D0 Upgrade Electronics

CFT L1 Trigger

by Fred Borcherding

1. System Requirements

1.1 Supply CFT Stand alone L1 Trigger

The desired CFT L1 Trigger Terms are:

- *Number of CFT tracks above threshold*
- *Number of CFT tracks above threshold with corresponding CPS hit*
- *Number of isolated CFT tracks above threshold*
- *Number of isolated CFT tracks above threshold with corresponding CPS hit*

Where each of the above is for four Pt thresholds giving a total of 16 trigger terms.

To satisfy this requirement the number of tracks must be counted and compared to a cut.

1.2 Supply the L2 Trigger

1.2.1 Supply the CFTpp

This system must supply track lists to the CFT L2 preprocessor. The CFTpp will send a list of up to 150 found L1 tracks to the L2 global processor.

1.2.2 Supply the SVTpp

This system must also supply a list of tracks to the SVTpp for use as data filters and seed tracks. The SVTpp needs the filter data before the silicon data arrives which is about 2 us after a L1 Accept.

1.3 Supply L3 Readout of L1/L2 information

2. Functional Description

2.1 Front End, FE

Each of the 80 FE's receives the analog signals from the VLPC's and finds a list of 6 tracks.

Each track is represented by a 16-bit number, which gives its momentum and its phi value at the outer layer of the CFT.

The list of six tracks is transmitted from the FE's each crossing to a receiver board, CFTrec.

2.2 CFT Receiver board, CFTrec

Each of the 16 CFTrec boards receives the track lists from 5 FE boards. The information is immediately re-transmitted over two serial links to the Muon L1.

The CFTrec determines if the tracks in the list from each FE should be tagged as isolated

This board sorts the track lists into four momentum bins, which correspond to the four Pt thresholds of the L1 trigger terms.

The track lists are then transmitted over the custom crate back plane to the concentrator board, CFTcon.

2.3 CFT Concentrator board, CFTcon

The track list from each CFTrec is sent over a back plane bus to the concentrator, CFTcon.

The first 4 tracks in each Pt bin from each chain of 5 CFTrec is transmitted.

2.3.1 CFTcon for L1

The CFTcon counts how many tracks are received, keeping 4 sums per Pt threshold.

At the end of the cycle it combines the sums from the two CFTrec boards and sends these 16 numbers to the CFTTM.

The data block of 16 numbers is sent over a serial link.

2.3.2 CFTcon for SVTpp at L2

The CFTcon also pipelines the track lists as they are received for later retrieval for the L2 trigger.

The pipeline is 32 crossings deep and is wide enough to hold the maximum 8 tracks received for each of 4 Pt bins.

When a L1 accept is received the CFTrec begins a different mode of processing.

They pull the appropriate event from their pipelines and sort them by an interpolated phi value at the outer surface of the silicon detector. The SVTpp is segmented into 24 phi wedges. The CFTcon is segmented into 8 phi wedges.

The tracks from one CFTcon board are sent to three SVTpp boards.

The CFTcon sorts each track according to which SVTpp phi wedge the track points to.

The data from all three phi bins is sent over a single link, sending each phi bin in turn.

2.3.3 CFTcon for CFTpp and Global L2

The track lists assembled above for the SVTpp are simultaneously transmitted over a second link per CFTcon to the CFTpp.

All sorting and reformatting for the L2 Global are done on the CFTpp boards.

The data from the CFTpp is sent to the L2 Global over the GL2 board developed by D0.

2.4 CFT Trigger Manager, CFTTM

The CFTTM receives 16 numbers from each of the eight CFTcon's and sums them.

After the sums are made each is compared to a cut number.

If the sum in any of the 16 meets its requirement the corresponding bit in the L1 AND-OR network term is set.

The CFTTM receives the 16 numbers in a block of 96 bits.

The 16 numbers are loaded as 4 bit fields in the first 4 words of the block.

The Muon Trigger Manager, MTM, board without modification is used as the CFTTM board.

The CFTTM resides in the Muon Trigger Crate.

3. Timing

The delivery of track information to muon is time critical.

This design delays the output while the CPS information is added.

Need to understand if this is a problem.

4. Product Quality

At each phi bin only the Highest Pt track is retained. In the present design each phi bin is one fiber of 44 in each sector.

Per FE sector only 6 tracks are kept. Several methods of picking these 6 candidates are under study to determine the resources needed and determine what inefficiencies each introduces.

The 6 tracks of above are separated into 4 bins by their Pt and then only 4 tracks per 5 FE sectors per Pt bin are kept. Up to 30 tracks are reduced to as few as 4 tracks or as many as 16 tracks. *This is the point at which the number of tracks is counted for comparison to the L1 Trigger Terms*.

5. Summary

This talk presents a top down overall design of the L1 trigger for the CFT and CPS with added functionality for the delivery of tracks found in the L1 CFT to the L1 Muon Trigger, the L2 CFTpp and the L2 SVTpp.

The design leaves the FE Trigger boards and their crates as they were in earlier designs for the FE only.

It has some time impact on the muon trigger since the delivery of tracks to them is now later in the FE trigger logic chain.

It requires crates to house 24 VME boards somewhere on the east platform.

Format of Data Words from CFT Front End							
Bit #		Field Bit #		Use			
15	Most Sig.	0		Track Found Flag [1=found]			
14		3		High Threshold Track Match			CPS cluste
13		2		High Threshold Track N / S			
12		1		Low Threshold Track Match			
11		0		Low Threshold Track N / S			
10		0		Sign of the Pt for Track			
9		3		Inner (A) Layer Offset from Outer Layer Bin			
8		2					
7		1					
6		0					
5		5		Outer (H) Layer Phi Bin			
4		4					
3		3					
2		2					
1		1					
0	Least Sig.	0					

Table 1. Definition of bits for the 16bit CFT/CPS track word. Six bits are used to identify the phi position. Five bits are used to identify the momentum including its sign. Four bits are used to identify matches with the CPS. And one bit is used to tag the word as containing valid track information.

	Bit				
Word	**15-12**	**11-8**	**7-4**	**3-0**	
6	-	-	-	-	Spare
5	-	-	-	-	Spare
4	Pt 1	Pt 2	Pt 3	Pt 4	CFT
3	Pt 1	Pt 2	Pt 3	Pt 4	CFT/CPS
2	Pt 1	Pt 2	Pt 3	Pt 4	isoCFT
1	Pt 1	Pt 2	Pt 3	Pt 4	isoCFT/CPS

Table 2. Definition of data block from each of the CFTcon to the CFTTM. Each Pt is a 4bit unsigned integer.

Term Number		Description of Term		
Term_15		CFT above	Highest	Pt Threshold
Term_14		CFT above	High	Pt Threshold
Term_13		CFT above	Medium	Pt Threshold
Term_12		CFT above	Low	Pt Threshold
Term_11		CFT/CPS above	Highest	Pt Threshold
Term_10		CFT/CPS above	High	Pt Threshold
Term_9		CFT/CPS above	Medium	Pt Threshold
Term_8		CFT/CPS above	Low	Pt Threshold
Term_7	isolated	CFT above	Highest	Pt Threshold
Term_6	isolated	CFT above	High	Pt Threshold
Term_5	isolated	CFT above	Medium	Pt Threshold
Term_4	isolated	CFT above	Low	Pt Threshold
Term_3	isolated	CFT/CPS above	Highest	Pt Threshold
Term_2	isolated	CFT/CPS above	High	Pt Threshold
Term_1	isolated	CFT/CPS above	Medium	Pt Threshold
Term_0	isolated	CFT/CPS above	Low	Pt Threshold

Table 3. The definition, version 1.0, of the AND-OR terms from the L1 CFTTM.

Luminosity	Crossings	Other	Av per 5	Ratio of 4	Ratio of 8	Ratio of 16
2.00E+32	108		4.72	0.4896	0.9483	1.0000
2.00E+32	108	1/40	1.19	0.9552	0.9998	1.0000
2.00E+32	36		7.07	0.1669	0.7202	0.9989
2.00E+32	36	1/40	4.53	0.5255	0.9581	1.0000
2.00E+33	108		13.54	0.0025	0.0774	0.7940
2.00E+33	108	1/40	10.00	0.0293	0.3330	0.9730

Table showing the number of tracks per event per 5 sectors for all tracks down to 1.5 GeV. This table is based on numbers for one trigger event plus dijet MC data for the background interactions. The MC backgrounds are weighted by relative cross section for parton energy and are weighted for number of events by a Poisson distribution for the luminosity. The trigger event is arbitrarily assigned 15 global tracks on average and either 0.6 or (15/40) per sector on average. Under the assumptions that went into this table, keeping 4 tracks per Pt bin per 5 sectors (Ratio of 16) is 100% efficient for run II even at 36 bunches. It is also close to efficient for run III with this low trigger threshold.

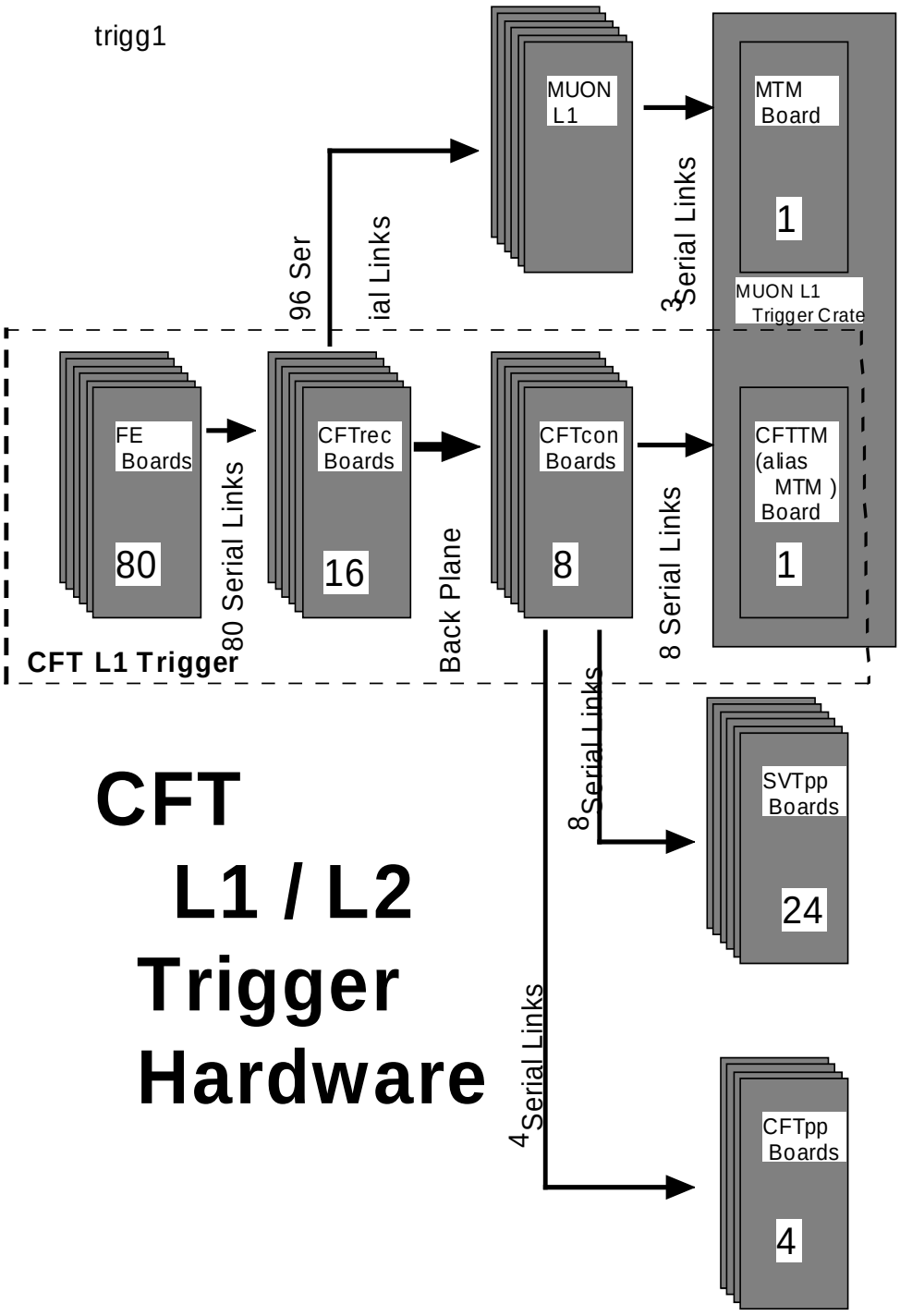

Figure 1. Cartoon of the hardware for the CFT L1 and L2 system. The parts in the dotted box are parts of this system. The parts in stippled boxes are being built or planned as part of other projects.

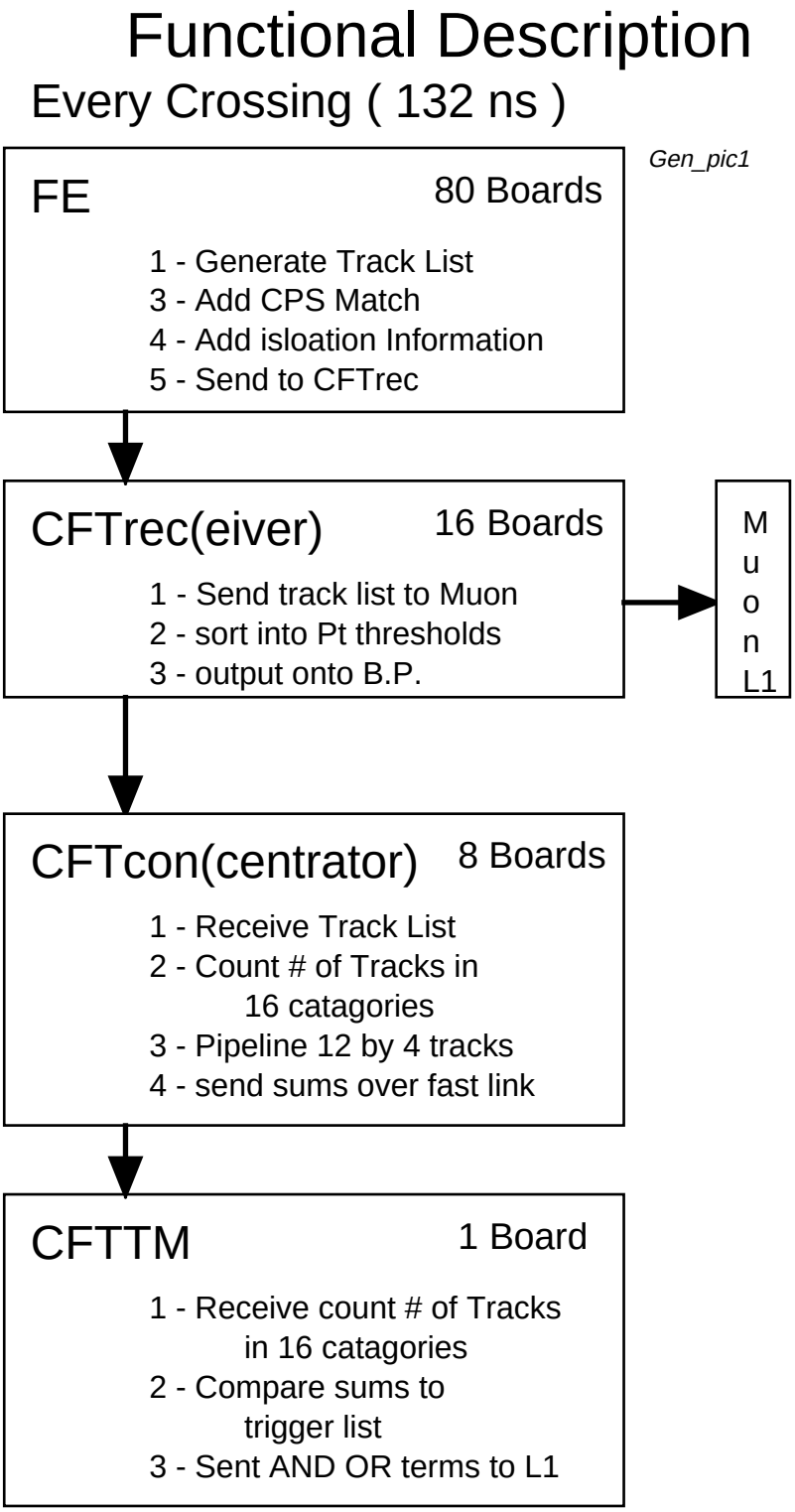

Figure 2. Functional description of the main blocks of the CFT L1 Trigger system. This figure shows the functions carried out for each crossing cycle during L1 live time.

Functional Description

On L1 Accept

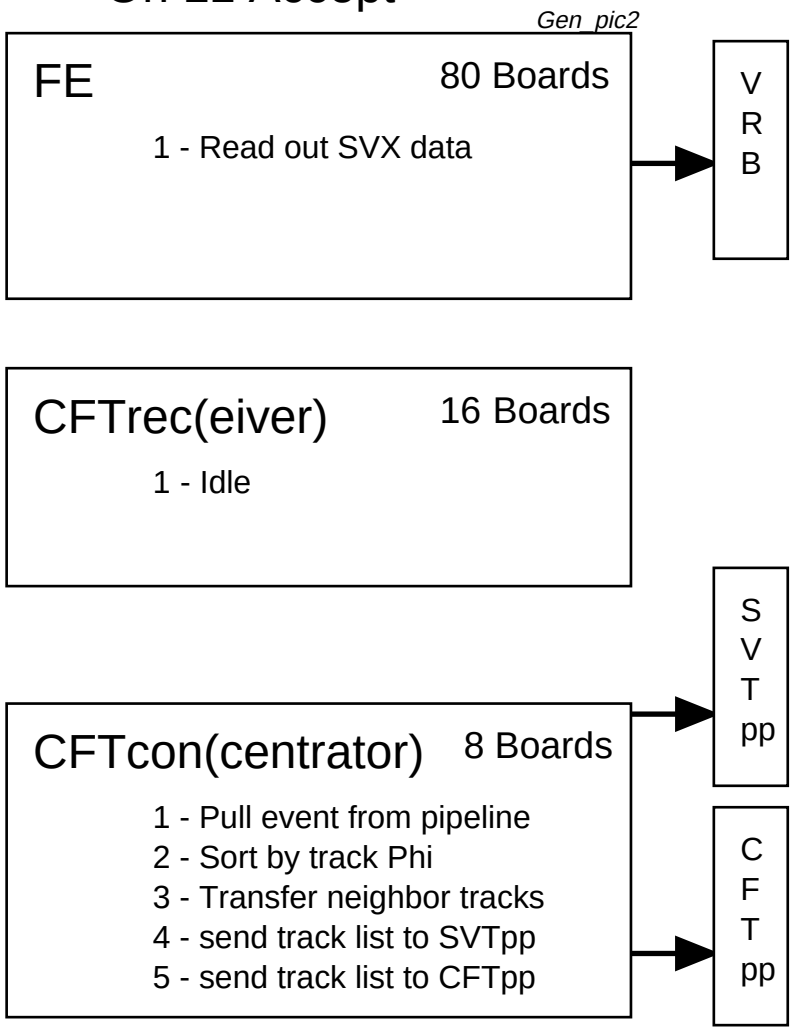

Figure 3. Functional description of the main blocks of the CFT L1 Trigger system. This figure shows the functions carried out after a L1 accept is received.

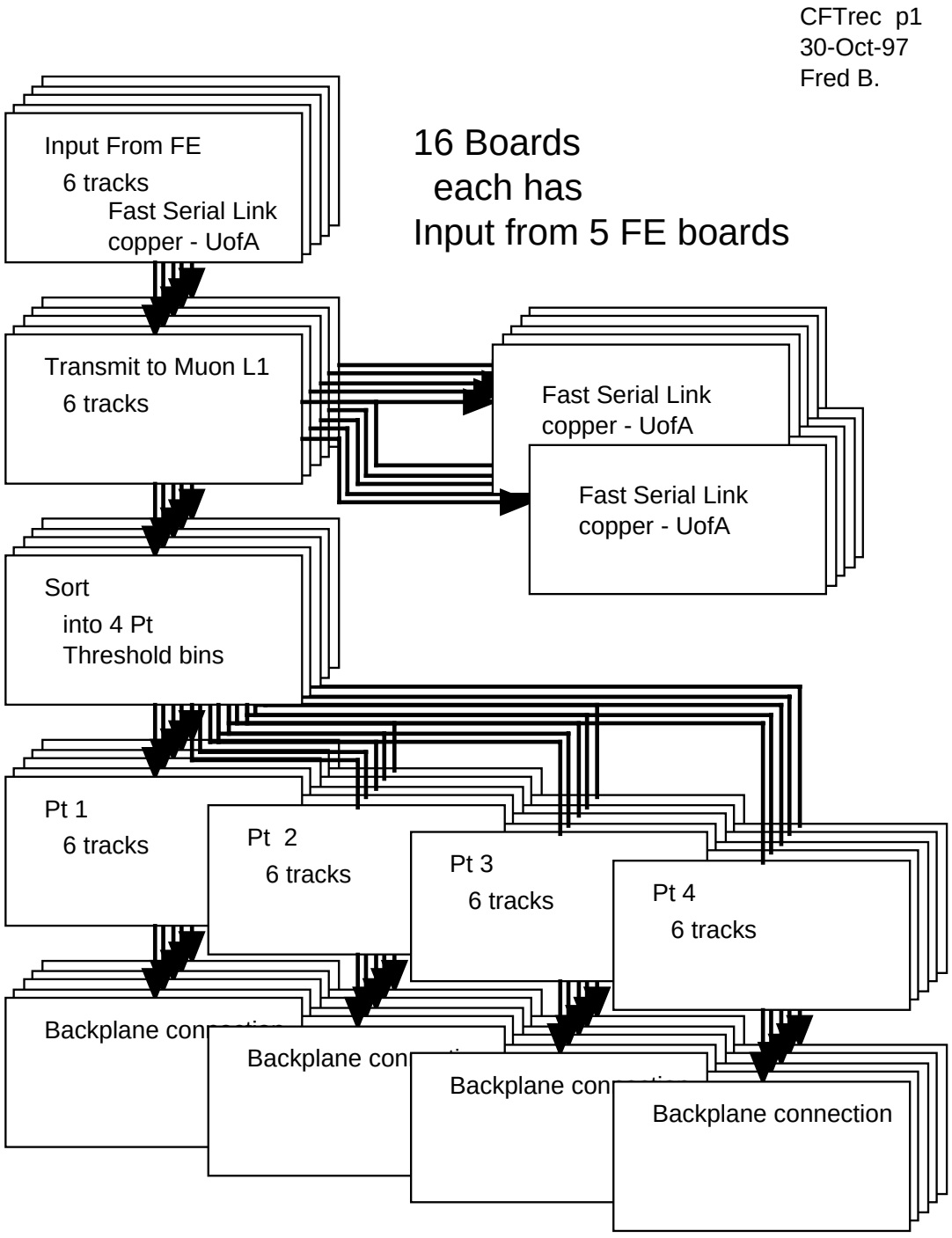

Figure 4. Block diagram of the functionality of the CFTrec boards. Each board receives the data from 5 FE boards and retransmits that data to 10 muon receivers. Each board also sorts the data and transmits it over the crate back plane.

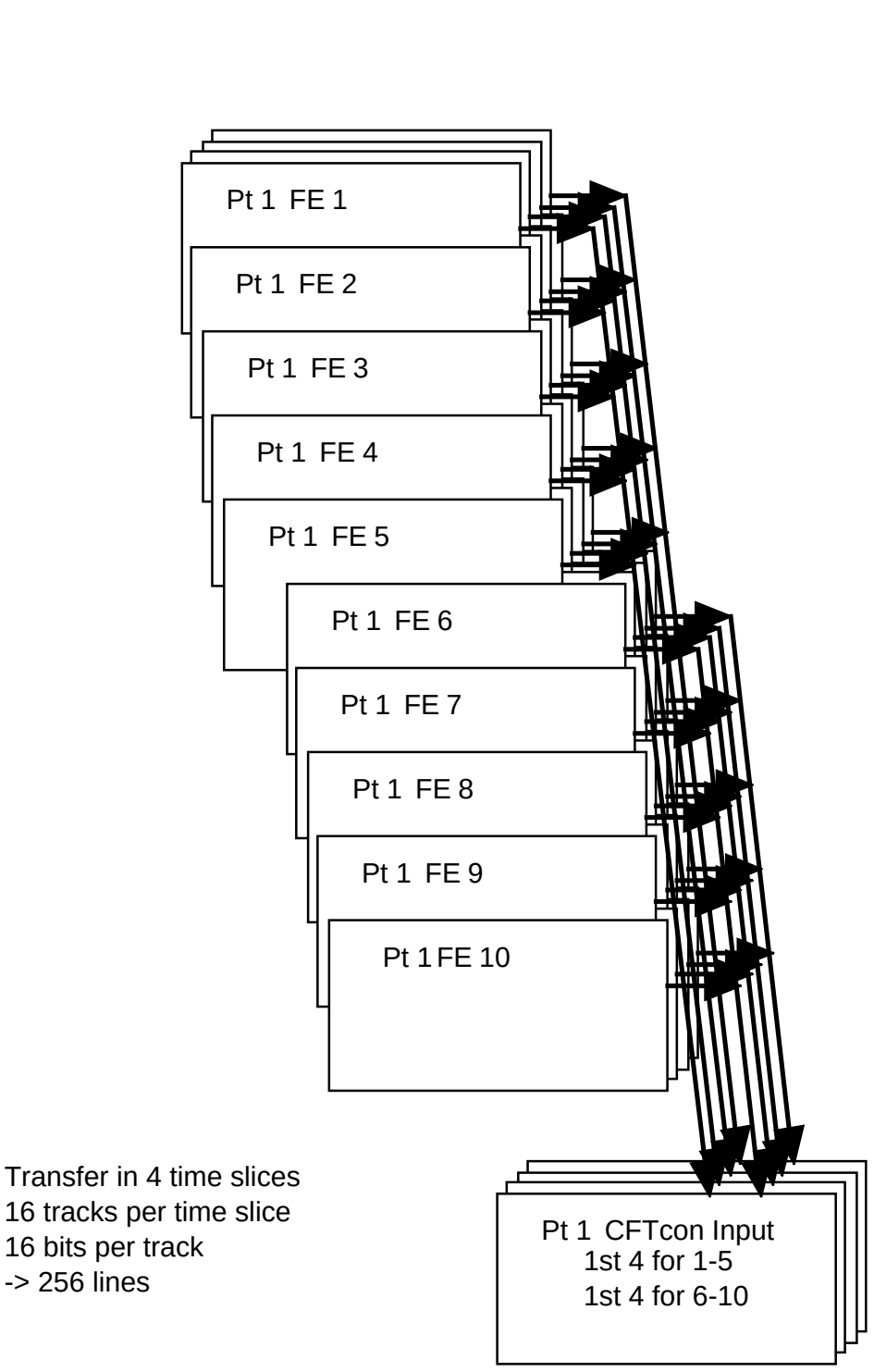

Figure 5. Block diagram of the track information over the back plane from two CFTrec boards to one CFTcon board.

CFTcon L1
30-Oct-97
Fred B.

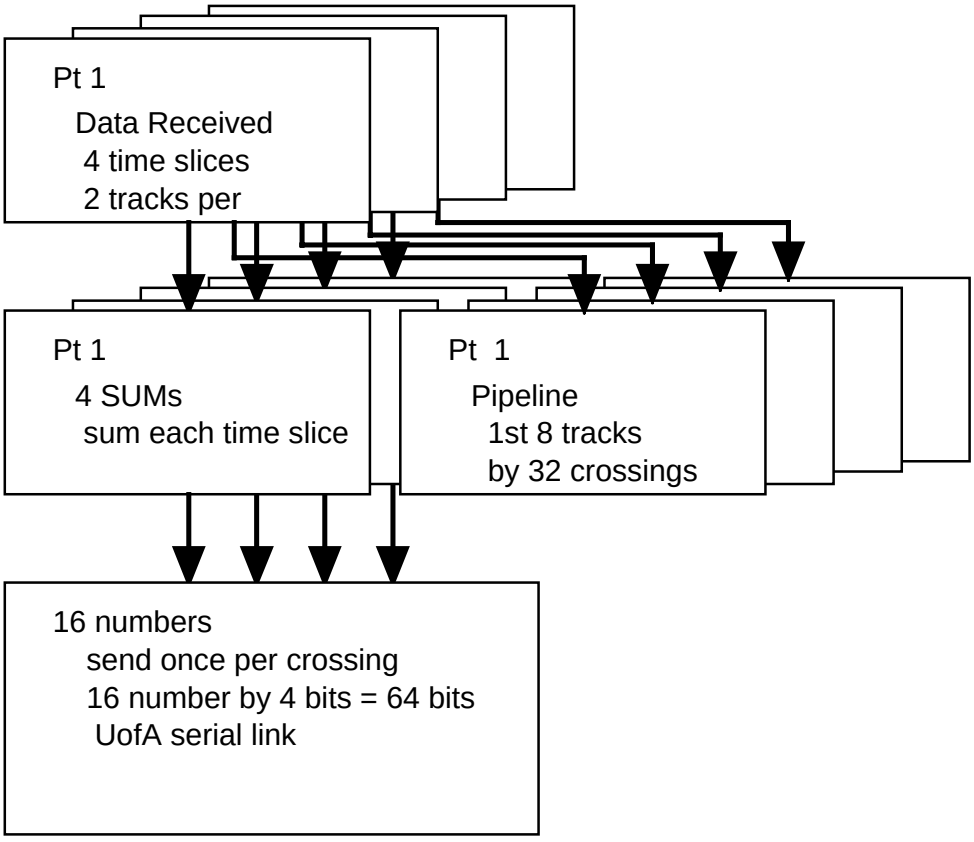

Figure 6. Block diagram of the track processing in the CFTcon board. As each track is received the 16 sums for the L1 are updated and the track index is stored in a pipeline. At the end of a crossing cycle the 16 sums are transmitted to the CFTTM.

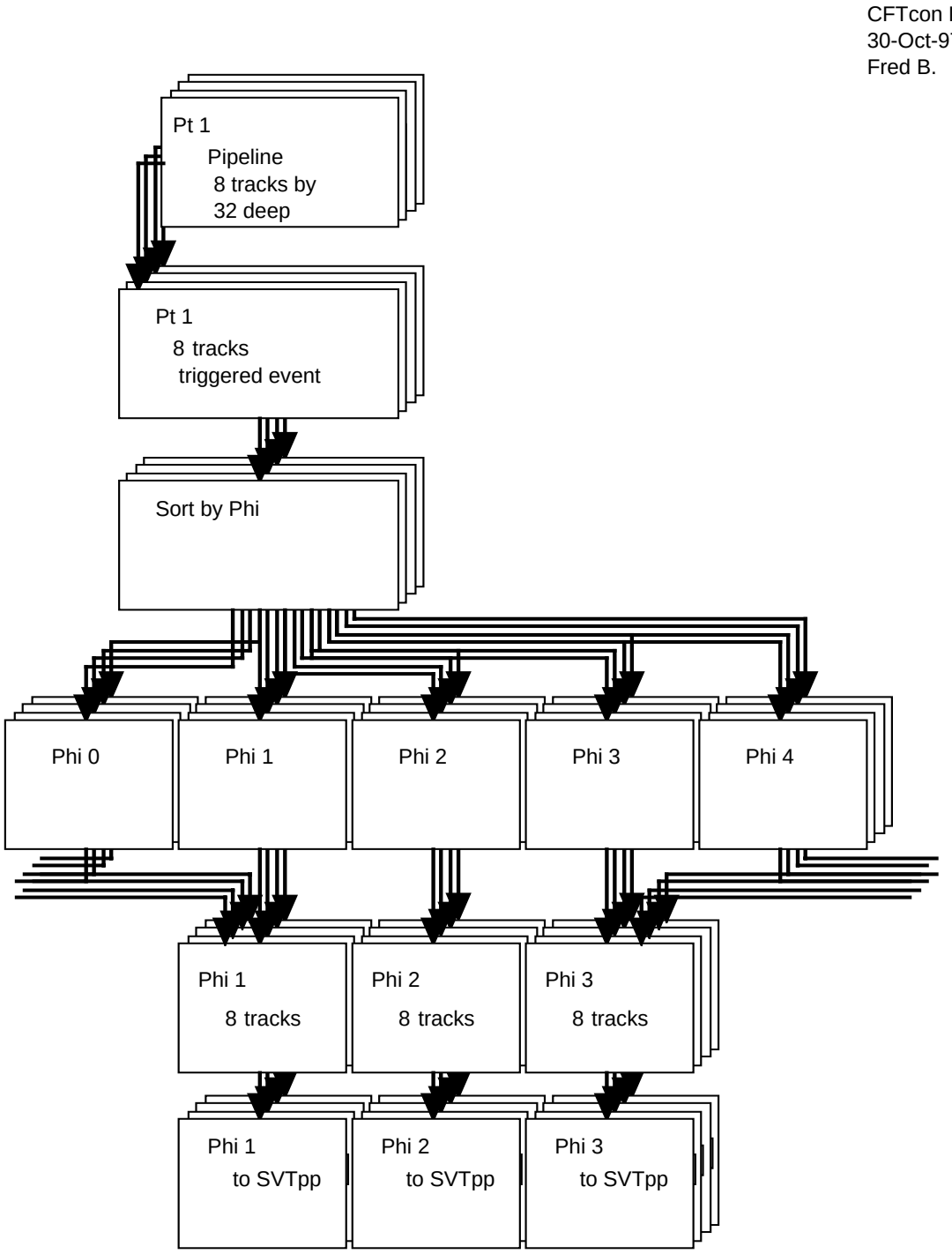

Figure 7. Block diagram for the function of the CFTcon board upon a L1 accept. The appropriate event is pulled from the pipeline and sorted by phi intercept in the silicon detector. Tracks that point outside the correct phi slice are sent to the neighbor CFTcon board for inclusion in its list. Finally the list is reformatted and sent to the SVTpp.

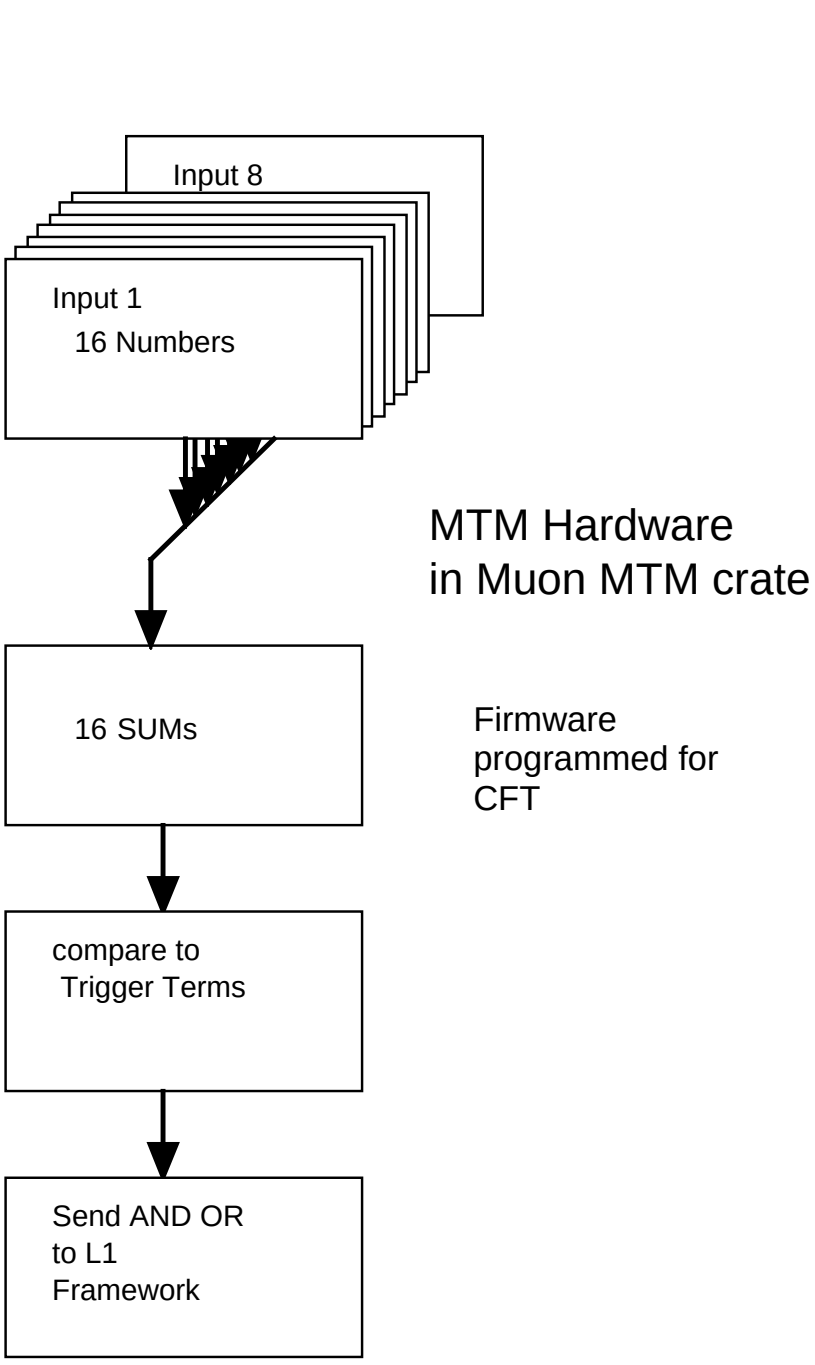

Figure 8. Block diagram of the CFTTM. The Muon TM hardware is used and the board is placed in the muon L1 crate. The onboard software for forming the trigger is unique for the CFTTM.