

Karlsruhe Institute of Technology



# Belle II L1 Preprocessing and Neuronal Network Track Trigger K. Unger<sup>1</sup>, S. Baehr<sup>1</sup>, S. Skambraks<sup>1</sup>, F. Meggendorfer<sup>2</sup>, C. Kiesling<sup>2</sup> and J. Becker<sup>1</sup>

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**1. Belle II Detector** 



- Particle accelerator experiment in Tsukuba, Japan
- Investigation of CP violation between matter and anti-matter
   Challange: High Luminosity  $\mathcal{L} = 8x10^{(35)}cm^{-2}s^{-1}$ .





Two different types of Track Segment. A pyramid type for SL 0 and a hourglass for SL 1-8
 The track segments limit the origin angle to approx 30° around the interaction point.
 Build Track Segments from hits to filter and reduce the data
 Implemented on 9 FPGAs and working stable since begin of 2019

### 5. Neuronal Network Trigger (NNT)





Main Detector for Tracks

- Gas field camber with 14,336 sensor wires and 42,240 field wires
- Organized in 9 Super Layer (SL)

## 3. CDC L1 Trigger System



Neural networks used to predict z-Vertex of an event
Feed-Forward Multi Layer Perceptrons used for prediction implemented in FPGA
Pipelined architecture for processing the data
As a singel track trigger it is running since January 2021
Since April all physic track triggers need a valid neuro track

## 6. Neuronal Network Trigger and 3D Hough preprocessing

- 3D Hough processing with clustering and center of gravity calculation
- Afterwards a special trained Feed-Forward Multi Layer Perceptrons is prediction the z-Vertex
- Higher efficiency expected than 2D preprocessing
- More details from Sebastian Skambraks "The 3D Track Finder for the Belle II Trigger"
- Implemented on FPGA UT4 via Vivado HLS tools
- First Prototype are build. Test at the 2021 autumn runs



- The L1 decision time is 5  $\mu$ sec from readout to Global Decision Logic.
- Low Latency data processing is required
- Maximum trigger rate from 30 MHz (at the moment 10 MHz)
- Logic implemented in FPGA as Universal Trigger Boards 3 or 4 (virtex6 or ultrscale)

#### 7. Long-term developments (depends on funding)

- Replace the Neuronal Network Trigger with the Neuronal Network Trigger and 3D Hough preprocessing
- Development of a new track segment finder which allows to find tracks with low energy or displaced Vertix as well
- Anomaly detection Trigger for Dark Matter

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