Recent Tracking Group Activities

Belle II PXD Workship

<u>Simon Kurz</u> for the Tracking Group Januar 20, 2020





CDC Wire Monitoring

Henrikas

- Larger than expected backgrounds observed in the CDC
- Local efficiency drops in wires from e.g. material deposits?
- Large number of wires, so automated tool necessary (offline)
 - · Looks for wires that register fewer than expected CDC hits in each layer
 - Generates a Belle2::CDCBadWires object



CDC Hit Reattaching

Henrikas, Cyrille

- Improve rejection of CDC hits that are most likely not real (noise, cross talk, ...)
 - Updated module and introduced new payload to define a threshold on ADC, TOT of each CDC hit
 ADC Raw
- This has an influence on the dE/dx
 distribution
 - Implemented a new module that reattaches previously rejected hits if compatible with fitted track
 - To avoid bias in dE/dx determination, additional info about added hits is needed (mostly hits with low ADC values added), e.g. weights from KalmanFitter
 - Submitted Pull Request



Cross Talk Filter

Sasha

- Significant fraction of events with signal in all ASIC channels observed
 - Most of them in-time, with larger ADC, with a single channel out-of-time, and even larger ADC value
 - Sometimes cross talk shows up in the neighboring ASICs, sharing a common connector. However typically the ADC values are small, can be suppressed by ADC/TOT cuts



Cross Talk Filter

Sasha

- Introduce ASIC cross talk filter, based on 8-channel correlation
 - · Optimised filter to retain actual hits while rejecting most of the cross talk
- Check CDC standalone tracking efficiency using VXDTF2 tracks as a reference for all tracks from the IP and pT>0.5 GeV/c
 - Significant improvement with ASIC filter



Cross Talk Simulation

Sasha



- Simulate CDC cross talk using a library based on data
 - Start with single ASIC cross talk
 - · Use cosmics for clean identification of hits associated with tracks
- DB object to hold the library is prepared, code to overlay extra hits is in progress



DESY. | Tracking Group Activities | Simon Kurz | Januar 20, 2020

SVD to CDC CKF

Sasha, Nils

- Up to this point, tracking reconstruction was performed in the following steps:
 - 1. CDC standalone track finder (TF)
 - 2. Extrapolation to SVD based on a Combinatorial Kalman Filter (CKF)
 - 3. SVD standalone TF (for hits that have not been assigned yet)
 - 4. Extrapolation of all tracks with SVD hits to PXD based on a CKF
- Room for improvement: Try to add CDC hits to SVD standalone tracks to improve momentum resolution (before extrapolation to PXD)
 - Very forward tracks are often not found by CDC standalone TF as these tracks only produce a small number of CDC hits (if any)
 - SVD has larger acceptance wrt CDC so SVD standalone TF should find these tracks
 - Another CKF has been implemented by Nils but never was thoroughly tested and optimised and thus not used

SVD to CDC CKF

Sasha, Nils

- Optimise performance, i.e. finding efficiency, hit efficiency, fake rate, pt resolution, CPU time,...
 - 1. Find good set of cuts used to select hits by CKF
 - 2. Find optimal "filter" to select best path found by CKF
- Achieved significant improvement of pt resolution for forward tracks



ECL seeded CKF

Simon, Svenja

- The CDC CKF can in principle use any kind of seed objects
- Idea: use ECL clusters as seeds to improve electron tracking
 - Expected to increase tracking efficiency especially in forward regions due to highest material budget
- Implemented a new findlet (= tracking module), as well as specific filters
 - Do helix propagation for both charge assumptions and try to find tracks for both of them
- Still have to optimise (and validate) the algorithm on data: Svenja (new PhD student at Bonn) will take care of that as her service project



Included in release 04 but not used yet

SVD Standalone Tracking

Thomas + Student

- VXDTF2 seems to have problems finding very forward tracks in some regions
 - If using full track reconstruction chain, CDC→SVD CKF is able to compensate for that
- Thomas and a student are working on improving the "sector maps" that are used for the standalone trackfinder
 - Problem in event T0 solved, bhabah events will be included



ROI filtering

Simon

- In data, ROI filtering not enabled yet as inst. luminosity low enough (apart from a short test run before Christmas)
- Found out that ROI filtering by default enabled in simulation
 - Unfortunately, this was the case for all previous MC campaigns
 - Created a new data base object so that data reduction is enabled/disabled depending on experiment number:
 - Filtering enabled for experiment 0
 - Filtering disabled for experiment 1002/1003
- PR was merged with master but will not be included before release 5
 - Made sure that ROI filtering is disabled manually for upcoming run dependent MC production (MC13b)

ROI filtering

Simon

- Problem: ROI selection on HLT is not identical to what we do in simulation
 - HLT: full tracking ~ Simulation: VXD only tracking
 - **Reason:** We don't want to do the full track reconstruction chain twice (once during simulation step, when ROIs are calculated and once in the actual track reconstruction)
 - Will discuss this during the upcoming F2F meeting to have everything in place once ROI filtering is enabled during data-taking

Properties of Beam Spot in Data Cyrille

- Select well-reconstructed dimuon events (good tracks from IP, invariant mass window, only one vertex candidate)
- Observe drift of vertical position by about 100µm
- Hydrostatic levelling system indicates changes of the same order of magnitude
- Also observed by gap sensors



Properties of Beam Spot in Data Cyrille



• Phi dependence of X, Y resolution observed in data

DESY. | Tracking Group Activities | Simon Kurz | Januar 20, 2020

Oct. 2019

Properties of Beam Spot in Data Cyrille

- · Found to be caused by residual alignment issues
 - Unfortunately, still not perfectly fixed by latest iteration





Jan. 2020

PXD Efficiency in Data

Navid

- Experiment 8, proc9
- Selecting all tracks with:

```
\begin{split} & |d_0| < 0.3 \text{cm}, \ |z_0| < 1 \quad \text{cm} \\ & p_T > 0.6 \text{ GeV} \\ & \text{N}(\text{tracks}) = 2 \\ & \text{N}(\text{SVD hits}) \geq 6, \ \text{N}(\text{CDC hits}) \geq 1 \end{split}
```

- Still not fully clear:
 - Why is the efficiency in the overlap region not as high as one would expect?
 - Why does the efficiency drop in the forward region?

NB: PXD track finding (CKF) is running more or less out of the box and has never been thoroughly optimised. **Christian** is working on that.



Track Extrapolation Uncertainty

Simon, Björn

- Need to apply a relatively harsh cut on the track uncertainty projected to the PXD sensor surface to obtain reasonable hit association efficiencies (sigma_u,v<100µm)
- Start to loose tracks in forward regions, which matches pattern of layer 3 overlaps

NB: We're not directly using the uncertainty sigma_u,v during track reconstruction, i.e. **we're not actually loosing all these tracks in the forward regions**. Still, we should understand this effect.



PXD Efficiency in Data

Navid

- Analyse interplay between PXD layers: use conditional probabilities to see what happens if second layer is added
 - ε(1): layer 1 eff (ignoring layer 2 in the track reconstruction)
 - ε(1|2): layer 1 eff given there is a hit in layer 2
 - vice versa for $\varepsilon(2)$ and $\varepsilon(2|1)$
- Presence of additional layer can degrade efficiency in some regions?



Track Extrapolation Uncertainty

Simon

- Uncertainty on extrapolated track increases with
 - A. the path length of the extrapolation
 - B. the crossed material budget
- Both prerequisites are given for
 - A. overlap regions
 - B. very forward tracks

➡ Effect well understood!





Summary

 What I haven't really mentioned during this talk at all: Everybody involved does a great job!

Achieved very high performance of track reconstruction and still many improvements in sight!

• Tracking Paper about to be submitted!





PXD Efficiency in Data

Navid

- Check residuals between fitted track and assigned PXD cluster
 - Strange features observed in some of the forward modules
- Investigations still going on

