Preliminary Study of the decay $\Xi^0 \rightarrow \Lambda\, \pi^0\, \gamma$ with KTeV detector

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- Preliminary $\Xi^0 \rightarrow \Lambda\, \pi^0$ analysis and results
- Preliminary $\Xi^0 \rightarrow \Lambda\, \pi^0\, \gamma$ analysis and results
- Background studies
- Conclusion & Future plan

$\Xi^0 \rightarrow \Lambda\ \pi^0$ Selection Cuts

$E_{\gamma} > 3.0$ Gev, $E_{\gamma i} + E_{\gamma j} > 18$Gev, $Z = Z_{CSI} - R_{ij}(\sqrt{E_{\gamma i} E_{\gamma j}})/M_{\pi 0}$
Both $\boldsymbol{\gamma}$ **s** are at least 20cm away from where the π^- hits the calorimeter.
$95m < Z_{\Xi 0} < 158m$, $0.000376 < X_{\Xi 0}/Z_{\Xi 0} < 0.00124$, $Y_{\Xi 0}/Z_{\Xi 0} < 0.00043$
$95m < Z_{\Lambda} < 158m$, $0.000376 < X_{\Lambda}/Z_{\Lambda} < 0.00124$, $Y_{\Lambda}/Z_{\Lambda} < 0.00043$, $Z_{\Lambda} > Z_{\Xi 0}$
$.075 < \lvert X_p \rvert < 0.225$ and $\lvert Y_p \rvert < .075$; $\lvert Y_{\pi^-} \rvert > .09$ or $\lvert X_{\pi^-} \rvert < .06$ or $\lvert X_{\pi^-} \rvert > 0.24$ at calorimeter
$P_p/P_{\pi^-} > 2.8$, $E_{\pi^-}/P_{\pi^-} < 0.8$, 110 Gev $< P_p < 375$Gev, 5Gev $< P_{\pi^-} < 100$Gev
$\lvert M_{p\pi^-} - 1.115684 \rvert < 0.015$Gev
$M_{kaon} > 0.55$ Gev
$P_T^2{}_{\Xi} < 0.0001$ Gev^2

In general, events with more than 2 neutral clusters were selected. The 3 highest energy neutral clusters were combined into 3 possible pi0 pairs. At the end, if after the application of the above cuts more than 1 pi0 candidates were found, the one yielding the lowest pt was kept.

Preliminary $\Xi^0 \rightarrow \Lambda\ \pi^0$ results

Monte Carlo Data:

Generated Monte Carlo : 3,999,908 events

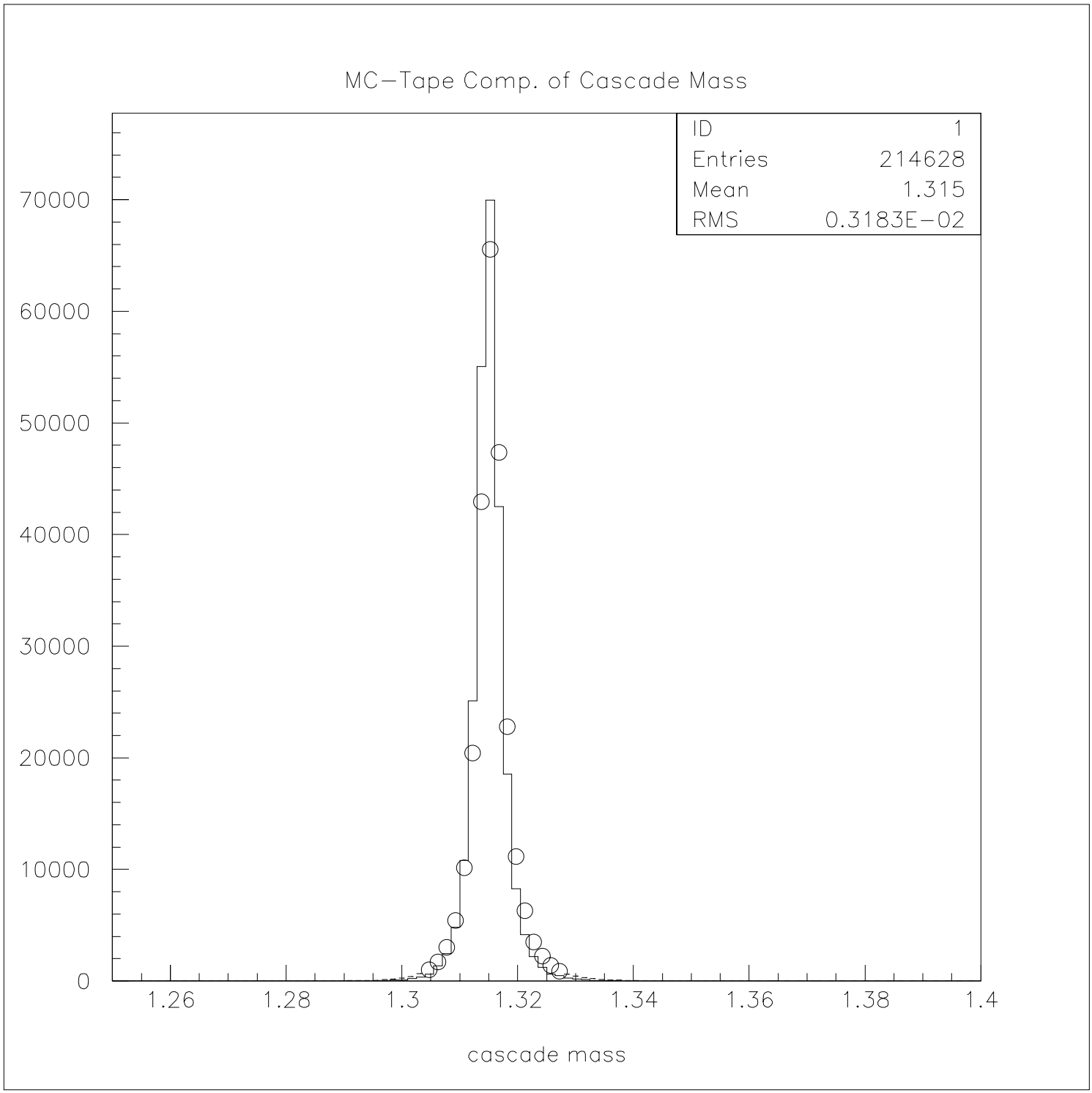
Remained after Cuts: 107,316 events

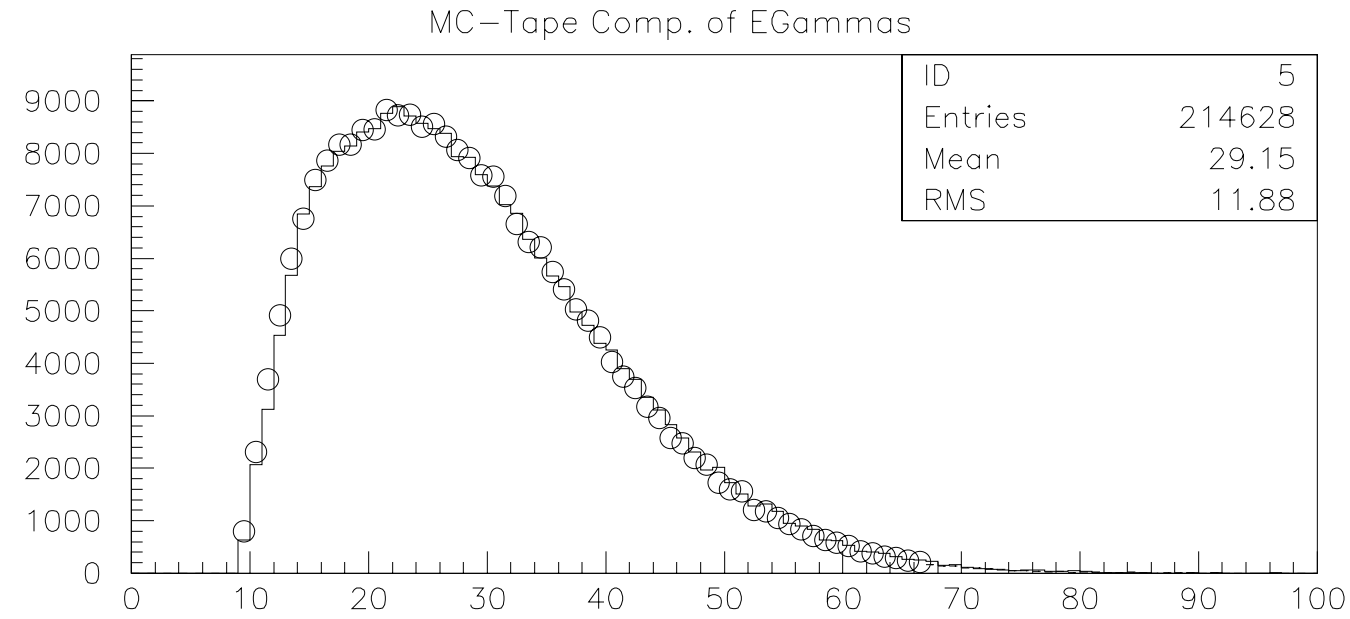
Detection Efficiency: $(2.683 \pm 0.008) \times 10^{-2}$

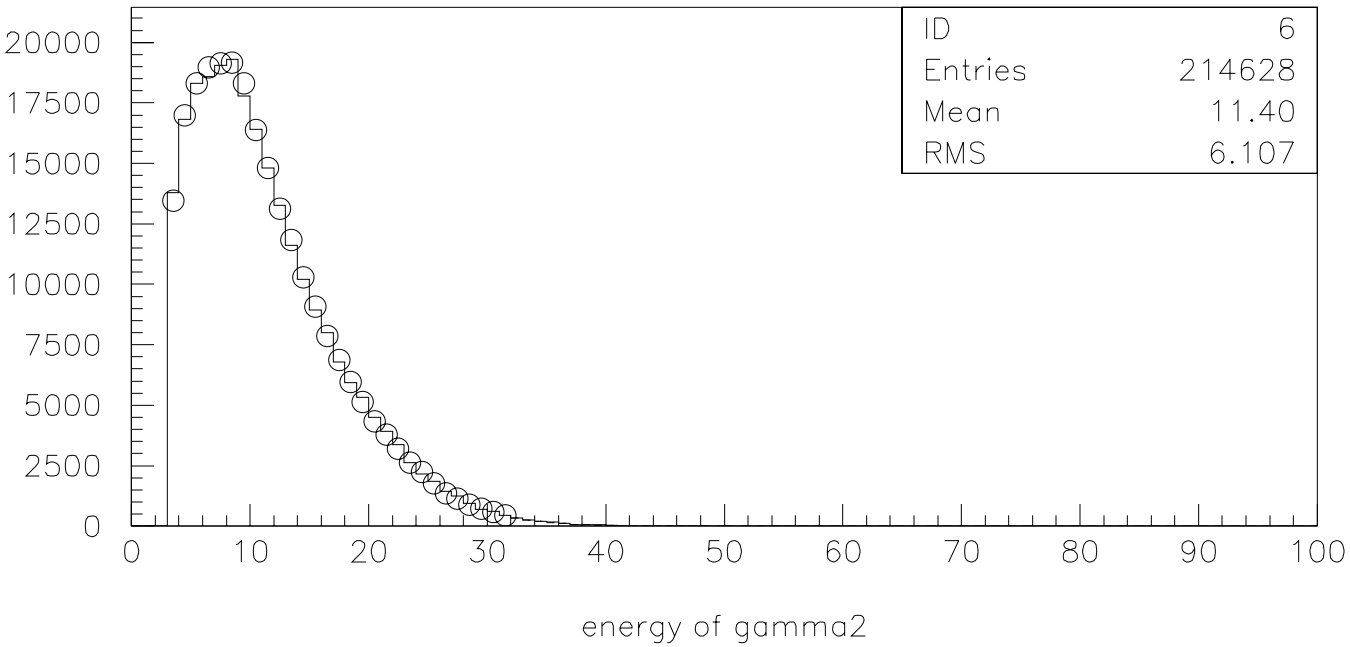
DST Tape Data:

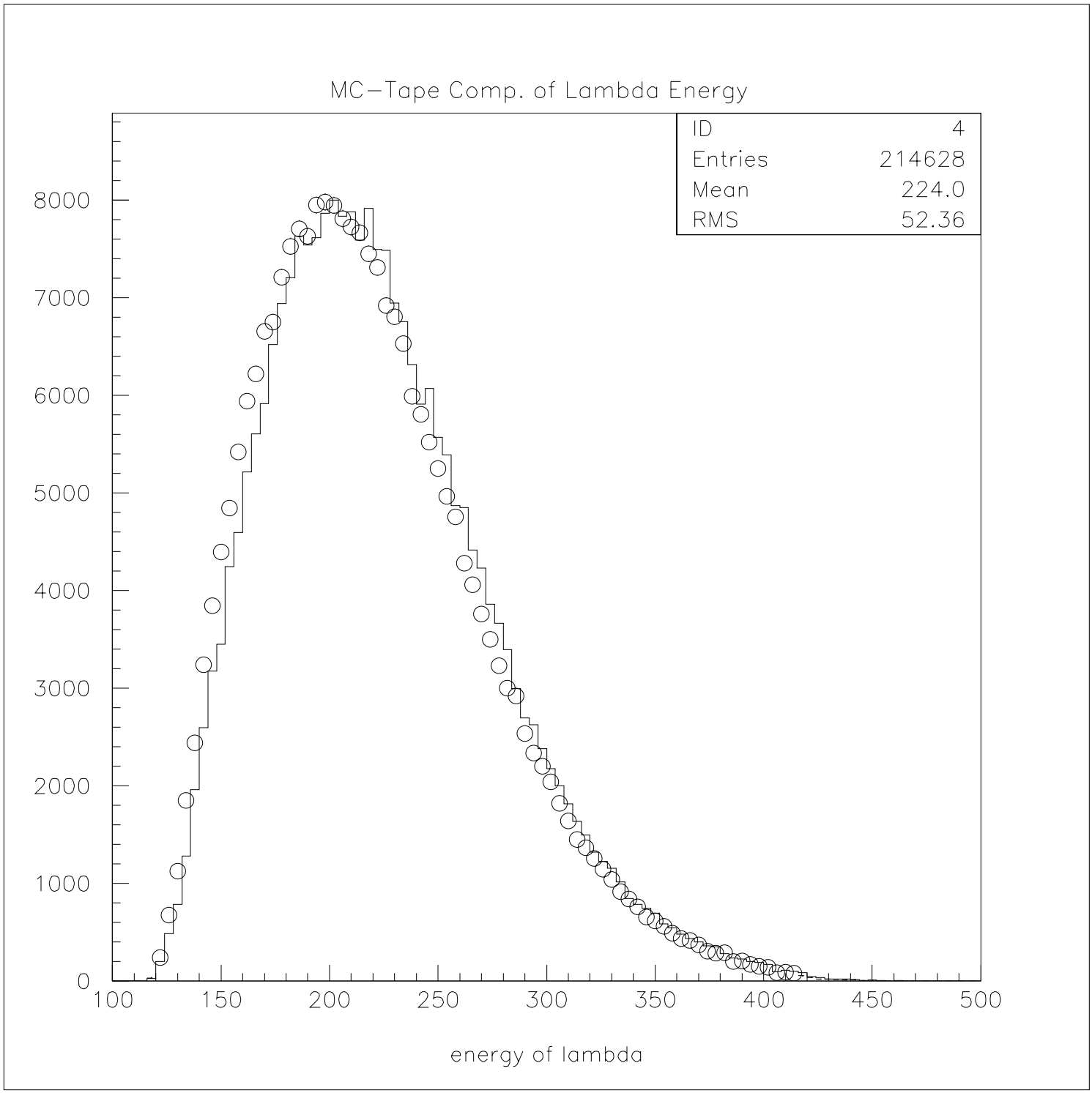
DST Tape #	Events#	Efficiency corrected #
UPH001~ UPH060 (‘99)	2,720,683 ± 1649	101,404,510 ± 308,535
KQHY042~KQHY046 (‘97)	274,299 ± 524	10,223,592 ± 36,197
TOTAL:	2,994,982 ± 1731	111,628,103 ± 338,824

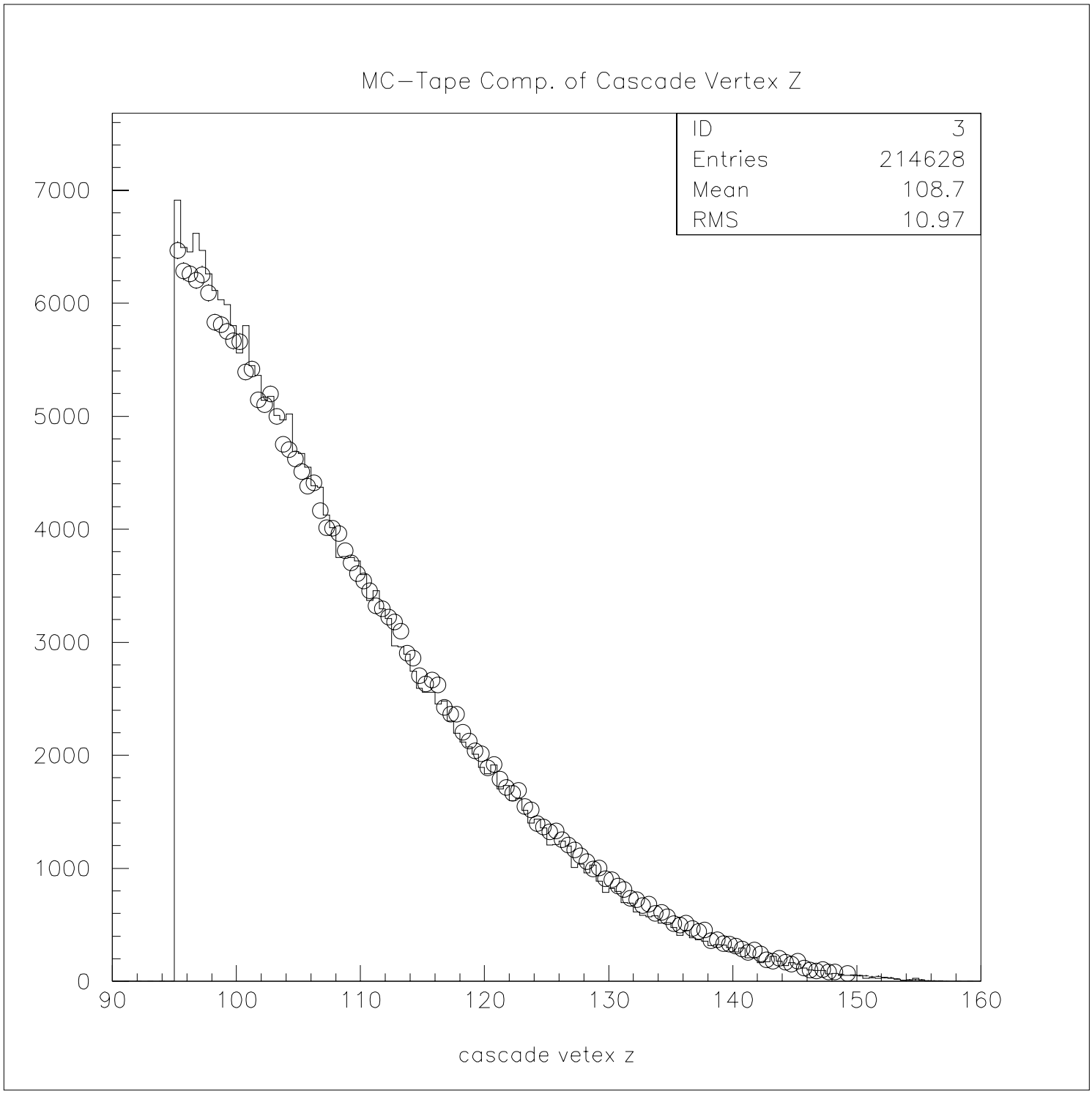
There are about 110 million events in 65 DST tapes.


MC−Tape Comp. of Cascade Mass
ID 1
Entries 214628
Mean 1.315
RMS 0.3183E−02
70000
60000
50000
40000
30000
20000
10000
0
1.26
1.28
1.3
1.32
1.34
1.36
1.38
1.4
cascade mass


MC−Tape Comp. of EGammas
ID 5
Entries 214628
Mean 29.15
RMS 11.88
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0 10 20 30 40 50 60 70 80 90 100
energy of gamma1


ID 6
Entries 214628
Mean 11.40
RMS 6.107
20000
17500
15000
12500
10000
7500
5000
2500
0
0 10 20 30 40 50 60 70 80 90 100
energy of gamma2


MC−Tape Comp. of Lambda Energy
ID 4
Entries 214628
Mean 224.0
RMS 52.36
8000
7000
6000
5000
4000
3000
2000
1000
0
100
150
200
250
300
350
400
450
500
energy of lambda

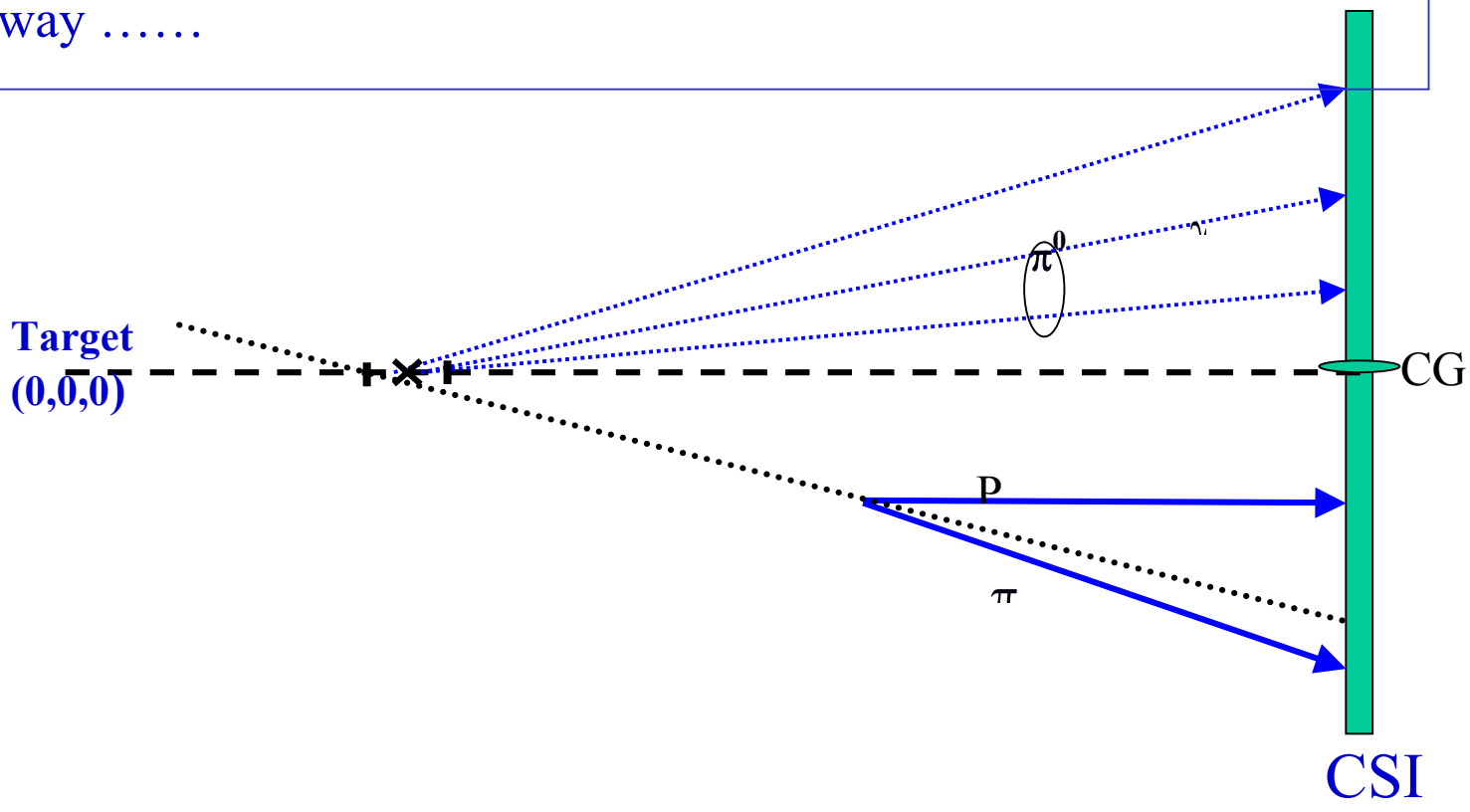

MC−Tape Comp. of Cascade Vertex Z
ID 3
Entries 214628
Mean 108.7
RMS 10.97
7000
6000
5000
4000
3000
2000
1000
0
90
100
110
120
130
140
150
160
cascade vetex z

$\Xi^0 \rightarrow \Lambda\, \pi^0\, \gamma$ Selection Cuts

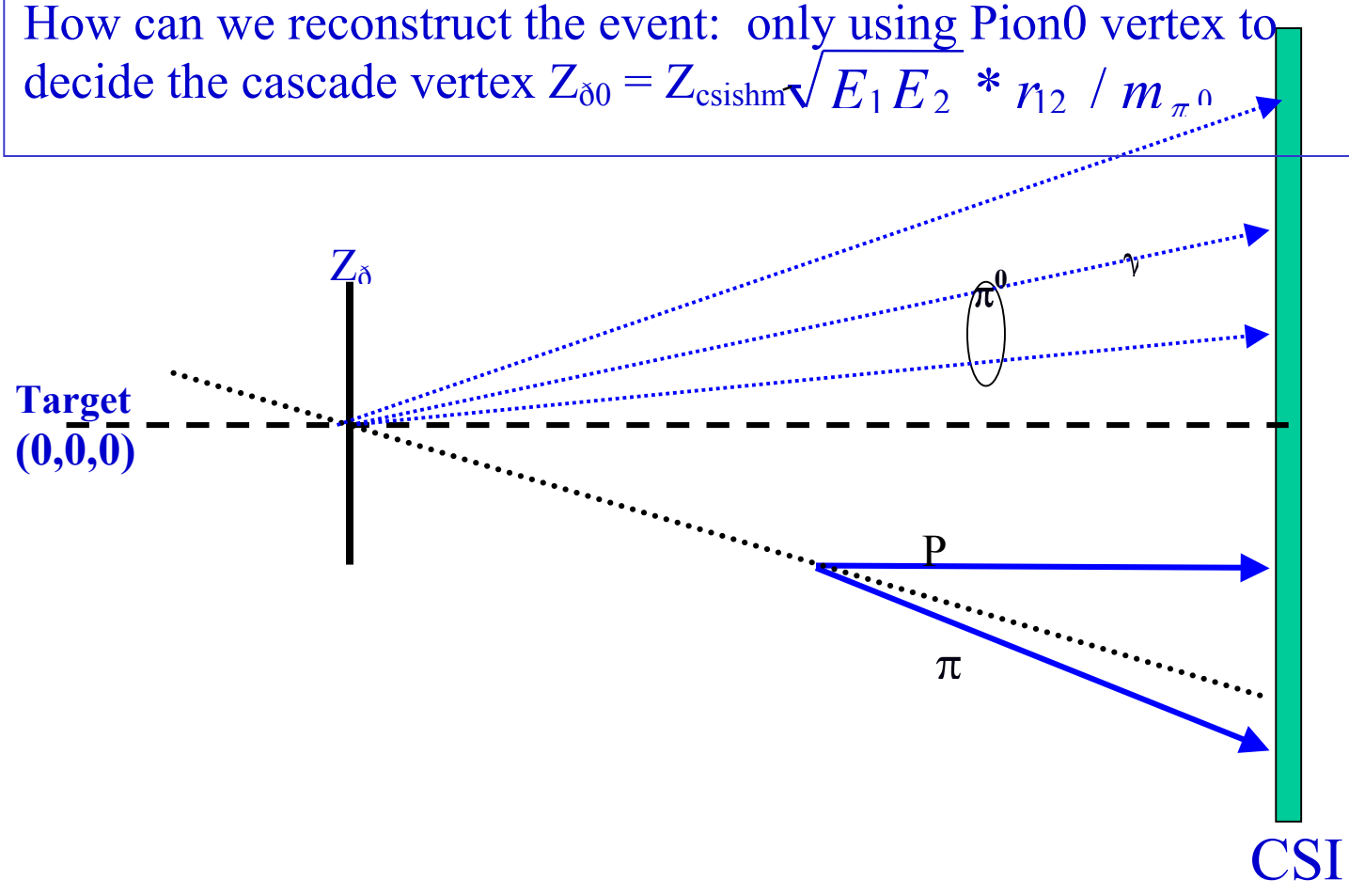
$E_{\gamma} > 3.0$ Gev, $E_{\gamma i} + E_{\gamma j} > 18$Gev, $Z = Z_{CSI} - R_{ij}(\sqrt{E_{\gamma i} E_{\gamma j}})/M_{\pi 0}$
All γ **s** are at least 20cm away from where the π^- hits the calorimeter.
Number of neutral cluster number = 3
$95 < Z_{\Xi}, Z_{\Lambda} < 158$, $.000376 < X_{\Xi}/Z_{\Xi}, X_{\Lambda}/Z_{\Lambda} < .00124$, $Y_{\Xi}/Z_{\Xi}, Y_{\Lambda}/Z_{\Lambda} < .00043$, $Z_{\Lambda} > Z_{\Xi}$
$0.075 < \lvert X_{\mathbf{p}} \rvert < 0.225$ and $\lvert Y_{\mathbf{p}} \rvert < .075$; $\lvert Y_{\pi^-} \rvert > .09$ or $\lvert X_{\pi^-} \rvert < .06$ or $\lvert X_{\pi^-} \rvert > 0.24$ at calorimeter
110 Gev $< P_{\mathbf{p}} <$ 375Gev, 20Gev $< P_{\pi^-} <$ 80Gev
$P_T^2{}_{\Lambda} > 0.0001$ Gev^2 (get rid of primal Λ)
$\lvert M_{\mathbf{p}\,\pi^-} - 1.115684 \rvert < 0.005$Gev, $M_{\Lambda\,\pi^0} < 1.275$Gev, $M_{\mathbf{kaon}} > 0.55$ Gev
$2.9 < P_{\mathbf{p}}/P_{\pi^-} < 9.0$
$E_{\pi^-}/P_{\pi^-} < 0.55$
Co-planarity: coplr($\Xi^0\, \Lambda\, \pi^0$) < 0.96 for decay $\Xi^0 \rightarrow \Lambda\, \pi^0\, \gamma$
$P_{\mathbf{T}}^2{}_{\Xi} < 0.0005$ Gev^2

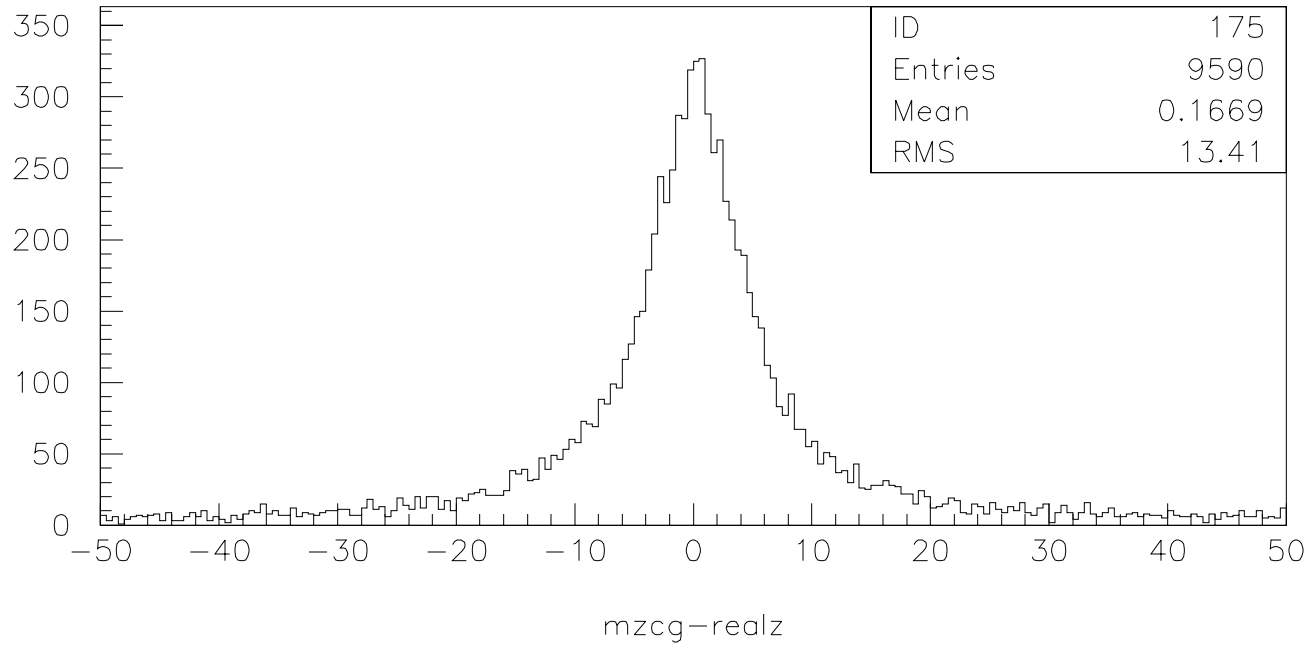
Some Cuts explanation

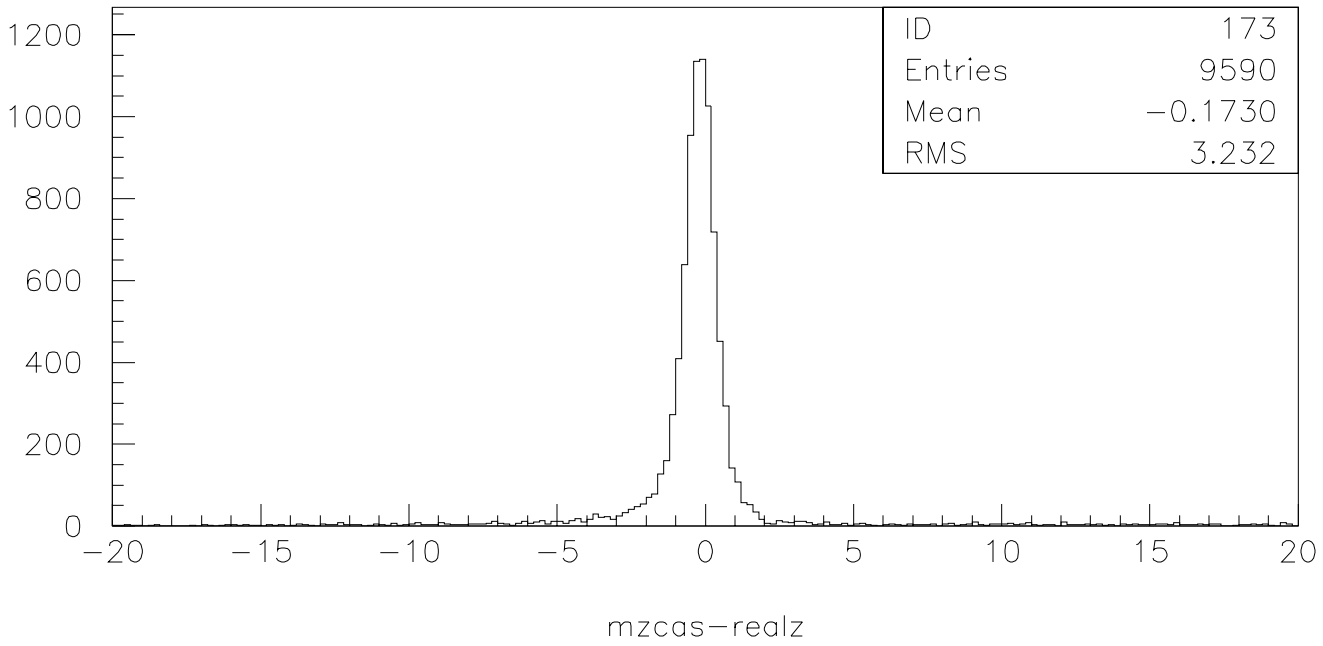
How can we reconstruct the event: Center of Gravity is not a good way ……

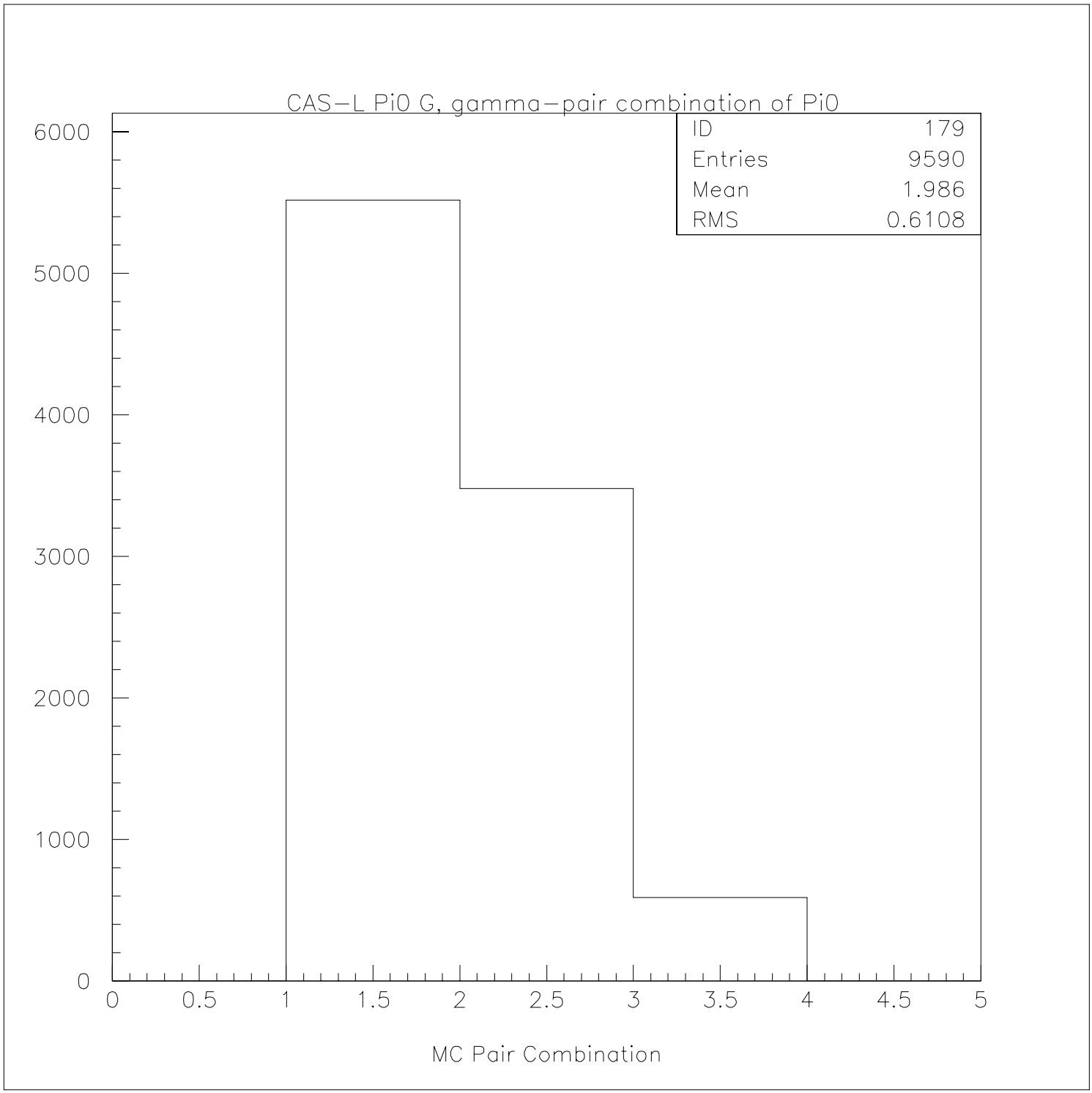


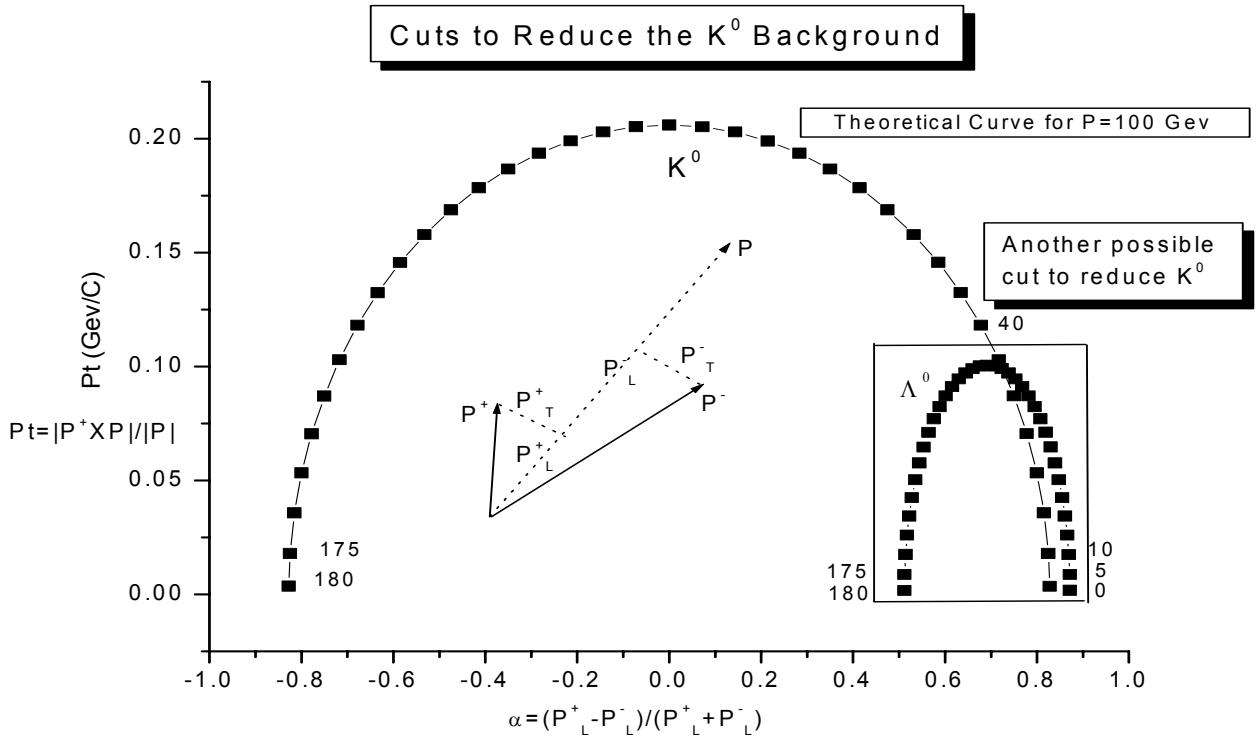
How can we reconstruct the event: only using Pion0 vertex to decide the cascade vertex $Z_{\delta 0} = Z_{csishm} \sqrt{E_1 E_2} * r_{12} / m_{\pi 0}$

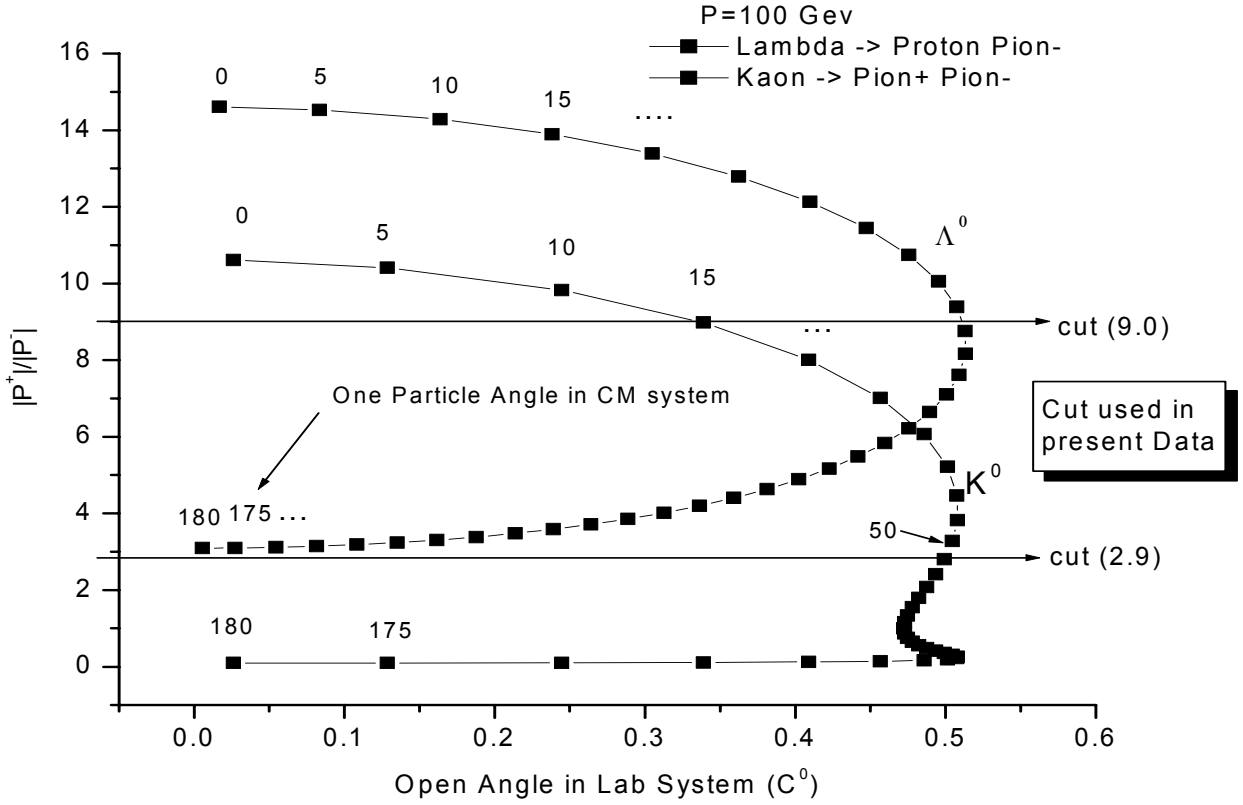


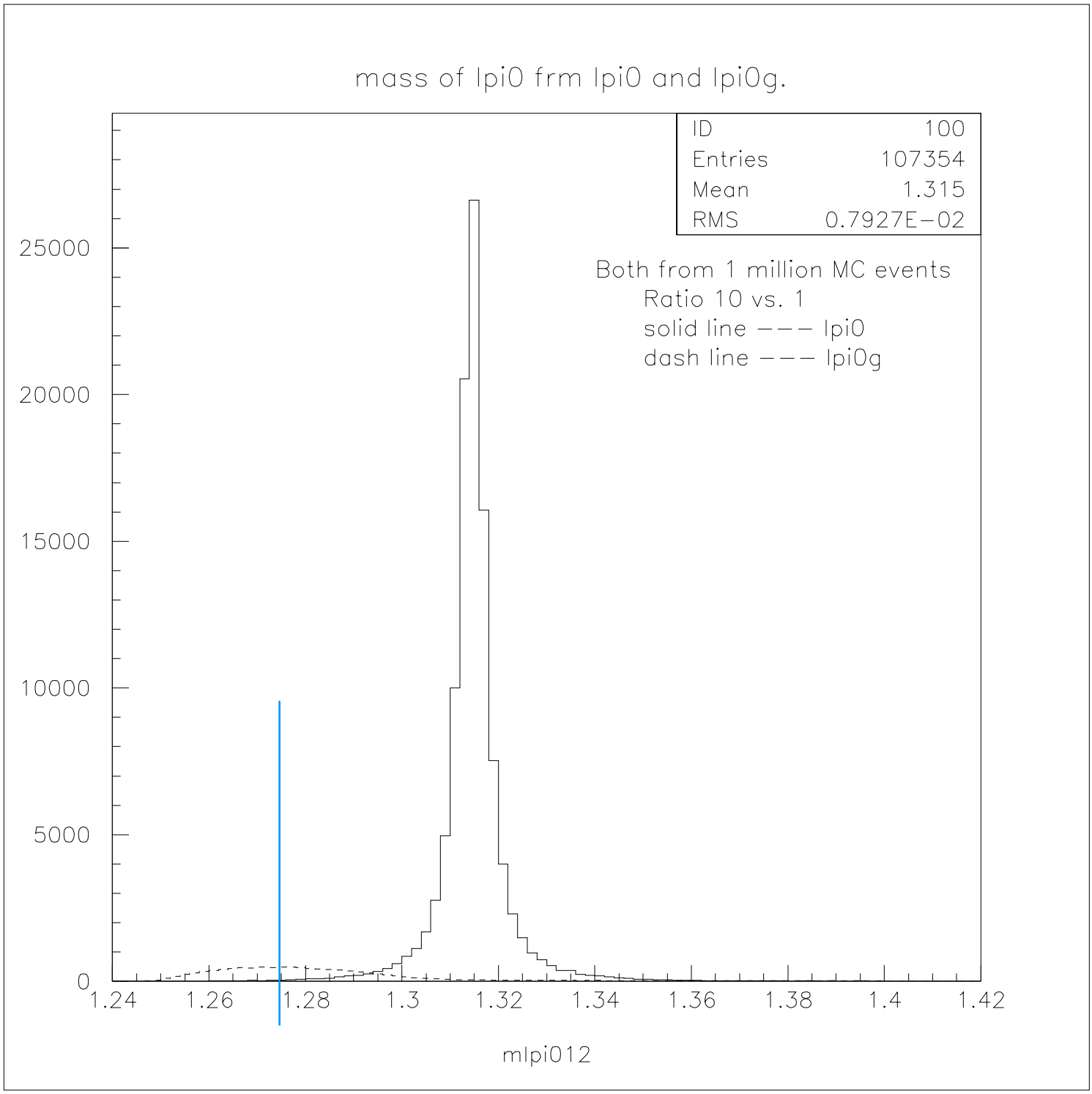

ID 175
Entries 9590
Mean 0.1669
RMS 13.41
350
300
250
200
150
100
50
0
−50 −40 −30 −20 −10 0 10 20 30 40 50
mzcg−realz

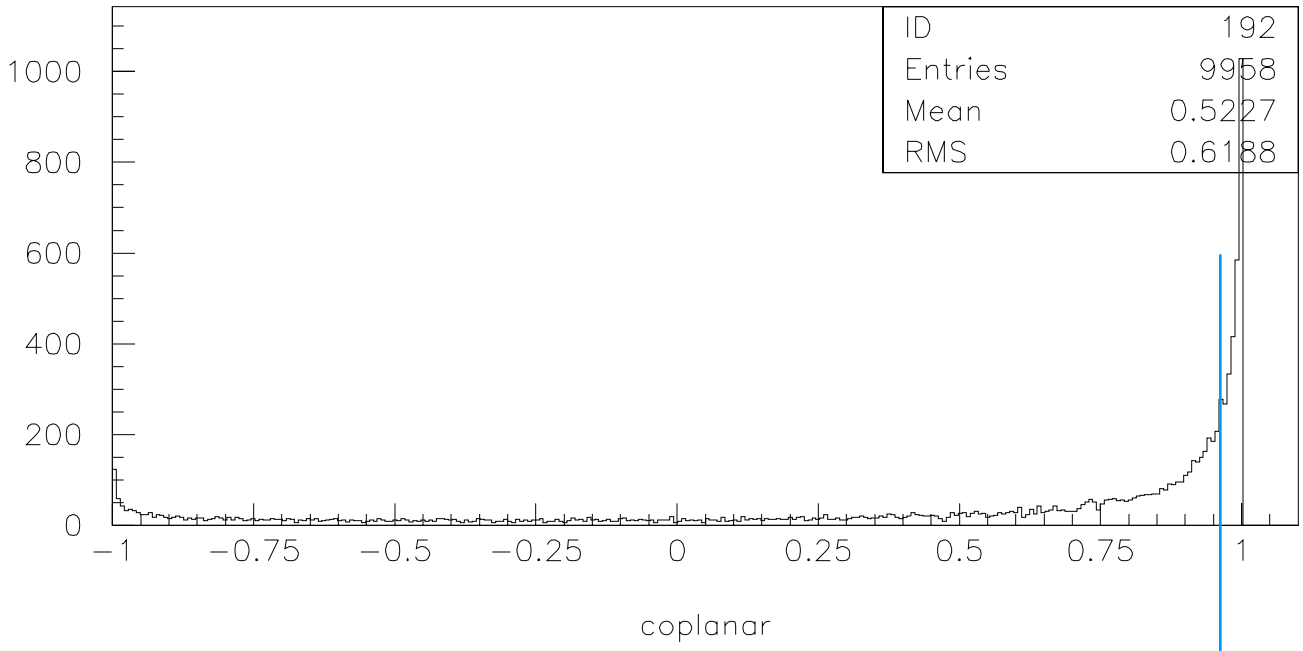

ID 173
Entries 9590
Mean −0.1730
RMS 3.232
1200
1000
800
600
400
200
0
−20 −15 −10 −5 0 5 10 15 20
mzcas−realz

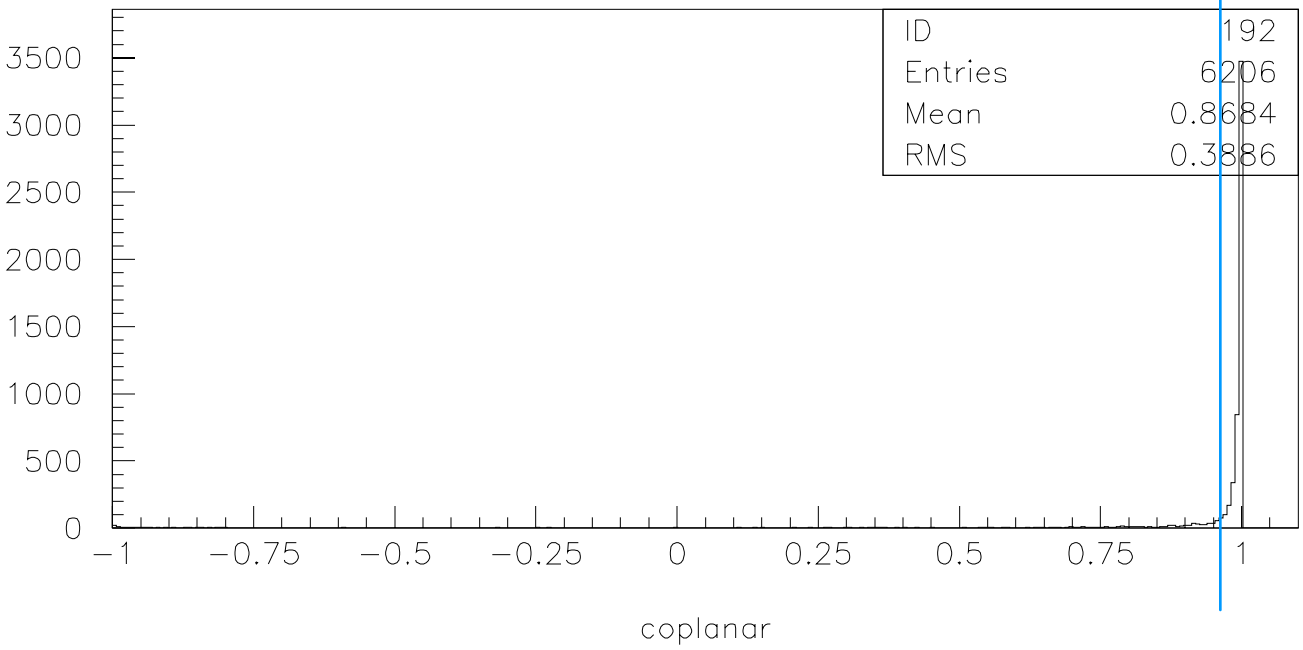

CAS−L Pi0 G, gamma−pair combination of Pi0
ID 179
Entries 9590
Mean 1.986
RMS 0.6108
6000
5000
4000
3000
2000
1000
0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
MC Pair Combination


Cuts to Reduce the K⁰ Background
Theoretical Curve for P=100 Gev
K⁰
Another possible cut to reduce K⁰
Pt (Gev/C)
Pt=|P⁺XP|/|P|
α=(P⁺L-P⁻L)/(P⁺L+P⁻L)
P
P⁺T
P⁺L
P⁻T
P⁻
P⁺
175
180
40
Λ⁰
10
5
0


P=100 Gev
Lambda -> Proton Pion-
Kaon -> Pion+ Pion-
Λ⁰
K⁰
cut (9.0)
cut (2.9)
One Particle Angle in CM system
Cut used in present Data
|P⁺|/|P⁻|
Open Angle in Lab System (C⁰)

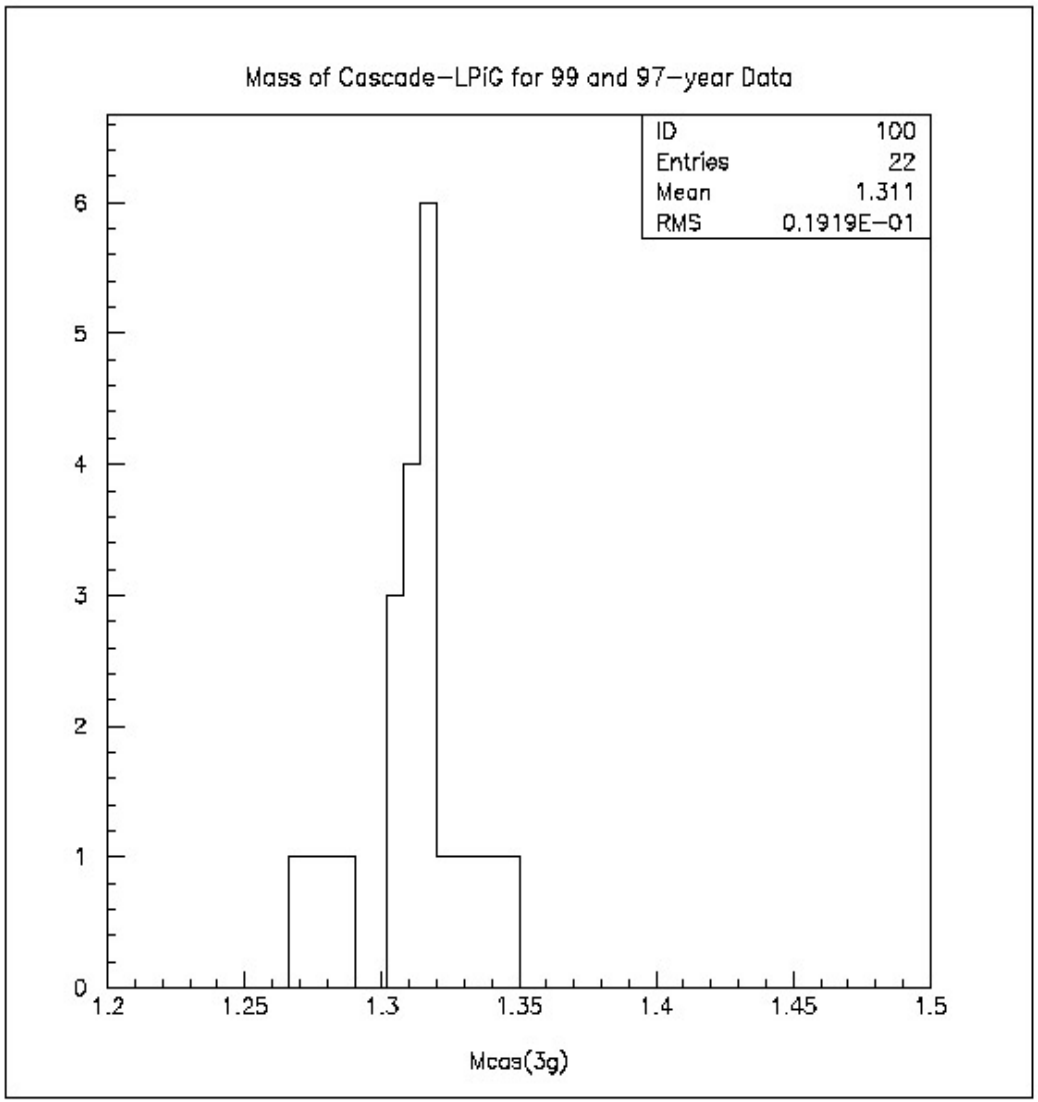

mass of lpi0 frm lpi0 and lpi0g.
ID 100
Entries 107354
Mean 1.315
RMS 0.7927E−02
Both from 1 million MC events
Ratio 10 vs. 1
solid line −−− lpi0
dash line −−− lpi0g
25000
20000
15000
10000
5000
0
1.24
1.26
1.28
1.3
1.32
1.34
1.36
1.38
1.4
1.42
mlpi012


ID 192
Entries 9958
Mean 0.5227
RMS 0.6188
1000
800
600
400
200
0
−1
−0.75
−0.5
−0.25
0
0.25
0.5
0.75
1
coplanar

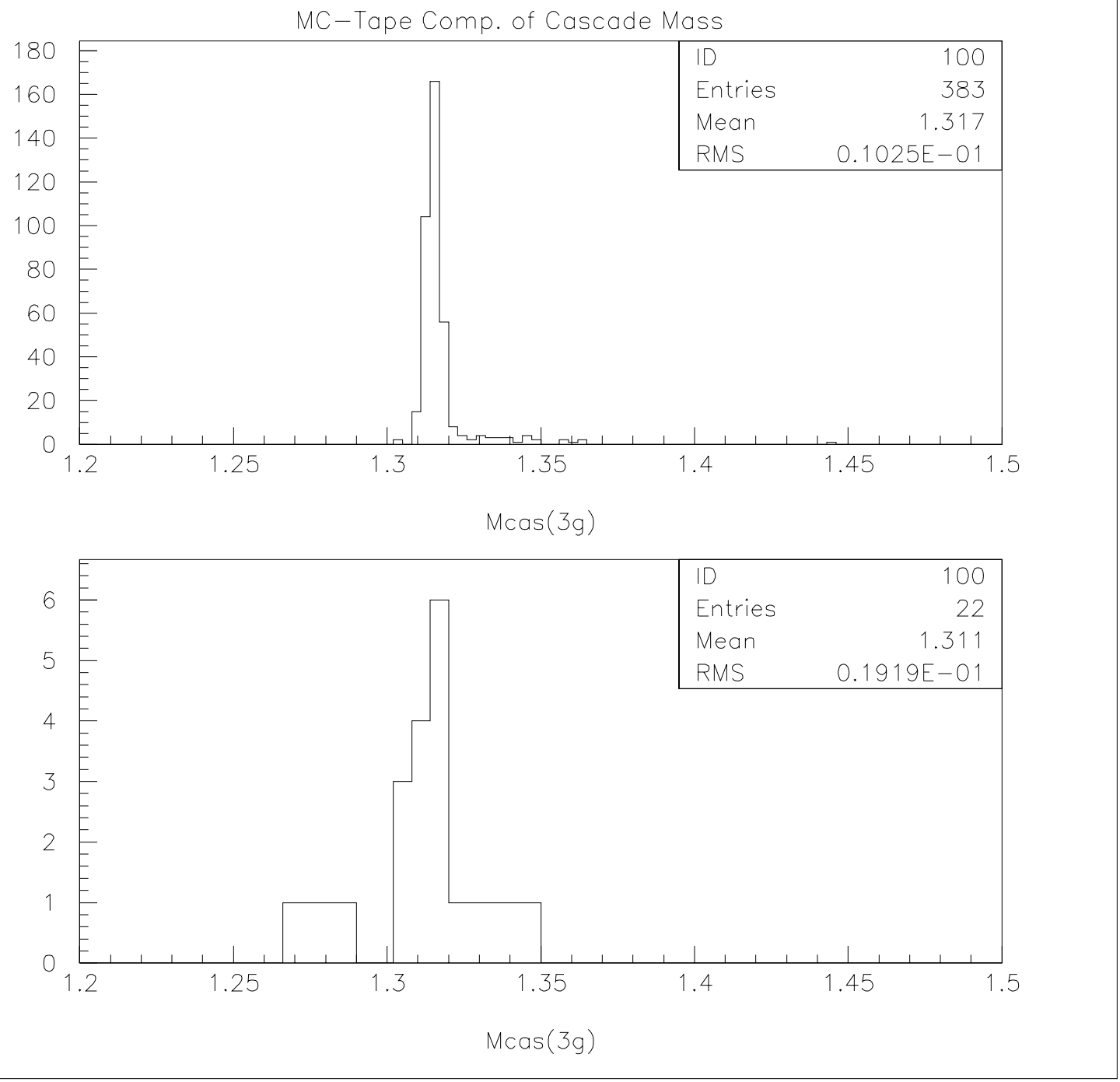

ID 192
Entries 6206
Mean 0.8684
RMS 0.3886
3500
3000
2500
2000
1500
1000
500
0
−1
−0.75
−0.5
−0.25
0
0.25
0.5
0.75
1
coplanar

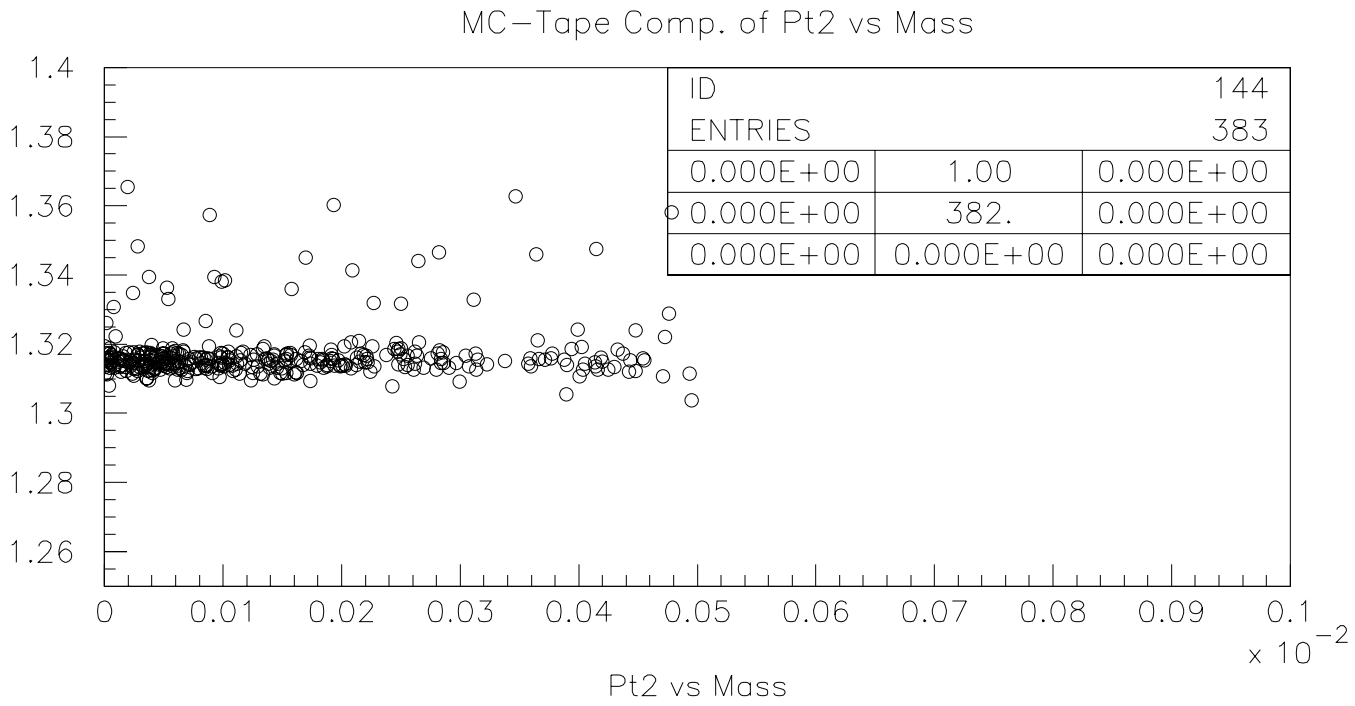
Preliminary Results

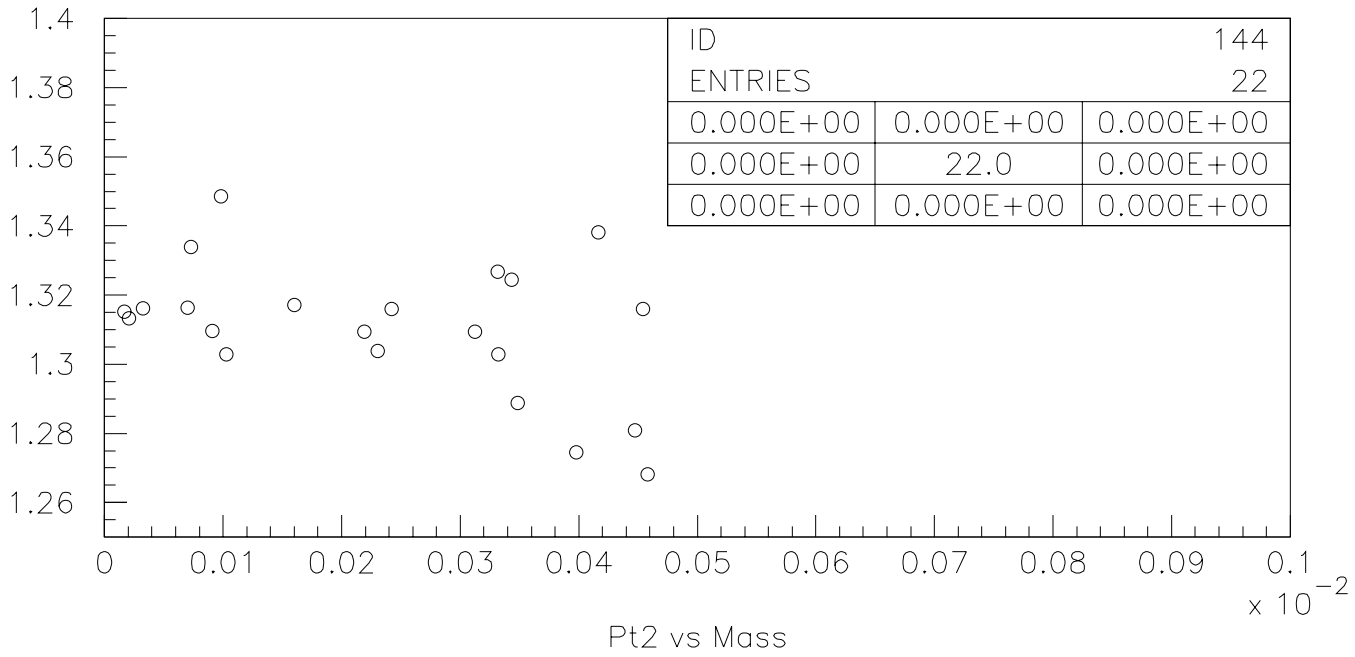
$\Xi^0 \rightarrow \Lambda\, \pi^0\, \gamma$ Branch Ratio (Preliminary)

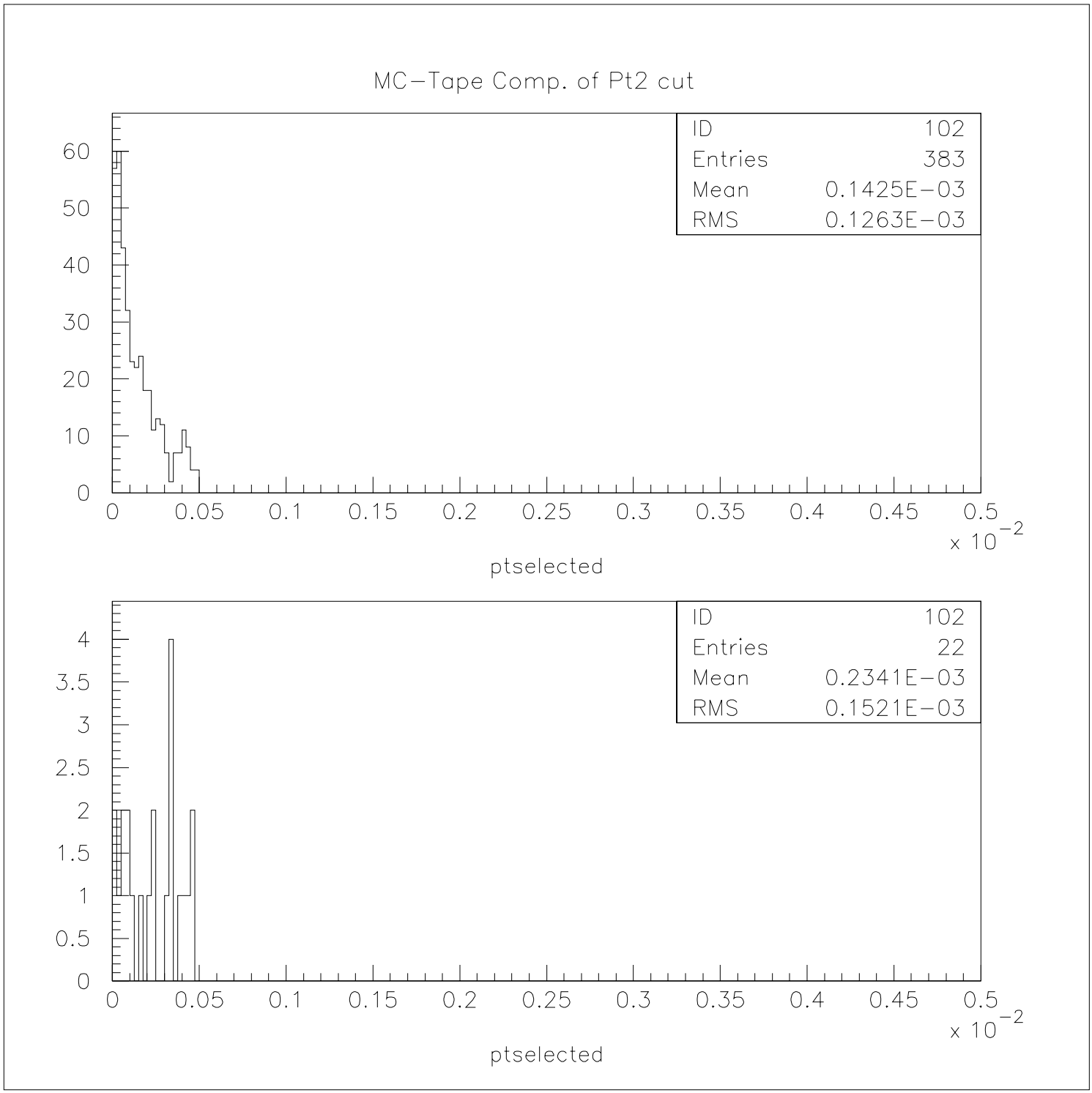


Efficiency of our cuts: $(3.904 \pm 0.197)\times10^{-3}$ From Monte Carlo.
From the plot, we got (22 ± 4.69) events with statistical error (no B.K subtraction).
Got Efficiency corrected events: (5635 ± 1235) events
Finally we got: $BR=(5.048 \pm 1.106)\times10^{-5}$ (Upper limit)


MC−Tape Comp. of Cascade Mass
ID 100
Entries 383
Mean 1.317
RMS 0.1025E−01
180
160
140
120
100
80
60
40
20
0
1.2
1.25
1.3
1.35
1.4
1.45
1.5
Mcas(3g)
ID 100
Entries 22
Mean 1.311
RMS 0.1919E−01
6
5
4
3
2
1
0
1.2
1.25
1.3
1.35
1.4
1.45
1.5
Mcas(3g)


MC−Tape Comp. of Pt2 vs Mass
ID 144
ENTRIES 383
0.000E+00 1.00 0.000E+00
0.000E+00 382. 0.000E+00
0.000E+00 0.000E+00 0.000E+00
1.4
1.38
1.36
1.34
1.32
1.3
1.28
1.26
0 0.01 0.02 0.03 0.04 0.05 0.06 0.07 0.08 0.09 0.1
x 10^-2
Pt2 vs Mass


ID 144
ENTRIES 22
0.000E+00 0.000E+00 0.000E+00
0.000E+00 22.0 0.000E+00
0.000E+00 0.000E+00 0.000E+00
1.4
1.38
1.36
1.34
1.32
1.3
1.28
1.26
0 0.01 0.02 0.03 0.04 0.05 0.06 0.07 0.08 0.09 0.1
x 10^-2
Pt2 vs Mass


MC−Tape Comp. of Pt2 cut
ID 102
Entries 383
Mean 0.1425E−03
RMS 0.1263E−03
60
50
40
30
20
10
0
0 0.05 0.1 0.15 0.2 0.25 0.3 0.35 0.4 0.45 0.5
x 10^−2
ptselected
ID 102
Entries 22
Mean 0.2341E−03
RMS 0.1521E−03
4
3.5
3
2.5
2
1.5
1
0.5
0
0 0.05 0.1 0.15 0.2 0.25 0.3 0.35 0.4 0.45 0.5
x 10^−2
ptselected

$\Xi^0 \rightarrow \Lambda\, \pi^0\, \gamma$ Background Study

We studied several possible backgrounds:

$\Xi^0 \rightarrow \Lambda\, \pi^0$ with accidental γ, $\Lambda \rightarrow p^+\, \pi^-$ 60 million (we have about **111** million) events of above decay mode are generated and studied, no background events are found .
$\Xi^0 \rightarrow \Lambda\, \pi^0$ with $\Lambda \rightarrow p^+\, \pi^-\, \gamma$ The BR of $\Lambda \rightarrow p^+\, \pi^-\, \gamma$ is $(8.4 \pm 1.4)\times10^{-4}$, so we need: $8.4 \times10^{-4}\times10^{8} \sim$ 84K events, we generated and studied 100K events, no background events are found
$\Xi^0 \rightarrow \Sigma\, \gamma$ with $\Sigma \rightarrow \Lambda\, \gamma$ with accidental γ The BR of $\Xi^0 \rightarrow \Sigma\, \gamma$ is $(3.34 \pm 0.05)\times10^{-3}$, so we need : $3.34\times10^{-3} \times10^{8} \sim 334$K events. We generated and studied 500K events, ***2 background*** events are found.

We should study more possible backgrounds in the future.

Conclusion and Future Plan:

- It is promising that there are signals of the decay mode:

$\Xi^0 \rightarrow \Lambda\, \pi^0\, \gamma$, and we give the preliminary BR=(5.048± 1.106)x10^{-5}

- Determine the systematic error due background uncertainty.
- Other background sources?
- Theoretical prediction?
- Troubling:

  1: Width of Ξ^0 mass

  2: Pt2 distribution of $\Xi^0 \rightarrow \Lambda\, \pi^0\, \gamma$ events is not good.