UT software numbering

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Abstract

In the LHCb software, each detector channel is labeled with a unique integer identifier. This identifier is composed of a number of pieces, encoded in different bits of the integer. This identifier is primarily used in the software as a "key" to relate a readout element to a geometrical location in the detector. Additional accessor methods can be provided to aid the developer in organizing related channels together. This document describes the updated UT numbering scheme, which is intended to replace an older map based on TT numbering.

1 UTChannelID

The UT scheme is encoded in the integer member of the `UTChannelID` class. This ID is built up from hierarchical pieces derived from the detector geometry, visualized in Fig. 1. Staring from the most significant division, numbering is assigned as follows:

- The entire UT is assigned the ID value of 2 to distinguish it from other subdetectors.
- The A and C sides of the detector, which are numbered 0 and 1 respectively.
- Each side is divided into four "half-layers", numbered from 0 to 3 from upstream to downstream. The first two layers are also called the UTa station, and the second two the UTb station.
- Each half-layer is made up of vertical staves: 8 in UTa, and 9 in UTb.
- The staves are numbered, starting from the innermost one (near the beamline). There are three types of staves: Type A for the outer staves with only A sensors, Type B for the second stave, and Type C for the innermost that mounts the C and D sensors.
- The next three divisions all are used to describe the positioning of four-ASIC groups, which are called "sectors" in the software. The most significant division is the front and back faces of a stave. To ensure that the sector at minimum global-y position is the smallest number, the face called "back" in construction is given ID 0, and the "front" is ID 1.
- On each face, the sensor modules are numbered from the bottom at minimum global-y to the top. Because the Type A and B staves have fewer modules, the identifiers reserved for Type D sensors are omitted on these staves.
- Modules with 4 ASICs are always given a sector bit 0. Modules with 8 ASICs have an additional sector with bit 1 for the higher numbered ASICs.
- Each sector has 512 channels, with an ordering given by the ASIC numbering.

In addition to the divisions just described, different bit groupings of the `UTChannelID` may be used to aid in matching or visualizing different parts of the detector. Some possible applications:

- The more significant bit of the half-layer number gives the station: 0 for UTa and 1 for UTb.
- The combination of face and module bits, or face, module, and sector bits can be used alternatively to refer to sectors on a stave.

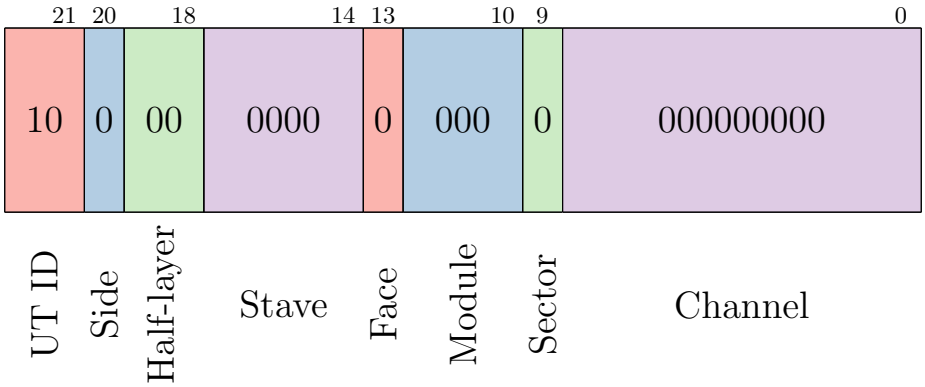

Figure 1: Bit formatting in UTChannelID.

- The combination of all fields besides the UT ID and channel number uniquely identifies a sector in the entire UT.
- The sector bit can be combined with the channel number to number the channels of 8 ASIC modules from 0 to 1023.
- The most significant two bits of the channel number give an ASIC number from 0 to 3 for a sector.

2 Visualizations of the numbering

To aid the user of the numbering scheme, visualizations of the layout on a half-layer are given in Figs. 2 to 4. Each figure shows the last layer (UTbX) on the A side of the detector, which is located at positive global x coordinate. Viewing the detector facing downstream places the A side on the left, as in the figure. Axes for the global x and y are shown. In each figure the ID components that specify this half-layer are not shown.

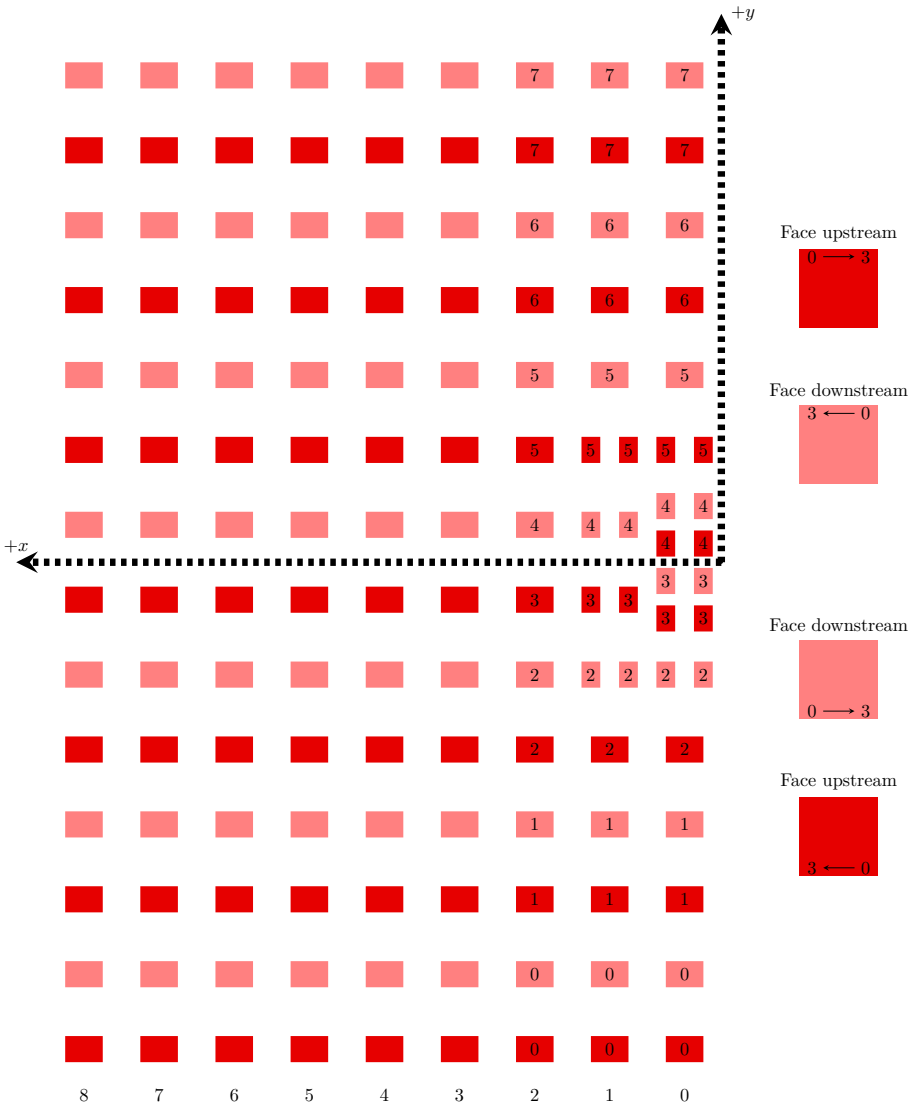

Figure 2: Stave and module numbering for UTbX A side from a perspective looking downstream. The boxes represent the positions of each sector (4 ASIC group). Only the 3-bit module number field is shown; the bits for the stave face and sector are not shown. Darker colors show modules which face upstream, lighter downstream. The key on the right shows the direction of the ASIC numbering, which differs on the top and bottom of the detector. Staves above 2 share numbering with stave 2.

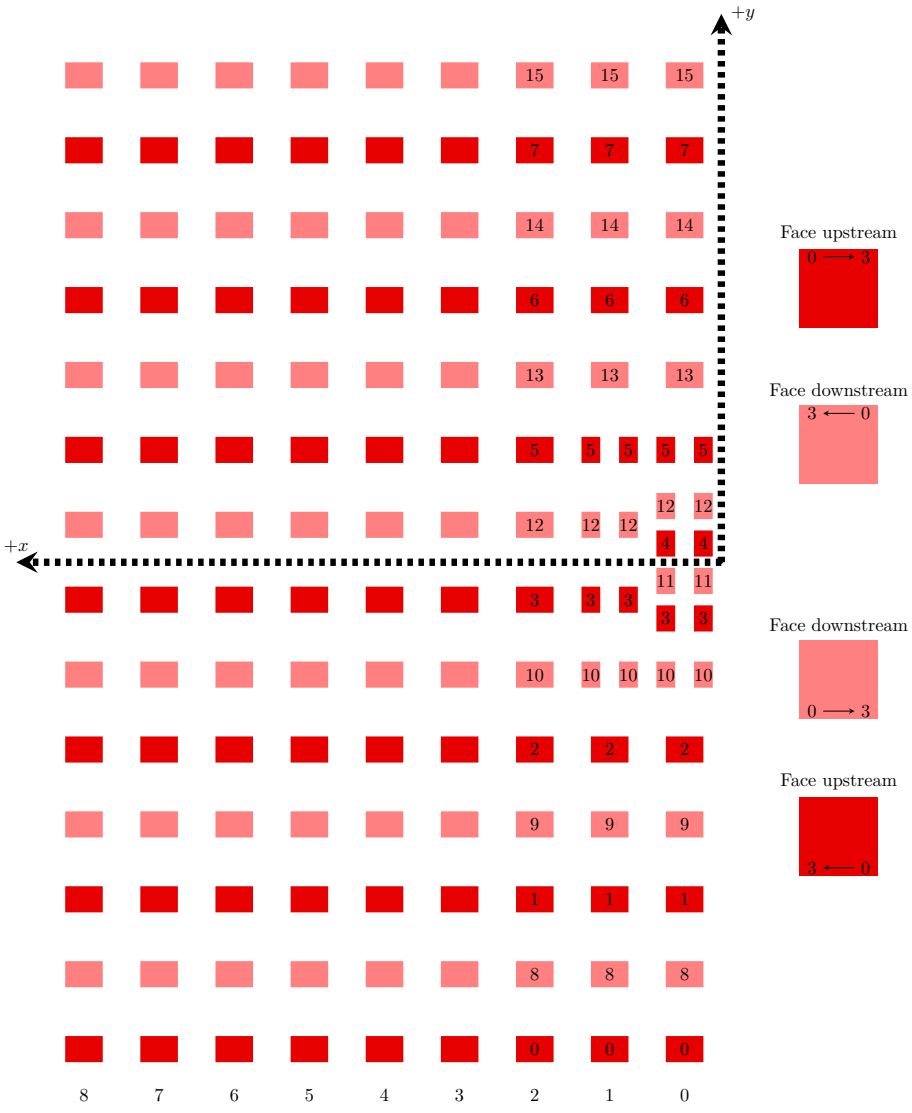

Figure 3: Stave and module numbering for UTbX A side from a perspective looking downstream. The boxes represent the positions of each sector (4 ASIC group). The stave face bit is included, but the sector bit excluded. On the A side, the "back" of the stave faces upstream. Darker colors show modules which face upstream, lighter downstream. The key on the right shows the direction of the ASIC numbering, which differs on the top and bottom of the detector. Staves above 2 share numbering with stave 2.

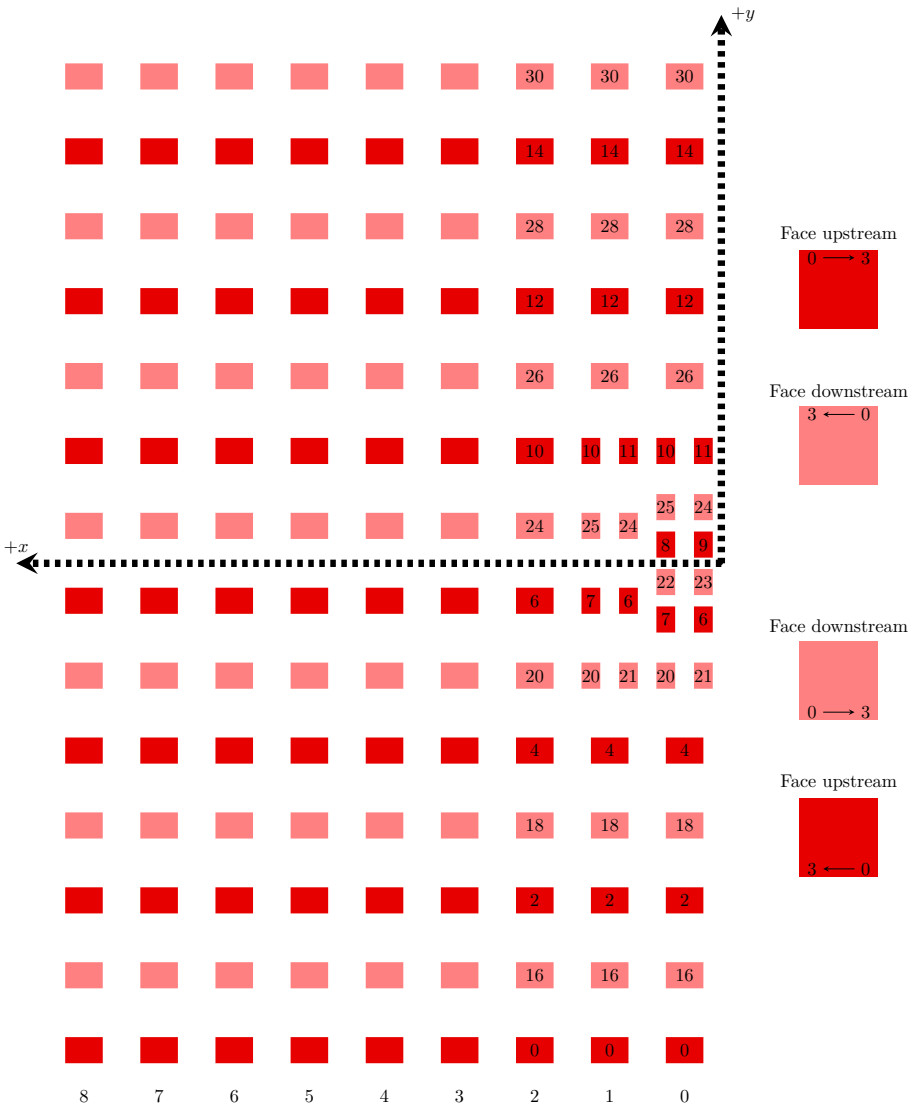

Figure 4: Stave and module numbering for UTbX A side from a perspective looking downstream. The boxes represent the positions of each sector (4 ASIC group). The stave face and sector bits are included. On the A side, the "back" of the stave faces upstream. Darker colors show modules which face upstream, lighter downstream. The key on the right shows the direction of the ASIC numbering, which differs on the top and bottom of the detector. The higher sector number always corresponds to ASICs 4-7 on the hybrid. Staves above 2 share numbering with stave 2.

3 Connections to DAQ and raw data

One of the primary uses of the software numbering is to connect readout elements to geometrical elements. We discuss here some aspects of this translation. The UT raw data format is described in Ref. [1]. Each UT "RawBank" processed in software contains hits divided into what are termed "lanes." Each lane corresponds to the readout from either two or four adjacent readout SALT ASICs attached to the same silicon sensor. At the current time, it is expected that the hits in a lane will be ordered based on the electronics channel numbering. Each rawbank has space allocated for six lanes, although not all lanes will be filled in all rawbanks. When decoding a UT rawbank in software, all hits in a lane are returned before moving to the next lane, so hits in a lane will always be contiguous during decoding.

We represent this scheme in software using the class `UTDAQID`, which combines a board number, the lane number, and the channel number in a lane. The board number is a fixed number based on the current assignment of readout elements to TELL40s in the fiber mapping [2], assigning consecutive numbers for each TELL40 output stream. It is intended that this number will always refer to these fixed groupings of readout ASICs, unless changes to the fiber groupings are required. There are two board numbers for each physical TELL40 card to separately refer to the two output streams. A UTDAQID board number does not necessarily correspond to the source ID of the raw data, though the mapping is intended to be read from the conditions database.

In terms of the software numbering, hits in a single lane will always be located in a single sector, and so a cache can be built mapping each raw data lane to a unique software sector. Sensors in high hit density areas that have only two ASICs assigned to a readout lane will have two lanes per sector, however. In general, lanes that are adjacent in the raw data will correspond to detector elements in close proximity, but the assignment to lanes is chiefly designed around load balancing. The resulting groups are visualized in Figs. 5 and 6 for two of the detector quadrants. Because of the way fibers are grouped, each rawbank will contain hits from only one quadrant of one detector layer. The pattern for each quadrant is identical up to flips and rotations, as can be seen comparing the two figures.

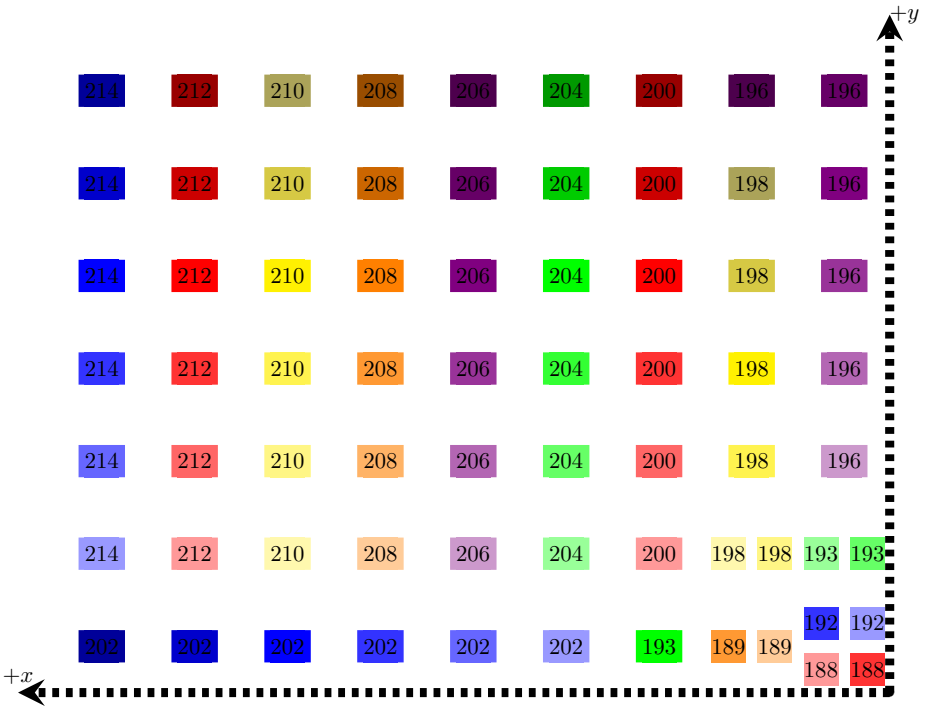

Figure 5: Visualization of the division of the UTbX layer, A-side, top quadrant into different TELL40 cards which produce the raw data output. Each box represents a software sector and is located inside it's physical area. The beamline is located at the bottom right corner at the global xy coordinate system origin. Other quadrants follow the same breakdown with appropriate flips or rotations. UTa quadrants do not include the outermost (left side in the figure) vertical stave. The numbers correspond to the board number of UTDAQID; sectors with the same number are grouped in the same raw data bank coming from a TELL40. Colors are used to aid association of different nearby sectors that belong to the same bank; the shades from light to dark represent the different lanes of the raw bank.

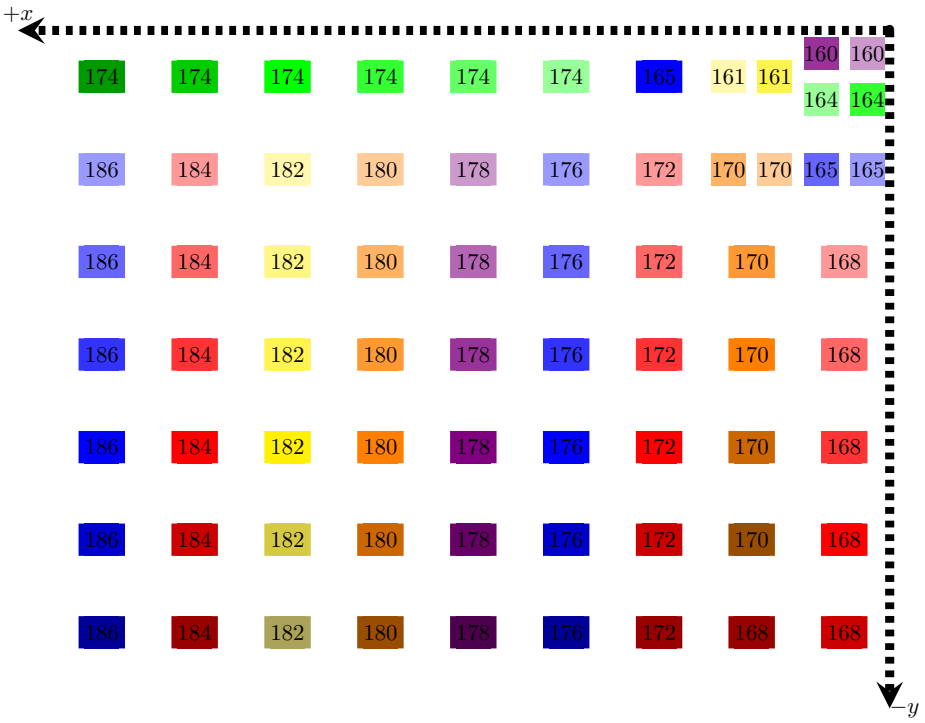

Figure 6: Visualization of the division of the UTbX layer, A-side, bottom quadrant into different TELL40 cards which produce the raw data output. Each box represents a software sector and is located inside it's physical area. The beamline is located at the top right corner at the global xy coordinate system origin. Other quadrants follow the same breakdown with appropriate flips or rotations. UTa quadrants do not include the outermost (left side in the figure) vertical stave. The numbers correspond to the board number of UTDAQID; sectors with the same number are grouped in the same raw data bank coming from a TELL40. Colors are used to aid association of different nearby sectors that belong to the same bank; the shades from light to dark represent the different lanes of the raw bank.

4 Summary and glossary

The numbering of Upstream Tracker detector elements in software is a combination of geometrical and readout concerns. This document gives a brief description of the key elements, along with useful visualizations in terms of geometry. This is intended to aid with understanding the use of the numbering scheme when developing software for the UT and reconstruction. To that end, we summarize here some particularly key terms that are frequently used:

UTChannelID a unique identifier to refer to a specific UT output channel, constructed from a set of geometrical indices.

Sector a software grouping of 4 readout ASICs with 512 channels, attached to the same silicon sensor and used in the geometry to match channels with positions.

RawBank a data fragment with associated header information, containing raw data as output from the TELL40 card.

Lane a part of the UT RawBank, containing hits from a single software sector.

UTDAQID a software identifier combining information on the TELL40 board number, lane, and channel number in the lane. Used to aid in constructing software maps.

SourceID index assigned to the RawBank by the event builder. May not correspond to the UTDAQID board number.

References

Abellan, C. and G. Loustau. *LHCb Upgrade Upstream Tracker Data Processing.* in preparation. CERN.

Wang, J.C. *UT optical connection mapping.* LHCB-RD-SPC-0006. EDMS document 2339408. CERN.