Automatised Data Quality Monitoring of the LHCb Vertex Locator
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on behalf of the LHCb Collaboration
22nd International Conference on Computing in High Energy and Nuclear Physics, Oct 10-14, 2016

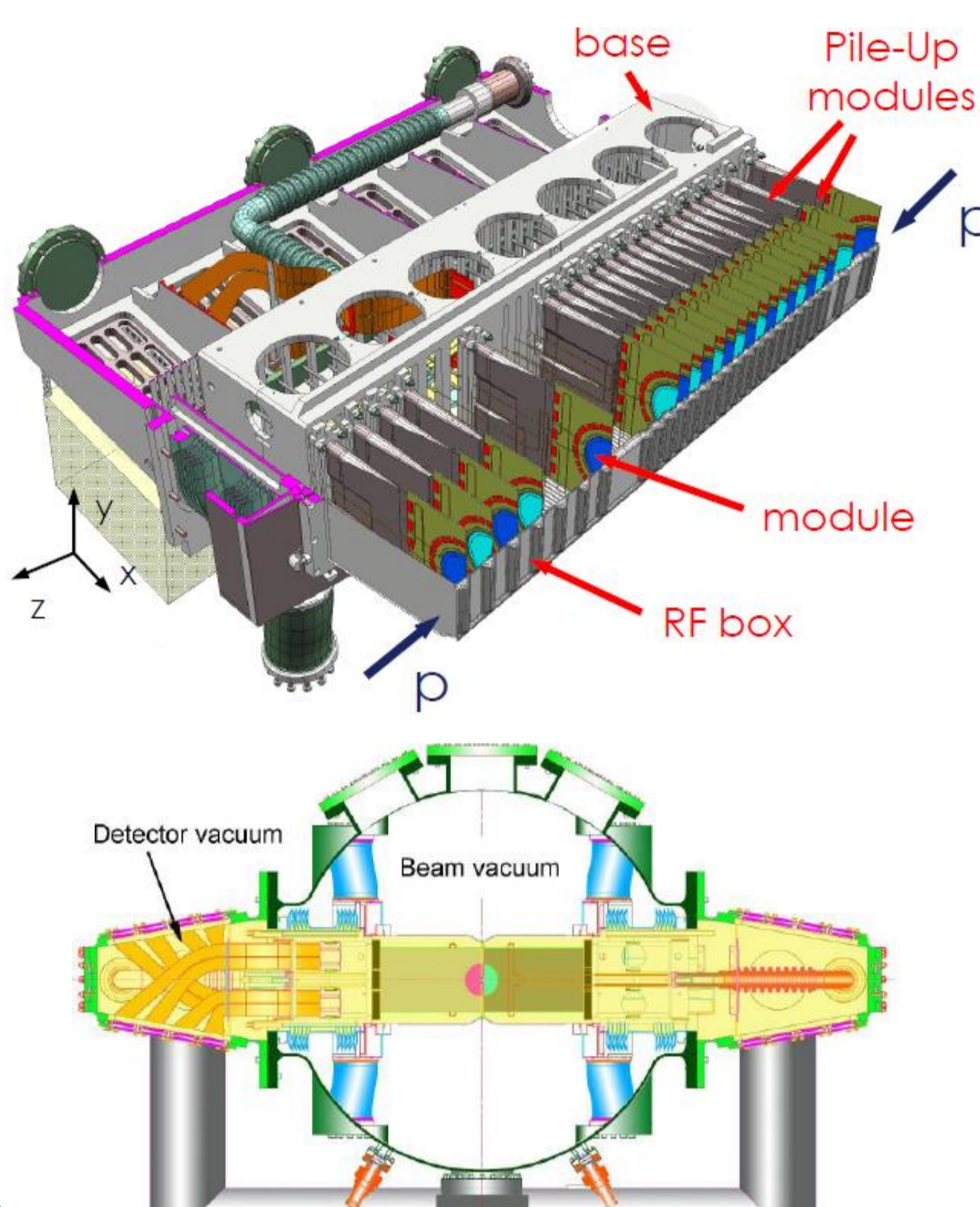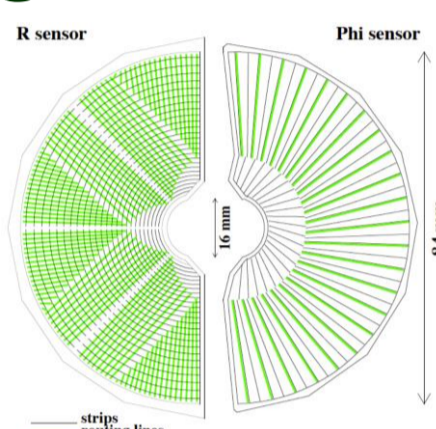## The LHCb VELO

base
Pile-Up modules
p
module
RF box
Detector vacuum
Beam vacuum

- Silicon micro-strip vertex detector
- Two retractable detector halves
- One half comprises of 21 stations
- Each station has an R- and ϕ-type sensor
- Close to 170 000 read out channels
- Operates in secondary vacuum – separated from the LHC vacuum by 300 μm foil
- CO_2 cooling system – working point @-30° sensors are kept @-10°
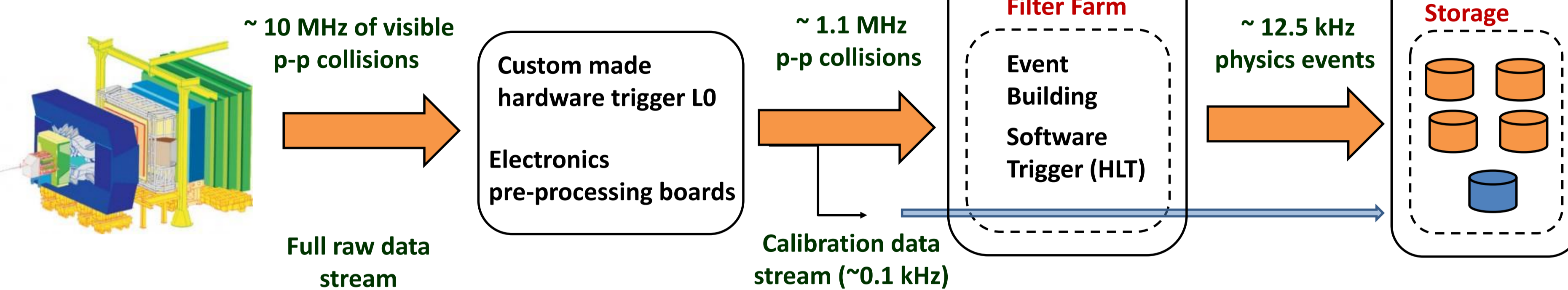
6 cm injection
stable beams

R sensor   Phi sensor

Impact parameter resolution
$\sigma_{IP} \sim 20\ \mu m$
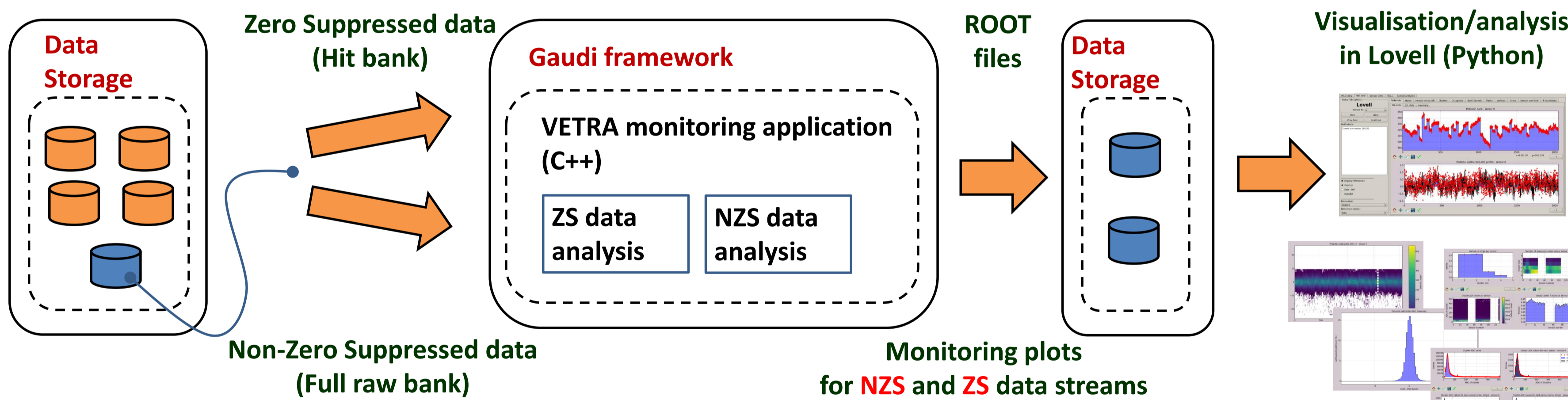for high p$_T$ tracks

New approach for monitoring in Run II

- LHCb VELO (VErtex LOcator) is a sophisticated device responsible for precise track reconstruction around the crossing point of proton beams
- **Critical** for the **primary** and **secondary vertex** reconstruction and the **impact parameter** resolution performance
- Each channel is individually read out and then processed by dedicated electronics boards that requires around **one million calibration constants**
- **Monitoring and control of such involved system is not trivial!**

- In order to efficiently cope with it on daily basis a **major re-design** of the VELO monitoring system, comparing to Run I, has been done
- The full chain of data processing and analysis **is triggered automatically** when fresh data arrives (data driven system)
- A dedicated analysis module reduces the data by calculating appropriate statistical measures that are subsequently used in long-term **trending plots**
- It is also possible to calculate a **single metric** that represent the **condition of the whole detector** – this flag may be used to detect specific problems

Monitoring software platform

~ 10 MHz of visible p-p collisions

Custom made hardware trigger L0

Electronics pre-processing boards

Full raw data stream

~ 1.1 MHz p-p collisions

Calibration data stream (~0.1 kHz)

Event Filter Farm
- Event Building
- Software Trigger (HLT)

~ 12.5 kHz physics events

Data Storage

Calibration data stream

- LHCb can initially reduce the input data stream from ~ 10 to ~ 1.1 MHz using its hardware (L0) trigger
- Data are then processed by the software (HLT) trigger which results in ~ 12.5 kHz of events written up to disks (persistent storage)
- Small portion of the data are not compressed, they are passed through the trigger and used for monitoring

Data Storage

Zero Suppressed data (Hit bank)

Gaudi framework
VETRA monitoring application (C++)
- ZS data analysis
- NZS data analysis

ROOT files

Data Storage

Visualisation/analysis in Lovell (Python)

Non-Zero Suppressed data (Full raw bank)
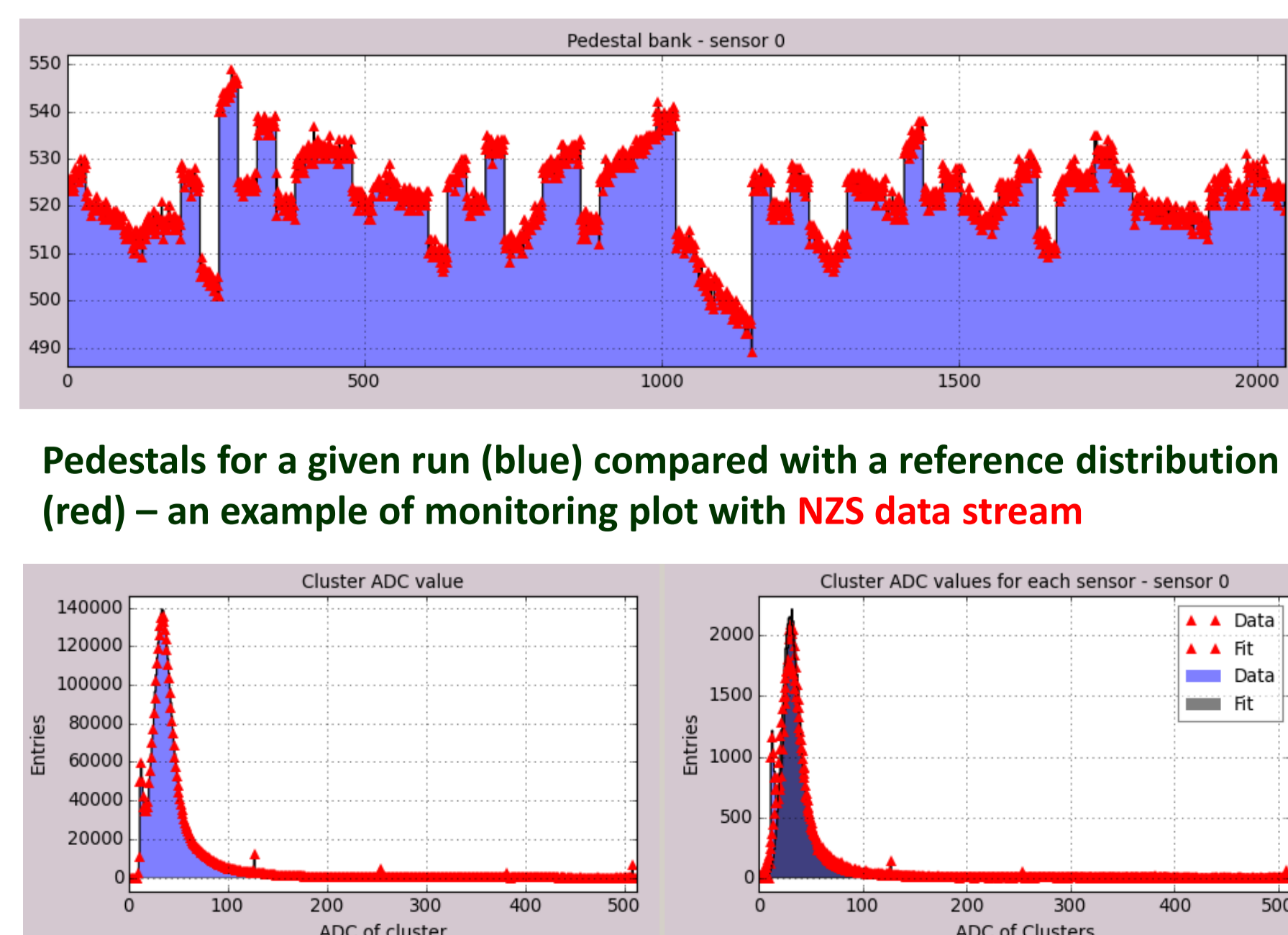
Monitoring plots for NZS and ZS data streams

Data processing and visualisation

- The calibration data are first processed by the VETRA application, which is a part of the official LHCb software (Gaudi)
- Processing is done automatically by a dedicated cron job
- VETRA is able to handle both ZS and NZS streams and produce appropriate histograms representing the detector state
- These monitoring plots are then analysed by Lovell

Lovell GUI overview

Major GUI tabs (input data content dependent)
Sub-tabs for respective data analyses
Sub-tabs for concrete monitored variables/features

Navigation panel
Messaging window
Data displaying modes
Drop-down menus for data files selection

VELO view | Run view | Sensor view | TELL1 | Special analyses

Global Tab Options

Lovell

Sensor ID: 0
Prev | Next
Prev Four | Next Four

Notifications:

Pedestals | Noise | Header cross-talk | Clusters | Occupancy | Bad Channels | Tracks | Vertices | Errors | Sensor overview | IP resolutions

VELO Overview | Per Sensor (Channels) | Per Sensor (Strips) | Average Distribution | Per Link Map

RMS CMS noise vs. station (neg. for C-side)

☒ Display References
● Overlay
○ Data - Ref
○ Data/Ref

Run number:
184183
Reference number:
184181

Main display pad

Lovell GUI views

Pedestal bank - sensor 0

Pedestals for a given run (blue) compared with a reference distribution (red) – an example of monitoring plot with **NZS** data stream

Cluster ADC value

Cluster ADC values for each sensor - sensor 0

ADC of cluster

ADC of Clusters

Deposited Energy in VELO sensors for a given run (blue) compared with a reference distribution (red) – an example of monitoring plot with **ZS** data stream