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A LOW-MASS DRIFT CHAMBER SYSTEM FOR THE HADES-SPECTROMETER*

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A new high resolution ($\Delta M/M < 1\%$) and high acceptance (45 %) di-electron spectrometer (HADES) has been designed to investigate in-medium properties of hadrons. For tracking of all charged particles (in particular with sufficient resolution for electrons) a system of 24 low-mass drift chambers (Helium based counting gas and Aluminum field and cathode wires), arranged in four tracking planes, is used. Design aspects of the chambers are reported. Results of performance optimization using various prototype detectors are discussed, including results of an ageing test. Stable operation in the high-multiplicity environment of heavy ion collisions, and a spatial resolution of 70 μm(σ) over 80 % of a cell have been demonstrated in two beam experiments.

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1. Introduction

The high acceptance di-electron spectrometer HADES [2, 5] is currently set up at GSI to investigate in-medium properties of hadrons and particular aspects of their electromagnetic structure. Its tracking system consists of 24 trapezoidal chamber modules arranged in a frustum-like geometry to form 4 tracking planes of increasing size, either two of which are located

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in front of and behind the toroidal superconducting magnet. The four tracking planes are built by different institutions: GSI Darmstadt (plane 1), LHE/JINR Dubna (plane 2), FZ Rossendorf (plane 3) and IPN Orsay (plane 4). Active areas of the modules range from 0.35 m^2 up to 3.2 m^2 respectively, while drift cell sizes increase from 5×5 mm^2 (plane 1) to 14×10 mm^2 (plane 4). Each module consists of six sense-field wire layers oriented at angles $-40°, +20°, -0°, +0°, -20°$ and $+40°$ with respect to the parallel top and bottom frames. Cathode wires at 90° separate the different cell layers.

In the past year, the R&D of the tracking chambers was completed. The main results are summarized below.

2. Optimization studies

The optimization studies [1] of the operating conditions for low-mass drift chambers with bare aluminum wires and He-based counting gas were completed with an ageing test using a small size module (prototype 0). A significant improvement operating the chamber with an quencher-enriched mixture of typically 60-40 He-iC_4H_{10} was achieved yielding good intrinsic position resolution and wide efficiency plateaus of typically 300 V yet keeping multiple scattering on a tolerable level. By irradiating the chamber with X-rays an equivalent charge dose of 2 years of HADES operation was accumulated. No significant gain drop was observed.

3. First full-size prototype

In January 1997, the first chamber module of final geometry (prototype 1) was shipped to GSI. It was built in the detector laboratory at LHE/JINR. The module has in total about 1100 cells and an active area of 0.52 m^2. After successfully commissioning the chamber using radioactive sources, it was tested in two test beam experiments.

4. Results from a test beam with 2.1 GeV/c protons

In April 1997, a beam of 2.1 GeV/c secondary protons (minimum ionizing particles) produced at the GSI fragment separator FRS was used for detailed investigation of the intrinsic parameters (drift velocity, spatial resolution, field homogeneity). External tracking of the beam was achieved by a high resolution Silicon micro-strip telescope [6]. 32 cells from different layers were read out by 8-channel preamplifier-discriminator prototype cards (developed at JINR) based on the fully customized array ASD-8 [3]. The chamber was operated at different high voltage settings and quencher concentrations. For the nominal setting, He-iC_4H_{10} (60-40) and $U_{cathode}$=U_{field} = −2 kV, the following results have been achieved:

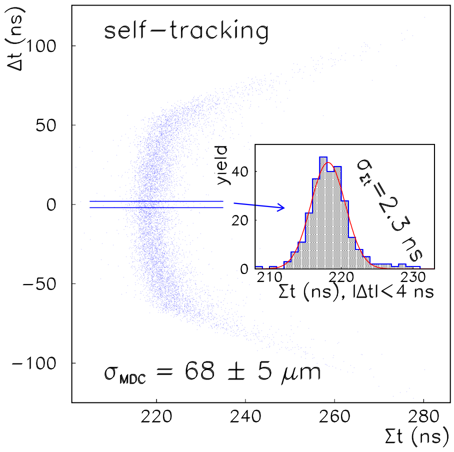

Fig. 1. Drift time difference Δt vs. sum Σt for two subsequent cells with staggered field–sense wire positions. Gating on Δt around 0 ns, *i.e.* half the distance sense–field wire for perpendicular tracks, the projected Σt spectrum allows to deduce the spatial resolution by means of the measured drift velocity.

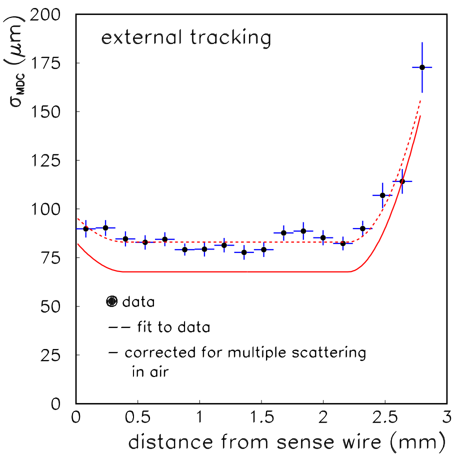

Fig. 2. Spatial resolution as function of the drift distance measured with the external tracker. The dashed line is a fit to the data. The solid line shows the same fit when correcting for multiple scattering of protons in air (about 50 μm quadratical contribution).

The intrinsic position resolution of a single cell was determined utilizing both a self tracking method in subsequent cells (Fig. 1) and the external trackers (Fig. 2). An average drift velocity of 4.27 ± 0.02 cm/μs was deduced by fitting straights to the linear part of the drift time–position correlation, which extends between 0.5 and 2.4 mm distance from the sense wire (3 mm being the maximum drift distance). The spatial resolution is constant over 70-80 % of the cell, but rises significantly towards the field wire. Comparing with results of prototype 0 we conclude that in this run the drift velocity was not fully saturated and higher potentials at the field wires could have reduced this effect. The depicted improvement of the spatial resolution deduced from the self-tracking results is attributed to contaminations from multiple scattering of protons in 0.5 m of air, given by the geometry of the set-up. We would like to point out that these observations are qualitatively understood by GARFIELD simulations [7]. Finally, the external tracker allows for measuring the pitch of the wires in the different planes. The deviations are within the specifications of ± 20 μm.

5. Results from a beam test with heavy ions

In July 1997, the full-sized prototype was exposed for the first time to a charged particle flux from central heavy ion collisions (Au+Au, 1 AGeV) at rates as anticipated in the HADES experiments. The chamber was located under 45 degrees with respect to the beam, in a distance of 1.0 m from the target. An area of $\approx 70 \times 10$ cm^2 was read out in the two horizontal planes. The chamber operated stable without noticeable deteriorations when increasing the beam intensity (up to 2×10^6 interactions/s). Correlations with the other detector components originating from lepton tracks have also been observed and are presently analyzed.

6. Outlook

The observed single hit position resolution of < 80 μm over 70-80 % of the drift cell results in an overall momentum resolution well below 1 % for all momenta higher than 0.2 GeV/c. This ensures an invariant mass resolution of better than $1\%(\sigma)$ for di-electron pairs needed for a clear separation of vector mesons as well as a significant background reduction.

Meanwhile work has started on all parts of the tracking system and the first modules have been completed, e.g. the first module of the tracking plane 1 was finished in March 1998 at the detector lab of GSI and has been successfully tested using a ^{90}Sr source.

The superconducting magnet [4] has been installed at the HADES cave in April 1998 and is currently tested at its final position.

Preparations for work on the large modules of plane 3 (to be built at FZ Rossendorf) has been finished and work starts in the second half of 1998.

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