Instrumentation and performance of the first TILECAL modules

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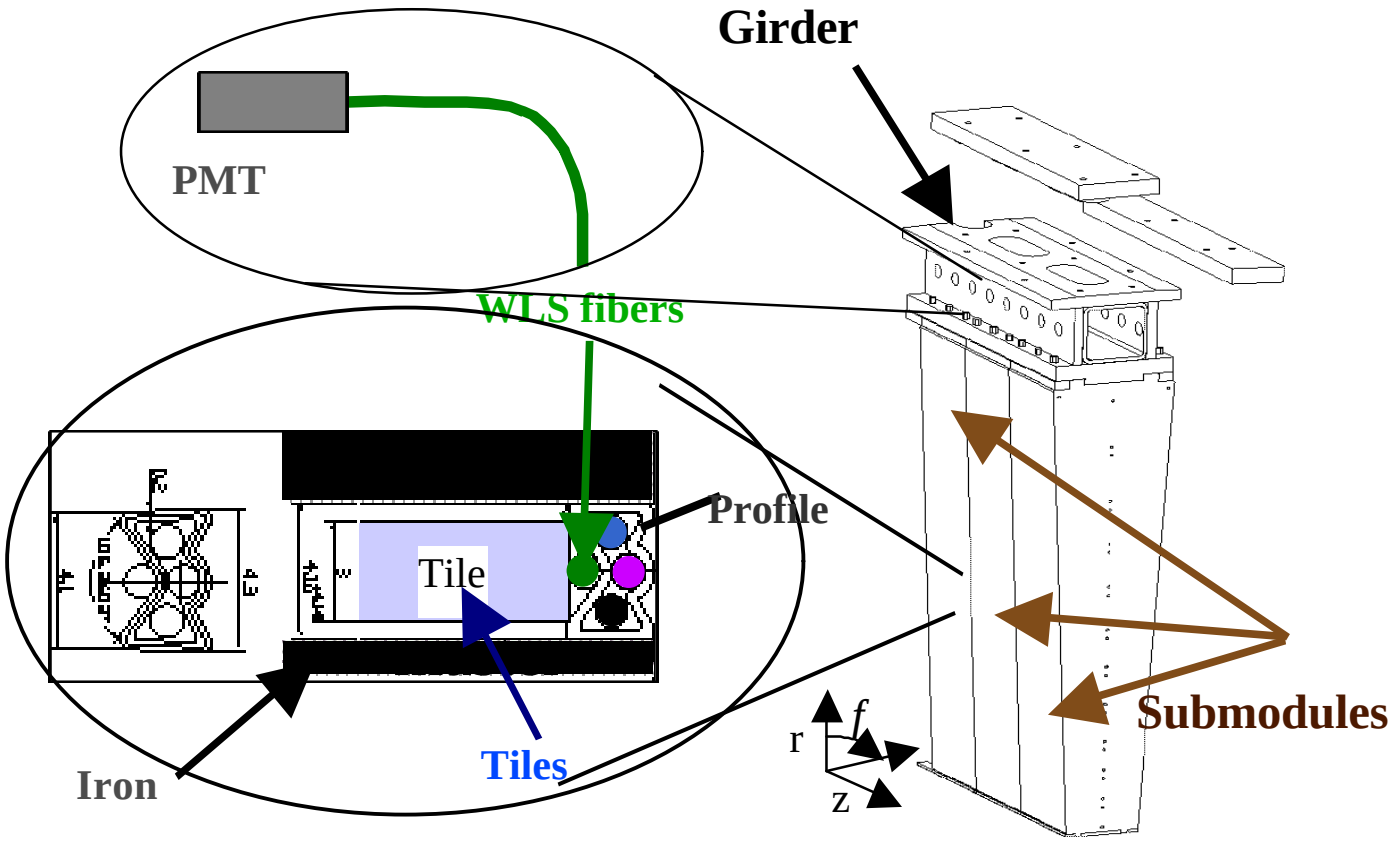
Outline

- TILECAL concept overview.
- Optics.
- Photomultipliers / readout electronics.
- Optical instrumentation.
- Modules uniformity.
- Summary of the performance.
- Conclusions.
- The future.

TILECAL concept overview



Longitudinal tile configuration Þ good hermeticity and "easy" construction

- **Iron + Scintillating Tiles Þ readout WLS fibers**
- **Ratio Fe/Scint. 4:1**
- **64 modules in azimuth ´ (1 Barrel + 2 Ext. Barrels)**
- **Coverage |h| < 1.7**

The Real Thing

Girders

Assembled:
Barrels 27/64 42%
Ext. Barrels 42/128 33%

Submodules

All together

Optics next

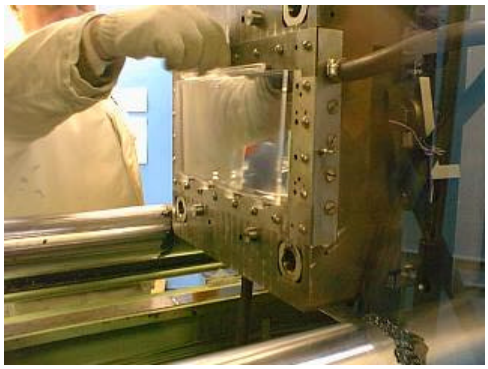
Scintillators

- Base material: polystyrene
- Dopants: 1.5% pTP, 0.04% POPOP
- 460 000 tiles of 11 sizes (dimensions ~40D19 to 20D10 cm^2), 3mm thick
- Injection molding technique

Polystyrene

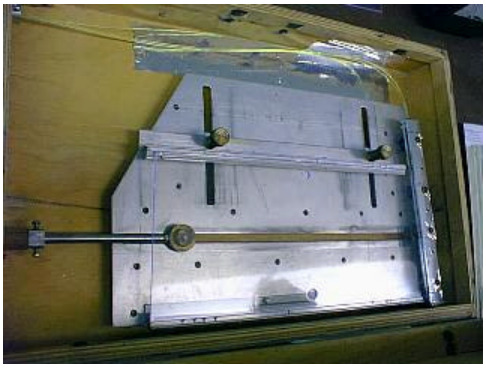
+

Dopants



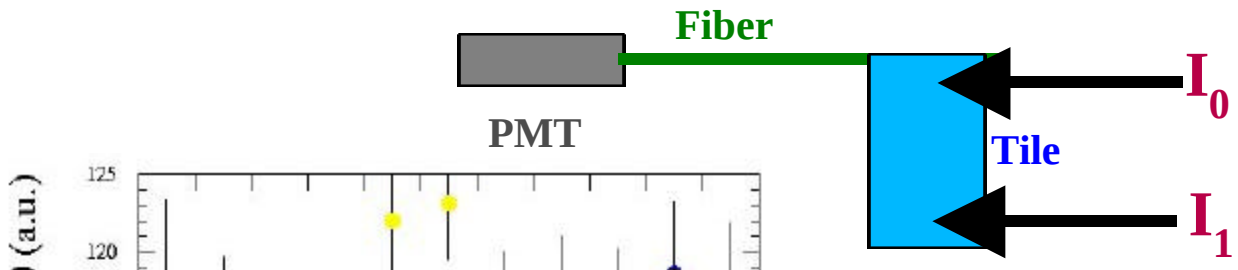
Injection molding

Quality Control

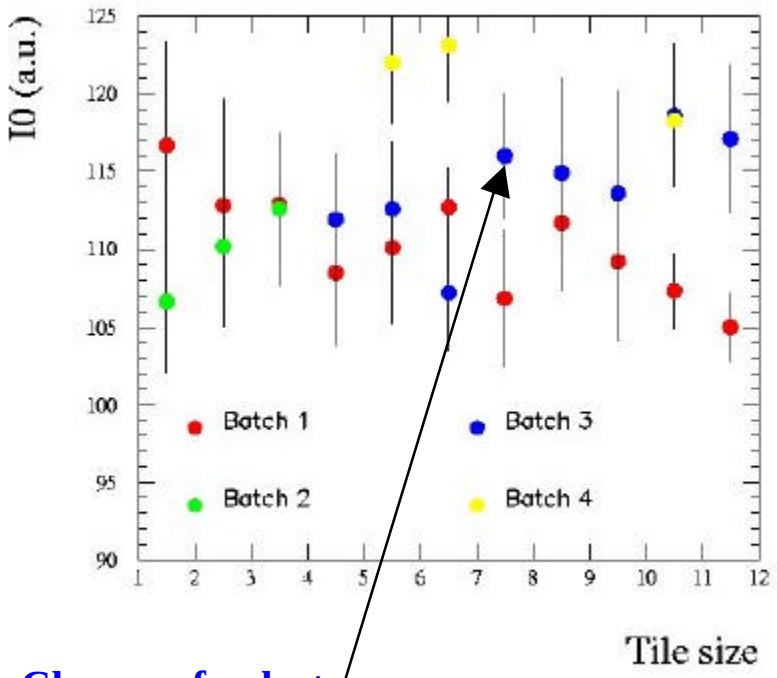


Scintillators Quality Control (QC)

- QC on 1 tile over 20 Þ 1 pack.
- I_0 , $R=I_0/I_1$ and $RMS(I_0)$, $RMS(R)$ for each tile size per batch.



I_0 = 100 Þ reference tile

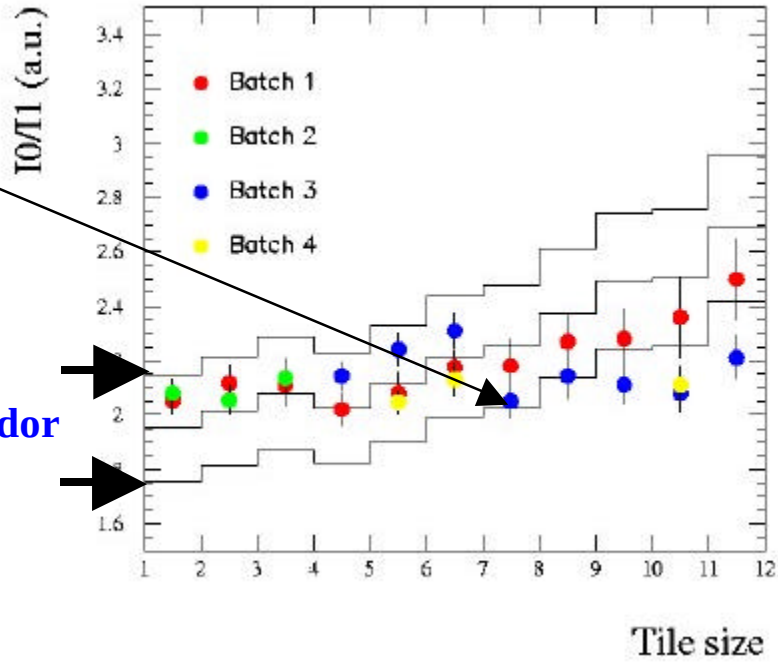


Each point: ~ 600 tiles
Error bars: RMS

Required: $RMS(I_0) \leq 8\%$
Typical: $RMS(I_0) \sim 4\%$

~5% of tiles rejected

Change of polystyrene
PSM115 Þ BASF
Batch 3 tile 7
Better I_0: ~25%
Better L_{att}: ~20%



66% of the tiles produced

Transmission (R) should satisfy

± 10% Corridor

RMS (R) ≤ 10%
Typical: 5%

WLS Fibres

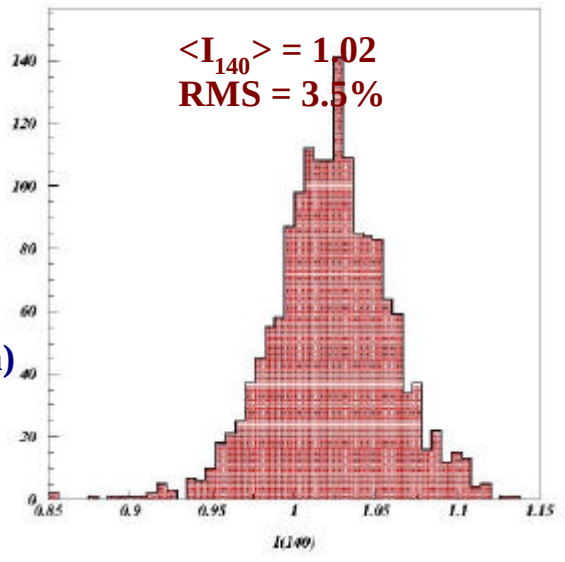
- Fibers: Y11(200)MSJ from Kuraray.
- Total of 572 000 fibers, 1 mm diameter.
- Length: [73,232] cm.
- All batches have passed the acceptance criteria defined by the TILECAL collaboration.

Acceptance: on 200 cm long fibers

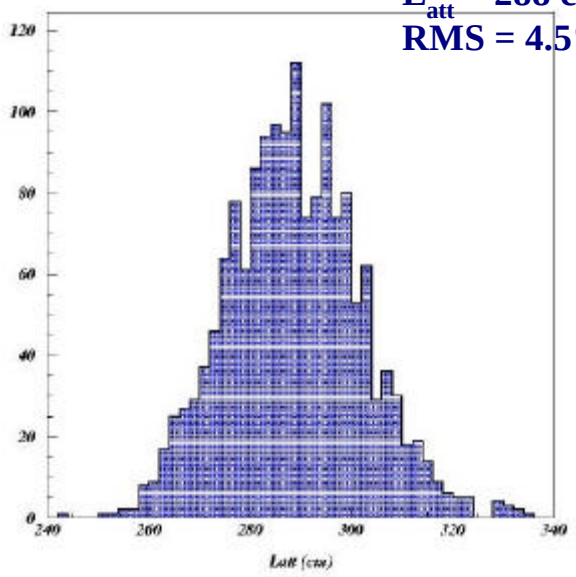
Requirements:

- $\langle I_{140} \rangle \geq 0.8$ of reference fibers
- $RMS(I_{140}) < 7\%$
- $L_{att} \geq 250$ cm
- $RMS(L_{att}) \leq 7\%$

1600 fibers



$L_{att} = 288$ cm
RMS = 4.5% (13 cm)



Acceptance criteria also on mechanical properties: (mechanical stress and diameter) and on radiation hardness

Fibres preparation

Hexagonal bundles of 1261 fibres.

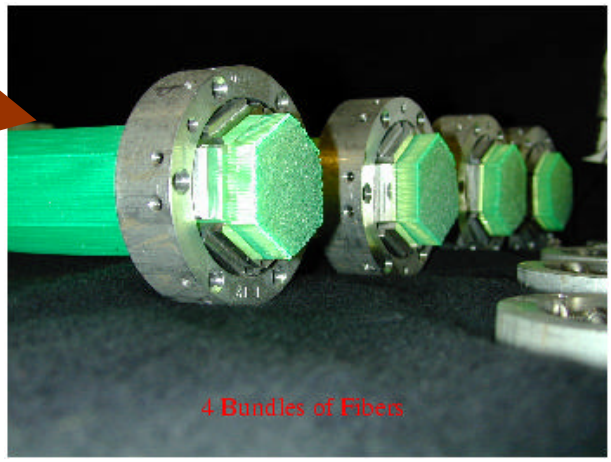
Cutting and polishing the bundles of fibres with a milling machine with a special diamond tool.

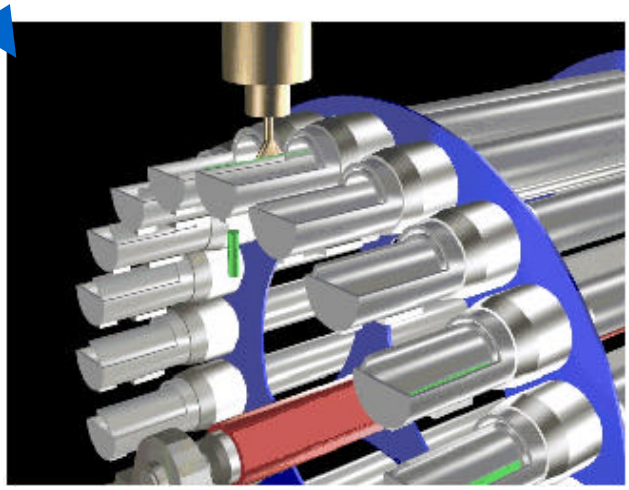
Aluminization by Magnetron Sputtering technique.

Quality Control of the aluminization:

- **Visual with photo of the bundle.**
- **Optical properties.**

Insertion of the fibres into the plastic profiles with a robot

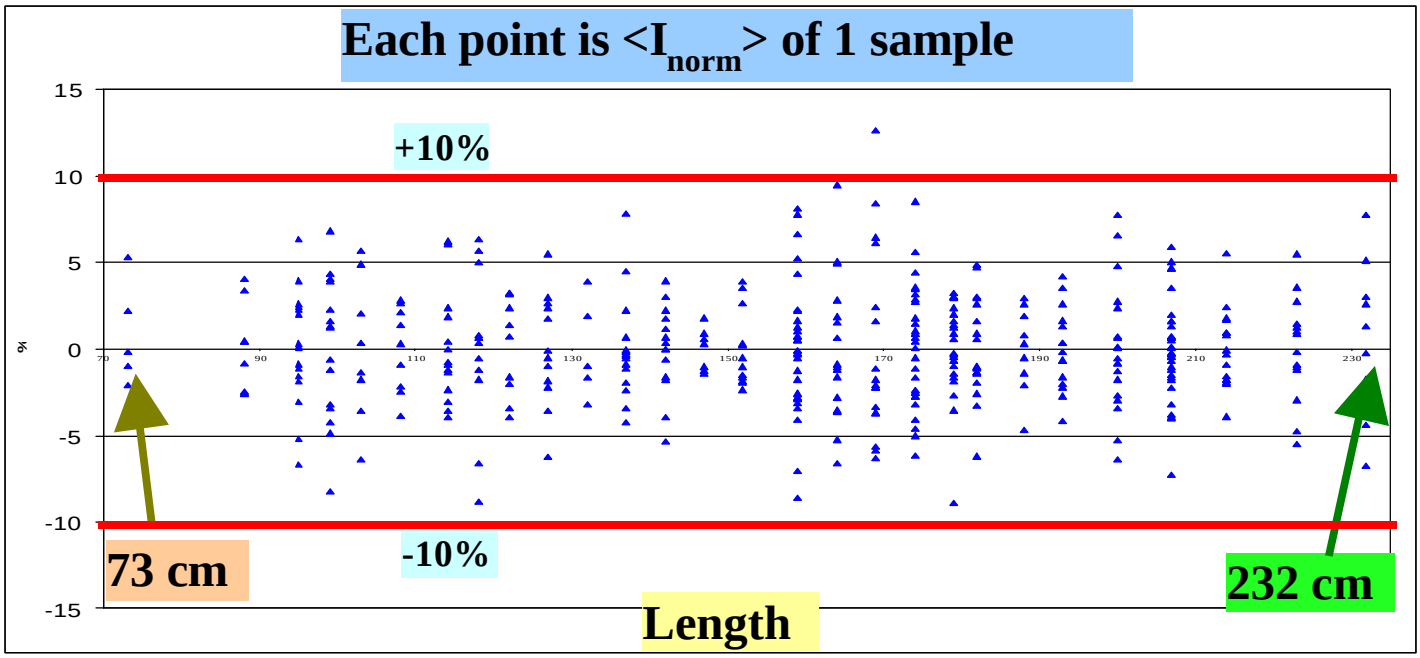




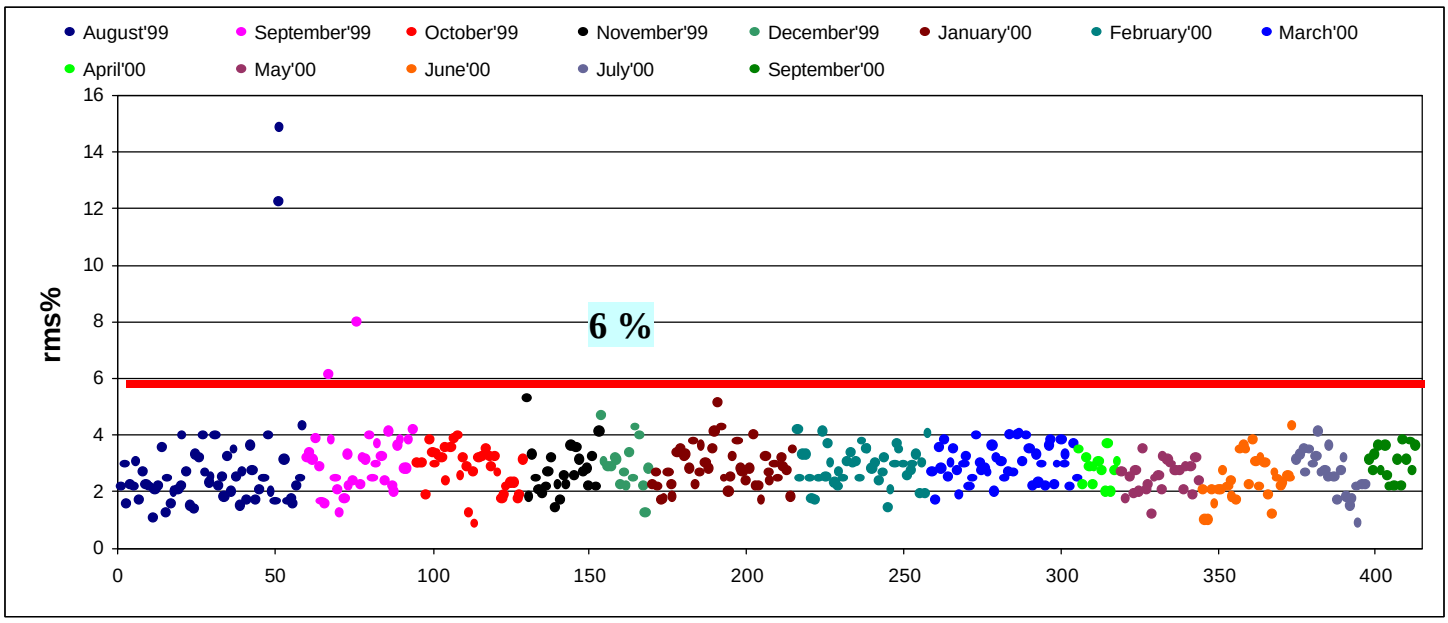
Aluminized fibres quality control - I

- A set of fibers is collected for each length in the bundle:
  - 16 fibers if the bundle is made of fibers with several lengths.
  - 32 fibers if there is only one length.
  - Each one of these defines a sample.
- The light yield of the fibers is controlled:
  - For each fiber length there is a reference value for the light yield at 10 cm of the aluminized top.
  - For each set of fibers the average and RMS of the light yield are calculated.
  - The average of each set of fibers is compared with the reference value giving a relative light yield.
- 249 bundles have been aluminized:
  - A total of 313 989 fibers (~55% of the total production).

Aluminized fibres quality control -II



Red lines are the limits for acceptance



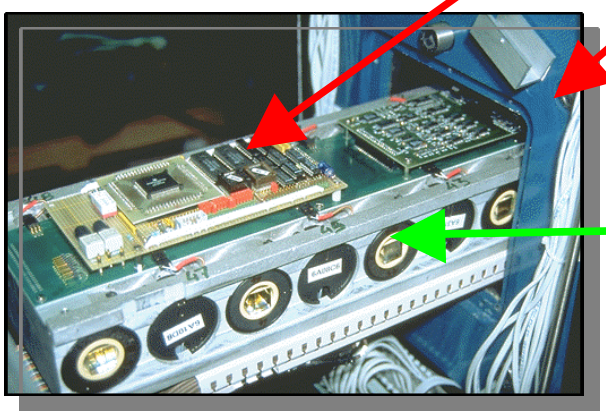
- Bundles not passing the QC are reprocessed.
- Only 990 fibers were rejected (not yet reprocessed).

Photomultipliers / readout electronics

- Hamamatsu R7877.
- Total of 10 140 PMT's.
- Nominal gain: 10^5.
- High voltage: 600-800V.
- Quantum efficiency @ 480nm: 18%.
- Response time: < 8 ns.
- Active cathode area: 250 mm2 (with a nonuniformity ≤ 10%).

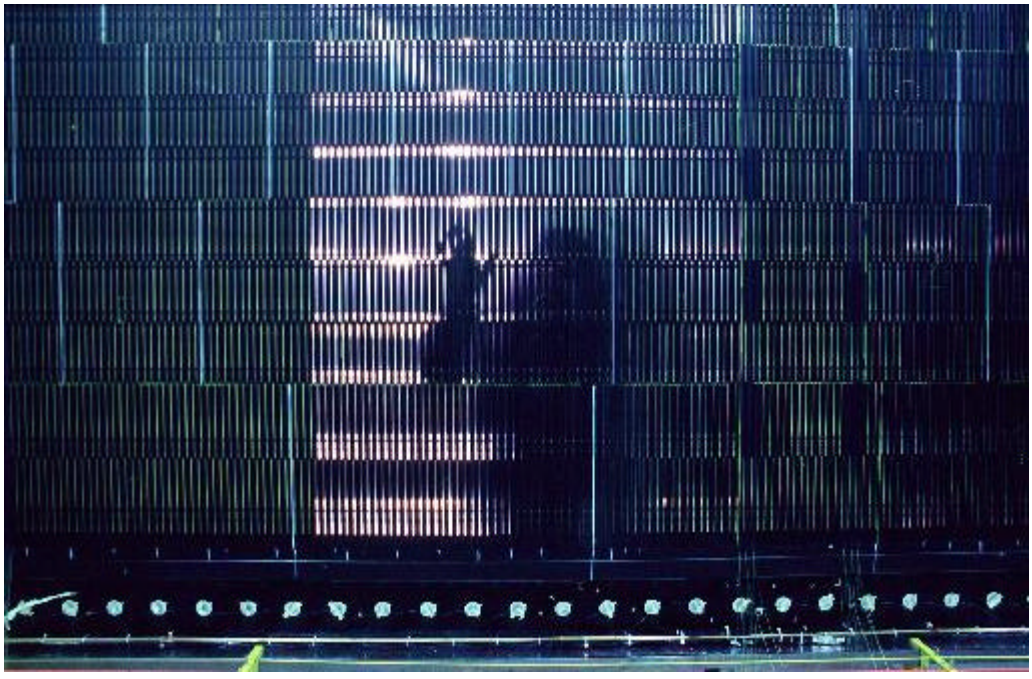
- 1250 PMT's produced, from which 250 were already tested and passed accptance QC, 80 were used in the test-beam and showed to be stable along a period of 1 month.

All the PMT blocks, Front End and R/O electronics are positioned in drawers which are inserted into the girder.

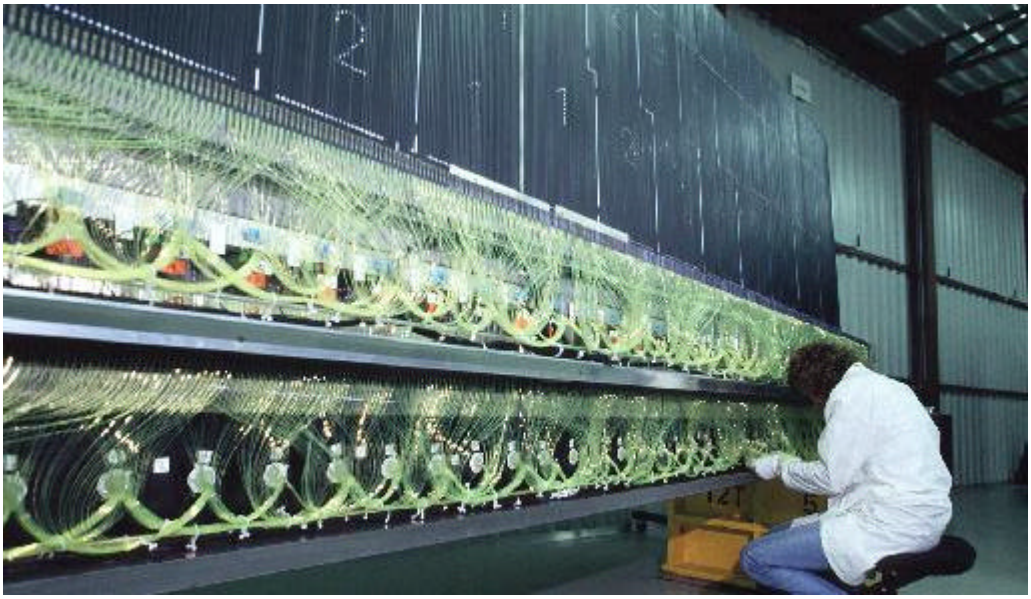


PMT blocks

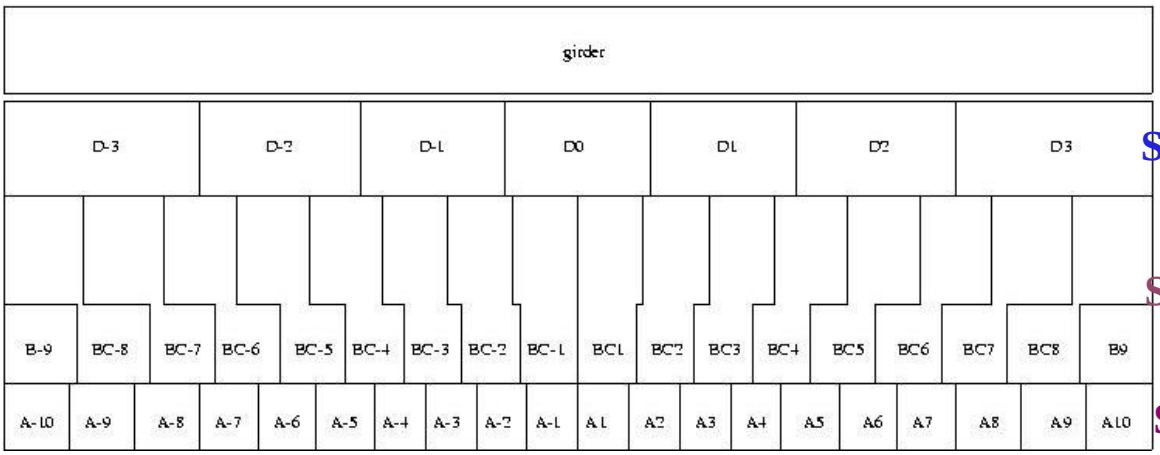
Optical instrumentation I



Optical instrumentation II

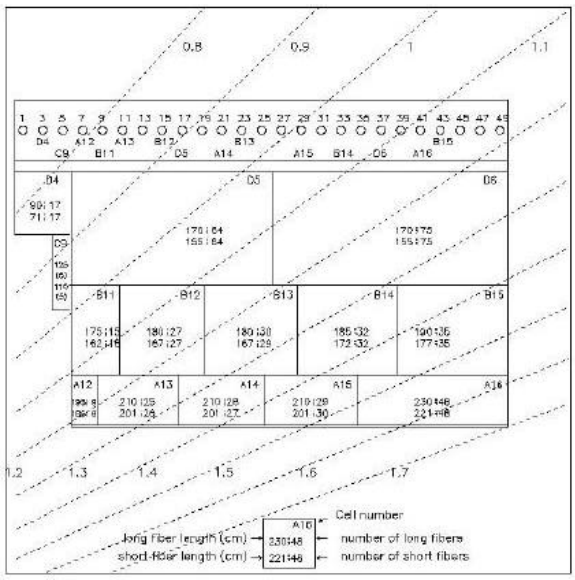


Barrel cell geometry



Dh =0.1 Þ samples 1,2
Dh =0.2 Þ sample 3

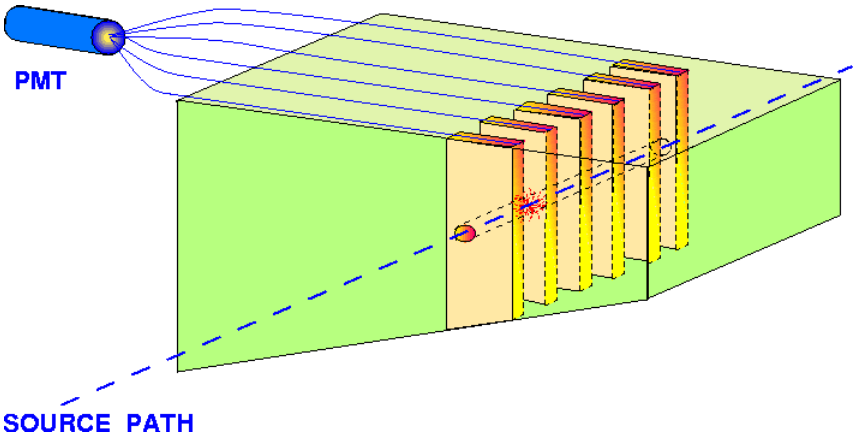
Extended Barrel cell geometry



Modules uniformity
Cs source system I

- **Movable Cs source system (probes whole optical chain).**
- **Signal response = Tile Ä Tile/fiber coupling Ä fiber Ä PMT response.**

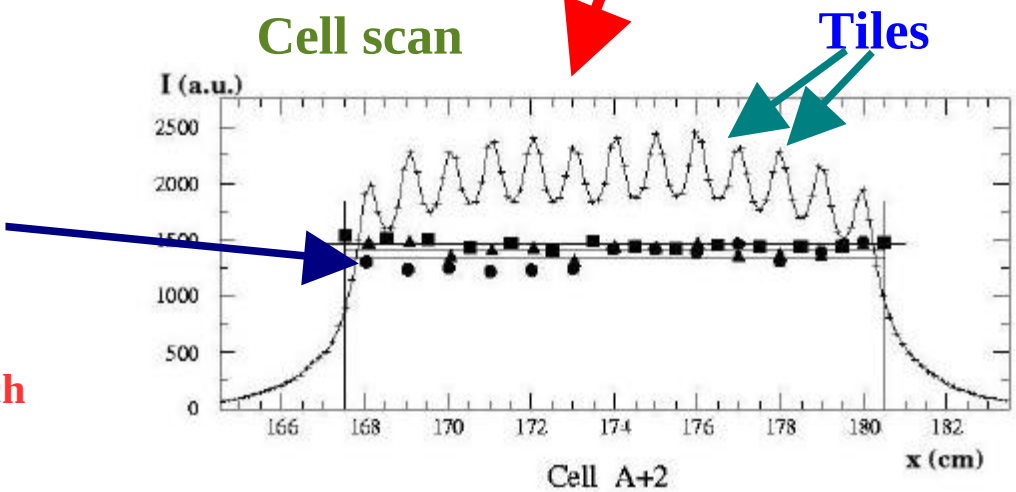
Concept



Source runs through a readout cell exciting all tiles. The results is:

Deconvolution of the signal of each tile Þ peak value

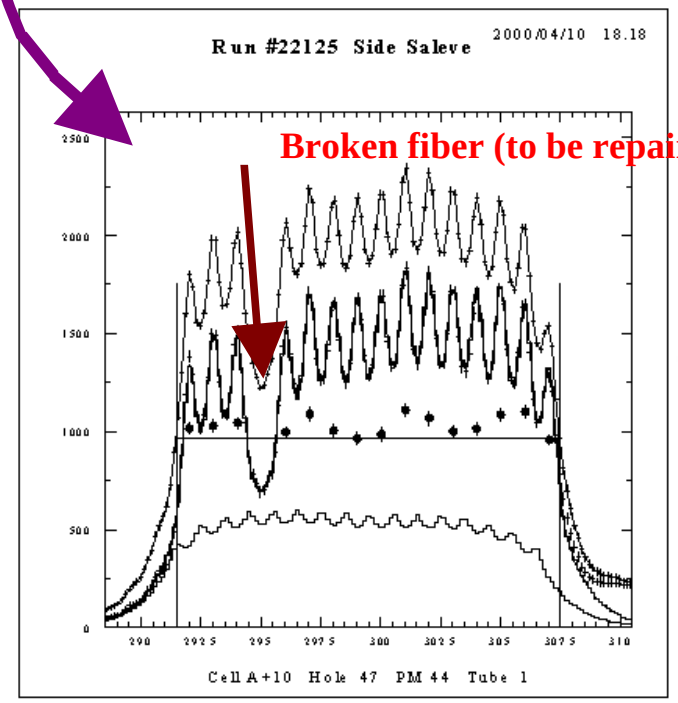
3 lines Þ average signal (<$I_{T\#}$>) for each tile size, per cell



Modules uniformity

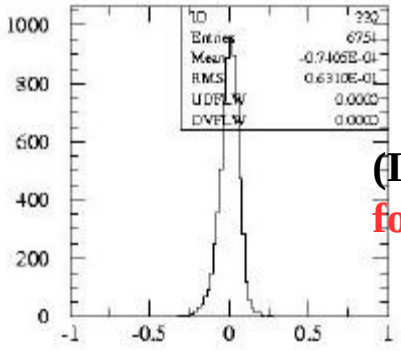
Cs source II

- Cs source system is ideal for:
  - Checking optics instrumentation and quality.
  - Intercalibration of the cells Þ equalization of the cells average signal.
  - Monitoring the stability along time.



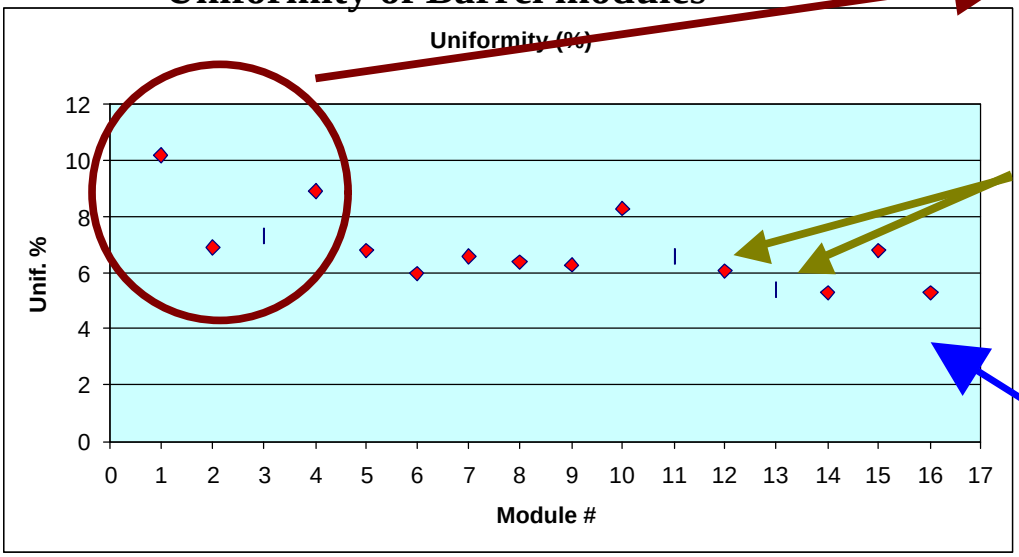
Uniformity of Barrel module #9

RMS = 6.3%



$(I_T - \langle I_{T\#} \rangle)/\langle I_{T\#} \rangle$ for all cells

Uniformity of Barrel modules



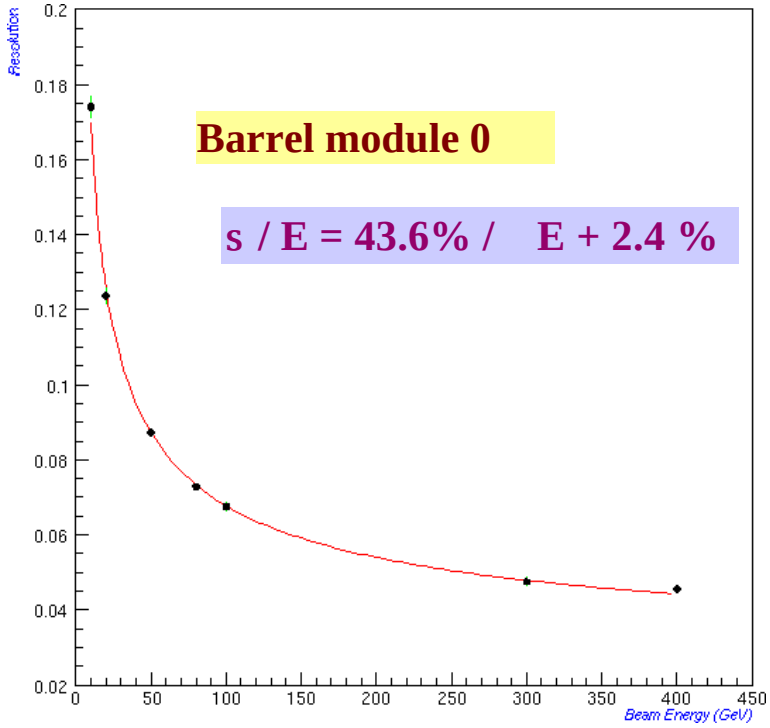
Learning phase

Change of polystyrene and, selection of tiles

Cruise speed production

Summary of the performance

Resolution for p's



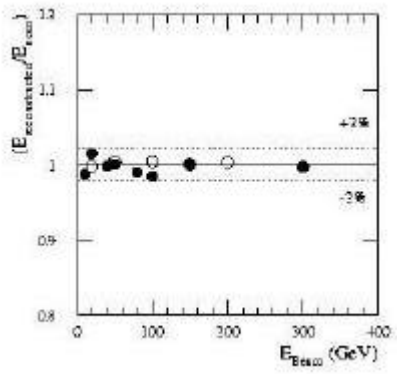
Applying offline weighting techniques:

Barrel and Extended Barrel modules 0:

Non-Linearity < 2 % in the range 10-300 GeV

e/h ~ 1.30 Barrel

e/h ~ 1.48 Ext. Barrel



Conclusions

- **Since the end of 1998, the collaboration started to construct the TILECAL calorimeter.**
- **Presently, about 40 % of the modules are mechanically assembled and about 30% are instrumented with the optic components.**
- **The WLS fibers and scintilating tile have shown a good optical performance, well inside the acceptance requirements (high light yield and small fluctuations). About 5% of the tiles that did not satisfy the citeriafor acceptance, were rejected.**
- **From the Cs source scans it was shown that, after a learning phase, the intrisic non-uniformity of the calorimeter modules is below 6%.**
- **One thus expects to have calorimeter modules with a perfomance as good as (or better than) the Modules 0 constructed and tested in the past, satisfying the physics requirement for the hadron calorimetry of ATLAS.**

The Future

- **The optical instrumentation of the modules is planned to finish in the end of 2001.**
- **Now starting the QC of the PMT's, and construction of the readout electronics. Some difficulties found in the purchase of the components.**
- **Calibration of the modules with Cs source (inter-cell equalization).**
- **1 over 8 modules will be calibrated also in test-beam, starting July 2001.**
- **Ready for data taking in 2005.**