Belle II Tracking in Phase III with the Full Detector
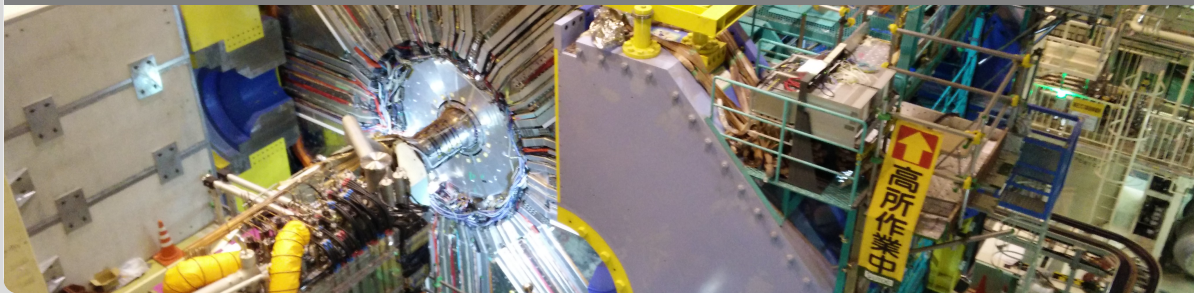
Connecting The Dots 2018

Felix Metzner | 21.03.2018

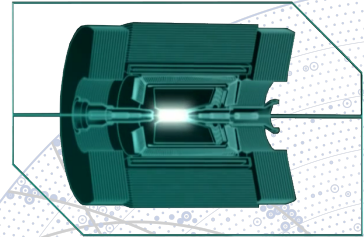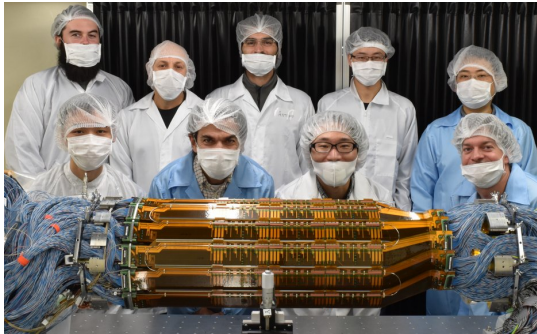KARLSRUHE INSTITUTE OF TECHNOLOGY (KIT)

The Silicon Detectors

The inner vertex detector (VXD), which consists of

- 2 layers of DEPFET pixel sensors (PXD) and
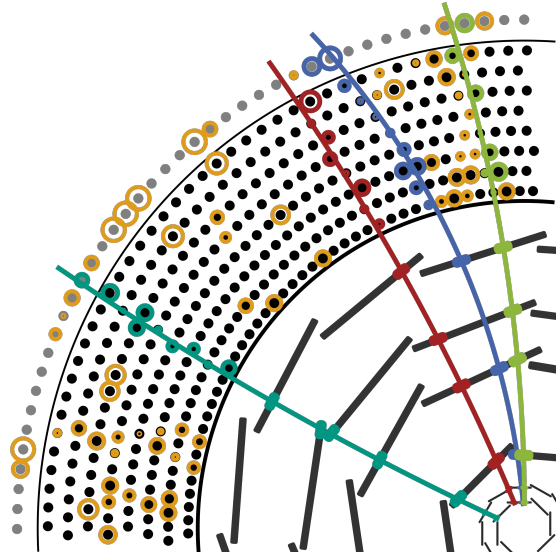- 4 layers of double-sided silicon strip sensors (SVD)

will be installed for Phase III.

	Acceptance in θ	$17° - 150°$
PXD	Layer Radii	14, 22 mm
	Channels	7,680,000 Pixles
SVD	Layer Radii	38, 80, 104, 135 mm
	Channels	224,000 Strips

The **Challenges** of Tracking at Belle II

On average **11 tracks** per event...
We want all of those, but **not a single fake**!

The **Challenges** of Tracking at Belle II

On average 11 tracks per event...
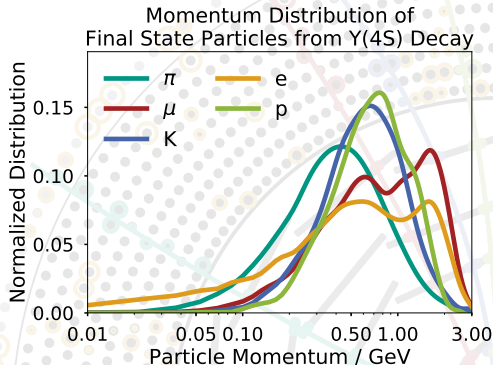**We want all of those, but not a single fake!**

Low momentum particles

- Non-negligible fraction
- Multiple scattering

Beam-induced background

High occupancy due to background hits:
11 tracks → 10^2 signal hits
vs. 10^4 background hits

Momentum Distribution of
Final State Particles from Y(4S) Decay

The **Challenges** of Tracking at Belle II

On average 11 tracks per event. . .
We want all of those, but not a single fake!
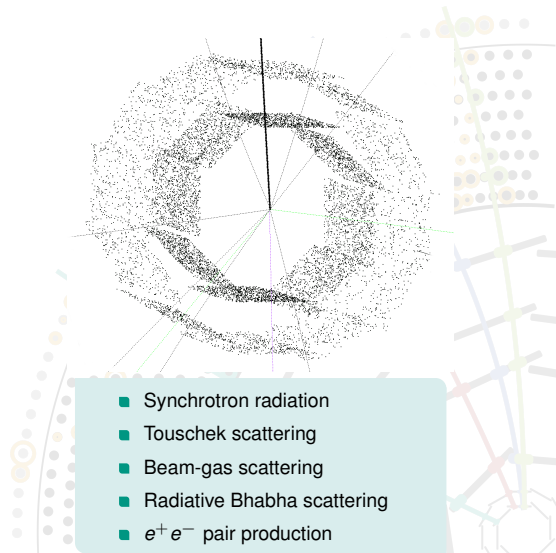
Low momentum particles

- Non-negligible fraction

- Multiple scattering

Beam-induced background

High occupancy due to background hits:
11 tracks $\rightarrow 10^2$ signal hits
vs. 10^4 background hits

- Synchrotron radiation
- Touschek scattering
- Beam-gas scattering
- Radiative Bhabha scattering
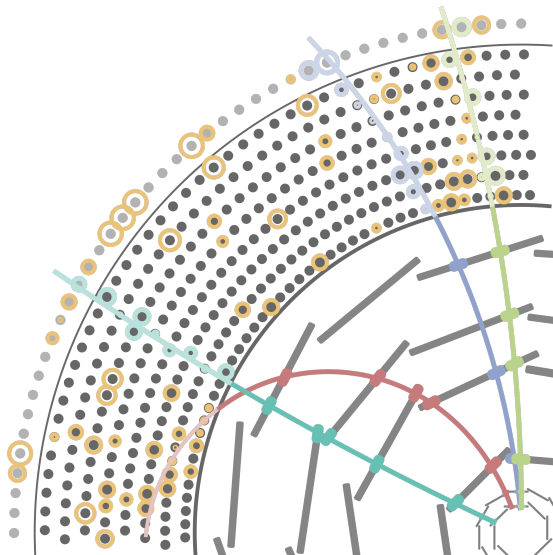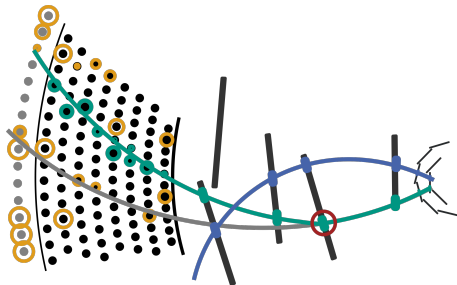- e^+e^- pair production

Utilizing the Silicon Detector Information
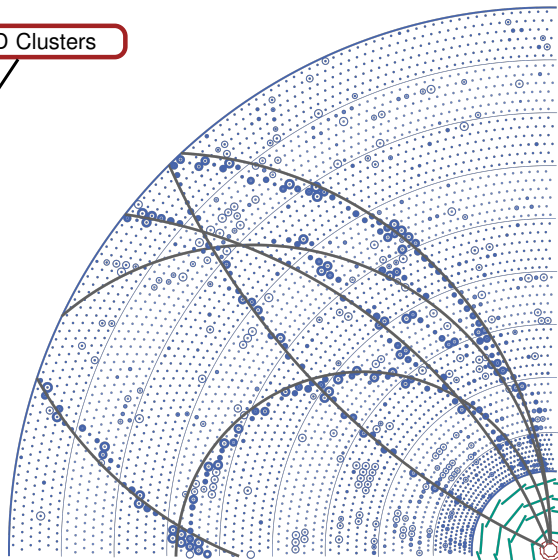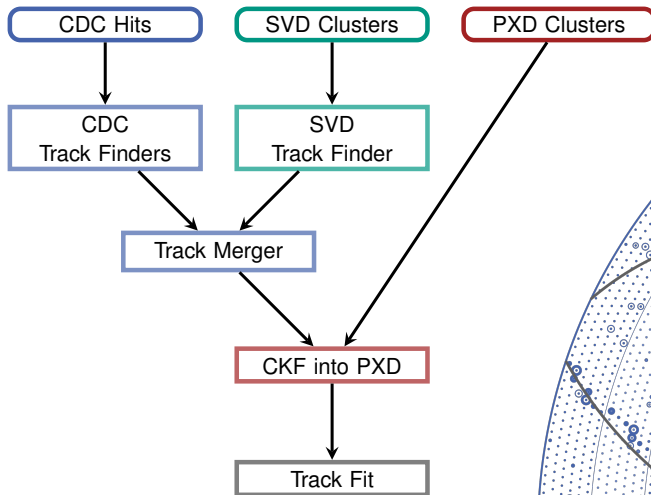
Improving the track parameters.
Better vertex resolution by adding VXD hits.

Tracking of low momentum particles.
Tracking particles which are not trackable by the CDC.

The Flowchart to Catch Them All


```
CDC Hits          SVD Clusters        PXD Clusters
   |                   |
   v                   v
CDC              SVD
Track Finders    Track Finder
   |                   |
   +---------+---------+
             v
       Track Merger
             |
             v
       CKF into PXD
             |
             v
        Track Fit
```

SVD Standalone Tracking

Cellular Automaton collects longest paths beginning with outermost SVD 3D-hits.
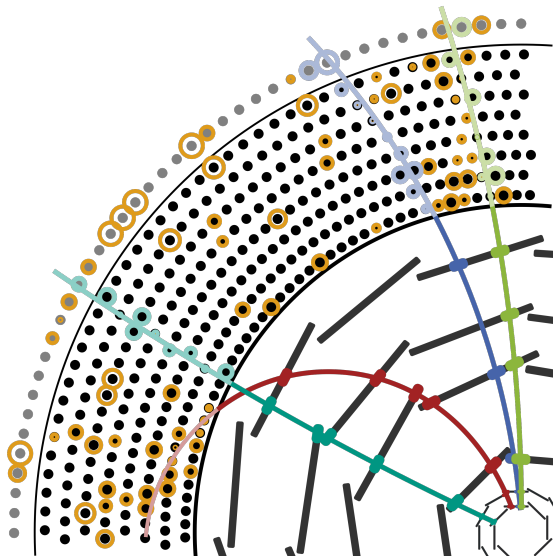
Neighboring 3D-hits are given by a set of **filters**:

- Evaluating duplets and triplets of 3D-hits
- Individual for every sensor
- Learned from simulation

⇒ Reduction of combinatorics
⇒ Allows for multiple scattering

Update with respect to talk by T. Lueck at CTD2017:
Now only SVD instead of full VXD is used.

SVD Standalone Tracking

The final set of tracks is chosen from all paths such that **no tracks share a SVD hit**.
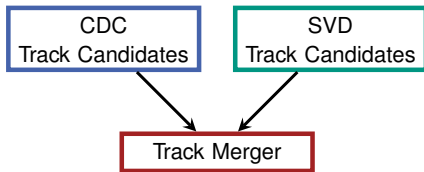
For competing paths a **quality estimation** is employed:

- Based on fitting 3D-hit triplets
  [A. Schöning, arXiv:1408.5536v1]
- Combine fit result with additional detector information via MVA method

$\Rightarrow$ Successful resolution of hit overlaps
$\Rightarrow$ Discriminator against fake tracks

Update with respect to talk by T. Lueck at CTD2017:
Now only SVD instead of full VXD is used.

Finding Efficiency and Fake Rate vs. QI
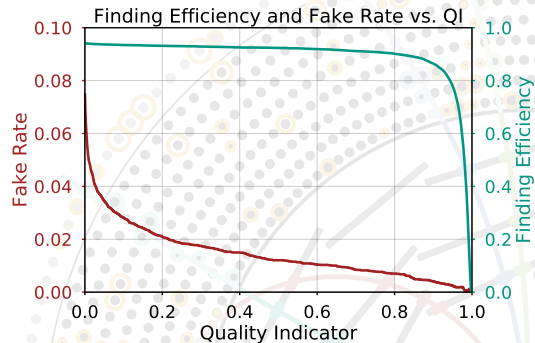
Track **Merging** with a Combinatorial Kalman Filter (CKF)

NKIT
Karlsruhe Institute of Technology
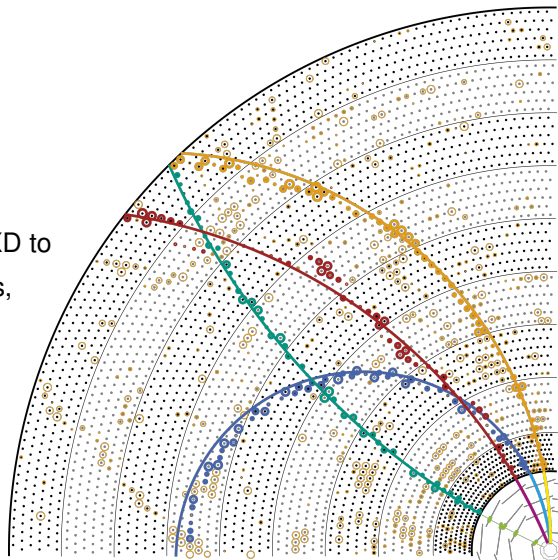
CDC
Track Candidates

SVD
Track Candidates

Track Merger

Extrapolation of CDC track candidates into the VXD to

- merge them with found SVD track candidates, or

- pick up unassigned SVD clusters.

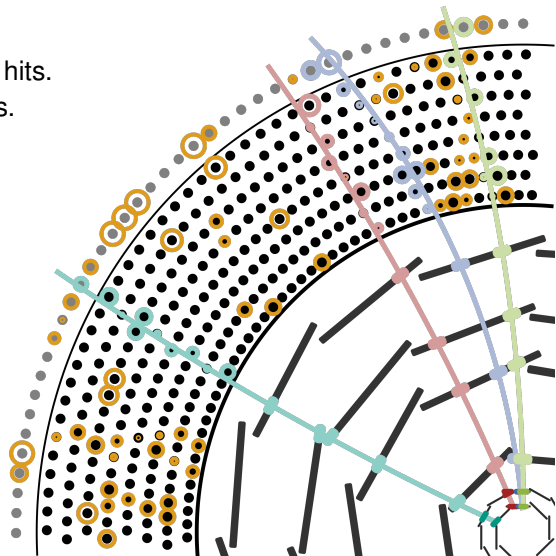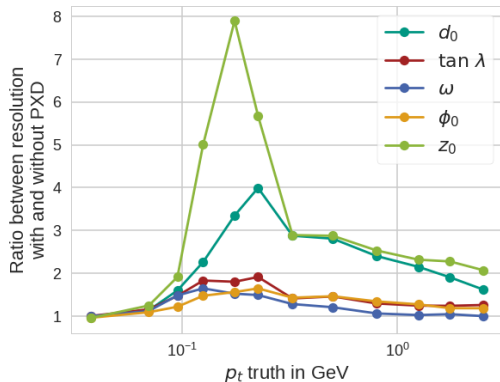$\Rightarrow$ Extrapolation considers material effects.

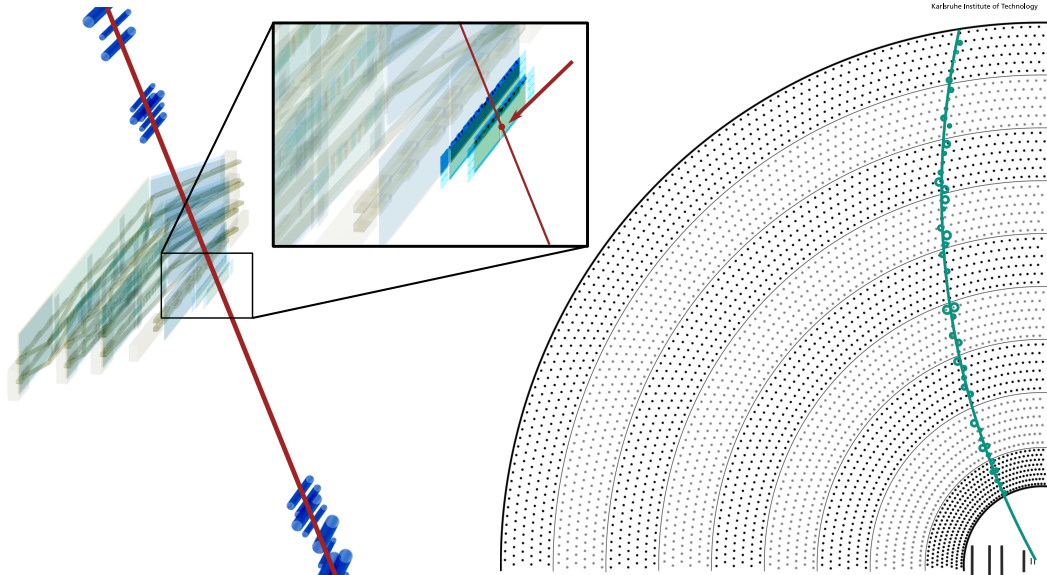$\Rightarrow$ MVA filters allow to adapt to different particle momenta.
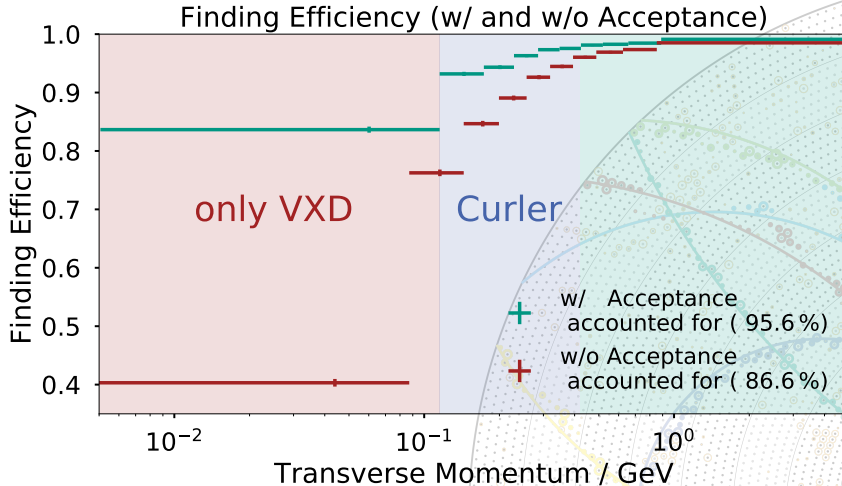
Picking up Pixel Hits with the CKF

Adding pixel hits via CKF into PXD.

$\Rightarrow$ High purity despite high number of background hits.
$\Rightarrow$ Significant improvement of the track parameters.

First Pixel Hit found with the CKF in Cosmics Data

Finding Efficiency (w/ and w/o Acceptance)

only VXD

Curler

w/ Acceptance
accounted for (95.6 %)

w/o Acceptance
accounted for (86.6 %)

Finding Efficiency

Transverse Momentum / GeV

Conclusion

At Belle II separate approaches are employed for track finding in the CDC and SVD.

CKF-based methods are used to merge tracks and pick up pixel hits.

The combined application of these algorithms was **tested successfully on simulation**, will be further tested during Phase II and is **ready to face data from collisions** in Phase III.

Thank You for Your Attention!