EMCal showers in data and MC

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(extracted most of it from Nicolas Arbor thesis)

ALICE
A JOURNEY OF DISCOVERY

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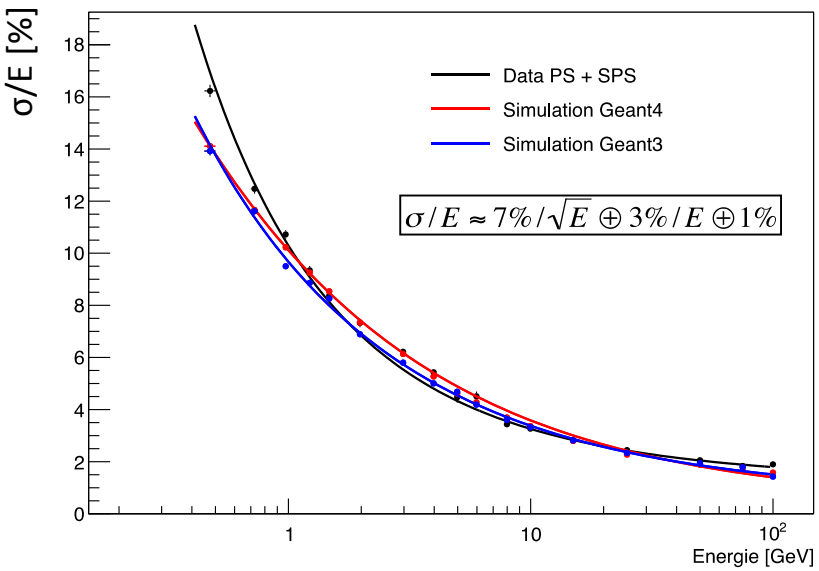
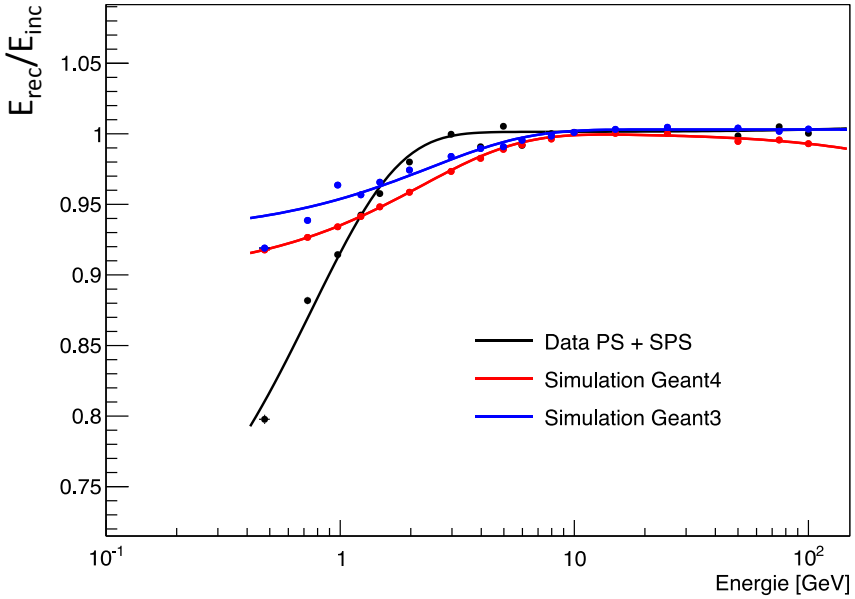
Calorimeter Performances



Electron energy resolution

- Good agreement data/ MC for E > 1 GeV

With APD poissonian fluctuations adjusted in MC with pi0's



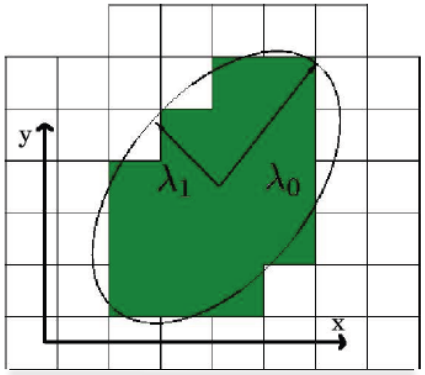
Electron non-linearity :

- linear for E > 3 GeV
- different corrections data / MC
- a bit different performance G3/G4

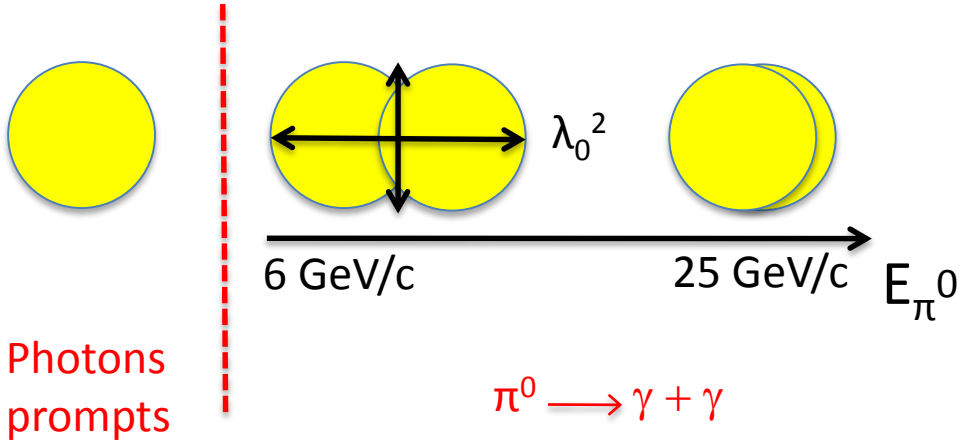
See effect of clusterization, fluctuations in back-up

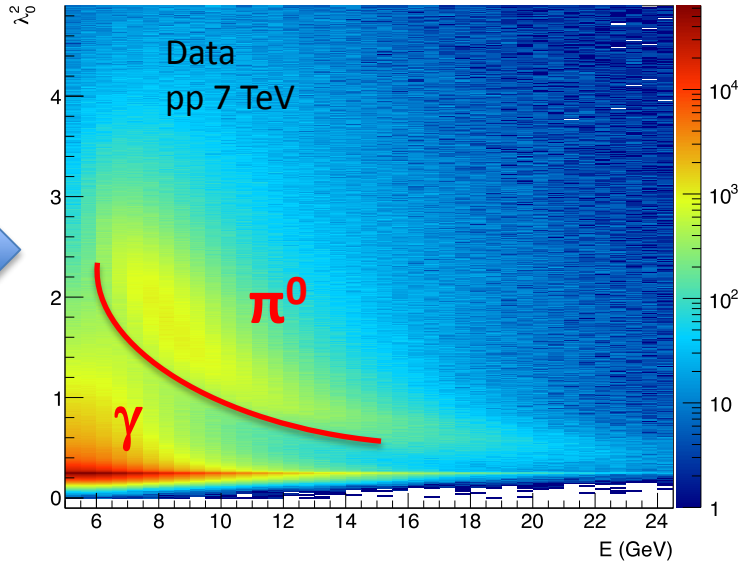
Photon Identification : Shower shape

Shower shape :
- clusters ⇔ ellipse
- λ_0,λ_1 ⇔ ellipse axis weighted by the cells energy distribution



See formulae in back-up

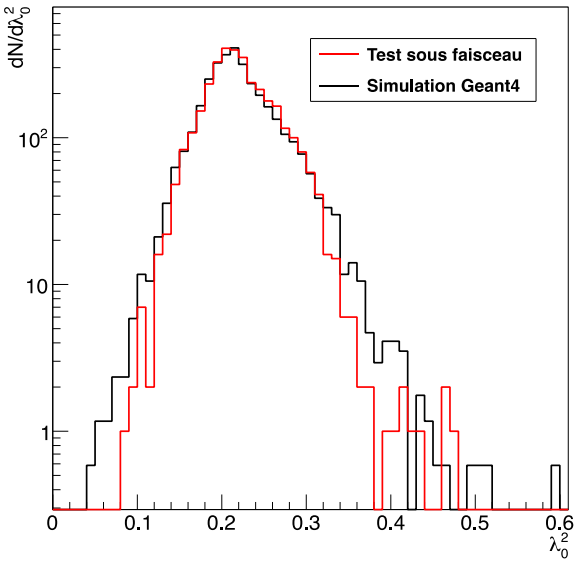




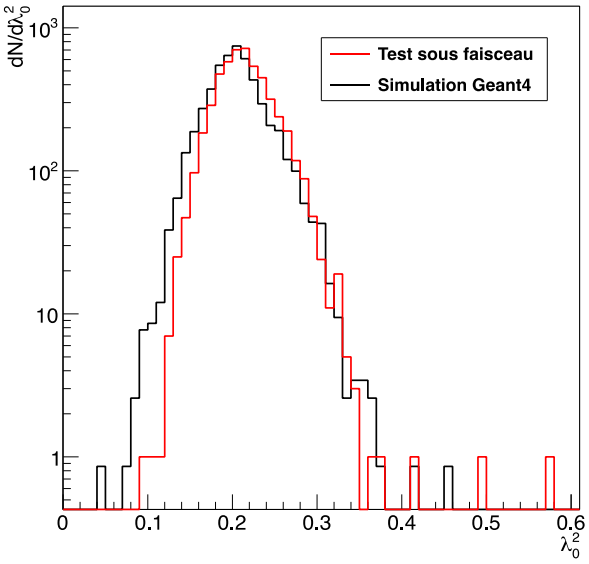
Shower shape: Beam test vs MC

- Beam test with electrons ⇔ shower shape
- Difference data/Monte Carlo from 6 GeV, increase with energy

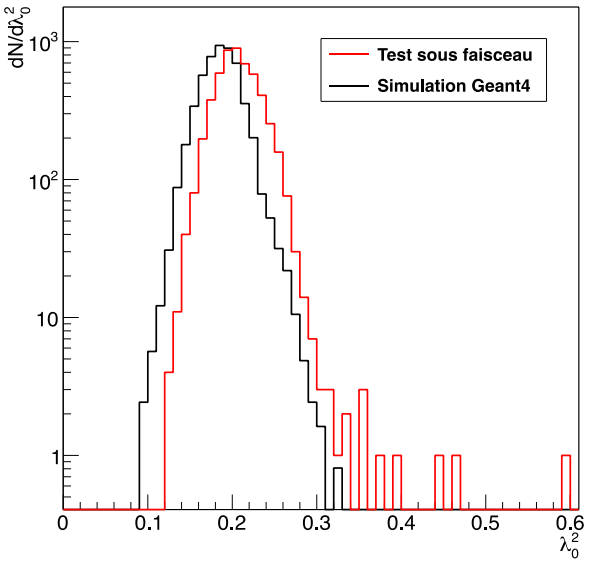
Electrons 6 GeV



Electrons 10 GeV



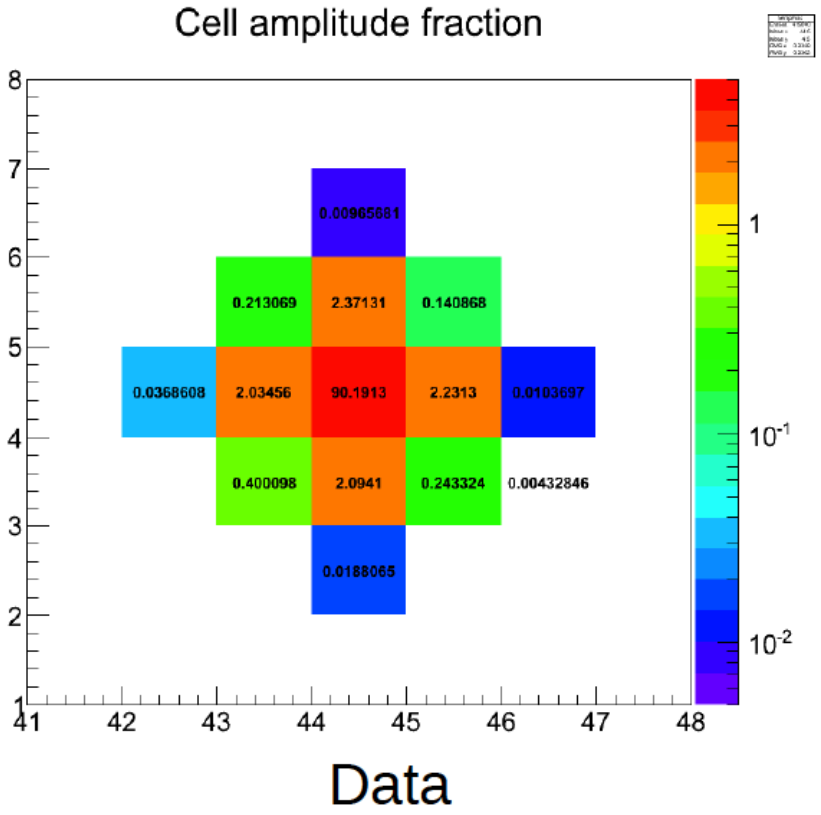
Electrons 25 GeV

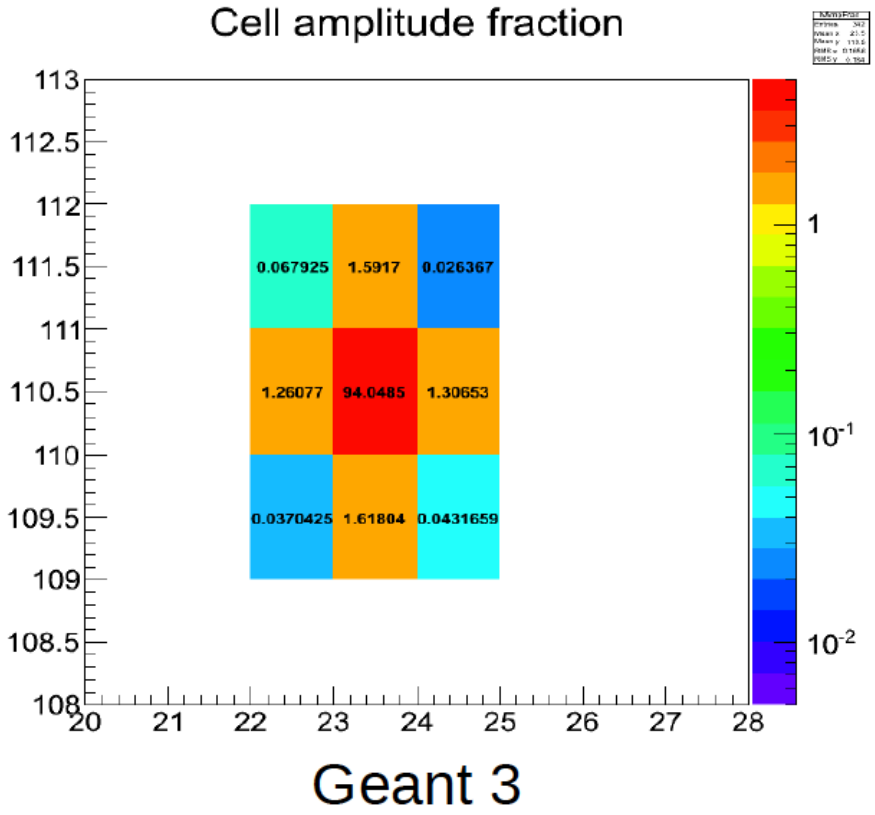


MC studies

- Problem in the EM GEANT simulation?
- Many things can affect: Physical processes, energy cuts, fluctuations, reconstruction biases …

Shower shape: How different are showers

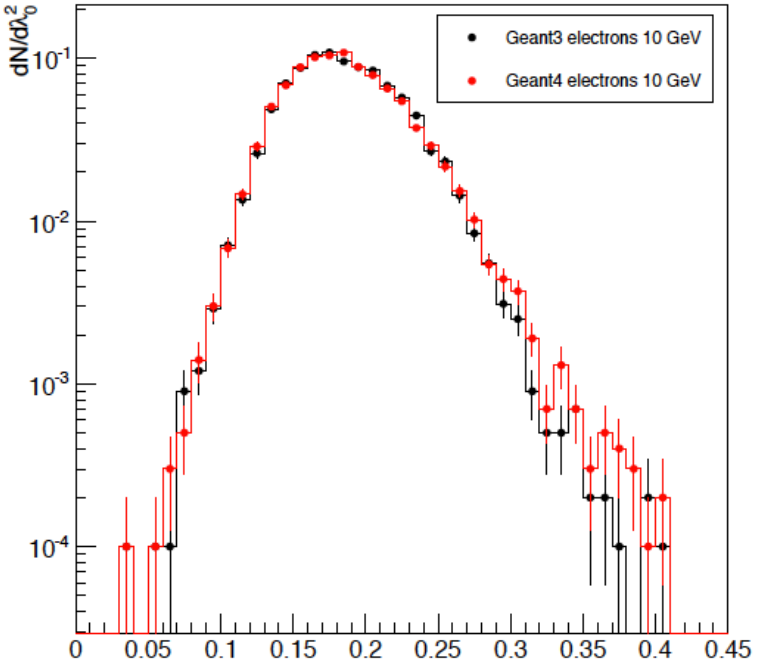




Clusters have few more cells on average and energy is a bit more spread in data compared to MC

Is the Geant transport cuts removing too much energy? Is the shower cut too soon? Is the tower Molière radius properly considered?

Shower shape: MC, G3 & G4



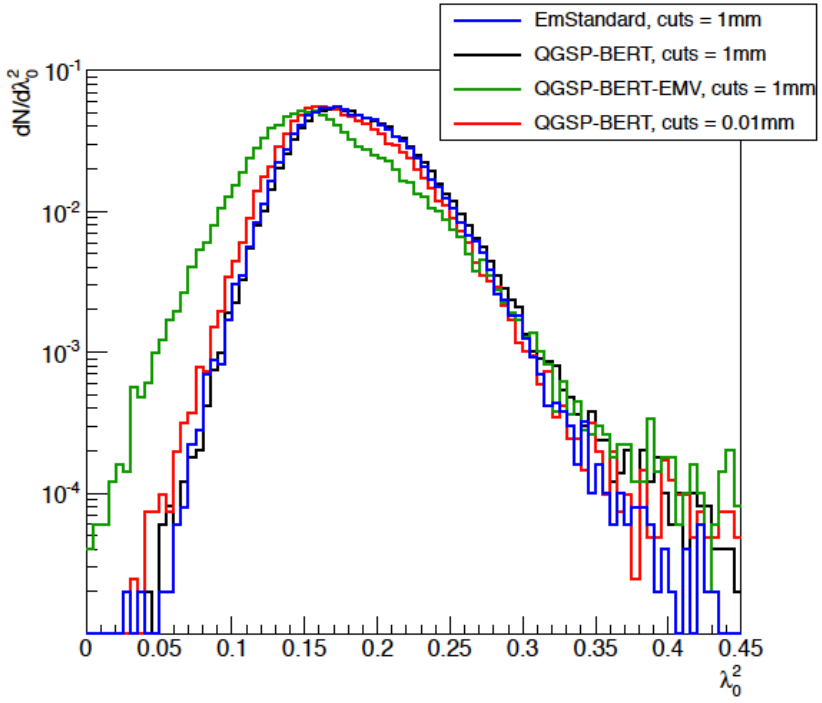
10 GeV electrons

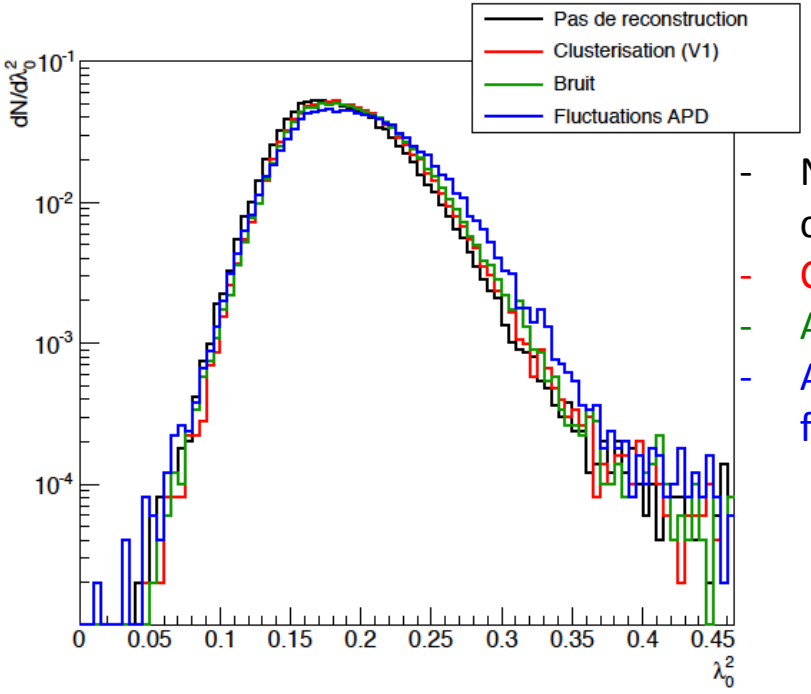
No significant difference in G3 and G4

G4 Physics list can affect,

- EMV list, worse description
- QGSP-BERT, and default have similar performance, maybe a bit more tail, cut =0.01 mm disfavoured vs 1 mm

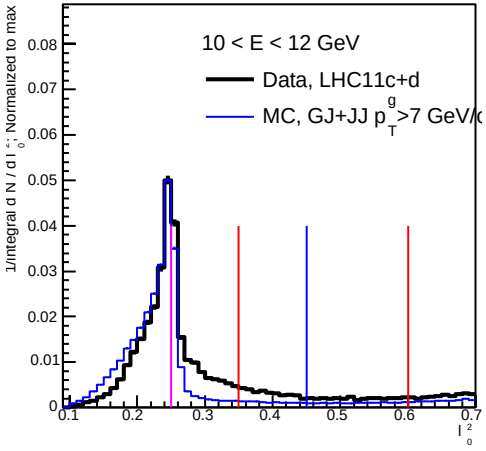
Fluctuations seem to introduce the bias we look for?

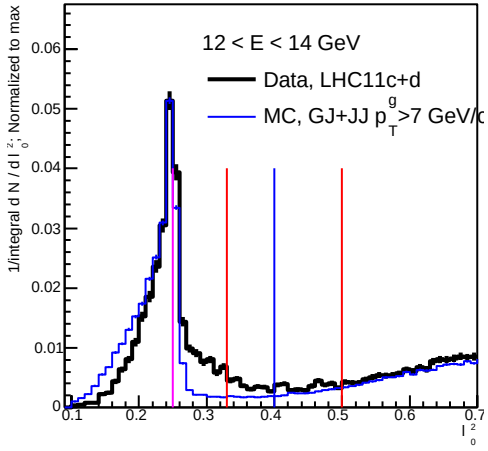


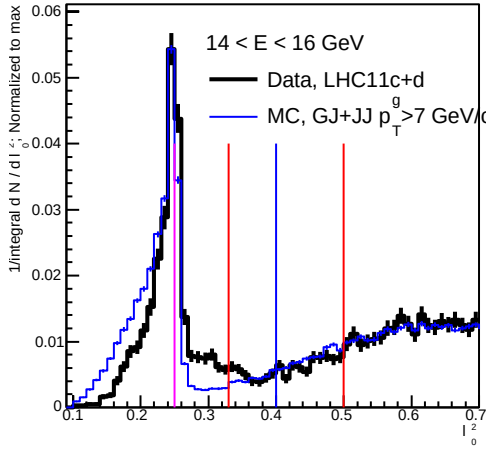


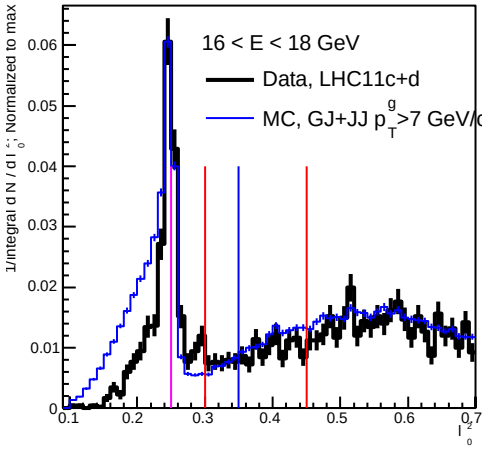
- No reco, add all cells with signal
- Clusterization
- Add noise
- Add APD fluctuations

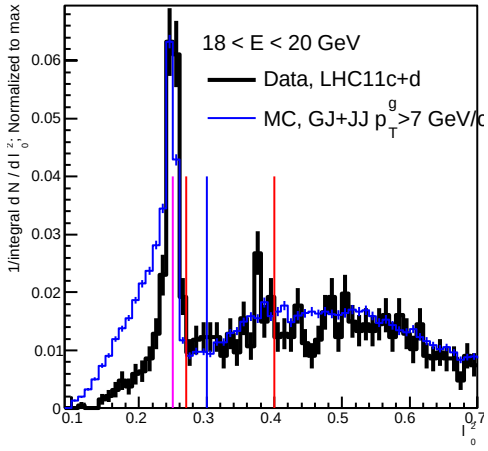
Shower shape in pp@7 TeV

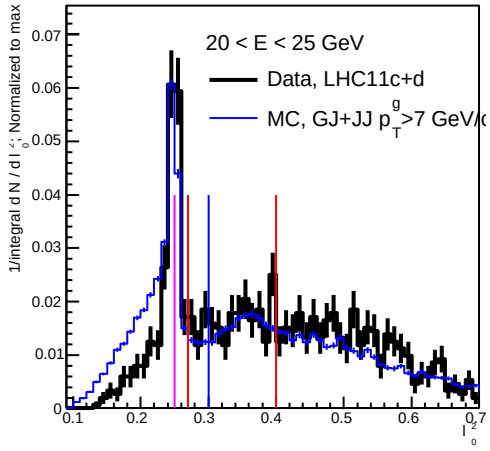


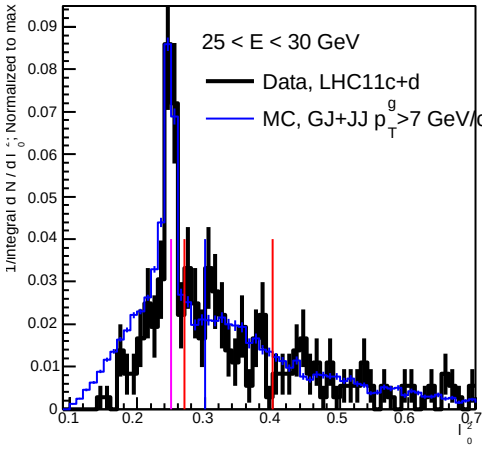


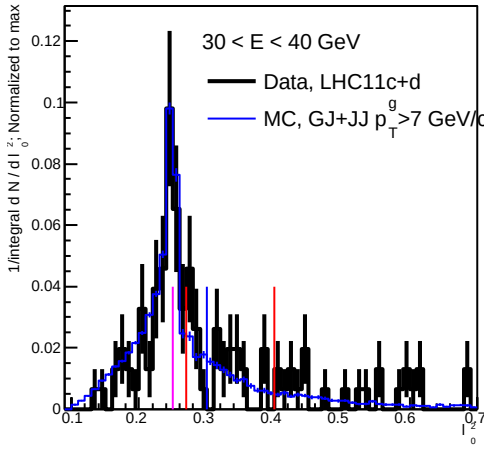


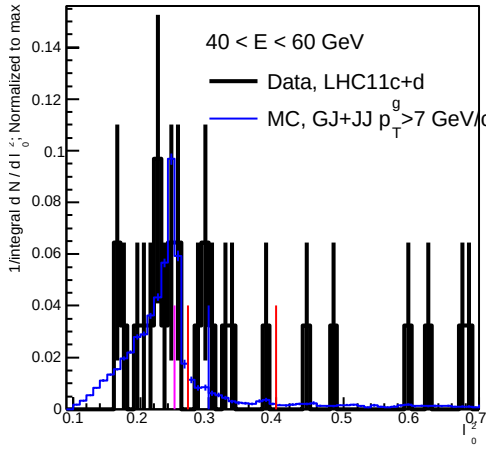












MC: Add Gamma-jet and jet-jet Pythia (jet triggered by decay photon in EMCal acceptance with p_T>7 GeV)

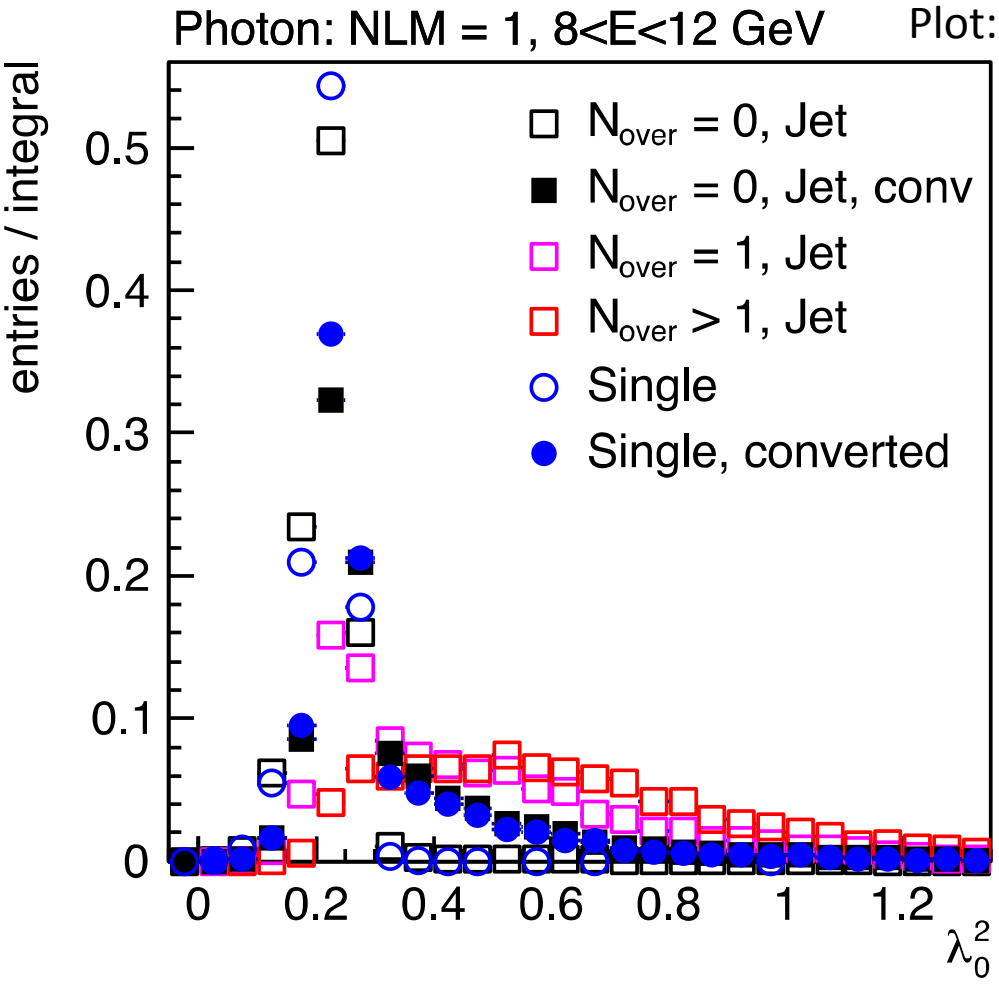
We are forced to select photon clusters in the blue line limit to properly calculate efficiency

Not quite the same Distributions as in beam test.
Similar effect anyhow.

Photon region seems more affected than pi0 region.

Photon conversion, particle overlaps

- Probability that a photon hits some material and converts ~ 50% (in MC)
- At high E the e+e- are too close and form a single cluster, effect on shower shape



Plot: Clusters with photon as main contributor
- N_over: Number of other particles in cluster

Squares Jet-Jet triggered MC, pp@7TeV

Bullets: Single photon simulations

In reality:
Do we have more material?
Is hadron response under control?

These contributions and beam test discrepancies could go together?

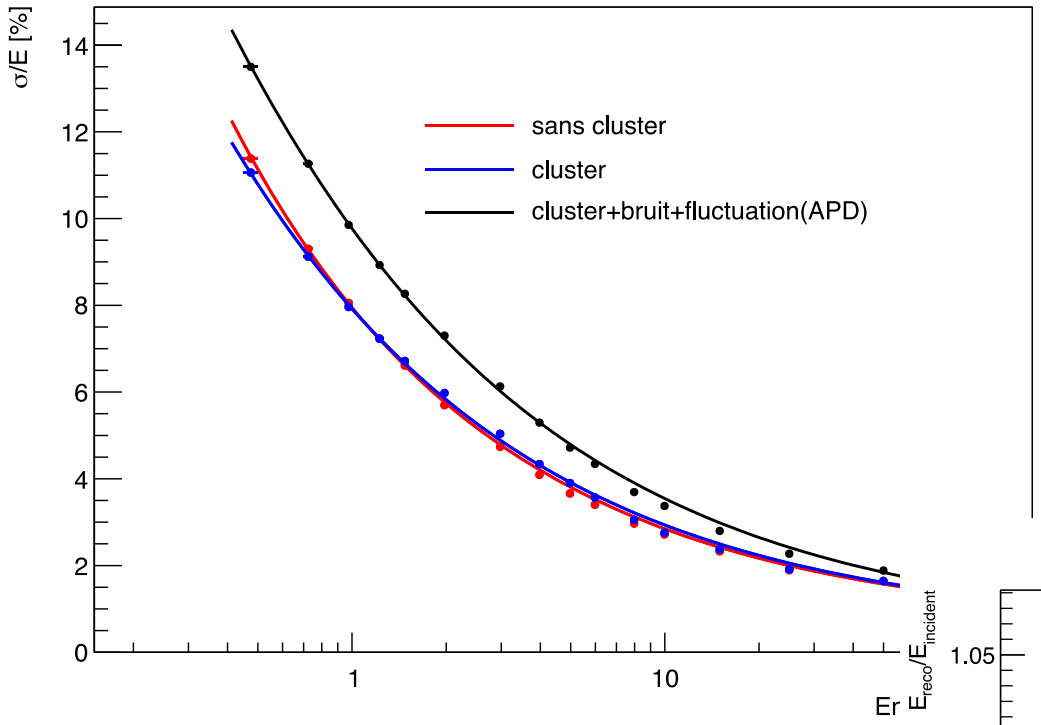
Is beam test contaminated by hadrons and not rejected properly?

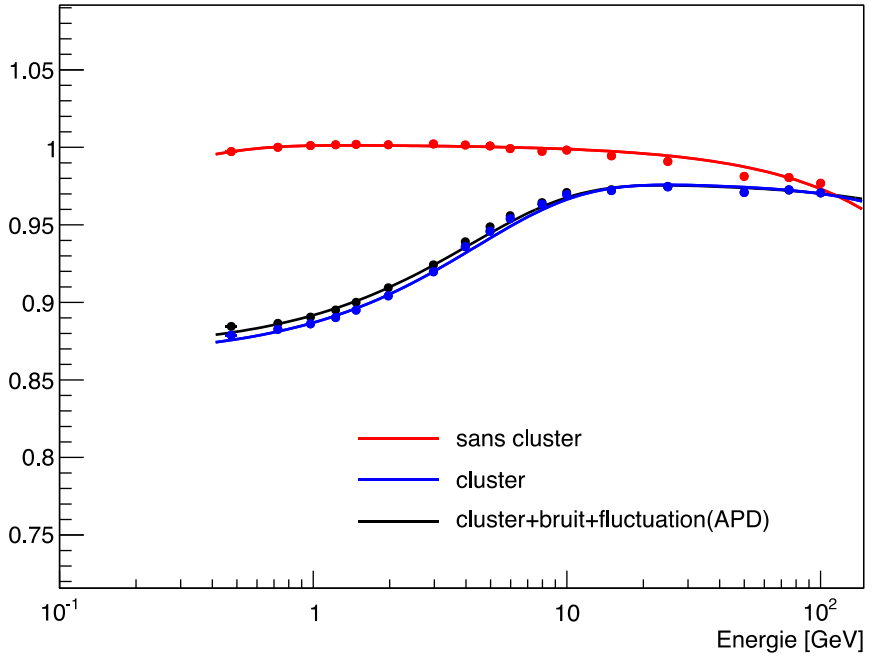
Summary

- A discrepancy in shower shape distributions and non linearity is observed in data and MC
  - Both in pp data and beam test, although discrepancies are not the same
- No clear origin, going to G4 does not seem to solve the discrepancy
- Possible effects that could contribute
  - APD gain fluctuations
  - Material conversions
  - Hadronique response of the calorimeter
  - Geant settings?
  - …
- Aim to set a task force but
  - The usual man power issue
  - Need some fresh ideas to test
  - Any input is welcome

Back-up

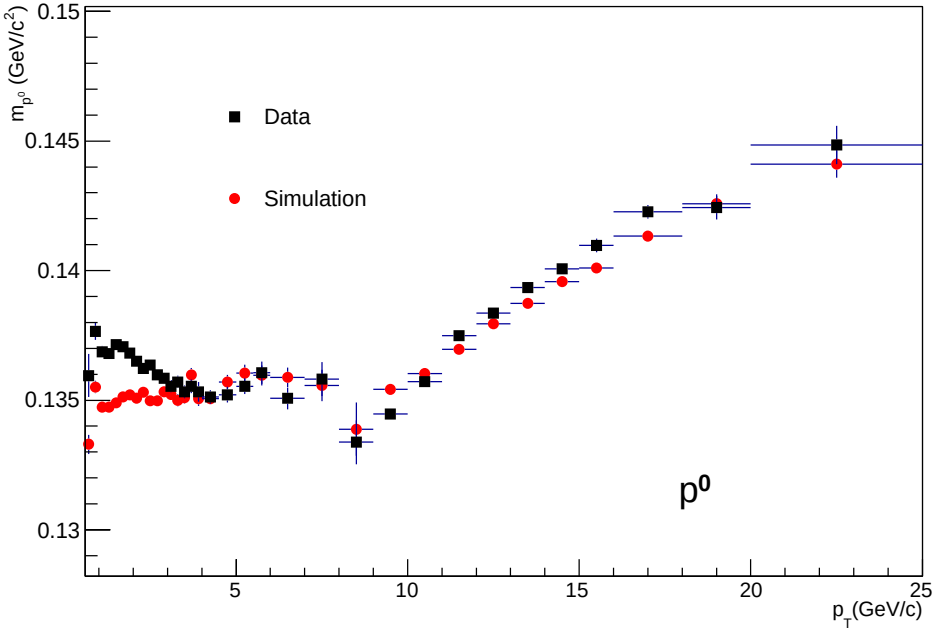
Detector performance in MC: effect of clusterization/noise/fluctuations



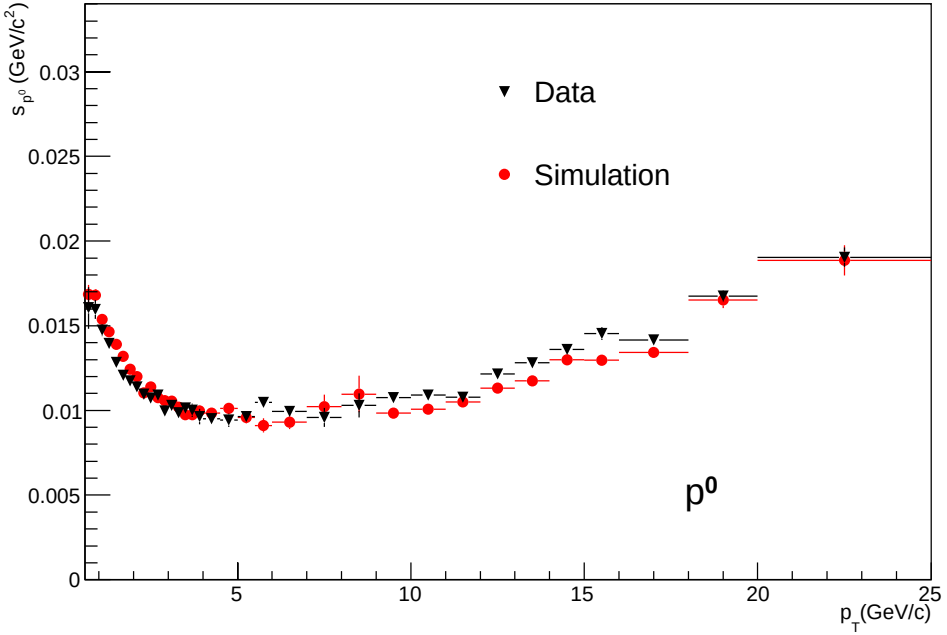


Detector performance: pi0 mass and width

Mass



Width



Shower shape: Beam test vs MC

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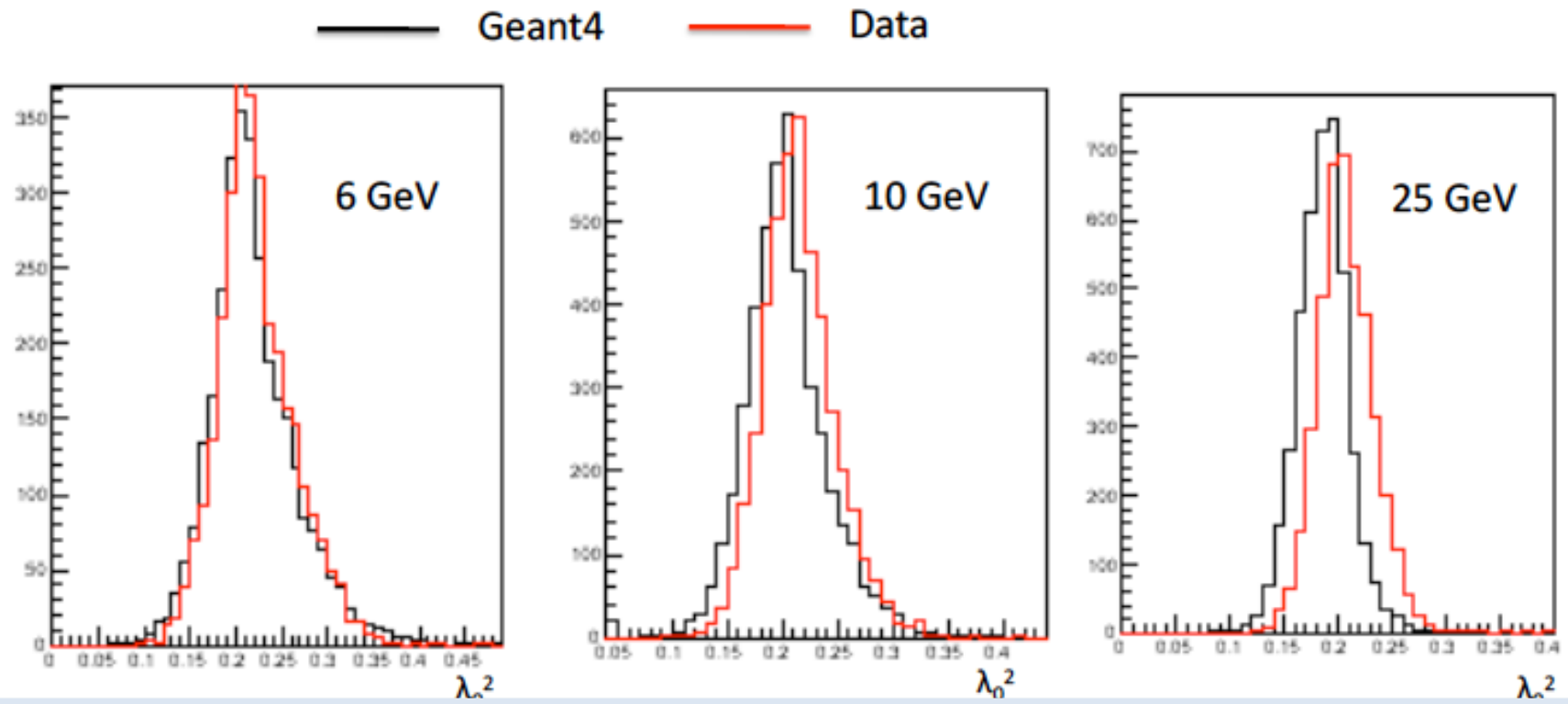
- Difference data/Monte Carlo from 6 GeV, increase with energy



MC studies

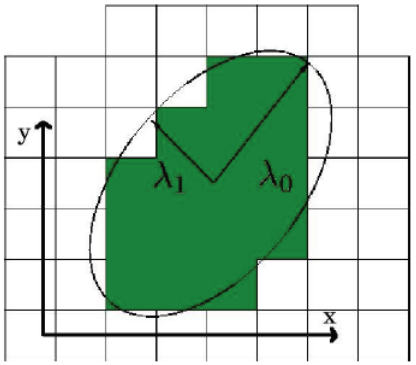
- Problem in the EM GEANT simulation?
- Many things can affect: Physical processes, energy cuts, fluctuations, reconstruction biases …

Shower shape : λ_0, λ_1

- Matrix eigen-values (cluster) :

$$\lambda_0^2 = 0.5*(d_{xx} + d_{zz}) + \sqrt{(0.25*(d_{xx} - d_{zz})^2 + d_{xz}^2}$$

$$\lambda_1^2 = 0.5*(d_{xx} + d_{zz}) - \sqrt{(0.25*(d_{xx} - d_{zz})^2 + d_{xz}^2}$$



with d_{xx}, d_{zz} and d_{xz} weighted by the tower energy

$$d_{xx} = \sum_i \frac{w_i}{w_{tot}} (col_{cell(i)})^2 - (\sum_i \frac{w_i}{w_{tot}} (col_{cell(i)}))^2$$

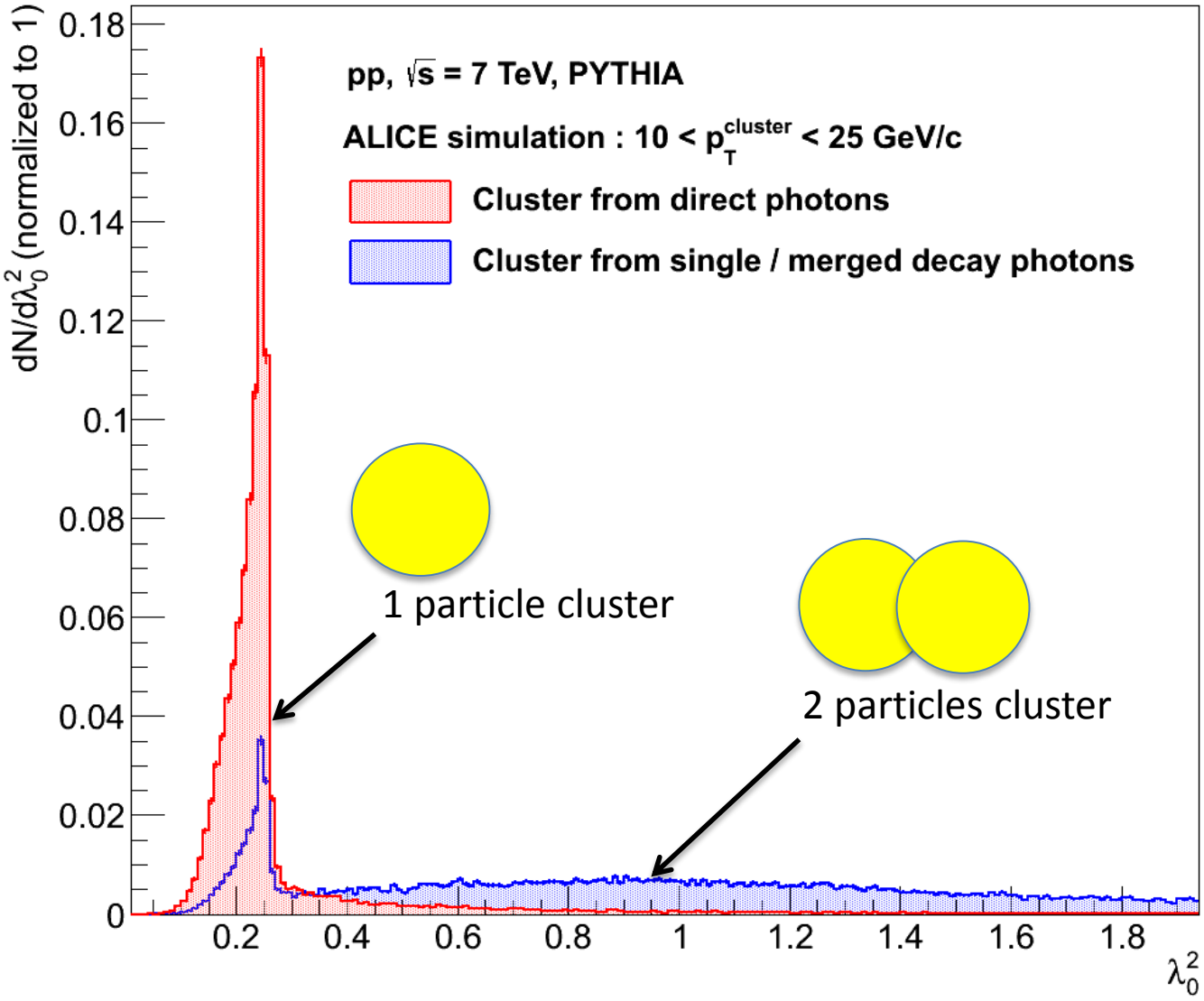
$$d_{zz} = \sum_i \frac{w_i}{w_{tot}} (row_{cell(i)})^2 - (\sum_i \frac{w_i}{w_{tot}} (row_{cell(i)}))^2$$

$$d_{xz} = \sum_i \frac{w_i}{w_{tot}} [(row_{cell(i)})(col_{cell(i)})] - \sum_i \frac{w_i}{w_{tot}} (col_{cell(i)}) * \sum_i \frac{w_i}{w_{tot}} (row_{cell(i)})$$

$$w = TMath::Max(0., w0 + \log(E_{cell} / E_{cluster}))$$

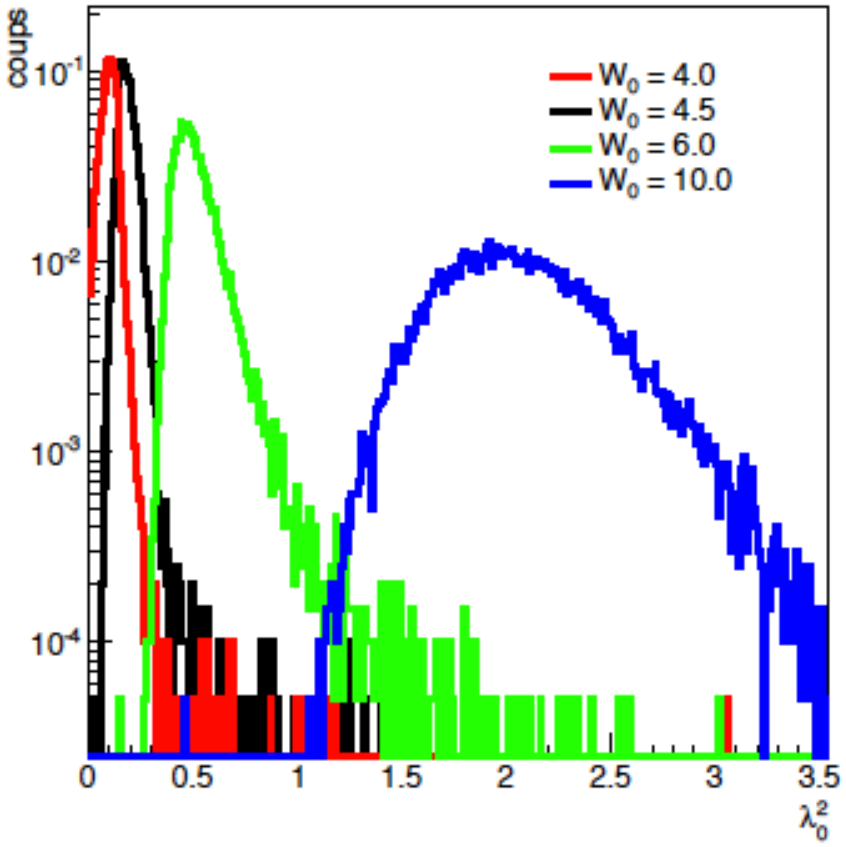
$$w_{tot} = \sum_i w_i \ , \ w0 = 4.5$$

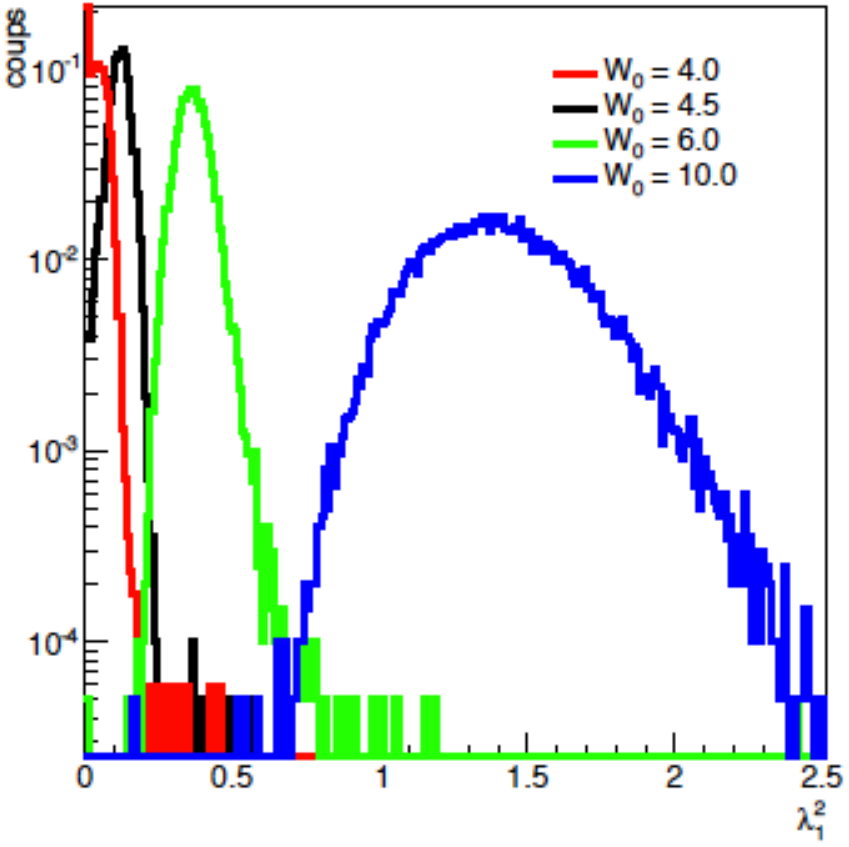
Shower shape: λ_0



Shower shape: λ_0 ,$\lambda_1$vs w_0

10 GeV photon, Geant 4





Parametrize *w0* in simulation to match data?

Shower shape: λ_0 ,λ_1 for photons, electrons, charged pions

10 GeV, Geant 4