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Specification of the Interface between the Global Muon Trigger and the Global Trigger

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Abstract

The Level-1 Global Muon Trigger sends up to four muon candidates per bunch crossing to the Level-1 Global Trigger. Transmission standard as well as format and coding of the muon candidate data are detailed in the present document.

1 Description

The Global Muon Trigger (GMT) is mounted in the Global Trigger (GT) crate [1, Chapters 14 and 15]. It sends the four best muons as parallel GTLP-signals at 80 Mwords/s via the backplane to the Global Trigger Logic Boards (GTL boards). Muon 1 is interlaced with muon 2 and muon 3 with muon 4. Muon 1 is sent before muon 2 and muon 3 before muon 4.

The four muons are sorted by rank. The muon with the highest rank is sent on channel 1, the one with the lowest rank on channel 4. If fewer than 4 particles are found, the channels for lower ranks are empty. Empty channels contain all 0 or at least p_T=0. One muon candidate is represented by 26 bits (Table 1).

Table 1: Data Format of the 26 bits used to transmit data of one muon candidate from the GMT to the GT.

Res = reserved for future use
SY_SIGN = sign of charge or synchronization code (2 bits)
MIP = Minimum Ionizing Particle bit (muon was confirmed by calorimeter)
ISO = Isolation bit (muon was isolated)
ETA = pseudorapidity: 6 bits (MSB is pseudo-sign)
QU = 3 quality bits
PT = transverse momentum, 5 bits
PHI = azimuthal angle, 8 bits

Bit nr.	27	26	25	24
	Res	**Res**	**SY_SIGN**	

23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
MIP	**ISO**	**ETA 5.....0**						**QU2,1,0**				**PT 4.....0**				**PHI 7.....0**							

2 Coding of Data Bits and Scales

This section deals with the coding and scales of the data bits and bit fields defined in the previous section. The regional triggers and the GMT use common scales for ϕ and p_T. Specific η-scales of the regional muon triggers are converted to a common scale by the GMT.

The following coordinate system is used for the spatial coordinates ϕ and η:

- CMS is north of centre of LHC; right handed system with origin in collision point
- Horizontal x-axis pointing to centre of LHC (south),
- vertical y-axis pointing upwards,
- horizontal z-axis horizontal pointing to west, parallel to beam, parallel to B-field.
- ϕ = 0°corresponding to x-axis, ϕ = 90° corresponding to y axis
- η = 0 in xy-plane, η > 0 for positive z-axis

The regional muon triggers determine the ϕ and η coordinates at a reference plane in the muon system. For the barrel, the reference plane is a cylinder going through the centre of the second muon station. For the endcaps, the reference plane is a plane going to the centre of the second disc of muon chambers. Optionally the GMT projects the ϕ coordinates from the muon system to the vertex.

2.1 Phi Scale

A common linear 8-bit ϕ scale is used by all regional muon triggers and the GMT: ϕ codes range from 0 to 143, each code representing a bin of 2.5° in ϕ. Bin 0 represents a ϕ value between 0° and +2.5°, bin 1 represents a ϕ value between 2.5° deg and +5.0° deg and so forth.

2.2 Pseudorapidity (η) Scale

The GMT converts the η scales of the regional triggers to a common non-linear 6-bit output η scale as given in Table 2. The scale is a symmetric scale with a bin boundary at η=0. The five lower bits of the η code give absolute bin number (count). The MSB is a pseudo-sign: 0 for the positive endcap, 1 for the negative one. The η-scale is programmable and may be changed simultaneously in the GMT and in the GT.

Table 2: GMT output η-scale (for positive η).

GMT to GT		
Count	bin low edge / units η	bin center / units η
0	0.0	0.05
1	0.1	0.15
2	0.2	0.25
.		.
16	1.6	1.65
17	1.7	1.725
18	1.75	1.775
.	.	.
.	.	.
31	2.35	2.375

2.3 Transverse Momentum (p_T) Scale

The regional triggers and the GMT use a common 5-bit non-linear pT scale. The scale has to be the same in all systems for a given running condition. If running conditions require it, the scale may be changed simultaneously in all the regional triggers.

Table 3 shows the default scale, that has been agreed [1, Chap. 14] upon for the start-up of LHC: the p_T scale is defined at 90% efficiency, i.e. setting a certain trigger threshold means that the trigger will be 90% efficient for muons with a real p_T equal to the selected threshold. P_T-code 0 is reserved to denote an empty muon candidate.

Table 3: Default transverse momentum (p_T) scale agreed for LHC start-up:

P_T code	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Low edge of pT bin /GeV/c	No muon	0.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	6.0	7.0	8.0	10	12	14
P_T code	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Low edge of pT bin /GeV/c	16	18	20	25	30	35	40	45	50	60	70	80	90	100	120	140

2.4 Quality Scale

The three-bit quality code defines the quality of a muon candidate. In principle the quality scale is freely programmable in the GMT and in the GT algorithms. The currently defined quality codes are shown in Table 4. Very low quality candidates are unconfirmed candidates of certain input qualities in certain regions of pseudorapidity.

Table 4: Current meaning of quality bits of GMT candidates sent to the Global Trigger.

Quality code	**GMT to GT**	**Intended special use**
7	DT/RPC or CSC/RPC Matched candidate	
6	DT or CSC unconfirmed candidate	
5	RPC unconfirmed candidate	
4	Very Low Quality Type 3	Skip in di-muon trigger
3	Very Low Quality Type 2	Skip in Single muon trigger
2	Very Low Quality Type 1	Skip in single and di-muon trigger
1	halo muon	Halo muons for alignment
0	no track	

2.5 Synchronization / Sign of Charge bits

Two bits are used to code the sign of charge or to identify a muon candidate word as a synchronization word (Table 5).

Table 5: Coding of the synchronization / sign of charge bits

Bit code	Meaning
1 1	Sync word
1 0	Undefined charge
0 1	Negative charge
0 0	Positive charge

2.6 MIP bit

The MIP bit indicates whether a muon was confirmed by the calorimeter, i.e. whether the calorimeter detected a minimum ionizing particle at the extrapolated region of passage of the muon (1: MIP, 0: not MIP).

2.7 ISO bit

The ISO bit indicates whether a muon candidate is isolated as determined by the isolation algorithm of the GMT (1: isolated, 0: not isolated).

References

[1] **CERN/LHCC 2000-38**, *"CMS, The TriDAS Project, Technical Design Report, Volume 1: The Trigger Systems"*.