Definition of Off-line Readout Identifiers for the ATLAS Detector

Last modified: 28 May 2001
Version 1.17
Editors: S. Goldfarb, A. Schaffer
Contributors: D. Barberis, S. Bentvelsen, D. Calvet, A. DiCiaccio, F. Djama, G. Gorfine, J.-F. Laporte, D. Lellouch, M. Leltchouk, F. Luehring, P. Loch, A. Rozanov, S. Simion, R. Sobie, M. Virchaux

1 Introduction

In this note we define a readout identification scheme to be used in the ATLAS offline software. This scheme uses hierarchically structured identifiers which follow a logical decomposition of the ATLAS detector. For example, a level in this hierarchy may distinguish between barrel or endcap, or specify which layer or define the eta/phi numbering within a layer. This scheme can be used to uniquely identify each readout channel individually. However, due to their hierarchical form, specifying only part of the hierarchy allows one to identify parts of the detector, for example, the detector element which contains the readout channels. Some of the possible uses foreseen for this identification scheme are:

- identifying the readout channels
- identifying groups of readout channels, e.g. those belonging to a particular Pixel module, to facilitate organizing and accessing the real or simulated raw data,
- a means of mapping calibration/alignment correction sets to the event raw data.

One should note that this scheme can identify (some) parts of the detector, but it identifiers them *as assembled*, as opposed to identifying the parts as they are manufactured[1].

It should also be noted that, at the time of writing this note, an effort is underway to define an identification scheme which defines sensitive volumes of the detector. This scheme may differ in some respects from the readout identification scheme proposed here. For example the readout scheme identifies the photo-multiplier tube in the TileCal readout (Section 4.4 and Table 10) but this is not sufficient to identify each individual scintillator as a separate sensitive volume. The elaboration of this geometric identification scheme may in turn require a revision of the current document.

In Section 2 we provide an example to help understand the identification scheme. In Section 3 we present a proposed set of conventions to follow to allow coherence for the identifiers of the different systems. In Section 4 we present the specific identifier layout for the different detectors and provide the detailed range values for each of the hierarchical levels.

[1] This should not be confused with the part identification scheme used to identify detector elements *as built*. See refs: ATC-OQ-QA-2040 ATLAS Part Identification http://edmsoraweb.cern.ch:8001/cedar/doc.info?document_id=ATL-GE-QA-2040

2 An example

To understand better the identifier scheme, let us take the SCT detector as an example (see Figure 1 for a simplified diagram of the SCT). For the SCT, one can identify the following logical parts, depending upon whether one is considering the barrel or the end caps:

r φ η

Inner Detector / SCT / barrel / layer / phi_module / eta_module / side / strip

Inner Detector / SCT / endcap / disk / phi_module / eta_module / side / strip

The identifier scheme is a mapping of this logical decomposition into a series of integers (or letters), delimited by '/', as explained further below. For example, for the identifier of a particular strip of the SCT barrel one might have: `2/2/0/1/38/-4/1/358`. (see Table 1 below).

The first two levels indicate the detector system (2 for Inner Detector) and subsystem (2 for SCT). The next level indicates the barrel or end cap. The next three levels enumerate spatial position in terms of a distance ("r") and two angular variables (φ and η). The first ("r") identifies a layer in the barrel or a disk in the end cap. The φ level identifies then the set of modules which occupy a constant wedge in φ, i.e. along z in the barrel or along the cylindrical radius in the end cap. Finally the η level identifies an individual module in the set of φ modules.

With this scheme one can, for example, identify any SCT module by specifying the numbers for the levels down to and including the eta_module, and for each wafer one would specify down to and including the side level. Similarly, specifying the numbers for all levels identifies individual strips on a particular wafer. As well, one can simply identify the whole of the SCT by specifying the first two levels only.

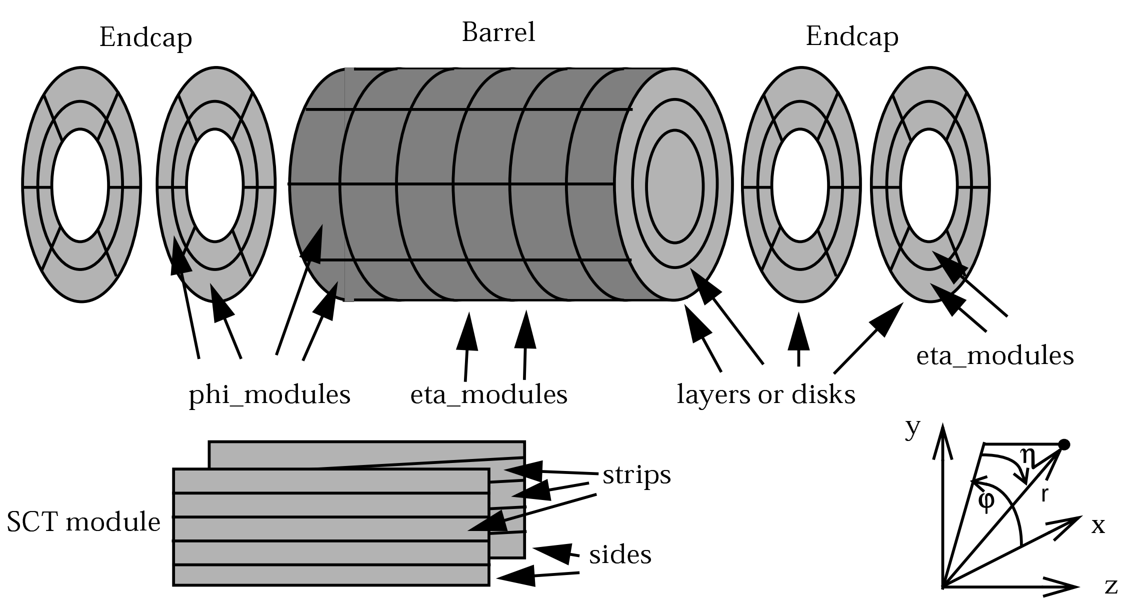

Figure 1: Simplified diagram of SCT detector showing the logical decomposition of the detector used in the readout identifier.

This schema can be extended to specify regions of the detector by allowing “number ranges” to be specified at each level, where a number range could be for example a list of numbers, min/max or even a wild card. In this way, one could identify an annular ring in the SCT barrel by 2/2/0/1/*/-4, corresponding to layer 1, all phi_modules indices and eta_module -4 (see Table 1 below).

The full list of value ranges for the various levels of the SCT readout identifier is given in Table 1.

Level	**Value Range**	**Meaning / Comment**
Inner Detector	2	
SCT	2	
barrel or endcap	0	barrel
	-2, 2	negative, positive endcap
layer or disk	[0, 3]	barrel layer
	[0, 8]	endcap disk
phi_module	[0, 31]	barrel layer 0
	[0, 39]	barrel layer 1
	[0, 47]	barrel layer 2
	[0, 55]	barrel layer 3
	[0, 51]	end cap for eta_module 0 of all disks
	[0, 39]	end cap for eta_module 1 and 2 of all disks, where existing
eta_module	[-6,-1], [1,6]	barrel modules centred at negative or positive z. Note that there is no module centred at z=0, and 0 is not valid as a barrel eta_module value.
	 [0, 1] [0, 2] [0, 1] 0	endcap disk 0 [1, 5] [6, 7] 8
side	[0, 1]	inner/outer wafer of module pair
strip	[0, 767]	strip number

Table 1: Set of value ranges for SCT readout identifier levels

3 Conventions and definitions

We propose to adopt the following conventions for the identifiers.

- The upper levels of the identifiers should follow the PBS convention of SystemName followed by SubSystemName.
- The numbering of different items should increase following the basic axes:
  - spherical radius,
  - eta,
  - phi.

  This means, for example, that eta numbering in endcaps increases from the large radius to the beam axis.
- The co-ordinate axis system follows the ATLAS global detector axis system[2]:
  - with the origin at the detector centre system
  - X-axis is horizontal, pointing towards the centre of the LHC ring
  - Y-axis points upwards, and
  - Z-axis is aligned with the beam to form a right-handed Cartesian co-ordinate system

  The phi numbering starts from the X-axis
- To distinguish the positive and negative halves along the z axis, a signed identifier level is used. For example a level distinguishing barrel and endcap uses -2, 0, +2 to distinguish the three elements, or for the muons the station eta has a sign[3].
- Numbering should in general begin with 0 - thus eta is an exception.
- Ranges are expressed with bracket notation, e.g. [0,..,7] runs from 0 to 7 inclusively.

4 Readout identifier structure for the different subsystems

In the following subsections we present the identifier structure for the various subsystems. For each subsystem, we present the overall structure of the identifiers. This is followed by tables containing the detailed numbering of the different levels.

4.1 Upper Level of the Identifiers

Following the conventions of Section 3, we have adopted the numbering for the upper levels of the readout identifiers according to the PBS. The names for the upper levels have been taken from the offline software's top level package names.[4] Most of the identifiers begin with SystemName/SubSystemName. This is followed by a level indicating the "positioning" of the subsystem, e.g. barrel or endcap, and whether it is the positive or negative half. The MuonSpectrometer follows a somewhat different structure:

---

2 for technical note see EDMS Doc. Id.: ATL-GE-QA-2041 which is the same as Proj. Doc. Num.: ATC-OQ-QA-2041

3 As seen below, this is implemented somewhat differently from system to system. We have tried to keep the "signed" level to be one of the upper-most levels in the identifiers and not the lower-most as in the case of the eta of a calorimeter cell.

4 The PBS defines numbers and letters for the break-down structure, but does not provide official names.

MuonSpectrometer/StationName, where this reflects the logical structure where the subsystems, MDT, RPC, TGC,CSC, are actually grouped into stations.

4.2 Inner Detector

Pixel:

r φ η

Inner Detector / pixel / barrel / layer / phi_module / eta_module / phi_index / eta_index

Inner Detector / pixel / endcap / disk / phi_module / eta_module / phi_index / eta_index

SCT:

r φ η

Inner Detector / sct / barrel / layer / phi_module / eta_module / side / strip

Inner Detector / sct / endcap / disk / phi_module / eta_module / side / strip

TRT:

r φ

Inner Detector / trt / barrel / layer / phi_module / straw_layer / straw

Inner Detector / trt / endcap / wheel / phi_module / straw_layer / straw

4.2.1 Comments

For the Pixels and SCT, the structure and order allows one to uniquely identify some of the physical elements leading to the readout channels:

- **staves**: consists of all modules in a barrel layer covering the same phi range, and hence the barrel identifier down to and including phi_module identifies a stave. (e.g. 2/2/0/1/37 identifies a stave in barrel layer 1.),
- **modules**: adding the eta_module (e.g. 2/2/0/1/37/-3) identifies a module:

  SCT: of 2 Si wafers

  Pixel: a single Si wafer
- **wafer**: for the SCT, the wafer in a module is identified by the 'side'. (e.g. 2/2/0/1/37/-3/0)
- **readout channels**: all levels must be specified (i.e. down to eta_index for the Pixels and down to strip for the SCT).

This allows some flexibility for, for example, using identifiers as associations to alignment constants or identifying grouping of raw data.

For the Pixels the last two components of the identifier, phi_index and eta_index, scan rows and columns on a wafer, respectively. It is also true that following the conventions of Section 3 for the numbering directions, which advocate increasing with phi and eta of the global coordinate system, the numbering for phi/eta_index are inverted for some pixel modules relative to the numbering directions of row/column on the pixel chip.

For the TRT, the “eta” level of the Pixel and SCT is “missing”. The barrel halves and different endcaps are distinguished by the barrel/endcap level (see Table 4). The “layer” level corresponds to a layer of phi modules in the barrel, and the “phi_module” level corresponds to the different TRT modules in the barrel and to the trigger towers in the endcaps.

4.2.2 Detailed value ranges

We provide here the detailed numbering for the Inner Detector. Note that the Pixel layout is still evolving so that the limits may not be final. They correspond to the “Dubna layout”.

Similarly for the TRT, the layer and wheel numbering is positive and negative starting from +/- 1 and increase with eta.

Pixel:

Level	Value Range	Meaning / Comment
Inner Detector	2	
Pixel	1	
barrel or endcap	0	barrel
	-2, 2	negative, positive endcap
layer or disk	[0, 2]	barrel layer
	[0, 4]	endcap disk
phi_module	[0, 21]	barrel layer 0
	[0, 39]	barrel layer 1
	[0, 55]	barrel layer 2
	[0, 53]	end cap disks 0 to 2
	[0, 65]	end cap disks 3 to 4
eta_module	[-6, 6]	barrel eta_module - note that 0 straddles z = 0.
	0	endcaps have only one ring
phi_index	[0,319]	barrel layer 0
	[0,327]	other layers and disks
eta_index	[0,191]	barrel layer 0
	[0,143]	other layers and disks

Table 2: Set of value ranges for Pixel readout identifier levels

SCT:

Level	Value Range	Meaning / Comment
Inner Detector	2	
SCT	2	
barrel or endcap	0	barrel
	-2, 2	negative, positive endcap
layer or disk	[0, 3]	barrel layer
	[0, 8]	endcap disk
phi_module	[0, 31]	barrel layer 0
	[0, 39]	barrel layer 1
	[0, 47]	barrel layer 2
	[0, 55]	barrel layer 3
	[0, 51]	end cap for eta_module 0 of all disks
	[0, 39]	end cap for eta_module 1 and 2 of all disks, where existing
eta_module	[-6,-1], [1,6]	barrel modules centred at negative or positive z. Note that there is no module centred at z=0, and 0 is not valid as a barrel eta_module value.
	 [0, 1] [0, 2] [0, 1] 0	endcap disk 0 [1, 5] [6, 7] 8
side	[0, 1]	inner/outer wafer of module pair
strip	[0, 767]	strip number

Table 3: Set of value ranges for SCT readout identifier levels

TRT:

Level	Value Range	Meaning / Comment
Inner Detector	2	
TRT	3	
barrel or end cap	+/- 1	positive/negative barrel
	+/- 2	positive/negative endcap
layer or wheel	[0, 2]	barrel module layer range
	[0, 17]	endcap wheel range
phi_module	[0, 31]	barrel
	[0, 31]	endcap
straw_layer	[0, 18]	barrel layer 0
	[0, 23]	barrel layer 1
	[0, 29]	barrel layer 2
	[0, 15]	endcap wheels 0 to 5 (type A) and 14 to 17 (type C)
	[0, 7]	endcap wheels 6 to 13 (type B)
straw	 [0, 14] [0, 15] [0, 16] [0, 17] [0, 18] [0, 17]	barrel layer 0, for straw layers 0 [1, 4] [5, 9] [10, 14] [15, 16] 17
	 [0, 18] [0, 19] [0, 20] [0, 21] [0, 22] [0, 23] [0, 22]	barrel layer 1, for straw layers 0 [1, 5] [6, 10] [11, 15] [16, 20] [21, 22] 23
	 [0, 22] [0, 23] [0, 24] [0, 25] [0, 26] [0, 27] [0, 28] [0, 27]	barrel layer 2, for straw layers 0 [1, 4] [5, 9] [10, 14] [15, 19] [20, 24] [25, 28] 29
	[0, 23] [0, 17]	endcap wheels 0 to 13 (types A,B) endcap wheels 14 to 17 (type C)

Table 4: Set of value ranges for TRT readout identifier levels

4.3 LAr Calorimeter

LAr EM:

r η φ

LAr Calorimeter / LAr EM / barrel / sampling / region / eta / phi

LAr Calorimeter / LAr EM / end cap / sampling / region / eta / phi

LAr HEC:

r ηφ

LAr Calorimeter / LAr HEC / pos_neg_z / sampling / region / eta / phi

LAr FCAL:

r "φ" x y

LAr Calorimeter / LAr FCAL / pos_neg_z / sampling / region / quadrant / x / y

4.3.1 Comments

The first level below the subsystem identifies the position along the z-axis, with a negative number corresponding to negative z. For LAr EM this level is used to distinguish between the barrel and the two end cap wheels.

The sampling level incorporates the EM presampler as sampling = 0. For the LAr HEC and LAr FCAL the sampling numbering increases from the origin and starts from 0.

For LAr EM and LAr HEC the region level corresponds to a region of uniform granularity in η and φ[5]. For the LAr FCAL, there are one or two regions of uniform granularity in each sampling. At the inner and outer radii of the LAr FCAL, the manner in which the tubes are joined together form a somewhat non-uniform granularity. These channels are labelled as being part of a separate region.

The LAr FCAL does not follow the r, η, φ conventions of the other detectors because its construction is regular in x, y not η, φ. The quadrant refers to the x/y quadrant in the global coordinate system (see Table 9 for the exact meaning of the numbers). x and y increase from 0 within each region and as well increase along the global x/y axes[6]. Note that the contours of the different regions are **not** rectangular and so the range values only express maximum values.

4.3.2 Detailed value ranges

We present here the value ranges for LAr EM, HEC and FCAL. For the LAr EM there are a large number of regions of uniform granularity in the barrel and endcap calorimeters. To

[5] Note that the granularity quoted in Table 5 to Table 8 for φ correspond to exact integral divisions of 2π, e.g. 0.1 and 0.025 correspond to 2π/64 and 2π/256, resply.

[6] Note that this is opposite to the direction of increasing η.

simplify the presentation of the value ranges, we have separated the EM value ranges into three tables:

- Table 5: Upper levels for LAr EM
- Table 6: Eta and phi levels for LAr EM barrel
- Table 7: Eta and phi levels for LAr EM endcap

In some cases, Table 6 and Table 7 include differences in numbering for the design used for the simulation in the Physics TDR and the final design.

LAr EM:

Level	Value Range	Meaning / Comment
LAr Calorimeter	4	
LAr EM	1	
barrel or endcap	+/- 1	positive/negative barrel
	+/- 2	positive/negative endcap outer wheel
	+/- 3	positive/negative endcap inner wheel
sampling	0	presampler
	[1, 3]	barrel and outer wheel of endcap
	[1, 2]	inner wheel of endcap
region	0	both presamplers
	[0, 1]	barrel sampling 1, 2
	0	barrel sampling 3
	[0, 5]	endcap outer wheel sampling 1
	0	endcap inner wheel sampling 1
	[0, 1]	endcap outer wheel sampling 2
	0	endcap inner wheel sampling 2
	0	endcap outer wheel sampling 3

Table 5: Set of value ranges for LAr EM readout identifier for levels down to region

Level	Value Range	Meaning / Comment
eta	[0, 60]	Barrel ps sampling 0 region 0 0 < eta < 1.52 deta is approximately equal to 0.025[a]
	[0, 447]	barrel sampling 1 region 0 0 < eta < 1.4 deta = 0.025/8
	[0, 2]	barrel sampling 1 region 1 1.4 < eta < 1.475 deta = 0.025
	[0, 55]	barrel sampling 2 region 0 [b] 0 < eta < 1.4 deta = 0.025
	0	barrel sampling 2 region 1 1.4< eta < 1.475 deta = 0.075
	[0, 26]	barrel sampling 3 0 < eta < 1.35 deta = 0.05
phi	[0, 63]	barrel presampler dphi = 0.1
	[0, 63]	barrel sampling 1 region 0 dphi = 0.1
	[0, 255]	barrel sampling 1 region 1 dphi = 0.025
	[0, 255]	barrel sampling 2 region 0 dphi = 0.025
	[0, 255]	barrel sampling 2 region 1 dphi = 0.025
	[0, 255]	barrel sampling 3 region 0 dphi = 0.025

Table 6: Set of value ranges for LAr EM barrel readout identifier eta and phi levels

a. For mechanical design details see ATL-LARG-98-100 (ATL-CAL-99-001)

b. Note that for the Physics TDR data, the barrel sampling 2 region 0 had [0, 58] channels from 0 < eta < 1.475 with deta = 0.025 and there was no barrel sampling 2 region 1.

Level	Value Range	Meaning / Comment
eta[a]	[0, 11]	endcap ps sampling 0 region 0 1.5 < eta < 1.8 deta = 0.025
	0	endcap outer wheel sampling 1 region 0: 1.375 < eta < 1.425 deta = 0.05
	[0, 2]	endcap outer wheel sampling 1 region 1: 1.425 < eta < 1.5 deta = 0.025
	[0, 95]	endcap outer wheel sampling 1 region 2 1.5 < eta < 1.8 deta = 0.025/8
	[0, 47]	endcap outer wheel sampling 1 region 3 1.8 < eta < 2.0 deta = 0.025/6
	[0, 63]	endcap outer wheel sampling 1 region 4 2.0 < eta < 2.4 deta = 0.025/4
	[0, 3]	endcap outer wheel sampling 1 region 5 2.4 < eta < 2.5 deta = 0.025
	[0, 6]	endcap inner wheel sampling 1 region 0 2.5 < eta < 3.2 deta = 0.1
	0	endcap outer wheel sampling 2 region 0 1.375 < eta < 1.425 deta = 0.05
	[0, 42]	endcap outer wheel sampling 2 region 1 1.425 < eta < 2.5 deta = 0.025
	[0, 6]	endcap inner wheel sampling 2 region 0 2.5 < eta < 3.2 deta = 0.1
	[0, 19]	endcap outer wheel sampling 3 region 0 1.5 < eta < 2.5 deta = 0.05

Table 7: Set of value ranges for LAr EM endcap readout identifier eta and phi levels

Level	Value Range	Meaning / Comment
phi	[0, 63]	endcap presampler sampling 0 region 0 dphi = 0.1
	[0, 63]	endcap outer wheel sampling 1 region 0 dphi = 0.1
	[0, 63]	endcap outer wheel sampling 1 region 1 dphi = 0.1
	[0, 63]	endcap outer wheel sampling 1 region 2 dphi = 0.1
	[0, 63]	endcap outer wheel sampling 1 region 3 dphi = 0.1
	[0, 63]	endcap outer wheel sampling 1 region 4 dphi = 0.1
	[0, 63]	endcap outer wheel sampling 1 region 5 dphi = 0.1
	[0, 63]	endcap inner wheel sampling 1 region 0 dphi = 0.1
	[0, 255]	endcap outer wheel sampling 2 region 0 dphi = 0.025
	[0, 255]	endcap outer wheel sampling 2 region 1 dphi = 0.025
	[0, 63]	endcap inner wheel sampling 2 region 0 dphi = 0.1
	[0, 255]	endcap outer wheel sampling 3 region 0 dphi = 0.025

Table 7: Set of value ranges for LAr EM endcap readout identifier eta and phi levels

a. For the Physics TDR, the eta region 1.375 < eta < 1.5 had a granularity of 0.025, the same as the subsequent channels. Thus for the Physics TDR region 0 comprised the first two regions of this definition.

LAr HEC:

Level	Value Range	Meaning / Comment
LAr Calorimeter	4	
LAr HEC	2	
pos_neg_z	+/- 2	positive/negative endcap
sampling	[0, 3]	[0, 1] first wheel, [2, 3] second wheel
region	[0, 1]	0 for outer part, 1 for inner part
eta	[0, 9]	Outer part region 0 1.5 < eta < 2.5, deta = 0.1
	[0, 3]	Inner part region 1 2.5 < eta < 3.3, deta = 0.2
phi	[0, 63]	Outer part, dphi = 0.1
	[0, 31]	Inner part, dphi = 0.2

Table 8: Set of value ranges for LAr HEC readout identifier levels

LAr FCAL:

Level	Value Range	Meaning / Comment
LAr Calorimeter	4	
LAr FCAL	3	
pos_neg_z	+/- 2	positive/negative endcap
sampling	[0, 2]	sampling
quadrant	[0, 3]	x/y quadrant: 0 = +/+, 1 = -/+, 2 = +/-, 3 = -/-
region	[0, 2]	regions 0, 1 have uniform granularity - 0 is the inner region[a]. Note that these regions are "round" and not rectangular so that not all combination of x/y ranges below are possible. region 2 groups together non-uniformly shaped readout channels (see text). Note that sampling 3 does not have a region 0 - these channels have been regrouped into region 2.
x	[0, 7]	sampling 1 region 0, 2 tubes in x per channel[b]
	[0, 13]	sampling 1 region 1, 4 tubes in x per channel
	[0, 15]	sampling 1 region 2
	[0, 5]	sampling 2 region 0, 2 tubes in x per channel
	[0, 12]	sampling 2 region 1, 4 tubes in x per channel
	[0, 15]	sampling 2 region 2
	[0, 7]	sampling 3 region 1, 6 tubes in x per channel
	[0, 15]	sampling 3 region 2
y	[0, 9]	sampling 1 region 0, 2 tubes in y per channel
	[0, 15]	sampling 1 region 1, 4 tubes in y per channel
	[0, 62]	sampling 1 region 2
	[0, 5]	sampling 2 region 0, 3 tubes in y per channel
	[0, 9]	sampling 2 region 1, 6 tubes in y per channel
	[0, 31]	sampling 2 region 2
	[0, 7]	sampling 3 region 1, 6 tubes in y per channel
	[0, 15]	sampling 3 region 2

Table 9: Set of value ranges for LAr FCAL readout identifier levels

a. "Inner" means closer to the beam or z-axis.

b. The total number of tubes per channel is (number in x)*(number in y).

4.4 Tile Calorimeter

φ η r

TileCalorimeter / detector / pos_neg_z / module / tower / sampling / pmt / adc

4.4.1 Comments

The “detector” level covers the Barrel, Extended Barrel and Gap detector (ITC and gap scintillators) and the pos_neg_z indicates the positive and negative sides. The order of the next three levels is inverted with respect to the other detectors, but reflects better the detector’s construction.

4.4.2 Detailed value ranges

Tile:

Level	Value Range	Meaning / Comment
Tile Calorimeter	5	
detector	[1, 3]	Barrel / Extended Barrel / Gap detector
pos_neg_z	+/- 1	positive/negative half
module	[0, 63]	phi modules (0.1 granularity)
tower[a]	[0, 15]	eta towers (0.1 granularity) For D cells, only 0,2,4,6,8,10,12 are used in the positive detector and only 2,4,6,8,10,12 in the negative detector.
	[0, 9]	in barrel
	[9, 15]	in extended barrel
	[8, 15]	in gap detector
tower[b]	[0, 16]	eta towers (0.1 granularity)
	[0, 10]	in barrel
	[8, 16]	in extended barrel
	[7, 15]	in gap detector
sampling	[0, 3]	
	[0, 2]	In barrel. (0=A 1=BC 2=D)
	[0, 2]	In extended barrel. (0=A 1=B 2=D)
	[1, 3]	In gap detector. (1=C 2=D 3=scintillator)
pmt	[0, 1]	photo-multiplier tube
adc	[0, 1]	0 - low gain, 1 - high gain

Table 10: Set of value ranges for Tile Calorimeter readout identifier levels

a. This is the full range of eta towers. The specific ranges for the different detectors is given.

b. This applies *only* to runs with projective geometry in some pre-TDR data.

4.5 Level-1 Calorimeter Trigger

em/had η φ

LVL1 Calorimeter / TriggerTower/ pos_neg_z / sampling / region / eta / phi

4.5.1 Comments

The proposed identifier is modelled, deliberately, on the calorimeter identifiers.

The regions correspond to the zones of uniform trigger tower granularity, as seen by the LVL1 preprocessor. These are not, in general, regions of uniform calorimeter granularity, and the numbers and types of calorimeter cells making up each trigger tower will vary within these regions.

4.5.2 Detailed value ranges

LVL1 calorimeter:

<table>
<tr><th>Level</th><th>Value Range</th><th>Meaning / Comment</th></tr>
<tr><td>LVL1_Trigger Towers</td><td>10</td><td>Note: 10 in Detector PBS is Trigger/DAQ</td></tr>
<tr><td>pos_neg_z</td><td>+/- 1</td><td>positive/negative</td></tr>
<tr><td rowspan="2">sampling</td><td>0</td><td>EM</td></tr>
<tr><td>1</td><td>Hadronic</td></tr>
<tr><td>region</td><td>[0, 3]</td><td>4 regions of different eta/phi granularity</td></tr>
<tr><td rowspan="4">eta</td><td>[0, 24]</td><td>region 0 (|eta| < 2.5), granularity = 0.1</td></tr>
<tr><td>[0, 2]</td><td>region 1 (2.5 < |eta| <3.1), granularity = 0.2</td></tr>
<tr><td>0</td><td>region 2 (3.1 < |eta| <3.2), granularity = 0.1</td></tr>
<tr><td>0</td><td>region 3 (3.2 < |eta| <4.9), granularity = 1.7</td></tr>
<tr><td rowspan="4">phi</td><td>[0, 63]</td><td>region 0 (|eta| < 2.5), granularity = 0.1</td></tr>
<tr><td>[0, 31]</td><td>region 1 (2.5 < |eta| <3.1), granularity = 0.2</td></tr>
<tr><td>[0, 31]</td><td>region 2 (3.1 < |eta| <3.2), granularity = 0.2</td></tr>
<tr><td>[0, 15]</td><td>region 3 (3.2 < |eta| <4.9), granularity = 0.4</td></tr>
</table>

Table 11: Set of value ranges for LAr EM readout identifier levels

4.6 Muon Spectrometer

4.6.1 Muon Station Identifier (prefix to all subsystems):

MuonSpectrometer / StationName / StationEta / StationPhi

4.6.2 Muon Station Prefix Comments

The **StationName** field effectively contains r, eta, phi and technology information. For example, one of the barrel stations containing both MDT and RPC components is called **BOL**. This name identifies the station as being in the **B**arrel (eta) and in the **O**uter ring (r) of the phi sectors containing “**L**ong” chambers (phi). In the endcaps, stations comprise either MDT, TGC or CSC components, but not combinations of components. For example, one type of TGC station is called **T1E**. This name identifies the station as being one of the **T**GC (technology) region **1** (eta) **E**ndcap (eta) stations. This scheme follows the existing nomenclature of the Muon Spectrometer Technical Design Report. Note that, in this scheme, the TGC station layer number increases with distance from the interaction point in the following sequence: 4, 1, 2, 3.

StationEta numbering increases with eta. For the barrel, 0 is reserved for any station which would appear at the exact center (eta = 0). For the MDT subsystem, the range is [-8,8] for the barrel, [1,6] for the forward endcap and [-6,-1] for the backward endcap. For the RPC subsystem, the range is [-6, 6]. For the TGC chambers in the forward endcap, the range is [1,5], with 5 closest to the beam; for the backward endcap, the range is [-5,-1], with -5 closest to the beam. This scheme is in fact opposite to that of the Technical Design Report, which places the lower values at the beam, but has the merit that the numbering is consistent with the eta positioning. For the CSC stations, there are only two possible eta positions, one in each endcap (-1 or 1).

StationPhi numbering increases with phi. For the barrel MDT/RPC stations and the endcap MDT and CSC stations, the range is [0,7]. Short and Long stations are counted separately. For the TGC forward (TxF) stations, the range is [0,23], and for the TGC endcap (TxE) stations, the range is [0,47].

4.6.3 MDT Subsystem Identifier

Station Prefix **/ Technology / Multilayer/ TubeLayer / Tube**

4.6.4 MDT Identifier Comments

MDT **Multilayer** numbering increases with distance from the interaction point; its range is [0,2] depending on the type of MDT chamber and denotes a stack of tube layers. The **TubeLayer** numbering also increases with radius; its range is [0,4], depending on the type of MDT chamber and denotes a single layer of tubes. The **Tube** numbering increases with the absolute value of eta, starting with 0.

4.6.5 MDT Detailed Value Ranges

Level	Value Range	Meaning / Comment
MuonSpectrometer	7	
StationName	BIL, BIR, BIS BEE BML, BMS, BMF BOL, BOS, BOF BOG, BOH EIL, EIS EES, EEL EML, EMS EOL, EOS	Barrel Inner radius (Long, Rib, Short) Barrel Extension (mounted on endcap toroid) Barrel Middle radius (Long, Short, Feet) Barrel Outer radius (Long, Short Feet) Barrel Outer radius (either side of feet) Endcap Inner radius (Long, Short) Endcap Extension (next to barrel toroid) Endcap Middle radius (Long, Short) Endcap Outer radius (Long, Short)
StationEta	[-8, 8] [-6, -1] + [1, 6]	Barrel ($\|\eta\| < 1$): Increases with eta. Endcap ($\|\eta\| > 1$): Increases with eta.
StationPhi	[0, 7]	Increases with phi.
Technology	MDT	
Multilayer	[0, 1]	Increases with distance from interaction point.
TubeLayer	[0, 4]	Increases with distance from interaction point.
Tube	[0, n-1]	Increases with eta.

Table 12: Set of value ranges for the Muon MDT readout identifier levels

4.6.6 RPC Subsystem Identifier

Station Prefix **/ Technology / DoubletSet / EtaDoublet / GasGap / PhiSector / PhiTriggerSector / Orientation / Strip**

4.6.7 RPC Identifier Comments

RPC **DoubletSet** numbering increases with distance from the interaction point; its range is [0,1], depending on the station type. The **EtaDoublet** numbering increases with the absolute value of eta; its range is [0,1], depending on the station type. The **GasGap** numbering increases with distance from the interaction point and its range is [0,1]. The **PhiSector** numbering increases with phi; its range is [0,1], depending on the RPC chamber type, and represents a physically separated set of gas gaps. The **PhiTriggerSector** numbering increases with phi; it's range is [0,1], depending on the type of the RPC doublet and represents a logical separation within a single gas gap. The **Orientation** field denotes whether the strips measure eta ("**E**") or phi ("**P**"). Finally, the **Strip** numbering increases with eta for "**P**" strips or increasing phi for "**E**" strips.

4.6.8 RPC Detailed Value Ranges

Level	Value Range	Meaning / Comment
MuonSpectrometer	7	
StationName	BIL, BIR, BIS BEE BML, BMS, BMF BOL, BOS, BOF BOG, BOH	Barrel Inner radius (Long, Rib, Short) Barrel Extension (mounted on endcap toroid) Barrel Middle radius (Long, Short, Feet) Barrel Outer radius (Long, Short Feet) Barrel Outer radius (either side of feet)
StationEta	[-6, 6]	Increases with eta.
StationPhi	[0, 7]	Increases with phi.
Technology	RPC	
DoubletSet	[0, 1]	Increases with distance from interaction point.
EtaDoublet	[0, 1]	Increases with eta.
GasGap	[0, 1]	Increases with distance from interaction point.
PhiSector	[0, 1]	Increases with phi. Represents physical separation of gas gap volumes.
PhiTriggerSector	[0, 1]	Increases with phi. Represents logical division of a single gas gap volume.
Orientation	E or P	Strips measuring eta (“E”) or phi (“P”).
Strip	[0, n-1]	Increases with eta for “P” strips, with phi for “E” strips.

Table 13: Set of value ranges for the Muon RPC readout identifier levels

4.6.9 TGC Subsystem Identifier

Station Prefix / **Technology** / **GasGap** / **WireOrStrip** / **Element**

4.6.10 TGC Identifier Comments

TGC **GasGap** numbering increases with distance from the interaction point. Its range is [0,2], depending on the TGC chamber type. The **WireOrStrip** field simply denotes the technology of the component being described and is “W” for wire or “S” for strip. The **Element** field is the numbering of the wires or strips and increases with phi or abs(eta), starting with 0.

4.6.11 TGC Detailed Value Ranges

Level	Value Range	Meaning / Comment
MuonSpectrometer	7	
StationName	T1E, T2E, T3E, T4E T1F, T2F, T3F, T4F	Endcap: (1.0 < $\|\eta\|$ < 1.4) approximately. Forward: (1.4 < $\|\eta\|$ < 2.0) approximately. Number represents layer (4 1 2 3)
StationEta	[-5, 1] + [1,5]	Increases with eta.
StationPhi	[0, 47] [0, 23]	Endcap: Increases with phi. Forward: Increases with phi.
Technology	TGC	
GasGap	[0, 2]	Increases with distance from interaction point.
WireOrStrip	W or S	Readout from Strips or Wire gangs
Element	[0, n-1]	Increases with radius for wire gangs, with phi for strips.

Table 14: Set of value ranges for the Muon TGC readout identifier levels

4.6.12 CSC Subsystem Identifier

Station Prefix **/ Technology / ChamberLayer / WireLayer / Orientation / Strip**

4.6.13 CSC Identifier Comments

CSC **ChamberLayer** numbering increases with distance from the interaction point and its range is [0,1]. The **WireLayer** numbering also increases with distance from the interaction point and its range is [0,3]. The **Orientation** field denotes whether the strips measure eta ("**E**") or phi ("**P**"). Finally, the **Strip** numbering increases with abs(eta) for "**P**" strips or phi for "**E**" strips, starting from 0.

4.6.14 CSC Detailed Value Ranges

Level	Value Range	Meaning / Comment
MuonSpectrometer	7	
StationName	CSS, CSL	Short and Long phi sectors
StationEta	-1 or 1	Increases with eta.
StationPhi	[0, 7]	Increases with phi.
Technology	CSC	

Table 15: Set of value ranges for the Muon CSC readout identifier levels

Level	Value Range	Meaning / Comment
ChamberLayer	[0, 1]	Increases with distance from interaction point.
WireLayer	[0, 3]	Increases with distance from interaction point.
Orientation	E or P	Strips measuring eta (“E”) or phi (“P”).
Strip	[0, n-1]	Increases with eta for “P” strips, with phi for “E” strips.

Table 15: Set of value ranges for the Muon CSC readout identifier levels