HGTD in ATLAS : Simulation study of t_0 calibration for HL-LHC

Tnourji Abdellah for the ATLAS collaboration | SSI 2020 [1]

[1]LPC Clermont-Ferrand, CNRS/IN2P3, Université Clermont Auvergne, France

Motivation

HL-LHC challenges :

- Pileup $< \mu > \backsim 200$
- Stochastic pileup jets
- z spread: 150ps (≈ 44mm nominal)
- t spread: 175ps (nominal)

To encounter the HL-LHC challenges, The High-Granularity Timing Detector(HGTD) is a new detector proposed to resolve the temporal spread of a bunch crossing :

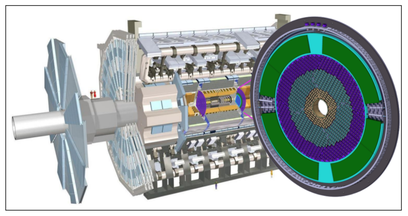


Figure 1. HGTD

- Forward region, 2.4 < η < 4.0
- Timing resolution from 30-50 ps per track
- Use timing to resolve the vertices «equal» in z, but distributed in time

Objectives

- Introduce t_0 calibration.
- How to compute calibration constants.
- Results.

Why do we need t_0 calibration ?

- The time of arrival of a hit measured in HGTD (t_{hits}) will be different between pads due to electronics contributions :
  - Flex, lpGBT, FELIX,...
- The different jitter contributions have been parametrized using MC samples.

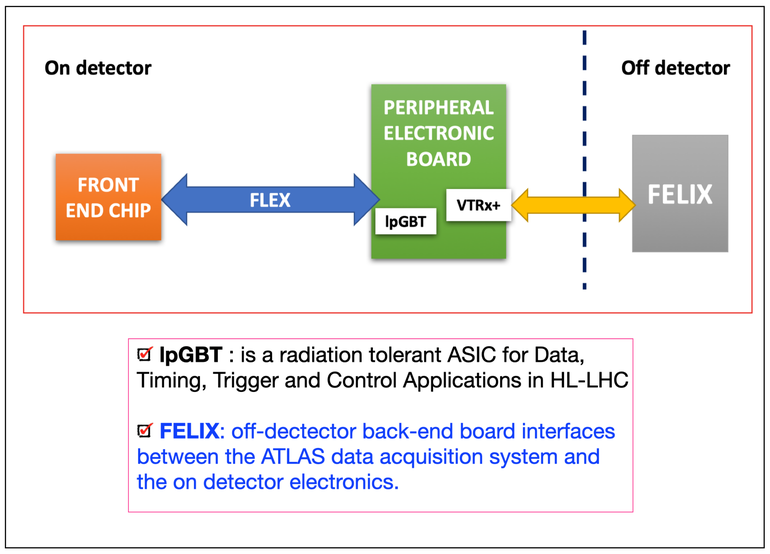


Figure 2. Source of electronics imperfections.

t_0 calibration methodology

- The calibration constants are calculated at regular intervals of events as the arithmetic mean of t_{hits} distributions.

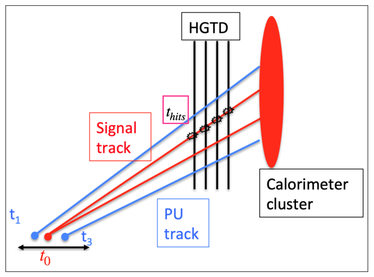


Figure 3. Hits in HGTD

- $t_{calib} = t_0 = t_{hits} - < t_{hits} >$

  where :

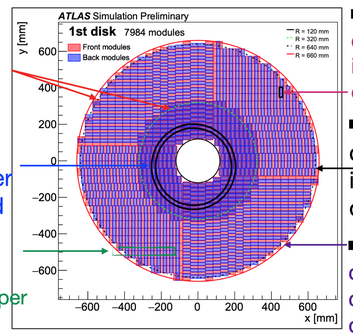
  $< t_{hits} >$ = calibration constant

- The number of events and the calibration method strongly affects the precision of the calibration constants.

■ **Calib. per ring** : constants calibration is computed per ring, inner and outer.

■ **Calib. per circl** : constants calibration per layer and circles defined by dR=40.

■ **Calib. per row** : constants computed per layer and per row, as defined by the readout electronics



■ **Calib. per module** : constants calibration is computed at level of module.

■ **Calib. per layer** : constants calibration is computed at level of layer.

■ **Calib. per inclusive** : constants calibration is computed at level of 2 disks.

Figure 4. Calibration Methods

- Time1kHz : t_{hits} + jitter contributions.

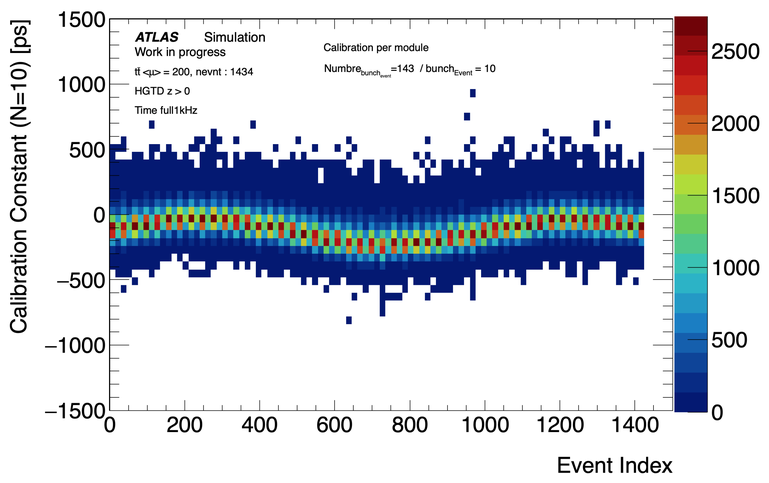


Figure 5. Calibration constant vs Event number. Calibration every 10 event.

Result 1

- The injected 1kHz fluctuation is clearly visible.
- Calibration per module shows good results with comparison with others calib. methods.

Timing correction

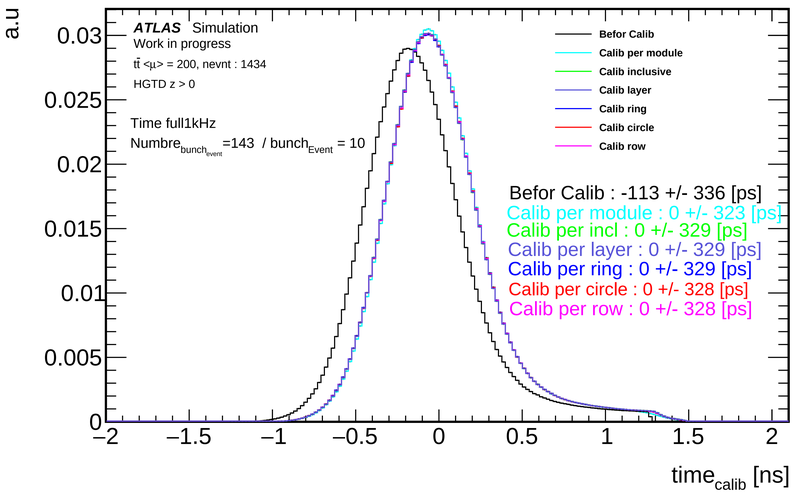


Figure 6. t_{hits} calibrated every 10 events.

Result 2

- Calibration per module and using short interval of event show smaller RMS distribution.
- Calibration per module best absorb the effect of 1khz variation.

Time of flight (ToF) effects

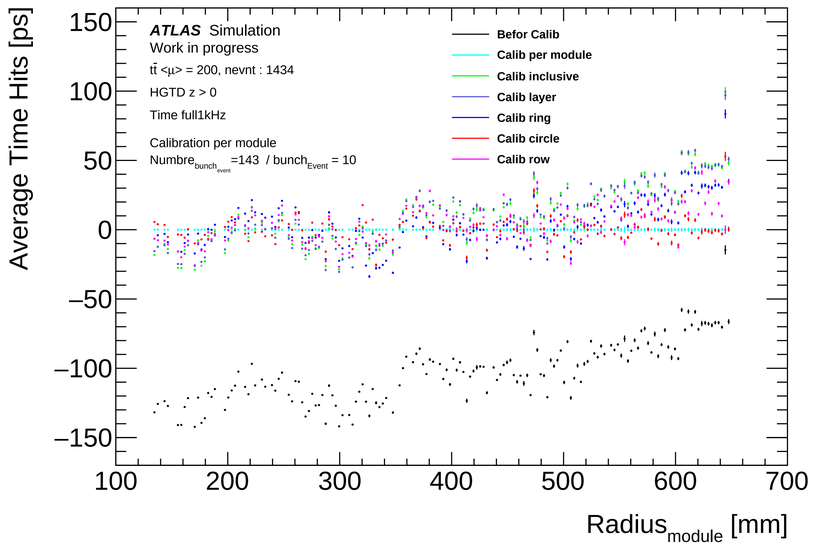


Figure 7. Time calibrated vs module radius

Result 3

- ToF effects are absorbed using the calibration per module method.

References

[1] ATLAS Collaboration Technical Design Report: A High-Granularity Timing Detector for the ATLAS Phase-II Upgrade CERN-LHCC-2020. CERN Geneva : https://cds.cern.ch/record/2721909?