Study of performances of a straw tube detector with high rate

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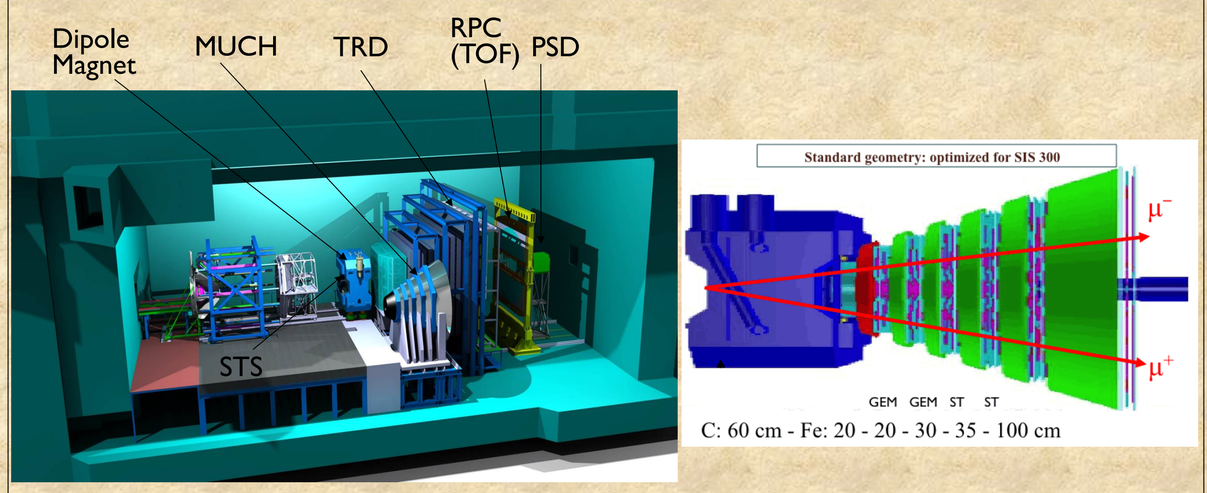
Introduction

The Compressed Baryonic Matter (CBM) experiment at the future Facility for Antiproton and Ion Research (FAIR) in Darmstadt, Germany is designed to explore the QCD phase diagram in the region of moderate baryon densities. With CBM we will enter a new era of nuclear matter research by measuring rare diagnostic probes never observed before at FAIR energies, and thus CBM has a unique discovery potential. This will only be possible with the application of advanced instrumentation, including highly segmented and fast gaseous detectors. Keeping in mind the high interaction rate of FAIR, the Muon Chamber (MUCH) detector in CBM will use Gas Electron Multiplier (GEM) in the first two stations. Given the interaction rate of 10 MHz the expected particle flux on the first station will be about 3.1 MHz/cm^2. Maximum particle flux on the 3rd and 4th stations of the MUCH have been estimated to be 10 kHz/cm^2 and 3 kHz/cm^2, respectively, for central Au-Au collisions at 8 AGeV. We are exploring the possibility of using straw tubes for the 3rd and 4th stations of CBM-MUCH.

We report the results from characteristic study of a straw tube detector prototype using premixed gas of Argon and CO_2 in 70/30 and 90/10 volume ratio. In this study the gain and the energy resolution are measured using Fe^{55} X-ray source. The effect of temperature and pressure on these parameters are also studied. Same X-ray source is used to irradiate the straw and to collect the spectra. The main motivation of this work is to study the variation of the gain and energy resolution of the straw tube detector with X-ray rate per unit length in a laboratory for the first time. No accelerator or X-ray generator is used. The details of the test set-up, the method of measurement and the test results are presented in this poster.

Schematic view of the CBM experiment



Schematic view of the CBM experiment with all detector systems (left). Muon detection system (MUCH) (right).

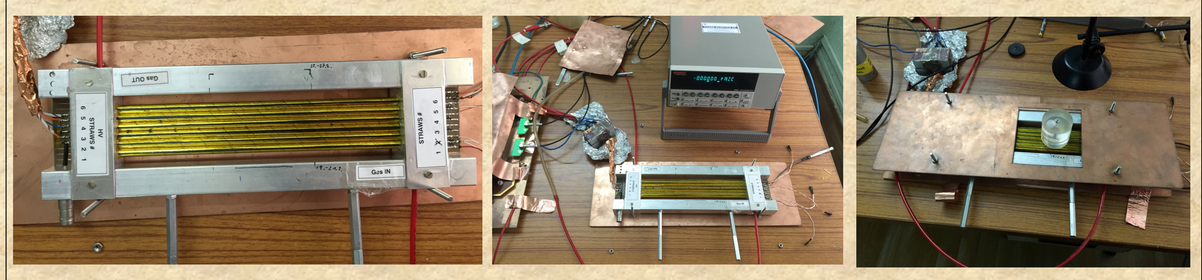
Straw tube detector

- Straw tube is typically prepared from a kapton film, one side containing a conductive layer of 1000-3000 Å Al + 4 μm carbon-loaded kapton and the other side containing a thermoplastic polyurethane layer of 3 μm.
- The thickness of the straw wall is around 60 μm

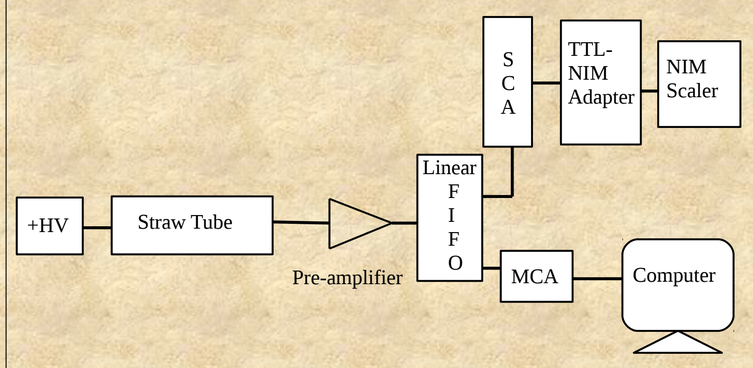
Working Principle of Straw tube detector

- A straw tube detector is basically a gas filled single channel drift tube with a conductive inner layer as cathode and a wire stretched along the cylindrical axis as anode
- When high voltage is applied between the wire and the tube an electric field is generated in the gas filled region.
- The electric field separates electrons and positive ions produced by an incident charged particle along its trajectory through the gas volume.
- The wire is kept at positive voltage and collects the electrons while the ions drift towards the cathode. By choosing thin wires, with a diameter of a few tens of μm, the electric field strength near the wire is made high enough to create an avalanche of electrons.
- Depending on the high voltage and the gas composition a gain of about $10^4 - 10^5$ can be achieved

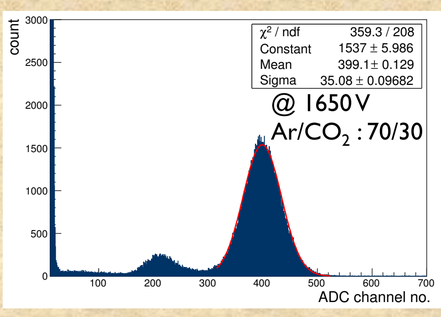
Straw tube prototype



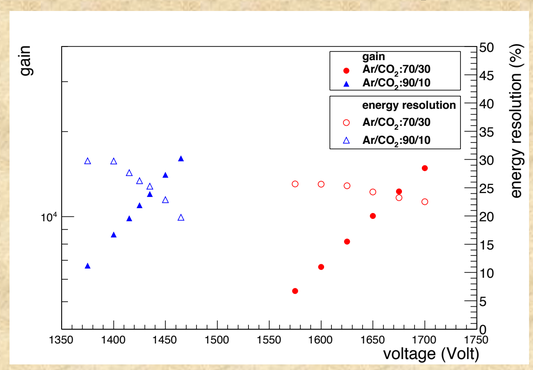
Schematic representation of the electronics setup



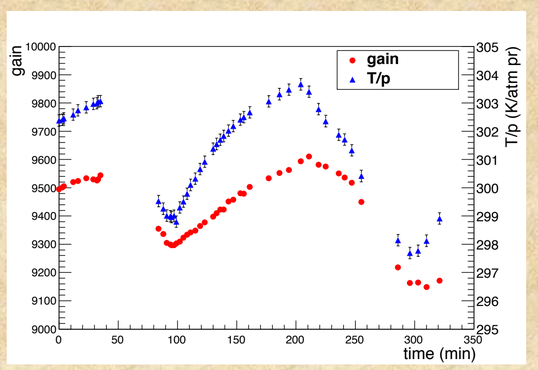
Energy Spectrum of the Straw Tube Detector



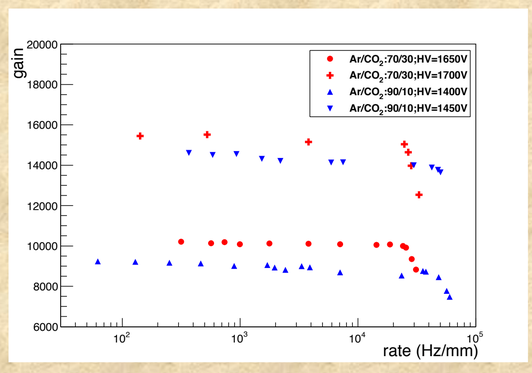
Experimental results



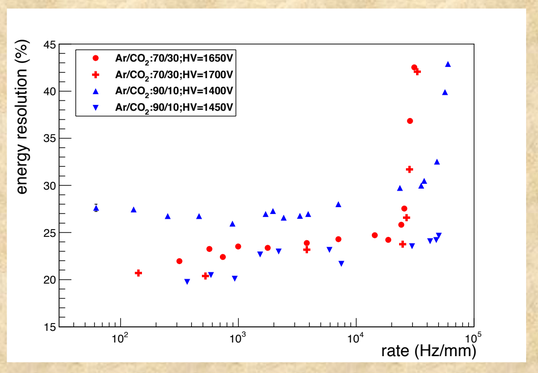
Gain and energy resolution Vs. voltage



Gain and T/p



Gain Vs. rate



Energy resolution Vs. rate

Summary and outlooks

- Basic characteristic studies are performed for straw tube with Ar/CO_2 gas in 70/30 and 90/10 ratio using conventional NIM electronics.
- Count rate, gain, energy resolution, rate handling capacity are studied
- With 5.9 keV Fe^{55} X-ray the gain and the energy resolution remain constant up to a rate of about 20 kHz/mm and 32 kHz/mm for Ar/CO_2 70/30 and 90/10 respectively
- Use of the straw tube in CBM MUCH is under investigation.

Acknowledgements

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