# AMS-02 RICH Science Data Format
# Rev. 1.5

Jorge Casaus - CIEMAT

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## 1 RICH Data Format

Each RICH Data Reduction Module (CDP) reads out up to 31 RICH PMTs. There are 24 RICH CDPs to read out the complete detection plane. Data coming from 12 CDPs is concentrated into a single RICH Command Distributor and Data Concentrator (CDDC). There are 4 CDDC modules so that data from every CDP can be read out by two different CDDCs.

A schematic view of the RICH detector with the naming convention which will be used throughout this document is shown in Fig. 1.

The correspondance between the RICH CCDC and CDP nodes with the tabular presentation of the AMS-02 node addresses in Ref. [1] is shown in tables 1,2. The primary configuration (JINF-R-0-P & JINF-R-1-P) will be used during the pre-integration data taking in March 2008.

The assignment of the PMT local address in the CDP follows the readout sequence. The mapping of a quarter of the detection plane is shown in table 3.

### 1.1 Raw Mode

The size of a RICH CDP raw event data block is 992 16-bit words. One RICH CDP performs the readout of up to 31 RICH ADCs, 1 ADC is used to digitize all pixels in a single PMT. Each PMT has 16 pixels and the front-end preamplifier applies two different gain factors (1 and 5) to each pixel output. The ordering in the RICH Raw block follows the sequencer readout. It is shown in table 4.

## 1.2 Data Reduction Mode

In Data Reduction Mode, event data block contains only those channels that are over a previously calculated threshold. A 16-bit word is used in order to identify the channel. The channel address gives the information about the PMT and the Pixel number following the format of table 4 in the range [0...495]. The amplitude above the pedestal for the signal is stored in bits 0–11 of the data word. To include the information about the gain, bit 12 of the data word is set to 1 when gain x1 is used. An example of the RICH compressed block is shown in table 5.

## 1.3 Data Mixed Mode

In this mode, compressed data blocks are added to their corresponding raw data blocks.

## 1.4 Calibration Tables

The output of the RICH online calibration performed by the CDP modules is stored in 5 tables: Pedestals (Gx1 and Gx5), Thresholds, Sigmas and Status. In a calibration run, the data of every CDP module is delivered a single event containing one calibration block. The RICH calibration block structure is shown in table 6. The sequencer readout ordering shown in table 4 is followed in all cases. Information on the status of individual channels is packed into a status word with a format specified in table 8. When the Mask bit is set, the data readout from that channel will not be processed in data reduction mode. The Mask bit is set during calibration if the nominal number of iterations during calibration is not reached or if the pedestal is in overflow state. In addition, the Mask bit is in logical OR with the external mask for that channel.

# References

[1] AMS-02 Command and Data Handling Interface Control Document, Rev. 05m.

| CDDC | | Node | | Node | | JINJ |
|---|---|---|---|---|---|---|
| Nb. | Name | Nb. | Name | Nb. | Name | Port |
| 0 | 0A | 158 | JINF-R-0-A | 160 | JINF-R-0-P | 10 |
| 1 | 0B | 159 | JINF-R-0-B | 161 | JINF-R-0-S | 10 (**TBC)** |
| 3 | 1A | 162 | JINF-R-1-A | 164 | JINF-R-1-P | 11 |
| 2 | 1B | 163 | JINF-R-1-B | 165 | JINF-R-1-S | 11 (**TBC)** |

Table 1: RICH CDDC node map. For every CDDC node (0-3), next two column groups show the correspondence with the AMS-02 node Address/Name appearing in Ref. [1] Section 23.4. Last column shows the assigned JINJ Ports.

| CDP | PMT | PMT | Node | | JINF-R-0-P | JINF-R-0-S |
|---|---|---|---|---|---|---|
| Nb. | First | Last | Nb. | Name | Port | Port |
| 00 | 0 (0) | 30 (30) | 242 | RDR-0-00 | 17 | 17 |
| 01 | 0 (31) | 26 (57) | 243 | RDR-0-01 | 16 | 16 |
| 02 | 0 (58) | 26 (84) | 244 | RDR-0-02 | 13 | 13 |
| 03 | 0 (85) | 26 (111) | 245 | RDR-0-03 | 20 | 20 |
| 04 | 0 (112) | 30 (142) | 246 | RDR-0-04 | 21 | 21 |
| 05 | 0 (143) | 26 (169) | 247 | RDR-0-05 | 1 | 9 |
| 06 | 0 (170) | 30 (200) | 248 | RDR-0-06 | 4 | 4 |
| 07 | 0 (201) | 26 (227) | 249 | RDR-0-07 | 0 | 0 |
| 08 | 0 (228) | 26 (254) | 250 | RDR-0-08 | 12 | 12 |
| 09 | 0 (255) | 26 (281) | 251 | RDR-0-09 | 5 | 5 |
| 10 | 0 (282) | 30 (312) | 252 | RDR-0-10 | 8 | 8 |
| 11 | 0 (313) | 26 (339) | 253 | RDR-0-11 | 9 | 1 |

| CDP | PMT | PMT | Node | | JINF-R-1-P | JINF-R-1-S |
|---|---|---|---|---|---|---|
| Nb. | First | Last | Nb. | Name | Port | Port |
| 12 | 0 (340) | 30 (370) | 254 | RDR-1-00 | 17 | 17 |
| 13 | 0 (371) | 26 (397) | 255 | RDR-1-01 | 16 | 16 |
| 14 | 0 (398) | 26 (424) | 256 | RDR-1-02 | 13 | 13 |
| 15 | 0 (425) | 26 (451) | 257 | RDR-1-03 | 20 | 20 |
| 16 | 0 (452) | 30 (482) | 258 | RDR-1-04 | 21 | 21 |
| 17 | 0 (483) | 26 (509) | 259 | RDR-1-05 | 9 | 1 |
| 18 | 0 (510) | 30 (540) | 260 | RDR-1-06 | 4 | 4 |
| 19 | 0 (541) | 26 (567) | 261 | RDR-1-07 | 0 | 0 |
| 20 | 0 (568) | 26 (594) | 262 | RDR-1-08 | 12 | 12 |
| 21 | 0 (595) | 26 (621) | 263 | RDR-1-09 | 5 | 5 |
| 22 | 0 (622) | 30 (652) | 264 | RDR-1-10 | 8 | 8 |
| 23 | 0 (653) | 26 (679) | 265 | RDR-1-11 | 1 | 9 |

Table 2: RICH CDP node map. For every CDP node (00-23), second and third columns show the first and last PMT local(global) addresses. Next two columns show the correspondence with the AMS-02 node number/name appearing in Ref. [1] Section 23.4. Last two columns show the associated JINF-R Port for primary and secondary CDDC. Note that the node names do not match those in Ref. [1]. Note that the same physical CDP node can correspond to different Ports for primary/secondary JINF-R modules.

| CDP | KAPTON | PMT First | PMT Last |
|---|---|---|---|
| 0 | A-0 | 0 (0) | 5 (5) |
| | A-1 | 0 (6) | 7 (13) |
| | A-2 | 0 (14) | 7 (21) |
| | A-3 | 0 (22) | 8 (30) |
| 1 | A-4 | 0 (0) | 8 (8) |
| | A-5 | 0 (9) | 8 (17) |
| | A-6 | 0 (18) | 8 (26) |
| 2 | A-7 | 0 (0) | 8 (8) |
| | A-8 | 0 (9) | 8 (17) |
| | A-9 | 0 (18) | 8 (26) |
| 3 | A-10 | 0 (0) | 8 (8) |
| | A-11 | 0 (9) | 8 (17) |
| | A-12 | 0 (18) | 8 (26) |
| 4 | A-13 | 0 (0) | 8 (8) |
| | A-14 | 0 (9) | 7 (16) |
| | A-15 | 0 (17) | 7 (24) |
| | A-16 | 0 (25) | 5 (30) |
| 5 | B-0 | 0 (0) | 0 (0) |
| | B-1 | 0 (1) | 1 (2) |
| | B-2 | 0 (3) | 2 (5) |
| | B-3 | 0 (6) | 3 (9) |
| | B-4 | 0 (10) | 4 (14) |
| | B-5 | 0 (15) | 5 (20) |
| | B-6 | 0 (21) | 5 (26) |

Table 3: PMT address scheme for a quadrant of the RICH detection plane. For every CDP (first column) the associated kapton lines are shown (second column). The last two columns show the first and last PMT position in the kapton. The values in parenthesis show their corresponding local addresses. The PMT address for the rest of the RICH mimics this scheme.

| Data Index | PMT [0...30] | Pixel [0...15] | Gain: x1 or x5 |
|---|---|---|---|
| 0 | 0 | 0 | x1 |
| 1 | 1 | 0 | x1 |
| ... | ... | 0 | x1 |
| 30 | 30 | 0 | x1 |
| 31 | 0 | 1 | x1 |
| ... | ... | ... | x1 |
| 495 | 30 | 15 | x1 |
| 496 | 0 | 0 | x5 |
| ... | ... | ... | x5 |
| 991 | 30 | 15 | x5 |

Table 4: RICH Raw Data Block. The amplitudes of the digitized signals from the Front End electronics are stored in a fixed length block of 992 16-bit words following the readout sequence shown above. for CDPs mapping 27 PMTs, appropriate gaps are kept in the positions corresponding to PMTs 27–30.

| Data block | |
|---|---|
| 0x0015 | Addr. : PMT = 21, Pixel = 0 |
| 0x0007 | Data : 7 ADCc, gain x5 |
| 0x0058 | Addr. : PMT = 26, Pixel = 2 |
| 0x00DB | Data : 219 ADCc, gain x5 |
| 0x01AB | Addr. : PMT = 24, Pixel 13 |
| 0x1022 | Data : 34 ADCc, gain x1 |

Table 5: Example of RICH Compressed Data Block. The addresses and amplitudes for of the digitized signals above previously computed thresholds are stored. The hit address follows the readout sequence. The pedestal subtracted amplitudes and the gain range are packed in a single 16-bit data word as described in the text.

| Descriptor | Words | Comments |
|---|---|---|
| Block Size | 1 | 4966 (bytes) |
| Node/Type | 1 | Node Number and Block Type (see table 7) |
| Pedestals (Gx1) | 496 | Pedestal Position in gain x1 |
| Pedestals (Gx5) | 496 | Pedestal Position in gain x5 |
| Sigmas | 496 | Sigma Pedestal in gain x5 ($\times$ 1024) |
| Thresholds | 496 | Threshold Position in gain x5 |
| Status | 496 | Channel Status (see table 8) |
| Status Word | 1 | 0x120 (Reply node is a CDP & Cummul. status = 1) |
| CRC-16 | 1 | starting from word #3 |

Table 6: Structure of the RICH Calibration Block. All words are 16-bit long.

| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | Node Number | | | | | | | | | Type=0x14 | | | | |

Table 7: Descriptor word of a RICH Calibration Block. Note that the Node Nb. corresponds to that in table 2.

| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M | O | S | R | | I | | | | | | | | | | |

I : Iterations counter (0x400)
R : Reserved
S : Skip bit. For internal use only
O : Overflow bit. Pedestal above maximum allowed value (0x800)
M : Mask bit. If set, the pixel will not be processed in compressed mode

Table 8: RICH Status Word for individual channels.

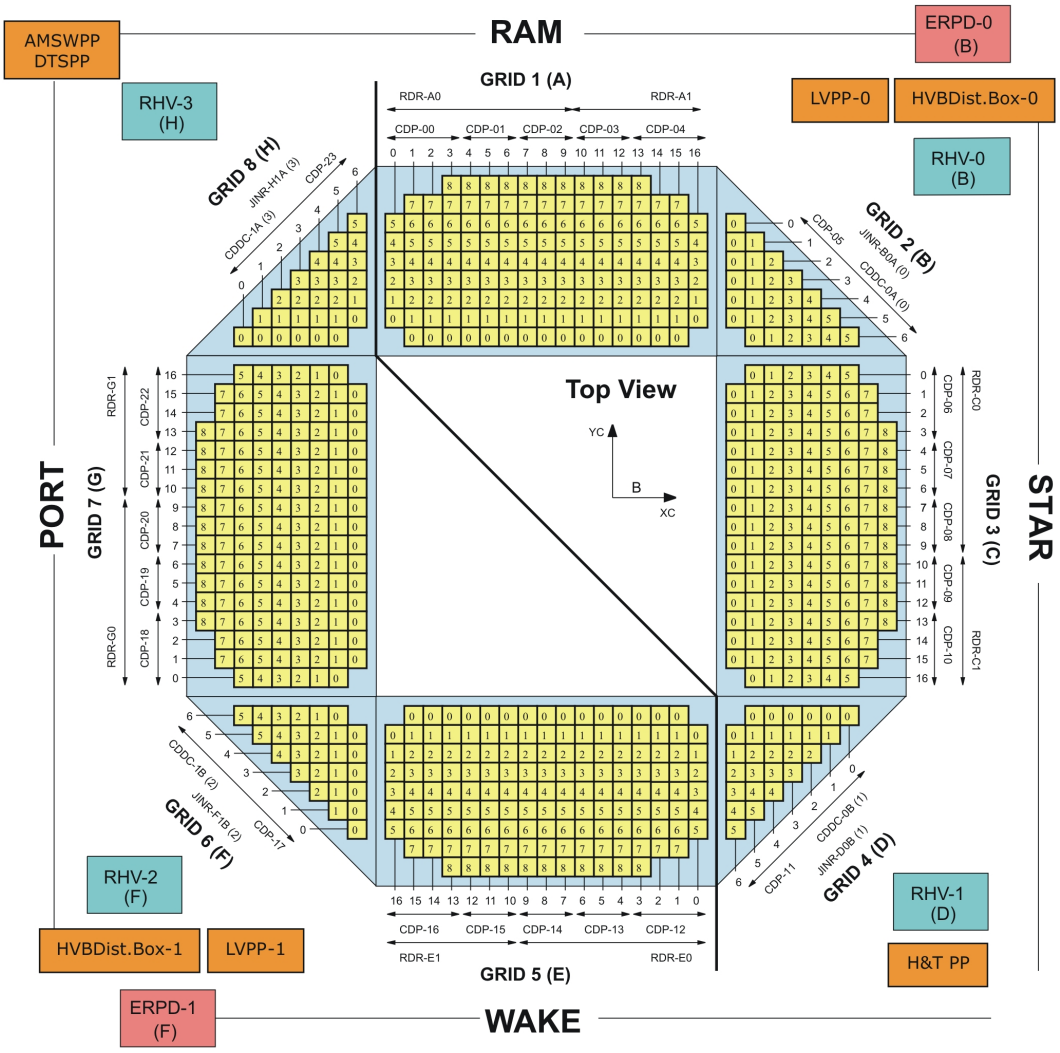


Figure 1: RICH plane layout and naming scheme used in this document.