Update On $K_{L,S} \rightarrow \pi^+\pi^-\gamma$

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KTeV Collaboration Meeting
December 11, 2004

Outline For Today

- Description of the crunch of the 1999 data and its results.
- Some plots of 1999 $\pi^+\pi^-\gamma$ data and MC
- Future plans

Crunch of 1999 Data is Complete

- During the 97 and 99 data taking runs, some L3 $\pi^+\pi^-\gamma$ tags did NOT receive the on line PP0KIN cut, since they overlapped with the B02 trigger .
  - See Rick's write-up in ktevdoc
- Rick took care of 1997 by rerunning L3 on crunched $\pi^+\pi^-\gamma$ data.
  - This time, tags overlapping with B02 received the pp0kine cut.
- The 99 $\pi^+\pi^-\gamma$ data still needed to be treated.
  - I've crunched the 99 data and rerun L3. This time the cuts were loosened to include $\pi^+\pi^-$ events as well.

99 Crunch Cuts

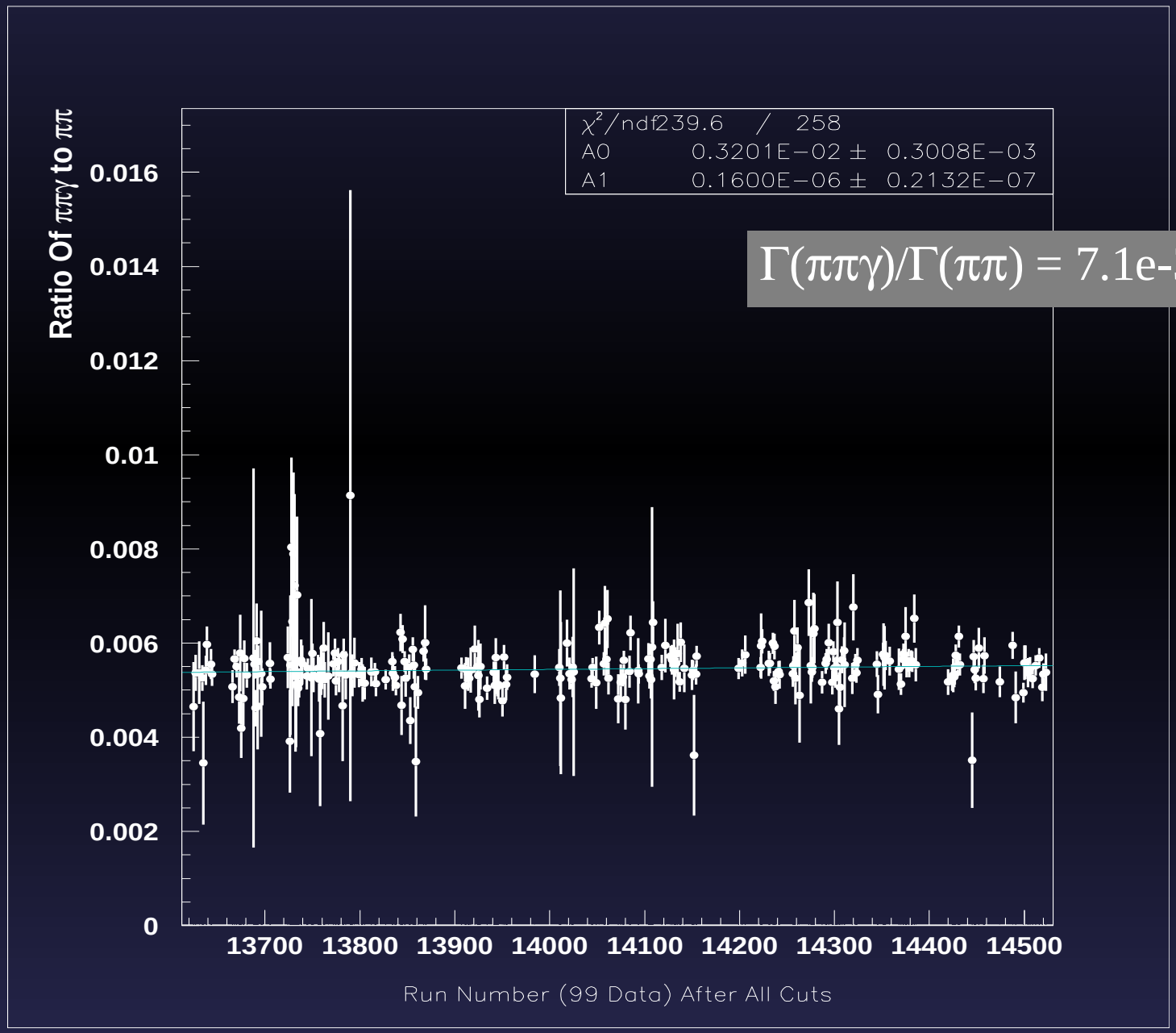
Cut Variable	*Remove Event If*	*Why?*
B01 Trigger Tag	Not present	
L3 $\pi^+\pi^-$ or L3 $\pi^+\pi^-\gamma$ tag	Not present	
OKEVT(1)	FALSE	Reject Bad Runs and Spills
Reg Veto	Fires	
Reg Pb Veto	Fires	
RC Veto	Fires	
MA Veto	Fires	
ZVTX – z vertex	<100 or >160	
TRKEOP -E/p for tracks	>0.9	Electron Rejection
F832CA	<0.0	Want tracks inside CA
PP0KIN	> - 0.002 for non - B02	Reject $\pi^+\pi^-\pi^0$
TRKP -track momentum	<7.0	Multiple scattering

Rerun L3 filter code with B02PS_ACCKE3 = 0,0 in B01NML.

Crunch Output

- After all crunch cuts:
  - 24,037,418 L3 $\pi^+\pi^-\gamma$ tags (~20% of total input)
  - 75,187,027 L3 $\pi^+\pi^-$ tags (~23% of total input)
- After all analysis cuts (see end of talk):
  - For the $\pi^+\pi^-\gamma$ sample:
    - 83,092 events in the regenerator beam
    - 109,108 events in the vacuum beam
  - For the $\pi^+\pi^-$ sample:
    - 15,181,540 events in the regenerator beam
    - 6,901,223 events in the vacuum beam

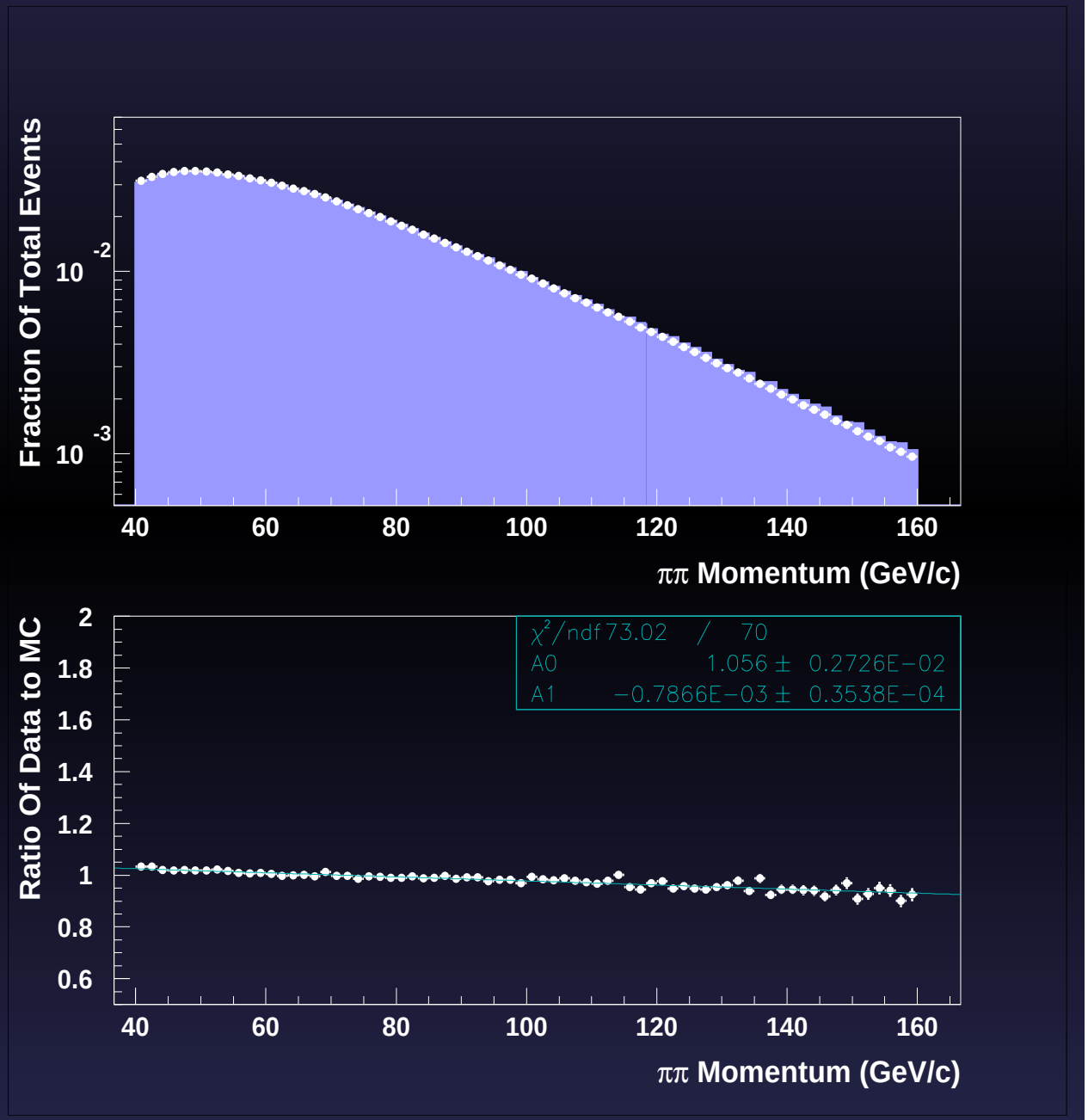
Ratio Of $\pi^+\pi^-\gamma$ to $\pi^+\pi^-$ Per Run



$\Gamma(\pi\pi\gamma)/\Gamma(\pi\pi) = 7.1e\text{-}3$ for K_S

Kaon Momentum For $K \rightarrow \pi\pi$

- There is a significant slope in all momentum distributions, in both beams, for both decay modes.
- $\pi\pi\gamma$ momentum distribution is affected by the photon energy spectrum, but $\pi\pi$ should be flat. This is confirmed for the vacuum beam.
- Any ideas?



DATA/MC Comparisons

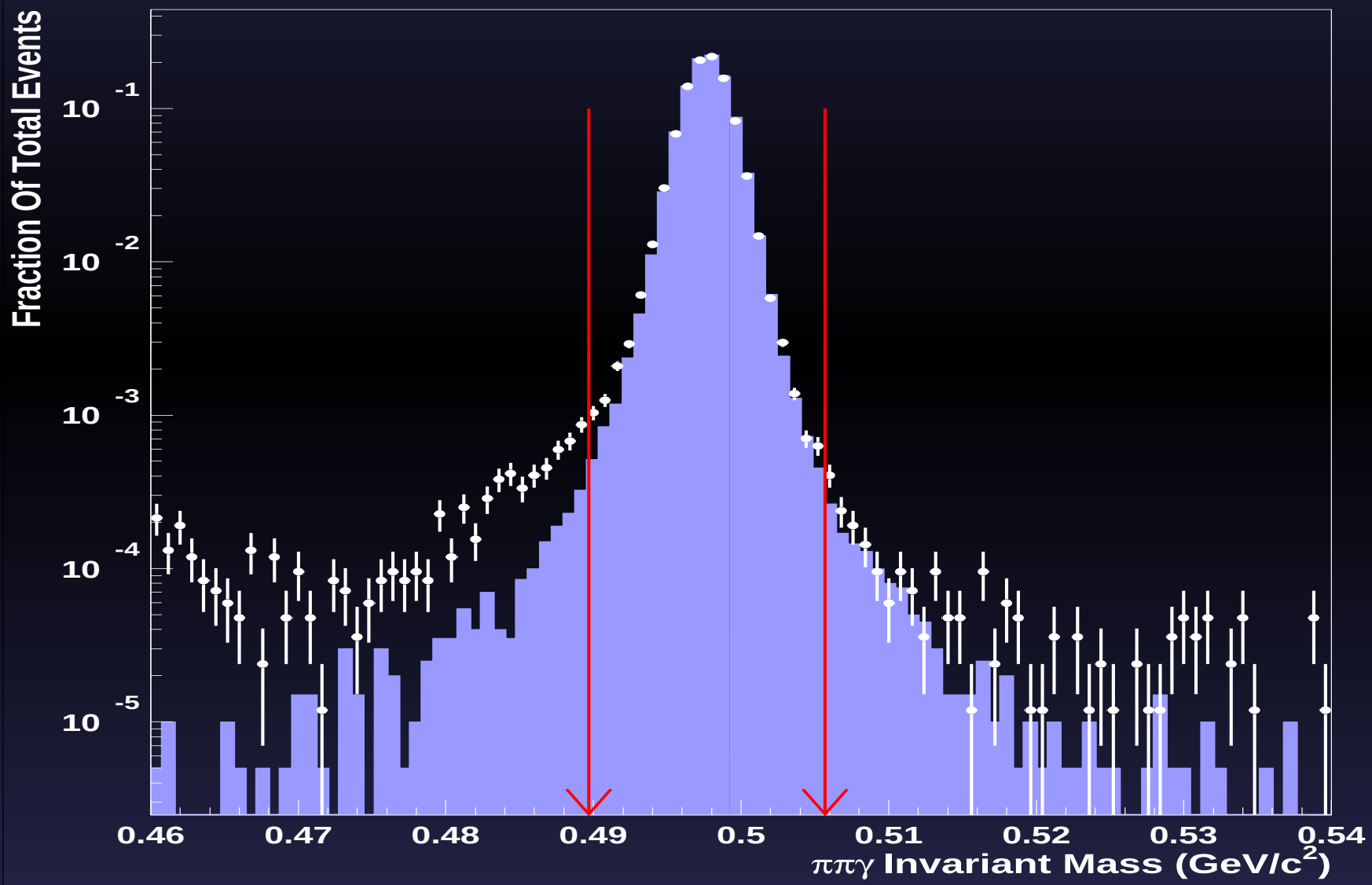
- The following plots are of regenerator beam $\pi^+\pi^-\gamma$ events from the full 99 data set. After all cuts, we are left with 83092 events.
- The number of Monte Carlo events remaining after all cuts is 201879.
- Generation and analysis were carried out with ktevana v6_03

Monte Carlo Input Parameters

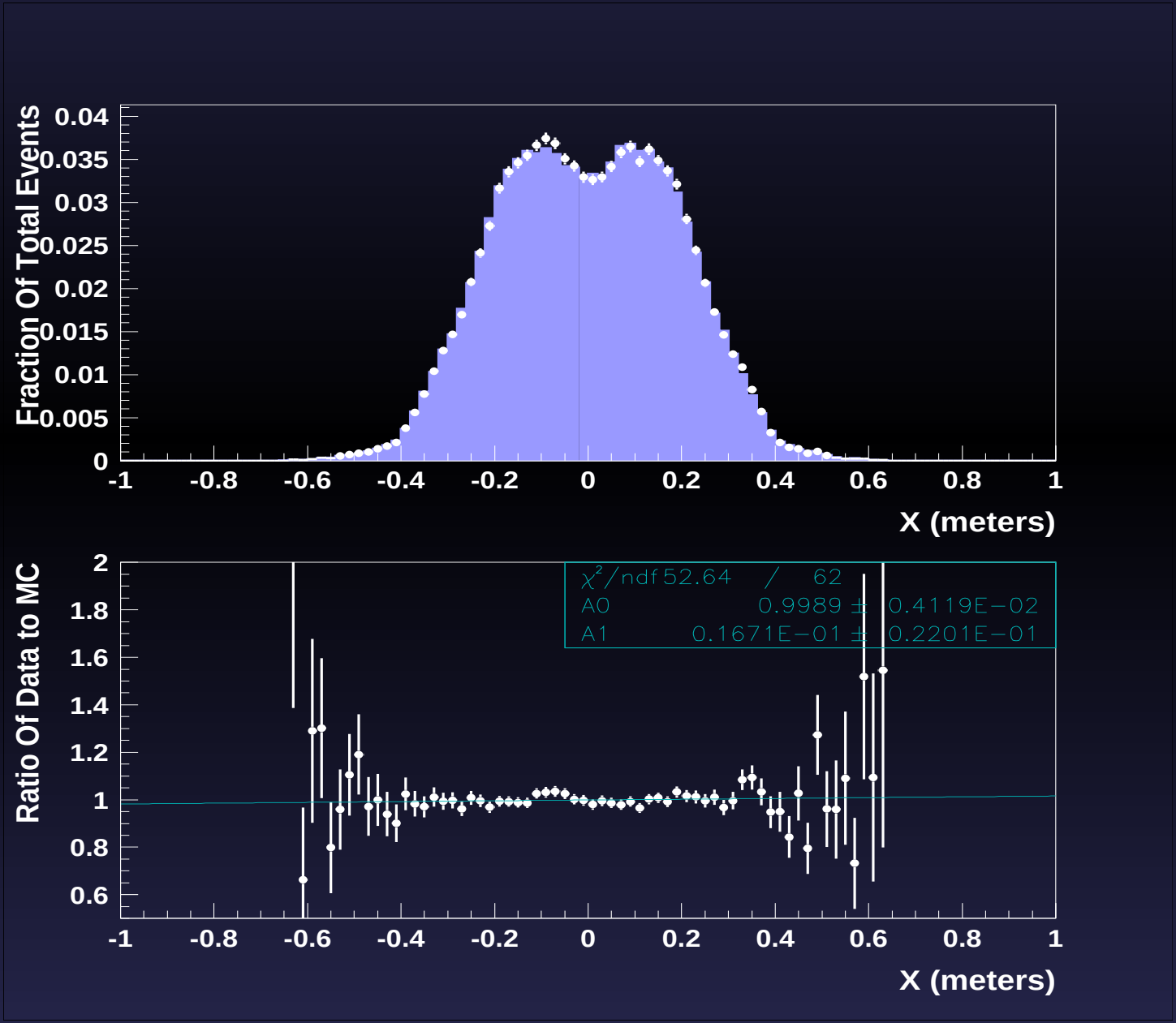
- The following values were used to generate $\pi^+\pi^-\gamma$ monte carlo events:
  - $\eta_{+-} = 2.282 \times 10^{-3}$, $\Phi_{+-} = 43.6°$ → $\varepsilon' = 0$
  - $g_{M1} = 1.229$, a1/a2 = -0.733
  - $g_{E1} = 0$, $\hat{\epsilon} = 0$ → $\eta_{+-\gamma} = \eta_{+-}$
- Strong interaction phase shifts are taken from K_{e4} data collected by E865.

parameter for CP violation in $\pi^+\pi^-\gamma$ direct emission <u>decay amplitude</u> → Direct CP Violation in $\pi^+\pi^-\gamma$

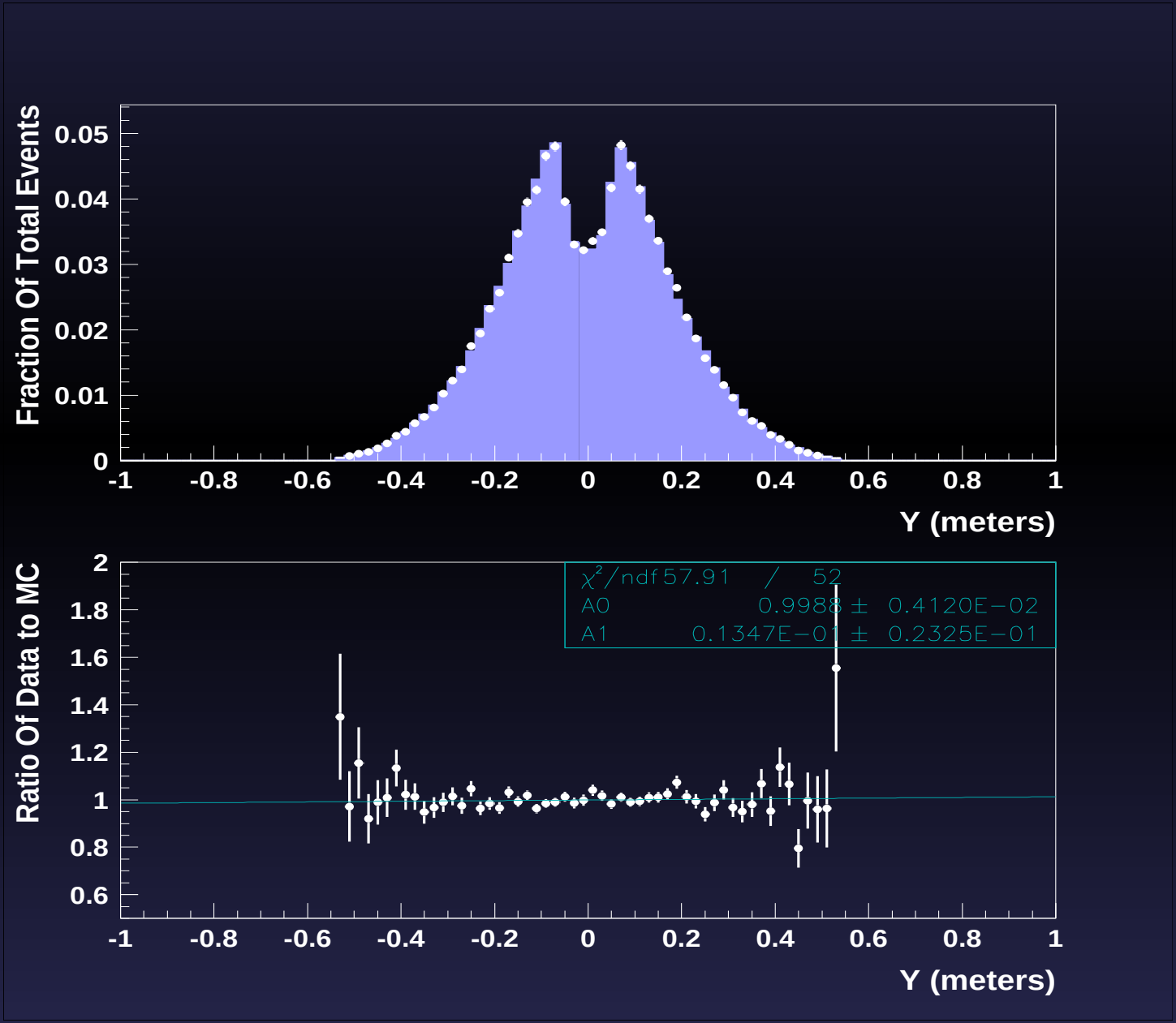
Kaon Mass Before Mass Cut



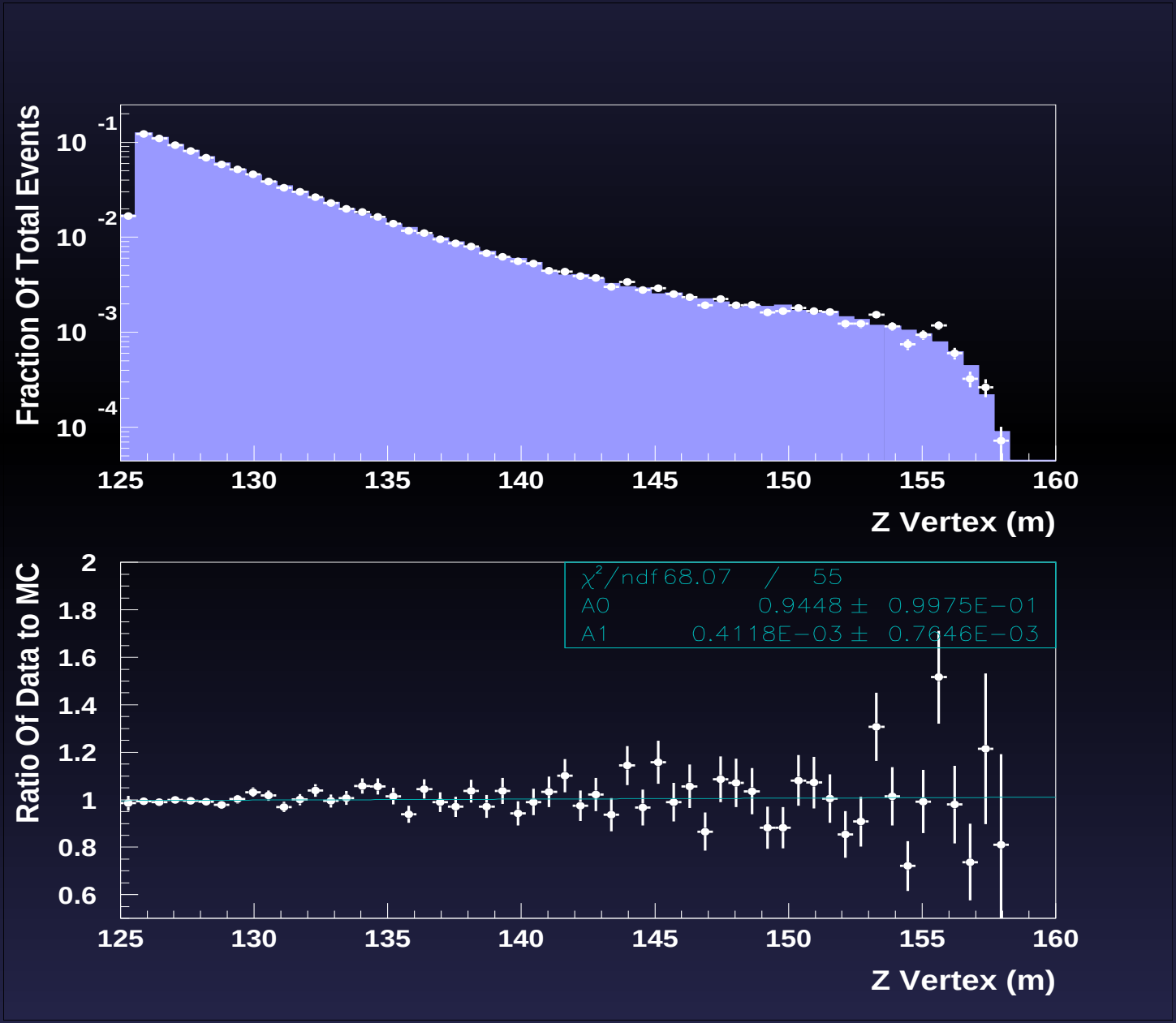
π^+ X Intercept at DC1



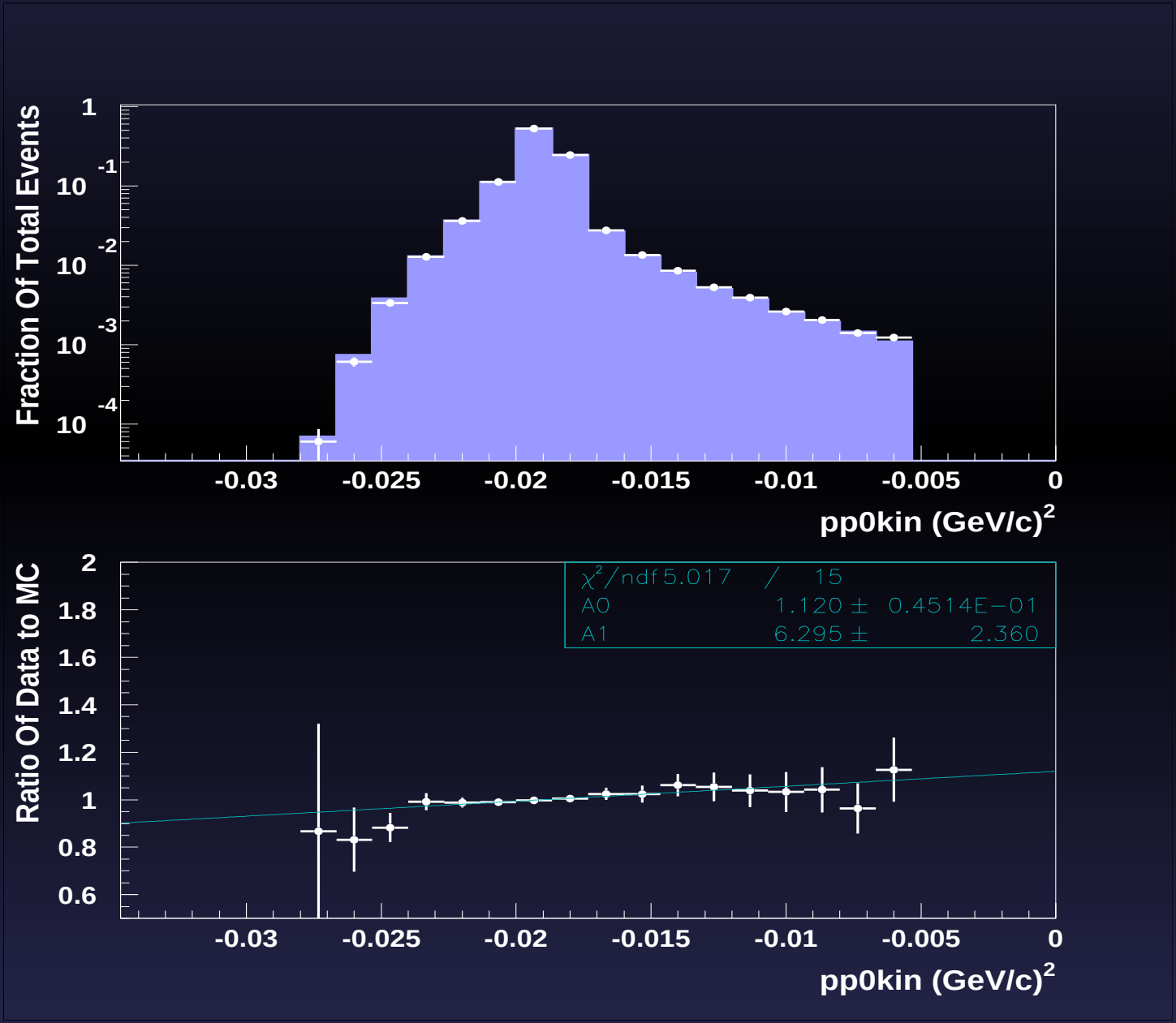
π^+ Y Intercept at DC1



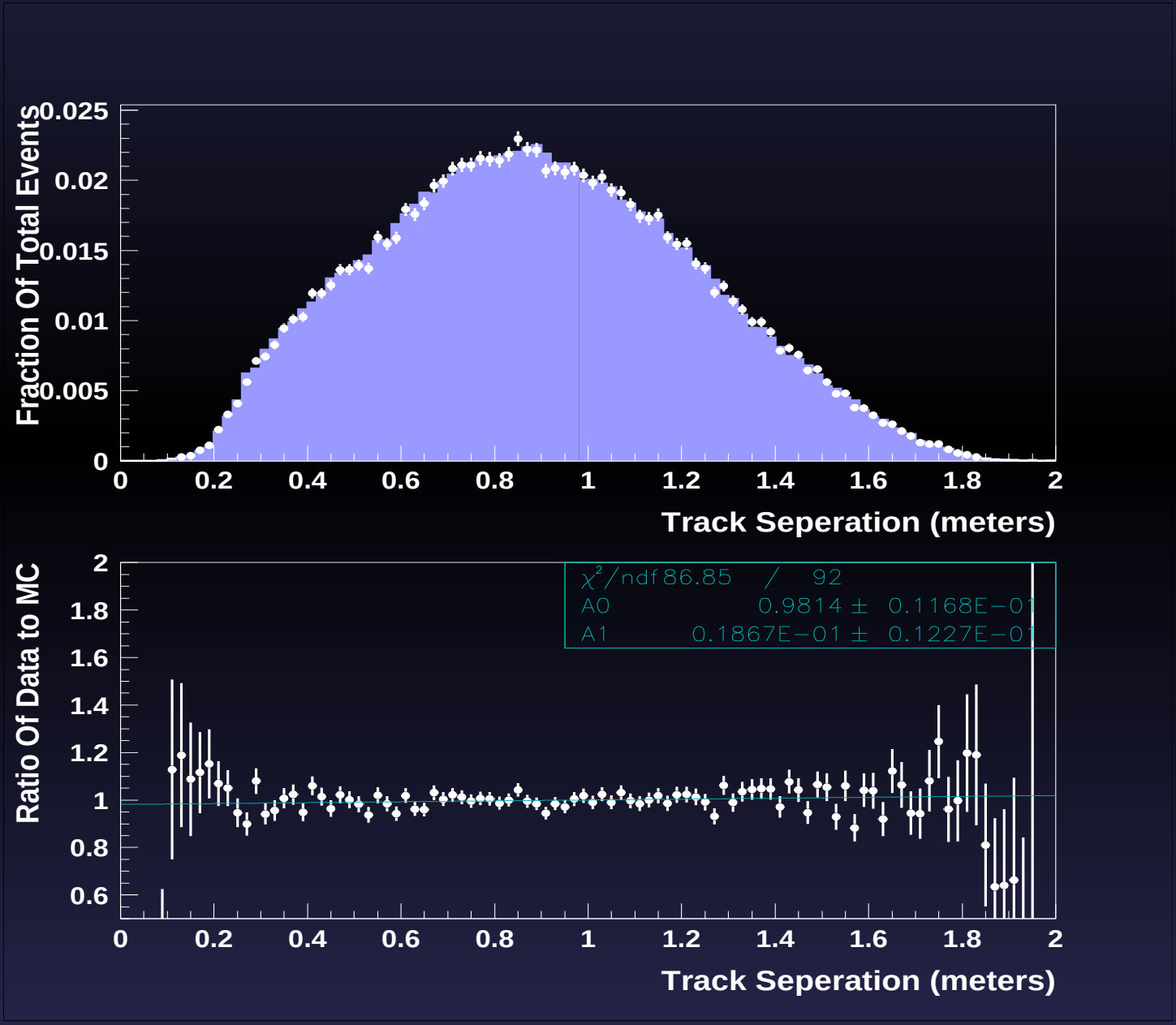
Z Vertex


Fraction Of Total Events
10^-1
10^-2
10^-3
10^-4
125
130
135
140
145
150
155
160
Z Vertex (m)
Ratio Of Data to MC
2
1.8
1.6
1.4
1.2
1
0.8
0.6
χ²/ndf 68.07 / 55
A0 0.9448 ± 0.9975E−01
A1 0.4118E−03 ± 0.7646E−03
125
130
135
140
145
150
155
160
Z Vertex (m)

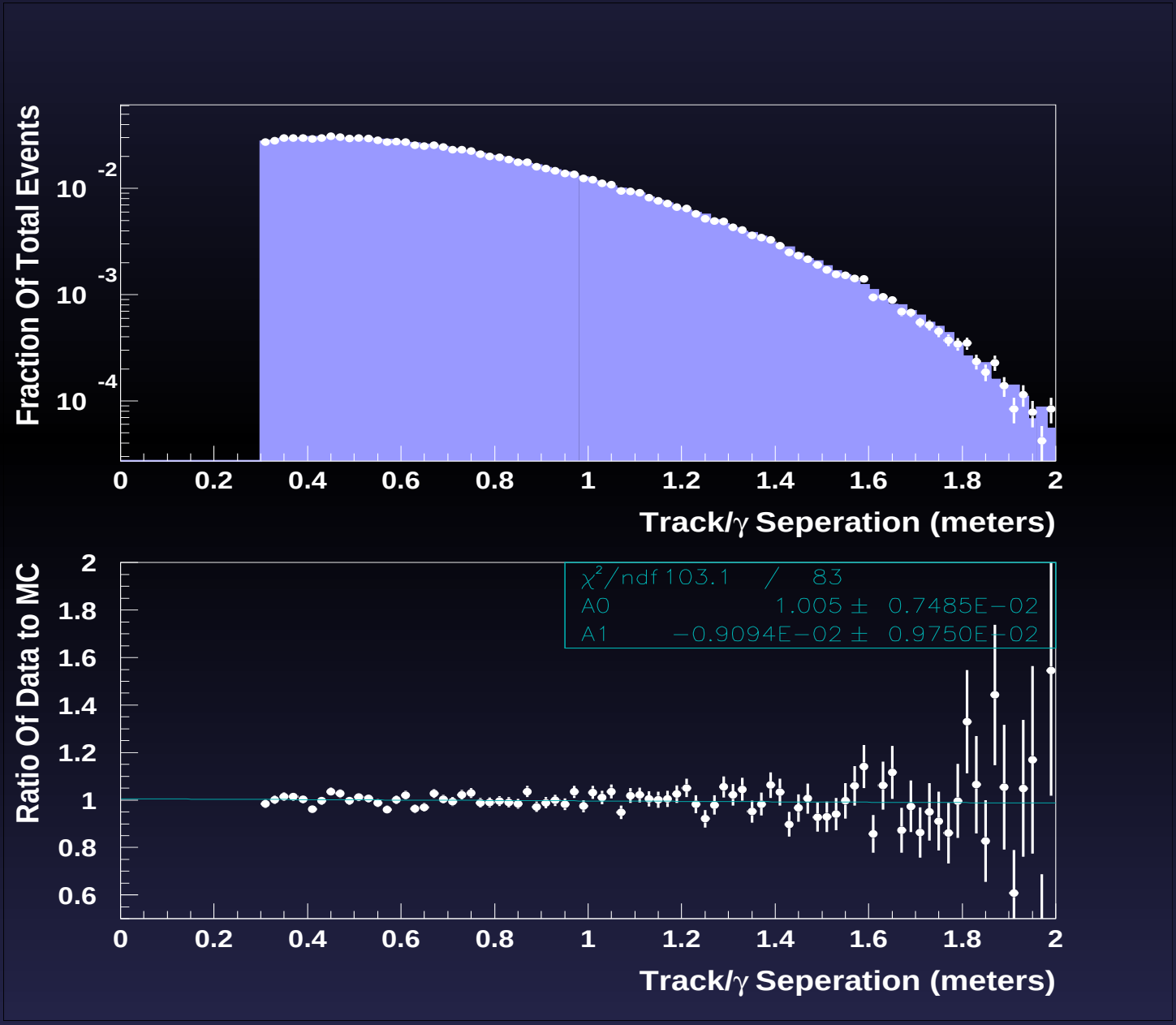
pp0kine


Fraction Of Total Events
1
10^-1
10^-2
10^-3
10^-4
-0.03
-0.025
-0.02
-0.015
-0.01
-0.005
0
pp0kin (GeV/c)^2
Ratio Of Data to MC
2
1.8
1.6
1.4
1.2
1
0.8
0.6
χ²/ndf 5.017 / 15
A0 1.120 ± 0.4514E−01
A1 6.295 ± 2.360
-0.03
-0.025
-0.02
-0.015
-0.01
-0.005
0
pp0kin (GeV/c)^2

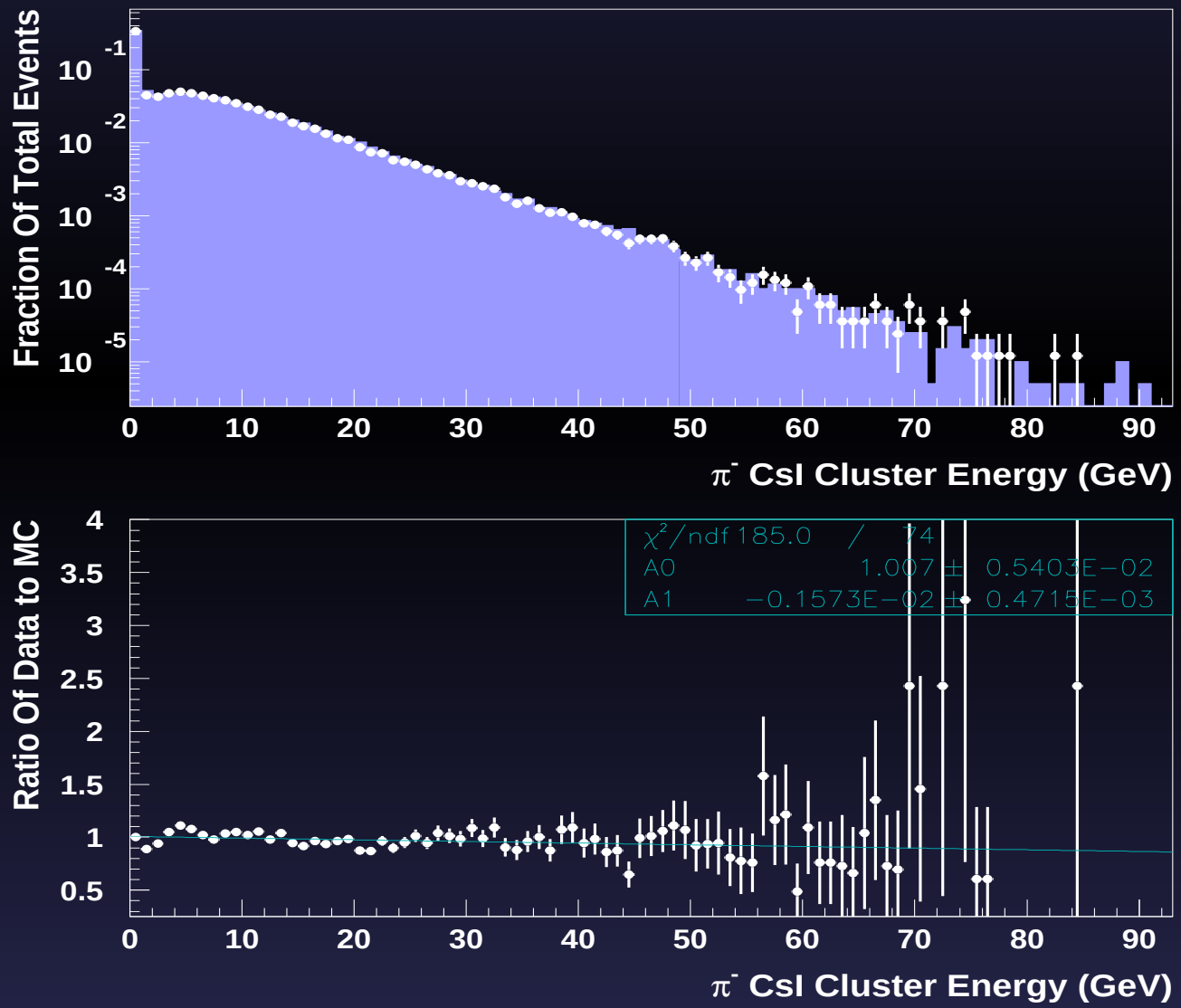
Track Separation at CsI



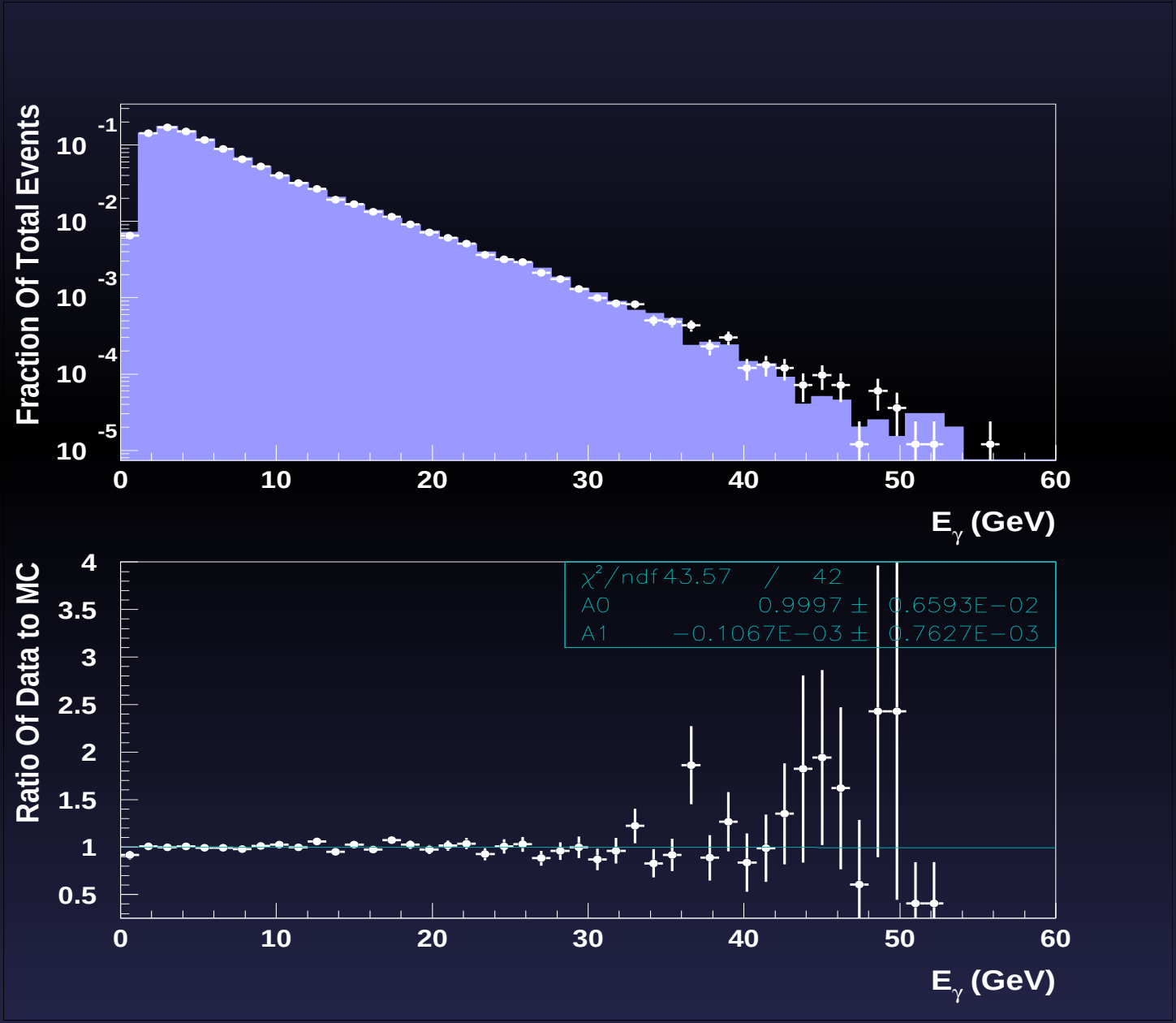
Track/γ Separation at CsI



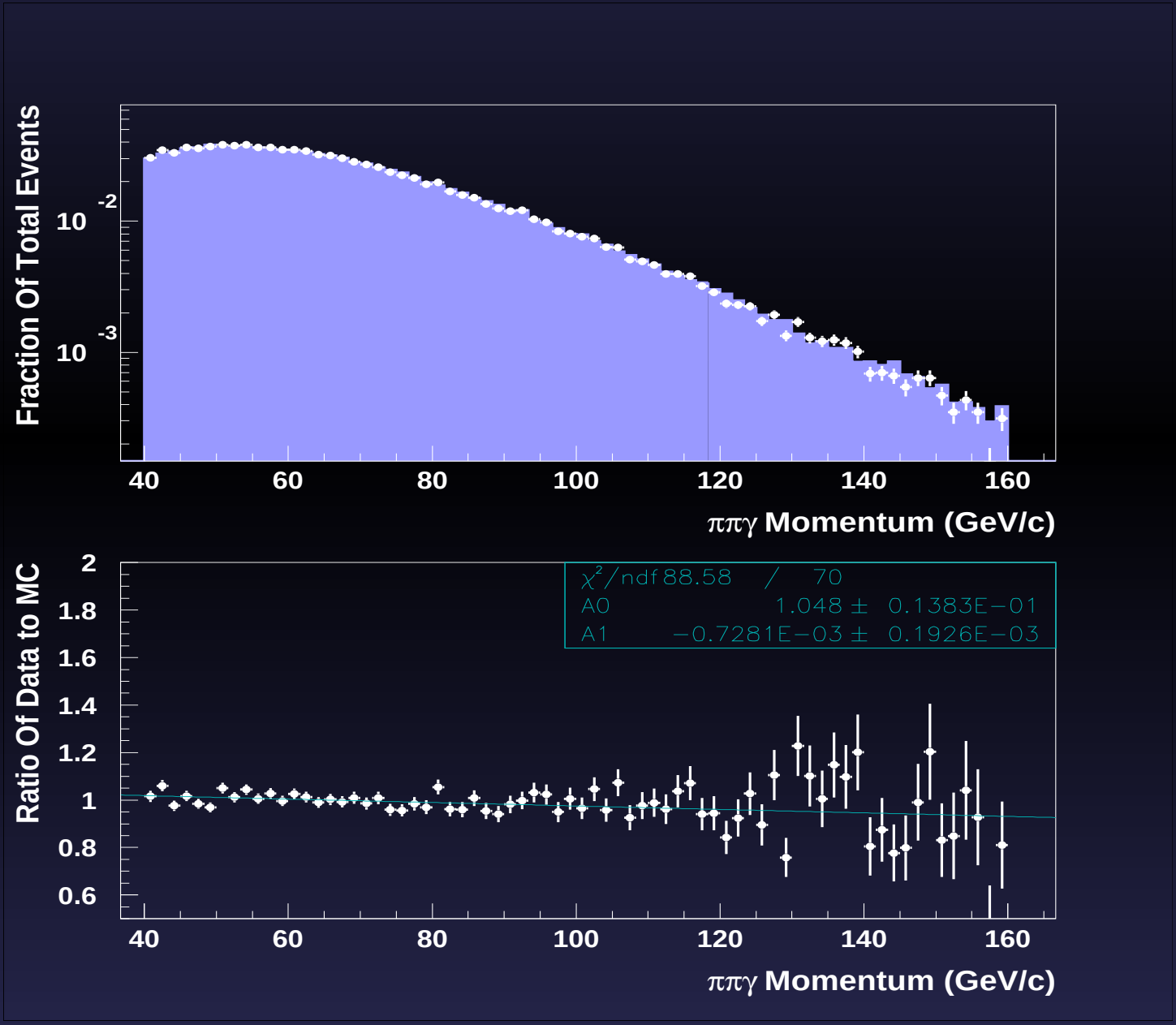
Pion Cluster Energy



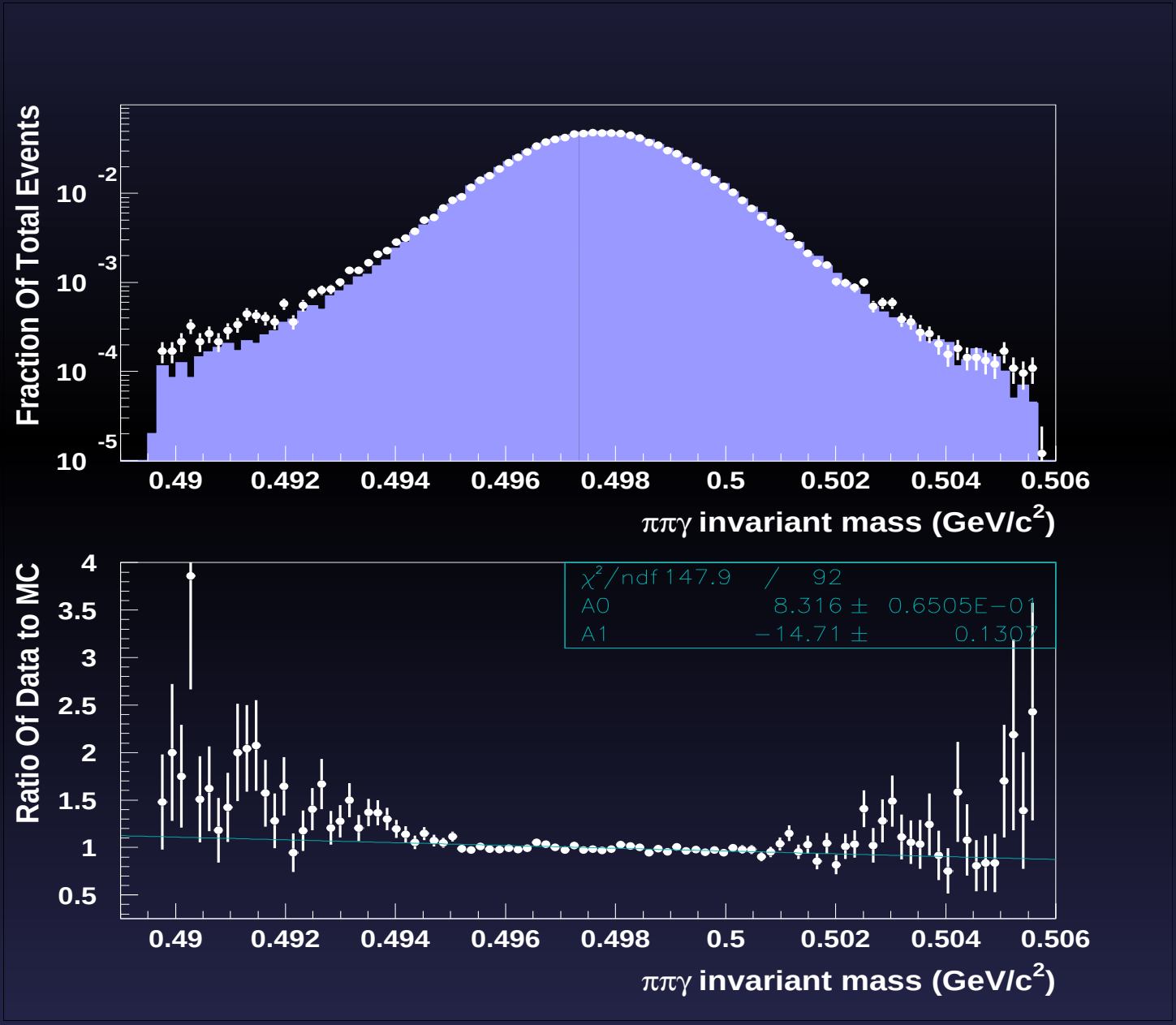
E_γ in Lab Frame



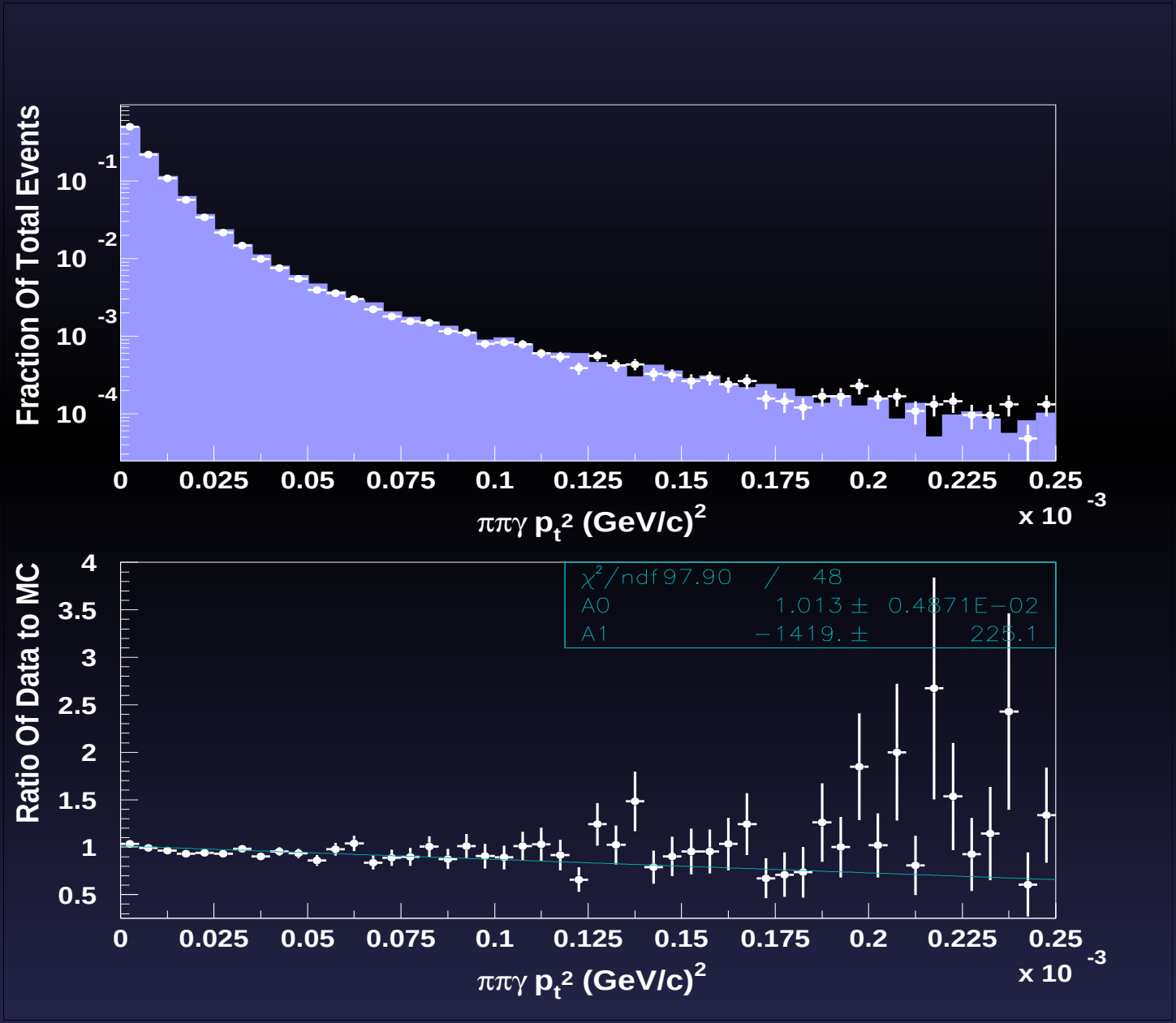
Kaon Momentum



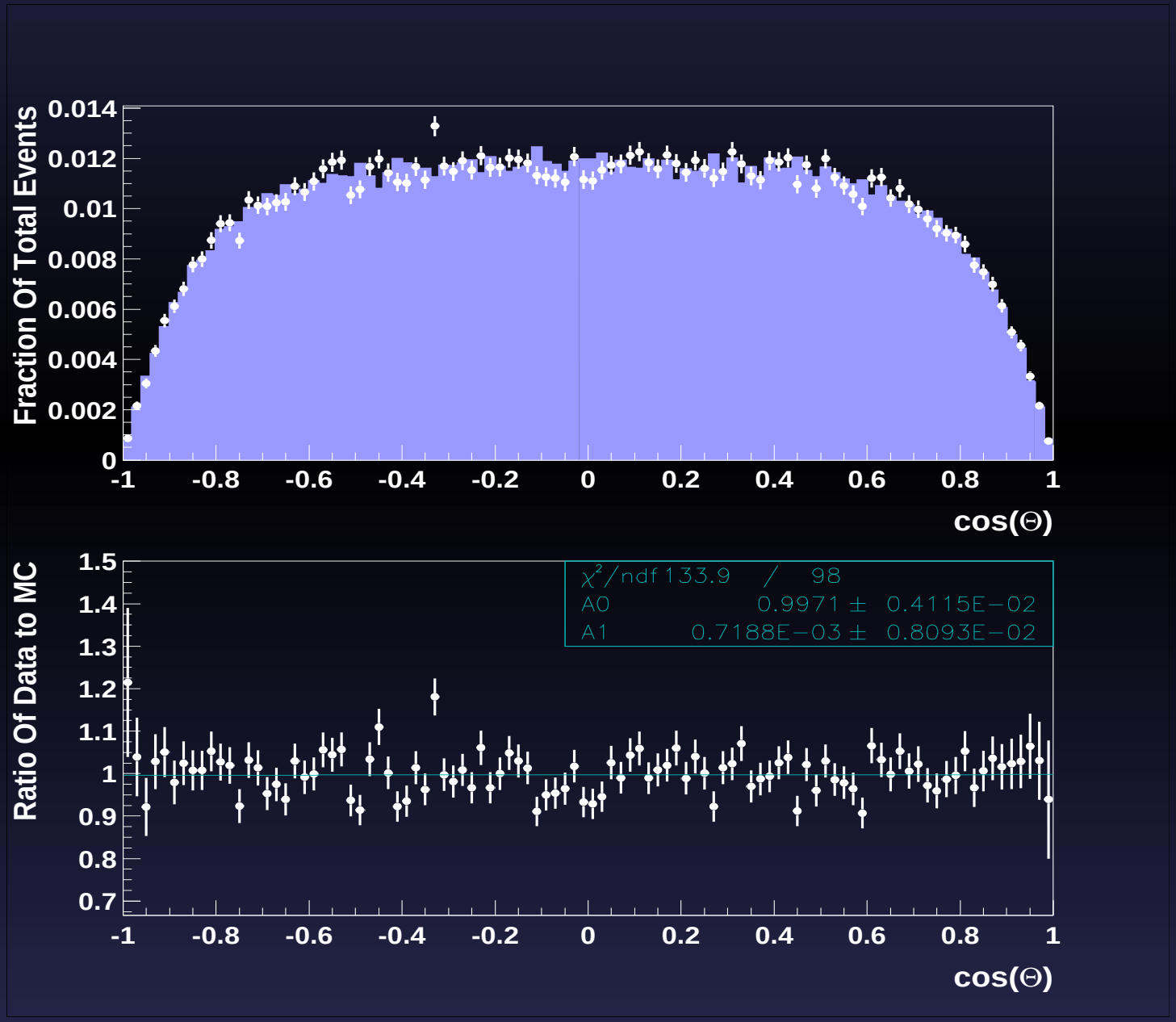
Kaon Mass


Fraction Of Total Events
10^-2
10^-3
10^-4
10^-5
0.49
0.492
0.494
0.496
0.498
0.5
0.502
0.504
0.506
ππγ invariant mass (GeV/c²)
Ratio Of Data to MC
4
3.5
3
2.5
2
1.5
1
0.5
χ²/ndf 147.9 / 92
A0 8.316 ± 0.6505E−01
A1 −14.71 ± 0.1307
0.49
0.492
0.494
0.496
0.498
0.5
0.502
0.504
0.506
ππγ invariant mass (GeV/c²)

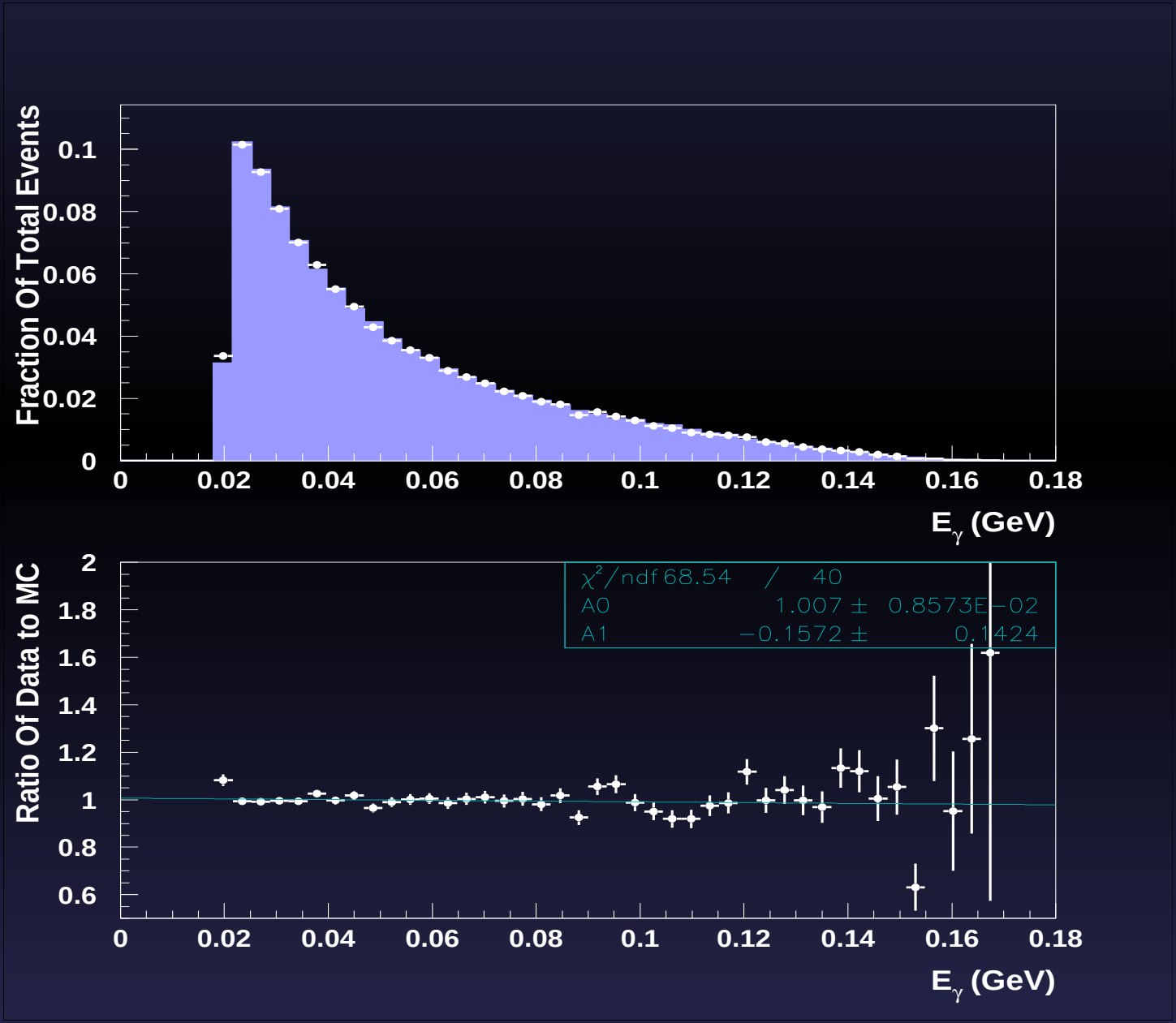
Kaon P_t^2


Fraction Of Total Events
10^-1
10^-2
10^-3
10^-4
0
0.025
0.05
0.075
0.1
0.125
0.15
0.175
0.2
0.225
0.25
x 10^-3
ππγ p_t^2 (GeV/c)^2
Ratio Of Data to MC
4
3.5
3
2.5
2
1.5
1
0.5
χ²/ndf 97.90 / 48
A0 1.013 ± 0.4871E−02
A1 −1419. ± 225.1
0
0.025
0.05
0.075
0.1
0.125
0.15
0.175
0.2
0.225
0.25
x 10^-3
ππγ p_t^2 (GeV/c)^2

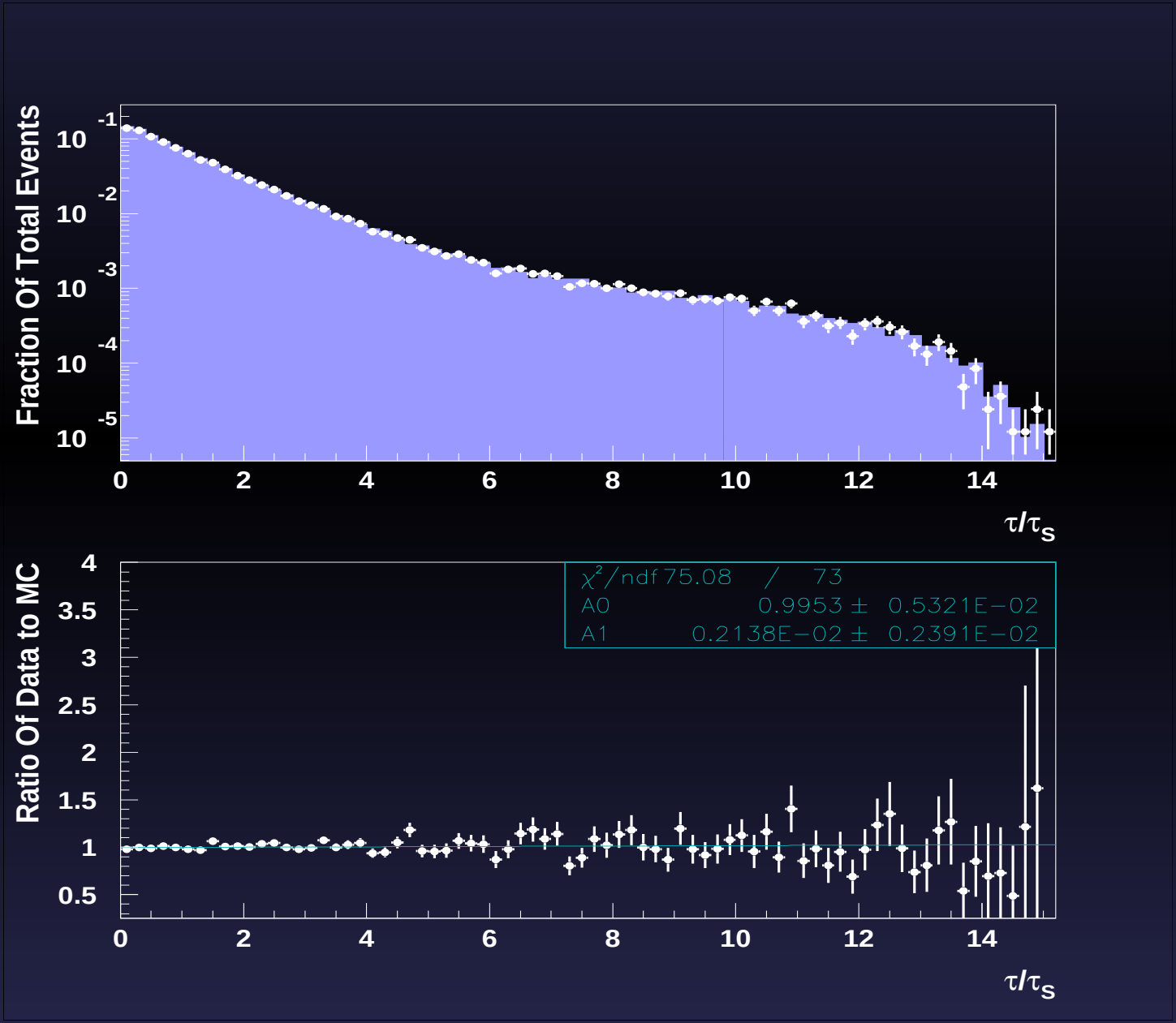
Cosθ


Fraction Of Total Events
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
cos(Θ)
Ratio Of Data to MC
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
χ²/ndf 133.9 / 98
A0 0.9971 ± 0.4115E−02
A1 0.7188E−03 ± 0.8093E−02
cos(Θ)

E_γ in Kaon Rest Frame



Kaon Lifetime



Plans

- With the 99 crunch completed, I need to investigate the momentum slope. It should NOT be present in pipi.
- Once that is complete, I can turn to the development of the likelihood fitter.
- Once that is done I can determine if the inclusion of the vacuum beam data and floating the M1 parameters will strengthen the fit.

Extra Slides
Notes On Analysis

Initialization Parameters For Public E832 Routines

- RECON832INI called for "K3PI"
- CSI832INI called with option 10
- Default VTO832 settings used except:
  - EVTO_XCLUS_CUT = 1.0E9
- FID832INI defaults used.

Event Selection-Crunch Cuts

Cut Variable	***Remove Event If***	***Why?***
B01 Trigger Tag	Not present	
L3 pipi or L3 pmg tag	Not present	
OKEVT(1)	FALSE	Reject Bad Runs and Spills
Reg Veto	Fires	
Reg Pb Veto	Fires	
RC Veto	Fires	
MA Veto	Fires	
ZVTX – z vertex	<100 or >160	
TRKEOP -E/p for tracks	>0.9	Electron Rejection
F832CA	<0.0	Want tracks inside CA
PP0KIN	> - 0.002 for non - B02	Reject pi+pi-pi0
TRKP -track momentum	<7.0	Multiple scattering

Event Selection-Analysis Cuts

Cut Variable	*Remove Event If*	*Why?*
KTSPILL(IPACK=1) IERR(1)	<> 0	Reject bad spills
INRUN	=13860 or 14048 or 14374 or 14377 or 14383 or 14505 or 14518	Can't reproduce L3 filtering for these runs
INRUN	>14530 and <13625	
RECON832 IERR	<> 0	Reconstruction error
MSK_L1VER832	<>0	L1 verification
FID832 IERR	<> 0	Fiducial cuts
IEVTAG	contains L3 Tag bit for desired mode	L3 filter confirmation
IEVTAG(1) bit 24	Not set for pipigamma	Apply L3 filter pp0kine cut
TRKP(1) x TRKP(2)	>0	Want negative and positive tracks
T3FPI0	Returns $M_{\pi 0} \neq 0.0$	Suppress $\pi^+\pi^-\pi^0$ background

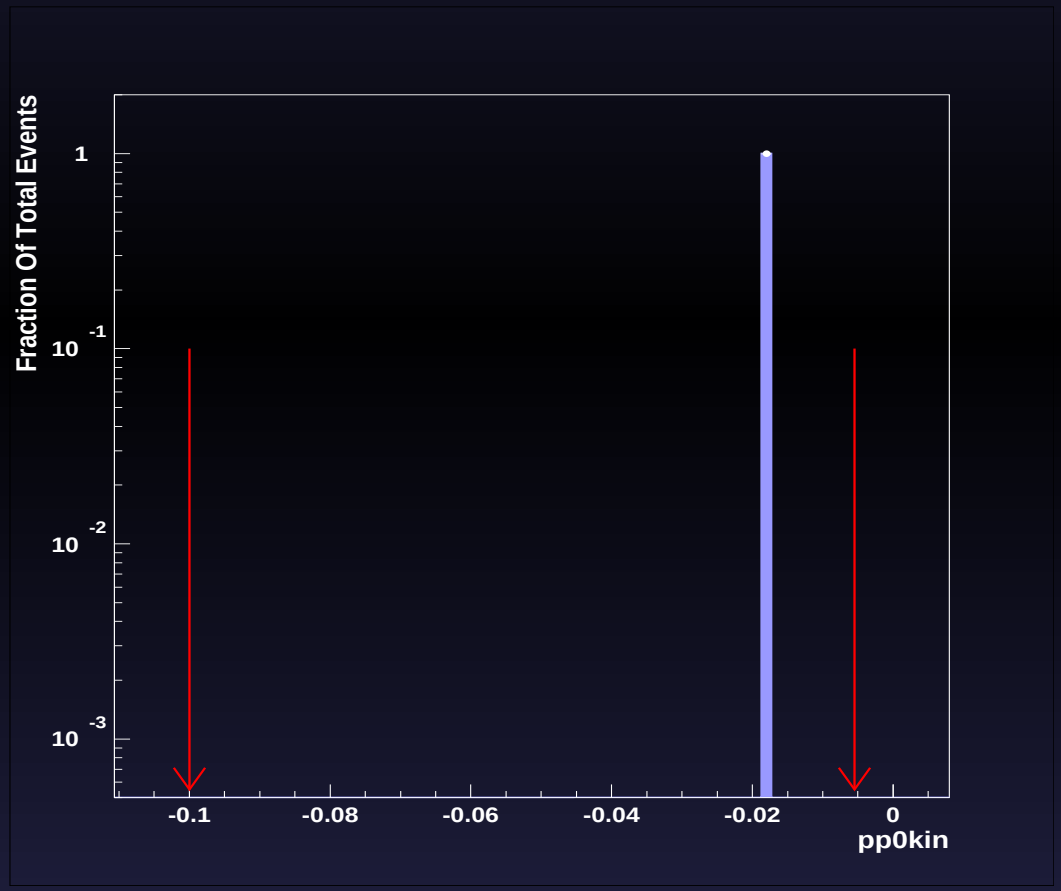
More Analysis Cuts For K->ππγ

VTXZ -Z Vertex	<125.476 , >158.0	
Kaon Mass	< 0.48967 , > 0.50567	
Kaon P_t^2	> 2.5e-4	
π+π– Mass	> 0.477	Suppress $\pi^+\pi^-$ background
E_γ in Kaon Center of Mass	< 0.02	
E_γ in lab	< 1.1	
PP0KINE- P_{π^0}	< -0.10 , > -0.0055	Suppress $\pi^+\pi^-\pi^0$ background
Kaon Momentum	< 40.0 , > 160.0	
TRKEOP-E/p for tracks	> 0.85	Reject e^+ and e^-
TRKP-track momentum	<8.0	
VTXCHI - vertex χ^2	>50.0	
FUSECHI2CS-fusion χ^2	>48.0	
Λ Mass	<1.112, >1.119	Reject Λ–>πp decays
Proton Momentum	No cut	
TRKOCHI-track offset χ^2	>50.0	
Track Separation at CSI	< 0.06 in x, or <0.03 in y	
Photon-Track Separation at CSI	<0.30	
ISEEDRING	>18.1	
ISMLRING2	< 4.5	

More Analysis Cuts For K->ππ

Cut Variable	*Remove Event If*	*Why?*
VTXZ -Z Vertex	<125.476 , >158.0	
Kaon Mass	< 0.48967 , > 0.50567	
Kaon P_t^2	> 2.5e-4	
PP0KINE- P_{π^0}	< -0.10 , > -0.0055	Suppress $\pi^+\pi^-\pi^0$ background
Kaon Momentum	< 40.0 , > 160.0	
TRKEOP-E/p for tracks	> 0.85	Reject e^+ and e^-
TRKP-track momentum	<8.0	
VTXCHI - vertex χ^2	>50.0	
Λ Mass	< 1.112 and >1.119	Reject Λ–>πp decays
Proton Momentum	No cut	
TRKOCHI-track offset χ^2	>50.0	
Track Separation at CSI	< 0.06 in X direction <0.03 in Y direction	
Photon-Track Separation at CSI AND E_γ in lab	>0.20m AND >1.0 GeV	

Effect of pp0kin cut on K->ππ events



- One possible issue is the effect of the pp0kine cut.
- This plot shows the final pp0kine distribution for K->ππ events, and the pp0kine cut window.