COGGING & FINE ADJUST

OF THE BEAM-BEAM PHASE

HINTS FOR OPERATION

DEFINITIONS

COGGING

The Cogging is the choice of the Frev (= Revolution Frequency = orbit) coarse phase of BEAM2 versus BEAM1 (by steps of one RF period (2.5ns)) to get the buckets 1 of each beam collide in IP1 and IP5. This should not change between injections. ***This action is performed by the RF.***

FINE ADJUST

The fine adjustment is also ***performed by the RF***. It consists in a fine dephasing of Beam2 versus Beam1 ***BEFORE filling***, to allow buckets1 of each beam to precisely collide in IP5 and IP1. According to the experience we have with 3.5TeV beams, the phase does neither change between fills nor during acceleration.

WHEN TO DO A FINE ADJUST?

The following has been agreed by the experiments and the RF at the start of 2010:

If the lumi centroids (z) of all experiments are off by more than 1cm (which roughly corresponds to |deltaT|> 60ps in the case of no crossing angle), the experiments may request a readjustment of the phase.*

In this case, please call the RF.

With the newly introduced crossing angles, the z_IP* (lumi centroid) is usually much better than 1cm, even if the BPTXs display values of the order of 100ps. So it is rare that the experiments do request such an adjustment of the fine phase. For information, since the start of 2010 run, the phase was set first on March 19 and then adjusted only once by 200ps in June 23, on request by the experiments.

*see definitions of z_IP and DeltaT below.

BPTX & READOUT SYSTEMS:

Each experiment is equipped with 2 BPTX (one on each beam), connected to one acquisition system. Each experiment chose its preferred system, each with different performances, advantages and drawbacks.

READOUT SYSTEMS

ATLAS & CMS: A SCOPE IN REMOTE CONTROL

ATLAS and CMS systems are based on simple commercial oscilloscopes. Sample rate 5Gs/s. Max resolution 20ps using shape reconstruction.

+: very intuitive (everything is available on the screen of the scope) and direct. The experts can see the 2 bunch trains and have in real time a picture of the phases. At high energy, can detect a possible bunch in a wrong bucket or a mismatch between real and DIP filling schemes.

-: the scope itself has only one point per 200ps. Averaging allows a measure with 20ps precision, but it requires accumulating points. Moreover, data acquisition takes time. This adds some latency in the system reaction, and some dead time in the data acquisition.

LHCB AND ALICE: A VME BOARD

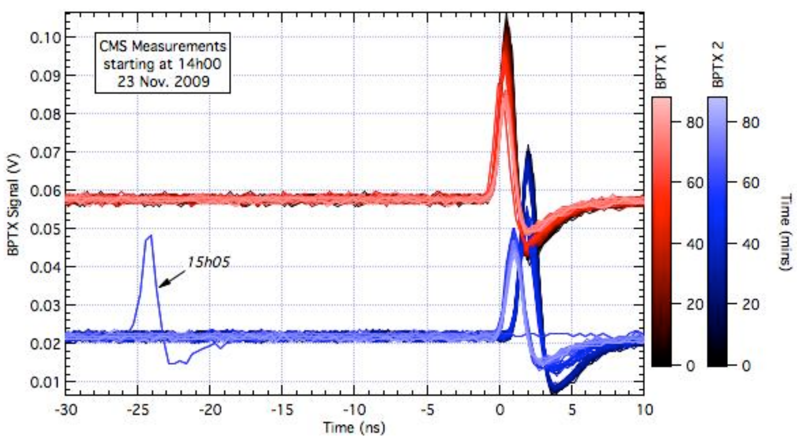
LHCb and ALICE systems are mainly based on a custom VME module (BPIM) designed from LHCb for this only purpose.

+: very precise (few ps resolution) and no deadtime. Able to look at bunch trains in real time and individual phases of each bunch wrt to clock edge, eventually detecting a possible bunch in a wrong bucket or a mismatch between real and DIP filling schemes.

-: much less intuitive, and initially not suitable for low intensities (<5.10^9ppb). That is why both LHCb and ALICE did the commissioning with scopes as well, and switched to the BPIM when intensity exceeded 1.10^{10}. Now, the BPIM are able to track low intensity bunches. Data are only available via the readout software.

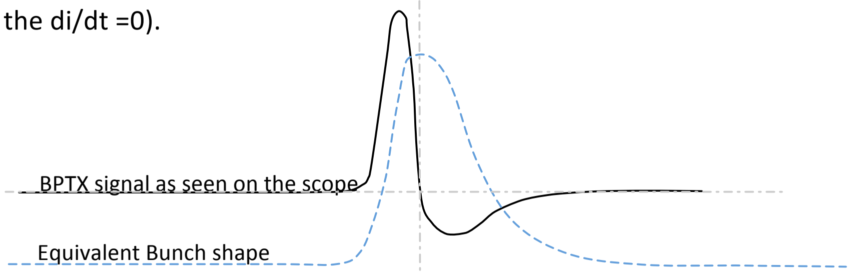
BUNCH TRIGGERING SYSTEMS

TYPICAL BPTX SIGNALS



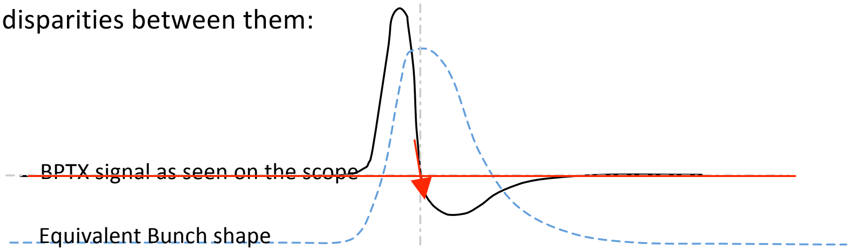
Behavior of Beam2 during first fine adjust operated right before first collisions in Nov 23rd 2009.

The BPTX signal is proportional of dI/dt (I = bunch intensity), which means that the top of the bunch is in fact the 0-crossing of the shape (when the di/dt =0).



TRIGGERING TECHNIQUES

In November 2009, each experiment chose its own triggering option (threshold on the 50% of the rising edge, 0-crossing of the falling edge, reconstructed 0-crossing of the falling edge (when the '0' is calculated using the 'DC' value of the signal, etc…). This was giving different behavior of their system, especially when intensity were changing. Now, all the experiments slowly tend to use the 0-crossing method or reconstructed 0-crossing method, but there can still be some disparities between them:



DELTAT AND LUMI CENTROID

DEFINITIONS

DELTAT AND LUMI CENTROID:

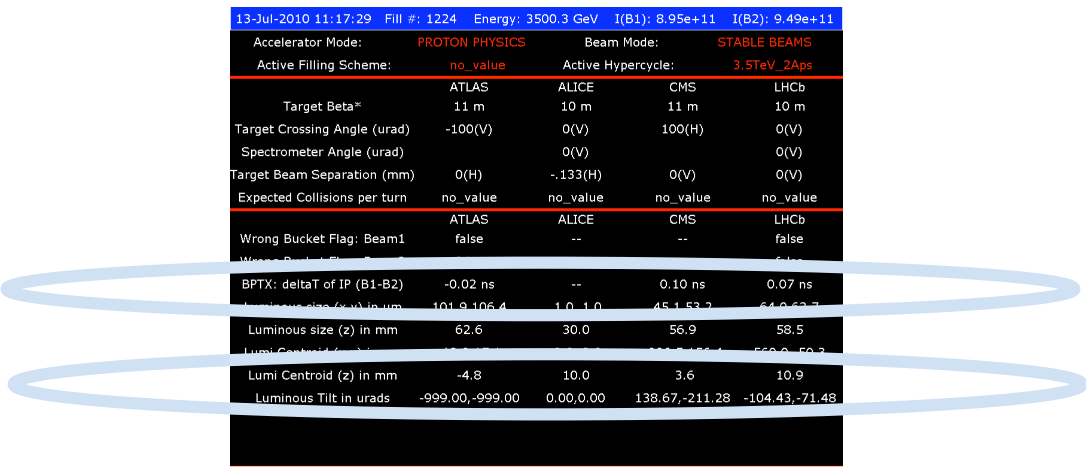
DeltaT: arrival time difference of paired bunches, measured by the BPTX. (delay between the 2 BPTX signals). Typical resolution around 20ps. A residual offset of ~50ps may remain for some experiments due to delicate timewalk calibration. This gives typical values of [-0.08ns; +0.08ns]. Available as soon as 2 beams are circulating. However, low intensities could give less accurate values. Available on the LHC Configuration Vistar, and on DIP. Refreshed every ~5s.

Lumi Centroid (z_IP): actual position of the luminous centroid, given by the trackers of each experiment. **Available only during STABLE BEAMS (as the trackers need stable beams to be turned on)**, on the *LHC configuration* Vistar and on DIP. Refreshed every ~30s.

WHERE TO SEE THEM

OP VISTAR

LHC configuration: Refreshed every second, based on values published on DIP (see below) . As the values result from a moving average on the latest 20 seconds (this is the case for ATLAS for example), a phase adjustment will be fully visible after this delay. However, the values should start changing quite fast. It can happen that the data from some experiments are not (or very slowly) updated (Here, for example, with ALICE. This could come either from Vistar-Dip communication issue or from experiments themselves). In case of doubt, go to the DIP publication to check.



DIP PUBLICATIONS

In case of troubles with the OPvistar, you can find the same information on DIP:

DeltaT on DIP/EXPT/LHC/TIMING/BPTX

Lumi Centroid on DIP/EXPT/LHC/LuminousRegion

DELTAT SENSITIVITY

SENSITIVITY TO RF CHANGES

Normally, deltaT is NOT sensitive to typical clock variations (chromaticity, dispersion etc).

Ramp: deltaT changes very slightly (10ps) between start and end of the ramp due to non linear characteristics of RF low-level VCXOs.

Remark: deltaT is not sensitive to clock variations. However, each BPTX signal moves relatively to its reference.

SENSITIVITY TO INTENSITY

If they use a 0-crossing equivalent triggering technique, the BPTX systems should not be really sensitive to intensity, if the variations are within a range of, say, 10%.

However, a big change in intensity (between pilot and nominal bunches, or when a big drop in intensity occurs for example), will show a difference because of the limited dynamic range of these systems. Now, most of the systems are set for high intensity. Values shown with low intensity bunches may show a little drift which is not real.

SENSITIVITY TO BUNCH LENGTH

The shape of the bunch may change a lot, and the 0-crossing technique is really dependent on the protons distribution within the bunch. So, yes, changes in the bunch length will very likely result in a drift of DeltaT.

SENSITIVITY TO CROSSING ANGLE

As the BPTX are out of the detectors, the DeltaT is NOT sensitive to crossing angle.

MATCHING WITH Z-IP

When there is no crossing angle, the deltaT variations match perfectly the z_IP in STABLE BEAMS (within 100ps). However, as soon as the crossing angle is introduced, the two values are not as tightly related.

OTHER RELEVANT TIMING INFORMATION

CONTACT PERSONS

EXPERIMENTS

Nights, week-ends: shift leaders of experiments

Working hours: BPTX experts of experiments:

ALICE: Antonello Di Mauro (164024), Ombretta Pinazza (169317)

ATLAS: Thilo Pauly (162242), Carolina Gabaldon Ruiz (72404)

CMS: Jeroen Hegeman (161395), Jan Troska (164096)

LHCb: Federico Alessio (160935), Richard Jacobsson (163730)

LOW-LEVEL RF:

Nights, week-ends: RF piquet

Working hours: Philippe Baudrenghien, Gregoire Hagmann, Andy Butterworth

COORDINATION:

Sophie Baron (160494)

In case of absence: Massi Ferro-Luzzi (164615)

INFORMATION

FORUM

To exchange results and analysis (***highly used by experiments***):

www.cern.ch/cogging

DOCUMENTATION & MEETING MATERIAL:

Timing meetings: http://indico.cern.ch/categoryDisplay.py?categId=1099

EDMS doc on DIP publications: https://edms.cern.ch/document/1026129/2