



UNIVERSITY OF
LIVERPOOL

Teaching a machine to recognize charged-particle tracks

Giuseppe Costantino

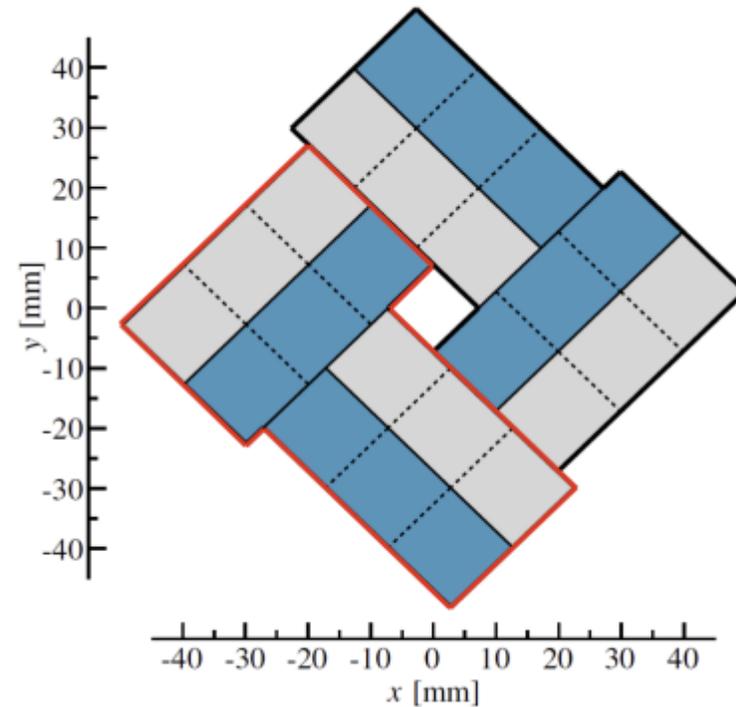
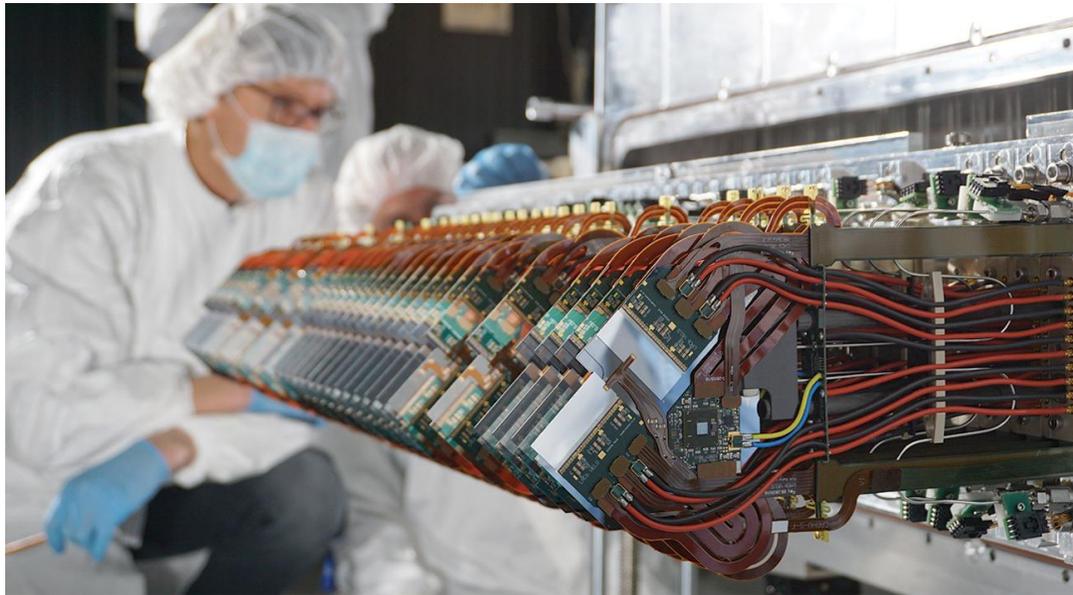
Supervised by: Karol Hennessy, David Hutchcroft, Tara Shears

PhD Project

- Exploring **Machine Learning** techniques for particle tracking in HEP experiments
- Run and evaluate ML algorithm performances on **compute accelerators** such as FPGAs and GPUs
- General approach, model learns from **physics**
- LHCb **VELO** used as target of test for trigger reconstruction
- During 1st year, **simulated data** is used

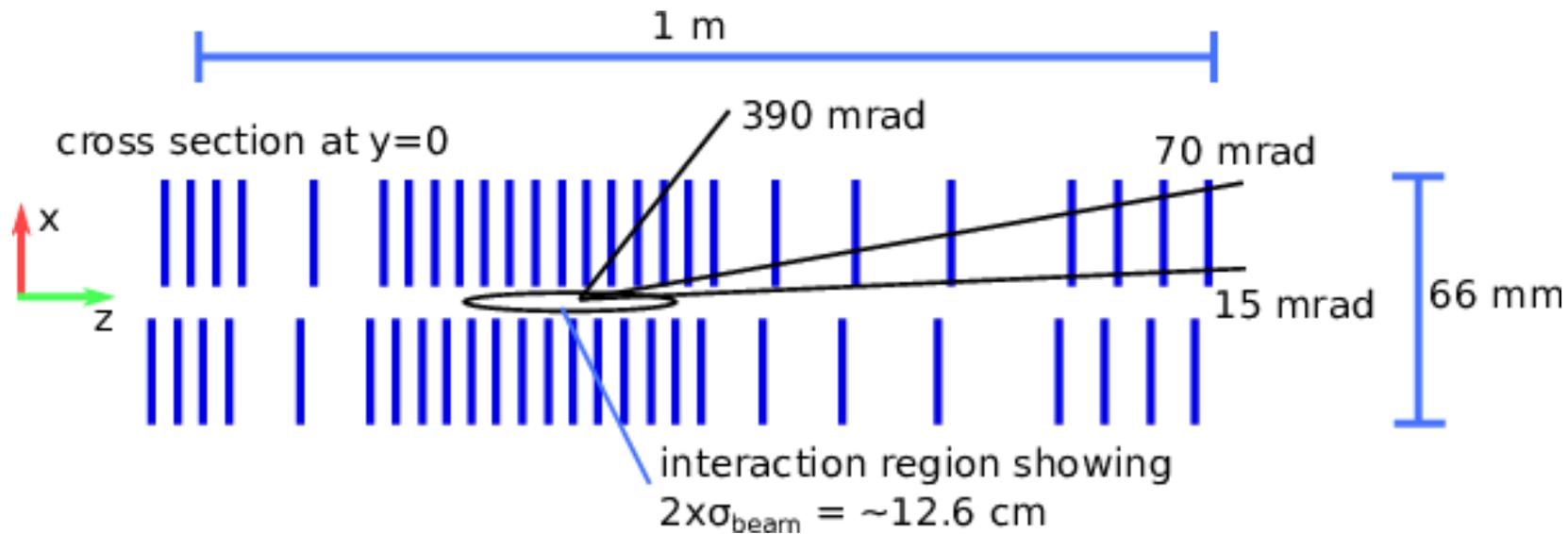
Vertex Locator Upgrade

- VELO upgrade consists of 52 silicon pixel modules arranged in two halves (A and C side)
- Pixel size of $55 \times 55 \mu\text{m}$

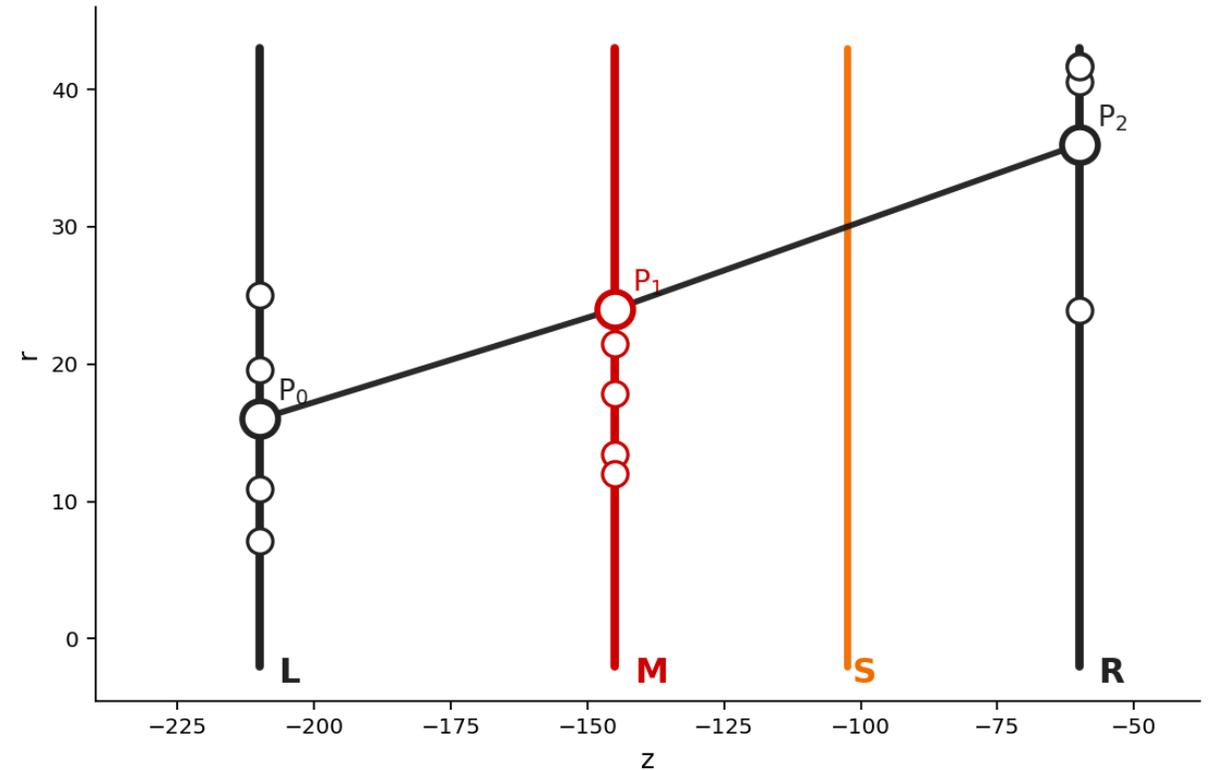
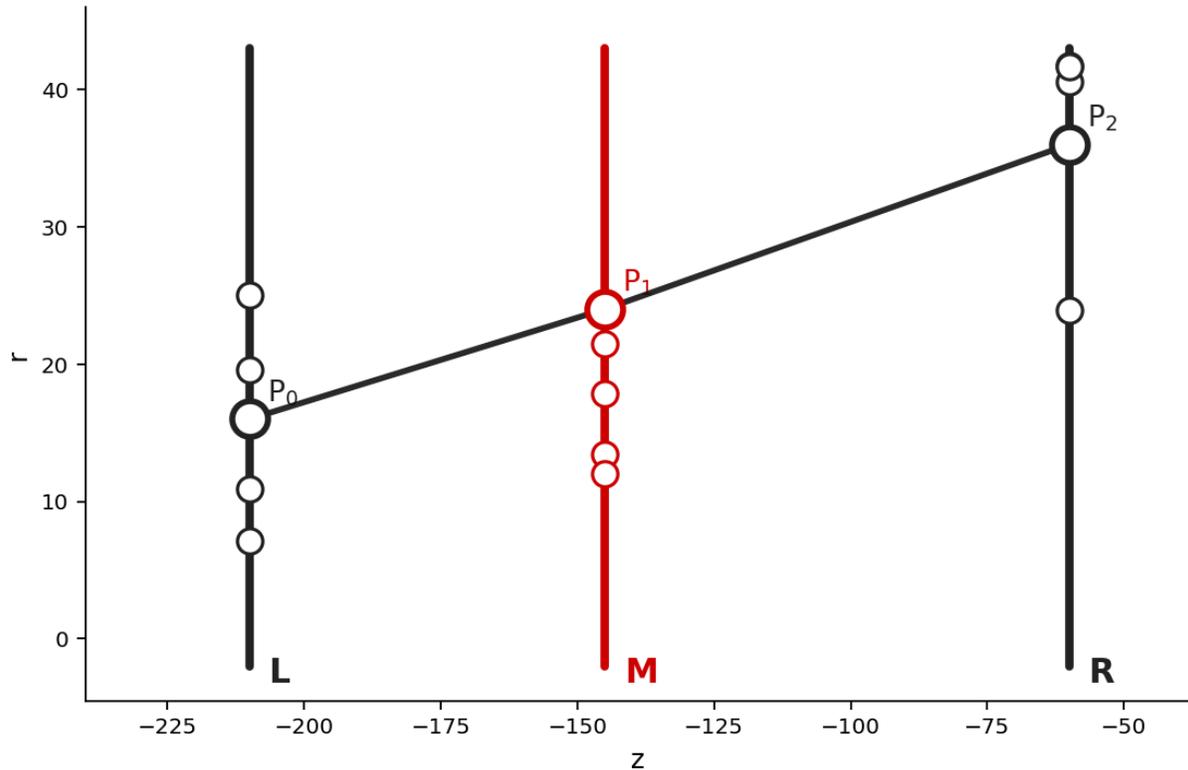


Vertex Locator Upgrade

- The VELO surrounds the IP and is the only sub-detector in which the collisions occur, in a small elliptical region.
- VELO's purpose is to reconstruct primary and secondary vertexes with extremely high precision.



Triplet generation



- Φ window: each cluster is required to lie within a window $|\Delta\phi| < 0.1$ rad of the previous cluster

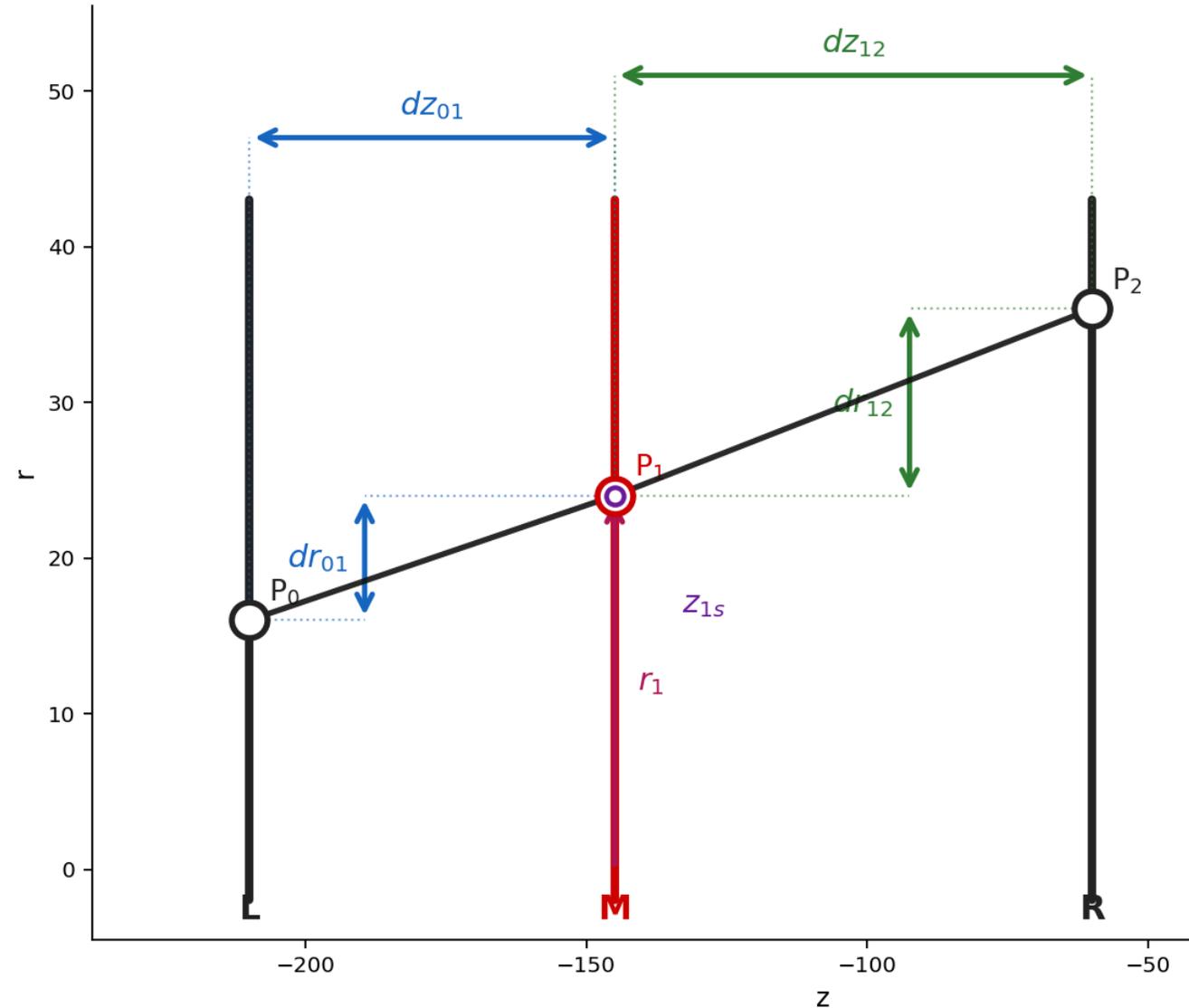
Feature engineering

The final dataset is then split in 3 balanced sets:

- Training set: 36M
- Validation set: 7.7M
- Test set 7.6M

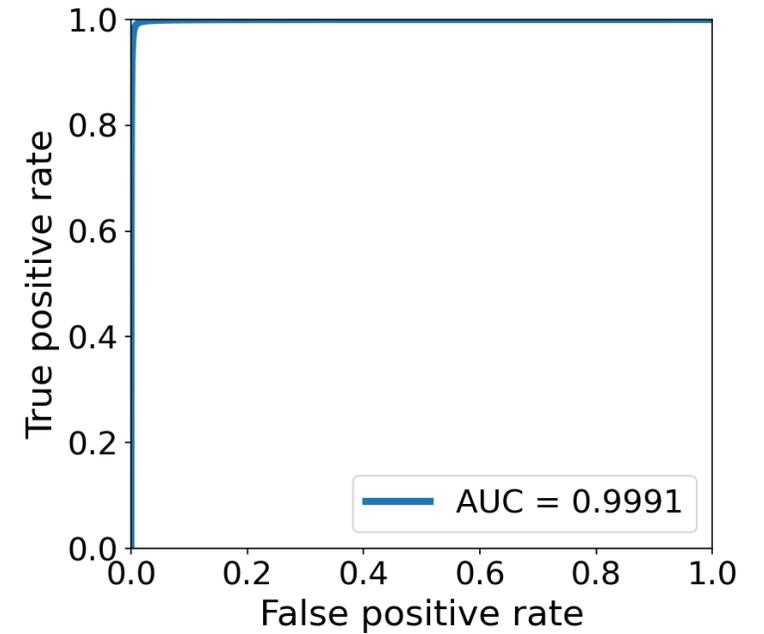
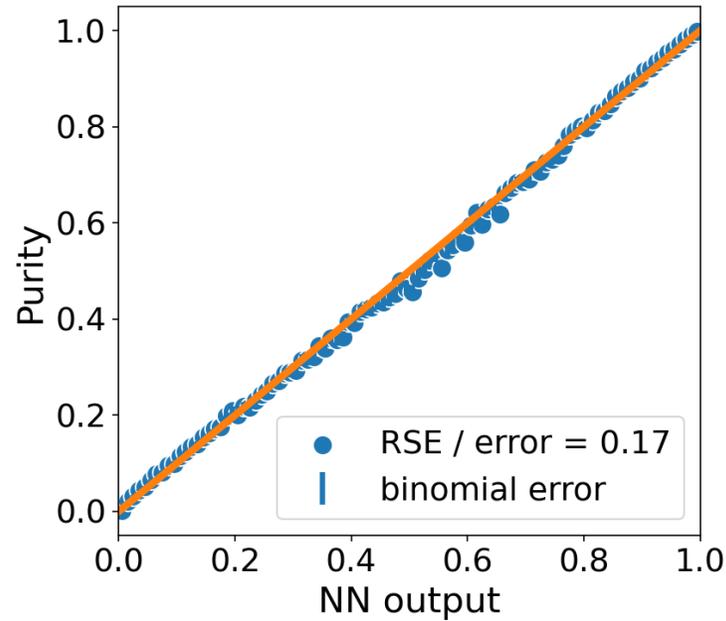
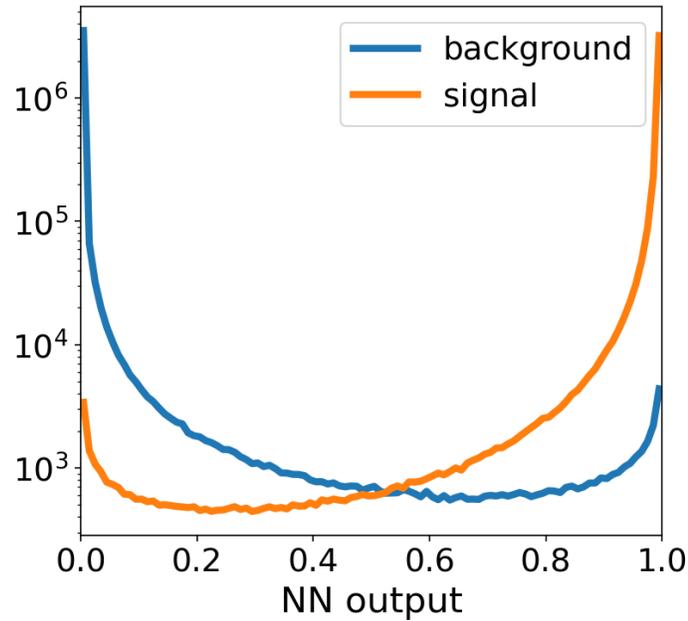
Each dataset has:

- ~40 events per run
- ~130k triplets per event

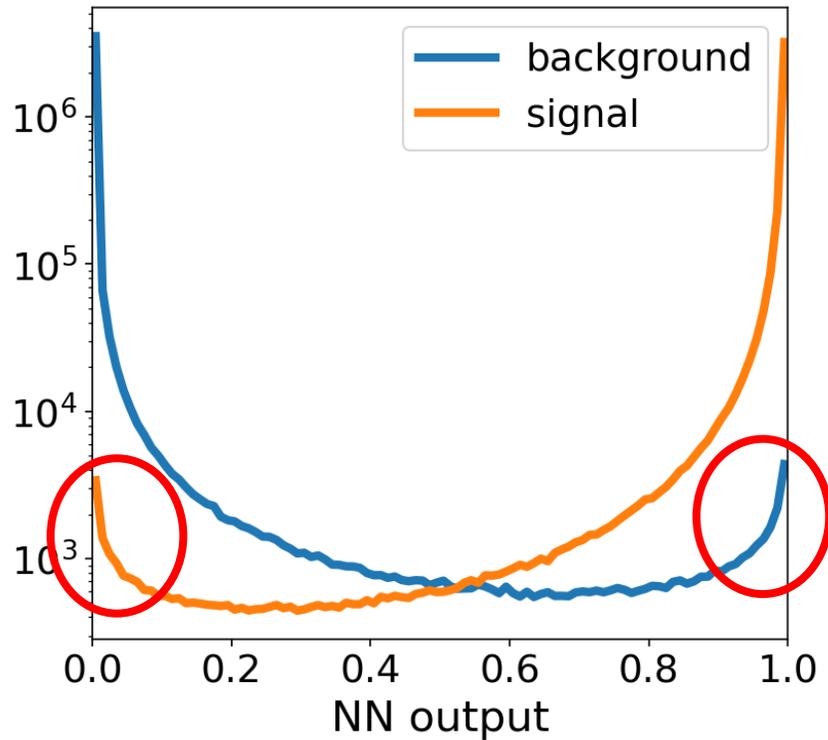


Training and evaluation

Triplet classification all (eng9) layout=(9, 16, 16, 1) split=test



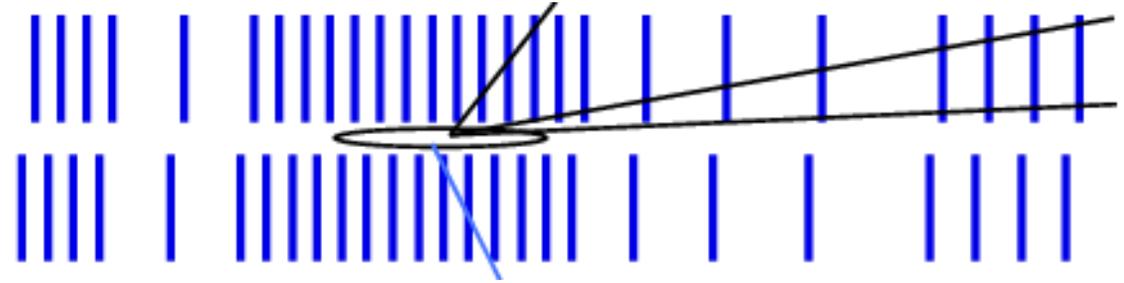
Ongoing work



- Not a problem:
 - Specific VELO regions
 - ϕ or η
- Maybe a problem:
 - Electrons
 - Low momentum ranges

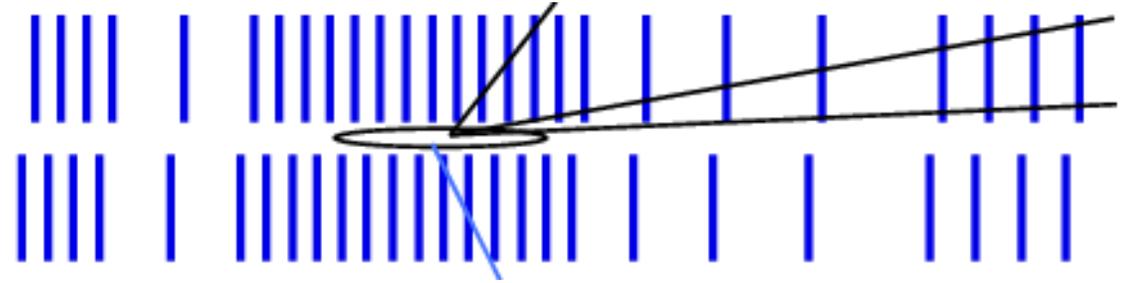
Future work

- Full tracks
 - Stitching triplets together
- Compute acceleration implementation
 - CUDA: NVIDIA platform for GPUs
 - FPGA: reprogrammable integrated circuit
 - Intel oneAPI: model for work with CPU/GPU, based on SYCL
 - Comparison between them
- Other detectors



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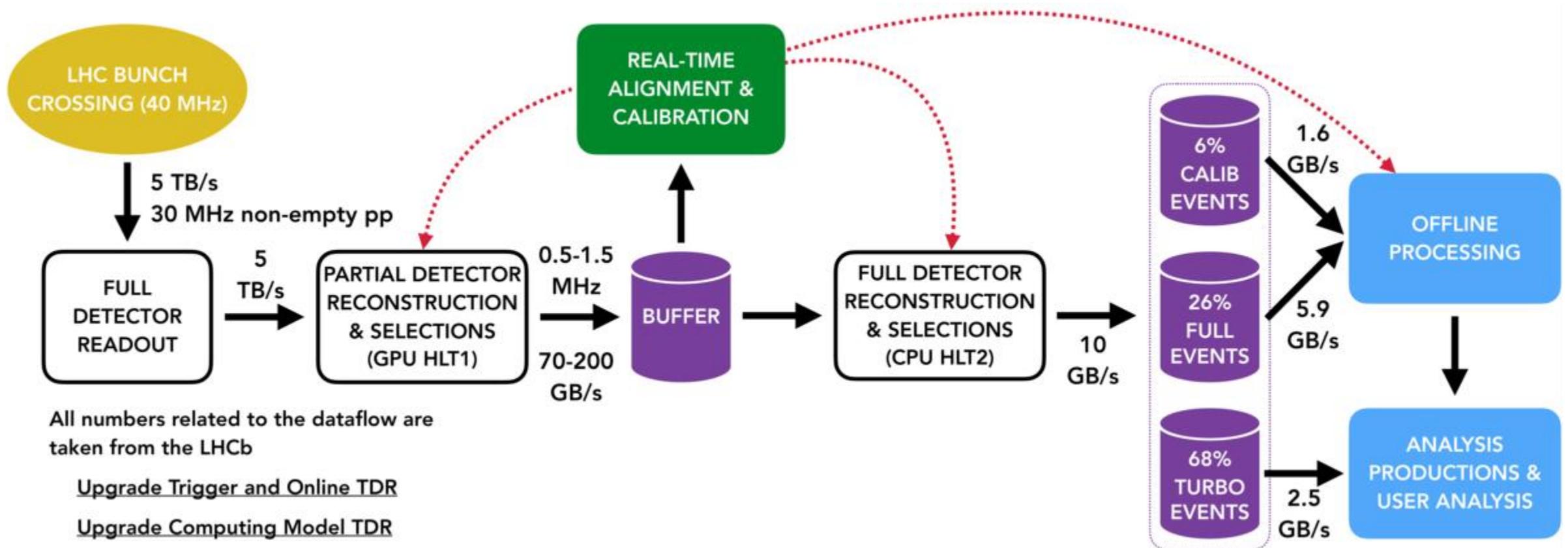
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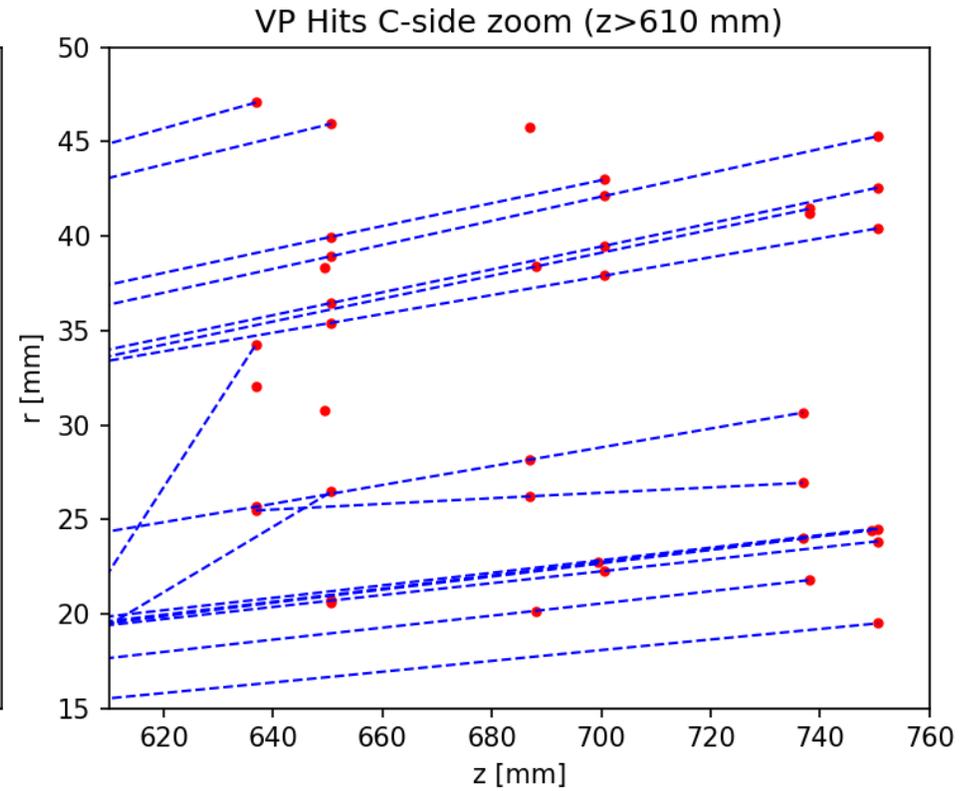
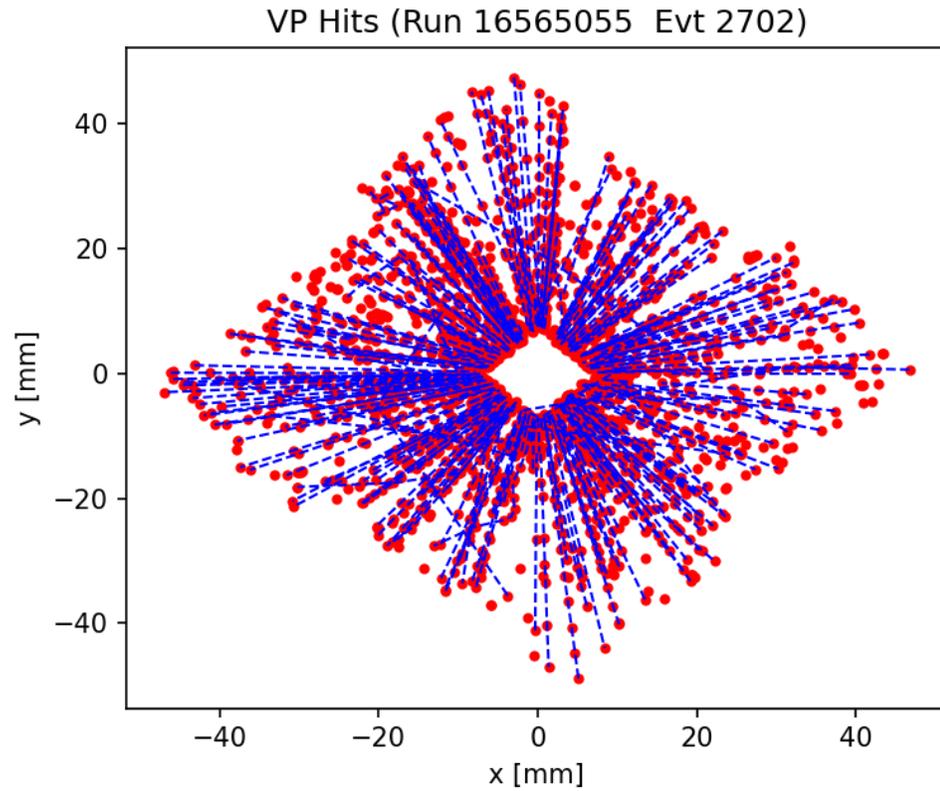
Thank you 😊

Backup

LHCb dataflow



Triplets construction



Features distribution

Feature Distributions: Signal vs Background

