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Large, Light, High-acceptance CSC Chambers for the PHENIX Muon Detector Using a Honeycomb Panel Design[1]

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Abstract

The Muon tracking system for the PHENIX detector uses cathode strip chambers (CSC) for the tracking detectors. These detectors must provide 58 micron resolution at each station to give satisfactory mass resolution of the vector mesons. Station 1 must have a high acceptance with a relatively low radiation length in order to avoid shadowing of the stations 2 and 3 via multiple scattering. We have built a full scale prototype of the station 1 detector using honeycomb panels for the substrate of the 20 mil G-10 etched cathode planes. The anode and o-ring planes are laminated to the cathode-covered honeycomb panels. The shape of the prototype is one quadrant of a 60" radius circle. Results of the mechanical and electrical tests are presented.

I. INTRODUCTION

The PHENIX Muon spectrometers consist of three tracking stations inside a radial-field magnet, followed by six planes of muon identification/pion absorber. The North magnet and tracking stations subtend an active area from 10 to 35 degrees from the beam line, and a full 2π in phi. The magnet extends from 200cm to 640cm from the PHENIX interaction point.

In order to accomplish many of the physics goals of the PHENIX experiment at RHIC, the muon spectrometers must meet certain design requirements. Resolution and track finding requirements led to the choice of CSC detectors for the tracking system. In addition, 200 MeV mass resolution for the Y and Y' vector mesons set an upper limit of 58 microns for the spatial resolution of these tracking chambers. For a chamber with three detector planes, this leads to a 100 micron resolution per plane.

The station 1 tracking chambers are located on the front of the muon magnets, and therefore have a less stringent requirement on the detector radiation thickness. However, since station 1 sits in front of the spectrometer, the shadow from inactive area must be kept to a minimum. The choice of honeycomb panels, which require little, if any frames was found to be the best choice for station 1 substrate.

In this paper, we discuss the design of the station 1 prototype, some proposals for improvements to this design, and the preliminary results of performance tests.

II. STATION 1 DETECTOR DESIGN

A. Overall Design

The prototype station 1 CSC chambers are built as quadrants of an circle of approximately 60" radius (Figure 1). Each of three detector planes (Figure 2) consists of two cathode planes separated by 6.35mm and an anode plane consisting of alternating field and anode wires separated by 5mm. The field wires are 75 micron CuBe and the anode (sense) wires are 20 micron diameter gold plated tungsten. The anode wires follow the cord in each 22.5 degree segment, and are attached to printed circuit read-out boards on the edges of the panel. The gap is maintained between the two panels with an o-ring and anode plane each glued to the outside edges of the cathode laminated panels.

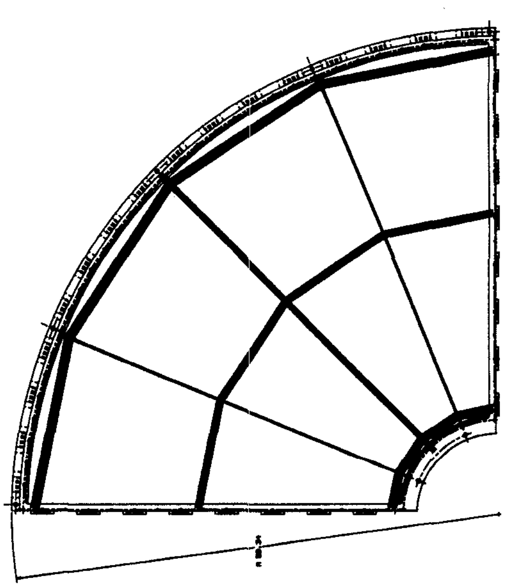

Figure 1: Front view of the station 1 CSC chamber design.

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B. Honeycomb Panels

The honeycomb panels provide the rigid, flat support for the CSC chambers. The prototype panels are made with a plexiglass frame filled with a Nomax honeycomb material [1] which is factory cut to a thickness of 0.710±0.003" . The honeycomb and frame are then sandwiched with epoxy between two skins of 0.010" G-10. The epoxy is cured with the sandwich held flat against a tooling plate using a vacuum bagging process. The resulting laminate has good rigid properties as well as a measured flatness of ±0.005".

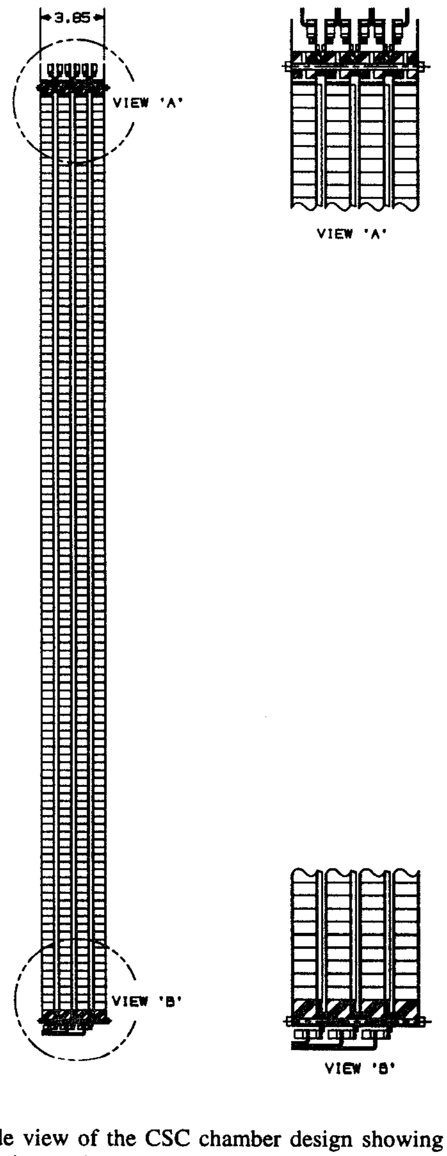

Figure 2: Side view of the CSC chamber design showing the three gas gaps. The insets show expanded views of the anode and cathode connector regions.

Preliminary tests with a frameless panel design have demonstrated sufficient strength and much reduced weight and cost. Therefore, future designs for station 1 will incorporate frameless panels. The gas distribution system, which in the original design was drilled into the panel frames, will pass through inserts glued into the honeycomb panels.

C. Cathode Planes

The cathode planes of the station 1 prototype are etched 1-oz copper coated 0.020" G-10 printed circuit boards. Two configurations of the cathode strips were used for the prototype: 1) radial strips 5mm wide at the outside radius, and 2) parallel strips 5mm wide and oriented parallel to one edge. The cathode PC boards were made in octants in order to keep the size of the artwork smaller than the maximum size set by the manufacturer [2]. The cathode sheets were laminated to the honeycomb panels using a 24 hour epoxy while being held flat against a granite table using a vacuum bag. Every other cathode strip was resistively coupled to ground to reduce read-out channels. Read-out of the cathode strips is through standard 34 pin IDC connectors along the outside radius of the chamber.

This basic design was found to be sufficient, however, simulations of the CSC performance have indicated that parallel strips perpendicular to the anode wires should be used in the final design.

D. O-ring Plane

The o-ring plane is made of 0.125" delrin machined flat with a 0.088" o-ring groove. An 0.063" o-ring made of material with a 50 shore nitrile was used. The low durometer for the o-ring material was necessary to prevent cupping of the panels between the compression bolts.

Machining any material in a large arc, such as the outer radius of the station 1 prototype, is rather expensive. Future designs for the station 1 chambers will utilize straight cords instead of arcs. Also, for the final construction, we are investigating the use of pulltruded plastics for the o-ring planes.

E. Anode Plane

The anode plane is comprised of a 0.125" thick delrin frame which is glued to the cathode plane on one side of the panels. In the region of the anode read-out, the delrin plane is cut to half the thickness. In this region, a printed circuit board is glued to the anode frame. This printed circuit board has all the connections for the wires, the input high voltage, the coupling resistors and capacitors and the sense wire read-out. In addition to the wires being soldered and glued to this board, they pass through a slotted rib at 22.5 degrees and are again attached at 45 degrees to a 0.59" wide G-10 board with solder pads and G-10 pins to hold the wires at the correct spacing.

The wires were layed by hand and each cord of each wire was checked for proper tension. Tension was checked by inducing a standing wave in the wire by passing an alternating current through the wire in the presence of a magnetic field. A capacitive pickup sensed the oscillation and the driving frequency was adjusted until the proper Lissigous figure was observed on an xy oscilloscope. After all the wires were installed for the anode plane, the wires were cut at the 45 degree rib between the two solder pads, so that there are separate read-outs for the two halves of the quadrant.

We are presently investigating the possibility of automating the process of laying the anode wires. We have built a prototype wire stringing jig with good preliminary results.

III. PERFORMANCE

After sandwiching together the two panels of the station 1 prototype, a good gas seal was achieved, and high voltage successfully applied. Good signals are seen from both the anodes and cathode strips. The prototype is being tested for resolution at the UNM cosmic ray test stand.

Many improvements on the original design have reduced the projected cost of manufacturing station 1 chambers by a factor of two.

X. REFERENCES

[1] Honeycomb material is manufactured by Hexcell Corporation.

[2] Buckbee-Mears Corporation etched the cathode planes.