# RF-TTC FAQs

September 24

# 2008

Typical questions about timing signals generated by the RF system and transmitted over fibres to TTC system

# A. Questions about setup period (10-19 Sept 2008)

## 1. Was BCref in sync with the beam during this period?

No, the equipment to rephase the beam to the reference clock is not operational yet. During the setup period, BCref was a fixed 40.078 900 MHz not related to the beam frequency. It was (almost) never resynchronized (only when rebooting the VME crate), and was derived from a commercial Signal Generator at 400.789 MHz driving the Divider-by-10.

## 2. Were BC1 and BC2 synchronous one to each other?

Yes, they were synchronized one to each other, and always at the same frequency (except when one loop would unlock…).

- First 40.078 878 MHz
- Then 40.078 893 MHz from Sept 10, 19:30
- Then 40.078 896 MHz from Sept 11, 22:00 Capture beam 2, -0.4 mm

They were re-synchronized when needed: after re-boot, after opening synchro loop or for test. And they were normally locked with the beam

However, this situation is not going to last, as the 2 beams will be controlled separately by 2 RF systems, and then may be asynchronous during filling and ramping for MD modes or when only one ring is used (see question: “will the BC1 and BC2 be synchronous?”)

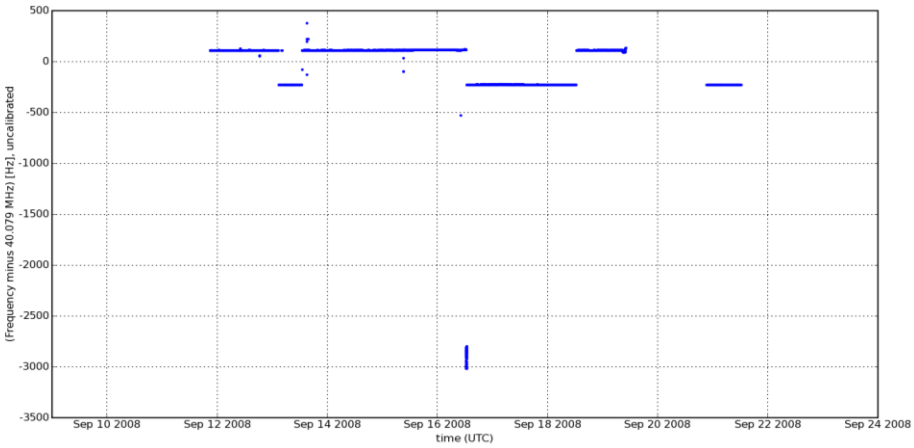


Figure 1: BC2 Frequency monitoring at CMS during Setup Period- courtesy of A. Holzner, CMS.

## 3. In case of future setup periods:

- When will the BC1 and BC2 be guaranteed?

  For further setup periods, the presence of the BCs will be guaranteed only when the beam is circulating.

- When may the BC1 and BC2 disappear without warning?

  During beam setup periods, the RF has to be adjusted. The BCs may thus be resynchronized, interrupted or changed without notice between runs. During access periods, the BCs can be interrupted for maintenance reasons and the experiments have to work on internal clock.

4. **Will BC1 and BC2 disappear during 1ms for resynchronization before injections during the setup test periods?**

   Normally no, as the runs are very short. However, they may change or be shortly interrupted between runs for adjustment purposes.

5. **Which Beam Modes sequences are used during the setup period**

   Setup (2), inject&dump (16) , circulate&dump(17)

6. **Was the bunch always at a fixed position with respect to the orbit signal during all this period?**

   The bunch position was random with respect to the orbit during the first 2 days. But it should have been stable as from September 12.

## B. Questions about final system

1. **What are the BC1 and BC2?**

   BC1 and BC2 are the Bunch Clocks 1 and 2. For each ring the Bunch Clock is a square wave at the RF frequency divided by 10. Its rising edge has a fixed delay with respect to bunch passage. This delay is reproducible from run to run. When present, BCx is always locked to the corresponding beam.

2. **Will BC1 and BC2 be synchronous?**

   They will always be synchronous *during physics*. However, they may be asynchronous during filling and ramping for MD modes or when only one ring is used. If you wish to observe the beam in such situations you should use BC1 to track beam 1 and BC2 to track beam 2.

   If physics is intended, they would be synchronous from injection on, but this decision could be reviewed.

3. **What is BCref?**

   BCref is the Reference Bunch Clock. It is a square wave at a fixed frequency equal to the collision RF frequency divided by 10.

   - It is locked to the beam during collisions only, and was foreseen to provide a very pure radio frequency clock allowing a better lifetime of the beam in case the Digital Direct Synthesizers generating BC1 and BC2 would not be pure enough.
   - During collision its rising edge has a fixed delay w.r.t. bunch passage.
   - But the equipment to rephase the beam to the reference clock is **not operational yet**. In the meantime use BC1 or BC2…
   - OP wishes to fine-tune the reference frequency during physics to compensate for very slow drift in machine circumference (effect of tides, …). This will correspond to very smooth shifts of the BCref, of the order of less than 1 Hz/s.

4. **What are the Orbit signals?**

   For each ring the Orbit is a train of 5 ns long pulses at the Revolution Frequency. The pulse has a fixed delay w.r.t. passage of a bunch in bucket 1. This delay is reproducible from run to run. When present, Orbitx is always locked to the corresponding beam.

### 5. What are the typical values of BC1, BC2 and BCref at 450GeV (at injection) and at 7TeV (after ramping)?

At 450 GeV:

BC1 and BC2 = 40.0788790 MHz

BCref = 40.0789658 MHz

At 7 TeV:

BC1 = BC2 = BCref = 40.0789658 MHz

Frequency variation during ramping: 87Hz.

### 6. What is "bucket1"?

- A bucket is a potential position to which the beam could be locked. Each bucket is locked to a rising edge of the 400.78HMz. There are 35640 buckets per turn. There are 10 buckets per 25ns period, and for a specific type of run, bunches will always be positioned on the same bucket out of 10.
- For each ring, bucket 1 is the first bucket after the 3 ms long abort gap (defined from bucket 34442 to 35640)
- Two bunches in buckets 1 of the two rings collide in IP1 (and IP5)

### 7. Will the BCref be used in the final system?

If the radio frequencies provided by the Digital Direct Synthesizer generating BC1 and BC2 are pure enough to ensure a good beam life time, the BCref may not be useful.

### 8. Will the BCref (and the BCs) be fixed during the flat top?

No, they may move very smoothly to shift the beam (< 1Hz/s) and compensate for very slow drifts in machine circumference.

### 9. What is the typical sequence of beam modes during a physics run, and on which modes will the main RF events occur?

1. No Beam
2. Setup - Abort
3. Injection probe beam
4. Injection setup beam
5. Injection Physics Beam
6. Prepare ramp
7. Ramp
8. Flat top
9. Squeeze
10. Adjust
11. Stable Beam – Unstable beams
12. Beam Dump Warning
13. Beam dump
14. Recover-cycling

- The resynchronization (or reset) of the 5 timing signals will occur during 'setup'.
- Injection set-up: Machine must go through INJECTION PROBE BEAM and INJECTION SETUP BEAM (pilot, intermediate,dump, pilot) and then finally INJECTION PHYSICS BEAM (>30 min)
- BC1, BC2 and BCref are not supposed to be synchronous until the end of 'ramp' mode.

- The resynchronization of BC1, BC2 and BCref will happen during 'flat top' mode.
- Smooth adjustments of the 3 BCs may happen during 'flat top', 'squeeze', 'Adjust', 'Stable Beam', 'Unstable Beam'
- During 'Beam Dump', the BCs stay running and are not interrupted until at least 5-10 minutes after

### 10. Timing signals resynchronization before 'pre-injection plateau'…

- Why are they resynchronized?
  To ensure a proper reset is done before each new run.
- Which signals are going to disappear?
  All of them (BC1, BC2, BCref, Orb1, Orb2).
- During which beam mode will it happen?
  During SETUP mode.

### 11. What is the typical delay between SETUP mode and the end of the RAMP mode?

Probably around 1 hour

### 12. Which are the beam modes (defined by EDMS 865811 (LHC-OP-ES-0005 v1.0)) during which the BCs are guaranteed?

The presence of the BCs is guaranteed from the end of 'Setup' mode (Setup mode not included) until the end of 'Beam Dump' mode (included). In general, after BEAM DUMP, the signals will still be there but it is not excluded that an intervention on the RF equipment interrupts them. They will then be re-started during the following SETUP mode.

### 13. Which are the beam modes during which the BCs are stable?

- BCref is stable from the end of 'SETUP' mode until the end of 'BEAM DUMP' (and most of the time during all modes except 'SETUP')
- BC1 and BC2 are stable from the end of 'FLAT TOP' mode until the end of 'BEAM DUMP' mode.
- However, all of them may smoothly change (at a rate of less than 1Hz/s) between 'FLAT TOP' and ''BEAM DUMP' for adjustment purposes.

### 14. Will the phase between ORBn and BCn be stable between runs? If yes, how and when will it be fixed?

Yes, the phase between ORBn and BCn is stable and is always the same from run to run. It is set during setup mode and does not change.

### 15. Will it be it possible to test a full ramping and rephrasing sequence without the beam?

Yes. It is being scheduled for the end of 2008 in agreement with the LHC Operation team, RF and experiments.

### 16. Practically, what happens on RF side where there is a beam dump? Do the signals disappear with the beam automatically, or does their frequency slowly/quickly ramp back down to their injection values?

In general, after BEAM DUMP, the signals will still be there, keeping the same value they had during flat top, but it is not excluded that an intervention on the RF equipment interrupts them.

## C. Questions about QPLL behavioral

### 1. What is the typical locking range of QPLLs

It depends on the way the board has been designed, but it is usually between : 40.076MHz and 40.081MHz.

### 2. What happens for the output clocks when there is a change of BC source in the RF2TTC?

Depending on the phase between the previous clock and the new one, the QPLL of the RF2TTC may lose the lock and begin to scan the frequency range. However, this does not necessarily mean that the next QPLL in the chain is going to lose its lock too. A document is available on:

http://ttc-upgrade.web.cern.ch/ttc-upgrade/New_system/rf2ttc_transient_BC.pdf