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Online-Analysis of Hits in the Belle-II Pixeldetector for Separation of Slow Pions from Background

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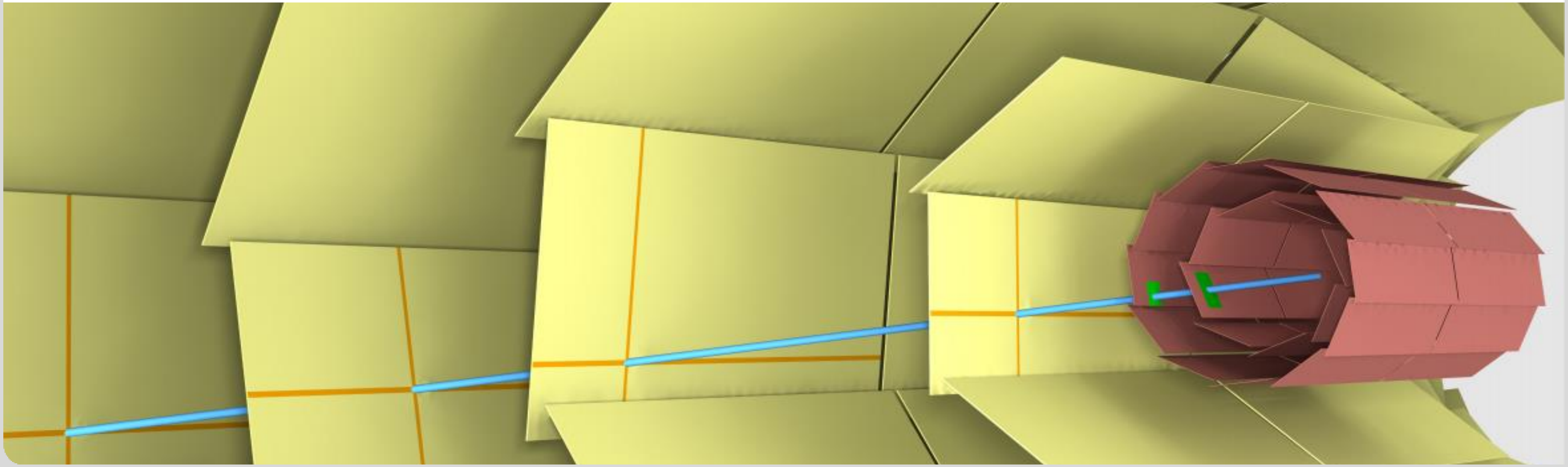
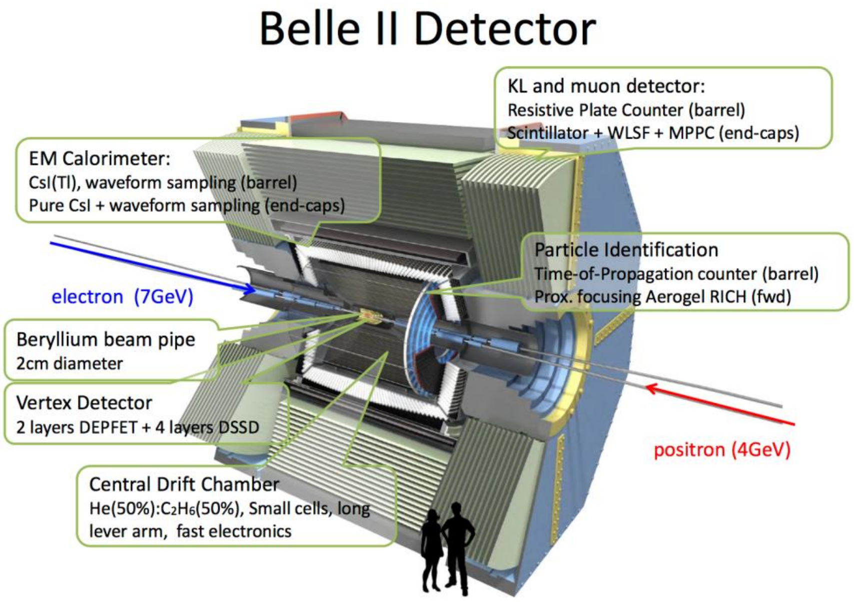
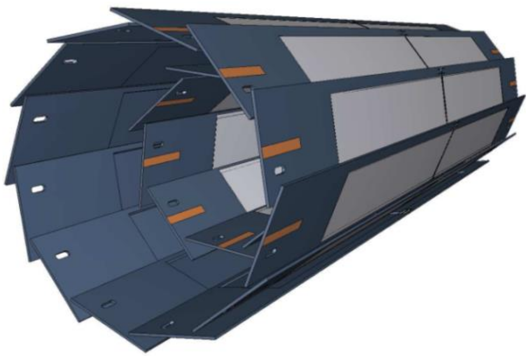


Data at the Belle-II Pixeldetector





- Increase of luminosity in Belle-II leads to high data rates
- About 1 MByte/event generated by the pixeldetector alone
- Demanded output data rate by DAQ at 100 kByte/event

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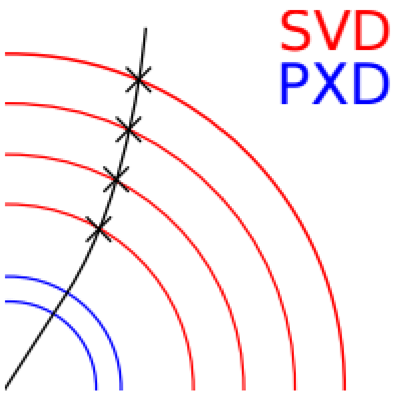
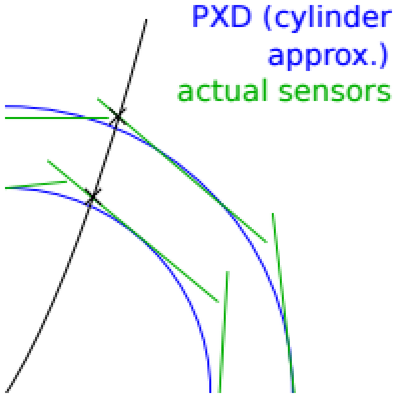
Data Reduction via Region of Interests

- Usage of clusters of hits in outer layers of the detector to extrapolate to the PXD
- Definition of Region of Interests and storage of all active pixels Inside this area
- Main mechanism for data reduction



rough extrapolation



exact extrapolation

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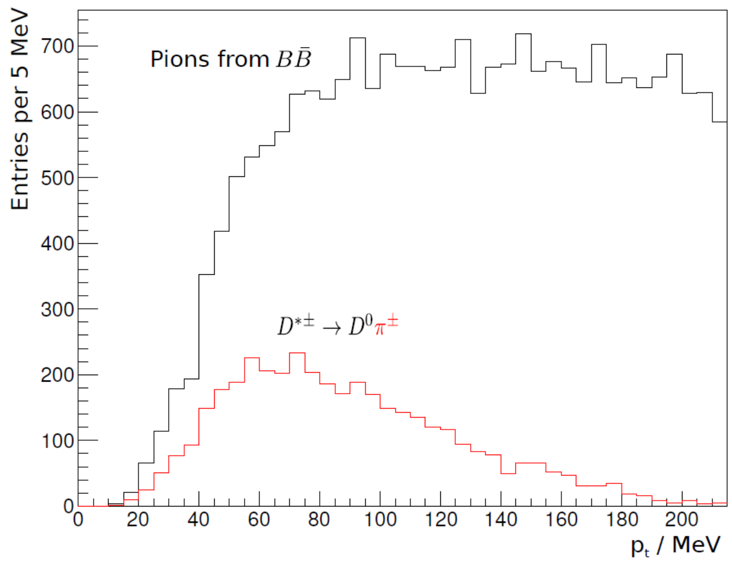
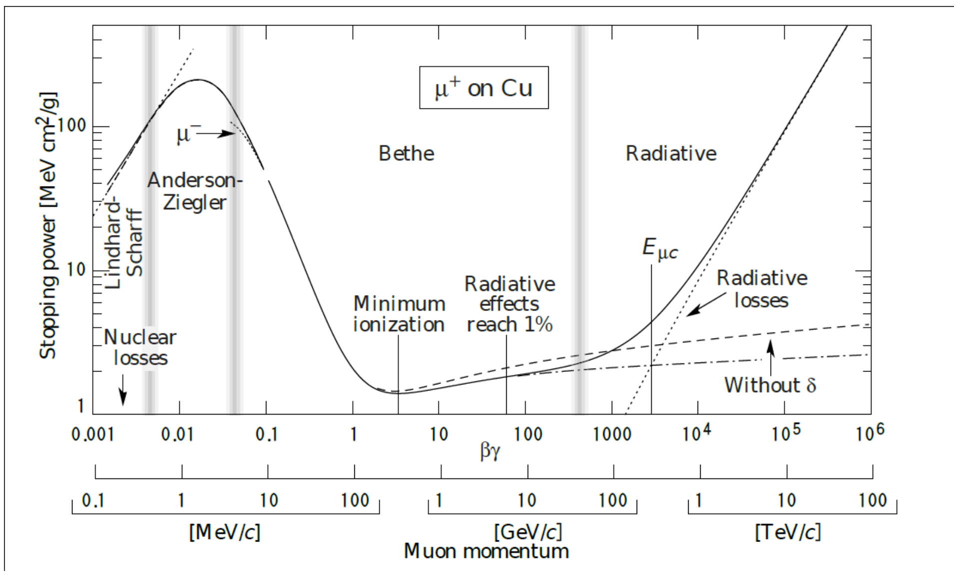
Problematic D* Decay

- Particles with low impuls experience high stopping power
- D* decays produce pions with low transversal momentum
  - Below 60 MeV majority of the pions attributed to to this decay





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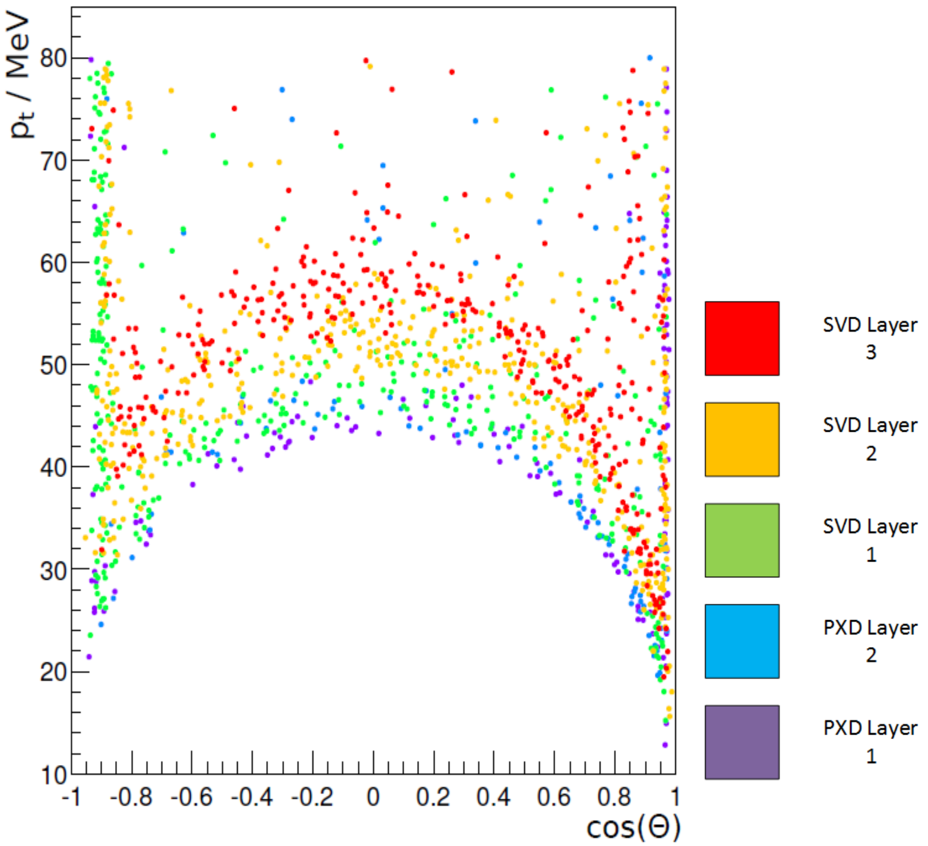
Momentum Distribution of Slow Pions

- $P_t < 60$ MeV may already be insufficient to reach outer SVD Layers
- Data reduction via track extrapolation is not feasible
- Alternative online recovery mechanism is necessary



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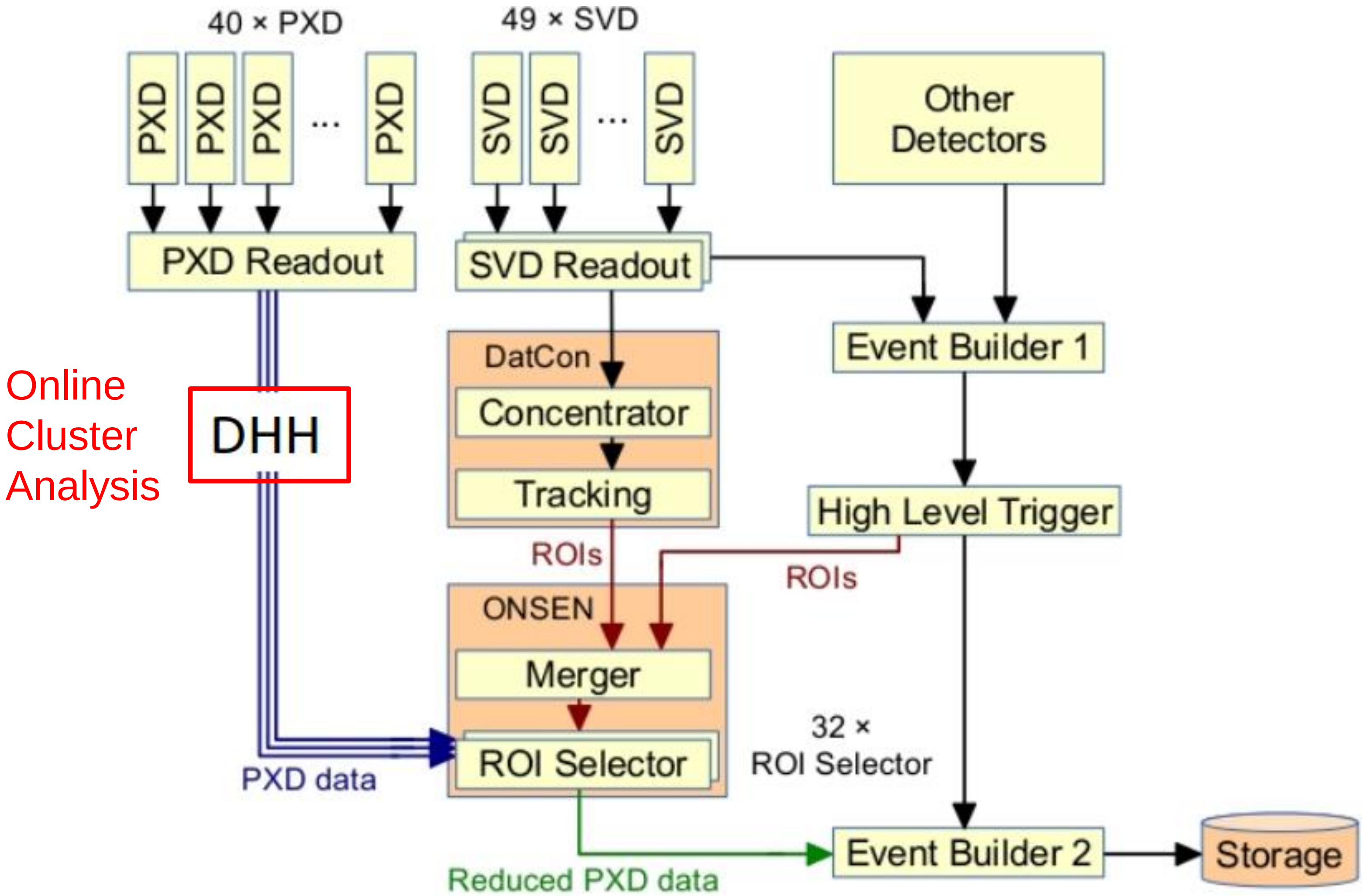
Pixeldetector Data Aquistion and Reduction



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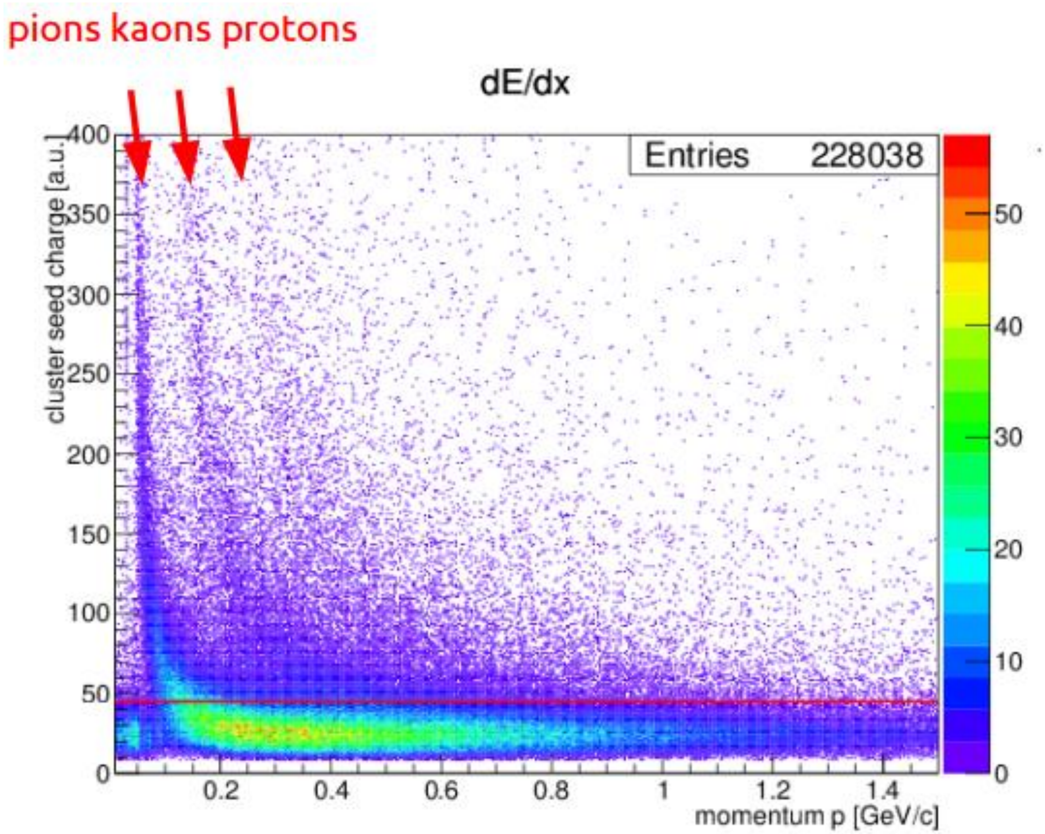
Charge of slow Pions within the Pixeldetector

- Usage of charge deposited in pixels for different momenta tracks to separate pions



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NeuroBayes Algorithm for Rescue

- NeuroBayes Algorithm to predict slow pions using clusters of hits in the pixeldetector
- Robust and has good generalization
- Algorithm based on neural networks
- Several characteristics of hit clusters used for classification

Cluster Feature
Total Charge
Standard Deviation
Maximum Pixel Charge
Minimum Pixel Charge
Length in Z
Length in Phi
Total Length
Number of Pixels
PXD Layer

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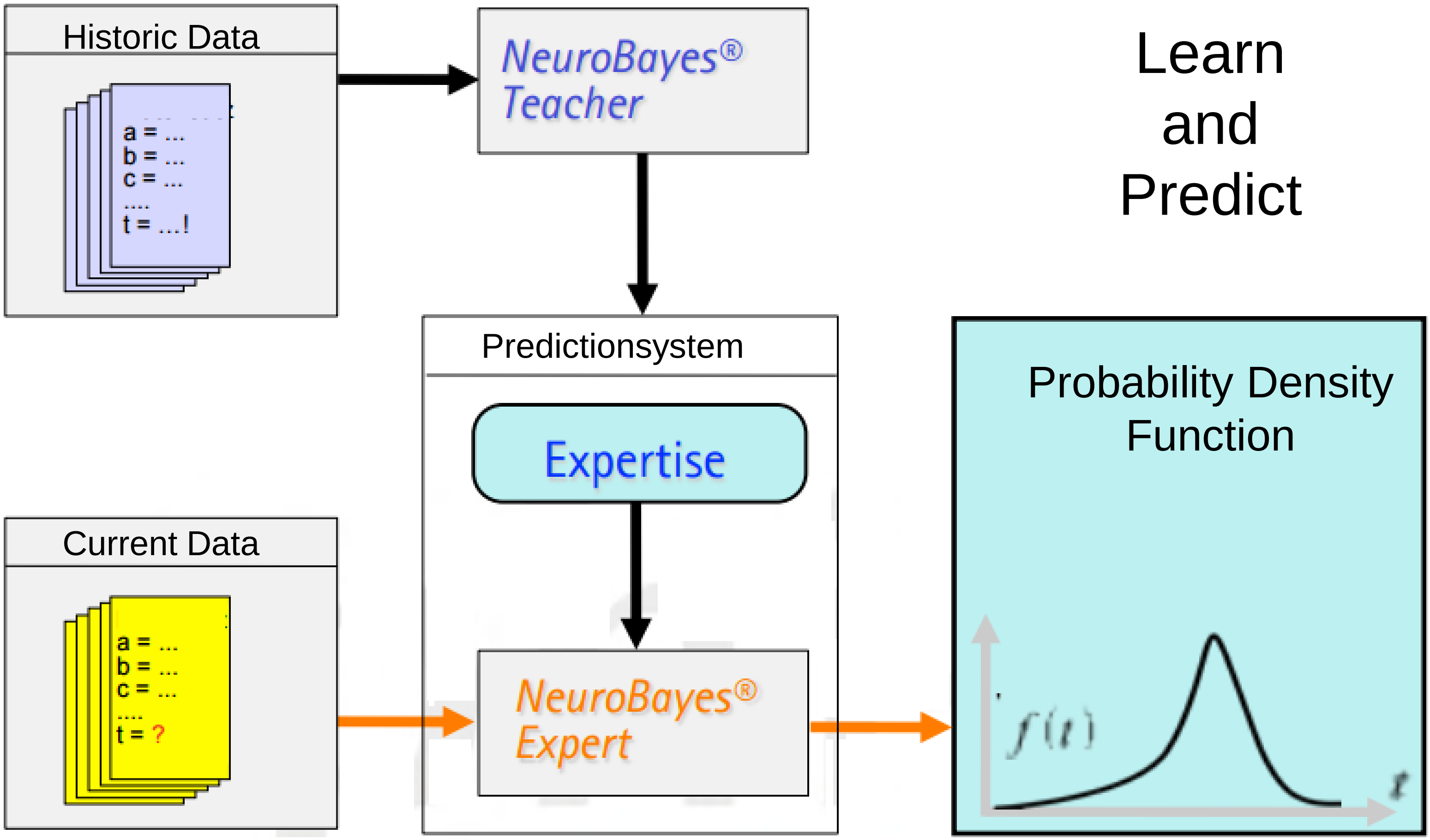
NeuroBayes Structure



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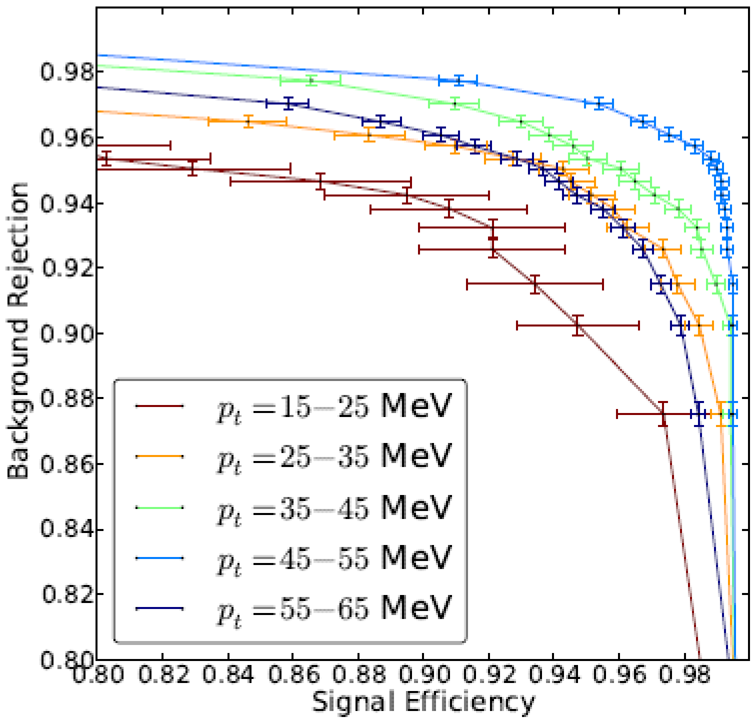
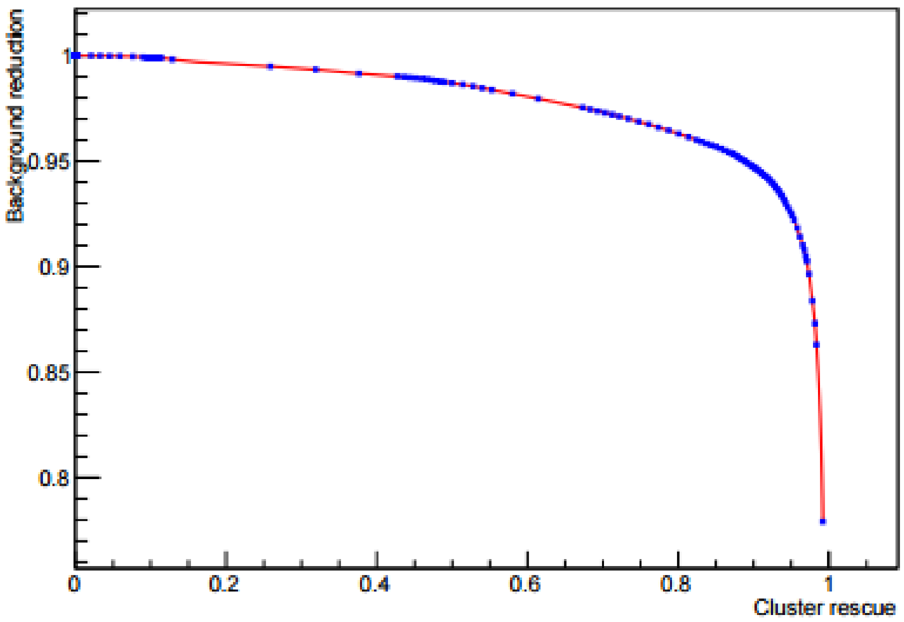
NeuroBayes Classification Performance

- NeuroBayes achieves very good signal efficiency and background rejection ratios for pions with $P_t < 65$ MeV





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Implementation on FPGAs

- Demanded characteristics of implementation
  - 200 Mio Clusters / Second
  - Low usage of ressources, FPGA is shared
  - Accuracy of implementation cannot deviate too far from

- Achievements of implementation on Virtex-6
  - 350 Mio Cluster / second
  - ~3 % of overall ressources used
  - Accuracy : Deviation < $1.5 * 10^{-5}$ from ideal, no negative Influence

Summary

- Pixeldetector data is too big to be handled
- Slow pions not detected by track extrapolation
- Recovery of slow pions using NeuroBayes algorithm on FPGAs near PXD
- FPGA Implementation‘s performance is sufficient to be deployed

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