

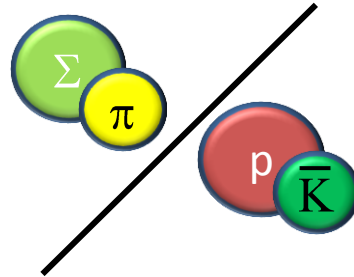
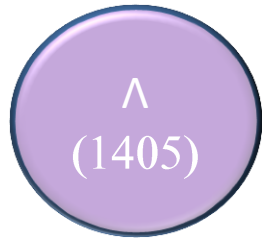
Status of the FOPI pp Beamtime

- Motivation
 - Particle Reconstruction
 - Inclusive Reconstruction
- Exclusive Reconstruction with kinematical Refit
 - Summary and Outlook

Motivation

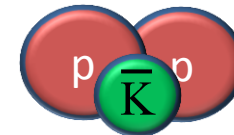
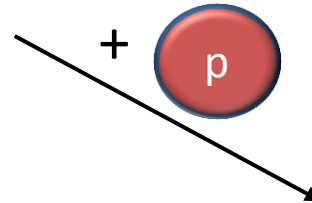
Kaonic bound states

$\Lambda(1405)$



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

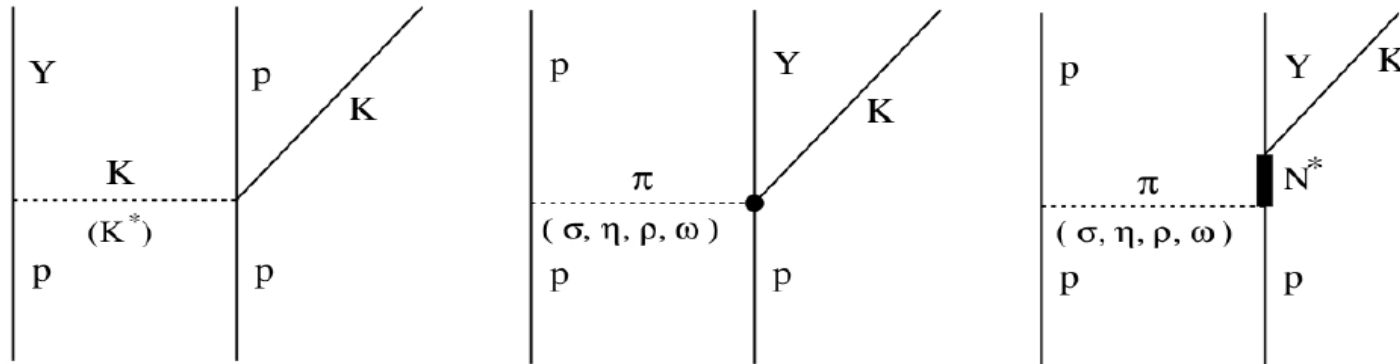
Doorway Mechanism



→ p-K⁻ Potential

N^* - Resonances

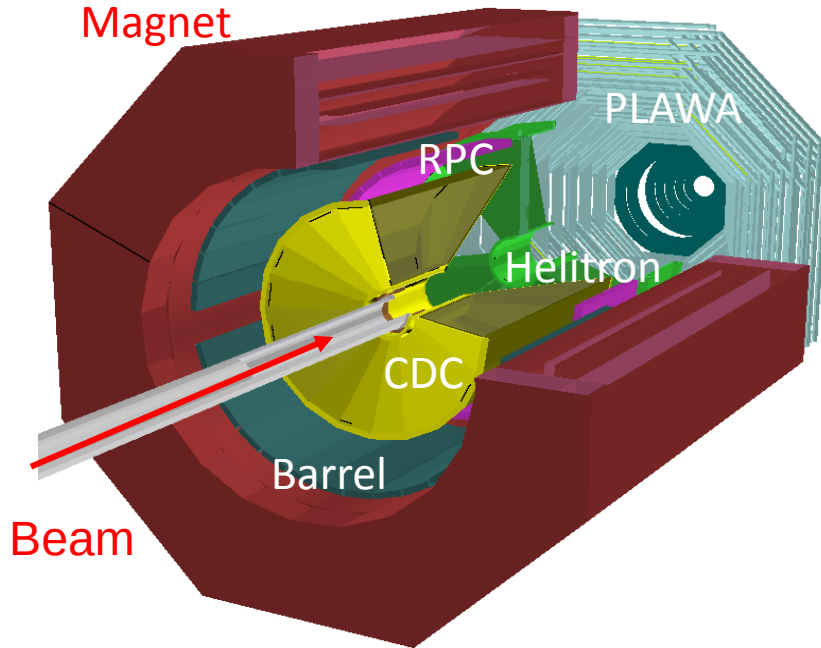
Production Mechanism: $p + p \rightarrow p + K^+ + \Lambda$



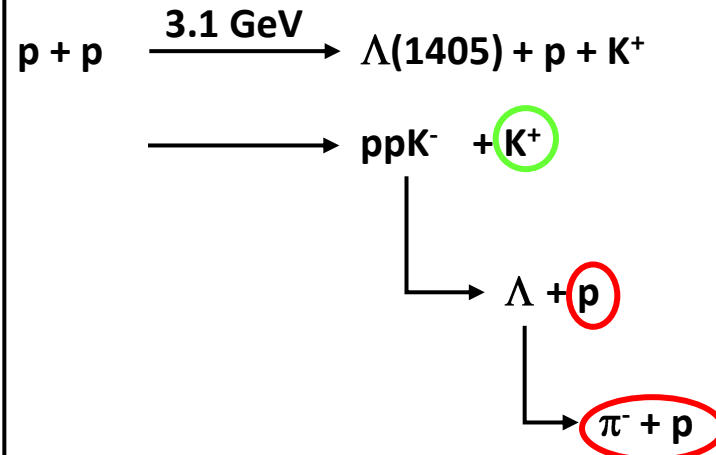
M. S.-W. : Eu. Phys. Jou. A 46

The Experiment

The Experiment



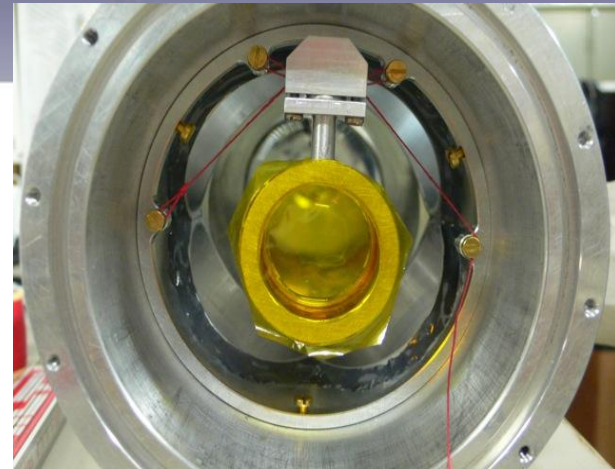
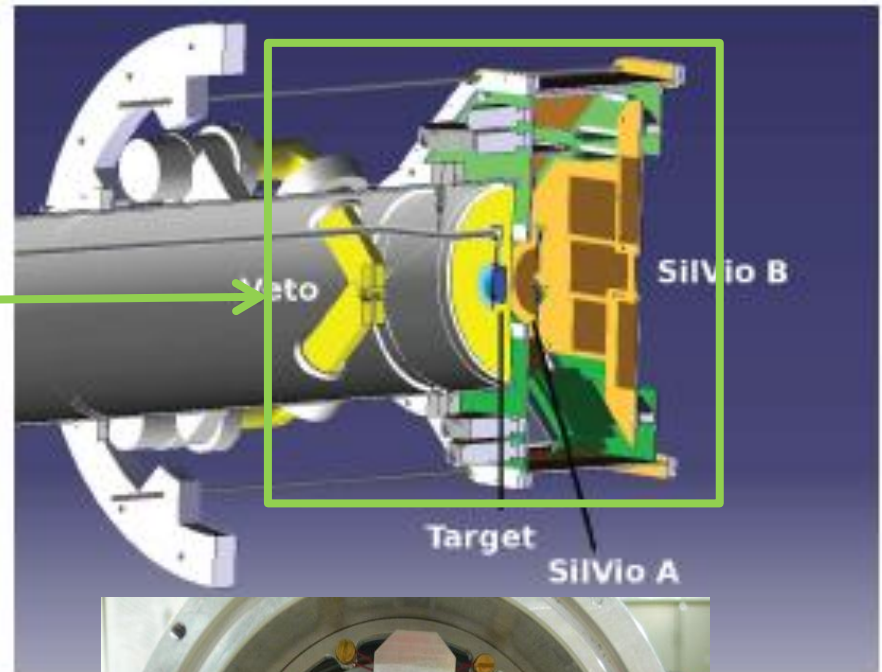
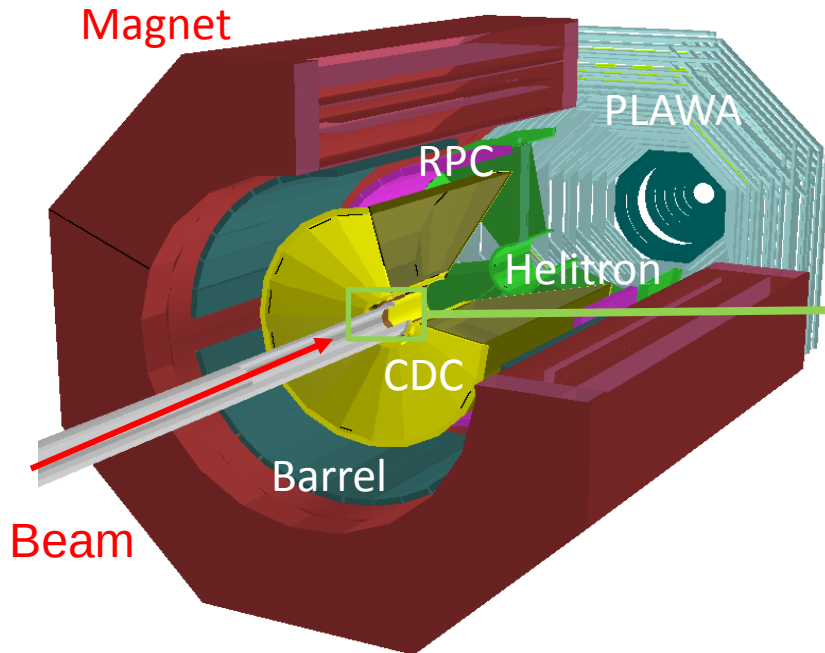
Exclusive measurement:



$\sigma(\text{Start} - \text{RPC})$: 200 ps
 $S(\text{Start} - \text{PLAWA})$: 400 ps

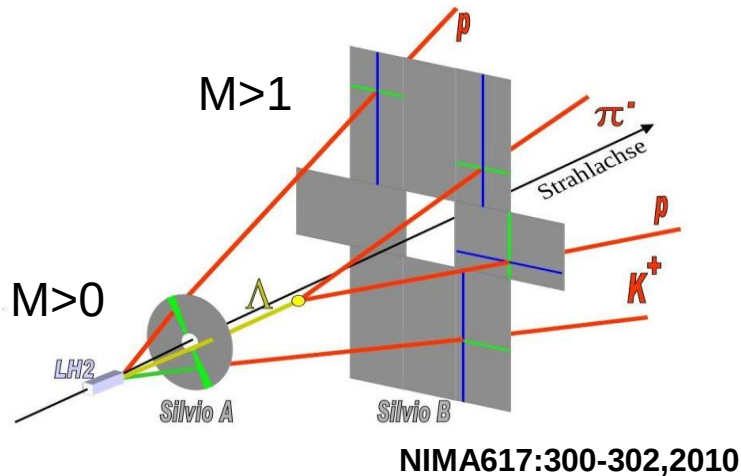
p-beam@3.1 GeV
 Target: 2cm Liquid Hydrogen
 80 Million LVL2 Trigger Events

SiLVio



SiΛViO

Silicon Λ-Vertexing and Identification Online



Trigger conditions

LVL1: $M(\text{TOF}) > 1$

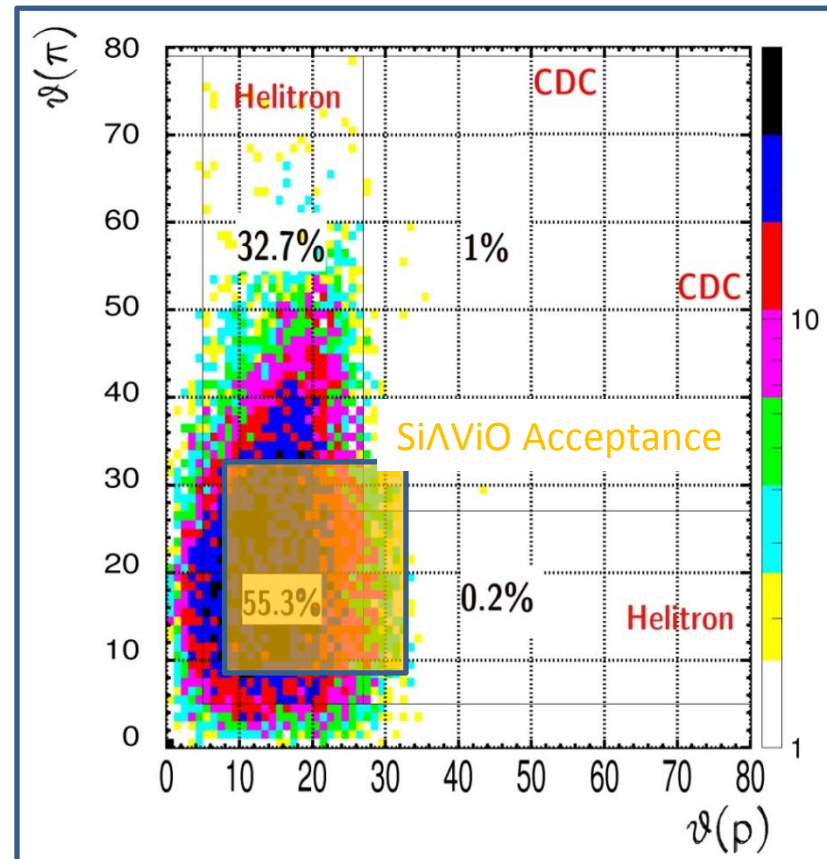
LVL2: LVL1 + SiΛViO

LVL1 / LVL2:

Signal ($pK^+\Lambda$): **5.8**

Background (UrQMD pp 3.1GeV): **20.3**

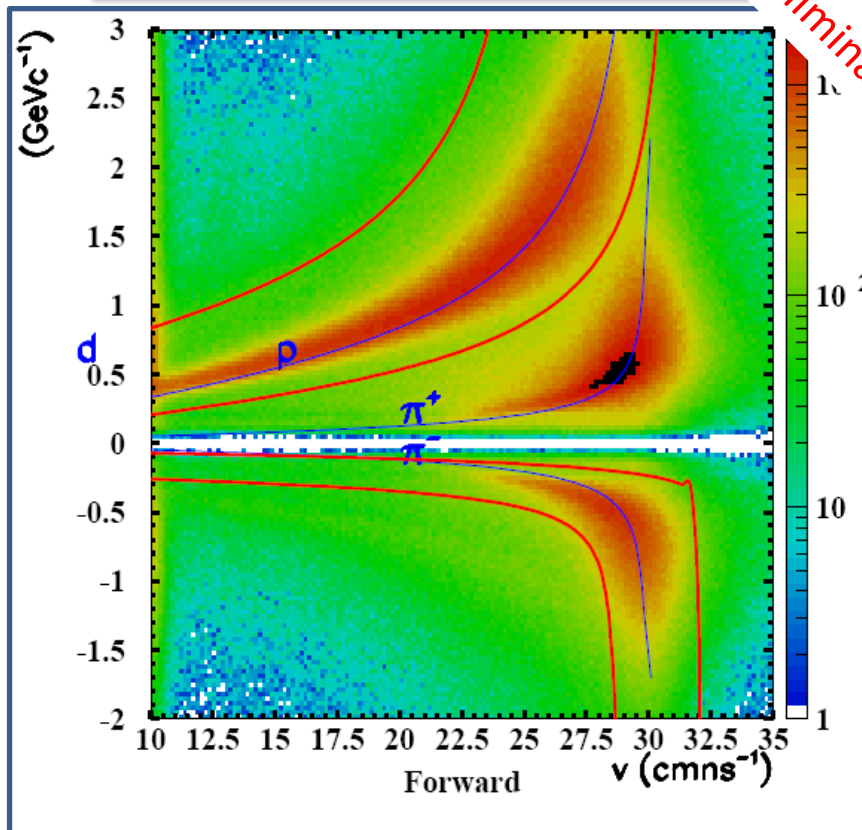
Polar angle of particles from Λ decay ($pK^+\Lambda$ / K^+ in RPC acceptance)



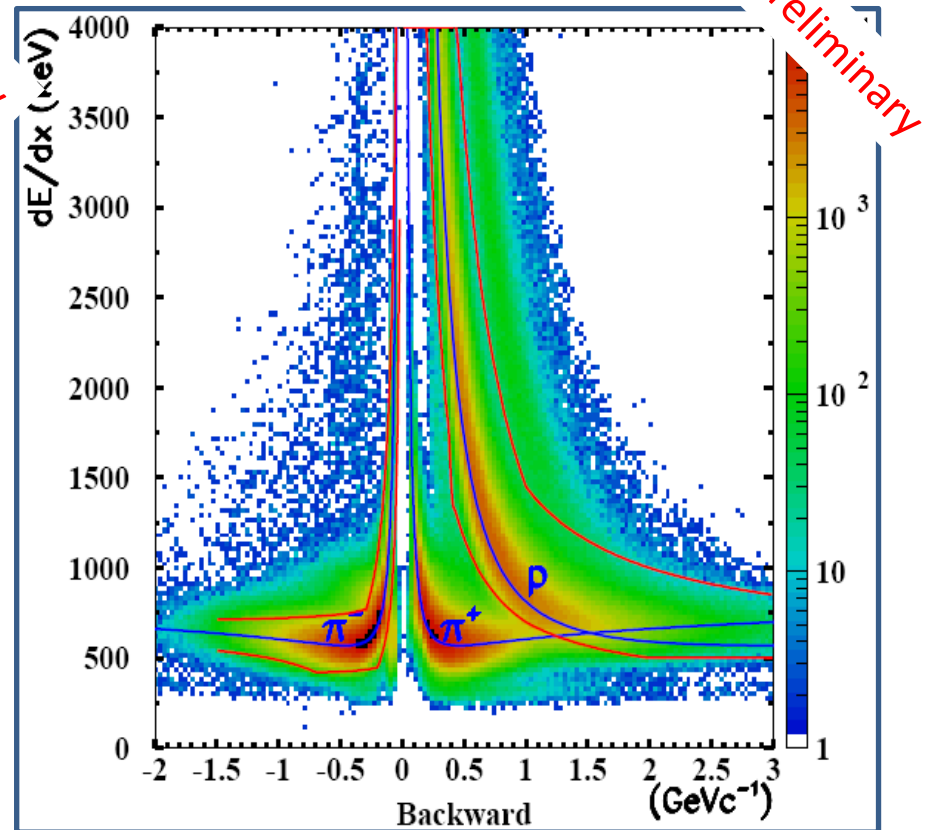
Particle Selection

Particle Identification

Forward Hemisphere
Helitron momentum + Plawa T

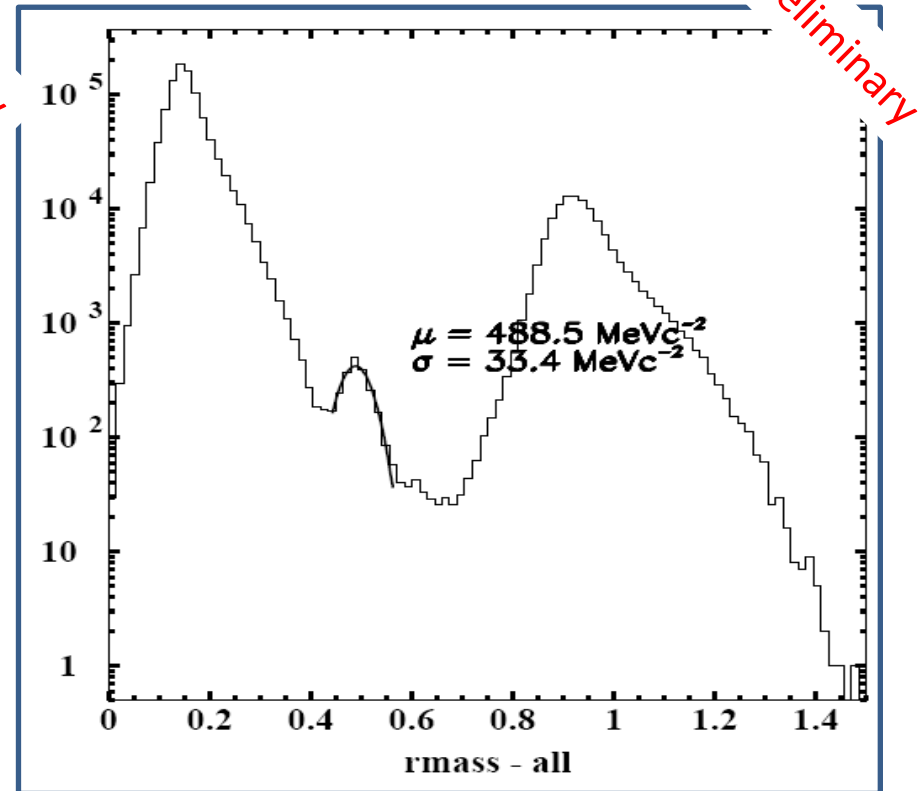
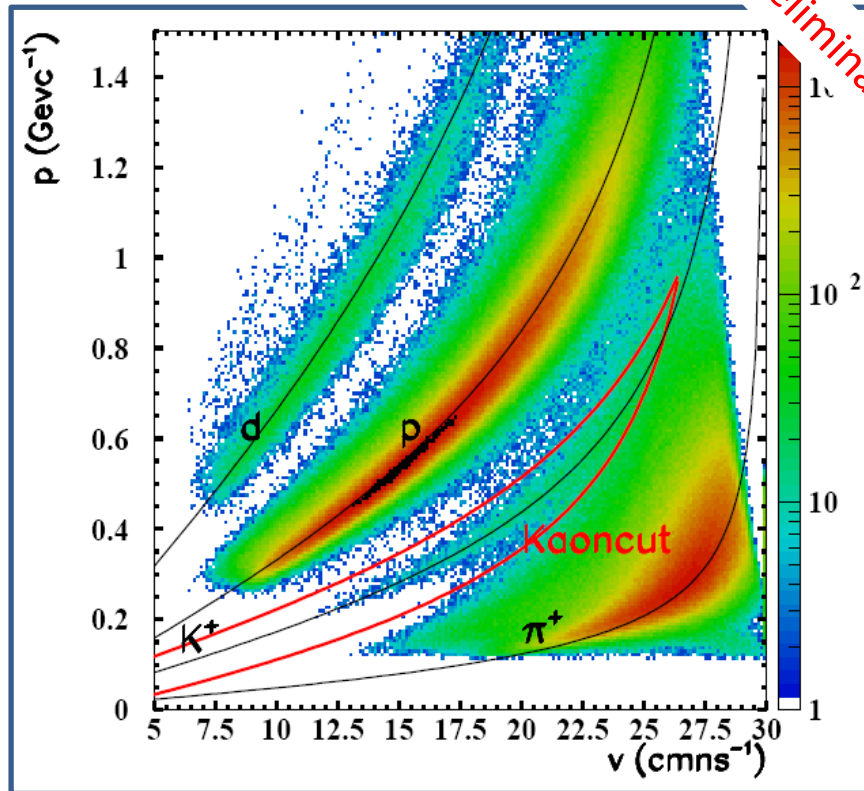


Backward Hemisphere
CDC momentum + energy loss



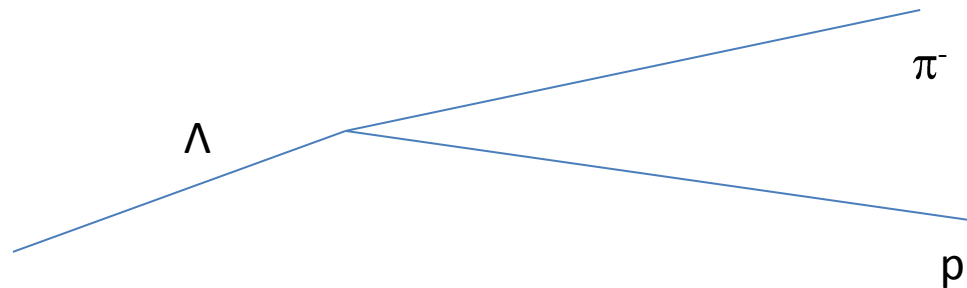
Kaon Identification

Time of Flight Detector Resistive Plate Chambers (RPC)

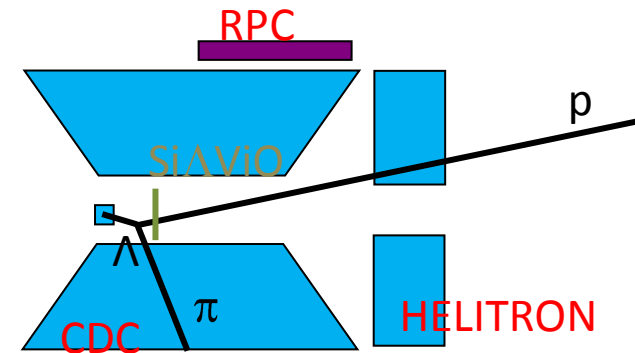


Calibration not final

Inclusive Reconstruction

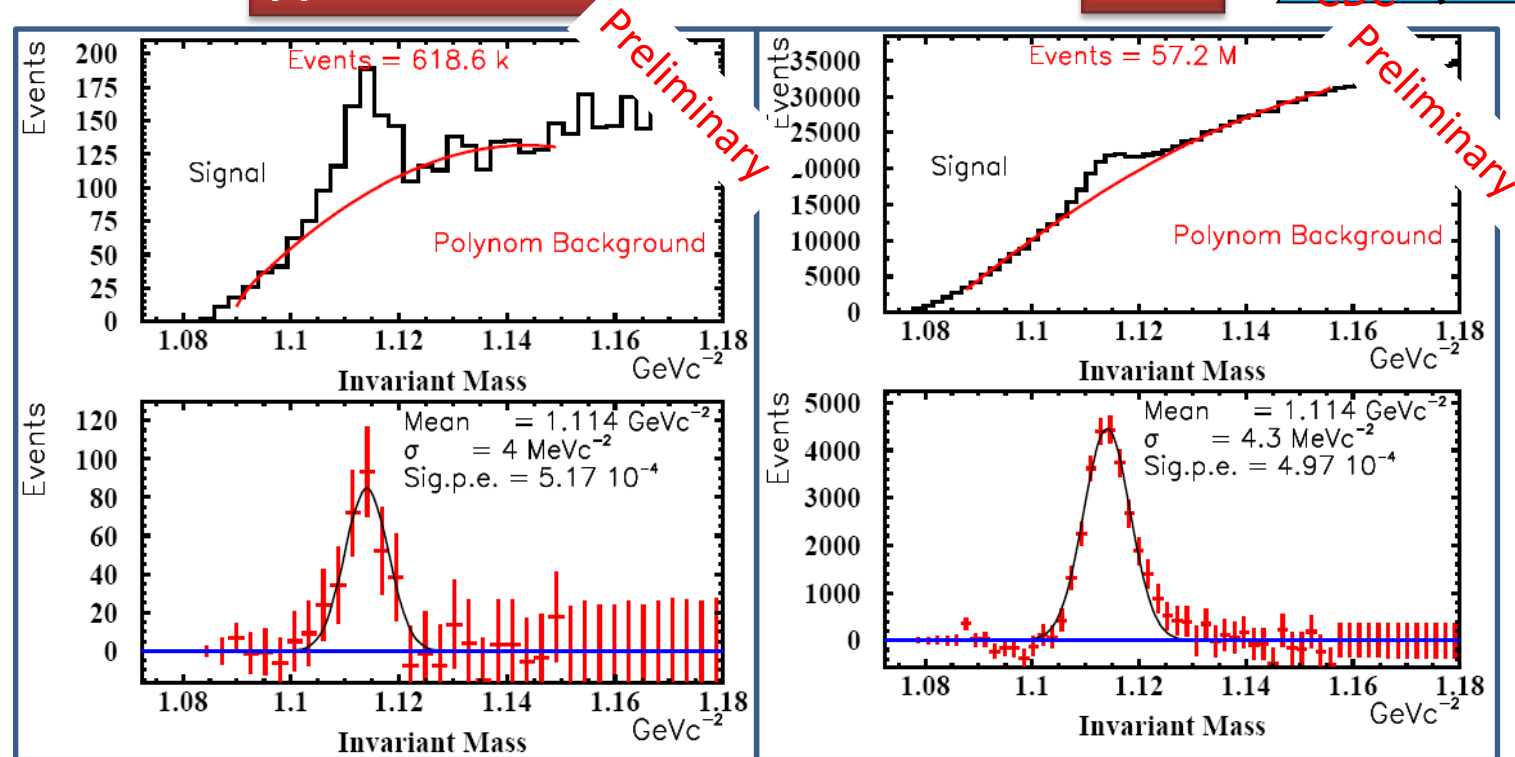


Inclusive Λ Reconstruction

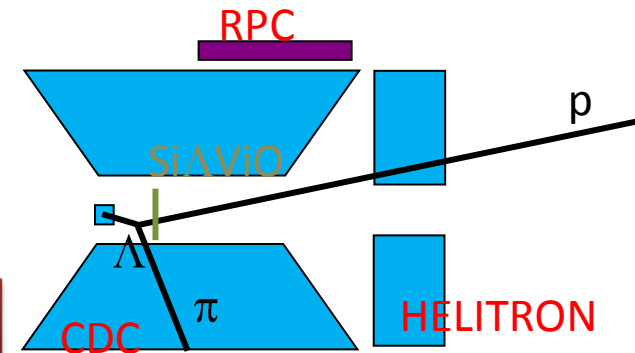


pp Simulation

Data

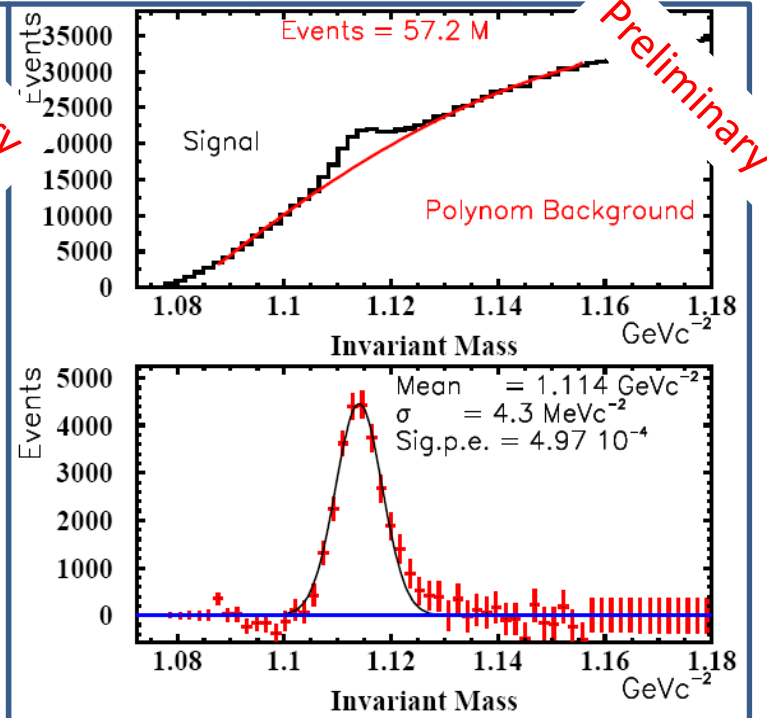
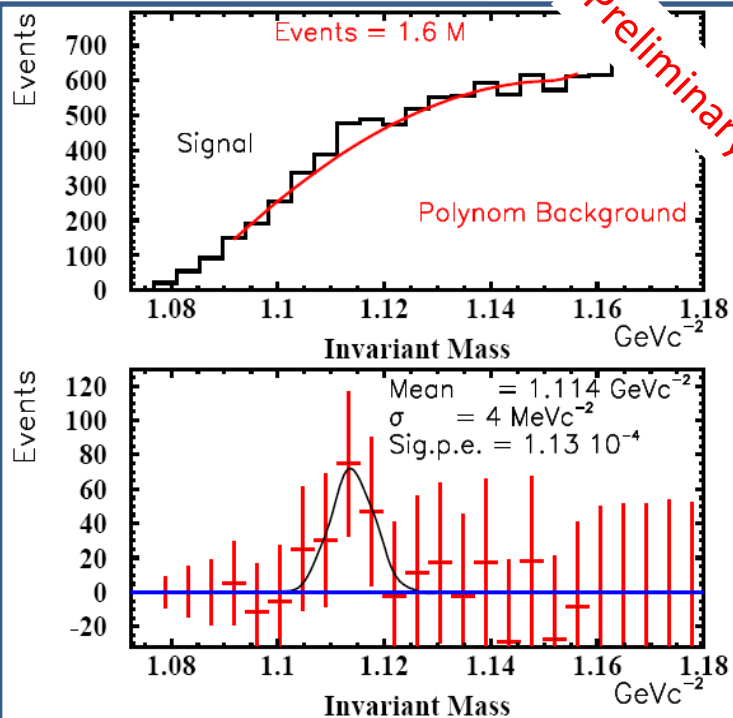


Inclusive Λ Reconstruction



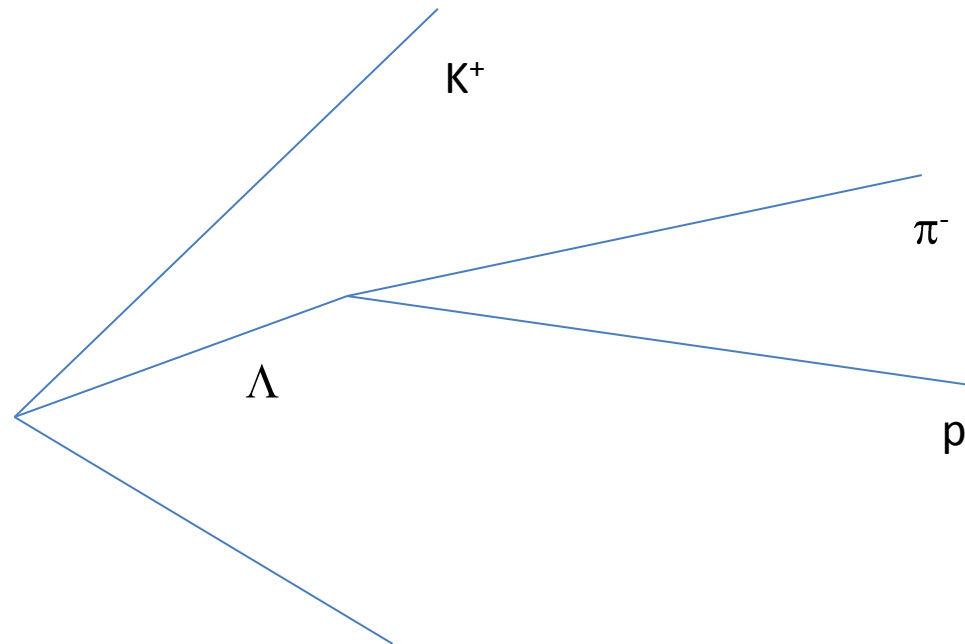
Data LVL1

Data LVL2



Enhancement:
 $> 4,4$
 Fits to simulation

Exlcusive Reconstruction

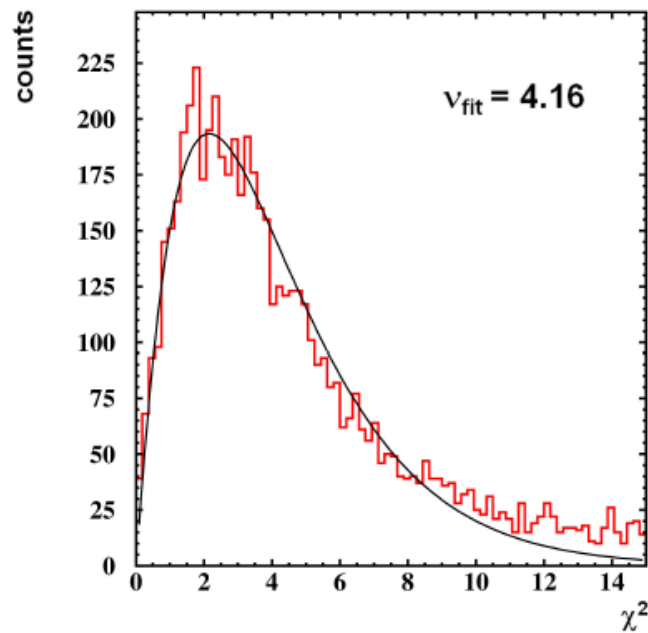


Kinematical Refit

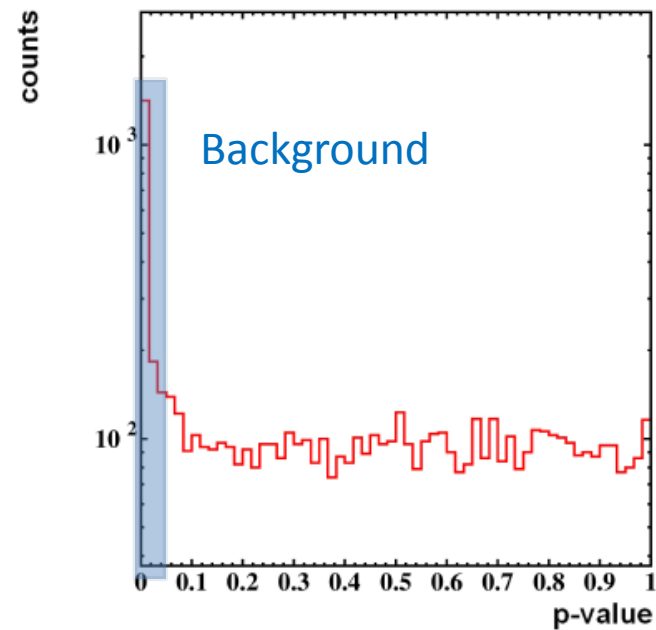
Modify Particle Track Parameters (mom, phi, theta) within error
to fulfill constraints.

Results: New Particle Track Parameters , χ^2

Diploma Thesis
D. Pleiner



(a)

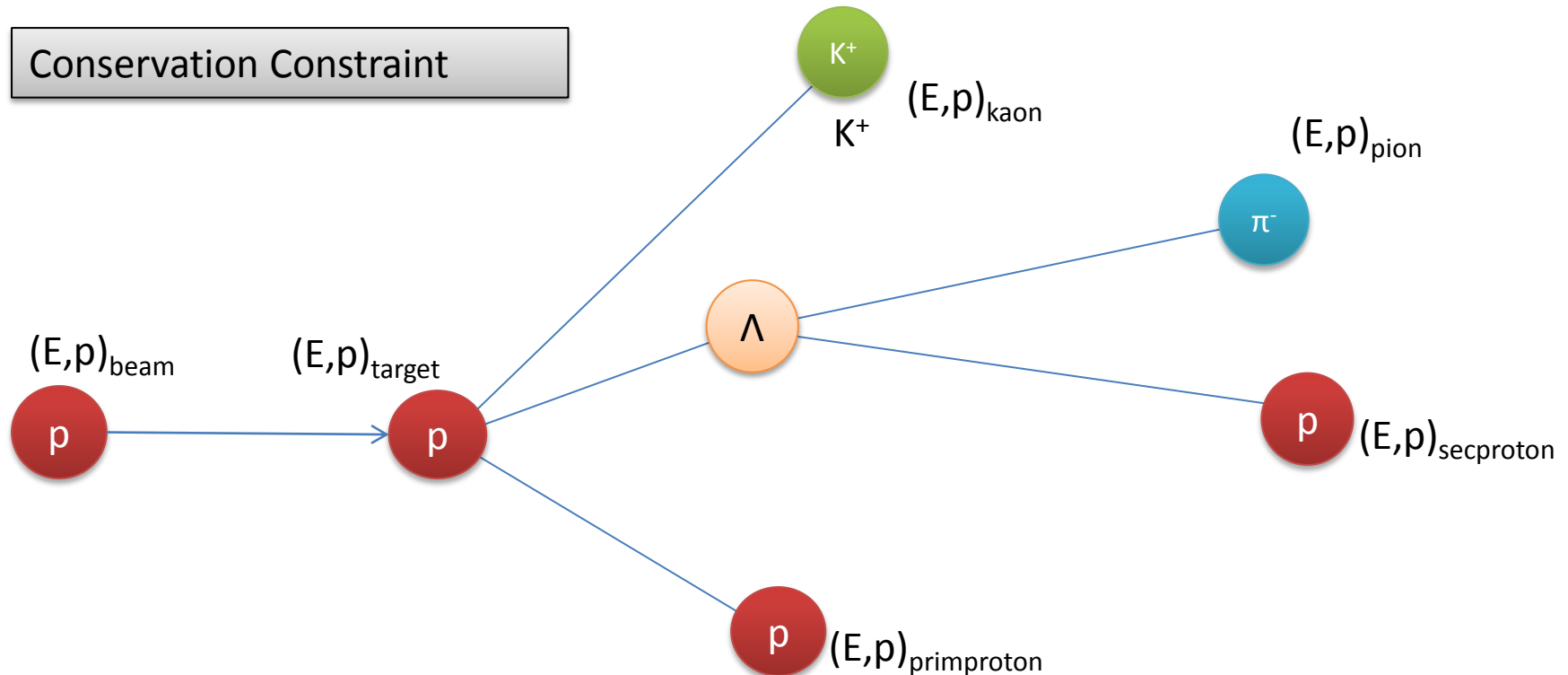


(b)

$$f_{\nu}(\chi^2) = \frac{1}{2^{\nu/2} \Gamma(\nu/2)} (\chi^2)^{\nu/2-1} e^{-\frac{1}{2}\chi^2}$$

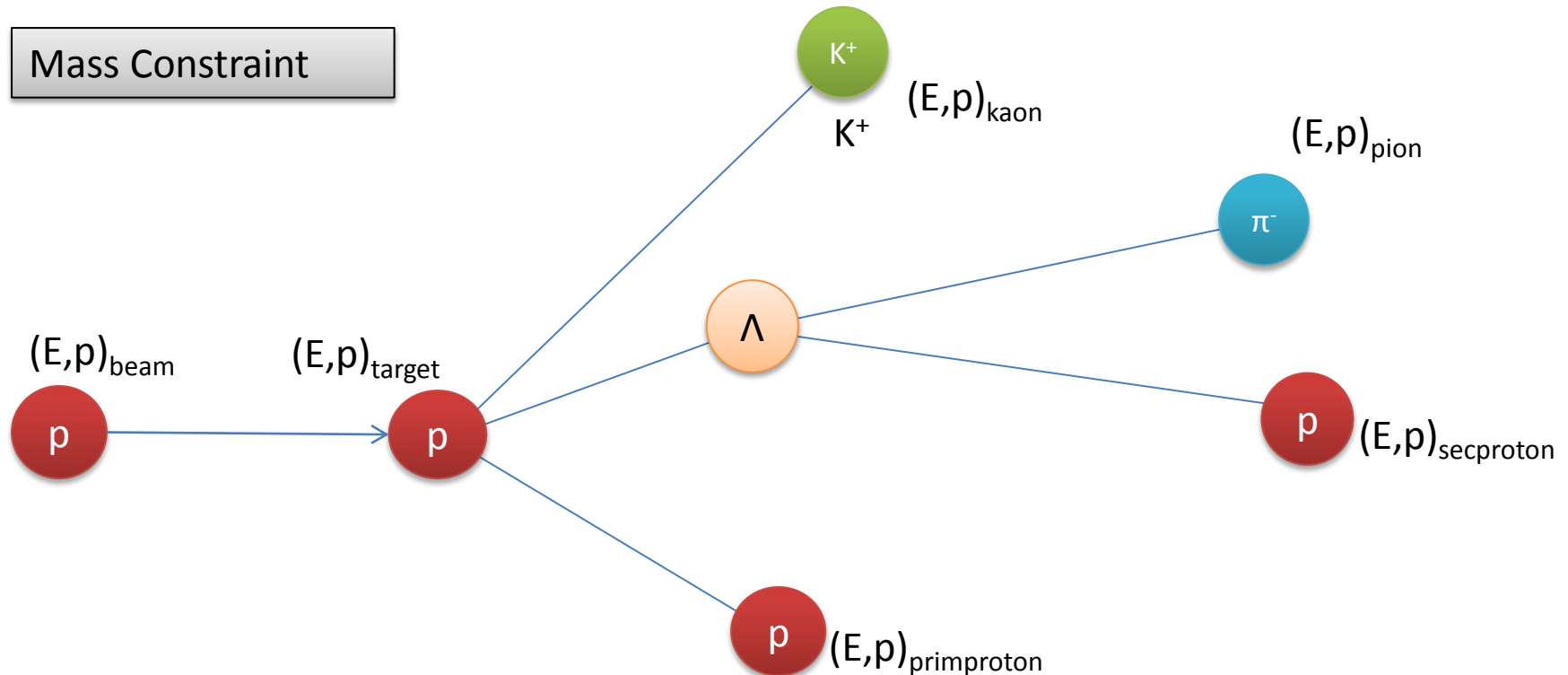
p-value(refit) =

Kinematical Refit



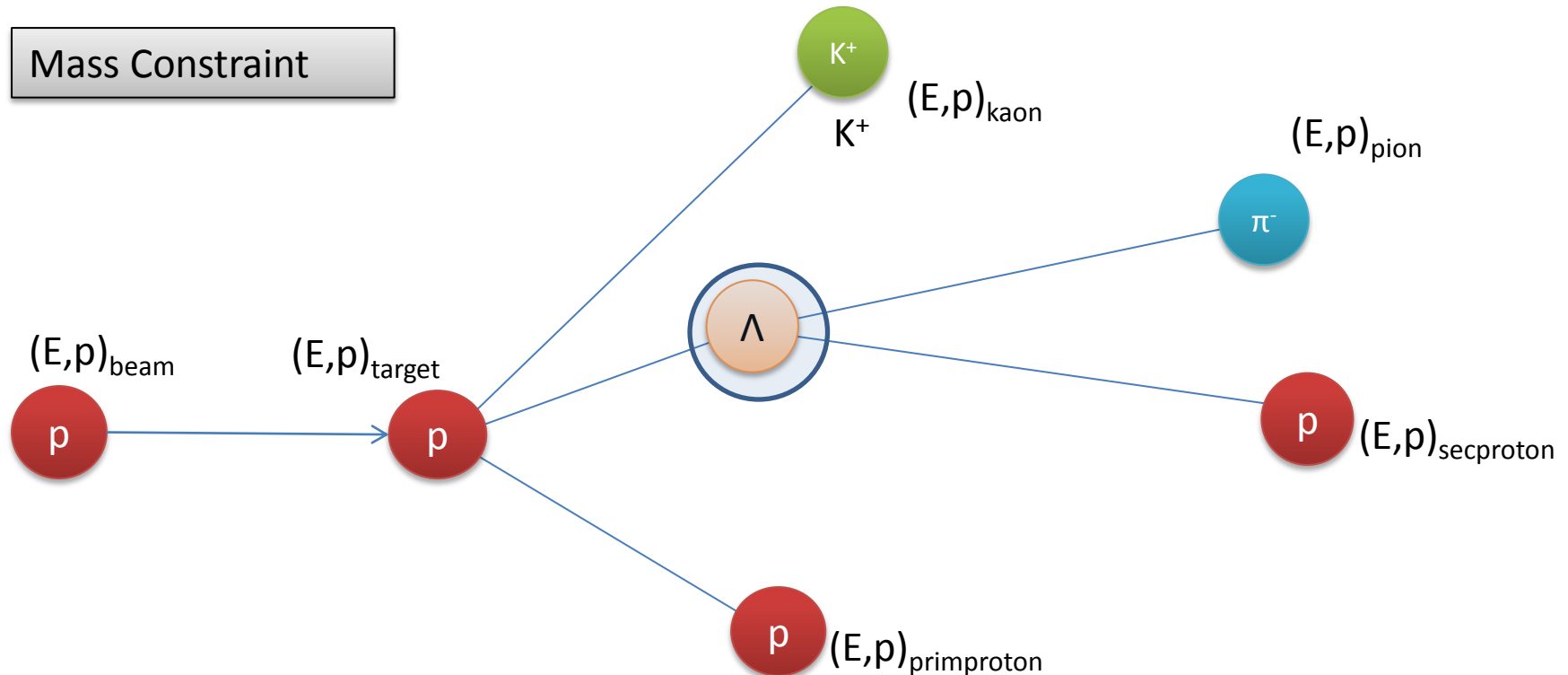
$$\begin{aligned}
 E_{\text{secproton}} + E_{\text{pion}} + E_{\text{primproton}} + E_{\text{kaon}} &= E_{\text{beam}} + E_{\text{target}} \\
 p_{\text{secproton}} + p_{\text{pion}} + p_{\text{primproton}} + p_{\text{kaon}} &= p_{\text{beam}} + p_{\text{target}}
 \end{aligned}$$

Kinematical Refit



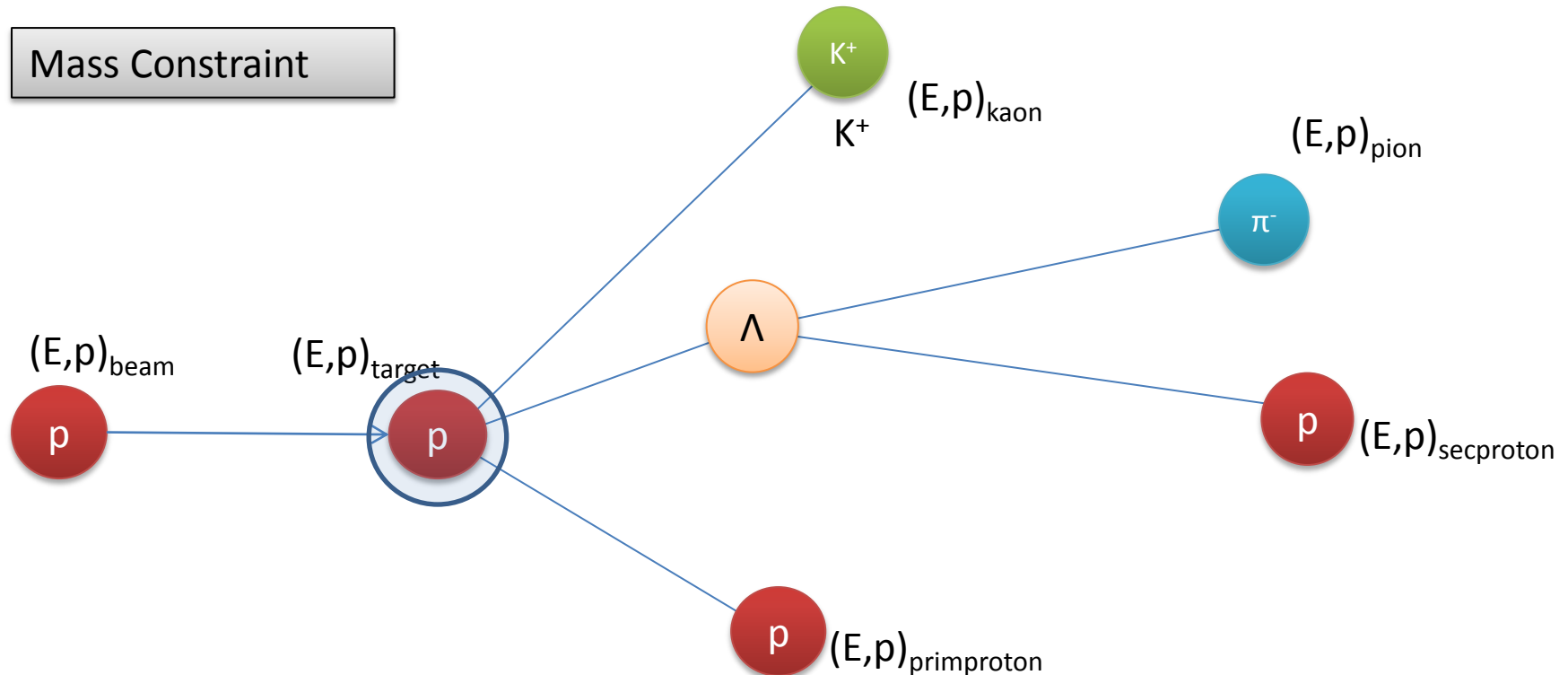
$$\{ (E, p)_{\text{secproton}} + (E, p)_{\text{pion}} \}^2 = M(\Lambda)^2$$

Kinematical Refit



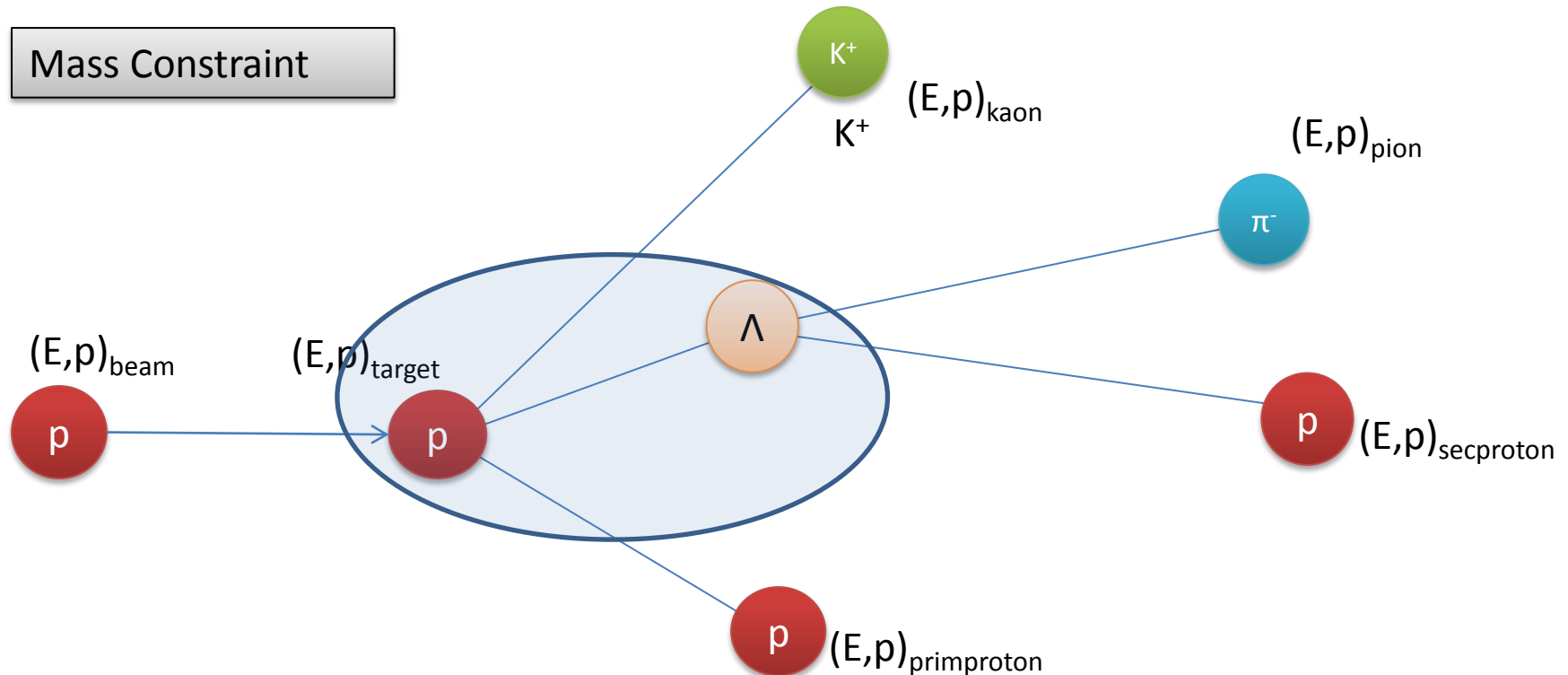
Vertex Constraints: Intersection p and π

Kinematical Refit



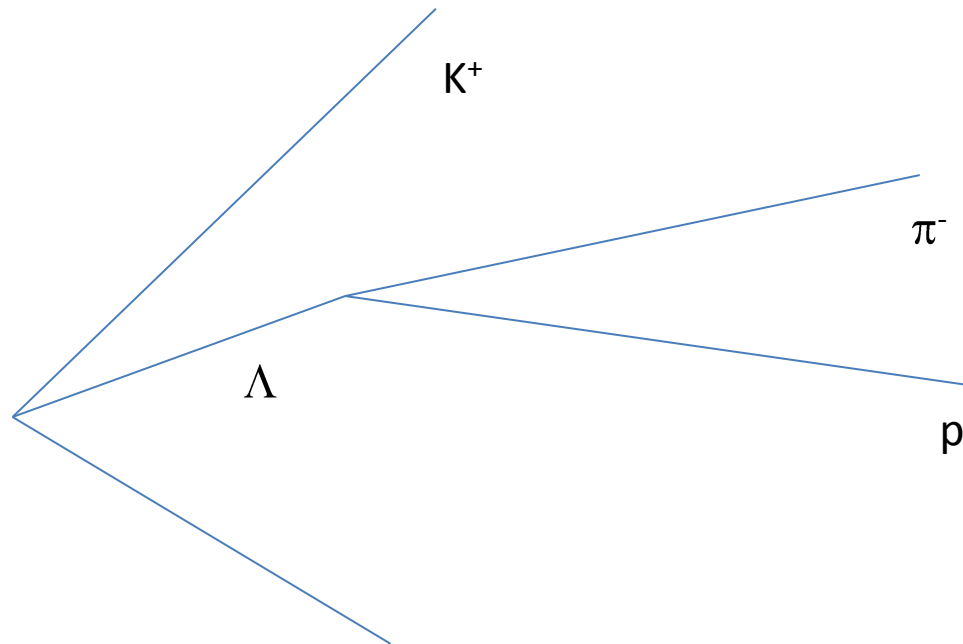
Vertex Constraints: Intersection p and K^+

Kinematical Refit



Vertex Constraints: Primary & Secondary Vertex

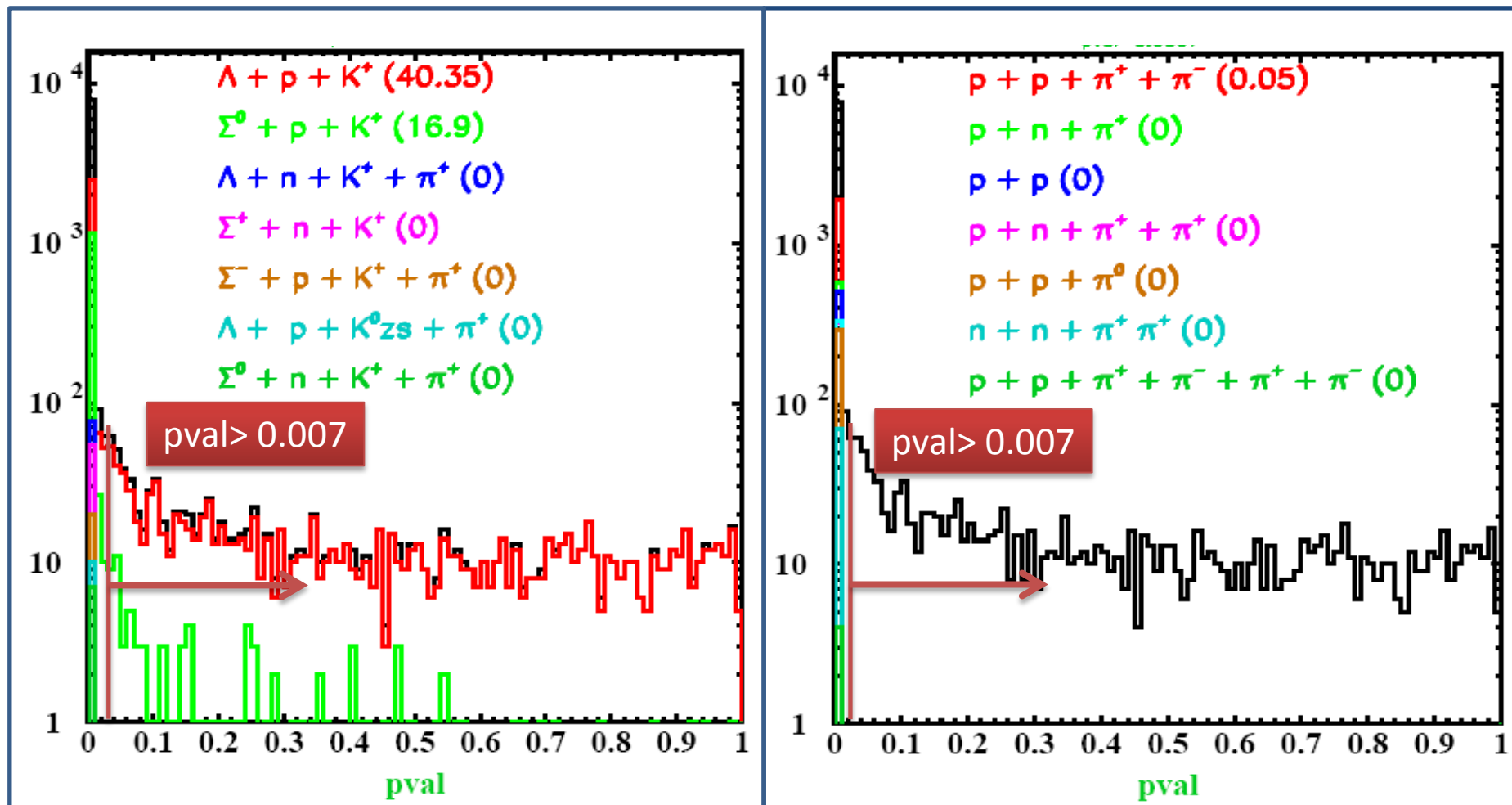
Exclusive Reconstruction pp – Simulation (URQMD)



Conservation Constraint

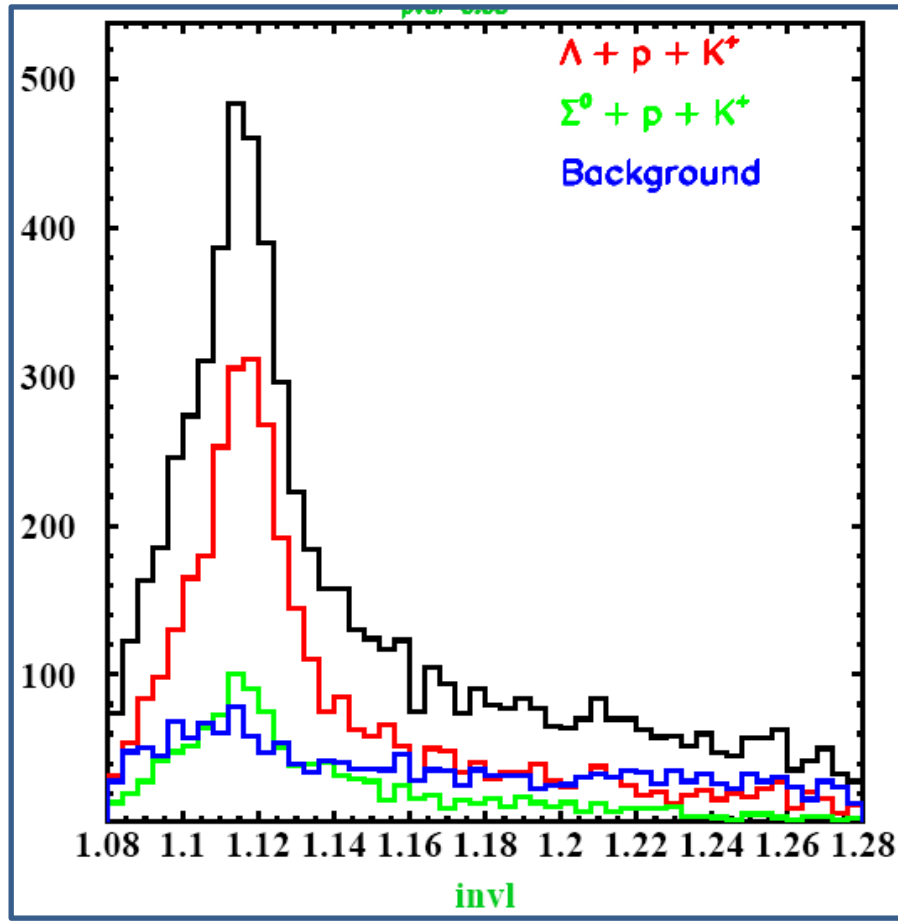
$$\begin{aligned} E_{\text{secproton}} + E_{\text{pion}} + E_{\text{primproton}} + E_{\text{kaon}} &= E_{\text{beam}} + E_{\text{target}} \\ p_{\text{secproton}} + p_{\text{pion}} + p_{\text{primproton}} + p_{\text{kaon}} &= p_{\text{beam}} + p_{\text{target}} \end{aligned}$$

Conservation Constraint

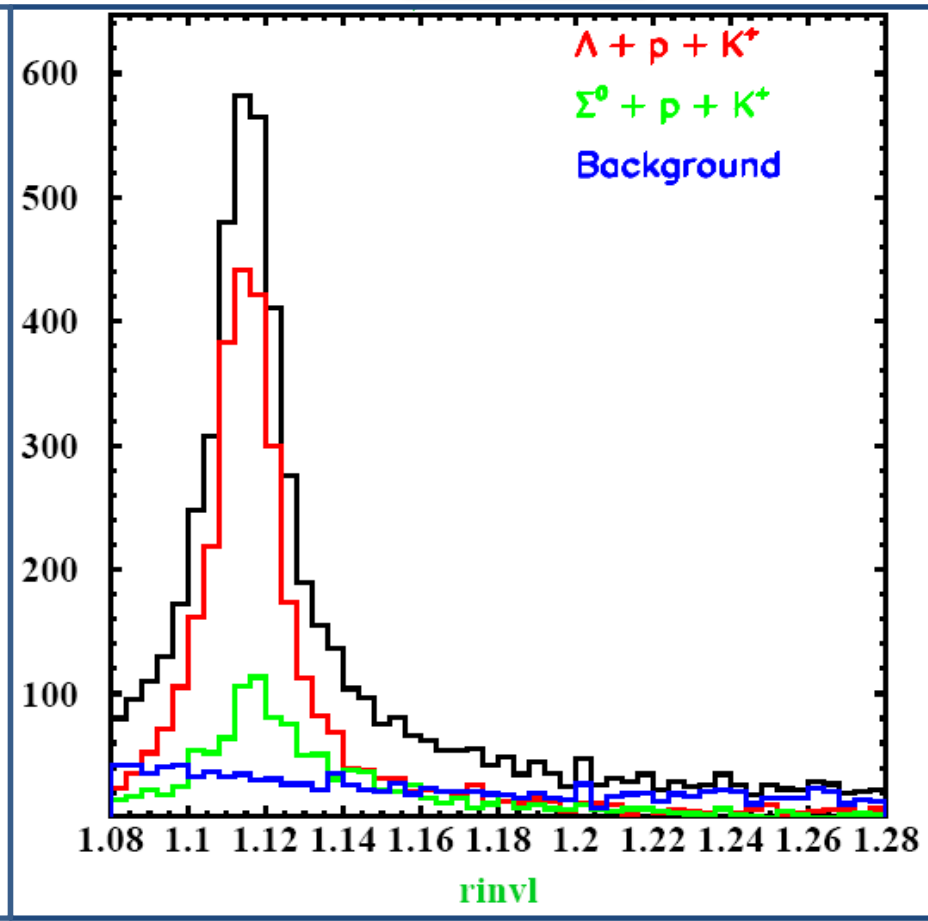


Invariant mass (p, π)

Without refit



With refit



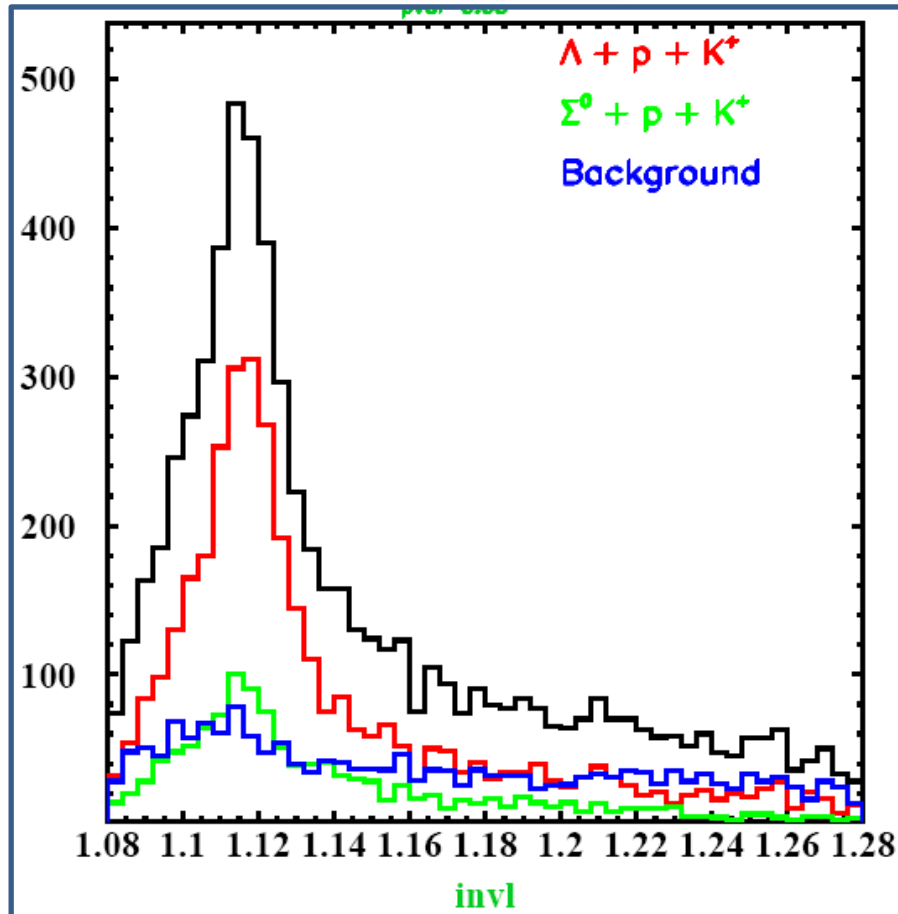
Conservation + Mass Constraint

$$\begin{aligned} E_{\text{secproton}} + E_{\text{pion}} + E_{\text{primproton}} + E_{\text{kaon}} &= E_{\text{beam}} + E_{\text{target}} \\ p_{\text{secproton}} + p_{\text{pion}} + p_{\text{primproton}} + p_{\text{kaon}} &= p_{\text{beam}} + p_{\text{target}} \end{aligned}$$

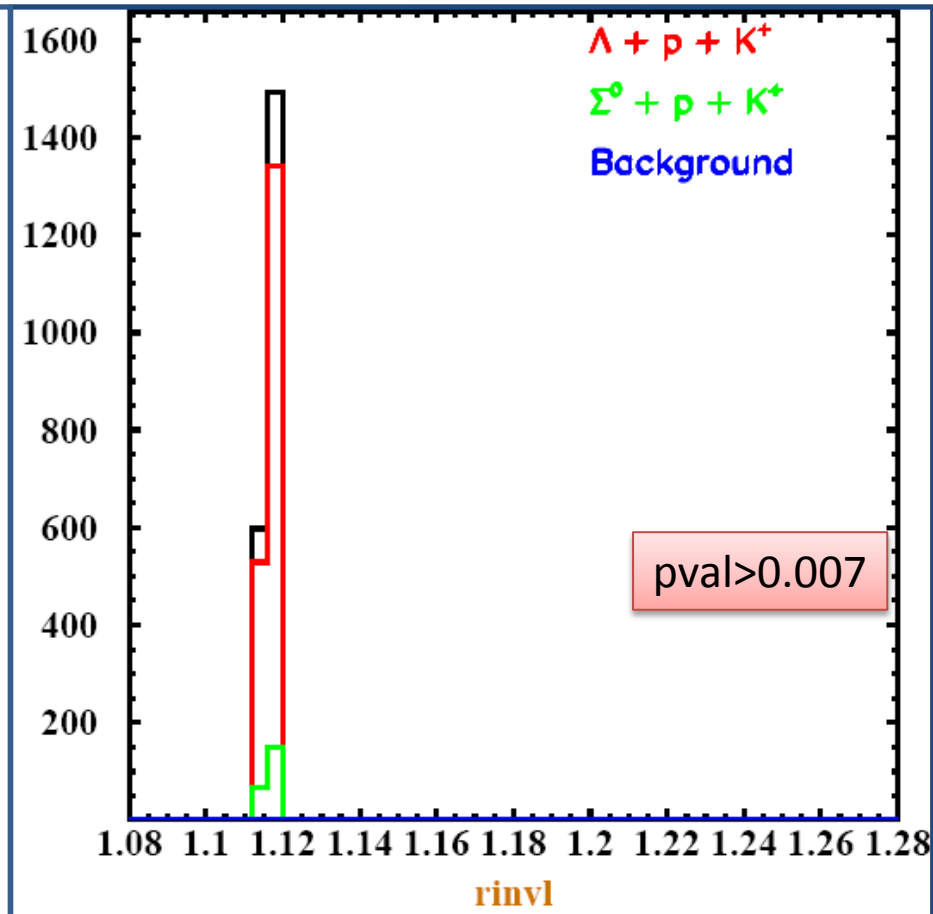
$$\{ (E, p)_{\text{secproton}} + (E, p)_{\text{pion}} \}^2 = M(\Lambda)^2$$

Invariant mass (p, π)

Without refit

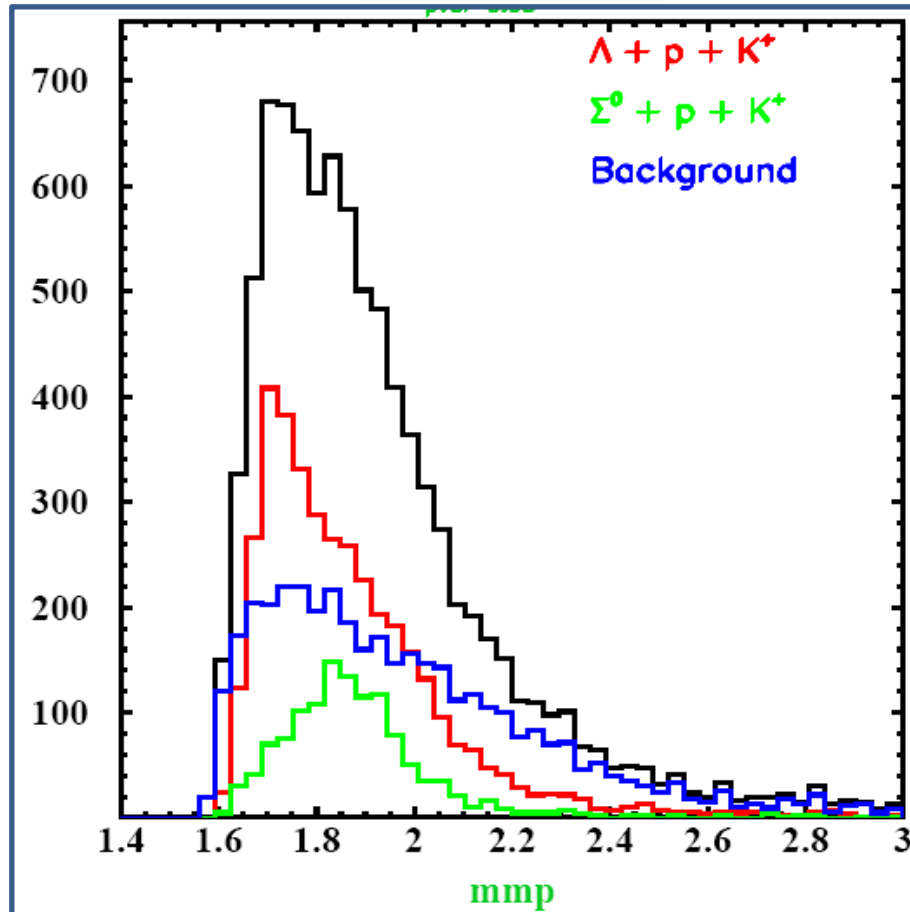


With refit

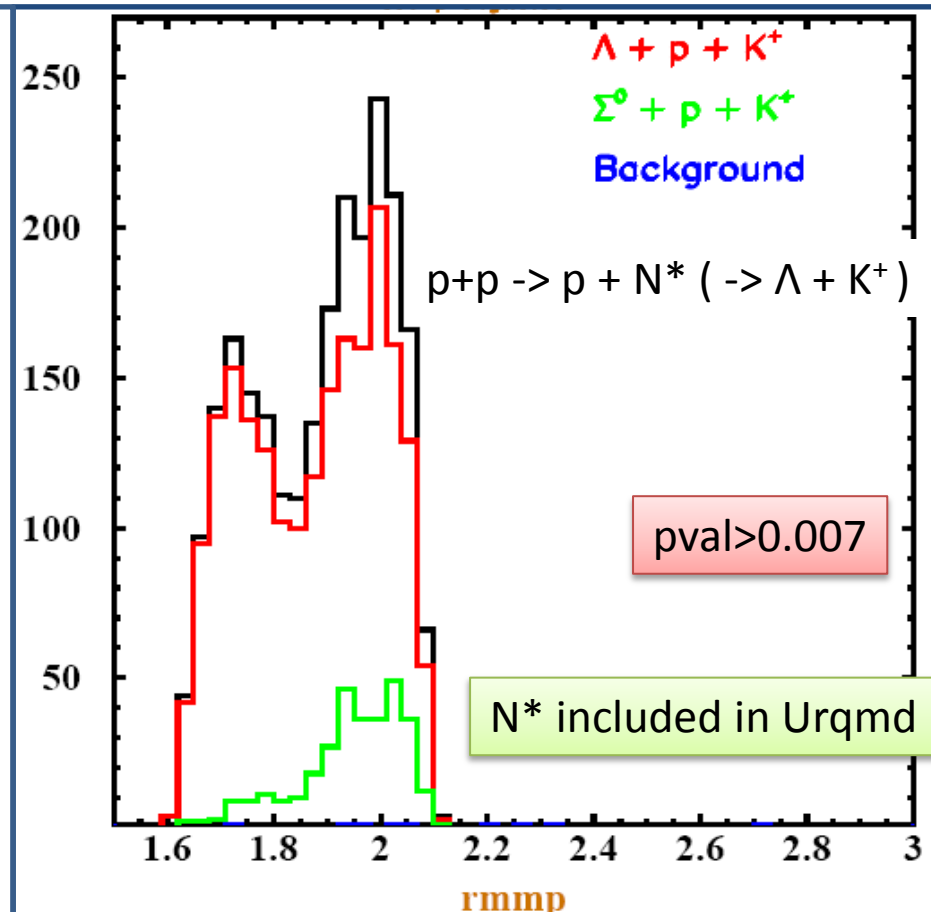


Missing Mass(p)

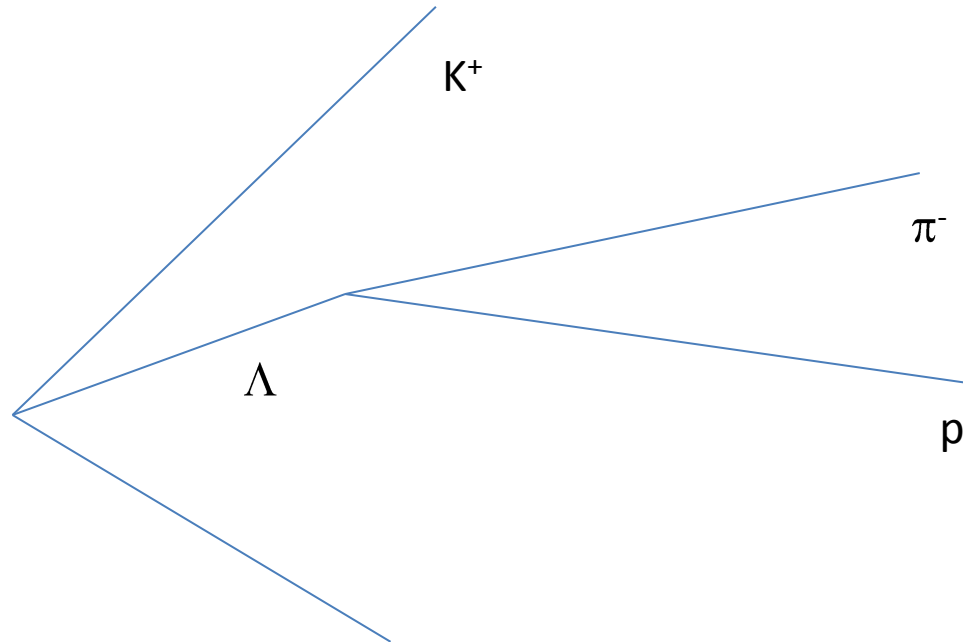
Without Refit



With Refit



Exclusive Reconstruction Data



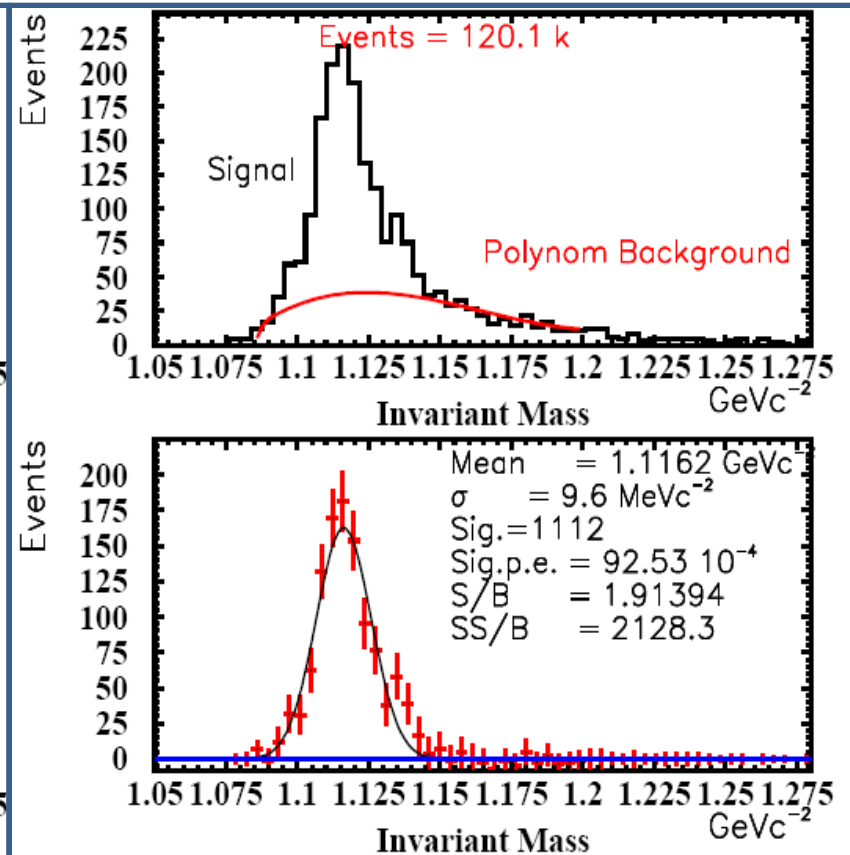
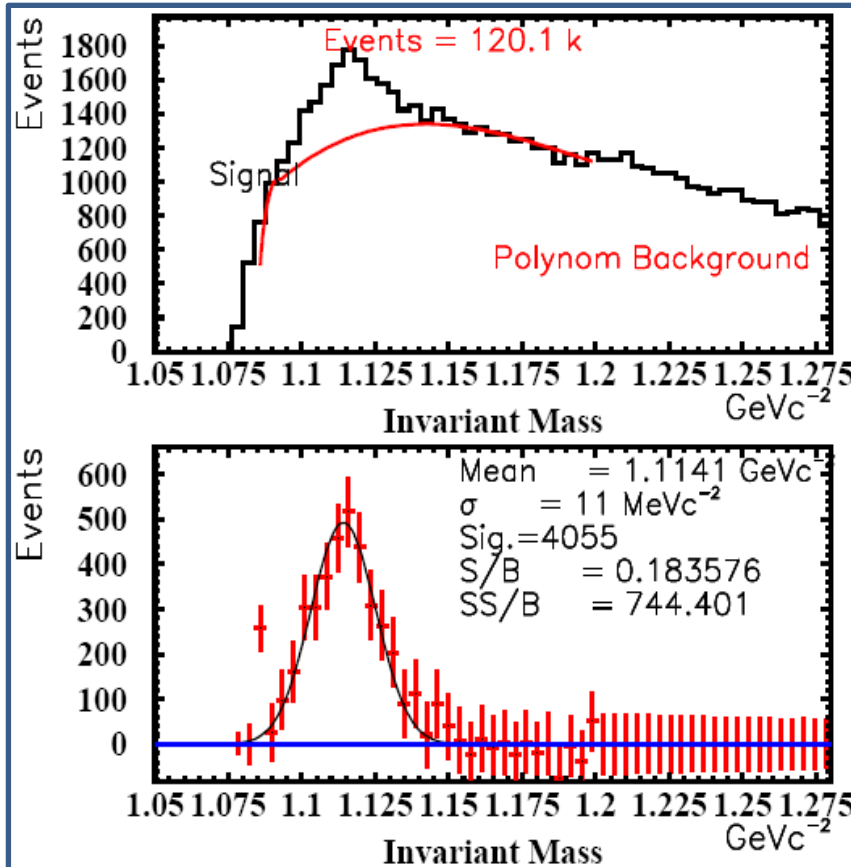
Data

Energy & Momentum Constraint

Original

Invariant Mass (ρ, π)

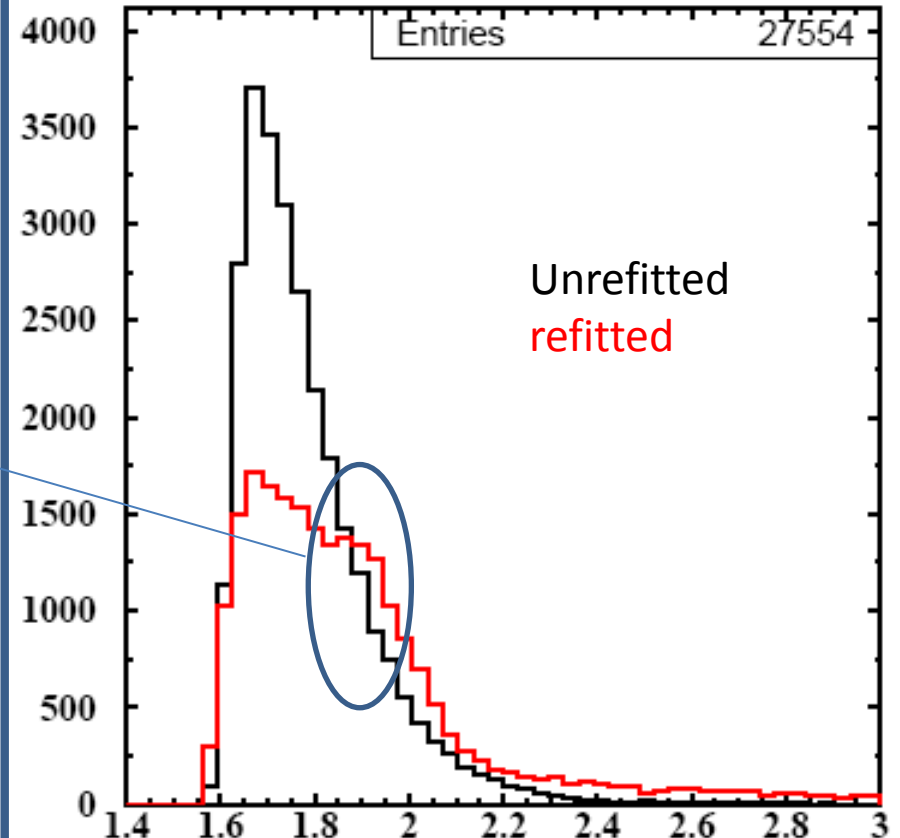
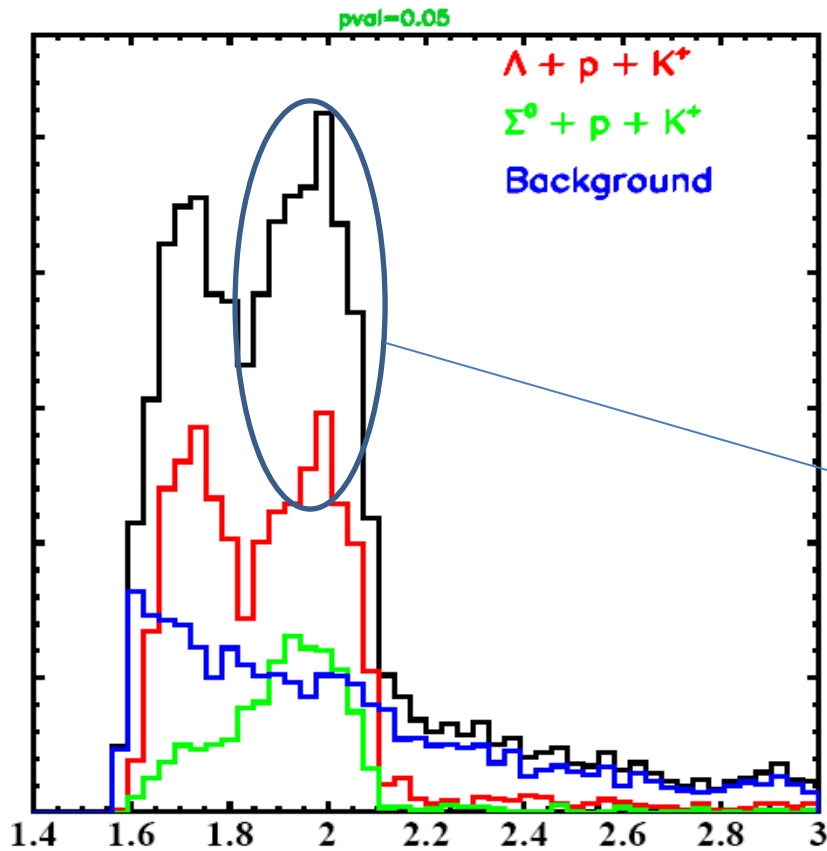
Original pval cut(>0.87)



N*

Pp UrQMD

Data



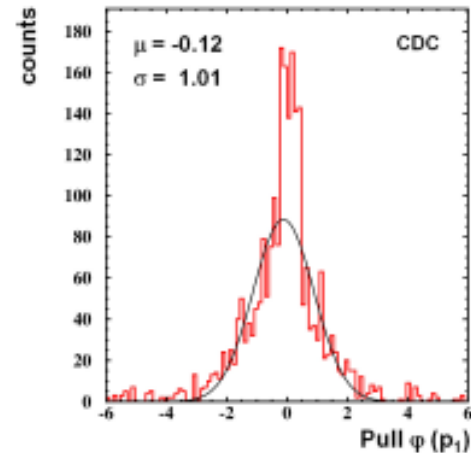
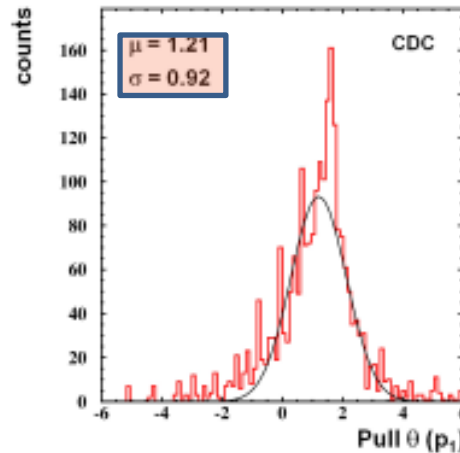
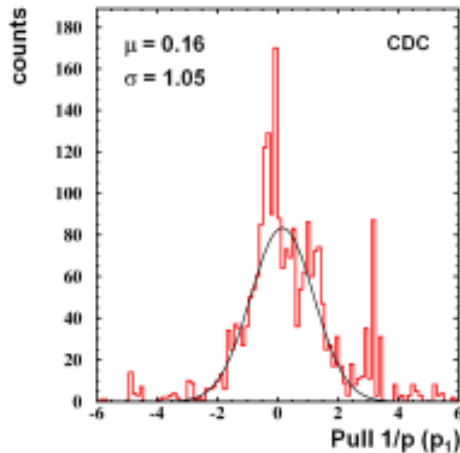
MM (p) - refitted

$|\text{Inv}(p,\pi)-1.116| < 40 \text{ Mev}$

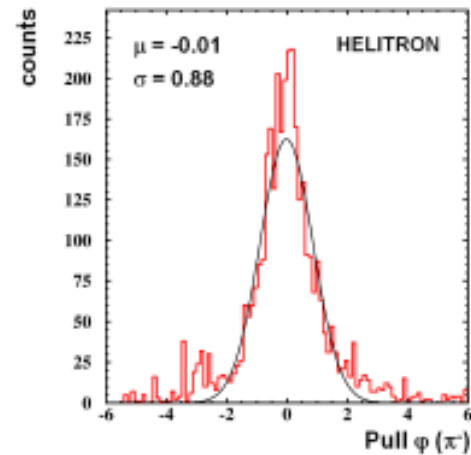
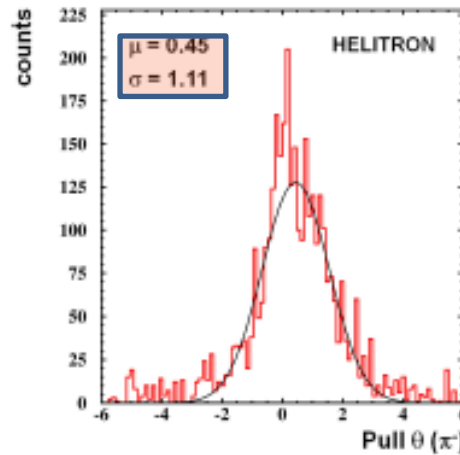
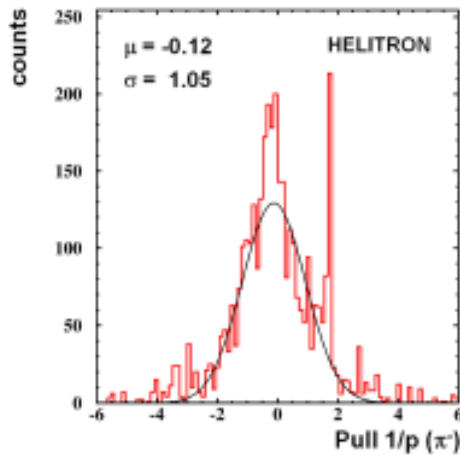
MM (p) - refitted

Systematical Errors

Primary
proton



pion



$1/p$

θ

ϕ

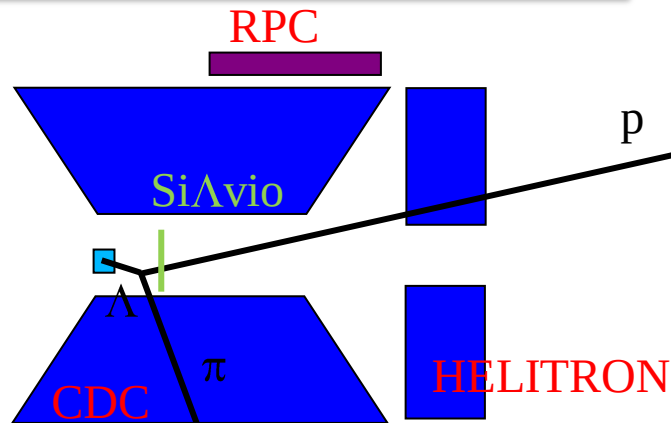
Summary & Outlook

- Inclusive Lambda-Routine:
 - Lambda are visible in Semi Forward Kombination
 - Reduction Compareable with Simulations
- Exclusive Reconstruction tested with simulation
 - Event Selection: Refit is sensitive to Different Channels
 - Additional Constraints (Vertex) has to be tested.
 - Resolution can be improved signal: N^* signal as a crosscheck
- Refit with Data
 - Pval Cut reduced Background of Exclusive Lambda.
 - N^* - signal visible : Crosscheck of analysis
 - Problem: **Systematical Errors**
- New Calibration
 - Finished recently. Has to be tested.

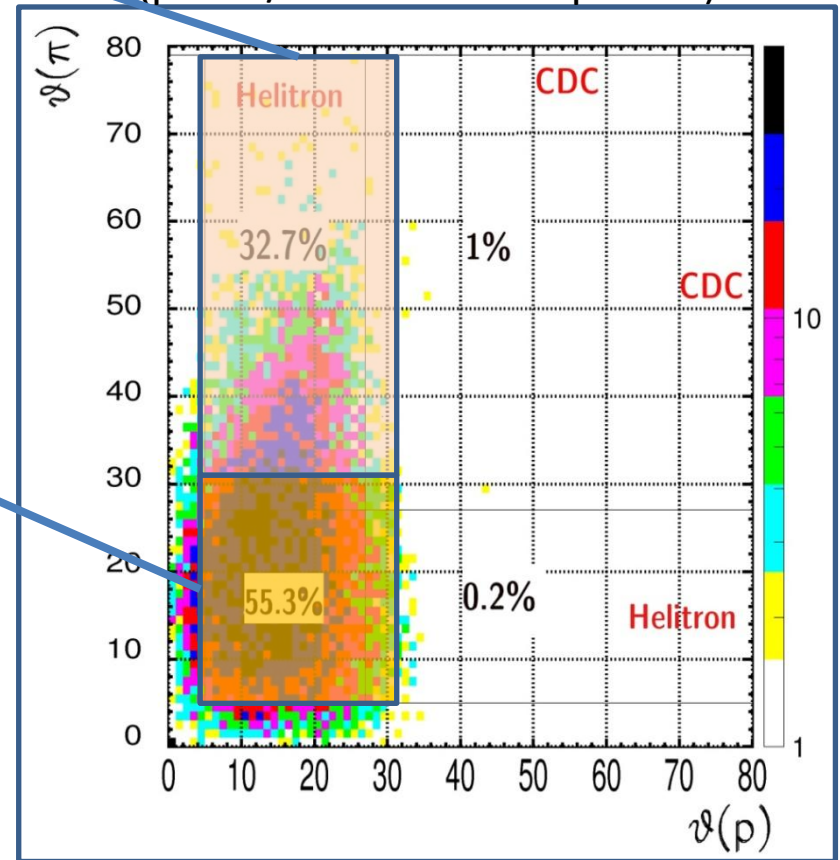
Backup

Different Regions

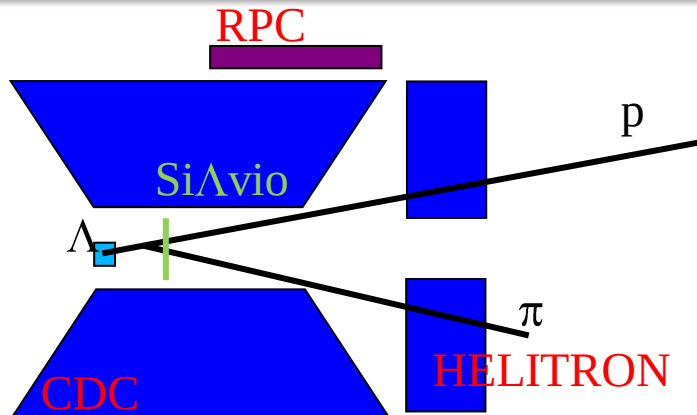
Semi – Forward (CDC – (RPC))



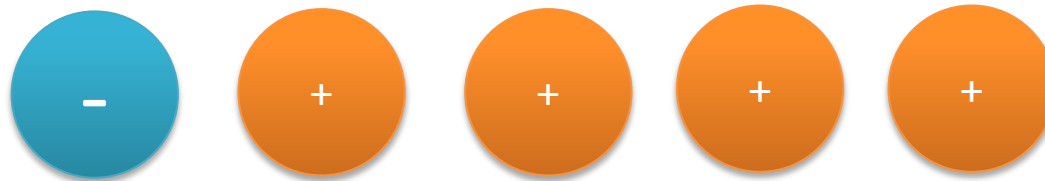
Polar angle of particles from Λ decay
($pK^+\Lambda$ / K^+ in RPC acceptance)



Forward (SiΛViO – Helitron - Plawa)



Event Selection



Available tracks

1 2 3 4 5



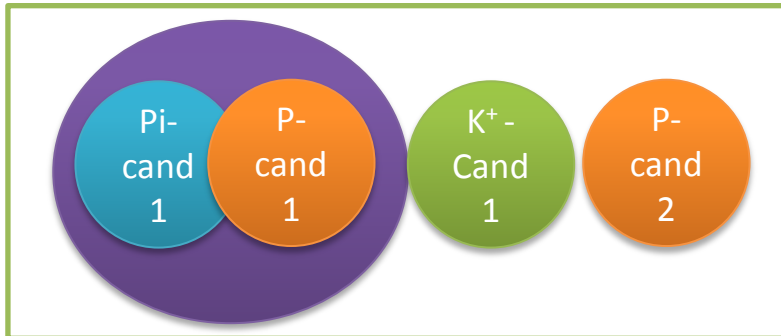
Rough PID

1 2 3 4 5

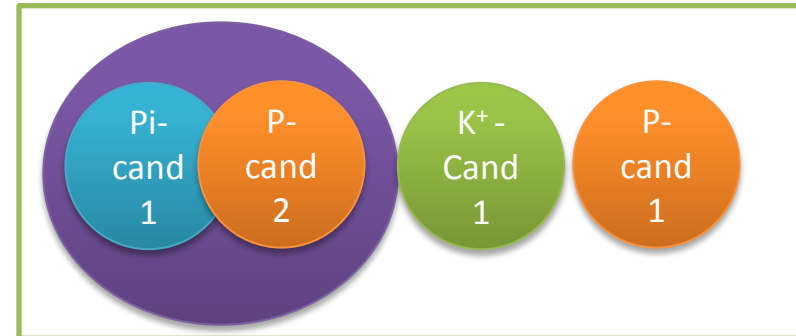


Bild Kombination

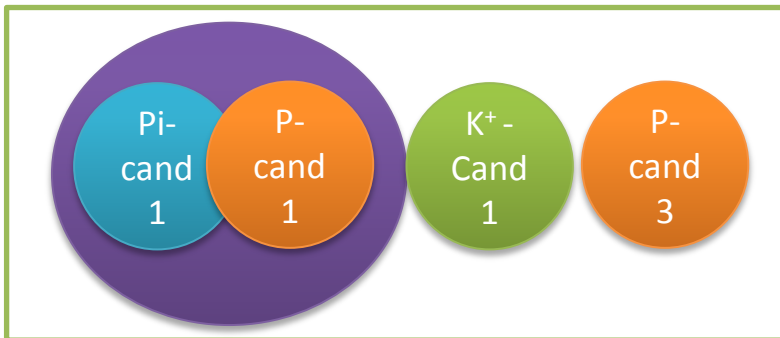
Komb 1



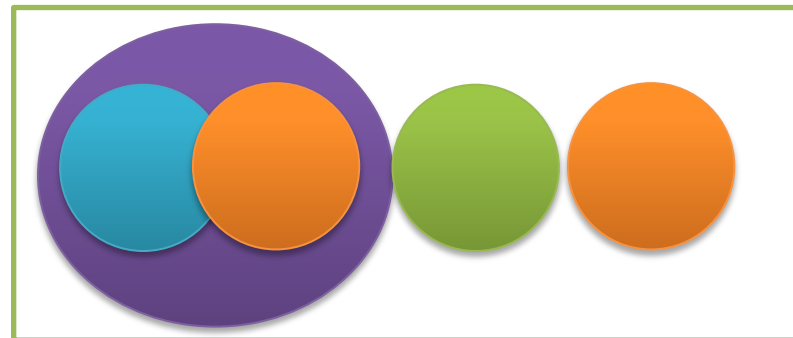
Komb 2



Komb 3

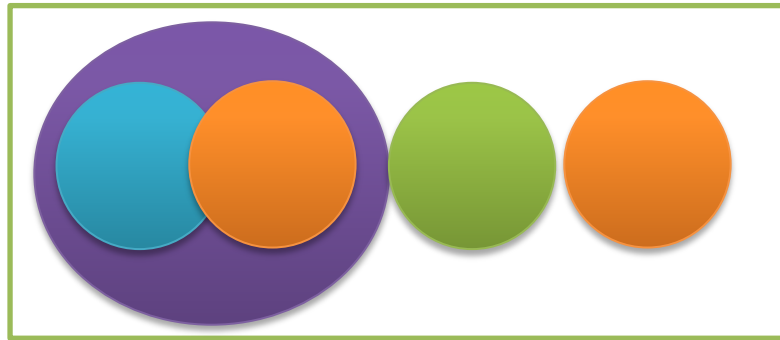


Komb i



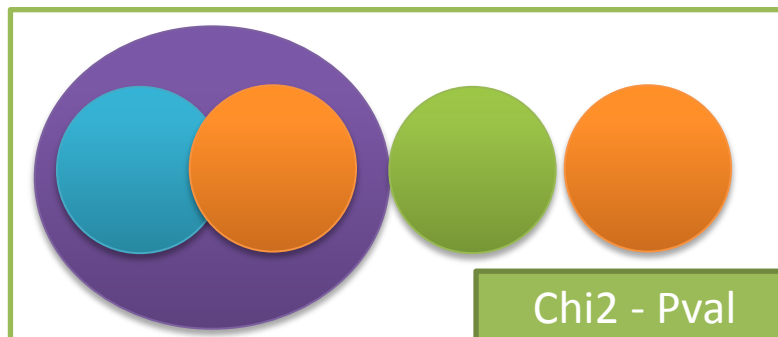
Prefit

Komb (i)



Prefit

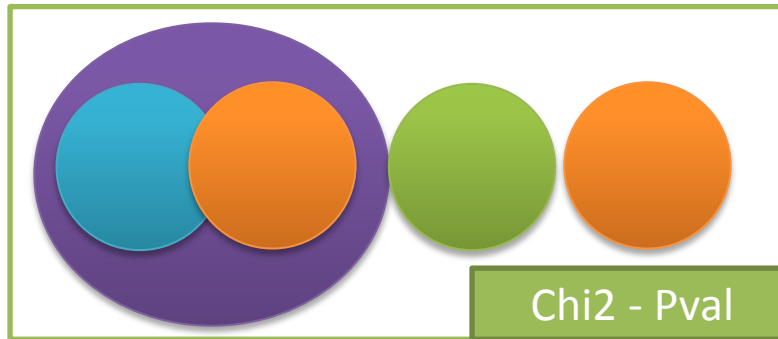
Komb (i)



Chi2 - Pval

Prefit

Komb (i)

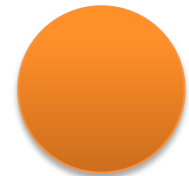


Sort descending by pval

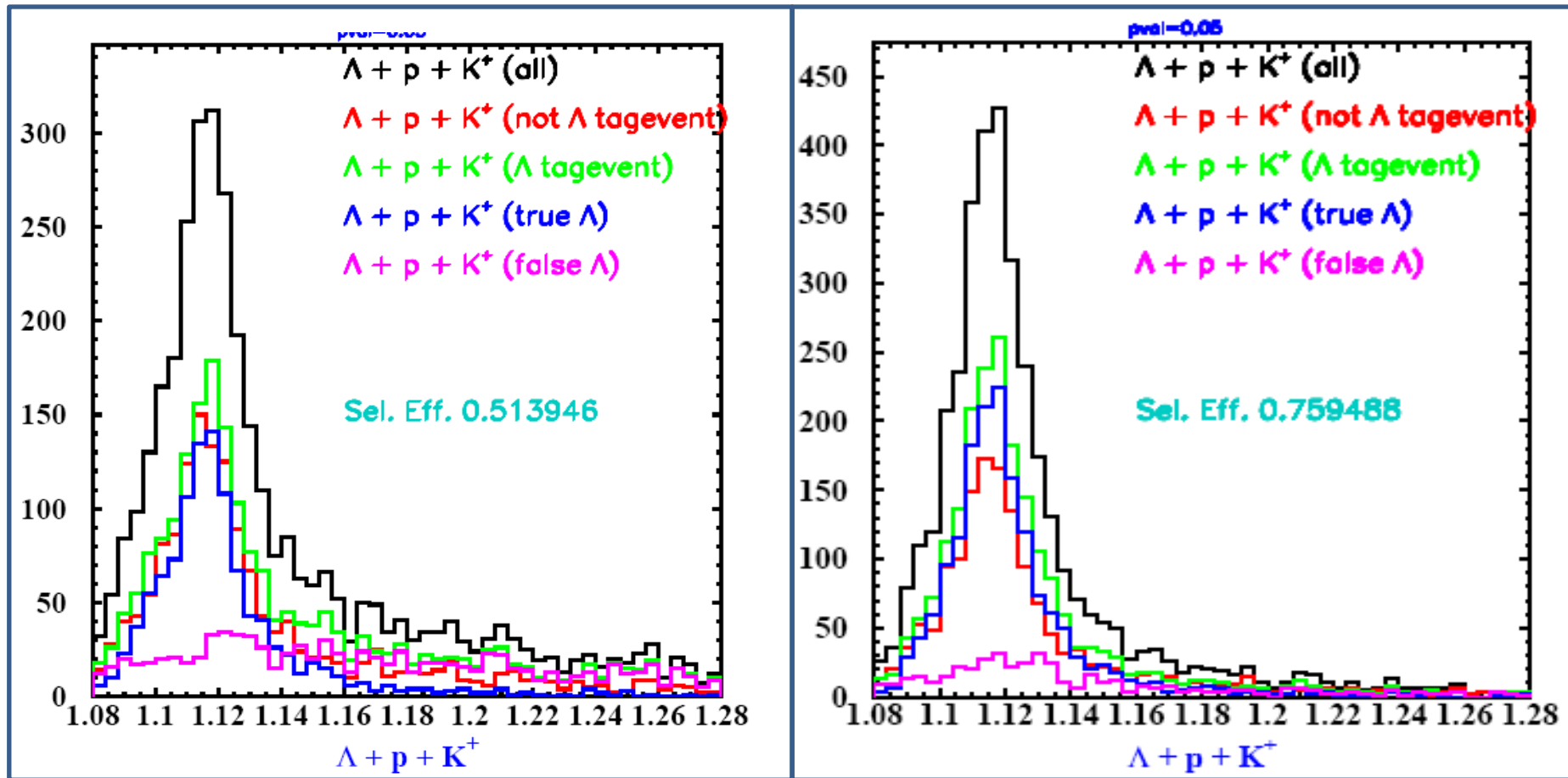
Komb 1 (biggest pval) will be used



Remaining particle is
treated as faketrack



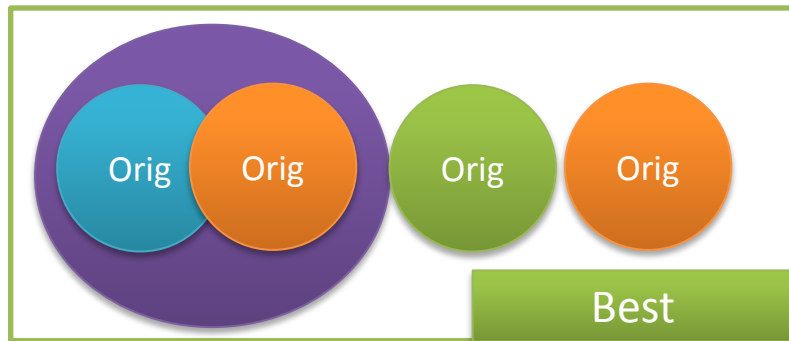
Lambda Preselection



Preselectio Option 2: 75% of Lambda Kombination are select

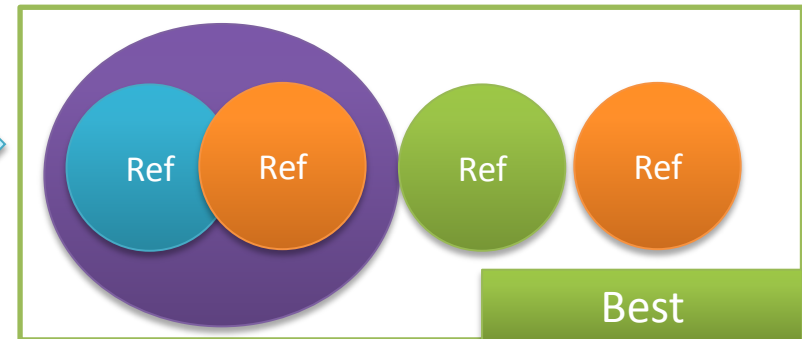
Main Fit

Komb 1 (biggest pval) will be used



Refit

Komb 1 (biggest pval) will be used



Ntuple

Chi2

Pval

Inv(p, π)

Inv(Λ ,p)

Inv(Λ ,K)

mm(p)

mm(K)

mm(K,p)

Vertices

rInv(p, π)

rInv(Λ ,p)

Inv(Λ ,K)r

rmm(p)

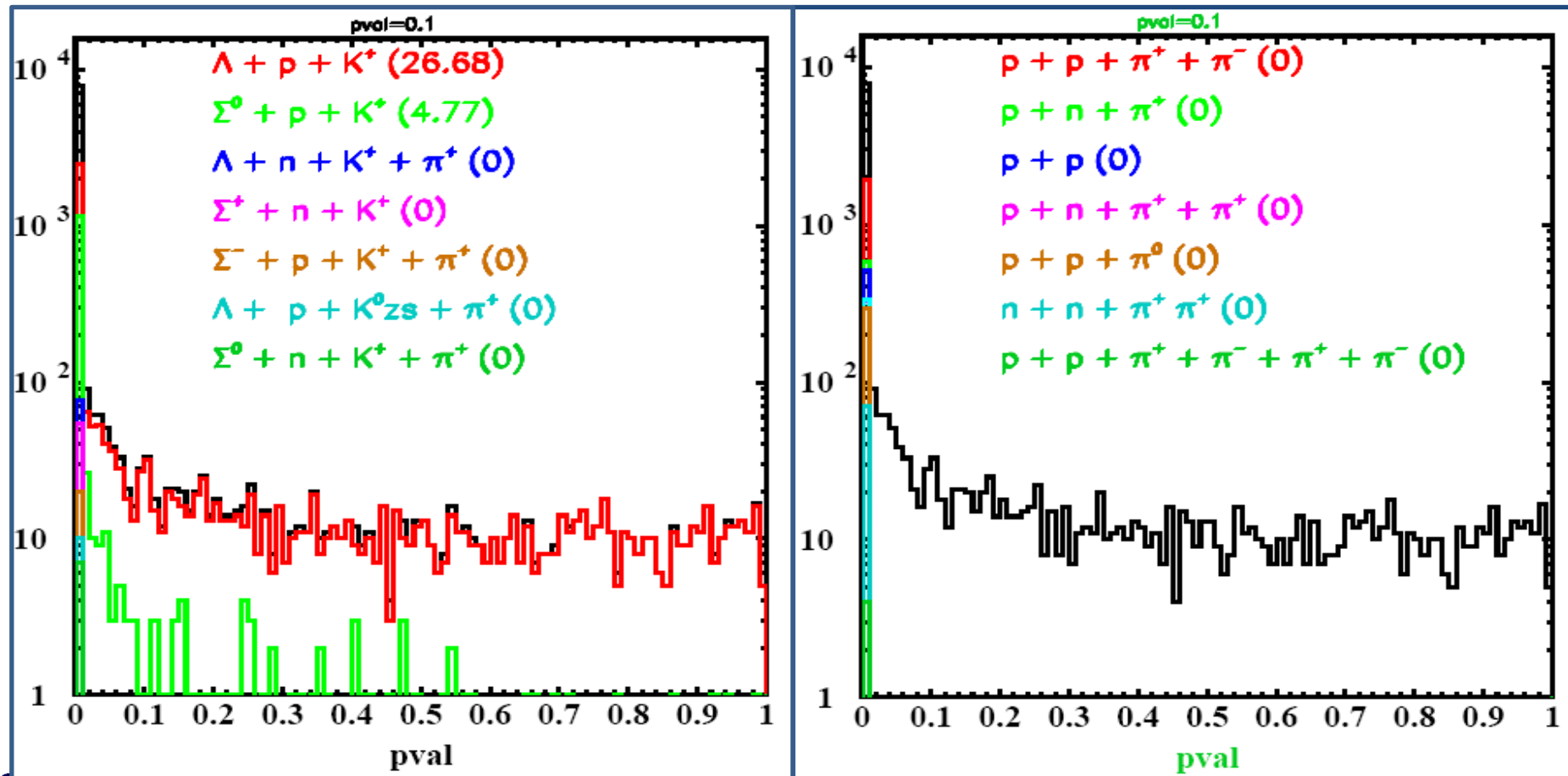
rmm(K)

rmm(K,p)

rVertices

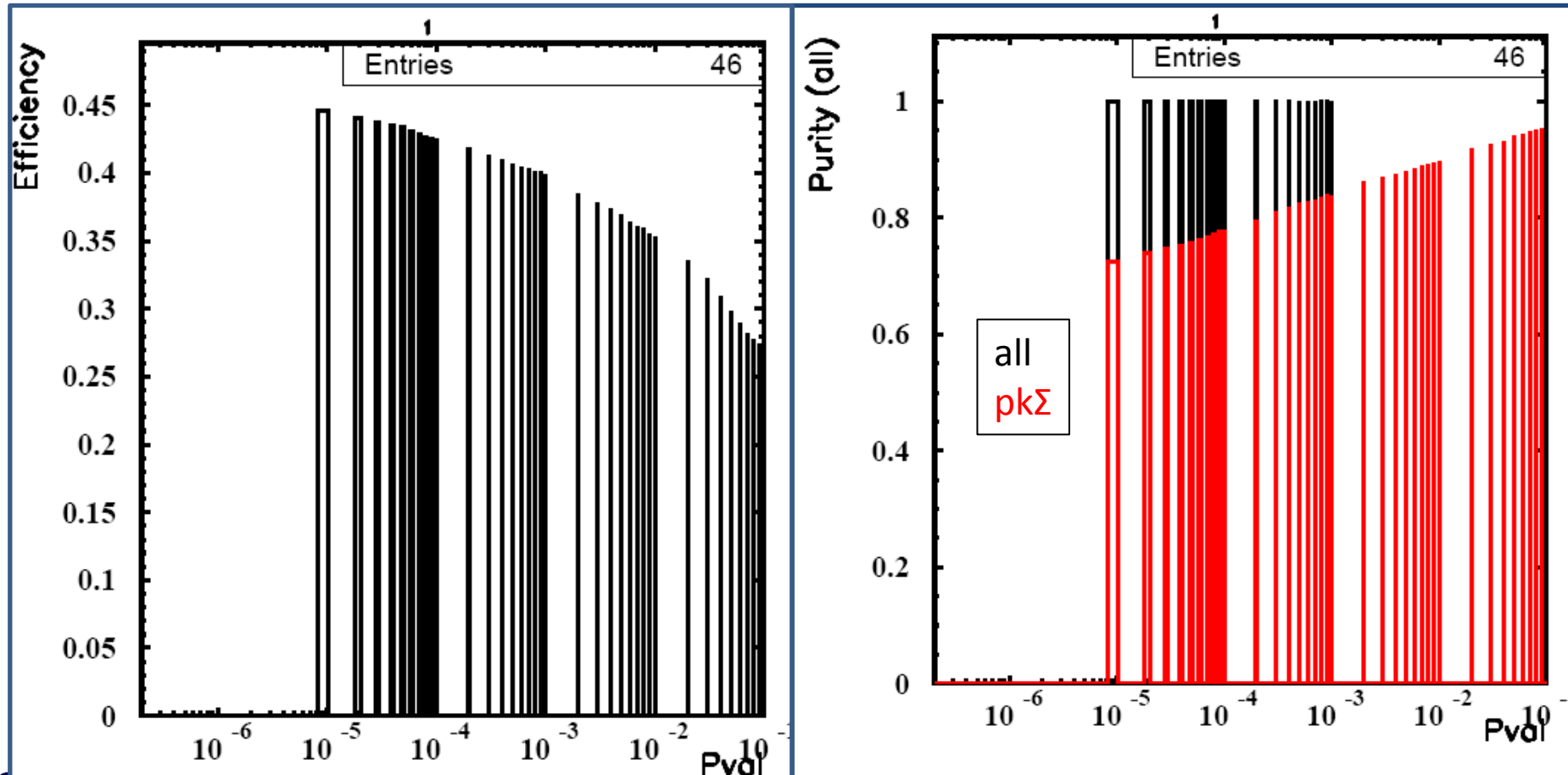
Conservation Constraint

Pval > 0.1



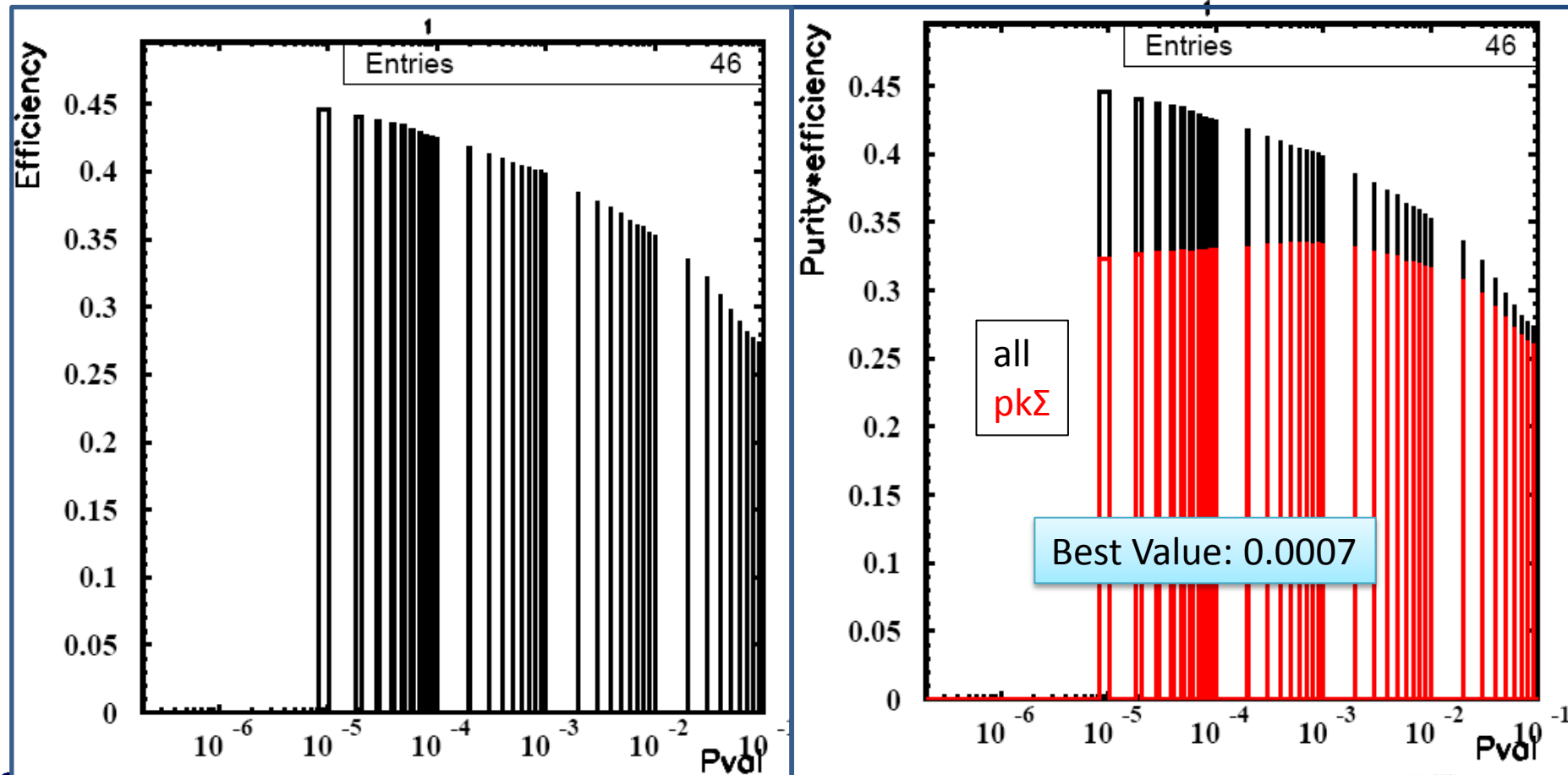
Conservation Constraint

Purity

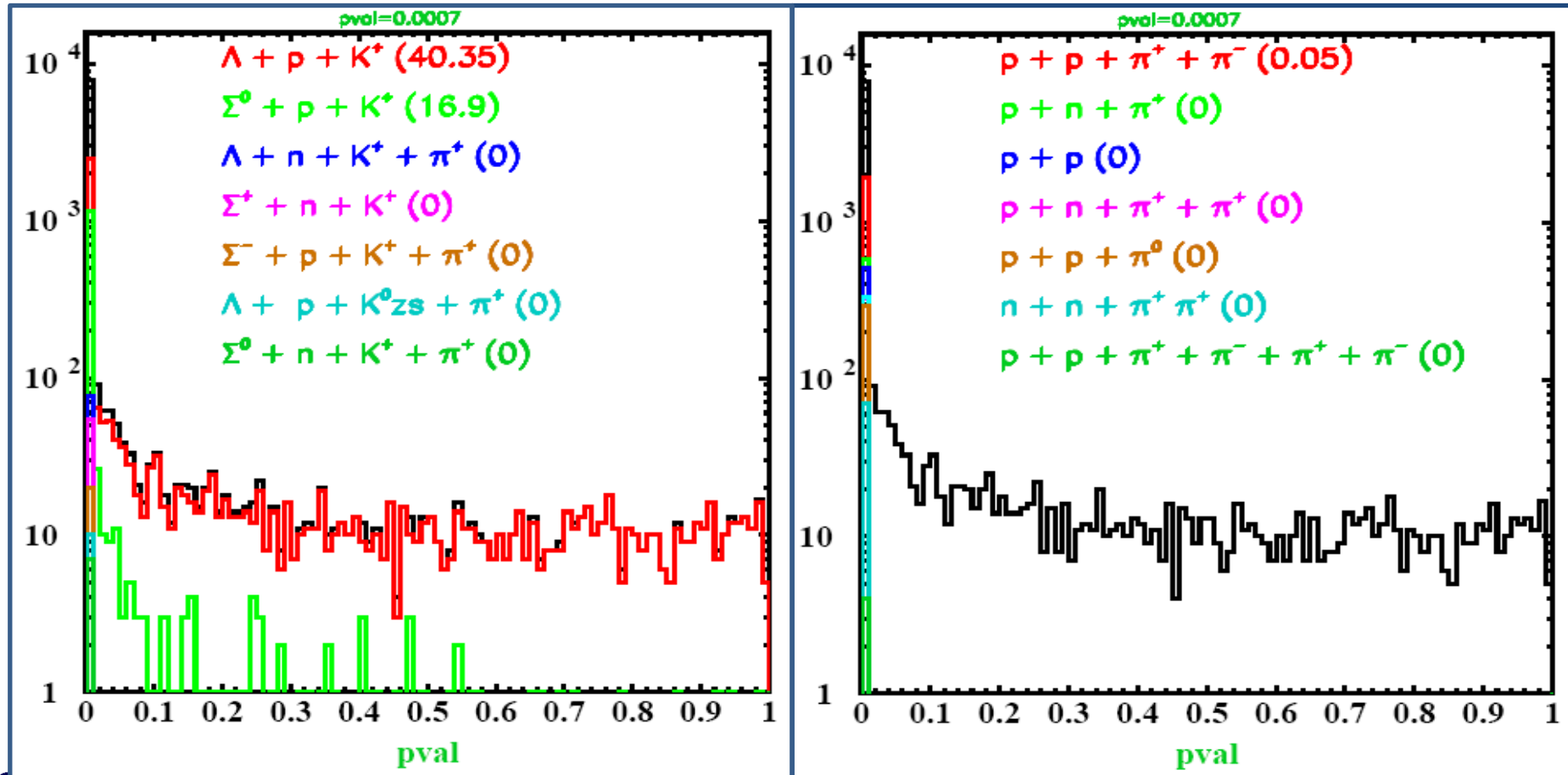


Conservation Constraint

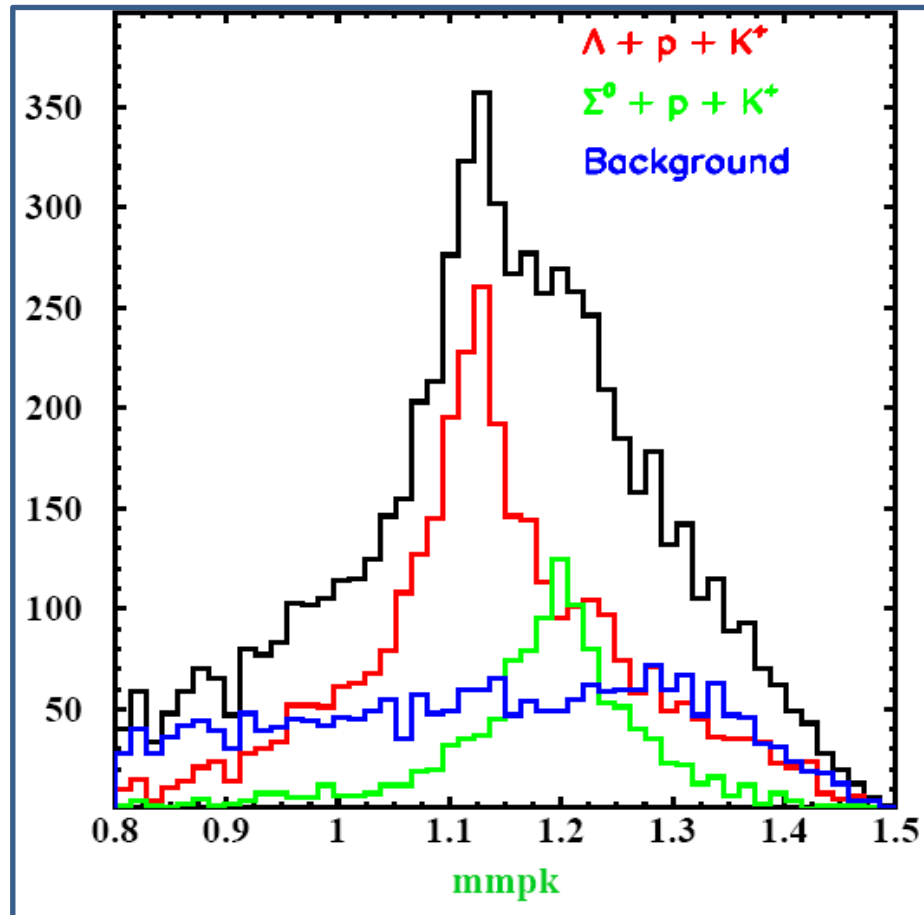
Purity



Conservation Constraint

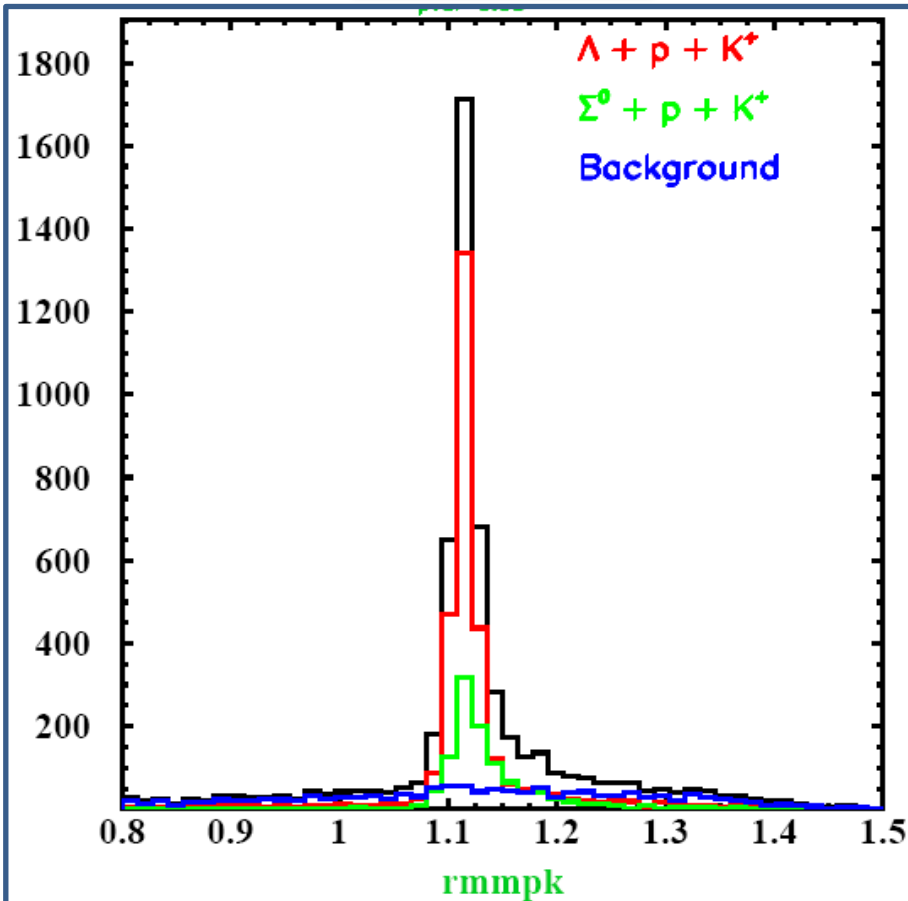


Missing Mass (p, K)

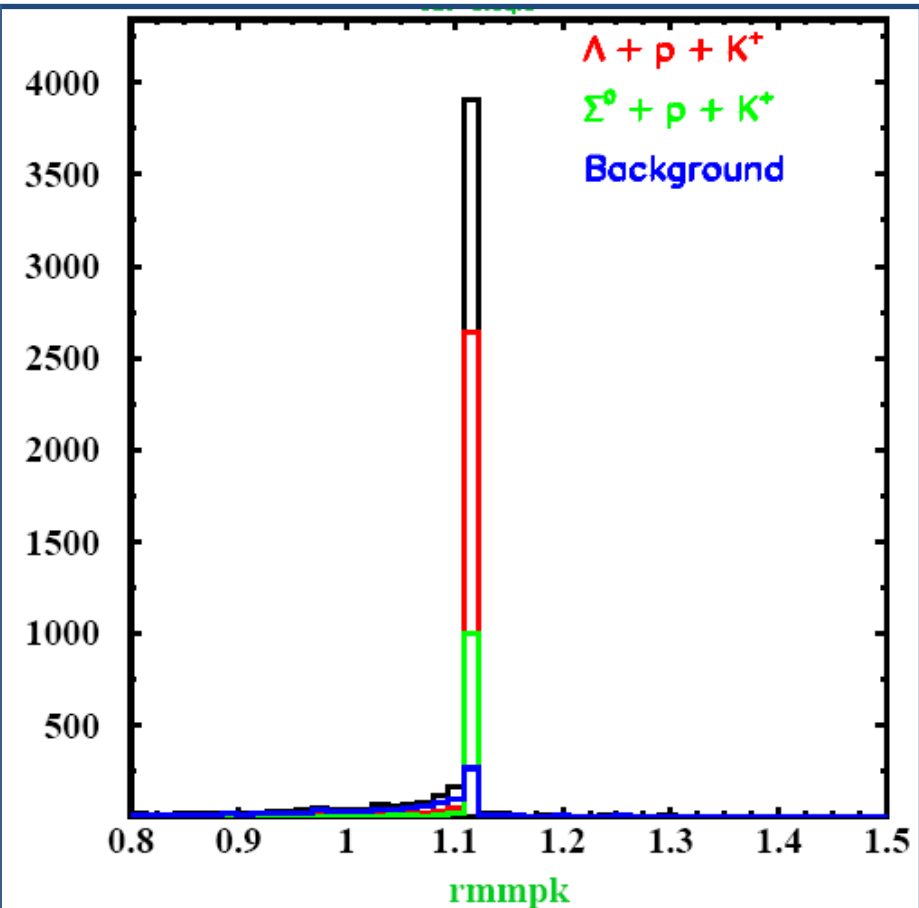


Different Constraints

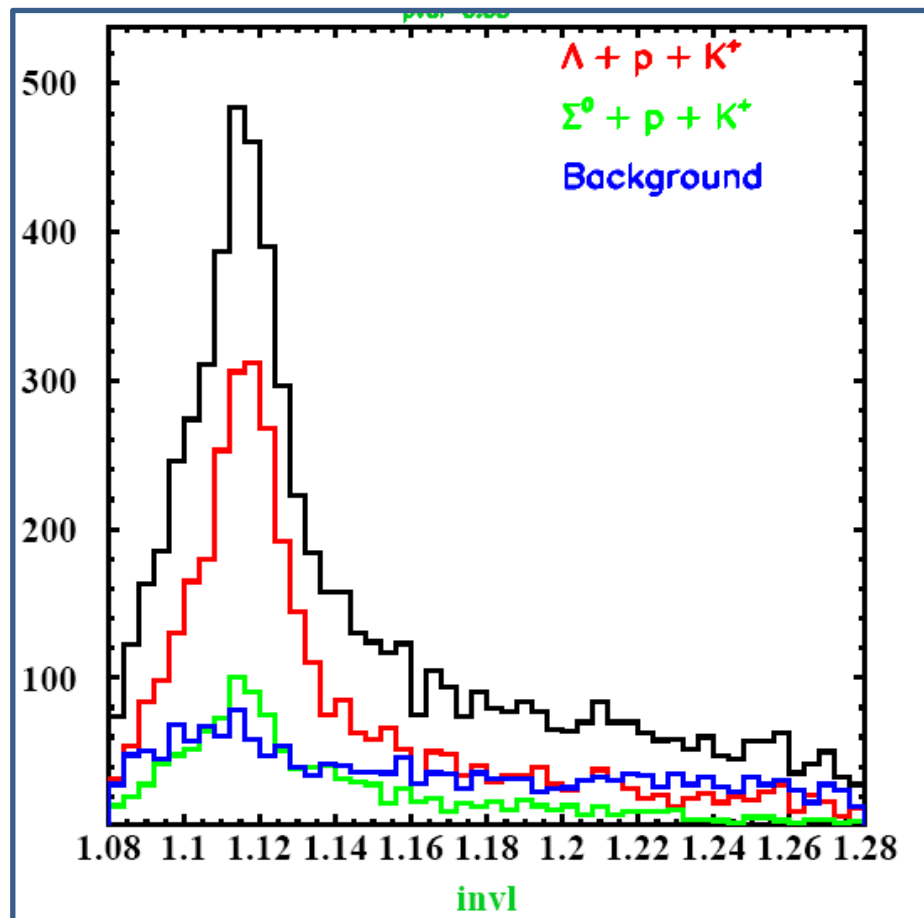
Conservation



Conservation+ Mass

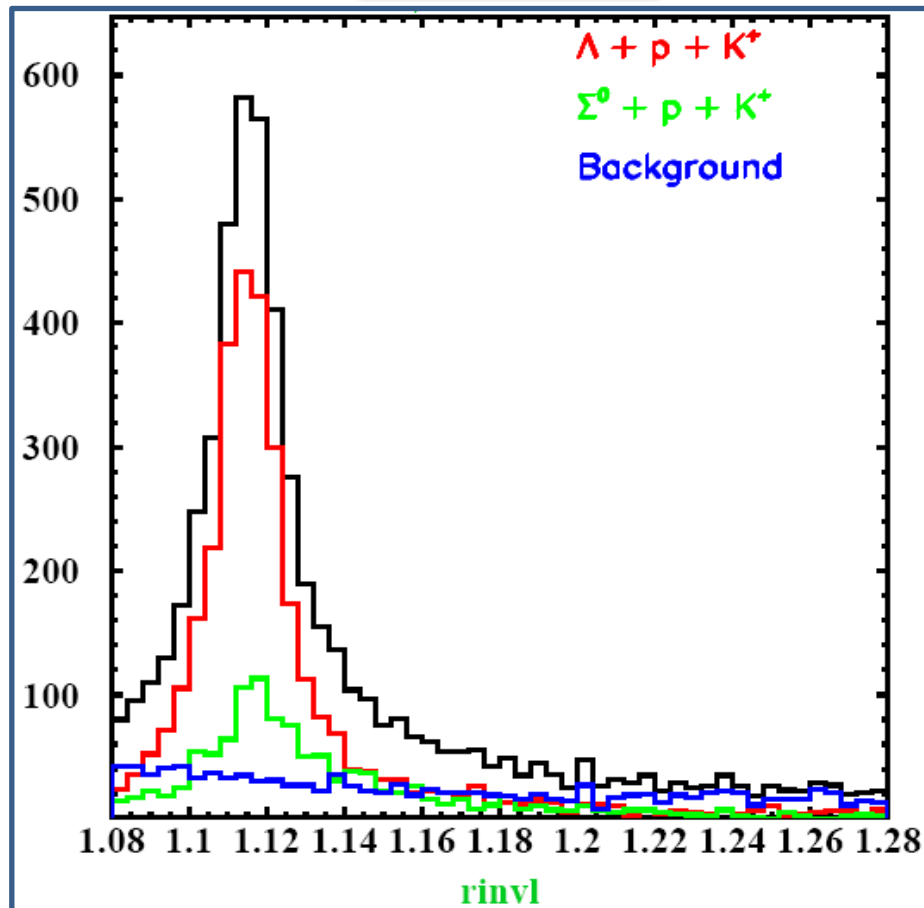


Invariant Mass (p, π)

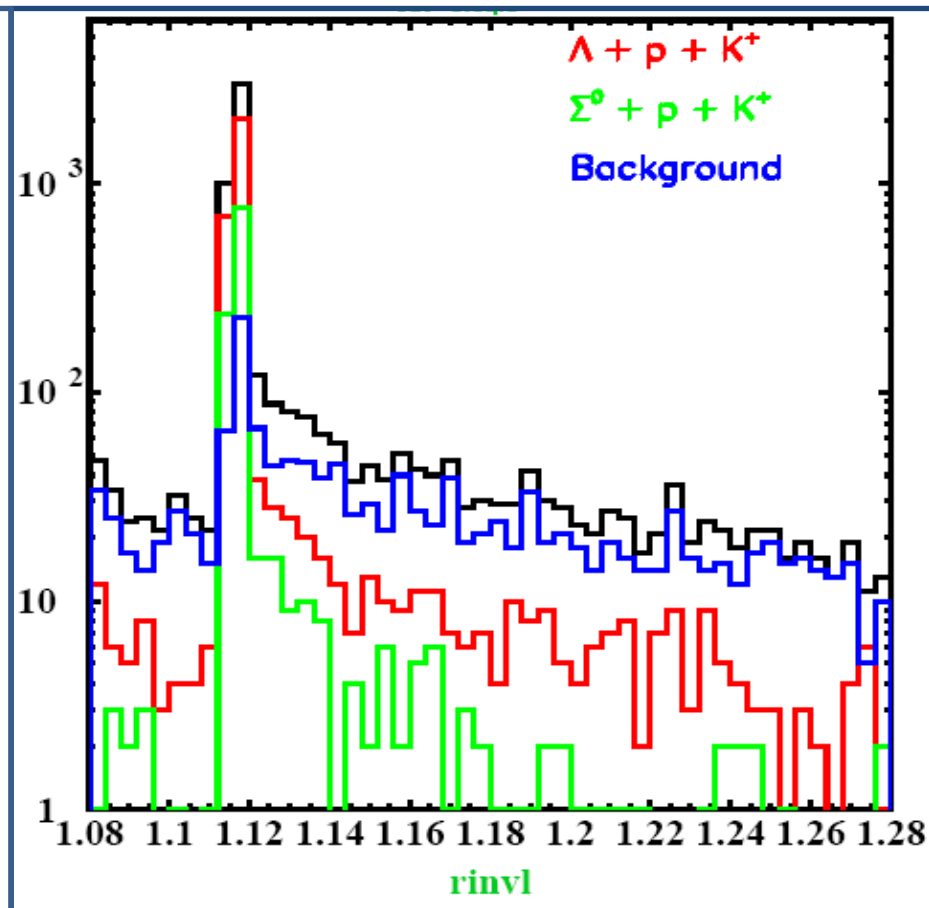


Invariant mass (p, π)

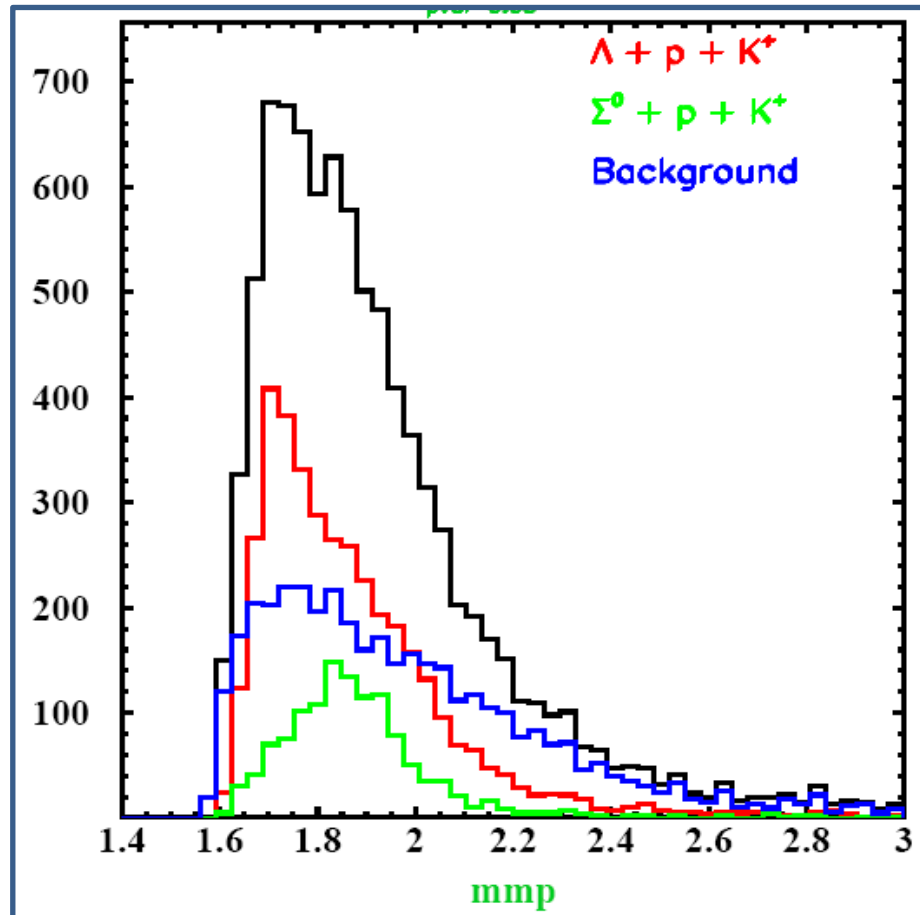
Conservation



Conservation+ Mass

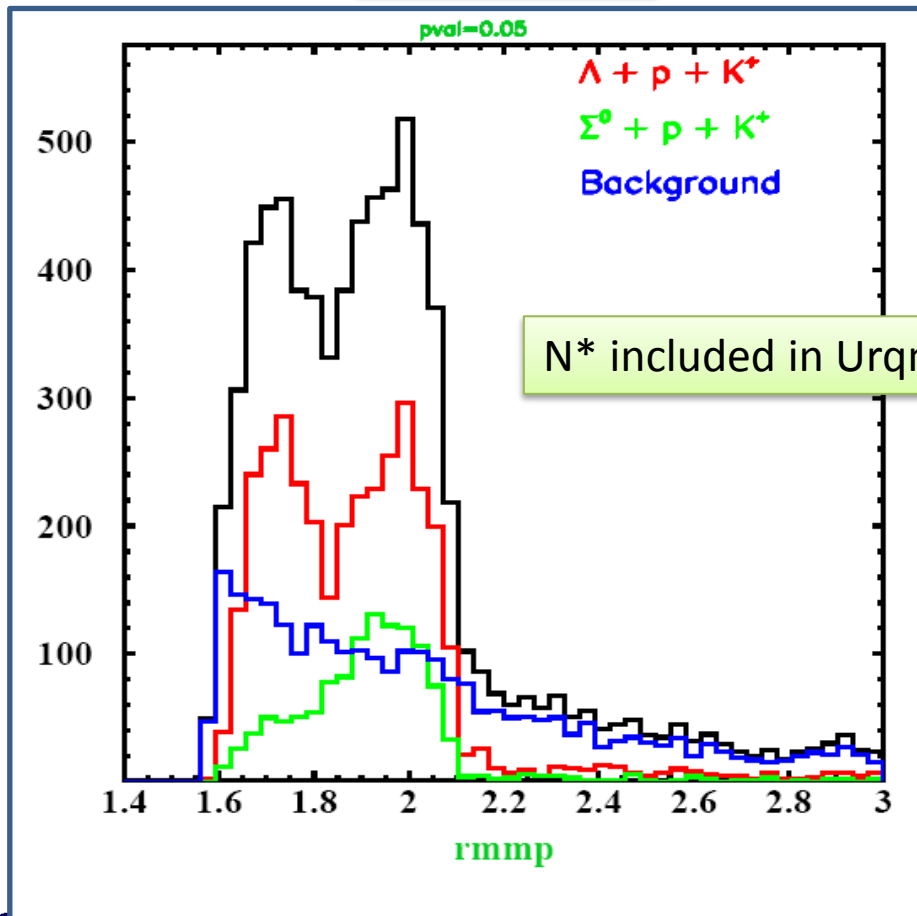


Missing Mass (p)

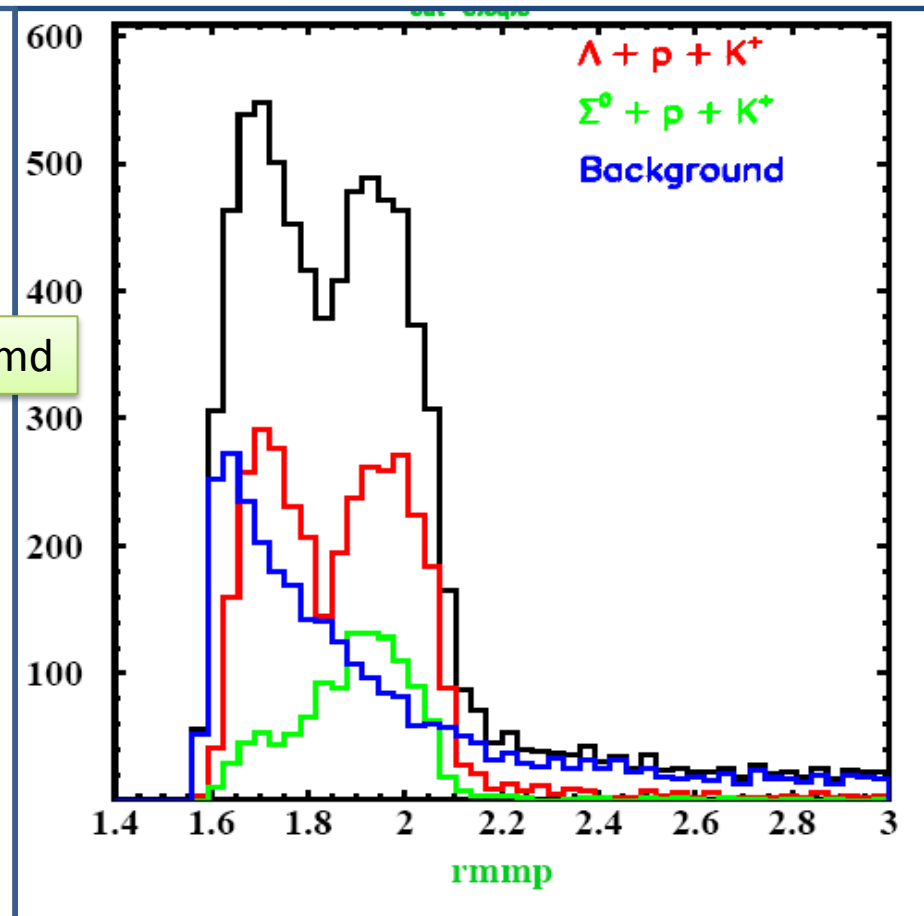


Missing Mass(p)

Conservation

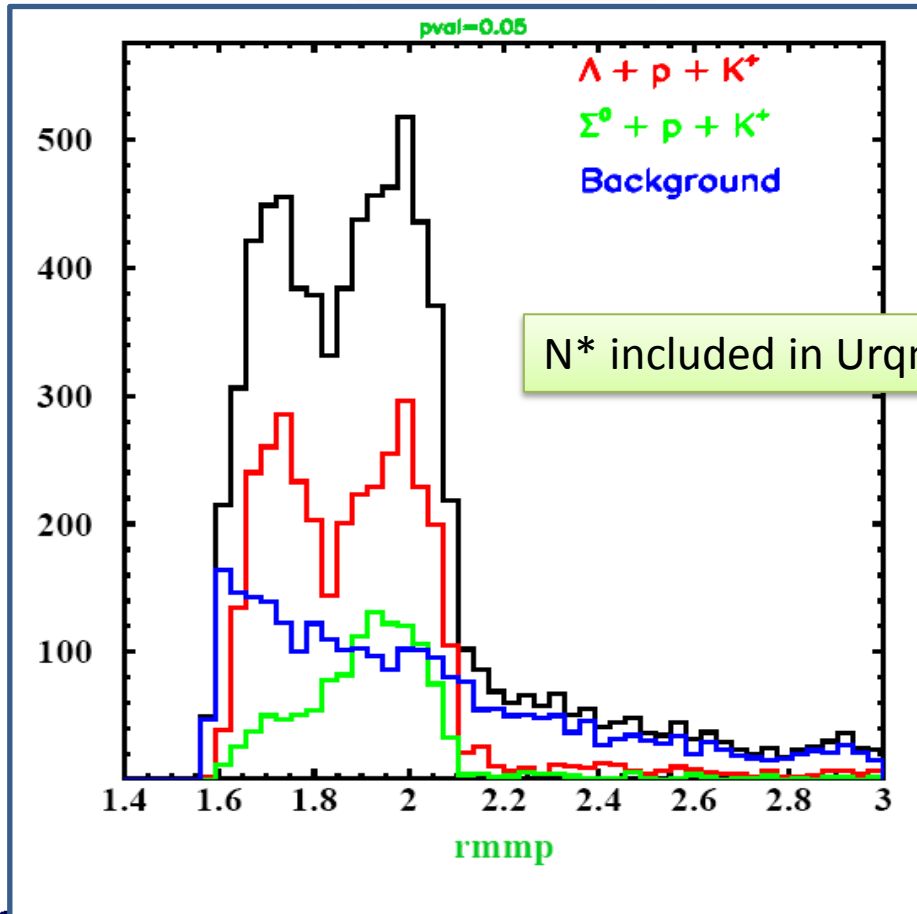


Conservation+ Mass

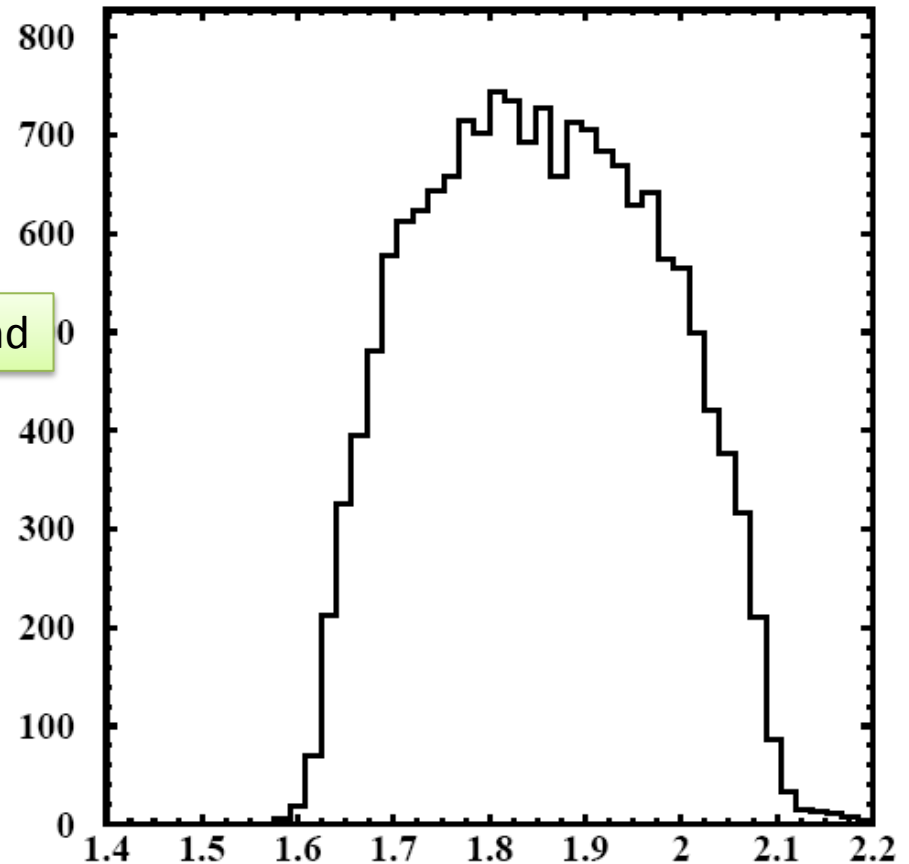


Missing Mass(p)

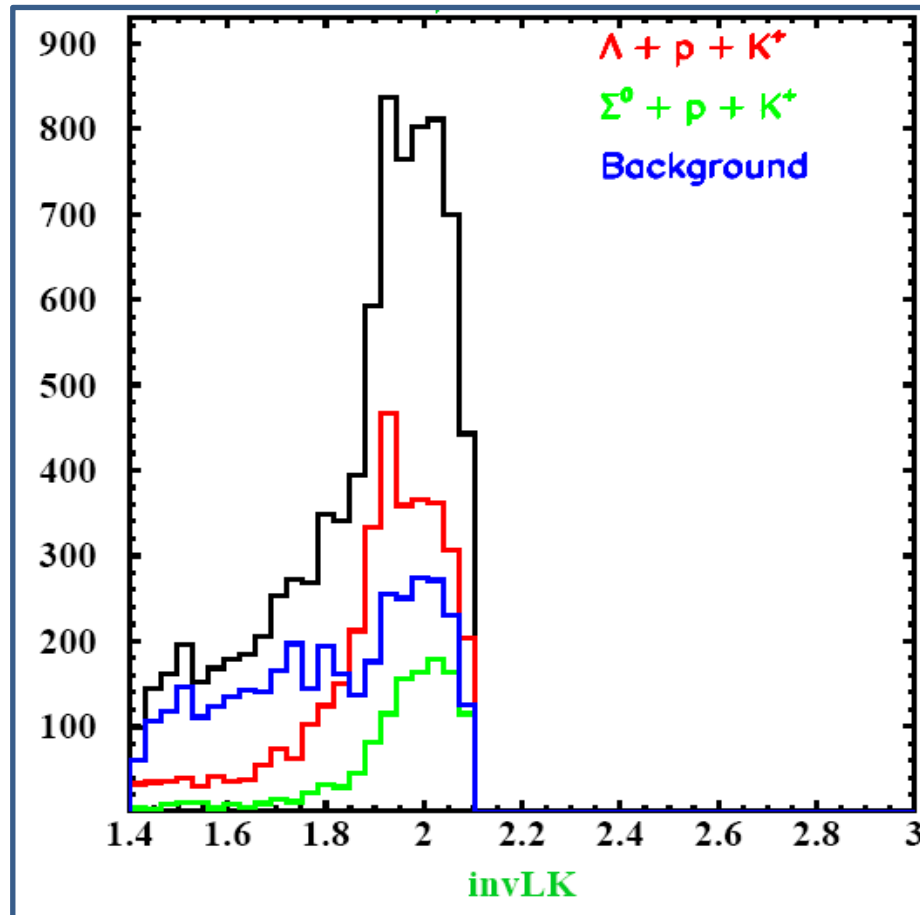
Conservation



pKL - Phasespace

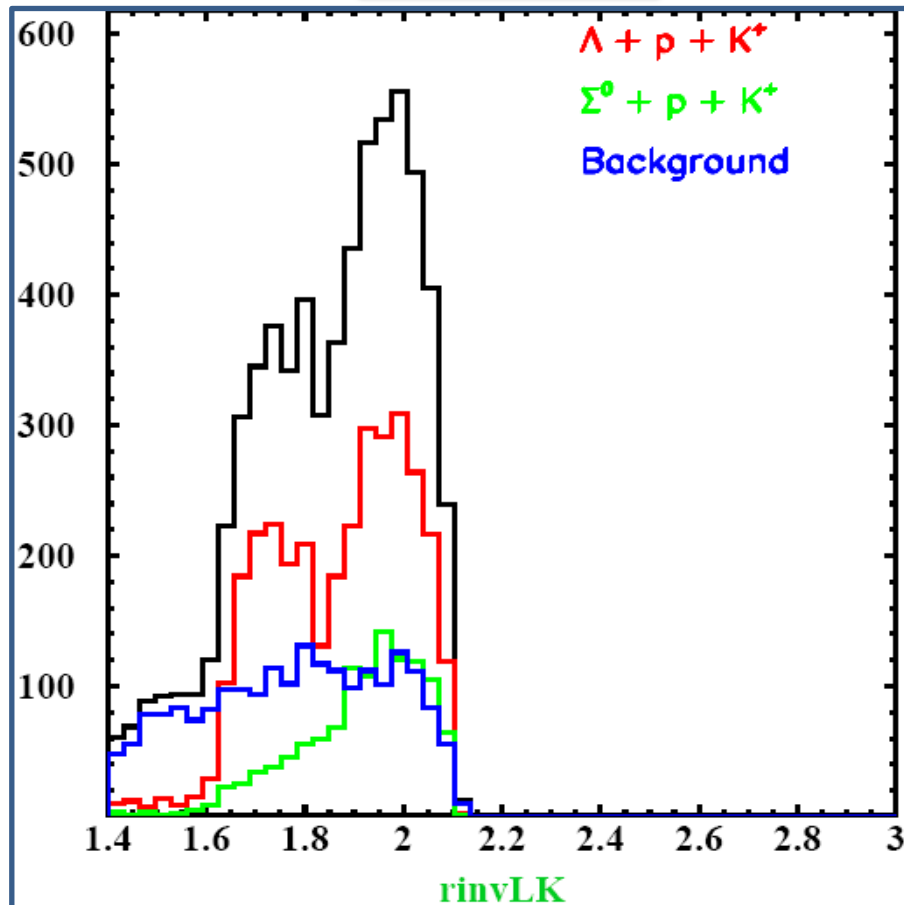


Missing Mass (p, K)

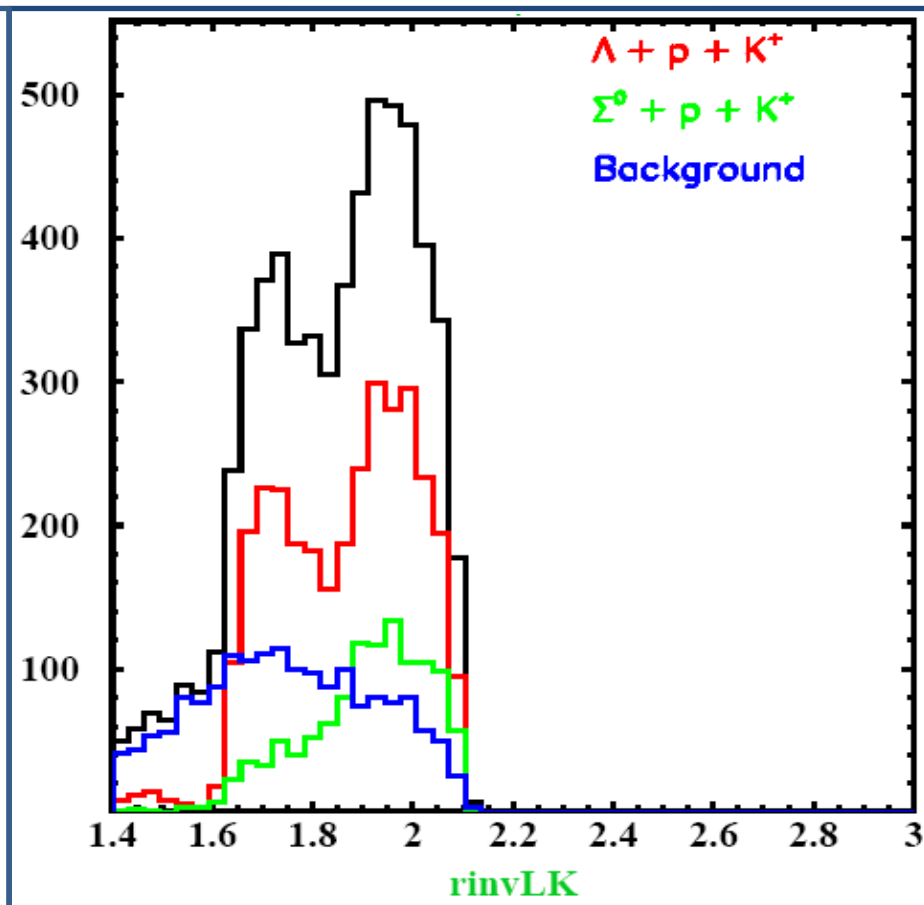


Different Constraints

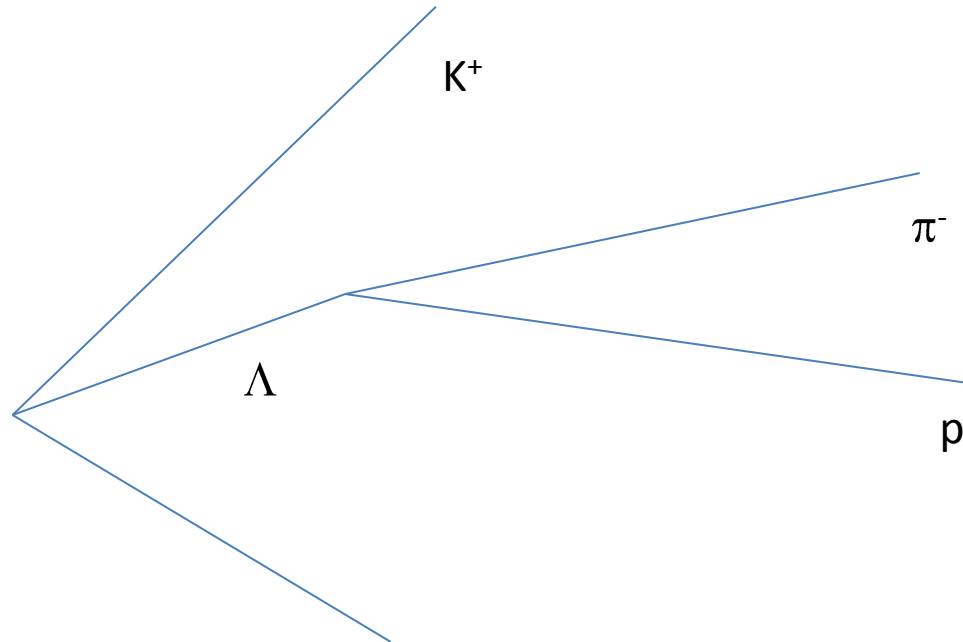
Conservation



Conservation+ Mass



Exclusive Reconstruction Data



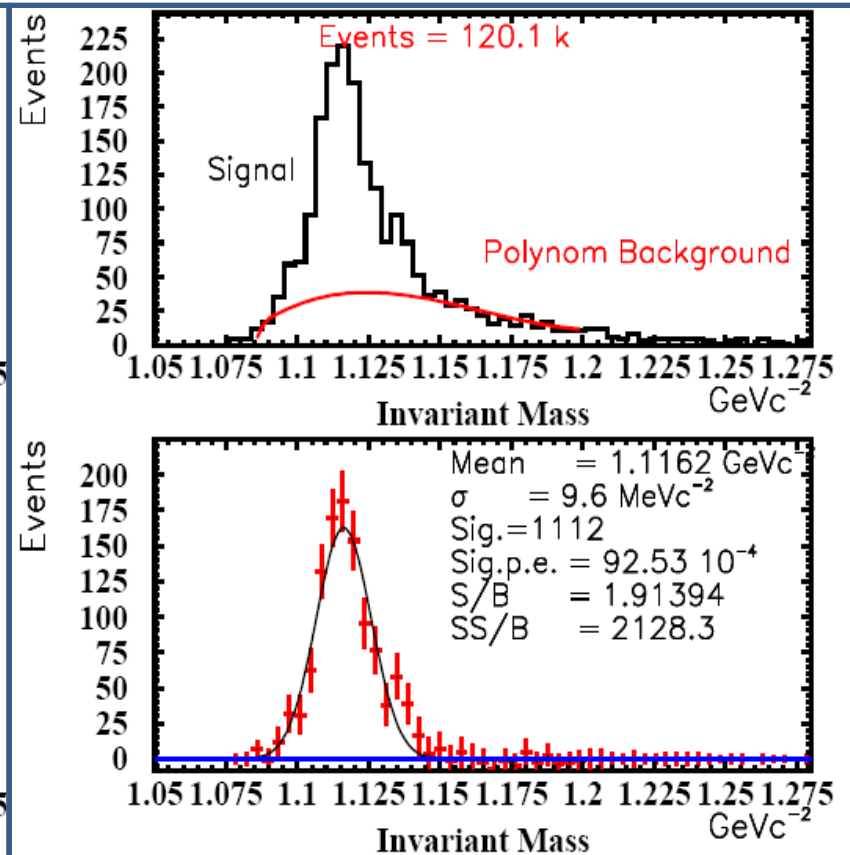
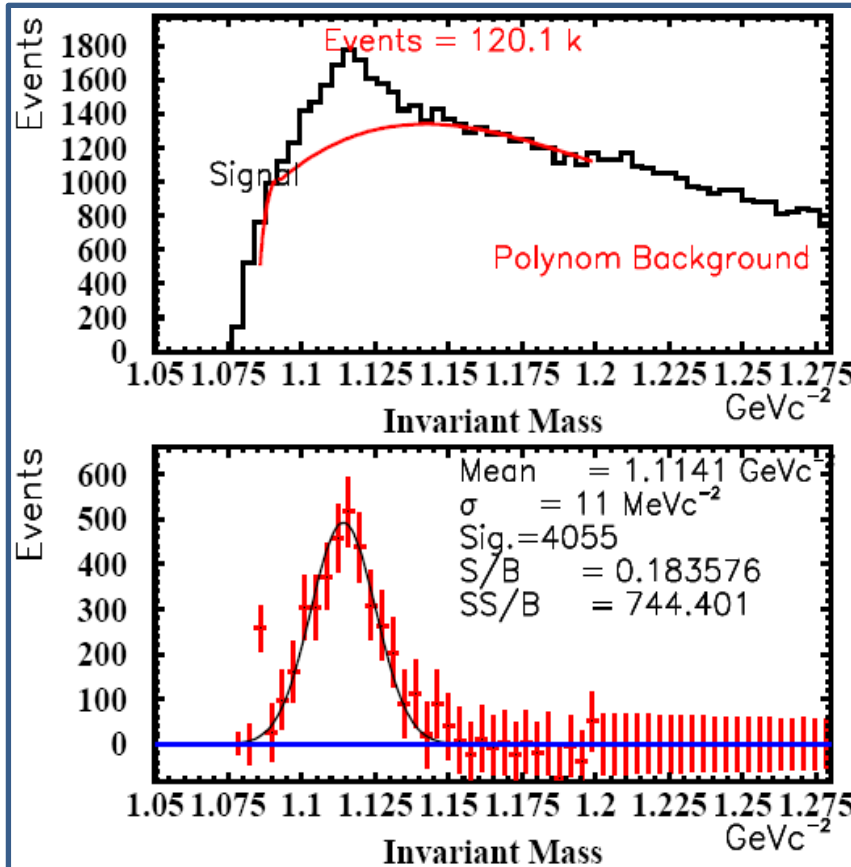
Data

Energy & Momentum Constraint

Original

Invariant Mass (ρ, π)

Original pval cut(>0.87)



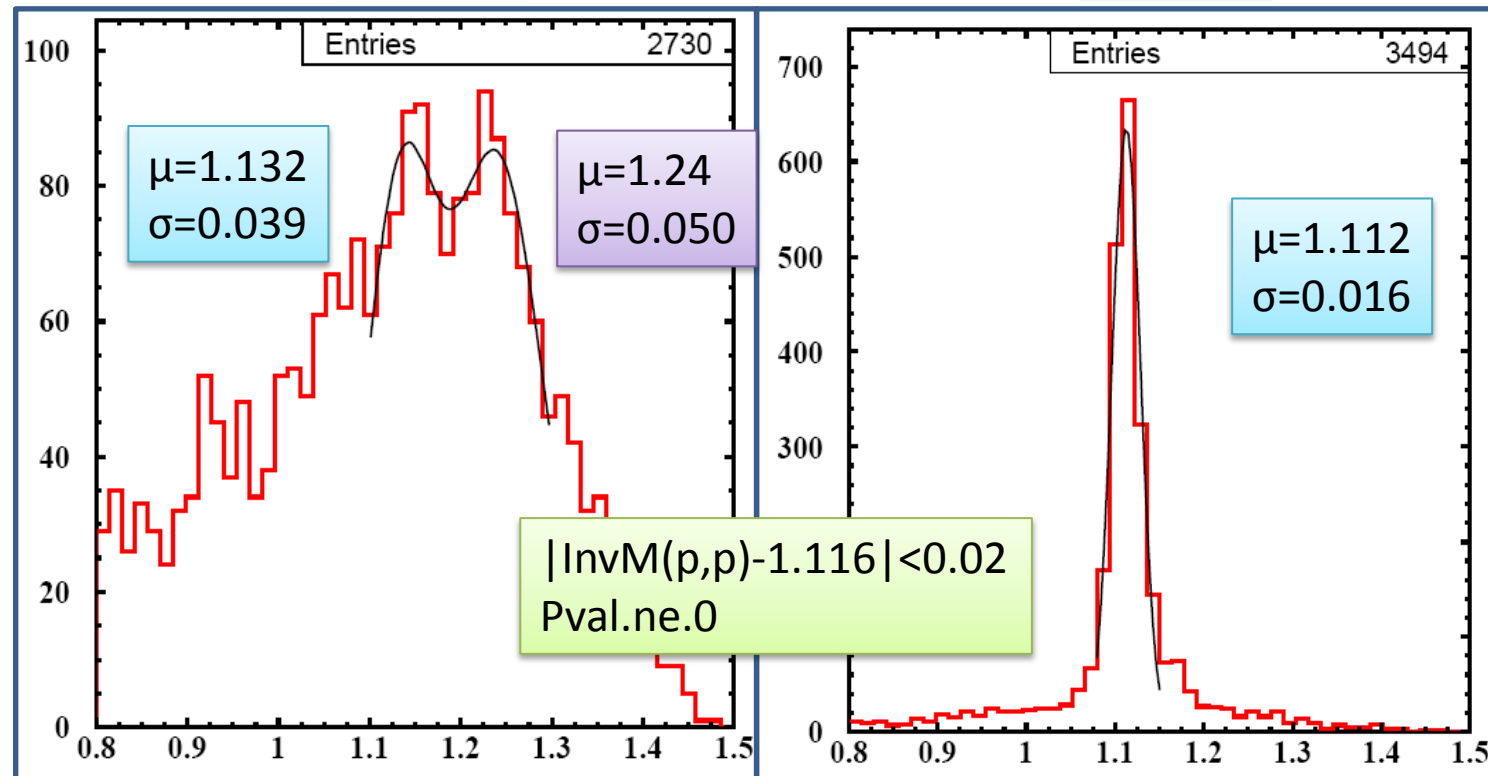
Data

Missing Mass pK^+

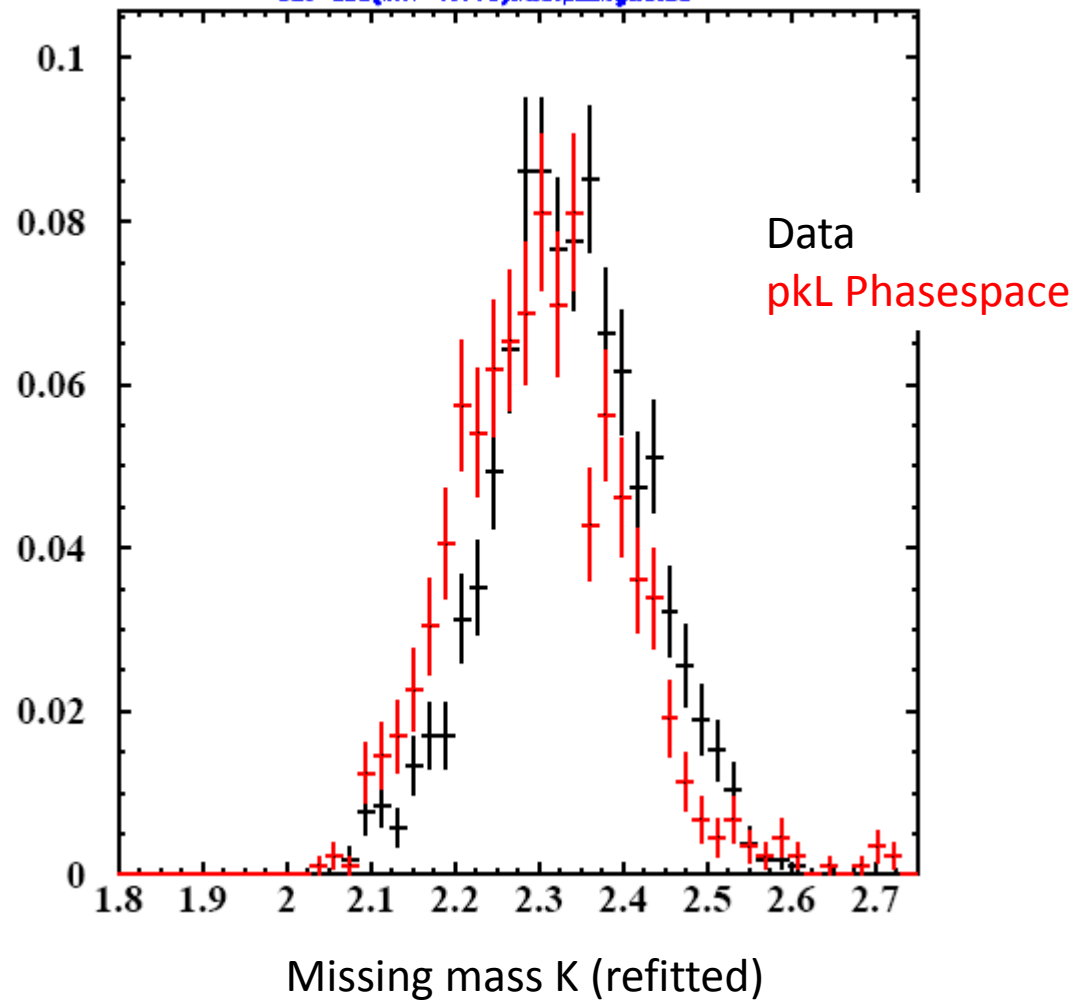
Energy & Momentum Constraint

Original

Refitted



Absolutely Preliminary



Refit

$$L(\vec{\alpha}, \vec{\lambda}) = (\vec{\alpha} - \vec{\alpha}_0)^T \mathbf{V}_{\vec{\alpha}_0}^{-1} (\vec{\alpha} - \vec{\alpha}_0) + 2\vec{\lambda}^T \vec{H}(\vec{\alpha})$$

$$\mathbf{V}_{\vec{\alpha}_0}^{-1} = \begin{pmatrix} \frac{1}{\sigma_{\alpha_1}^2} & 0 & \cdots & 0 \\ 0 & \frac{1}{\sigma_{\alpha_2}^2} & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \frac{1}{\sigma_{\alpha_{6n}}^2} \end{pmatrix} \quad \vec{\alpha} = \begin{pmatrix} \vec{\alpha}_1 \\ \vec{\alpha}_2 \\ \vdots \\ \vec{\alpha}_n \end{pmatrix} \quad \vec{\alpha}_i = \begin{pmatrix} p_{x,i} \\ p_{y,i} \\ p_{z,i} \\ x_i \\ y_i \\ z_i \end{pmatrix}$$

$$\chi^2 = (\vec{\alpha} - \vec{\alpha}_0)^T \mathbf{V}_{\vec{\alpha}_0}^{-1} (\vec{\alpha} - \vec{\alpha}_0) = \sum_l^{6n} \frac{(\alpha_l - \alpha_{0,l})^2}{\sigma_{\alpha_l}^2}$$

Refit

$$L(\vec{\alpha}, \vec{\lambda}) = (\vec{\alpha} - \vec{\alpha}_0)^T \mathbf{V}_{\vec{\alpha}_0}^{-1} (\vec{\alpha} - \vec{\alpha}_0) + 2\vec{\lambda}^T \vec{H}(\vec{\alpha})$$

$$L(\vec{\alpha}, \vec{\lambda}) = (\vec{\alpha} - \vec{\alpha}_0)^T \mathbf{V}_{\vec{\alpha}_0}^{-1} (\vec{\alpha} - \vec{\alpha}_0) + 2\vec{\lambda}^T (\mathbf{D}\delta\vec{\alpha} + \vec{d})$$

$$\chi^2 = (\mathbf{D}\delta\vec{\alpha}_0 + \vec{d})^T \mathbf{V}_D^{-1} (\mathbf{D}\delta\vec{\alpha}_0 + \vec{d})$$