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Performance of Micro Wire Detector at a PSI test-beam

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This note describes the behaviour of a Micro Wire Detector in a test-beam at the Paul Scherrer Institute (PSI), Switzerland. The results of the irradiation tests done with π^- and p-π^+ beams at intensities $2 \times 10^4 mm^{-2} s^{-1}$ show no evidence of degradation of detector performance with respect to its laboratory operation parameters, previously determined with X-rays, up to an integrated charge of 150mC over the area of $12.8cm^2$. The time resolution of the detector was also determined to be better than 21ns.

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1 Introduction

The μWD [1] is a new kind of micro-pattern kapton-etched detector, which combines high amplification and charge collection in a single stage. A prototype $10 \times 10 cm^2$ has been built, which consists of a kapton foil with a thickness of 50μm copper metallized (5 μm) on both sides. On one side a pattern of square holes 70 x 70μm^2 has been litographically etched. On the opposite side 25μm wide strips are also etched ensuring that they run in the middle of the square holes pattern. The kapton is then removed in such a way that just an insulating mechanical joint between anode (strips) and cathode (mesh of square holes) remains (see figure 1). The real setup can be appreciated in the electron microscope photographies shown in figure 2 as well as in figure 3. The pitch of the anode strips is 100μm. In this design, the strips are joined in groups of two at the detector end. The chamber is finally assembled by enclosing the detector foil between two 3mm height Vectronite frames, sealed with two kapton metallized foils. The foil in front of the cathode provides the drift field, while the other is set to ground. This detector exhibits high rate capability and large gains, as shown in figures 4 and 14 obtained with X-rays in a laboratoy test.

The main differences respect to other micropattern gas detectors are that anodes are suspended and no substrate for them is needed, and that these anodes run aligned respect to the holes in the cathode metallic mesh. The detector foil material represents only 0.037% of a radiation lenght [3] .

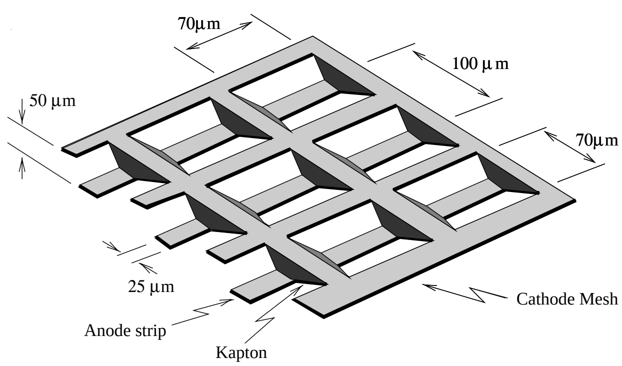

Fig. 1. *Design of the Micro Wire Detector foil.*

Figure 5 shows the electric field configuration in a given detector cell, mapped in the plane perpendicular to the anode direction (across the middle of the hole). The calculation was done using by the program MAXWELL. Lines correspond to equal electric field intensity in kV/cm (V$_{anode}$=0V, V$_{cathode}$=-500V, V$_{drift}$=-3000V). Two straight lines indicate the limits of the kapton

[3] In the complete detector, the contributions of the drift electrode and gas should be added.

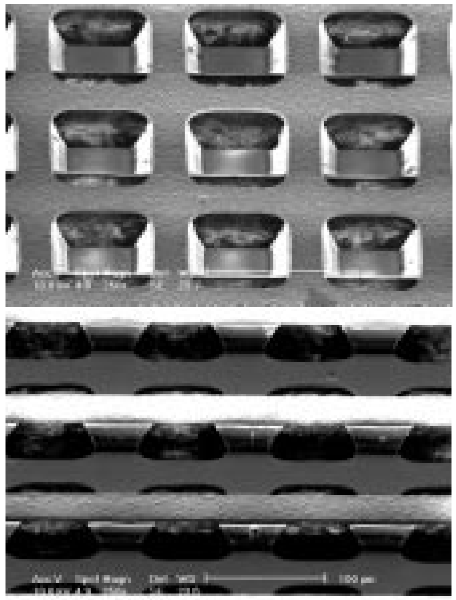

Fig. 2. *Electron microscope pictures of the detector foil as seen from the cathode side (top), and from the anode side (bottom).*

spacer, which is not intersected by the xz plane.

2 The PSI test-beam

In order to study the detector performance in a radiation environment close to the one at LHCb, with particle rates of $10^4 mm^{-2}s^{-1}$, including presence of light nuclear fragments, we have tested the μWD with beam from the SINQ accelerator at the PSI, in march/april 1999. In figures 6 and 7 a general view of the experimental setup is shown. The trigger was given by crossed scintillators defining a sensitive area of $5 \times 5mm^2$.

The prototype was irradiated with two types of beams, negative pions with momentum $p = 250MeV/c$ and positive particles (π^+ and p) with $p = 350MeV/c$ at different rates. It was flushed with an Ar-DME gas mixture 50-50%. An oscilloscope Tektronix TDS 684A [4] and a PC were used as data acquisition system as ilustrated in figure 8. During the main part of the test, a total of 128 anode strips were conected to ground through a 1MΩ resistor, with the cathode plane set to different voltages, ranging from -480V to -550V. The anodes were read with a charge sensitive preamplifier followed by a timing filter amplifier 454 ORTEC with a integration time set to $50ns$.

[4] Bandwidth 1GHz

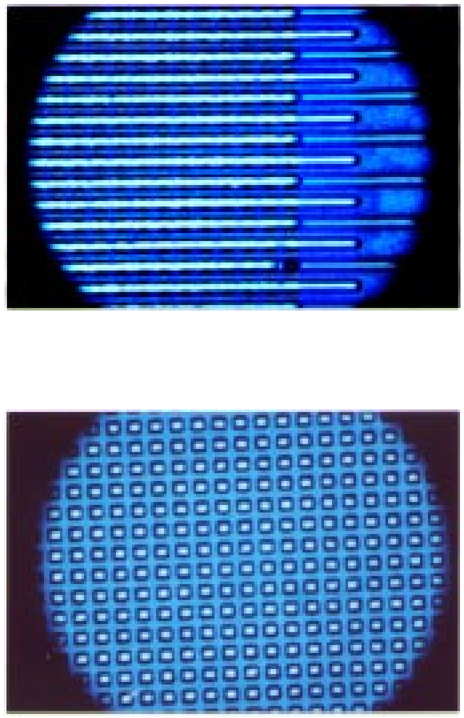

Fig. 3. *Microscope image of the detector foil seen from the anode side (top) and from the cathode side (bottom).*

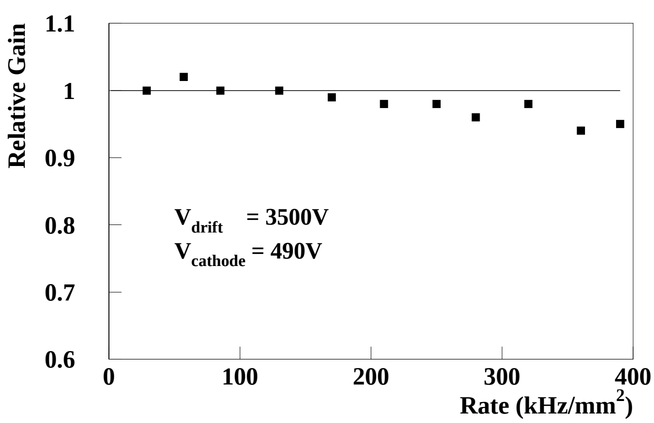

Fig. 4. *Relative values of the peak current spectra versus the photon rate from a Cr X-ray tube.*

3 Results of the test

In figure 9 we present the Landau distributions obtained with the π^- beam at different cathode voltages (gains of 15000, 10000 and 8100); where P1 is the

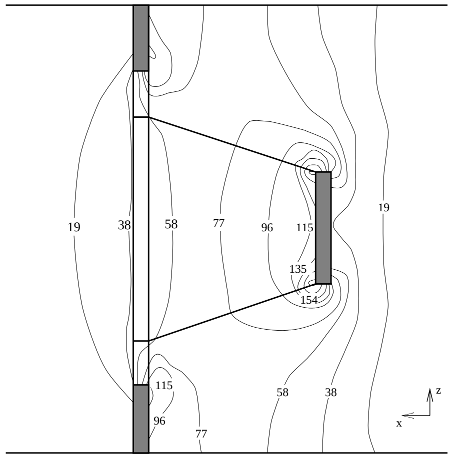

Fig. 5. *Electric field configuration for one detector cell in the plane perpendicular to the anode direction.*

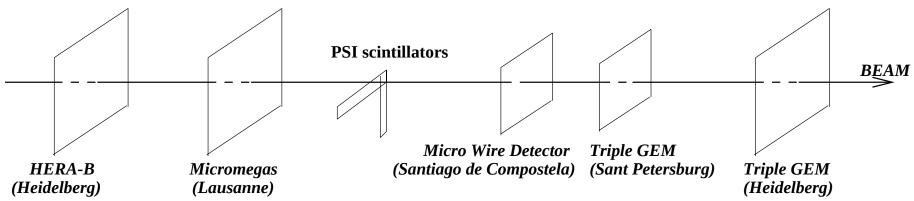

Fig. 6. .

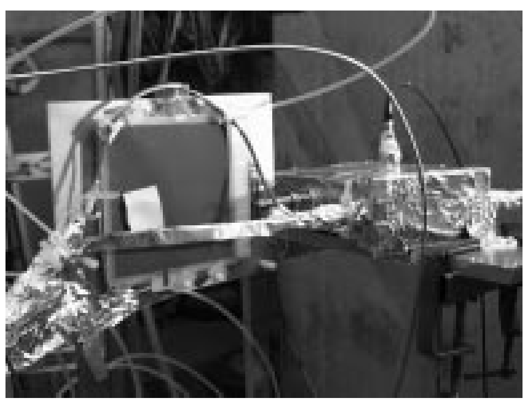

Fig. 7. *Micro Wire Detector prototype at the PSI test-beam.*

normalisation factor, P2 and P3 the most probable and the mean pulse-height, respectively. This measurement was made with a charge sensitive preamplifier PC142 ORTEC.

In figure 10 we show the procedure used to determine the time resolution. The trigger was determined by a coincidence between the anode signal after a constant fraction discriminator ORTEC 935 (CFD) and the signal of PSI scintillator. A fast charge sensitive preamplifier IH142 ORTEC was used for

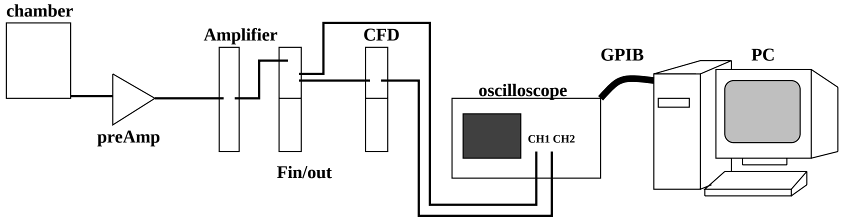

Fig. 8. *Experimental setup.*

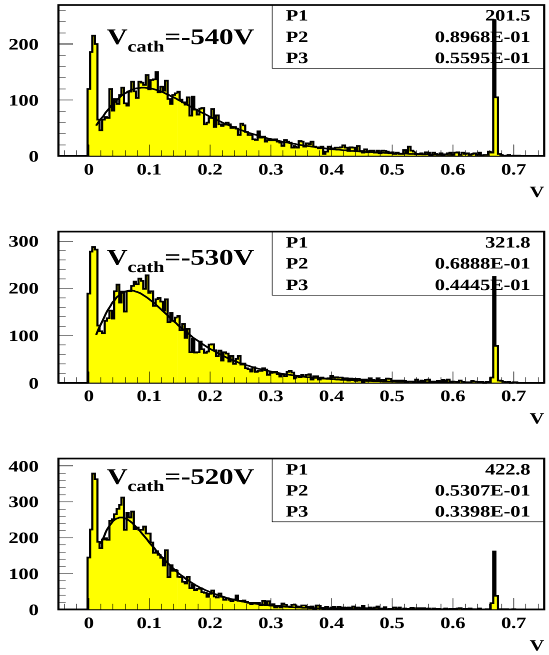

Fig. 9. *Landau distributions observed with the π^- beam (p=250MeV/c) at three different cathode voltages.*

this study. We measured the delay between the discriminated anode signal and the PSI scintillators.

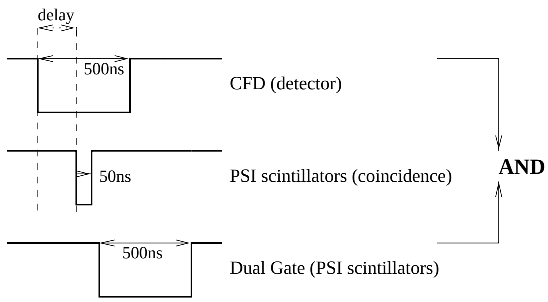

Fig. 10. *Signals to measure time resolution.*

The distribution of the observed time differences is shown in figure 11. A Gaussian fit yielded $\sigma = 21ns$. Because of the non-negligible risetime of the preamplifier (approximately 100ns), and the presence of noise, this result can only be a upper limit of the actual detector resolution, if faster electronics were used.

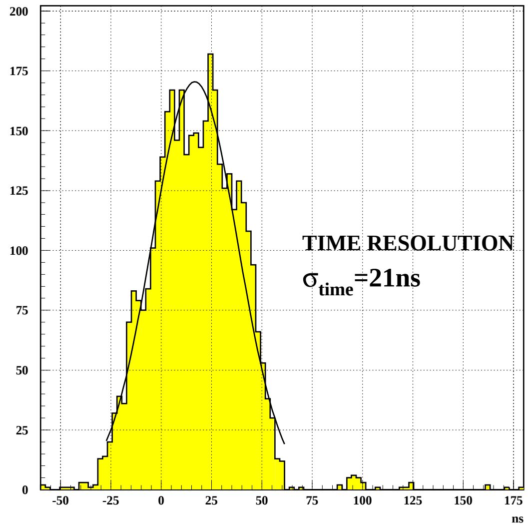

Fig. 11. *Micro Wire Detector time resolution.*

The detector was left under continuous irradiation with the π^+/p beam at intensity 20kHzmm^{-2}. A scan of the beam profile is shown in figure 12, as it was determined at the run start. We also indicate the relative position of the beam with respect to the chamber.

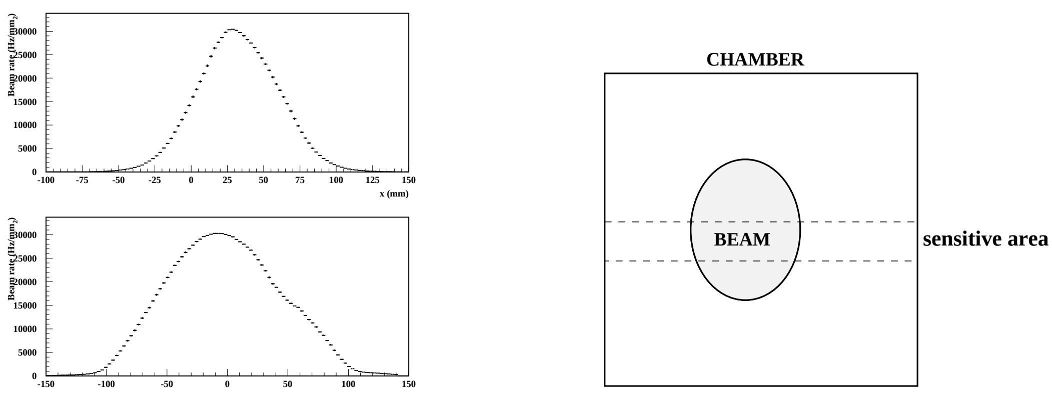

Fig. 12. *Beam profile of the π^+/p beam.*

During the irradiation time, we monitored the current driven by the cathode plane from the CAEN N471A power supply, using one channel of the Tektronix TDS 684A. After 9 hours of irradiation, a failure in the SINQ accelerator water cooling system on April,12 forced to stop the beam-test, originally scheduled to continue for 48 hours. As far as the overall trend is concerned during this time, we did not observe variations that cannot be attributed to ambiental changes, or variations in the beam conditions. In figure 13 we show the evolution of the cathode current for a time window of approximately four hours. The total charge collected during the whole period was in excess of 150mC over a sensitive area of $12.8 cm^2$.

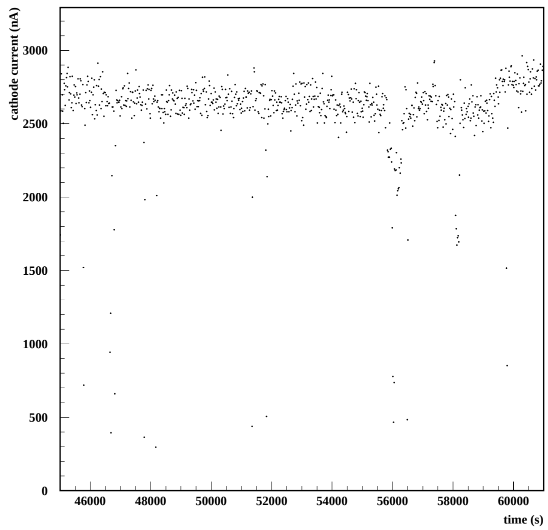

Fig. 13. *Evolution of the cathode current.*

A detailed comparision of the detector gain as a function of the cathode voltage before and after the PSI irradiation test is shown in figure 14. Both gains were determined with Fe^{55} source in the Santiago laboratory using the same experimental setup.

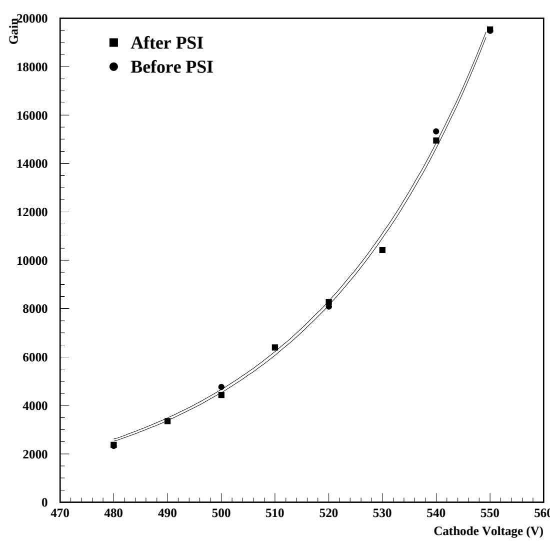

Fig. 14. *Gain as function of cathode voltage before and after irradiation at the PSI.*

In order to evaluate instabilities due to discharges by small streamers, we set up the device illustrated in figure 15, where a capacitor of 1nF to ground is used to generate a signal in coincidence with voltage variations in the cathode plane. This signal is then discriminated and sent to a scaler.

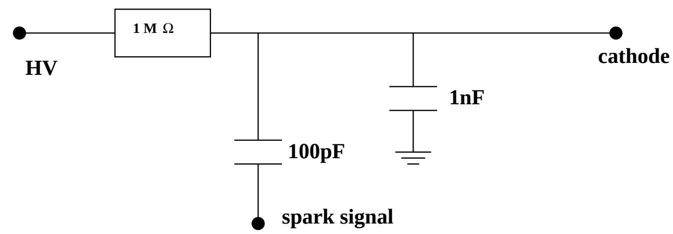

Fig. 15. *Setup to detect voltage trips in the cathode plane.*

By normalizing to the incident particle flux, we could determine in this way spark probabilities per particle $P = 2 \times 10^{-8}$ at a gain $G = 1400$ (-460V), and $P = 1.1 \times 10^{-6}$ at $G = 4400$ (-500V), being roughly independent of the beam intensity. We ignore in the moment of writing this note what is the precise origin of these discharges, and at which location of the chamber are they produced.

Upon return to our laboratory in Santiago, we carefully examined the detector irradiated area with a microscope. No broken or dammaged anode strips were found. As it can be seen in figure 16, some dark spots are observed in the cathode plane, confined to the region within 1.5 mm distance from the detector end. They might be associated with alterations of the kapton joints, as a result of the instabilities previously reported. We plan to investigate this further by: a) a 3D scan, by means of an electron microscope, b) a sampling of the sparking rate along the anode strip length, by using a narrow, high intensity, electron beam.

4 Conclusions

A Micro Wire Detector prototype with 10cm length was operated succesfully in a PSI test-beam, with fluences of $2 \times 10^4 mm^{-2} s^{-1}$ for a continuous period of 9 hours, after which the accelerator was stoped, due to a failure. High gains (up to 16000) with a single-stage amplification were observed. After an integrated charge of more than 150mC, over an irradiated area of $12.8 cm^2$, the detector did not show ageing effects, neither destruction or degradation of anode strips. The time resolution was determined to be better than 21ns. Spark probabilities per particle in the range $10^{-8} - 10^{-6}$ depending of cathode voltages were detected, possibly originated at the detector terminations. This effect will be studied further.

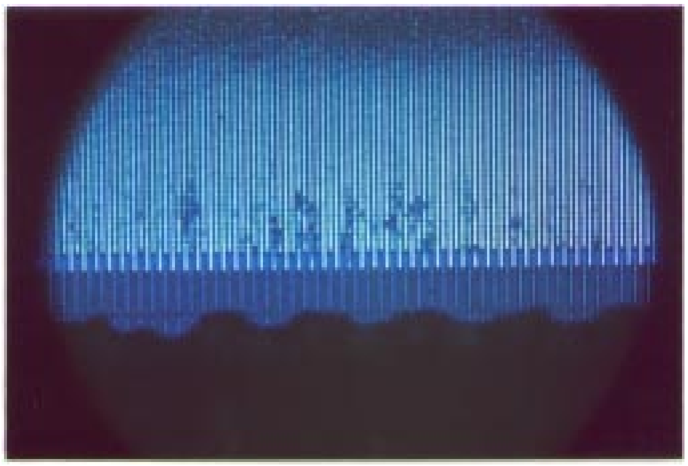

Fig. 16. *Microscope image of the detector foil as seen from the anode side, close to the detector end, in the irradiation zone.*

5 Acknowledgements

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References

[1] B. Adeva et al., **The Micro Wire Detector**, *hep-ex/9902017 v3 30-04-99*, to be published in Nuclear Inst. and Methods