Irradiation Response of Straw Drifttubes

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The large-angle tracking system of the COMPASS experiment at CERN, to be commissioned in the year 2000, will use drifttime detectors of the straw type. A set of 9 double layers, with active areas of about 350cm x 250cm and a total number of straws of about 13 000 will be built in Dubna. The straws are metallized kapton tubes of 6-10 mm diameter with central anode wires of 30 μm diameter. Gas mixtures of Ar, CF_4 and CH_4 were chosen in order to combine fast drift velocity, good linearity of the distance-to-drifttime relation and resistivity to radiation damage.

1. Gas Gain

The charge multiplication of various gas mixtures was studied with 26 MeV protons at the vertical beamline of the Garching Tandem Accelerator. As for any gas detector working in the proportional chamber mode, the gas gain, i.e. the number of secondary avalanche electrons per electron from primary ionization, is crucial for the detector performance. The medical irradiation facility with its broad, homogenuous beam profiles and precise dosimetric control allows for a simple and direct determination of the gas gain by comparison of the detector current and the primary ionization current. The resulting gas gains show an increase with increasing Ar content (Fig. 1) and disagree by factors of 2-4 with estimates of a simulation program [1].

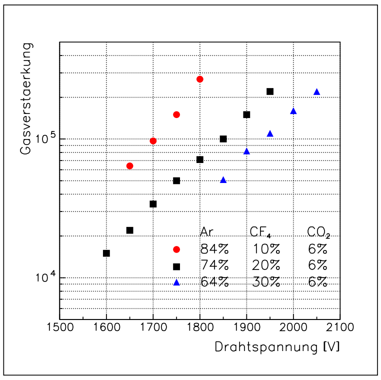

Fig. 1: Measured gas gains for different gas mixtures.

2. Ageing

A loss of pulse height and an increase in dark current are signatures of radiation damage. In our proton irradiation experiments, straws filled with Ar/CH_4 were operated in parallel with straws filled with the COMPASS gas mixtures. The former show a clear increase in electrical current at constant proton flux. This effect, which is ascribed to the build-up of an electric dipol layer on the cathode, does not occur with the COMPASS gas (Fig. 2). Similarly, a loss in pulse height, ascribed to deposits on the anode wire, is observed for the former gas but not for the COMPASS gas [2]. Up to charges of 1 C/cm collected on the anode wire, corresponding to 5-20 years of COMPASS operation, no significant ageing effect was observed with the chosen gas.

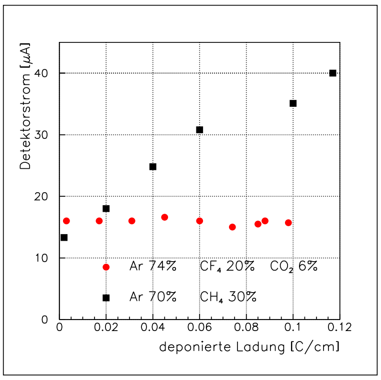

Fig. 2: Detector current as a function of the totally accumulated charge for constant proton flux.

3. Spatial Resolution

The resolution was measured for protons with multiple detector layers at the Tandem and for minimum ionizing particles with a Si tracker at CERN. The results (Fig. 3) are successfully reproduced with a simulation program [1], taking into account only the effects of diffusion and of the primary ionization statistics. The dominance of the latter becomes apparent by the observed increase in resolution with increasing distance from the wire (Fig. 3). This effect is essentially determined by the trigger threshold in terms of the primary ionization charge [3]. This quantitative understanding of the resolution will help to adjust the operation parameters for the project.

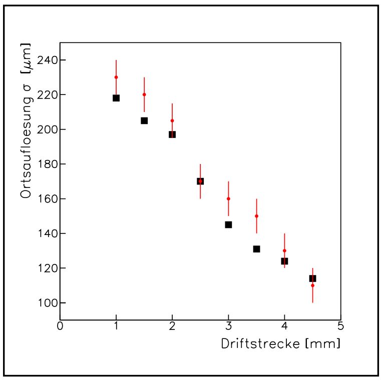

Fig. 3: Comparison of simulated and measured (squares and dots, respectively) spatial resolutions as a function of the distance of a muon track from the anode wire.

References

[1] R. Veenhof, Garfield, A Drift Chamber Simulation PROGRAM, CERN Program Library W 5050 (1998)
[2] J. Estermann, diploma thesis, LMU München, 1999
[3] K. Platzer, diploma thesis, LMU München, 1999