Naming and numbering scheme for the Endcap muon trigger system

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7 February 2005

Version 1.19

Interim version: Please check for updated version.

Abstract

A naming and numbering scheme is described which meets the requirements of all aspects of the construction and operation of the Muon Endcap trigger detector system: simulation, assembly, installation, trigger, read-out, data-base operations, item bar-coding, and finally analysis.

Revision	Date	(Changes from previous version are marked by revision bars in the margin.)
DRAFT	1 Mar 2000	initial draft for comments
1.0	5 June 2000	Indicated that channel numbering is from 0 from the patch panels to offline. Added appendix on mirror symmetry and parity Clarified F and B-type units and their alternating placement on the wheels Added tomographs of T8 F and B-type triplet units Added reference to Dallas DS2401 Added LDB for Sector Logic readout added section on difference between MUCTPI and TGC octant definitions
1.01	6 June 2000	update to Figure 10
1.1	14 Jan 2001	Corrected error in chamber type: M1 E2 is T07. All Forward chambers are now either F-type (side C) or B-type (side A). Issued as ATL-MUON-2001-002 on 19-Mar-2003.
1.19	28 Jan 2005	Explicitly clarify numbering of $1/12^{th}$'s inTable 5; add a figure for Side A. Add figures for Inner wheel. Add sub-sections for location names for assembly and locations of the alignment holes.

This document can be found at: `http://cern.ch/ATLAS-TGC/docs/numbering.pdf`

1 Introduction

The terms "naming" and "numbering" refer in fact to three totally different concepts:

`Type Naming`: The "taxidermy" of the zoology. The same name can be shared by several physical objects, this defining the "multiplicity" of the object. An example of type naming in a zoo is 'lion', or hierarchically, *'felis leo'*; in this example, the "multiplicity" is the number of lions living in the zoo.

`Object Numbering`: In order to differentiate physical objects with the same type name, a running number is used. This numbering can be shared by objects of different types (pure serial number) or be different for objects of different type (serial number by type). Examples of pure serial number object naming in a zoo are the animal id number, e.g. '4375', or just their names (Simba, Mufasa, Scar, ...). An example of serial number by type object naming in a zoo is the lion id number, e.g. 'LN027'.

`Location naming`: The list of "locations" or "virtual objects" that need to be filled. Each of these locations is unique but is filled by a defined type. Another location may have the same defined type. Examples of location naming in a zoo is 'lion cage4', or 'cage436'.

A closely related, but separate issue is **data formats**. Type, object and location names are used in many contexts, including documents, stickers, database field names and field contents, and in various forms of the event data. The names may be encoded in different ways, depending on the context. Data formats, e.g. hit formats, use object or location names to identify data items. Data is often sorted to optimize a particular algorithm, e.g track finding. Different parts of a name may be used as sort keys in an order different from the name itself.

2 General principles

1. Hierarchical naming is preferred rather than flat lists of names.
2. At each stage, the naming should be best adapted to its environment. This implies that some schemes start counting from 0 and others from 1. Nonetheless, whenever possible, the numbering runs from 0 to n-1 and not from 1 to n.
3. The same is true for the channel counting direction in both θ (r increasing vs η increasing), for which preference is given to increasing η, and ϕ, for which, whenever possible, preference is given to the ATLAS coordinate system ($\phi = 0$ pointing to the center of the accelerator for both ends) over hardware oriented counting.

3 Naming of the chambers

A “unit”, the basic item coming out of the production line, is a sandwich of either 2 or 3 “detectors” (i.e. gas gaps). These units are named according to their external dimensions (their “major type”); there are 11 major types, 01 to 11. For the wires, read-out electronics can be located on either side of the trapezoid: a unit will be called ‘F’ (Forward) if, for an observer at the interaction point, the wire ASD boxes are on the *clockwise* side of the unit they service, and ‘B’ (Backward) conversely. Each wheel has **both** F and B-type units as shown in Figure 5. The two

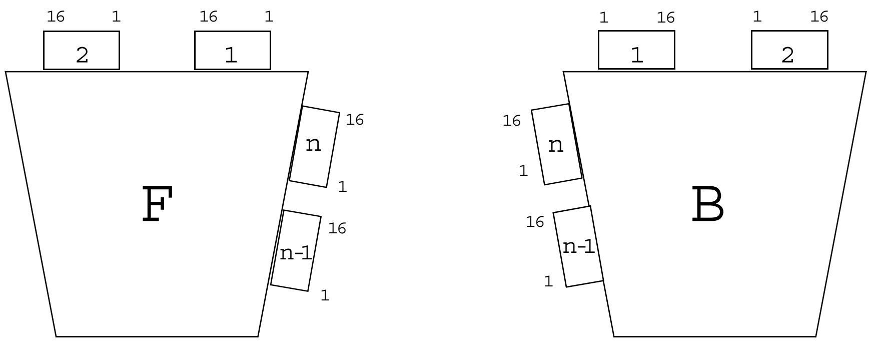

Figure 1: Forward and Backward Units, with their FE-electronics, ASD, boards, as seen from the Interaction Point. Refer also to Figure 5 to see how the 'F' and 'B' chambers are arranged on the wheels.

endcaps are none-the-less mirror images of each other in order to maintain parity invariance. See Section 14, "Appendix: Chamber mirror symmetry". For the strips, because of the gas flow connections, the strips are read out from the outer (large) side of the trapezoid for types T01–T05, T07 and T10, and from the inner (small) side for types T06, T08, T09 and T11. This difference for the strips is not reflected in the naming.

A unit of a given major type can be placed in one or more of the four substations: 1 for M1 (triplets), 2 and 3 for M2 and M3 (doublets), and 4 for the I substation (doublets). Major types are further differentiated into “minor types”: ‘I’ (for integral, or regular), ‘H’ (hollowed to allow space for the alignment corridors) and ‘S’ (special or short chambers). The full scheme is shown in Table 1.

U	major-type	B/F	Wheel	minor-type
	01..11	B=Backward F=Forward	1=M1 (triplet) 2=M2 (doublet) 3=M3 (doublet) 4=I (doublet)	I=Integral H=Hollowed S=Short

Table 1 Type naming scheme for the Units

Thus, valid examples of unit names are:

U08B1I Unit type 8, backward read-out, substation M1, integral detector

UO6F3H Unit type 6, forward read-out, substation M3, hollowed detector

The exact breakdown of the various types and their multiplicities is shown in Table 2.

Major type	Units (multiplicity)
T01	U01B1H(8) U01B1I(16) U01F1H(8) U01F1I(16)
T02	U02B2H(8) U02B2I(16) U02B3H(8) U02B3I(16) U02F2H(8) U02F2I(16) U02F3H(8) U02F3I(16)
T03	U03B1I(48) U03F1I(48)
T04	U04B2I(48) U04F2I(48)
T05	U05B3I(48) U05F3I(48)
T06	U06B1H(8) U06B1I(40) U06B2H(8) U06B2I(40) U06B3H(8) U06B3I(40) U06F1H(8) U06F1I(40) U06F2H(8) U06F2I(40) U06F3H(8) U06F3I(40)
T07	U07B1I(48) U07B2I(48) U07B3I(48) U07F1I(48) U07F2I(48) U07F3I(48)
T08	U08B1I(48) U08B2I(48) U08B3I(48) U08F1I(48) U08F2I(48) U08F3I(48)
T09	U09B2I(48)U09B3I(48) U09F2I(48) U09F3I(48)
T10	U10B4I(16) U10B4S(8) U10F4I(16) U10F4S(8)
T11	U11B4I(20) U11B4S(2) U11F4I(20) U11F4S(2)

Table 2 Breakdown of all possible unit names and their multiplicities

4 Channel Numbering

For the doublets, both gangs of wires and read-out strips are fully read out by the front end electronics. For the middle chamber of the triplet sandwich, only the wires are read. In order to be consistent with channel numbering on connectors, channels are numbered from **1 to n** from the chambers though the ASD boards, as follows:

Wires: channel 1 is the gang of wires closest to the beam (i.e. close to the small base of the trapezoid).

Strips: channel 1 is the one closest to the side of the electronics boxes (ASD) of the wires. Thus, for an observer sitting at the IP and observing the detector wheels, the strip read-out goes *clockwise* for backward detectors and *anti-clockwise* for forward detectors. See also Section 3, "Naming of the chambers" above.

After the ASD board, i.e. from Patch Panel through to the offline software, channels are numbered from 0 to n-1.

Note that in each of the Trigger and Read-Out chains one, and only one, element must reverse the strip channel numbers from Forward chambers side A and Backward chambers side C to ensure a monotonic ϕ numbering. See Figure 1. Our proposal is that this operation *be performed at the first opportunity in the safe room USA15*, i.e. by the Read Out Driver for the read-out chain and the Sector Logic for the trigger one.

“Tomographs” of B and F units showing wire gangs, strips, supports, etc. are shown in Figures 2 and 3.

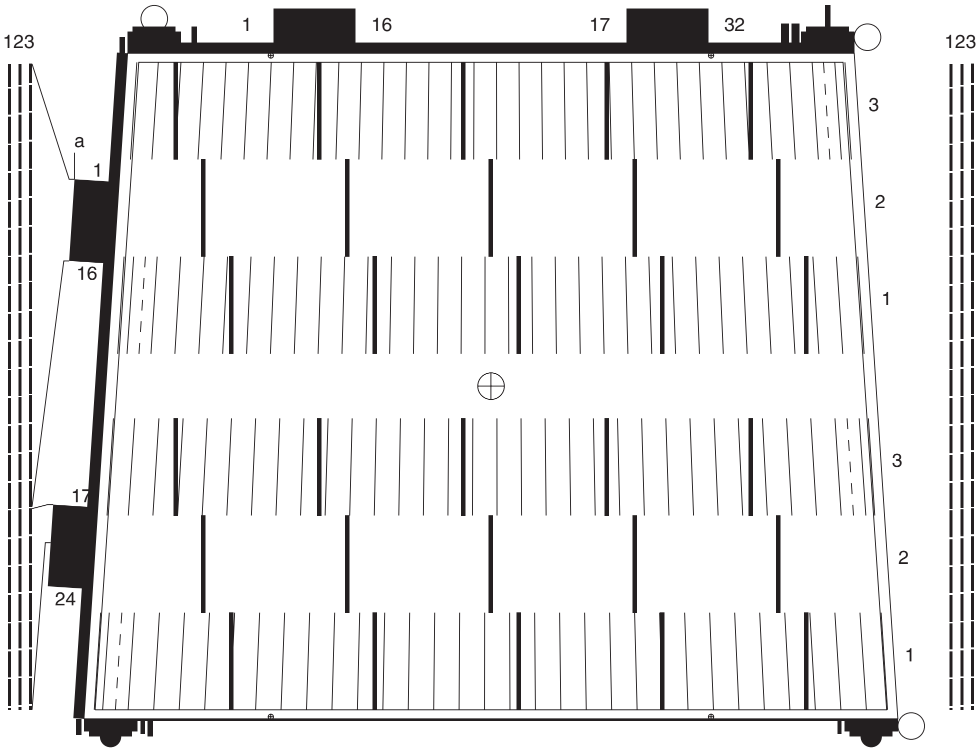

Figure 2: Tomograph of a Type 8 Forward (as in forward-backward) triplet unit (U08F1I). For Side A, f increases from right to left; for side C from left to right.

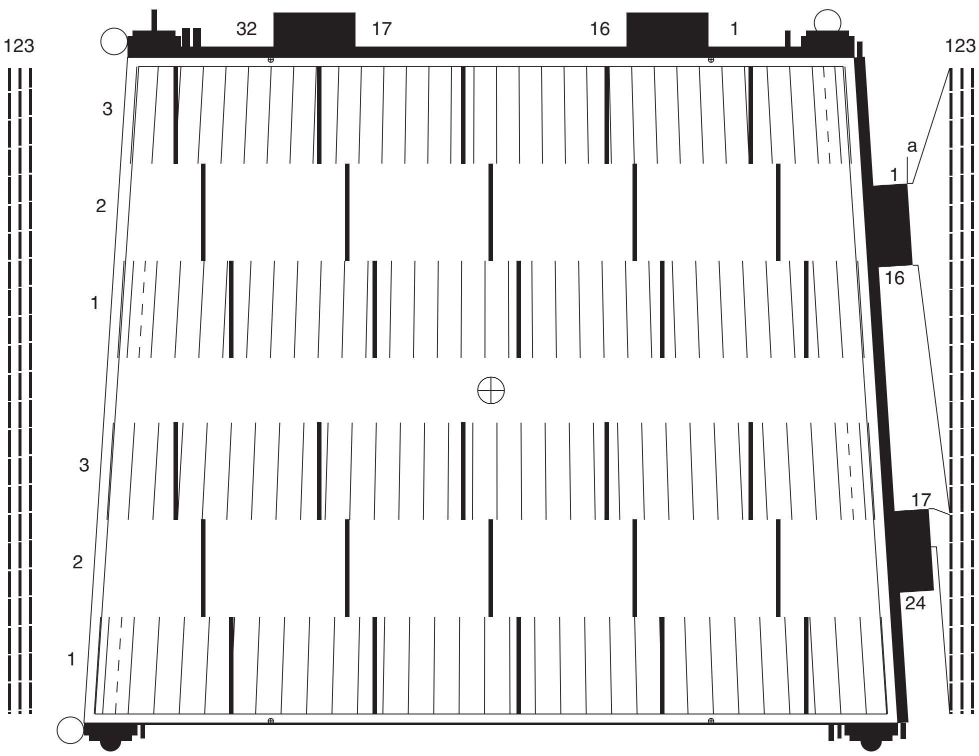

Figure 3: Tomograph of a Type 8 Backward (as in forward-backward) triplet unit (U08B1I). For Side A, f increases from right to left; for side C from left to right.

5 Overall geometry and location naming

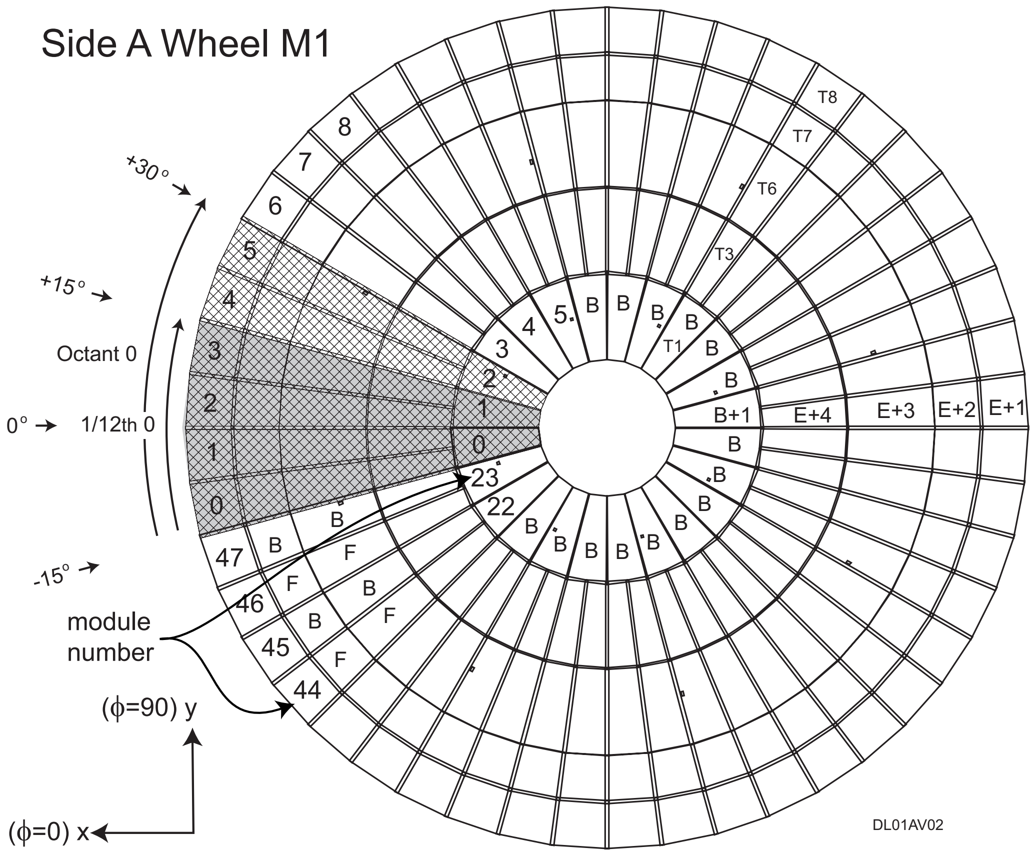

Figure 4: Location naming for Wheel M1A according to the various schemes. The "+" in the E+1, etc. rings denotes that they are on Side C. T1, T3, T6, T7, T8 are type names. (The small squares are the alignment corridors.) The view is from the interaction point. F and B denote the Forward and Backward-edge readout described in Section 3, "Naming of the chambers". Side C has an F-type unit opposite side A's B-type unit, and vice versa. See also Figure 5.

The TGC system consists of two sides, A and C, which are **mirror** images of each other. A is on the side of the +*z* axis (which points to Mont Blanc) and C of the -*z* axis (which points to the Jura). Because of the slope of the tunnel (1.23%), C is located ~30 cm above A. This is the standard ATLAS coordinate system described in [ref. 1].

The TGC System is designed to match more or less the MDT arrangement, with its large and small sectors. But the matching is only approximate: the basic ϕ segmentation of the TGC system, a 1/24th is 15°, while an MDT octant is divided into a small (18°) and a large (27°) sector. We propose to just ***FORGET ABOUT MDT SECTORS*** as far as the TGC geometry is concerned.

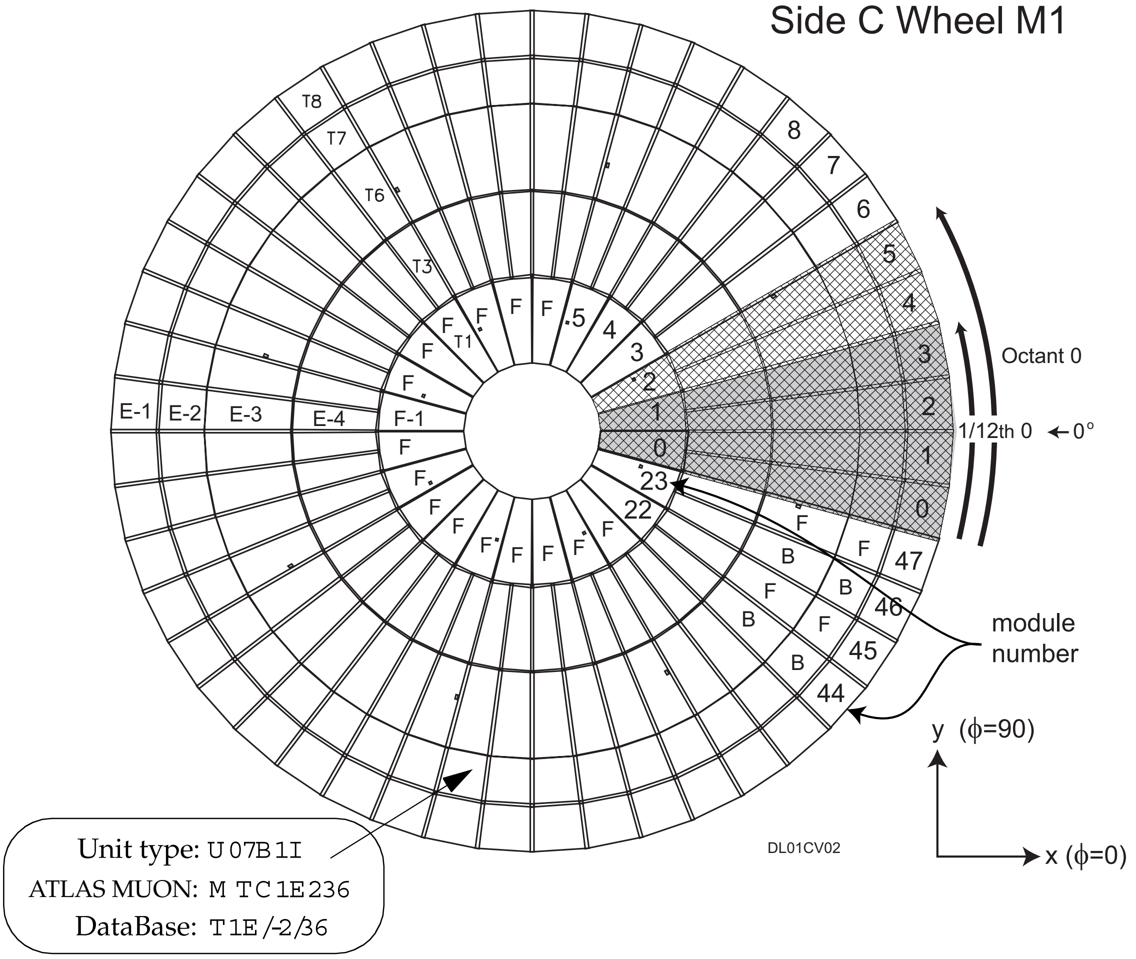

Figure 5: Location naming for Wheel M1C according to the various schemes. The "–" in the E-1, etc. rings denotes that they are on Side C. T1, T3, T6, T7, T8 are type names. (The small squares are the alignment corridors.) The view is from the interaction point. F and B denote the Forward and Backward-edge readout described in Section 3, "Naming of the chambers". Side A has an F-type unit opposite side C's B-type unit, and vice versa. See also Figure 4.

The TGC segmentation for the M station is as follows:

- In η, there are two totally independent regions: F (Forward, $1.6<|\eta|<2.0$) and E (Endcap, $1.<|\eta|<1.6$).
- The ϕ segmentation of the forward region is 24 (detector angular span=15°).
- the smallest ϕ segmentation of the endcap region is 48 (detector angular span=7.5°)
- Units in the Endcap region are assembled into "modules" (ladders) of four (M1) and five (M2, M3) units along the radius.
- In the Endcap two modules are further grouped by twos to form a "set" of 2×4 or 2×5 units. One of the modules of the set is made of Backwards units and the other one of Forward units. In the Forward region, each unit is also both a module and a set.
- The assembly of one forward detector and one endcap set of units is itself called a SET and is the basic physical assembly to be mounted on the wheels in the cavern.

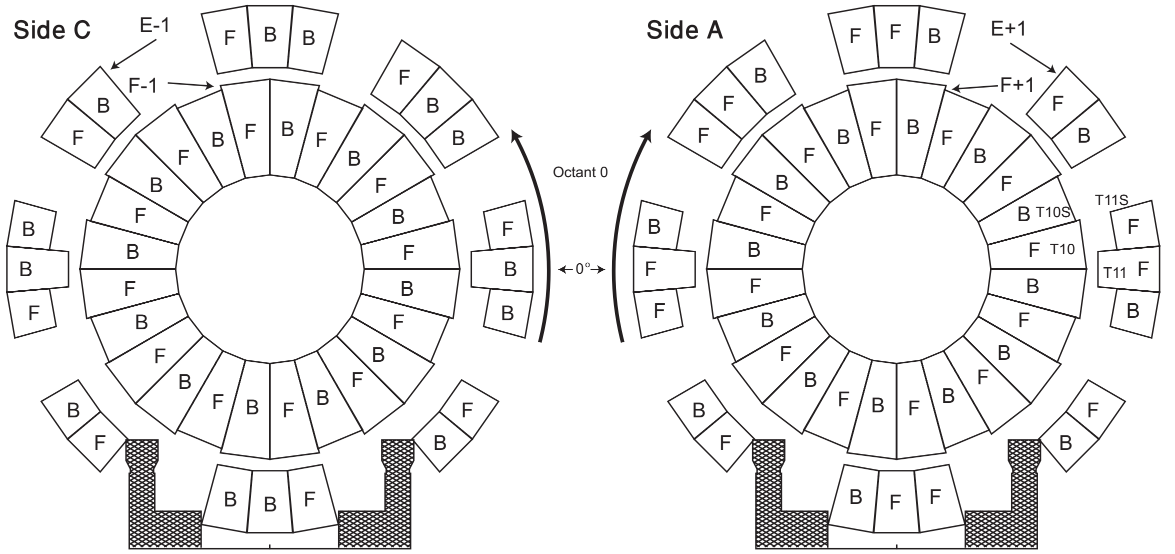

Figure 6: Location naming for the Inner wheels according to the various schemes. The "+/–" in the E+1, etc. rings denotes that they are on Side C/A. T10, T10S, T11, T11S are type names (T10S face the barrel toroids.). Modules are numbered the same as for the Forward modules of the M wheels. (There are no alignment corridors.) The view is from the interaction point. F and B denote the Forward and Backward-edge readout described in Section 3, "Naming of the chambers". Side C has an F-type unit opposite side A's B-type unit, and vice versa.

In order to cope with the global ATLAS chamber nomenclature [ref. 1], we propose the location naming detailed in Table 3.

ATLMT	A/C	wheel	Ei/F	ϕ
	Side	1=M1 2=M2 3=M3 4=I	E1= Endcap outermost, E4 or E5= Endcap innermost	ϕ division (0..23 for F, 0..47 for E)

Table 3 Unit location naming

It should be noted that this scheme is no longer compatible with what is already used for the geometrical description of the system by the AMDB format [ref. 2] and the ganging description format [ref. 3]. The price of this change is believed to be minimal. Also note that in this scheme ϕ runs according to the ATLAS reference system (x points to the center of the LHC), while r runs from inside outwards.

The reason for starting the η numbering from 1 instead of 0 has to do with the convention adopted by the database working group (see Section 6).

Examples of location names are shown in Figures 4 and 5 and the assignment of the major unit types to the η divisions of the four wheels is shown in Table 4.

		$\lvert\eta\rvert \longrightarrow$					
Station #	Wheel	E1	E2	E3	E4	E5	F
1	M1	T08	T07	T06	T03		T01
2	M2	T09	T08	T07	T06	T04	T02
3	M3	T09	T08	T07	T06	T05	T02
4	I	T11					T10

Table 4 Assignment of the major types to the η divisions of the four wheels

5.1 Location names for the assembly of inner octants and one twelfths

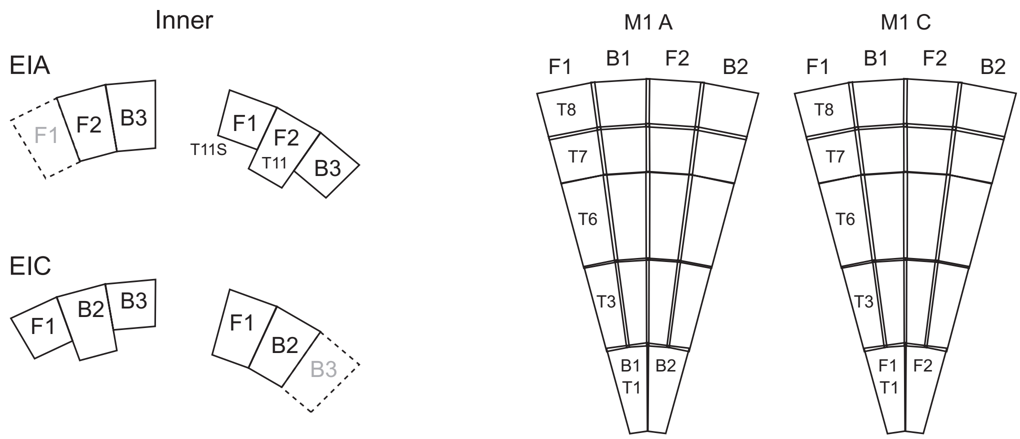

Figure 7: Location naming used in the assembly of chambers into the frames for the Inner Endcap wheels EIA, EIC and into the 1/12th sectors for wheels M1A, M1C. (Chambers are mounted individually on the FI wheel.) The chamber types, "Ti", are as in Table 4. "F" and "B" refer to Forward and Backward chambers. The view is from the interaction point. Note that there are alignment holes in T6 and T1 for Side A: 1B1, 2B2, 4B1, 5B2, 7B1, 8B2, 10B1, 11B2 and for Side C: 1F2, 2F1, 4F2, 5F1, 7F2, 8F1, 10F2, 11F1.

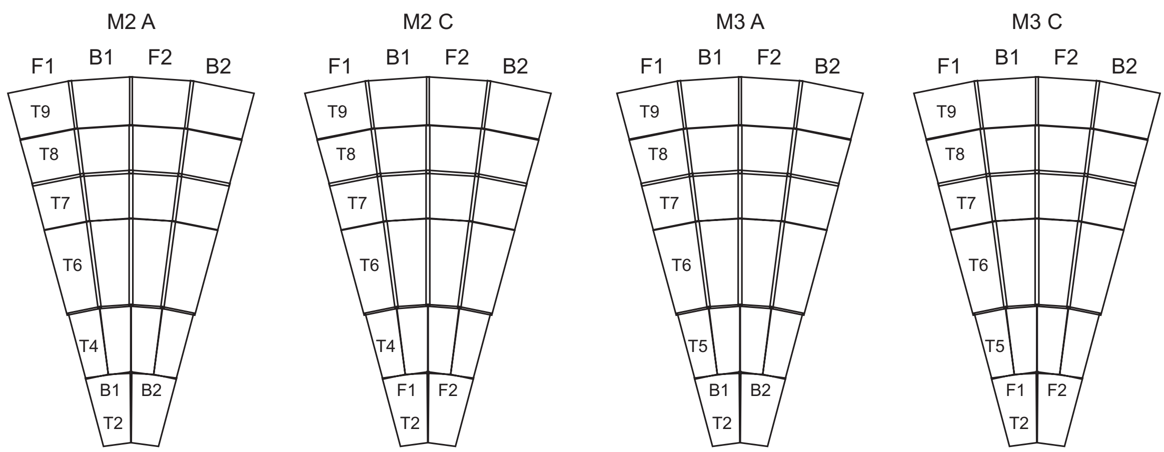

Figure 8: Location naming used in the assembly of chambers into the 1/12th sectors for wheels M2A, M2C, M3A and M3C. The chamber types, "Ti", are as in Table 4. "F" and "B" refer to Forward and Backward chambers. The view is from the interaction point. Note that there are alignment holes in T6 and T2 for Side A: 1B1, 2B2, 4B1, 5B2, 7B1, 8B2, 10B1, 11B2 and for Side C: 1F2, 2F1, 4F2, 5F1, 7F2, 8F1, 10F2, 11F1.

5.2 Locations of the alignment holes

The MDT alignment system requires a line-of-sight through each octant of the Forward and Endcap regions of the M1, M2 and M3 wheels. Chamber types T1, T2 and T6 have holes for this line-of-sight. The holes are marked in Figures 4 and 5. The chambers with holes (for both forward and endcap 1/12th's) are as follows (where, e.g. "11" in "11B2", refers to 1/12th "11", numbering from 0, and "B2" is as in Figures 7 and 8):

Side A: 1B1, 2B2, 4B1, 5B2, 7B1, 8B2, 10B1, 11B2

Side C: 1F2, 2F1, 4F2, 5F1,7F2, 8F1, 10F2, 11F1

6 DataBase identifiers

In the wake of discussions among ATLAS General Detector Description (AGDD, based on XML) database experts [ref. 4], it was decided to enforce an "identifier scheme" common to all muon subsystems. The proposal for the η division is shown in Figure 9. The location naming scheme agreed upon is detailed in Table 5 and an example is given in Figure 5.

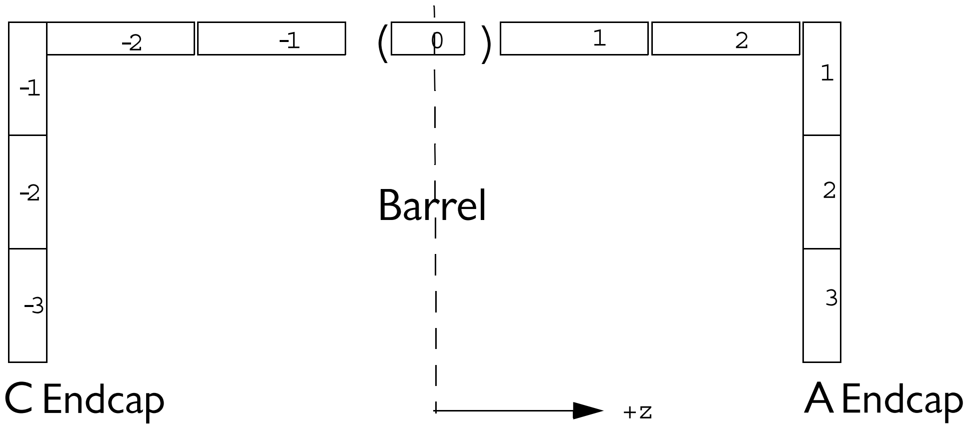

Figure 9: η division identifiers, as proposed for the ATLAS General Detector Description (AGDD) database.

TGC	wheel	E,F	±η	ϕ	L
	1=M1 2=M2 3=M3 4=I	E=EndCap, F=Forward	η division **numbered from 1** (-ve for side C, +ve for side A)	ϕ division 0..23 for F, 0..47 for E	layer (0..1 or 0..2)

Table 5 Proposal for ATLAS General Detector Description (AGDD) database identifiers for location names

7 Front-End Electronics location naming

There are two types of front-end amplifier-shaper-discriminator, ASD, boards: one with, the other without, a LEMO connector for the analog charge output from channel 1. One wire channel per chamber will have its analog charge monitored. It is not yet defined which channel will be monitored. The ASD boards have no object serial number. The ASD boards are located on the chambers and, following the hierarchical principle, their location naming follows that of the units:

ASD	A/C	wheel	Ei/F	ϕ	layer	W/S	board
	Side	1=M1 2=M2 3=M3 4=I	E1= Endcap outermost E4 or E5= Endcap innermost F=Forward	ϕ division (0..23 for F, 0..47 for E)	A,B for doublet A,B,C for triplet	W=wire S=strip	**1** to n Strips: n=2

Table 6 ASD board location numbering scheme

8 PSpacks, Patch Panels and Slave boards

Patch Panels and Slave Boards are assembled into PSpacks. For every $1/24^{th}$ slice of one Middle station, there are two PSpacks: one mounted on the triplet (M1), the second mounted on the doublets (M2, M3). Note that there are only three types of PSpacks types: D, T, and, in the future, I. Their location names are shown in Table 7:

PSP	A/C	D/T/I	set
	Side	D=Doublet T=Triplet I=Inner	For D, T: set number (0..23) For I: octant number (0..7)?

Table 7 PSpack location naming

Each PSpack which services a "set" deals with three different areas of the system: the forward unit, and two endcap modules (half set in ϕ, see Section 5). The basic components of the PSpacks are Patch Panels (PP) and Slave Boards (SLB). Because of read-out constraints, the naming **increases from 0** with respect to η. The type names for the SLB are shown in Table 8:

SLB	W/S	D/T/I
	W=Wires S=Strips	D=Doublet T=Triplet I=Inner

Table 8 Slave Board type naming

This means that they are only four different types of Slave Boards (excluding the Inner station).

For the Patch Panels (PP), the situation is a bit more complex and the type naming is shown in Table 9 The breakdown of SLB and PP types, with their multiplicities, is shown in Table 10 and in Figure 10 .

PP	E/F	W/S	D/T/I	η
	E=Endcap F=Forward	W=Wires S=Strips	D=Doublet T=Triplet I=Inner	η division, running from 0 to the maximum value shown in Table 10

Table 9 Patch Panel type naming

	Doublet Wires	Doublet Strips	Triplet Wires	Triplet Strips
PP	FWD0, FWD1, 2×[EWD0, EWD1, EWD2, EWD3,EWD4]	FSD0, 2×[ESD0,ESD1,ESD2]	FWT0, FWT1, 2×[EWT0,EWT1, EWT2,EWT3]	FST0, 2×[EST0,EST1]
SLB	4×WD	11×SD	18×WT	5×ST

Table 10 Breakdown of PP and SLB names and multiplicities in PSpacks

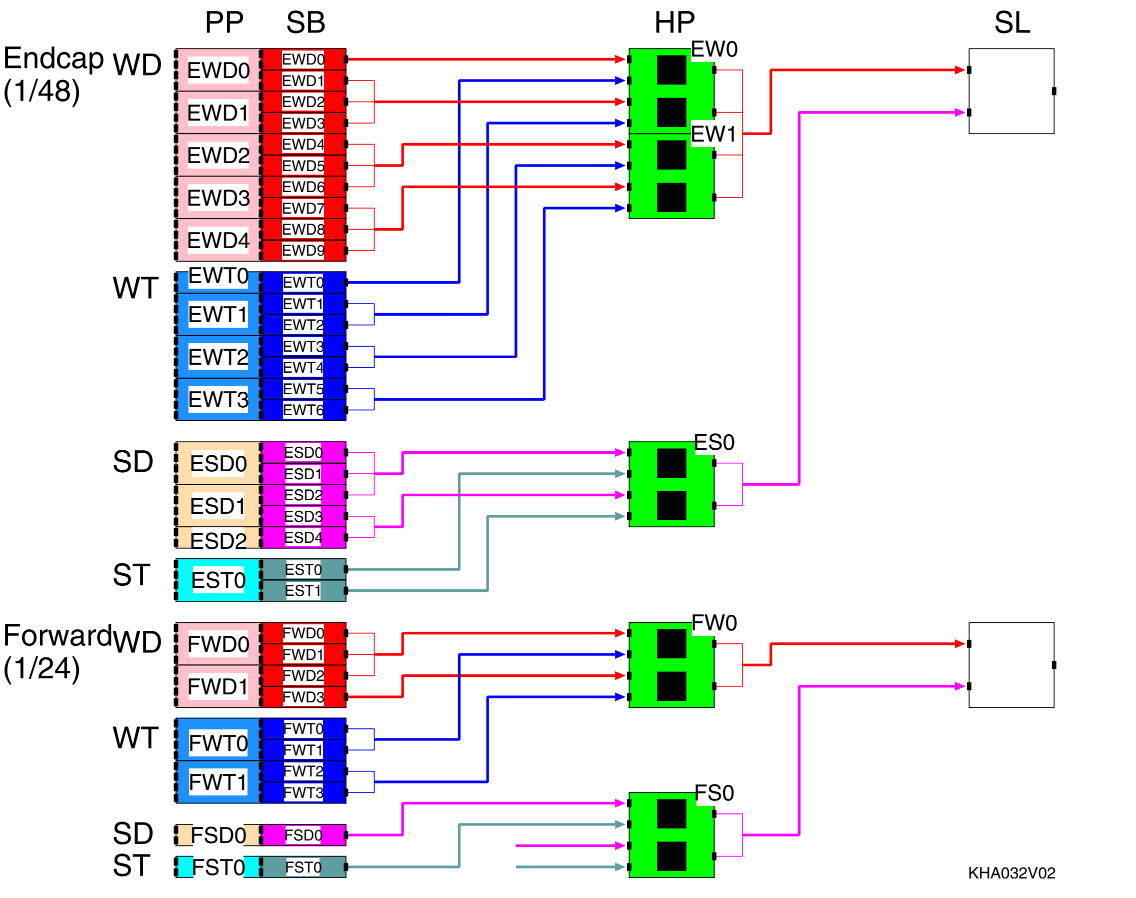

Figure 10: Sub-fields of location names for one Endcap and one Forward sector of trigger boards and their interconnection. The ϕ part of the field, which runs from 0 to 23 for the forward and 0 to 47 for the endcap region, has been omitted.

The location naming scheme is shown in Table 11. Note that it slightly breaks the principle of hierarchical naming: in the endcap region, the module numbering runs from 0 to 47, though the fact that pairs of adjacent modules ($2i$, $2i+1$) belong to the same PSpack should be reflected in the naming scheme. Hierarchical naming is also broken for the running η division of the Slave Boards, which ignores the fact the two adjacent Slave Boards service the same Patch Panel.

SLB/PP	A/C	E/F	ϕ	W/S	D/T/I	η
	Side	E=Endcap F=Forward	Set (0..23 for F 0..47 for E)	W=Wires S=Strips	D=Doublet T=Triplet I=Inner	η division, running from 0 to the maximum value shown in Table 10.

Table 11 Location naming for Slave Boards and Patch Panels

9 Unique, electronically readable ID for each Patch Panel

Downstream of the Patch Panels there are several stages of trigger and readout electronics, each connected by cables or fibers. These stages are spread out geographically over three layers per endcap, the circumference of the I and M1 wheels, fiber patch panels between UXA15 and USA15, and finally racks in USA15. Tracing cable connections by wiggling cables is obviously impossible. Considering that there are about 2500 Slave Boards, it is even unreasonable to work via telephone with a person and pulser at one end, e.g. on a wheel, and another person and receiver at the other. The solution is a unique electronic ID integral to each Patch Panel. This ID can be loaded into the Slave Board and passed through the entire readout chain to the ROD buffers. One then knows the route the data took.

Since the Patch Panels are mounted on the chambers, if great care is taken in connecting the ASD board output cables to the correct Patch Panel inputs, then the ROD knows the wire or strip for any hit it receives, even if there are cabling errors downstream from the Patch Panel. Use of such an ID system will save days of checking and will guarantee the integrity of the data readout.

Similarly the DCS system can know the Patch Panel source of all DCS channels by injecting this same ID into the DCS node on each Patch Panel. The Slave Board−HipT−Sector Logic connections can be verified by sending the ID on this pathway and using the DCS system to read it at each point.

Dallas Semiconductor provides a “silicon serial number” part, `DS2401`[ref. 5], which provides a unique, factory-lasered and tested 64-bit registration number with no two parts alike. They are read out via a serial protocol.

10 HipT boards and Sector Logic

In the trigger system, a tower, along z, of modules is called a sector. Recall that a module is $1/48^{th}$ of the wheel for the Endcap and $1/24^{th}$ for the Forward. Each sector is served by one (Forward) or two (Endcap) HipT boards for the wires and one HipT board for the strips. The location naming scheme for these boards is summarized in Table 12. All the boards in one sector are shown in Figure 10 above.

For the Sector Logic, which consists of one board per sector, the situation is even simpler, as shown in Table 13. The sector numbering is such that module 0 is in Sector 0. There is only one type of Sector Logic board. See also Figure 11, below. Trigger sectors and Regions-of-Interest

HIPT	A/C	E/F	ϕ	W/S	board
	Side	E=Endcap F=Forward	Sector 0..23 for F 0..47 for E	W=Wires S=Strips	0 or 1 for wire Endcap 0 otherwise

Table 12 Location naming scheme for the HipT boards

SL	A/C	E/F	ϕ
	Side	E=Endcap F=Forward	Sector 0..23 for F 0..47 for E

Table 13 Location naming scheme for the SectorLogic.

The trigger sectors are numbered from 0, from $\phi = -15°$, as shown in Figure 11. Also shown are the sub-sectors in each sector. Each sub-sector is a Region-of-Interest. There are $4 \times 16 = 64$ sub-sectors in each Forward sector; there are $4 \times 37 = 148$ sub-sectors in each Endcap sector. They are numbered in the direction of increasing ϕ.

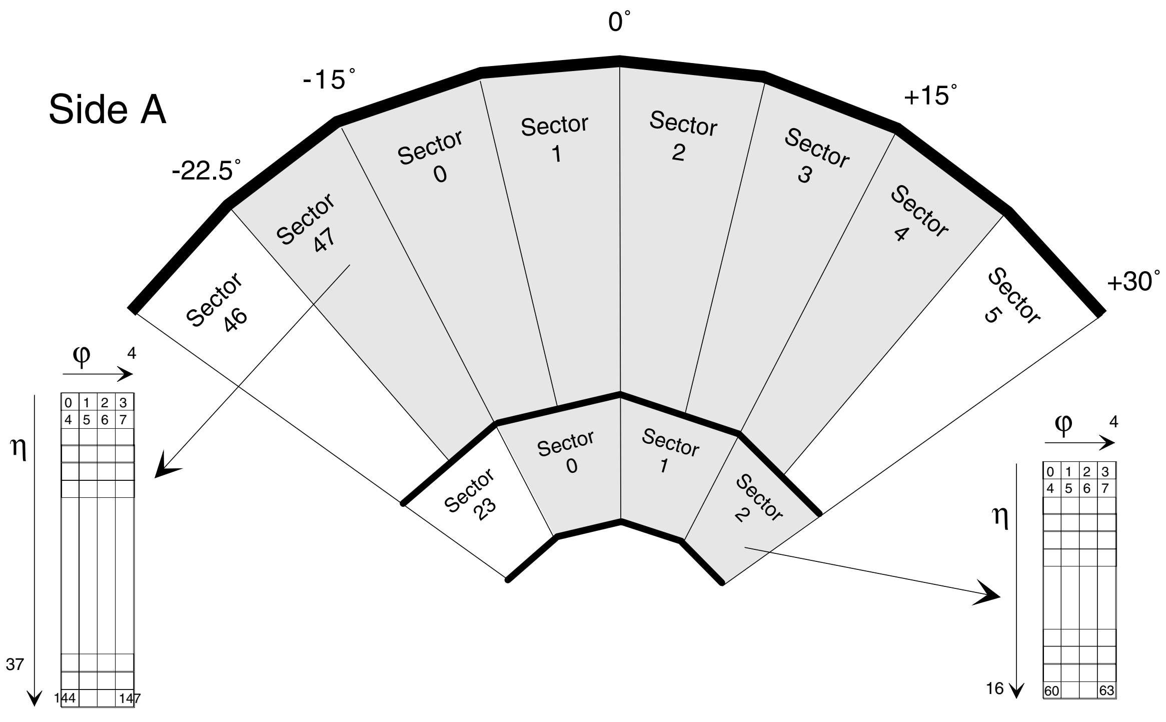

Figure 11: Trigger sectors and ROI numbering for Side A, viewed from the interaction point. Side C, a mirror image of Side A, has ϕ increasing in the opposite direction. Note that Sector 0 does not begin at $\phi = 0$. The shading identifies MUCTPI octant 0; TGC octant 0 consists of EndCap sectors 0 to 5 and Forward sectors 0 to 2.

10.1 Octant definitions and the connection to the MUCTPI

The TGC octant definition, -15° to +30°, is not the same as that for the RPC trigger sectors, -22.5° to +22.5°. (The boundary of the TGC octant is the edge of a unit. The boundary of the RPC octants is the *center* of a small RPC.) A MUCTPI octant, however, must match hits in the same ϕ range for both detectors. The difference is the range in ϕ of exactly one Endcap trigger sector. In order to accommodate this difference (see Figure 11), MUCTPI octant 0 is sent the trigger data from TGC trigger sectors 47, 0, 1, 2, 3, 4, MUCTPI octant 1 is sent sectors 5 to 10, ... MUCTPI octant 7 is sent sectors 41 to 46. The Forward TGC chambers are designed not to have any overlap with the Endcap chambers, so their MUCTPI processing is done independently. Consequently MUCTPI octant 0 receives trigger data from TGC Forward sectors 0, 1, 2, MUCTPI octant 1 receives sectors 3, 4, 5, and so on.

11 Star Switches and RODs

Each Star Switch serves a Local Data Block, LDB. The LDBs are named by location for each octant as in Table 14. There are nine LDBs in each octant for the Slave Boards on the M wheels, one for the Sector Logic[1], and one LDB per quadrant for the Inner wheel.

SSW	A/C	octant	E/F	T/D/I	n (Endcap T and D only)
	Side	0..7, in increasing ϕ	E=Endcap F=Forward	T=Triplet D=Doublet pair I=Inner Doublet	for T: n=0..2, in increasing ϕ for D: n=0..5, in increasing ϕ for I: not used
			S=Sector Logic		

Table 14 Location naming scheme for the star switches. There is one Sector Logic Star Switch per octant.

The RODs are named by location as shown in Table 15.

ROD	A/C	octant
	Side	0..7, in increasing ϕ

Table 15 Location naming scheme for the RODs

12 ROB input hit format

This section is preliminary.

We propose a ROB input hit format that is meant to aid RoI retrieval and track finding by the Level-2 trigger[2]. It is shown in Table 16. When sorted in this format, all the hits in a trigger sector are close together. Note that since the information of the actual chamber in η division is lost for wires downstream of the Patch Panels, one just gets a running wire group number, from 0 to 511, 0 being the outermost one. The situation for strips is more complicated and is described below.

1. The HipT boards are not read out directly. Instead both Sector Logic input (i.e. output of the HipT boards) and Sector Logic output is read out.
2. This format is somewhat different from that presented at the September 1999 ATLAS week [ref. 6].

	Side	Octant	E/F	set	module	w/s	Station	layer	Channel	Total
# of bits	1	3	1	2	1	1	2	2	9	22 bits
Values	0=A 1=C	0..7	0=E 1=F	0..2	E: 0/1 F: 0	W=0 S=1	0=M1 1=M2 2=M3 3=I	D: 0/1 TW: 0/1/2 TS: 0/2	wires: 0..511 strips: see text	

Table 16 ROB input hit format

Strip numbering in the ROB input hit format:

Strips for M-Forward, I-Endcap, and I-Forward
the strips are numbered from 0 to 31, in increasing ϕ.

Strip in M3-Endcap
This is the pivot plane. There are four chambers along η in the module. The strips are numbered as $32\times$ chamber-number + strip-number-in-the-chamber, where chamber-number is 0 for E1, to 3 for E4 and strip-number-in-the-chamber is 0..31, in increasing ϕ.

Strips in M1-Endcap and M2-Endcap These are non-pivot planes where each pair of strips in the η direction are OR'ed together. There are four (in he case of M1) or five (in the case of M2) pairs along η. The strips are numbered as $32\times$ chamber-pair-number + strip-number-in-the-chamber, where the chamber-pair-number is 0 for E1, 1 for E1-E2, 2 for E2-E3, 3 or E3-E4 and 4 for E4-E5 and strip-number-in-the-chamber is 0..31, in increasing ϕ.

Other documents detail the data formats for the system upstream from the ROB input.

13 LHC unique barcode system

As described in [ref. 7], any piece of equipment of the ALTAS detector will be identified by a unique LHC-wide barcode identifier. The decision on which part of our equipment will be tagged in such a way (Units, cables, PSpacks, ...) remains to be taken. As a first step, we show in Table 17 the system already implemented for the Units.

20	MT	Institute	U	Type	SerialNumber
Reserved code for ATLAS	Reserved code for Muon TGC	WEI=Weizmann KEK, ... see [ref. 8]	U=Unit	01..11	0001..9999

Table 17 LHC-wide barcode system

For example, the first unit of type 8 ever produced in Israel is tagged as: 20MTWEIU080001

14 Appendix: Chamber mirror symmetry

A vital constraint of the whole ATLAS system is that Endcap Side A and Endcap Side C be mirror images: the magnetic field is toroidal, and, in order not to bias CP studies, one wants the trajectory of a μ^+ in one endcap be the same as that of a μ^- in the other one. Since the field non-uniformities produce bending in ϕ as well, it implies that not only in η, but also in ϕ, that the complete segmentation, readout chain, online processing be mirror images.

The smallest physical object to be assembled on the surface and mounted *in situ* is a 'set', an assembly of two units in ϕ times 4 or 5 in η. Because of construction and space constraints, the readout cables run along a common rail situated in the center of the set; two adjacent units at the same η in a set thus have wire ASD boards symmetrically arranged. Counting clockwise, an observer standing at the interaction point first sees the "Forward", then the "Backward" unit.

In the Forward region ($|\eta|>1.6$) all chambers on side C are Forward-type units while those on side A are Backward-type units.

The holes for the alignment system beam are always located close to the side furthest from the read out (resistor side).

With this arrangement, one can see that opposite to any Forward unit stands a Backward one, but this is not enough: one has to make sure that the channel connections themselves are mirror images, i.e. that the electronic numbering of strips runs along the same global ϕ for the two facing units. This is needed not two introduce biases from the clustering algorithms: when two neighbour strips, for example, are hit, the logic systematically selects the first (lower channel number) one; it is thus vital that the ϕ directions, as given by the strip numbering, are mirror images, so that the strip numbers passed downstream to the sector logic correspond to mirror image coordinates.

One could decide that for side A, for example, one always reads clockwise, while for C one always reads anti-clockwise. But doing so would ruin the property that a unit of type Backward, for example, can be mounted on either endcap, since one would have to build "clockwise" and "anti-clockwise" Backward units. Apart from the extra complexity in managing the production chain, it might introduce a "time" bias: a production line produces batches of units of the exact same type, and, because of possible drifts of the physical properties of the various detector components, it is important that two units produced the same week can be mounted on two different endcaps.

The only solution remaining is that inside a set, the strip numbering always goes clockwise for one type (B or F) and anti-clockwise for the other (F or B); By convention, strip number one is always the one closest to the center rail of the set, i.e. Backward units are read clockwise and Forward ones are read anti-clockwise.

Going down to the very last details, this mirror image property is violated in two places which are believed to have negligible effect:

- **strip staggering:** to give a better strip granularity, each unit has two strip patterns, staggered in ϕ by +1/4 and -1/4 of a strip width; again, to avoid extra complexity in the construction, the current arrangement is such that for Side A the strip pattern of the front detector in the unit will be staggered towards positive ϕ and that of the back detector towards negative ϕ, and conversely for Side C.

- **wire supports:** for the same construction reason, the staggering of the internal wire supports, which is needed to minimize correlated inefficiencies, in not a perfect mirror image in Side A and C. For triplets, the staggering of the front plane (1) in A is that of the back plane (3) in C and vice versa. For doublets, the same is true for planes 1 and 2.

This can be seen in Figures 2 and 3. Note that in these figures, which show the units as seen from the interaction point, ϕ runs from 1.

15 References

1 ATLAS Muon Technical Design Report CERN/LHC 97-22, Chapter 3, p53-61;
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