T 55: Data, AI, Computing, Electronics VI (DAQ and Trigger)

Time: Wednesday 16:15–18:30 Location: VG 2.102

T 55.1 Wed 16:15 VG 2.102

Development of an FPGA-based DAQ system for the OBELIX sensor for the Belle II VTX upgrade — •Tobias Blesgen[1], Maximilian Babeluk[2], Christian Bespin[1], Jochen Dingfelder[1], Hans Krüger[1], and Alexander Walsemann[1] — [1]University of Bonn, Physikalisches Institut, Nußallee 12, 53115 Bonn, Germany — [2]Austrian Academy of Sciences, Institute of High Energy Physics, Nikolsdorfer G. 18, Vienna, Austria

To address the demands of higher luminosities at the Belle II experiment, a new vertex detector system featuring the monolithic OBELIX pixel sensor is currently under development. The large (3 cm x 2 cm) sensor area consists of over 400,000 pixels utilizing DMAPS technology. Alongside the OBELIX chip, a dedicated readout system for laboratory and beam tests is being designed and verified. The FPGA-based DAQ system builds upon the existing TJ-Monopix2 DAQ framework and has been adapted to include new features required to work with the OBELIX chip.

The FPGA is placed on the multi-purpose BDAQ board, originally developed for the RD53 readout for the upgrade of the ATLAS and CMS pixel detectors. TJ-Monopix2 and OBELIX exhibit the same command protocol as the RD53B chip while implementing a different hit data receiver logic to match the updated hit structure.

This talk presents the development process, key features and verification process of the data acquisition system.

T 55.2 Wed 16:30 VG 2.102

The XENONnT Data Acquisition System — •Robin Glade-Beucke for the XENON-Collaboration — Albert-Ludwigs Universität, Freiburg, Germany

The XENONnT experiment is an ultra-low background liquid xenon TPC for direct dark matter detection. Its trigger-less Data Acquisition System aims at achieving maximal total uptime and the lowest possible energy threshold. Live processing of the data allows timely insight in current data taking, even in high-rate scenarios such as during calibration. Later reprocessing with improved processing parameters is possible. The high data rates during calibration can be mitigated on-line with FPGA-based veto decision-making.

T 55.3 Wed 16:45 VG 2.102

On-Board Data Processing for a Mission to Study the Antiproton Content in Earth's Radiation Belts — •Peter Hinderberger, Martin J. Losekamm, Luise Meyer-Hetling, and Stephan Paul — School of Natural Sciences, Technical University of Munich, Garching, Germany

The Earth's magnetic field traps charged particles in the Van Allen radiation belts. We intend to precisely measure the flux of trapped antiprotons with energies of tens to hundreds of MeV using a tracking calorimeter made from scintillating plastic fibers and silicon photomultipliers. The instrument will fit on a compact satellite that will, however, restrict the power, volume, computing capacity, and transmission bandwidth available to our experiment. In addition, a low signal-to-background ratio and high event rates make data acquisition and processing challenging. To address these challenges, we are developing a hardware and software framework based on a field-programmable gate array (FPGA) that can acquire, filter, and compress data efficiently in orbit, exploiting its advantages in low-power parallel computing. Our pipelined multi-stage processing approach is designed to reliably identify, count, and partly reject clearly identifiable background events, and to compress the remaining signal candidates without losses. This minimizes the amount of data that must be transmitted to the ground without impacting our measurement. I present the motivation, current status, and short-term plans of our work. It is funded by the German Research Foundation (DFG, project number 414049180) and under Germany's Excellence Strategy-EXC2094-390783311.

T 55.4 Wed 17:00 VG 2.102

Constellation - a flexible DAQ and control system for test beam environments — •Stephan Lachnit and Simon Spannagel — Deutsches Elektronen-Synchrotron DESY

The qualification of new detectors in test beam environments presents a challenging setting that requires stable operation of diverse devices, often employing multiple Data Acquisition (DAQ). Changes to these setups are frequent, such as using different reference detectors depending on the facility. Managing this complexity necessitates a system capable of controlling the data taking, monitoring the experimental setup, facilitating seamless configuration, and easy integration of new devices.

Due to limitations in existing frameworks, collaborative efforts between DESY, DVel, Lund University, and the University of Hamburg have led to the development of Constellation - a new, flexible framework tailored towards laboratory and test beam environments. Constellation streamlines setup integration through network discovery, enhances system stability by operating autonomously, and simplifies onboarding with comprehensive documentation.

This contribution will provide a brief overview of the Constellation and insights from the first test beams with Constellation.

T 55.5 Wed 17:15 VG 2.102

Development and Tests of Python-based Control Software for a EUDET-type Beam Telescope at the ELSA Test Beam Area — •Rasmus Partzsch, Christian Bespin, Yannick Dieter, Jochen Dingfelder, Fabian Hügging, and Lars Schall — Physikalisches Institut, Nußallee 12, 53115 Bonn, Germany

Test-beam telescopes are reference tracking devices used to investigate the performance of detector prototypes. The EUDET-type beam telescope consists of six MIMOSA26 pixel detector planes. These feature a small pixel pitch (18.4 um) to enable a high spatial resolution for particle tracks. A time-reference plane is added to the ANEMONE beam telescope to provide precise timing information for individual particle tracks. The detectors are synchronized with a trigger logic unit (AIDA-TLU). One of the main requirements of the test-beam infrastructure is flexibility to accommodate different types of devices under test and different experimental setups. This flexibility applies not only to the hardware setup but also to the control software, detector readout, and analysis tools. A new Python-based control software has been developed for the control of the AIDA-TLU, implementing various trigger logic configurations and communication modes for different devices.

In this talk, the Python-based control software for a EUDET-type beam telescope setup is presented. Additionally, test results using an ATLAS ITkPix chip, designed for the ATLAS inner tracker upgrade, as the time reference plane, along with the AIDA-TLU control software at trigger rates of up to 100 kHz at the ELSA test-beam area, will be discussed.

T 55.6 Wed 17:30 VG 2.102

Compact converters for fast frame rate detectors — •Kennedy Caisley[1], Hans Krüger[1], Bart Dierickx[2], and Jochen Dingfelder[1] — [1]University of Bonn, Bonn, Germany — [2]Caeleste, Mechelen, Belgium

Frame-based radiation detectors with integrating front-ends are especially well-suited for applications like electron microscopy and X-ray imaging where hit-rates are high, spatial resolution should be maximized with simple pixels, and energy resolution is needed, but particles need not be individually discriminated in time, space, or spectrum. In an experimental setting, fast frame rates allow for real time in-situ observations. Potential subjects include rapid chemical processes, molecular dynamics of proteins, crystal nucleation and growth, material phase transitions, thermal conductivity, charge transfer, and mechanical strain.

Our work pursues the possibility of a single-reticle array larger than 1 Mpixel with a continuous frame-rate surpassing 100,000 fps. For the conjunction of these two specifications to be met, we will discuss initial investigations into a compact and power efficient bank of column-parallel data converters, which at 10-12 bit resolution churn out data at a rate in excess of 1000 Gbps. To fit within the constraints of a chip bottom, the converter fabric must respect a restricted metric of 1 W/cm^2 while exceeding a 5 ksps/μm^2 sampling rate density. Successive-approximation ADCs are identified as the optimal choice, and various topologies and techniques will be analyzed to meet our goals.

T 55.7 Wed 17:45 VG 2.102

A parametrised Kalman filter for the GPU-based first level trigger of the upgraded LHCb experiment — Michel De Cian[1,2], Stephanie Hansmann-Menzemer[1], and •Lennart

Uecker[1] — [1]Physikalisches Institut, Ruprecht-Karls-Universität Heidelberg, Germany — [2]Department of Physics and Astronomy, University of Manchester, United Kingdom

The LHCb Upgrade I detector implements a fully software-based trigger to select a wide range of physics signatures. The first-level trigger employs 500 GPU cards to perform partial event reconstruction at the complete LHCb collision rate of 30 MHz. This includes finding charged tracks, reconstructing proton-proton collisions, particle identification and finding displaced vertices. The implementation enables an increased trigger performance, especially for hadronic channels, thus elevating signal yields above the increase in luminosity.

Kalman filters are commonly used in High Energy Physics to process pattern recognition tracks and extract optimal track parameters. However, these filters' sequential nature and substantial memory requirements make them suboptimal for GPU implementation. We developed a method that replaces computationally demanding operations with parametrized approximations, specifically material scattering calculations and state extrapolation in the magnetic field. This approach achieves high-throughput track fitting while maintaining track information quality, making it suitable for GPU-based processing in high-rate environments. In this talk we present the implementation and performance of the GPU based Kalman filter for LHCb Run 3.

T 55.8 Wed 18:00 VG 2.102

Reconstruction of photon conversion in rare decays — •Bernd Mumme — Physikalisches Institut, Heidelberg, Germany

Flavour changing decays involving the emission of an energetic photon are of great interest to study the peculiar flavour structure of the Standard Model and search for indirect signs of new dynamics at very high energy. Some of the most sensitive probes are the rare or forbidden flavour-changing neutral current decays of heavy fermions: $b \to s\gamma$, $c \to u\gamma$ and $\tau \to \mu\gamma$. Rare decays involving a photon in the decay products are reconstructed through the dielectron pair they convert to. To efficiently detect these dielectron pairs significant upgrades are being implemented in LHCb's trigger system to enhance efficiency. The trigger consists of a GPU-driven first high level trigger (HLT1) and a CPU-run second level trigger (HLT2). Improvements include the development of a new trigger line in HLT1 capable of reconstructing significantly displaced electrons from photon conversions in real time as well as incorporating these electron tracks in HLT2, both driven by modern machine learning techniques. These upgrades aim to maximize event selection efficiency and keep data throughput for rare decays manageable. This talk will outline the physics motivation for searches for flavour-changing neutral current decays and detail the technical developments in optimizing the LHCb trigger for these and similar rare decays.

T 55.9 Wed 18:15 VG 2.102

Development of an automated pixel monitoring website — Arnulf Quadt, Marcello Bindi, and •Tim Schlömer — II. Physikalisches Institut, Georg-August-Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen

The ATLAS Pixel detector registers charged particles by the charges generated in the detector by the incoming particles. A specific number of electrons, defined by the threshold, is required to register a hit. Additionally, the time-over-threshold (TOT) is measured. The charge threshold and TOT of the Pixel Detector are regularly tuned to maintain target values as they detune with integrated luminosity, as a result of radiation damage effects. Monitoring key parameters including but not limited to charge threshold, TOT, digital-to-analogue converters, the number of masked pixels, and the number of disabled columns is crucial. Tracking these parameters over time and across integrated luminosity is essential for maintaining optimal detector performance and contributes to studies on radiation damage.

The detector operation parameters are presented via a web framework which displays relevant plots and values. A pipeline for automatic updates after each detector tuning ensures the plots are up-to-date, while older versions remain accessible for reference. The framework also allows the user to visualise the evolution of critical parameters over time and compare specific tunings belonging to different period of the detector lifetime.