ATLAS Tile Hadronic Calorimeter:

status, commissioning and performances

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OUTLINE

TileCal concept

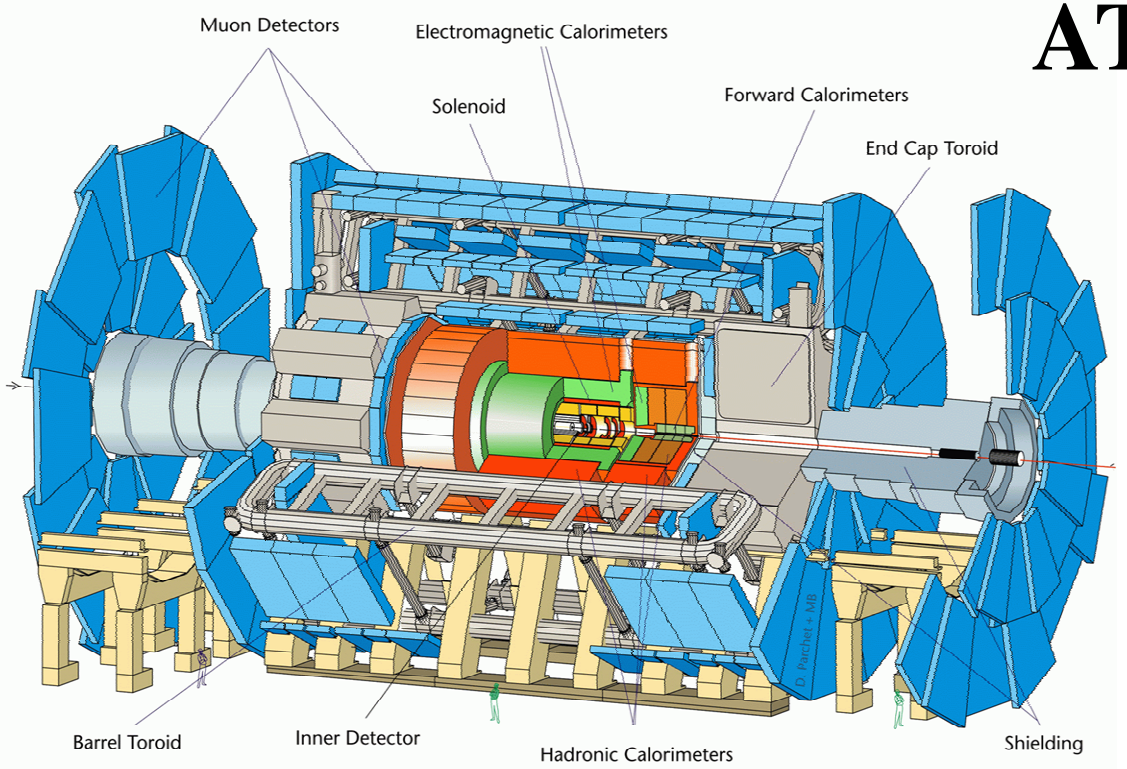
Construction

Commissioning

Performances

Conclusions

ATLAS DETECTOR



to exploit at maximum the discovery potential of LHC

Length : ~ 46 m
Radius : ~ 12 m
Weight : ~ 7000 tons
~ 10^8 electronic channels
~ 3000 km of cables

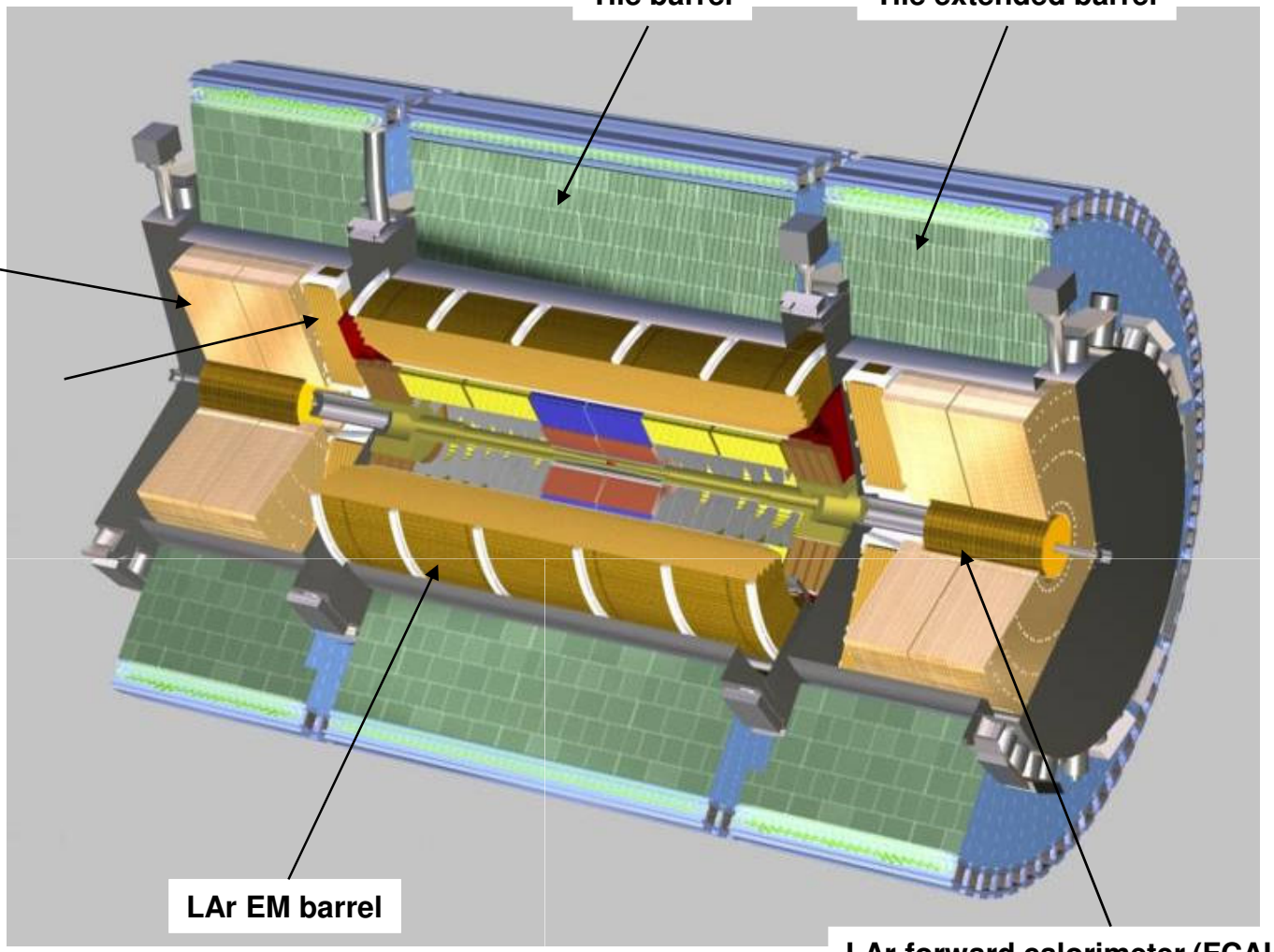
- **general study of p+p at $\sqrt{s} = 14$ TeV**
- **study of Pb+Pb collisions at 5.5 TeV per nucleon pair**

- **Tracking ($|\eta|<2.5$, B=2T) :**
  - **-- Si pixels and strips**
  - **-- Transition Radiation Detector (e/π separation)**

- **Calorimetry ($|\eta|<5$) :**
  - **-- EM : Pb-LAr**
  - **-- HAD: Fe/scintillator (central), Cu/W-LAr (fwd)**

- **Muon Spectrometer ($|\eta|<2.7$) :**
  air-core toroids with muon chambers

ATLAS calorimeter system : LAr and Tile Calorimeters



TileCal:

Inner Radius: 2280 mm

Outer Radius: 4230 mm

Each Tilecal barrel has 64 modules

EM : $|\eta| < 3.2$

HADRONIC:

TileCal $|\eta| < 1.7$

EndCap :

$1.5 < |\eta| < 3.2$

Forward :

$3.2 < |\eta| < 4.9$

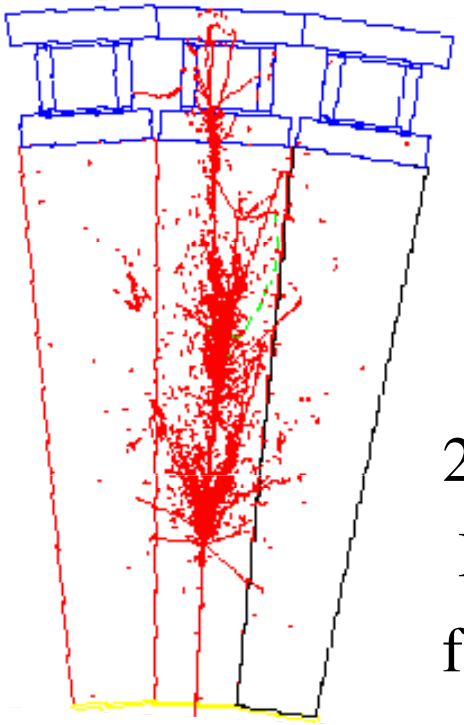
Active medium :

-Scintillating Tiles: Tile Hadronic Calorimeter (TileCal)

- **LAr :** EM barrel and EM end-cap, Hadronic end-cap, Forward Calorimeter

TILECAL Calorimeter Concept

Measure light produced by charged particles in plastic scintillator



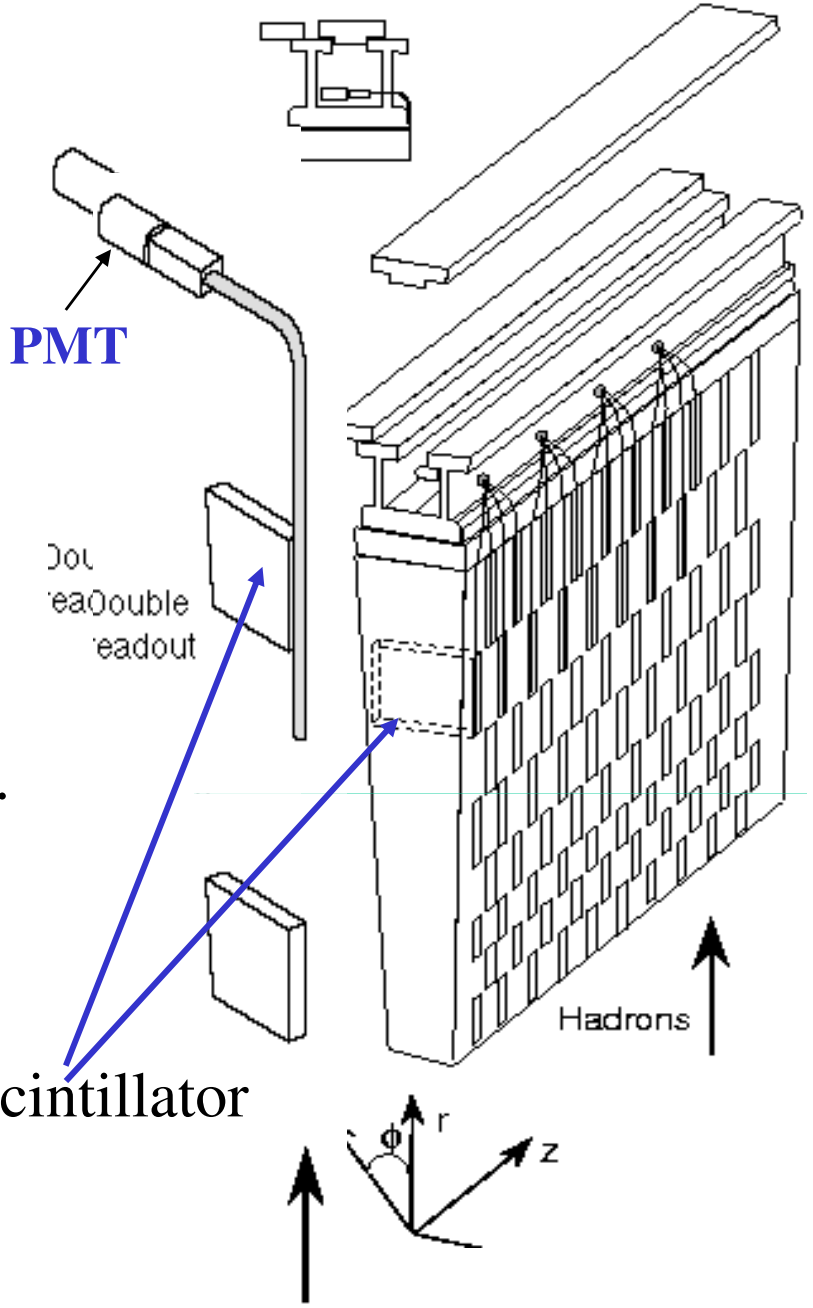
Particles

Plastic scintillator inside steel absorber structure. (456 000 tiles)

2 fibres / scintillator.

Bundle fibres to form cells of 0.1 x 0.1 (η,φ)

2 PMT's (channels) per cell



Segmented into 3 layers:

1.5, 4.1, 1.8 λ_{int}

Construction and instrumentation of Tilecal

- 1993–1995 **R&D 34**

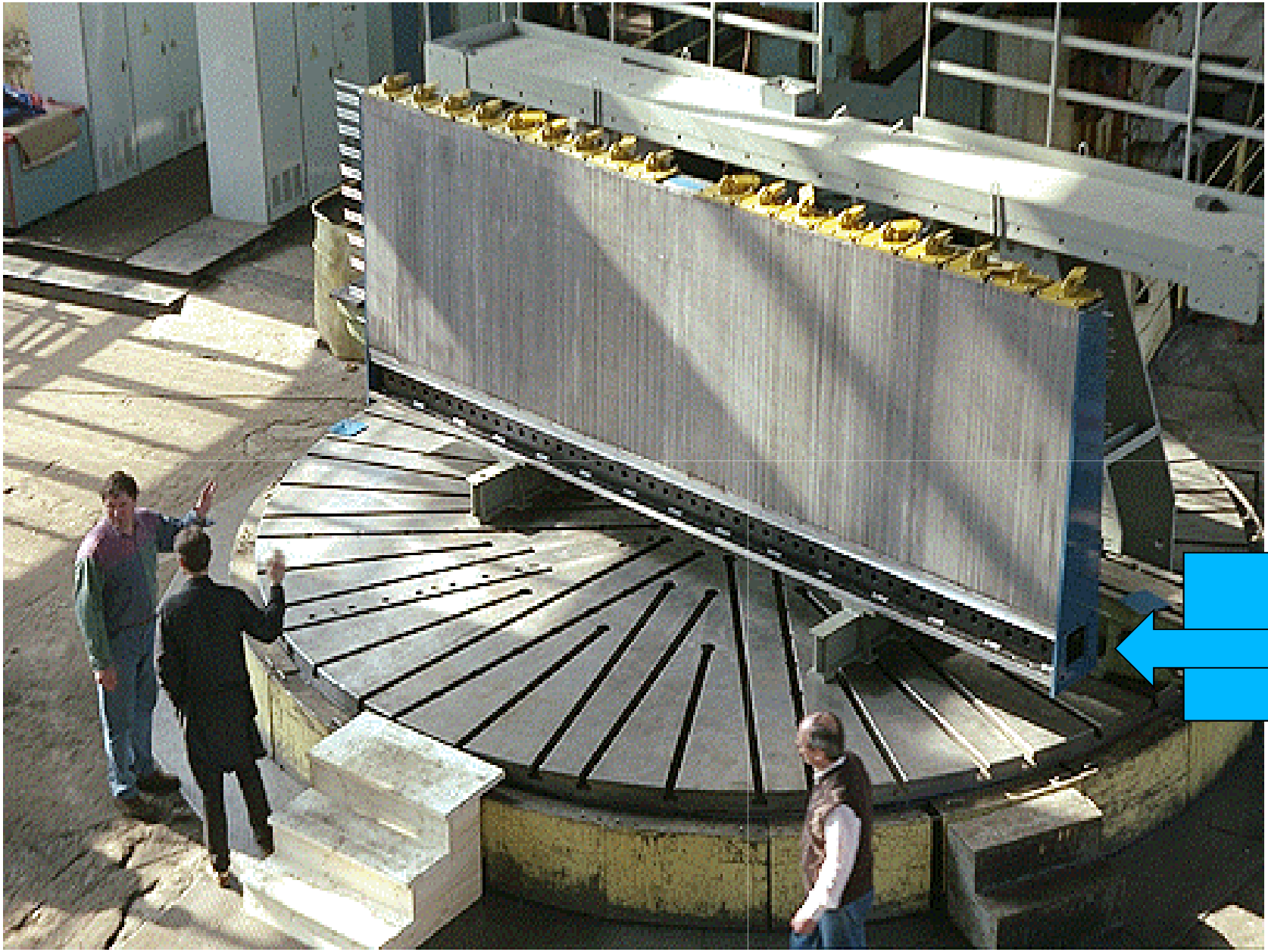
- 1996–2002 **Mechanics+optics construction**

  the iron structure of modules has been built in several countries;

  (at Cluj a number of 64 support girders were built, representing the support structure of the large barrel with a required precision of about 30 microns for a 6m long object)

Some girders at their production site in Cluj-Napoca

The iron structure of a large barrel module



One of the link elements between modules used in the assembly of the large barrel (built also at Cluj)

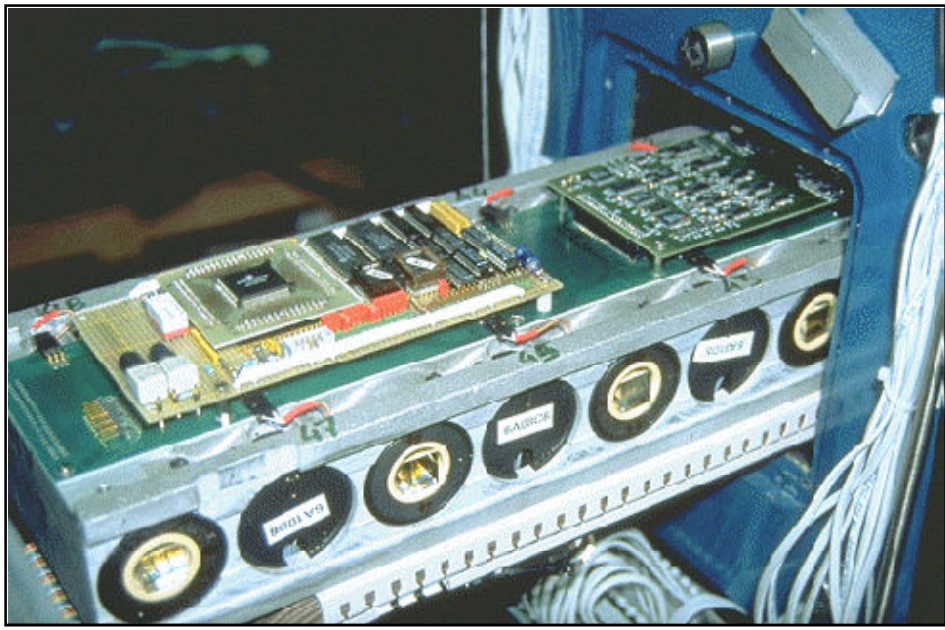
1999–2002 Instrumentation

456 000 scintillating tiles were fabricated using the injection molding

1000 km of fibers were used during the instrumentation

- **1999-2004: Electronics Construction**

- the Read Out electronics assembled inside drawers inserted into girders



- **2002-2004: Calibrations**

(will be described in the next slides)

- **2004-2006 Installation**

2004 Assembly of the large barrel at the surface

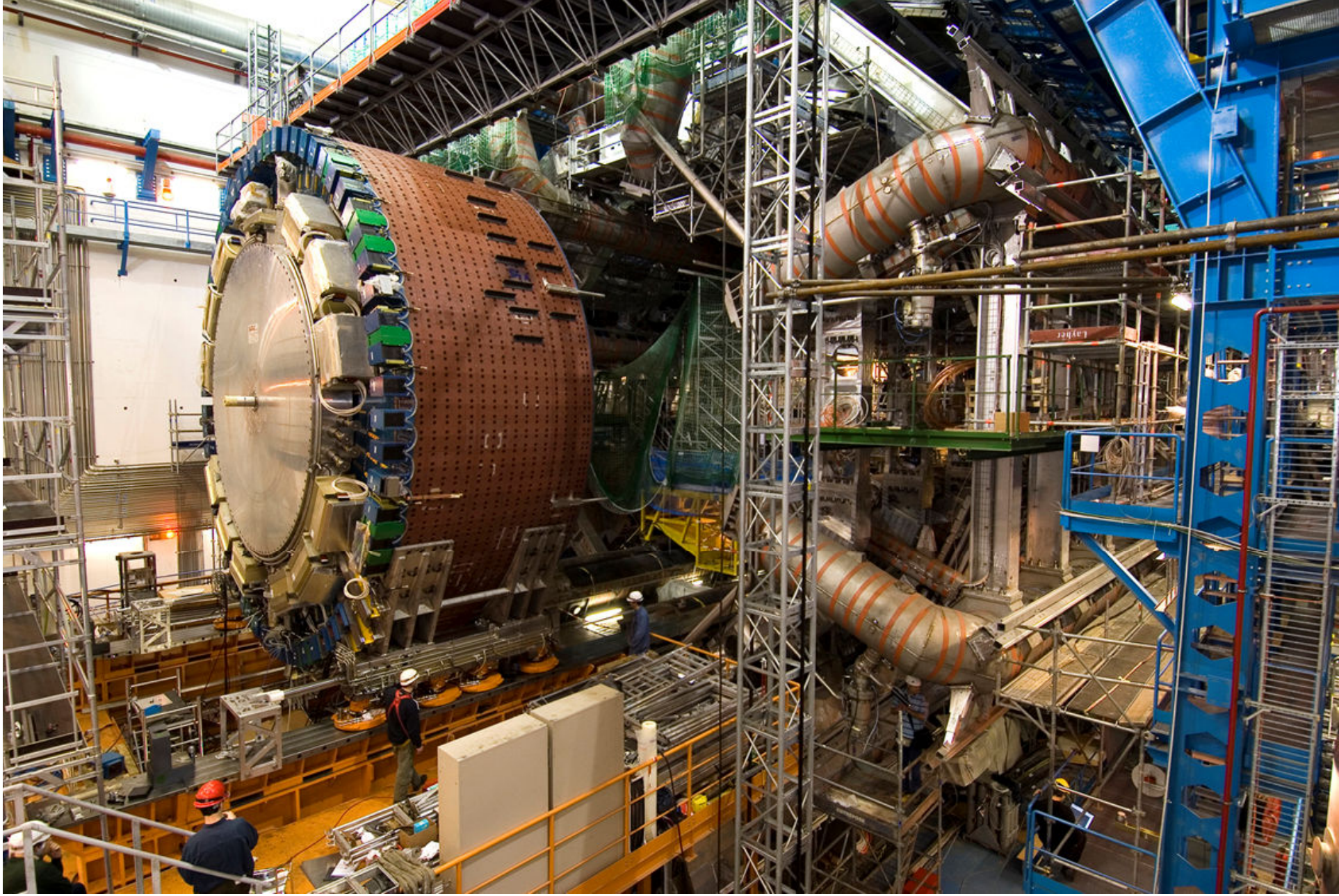
Barrel LAr

and

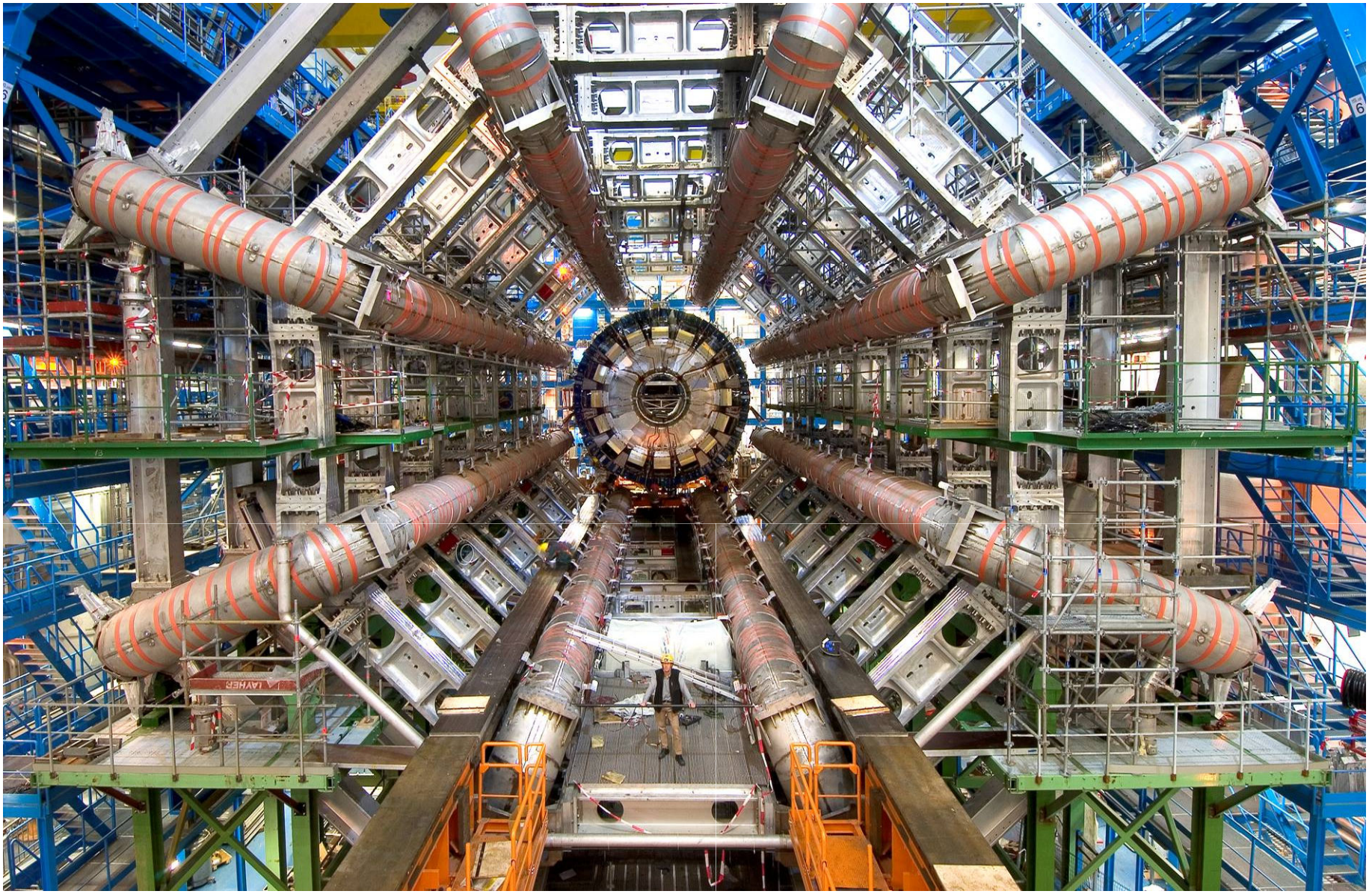
Barrel Tile

Calorimeters

The barrel LAr and scintillator tile calorimeters have been since January 2005 in the cavern in their 'garage' Position.



Movement of the barrel at Z=0



TileCal inside the toroid barrel

- **2005-2006 The Tile calorimeter (TileCal) installation completed and the start up of the commissioning**
- **2007 Tile Detector Control System (DCS) start to work**

  Tile DCS system monitors the TileCal functionality => all errors, warning and alarms concerning the hardware of the detector

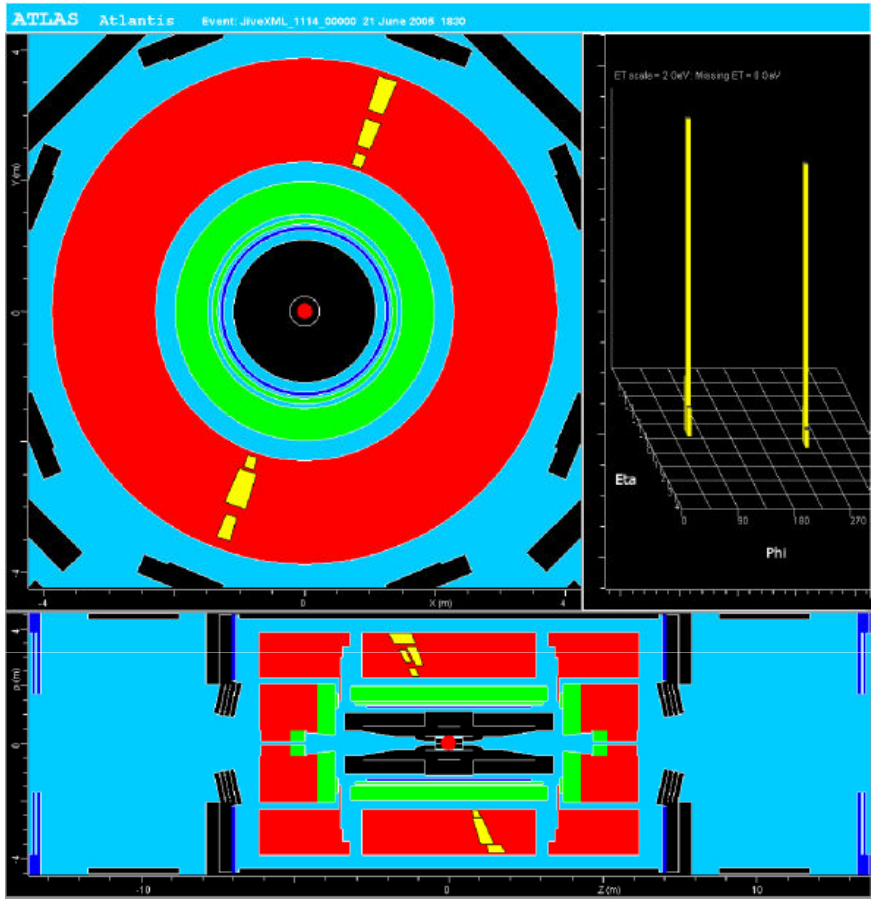
  The TileCal DCS system mainly controls for each partition:

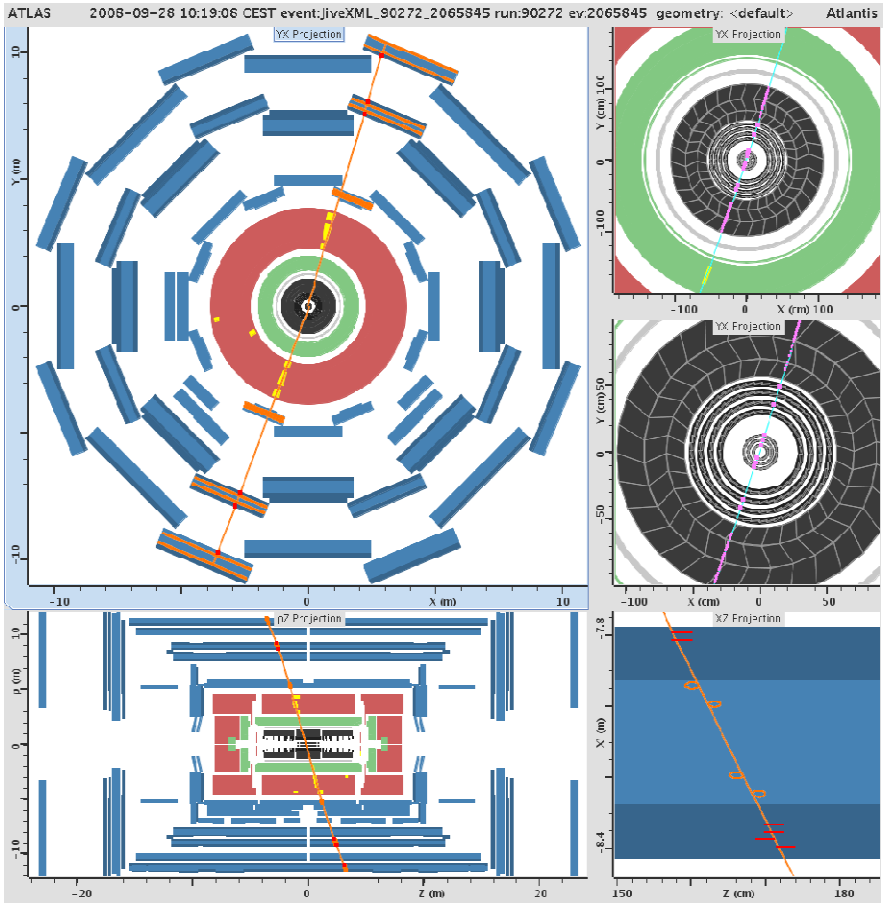
  a) the High Voltage system required for the operation of PMT's

  b) the Low Voltage system required for the readout electronics & HV regulation

One of our present task in DCS data analysis is related to the identification of the vulnerable LVPS to be replaced during the next shut-down.

Status of commissioning (2005-2009)





2005 2008

2005: First cosmics observed in TileCal in the ATLAS cavern using TileCal as trigger.

Since 2008 all systems (ID, Calorimeters, Muon Spectrometer) collecting cosmics triggered by muon trigger chambers

Hardware status today

12 Oct 09

Partition	Masked Ch's	% Masked	Masked Cells	% Masked
LBA	106	3,68%	47	3,26%
LBC	81	2,81%	35	2,43%
EBA	9	0,44%	1	0,10%
EBC	4	0,20%	1	0,10%
TileCal	200	2,03%	84	1,63%

-Tilecal rather stable, 1.63% of the cells are bad (*0.84% from 2 LVPS OFF*).

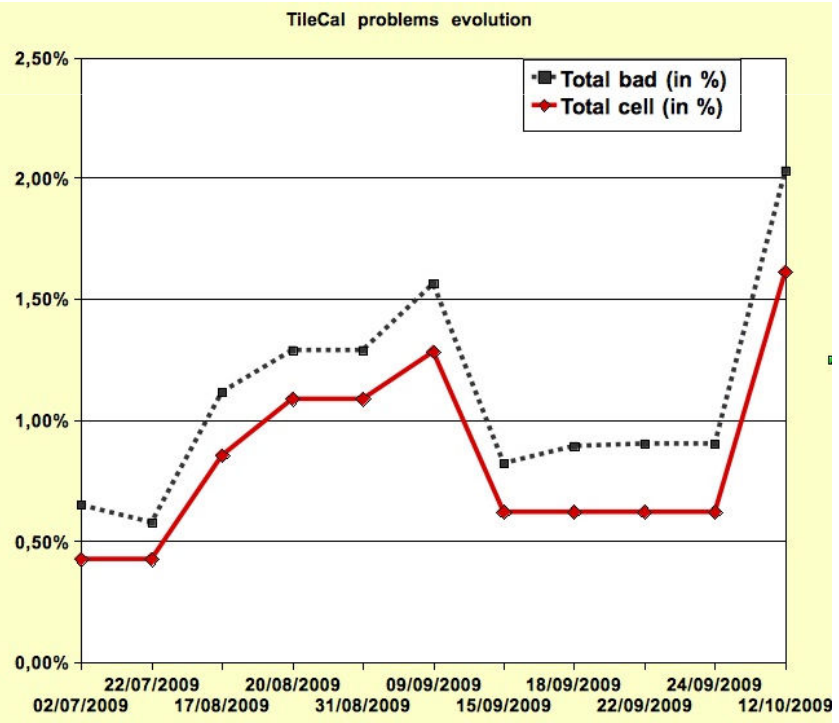
-Monitoring any sign of bad functionality of electronics (e.g. data corruption , noise, failures of LVPS)

Now emphasis on:

-preparation for data-taking

- shape up and push the cosmics analyses conclusions before 09 beam data

- understanding stability, precision, systematics in TileCal cells calibrated response.

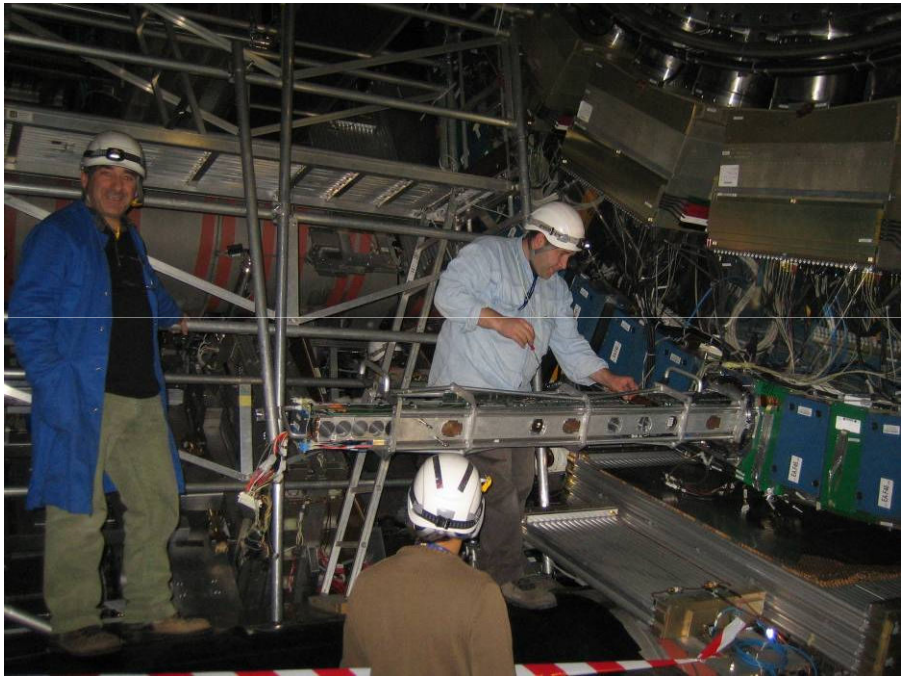


Maintenance

•**During last maintenance (Nov 08-May 09):**

- **81 (32%) FE electronics drawers opened, ending a long refurbishing programme**

- **11 (4.2%) LVPS replaced and repaired.**



Today: two (0.8%) LVPS dead. LBA22 & LBC47 =>0.84% channels/cells OFF
(LBC47 is dead starting with October snd)
No serious problems in drawers (few channels with corrupted data or noisy)
We have ~5% of spares of all components

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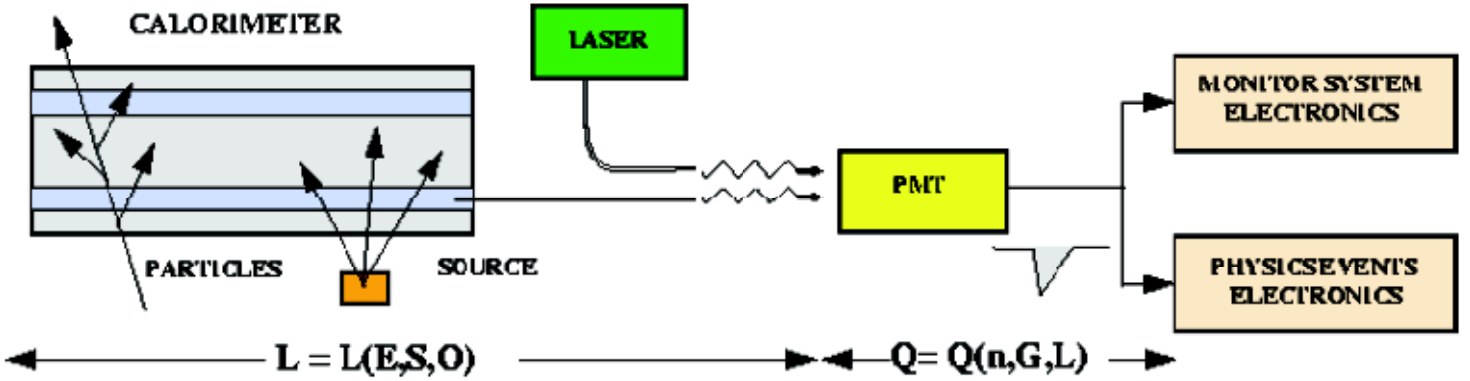
Tile Calibration Systems



Cesium System - calibrate (optics+PMTS+electronics) keep gain to the level of 1.05 pC/GeV - now every 2 weeks

(monthly during collisions)

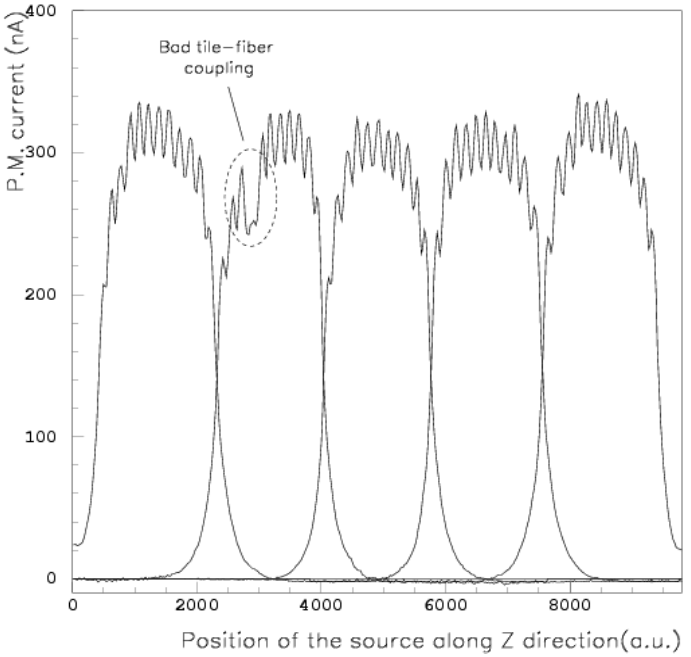
Laser System - inject pulsed laser light into all PMTs

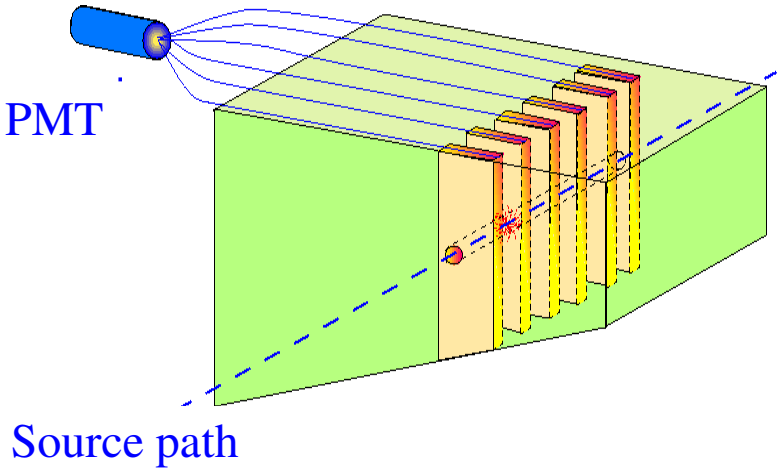
measure stability of PMT response + electronics, PMTs linearity, and relative timing of digitizer boards - 1-2 times per week

Charge Injection System -> injects well defined charge into fast bi-gain electronics) gives correspondence ADC counts->pC 1-2 times per week

Cesium System

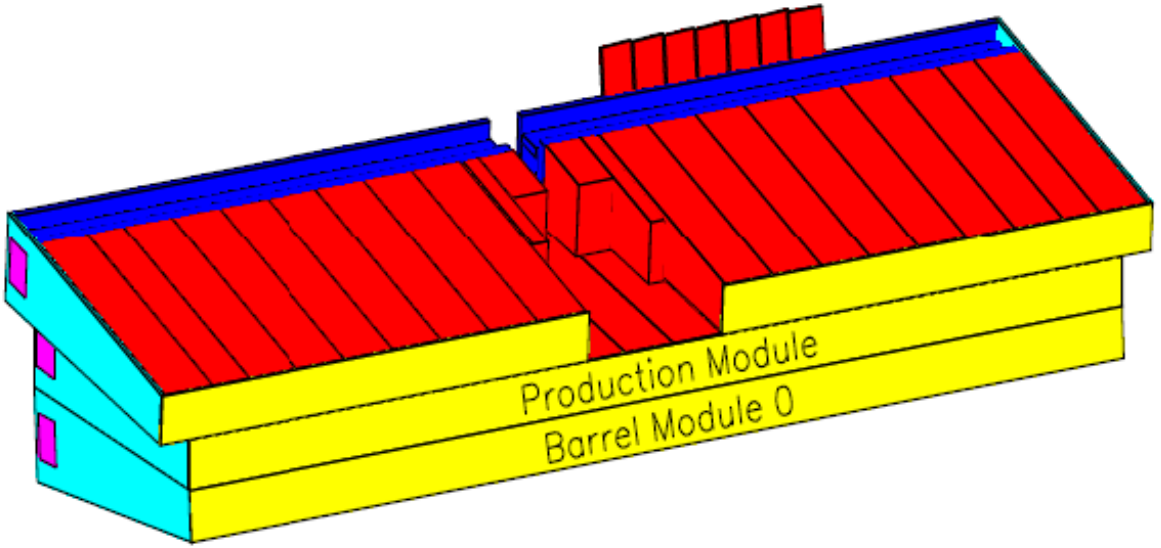
- Hydraulic drive of a Cs source through each scintillator tile
- Check quality and uniformity of optical response
- Equalize average response of all cells
- Monitor in time the average current of each cell





New calibration constants were obtained after the introduction of corrections taking into account the effects due to the increase of the tile size with the calorimeter depth

About 11% of the total 192 final modules were tested using electron, muon, hadron beams with incident energies mainly in the interval 20 GeV – 180 Ge , with few runs at 350 GeV and at lower energy - 10 GeV and less.



The setup used in beam tests with final modules

The modules were placed an a scanning table able of placing the modules at any desired angle with respect to the incident particles.

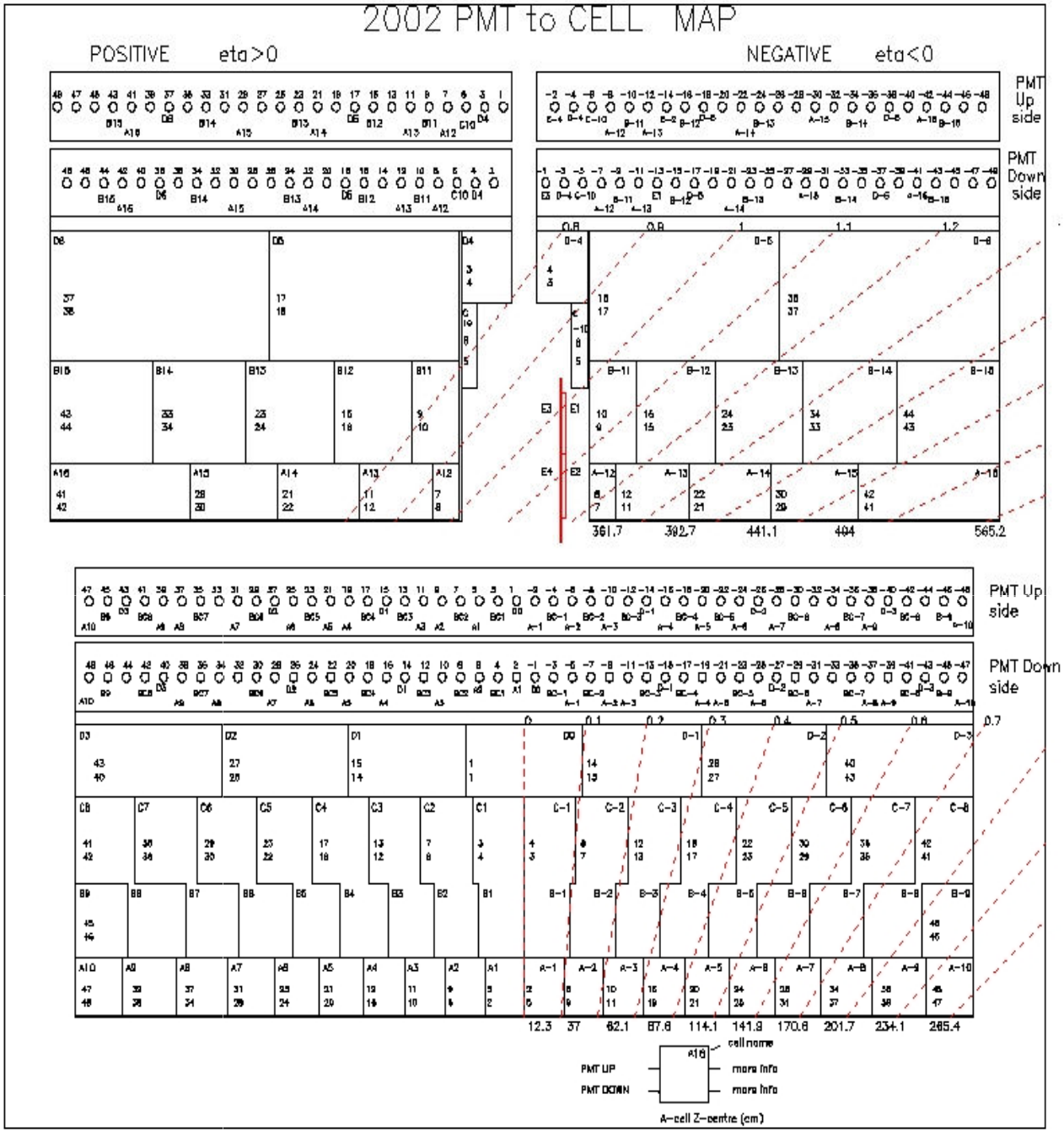
Data were taken in different geometries :

- **Beam incident into the center of each cell of the first sample, incident at 20 degrees**

- **Beam incident into the center of each cell of the first sample with projective geometry**

- **Beam incident into the center of each tile-row at 90 degrees incidence.**

The cell map for the large barrel module and the two extended modules



The main objectives of the beam tests of production modules:

- **to set and measure the charge-to-energy conversion factor using electron beams and further, using the Cs source system, to reproduce the setting in the all untested modules.**

- **to explore the calorimeter uniformity using muons beams**

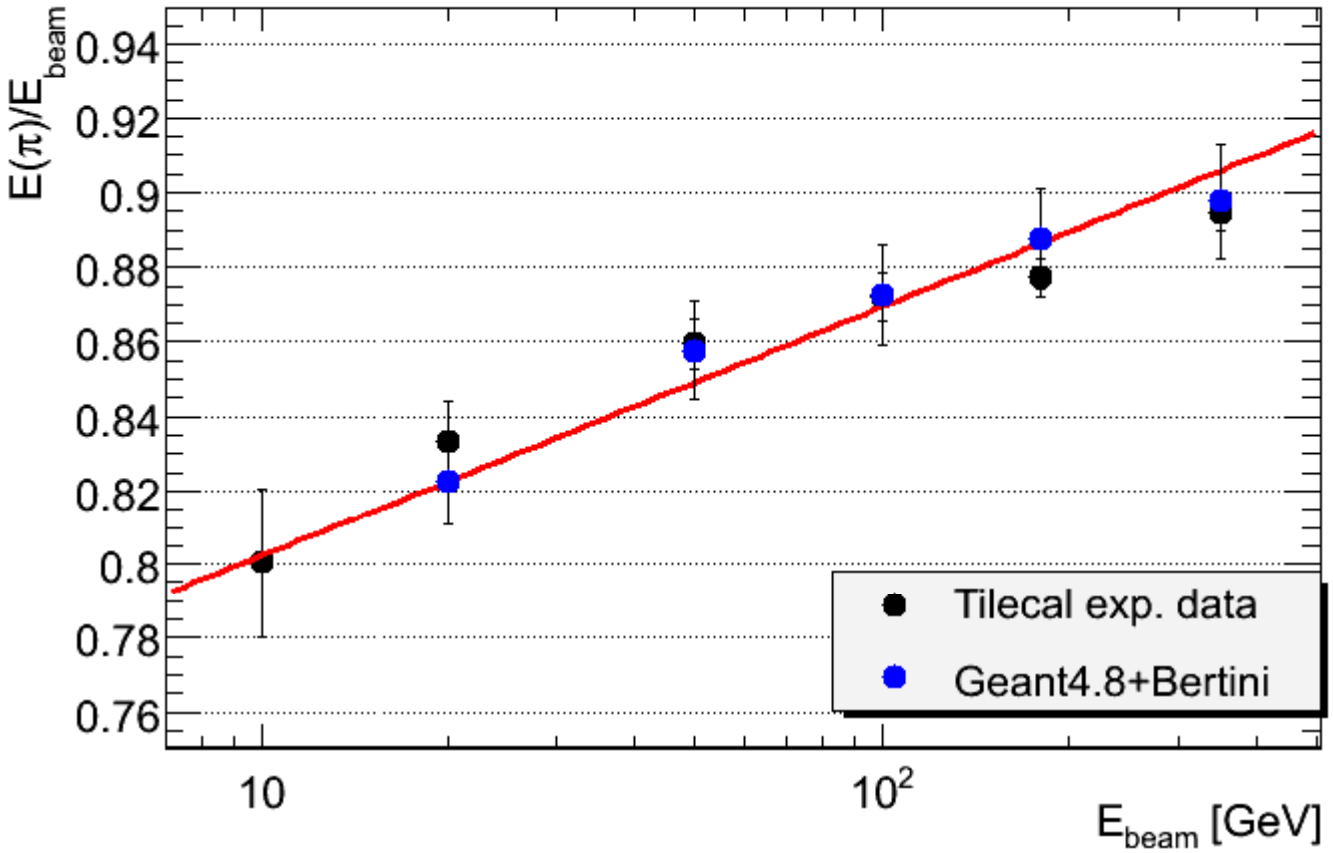
- **to study the response of the production modules to hadrons**

Linearity of pion response

Pion response normalized to the beam energy:

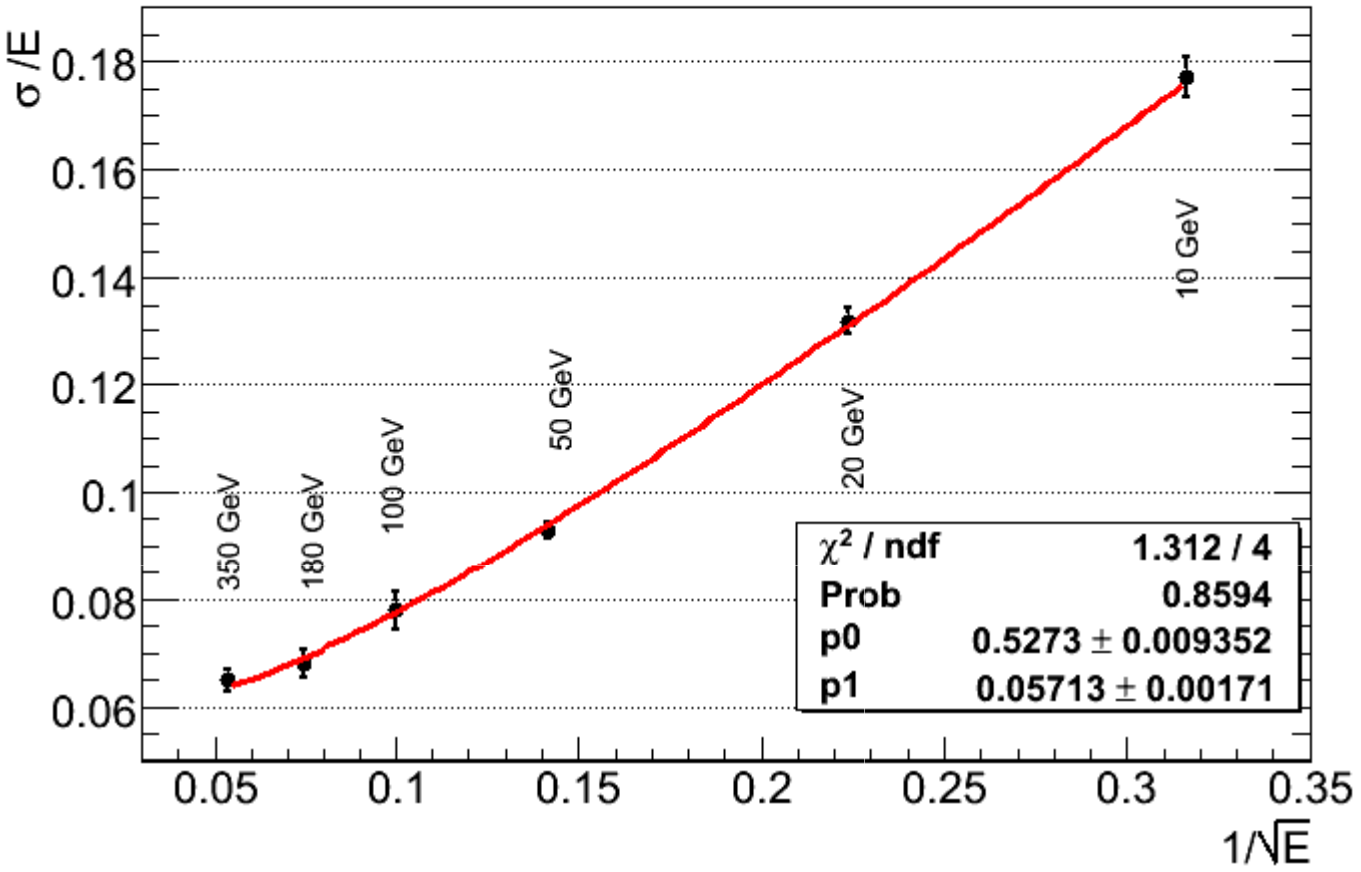
for $|\eta| = 0.35$

- **data from several inter-calibrated modules**
- **good agreement data vs. MC**
- **good agreement with earlier Tilecal prototype modules**



All corrections applied

Fractional energy resolution for pions



$\sigma/E = (52.7\pm0.9)\%/\sqrt{E} + (5.7\pm0.2)\%$

$|\eta| = 0.35$

result in good agreement with the resolution obtained for prototypes

A special attention was devoted in our group to the comparative analysis of TileCal response to pions and protons .

TileCal being a non-compensated calorimeter, differences were observed in the response of the pions and protons of the same energy:

a) a higher TileCal response to pions,

b) a better resolution for protons

c) different shower profiles

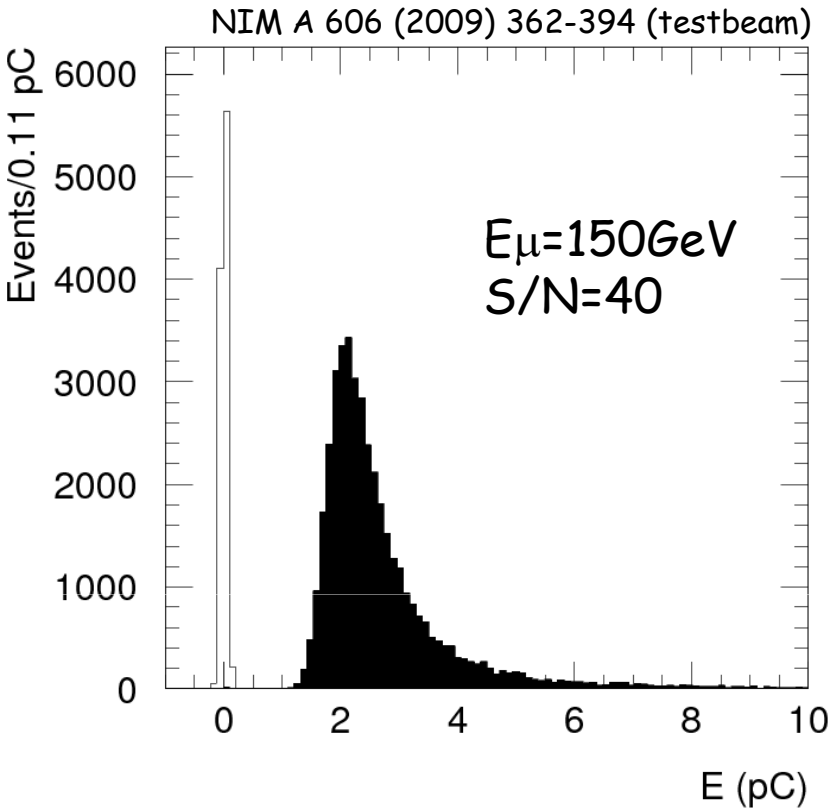
A good agreement of data with GEANT4 simulations was observed.

The difference observed in the shower profiles:

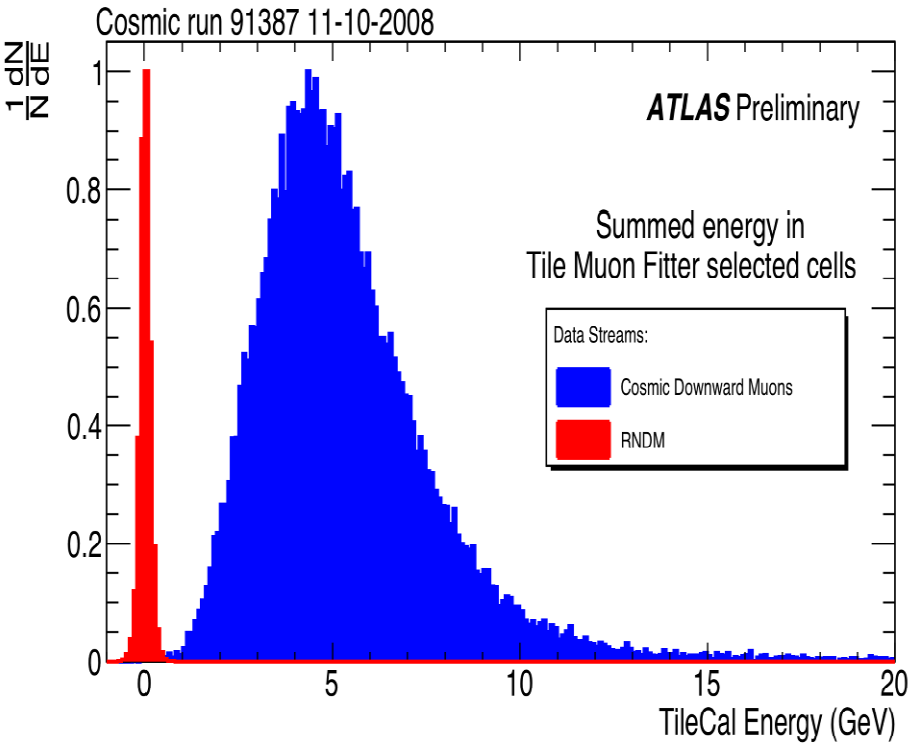
- more energy deposition in the central tower for pions than for protons of the same energy.

An effect to be taken into account for a possible identification of an isolated particle depositing its energy into TileCal calorimeter.

Response to muons



Cosmics (top+bottom cylinder)



A clear separation of muons from noise was seen in testbeam and in the pit with cosmics

Conclusions

- **The obtained results are showing that we will be able to calibrate all ~ 10000 TileCal channels at EM scale in ATLAS within 1-2 %**
- **The Tilecal performances fulfil the physics requirement of ATLAS for hadronic calorimetry**
- **The commissioning activity will continue during data taking for a better understanding of our detector**
- **The Tilecal is ready for collisions**