Belle II tracking

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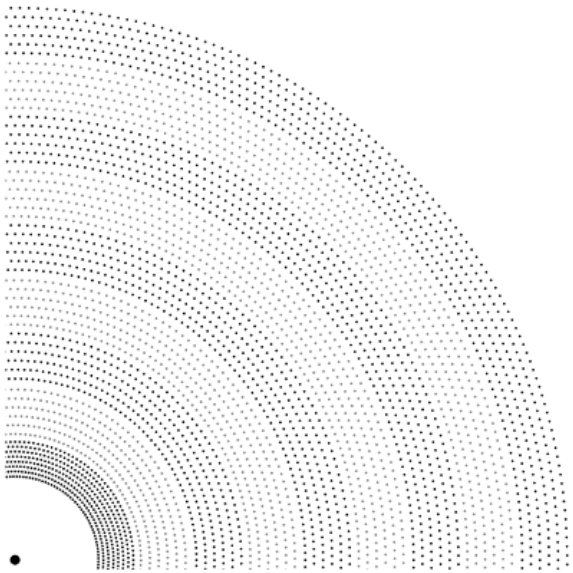
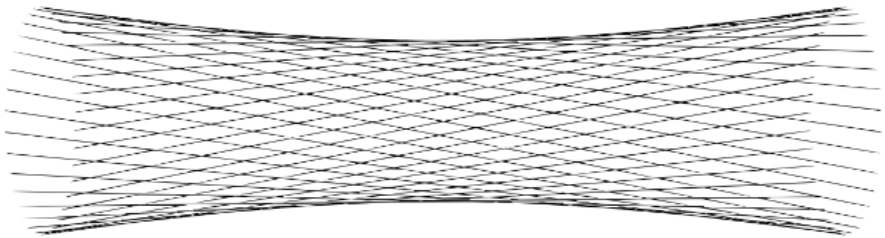
Tracking detectors: CDC

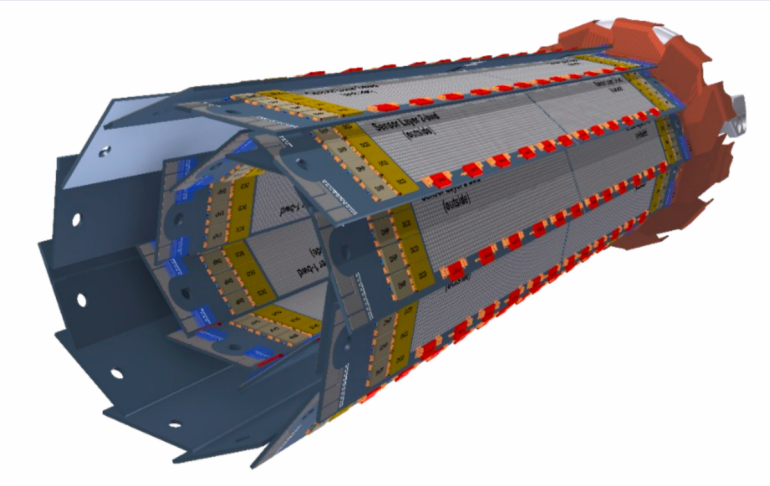
- 56 layers (r = 168-1111 mm)
- arranged into alternating super-layers of
  - axial wires
  - and stereo wires for 3D-track reconstruction





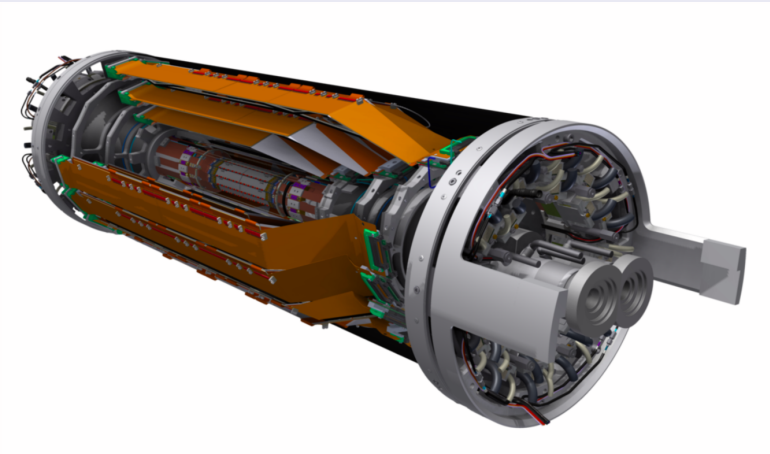
Tracking detectors: Silicon

PXD



- 2 layers of DEPFET pixels
- radii: 14, 22mm
- 40 sensors

SVD

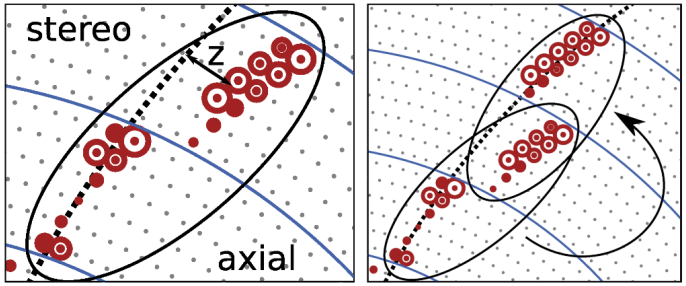


- double sided silicon strip sensors
- radii: 39, 80, 104, 135mm
- 172 sensors

CDC tracking

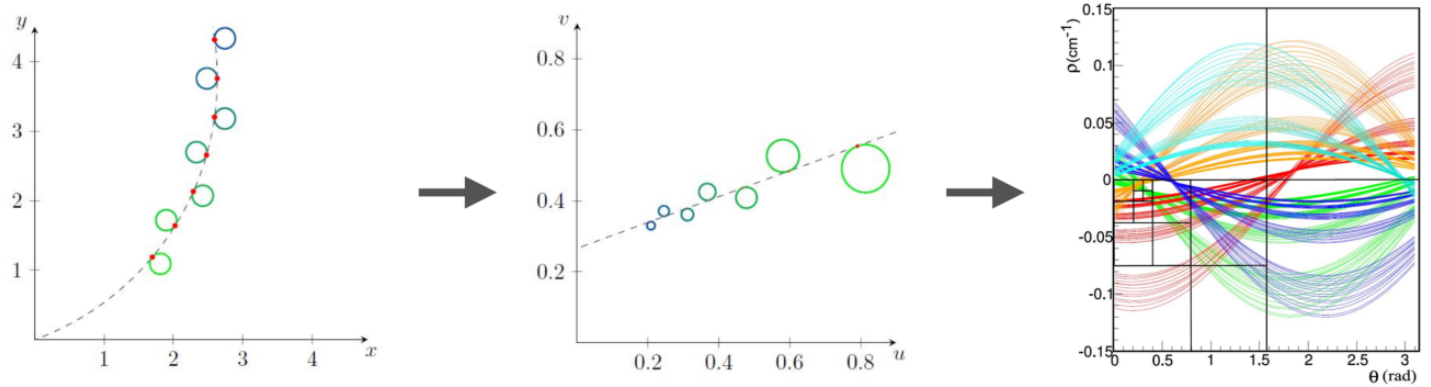
Local CDC finding algorithm

- find short segments
- combine overlapping segments to tracks using cellular automaton



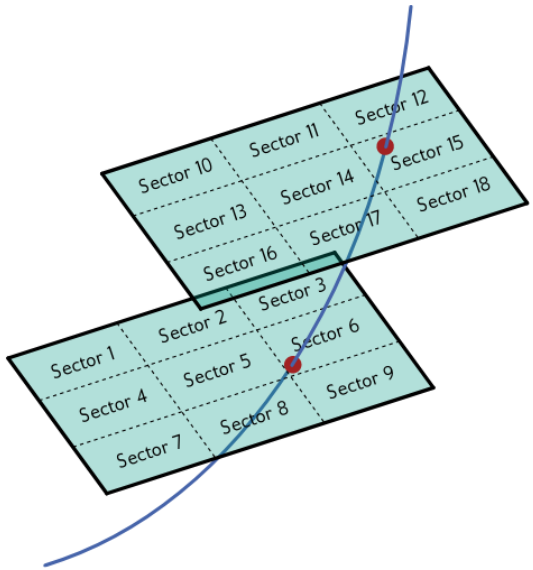
Global CDC Finding Algorithm

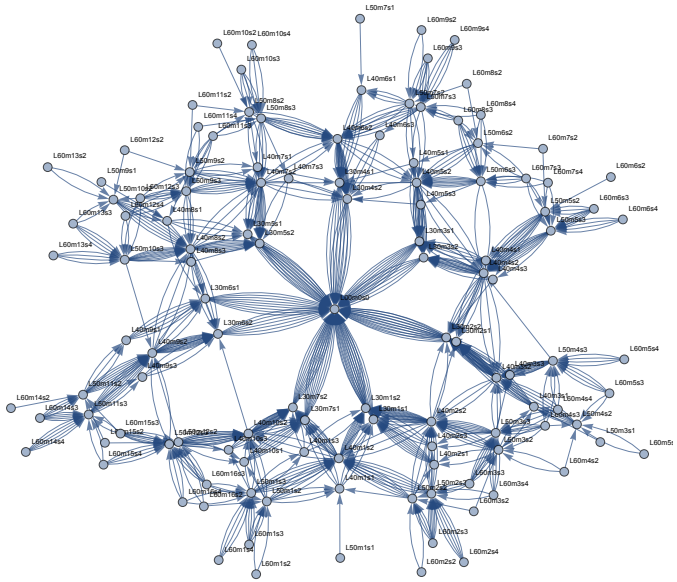
- use conformal transformation and Legendre transformation
- search for tracks in Hough space of Legendre parameters



Silicon track finding: VXDTF2

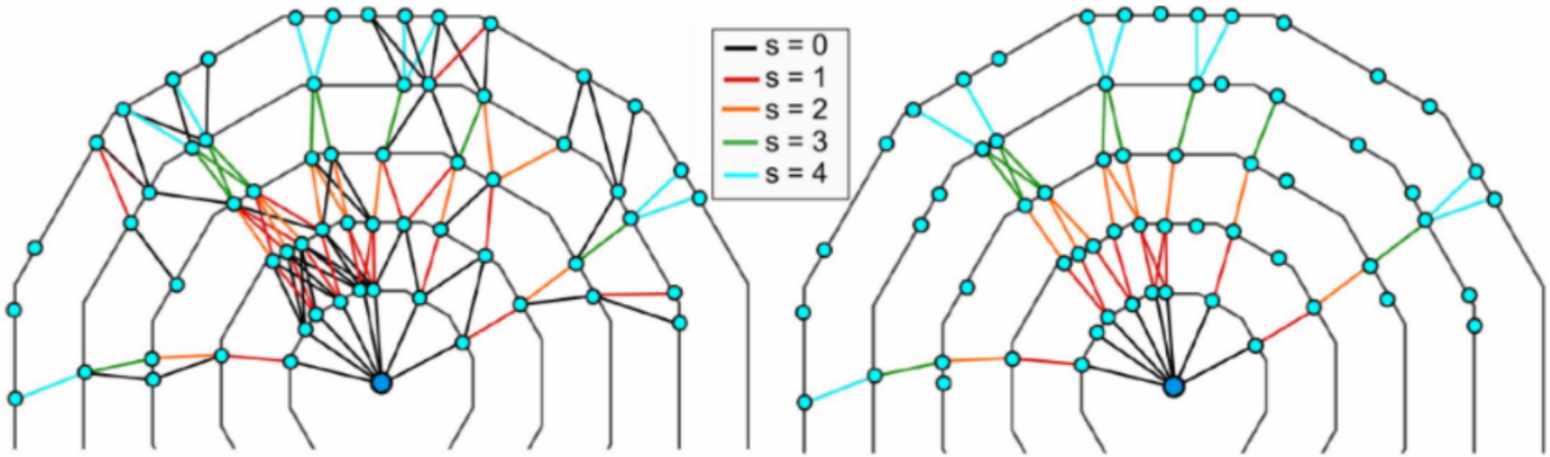
- sub-divide sensors into Sectors
- use MC events to learn allowed connections between sectors (training)
- for each connection learn simple geometric relations (e.g. angle, distance)
- only search for hits following allowed connections
- found hits have to obey above mentioned geometric relations
- object storing all this is called "SectorMap"





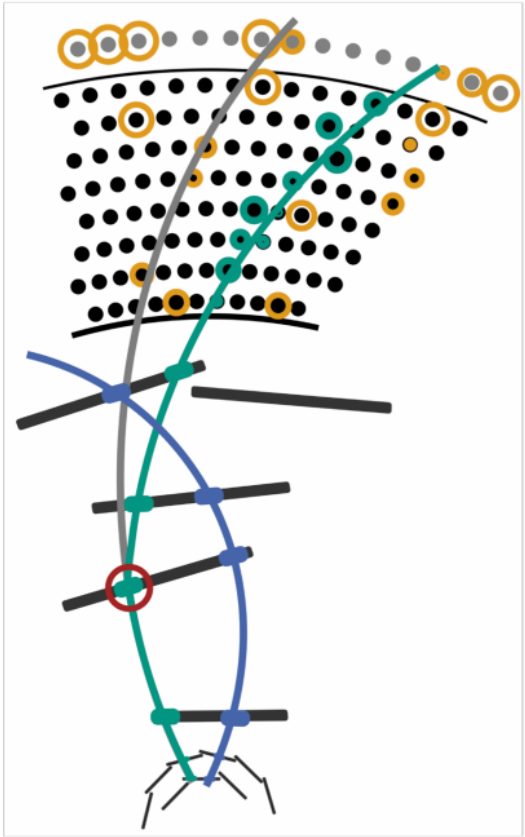
Silicon track finding: VXDTF2

- hit pairs and hit triplets are connected using a cellular automaton
- quality estimation uses simple and fast triplet fit
- select track set with best quality estimators, while not allowing sharing of hits between track candidates

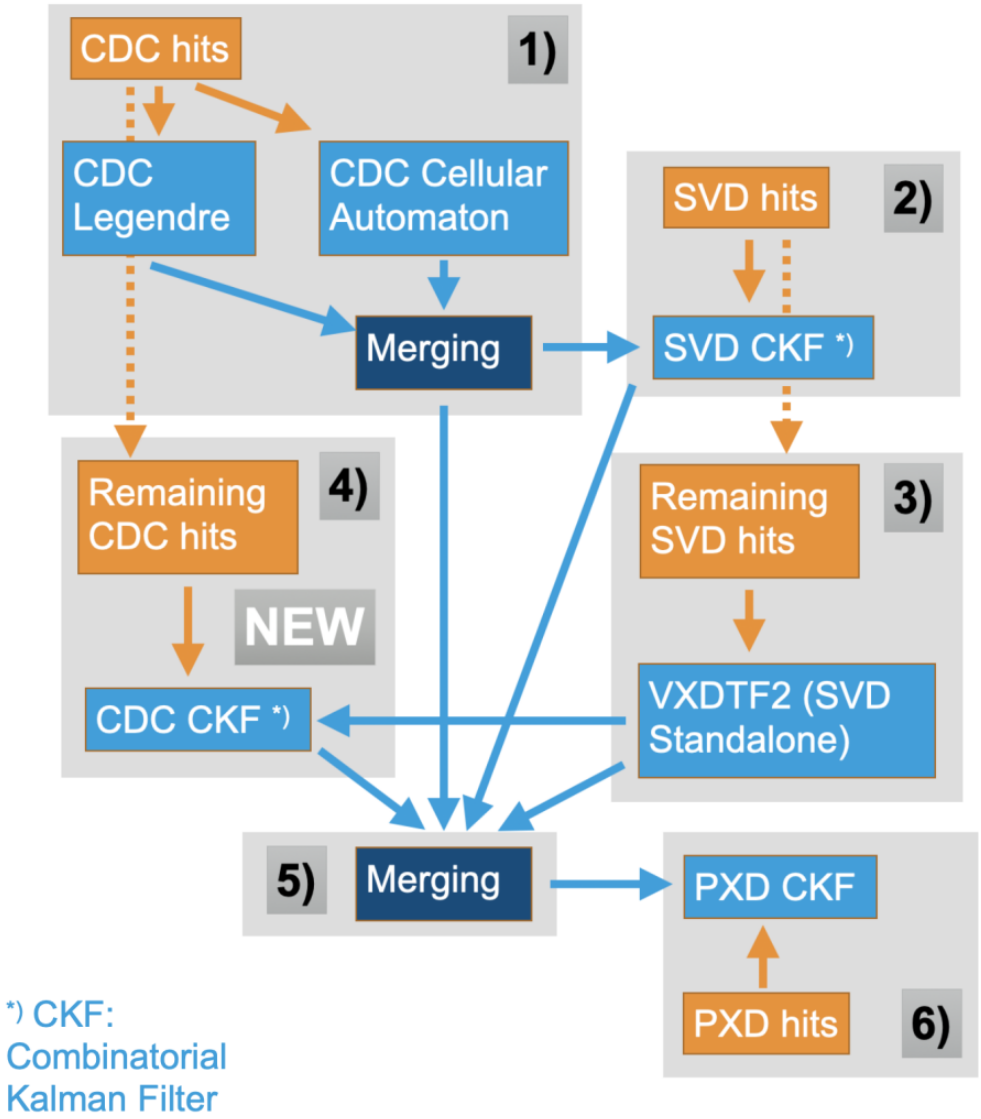


Combinatorial Kalman Filter

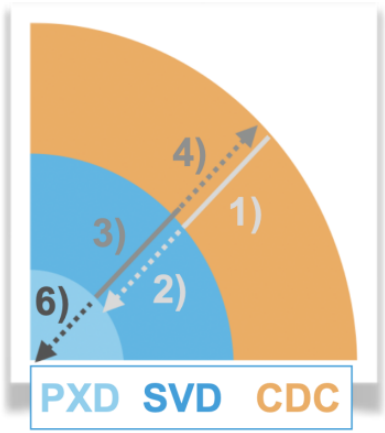
- Combinatorial Kalman Filter (CKF) used at several places in tracking chain:
  - track merging
  - track fitting
  - extrapolation of tracks into different tracking volumes to find hits



The full tracking chain

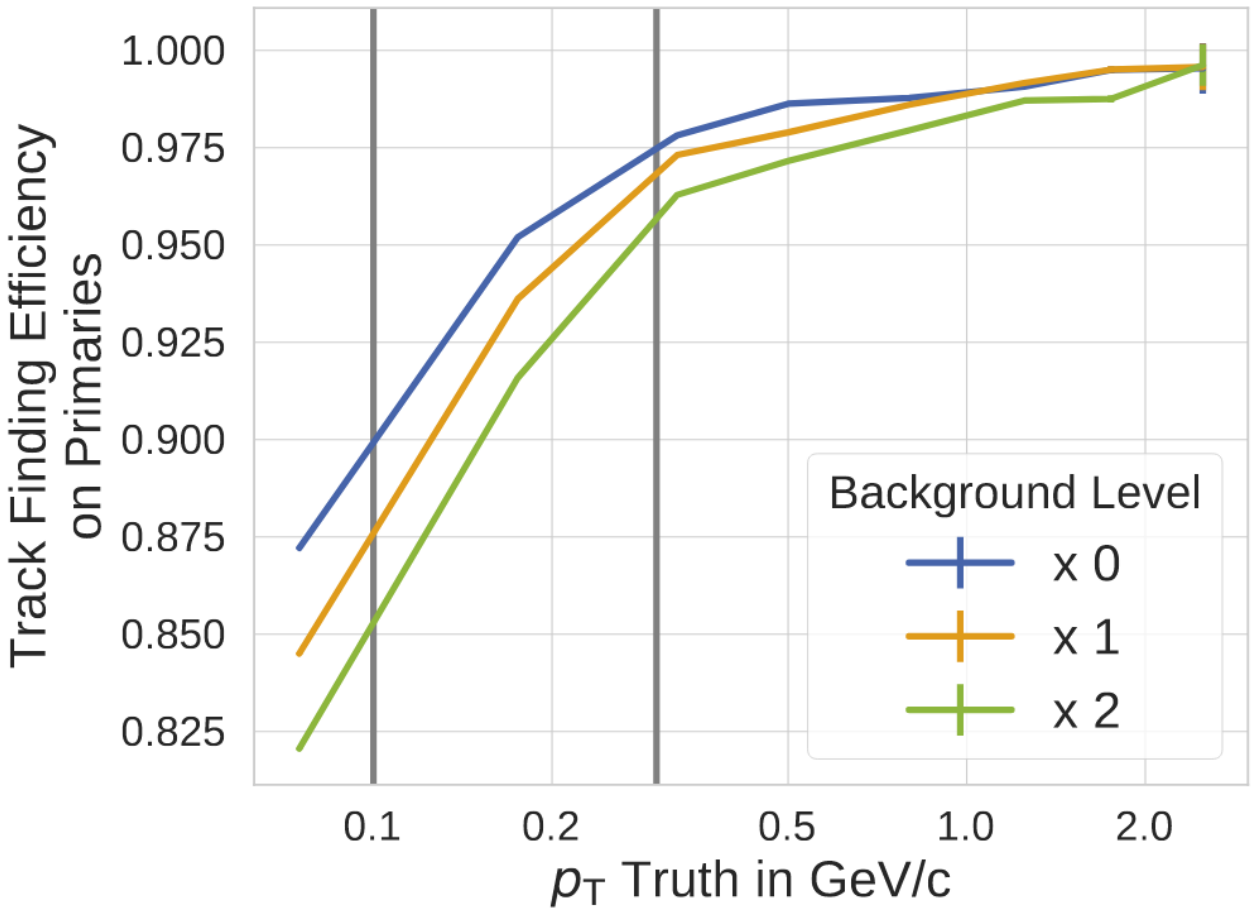


(a)



(b)

Tracking performance

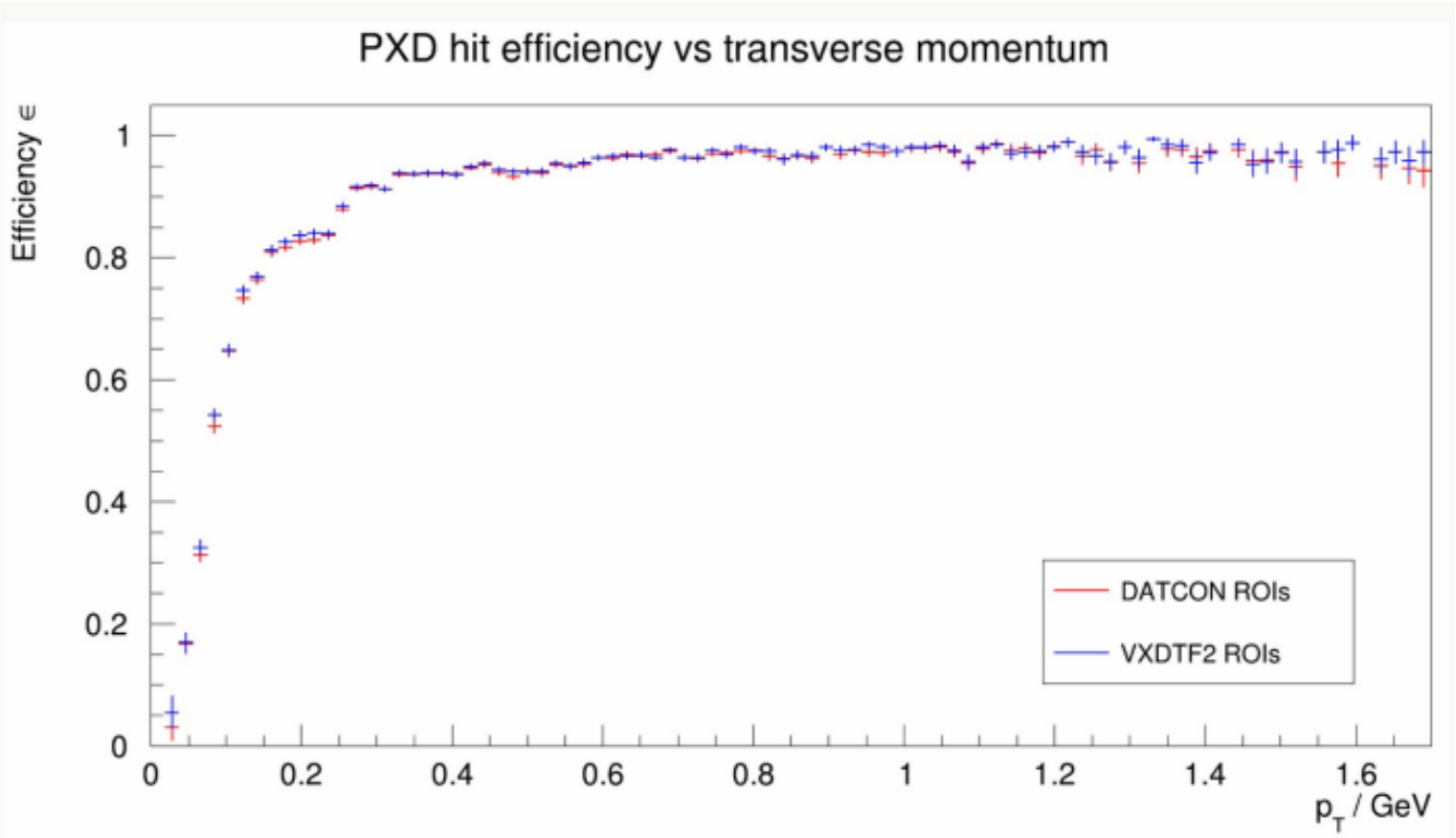


Summary current scheme

- to fit track need at least 5 measurements (x or y on Sensor)
- tracks not reaching layer 5 (3 SVD layers) will not be reconstructed ($p_T > \approx 50 MeV$)
- PXD hits are not used for track finding:
  - PXD hits are only selected if in Region of Interest (ROI)
  - ROI defined by fitted track extrapolated to PXD
  - PXD hits are attached to already found and fitted tracks
- if track not found in SVD+CDC the PXD hit is lost
- ROI finding currently not activated for data taking
- we may need to activate ROI finding with increasing bkg level

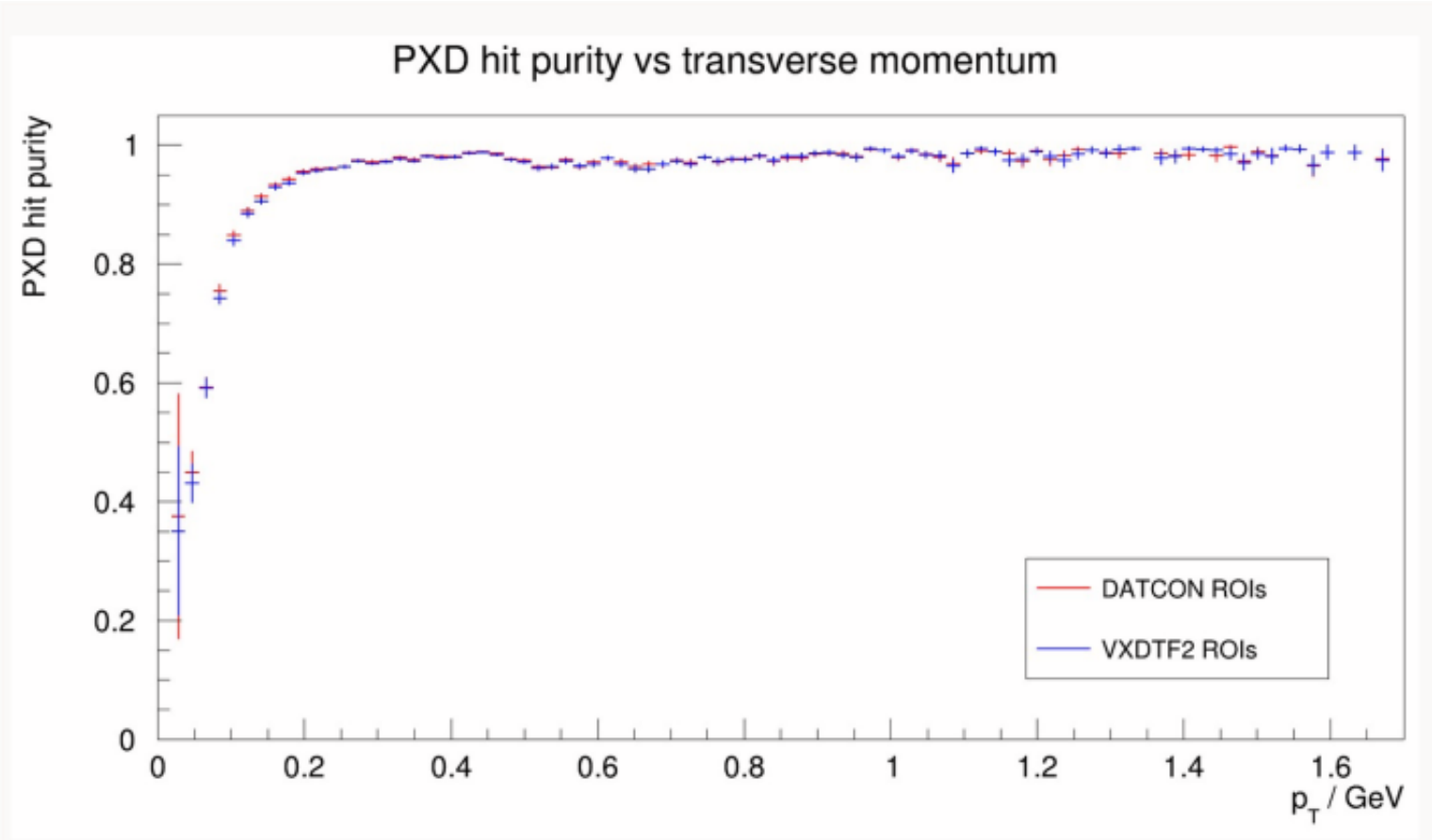
ROI performance: PXD hit efficiency

- presented by Christian Wessel at tracking meeting 25.06.2021
- bkg campaign 19



ROI performance: PXD hit purity

- presented by Christian Wessel at tracking meeting 25.06.2021
- bkg campaign 19

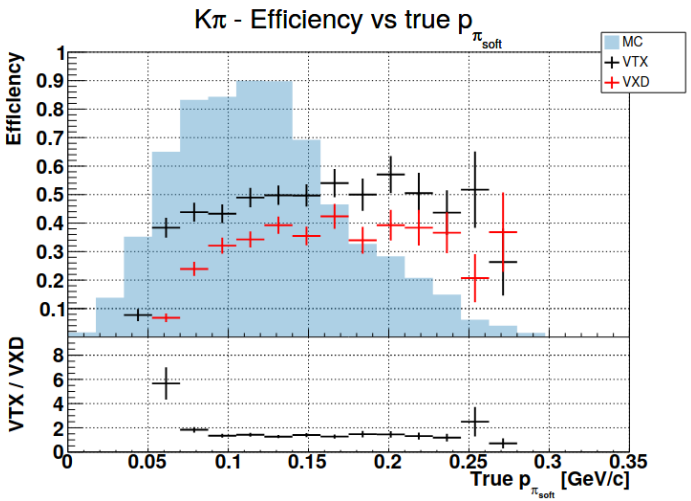


Possibility of slow pion rescue with existing tracking software

- condition: PXD hits become available on HLT (needs changes in DAQ chain)
- VXDTF2 is capable of doing 6 layer tracking (SVD + PXD)
- has been done in the past (more than 4 years ago):
  - very slow due to high combinatorics
  - high fake rate
  - ROI scheme made it unnecessary
- possible scenarios to rescue slow particle PXD hits:
  - do full 6 layer VXD tracking
  - 3 or 4 layer tracking (2 PXD + 1 or 2 SVD layer), after full tracking chain
  - both need retrained SectorMap
- several changes in the code, and bkg simulation has been adjusted:
  - performance has to be evaluated again (man power?!)
  - currently no one working on that

Upgrade study silicon tracking using VXDTF2

- study by Massaccesi et al (https://indico.belle2.org/event/4945/)
- reconstruct $B^0 \to D^{*-}(D^0\pi^-_{soft})\mu\bar{\nu}_\mu$ with $D^0 \to K^+\pi^-$
- compare VXDTF2 for VXD vs 5-Layer silicon VTX in VXD-volume



- comparison has to be taken with a large grain of salt:
  - different geometry, technology, background simulation, ...
- but:
  - 5-layer tracking with VXDTF2 works
  - p_T cutoff lower for 5 layer tracking due to inner layers

Final remarks / Summary

- tracking has to be fast, in particular on HLT
- using current code is possible:
  - several studies need to be done / redone
  - currently no one working on that
  - PXD hits on HLT needed
- whatever scheme is chosen no degradation of tracking performance should occur
- Even with rescue without using tracking, you still need a track finding including PXD (no CKF) offline !!!