NATIONAL INSTITUTE FOR NUCLEAR AND HIGH ENERGY PHYSICS

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CTT
Cosmics Trigger and Timing module.
Technical Documentation

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Abstract: The CTT is a VME module to provide triggers for phase I in the L3+Cosmics experiment. It consists of a trigger part and a timing part. Within the trigger part a cosmic trigger is made out of selectable combinations of the signals from L3 muon chambers. Within the timing part trigger signals are selected which are send, with the right timing, to the NIMRODs and the GPSTIM.

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Contents

1. CTT - Cosmics Trigger & Timing

The CTT consists of two parts: A trigger part and a timing part. Within the trigger part a cosmics trigger is formed by combining the signals from the L3 muon chambers and the scintillator signals. Within the timing part a trigger source can be selected, which is then synchronized and timed with the 40 MHz clock to make the right trigger signals for the NIMRODs and the GPS module.

2. Trigger principle

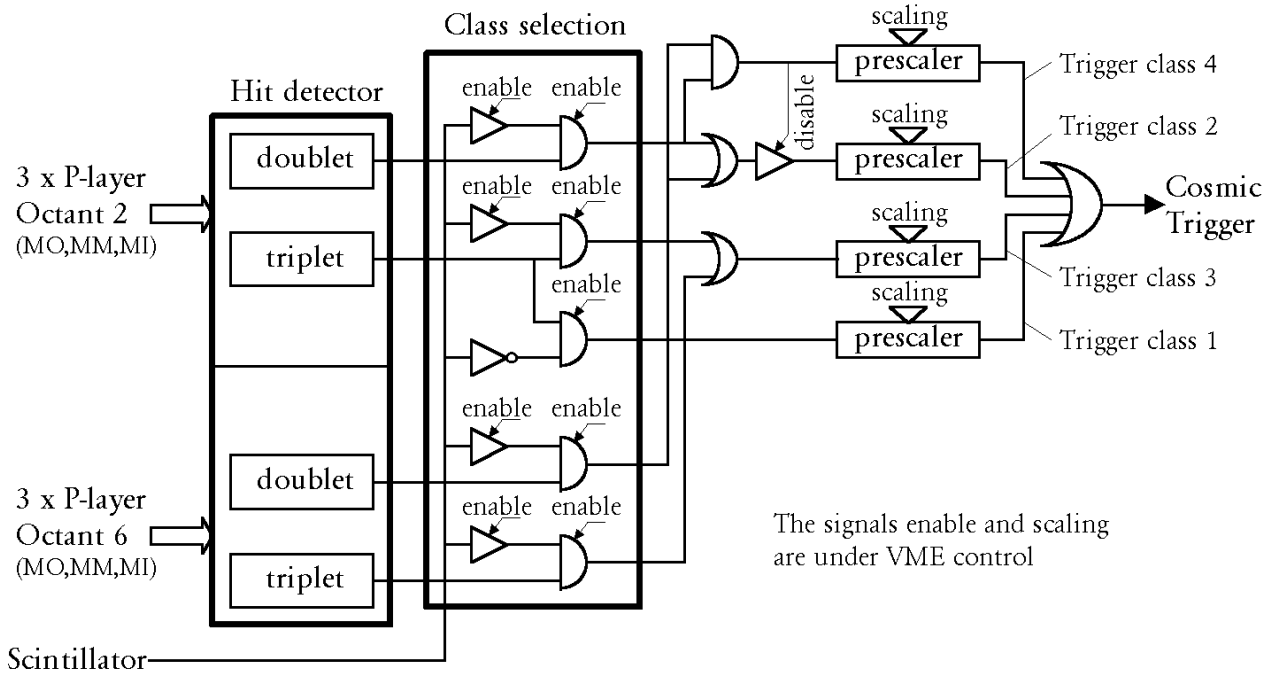
The trigger principle is to use the information of the P-layers to recognize a track. (The signals of a P-layer are a logical OR of the P-cell majority signals in a chamber.)
Each octant has three P-layers. At an event the number of layers that are hit is determined : 2 (doublet) or 3 (triplet). The combinations of doublets and triplets define a number of trigger classes. Trigger classes 2 to 4 are exclusive (just one class can be true).
At this level the scintillator signal can be enabled and used in coincidence for class 2 to 4, i.e. pass the trigger if there were scintillator hit(s). Class 1 can only be true if there was no scintillator hit. There could be an overlap (depending of the settings) of class 1 and 3. Each class can be enabled and prescaled.

The following trigger classes are implemented:

Trigger classes	
Type	**Content**
Class 1	A triplet in octant 2 AND NO scintillator hit.
Class 2	A doublet in octant 2 OR a doublet in octant 6.
Class 3	A triplet in octant 2 OR a triplet in octant 6.
Class 4	A doublet in octant 2 AND a doublet in octant 6.

The Trigger-class scheme is realized as follows:

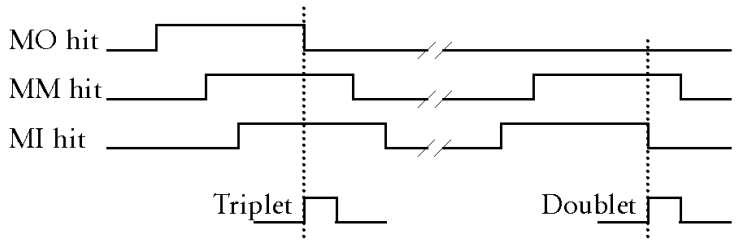
3. Trigger part of the CTT



The possible trigger conditions can be made from the combinations of the P-layers of the L3 muon chambers and scintillator signal. Within the section "Hit detector" the number of layers that are hit is defined for each octant. From the three P-layers the highest value in coincidence is determined. For example if three layers are hit, a triplet signal is generated and not a doublet also. The doublet has a lower priority.
In the section "class selection" the selection can be made which class will be enabled. One can select doublets and triplets from the various octants in combination with the scintillator signal.
A 4th class generates a trigger when in each octant two layers are hit. In that case the "normal" doublets are disabled. The benefit is that one can prescale the two groups individually.

3.1 Hit detector

This section derives its input signals (MO, MI, MM) from the CPCs majority logic. These signals are about 1.5 μs in width, due to the drifttime of the chamber and synchronisation of the electronics. The hit detector counts the number of signals that are hit at the falling egde of the first signal that goes low after a previous rising egde. This detection mechanism works under flight, therefore it does not introduce deadtime.



Example

3.2 Scintillator

The scintillator signals are connected to an extra CPC to create the logical OR needed for the trigger. Timing adjustment of this signal is done in that CPC. This CPC is part of the “Nijmegen box”.

3.3 Class selection

In this section the choice is made which classes contribute to a trigger. This selection is under VME control. It is also possible to enable the scintillator signal to coincide with the P-layer signals.

3.4 Prescalers

The trigger class signals can be prescaled. The prescaling factors are set under VME control in a range of $0 \leq N < 2^{10}$.

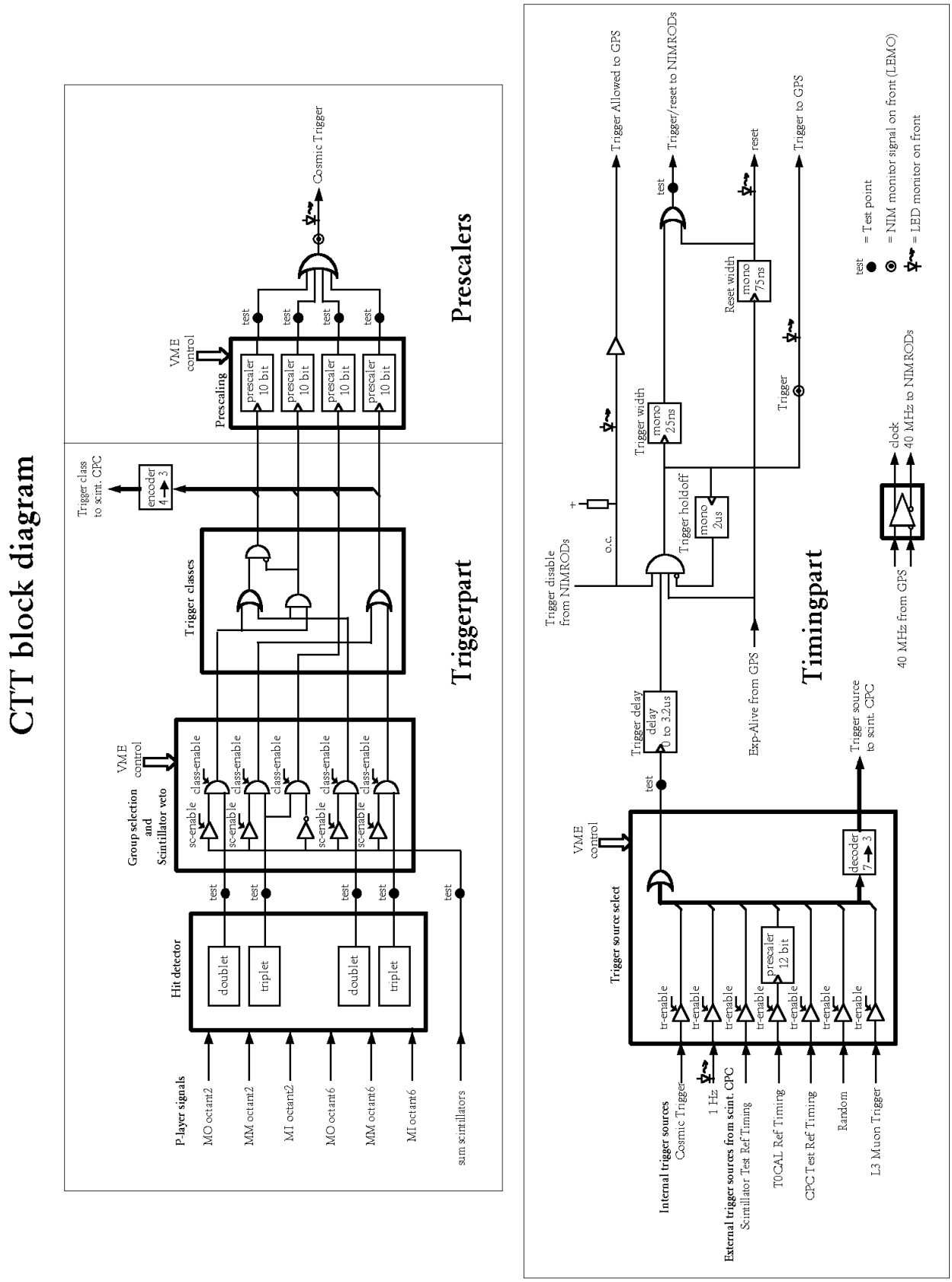
3.5 Trigger hit pattern

The trigger hit pattern can be obtained relatively simple by putting the P-layer input signals and the trigger classes into a "Christiansen [1]" TDC. This function will be implemented into the extra CPC. Recording of the trigger class signals allows the off line reconstruction of the internal functioning of the Cosmics trigger part.

[1] A 32 channel general purpose Time to Digital Converter, J. Christiansen CERN/ECP-MIC.

4. Timing part of the CTT

The functionality of the timing part can be explained best on the basis of the scheme below.



4.1 Trigger source select

Within this part one or more trigger sources can be chosen. In normal run mode the cosmics trigger should be selected. To facilitate various test, several external trigger sources can be selected.

4.2 T0cal prescaler

The external T0cal trigger input can be prescaled. The prescaling factor is set under VME control in a range of $0 \leq N < 2^{12}$.

4.3 Trigger pattern

The trigger pattern is, like the hit pattern, written into a TDC on the extra CPC. In the offline reconstruction can be examined which trigger source caused a trigger.

4.4 Trigger delay

This delay is the delay between the input triggers chosen and the output triggers. The delay is programmable and can be set from 0 to 3.1 μs. This is used for timing purposes during test modes.

4.5 Trigger holdoff

This is a programmable timer which sets the maximum frequency of the trigger rate. Normally it is set to 2 μs. This time is also the width of the trigger signal to the GPS module.

4.6 Signals to and from NIMRODs

The NIMRODs can send a trigger disable signal in case they get too much data. This signal stops the trigger generation of the CTT and it is also send to the GPSTIM for life time measuring.
The CTT provides the NIMRODs with a 40MHz clock signal which is received from the GPS module.
The CTT sends a combined trigger/reset signal to the NIMRODs also. The width of a trigger signal is one period and a reset uses three periods of 40MHz.

4.6 Signals to and from GPS module

The CTT sends a trigger signal to the GPS with a width of the holdoff time.
If the NIMRODs disable the trigger, the CTT reports this to the GPS.
The GPS gives a signal to the CTT that the GPS is ready. If this is false the triggers from the CTT are disabled.
The GPS also provides a 40 MHz and a 1 Hz clock signal. The 1 Hz signal can be used as a trigger source.

5. VME interface

Access must be performed using address modifier AM = 0x39 (24 bit address)

Only VME - D16 access allowed; LWORD_L = 1

Base address (A23…..A19) = 0x3

5.1 VME64 Control/Status Register (CSR) Assignments

CSR Address	Content	Comments
0x7FFFF	Base Address Register (BAR)	D7 - D3 = BAR D2 - D0 = 0
0x7FFFB	Bit Set Register	D7 = RESET (R/W) D6 - D5 = no effect (R/W) D4 = RUN (R/W) D3 = ERROR (R/W) D2 - D0 = no effect (R/W)
0x7FFF7	Bit Clear Register	same as above

5.2 VME64 Module Configuration ROM (CR) Assignments

CR Address	Content	Comments
0x03	Checksum	1 byte
0x0F, 0x0B, 0x07	Length of ROM	3 bytes
0x13	Configuration ROM data Access width	1 byte
0x17	CSR data access width	1 byte
0x1B	CR/CSR Space Specification ID	1 byte
0x1F	0x43	1 byte; ASCII “C”
0x23	0x53	1 byte; ASCII “R”
0x2F, 0x2B, 0x27	Manufacturer’s ID	3 bytes; IEEE OUI
0x3F, 0x3B, 0x37, 0x33	Board ID	4 bytes; supplied by manufacturer
0x4F, 0x4B, 0x47, 0x43	Revision ID	4 bytes; supplied by manufacturer
0x5B, 0x57, 0x53	Pointer	3 bytes
0x7B to 0x5f	RESERVED	8 bytes
0x7F	Program ID code	1 byte

5.3 Serial number Assignment

Address	Content	Comments
0x0100	Serial number	1 byte

5.4 Device Assignments

Device Address	Content	Comments
0x0206	Trigger delay	5 bits; D4 to D0 LSB :: 100 ns; F.S. = 3.1 us
0x0208	Trigger holdoff	5 bits; D4 to D0 LSB :: 100 ns; F.S. = 3.1 us
0x0300	Prescaling factor Class 1	10 bits; D9 to D0 data = 0 or 1 then divide by 1
0x0302	Prescaling factor Class 2	10 bits; D9 to D0 data = 0 or 1 then divide by 1
0x0304	Prescaling factor Class 3	10 bits; D9 to D0 data = 0 or 1 then divide by 1
0x0306	Prescaling factor Class 4	10 bits; D9 to D0 data = 0 or 1 then divide by 1
0x0406	Prescaling factor T0Cal	12 bits; D11 to D0 data = 0 or 1 then divide by 1
0x0400	Scintillator enable	6 bits; D5 to D0 Dn = 1 -> enabled D0 = No assignment D1 = Scintillator coincidence with Octant 2 - doublet D2 = Scintillator coincidence with Octant 2 - triplet D3 = No assignment D4 = Scintillator coincidence with Octant 6 - doublet D5 = Scintillator coincidence with Octant 6 - triplet
0x0402	Class selection	6 bits; D5 to D0 Dn = 1 -> selected D0 = Class 1 D1 = Octant 2 - doublet D2 = Octant 2 - triplet D3 = No assignment D4 = Octant 6 - doublet D5 = Octant 6 - triplet
0x0404	Trigger source selection	7 bits; D6 to D0 Dn = 1 -> selected D0 = Cosmics trigger D1 = 1 Hz D2 = Scint. Test Ref. Timing D3 = T0cal Ref. Timing D4 = CPC Test Ref. Timing D5 = Random trigger D6 = L3 Muon trigger

6. Signals to the TDCs on the auxiliary CPCs

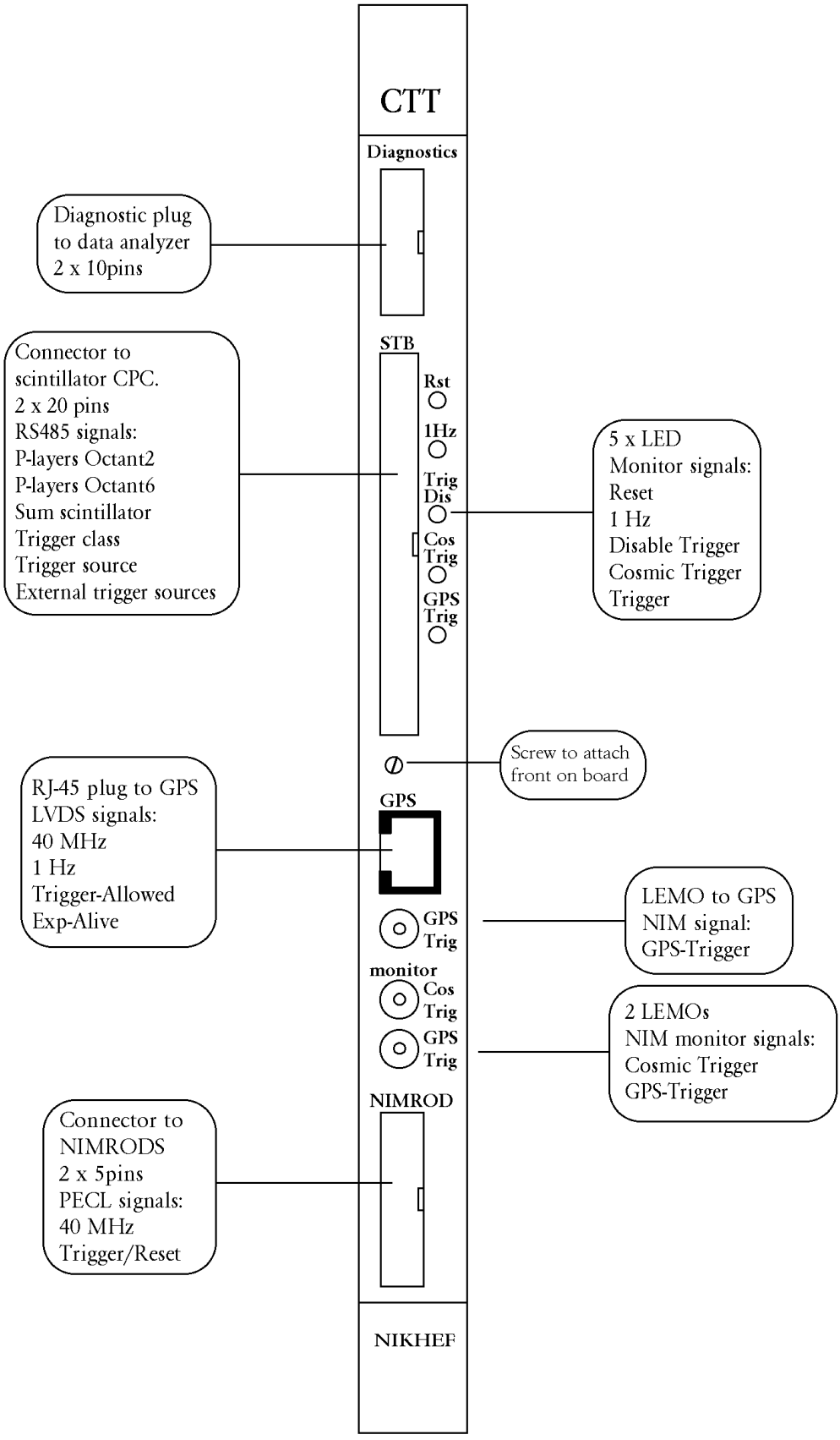
Trigger Class

Bits			Trigger Class	Comments
2	1	0		
0	0	1	1	Triplet in octant 2 and no scintillator hit (and no class 3)
0	1	0	2	A doublet in at least 1 octant
0	1	1	3	A triplet in at least 1 octant (and no class 1)
1	0	0	4	Doublets in both octants
1	0	1	1 and 3	Overlap of class 1 and class 3

Selected trigger source

Bits			Trigger source
2	1	0	
0	0	0	Nothing selected
0	0	1	Cosmics trigger
0	1	0	1 Hz
0	1	1	Scint. Test Ref. Timing
1	0	0	T0cal Ref. Timing
1	0	1	CPC Test Ref. Timing
1	1	0	Random trigger
1	1	1	Muon trigger

7. View of front



8. List of frontpanel connectors

ANA1-2 x 10 pins 0.1 inch connector.
Connection between CTT and analyzer.

Pin	Signal	Pin	Signal
1	n.c.	11	Scintillator signal
2	n.c.	12	Octant6 - triplet
3	n.c.	13	Octant6 - doublet
4	10MHz clock	14	n.c.
5	Trigger / reset to NIMRODs	15	Octant2 - triplet
6	OR ext. trigger sources	16	Octant2 - doublet
7	Trigger class 4	17	n.c.
8	Trigger class 3	18	n.c.
9	Trigger class 2	19	n.c.
10	Trigger class 1	20	GND

CPC1-2 x 20 pins 0.1 inch connector.
Connection between CTT and CPC.

Pin	Signal	Pin	Signal
1	Octant2-MO (+)	2	Octant2-MO (-)
3	Octant2-MM (+)	4	Octant2-MM (-)
5	Octant2-MI (+)	6	Octant2-MI (-)
7	Octant6-MO (+)	8	Octant6-MO (-)
9	Octant6-MM (+)	10	Octant6-MM (-)
11	Octant6-MI (+)	12	Octant6-MI (-)
13	Scintillator input (+)	14	Scintillator input (-)
15	Scintillator Test Ref. Timing (+)	16	Scintillator Test Ref. Timing (-)
17	T0CAL Ref. Timing (+)	18	T0CAL Ref. Timing (-)
19	CPC Test Ref. Timing (+)	20	CPC Test Ref. Timing (-)
21	Random (+)	22	Random (-)
23	L3 Muon Trigger (+)	24	L3 Muon Trigger (-)
25	Trigger class 0 (+)	26	Trigger class 0 (-)
27	Trigger class 1 (+)	28	Trigger class 1 (-)
29	Trigger class 2 (+)	30	Trigger class 2 (-)
31	Trigger source 0 (+)	32	Trigger source 0 (-)
33	Trigger source 1 (+)	34	Trigger source 1 (-)
35	Trigger source 2 (+)	36	Trigger source 2 (-)
37	Spare	38	Spare
39	GND	40	GND

GPS1-RJ45 connector.
Connection between CTT and GPS.

Pin	Signal	Pin	Signal
1	40 MHz (+)	2	40 MHz (-)
3	1 Hz (+)	4	1 Hz (-)Octant2-MM (-)
5	Exp. Alive (+)	6	Exp. Alive (-)
7	Trigger Allowed (+)	8	Trigger Allowed (-)

LEMO connector
Connection between CTT and GPS.
Signal name: GPS-Trigger

LEMO connector
Signal name: Monitor GPS-Trigger

LEMO connector
Signal name: Monitor Cosmics Trigger

NIMROD1-2 x 5 pins 0.1 inch connector.
Connection between CTT and NIMRODS

Pin	Signal	Pin	Signal
1	Trigger Disable_L	2	GND
3	Clock 40 MHz (+)	4	Clock 40 MHz (-)
5	GND	6	GND
7	Reset/Trigger (+)	8	Reset/Trigger (-)
9	GND	10	Spare