

The ETT System

communication protocols
and
data encoding

Version 6.0

This document is written as an attempt to reach agreement in the type of data arriving at the L1 Trigger Managers and at the L2 Pre-processors.

Please read it carefully and send comments/ suggestions to
J. Blazey, P. Grannis and M. Martin.

We want to sign on it before the Seattle Workshop !!

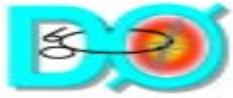
Manuel J. Martin

June 2, 1999



Glossary of terms

- Frame** a set of bits (bytes) that are transferred in one tick of the clock controlling the transmission link.
- Record** the set of consecutive Frames needed to transfer all the pertinent information of an event. The Record always includes a Trailer and some times a Header. The Record does not including Filler frames.
- File** a Record with added Filler if necessary.
- Data** set of consecutive Frames carrying the selected information about the collisions. The Data follows the Header (if there is one) and proceeds the Trailer.
- Header** a set of consecutive frames located at the beginning of a Record which provide information relative to the interpretation of the Record.
- Trailer** a set of consecutive frames located at the end of a Record. This provides a mean to determine the “goodness” of the transmission.
- Filler** a set of consecutive ‘null’ frames that may be appended to the Record to fulfill requirements regarding the length of a File. This is used with the G Links only.



Glossary of terms

Track	an object defined by hits in the eight CFT layers such that they fulfill one of the $\cong 16K$ predefined Boolean Equation for trajectories
Isolated Track	a Track that is the only Track in a 13.5° wedge
Cluster	an object formed by one or more consecutive PS strips with energy above a threshold
H PS	a cluster with hits above the High Threshold
L Ps	a cluster with hits above the Low Threshold
electron	a Track matched to a PS Cluster (H and/or L)
Isolated electron	an electron without other electrons in the corresponding 4.5° wedge or adjacent ones
γ	a PS cluster with no matched Tracks above a given Pt or upstream PS hits
Isolated γ	a γ with no other objects in the corresponding 4.5° wedge or adjacent ones
Jet	To be defined



Types of Links used in the CTT System

The terms defined here are used to define a physical link between two pieces of hardware as well as the specific way to transmit data through the physical link.

FSCL Fast Serial Copper Link

Data is transmitted as electrical pulses through a balanced pair of conductors. Capable of sending signals at moderated distances (order of few meters). The transfer rates can be as high as 1.2 Gbit/s. The transmission has an error rate of the order of 10^{-14} . Negative impact: it can create ground loops that are a source of noise and unwanted couplings.

G Link Originally Glass Fiber Link

Fast Serial Link using Optical Signals over Glass or Plastic Fibers. Capable of transmitting signals over long distances (order of kilometers). Transfer rates of 1.2 Gbit/s. The transmission has an error rate of the order of 10^{-15} . Negative impact: cost and power consumption.

LVDS Low Voltage Differential Signal .

A hybrid between serial and parallel transmission of data. Several differential pairs are used to transfer information at high rates over short distances (order of feet). The driver clock is carried over one differential pair. In the CTT four pairs are used for data with a driver clock of 53MHz. With these parameters, the transfer rate is 1.8 Gbit/s. The transmission has an error rate of the order of 10^{-12} . Negative impact: high error rate.



General Notes about the CTT System

The LVDS links between the Analog Front End boards and the Mixer or the Digital Front End boards do not use Headers in their protocols.

The LVDS links between the Analog Front End boards and the Mixer or the Digital Front End boards do not generate Transverse Parity. Thus, the error rate could be as high as 10^{-12} . This is tolerable because a wrong bit does not carry more penalty than the one incurred by electrical noise.

L1 information must be transferred from board to board in no more than 132ns.

L2 information going from the Digital Front End boards to the Collector or Broadcaster boards is sent through the same physical links as the corresponding L1 information. Physical links are time-shared.

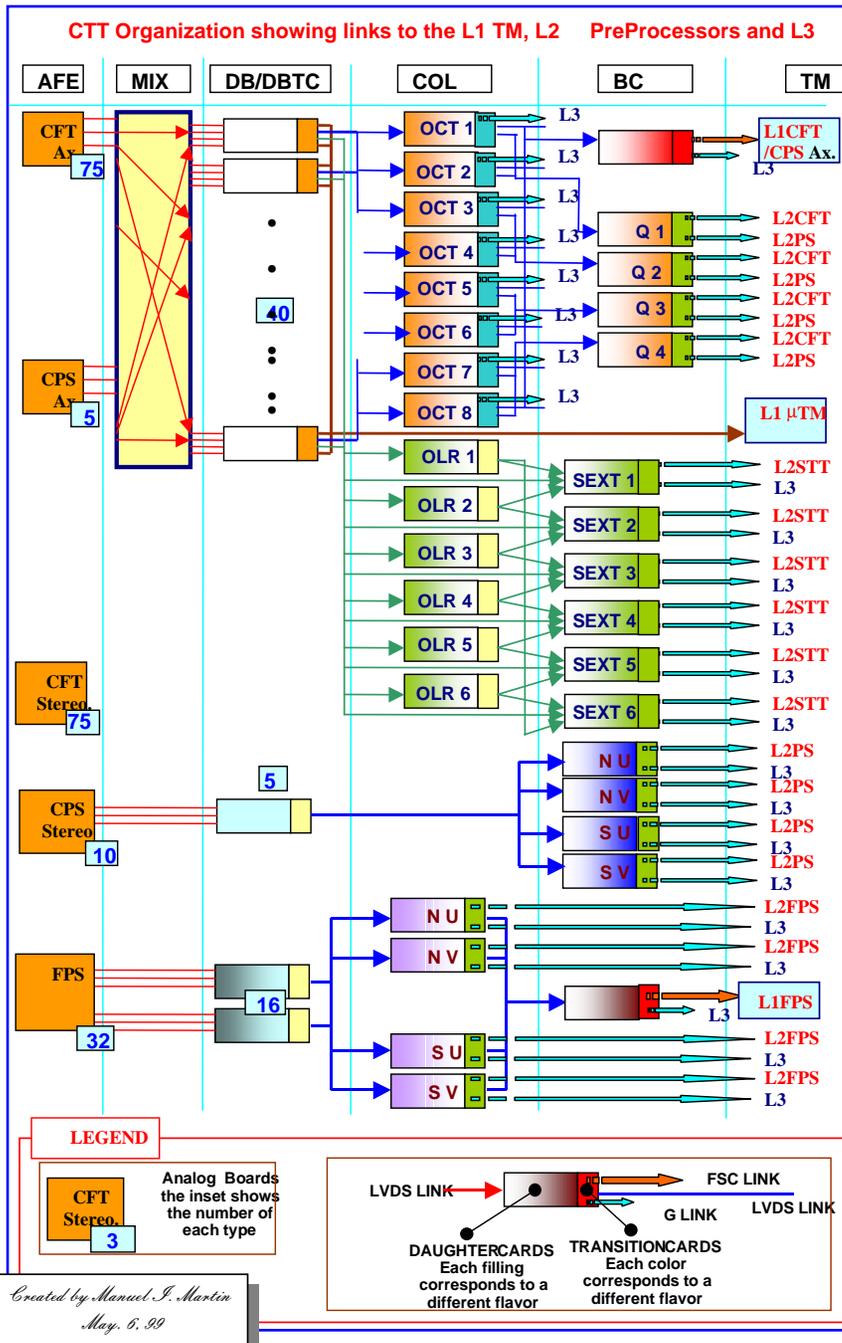
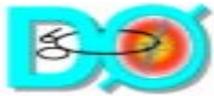


Diagram of the CTT System.

For a better view go to Manuel's Web pages at

<http://D0server1.fnal.gov/users/manuel/protocols/diagram.doc>

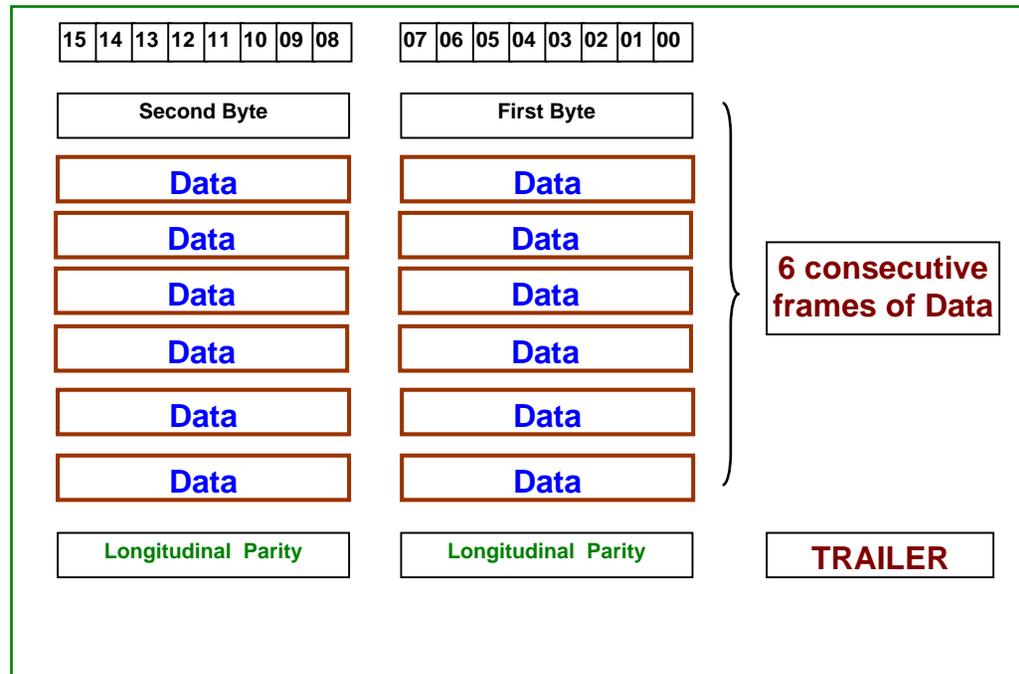
GLOSSARY

AFE	Analog Front End Board
MIX	Mixing Box
DB	Digital Board
DBTC	DB Transition Card
COL	Collector Board
BC	BroadCaster Board
TM	Trigger Manager
OCT	COL serving an Octant
Qx	BC serving Quadrant x
OLR	COL serving the Overlapping Regions of the SI match
SEXT	BC covering a Sextant
N/Sx	board serving the North/South side
xU/V	Refers to the U V orientation of the PS strips

June 2, 1999



Protocol for transfer of data via FSC Link

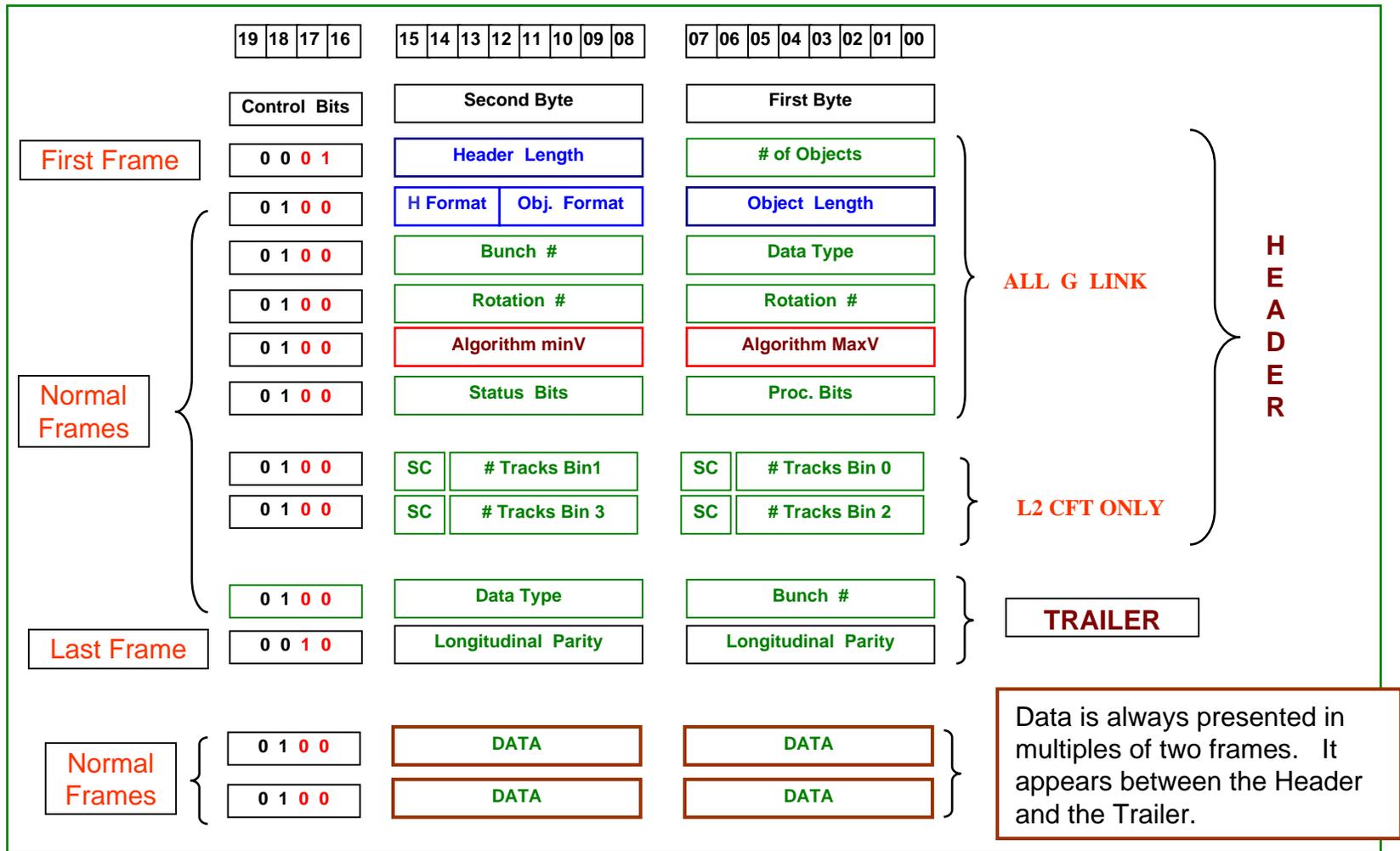


This protocol was adopted by the μ group and it is used only to interact with hardware designed by the μ group.

The major disadvantages of this protocol are the lack of Header and the lack of means to recover synchronization if it is lost. Synchronization can be recover only during the "gaps" on the collider beams.



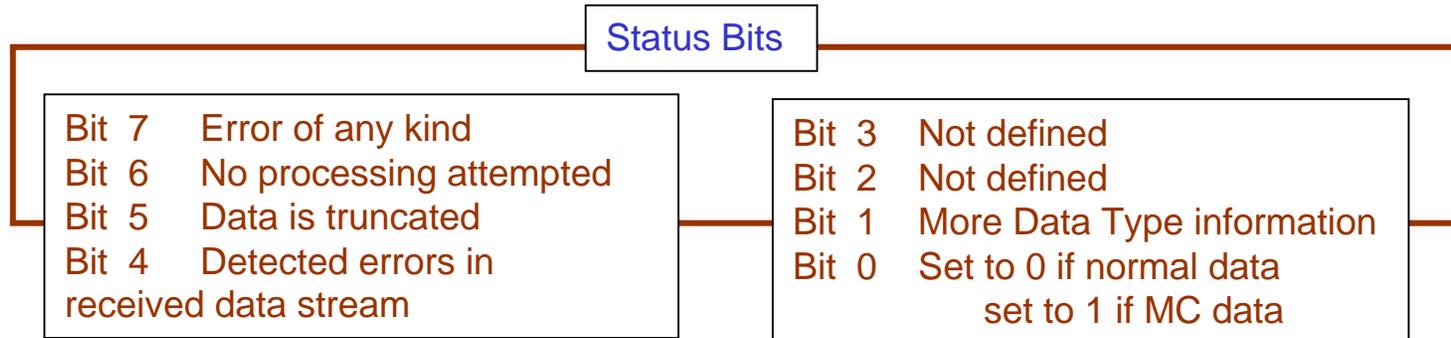
Protocol for transfer of data via G Links





Glossary of terms

- ◆ **Header Length** Number of Words (2 frames per word) of header (3 or 4)
- ◆ **# of Objects** Number of physical objects (tracks, clusters, etc.). An object requires a minimum of a full word (two frames) or a multiple thereof. (0 to 48)
- ◆ **Header Format** Defines the structure of the header (1, 2)
- ◆ **Object Format** With the Data Type defines the bit pattern of the object (1, 2)
- ◆ **Data Type** What Type of data (CFT, CPS, etc)
- ◆ **Algorithm MaxV** Not used. Relates to the ALPHAS
- ◆ **Algorithm minV** Not used. Relates to the ALPHAS
- ◆ **Proc. Bits** Code to define the Firmware version used (1 to 255)
- ◆ **Status Bits** Specific code providing information about the data transferred





Glossary of terms

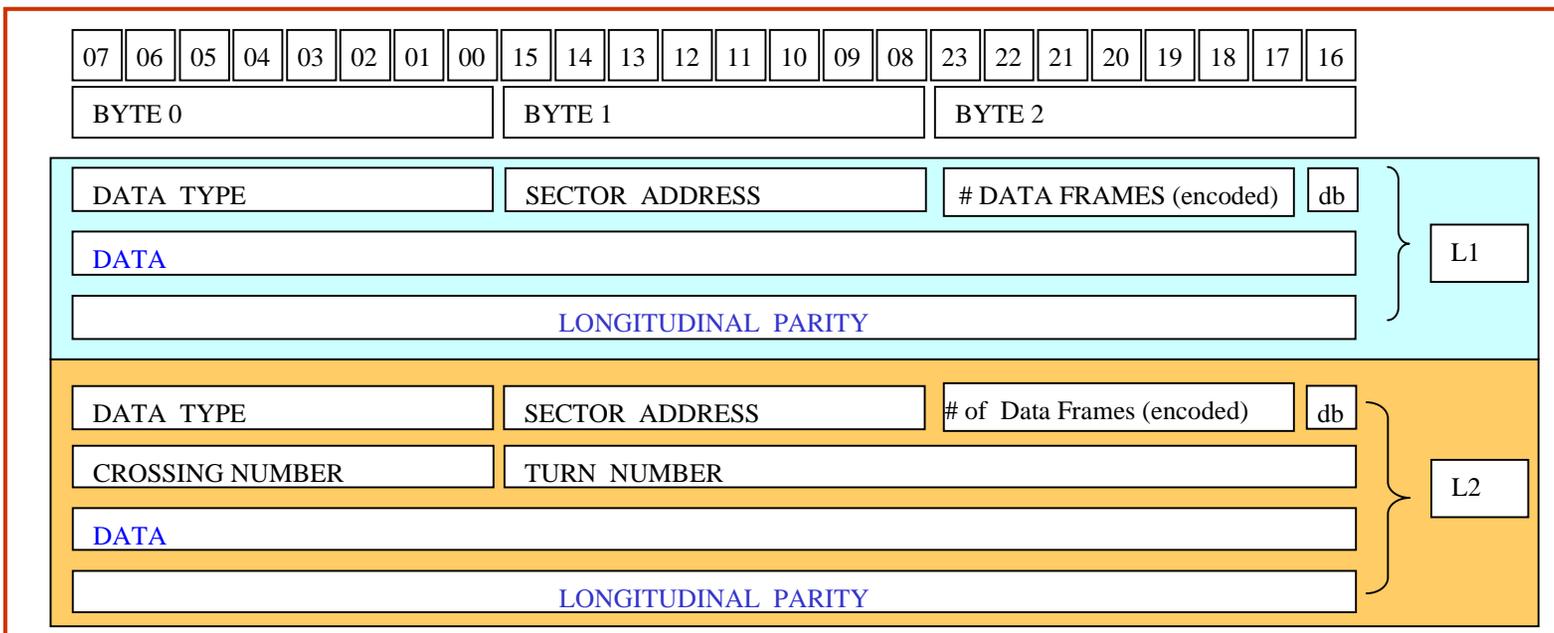
Data Type Used by the G Link Protocols

CFT Quadrant 1	162	CPS Axial Quadrant 1	130
CFT Quadrant 2	163	CPS Axial Quadrant 2	131
CFT Quadrant 3	164	CPS Axial Quadrant 2	132
CFT Quadrant 4	165	CPS Axial Quadrant 2	133
STT Sextant 1	166	CPS Stereo NU	134
STT Sextant 2	167	CPS Stereo NV	135
STT Sextant 3	168	CPS Stereo SU	136
STT Sextant 4	169	CPS Stereo SV	137
STT Sextant 5	170	FPS Stereo NU	138
STT Sextant 6	171	FPS Stereo NV	139
		FPS Stereo SU	140
		FPS Stereo SV	141

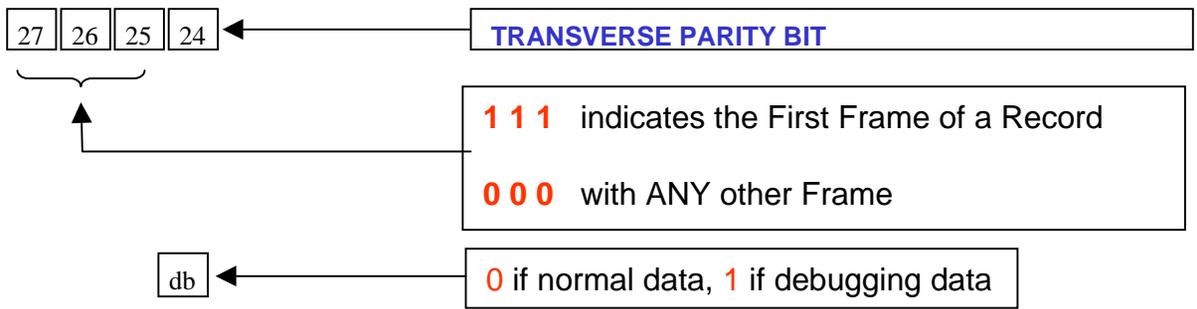
It is the responsibility of the Collector/Broadcaster Boards' Firmware to insert the proper Header in the data stream.



Protocol for transfer of data via LVDS Links between DFE and COL and between COL and BC



CONTROL BITS



NOTE
L1 Data Transfers between Collector Boards and Broadcaster Boards do not require Header information



Glossary of terms

- ◆ **Data Type** What Type of data (CFT, CPS, etc).
- ◆ **Sector Address** An unique number identifying the “Analog Board” source of the data. There are a total of 196 Analog Boards in the CTT System.
- ◆ **# Data Frames** The number of Data Frames carrying data. It does not include Header or Trailer frames.
- ◆ **db** A reserved bit for debugging.

Notes about the LVDS Links

- * With the exception of the links between the Mixer Board and the Digital Boards, error rates higher than $\approx 10^{-15}$ are not acceptable. Because the LVDS error rate ($\approx 10^{-12}$) is too high, special measures are taken to ensure transfers with virtually no errors.
- * The usage of Longitudinal and Transverse parity permits to correct any single error in a transmission and detect any double error. This makes the transmission of data using the LVDS practically error free. After correction for single errors, the error rate is $\approx 10^{-24}$.
- * Because the Longitudinal error is not available until the end of the record, special codes are used for Data Type and # of Data Frames. These codes are self-correcting in the sense that a single bit error results in a code whose original value is known. This is necessary because the Firmware must make decisions about how to treat the data based on these two Header fields.



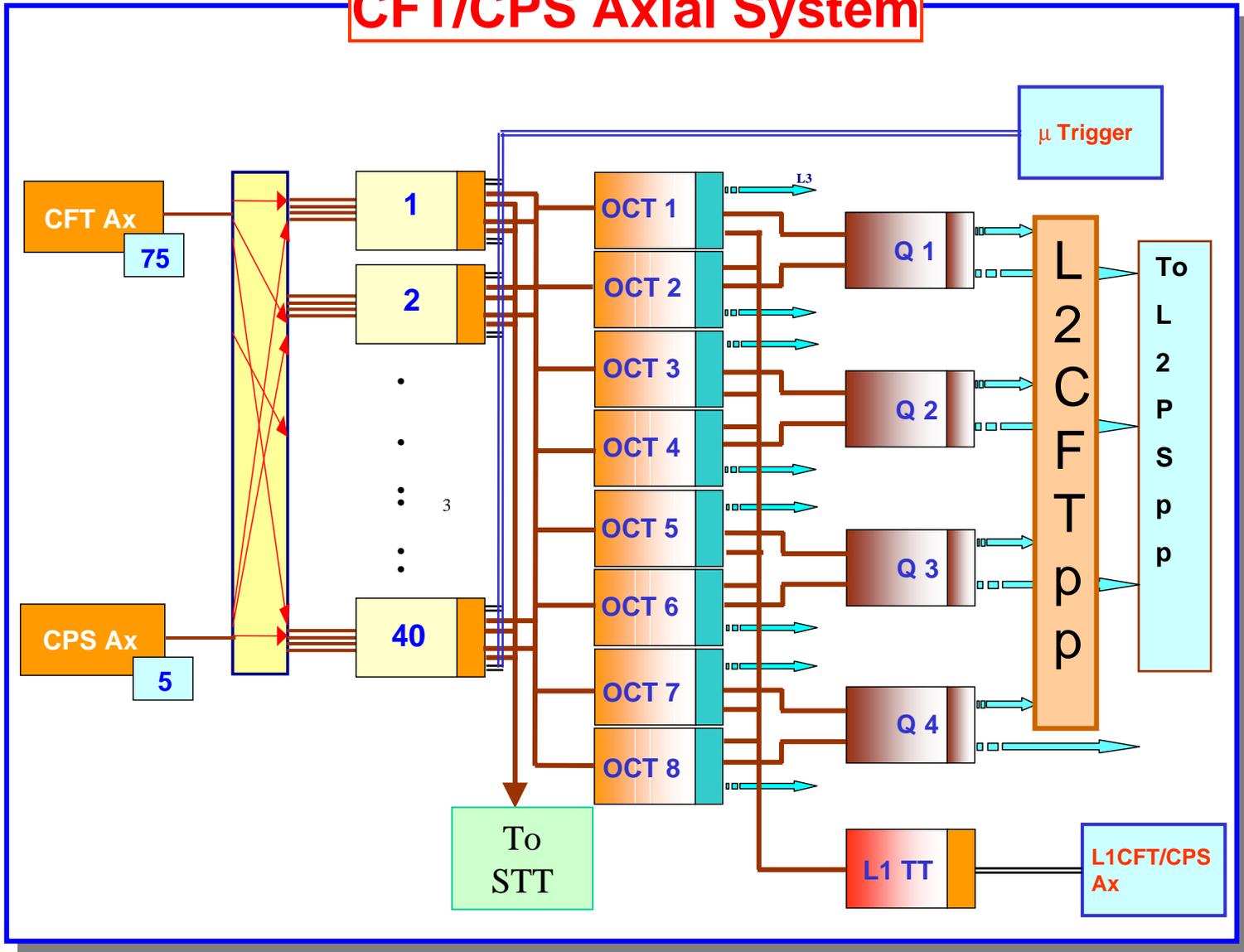
Special Codes for Data Type

		07	06	05	04	03	02	01	00	
		TRIGGER			SOURCE					
L1	{	1	0	1	0	0	1	0	1	L1 CFT/CPS Axial
		1	0	1	0	0	0	1	0	L1 FPS
		1	0	1	0	1	0	0	0	L1 Forward Proton
L2	{	0	1	0	0	0	1	0	1	L2 CFT
		0	1	0	0	1	0	1	0	L2 CPS Axial
		0	1	0	1	1	1	0	1	L2 STT
		0	1	0	1	0	0	1	0	L2 CPS Stereo
		0	1	0	0	0	0	1	0	L2 FPS

Any single error can be corrected without Parity checks

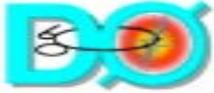


CFT/CPS Axial System



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June 2, 1999



CFT/CPS Axial

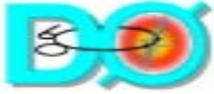
FUNCTIONS PERFORMED BY THE BOARDS

DB Front End Digital Board

Collects hits on CFT and CPS Axial. Finds Tracks and Clusters. Associates Tracks with Clusters. Obtains number of Tracks found in each Pt Bin. Identify Isolated Tracks or Isolated electrons. Sends an ordered list of Tracks to the μ -Trigger for L1. Sends number of Tracks, isolated objects, total sum of Pt of all found Tracks and a Occupancy number to the Collector Boards for L1CFT/CPS Axial. When L1 Accept is received, sends two concatenated records of information to the Collector Boards: an ordered list by Pt Bin of Tracks with PS cluster association, an ordered list in Φ of Clusters with possible Track association. The Track list has a maximum of six Tracks per Pt Bin. If truncation is necessary, Tracks with lower Φ are selected. The Cluster list has a maximum of eight Clusters and no truncation is needed.

COL Collector Board

Each COL receives information from 5 DBs (one completed Octant). When L1 information is detected, adds the numbers of Tracks in each Pt Bin, review the list of isolated objects and modify it if necessary, calculates Occupancy for the Octant and calculates the sum of Pt for the Octant. Send this information to a single BC board for further manipulations. When L2 information is detected the COL acts on the Track lists and the Cluster lists before it sends the information to BCs.



FUNCTIONS PERFORMED BY THE BOARDS

(Continuation)

COL Collector Board

The COL merges the ten Track lists into a single list ordered by Pt including the extended Pt. This list reports a maximum of twenty four Tracks regardless of Pt Bin. If the total number of tracks exceeds twenty four, the list is truncated. Truncation follows two criteria: first the Tracks with higher Pt (including extended Pt) are selected, if further truncation is needed the Tracks with lower Φ are selected.

The COL merges the ten Clusters list into a single one. The maximum number of clusters reported at the Octant level is twenty four. If truncation is required it is done selecting Clusters with lower Φ . We should think if we want to preserve HPS regardless of Φ .

BC BroadCaster Board

There are two types of Broadcaster boards: CFT/CPS Axial L1 (L1TT) and CFT Quadrants (Qx).

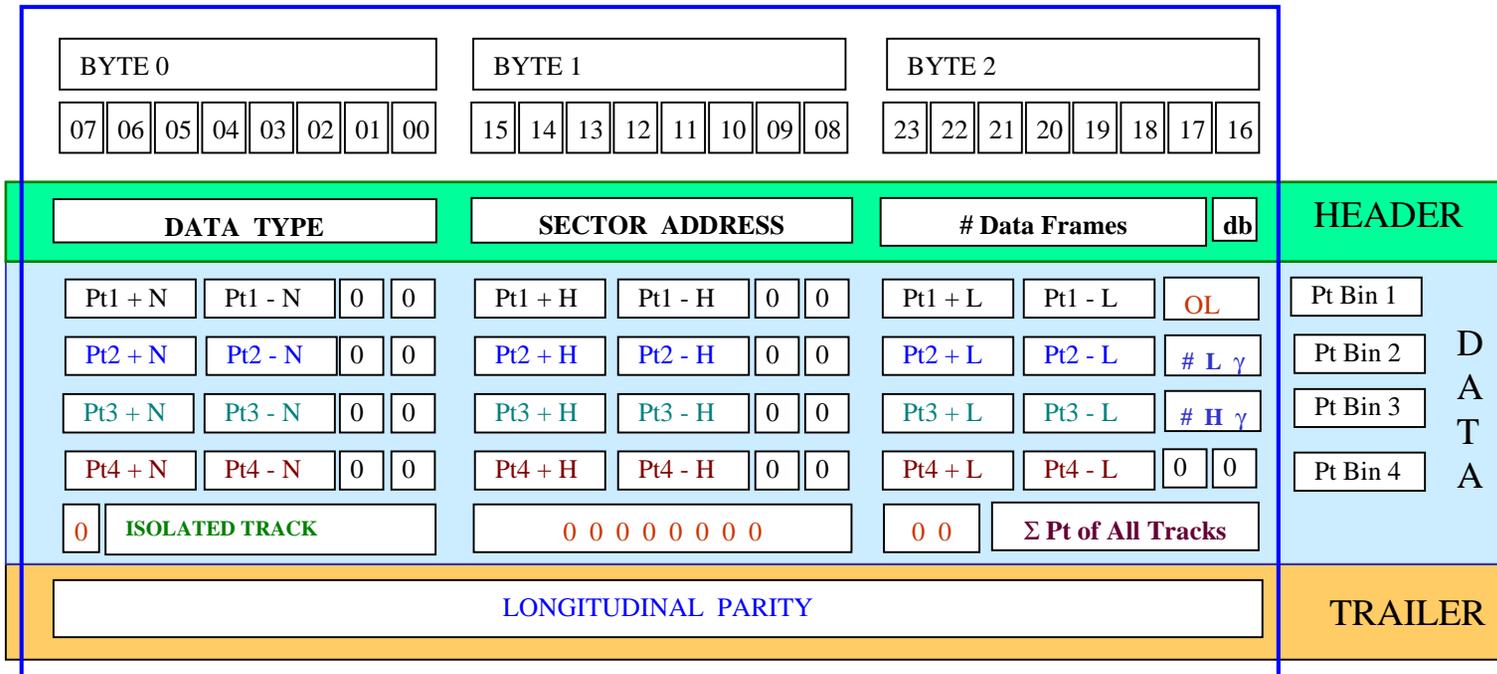
L1TT It receives L1 information from the eight Octants and generates a exhaustive list of L1 AND/OR terms. This list is sent to the L1CFT/CPS Axial Trigger Manager via a FSC Link. The Trigger Manager will select a subset of forty eight to use in the L1 Trigger.

Qx Each Quadrant BC collects information from two adjacent Octants. The two Track list are merged and its contents reorder in order of Pt in a single list with no more than Forty six Tracks. The possibility exist of discarding up two tracks from the original lists. When this is necessary, truncation is done as in the Octants. The resulting list is sent to the L2CFTpp and to the L2CPSpp via separated G Links.

The two Cluster lists are merged into one with a maximum of forty six clusters. Truncation, if required, is done as before. The resulting Cluster list is sent to the L2CPSpp via a G Link.

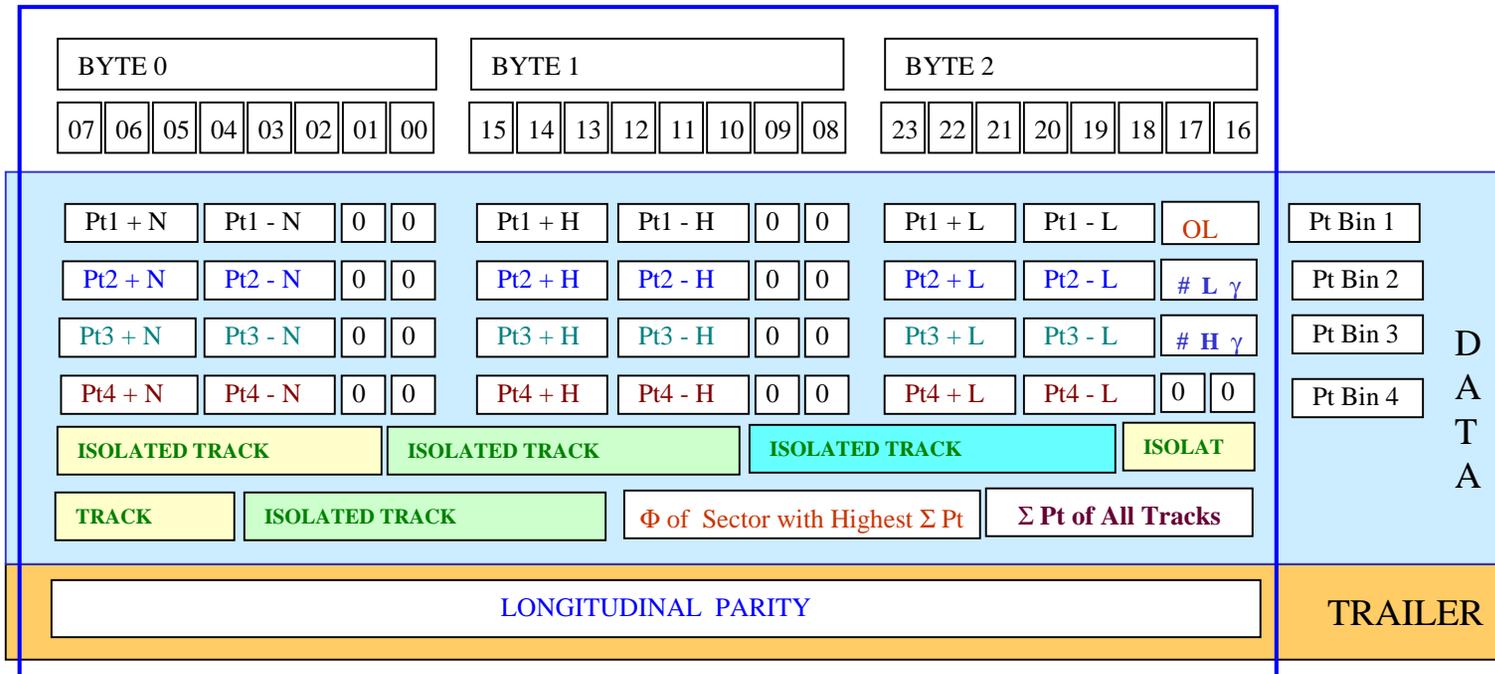


**Bit Fields allocation for L1 CFT/CPS data transfers between
the Digital Front End boards
and
the Collector Boards using LVDS Links**





**Bit Fields allocation for L1 CFT/CPS data transfers between
the Collector Boards
and
the Broadcaster Boards using LVDS Links**





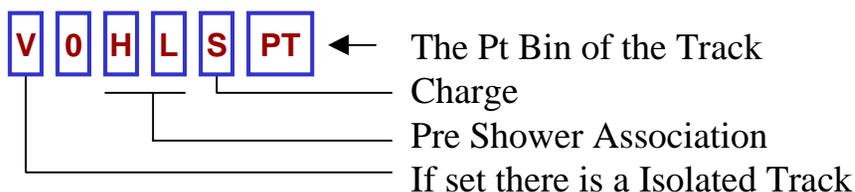
Meaning of Terms used in the Data Fields

Pt x s y Number of Tracks found in Pt Bin x with charge s and without a PS Cluster Associated [y = N]
associated with High Threshold Cluster [y = H]
associated with Low Threshold Cluster [y = L]

This number can be between 0 and 7 for any of the 24 tagging combinations

Isolated Track

A six bit code for an isolated track that is contained in the sector. The meaning of the bits is:



Σ Pt of All Tracks Sum of the absolute value of the Pt of all tracks above some Pt.

Φ of the Sector with Highest Σ Pt of all tracks in the sector

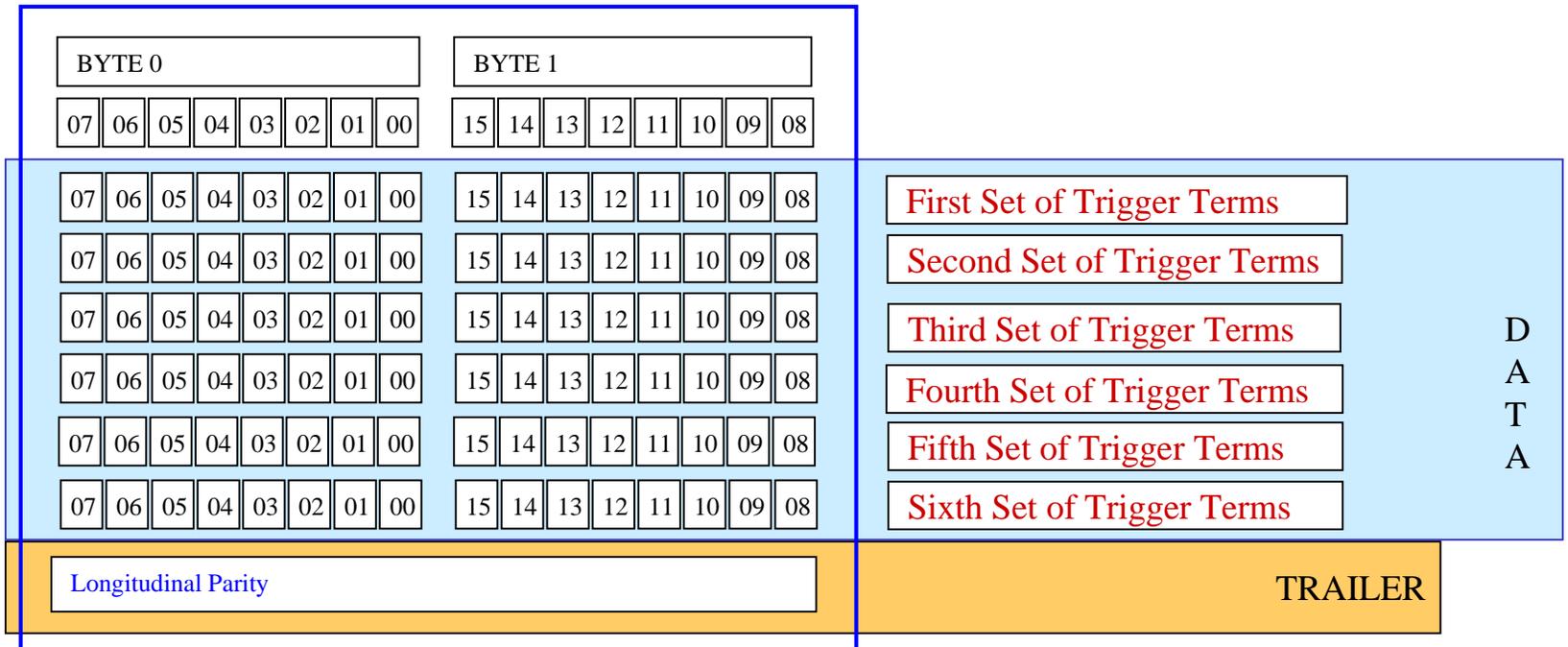
L γ Number of Low γ (Low γ is a γ defined by a LPS)

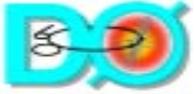
H γ Number of High γ (High γ is a γ defined by a HPS)

OL A measure of the level/number of interactions in the event. There are four ranges: Low one to two, Med-Low three to four, Med-High five to six, High seven or more interactions per event.



**Bit Fields allocation for L1 CFT/CPS data transfers between
the Broadcaster Board
and
the Trigger Manager using FSC Links**





The Trigger Terms Sent to the L1CFT/CPS Trigger Manager

First Set

Bit	Trigger Term
00	TTK(1,5): 1 Trk Pt > 5 GeV
01	TTK(2,5): 2 Trk Pt > 5 GeV
02	TEL(1,1): 1 Trk Pt > 1.5 GeV + LPS
03	TEL(1,3): 1 Trk Pt > 3 GeV + LPS
04	TEL(1,5): 1 Trk Pt > 5 GeV + HPS
05	TEL(2,1): 2 Trk Pt > 1.5 GeV + LPS
06	TEL(2,3): 2 Trk Pt > 3 GeV + LPS
07	TIS(2,1): 1 Iso Elec. Pt > 1.5 GeV + LPS
08	TIS(2,5): 1 Iso Elec. Pt > 5 GeV + LPS

NOTE

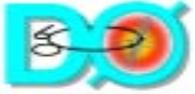
There are 96 possible Trigger Terms. The philosophy followed is to provide a list of interesting Terms; the Trigger Manager Selects 48 from the List to send to the Trigger Framework

Second Set

Bit	Trigger Term
00	TIQ1(1,L): 1 Iso Elec. In Q1 Trk + LPS
01	TIQ2(1,L): 1 Iso Elec. In Q2 Trk + LPS
02	TIQ3(1,L): 1 Iso Elec. In Q3 Trk + LPS
03	TIQ4(1,L): 1 Iso Elec. In Q4 Trk + LPS
04	TIOCT1(1,L): 1 Iso Elec. In OCT1 Trk + LPS
05	TIOCT2(1,L): 1 Iso Elec. In OCT2 Trk + LPS
06	TIOCT3(1,L): 1 Iso Elec. In OCT3 Trk + LPS
07	TIOCT4(1,L): 1 Iso Elec. In OCT4 Trk + LPS
08	TIOCT5(1,L): 1 Iso Elec. In OCT5 Trk + LPS
09	TIOCT6(1,L): 1 Iso Elec. In OCT6 Trk + LPS
10	TIOCT7(1,L): 1 Iso Elec. In OCT7 Trk + LPS
11	TIOCT8(1,L): 1 Iso Elec. In OCT8 Trk + LPS

NOTE

The definition of the terms used is consistent with the definitions given by the L1 Trigger Group. See http://wwwd0.fnal.gov/~lucotte/TRG/trigger_list.html



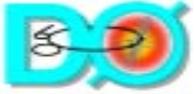
The Trigger Terms Sent to the L1CFT/CPS Trigger Manager

Third Set

Bit	Trigger Term
00	TPQ1(1,L): 1 Elec. In Q1 Trk + LPS
01	TPQ2(1,L): 1 Elec. In Q2 Trk + LPS
02	TPQ3(1,L): 1 Elec. In Q3 Trk + LPS
03	TPQ4(1,L): 1 Elec. In Q4 Trk + LPS
04	TPOCT1(1,L): 1 Elec. In OCT1 Trk + LPS
05	TPOCT2(1,L): 1 Elec. In OCT2 Trk + LPS
06	TPOCT3(1,L): 1 Elec. In OCT3 Trk + LPS
07	TPOCT4(1,L): 1 Elec. In OCT4 Trk + LPS
08	TPOCT5(1,L): 1 Elec. In OCT5 Trk + LPS
09	TPOCT6(1,L): 1 Elec. In OCT6 Trk + LPS
10	TPOCT7(1,L): 1 Elec. In OCT7 Trk + LPS
11	TPOCT8(1,L): 1 Elec. In OCT8 Trk + LPS
12	
13	
14	
15	

Fourth Set

Bit	Trigger Term
00	TIQ1(1,H): 1 Elec. In Q1 Trk + HPS
01	TIQ2(1,H): 1 Elec. In Q2 Trk + HPS
02	TIQ3(1,H): 1 Elec. In Q3 Trk + HPS
03	TIQ4(1,H): 1 Elec. In Q4 Trk + HPS
04	TIOCT1(1,H): 1 Elec. In OCT1 Trk + HPS
05	TIOCT2(1,H): 1 Elec. In OCT2 Trk + HPS
06	TIOCT3(1,H): 1 Elec. In OCT3 Trk + HPS
07	TIOCT4(1,H): 1 Elec. In OCT4 Trk + HPS
08	TIOCT5(1,H): 1 Elec. In OCT5 Trk + HPS
09	TIOCT6(1,H): 1 Elec. In OCT6 Trk + HPS
10	TIOCT7(1,H): 1 Elec. In OCT7 Trk + HPS
11	TIOCT8(1,H): 1 Elec. In OCT8 Trk + HPS
12	
13	
14	
15	



The Trigger Terms Sent to the L1CFT/CPS Trigger Manager

Fifth Set

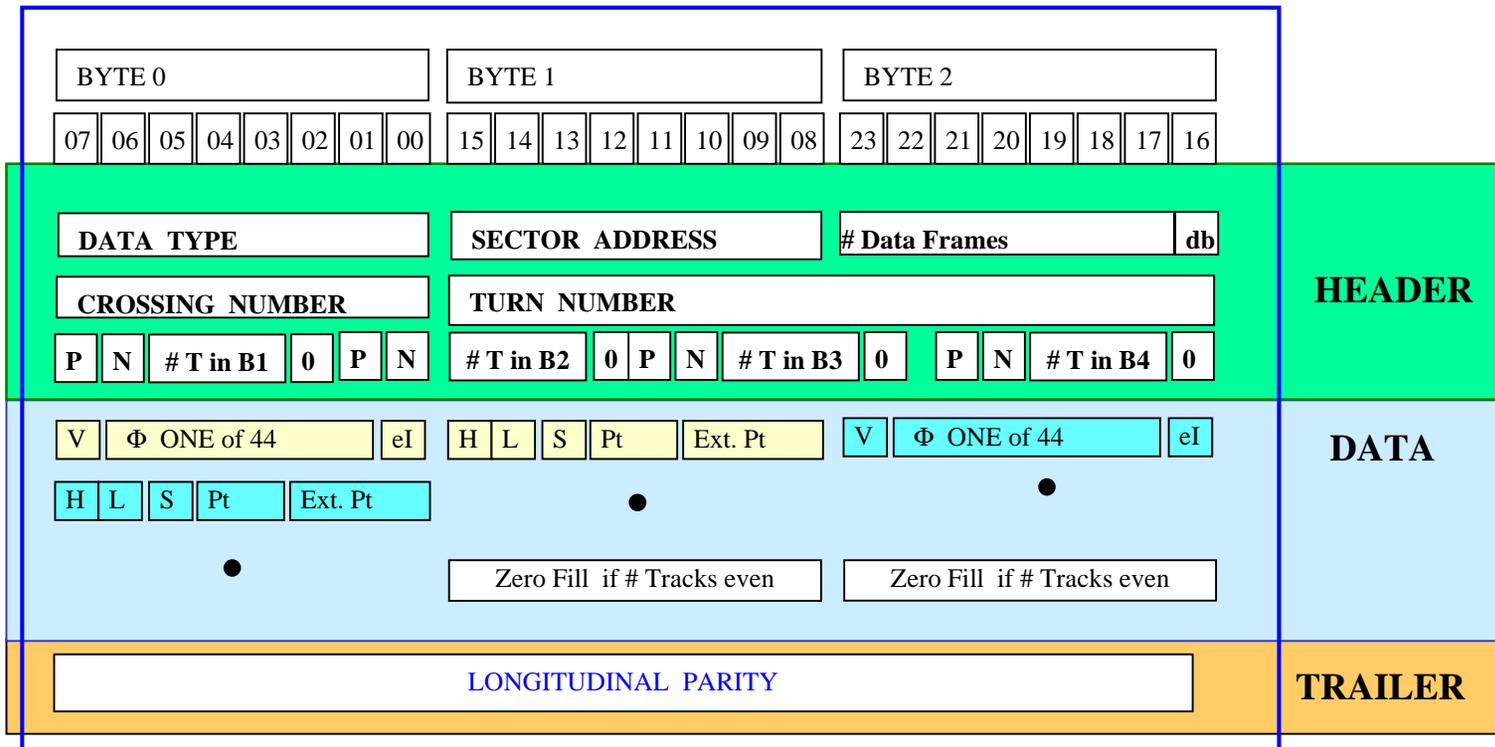
Bit	Trigger Term
00	TNQ1(1,L): 1 Pho. In Q1 Trk + LPS
01	TNQ2(1,L): 1 Pho. In Q2 Trk + LPS
02	TNQ3(1,L): 1 Pho. In Q3 Trk + LPS
03	TNQ4(1,L): 1 Pho. In Q4 Trk + LPS
04	TNOCT1(1,L): 1 Pho. In OCT1 Trk + LPS
05	TNOCT2(1,L): 1 Pho. In OCT2 Trk + LPS
06	TNOCT3(1,L): 1 Pho. In OCT3 Trk + LPS
07	TNOCT4(1,L): 1 Pho. In OCT4 Trk + LPS
08	TNOCT5(1,L): 1 Pho. In OCT5 Trk + LPS
09	TNOCT6(1,L): 1 Pho. In OCT6 Trk + LPS
10	TNOCT7(1,L): 1 Pho. In OCT7 Trk + LPS
11	TNOCT8(1,L): 1 Pho. In OCT8 Trk + LPS
12	
13	
14	
15	

Sixth Set

Bit	Trigger Term
00	TJTQ1(1,H): 1 JET In Q1 Trk + HPS
01	TJTQ2(1,H): 1 JET In Q2 Trk + HPS
02	TJTQ3(1,H): 1 JET In Q3 Trk + HPS
03	TJTQ4(1,H): 1 JET In Q4 Trk + HPS
04	TJTOCT1(1,H): 1 JET In OCT1 Trk + HPS
05	TJTOCT2(1,H): 1 JET In OCT2 Trk + HPS
06	TJTOCT3(1,H): 1 JET In OCT3 Trk + HPS
07	TJTOCT4(1,H): 1 JET In OCT4 Trk + HPS
08	TJTOCT5(1,H): 1 JET In OCT5 Trk + HPS
09	TJTOCT6(1,H): 1 JET In OCT6 Trk + HPS
10	TJTOCT7(1,H): 1 JET In OCT7 Trk + HPS
11	TJTOCT8(1,H): 1 JET In OCT8 Trk + HPS
12	
13	
14	
15	



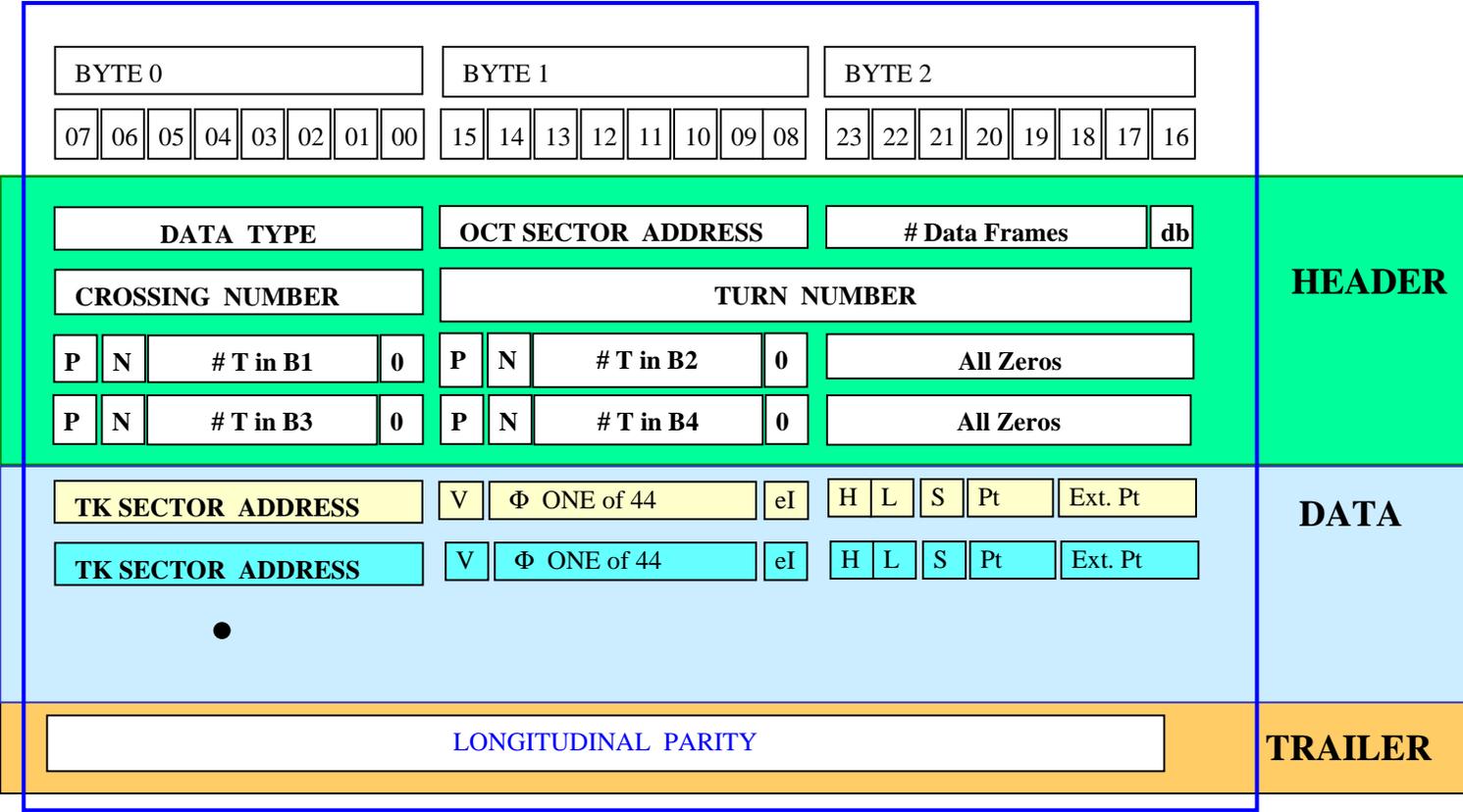
Bit Fields allocation for L2 CFT data transfers between the Digital Front End boards and the Collector Boards using LVDS Links



NOTES The Maximum number of Tracks reported per 4.5⁰ Wedge is 6 per Pt Bin (24 Max. Total)
 The Track List is ordered in Pt Bin



**Bit Fields allocation for L2 CFT data transfers between
the Collector Boards
and the Broadcaster Boards using LVDS Links**

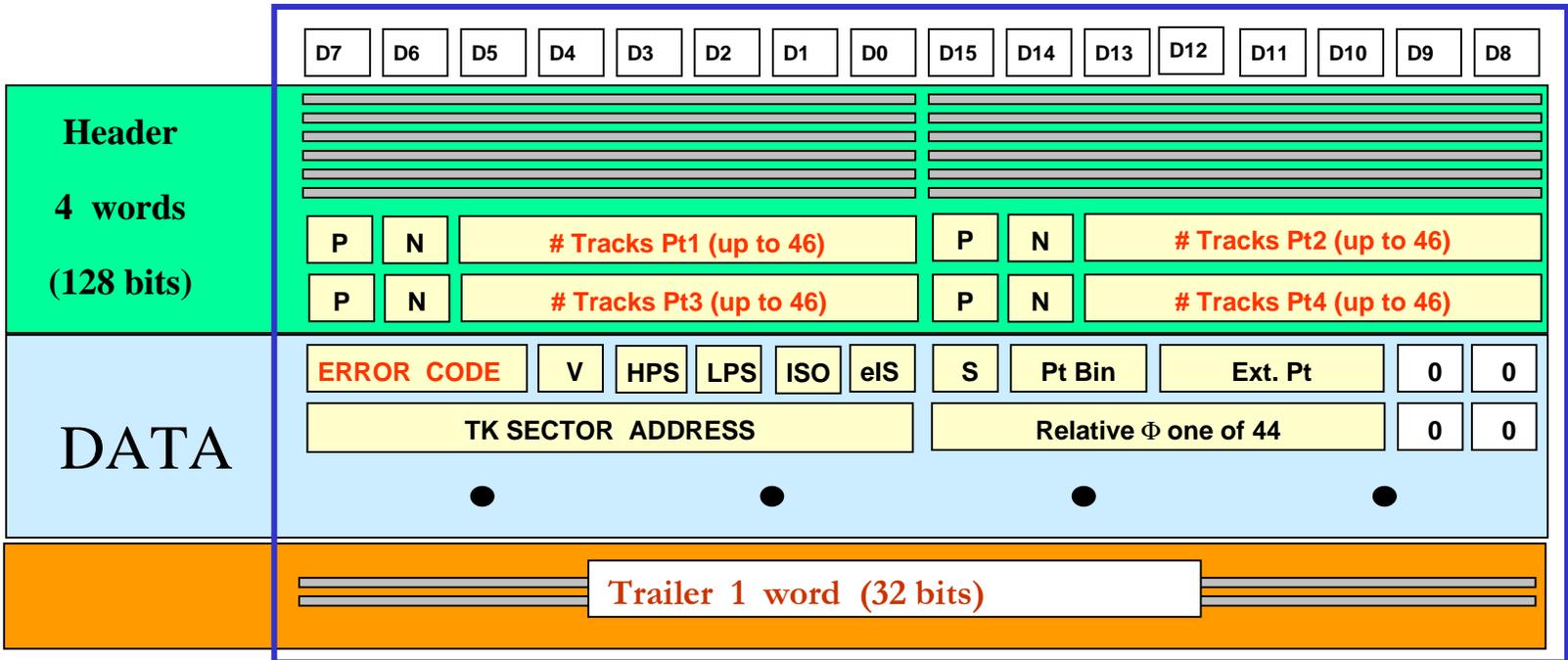


NOTES The Maximum number of Tracks reported per Octant is 24 (The 24 with higher Pt) The Track List is ordered in Pt If truncation of data is necessary the reporting is done moving counter clock wise, this will result in a possible Φ dependence.

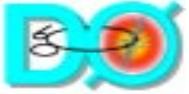
Manuel J. Martin June 2, 1999



**Bit Fields allocation for L2 CFTpp data transfers between
the Broadcaster Boards
and the L2 Pre Processors (via FIC) using G Links**

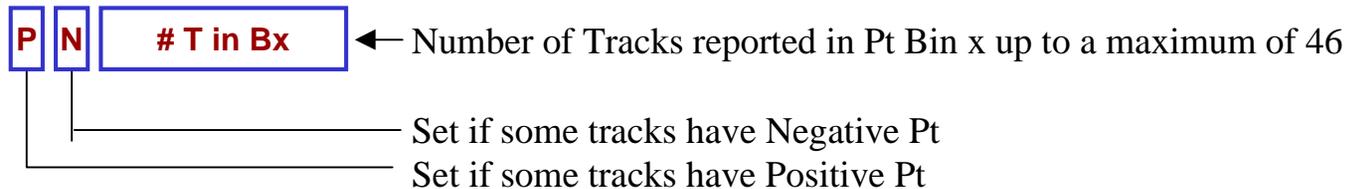


Number of Tracks per Pt bin 4*8 bits for a maximum of 46 tracks
 List of tracks with tagging and address n*32 bits for a maximum of 46 tracks
 If truncation of data is necessary the reporting is done moving counter clock wise,
 this will result in a possible Φ dependence.

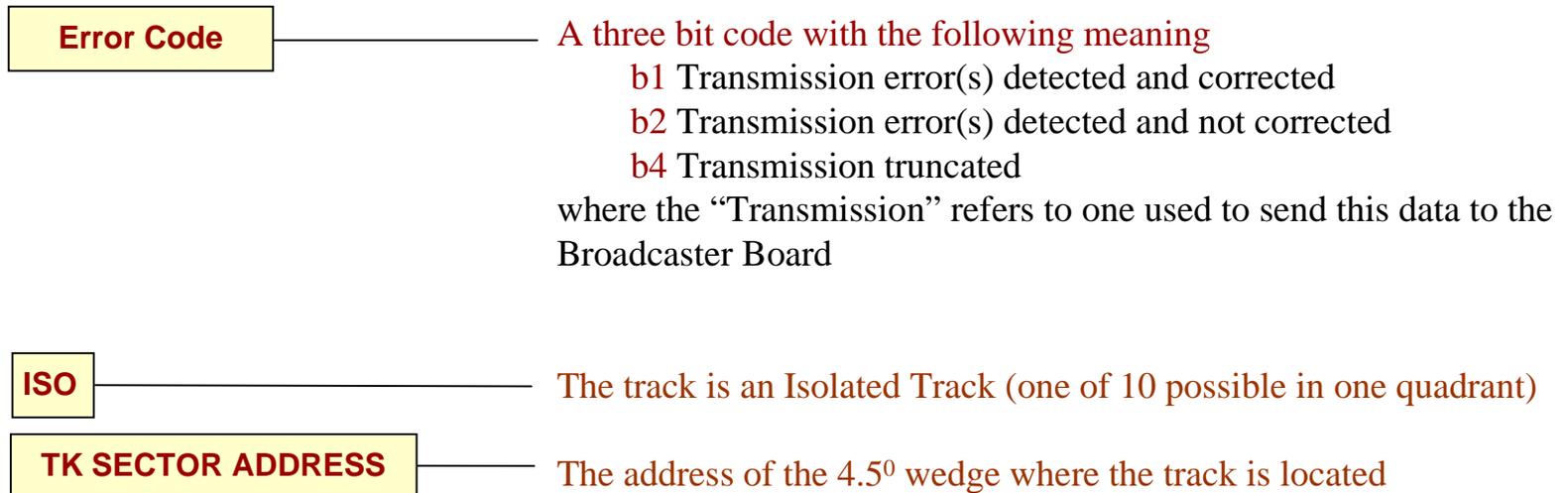


Meaning of Terms used

In this case the Header has four Frames. The code for the four Frame is

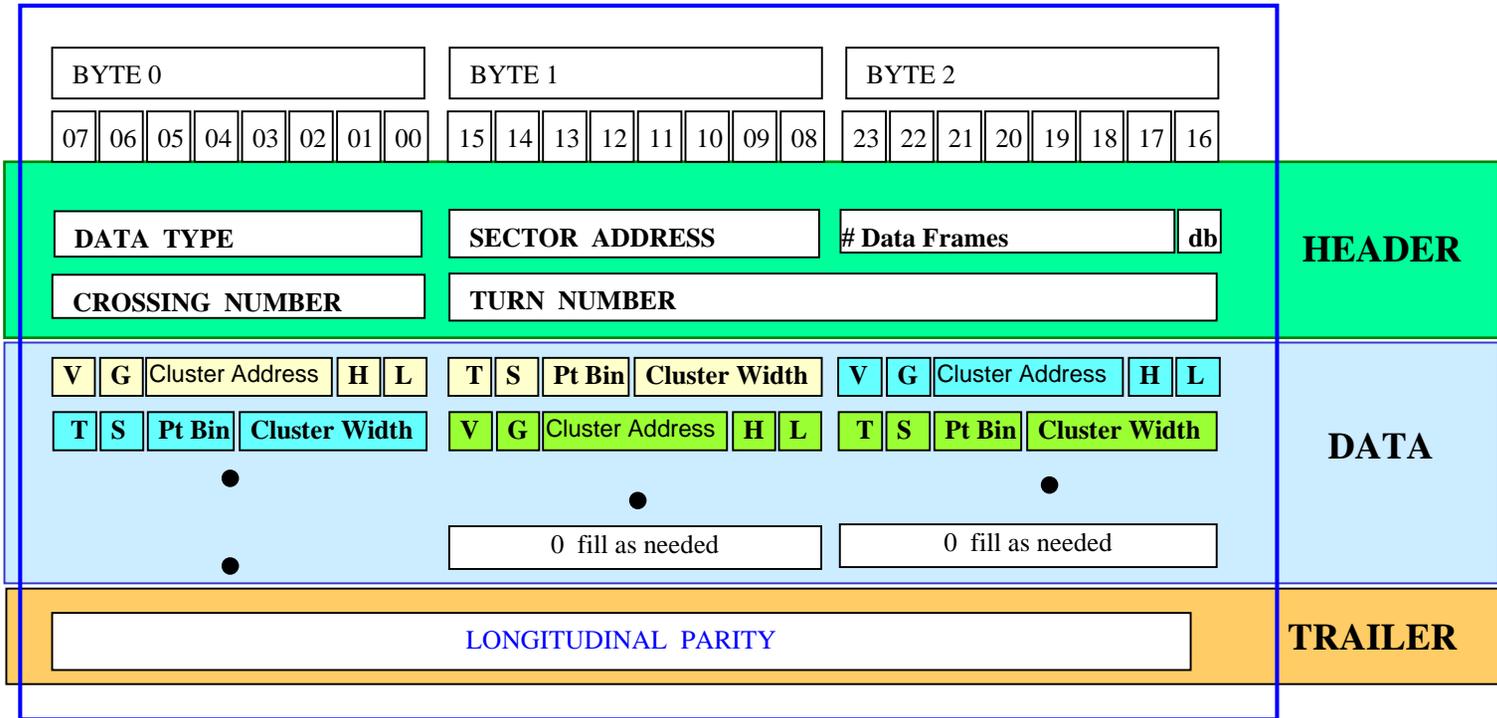


Each reported track carries the same information that in the previous case plus the following





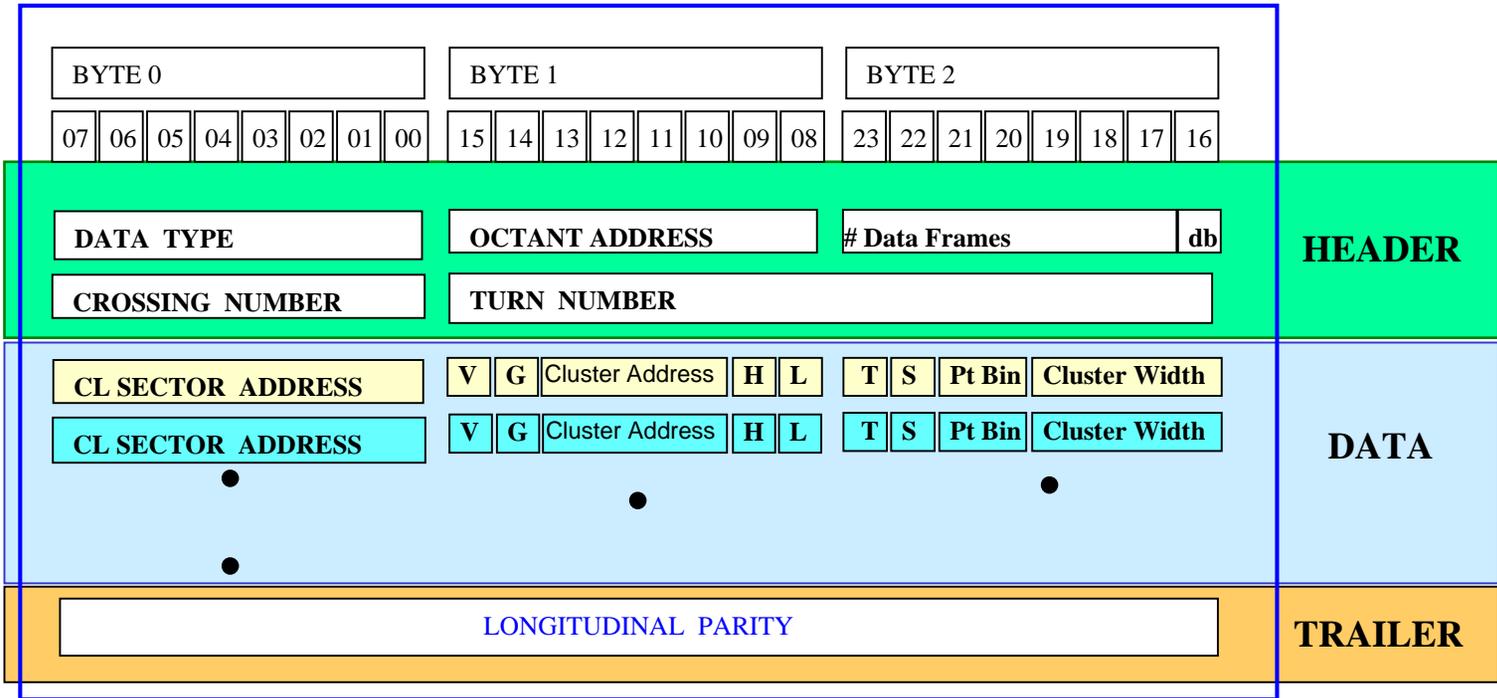
**Bit Fields allocation for L2 CPS Axial data transfers between
the Digital Front End boards
and the Collector Boards using LVDS Links**



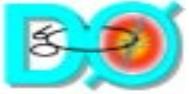
NOTES The Maximum number of Clusters reported per 4.5° Wedge is 8



**Bit Fields allocation for L2 CPS Axial data transfers between
the Collector Boards
and the Broadcaster Boards using LVDS Links**



NOTE The Maximum number of Clusters reported per Octant is 24. If truncation of data is necessary the reporting is done moving counter clock wise, this will result in a possible Φ dependence.



Meaning of Terms used

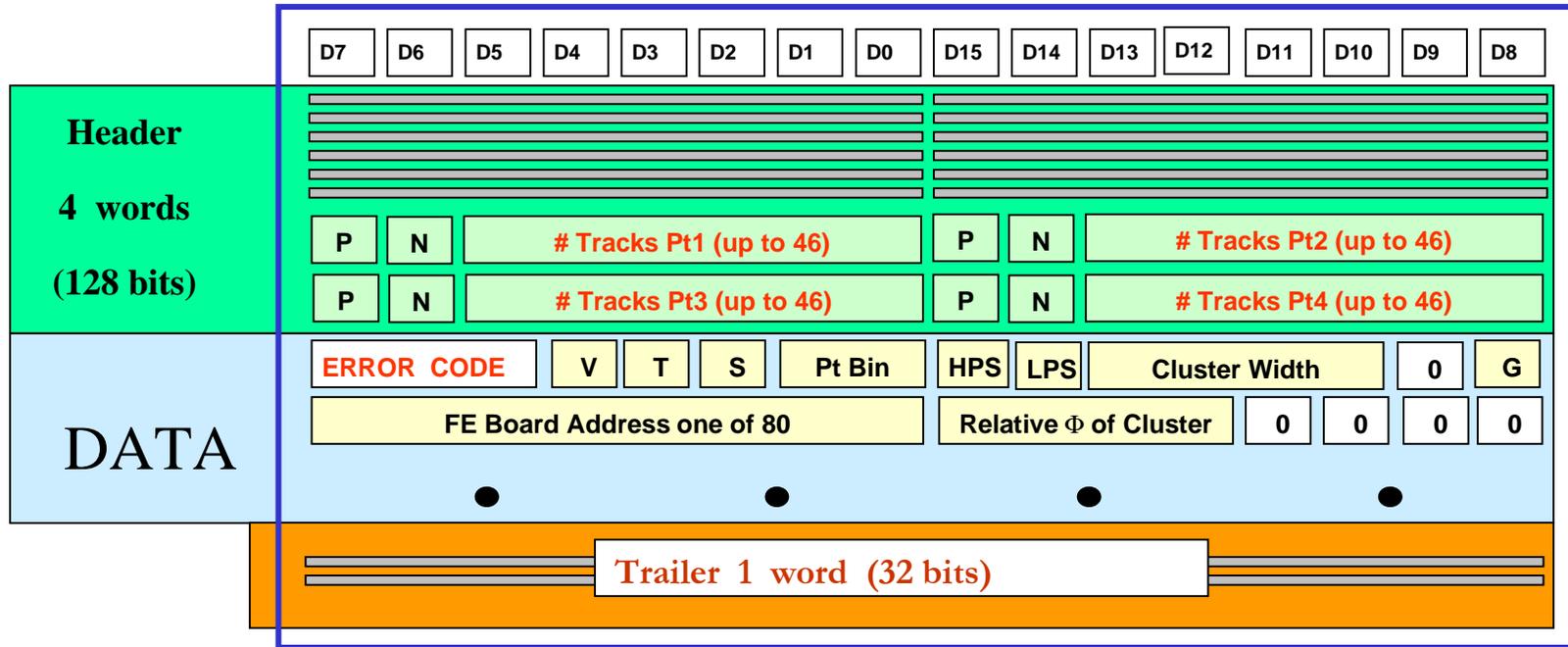
In this case the Header has only two Frames.

Each reported Cluster carries the following information

CL Sector Address	The Address of the 4.50 wedge were Clusters are native (same as TK Sector Address)
V	Set to 1 if there is a valid Cluster
G	Set to 1 if North, set to 0 if South
Cluster Address	The relative Address of the first element of the Cluster (Offset)
H	If set the Cluster is a High Threshold PS Cluster
L	If set the Cluster is a Low Threshold PS Cluster
T	Set to 1 if there is a valid Track
S	Sign of the Pt of the associated Track
Pt	The Pt Bin of the associated Track
Cluster Width	The number of elements in the Cluster



Bit Fields allocation for L2 CPS Axial data transfers between the Broadcaster Boards and the L2 PSpp (via FIC) using G Links



List of Clusters with tagging and address $n \times 32$ bits for a maximum of 46 Clusters
 If truncation of data is necessary the reporting is done moving counter clock wise, this will result in a possible Φ dependence of the efficiency.



Meaning of Terms used

In this case the Header has only three Frames.

Each reported Cluster carries the same information that in the previous case plus the following

Error Code

A three bit code with the following meaning

b1 Transmission error(s) detected and corrected

b2 Transmission error(s) detected and not corrected

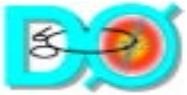
b4 Transmission truncated

where the “Transmission” refers to one used to send this data to the Broadcaster Board

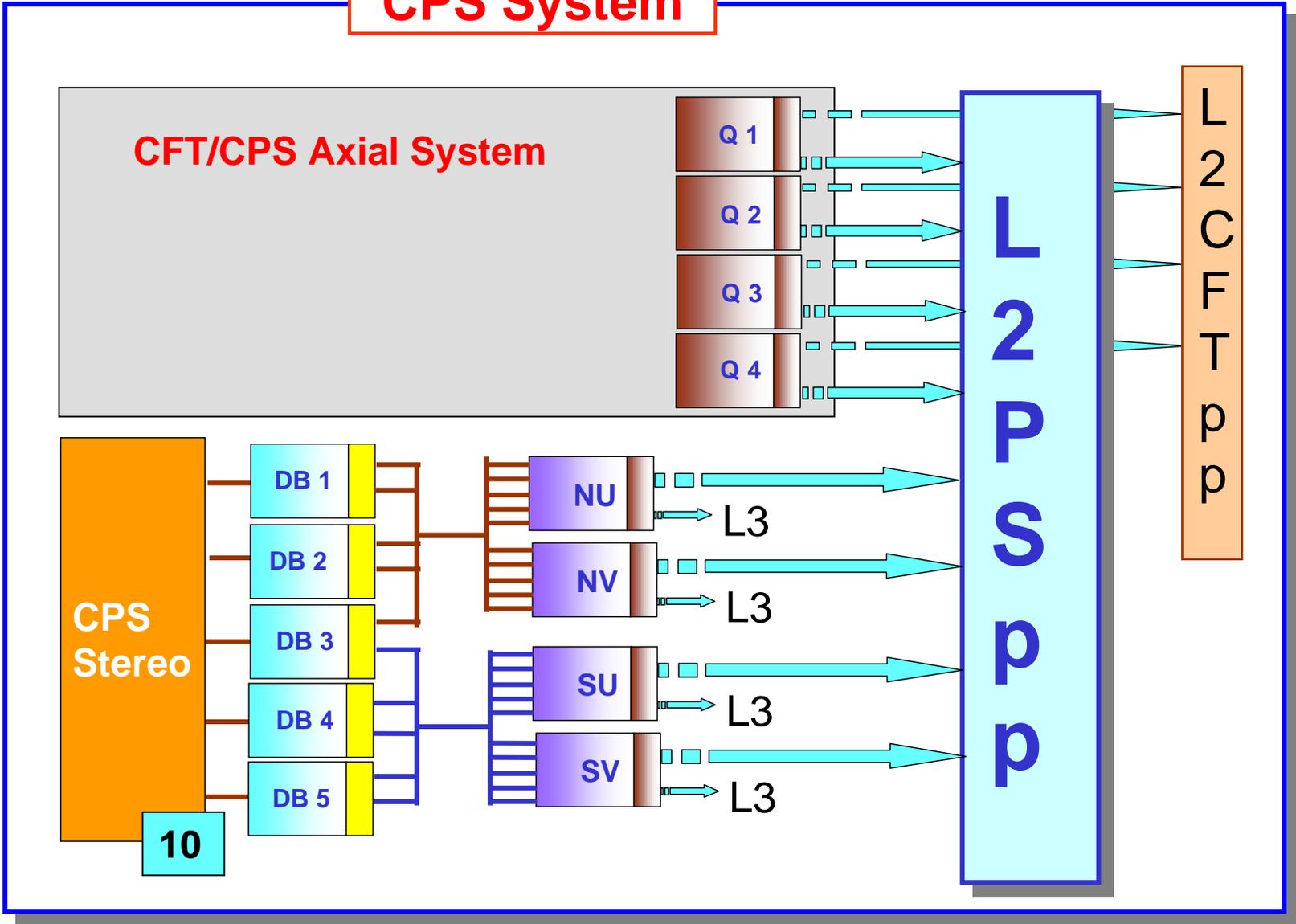
FE Board Address

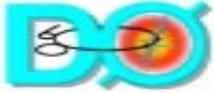
The address of the 4.50 wedge where the associated track is located or if there is not an associated track

the address of the 4.50 wedge where the Cluster is contained. This is the result of the curvature of the tracks: a cluster located in a given 4.50 sector could be associated with a track whose intersection with the H layer is in an adjacent sector!!



CPS System





CPS Stereo

FUNCTIONS PERFORMED BY THE BOARDS

DB Front End Digital Board

There are ten DBs, five for the North and five for the South ends of the CPS Stereo Tracker. Each DB generates a list of Clusters tagged with information pertaining to the threshold level of the Cluster, its orientation (U/V), its length and its geographical position defined as N/S and index of the first PS strip of the Cluster. The information collected is sent to two BC when a L1 Accept is received.

BC BroadCaster Board

Each BC receives information from the five DB and merges and reorganizes the information in a single list. The four list generated by the four BC boards are organized as follows:

NU List contains up to 46 Clusters with **U** orientation from the **N**orth half of the CPS

SU List contains up to 46 Clusters with **U** orientation from the **S**outh half of the CPS

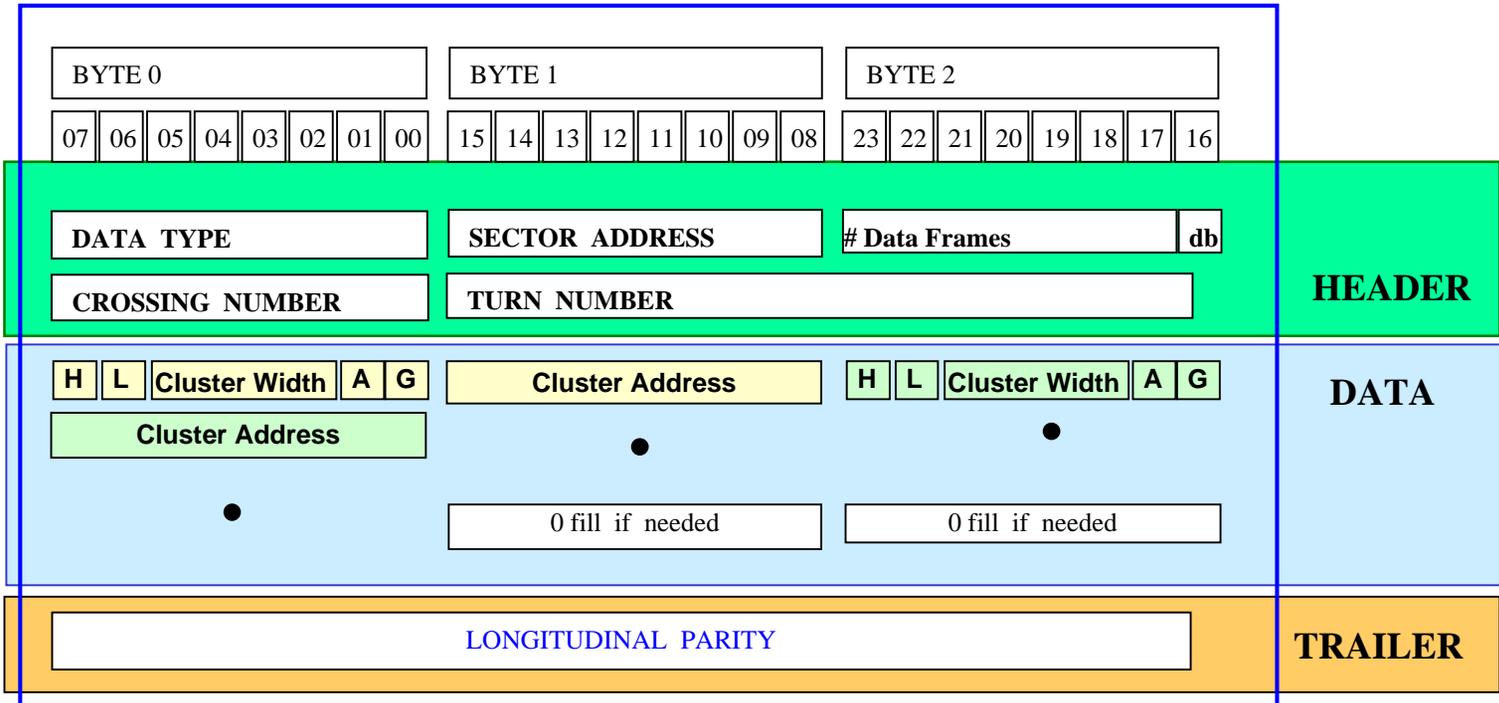
NV List contains up to 46 Clusters with **V** orientation from the **N**orth half of the CPS

SV List contains up to 46 Clusters with **V** orientation from the **S**outh half of the CPS

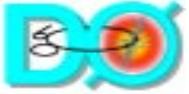
The lists are sent to the L2PSpp via four G Links.



**Bit Fields allocation for L2 CPS Stereo data transfers
between the Digital Front End boards and the Broadcaster Boards
using LVDS Links**



NOTES The Maximum number of Clusters reported per Digital Front End board is 16
The Cluster List is ordered in increasing stereo strip index

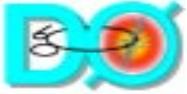


Meaning of Terms used

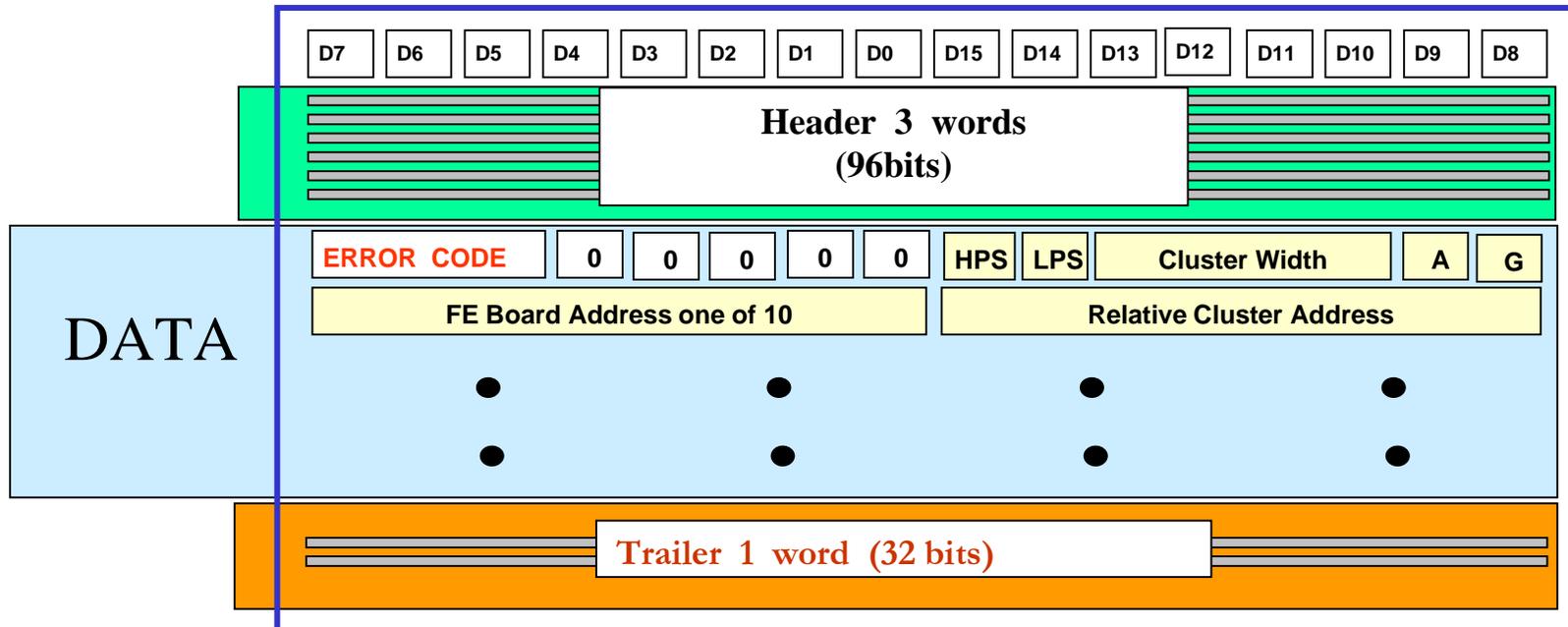
In this case the Header has only two Frames.

Each reported Cluster carries the following information

H	If set the Cluster is a High Threshold PS Cluster
L	If set the Cluster is a Low Threshold PS Cluster
Cluster Width	The number of elements in the Cluster
A	Orientation of the Cluster U/V
G	Set to 1 if North, set to 0 if South
Cluster Address	The relative Address of the first element of the Cluster



**Bit Fields allocation for L2 CPS Stereo data transfers between
the Broadcaster Boards
and the L2 Pre Processors (via FIC) using G Links**



List of Clusters with tagging and address $n \times 32$ bits for a maximum of 46 Clusters
If truncation of data is necessary the reporting is done moving counter clock wise,
this will result in a possible bias of the efficiency.



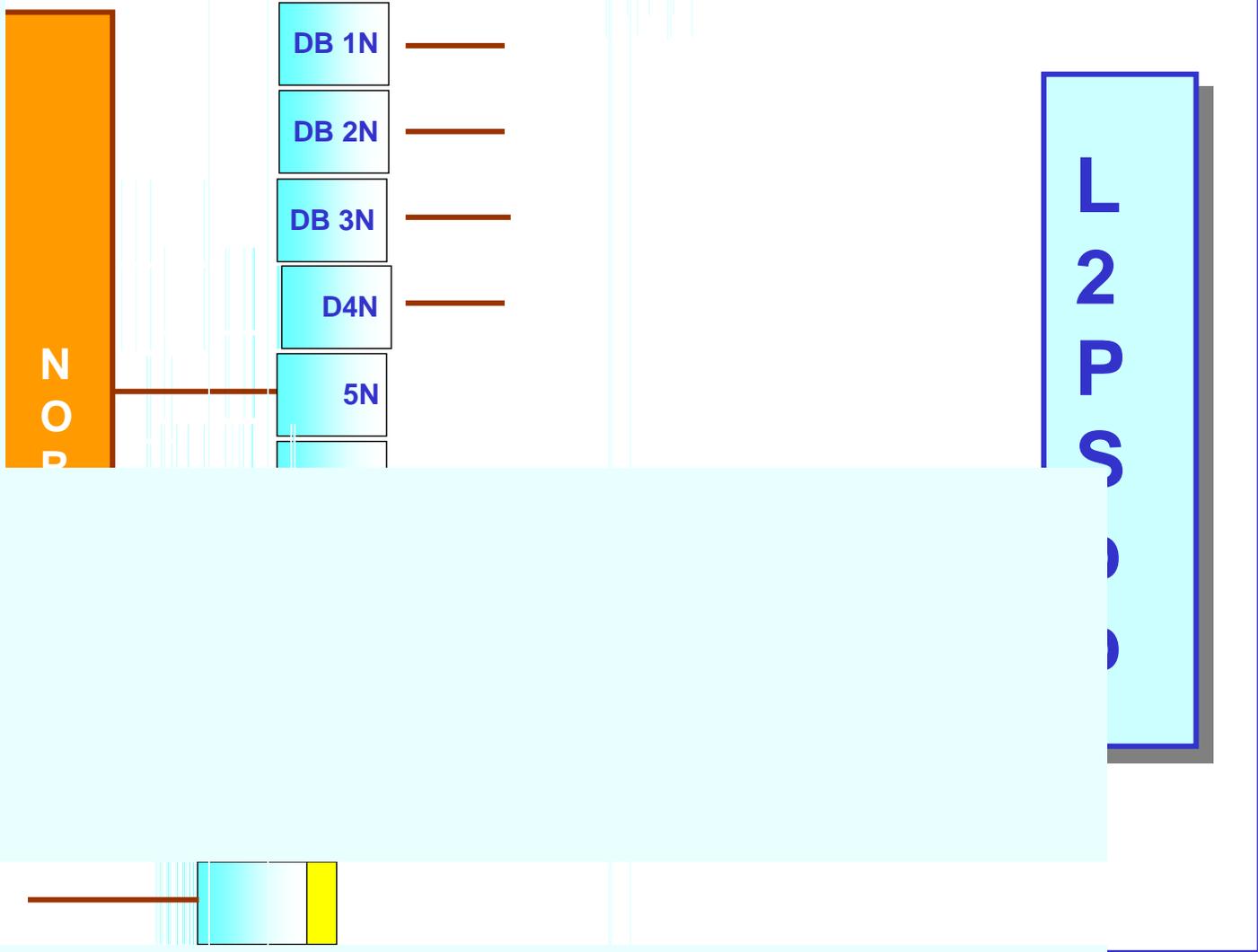
Meaning of Terms used

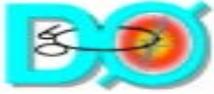
In this case the Header has three Frames.

Each reported Cluster carries the following information

Error Code	A three bit code reporting possible errors (same as before)
H	If set the Cluster is a High Threshold PS Cluster
L	If set the Cluster is a Low Threshold PS Cluster
Cluster Width	The number of elements in the Cluster
A	Orientation of the Cluster. Set to 1 for U, set to 0 for V
G	Set to 1 if North, set to 0 if South
FE Board Address one of 10	The address of the Analog Front End Board
Relative Cluster Address	The relative Address of the first element of the Cluster

FPS System





FPS System

FUNCTIONS PERFORMED BY THE BOARDS

DB Front End Digital Board

Collects hits from the FPS and tags them according to their energy threshold level into L or H. Find Clusters in the U and V layers before and after the 'absorber' panel. Match Cluster information according to orientation and threshold. Calculates the number of matched and unmatched tag Clusters and sends this L1 information to the assigned Collector boards. When the L1 Accept is asserted, it send the list of the Clusters found in the "Shower" side and the MIP Pattern associated with it in the corresponding "MIP" layer to the Collector. The Maximum number of clusters that each DB can send is 16. If necessary, the list is truncated by selecting the Clusters with lower address.

COL Collector Board

When L1 information arrives, adds the numbers of matched and unmatched Clusters according to their tagging. Sends this information to a BC via LVDS links.

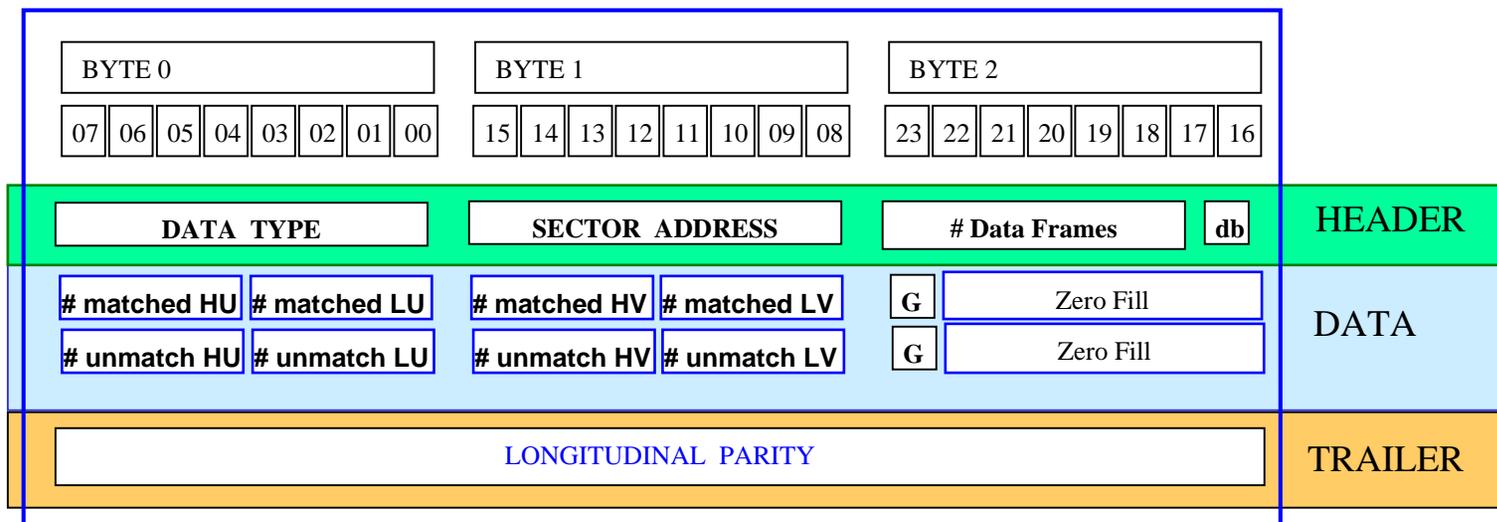
When L2 information arrives, each Collector board merges its eight input lists (Octants North or South) into one selecting U or V information. If the merged lists need to be truncated, priority is given to Clusters with lower address.

BC BroadCaster Board

The Broadcaster board receives L1 information from the four Collectors. It uses this information to create an exhaustive list of up to ninety six Trigger Terms which are sent to a L1FPS Trigger Manager board. The Trigger Manager board selects a subset of 32 terms to be sent to the L1 Trigger.



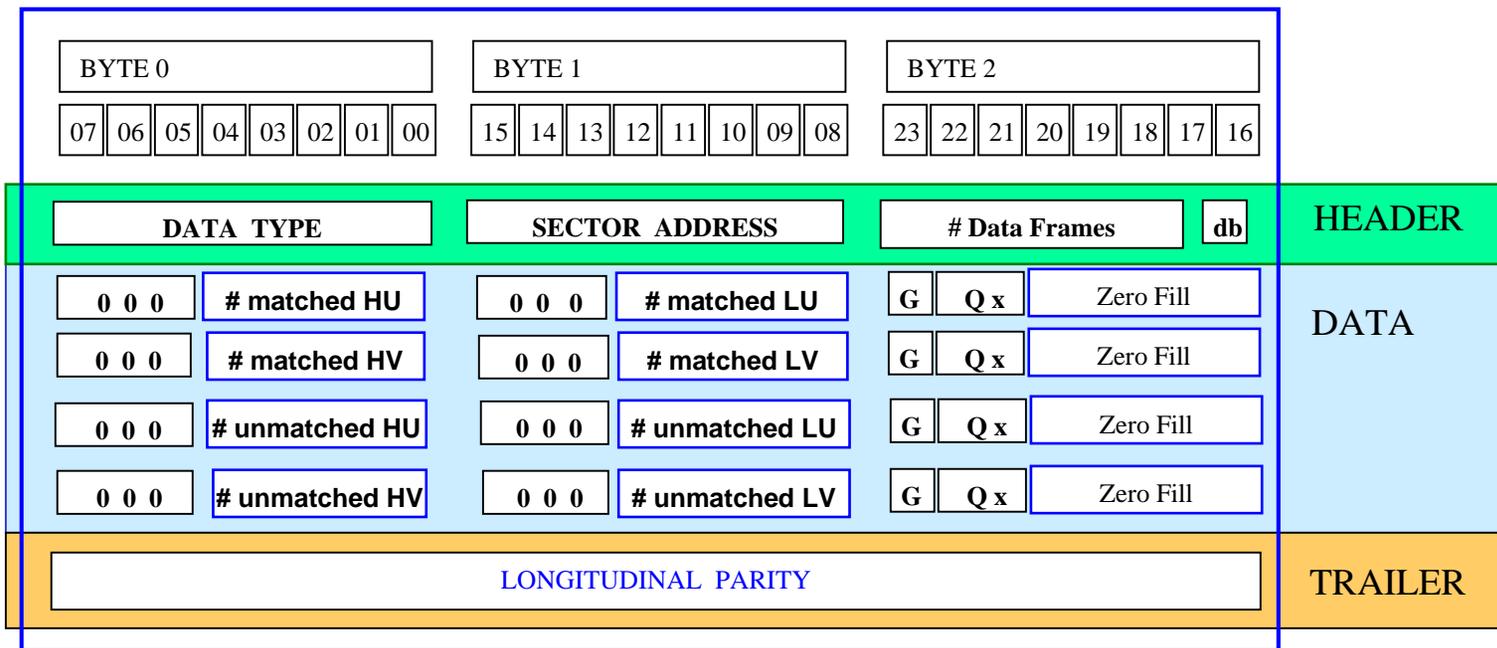
**Bit Fields allocation for L1 FPS data transfers between
the Digital Front End boards
and
the Collector Boards using LVDS Links**



NOTE Only 2 frames of Data are required
 The Maximum number of Matched or Unmatched Clusters reported by type is 16 for a theoretical maximum total of 128.
 Clusters are listed ordered in increasing stereo strip index
G is **1** if North side, **0** if South side



**Bit Fields allocation for L1 FPS data transfers between
the Collector Boards
and
the Broadcaster Board using LVDS Links**



NOTE The Maximum number of Matched or Unmatched Clusters reported per Collector board is 24 for a theoretical maximum of 96.



Meaning of Terms used

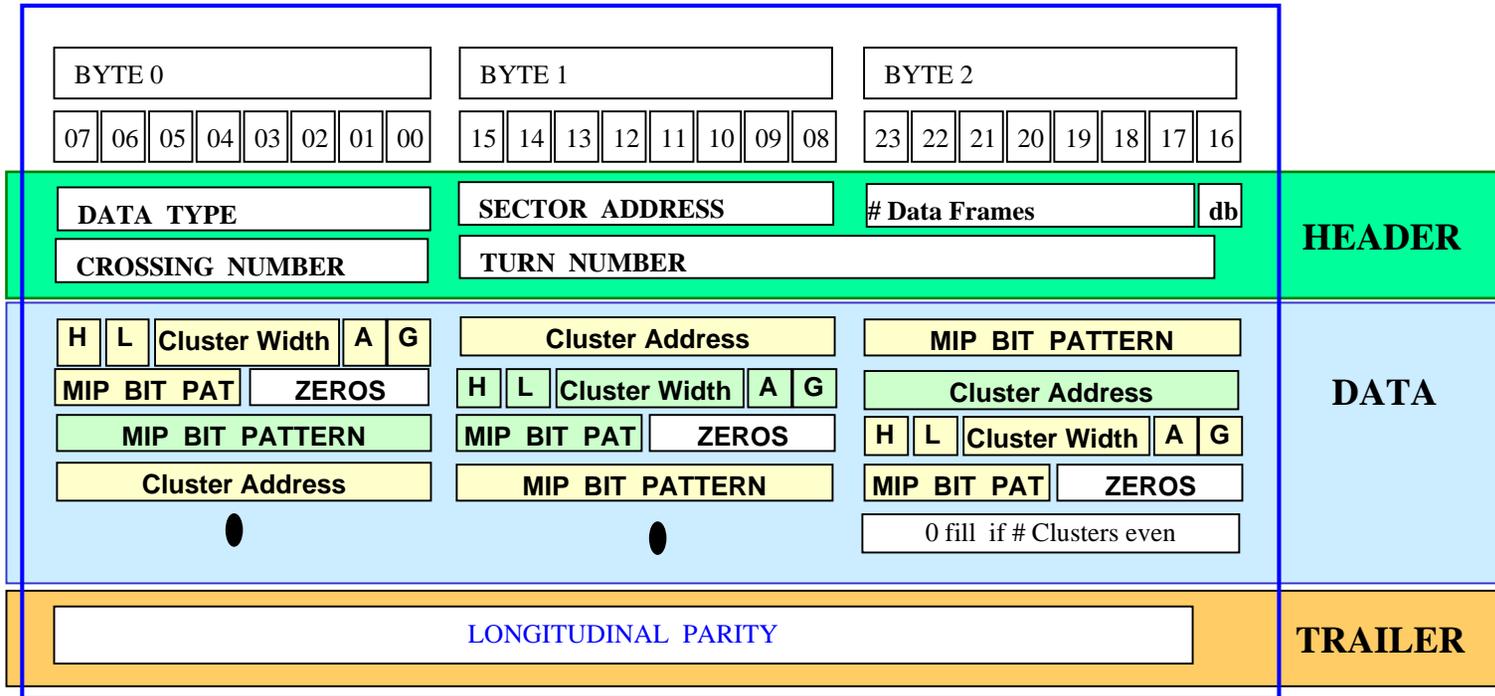
In this case the Header has only two Frames.

Each reported Cluster carries the following information

HU	The Cluster is a High Threshold PS Cluster in the U layer
LU	The Cluster is a Low Threshold PS Cluster in the U layer
HV	The Cluster is a High Threshold PS Cluster in the V layer
LV	The Cluster is a Low Threshold PS Cluster in the V layer
Matched xx	
Unmatched xx	
G	Relative Z orientation G = 1 for North, G = 0 for South
Qx	Quadrant information: Q1, Q2, Q3 or Q4



Bit Fields allocation for L2 FPS data transfers between the Digital Front End boards and the Collector Boards using LVDS Links

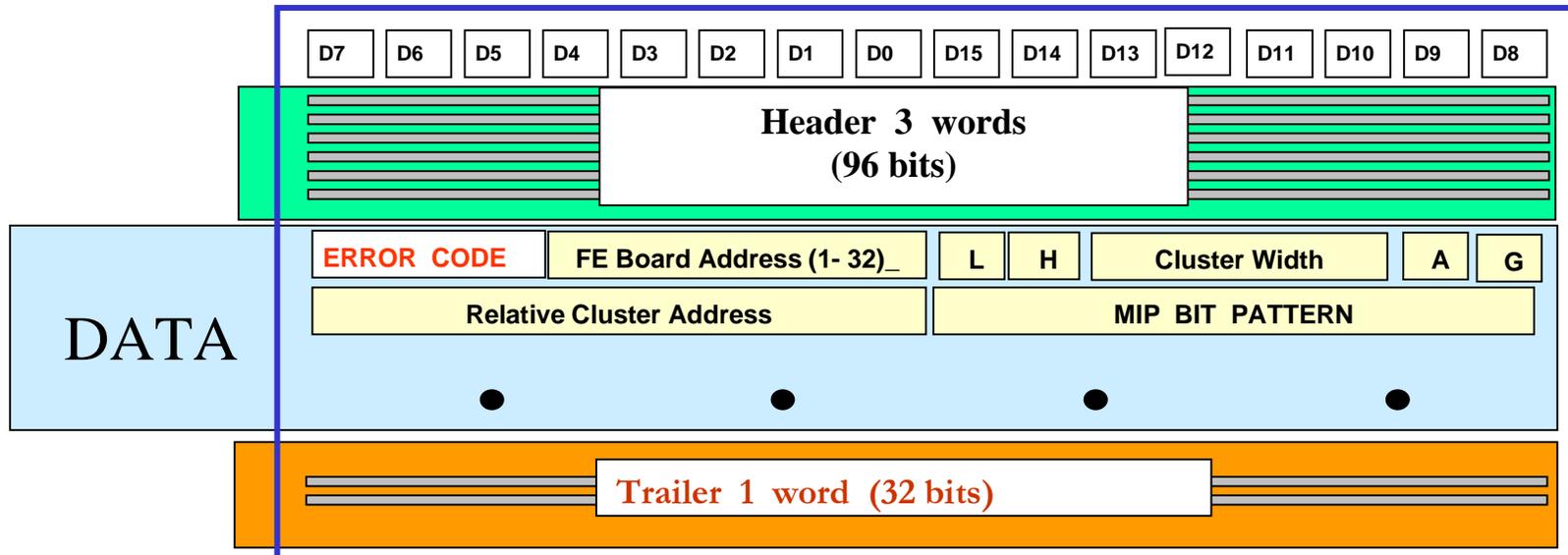


NOTES The Maximum number of Clusters reported per 22.5° Wedge is 16 from each side (N/S)

The Cluster List is ordered in increasing strip index



Bit Fields allocation for **L2 FPS** data transfers between
the **Collector Boards**
and the **L2 PSpp (via FIC) using G Links**



List of Clusters with tagging and address $n \times 32$ bits for a maximum of 48 Clusters per Collector board.

If truncation of data is necessary the reporting is done moving counter clock wise, this will result in a possible bias of the efficiency.



Meaning of Terms used

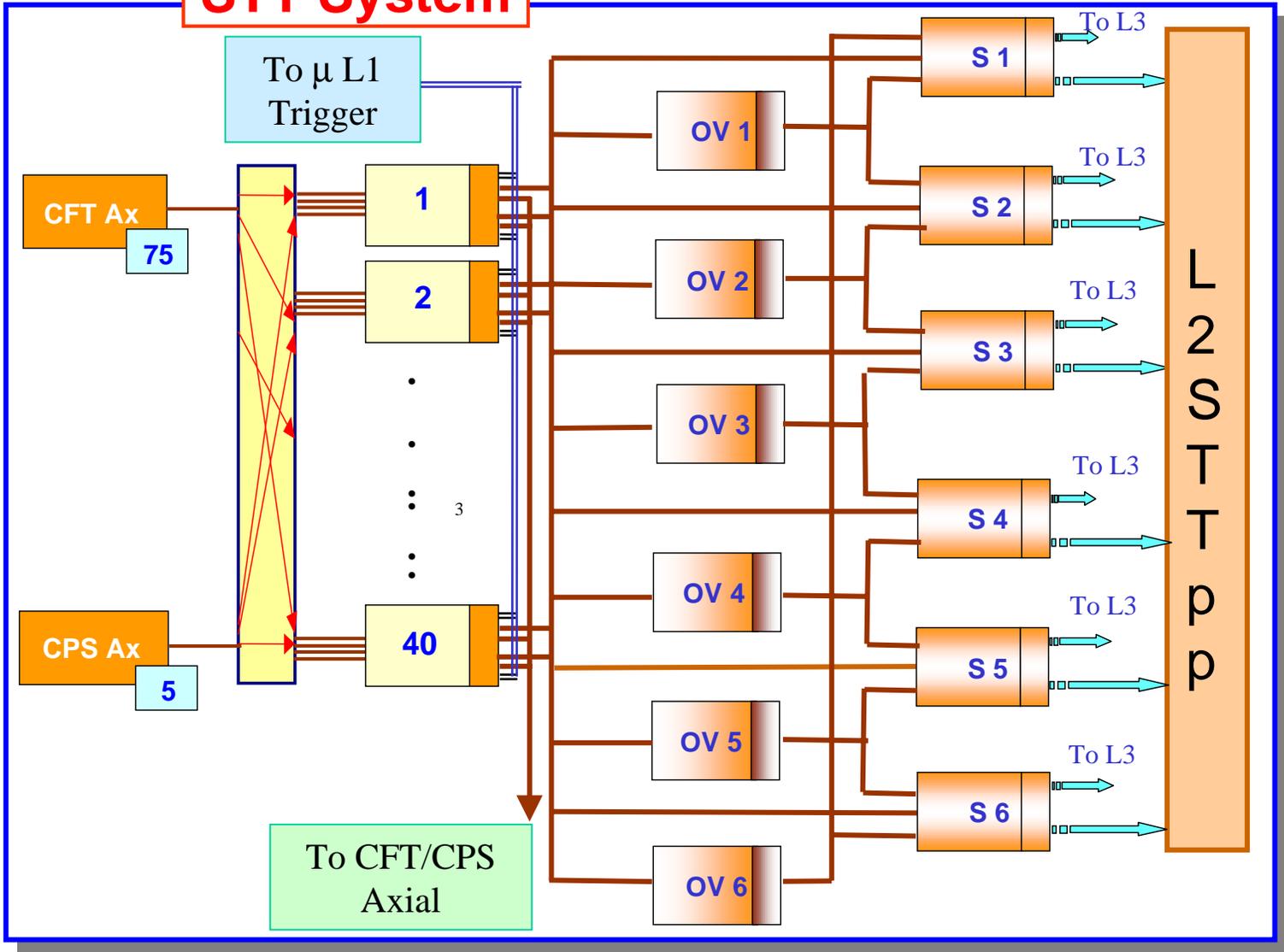
In this case the Header has only two Frames.

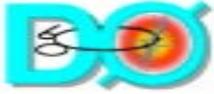
Each reported Cluster carries the following information

H	If set the Cluster is a High Threshold PS Cluster
L	If set the Cluster is a Low Threshold PS Cluster
Cluster Width	The number of elements in the Cluster
A	Orientation of the Cluster U/V
G	Set to 1 if North, set to 0 if South
Cluster Address	The relative Address of the first element of the Cluster
MIP BIT PATTERN	Pattern of 1s and 0s corresponding to the PS Strips Hits in a window in the MIP layer “in front” of the Shower layer cluster.



STT System





STT System

FUNCTIONS PERFORMED BY THE BOARDS

DB Front End **D**igital **B**oard

These are the same as the ones used in the CFT/CPS Axial System.

COL **C**ollector Board

Each COL receives information from 6/2 DBs (data from 6 Analog Front End Cards) corresponding to one Overlay region. When L1 information is detected the OV Collectors are inactive. When L2 information is detected the OV COL acts the same way that the Octant COL in the CFT but with a diminished number of inputs.

BC **B**road**C**aster Board

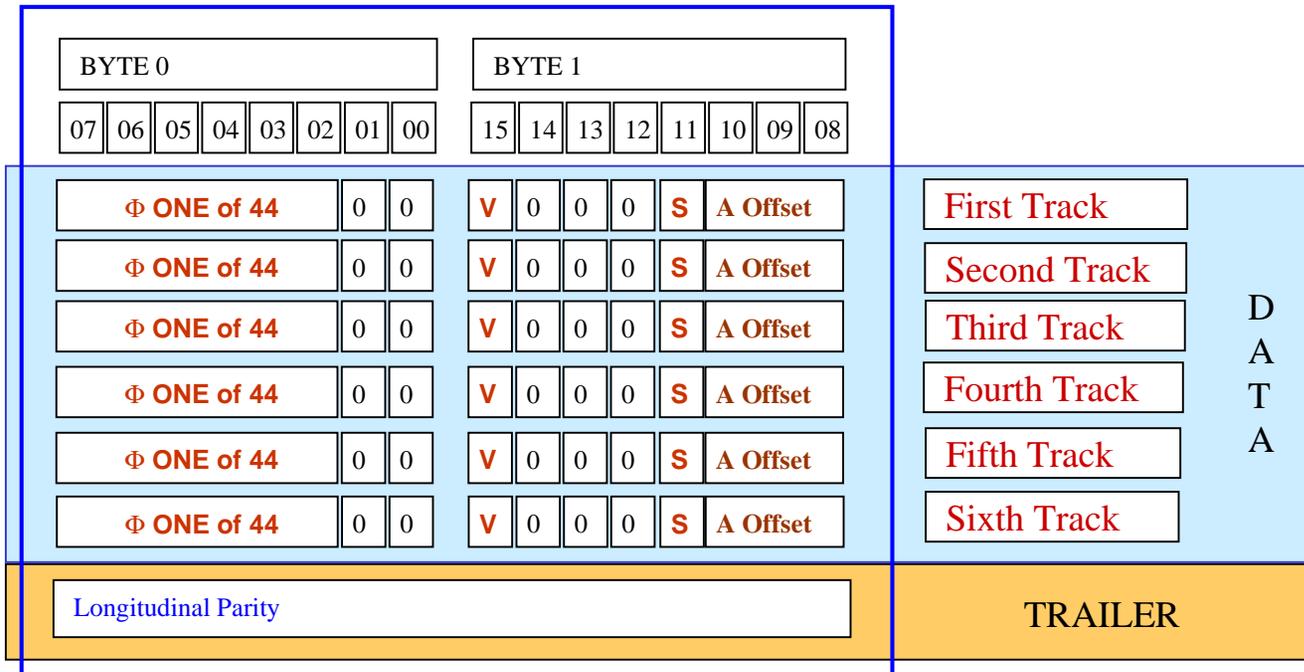
These boards receive information from the two adjacent Overlay regions and from the necessary number of DBs to complete a Sextant. In all respects these BC behave the same way that the Octants in the CFT System with two exceptions:

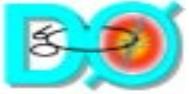
- 1) data is for a Sextant only
- 2) one G Link sends information to the L3, the other sends information to the L2STTpp.

The protocols and data patterns followed are exactly the same as the ones used by the L2CFT



**Bit Fields allocation for L1 CFT/CPS data transfers between
the Front End Digital Board
and
the μ Trigger Manager using FSC Links**





Meaning of Terms used

In this case there is no Header, only Data and Trailer.

Each track field (16 bits) carries the following information

