Development of the LHCb Upstream Tracker at UMD

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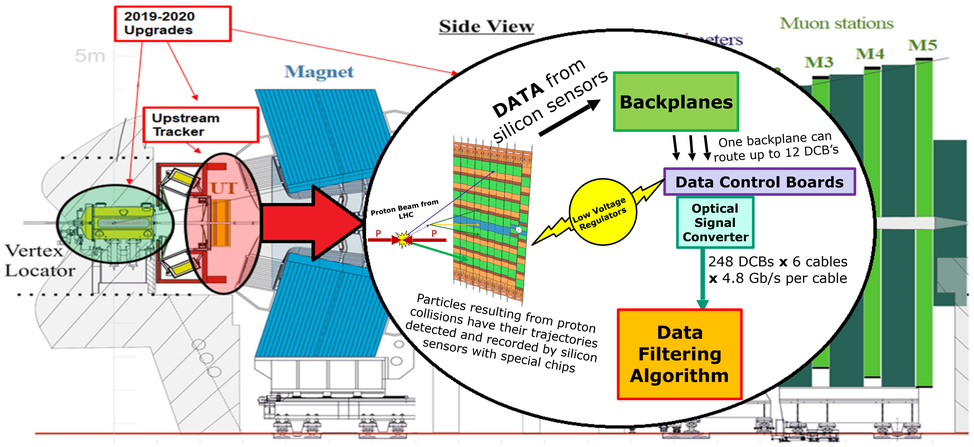
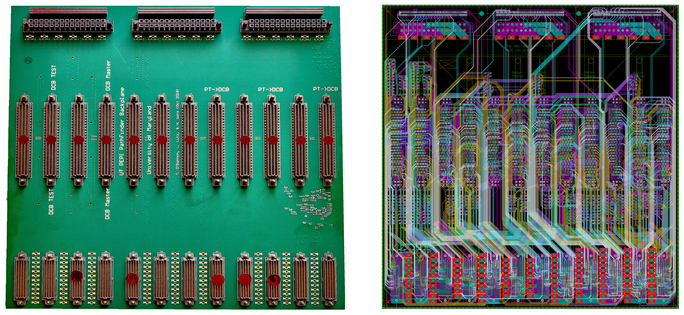
The **Upstream Tracker** is one of the electronics upgrades being made to LHCb, improving the experiment's ability to track the paths of charged particles following collisions. The particles that pass through the detector deposit charge through four layers of silicon. These charge deposits are then analyzed and their trajectory can be deduced.



The **University of Maryland** is contributing to the LHCb upgrade with the design, construction, and installation of three electronic systems that will **organize the flow of data from the sensors**, **package the data and convert it to an optical signal**, and **provide power to the detector**.

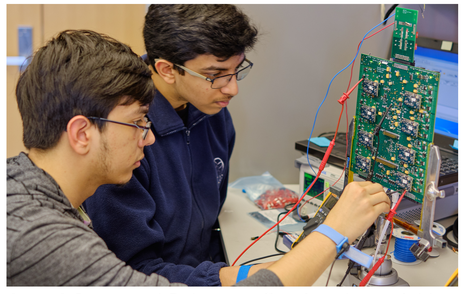
- **Backplanes:** The backplane is the circuit board that receives digitized data about the charge deposits from the silicon sensors and routes it to up to 12 data control boards.
- **Data Control Boards (DCBs):** The DCBs are boards that receive data from the backplane and use 7 CERN-designed chips to serialize the data and send it out via fiber optical cables at 4.8 Gb/s.
- **Low Voltage Regulators (LVRs):** The LVRs are power supply boards that are designed to be able to provide 1.2v, 1.5v, and 2.5v power rails to the electronics in the UT with very little fluctuation.

The backplane's role is to **distribute the data** from the Upstream Tracker's silicon micro-strip detectors, as well as providing a frame for the LVRs and data processing DCBs. These boards also route power to all the new electronics system and silicon detectors in the upstream tracker.



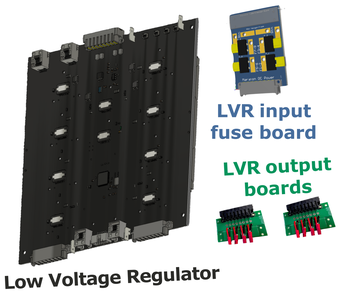
(above) A picture of the front-side of the backplane, with the matching PCB schematic showing the 28-layer distribution of connections and vias.

The low voltage regulators are critical to the functionality of the detector. These boards **provide stable power** sources of 1.2v, 1.5v, and 2.5v to the silicon detectors whose ASICs cannot handle a surge of higher than 1.575V before being permanently damaged.



(above) Jorge and Rohan configuring the variable resistors and confirming the stability of the 1.2/1.5/2.5 power lines

(above) Ben soldering resistors onto a module that connects to the LVR

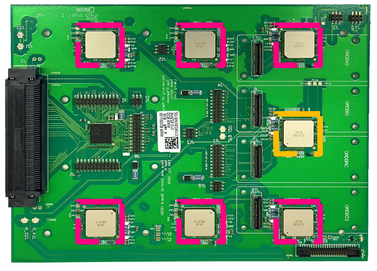


Low Voltage Regulator

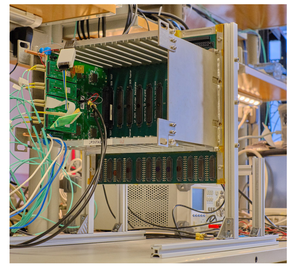
The Data Control Board (DCB) is the powerhouse circuit board that is designed to handle the large amounts of data routed from the silicon sensors. It has three main responsibilities:

- **Serializes** the 320 Mb/s data from the silicon sensors into a single 4.8 Gb/s line in its CERN-made GBTx ASICs.
- **Converts** the electrical signals to optical signals by feeding the data into four modular optical transceivers.
- The GBTxs **sends control signals** to the ASICs located on the silicon sensors.

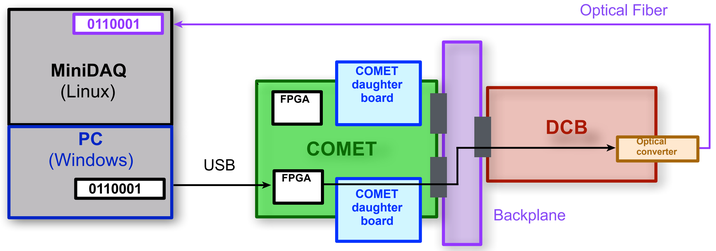
DCB with Master and Slave GBTx ASICs.



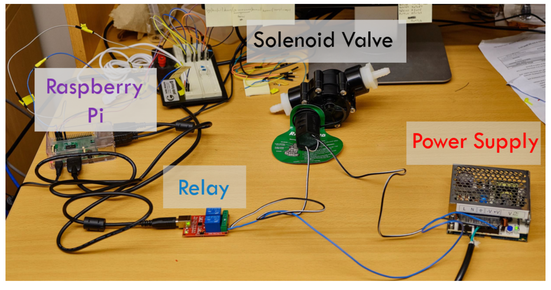
DCB connected to a backplane



Our current work involves a large-scale production of these three electronic systems. The manufactured boards must be tested and configured on a board-by-board basis and then undergo an intense **burn-in phase** before finally shipping them to CERN. To test the DCBs, we send a stream of data using specialized COMET boards and verify their integrity with python algorithms.



The last step before installation is the **burn-in**, which will occur during Summer 2019 and will have two main objectives. The LVRs will be stress-tested by being connected to several resistive load boards in order to test any voltage fluctuations. The DCBs will be stress-tested with dummy data to verify their longevity. The burn-in will occur in two equal sized batches.



The burn-in will require several safety systems that will be controlled by Raspberry Pi's.

Here is the relay controlled watercooling system that will be used to thermally cycle the electronics.