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Introduction:

This is the minority report on the decision to use local ganging in the central calorimeter and major portions of the end cap calorimeters.

Distant Ganging:

The method not chosen for the readout is distant ganging. This method requires that the signal from each pad be carried to the outer radial edge of the board. There the signals from successive boards are connected together in parallel(ganged). From there the signal is carried to the cryostat port.

All of the procedures needed to effect this design are known at this time. The line connecting each pad to the outer edge of its board can be produced by routing the line onto the readout board when the pads are routed. The lines are designed to be .007 inches wide with .008 inch spacings between lines. Lines of these dimension have been produced at Fermi Lab with very little difficulty. Three lines each 50 feet long were cut with out a break or short on the first attempt using the Fermi Gerber router.

The connection from the lead to ganging cable is made with lands at the outer edge of the board. The ganging cable is created by layering copper and mylar. The first surface is copper with spaces etched on it to create leads with the same spacing as the lands on the boards. the second layer is mylar. The third layer is a solid copper sheath. The fourth layer is mylar. This cable is held in contact with the lands by spring clips. This system was used to connect over 300 lines in series. The test piece was cold shocked in LN₂ ten times without a failure in any connection.

The ganging cable is then connected to a twisted pair cable. Several connectors are commercially available for this transition. All are extremely reliable.

Effects:

Several questions about the effects of this design have been raised.

Q. Will the large number of long leads cause the capacitance of a depth segment to exceed the limit proposed by the electronics group?

A. No. In all designs the outer pads have a larger capacitance than the longest lead in that depth segment.

Q. Will the close spacing of the leads cause capacitive coupling between leads?

A. No. The electronics group has calculated that a 100 pf capacitance between lines will result in .3% of a signal appearing on an adjacent channel. The lead to lead capacitance in the current design is always less than 100 pf. The cross talk would not be detectable.

Q. Will the spacing between the signal trace and the ground return create inductances that are too large?

A. We do not know. The amount of inductance that is acceptable is unknown. The inductance for distant ganging is of the same order of magnitude as any of the local ganging procedures proposed so far. If the easiest local ganging process is used then the inductance is expected to differ by a factor of two or three. In general local ganging produces lower inductances and is more conservative on this issue. However, no one has yet established whether either of the methods is acceptable.

Q. Will the energy from showers that occur over lead bundles be attributed to the wrong pads.

A. We do not know. It has been suggested that the resistive coat could be routed from the areas above lead bundles. Efforts to determine if this will work have been blocked for the last year and a half. While this seems like a very viable solution, we can not say with certainty that this problem has been eliminated until it has been tested.

Local Ganging:

In local ganging connections are made from pad to pad within a depth segment before the signal is taken to the outer edge of the module. This is relatively easy to do in the C.C. where every pad has one edge exposed to a crack in the detector. By notching the uranium connections can be made along the depth of the module without any surface leads. In the E.C., using the n=4 division, half the pads are connected to the ganging cables by surface leads and

lands at the side of the board. Here again the uranium is notched to provide a space for wires to pass back through the depth of the module. In both portions of the detector ground wires are also brought with the signal leads and attached to the uranium in a notch near each pad.

Problems:

There are three reasons why the why local ganging should not have been chosen for the DO calorimetry. First, it is untested. None of the technology proposed for this approach has been proven to the same level as distant ganging. The ground connection to the uranium is still undetermined. The latest attempt to percussion weld to the uranium has shown a 5% failure after a week of aging. The back up to welding is the use of clips. The contact resistance of clips is unknown. Using clips will certainly increase the size of the dead area on the signal boards. The ganging connector has been tested in only very small numbers. The precision required in notching the uranium has never been demonstrated. After a year and a half of concentrated effort the technology required to implement local ganging is still a question mark.

The second problem is cost. All estimates of the cost of notches are in excess of half a million dollars. The estimated cost of making grounding connections is over one hundred thousand dollars. The cost to make all of the ganging connections has never been calculated. All of these costs are in excess of those required by distant ganging. This proposal is too expensive.

Finally, local ganging hurts physics. The notches required represent an appreciable fraction of the detector. If tight tolerances can be produced on the notch location and dimension then this effect will be on the order of the cracks between modules. If not, the gray area plus white area of the notches will be almost 10% of the absorber area in some plates. The loss in absorber due to distant ganging is never more than 1% of a module. The loss in effective signal board area is also always less 2%. Local ganging has a significant negative impact on calorimetry that can be avoided by using distant ganging.

Conclusion:

We have chosen a method which yields inferior results yet is much more expensive. We have chosen it before we even know if it can be made to work. This is clearly a mistake.