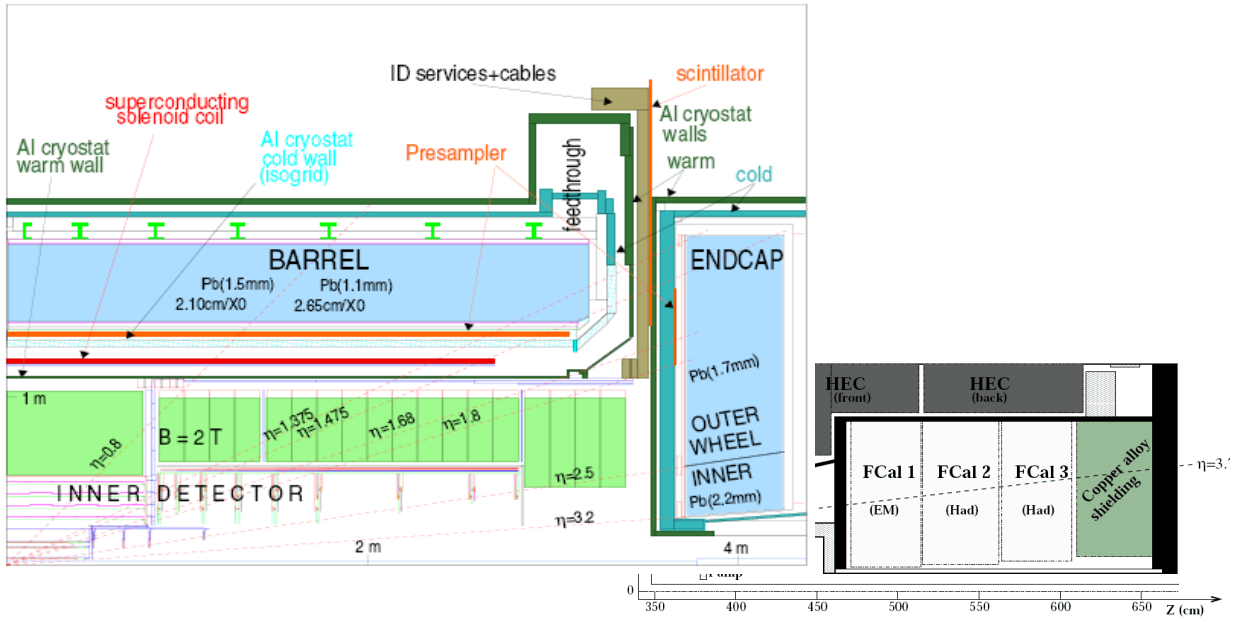
Fast Parametrisation of electromagnetic showers in LAr Calorimeter: Frozen Showers

Wolfgang Ehrenfeld, Alexander Glazov, Ringailė Plačakytė
DESY - ATLAS

- Introduction to Frozen Showers (FS)
- Study of FS energy response in different LAr calorimeters:
  - EMB
  - EMEC
  - FCAL
- Summary



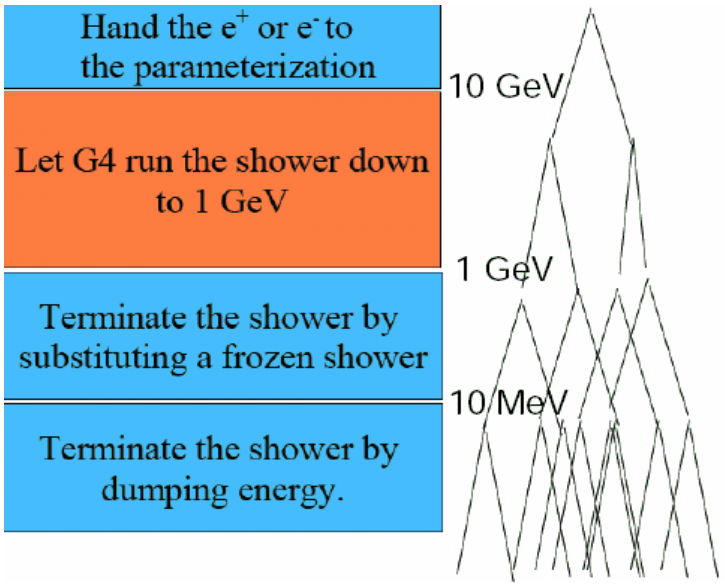
Introduction to Frozen Showers (FS)

The time needed to simulate EM shower in LAr calorimeter may be significantly reduced using fast shower parametrisation techiques (e.g. Frozen Showers) thus reducing overall simulation time

Frozen Shower Library (FS):

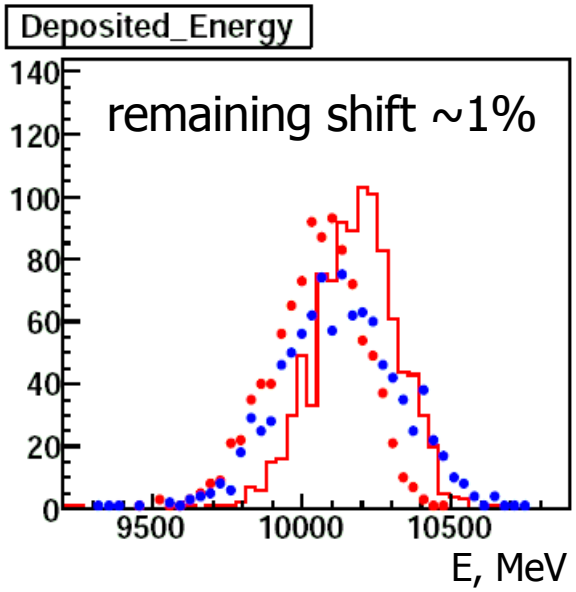
- full simulation down to 1 GeV cut-off
- pre-stored shower library of compressed GEANT hits

- shower shape description should have good agreement with full simulation



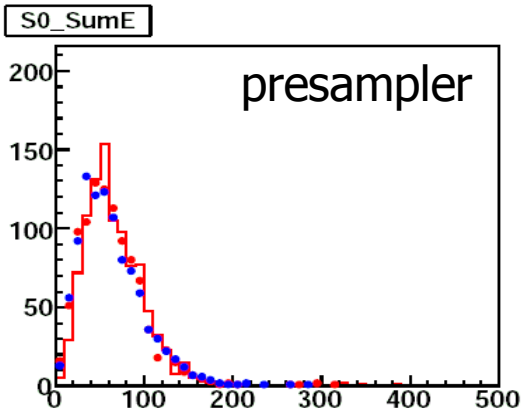
FS libraries are implemented for EMB, EMEC, FCAL1 calorimeters

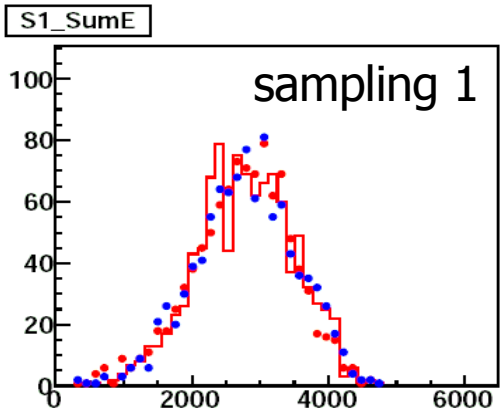
Performance of Frozen Showers: **EMB**, generator quantities

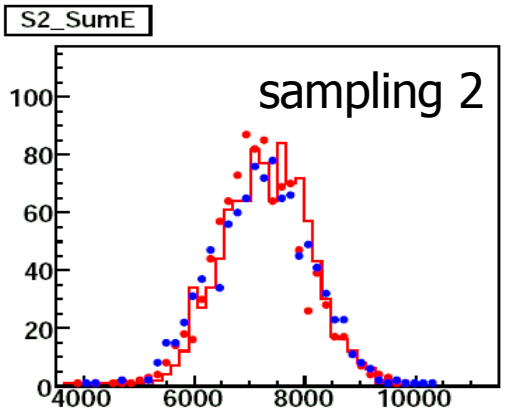


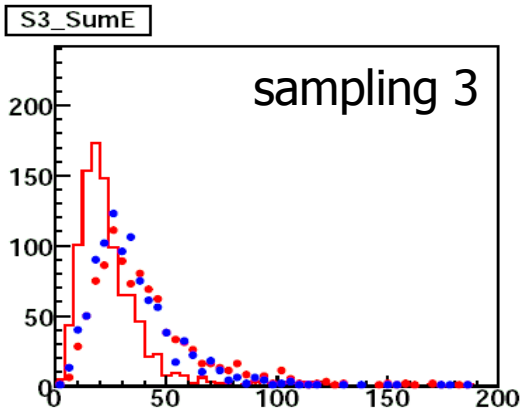
— full simulation (e of 64 GeV)

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







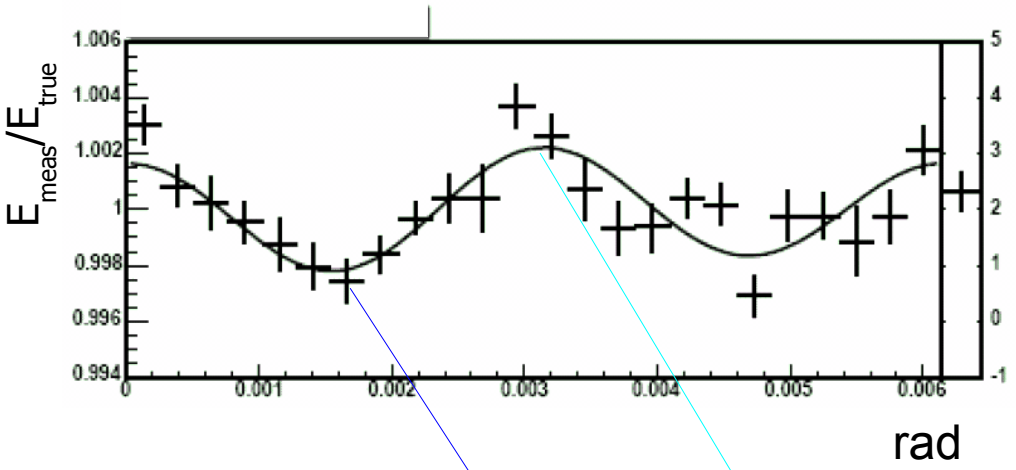


<u>average time per event:</u>

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

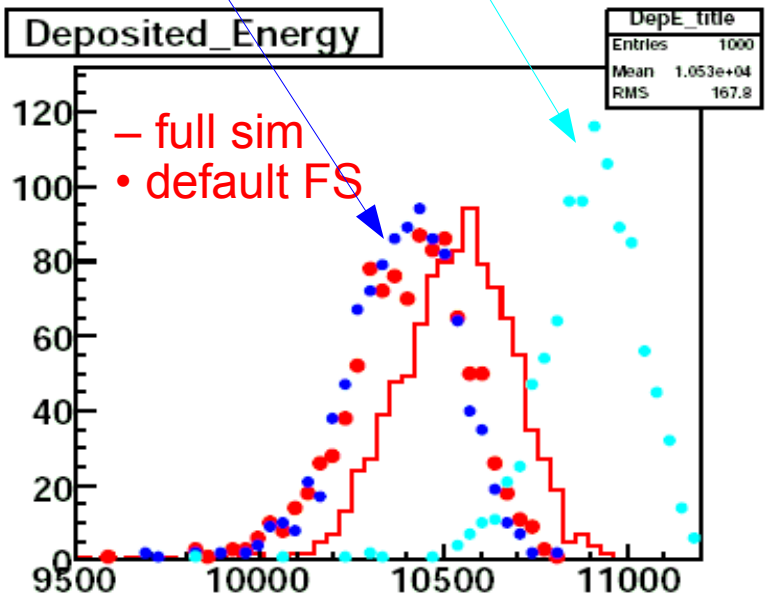
Energy shift in Frozen Showers vs Phi

FS library is generated 'injecting' particles to the calorimeter surface at fixed eta (e.g EMB eta binning: 1.3 1.1 0.75 0.85 0.5 0.3 0.1) and same phi

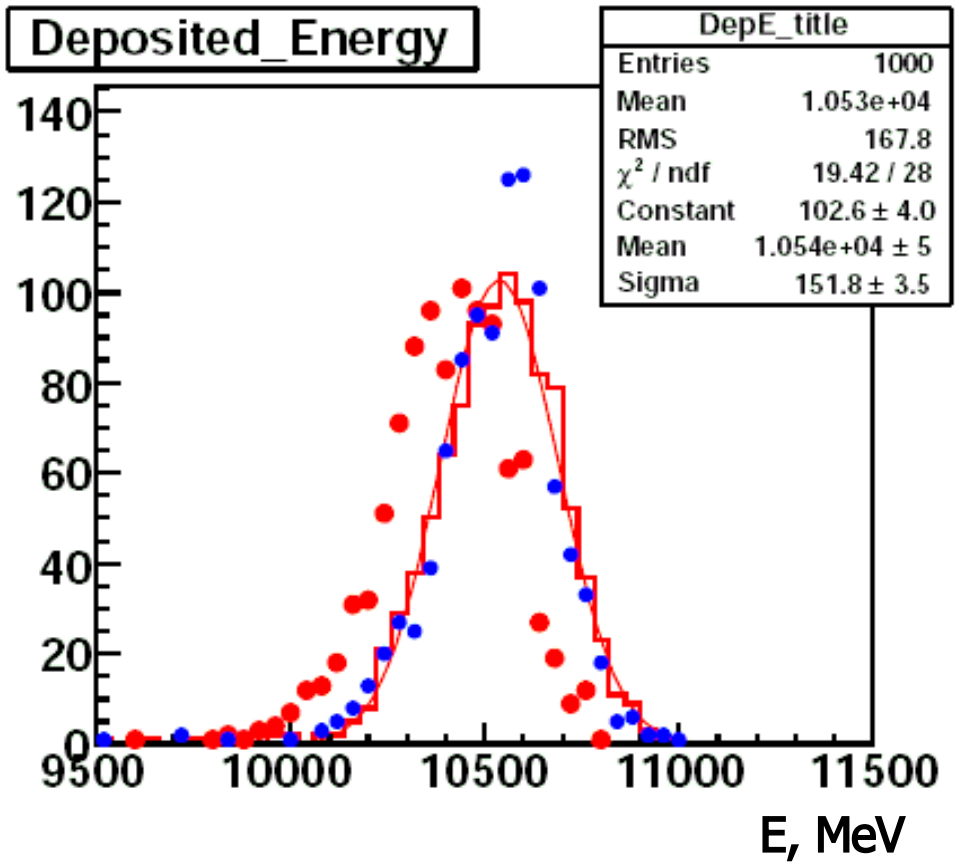


after generating FS libs at min/max of phi modulation...

... observed change in energy reaches 5%



Frozen Showers generated with average Phi: EMB



full sim (10529.5)

DepE_title	
Entries	1000
Mean	1.053e+04
RMS	167.8
χ^2 / ndf	19.42 / 28
Constant	102.6 ± 4.0
Mean	1.054e+04 ± 5
Sigma	151.8 ± 3.5

FS(e) (10400.4)

DepE_title	
Entries	1000
Mean	1.04e+04
RMS	163.9
χ^2 / ndf	40.31 / 24
Constant	100.1 ± 4.1
Mean	1.04e+04 ± 5
Sigma	152.8 ± 4.0

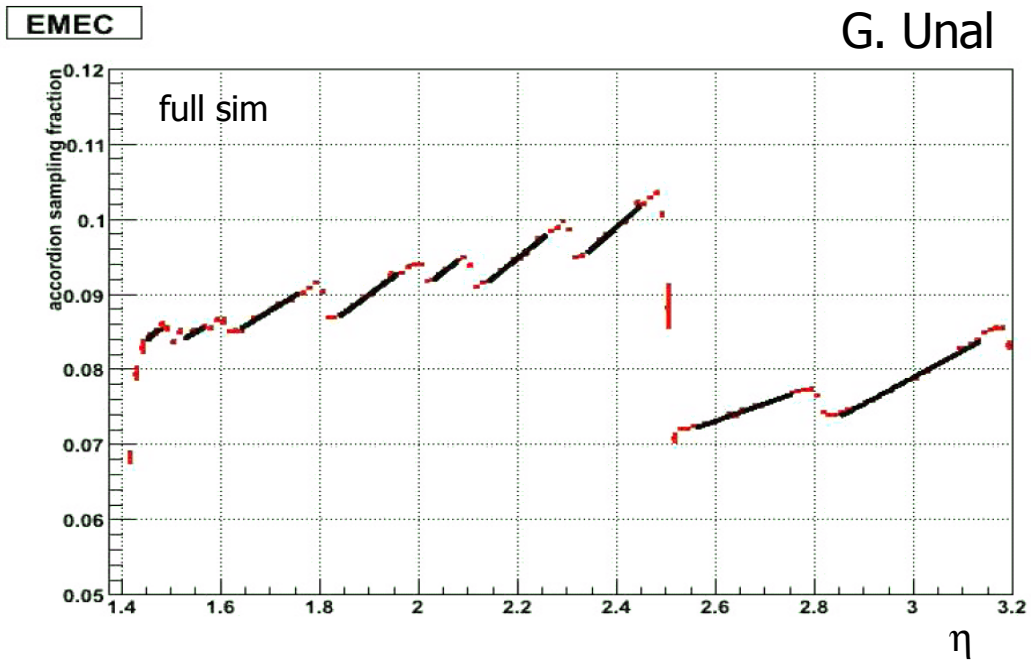
FS(e) with av φ (10527.5)

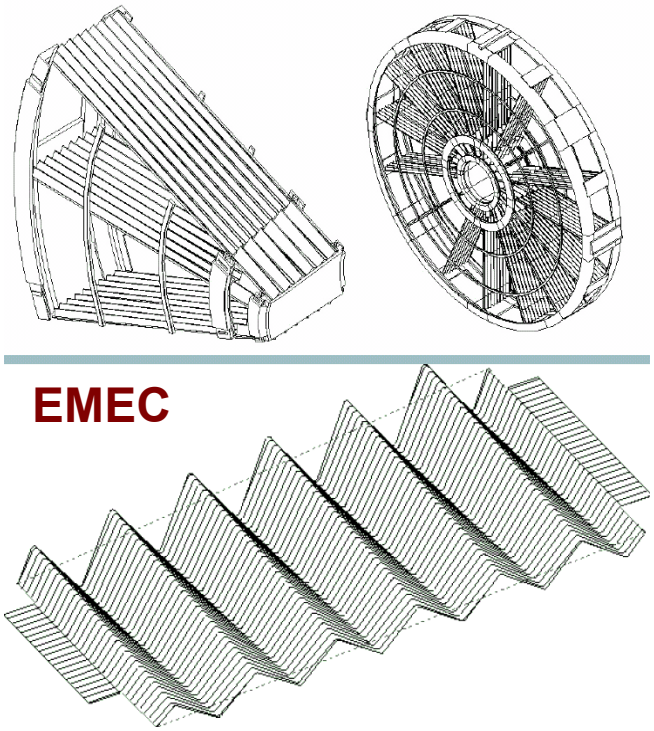
DepE_title	
Entries	1000
Mean	1.053e+04
RMS	156.4
χ^2 / ndf	50.63 / 25
Constant	108.3 ± 4.7
Mean	1.054e+04 ± 5
Sigma	139.8 ± 4.1

- Full sim and new FS have the same mean
- new FS distribution width is more narrow than full sim (was larger)

Frozen Showers for EMEC

Reminder: EMEC FS library is fine binned in eta (14 bins) in order to describe energy responds as a function of eta (~10 % effect):

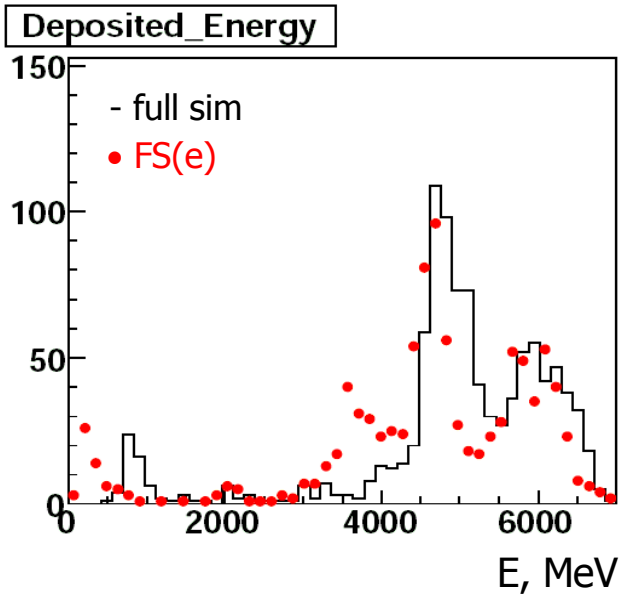


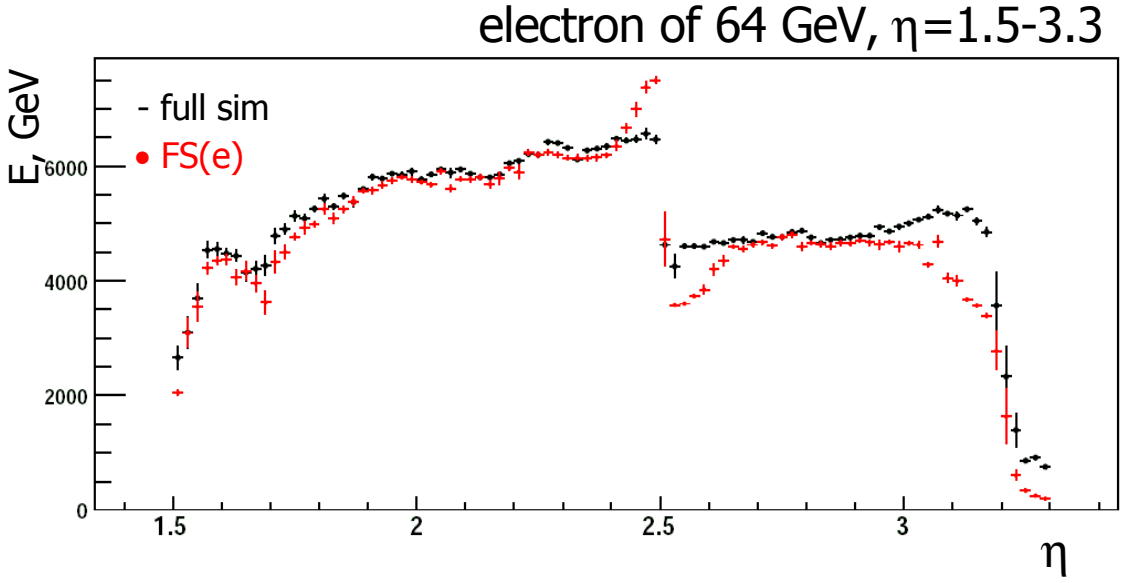


EMEC library eta bins: 1.62, 1.78, 1.82, 1.98, 2.02, 2.08, 2.12, 2.28, 2.32, 2.4, 2.6, 2.78, 2.82, 3.15

Frozen Showers for EMEC

Averaging in phi FS library brings small improvement to EMEC compare to the shower response in the crack and edge regions:



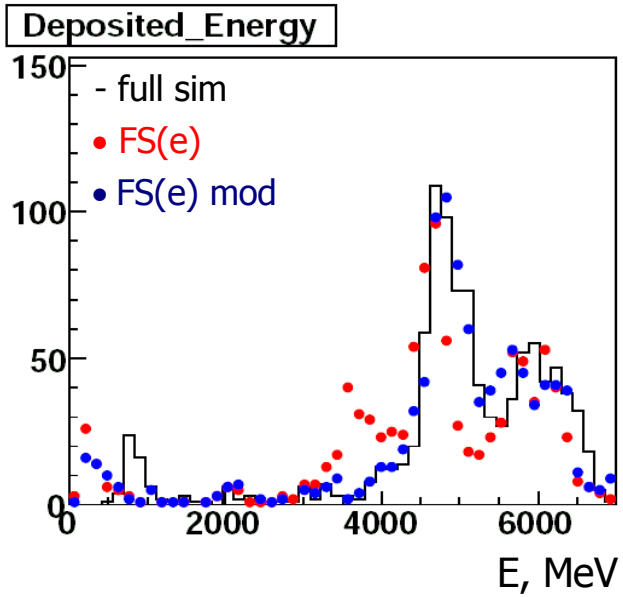


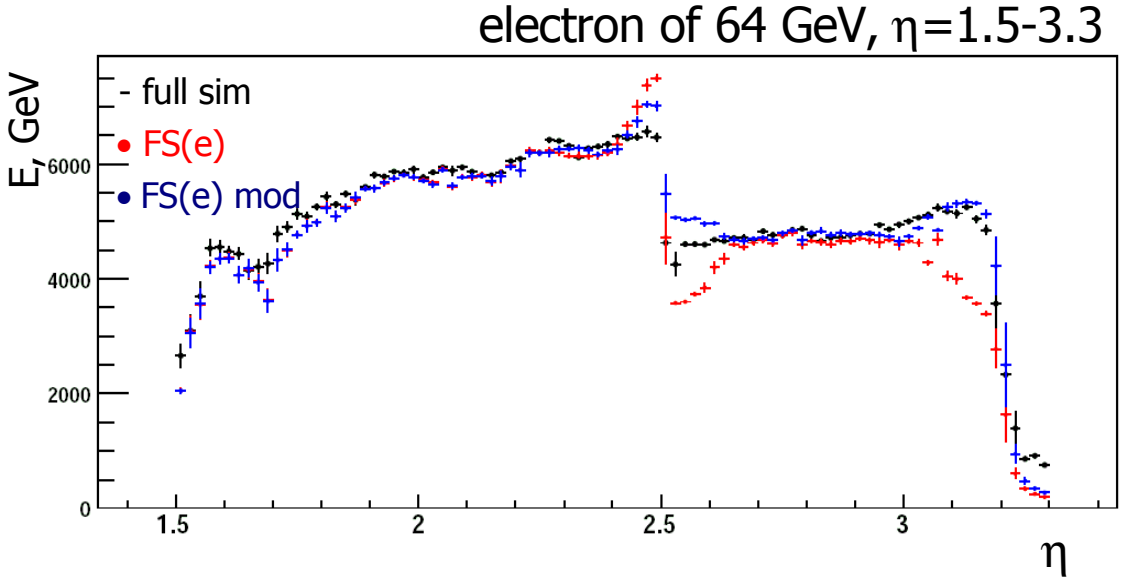
r13.0.40

Frozen Showers for EMEC

Possible to improve FS response generating library with the eta bins more far from the crack/edge region

e.g. generate FS lib bin at eta=2.8 while read the same bin as it was generated at eta=3.15





→ improved energy description (could be further improved)

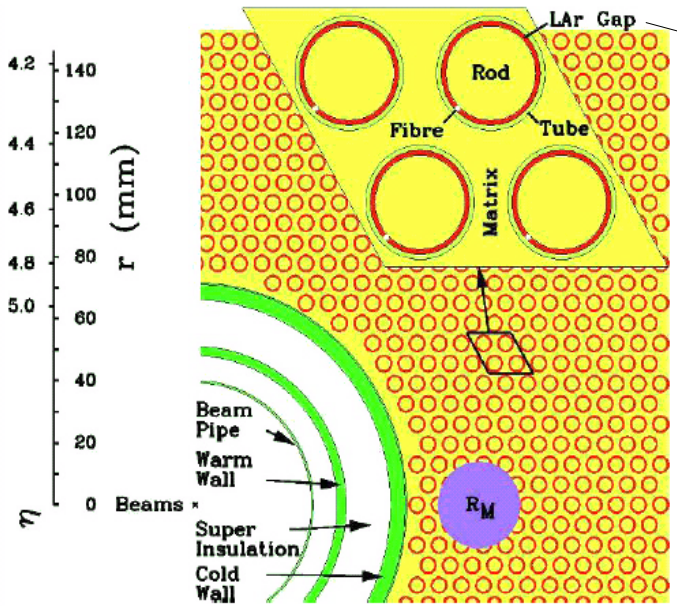
Frozen Showers for FCAL1

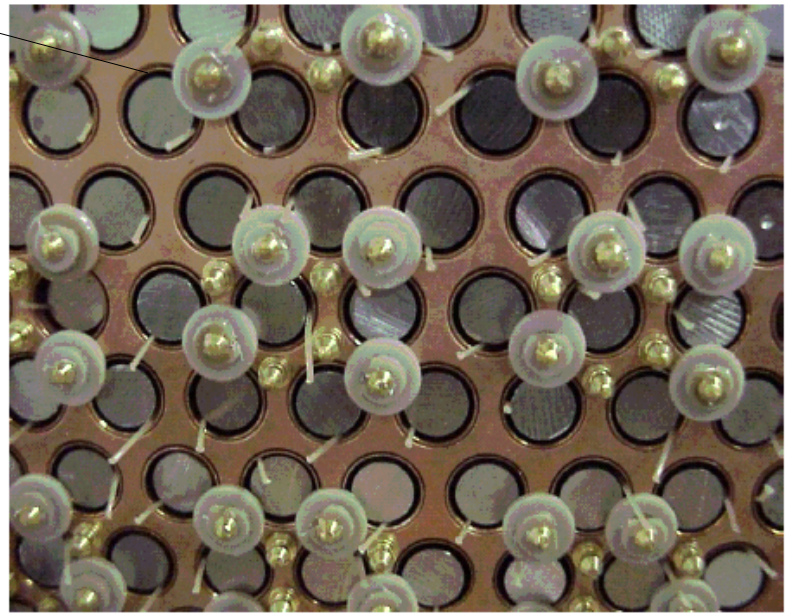
- EMB and EMEC frozen libraries has energy and eta binning
- FCAL response has little eta dependence BUT low energy showers are strongly depend from the LAr gap (position dependence)

FCAL1:

hexagonal array of cooper tubes/rods

LAr gaps in between

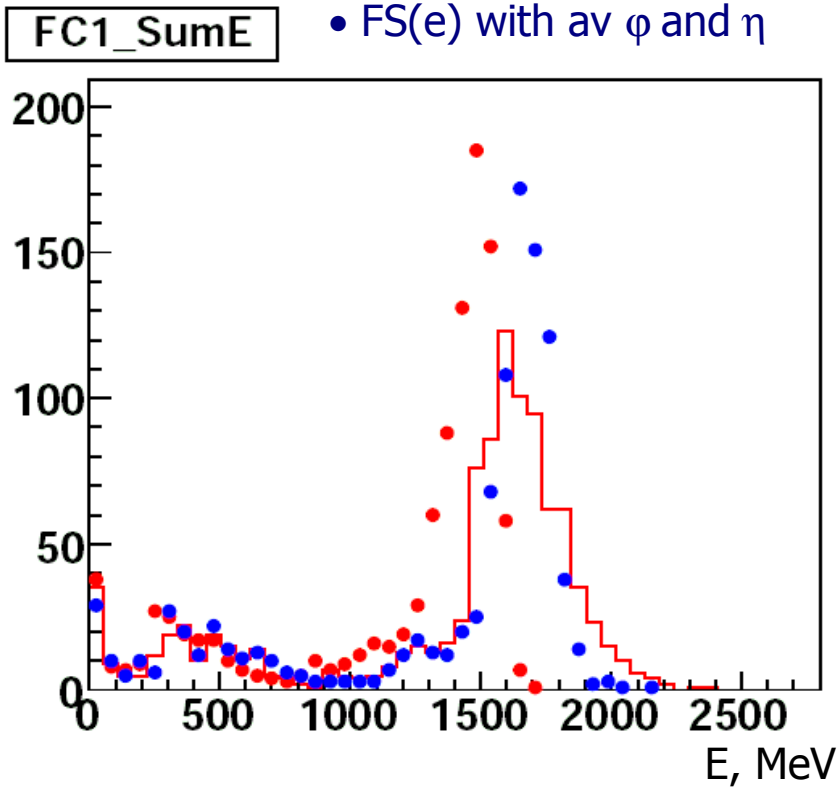


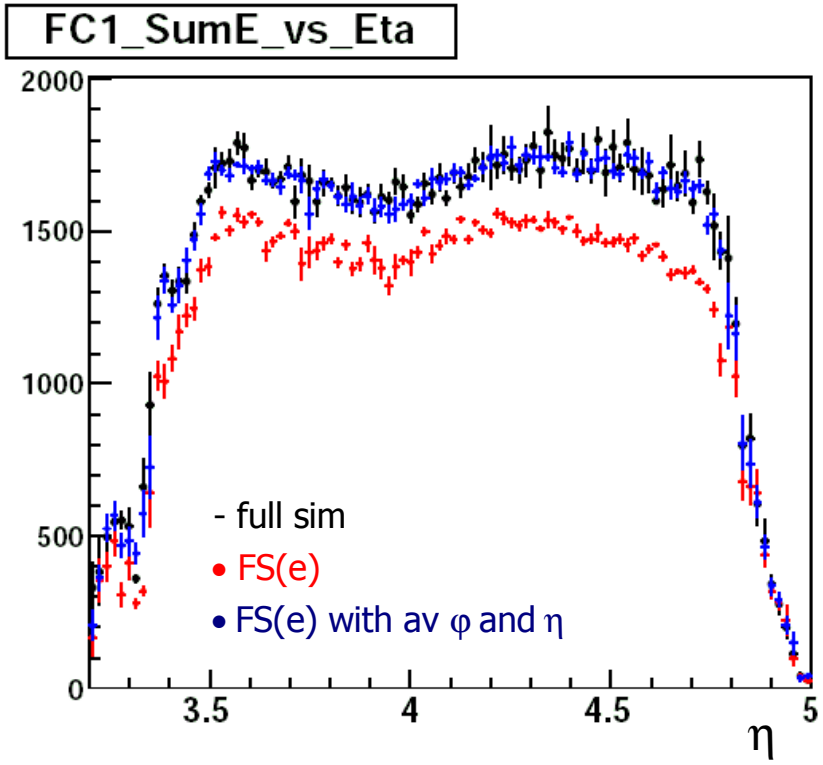


- Now eta bins are replaced with the distance from the center of the closest rod (two bins: in and outside the gap)

Frozen Showers generated with average phi, eta: FCAL1

- full sim (e of 64 GeV)
• FS(e)
• FS(e) with av φ and η

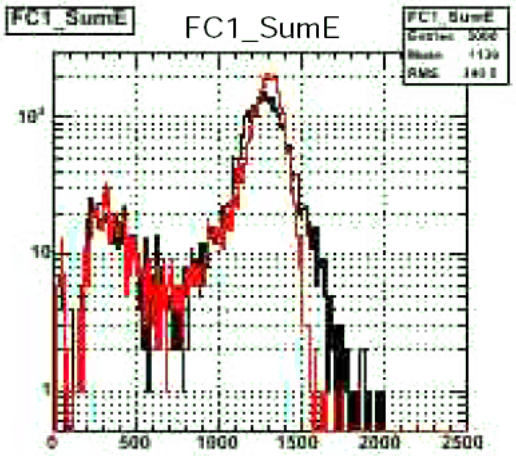


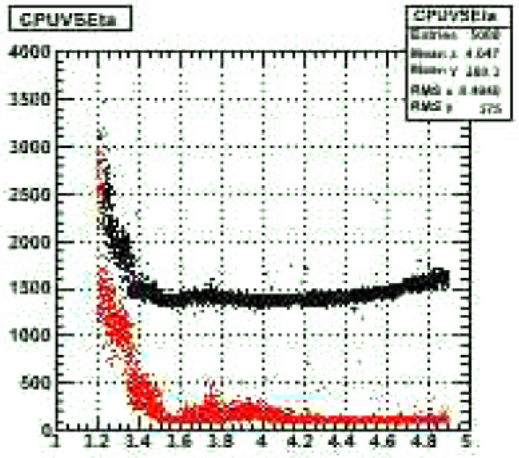


- much better energy description (still more narrow with respect to the full simulation)

Frozen Showers generated with average phi, eta: FCAL1

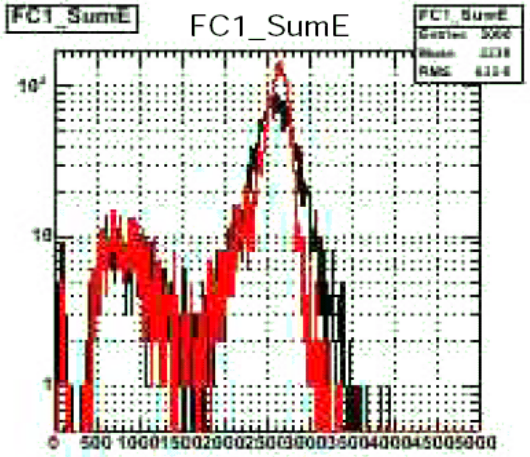
- full sim (50 GeV e^-)
  - FS(e)

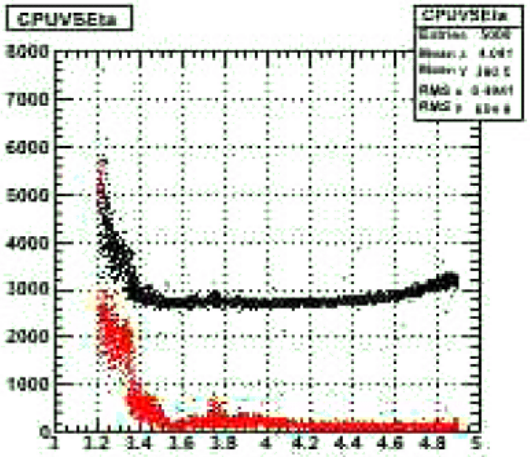




CPU VS Eta

- full sim (100 GeV e^-)
  - FS(e)





CPU VS Eta

SL Cheung

Open issues

- Storage of the shower libraries: database instead of text files
- Separate instance of the service for different calorimeters (difference of FCAL binning)
- Tuning of EMEC (crack region and phi boundaries)
- Understanding of resolution difference/adding extra smearing

Summary

Frozen Shower performance is good in EMB, EMEC, FCAL1 calorimeters
(here mainly energy response of Frozen Showers has been presented)
with
the improvement in time of ~10 times
(~2 of the whole simulation time)

some additional work is required to improve further