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IMPROVEMENT OF THE WIRE GAIN NEAR THE FRAME
OF A TIME PROJECTION CHAMBER

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In wire chambers the gain usually drops to zero near the frame. In many geometries used for proportional chambers (PC) and drift chambers (DC), the resulting efficiency loss and dead space is not important. On the other hand, in a Time Projection Chamber (TPC) the loss of precise pulse height information for dE/dx and tracking is significant, due to the splitting of the detector into several sectors.

In the course of the development of a TPC for DELPHI we have carried out tests on this subject. DELPHI [1] is a detector for the Large Electron Positron collider (LEP) being built at CERN. A TPC was chosen for its highly segmented 3D information and corresponding pattern recognition power. The sensitive volume of the DELPHI TPC is 1.36 m long and extends radially from 39 to 112 cm. Each end is subdivided into 6 sector plates, containing 186 sense wires for dE/dx and 16 pad rows.

The gain loss close to the frames which hold sense and field wires is caused by modifications of the E field: due to the dielectric constant ϵ of the glassfiber epoxy frame (G10) and the glue, the density of the electric field lines is reduced close to the sense wires edges.

We have carried out tests in order to measure this effect quantitatively and to find a simple technique to reduce the efficiency loss. Other experiments [2] have done analytical calculations of the field near the sector boundary and chamber tests on different geometries.

Earlier results indicated that it is possible to obtain a gain increase near the frame by shaping the electric field with guard strips. We have built a test chamber using this method. The guard strips consisted of .8 mm thick copper wire fixed along the frame; one wire half way between the cathode grid terminating the drift volume and the sense wire plane, and the other wire half way between the sense wire plane and the cathode plate (fig. 1). The frames were rapidly dismountable, allowing precise comparison with a "mixed" solution, with the lower guard strip above the cathode plate removed.

Argon/CO₂ 70/30% from premixed bottles was used as gas filling. The drift field, 1 cm high, was built up between a 100 μ m thick stainless steel mesh, kept at -250 V, and the grid plane (100 μ m thick copper/beryllium wires, spaced 1 mm) kept at ground potential. The potential and sense wires were 100 μ m Cu/Be and

20 μm gold/tungsten wires respectively, with 2 mm spacing. The HV on sense/ field wires was normally +1550 V/0 V. The cathode plate was a thin copper foil glued onto a G10 plate and kept on ground. No pad engraving was necessary for our purposes, as we were concerned only with gas amplification. The whole chamber was enclosed in a gas tight metallic box with a large mylar window on top and two quartz windows on the side.

The signal on the wires was obtained by ionising the drift space gas with a Mopalite^(*) MOPA 600S laser through the quartz windows. The nitrogen laser operates in monomode at 337 nm. By focusing the laser we obtained a beam spot with a diameter of some hundred microns, in which most of the energy (about 180 μJ) is concentrated. The stability of the preamplifier/shaper/multichannel analyser read-out was checked before every test recording the pulse height and the FWHM of a Fe^{55} source.

The position of the laser with respect to the frame (zero setting) was checked with a movable gauge. With this procedure the systematic error due to a zero shift was kept around ± 1 mm.

The test consisted in shooting with the laser in the drift region of the TPC, parallel to the wire plane and to the frame, and varying the distance to the frame. The pulse height and the FWHM over some hundreds laser shots were recorded. In fig. 2 the multichannel analyser output is shown for 1000 shots, with the laser beam at 2 cm from the frame. The FWHM is 22% of the mean pulse height.

The aim of the test was to find a voltage combination on the guards that could recover the gain keeping safe chamber operations.

The most significant results are displayed in fig. 3.

At first the behaviour of the chamber with +750 V on the guard strips was checked; this voltage value was chosen as naive estimate of the potential half way between 0 V and +1550 V. The close values of the experimental points in fig. 3 (dots and triangles) confirm that the hypothesis is not far from reality. The behaviour of the guard strips was checked with a scan between +1550 V and -250 V; -180 V was found to be the best voltage value.

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The results obtained with $-180\text{ V}/-180\text{ V}$ and $-180\text{ V}/0\text{ V}$ applied to the guards above/below the sense wire plane were practically identical. We see that the gain falls by 10% at 10 mm from the frame without guard rings, at 2 mm with guard rings at $0\text{ V}/0\text{ V}$ and at 0.5 mm with guard rings at $-180\text{ V}/0\text{ V}$. In the same chamber tests were performed with one guard ring only, placed half way between the grid and the sense wires plane. The lower frame had no grooves in this case.

In a fine scan between 0 V and -200 V , the value -180 V was again found to be the best. However even 0 V is interesting, as it avoids an additional potential to be controlled and still keeps the region with reduced gain reasonably small. The results obtained for this case of a single guard ring are shown in fig. 4. A 10% gain drop occurs around 2 mm from the frame with -180 V on the guard. These results are only slightly worse than those for the geometry with two guard rings.

A finer scan of the gain has been performed in the zone 0 to 15 mm off the frame (fig. 5). With each single configuration at least two tests were carried out, normally on different days (i.e. with different values of temperature, pressure and humidity) and after a recalibration of the zero setting. The statistical errors on our points are estimated to be less than 5%. These results show that it is possible to enlarge the region of constant gain by at least 8 mm near the frame of a TPC, by installing guard strips kept on a reasonably small negative voltage. Further tests are needed to analyze the possibility of obtaining useful pad information very close to the frame.

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REFERENCES

- [1] DELPHI Technical Proposal, May 1983.
- [2] P. Martin, LBL, PEP4 TPC (private communication);
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calculation, TOPAZ Int.Rep. TPC-UT-83/5.

FIGURE CAPTIONS

- Fig. 1 Section of the frame. The 800 μ m copper wires (guard rings) are marked A, B.
- Fig. 2 Pulse height spectrum obtained from the chamber with 1000 shots of a Mopalite MOPA 600 S laser. The full width at half maximum (FWHM) is 22% of the pulse height.
- Fig. 3 Results of the test with both guard rings. The error on the zero-position is estimated to be ± 1 mm.
- Fig. 4 Results of the test with one guard ring only, placed half way between the cathode grid and the sense/field wire plane (guard ring A).
- Fig. 5 Fine scan of the region up to 3 cm off the frame, with guard ring A at -180 V.

Fig. 1

Fig. 2

Fig. 3

Fig. 4