# Strange Resonances at SIS18

**Laura Fabbietti for the HADES Collaboration**
Excellence Cluster ‚Universe' TU-Munich

Auryn Amulet, Neverending Story

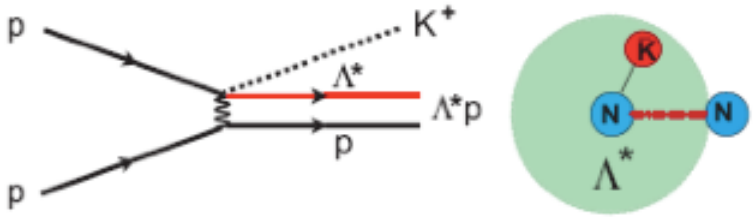
# Our Stage

p+p @ 3.5GeV

$p + p \rightarrow K^- + p + .....$

K⁻p Interaction??

T. Yamazaki et T. Akahishi, Phys. Rev. C 76 (2007) 045201



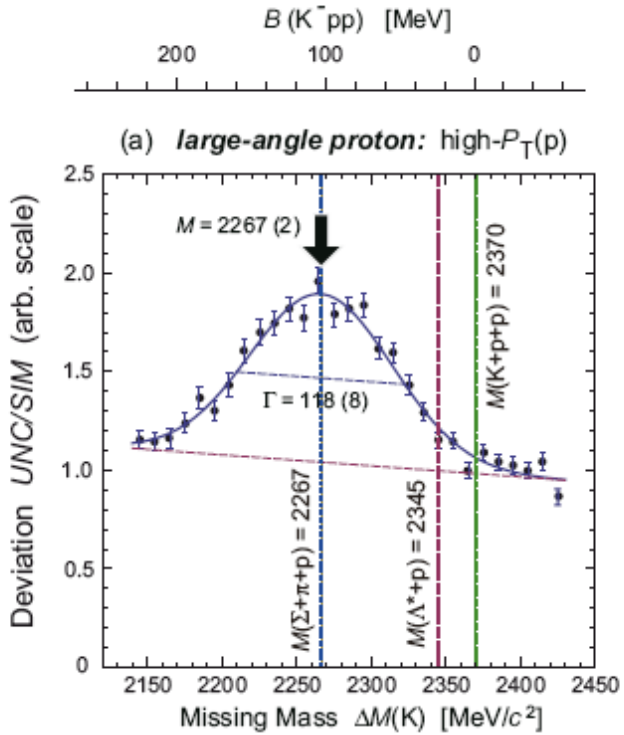

Λ* ≡Λ(1405)

ppK⁻ bound state?

$p + p \rightarrow ppK^- + K^+$

$\hookrightarrow \Lambda + p$

T. Yamazaki et al. (DISTO Coll.) Phys. Rev. Lett 104 (2010)



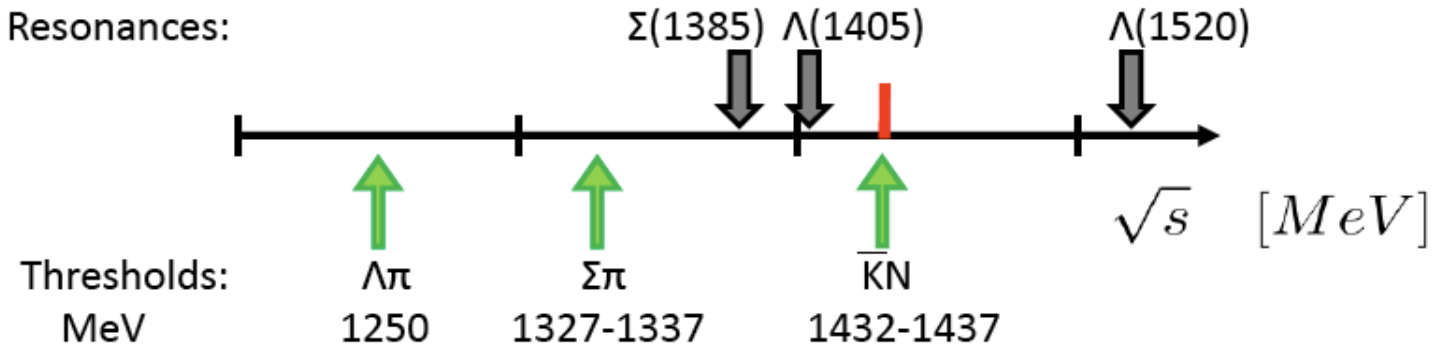

$M_X = 2265 \pm 2\ (stat) \pm 5\ (syst)\ MeV/c^2$

$\Gamma_X = 118 \pm 8\ (stat) \pm 10\ (syst)\ MeV.$

# Our Stage

$$p + p \rightarrow \Lambda(1405) + K^+ + p \qquad \Gamma\sim 50 \text{ MeV}$$

$$p + p \rightarrow \Sigma(1385)^+ + K^+ + n \qquad \Gamma\sim 40 \text{ MeV}$$




- Λ(1405) predicted as a KN bound state — R.H. Dalitz et al.; Phys. Rev. 153 (1967) 1617
- Important for the understanding of K-N interaction
- Coupled channel approach based on Chiral Dynamics generates the Λ(1405) dynamically as a quasi-bound KN state and a Σπ resonance
- Different strengths of the KN and the Σπ contributions still unclear
  → experimental data are needed to clarify the situation

# Entangled States

‚Do What you Wish‘

✔ Λ(1405)

✔ Σ(1385)

ppK

KN Interaction

# The $\Sigma(1385)^+$

From the PDG:

$\Sigma(1385)\ P_{13}$ $\quad I(J^P) = 1(\frac{3}{2}+)$

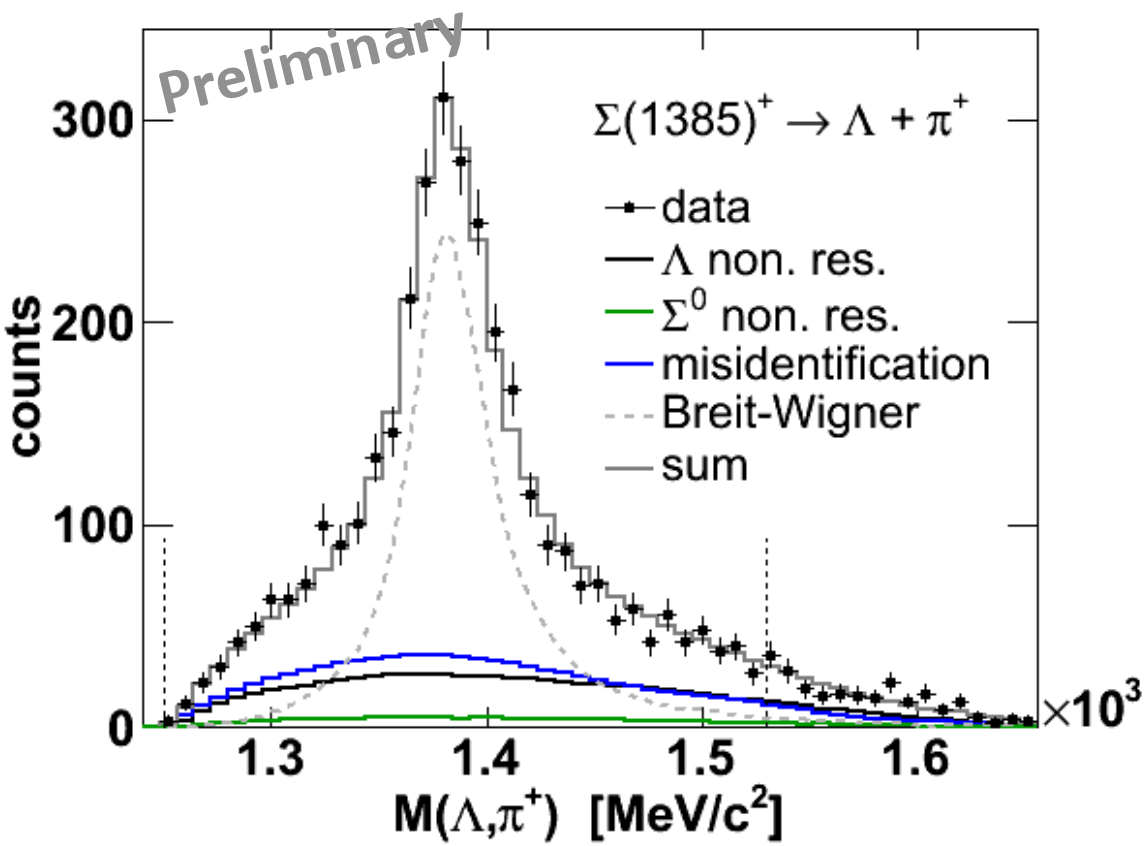
$\Sigma(1385)^+$ mass $m_0 = 1382.8 \pm 0.4$ MeV/$c^2$
width $\Gamma_0 = 35.8 \pm 0.8$ MeV/$c^2$

Data stemming from $K^-p$ measurement

We have measured it in p+p@3-5GeV:

- Spectral shape ➔ Determination of the width in p+p, precise evaluation of all background contributions
- Angular Distribution ➔ Information on the production mechanism
- Cross Section ➔ upper limit for the $\Sigma(1385)^0$ contamination to the $\Lambda(1405)$ spectra

# The $\Sigma(1385)^+$ Spectral Shape




$$p + p \rightarrow \Sigma(1385)^+ + n + K^+$$
$$\Sigma(1385)^+ \rightarrow \Lambda + \pi^+$$
$$\Lambda \rightarrow p + \pi^-$$

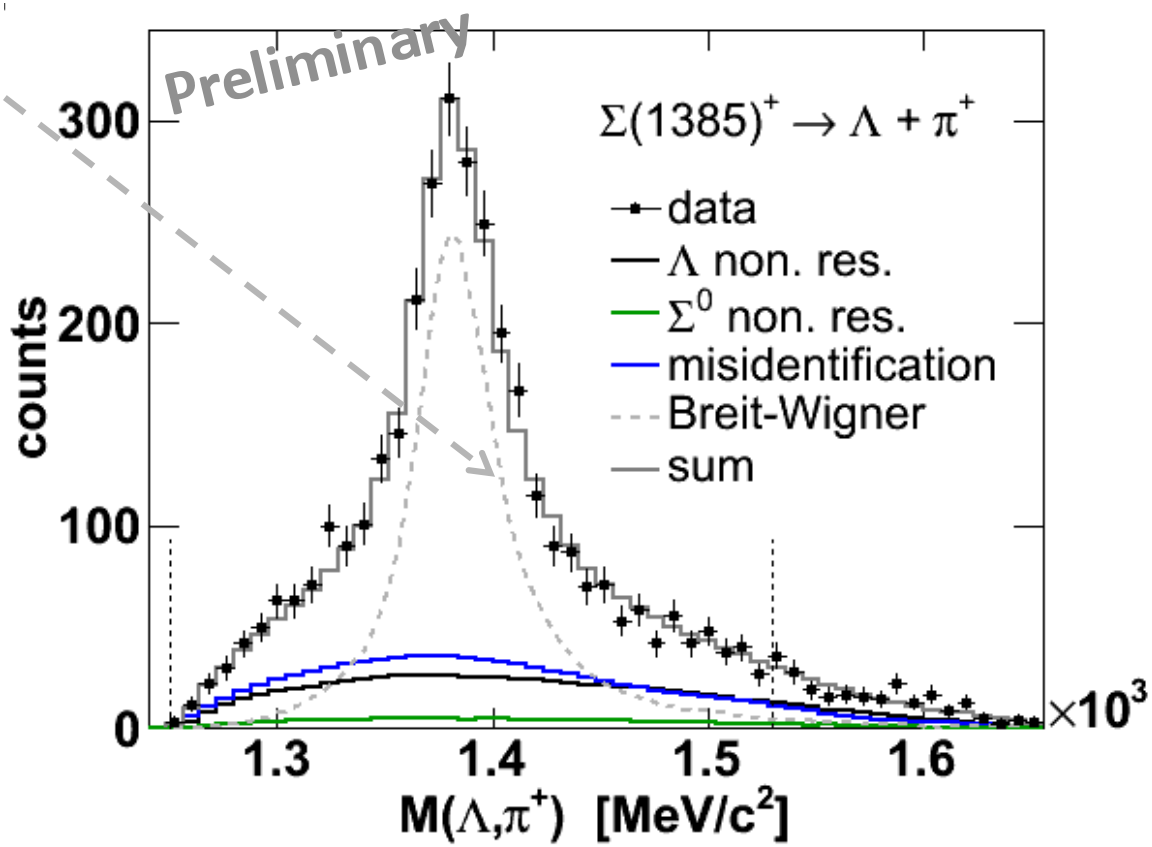
# The Σ(1385)⁺ Spectral Shape

Relativistic p-wave Breit-Wigner folded with the HADES **acceptance**, **efficiency** and **available phase** space

$$\text{Breit-Wigner} \propto \frac{q^2}{q_0^2}\frac{m_0^2\Gamma_0^2}{(m_0^2-m^2)^2+m_0^2\Gamma^2}$$

$$\Gamma = \Gamma_0\frac{m_0 q^3}{m q_0^3}F_1(q)$$

$$F_1(q) = \frac{1+(q_0R)^2}{1+(qR)^2},$$




$$p + p \to \Sigma(1385)^+ + n + K^+$$
$$\hookrightarrow \Lambda + \pi^+$$
$$\hookrightarrow p + \pi^-$$

# The $\Sigma(1385)^+$ Spectral Shape

Relativistic p-wave Breit-Wigner folded with the HADES **acceptance**, **efficiency** and **available phase** space

$$\text{Breit-Wigner} \propto \frac{q^2}{q_0^2}\frac{m_0^2\Gamma_0^2}{(m_0^2-m^2)^2+m_0^2\Gamma^2}$$

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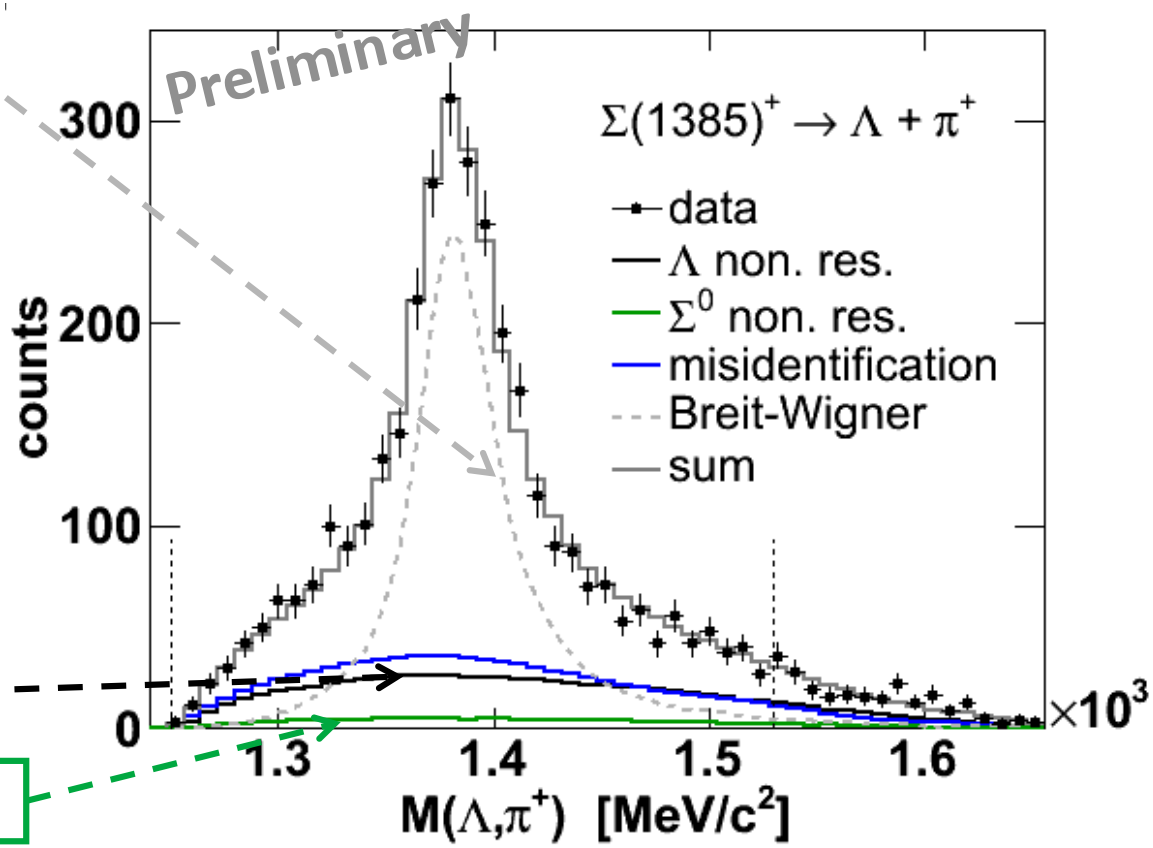
$$F_1(q) = \frac{1+(q_0R)^2}{1+(qR)^2},$$

Direct production of $\Lambda\pi^+nK^\pm$

Direct production of $\Sigma^0\pi^+nK^+$




$$p + p \to \Sigma(1385)^+ + n + K^+$$
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$$\hookrightarrow p + \pi^-$$

# The $\Sigma(1385)^+$ Spectral Shape

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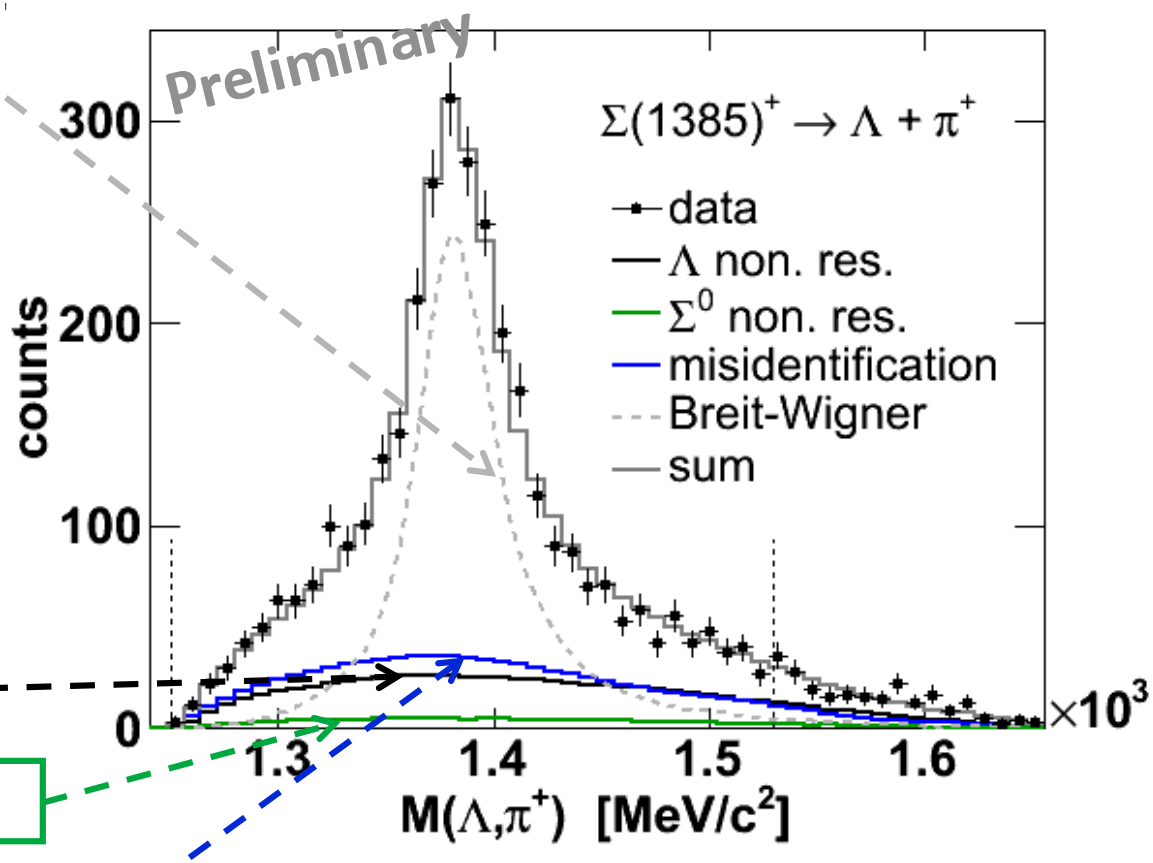


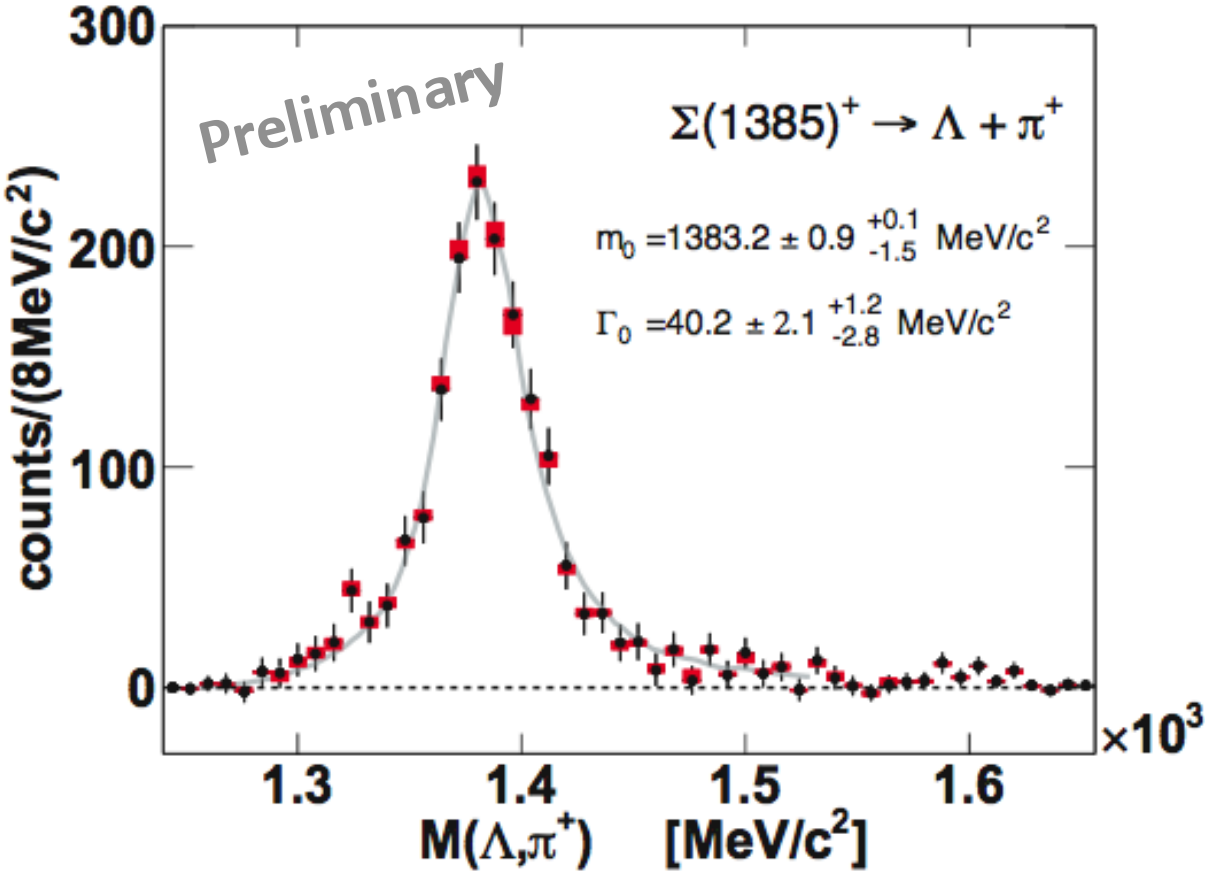

Direct production of $\Lambda\pi^+nK^+$

Direct production of $\Sigma^0\pi^+nK^+$

Misidentification of $K^+$. **Strength fixed** by a sideband analysis on $K^+$ mass

$$p + p \to \Sigma(1385)^+ + n + K^+$$
$$\hookrightarrow \Lambda + \pi^+$$
$$\hookrightarrow p + \pi^-$$

# The $\Sigma(1385)^+$ Spectral Shape

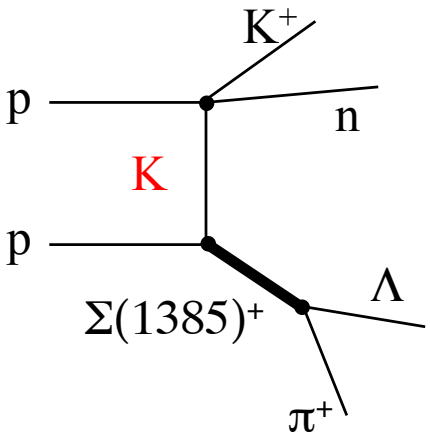



Total statistics: ~1800 counts
Measured width: 4 MeV/c$^2$ larger than the PDG value

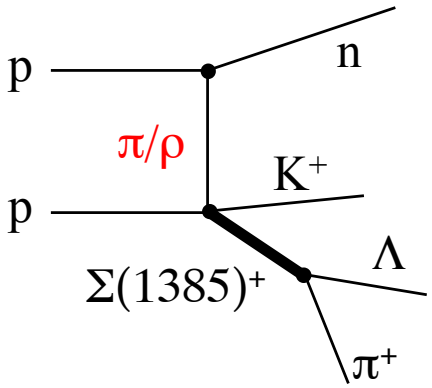
# Production Mechanism

Production mechanism of $\Sigma(1385)^+$ in pp reactions not well studied:

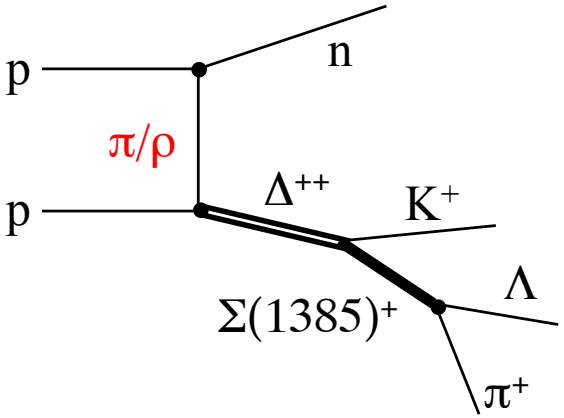
Kaon exchange:




Pion exchange:

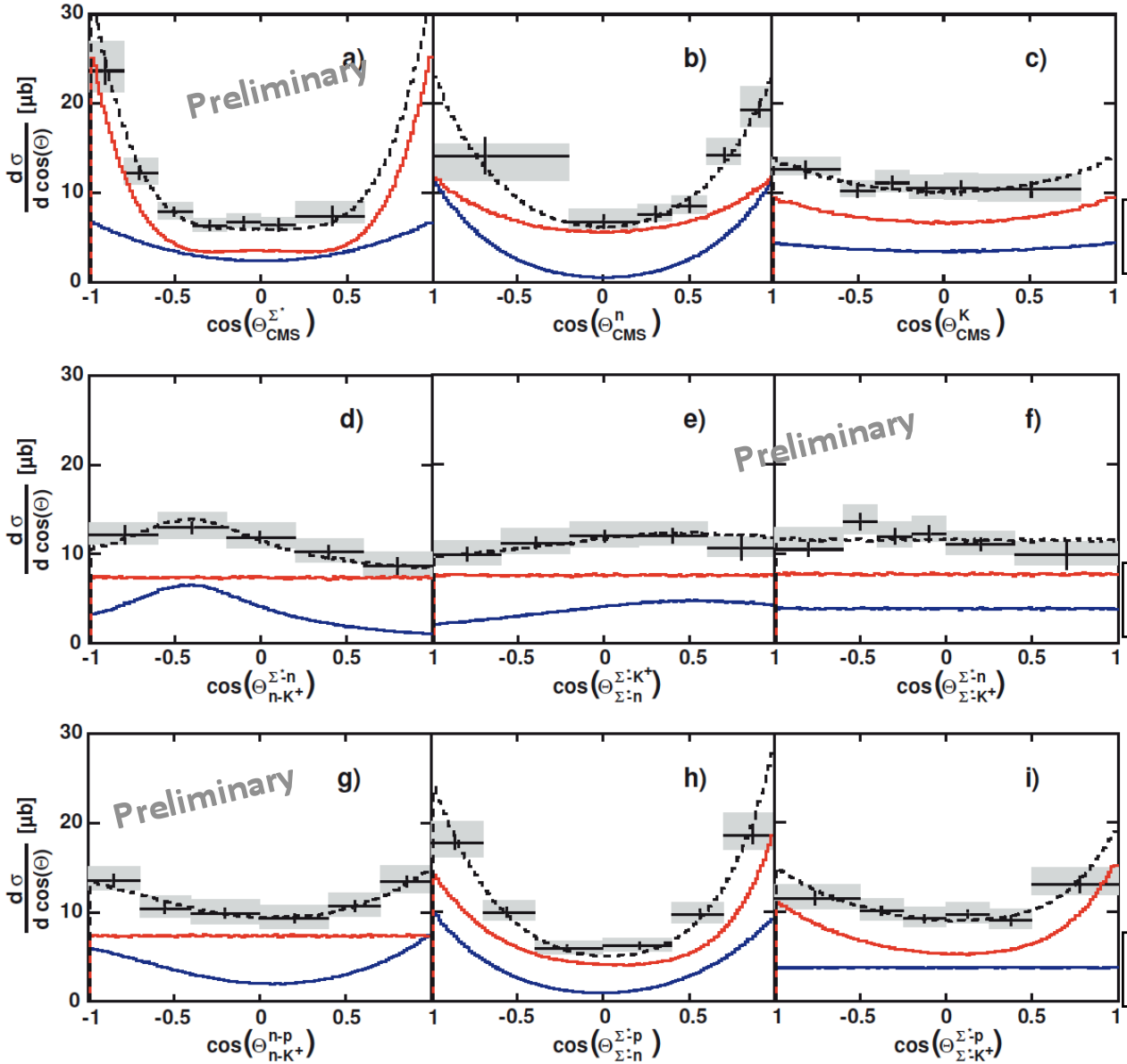



$\Delta^{++}$ production:




$\Delta^{++} \rightarrow \Sigma(1385)^+ + K^+$ seen by:
W.Chinowsky et. al. Phys. Rev. 171,5 1968

# $\Sigma(1385)^+$:Angular Distributions




$$p + p \rightarrow \Sigma(1385)^+ + n + K^+$$

CM Angles

Simulation:

——— $\pi/\rho$ or $K^0/K^{0*}$ Exchange

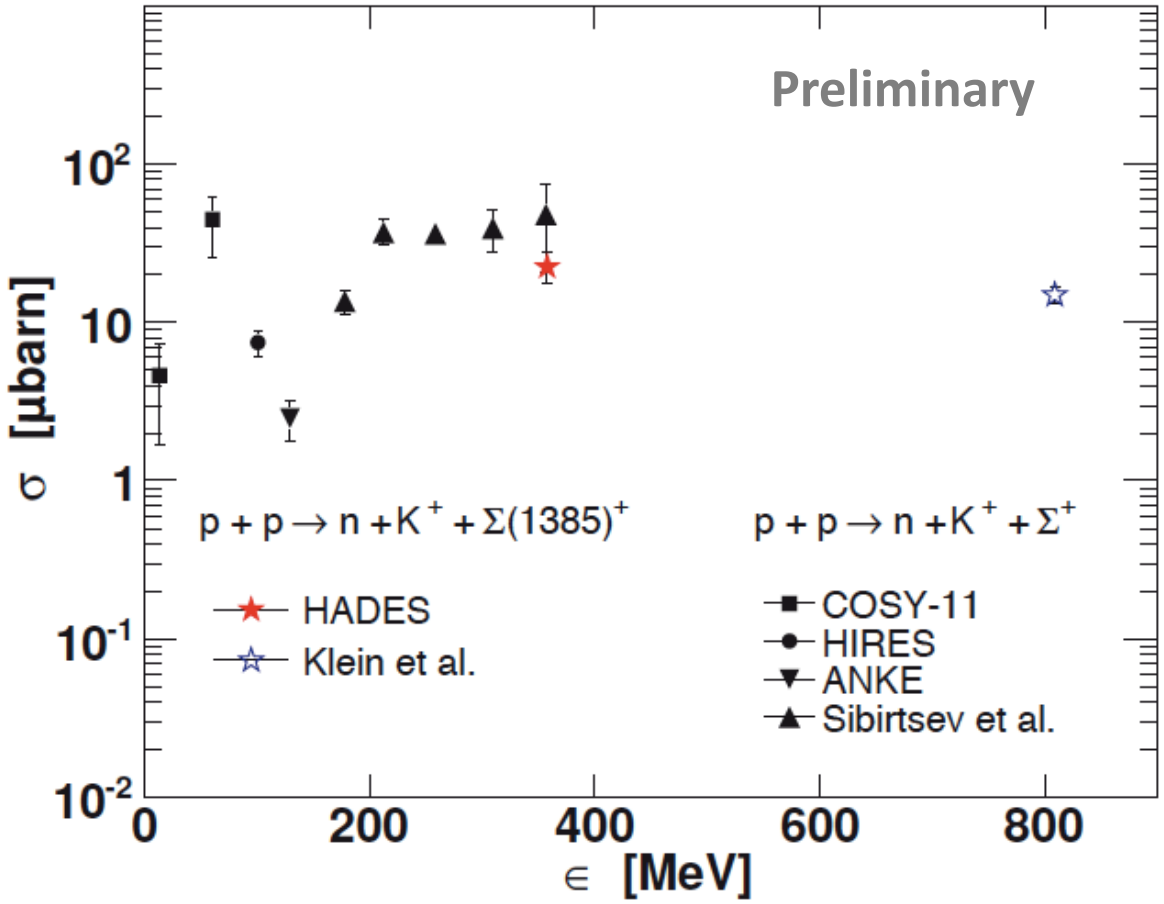
——— $\Delta^{++}$ Decay (30%)

Helicity Angles

All experimental angle distributions are reproduced by the model

Gottfried-Jackson Angles

# $\Sigma(1385)^+$: Cross Section

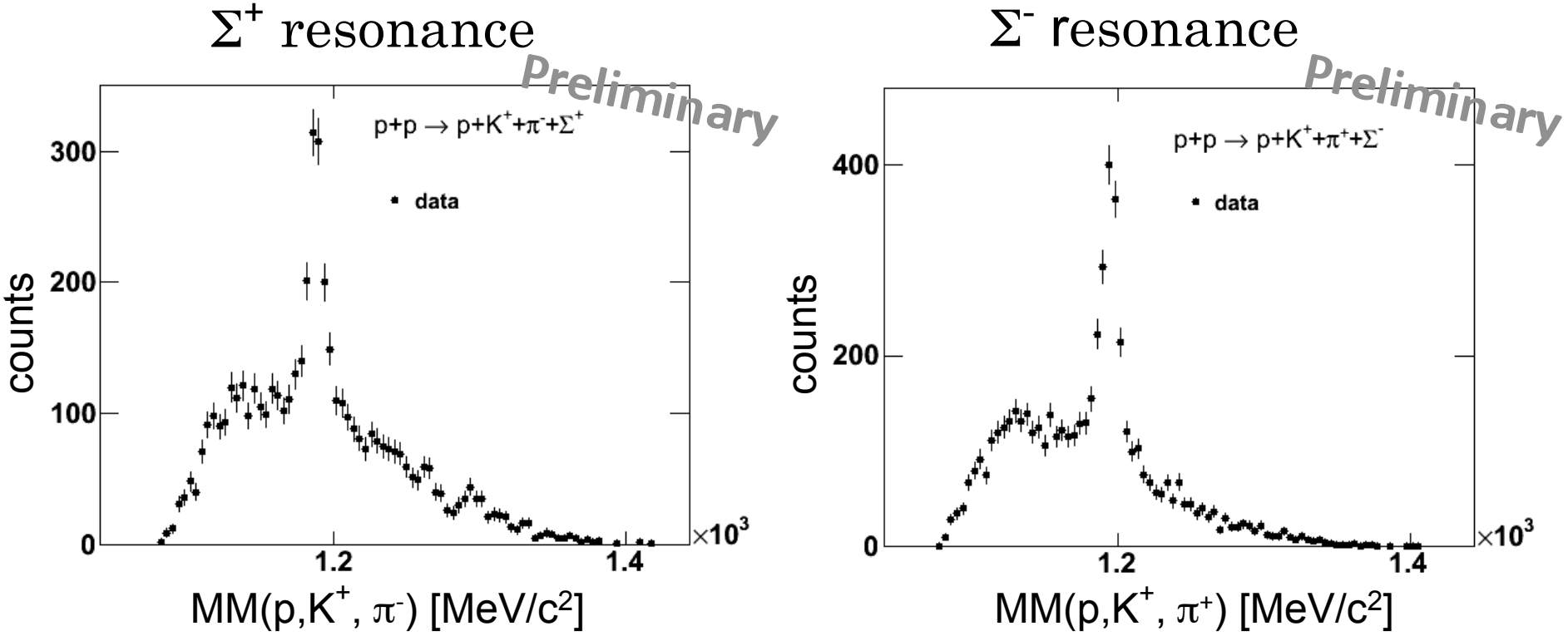


# The Λ(1405)

# Reconstruction of the $\Sigma^{+/-}$

$$p + p \rightarrow \Lambda(1405)/\Sigma(1385)^0 + p + K^+$$
$$\hookrightarrow \Sigma^{+/-} + \pi^{-/+}$$
$$\hookrightarrow n + \pi^{+/-}$$

PID cut + neutron missing mass cut



# Reconstruction of the $\Sigma^{+/-}$

$$p + p \rightarrow \Lambda(1405)/\Sigma(1385)^0 + p + K^+ \quad \Lambda(1405)/\Sigma(1385)^0 \rightarrow \Sigma^{+/-} + \pi^{-/+}$$

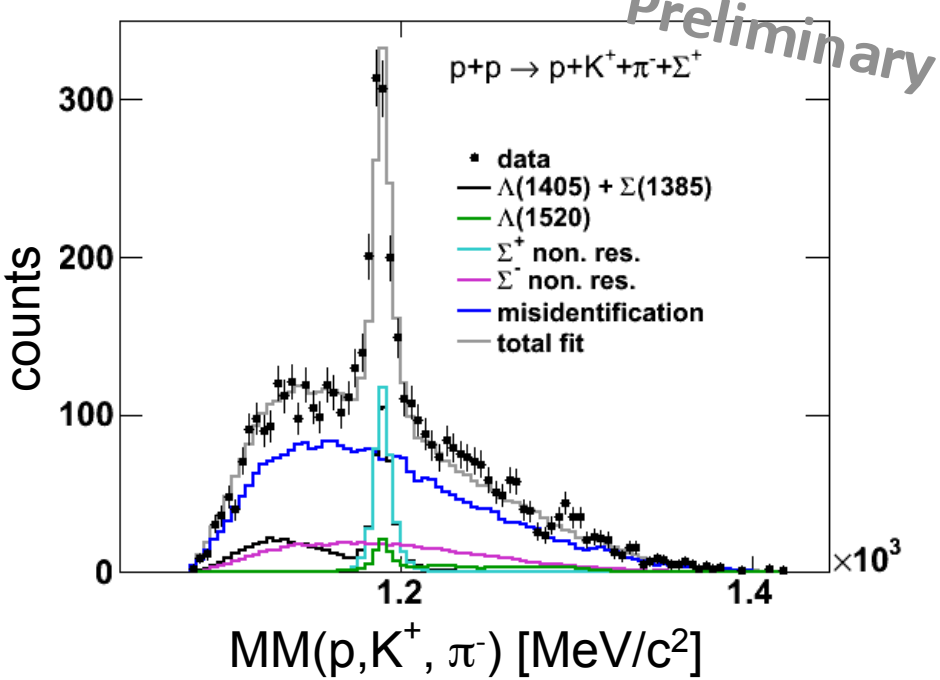
$$p + p \rightarrow \Lambda(1520) + p + K^+ \quad \Lambda(1520) \rightarrow \Sigma^{+/-} + \pi^{-/+}$$

$$p + p \rightarrow \Sigma^+ + p + K^+ + \pi^-$$

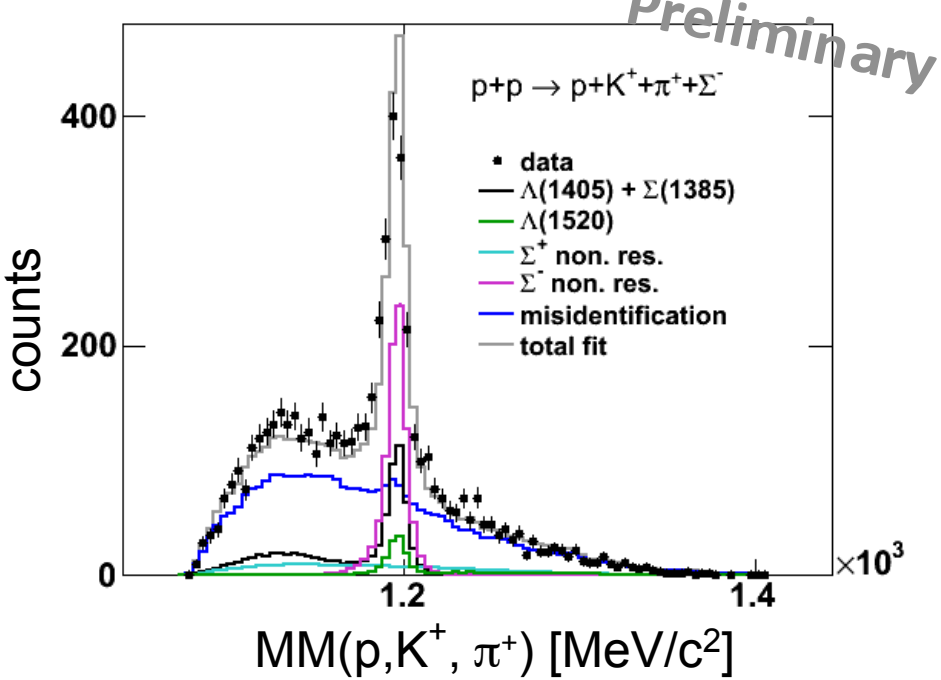
$$p + p \rightarrow \Sigma^- + p + K^+ + \pi^+$$

misidentification of p or $\pi^+$ as $K^+$

$\Sigma^+$ resonance




$\Sigma^-$ resonance



# Reconstruction of the $\Sigma^{+/-}$

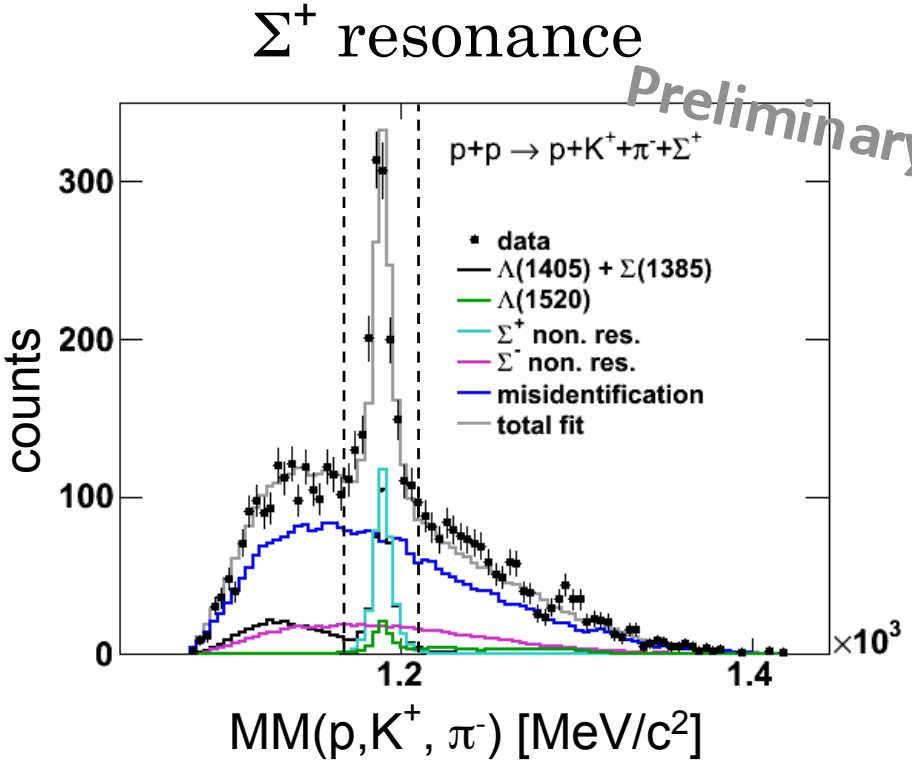
$$p + p \rightarrow \Lambda(1405)/\Sigma(1385)^0 + p + K^+ \quad \Lambda(1405)/\Sigma(1385)^0 \rightarrow \Sigma^{+/-} + \pi^{-/+}$$

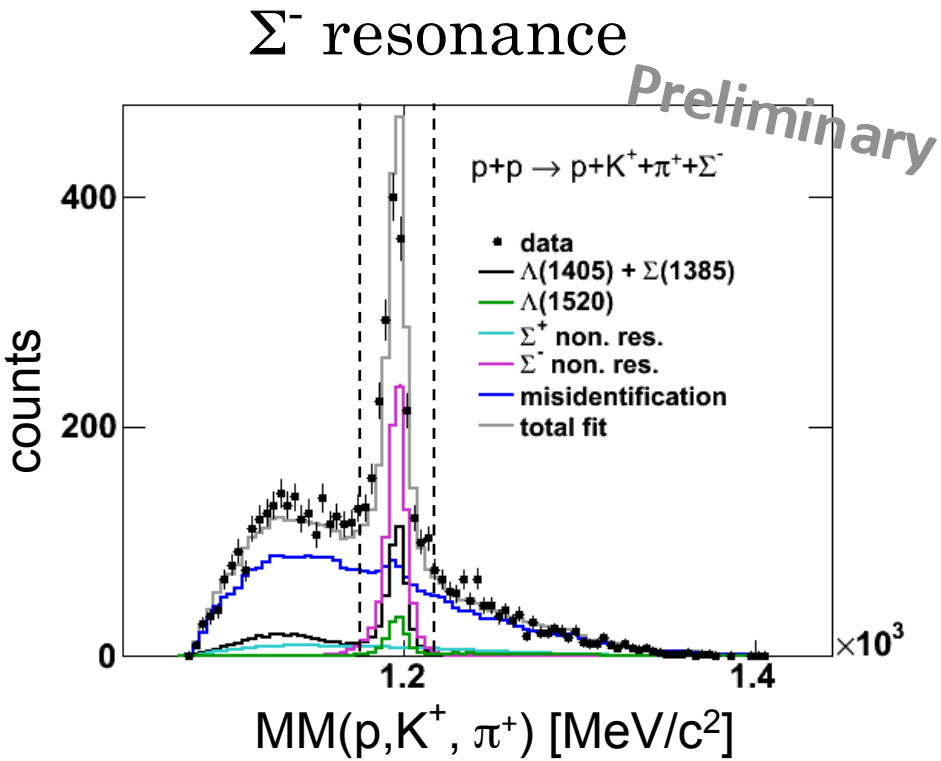
$$p + p \rightarrow \Lambda(1520) + p + K^+ \quad \Lambda(1520) \rightarrow \Sigma^{+/-} + \pi^{-/+}$$

$$p + p \rightarrow \Sigma^+ + p + K^+ + \pi^-$$

$$p + p \rightarrow \Sigma^- + p + K^+ + \pi^+$$

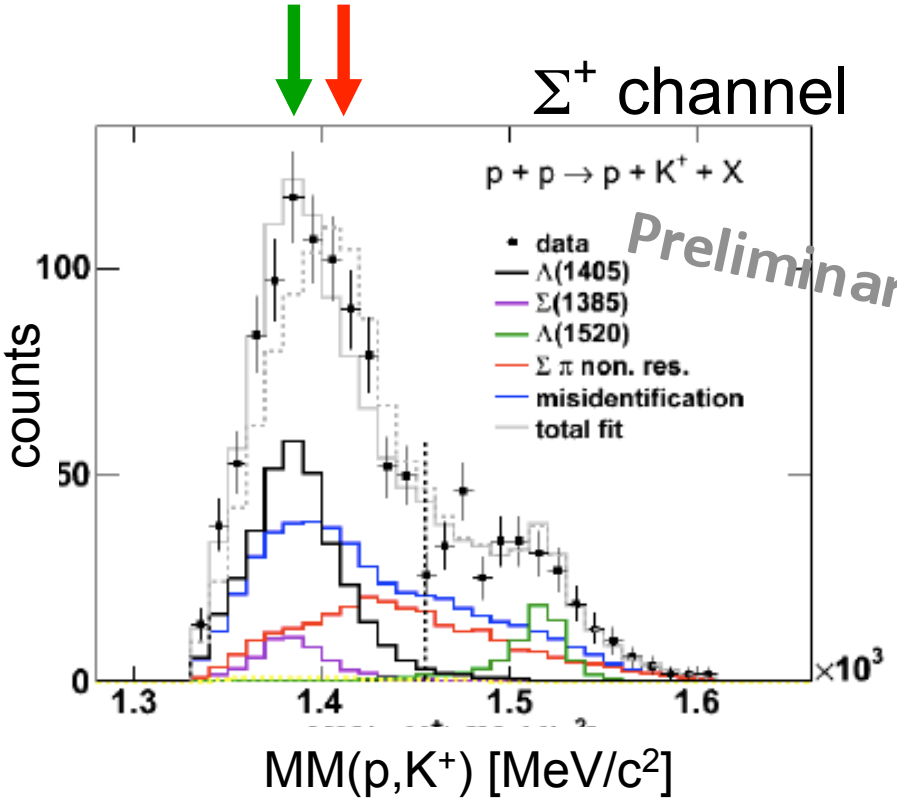
misidentification of p or $\pi^+$ as $K^+$

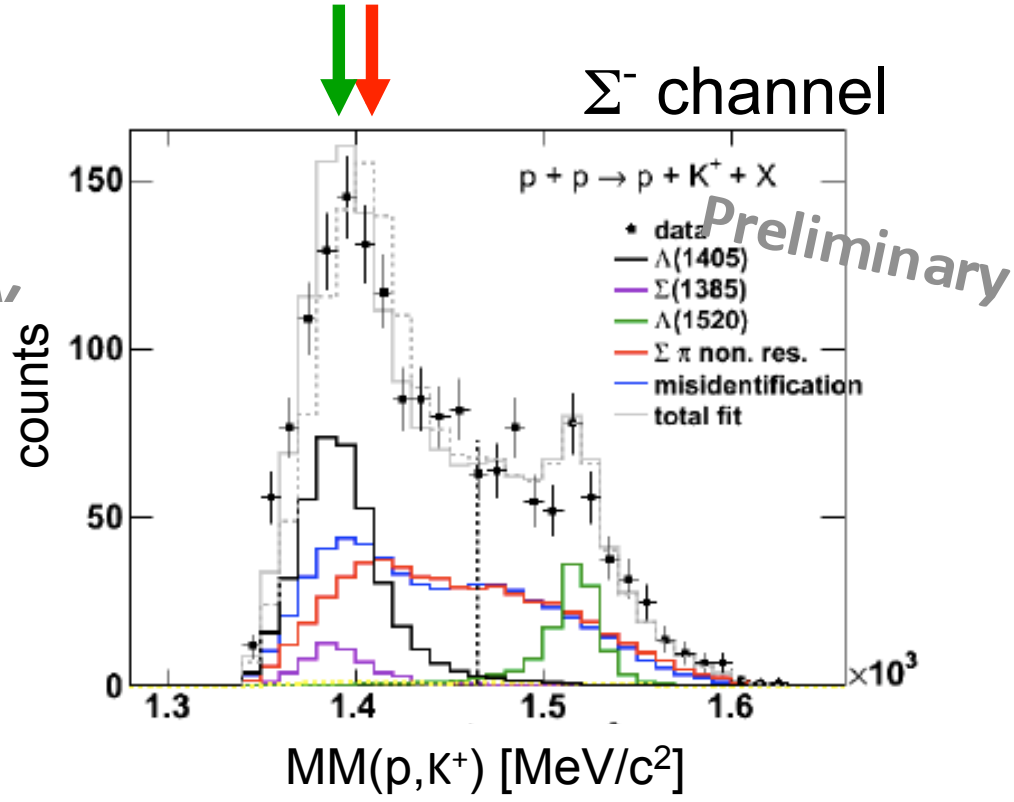


# The Λ(1405) Signal I

$$p + p \rightarrow \Lambda(1405)/\Sigma(1385)^0 + p + K^+$$

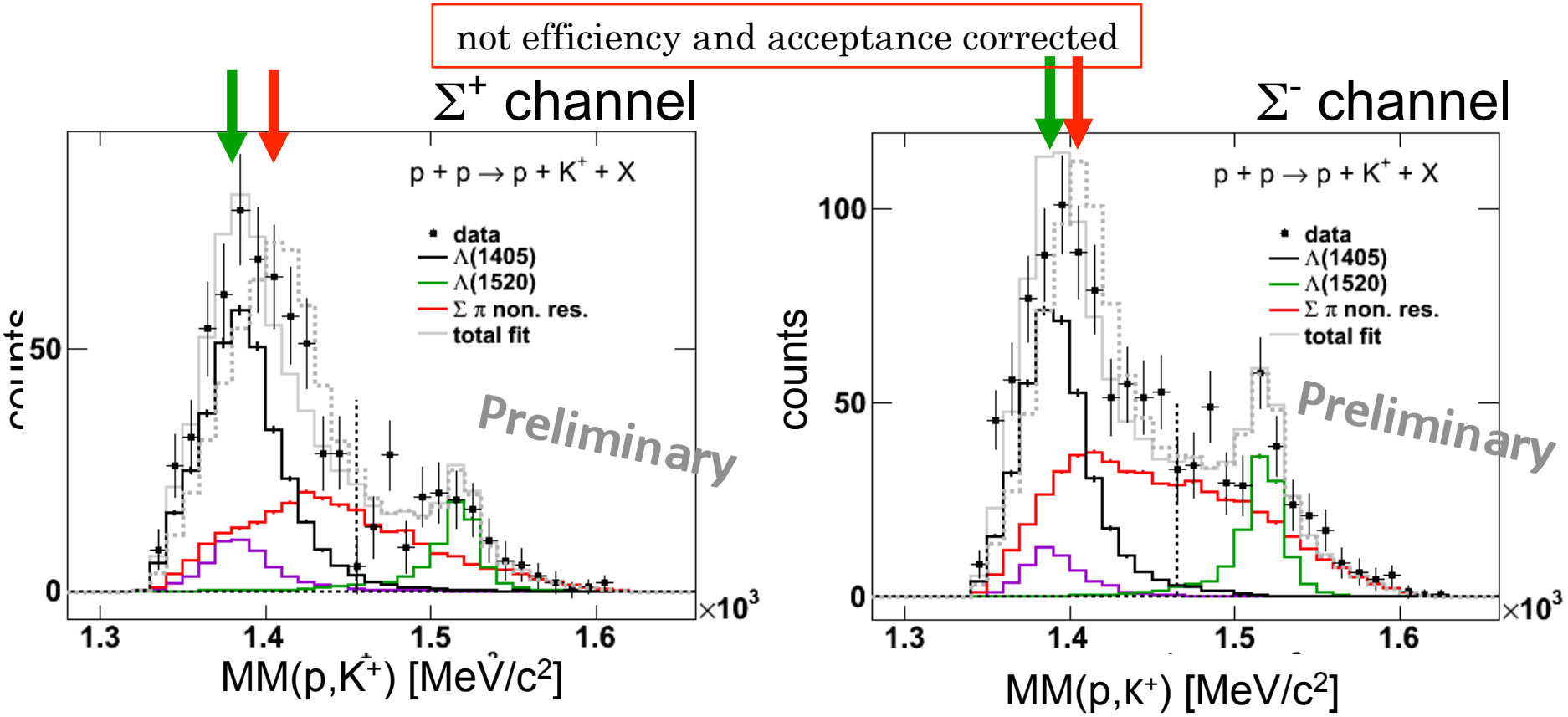



- Relative cross section: $\Sigma(1385)^0/\Lambda(1405) \approx 0.5\text{-}1.0$, extracted from analysis of $\Lambda(1405) \rightarrow \Sigma^0\pi^0$, $\Sigma(1385)^0 \rightarrow \Lambda\pi^0$
- $\Lambda(1405)$ simulated with a mass of 1405 and 1385 MeV/$c^2$

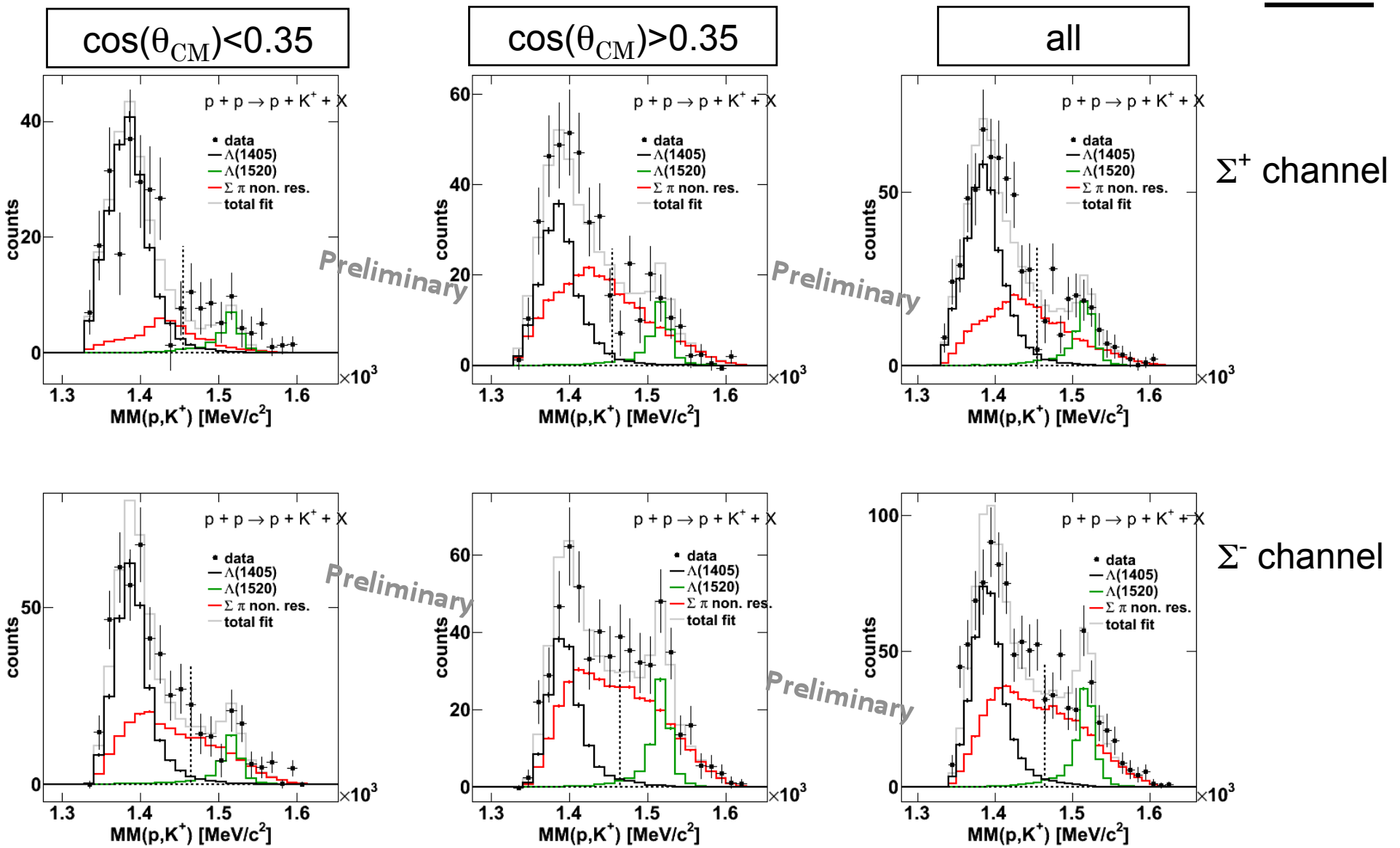
# The Λ(1405) Signal II

not efficiency and acceptance corrected

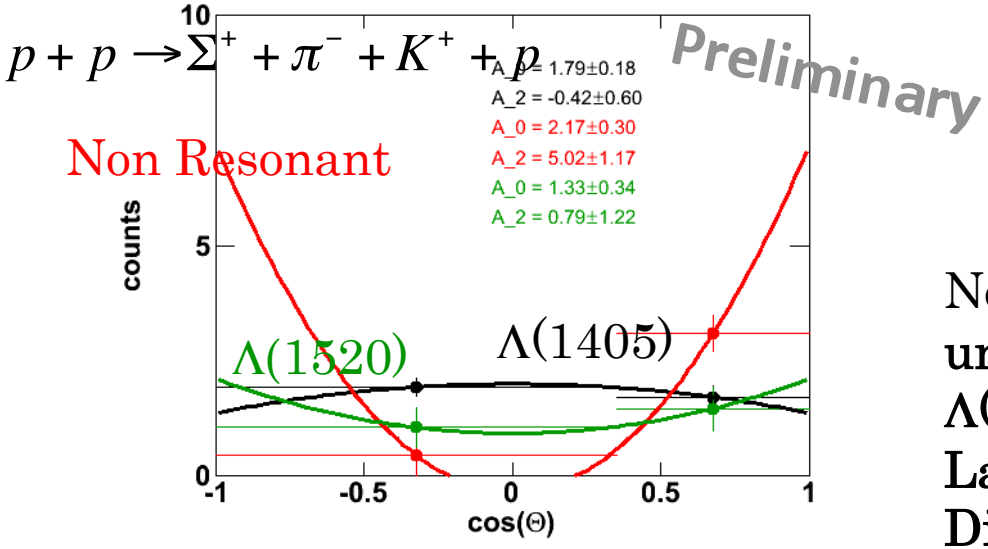


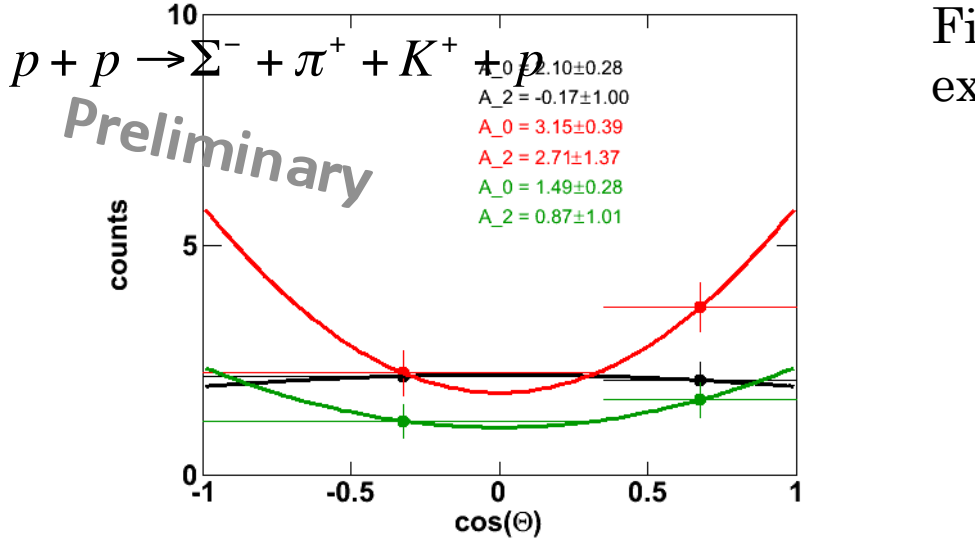

• Non-resonant channels are not subtracted, as interference effects are expected

# Differential Distributions



# Angular Distribution

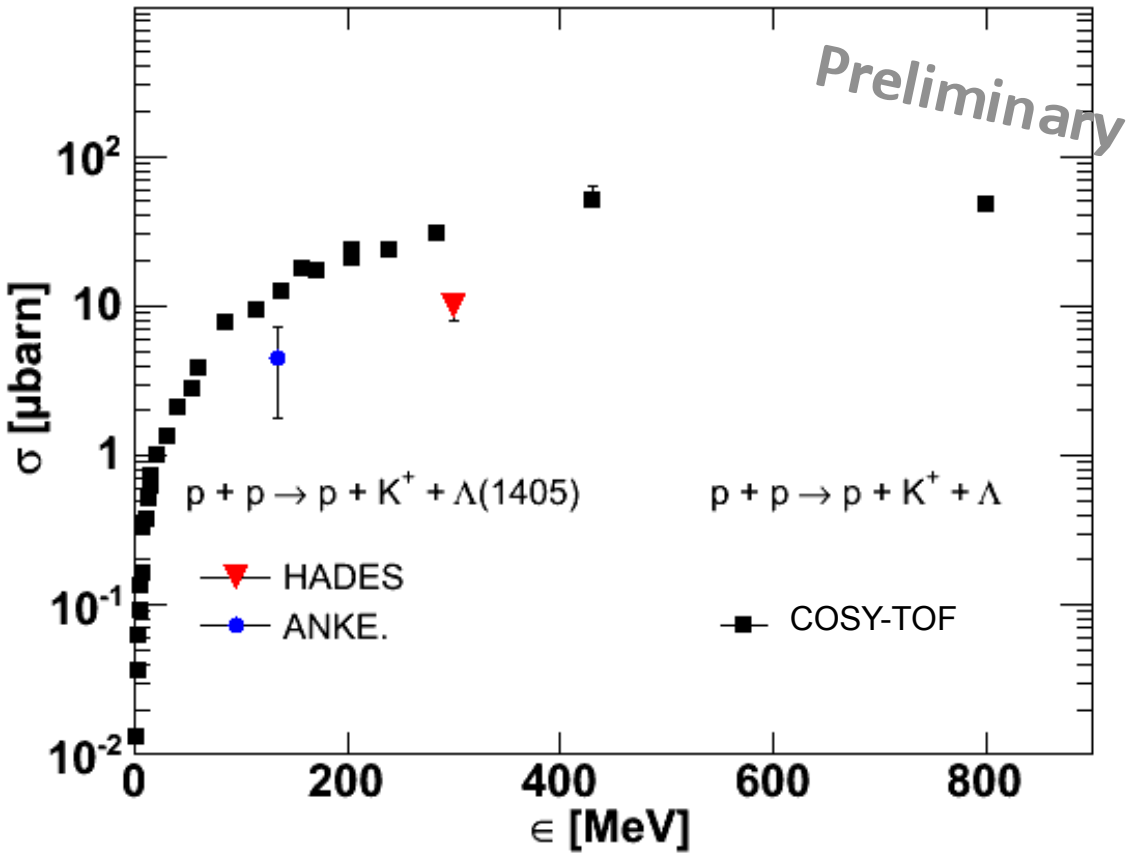



Non resonant is produced rather **unisotropic**.
**Λ(1405)** is produced more or less isotropic:
**Large Momentum Transfer?**
**Differently from the Σ(1385)⁺**

Filter the non resonant simulations by the extracted differential cross sections.

# Λ(1405): Cross Section

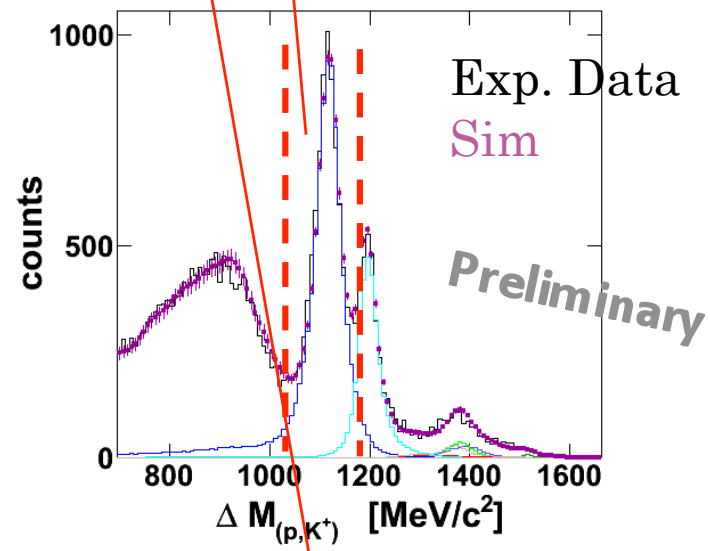


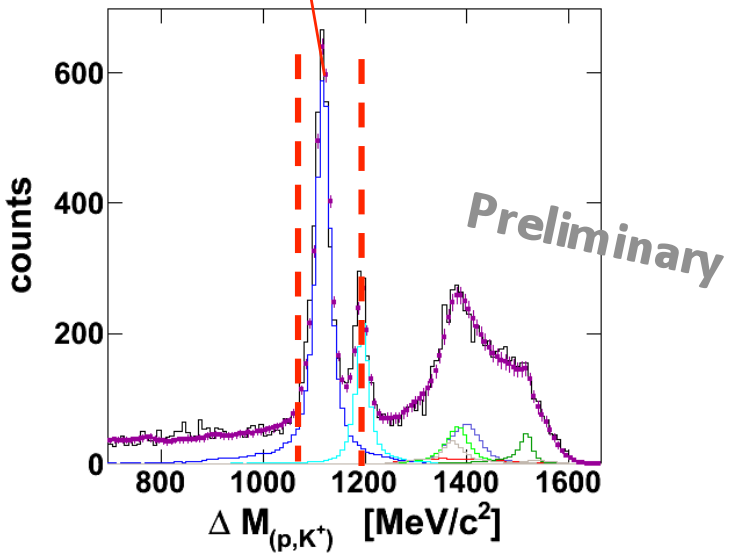


I. Zychor et al. (ANKE) Phys. Lett. B660 167 (2008)
II. M. Abdel-Bary et al. (COSY-TOF) Eur. Phys. J. A46 27 (2010)

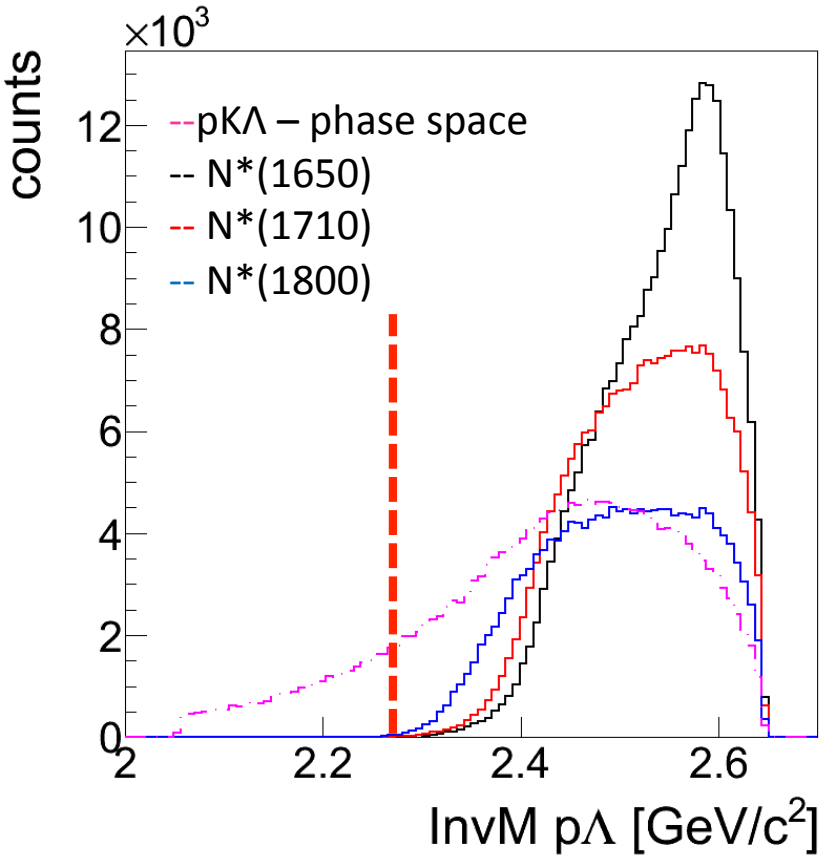
# ppK$^-$ Analysis

$p + p \rightarrow pK^+\Lambda$



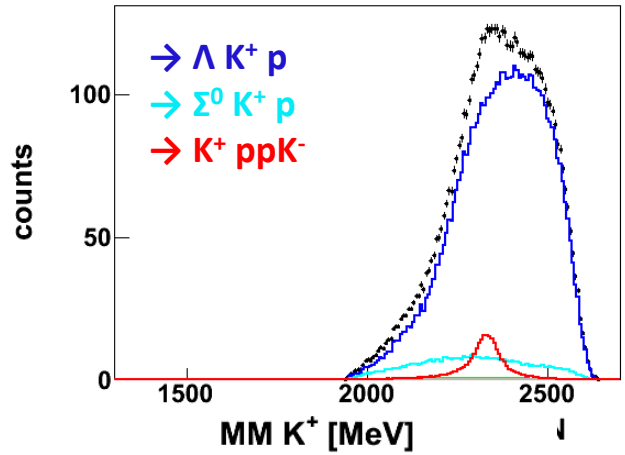

WITH CUT 15º<θ<85º

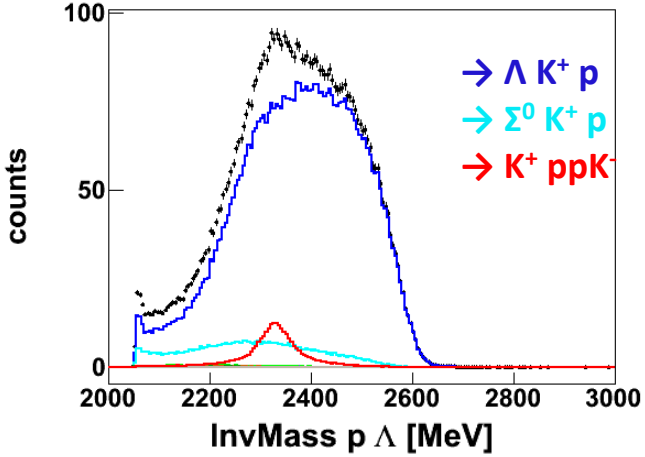


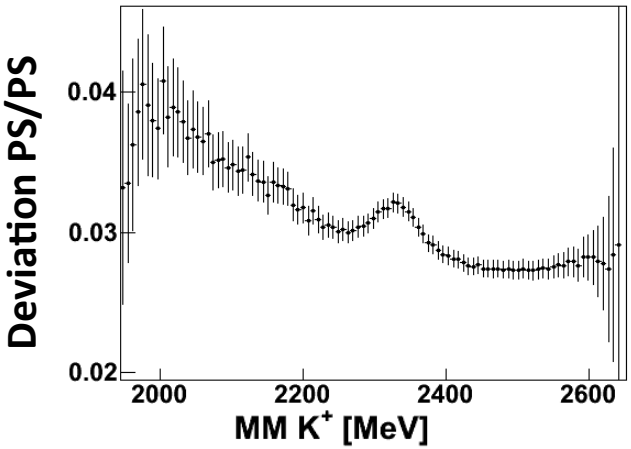

**DISTO Bump**

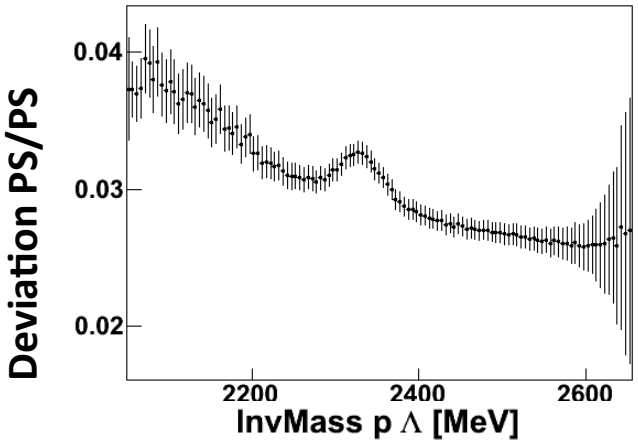
# Deviation Plot I: Phase Space

**Simulation!** ppK$^-$@ 2270 MeV/c$^2$, Γ= 60MeV/c$^2$



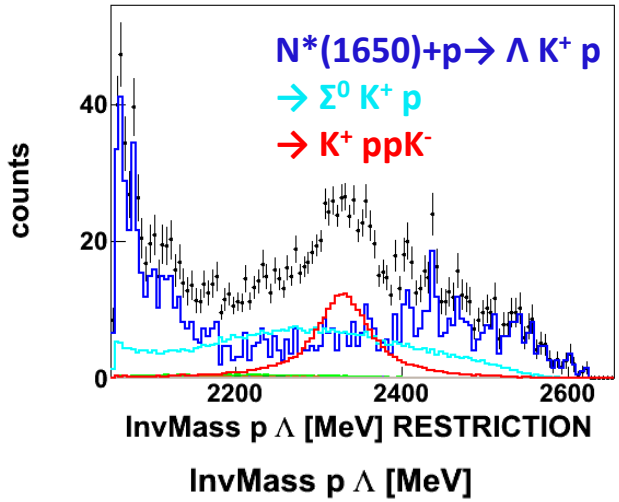



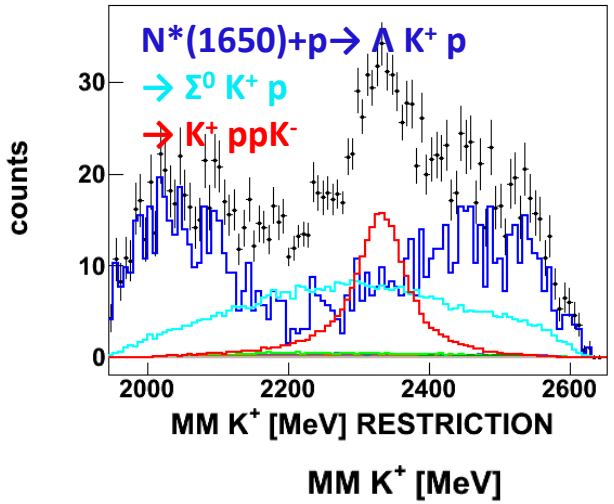



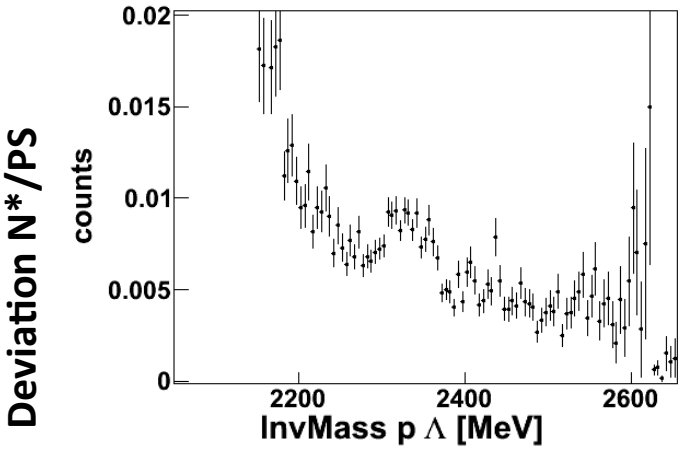



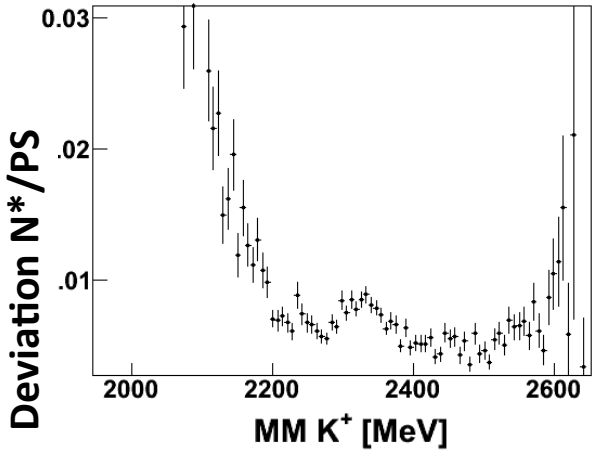
# Deviation Plot II: N*(1650)

**Simulation!** ppK$^-$@ 2270 MeV/c$^2$, Γ= 60MeV/c$^2$




The contribution of the N* should not effect the deviation plot

# Summary and Outlook

p(3.5GeV)+p:

✔ Λ(1405)

- Spectral Shape
- Angular Distributions
- Cross-Section

✔ Σ(1385)

- Spectral Shape
- Angular Distributions
- Cross-Section
- Contribution to Λ(1405) spectrum

ppK-

•Description of the pKΛ angular distribution accounting for the N* contribution

•Analysis of the deviation spectra.

KN Interaction ???