Test Beam Results of the Quartz Fibre Calorimeter for the H1 Luminosity Measurement at HERA

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For the luminosity measurement at HERA after the machine upgrade in the year 2000, the H1 collaboration has chosen to build a quartz-fibre/tungsten Čerenkov calorimeter since this recent technology has proven suitable for high radiation level (≈GGy) environments. This electro-magnetic sampling calorimeter has a strip geometry in order to provide position measurement. The fibres are oriented at 45° in two orthogonal directions with respect to the incoming particle direction in order to maximize Čerenkov light collection. The combination of these two properties leads to a rather complicated geometry (cf. fig.) fand make it the first calorimeter of its kind.

The calorimeter has been tested at the CERN SPS in summer 1999 with electrons of 8 to 100 GeV, muons and gammas. After intercalibration of the strips to better than 1%, a - within roughly 1% - linear energy response of 130 ± 5 photo-electrons/GeV has been measured. The energy resolution $\sigma(E)/E$ varies as $a/\sqrt{E} \oplus b$ (cf. fig. reffig:nrgres) with a stochastic term of $a = 19\%$ and a constant term compatible with zero. By deducing quadratically the photo-statistic contribution of $8.8\%/\sqrt{E}$ from the stochastic term we calculate the sampling fluctations to be 16.8%. This value is in good agreement with the value of 16.4% obtained from an analytical formula. The shower is sampled independently by the horizontal and vertical fibre layers since the corresponding energy resolutions add in quadrature. The response to muons of 225 GeV is 112

beam-fibre angle:	45°
beam incident angle:	54.7°
fibre core diameter:	600 μm
fibre num. aperture:	0.37
tungsten thickness:	0.7 mm
W/fibre vol. ratio:	1.68
active vol.:	$12 \times 12 \times 19$ cm^3
granularity:	10 mm
number of channels:	12+12
radiation length:	7.8 mm
sampling frequency:	0.36
total depth:	25 X_0
Moliere radius:	17.2 mm

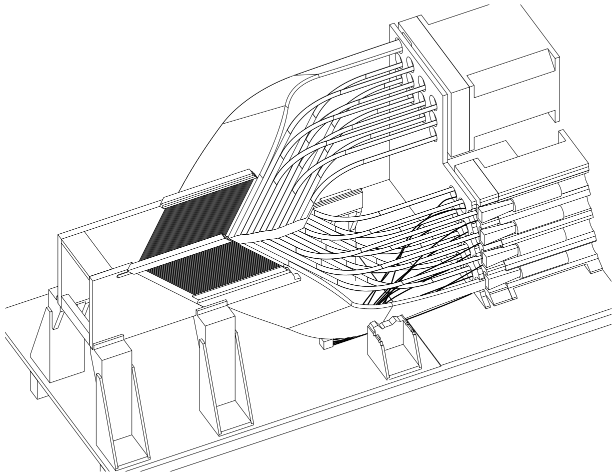

Fig. 1. Main parameters and artist's view of the quartz-fibre/tungsten calorimeter.

photoelectrons (most probable value), i.e. an equivalent energy of 0.86 GeV for minimum ionizing particles.

The combination of tungsten absorbers and of increased sensitivity to the shower core due to a particular fibre orientation leads to very narrow apparent showers. The projected shower profile, e.g. at 12 GeV can be well described as a sum of two gaussian components a narrow core with $\sigma \approx 2.5$ mm yielding $\sim 83\%$ of the signal and a isotropic cloud with $\sigma \approx 14$ mm.

The fine-grained strip-hodoscope geometry of this calorimeter takes full advantage of this effect in order to provide position reconstruction. The relation between the linearly energy weighted shower center and the impact point position as measured by drift chambers can be modeled by "wavy" step function. The width of the distribution of the fit residues (cf. fig.) varies approximately with energy as $5\text{mm}/\sqrt{E}$.

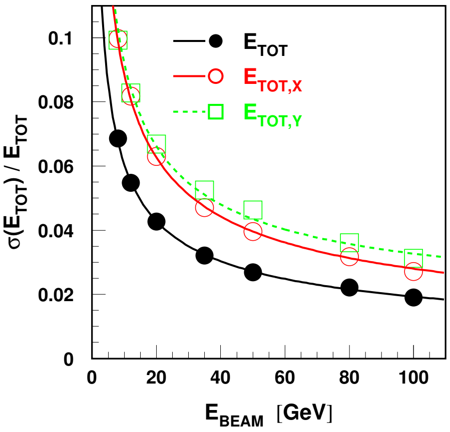

Fig. 2. Energy resolution

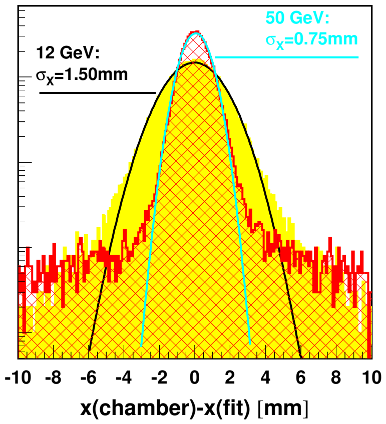

Fig. 3. Position resolution