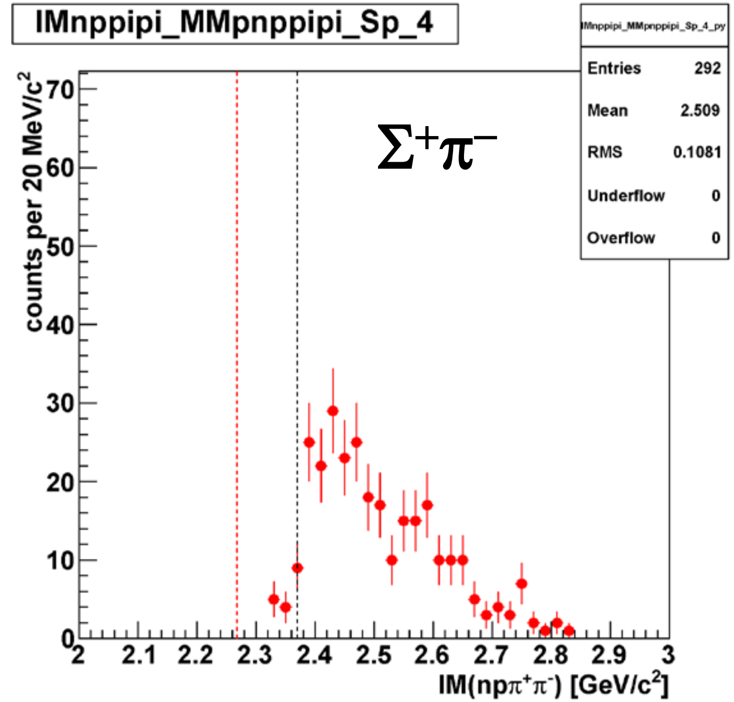


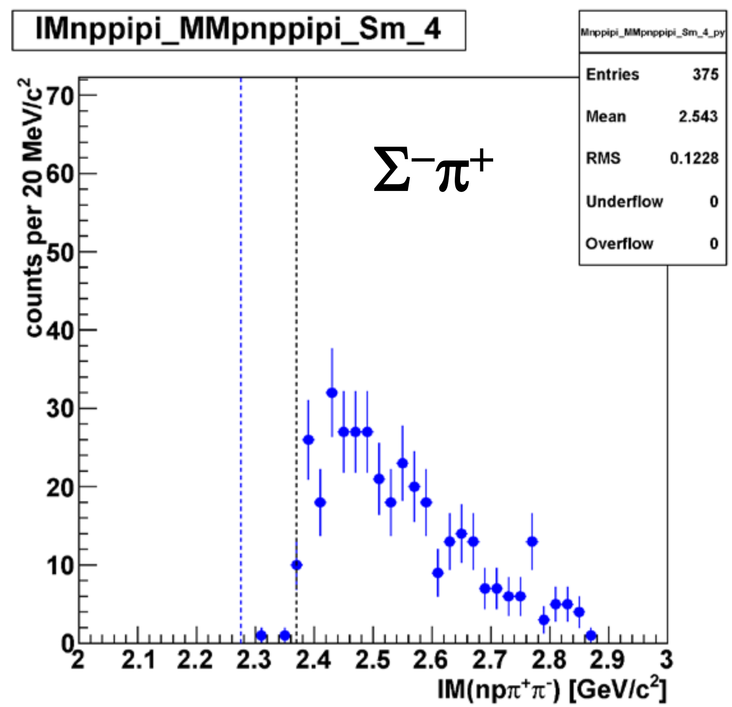




$\pi^-\Sigma^+p$ and $\pi^+\Sigma^-p$







K-p = elastic: 22mb
K-p = n K0: 7 mb
K-n = elastic: 20 mb

Σ^0(1385) Cross-Section?

- No data of Σ^0(1385) CS around 1.0 GeV/c
- In 1.2~1.8 GeV/c, CS of QF Σ^0(1385) was measured, and is almost the same as that of $\Sigma^\pm$(1385)

- Relative ratios of Σ^* productions via 2-step reaction are assumed as follows:
  - $K^-{}^3He \rightarrow (K^-p_sp_s)n \rightarrow \Sigma^{*0}pn$ (1*20*0.5=10)
  - $K^-{}^3He \rightarrow (K^-p_sp_s)n \rightarrow \Sigma^{*+}nn$ (1*20*0.5=10)
  - $K^-{}^3He \rightarrow (K^-n_sp_s)p \rightarrow \Sigma^{*0}pn$ (2*22*0.5=22)
  - $K^-{}^3He \rightarrow (K^-n_sp_s)p \rightarrow \Sigma^{*-}nn$ (2*22*0.5=22)
  - $K^-{}^3He \rightarrow (K^0n_sp_s)n \rightarrow \Sigma^{*0}pn$ (2*7*0.5=7)
  - $K^-{}^3He \rightarrow (K^0n_sp_s)n \rightarrow \Sigma^{*+}nn$ (2*7*0.5=7)

  where cross sections of 2NA Σ^{*0+-} are assumed to be the same
- Then we assume Σ^0(1385) CS at 1.0 GeV/c to be:

$\sigma(\Sigma^{*0}) = 39/17 \times \sigma(\Sigma^{*+}) = 2.3 \times \sigma(\Sigma^{*+})$