Calibration With Z $\rightarrow$ ee Events

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- Purpose

Determine simultaneously the energy scale in various parts of the DØ LAr calorimeter using $Z \longrightarrow e^+e^-$ events.

- Method

We propose to use the likelihood

$$\mathcal{L} = -\Sigma_i^N \ln p_i(\frac{m_i}{m_Z})$$

where p_i is the probability density that the invariant mass of the pair of event i is m_i , and m_Z is the nominal mass of the Z, i.e. 91.2 GeV.

$m_i^2 = 2E_{1i}^k E_{2i}^l (1 - cos\theta_i)$

E_{1i}^k energy of the first reconstructed electron detected in zone k

θ_i is the angle between the electron and the positron

The energy in the calorimeter is given by

$$E = \alpha \, \Sigma_j^n \, \beta_j a_j + \gamma$$

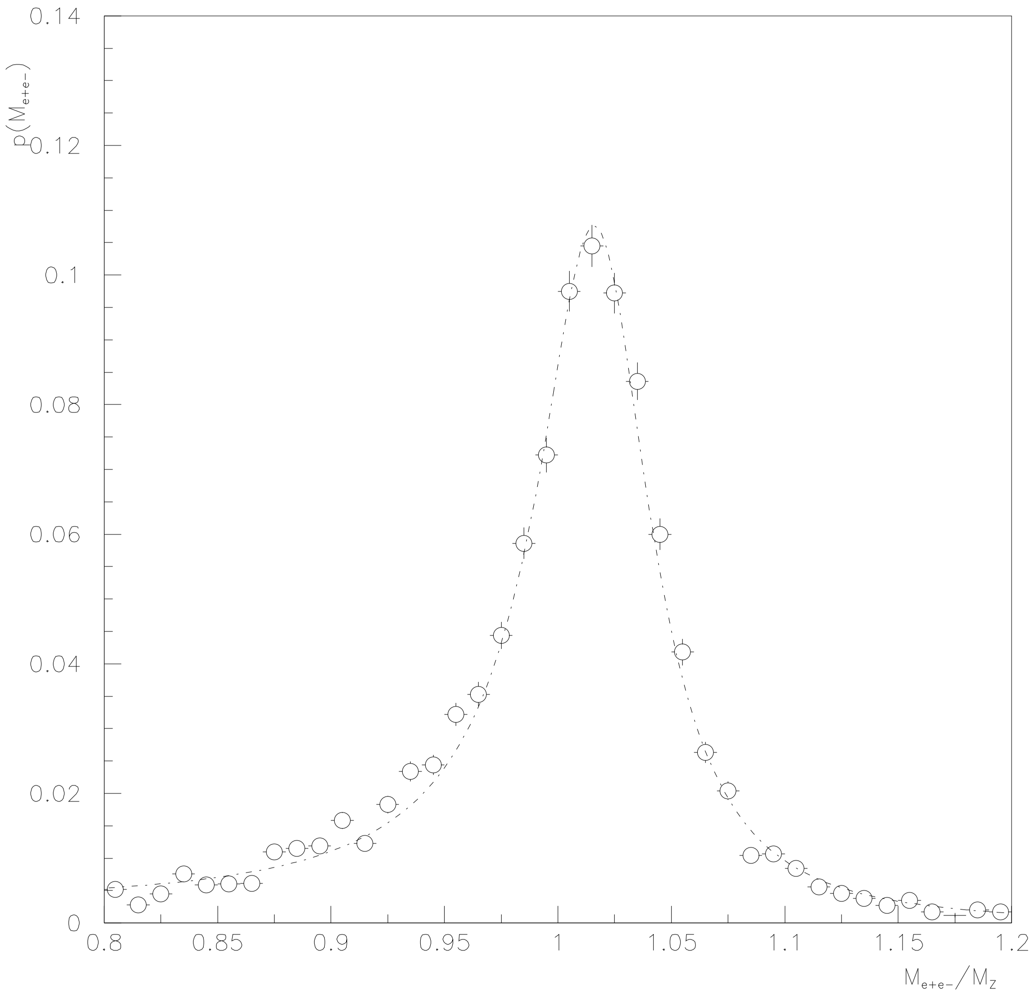
where α is the overall energy scale, β_j the sampling fraction and γ is the bias

Only the evolution of α is considered and we assume $\gamma = 0$

This evolution is small (1-2%), the aim of the proposed method is to recover the evolution of α by minimizing the likelihood

Need to have a good determination of the invariant mass distribution by the MC

10k events of the full simulation



The invariant mass distribution has been parametrized with

$$p_i(x) = A \cdot \frac{B}{(x^2 - C)^2 + B} \cdot \frac{1}{x^D}$$

where x is $\frac{m_i}{m_Z}$

- Application of the method

We have tested the method with MC events

The calorimeter has been divided in zones in η and ϕ

In each of these zones the evolution of the detector is simulated by a set of ϵ_r miscalibration coefficients

$$E_i^k \rightarrow E_i^k \times \frac{1}{1+\epsilon_r^k}$$

miscalibration coefficients $\rightarrow$ gaussian distribution

$< \epsilon_r >= 0.$

variance σ_{ϵ_r}

We have taken σ_{ϵ_r} to be 1%

Writing

$\bar{m}_i^2 = m_i^2(1+\epsilon^k)(1+\epsilon^l)$

we minimize the likelihood in terms of $\epsilon^{k(l)}$ and get the ϵ_f correction factors

the final bias after the correction is noted

$$b_\epsilon = < \epsilon_f - \epsilon_r >$$

and the final error

$$\delta_\epsilon = \sqrt{< (\epsilon_f - \epsilon_r)^2 > - b_\epsilon^2}$$

We have studied the results of the calibration

- in function of the statistics,

- the number of zones,

- and in the case where some zones were miscalibrated with a larger dispersion (3%) than the rest of them

- Chain of simulation

Full simulated events

22k events from the MCC99

Pythia MC, with ISR and FSR

D0Reco

At least two reconstructed EM cluster

η cuts, $|\eta| \leq 1.1$ or $1.5 \leq |\eta| \leq 2.5$

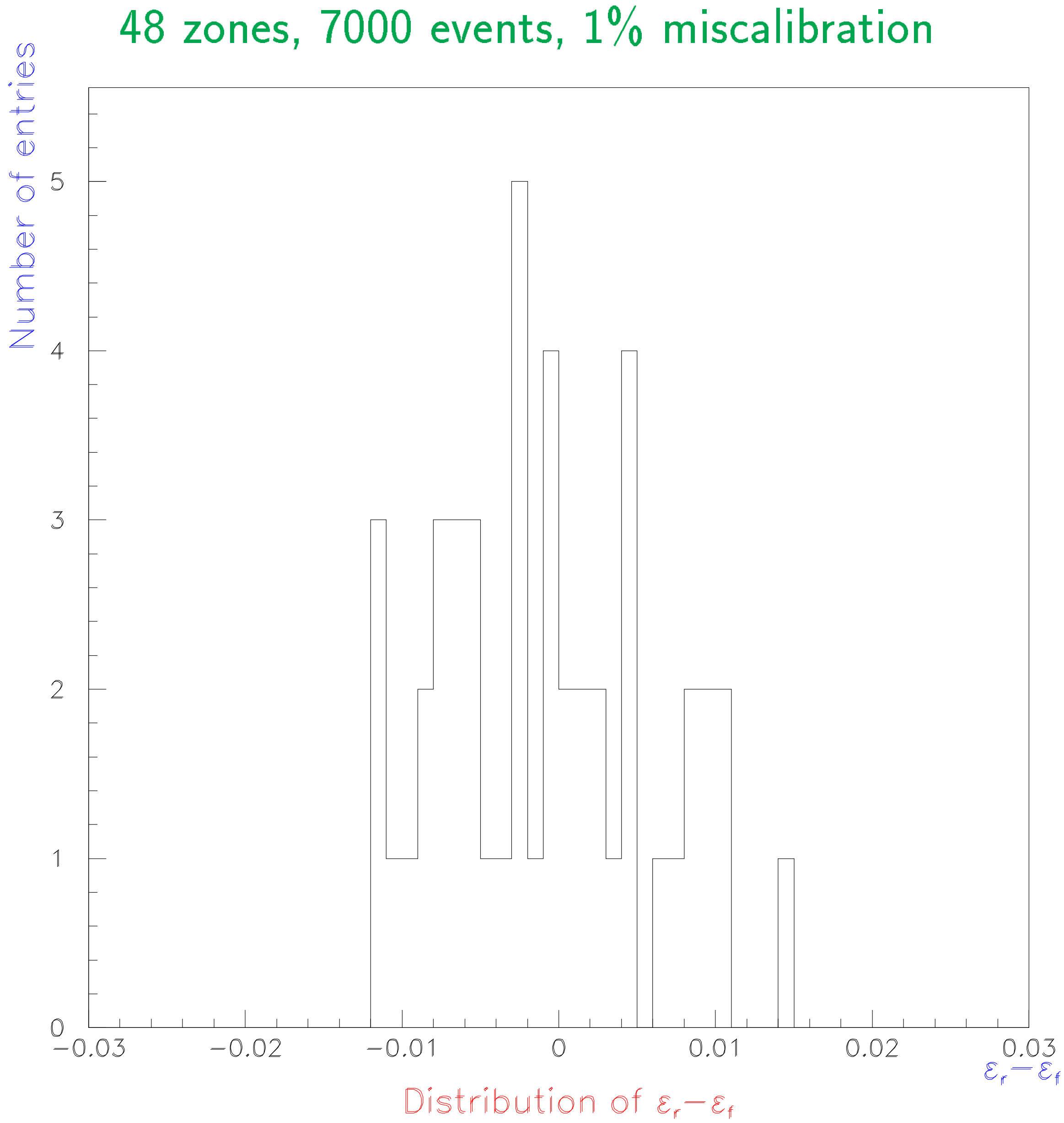
(high efficiency area of the detector)

Invariant mass cut $87 \leq m_i \leq 101$ GeV

(trade off between statistics versus small bias)

$\downarrow$

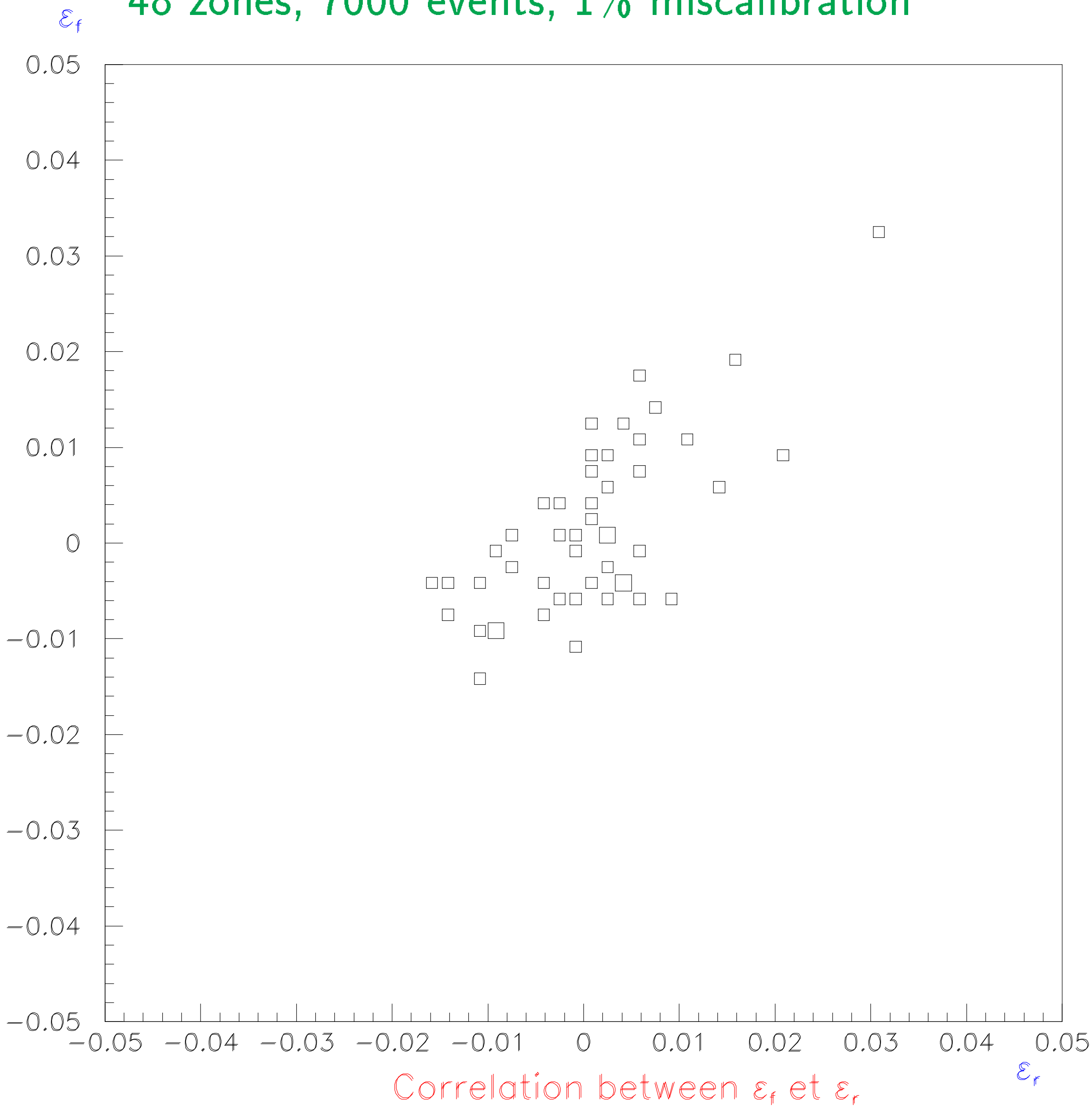
7k events were used for the fit algorithm



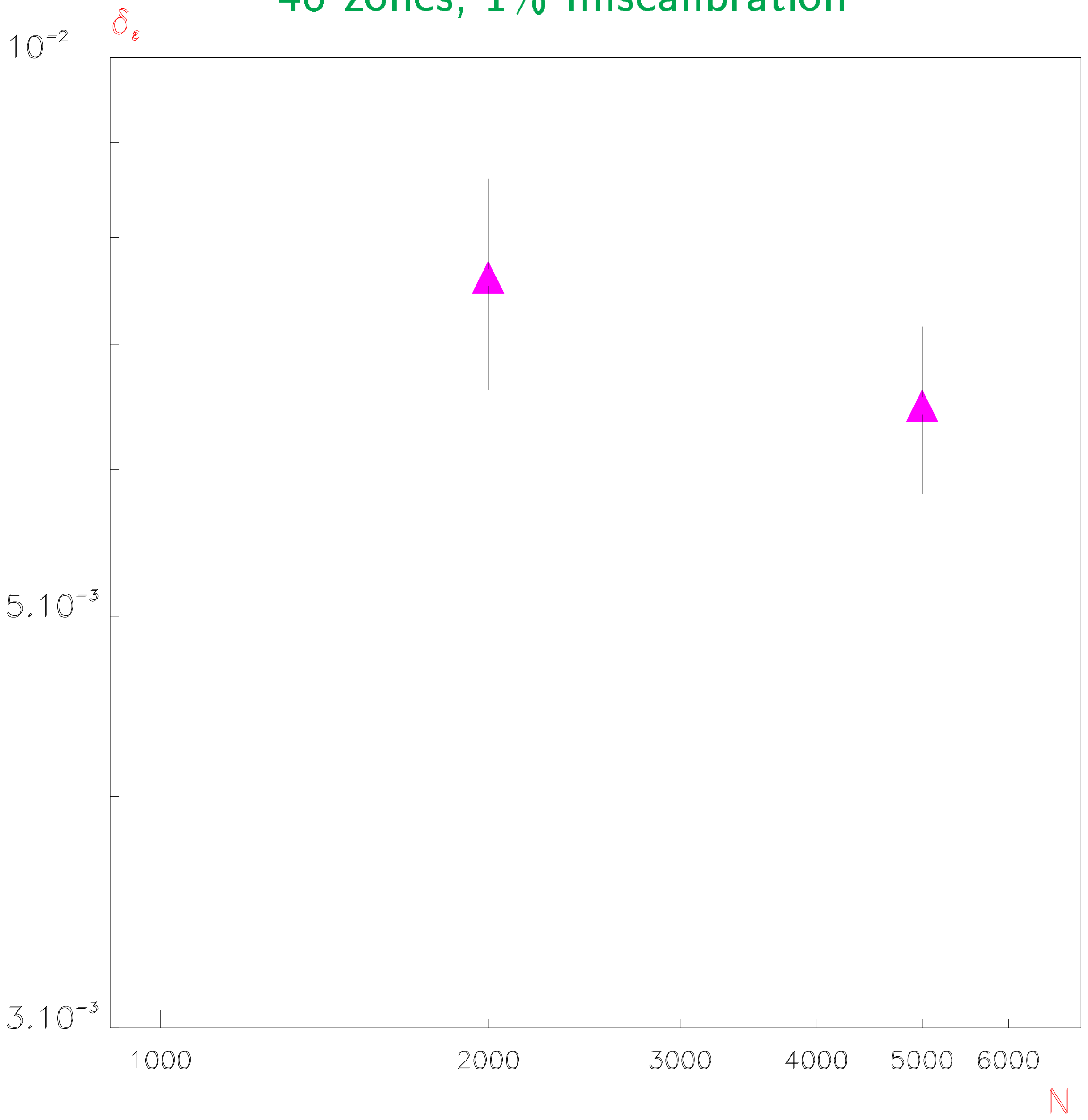
$$b_\epsilon = -0.751\ 10^{-3} \pm 0.959\ 10^{-3}$$

$$\delta_\epsilon = \ 6.66\ 10^{-3} \pm 0.775\ 10^{-3}$$

48 zones, 7000 events, 1% miscalibration



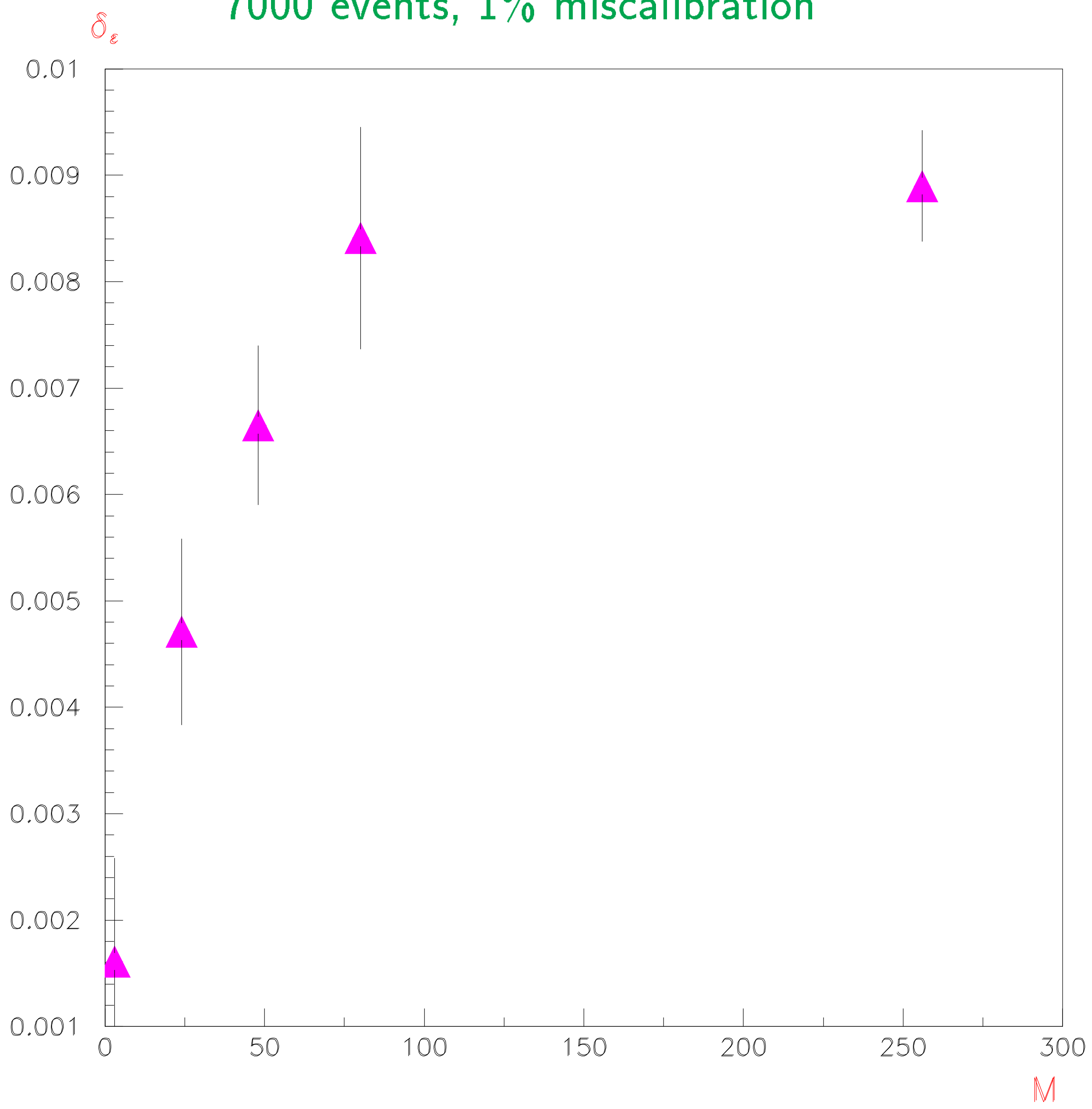
48 zones, 1% miscalibration



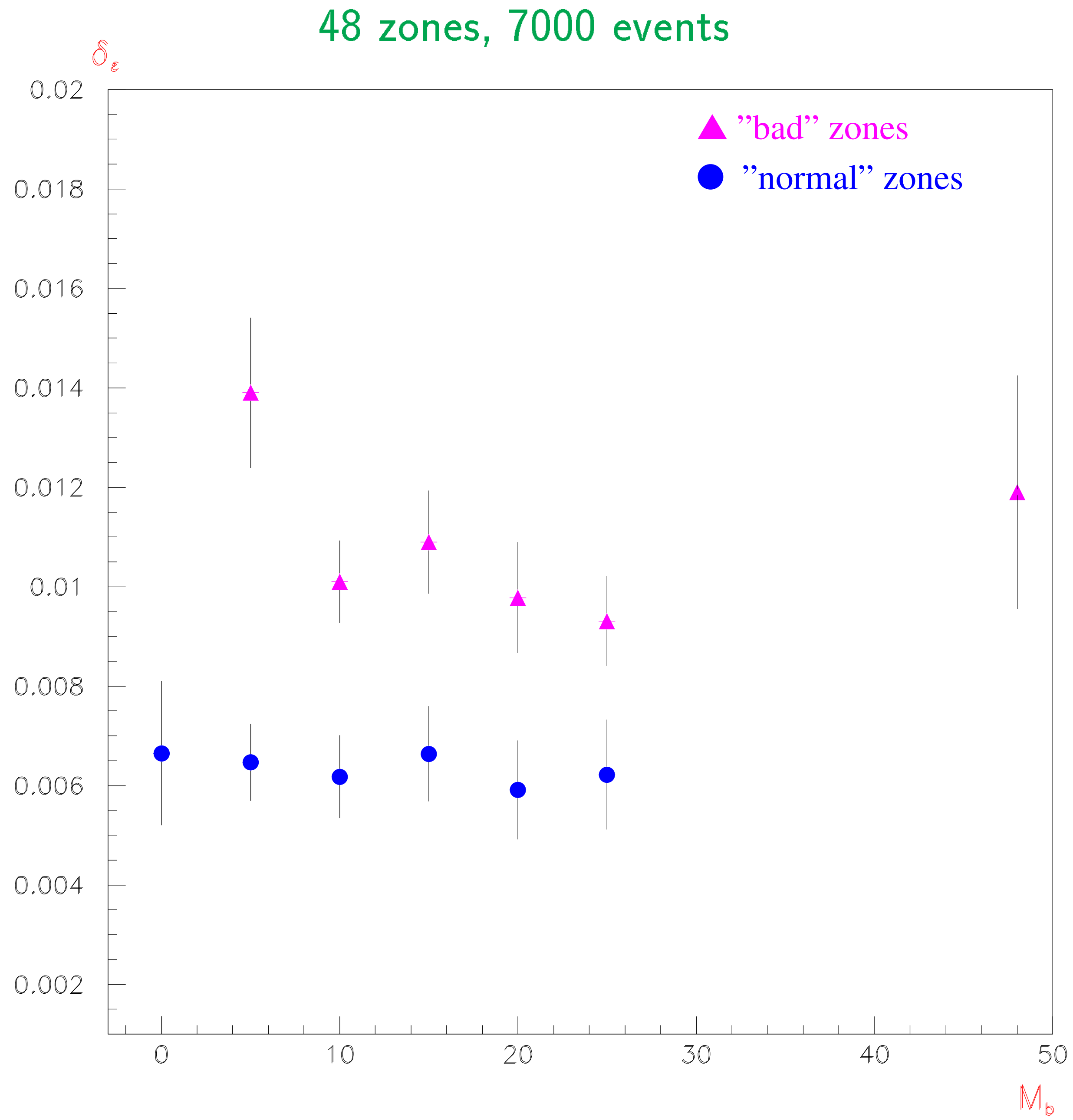
if we consider $\delta_\epsilon = N^{-d}$

we have $d = 0.25 \pm 0.19$

7000 events, 1% miscalibration



Evolution of the results with the number of zones (M)



"bad" zones are miscalibrated with a variance of 3%

Conclusion

With the given statistics ($L_{int} \sim 0.1 fb^{-1}$), we can recover an evolution of the calibration constant from 1% to 0.2 to 0.8 %(depending on the number of zones)

This may be improved with more statisics

In the case where some of the zones have anomalous behaviour :

- we can detect the "bad" zones

- we can recover the evolution for these to around 1%

- the others are not affected and are still restored to 0.6% (in the case of 48 zones)