CLAWS for Beam Abort in SuperKEKB

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Workshop on Beam Loss Monitors and Beam Abort Systems

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MAX-PLANCK-INSTITUT
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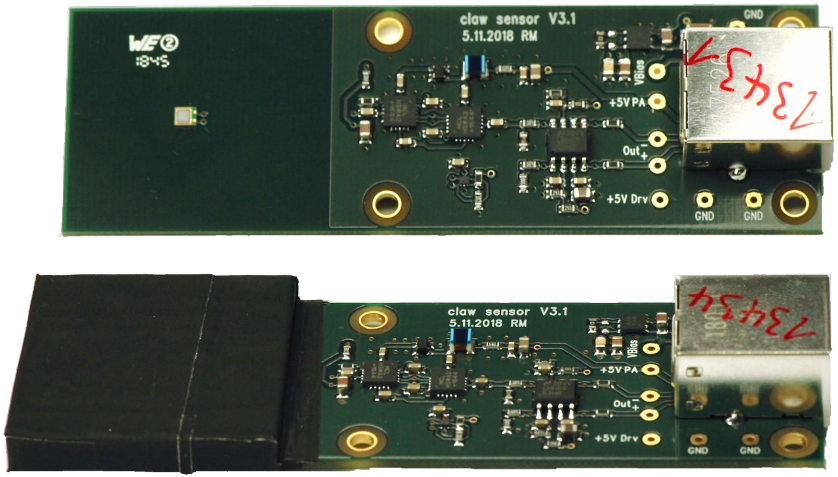
The CLAWS System

Scintillator **L**ight **a**nd **W**aveform **S**ensors:

- ➔ Hamamatsu silicon photomultipliers mounted on 3x3 cm² plastic scintillators, mostly great sensitivity to charged particles
- ➔ 32 sensors, 16 on forward and backward side of the Belle 2 detector, mounted on the QCS with varying z and φ positions
- ➔ Monitoring of the timing properties of circulating injection bunches and the rate of ionizing particles around IP

Ideal for fast detection of beam disturbances and subsequent beam aborting!



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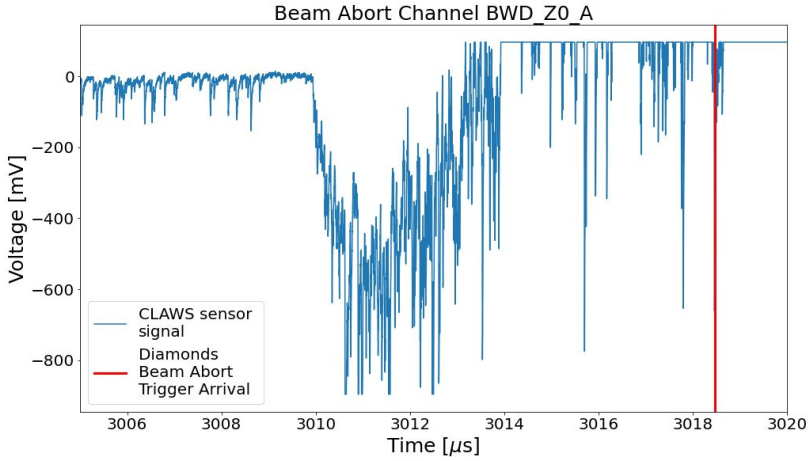
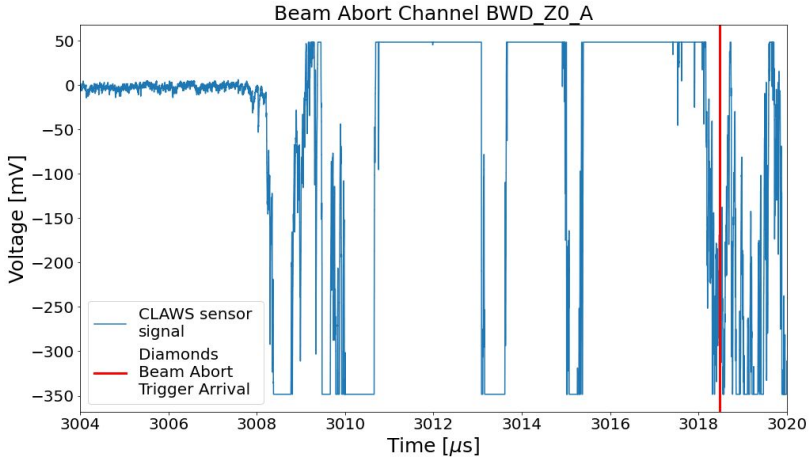
Beam Abort Events

To set an appropriate trigger, one must first observe such an event with the CLAWS sensors

- ➔ Since 07.04.2020 CLAWS sensors trigger on the abort triggers emerging from the Beam Abort Diamonds
- ➔ Currently more than 35 beam abort events observed in the CLAWS sensors
- ➔ Signal amplitude consistently extremely high for a duration of couple hundred ns





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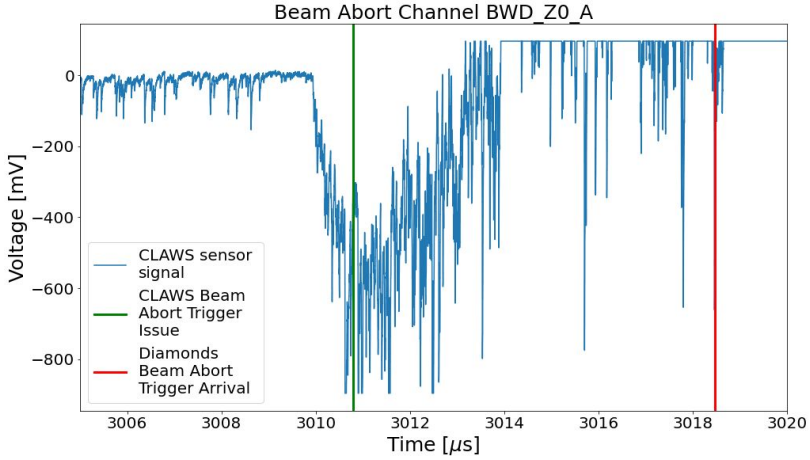
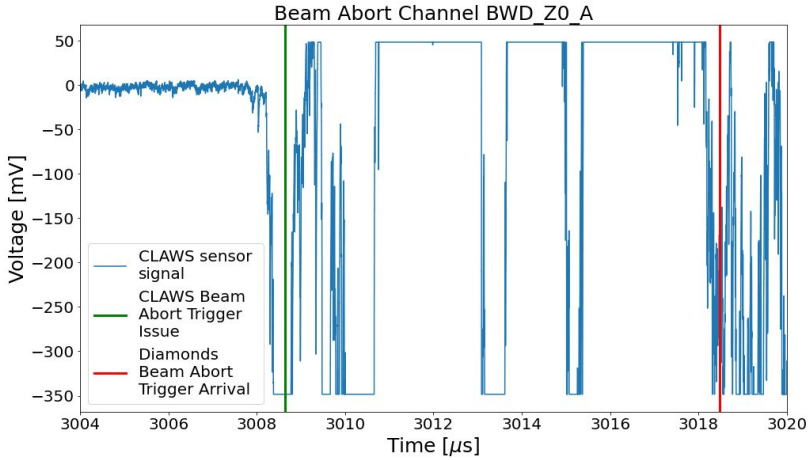
Trigger proposition

- ➔ To avoid false triggering both a duration and an amplitude thresholds must be set
- ➔ Tested with previously recorded Phase 3 CLAWS data, no false triggers so far, would allow to issue a beam abort trigger up to 10 µs before the arrival of the Beam Abort Diamonds signal
- ➔ No additional CLAWS sensors required, signal will be doubled to two DAQ systems and a new readout device will be installed in the ehut for the purpose of beam aborting





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Keysight P9242A

Technical overview:

- ➔ USB Oscilloscope with two analog channels
- ➔ 500 MHz bandwidth, 5 GSa/s sample rate
- ➔ Allows for complex trigger settings
- ➔ When triggered, it outputs a 0-2.5V rising edge signal with 1.2 µs duration

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Keysight P9242A

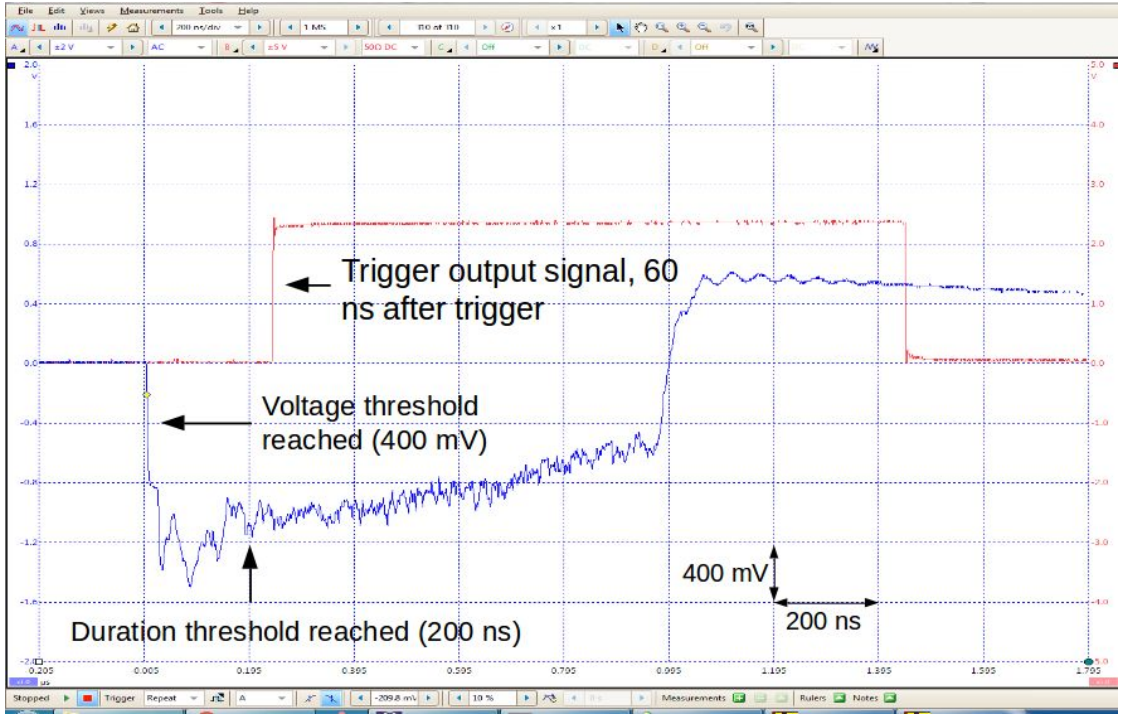
Trigger test setup:

- ➔ A UV-LED diode was powered with very short pulses from an Agilent 81110A Pulse Pattern Generator
- ➔ The diode and an unwrapped CLAWS sensor were placed in a light tight box with a thin barrier between the sensor and the diode
- ➔ Scope set to trigger on negative signals which stay above 400 mV for at least 200 ns
- ➔ The CLAWS sensor signal (in blue) and the USB Oscilloscope output signal (in red) were fed into a Picoscope in order to observe trigger delay

Keysight P9242A

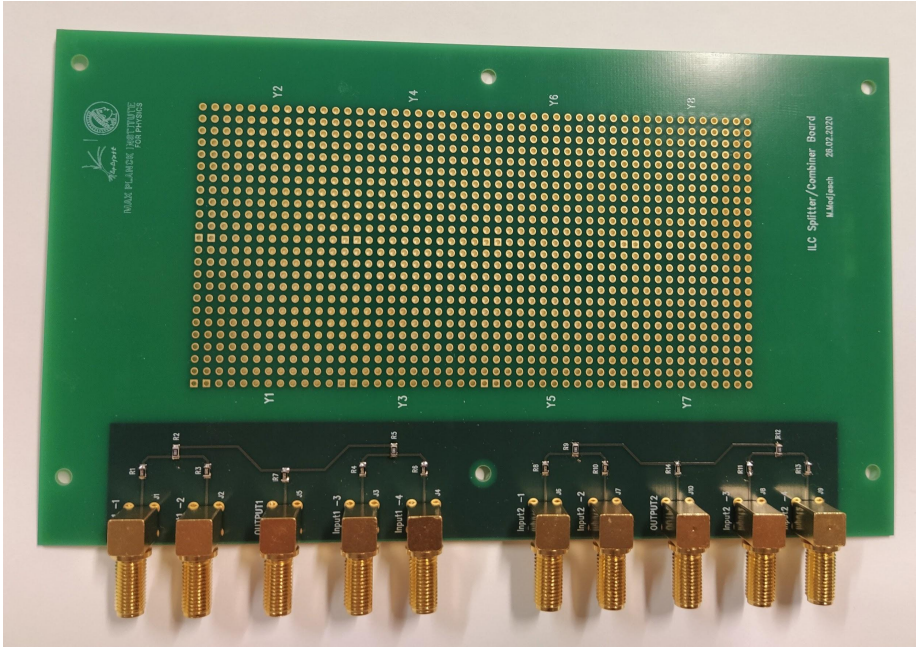
Trigger test results:

- ➔ The scope behaved as expected and did not issue any false triggers
- ➔ The output signal is sent 60 ns after trigger conditions are fulfilled, which is a negligible delay



CLAWS Sensor Signal Addition

- ➔ To optimize reliability, at least four sensors per side should be considered for the trigger
- ➔ Due to high cost of scope modules a custom-designed combiner box will be used to add signals from up to four sensors
- ➔ Same tests as described in the previous slides were repeated successfully with the combiner box



Summary

- ➔ The CLAWS sensor modules consistently observe beam abort events
- ➔ The Keysight P9242A USB Oscilloscope triggered quickly and reliably on conditions comparable to beam abort conditions
- ➔ No extra detector hardware will be needed, setup can be installed during SKB run time accessing the ehut only
- ➔ Tests with actual CLAWS sensors successful
- ➔ Addition of CLAWS sensor outputs via passive power splitter/combiner possible
- ➔ Order of two oscilloscopes for read-out and development of signal distribution box necessary before setup is ready to be installed