



# POCA Problems with displaced tracks

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ETP - KIT



# How do we store Track Fit Information?



Belle2::Tracks are created from RecoTracks and used for analysis

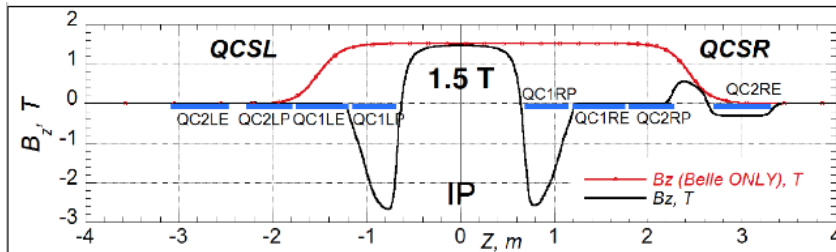
- If the track fit was not successful: skip track
- The track state is taken from the closest hit to the IP (0,0,0) and extrapolated to the point-of-closest-approach (POCA) line formed by the beam spot and beam axis
- `msop.extrapolateToLine(m_beamSpot, m_beamAxis);`
- The B-Field in z-direction at the POCA is loaded
- A new `TrackFitResult` is created and track momentum and position and  $B_z$  are given to the constructor
- The `TrackFitResult` uses the `UncertainHelix` class to compute the well-kown track parameters

```
UncertainHelix h(pos, mom, charge, bField, ...);  
m_tau[iD0] = h.getD0();  
m_tau[iPhi0] = h.getPhi0();  
...
```

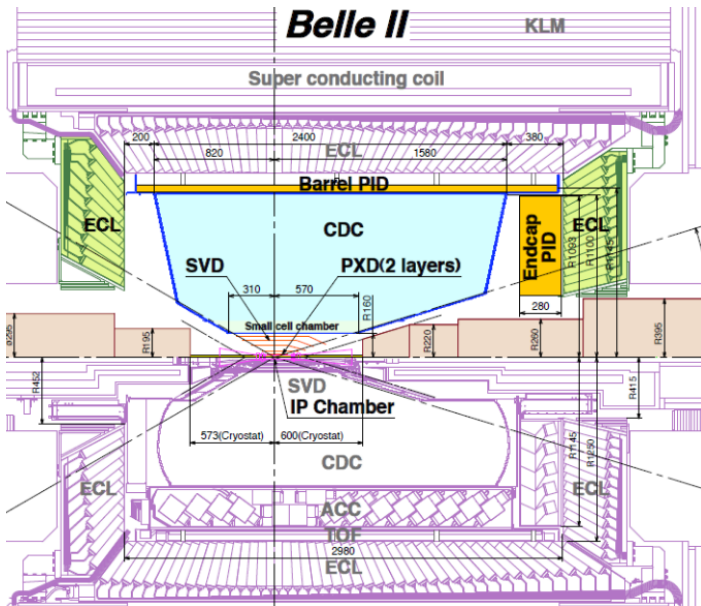
Note: We do this for multiple hypothesis, but this is not important here

# What's the problem?

- This procedure works fine as long as the extrapolation ends up somewhere in the VXD-region: homogeneous magnetic field and the helix approximation of class `UncertainHelix` works
- But if a track's POCA is left or right of the VXD we end up in the **QCS-magnets**: Superconduction final focusing magnets with **HUGE** field gradients



# Belle 2 Schematic

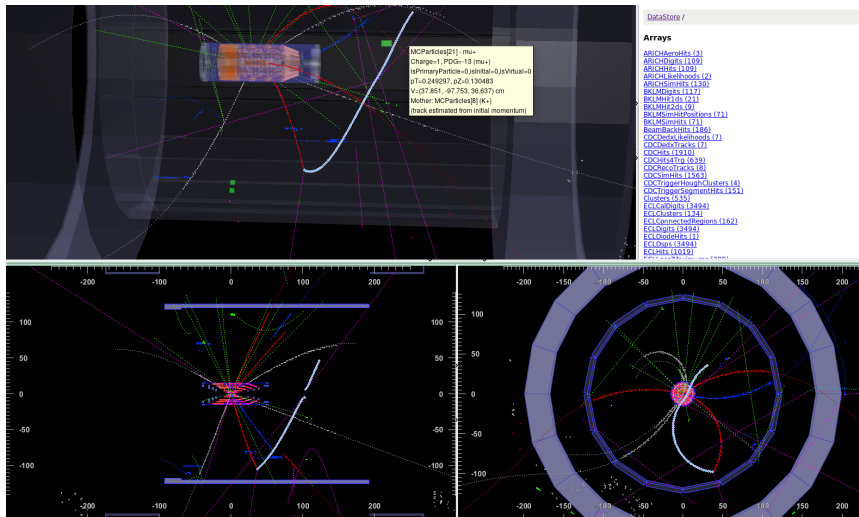


# What's the problem?

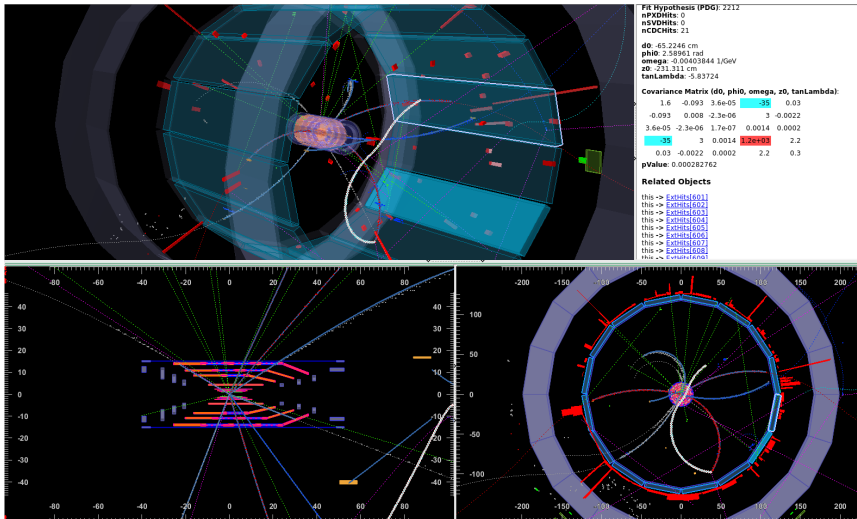


- We have seen this problem before for tracks not from the IP: with cosmic tracks it led to wrong charge assignment
- This was fixed around 4 month ago by not extrapolating to the beam line but using the innermost hit as a reference point
- The TrackCreatorModule has two options for this: `useClosestHitToIP` and `useBFieldAtHit` which are turned on for cosmics reconstruction
- **I now have observed cases where the POCA treatment leads to problems also in collision events**
- In around 1 track in 100 events, the charge of a track is zero because the `UncertainHelix` computations break down:  
<https://agira.desy.de/browse/BII-2329>
- The cases I have seen so far are all displaced tracks of decays in flight

# Example: $K^+ \rightarrow \mu \nu$



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# Solution ?



- I think no easy fix (as we did with cosmics) is possible: in collisions we rely on most tracks coming from the IP
- **Solution A \$:** don't use the POCA with the beamline but the innermost hit for tracks which would end up in the QCS  
*This is quite intransparent to the analysis users, and the last hit has no physical meaning*
- **Solution B \$\$:** use the decay vertex position as helix parametrisation point  
*Not always sure that we are able to identify if the track comes from inner or outer part of the detector*  
*This will only work for decay-in-flight tracks, but we can also have background tracks coming from the QCS magnet volume*

\$ = Work to implement



# Solution ?



- **Solution C \$\$\$**: still extrapolate to the POCA with the beamline, but ignore the QCS fields and assume a uniform B-field from the last hit  
*Would keep the parametrisation of all tracks consistent*  
*Might lead to weird border effects, as the QCS fields already influence the field inside of the tracking volume*  
*Difficult to implement*

\$ = Work to implement