TESTING OF THE ATLAS ITK DATA TRANSMISSION CHAIN

Daniele Dal Santo (daniele.dalsanto@unibe.ch), Dr. Aaron O'Neill, Dr. Silke Möbius, Roman Müller, Lea Halser, Prof. Dr. Michele Weber

THE ATLAS ITK PIXEL DETECTOR

The High Luminosity LHC (HL-LHC) will deliver on average 200 interactions per bunch crossing at 40 MHz. In view of the HL-LHC, the current Inner Detector (ID) of the ATLAS experiment will be substituted by the Inner Tracker (ITk).

ITk requirements:

- higher resolution tracking compared to ID to deal with the more challenging pile-up $\longrightarrow$ from $\sim 10^8$ to $5 \cdot 10^9$ electrical channels;
- read-out speed of 1 MHz, which corresponds to 50 Tbps;
- resistant to the harsh radiation environment of HL-LHC as the foreseen maximum integrated dose is of $\sim$ 10 MGy.

The key component to read out the ITk Pixel detector is the Optosystem which equalizes, multiplexes, converts all the signals coming from the front-end chips from electrical to optical and transport them to the off-detector readout FELIX cards; it also distributes the command and trigger lines. A total of $\sim$ 1600 Optoboards, connected to $\sim$ 190 FELIX cards via more than 4000 optical fibers, is needed to read out the ITk.

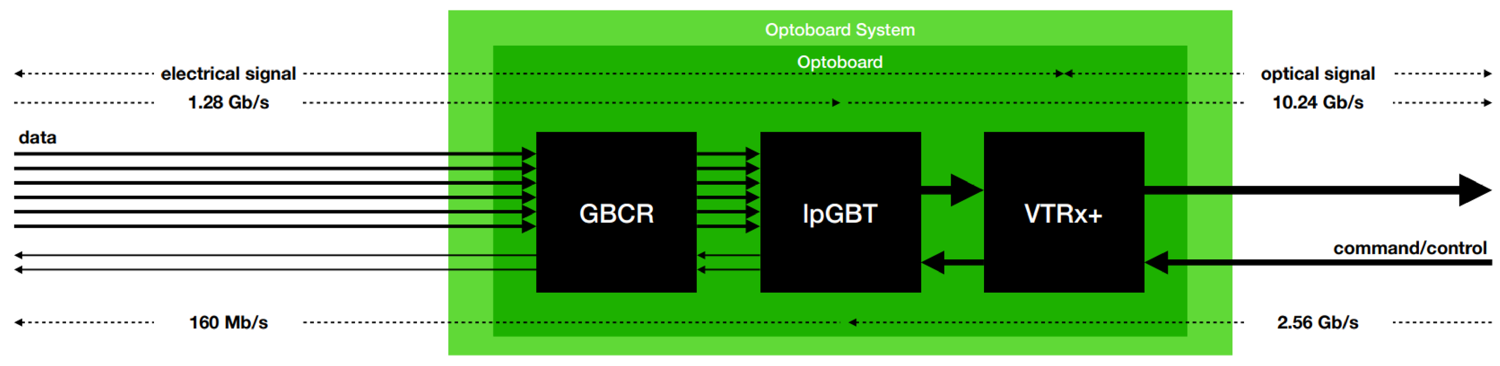

FIG. 1: Optosystem simplified scheme.

THE ITK PIXEL OPTOSYSTEM: FROM THE OPTOBOARD TO THE OPTOPANELS

- Up to 8 Optoboards are housed in an Optobox.
- 8 Optopanels are foreseen for the ITk detector, housing 28 Optoboxes each and providing them with Faraday cage shielding and cooling system.

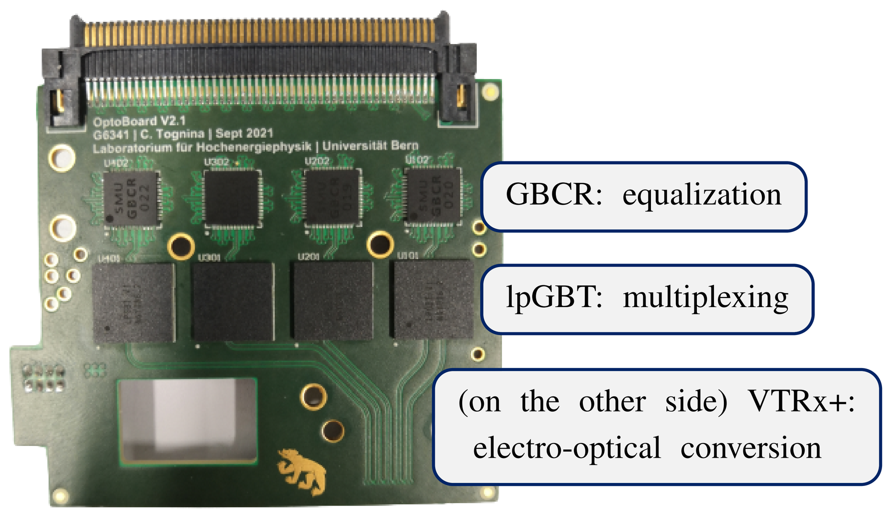

FIG. 2: Optoboard V2.1.

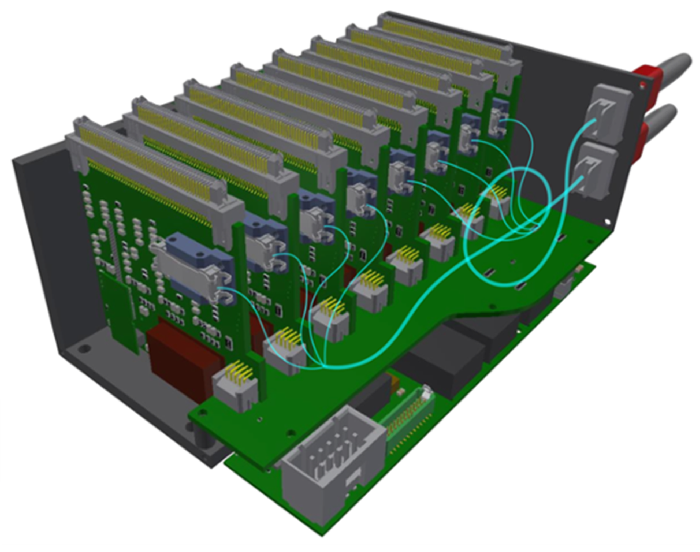

FIG. 3: CAD drawing of an Optobox.

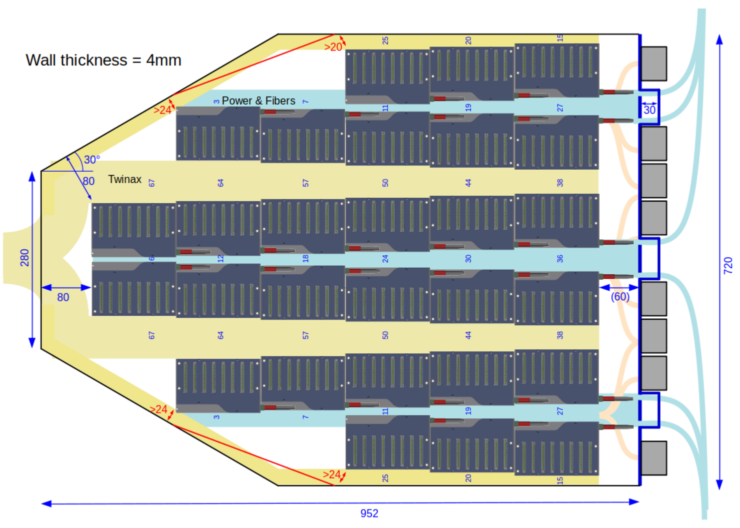

FIG. 4: CAD drawing of an Optopanel.

I. TESTS OF THE OPTOSYSTEM

To ensure high quality in the ITk readout, the 95% C.L. Bit Error Ratio (BER) limit of the Data Transmission Chain is required to be lower than 10^{-12}.

The Optoboard configuration is optimized, using the setup in FIG. 5, to achieve this goal. The BER limit is estimated with 2 methods:

- checking the PRBS7 produced by ITkPix on the pattern checker of the lpGBT
- checking the 64b/66b ITkPix idle frames with FELIX.

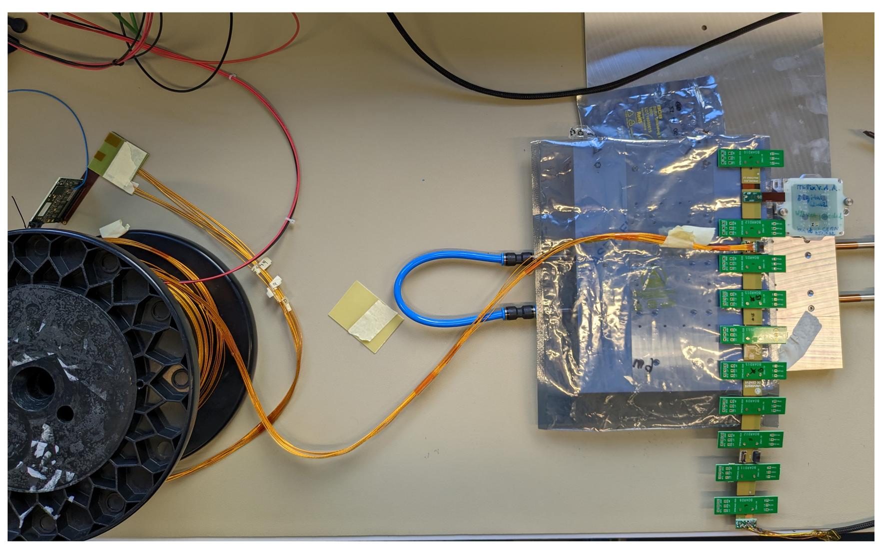

FIG. 5: Setup for the QC of the Optoboard Data Transmission.

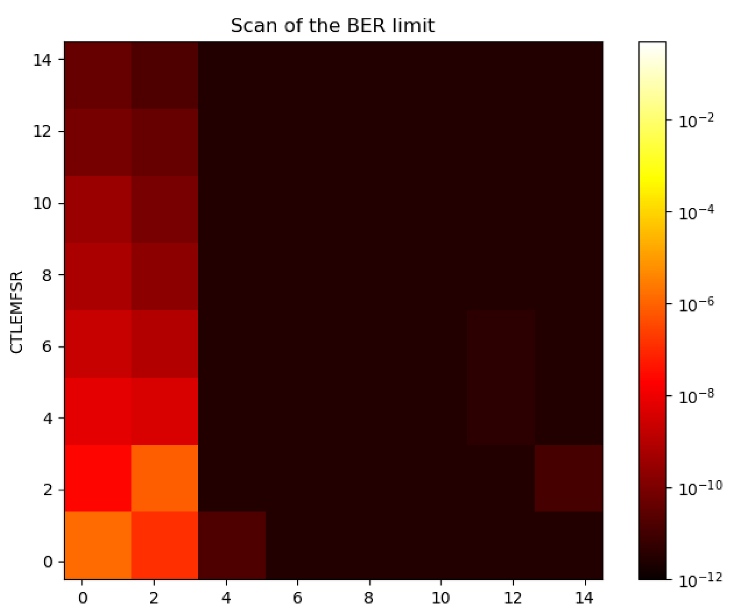

FIG. 6: Scan of the BER limit varying the equalization parameters, using PRBS7.

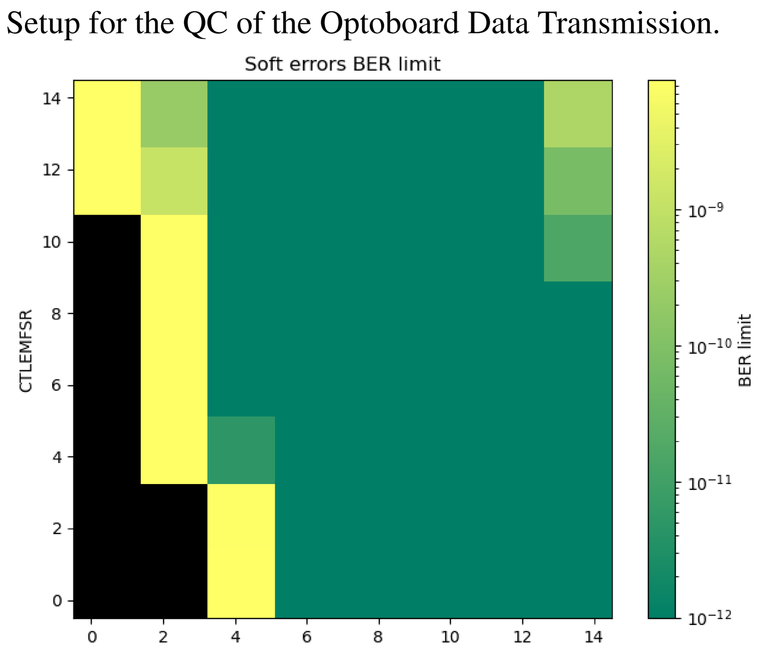

FIG. 7: Scan of the BER limit varying the equalization parameters, using ITkPix idle frames.

Additional tests on the Optosystem:

- the BER limit has been monitored during Optoboard irradiation with 18 MeV protons at the Bern Medical Cyclotron to ensure radiation hardness;
- the thermal behaviour of an Optopanel populated with heat dummies and heat pads has been tracked;
- the ITkPix module has been read out during a testbeam at CERN.

II. CONTRIBUTION TO LOCAL LOADED SUPPORT

In view of the HL-LHC upgrade, 11 sites have been appointed to build and test sections of the ITk detector. The contribution of the Bern group to the Local Loaded Support (LLS) is twofold:

A) provide a user-friendly software for the configuration of the Optoboards (FIG. 8), integrated in a suite of microservices for the operation of the demonstrators:

- each microservice is composed of a GUI connected to a backend (FIG. 9), distributed over various docker containers
- the microservices orchestration is done via ETCD, a distributed key-value store, that implements a dynamic service discovery approach and is used for runtime configuration
- the status of the system can be monitored via Portainer.

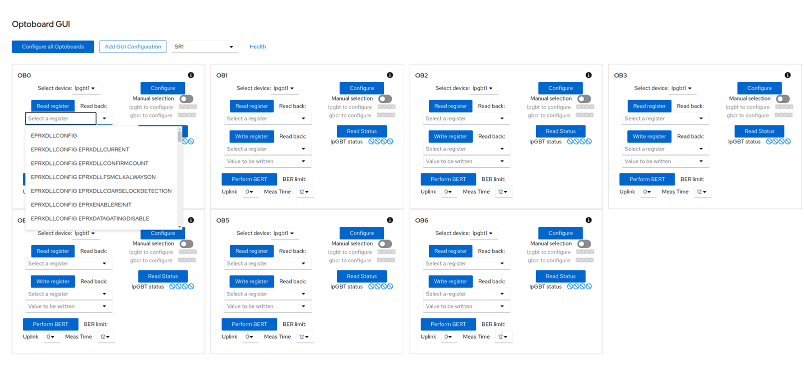

FIG. 8: GUI for Optoboard configuration.

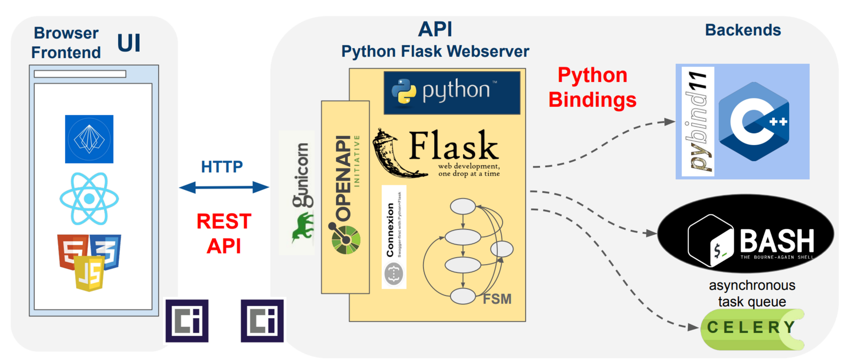

FIG. 9: Microservice architecture.

B) provide single-box Optopanels (FIG. 10) with realistic mechanics, powering and cooling to be used for module readout.

FIG. 10: Single-box Optopanels for LLS, each containing one Optoboard.

OUTLOOK

- Validation of the latest Optoboard iteration (halogen-free).
- Finalization of the software for Loading Sites.
- Production Readiness Review and QA/QC on final production components.

UNIVERSITÄT BERN
AEC ALBERT EINSTEIN CENTER FOR FUNDAMENTAL PHYSICS
LABORATORIUM FÜR HOCHENERGIEPHYSIK LHEP UNIVERSITÄT BERN
ATLAS EXPERIMENT