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PRELIMINARY RESULTS ON A IRON/ SCINTILLATING TILES HADRON CALORIMETER

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Abstract

We present preliminary results on a Fe/scintillating tiles hadron calorimeter which has been selected by the ATLAS Collaboration as hadron calorimeter in the central region (i.e. $|\eta| \leq 1.7$). In this detector, the tiles are oriented in an 'unconventional' way, i.e. parallel to the incident particles. Preliminary test beam results are presented.

1 Principle-Mechanics

The ATLAS Collaboration [1] has chosen as a hadron calorimeter for the central region a Iron/scintillating tiles hadron calorimeter [2]. It is preceded by an electromagnetic Liquid Argon 'Accordion' section (Fig. 1). The basic element of the hadron calorimeter is a sector covering 0.1 in ϕ and spanning 5.9 m along the z axis.

This novel technique has been described previously in [3, 4]. The principle is a traditional Iron-Scintillator sandwidch calorimeter, in which the tiles are oriented in a 'longitudinal' direction, i.e. parallel to the incoming particles. Tiles are read out at both ϕ-edges with wavelength shifting (WLS) fibers (Fig. 2). This orientation allows for good hermiticity, easy mounting and low cost.

For the prototype built, the iron structure has been made by piling laser cut iron sheets 5 mm thick, 1 m long, alternately with smaller sheets 4 mm thick, 10 cm long, thus allowing to insert the 3 mm thick tiles (Fig. 3). This leads to a staggered positioning of the tiles, with an effective period of 1.8 mm and an effective Iron:scintillator ratio of 5:1.

The tiles have been produced by injection molding technique and use polystyrene granulated scintillator doped with PTP and POPOP. They have been wrapped in a white paper acting as a diffusor, and the edges have been covered with a reflector (aluminized mylar).

At both ends of each tiles 1 mm diameter WLS green fibers (BICRON BCF91A) aluminized at the front face by sputtering technique were inserted.

Fibers are then bunched and connected to phototubes (XP2012 5/4" blue) via light mixers.

The whole structure is compressed by rods traversing the absorber stack and the tiles along the full length of the sector.

Each sector is covering 0.1 in ϕ, 1 m along z, and is 1.8 m long (i.e. 9 λ_{int}). It has 4 compartments in depth and 5 along z (corresponding to a granularity of 0.1 in η). 3 sectors have been built and exposed to particles in the H2 test beam at SPS in June and August 1993.

2 Calibration and monitoring

The monitoring of the response of the light detectors has been achieved using a YAG type laser injecting light pulses of different amplitudes to all phototubes via clear fibers. The stability of the laser response has been ensured using photodiodes. This device allows to monitor the gain and the linearity of the light detectors, and a precision of 1 % has been achieved.

The critical point of calibration has been handled using a Cesium source (5 mCi) embedded in a wire which is moved along z inside the rods, thus allowing to probe each individual tile by measuring the DC-current (Fig. 4). Thanks to the well adapted geometry of the tile calorimeter and the optimum range of the γ's produced by the Cs ($\simeq$ 2 cm), this method is a very powerful tool for controlling the quality of the detector during its bulding and for extracting the contribution of tile-to-tile and fiber-to-fiber fluctuations.

The reproducibility of the Cesium calibration procedure has been measured to be 1 %.

This method has allowed to perform an initial adjustement (before putting the prototype in the beam) of the cell-to-cell response to 3.5 % accuracy (Fig. 5).

The precision of the calibration with respect to particles response has been investigated during the test beam using electrons, muons and pions. It is at present 4 % (Fig. 6) and is expected to improve further.

3 Preliminary Test beam results

3.1 Muons

The response to 225 GeV muons for various incident angles is shown in Fig. 7. The slight angular dependence is mostly geometrical. The peak signal is around 16.6 pC, corresponding to 2.6 GeV. Considering a noise due to pile-up at LHC nominal luminosity of 0.4 GeV in a $\Delta\eta \times \Delta\phi = 0.1 \times 0.1$ cell, this will lead in ATLAS to $S/B = 6.5$ which is quite satisfactory.

3.2 Pions

A scan along the z direction has been performed using 80 GeV pions over 60 cm. The uniformity of the response is 0.85 % in r.m.s (Fig. 8).

The energy resolution has been studied for various incident angles, for energies ranging between 20 and 300 GeV. The result is well described by (Fig. 9) : $\sigma/E = 47\%/\sqrt{E} + 2.3\%$.

The slightly worse resolution at 0 degree comes from some residual channeling effect in the tiles. The energy resolution can be improved using a weighting

technique on the 4 depths to $\sigma/E = 39\%/\sqrt{E} + 1.8\%$. These very promising results for single pions in stand-alone mode (i.e. no electromagnetic section in front) have been obtained without using any weighting technique nor any cuts, and are in agreement with GEANT simulations.
The e/π ratio has been measured to be 1.2 at 20 GeV.

It is planned next year to make a combined test with the liquid argon electromagnetic 'Accordion' section in front to assess our pion performance with respect to ATLAS specifications.

3.3 Light yield

In the electron energy resolution, the statistical fluctuations coming from the number of photoelectrons produced contributes to the $1/\sqrt{E}$ term (to be added in quadrature to the sampling fluctuations contribution). Variable density filters have been used to reduce the effective light yield production and observed the degradation of the energy resolution [5]. This gives a light yield of 20 p.e./GeV.

New components (as double cladding fibers of the type Y11(200)M from KURARAY) have been measured in the beam. They produce an increase of 1.6 in the light production.

References

[1] ATLAS Letter of Intent for a General Purpose pp Experiment at the Large Hadron Collider at CERN, CERN/LHCC/92-4, LHCC/I2 (1992).

[2] Progress Report on ATLAS Milestones, The ATLAS Collaboration, CERN/LHCC/93-51 (1993).

[3] O.Gildemeister, F. Nessi-Tedaldi, M. Nessi, Proceedings of the Second International Conference on Calorimetry in High energy Physics, Capri, 1991, page 189.

[4] Developments for a Scintillator Tile Sampling Hadron Calorimeter with 'Longitudinal' Tile Configuration, CERN/DRDC 93-3, DRDC/P-46 (1993).

[5] J. Badier et al., the RD1 Collaboration, CERN/PPE/93-20 and 93-21 (1993) to be published in NIM.

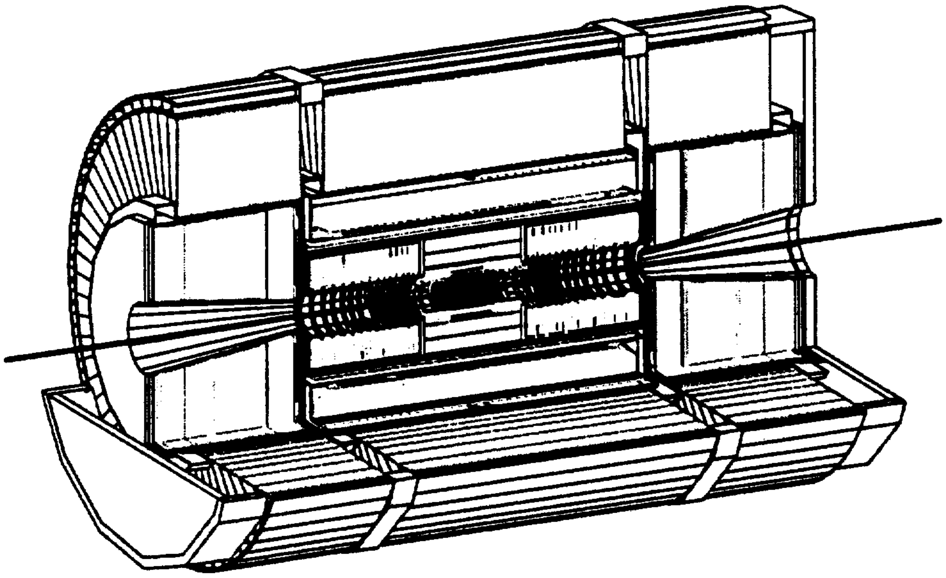

Figure 1: *Conceptual layout of the ATLAS calorimeter*

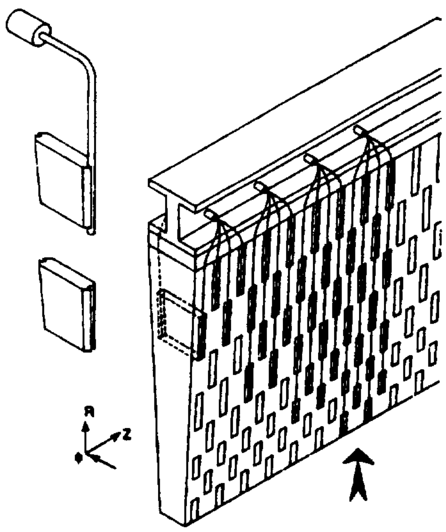

Figure 2: *Principle*

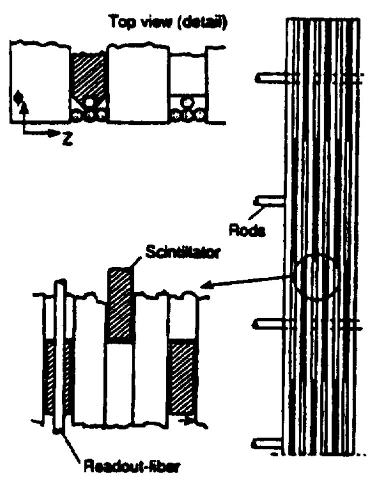

Figure 3: *A sector assembly*

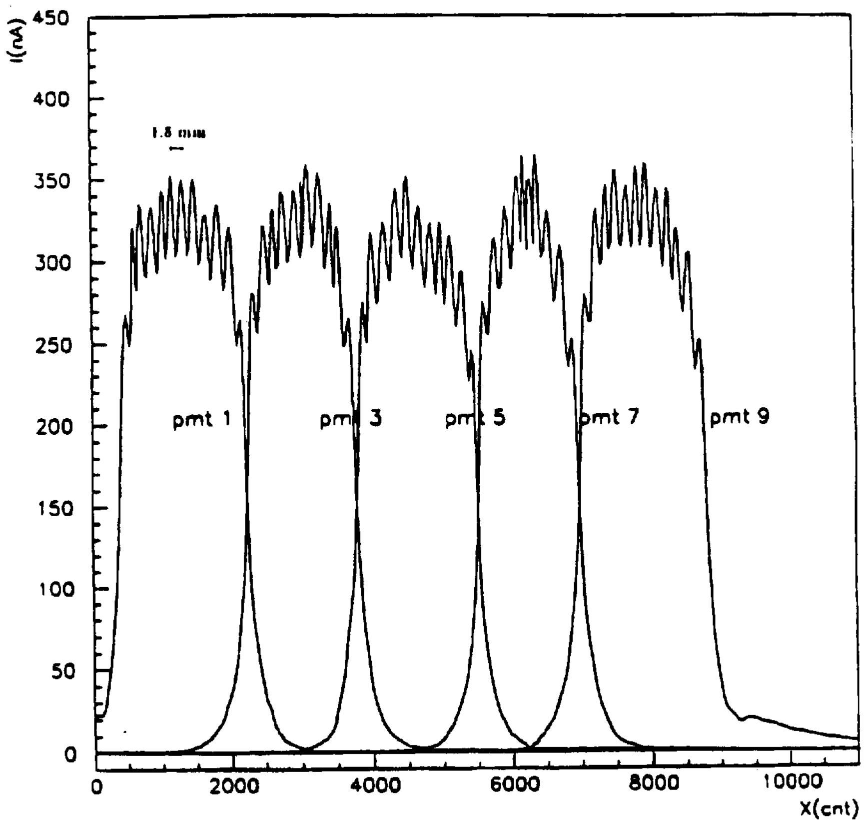

Figure 4: *Measurement with the source along z*

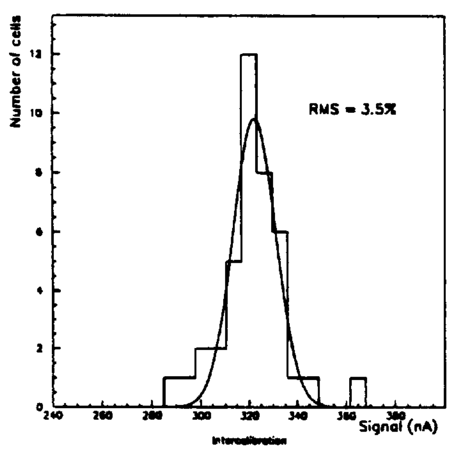

Figure 5: *Initial Cs cell-to-cell adjustement*

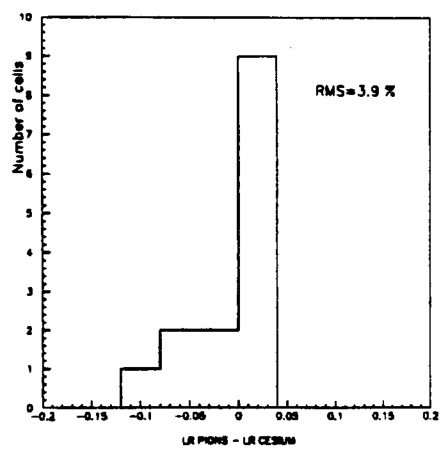

Figure 6: *Comparison Cs to pion calibration*

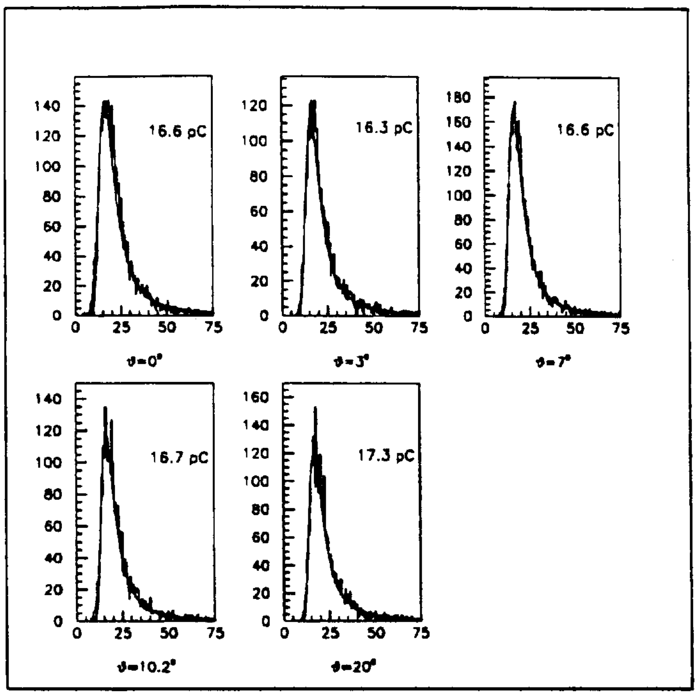

Figure 7: *Muon response for various incident angles*

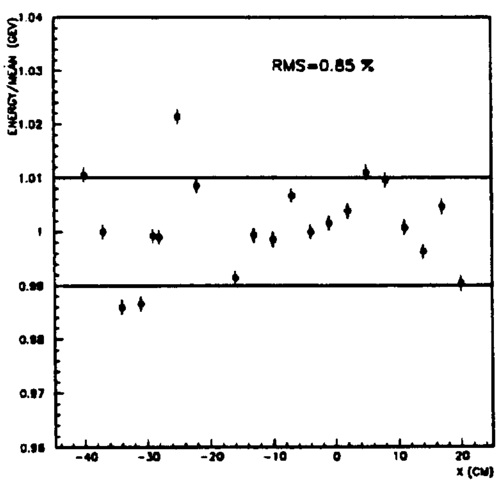

Figure 8: *80 GeV pion X scan*

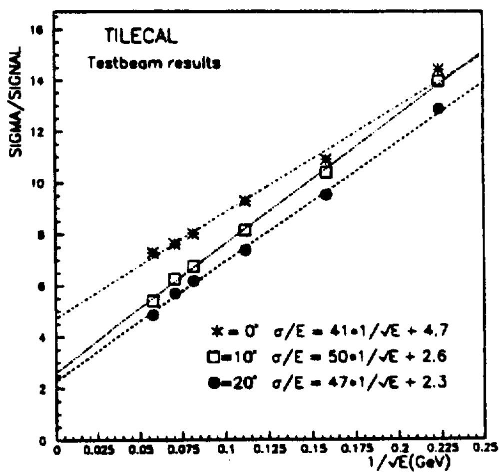

Figure 9: *Pion energy resolution*