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ADVANCED FIELD SHAPING DRIFT CHAMBERS FOR SSC FORWARD TRACKING

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ADVANCED FIELD SHAPING DRIFT CHAMBERS FOR SSC FORWARD TRACKING

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Abstract

Drift cell design and construction methods are described which can be used to form high-precision gas pixel drift chambers that have a linear voltage-to-distance relationship over large portions each of the drift cells. Use of resistive sheet film plastics, and alteration to form nonuniform patterns of resistance (and consequently uniform electric fields) is discussed. Examples are given with respect to triggering and track reconstruction in the intermediate angle region at the supercollider and other high rate experiments.

Introduction

Intermediate angle tracking, indeed tracking of any kind within the interior of a typical SSC detector is extremely challenging due to many considerations of rate, occupancy and instrumentation cost. Any device that has a large active area per instrumented channel will have problems due to the high rates; on the other hand, the present ideas for densely instrumented devices would appear to have associated with them very high costs.

In central rapidities, η less than 1.5 or so, possible solutions exist that involve tradeoffs between the densely packed cells of silicon strip and drift devices at close distances and the more cost-effective larger cells provided by straw tubes at larger values of distance from the interaction point. In the forward (or so-called "intermediate" angle) region, with rapidity between 1.5 and 2.5 (say), the solutions would appear to be a bit less obvious. Radial wire drift chambers[1] which incorporate densely instrumented cathodes or "crossing taggers" have been mentioned as a possible solution.

We would like to suggest an option based on two-dimensional gas-filled pixel devices with active field shaping, bonded on mechanical components that are stress-skin panels formed from a light core with a cladding of resistive or conductively-printed or etched metal-coated sheet plastic. Such devices extend from previous work[2,3] done to produce relatively conventional drift cells from similar materials and with similar methods.

The detectors we propose can be made entirely from commercially available materials to allow a construction that is light, strong, and economical to assemble. The goal is to combine the relatively cheap drift of gas-based technology with the dense channel count for readout provided by recent developments in silicon and straw-tube-based electronics. The result would be pixel gas drift devices with cells of nominal size on the order of millimeters to centimeters, depending on rates. It would be easy to arrange these in layers to provide projective towers of cells, giving a natural method to produce online triggering and track recognition in a high rate environment.

Basic Patterns

The simplest possible arrangement for the unit cell of such a device is shown for three possible cases in Figure 1. These show conductive lines which are assumed to be drawn on a resistive substrate such as those discussed in reference 3. The most basic would be just a central spot at ground potential, through which a sense wire is extended (held by an insulative feed-through), and surrounded by a conductive trace which is placed at some side field shaping potential. The shape of the cell can be either square or hexagonal in basic outline, though these borders need not be precisely rectilinear, and in fact would be altered to grow in outline as a function of distance from the beam line in order to maintain projective towers if that were desired.

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The anode can be either a fairly conventional sense wire or a sharp point, as discussed below. The cell is closed on top with another similar resistive layer separated by a few millimeters and so form a gas drift pixel, here viewed from the top directly above the central anode.

Sense Wire Anodes and Tips

Until recently it was not possible to obtain a large quantity of sharply etched metal tips; however, recent development of the scanning tunneling microscope (STM) into a low-cost commercially available device has introduced a consequent need for suppliers of the sharp etched-wire metal tips that are used in such devices. Suppliers[5] for that industry now can provide quantities of several hundred tips, all generally sharp to better than 0.5 microns, out of materials such as tungsten and platinum-iridium as well as others), and of length up to a couple of centimeters. Wire diameters can be specified, and the rapidness of the taper of the wire to the tip can also be set by the user. Typical cost is on the order of a few US dollars per tip.

A side view of the gas pixels of Figure 1, along with the equipotentials these would produce, is shown in Figure 2. The case of a sense wire anode of radius 20 μm is shown, and also in the case of such a very sharp tip.

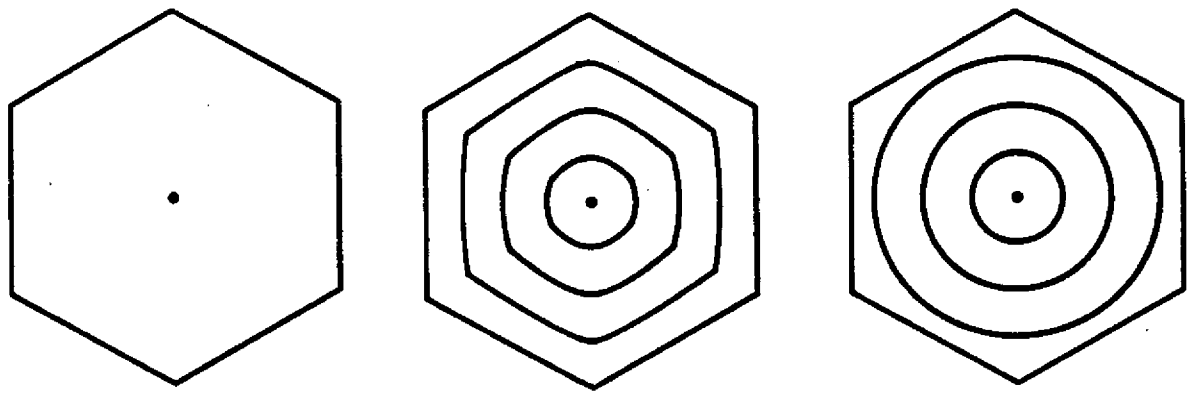

FIG. 1. Several possibilities for the basic layout of conductive patterns for the graded potential gas pixel drift chamber cells discussed in the text.

Resistive Field Gradient Alteration

Devices that are built for triggering should have an intrinsically linear time-to-distance relation for drift time as a function of distance from the anode, or at the least one that can be linearized with ease early in the electronic processing of the anode pulses. Because of simple geometrical effects this is not true for the simplest possible cell, and it would be helpful to consider the possibility of altering the resistance as a function of this distance (i.e. the radius from the sense wire). Of course the simplest method would be to produce conductive patterns of traces on an insulator, then tie them together electrically with a thin resistive strip running from the outside to the inside of the cell, passing through and connected to the intermediate traces as well.

More sophisticated methods of linearizing the voltage-vs.-radius relation would be to print or silkscreen a half-tone or random-dot pattern of very fine conductive dots onto the resistive surface, such that the resistance between two hypothetical traces concentric to the central dot and separated by a constant dr would stay the same regardless of their overall radius.

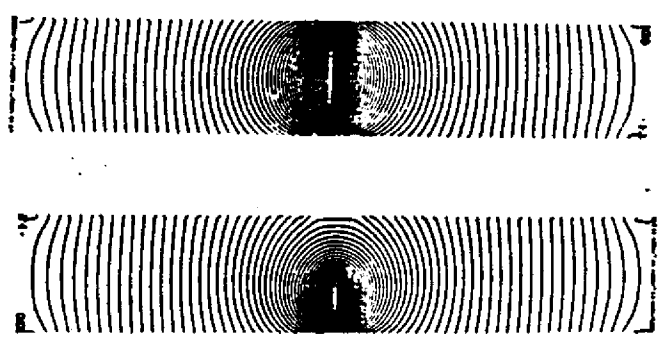

FIG. 2. Equipotentials for the gas pixel drift tiles shown in the previous figure. The plots show lines of constant voltage for the sense-wire and sharp-point versions of these cells as viewed from their sides.

This halftone screening method is shown in the first of the plots in Figure 3. The next two show an exaggerated view of a method which involves the printing or etching of conductive traces which grow in radial width (there would be many more in actual practice than shown here) as the radius becomes smaller.

The resistive plastic would have to be chosen to allow for fast dissipation of excess accumulated charge from within the chamber at high rates. As discussed in reference [3], this would imply a surface resistivity as low as possible without running into problems due to power deposited into the gas by resistive heating within the drift cell. Unlike the situation in long narrow cells, pixels have the advantage that the "squares" of resistance are mostly in series and so surface resistivities approaching the antistatic range can potentially be reached. The performance of such chambers in terms of ion clearing with respect to rate dependence will have to tested. We have begun a program to construct such prototypes to check this and other effects.

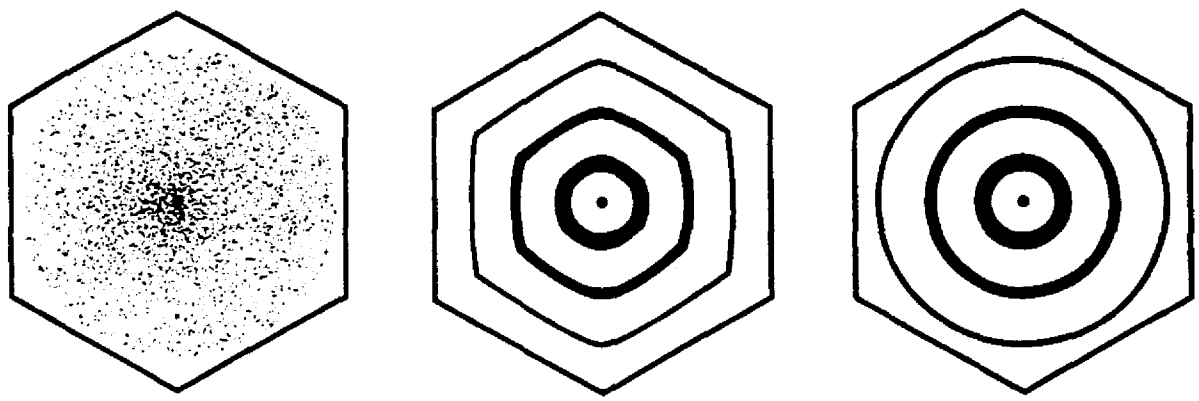

FIG. 3. Methods of providing a uniform drift field by altering the pattern of surface resistance to be proportional to the radius from the sense anode within the graded potential drift tile cell.

Application to SSC Forward Tracking

The greatest application of such a device would be to the online recognition of stiff projective tracks in a simple way. The trigger could even measure and cut on momentum if the alignment between adjacent layers of cells was done precisely enough to minimize the effects of misalignment during assembly. This would in turn imply a very stiff and easily aligned mechanical support structure and method. Possibilities for mechanical support include hexcell, graphite-reinforced composites, and polyimide foams. These should be selected to provide the maximum possible stability and accuracy in placement of the sense anodes.

Acknowledgement

I am extremely grateful to Dr. Robert Walker of Rochester and KEK, and to Dr. P. N. Kirk of Louisiana State University for enlightening conversations about drift chambers and other topics throughout the work described in this paper and reference [3].

Note Added

After presentation of this talk at the conference, my attention was called to recent work which appears to be along related lines being done at CERN with respect to the LAA project. Please see reference [6].

References

1. D. Saxon, this proceedings.
2. A. Sill, Proceedings of the Meeting of the Division of Particles and Fields of the American Physical Society, Rice University, Houston, TX, Jan. 5-9, 1990.
3. A.F. Sill, "Advanced Field Shaping Drift Chambers for SSC Muon Tracking," this proceedings.
4. XC series resistive Kapton™ polyimide film, DuPont Corporation, Wilmington DE 19880.
5. Many such STM support companies now exist; for instance, Longreach Scientific Resources, RFD 1, Box 549, Orr's Island, Maine 04066.
6. D. Mattern, M.C.S. Williams, A. Zichichi, CERN-EF-90-4, Jun. 1990, submitted to Nucl. Instrum. Methods