Rough Estimation of shower profile determination uncertainites (runs with 100 evts): GEANT4 *(4.8.2)*- EGS5

Simple/ideal calorimeter of CsI:

30 radiation lengths, segmented in 1/2 rad length (1.85/2. cm)

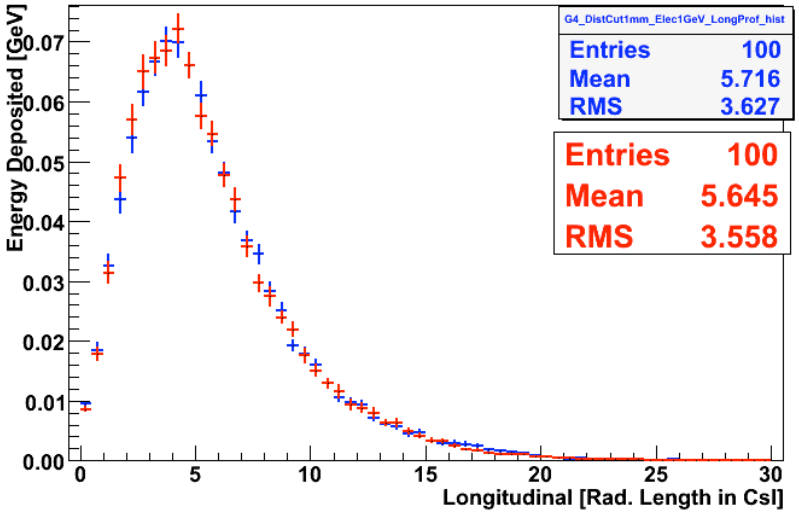
16 cm segmented in 0.04 cm

Conclusion: Shower profiles (determined with 100 evts) can vary (mean and rms) by few percent. The variations are energy dependent.

Electrons 1 GeV

GEANT 4 **EGS 5**

Longitudinal

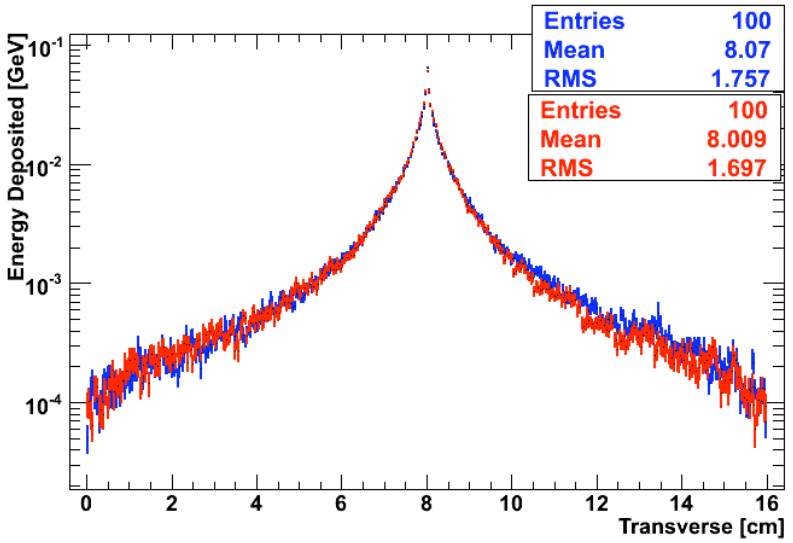


Relative Changes:

mean= (5.716-5.645)/5.716 = **1.2 e-2**

RMS= (3.627-3.558)/3.627 = **1.9 e-2**

Transverse



Relative Changes:

mean= (8.07-8.009)/8.005 = **0.8 e-2**

RMS= (1.757-1.697)/1.757= **3.4 e-2**

Are those differences significant ????

Simulation of different runs (100 evts) changing random number generation seed: EGS5

EGS5 manual (slac730-070620.pdf)

*EGS5 employs the random number generator **RANLUX**. Depending on the input specification, called the luxury level, RANLUX provides random sequences which pass different levels of tests for randomness and execute at different speeds. Independent random sequences for the same luxury level can be generated with RANLUX by simply specifying a different input seed; any integer in the range from 1 to 2^{31}*

Several Luxury levels available for RANLUX (HEPRandom)

level 0 (p=24): equivalent to the original RCARRY of Marsaglia and Zaman, very long period, but fails many tests.

level 1 (p=48): considerable improvement in quality over level 0, now passes the gap test, but still fails spectral test. *Default in the examples of EGS5; USED in these simulations*

level 2 (p=97): passes all known tests, but theoretically still defective.

level 3 (p=223): Any theoretically possible correlations have very small chance of being observed. *Recommended by GEANT4 manual for usage of HEP Random class.*

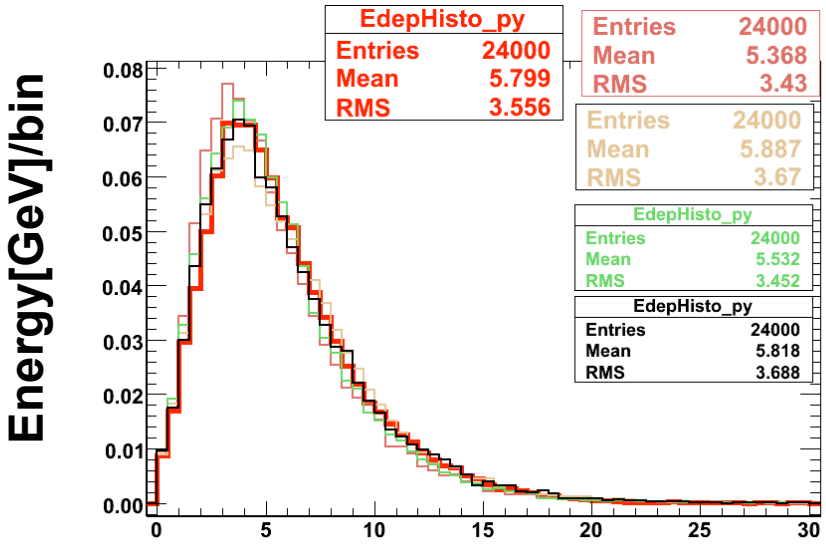
level 4 (p=389): highest possible luxury, all 24 bits chaotic.

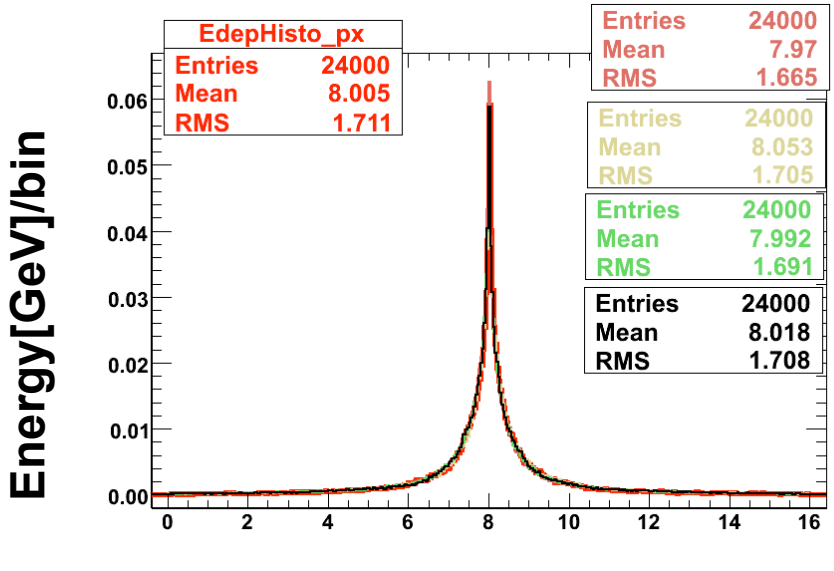
Study of shower profile fluctuations from run-to-run when varying seed for random number generations

Electrons 1 GeV Done with EGS5

seed = 10 (default)

seed = 11 seed = 12 seed = 100 seed = 1000





Max diff. between seed 11 and 12

Relative Changes:

mean= 5.887-5.368/5.799 = **8.9 e-2**

RMS= 3.67-3.43/3.556 = **6.7 e-2**

Relative Changes:

mean= 8.053-7.97/8.005 = **1.0 e-2**

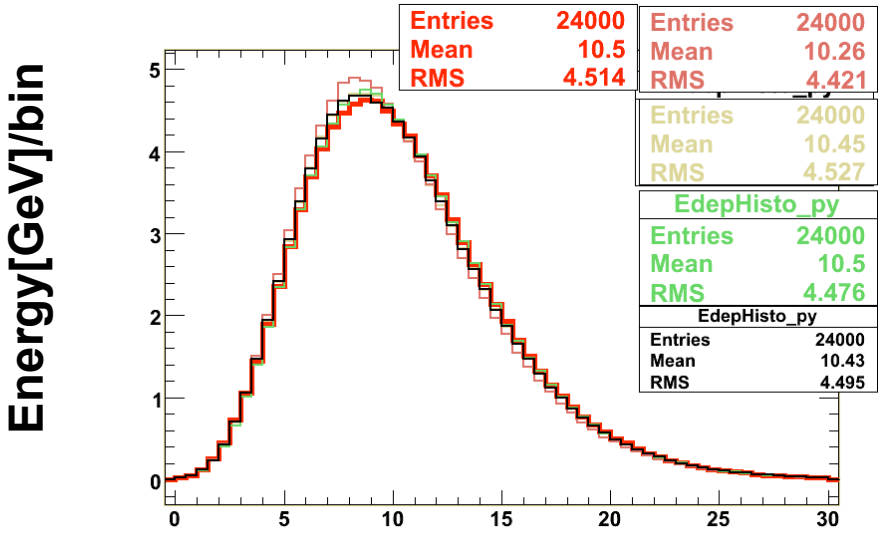
RMS= 1.705-1.665/1.711= **2.3 e-2**

Study of shower profile fluctuations from run-to-run when varying seed for random number generations

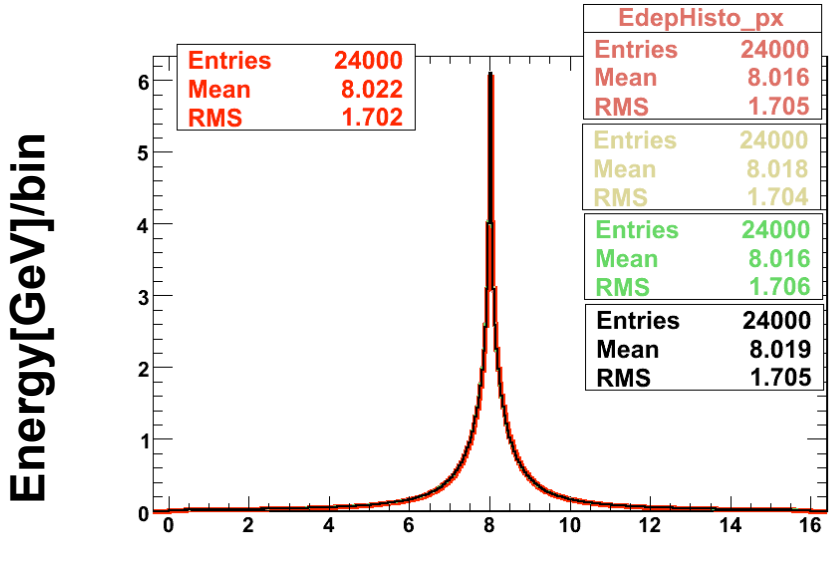
Electrons 100 GeV Done with EGS5

seed = 10 (default)

seed = 11 seed = 12 seed = 100 seed = 1000



Longitudinal (RadLengths)



Transverse (cm)

Max diff. between seed 11 and 10

Relative Changes:

mean= 10.5-10.26/10.5 = **2.3 e-2**

RMS= 4.514-4.421/4.514 = **2.1 e-2**

Relative Changes:

mean= 8.022-8.016/8.022 = **0.07 e-2**

RMS= 1.705-1.702/1.702= **0.17 e-2**

Simulation of different runs (100 evts) changing random number generation seed: GEANT4

http://geant4.web.cern.ch/geant4/UserDocumentation/UsersGuides/ForApplicationDeveloper/BackupVersions/V8.3/html/index.html

RANLUX (taken from the original implementation in fortran 77) algorithm is also available for GEANT4; class RanluxEngine

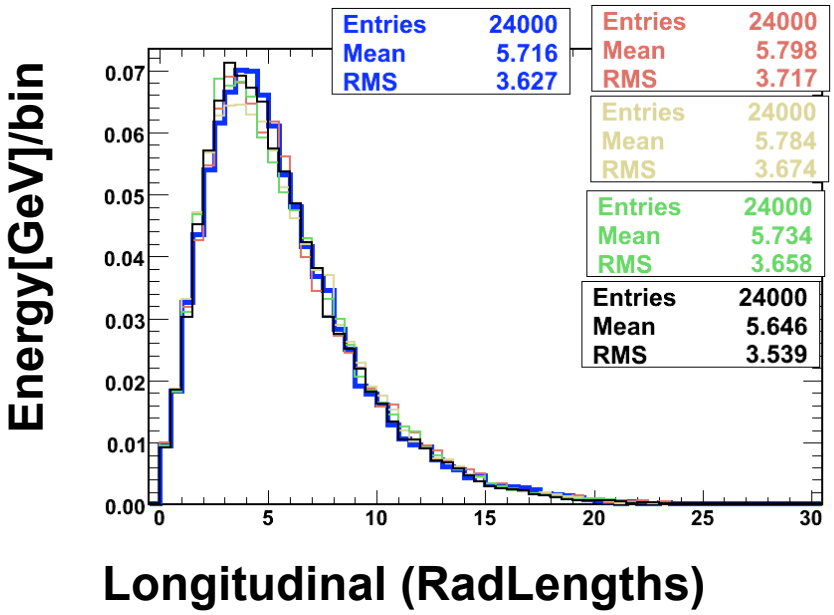
Yet *default engine is* ***HepJamesRandom****; this is what I used for those simulations*

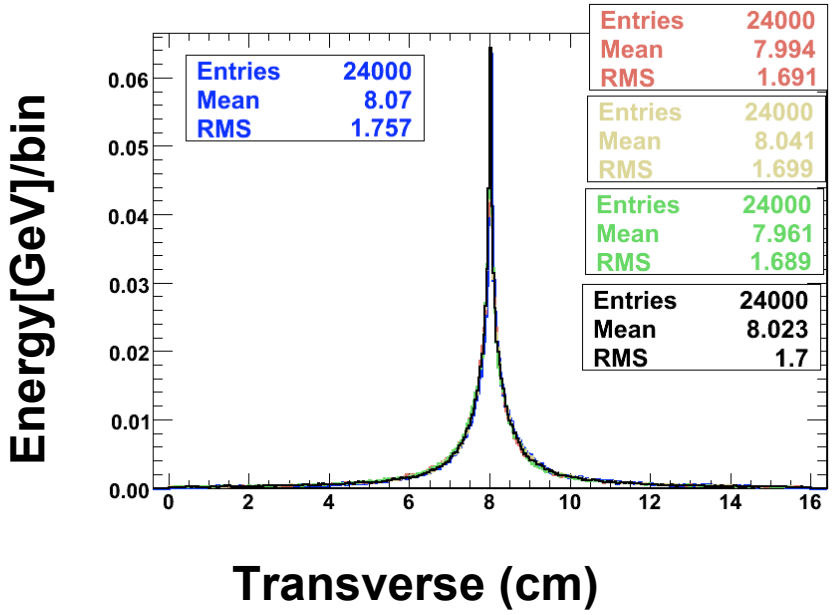
Study of shower profile fluctuations from run-to-run when varying seed for random number generations

Electrons 1 GeV Done with GEANT 4

seed = 9876 (default)

seed = 10 seed = 100 seed = 1000 seed = 10000





Max diff. between seed 10 and 10000

Relative Changes:

mean= (5.798-5.646)/5.716 = **2.7 e-2**

RMS= (3.717-3.539)/3.627 = **4.9 e-2**

Max diff. between default and 1000

Relative Changes:

mean= (8.07-7.961)/8.07 = **1.4 e-2**

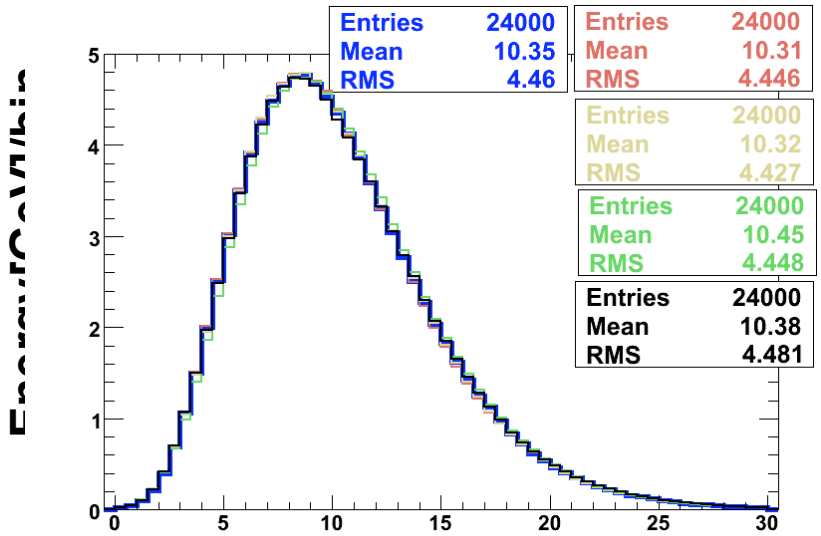
RMS= (1.757-1.689)/1.757= **3.9 e-2**

Study of shower profile fluctuations from run-to-run when varying seed for random number generations

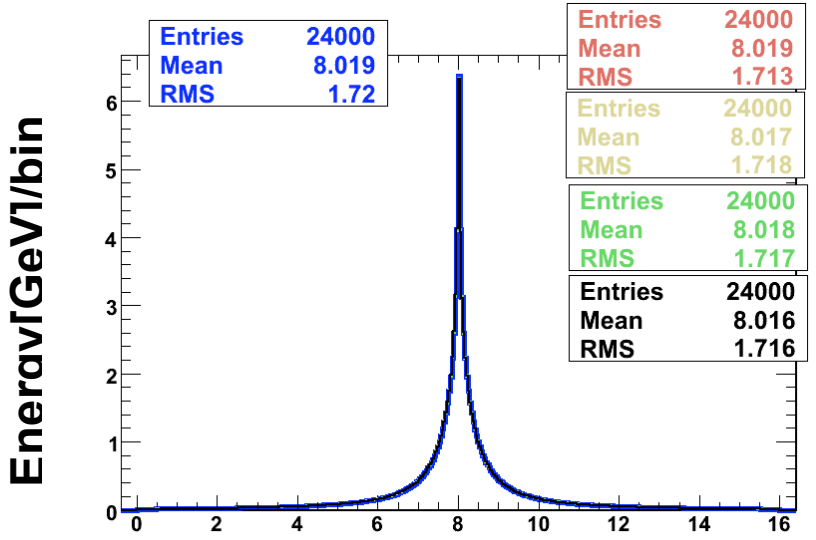
Electrons 100 GeV Done with GEANT 4

seed = 9876 (default)

seed = 10 seed = 100 seed = 1000 seed = 10000



Longitudinal (RadLengths)



Transverse (cm)

Max diff. between seed 10 and 1000 (mean) and seed default and 100 (rms)

Relative Changes:

mean= (10.45-10.31)/10.35 = **1.3 e-2**

RMS= (4.46-4.427)/4.46 = **0.7 e-2**

Max diff. between default and 1000

Relative Changes:

mean= (8.019-8.017)/8.019 = **0.02 e-2**

RMS= (1.72-1.713)/1.72= **0.41 e-2**

Conclusions

Valid for 100 evts run:

At relatively low energies (1 GeV) one can expect fluctuations at the level of 5% in the shower profile parameters (mean/rms)

At high energies (100 GeV) the shower fluctuations are smaller and thus the fluctuations in the shower parameters decrease to about 1% (or less)

Need to investigate the run with EGS5 and seed 11… perhaps 1 or 2 weird events shifting the mean/rms somewhat…