GEM TN-93-261

Reconstruction of 135 GeV Higgs From Z, Z Star Into Four Muons

Peter Dingus
SSC Laboratory

December 22, 1992

Abstract:

We have reconstructed the Higgs $\rightarrow$ ZZ* $\rightarrow$ 4 muons, for a Higgs mass of M_H =135 GeV. The soft P_T spectrum of the muons coming from this low mass Higgs can suffer large relative energy losses resulting in both a substantial shift and loss of resolution in the M_H distribution. We apply a simple algorithm to replace the missing muon energy and greatly improve both the mean value and resolution of the M_H distribution.

Peter Dingus 12/22/92

H_0 = > ZZ* - > 4MU

Higgs Production in the Channels:

$f + \bar{f}$ => H_0 ->ZZ* -> 4MU
g + g => same
f + f' => f + f' + H_0 -> same
f +f' = > f'' + f''' + H_0 -> same

for a Higgs of mass 135 GeV. This is a significant low mass Higgs decay mode for Gem. It is especially important for Gem to show that it has been adequately designed to cover this mass range for the Higgs, the PAC were concerned with this decay mode and choose to address the electron channel assuming that there would be no problem in the muon channel. However, this is an important test or the muon system since the muons coming from the decay of the Z* can lose a significant percentage of their energy in the calorimeter and can even range out. There is also some question that a sufficiently good resolution can be maintained on the muon momentum measurement since fluctuations incurred in energy loss in the calorimeter can be large for low energy muons. This is the reason for looking at the lowest possible Higgs Mass in this channel, so as to induce the largest possible loss of resolution. In Figure 1 is shown the momentum resolution measured for 10 GeV muons in the Gem Baseline 1. We have measured, for the 135 GeV H_0, a shift in the peak of about 17 GeV or 13% from the true position. More importantly the resolution of the peak for the resulting H_0 distribution without correction for energy loss is measured from a fit to be 6.9% while correcting this distribution in a systematic way results in a peak that is off by only 0.7% from its true position with a resolution of 2.2%. These two peaks uncorrected and corrected are shown in Figures 3 and 4 respectively. The correction was made by compiling many (500,000 simulated events) events and using the average value of the de/dx distributions as a function of the initial muon direction to restore the energy. At these low muon energies, in the range of 10 GeV, the muon can lose as much as 30% of its initial energy. However, at these energies the probability of hard bremsstrahlung is extremely small keeping the energy loss distributions narrow with a very small tail. Energy loss spectrums in Lkr/Pb, Cu/Scin, and Lar/Cu are shown in Figure 2.

A) All combinations of oppositely charged muons are taken in pairs until the best Z is found in the interval between 80.0 GeV and 95 GeV. If some pair is not found in this interval the event is dropped.

This happens 11% of the time. The Z spectrum is shown in Figure 5.

B) Approximately 16% of the real Higgs events have more than 4 muons and we require at least 2 other muons once the candidate is found. From this criterion 0.3% of the events are lost or one in 300.

C) Approximately 1% of the events are lost via a muon ranging out in the calorimeter.

D) The trigger was arranged so as to pass an event if;

1) one muon $\geq$ 20 GeV
2) two muons $\geq$ 10 GeV

The trigger efficiency was calculated to be Sum (Trig)/Sum (events)= 90%.This assumes 1.35 cm RPC pads in the barrel and 0.5 cm pads in the end caps.

E) The largest loss by far was due to acceptance. A fit to the 4 muon Higgs peak yields 28% of the original Higgs. 77% of the losses were from acceptance losses in η, and 75% of these are lost from one of 4 muons being at $\eta > 2.4$. 10.6% are from losses in phi acceptance.

F) Now, we get a cross section of 4.4 X 10^{-12} mb which translates into 44 events/yr for L = 10^{33} and 1yr = 10^7 sec. With the losses I've described and a 90% trigger efficiency this gives 11 events/yr.

G) I now have the background program running and will try to update this for background ($t\bar{t}$, $b\bar{b}$, ff->ff+Z). Also, I will repeat the procedure for 145 GeV, 170 GeV H_0.

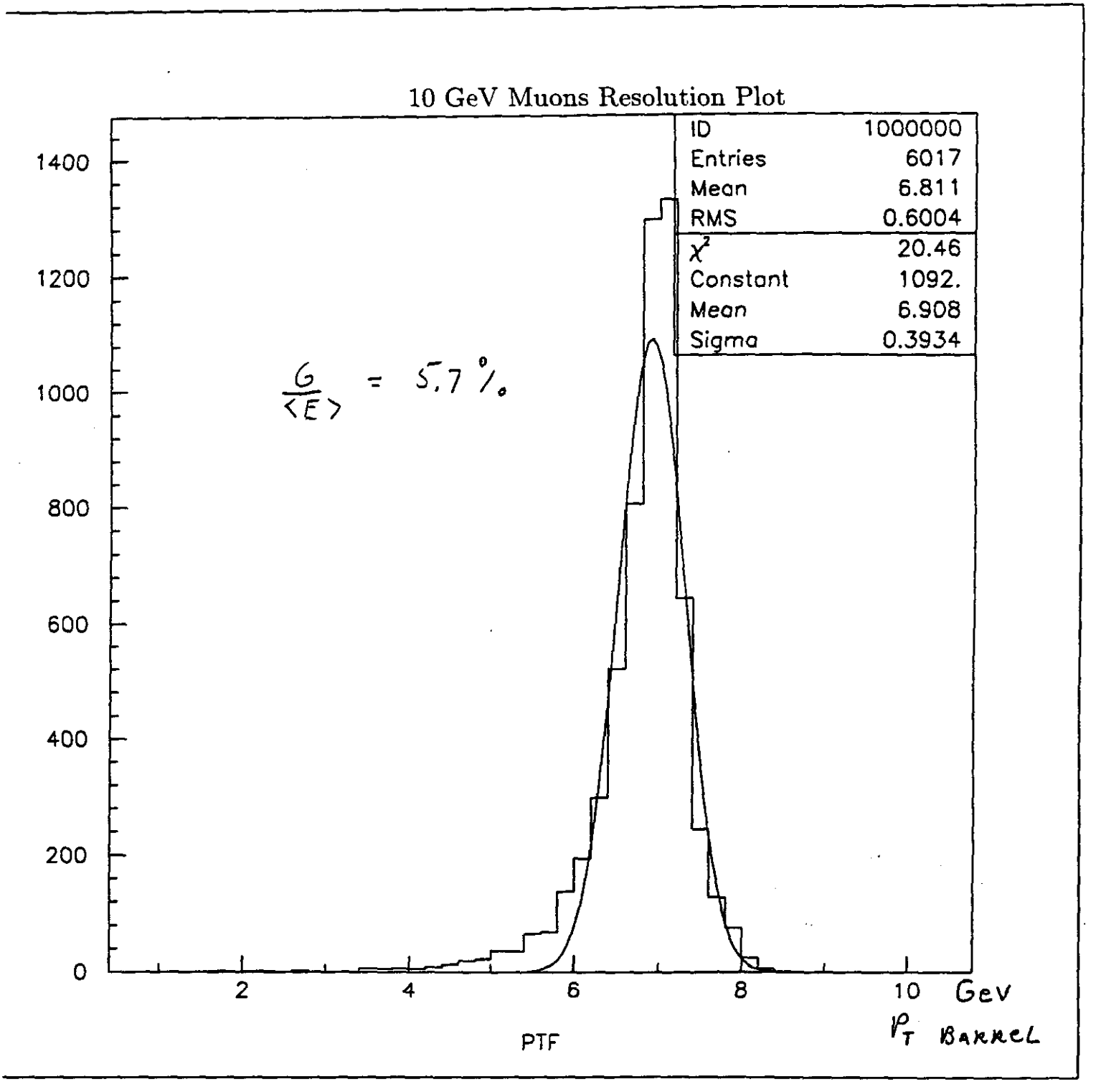
10 GeV Muons Resolution Plot
ID 1000000
Entries 6017
Mean 6.811
RMS 0.6004
χ² 20.46
Constant 1092.
Mean 6.908
Sigma 0.3934
σ/⟨E⟩ = 5.7 %
1400
1200
1000
800
600
400
200
0
2
4
6
8
10
GeV
PTF
P_T BARREL

FIGURE 1

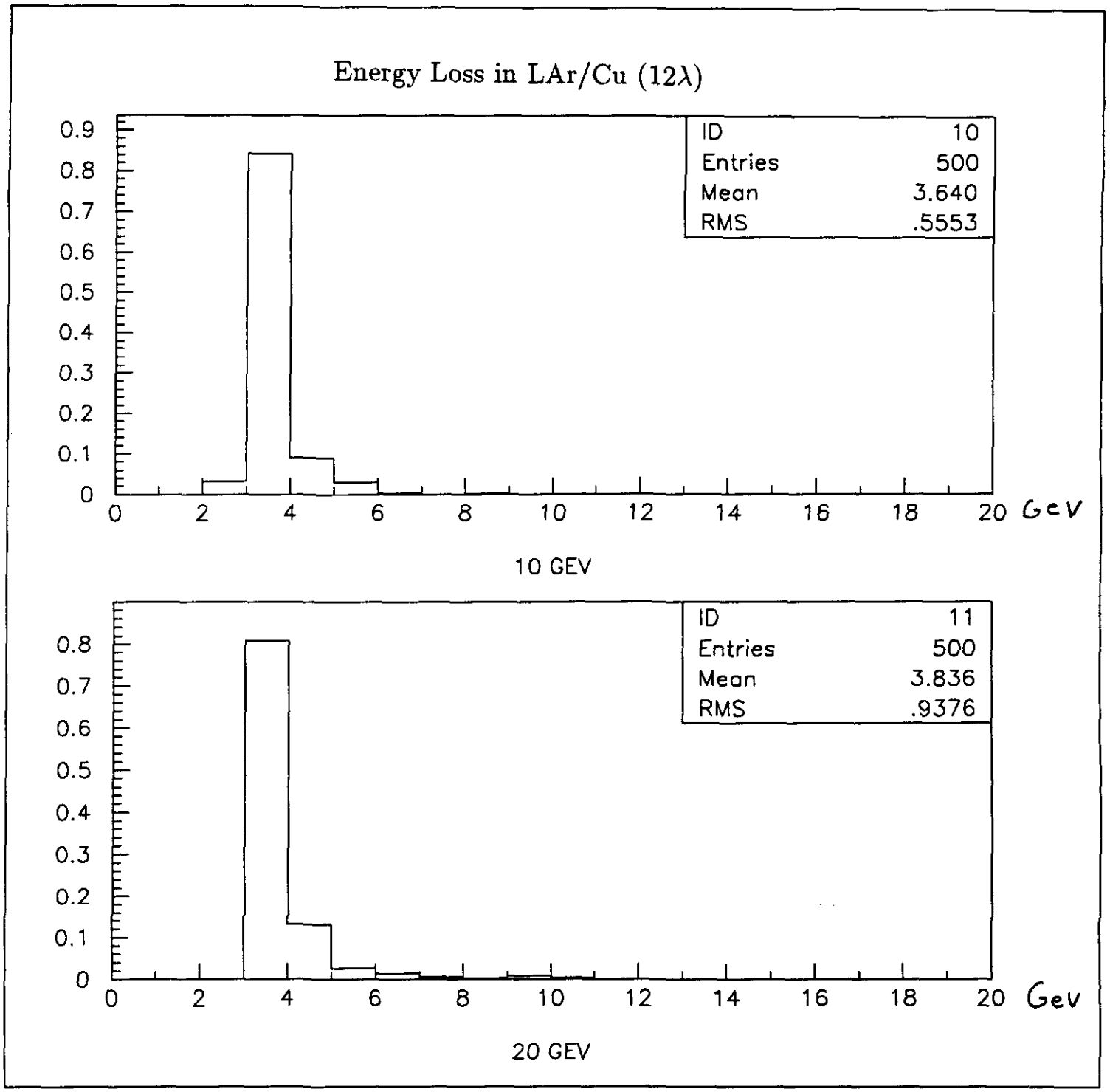
Energy Loss in LAr/Cu (12λ)
ID 10
Entries 500
Mean 3.640
RMS .5553
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0 2 4 6 8 10 12 14 16 18 20 GeV
10 GEV
ID 11
Entries 500
Mean 3.836
RMS .9376
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0 2 4 6 8 10 12 14 16 18 20 GeV
20 GEV

FIGURE 2 a

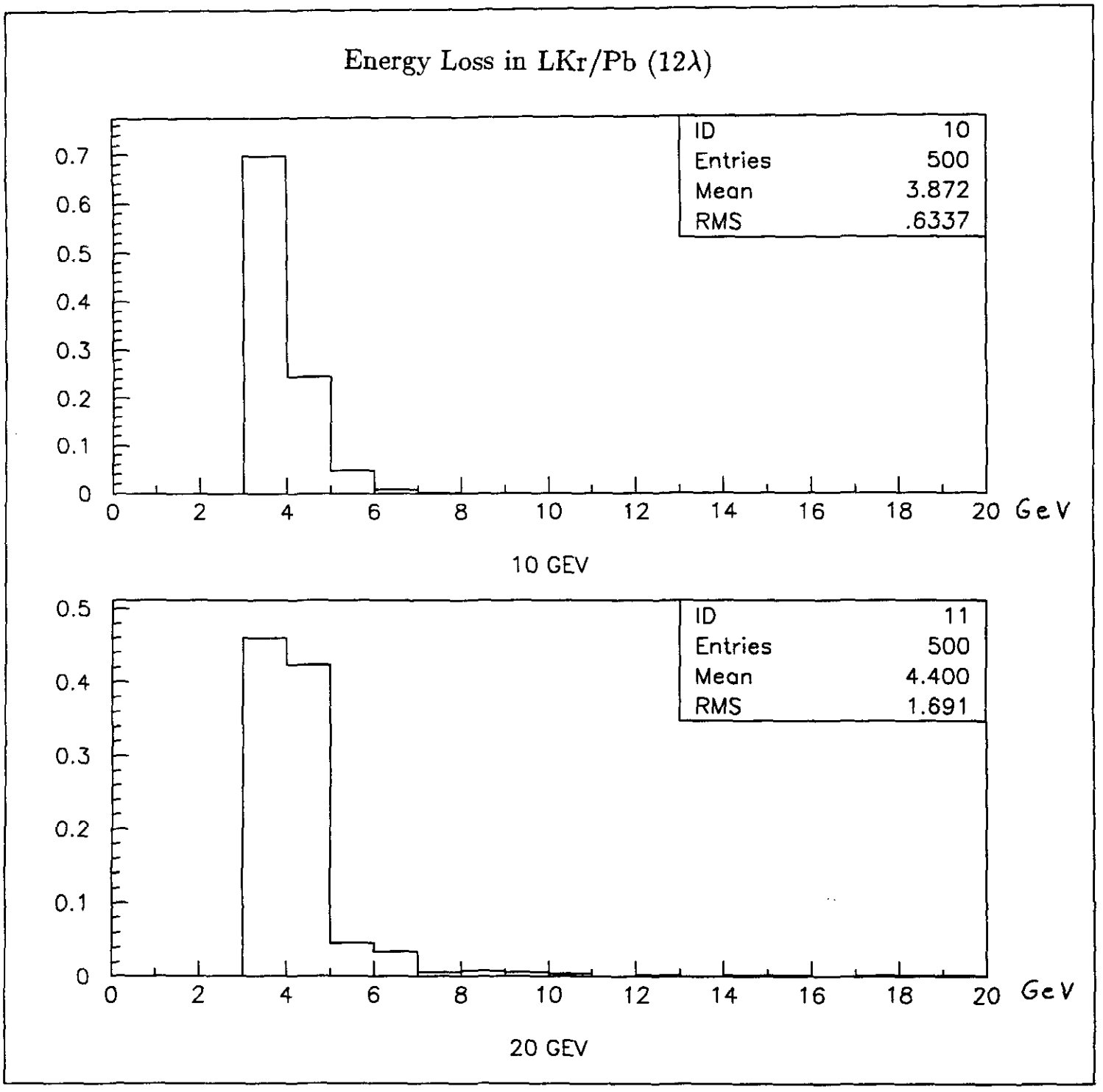
Energy Loss in LKr/Pb (12λ)
ID 10
Entries 500
Mean 3.872
RMS .6337
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0 2 4 6 8 10 12 14 16 18 20 GeV
10 GEV
ID 11
Entries 500
Mean 4.400
RMS 1.691
0.5
0.4
0.3
0.2
0.1
0
0 2 4 6 8 10 12 14 16 18 20 GeV
20 GEV

FIGURE 2 b

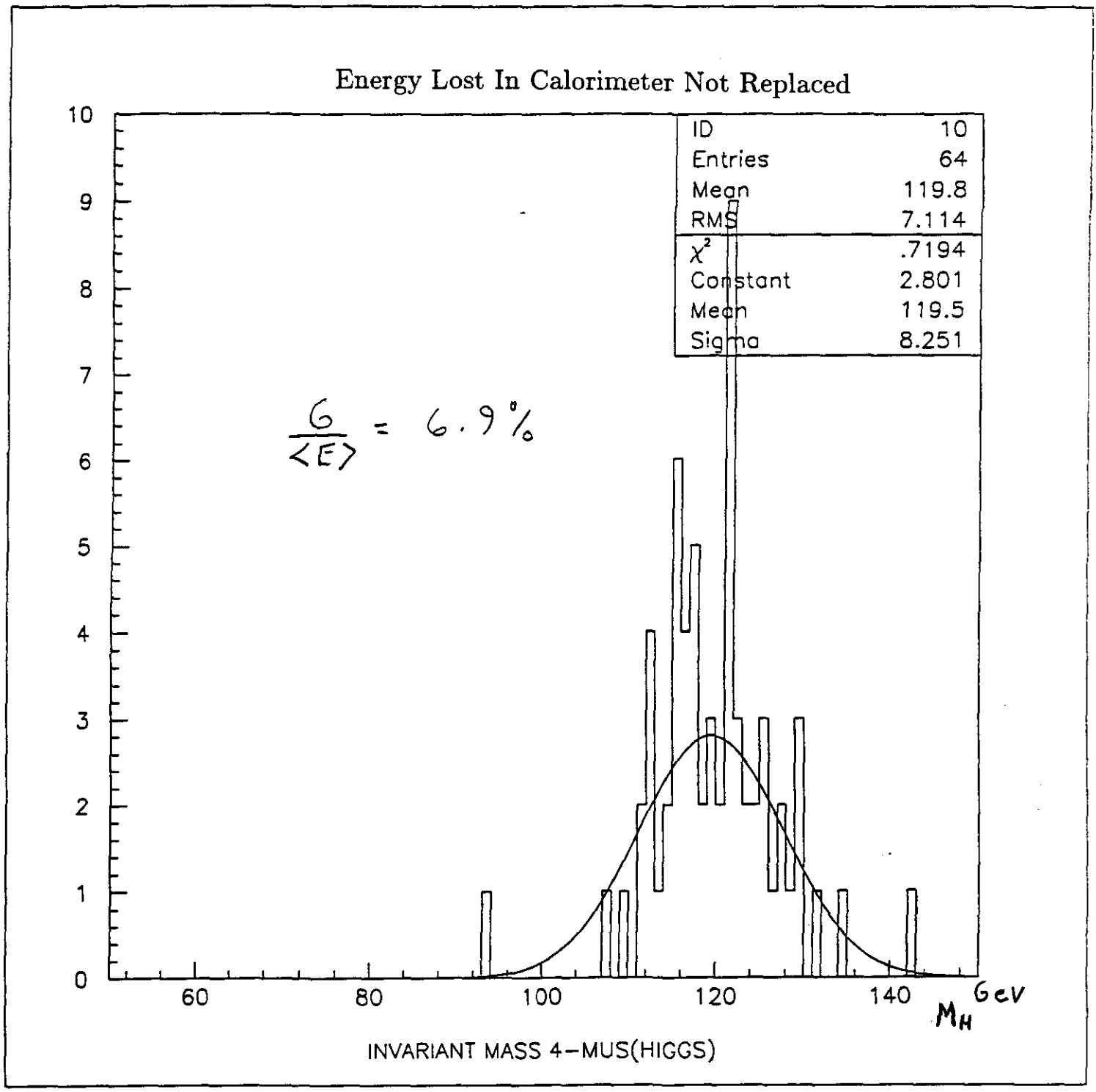
Energy Lost In Calorimeter Not Replaced
ID 10
Entries 64
Mean 119.8
RMS 7.114
χ² .7194
Constant 2.801
Mean 119.5
Sigma 8.251
σ/<E> = 6.9%
0
1
2
3
4
5
6
7
8
9
10
60
80
100
120
140
GeV
M_H
INVARIANT MASS 4-MUS(HIGGS)

FIGURE 3

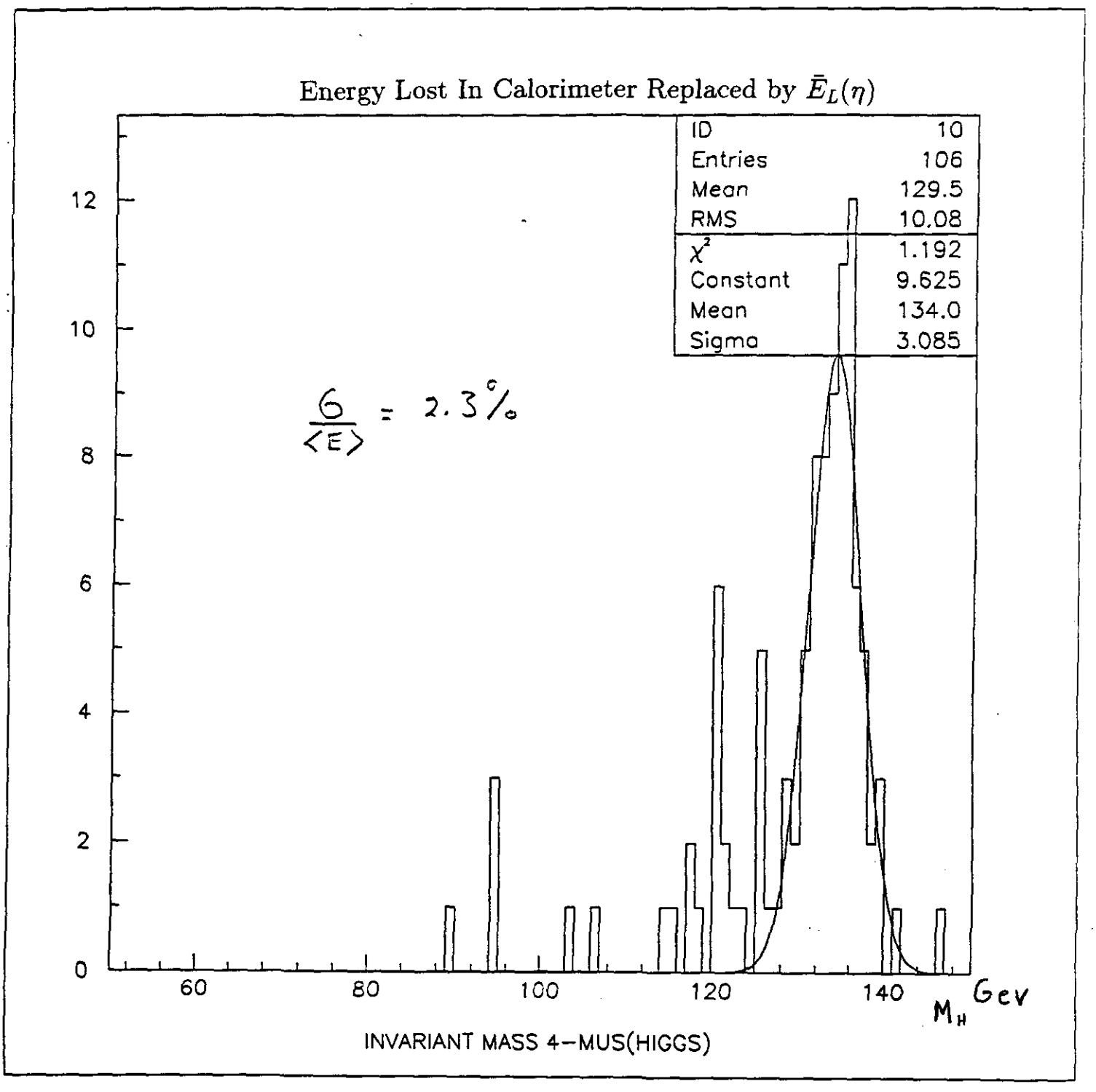
Energy Lost In Calorimeter Replaced by $\bar{E}_L(\eta)$
ID 10
Entries 106
Mean 129.5
RMS 10.08
χ^2 1.192
Constant 9.625
Mean 134.0
Sigma 3.085
$\frac{\sigma}{\langle E \rangle} = 2.3\%$
0
2
4
6
8
10
12
60
80
100
120
140
M_H Gev
INVARIANT MASS 4-MUS(HIGGS)

FIGURE 4

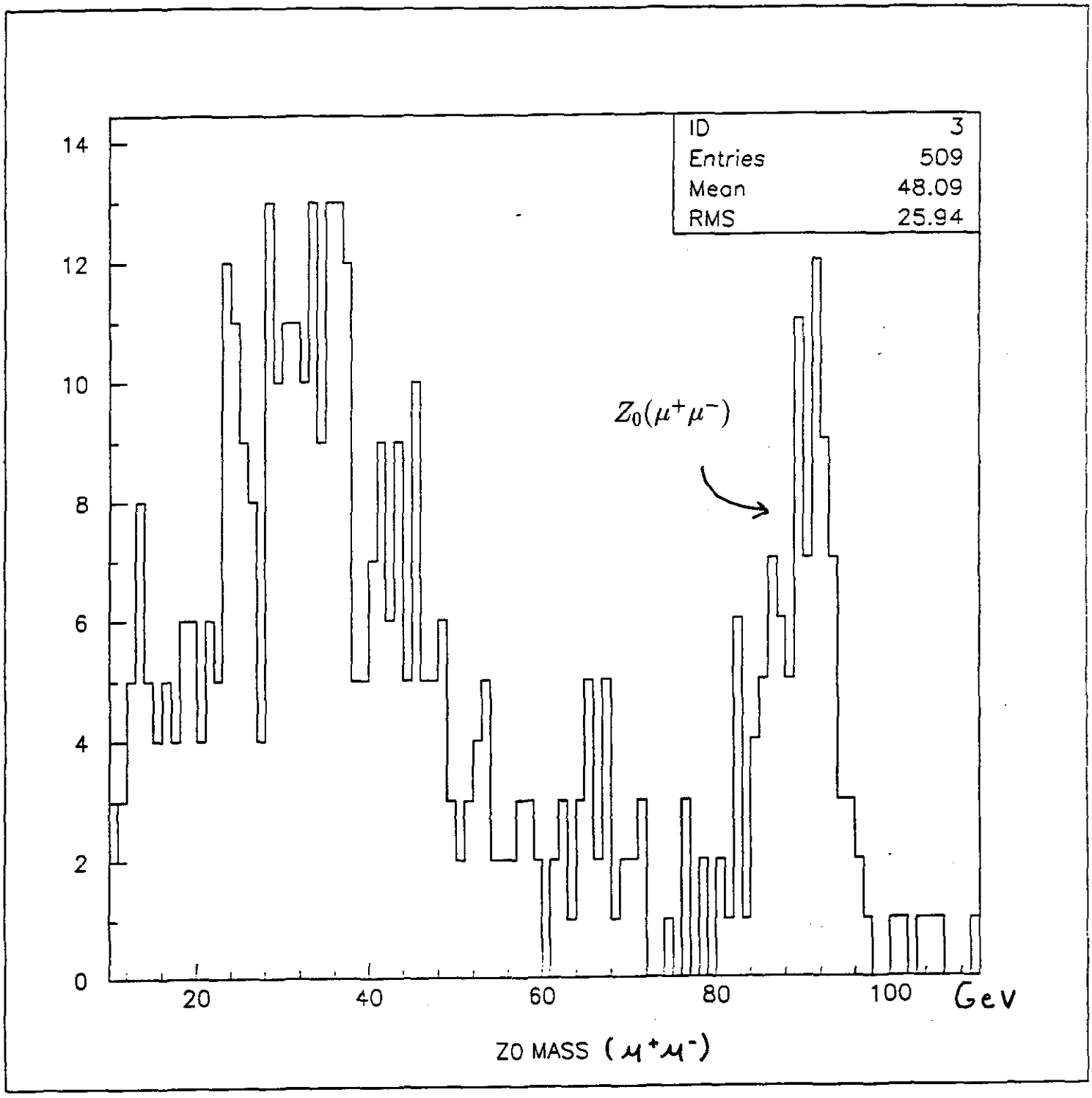
ID 3
Entries 509
Mean 48.09
RMS 25.94
$Z_0(\mu^+\mu^-)$
14
12
10
8
6
4
2
0
20
40
60
80
100
GeV
Z0 MASS ($\mu^+\mu^-$)

FIGURE 5

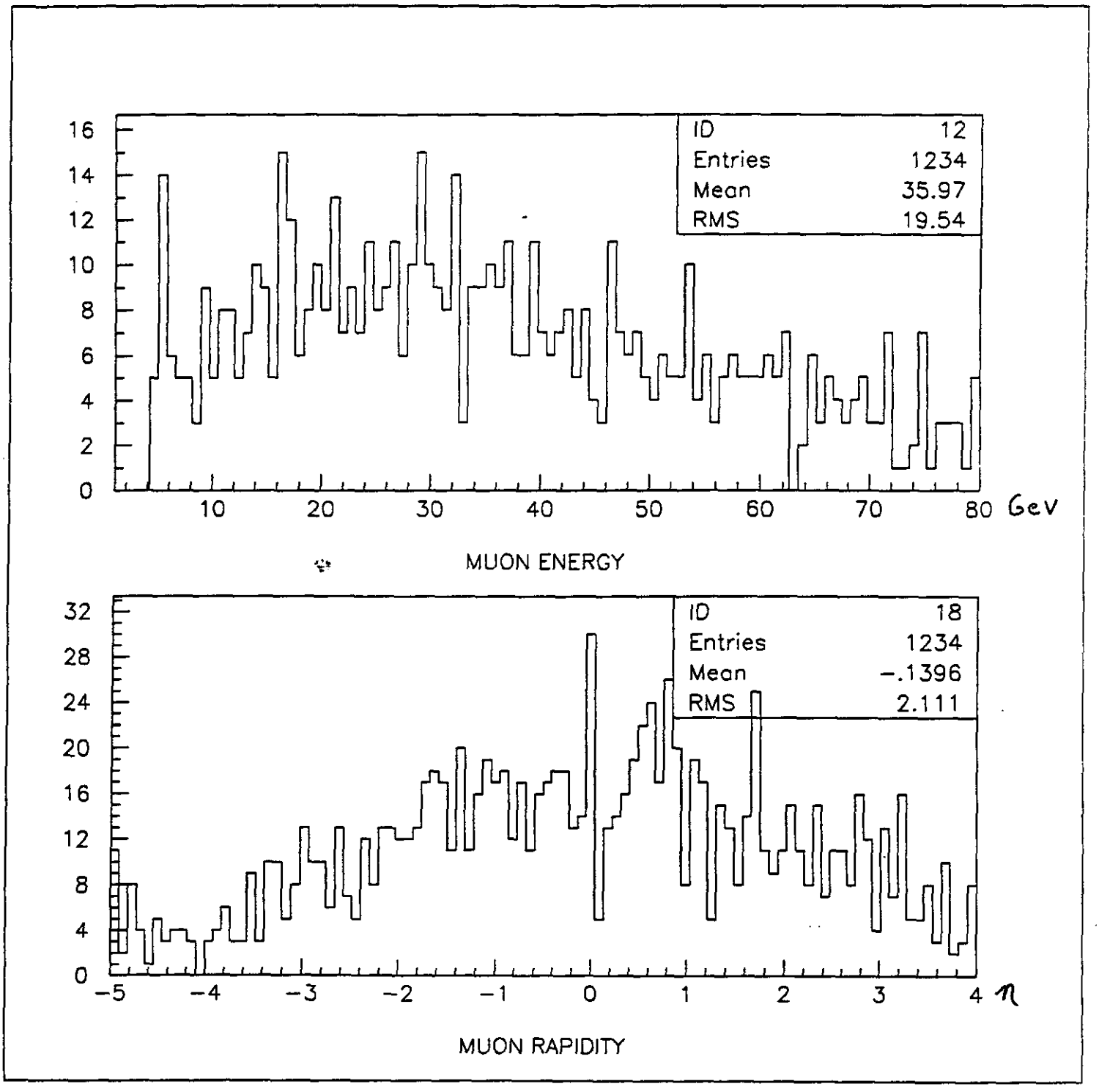
ID 12
Entries 1234
Mean 35.97
RMS 19.54
0 2 4 6 8 10 12 14 16
10 20 30 40 50 60 70 80 GeV
MUON ENERGY
ID 18
Entries 1234
Mean −.1396
RMS 2.111
0 4 8 12 16 20 24 28 32
−5 −4 −3 −2 −1 0 1 2 3 4 η
MUON RAPIDITY

FIGURE 6

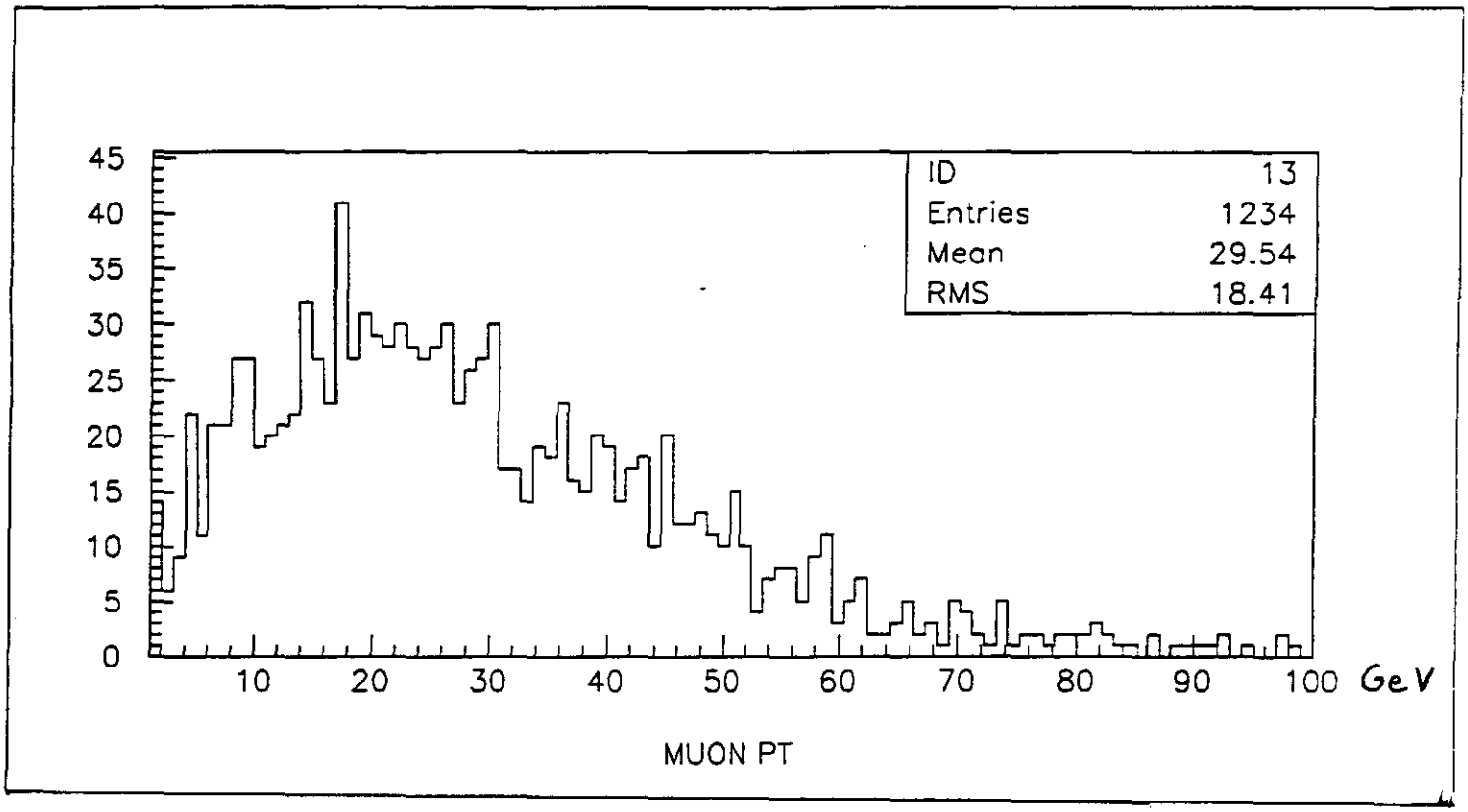
ID 13
Entries 1234
Mean 29.54
RMS 18.41
45
40
35
30
25
20
15
10
5
0
10
20
30
40
50
60
70
80
90
100
GeV
MUON PT

FIGURE 6