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The TPC According to GARF

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Abstract

This note will describe the results of electrostatic calculations performed on the TPC geometry with and without field wires for both the inner and outer sectors. The calculations were performed with the program GARFIELD.

The results shown in this note were obtained using the GARFIELD package[1] available from CERN. GARFIELD is a program designed to perform electrostatic calculations on drift chambers made up of thin wires and up to two not necessarily grounded planes. The description of the chamber geometry is provided as a listing of wire positions, potentials, and diameters, along with a description of the gas. GARFIELD uses this information to calculate equipotential lines, drift lines, drift times, etc.

The first set of results described here concern the EOS prototype TPC geometry, both with and without field wires. The anode-to-anode wire pitch is 4 mm, with cathode wires placed halfway between them when present. The pad plane is treated as an infinite grounded plane 4 mm below the wire plane. The drift distance is 7.2 cm and the drift field is generated by an infinite plane at the position set at a potential of -600 volts. The anode wire diameter is 20 microns and the field wire diameter is 74 microns. The cathode wires are always grounded while the anode wire potentials are varied. There is also a plane of grounded wires 4 mm above the anode wire planes with a 1 mm pitch to represent the grounding grid. An additional set of wires with a 1 mm pitch and a -150 volt potential lie 8 mm above the anode wire plane to represent the gating grid. The gas is an 80:20 mixture of argon and ethane at atmospheric pressure. This gas mixture is not equivalent to the P10 gas (80:10 argon-ethane mixture) used in the EOS prototype TPC, but was the closest default gas installed in GARFIELD. The GARFIELD geometry described above, however, does match the optimal running conditions of the EOS prototype TPC.

Figures 1 and 2 show the GARFIELD calculations for the equipotential lines for the geometry described above with and without field wires. Note that the structure of the field lines are roughly the same for the two geometries. These figures also show the electron drift lines for an ionizing track injected parallel to the wire plane and 3.0 cm above the pad plane. Without field wires, the resulting drift length distribution along the wires is wider than with field wires. This will have the effect of slightly spreading out the arrival time of the electrons from the track at the anode wire with respect to the geometry with field wires. The drift times for the electron paths shown in the figures vary from 67 to 140 nanoseconds with field wires and from 74 to 160 nanoseconds without field wires, as calculated by GARFIELD. The spread of the electron arrival times is 13 nanoseconds wider without field wires than with field wires.

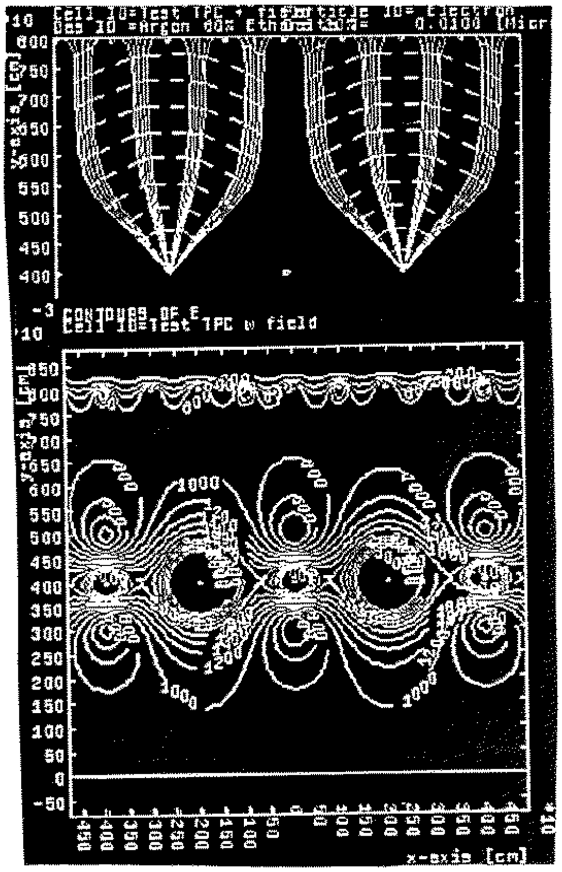
GARFIELD also calculates the electric field at each wire, which is proportional to the gas gain. These values are compared to the gain measurements of the EOS prototype TPC in Figure 3. The measured gas amplification is plotted on the horizontal axis and the GARFIELD-calculated average electric field at the wire surface is plotted on the vertical axis for both geometries. Each point on the two curves corresponds to a different anode voltage (varying in 25 volt increments from 1100 volts to 1350 volts for the field wire geometry and from 1250 volts to 1500 volts for the no field wire geometry). There is very good agreement for the two geometries, suggesting that this is a reliable calculation.

GARFIELD has also been used to compare the potentials in the drift volume of the STAR TPC in the inner and outer sector geometries. These were set up with the same geometry as described above, but without a gating grid. There is a 4mm separation between the wire plane and the grounding grid for both sectors. The pad plane to wire plane separation is 4mm for the outer sector and 2mm for the inner sector. The drift field in this case is defined by a plane at -600 volts situated 7.2 cm above the pad plane. With an anode voltage of 1265 volts in the outer sector, the electric field in the drift region is constant at 96.6 V/cm. For the inner sector, this value is 93.3 V/cm. The anode voltage on the inner sector must be increased by 23 volts to attain the same drift field. As a result, we may want the flexibility to put different anode voltages in these two regions of the TPC. But, if a gating grid, defined by a row of wires with 1mm pitch at -150 V situated 1.4 cm above the pad plane, the electric field in the drift region becomes 78.3 V/cm for the outer sector geometry and 78.1 V/cm for the inner sector geometry - a much smaller difference.

References

[1] R. Veenhof, CERN Helios Note (1988). The users manual is available from CERN.

1)



2)

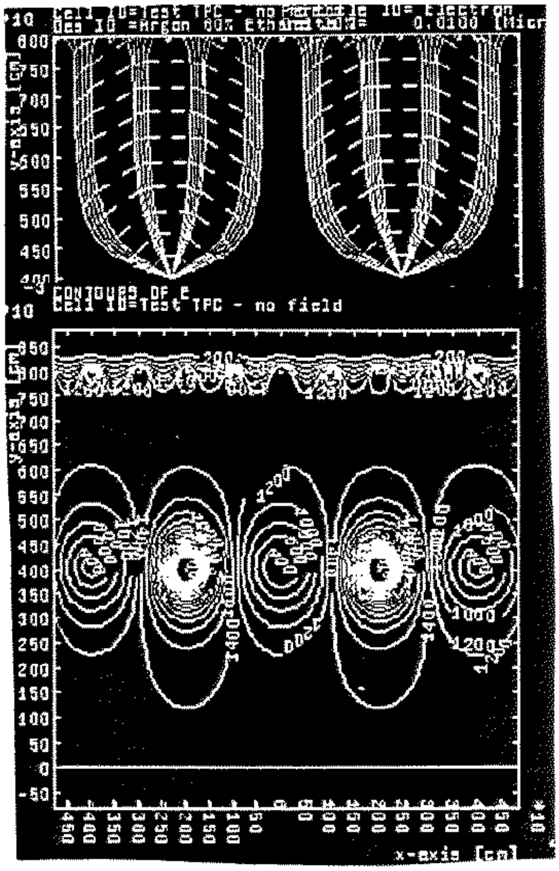


Figure 1: Figure 1 shows the equipotential lines and drift lines for the TPC geometry with field wires.

Figure 2: Figure 2 shows the same without field wires. The electrons drift into the anode wires.

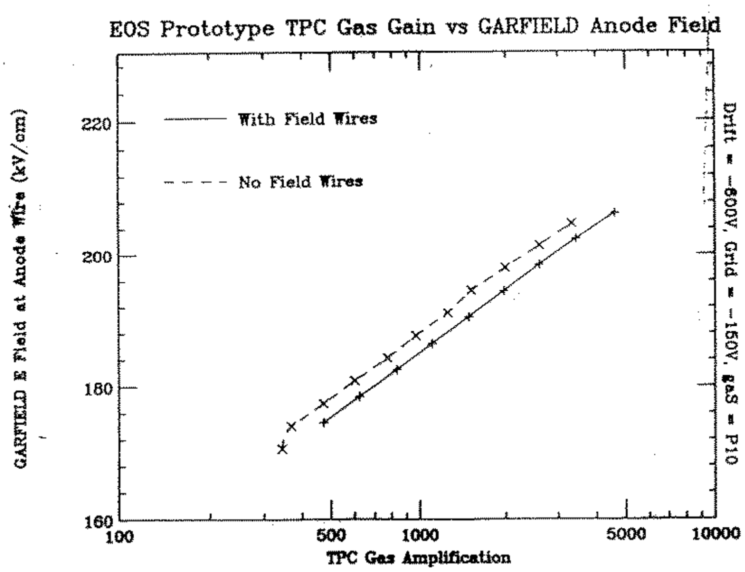


Figure 3: GARFIELD calculated average electric field on the anode wire surface versus the measured gas amplification with and without field wires. Each point on the plot corresponds to a different anode voltage.