



Trigger Tower Analogue Signals

Test Beam measurements with EM Barrel, HEC and Tile

H. Stenzel, presented by **P. Hanke**
Kirchhoff-Institut für Physik, University of Heidelberg

November 2001

ATLAS Level1 Calorimeter Trigger Joint Meeting

- F Test beam set-up
- F Particle signals
- F Calibration signals
- F Saturation issues
- F Cable impact
- F Summary



Tile Calorimeter

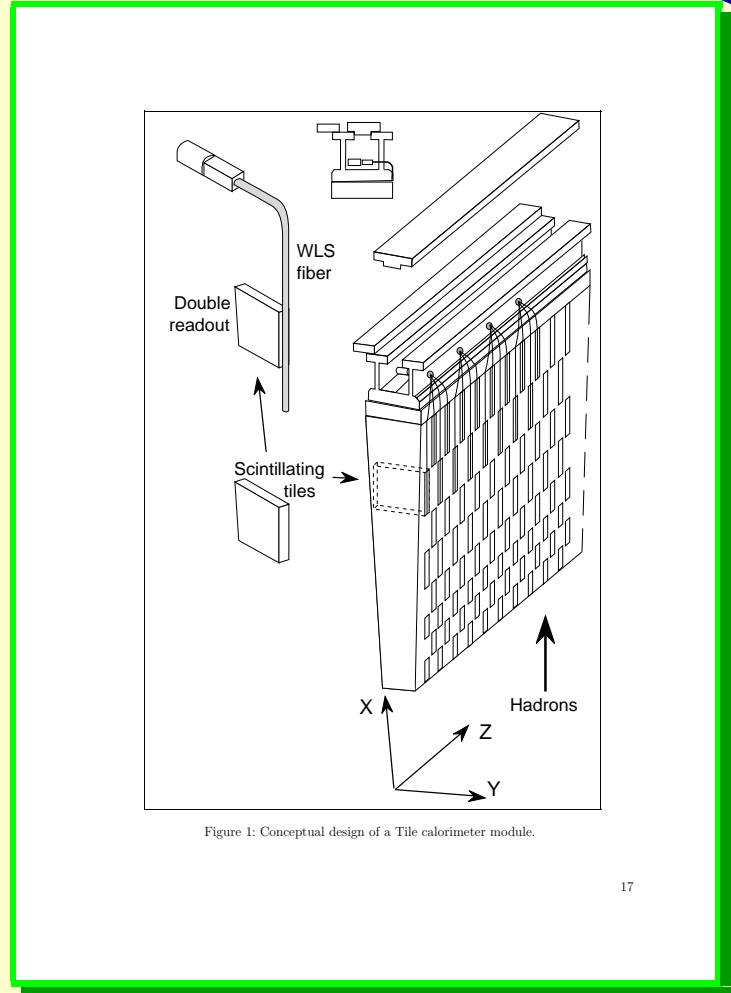
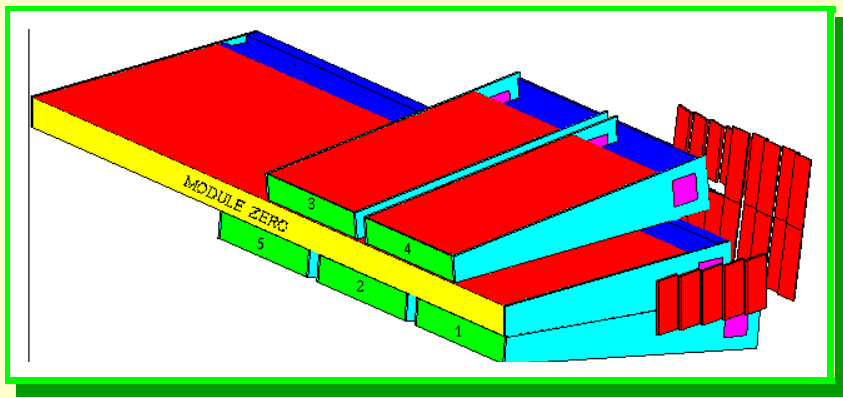
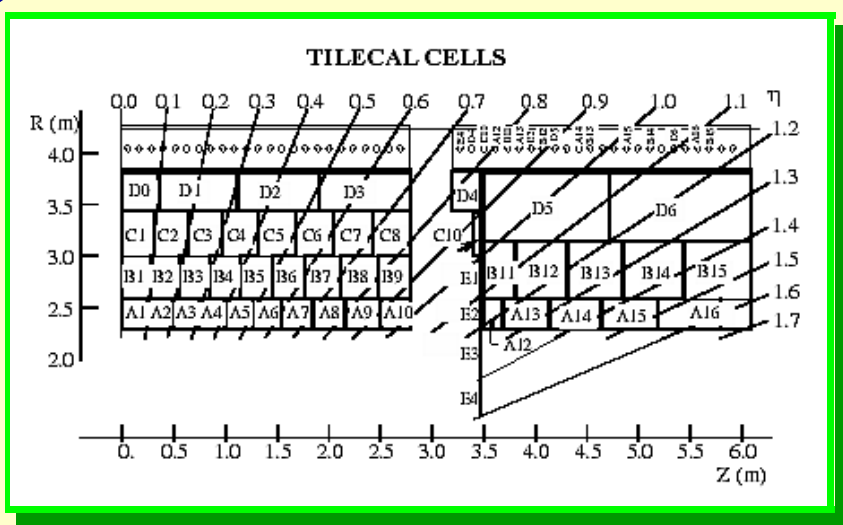
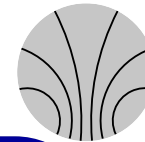
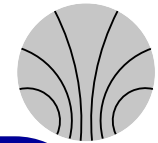


Figure 1: Conceptual design of a Tile calorimeter module.

Two extended tile modules in this test-beam $0.8 \leq \eta \leq 1.6$, $\Delta\phi = 0.1$, 6 Trigger towers with 3-6 cells. 180 GeV beams of e and π , calibration signals with CIS and Laser.



Tile trigger tower signal specifications



TileCal Trigger Signals

The TileCal LVL1 trigger signals are produced by analog adders located in the electronics drawers. The inputs to the adders are shaped analog signals from the the 3-in-1 cards associated with each PMT. The signal amplitudes are proportional to the charge from the PMT and the timing is set with fixed delay cables to obtain a coincidence of all signals in the tower.

The output timing from each tower varies because of time-of-flight effects and the location of the adder circuit. The signals represent energy sums not E_T sums.

Trigger tower output signals

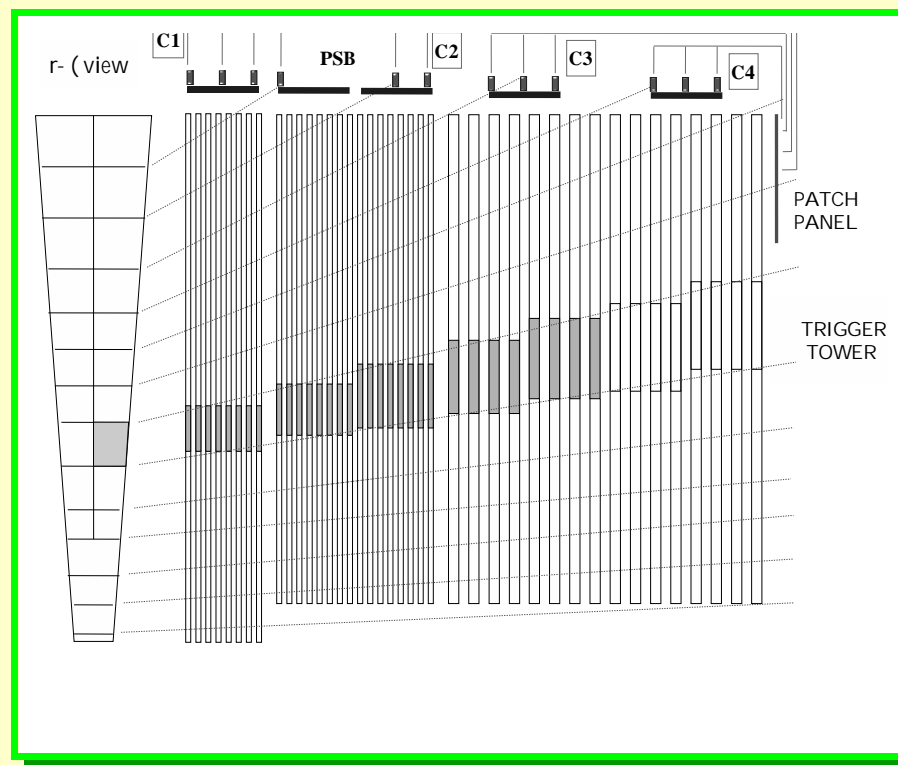
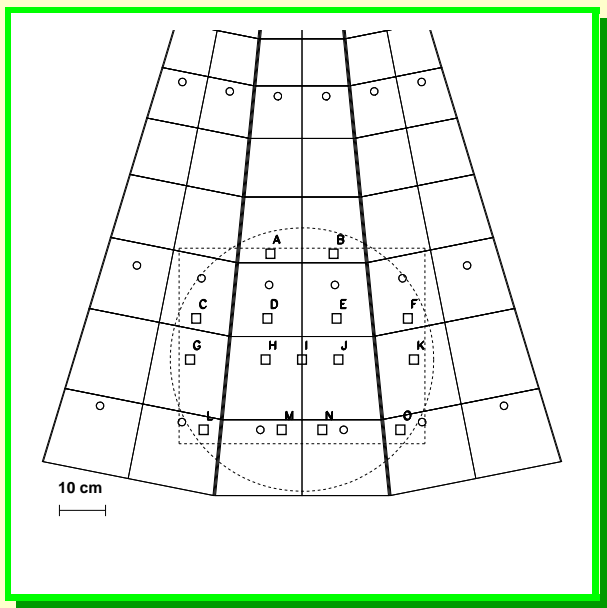
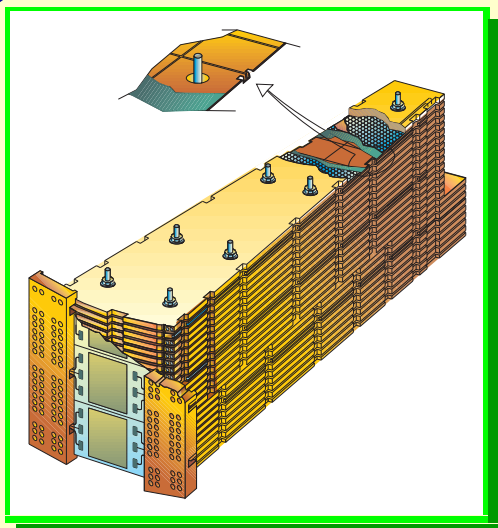
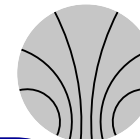
- unipolar, 50 ns FWHM
- calibration, ± 4 mV/GeV
- differential, ± 2 V full scale (500 GeV)
- outputs are capable of driving 50 ohm loads with respect to ground
- noise $< \pm 1$ mV RMS
- fast overload recovery

Input signals to trigger tower adders

- unipolar, 50 ns FWHM
 - shaped pulses derived from PMT signals
 - coincident in time to ± 1.5 ns
 - calibration, ± 0.5 mV/GeV
 - differential, ± 0.5 V full scale (1000 GeV)
 - enable/disable for each signal via 3-in-1 control
-



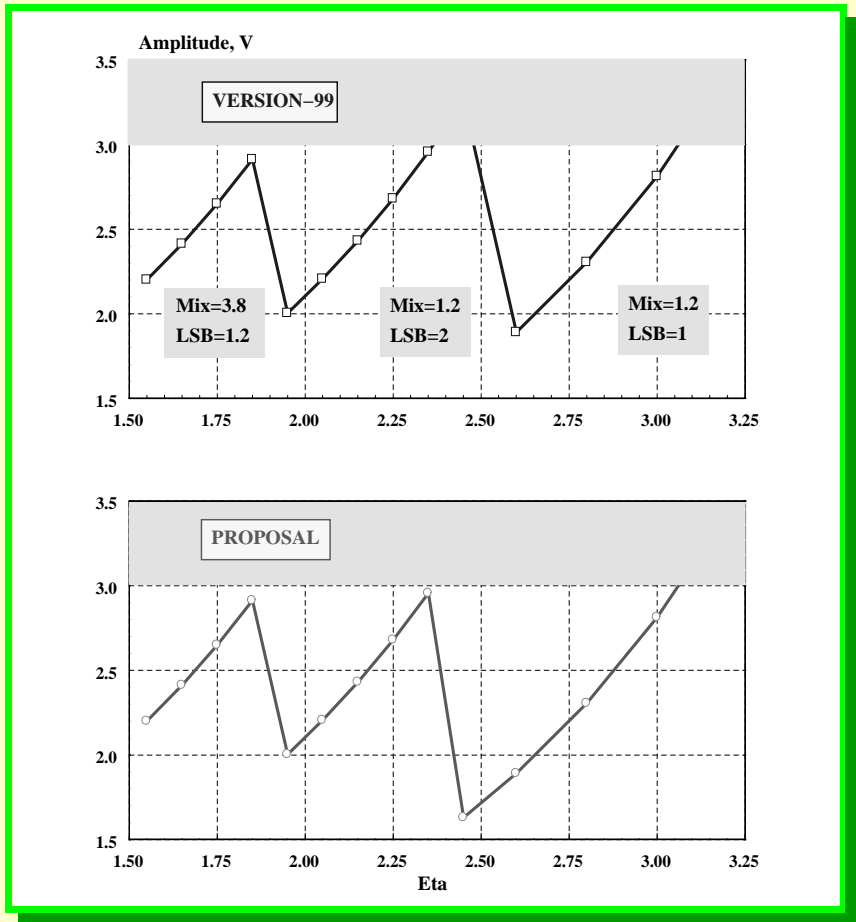
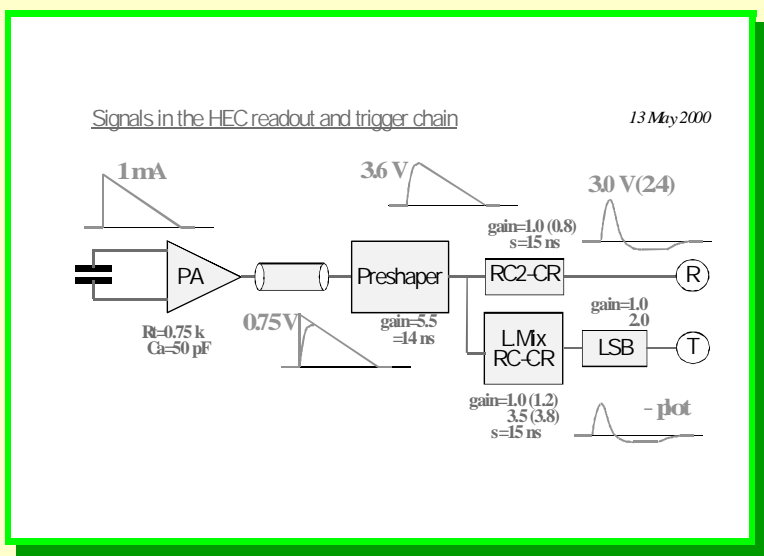
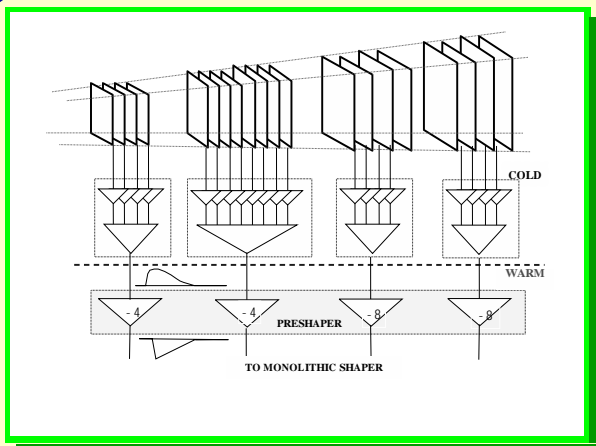
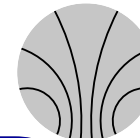
HEC test-beam set-up



$3 \oplus 3$ HEC modules, non-pointing geometry, e and π of 148, 120 and 60 GeV, electronic calibration, optional signal transmission via 70 m cable

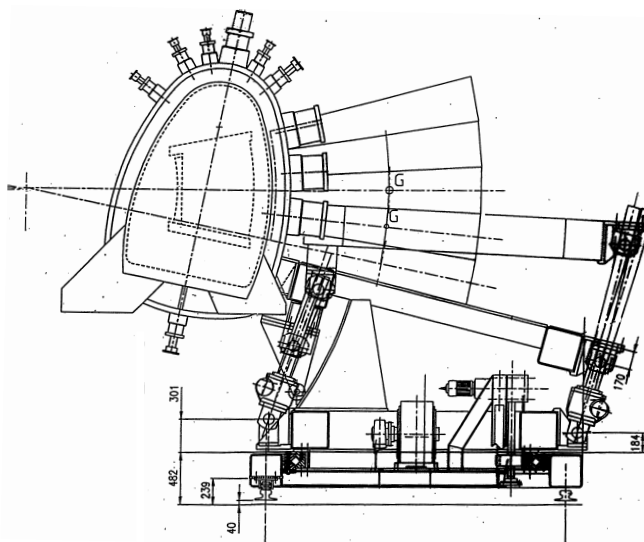
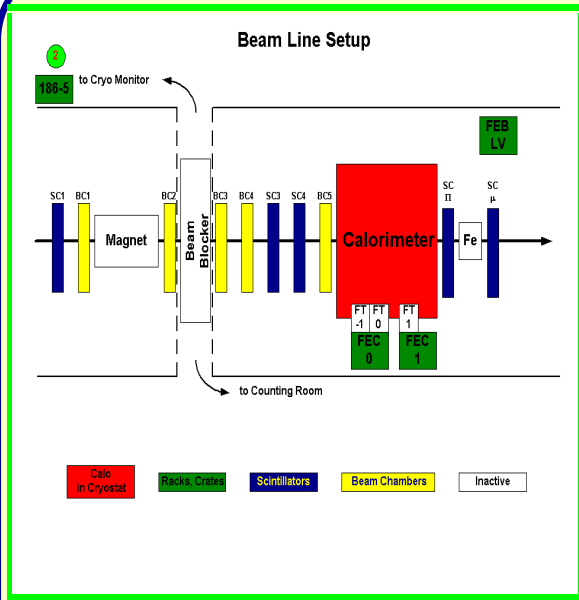
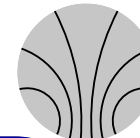


HEC Trigger Tower Signals





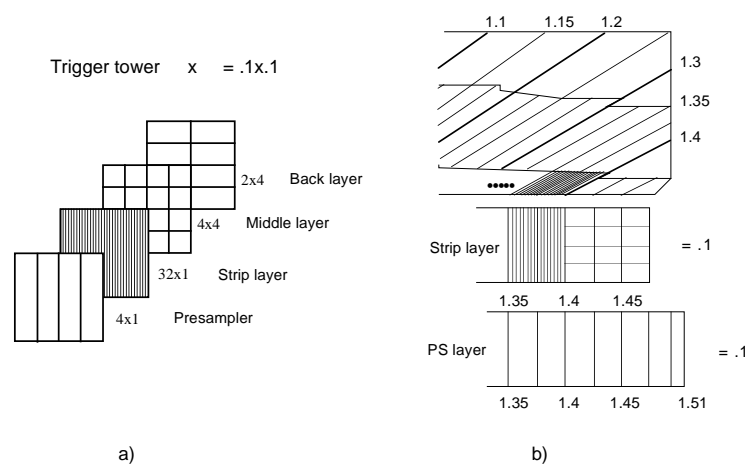
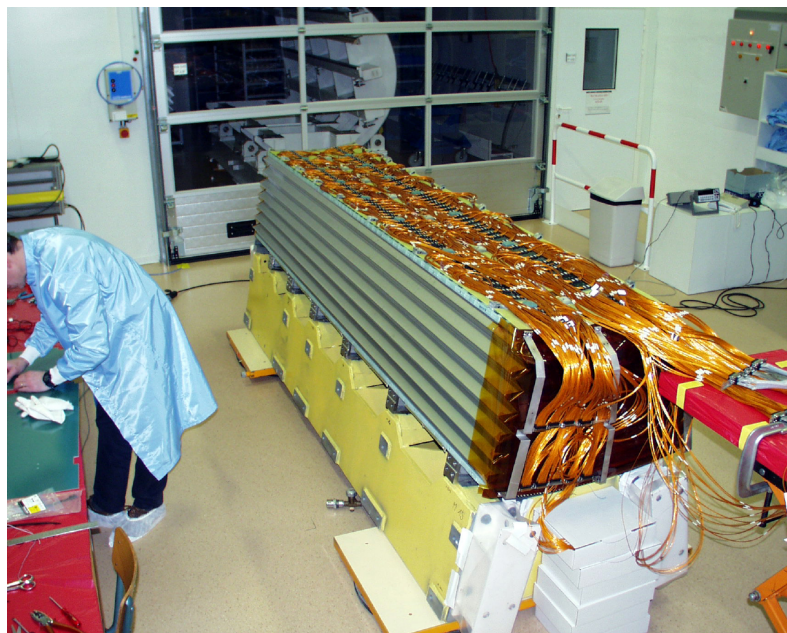
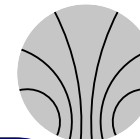
EM barrel test beam (October 2001)



Test beam of production module M10 with e of 245 GeV.
One half-barrel module covers $0 \leq |\eta| \leq 1.4$ and $\Delta\phi=0.4$.
Trigger towers are summed over 4 longitudinal sections and the variable transversal read-out granularity ($\Delta\eta \times \Delta\phi = 0.025 \times 0.025$ in second sampling).



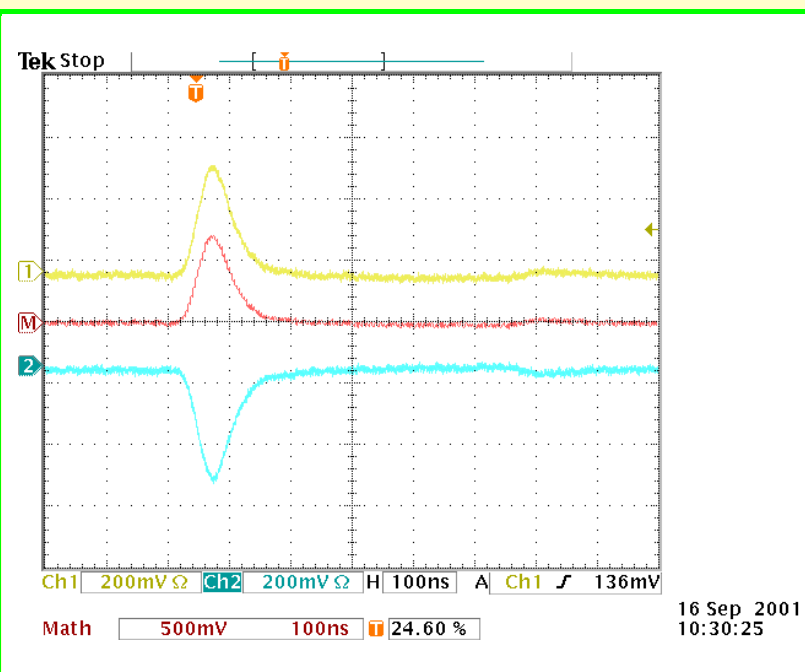
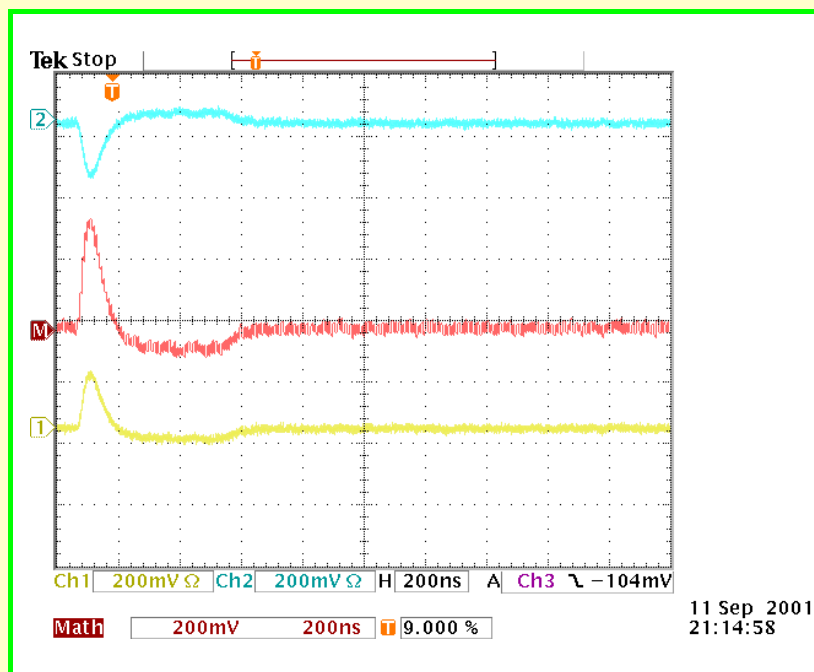
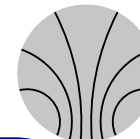
EM barrel set-up



The full analogue trigger chain with (almost) final production components is installed at the test beam, including LayerSum, TowerBuilder, TowerDriver, Transmission cable (70m) and receiving station (prototype, cable compensation factor ≈ 2 missing). Analogue signal measurements during October test beam were done by **Esther Ferrer Ribas**.



Oscilloscope measurements

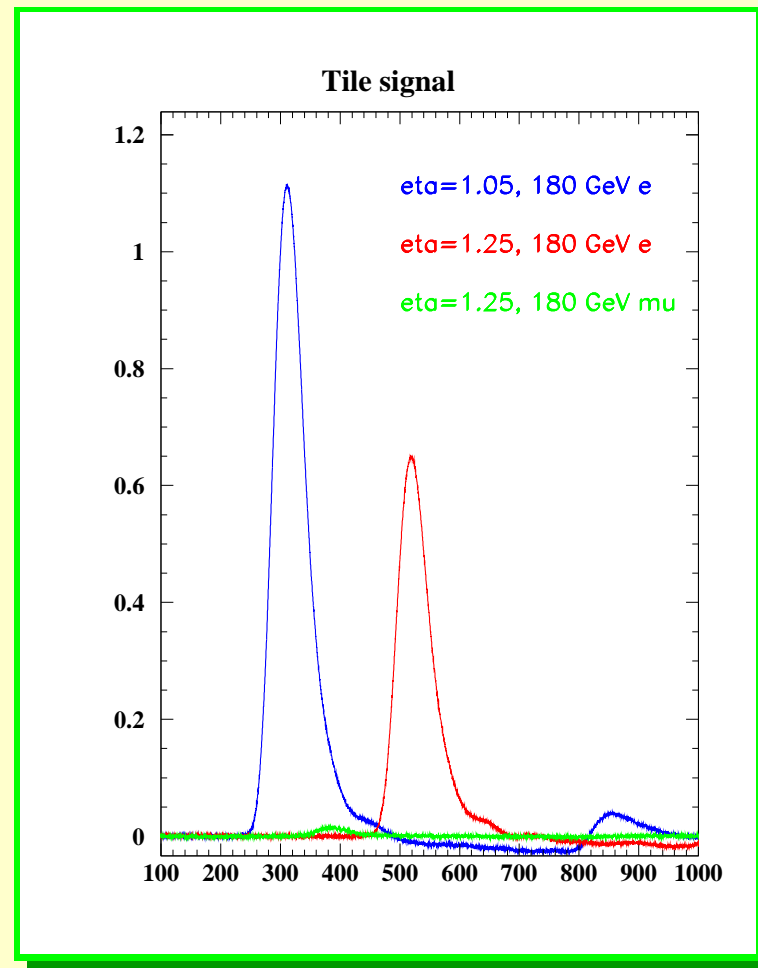
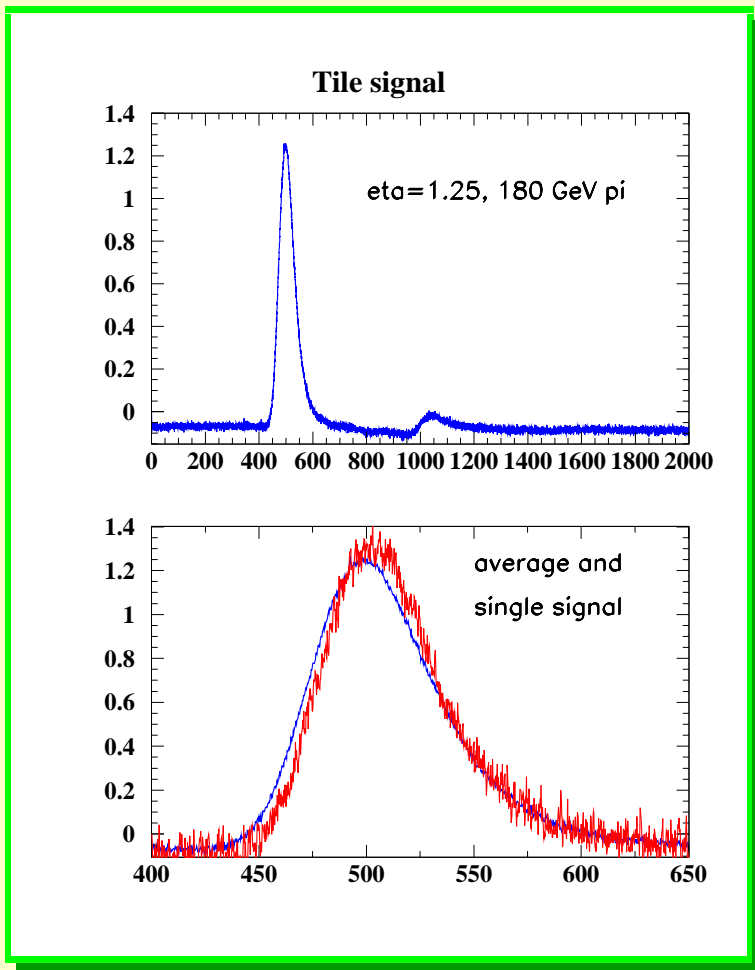
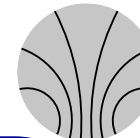


Differential signals subtracted with scope, single ended signal recorded with $\Delta_T=200$ ps, signal length $2 \mu\text{s}$, 10k points (HEC/Tile).

Measurements at the EM barrel were done after the receiving station with $\Delta_T=400$ ps over $1 \mu\text{s}$ with 2500 points (different oscilloscope).



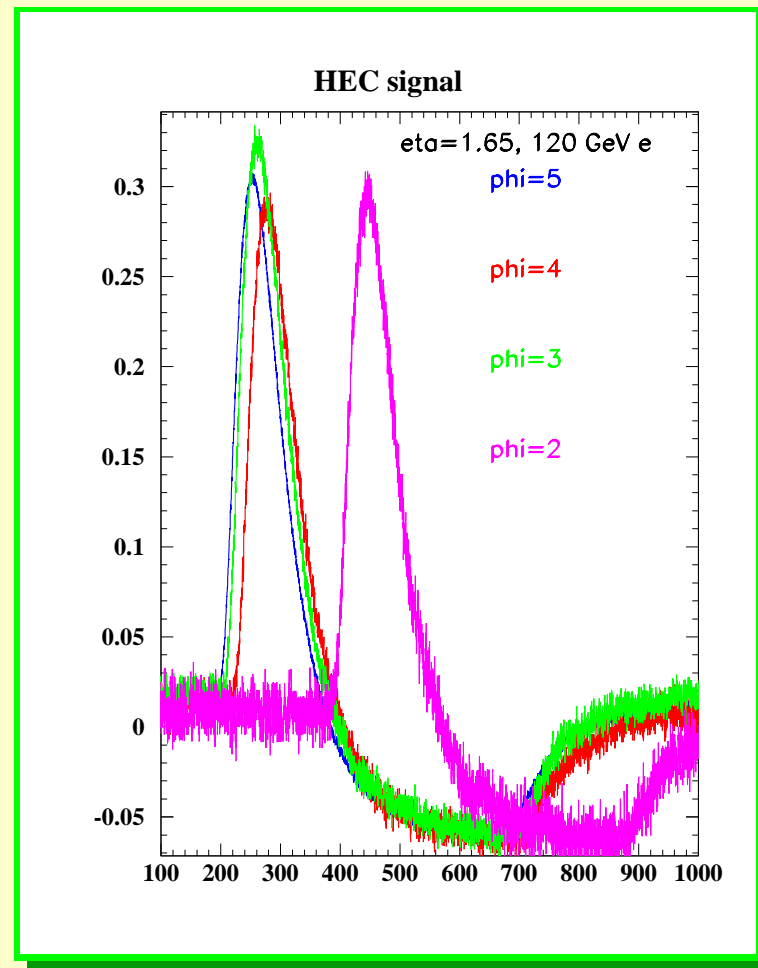
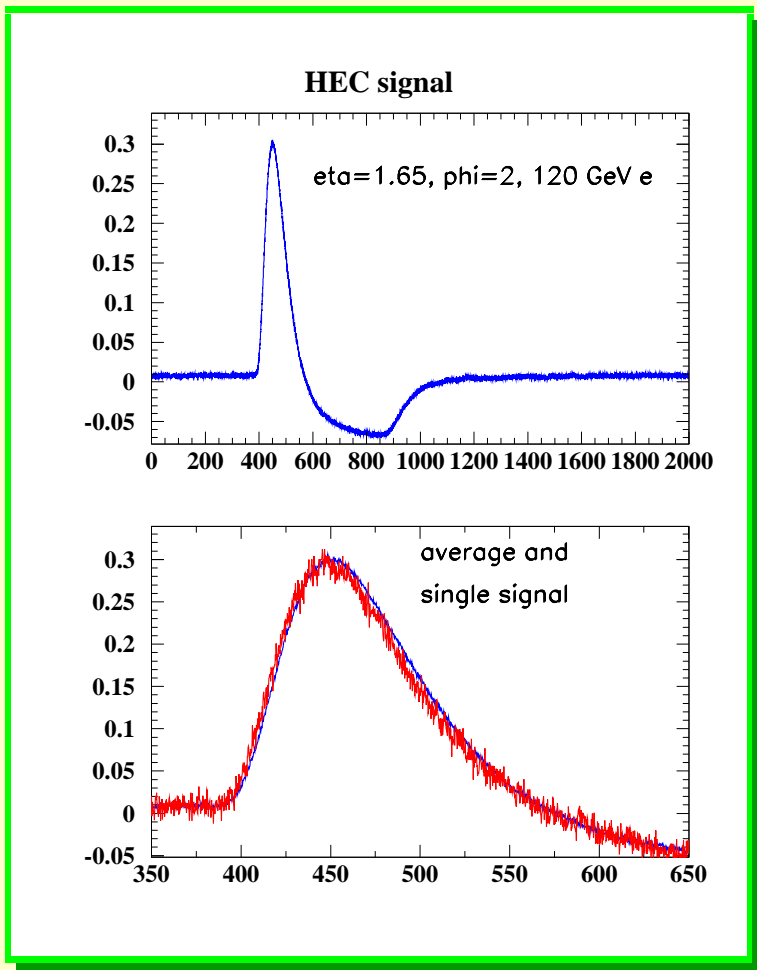
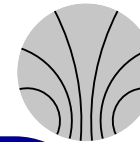
Tile particle pulses



Signal about about 0.6 V/100 GeV, peaking time around 55 ns, channel-to-channel amplitude variations, $0.45 E \leq E_T \leq 0.7 E$.



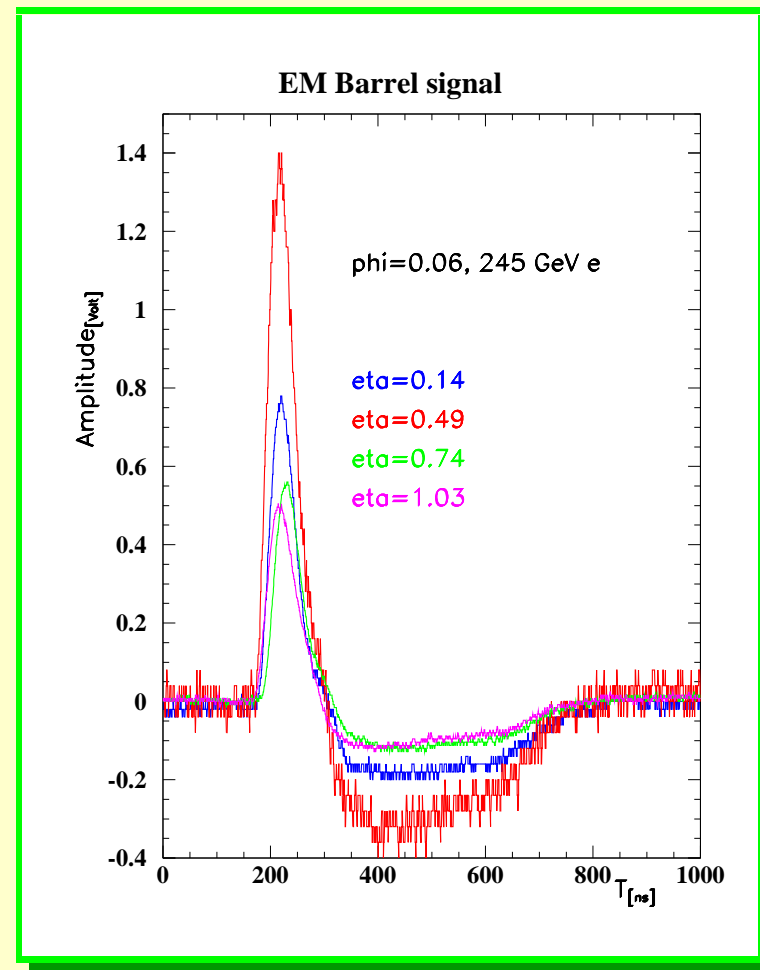
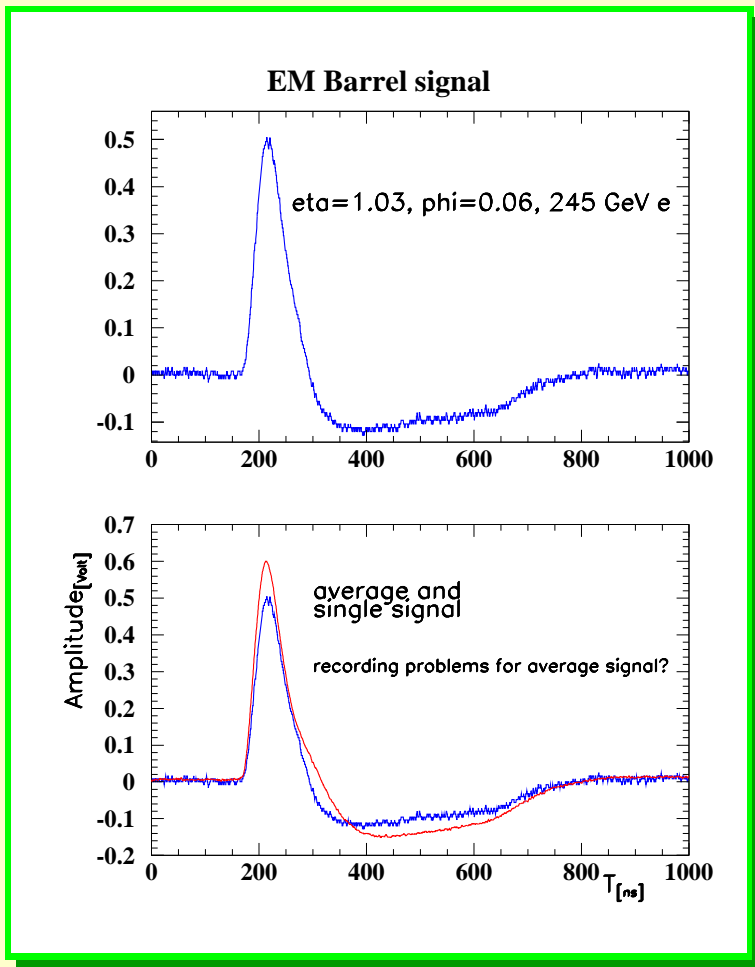
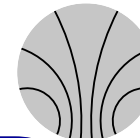
HEC particle pulses



Signal about about 0.75 V/100 GeV (E_T !), peaking time around 65 ns, good homogeneity, $0.1 E \leq E_T \leq 0.4 E$.



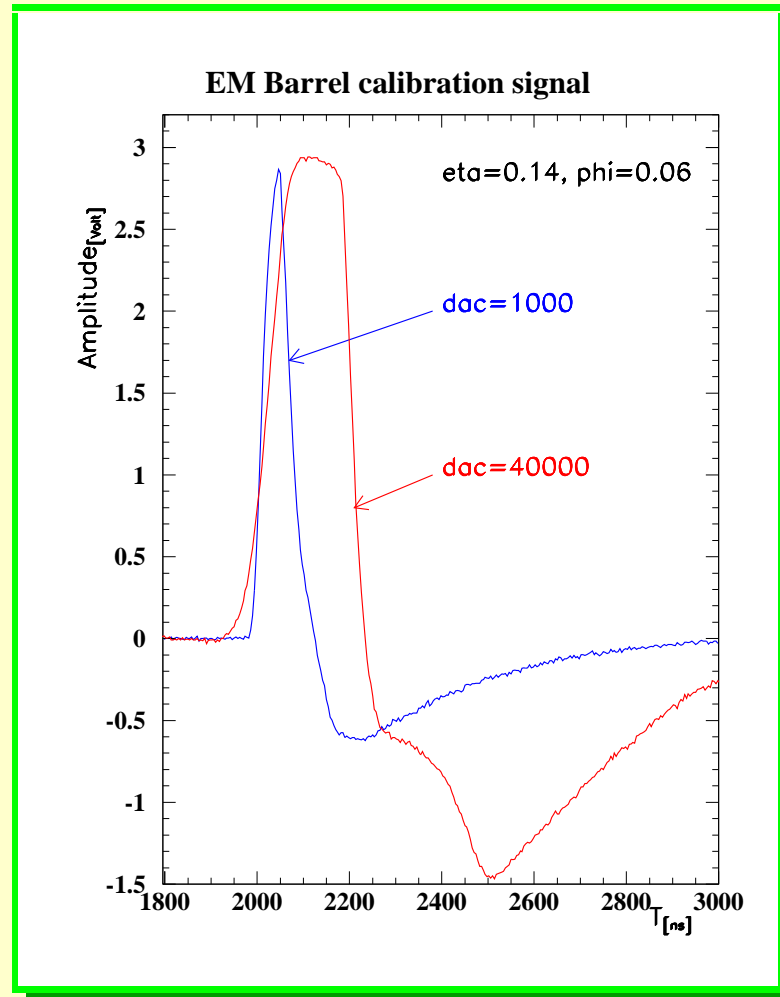
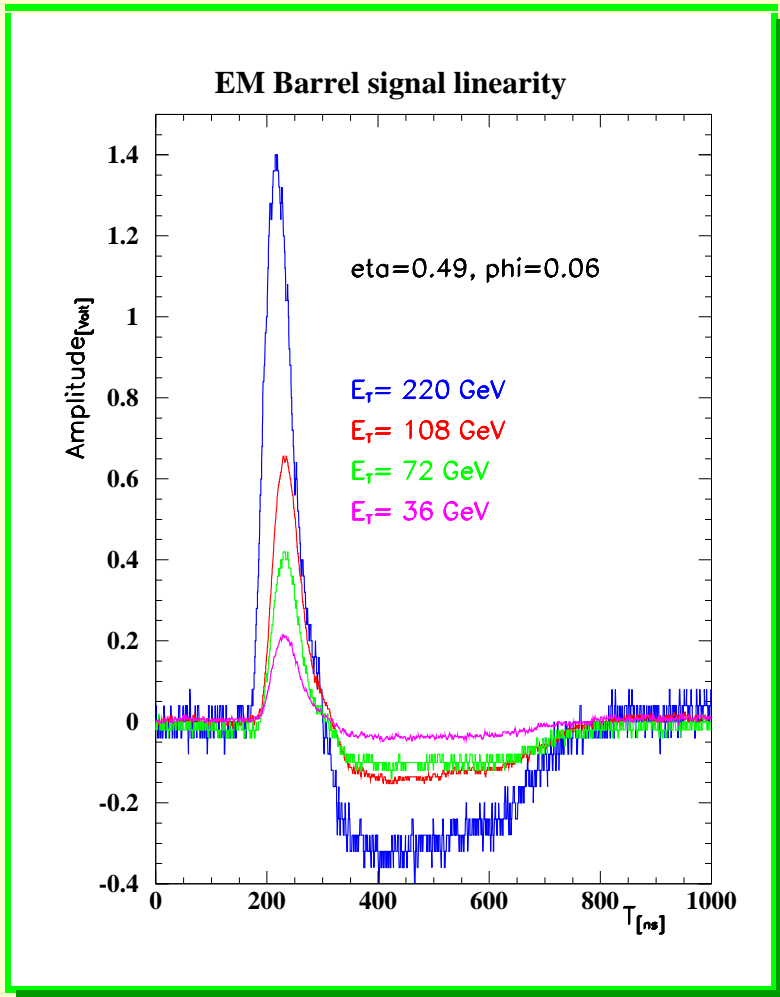
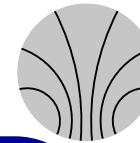
EM barrel particle pulses



Signal amplitude about 1.5 V/256 GeV (E_T),
no compensation for cable attenuation (factor 2)
peaking time around 50 ns. **Very preliminary!**

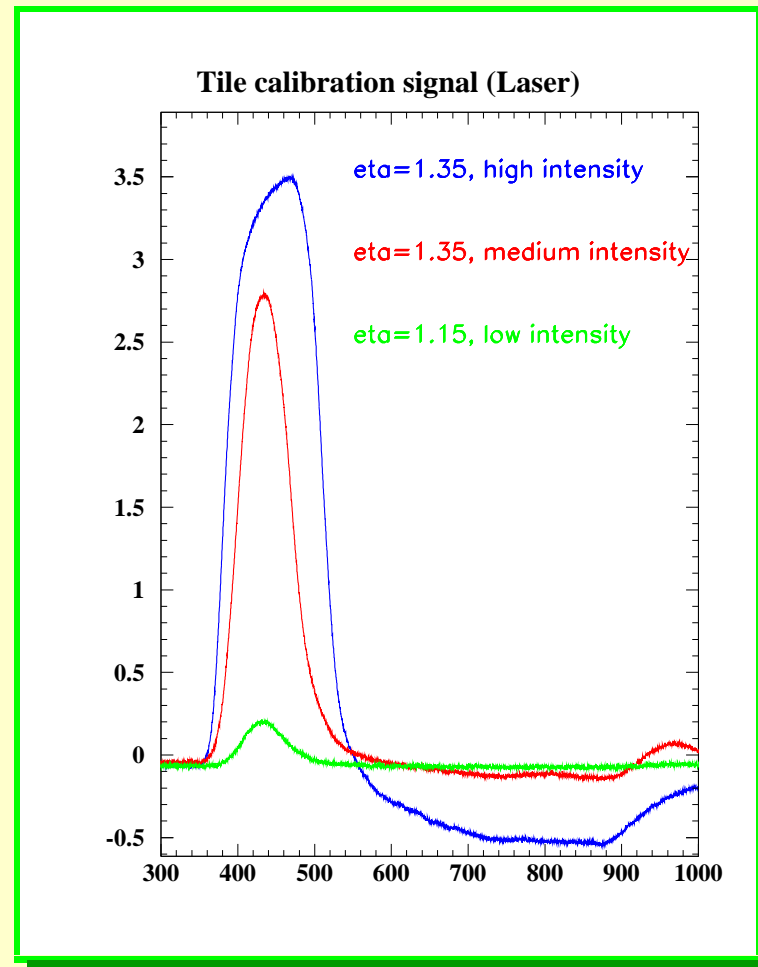
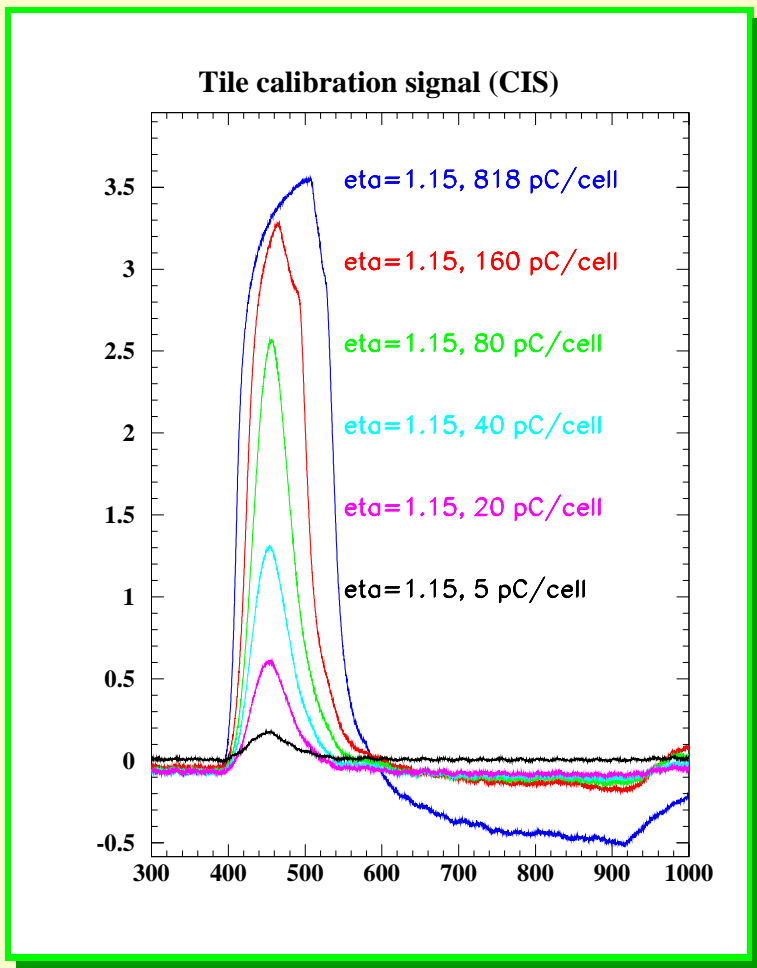
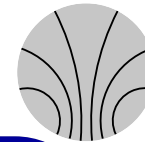


EM barrel linearity and calibration





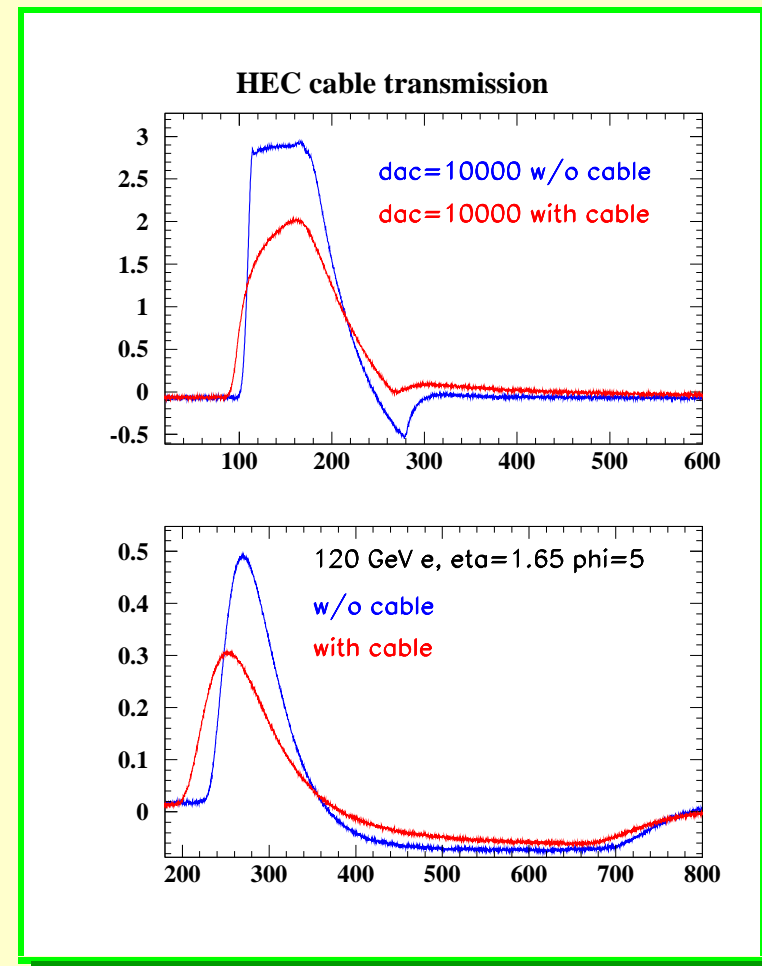
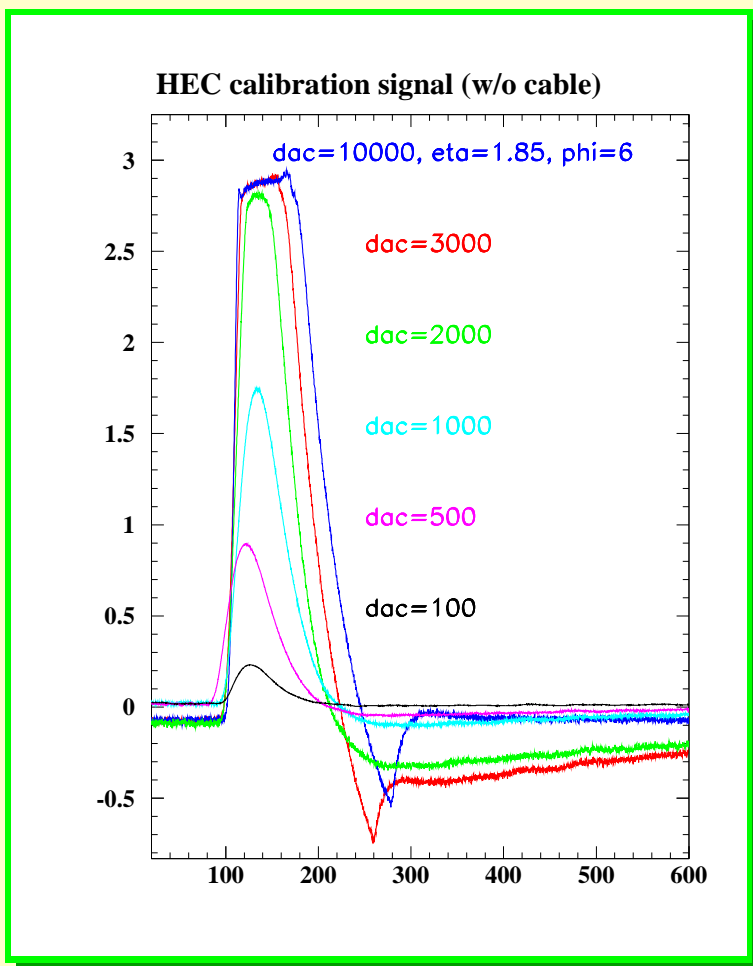
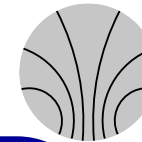
Tile calibration/saturation



Calibration with charge injection, laser, and caesium source (no data), Signal linearity better than 2 %, saturation around 3 V.



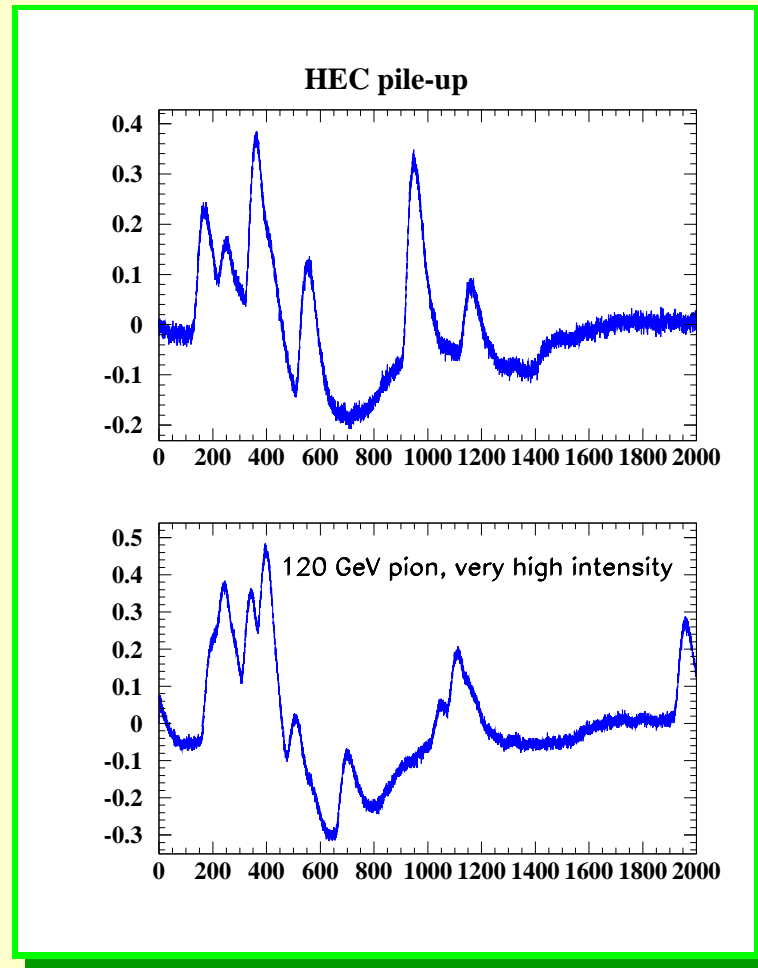
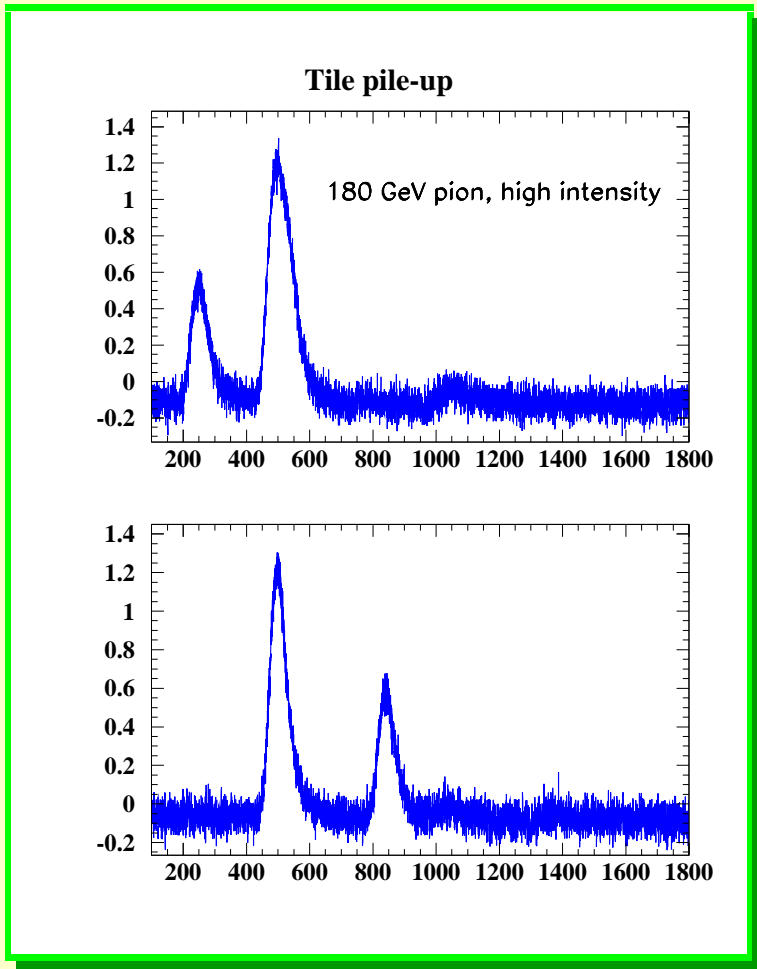
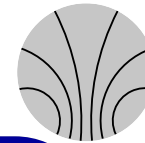
HEC calibration/saturation



Electronic calibration, signal saturation at TrDr around 2.7 V.
Strong signal attenuation by 70m prototype cable.



Tile + HEC pile-up



10^6 (Tile) to 10^9 (HEC) hadrons per burst (4.5 s).
Mostly high energy pions, not directly comparable to LHC pile-up.



Summary of available data



Calorimeter	electron	pion	calibration	special
HEC	148, 120 and 60 GeV	120 GeV	full range MIP-5 TeV	cable studies saturation pile-up
Tile	180 GeV	180 GeV	full range CIS and Laser	muons saturation pile-up
EM Barrel	245, 120 100, 80 40, 30 GeV	-	256 GeV 5 TeV -	saturation - -

More than 400 signal shapes have been measured.

Data are available as ascii-file and histogram. Measurements and documentation will soon be made publicly available