
Data Format of the RPC Detector of the Muon System

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Abstract

This note presents the RPC data format that is used to collect the Resistive Plate Chamber (RPC) data of the Muon Spectrometer. It covers the data format from the Coincidence Matrix Asic to the input of the RPC Read Out Driver (ROD).

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1 Introduction

This note presents the RPC data format that is used by the readout system of this detector. The data structure reflects the architecture of the barrel LVL1 muon trigger [1] system that is indeed based on RPCs. Information on the geometry of the RPC system is available in [2].

The RPCs are strip detectors with time resolution $\sigma_t=1.5$ ns; the typical strip size is 3 cm. The trigger is based on three stations. Two stations are used for low- p_T triggers, while the third station is used in addition for high- p_T triggers. Each station is composed of two detector planes and each detector plane is read out in two orthogonal projections, η and ϕ . The RPC system is important also for high-level trigger algorithms and offline muon reconstruction program because it provides the measurement of the second coordinate of muon trajectories.

2 The barrel Level-1 Muon trigger system

The signals from the RPC detector are amplified, discriminated and digitally shaped on the detector. The Amplifier-Shaper-Discriminator (ASD) boards are attached to the chamber at the end of the RPC strips. In the low- p_T trigger, for each of the η and ϕ projections, the RPC signals of the first two RPC stations are sent to a Coincidence Matrix board (CM), that contains a CM chip. This chip performs almost all of the functions needed for the trigger algorithm and also for the readout of the RPC strips. The CM board produces an output pattern containing the low- p_T results for each pair of RPC doublets in the η or ϕ projection. Moreover, the highest thresholds satisfied by the trigger conditions and a flag indicating triggers occurring in regions of overlapping RPCs are also provided. The information of two adjacent CM boards in the η projection, and the corresponding information of the two CM boards in the ϕ projection, are combined together in the low- p_T Pad Logic board. Globally 4 CMs are hosted by each Pad board. In the high- p_T trigger, for each of the η and ϕ projections, the RPC signals of the third station, and the corresponding pattern result of the low- p_T trigger, are sent to a CM board, very similar to the one used in the low- p_T trigger. The information of two adjacent CM boards in the η projection, and the corresponding information of the two CM boards in the ϕ projection, are combined together in the high- p_T Pad Logic board. Again, 4 CMs are hosted by each Pad board. The high- p_T Pad board combines the low- and the high- p_T trigger results. The combined information is sent to a Sector Logic (SL) board, located in the USA15 counting room.

3 The RPC data format

3.1 The Read-Out scheme

The whole RPC barrel trigger system is read-out by 16 RODs. The ROD collects the information, of both middle and outer chambers, of two adjacent half-barrel large octants. The ROD will be located in the USA15 underground counting room.

The format structure of the RPC data is based on the fragment provided by the CM boards. Here the fired RPC strips, the trigger output and the highest threshold satisfied by the trigger logic, as well as the overlap flag, are reported. The fragments of the (up to) eight CMs belonging a given Pad board (4 low- p_T CMs plus 4 high- p_T CMs) are written out one after the other, adding a header/footer at the beginning/end of this list. This is a Pad fragment.

bit-2	bit-1	bit-0
<i>0 : low-p_T CM</i>	<i>0 : eta projection</i>	<i>0 : address of 1st CM</i>
<i>1 : high-p_T CM</i>	<i>1 : phi projection</i>	<i>1 : address of 2nd CM</i>

Table 1: the CM identifier scheme.

The sub-header word is identified by the bit sequence “1000” from bit 15 to 12. It contains the bunch crossing identifier from the Front-End Electronics. The words following the subheader collect the RPC hits and the trigger output. These words are identified by the bit sequence “00” from bit 15 to 14.

First RPC fired strips are reported. Each hit is described by 4 fields: the bunch crossing id BCID, the interpolatore clock time TIME, the RPC layer and station IJK, and the CM channel number (STRIP) connected to the fired RPC strip. BCID and TIME give the time coordinate of the given hit. The IJK identifiers are described in Table 2.

IJK	layer - station
<i>0</i>	<i>pivot station, layer 0</i>
<i>1</i>	<i>pivot station, layer 1</i>
<i>2</i>	<i>coinc. station, channel 0-31, layer 0</i>
<i>3</i>	<i>coinc. station, channel 31-63, layer 0</i>
<i>4</i>	<i>coinc. station, channel 0-31, layer 1</i>
<i>5</i>	<i>coinc. station, channel 31-63, layer 1</i>
<i>6</i>	<i>trigger pattern</i>
<i>7</i>	<i>highest thres. & overlap</i>

Table 2: Description of the IJK identifier.

These hits are ordered following increasing values of IJK first, then of BCID, TIME and STRIP. In case of trigger, additional words are added: first the strips of the pivot plane that provided the trigger itself, and then an additional word where the STRIP identifier is replaced by the identifier THR that is the identifier of the highest threshold satisfied by the trigger

logic, and the overlap flag OVL. THR values are 1,2 and 3; the OVL flag is described in Table 3.

OVL	overlap description
0	no overlap
1	overlap in low CM channels (low !η/)
2	overlap in high CM channels (high !η/)
3	OVL=1 and OVL=2

Table 3: Description of overlap flag OVL.

Finally, the CM fragment is completed by the footer word; this word is identified by the bit pattern “0100” from bit 15 to 12. It contains the CRC calculated using all the data present in the CM fragment described so far, and a status word STATUS.

3.3 The Pad Fragment

The Pad fragment is illustrated in Fig. 2.

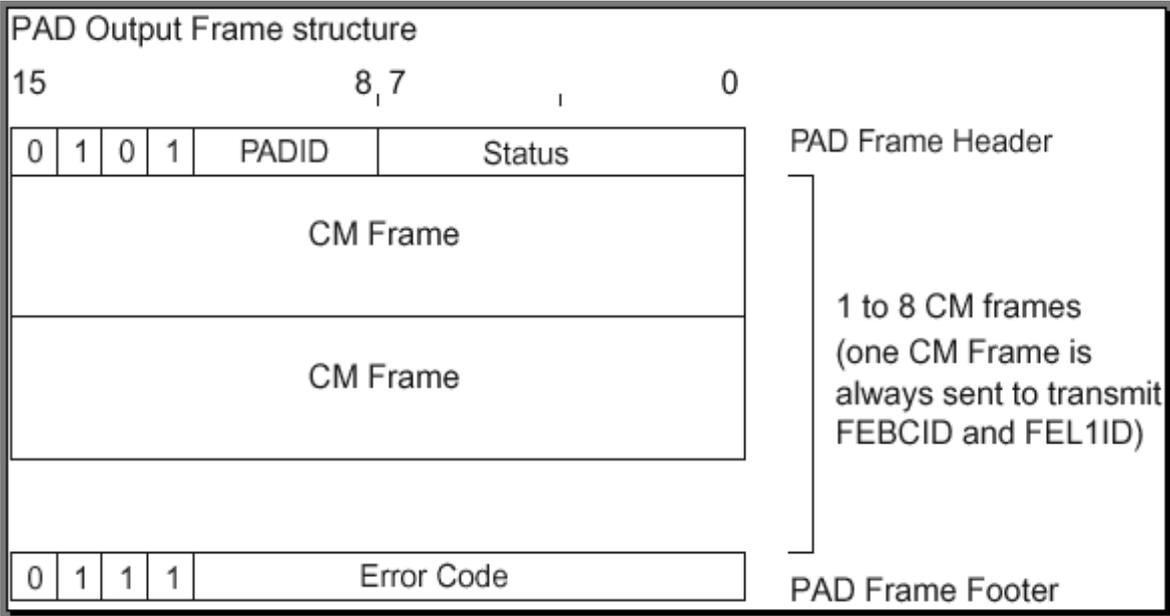


Figure 2: Scheme of the Pad readout fragment.

As already illustrated, the Pad fragment is the collection of the (up to) eight CM fragments belonging to the same Pad (low- and high-p_T) board. The header is the first word of this fragment; it is identified by the bit pattern “0101” from bit 15 to 12. It contains the Pad Identifier PADID (starting from 0) and a status word Status. Then all CM fragments are appended if at least one hit has been seen in the given CM; at least one CM is always sent to transmit FEBCID and FEL1ID. The fragments are ordered with increasing values of CMID. The footer word completes the Pad fragment and it is identified with the bit pattern “0111” from bit 15 to 12.

3.4 The RX fragment

The RX fragment collects the Pad data belonging to a given logic sector. Its scheme is illustrated in Fig. 3.

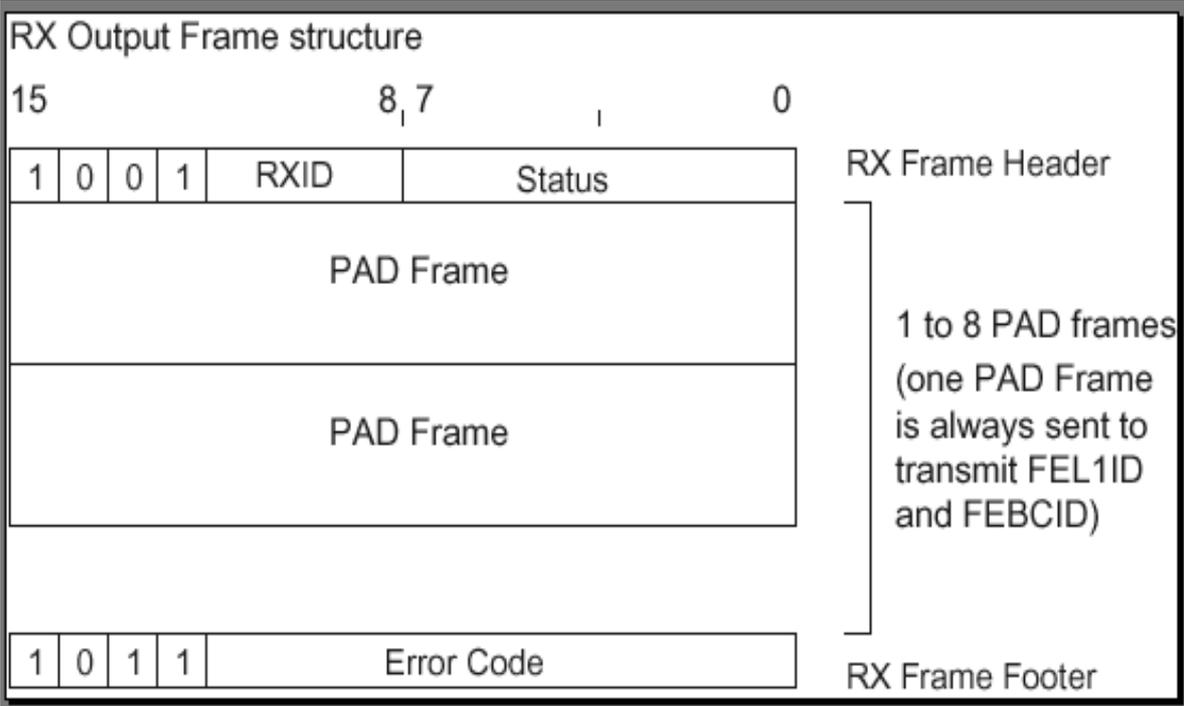


Figure 3: Scheme of the RX readout fragment.

The header word is identified by the bit pattern “1001” from bit 15 to 12. The RX header word contains the RX identifier (starting from 0) and the status bits. Up to 8 Pad frames, belonging to the same sector, are then appended below in ordered way, following the increasing value of PADID. At least one Pad fragment is always reported to transmit FEL1ID and FEBCID. Finally, the footer word, identified by the bit pattern “1011” from bit 15 to 12, is added and it contains error flags.

3.5 The ROD fragment

The general format of the ROD fragment of ATLAS is reported in details in [3]. The size of the ROD fragment word is 32 bits. The 16-bit RX words are copied in the “Data Elements” region of the ROD fragment starting from bit-0.

References

[1] ATLAS First-Level Trigger Technical Design Report, CERN/LHCC/98-14.

[2] <http://atlas.web.cern.ch/Atlas/GROUPS/MUON/layout.html>

[3] C. Bee et al., “The raw event format in the ATLAS Trigger & DAQ”, Atlas Technical Note ATL-DAQ-98-129, October 2002.

Appendix

RPC data word identifiers

The table below summarizes all 4-bit words used to identify RPC data in the field from bit 15 to 12.

bit 15	bit 14	bit 13	bit 12	data word type
0	0	0	0	<i>CM hit</i>
0	0	0	1	<i>CM hit</i>
0	0	1	0	<i>CM hit</i>
0	0	1	1	<i>CM hit</i>
0	1	0	0	<i>CM footer</i>
0	1	0	1	<i>Pad header</i>
0	1	1	0	<i>(reserved)</i>
0	1	1	1	<i>Pad footer</i>
1	0	0	0	<i>CM subheader</i>
1	0	0	1	<i>RX header</i>
1	0	1	0	<i>(reserved)</i>
1	0	1	1	<i>RX footer</i>
1	1	0	0	<i>CM header</i>
1	1	0	1	<i>(reserved)</i>
1	1	1	0	<i>(reserved)</i>
1	1	1	1	<i>(reserved)</i>

Use of reserved bits

bit 15	bit 14	bit 13	bit 12	data word use
0	1	1	0	<i>free</i>
1	0	1	0	<i>free</i>
1	1	0	1	<i>free</i>
1	1	1	0	<i>free</i>
1	1	1	1	<i>“empty” 16-bit word used to complete the 32-bit ROD words with 16-bit RX words; the remaining bits from 0 to 11 are meaningless</i>