A Trigger Interface Board to manage trigger and timing signals in CTA Large-Sized Telescope and Medium-Sized Telescope Cameras

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ABSTRACT

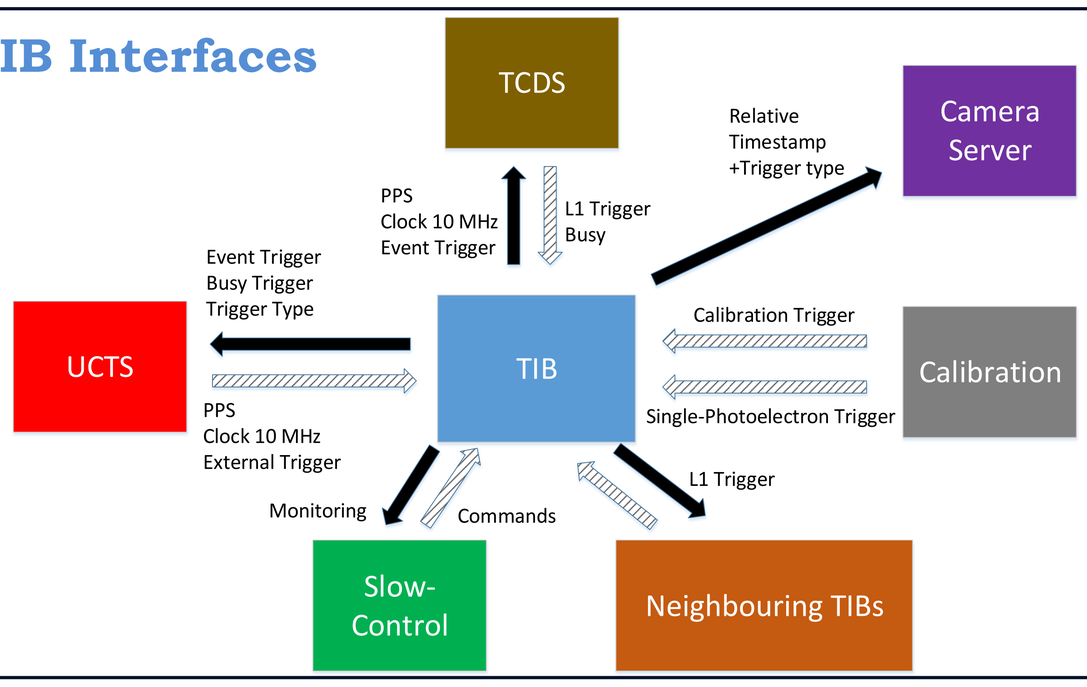
The Large-Sized Telescopes (LST), which focus on the lowest energies, are operated in a region dominated the night sky background. To reduce background events, the cameras are only read out if at least two of them have been triggered in a short time coincidence window. Such trigger is implemented for each LST by the Trigger Interface Board (TIB). In addition, the TIB is used in the LSTs and NectarCAM Medium-Sized Telescopes (MST) to manage their different trigger and timing signals, as well as to monitor the different counting rates and dead-time of the cameras. It also assigns a time stamp to each event, which is recorded along with the information provided by the Cherenkov Telescope Array (CTA) global timing distribution system, based on the White Rabbit protocol.

Supported by:

Introduction

The CTA will be the next ground-based γ-ray observatory, with the aim to improve both the sensitivity and the energy coverage with respect to current observatories, building two different sets of telescopes in each hemisphere. Three different kind of telescopes will be placed in the observatories according to their mirror diameters: Large-Sized Telescopes (LSTs), Medium-Sized Telescopes (MSTs) and Small-Sized Telescopes (SSTs). Regarding the LST and NectarCAM, their cameras must handle essentially in the same manner the trigger and timing signals they require. For that purpose, a Trigger Interface Board has been designed and produced.

TIB Interfaces



➢ **UCTS (Unified Clock distribution and Trigger time-Stamping):**

- → *1PPs* : pulse-per-second (PPS). } White Rabbit Network
- → *10 MHz* : clock signal.
- → *External trigger:* enable the trigger of the camera.
- ← *Event trigger* : signal triggering the camera read out, to be time-stamped.
- ← *Busy trigger* : trigger generated while a previous readout memory process is still active to be time-stamping.
- ← *Trigger type* : bit pattern characterizing the sources of event trigger.

➢ **TCDS (Trigger and Clock Distribution System):**

- → *L1 Trigger:* signal generated when the camera has detected a camera trigger.
- → *Busy:* trigger signal generated while camera readout process is busy, to be time-stamped.
- ← *PPS + 10-MHz clock signals.*
- ← *Event trigger*: triggers the camera readout process.

➢ **Camera Server:**

- ← *trigger type + TIB time-stamping* (100-ns precision): serving as cross-check of the high-precision UCTS time-stamp.

➢ **Calibration:**

- → *Flat-fielding*
- → *Single-photoelectron*

}
- Cause the readout process of the camera.
- Should not participate in the stereo trigger.
- Must be clearly identified for their processing.

➢ **Neighbouring TIBs:**

- ←→ *L1 Trigger:* transmission/reception to/from other telescopes in stereo mode.

➢ **Slow-Control (implemented as a OPC UA server):**

- → *Commands*: configuration parameters (IP addresses, thresholds…), actions (shutdown, reboot, reset…), establishing the connection with camera server, …
- ← *Monitoring* : trigger rates (busy, calibration, stereo…), camera server connection status, internal state, temperature, error alarms, …

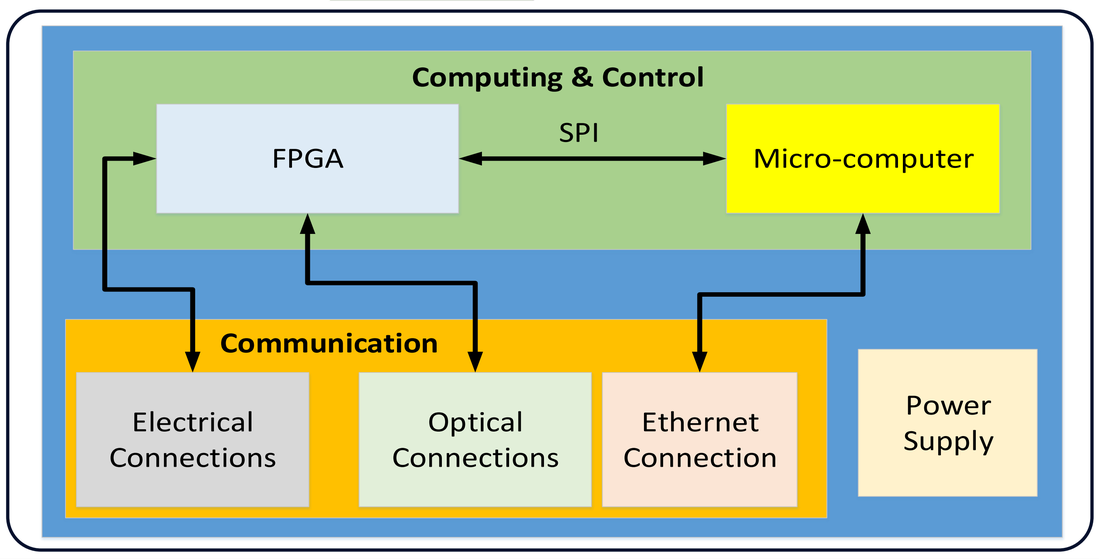
TIB HW Structure & Functional Behaviour

➢ **Computing & Control:**

- ❑ ***FPGA*: managing of all trigger inputs; enabling or disabling the connections (calibration, busy…) and the PPS distribution to the TCDS; building the trigger type information associated to the event and sending it to the UCTS; create the trigger type and the TIB time-stamp, managing the rates of all trigger inputs and outputs…**
- ❑ ***Micro-Processor*: programming the FPGA via Serial Peripheral Interface (SPI) bus; executing slow-control server; sending the trigger type + TIB time-stamping to camera server.**

➢ **Communication:**

- ❑ ***Electrical*: to receive (from UCTS)/transmit (to TCDS) the different clock signals used for trigger time-stamping; to transmit the event trigger and the trigger type to the UCTS.**
- ❑ ***Optical*: to receive the calibration signals for camera testing; to receive/transmit the signal used to synchronize the telescopes involved in the LST stereo observation.**
- ❑ ***Ethernet*: to carry out the slow-control tasks; to establish the communication TIB-camera server.**



Results

- ❑ **The TIB works at different LST and NectarCAM demonstration test benches.**
- ❑ **Test benches include a UCTS, a TCDS, a camera server emulator and a slow-control OPC UA server.**
- ❑ **The coherence between the trigger type and the time-stamp generated by the TIB and the event information produced by the UCTS has been verified.**
- ❑ **The maximum trigger processing rate achieved by TIB is around 16 kHz.**
- ❑ **Jitter of trigger signal of up to 0.9 ns for the maximum asynchronous delay of 4 us.**
- ❑ **10 MHz and PPS delivery from the UCTS to the TCDS, adding ~10-ps and ~30-ps jitter, respectively.**

Conclusions

A Trigger Interface Board has been designed in order to equip the camera of the LST and the NectarCAM MSTs. Its purpose is to handle the trigger and timing signals required in both cameras. It will also implement the stereo trigger scheme among LSTs. Several prototypes has been constructed and successfully characterized, so it is finally ready to be installed the preproduction version of the LST and the NectarCAM-MST.

ACKNOWLEDGEMENTS

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