Qualification of the final LHCb VELO electronics

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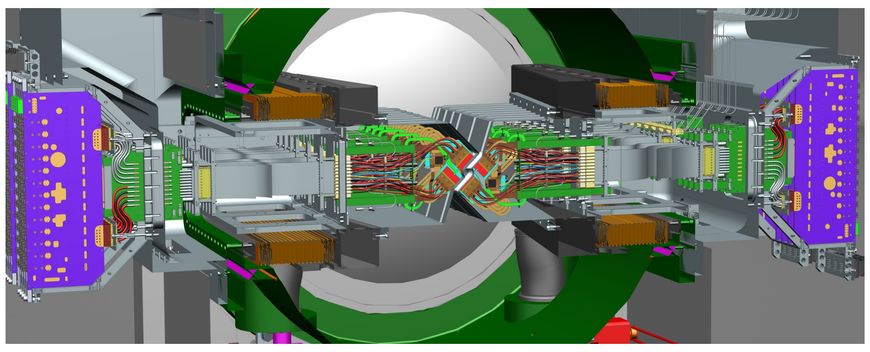
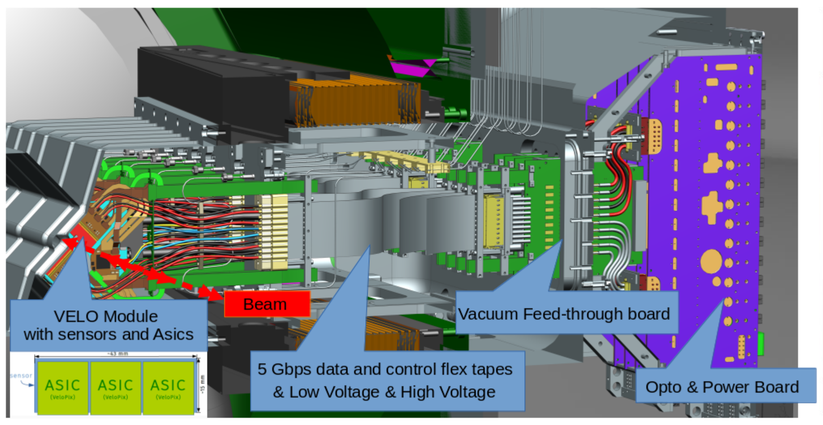
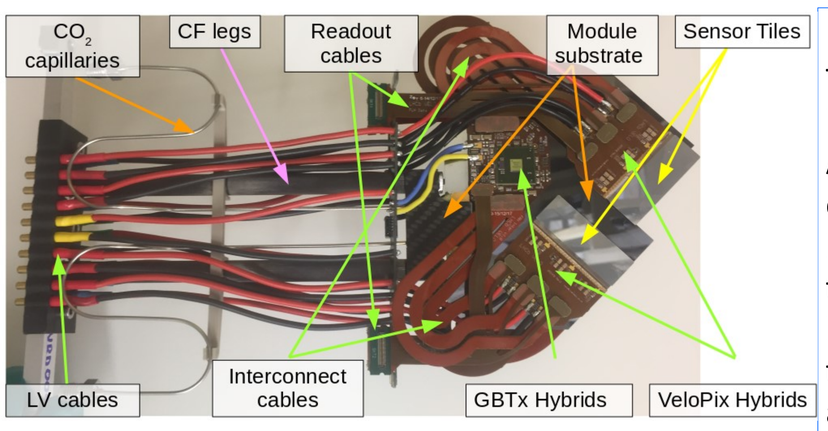
LHCb VELO

The LHCb silicon VErtex LOcator detector (VELO) will be fully replaced by a new pixel detector in 2020. The detector provides precision space points close to the interaction point and thus used to reconstruct b decay vertices, in both the trigger and offline track reconstruction as well as being an important part of the tracking system. In order to match the upgraded LHCb readout system, which aims at a trigger-free read-out of the entire detector at the bunch-crossing rate of 40 MHz, all silicon modules and electronics must be replaced. The upgraded VELO will be a hybrid pixel detector (55x55 um pitch), read out by the VeloPix ASIC derived from the Timepix3. The sensors and ASICs will approach the interaction point to within 5.1 mm and be exposed to a radiation dose of up to 370 Mrad.



LHCb VELO





VELO electronics

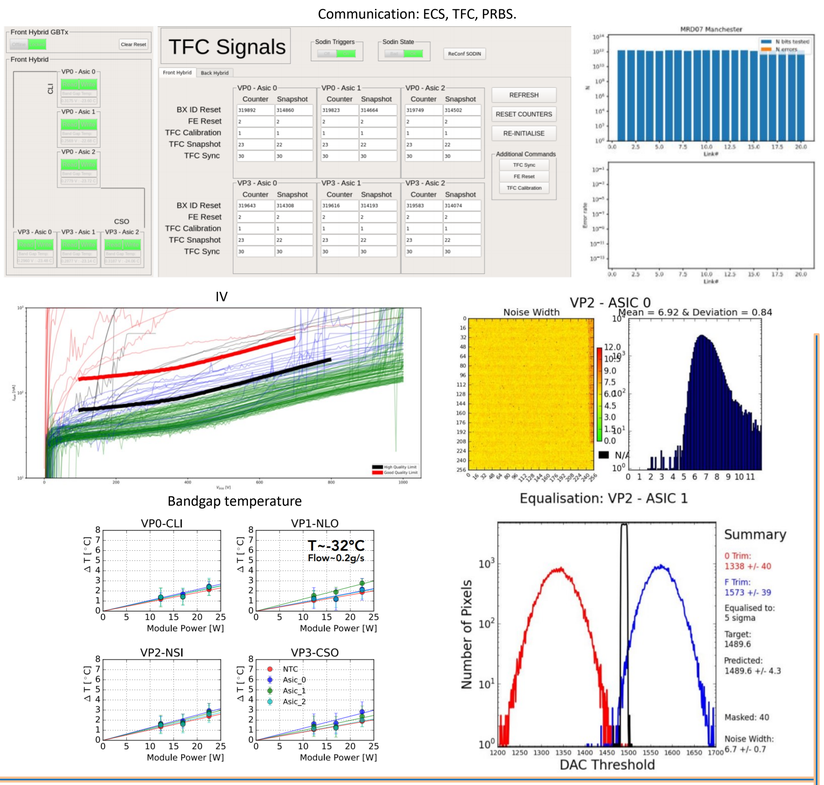
The LHCb Vertex Locator is composed of 208 sensors bump bonded to 624 VeloPix ASICs (3 ASICs per sensor). All these ASICs are wire-bonded to 208 hybrids and controlled by 104 GBTx ASICs using another specific hybrid. These hybrids are interconnected with 208 flex tapes using 832 connectors (4 each tape) and placed with high precision on a silicon substrate together with the tiles (1 sensor + 3 VeloPix) that are used as a support and as micro-channel CO2 cooling. The VeloPix ASICs readout signals and the GBTx control signals are transmitted via 208 flex tapes divided in two segments: one with low mass in the acceptance area made of micro-strip lines and another made of ~0.5 metre strip-lines. These readout flex cables are connected to the hybrid using 728 connectors and have to be able to transmit 5.13 Gbps signals. The flex tapes are connected to a Vacuum Feed-through Board and which are then connected to an Opto and Power Board.

VELO electronics qualification

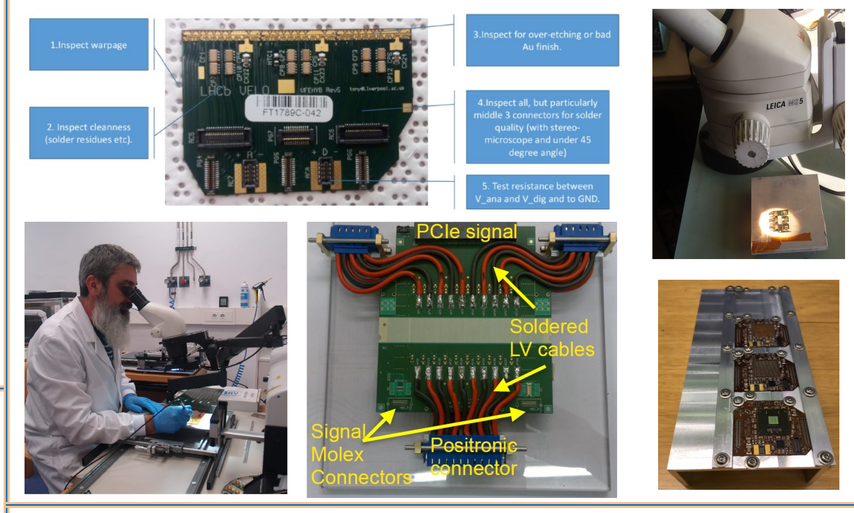
As the installation is approaching all the electronics have to be verified and tested. Due to the quantity of sensors, ASICs, and boards required and the inability to replace most of the components after the installation, precise systematic tests have to be done for all the detector components at each production and assembly step.

- Full ASIC and sensor qualification.
- Visual inspection of all the hybrids and flex cables. Re-solder some of the Molex connectors.
- GBTx test with cooling after found a problem on modules when it is cold. Electrical test using a final electrical system.
- High speed flex test using VC707 board.
- High voltage flex test up to 1000 V.
- TDR test of the vacuum feedthrough board.
- Full slice test of every module produced. 3 Set-up: one in each assembly side and one at CERN for debug and slide test of the final parts.

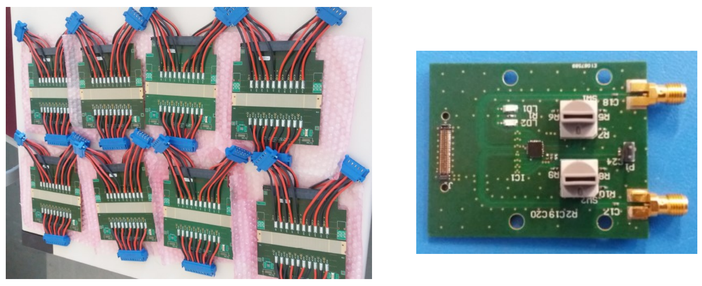
Electrical test of the VeloPix and sensors



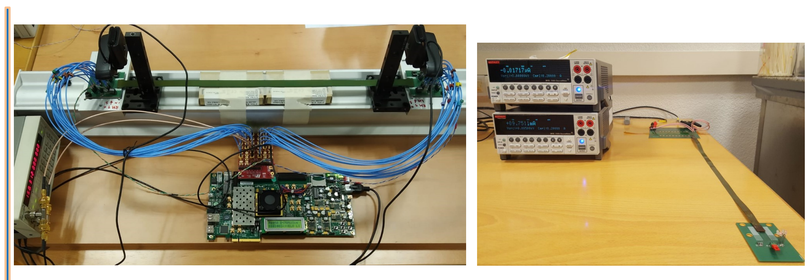
Visual inspection



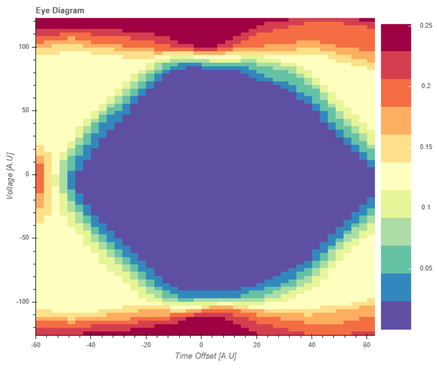
TDR measurement of the VFB



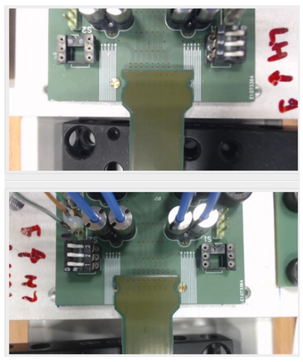
High speed and high voltage test setups



Eye diagram

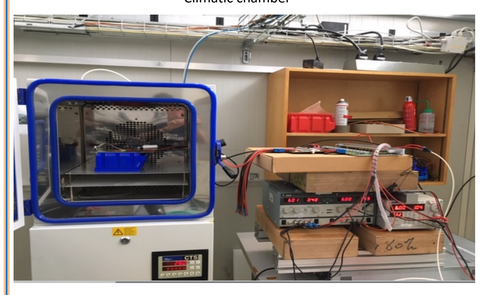


Aligment

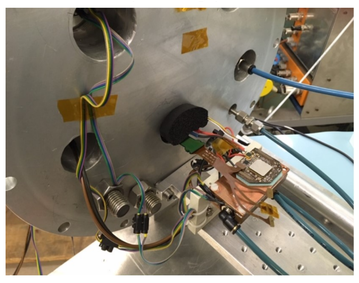


GBTx test

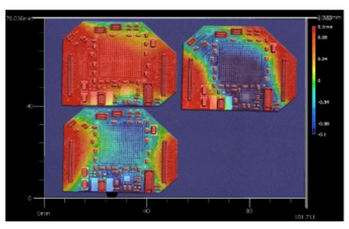
Climatic chamber



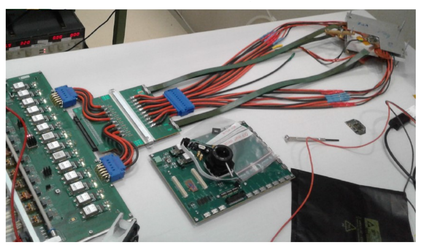
Dry air cooling system



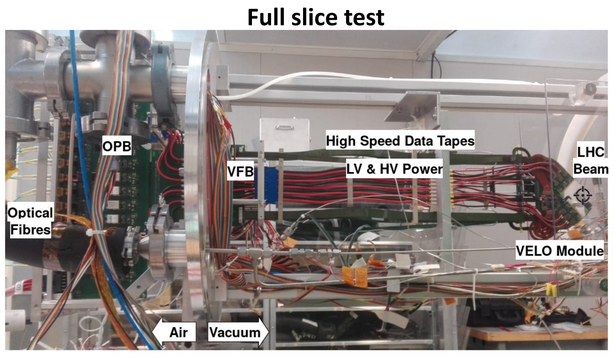
Flatness measurements



Electrical set-up

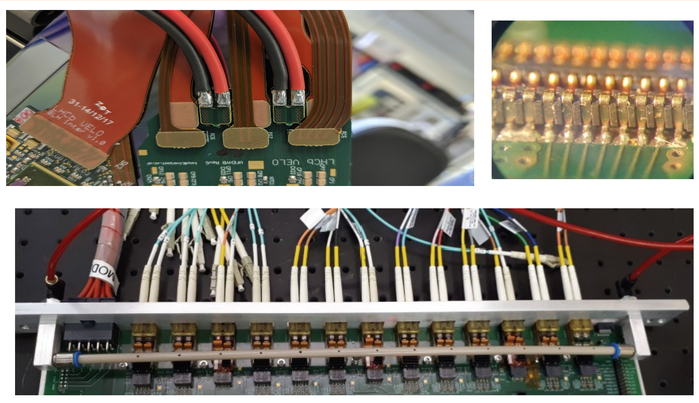


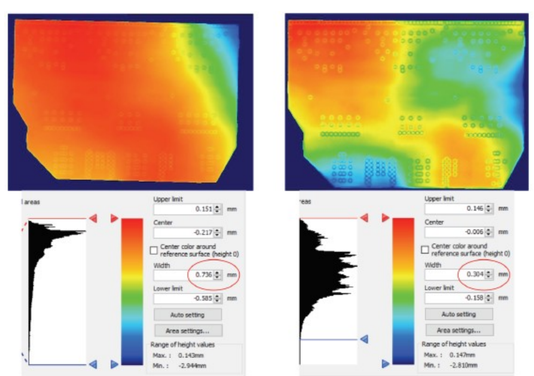
Full slice test



Problems found and solutions adopted

- Flatness of the PCBs -> change the PCB stack up and design.
- GBTx not working at cold temperatures -> Increase the charge pump current on fuse.
- Bad solder of Molex connectors -> use of jigs during the reflow and re-solder some of them.
- Tin pest at low temperatures -> use Pb.
- Cables in same place -> cut one of them.
- Death of the GBLD on the VTTx and VTRx -> multi hole air cooling.





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