Energy Weighting for CMS-HCal Upgrade

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DESY-CMS Hamburg

Calibration Meeting
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PHYSICS AT THE TERA SCALE
Helmholtz-Alliance

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Motivation

- 31th January: deadline for proceedings of LP09
- Want to finish internal note by this time (on every case before ITEP 2010)

➔ Want final plots

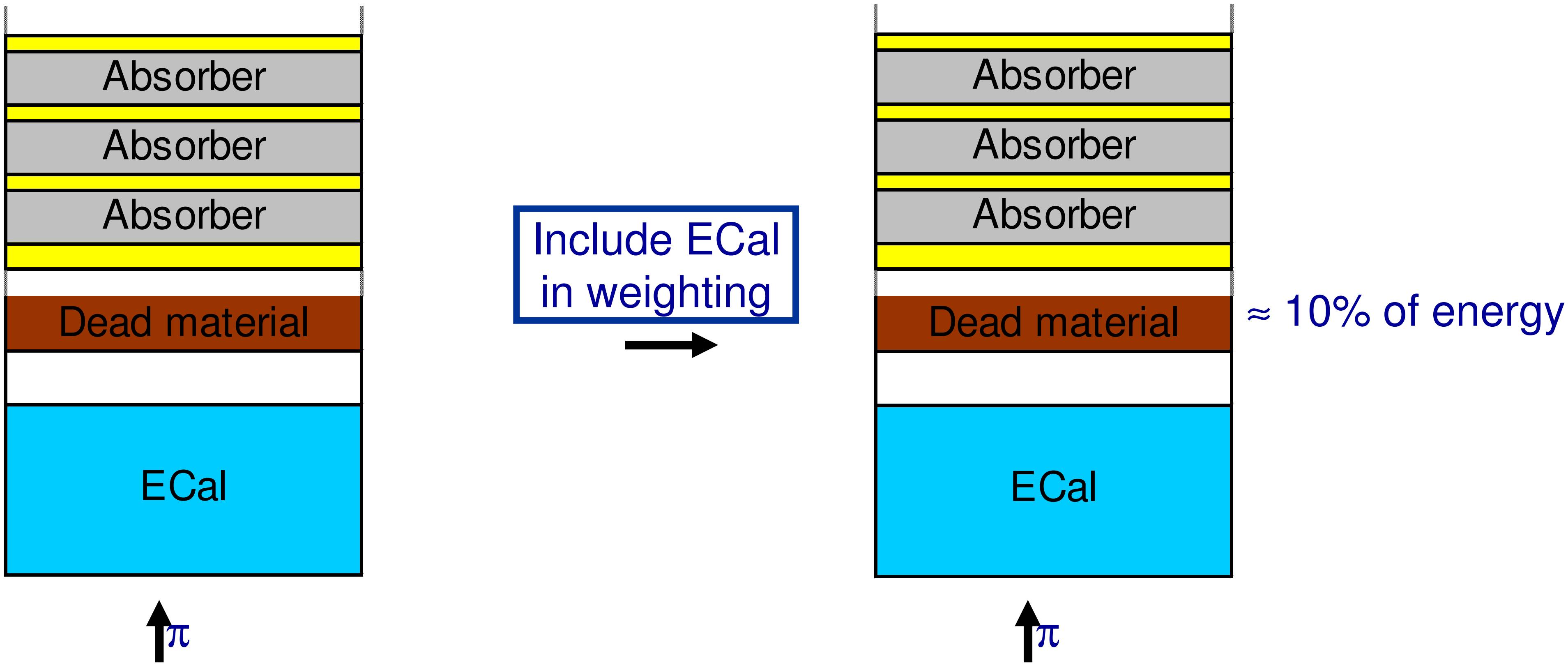
- in the past: lots and lots of detailed studies about cuts, weighting concept, readout designs, interpolation, fit of weighting factors, weighting scenario, geant3 simulation,……….
  ➔ lots of screws one can turn ➔ want final criteria

- Now: explain 2 aspects before showing result plots:
  - weighting without ecal
  - weighting without first layer

π, gcalor, 50 GeV

So far ("1st scenario"):

Now: ("2nd scenario"):



- Cut: $E_{ecal} < 2$ GeV

➔ From 50.000 Events, 19.626 pass

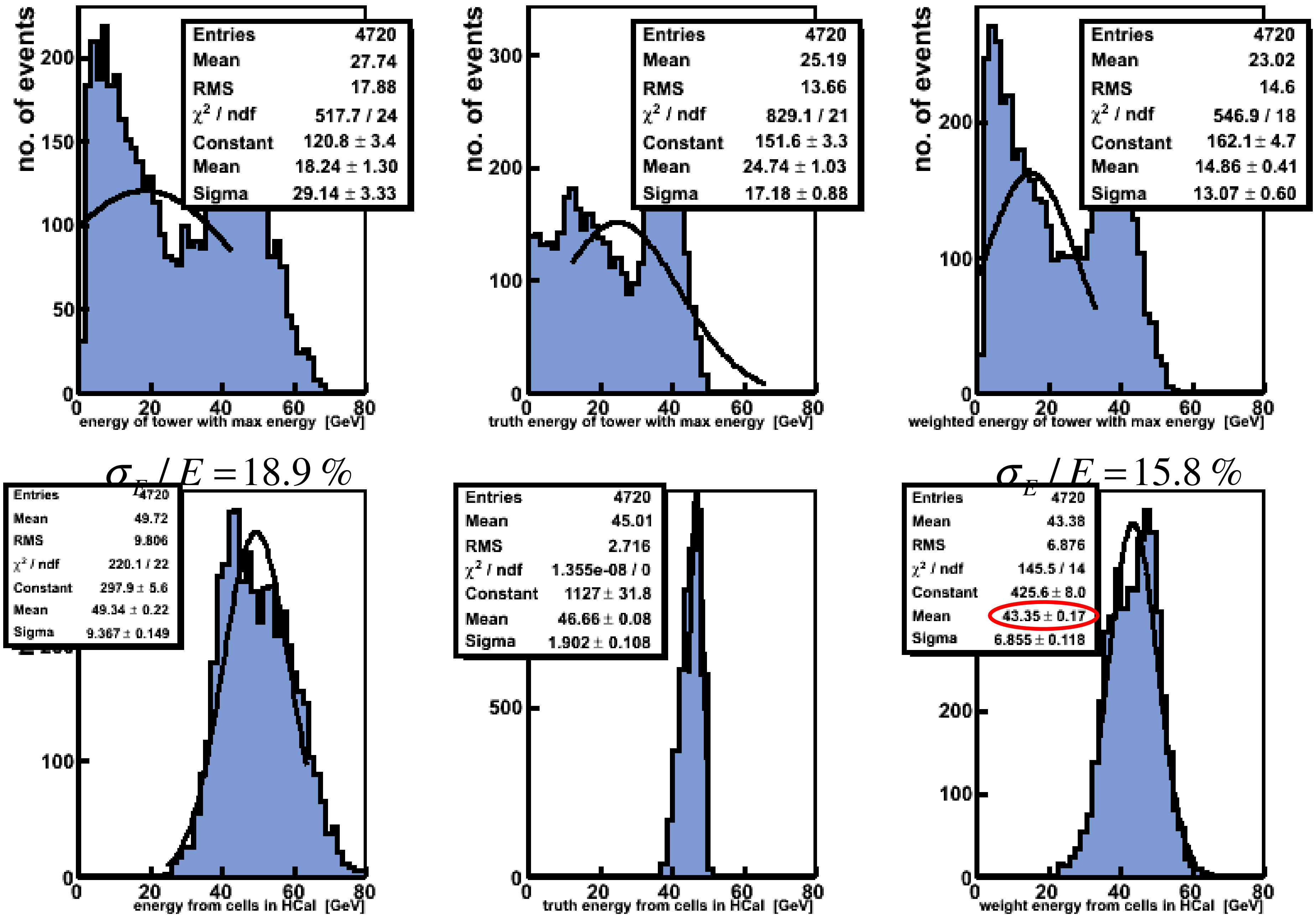
- No ECal cut
- $E_{ges} = E_{hcal} + E_{ecal}$

➔ From 50.000 Events, 47.020 pass

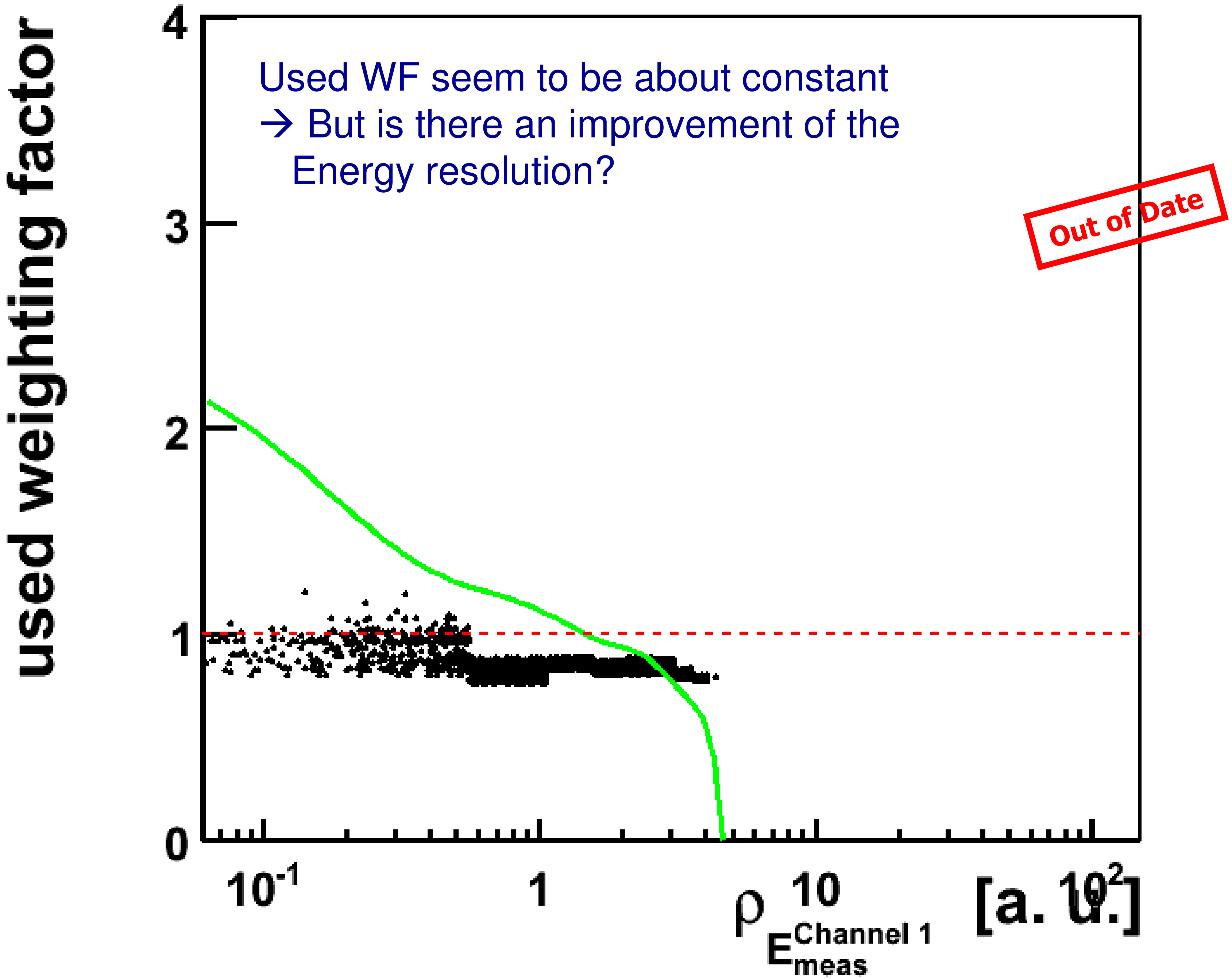
Hypothesis

Weighting only measurable in ecal_0 scenario (= with ecal cut)

50 GeV, 17, ecal_1



50 GeV, 17, ecal_1, Used WF



50 GeV, 17, ecal_1

Well, then just assume a constant weighting factor, e. g.:

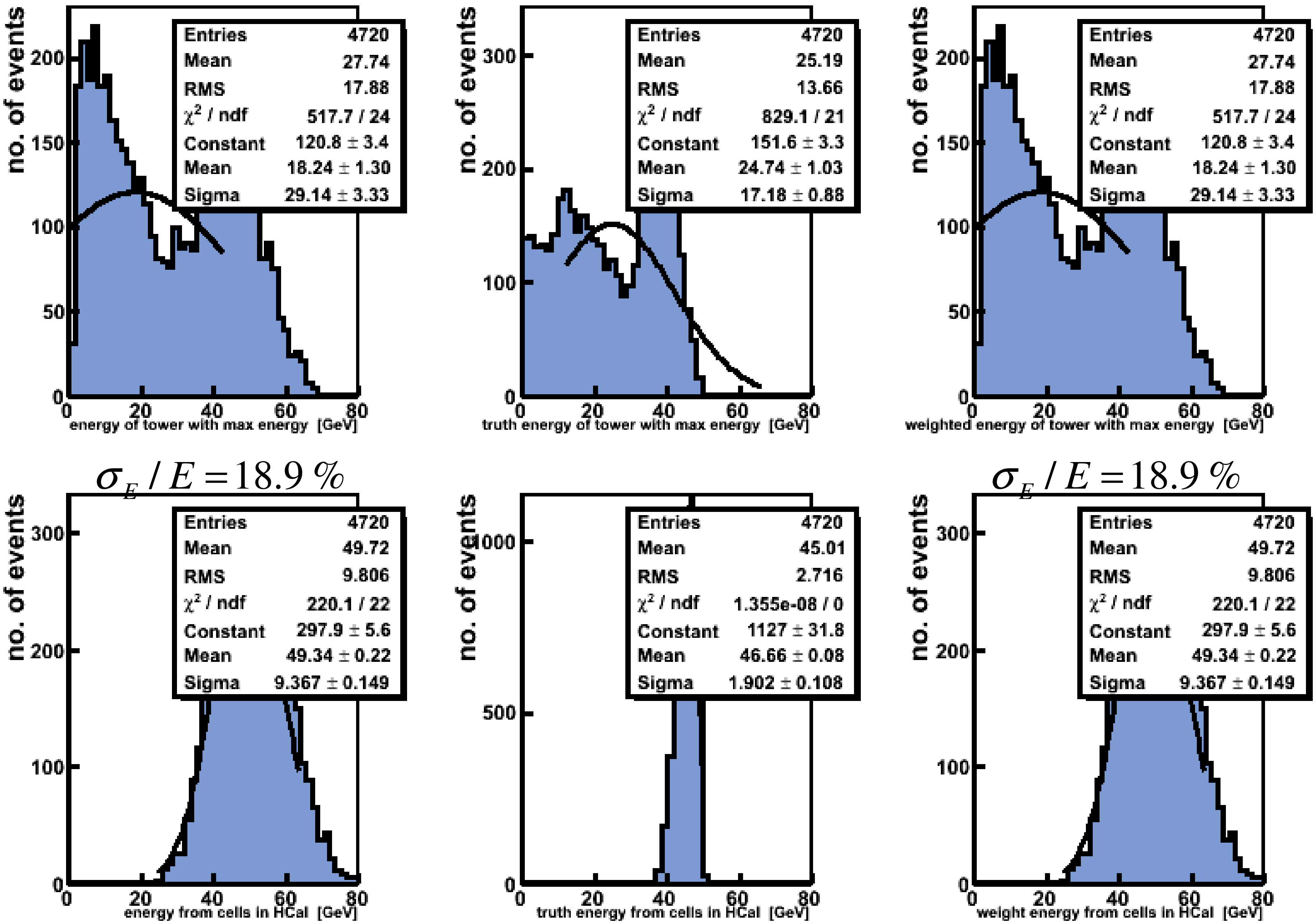
- 1
- 0.8
- 0.5
- 1.2
- 0

→ Only influences E_HCal

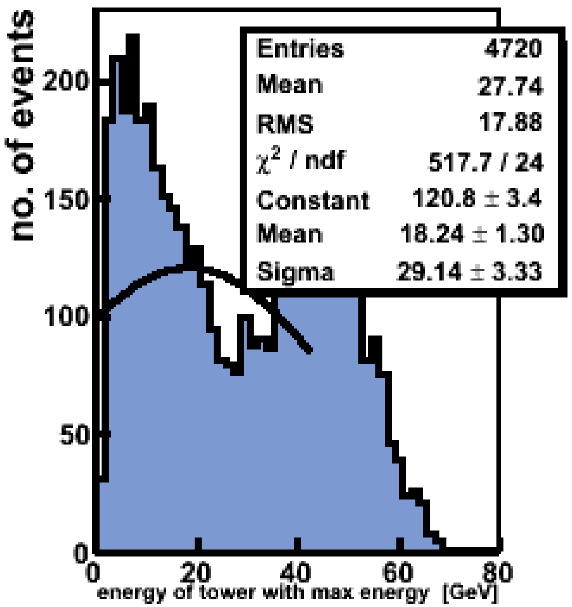
Reminder:

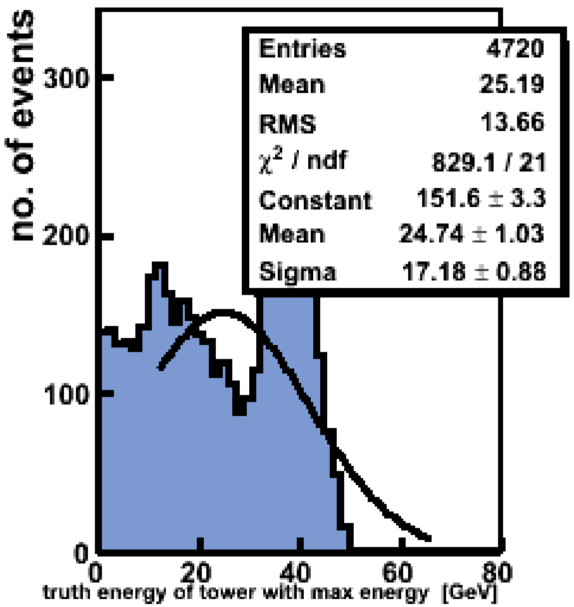
$$E_{ges} = E_{ECal} + E_{HCal}$$

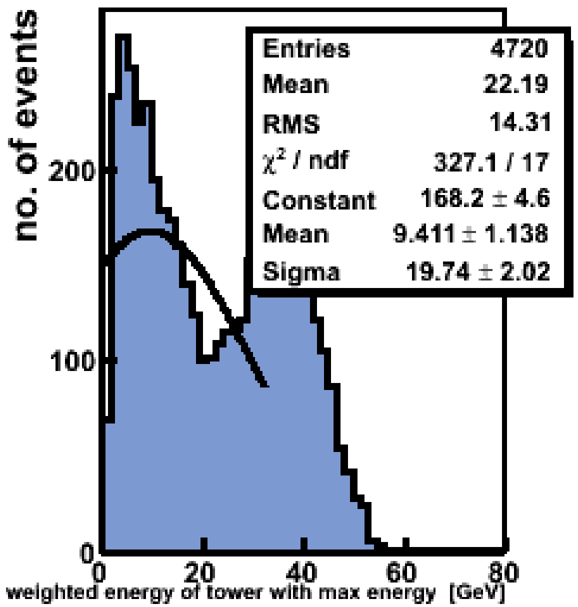
50 GeV, 17, ecal_1, fake: WF = 1



50 GeV, 17, ecal_1, fake: WF = 0.8

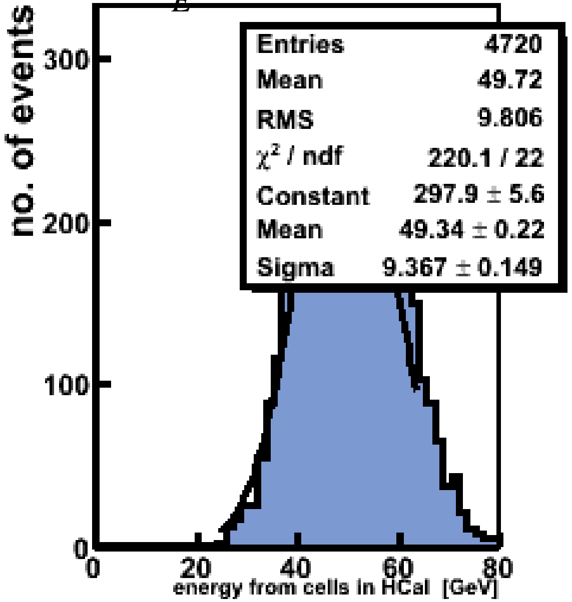


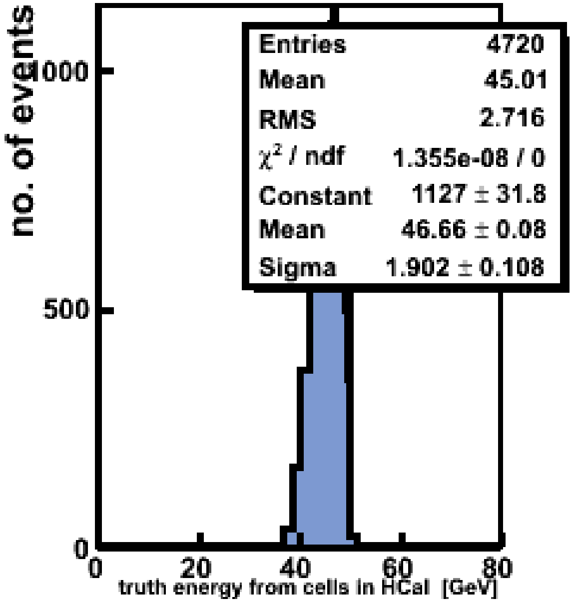


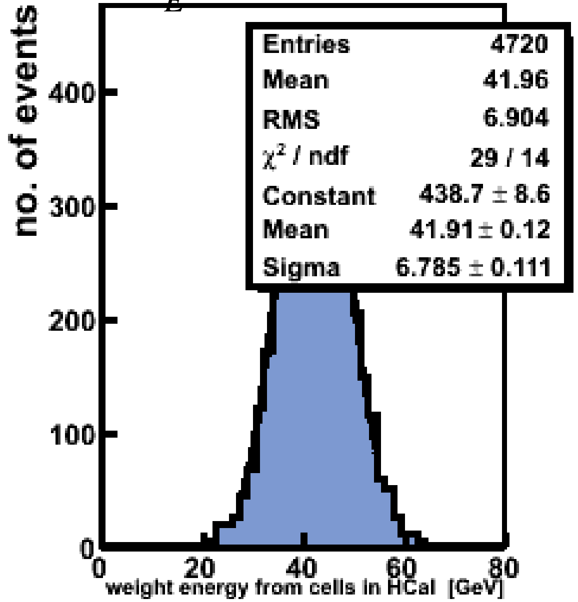


$\sigma_E / E = 18.9\ \%$

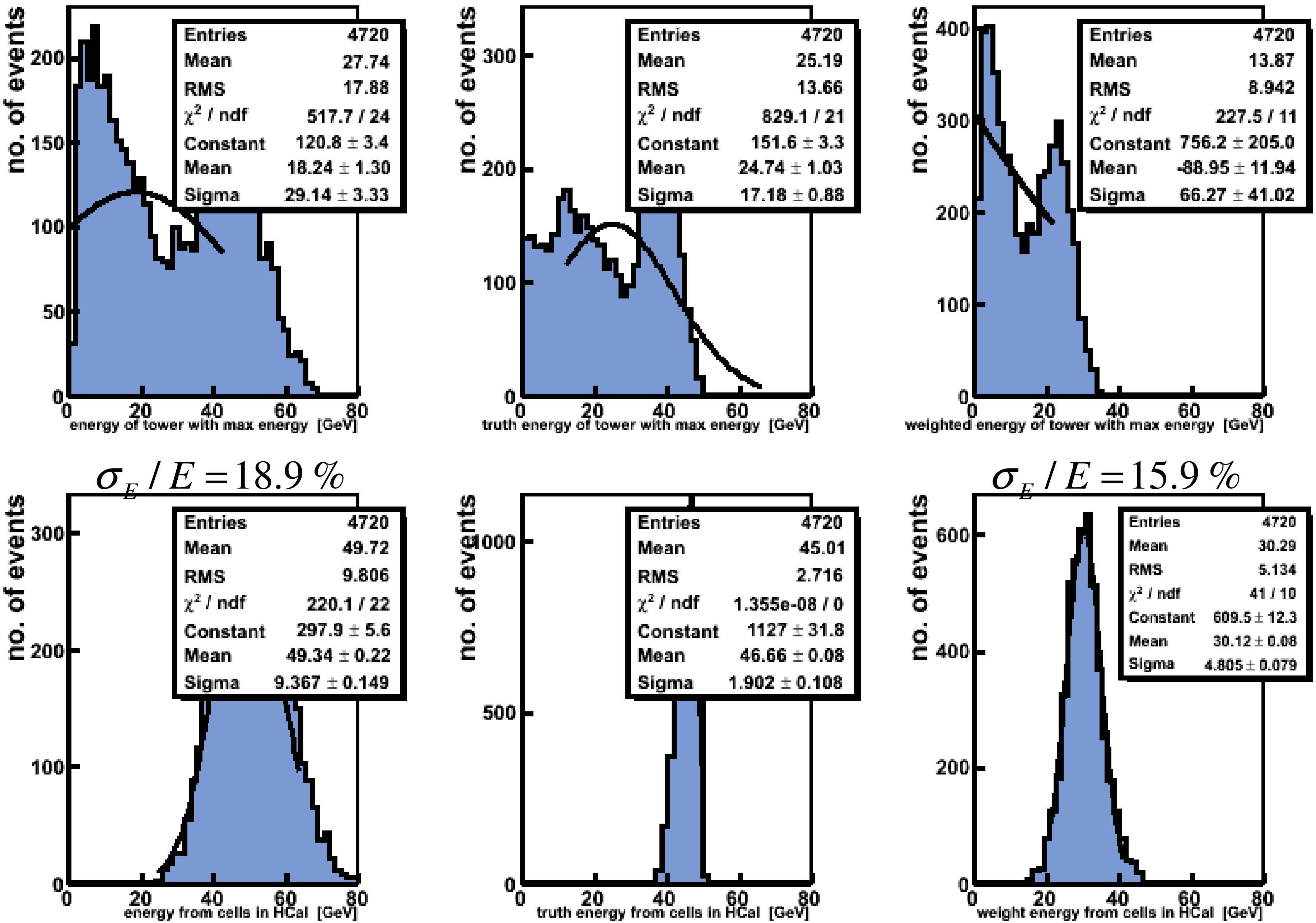
$\sigma_E / E = 16.2\ \%$



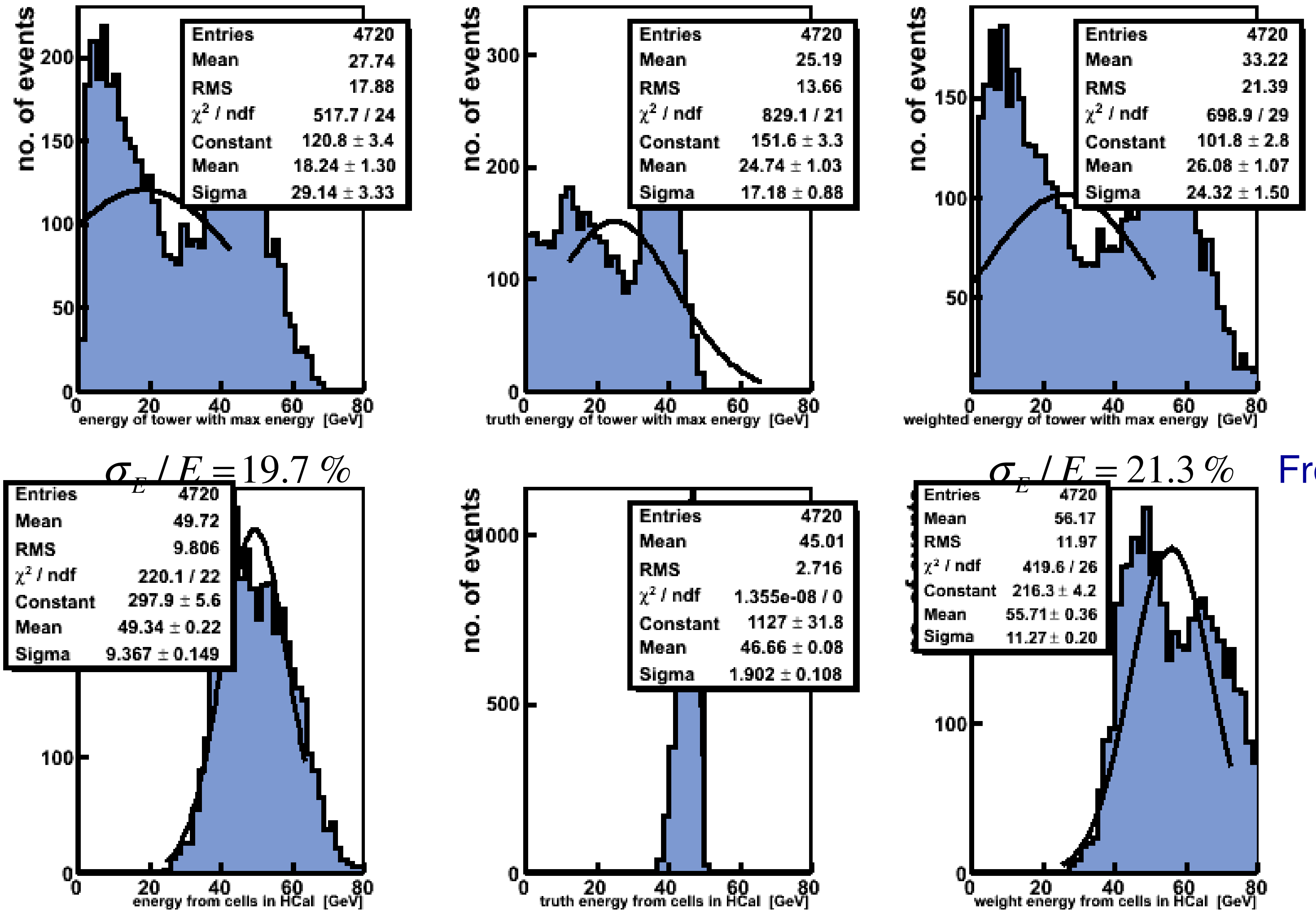




50 GeV, 17, ecal_1, fake: WF = 0.5

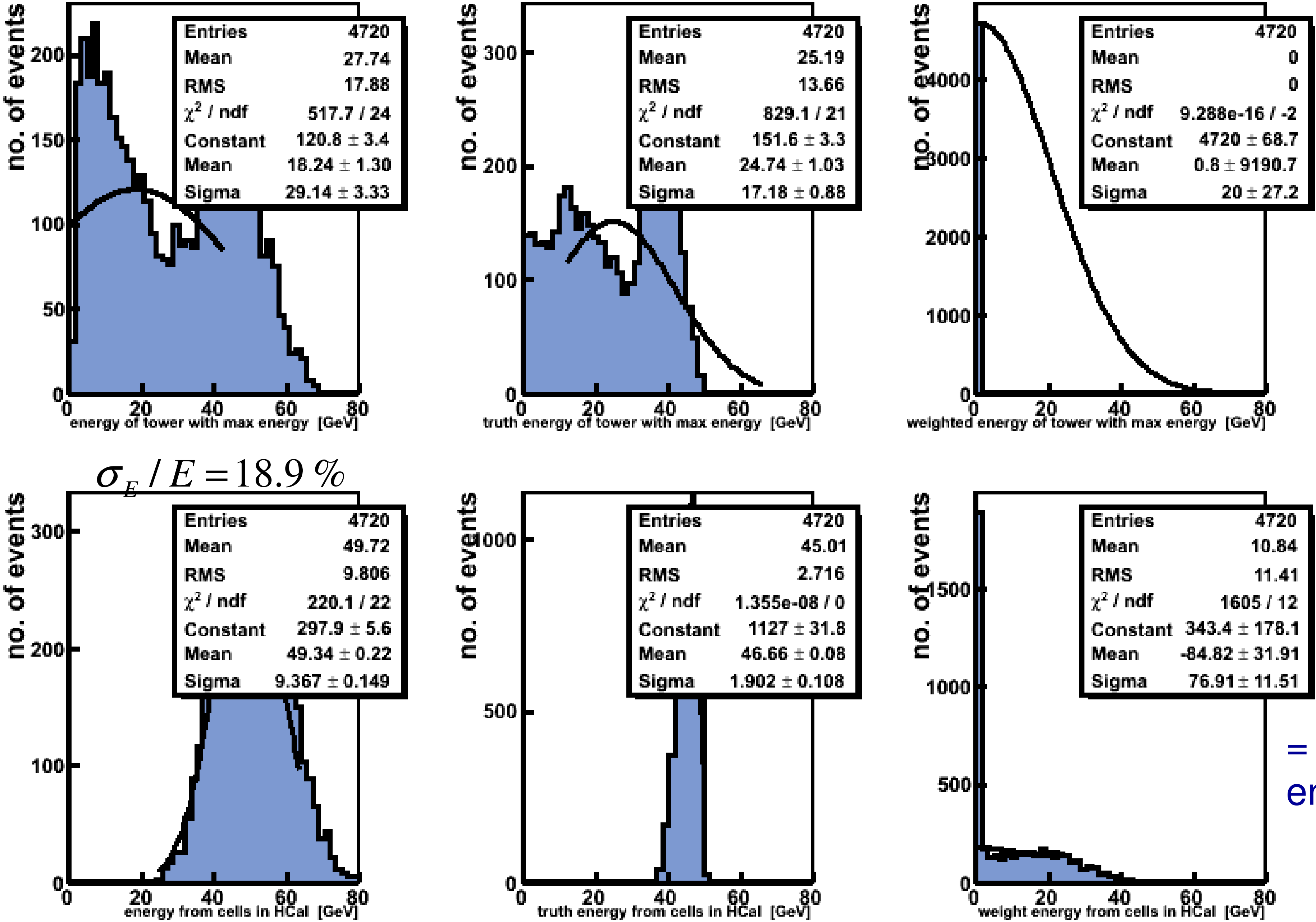


50 GeV, 17, ecal_1, fake: WF = 1.2



From RMS

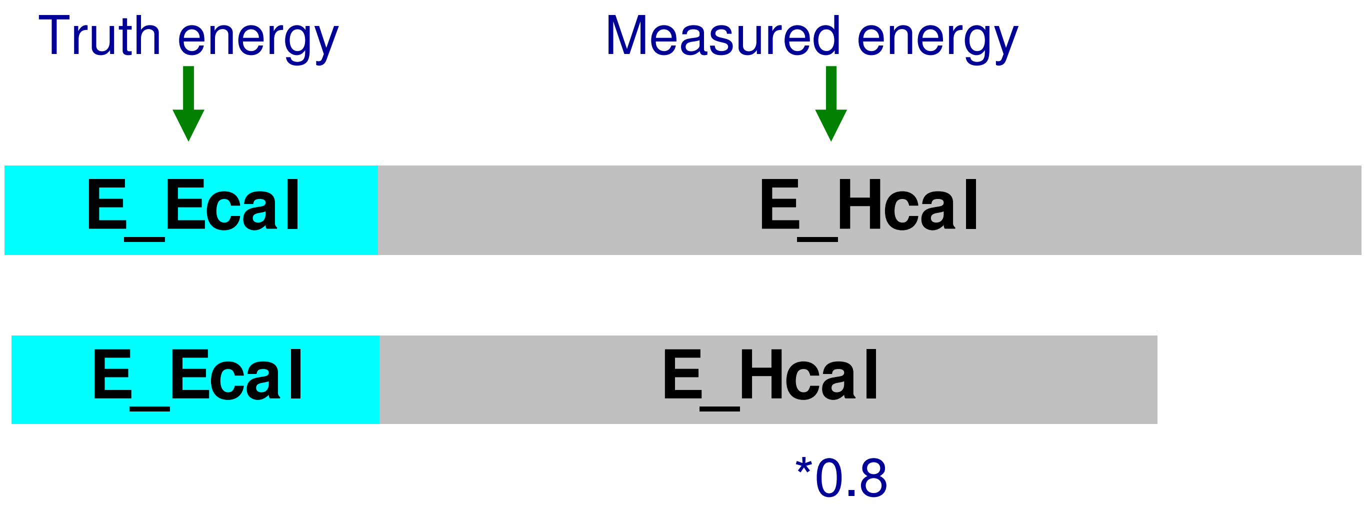
50 GeV, 17, ecal_1, fake: WF = 0



= Ecal energy

Explanation

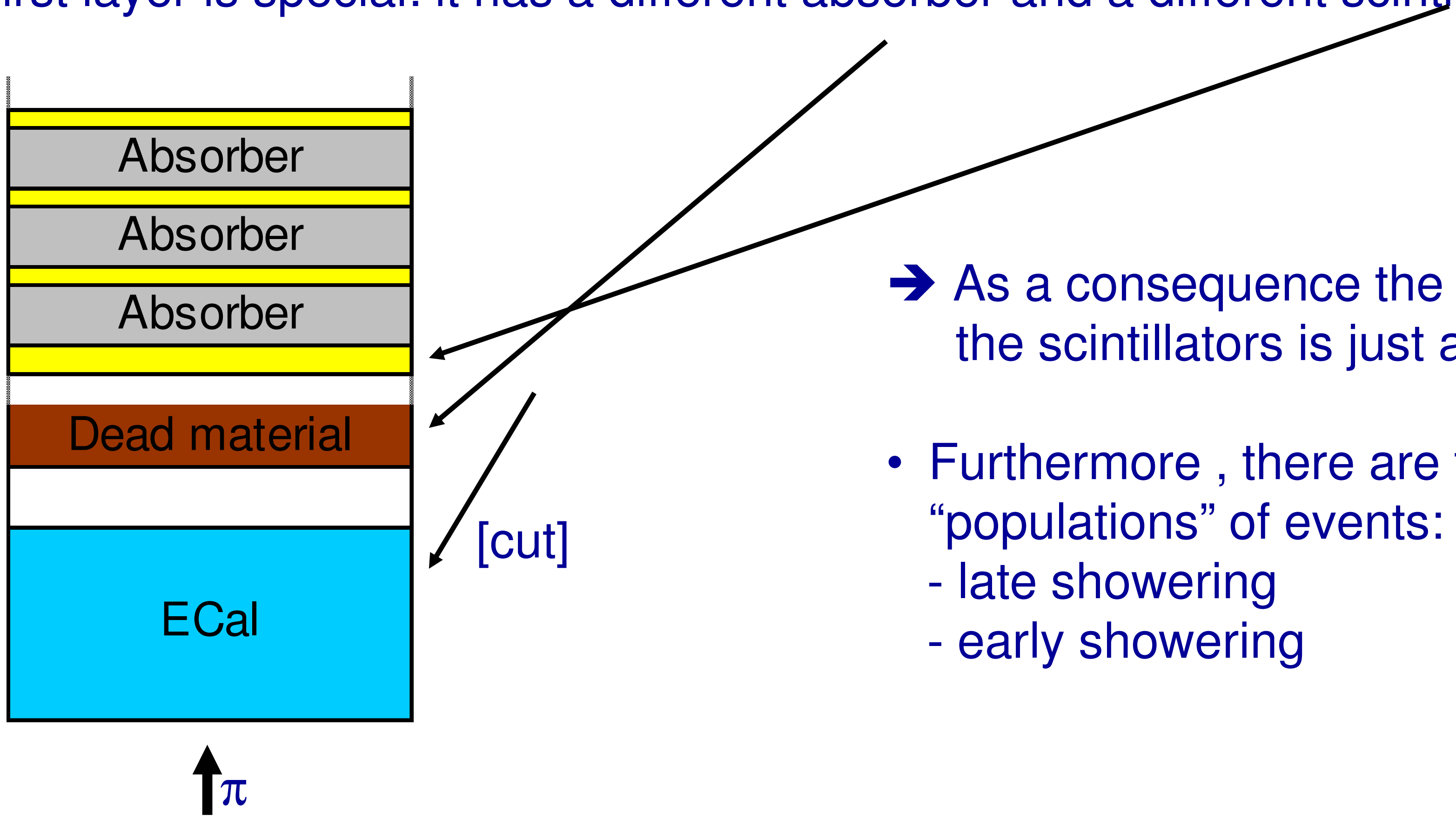
Due to simulation, E_ECal is only knows as truth energy (= perfectly measured!)
➔Diminishing E_HCal improves rel. Energy resolution
➔Fake by weighting: it is always good to diminish HCal energy
➔Cannot use this Scenario with ecal to quantize the weighting



<u>Conclusion:</u>
You shall not use the scenario with ecal for quantize the effect of the weighting

First Layer

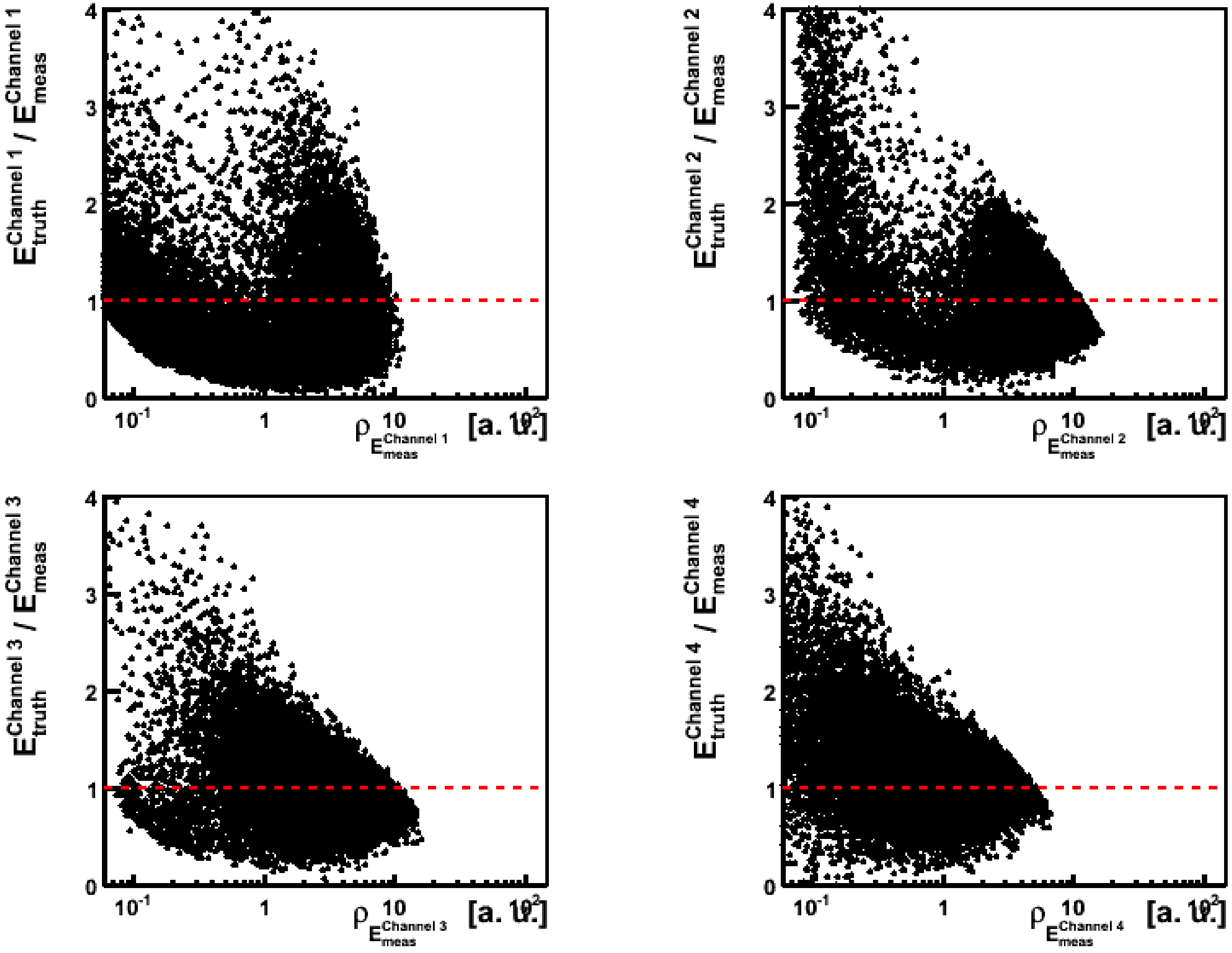
First layer is special: it has a different absorber and a different scintillator



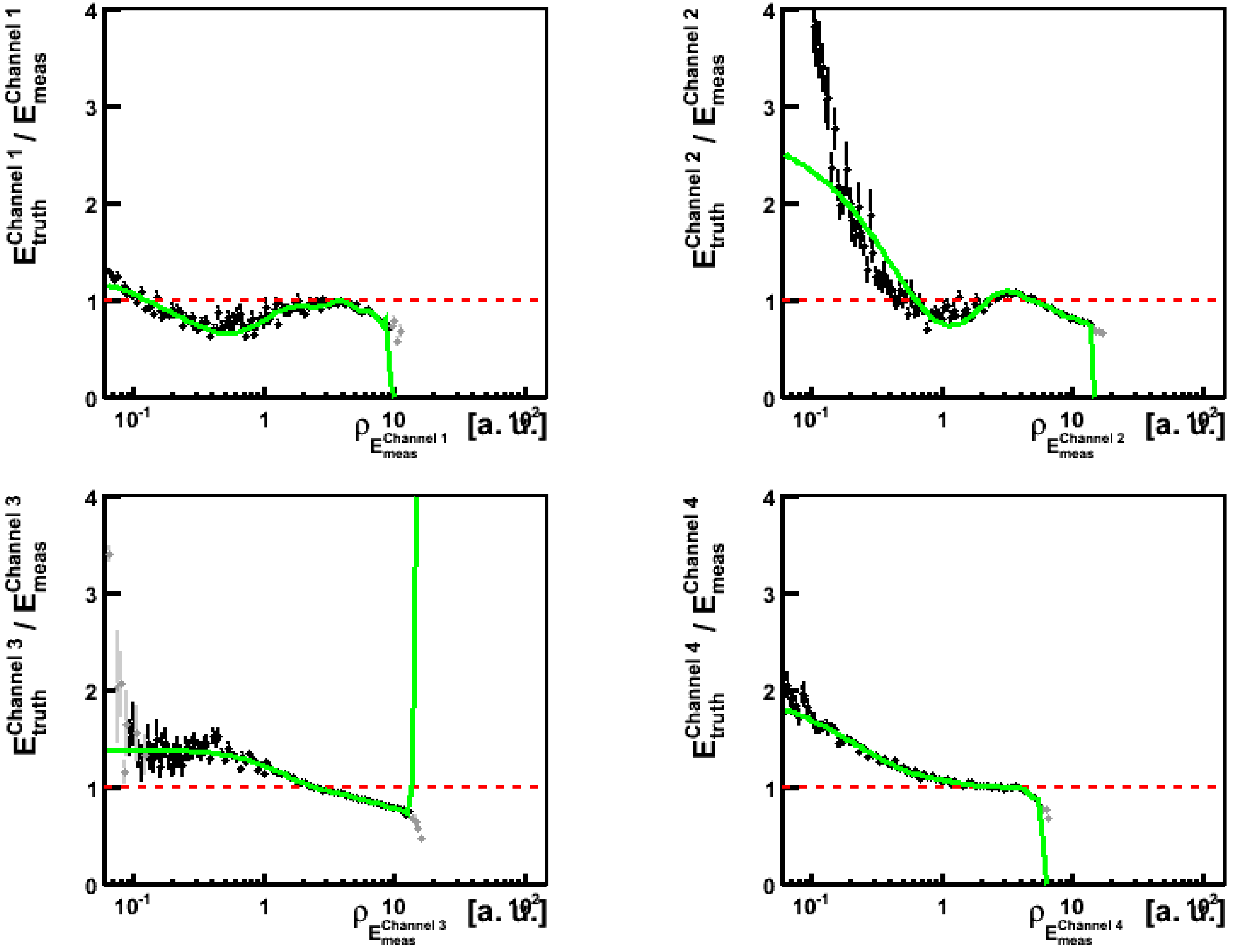
➔ As a consequence the calibration of the scintillators is just a compromise

- Furthermore , there are tow "populations" of events:
  - late showering
  - early showering

1448, 50 GeV π, ecal_0

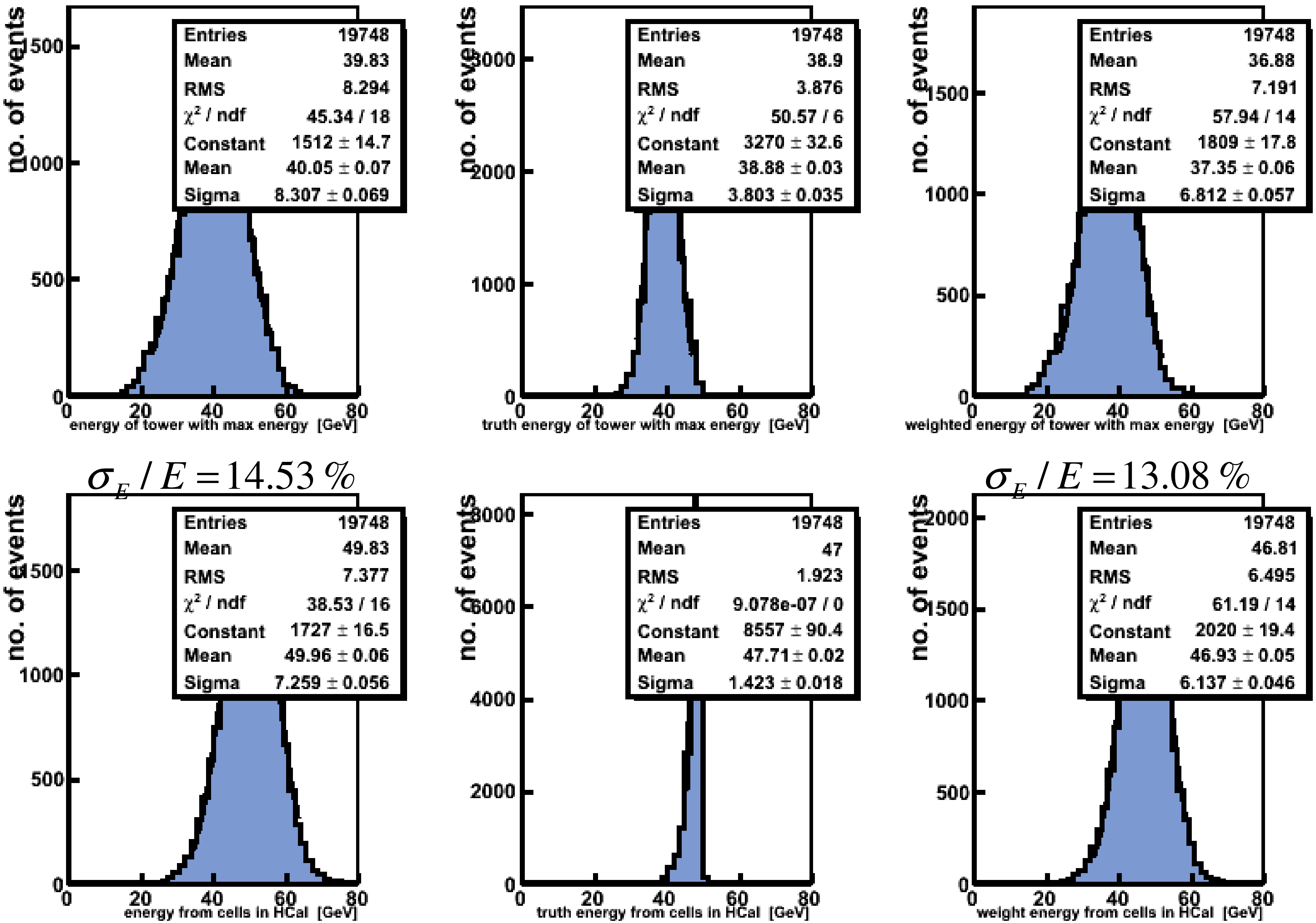


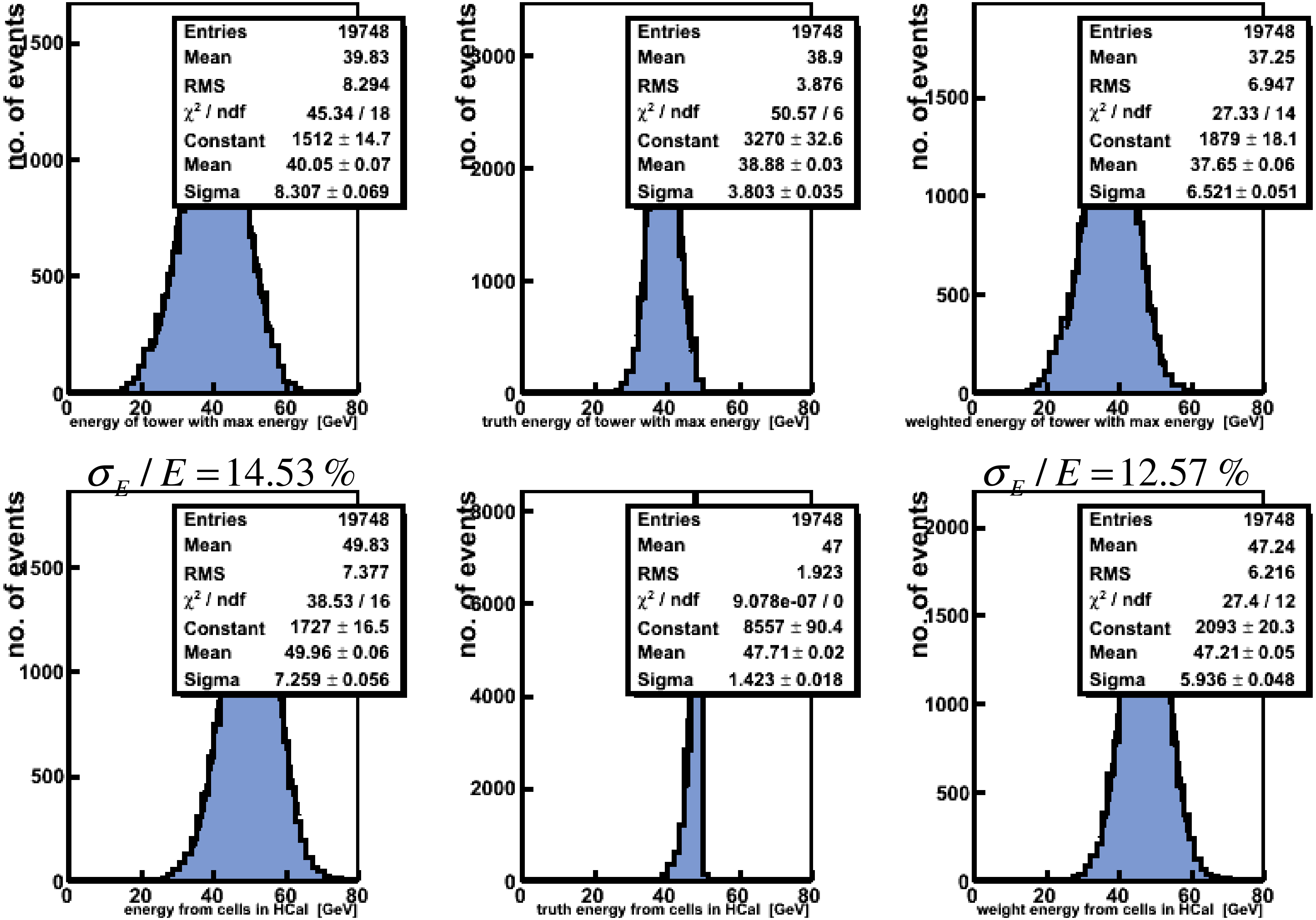
1448, 50 GeV π, ecal_0, profile = WF



Consequence

Weighting for the first layer seems difficult. Maybe it is better without. Test it by weighting and not weighting the first layer


no. of events
Entries 19748
Mean 39.83
RMS 8.294
χ² / ndf 45.34 / 18
Constant 1512 ± 14.7
Mean 40.05 ± 0.07
Sigma 8.307 ± 0.069
energy of tower with max energy [GeV]
Entries 19748
Mean 38.9
RMS 3.876
χ² / ndf 50.57 / 6
Constant 3270 ± 32.6
Mean 38.88 ± 0.03
Sigma 3.803 ± 0.035
truth energy of tower with max energy [GeV]
Entries 19748
Mean 36.88
RMS 7.191
χ² / ndf 57.94 / 14
Constant 1809 ± 17.8
Mean 37.35 ± 0.06
Sigma 6.812 ± 0.057
weighted energy of tower with max energy [GeV]
σ_E / E = 14.53 %
σ_E / E = 13.08 %
Entries 19748
Mean 49.83
RMS 7.377
χ² / ndf 38.53 / 16
Constant 1727 ± 16.5
Mean 49.96 ± 0.06
Sigma 7.259 ± 0.056
energy from cells in HCal [GeV]
Entries 19748
Mean 47
RMS 1.923
χ² / ndf 9.078e-07 / 0
Constant 8557 ± 90.4
Mean 47.71 ± 0.02
Sigma 1.423 ± 0.018
truth energy from cells in HCal [GeV]
Entries 19748
Mean 46.81
RMS 6.495
χ² / ndf 61.19 / 14
Constant 2020 ± 19.4
Mean 46.93 ± 0.05
Sigma 6.137 ± 0.046
weight energy from cells in HCal [GeV]

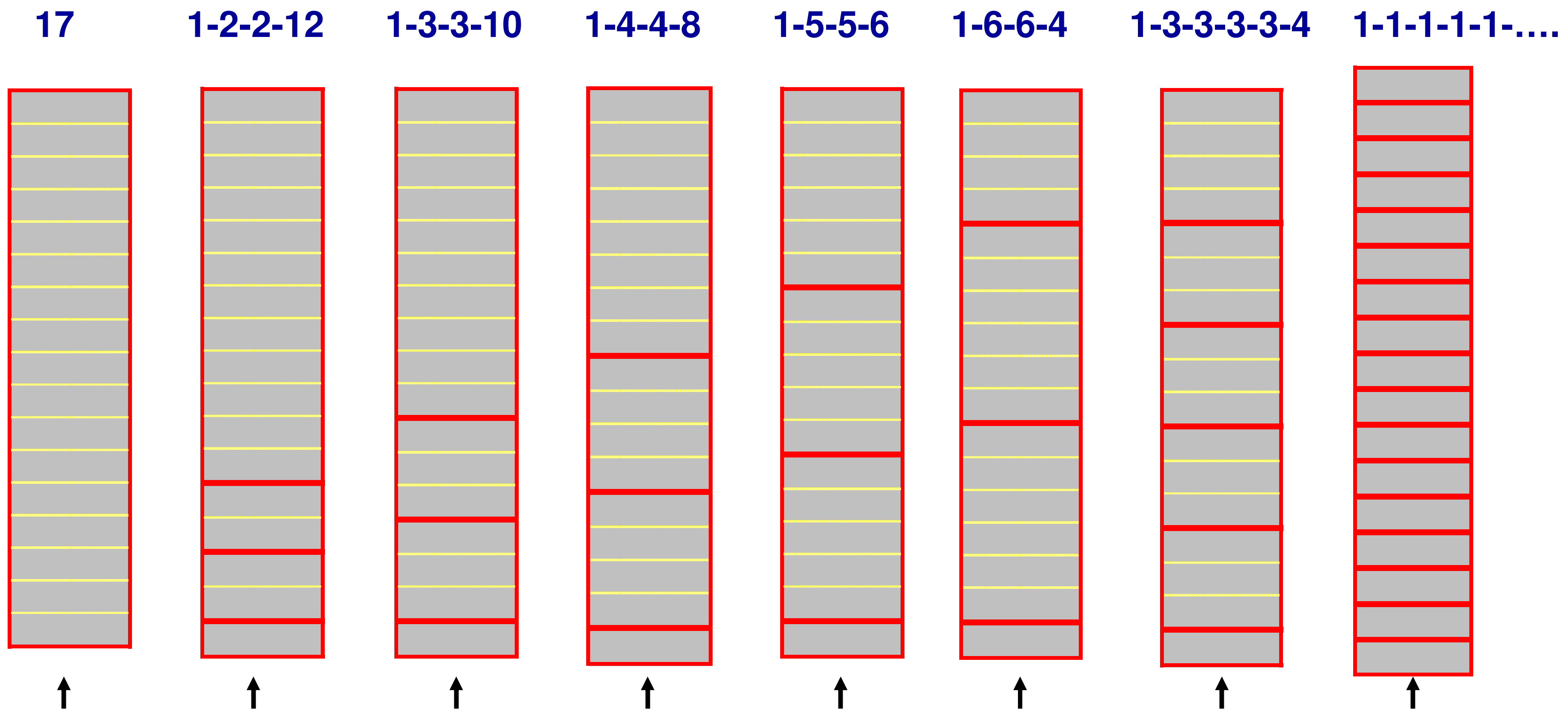

no. of events
Entries 19748
Mean 39.83
RMS 8.294
χ^2 / ndf 45.34 / 18
Constant 1512 ± 14.7
Mean 40.05 ± 0.07
Sigma 8.307 ± 0.069
energy of tower with max energy [GeV]
no. of events
Entries 19748
Mean 38.9
RMS 3.876
χ^2 / ndf 50.57 / 6
Constant 3270 ± 32.6
Mean 38.88 ± 0.03
Sigma 3.803 ± 0.035
truth energy of tower with max energy [GeV]
no. of events
Entries 19748
Mean 37.25
RMS 6.947
χ^2 / ndf 27.33 / 14
Constant 1879 ± 18.1
Mean 37.65 ± 0.06
Sigma 6.521 ± 0.051
weighted energy of tower with max energy [GeV]
$\sigma_E / E = 14.53\ \%$
$\sigma_E / E = 12.57\ \%$
no. of events
Entries 19748
Mean 49.83
RMS 7.377
χ^2 / ndf 38.53 / 16
Constant 1727 ± 16.5
Mean 49.96 ± 0.06
Sigma 7.259 ± 0.056
energy from cells in HCal [GeV]
no. of events
Entries 19748
Mean 47
RMS 1.923
χ^2 / ndf 9.078e-07 / 0
Constant 8557 ± 90.4
Mean 47.71 ± 0.02
Sigma 1.423 ± 0.018
truth energy from cells in HCal [GeV]
no. of events
Entries 19748
Mean 47.24
RMS 6.216
χ^2 / ndf 27.4 / 12
Constant 2093 ± 20.3
Mean 47.21 ± 0.05
Sigma 5.936 ± 0.048
weight energy from cells in HCal [GeV]

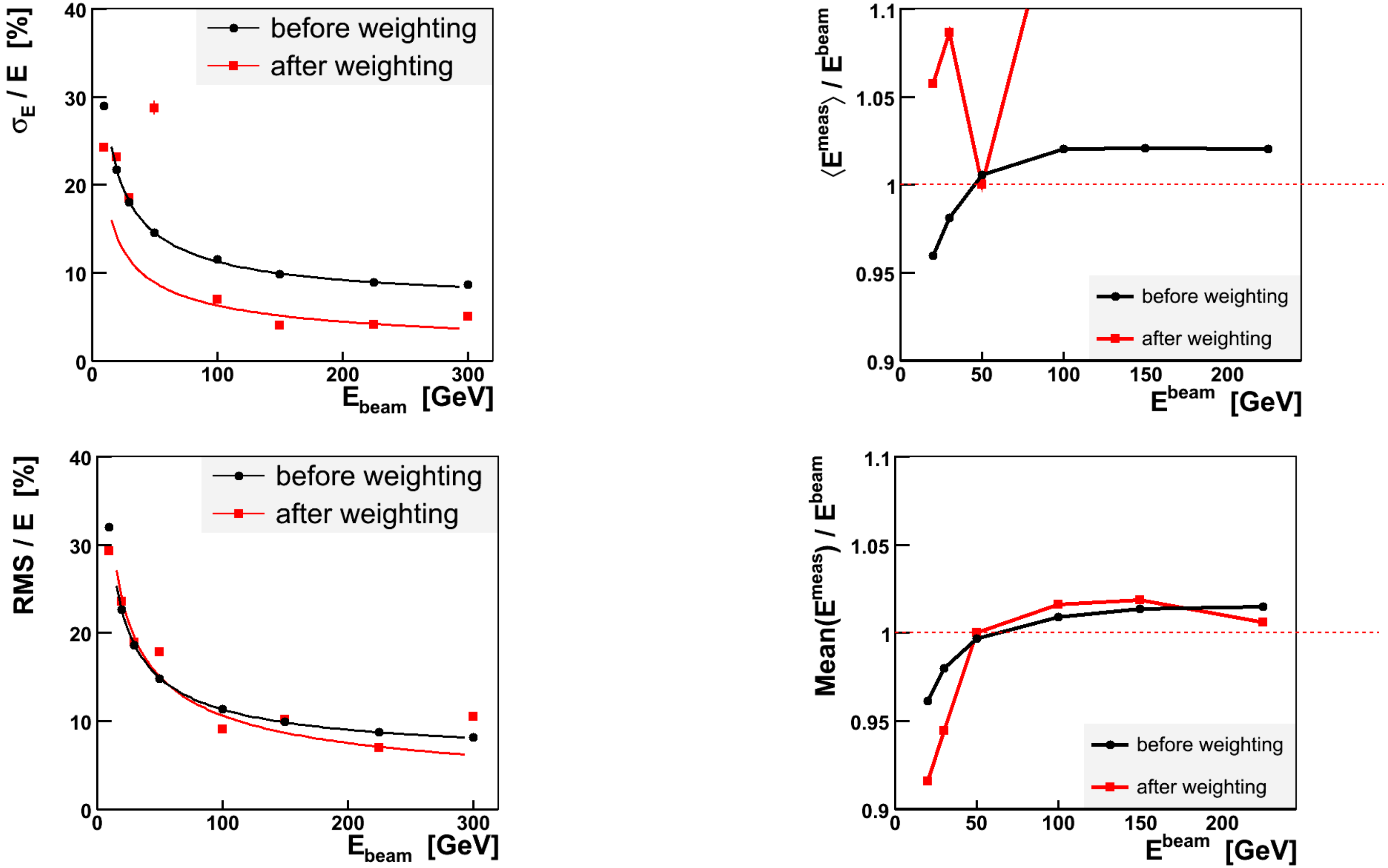
Conclusion

- Weight without ecal
- Weight without first layer

Now: Lets weight!

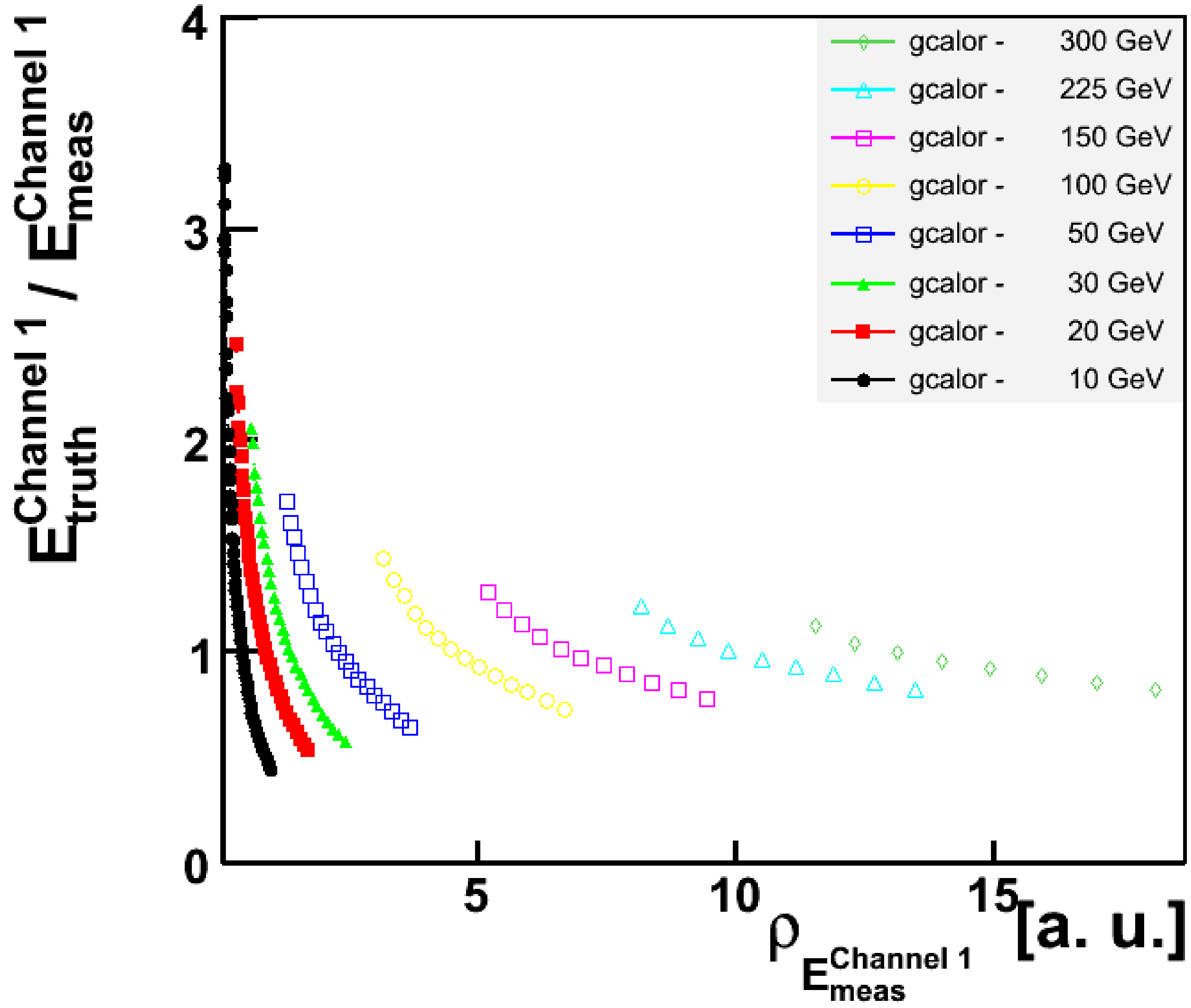
NB: entry for 10 GeV and 300 GeV skipped because unrealistic (ideal weights, etc.)



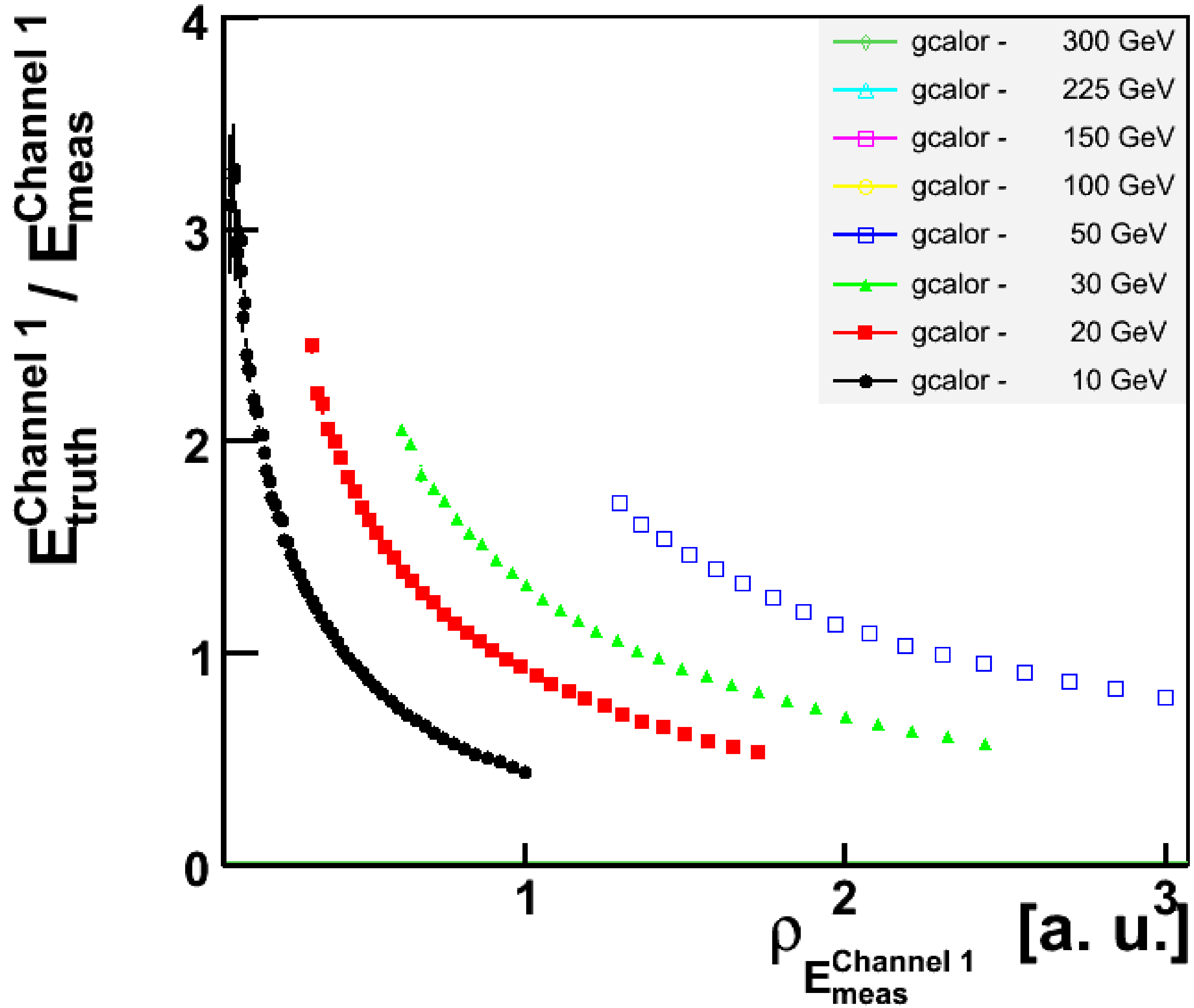


before weighting
after weighting
σ_E / E [%]
E_{beam} [GeV]
$\langle E^{meas} \rangle / E^{beam}$
E^{beam} [GeV]
RMS / E [%]
Mean(E^{meas}) / E^{beam}

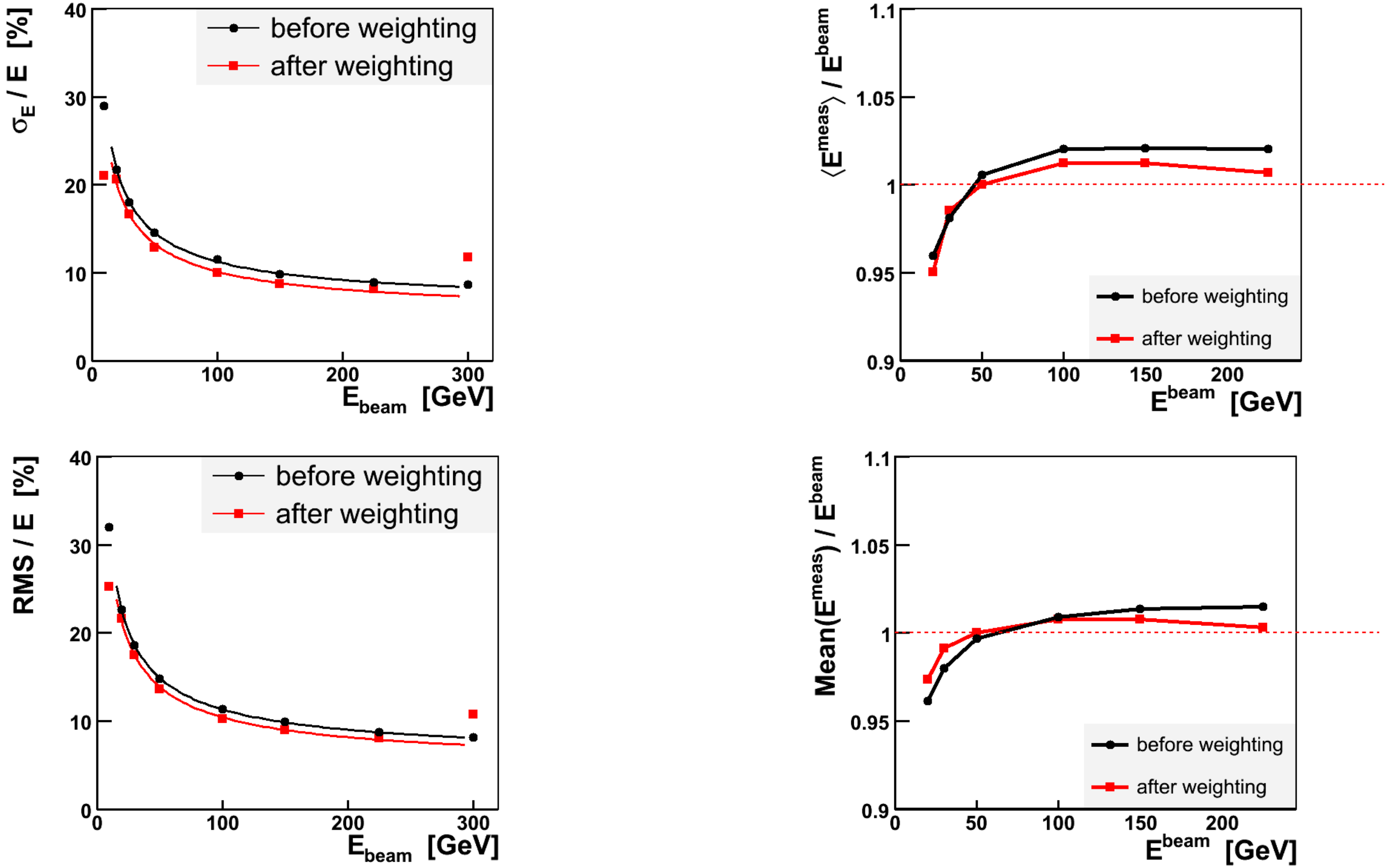
Gcalor, ecal_0, first_layer_0, 17

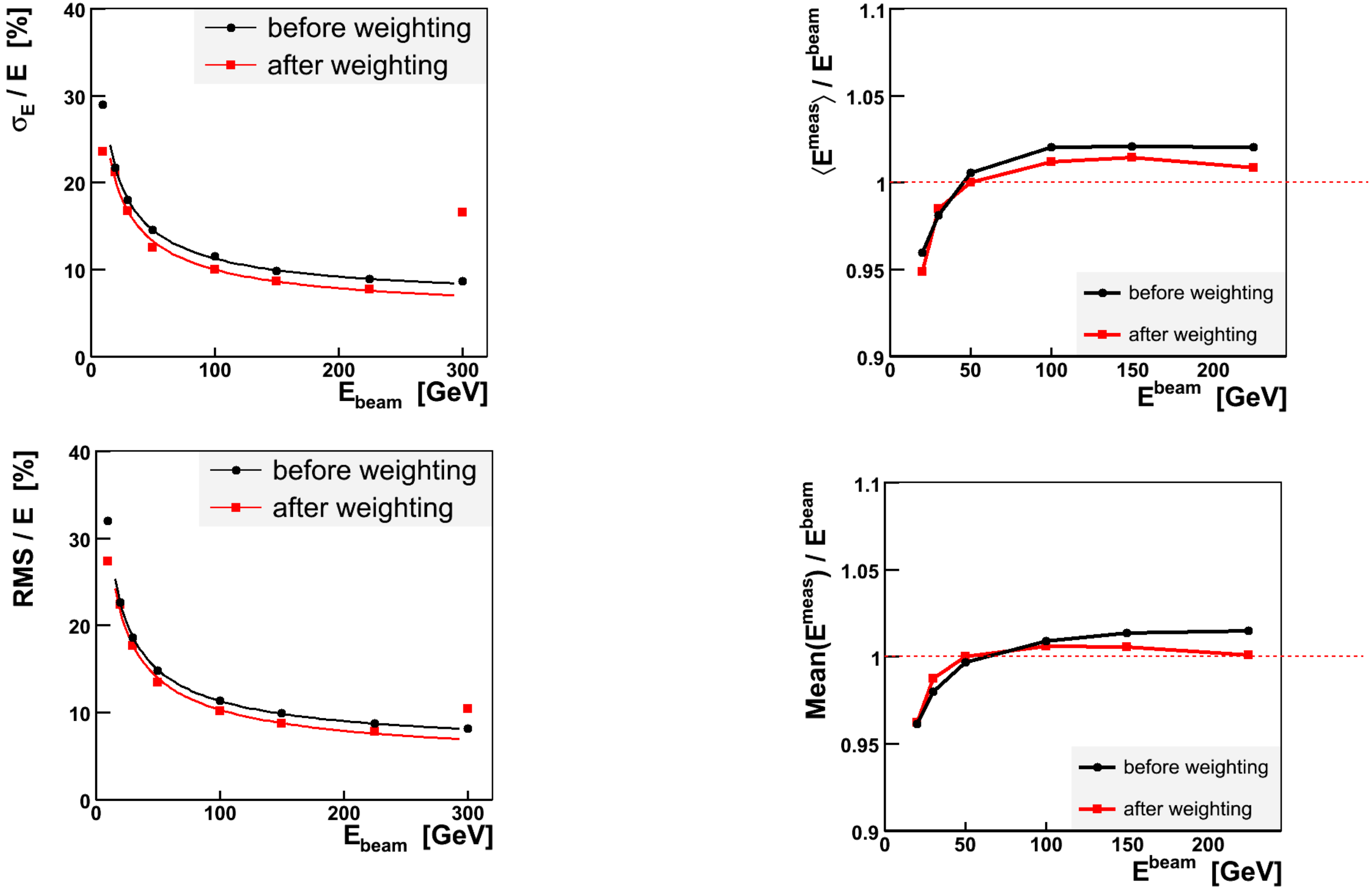


Gcalor, ecal_0, first_layer_0, 17

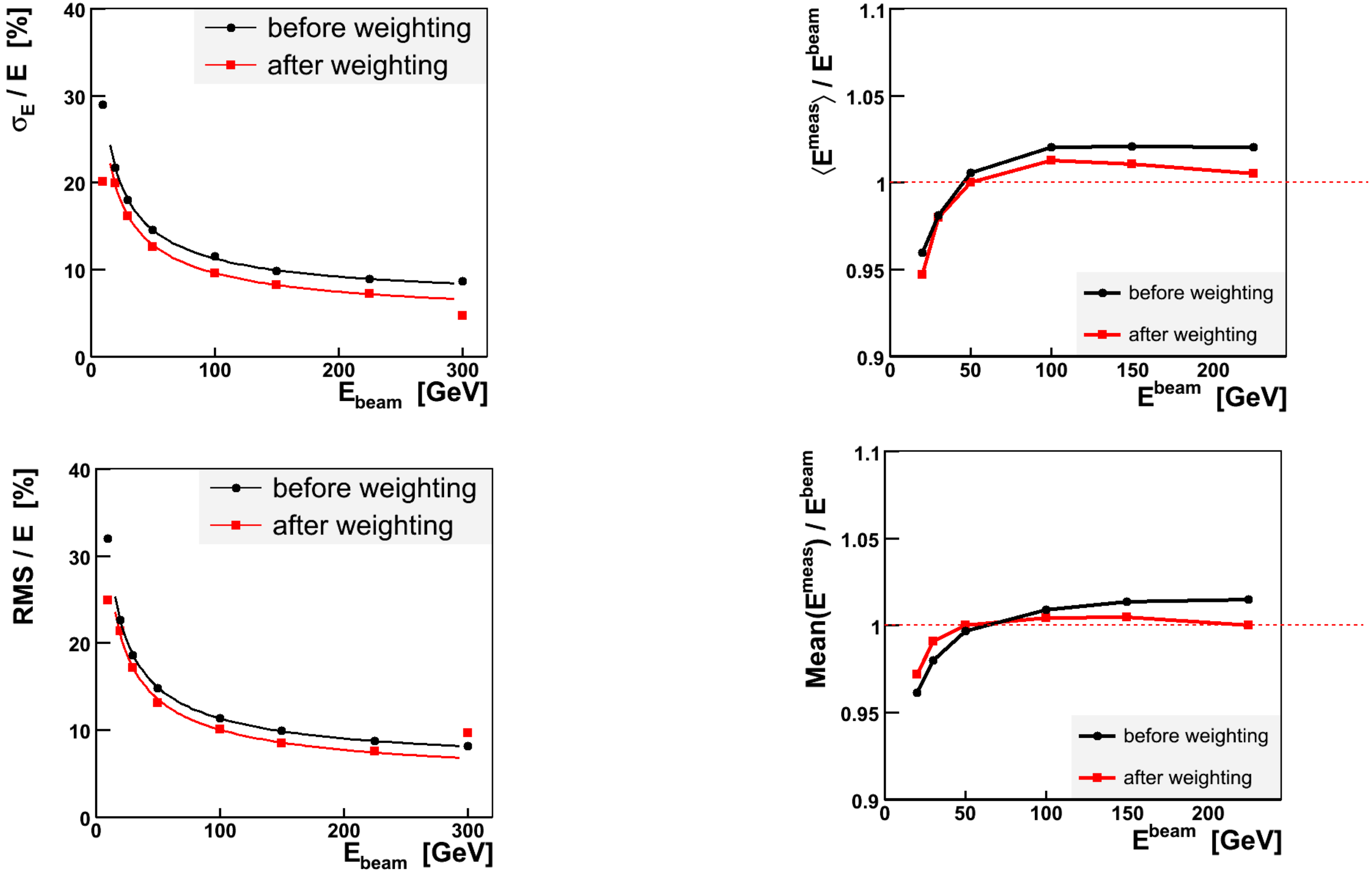


Gcalor, ecal_0, first_layer_0, 12212

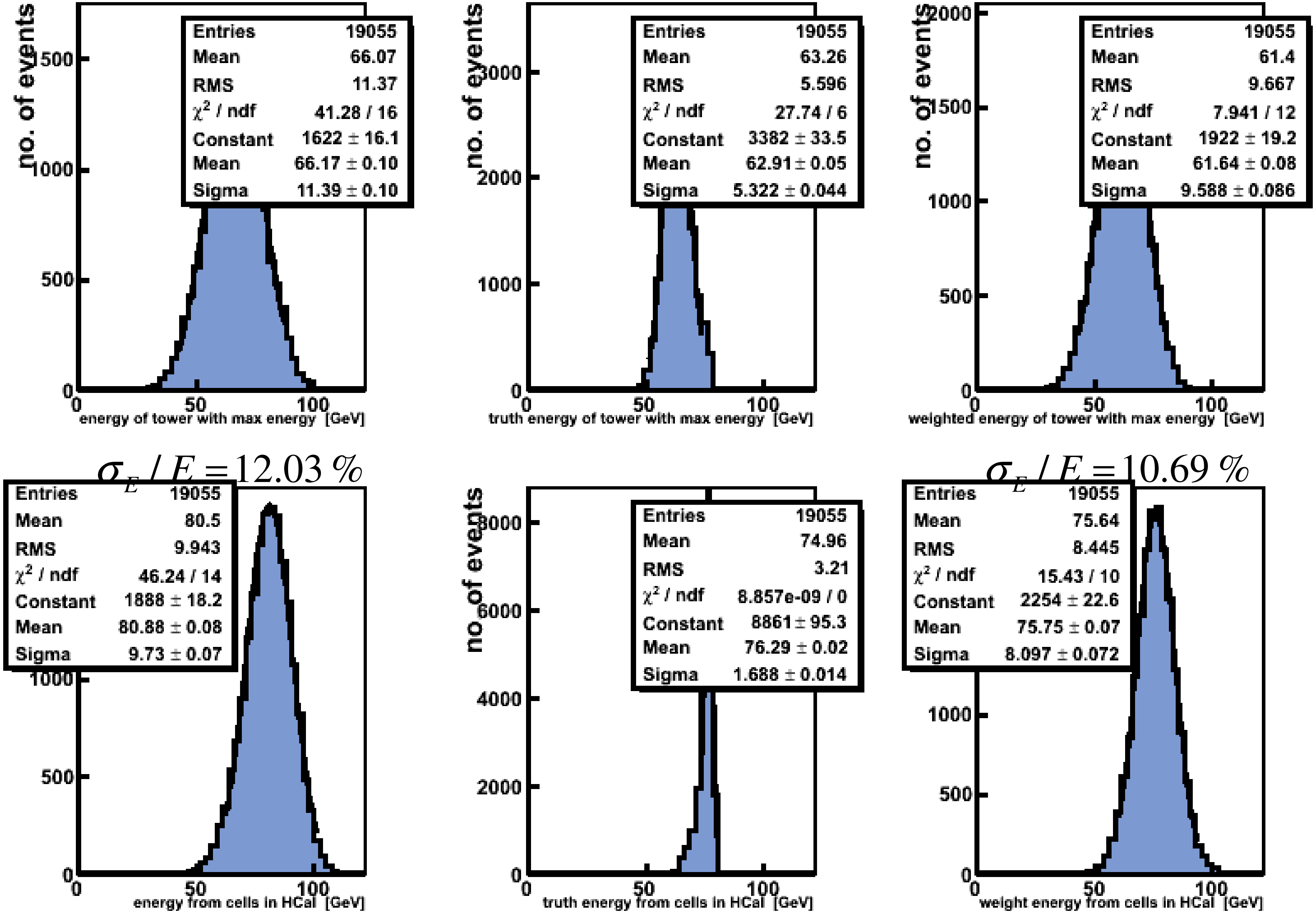



before weighting
after weighting
σ_E / E [%]
E_{beam} [GeV]
$\langle E^{meas}\rangle / E^{beam}$
E^{beam} [GeV]
RMS / E [%]
Mean(E^{meas}) / E^{beam}

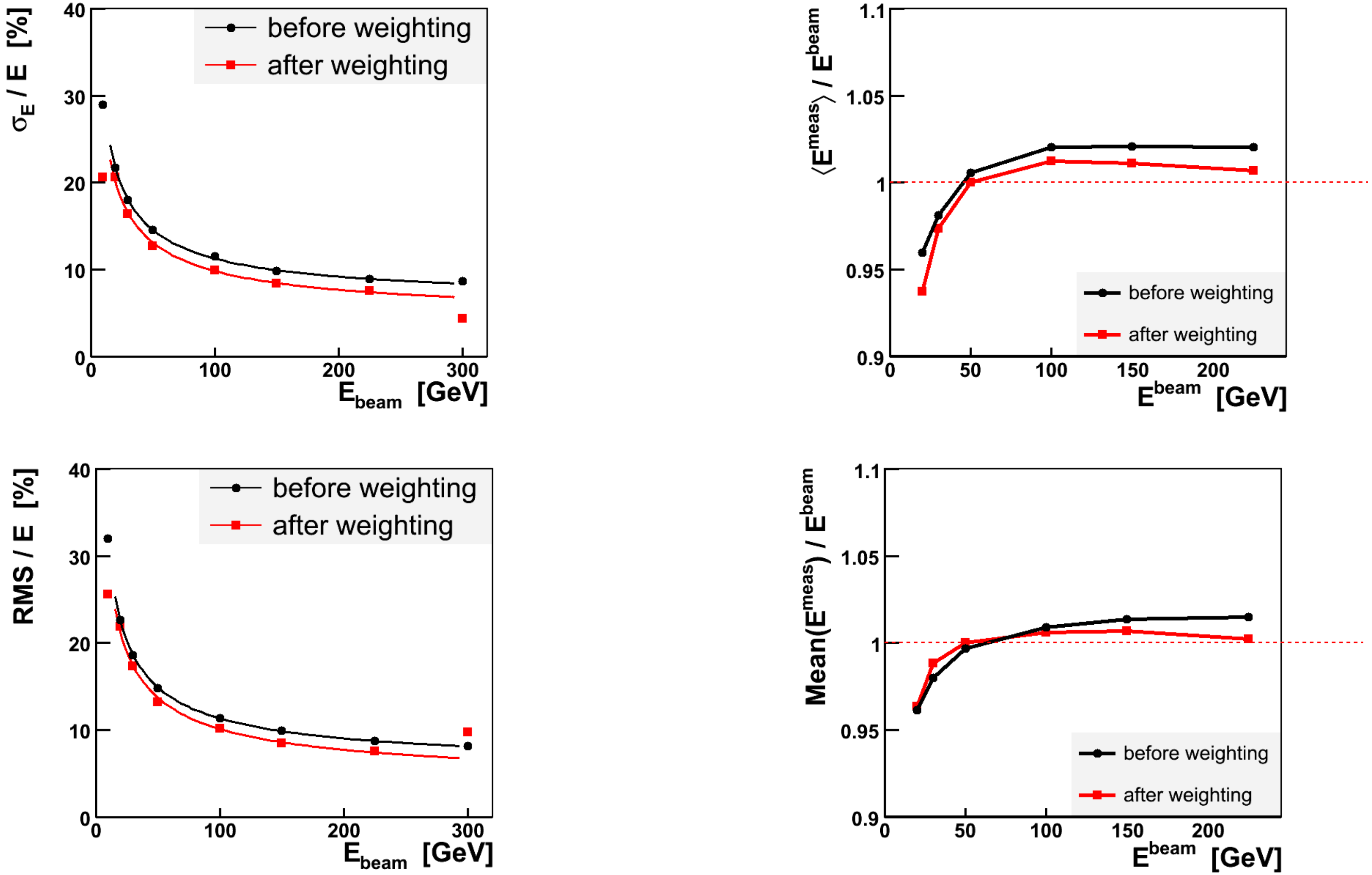
Gcalor, ecal_0, first_layer_0, 1448



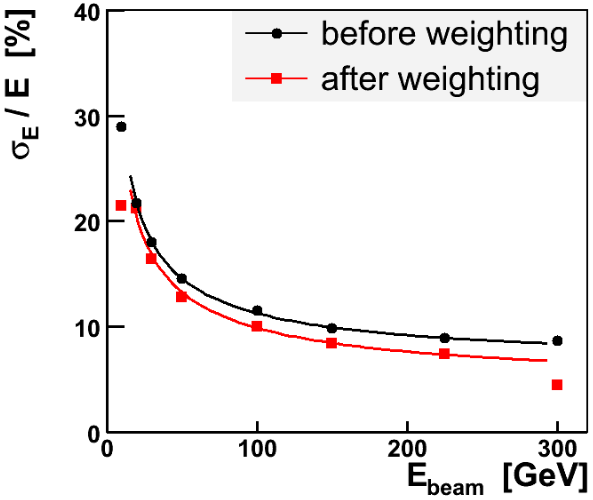
Gcalor, ecal_0, first_layer_0, 1448, 80 GeV

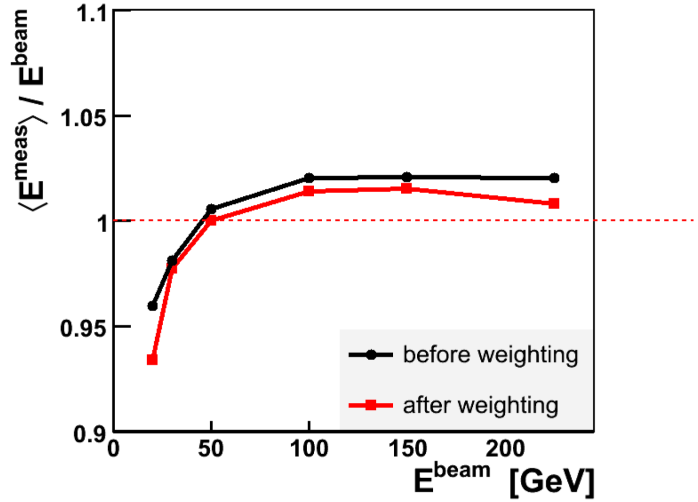


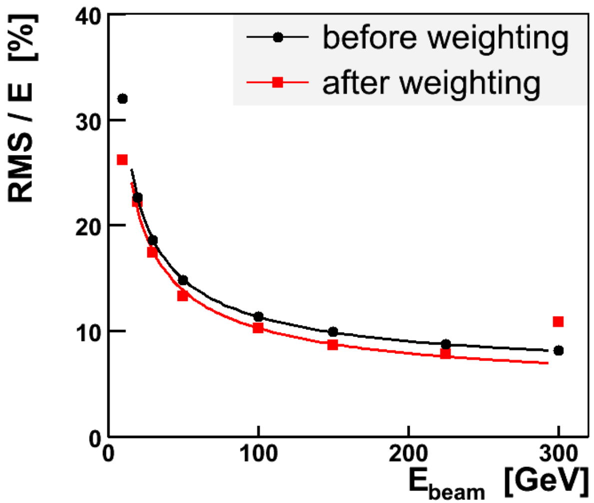
Gcalor, ecal_0, first_layer_0, 1556

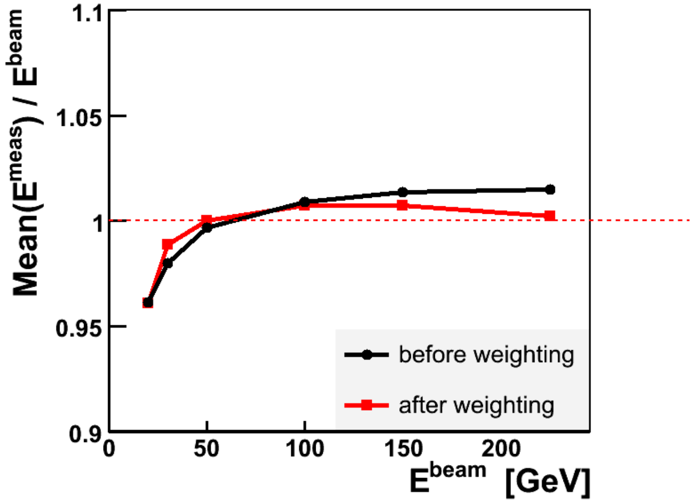


Gcalor, ecal_0, first_layer_0, 1664

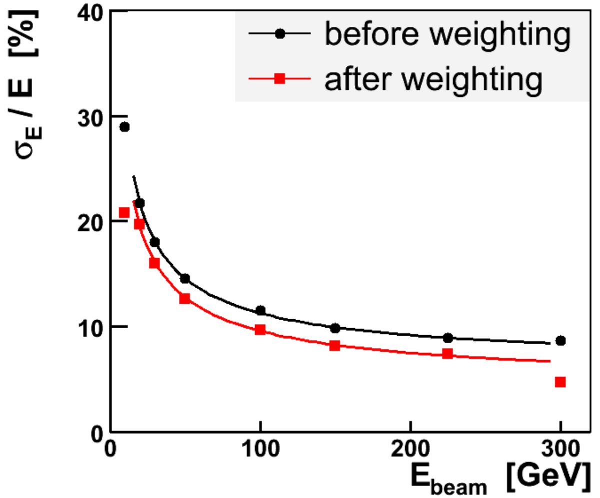


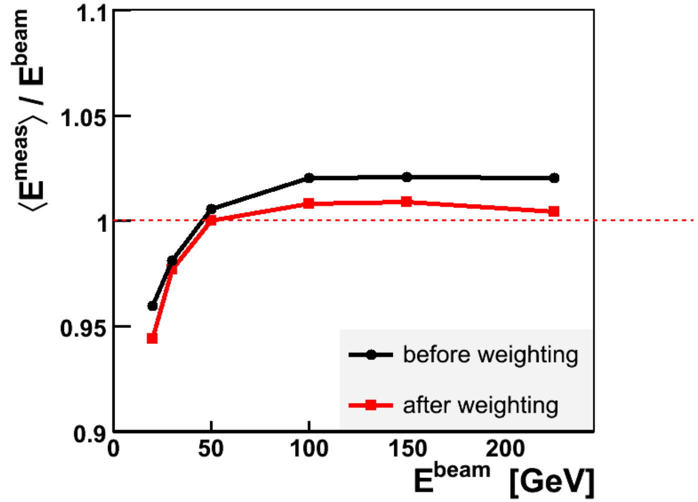


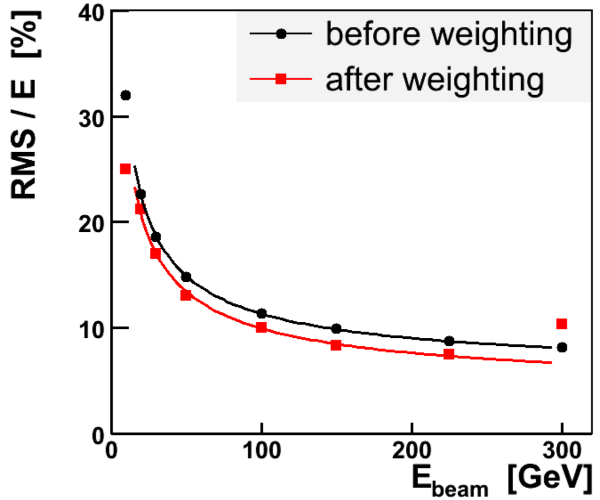


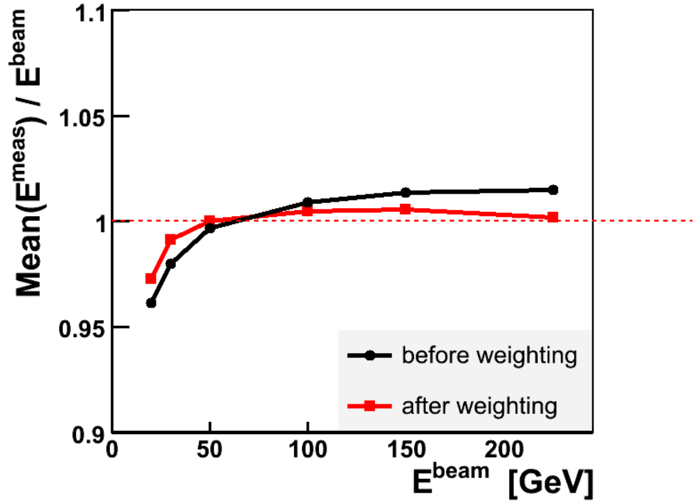


Gcalor, ecal_0, first_layer_0, 133334

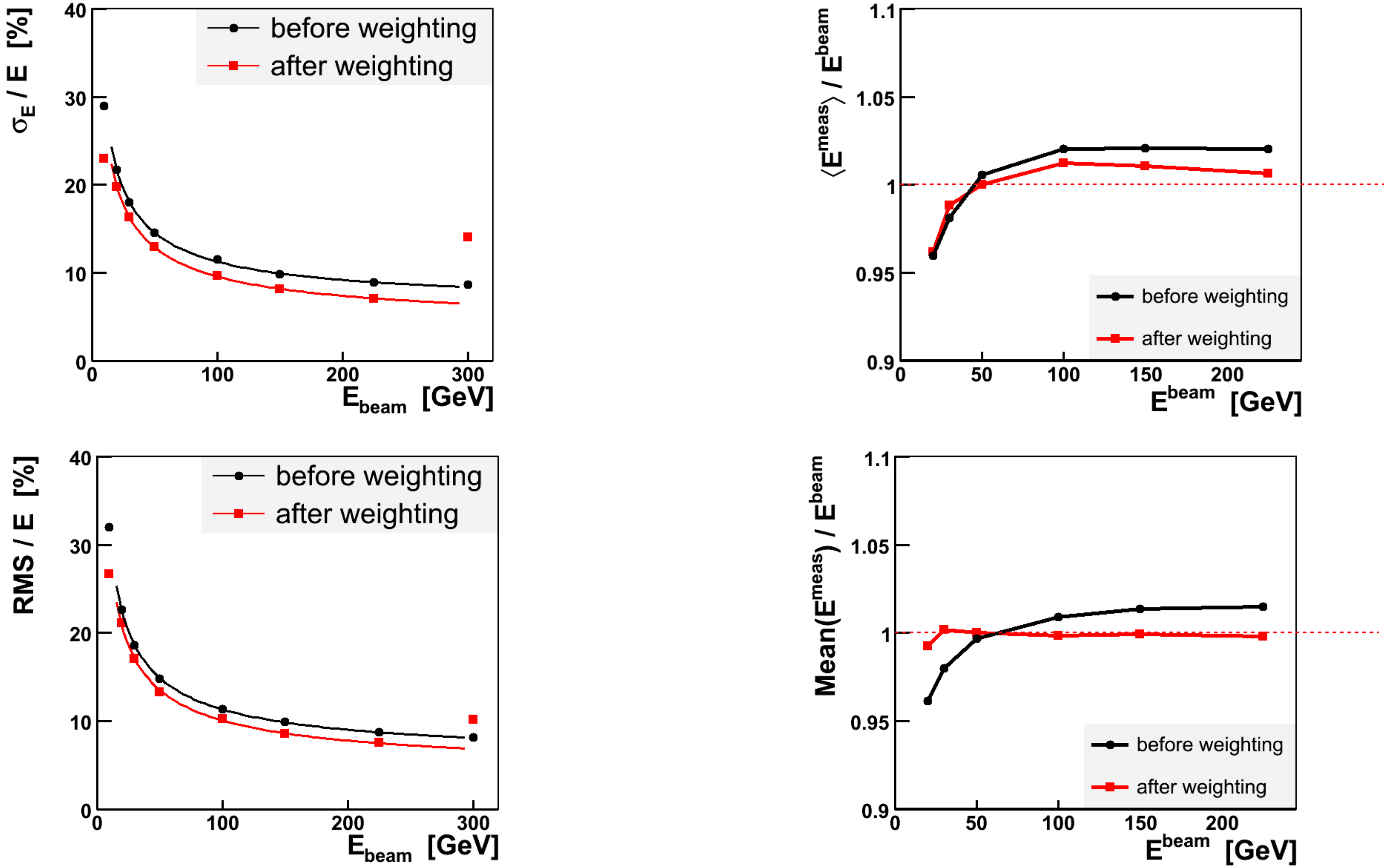








Gcalor, ecal_0, first_layer_0, 1111111111111



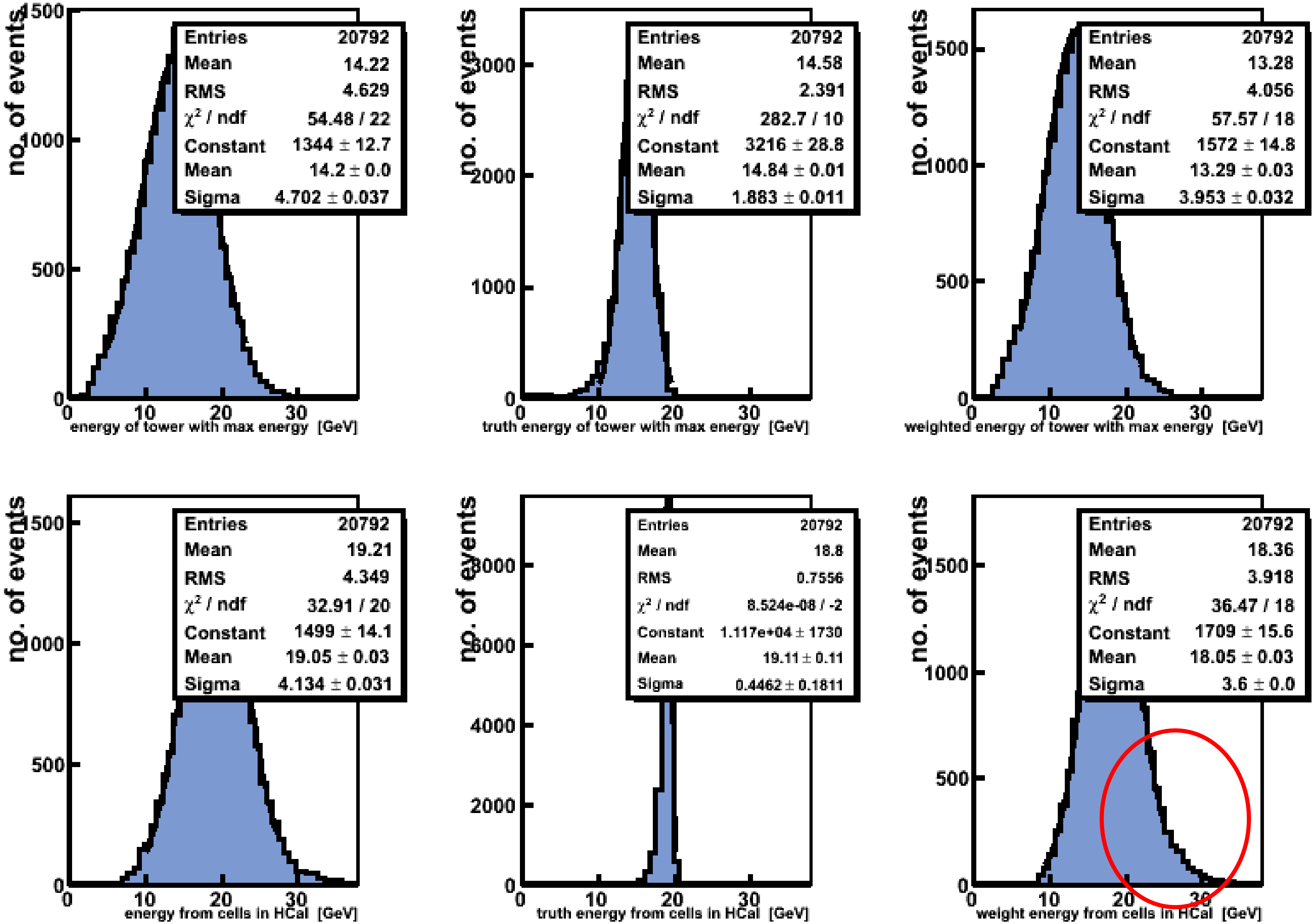
Summary results

Measured: $$\left(\frac{\sigma(E)}{E}\right)^2 = \frac{92.2\%^2}{E} + 6.5\%^2$$

Design	after weighting sampling term	constant term	improv. Sampl. Term [%]
17	62,8	0,0	31,8
12212	86,0	5,3	6,7
13310	87,4	4,8	5,2
1448	85,4	4,4	7,4
1556	86,9	4,6	5,8
1664	88,4	4,4	4,0
133334	84,3	4,5	8,5
1111111…	86,4	4,1	6,3

Error of sampling term ≈ 0.6 GeV
Error of constant term ≈ 0.1 GeV

Mean better than Gauss fit for the Linearity, because of non-gaussian tails



Conclusion / Outlook

Conclusion

Weighting works fine:

☺ Improvement of energy resolution (sampling term + constant term)

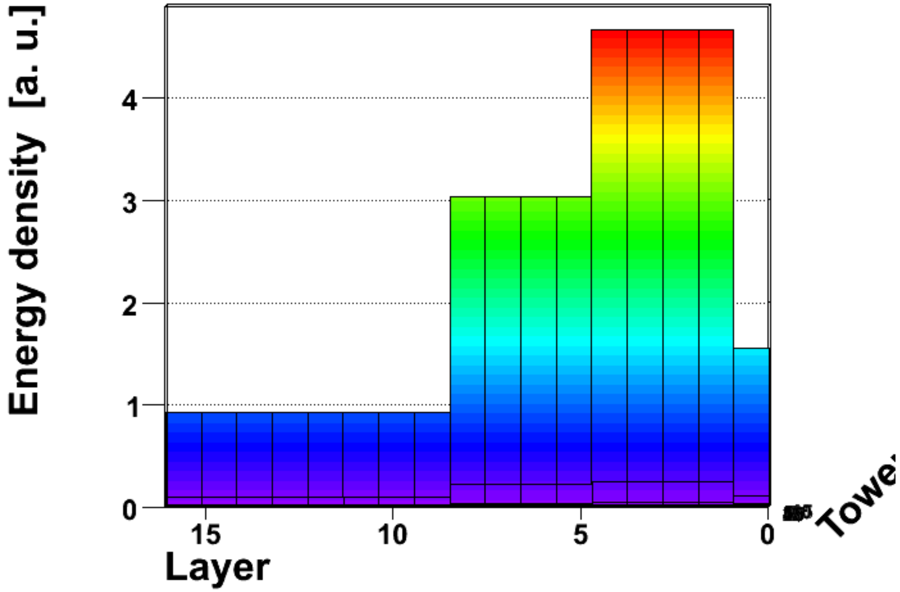
- (almost) no gain in Linearity

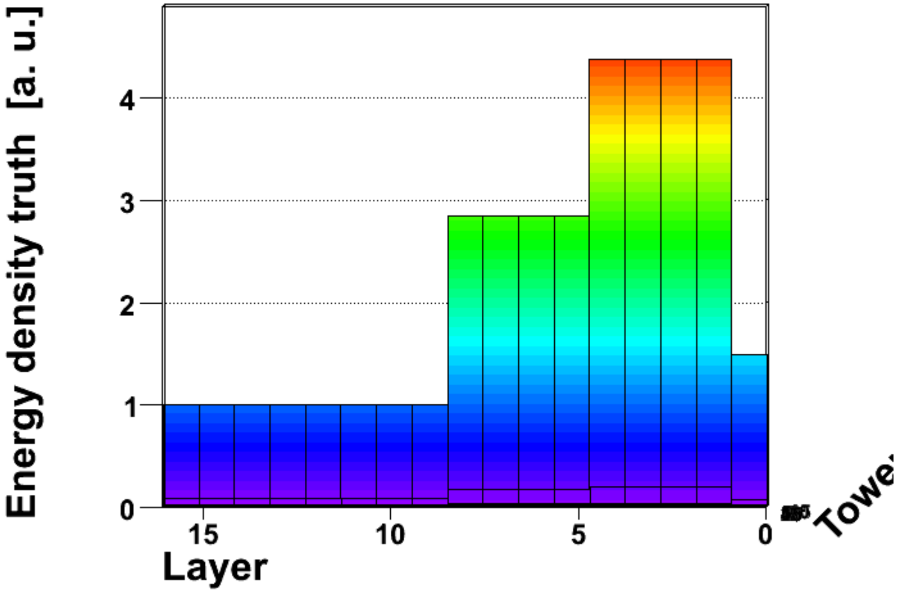
Outlook

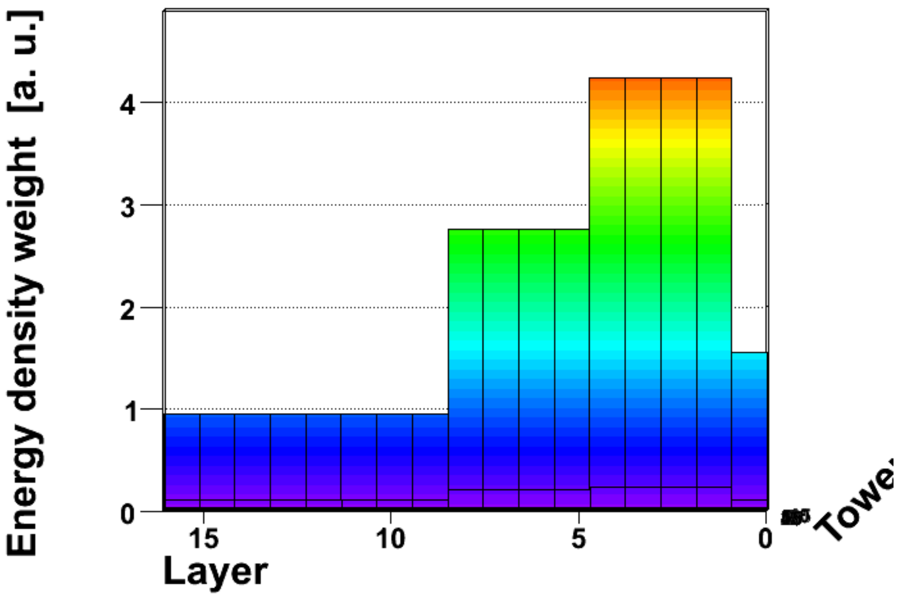
- Establish weighting in CMSSW
- Realize weighting with both populations (for each a set of WF)
- Investigate Weighting with jets (CMSSW and Geant3)
- Investigate other shower algorithms (for systematic error estimation)
- Find correction function instead of tabulated weights
- Play with interpolation of WF
- Study impact on physics analysis (e. g. W-reconstruction)
- Play a bit more with readout schemes

Backup

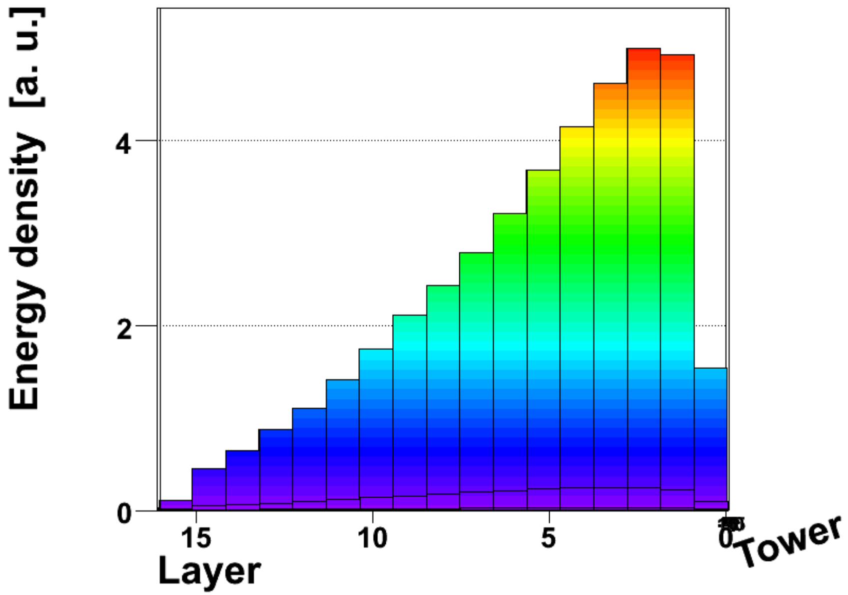
50 GeV, ecal_0, first_layer_0, 1448

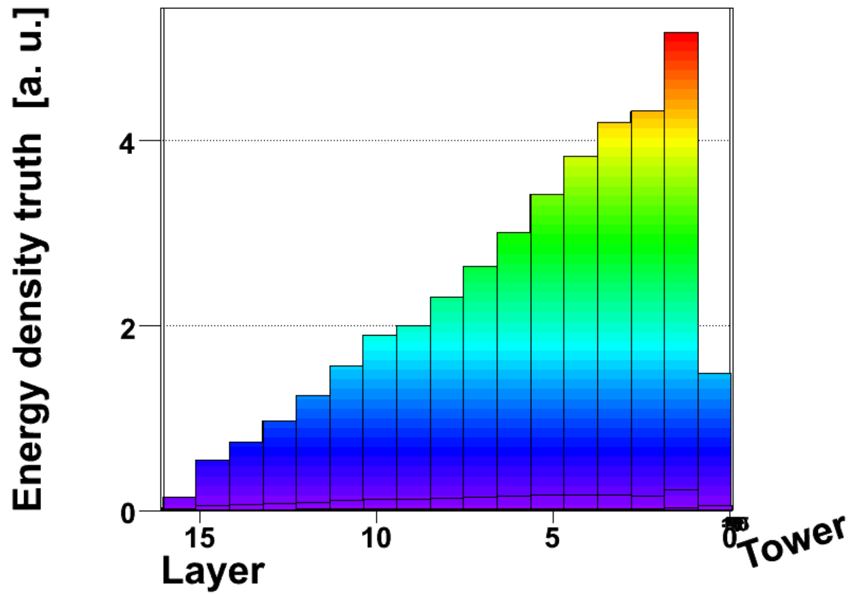


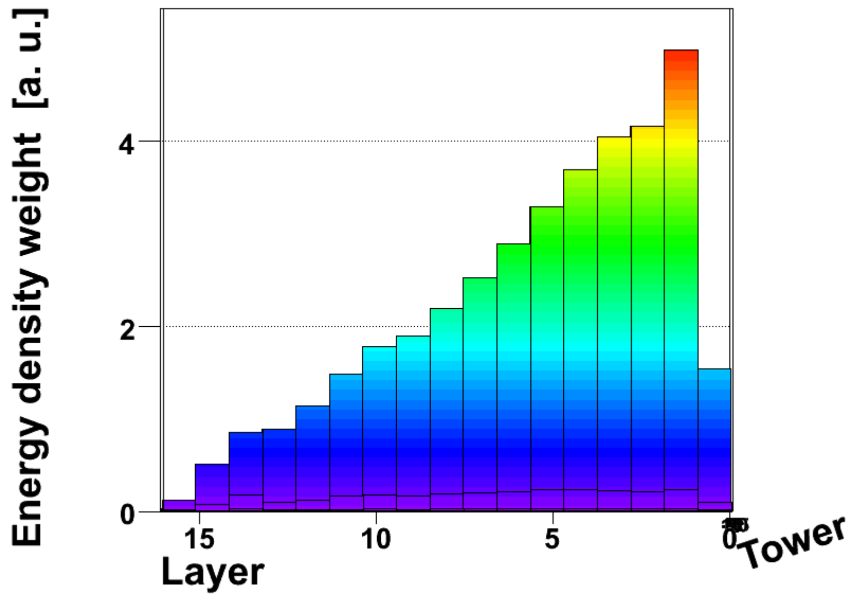




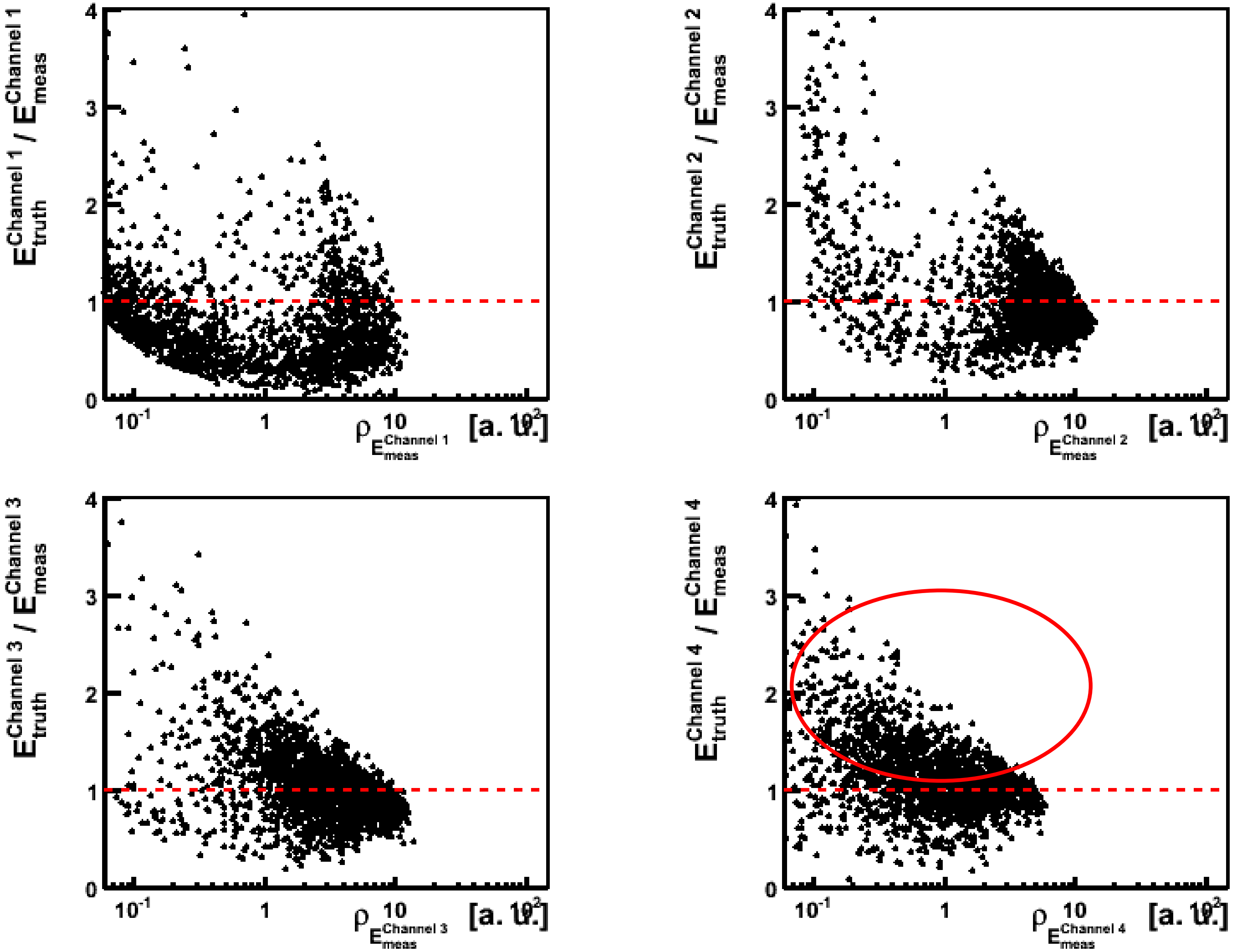
50 GeV, ecal_0, first_layer_0, 111111111



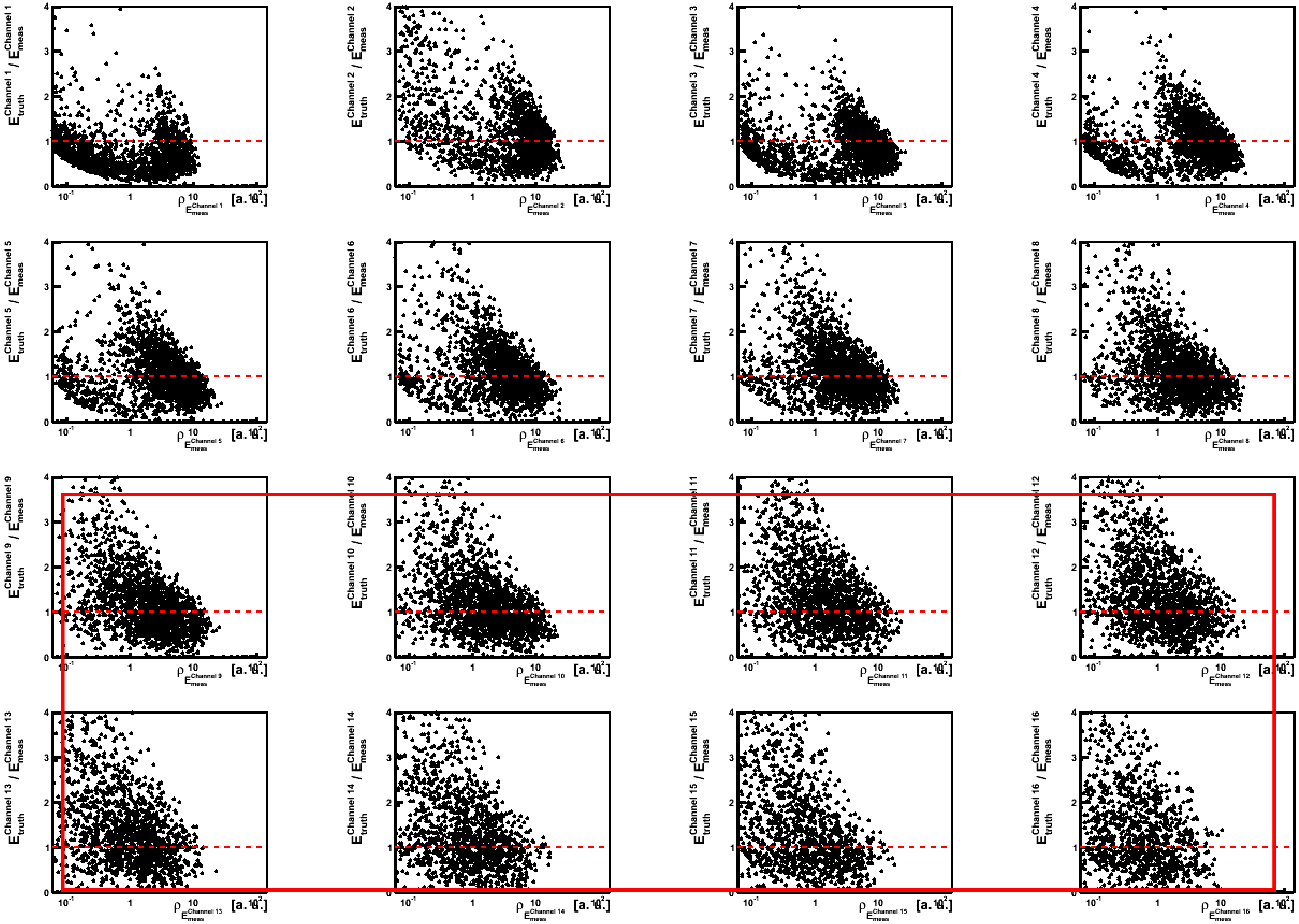




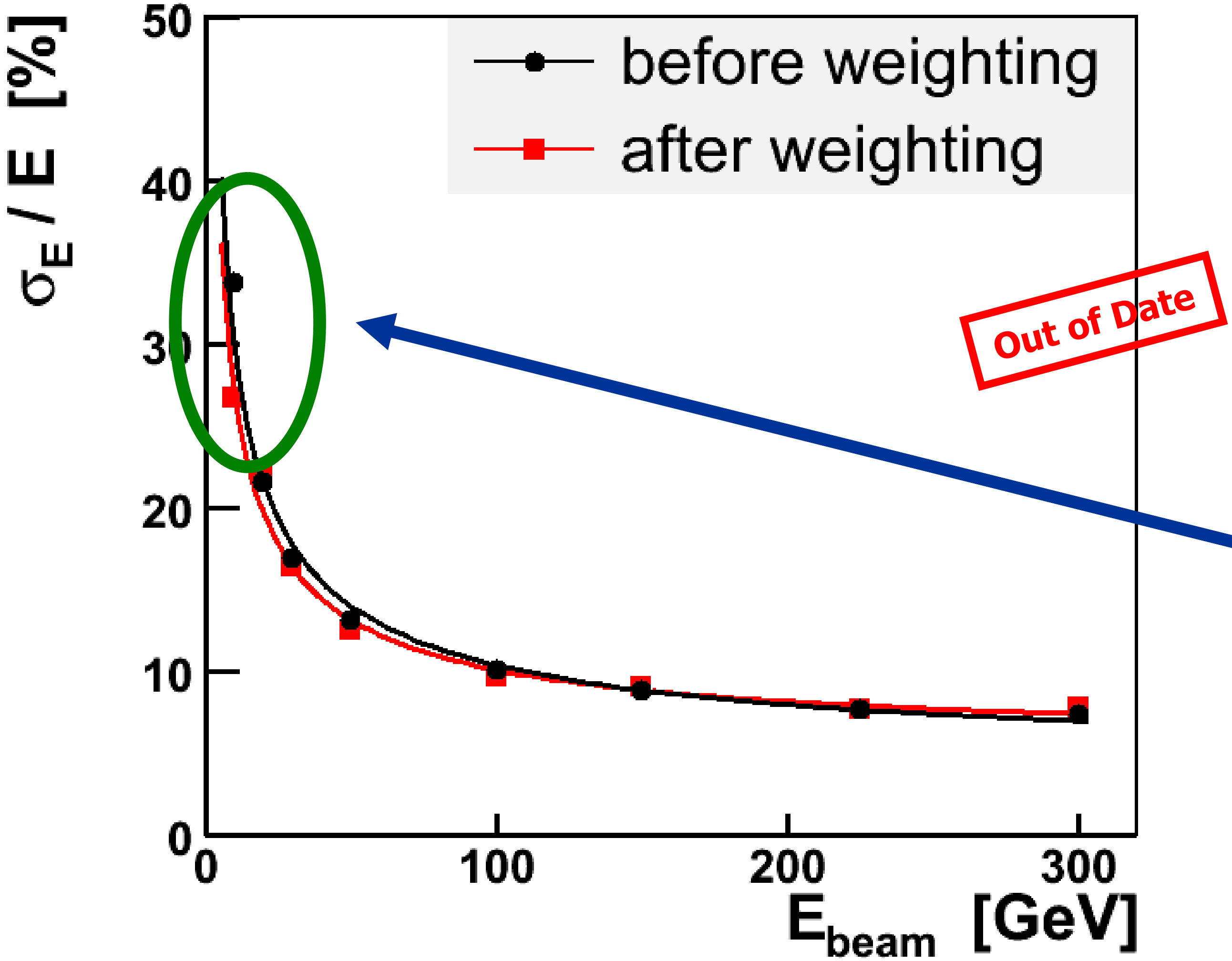
50 GeV π, gcalor, ecal_0, cut_0, 1448



50 GeV π, gcalor, ecal_0, cut_0, 11111



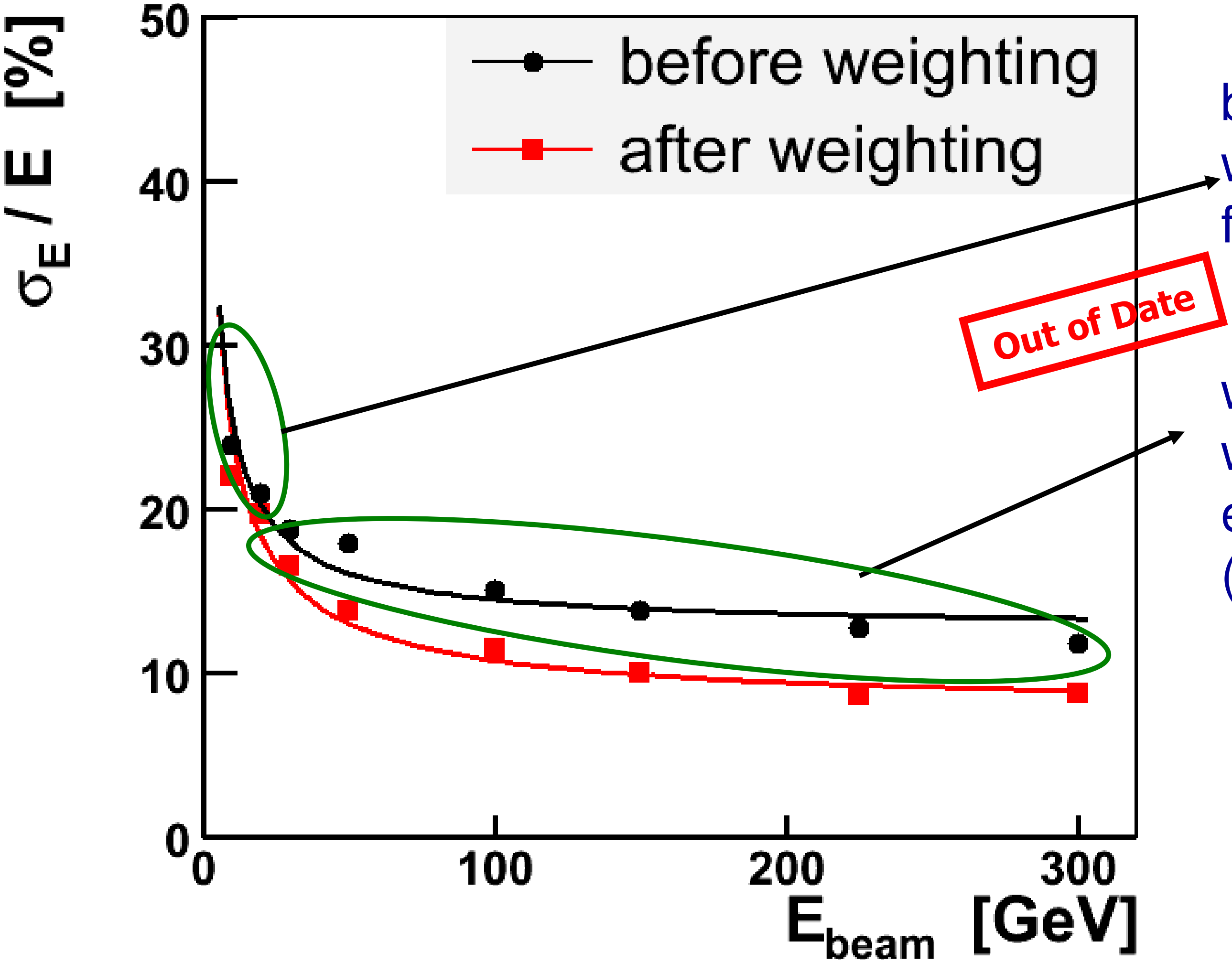
Energy resolution, 1448, without ECal, interpol



?

➔ Ideal WF used
Because there are no others…

Energy resolution, 1448, with ECal , interpol



better energy resolution (than without ECal) because energy fraction in ECal is larger.

worse energy resolution (than without ECal) because more energy in passive Material (now also early showers)

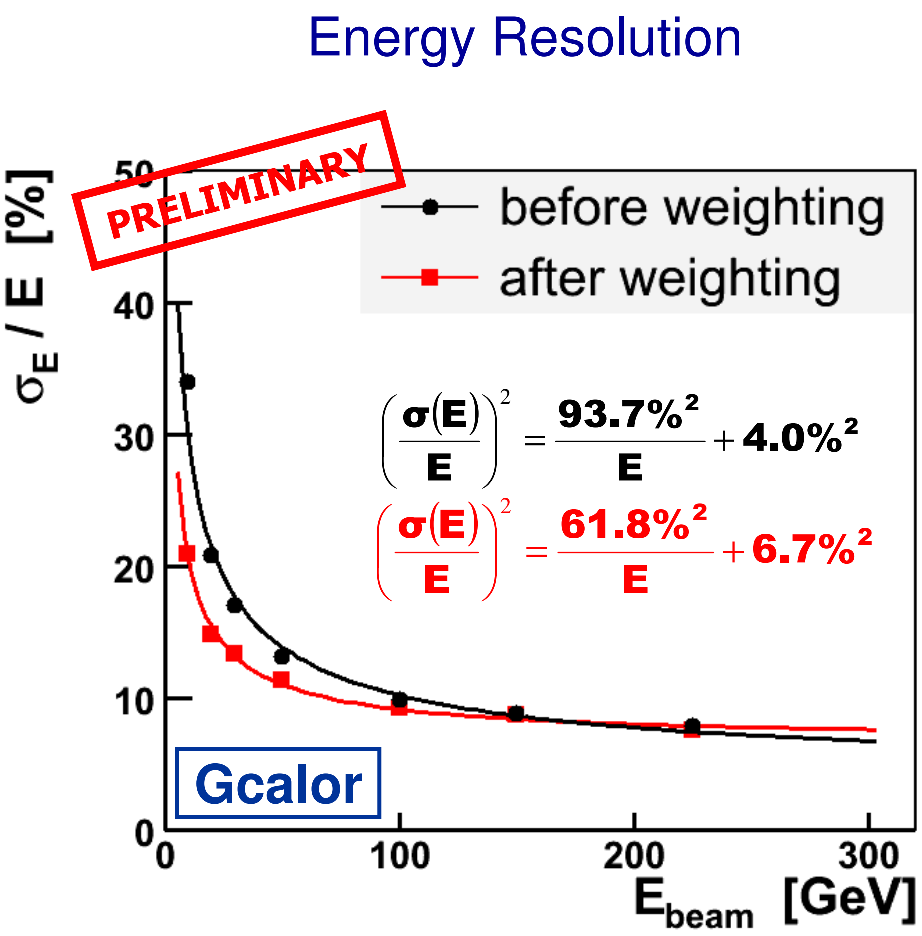
Energy resolution, 1448, with ECal , interpol

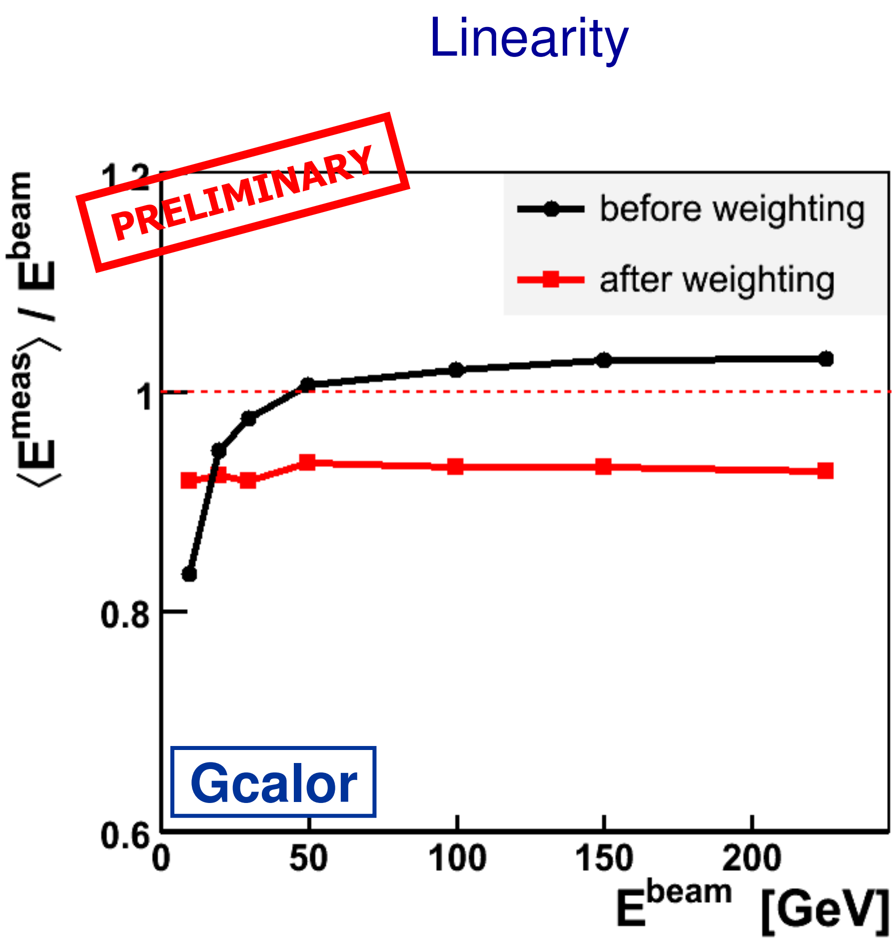
One could conclude:
Well then! So the weighting compensates very well for the dead material!

Detailed plots in Folder

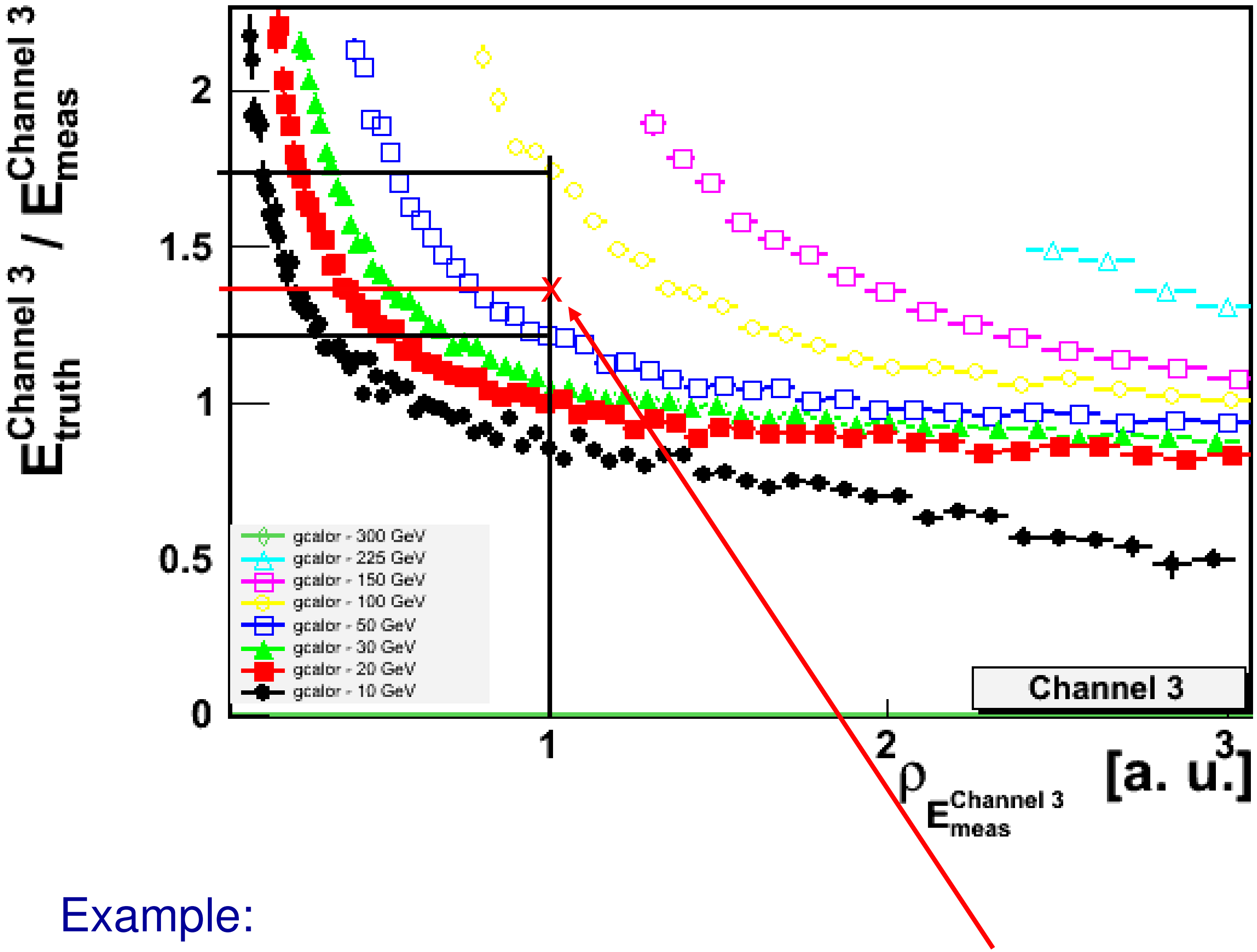
			before weighting		ater weighting		improv.
design	**first_layer**	**correction**	**sampling**	**constant t**	**sampling**	**constant t**	**Sampl.**
1448	1	1	86,78	4,91	83,89	5,20	3,33
11111	1	1	86,78	4,91	87,38	3,78	-0,69
1448	1	2	91,80	6,59	85,57	5,54	6,79
11111	1	2	91,80	6,59	88,97	3,80	3,08
→ 1448	0	1	86,78	4,91	81,53	3,73	6,05
11111	0	1	86,78	4,91	83,38	3,81	3,91
→ 1448	0	2	91,80	6,59	85,93	4,12	6,39
11111	0	2	91,80	6,59	87,16	3,50	5,05
first_layer	also the first layer is weighted						
correction	factor 0,5 for first layer						
correction	factor 3.7/9 for first layer						

1448, without ECal, ideal WF





- ☺ **Energy resolution (sampling term) improved**
- ☺ **Linearity improved**



Example:

E_{meas} = 60 GeV;

$E_{meas}^{channel\ 3}$ = 4 GeV ➔ rho = 1

Logical chain weighting concept

Good Results, when weighting is used with Certain test beam weights (everything seems consistent)

→ more realistic →

Weighting including ECal: Results even better (due to truth energy of ECal)
Fake: Implicit use of energy-hypothesis

↓ more realistic ↓

Energy-hypothesis: measured Energy → strange results.
Understood: not enough Weighting factors/ statistics.

← Solution ? ←

Fit to weighting factors:
- Fewer problems due to statistics
- Estimated weighting factors for every energy density
- Smooth WF distribution