Nuclear Instruments and Methods in Physics Research A 593 (2008) 232–254

Contents lists available at ScienceDirect

Nuclear Instruments and Methods in Physics Research A

journal homepage: www.elsevier.com/locate/nima

System test of the ATLAS muon spectrometer in the H8 beam at the CERN SPS ☆

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☆ Dedicated to our friend Marc Virchaux who initiated most of this work.

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0168-9002/$ - see front matter
doi:10.1016/j.nima.2008.05.027

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A R T I C L E I N F O

Article history:
Received 13 November 2007
Received in revised form
2 May 2008
Accepted 2 May 2008
Available online 24 May 2008

Keywords:
ATLAS muon spectrometer
Test beam
SPS
CERN

A B S T R A C T

We describe a system test of the ATLAS muon spectrometer performed at the H8 beam line of the CERN Super-Proton-Synchrotron (SPS) during 2003. The setup includes one barrel tower made of six Monitored Drift Tube chambers equipped with an alignment system and four Resistive Plate Chambers, and one end-cap octant consisting of six end-cap MDT equipped with an alignment system and one triplet and two doublets of Thin Gap Chambers. Many system aspects of the muon spectrometer have been studied with this setup, from the performance of the precision and trigger chambers to the capability to align the precision chambers at the level of a few tens of micrometers and to operate the muon trigger at the crossing frequency of the LHC.

1. Introduction

The muon spectrometer of the A Toroidal Lhc ApparatuS (ATLAS) experiment has been designed for the stand-alone measurement of muons produced in high-energy proton–proton collisions at the CERN Large Hadron Collider (LHC) with a resolution better than 10% for transverse momenta up to 1 TeV, and to trigger on single muons with transverse momenta down to a few GeV. A detailed description of the spectrometer and of its expected performance can be found in Refs. [1,2].

Since the year 2000, a large-scale system test of the ATLAS muon spectrometer has been set up and operated in the north area of the CERN Super-Proton-Synchrotron (SPS), at the H8 beam line. The test setup emulates one full-size projective tower of the barrel and of the end-cap spectrometer and has evolved with time, integrating more muon detectors and control devices. The main goal of the system test was to study the integration of all the components of the ATLAS muon spectrometer and to evaluate the performance of the system in a configuration as close as possible to the final setup in the ATLAS experiment.

In this paper, after a general introduction to the H8 setup, performance studies of the Monitored Drift Tube (MDT) chambers are given in Section 2. The barrel and end-cap alignment systems are discussed in Sections 3 and 4. Resistive Plate Chambers (RPC) performance studies are reported in Section 5, Thin Gap Chambers (TGC) and Level-1 trigger studies are detailed in Sections 6 and 7.

1.1. Setup overview

In the ATLAS experiment, the muon momentum is determined by measuring the track curvature in a toroidal magnetic field provided by three superconducting air-core toroid magnets, one in the barrel and one in each end-cap of the spectrometer, with a field integral in the range 2–8 Tm. The track curvature is measured with three layers of precision tracking chambers positioned along the muon trajectory. Most of the precision chambers in the muon detector are built from high-pressure drift tubes, referred to as MDT [3]. In the end-cap inner region, for pseudorapidities greater than 2, CSC [1,4] are used since they are able to cope with higher background rates, at the expense of an increased electronics channel density. The expected background rates range from 10 to 100 Hz/cm^2 in the MDT region, increasing up to 1 kHz/cm^2 in the CSC region. These values have been computed by simulating high luminosity LHC running conditions and are affected by large systematic uncertainties.

Trigger chambers are based on two different technologies: RPC [5] cover the barrel region while TGC [6] are used in the higher background environment of the end-cap region. Two RPC doublets (two gas gaps) attached to the middle barrel chambers provide the low-p_T trigger information. The information from a RPC doublet installed on the outer barrel chambers is combined with the signal from the middle chambers to produce the high-p_T trigger. RPC chambers are also used to provide the coordinate along the MDT tubes ("second coordinate"), which is not measured by the MDT chambers. Similarly in the end-cap, two TGC doublets and one triplet (three gas gaps) are installed close to the middle station and provide the low- and high-p_T trigger signals. The TGC also measure the coordinate of the muons in the direction of the MDT wires. For this purpose, additional TGC chambers are installed close to the inner MDTs to improve the measurement accuracy of this coordinate.

This section describes the setup during the 2003 period of data taking; a schematic overview is shown in Fig. 1. The test concerned different detectors (MDT, RPC, and TGC), auxiliary subsystems such as alignment or Detector Control Systems (DCSs) and key software tools (Data Acquisition, (DAQ), calibration, track reconstruction, alignment software, and database).

A muon beam with momenta ranging from 20 to 350 GeV/c was available in this area during SPS running periods. Most of the data during summer 2003 were taken with a narrow-band beam of 180 GeV central energy. At this energy, the beam profile is characterized by an intense core with an r.m.s. radius of about 3 cm and an extended beam halo with an r.m.s. radius of about 1 m. Beam triggers were made with two sets of scintillation counters: a coincidence of two $10 \times 10\,\mathrm{cm}^2$ scintillators, hereafter referred to as 10×10 trigger, to trigger on the beam core, and a coincidence of two hodoscope planes of $100 \times 60\,\mathrm{cm}^2$ size in anti-coincidence with the 10×10 trigger, hereafter referred to as hodoscope trigger, to trigger on the beam halo. The time resolution of the 10×10 trigger was better than 1 ns while the hodoscope trigger had a time resolution better than 2 ns. For some periods of the 2003 run, signals provided by the TGC and RPC trigger chambers were also used for triggering.