Laboratori Nazionali di Legnaro

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THE LEAK MICROSTRUCTURE . PRELIMINARY RESULTS

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Abstract. The Leak Microstructure, a new type of element for position sensitive proportional gas counter, is introduced For every-single detected ionizig radiation it gives a pair of "induced" charges of the same amount (pulses of the same amplitude), of opposite sign, with the same collection time and essentially in time coincidence, that are proportional to the primary ionization collected A gas multiplication up to $1.5x10^5$ was achieved The complete lack of insulating materials in the active volume of this microstructure avoids problems of charging-up and makes stable and repeatable its behaviour. By using the charge pair generated, it allows the development of a position sensitive detecting board with a two-dimensional read-out. Between the two external surfaces of this board it is possible to insert an intermediate third conducting layer which reduces (or practically suppresses) the capacitive crosstalk, between the X and Y read-out strip systems. Furthermore this intermediate layer can give a very fast trigger to coordinate the charge-pair and to govern the data acquisition system. By reading any strip separately it is possible to resolve the multihit problem in two-dimentions. Using isobutane as the gas, an energy resolution of about 8% FWHM was recorded with α particles from an ^{241}Am source. Always in isobutane gas, X rays from a ^{55}Fe source and β^- particles from a ^{14}C source were also detected

1- Introduction

In order to develop a position sensitive detecting board with a two-dimensional read-out we wondered whether dimensions and working conditions for a microstructure , anode-point based, could be found that would allow the generation of charges proportional to the primary ionization collected, that is working in the proportional region. As will be seen later an anode-point configuration is well suitable for the purpose.
It was pointed out by previous investigations into this type of anode [1,2] that this strongly influences the mode of avalanching : a small (tens of microns) radius tip leads to early streamer operation. On the other hand it is also reported [2] that for a pin detector working in the proportional region the gas gain doubles every~100 V while the gas gain doubles in about 600 V when working in self-quenching streamer mode. To find the proper sizes of this microstructure , and for practicality, we proceeded at first to detect α particles in room air looking for to avoid the corona noises. We tested then these microstructures in isobutane gas.

2- The leak microstructure

The leak microstructure (LM in the following), fig.1, consists of a wire-point (ϕ=10 up to 50μm), acting as anode, well centred and perpendicular to the plane formed by two conductive strips some tens microns thick (cathode). As alternative it can consist of a bodking needle (ϕ=400μm) as anode well centred in a hole (ϕ=400μm) made on a conducting layer (cathode). An electron, produced anywhere in the gas volume, that reaches the strong electric field between the wire-point and the strips of the LM, will drift along the field line towards the anode where it will experience an avalanche multiplication in the gas close to the surface of the point. The signals from the LM are collected by two fast pick-ups (Z_{in}=100 Ω, V_{out}/V_{in}~3 or 0.3 mV/μA). They give, for every-single detected ionizig radiation, a pair of charges of the same amount (pulses of the same amplitude), of opposite sign, with the same collection time and essentially in time coincidence, as can be seen in fig.2. When the distance **b** (fig.1) of the two borders of the strips nearest to the wire-point is in the range 100-300μm (or few more) , it is possible to detect α particles in room air without corona noise or instabilities due to secondary processes with an High Voltage ranging from 650 - 1200 V depending on the LM size.. In fig.3 is reported the gas multiplication , in 760 Torr of isobutane , as function of the HV, of three different LM's [1: wire-point ϕ=20 μm,b=200 μm. 2: wire-point ϕ=20 μm, b=300 μm. 3: a needle (with tens of microns radius tip) of ϕ=400 μm centred in a hole ϕ=400 μm] . In fig. 4 pulses from a LM of the type 3 (needle) working at 1200 V with a ^{55}Fe source in 760 Torr of isobutane. In these experimental conditions the absorbed X ray of 5.9 KeV from the ^{55}Fe source gives rise up to ~200 electrons of primary ionization. With the formula G=VT/2AZe where G=gas multiplication, V=maximum recorded amplitude (~80 mV) of these pulses, T=the duration of the ion collection process (~30 ns.), A=electronic amplification (3), Z=input impedance of the pick-ups (100 Ω) and e is the electron charge, we evaluate the gas multiplication to be about 1.25x10^5. In the same working conditions but at 600 Torr of isobutane a gas gain 1,5x10^5 was achieved.

3- The two-dimensional position sensitive detecting board

In a sandwich, fig 5, made with two pieces of printed circuits board (glass-epoxy laminate, both ~10x10 mm^2 and 1 mm thick, with copper foils 37μm thick coating both sides) a matrix of nine holes of ϕ=400 μm was drilled (pitch 1 mm). One of the two external conducting-layers was divided into strips, separated by the nine holes. The other external conducting-layer was also divided into strips, orthogonal to the previous ones, but centred on the holes. Nine needles, ϕ=400 μm, were inserted with their points well centred in the holes between the strips to form nine LM's. On the other external layer the needles passing in the middle of the strips were soldered to them and cut. On the two internal copper-layers, adhering to each other, and forming an intermediate conducting layer, the holes were reamed to prevent contact with the pass-through needles .The structure, therefore, consists of a cathodic surface (**detecting surface**) with nine LM's, of an **intermediate conducting layer** and of an anodic surface (**backplane**: strips in contact with the needles). Let us name this structure as the **L.N.L. structure** (Laboratori Nazionali di Legnaro). After cleaning up with trichlorethylen in an ultrasonic bath we verified that each of the nine LM's were running with α particles. In fig. 6 an energy distribution obtained with α particles with the L.N.L. structure in isobutane is shown. The latter is the sum of the spectra of the nine LM's working together at the same HV but with different gas multiplication (due to little differences in the mechanical sizes of the LM's). It is possible to obtain fast "kicks" pulses by connecting the intermediate layer of the L.N.L. structure to a fast pick-up. These kick pulses are the OR of the anodic and the cathodic pulses of the external surfaces (no matter how they were subdivided) offering a good trigger to coordinate them in a two-dimensional read-out system. Moreover the intermediate layer limits the capacitive cross-talk (or can shield electrostatically quite completely if grounded) between the two external surfaces.

CONCLUSIONS

It was put in evidence the possibility to use points, arranged in particular microstructures, to detect gas ionizing radiations working in proportional region with high gas multiplication and consequently with output pulses of high amplitude on low impedance with a rapid risetime. The ratio Q_x/Q_y of each charge-pair supplied by these microstructures for each detected ionizing radiation is 1 and both Q_x and Q_y charges of each pair give the same energy and time information. The energy resolution FWHM with α particles is good. The absence of insulating materials in the active volume of this microstructure gives stable and repeatable its behaviour. The possibility of communication between two conducting surfaces, via "conductivity" through the wire-points of the LM's was verified in practice with the L.N.L. structure of fig.5. The two external surfaces, which do not need to be parallel and flat, can be subdivided, not necessarily, in straight orthogonal strips, to form a sensitive position two-dimensional readout. Between the two "active surfaces" it is possible to insert a third intermediate conducting layer to limit (or practically suppress) the capacitive cross-talk between them. Moreover this intermediate layer can give a very fast OR-trigger to coordinate the charges (pulses) of the two external surfaces and to govern the data acquisition system.

FIGURE CAPTIONS

Fig.1- Cross-section of a LM and electronic set-up. Fig.2-Anodic and cathodic pulses with α particles in room air. Fig.3-Gas multiplication in 760Torr isobutane. Fig.4-Anodic pulses with a ^{55}Fe source. Fig. 5-The L.N.L. structure. Fig.6-Energy distribution obtained with the L.N.L.stucture.

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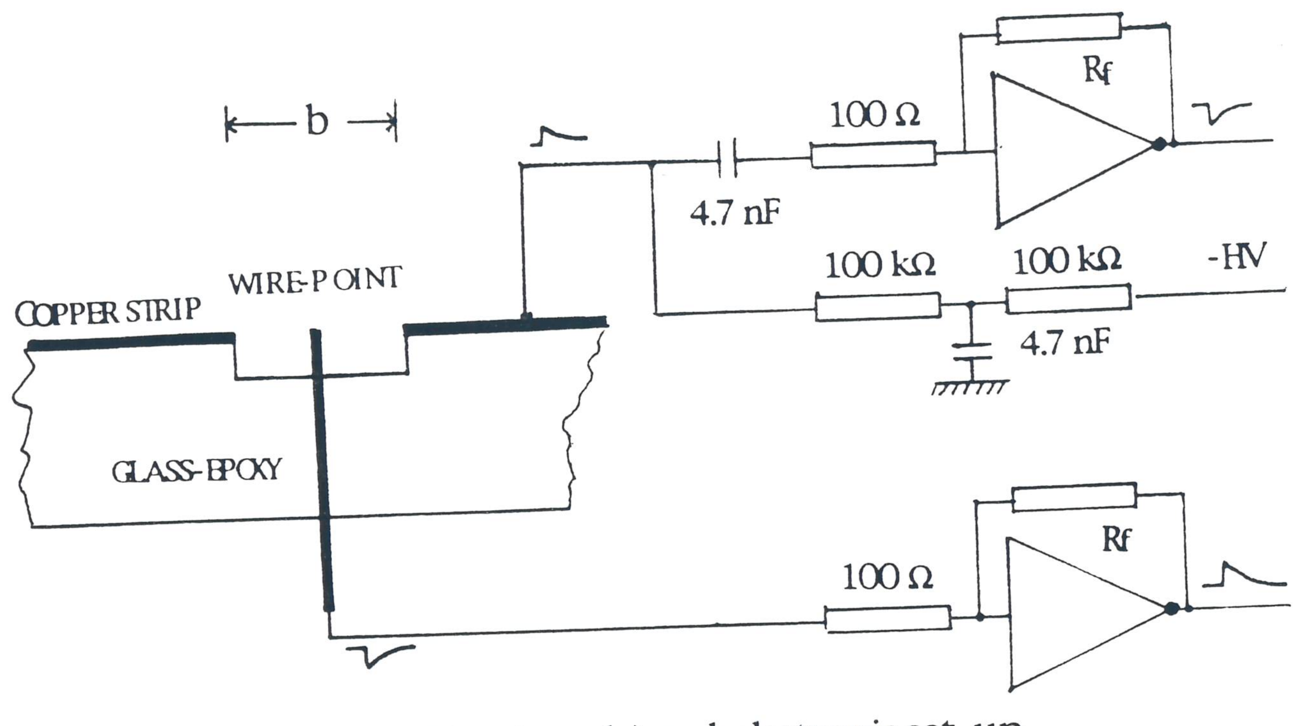

Fig.1- Cross-section of a LM (not in scale) and electronic set-up.

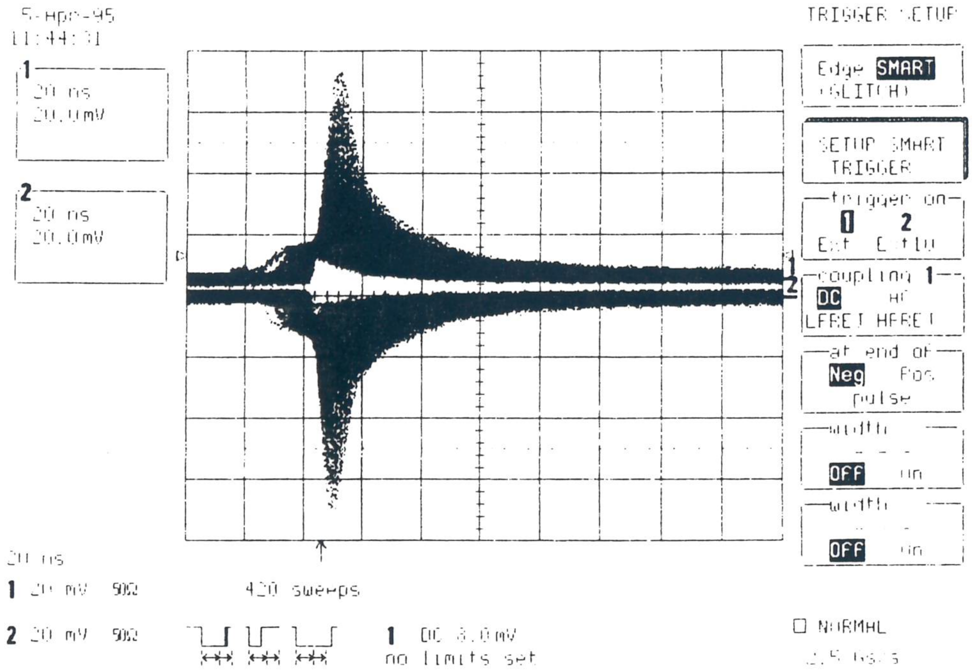

Fig.2 - Anodic and cathodic pulses with α particles in room air.

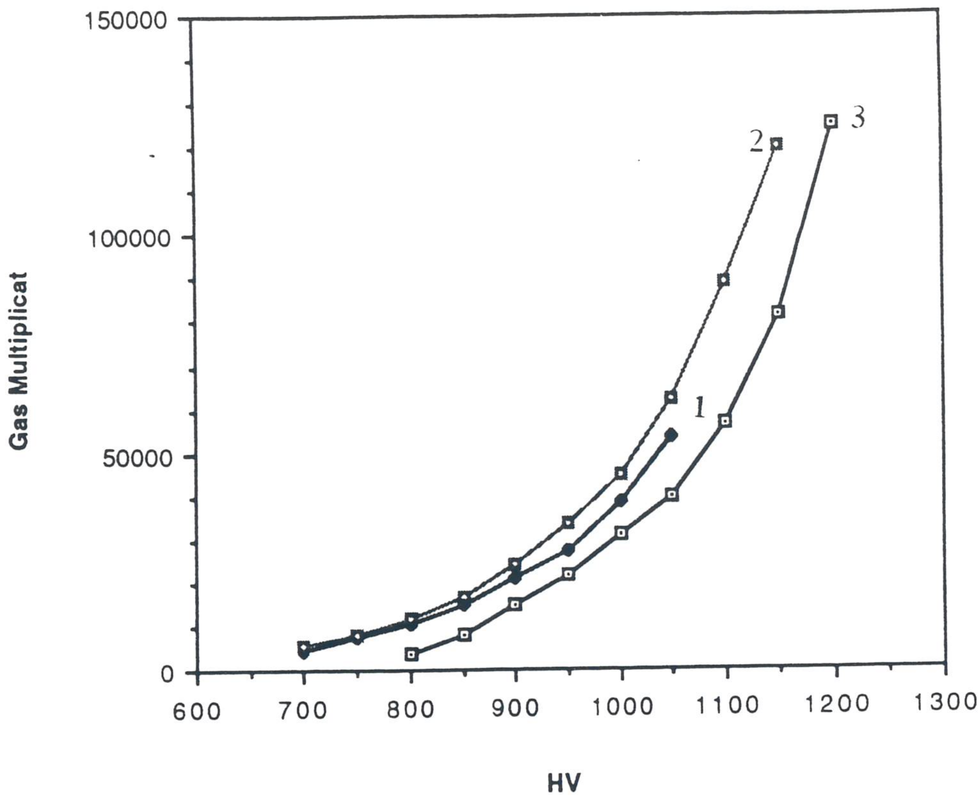

Fig.3-Gas multiplication in 760 Torr isobutane.

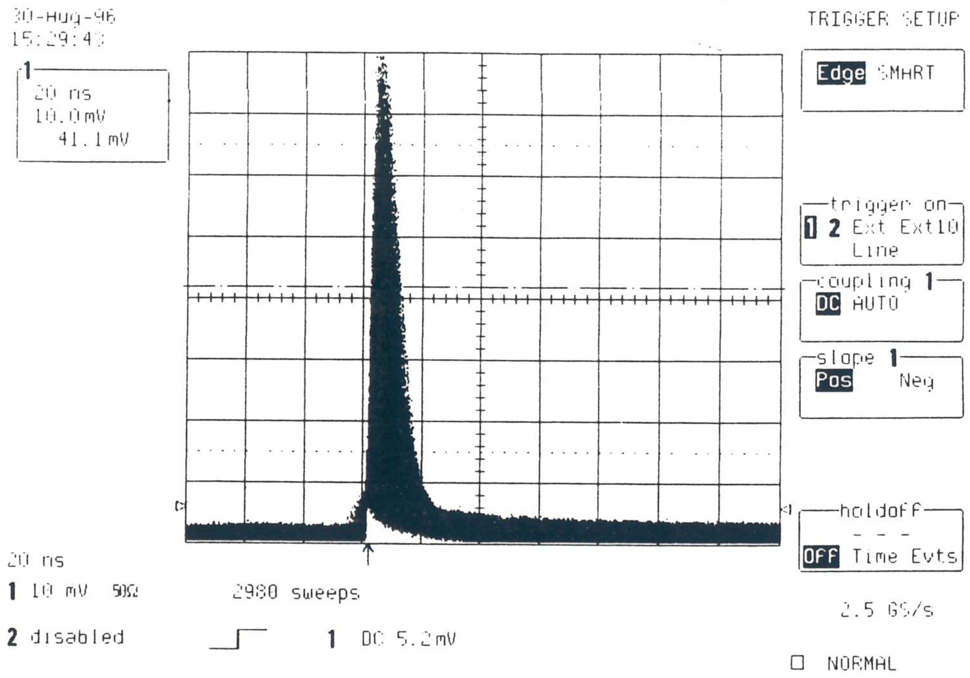

Fig.4- Anodic pulses with a ^{55}Fe source.

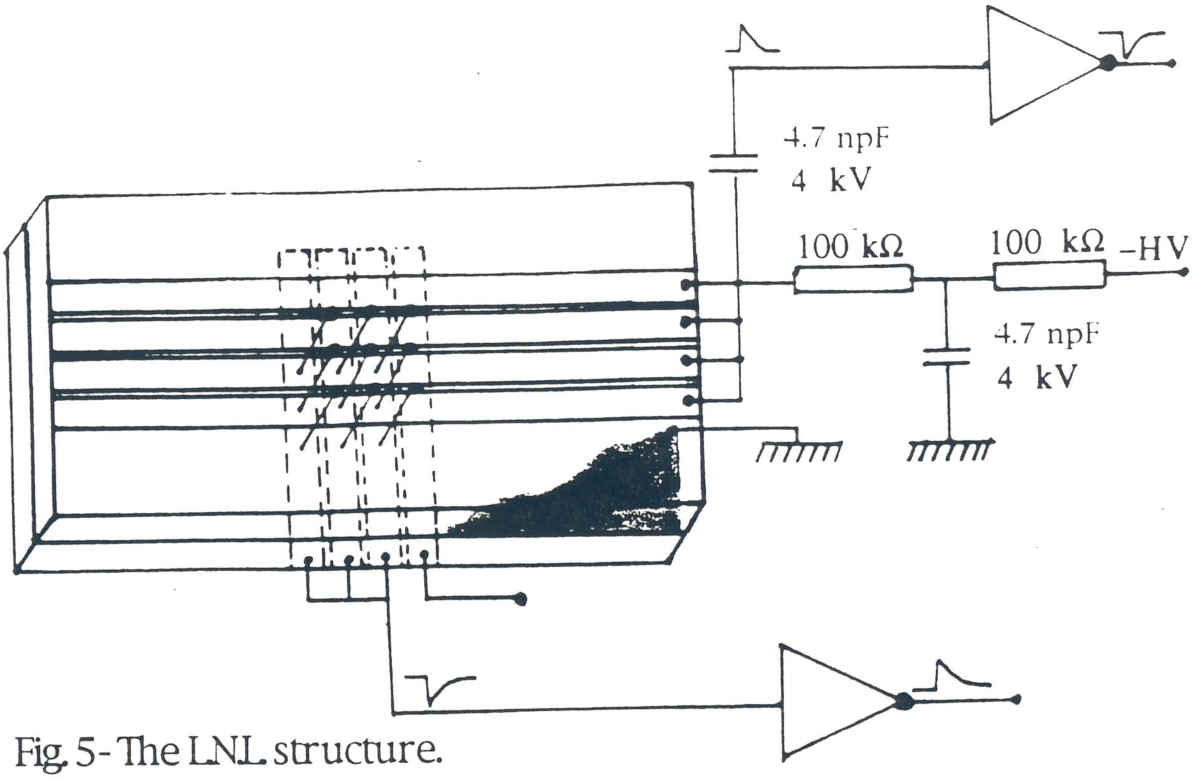

Fig. 5 - The LNL structure.

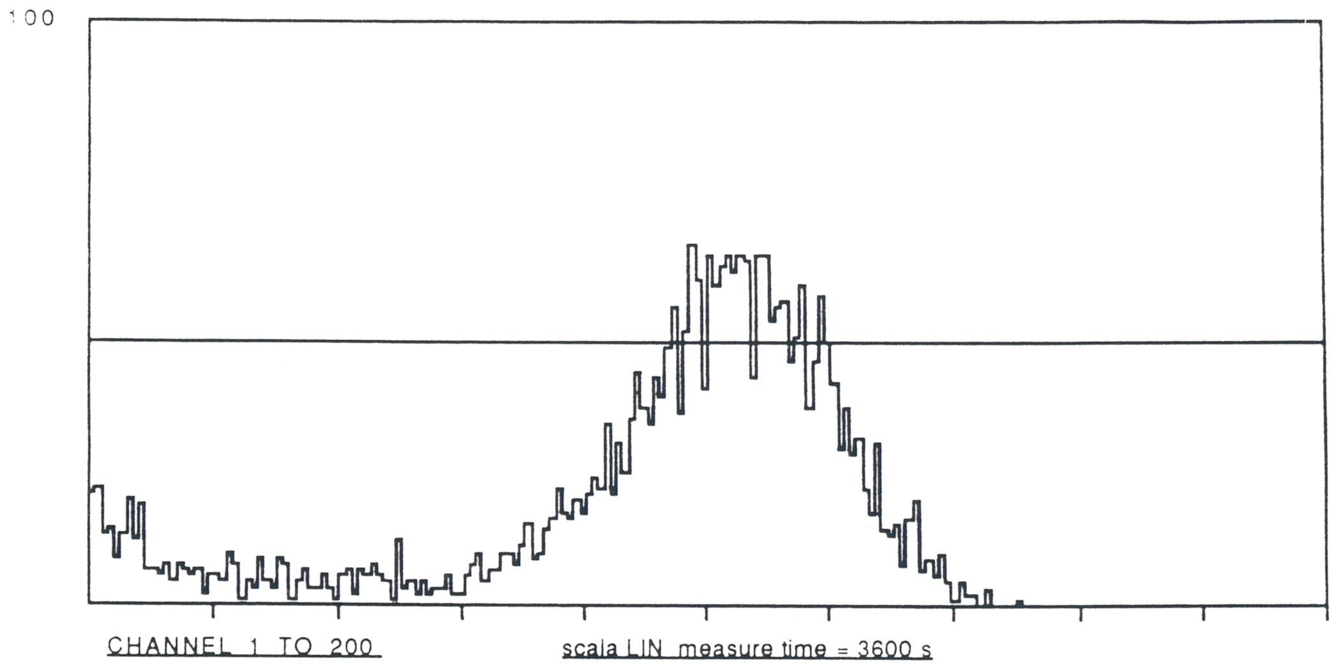

Fig.6 - Energy distribution obtained with the LNL stucture.