The Tracking, Calorimeter and Muon Detectors of the H1 Experiment at HERA

H1 Collaboration

Abstract:

Technical aspects of the three major components of the H1 detector at the electron-proton storage ring HERA are described. This paper covers the detector status up to the end of 1994 when a major upgrading of some of its elements was undertaken. A description of the other elements of the detector and some performance figures from luminosity runs at HERA during 1993 and 1994 are given in a paper previously published in this journal.

H1 Collaboration

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1 Introduction

This paper describes the three major detector components of the H1 experiment:

- the central and forward tracking systems,
- the liquid argon and warm calorimeters,
- the muon detector consisting of the iron instrumentation and forward muon chambers.

A complete overview of the detector as well as descriptions of the magnets, luminosity system, trigger, slow control, data acquisition, off-line data handling and simulation can be found in a paper recently published in this journal (see [1]) or in [2] where both papers are combined. A survey of the detector parameters is given in Table 1 and, for the sake of convenience, the main elements of the detector are shown again in Figure 1. This figure also shows the reference frame adopted in this experiment.

In the papers quoted above some performance results obtained during the first years of HERA operations can be found and the upgrade programme undertaken during the 1994-95 shutdown is outlined.

Calorimetry		
Main calorimeter: liquid Argon (LAr)	Electromagnetic part	Hadronic part
Granularity	10 to 100 cm^2	50 to 2000 cm^2
Depth (number of channels)	20 to 30 X_0 (30784)	4.7 to 7 λ_{abs} (13568)
Resolution $\sigma(E_{e,h})/E_{e,h}$	$\approx 11\%/\sqrt{E_e} \oplus 1\%$	$\approx 50\%/\sqrt{E_h} \oplus 2\%$
Stability of electronic calibration	$\leq 0.2\%$ over one month	
LAr purity (decrease of signal)	$\leq 0.2\%$ over one year	
Noise per channel	10 to 30 MeV	
Angular coverage – dead channels	$4^\circ < \theta < 154^\circ$	$< 0.3\%$
Backward calorimeter: Pb–scintillator		
Angular coverage – granularity	$151^\circ < \theta < 176^\circ$	16×16 cm^2
Depth – resolution $\sigma(E_e)/E_e$	21.7 X_0 (1 λ_{abs})	$10\%/\sqrt{E_e} \oplus 1.7$ [1]%
Tail catcher: iron–streamer tubes		
Angular coverage	$4^\circ < \theta < 176^\circ$	
Depth – resolution $\sigma(E_h)/E_h$	4.5 λ_{abs}	$100\%/\sqrt{E_h}$
PLUG calorimeter: Cu–Si		
Angular coverage – granularity	$0.7^\circ < \theta < 3.3^\circ$	5×5 cm^2
Depth – resolution $\sigma(E_h)/E_h$	4.25 λ (44.6 X_0)	$\approx 150\%/\sqrt{E_h}$
Electron tagger: Tl(Cl/Br)		
Angular coverage – granularity	$\theta > 179.7^\circ$	2.2×2.2 cm^2
Depth – resolution $\sigma(E_e)/E_e$	21 X_0	$\approx 10\%/\sqrt{E_e} \oplus 1\%$
Tracking		
Coil: radius – field	3 m – $B = 1.15$ T, $\Delta B/B \leq 2\%$	
Central tracking		
Angular – radial coverage	$25^\circ < \theta < 155^\circ$	$150 < r < 850$ mm
Jet chamber: spatial resolution	$\sigma_{r\phi} = 170\,\mu$m	$\sigma_z = 22.0$ mm
z-chambers: spatial resolution	$\sigma_{r\phi} = 25$ and 58 mm	$\sigma_z \approx 350\,\mu$m
Momentum – dE/dx resolution	$\sigma_p/p^2 < 0.01$ [0.003] GeV^{-1}	$\sigma(dE)/dE = 10$ [6]%
Forward/backward tracking		
Angular – radial coverage (f)	$7^\circ < \theta < 25^\circ$	$120 < r < 800$ mm
Spatial resolution (f)	$\sigma_{r\phi} = 170\,\mu$m ($\sigma_r = 29$ mm)	$\sigma_{x,y} = 210\,\mu$m
Angular coverage – resolution (b)	$155^\circ < \theta < 175^\circ$	$\sigma_{x,y} = 1$ mm
Trigger proportional chambers		
Angular coverage – channels	$7^\circ < \theta < 175^\circ$	3936
Muon detection		
Instrumented iron		
Angular coverage – total area	$4^\circ < \theta < 171^\circ$	4000 m^2
Number of channels	wires: 103700, strips: 28700, pads: 4000	
Spatial resolution	$\sigma_{wire} = 3 - 4$ mm	$\sigma_{strip} = 10 - 15$ mm
Angular – momentum resolution barrel	$\sigma_\theta(\sigma_\phi) = 15(10)$ mrad	$[\sigma_p/p \approx 0.35]$
Forward muon toroid		
Angular coverage – resolution	$3^\circ < \theta < 17^\circ$	$[0.25 < \sigma_p/p < 0.32]$
Overall size (x, y, z) – weight	$12 \times 15 \times 10$ m^3	2800 t

Table 1: Summary of H1 detector parameters.
Alternatively, design and test beam figures are given in brackets [ ]. Energies are given in GeV.