

# Preliminary KLOE data analysis in the search for kaonic clusters

by the AMADEUS collaboration

Oton Vázquez Doce

36<sup>th</sup> Meeting of the LNF Scientific Committee  
May 21, 2008

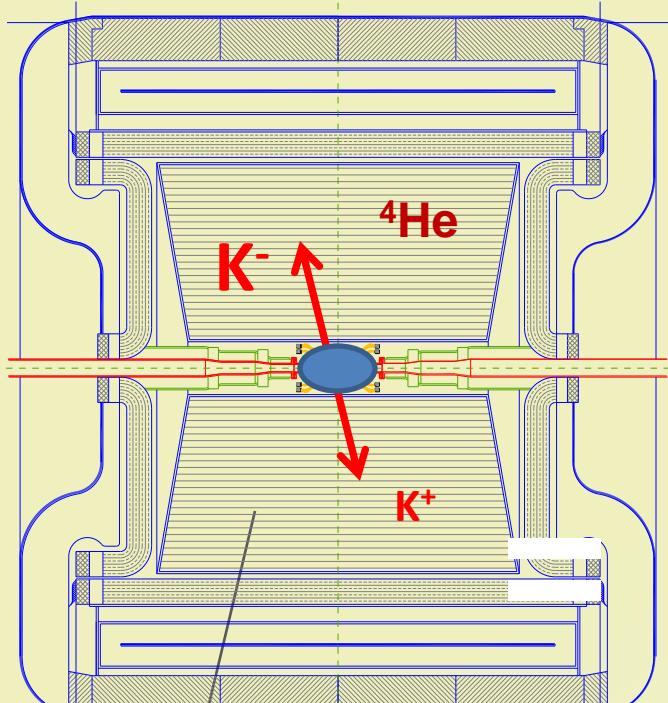
## Introduction

## LAMBDA selection

## Lambda correlations

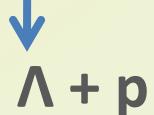
- Lambda-PROTON analysis
- Lambda-DEUTERON analysis
  - Neutron search
  - $\Lambda(1405)$

# Introduction



KLOE Drift Chamber

- The Drift Chambers of KLOE contain mainly  $^4\text{He}$
- From analysis of KLOE data and Monte Carlo:  
**0.1 % of  $K^-$  from daΦne should stop in the DC volume**
- This would lead to hundreds of possible kaonic clusters produced in the  $2 \text{ fb}^{-1}$  of KLOE data.



## • Statistics:

- Total amount of data analyzed up to an integrated luminosity of **~1,1 fb<sup>-1</sup>** from KLOE data (K-charged group).
- Special ntuples of KLOE data were created, with kaons tagged by **2-body decay** or by the **dE/dx** signature in the DC gas.

## • Strategy:

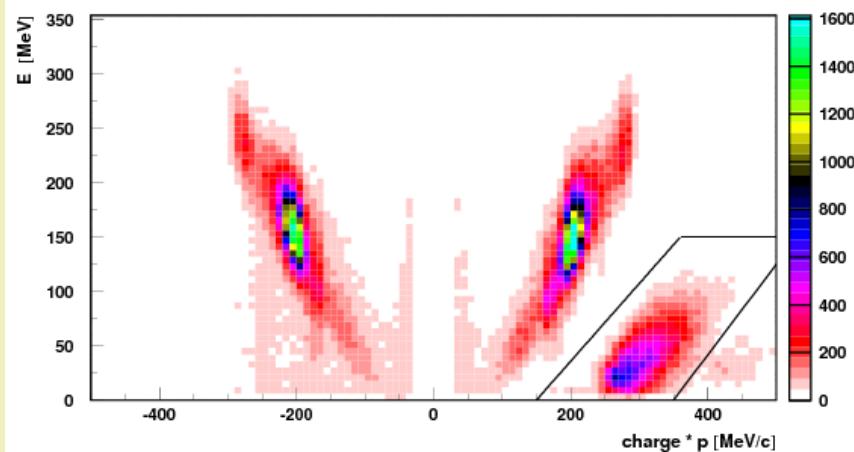
Search for hadronic interactions with  $\Lambda(1115)$  as products:

- $\Lambda \rightarrow p + \pi^-$  (64% BR) vertex made by KLOE reconstruction
- Construct a vertex with  **$\Lambda + \text{an extra particle}$**

## Lambda selection criteria:

$$\Lambda \rightarrow p + \pi^-$$

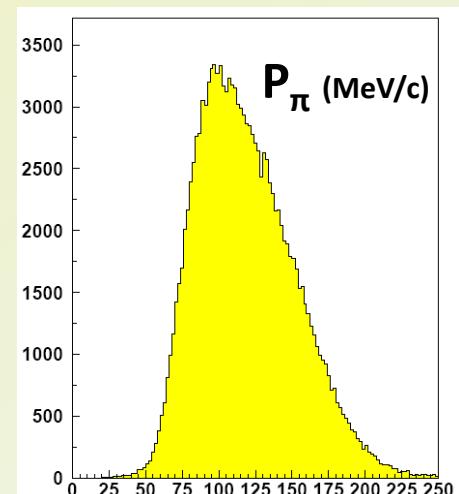
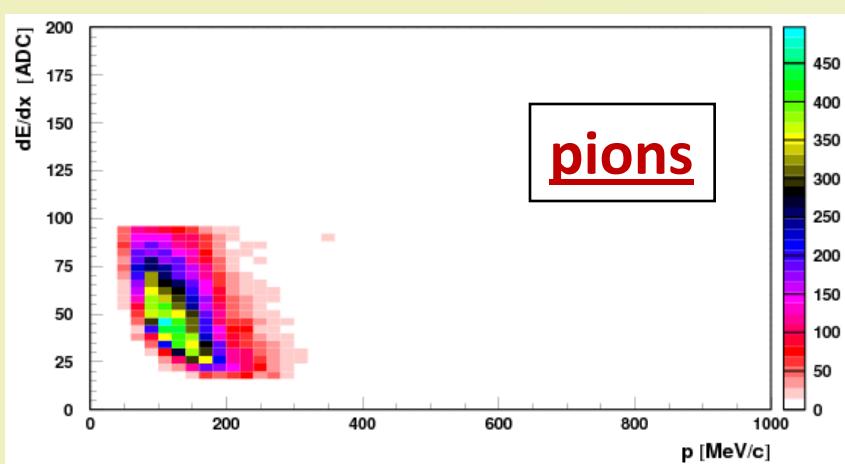
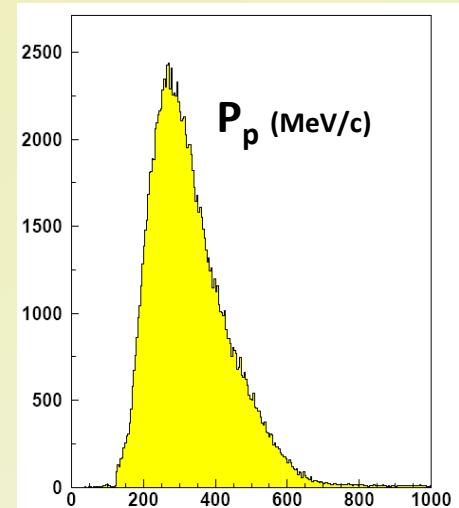
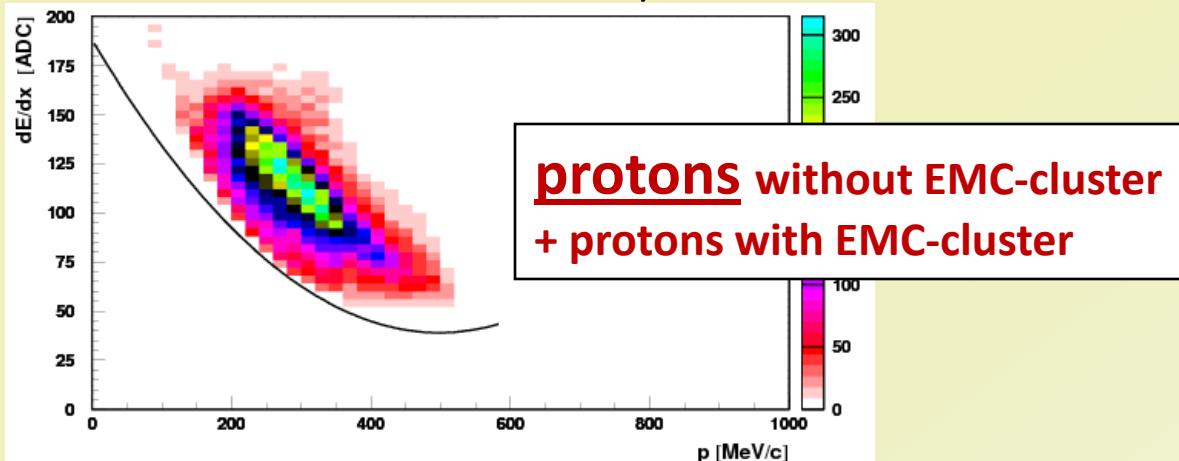
- $\pi^-$  identified by low  $dE/dx$  in DC wires
- protons identified by:
  - EMC-cluster associated energy
  - $dE/dx$  in the wires



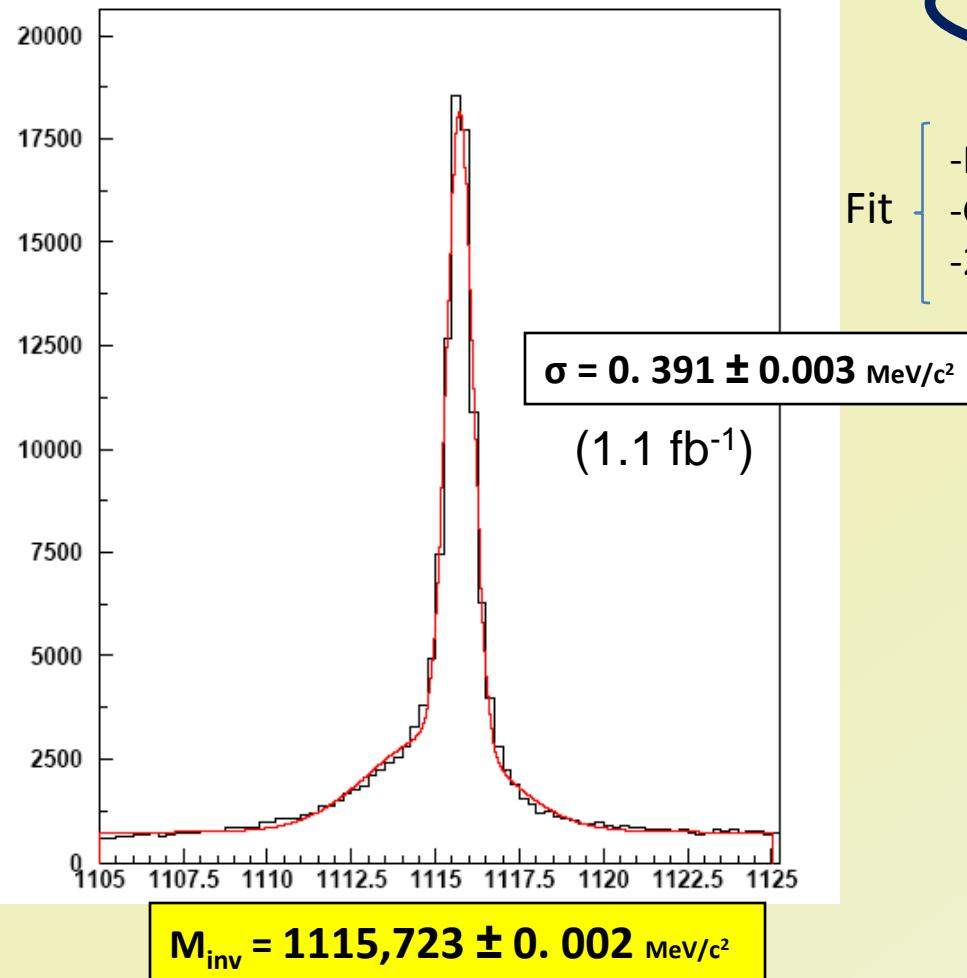
## Lambda selection criteria:

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## Lambda invariant mass



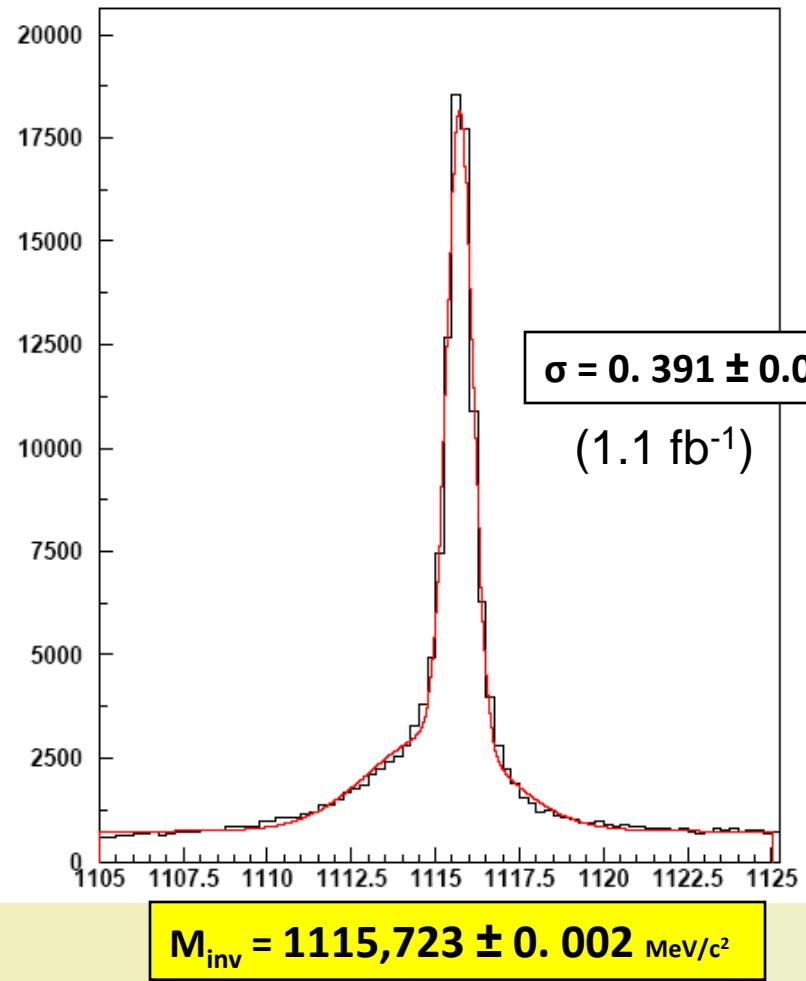
Fit



- Flat background
- Gaussian describing the resonance
- 2nd Gaussian to account for E.loss in the DC wall

PDG:  $M_\Lambda = 1115,683 \pm 0.006 \text{ MeV}/c^2$

## Lambda invariant mass



PDG:  $M_{\Lambda} = 1115,683 \pm 0.006 \text{ MeV/c}^2$

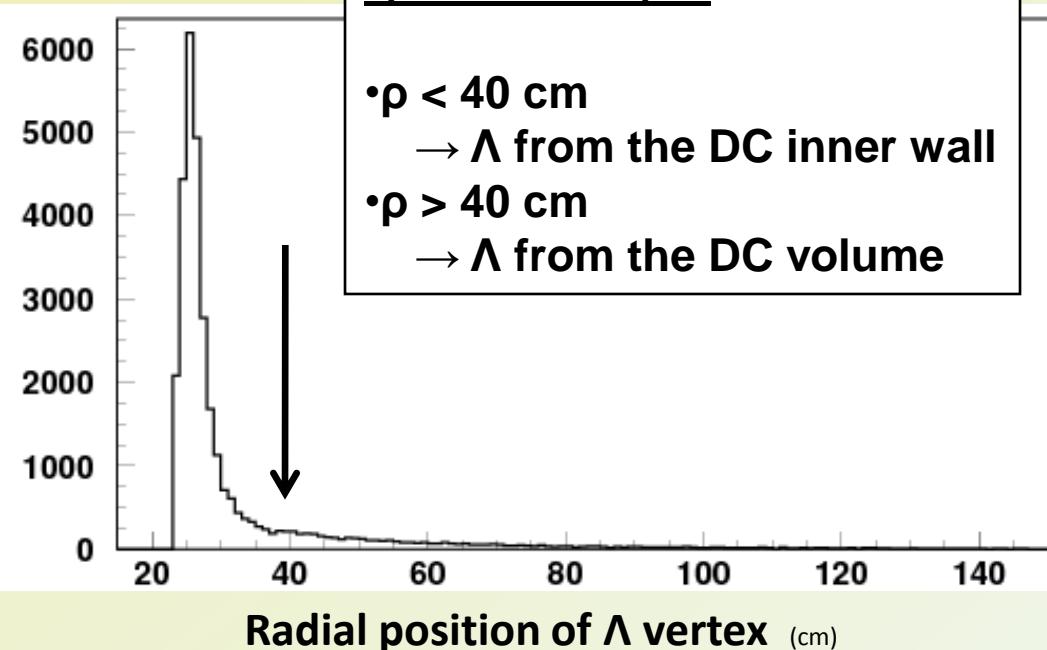


Fit

- Flat background
- Gaussian describing the resonance
- 2nd Gaussian to account for E.loss in the DC wall

### Split data sample:

- $p < 40 \text{ cm}$   
→  $\Lambda$  from the DC inner wall
- $p > 40 \text{ cm}$   
→  $\Lambda$  from the DC volume

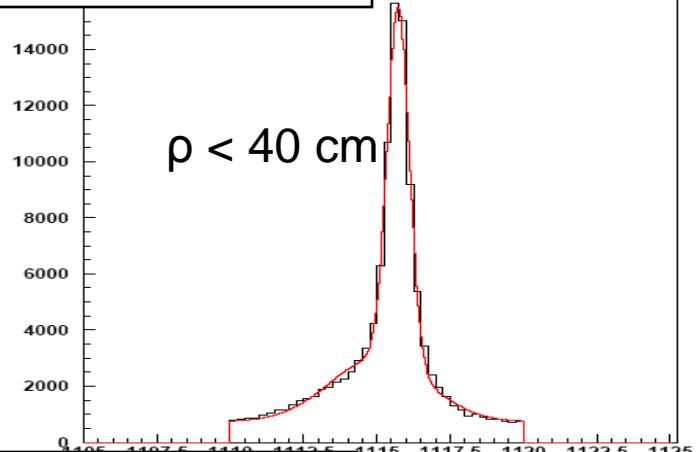


## Lambda invariant mass



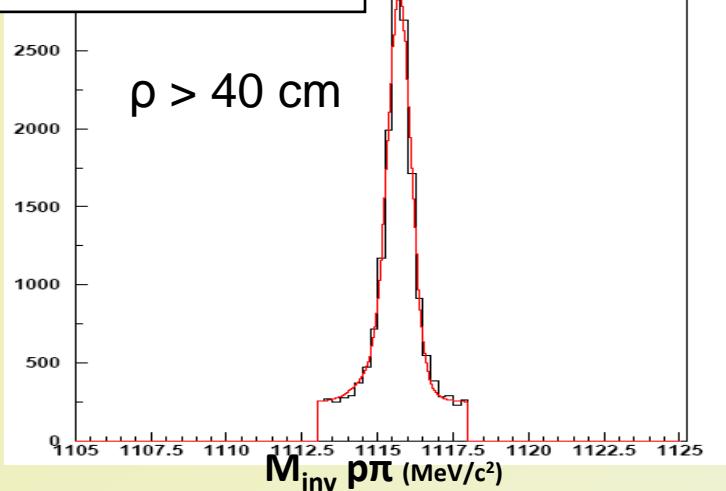
$$M_{\text{inv}} = 1115,731 \pm 0.002 \text{ MeV}/c^2$$

$$\sigma = 0.378 \pm 0.003 \text{ MeV}/c^2$$

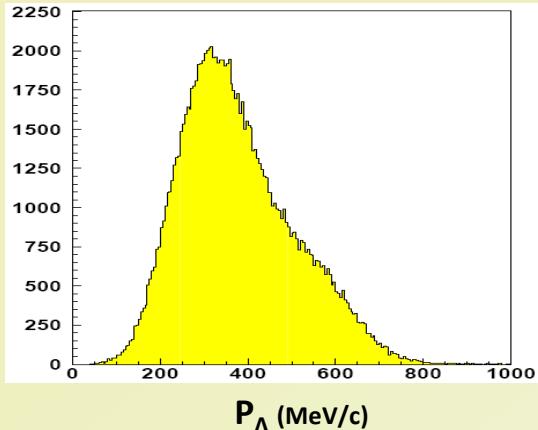


$$M_{\text{inv}} = 1115,719 \pm 0.007 \text{ MeV}/c^2$$

$$\sigma = 0.392 \pm 0.008 \text{ MeV}/c^2$$

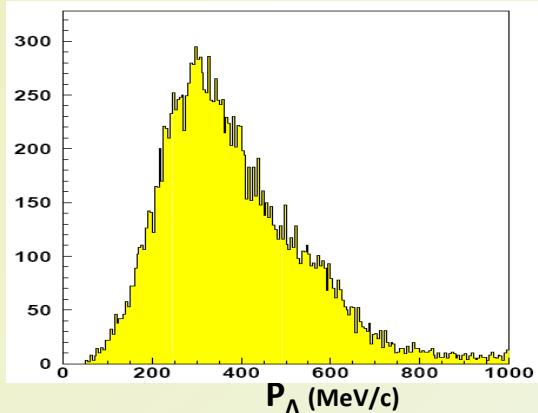


116622 Events (in  $1.1 \text{ fb}^{-1}$ )



$\Lambda$ s from the DC inner wall

18258 Events (in  $1.1 \text{ fb}^{-1}$ )



$\Lambda$ s from the DC volume

$K^-_{\text{stopped}} + {}^4\text{He} \rightarrow n + n + (\underline{K^- pp})$

$\Lambda + p$

$K^-_{\text{stopped}} + {}^4\text{He} \rightarrow n + (\underline{K^- ppn})$

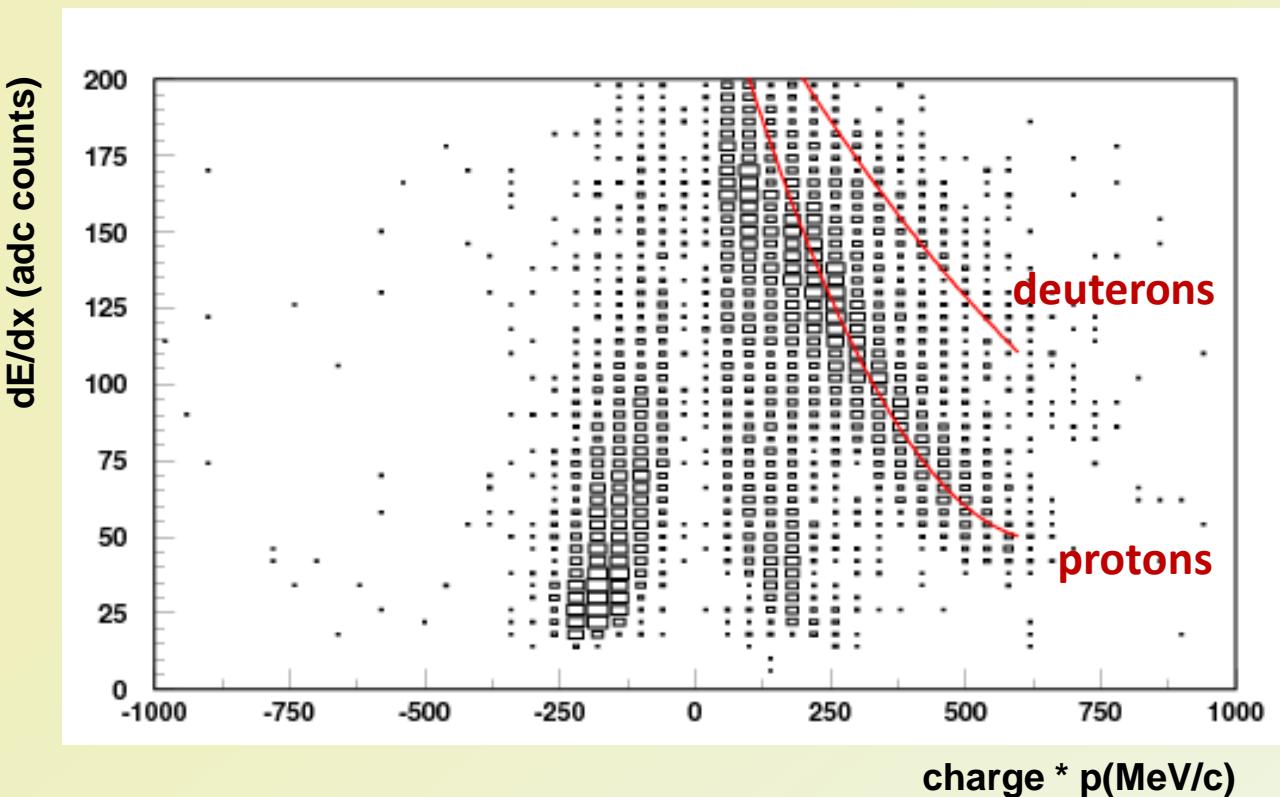
$\Lambda + d$

- Search for the proton with first DC measurement around the lambda vertex (30 cm. cylinder)
- Vertex lambda+(proton or deuteron) assumption
- Proton/deuteron candidates are required to have an associated cluster in the EMC and its mass is measured by **time of flight**.

## PID

Selection of protons and deuterons

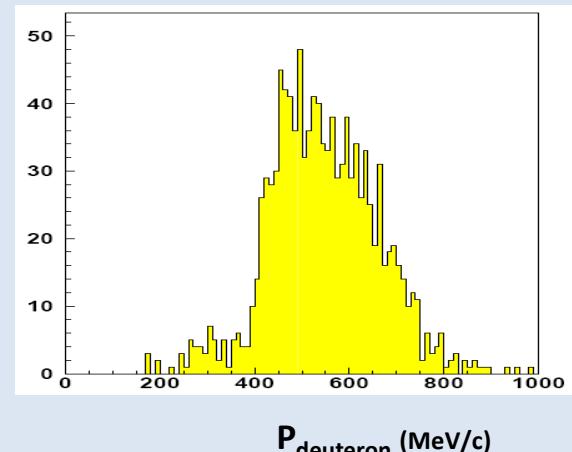
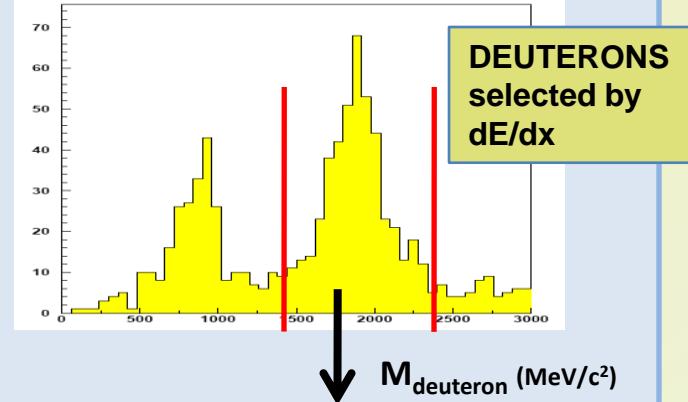
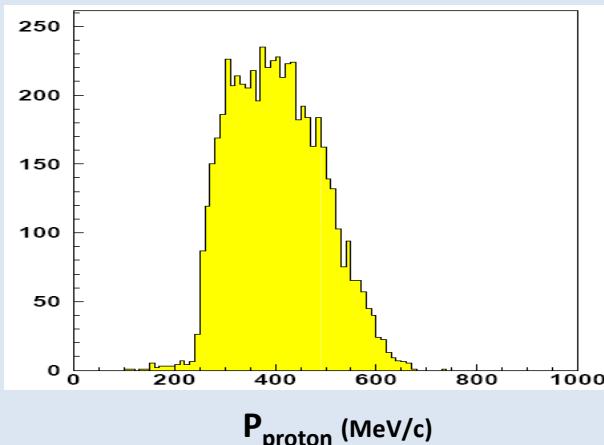
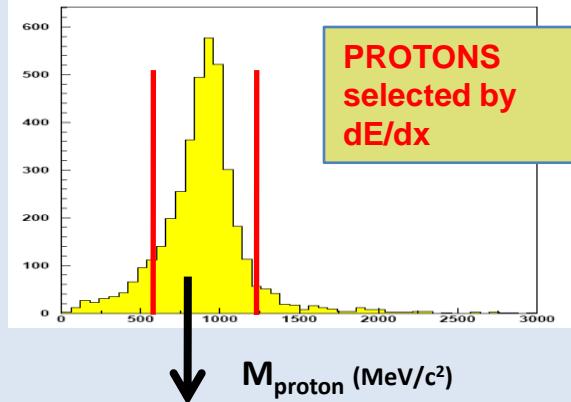
- Protons and deuterons are **firstly** selected from the spectrum of particles near to the Lambda vertex **by  $dE/dx$**



## Selection of protons and deuterons

PID

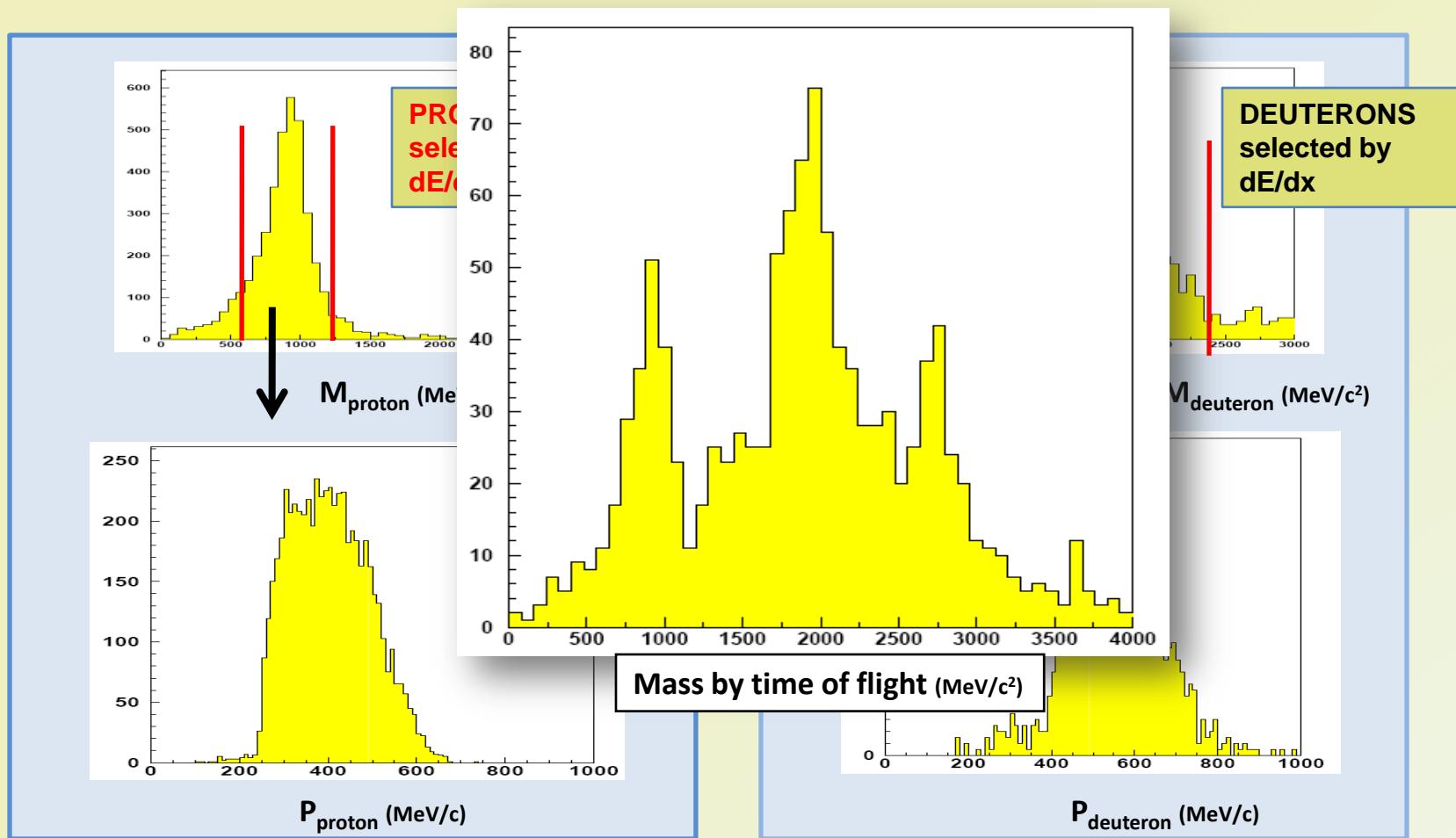
- Proton/deuteron candidates are required to have an associated cluster in the EMC and its mass is measured by **time of flight**.

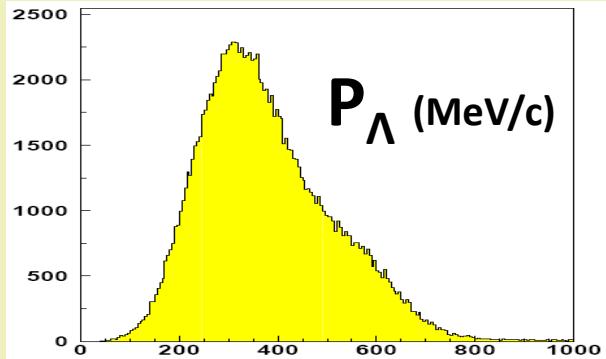
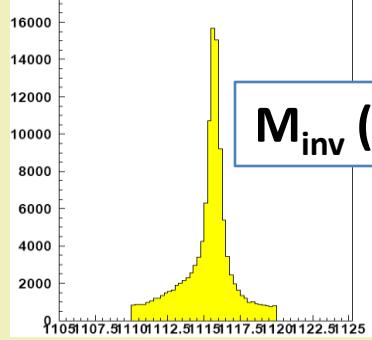


## Selection of protons and deuterons

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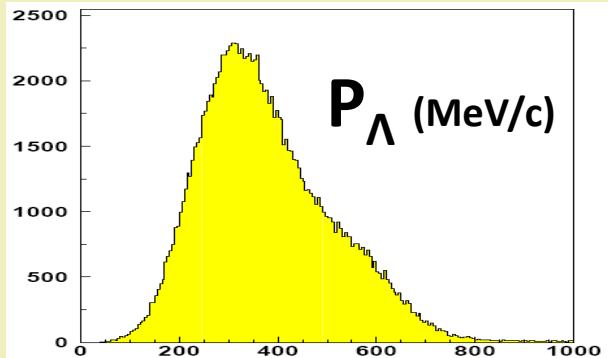
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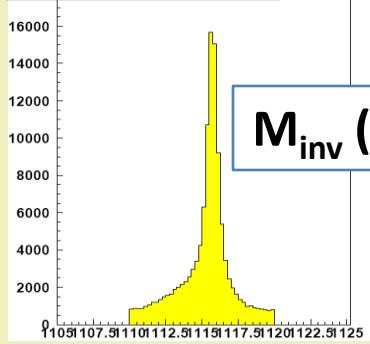
Selection of protons and deuterons $P_\Lambda$  (MeV/c) $\rho > 40\text{cm}$   
DC volume $\rho < 40\text{ cm}$   
DC inner wallAll selected  $\Lambda$ s

## Selection of protons and deuterons

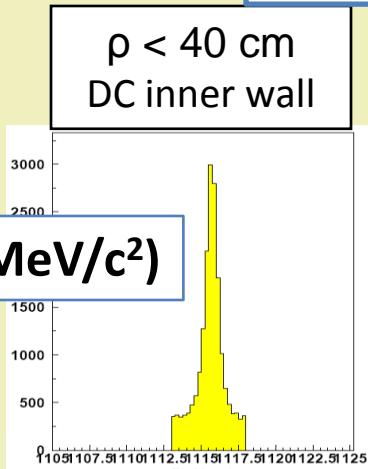
$P_\Lambda$  (MeV/c)



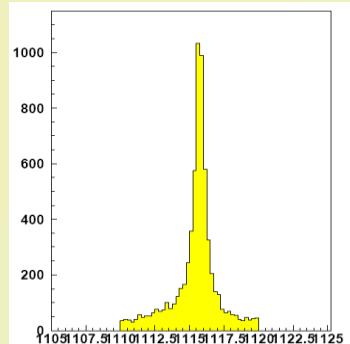
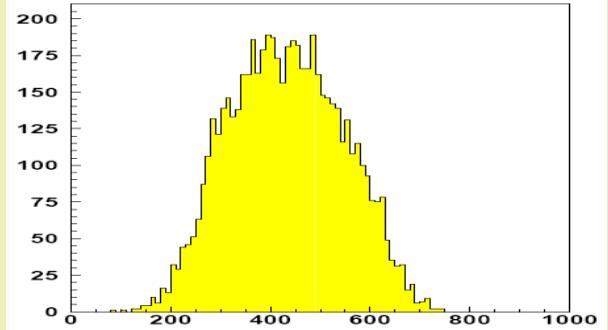
$\rho > 40\text{cm}$   
DC volume



$\rho < 40\text{ cm}$   
DC inner wall



All selected  $\Lambda$ s

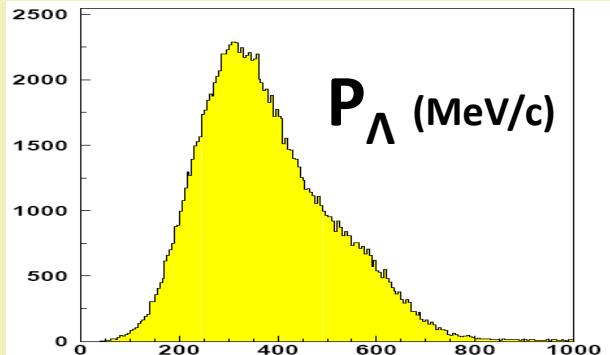
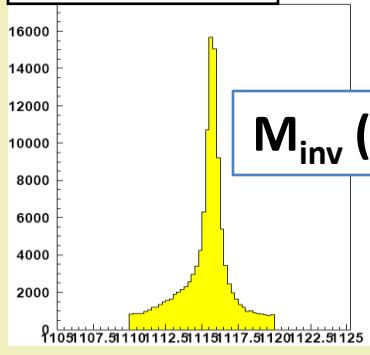
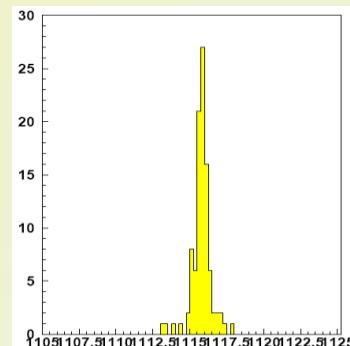
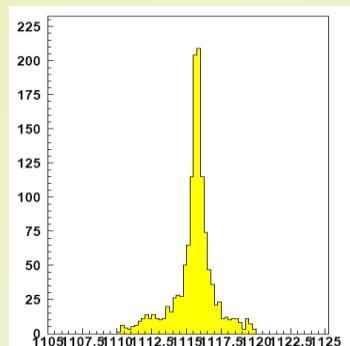
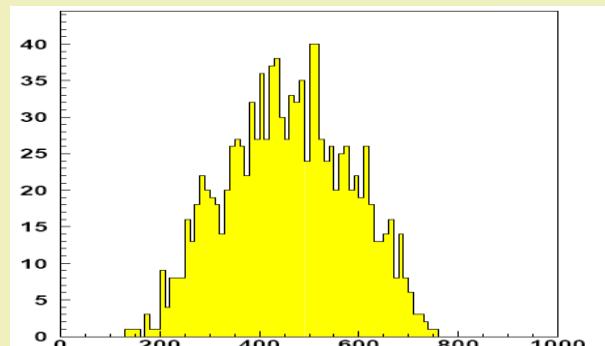
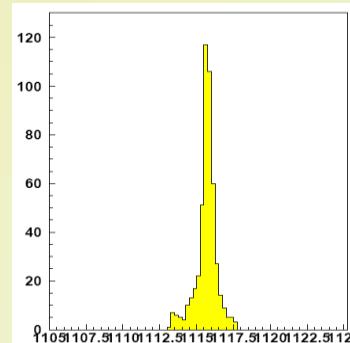
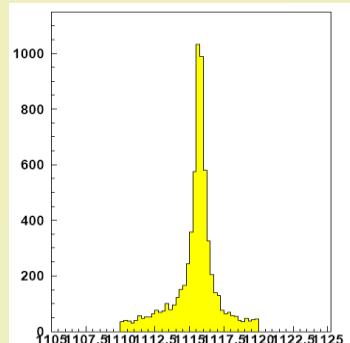
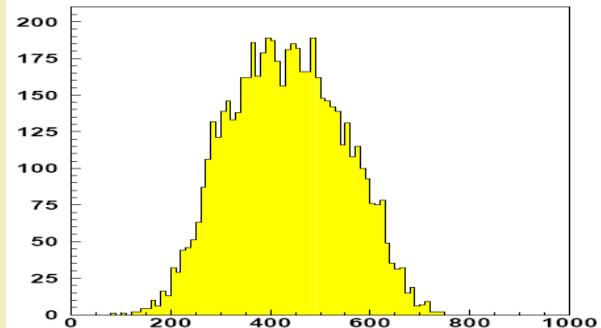


$\rightarrow \boxed{\Lambda p}$   
protons

**Introduction****LAMBDA selection****Lambda correlations**

Lambda-PROTON analysis

Lambda-DEUTERON analysis

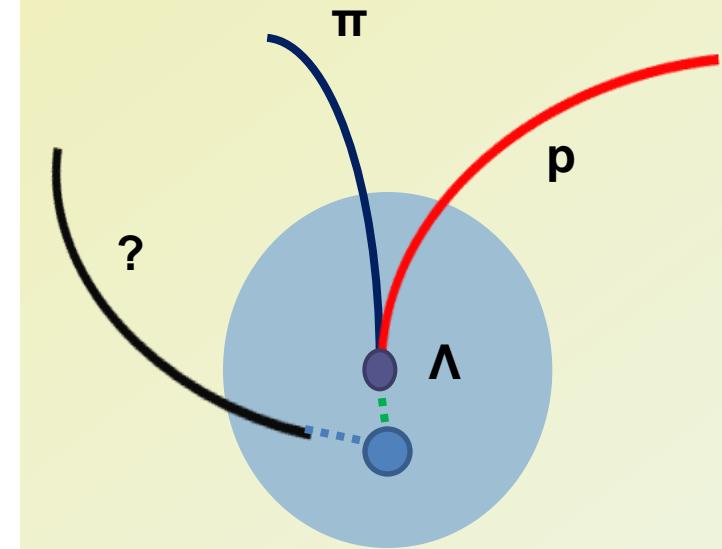
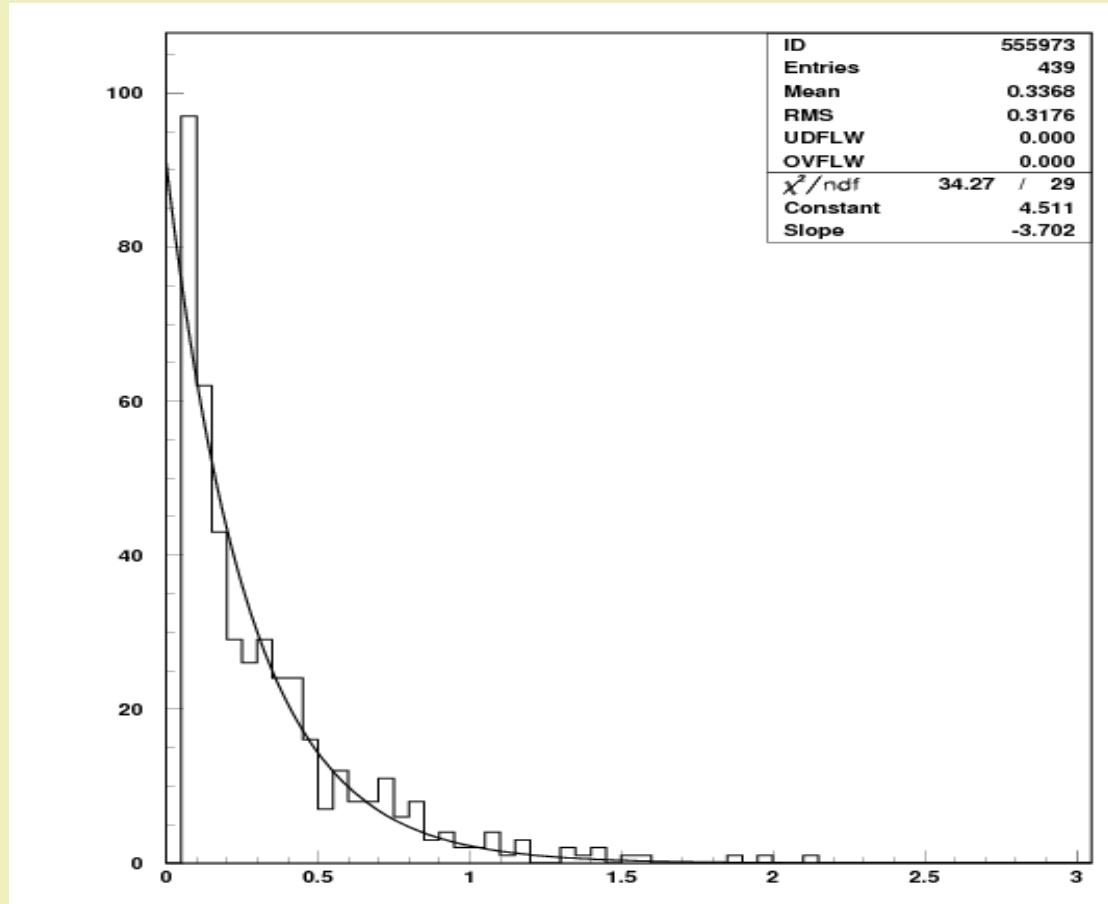
 $\Lambda(1405)$  search**Selection of protons and deuterons** $P_\Lambda$  (MeV/c) $\rho > 40\text{cm}$   
DC volume $\rho < 40\text{ cm}$   
DC inner wallAll selected  $\Lambda$ s

→  $\Lambda p$   
protons

→  $\Lambda d$   
deuterons

## Selection of protons and deuterons

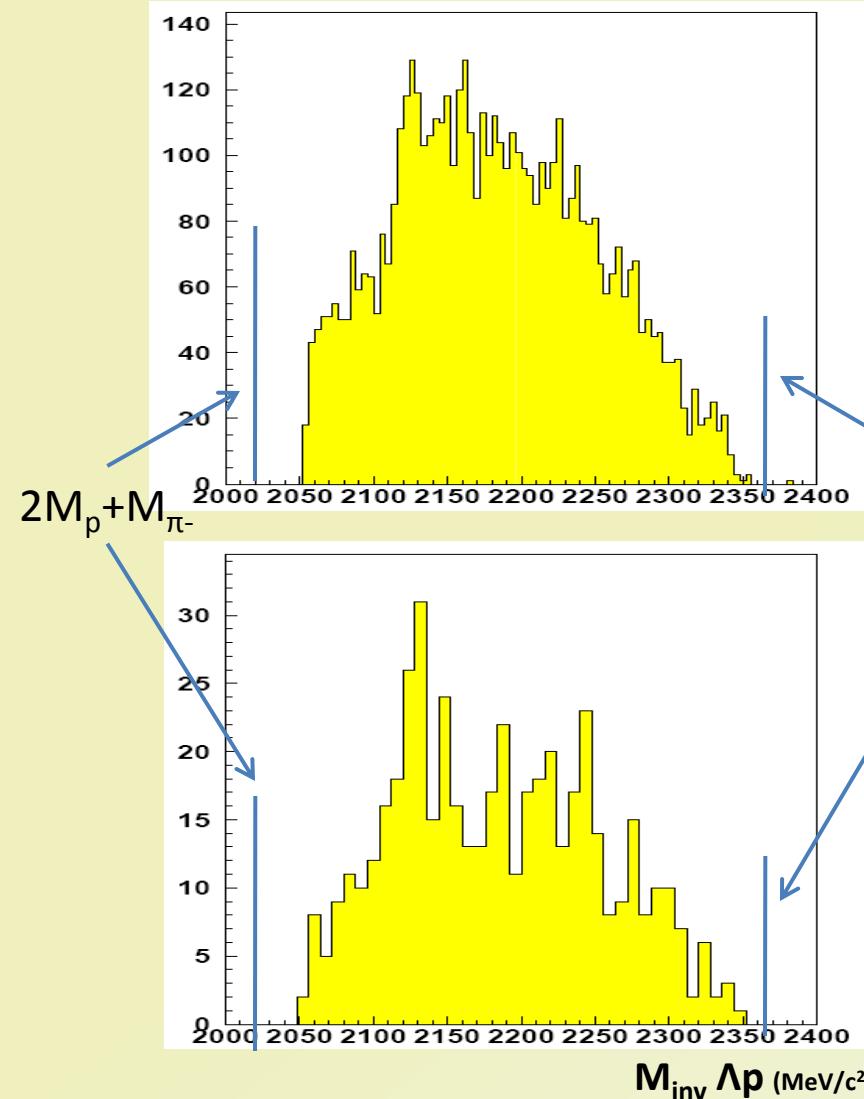
### LAMBDA LIFETIME (also as quality cut)



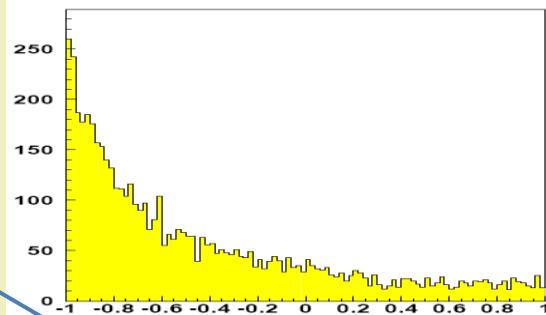
$1/3.7 \rightarrow \tau = 0.25 \text{ ns}$   
 $(\text{PDG} = 0.26)$

# Invariant mass

## $\Lambda p$ analysis



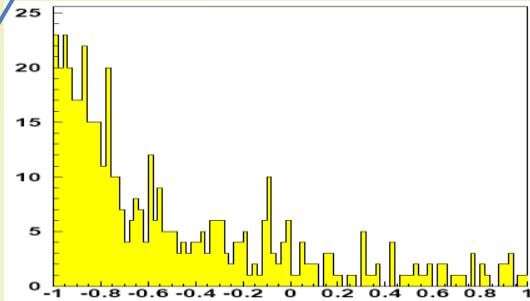
Total events 5308



$\rho < 40$  cm  
DC inner wall

2M<sub>p</sub> + M<sub>K</sub>

Total events 482

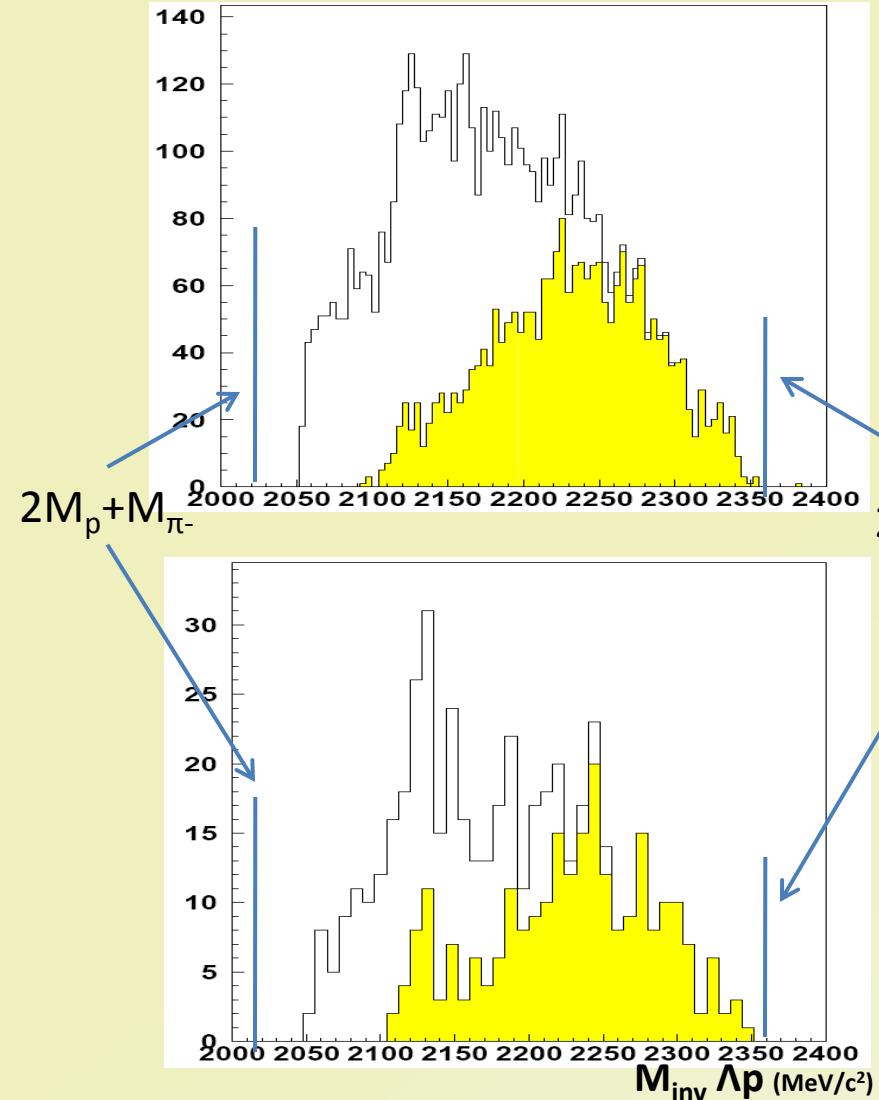


$\rho > 40$  cm  
DC volume

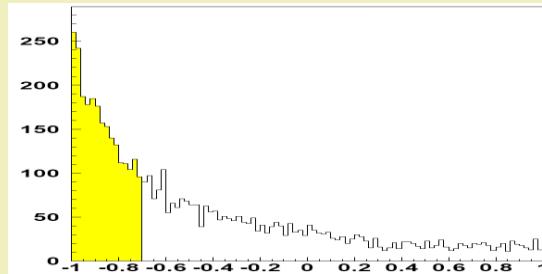
Cos  $\theta$  ( $\Lambda p$ )

# Invariant mass

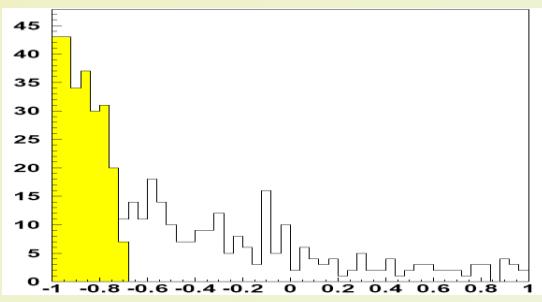
## $\Lambda p$ analysis



Total events 5308  
back to back 2393



Total events 482  
back to back 247



$\rho < 40$  cm  
DC inner wall

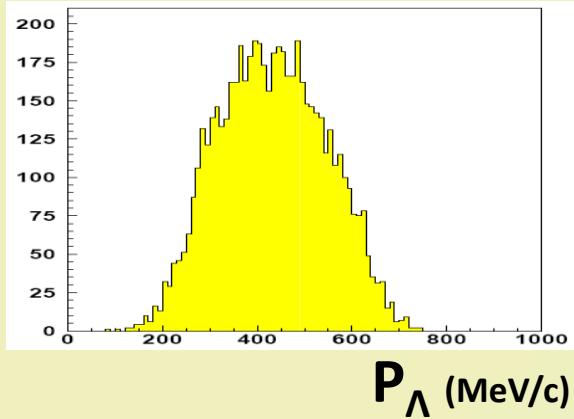
Total Yield = 0.05%  
BtB Yield = 0.02%  
(per stopped K<sup>-</sup>)

$\rho > 40$ cm  
DC volume

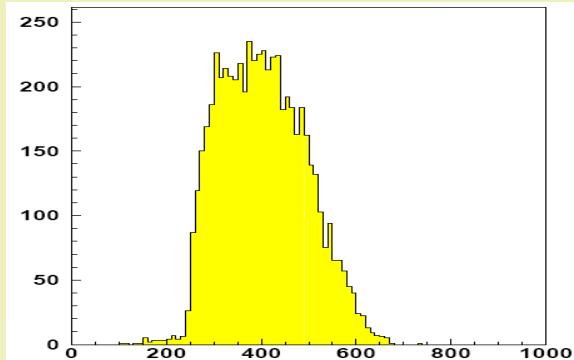
Total Yield = 0.03%  
BtB Yield = 0.02%  
(per stopped K<sup>-</sup>)

# $\Lambda p$ analysis

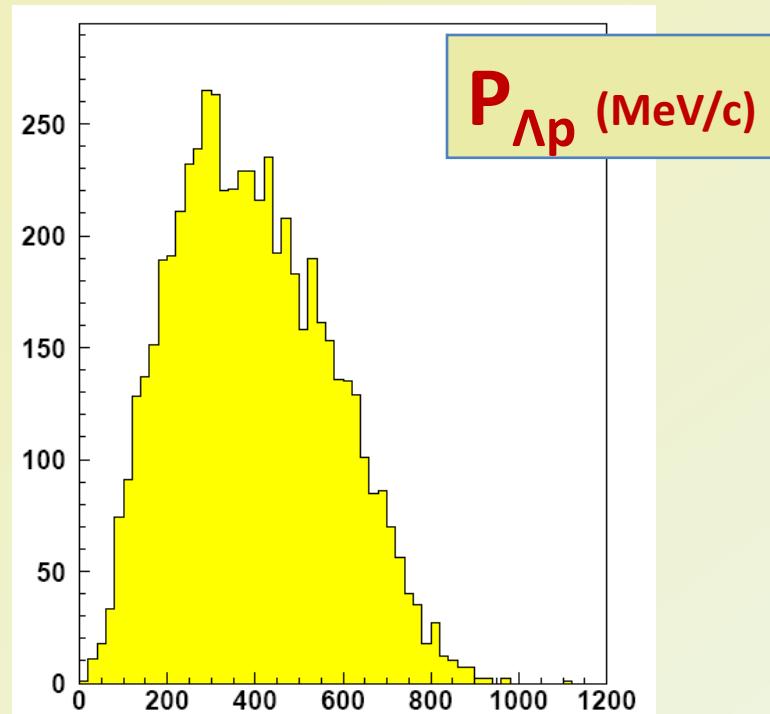
## P of $\Lambda p$ system



$P_\Lambda$  (MeV/c)



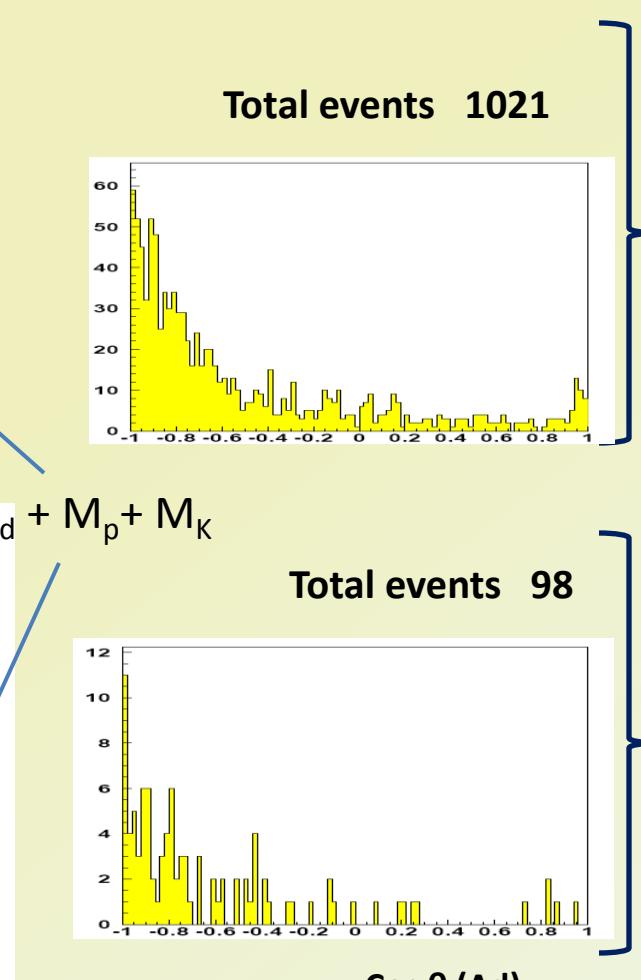
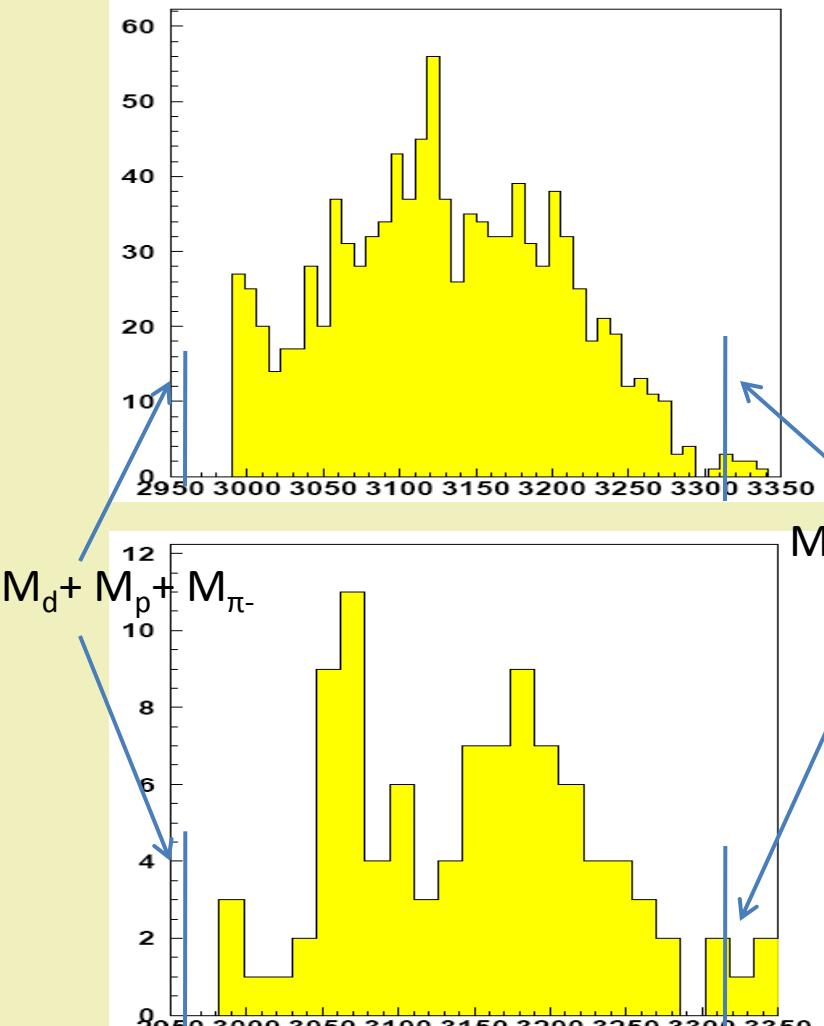
$P_p$  (MeV/c)



$P_{\Lambda p}$  (MeV/c)

# Invariant mass

## $\Lambda d$ analysis

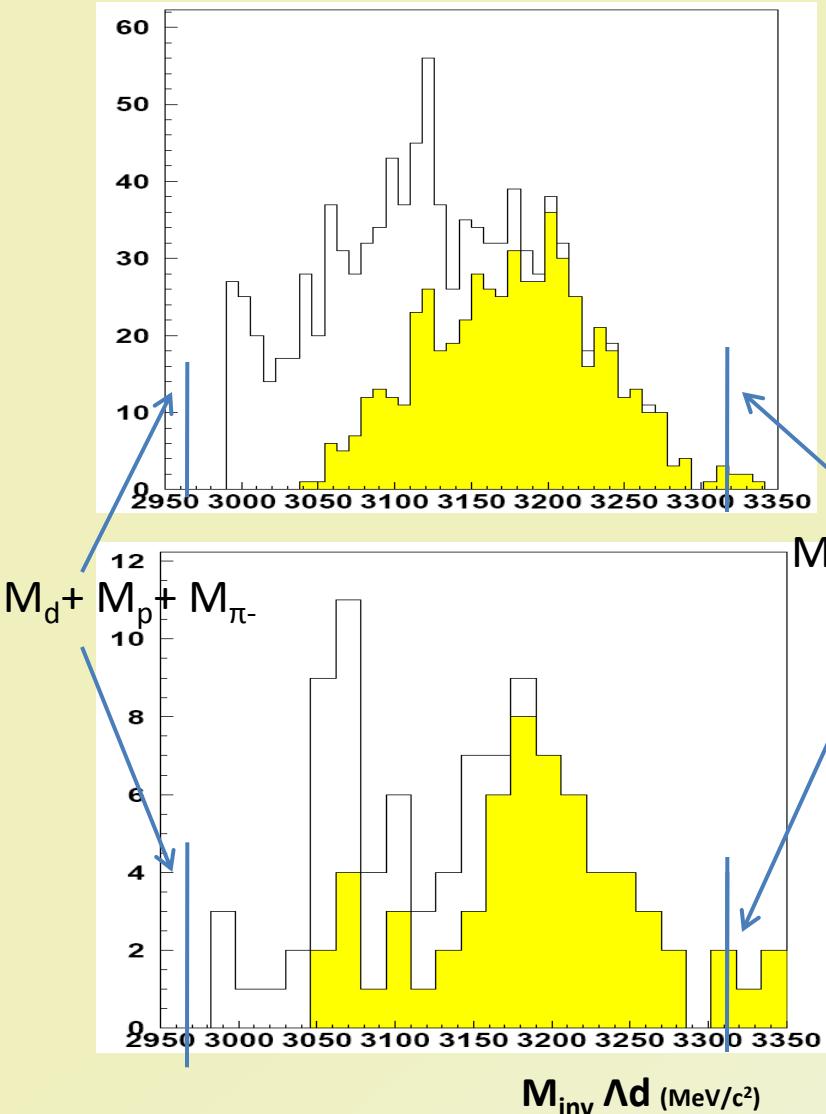


$\rho < 40$  cm  
DC inner wall

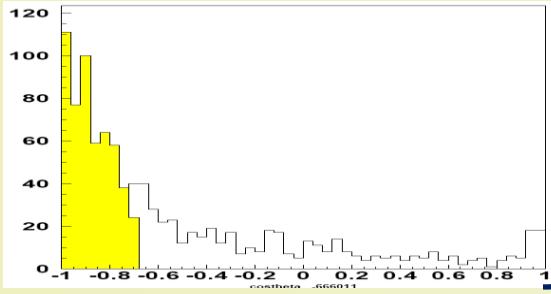
$\rho > 40$  cm  
DC volume

# Invariant mass

## $\Lambda d$ analysis



Total events 1021  
back to back 548

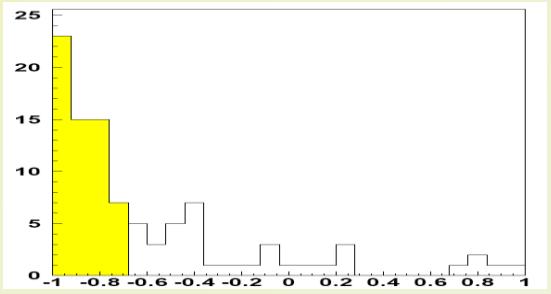


$\rho < 40$  cm  
DC inner wall

Total Yield = 0.01%  
BtB Yield = 0.005%  
(per stopped K<sup>-</sup>)

$M_d + M_p + M_K$

Total events 98  
back to back 61



$\rho > 40$  cm  
DC volume

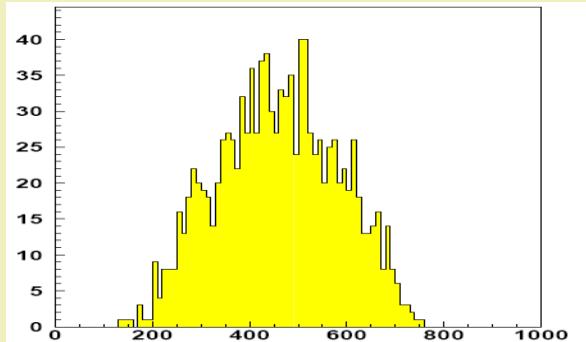
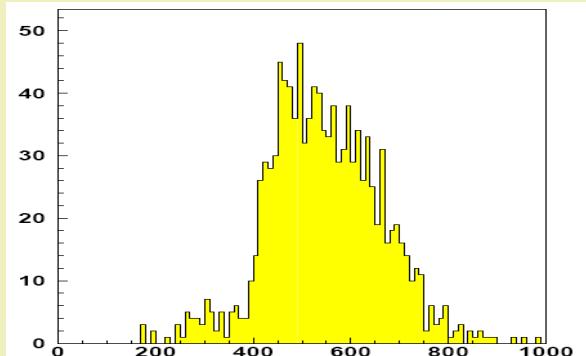
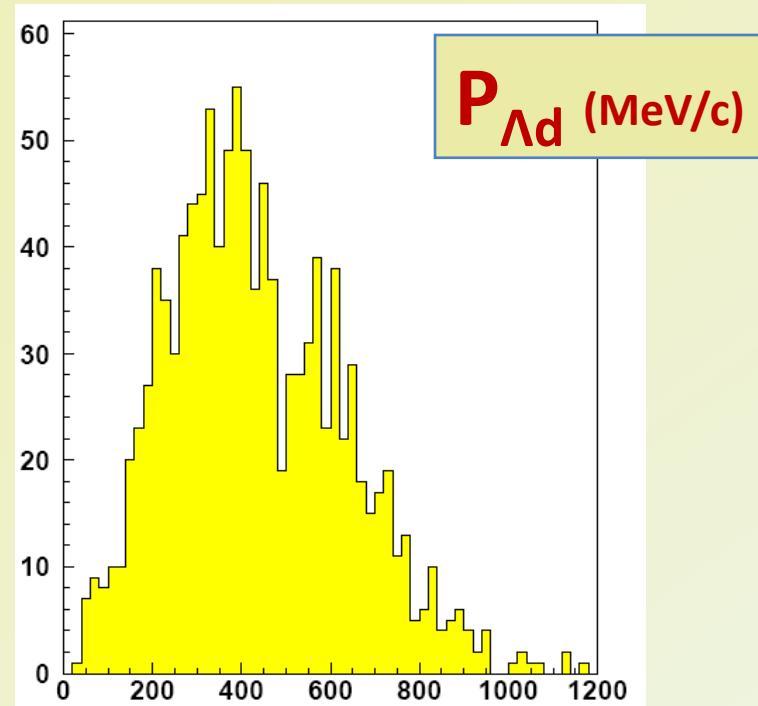
Total Yield = 0.006%  
BtB Yield = 0.004%  
(per stopped K<sup>-</sup>)

Cos θ ( $\Lambda d$ )

$\Lambda d$ 

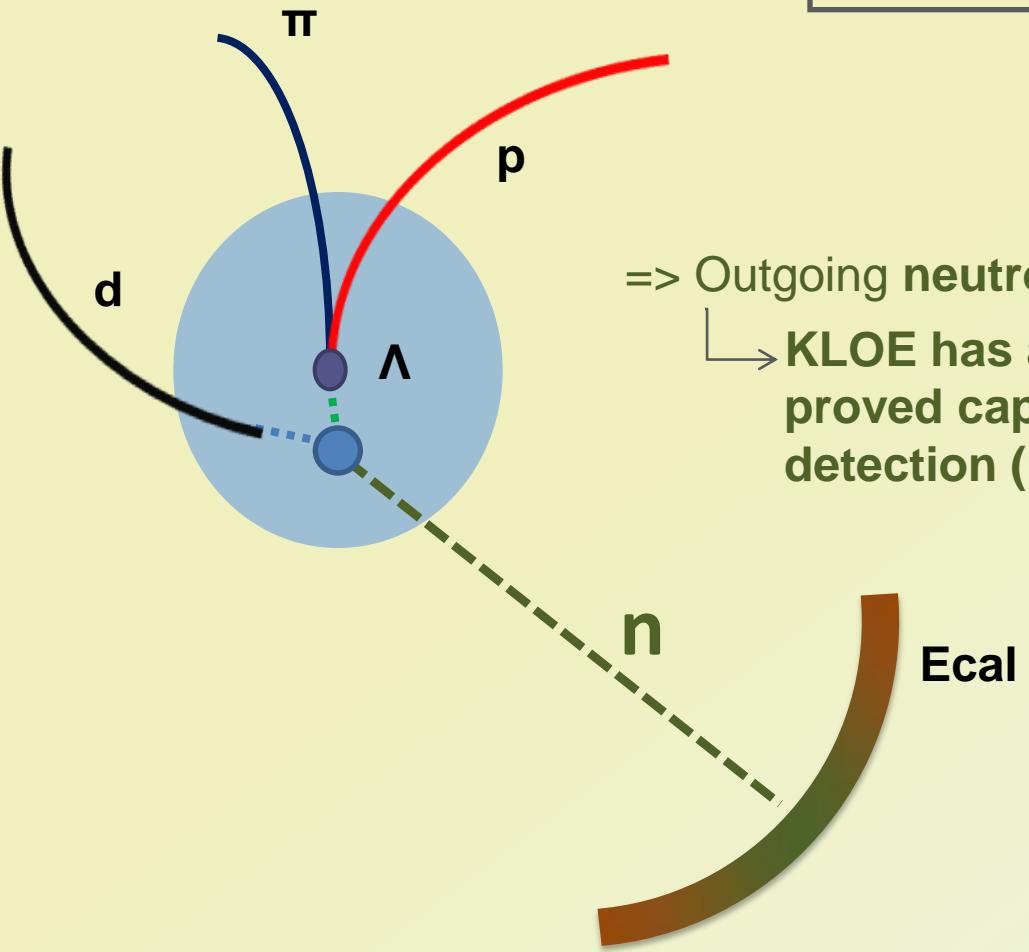
analysis

## P of $\Lambda d$ system

 $P_\Lambda$  (MeV/c) $P_d$  (MeV/c) $P_{\Lambda d}$  (MeV/c)

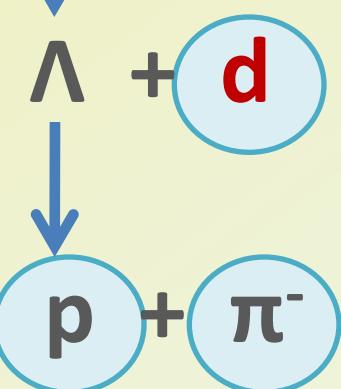
# Neutron Search

## $\Lambda d$ analysis



=> Outgoing neutrons 400-600 MeV/c

↳ KLOE has an experimentally proved capability for neutron detection (KLOnE)



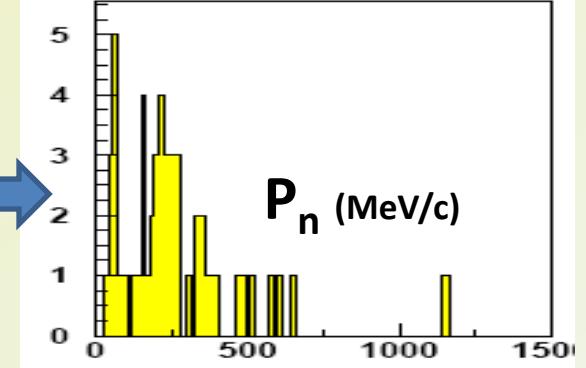
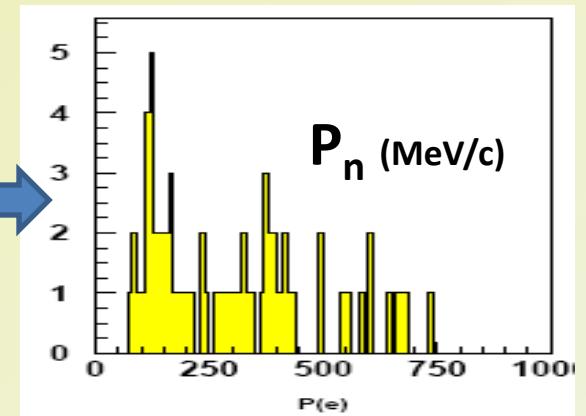
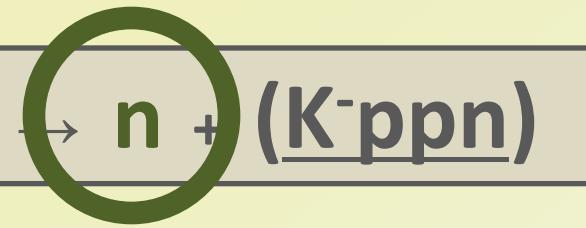
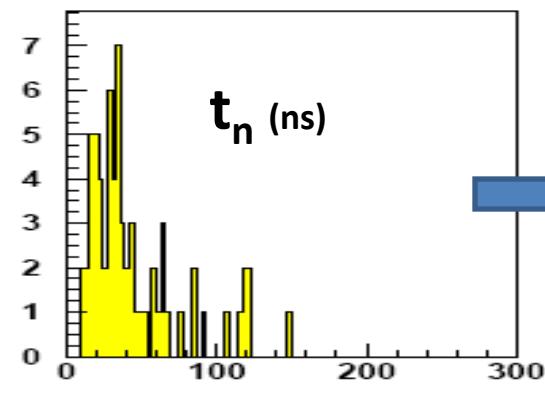
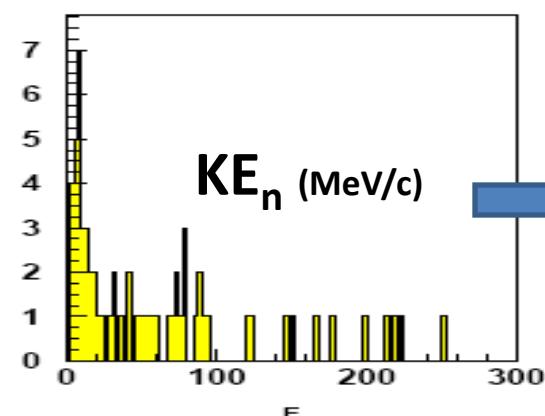
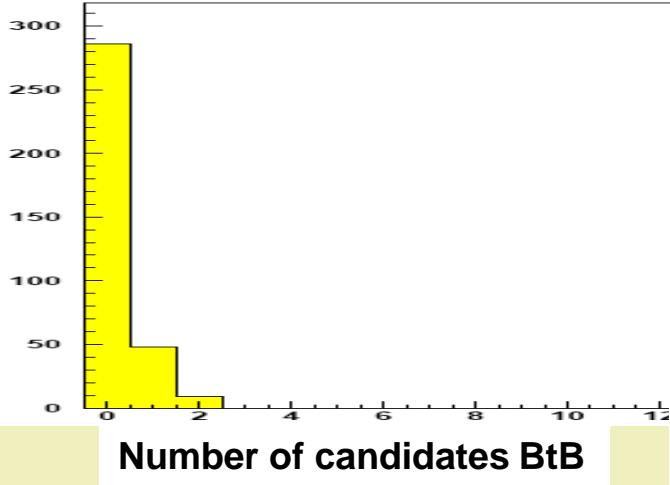
# Neutron Search

$\Lambda d$  analysis



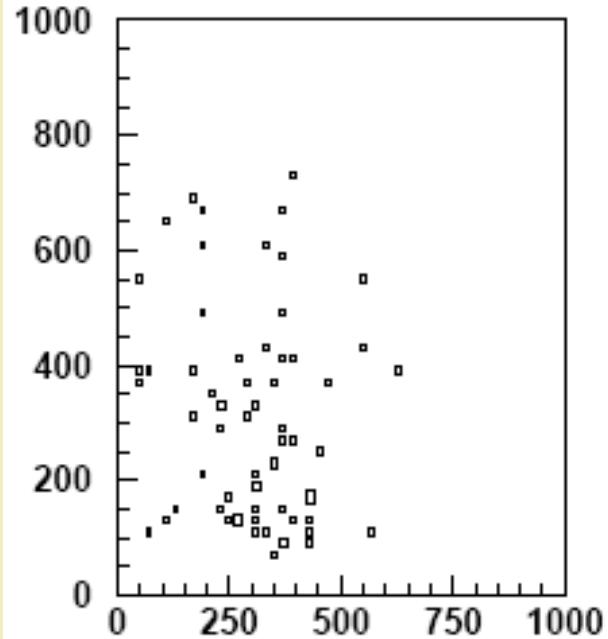
# Neutron Search

## $\Lambda d$ analysis



# Neutron Search

$P_n$  (MeV/c)

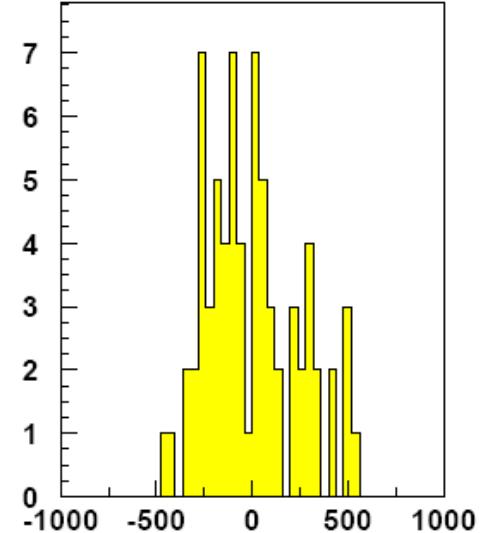


$P_{\Lambda d}$  (MeV/c)

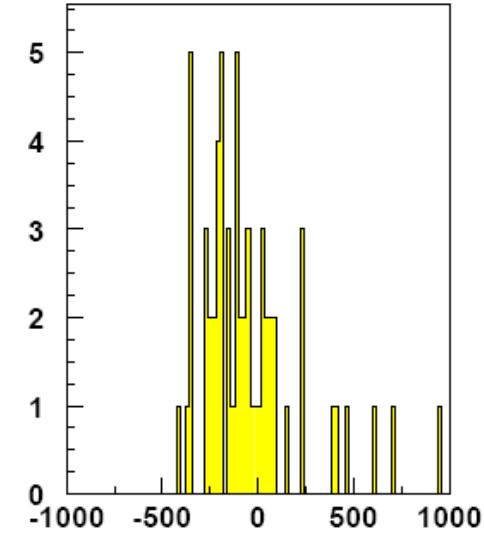
$\Lambda d$  analysis



$P_{\Lambda d} - P_n^E$  (MeV/c)



$P_{\Lambda d} - P_n^t$  (MeV/c)



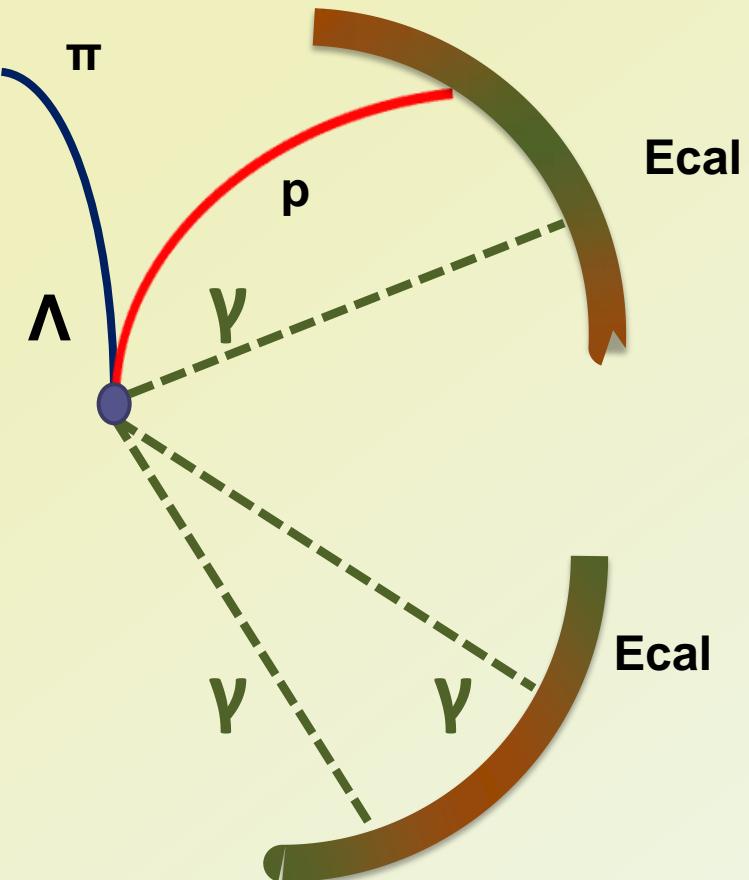
## $\Lambda(1405) / \Lambda(1420)$ search

- Strongly related with the deeply bound kaonic states prediction
- Lack of experimental data

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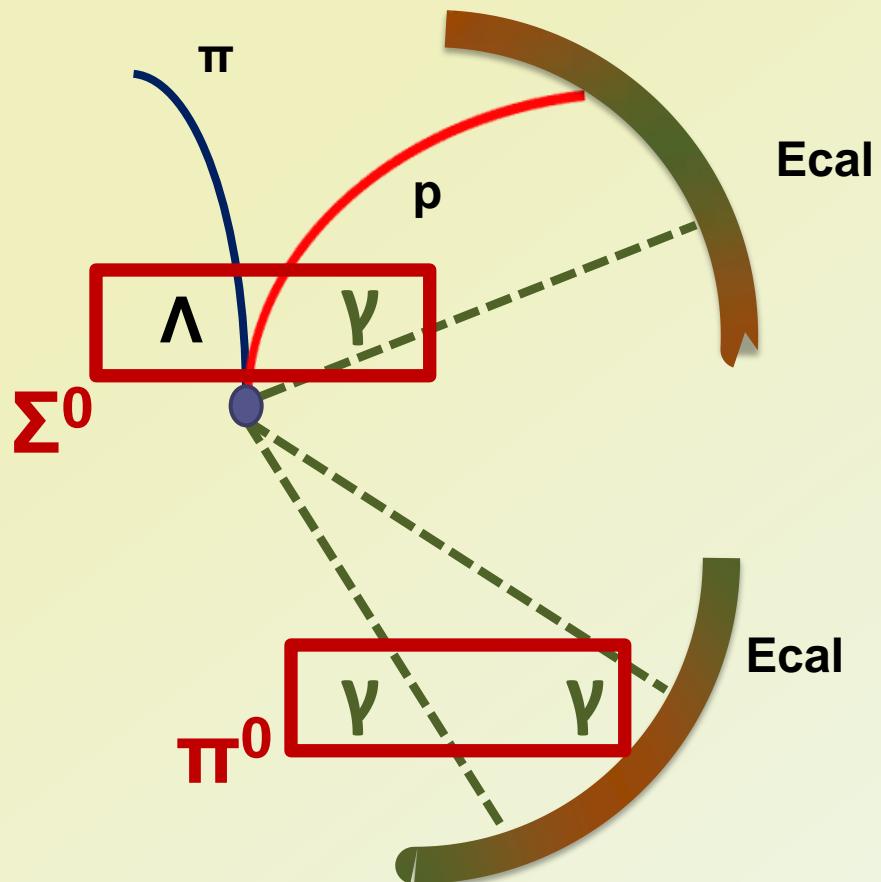
**Λ(1405) → Σ<sup>0</sup>π<sup>0</sup>**



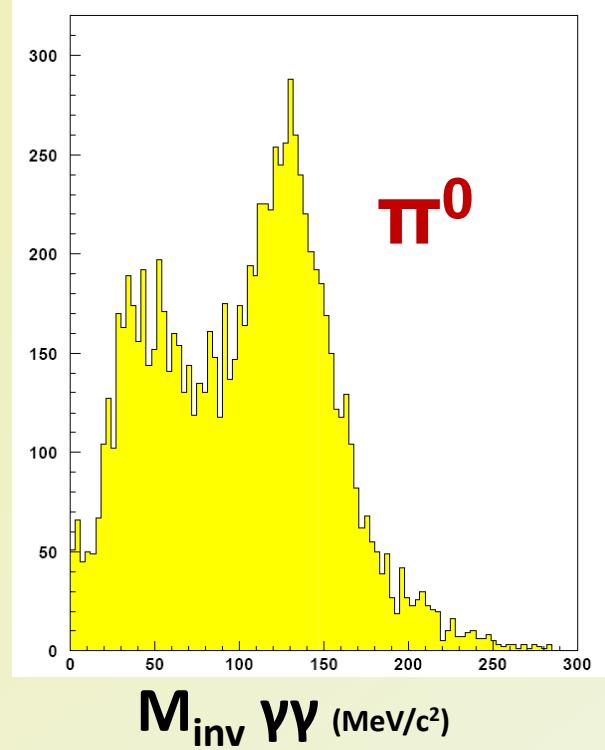
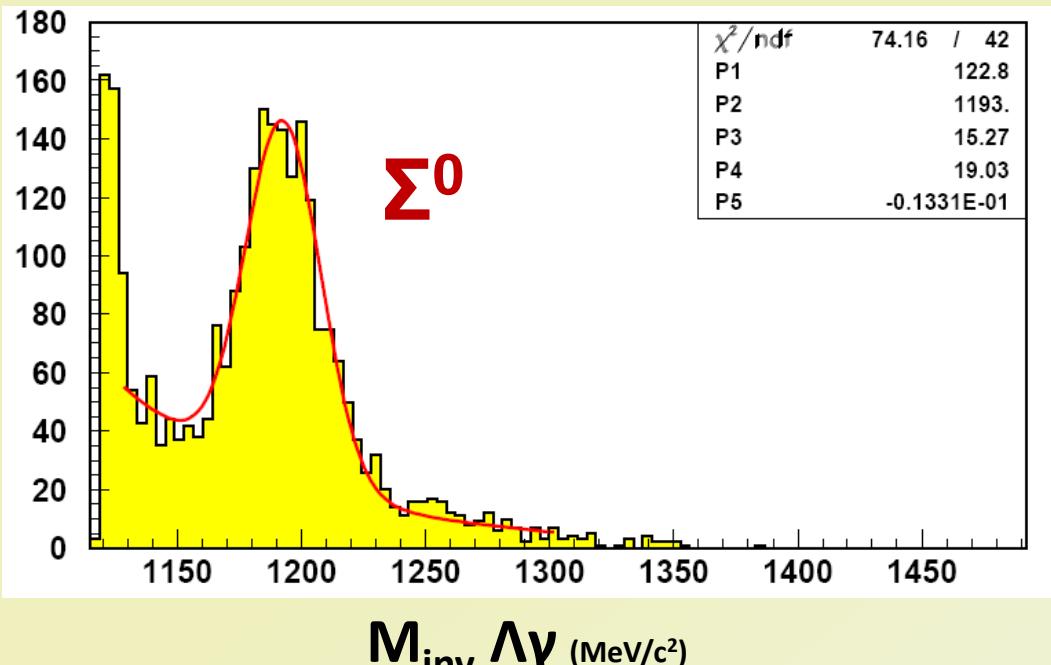
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- Lack of experimental data

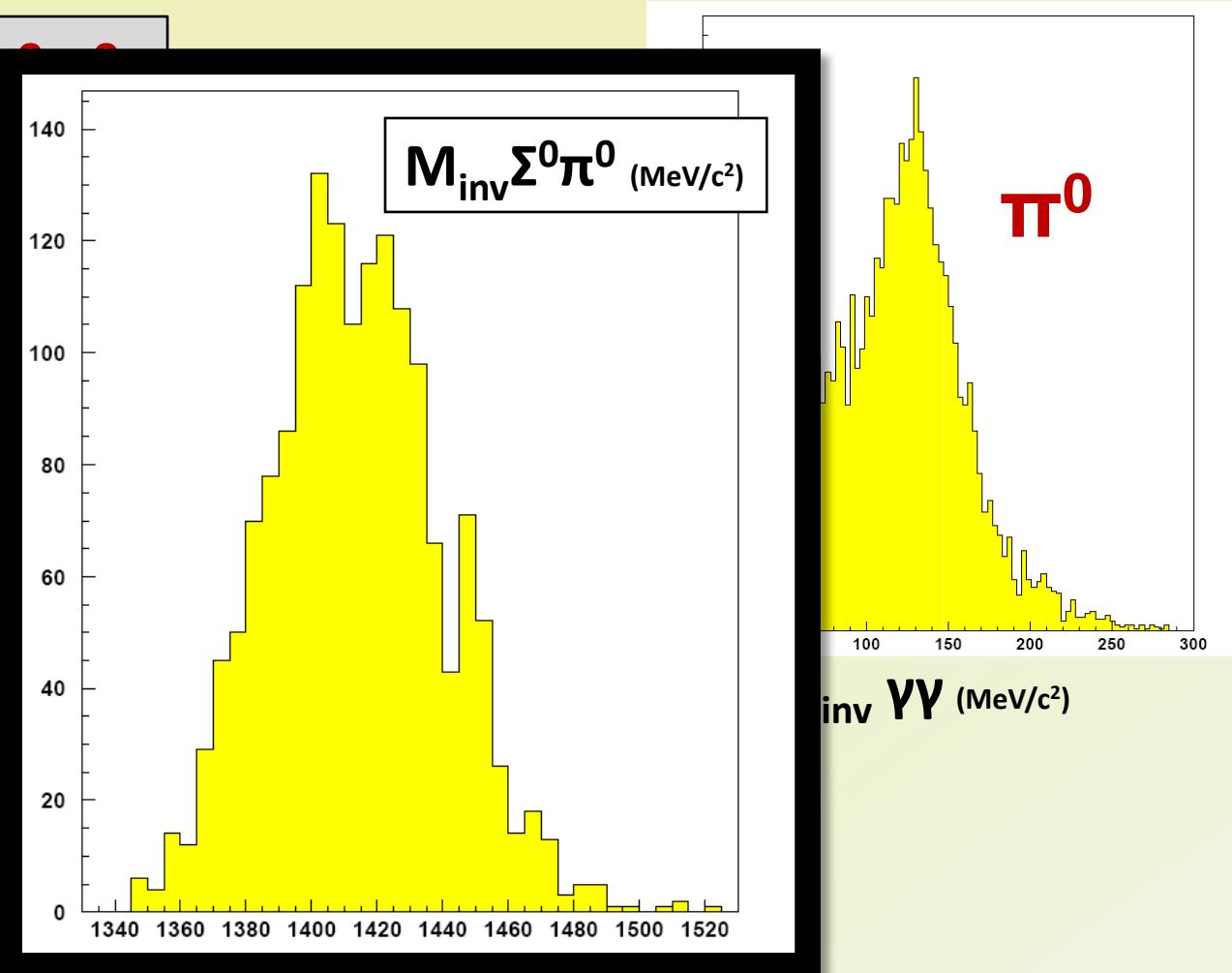
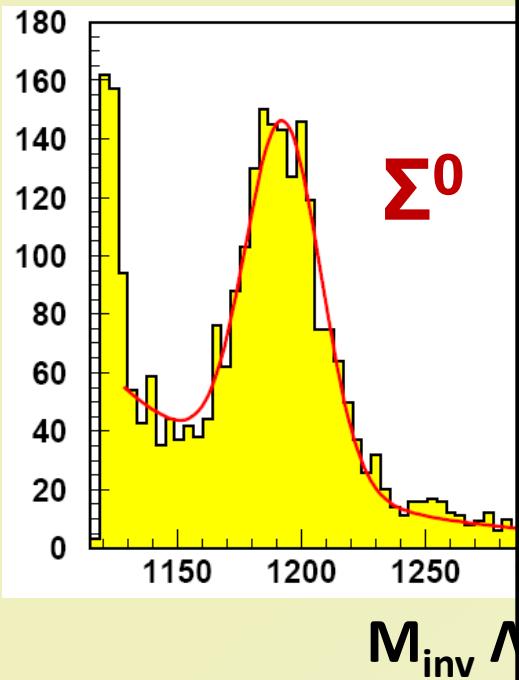
**Λ(1405) → Σ<sup>0</sup>π<sup>0</sup>**



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



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



## Conclusions

- **1.1 fb<sup>-1</sup>** of the KLOE data have been **analyzed** looking for physics generated by the 0.1 % of K<sup>-</sup> stopped in the DC volume (no target).
- Excellent  **$\Lambda(1115)$  measurement** has been performed showing the **KLOE capabilities** to study KN interactions at low E.
- Capacity to analyze  **$\Lambda p$**  and  **$\Lambda d$**  in a broad kinematic range with **high acceptance** representing key ingredients for AMADEUS success.

## Future plans

- Refine selection criteria for  $\Lambda p$ ,  $\Lambda d$  and  $\Lambda t$
- Analyze neutron-events in the  $\Lambda d$  case
- Improve the algorithm for  $\Sigma$  selection in the search for  $\Lambda(1405)$
- Increase the statistics to the whole 2004-2005 KLOE data set (x2)