View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by CERN Document Server

CERN

ALICE Internal Note
ALICE reference number
ALICE-INT-2002-010 V 11.0
Institute reference number
[000]
Date of last change
2007-Mar-6

Data Format over the ALICE DDL

Authors:
R. Divià, P. Jovanovic, P. Vande Vyvre

Abstract:

The data blocks transferred by the readout electronics over the DDL have to be identified and formatted to permit their identification and an efficient processing in the receiving LDCs. A common header for ALICE has been defined including the minimal set of mandatory information. This common header must be added to the raw data before sending them over the DDL.

This note includes the motivations for this common data format and describes the current implementation, which maps to the unique format version identifier equal to 2.

Contact Person P.Vande Vyvre e-mail:Pierre.Vande.Vyvre@cern.ch
Tel: + 41-22 767.83.36 / Fax : + 41-22.767.95.85 Creation Date: 2001-Jun-08

Distribution lists
For Approval:

For Information:

EDMS Number: version 0.0

1 Introduction

It is mandatory for the DAQ to be able to identify all the data blocks transferred by every detector readout electronics over the DDL [1, 2]. A proposal of implementation of a common data format has been elaborated and discussed between the DAQ group and representatives of all the detector projects. It has then been presented and discussed in the Technical Board meetings of June 2001, July 2002 and July 2006. This new version of the note has been updated according to the discussions in the TB and it includes the input of the detector groups concerning the standard error bits [3, 4, 10]. It also reflects the changes made in the last version of the Trigger CTP Preliminary Design Review [5] and it includes the peculiar format used for the CTP readout.

The data format described here must be generated by the readout electronics. It covers the mandatory minimum data format for all the data blocks sent over the DDL and provides the information required to identify the data in the DAQ system. Extensions could be defined in different areas such as the data themselves.

The identification of a data block and its processing in a data-driven system requires at least the following information: the format version, the event identification and the trigger information. The corresponding fields of the common data format header are therefore mandatory.

In addition, three fields have been added to the common data format header: the block length, the event attributes and the ROI data. These fields must be present in each data block transferred but it is not mandatory to fill them in.

The format of the raw data themselves is detector dependent. The internal format of the data payload is therefore not covered in this note. There would however be some benefit if the detector groups could publish the data format that they plan to use at least for information purposes.

2 Common data format

Data transferred from the Front-End Electronic (FEE) to the Local Data Concentrators (LDCs) must be formatted as follows:

1. A header – describing the associated data block(s), the trigger conditions, the error and status conditions and other information dependent on the readout electronics – has to be created while the raw data is collected and must be sent first.

2. One or more data blocks – described by the preceding header – belonging to the same physics or software trigger, may follow the header.

While the header is mandatory and must be created for all data blocks sent over the DDL, the data blocks are optional and may be skipped in case there is no valid data associated to a given event.

All the events associated to the same trigger (physics or software) must be sent over the DDL within the same block and preceded by one header. It is not possible to send two headers with the same trigger identification information (Event ID 1/Event ID 2 – see Figure 1).

<table>
<tr><th></th><th colspan="2">31 … 24</th><th colspan="3">16</th><th>8 … 0</th></tr>
<tr><td>0</td><td colspan="7">Block length [5]
[0-31]</td></tr>
<tr><td>1</td><td colspan="2">Format version [5]
[24-31]</td><td>MBZ
[22-23]</td><td colspan="2">L1 trigger message [1] [14-21]</td><td>MBZ
[12-13]</td><td>Event ID 1
(bunch crossing) [2] [0-11]</td></tr>
<tr><td>2</td><td colspan="2">MBZ
[24-31]</td><td colspan="5">Event ID 2 (orbit number) [2]
[0-23]</td></tr>
<tr><td>3</td><td colspan="2">Block attributes [5]
[24-31]</td><td colspan="5">Participating sub-detectors [2]
[0-23]</td></tr>
<tr><td>4</td><td>MBZ
[28-31]</td><td colspan="5">Status & error bits [5]
[12-27]</td><td>Mini-event ID
(bunch crossing) [3] [0-11]</td></tr>
<tr><td>5</td><td colspan="7">Trigger classes low [2]
[0-31]</td></tr>
<tr><td>6</td><td>ROI low [4]
[28-31]</td><td colspan="3">MBZ
[18-27]</td><td colspan="3">Trigger classes high [2]
[0-17]</td></tr>
<tr><td>7</td><td colspan="7">ROI high [4]
[0-31]</td></tr>
</table>

Figure 1. Format of Common Data Header.

The various fields of the common data format header are either loaded using the data transmitted by the ALICE Trigger system or created locally by the FEE when running without the ALICE Trigger system (e.g. for standalone tests). The presence or absence of the ALICE Trigger system is marked by the “trigger information unavailable” status bit (see Section 2.7). This bit must be set when the event is generated without the directives from the ALICE Trigger system. The sources of the fields are indicated [1,2,3,4,5] for the case of ALICE Trigger system present. If the ALICE Trigger system is not present, the readout electronics must handle autonomously all the fields as indicated in this document. By respecting these conventions, the DAQ system can perform part of its functions and ensure a minimum check on the data format under all running conditions. Readout is performed assuming a “global trigger” condition and a set of consecutive Event IDs will be created.

The fields marked with white background (e.g. “Block length”) are optional and can be left void if their value is not available or not needed. The fields marked in gray background (e.g. “Format Version”) are mandatory and must be filled with their correct value, as defined at the moment the event is generated. All fields marked “MBZ” (Must Be Zero) are reserved for future use and must be set to zero by the readout electronics.

[1] From Trigger Level 1 (trigger L1 Message)
[2] From Trigger Level 2 Accept (trigger L2a Message)
[3] From local TTC Rx
[4] From RoIP, following Trigger Level 1 arrival
[5] Generated by readout electronics

We will now review the individual fields of the common data format header.

2.1 Block length

The block length is an optional field. It can be filled in by the detector readout electronics to indicate the total length of the data block including header and payload(s). The length must be expressed in bytes being transferred over the DDL. If not handled, the field must be loaded with hexadecimal FFFFFFFF to distinguish it from an erroneous zero value.

2.2 Format version

The format version indicates which version of the present data format is used. The presence of this field provides the backward compatibility in case of change or upgrades. The content of the field must be compared with the current format version number (zero-extended to 8 bits), as defined within the first page of this document.

2.3 L1 Trigger message

The L1 Trigger message consists of selected parts of the trigger L1 Message (a preliminary description is available in [5], currently under review). This information is distributed over the TTC to the detector readout. This field is a direct (bit-by-bit) copy of the eight data bits [4..11] of the L1 Message Word 1. It should contain the information given in Table 1.

L1 Trigger message field of the Common Data Header	Data payload of the L1 Message Word 1
Bit 21	Spare bit
Bit 20	ClT bit
Bit 19-16	RoC[4..1]
Bit 15	ESR bit
Bit 14	L1SwC bit

Table 1. Mapping between the L1 Trigger message field of the Common Data Header and the Trigger L1 Message Word 1.

When the ALICE Trigger system is not available, this field can contain any value.

2.4 Event ID (1 & 2)

The LHC clock will supply the event identification in ALICE. This clock is distributed to all the detectors readout units by the TTC [6] system used as trigger distribution network. The current LHC design foresees 3564 bunches in one orbit. The LHC clock identifies each bunch crossing within an orbit and signals the beginning of a new orbit.

Currently the TTC foresees 12 bits for the bunch crossing number. The Trigger system shall include a cyclic counter of 24 bits to count the orbit. This scheme uniquely identifies every bunch crossing in a period of more than 20 minutes (2^{24} x 88 μs = 1476 s = 24 minutes), which is sufficient for this purpose. Further identification will be added by the DAQ to uniquely identify one event in a run.

The information stored in the Event ID fields (1 & 2) is transmitted by the CTP. It is distributed over the TTC in a dedicated part of the L2a Message and received via the TTC Rx chips.

When running without the ALICE Trigger system, the Event ID 1 field must be set to zero and the Event ID 2 must contain an incremental, unsigned binary number, to be reset at FEE reset.

2.5 Block Attributes

The block attributes is an optional field that can be used freely by the detector groups to encode specific information such as the event type. If unused, this field should be set to zero.

2.6 Participating Sub-Detectors

The mask of participating detectors is a mandatory field. Its information is produced by the CTP only while handling software triggers (Test Classes). It is distributed over the TTC in a dedicated part of the L2a Message and received via the TTC Rx chips. The received value must be copied as-is in the "Participating Sub-Detectors" field.

When running without the ALICE Trigger system, the "Participating Sub-Detectors" field can be loaded with any value.

2.7 Status and error bits

This is a mandatory field, to be loaded by the readout electronics under all running conditions. An error or status condition that occurred before, during or right after FEE readout must be signaled by setting to one the corresponding bit(s) of this field. The assignment of the individual bits is described in Table 2.

Bit 0	Trigger overlap error (L0 received while processing another L0)
Bit 1	Trigger missing error (L1 received while no L0 received, or L2a or L2r received while no L1 received)
Bit 2	Data parity error
Bit 3	Control parity error (instruction and/or address)
Bit 4	Trigger information unavailable
Bit 5	FEE error

Bit 6	HLT decision flag
Bit 7	HLT payload flag
Bit 8	DDG payload flag
Bit 9	Trigger L1 time violation (transmission of any L1 signal outside the L1 decision BC interval)
Bit 10	Trigger L2 time violation (L1 received while no L2a/L2r received after 500 us)
Bit 11	Pre-Pulse error (transmission of the Pre-Pulse signal in a bunch crossing different from the programmable Pre pulse BC interval/range)
Bit 12	Trigger error (any other trigger error, e.g. error in the trigger message)
Bit 13	Trigger L1 missing error. L2 received while no L1 received
Bit 14	Multi-Event Buffer error. Buffer not empty after last L2 or L2 timeout
Bit 15	Reserved for future use

Table 2. Status and error bits definition.

The significance of some bits has been defined based on the input from detectors [3, 4, 10]. Other bits have been defined by the ALICE DAQ project (HLT decision/payload and DDG payload) and are reserved for HLT and ALICE/DAQ use. New bits may be assigned when further need will arise. Already assigned bits will never change their meaning in future versions of this document,

2.8 Mini-Event ID

As proposed in the CTP Preliminary Design Review [5], local event identification must also be included in the common data format for cross-verification with the global event identification. This local event identification is the value of the local BC counter at the time the detector has received the trigger L1 signal. The counter is a part of the TTC Rx chip [7].

The local bunch-crossing counters of all the TTC Rx chips of the experiment must be synchronous. A key issue is to resynchronize them at regular intervals to ensure that this synchronism is maintained. The solution chosen is to use the mechanism foreseen by the TTC system.

The local bunch-crossing counter in the TTC Rx chip is automatically reset by a fast signal synchronous with the LHC orbit. The LHC orbit signal is delivered by the TTCmi module [8]. This signal is then sent over the TTC as a short-format broadcast signal. Proper usage and setting of the TTCvi module [9] will guarantee that the TTC Rx chip receives this reset command by the end of the LHC extractor gap. The TTCvi provides four priority levels for data transmission. The bunch counter reset command uses the highest priority (level 0).

The Mini-Event ID is a mandatory field.

When running without the ALICE Trigger system, the Mini-Event ID field must be set to zero.

2.9 Trigger classes (Low & High)

For physics triggers, the bits encoded in the Trigger Classes Low and Trigger Classes High fields (see Figure 1) are taken as-is from the trigger L2a Message.

When running without the ALICE Trigger system, these two fields can contain any value.

2.10 Region Of Interest (ROI) (Low & High)

The ROI data is distributed over the TTC system. The value - if available - should be stored in the ROI Low and ROI High fields.

When running without the ALICE Trigger system, the ROI Low and ROI High fields can contain any value.

3 Central Trigger Processor Readout and Interaction Record data format

The *CTP Readout* and the *Interaction Record* data shall be generated by the CTP and transmitted to the DAQ *via* the ALICE optical Detector Data Link (DDL) [1, 2]. The hardware and the communication procedure shall be standard - identical to the channels that transmit the sub-detector readout. The nature of the data, and the timing and rate of their generation, on the other hand, differ significantly from the sub-detector readout and shall be formatted by a “customized” data format.

The *CTP Readout* will contribute to the event-building task. It is *a redundant channel* that carries *exactly the same information* broadcast, at the time of **L2a** decision, to all the participating sub-detectors (***L2a** Message*). It will be used by the ALICE data-driven DAQ system to resolve error conditions.

The *Interaction Record* is an *aid* to the pattern recognition task. The generation of the record is continuous, rather than “triggered” by any CTP or DAQ action. The data do not “interfere” with any on-line operation - they only need to be archived for the off-line use. The CTP Preliminary Design Review [5] “permits” occasional gaps in the recording.

The data format significantly simplifies the hardware blocks in the CTP that deal with the record generation: the data word is effectively reduced to 12 bits; the sequence closely follows the data flow in the CTP. The data transmitted to the DAQ contain very different information compared to the raw event data that make up the sub-detector readout and they will have to be “processed” by ad-hoc DAQ software. Inside the DAQ, the data from the CTP will be “re-edited”, headers appended, *etc*. by the dedicated software that will make the data block compatible with the standard readout format used by the sub-detector.

3.1 The CTP Readout data format

For *each* **L2a** decision, the CTP transmits to the DAQ a data block, the *CTP Readout*, containing the same information that is also broadcast to all the participating sub-detectors. The transmission medium, the DDL dedicated to the CTP, is also used for the *Interaction Record*; the *CTP Readout* block is uniquely "marked" by the *Block Identifier* bit cleared to 0. The proposed data format is shown in Figure 2.

The following abbreviations have been used:

BlockID	*Block Identifier* bit: cleared (0) for the *CTP Readout*; asserted (1) in case of the *Interaction Record*.
BCID[11..0]	*Bunch-crossing number*, part of the *Event Identifier*.
OrbitID[23..0]	*Orbit number*, part of the *Event Identifier*.
ESR	*Enable Segmented Readout* flag (RoI option).
L2SwC	*Software Class L2 trigger* status: cleared for the *physics trigger*; asserted for *the software trigger*.
L2Cluster[6..1]	*Cluster [6..1] L2 trigger* status flag.
L2Class[50..1]	*Class [50..1] L2 trigger* status flag.
ClT	*Calibration Trigger* flag.
L2Detector[24..1]	*Detector [24..1] L2 trigger* status flag.
RoC[4..1]	*Readout Control bits*.
EOBTR	*End of Block Transmission,* front-end command that closes any block transmission transaction (DDL).

The *CTP Readout* data block has a constant length of 8 DDL words. The block is terminated by the **EOBTR** command, in compliance with the DDL interface protocol [1, 2].

The *"don't care"* bits carry no information and should be ignored; if required, they could be made to read 0.

The first three words always contain the *Event Identifier* (**BC** and **Orbit** number of the corresponding event). The remaining words (*Word 4-8*) carry different information in case of the *physics trigger* (**L2SwC** = 0) and in case of the *software trigger* (**L2SwC** = 1).

Word	[31..16]	[15]	[14..12]	[11..0]
1	*Don't care* (0)	**BlockID** = 0	*Don't care* (0)	**BCID**[11..0]
2				**OrbitID**[23..12]
3				**OrbitID**[11..0]

Physics trigger

	Bit	Data
Word 4	[31..16]	*Don't care* (0)
	[15]	**BlockID** = 0
	[14..11]	*Don't care* (0)
	[10]	**ESR**
	[9]	*Don't care* (0)
	[8]	**L2SwC** = 0
	[7..6]	**L2Cluster** [6..5]
	[5..2]	**L2Cluster** [4..1]
	[1..0]	**L2Class** [50..49]

Software trigger

	Bit	Data
Word 4	[31..16]	*Don't care* (0)
	[15]	**BlockID** = 0
	[14..11]	*Don't care* (0)
	[10]	*Don't care* (0)
	[9]	**ClT**
	[8]	**L2SwC** = 1
	[7..6]	*Don't care* (0)
	[5..2]	**RoC**[4..1]
	[1..0]	*Don't care* (0)

Word	[31..16]	[15]	[14..12]	[11..0]
5	*Don't care* (0)	**BlockID** = 0	*Don't care* (0)	**L2Class** [48..37]
6				**L2Class** [36..25]
7				**L2Class** [24..13]
8				**L2Class** [12..1]

Word	[31..16]	[15]	[14..12]	[11..0]
5	*Don't care* (0)	**BlockID** = 0	*Don't care* (0)	**L2Detector** [24..13]
6				**L2Detector** [12..1]
7				*Don't care* (0)
8				*Don't care* (0)

Figure 2. CTP Readout data format.

"Proper" buffering of the *CTP Readout* (and the *Interaction Record*) data shall be provided by the CTP's Local Data Concentrator (LDC). The capacity of the buffer is massive, and especially so if the small size of the CTP data blocks is taken into account.

If, for whatever reason, the "back-pressure" of the DDL halts the data transmission and the *Nearly Full* mark of the CTP FIFO is reached, the **CTP BUSY** signal shall be asserted which, in turn, disables further generation of the **L0** triggers. The action is fully in accordance with the procedure described in the CTP Preliminary Design Review [5]. The status of the **CTP BUSY** signal is monitored and timed.

The remaining free capacity of the FIFO must be sufficient to "absorb" all the **L0/L1** triggers already in the pipeline that are waiting for the corresponding **L2** decisions. In real conditions, their *maximum* number is likely to be rather small - 5 to 10 events. But the hardware must be capable of error-free operation in *all possible* situations, regardless of how unlikely they might be. Assuming at least 4 non-overlapping sub-detector clusters, with at least 15-event effective capacity of their front-end multi-event buffers, with no past-future protection, the CTP **L0** dead time reduced to 1.5μs, the **L1** decision time equal to 6μs and the **L2** decision time equal to 90μs, the *theoretical* maximum number of the **L0/L1** triggers already in the pipeline would be 60 events. It could also be assumed that the "moderate" FIFO capacity of 25 events is sufficient to "smooth" the irregularities of the DDL operation and enable the link sharing (see above). The resulting requirement for the FIFO capacity is 85 data blocks (765 words), with the *Nearly Full* status set to become active when the occupancy exceeds 25 events.

3.2 *The Interaction Record data format*

The CTP shall transmit the Interaction Record data block for each LHC orbit, even if no interaction has been detected during the orbit. The transmission medium, the DDL dedicated to the CTP, is also used for the CTP Readout; the Interaction Record block is uniquely “marked” by the Block Identifier bit asserted to 1. The proposed data format is shown in Figure 3.

<table>
<tr><th>Word</th><th>[31..16]</th><th>[15]</th><th>[14]</th><th>[13..12]</th><th>[11..0]</th></tr>
<tr><td>1</td><td rowspan="10">Don’t care (read 0)</td><td rowspan="10">BlockID = 1 (Interaction Record)</td><td>Err</td><td>0</td><td>Orbit number [23..12]</td></tr>
<tr><td>2</td><td>Err</td><td>1,1</td><td>Orbit number [11..0]</td></tr>
<tr><td>3</td><td>0</td><td>Int[2..1]</td><td>BC number [11..0]</td></tr>
<tr><td>4</td><td>0</td><td>Int[2..1]</td><td>BC number [11..0]</td></tr>
<tr><td>⋮</td><td>⋮</td><td>⋮</td><td>⋮</td></tr>
<tr><td>n</td><td>0</td><td>Int[2..1]</td><td>BC number [11..0]</td></tr>
<tr><td>⋮</td><td>⋮</td><td>⋮</td><td>⋮</td></tr>
<tr><td>251</td><td>0</td><td>Int[2..1]</td><td>BC number [11..0]</td></tr>
<tr><td>252</td><td>0</td><td>Int[2..1]</td><td>BC number [11..0]</td></tr>
<tr><td>253</td><td>0</td><td>1,1</td><td>Incomplete record (hFFF)</td></tr>
</table>

Figure 3. Interaction Record data block.

The following abbreviations have been used:

BlockID *Block Identifier* bit: cleared (0) for the *CTP Readout*; asserted (1) in case of the *Interaction Record*.

Err *Transmission Error* flag.

Int[2..1] *Interaction Signal* field, status of the CTP’s interaction signals.

EOBTR *End of Block Transmission*, front-end command that closes any block transmission transaction (DDL).

The first two words of the data block contain the number of the corresponding LHC orbit (24 bits). They are followed by a string of words containing numbers (12 bits) of bunch-crossings in which the interactions have been detected and the corresponding status of the two CTP’s interaction signals **Int[2..1]**; at least one of them must be asserted.

The maximum number of “bunch-crossing” words in the data block is set to 250. The limit allows nearly an order of magnitude margin even for the highest quoted interaction rate of 300kHz (proton-proton mode; nominal luminosity). Should the limit be nevertheless exceeded, further interaction “recording” in the corresponding orbit would be abandoned and the *Incomplete Record* message (interaction at a virtual bunch-crossing 4095 - hexadecimal FFFF) would be appended as a word 253. The “loss” of recording hardly matters since, in the circumstances, the pattern recognition would be no longer an option.

In case when no interaction is detected during the orbit, the data block contains only the orbit number (words 1 and 2).

The block is terminated by either a request to transmit the CTP Readout block or whenever the overall length of the Interaction Record approaches 512 K DDL words. The block is always terminated with the **EOBTR** command, in compliance with the DDL interface protocol [1, 2].

The *"don't care"* bits carry no information and should be ignored; if required, they could be made to read 0.

During a run, under normal circumstances, the DAQ should receive, in sequential order, the *Interaction Record* data blocks for *all* the LHC orbits. If, for whatever reason, the transmission of a block, or of a number of consecutive blocks, fails, the first block *after* the "gap" shall have the *Transmission Error* flag (**Err**) asserted. The *Interaction Record* data are not essential (see ***Introduction***) and, in the CTP Preliminary Design Review [5], provisions have been made for instances of "gap" occurrence.

4 Conclusions

All the data blocks transferred by every detector readout electronics over the DDL must be identified. This note describes the common data blocks header to be used by all detectors over the ALICE DDL. It has been updated following the discussion on data format held in the Technical Board of June 2001[6]. Following the Technical Board of July 2002, a section has already been added for the format used by the Trigger CTP.

5 Bibliography

1. ALICE DDL - *Interface Control Document*, ALICE/96-43, Internal Note/DAQ, 12 December 1996, Revision 9.1.
2. ALICE DDL - *Hardware Guide for the Front-end Designers*, ALICE/98-21, Internal Note/DAQ, 19 May 1998, Revision 1.3
3. L. Musa, TPC ALTRO chip status register.
4. A. Kluge, Error information available from the SPD detector, *11 December 2001*.
5. ALICE Central Trigger Processor, *Preliminary Design Review, Rev. 0.2 29 June 2004*.
6. B. G. Taylor, *LHC Machine Timing Distribution for the Experiments*, in proceedings of 6th Workshop on Electronics for LHC Experiments, Krakov, September 2000.
7. J. Christiansen, A. Marchioro, P. Moreira, T. Toifl, *TTCrx Reference Manual – A Timing, Trigger and Control Receiver ASIC for LHC detectors*, RD12 project.
8. B. G. Taylor, *TTC machine interface (TTCmi) User Manual*, RD12 project.
9. P. Farthouat and P. Gällnö, *TTC-VMEbus interface TTCvi - MkII*, RD12 project.
10. P.Antonioli, P.Jovanovic, L.Musa, K.Schossmaier, P.Vande Vyvre, *Update of the list of status and error bits of the Common Data Header*, presented at the ALICE Technical Board, ALICE-MIN-2006-017, *20 July 2006*.

[6] Minutes available at https://edms.cern.ch/document/319587/1