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

Tnourji Abdellah for the ATLAS collaboration | RJP 2021 [1]

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

Motivation

HL-LHC challenges :

- **Pileup $< \mu >$∽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** :

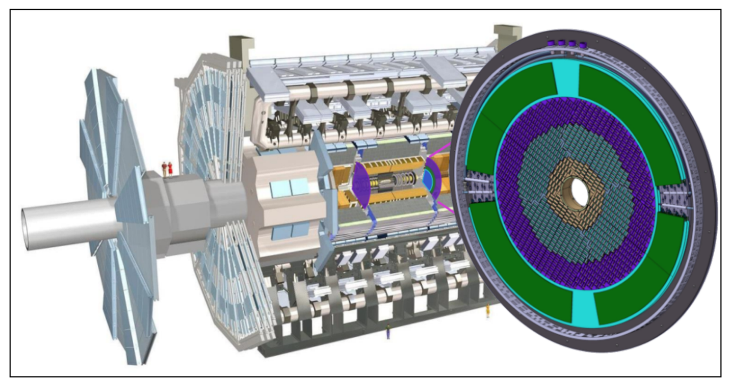


Figure 1. HGTD

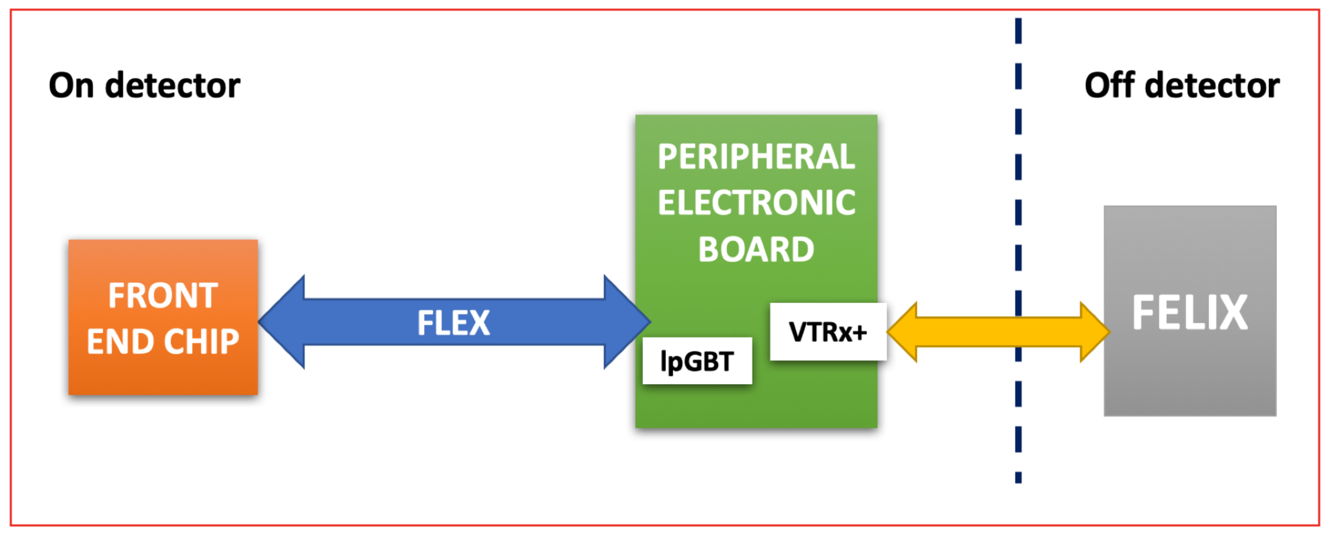
- **Forward region, 2.4 < < 4.0**
- **Timing resolution from 30-50 ps per track**
- **Use timing to resolve the vertices «equal» in z, but distributed in time**

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.**



☑ **lpGBT** : is a radiation tolerant ASIC for Data, Timing, Trigger and Control Applications in HL-LHC

☑ **FELIX**: off-dectector back-end board interfaces between the ATLAS data acquisition system and the on detector electronics.

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.

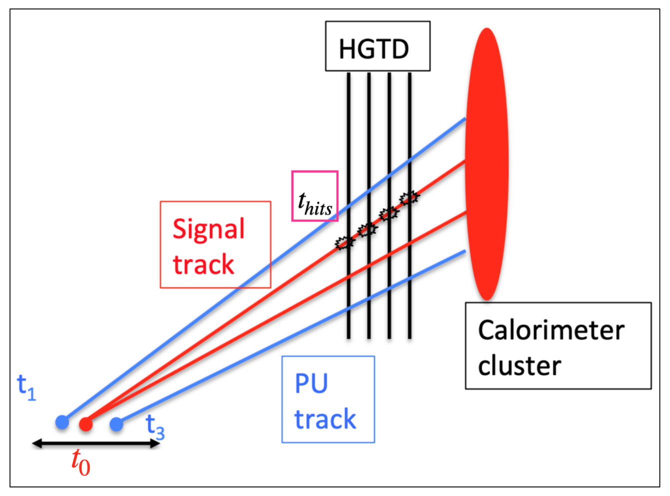


Figure 3. Hits in HGTD

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

where :

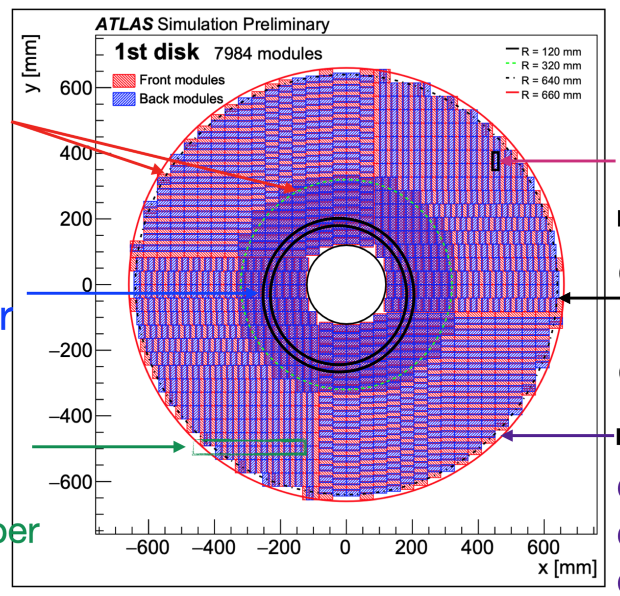
$< t_{hits} >$ **= calibration constant**

- **The number of events and Special granularity used to compute $< t_{hits} >$ 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.**

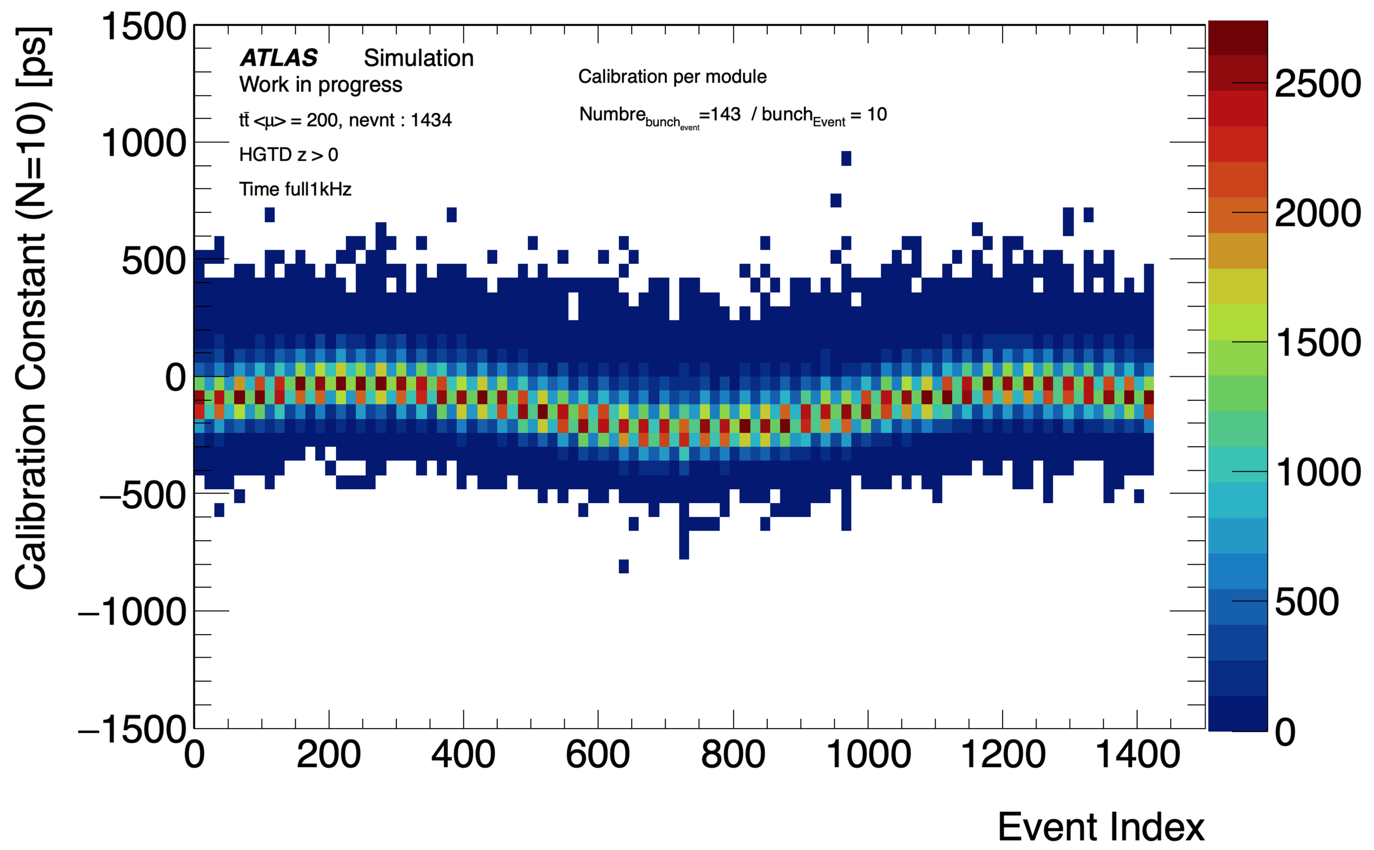


Figure 5. Calibration constant vs Event number. Calibration every 10 event.

Result 1

- **The injected 1kHz fluctuation is clearly visible.**

Timing correction

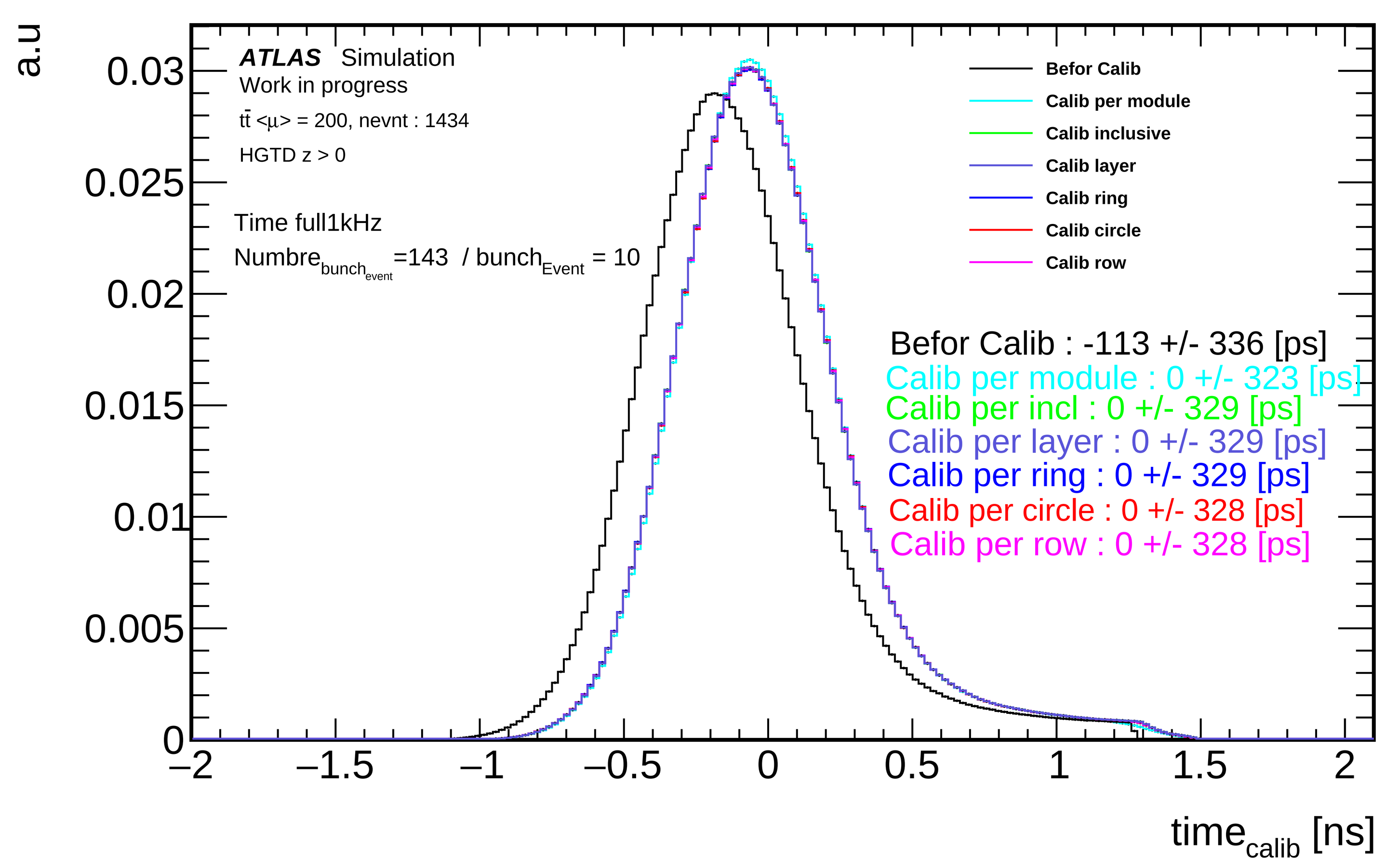


Figure 6. t_{hits} **calibrated every 10 events.**

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

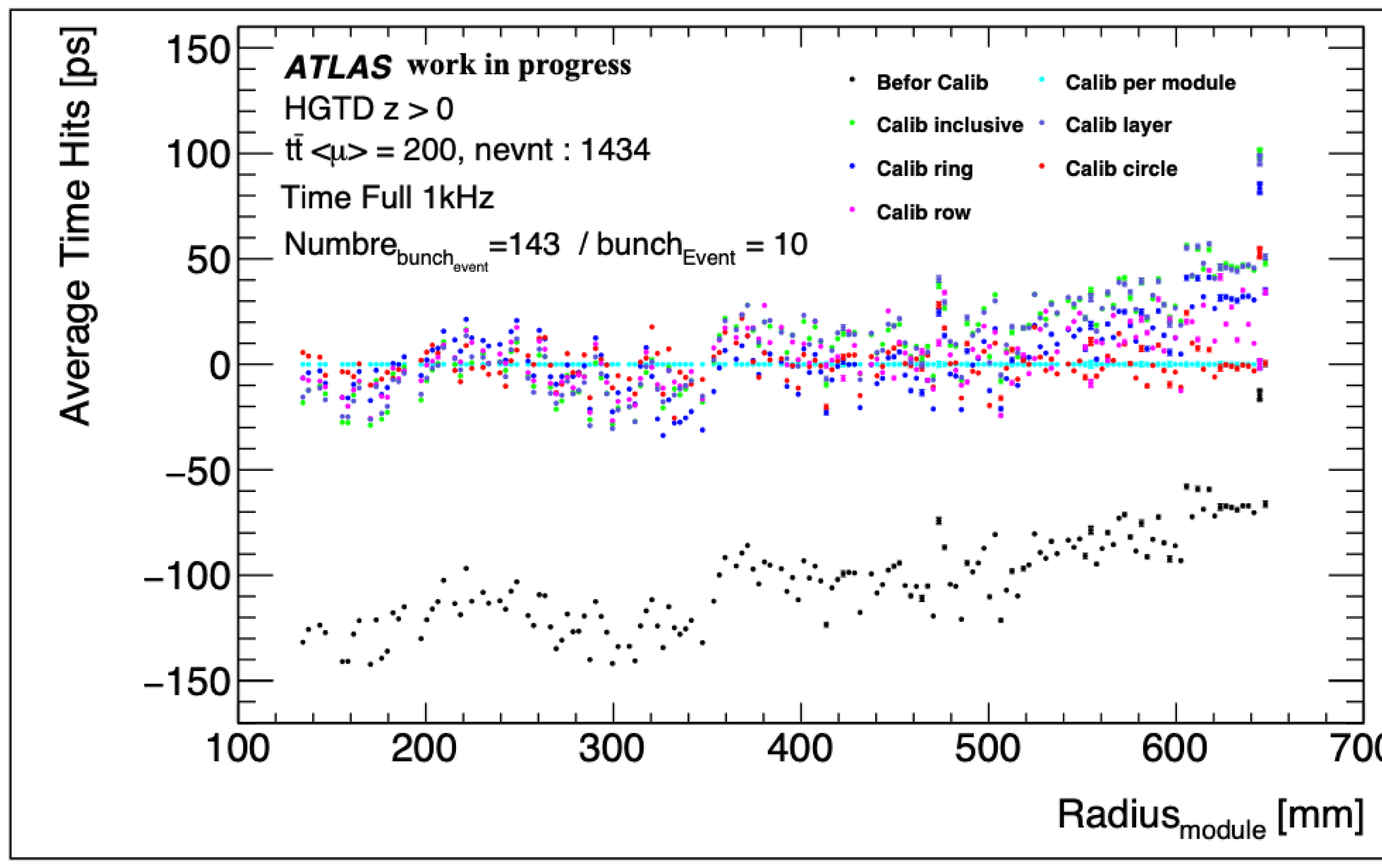


Figure 7. Time calibrated vs module radius

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?