FPPA design

Dave Cockerill, 11 Feb, 2002

1. FPPA gain stages – are they appropriate?

The current FPPA has four relative gain stages of x1, x5, x9 and x33 with a full scale range of 1.5 TeV and 3 TeV on the x1 range, assuming charge inputs of (4-6) p.e./MeV and 5.5 pC/TeV for the barrel and endcap respectively.

The full scale ranges for each of the gain stages, and the consequent least significant bit, for the current 12 bit ADC, are summarized in the table :

	Gain	Full scale range	l.s.b.
Barrel	x1	1500 GeV	373 MeV
	x5	300 GeV	75 MeV
	x9	167 GeV	41 MeV
	x33	45 GeV	11 MeV
Endcap	x1	3000 GeV	745 MeV
	x5	600 GeV	149 MeV
	x9	333 GeV	82 MeV
	x33	91 GeV	23 MeV

Gain range x33 has an lsb of 11 MeV in the barrel and 23 MeV in the endcaps. This gain range seems inappropriate with respect to the target noise per channel in the barrel and endcaps of 40 MeV and 150 MeV respectively.

Proposal 1: Drop gain range x33 from the FPPA.

Proposal 2: Use only gain range x9 for high precision physics.

The barrel and endcap energy distributions for gammas which trigger CMS, from Higgs-$\gamma\gamma$ decays, are shown in figures 1 and 2, for M_H= 100 GeV. The associated acceptance and P_T cuts are shown in figures 3 and 4. Electrons from Z decays (which would be used in calibration) will have a similar energy distribution.

Gain range x9 has a full scale range of 167/333 GeV which encompasses most of the gammas in Figures 1 and 2. Gain range x9 has a lsb of 82 MeV which is more appropriately matched to the EE noise per channel target of 150 MeV. The lsb is less well matched in the barrel case. This could be improved with a gain range of 12-15 instead of 9.

The switching points, from gain range x33 to x9, are shown by the arrows in figures 1 and 2. Relatively few photons are measured within gain range x33.

Proposal 3: Drop gain range x5 from the FPPA

Gain range x5 only covers the energy range from 167 to 300 GeV (barrel) and 333 GeV to 600 GeV (endcap). By dropping gain range x5 and using only the gain range x1 has minimal consequences for the resolution in this energy range. The central crystal, and perhaps the adjacent crystal, would be measured on the x1 range with an lsb of 373 MeV (barrel) and 745 MeV (Endcap), a digital degradation to the resolution of only 0.2 – 0.4% at these energies. All the other crystals in the 25 sum would be on the x9 range with an lsb of 41 MeV (barrel), 82 MeV (endcap).

Benefits of Proposals 1 – 3

At present the pulses on each channel are sampled at 40 MHz. 4-6 digital voltage samples are added to obtain the total energy deposit for the channel. One of these samples is at the peak of the preamplifier response.

Benefit 1) From figures 1 and 2 it is clear that the peak digitization will almost always be on gain range x9. The other samplings of the pulse will certainly involve gain range x33. Thus it will **nearly always** be necessary to use a cross calibration from gain range x9 to gain range x33 for the struck crystal. This is an unwelcome degree of extra complexity, which the proposals would largely eliminate.

Benefit 2) The *in-situ* calibration with electrons, from Z-ee, will involve similar complications. The energy spectrum for the electrons will be similar to figures 1 and 2. However, not only will inter-calibration be difficult, it will be further complicated by the necessity to deal with switching gain ranges within the struck crystal. The proposals would simplify the calibration task.

Benefit 3) At present the ADC pedestal is taken from the single digital sample before the waveform. This is carried out on the most sensitive range, the x33 range. The pedestal information for the x9 range is therefore absent and any movements on this range (coherent noise etc) will have to be inferred from what is seen on the x33 range. The proposals would remove this difficulty.

Benefit 4) With only 2 gain stages (x1 and x9) the previous 2 bit code required for indicating which gain stage was employed can be reduced to only one bit. This bit reduction may be useful for any move to 1.6 Gb/s operation.

Benefit 5) The trigger primitive generator in the upper level readout currently determines the particle energy by calculating

$$E = \alpha(G) \times D + \beta(G),$$

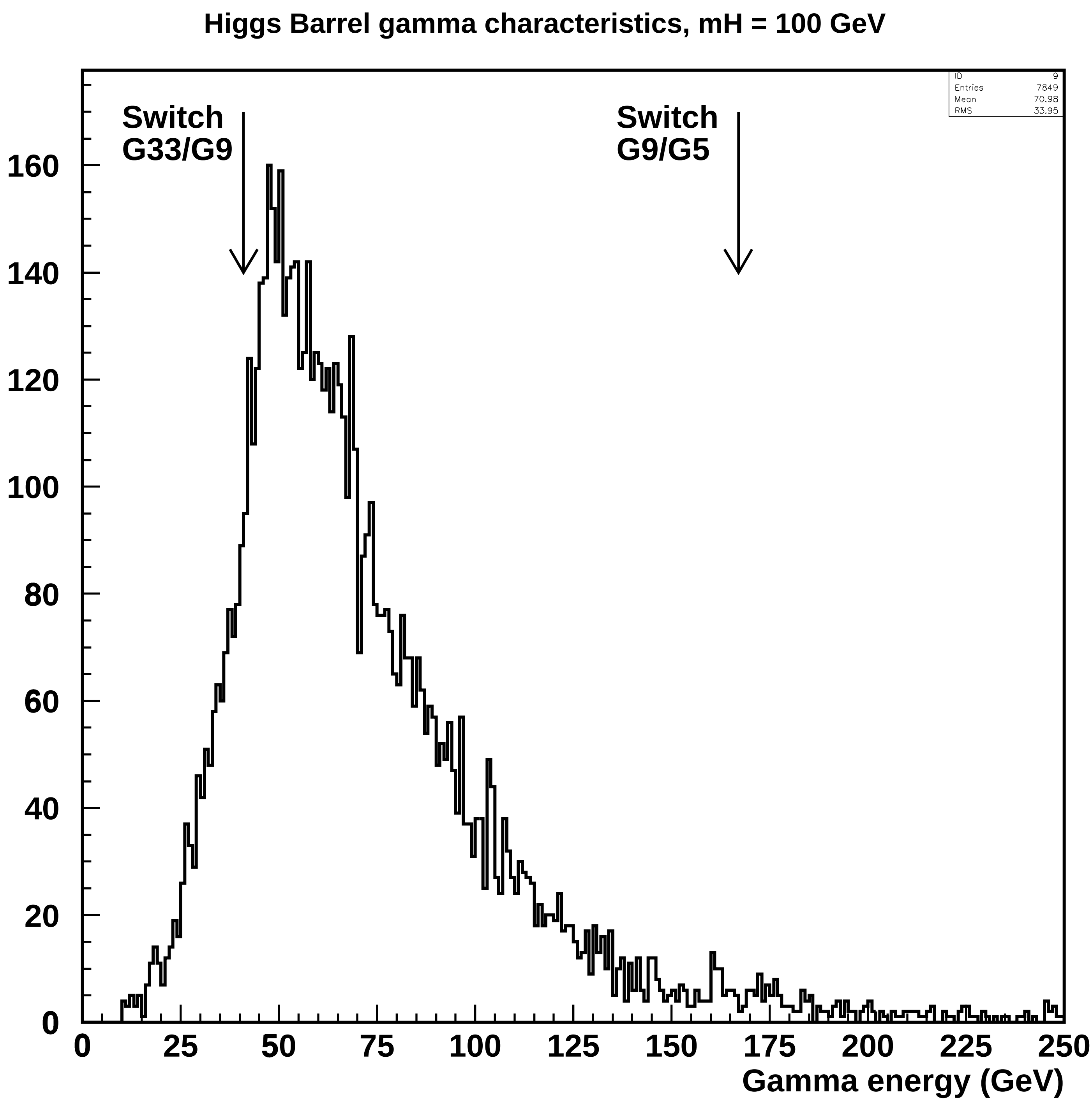
where $\alpha(G)$ is the gain determined by the 2 bit code, D is the 12 bit mantissa, from the 12 bit ADC, and $\beta(G)$ is an offset which is also a function of G.

Currently there are 4 gain stages and 4 offsets. The proposals would reduce this to 2 gains and 2 offsets. This reduces the complexity of the energy calculation by a factor of up to 4. This will reduce the latency for trigger generation.

Proposal 4: Remove the x33 and x5 gain ranges from the FPPA

Entirely removing the components for the x33 and x5 gain ranges from the FPPA will

- Simplify the ASIC
- Simplify the multiplexer and associated logic
- Increase yield
- Reduce power consumption.



Higgs Barrel gamma characteristics, mH = 100 GeV
ID 9
Entries 7849
Mean 70.98
RMS 33.95
Switch G33/G9
Switch G9/G5
0
20
40
60
80
100
120
140
160
0
25
50
75
100
125
150
175
200
225
250
Gamma energy (GeV)

Figure 1

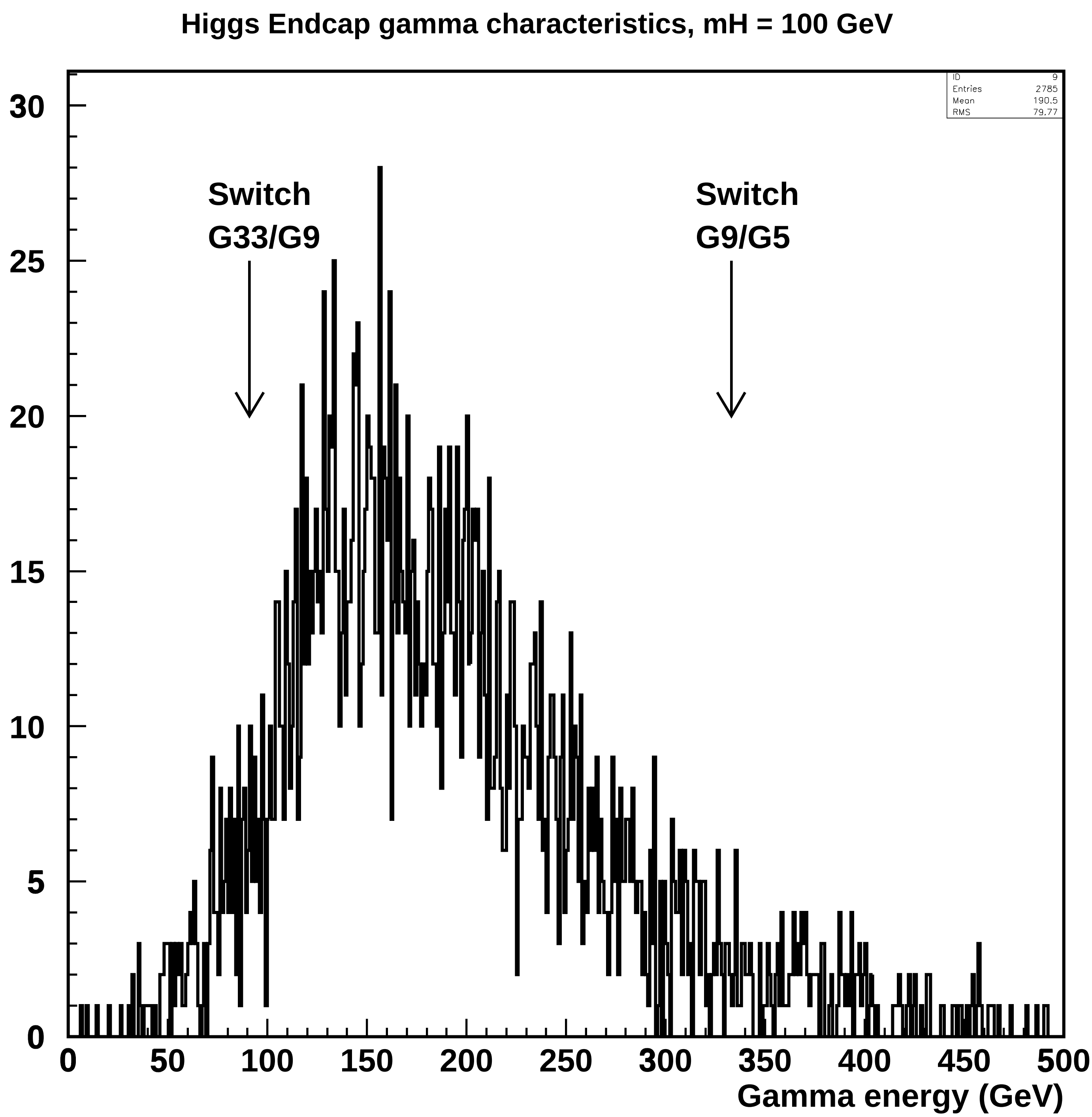

Higgs Endcap gamma characteristics, mH = 100 GeV
ID 9
Entries 2785
Mean 190.5
RMS 79.77
Switch
G33/G9
Switch
G9/G5
0
5
10
15
20
25
30
0
50
100
150
200
250
300
350
400
450
500
Gamma energy (GeV)

Figure 2

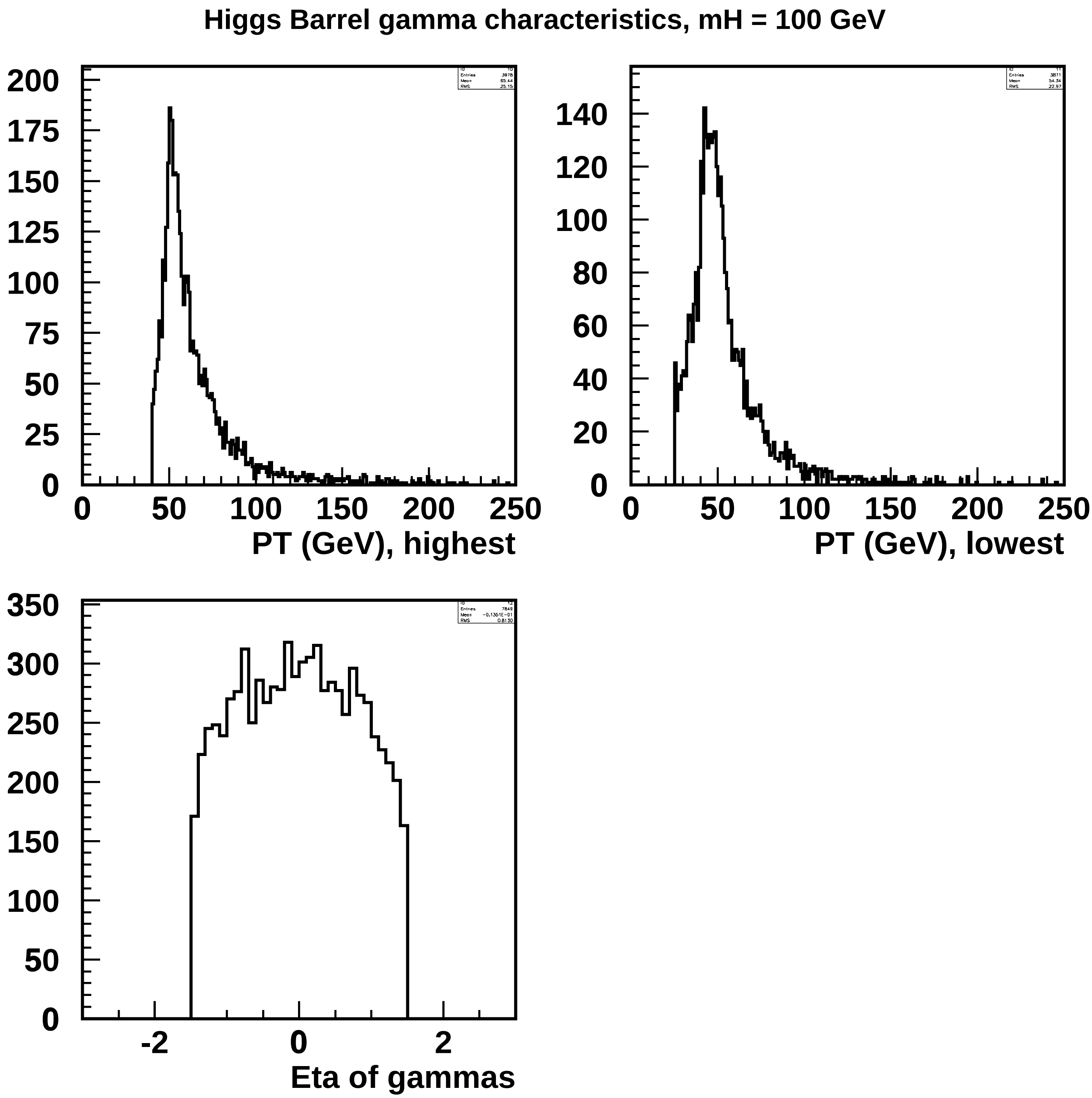

Higgs Barrel gamma characteristics, mH = 100 GeV
PT (GeV), highest
PT (GeV), lowest
Eta of gammas

Figure 3

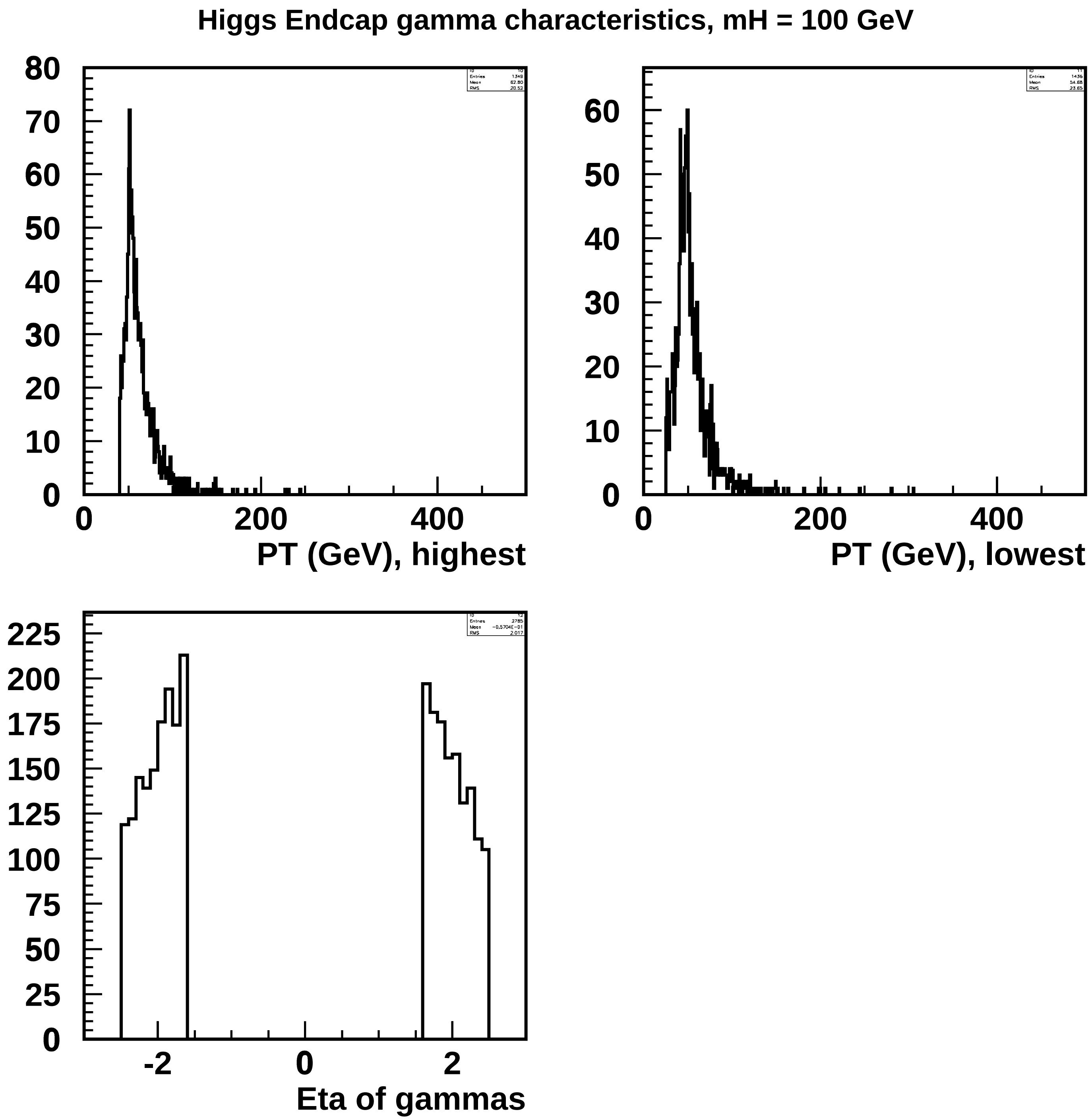

Higgs Endcap gamma characteristics, mH = 100 GeV
PT (GeV), highest
PT (GeV), lowest
Eta of gammas
0
10
20
30
40
50
60
70
80
200
400
-2
2
25
75
100
125
150
175
200
225

Figure 4