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Directional Muon Jet Chamber for a Muon Collider (Groovy Chamber)

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ABSTRACT

A directional jet drift chamber with PAD readout is proposed here which can select vertex originated muons within a given time window and eliminate those muons which primarily originate upstream, using only a PAD readout. Drift time provides the Z-coordinate, and the center of gravity of charge distribution provides the r-ϕ coordinates. Directionality at the trigger level is obtained by the timing measurement from the PAD hits within a given time window. Because of the long drift time between the bunch crossings, a muon collider enables us to choose a drift distance in the drift chamber as long as 50 cm. This is an important factor in reducing cost of drift chambers which have to cover relatively large areas.

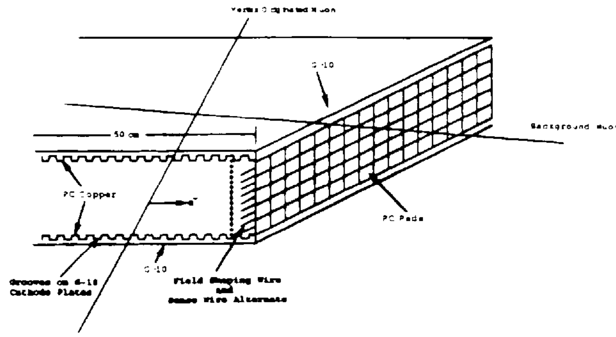
I. INTRODUCTION

The GEANT calculations of I. Stumer[1] and the MARS calculations M. Mokhov[2] yield similar background fluxes of approximately 1 muon per bunch crossing, at a radius of about 3 meter. The background can be worse with probable background tracks caused by bremstrahlung and other sources of gamma conversions in the muon chambers. A major source of the muon background may come from Bethe-Heitler muon-pair production through the shielding blocks.

There may be techniques other than the directional jet chamber with the PAD readout for selecting the muons, but I believe that this is perhaps the least ambiguous and least expensive way to provide a trigger due to long bunch crossing time (expected to be 10 microseconds). Projective quartz Cherenkov bars would be very expensive, with its readout, to cover large areas, and the cathode strip chambers would have very large number of ambiguities due to the substantial background tracks. Because of the long bunch crossing time, we can have jet chambers with long drift spacing for the electrons produced in the gas by the passage of charge particles. During the Snowmass studies[3], it occurred to me that such a trigger alone would be very valuable in the selection of events, because the calorimeters would have high occupancies due to the expected large background making it difficult to use them in the trigger. Three layers of toroidal muon jet chambers can provide good momentum resolution, due to the high resolution measurement in the r, ϕ, Z coordinates.

II. DESCRIPTION OF "GROOVY" CHAMBER

A schematic view of the chamber is shown in Fig. 1. It consists mainly of the top and bottom G-10 cathode plates that have grooves with a width of 2 mm and a depth of 2 mm, milled by a computer controlled machine (Fermilab has such a facility), a drift grid, an alternate sense and field shaping wire plane, and



a printed circuit PAD plane. We may use only a proportional wire plane structure, without the alternate field shaping wires. The wire plane is there mainly to provide avalanche gain, and they need not be read out, allowing the wires to be made as long as necessary. Each wire can develop avalanches if two simultaneously arriving tracks are separated by 5 mm along the wire, and if two tracks which are to hit same 5 mm section of the wire are 5 mm apart from each other in the Z-direction. The PADs will be detecting the image (induced) charges as they are produced. We could use a pipeline readout to store the coordinate information. To make the cathode plates, we start with Cu laminated PC G-10 material and mill the grooves with 1 cm pitch. The grooves have an important function, which is to prevent discharge between the PC strips by increasing the dielectric-path length. They also greatly reduce the charge up of G-10 due to the fact that the positive ions would be collected on the Cu-strips (where electric field is highest). A resistive voltage divider network provides a uniform drift field along the long drift space. The drift spacing can be as long as 50 cm when we use a fast gas mixture of 90 percent argon plus 10 percent CF_4. CF_4 is a very expensive gas, and consequently we may choose to use slower gas mixture such as 50 percent A - 50 percent C_2H_6 gas mixture bubbling through isopropyl alcohol at 0 degrees Celcius to add about 1 percent vapor. In this case the drift spacing may be reduced to 25 cm because the drift velocity in the C_2H_6 mixture is about a factor of two slower relative to the CF_4 mixture. In both cases the total drift time would be around 5 microseconds. The remaining 5 microseconds before the next beam crossing can be used for eliminating the background tracks, and selecting and triggering on vertex originated muons. The circuitry for this is relatively simple, and thus the details are not provided here.

There may have been earlier unsuccessful attempts made to make and operate similar chambers without the groove technique on the field shaping cathodes, due to the mentioned discharge possibility. For this reason I have named this chamber the "Groovy Chamber." I have made a prototype chamber at UCLA with this novel idea of grooves for educational purposes

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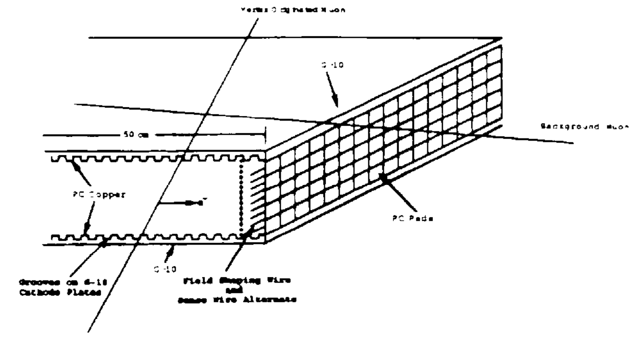

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Detecting the charges from the PADs would be sufficient to obtain the r, ϕ, Z coordinates. Using an ASD (Analog-Shaper-Discriminator) card having circuitry that provides analog outputs for determining the charge center of gravity, as well as discriminated pulses for Z-coordinate (timing) measurement would be sufficient.

III. REFERENCES

[1] I. Stumer, The results presented at this symposium.

[2] N. V. Mokhov, The MARS Code System User's Guide, Verion 13 (1995), FNAL-FN-628(1995).

[3] Muon Collider Detector and Background Working Group Participants: M. Atac, J. Brau, D. Burke, J. Chapman, P. Shen, G. Crawford, C. Damerell, T. Diehl, S. Geer, G. Gollin, H. Gordon, J. Gunion, B. Jacobson, H. Jensen, C. Johnstone, S. Kahn, K. Kephart, P. Lebrun, D. Lissauer, T. Markiewics, N. Mokhov, F. Paige, M. Peskin, P. Rehak, R. Roser, A. Sill, I. Stumer, D. Summers, A. Tollestrup, E. Willen.