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Updated channel numbering and readout partitioning for the Silicon Tracker

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Abstract

The channel numbering scheme and readout partitioning for the LHCb Silicon Tracker is updated to take account of changes to the detector cabling that have occurred since the start of DC '06. In addition, several typographical errors in the previous note have been corrected.

1 Introduction

The offline channel numbering and readout partitioning used in the DC 06 data challenge is described in [1]. Since that time cabling constraints have led to changes to the readout scheme and channel numbering for the TT

station. In this note the scheme described in the previous note is updated to account for these changes. In addition, the previous note contained a serious typographical error: the labeling on the figure describing the partitioning for the Inner Tracker was wrong. This has also been fixed.

2 The LHCb Coordinate System

The LHCb coordinate system is a right handed system with positive z running along the beam-line away from the interaction point and positive y 'upward'. From this it follows that positive x points toward the cavern access (A-side) and away from the LHC cryogenics (C-side).

3 Channel Numbering

Similar channel numbering schemes have been adopted for the two detectors that comprise the Silicon Tracker project — the Trigger Tracker and the Inner Tracker. This allows the same class (**STChannelID**) to be used to describe the channel number. This is a bit-packed word that contains the fields: **detector** - either TT or IT, **station**, **layer**, **detRegion**, **sector** and **strip**. The exact meaning of these fields in the case of the two sub-detectors is described in the following sections. It should also be noted that all fields number from one.

3.1 TT numbering

The Trigger Tracker consists of two pairs of layers (TTa and TTb). These correspond to **station** one and two in the chosen numbering scheme. Each **station** contains two **layers** which are numbered one and two in increasing z. The layout of a layer is shown in Fig. 1. A layer consists of detector modules constructed from seven silicon sensors. Electronically, each module is split into several readout **sectors** indicated by the different shadings on the figure. It is chosen to divide each layer into three **detRegions**: cryo, beam-pipe and access which are numbered 1-3 (Fig. 2). In TTa the beam-pipe region corresponds to the three innermost columns of the detector whilst in TTb it corresponds to the five innermost columns. For both TTa and TTb there are 24 readout sectors in the cryo and access regions. In TTa (TTb) there are

18 (26) readout sectors in the beam-pipe region. The readout sectors within

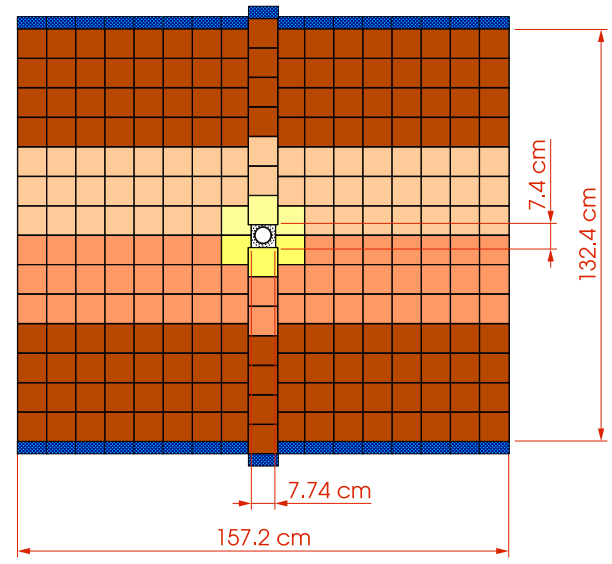

Figure 1: Layout of a layer in TTb.

each **detRegion** are numbered by column and by increasing y as shown in Fig. 2. The strips within a readout sector are numbered from 1 to 512 according to the order that they are read out (Fig. 3). Due to the design of the detector the orientation of readout hybrids is different for modules located in the upper and lower parts of the TT detector. In addition, the layers in TTa have the hybrids orientated such that the Beetle chips face towards the interaction point whilst in TTb the reverse is true. Within one readout sector, in the case of TTa, increasing Tell1 strip number corresponds to increasing x in the sectors below the beam-pipe whilst increasing Tell1 strip number corresponds to decreasing x in the sectors above the beam-pipe. In TTb this pattern is reversed. That is to say increasing Tell1 strip number corresponds to decreasing x for the sectors below the beam-pipe whilst increasing Tell1 strip number corresponds to increasing x for the sectors above the beam-pipe. This is summarized pictorially in Fig. 2.

Nota Bene, the scheme described here is different from that used in DC 06 where all strips were numbered by increasing x.

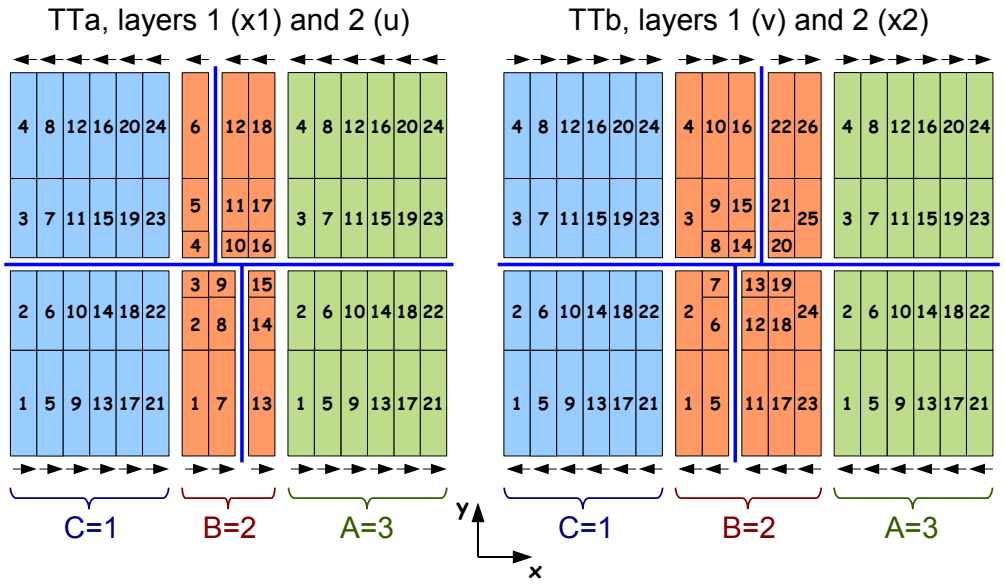

Figure 2: TT Hybrid Orientation and sector numbering.

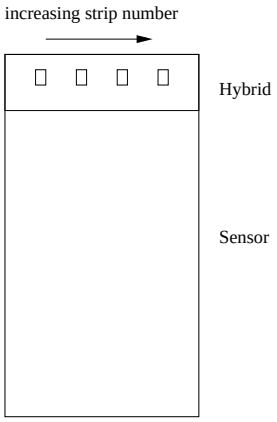

Figure 3: ST strip numbering.

3.2 IT numbering

The Inner Tracker consists of three **stations** that are numbered 3-5 in increasing z. Each station contains four detector boxes arranged around the beam-pipe. The four boxes are named cryo, access, bottom and top and correspond to **detRegion** 1 to 4 respectively (Fig 4). Each **box** contains

four **layers** that are numbered from one to four in increasing z. The ladders (**sectors**) within each layer are numbered from one to seven by increasing x coordinate. The same strip numbering scheme as TT is used. The strips within a readout sector are numbered from 1 to 384 according to the order that they are read out. For the bottom and side boxes increasing Tell1 strip number corresponds to increasing x on a readout sector for the first and third layers in a station and to decreasing x for the second and fourth layers (see Fig. 4). For the top box this pattern is reversed. As in the TT case the strip numbering scheme is different from that used in DC 06 where all strips were numbered by increasing x.

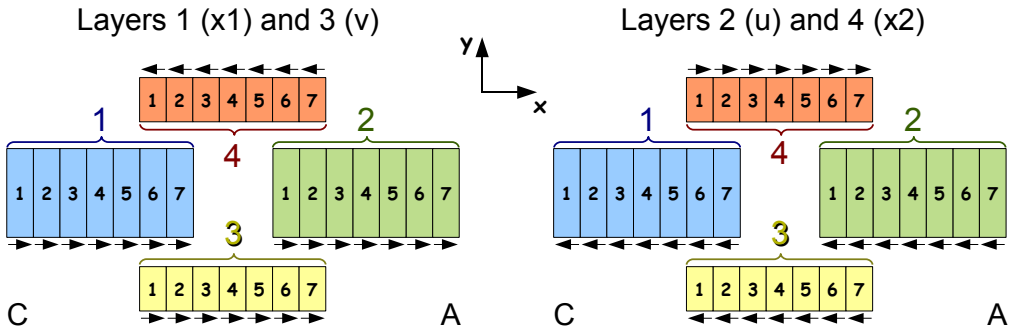

Figure 4: IT Hybrid Orientation and sector numbering.

4 Readout partitioning

Every readout strip on the Silicon Tracker maps to a channel on a Tell1 readout board [2]. A Tell1 board can process twenty-four Beetles each with 128 readout strips. This corresponds to six readout sectors in the case of the TT station and eight readout sectors for the case of the Inner Tracker.

Every Tell1 board sends in the raw data header the data bank type and an 8-bit board identifier — the **sourceID**. *Nota Bene*, in this context IT and TT are considered to be different types. For the Silicon Tracker the following scheme is proposed:

- Two bits are used to indicate the detector area in which the board is located. In the case of the TT station this corresponds to a layer. In

the Inner Tracker it corresponds to a detector station.

- Five bits are used to identify a board within an aread —- '**subID**'.

This numbering scheme is shown pictorially in Fig. 5. Using this scheme boards with the same **subID** correspond to a specific physical area of the detector. In addition, it is easy to decode only a specific part of a detector — for example one of the Inner Tracker stations. The Tell1 **sourceIDs** assigned to the different areas are summarized in Table 1. The channels within a Tell1 board are identified by a 12-bit number and are numbered sequentially from 0 to 3071.

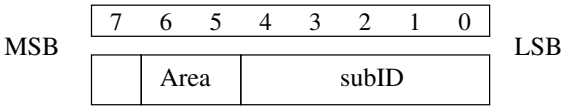

Figure 5: ST Tell1 board numbering scheme.

Area	**SourceIDs**
TTa, Layer 1	0 - 10
TTa, Layer 2	32 - 42
TTb, Layer 1	64 - 76
TTb, Layer 2	96 - 108
IT1, Station 1	0 - 13
IT2, Station 2	32 - 45
IT3, Station 3	64 - 77

Table 1: Tell1 sourceIDs.

4.1 TT partitioning

The chosen partitioning is shown in Fig. 6 for the first two layers in the station (TTa) and in Fig. 7 for the second two (TTb). A total of 48 Tell1 boards are needed to read out the TT station. The partitioning within a Tell1 board is described in Appendix A.

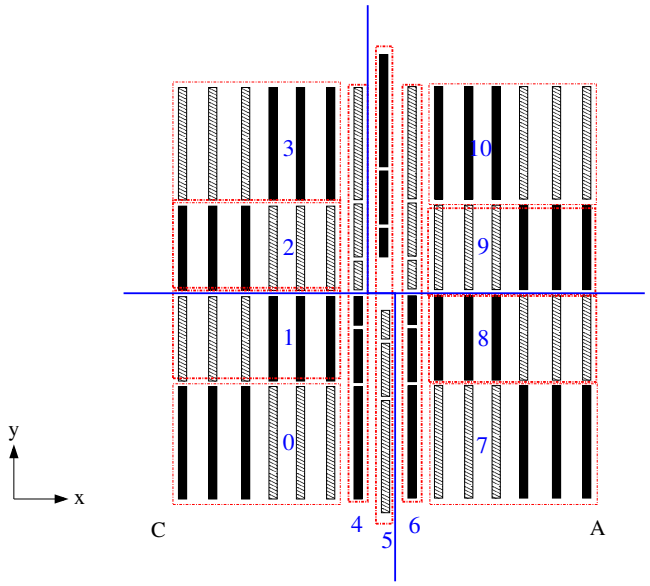

Figure 6: Readout partitioning for TTa. The numbers on the figure correspond to the board **subID**. Each black or hashed rectangle represents one readout sector. The black and grey shading on the sectors corresponds to separate optical fibre bundles. The partitioning of the sectors into quadrants corresponding to service boxes is also shown. Positive z is out of the page.

4.2 Inner Tracker partitioning

In each of the three Inner Tracker stations there are 112 readout sectors which corresponds to 14 Tell1 boards. The proposed partitioning is shown in Fig. 8. Since an Inner Tracker box contains 28 ladders it is necessary to have the inputs for two boards come from different detector boxes. Support and cabling constraints lead to the pairing of the top and cryo-side boxes. It should be noted that in the region directly to the left and right of the beampipe the occupancy is highest. If a Tell1 board were to fail a track would still leave ~ 2 hits in the station allowing a reasonable chance of reconstruction. A total of 42 Tell1 boards are needed to read out the Inner Tracker.

4.3 Implementation

The new readout mappings have been implemented and will be used in subsequent LHCb Monte Carlo productions. The actual mappings are stored

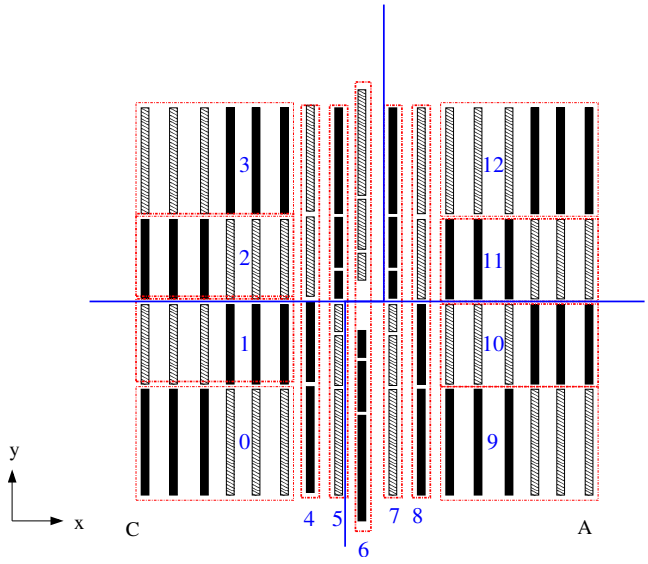

Figure 7: Readout partitioning for TTb. The numbers on the figure correspond to the board **subID**. Each black or hashed rectangle represents a readout sector. The black and grey shading on the sectors corresponds to different optical fibre bundles. The partitioning of the sectors into quadrants corresponding to service boxes is also shown. Positive z is out of the page.

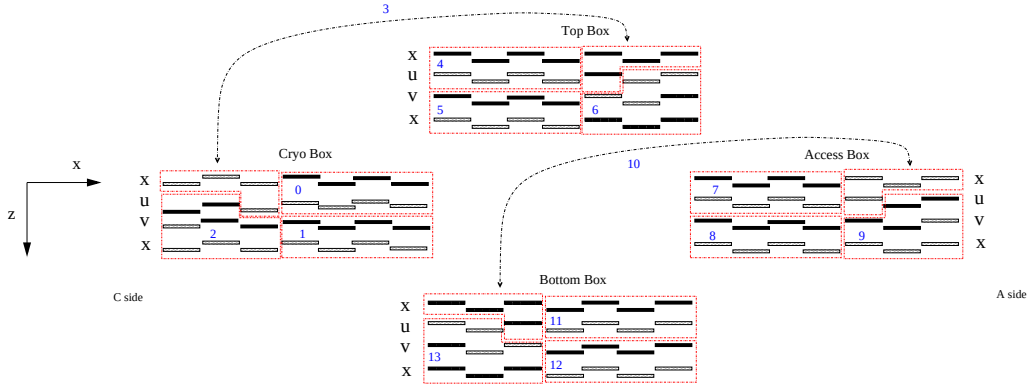

Figure 8: Readout partitioning for an Inner Tracker station. The numbers on the figure correspond to the board **subID**. Each black or hashed rectangle represents one readout sector. The black and grey shading on the sectors corresponds different optical fibre bundles and to the HV and LV partitioning. *Nota Bene,* the corresponding figure in [1] is wrong.

in the LHCb conditions database. Information is uploaded to the database using XML files. The XML files were generated using the genx package [3]. The code used in this procedure can be obtained from:

`http://ckm.physik.unizh.ch/software/det/index.php`

References

[1] M. Needham. Channel Numbering and Readout Partitioning for the Silicon Tracker. LHCb-Note 2006-033.

[2] G,Haefeli *et al.* TELL1 - Specification for a common readout board for LHCb. LHCb-Note 2003-007.

[3] http://www.tbray.org/ongoing/When/200x/2004/02/20/GenxStatus.

[4] Boole v12 and v13 series.
http://lhcb-release-area.web.cern.ch/LHCb-release-area/DOC/boole/.

A Readout Mappings

In this appendix the full readout mappings currently used in the Monte Carlo are given.

0	(1,1) (1,5) (1,9) (1,13) (1,17) (1,21)
1	(1,2) (1,6) (1,10) (1,14) (1,18) (1,22)
2	(1,3) (1,7) (1,11) (1,15) (1,19) (1,23)
3	(1,4) (1,8) (1,12) (1,16) (1,20) (1,24)
4	(2,1) (2,2) (2,3) (2,4) (2,5) (2,6)
5	(2,7) (2,8) (2,9) (2,10) (2,11) (2,12)
6	(2,13) (2,14) (2,15) (2,16) (2,17) (2,18)
7	(3,1) (3,5) (3,9) (3,13) (3,17) (3,21)
8	(3,2) (3,6) (3,10) (3,14) (3,18) (3,22)
9	(3,3) (3,7) (3,11) (3,15) (3,19) (3,23)
10	(3,4) (3,8) (3,12) (3,16) (3,20) (3,24)

Table 2: TTa readout mapping. The readout sector column corresponds to (detRegion,sector)

Board **subID**	Readout sectors
0	(1,1) (1,5) (1,9) (1,13) (1,17) (1,21)
1	(1,2) (1,6) (1,10) (1,14) (1,18) (1,22)
2	(1,3) (1,7) (1,11) (1,15) (1,19) (1,23)
3	(1,4) (1,8) (1,12) (1,16) (1,20) (1,24)
4	(2,1) (2,2) (2,3) (2,4) (0,0) (0,0)
5	(2,5) (2,6) (2,7) (2,8) (2,9) (2,10)
6	(2,11) (2,12) (2,13) (2,14) (2,15) (2,16)
7	(2,17) (2,18) (2,19) (2,20) (2,21) (2,22)
8	(2,23) (2,24) (2,25) (2,26) (0,0) (0,0)
9	(3,1) (3,5) (3,9) (3,13) (3,17) (3,21)
10	(3,2) (3,6) (3,10) (3,14) (3,18) (3,22)
11	(3,3) (3,7) (3,11) (3,15) (3,19) (3,23)
12	(3,4) (3,8) (3,12) (3,16) (3,20) (3,24)

Table 3: TTb readout mapping. The readout sector column corresponds to (detRegion,sector)

Board **subID**	Readout sectors
0	(1,1,4) (1,1,5) (1,1,6) (1,1,7) (2,1,4) (2,1,5) (2,1,6) (2,1,7)
1	(3,1,4) (3,1,5) (3,1,6) (3,1,7) (4,1,4) (4,1,5) (4,1,6) (4,1,7)
2	(2,1,1) (2,1,2) (3,1,1) (3,1,2) (3,1,3) (4,1,1) (4,1,2) (4,1,3)
3	(1,1,1) (1,1,2) (1,1,3) (2,1,3) (1,4,5) (1,4,6) (1,4,7) (2,4,5)
4	(1,4,1) (1,4,2) (1,4,3) (1,4,4) (2,4,1) (2,4,2) (2,4,3) (2,4,4)
5	(3,4,1) (3,4,2) (3,4,3) (3,4,4) (4,4,1) (4,4,2) (4,4,3) (4,4,4)
6	(2,4,6) (2,4,7) (3,4,5) (3,4,6) (3,4,7) (4,4,5) (4,4,6) (4,4,7)
7	(1,2,1) (1,2,2) (1,2,3) (1,2,4) (2,2,1) (2,2,2) (2,2,3) (2,2,4)
8	(3,2,1) (3,2,2) (3,2,3) (3,2,4) (4,2,1) (4,2,2) (4,2,3) (4,2,4)
9	(2,2,6) (2,2,7) (3,2,5) (3,2,6) (3,2,7) (4,2,5) (4,2,6) (4,2,7)
10	(1,2,5) (1,2,6) (1,2,7) (2,2,5) (1,3,1) (1,3,2) (1,3,3) (2,3,3)
11	(1,3,4) (1,3,5) (1,3,6) (1,3,7) (2,3,4) (2,3,5) (2,3,6) (2,3,7)
12	(3,3,4) (3,3,5) (3,3,6) (3,3,7) (4,3,4) (4,3,5) (4,3,6) (4,3,7)
13	(2,3,1) (2,3,2) (3,3,1) (3,3,2) (3,3,3) (4,3,1) (4,3,2) (4,3,3)

Table 4: Inner Tracker readout mapping. The readout sector column corresponds to (layer, detRegion, sector)

B DC 06 Readout Mapping for TT

In this appendix the TTb readout mapping used in the DC 06 data challenge [4] is given. The readout mappings for TTa and the Inner Tracker that were used are those described in Appendix. A.

Board **subID**	Readout sectors
0	(1,1) (1,5) (1,9) (1,13) (1,17) (1,21)
1	(1,2) (1,6) (1,10) (1,14) (1,18) (1,22)
2	(1,3) (1,7) (1,11) (1,15) (1,19) (1,23)
3	(1,4) (1,8) (1,12) (1,16) (1,20) (1,24)
4	(1,25) (1,26) (1,27) (1,28) (0,0) (0,0)
5	(2,1) (2,2) (2,3) (2,4) (2,5) (2,6)
6	(2,7) (2,8) (2,9) (2,10) (2,11) (2,12)
7	(2,13) (2,14) (2,15) (2,16) (2,17) (2,18)
8	(3,1) (3,2) (3,3) (3,4) (0,0) (0,0)
9	(3,5) (3,9) (3,13) (3,17) (3,21) (3,25)
10	(3,6) (3,10) (3,14) (3,18) (3,22) (3,26)
11	(3,7) (3,11) (3,15) (3,19) (3,23) (3,27)
12	(3,8) (3,12) (3,16) (3,20) (3,24) (3,28)

Table 5: TTb readout mapping used in DC 06. The readout sector column corresponds to (detRegion,sector)