Realistic noise in the ECAL MC

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Current ECAL noise generation algorithm

Noise generation in the algorithm CaloDigitAlg of CaloDigit package:

$$ADC = (1 + gainError)\frac{energy}{gain} + pedestal + coherent + incoherent$$

Boole v14r9:

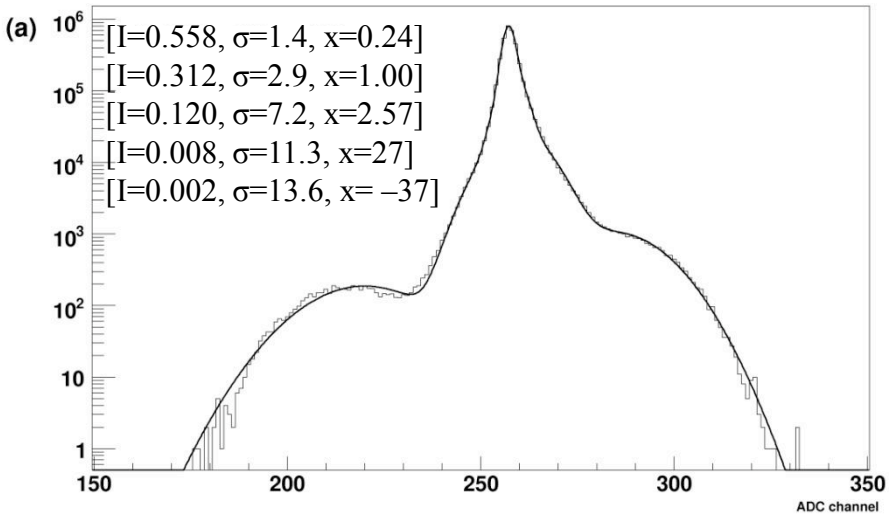
pedestal = 0.6
coherent = 0.3
incoherent = 1.2

As it was presented in [LHCb-2008-016] the noise spectrum has non Gaussian distribution and in addition it depends on the zone of the calorimeter (inner, middle, outer).

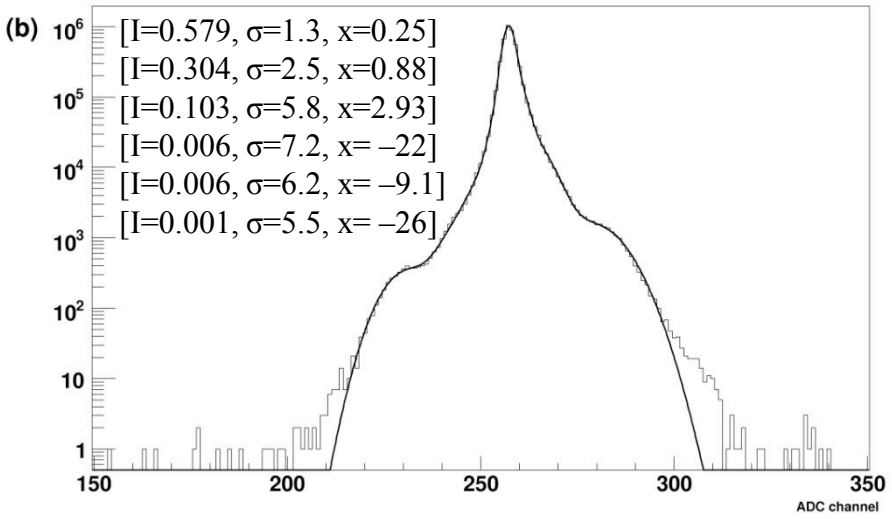
Noise spectra for ECAL zones

- Noise spectra were fitted with the sum of Gaussians.
- The mean value is calculated from the default pedestal value which is 256 ADC channel.
- The tail components have contribution less then 0.1% and were neglected.

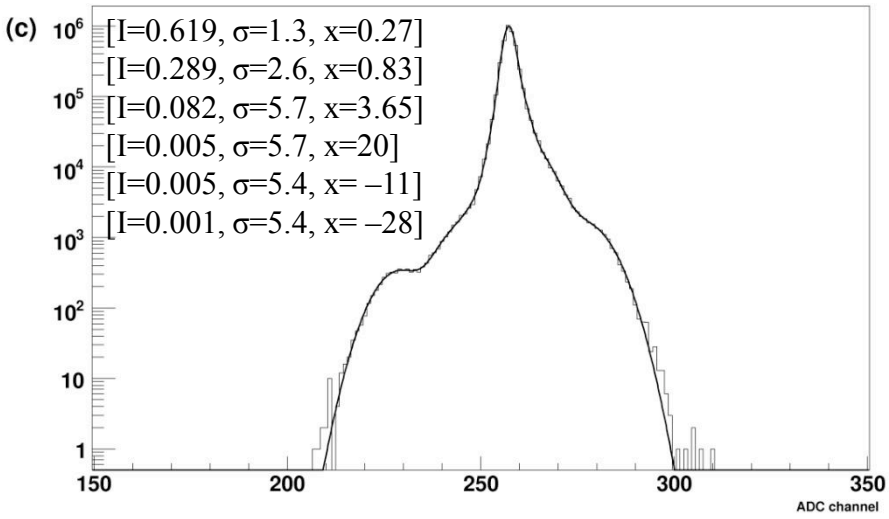
Inner zone



Middle zone



Outer zone



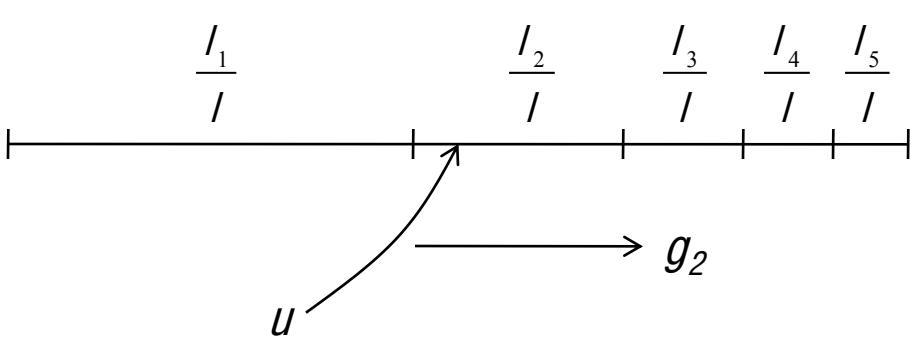
Implementation of the algorithm

$$f_{noise} = \sum_{i=1}^{N} Gaussian\ (I_i, x_i, \sigma_i), \quad I = \sum_{i=1}^{N} I_i$$

I_i – component fraction

x_i – mean

σ_i – sigma



1. Generate uniform random number u in the range (0, 1)
2. Select Gaussian corresponding to its component fraction
3. Generate random value g_i for Gaussian i.

The monitoring histograms for generated noise values are created for each zone of ECAL. Generated noise spectrums are fitted with the initial noise functions with free component fraction parameters. The χ^2 of the fit and values of partial components obtained from the fit can be used to check consistence of the generated spectrums.

Configuration of the algorithm

The standard algorithm CaloDigitAlg was modified to provide new noise spectrum generation.

The algorithm is configured via small number of parameters.

AdvancedNoiseInner = { [I, x, σ], … }

AdvancedNoiseMiddle

AdvancedNoiseOuter

UseAdvancedNoise = false or true

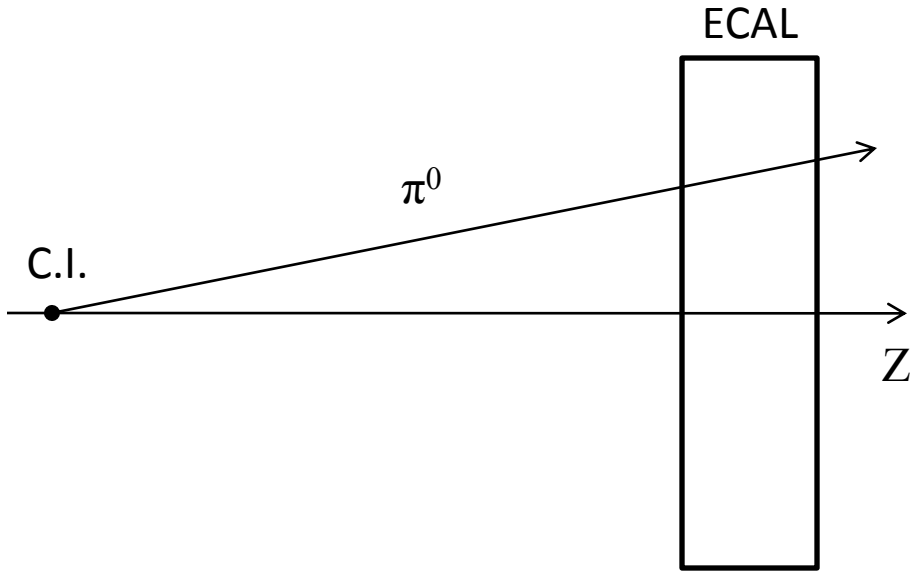
MonitorNoise = false or true

Study of new noise influence on the π^0 resolution

The study of new noise influence on π^0 width was done by MC simulation of π^0 with different transverse energies.

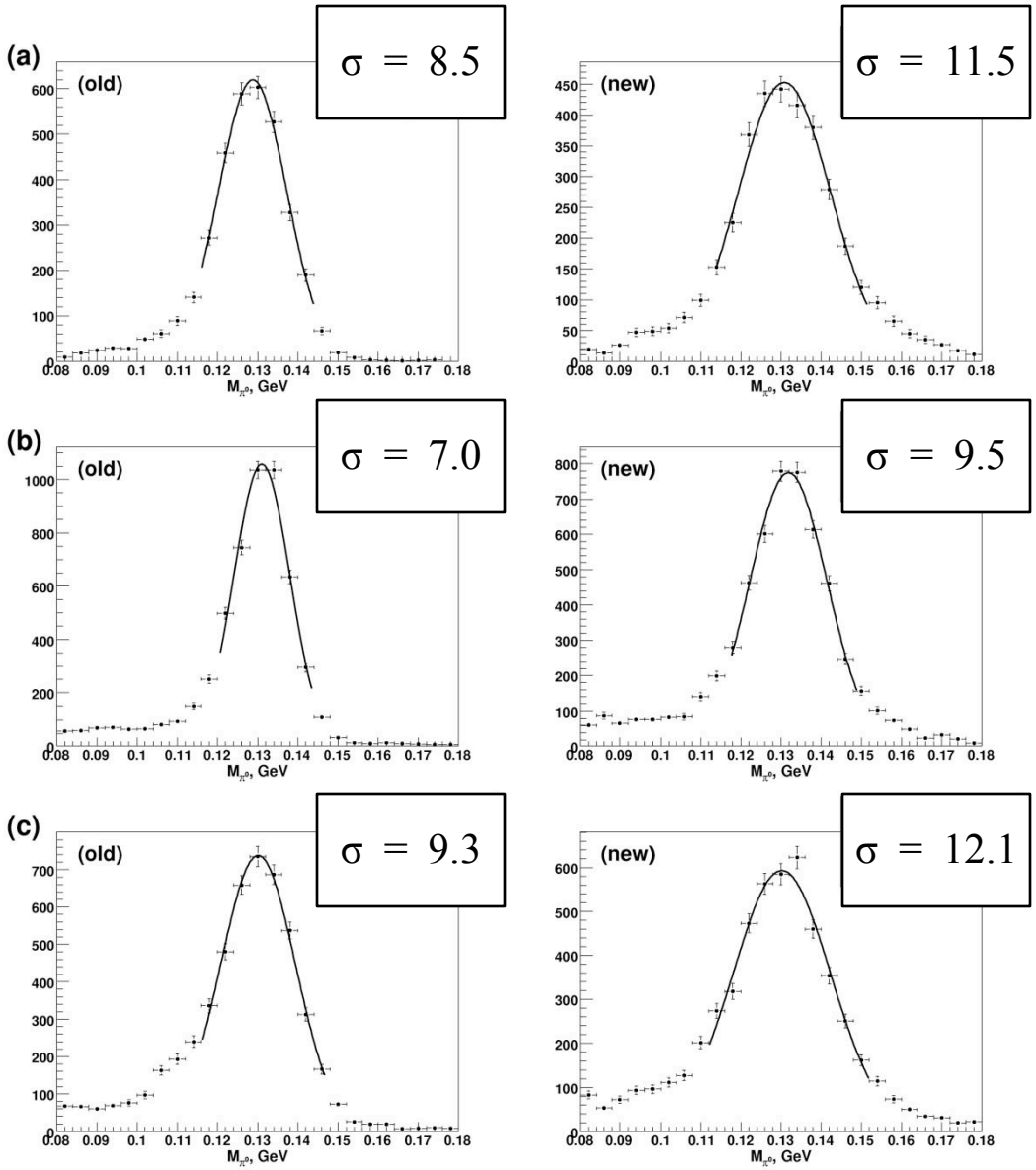
The modified ParticleGun algorithm was used to generate π^0's.

π^0's were generated from the center of interaction with direction to the fixed point in the inner part of ECAL.



π^0 width for different transverse energies

a) $E_t = 0.75$ GeV
b) $E_t = 1.25$ GeV
c) $E_t = 2.00$ GeV

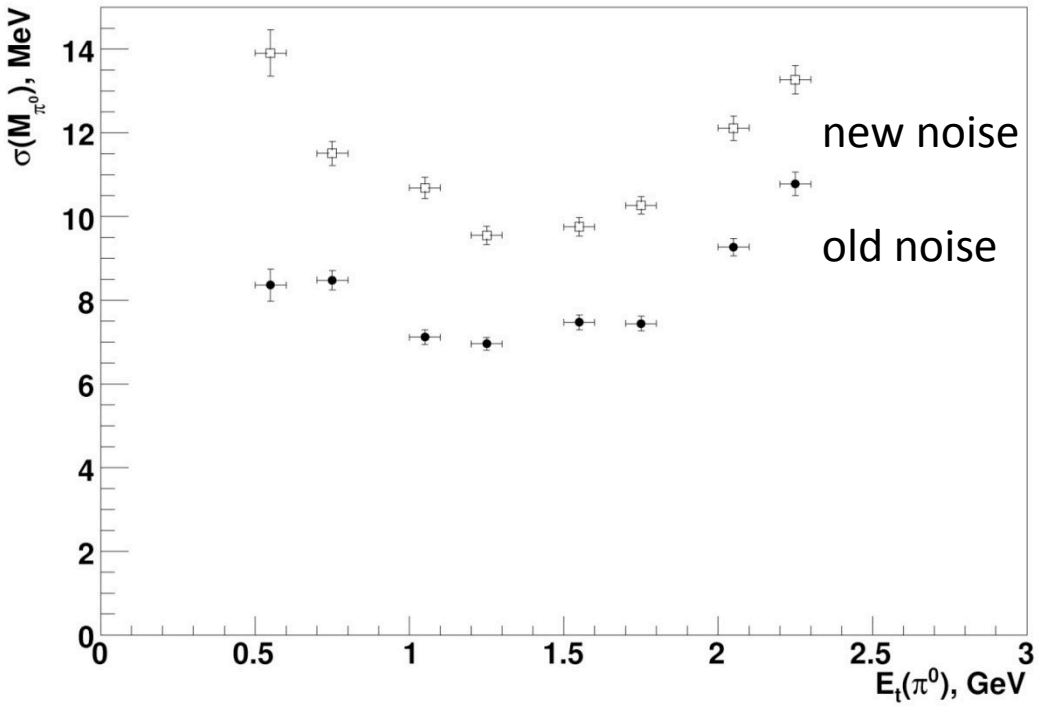


The digitization was performed with new and old noise implementation. The reconstructed π^0's were matched with MC pions.

The π^0 width for new noise is about 30% higher then with old noise

The dependence of reconstructed π^0 width versus the transverse energy

E_t, GeV	σ_{old}, MeV	σ_{new}, MeV
0.50	8.4 0.4	13.9 0.6
0.75	8.5 0.2	11.5 0.3
1.00	7.1 0.2	10.7 0.3
1.25	7.0 0.2	9.5 0.2
1.50	7.5 0.2	9.8 0.2
1.75	7.4 0.2	10.3 0.2
2.00	9.3 0.2	12.1 0.3
2.25	10.8 0.3	13.3 0.4



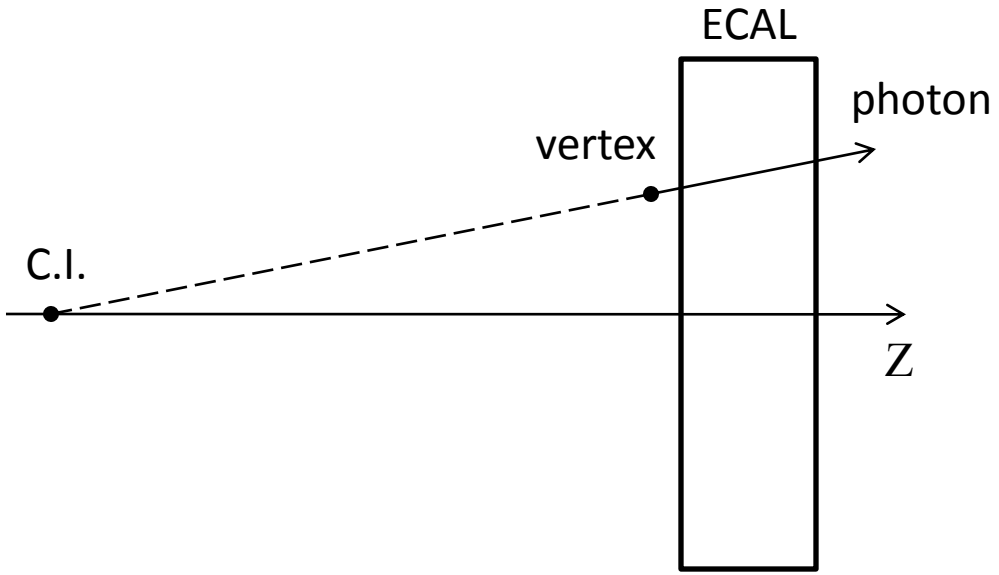
It can be seen, that in low energy range the resolution is improving with energy. From the other hand, above transverse energy E_t = 1.5 GeV the resolution starts to decrease, due to merging of photons.

Study of ECAL energy and space resolution

$$\frac{\sigma(E)}{E} = \frac{a}{\sqrt{E}} \oplus b \oplus \frac{c}{E}$$

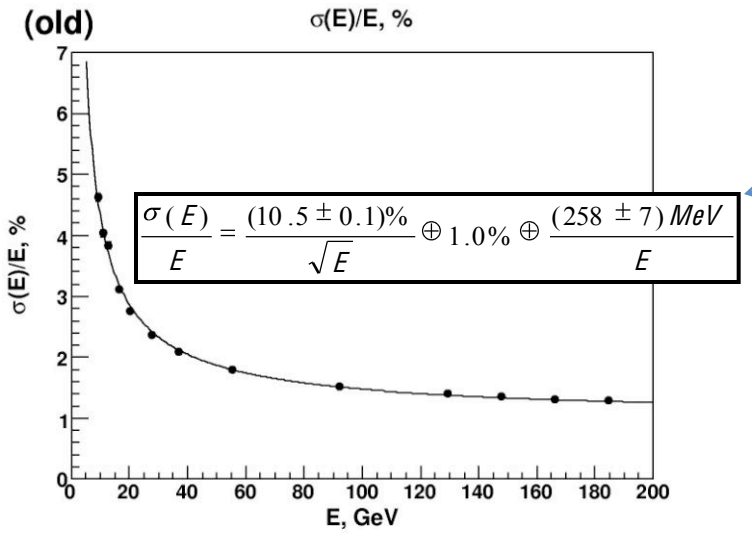
a – stochastic term
b – constant term (1%)
c – noise term

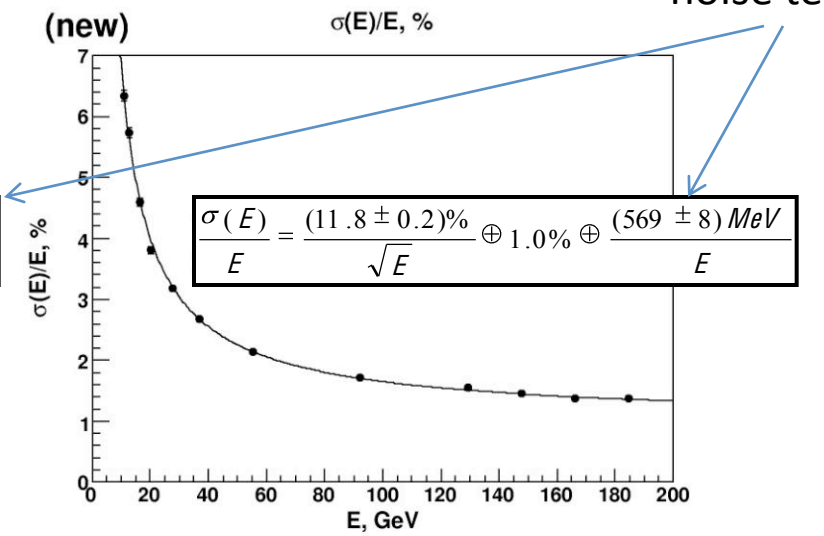
The photons were generated from the vertex positioned just before the ECAL and with direction from the center of interaction and fixed target point in the inner part of the calorimeter.

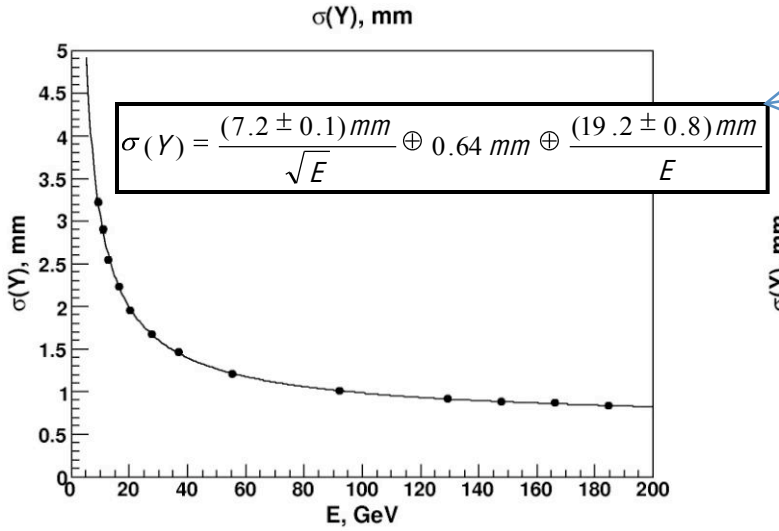


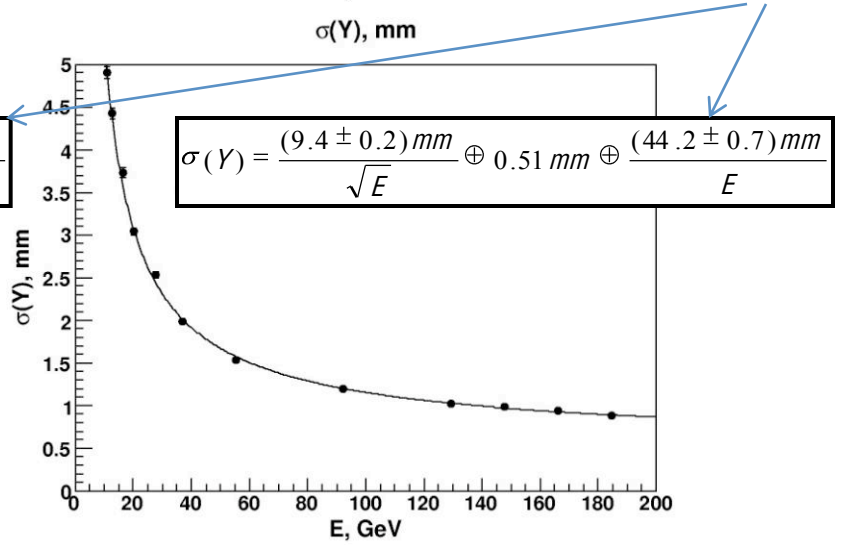
Energy and space resolution for old and new noise

noise term









Conclusion

1. The effect of realistic noise is added to ECAL digitization.
2. The impact on π^0 width and ECAL energy resolution is described.
3. The π^0 width rise on about 30%.
4. The noise term in ECAL resolution changed from 260 to 570 MeV.

- The new noise implementation is ready for CVS commitment.
- The note about new noise will be available soon.