LHCb note 2006-033

Channel Numbering and readout partitioning for the Silicon Tracker

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July 25, 2006

Abstract

An updated channel numbering scheme and readout partitioning for the LHCb Silicon Tracker is presented.

1 Introduction

First proposals for the offline channel numbering and readout partitioning for the Silicon Tracker are described in [1] and [2] respectively. In this note an improved channel numbering scheme together with an updated readout partitioning is described. Both have been implemented in the LHCb software and will be used in the forthcoming data challenge — DC'06.

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. The centre region corresponds to the three innermost columns of the detector where each detector module is segmented into a four, a two and a one sensor readout sector. For the beam-pipe region in both TTa and TTb there are 18 readout **sectors**. In the case of TTa (TTb) there are 24 (28) readout sectors each in the cryo and access regions.

The readout sectors within each **detRegion** are numbered by column and by increasing y as shown in Fig. 2. The strips within a sector are numbered by increasing x.

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, lift, bottom and top and correspond to **detRegion** 1 to 4 respectively. 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. As in

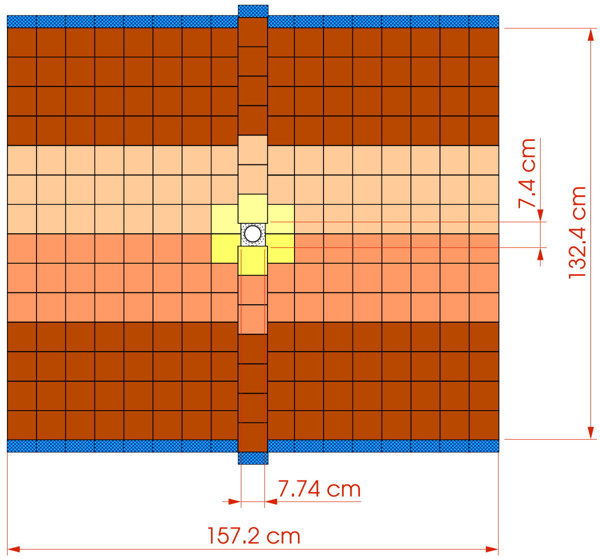

Figure 1: Layout of a layer in TTb.

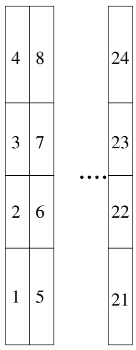

Figure 2: Example of TT sector numbering. The example of the cryo side of TTa is shown.

the case of TT strips are numbered by increasing x.

4 Readout partitioning

Every readout strip on the Silicon Tracker maps to a channel on a Tell1 readout board [3]. A Tell1 board can process twenty-four Beetles each with 128 readout strips and has two outputs. This corresponds to six readout sectors in the case of the TT station and eight readout sectors for the case of the Inner Tracker. This together with the different geometry of the two sub-detectors naturally leads to two distinct mappings.

Every readout board sends in the raw data header the data bank type and an 8-bit board identifier. *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 a region —- '**subID**'.

This numbering scheme is shown pictorially in Fig. 3. 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 channels within a Tell1 board are identified by a 12-bit number and are numbered sequentially from 0 to 3071.

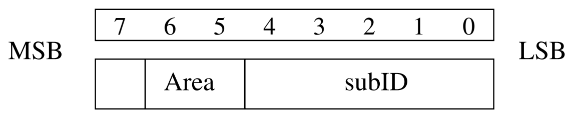

Figure 3: ST Tell1 board numbering scheme.

4.1 TT partitioning

The chosen partitioning is shown in Fig. 4 for the first two layers in the station (TTa) and in Fig. 5 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 the appendix.

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

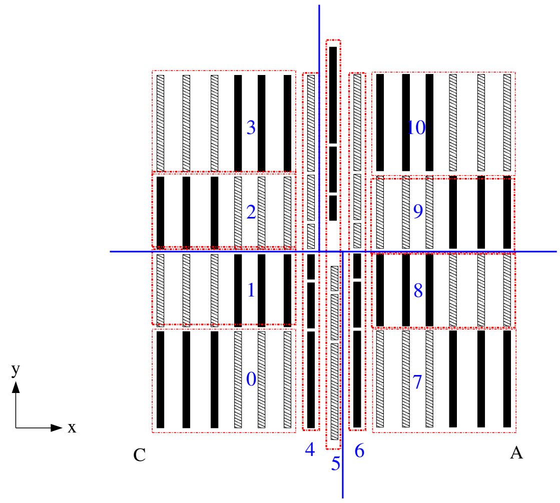

Figure 4: Readout partitioning for TTa. The numbers on the figure correspond to the board **subID**. Each black or hashed rectangle represents one readout sector. The black and grey shading on the sectors corresponds to separate optical fibre bundles. The partitioning of the sectors into quadrants corresponding to service bocxes is also shown. Positive z is out of the page.

in Fig. 6. Since an Inner Tracker box contains 28 ladders it has been decided to have inputs for two boards coming 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 beam-pipe where 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 Tell 1 boards are needed to read out the Inner Tracker. *Nota bene,* the partitioning for both the high and low voltage will follow the same scheme.

4.3 Hybrid Orientation

Due to the design and construction 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

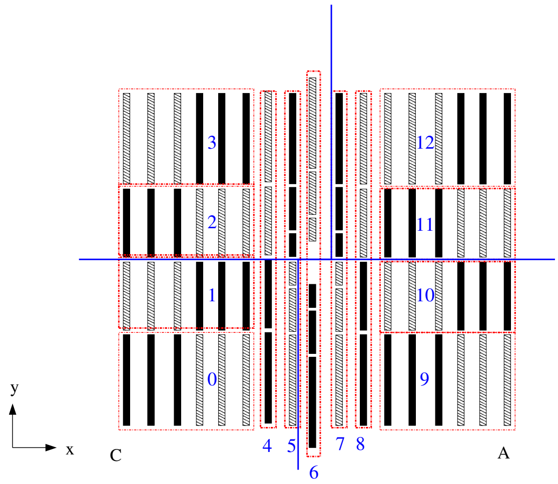

Figure 5: Readout partitioning for TTb. The numbers on the figure correspond to the board **subID**. Each black or hashed rectangle represents a readout sector. The black and grey shading on the sectors corresponds to different optical fibre bundles. The partitioning of the sectors into quadrants corresponding to service boxes is also shown. Positive z is out of the page.

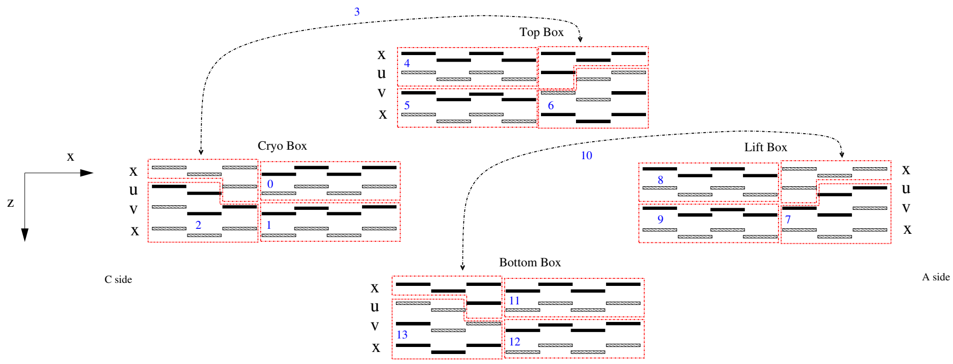

Figure 6: Readout partitioning for an Inner Tracker station. The numbers on the figure correspond to the board **subID**. Each black or hashed rectangle represents one readout sector. The black and grey shading on the sectors corresponds different optical fibre bundles and to the HV and LV partitioning.

the reverse is true. This leads to a swapping of the strip numbers used to identify the strips on the Tell1 board relative to the offline convention that has to be corrected for during the decoding. 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. In the case of the Inner Tracker 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. For the top box this pattern is reversed.

4.4 Implementation

The new readout mappings are used in Boole version v10r0 onward. The actual mappings are stored in the LHCb conditions database. The current implementation of this is based on XML files. The XML files were generated using the genx package [4]. The code used in this procedure can be found at:

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

A Readout Mappings

In this appendix the full readout mappings currently used in the Monte Carlo are given. The chosen ordering of readout sectors within a Tell1 board is somewhat arbitrary and therefore could change in the future.

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) (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 1: 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	(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 2: 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 3: Inner Tracker readout mapping. The readout sector column corresponds to (layer, detRegion, sector)

References

[1] M. Needham. Silicon Tracker Simulation Performance. LHCb-Note 2003-015.

[2] M. Needham *et al.* Raw data format and readout partitioning for the Silicon Tracker. LHCb-Note 2004-044.

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

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