Fast Parametrisation of electromagnetic showers in LAr Calorimeter: Frozen Showers

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DESY - ATLAS

- Introduction to Frozen Showers (FS)
- Implementation and performance
- Status and plans
- Summary

Introduction to Frozen Showers (FS)

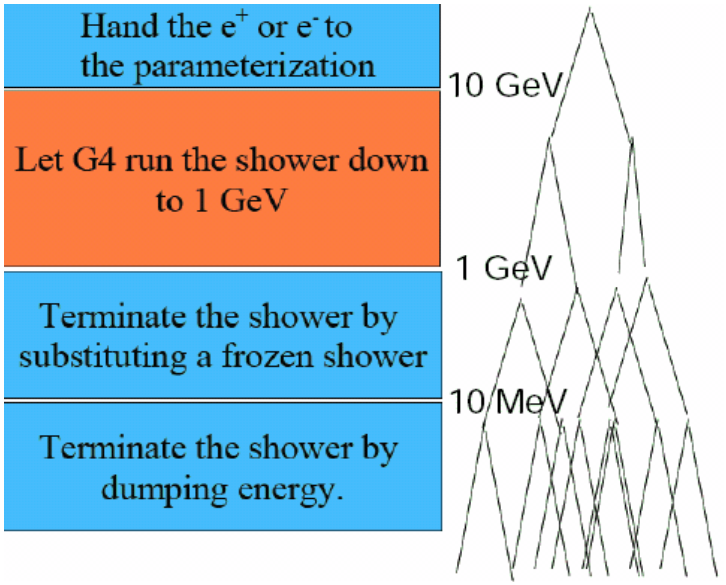
Full simulation of typical QCD event in ATLAS LAr calorimeter takes ~15 min

largely this time is spend simulating electromagnetic showers

simulation time can be reduced using special techniques as:

- Parametrisation of the shower (Grindhammer/Peters)

- Frozen Shower Library (FS):
  - full simulation down to 1 GeV cut-off
  - pre-stored shower library of compressed GEANT hits



Must meet requirements:

- speed-up MC simulation
- good shower shape description with respect to full simulation

Implementation of Frozen Showers (1)

Frozen Shower approach contains to distinct parts:

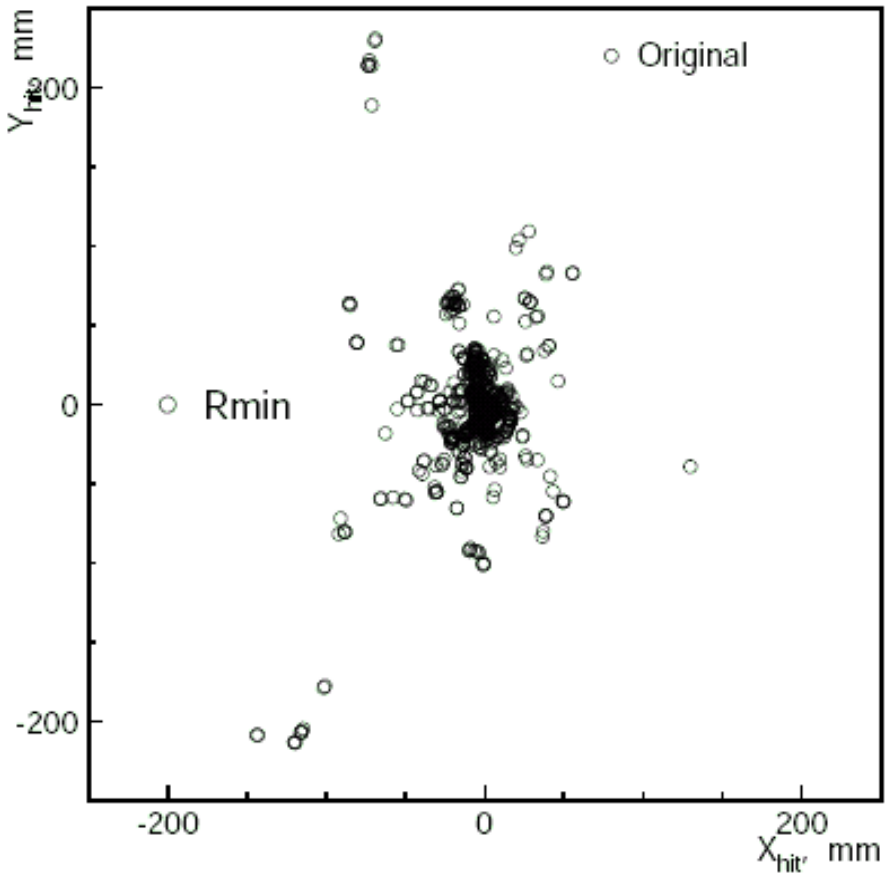
- creation of the library (LArG4GenShowerLib)
- usage of the library during the simulation (LArG4ShowerLibSvc and supporting packages)

FS library is created from GEANT4 hits after clustering:

- find a pair of energy deposits with smallest spacial separation R
- if $R < R_{min}$ (5 mm), replace the pair by one point at the center of energy
- repeat first step

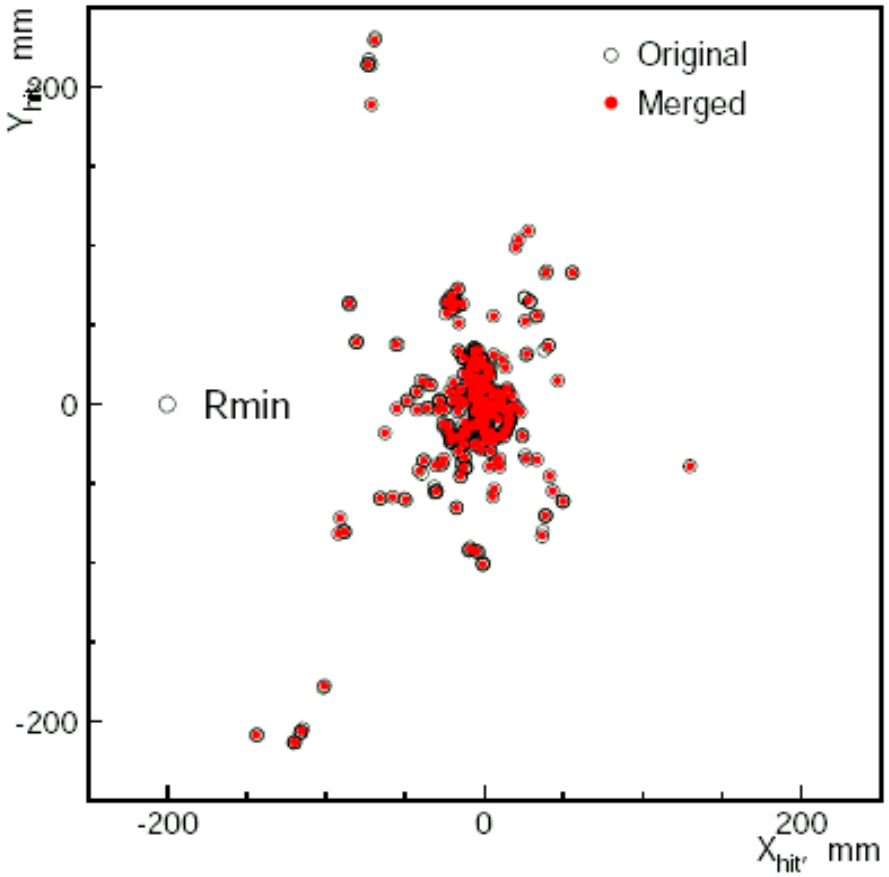
Implementation of Frozen Showers (2)

500 MeV electron in LAr



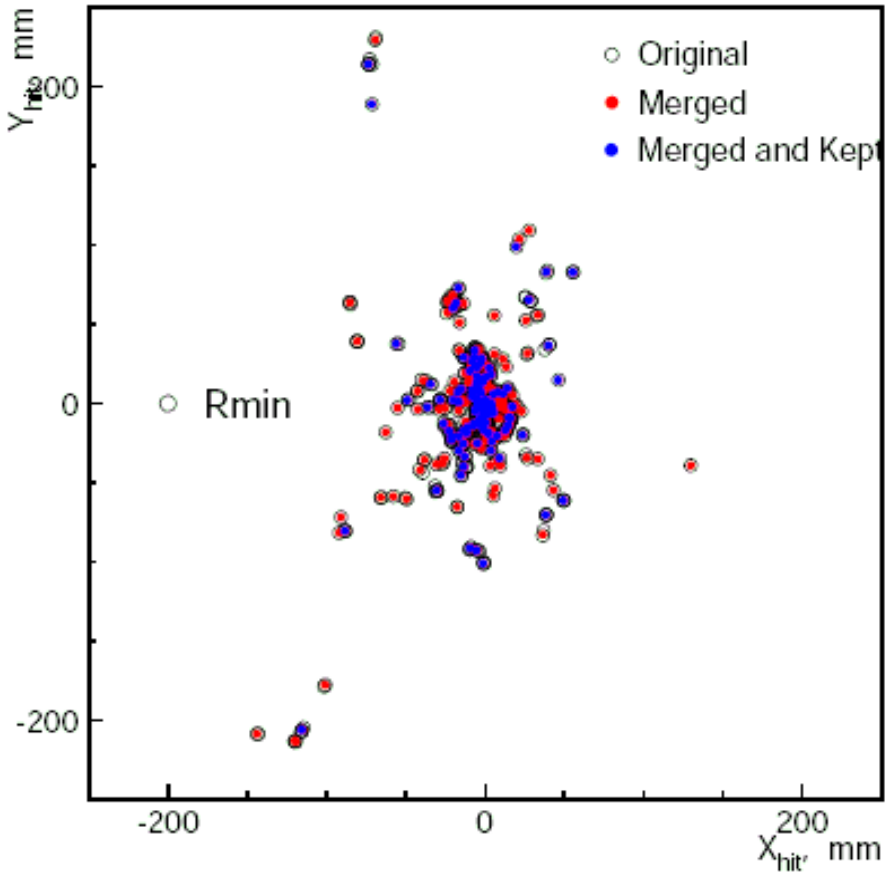
Implementation of Frozen Showers (3)

500 MeV electron in LAr



Implementation of Frozen Showers (4)

500 MeV electron in LAr



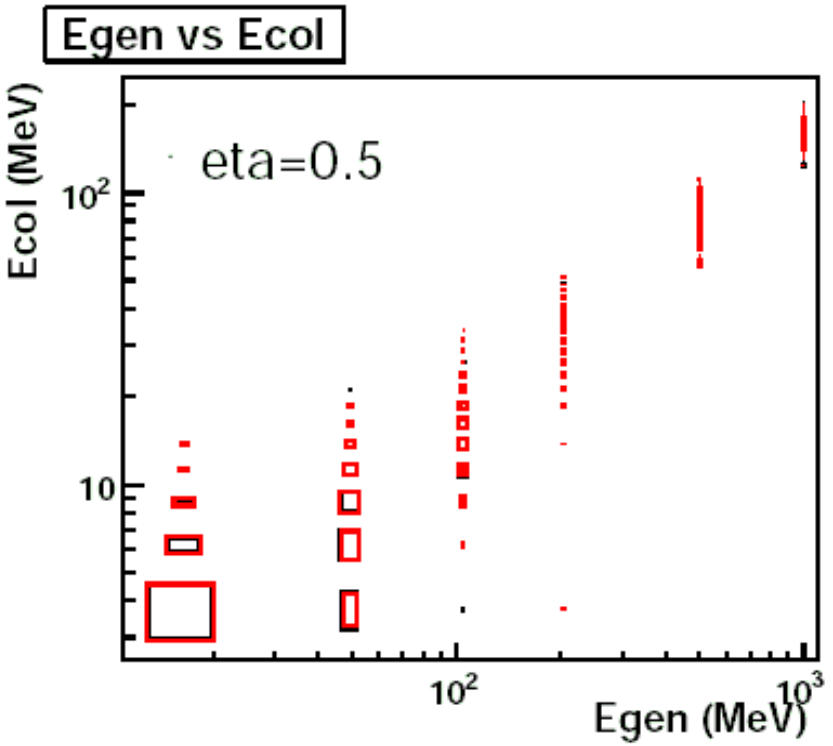
significant reduction in shower size (~10 times for low E showers)

Implementation of Frozen Showers (5)

The Frozen Shower library is organized in energy (10-1000 MeV) and eta bins

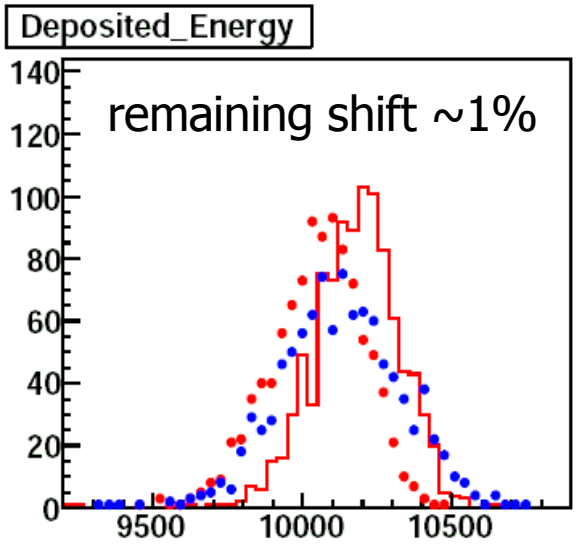
typically 1000 showers are stored in each energy bin with a list of hits as well as their position (X,Y,Z) and E

chosen energy binning fully covers deposited energies in LAr



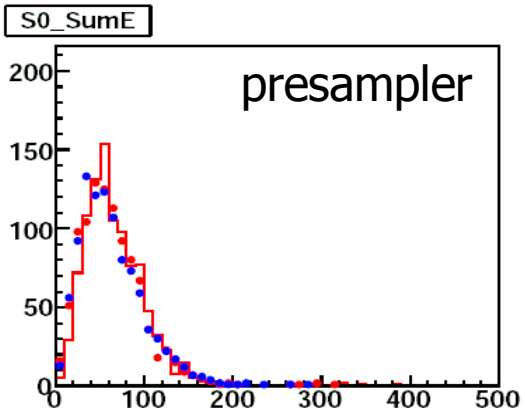
FS libraries are implemented for EMB, EMEC, FCAL calorimeters

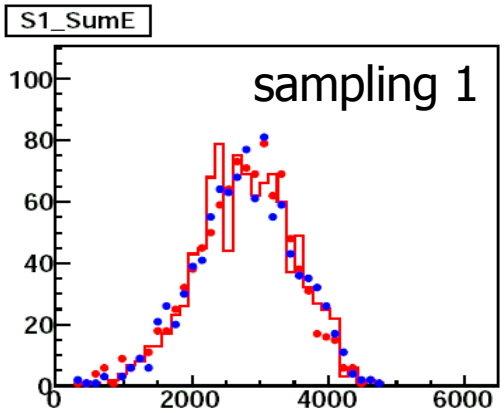
Performance of Frozen Showers: **EMB**, generator quantities

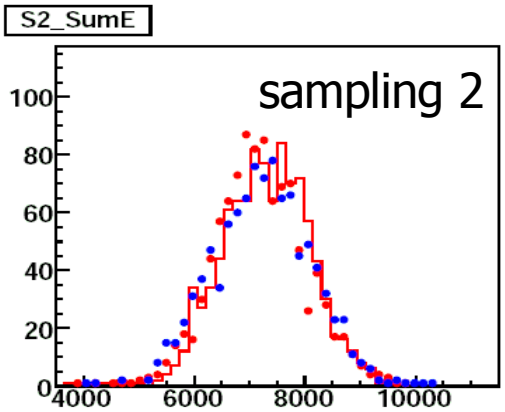


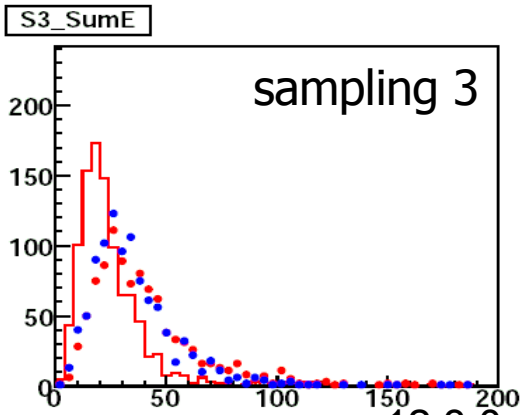
— full simulation (e of 64 GeV)

- FS < 1 GeV < full simulation
- FS < 1 GeV < full sim < 12 GeV < parametrisation







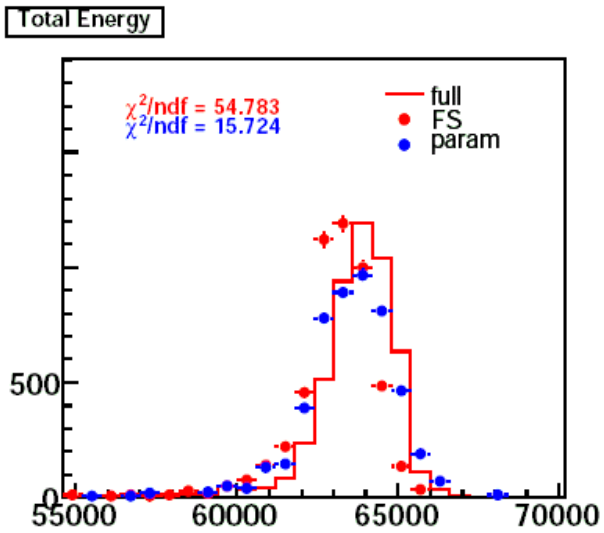


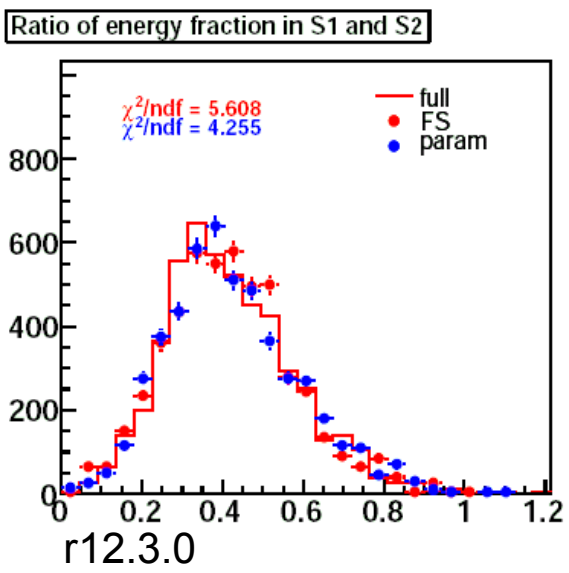
r12.3.0

<u>average time per event:</u>

full sim	16.0 s
FS	0.9 s
FS+param	0.8 s

Performance of Frozen Showers: **EMB**, reconstructed quantities

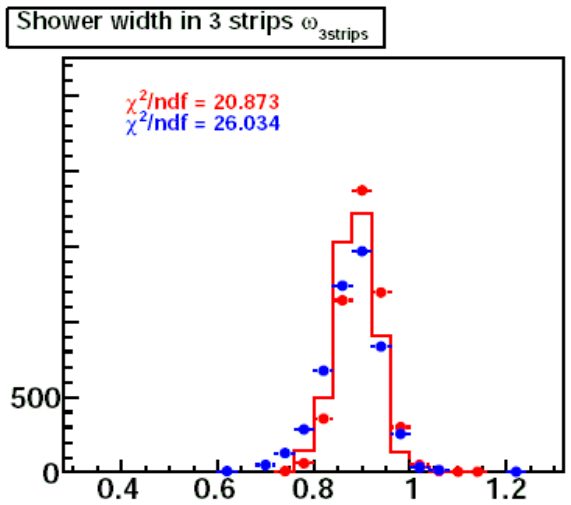


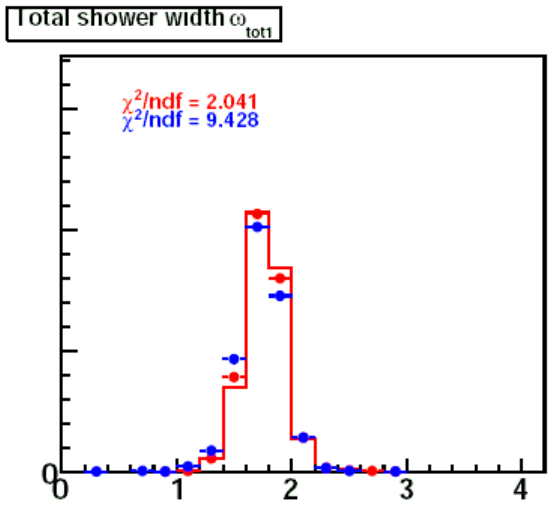


r12.3.0

— full simulation (e of 64 GeV at η=0.25)

- FS < 1 GeV < full simulation
- FS < 1 GeV < full sim < 12 GeV < parametrisation

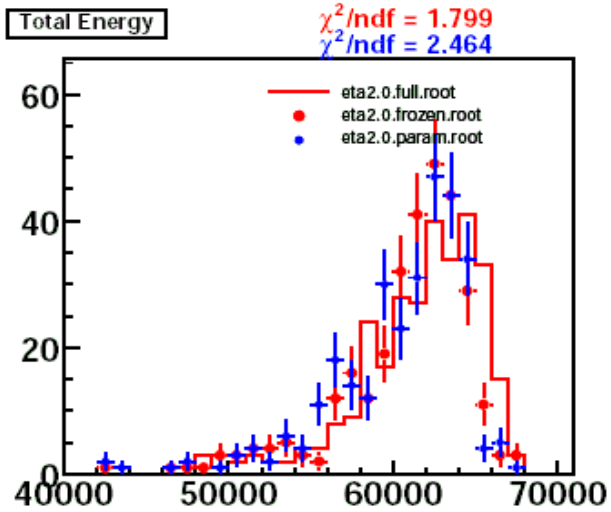


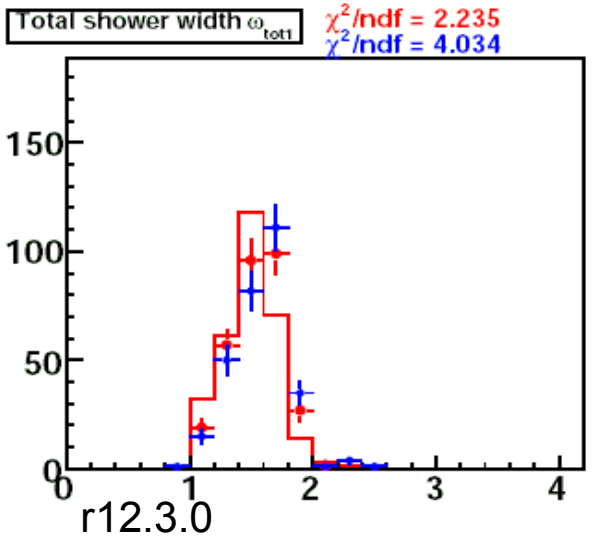


(EGamma container quantities)

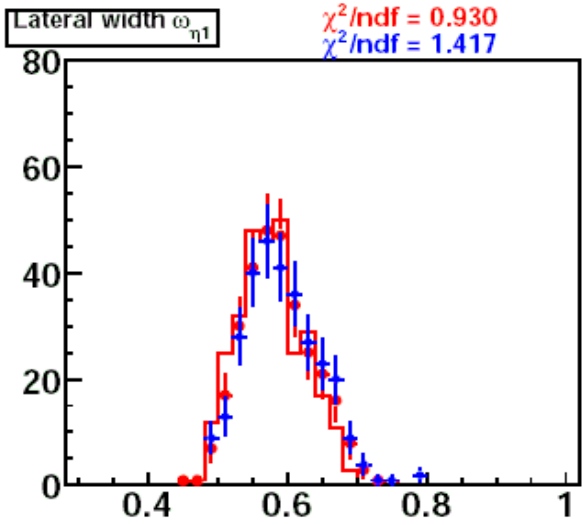
good agreement with full simulation

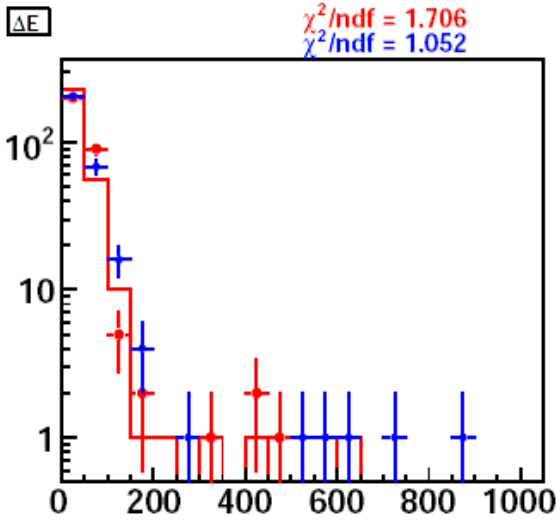
Performance of Frozen Showers: **EMEC**





- full simulation (e of 64 GeV at η=2.0)
  - FS < 1 GeV < full simulation
  - FS < 1 GeV < full sim < 12 GeV < parametrisation





good agreement with full simulation

Recent update of Frozen Showers: **Photon library**

Dijet spectrum numbers

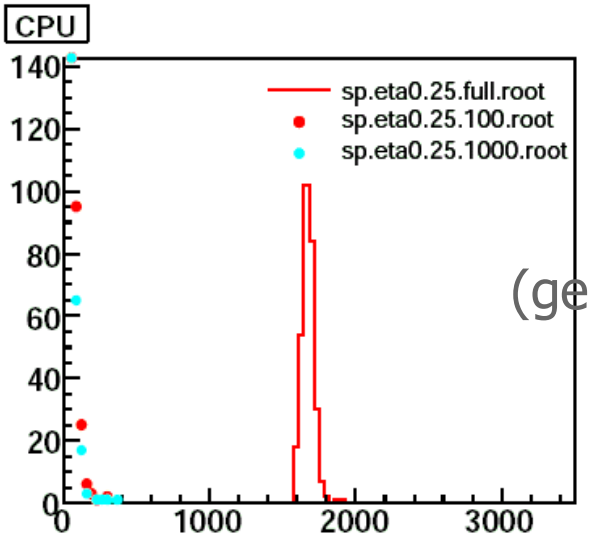
Energy range	Photons	$e^{\pm}$	Other particles
Up to 10 MeV	57582.9	2266	12
10 MeV-1 GeV	3834.7	1971.4	3387.2
1-10 GeV	91.2	64	529.3
From 10 GeV	9.6	6.3	39

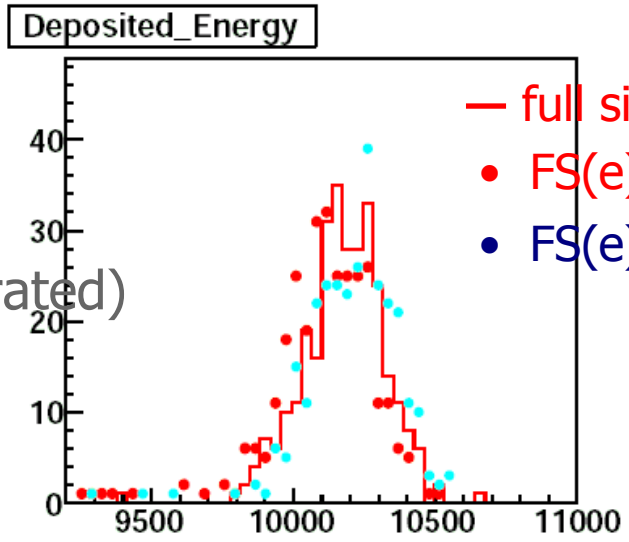
← low energy photons dominate, interesting region to parametrise

frozen shower library for photons?

preliminary studies show that another factor of 2 could be gained
use similar approach as for $e^{\pm}$

Photon shower library: performance



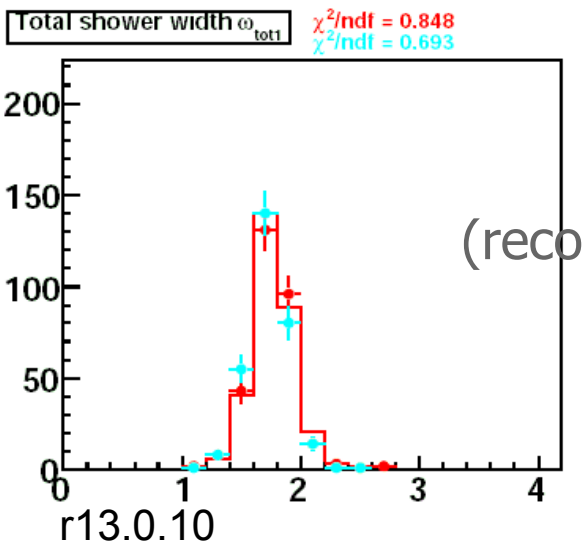


(generated)

— full simulation (e of 64 GeV)

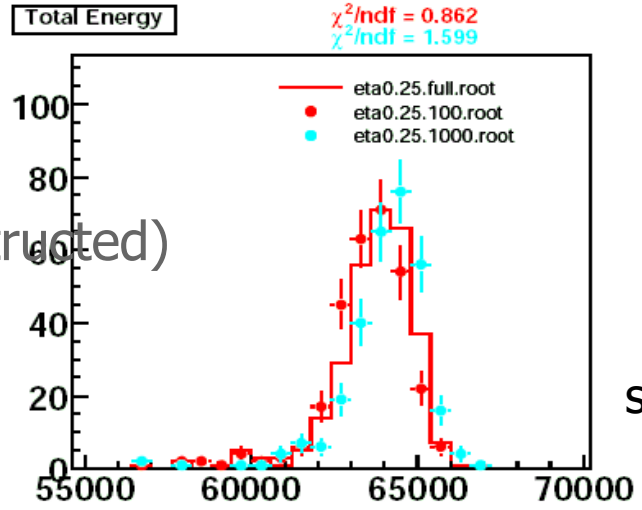
• FS(e) + FS(γ) up to 100 MeV

• FS(e) + FS(γ) up to 1 GeV



r13.0.10

(reconstructed)



<u>average time per event:</u>

full sim	16.0 s
FS(e)	0.9 s
FS(e)+FS(γ)	0.7 s

improvement in speed but less than expected (to be understood)

good description but still in optimisation phase

summary

- the novel idea for fast simulation of electromagnetic showers ("Frozen Showers") is developed, implemented and showing good performance (a factor of ~10 in speed, can be still improved)
- certain improvements (e.g. photon library) are being implemented and tested
- FS are already included in 13 release, large scale validation (energy, shower shapes, resolution, ...) to be carried out together with performance and physics groups

Backup slides

Implementation of Frozen Showers

ShowerLib class implementation (LArCalorimeter/LArG4/)

- LArG4FastSimulation - *does fast simulation*
- LArG4GenShowerLib - *creates shower library (record hits)*
- LArG4ShowerLibAthenaPool - *interface for ATHENA pool*
- LArG4ShowerLib - *defines classes for shower library*
- LArG4ShowerLibSvc - *service which provides showers from library to simulation*