NIKHEF activities within EUDET/SiTPC

[1] ***Maximilien Chefdeville***,
Martin Fransen, Jan Timmermans, Harry van der Graaf, Jan Visschers

December 22, 2006

Abstract

We report on the ongoing NIKHEF R&D activities toward a pixel readout TPC for the future linear collider.

[1] NIIKHEF, Amsterdam, The Netherlands

1 Introduction

The concept of pixel readout of gas filled detectors has been validated by combining a Micromegas amplification grid with a MediPix2 CMOS chip as a pixel segmented anode. Due to the fine granularity offered by the pixels, the spatial resolution may be further reduced with respect to traditional pad readout where the flat pad response function sets a fundamental limit equals to roughly one third of the pad size. Furthermore the good single electron sensitivity of this detector may also improve the energy loss measurement by efficient cluster counting. A typical cosmic MIP event is depicted on figure 1. It shows the single electrons created along a cosmic track. The readout consisted of a Micromegas mesh maintained above a MediPix2 chip.

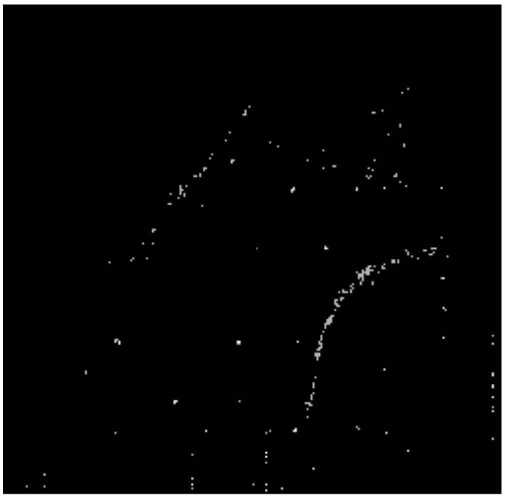

Figure 1: Track of a cosmic particle going through a 1 cm^3 volume of Helium Isobutane 80/20.

2 An integrated Micromegas

The developments we propose are the integration in a monolithic device of a spark protection layer (SiProt) and a Micromegas amplification grid (InGrid, figure 2) by wafer post processing.

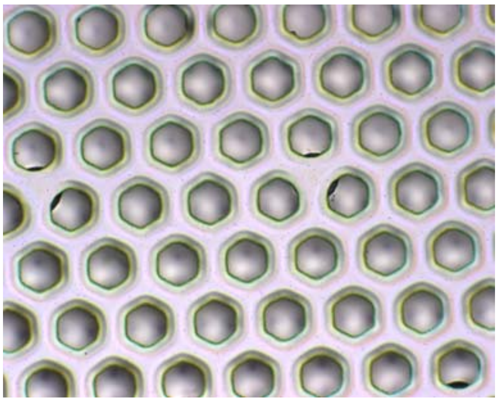

Figure 2: Picture of the grid of one InGrid. The hole pitch is 60 µm and the hole diameter is 30 µm. Note the pillars in between the grid holes.

Thanks to the flexibility of the grid integration process, gain and energy resolution were studied as a function of grid shapes and gap thicknesses in various gas mixtures.
The gain was shown to drop with the optical transparency of the grid while the energy resolution trend with respect to the gain was almost independent of the grid geometry. Furthermore it was measured that for a given gas mixture, the gain at which the minimum energy resolution is reached is around 5000. We believe the degradation of the resolution at gains above 5000 to be due to insufficient UV photons quenching that modify the avalanche statistic (Figure 3).

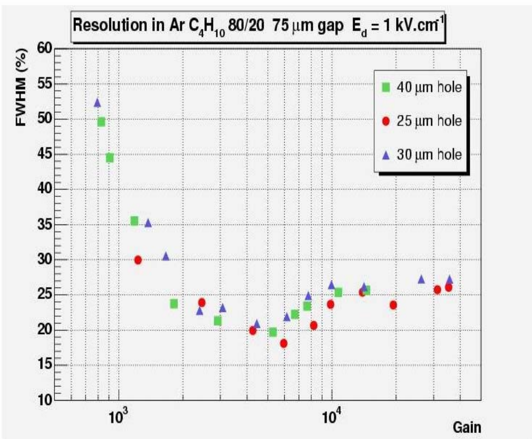

Figure 3: Resolution as a function of grid geometry for 75 µm gap InGrids.

Measurements of gain as a function of gap were performed in argon and helium based mixtures with isobutane and carbon dioxide quenchers (Figure 4). They hardly suggest maximum gains for gaps between 40 and 55 microns; however more points are required for a stronger assessment as well as error bars on the gap thicknesses.

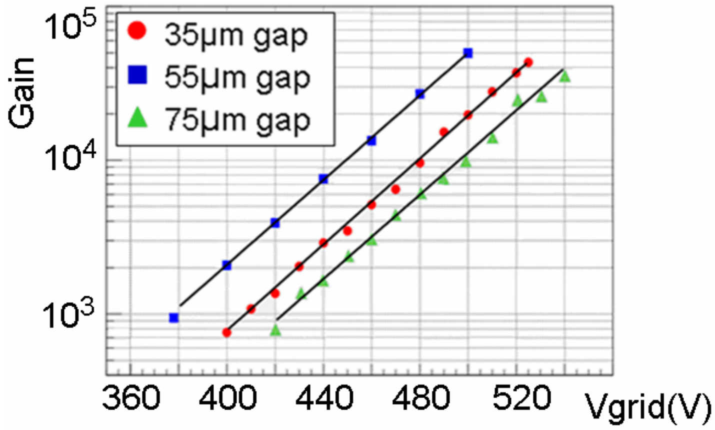

Figure 4: Gain as a function of gap in various gas mixtures.

3 A protection against gas discharges

The use of a high resistive layer as a protection against gas discharges was investigated by depositing a 4 microns thin layer of high resistivity (10^{11} Ω.cm) hydrogenated amorphous silicon over an aluminum covered silicon wafer. The expected effect is a limitation of the current of large avalanche sizes (i.e. discharges) because of the high resistance in series with the anode. A Micromegas grid was maintained above a 1 cm^2 area of the wafer. For comparison with standard “unprotected” anode, a second Micromegas grid was set above an aluminum covered silicon wafer without any H:aSi layer on top (Figure 5).

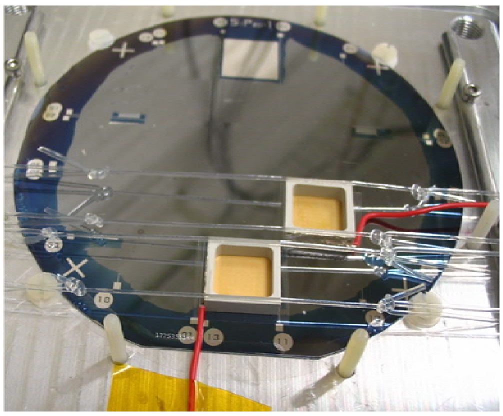

Figure 5: 4 inch silicon wafer with 2 Micromegas detector.

Gains of both protected and unprotected detectors were measured by means of an iron source in an argon 20% isobutane mixture. The unprotected detector gain could not be brought above few thousands because of sudden and repeated grid discharges that prevented any voltage to remain on the grid. On the other hand the protected detector could achieve gains of few hundreds thousands as the grid could not (or didn’t have time for) completely discharge (Figure 6). This is due to the high resistivity of H:aSi that prevents charge from flowing to fast from the grid to the ground.

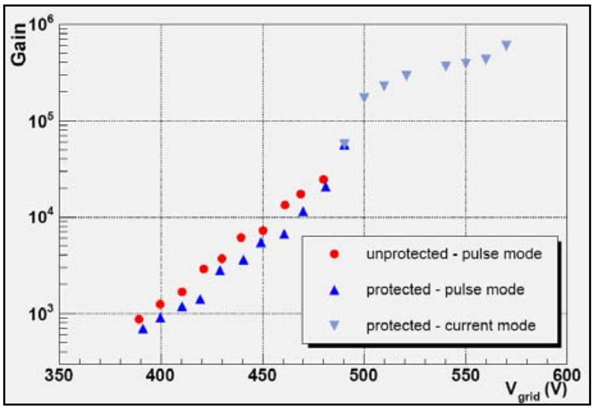

Figure 6: Gain of "protected" and "unprotected" detectors.

A careful study of discharge signals from protected and unprotected detectors was performed in Argon based gas mixtures. Discharges were induced by adding small amount of Thorium in the gas. Thorium decays result in the emission of alphas of few MeV. These alphas give proportional as well as discharge signals in both detectors. While looking at the discharge signals by means of a specific readout scheme and a fast scope it was observed that the electron peak was faster in the unprotected detector, resulting in higher power dissipation i.e. more destructive spark. The time development was different in the protected detector (less steep slope of charge with respect to time for the electrons, smaller amplitude) even though the total time was similar (Figure 7).

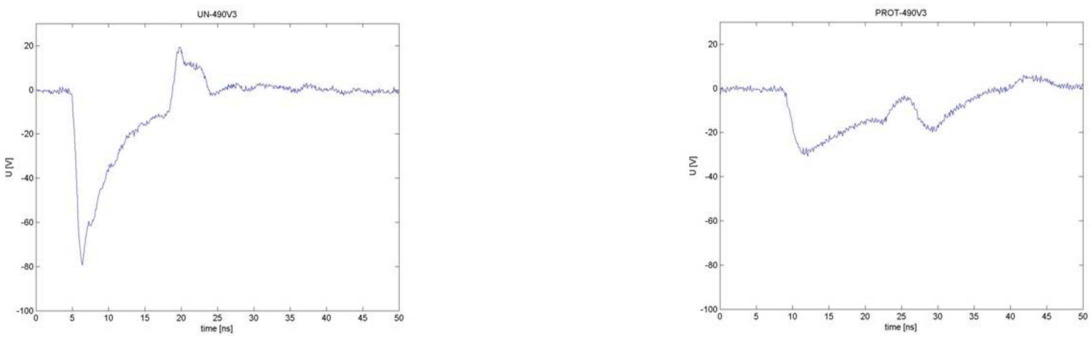

Figure 7: Time development of discharge signals from "unprotected" (left) and "protected" (right) detectors.

As a conclusion there is a strong hope that a stable operation of pixel readout Micromegas detectors could be achieved with SiProt.

Acknowledgement

This work is supported by the Commission of the European Communities under the 6^{th} Framework Programme "Structuring the European Research Area", contract number RII3-026126.