C++ implementation of a RandomNoiseModifier in digisim

- Implemented for the ECAL prototype
- Definition of noise model using DESY and CERN raw data
- MC studies of digitisation step, noise model
- first look at DESY data compared to MC

Digisim and Modifiers

- A modifier acts on SimCalorimeterHits.
- Do the following steps in that order :
  - Copy in a map, "uncalibrate", create RawCalorimeterHits
  - Add noise to existing cells, and noise-only cells,
  - Recalibrate and apply threshold,
  - create CalorimeterHits
- Random number generator : ROOT (CLHEP)
- Noise-only cells: for the time being of testbeam prototype, one noise added per cell.

  ➔ CPU and MEM fine if threshold is high enough.
- Noise model tested : one value per PCB (= per layer) and eventually adding of a coherent noise per layer:

  ampl = cohnoise[lay] + randnum.Gaus(pedestal, noise[lay])

  - pedestal is chosen per channel between -0.5 and 0.5,

  - noise[lay] and cohnoise[lay] are Input Parameters given in the steering file.

Steering file to run digisim

```
##################################################
#
#  Example DigiSim steering file for Marlin
#
#  20050307 G.Lima - Created
#
##################################################

.begin Global  ---------------------------------------

# specify one ore more input files (in one ore more lines)

LCIOInputFiles inputfile.slcio

# the active processors that are called in the given order
ActiveProcessors CalHitMapProcessor
ActiveProcessors EMDigitizer
#ActiveProcessors HCALDigitizer
ActiveProcessors CalorimeterHitsProcessor
ActiveProcessors OutputProcessor

# limit the number of processed records (run+evt):
MaxRecordNumber 1000
.end Global  ---------------------------------------------
```

```
#####################################################################
# Utility processor.  It fills hit maps for use by other processors,
#  so they don't need to fill the same maps themselves

.begin CalHitMapProcessor

ProcessorType CalHitMapProcessor

.end -------------------------------------------------
#####################################################################
# Cal digitizer processor.  Instantiates one or more calorimeter hit
#  "modifiers", which together represent the full digitization process.
#####################################################################

.begin EMDigitizer

ProcessorType DigiSimProcessor

InputCollection              ProtoDesy0205_ProtoSD03
OutputCollection             MyRawCalorimeterHit
Raw2SimLinksCollection   EcalProtoRaw2sim
```

Specific input parameters for the list of modifiers used

ModifierNames EMGaussianGain EMAddRandomNoise EMThreshOnly

List of modifiers to use in the right order

#EMAddRandomNoise
1./0.00016*47 = 293750
modifierName Type Parameters (floats)
EMThreshOnly GainDiscrimination 1 0 18 2.5
EMGaussianGain GainDiscrimination 293750 8812 0 0
EMGainThresh GainDiscrimination 1000000 50000 25 1.5

Inversed calibration and threshold
For now on : fixed gain at 47 ADC/MIP, and various threshold.

#RandomNoiseModifier Parameters : Noise of each of 30 layers,
plus coherent noise per layer as well,
then DebugMode, SymetryOrder (1=prototype, 2=endcap, 8=barrel, 16=MAPS)
then TimeMean, TimeSigma (to generate a timestamp for the noise hits).
EMAddRandomNoise RandomNoiseModifier 5.8 6.0 6.0 5.8 6.0 5.8 6.0 6.0 5.7 6.0 5.6 6.1 5.8 6.2 6.0 6.0 5.8 5.9 5.8 6.0 6.0 6.0 6.0 6.0 6.3 5.7 6.0 6.0 6.0 6.0 0.0 0.0 0.0 0.0 3.1 0.0 3.0 6.5 0.0 1.6 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 1 1 0 0

.end --

Noise parameters :
30 values (per layer)
+ 30 values (coherent noise per layer)
+ debug mode (digisim specific)
+ symetry order : 1 is prototype
+ time mean and spread if you want to add a random timeStamp to the noise hits.

Creation of final collection

```
############################################################
##
# A processor to convert raw hits into calibrated hits.
.begin CalorimeterHitsProcessor

# mandatory processor type (the name of the class)
ProcessorType CalorimeterHitsProcessor

# Input collections to be converted
# InputCollections EcalBarrRawHits HcalBarrRawHits
InputCollections MyRawCalorimeterHit

# Output collections with calibrated hits
# OutputCollections EcalBarrCalibHits HcalBarrCalibHits
OutputCollections MyCalorimeterHit

# Conversions based on simple factors (at least for now)
# 1./47*0.00016 in GeV...
EnergyFactor    3.40426e-6
TimeFactor     1.0

.end ------------------------------------------------
```

Recalibration

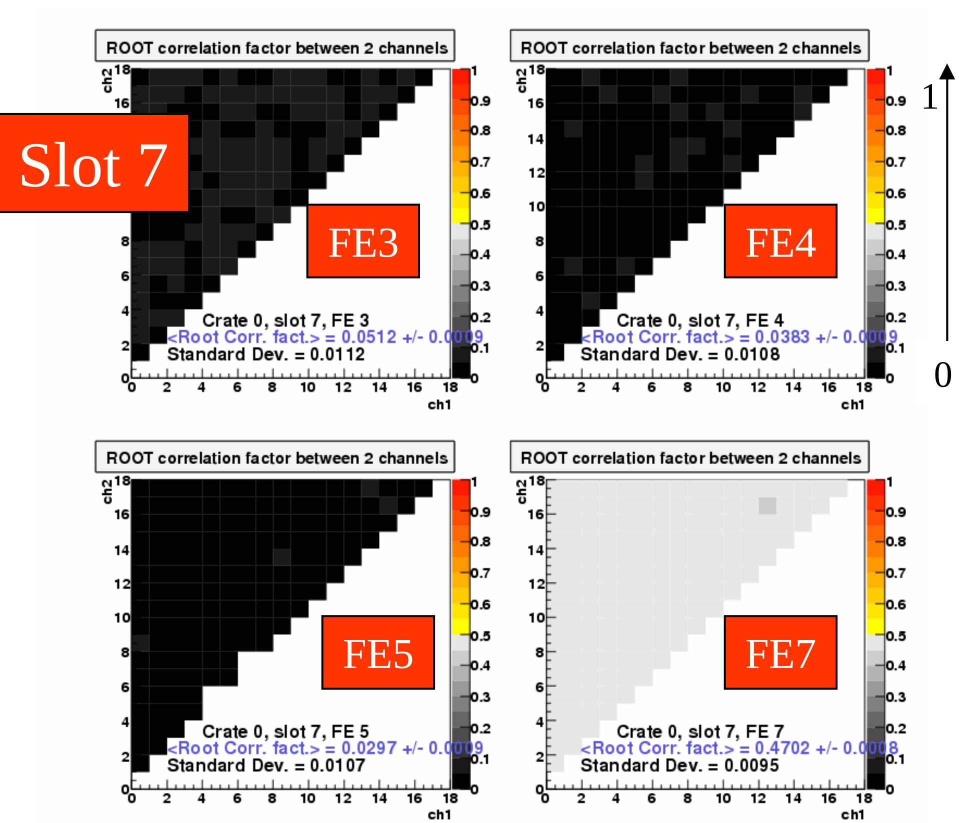
Noise model

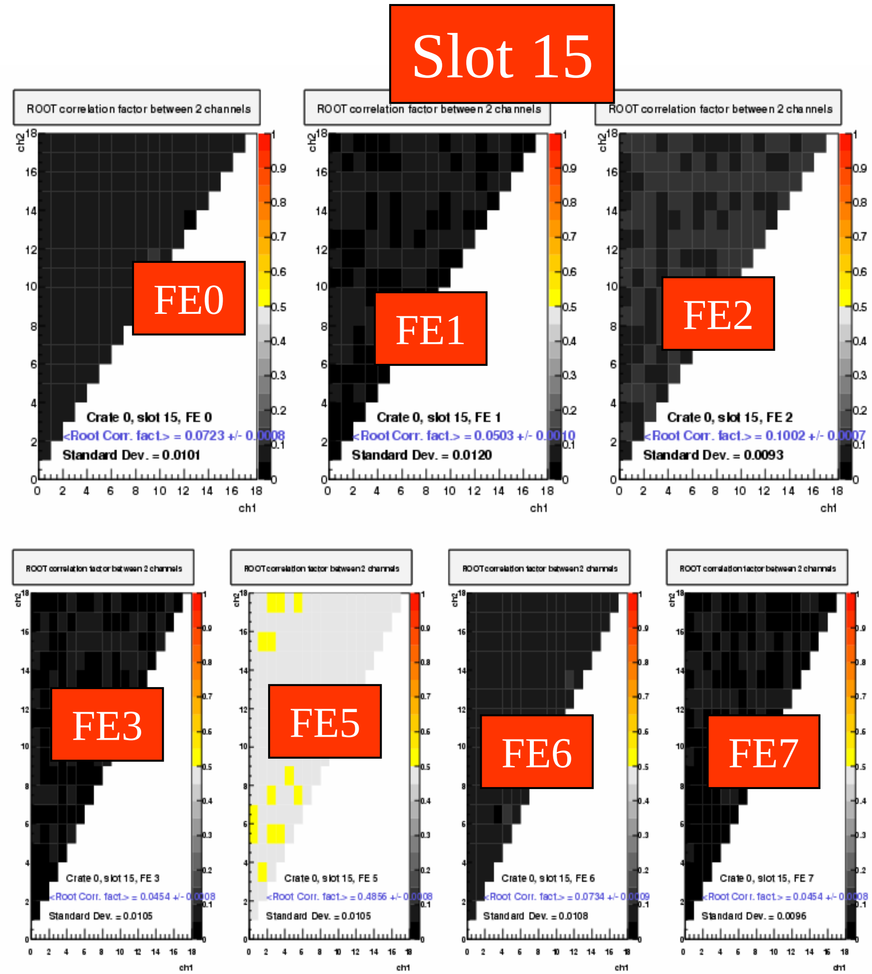
- Study of correlations between 2 channels.
- In the following : systematic study of channel response 2 by 2, for all layers, only one chip (usually it's the same for other chips).
- Use of binary data noise runs at DESY, one muon run (part of 300111) at CERN, before pedestal substraction.
- Definition of the correlation factor with root

Calorimeter for ILC

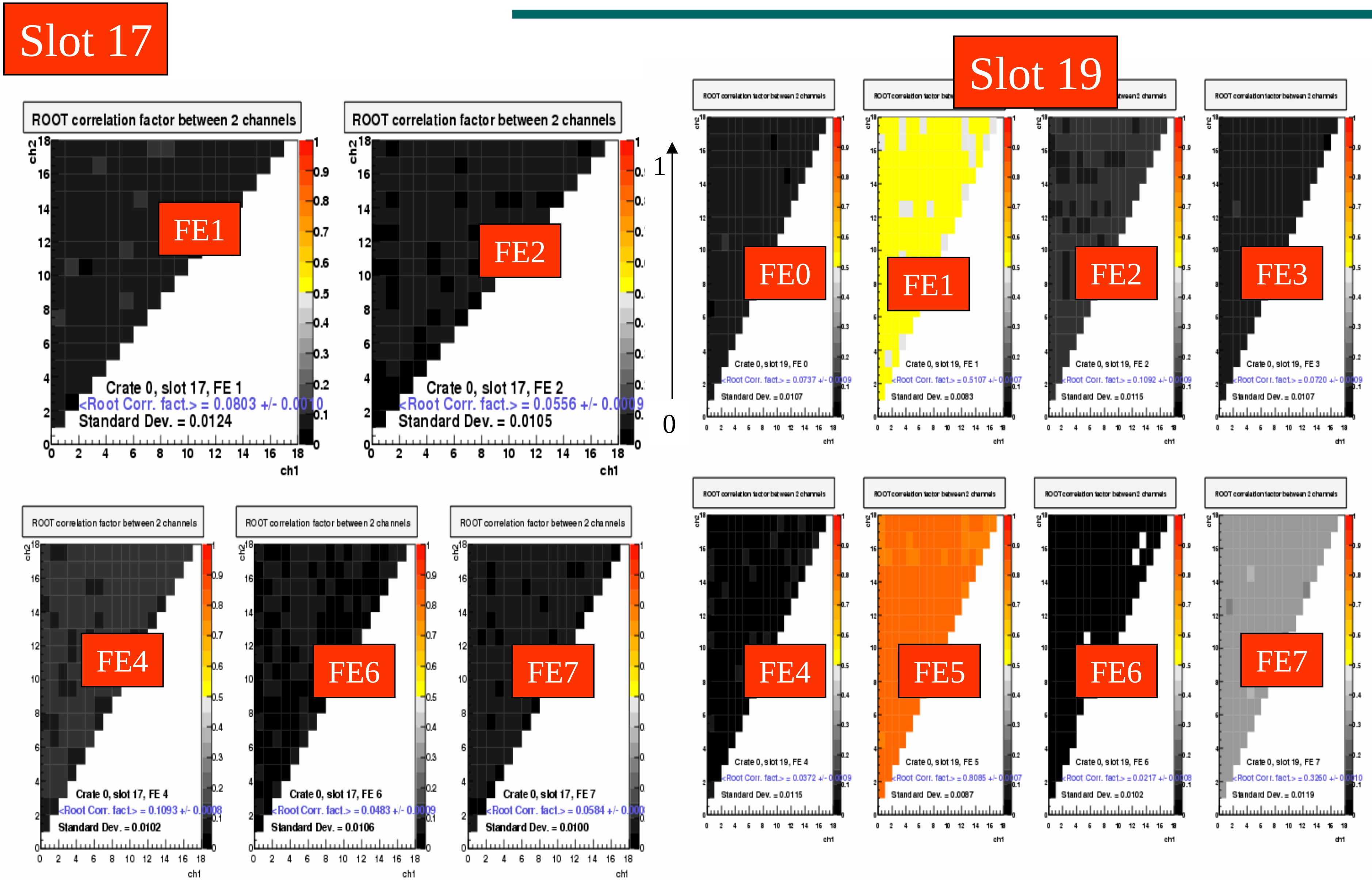
Look at DESY binary data (1)

- DESY testbeam : correlation between 2 channels for chip#0 and all connected FEs



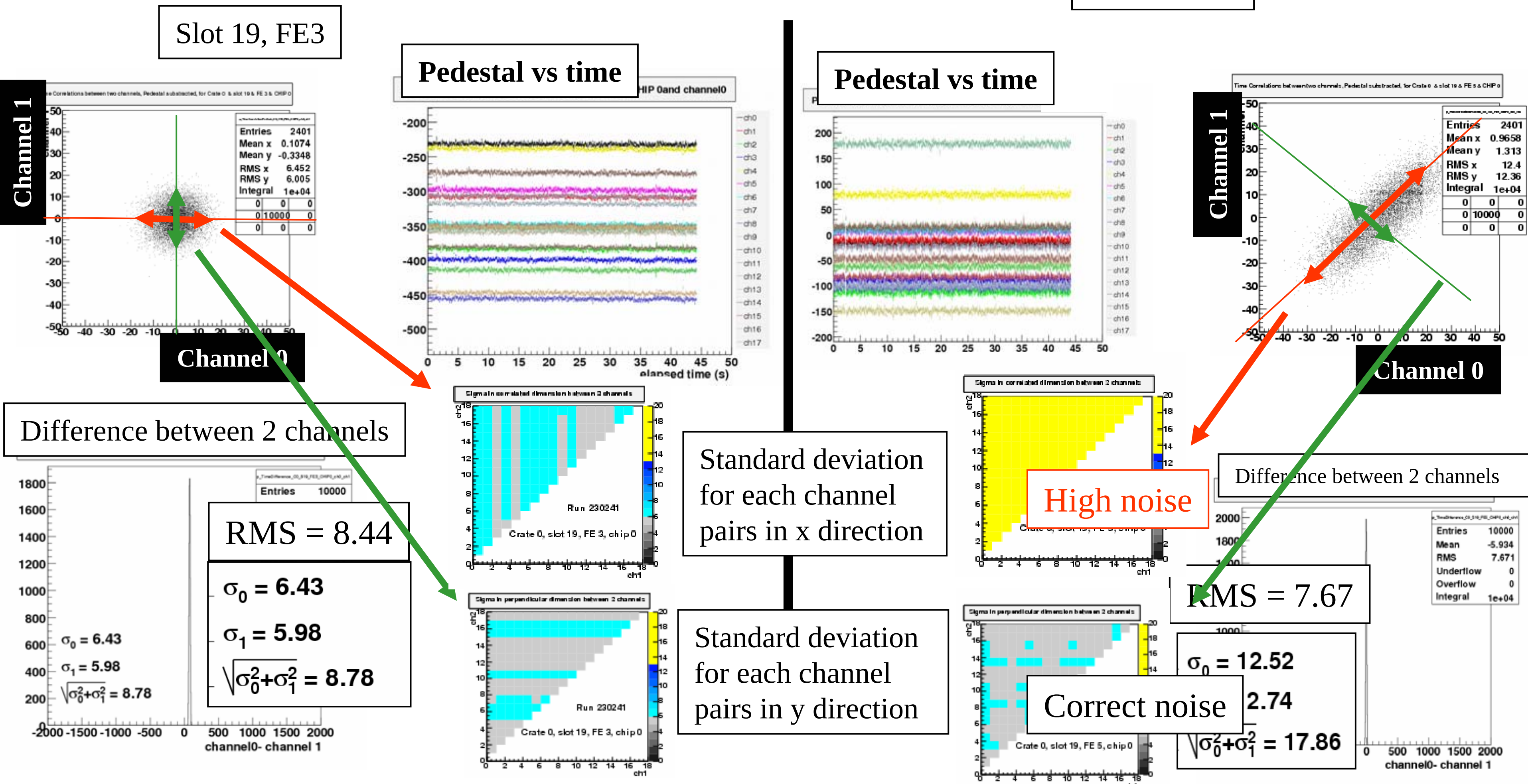


Look at DESY binary data (2)



DESY TB: 2 types of behaviour

- Same results have been obtained for all chips, and all studied runs



Summary for DESY TB

- Slot 15, FE7 and slot19, FE3, corresponding to PCBs number 18_C and 19_C , layers 14 and 15 (starting numbering at 0...) ➔ always uncorrelated with perfect flat pedestals for every studied runs.
- Slot 7, FE7, slot15, FE5, and slot19, FEs1-5-7, corresponding to PCBs number 12_C, 4_C, 8_C, 5_C, 9_C, that is layers 9, 6, 4, 7, and 0 ➔ always correlated, independantly of pedestal behaviour. This seems clearly an added noise which is the same for all channels (the difference between 2 channels make this noise disappear).

- All other slot have moving pedestals for runs number 230194, 230211, 230216, 230241, and 230263, which creates correlations between channels, probably due to ECAL powering up...........
- ....but are perfectly normal for runs 230149, 230212, and 230264.

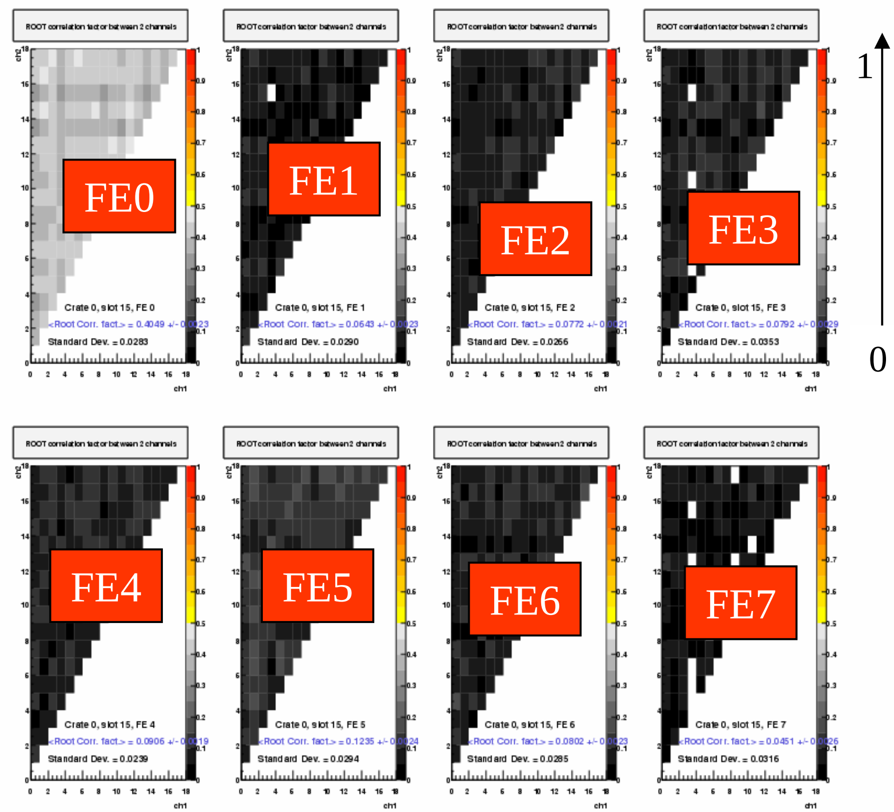
Look at CERN TB data (1)

- Part of Run 300111 : pedestal events only.

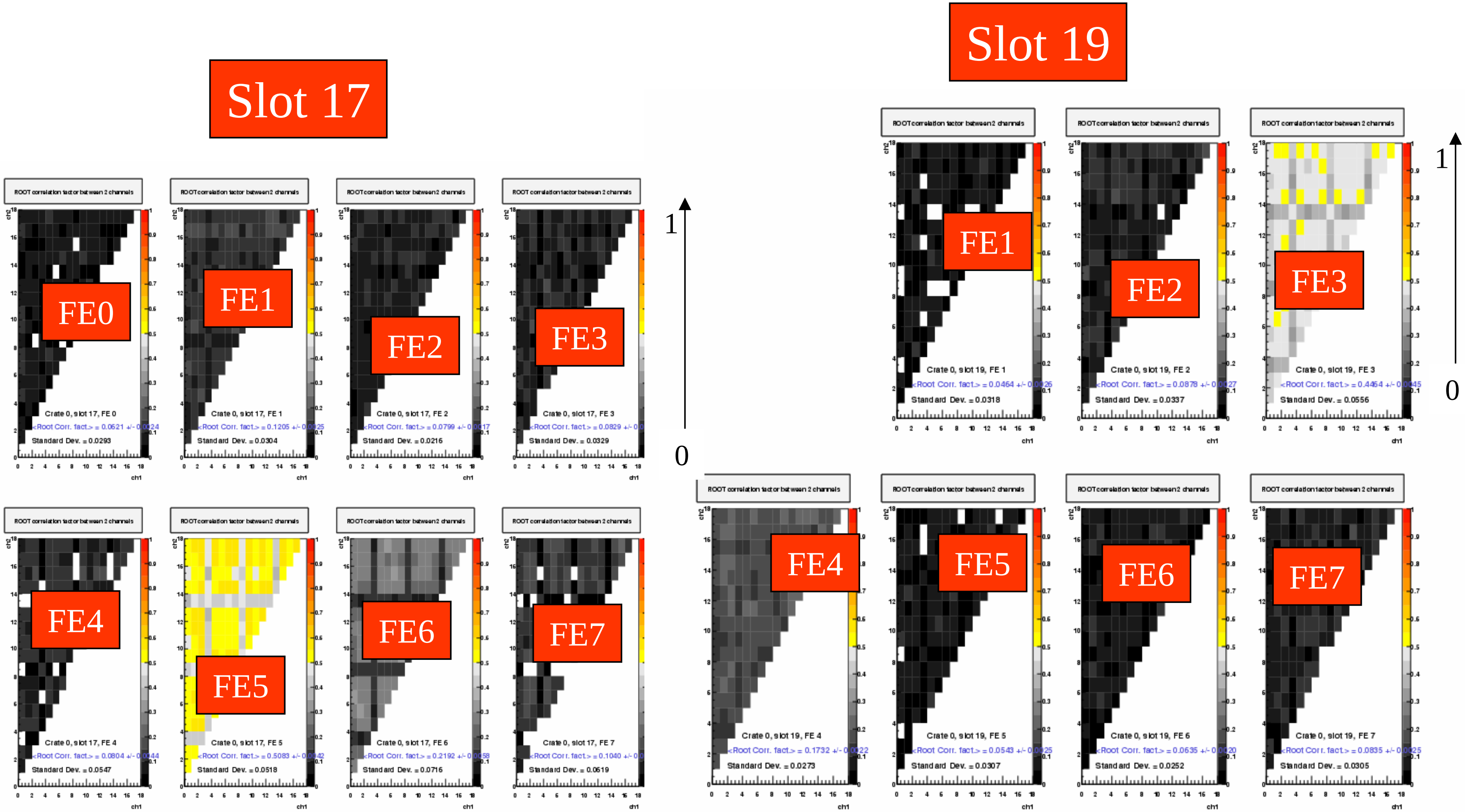
Correlation between 2 channels for chip#0 and all connected FEs

Slot 9

Slot 15

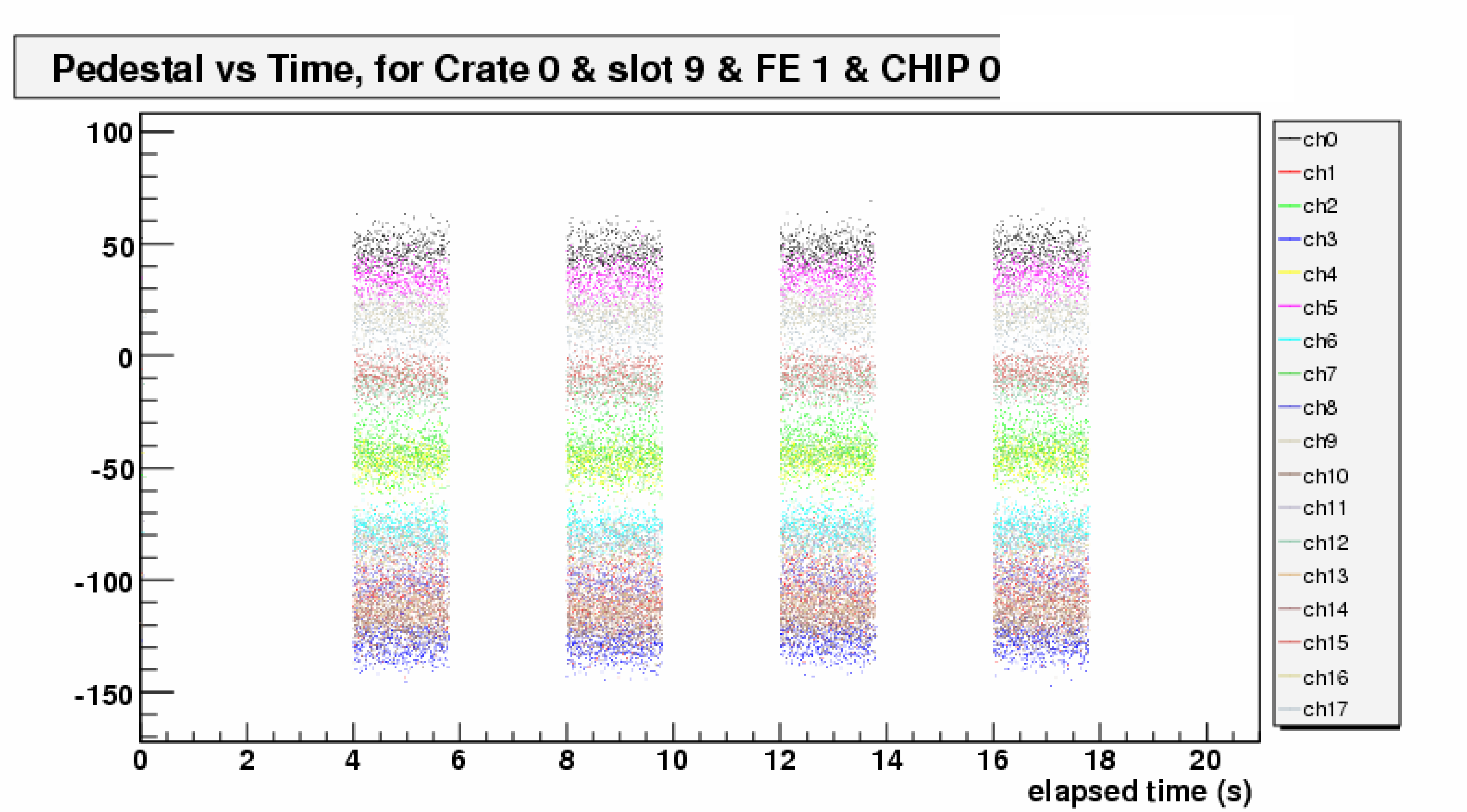


Look at CERN TB data (2)



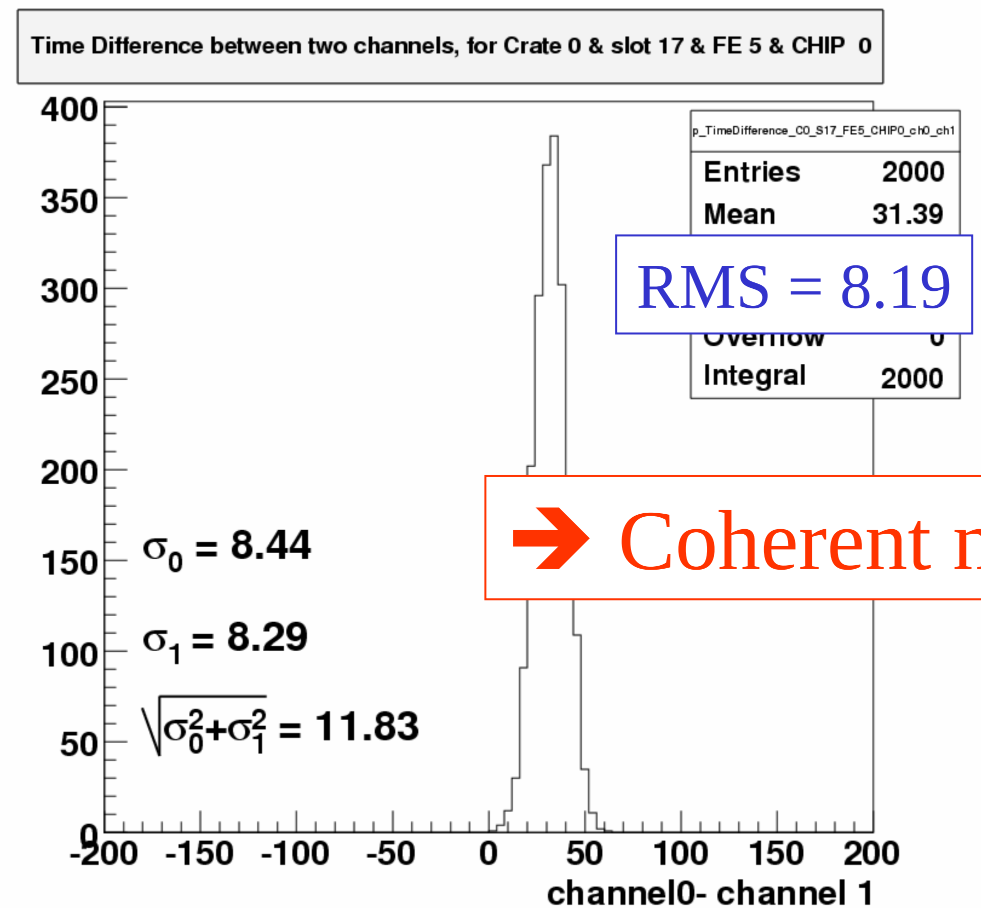
Flat pedestals ??

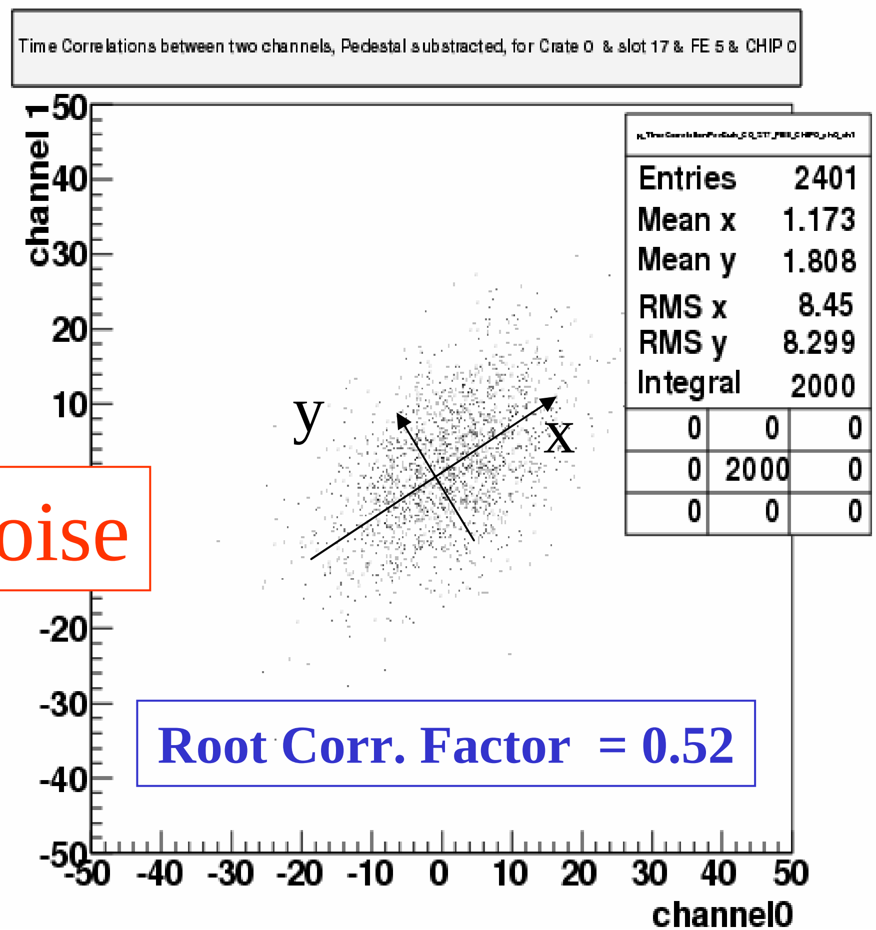
- Same results for all FEs, chip #0.
- ➔ correlations don't come from pedestal instabilities.



Coherent noise or not ?

- Difference between 2 channels, and definition of width in correlated axis “x” and “y” :

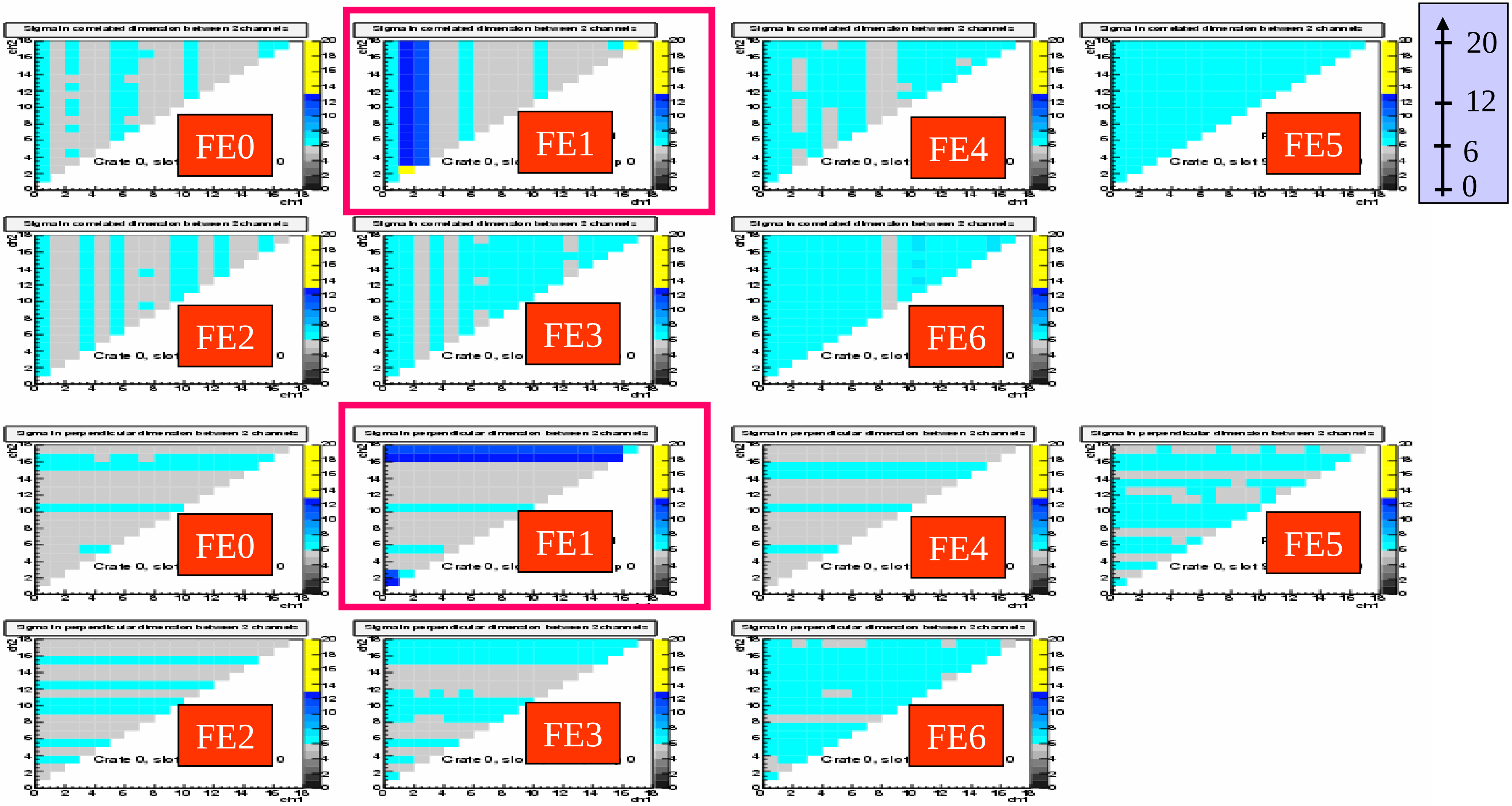




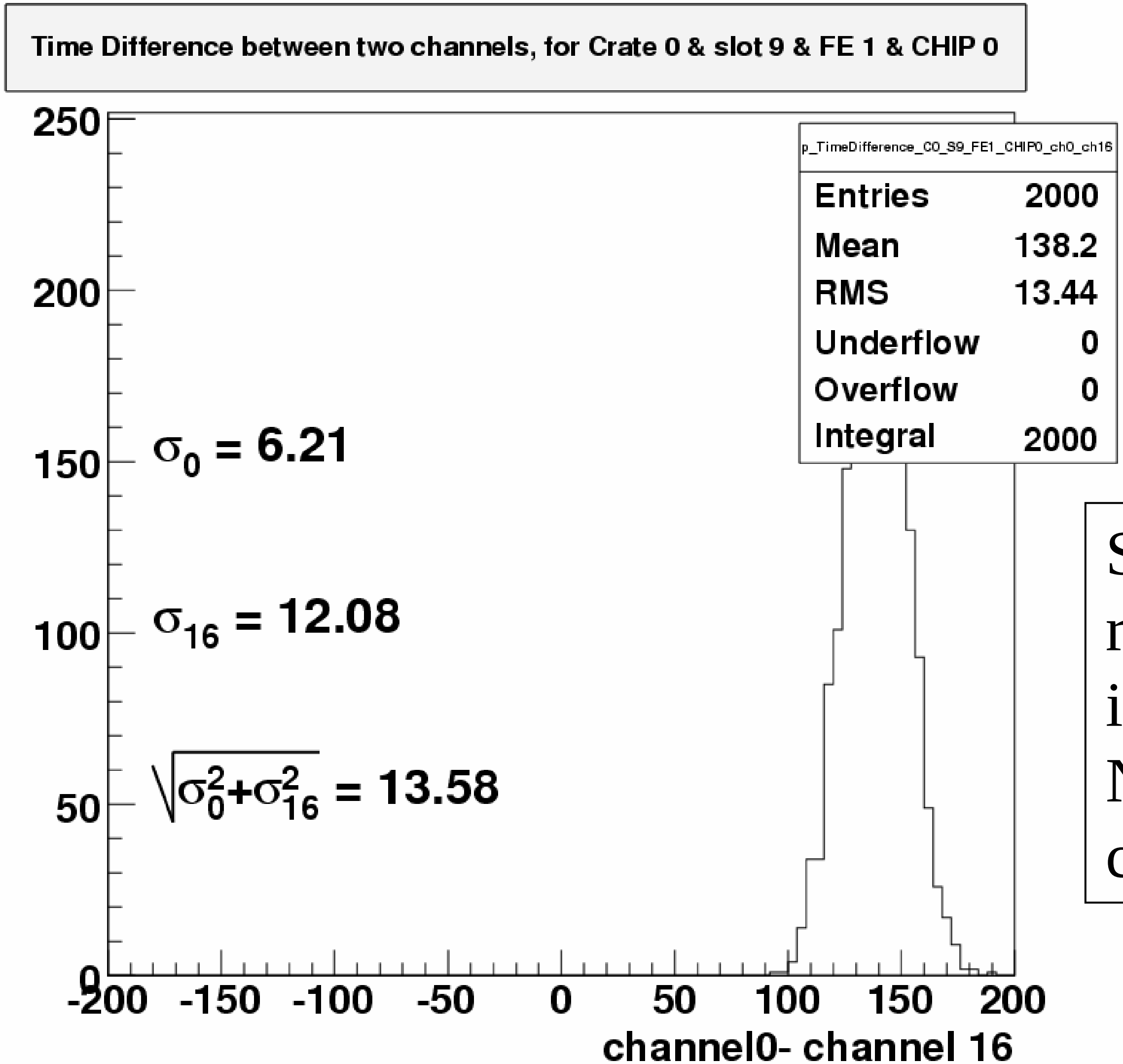
→ Coherent noise

Look in more details, slot 9

Correlation between 2 channels for chip#0 and all connected FEs
In “x” and in “y” direction



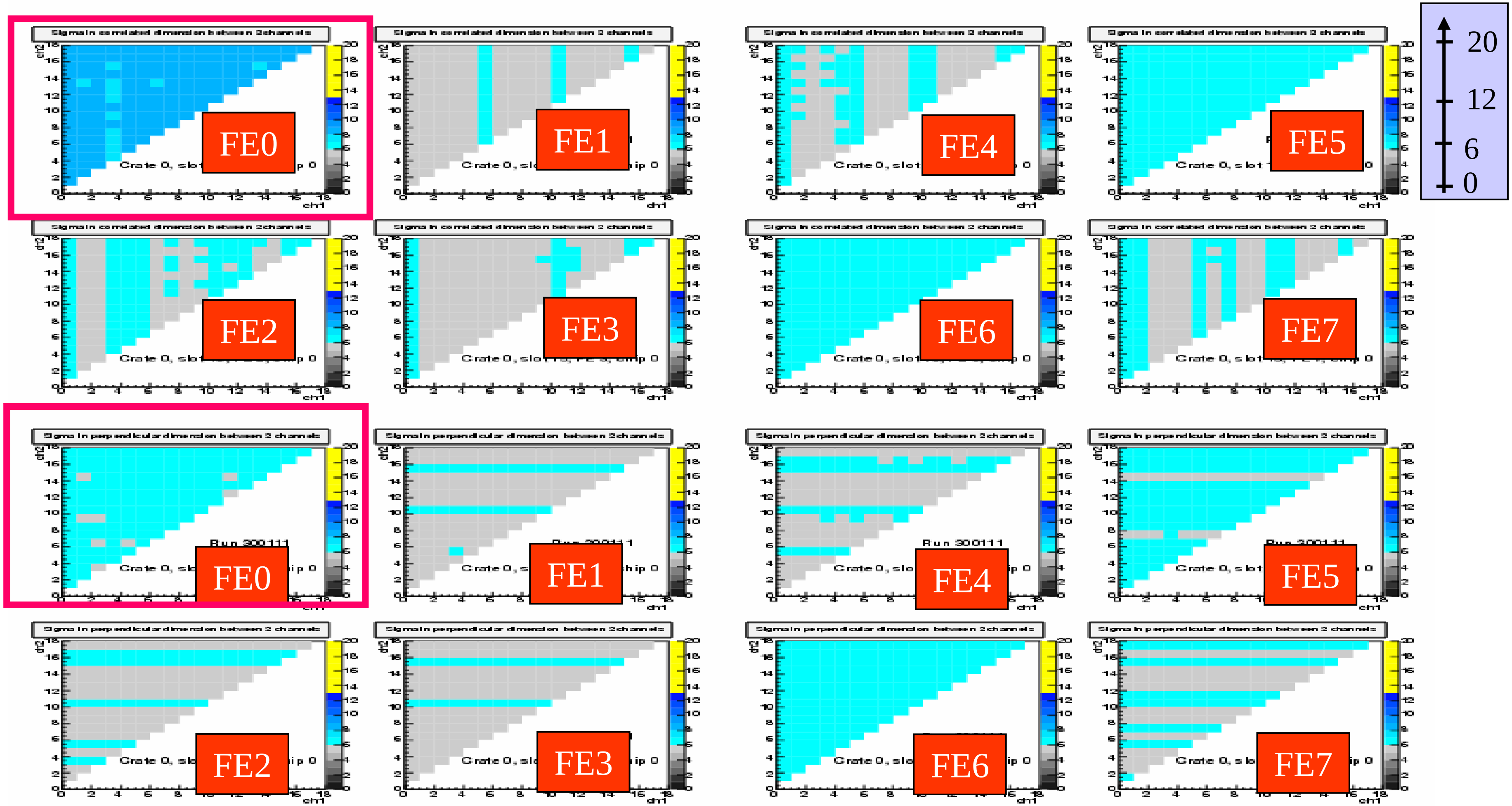
Particularity of slot9-FE1 (PCB 30_C, layer 25, new one)



Some channels have a really high noise, but independantly of others. Need more studies ! And check in time...

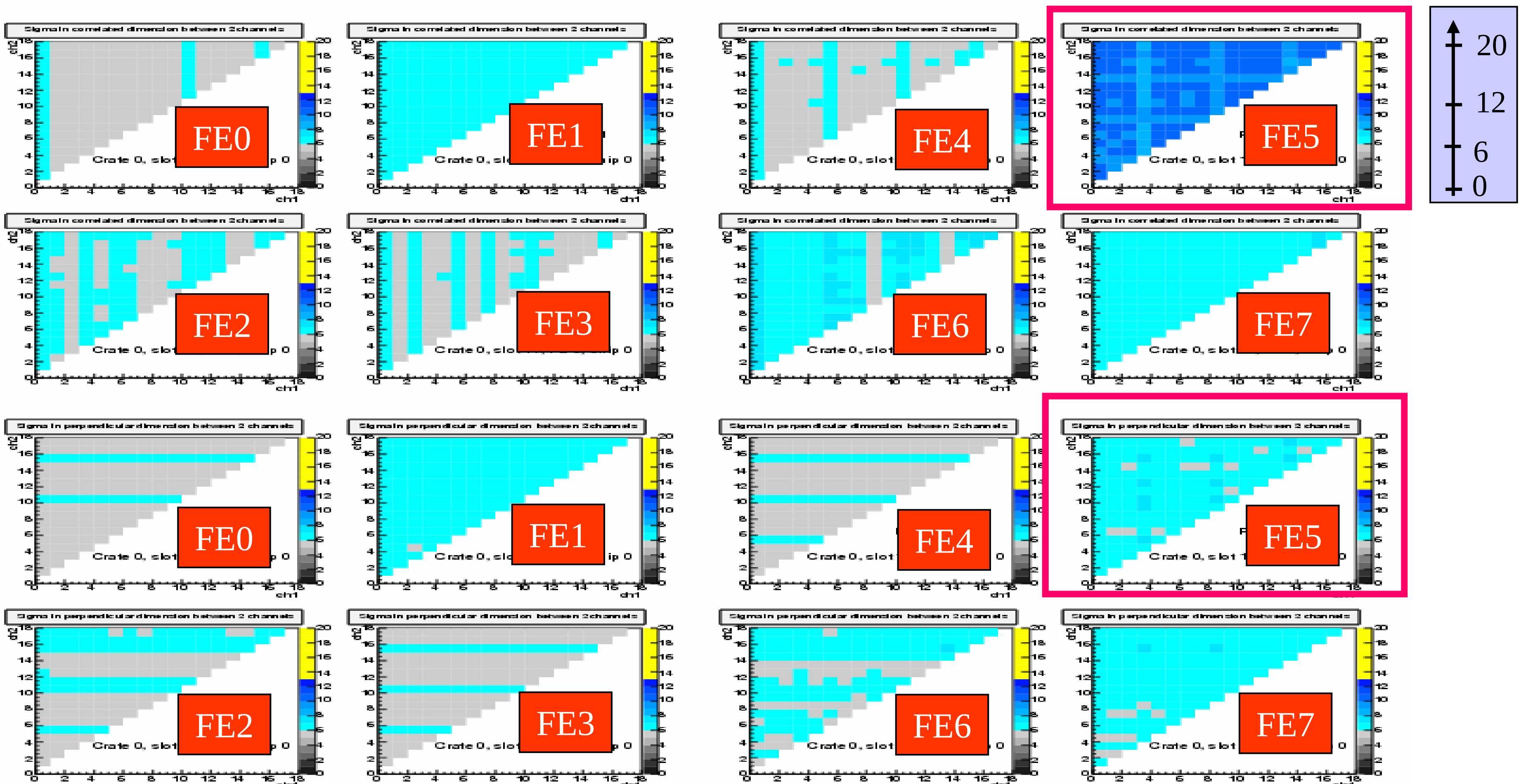
Look in more details, slot 15

Correlation between 2 channels for chip#0 and all connected FEs
In “x” and in “y” direction



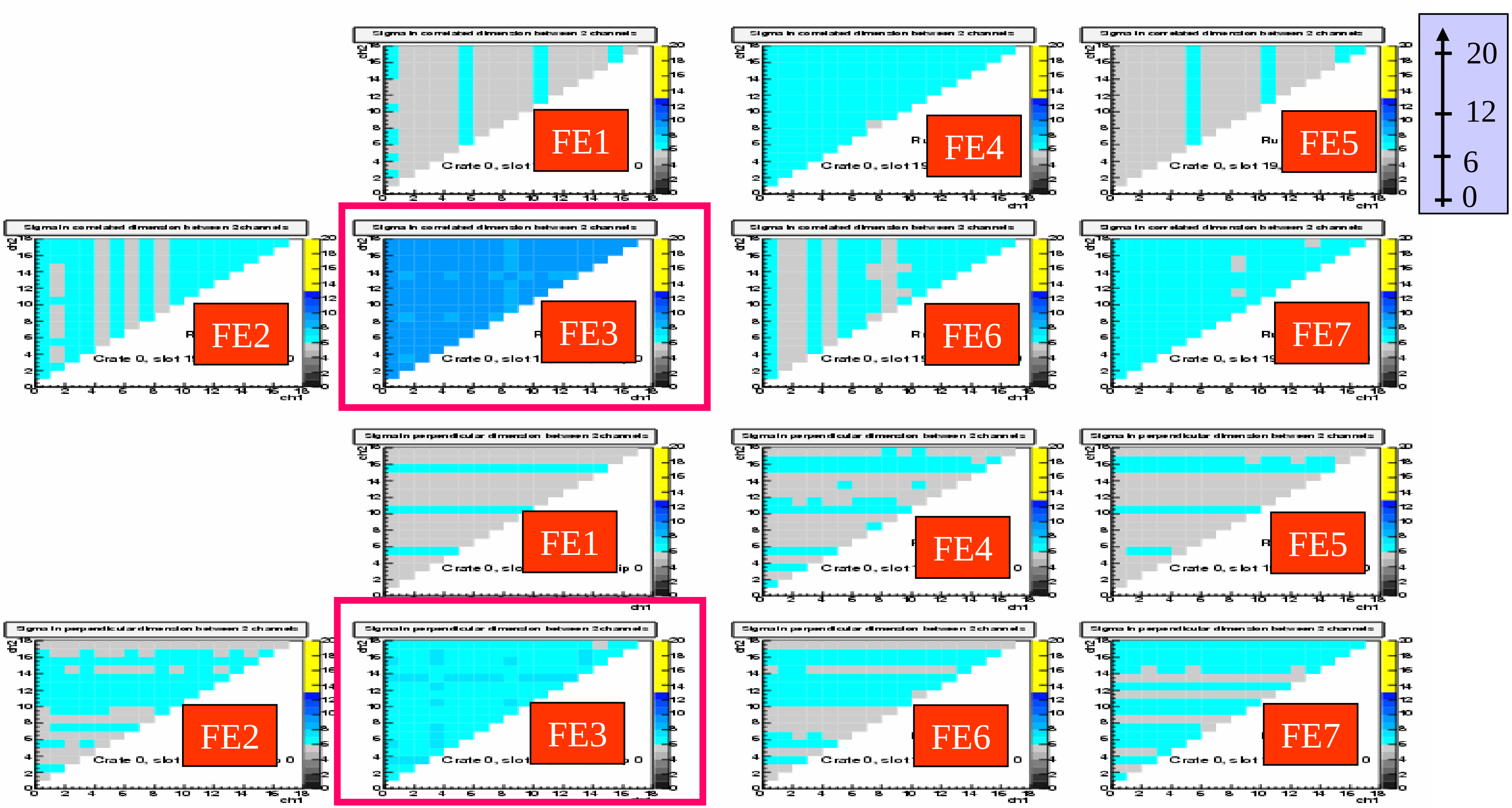
Look in more details, slot 17

Correlation between 2 channels for chip#0 and all connected FEs
In “x” and in “y” direction



Look in more details, slot 19

Correlation between 2 channels for chip#0 and all connected FEs
In “x” and in “y” direction



Summary for CERN TB data

- Need to check on several runs over the whole period.
- Slot15-FE0 (PCB 12_C, layer 1), slot17-FE5 (PCB 4_C, layer 2) : coherent noise

  ➔ SAME AS IN DESY TB DATA.
- Slot17-FE6 : had coherent noise @ DESY, is now mixed, depends on channel #.... Need more studies.
- Slot9-FE1 : differences between channels, can have strong correlations, need more studies and checks in time !!
- slot19-FE3 (PCB 18_C, layer 14) ➔ was perfect in DESY TB, for slot-FE pair as well as PCB ?!??? Has now coherent noise.

  PS: Cable #20, not used at DESY....
- PCB 5_C had a strong coherent noise before (6 ADC counts) but is now perfect . No problem neither at its previous slot-FE and cable... Has something changed between DESY and CERN for this PCB ?!?

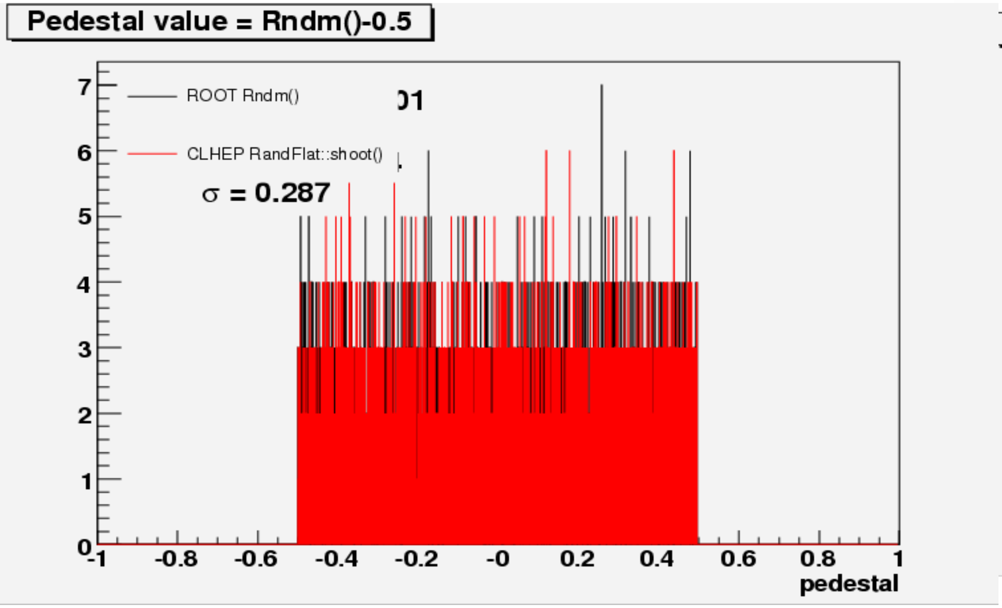
Back to MC studies

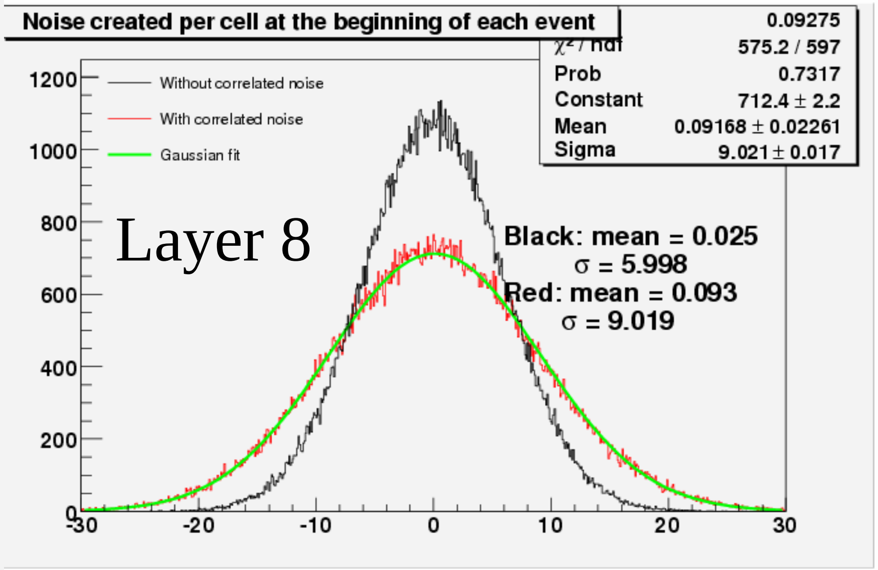
layer	noise	Coherent noise
1	5.8	
2	6.0	
3	6.0	
4	5.8	
5	6.0	2.1
6	5.8	
7	6.0	2.0
8	6.0	6.5
9	5.7	
10	6.0	1.6
11	5.6	
12	6.1	
13	5.8	
14	6.2	
15	6.0	
16	6.0	
17	5.8	
18	5.9	
19	5.8	
20	6.0	
21	6.0	
22	6.0	
25	6.3	
26	5.7	

- With this noise model : normal ~ 6 ADC counts noise per layer, and add a coherent noise for the few concerned layers.
- With DESY TB only

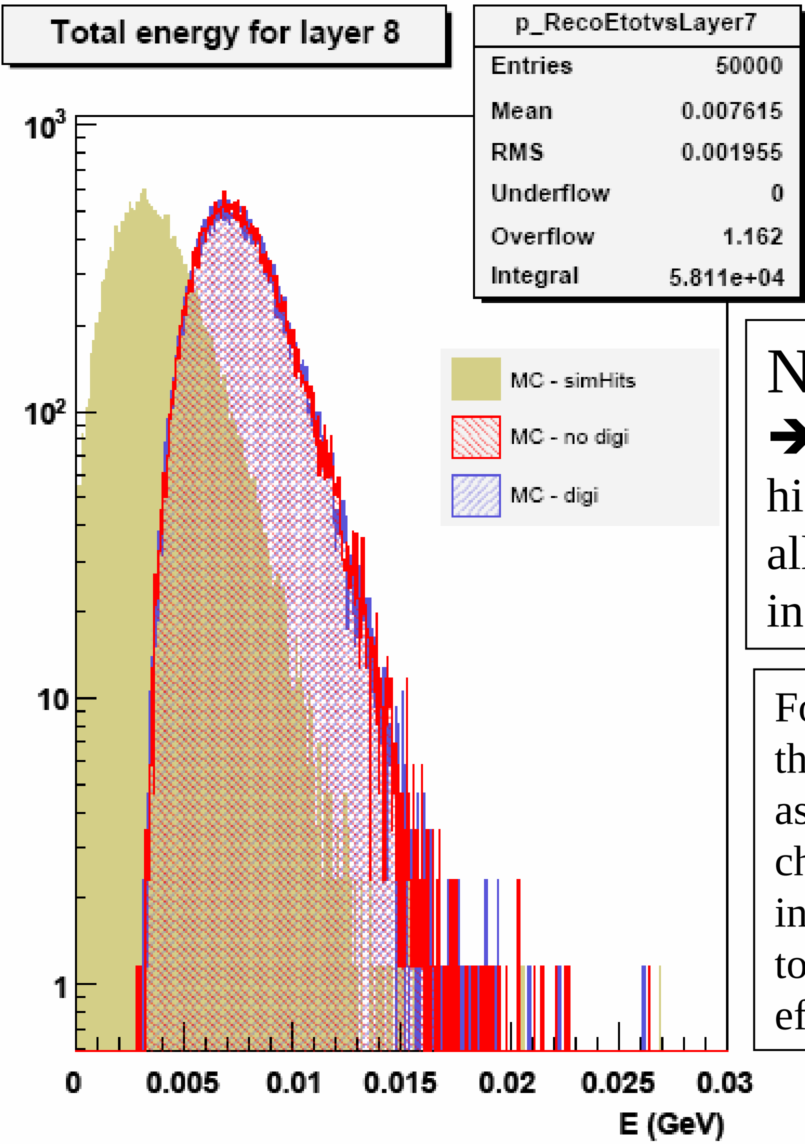
Random number generation

- Comparison ROOT and CLHEP : same results.
- Choose ROOT for easy SEED number handling.
- TO BE DONE : get the last Mokka seed as input. Currently, seed is initialized to unix time.





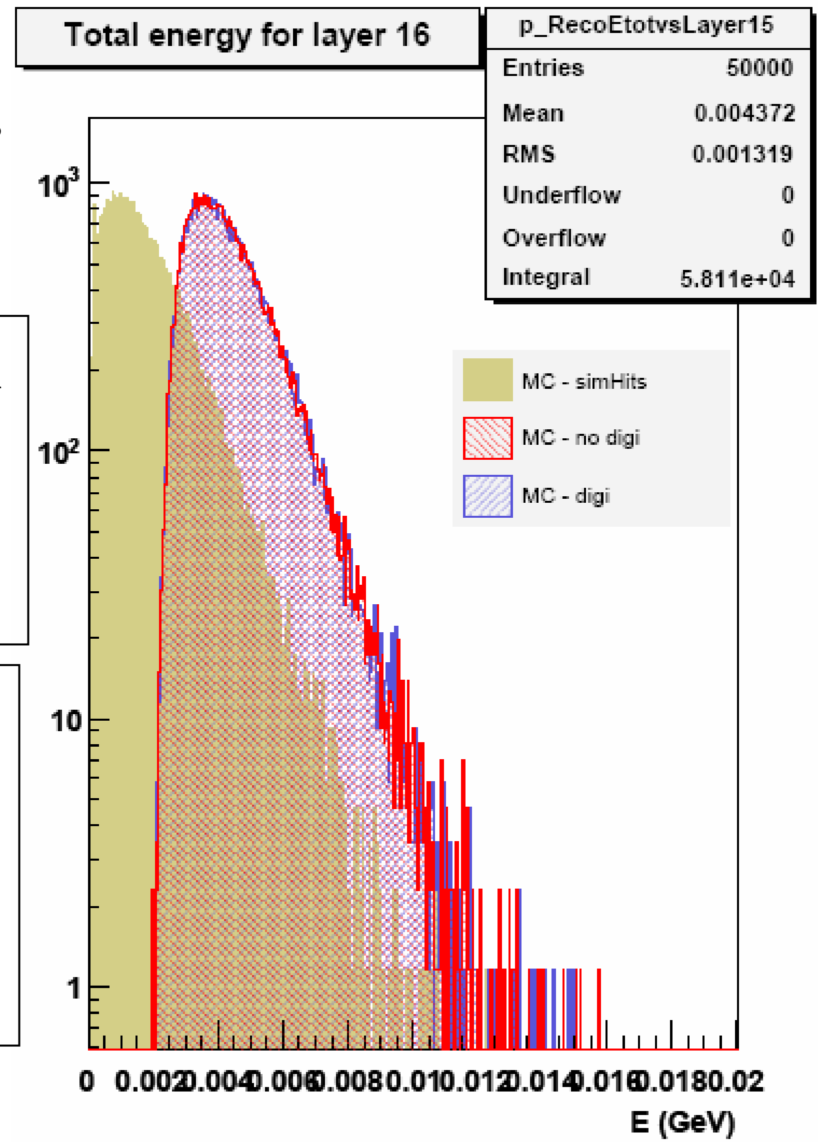
Comparision with or without the (float)→(int) rounding step



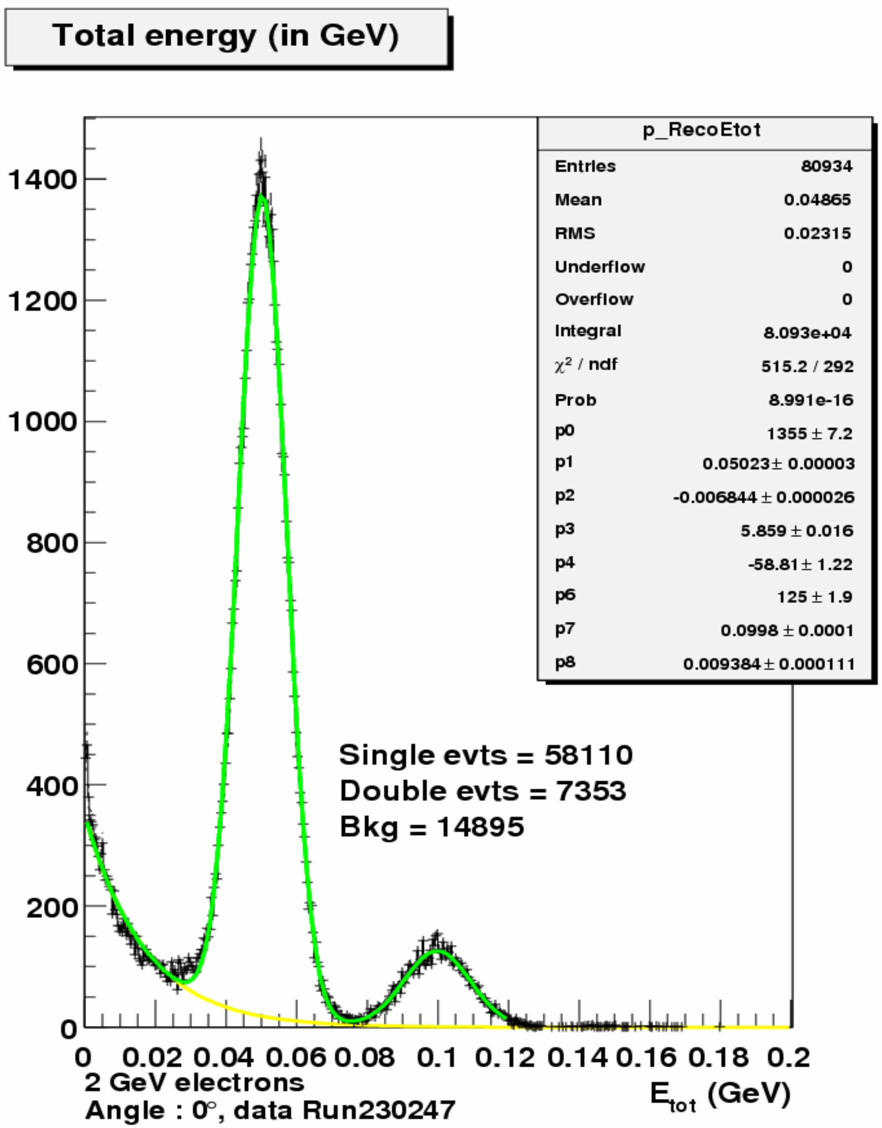
2 GeV electrons
0° angle

No threshold
➔ blue and red histograms have all noise hits included.

For now on, keep the rounding step as it doesn't change anything in the code. Need to quantify the effect exactly.

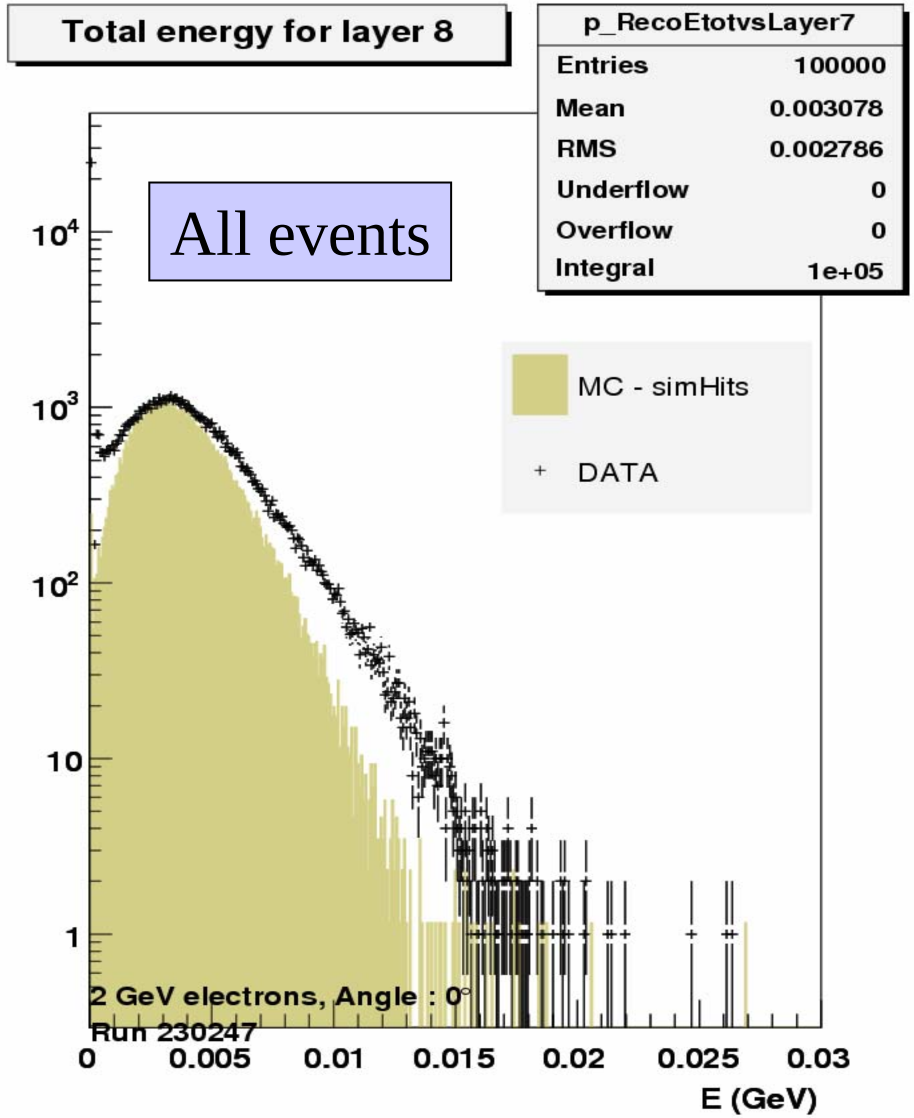


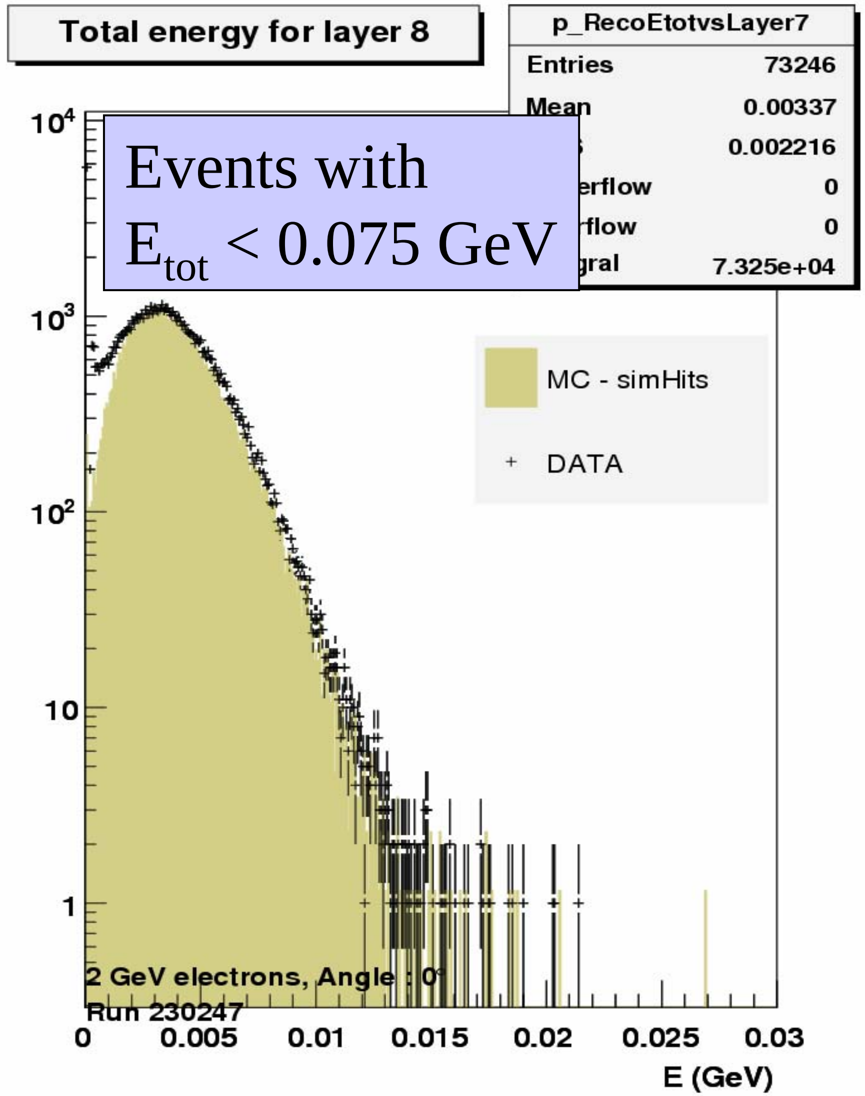
Normalisation to dataset



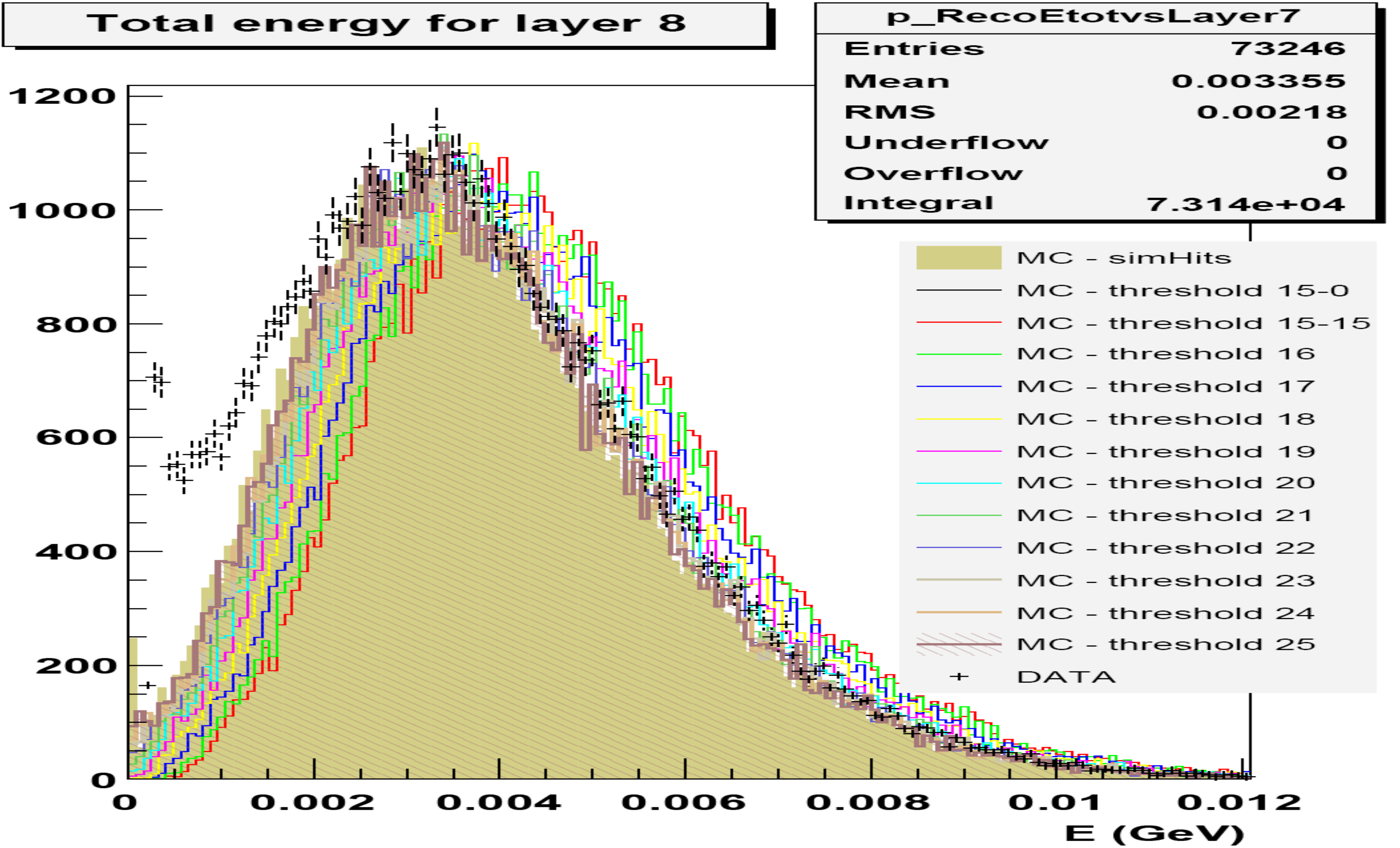
- Data : run 230247, 2GeV electrons with 0° angle, not calibrated ! Constant 47/MIP for all channels applied.
- Cut double events based on this distribution : cut events with Etot > 0.075 GeV.
- In the following, only single data events with that cut, and MC (50000 evts) is normalized to 58110 data events.
- See David's talk from yesterday : the geometry agreement between DATA and MC is not corrected in the following. Still Mokka06-00.

With or without double events

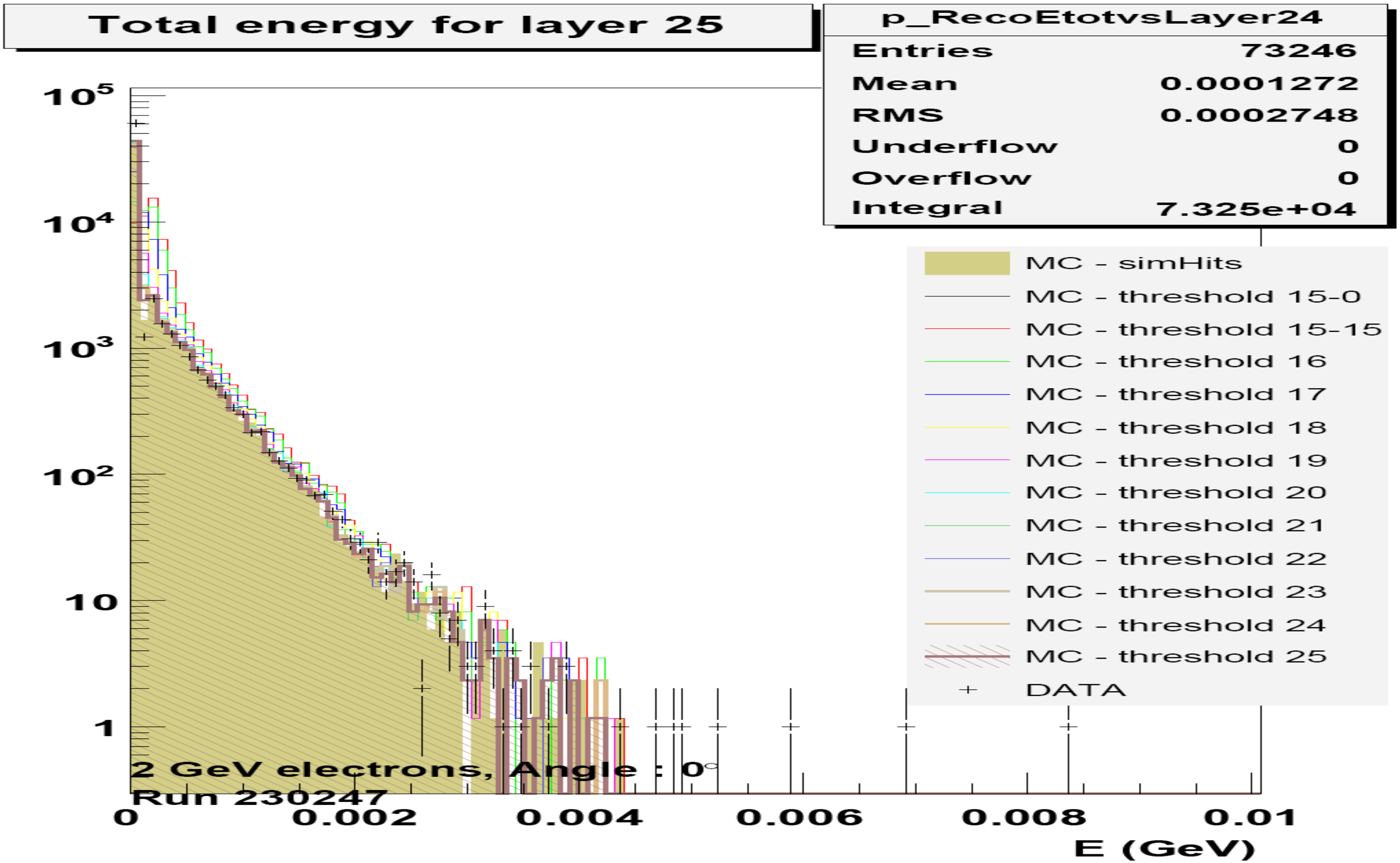




Total energy of hits in layer 8

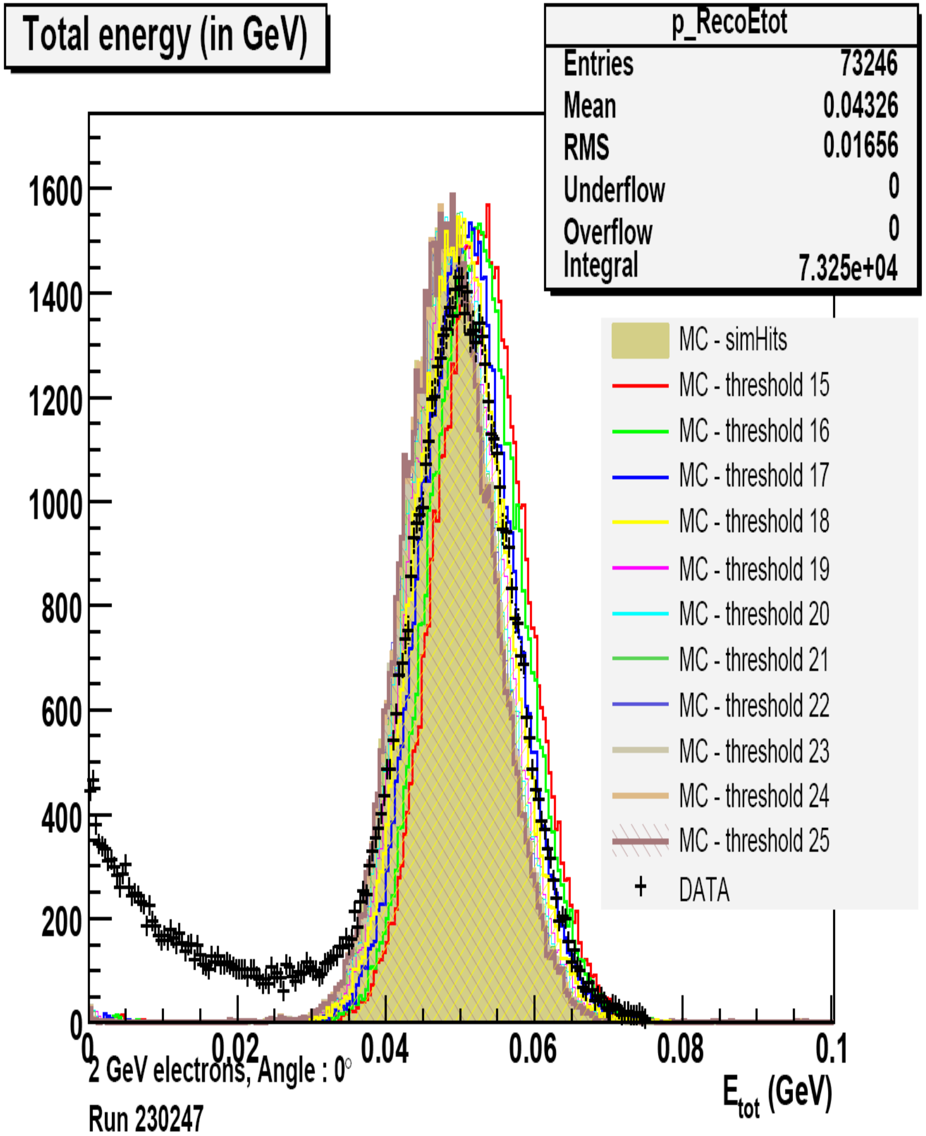


Layer 25

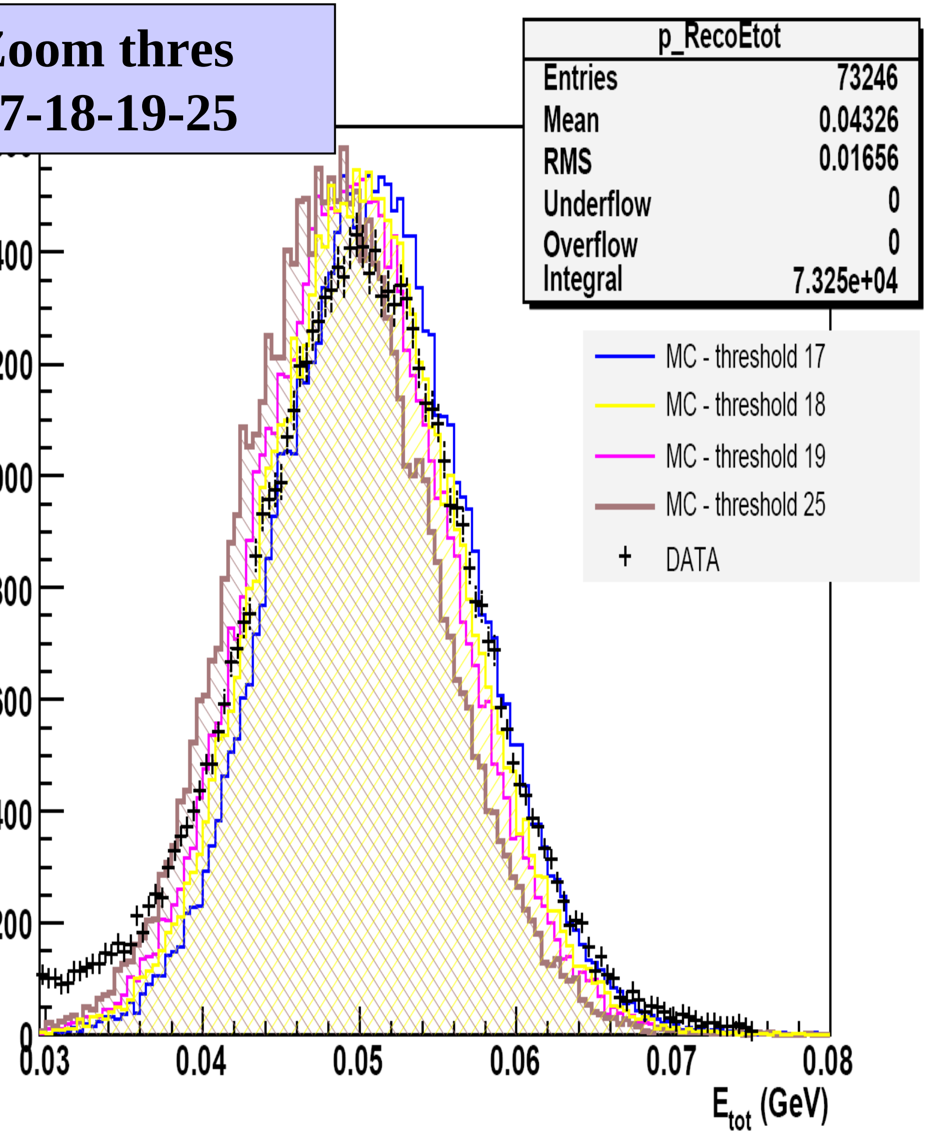


Total energy for layer 25
p_RecoEtotvsLayer24
Entries 73246
Mean 0.0001272
RMS 0.0002748
Underflow 0
Overflow 0
Integral 7.325e+04
MC - simHits
MC - threshold 15-0
MC - threshold 15-15
MC - threshold 16
MC - threshold 17
MC - threshold 18
MC - threshold 19
MC - threshold 20
MC - threshold 21
MC - threshold 22
MC - threshold 23
MC - threshold 24
MC - threshold 25
DATA
2 GeV electrons, Angle : 0°
Run 230247
E (GeV)

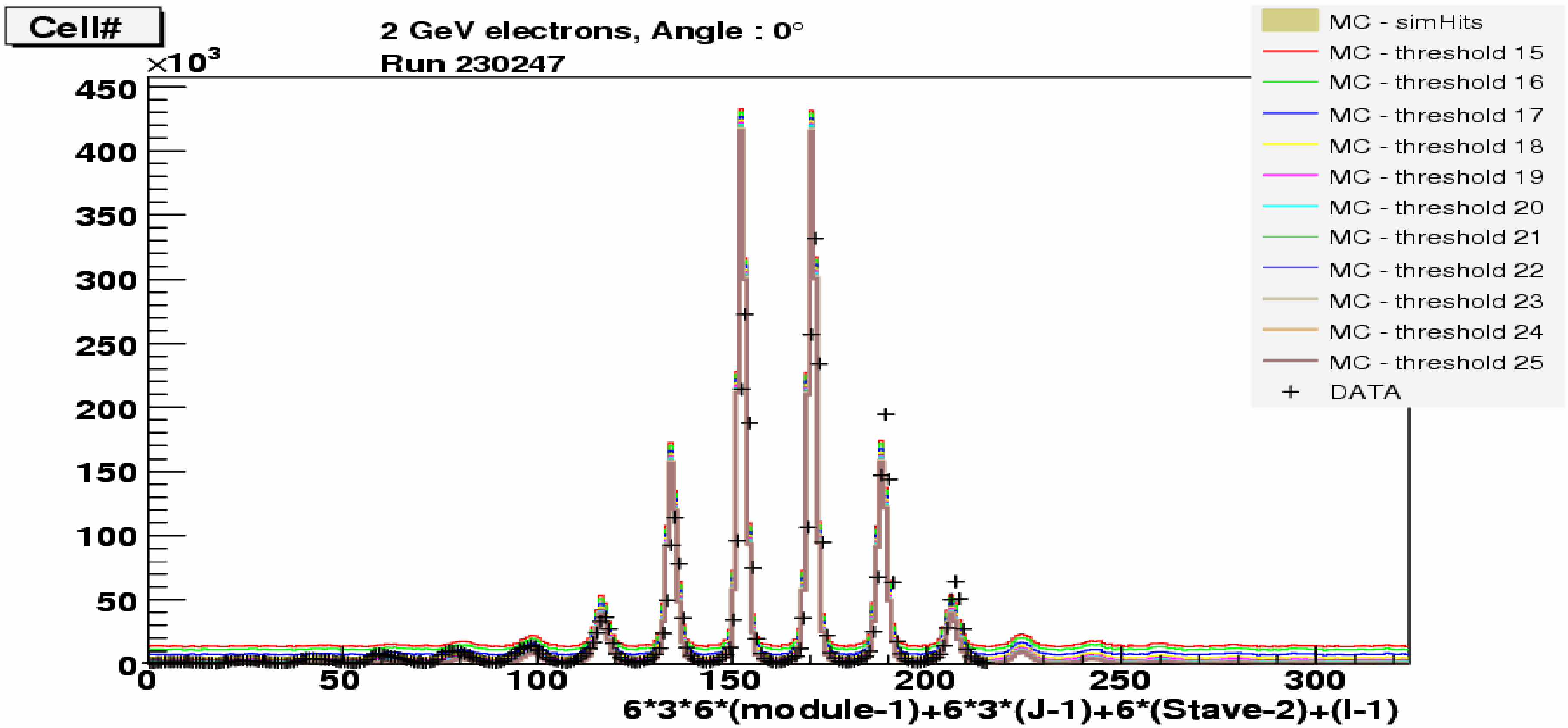
Total energy with different threshold values



Zoom thres 17-18-19-25

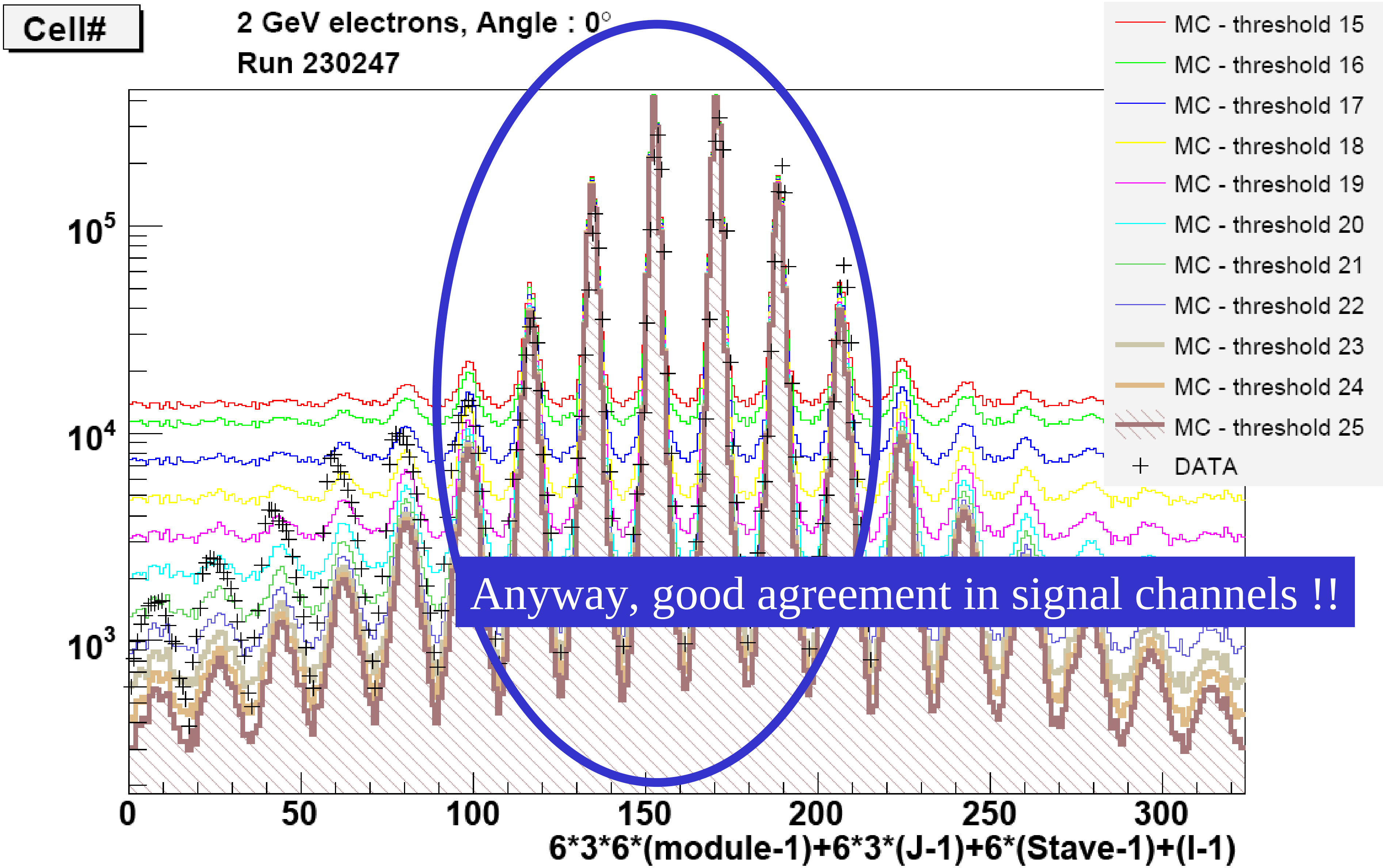


Number of hits per channel



- Remark : for MC, module goes from 1 to 3, and stave from 1 to 3.
  for DATA, module goes from 2 to 3 (4), and stave from 2 to 4....
- Don't we want to agree on a common encoding ?!???????

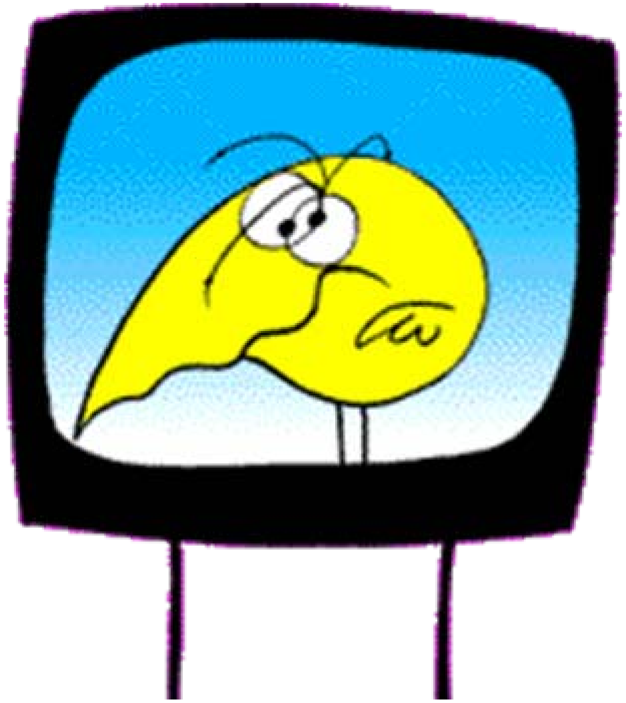
Number of hits per channel, log scale



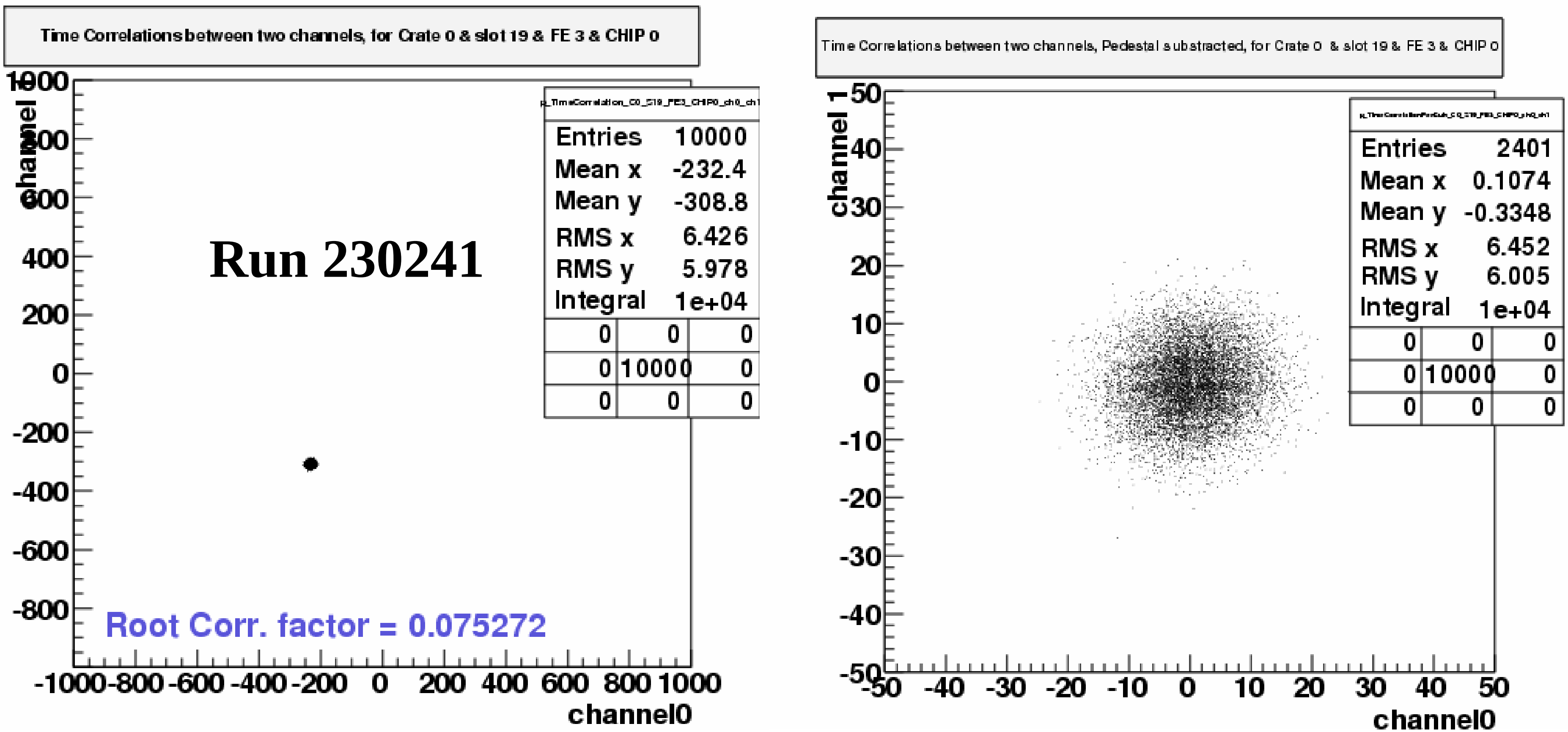
Conclusions

- Digisim v01-06 has been released on Calice-CVS with the new code added.
- Noise value per layer as well as coherent noise are input parameters in the steering file, which allows to change easely the values for test purposes.
- Still cleaning of data to perform, and use of last version of Mokka with the correct geometry, to really be able to compare with the simulation in details, and refined the noise model to see the effect.
- Define CERN noise model and comparison data/MC ASAP.

Thank you for your attention

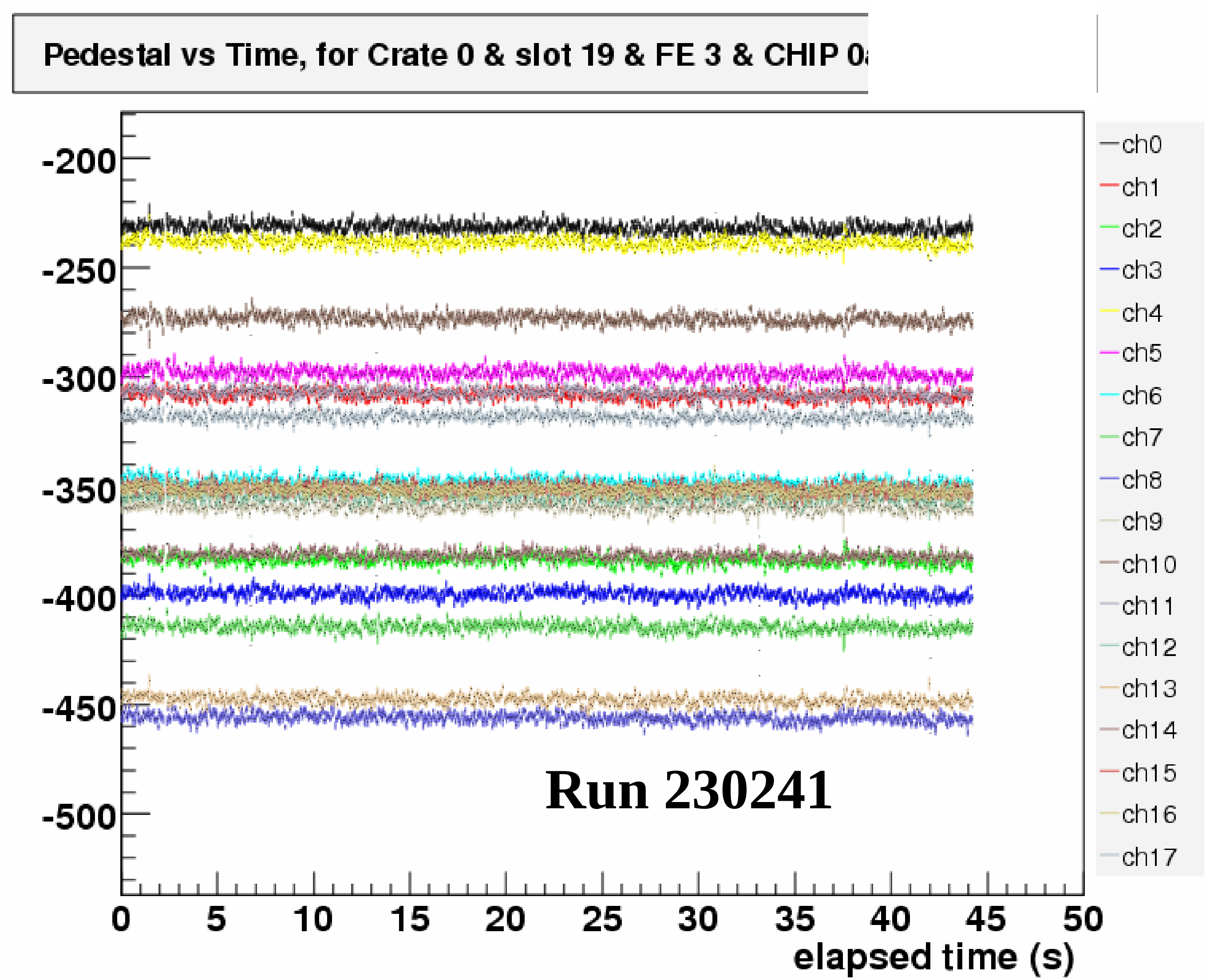


1st type : uncorrelated, slot 19, FE3



- This slot-FE is intrinsically uncorrelated : same result is obtained for all runs. This is also the case of slot 15, FE7.
- Same result is obtained for the 12 chips, and for every channel pair.

1st type : uncorrelated, slot 19, FE3

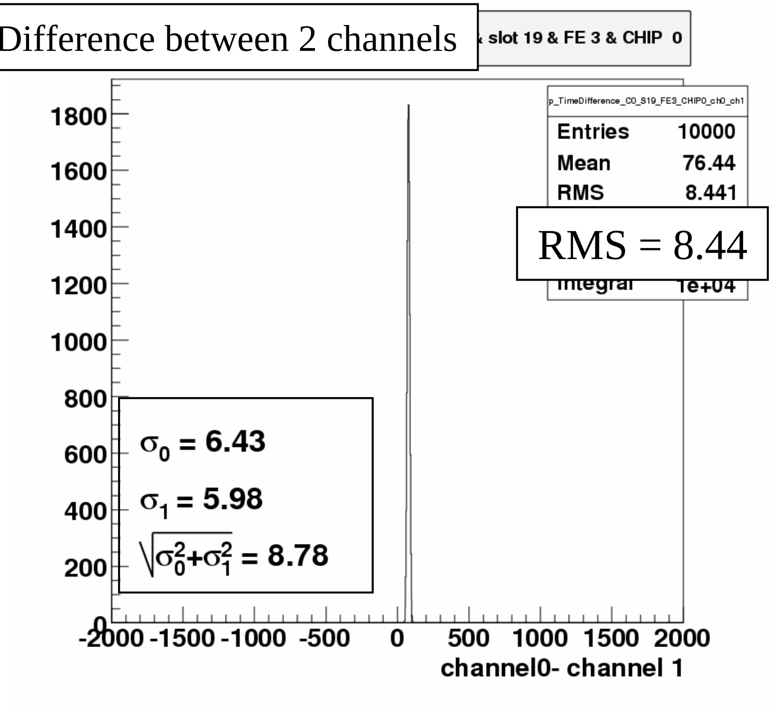


All flat, what is expected.

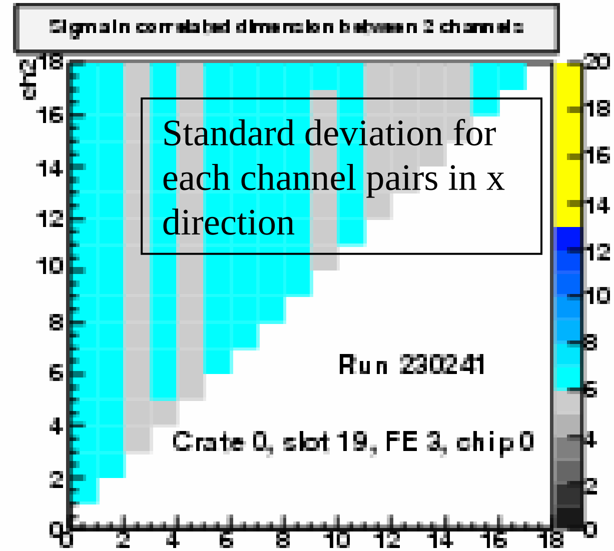
Further checks

Run 230241

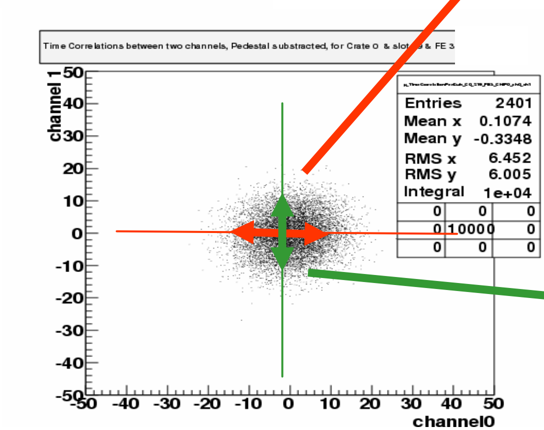
Difference between 2 channels

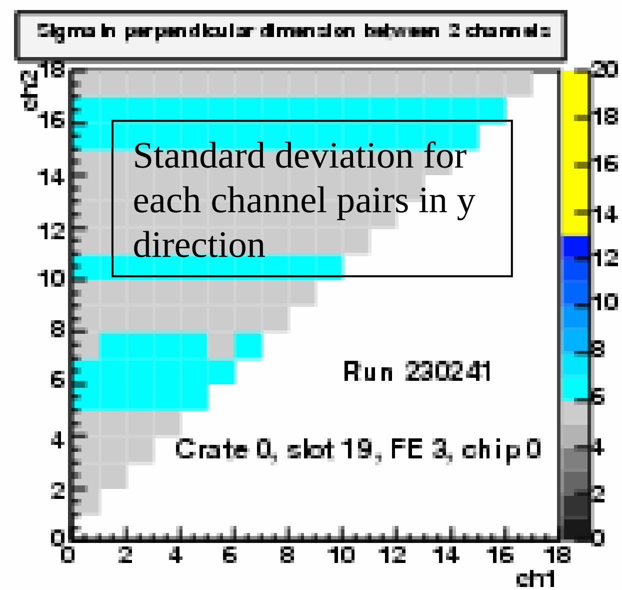


Noise ~ 6
For all channels and all chips

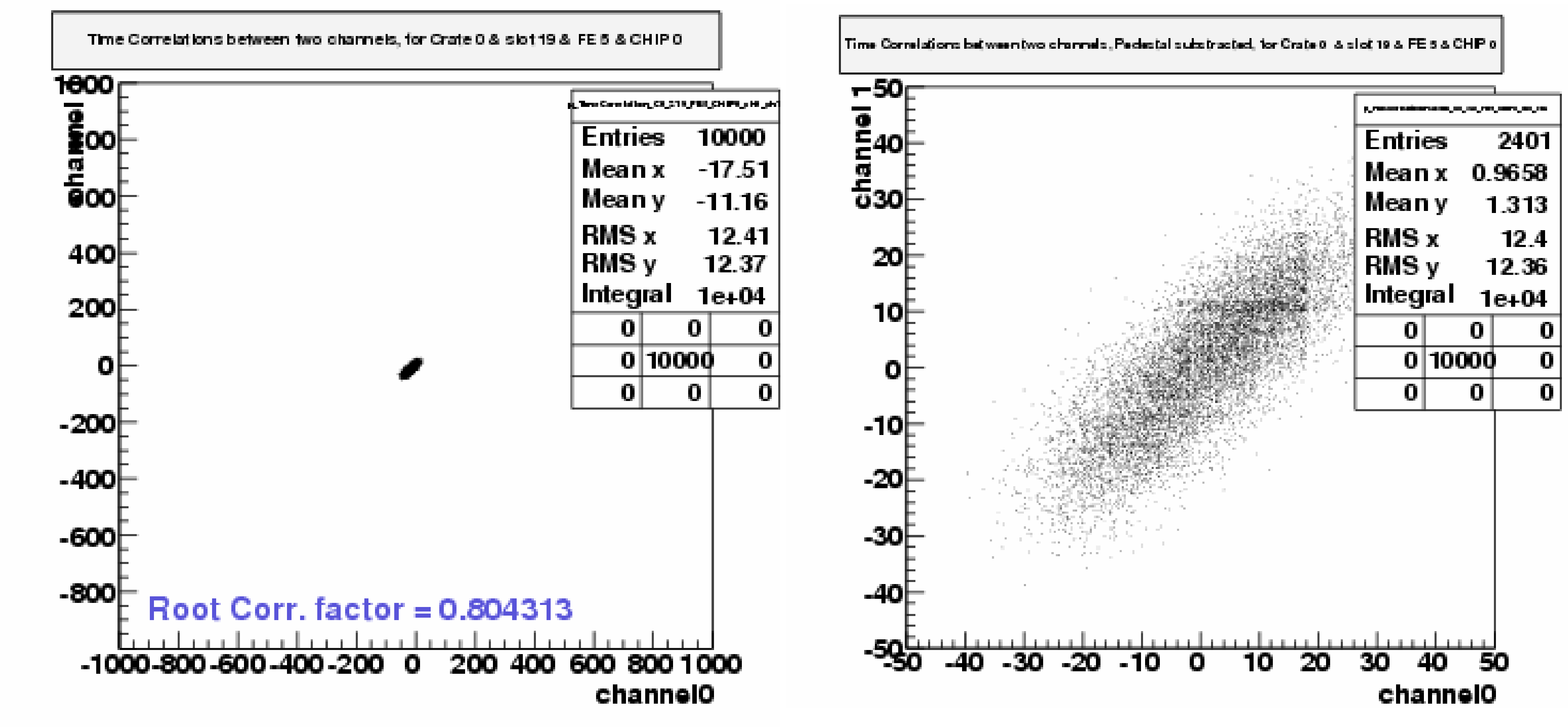


Correlation ~ 0



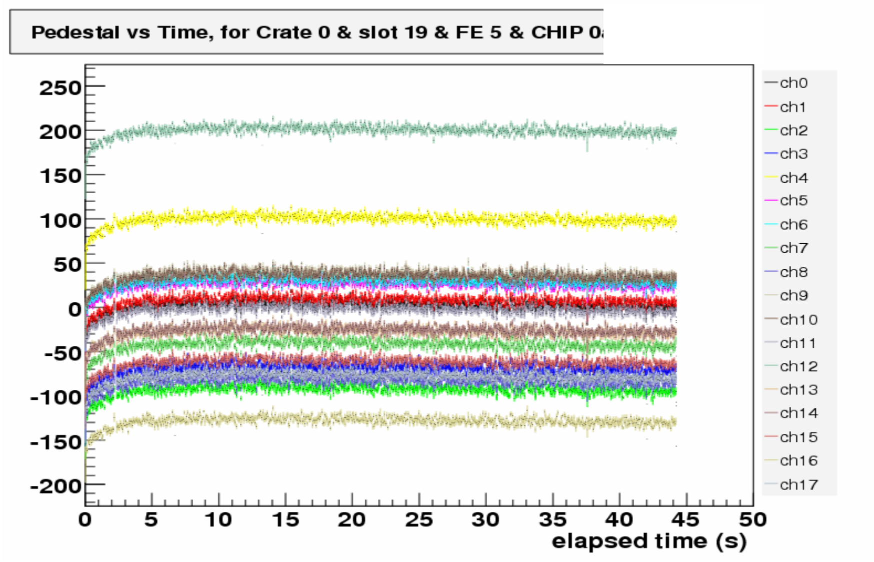


2nd type : correlated, Run 230241, slot 19, FE5



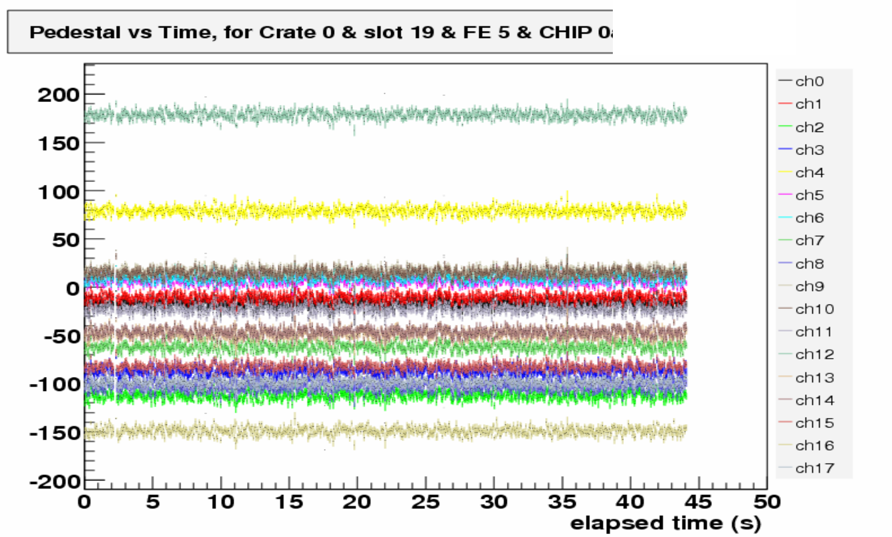
- This slot-FE is intrinsically correlated : same result is obtained for all runs. This is also the case of slot7 FE7, slot15 FE5, slot19 FEs 1,5,7.
- Same result is obtained for the 12 chips, and for every channel pair.

2nd type : correlated, slot 19, FE5



Run 230241

- Increasing (and then decreasing ??) pedestals.



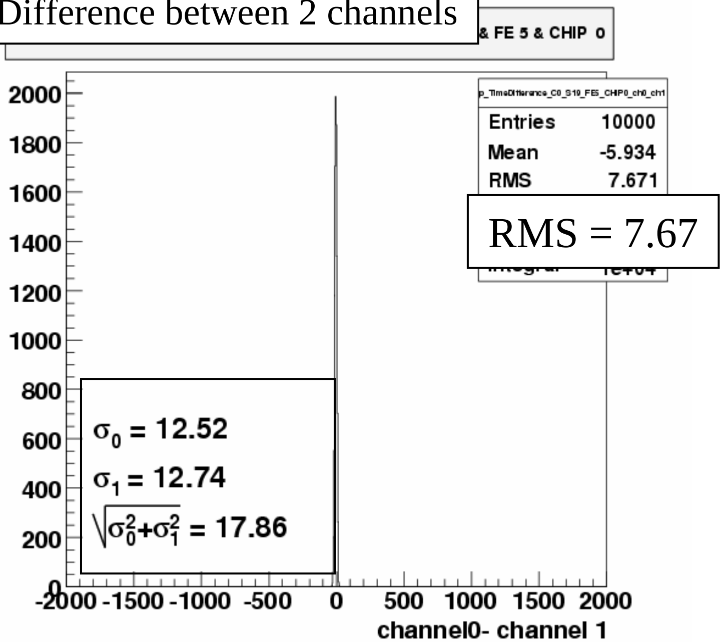
Run 230149

- Flat pedestals.

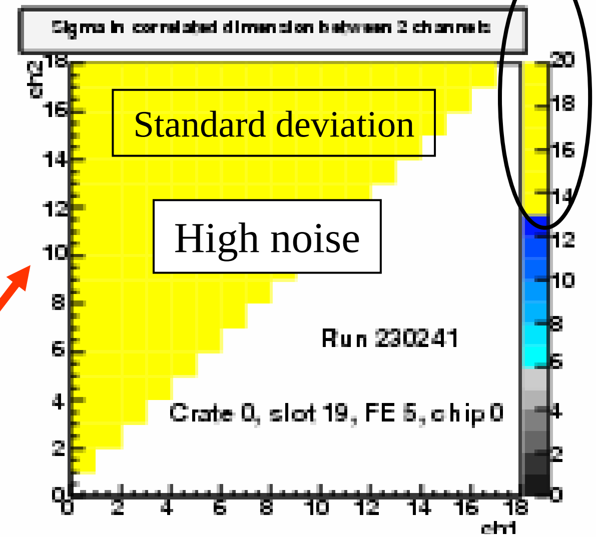
Runs 230241 and 230149 : same results.

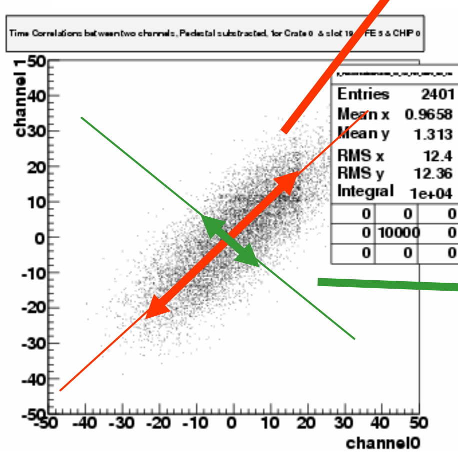
Further checks

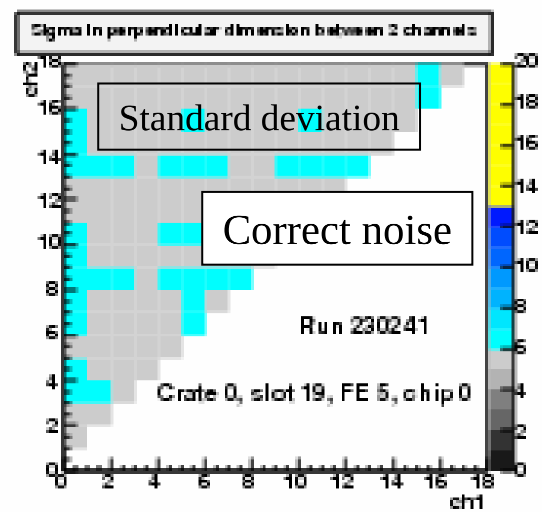
(all yellow = ps bug, but in reality no big variations around 14).



Difference compatible with normal noise level of 6 and no correlation. Correlation coming from moving pedestals ?? -> NO!! because run 230149 show the same correlation and flat pedestals !!

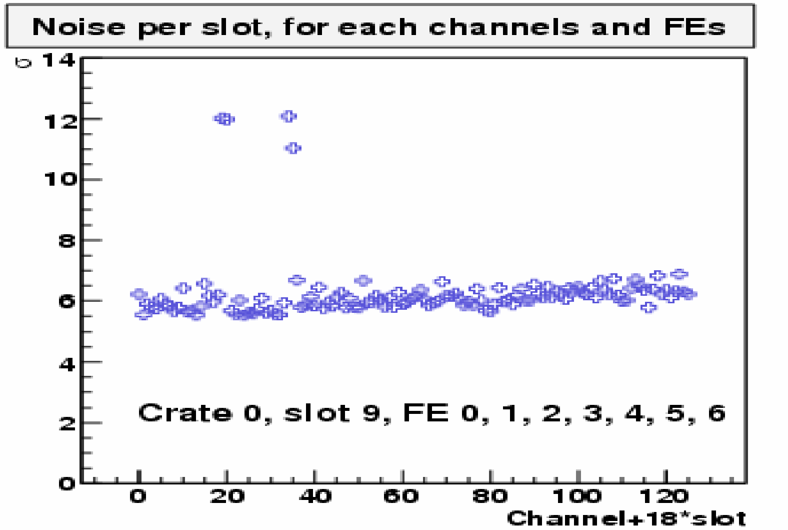


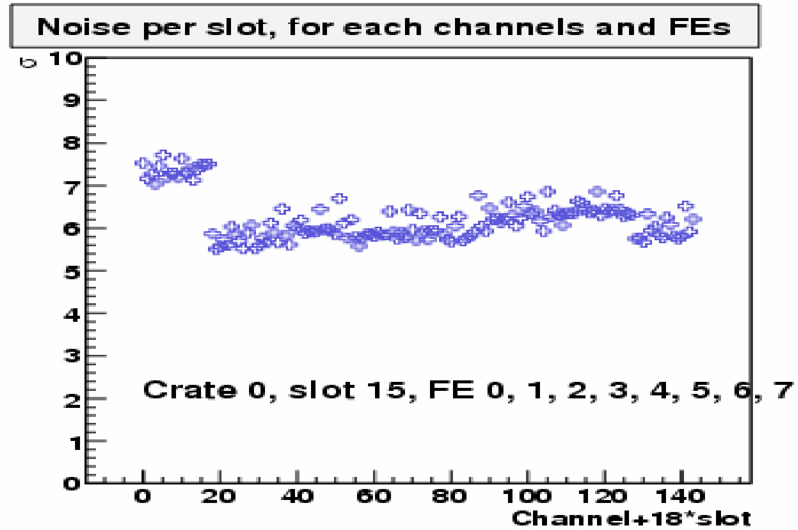


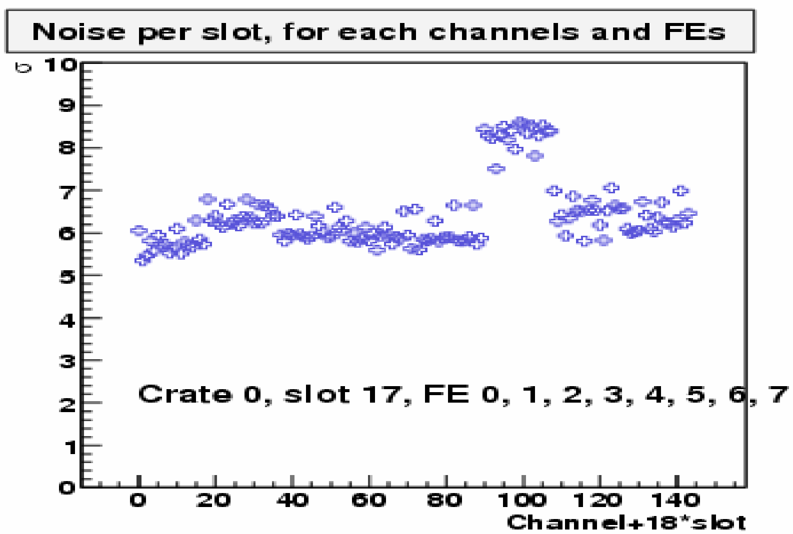


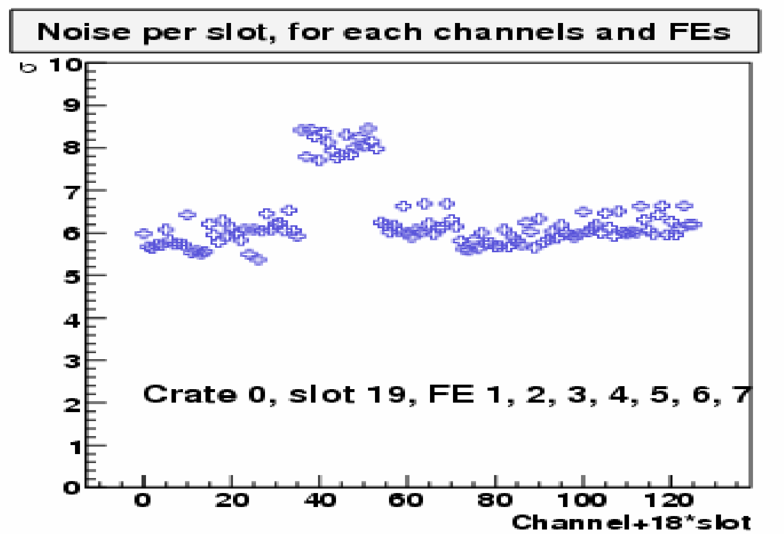
Correlation ~ 0.8

Noise values for all connected channels and chip #0

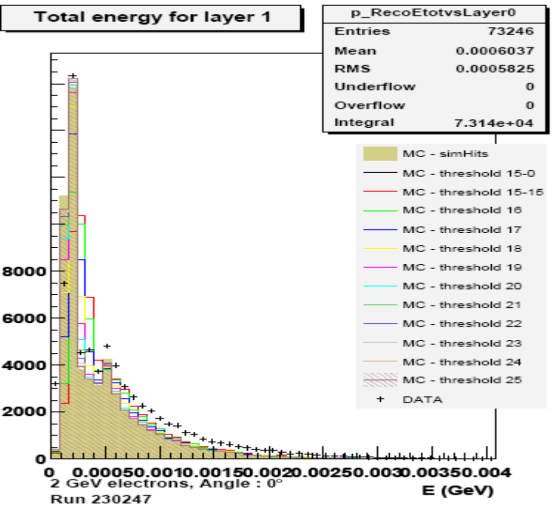


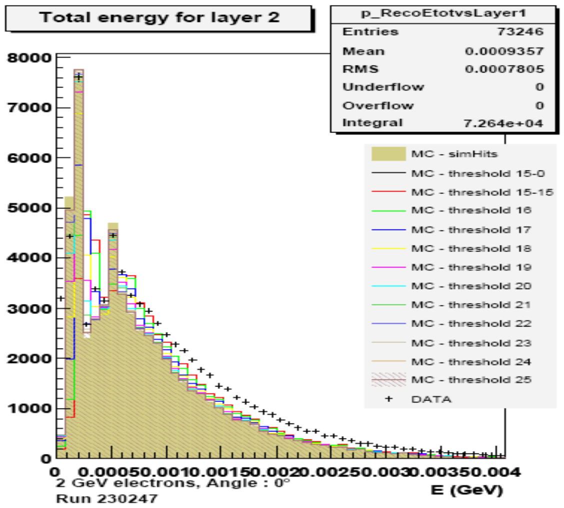


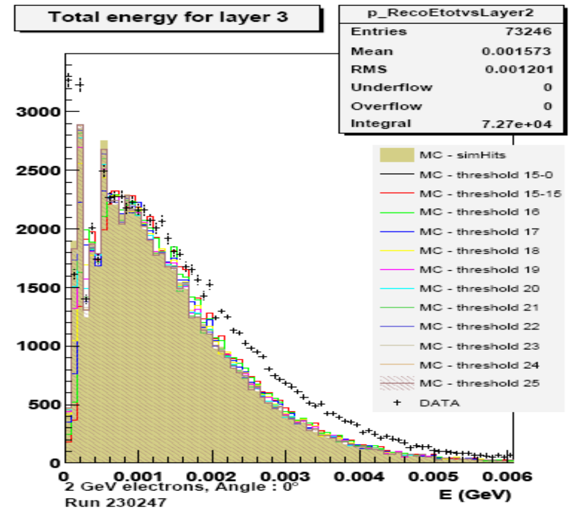


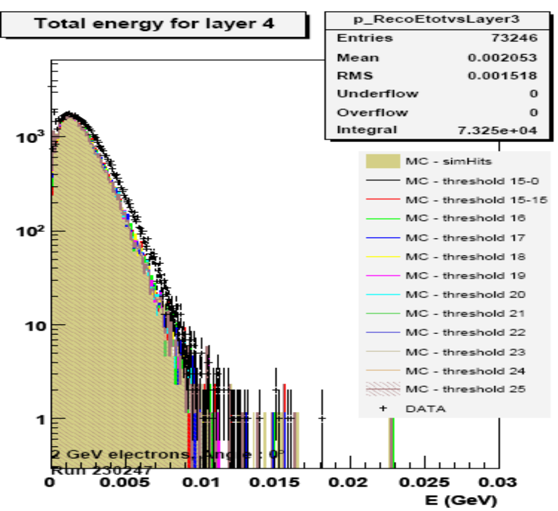


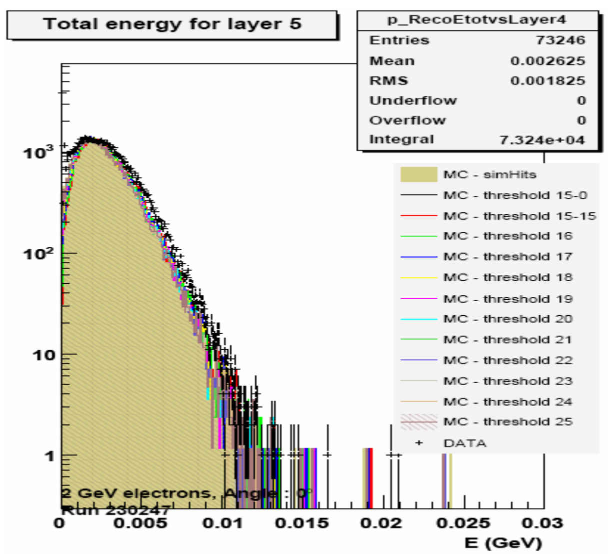
Total energy per layer, with different noise threshold from 15 to 25 ADC counts

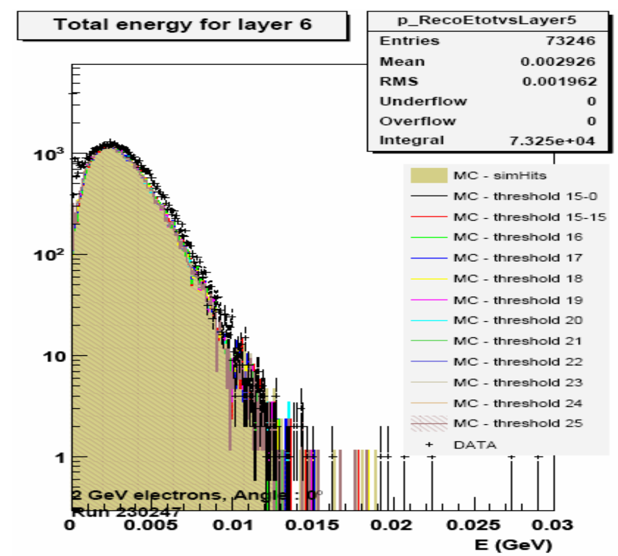




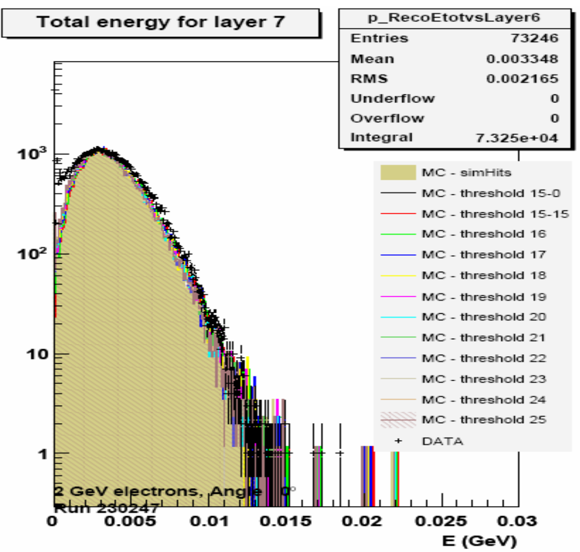


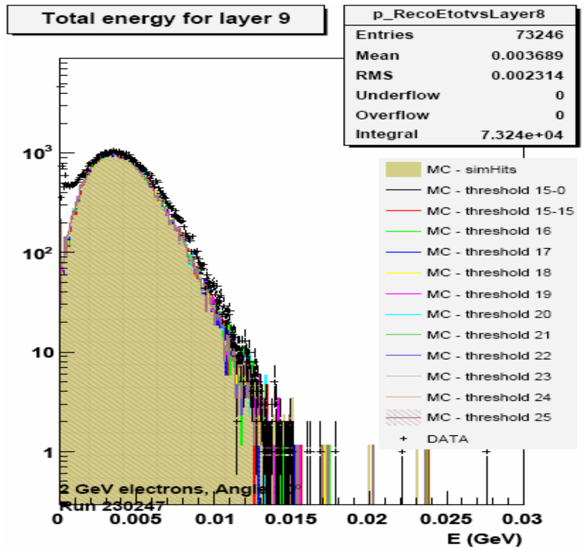


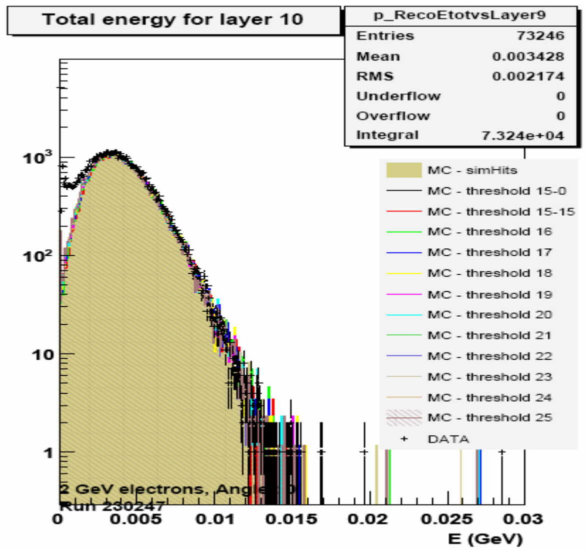


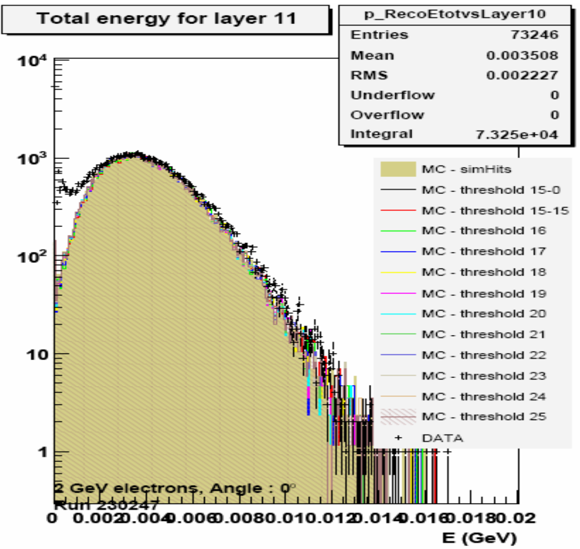


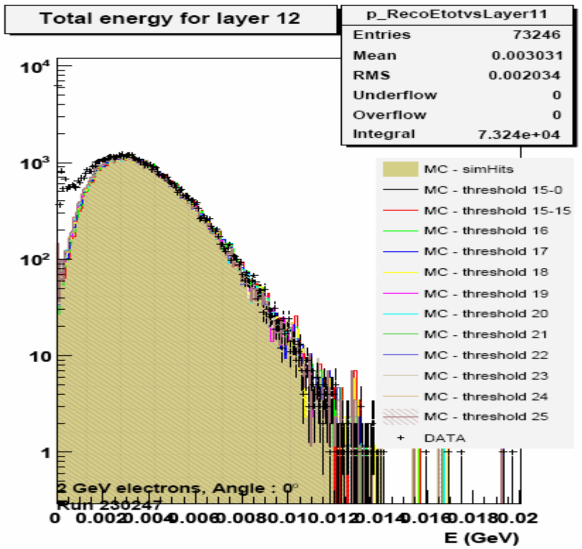
Layers 7, 9, 10, 11, 12, 13

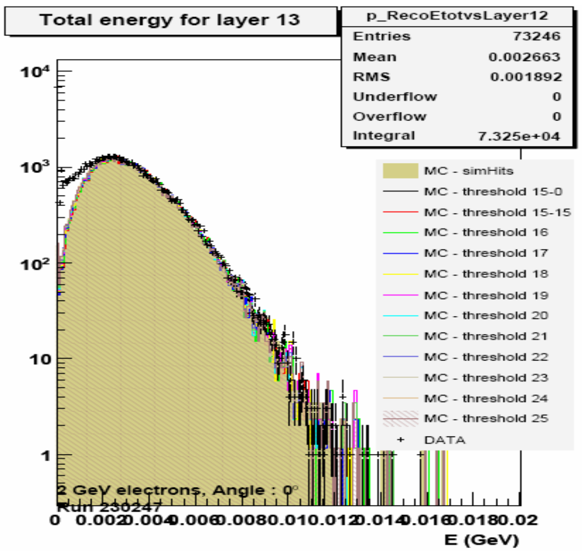




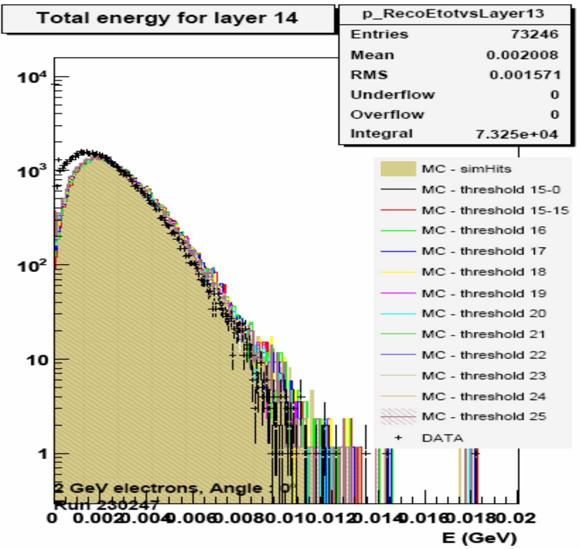


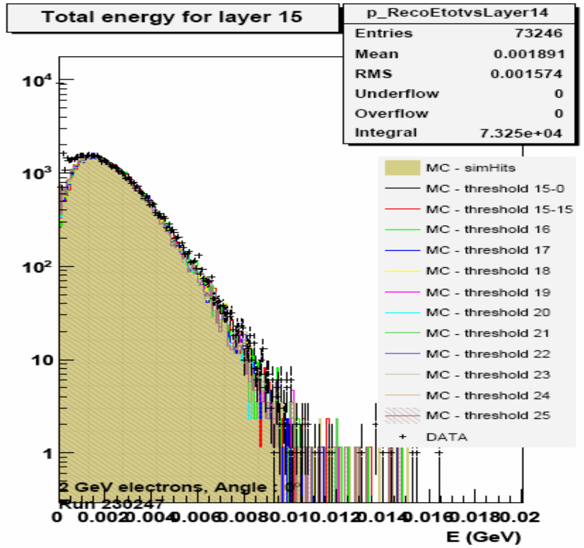


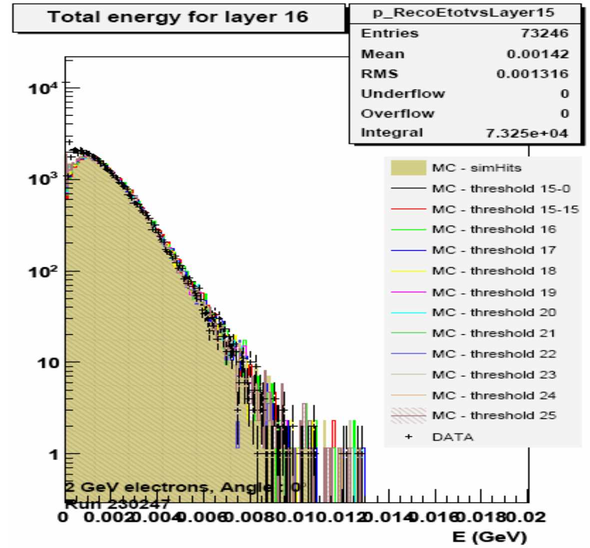


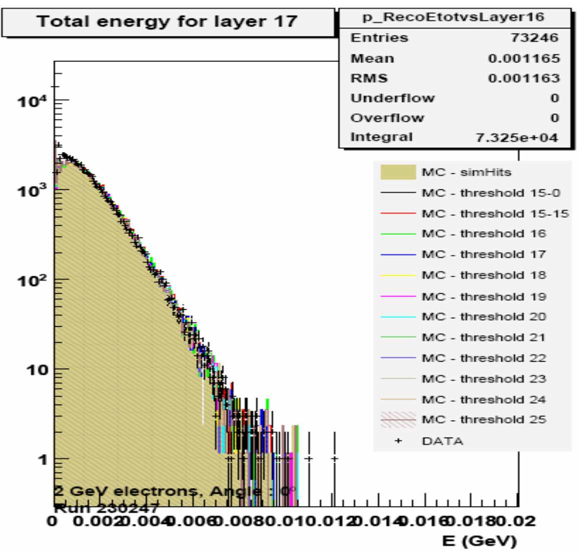


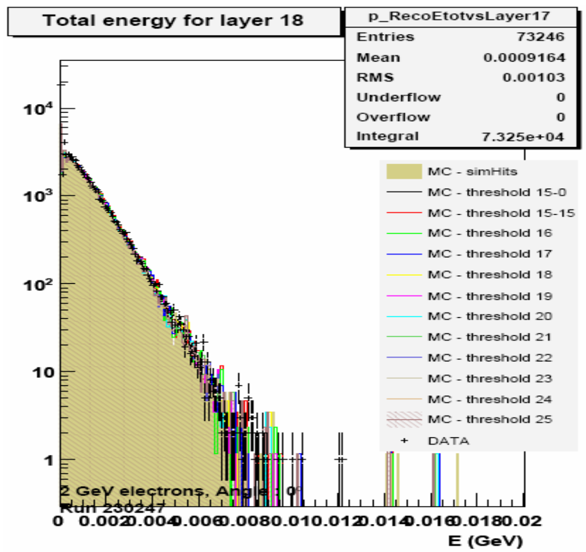
Layers 14, 15, 16, 17, 18, 19

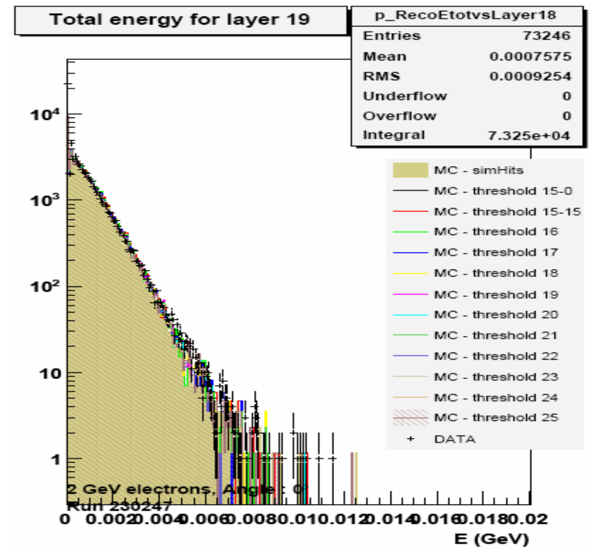












Layers 20, 21, 22, 26