KABES & SEXTANT

Beam Spectrometers using Micromegas in Time Projection Chamber mode

Philippe Legou, CEA-Saclay, France

plegou@cea.fr, phone (33)1-69-08-42-92, fax (33)1-69-08-89-90.

Abstract

Sextant is a new study of a Beam Spectrometer, it can be seen as a KABES upgrade (KAon Beam Spectrometer), a beam spectrometer on NA 48II at CERN. The both are using a gaseous detector called Micromegas[1]. In this application this detector is used in a Time Projection Chamber (TPC) mode. Thus, we have a better efficiency, with the minimum amount of material in the way of the beam. Using the TPC technique, the Mesh of the detector is positioned outside the high intensity region covered by the beam. Performances of this detector are very good in high intensity hadrons beams (spatial resolution: 70µm and time resolution 600ps). The integration of the front end on the PCB of the detector provides a very low noise for the entire detector. Main characteristics of the preamplifier are 1ns of rise time and a very low noise, lower than 600 µV rms. This concept has shown very good performances and robustness. The role of KABES is outlined, and the construction is described. The SEXTANT improvements are presented.

I. INTRODUCTION

A beam spectrometer which measure with good precision kinematics characteristics of particles in the K^+/K^- increases significantly the accuracy of observations. The positive and negative beams are produced with 400 GeV/C primary protons from the SPS accelerator. KABES is composed by two stations; the first one see the K+ and the K- beam, second is 8m away and see only the recombined beam. KABES measures the transverse coordinates of charged tracks.

II. DETECTOR

Each KABES station is composed of a pair of micromegas chamber used in TPC mode with an opposite drift direction (see Fig. 1). Since, particles ionisation are drift in both directions, so the addition on the two drift time gives an accurate track time and horizontal position. The utilisation of TPC guarantee minimum amount of material on the way of the beam minimizing multiple scattering effects and parasitic interaction with the detector. The beam sees only very thin mylar windows (1.5 µm) and the gas inside the chamber, is a mixture as follows: Ne 79%; C_2H_6 11%, $CF_4$10%. On SEXTANT the proportion of CF4 is increased (up to 35 %) in order to decrease the time signal occupancy.

On each chambers, 48 strips of 835 µm width and 4 cm long are enough to cover the area of 4 cm x 4 cm. That is to say that 288 electronics channels are necessary to read the six chambers of KABES.

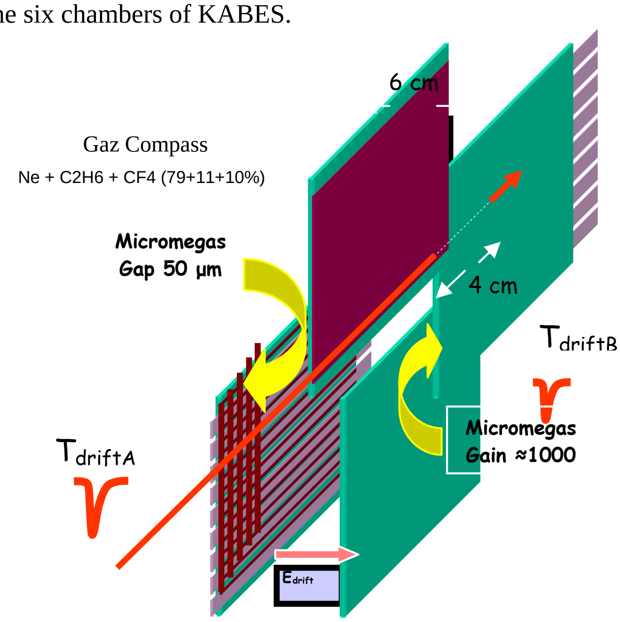

Figure 1: A pair of micromegas chamber.

Meshes of Micromegas detector are realised at CERN [1]. Meshes are made with kapton from a 50 µm copper-plated KApton foil, with 5µm of copper. Spacers of 50µm high realize the amplification gap of the micromegas. On SEXTANT a test has been done with 25 µm gap, and a new 12 µm gap is going to be tested very soon (see Fig. 2).

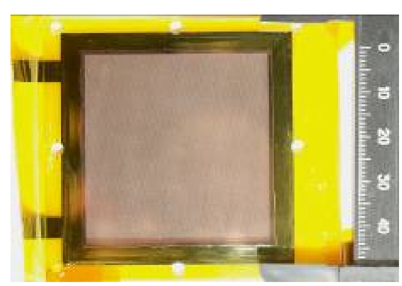

Figure 2: A picture of 12 µm gap mesh.

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In order to guarantee a good uniformity of the electric field (0.83 KV/cm) as far as the edge of the chamber an electric field cage has been designed at Saclay. It is made with an epoxy frame and very thin mylar window of 1.5 µm thick (see Fig. 3).

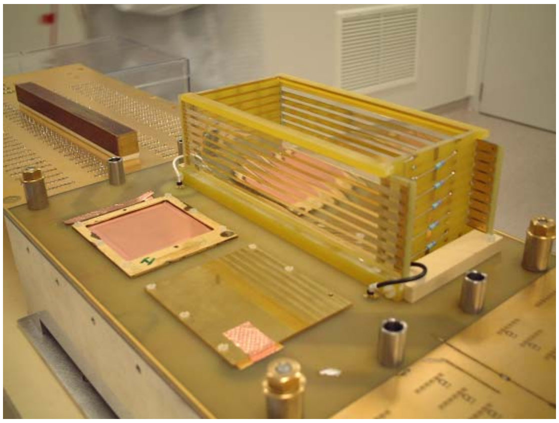

Figure 3: The mother board, the mesh and the electric field cage.

III. THE FRONT END ELECTRONICS

In order to read the 288 channels of KABES, a special front end module called V1 has been designed [2]. Each strip on the mother board under meshes is fed by a V1 card (see Fig. 4). The size of the module is: 60x22x5 mm.

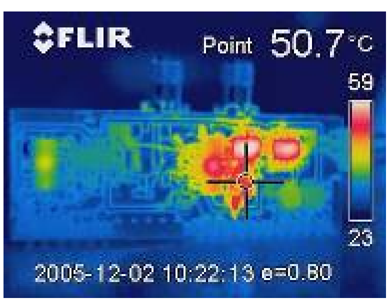

Figure 4: Infrared picture of the V1(Red parts are the two buffers, the hotest area).

Each card houses several functions : a very fast current preamplifier, an amplifier, a shaper (not use in KABES at the end) a fast ECL discriminator with a programmable threshold voltage and two buffers to carry output differential signals of the discriminator up to the read out units, 30 meters away over a 110 ohms twisted pair cable. The leading edge at the input of the discriminator can be as sharp as 4ns. The programmable module which delivers the threshold through an 8 bits Digital to Analog Converter (DAC) can provides a voltage from few µv up to 100mV. To avoid noise from slow control units which generate the 8bit threshold, an electrical isolation is realised using optocoupleurs at the input of the module.

The mother board houses the strips of the detector, power supplies and the preamplifier cards, thus the electrical architecture is simple and at the end leads to a very low noise in running conditions. It is important to notice that there is no crosstalk on the Printed Circuit Board in spite of very fast signals (see Fig.5).

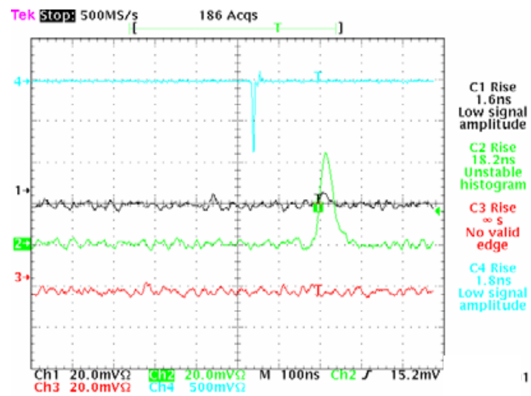

Figure 5: Response of three neighbour channels in the beam after a 30m coaxial cable.

IV. LAST IMPROVEMENTS

The KABES detector on NA 48II had to support a high flux of 20 MHz of charged hadrons on few cm2. A future possible application for sextant could be the P326 experiment at CERN. In this case it is foreseen that SEXTANT should be able to deal with a flux 30 to 40 times higher than KABES had to do.

In order to accept higher flux on SEXTANT it is important to minimize the signal time occupancy that is to say width of signals at the output of the amplifier.

Improvements rely on four axes:

- a new front-end.
- A new gas.
- A new readout system.
- A new mesh.
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The new front module, FAMMAS (Fast Amplifier Module for Micromegas Applications) [3] offers a rising time lower than 1ns, a noise below 700 µVrms (see Fig. 6 and 7).

Figure 6: The FAMMAS front-end module.

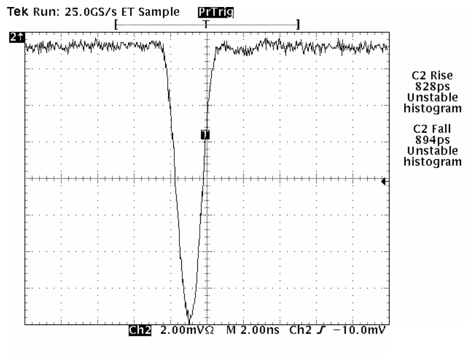

Figure 7: Response of the FAMMAS.

The possible use of a very fast ADC after the FAMMAS should increase time and amplitude measurements and help for reject pile-up pulses which is more difficult when we use a TDC.

In SEXTANT, the utilization of a 25 µm mesh with a gas with more CF4 and the FAMMAS module leads to a signal time occupancy lower 7ns (instead of 35 ns on KABES for the average TOT (time over threshold).

KABES has already shown that this concept is very reliable in a high intensity hadrons beam, the detector itself but the front-electronics also, no damage after three years of utilisations.

V. PHYSICS RESULTS

In KABES the time resolution is 600 ps corresponding to a spatial resolution in the horizontal drift direction of 70 µm, with efficiency close to 100%.

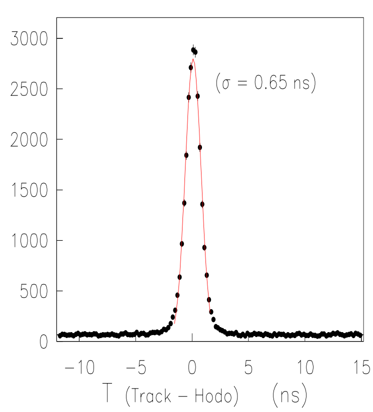

Figure 8: Time resolution.

VI. CONCLUSION

For a beam spectrometer application, this technique using gaseous detector allows very good performances in high intensity hadrons beams (spatial resolution: 70µm and time resolution 600ps, efficiency close to 100%) and presents many advantages. Using TPC mode, the few amount of material in the way of the beam minimizes parasitic interactions with the detector, moreover there is no need to replace some parts of the detector from time to time (as a silicon solution for example). It is a very reliable and low cost solution, using printed circuit board technology. Due to the small number of electronics channels necessary to read the whole detector, a solution with discrete front-end card with SMC (Surface Mounted Components) seems to be the better solution allowing thus a very low cost solution with excellent performances and can be very convenient to improve performances of the whole detector. This detector could be an answer for next physics experiments.

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