Endcap Muon trigger system: ROB input buffer format

ATLAS Israel TGC group

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This document contains information which might change[1].

Revisions:	(changes from previous version are marked by revision bars)
20 Feb 2001	Initial release, preliminary.
24 Nov 2001	Revised, but still preliminary. Still no Sector Logic.
25 June 2002	Version 2: Update to ATLAS Version 2, plus many additions and changes. Include Sector Logic ATLAS Version 2 format is preliminary; it is not yet approved.
17 July 2002	Add HipT data
1 Sept 2002	Release to TGC group for comments
1 May 2004	TGC Version 2.4, for ATLAS Version 2.4: used in H8 2004 test beam add run number and change SourceID in header; add first status word, as specified in [ref. 1], updates to ROD error flag list. Table 3.
1 June 2006	TGC Version 3.0, for ATLAS Version 3.0: Major revisions: New format for Source ID R,ϕ hit and tracklet fragments (6, 7) will not be implemented. Added filter bits; changed local status word. Order of fields in tracklet readout format changed so that low bits are more like a coordinate. Tracklet chamber format defined. Also details of associated tracks. Added details on Inner layer data.
6 Dec 2007	Change to reflect 1/12th segmentation per ROD instead of octants
21 Feb 2010	Remove details of Chamber Format of hits and tracklets. Add & correct HipT details Add & correct Inner details Refer to SB LOC instead of SB ID Changes to Event Status word to reflect new and changed exceptions Correct sector numbering in description of Sector Logic word
19 Mar 2010	Corrected Inner tracklet segment numbering: 1 for wires, 0 for strips
14 Oct 2014	Describe Tilecal additions and EI/FI veto bits: Format Version 4.0
2 Jul 2015	Revise Tilecal and EI/FI data formats in Table 9. Format Version remains 4.0.
28 July 2015	Correct EI/FI bit order

1. Please check the revision date on your copy. The latest version of this document can be found at: http://cern.ch/atlas-tgc/doc/ROBformat.pdf

This document describes the format of the output record sent from the TGC ROD to the ATLAS readout system, ROS, i.e. the bytestream for one 1/12th sector. The format conforms to the ATLAS event format[ref. 1]. An overview of the TGC read-out can be found in the ATLAS Level-1 Trigger Technical Design Report [ref. 2] and [ref. 3]. An overview of the ROD crate and ROD can be found in [ref. 4] and [ref. 5]. Shading indicates features not yet implemented. Note that the naming and numbering conventions follow [ref. 6] and [ref. 7].

Table 1 The ROD output data format to the ROB

	Data word				Comments
	31..24	**23..16**	**15..8**	**7..0**	
Frame	x'B0F0xxxx'				event frame word (control mode word)
Hdr 0	x'EE1234EE'				start of header marker for ROD data
Hdr 1	*reserved*	*reserved*	header size = 9		words (excluding the x'B0F0xxxx' word)
Hdr 2	ATLAS format version=31		TGC format version=4.0		i.e.: ATLAS=0x03'01, TGC=0x04'00
Hdr 3	0	x'67' or x'68'	0	sector[12..1]	source id: x'67' / x'68' = A / C endcap;
Hdr 4	Run type	Run number			
Hdr 5	Level-1 ID				High byte is Extended Level-1 ID
Hdr 6	*reserved*	*reserved*	Bunch crossing ID[11..0]		
Hdr 7	*reserved*	*reserved*	*reserved*	Trigger type	
Hdr 8	Detector event type				not used yet
Status	First status word: specific | generic				≠0: event is ***not*** OK. See Table 2, & [ref. 1]
Status	TGC ROD event status				See Table 3.
Status	ROD VME filter bits		Star Switch timeout or dropped status		one bit per SSW; Filter:1 = accepted. SSW: 1 = dropped or timed-out (see Table 4)
Status	Local status word		presence		Presence indicates which of the following fragments are present[a]. See Tables 5 & 6.
Status	orbit count				orbit count; zero for first L1AID.[b]
Data	Fragment ID	"raw" data word count[c]			fragment ID =1, length in words
Data	Fragment ID	"readout format" hit data word count			fragment ID =2, length in words[d]
Data	Fragment ID	"readout format" tracklet data word count ("tracklet"= 3/4 or 2/3 coincidence)			fragment ID =3, length in words
Data	Fragment ID	"chamber format" hit data word count			fragment ID =4, length in words
Data	Fragment ID	"chamber format" tracklet data word count			fragment ID =5, length in words
Data	Fragment ID	HipT output word count			fragment ID =8, length in words
Data	Fragment ID	Sector Logic word count			fragment ID =9, length in words
Data	raw data, hit, tracklet, sector logic, etc. fragments, in the order of the word counts.				See [ref. 6] and[ref. 8](raw) and Tables 7 to 10.
Data	. . .				
Data	last raw data, hit or tracklet word				
Trail 0	number of status elements = 5				
Trail 1	number of data elements				
Trail 2	Status block position = 0, i.e. data follows status				
Frame	x'E0F0xxxx'				event frame word (control mode word)

a. The number of fragment ID|WC words and fragments is equal to the number of **Hi** bits in this pattern.
b. 32 bits give >100 hrs
c. For debugging; not usually present
d. Fragment ID=6 is used for hits in testpulse format. Normally runs with this format are not sent to the ROB. In this case, ID=6 replaces ID=2 and the order will be 1,6,3,8,9, i.e. the fragments are not in order.

Table 2 ATLAS standard, first status word, all zero means no known errors

31..15	15..0
Specific	Generic

Bit	Specific error conditions
0	
1	
2	
3	
4	
7..5	
15..8	

Bit	Generic error conditions
0	incorrect BCID
1	incorrect L1AID
2	Timeout occurred in at least one of the FE links. Fragment is incomplete.
3	Data may be incorrect, see TGC ROD event status word (Table 3).
4	An overflow in one of the ROD internal buffers has occurred. The fragment is incomplete.
7..5	*reserved*
15..8	*reserved*

Table 3 TGC ROD event status word (32 bits). (See TGCrod_shared.h for bit numbers)

Symbol for bit number in status word	Error
EC_FELdown	A Front End link has gone down - abandoned
EC_frame	Invalid FE link framing words
EC_Glnk	Front End link G-link error
EC_xor	Invalid XOR event checksum
EC_ovfl	Input FE event is too long or FE FIFO overflow
EC_timeout	Timeout expired for at least one FE link
EC_xormezz	Bad XOR checksum from mezz board
EC_noEoE	No End-of-event marker received
EC_missrx	Data from an expected SSW RX port is missing.
EC_unxrxid	Data from disabled SSW RX ID
EC_SLbc	Sector Logic BCID[2:0] does not match its SB BCID
EC_rectype	Unrecognized record type
EC_null	Unexpected nulls in FE input
EC_order	Word is out of order
EC_LDB	Invalid or unexpected Star Switch ID
EC_RXovfl	RXfifo has overflowed
EC_SSWerr	SSW reports T1C, NRC, T2C, or GlinkNoLock error
EC_sbid	SBid does not match SBinfo table
EC_SBtype	SBtype does not match SBinfo table
EC_duprx	RX ID is duplicated in the event
EC_ec4	Unexpected SB L1 Event ID(lo 4)
EC_bc	Unexpected SB BCID
EC_celladr	Invalid cell address
EC_hitovfl	Too many hits in event
EC_trgbit	Unexpected trigger bits
EC_badEoE	Bad End-of-event marker received, not 0xFCA
EC_endWCnot0	WC not 0 after End-of-event marker
The following errors imply that data for a whole LDB is missing:	
EC_wc0	Event has WC=0 or WC > max WC
EC_RXsend	Error in request to send an event via RXlink
EC_nohdr	First word of SSW fragment is not a header

Table 4 Star switch time-out status and ROD VME filter bits

31..28	27..16	15..12	11..0
rsrvd	bit*i* on indicates data from SSW*i* gave filter "accept"	*rsrvd*	bit*i* on indicates SSW*i* was dropped or timed-out

Table 5 Local status word (Items in grey are not implemented.)

15	14	13..4	3	2	1	0
no L1AID, BCID check wrt ROD[a]	ROI in this fragment	*reserved*	Tracklets are sorted	Hits are sorted	Tracklet BCs are merged[b]	Hit BCs are merged[b]

a. In this running mode the BCID and L1ID from the slave boards are checked for consistency with each other and NOT for consistency with the BCID and L1ID generated in the ROD using BCclk and L1A from the ROD TTCrx.

b. In merge BCs mode, if the same tracklet/hit occurs in more than one of the three adjacent BCs, it is output only once with the BC bitmap indicating in which BCs it was present.

Table 6 Presence bits (Items in grey are not implemented.)

15..10	9	8	7..6	5	4	3	2	1	0
rsrvd	Sector Logic	HipT output	*rsrvd*	tracklets in chamber format	hits in chamber format	tracklets in readout format	hits in readout format	raw data	*rsrvd*

Data words

The raw data format is described in [ref. 8]. In readout channel format a hit is defined in terms of the hierarchy of read out system objects: Slave Board channels, slave boards, SSWs. etc. Chamber format defines a hit in terms of the hierarchy of chambers, modules, wheels, etc. In the offline world the former are called "online identifiers" and the latter, "offline identifiers". "Tracklets" for the doublet pairs are, by default, 3-out-of-4 coincidences, for the triplet, 2-out-of-3 coincidences, for the Inner pairs, 1-out-of-2 coincidences. Chamber format in the ROD output is not implemented. Since SB IDs are not unique, SB LOCs, which are mapped from the RX ID according to a LUT loaded into the ROD at configuration time, are used.

Table 7 Hit in read out channel format

	31	30	30..24	23..21	20..17	16	15..13	12..8	7..0
# of bits	**1**	**1**	**6**	**3**	**4**	**1**	**3**	**5**	**8**
	OK	*rsrvd*	associated tracklet	BC bitmap[a]	LDB[b] ID	norm=0 adj=1	SB type[c]	SB LOC	input chan #[d]

a. Bunch Crossing occupancy bitmap: |-1| 0 |+1|

b. LDB: Local Data Block: for doublet pairs is a trigger sector; for triplets is two trigger sectors. Each Star Switch reads out one LDB.

c. Slave Board type: 0,1: doublet wire, strip; 2,3: triplet wire, strip; 4: inner wire or strip

d. For Inner: hits 0-71 are strips; 72-159 are wires. The slave board type is 4 for *both* cases (unlike tracklets).

Associated tracklet: If the hit-tracklet association logic was not run for a SBIC, its tracklets will have tracklet type (see below) set to 0 and all its hits will have their associated tracklet field set to zero. If association logic was run, the associated tracklet field of each associated hit contains the sequence number, from 1, of the tracklet in the list of tracklets, otherwise it is zero. If there are 63 or more tracklets, the tracklet number stored in their associated hits will be 63 for all the tracklets.

Table 8 Tracklet in read out channel format ("Tracklets" are 3-out-of-4 or 2-out-of-3 coincidences.) (Items in grey are not implemented.)

	31	30..28	27	26..24	23..21	20..17	16..12	11..8	7	6..5	4..0
# of bits	**1**	**3**	**1**	**3**	**3**	**4**	**5**	**4**	**1**	**2**	**5**
Doublet wire	OK	0	*rsrvd*	tracklet type [a]	BC bitmap[b]	LDB ID	SB LOC	±ΔR[c]	0	sub-matrix[d]	R or ϕ
Doublet strip		1						±Δϕ[c]			
Triplet wire		2						0			
Inner[e] wire		4							seg[f]		0
Inner[e] strip		5[g]									
Triplet strip		3							**7**	**6**	**5..4**	**3..0**
									seg[h]	0	sub[d]	ϕ

a. Tracklet type: currently 0
b. Bunch Crossing occupancy bitmap: |–1 | 0 | +1|
c. This is a 2's complement signed number that must be properly sign extended when moved to a byte.
d. Sub-matrix, also known as "candidate". Range: doublets: 0..1, triplet wires: 0..2, triplet strips: 0..3, Inner: 0..3. Only the highest p_T coincidence in each sub-matrix is reported by the Level-1 hardware.
e. Inner coincidences are 1-out-of-two (default) or 2-out-of-2. Only the sub-matrix is identified, i.e. no wire or strip coordinate.
f. Inner segments: wires=1; strips=0 (redundant with bits 30..28 = 4 or 5)
g. Unlike hits, code 5 is used to distinguish strips from wires (code 4).
h. Triplets have only two strip layers. Each segment of the triplet strip ASIC services a separate triplet chamber.

Table 9 HipT output data

	31..21	20..18	17	16	15..13		12..11		10	9	8..6	5	4..0
# bits	**11**	**3**	**1**	**1**	**1**	**2**	**1**	**1**	**1**	**1**	**3**	**1**	**5**
FWD wire	*rsrvd*	BC bit-map[a]	0	1	0	sector [b,c]	0	chip	cand	hip_T / lop_T [d]	Hit-ID[e]	sub[f]	±ΔR [g]
FWD strips			1	1			0						±Δϕ [h]
EC wires			0	0			chip						±ΔR [g]
EC strip			1	0			0	chip					±Δϕ [h]
Inner			0	0	1	SBLOC[i]	0		0	0	EI/FI bits [j]		
Tilecal			1	0		SBLOC[i]	0		0	0	Tilecal bits [k]		

a. Bunch Crossing occupancy bitmap: |–1 | 0 | +1|
b. Forward sectors are 0 and 2
c. Endcap sectors are 0, 1, 2, and 3
d. HipT is 1, LopT is 0
e. Hit-ID is 1 to 6 for main wheels and 0 to7 for the EI/FI wheels.
Note that HitIDs for Endcap strip chip1 are ambiguous; so the ROD duplicates each hit as follows: HitID=1 gives both 1 and 4, HitID=2 gives both 2 and 6.
f. sub is 0 for Hi-pT sub-matrix closest to lowest hit-ID
g. -15 < ΔR < 15
h. -7 < Δϕ < 7
i. denotes which of the four Inner Slave boards
j. EI/FI bits, bits 8..0: | 0 | 0 | 0 | FI2 | EI2 | FI1 | EI1 | FI0 | EI0 |
k. Tile module, bits 8..0: | 0 | TM3 D6 | TM3 D5+6 | TM2 D6 | TM2 D5+6 | TM1 D6 | TM1 D5+6 | TM0 D6 | TM0 D5+6 |

Table 10 Sector Logic Region-of-Interest word, based on [ref. 7], for Forward and End-cap sectors. Note that there can be up to two candidates per sector reported.

	31..27	26	25	24..22	21	20..18		17	16	15..13	12	11..9	8	7..6	5..0
# bits	**5**	**1**	**1**	**3**	**1**	**1**	**2**	**1**	**1**	**3**	**1**	**3**	**1**	**2**	**6**
FWD	*rsrvd*	*rsrvd*	>2 cands [a]	BC bit-map [b]	1	0	sector [c,d]	cand	p_T sign [e]	BCID	>1 cand in RoI [f]	p_T thresh	0 [g]	0	RoI
EC		veto [h]			0									RoI	

a. If there are two candidates in a sector, the >2 candidates field is duplicated in both candidates.
b. Bunch Crossing occupancy bitmap: |–1 | 0 | +1|
c. Forward sectors are 0 and 1
d. Endcap sectors are 0, 1, 2, and 3
e. As in [ref. 7], 0 for μ^-, 1 for μ^+
f. >1 candidate in RoI is always 0 for TGC
g. Bit 8, "overlap", is now always zero, since all overlaps are handled now by the MUCTPI.
h. veto, i.e. no matched inner coincidence

References

Note In Acrobat Reader, click on URLs.

1 The raw event format in the ATLAS Trigger & DAQ, ATL-DAQ-98-129, Version 2.0, 11 March 2002, http://doc.cern.ch//archive/electronic/cern/others/atlnot/Note/daq/daq-98-129.pdf

2 ATLAS First Level Trigger Technical Design Report, CERN / LHCC 98-14, ATLAS TDR 12, 30 June 1998, see Chapter 12.6, http://atlasinfo.cern.ch/Atlas/GROUPS/DAQTRIG/TDR/tdr.html

3 Endcap Muon Level-1 Trigger – TDR update, June 2000, see Chapter 12.6, http://cern.ch/atlas-tgc/doc/MuonEndcap_rev01.pdf

4 The TGC ROD Crate, presented at The ATLAS Muon Endcap Trigger Electronics Workshop, Kyoto, October 2000, http://cern.ch/atlas-tgc/doc/ROD_KyotoWrkshp00.pdf

5 Endcap Muon Trigger system: Read-out Driver Requirements and Specifications, http://cern.ch/atlas-tgc/presentations/offPDR/ROD_PDR.pdf

6 Naming and numbering scheme for the Endcap muon trigger system, http://cern.ch/atlas-tgc/doc/numbering.pdf

7 Interfaces and Overlaps in the Muon System, http://edms.cern.ch/file/114604/4/muoninter-rev10.pdf

8 Endcap Muon Trigger System: Front End Link Protocol and Data Format, (*under revision*) http://cern.ch/atlas-tgc/doc/FElnkprotocol.pdf