H1-10/92-250

Contribution to the
3 d International Conference on Calorimetry in High Energy Physics.
Sept. 29 - Oct.2, 1992, Corpus Christi, Texas

PERFORMANCE OF THE H1 LIQUID ARGON CALORIMETER

Jörg Gavier
DESY, Hamburg, H1 Collaboration

ABSTRACT

Results are presented on the calibration of the liquid argon calorimeter of the H1 Collaboration by particles at a test beam and at the complete detector at HERA. The beam tests were performed with electrons and pions in the energy range 3.7 to 170 GeV. The data are compared with GEANT/GHEISHA simulation. Calibration tests at HERA were performed with cosmic muons and electrons, which allowed to verify the test beam calibration to 2%. Finally it is reported on first experience with reconstruction of hadrons at HERA.

1. Introduction

The H1 collaboration has reported previously on various tests[1] performed at CERN with prototypes of the H1 liquid argon calorimeter. In this report data are presented obtained from the actual stacks built for HERA. Only a very short description of the H1 liquid argon calorimeter can be given here. The front section for e and γ detection ("EMC" here after) has a depth of up to 29 X_0 (1.3 λ) with lead absorber plates and liquid argon gaps of 2.4 mm. Copper claded read out boards are glued on either side of every second lead plate. The hadronic calorimeter ("HAC") has a depth of up to 7 interaction lengths (λ) with steel absorber plates of 16 mm thickness. A readout structure (2 x 1.5 mm steel, G10), providing two gaps of liquid argon of 2.4 mm. is inserted between every 2 absorber plates. The calorimeter is described in much more detail by G. Cozzika[2].

Reliable simulation is important for the analysis of HERA events. The results of this report were obtained by GEANT 3.14/GHEISHA with cuts at 200 keV for γ s and 1 MeV for other particles.

2. Calibration by Electrons

At least one octant of every calorimeter wheel has been exposed to electrons and pions at CERN. The data supplied the basic calibration constants of the calorimeter. Now this calibration is verified at HERA by particles (section 4).

2.1. Definition of the Electromagnetic Scale

For each wheel we determine 2 calibration constants c_{exp}^{EMC}, c_{exp}^{HAC}, which transform the measured electric charge per tower into energy deposited by electron showers. Corresponding constants c_{MC}^{EMC}, c_{MC}^{HAC}, transforming visible energy into deposited energy are obtained for Monte Carlo (M.C.) by putting electrons (of 30 GeV) directly into the stacks. These constants are ideal in the sense that they are defined to be independent of effects of dead materials in front of the calorimeter, any leakage and analysis cuts. The numerical value of the corresponding experimental constant c_{exp}^{EMC} is obtained by comparison (see fig.1) of experimental data with detailed simulation of the test setup and requiring the reconstructed energies to agree:

$$E_{rec}^{exp} = c_{exp}^{EMC} \sum_i^{EMC} Q_i = E_{rec}^{MC} = c_{MC}^{EMC} \sum_j^{EMC} E_j^{vis} \quad (1)$$

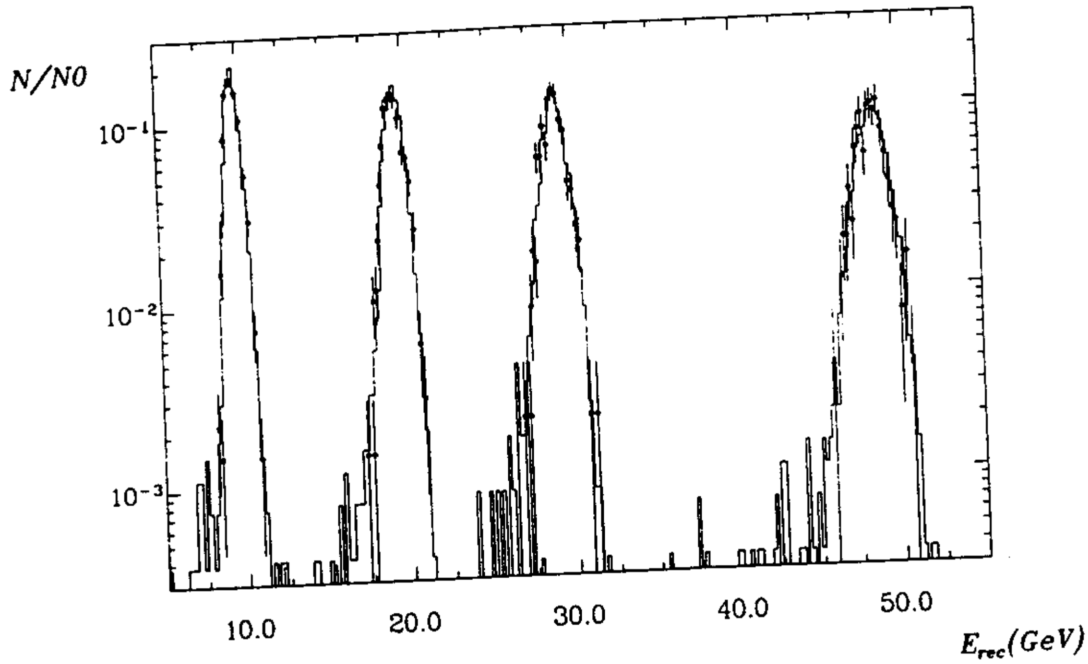

Figure 1: E_{rec} for data and M.C. at various electron energies. (Wheel BBE)

2.2. Results

We obtained as average calibration constant $c_{exp}^{EMC} = 3.55$ GeV/pC. But only the constant c_{exp}^{EMC} is determined by beam electrons. For the hadronic stacks no electron data are available yet and $c_{exp}^{HAC} = 7.1$ GeV/pC results from scaling the value of EMC by M.C.

The resolutions σ/E obtained for various stacks are in the range 10% to $13\%/\sqrt{E}$ with constant terms below 1%. Nonlinearities are as well below 1%.

However the variation of the calibration constants of the various stacks is found to be about 2.5% larger than expected from the known mechanical differences of different wheels. The main error source were impurities in the liquid argon during the CERN test. This can be checked at HERA (see section 4.2).

3. Test Beam Results for Pions

The data on pions were compared on the electromagnetic scale with simulation in many distributions. The result for the lowest pion energy is shown in fig.2 (wheels FB2/OF[2])). The predictive power of the simulation is impressive. Much more comparisons can be found elsewhere[3].

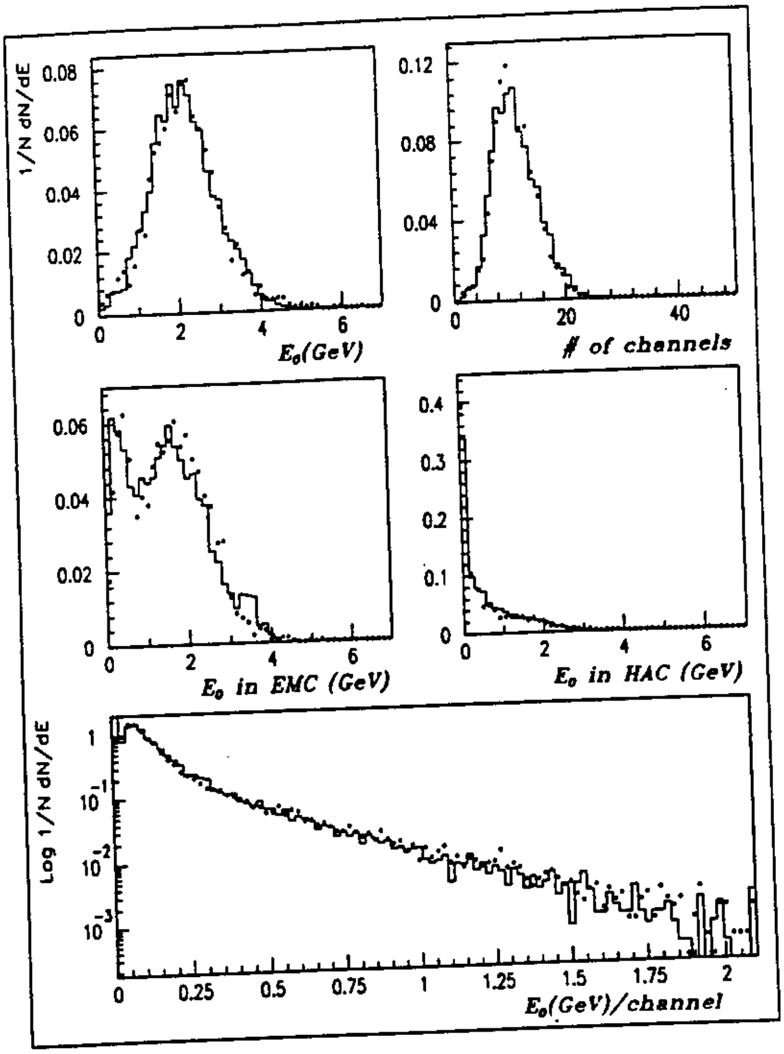

Figure 2: π at 3.7 GeV. Data (histo) and M.C. (dots)

The response across a severe crack (between wheels CB2 and CB3 [2]) was explored with pions (fig.3). Data and M.C. show the same behaviour, and the event by event corrections of the general H1 reconstruction code, which were deduced from M.C., work the same way for data as for M.C.

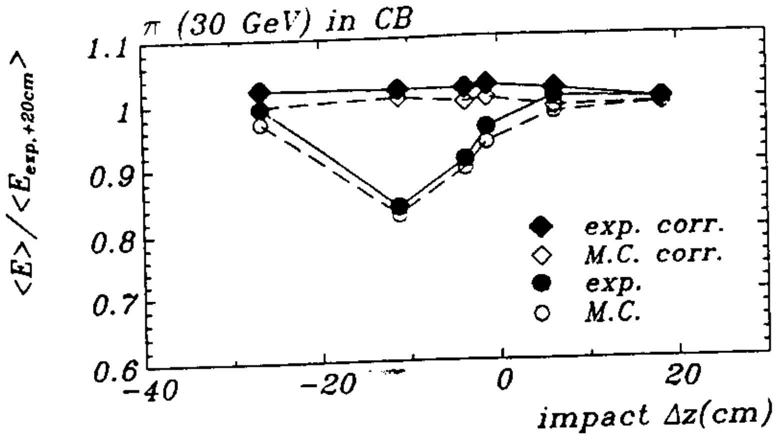

Figure 3: Response accross CB2/CB3 crack

The energy resolutions obtained are around $50\%/\sqrt{E}$ with constant terms of 3%. This resolution is achieved for this non compensating calorimeter only by software weighting techniques by which hadronic and electromagnetic components of the showers are approximately separated and scaled differently.

4. Energy Scale at HERA

4.1. Cosmic Muons

The H1 detector is operational since April 91. Extensive data taking with cosmic muons resulted in a verification of the electromagnetic energy scale as determined at the CERN beam tests (section 2) to 8%. The charge collection efficiency at 1.5kV was determined by high voltage plateau curves to be .944 $\pm$ .014. The muon signal was observed to be stable to $\pm 2\%$ from November 91 to March 92.

4.2. Cosmic Electrons

The energy scale at HERA could well be checked by electrons generated by muons passing through the detector. A typical event is shown in fig.4. By comparing the momentum measurement in the tracker with the calorimeter response, the overall energy scale from the beam tests at CERN could be verified to 2% (fig.4). The width and mean of the distribution of E/p agrees with the expectation from simulation.

4.3. Hadrons

The first attempts to verify the hadronic energy scale at HERA are limited by present statistics. Two methods were used for deep inelastic events:
1) measurement of isolated tracks in tracker and calorimeter (fig.5 a),b)) and

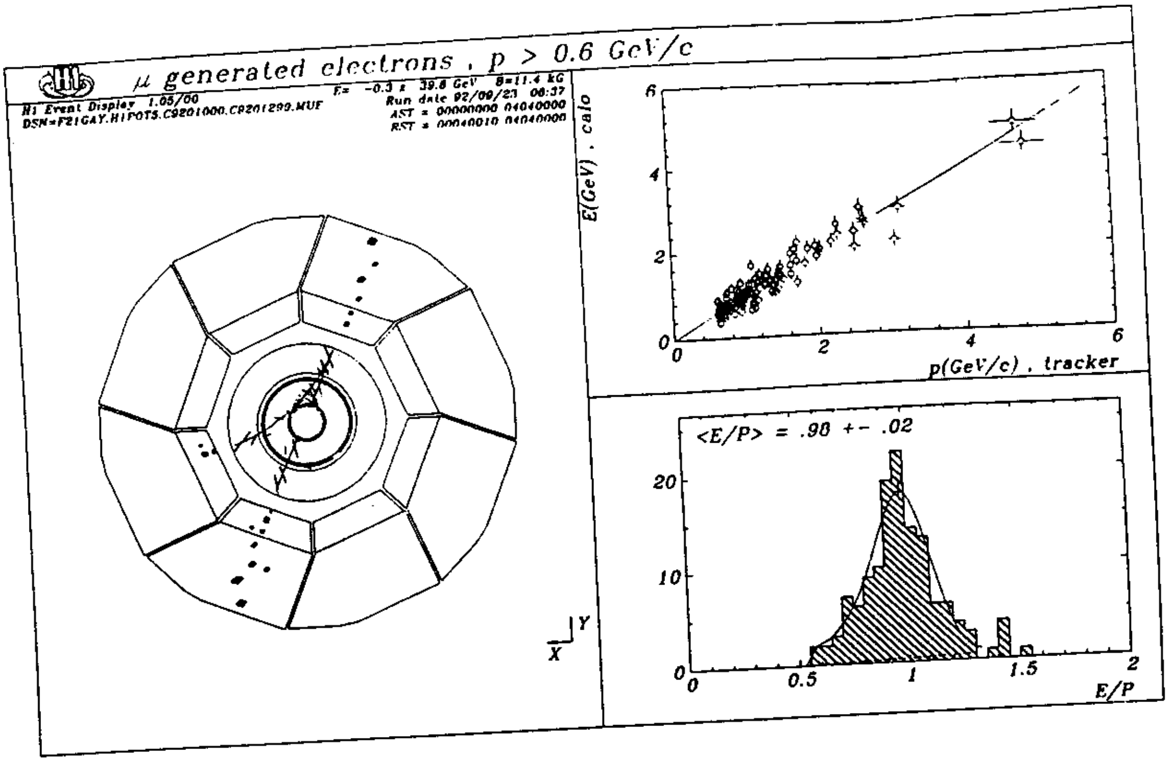

Figure 4: Energy match of electrons in tracker and calorimeter

2) balance of p_t of the scattered electron (which is detected in a different calorimeter) and that of the summed vectorial hadronic p_t as measured with the liquid argon calorimeter (fig.5 c),d)).

With both methods the energy scale is checked at present on the level of 10%.

5. Conclusions

- The H1 liquid argon calorimeter is well understood.
- Test beam results for electrons: resolution $\sigma/E = 12\%/\sqrt{E}$ with a constant term $< 1\%$.
- Test beam results for pions: resolution $\sigma/E = 50\%/\sqrt{E}$ with a constant term of 3%.
- The response to cosmic muons was constant to $\pm$ 2% over 4 months.
- The overall energy scale as determined by electron beam tests was verified at HERA to 2% by comparison of momentum (tracker) and energy (calorimeter) of electrons generated by cosmics.

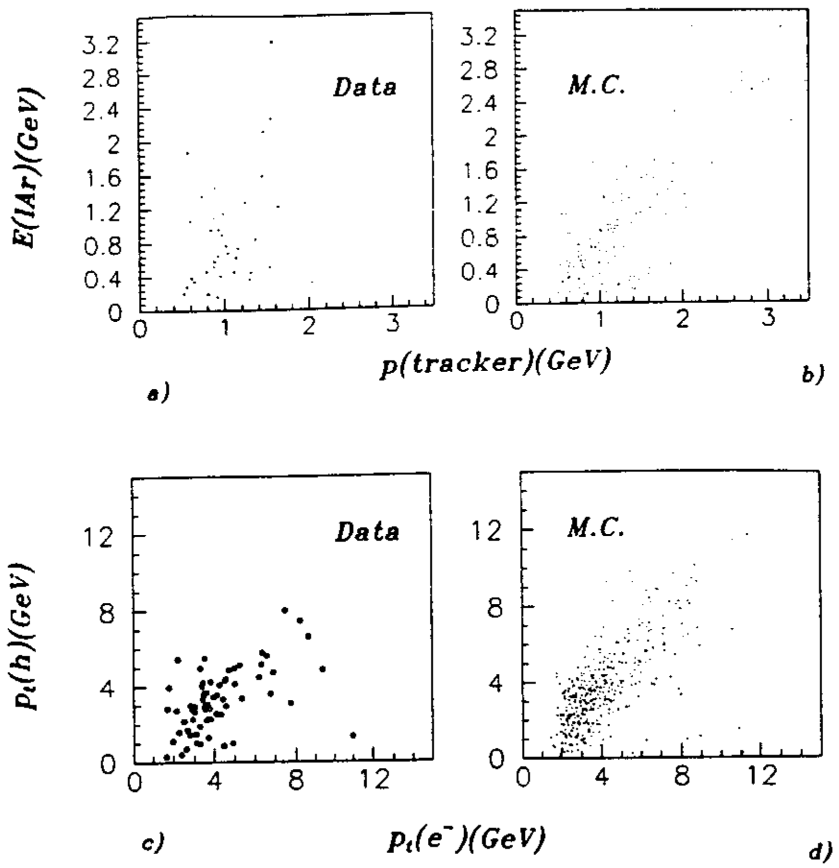

Figure 5: a),b) Energy match of isolated hadron tracks in tracker and calorimeter. b),c) p_t balance

6. Acknowledgements

I am grateful to my colleagues of the H1 Collaboration, especially to V. Shekelyan for a critical reading of the draft.

7. References

1. H1.Calorimeter Group. *NIM* **A265** (1988) 419, *NIM* **A275** (1989) 246, *DESY* **89-22** (1989).
2. G. Cozzika. *The H1 Detector* . these Proceedings.
3. J. Gayler. *in MC91. Workshop of Detector and Event Simulation*, ed. K. Bos and B van Eijk (NIKHEF-H, Amsterdam,1991),p. 312. / H1 – 06/91 – 175
   P. Loch. Thesis. University of Hamburg (1992).
   M. Flieser, *MPI-PhE* **92-08**, *H1 Internal Report* **07/92-231** (1992).
   J. Zacek et al., *H1 Internal Report* **04/92-220** (1992).