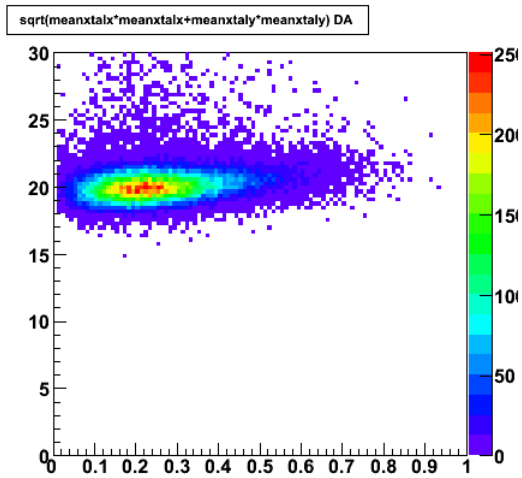
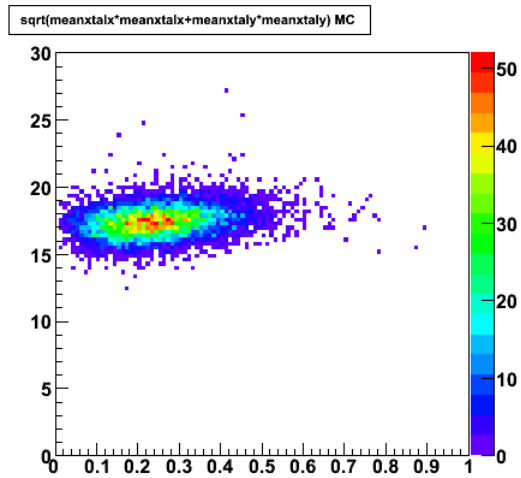
Transverse size analysis of electrons showers

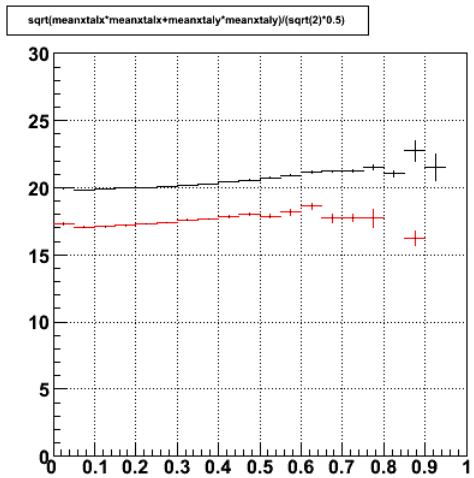
- CalTransRms definition
- Transverse size estimation
- Transverse and longitudinal position measurement

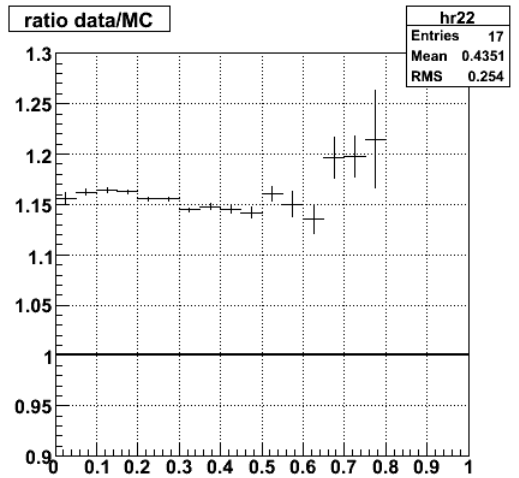
CalTransRms discrepancy (reminder)

- 100 GeV on-axis
- X-axis :
  - 0 = center of xtal
  - 1 = between 2 xtals
- CalTransRms is 15% larger than in MC









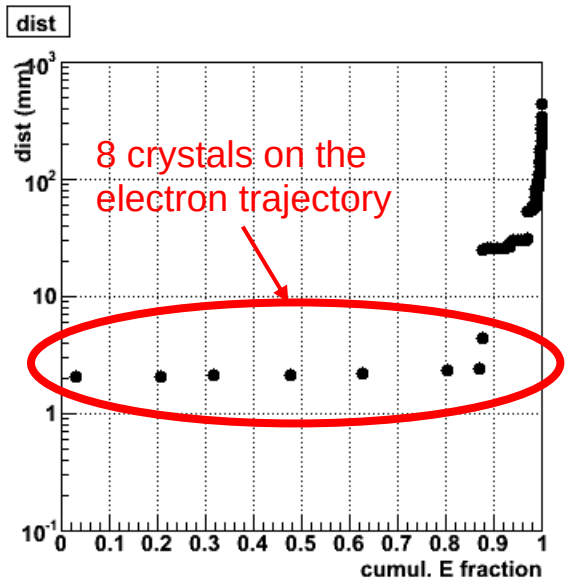
CalTransRms definition

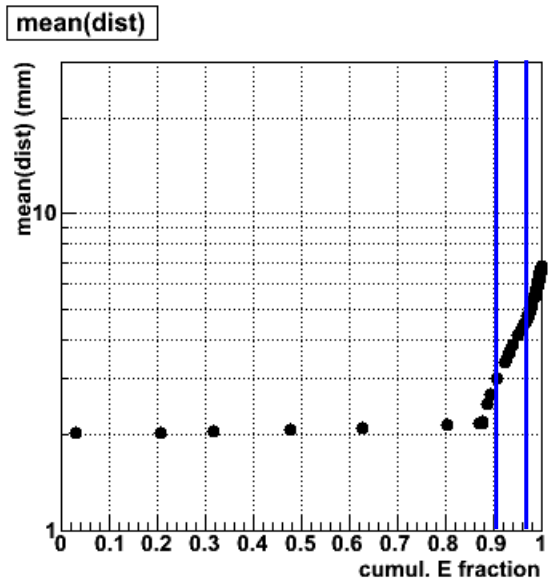
- Inertia tensor : when calculated in the referential defined by the principal axis, the inertia tensor is diagonal and the 3 moments of inertia are :
  - $Ixx = \int(y^2+z^2)\, dm\, dxdydz$
  - $Iyy = \int(x^2+z^2)\, dm\, dxdydz$
  - $Izz = \int(x^2+y^2)\, dm\, dxdydz$
- CalMomentsAnalysis determines, using m=E :
  - the centroid
  - the principal axis (z gives the shower axis, thus the particle direction)
  - the 3 moments : CalTransRms = sqrt(Izz/E)
- It is an iterative procedure during which the more distant crystals are discarded : if distance to axis is greater than CalTransRms x scalefactor (=1.5 in first iteration, 3, 6, 12…)
- CalTransRms is then recalculated with final centroid and with all crystals

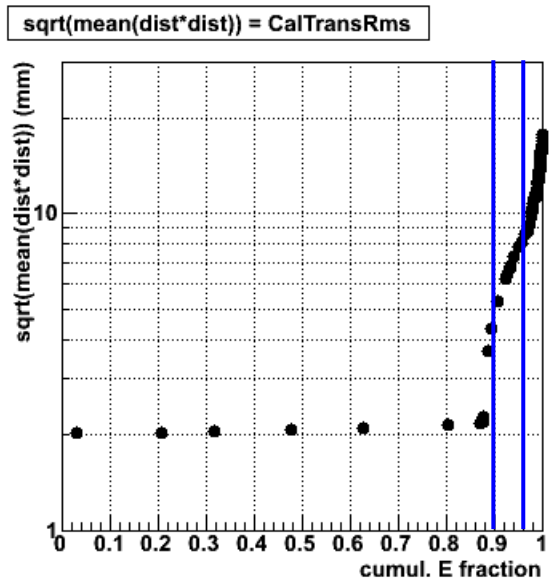
Transverse size estimation

- I wanted to see how sensitive we are to the edges of the shower
- I've used the Tkr1 direction instead of Cal direction
- Sort the crystals in increasing distance to the first track
- For crystal i, Efrac[i] = (E[0]+E[1]+…+E[i])/CalEnergyRaw
- Estimate the transverse size at Efrac= 0.9 or 0.95 or 0.99

One event from run 1981 (100 GeV, on-axis) :



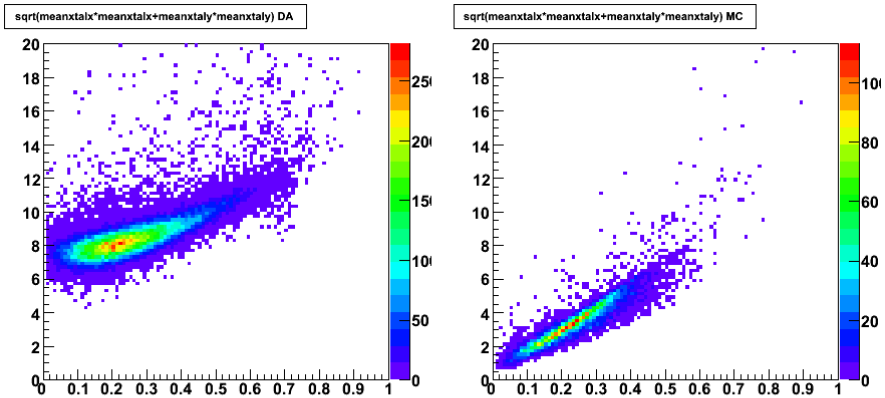


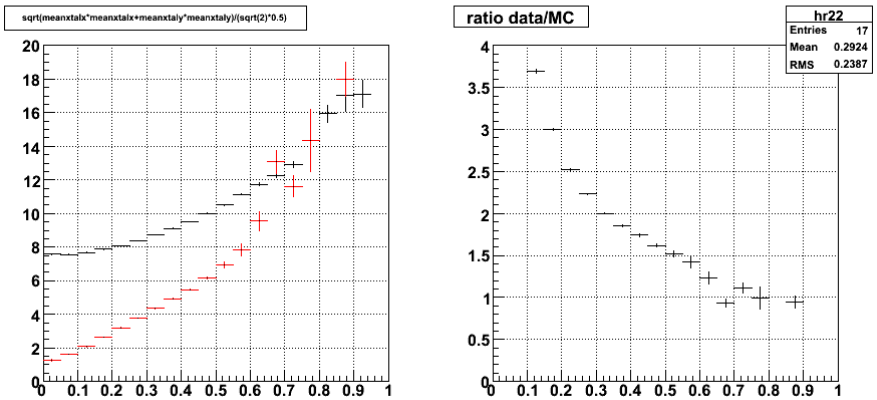


Transverse size estimation

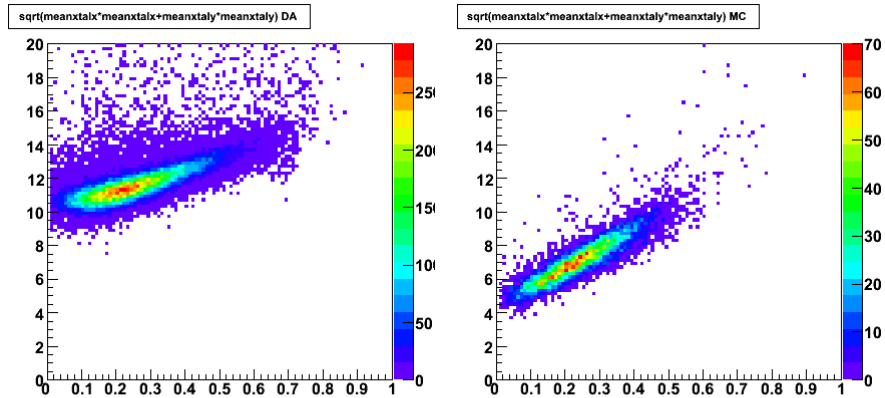
- X-axis : 0 = center of crystal, 1 = between two crystals
- **100 GeV on-axis (7001981)**

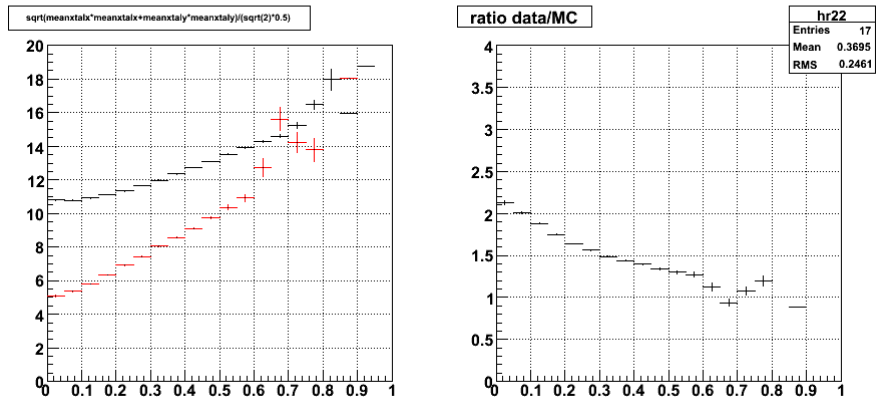
Mean dist at Efrac=0.9





Mean dist at Efrac=0.99





Transverse size estimation

- The discrepancy between data and MC is larger than for CalTransRms !
- The discrepancy is larger at Efrac=0.9 than at Efrac=0.99
- So the problem does not come only from the edge of the shower but mainly comes from the core of the shower !
- So let's separate the two position measurements given by the crystal :
  - Longitudinal position (given by E_left/E_right)
  - Transverse position (given by the center of the crystal, independent of E)

5 GeV on-axis electrons

Transverse distance

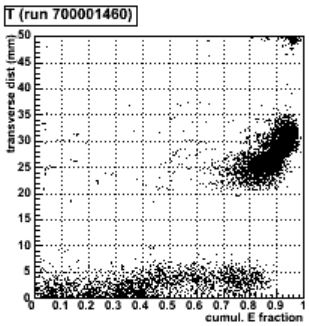
Longitudinal distance

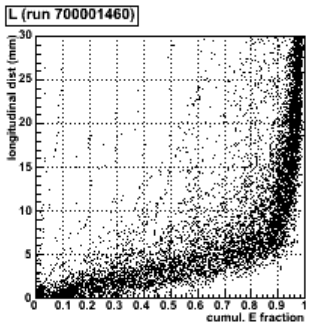
Distance

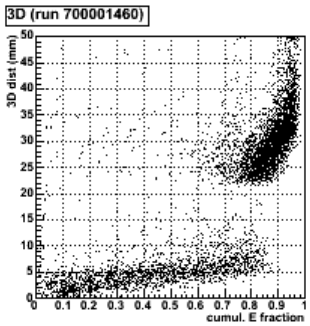
mean distance

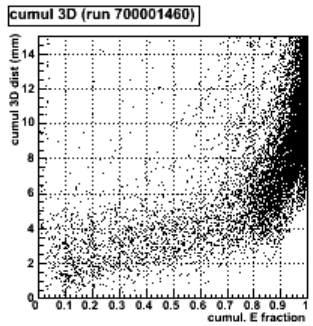
Sqrt(mean dist*dist)

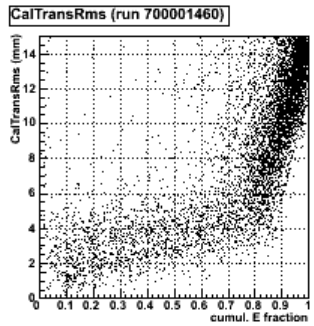
DATA



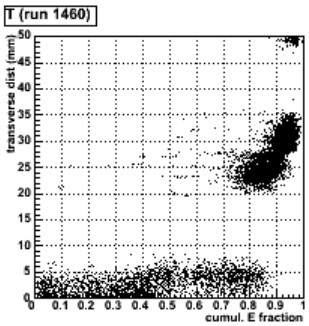


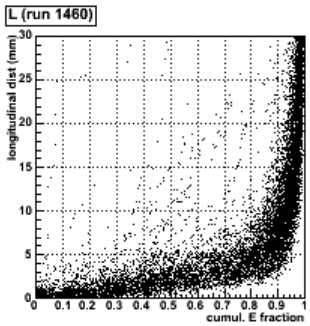


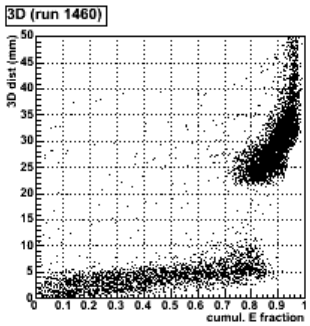


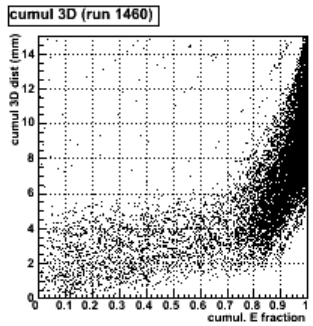


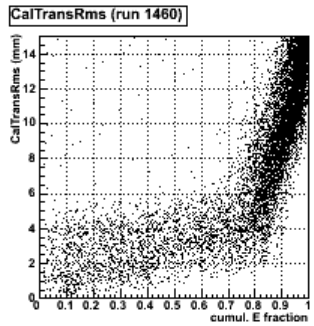
MC









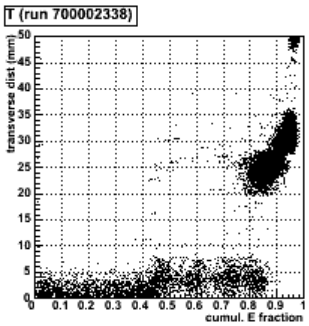


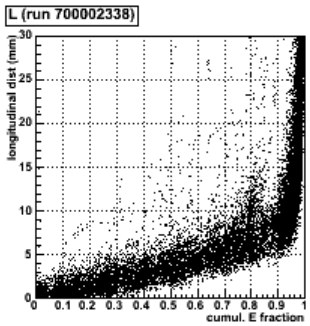
10 GeV on-axis electrons

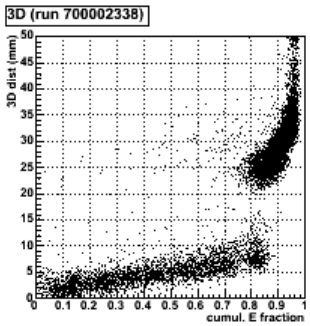
Transverse distance

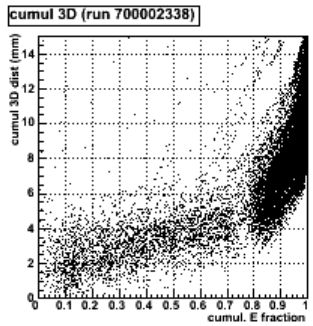
Longitudinal distance

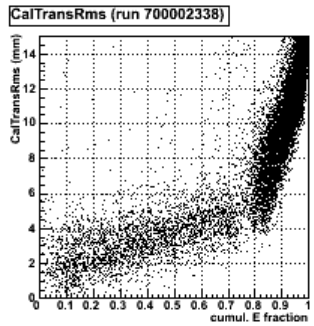
DATA



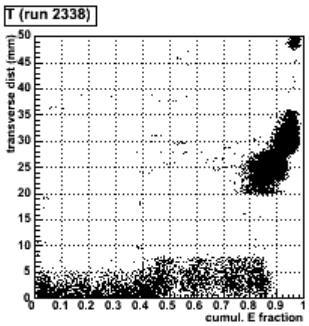


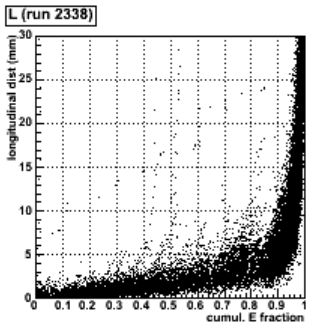


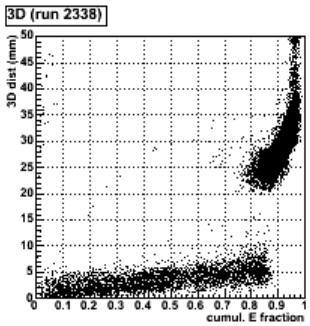


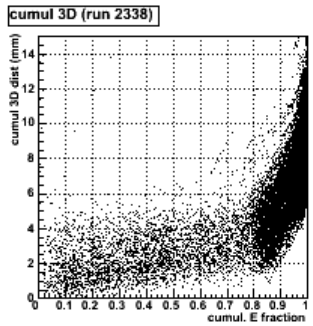


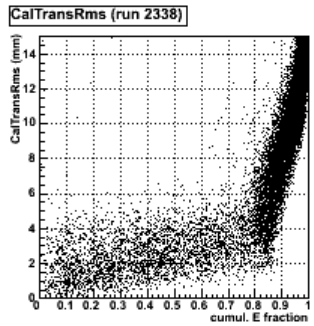
MC









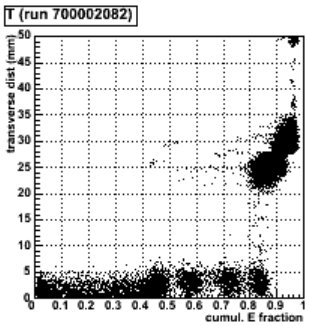


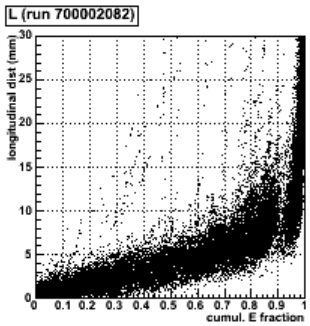
20 GeV on-axis electrons

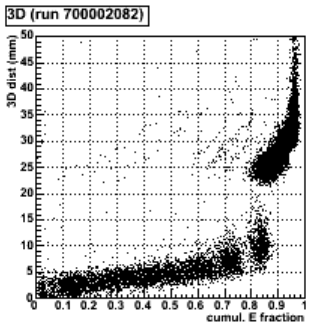
Transverse distance

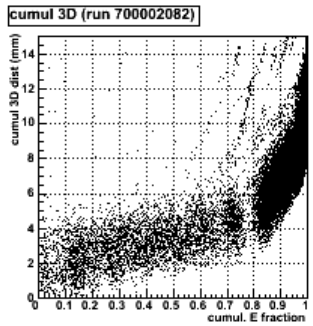
Longitudinal distance

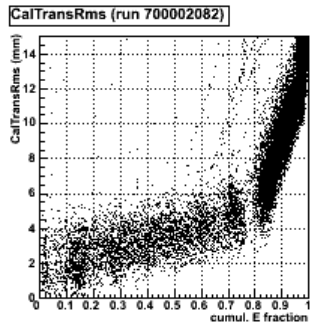
DATA











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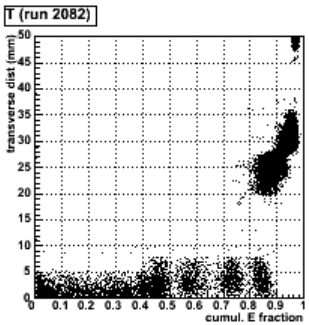
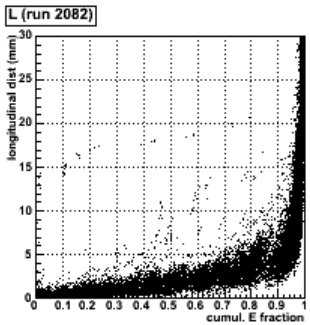
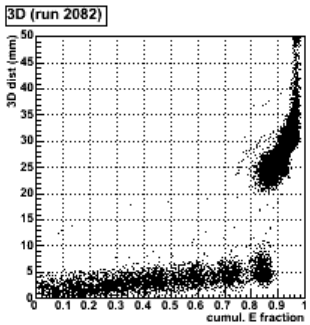
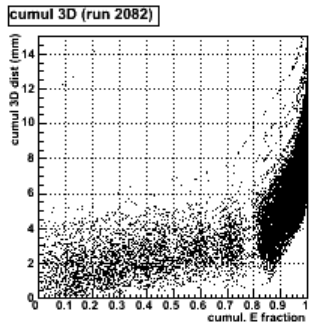
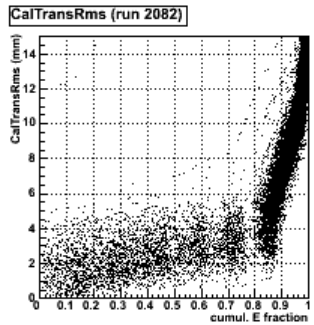








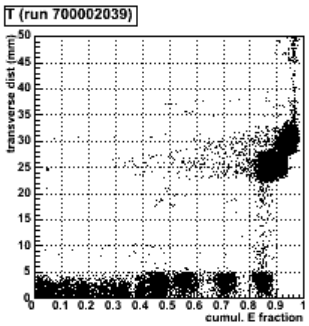


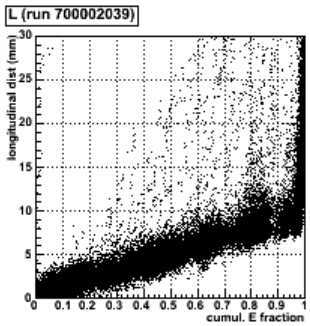
50 GeV on-axis electrons

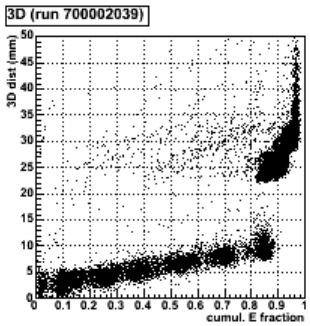
Transverse distance

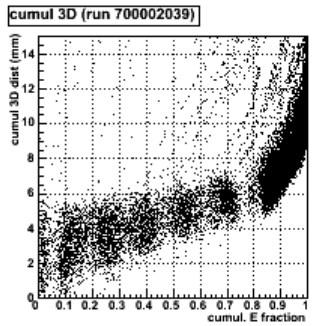
Longitudinal distance

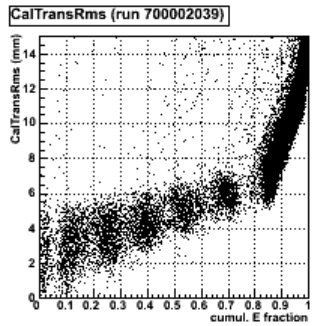
DATA



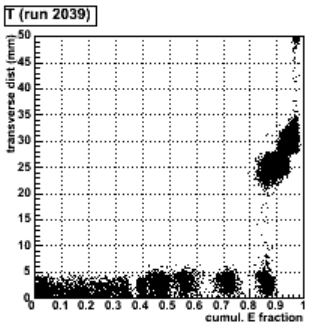


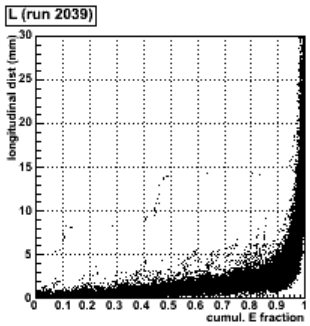


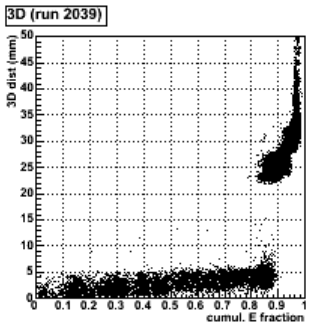


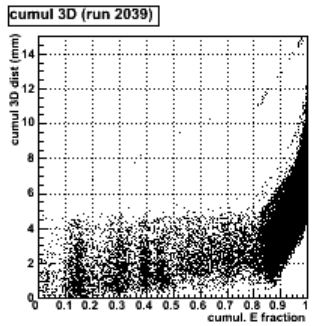


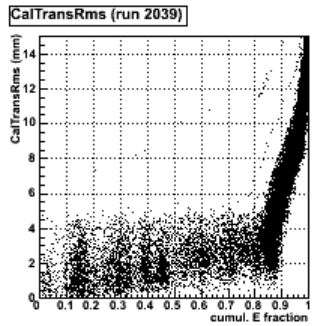
MC









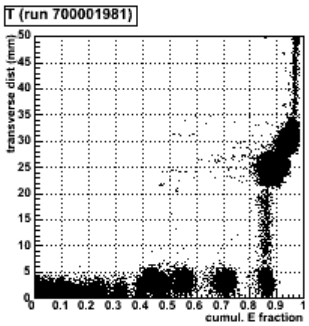


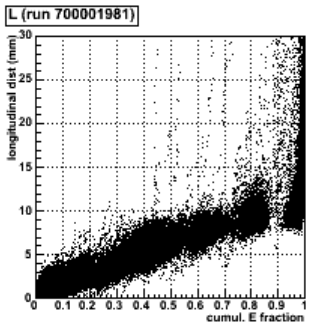
100 GeV on-axis electrons

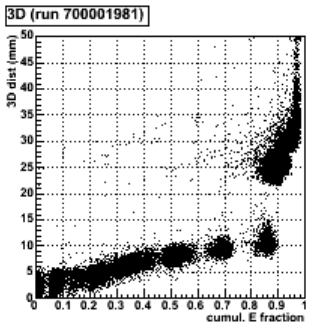
Transverse distance

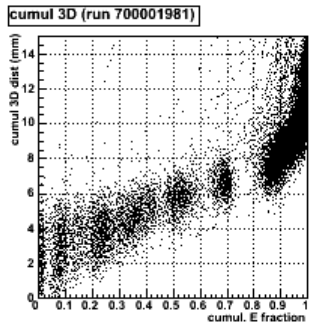
Longitudinal distance

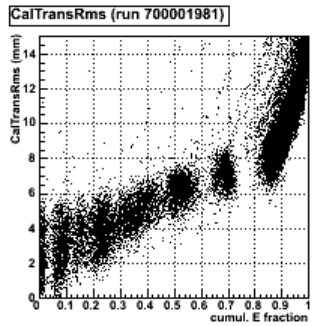
DATA



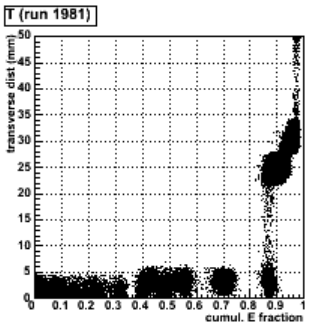


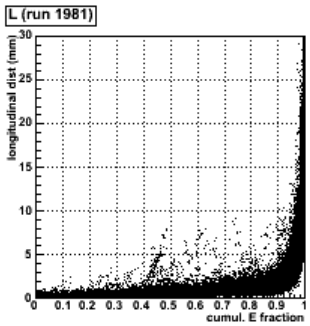


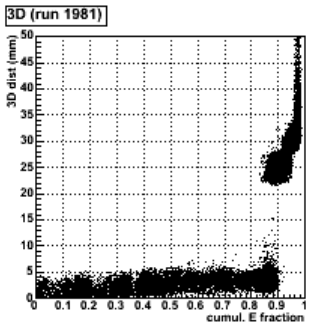


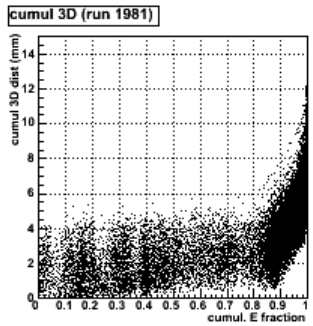


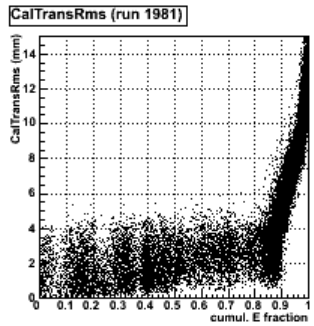
MC









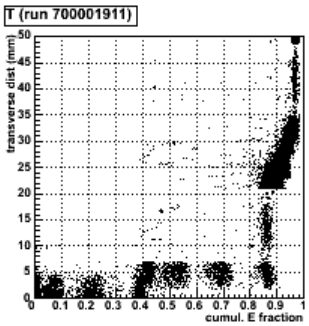


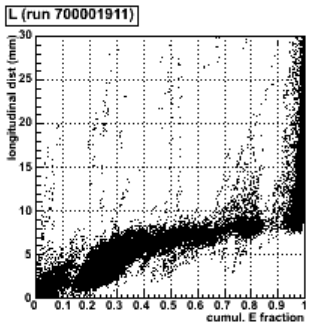
196 GeV on-axis electrons

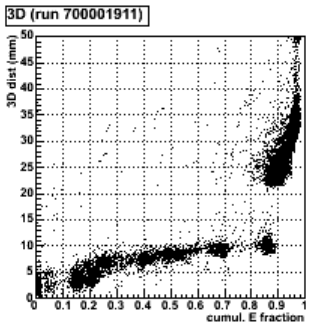
Transverse distance

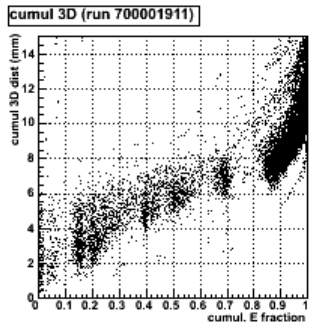
Longitudinal distance

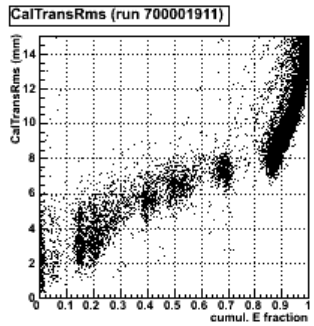
DATA











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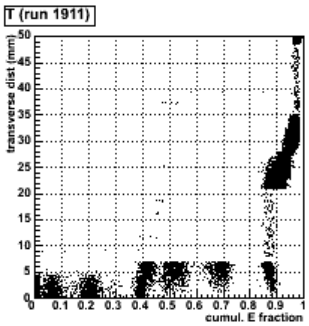
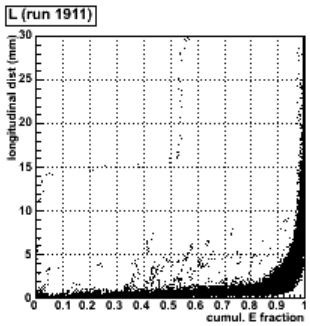
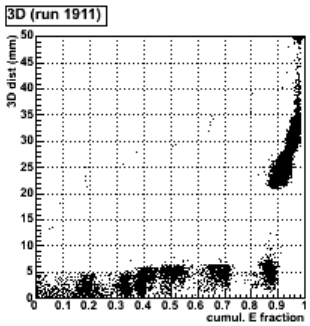
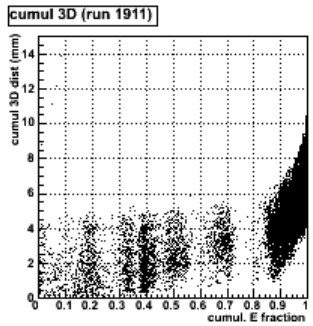
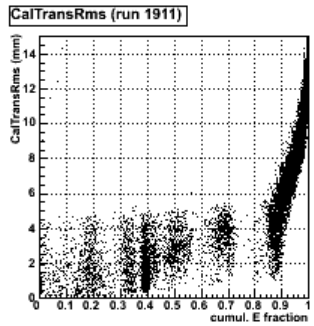








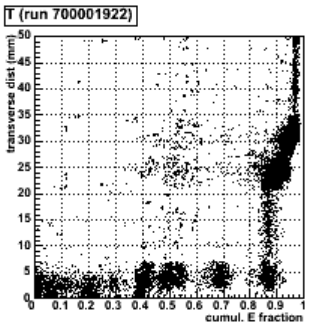


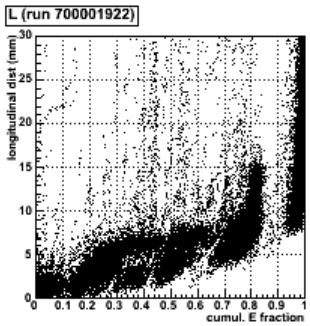
282 GeV on-axis electrons

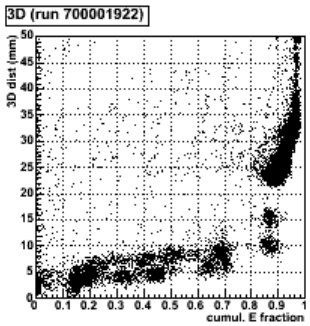
Transverse distance

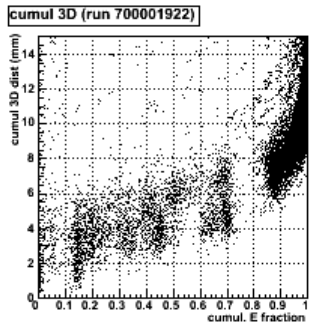
Longitudinal distance

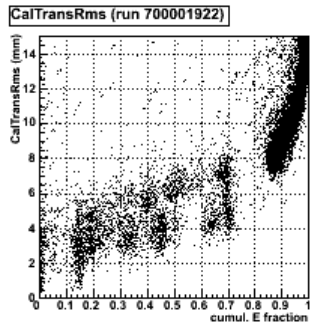
DATA



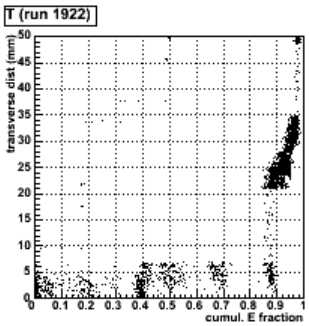


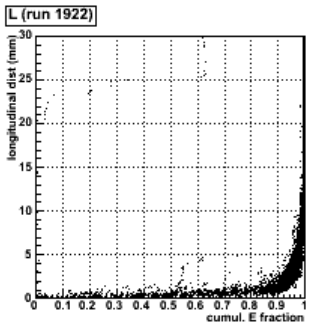


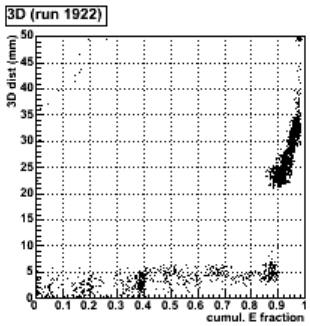


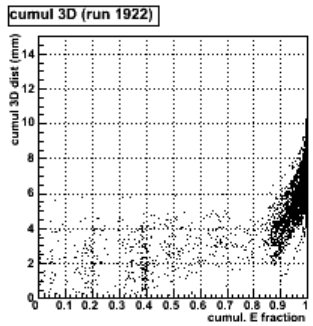


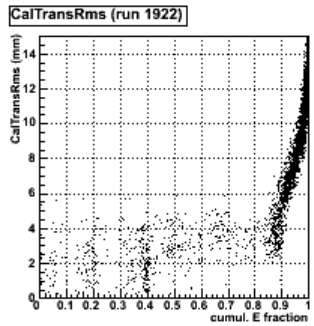
MC











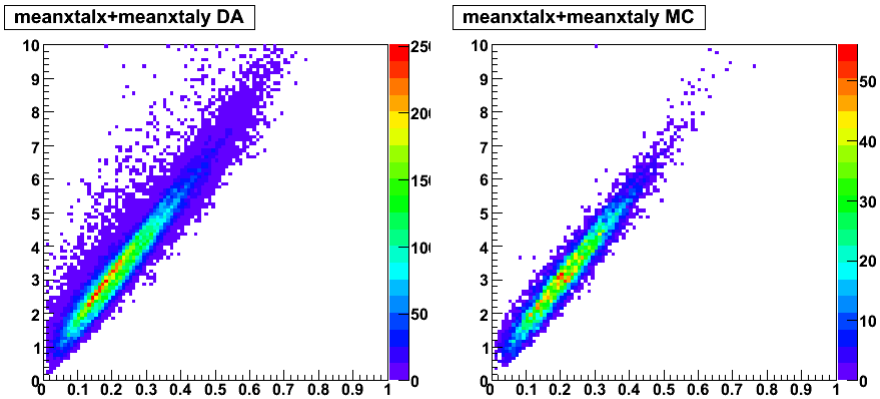
Transverse size estimation

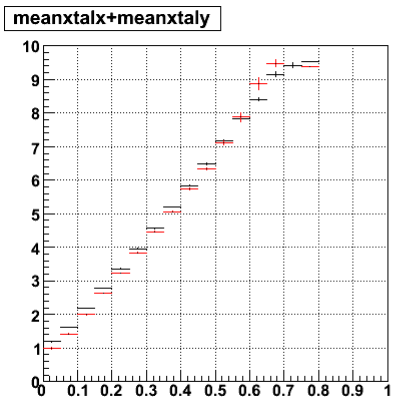
- The main difference comes from the crystal longitudinal position measurements
- The longitudinal distance is larger in the data
- It increases with energy in the data !
- The longitudinal distance in the MC decreases with energy : the longitudinal position precision increases with energy as one would expect
- Let's estimate the transverse size of the showers using only the transverse position measurement

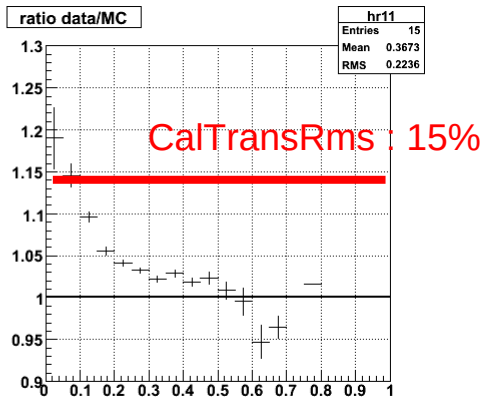
100 GeV on-axis

- X-axis : 0 = center of crystal, 1 = between two crystals

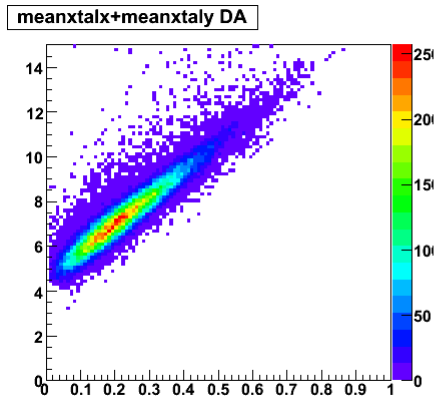
Mean dist at Efrac=0.9

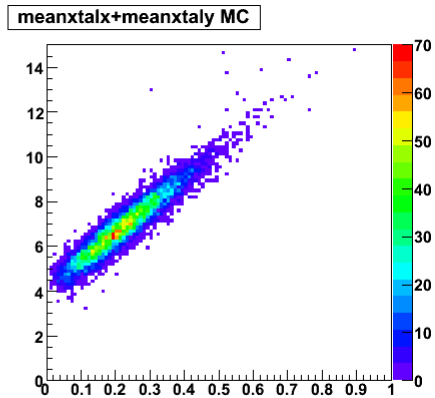


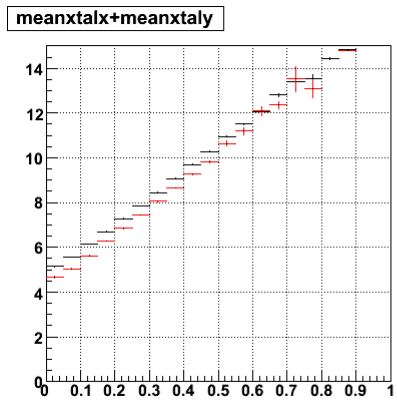


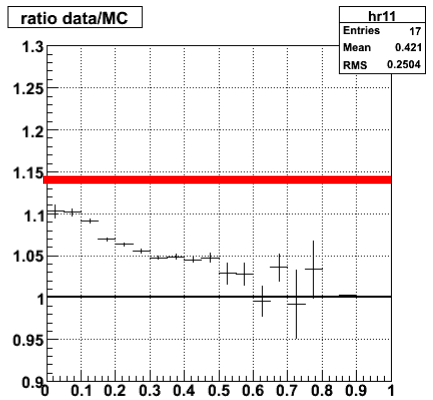


Mean dist at Efrac=0.99





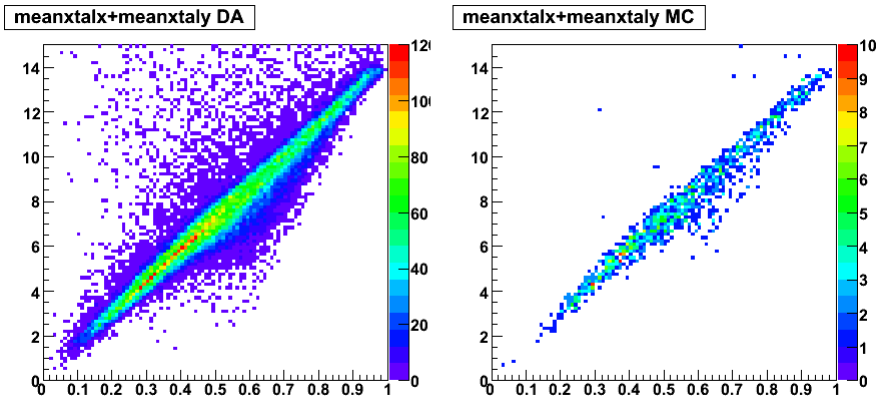


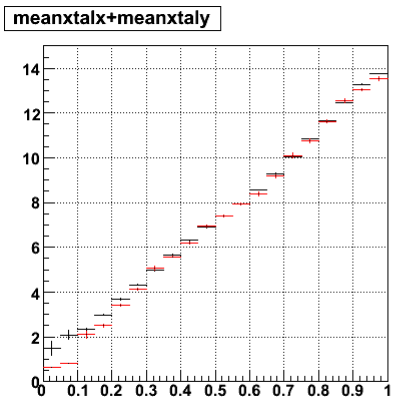


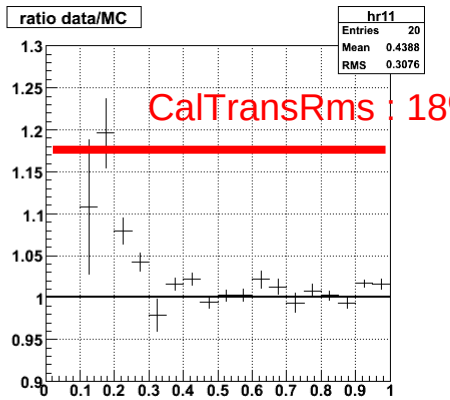
282 GeV on-axis

- X-axis : 0 = center of crystal, 1 = between two crystals

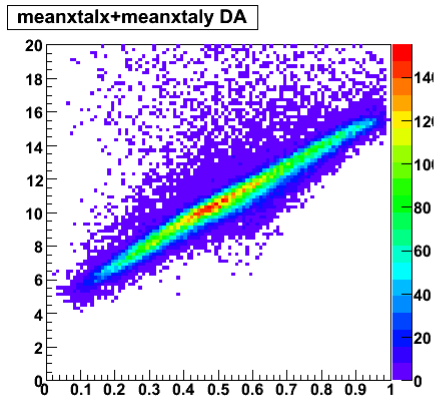
Mean dist at Efrac=0.9

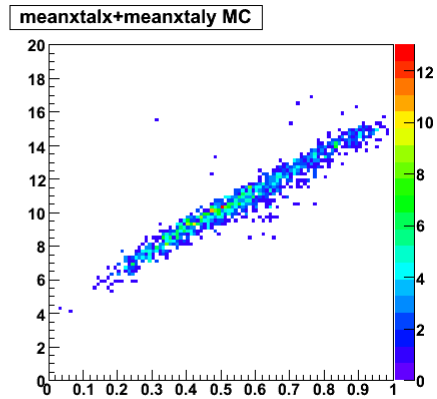


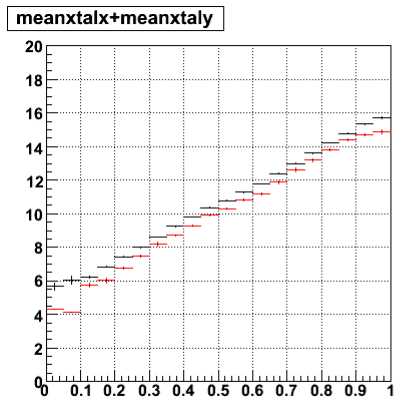


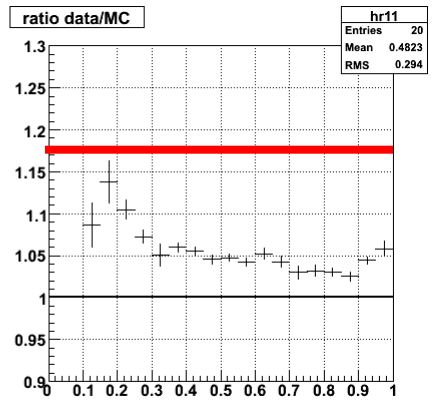


Mean dist at Efrac=0.99





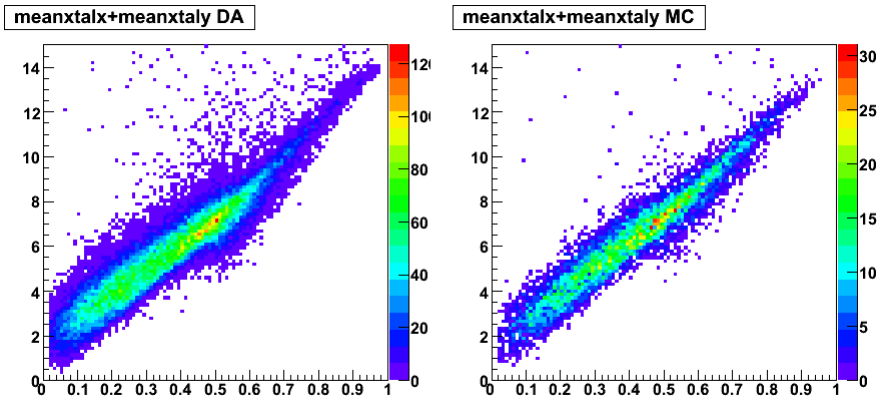


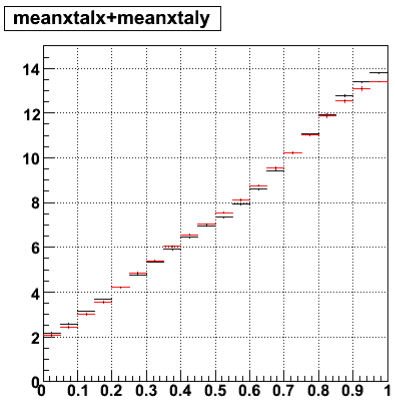


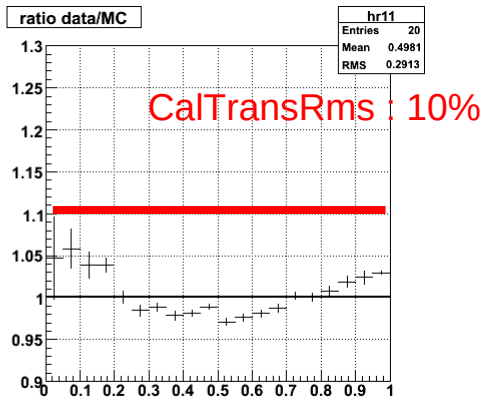
20 GeV on-axis

- X-axis : 0 = center of crystal, 1 = between two crystals

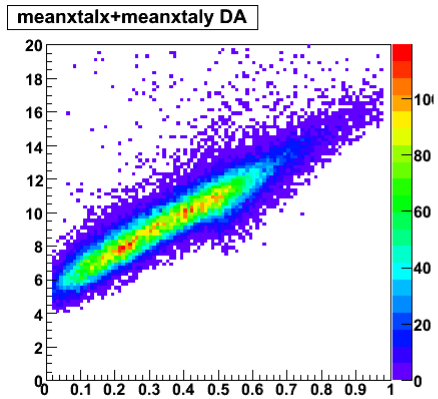
Mean dist at Efrac=0.9

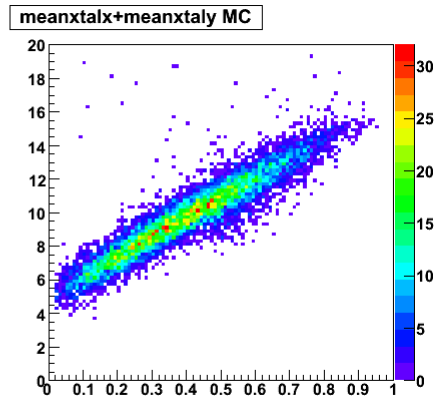


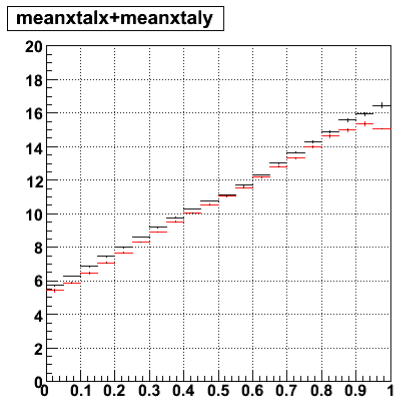


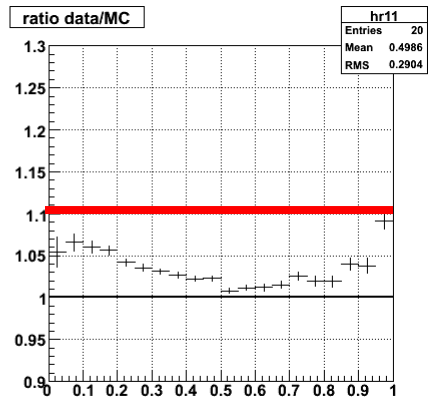


Mean dist at Efrac=0.99





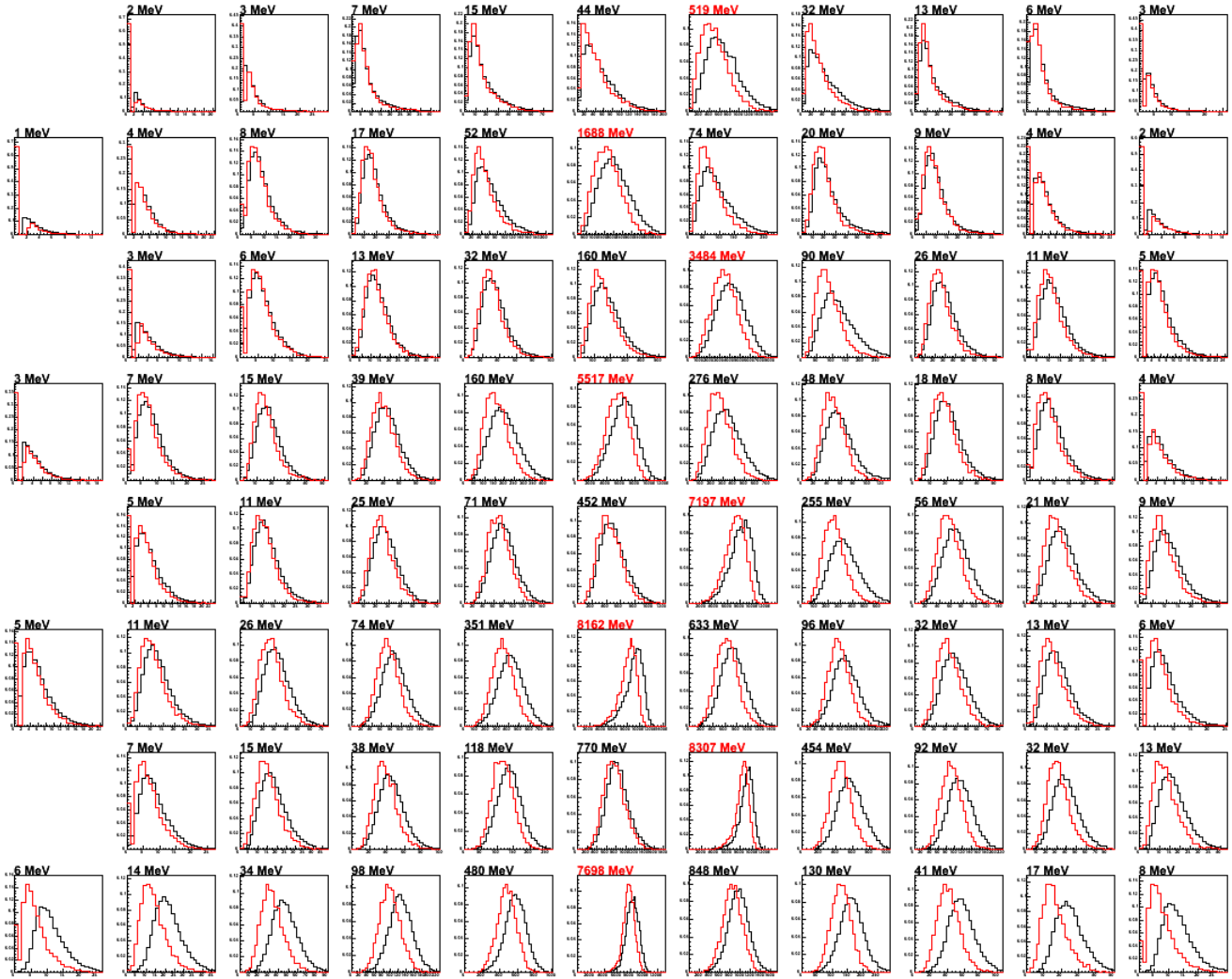




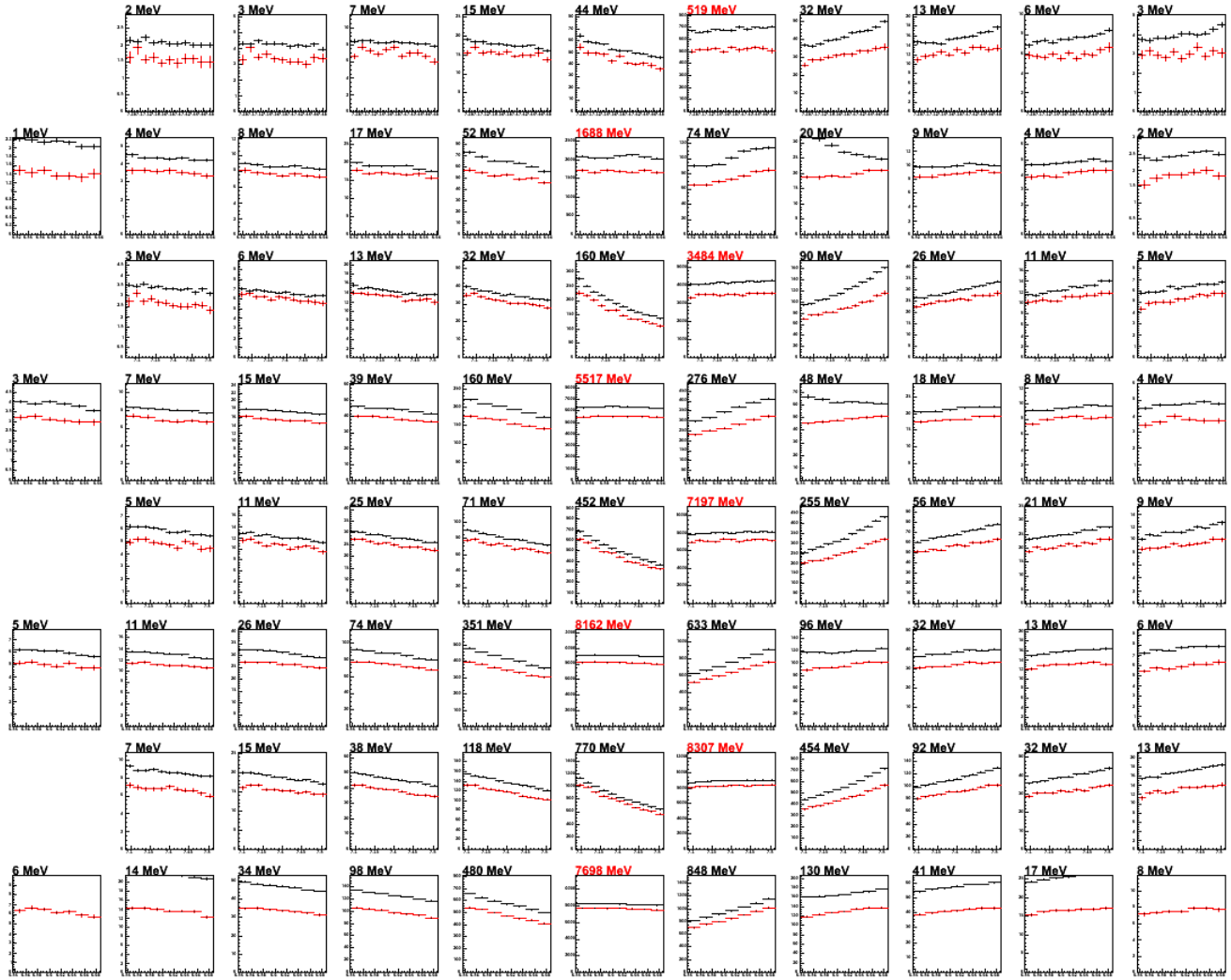
Transverse size estimation

- With the transverse size of the showers using only the transverse position measurement, we have a far better agreement between data and MC
- The agreement is better at Efrac=0.9 than at Efrac=0.99 : the remaining discrepancy comes from energy deposition discrepancy between data and MC at the edge of the shower

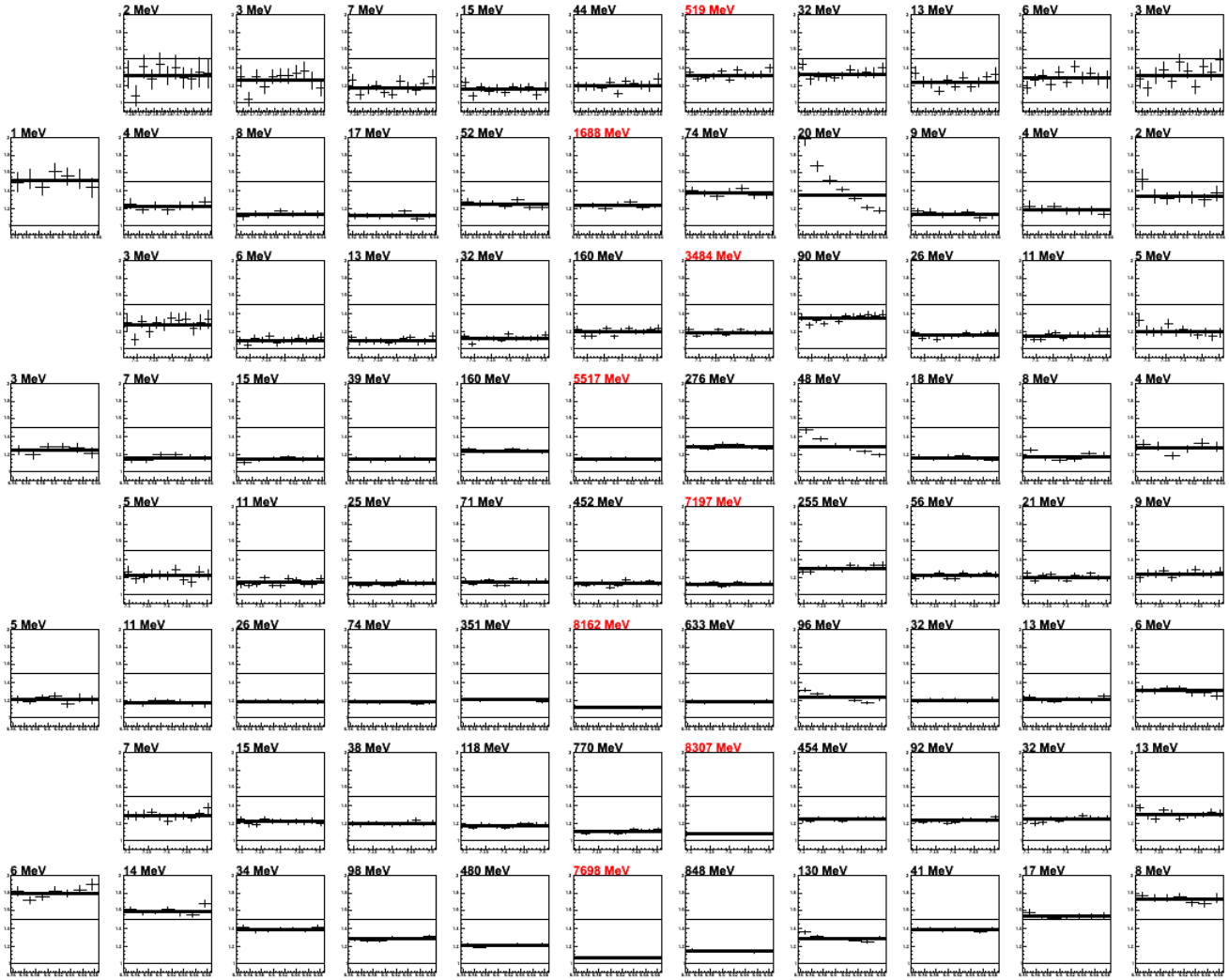
Shower imaging (100 GeV on-axis)



Shower imaging (100 GeV on-axis)

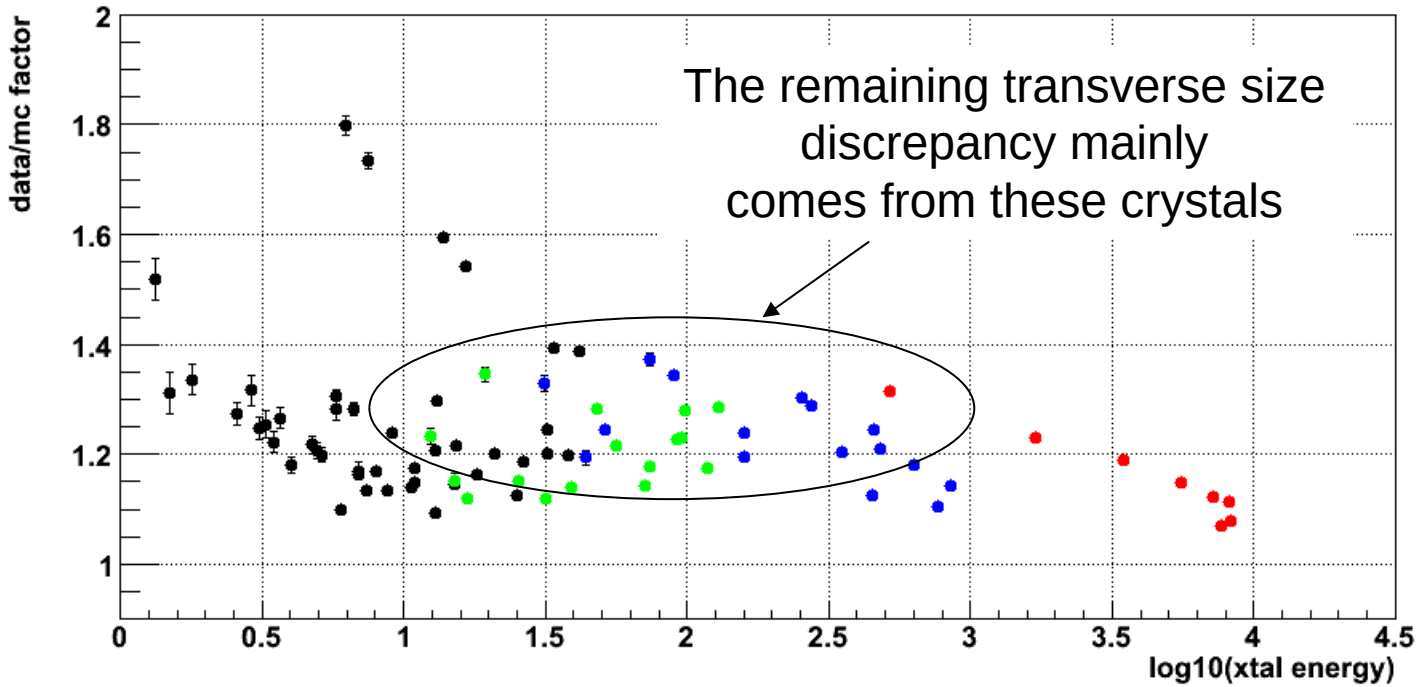


Shower imaging (100 GeV on-axis)



Shower imaging (100 GeV on-axis)

- Red : xtals on the trajectory
- Blue : xtals at +/- 1 of the trajectory
- Green : xtals at +/- 2 of the trajectory
- Black : other xtals



Conclusions

- The transverse size of electrons showers (from 5 geV upto 182 GeV) is not so badly reproduced by Geant4 : the disagreement is 5% or less
- There is something wrong with the longitudinal position measurement in data : why is it worse at high energy ?
- If the longitudinal measurement is not perfectly correct, we can not be sure that the energy meaurement is perfectly correct : we can not say now that the remaining discrepancy of the transverse size is due to Geant4 problems
- Urgent action items :
  - Understand why the longitudinal position measurement is not correct at high energy
  - Duplicate in the analysis the variables that use the longitudinal position measurement with equivalent variables using only the transverse position measurement