Fermilab

A Speculation on a Level 1 CFT Stereo Fiber Trigger

for the
Upgrade CFT Electronics

NOTE: This is a fast and dirty analysis of the problem that I put together today partly based on notes from July 28. Does this make sense to you? What do you think of the options? Fred

Introduction

The possibility of adding the stereo fiber information to the level 1 CFT trigger has been proposed by others.[1] This note speculates on the possibility of doing this within or close to the scope of the present design for the axial trigger hardware. Also after the first draft was written the question of costs was raised.

The outline of this note is:

1 General considerations for any stereo trigger,
2 Local Stereo Trigger,
3 UCDavis Style Trigger. (My interpretation of their design.)

Base-Line Detector

The present base line detector has four super layers each of which has a u and a v stereo layer, all with a stereo angles of 2^o. Table 1 is a spread sheet with the relevant information. The 'layer' column is the stereo doublet layer, the 'pitch' column is the fiber center to center distance in microns for each layer, the 'length' is the length in meters of each layer, the 'offset um' is the angle times the length in um, the 'offset fibers' is the 'offset um' divided by the pitch for the layer. This table uses the 4 super layer design. All the points addressed in this note are independent of whether the detector is constructed in 4 super layers or 8 as long as the basic number of fibers per sector does not change.

The present level 1 axial trigger design forms the trigger in three steps each of which take one 132 nsec crossing interval. The steps are;

1 Move axial fiber information across BP and into trigger logic.

2 Find track candidates
3 Move track information to other detectors

It is important to note that step 1, the moving of information over the back planes of the near 400 channels of fiber data, is separated into 4 time slices. Also the back plane, using standard VME style connectors, is limited to 96 signals in and 96 signals out of each sector board.

Stereo Trigger

The algorithm for the stereo part of the trigger would be similar but the track finding would have to wait for the arrival of the axial track candidates. Its steps would be;

1 Move stereo fiber information across BP and into Stereo trigger logic.
2 Idle
3 Receive axial track candidate from corresponding sector
4 Match u/v hits to axial track
5 Send track information to TF/other detectors

Notice as was mentioned above that the stereo trigger doesn't start work until it has received the information on the axial tracks. Also notice, and this is important, that step 2 is idle. One might hope to use this step to extend step 1, the moving of fiber information into the logic, but you can't. Remember that each crossing brings a fresh batch of fiber hit data. To keep up all the data for each crossing must be moved within each crossing. [If we were to operate at 396 nsec crossings then we would have a factor of 7 more time and the problem would be much simpler. But that has other physics related problems.]

Inspection of table 1 shows that the number of fibers that cross a given axial fiber is 56 or 83. For the left most axial fiber in the sector, the above number of v fibers must be transferred into the sector from the sector on the left. The table is in terms of singlet layers, but each layer is a doublet so the number of fibers needs to be multiplied by another factor of 2. The total sum of fibers shown is the column sum multiplied by 2. To check the coincidence of all u/v fibers with each x fiber hit requires that the hit information for all of these 1220 fibers be available.

Note that a track of less than infinite momentum can cross over from one sector at the inner layer to a neighbor sector in the outer layers. At 10 GeV the number of fibers the track if bent is less than 10, but if tracks of down to 3 GeV are used the track can bend one entire sector. For stereo track matching down to these momenta an extra sector would need to be transferred. In the axial trigger design just this one sector from each side, for + and - Pt tracks, is transferred.

The problem is how to move this data. If it were shipped over the BP where 96 input pins are available it would require;

1220 bits / 96 bits/cycle = 13 cycles,

if one tried to do this in 132 nsec we have;

132 nsec / 13 cycles = 2.5 nsec/cycle or 100 MHz,

a rate which is not possible over a VME back plane which normally operates at 20 MHz. Instead we could use the fast optical link from the SVX readout design. This moves a 16 bit word every 53 MHz. The time required for this is;

1220 bits / 16 bits/cycle x 18.8 nsec/cycle = 1434 nsec.

which is much longer then one 132 nsec crossing time.

This tells us that moving this information in the time required is not easy. In fact some reduction of information or increased parallelism of the transfers by factors of 4 or more are needed.

Local Trigger Design

Assume we locate the stereo trigger finder for each sector on the stereo board for that sector. Also assume that we transfer the data needed across the back plane from the next stereo boards. Also assume that we have 3 back planes each of which have a higher density connector of 160 pins. Also lets transfer the data in 3 time slices within the 132 nsec crossing time. We then have;

160 channels x 3 connectors x 3 time slices = 1440 channels

of data transferred to a board. Also assume that we do some data reduction before we ship. Lets combine the singlet layer hits into doublet layer hits for a reduction factor of 2. Therfore we should be able to transfer the doublet hits from 6 neighbor sectors and extend the trigger down to some low Pt. Lets further assume that we use a new generation PLD for the track matching which has 408 user I/O pins and we input the data into it in our 3 time slices;

408 inputs x 3 time slices = 1224 channels input.

These 1224 channels should cover the 660 needed at infinite Pt plus the extra channels needed to go down to some Pt less than 10 GeV.

The complication of event pipe-lining has not been addressed. Remember that while the stereo trigger is taking 5 crossings to find a trigger that the data for each of those 5 crossing are behind it in the system. Each board must hold the data for 5 events and keep that data isolated from the other 4 events. If step 4, the trigger finding logic is stretched out into more than one crossing then the pipeline grows. Any trigger logic using DSP's can be powerful but could not run in one or even two crossing times. The trigger finding logic has to be very fast which is a feature of PLD's. The track matching algorithm for a PLD could be severely limited, however.

How much would such a system cost if some way could be found to build it? It is very similiar to the present axial trigger design in terms of hardware. It would need more processing power by some unknown factor but probably by no more than x2. Table 2 presents a cost estimate. The range between the cost and the cost plus contingency reflects the large uncertainty in the details of the PLD design.

UC Davis Design

The proposal by our U C Davis colleges, as I understand it, hinges on their observation that, at least for the case with 4 min bias interactions per crossing, there is rarely more than 1 high Pt track candidate per event. Therefore they restrict the trigger to looking at only one candidate. They see, instead of a trigger per sector, a single global trigger. Under these assumptions the design outlined above reduces to one sender only from each stereo sector. They propose for this sender multiplexing in time with the SVX read out already installed for that sector. Since it is only used after a level 1 accept while a BUSY has been raised and the input data flow has stopped, this may seem reasonable. This hardware is designed though, for point to point data transmission. Sharing it in time slices requires changing it to some sort of a shared bus. This cannot be done once the signals are converted to optical form. Something may be done to accomplish this in the earlier copper part of the circuit. Lets then postulate that all the links are copper.

At the receiving end their proposal requires the acceptance of information from 80 different sectors. Again the fast data links are designed for point to point communication which means 80 receivers. But only 9 of them would be used for any given event. (The home sector and four to one side for the u fibers, and the home sector and four to the other side for the v fibers, giving a total of 9.) One would try to solve this problem by taking the 80 input copper lines and building a switch that would pick the correct 9 and send them to a set of only 9 installed receivers.

It is probably clear at this point that this design requires quite a bit of control logic and control communications. And this is going on in very short times since set up and transfer are to take place within the same short crossing time.

This design proposes using DSP's and a longer decision time. The data has been shipped off the stereo boards, slave boards in their terminology, so the pipe line on them can end at 5 crossings. The master processor must, however, maintain a pipe line for the data passed to it for each crossing, that lasts through the decision time. Also this processor must process n events in parallel where n is the total processor time divided by the 132 nsec crossing time. Remember data from each crossing is input into a processor. n could possibly be as large as 24 and still meet the level 1 decision time dead-line. That implies as many as 24 processors on the master board.

How much would this design cost? The proposers are the best source of the processor costs. Lets look only at the cost of moving the data to their processor array. Table 3 outlines the costs for a Receiver which collects the data from the stereo and axial front end boards. As for the cost estimate in table 2 the additional costs at the axial and stereo front end boards are also included. The total is higher because the base-line design calls for a G-link on only 1 in 4 of the axial and stereo boards. Now each board must have one. For the Receiver board 10 G-link receivers have been assumed and a pipe-line depth of 8 is assumed. No cost estimate is given for the command and control hardware and communications.

---

[1] UCDavis Proposal, Mani et al.