May 2003 Tentative Test Beam Program

The program foresees a complete test of the local trigger (BTI-TRACO-TSS-TSM) performance. Hence it is foreseen to vary the parameter of each trigger component. The definition of a standard configuration for any involved device is therefore important and necessary. We will then modify the parameters for each proposed test listing only the ones modified with respect to this configuration. It is foreseen to collect data in a default configuration; data in which some relevant parameters were modified one by one in order to avoid superposition of effects that would complicate results interpretation; special data to verify particular situations

1. Standard configuration

1.1 BTI and TRACO

We will refer to the following BTI and TRACO configuration as **SET STD**. The other configurations of these devices are supposed to be variations of one or more parameters with respect to this configuration.

BTI

The BTI parameters are classified in two groups:

- parameters that will be fixed from the synchronization procedure

ST43	RE43	DEAD	LH	LL	CH	CL	RH	RL

- parameters independent of the synchronization procedure

Parameter	WEN(0:8	XON	RON	SET(2:0)	LTS(1:0)	AC1(1:0)	AC2(1:0)	ACH(1:0)	ACL(1:0)
Default	11111111	0	0	111	11	00	11	01	10

TRACO

The TRACO can send two tracks per bunch crossing on the same bus. The configurable parameters can be set independently for the first and the second track, but we believe that no difference will be needed. Then the value of each parameter is considered equal for both tracks.

Parameter	HISM	HTPRF	HTMSK	LTMSK	SLMSK
Default	0	1	0	0	0

Parameter	PRGCOMP(1:0)	LTF	LTS	REUSE(I/O)	BENDING CUT(7:0)
Default	10	0	0	1	11111111

The parameters HTMSK e LTMSK can be configured in a way in which their action depend on a trigger coming from SLθ through the TS device and must therefore be configured coherently with TS programmation. The BTIC parameter depends on BTI programmation and can be fixed only after synchronization, while the RAD parameters depends also on the geographical position of a TRACO inside the chamber,

1.2 TS

The Trigger Server implements a cascade sorting algorithm in two consecutive steps. In the first stage Track Sorter Slaves (TSS) analyze groups of 4 TRACO each. In the second stage only one Track Sorter Master (TSM) makes a priority sorting of data output from the first stage. The two best tacks are selected and output.

The algorithm must balance two contrasting needs:

- the selection of the second best track, complicated from the fact that TRACO is sending two tracks of the same bx in two consecutive bxs, solved with the CARRY mechanism
- the GHOST rejection, that are duplicated tracks (either in two contiguous TRACOs or in the same TRACO in two consecutive bxs: respectively ghosts type 1 and type 2)

The 4 TRACO per TSS architecture was in fact designed to give a good trade off between these two needs for dimuons in CMS.

In the following we will call CARRY, GHOST1 and GHOST2 the group of parameters to vary in the TSS and TSM configuration registers in order to act on these functionalities.

Another problem to consider is represented from the simultaneous presence of first tracks sent from some TRACOs with second tracks sent from other TRACOs (trigger pile-up inside TS), where the algorithm must decide whether to reject second tracks or to recover some high quality second tracks. We will refer to this group of parameters as "Hin recovery".

At last, since the TSM is the bottleneck of trigger output from the chamber, its functionality was dived in several parts (TSMS, TSMD1, TSMD2) with partial redundancy. The system foresees several possible performing modes up to the limit of only one TSMD working circuit, with a limited functionality loss ("**TS Back-up Mode**").

For this test-beam we will define two possible options for the base configuration of the server.
The first one is the **DEFAULT SET** (active at power up) that has the following relevant parameters.

Parameter	CARRY	GHOST1	GHOST2	TRMSKII[‡]	THCRL(2:0)	Hin recovery
Default	active	active	active	0000	000	inactive

This set associated to the **SET STD** is the default configuration foreseen for the data taking at LHC.
The parameters THCRL(2:0) and TRMSKII are belonging to TSS configuration; the second one permits the selective masking of the TRACO preview output in the same way inside TSMS, TSMD1, TSMD2 it is possible to mask the TRB outputs (both previews and full tracks). We always assume that the configurations were set coherently.

The second configuration is the **DEBUG SET** identified from the parameters

Parameter	CARRY	GHOST1	GHOST2	trmskII	THCRL(2:0)	Hin recovery
Default	inactive	inactive	inactive	input from one TRACO only	000	inactive

This configuration allows the output of one TRACO to reach the chamber output without being processed. It should be important to debug BTI and TRACO and to study ghosts, since the beam should hit the chamber in a zone covered by only one TRACO.

In this first minicrate test-beam it looks premature to use all the other TS possibilities that for instance allows modifying the priority selection order of the tracks or the introduction of alternative ghost rejection schemes.

The group **SET STD + DEFAULT SET** is the default configuration called **SET STD-DEF.**
The group **SET STD + DEBUG SET** is the debug configuration called **SET STD-DEB.**

The group **SET STD + BACKUP** is a configuration with BTI, TRACO and TSS in default mode, while TSM is working in Back-up Mode: in this situation the second stage selection is performed from a TSMD directly on the full track data. Notice that during test beam the three trigger boards used must be connected to the same TSMD.

[‡] The configuration parameter TRMSKII is in fact a number of parameters equal to the number of TRACOs connected to the same TSS: we assume it is the same for all TRACOs

2. Synchronization

We have first at all take some runs in order to decide the value to assign to the ST43 e RE43 BTI parameters that essentially fix the drift velocity value. The determination of these parameters is possible only using a procedure[1] (*synchronization*) that finds simultaneously the ST43 and RE43 values and the size of the delay between the clock and the moment of drift-times sampling inside BTIs (*phase*).

This operation must be performed offline, analyzing the TDC data collected using a particular extremely clean trigger configuration. This computation would require data at different angles (e.g. 0,10 and 20 degrees) because of cell non-linearity. Previous studies[2] show that is probably possible to get a correct result using the 15 degrees inclination only. In this condition the efficiency of the hypothetical algorithm is very low (somewhere between 10% and 30% as a function of the phase, but since it was only tried on BTI alone it could be lower), and is it therefore sensible that, in order to have about thousand events to make the needed histograms, we need to collect at least10000 events/run.

Since this is the first time we try the synchronization algorithm online it should be natural to try to modify the phase in steps of one nanosecond. Besides the non-linearity leaves a wide margin for the parameters choice. Since we expect T_{MAX} to be about 380 ns we will try the parameters about this value. The numbers of events needed and the parameters to be used are listed in the following table:

ST43	RE43	Phase interval (ns)	Number of runs	Number of events
40	0	1	25	250000
40	2	1	25	250000
41	1	1	25	250000

Supposing a collection of 100000 events/hour we need about 8 hours to complete the synchronization.

It is obvious that we may need adjustments as a function of the real collection efficiency that we will have and of the real sensitivity of the algorithm proposed for the determination of the best phase.

The configuration foreseen for the synchronization is based on the default configuration (**SET SYNCHRO** and is as follows:

BTI				**TRACO**			**TS**
AC1(1:0)	AC2(1:0)	ACH(1:0)	ACL(1:0)	HTMSK	LTMSK	PRGCOMP(1:0)	THCRL(2:0)
01	01	01	01	1	1	01	111

[1] CMS/IN 2000/031

[2] CMS note 2000/044

3. Performance test of single trigger algorithms

Aiming to avoid interpretation difficulties of the results, we propose to modify the parameter separately with respect to the standard configuration, without mixing the various choices. Tests combining variations of more than one parameter will be added to the ones listed below. The various tests must be done at different beam incidence angle in order to evaluate their effect as a function of the angle. Ideally we could consider a 5 degrees angular range starting from 0 degrees up to +45 degrees and –45 degrees (keeping in mind that the maximum inclination will be limited from the actual test-beam area arrangement). Measurements at 0, 10, 20, 30 degrees and (if time will be available) at –10 and –20 degrees could anyway be sufficient.

We suppose to collect this kind of data:

- data as a function of the angle in the default configuration (**SET STD-DEF**)
- data at only one angle in the debug configuration (**SET STD-DEB**)
- data as a function of the angle for the parameters to vary singularly
- the test of the back-up mode configuration is foreseen for the TS, this test will be done in comparison with the default configuration.
- Tests in chamber autotrigger configuration.

All the tests based on a single parameter variation are centred on the noise suppression problem and on efficiency measurements, but they can be grouped as variations of:

- parameters to verify necessarily
- parameters to verify at least at one incidence angle

The first ones gives the following list, where the BTI e TRACO parameters are varied with respect to the **SET STD**, while the TS parameters are varied both with respect to the **DEBUG SET** and the **DEFAULT SET**. (configurations **SET A-DEF** and **SET A-DEB** respectively)

	Parameters		
	BTI	TRACO	TS
TRGθ effect	—	LTMSK 0	THCRL(2:0) 001
	—	LTMSK 1	—
BTI noise	LTS(1:0) 00	—	—
	LTS(1:0) 00 only on SLθ	—	—
BTI acceptance	ACx(1:0) 01	—	—
	ACx(1:0) 10	—	—
TRACO noise	—	LTS 1	—
TRACO acceptance	—	PRGCOMP(1:0) 01	—
	—	PRGCOMP(1:0) 11	—
TS selections	—	—	CARRY active
			Hin recovery active
TS noise	—	—	GHOST1 active
			GHOST1 active & GHOST2 active

The parameters that could be useful to vary at least at one angle based on the **SET STD-DEB** configuration are (**SET B-DEB**):

- HTMSK
- SLMSK
- HTPRF
- REUSEI/O

We foresee 15 tests for every incidence angle (**SET STD-DEF, SET A-DEF**) equal to 1500000 events (corresponding to 15 hours of acquisition time at 100000 events/hour/test rate). Supposing to use 4 angles (0,10,20,30 degrees) it corresponds to two and one half day. A further complication could be the need to collect more data for the TS as a function of actual channel occupancy (multiple track tests).

We foresee 15 runs (**SET STD-DEB, SET A-DEB**) at one incidence angle (e.g. 10 degrees) equal to 15 hours of acquisition time.

We also foresee 400000 events using **SET B-DEB** at one incidence angle (e.g. 10 degrees) equal to 4 hours of acquisition time.

Optionally and depending on remaining time we could be interested in data with standard configuration at other incidence angles, on different trigger boards or exactly between trigger boards. A list of optional runs is listed in the summary table.

4. Test summary

	Angle (degrees)	Configuration	# runs	#events/run	Time (hours) (at 100000 ev/hour)
Synchronization	15	SET SYNCHRO	75	10000	8
Compulsory algorithms tests[‡]	10	SET STD-DEF	1	100000	1
	10	SET STD-DEB	1	100000	1
	10	SET A-DEF	14	100000	14
	10	SET A-DEB	14	100000	14
	10	SET B-DEB*	4	100000	4
	10	SET STD-BACKUP	6	100000	6
	10	AUTOTRIGGER	1	100000	1
	0	SET STD-DEF	1	100000	1
	0	SET A-DEF	14	100000	14
	0	AUTOTRIGGER*	1	100000	1
	20	SET STD-DEF	1	100000	1
	20	SET A-DEF	14	100000	14
	20	AUTOTRIGGER*	1	100000	1
	30	SET STD-DEF	1	100000	1
	30	SET A-DEF	14	100000	14
	30	AUTOTRIGGER*	1	100000	1
Optional algorithms tests ordered in priority	-10	SET STD-DEF	1	100000	1
	-20	SET STD-DEF	1	100000	1
	-30	SET STD-DEF	1	100000	1
	5	SET STD-DEF	1	100000	1
	15	SET STD-DEF	1	100000	1
	25	SET STD-DEF	1	100000	1
	35	SET STD-DEF	1	100000	1
	40	SET STD-DEF	1	100000	1
	45	SET STD-DEF	1	100000	1
	-10	SET A-DEF	14	100000	14
	-20	SET A-DEF	14	100000	14
	-30	SET A-DEF	14	100000	14
Compulsory Tests					97
Optional Tests					51
TOTAL					148

[‡] Tests marked with * (10 hours). can be removed if there will be problems with acquisition time. We can also reduce the number of tests foreseen for SET A-DEF configuration e even more effectively for SET A-DEB configuration.