

The background of the slide features a faded musical score for piano, showing staves with notes and rests. The score is arranged in a vertical column on the left side of the page, with measures numbered 117, 120, 123, 126, 129, and 131. The main title is overlaid on this background.

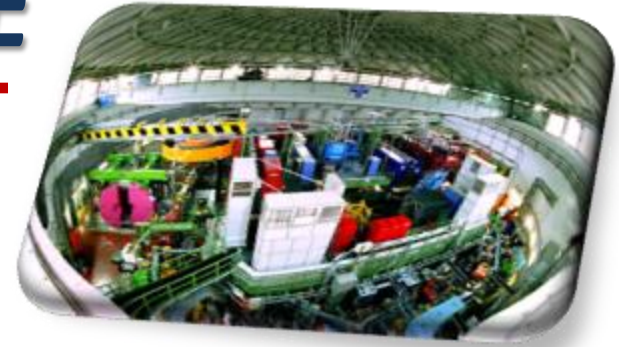
Analysis of the K-He interactions in the KLOE drift chamber

Oton Vázquez Doce

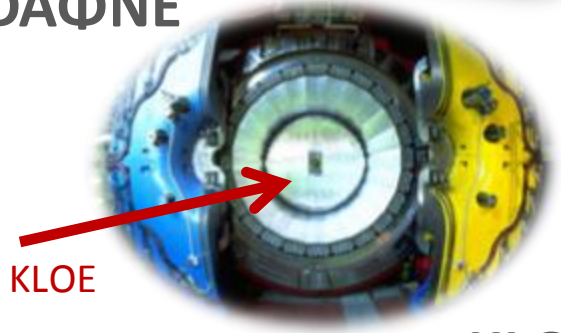
ECT*09, Trento
14 October, 2009

AMADEUS @ DAΦNE

- The main aim of AMADEUS is to confirm or deny the existence of Kaonic Clusters,
- **EXTENDED PROGRAM:** Low-energy interactions, cross sections in light nuclei, decay of resonance states and exotic channels in nuclear medium will be studied



DAΦNE



KLOE

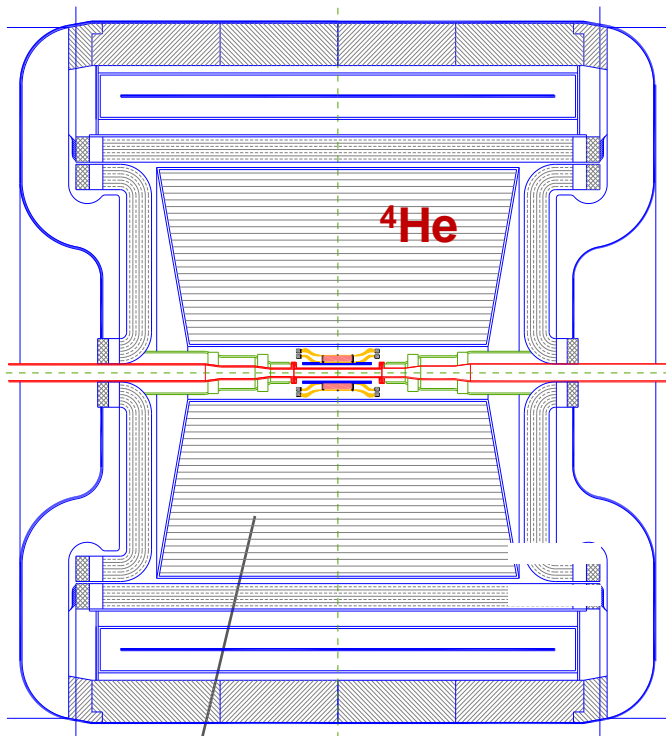
Implementation of the KLOE detector with an inner AMADEUS setup

Talks at this workshop:

- A. Scordo** “The trigger system for the AMADEUS experiment”
- J. Zmeskal** “The AMADEUS experiment”

Hadronic interactions of K^- in KLOE

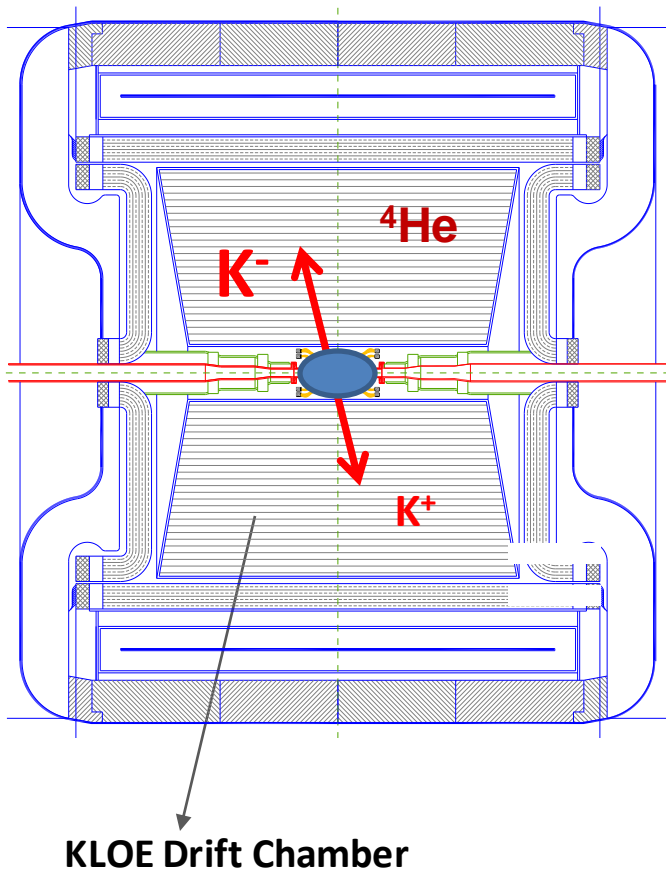
- The Drift Chambers of KLOE contain mainly ^4He (90% helium, 10% *isobutane* mixture)



KLOE Drift Chamber

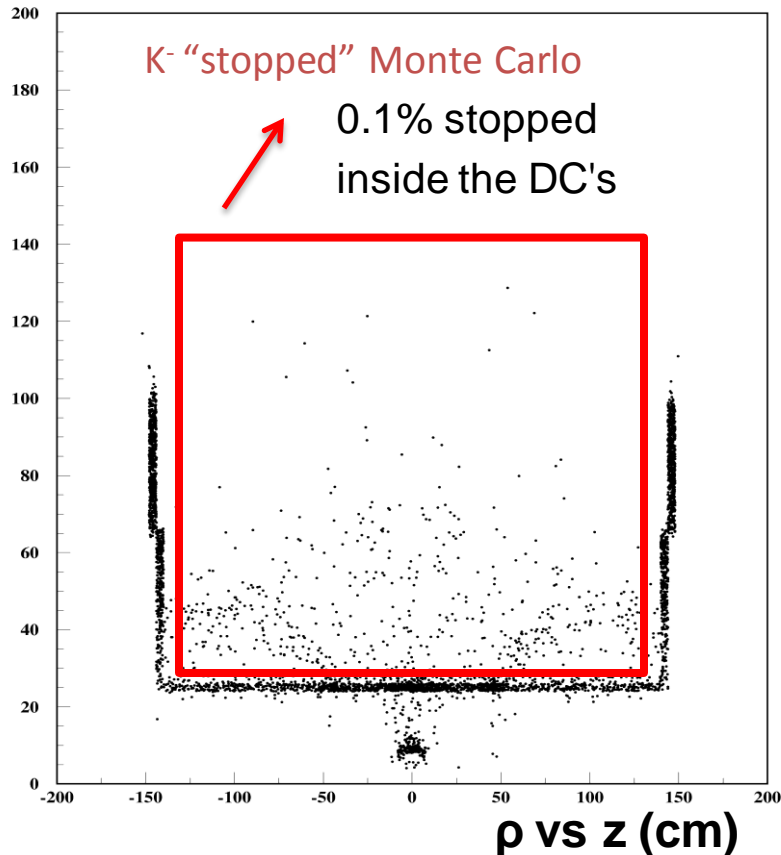
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KLOE Drift Chamber

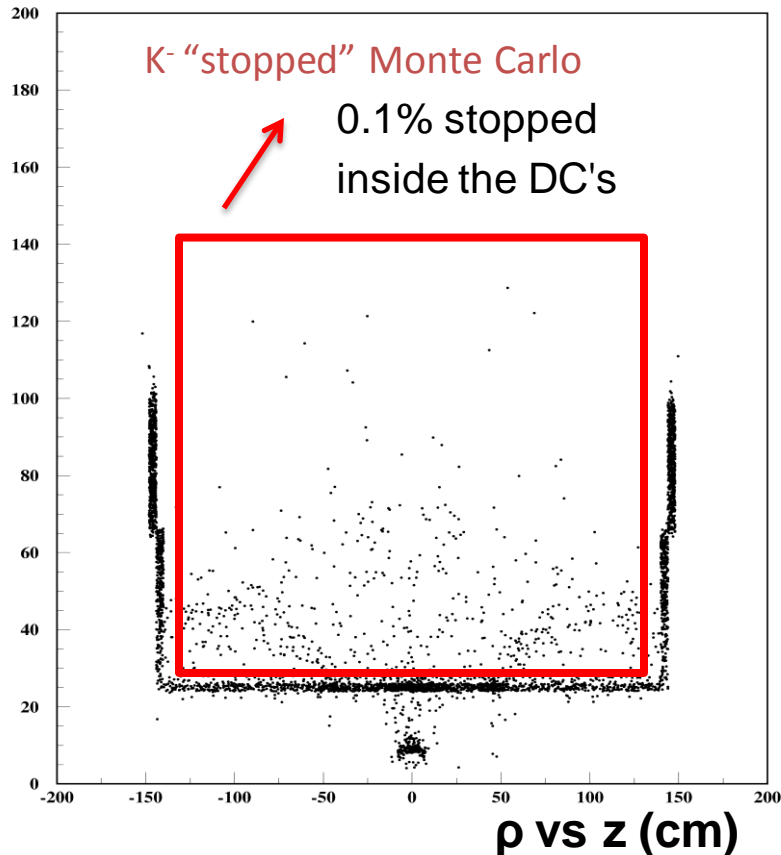
- From analysis of KLOE data and Monte Carlo: **0.1 % of K^- from daΦne should stop in the DC volume**

Hadronic interactions of K^- in KLOE

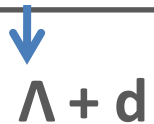
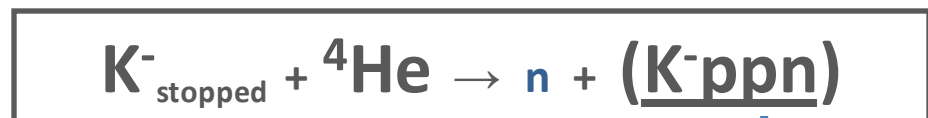
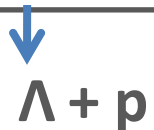
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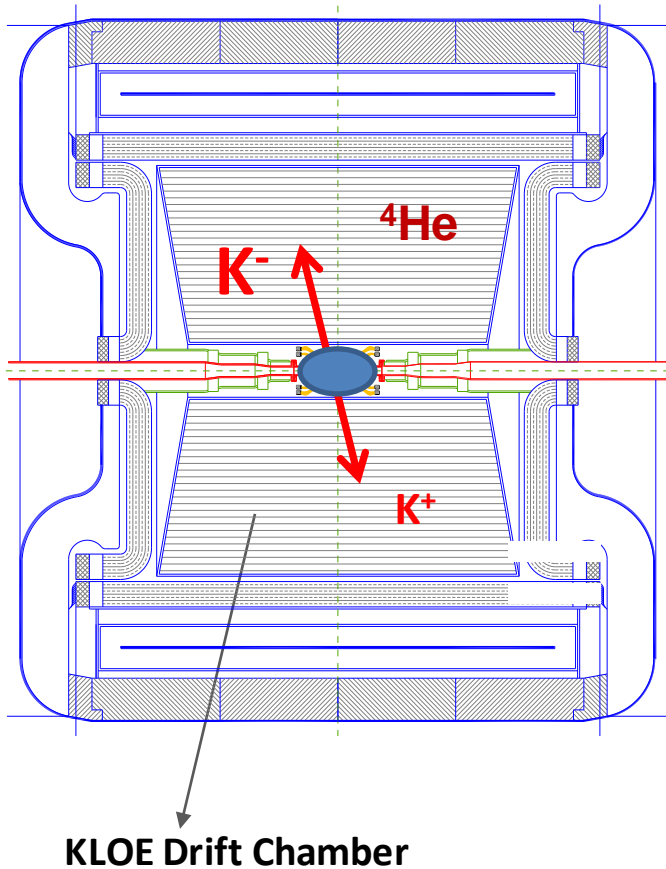
- This would lead to hundreds of possible kaonic clusters produced in the 2 fb^{-1} of KLOE data.



KLOE Drift Chamber



Hadronic interactions of K^- in KLOE



• Statistics:

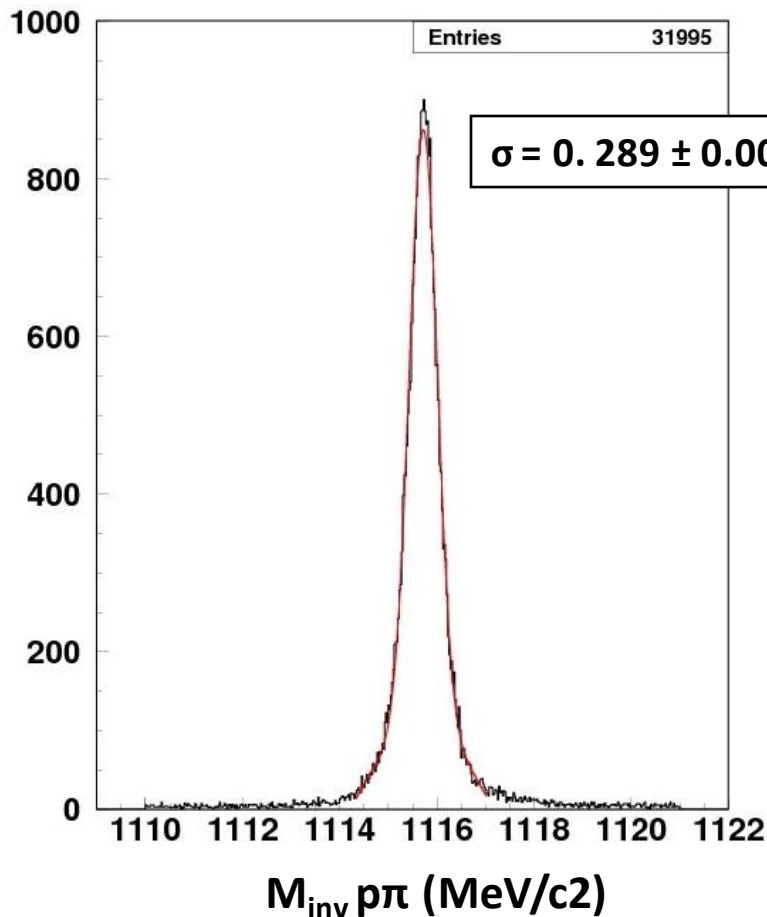
- Total amount of data analyzed up to an integrated luminosity of $\sim 1,1 \text{ fb}^{-1}$ from KLOE data (K-charged group).
- Kaons **TAG** system: **2-body decay** or by the **dE/dx** signature in the DC gas.

• 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 Λ + an **extra particle**

Lambda invariant mass

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



- Dedicated event selection to avoid Eloss in the DC wall
- Best χ^2 tracks and vertices

KLOE:

$$M_{\text{inv}} = 1115,723 \pm 0.003 \text{ stat} \quad (\text{MeV}/c^2)$$

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

- Systematics dependent of momentum calibration
- Evaluated by 2-body decay of K^{\pm} :

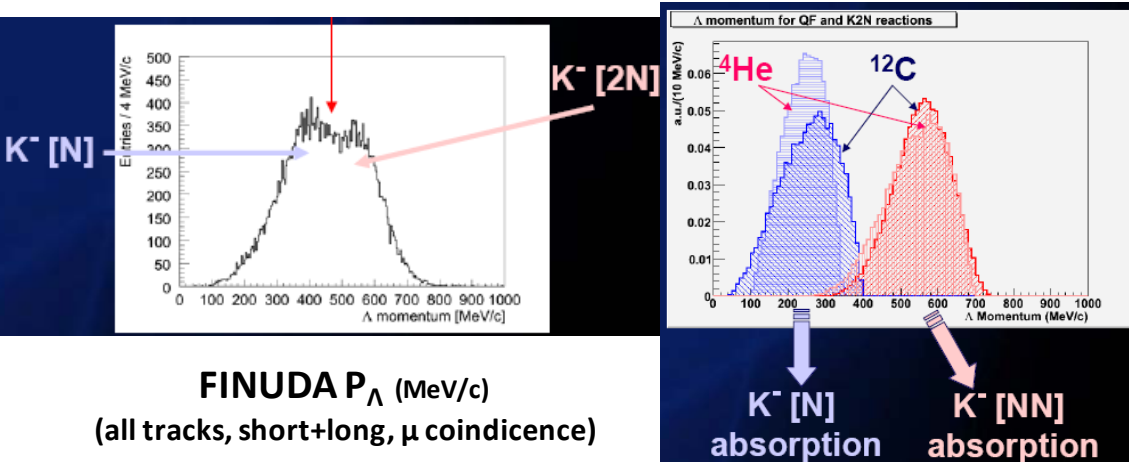
$$K^{\pm} \rightarrow \mu^{\pm} \nu$$

$$K^{\pm} \rightarrow \pi^{\pm} \pi^0$$

Lambda momentum

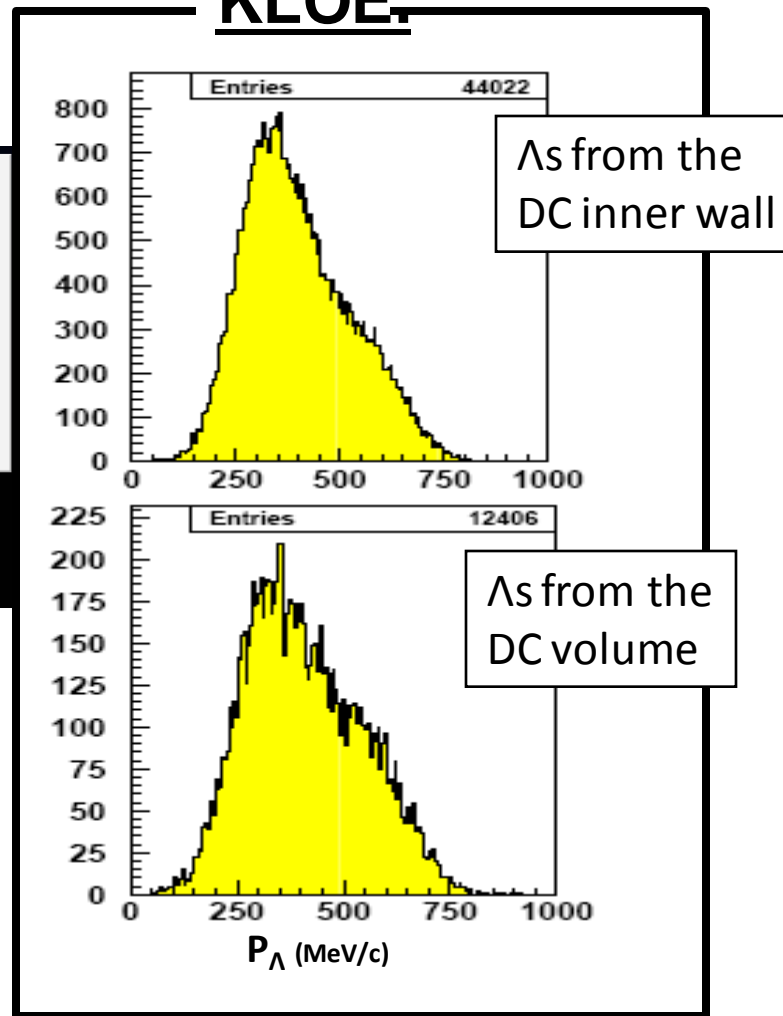


Simulation: expected signals for inclusive Λ production in ^4He and ^{12}C



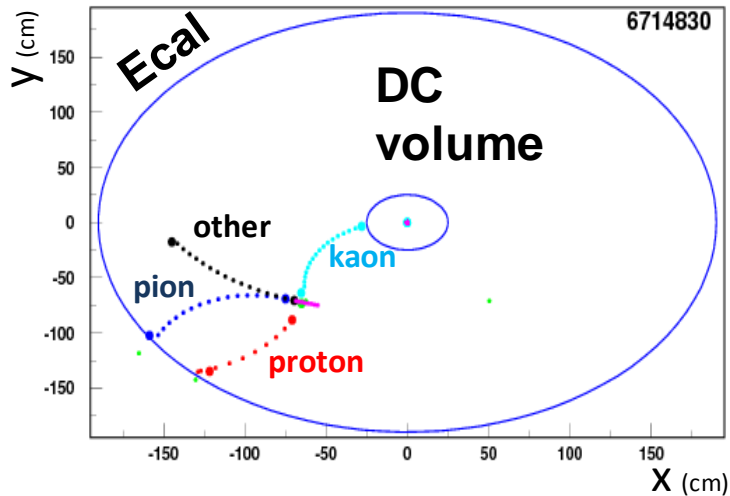
- Well defined double structure in both cases
- Similar momentum range
- Differences at lower momentum due to acceptancy
- Perfectly compatible**

KLOE:



Selection of protons and deuterons

PID



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

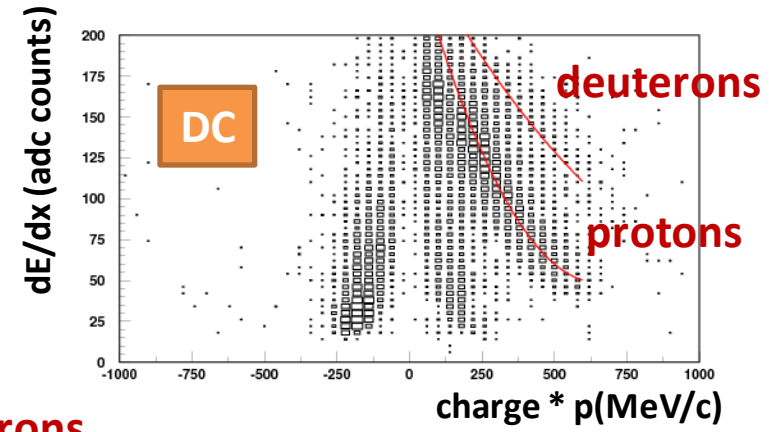
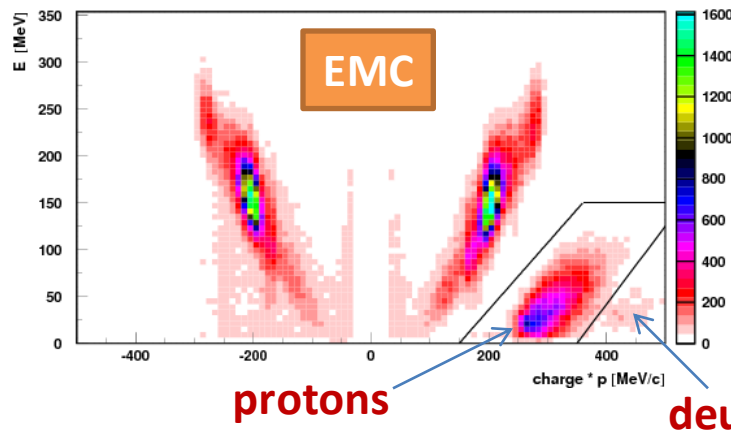
-Require the presence of the tracked/extrapolated K^-



$\Lambda + p$

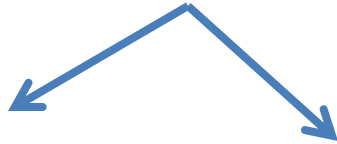


$\Lambda + d$



Correlations: Lambda-d vertices

Improved Λ d vertex reconstruction



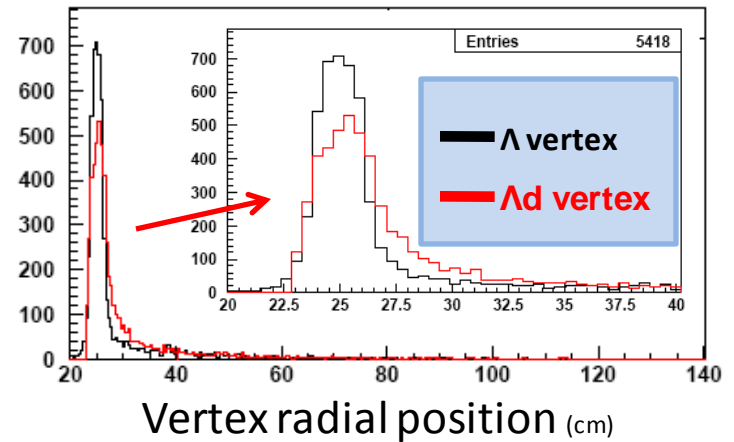
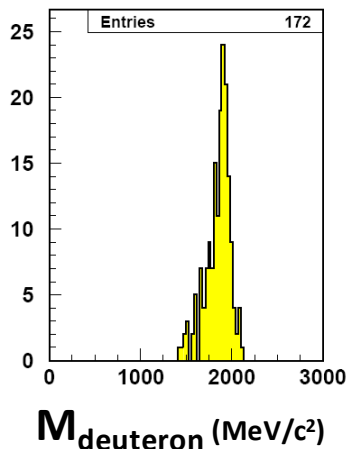
Improved mass recognition (PID) of deuterons and protons



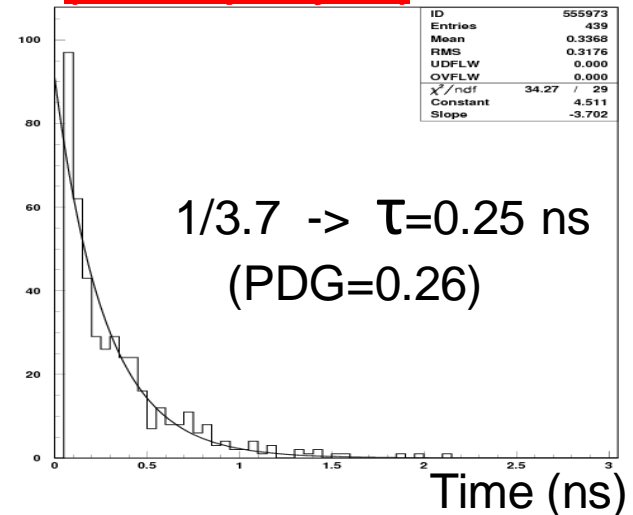
Improved selection of events in DC-gas



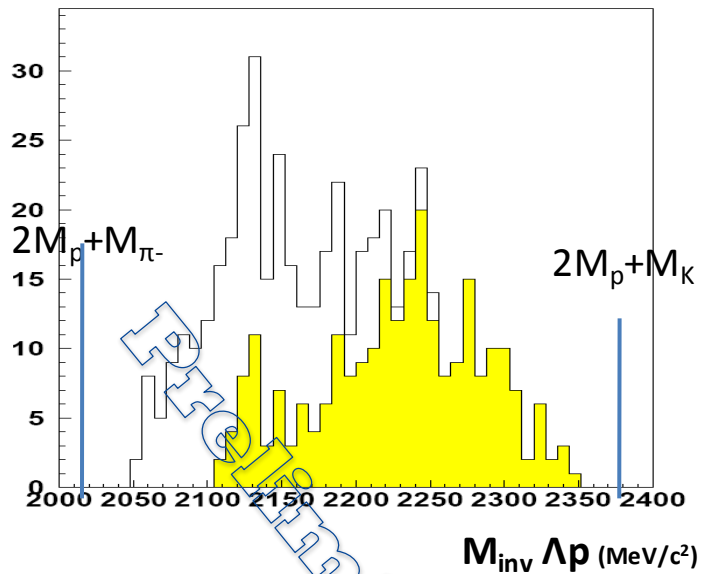
- Proton/deuteron candidates are required to have an associated cluster in the EMC and its mass is measured by **time of flight**.



LAMBDA LIFETIME (also as quality cut)



Invariant mass Λp analysis



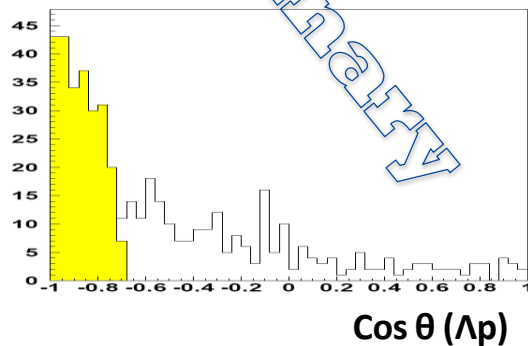
Total events 482

back to back 247

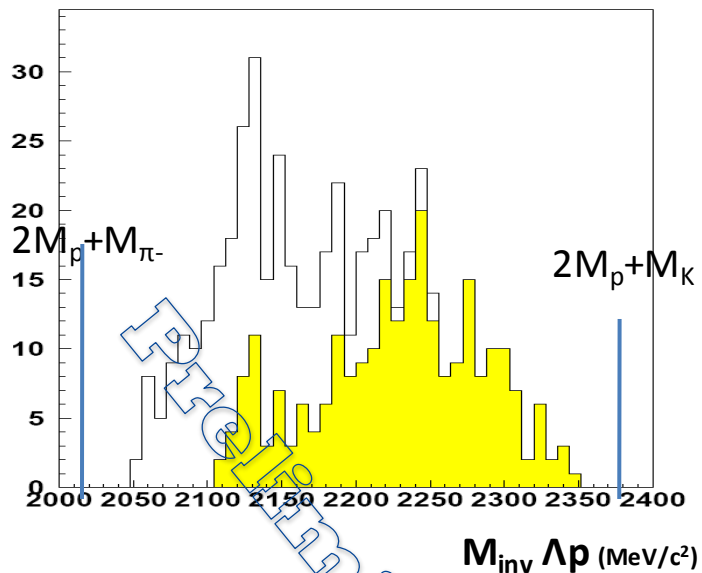
Total Yield = **0.03%**

BtB Yield = **0.02%**

(per stopped K^-)



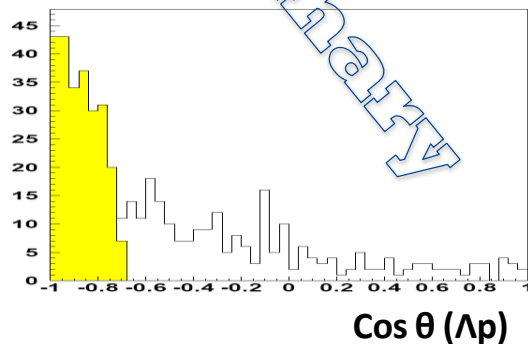
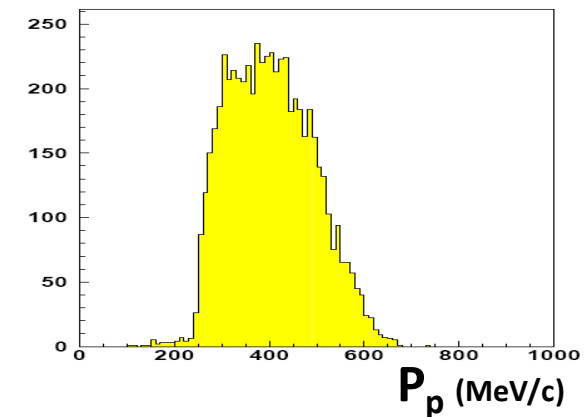
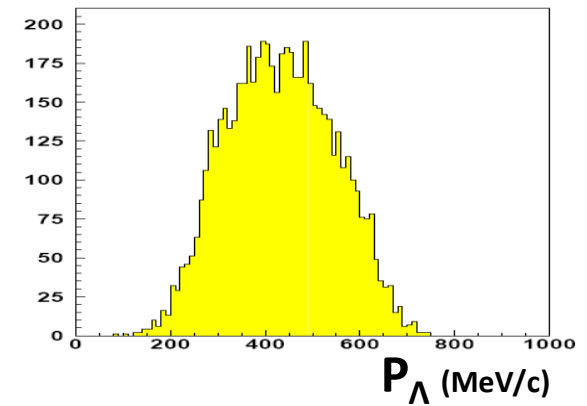
Invariant mass Λp analysis



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Momentum for
Lambda and proton:

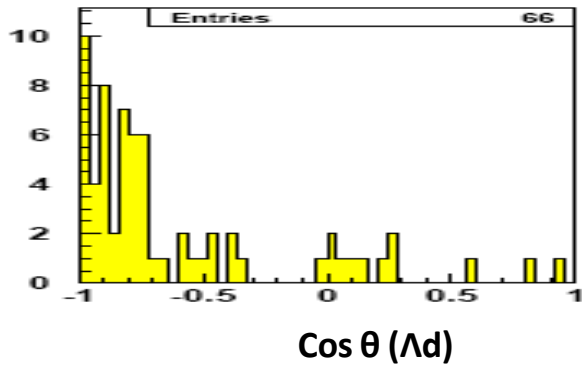
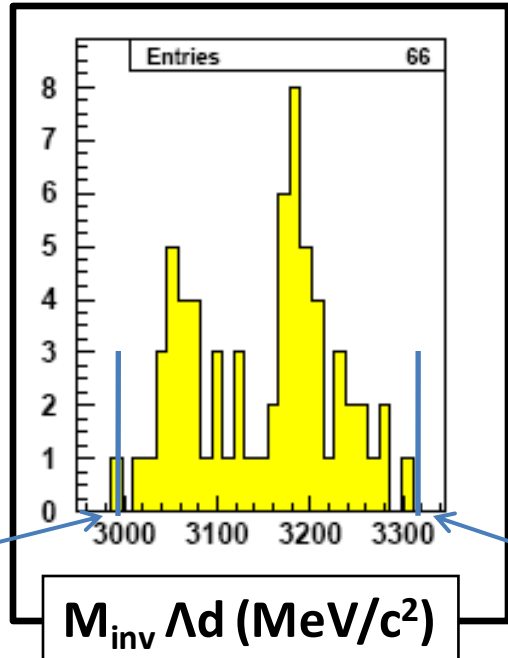


Lambda-d



$\Lambda + d$

Events in the
DC volume



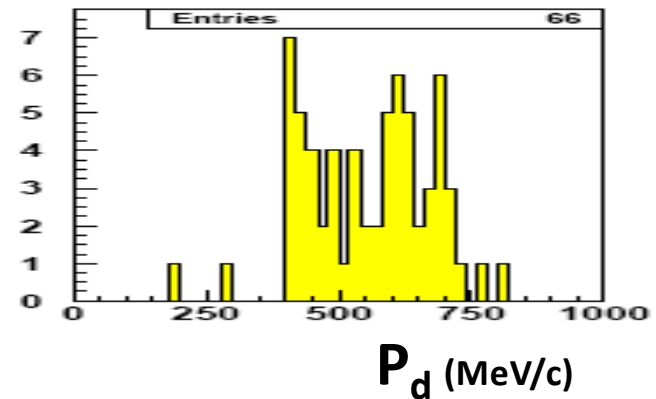
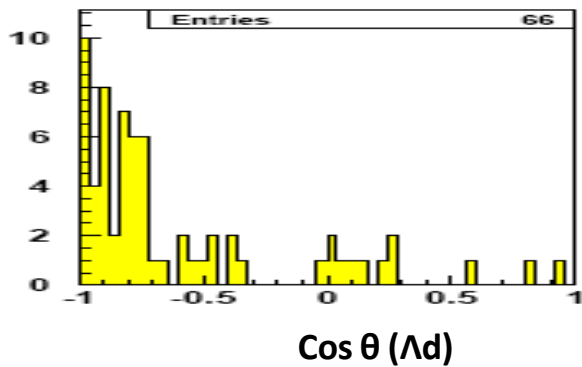
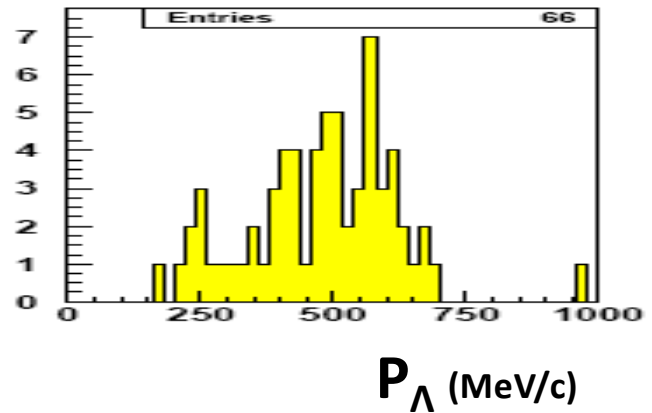
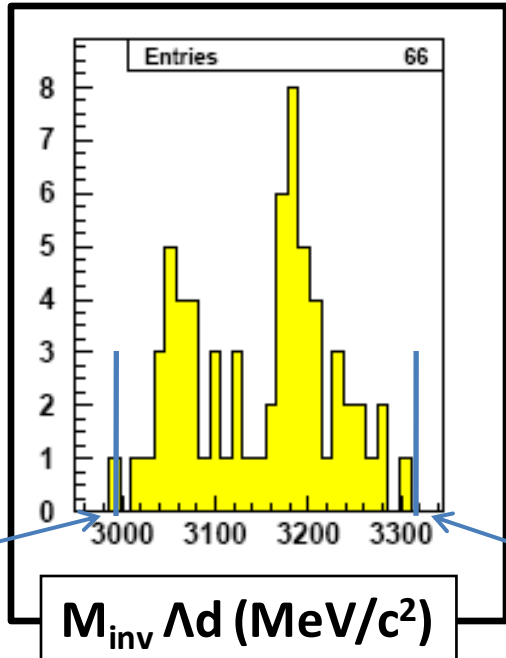
Lambda-d



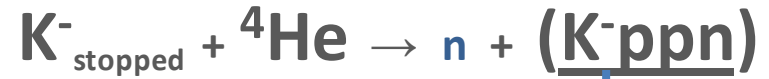
$\Lambda + d$

Events in the
DC volume

Momentum of lambda and deuteron:



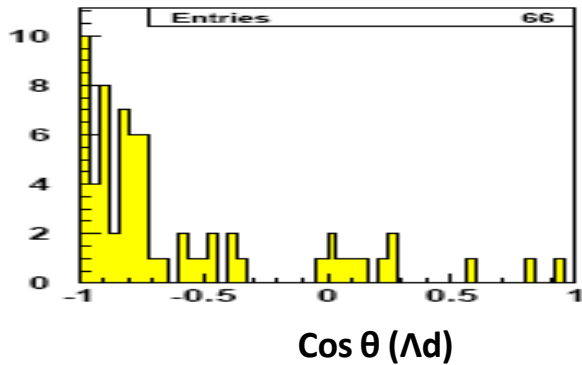
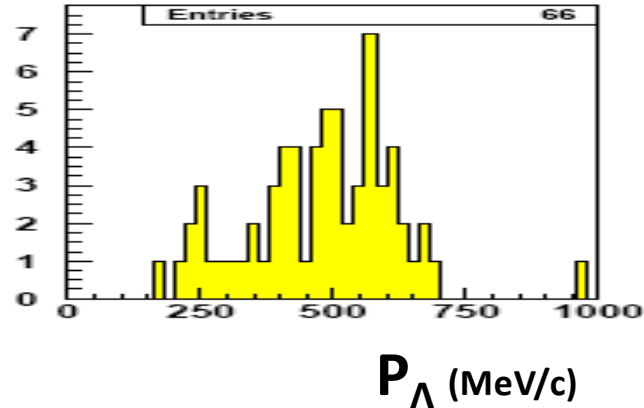
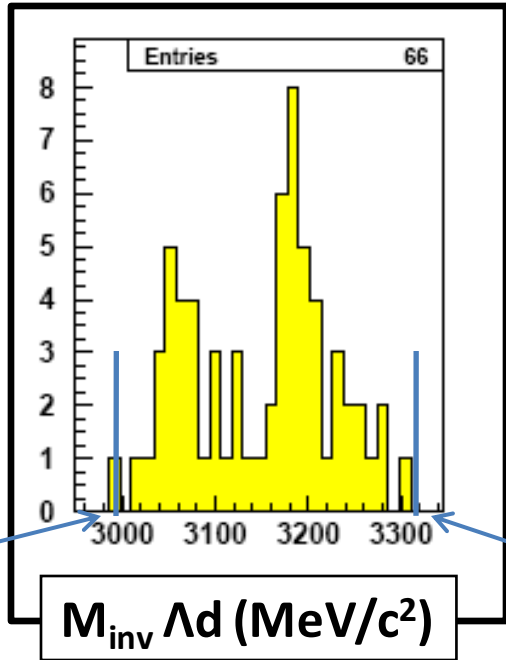
Lambda-d



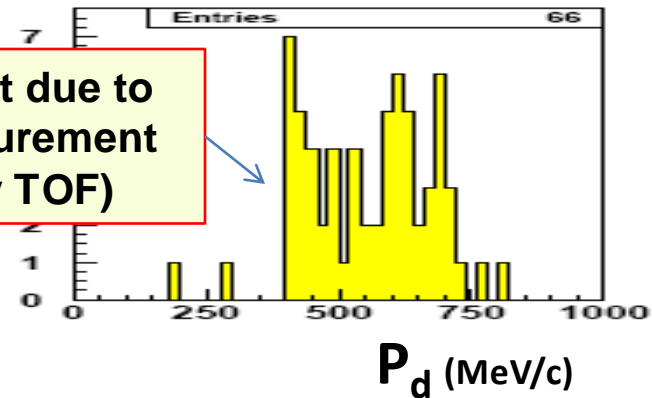
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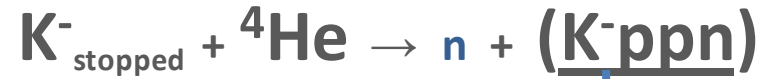
Momentum of lambda and deuteron:



Sharp cut due to EMC requirement (mass by TOF)

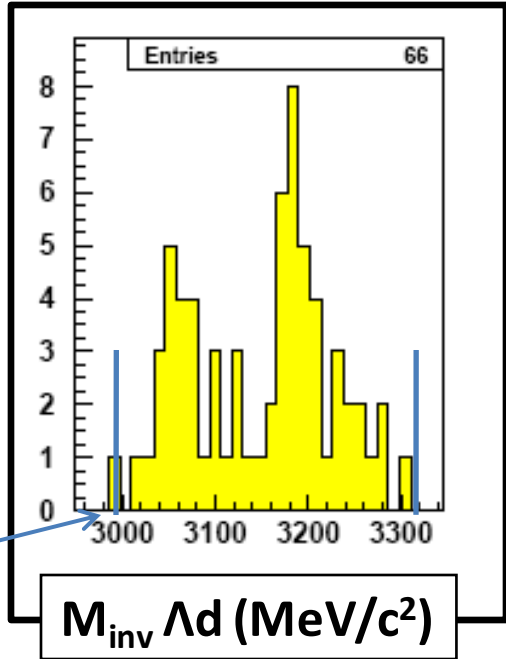


Lambda-d

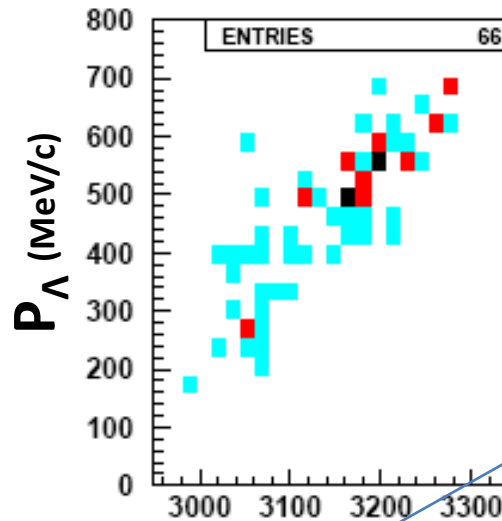


$\Lambda + d$

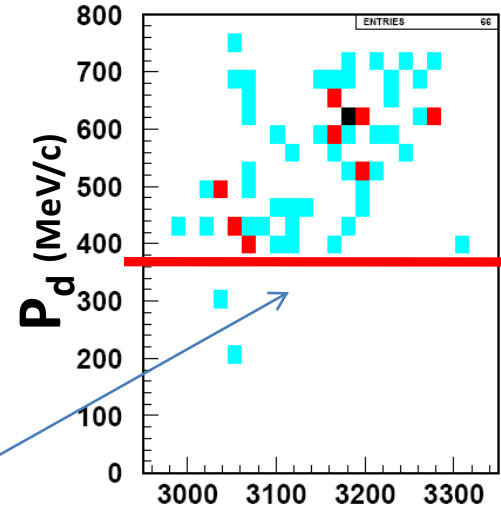
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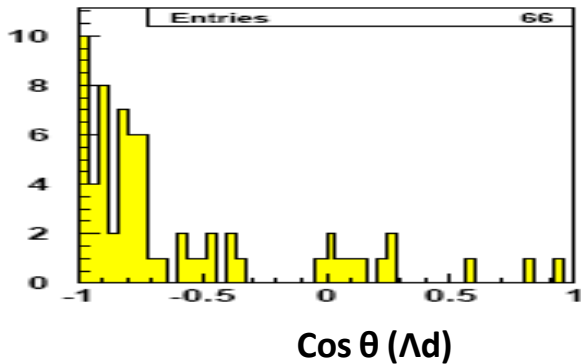
lambda momentum vs. Minv



deuteron momentum vs. Minv



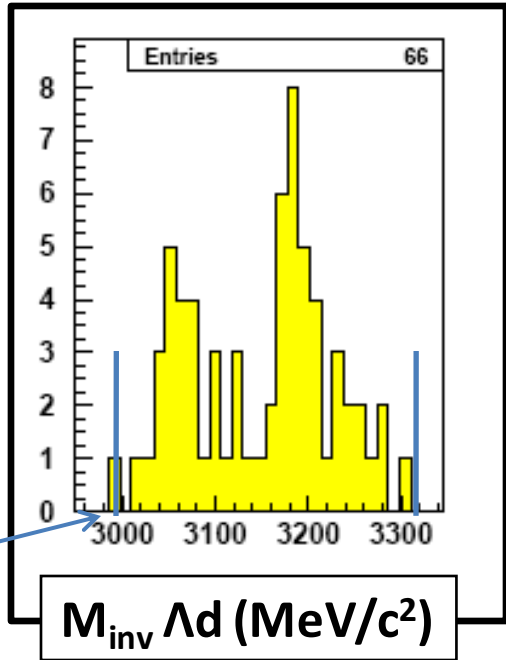
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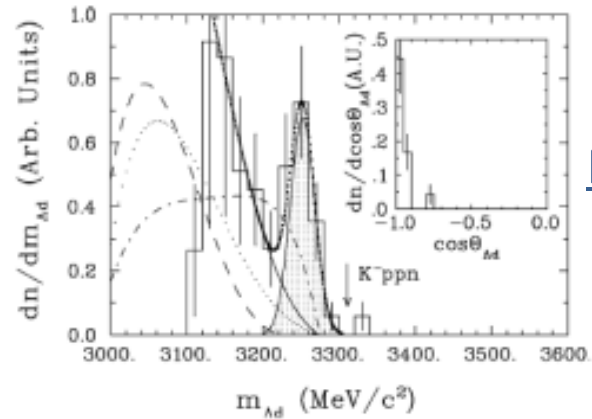
Lambda-d



$\Lambda + d$

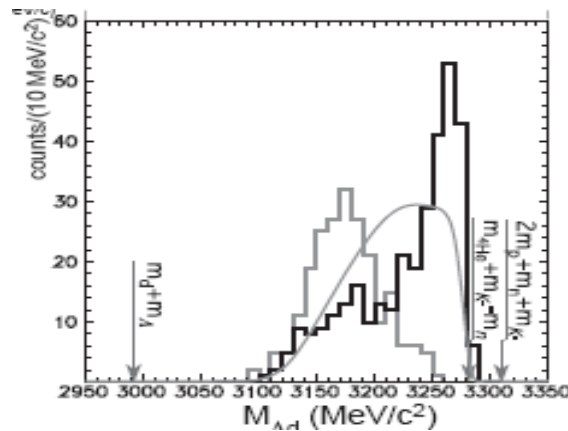
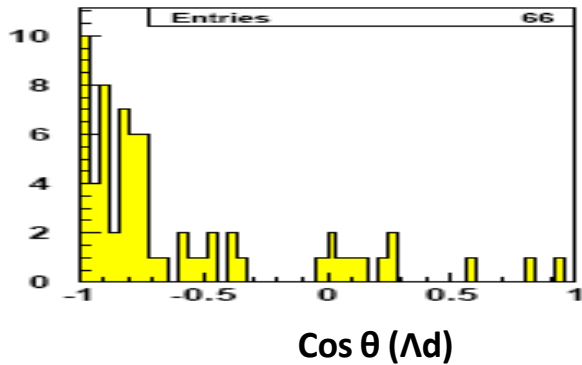


$M_d + M_p + M_{\pi^-}$



FINUDA

K- stopped in light nuclei

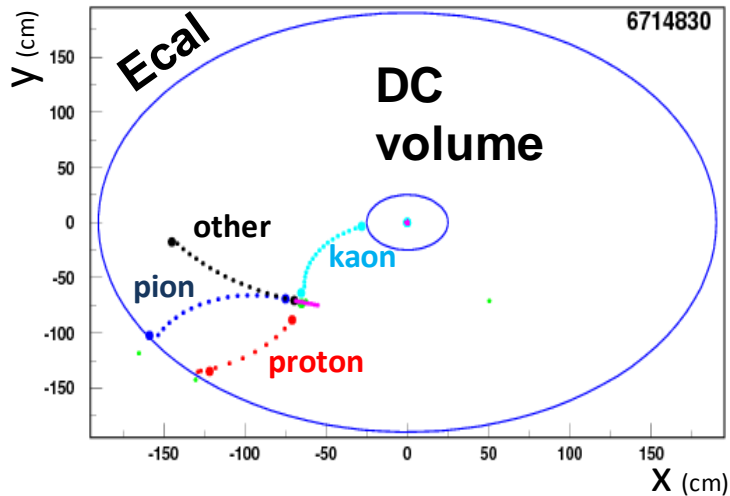


KEK

K- stopped in ${}^4\text{He}$

Selection of protons and deuterons

PID



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

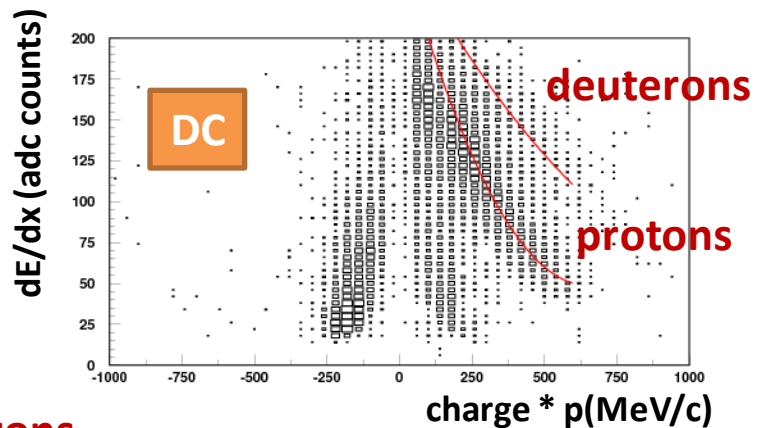
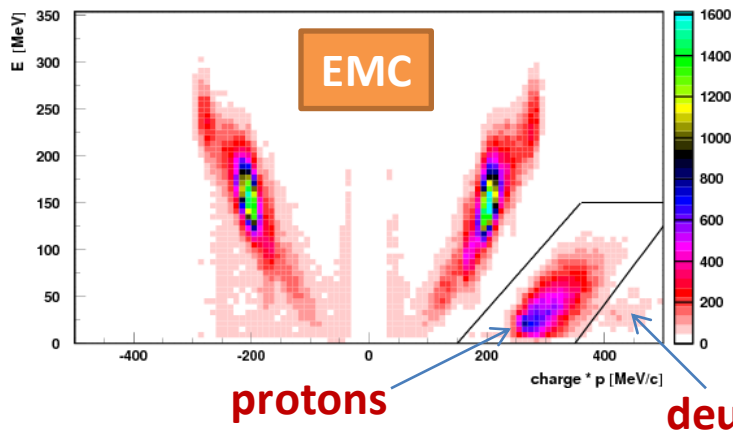


$\Lambda + p$



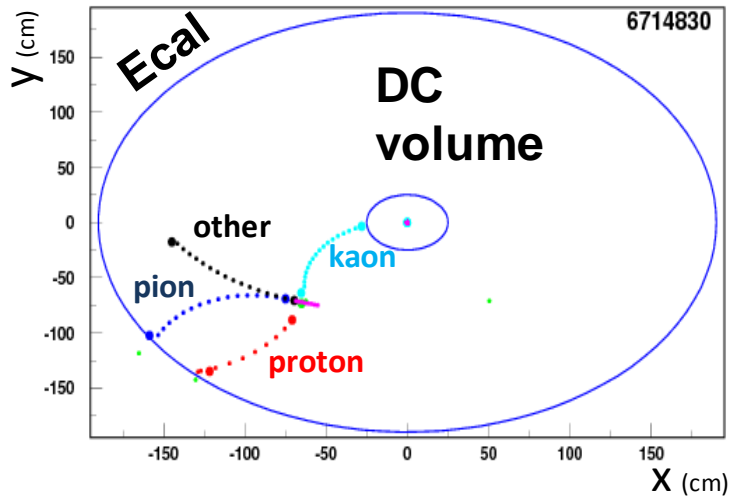
$\Lambda + d$

-Require the presence of the tracked/extrapolated K^-



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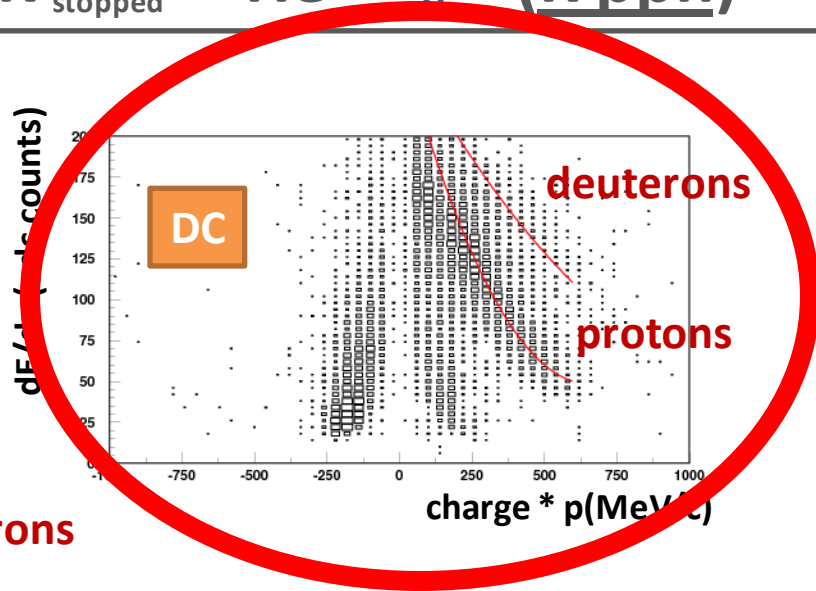
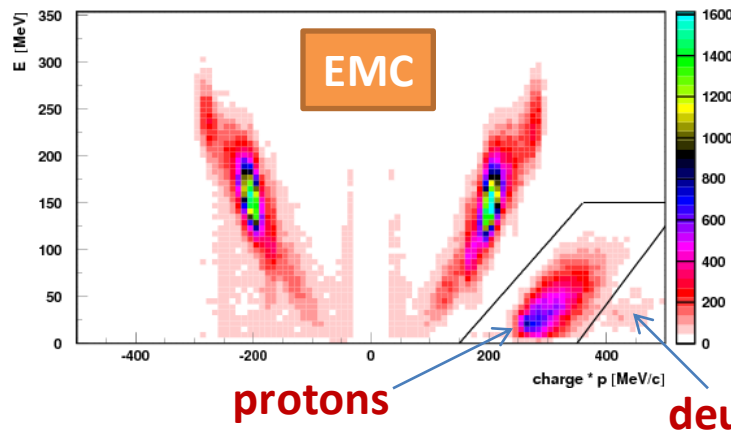


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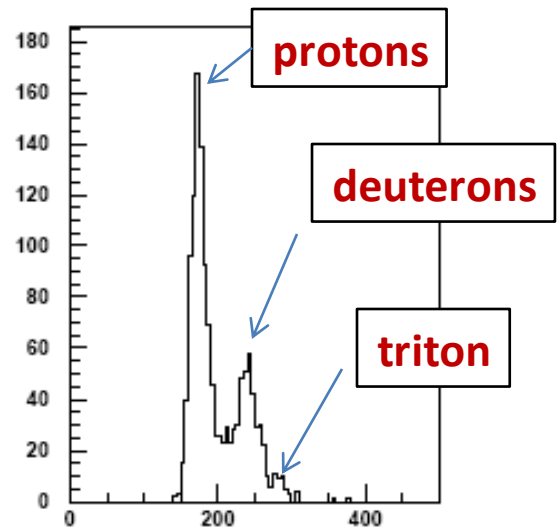
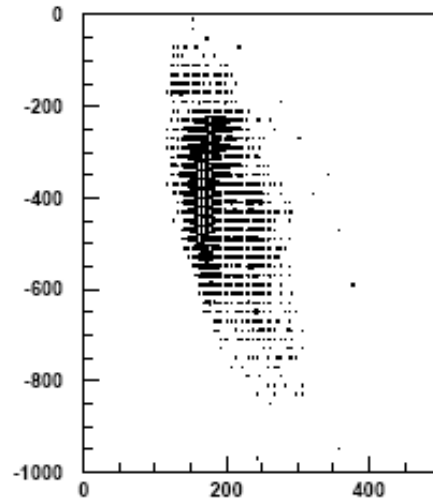
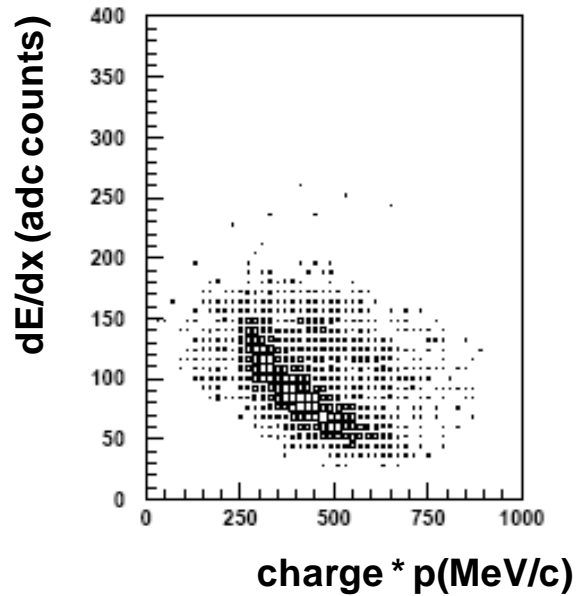
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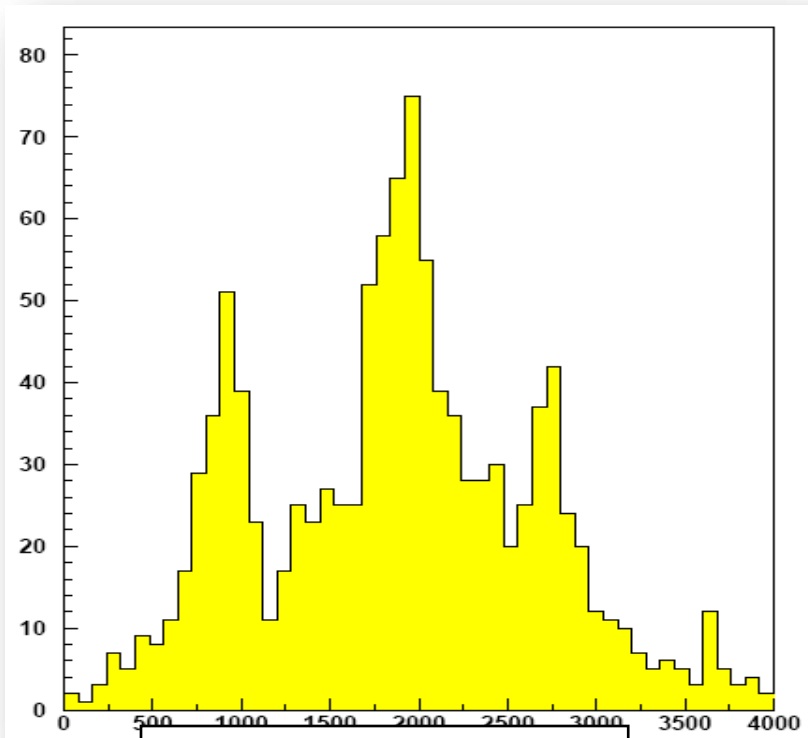
Selection of triton

PID

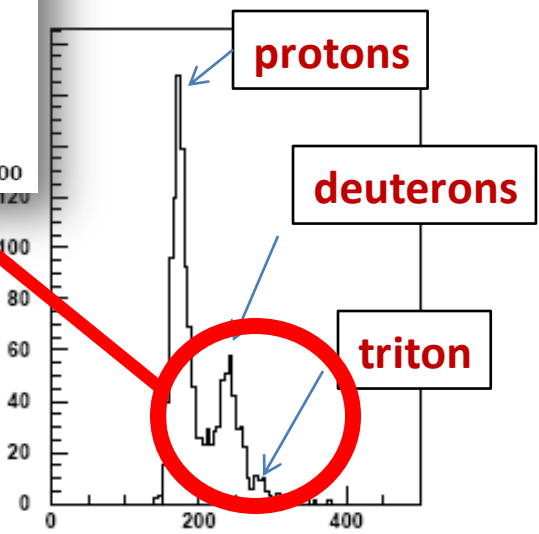
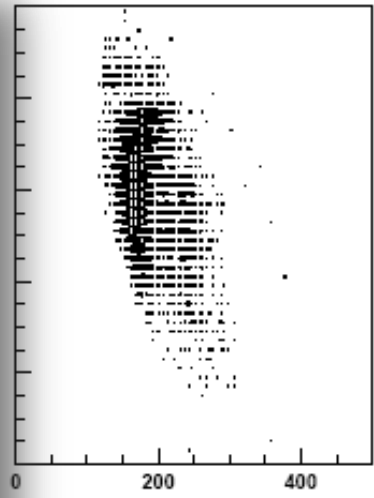


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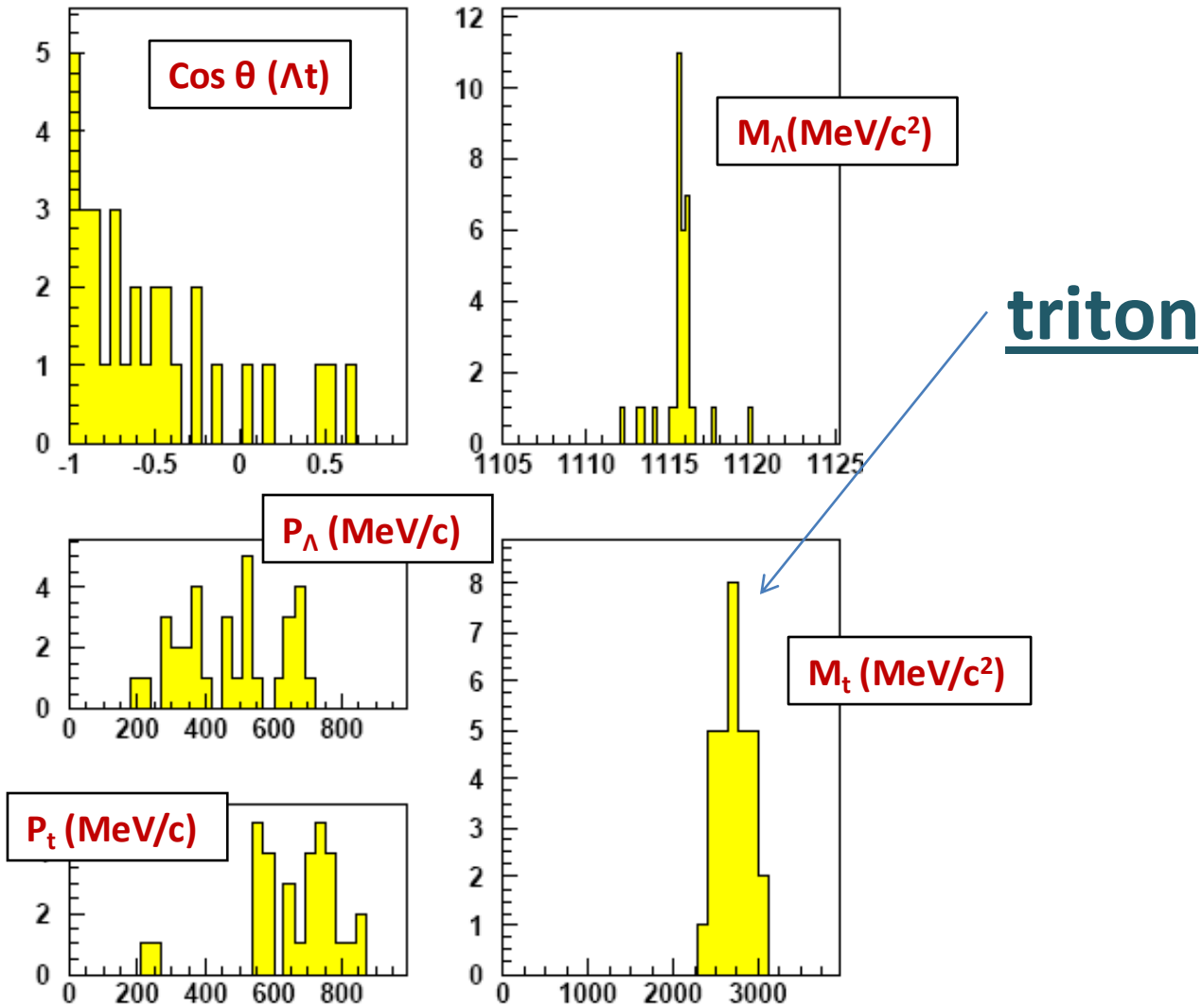
PID



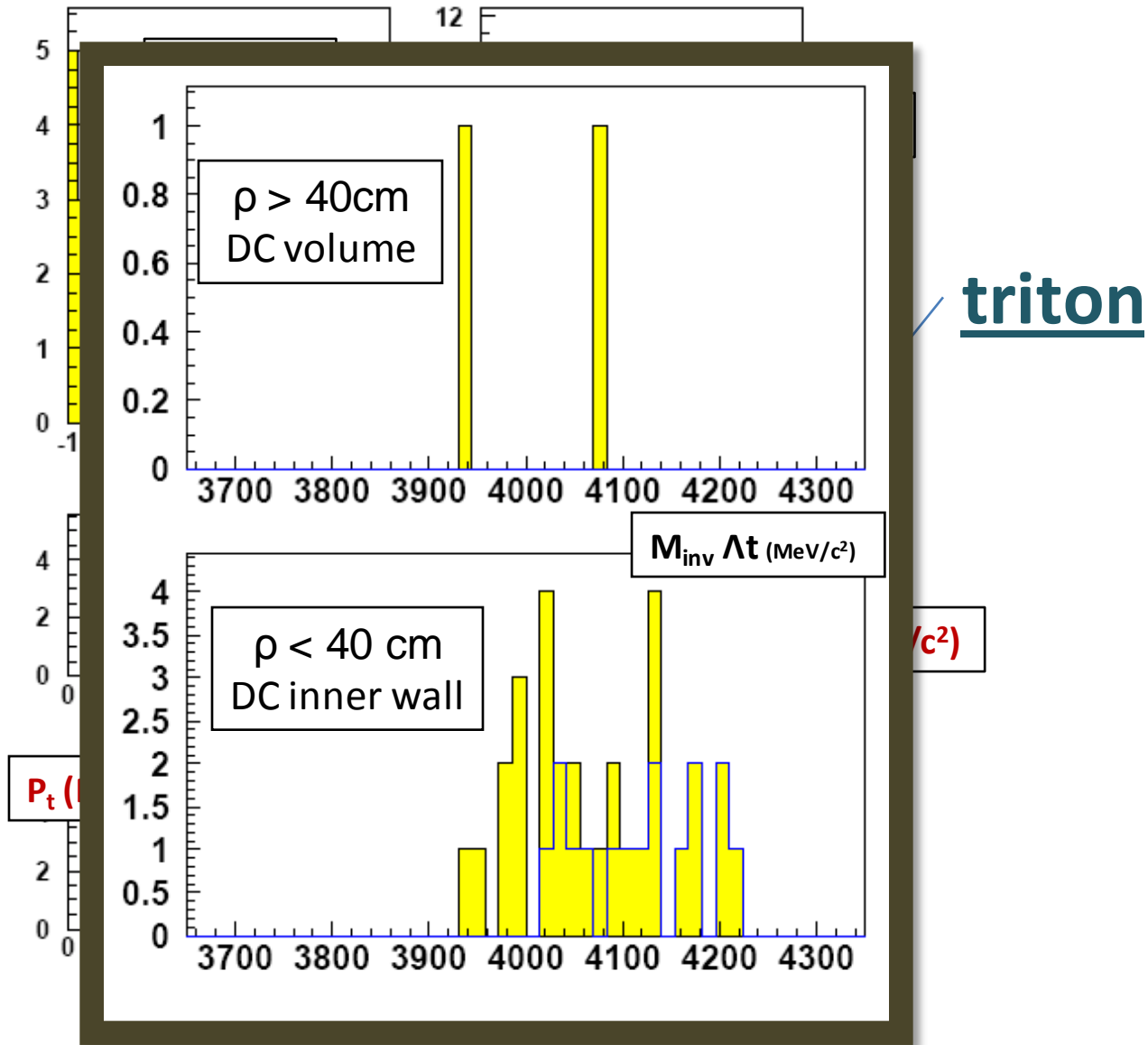
Mass by time of flight (MeV/c^2)



Lambda-triton



Lambda-triton



$$(\Sigma\pi)^0$$

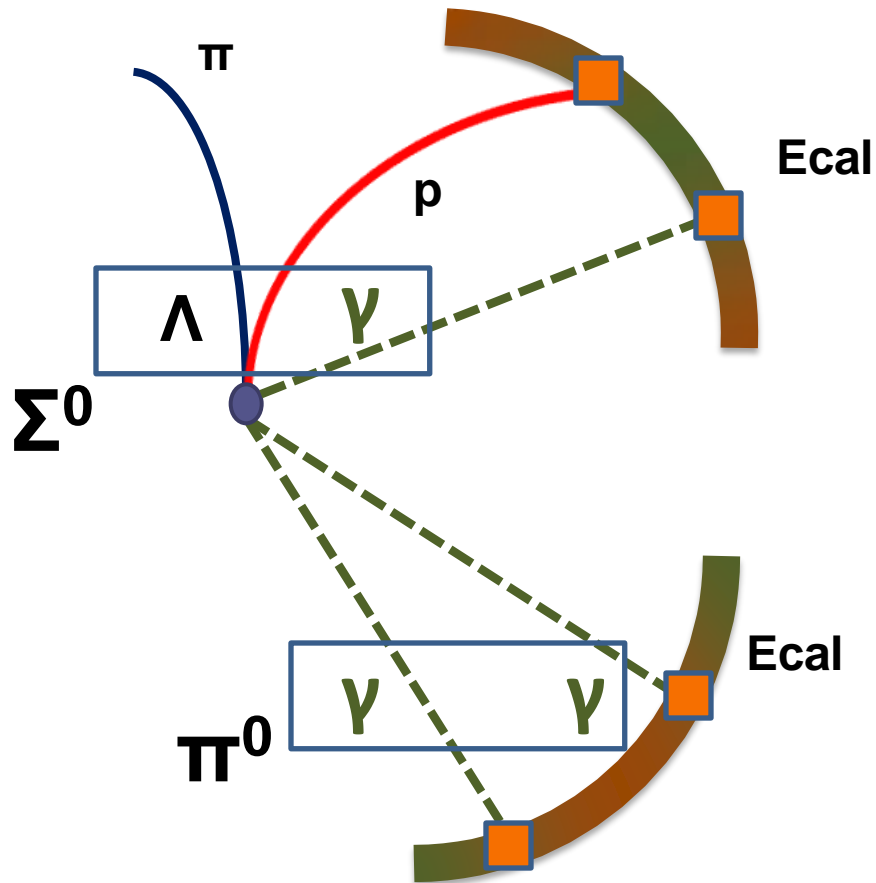
$\Lambda(1405)/\Lambda(1420)$ search

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

$$(\Sigma\pi)^0$$

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

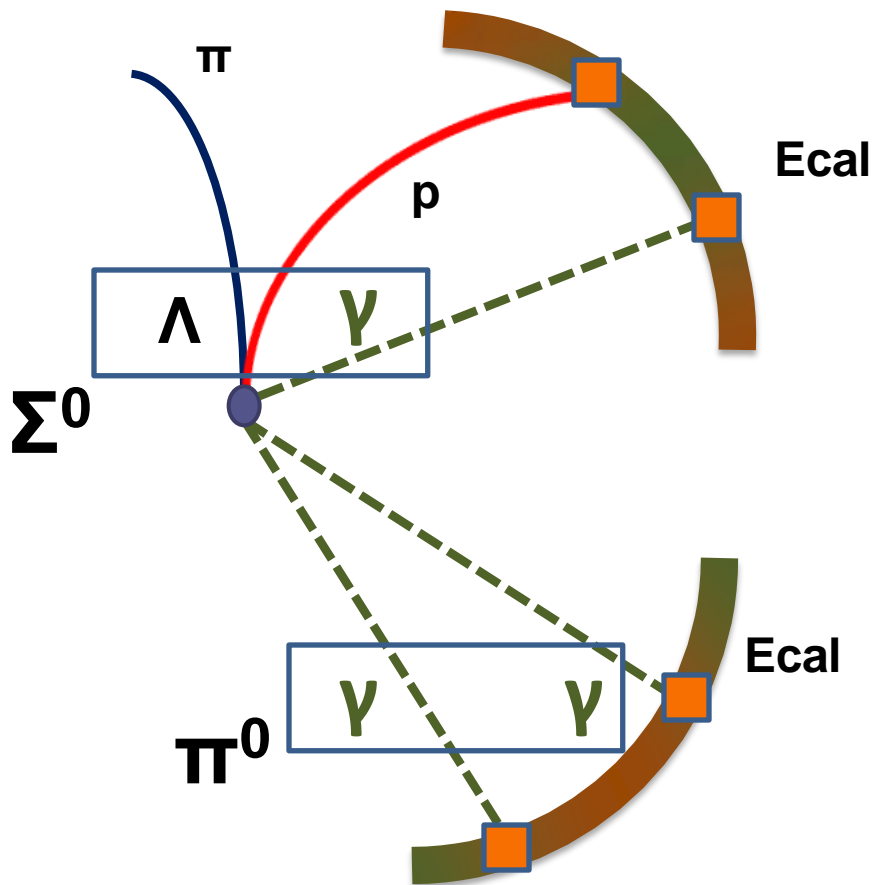
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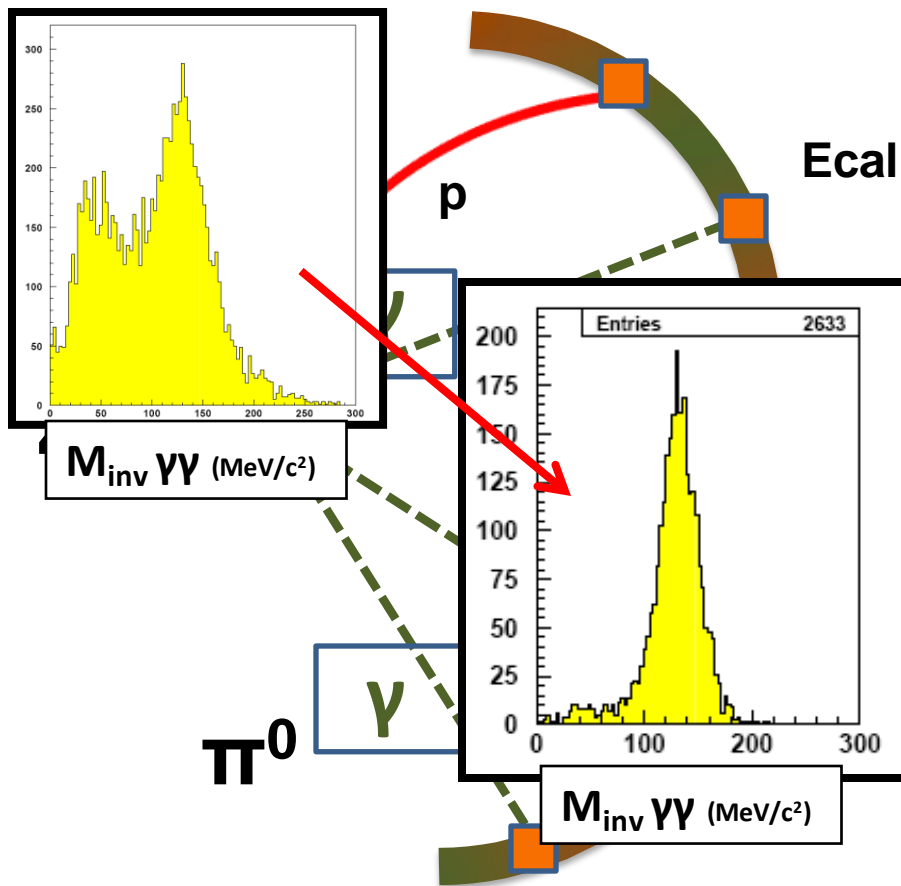
Kinematic fit:

- χ^2 computing:
 - momentum of proton and pion
 - Covariance matrix elements for every track
 - time and positions and resolutions for photons
- **Allows to reject background selecting the right combination of photons**
- Constraints: Δt for the arrival time of photons
- No mass assumption -> unbiased mass spectras

$(\Sigma\pi)^0$

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

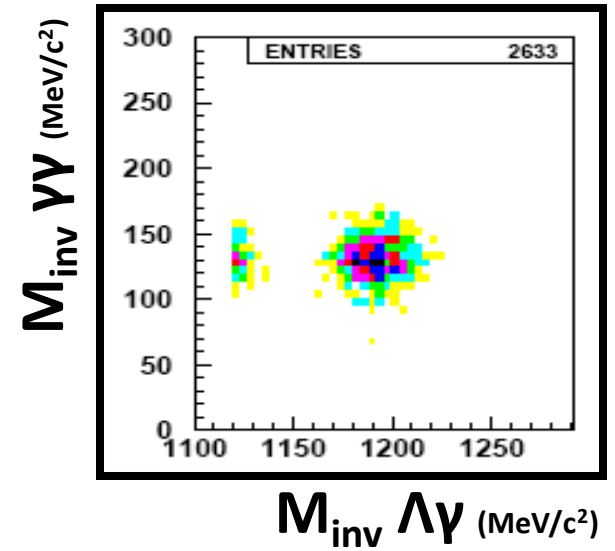
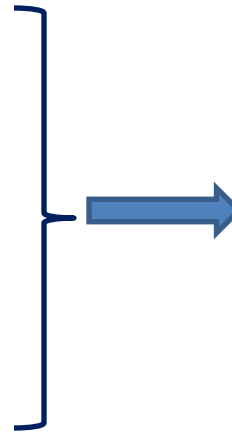
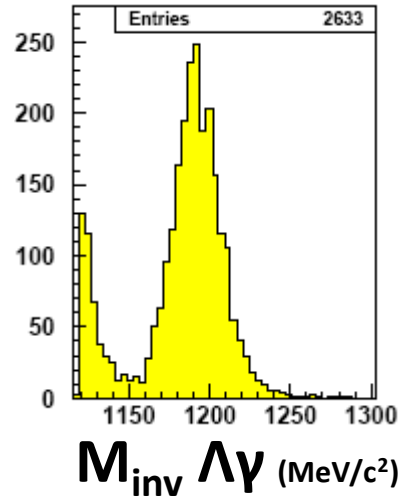
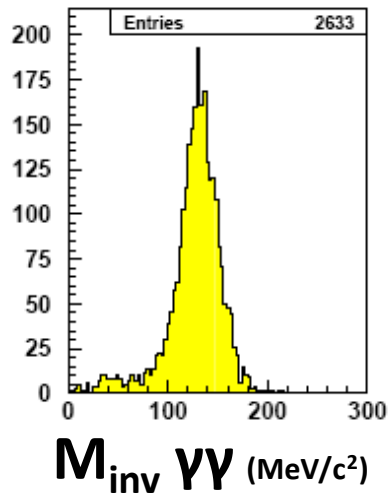
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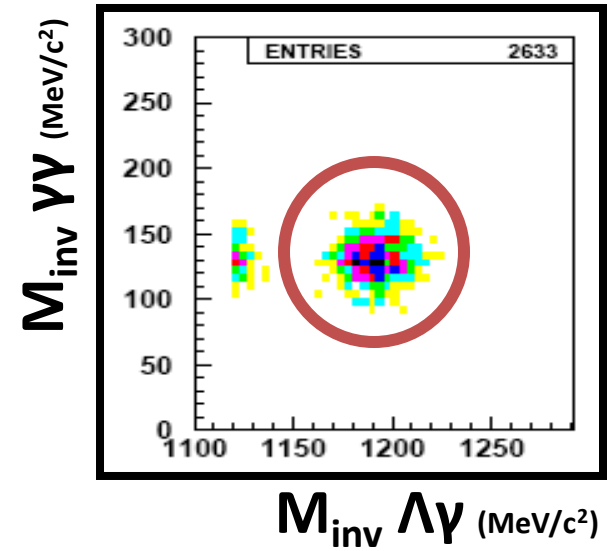
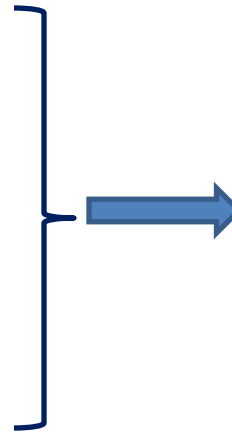
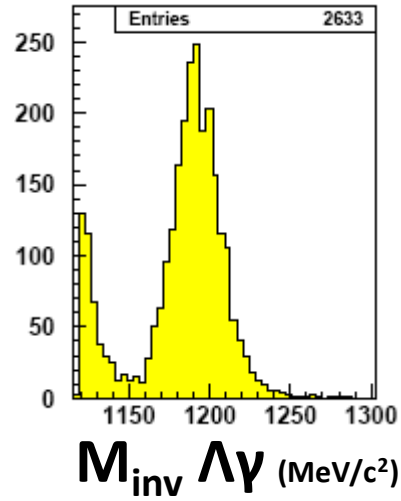
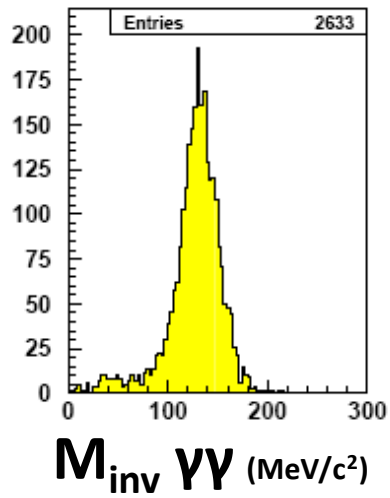
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- No mass assumption -> unbiased mass spectrum

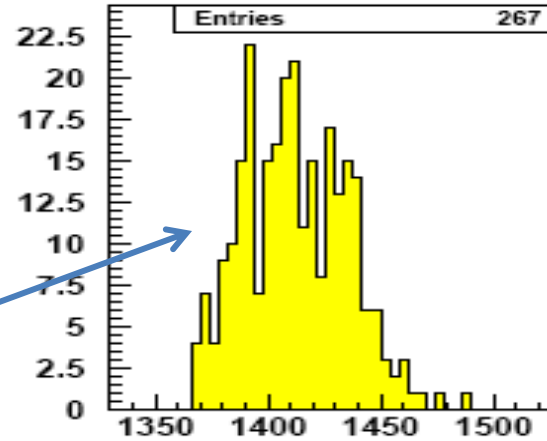
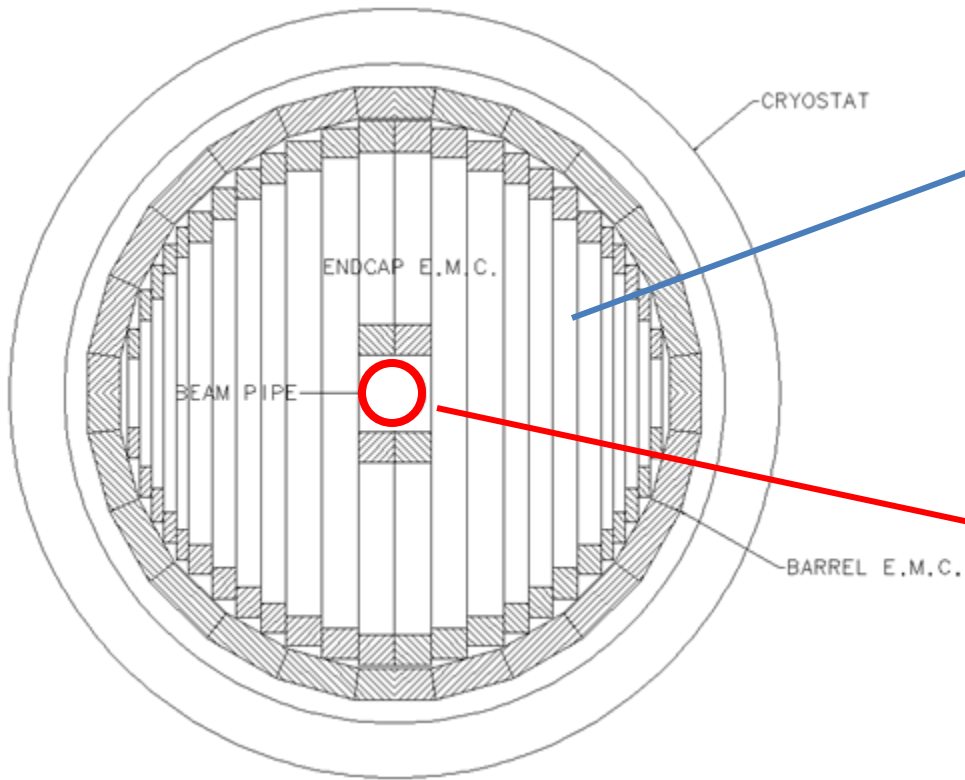
$(\Sigma\pi)^0$



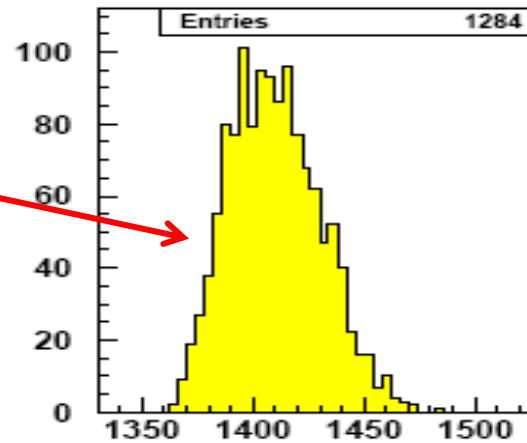
$$(\Sigma\pi)^0$$



$$(\Sigma\pi)^0$$



Events in the
DC volume



DC wall

$$M_{inv}^{\Sigma^0\pi^0} \text{ (MeV/c}^2\text{)}$$

$(\Sigma\pi)^0$

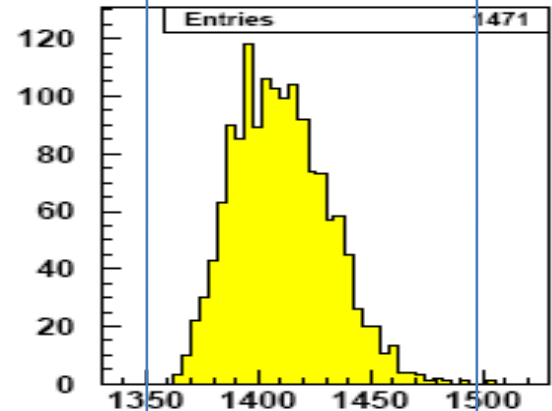
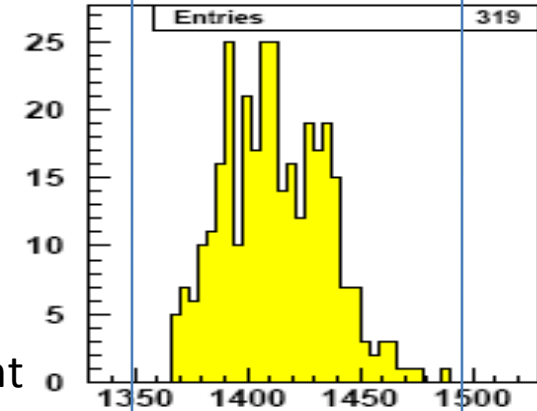
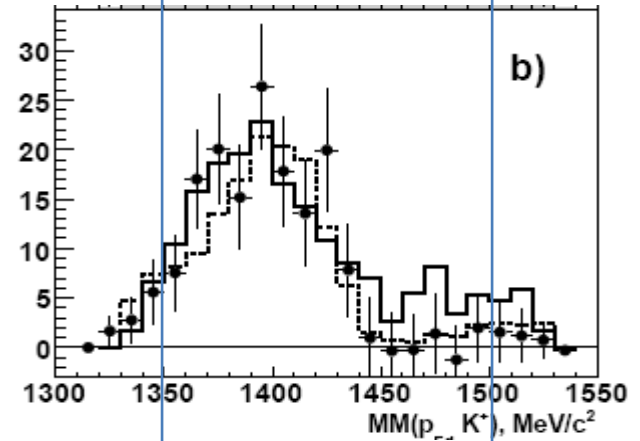
- $\pi^-p \rightarrow K^0 \Sigma^0 \pi^0$ (solid line) PDG
- $K^-p \rightarrow \pi^+ \pi^- \Sigma^+ \pi^-$ (dotted line) PDG
- $pp \rightarrow p K^+ Y^0$ (points with errors) ANKE

Comparison with available experimental data

DC volume

Production of $(\Sigma\pi)$ with K- of initial moment of ~127 MeV on Carbon and Helium

DC wall



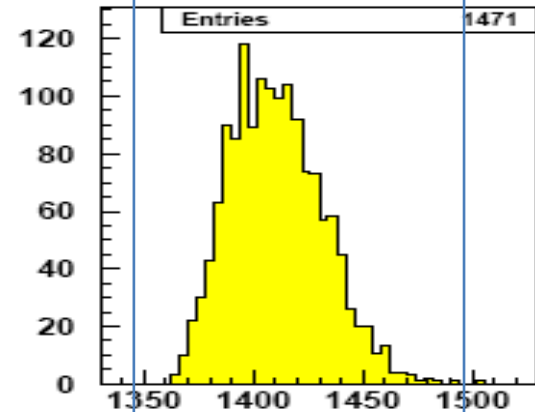
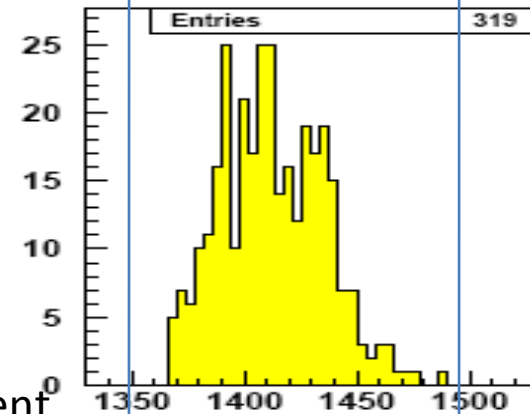
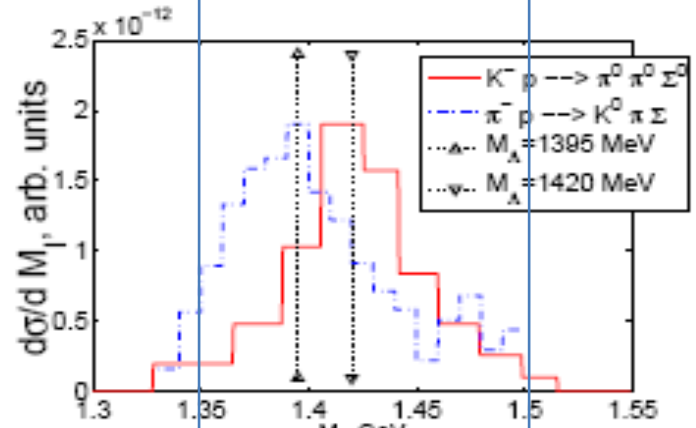
$$(\Sigma\pi)^0$$

Comparison with available experimental data

DC volume

Production of $(\Sigma\pi)$ with K- of initial moment of ~ 127 MeV on Carbon and Helium

DC wall



Further analysis & future goals

- Analyze **neutron**-events in the Λd case
- Study background from $\Sigma \rightarrow \Lambda \gamma$ missidentification
- Increase “acceptancy” by removing EMC (mass by TOF) cut
- Study $\Sigma^+ \pi^-$, $\Sigma^- \pi^+$ events
- Increase the **statistics** to the whole 2004-2005 KLOE data set (**x2**)
- **Publication of Λd , Λp , $\Lambda t(?)$, $\Sigma \pi$ results**
- **Analyze KLOE 2 data !!!**

Conclusions

- **1.1 fb⁻¹** of the KLOE data have been **analyzed** looking for physics generated by the 0.1 % of K⁻ 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 **Λp , Λd , $\Sigma \pi$** , in a broad kinematic range with **high acceptance** representing key ingredients for AMADEUS success.
- Possibility to bring some light and add new and clean data to the low energy K⁻-nucleus hadronic interactions.

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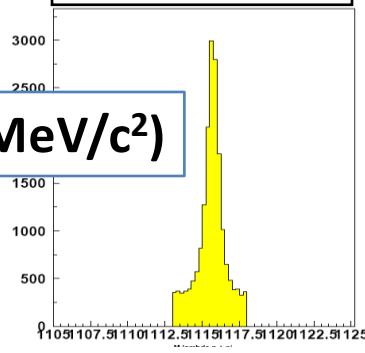
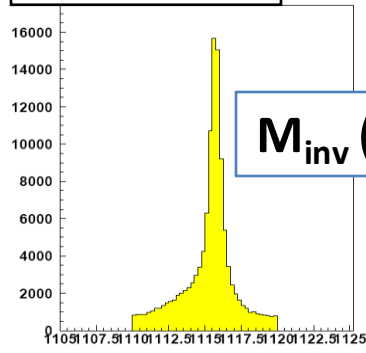
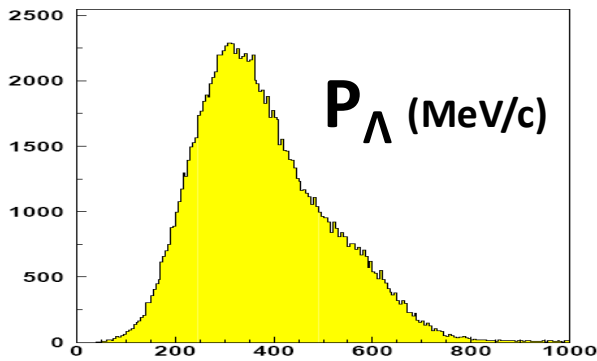


SPARE

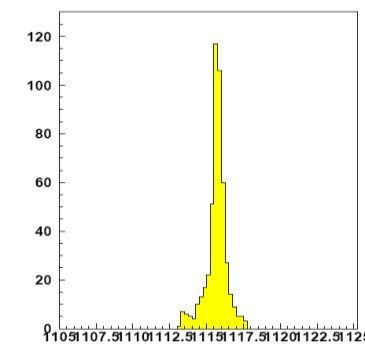
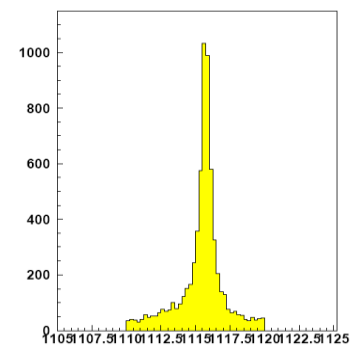
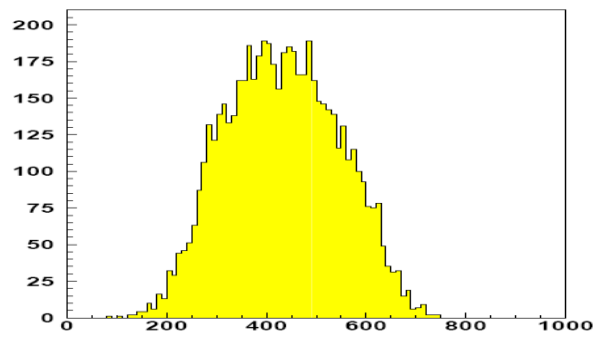
Selection of protons and deuterons

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

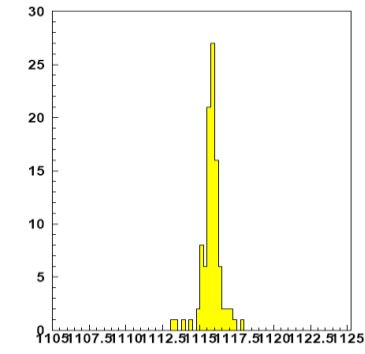
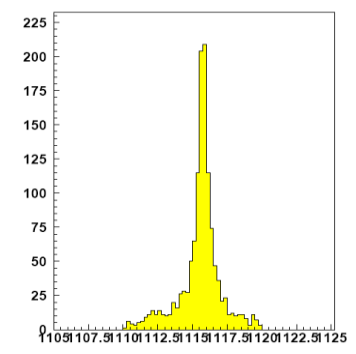
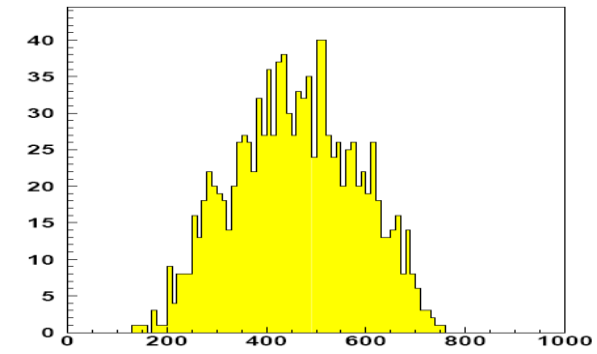
$\rho < 40\text{cm}$
DC inner wall



} All selected Λ s

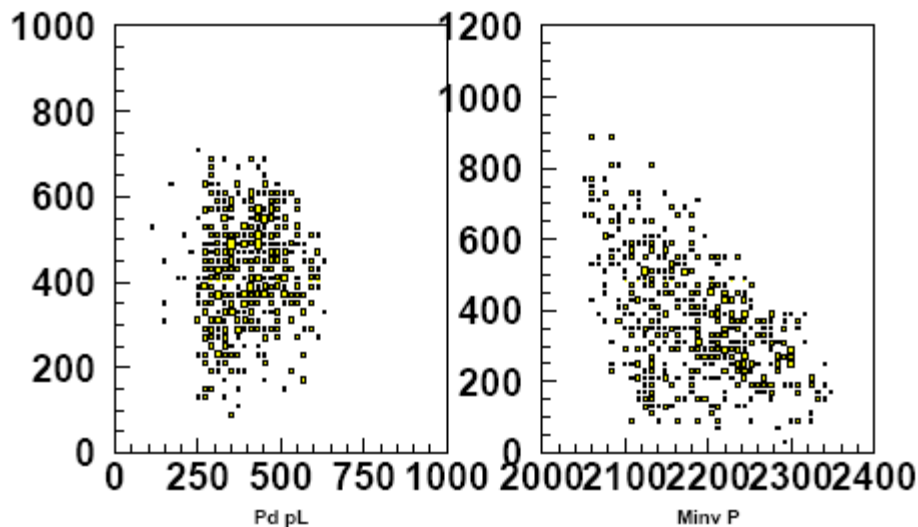


➔ Λp
protons

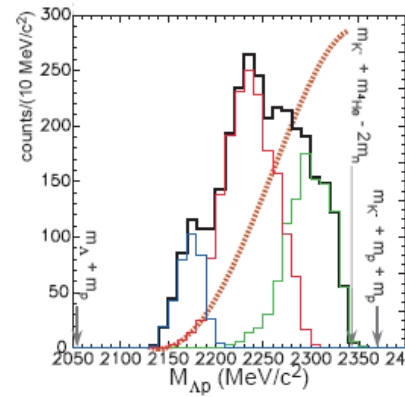
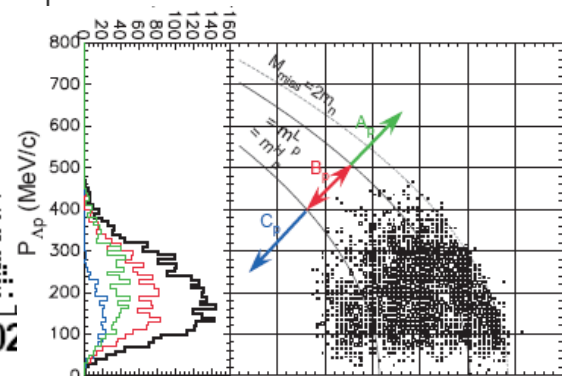
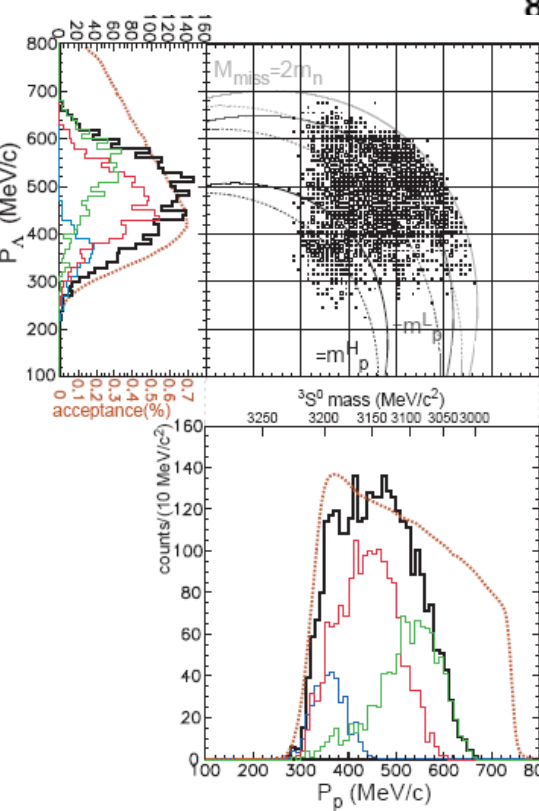
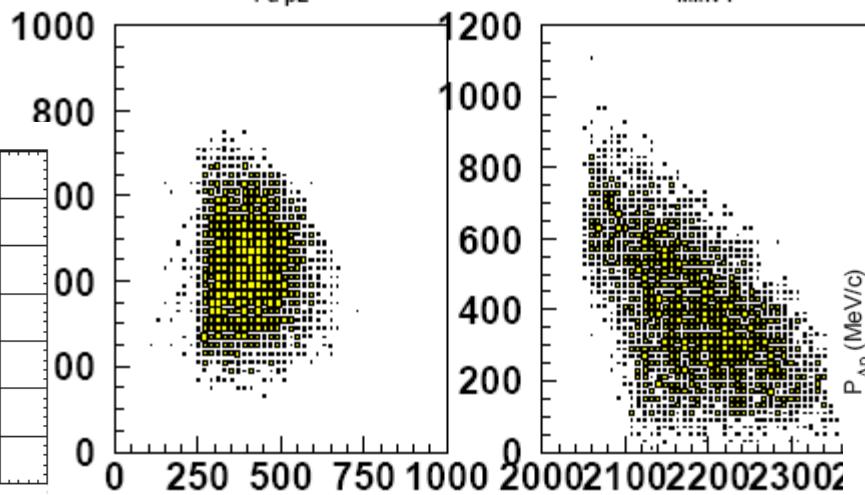


➔ Λd
deuterons

Λp analysis



Λp analysis



Invariant mass **Lambda+proton** BACK TO BACK

FINUDA

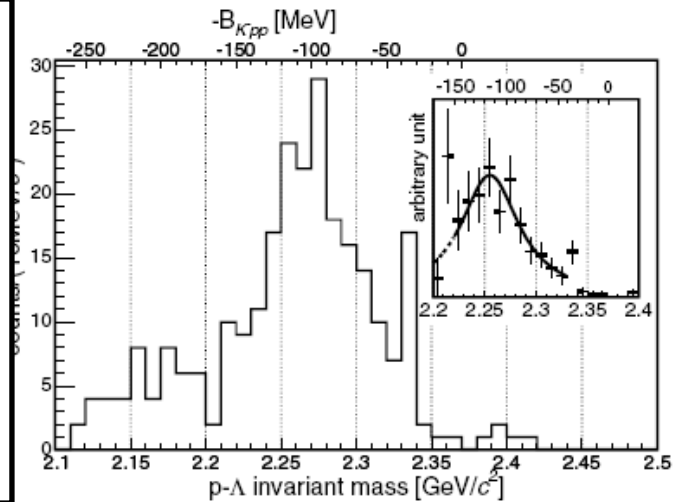
$B = 115 \text{ MeV}$

$\Gamma = 67 \text{ MeV}$

260 Λp

3×10^7 K^- stopped

(190 pb^{-1})



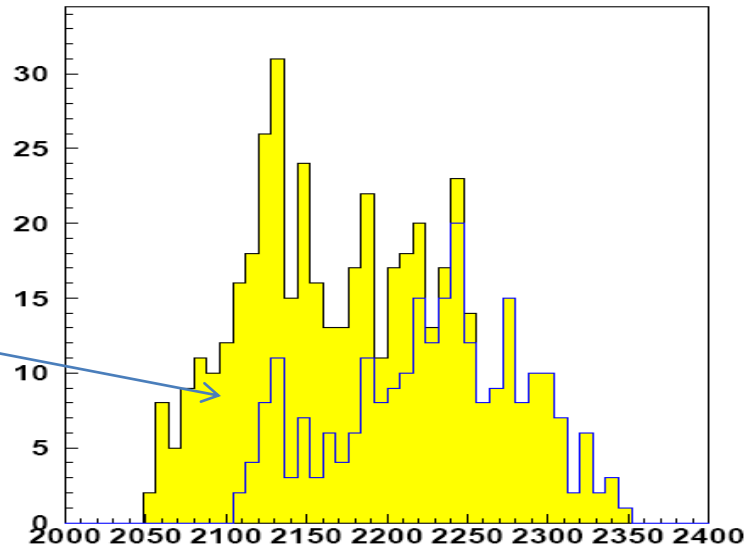
$B \approx 120 \text{ MeV}$

$\Gamma \approx 70 \text{ MeV}$

250 Λp

2×10^6 K^- stopped

(1.1 fb^{-1})



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