Performance of Belle II's Level 1 Single Track Trigger

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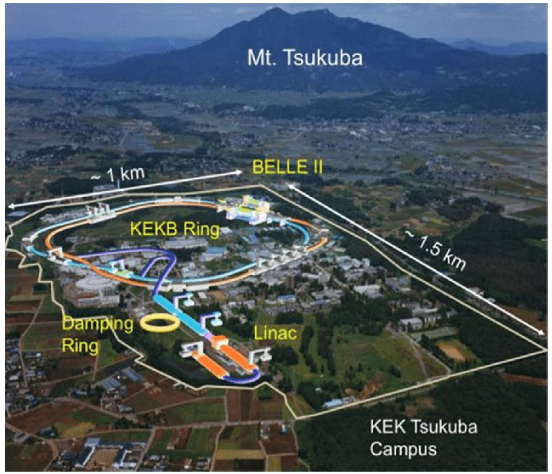
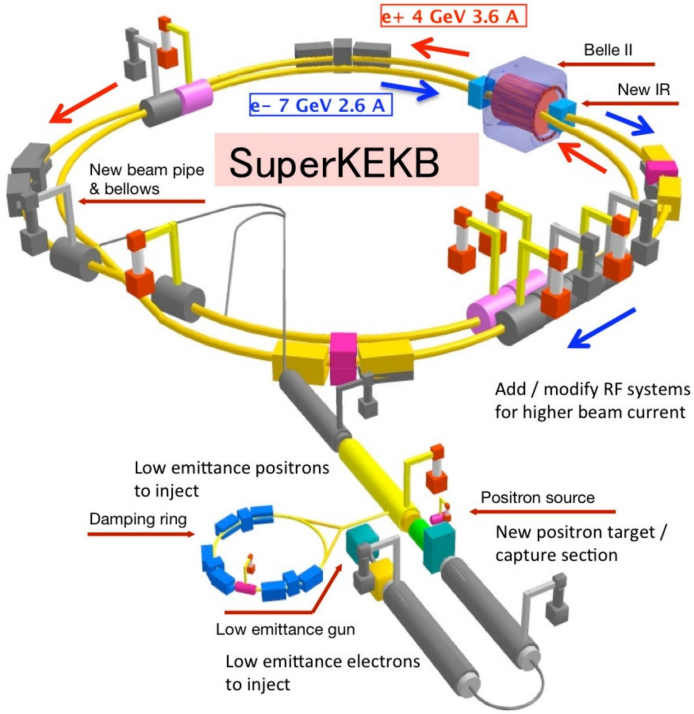
The Belle II Experiment

- Located at the SuperKEKB in Tsukuba, Japan
- asymmetric e+/e- collider operating at 10.58GeV (Y(4S)-resonance for B-meson pair production)





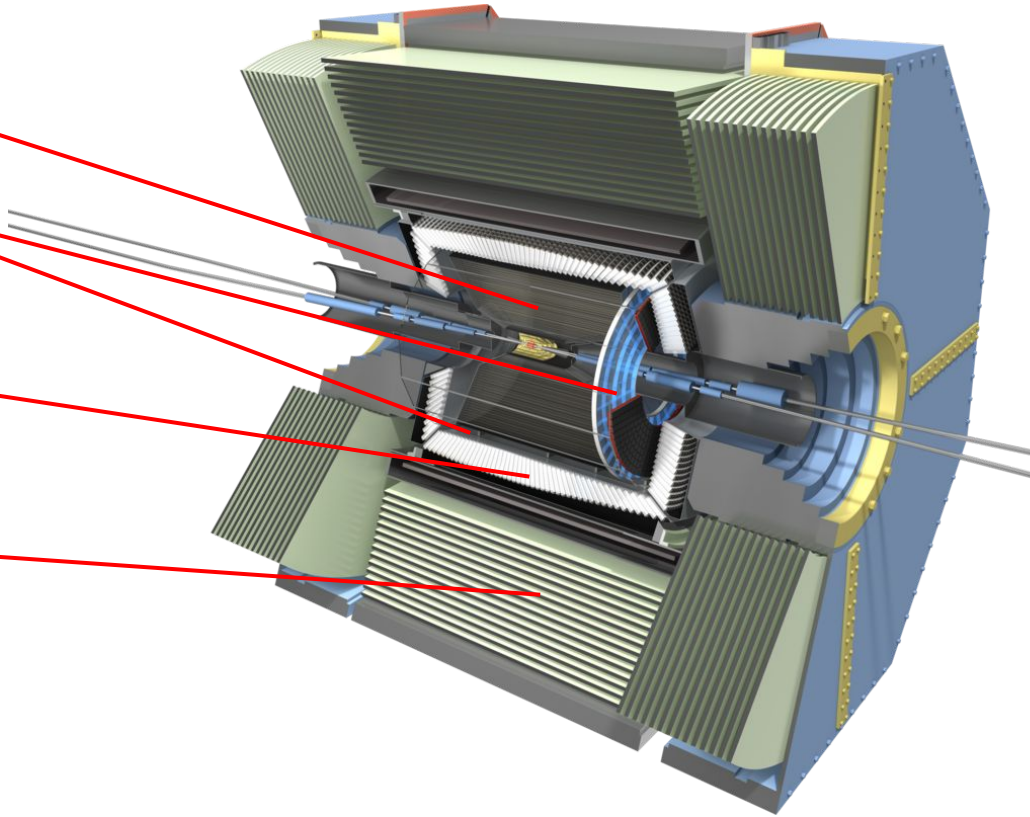
The Belle II L1 Trigger System

Central Drift Chamber (CDC)

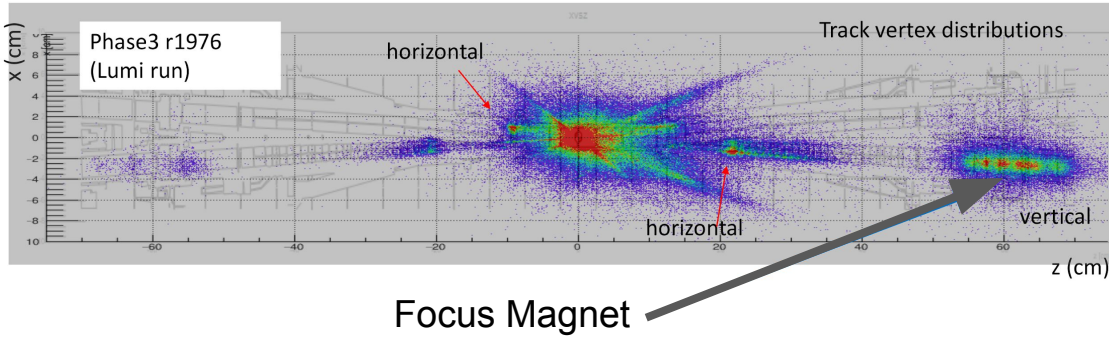
Particle Identification (PID)
(TOP + ARICH)

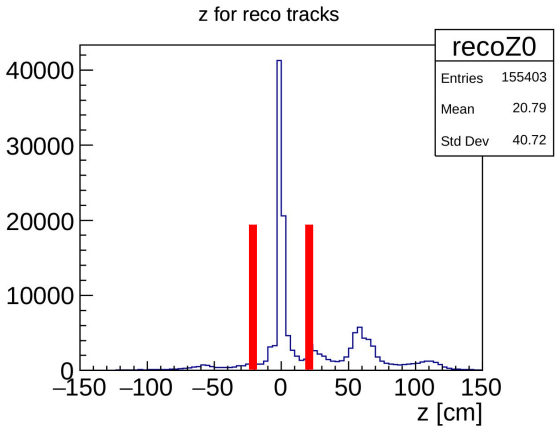
Electromagnetic Calorimeter
(ECL)

Scintillator Based KLong and
Muon Detector (KLM)



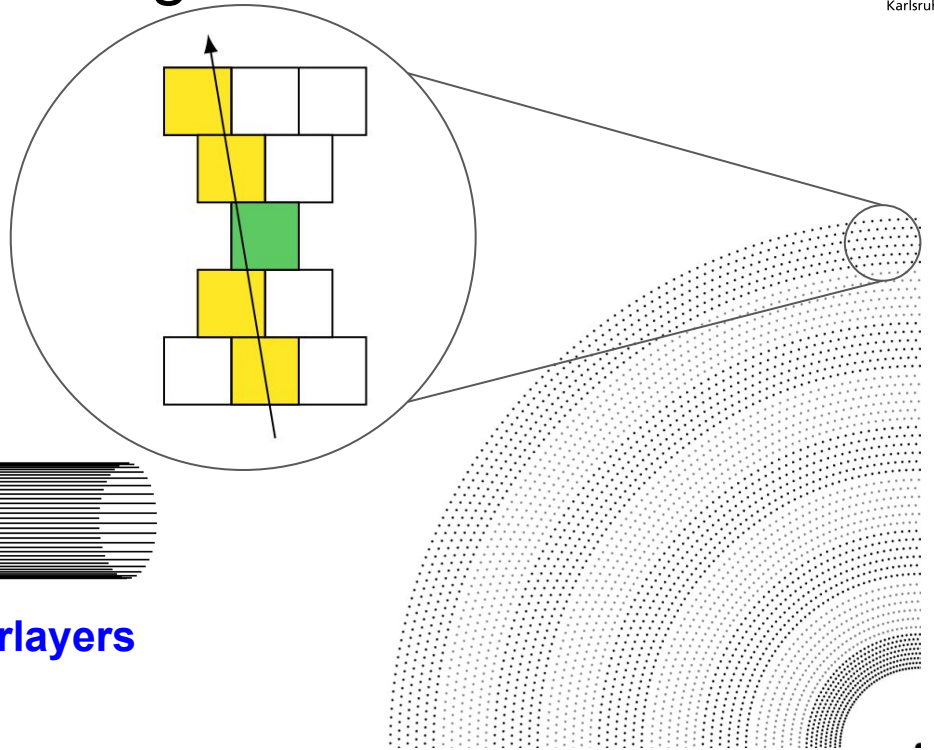
Goal of the Neurotrigger

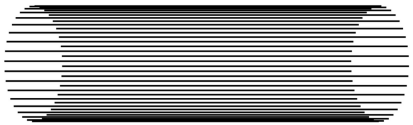




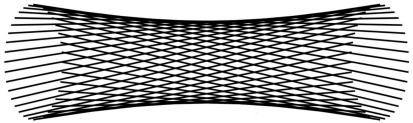
- Differentiate between physics and background
- **Introduce z-vertex cut at first trigger level**

The Track Segment Finder





Axial Superlayers

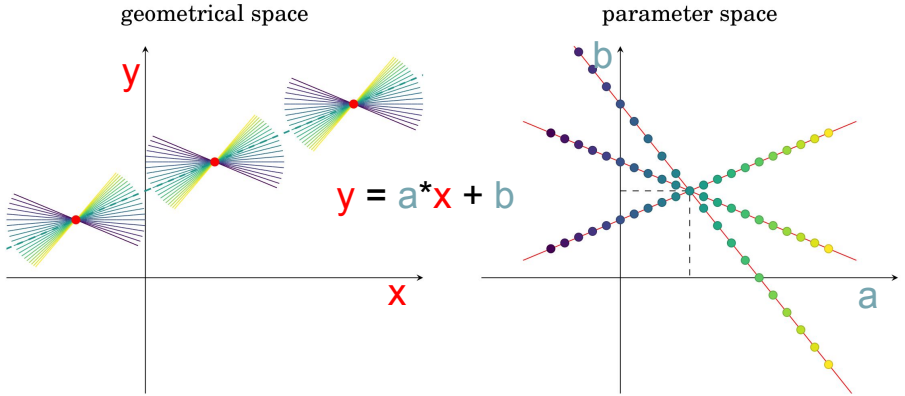


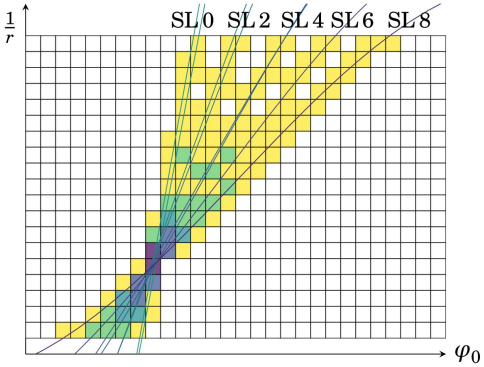
Stereo Superlayers

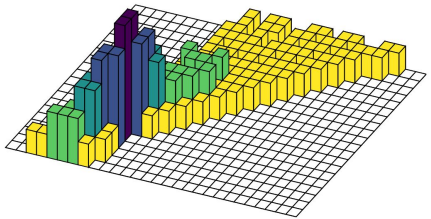
A S A S A S A S A

- Used for data reduction / background suppression
- Find hit patterns “Track Segments” within Superlayers (SL)
- 4 out of 5 Wire Layers in a SL need a Hit
- Outputs Track Segment Number, left/right information and the time of the priority wire (green)

The 2D Finder

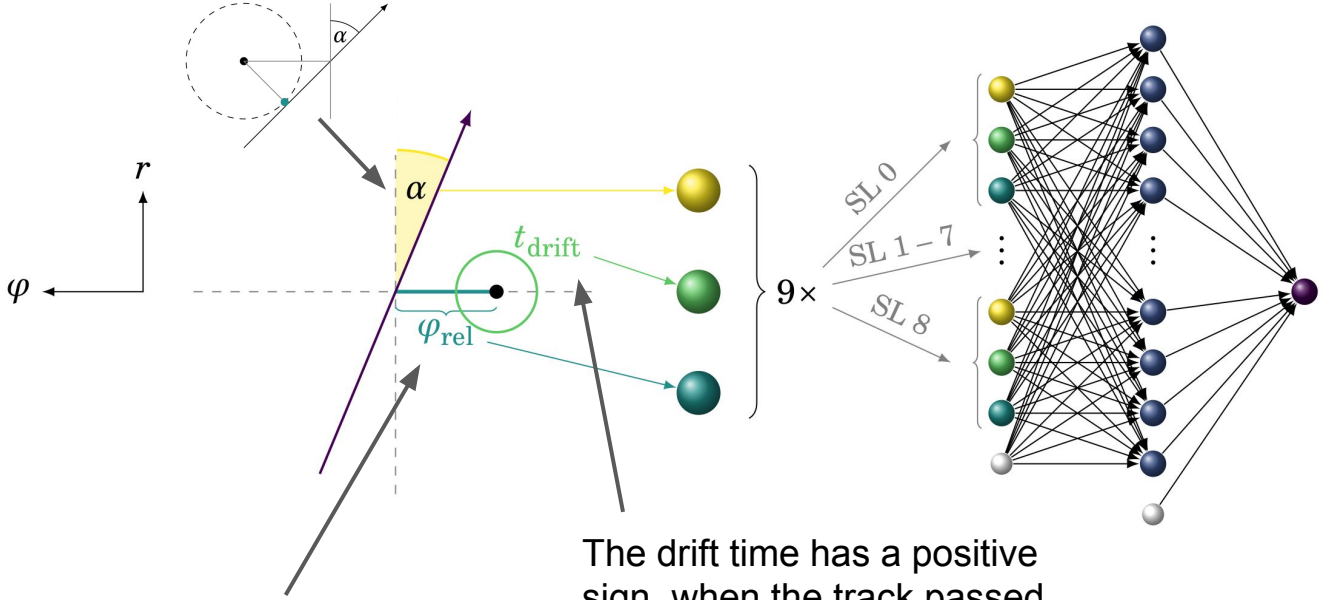






- Finds 2-dimensional Tracks without z-information
- Takes only Axial Track Segments as Input
- Uses the Hough-Transformation: Every Point in the geometrical space corresponds to a line in the parameter space
- **only when a 2D-Track is found, the Neurotrigger starts**

The Neurotrigger



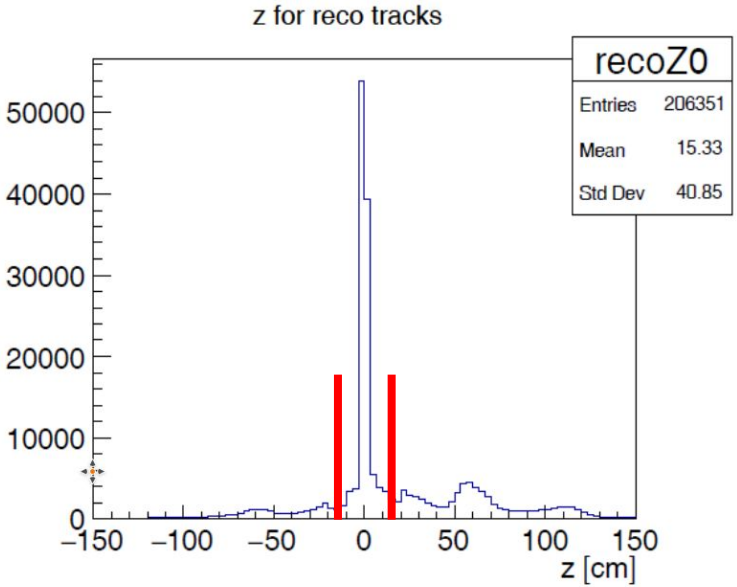
Delta φ relative to the 2DTrack. For Axial TS this is 0.

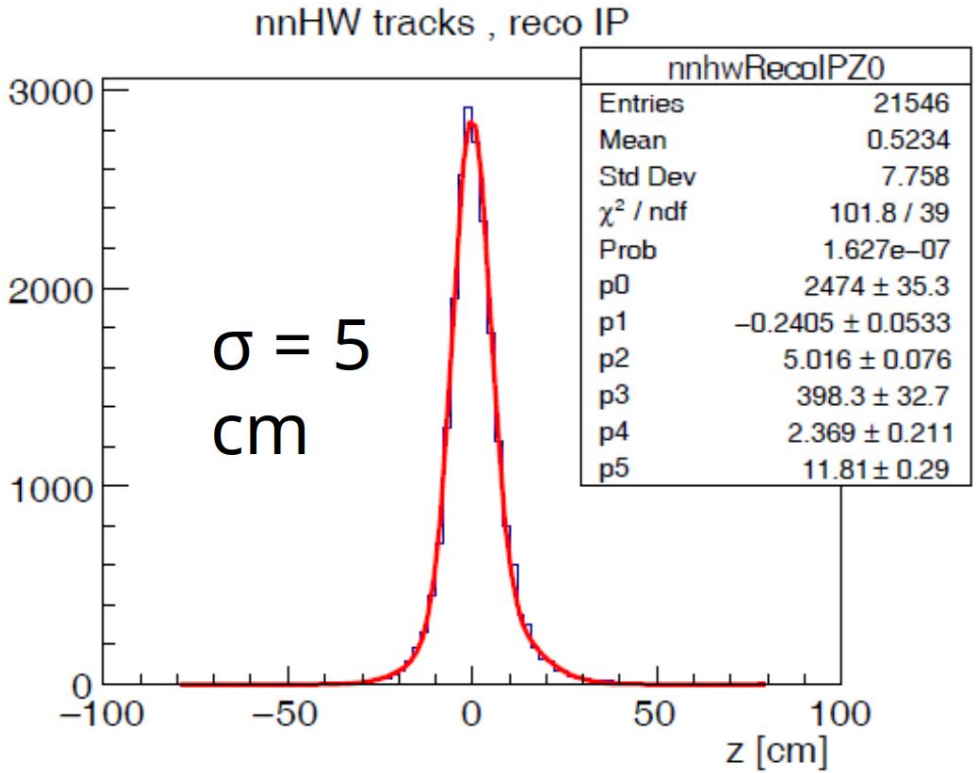
The drift time has a positive sign, when the track passed on the right side, and a negative sign if it passed on the left.

- Multilayer Perceptron with 1 hidden layer
- Inputs:
  - Crossing angle
  - Drift time
  - φ relative to 2DTrack
- Outputs:
  - z vertex
  - θ angle

ΔZ Resolution

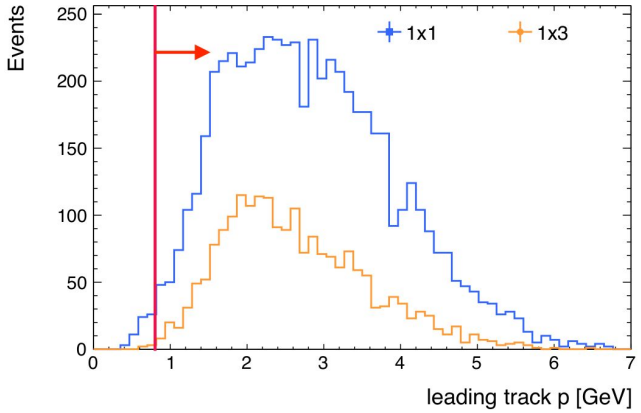
- ΔZ resolution at interaction point (IP) between Neurotracks and reconstructed tracks: 5cm
- Cut at 3σ → |z| = 15cm

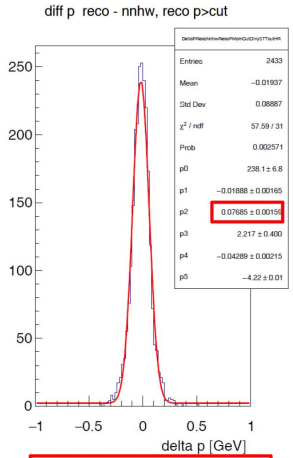




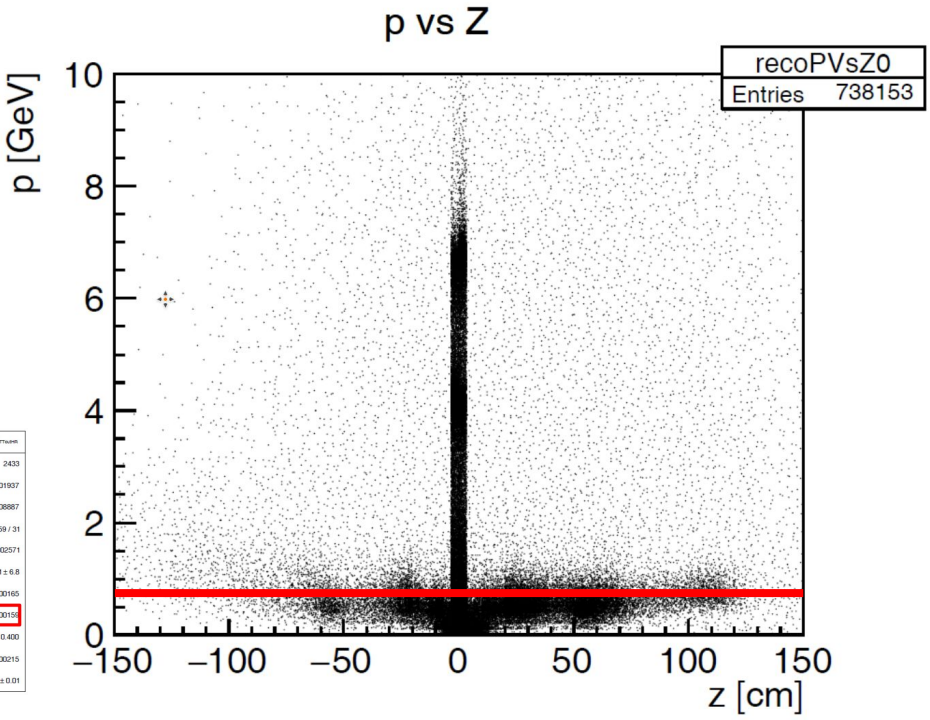
Trigger Bits: The STT

- Various trigger bits are fed into “Global Decision Logic” (GDL)
- STT: “Single Track Trigger” Bit
  Triggers on single tracks
  |Z| < 15cm and momentum > 0.7GeV



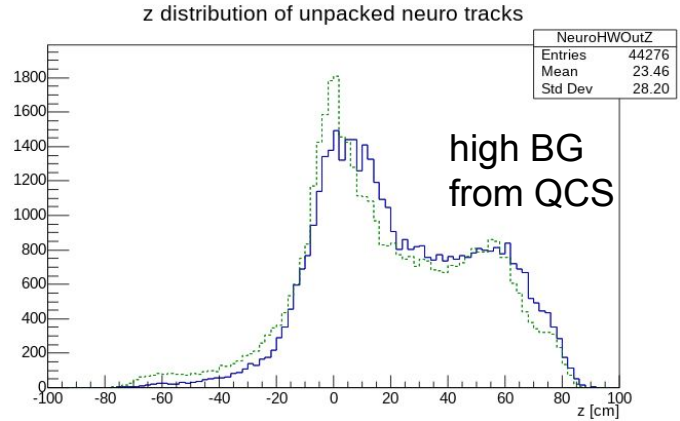


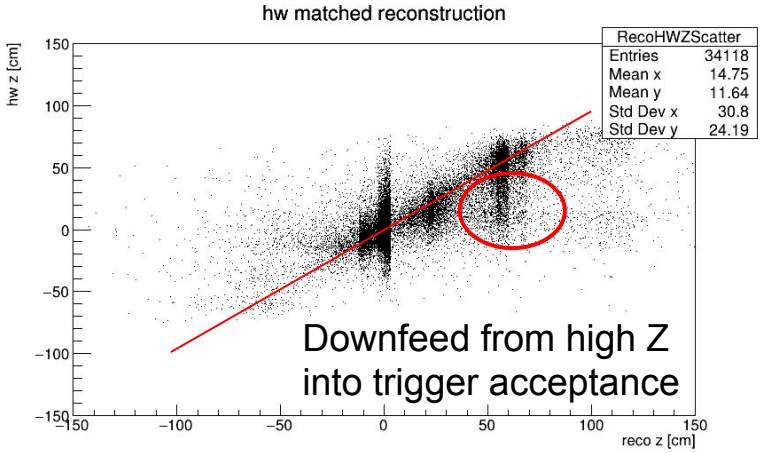
Resolution in p ~ 80 MeV



High Trigger Rates in 2021C

- Several luminosity records during end of last year, currently 3.81 x 10^34cm^{-2}s^{-1}
- Total trigger rate became very close to the data aquisition limit of 12kHz
- STT trigger rate was ~1.8kHz (~1kHz exclusive)
- Problem: Tracks with missing innermost Track Segment are biased towards the IP





New Network Training

- Training is now done externally of our software framework with the PyTorch library (previously FANN was used)
- Improved training algorithm by using batch training with small batch sizes
- Better optimizer is used now (ADAM)
- Weights are initialized with the XAVIER initialization method
- Downfeed problem was prevented by correcting the training data selection

Neurotrigger Performance in 2022

- Since march, Belle II is running again
- Luminosity currently around 2.6 x 10^34cm^{-2}s^{-1}
- Neurotrigger performance nearly doubled!
- Downfeed problem is solved

Neurotrigger is prepared for new Belle II luminosity records!