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On behalf of the LHCb-UT group

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Calibration and monitoring of the SALT readout ASIC for the LHCb UT detector

Calibration stability studies

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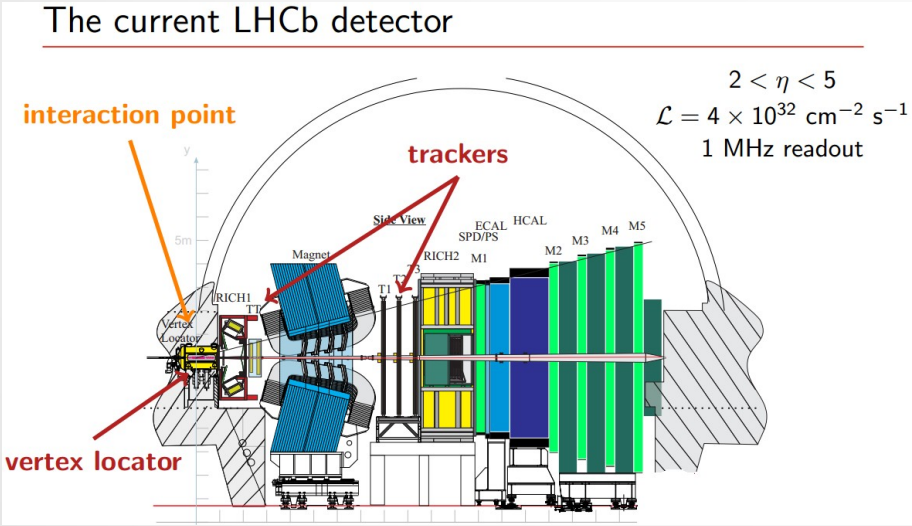
Outline

- Brief description of the LHCb experiment
- General motivation of the LHCb detector upgrade
- Few words about Upstream Tracker (UT) detector
- Motivation of the testbeam
- Testbeam analysis software (TbUT)
- Details of the calibration process
- Summary

The LHCb detector



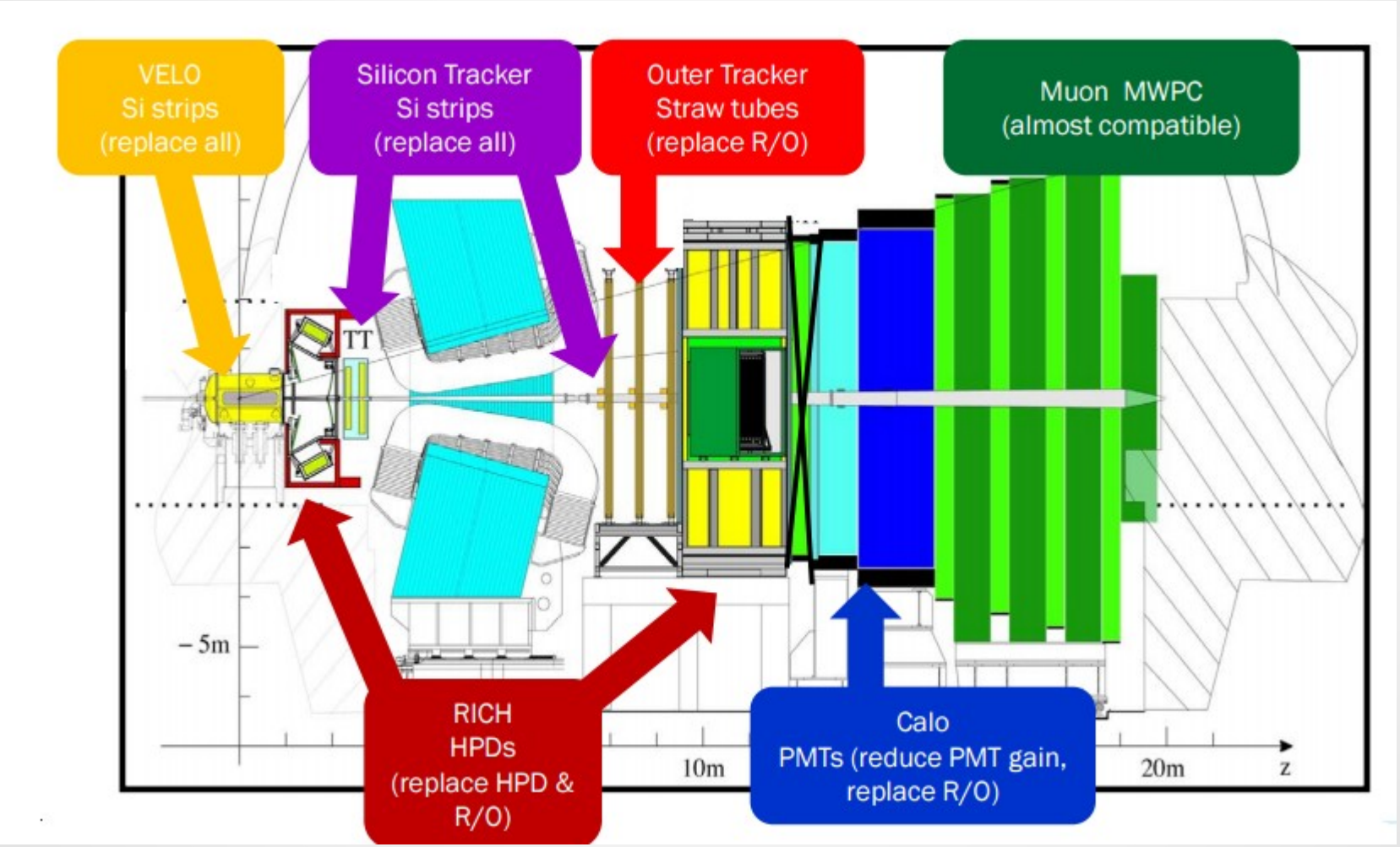
- The LHCb detector is dedicated for searching New Physics phenomena and precise CPV
- It is a single arm forward spectrometer, that covers pseudorapidity in a range <2,5>
- Complementary approach w.r.t. Atlas and CMS
  - Indirect search for New Physics using quantum loops
- One of the most important task - momentum measurement
- LHCb detector contains 3 tracking stations

Why we need to upgrade

- The present 1 MHz readout is a sever limit
  - We can collect only ~ 2-3 fb^{-1} per year
  - Many rare processes required more data
  - cannot gain with increased luminosity – trigger yield for hadronic events saturates
- Upgrade goals:
  - full event read-out at 40 MHz (LHC bunch crossing rate)
  - design new front-end electronics
  - redesign DAQ system
  - new flexible software trigger architecture
- Expect to collect about 50 fb^{-1} of data during Run III

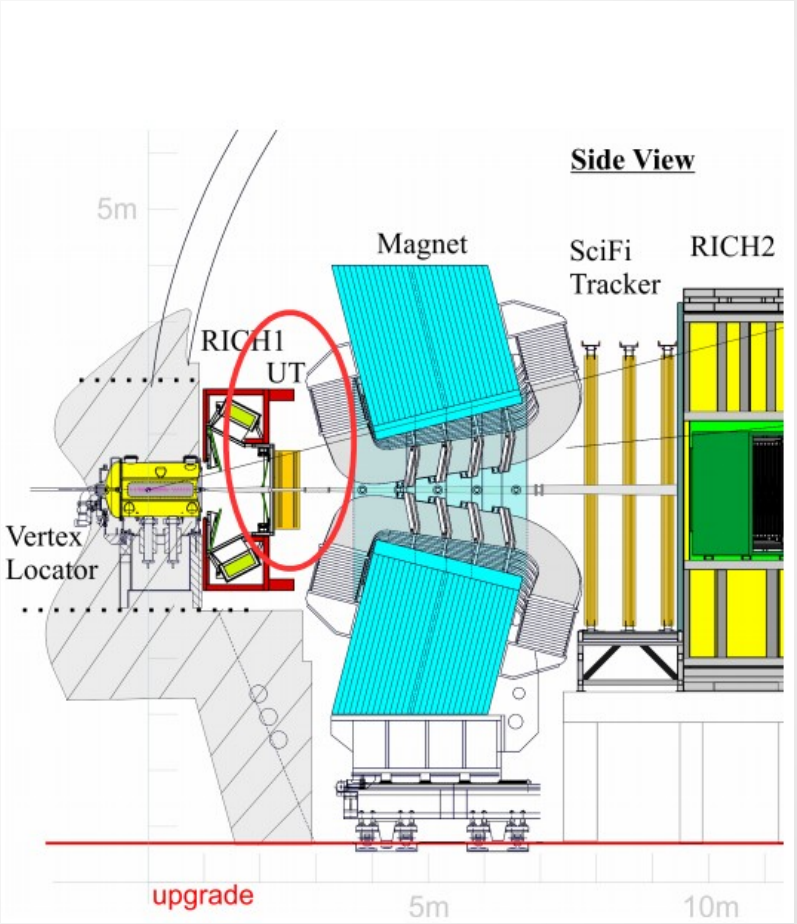
Expected implementation period 2019-20

The upgraded LHCb detector



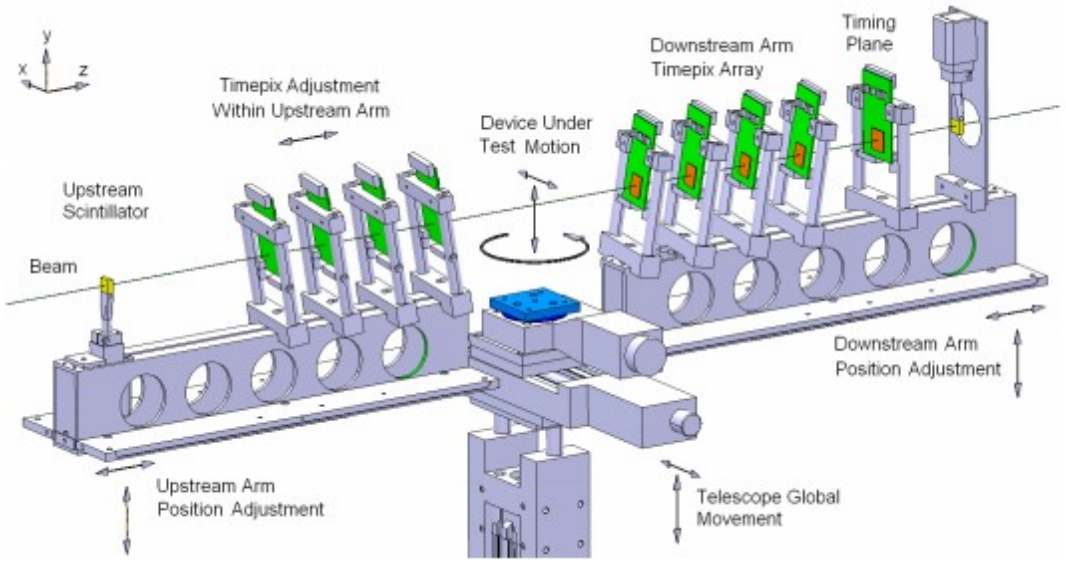
Upstream Tracker

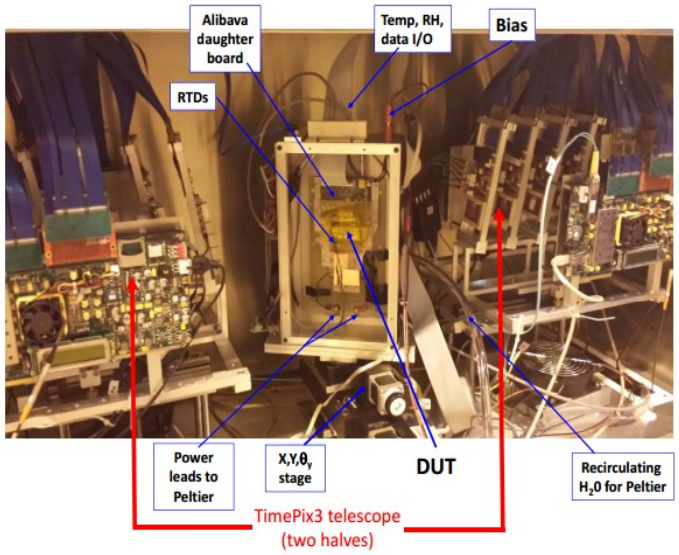
- Role in upgraded LHCb detector
  - Situated between VELO and SciFi tracker helps to reduce ghost track rate
  - Speedup of the trigger decision
  - Stray magnetic field allows fast momentum estimation
  - Improvement of the LHCb acceptance coverage
- Design challenges:
  - Increased luminosity
  - Read-out speed (40 MHz)
  - Radiation damage



Testbeams

- To build a new detector we need to be sure that all designed components work as expected.
- The testbeams are only way to verify correctness of the performance of sensors and readout chips.
  - all sub-detectors started their own Testbeams
  - in order to test new pixel chip VELO group created TimePix(3) telecope
  - can serve as a test bed for various DUTs
  - during the set of 2015 Testbeams the UT group used the TimePix telescope to test its sensors
  - Use telescope track to study DUT performance



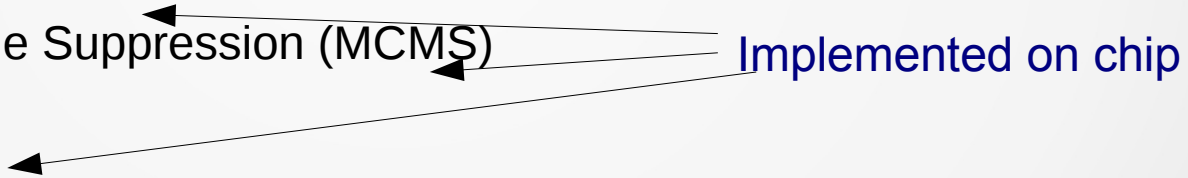


My activities during the testbeams

- All 2015 testbeam campaigns used SPS beams (North Area)
- Testbeam's goals
  - Landau distribution as a function of bias voltage
  - Cluster size vs bias voltage and angle of incidence
  - Noise performance
  - Resolution vs angle
  - Characteristic of a sensors near the quarter-circle region
- The most important part of my research was to prepare the data analysis software
- The key part of this software is to perform calibration

TbUT software platform

- The main aim of the designed and developed software platform is to emulate the SALT read-out chip – specifically the DSP algorithms
- It is also used to process data taken during testbeams.
- The DSP emulation sequence consists of the following steps:
  - Raw Data decoding and formatting
  - Pedestal subtraction
  - Mean Common Mode Suppression (MCMS)
  - Zero Suppression
  - Clusterisation



- The emulation suite requires the appropriate configuration parameters
  - Calibration procedure!
- The platform also generates set of monitoring plots

Calibration

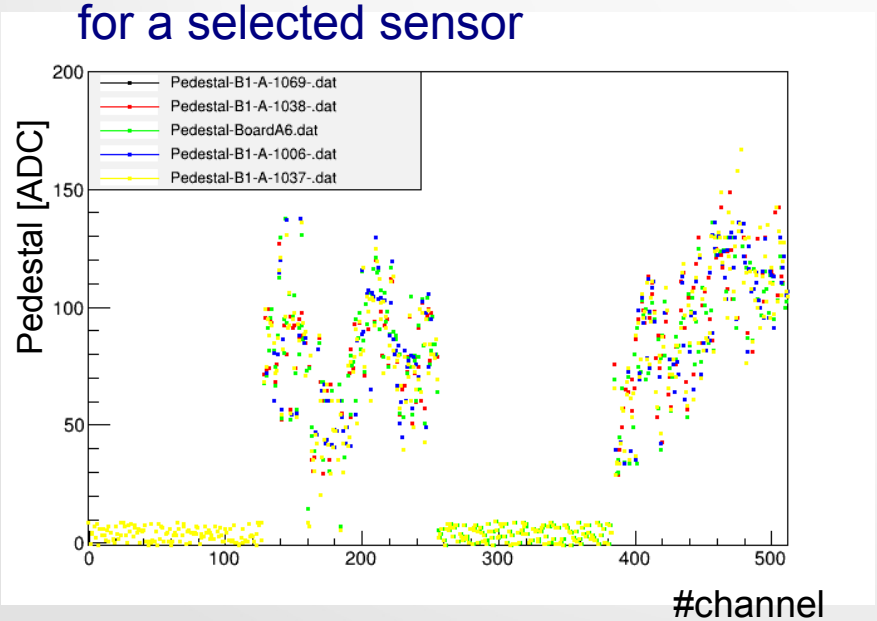
- Using Machine Learning terminology calibration can be interpreted as a training and the rest of the TbUT algorithms as a regression problem
- TbUT calibration is performed to evaluate:
  - Pedestal values - one integer value per readout channel
  - MCMS thresholds – one floating point number per chip
  - Zero Suppression thresholds - one floating point number per readout channel
  - Dead/noisy channels - boolean value

Pedestal calculation and stability study

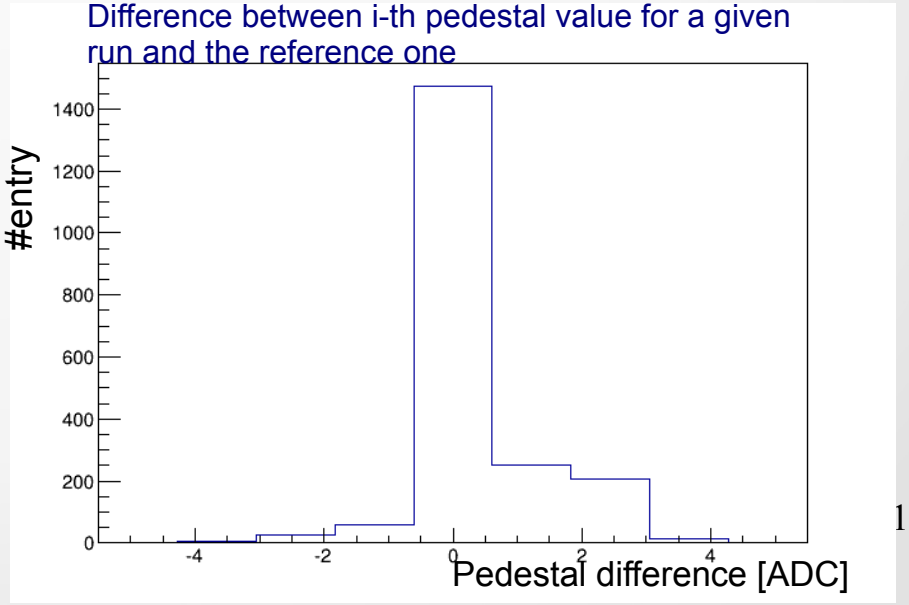
- The Pedestal values are calculated for each channel separately.
- As a model (ML) the TbUT uses running average.

Time dependent analysis proved that the pedestals are stable

Pedestal value per channel for a selected sensor



Difference between i-th pedestal value for a given run and the reference one

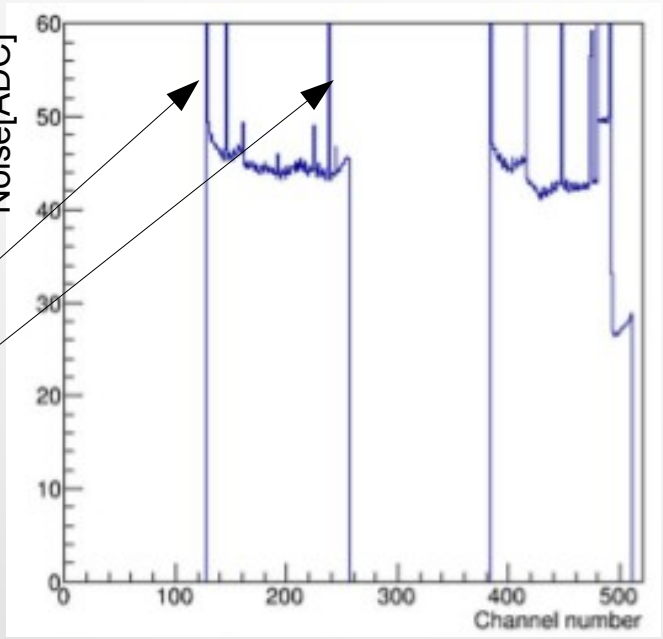


ZS Thresholds and dead channels detection

- The software platform is able to calculate the noise
- The noise is used as a cluster threshold in clusterization algorithm
- Decision if a channel is dead or not is also made based on the noise

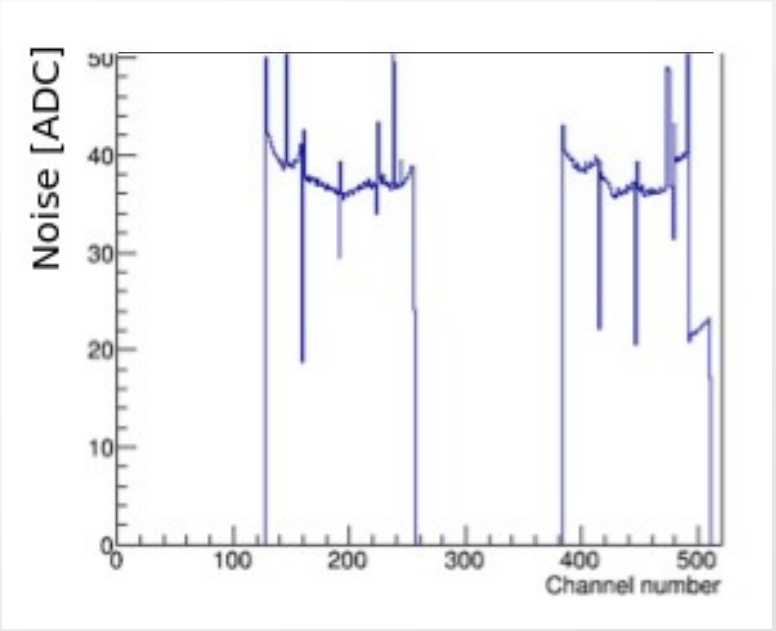
Results for two different, exemplary sensors

The noise vs channel number



Noisy channels need to be masked

The noise vs channel number



Summary

- UT is crucial for charged particle tracking and trigger decisions for upgraded LHCb.
- The UT sensors are being tested
- The first note has been published [Nucl.Instrum.Meth. A806 (2016) 244-257]
- The critical point of these testbeams was to develop generic data analysis software
- This software will be used in the future to calibrate and monitor of the performance of the UT detector [Acta Phys.Polon. B46 (2015) 1263-1269]
- **Vital for high quality physics data**

Thank you for your attention!