Available online at www.sciencedirect.com
SCIENCE DIRECT®
Nuclear Instruments and Methods in Physics Research A 556 (2006) 66–79
NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH Section A
www.elsevier.com/locate/nima

The large size straw drift chambers of the COMPASS experiment

V.N. Bychkov[a], N. Dedek[b], W. Dünnweber[b], M. Faessler[b], H. Fischer[c], J. Franz[c], R. Geyer[b,*], Yu.V. Gousakov[a], A. Grünemaier[c], F.H. Heinsius[c], C. Ilgner[b,1], I.M. Ivanchenko[a], G.D. Kekelidze[a], K. Königsmann[c], V.V. Livinski[a], V.M. Lysan[a], J. Marzec[d], D.A. Matveev[a], S.V. Mishin[a], V.V. Mialkovski[a], E.A. Novikov[a], V.D. Peshekhonov[a], K. Platzer[b], M. Sans[b,2], Th. Schmidt[c], V.I. Shokin[a], A.N. Sissakian[a], K.S. Viriasov[a], U. Wiedner[b,3], K. Zaremba[d], I.A. Zhukov[a], Yu.L. Zlobin[a], A. Zvyagin[b]

[a] *Joint Institute for Nuclear Research (JINR), 141980 Dubna, Moscow Region, Russia*
[b] *Ludwig-Maximilians-Universität München, Department für Physik, 80799 München, Germany*
[c] *Universität Freiburg, Physikalisches Institut, 79104 Freiburg, Germany*
[d] *Warsaw University of Technology, Institute of Radioelectronics, 00-665 Warsaw, Poland*

Received 12 September 2005; accepted 10 October 2005
Available online 10 November 2005

Abstract

Straw drift chambers are used for the Large Area Tracking (LAT) of the Common Muon and Proton Apparatus for Structure and Spectroscopy (COMPASS) at CERN. An active area of 130 m^2 in total is covered by 12 440 straw tubes, which are arranged in 15 double layers. The design has been optimized with respect to spatial resolution, rate capability, low material budget and compactness of the detectors. Mechanical and electrical design considerations of the chambers are discussed as well as new production techniques. The mechanical precision of the chambers has been determined using a CCD X-ray scanning apparatus. Results about the performance during data taking in COMPASS are described.

PACS: 29.40.Gx; 41.50.+h

Keywords: COMPASS; Straw drift chambers; Straw tube; X-ray; Aging

1. Introduction

The Common Muon and Proton Apparatus for Structure and Spectroscopy (COMPASS) [1] is a large aperture, high rate spectrometer, set up at the CERN Super Proton Synchotron SPS to study the spin structure of nucleons using a polarized muon beam, interacting in a polarized target. In particular, the process of photon gluon fusion into a charm-anticharm quark pair, which fragments to $D+\overline{D}$ mesons, is used to measure the contribution of gluons to the nucleon spin. Moreover, hadron beams are used to study the production of charmed baryons, of "exotic" hadrons (hybrids and glueballs) and to measure the polarizability of hadrons.

The setup of COMPASS, as it was in 2004, is shown in Fig. 1. The detection of particles over a large acceptance and a large momentum range requires the use of a two-stage spectrometer. The 15 double layers of large area straw drift chambers, which are described here, are used for tracking and momentum determination of charged particles produced at large scattering angles (15–200 mrad). The chambers are grouped together in five modules. Each module contains three double layers with vertical, hor-

*Corresponding author. Tel.: +41 22 767 6437; fax: +41 22 767 7910.
E-mail address: Reiner.Geyer@cern.ch (R. Geyer).
[1]Present address: CERN, Dept. TS-LEA, 1211 Geneva 23, Switzerland.
[2]Present address: Institut universitaire de radiophysique appliquée, Grand-Pré 1, 1007 Lausanne, Switzerland.
[3]Present address: Uppsala University, Department of Radiation Sciences, Box 535, SE-75121 Uppsala, Sweden.

0168-9002/$ - see front matter
doi:10.1016/j.nima.2005.10.026

izontal and inclined straw tubes and measures one space point. The inclined double layers are rotated by 10° with respect to the vertical ones. The chambers with vertical and inclined straws are of the same type (called type X), while the chambers with horizontal straws have a slightly different geometry (type Y). The exact dimensions of both types are given in Table 1.

In the following, the detailed dimensions refer to the type X chambers with vertical wires, which measure horizontal coordinates. A schematic view of a double layer is shown in Fig. 2. Each chamber consists of two layers of thin-film drift tubes (straws) of a length of 3202 mm which are mounted into an Al-frame. The area, covered by each double layer, is about 9 m^2. The straws of one layer are glued together to one plane. Every plane is divided into three sections. The central part (section B, see Fig. 2), being closer to the beam axis, is exposed to higher rates. This part is made of 254 straws with 6.144 mm outer diameter while the outer two parts (section A and C) have 96 straws each with 9.654 mm outer diameter. The chosen diameters are a compromise between minimizing the number of channels and production cost while keeping the occupancy in each tube below 2% at maximum beam rates. The intensities, required at COMPASS, are 2×10^8 muons and up to 4×10^7 hadrons per 5.1 s spill for muon and hadron beams, respectively. A fast counting gas has to be used ($Ar/CO_2/CF_4$, 74:6:20).

The anode wires of the drift tubes are centered in the straws by two end-plugs and four small plastic pieces (spacers). The diameter of these gold-plated tungsten wires is 30 μm. The straws are supplied with the counting gas through the end-plugs and a gas-manifold, which is integrated into the Al-frame construction.

A thickness of only 40 mm along the beam direction was allowed for one double layer, so that three modules, containing 15 double layers in total, would fit in a volume with a length of less than 1 m between the first spectrometer magnet SM1 and the RICH detector of COMPASS. Thus, a large acceptance at a tolerable transverse size for the first stage of the spectrometer could be achieved by minimizing the thickness of the detectors.

The amount of material in the active part of the detector was optimized with respect to scattering and secondary interactions. The central part of the detector has a rectangular hole of about $20 \times 10\,cm^2$ for the beam.

The required spatial resolution per double layer is 200 μm at a detection efficiency larger than 99%. The internal mechanical precision of each double layer has been required to be (or to be known) better than 100 μm.

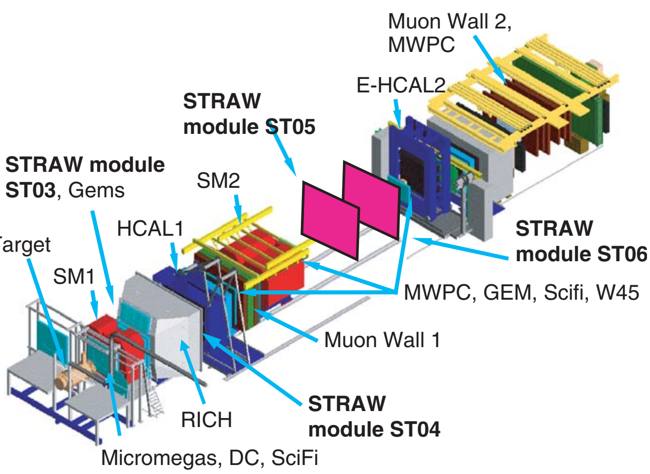

Fig. 1. The COMPASS two stage spectrometer. The straw chambers are placed directly behind the first spectrometer magnet SM1 (ST03), behind the Rich detector (ST04) and behind the second spectrometer magnet SM2 (ST05, ST06). The shown setup, which was used during the years 2002–2004, differs from the originally planned, where all chambers were to be positioned directly behind SM1.

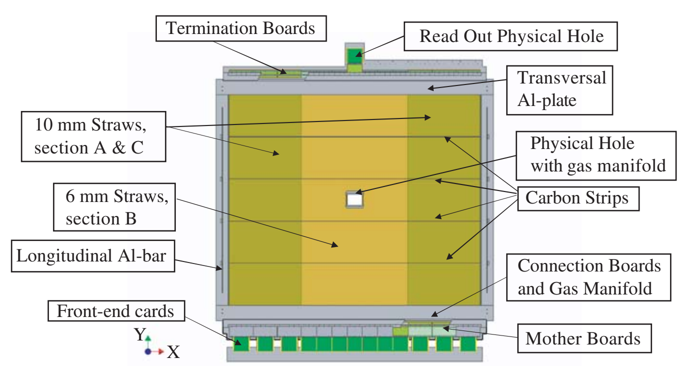

Fig. 2. Schematic view of a chamber (type X).

Table 1
Sizes and number of straws of the different double layers

Type	Sensitive area (mm × mm)	Length of straws (mm)	Number of straws with different outer diameter		Number of readout channels	Overall dimensions (mm × mm)
			6.144 mm	9.654 mm		
X	2802 × 3232	3202	380	384	892	4117 × 3570
		1523	128			
Y	3254 × 2427	3652	320	256	704	4567 × 3160
		1752	128			

The inclined layers are from type X too, but are rotated by 10°.