Reconstruction of $K_L + p \rightarrow K_s + p + \ldots$

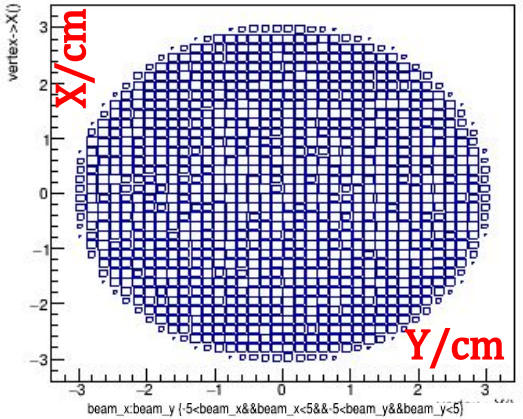
generated with uniform profile of K_L beam momentum

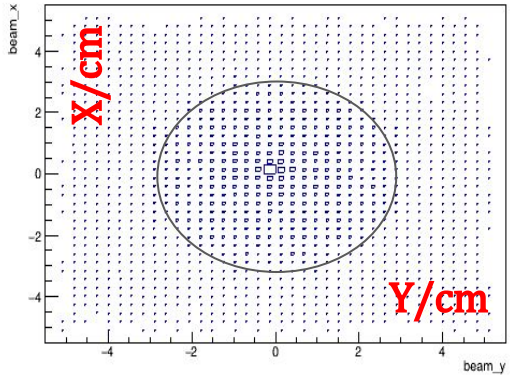
within (0.1 , 10) GeV/c.

04/28/2024

Vertex reconstruction of **uniformly distributed** over in the volume of the LH2 cylinder,

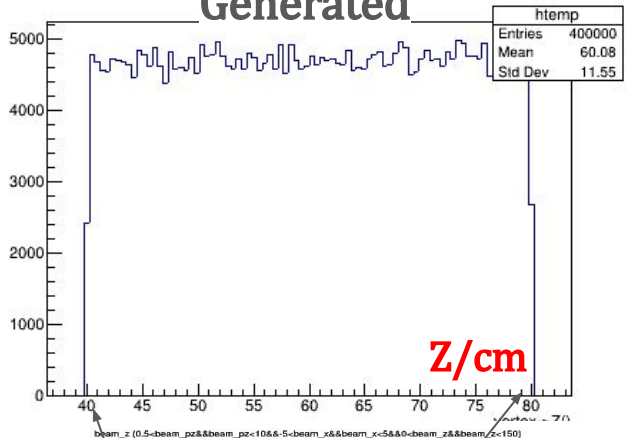
Generated

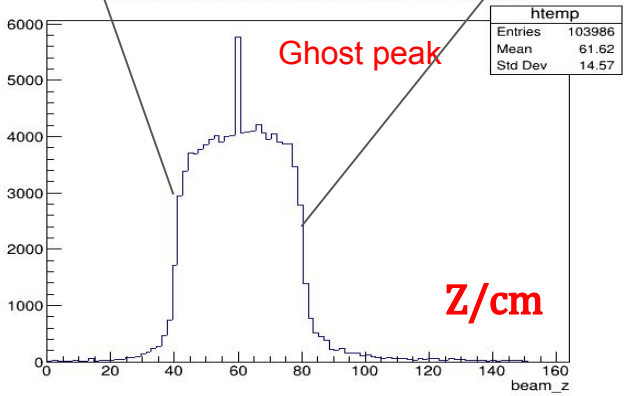




Reconstructed

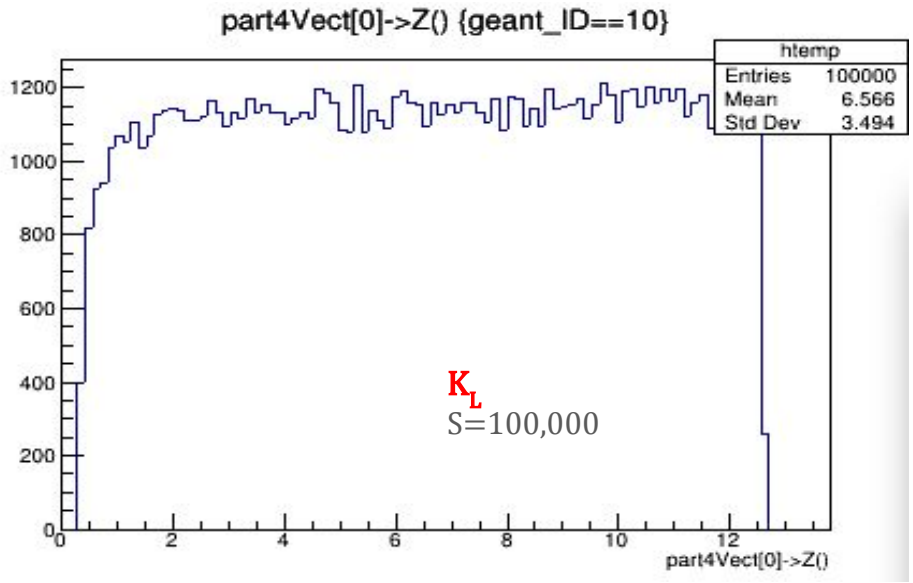
Generated



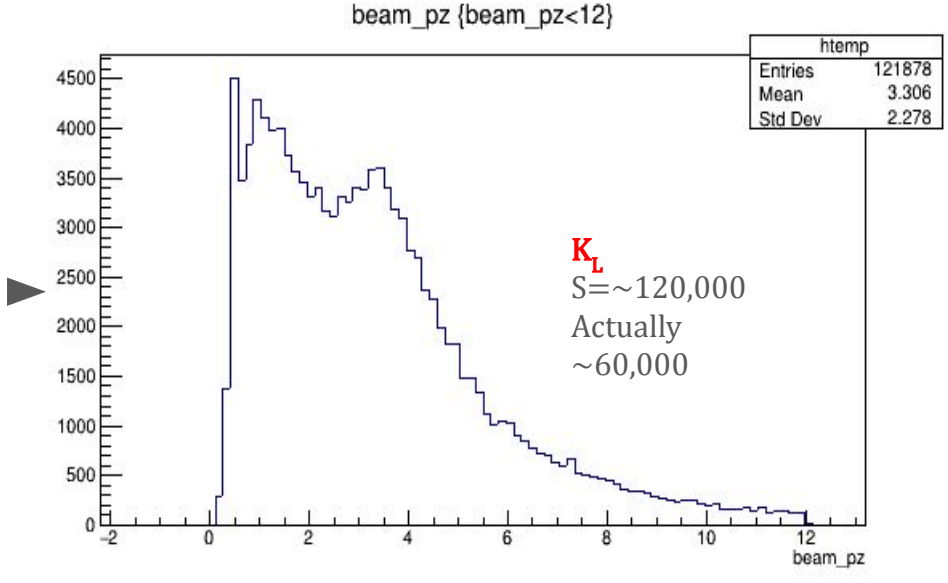


Reconstructed

Reconstruction of beam momentum.



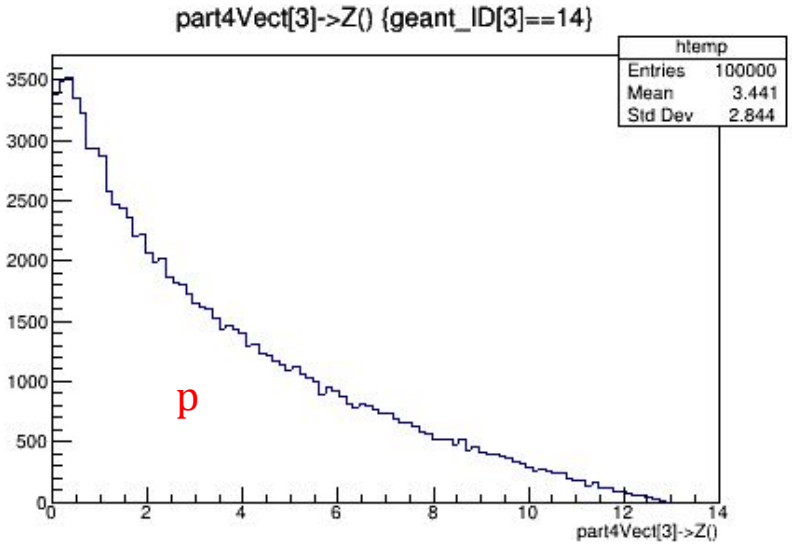
Generated momentum of beam K_L



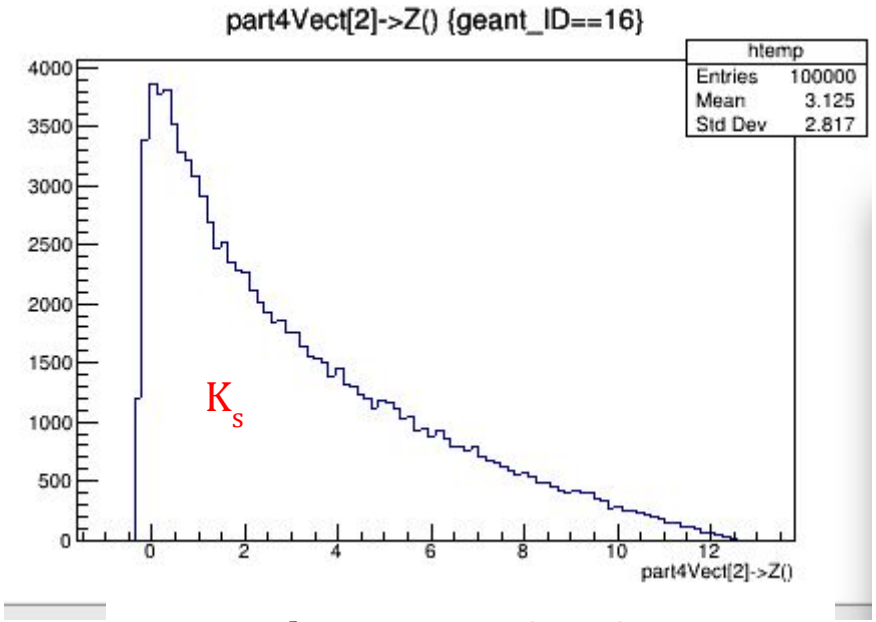
Reconstructed momentum of beam K_L

- Why reconstructed beam momentum histogram is not flat?-
- Perhaps because at least one track is required to fill the Tree.

Reconstruction of simulated $K_L + p \rightarrow K_s(\pi^- \pi^+) + p$ interactions **uniformly distributed** over in the volume of the LH2 cylinder,

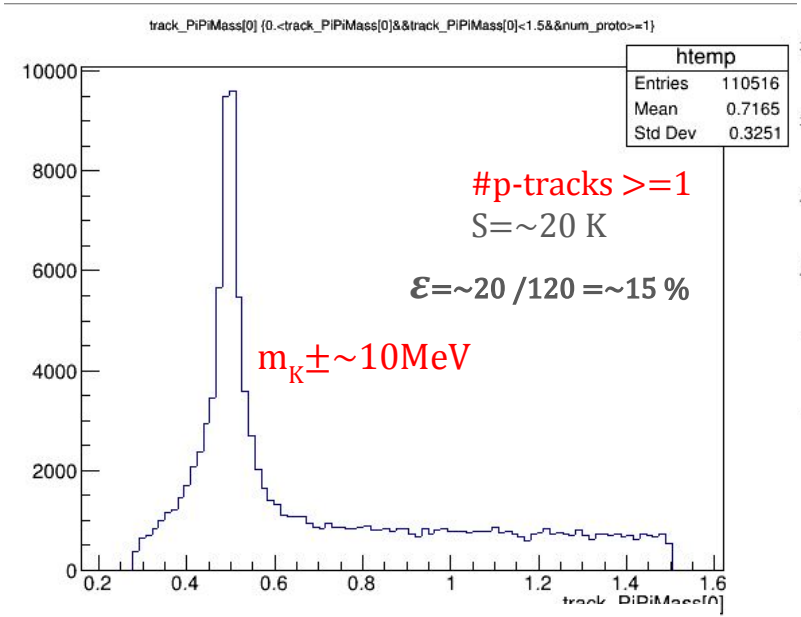


Generated momentum /GeV/c.

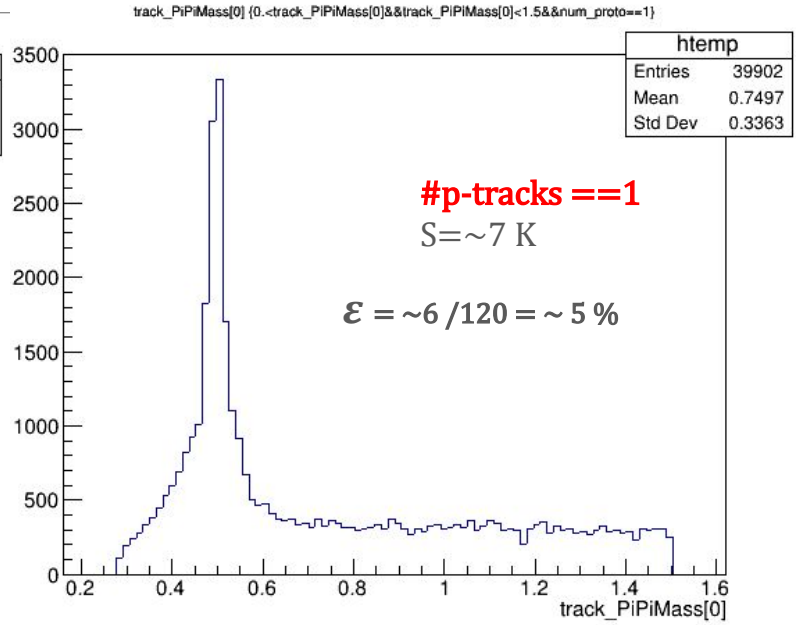


Generated momentum/GeV/c

Reconstruction of $K_L + p \rightarrow K_s (-> \pi^-\pi^+) + p + \ldots$.

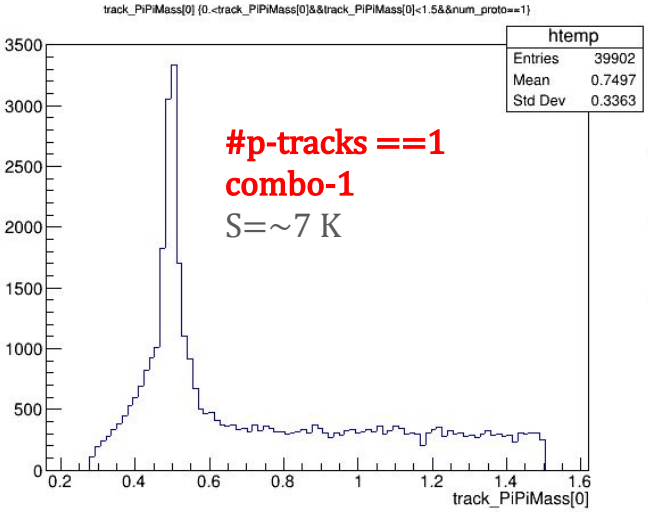


Effective Mass of $\pi^-\pi^+$ in GeV

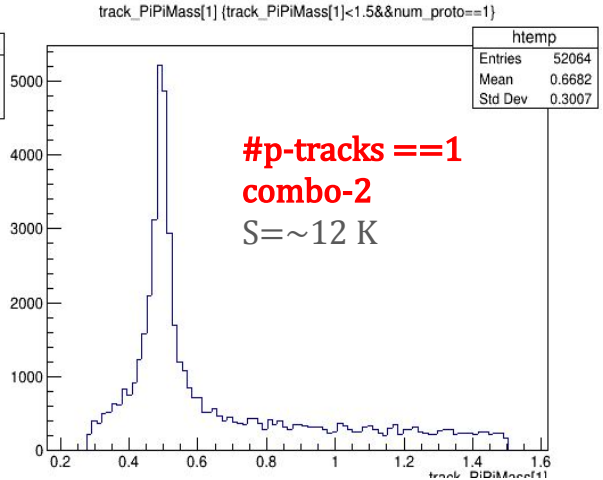


Effective Mass of $\pi^-\pi^+$ in GeV

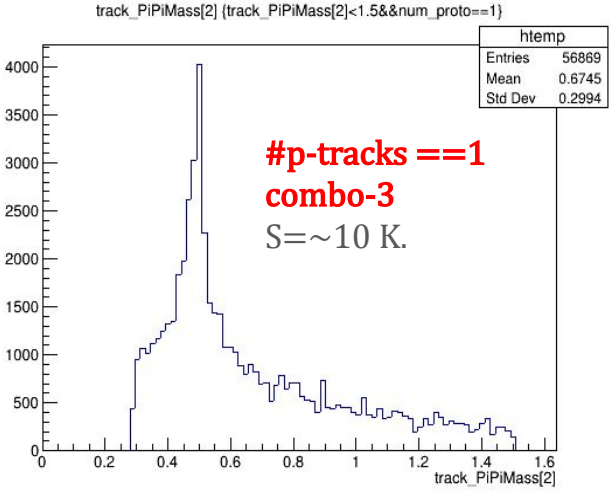
Reconstruction of $K_L + p \rightarrow K_s (-> \pi^- \pi^+) + p$!



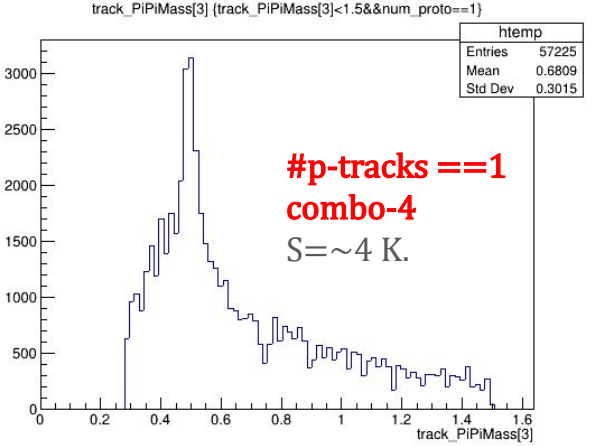
#p-tracks ==1
combo-1
S=~7 K



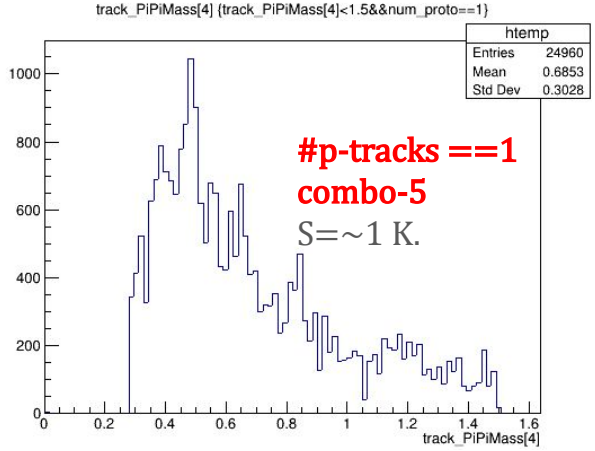
#p-tracks ==1
combo-2
S=~12 K



#p-tracks ==1
combo-3
S=~10 K.



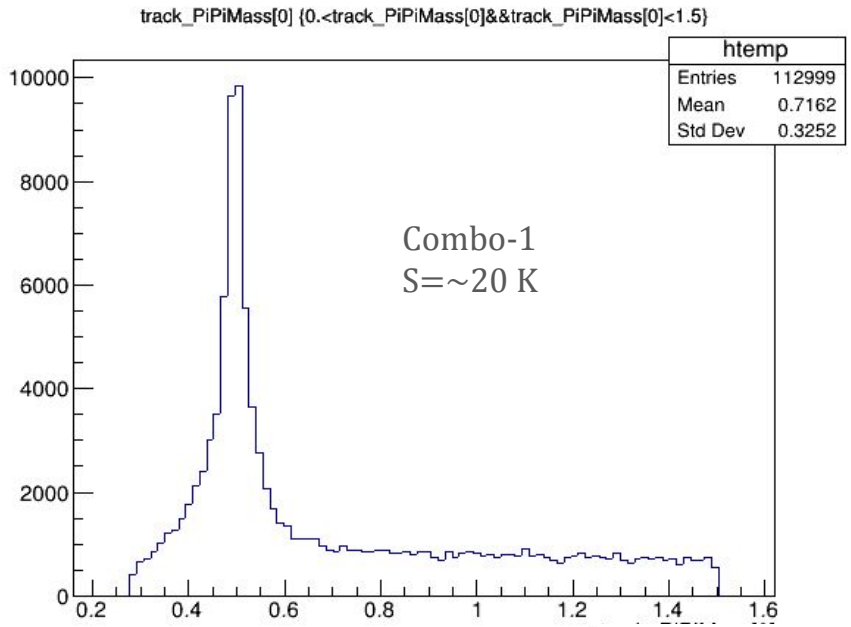
#p-tracks ==1
combo-4
S=~4 K.

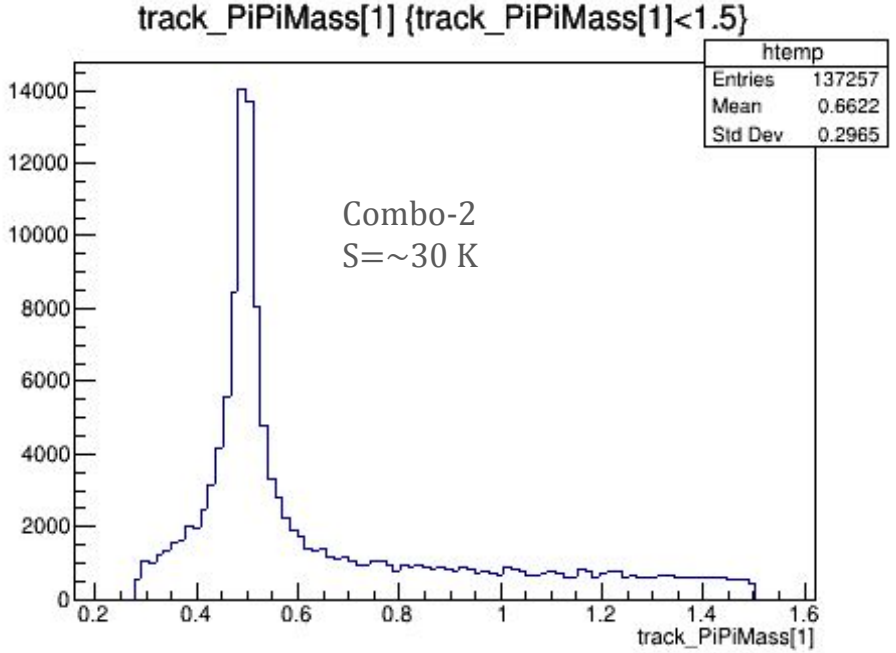


#p-tracks ==1
combo-5
S=~1 K.

$\varepsilon(K_S+p)$ = 35K/120K =~30%

Reconstruction of $K_L + p \rightarrow K_s (-> \pi^- \pi^+) + \ldots$.

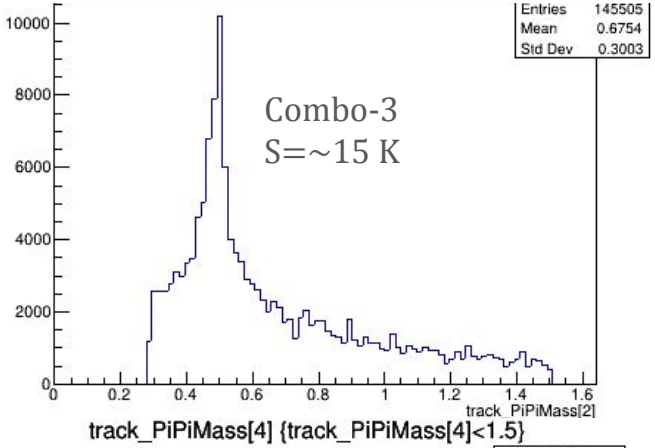


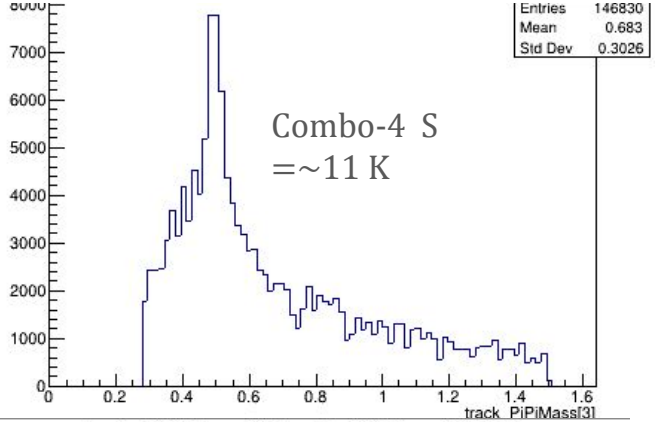


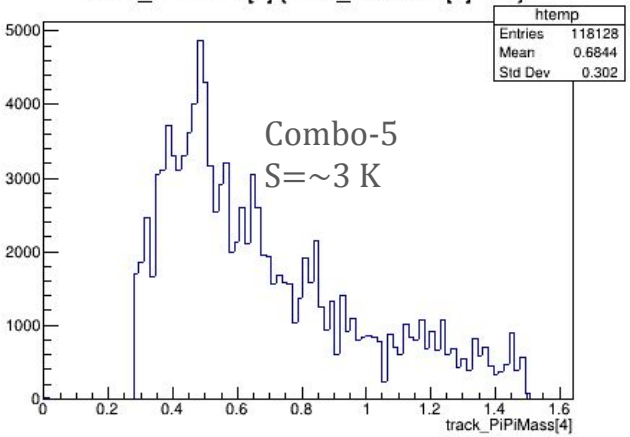
Effective Mass of $\pi^- \pi^+$ in GeV

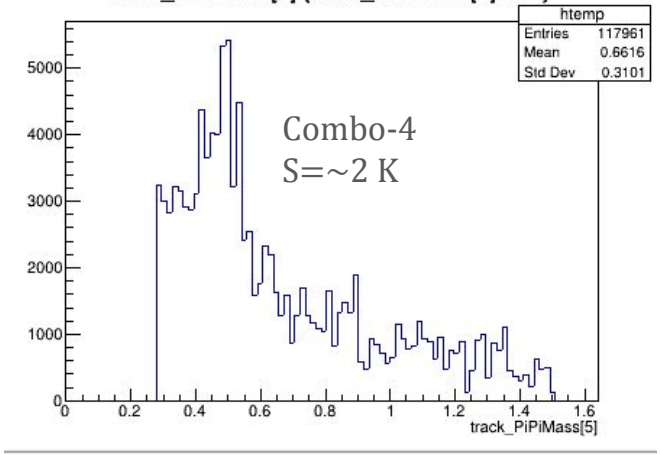
- Reconstruction efficiency is higher due to other combos: ε=~75 K/120K =~60 %.

K_s (–> $\pi-\pi+$) + … reconstruction efficiency due to other combos: ε=~75 K/120K =~60 %.



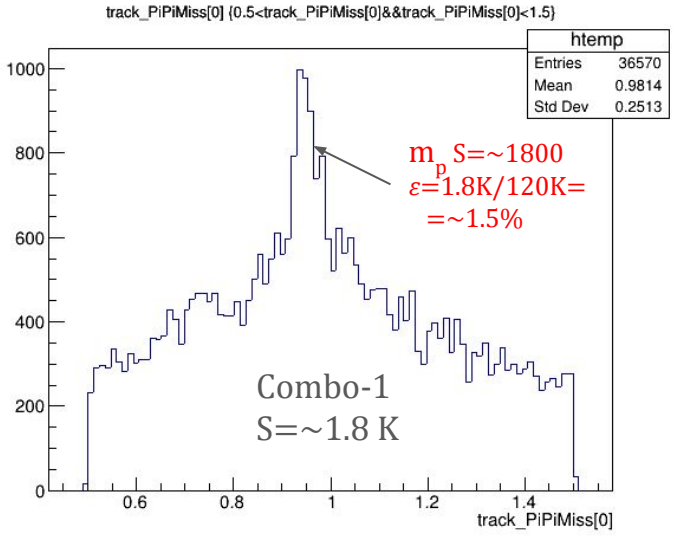




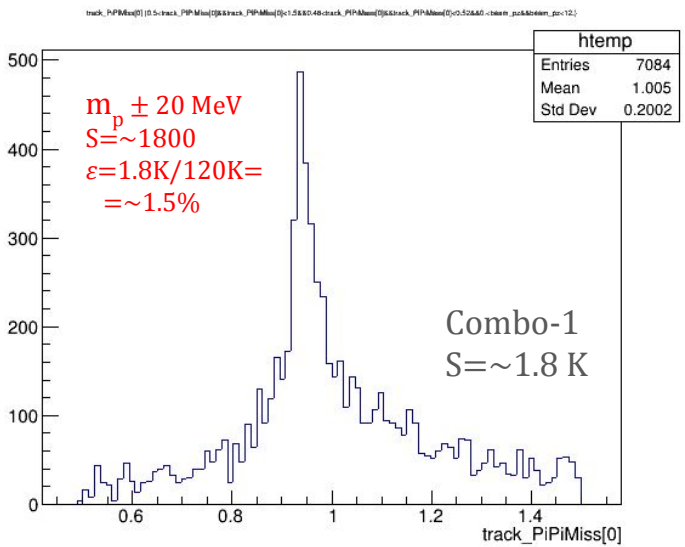


Reconstruction of $K_L + p \rightarrow K_s (-> \pi^-\pi^+) + p$.

Effective Mass of $\pi^-\pi^+ = m_{Ks} \pm 0.05$ GeV



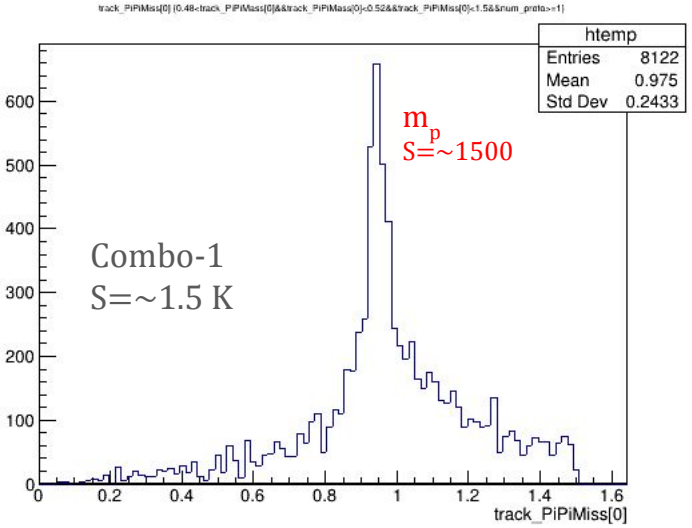
Missing Mass of $\pi^-\pi^+$ in GeV

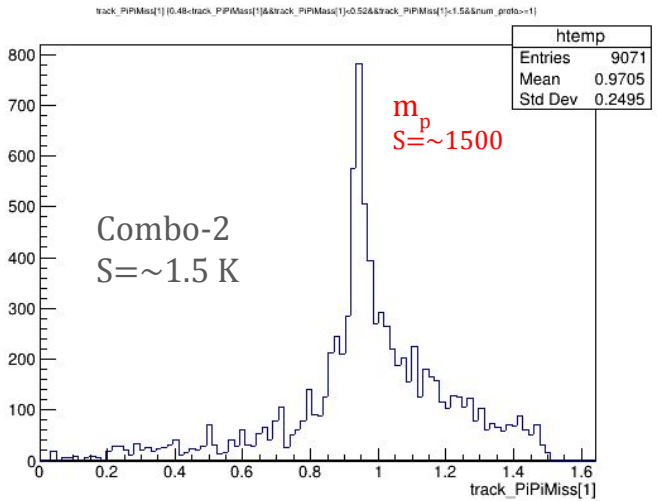


Missing Mass of $\pi^-\pi^+$ in GeV

Selection criterion for K_s+p final state !

$\pi^-\pi^+$ Effective Mass = m_{Ks} ± 0.05 GeV and $\pi^-\pi^+$ Missing Mass = m_p ± 0.05 GeV





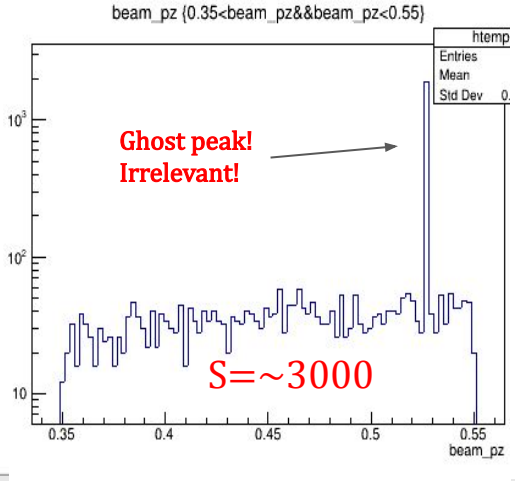
- (K_s+p) reconstruction efficiency **ε=3K/120K=~2.5 %** (K_s& p selected!)

Reconstruction of $K_L + p \rightarrow K_s(->\pi^-\pi^+) + \ldots$

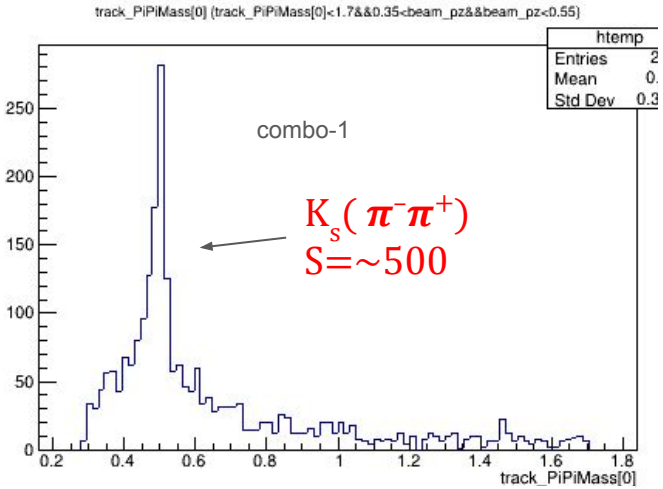
in the **K_L momentum domain of 5q**.

Reconstruction of $K_L + p \rightarrow K_s(->\pi^-\pi^+) + \ldots$ in the K_L momentum domain of 5q.

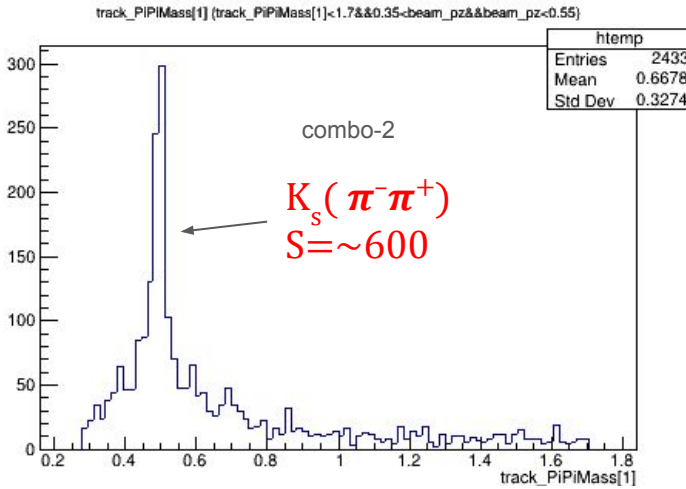
(1) K_L beam momentum = **0.45 ± 0.1 GeV/c**. (2) Effective Mass of $\pi^-\pi^+$ = m_{Ks} **± 0.05 GeV**



Beam momentum in GeV/c



Effective Mass of $\pi^-\pi^+$ in GeV

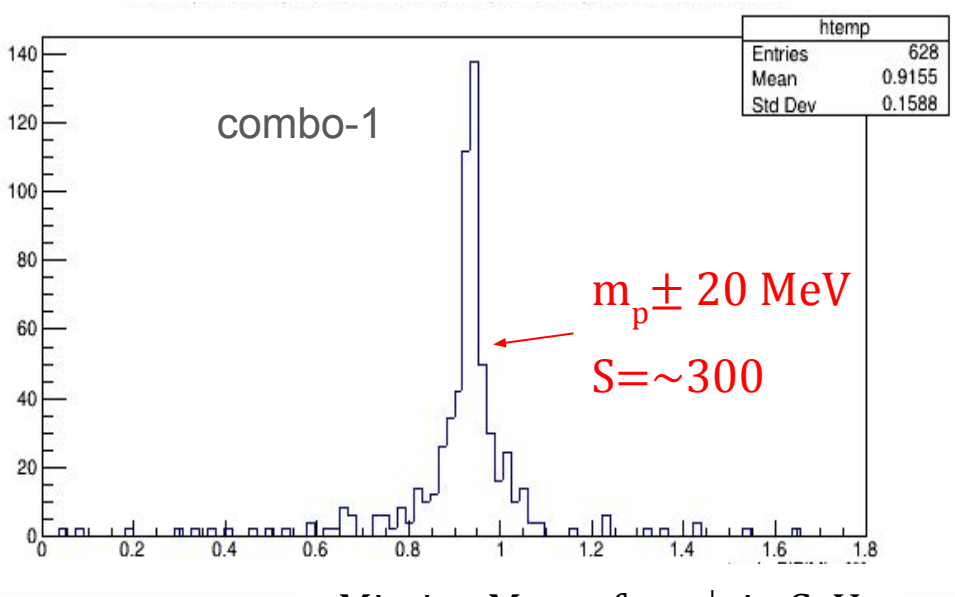


Effective Mass of $\pi^-\pi^+$ in GeV

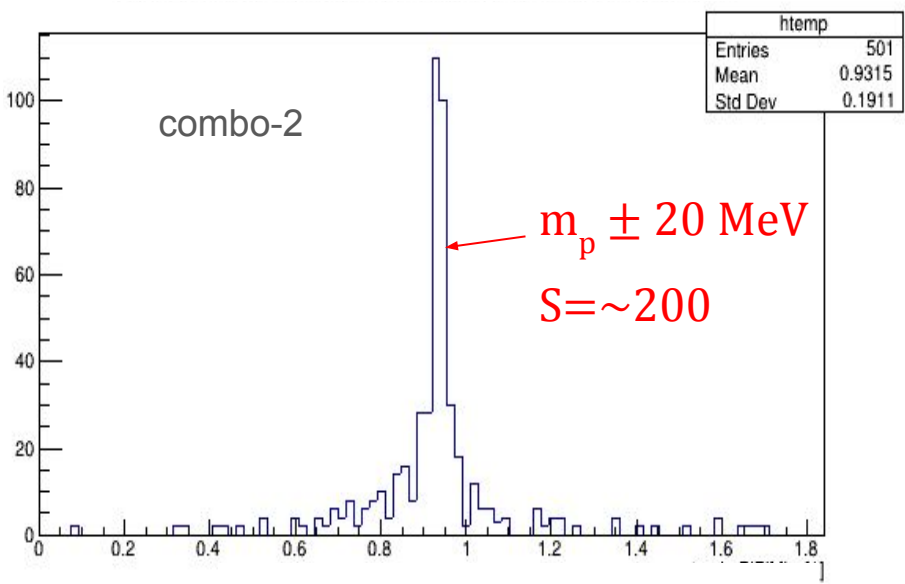
Total # of K_s in all combos is ~1500 out of ~3000. => Reconst. efficiency ε_{Ks} = **~50%.**

Reconstruction of $K_L+p \rightarrow K_s(\pi^-\pi^+)+p$ in the **domain of 5q.**

(1) K_L beam mom. = 0.45 ± 0.1 GeV/c. (2) Eff. Mass of $\pi^-\pi^+ = m_{Ks}$ ± 0.05 GeV (3) # proton tracks>=1
(4) Miss. Mass of $\pi^-\pi^+ = m_p$ ± 0.02 GeV

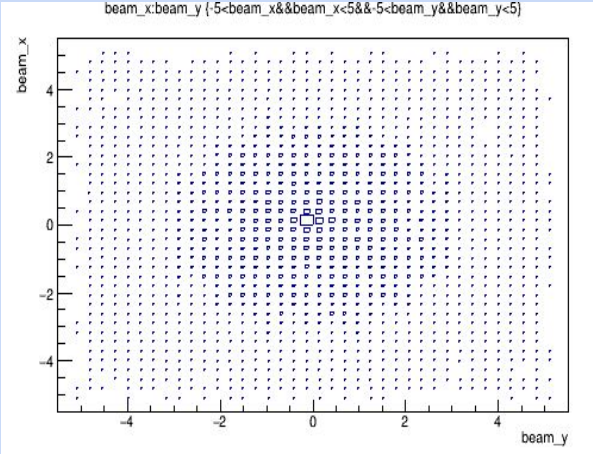


Missing Mass of $\pi^-\pi^+$ in GeV

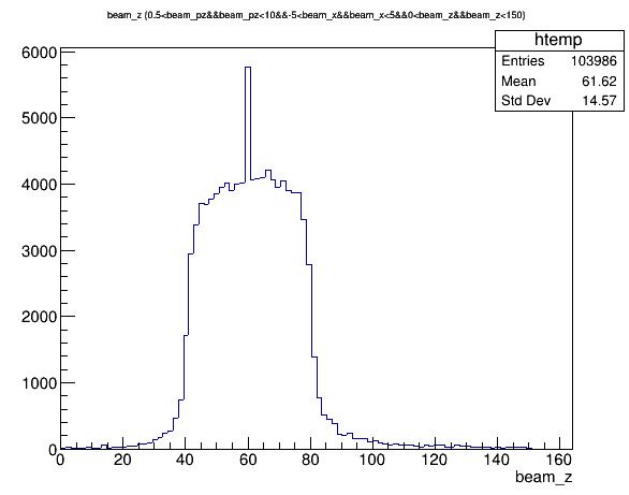


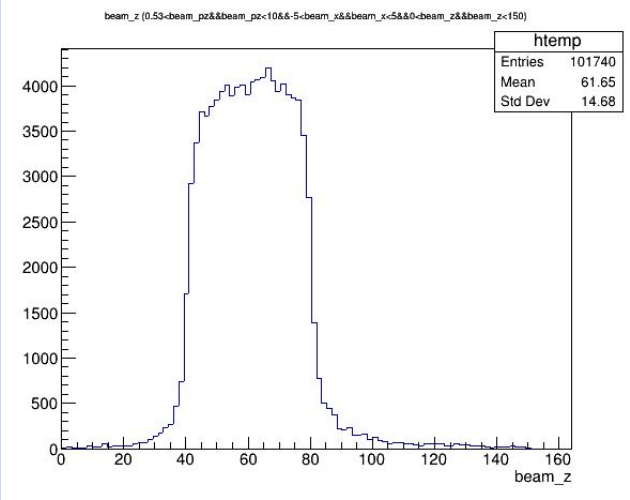
Missing Mass of $\pi^-\pi^+$ in GeV

- Reconstruction efficiency of $K_L+p \rightarrow K_s+p$ ε_{Ks+p}=~20 % (~500/3000)

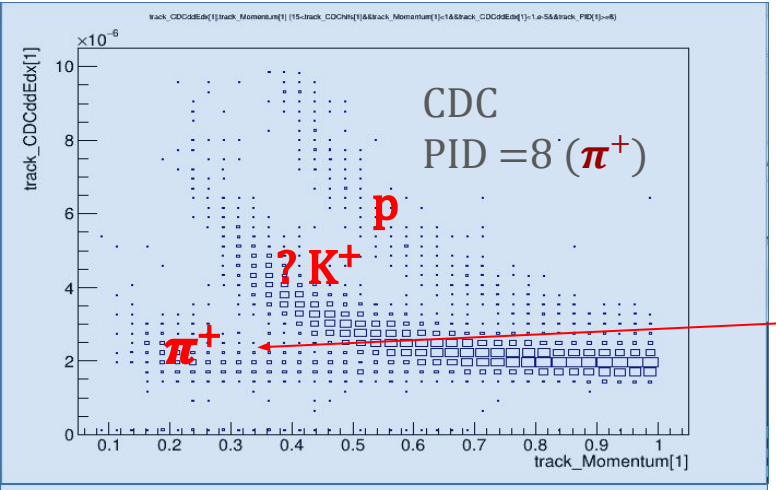

beam_x:beam_y (-5<beam_x&&beam_x<5&&-5<beam_y&&beam_y<5)
beam_x
beam_y
4
2
0
−2
−4
−4
−2
0
2
4

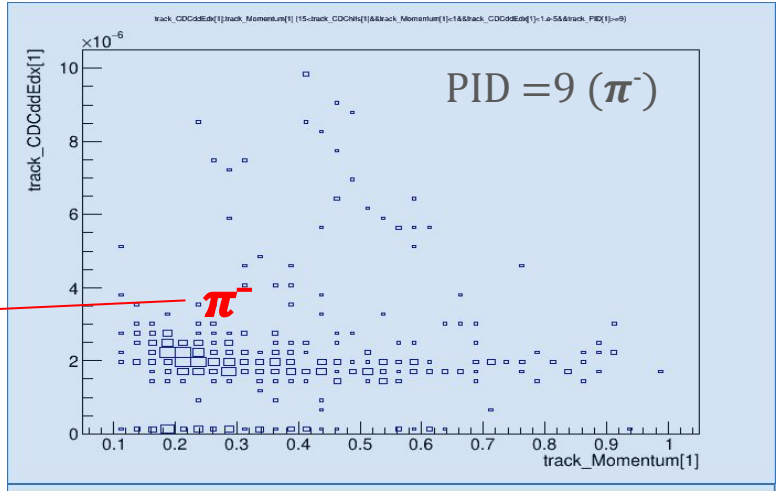
t peak

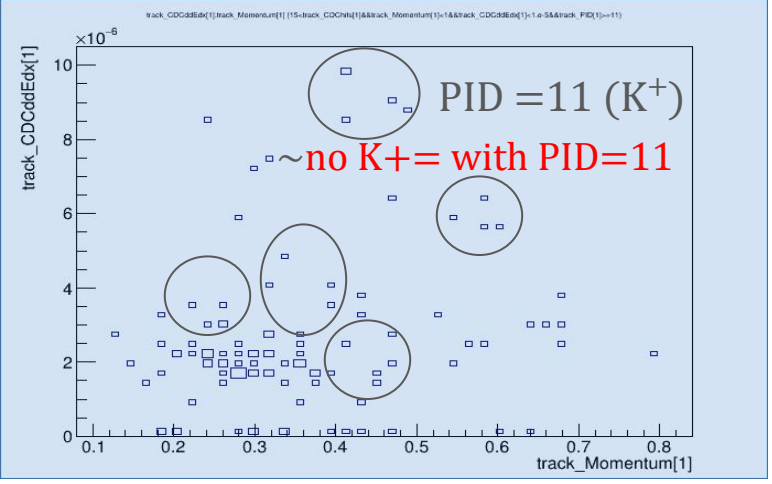

beam_z (0.5<beam_pz&&beam_pz<10&&-5<beam_x&&beam_x<5&&0<beam_z&&beam_z<150)
htemp
Entries 103986
Mean 61.62
Std Dev 14.57
6000
5000
4000
3000
2000
1000
0
0
20
40
60
80
100
120
140
160
beam_z

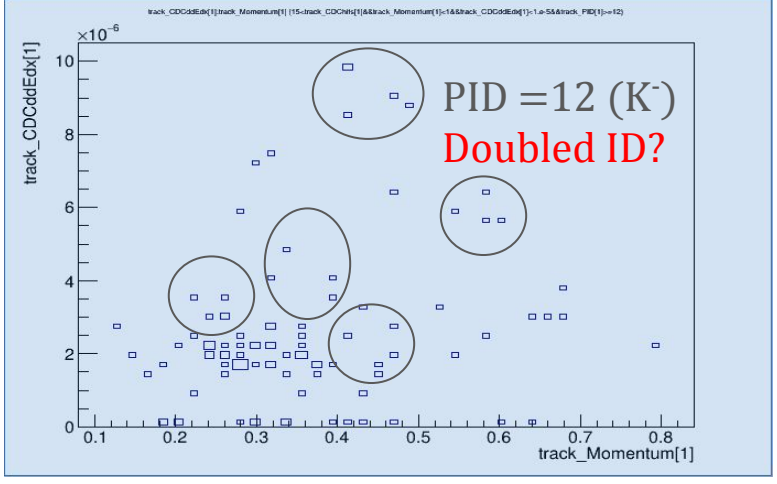

beam_z (0.53<beam_pz&&beam_pz<10&&-5<beam_x&&beam_x<5&&0<beam_z&&beam_z<150)
htemp
Entries 101740
Mean 61.65
Std Dev 14.68
4000
3500
3000
2500
2000
1500
1000
500
0
0
20
40
60
80
100
120
140
160
beam_z

Where K^+ on the dE/dx .vs. momentum map?

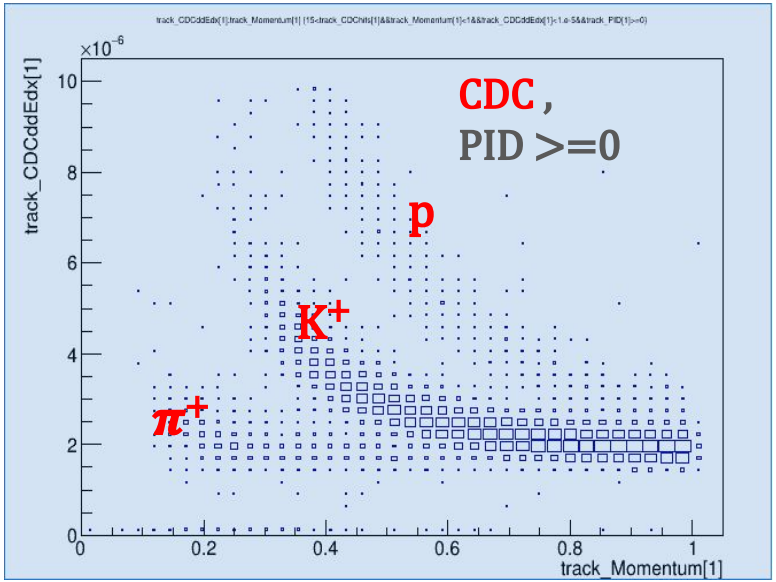


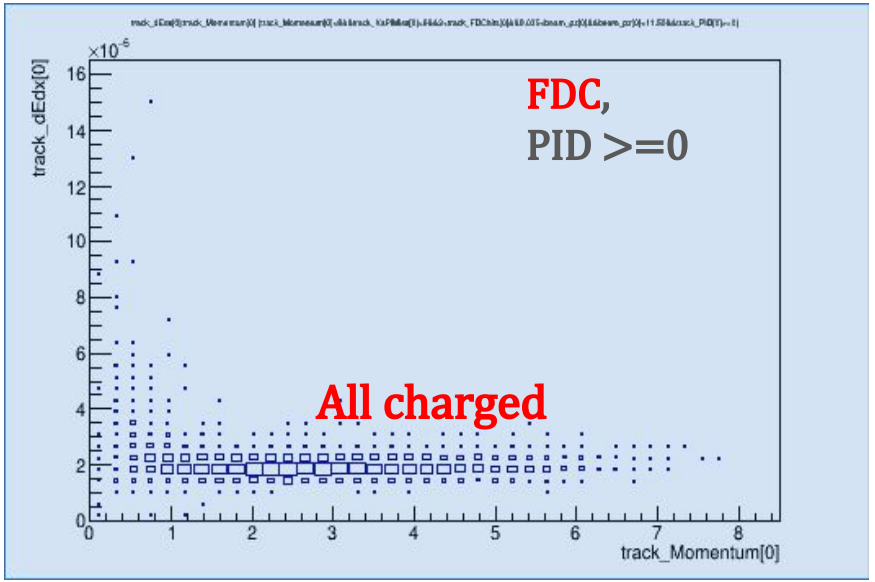






K^+ identification from generated particles using CDC and FDC.

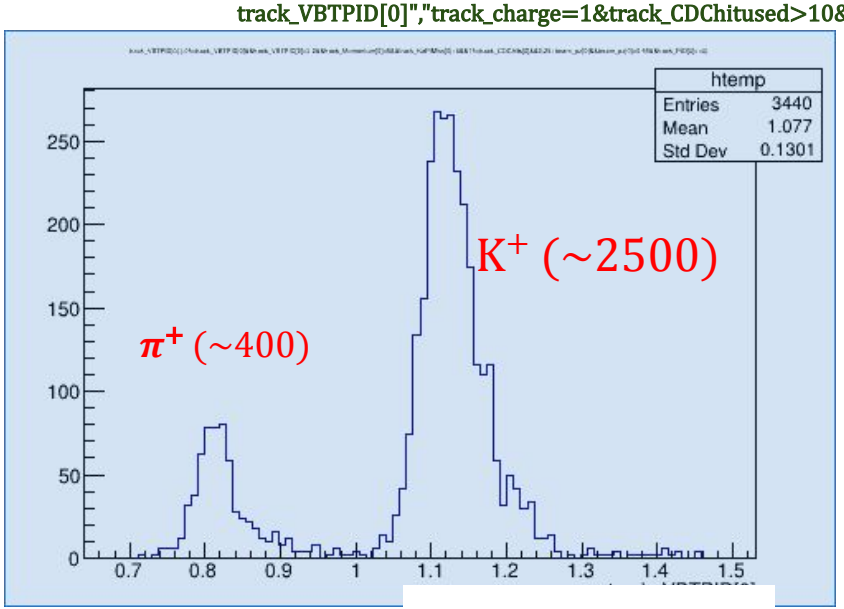




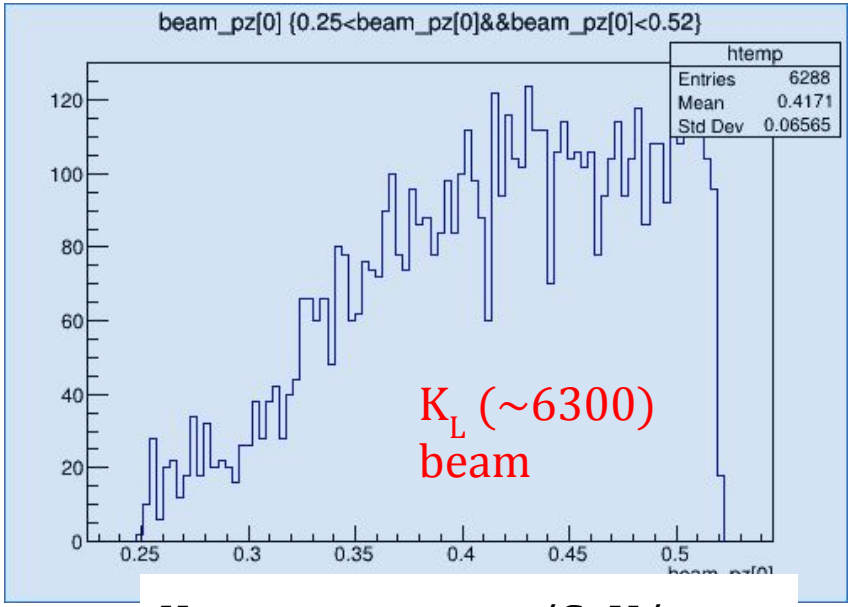
- **Good K^+ separation** in **CDC** at 0.25<p/GeV/c<0.55. Allows **K^+-yield vs. momentum** measurement!
- **K^+-yield** vs. momentum using **FDC** is possible only at **low background** of pions.

Reconstruction of $K_L + p \rightarrow K^+ + \ldots$ in 5q domain of K_L momenta.

K^+ identification via $f(dEdx, p) = \text{const.} \times (dE/dx)^{0.25} \times p^{0.25}$



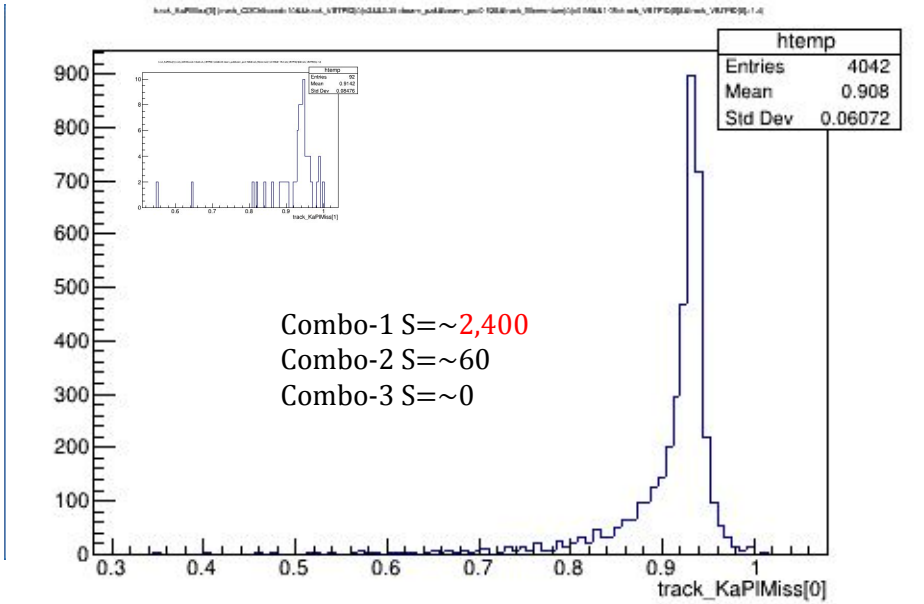
f (dE/dx, p)



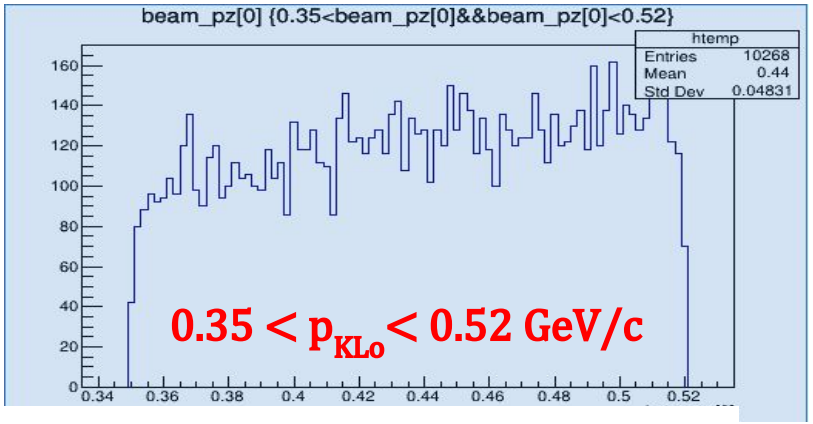
$K_{L\ beam}$ momentum/GeV/c

- **K^+ reconstruction efficiency** in 5q domain **ε = ~40%** (2500 K^+/6300 K_L)

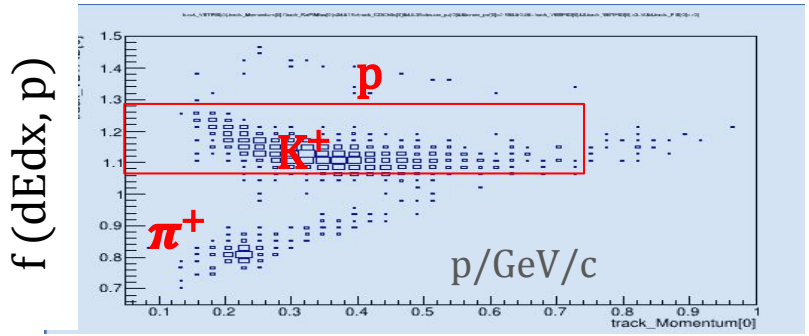
Reconstruction of $K_L + p \rightarrow K^+ + n$ in 5q region of beam momentum.



K^+ missing mass/GeV



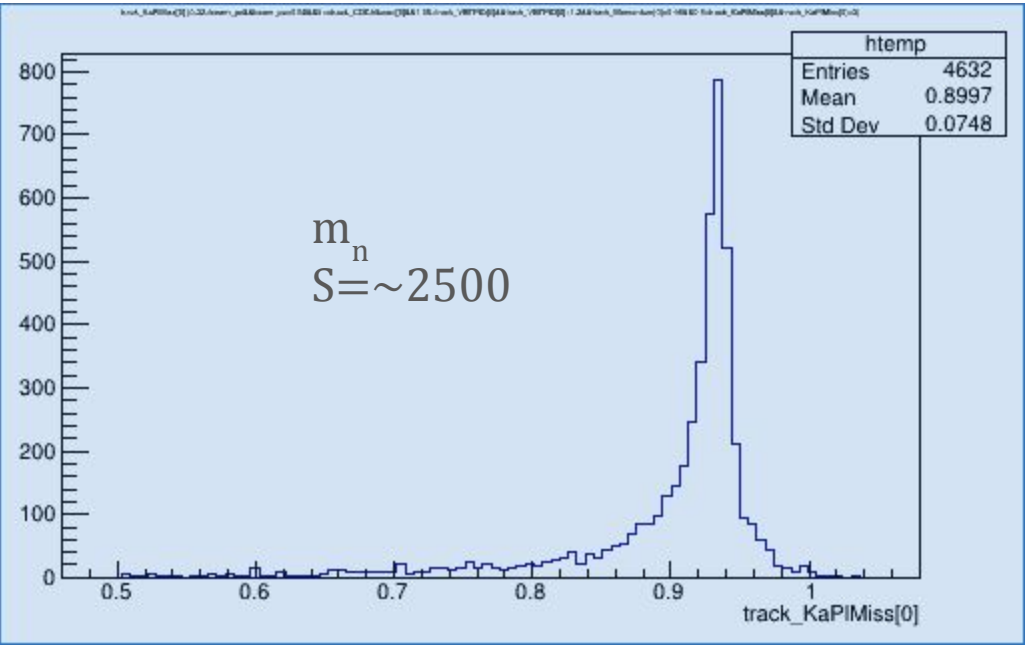
Beam momentum in GeV/c

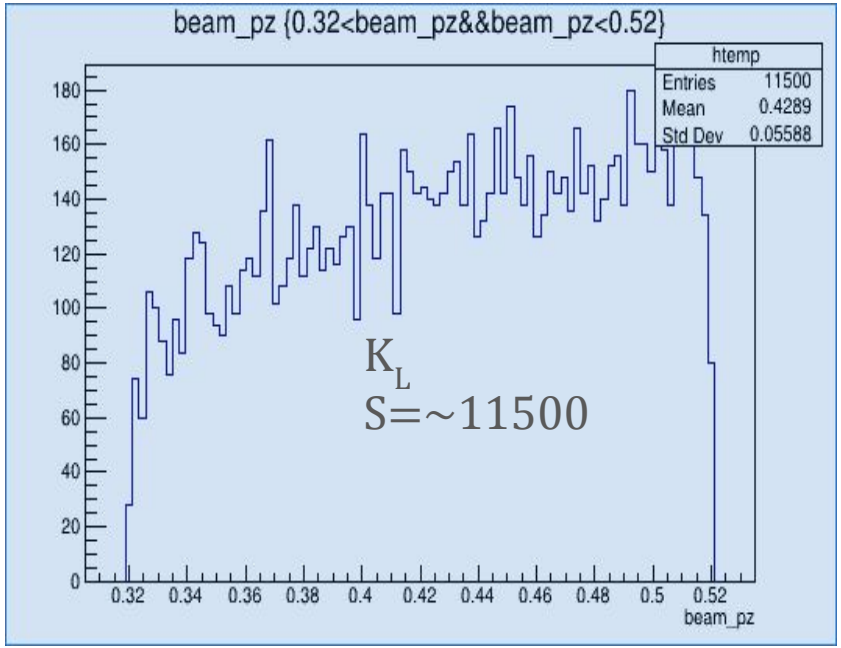


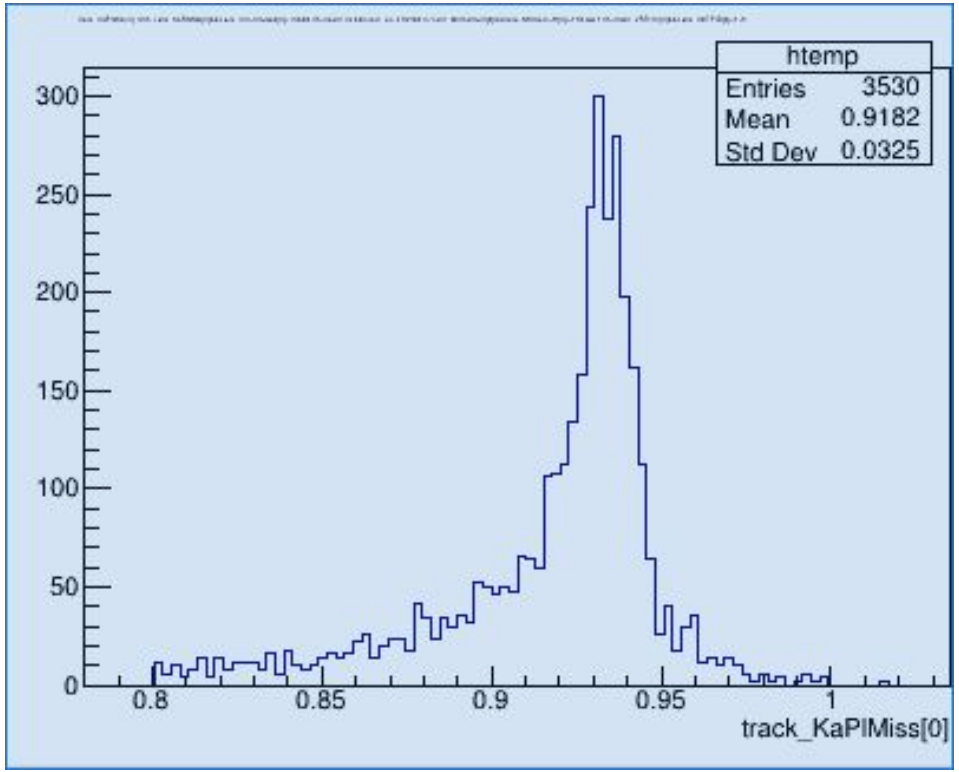
- track_CDChitused[0]>10&**0.35<beam_pz<0.52**&track_Momentum[0]<0.55&1.05<track_VBTPID[0]<1.4
- Reconstruction efficiency of neutron, ε_n=~25 % (~2,400/10,268)

Reconstruction of $K_L + p \rightarrow K^+ + n$ in 5q region of beam momentum.

0.32<beam_pz<0.52 & 5<=track_CDChitused[0] & 1.05<track_VBTPID[0]<1.2 & track_Momentum[0]<0.95 & 0.5<track_KaPlMiss[0]<3.



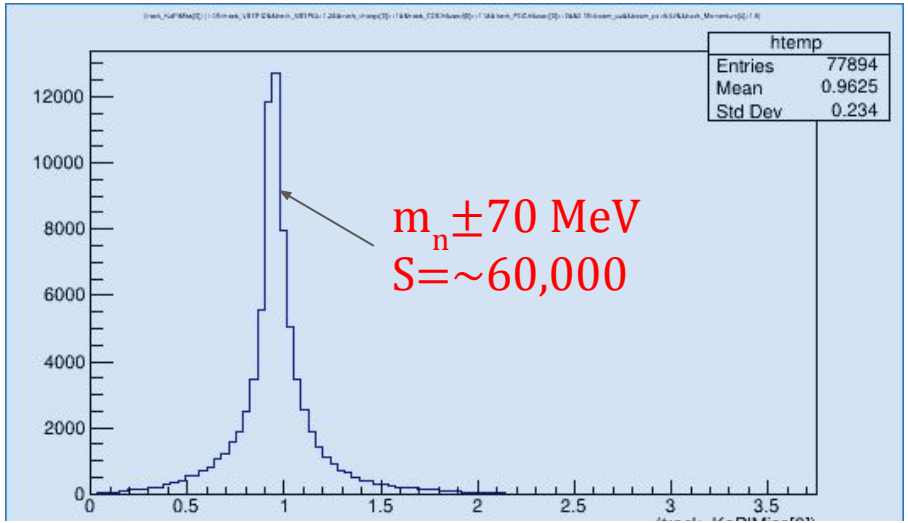




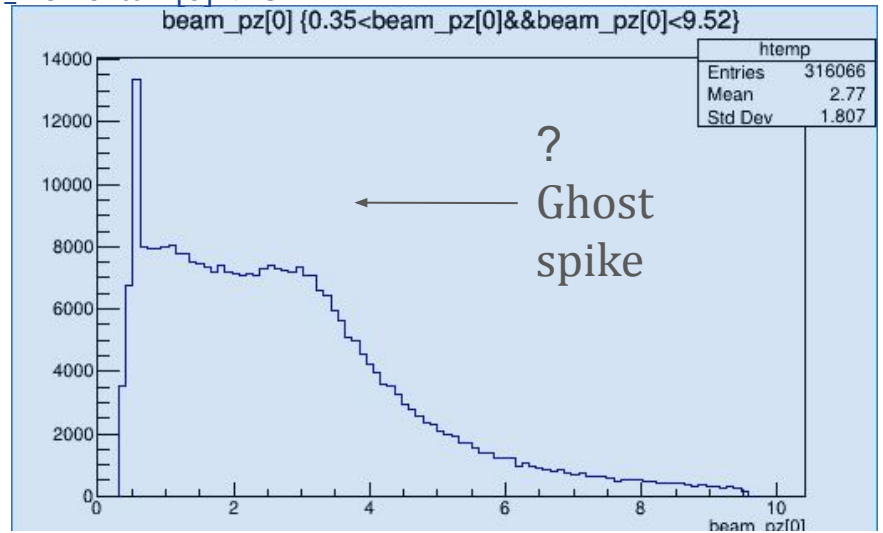
0.8<track_KaPlMiss[0]&track_CDChitused[0]>10&&**0.35<beam_pz&&beam_pz<0.52** &&
0<track_Momentum[0]&&track_**Momentum[0]<2.55** && **1.05<track_VBTPID[0]&&track_VBTPID[0]<1.2**

Reconstruction of $K_L + p \rightarrow K^+ + n$ in wide beam momentum range !

1.05<track_VBTPID&&track_VBTPID<1.2 & track_charge[0]=1 & track_CDChitused[0]>=11 & track_FDChitused[0]>=0 &
0.35<beam_pz<9.52 & track_Momentum[0]<4.5



K^+ missing Mass/GeV



Beam Momentum/GeV/c

- $(K^+ + n)$ reconstruction efficiency with CDC&FDC, ε_n=~20 % (60,000/300,000)!
- Why the beam histogram is not flat?

Conclusion

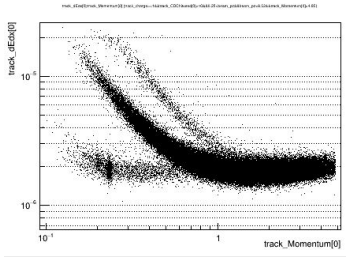
(1) Reconstruction efficiency in **momentum domain of 5q (0.35,0.55)** GeV/c:

K^+ + ... ~40 %.

K^+ +n ~30 % with a peak at neutron mass

K_s + ... ~50 %

K_s +p ~20 % with a peak at proton mass



(2) Reconstruction efficiency in the **momentum region (0,10)** GeV/c:

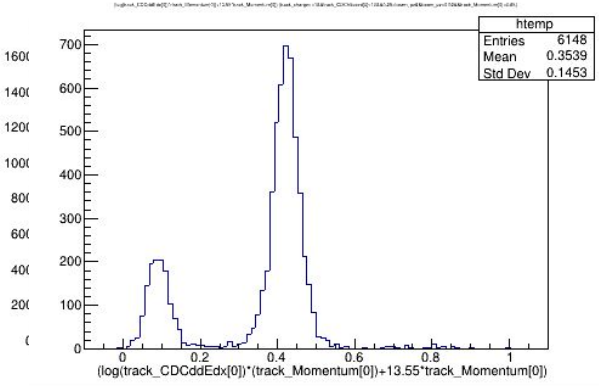
K^+ + ... ??? No separation beyond ~0.6 GeV/c

K^+ + n ~25 % with peak at neutron mass

K_s + ... ~60 %

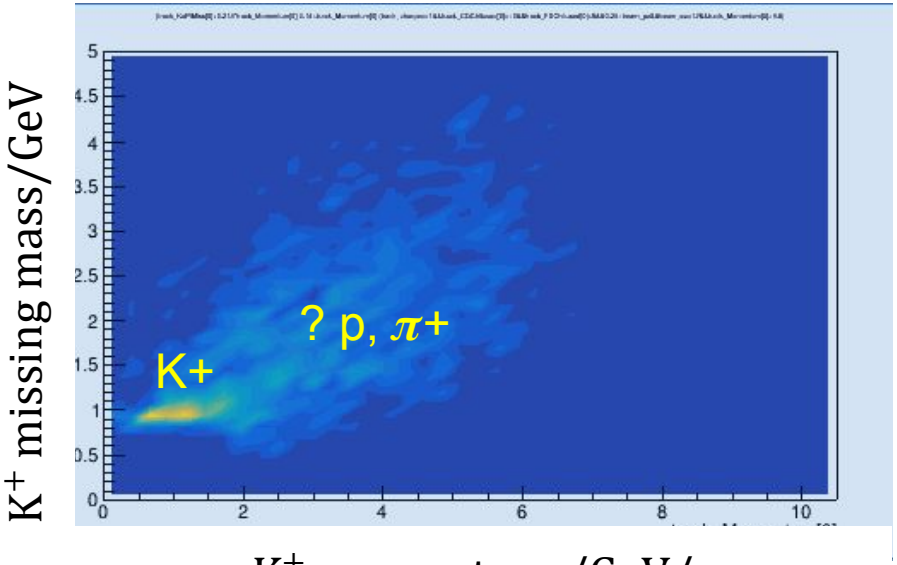
K_s +p+ ... ~30 % # of proton track identified ==1

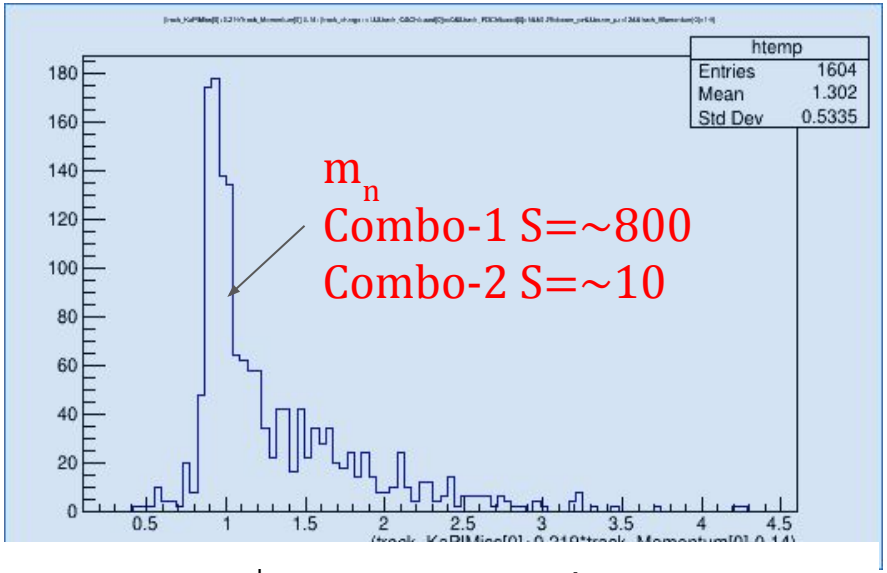
K_s +p ~2.5 % with peak at proton mass



Reconstruction of $K_L + p \rightarrow K^+ + n$ using only FDC data.

"track_charge=1&track_CDChitused[0]=0&track_FDChitused[0]>5&**0.25<beam_pz<12**&track_Momentum[0]<9.8"



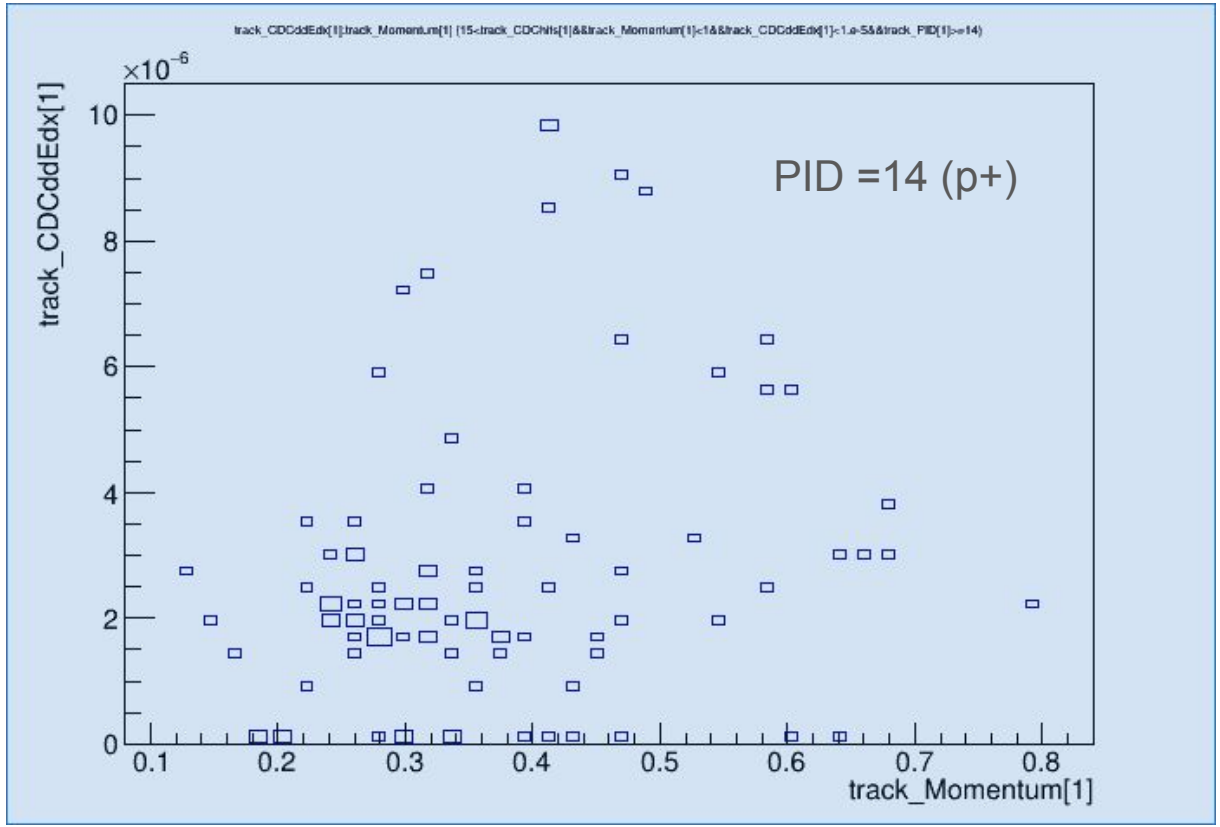


- Reconstruction efficiency of K^++p final state using FDC is of 0.5 %

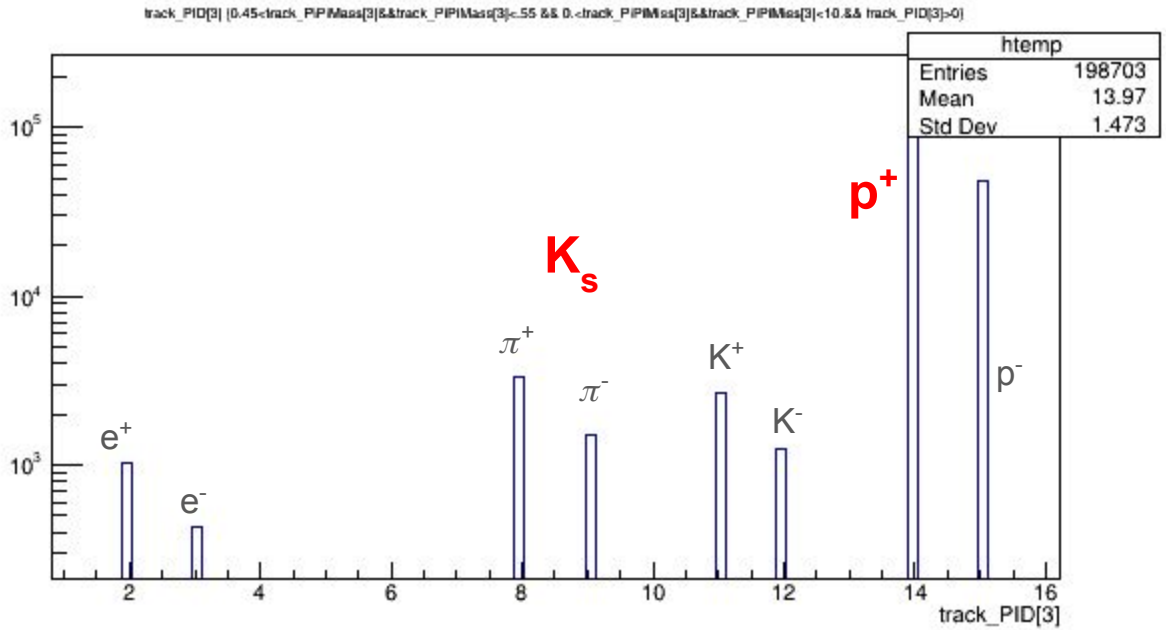
ROOT analysis of generated/reconstructed reactions

$$K_L + p \rightarrow K_s(\boldsymbol{\pi}^- \boldsymbol{\pi}^+) + p$$

04/04/2024

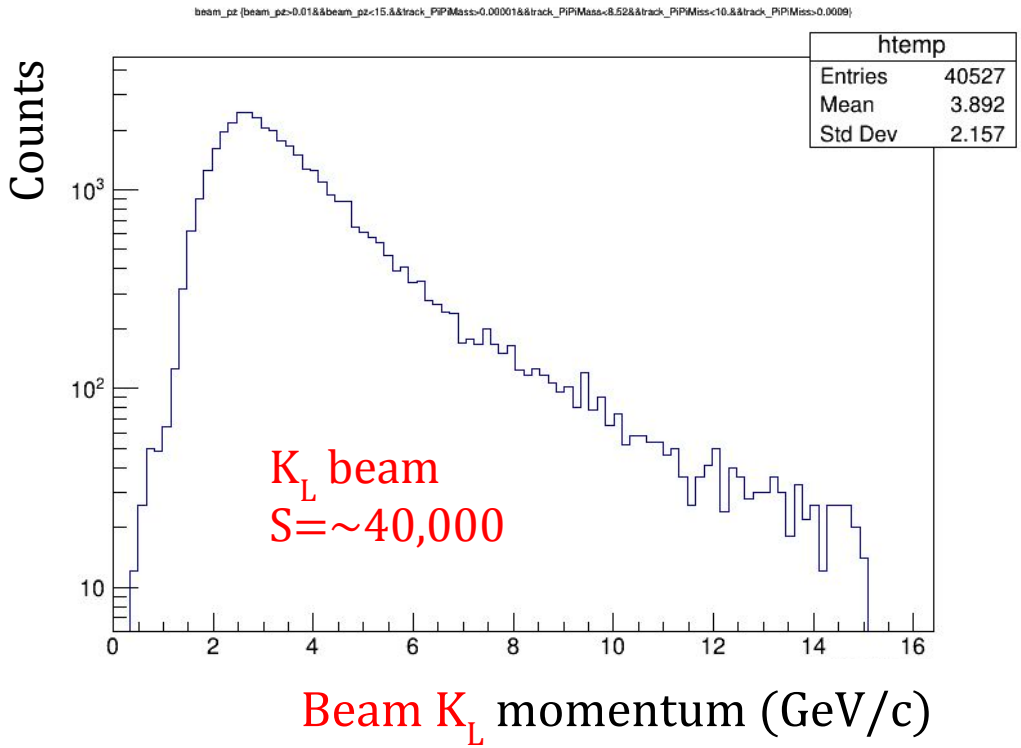

track_CDCddEdx[1]:track_Momentum[1] (15<track_CDCNHs[1]&&track_Momentum[1]<1&&track_CDCddEdx[1]<1.e-5&&track_PID[1]==14)
×10⁻⁶
track_CDCddEdx[1]
10
8
6
4
2
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
track_Momentum[1]
PID =14 (p+)

ROOT analysis of generated/reconstructed reactions $K_L + p \rightarrow K_s(\pi^- \pi^+) + p$



- Statistics of reconstructed tracks in the final state (track_PID).

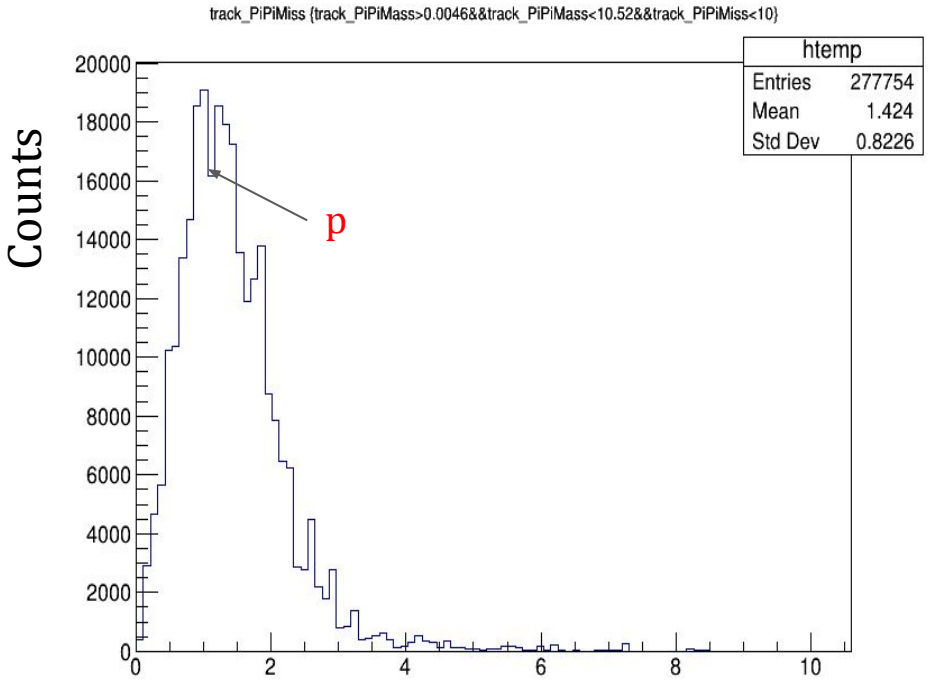
ROOT analysis of 50000 generated/reconstructed reactions $K_L + p \rightarrow K_s(\pi^- \pi^+) + p$

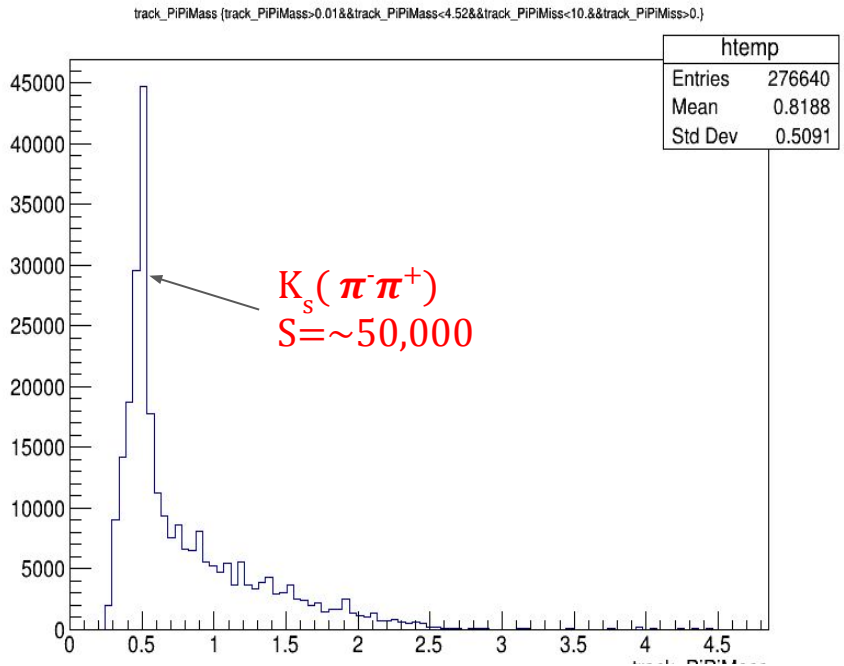


- Looks like in the Proposal.
- Low statistics of beam particles in the region of special interest- around 450 MeV/c.
- Can the beam range be changed via a E-option ?

KLGenerator_hddm_V3 -Ekaon:histo:1.0:4.0

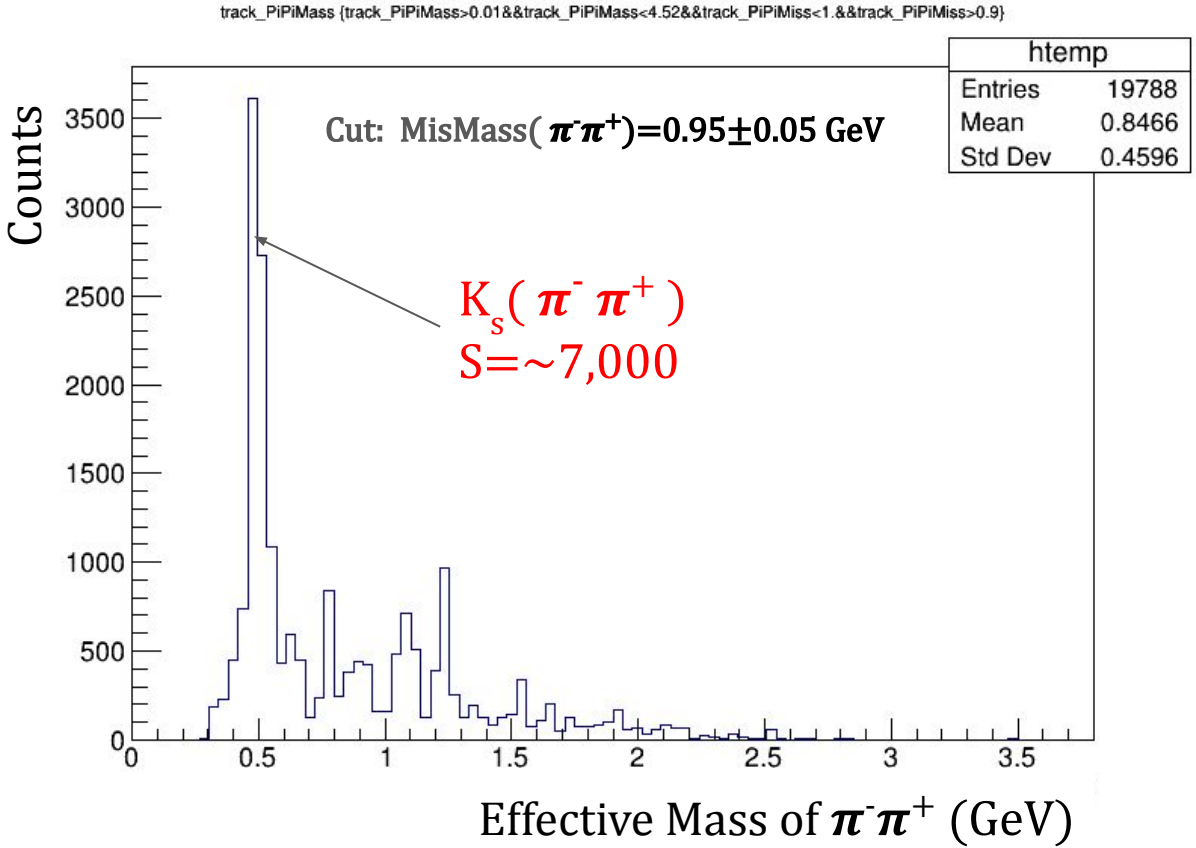
ROOT analysis of 50000 generated/reconstructed reactions $K_L + p \rightarrow K_s(\pi^- \pi^+) + p$





- A distinct peak of K_s is seen in the effective mass spectrum of $\pi^- \pi^+$ tracks.
- Reconstruction yield ~ 1.2 K_s per beam K_{Long} ! Need to test the yield around 450 MeV/c!

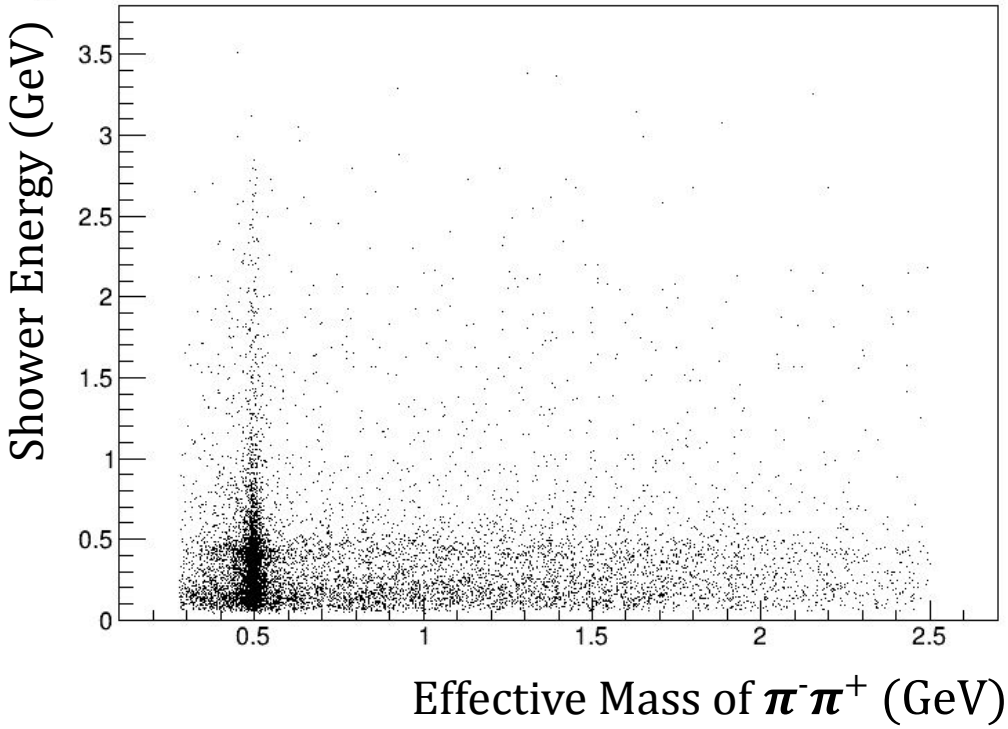
ROOT analysis of 50000 generated/reconstructed reactions $K_L+p\rightarrow K_s(\pi^-\pi^+)+p$



- Seems the K_s-peak looks more pronounced with Miss. Mass cut?

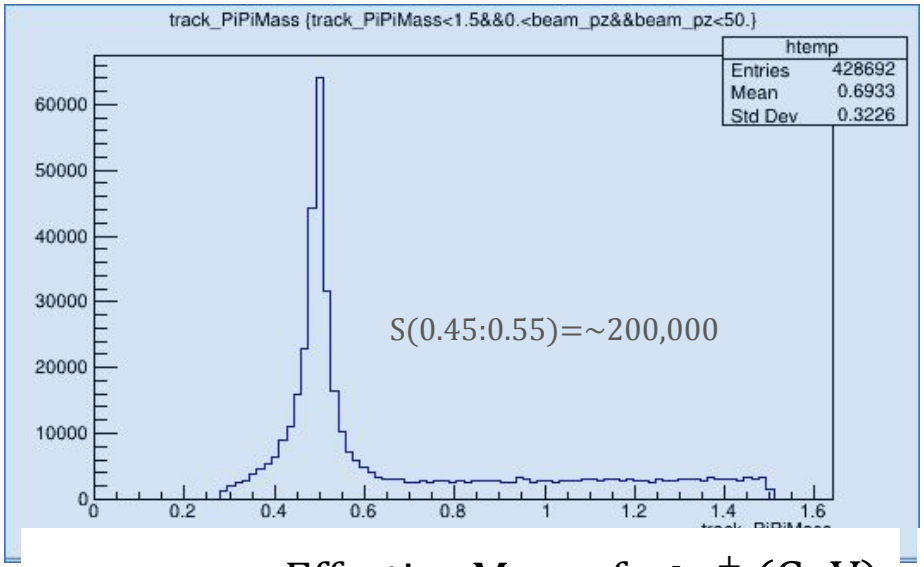
X: ~track_pz	hit_y	sh_x	thrown_pz
Y: ~sh_E	hit_E	sh_y	num_tracks
Z: -empty-	hit_t	sh_z	track_PiPiMass
~CUT	num_clusters	sh_E	track_PiPiMiss
Scan box	cl_x	sh_nhits	track_PID
E( ) -empty-	cl_y	sh_time	track_charge
E( ) -empty-	cl_z	sh_docatrack	track_px
E( ) -empty-	cl_E	sh_timetrack	track_py
E( ) -empty-	cl_Emax	sh_sumu	track_pz
E( ) -empty-	cl_channelEmax	sh_sumv	track_fcalmatch
E( ) -empty-	cl_nhits	sh_e1e9	track_matchshen
E( ) -empty-	cl_time	sh_e9e25	track_matchx
E( ) -empty-	cl_timemaxe	num_beam	track_matchy
E( ) -empty-	cl_timeewight	beam_px	track_matchz
E( ) -empty-	cl_getrms	beam_py	track_matchshx
runnumber	cl_getrms_t	beam_pz	track_matchshy
eventnumber	cl_getrms_x	num_thrown	track_matchshz
num_hits	cl_getrms_y	thrown_VBT	track_matchbackx
hit_row	cl_getrms_u	thrown_charge	track_matchbacky
hit_column	cl_getrms_v	thrown_px	track_matchbackz
hit_x	num_showers	thrown_py	track_matchdoca

ROOT analysis of 50000 generated/reconstructed reactions $K_L + p \rightarrow K_s(\pi^- \pi^+) + p$

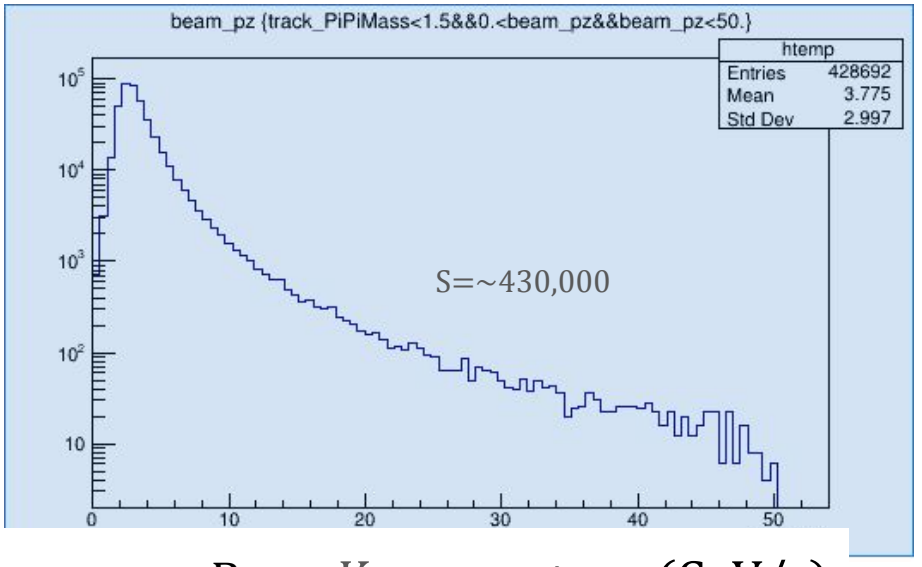


- No correlations of of $\pi^- \pi^+$ effective mass with other tree variable were observed, except of , perhaps, with the "shower/cluster energy" ?

ROOT analysis of 400,000 generated/reconstructed reactions $K_L + p \rightarrow K_s(\pi^- \pi^+) + p$



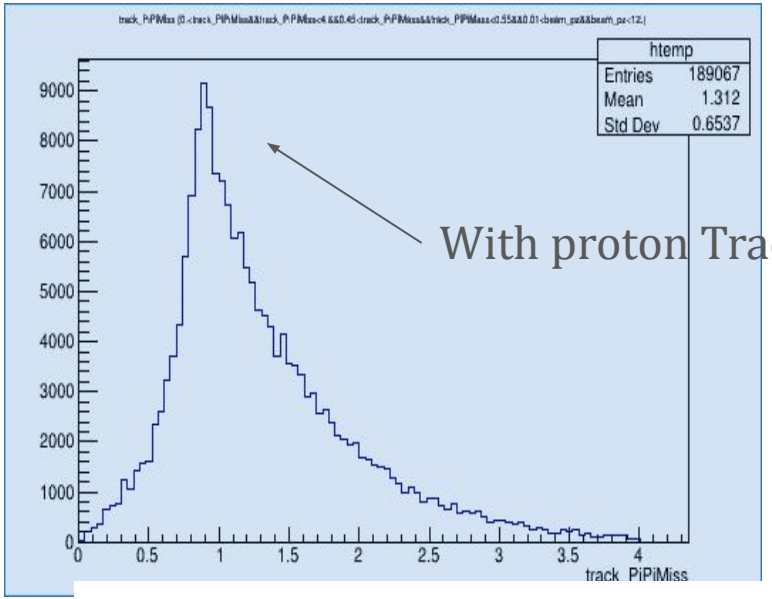
Effective Mass of $\pi^-\pi^+$ (GeV)



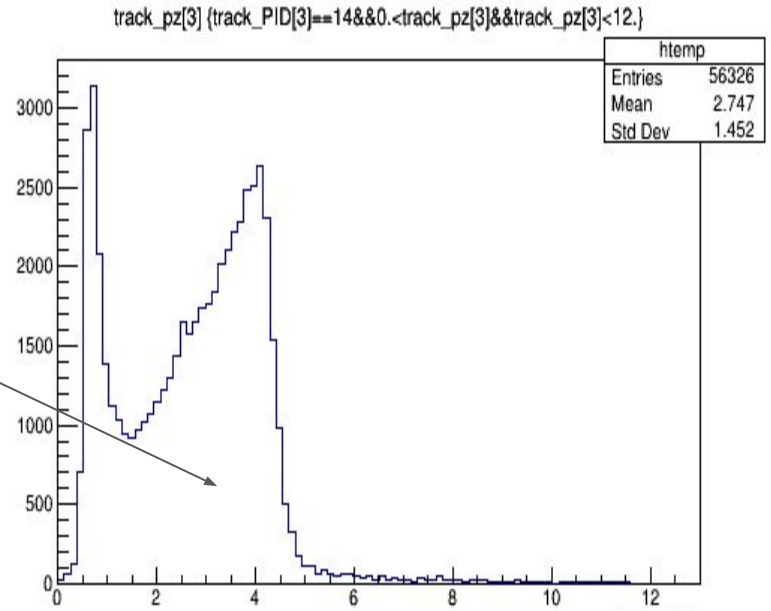
Beam K_L momentum (GeV/c)

- The yield of K-shorts from all combinations is ~0.5 K_s per one K-Long from the beam..

ROOT analysis of 400,000 generated/reconstructed reactions $K_L + p \rightarrow K_s(\pi^- \pi^+) + p$



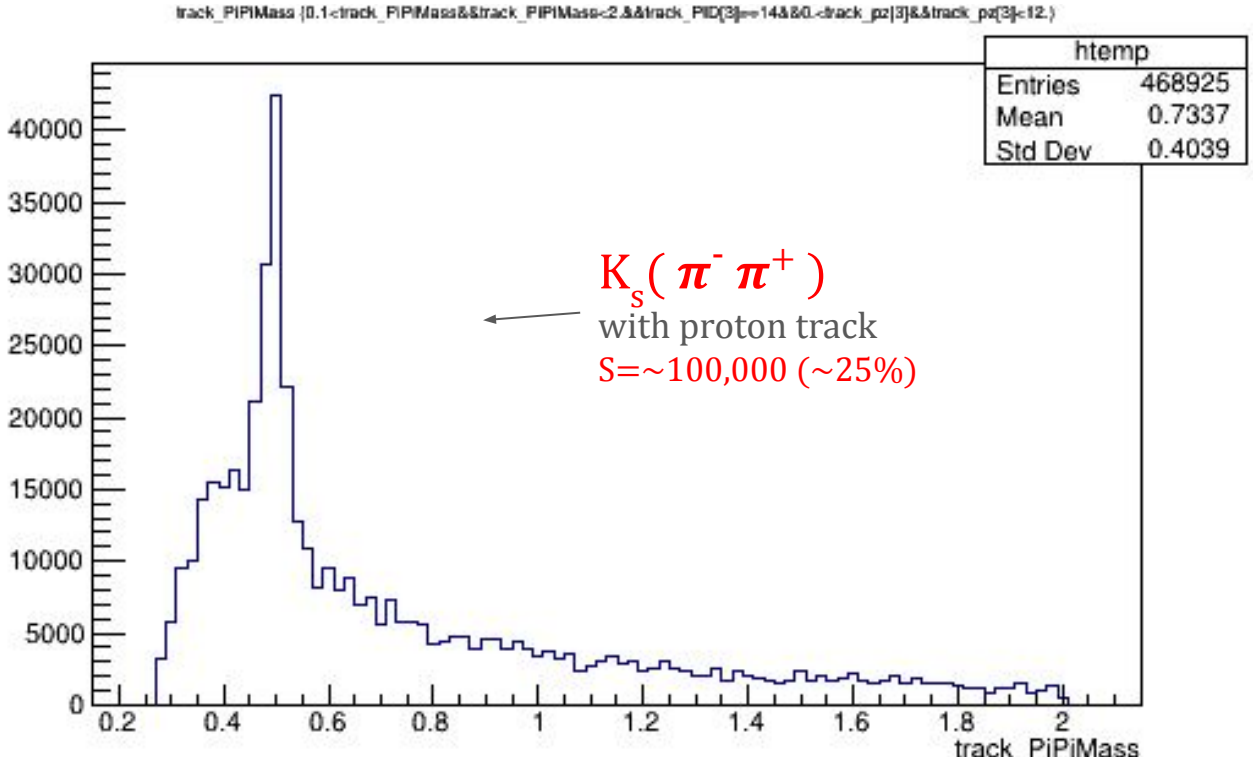
With proton Track



Missing Mass of $\pi^-\pi^+$ (GeV)

Proton momentum (GeV/c

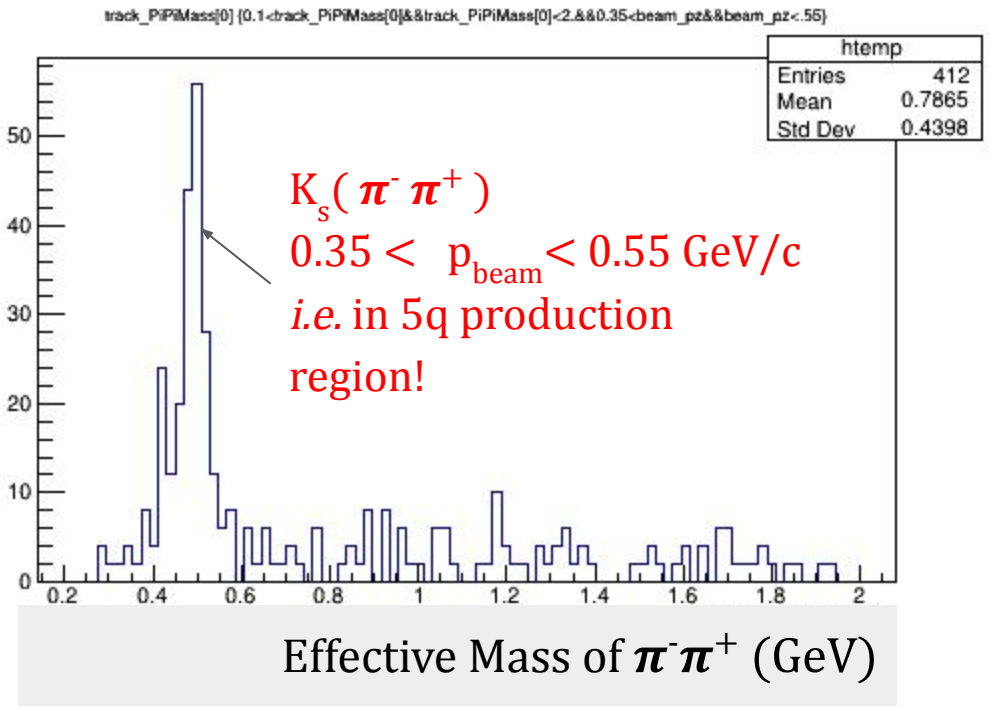
ROOT analysis of 400,000 generated/reconstructed reactions $K_L + p \rightarrow K_s(\pi^- \pi^+) + p$



Effective Mass of $\pi^-\pi^+$ (GeV)

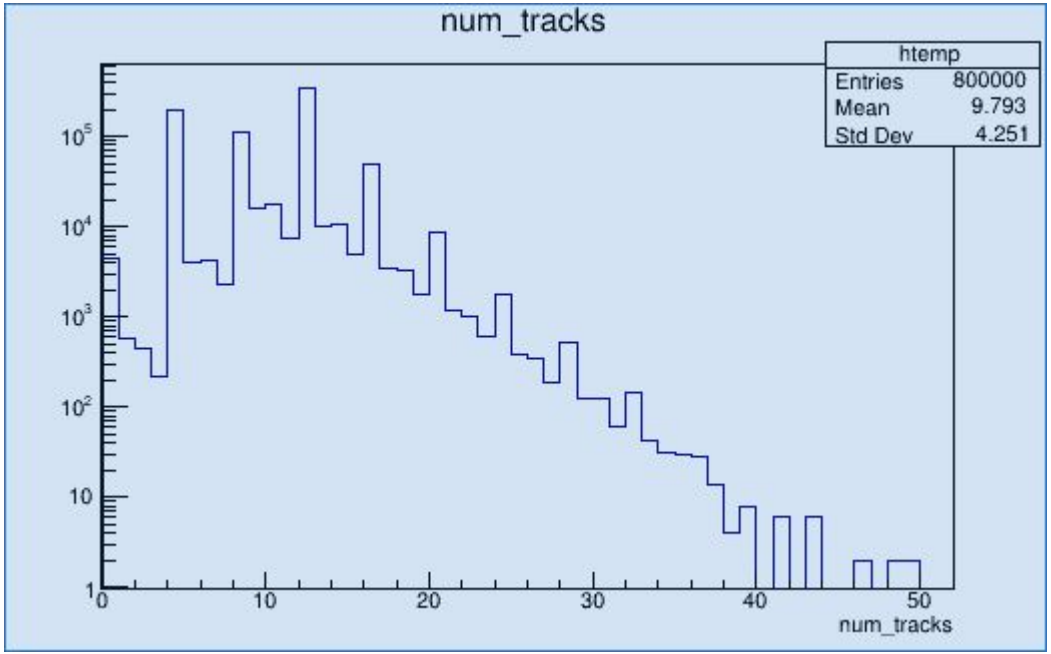
- Combinatorial background comes from wrong partner of pion.
- Other combinations should be accounted=>higher percentage up to 100%

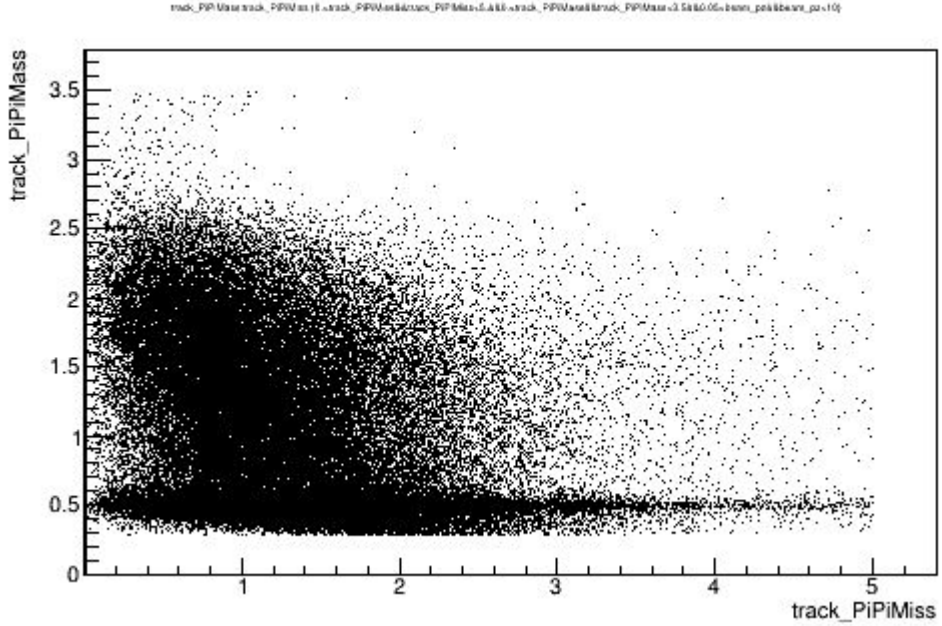
ROOT analysis of 400,000 generated/reconstructed reactions $K_L + p \rightarrow K_s(\pi^- \pi^+) + p$



K_s rescattering probability very small and is of $=$

$=\sigma\ (20.E^{-27}\ cm^2) \times L\ (3.cm) \times \varrho\ (0.07\ g/cm^3)/\mu(1.g/mol) \times N_A(6.E^{+23} mol^{-1}) = \sim 25.E\text{-}4$

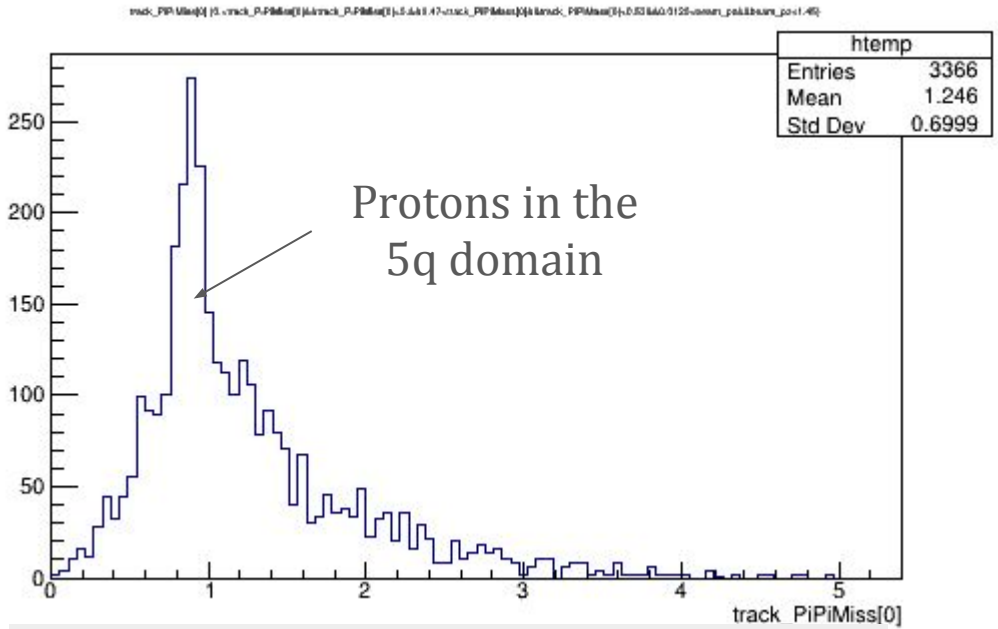

num_tracks
htemp
Entries 800000
Mean 9.793
Std Dev 4.251
10^5
10^4
10^3
10^2
10
1
0
10
20
30
40
50
num_tracks


track_PiPiMass
track_PiPiMiss
0
0.5
1
1.5
2
2.5
3
3.5
1
2
3
4
5

Draw("track_PiPiMiss[0]",

"(0.<track_PiPiMiss<5) & (0.47<track_PiPiMass<0.53) & (0.0125<beam_pz<1.45) "

,"", 800000, 0);



Missing Mass of $\pi^-\pi^+$ (GeV)

- In the momentum domain of 5q production, K-shorts are selected via PiPiMass cut. Protons are clearly see in the of $\pi^-\pi^+$ Missing Mass spectrum.

Draw("track_PiPiMass[3]",
"track_PiPiMiss[3]<8 && 0.1<track_PiPiMass[3] &&
track_PiPiMass[3]<3.5&&0<beam_pz&&beam_pz<12 &&track_PID[3]==14"