Search for Right-Handed Weak Decays with LHCb

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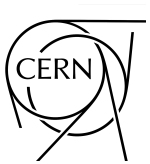

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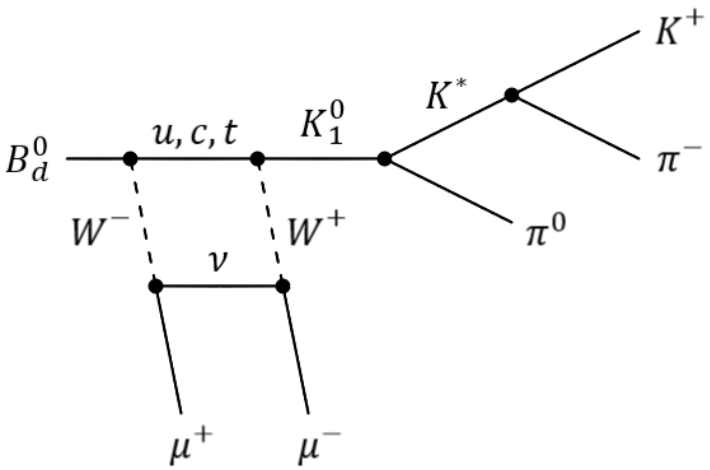
Theory – Motivation

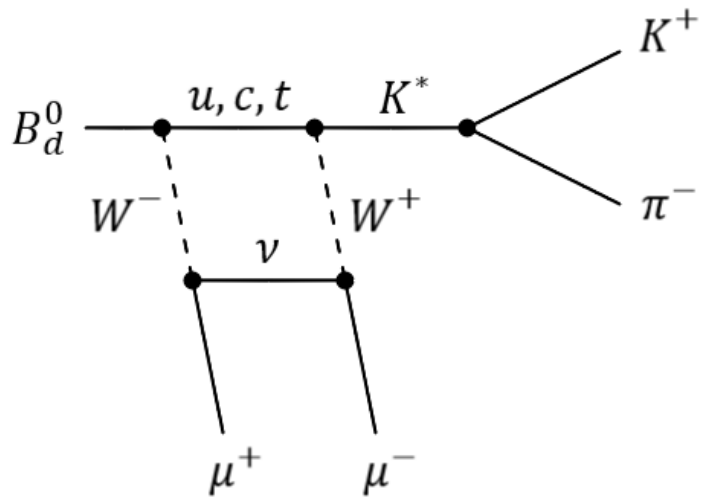
- Standard Model Weak interactions only couple to left-handed particles.
- No specific theoretical reason for this, falls out of surrounding theory and has agreed with observation.
- Right-handed weak decays may exist but are 'drowned out' by existing Standard Model left-handed decays.
- Past searches have limited sensitivity and set constraints.
- *Parity Doubling* - Comparing two decay channels with parity degenerate states effectively cancels out left-handed contributions.

Theory – Decay Channel

Feynman Sketches



(Signal Channel)



(Normalisation Channel)

- Flavour Changing Neutral Currents (FCNC). Standard Model interactions that proceed only through boxes and loops.
- Additionally highly suppressed by the GIM mechanism $\rightarrow$ Rare decays.
- Effective couplings are very well predicted, deviations from SM are easy to see.
- The K_1 and K^* states have the same spin but opposite parity, they are (almost) parity-degenerate states.

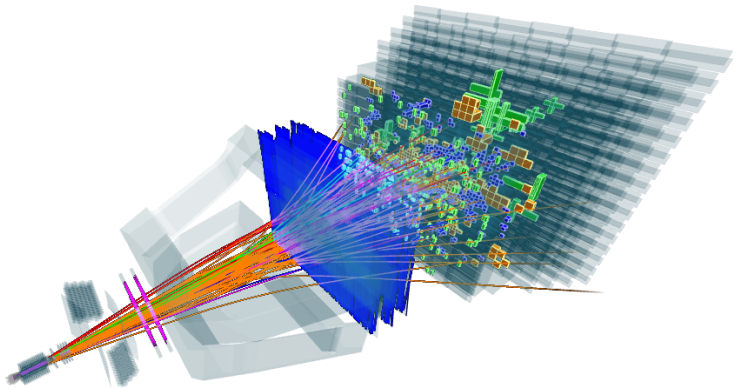
Theory – Aims

- Discover the $B_d \to K_1^0 J/\psi$ decay.
- Make a measurement of the branching fraction via:

$$\mathbf{R} = \frac{\mathcal{B}(B_d \to J/\psi K_1^0)}{\mathcal{B}(B_d \to J/\psi K^*)}$$

- Use the K_1 and K^* channels to perform a sensitive search for the relative contributions of left- and right-handed weak currents in B decays.

Candidate Selection – Partial Reconstruction



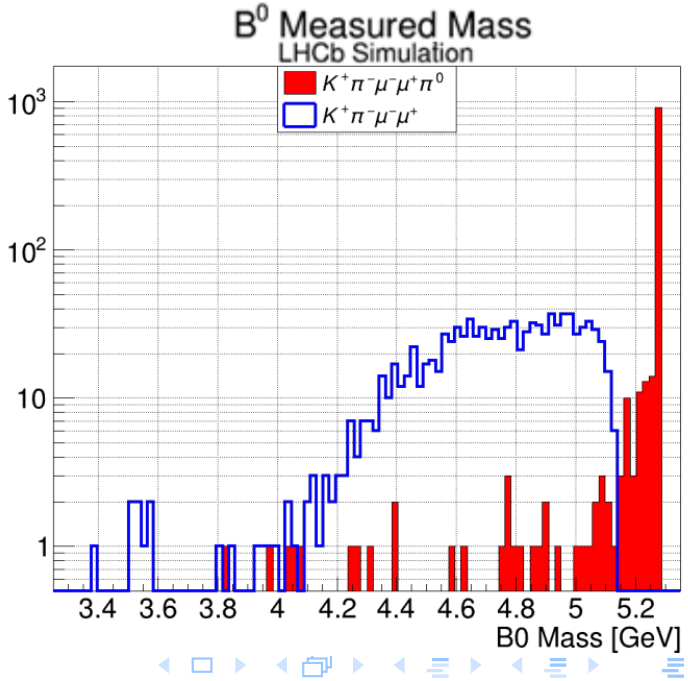
Full reconstruction including the π^0 is not viable for multiple reasons:

- Very low π^0 reconstruction efficiency ($\sim$3.7 %).
- Very busy hadronic event and neutral reconstruction information.

$\rightarrow$ Little signal & large combinatorial background.

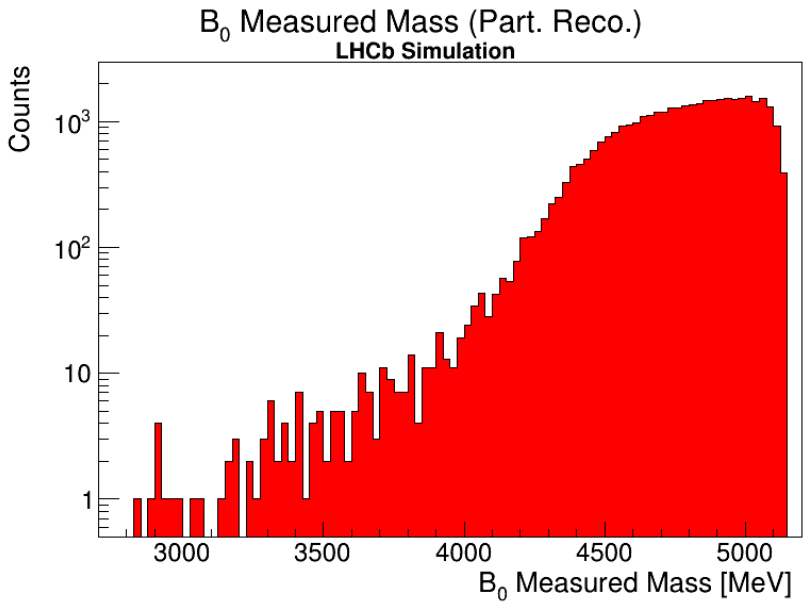
Partial reconstruction results in:

- Huge increase in found signal events.
- Very few combinatoric background events.
- A significantly wider signal region.

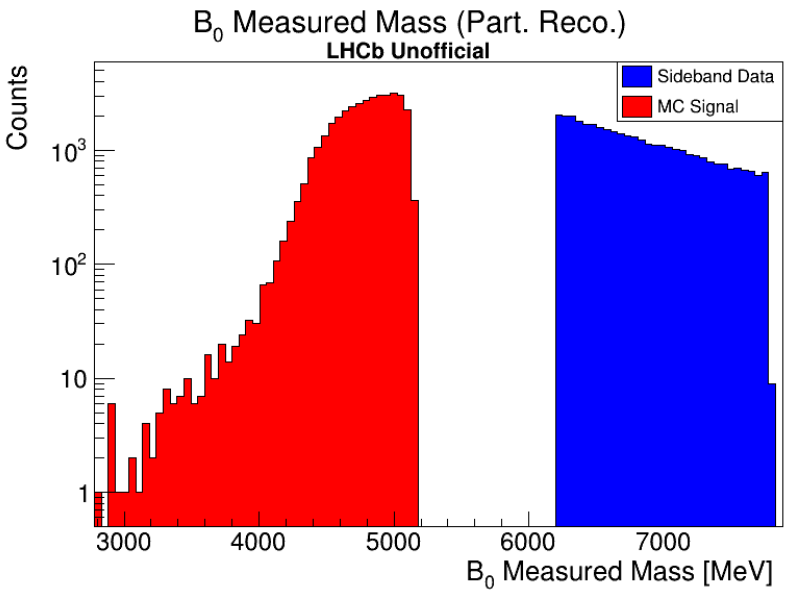


Candidate Selection – Triggers

- Developed a trigger for the Run-2 software which filters previous LHCb data (2016/17/18) for this channel.
- Developed a trigger for Run-3 data collection this year and beyond, planning for data collection beyond the current analysis.
- Both triggers optimised using an MC generated signal and background samples for the best signal efficiency.
- Much wider mass window than other analyses, triggers feature tighter particle identification to compensate.

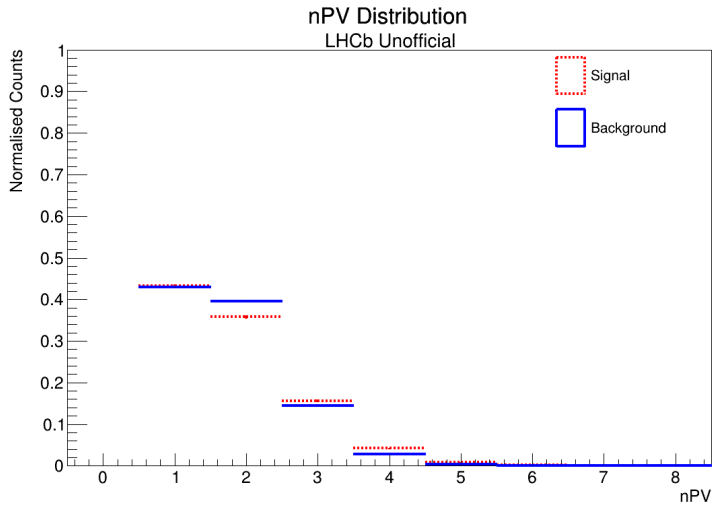


Multivariate Analysis – Overview

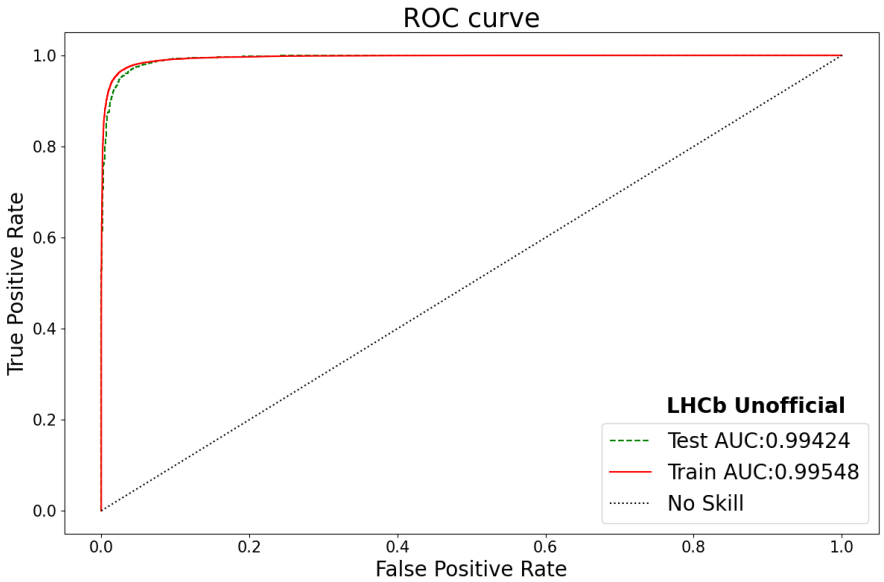


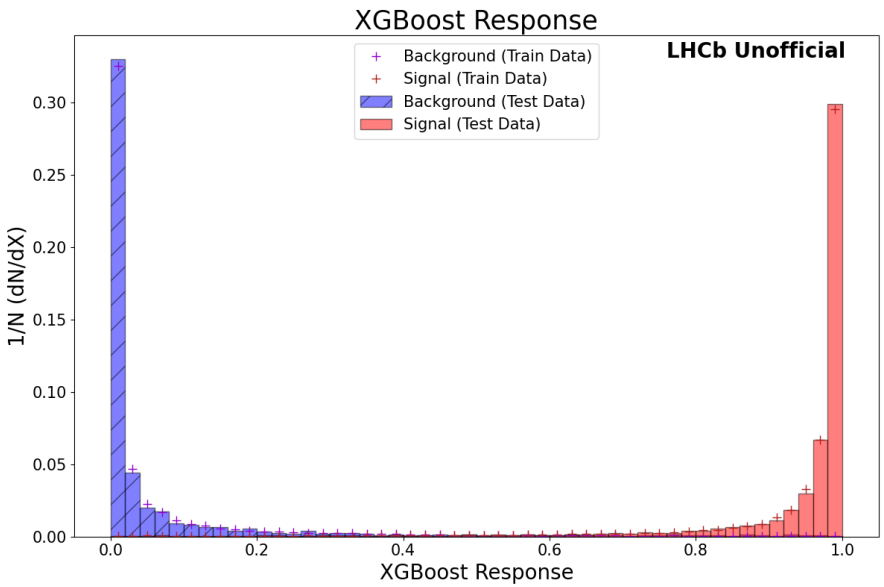
- XGBoost Classifier used to reduce the combinatorial background.
- Sideband data as a background proxy & truth matched MC signal events as a signal proxy.
- High-mass sideband (>6200 MeV) to avoid B enriched regions.

- Weight corrections account for differences between data and simulation - e.g. number of primary vertices (nPV).



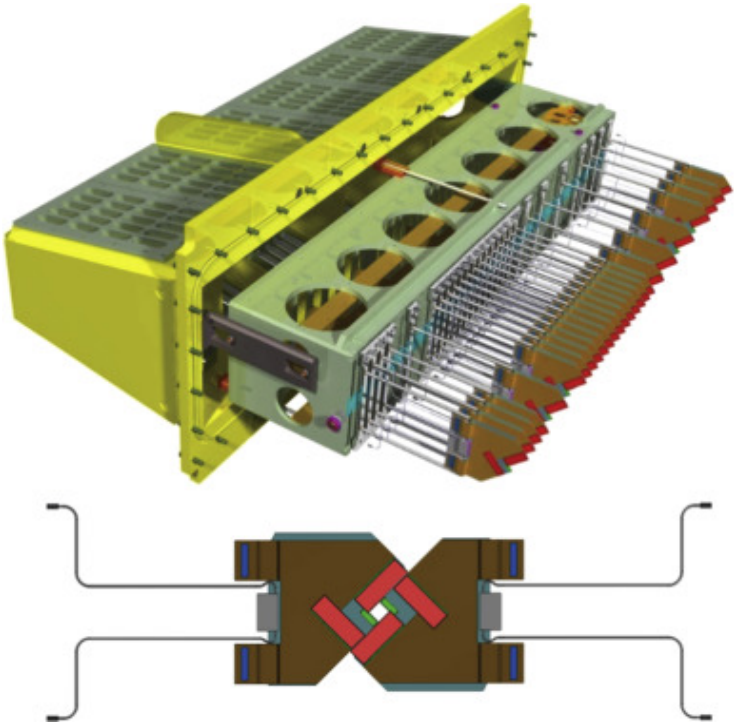
Multivariate Analysis – Current Status





- Considerably reduces the expected combinatorics in the signal region.
- Large errors associated with the prolonged extrapolation.
- Current estimate looks promising for next steps!

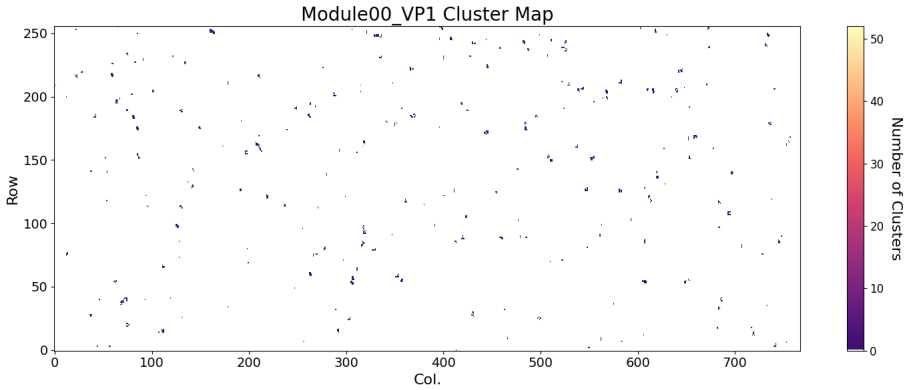
VELO – Overview

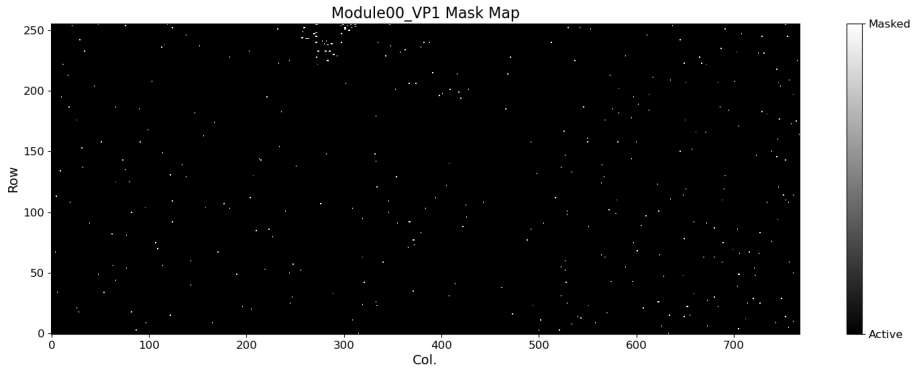


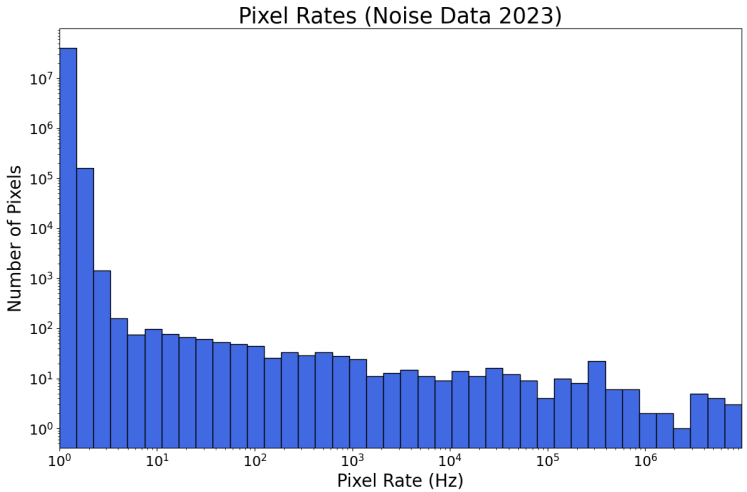
- Vertex Locator (VELO) is a silicon based pixel tracking detector.
- Composed of 52 modules at 26 stations.
- Modules are extended to reach $\sim 5\,\text{mm}$ from the beam.

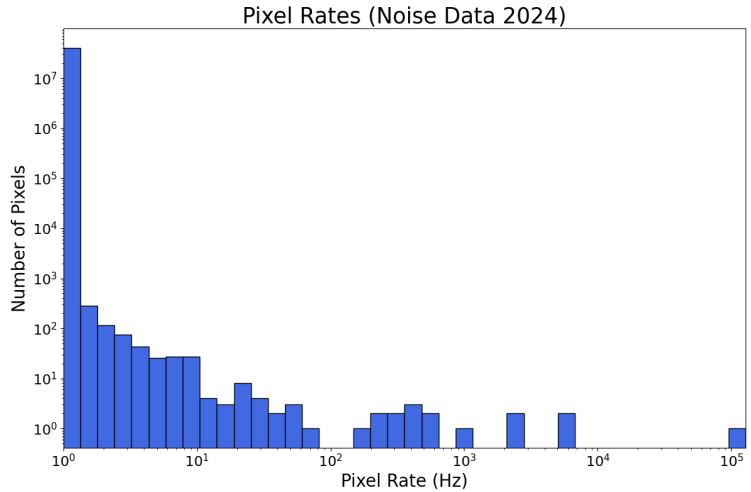
VELO – Noise Studies

- Aim is to minimise noise via masking, monitor noise, and investigate any anomalies.
- Considerable noise reduction over the past year of commissioning.





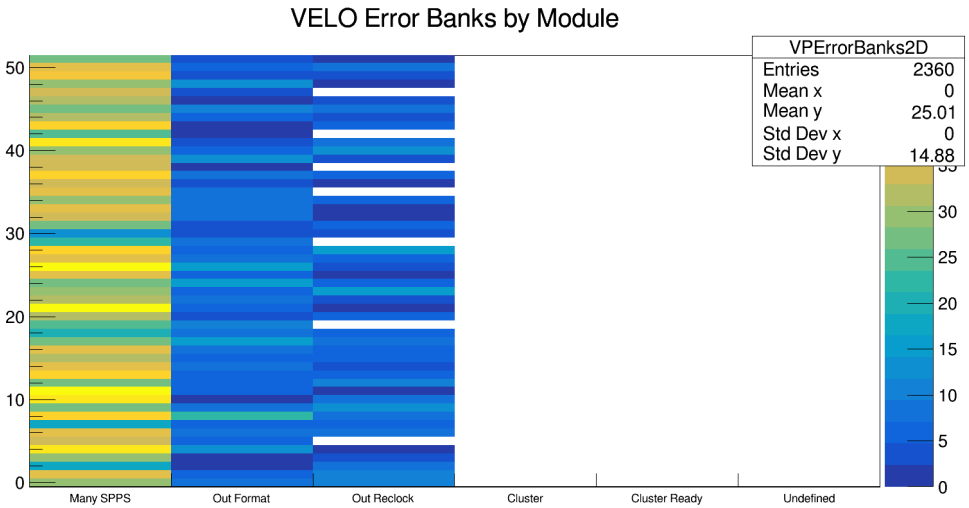


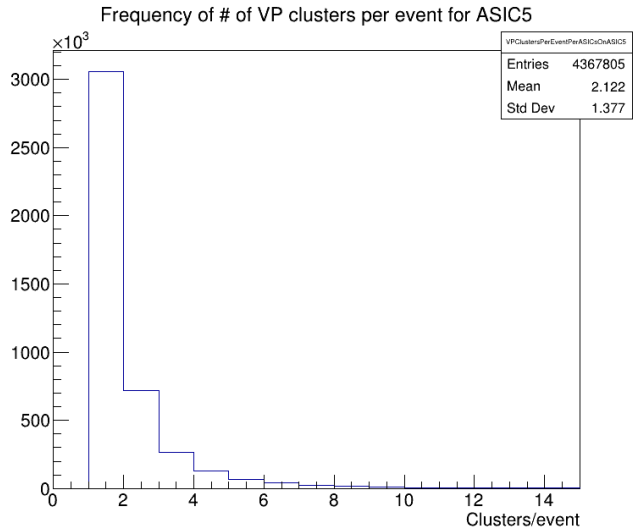


VELO – Monitoring

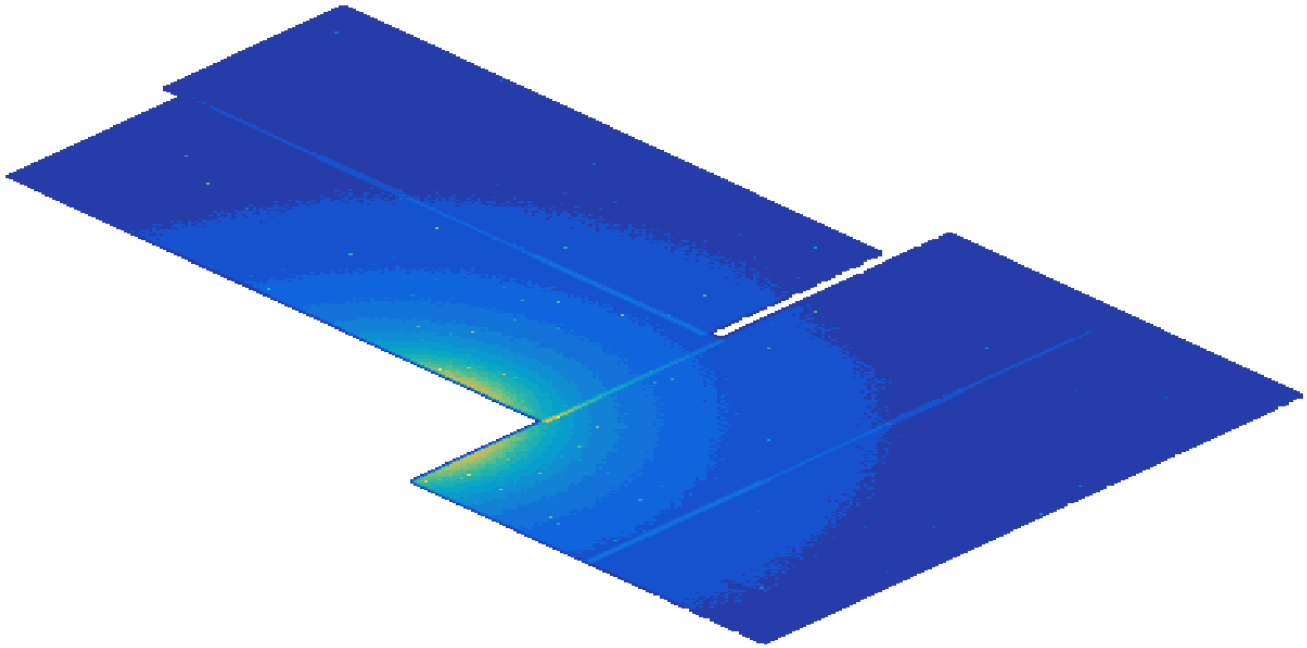
Made various contributions to LHCb's monitoring service:

- Created additional plots for monitoring the noise.
- Created plots to monitor VELO errors.
- Added a filter for isolated empty-empty events.





VELO – Ongoing Work



Global Cluster Map for A-Side

- Increased activity of Run-3 is causing single event upsets, resulting in random noise throughout data taking.
- Working to automatically reconfigure chip columns with excess noise.
- Further work to automatically mask or flag real noisy pixels.

Summary & Outlook

- Selections for data collection across Run-2 and Run-3 are complete.
- Analysis of the Run-2 data is underway.
- Starting background sample generation and fitting.
- The variety of decay channels within the partially reconstructed shoulder of the B_d^0 peak will present a challenge in the fitting.
- Future analysis can benefit from the larger data samples provided by the Run-3 trigger.
- Significant noise reduction and resolutions to final issues are underway for the VELO.

Thanks for listening!