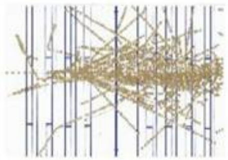


Università del Salento

Simulation of the 4th concept calorimeter

XIII International Conference
on Calorimetry
in High Energy Physics

Vito Di Benedetto

INFN Lecce and Università del Salento

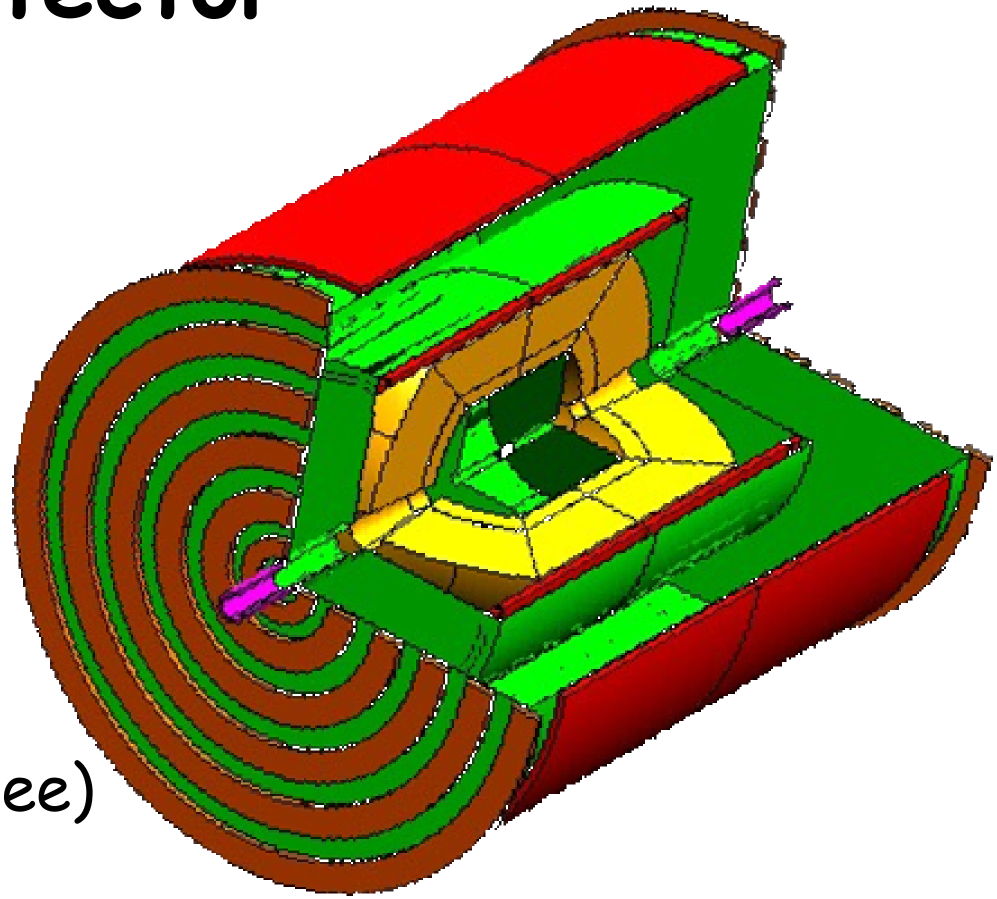
27 May 2008, Pavia

Outline

- The 4th Concept
- ILCroot Offline Framework
- Hadronic Calorimeter geometry
- Calibration studies
- Conclusion

The 4th Concept detector

- VXD (SiD Vertex)
- DCH (Clu Cou)
- ECAL (BGO Dual Readout)
- HCAL (Fiber Dual Readout)
- MUDET (Dual Solenoid, Iron Free)



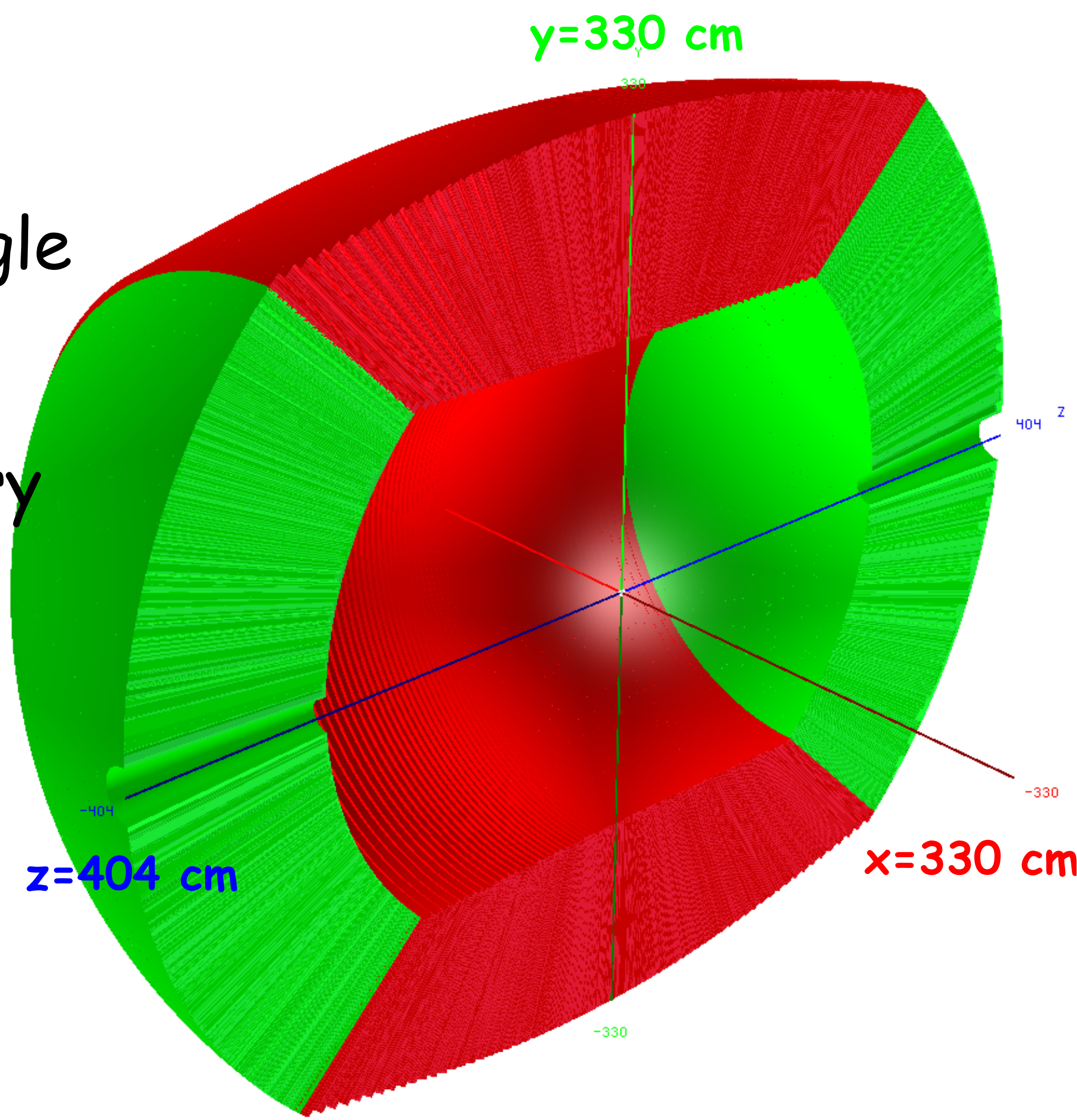
Subject of this talk

ILCRoot: summary of features

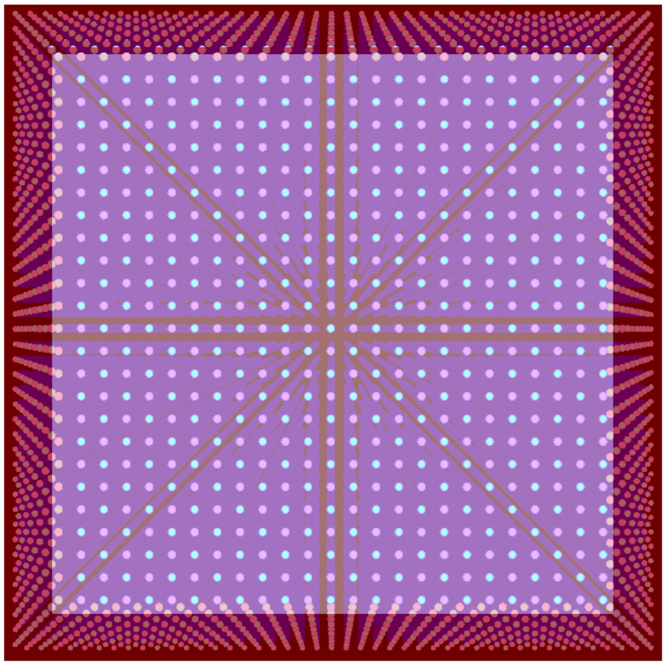
- CERN architecture (based on Alice's Aliroot)
- Full support provided by Brun, Carminati, Ferrari, et al.
- Uses ROOT as infrastructure
  - All ROOT tools are available (I/O, graphics, PROOF, data structure, etc)
  - Extremely large community of users/developers
- Six MDC have proven robustness, reliability and portability
- Single framework, from generation to reconstruction through simulation. Don't forget analysis!!!

The 4th Concept HCAL

- Cu + scintillating fibers
  + Čerenkov fibers
- ~1.4° tower aperture angle
- ~ 10 λ_{int} depth
- Fully projective geometry
- Azimuth coverage
  down to ~2.8°
- Barrel: 16384 towers
- Endcaps: 7450 towers



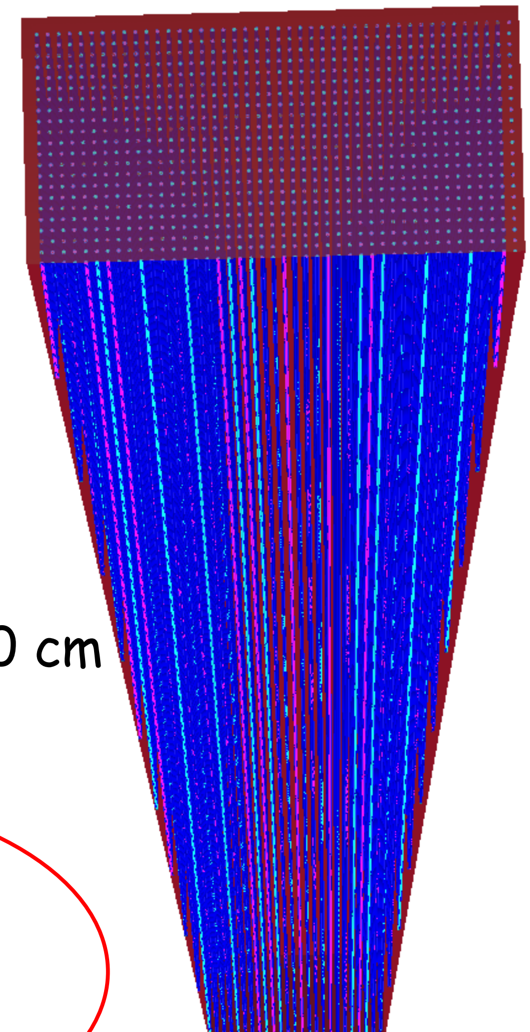
Hadronic Calorimeter Towers



Bottom view of single tower

Top tower size: ~ 8.1 × 8.1 cm^2

Prospective view of clipped tower



Cell length: 150 cm

Bottom tower size: ~4.4 × 4.4 cm^2

- 300 μm radius plastic fibers
- Fiber stepping ~2 mm
- Number of fibers inside each cell: ~1600 equally subdivided between Scintillating and Čerenkov
- Each tower works as two independent towers in the same volume

Dual Readout Fibers Calorimeter

MonteCarlo

- ROOT provides the Virtual MonteCarlo (VMC) interface
- VMC allows to use several MonteCarlo (Geant3, Geant4, Fluka)
- The user can select at run time the MonteCarlo to perform the simulations without changing any line of the code

The results presented here have been simulated using Fluka

Calibration

The energy of HCAL is calibrated in 2 steps:

- Calibrate with single 45 GeV e^-

  ➡ raw $\mathbf{E}_c$ and $\mathbf{E}_s$

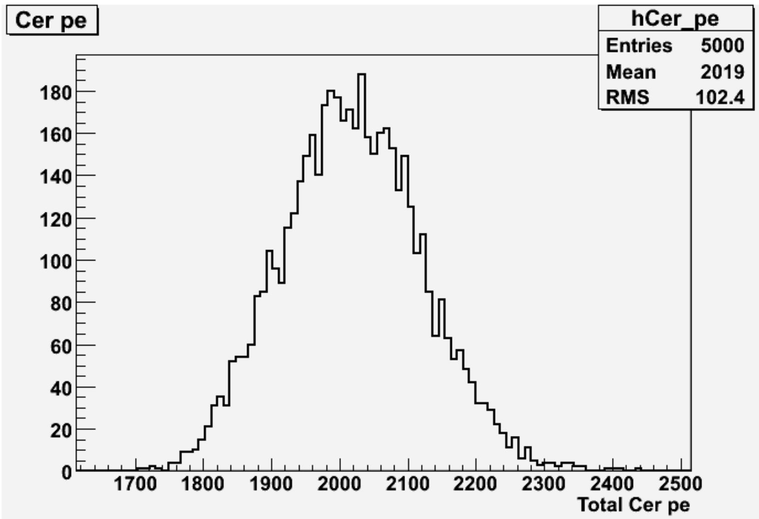
- Calibrate with single 45 GeV π^-

  ➡ $\boldsymbol{\eta}_c$ and $\boldsymbol{\eta}_s$

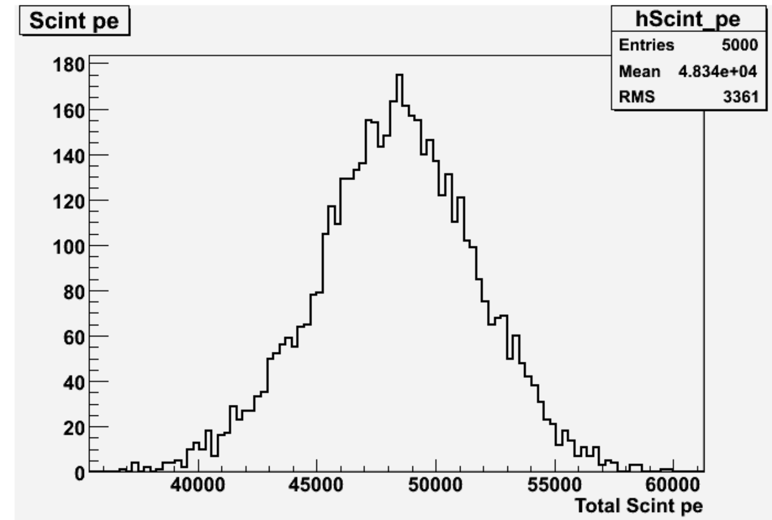
$$\eta_C = \left(\frac{e}{h}\right)_C \qquad \eta_S = \left(\frac{e}{h}\right)_S$$

First step calibration

Beam of 45 GeV e^-

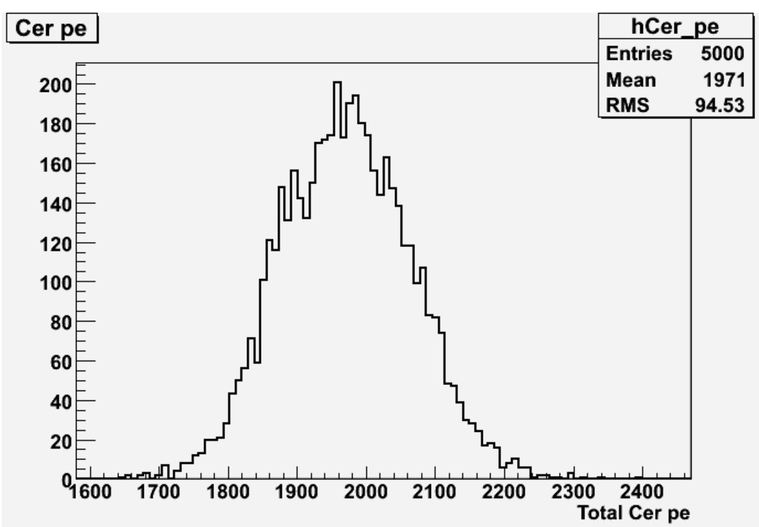


boundary

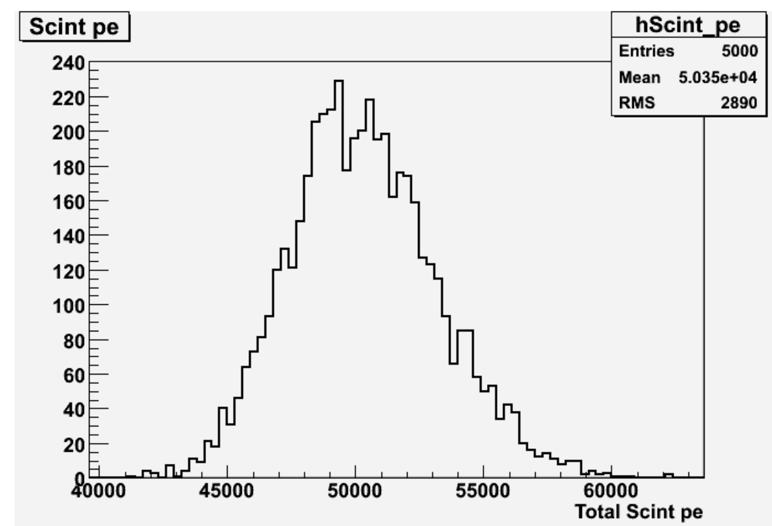


Cer #pe/GeV = 44.9

Scint #pe/GeV = 1074.2

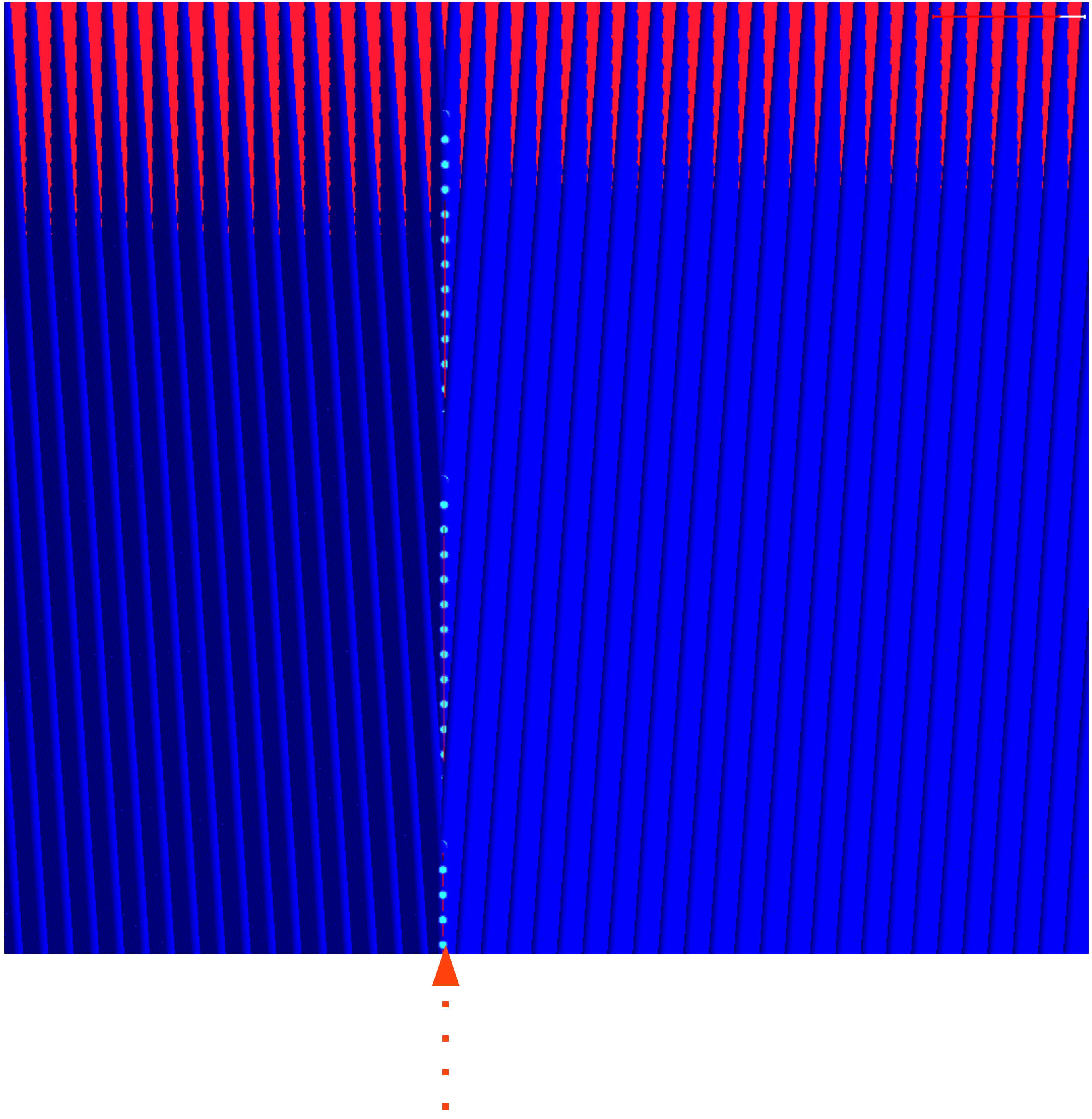


core

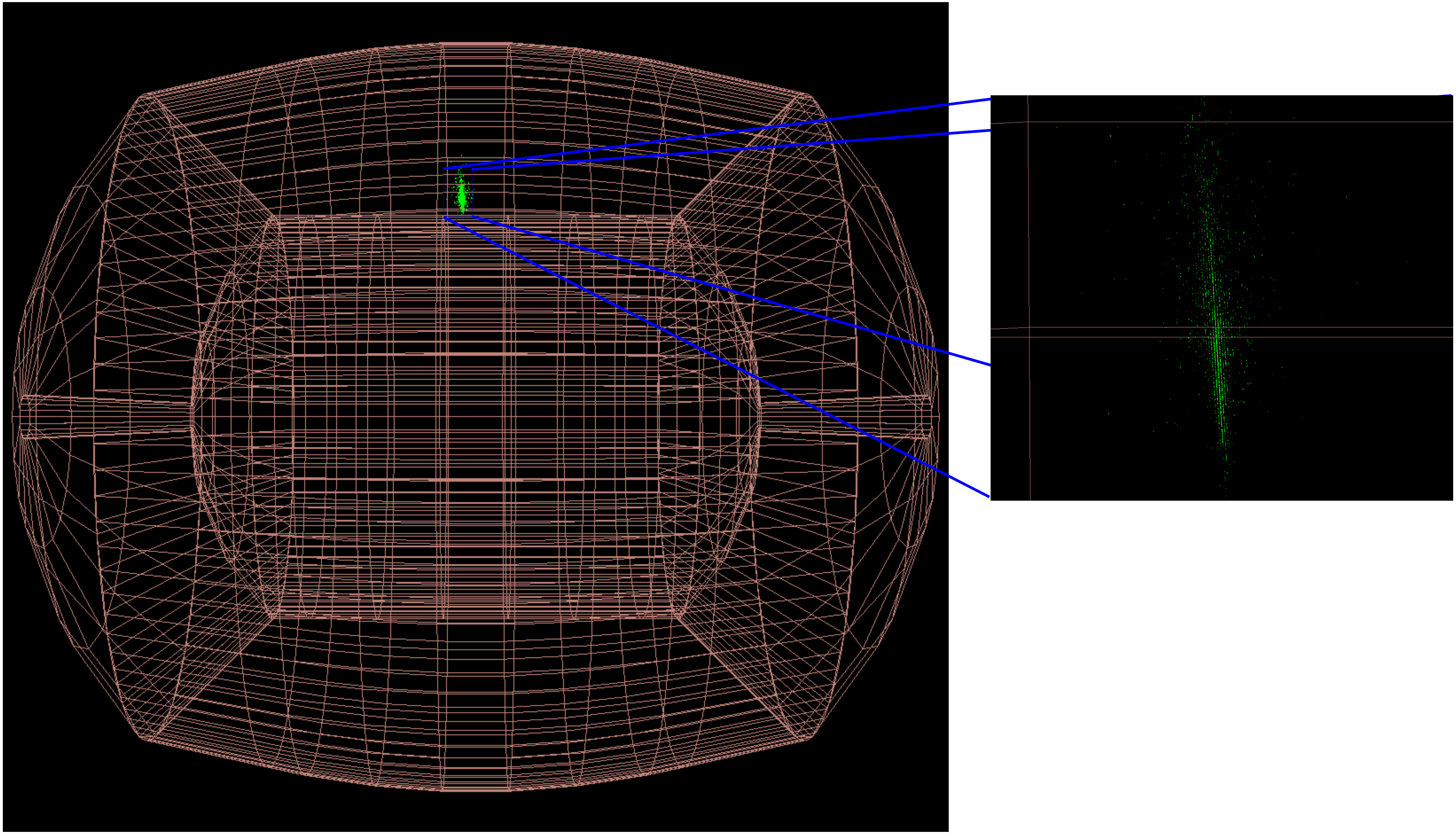


Cer #pe/GeV = 43.8

Scint #pe/GeV = 1118.9

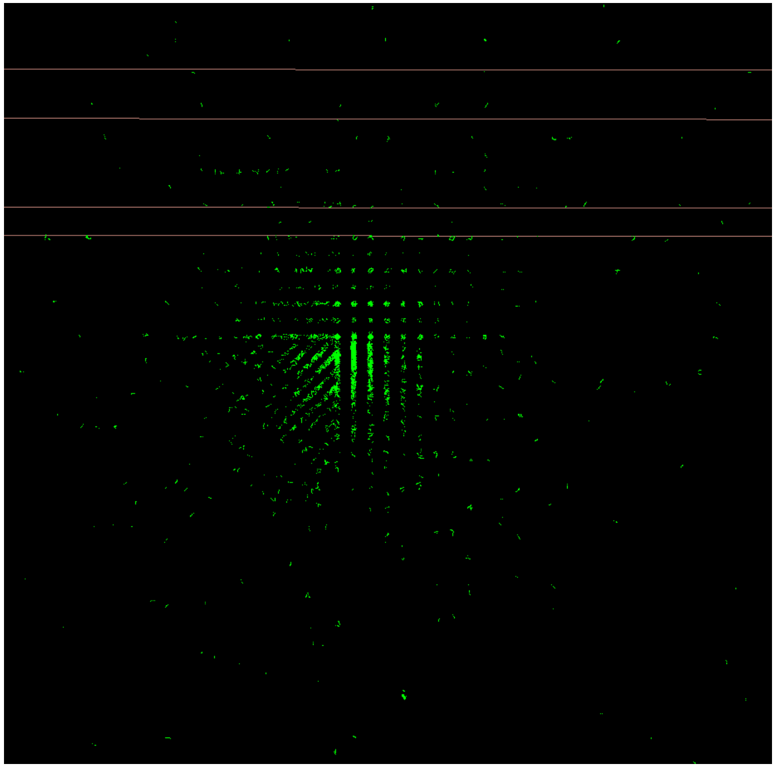


45 GeV e^- shower



in the hadronic calorimeter

Top view of the shower of a 45 GeV e^-



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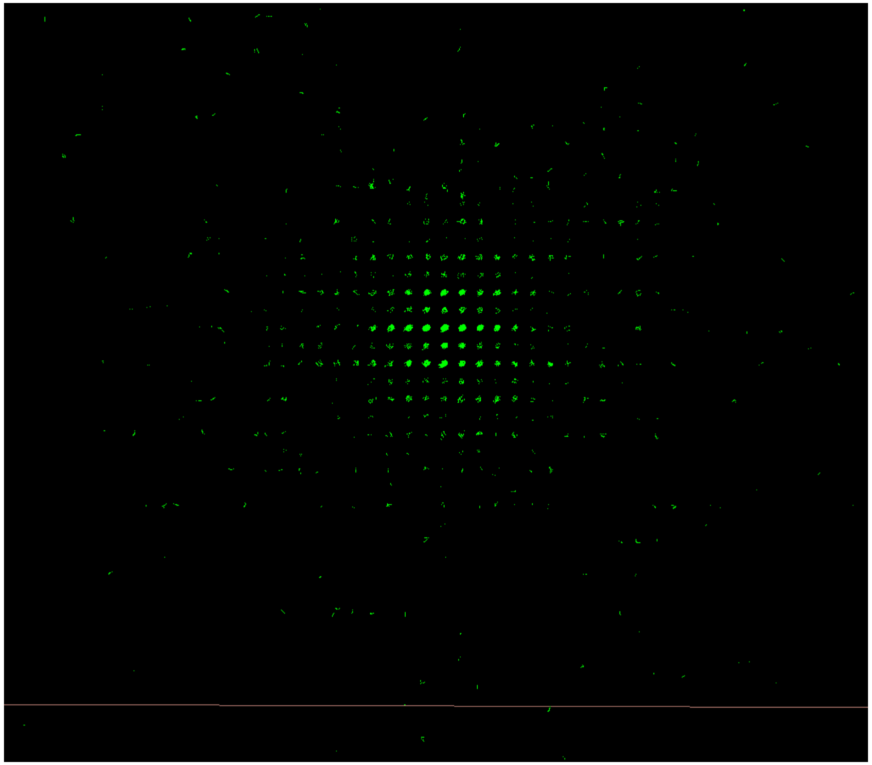
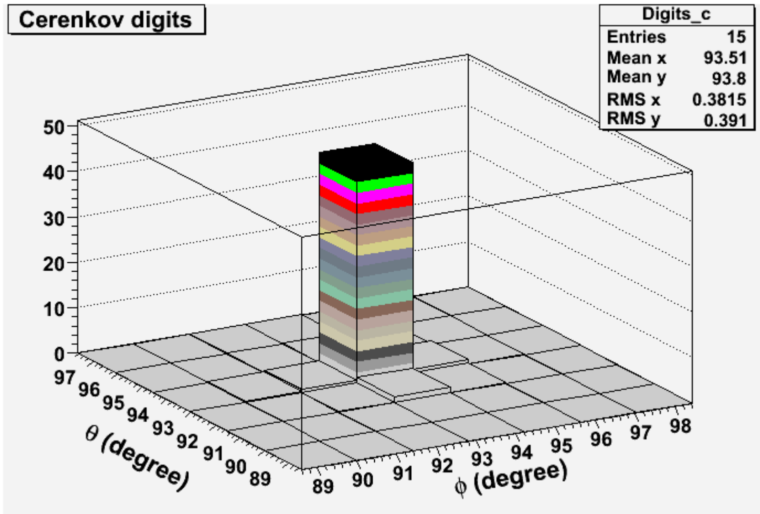


core

Calorimeter response for 45 GeV e^-



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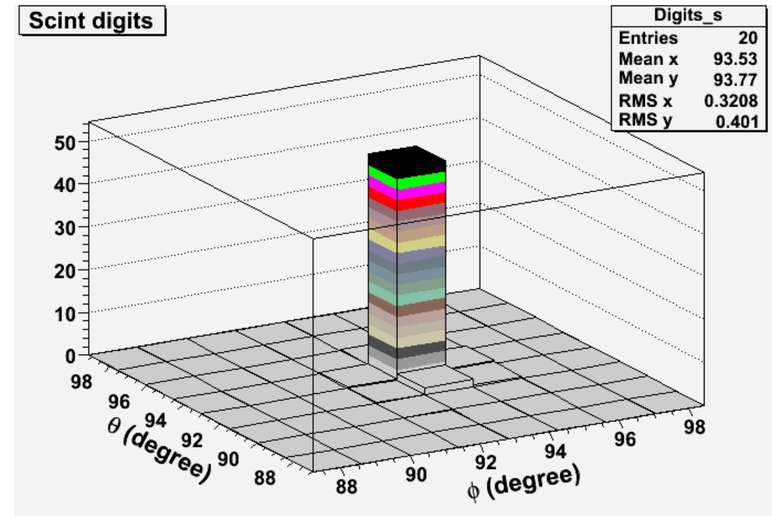

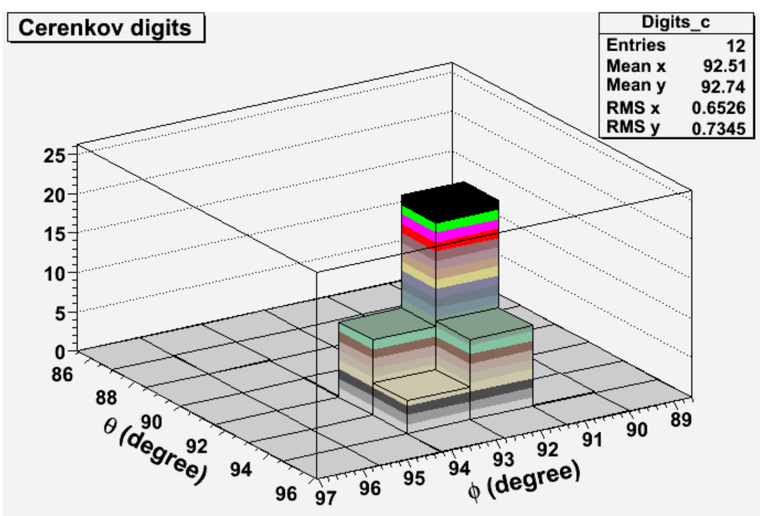

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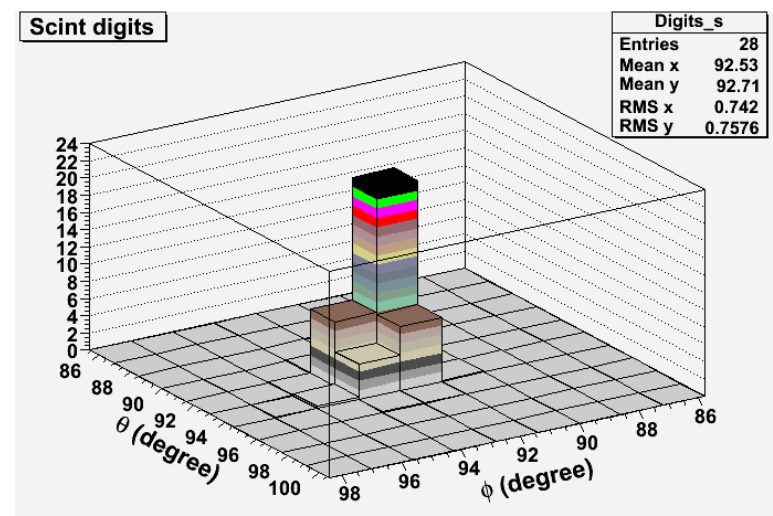
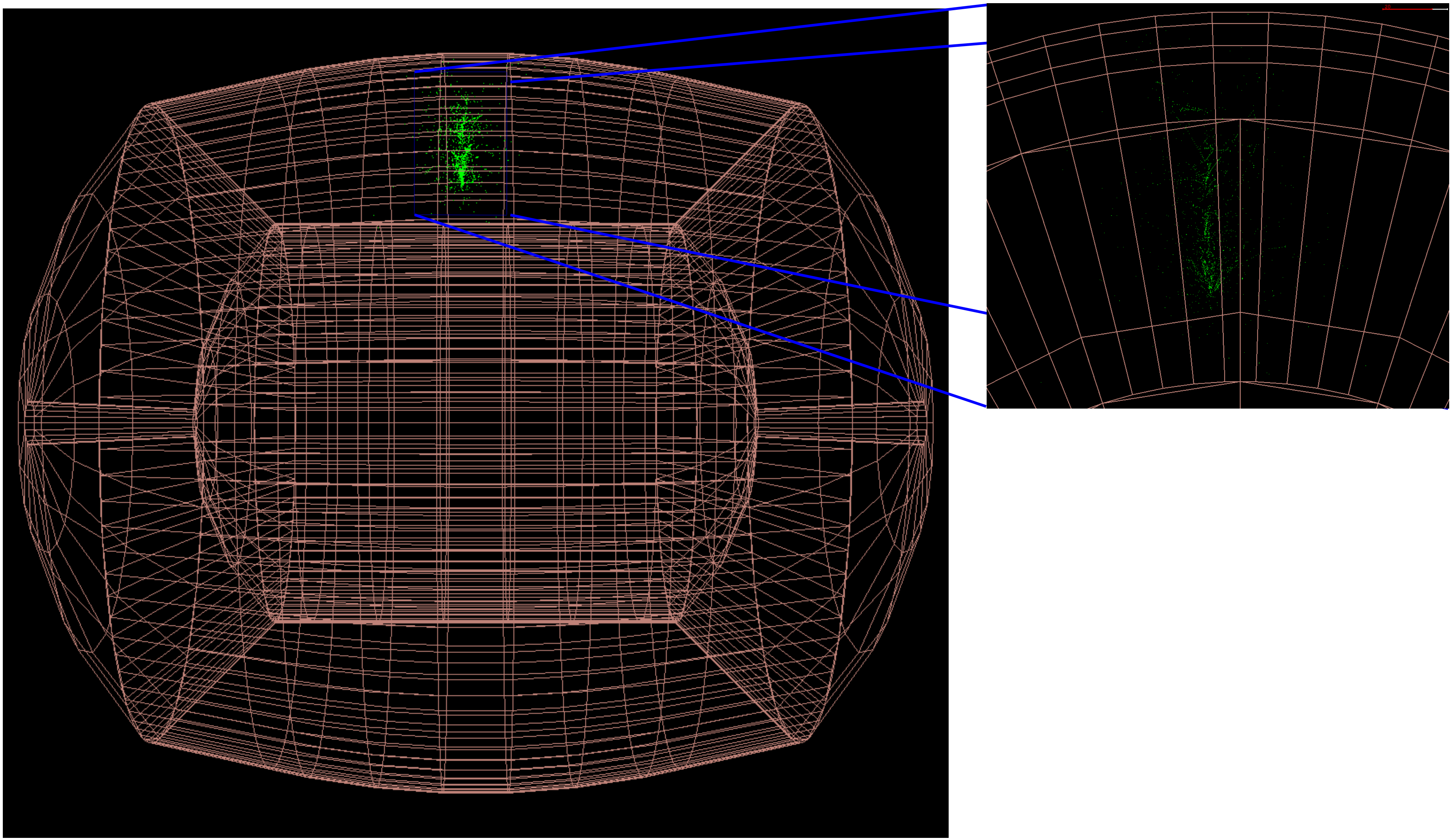
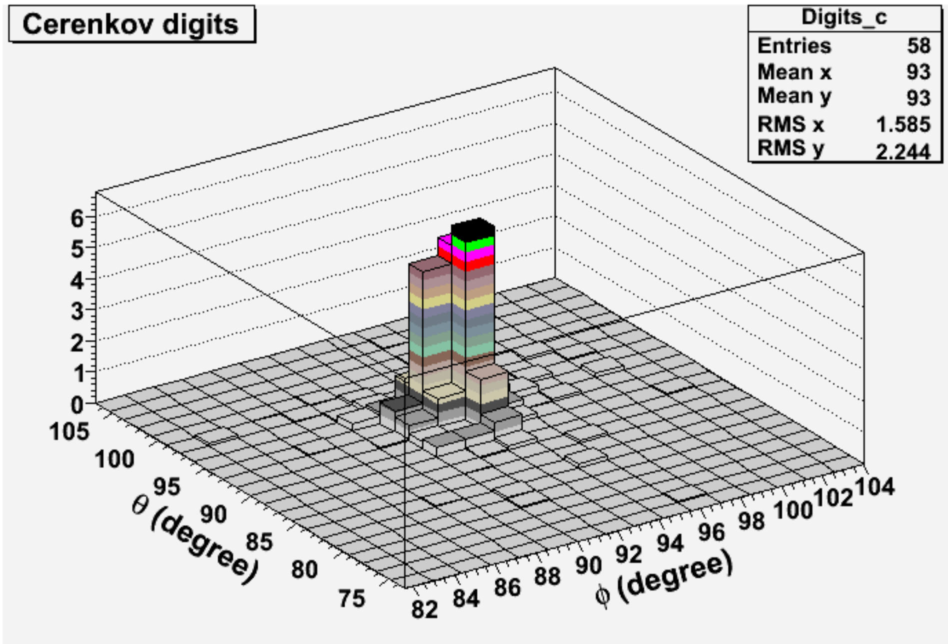


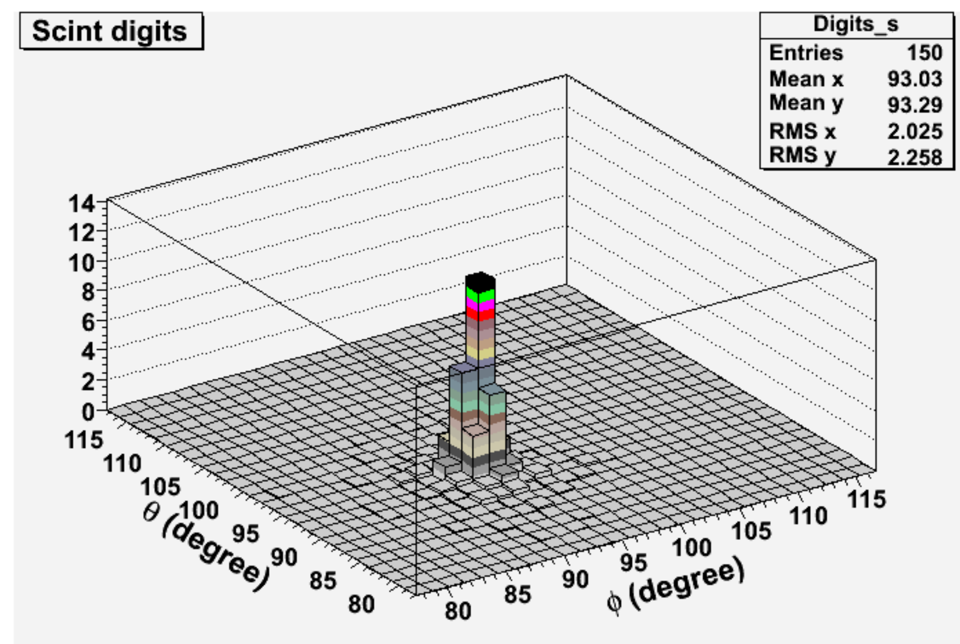
45 GeV π^- shower



in the hadronic calorimeter

Calorimeter response for 45 GeV π^-





Second step calibration π^- @ 45 GeV

$$R(f_{em}) = f_{em} + \frac{1}{\eta}(1 - f_{em})$$

$$R = \frac{E_{RAW}}{E}$$

f_{em} = em fraction of the hadronic shower

η = em fraction in the fibers

hadronic energy:

$$E_{Beam} = \frac{\eta_S E_S (\eta_C - 1) - \eta_C E_C (\eta_S - 1)}{\eta_C - \eta_S}$$

$$\lambda = \frac{1 - 1/\eta_S}{1 - 1/\eta_C} \qquad E_{Beam} = \frac{E_S - \lambda E_C}{1 - \lambda}$$

From the calibration fit

$\eta_c = 6.876$ $\eta_S = 1.449$

$\lambda = 0.362$

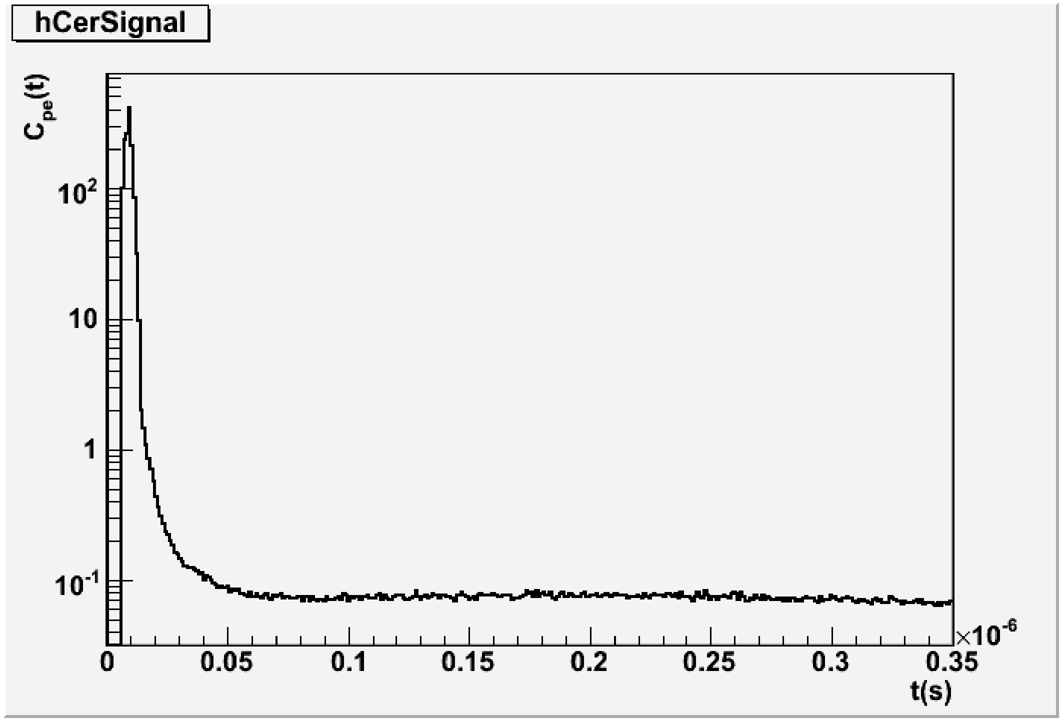
Once calibrated this is the response of the calorimeter

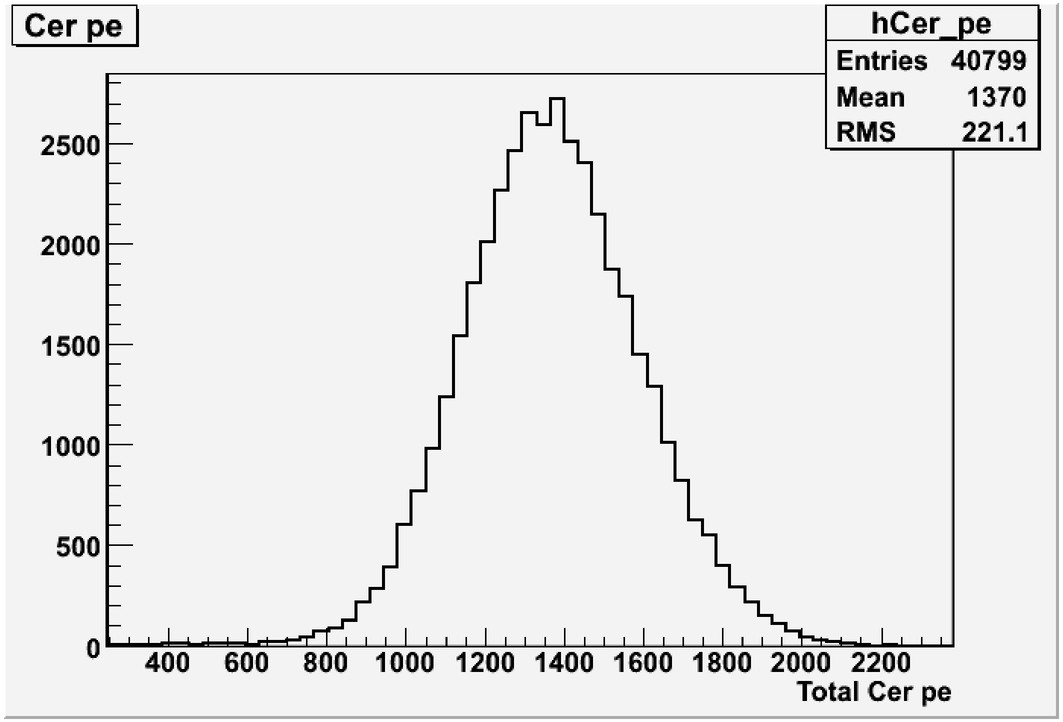
$$E_{HCAL} = \frac{\eta_S E_S (\eta_C - 1) - \eta_C E_C (\eta_S - 1)}{\eta_C - \eta_S}$$

$$\lambda = \frac{1 - 1/\eta_S}{1 - 1/\eta_C} \qquad E_{HCAL} = \frac{E_S - \lambda E_C}{1 - \lambda}$$

Beam of 45 GeV π^-

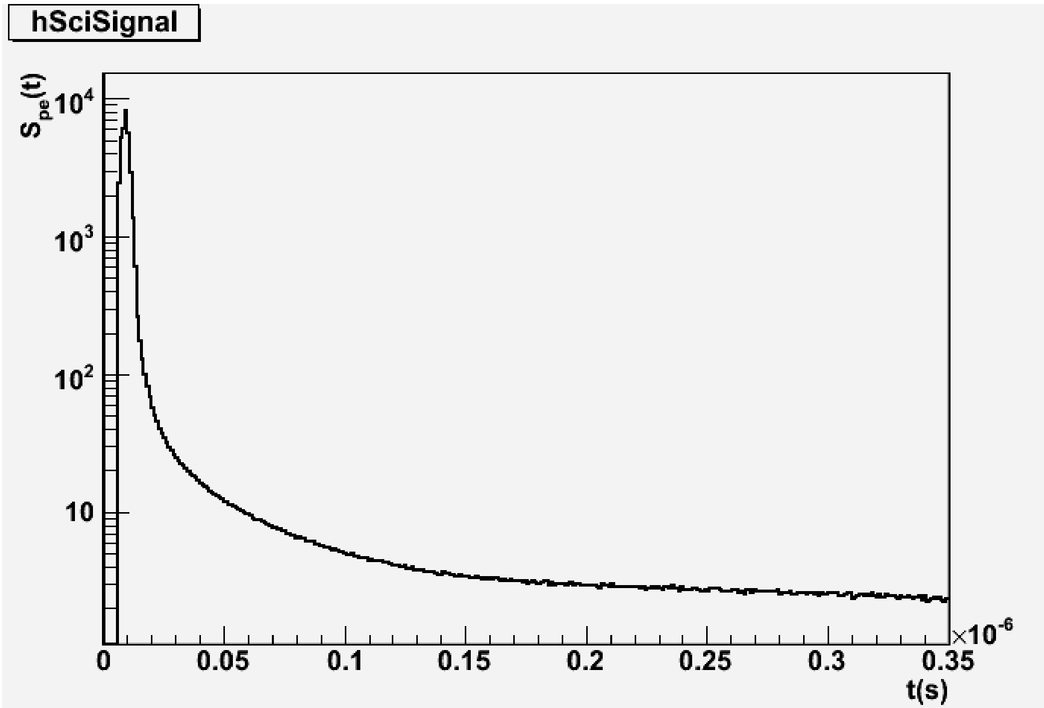
Time history of the Cer pe





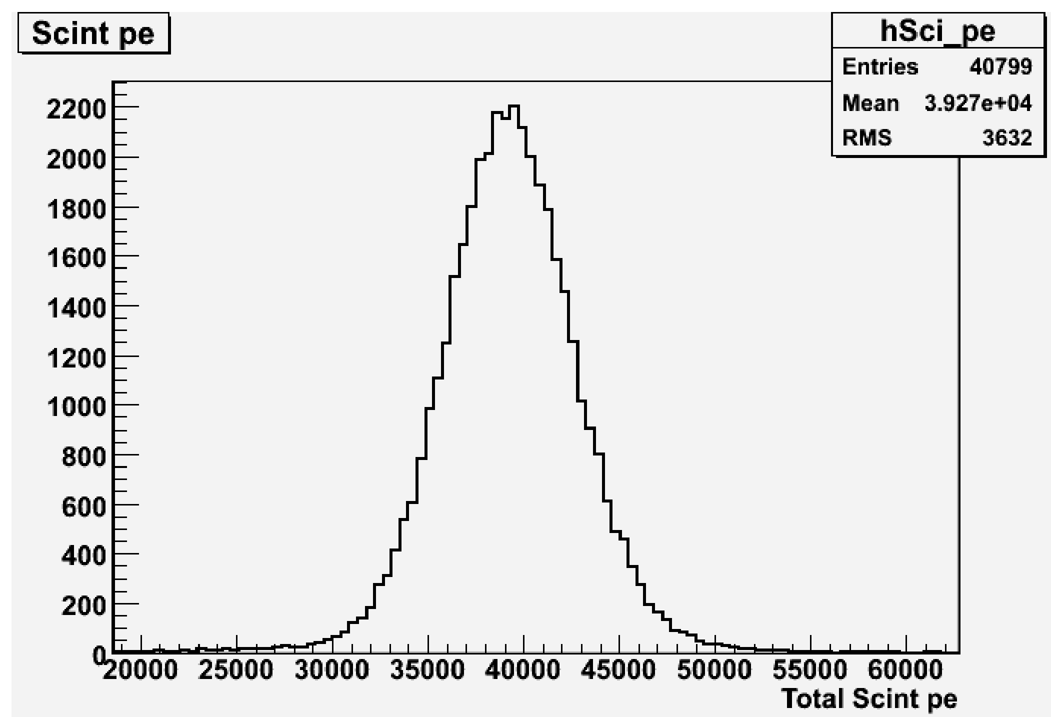
Distribution of the Cer pe

Beam of 45 GeV π^-



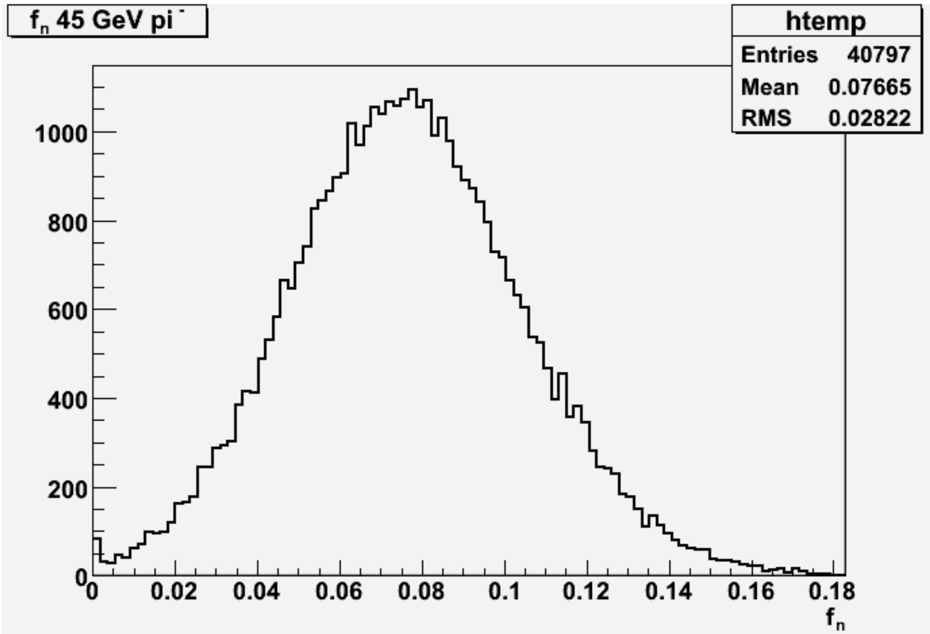
Time history of the Scint pe

Distribution of the Scint pe

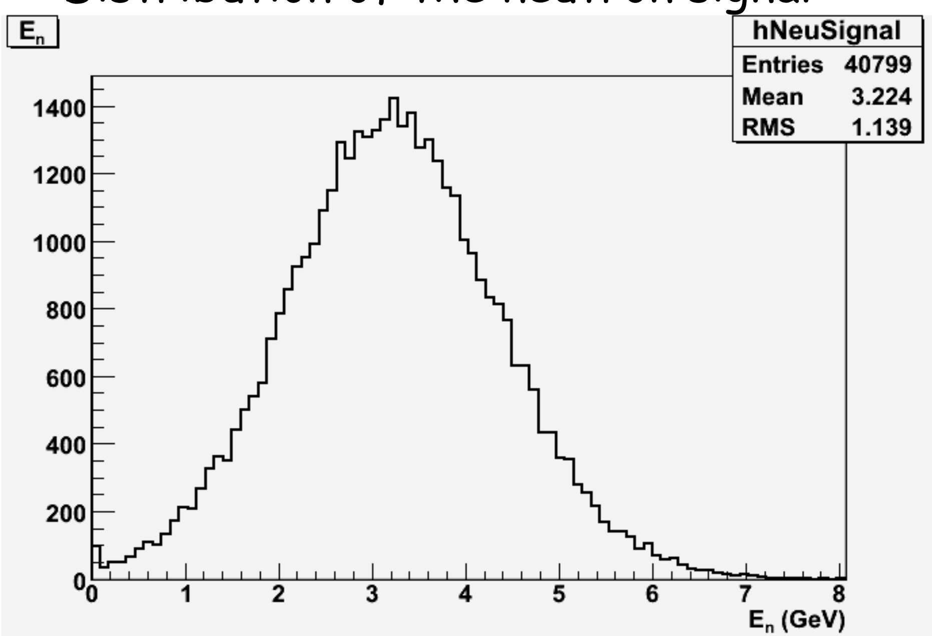


Beam of 45 GeV π^-

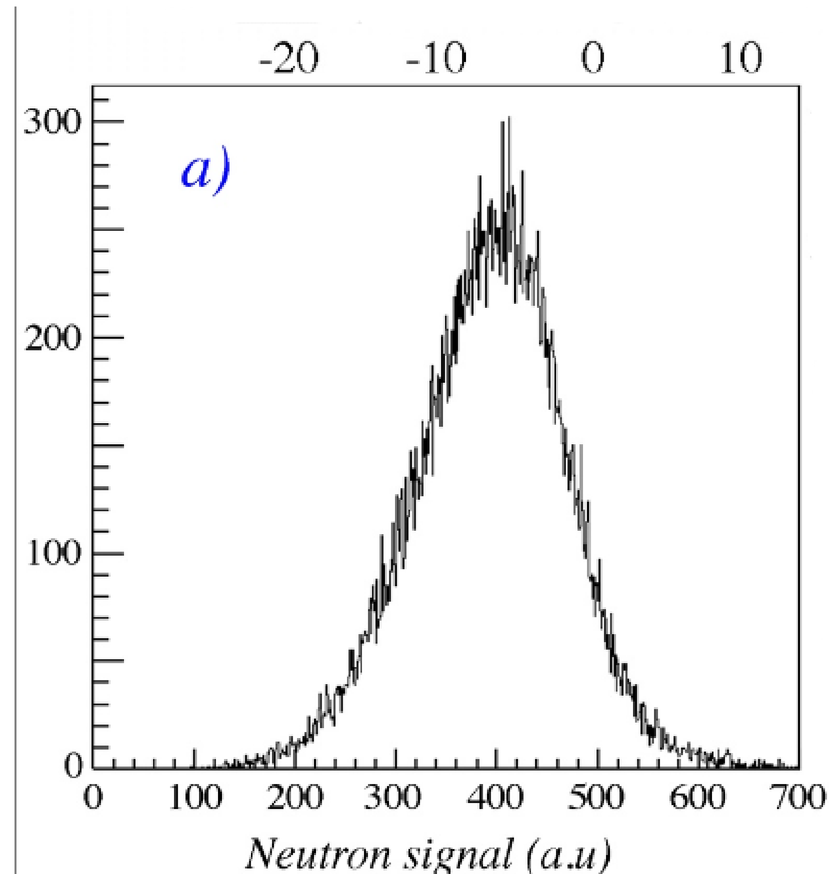
Distribution of the neutron fraction signal



Distribution of the neutron signal

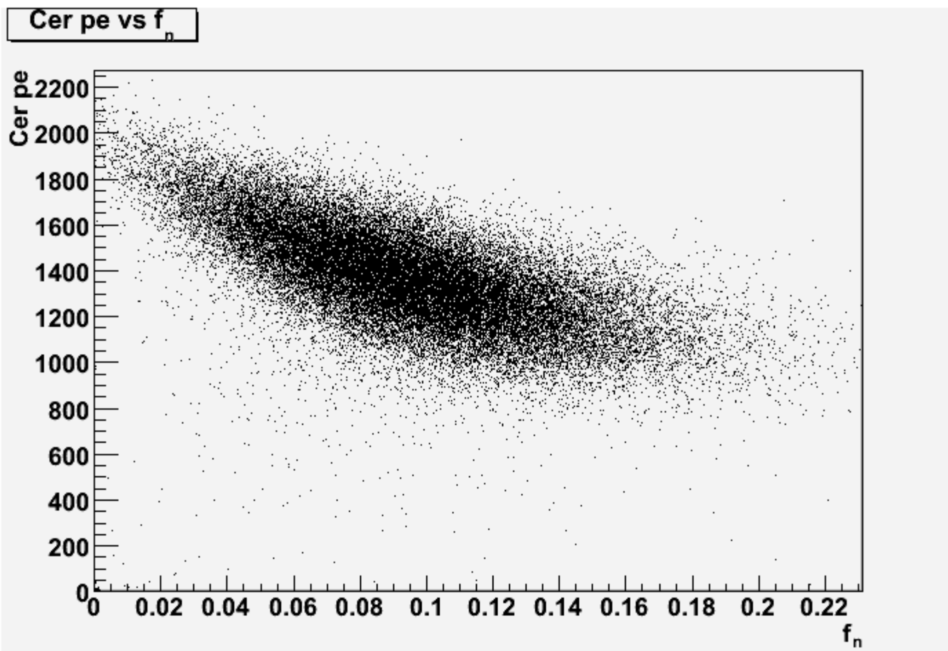


From DREAM data:
neutron signal of 200GeV jets

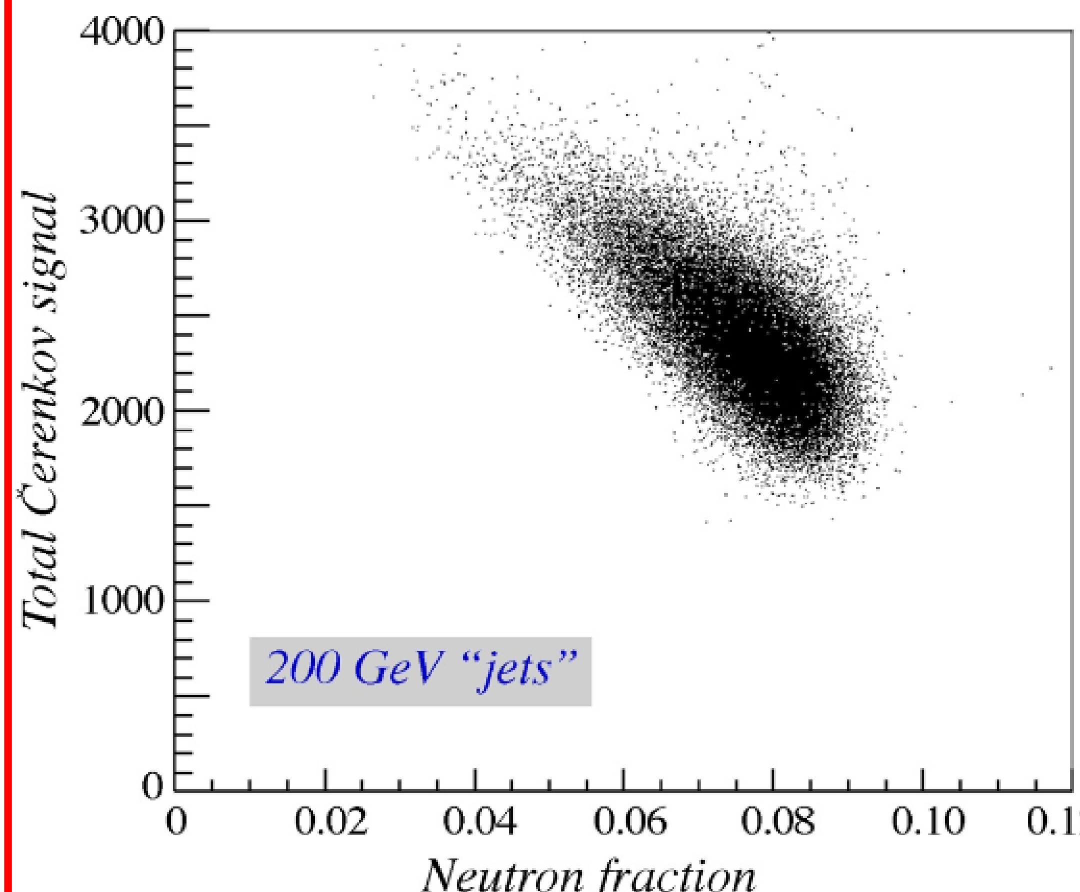


Beam of 45 GeV π^-

Cer pe versus Neutron fractionl

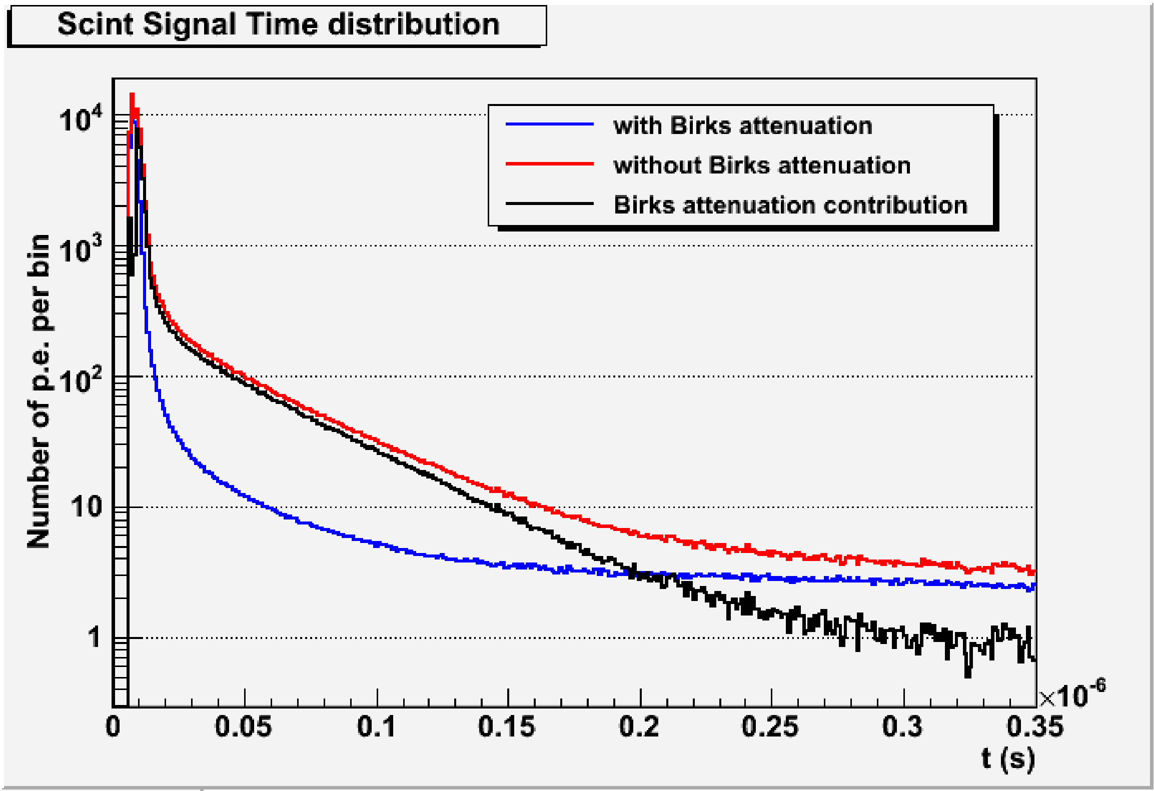


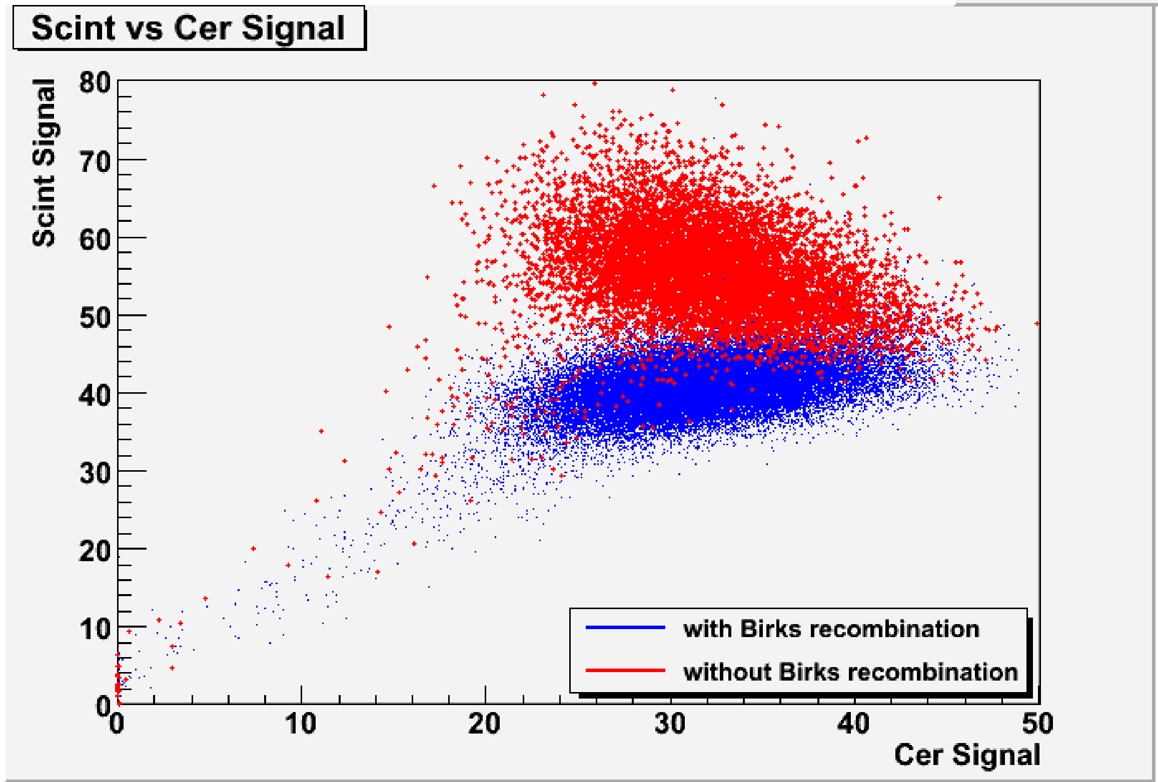
From DREAM data:
Cer Signal versus Neutron fraction



Beam of 45 GeV π^-

Birks recombination effect



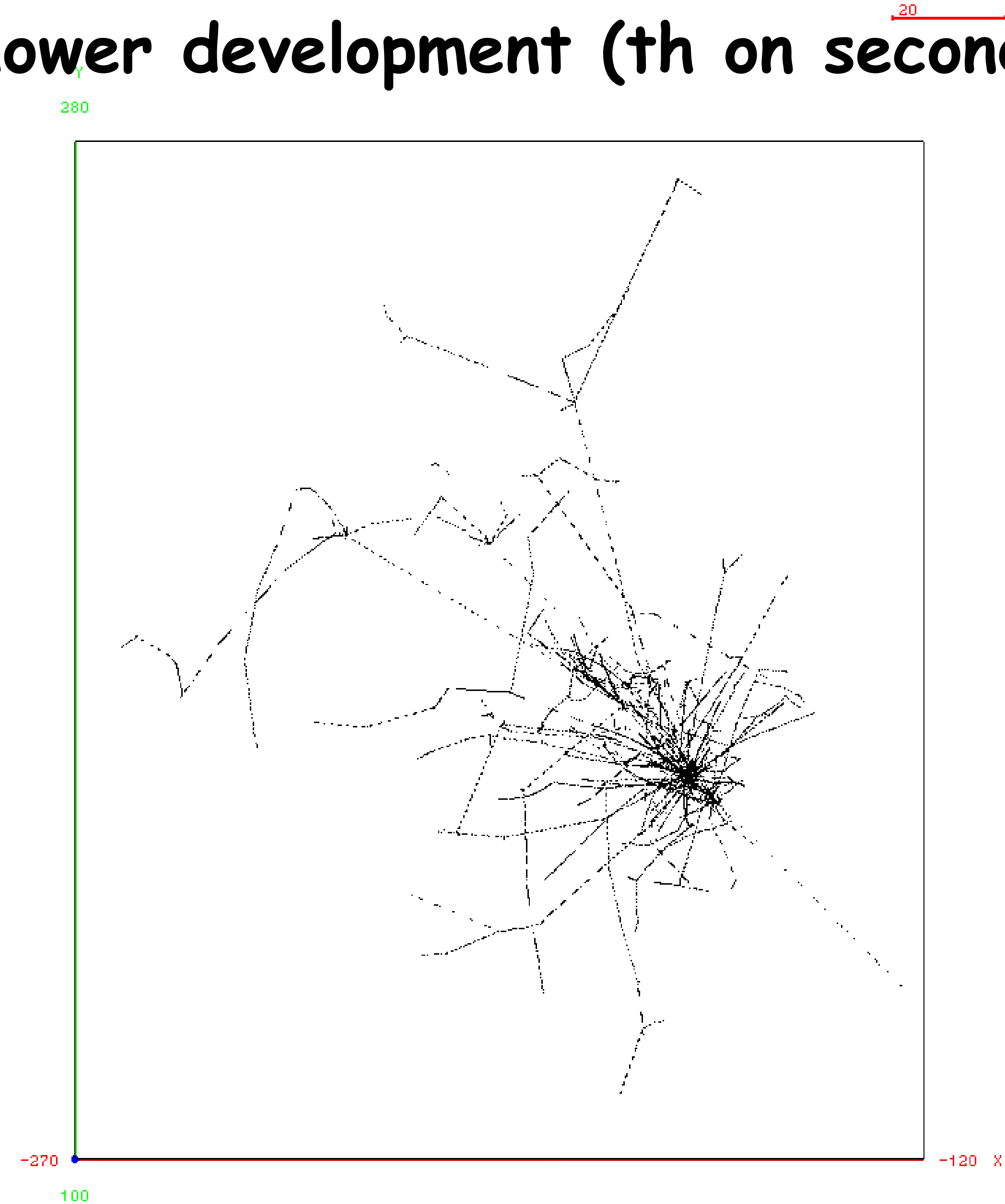


Conclusion

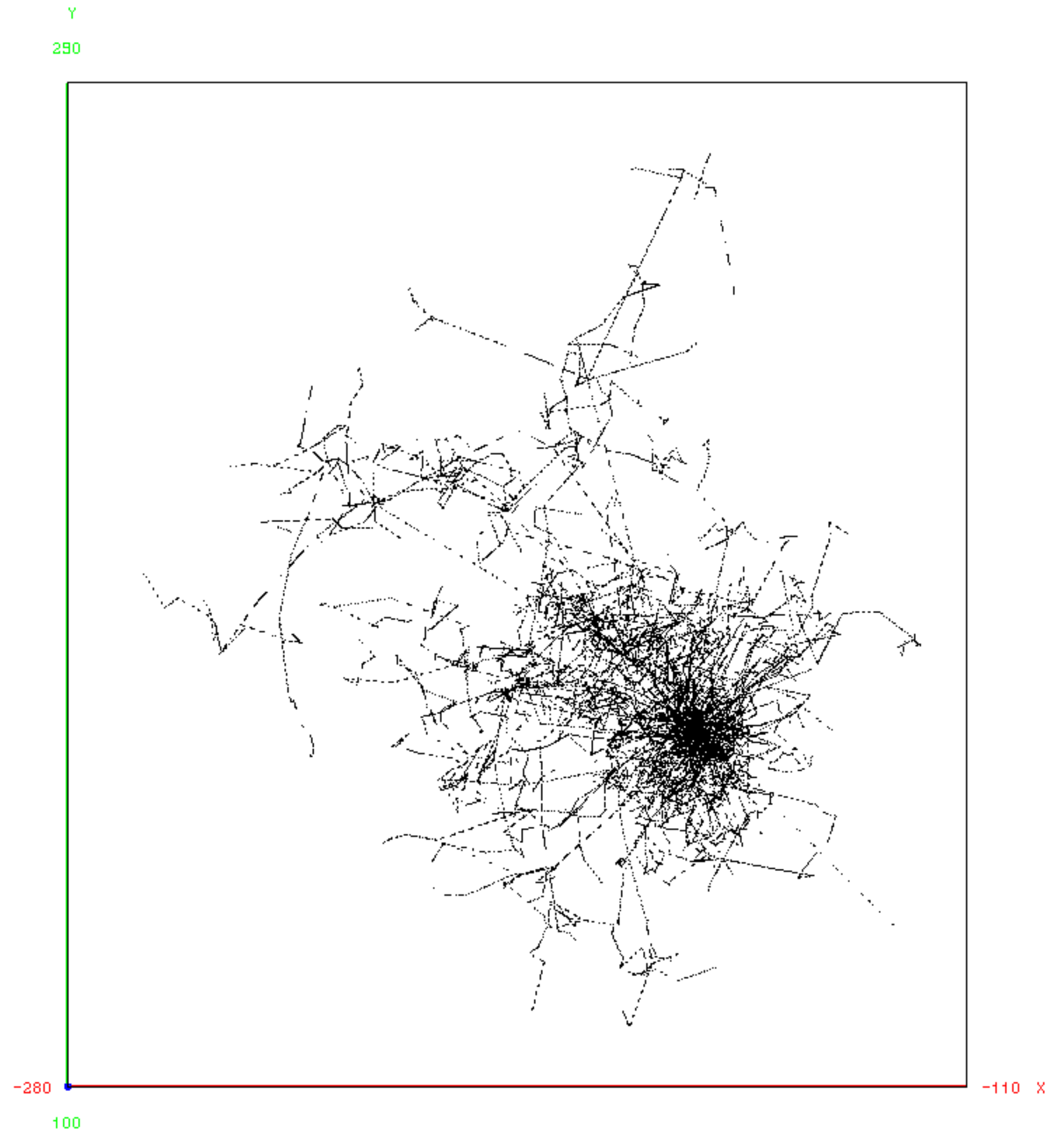
- Improvement of the geometry
  in order to get uniform response

- Further study to better understand
  the neutron effect

45 GeV π^- shower development (th on secondaries 100MeV)



45 GeV π^- shower development (th on secondaries 35MeV)



45 GeV π^- shower development