# The LHCb Silicon Tracker: Running experience

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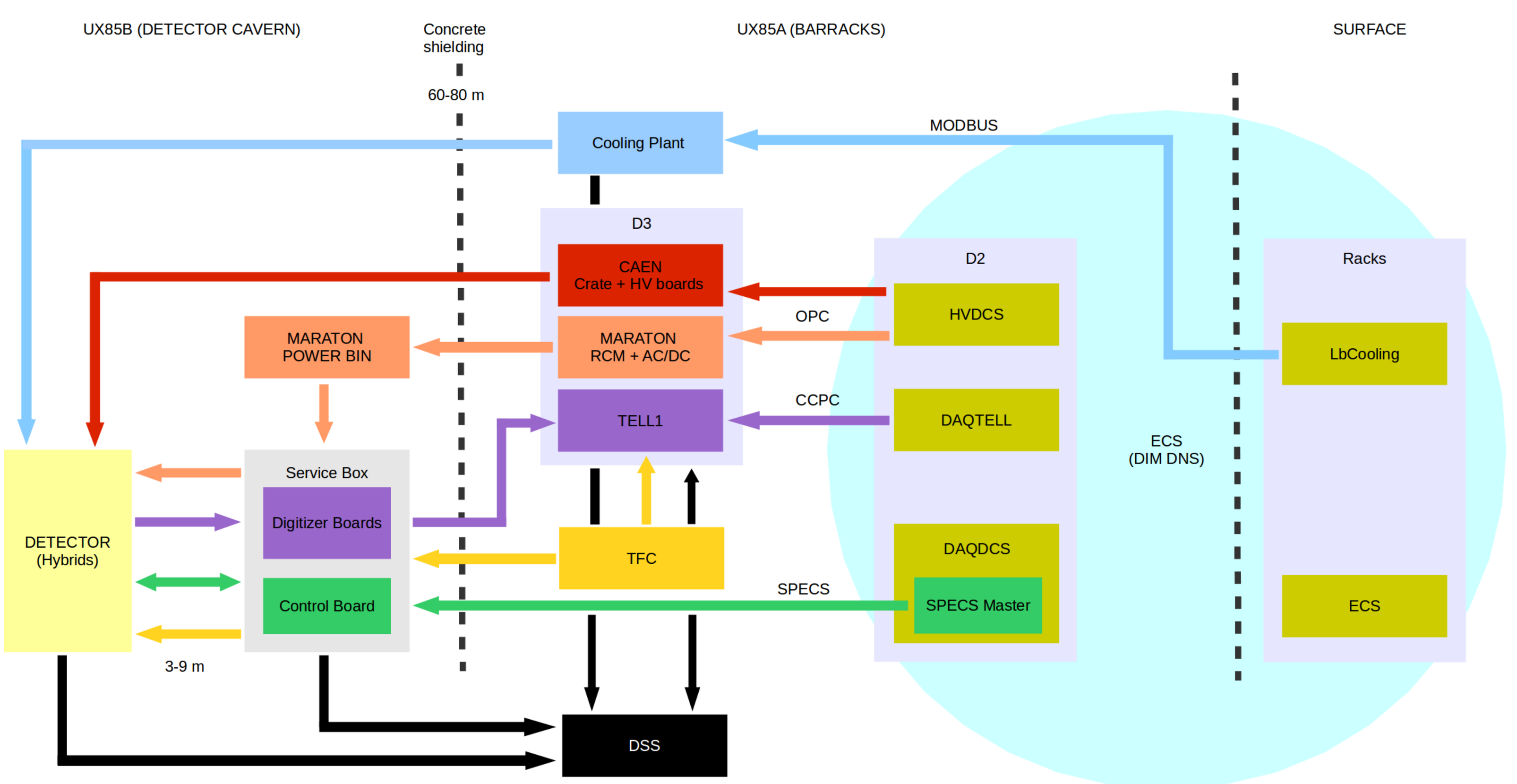
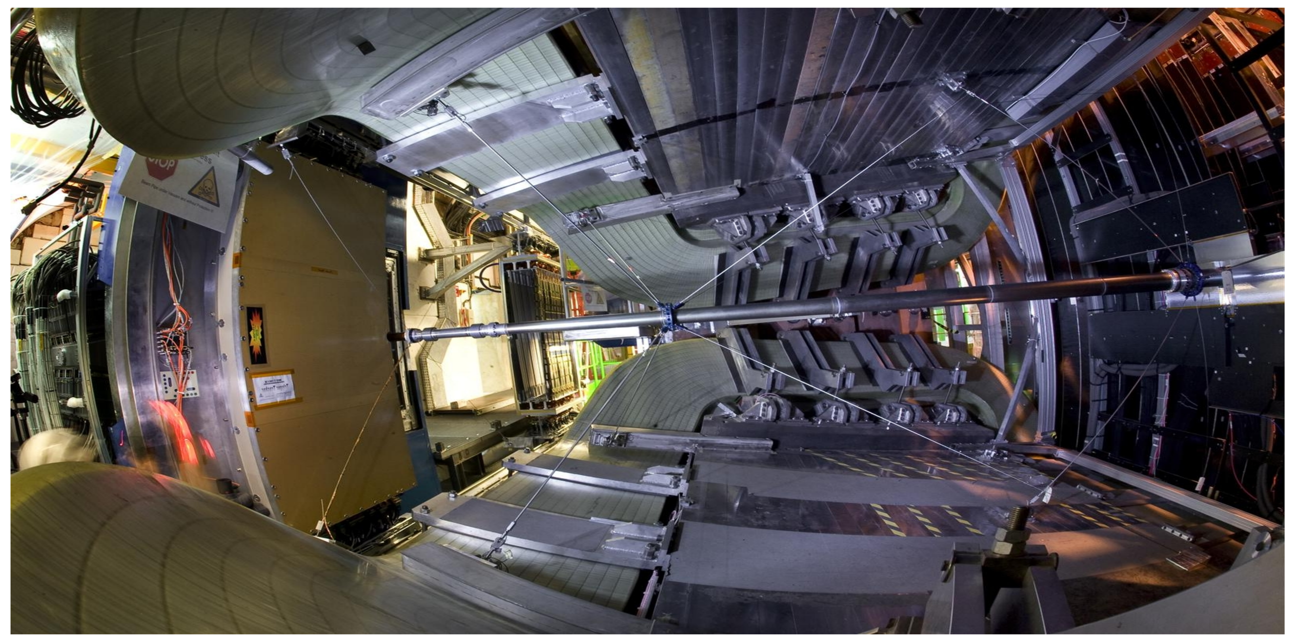
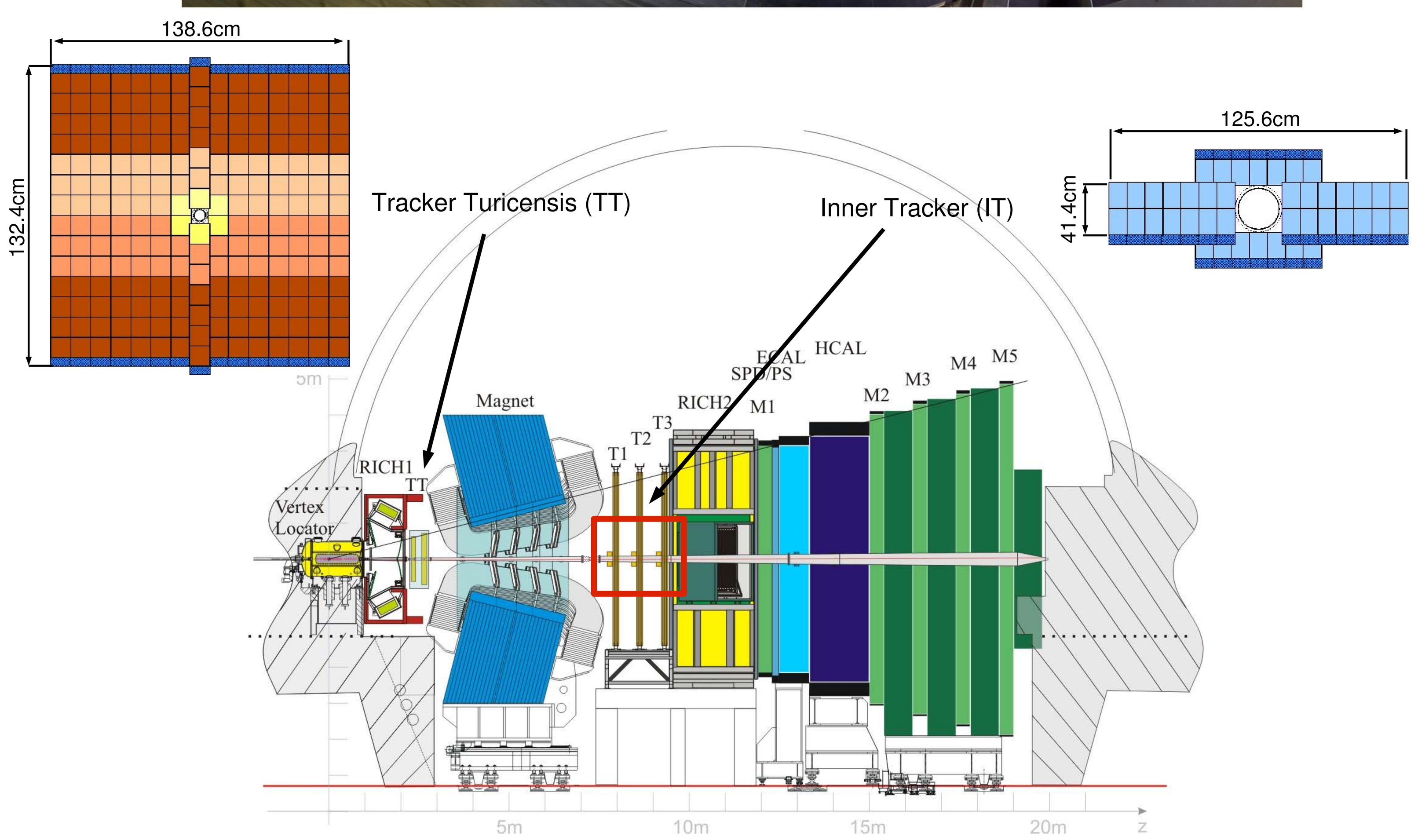
## System overview




The LHCb Silicon Tracker is part of the LHCb main tracking system and provides data for the region of high track densities. For the tracking station TT in front of the main dipole magnet, the Silicon Tracker covers the full acceptance angle of the experiment, while for the stations T1-T3 after the magnet, the Silicon Tracker only covers the region directly around the beam pipe. The analogue hit information of the silicon strip detectors, which is amplified by the Beetle readout chip, is transmitted via copper cables to the Services Boxes, which are located outside the acceptance area. This not only reduces the amount of material inside the detector but also relaxes the requirements on the Service Box electronics concerning radiation tolerance. The Service Boxes hold the Digitizer Boards, on which the analogue signals from the Beetle front-end chips are digitized and encoded into a Gigabit data stream for transmission via VCSEL diodes and 120m of multi-ribbon optical fibre to the counting house. In the counting house, the optical ribbons can be directly connected to TELL1 preprocessor boards equipped with two multi-channel optical receiver cards.



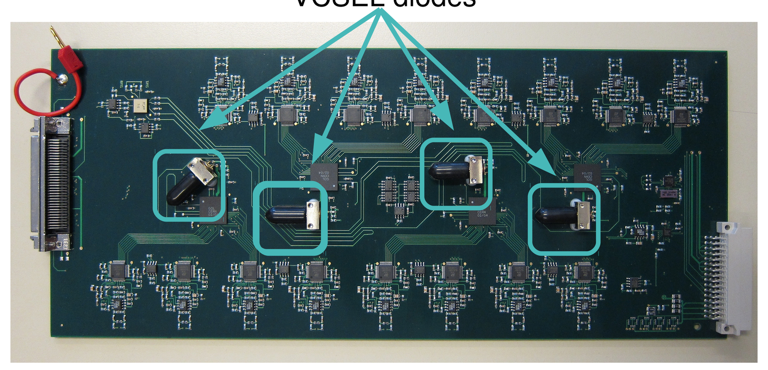



LHCb experiment

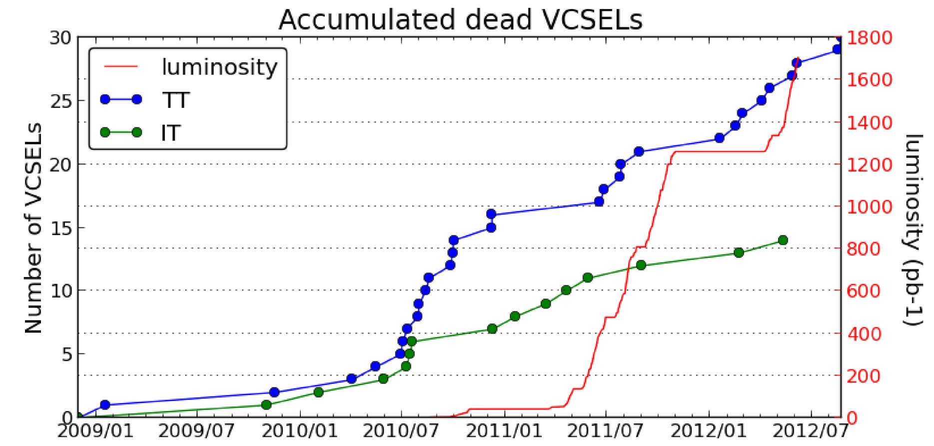
## VCSEL reliability

A study was already presented in TWEPP 2008.
The VCSEL diodes used in the readout system were wave soldered in production. 30% presented low output power, these were hunted and replaced.

Since then some other VCSEL diodes had to be replaced due to malfunction (only 2%). No significant correlation has been observed.




TT Digitizer Board



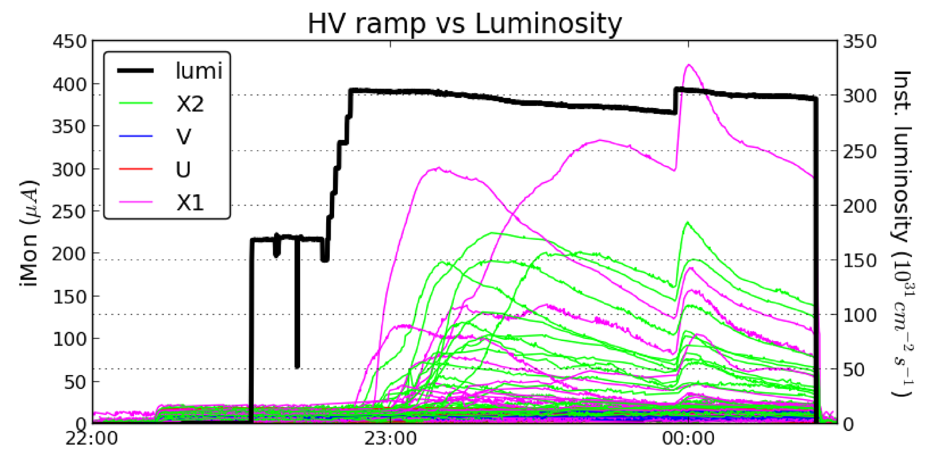

The VCSEL diodes are not exchanged "in situ", the whole digitizer board is replaced, and in the process multiple cables need to be unplugged, sometimes including the optical fiber carrying the clock signal. This has caused another problem, only understood this year.

## The TT High Voltage mystery

Since October 2010, various TT detector biasing voltage channels present peaks in the current that sometimes reach 1mA while taking data, and can reach 5mA with no beam, which leads to the trip of several HV channels.

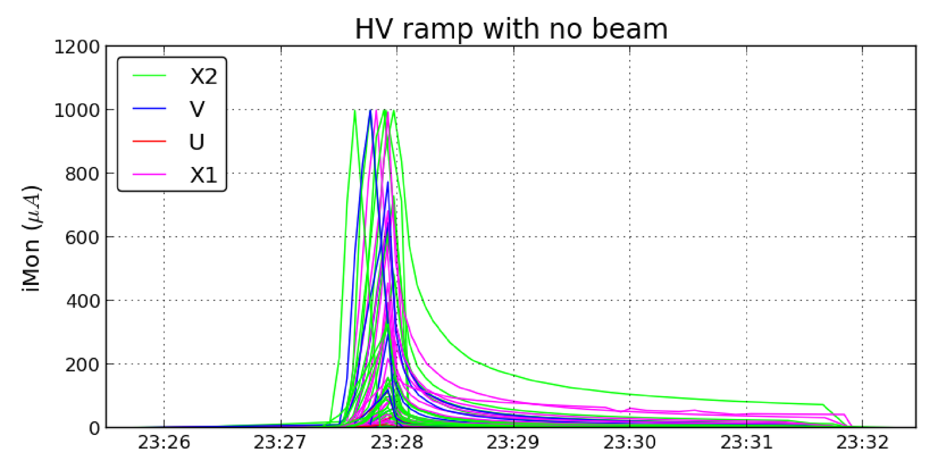
**Ramping HV with beam**

- Correlation effect with instantaneous luminosity ramp
- Moderately fast ramp up
- Slow ramp down
- Mostly X1 and X2 layers

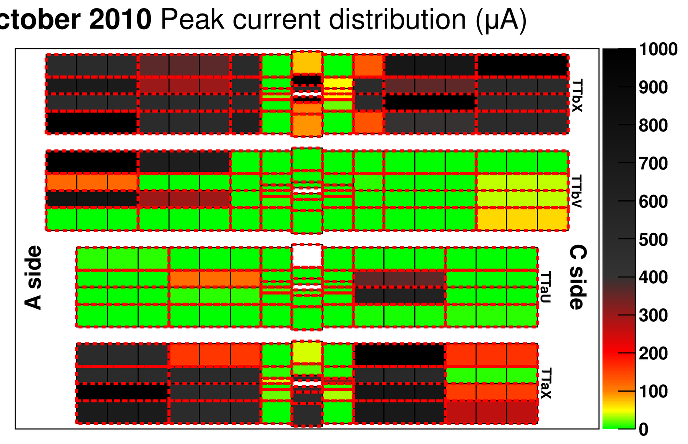



**Ramping HV with no beam**

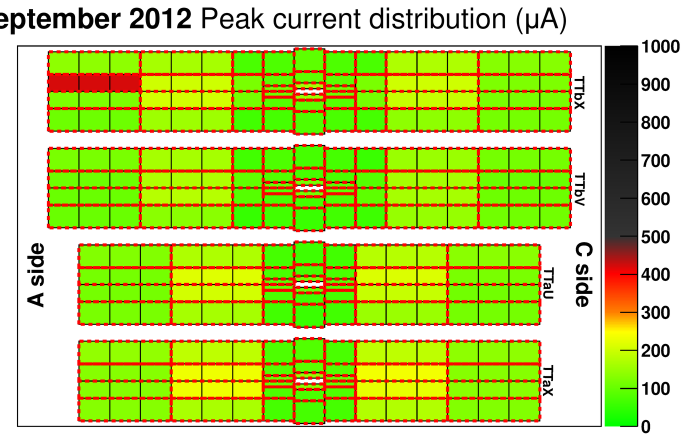
- Considerably higher peaks (Trip limit set at 1mA)
- Very fast ramp up and ramp down
- Training effect not conclusive
- Effect also observed in few channels for U and V layers




**October 2010** Peak current distribution (μA)



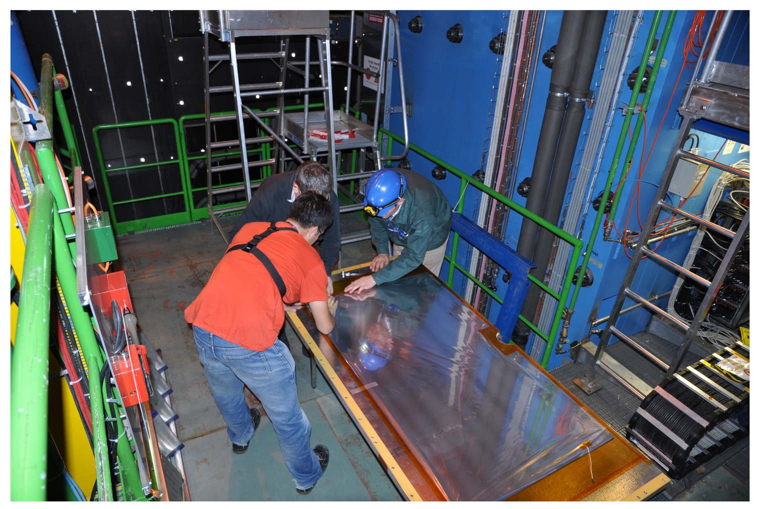

**September 2012** Peak current distribution (μA)




**The electrostatic shield**

U and V layers have the biasing voltage on both sides of the sensor, while X1 and X2 layers have the Detector box cover lid in one of the sides, connected to ground voltage.

MYLAR (since May 2012)
Aluminium foil (electrostatic shield, May 2012)
KAPTON (since May 2011)
Aluminium foil (existing cover lid)



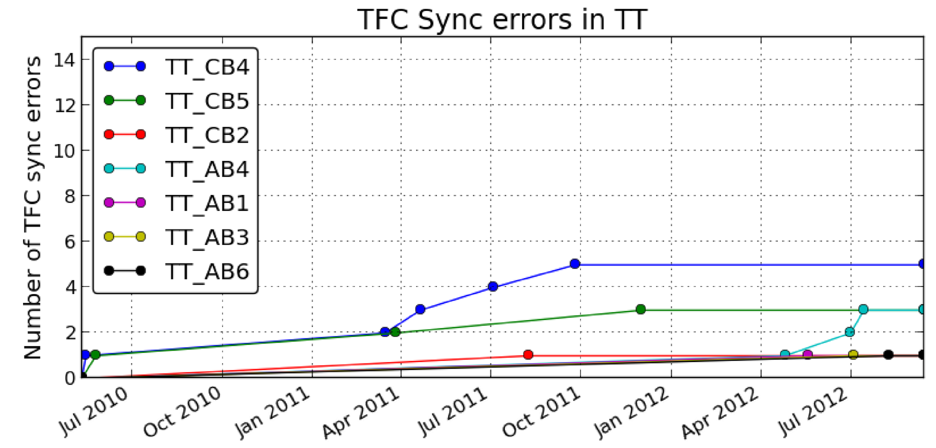
**Attempts/tests made in order to fix or palliate the problem:**

- Lowering the Voltage from 350V to 300V ✓
- Lowering the Temperature from 5°C to -15°C ✗
- Training the detector HV without beam ≈
- Luminosity leveling (ramp luminosity in small steps) ✓
- May 2012: Installing Kapton insulation (confined the problem to X layers) ✓
- May 2012: Installing electrostatic shield ≈
- **Mid June 2012: Keep HV and shield on after beam dump** ✓
- **Mid June 2012: Change in LHC beam filling scheme** ?

## Human induced clock synchronization problems

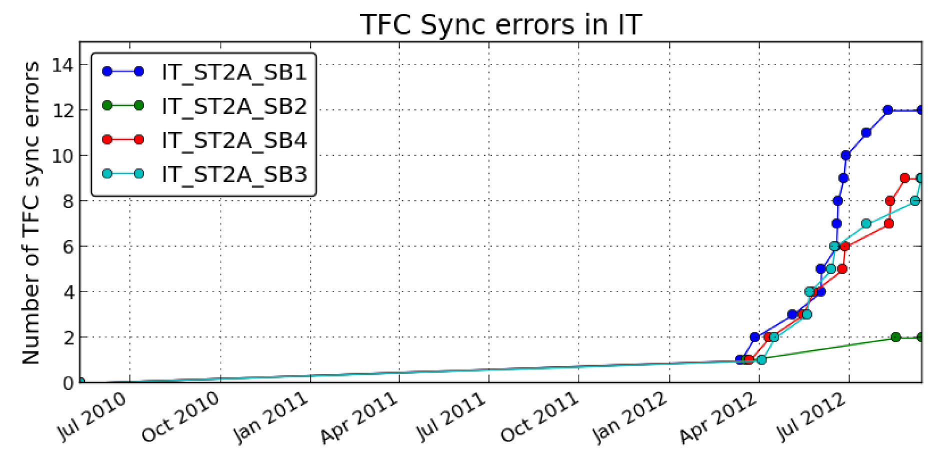
- May 2010. Since the start of operation in the shape of unphysical/wrong readings for Temperature sensors and LV regulators for TT
  - Found the cause for unphysical readings was the communication server (SPECS) could not read the DCU and sent back random values
- January 2012. Digitizer Board exchange for IT and TT during LHC Long Technical Stop for Winter 2011-2012
- March 2012. Problem appears also in IT, only in one half-station, with a higher rate than TT.
  - Between January and March 2012 it was masked by a software problem
- Discovered relation between these failures and an IncompleteEvents flag sent from the High Level Trigger
- Deduced problem was in the clock (TFC) fiber connection with the Control Board in the Service Boxes
- 19th April 2012. Software automatic recovery workaround was put in place. No access to the hardware
  - The automatic recovery takes almost 2 minutes since the error detection until the detector is taking data again

*Plots may be incomplete due to problem masking and loss of log files*

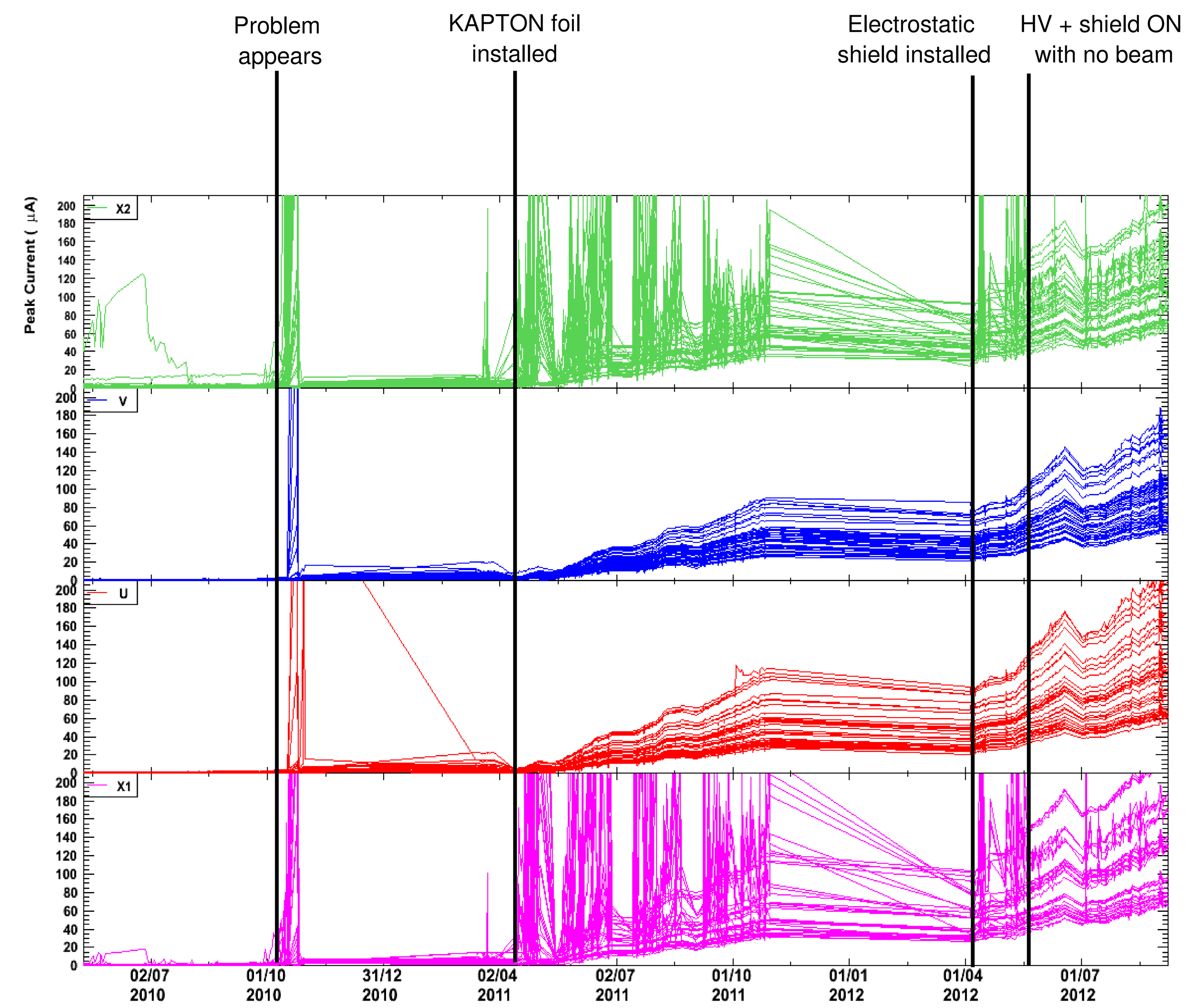



- Before January 2012, only seen in one quadrant (Cryo-Bottom).
- January 2012. VCSEL exchange operation.
- Afterwards, problem fixed in CB quadrant but now shows in AB (Access-Bottom) quadrant.

- Before March 2012, problem not observed
- January 2012. VCSEL exchange operation
- SPECS software problem until March 2012
- March 2012, problem shows in ST2A half-station
- 24th April 2012, attempt to clean the TFC fibers reduces the frequency of the problem.




**HV maximum current per fill vs time**



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