

TOF Fiber Data Format

Version 2.5 (5 March 2013)

The TOF fiber data format is based on the assumption that the data will be produced by HPTDC's on the TOF trays, and these data will already be preformatted by the HPTDC's. The TCPU will not manipulate the words produced by the HPTDC's but rather send them on the fiber unmodified. However, the TCPU will add additional information data words to the data stream to uniquely identify the data being sent over the fiber as well as optionally send additional debug data.

The unit of data on the DDL fiber is a 32-bit word. This matches the HPTDC data word which is also 32bit. Since the HPTDC already provides a scheme for data formatting, we will adopt this scheme in the TOF fiber data as well. The HPTDC data format defines the most significant (MSB) 4 bits of each 32-bit word as a packet identifier as follows:

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
p	p	p	p	data																											

where *pppp* is the packet identifier. The HPTDC defines 8 of the possible 16 identifiers internally, and leaves the other 8 (all identifiers with *pppp* > 7) to the user. For the TOF we will define the packet identifiers as follows:

<i>pppp</i>	Packet Use
0100	Leading edge HPTDC data
0101	Trailing edge HPTDC data
0010	TDC header
0110	TDC errors
1001	Multiplicity data
1010	Header trigger data
1011	Header debug data
1100	Geographical data
1101	Header tag word
1110	TDIG Separator word
1111	reserved

Leading Edge Data

The **leading edge data** is produced by the HPTDC in “very high resolution” mode with 8 channels per HPTDC and the HPTDC defines the packet format as follows:

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	0	TDC		Channel		Inter.		Leading edge time																					

Table 1: Leading edge HPTDC data word

where:

TDC: Programmed ID of TDC
 Channel: TDC channel number (0 – 7)
 Inter: Interpolation factor (2 least significant bits of time measurement)
 Leading edge time: Time measurement in 100ps bins (most significant 19 bits)

Trailing Edge Data

The **trailing edge data** is produced by the HPTDC in “very high resolution mode” in the same TDC that generates the leading edge data. The HPTDC defines the packet format for these trailing edge data as follows:

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	TDC				Channel	Inter.	Leading edge time																					

Table 2: Trailing edge HPTDC data word

where:

TDC: Programmed ID of TDC
 Channel: TDC channel number (0 – 7)
 Inter: Interpolation factor (2 least significant bits of time measurement)
 Trailing edge time: Time measurement in 100ps bins (most significant 19 bits)

TDC header

The **TDC header** is produced by the first HPTDC in each readout chain (one per half tray). The HPTDC defines the packet format for these trailing edge data as follows:

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	TDC				Event ID														Bunch ID									

Table 3: HPTDC header word

where:

TDC: Programmed ID of TDC
 Event ID: Event ID from event counter
 Bunch ID: Bunch ID of trigger (trigger time tag)

TDC errors

If the TDC detects an error condition, it will send extra error words with the error condition indicated in the corresponding error flag bits:

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	TDC														Error flags													

Table 4: HPTDC errors

“TDC” is the programmed TDC ID of the HPTDC with errors. See the HPTDC manual for the meaning of the error flag bits.

Geographical Data

As shown in these two packets, the HPTDC allows the user to program a 4-bit TDC ID. In TOF we can use this TDC ID as part of the geographical information of the TDC as follows:

There are a total of 8 TDIG boards on each tray, numbered 0 to 7 with increasing eta. Each TDIG has 3 HPTDC chips. We define the ID’s of the 4 TDC’s of board 0 to be 0, 1, and 2; board 1 will have IDs 4, 5, and 6; board 2 will have IDs 8 through 10; board 3 will have IDs 12 through 14. This scheme will be repeated through boards 4 through 7. In this way, each half tray will have every TDC on its TDIG board uniquely identified, and the data from each half tray will not need any additional geographical information, if these data packets are kept together on the fiber. There are a total of 120 trays in TOF, i.e. 240 half trays. We will use the “Geographical Data” packets to identify sections of “half-trays” on the fiber by pre-pending the data from each half tray with a geographical data word which is formatted as follows:

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0											tray ID										H							

Table 5: Geographical Data Word

where

- “1100” is the packet identifier for a geographical word,
- “tray ID” is a number between 1 and 120, uniquely identifying each tray according to the document “STAR Geometry” (STAR Note 229)
- “H” is either 0 or 1, identifying a *half tray* corresponding to 4 TDIG boards; TDIG boards 0 – 3 correspond to $H = 0$, while TDIG boards 4 – 7 correspond to $H = 1$.
- In case of the start detectors we define the “tray ID” to be “121” (West) or “122” (East). Depending on the number and arrangement of TDIG boards for the start detector, there might be two “halves” of the start detector that will be identified in a fashion similar to the actual trays, i.e. TDIG board 0 – 3 will have $H = 0$, while TDIG boards 4 – 7 will have “ $H = 1$ ”.

Header Trigger Data

The sequence of geographical data and HPTDC data will be pre-pended on the fiber by 3 32-bit words of header data. The first word will be a trigger data word, which is formatted as follows:

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0									trigger				daq				token											

Table 6: Trigger data word (header word 1 of 3)

where:

trigger: Trigger command word from the TCD
 daq: DAQ command word from the TCD
 token: 12-bit trigger token from the TCD

Header Debug Data

The following word is a “*Header Debug Data*” word and can be used to send additional data across the fiber to aid in debugging data errors. It is formatted as follows (the content of the data word is currently undefined):

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	1																												

Table 7: Debug data word (header word 2 of 3)

Header Tag Word

The 3rd word on the fiber is a place holder for future use. For the moment, we can define this word with a tag word as its content, e.g. 0xdeadface, as follows:

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	1	1	0	1	0	1	0	1	1	0	1	1	1	1	1	1	0	1	0	1	1	0	0	1	1	1	0

Table 8: Tag data word (header word 3 of 3)

TDIG Separator Word

The TDIG Separator word is an optional data item that follows the HPTDC data in order to indicate the end of the half tray readout. Current firmware has this word enabled even if there are no data from a half tray.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	H											Item Ctr							Readout Ctr									

Table 9: TDIG Separator Word

where:

- H: Tray half (0 or 1)
Item Ctr: Number of HPTDC data words from this half tray (i.e. not including geographical word and separator word)
Readout Ctr: Number of readouts (triggers) since last reset (modulo 256)

To summarize, the data sequence on the fiber with this definition would look as follows:

Word #:	Contents:
1	Header Trigger Data Word
2	Header Debug Data Word (if available)
3	Header Tag Word (0xdeadface)
4	Geographical Data (e.g. half tray H=1)
5	HPTDC data word (boards 4 – 7)
...	...
5+n	HPTDC data word (boards 4 – 7)
5+n+1	TDIG Separator Word (optional)
5+n+2	Geographical Data (e.g. half tray H=0)
5+n+3	HPTDC data word (boards 0 – 3)
...	...
m	HPTDC data word (boards 0 – 3)
m+1	TDIG Separator Word (optional)
m+2	Geographical Data (next half tray with data)
m+3	HPTDC data word
...	...

For debug purposes, additional debug words or separator words might be interspersed in this data stream. The specific meaning of these words is left unspecified by this document, but can be defined as needed. For data analysis purposes, these additional words can safely be ignored.