Setup for testing LHCb Inner Tracker Modules

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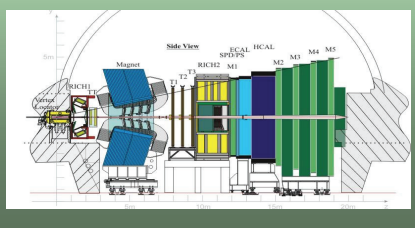
The LHCb experiment:

- Single-arm forward spectrometer dedicated to B-physics
- Acceptance: 15-300(250)mrad
- pp@14 TeV, luminosity=$2 \cdot 10^{32}$ $cm^{-2}s^{-1}$
- 10^{12} bb/year, full B spectrum

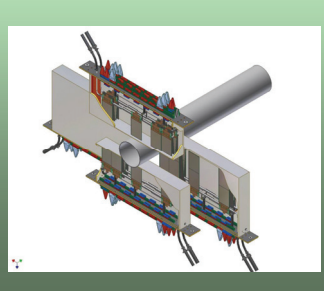
The Tracking Detectors:

- The tracking system is formed by the Vertex detector (VELO), the Trigger Tracker (TT) station and the Tracking stations (T1-T3) behind the magnet which are split into and Inner Tracker (IT) and an Outer Tracker (OT)



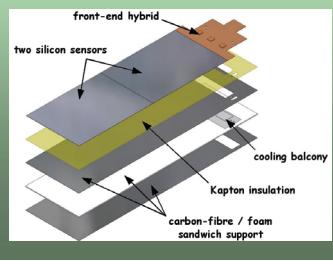
The Inner Tracker:

- Silicon strip detector covering provides granularity in the high multiplicity region around the beam pipe - 1.3% of sensitive area → 20% of tracks
- Active area: 4.3m^2, readout channels: ~130k
- Modules: 1-, 2-sensor modules (11 and 22cm)
- 3 stations with 4 boxes, 4 layers per box (2 stereo): → 336 modules



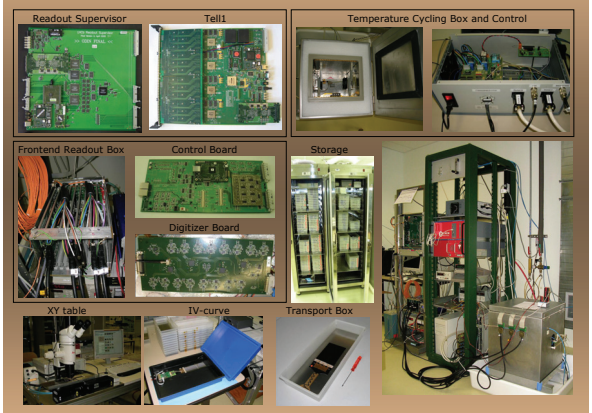
IT - modules:

- p-n silicon micro-strip single side sensors (Hamamatsu)
- 384 AC coupled readout strips, 108 mm long
- 198μm pitch, w/p=0.25, 320(410) μm thickness
- Hybrid with 3 "Beetle" readout-chips
- Cooling "balcony" for mounting and positioning of the module on the supporting cooling rod which is connected to the liquid cooling system
- Carbon Fibre (CF) support produced out of high thermal conductive fibre used to cool the sensors



Testing hardware:

- Custom made temperature cycling box and control electronics:
  - Temperature cycling box based on water cooled peltier elements
  - Control electronics with RS-232 computer interface
- DAQ setup
  - Frontend Readout (1 Control Board, 6 Digitizer Boards)
  - Readout Supervisor (clock, trigger distribution)
  - TELL1 board (readout board for zero suppression etc.)
  - CAEN HV with A1511B module
- IV-curve using Keithley picoampermeter
- Metrology with XY table and Leica microscope

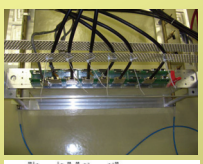


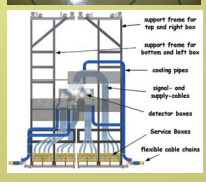
Testing procedures:

- IV-curves (before bonding and before and after cycling/burn-in)
- Temperature cycling/burn-in (44h, 30cycles, -5C to 40C)
  - Readout hybrids undergo previous burn-in (96h) before module assembly
- Test for open/shorted channels by injecting charge via the Beetle test-pulse
  - we perform this test for every temperature, 270 times per burn-in
- Test for pinholes
- Metrology X,Y,Z
- Inert atmosphere storage

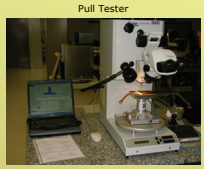
Box assembly:

- First IT box assembled (only 1 out of 4 rows)
- 5 out of 12 boxes already built in Santiago (3 already delivered to CERN)
- All CF support frames produced and in the pit, without cabling yet

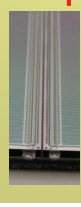


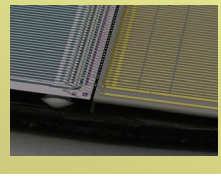


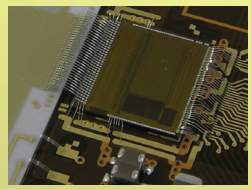
Pull Tester



K&S8060 Bonding Machine





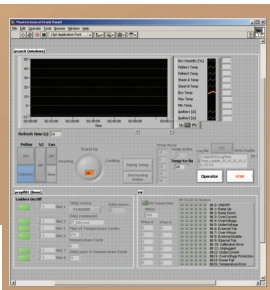


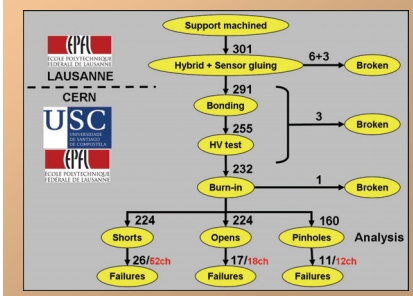
Bonding:

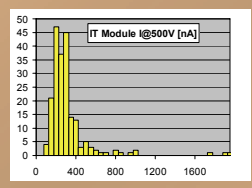
- Wedge bonding machine with Al Ø=25um wire
- Pull Tester
- 776/1164 wire bonds for 1-/2-sensor ladders
- Beetle-to-Pitch Adapter 4 rows pitch 40um
- Pitch Adapter-to-Sensor single row
- Sensor-to-Sensor single row

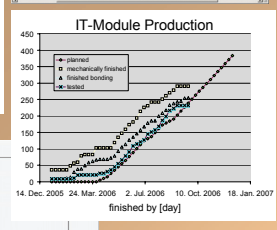
Testing software:

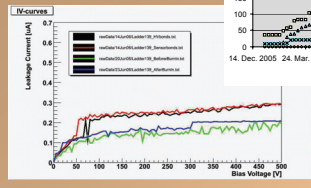
- Control for temperature cycling and burn-in based on LabVIEW
- A Windows PC controls the Temperature Cycling Box and a Linux PC acquires data
- HV power supply controlled via CAEN OPC server
- C++ based readout software allows: normal data taking, delay scan, pinhole tests, ADC timing scans, pedestal acquisition
- Trigger, Control and Readout uses final LHCb hardware as well as LHCb software/firmware with adaptations where necessary

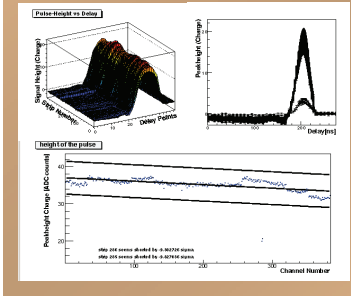












Analysis:

- Noise and common mode monitoring
- Delay scan for pulse-shape monitoring
- Shorted channels are identified by smaller signal height due to larger load capacitance
- Unbonded/open channels are identified by larger signal heights due to smaller load capacitance
- Pinholes are identified by artificial low noise due to preamplifier saturation under (IR-) illumination