Performance of the Belle II z-Trigger under Luminosity Conditions: First Experience

Neurotrigger Team: Steffen Bähr, Christian Kiesling, Felix Meggendorfer, Sebastian Skambraks, Kai Unger
The Belle II Experiment

- Located at the SuperKEKB in Tsukuba, Japan
- Asymmetric e+/e- collider operating at 10.58GeV
  ($\gamma_{4s}$ -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)
CDC: The Neurotrigger

- The Neurotrigger is a first level track trigger
- It is able to filter tracks from outside the interaction region

![Graph of z for reco tracks with a peak at z = 0 and entries, mean, and std dev displayed]

Felix Meggendorfer | fmegg@mpp.mpg.de | Max-Planck-Institute for Physics | 21.04.2020 | Slide 03/16
The Trigger System and Data Flow

- CDC
- ECL
- TOP
- ARICH
- KLM

Global Decision Logic (GDL)

- time passed: 5μs

High Level Trigger (HLT)

Express Reconstruction

Storage

- PXD + SVD

Freqs:
- 30 kHz
- 6 kHz

Felix Meggendorfer | fmegg@mpp.mpg.de | Max-Planck-Institute for Physics | 21.04.2020 | Slide 04/16
The CDC Data Flow

CDC

5 Axial Superlayers → 41 Axial Boards → 5 Axial TSF Boards → 4 2DFinder Boards → 4 Neurotrigger Boards

CDC

4 Stereo Superlayers → 32 Stereo Boards → 4 Stereo TSF Boards

4 Neurotrigger Boards

Felix Meggendorfer | fmegg@mpp.mpg.de | Max-Planck-Institute for Physics | 21.04.2020 | Slide 05/16
Central Drift Chamber (CDC)

- 56 wire layers, total of 14436 sense wires
- divided into 9 Superlayers (5 Axial, 4 Stereo)
The Track Segment Finder

- 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

- Multilayer Perceptron with 1 hidden layer
- Inputs:
  - Crossing angle
  - Drift time
  - $\phi$ relative to 2DTrack
- Outputs:
  - $z$ vertex
  - $\theta$ angle

Delta $\phi$ 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.
The Neurotrigger - z-Resolution in Hardware

- Delta-z resolution plot for Neurotrigger results and matched reconstructed tracks
- The fitted Gaussian returns a standard deviation of $\sigma = 4.2\text{cm}$
Rejection for $|z| < 35\text{cm}$

Simple trigger logic: every track outside 35cm of the interaction point is rejected

Felix Meggendorfer | fmegg@mpp.mpg.de | Max-Planck-Institute for Physics | 21.04.2020 | Slide 11/16
Rejection for $|z| < 35\text{cm}$

Simple trigger logic: every track outside 35cm of the interaction point is rejected.

Background rejection works, peak has the same height.
Rejection for $|z| < 35$ cm

Simple trigger logic: every track outside 35cm of the interaction point is rejected

Also some events from the IR are rejected
Rejection for $|z| < 35$cm

Simple trigger logic: every track outside 35cm of the interaction point is rejected.
Rejection for $|z| < 35\text{cm}$

Simple trigger logic: every track outside 35cm of the interaction point is rejected.

Those false negatives remain to be understood.
Conclusions and Outlook

- With the Neurotrigger, a great background reduction is possible
- We still need to understand, where the false negatives are coming from
- Next step: Move from track based to event based trigger decisions and implement 2-track trigger algorithms
- Tomorrow there will be a talk from Sebastian Skambraks about improving the 2D-Finder to a 3D-Finder
Thanks for Your Attention!