COMPASS NOTE

TRIGGER CONFIGURATION SUMMARY 2002 - 2012

Authors:
J. Barth, J. Bernhard, E.M. Kabuß, N. du Fresne, B. Veit

May 10, 2016

1 Introduction

The COMPASS trigger system [1] mainly consists of pairs of scintillator hodoscopes and is able to trigger on muons coming from the target (target pointing trigger). In addition, a minimal energy-loss in the target and/or deposition in the calorimeter can be required. Since the beginning of the COMPASS data taking in 2002, the muon trigger has been maintained and changed several times: new slabs have been implemented, the detector geometry was changed or the trigger logic was adapted to the current physics program. This note gives an overview about most trigger activities for the COMPASS trigger system from 2002 until 2012, including the muon triggers, auxiliary triggers and the first attempts of a di-muon trigger for Drell-Yan. The triggers for the hadron runs 2008 and 2009 are not covered. It is a look-up list for most of the spontaneous trigger-related questions, which commonly occur during analysis discussions. A list of the used triggers with comments about their composition, typical prescaling factor N_{presc} and the typical unprescaled rates $R_{\text{unpr.}}$ ($1/10^3$ per spill) are given with a reference run. For each year, a comment section describes the major changes and gives further information.
Figure 1 is a schematic view of the experiment showing the positions of the hodoscopes. Most of them (except H1, HI04 and HO03) are located behind muon filters. In front of the beam telescope, a veto system consisting of scintillator slabs is used that prevents a trigger, in case a halo muon is detected.
Table 1 is an rough overview of the various data taking periods beginning from 2002. It shows used target material, a very rough flux per spill (for orientation only), the spill length and the main physics program of this year. Data taking with a longitudinal (transverse) polarised target is shortened with "L" ("T"). In addition, the veto dead time [2] and the DAQ dead times are shown. Some of these values are not available.

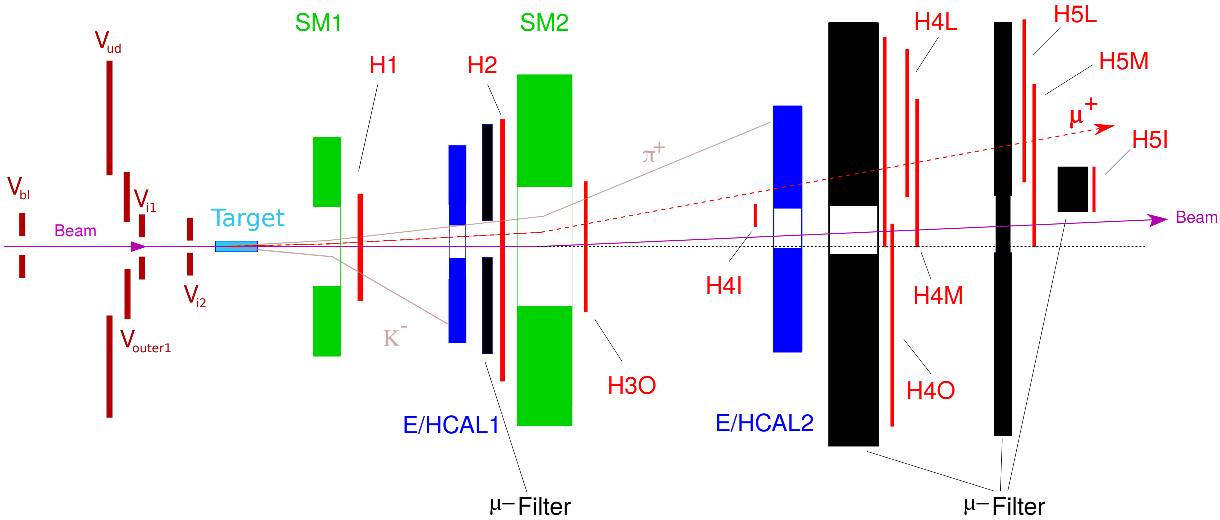

Figure 1: Most of the trigger elements in the experimental set-up

Year	Target	p_{beam} (GeV)	rough flux/spill	t_{spill} (s)	DT_{DAQ}	DT_{Veto}	Programm
2002	LiD	160	$2.0 \cdot 10^8$	4.8	N/A	N/A	L
2003	LiD	160	$2.0 \cdot 10^8$	4.8	N/A	22 %	L/T
2004	LiD	160	$2.0 \cdot 10^8$	4.8	8 %	20 %	L/T
2006	LiD	160	$2.0 \cdot 10^8$	4.8	9 %	20 %	L
2007	NH_3	160	$2.0 \cdot 10^8$	10.4	13 %	19 %	L/T
2009	lH_2	160	$2.5 \cdot 10^8$	10.4	10 %	30 %	DVCS test
2009'	lH_2	160	$2.5 \cdot 10^7$	10.4	6 %	3 %	DY test (π^-)
2010	NH_3	160	$2.0 \cdot 10^8$	10.4	13 %	10 %	T
2011	NH_3	200	$1.0 \cdot 10^8$	10.4	6 %	11 %	L
2012	NH_3	160	$2.5 \cdot 10^8$	10.4	16 %(5.5 %)	27 %(11 %)	DVCS test

Table 1: Table with characteristics of the muon data taking years 200-2012 (L= longitudinal, T= transverse). The values in brackets are for the negative muon beam.

2 Trigger Elements

The physics and auxiliary triggers make use of various hodoscopes, calorimeter conditions, veto conditions or any combination of the latter three.

1. **Calo Mix Condition (CM)** : The CM is given by the calorimeters and is fired when a cluster in either HCAL1 or HCAL2 (in 2007 and 2011, also ECAL1 was included in the CM logic [3]) is larger than an adjustable threshold. The CM is used as a semi-inclusive condition on the muon triggers.

2. **Calo Trigger Condition (CT)** : Similar to the CM, the CT fires on clusters presumably coming from hadrons in a calorimeter. The threshold is mostly higher than the CM one. The CT in combination with a veto signal (V_{tot}), it is used as a hadron trigger, especially for the large Q^2 region and for the determination of the trigger hodoscope efficiencies. Please note the difference between the Calo Trigger Condition CT and the Calo Trigger ($CT \wedge \overline{V_{tot}}$).

3. **Inner Trigger (IT)** is an energy loss trigger and consists of the hodoscopes HI4 and HI5 with vertical strips [4]. The hodoscope HI4 is installed in front of the ECAL2, while HI5 is installed behind the last muon filter (MF3) at the very end of the spectrometer. The Inner Trigger hodoscopes are only read out on one side. It is used for the smallest energy loss measurements of the scattered muon. With its small scintillator strips and thus higher resolution, HI5 is also used as a tracking detector. The IT is used to collect data of low four-momentum transfer $0.001\,(\mathrm{GeV/c})^2 < Q^2 < 1\,(\mathrm{GeV/c})^2$ and $y > 0.2$. The IT is the only physics trigger that does not include the anti-coincidence with the veto. With the proximity of the scintillator elements to the beam, the veto would be constantly interfering and considerably decreasing the efficiency. To reduce the rate, this trigger can only be used as a semi-inclusive trigger, thus the calorimeter condition CM is applied.

4. **Ladder Trigger (LT)** is an energy loss trigger, which consists of two vertical hodoscopes

(HL4 and HL5) with varying slab sizes: fine slabs close to the beam and wider ones outside. Starting in 2010, this trigger is used as an inclusive trigger. Before 2010, LT was used as a semi-inclusive trigger, thus the calorimeter condition CM was applied.

5. **Middle Trigger (MT)** is a target pointing trigger covering angles from 0.5 mrad to 5 mrad. To reduce the rate at these small angles, the horizontal planes are supplemented by vertical ones providing an energy loss trigger. It consists of four vertical hodoscopes (HM4X up/dn and HM5X up/dn), which are read out on one side. In addition, the MT has four horizontal hodoscope planes: HM4Y (up), HM4Y (dn), HM5Y (up) and HM5Y (dn). The timing of the MT is done with the Y planes as they are read out on both side This trigger is simultaneously used inclusively and semi-inclusively.

6. **Outer Trigger (OT)** is a large target pointing trigger. It consists of two large horizontal hodoscopes (HO3 and HO4). Due to its size, H04 is divided into two halves. The OT covers angles θ larger than 5 mrad, up to the end of the acceptance of the small angle spectrometer. The OT is mainly used to select muons in the momentum-transfer range of $10\,(\mathrm{GeV/c})^2 < Q^2 < 20\,(\mathrm{GeV/c})^2$.

7. **Large Angle Spectrometer Trigger (LAST)** is a target pointing trigger and is the only trigger system that is completely set up in the large angle spectrometer of COMPASS [5] [6] [7]. It consists of two horizontal hodoscopes: H1 and H2, with H2 further divided into two hodoscope halves. This trigger covers the range of large momentum-transfers ($Q^2 > 10\,(\mathrm{GeV/c})^2$) and large x. This trigger was newly implemented in the COMPASS setup in 2010.

8. **Vetos**: A veto system is used in most of the trigger conditions to prevent triggers coming from halo muons. The following veto sub-systems are used at COMPASS: V_{bl}, V_{ud}, V_{out1}, V_{i1} and V_{i2}. The "OR" of all veto elements is called $\mathrm{V_{tot}}$. V_{prime} is similar to $\mathrm{V_{tot}}$, but without the two inner vetos. Starting from 2009, all physics trigger are using $\mathrm{V_{tot}}$ (except the IT). The veto dead time can be determined with the Middle Trigger and the True Random Trigger according to the COMPASS Note 2010-8.

9. **Scintillating Fibres (FI1 and FI2)** : The two fibre stations have two planes each (X and Y) and are part of the beam telescope. The anode signal is used to trigger on the beam particle. The coincidence forms the beam trigger (BT). For the hadron data taking, the so called beam counter BC was implemented. It was also used for the DVCS measurement. It was a small scintillator disc with a diameter of 5 cm, located right behind the scintillating fibre stations in the beam telescope. The alternative beam trigger (aBT) was a coincidence of the BC and FI02.

The expected kinematic range of the various triggers is illustrated in Figure 2 for a muon beam momentum of 160 GeV. The size of the hodoscope slabs and the PMT used are summarised in the Table 2. Figure 3 shows an overview of most hodoscope planes. The Inner Trigger elements are not shown, the geometry is more complicated with inclined slabs and the size is considerably smaller than the remaining hodoscopes.

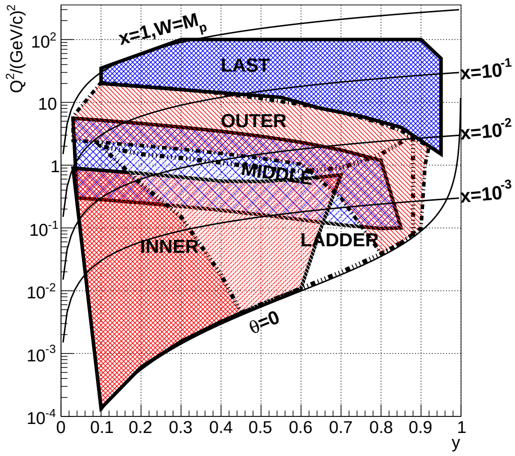

Figure 2: Kinematic acceptance of the COMPASS muon trigger.

System	Hodoscope	No. of stripes	Width (mm)	z-Pos.	Area (cm^2)	PMT type
Inner	H4I (up)	32	6	32	17.34×19.4	R7400
	H4I (dn)	32	6	32	17.34×19.4	R7400
	H5I (up)	32	12	51	35.3×25.95	XP2900
	H5I (dn)	32	12	51	35.3×25.95	XP2900
Ladder	H4L	32	22-57	40.65	128.2×40	XP2900
						2090,2020
	H5L	32	27-87	48.05	168.2×47.5	XP2900
						2090,2020
Middle	HM4X (up)	20	62	40.3	120 × 35.5	XP2072B
	HM4X (dn)	20	62	40.3	120 × 35.5	XP2072B
	HM4Y (up)	32	21.5-25	40.4	120 × 35.5	XP2900
	HM4Y (dn)	32	21.5-25	40.4	120 × 35.5	XP2900
	HM5X (up)	20	77	47.7	150 × 42.5	EMI9954B
	HM5X (dn)	20	77	47.7	150 × 42.5	EMI9954B
	HM5Y (up)	32	25-30	47.8	150 × 42.5	XP2900
	HM5Y (dn)	32	25-30	47.8	150 × 42.5	XP2900
Outer	HO3	16	70	23	200 × 100	9813/XP2020
	HO4	32	150	40	480 × 225	9813/XP2020
LAS	H1	32	60	5.8	230 × 192	XP2900/2982
	H2	32	136	16	500 × 420	9813KB

Table 2: Table with all trigger hodoscopes, their relevant dimensions and the photomultiplier tube types. The hodoscope HO03 and H2 are divided in two halves. The z position of HO03 varies due to movement of SM2 in 2009.

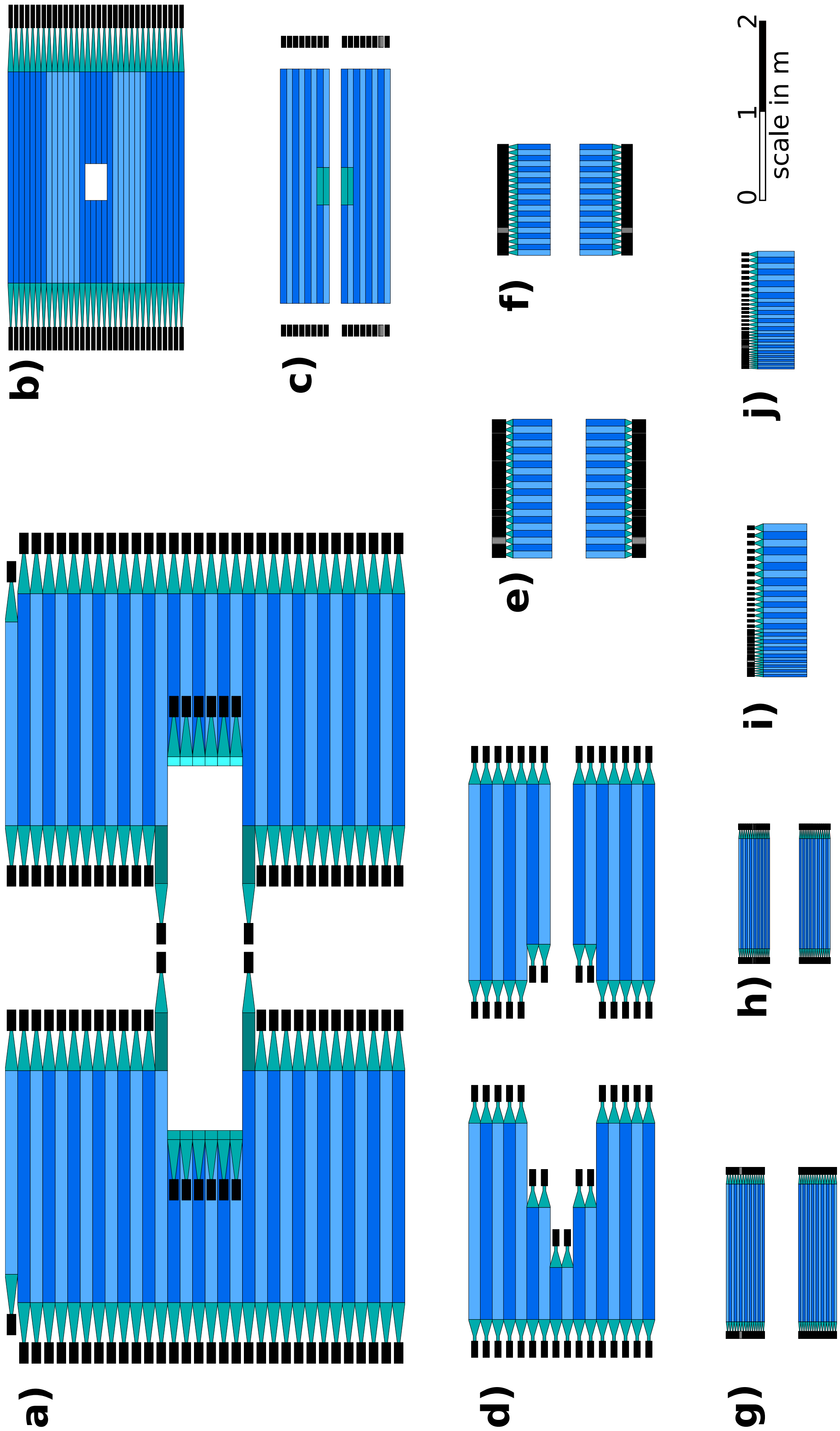

Figure 3: Overview of most hodoscopes for the data taking in 2010 a)-j): H2, H1, HO3, HO4, HM4X, HM5X, HM4Y, HM5Y, HL4 and HL5. The hodoscopes are shown in scale with a reference scale. The Inner Trigger elements are not shown here due to their small size.

3 Coincidence Matrix

The pair of hodoscopes in each trigger subsystem is connected via a coincidence matrix. Depending on the used trigger principle, the shape of the matrix is adjusted. This is illustrated in Figure 4 and the various coincidence matrices are shown below. The matrix pattern should be adjusted to the target position and therefore change over the years. The pattern shown here in Figure 5-7 are from the 2012 DVCS test run.
In the case of target pointing, the triggering is done in the non-bending plane with horizontal hodoscope slabs. To trigger on scattered muons coming from the target, the matrix shape is a diagonal. Trigger hodoscopes with horizontal slabs are H1, H2, HO03, HO04, HM04Y and HM05Y. The coincidence matrix for the LAST is done on a FPGA [8]. For OT and LAST, two matrices are needed as the larger hodoscope of the pair is divided into two halves. Each half is put into coincidence with the smaller hodoscope.
In the case of the energy-loss trigger, a scattered muon with a minimal energy-loss in the target is desired. This is realised with vertical hodoscope slabs and a triangular coincidence matrix, which takes into account the angular spread of the scattered muons. Trigger hodoscopes with vertical scintillator slabs are HM04X, HM05X, HL04, HL05, HI04 and HI05.

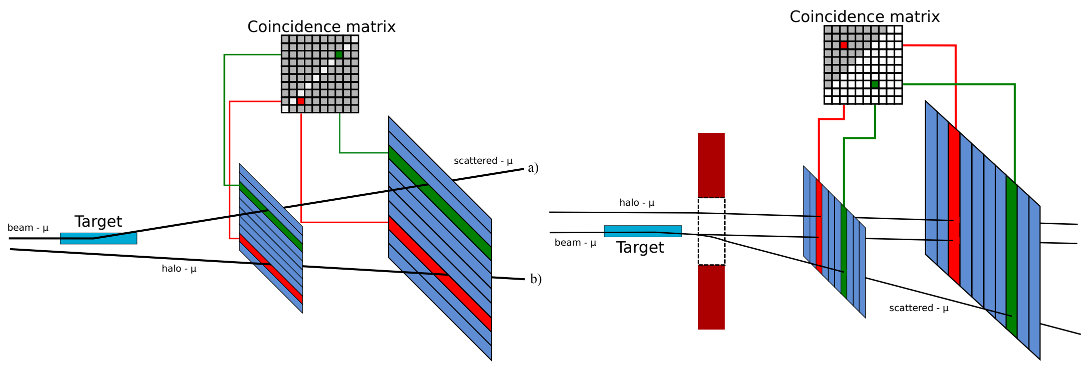

Figure 4: Principle of target pointing (left) and energy-loss triggers (right).

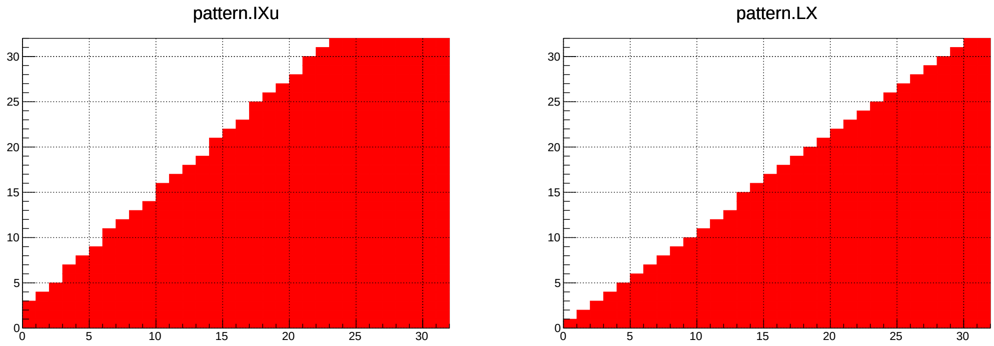

Figure 5: Matrix pattern of IT and LT (2012)

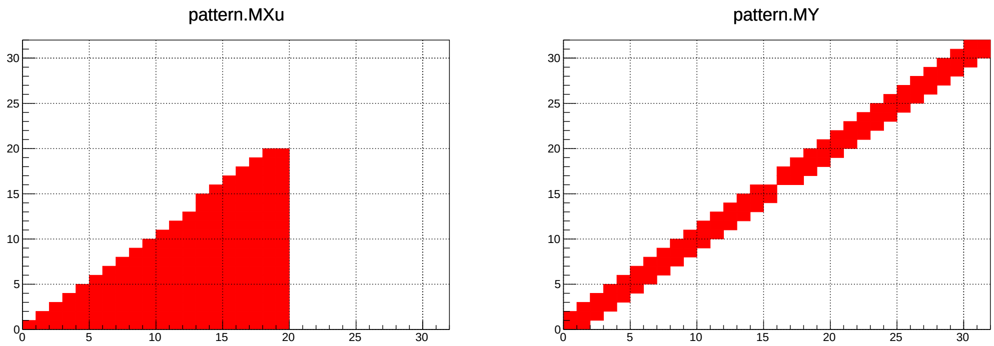

Figure 6: Matrix pattern for the target-pointing and energy-loss part of the MT (2012)

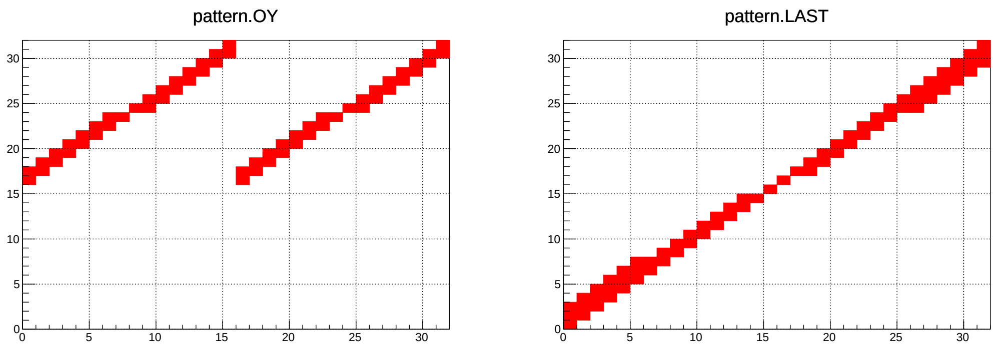

Figure 7: Matrix pattern for OT and LAST (2012)

Auxiliary Trigger	**Logical composition**
Beam Trigger (BT)	SciFi1X $\wedge$ SciFi1Y
Veto Inner (VI)	$V_{i1} \wedge V_{i2}$
Halo	$V_{out1} \wedge$ HO04
Random	Output from noise generator
True Random (TRand)	rad. source 892
ECAL1 Laser (Laser)	on-spill calibration trigger for ECAL1

Table 3: Overview of auxiliary triggers used for specific data taking (*e.g.* alignment, tracking studies).

4 Auxiliary Trigger

In addition to the physics trigger, some auxillary triggers are used. The beam trigger is the first triggers to be set up at the beginning of the data taking period due to the simple logic of this trigger. With the good timing of the fibre stations, the BT is used to time in the hodoscope trigger. The beam trigger, veto Inner trigger and the halo trigger are used during the alignment runs to illuminate all detectors with parallel tracks (near halo, far halo and beam).
The random and the true random trigger are used for detector tests and commissioning. The main purpose of the true random trigger is the measurement of the incoming beam flux [9].
After the contrustion of the LAST in 2010, the Calo Trigger (CT) is not used as a physics trigger. The main purpose now is to provide a data sample (independent of the hodoscope triggers) to determine the hodosocpe and trigger efficiency [10] [11].

5 Trigger Summary

In the following tables, the used triggers are shown for the years 2002 - 2012. Each table contents (for a reference run) the trigger bit number, the short name of the trigger, the composition, the used prescaling factor and the unprescaled rate in 10^3/spill. Further important comments are shown below the tables.

5.1 2002

Run 22939

Bit	2^{Bit}	Name	Composition	N_{presc}	$R_{\text{unpr.}}/10^3$
0	1	IT	HI4/5 $\wedge$ CM	1	N/A
1	2	MT	HM4/5XY $\wedge$ CM $\wedge$ $\overline{\text{V}_{\text{tot}}}$	1	N/A
2	4	LT	HL4/5 $\wedge$ CM $\wedge$ $\overline{\text{V}_{\text{prime}}}$	1	N/A
3	8	OT	HO3/4 $\wedge$ $\overline{\text{V}_{\text{tot}}}$	1	N/A
4	16	CT	CT $\wedge$ $\overline{\text{V}_{\text{tot}}}$	0	N/A
5	32	VI	$\text{V}_{\text{i1}} \wedge \text{V}_{\text{i2}}$	0	N/A
6	64	Halo	HO4 $\wedge$ V_{out}	0	N/A
7	128	BT	FI01 $\wedge$ FI02	0	N/A
8	256	inclMT	HM4/5XY $\wedge$ $\overline{\text{V}_{\text{tot}}}$	2	N/A
9	512	VO1	Veto outer 1	0	N/A
10	1024	clock		0	N/A
11	2048	random		0	N/A

Trigger rates are not visible in the COMPASS run logbook.

5.2 2003

Run 28990

Bit	2^{Bit}	Name	Composition	N_{presc}	$R_{unpr.}/10^3$
0	1	IT	HI4/5 $\wedge$ CM	1	12.4
1	2	MT	HM4/5XY $\wedge$ CM $\wedge$ $\overline{V_{tot}}$	1	1.5
2	4	LT	HL4/5 $\wedge$ CM $\wedge$ $\overline{V_{prime}}$	1	7.0
3	8	OT	HO3/4 $\wedge$ $\overline{V_{tot}}$	2	9.5
4	16	CT	CT $\wedge$ $\overline{V_{tot}}$	0	5.8
5	32	VI	$V_{i1} \wedge V_{i2}$	100000	20441
6	64	Halo	HO4 $\wedge$ V_{out}	100000	2424
7	128	BT	FI01 $\wedge$ FI02	1000	7810
8	256	inclMT	HM4/5XY $\wedge$ $\overline{V_{tot}}$	2	21.3
9	512	OCT	HO3/4 $\wedge$ CM $\wedge$ $\overline{V_{tot}}$	1	0.7
10	1024	JPsi		1	0.4
11	2048	random	Noise random generator	0	144.3

The JPsi trigger was an attempt to build a di-muon trigger. It was not used in the analysis.
Inclusive Middle Trigger is prescaled by a factor of 2.

5.3 2004

Run 40997

Bit	2^{Bit}	Name	Composition	N_{presc}	$R_{unpr.}/10^3$
0	1	IT	HI4/5 ∧ CM	1	13.0
1	2	MT	HM4/5XY ∧ CM ∧ $\overline{V_{tot}}$	1	1.7
2	4	LT	HL4/5 ∧ CM ∧ $\overline{V_{prime}}$	1	6.7
3	8	OT	HO3/4 ∧ $\overline{V_{tot}}$	1	10.3
4	16	CT	CT ∧ $\overline{V_{tot}}$	1	19.4
5	32	VI	$V_{i1} \wedge V_{i2}$	100000	19290
6	64	Halo	HO4 ∧ V_{out}	100000	2297
7	128	BT	FI01 ∧ FI02	1000	777
8	256	inclMT	HM4/5XY ∧ $\overline{V_{tot}}$	2	21.0
9	512	OCT	HO3/4 ∧ CM ∧ $\overline{V_{tot}}$	0	0.8
10	1024	JPsi		1	0
11	2048	random	Noise random generator	333	183.8

Inclusive Middle Trigger is prescaled.
The JPsi trigger was an attempt to build a di-muon trigger. It was not used in the analysis.

5.4 2006

Run 52959

Bit	2^{Bit}	Name	Composition	N_{presc}	$R_{\text{unpr.}}/10^3$
0	1	IT	HI4/5 $\wedge$ CM	1	12.4
1	2	MT	HM4/5XY $\wedge$ CM $\wedge$ $\overline{V_{\text{tot}}}$	1	1.7
2	4	LT	HL4/5 $\wedge$ CM $\wedge$ $\overline{V_{\text{prime}}}$	1	7.8
3	8	OT	HO3/4 $\wedge$ $\overline{V_{\text{tot}}}$	1	9.7
4	16	CT	CT $\wedge$ $\overline{V_{\text{tot}}}$	1	15.2
5	32	VI	$V_{i1} \wedge V_{i2}$	40000	15255
6	64	Halo	HO4 $\wedge$ V_{out}	10000	2168
7	128	BT	FI01 $\wedge$ FI02	99999	53748
8	256	inclMT	HM4/5XY $\wedge$ $\overline{V_{\text{tot}}}$	2	14.5
9	512	ECAL1	Testing for ECAL1 part of CM/CT	0	0
10	1024	lowrandom	True random trigger from rad. source in 892	1	0.1
11	2048	random	Noise random generator	4000	158.8

Inclusive Middle Trigger is prescaled by 2.
After determination of the trigger efficiency, it was found that parts of the MT were not working properly. For analyses, this part has to be excluded. The MT trigger bit is removed when scattered muons hitting the inefficient part by:

```
{
int idet = PaSetup::Ref().iDetector("HM05X1_d");
 const PaDetect& HM05 = PaSetup::Ref().Detector(idet);
 HM05z = HM05.Z();
int Npars = scatmuon.NTPar(); // track is the PaTrack of the mu1
PaTPar partr = scatmuon.vTPar(Npars-1);
PaTPar parHM;
partr.Extrapolate(HM05z, parHM, false);
HM05x = parHM(1);
HM05y = parHM(2);
static const double xminHM05X1_u = 14.55 -0.15; // values taken from detectors
static const double xminHM05X1_d = 22.02864 -0.12864;
if((trigMask&256) && HM05x < (HM05y>0. ? xminHM05X1_u:xminHM05X1_d) )
{ // eliminate iMT bit
trigMask -= 256;
}
```

5.5 2007

Run 61058

Muon run with a transversely polarised NH_3 target and longitudinal muon run.

Bit	2^{Bit}	Name	Composition	N_{presc}	$R_{\text{unpr.}}/10^3$
0	1	IT	HI4/5 ∧ CM	1	21.0
1	2	MT	HM4/5XY ∧ CM ∧ $\overline{V_{\text{tot}}}$	1	2.2
2	4	LT	HL4/5 ∧ CM ∧ $\overline{V_{\text{prime}}}$	1	9.0
3	8	OT	HO3/4 ∧ $\overline{V_{\text{tot}}}$	1	14.1
4	16	CT	CT ∧ $\overline{V_{\text{tot}}}$	1	30.8
5	32	VI	$V_{i1} \wedge V_{i2}$	40000	12401
6	64	Halo	HO4 ∧ V_{out}	10000	2568
7	128	BT	FI01 ∧ FI02	99999	53385
8	256	inclMT	HM4/5XY ∧ $\overline{V_{\text{tot}}}$	1	22.6
9	512	LargeQ2	Large Q^2 test trigger with hodoscope and HCAL1	0	0
10	1024	lowrandom	True random trigger from rad. source in 892	1	0.6
11	2048	random	Noise random generator	4000	730

No Inner Trigger used during transversity.

LargeQ2 was implemented using a make-shift hodoscope and the HCAL1. First test of a large Q^2 trigger (COMPASS Note 2008-7).

ECAL1 included into CT/CM.

5.6 2009 DVCS

Run 79652

The main data taking in 2009 was hadron spectroscopy and a Primakoff run. In addition, a test DVCS run with muon beam was taken. Inclusive hodoscope triggers and the RPD were used.

Bit	2^{Bit}	Name	Composition	N_{presc}	$R_{\text{unpr.}}/10^3$
0	1	RPDVeto	RPD $\wedge$ $\overline{\text{V}_{\text{tot}}}$	16	1218
1	2	MTi	HM4/5XY $\wedge$ $\overline{\text{V}_{\text{tot}}}$	1	115.2
2	4	LTi	HL4/5 $\wedge$ $\overline{\text{V}_{\text{tot}}}$	1	72.5
3	8	OTi	HO3/4 $\wedge$ $\overline{\text{V}_{\text{tot}}}$	1	14.4
4	16	DVCS	(MTi$\vee$OTi $\vee$LTi) $\wedge$ $\overline{\text{V}_{\text{tot}}}$	1	13.4
5	32	VI	$\text{V}_{\text{i1}} \wedge \text{V}_{\text{i2}}$	12000	37106
6	64	Halo	HO4 $\wedge$ V_{out}	1200	5666
7	128	BT	FI01 $\wedge$ FI02	6000	95807
8	256	aBT	FI02 $\wedge$ BC	0	0
9	512	RPD	RPD ring A $\wedge$ RPD ring B	12000	3722
10	1024	TR	True random trigger from rad. source in 892	1	30.4
11	2048	TRV	Random trigger generator	0	25.1

No Inner Trigger for DVCS, but HI5 detector is switched on for tracking.
The CM is removed; the remaining trigger are inclusive during DVCS.
The rates of LT and MT are larger due to a smaller ECAL2 hole. This effect was reproduced in 2011 in a test (see Collaboration Meeting Sept. 2011)
For the hadron run the spectrometer magnet SM2 and the HO3 hodoscope along with it was shifted along the beam. Thus, the Outer Trigger coincidence timing was off by the time of flight of the muons between the two SM2 positions (around 20 ns), which makes the OT unusable for physics analysis.
From 2009 on, all muon triggers now use the V_{tot}.

5.7 2009 DY

Run 82231

The Drell-Yan process was measured using the negative pion beam. A combination of the hodoscopes and the HCAL triggers was used to trigger on the muon pairs.

Bit	2^{Bit}	Name	Composition	N_{presc}	$R_{\mathrm{unpr.}}/10^3$
0	1	LTi	$\mathrm{HL4/5} \wedge \overline{\mathrm{V_{tot}}}$	1	38.9
1	2	MT + 1mu HCAL1	$\mathrm{HM4/5XY} \wedge \mathrm{HCAL} \wedge \overline{\mathrm{V_{tot}}}$	1	0.3
2	4	LT + 1mu HCAL1	$\mathrm{HL4/5} \wedge \mathrm{HCAL} \wedge \overline{\mathrm{V_{tot}}}$	1	0.6
3	8	OT + 1mu HCAL1	$\mathrm{HO3/4} \wedge \mathrm{HCAL} \wedge \overline{\mathrm{V_{tot}}}$	1	0.2
4	16	2muHCAL1	2 cluster in HCAL1	0	0
5	32	VI	$\mathrm{V_{i1}} \wedge \mathrm{V_{i2}}$	1000	1.5
6	64	Halo	$\mathrm{HO4} \wedge \mathrm{V_{out}}$	500	0.7
7	128	BT	$\mathrm{FI01} \wedge \mathrm{FI02}$	1000	51.9
8	256	MTi	$\mathrm{HM4/5XY} \wedge \overline{\mathrm{V_{tot}}}$	1	73.6
9	512	1muHCAL1	1 cluster in HCAL1	0	0
10	1024	OTi	$\mathrm{HO3/4} \wedge \overline{\mathrm{V_{tot}}}$	1	1.9
11	2048	TRV	True random trigger from rad. source in 892	100	3.1

The HCAL muon trigger uses HCAL 1 with two thresholds. It triggers on particles between 0.7 MIPS and 2.0 MIPS (discriminator window), and thus on muons and not on hadrons.

5.8 2010

Run 87991

A continuation of the transverse polarised data taking. The major set-up change was the installation of the large angle spectrometer trigger (LAST).

Bit	2^{Bit}	Name	Composition	N_{presc}	$R_{\text{unpr.}}/10^3$
0	1	IT	HI4/5 ∧ CM	1	24.7
1	2	MT	HM4/5XY ∧ CM ∧ $\overline{V_{tot}}$	1	3.4
2	4	LT	HL4/5 ∧ $\overline{V_{tot}}$	1	38.2
3	8	OT	HO3/4 ∧ $\overline{V_{tot}}$	1	25
4	16	CT	CT ∧ $\overline{V_{tot}}$	1	71.6
5	32	VI	$V_{i1} \wedge V_{i2}$	40000	25873
6	64	Halo	HO4 ∧ V_{out}	10000	5617
7	128	BT	FI01 ∧ FI02	99999	94139
8	256	inclMT	HM4/5XY ∧ $\overline{V_{tot}}$	1	37.1
9	512	LAST	HG01/2 ∧ $\overline{V_{tot}}$	1	131.5
10	1024	TRand	True random trigger from rad. source in 892	1	3.5
11	2048	NRand	Noise random generator	0	125.3

The LAST was installed end of May into the set-up. (COMPASS note 2010-13, 2011-5)
Four slabs in HO04 (Saleve side) were elongated by ≈ 20 cm to close a small acceptance hole (Figure 8).
The CM condition on the Ladder Trigger was removed by request of the Transversity group.

Figure 8: HO04 before 2010 and after. Four slabs were elongated by 20 cm on the Saleve side towards the hole

5.9 2011

Muon physics data taking with a longitudinal polarised target (NH_3) and a 200 GeV muon beam.

Bit	2^{Bit}	Name	Composition	N_{presc}	$R_{unpr.}/10^3$
0	1	IT	HI4/5 $\wedge$ CM	1	11.6
1	2	MT	HM4/5XY $\wedge$ CM $\wedge$ $\wedge$ $\overline{V_{tot}}$	1	1.8
2	4	LT	HL4/5 $\wedge$ $\overline{V_{tot}}$	1	22.2
3	8	OT	HO3/4 $\wedge$ $\overline{V_{tot}}$	1	13.6
4	16	CT	CT $\wedge$ $\overline{V_{tot}}$	1	55.6
5	32	VI	V_{i1} $\wedge V_{i2}$	40000	10090
6	64	Halo	HO4 $\wedge$ V_{out}	10000	2625
7	128	BT	FI01 $\wedge$ FI02	99999	64938
8	256	inclMT	HM4/5XY $\wedge$ $\overline{V_{tot}}$	1	16
9	512	LAST	HG01/2 $\wedge$ CM $\wedge$ $\overline{V_{tot}}$	1	4.5
10	1024	TRand	True random trigger from rad. source in 892	1	4.6
11	2048	NRand	Noise random generator	4000	42

The CM and the CT were both used with the same low threshold.
The Ladder Trigger was used in the inclusive mode.
LAST with CM condition.
All muon trigger use V_{tot} ECAL1 was included in the trigger (CT/CM) . After the 2011 run, the ECAL1 trigger electronic was completely removed and thus is not used anymore.

5.10 2012

Run 107984

After a long Primakoff measurement, a DVCS measurement was started in October 2012. The major installation was the new recoil proton detector CAMERA.

Bit	2^{Bit}	Name	Composition	N_{presc}	$R_{unpr.}/10^3$
0	1	Tiger	CAMERA FPGA trigger	10000	4.3
1	2	Middle	HM04XY $\wedge$ HM05XY $\wedge$ $\overline{V_{tot}}$	1	82.3
2	4	Ladder	HL04X $\wedge$ HL05X $\wedge$ $\overline{V_{tot}}$	1	45.2
3	8	Outer	HO03Y $\wedge$ HO04Y1/Y2 $\wedge$ $\overline{V_{tot}}$	1	84.4.5
4	16	Calo	CT $\wedge$ $\overline{V_{tot}}$	0	63.8
5	32	VI	$V_{i1} \wedge V_{i2}$	12000	32079
6	64	Halo	HO4 $\wedge$ V_{out}	2400	10526
7	128	BT	FI01 $\wedge$ FI02	6000	111384
8	256	aBT	FI02 $\wedge$ BC	0	0
9	512	LAST	HG01/2 $\wedge$ $\overline{V_{tot}}$	4	83
10	1024	True Random	True random trigger from rad. source in 892	1	29.5
11	2048	DT0	a hadron trigger, not described here	0	0

Hole of H1 was changed for DY and DVCS requirement (Figure 9) [12] [13] . This takes the shifted target position and has about the same acceptance for μ^+ and μ^-.

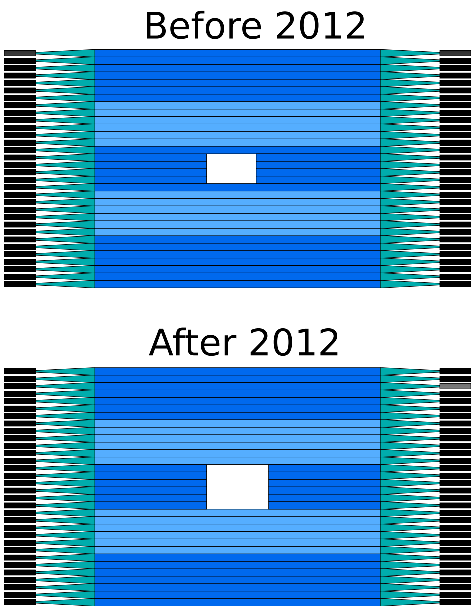

Figure 9: H1 before 2012 and after. The central hole was shifted to the center and enlarged by two slabs.

References

[1] C. Bernet et al. “The COMPASS trigger system for muon scattering”. In: *Nucl.Instrum.Meth.* A550 (2005), pp. 217–240. DOI: 10.1016/j.nima.2005.05.043.

[2] J. Pretz. “Veto dead time & beam duty factor”. COMPASS Note. 2010.

[3] C. Kurig. *Aufbau, Test und Weiterentwicklung des Triggersystems fÃ¼r das elektromagnetische Kalorimeter ECAL1 des COMPASS-Experiments*. 2007.

[4] M. Leberig. “Das COMPASS Triggersystem zur Messung des Gluonbeitrags ΔG zum Protonspin”. PhD thesis. Institut für Kernphysik, Johannes Gutenberg-Universität Mainz, 2002.

[5] A. Zimmermann. *Design und Test von Szintillationszählern mit Luftlichtleitern für das Triggersystem des COMPASS Experiments*. 2010.

[6] C. Seiffert. *Aufbau und Charakterisierung eines Triggerhodoskops für das COMPASS Experiment*. 2010.

[7] N. du Fresne von Hohenesche et al. “Technical Summary of the Large Angle Spectrometer Trigger”. COMPASS Note. 2011.

[8] J. Bieling. *Entwicklung eines ungetakteten 64-Kanal-Meantimers und einer Koinzidenzschaltung auf einem FPGA*. 2010.

[9] N. du Fresne von Hohenesche et al. “Flux Determination for 2009 DVCS Data”. COMPASS release note. 2012.

[10] K. Novotny et al. “Performance of the Trigger Hodoscopes in 2007 and 2010”. COMPASS Note. 2012.

[11] N. du Fresne von Hohenesche. “Measurement of Hadron Multiplicities in Deep Inelastic Muon-Nucleon Scattering”. PhD thesis. Institut für Kernphysik, Johannes Gutenberg-Universität Mainz, 2015.

[12] Dudder, A. *Umbau des Large Angle Triggersystems des COMPASS Experiments*. 2012.

[13] A. Dudder et al. “Modification of H1”. COMPASS Note. 2013.