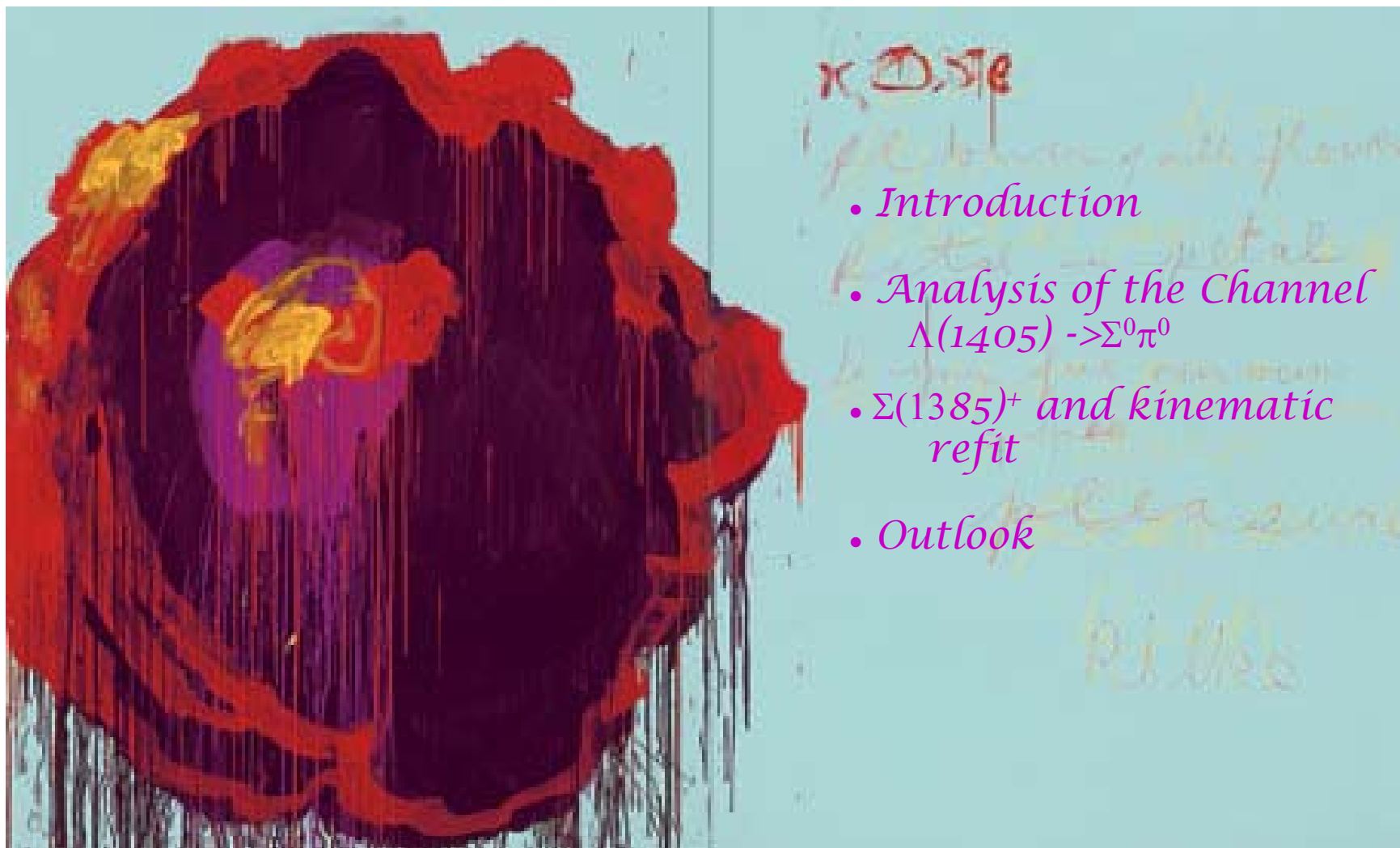


Study of the $\Lambda(1405)$ Resonance in Proton Induced Reactions

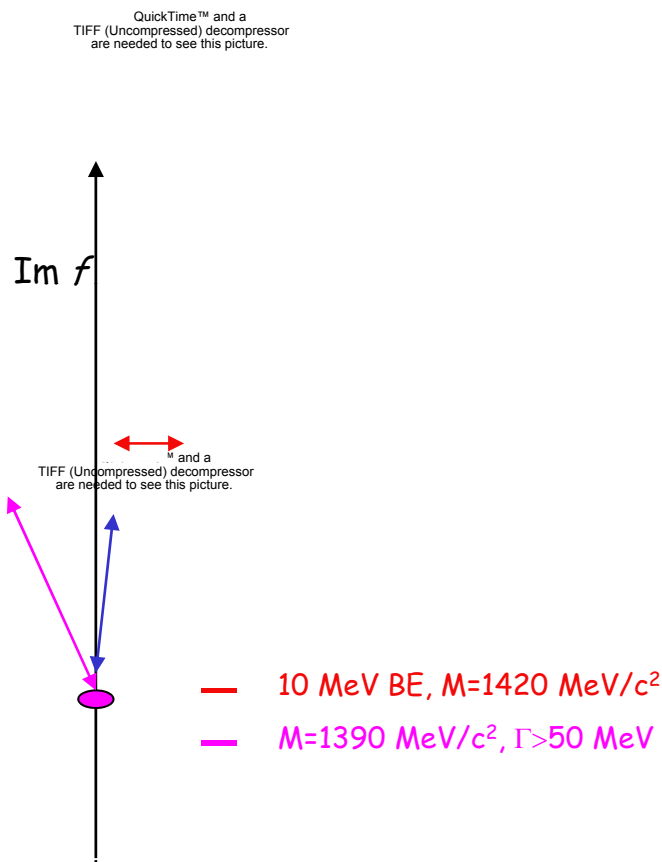
Laura Fabbietti
 Excellence Cluster 'Universe' TU-München
 HADES Collaboration



Cy Twombly

$\Lambda(1405)$

How many poles?

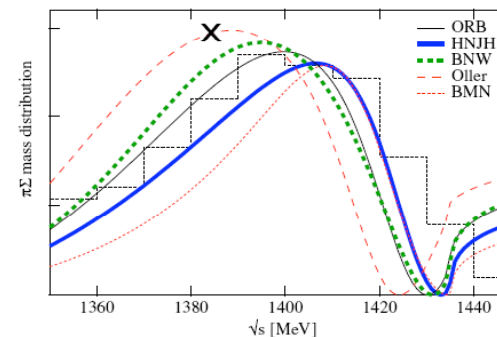


T. Hyodo et al., *Mod. Phys. Lett A* 23 (2008) 2393
 V.K. Magas et al. *Phys. Rev. Lett.* 95(5):052301 (2005)

Can we measure $\Lambda(1405)$ with HADES?

R.J. Hemingway et al., *Nucl. Phys. B* 253 (1985) 742

$\pi\Sigma$ mass spectrum



$K^-+p@4.2\text{GeV}/c$

I. Zychor et al *nucl-exp/0705.1039v2*

$p+p@2.8\text{GeV}/c$

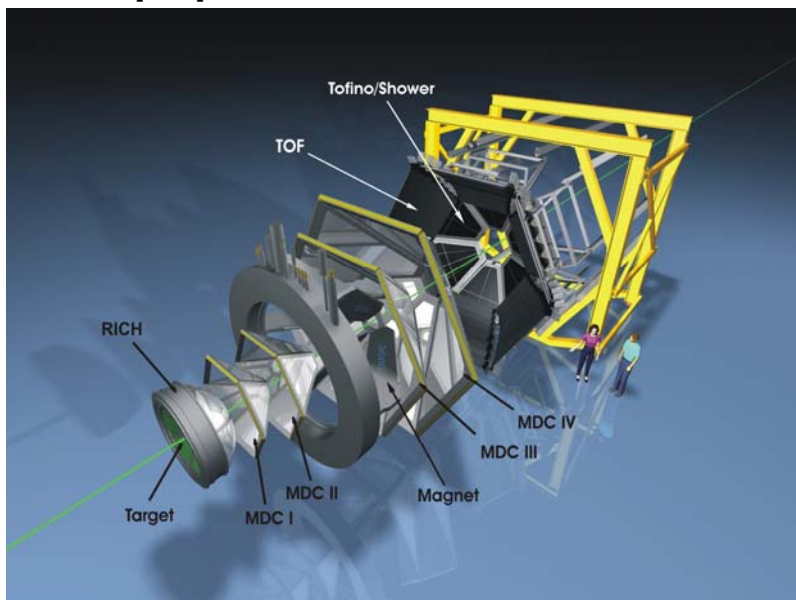
~1400 Counts from KLOE

$\Lambda(1405) \rightarrow \Sigma^0 \pi^0$ Different?

$\rightarrow \Sigma^\pm \pi^\mp$

J.C. Nacher et al., *Phys. Lett.* B455 (1999) 55-61

p+p@3.5GeV



Missing Mass of (K^+, p)

- $p + p \rightarrow \Lambda^0(1116) + K^+ + p$
 - $p + p \rightarrow \Sigma^0(1193) + K^+ + p$
 - $p + p \rightarrow \Sigma^0(1385) + K^+ + p$
 - $p + p \rightarrow \Lambda^0(1405) + K^+ + p$
- clear distinguishible
- 2 nearby resonances ($\Delta M = 20 \text{ MeV}/c^2$)
 $\Gamma = 36\text{-}50 \text{ MeV}/c^2$

No Start-Detector
 Leading Particle Methode

$$\Delta p/p \approx 3\%$$

$$18^\circ < \theta < 85^\circ$$

$$\approx 2\pi \text{ in } \phi$$

$1.2 \cdot 10^9$ LVL1 Trigger Events

$$\sigma_{\Lambda(1405)} \approx 10 \mu\text{b}$$

$$\sigma_{pp} \approx 42 \text{ mb}$$

Decay Channel	p and K^+ in acceptance	4 particles in acceptance	Total Expected
	5.7%	0.9%	2500
$\Sigma^- + \pi^+$	5.7%	0.33%	450
$\Sigma^+ + \pi^-$ $\rightarrow p + \pi^0$	6 %	1.2%	1600
$\Sigma^+ + \pi^-$ $\rightarrow n + \pi^+$	4.3%	0.12%	400

$$\Sigma^0 + \pi^0$$

Hadron identification with HADES

Energy loss per distance travelled of swift charged particles traversing matter (dE/dx)

$$\beta = v / c$$

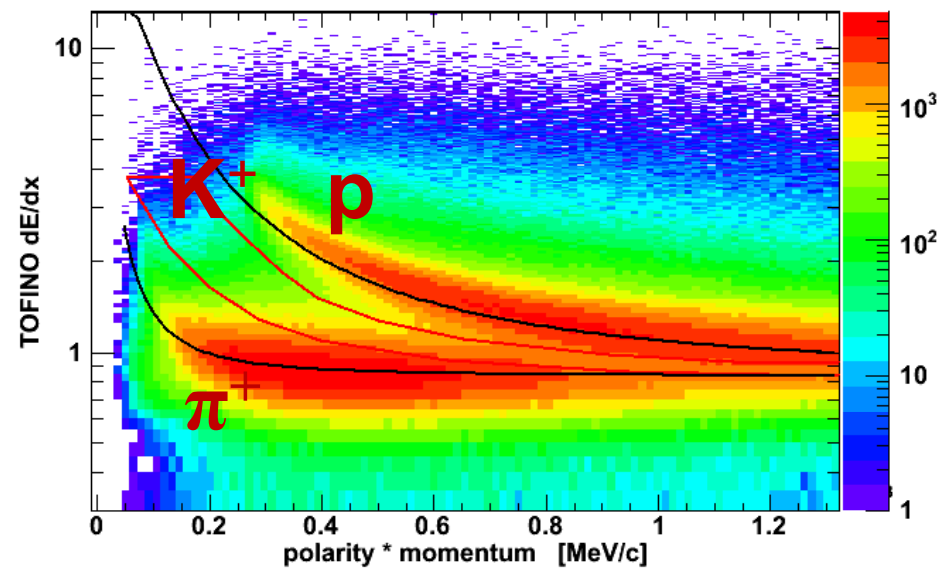
$$-\frac{dE}{dx} = \frac{4\pi}{m_e c^2} \cdot \frac{nz^2}{\beta^2} \cdot \left(\frac{e^2}{4\pi\epsilon_0}\right)^2 \cdot \left[\ln \left(\frac{2m_e c^2 \beta^2}{I \cdot (1 - \beta^2)} \right) - \beta^2 \right]$$

I mean excitation potential of the target

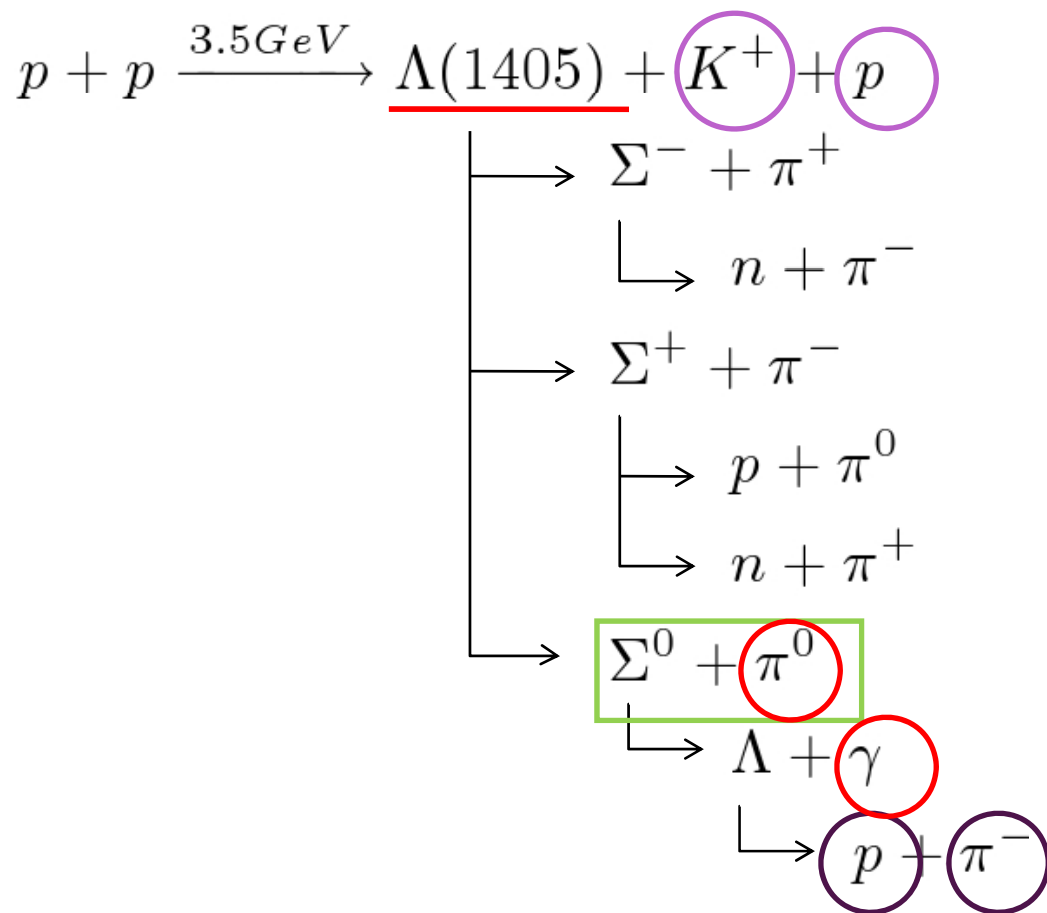
x distance travelled by the particle

n electron density of the target

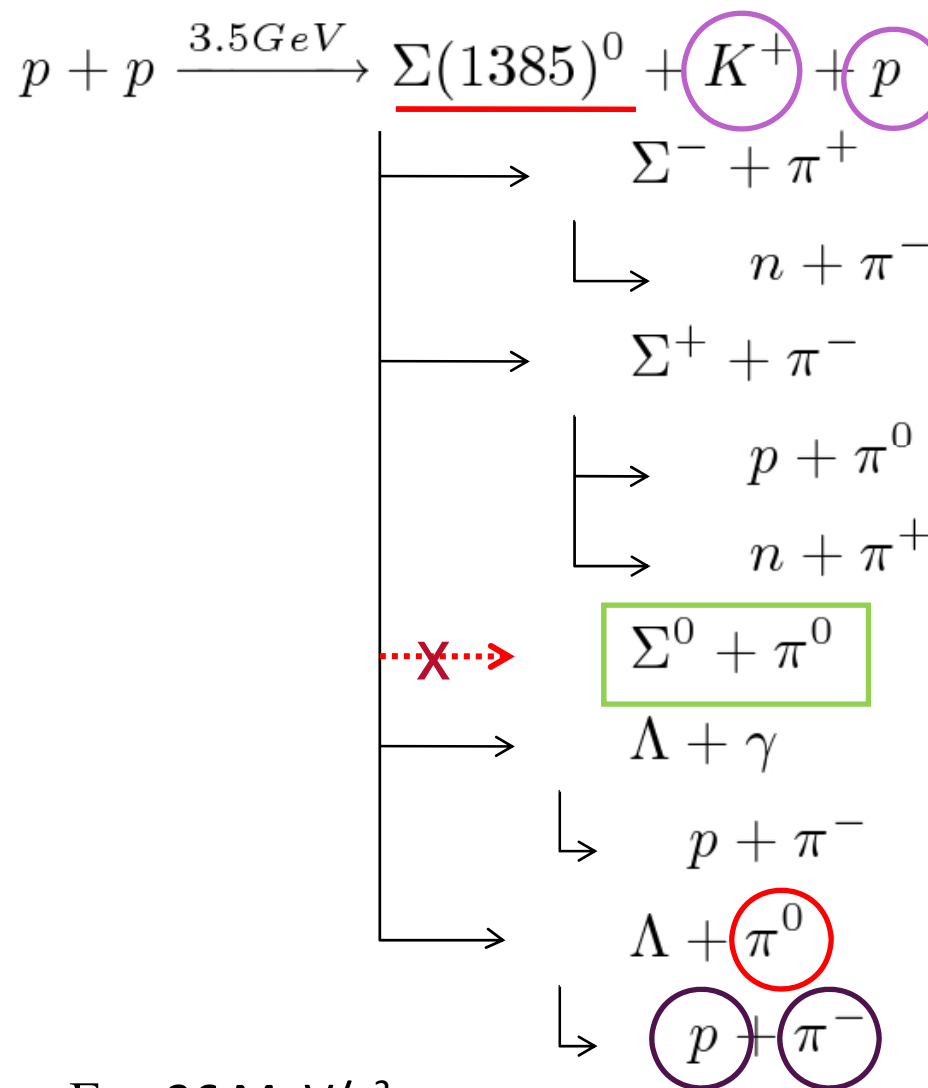
dE/dx and p are measured by the Detector



Decay channels of $\Lambda(1405)$ / $\Sigma(1385)^0$

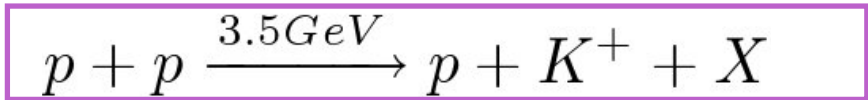


$\Gamma \approx 50 \text{ MeV}/c^2$

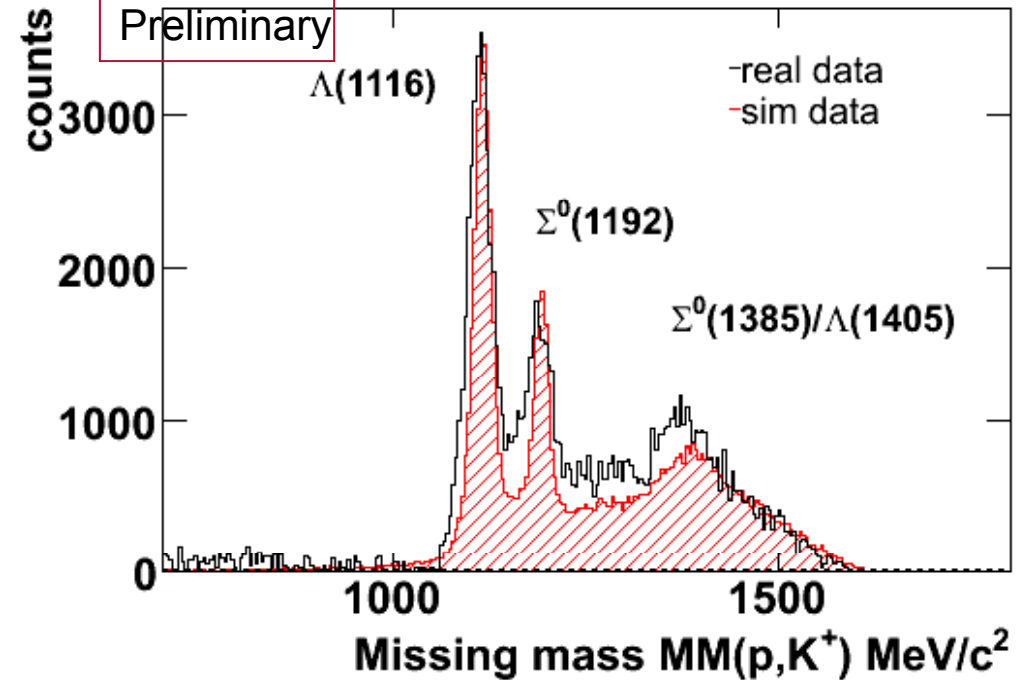
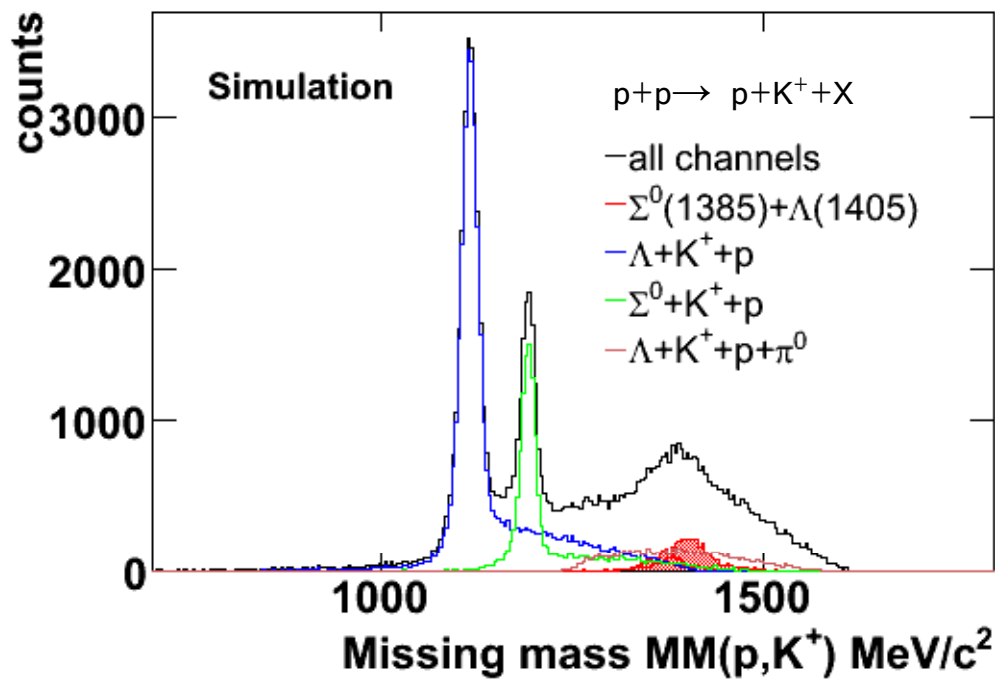


$\Gamma \approx 36 \text{ MeV}/c^2$

Missing mass analysis



Simulation



Landolt Börnstein tables Group I Volume 12

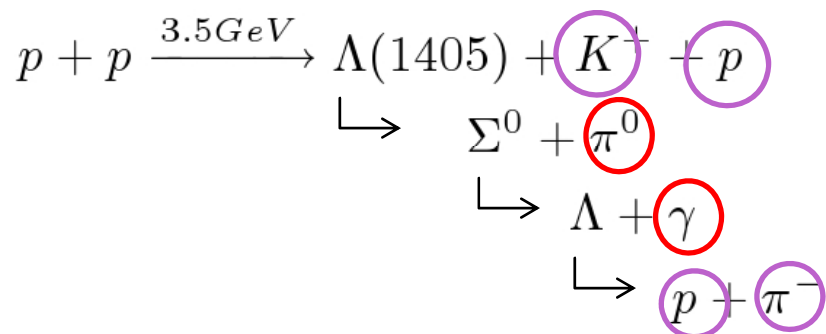
Event Generator **PLUTO**

→ **GEANT**

Digitizer Analysis of simulated events with

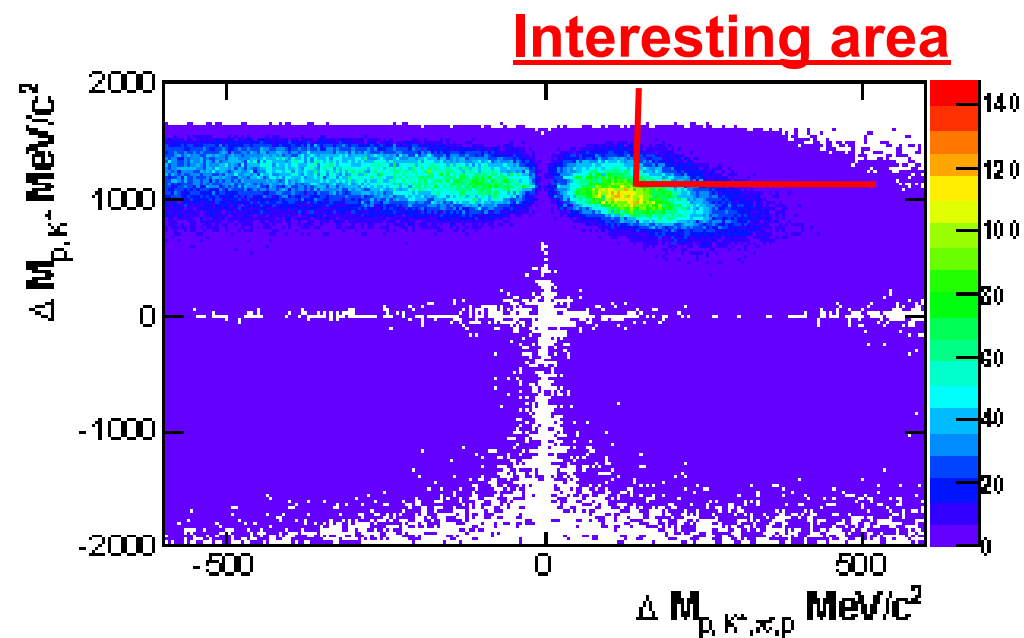
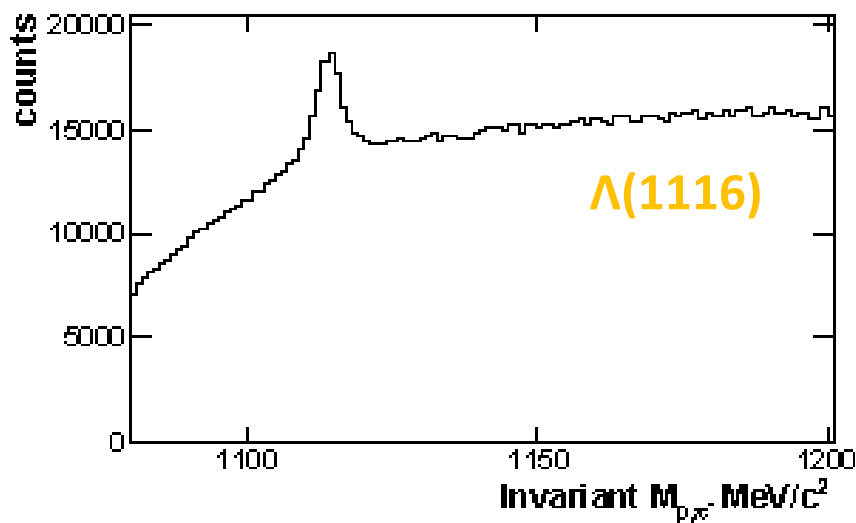
strangeness content

Analysis of the Λ (1405)

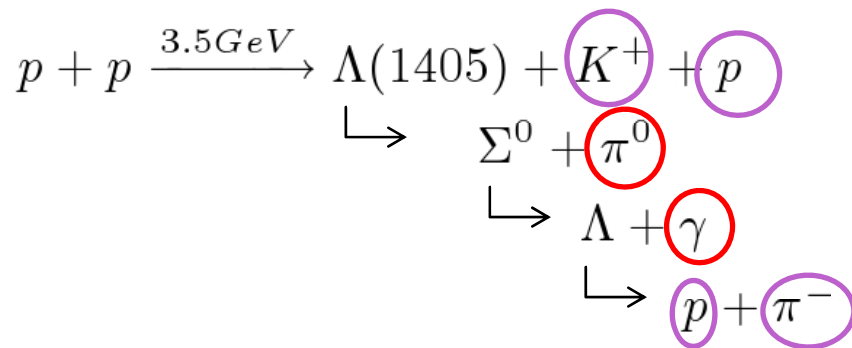


All Events with: p_1, π^-, p_2 and K^+

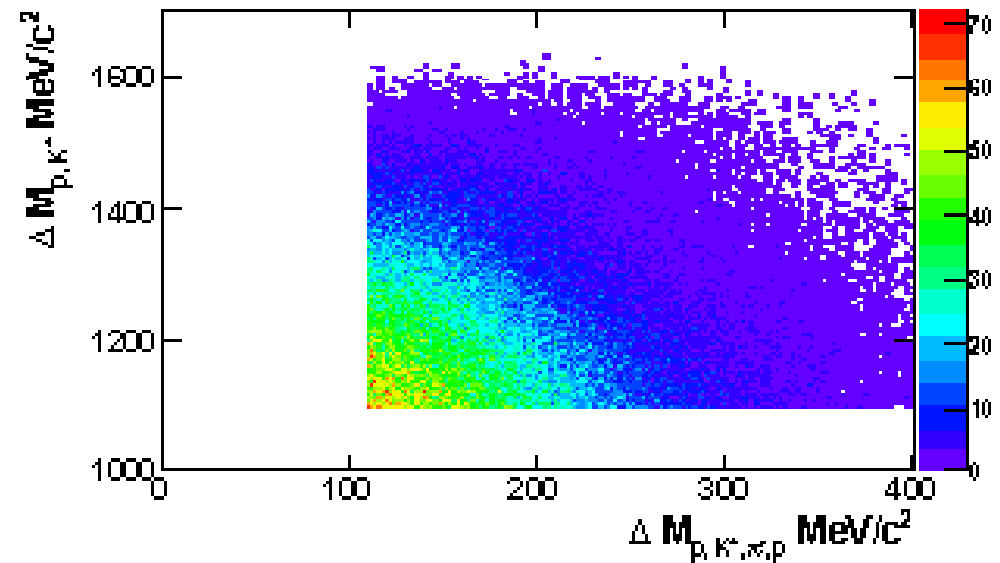
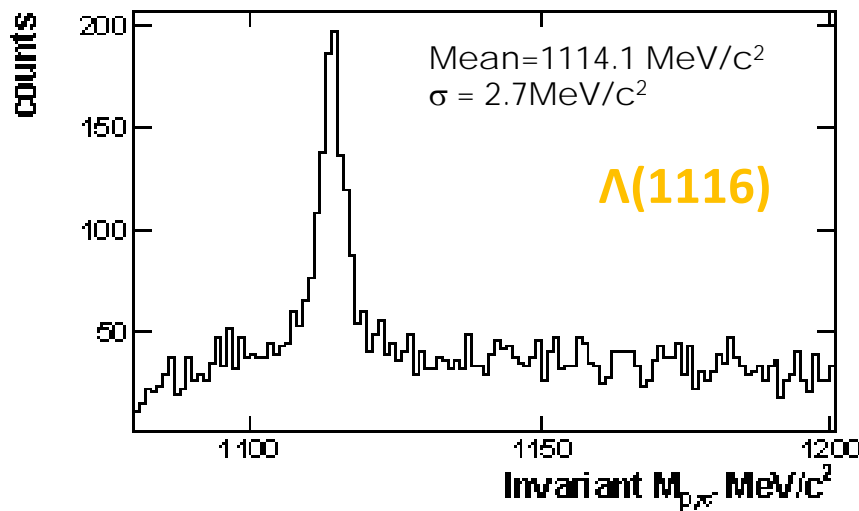
- cuts on primary Vertex
- track quality cuts
- cuts on $\Lambda(1116)$ [mass and track cuts]
- cuts on missing mass of all charged particles [$> \pi^0 \gamma$]
- cuts on the K^+ mass



Analysis of the Λ (1405)

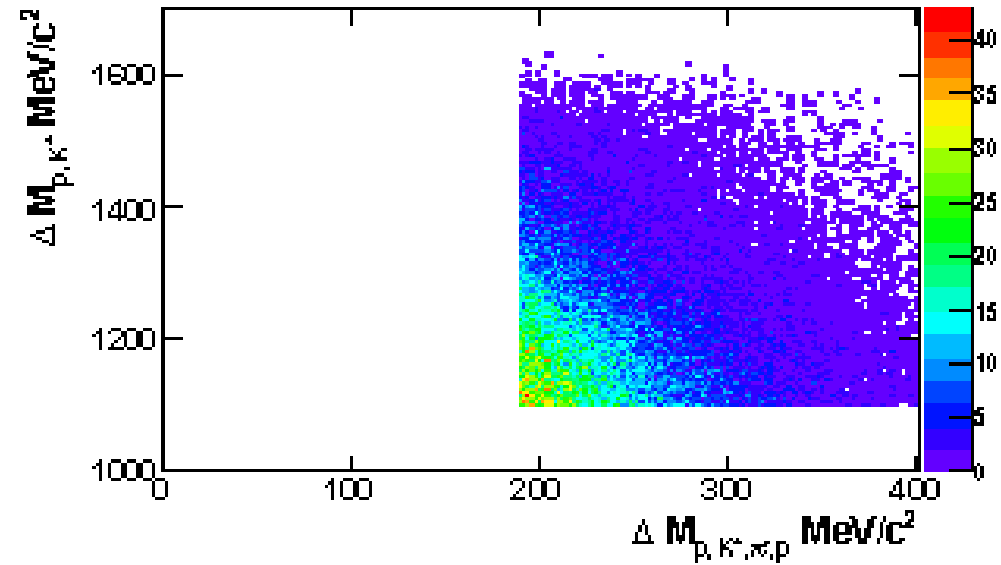
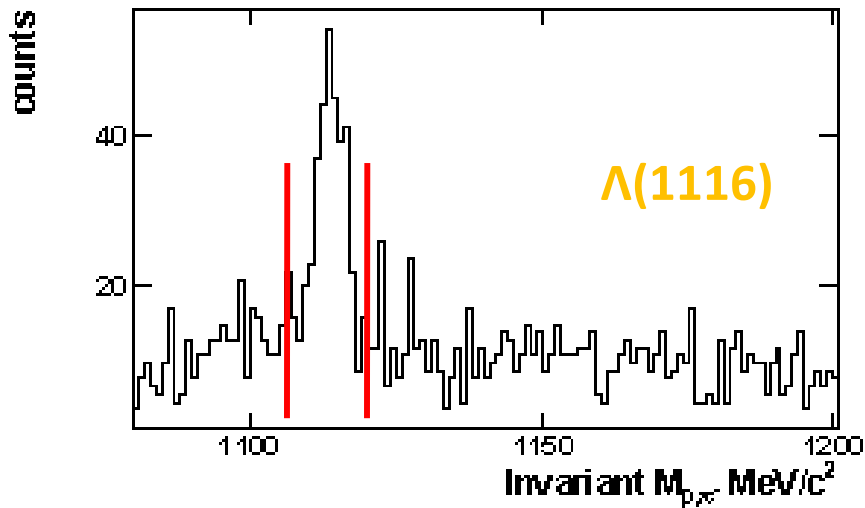
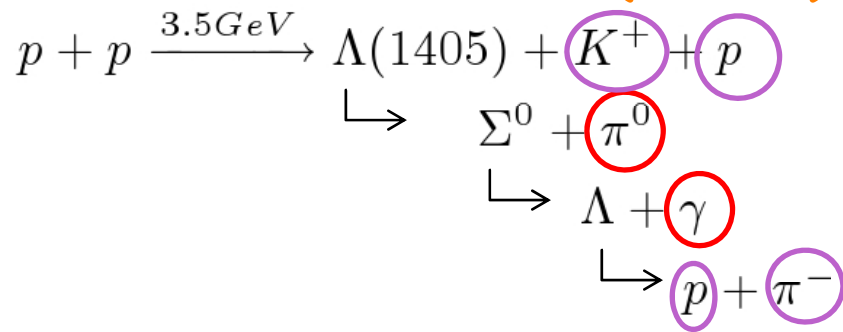


Reduce background from the $\Lambda(1116)$ signal to tune the $\Lambda(1116)$ track cuts on these pure Λ 's



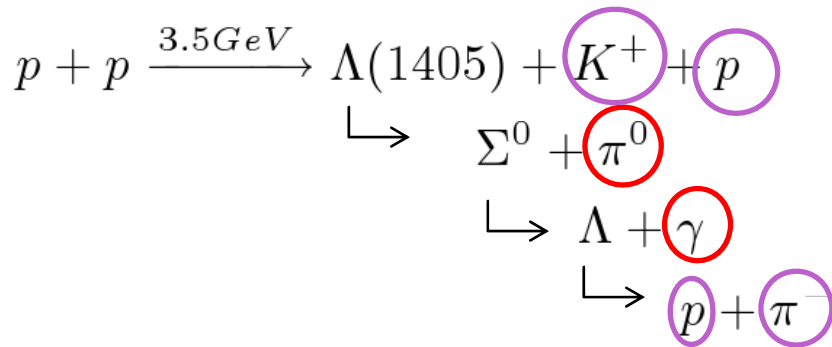
- cut on $\Delta M(pK^+) > 1100 \text{ MeV}/c^2$
- cut on $\Delta M(p_1,K^+,p_2,\pi^-) > 100 \text{ MeV}/c^2$

Analysis of the Λ (1405)

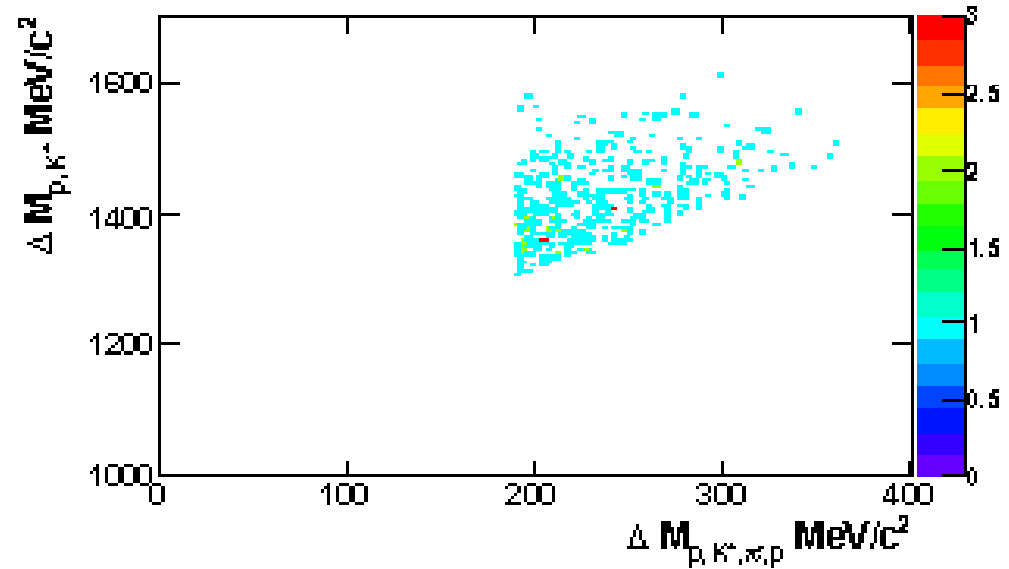
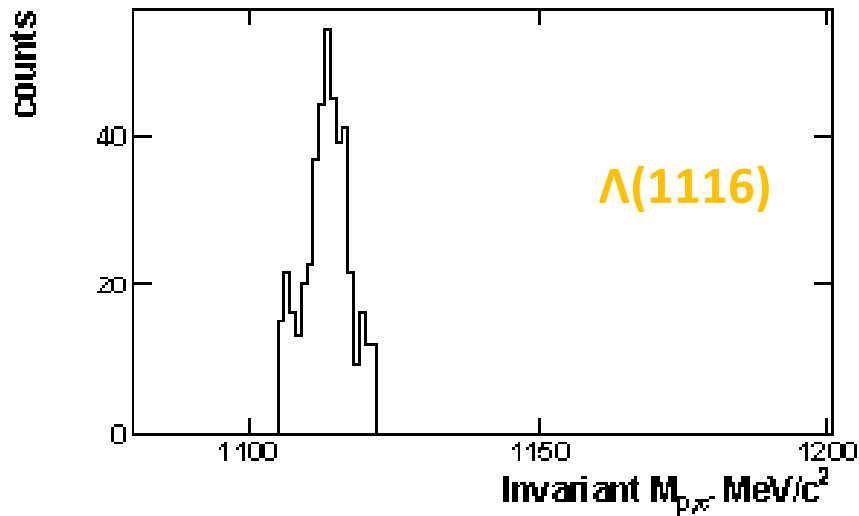


- cut on $\Delta M(pK^+) > 1100 \text{ MeV}/c^2$
- cut on $\Delta M(p_1, K^+, p_2, \pi^-) > 100 \text{ MeV}/c^2$
- Λ (1116) track cuts
- cut on $\Delta M(p_1, K^+, p_2, \pi^-) > 200 \text{ MeV}/c^2$

Analysis of the Λ (1405)



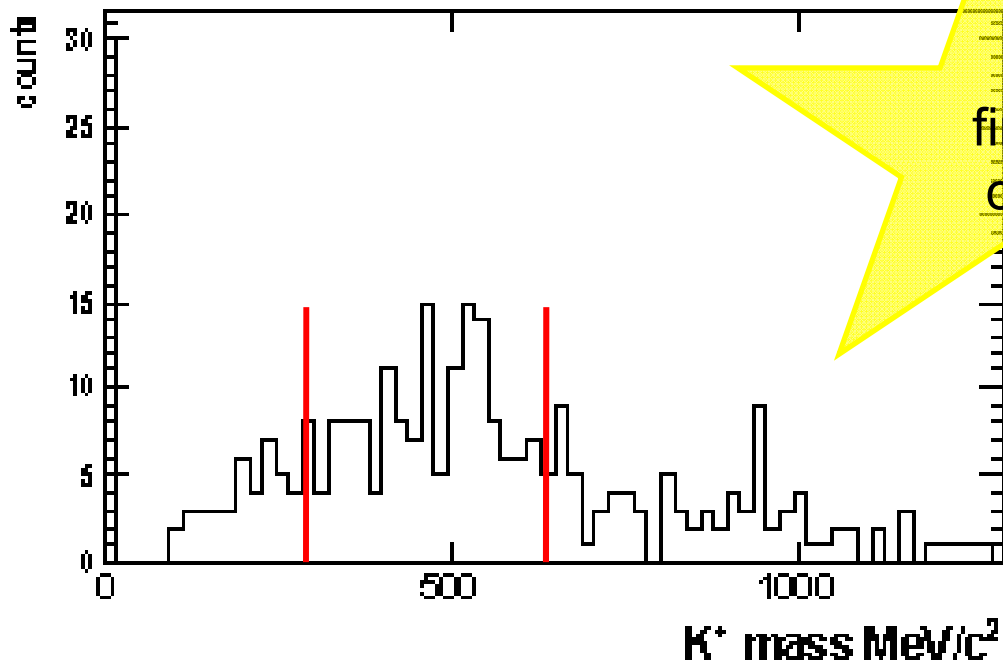
Final cut on the Λ (1116) mass



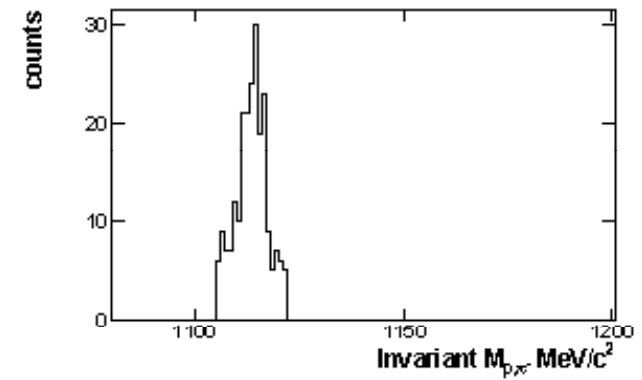
- cut on $\Delta M(pK^+) > 1100 \text{ MeV}/c^2$
- cut on $\Delta M(p_1, K^+, p_2, \pi^-) > 100 \text{ MeV}/c^2$
- Λ (1116) track cuts
- cut on $\Delta M(p_1, K^+, p_2, \pi^-) > 200 \text{ MeV}/c^2$

Analysis of the Λ (1405)

Mass Cut for K^+

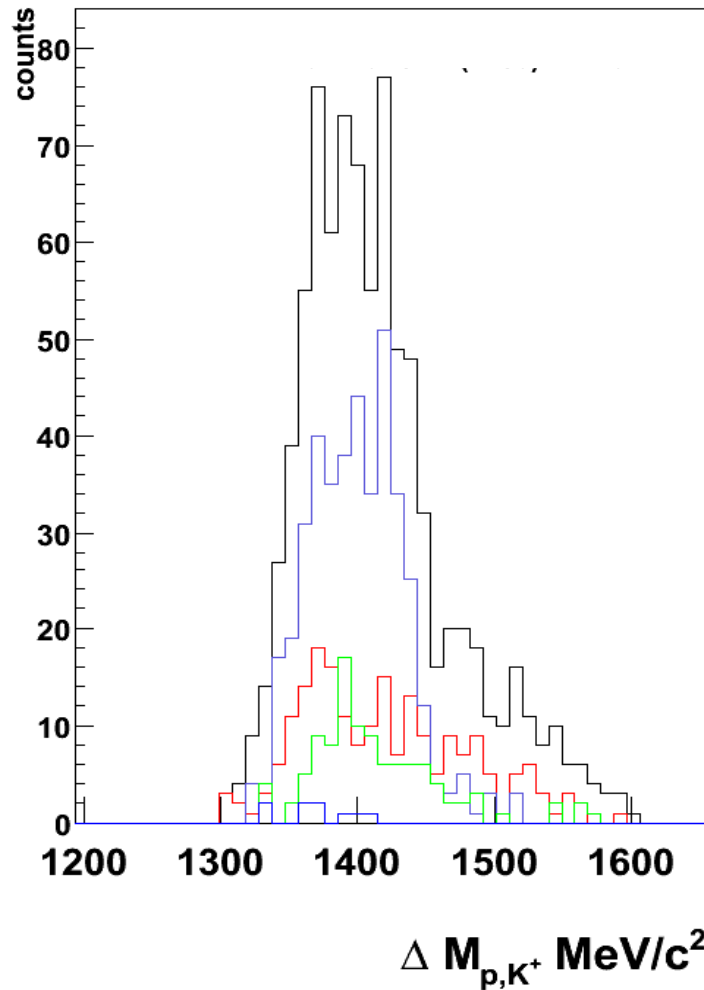


Λ Cut



mass seems to be quite broad
 \rightarrow needs to be investigated

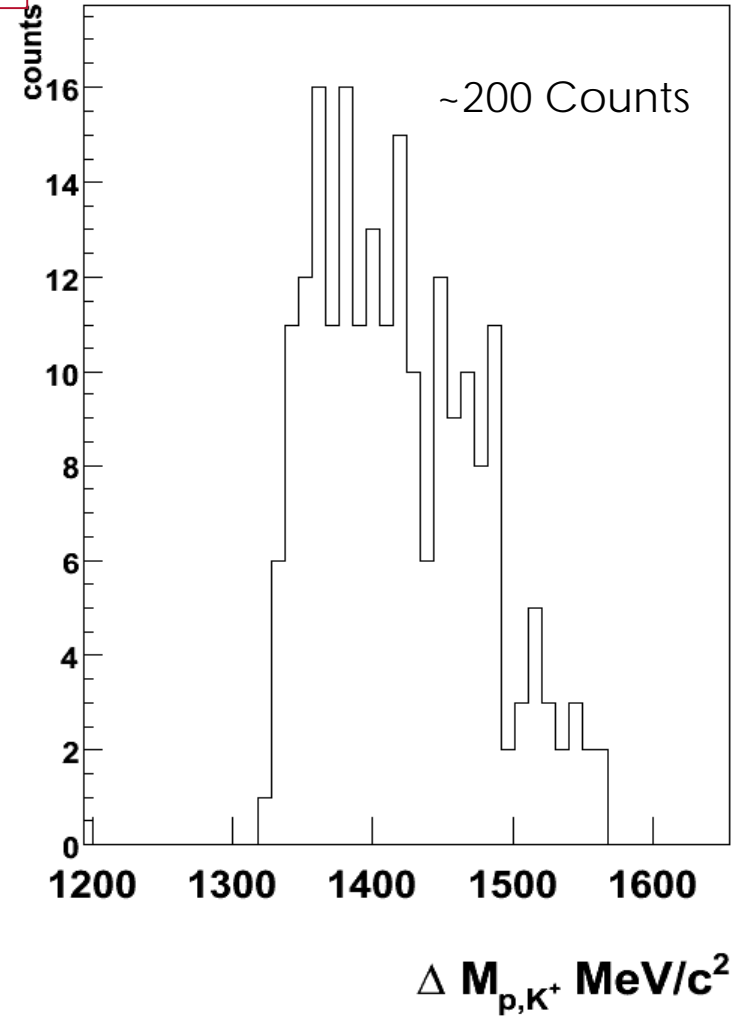
Simulation



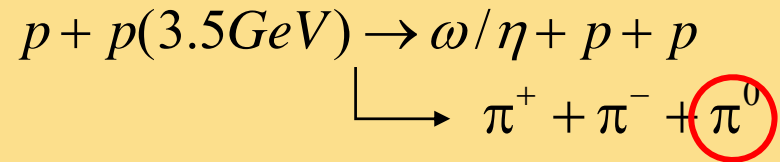
$\Lambda(1405)$, $\Sigma(1385)$ 20% $\Lambda(1116) + \pi^0$ 10%

Preliminary

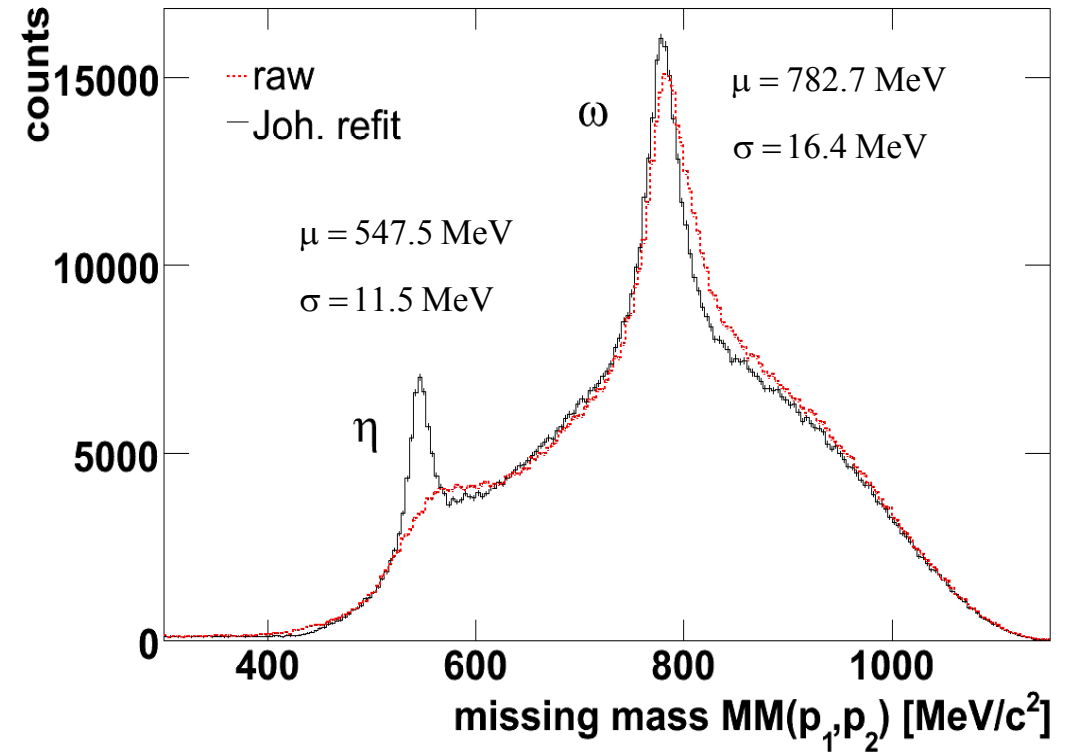
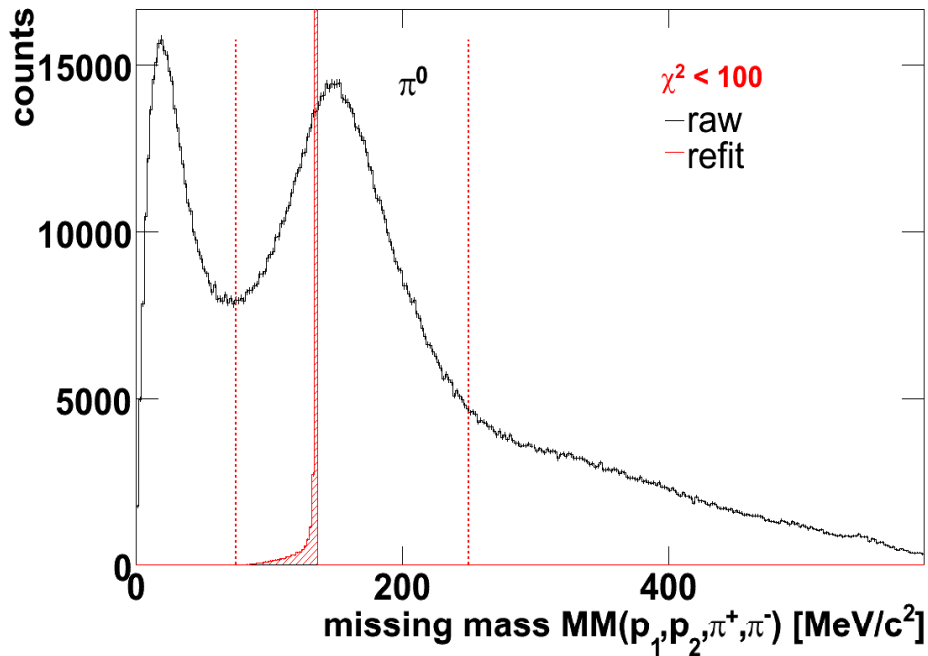
Experiment



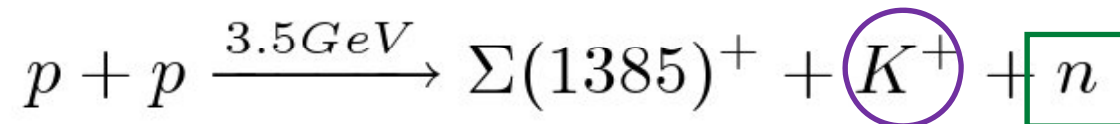
Kinematic Refit



$$\Delta M^2(pp\pi^+\pi^-) - M^2(\pi^0) = 0$$



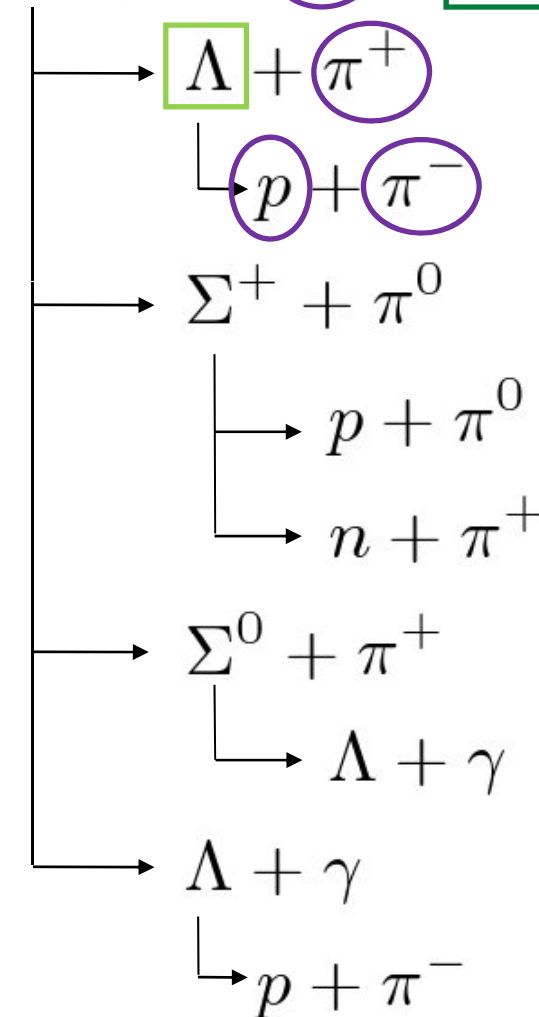
Decay channels of the $\Sigma(1385)^+$ resonance



Constraints:

- $1103 \text{ MeV}/c^2 < M_{\text{Inv}(p\pi^-)} < 1123 \text{ MeV}/c^2$
- $900 \text{ MeV}/c^2 < \Delta M_{(p,K^+,\pi^-\pi^+)} < 935 \text{ MeV}/c^2$

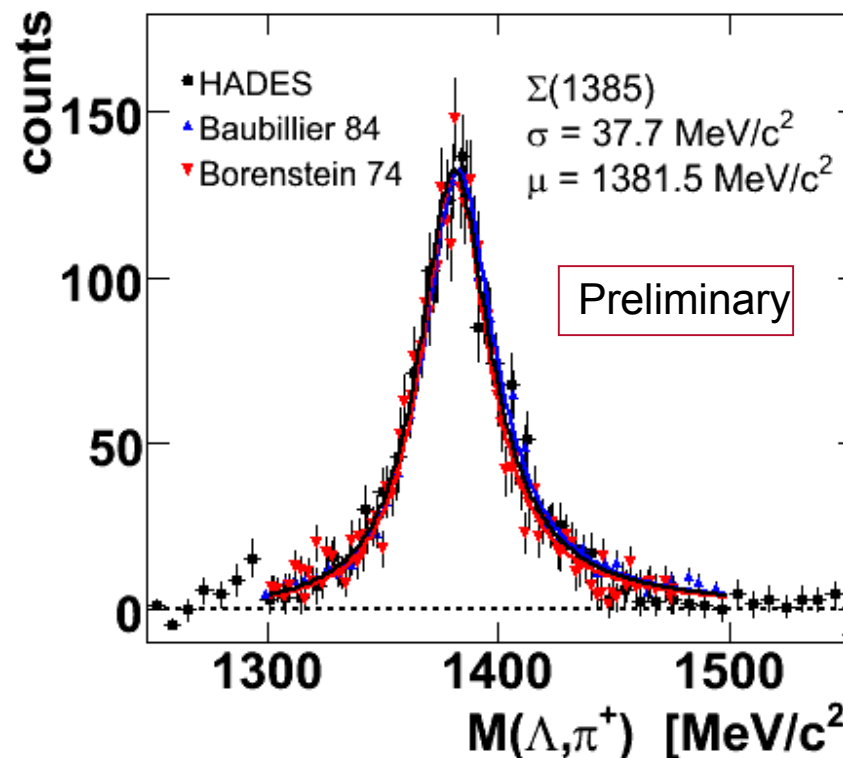
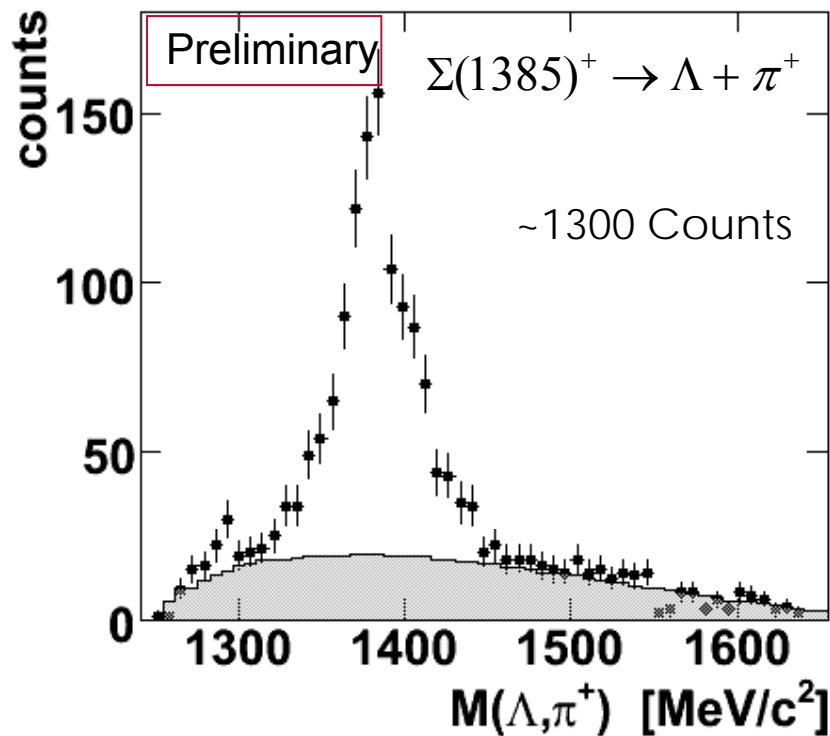
Kinematic Refit on missing Neutron



Reconstruction of $\Sigma(1385)^+$

Experiment

M. Baubillier et al., Z. Phy. C23 213 (1984)
 S.R. Borenstein et al., Phys. Rev. D 9 3006 (1974)
PDG Entries

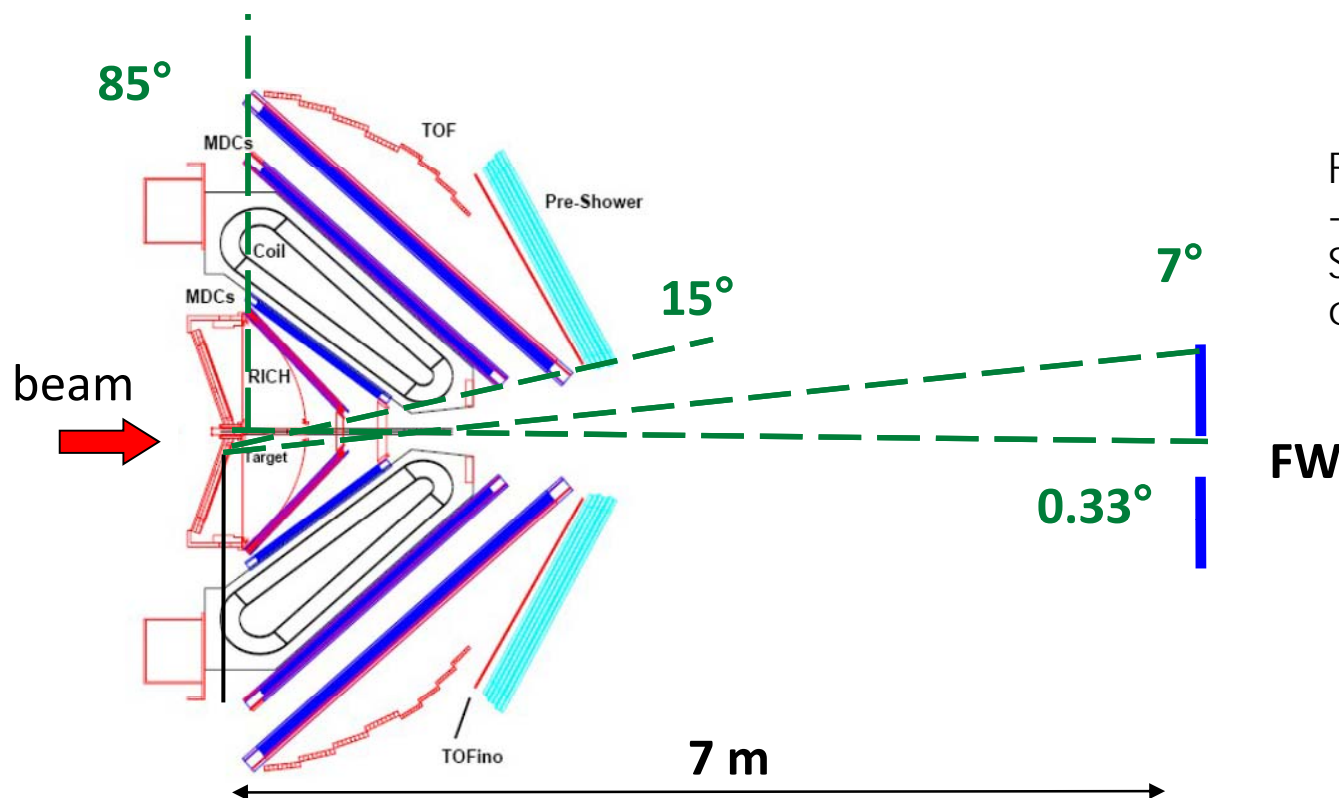


- Background fitted via phase space
- Agreement with other measured data

fitted with modified Breit-Wiegner curve

Evaluation of the cross-section is in preparation
 Efficiency and Acceptance corrections missing

Take the FW into account

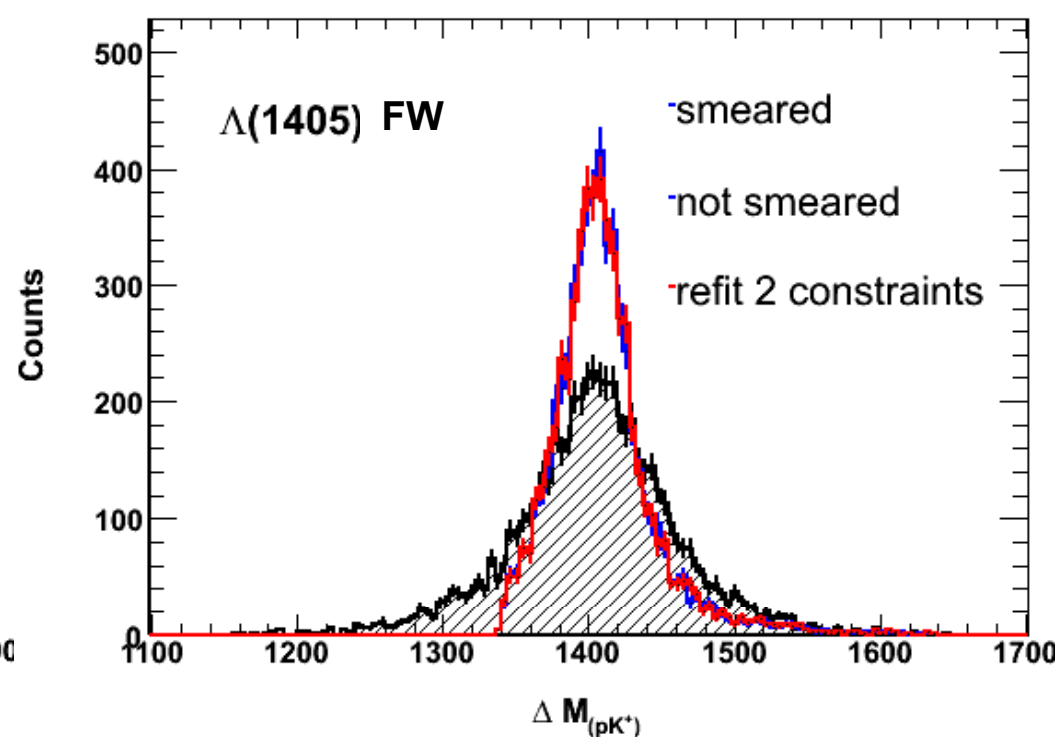
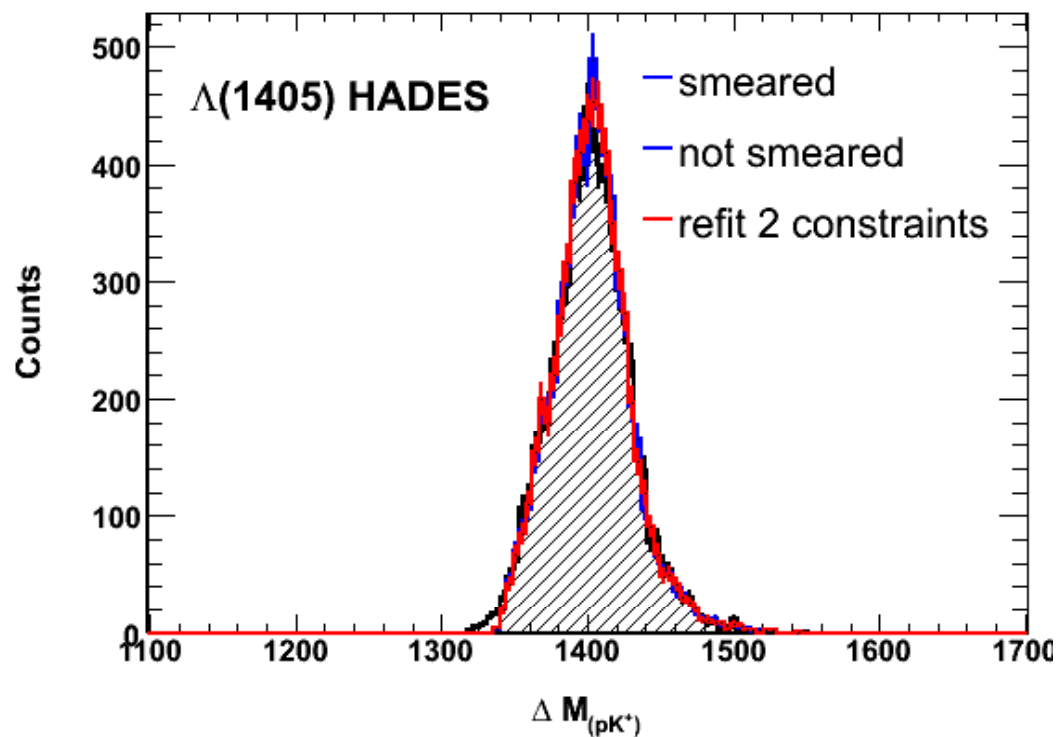
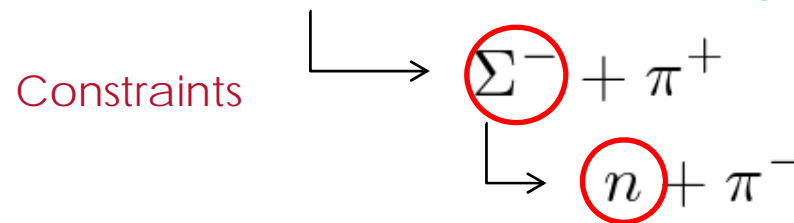
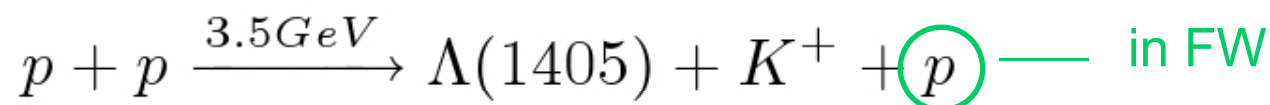


FW Momentum Resolution = 10%
 --> Kinematic Refit is necessary
 Systematic studies and calibration currently on-going

Channel	$\Sigma^- \pi^+$	$\Sigma^+ \pi^-$ \searrow $p \pi^0$	$\Sigma^+ \pi^-$ \searrow $n \pi^+$	$\Sigma^0 \pi^0$
HADES acceptance	2500	450	1600	400
HADES + FW	3500	1300	2000	900

Take the FW into account

kinematic refit applied
in the the reaction



Summary and Outlook



- *The feasibility of the Measurement of $\Lambda(1405)$ with HADES has been shown*
- *The Statistics collected in the Channel $\Lambda(1405) \rightarrow \Sigma^0 \pi^0$ is not sufficient to study the line shape in details but provides a reference for the other decays*
- *New High Quality Data for the $\Sigma(1385)^+$ line shape*
- *Analysis employing a kinematic fit is going on, to study the line shape in the $\Sigma^\pm \pi^\pm$ channel*

Hadron identification with HADES

Standard method for HADES

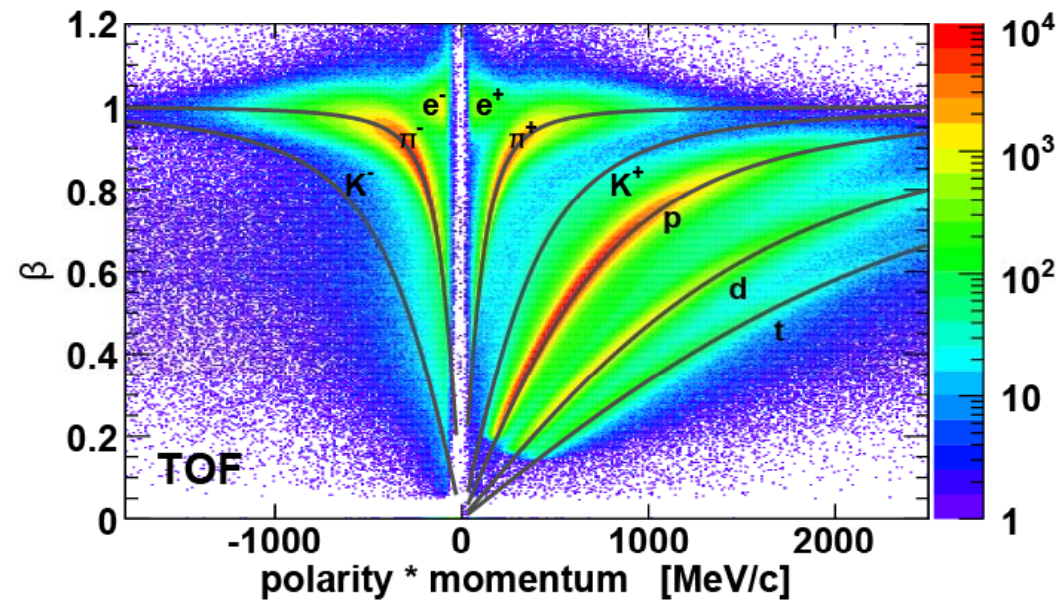
Measuring the Time of flight (TOF) and the **momentum** p

$$p = m \cdot \beta \cdot \gamma \cdot c$$

TOF and path length $\rightarrow \beta$

with β and $p \rightarrow m$

Time of flight (TOF)



Picture from the
beam time
ArKCl