The Simulation of the ATLAS Liquid Argon Calorimetry

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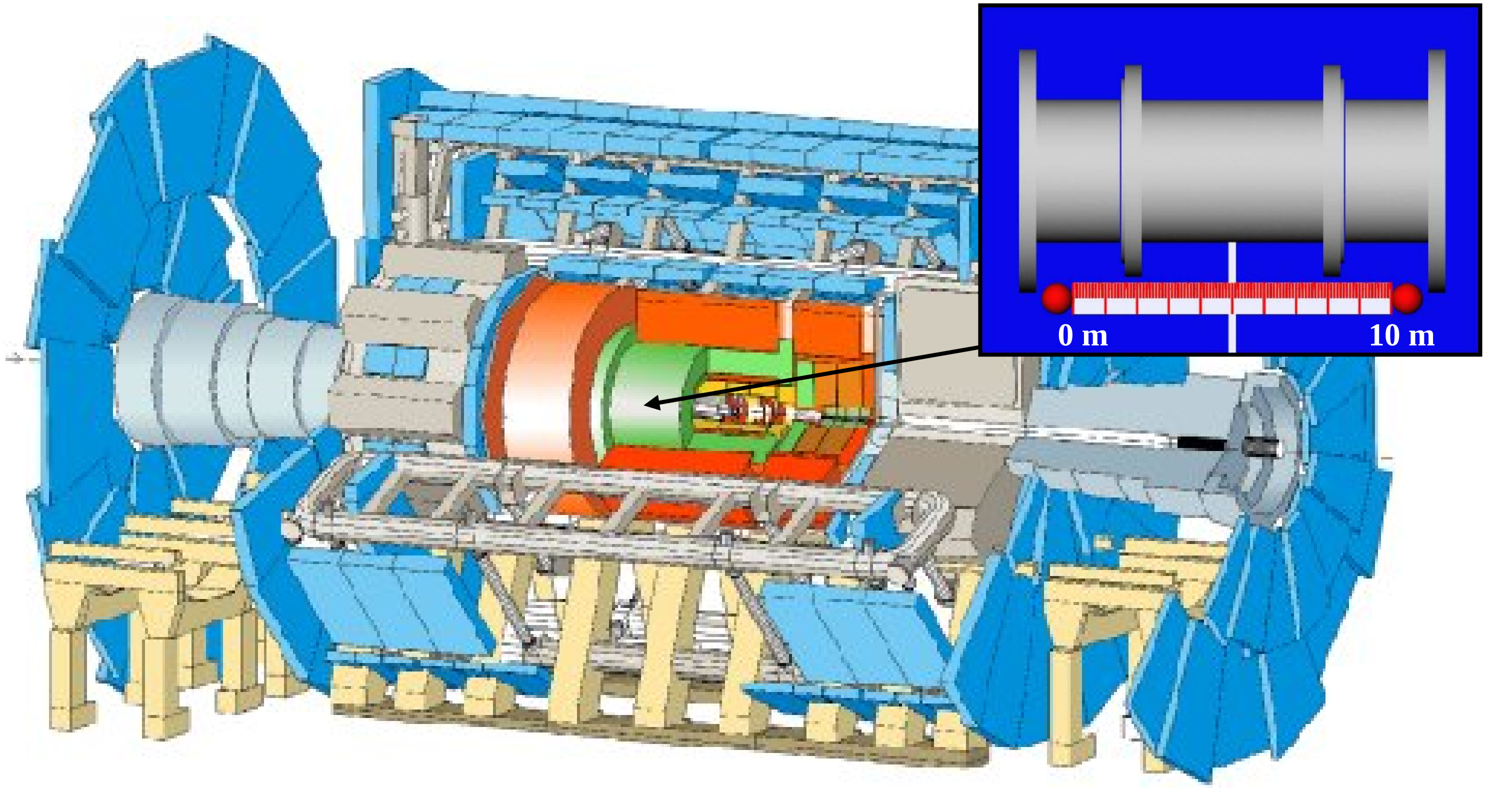
On behalf of the ATLAS collaboration Liquid Argon Calorimetry Group

The Liquid Argon Calorimeter in ATLAS



Sampling calorimeter

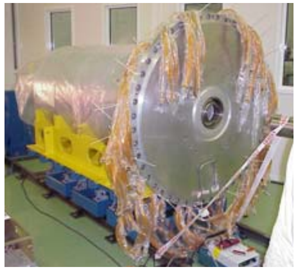
Active	:	Liquid Argon (LAr)
passive	:	Metals and alloy

4 LAr sub-detector systems

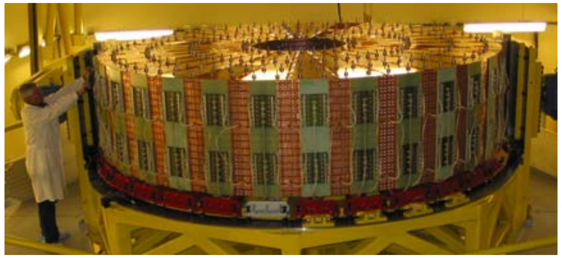
Electromagnetic + Hadronic calorimetry

Electromagnetic Barrel (EMB)

Forward Calorimeter (FCAL)



Hadronic Endcap (HEC)



Electromagnetic Endcap (EMEC)

Motivation for a Full Simulation

Stringent calorimetry performances required by physics :
Rare final states, High background

i.e : $H \rightarrow 2\gamma$
limited instrumental mass resolution
$\Gamma_H \sim MeV$
$\Rightarrow \Delta m / m < 1\%$ *required*

High energy (100+ GeV) $\Rightarrow$ mostly systematic effects

Understand, Calibrate these systematics
Requires a detailed description

A few Facts about the Simulation

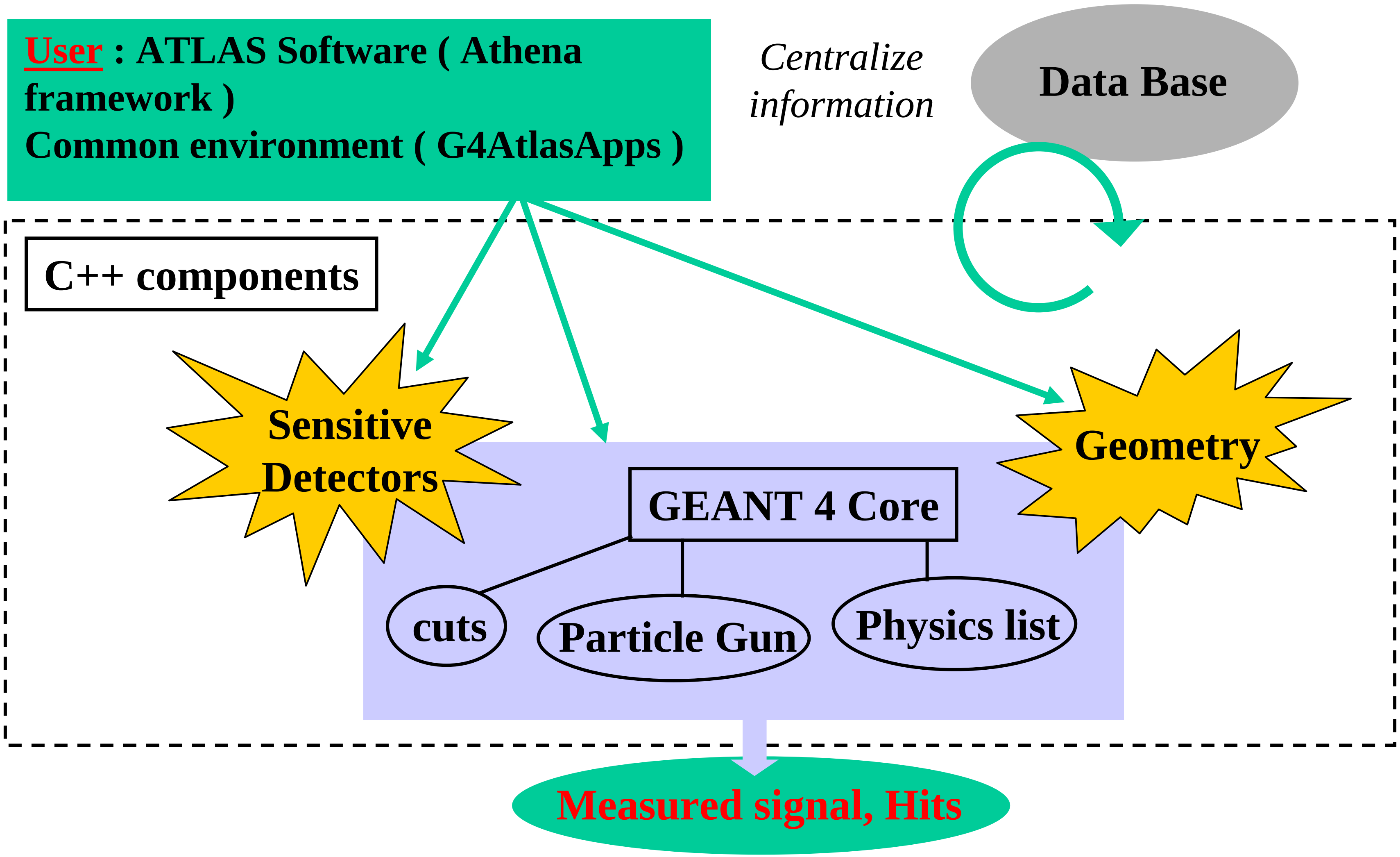
Simulation started in GEANT3 …
Now full GEANT4 core integrated in ATLAS software (Athena)

Used Regularly : Big exercises, data challenges
e.i : Rome production ~ 8.5 M events simulated

Distributed community of physicists

Validation : Comparison to experimental data
Multiple test beam setups, Stringent constraints

Global Overview of the Simulation



The Geometry Description

Key entry : complex geometries, fine effects

Data Base

Setup : Full detector, Test beam, CTB, Cosmic

materials

Single Components Description

GeoModel Layer

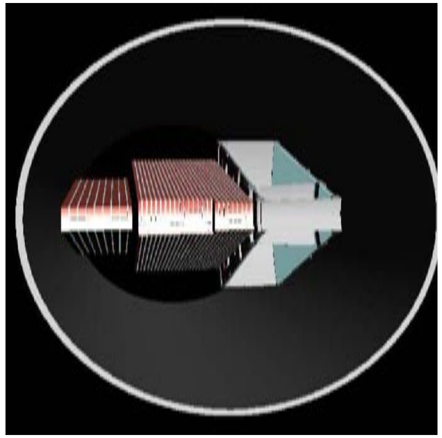
disentangle geometry description from GEANT4
alignable transforms, version control

Centralize information on geometry

Geant 4 description

2002 EMEC/HEC

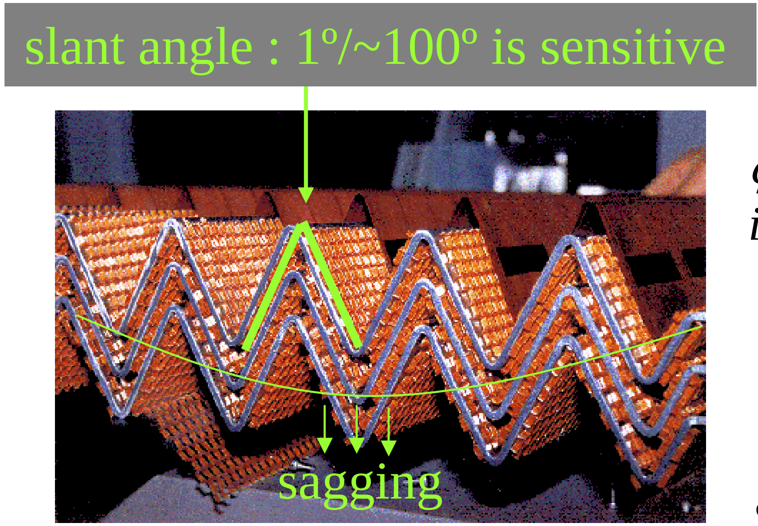
Visualisation tools required
e.i: v-atlas



Non-Uniformities Control

Design specificities : may be deliberate or not

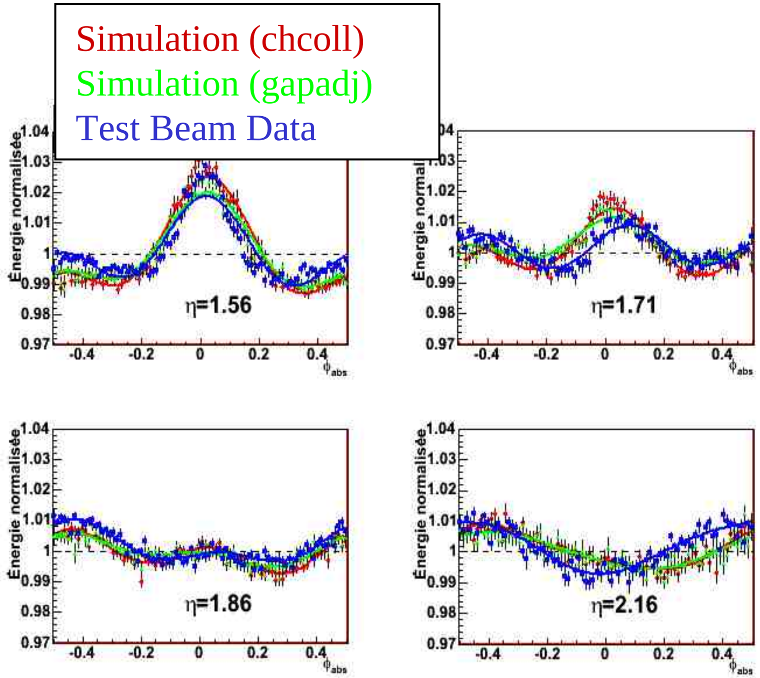
<u>For example</u> : ϕ-modulations in the EM calorimeters



EM calorimeter : Pb absorbers
Peculiar accordion shape

ϕ-modulations in the EMEC

Calorimeters response is affected ~ 3 %



Response to 120 GeV e-showers

Complex behaviour, but … good for validation

Understand fine effects / We can provide control on non-uniformities

$\Rightarrow$ *an 'as built detector' : HV, sagging, misalignment*

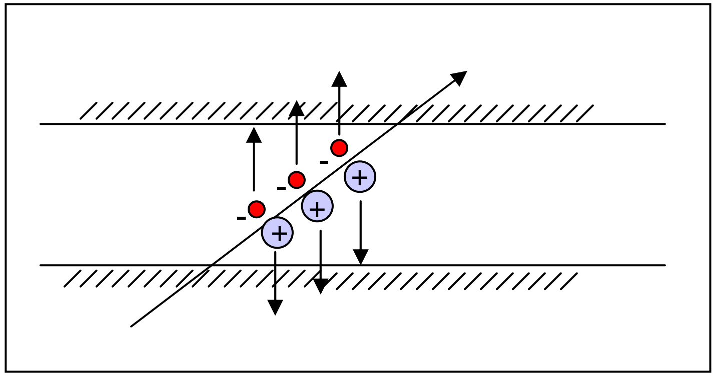
Sensitive Detectors and Visible Energy

Large number of GEANT tracks ⇒ hits are <u>binned</u>

<u>Active volumes</u> :

readout cells define bins

Sensitive detectors for Charge collection methods



$$\frac{\Delta I_0}{\Delta E} \propto r(\varepsilon)\times v_d(\varepsilon)\times\frac{\varepsilon}{V}$$

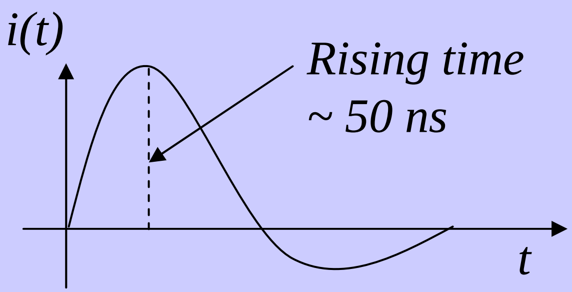
current — recombination — electric field map

energy Deposition (GEANT 4) — drift velocity — high voltage

Include the electronics response

e.i: deposition too close electrode

⇒ suppressed



Dead Materials Calibration

Passive volumes :

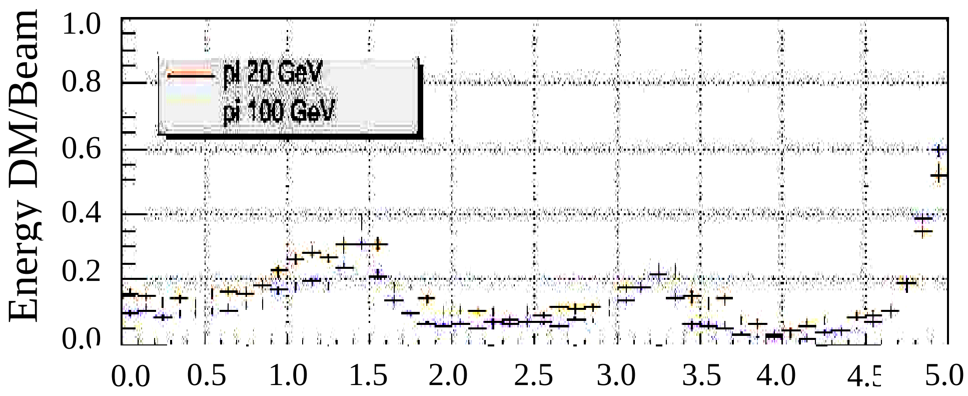
Bins in angular grid in $\eta\times\phi$

Reconstruction :

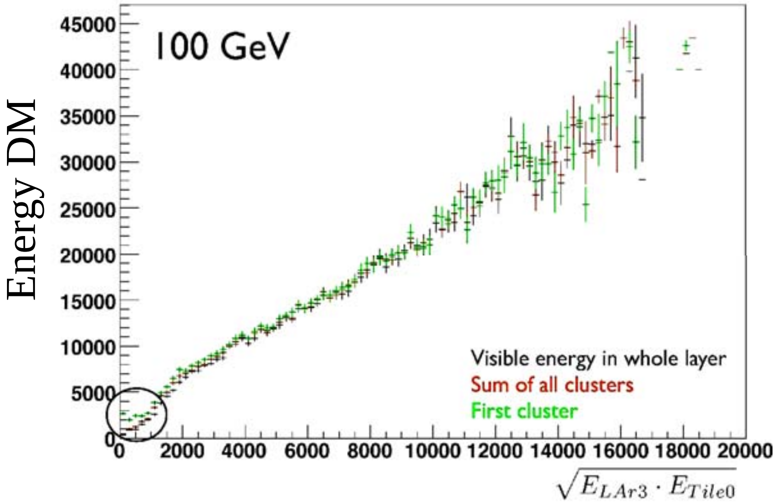
Recover energy 'lost' between sub detector elements

$\Rightarrow$ Use the simulation for calibration

Fraction of energy lost in dead materials



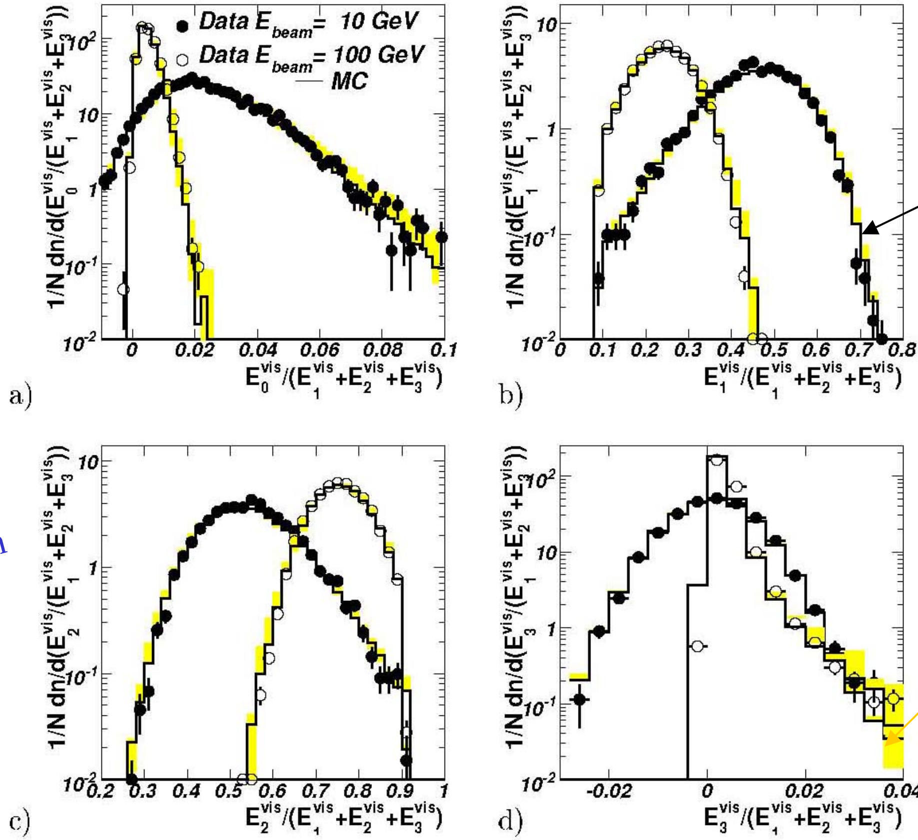
Recover energy from neighbouring active cells



Example : The LAr-Tile crack

Accuracy : EMB Test Beam

Good agreement between data and MC / MC used in calibration scheme



Solid black Monte-Carlo

Data :
● 10 GeV
○ 100 GeV

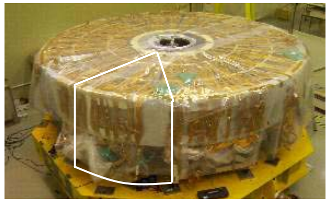
Yellow band MC uncertainties

'Energy Linearity and Resolution of the ATLAS Electromagnetic Barrel Calorimeter in an Electron Test Beam'
M. Aharrouche *et al.*
Submited to NIM

10 GeV and 100 GeV electron showers
Visible energy in pre-sampler and various samplings

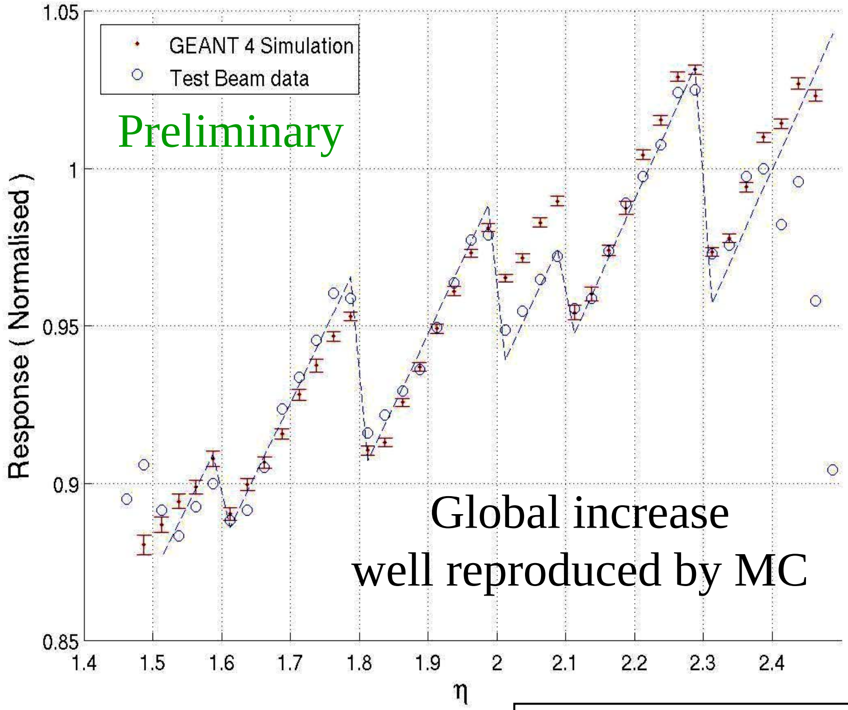
0.1 % agreeement on mean visible energy linearity

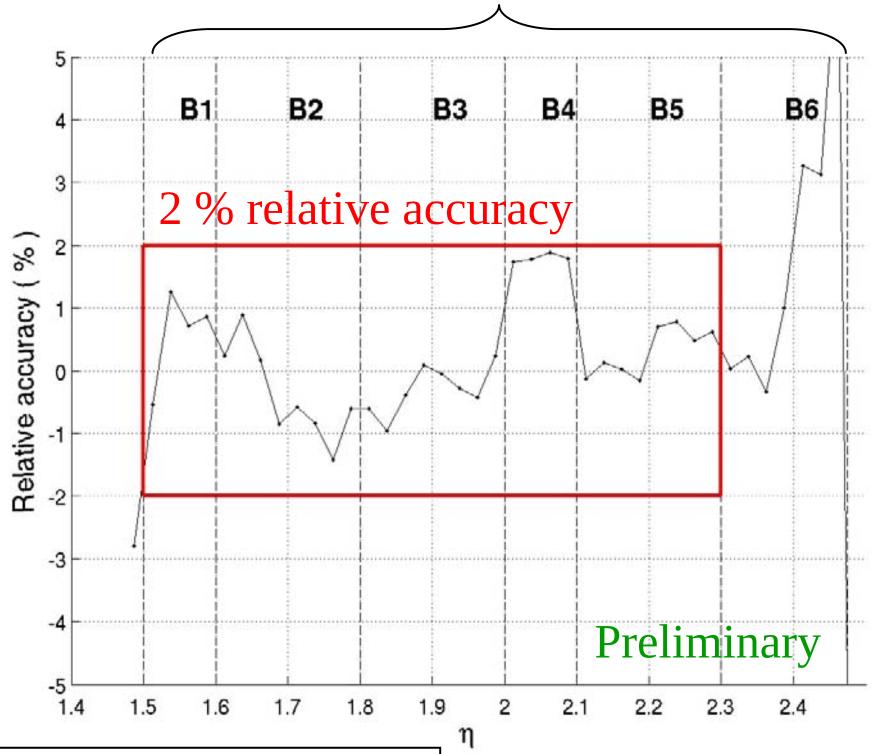
Accuracy : EMEC Test Beam



More complex response
General agreement, but work left on fine details …

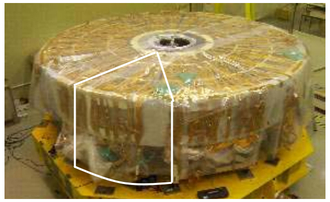
High Voltage sectors





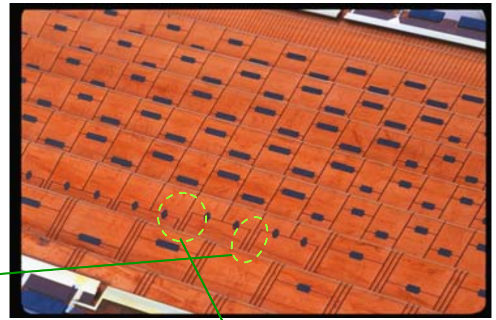
Simulation 'ideal detector' vs Test Beam
EMEC, 120 GeV electron Showers

Accuracy : EMEC Test Beam



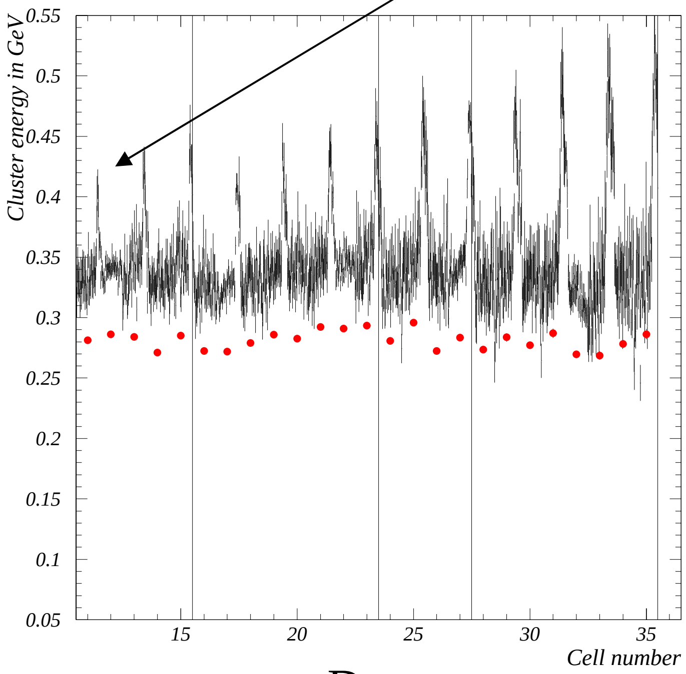
Muons (100-150 GeV)

Fine structure of electrode compartments well reproduced



EMEC electrode

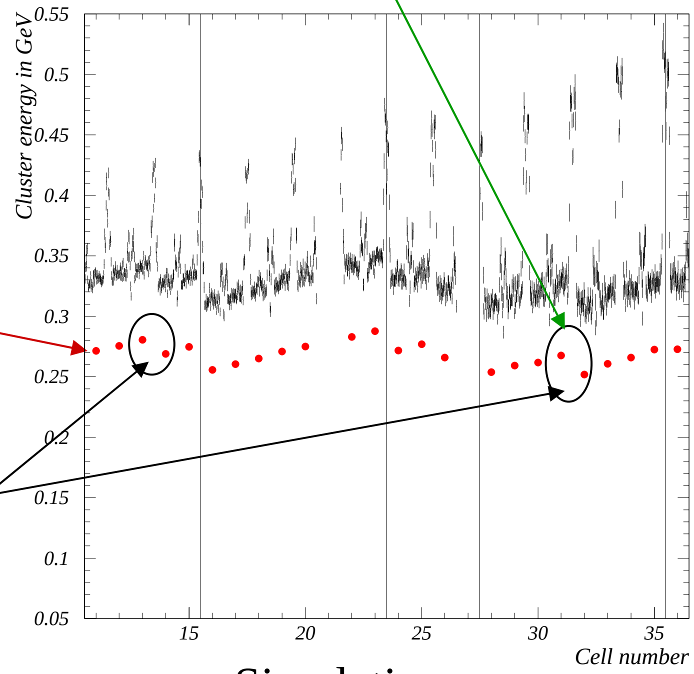
HV strips



Data

Peak of the Landau

Drops in middle's length



Simulation

Ressources Usage

Simulation time for 100 GeV electron showers
(GEANT 4.7 : standard cuts)

Benchmark	Time per event (KSI2K minutes)
G4AtlasApps	9.5
EMEC Test Beam	1.7

Memory usage :
~ 600 Mbytes
(50 % GEANT 4)

Simulation time can be affected by a factor of :

•Looser cuts (30 µm → 1 mm)	~ 1.5
•GEANT 4.8 : more accurate Multiple Scattering but slower	~ 0.5
•Parameterisation for EM showers (single e : 0.5-100 GeV)	~ 20-100

Obvious balance between accuracy & time

Conclusion and Outlook

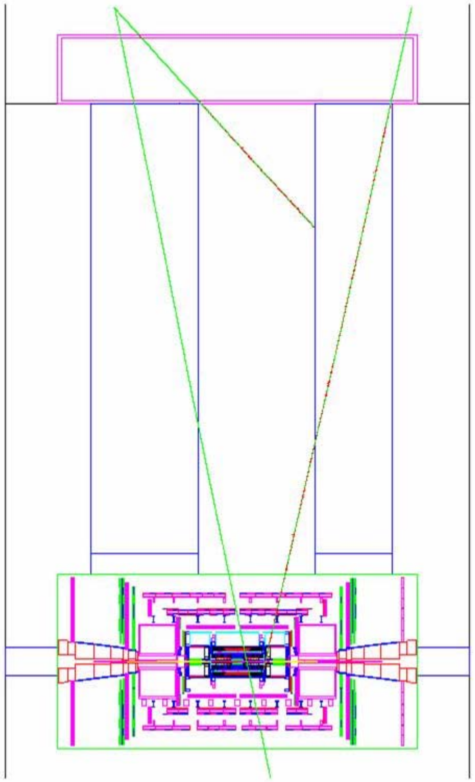
- Good over-all description/Simulation of detector
- Cross-check with various TB

- Stabile & reliable : Good shape for Full ATLAS Data Taking

So what's next ?

- Track down fine effects, systematics and provide an ‘as built detector’
- Cosmics rays simulation studies …

cosmic μ



ATLAS