T 70: Electronics, Trigger, DAQ III

Time: Thursday 16:15–18:00 Location: KH 00.023

T 70.1 Thu 16:15 KH 00.023

The Hypothesis Firmware for the ATLAS L0 Trigger system for HL-LHC — •Emanuel Meuser — Institut für Physik, Johannes Gutenberg-Universität Mainz

During the upgrade for HL-LHC, parts of the ATLAS detector will be upgraded, and the time-multiplexed L0Global Trigger system will be added to the first-level trigger. As part of this L0Global Trigger system, a hypothesis firmware to evaluate all the trigger objects/candidates of an event in a serialized and non-LHC-synchronous manner will go into operation in 2031.

This hypothesis firmware has to perform multiplicity triggers, as well as topological ones, as configured by a trigger menu. Since this trigger menu can change in periods too short to rebuild and validate new firmware, the hypothesis firmware needs to be runtime-configurable within certain boundaries. The design and implementation of the hypothesis firmware, focusing on resource optimization, robustness, and configuration via a trigger menu, will be discussed.

T 70.2 Thu 16:30 KH 00.023

Commissioning, Validation, and Simulation of the JUNO hardware trigger logic — •Ze Chen[1,2] and Livia Ludhova[1,2] — [1]GSI Helmholtzzentrum für Schwerionenforschung, 64291 Darmstadt, Germany — [2]Institute of Physics and EC PRISMA+, Johannes Gutenberg Universität Mainz, Mainz, Germany

The Jiangmen Underground Neutrino Observatory (JUNO) is a large-scale neutrino experiment using a 20-kt liquid scintillator as the Central Detector (CD) surrounded by a 35-kt water Cherenkov veto Detector (WCD). The experiment completed full detector commissioning and subsequently began physics data taking on August 26 2025. Using an exposure of 59.1 days, JUNO has achieved world-leading precision in the measurement of solar neutrino oscillation parameters. Reaching this level of performance requires a robust and accurately functioning hardware trigger system for both subdetectors.

In this talk, we present a comprehensive validation of the JUNO hardware trigger logic using commissioning data. The two JUNO subdetectors employ different trigger logics: the CD uses a multiplicity trigger with dedicated handling of muons, while the WCD adopts a regional scheme that fires when a cluster of Photomultiplier tubes (PMTs) in a local area is hit. To evaluate trigger performance, PMT hit information is analysed across all event categories. In particular, we examine the dynamic CD trigger conditions, which aim to suppress consecutive muon-induced triggers and mitigate DAQ I/O bottlenecks. We also implemented the trigger logic in JUNO's detector simulation framework, enabling future optimization of trigger configurations.

T 70.3 Thu 16:45 KH 00.023

The Mu3e DAQ build system and CI — •Alexandr Kozlinskiy for the Mu3e-Collaboration — Johann-Joachim-Becher-Weg 45, 55128 Mainz, Germany

The *Mu3e* experiment is designed to search for the lepton flavor violating decay $\mu^+ \to e^+e^-e^+$ with the aim of reaching a branching ratio sensitivity of 10^{-16}. The experiment is located at the Paul Scherrer Institute (Switzerland). The existing beam line will provide 10^8 muons per second and at first will allow to reach a sensitivity of a few 10^{-15}.

The readout system of *Mu3e* uses Intel FPGA chips for which the firmware and IP components are compiled with the Quartus software. To improve the development and testing of the *Mu3e* DAQ firmware, custom scripts were developed to build firmware directly from the command line. The continuous integration is used to build and test the firmware on each commit. This allows for faster development of firmware and tracking of regressions during development.

The talk will cover the scripts, tools and the design of the *Mu3e* DAQ build system.

T 70.4 Thu 17:00 KH 00.023

Online Track Reconstruction for the Mu3e Experiment — •Haris Avudaiyappan Murugan for the Mu3e-Collaboration — Institute of Nuclear Physics, Johannes Gutenberg University of Mainz, Germany

The Mu3e experiment aims to find or exclude the lepton flavour violating decay of a positive muon to two positrons and an electron with a branching fraction sensitivity of 10^-16. To observe such a rare event, we require a tracking detector from custom-designed High-Voltage Monolithic Active Pixel Sensors (HV-MAPS) together with timing detectors made from scintillating fibres and tiles for the experiment. The detector will be streaming up to 1 TBit/s of data to the filter farm composed of graphics processing units (GPUs), in which the data rate is reduced to less than 100 MB/s and this filtered data is stored for later analysis. This reduction can be achieved by selecting potential signal events with two positrons and one electron originating from a single vertex through online track and vertex reconstruction on the GPU. During the 2025 beam run we were able to perform/test online tracking and selection of events using the filter farm.

T 70.5 Thu 17:15 KH 00.023

The Tile Calorimeter Trigger and Data Acquisition interface: Realtime and Readout Developments — •Anna Dunz and Thomas Junkermann — Kirchoff-Institut für Physik, Heidelberg

With the Phase-II Upgrade of the ATLAS experiment, the front- and back-end electronics for the Tile Calorimeter will be replaced. This upgrade is made necessary by the increase in luminosity of the LHC. The new electronics are designed to improve signal reconstruction while coping with more simultaneous Proton-Proton collisions.

The Tile Calorimeter Trigger and Data Acquisition interface (TDAQi) is part of the new electronics design. It is an ATCA rear transition module equipped with an AMD Kintex Ultrascale+ FPGA. The TDAQi provides an interface between the Tile Calorimeter electronics and the ATLAS trigger systems. Following the requirements of the Level-0 trigger subsystems, different algorithms are performed to calculate trigger inputs. Cell energies from the Calorimeter are decoded and high energy cells are identified. Cells are summed up to provide lower granularity objects to the electron and jet triggers. For the muon trigger, cells are summed up at a high granularity, and threshold comparisons are performed. The processing algorithms and data transmission are carried out on the FPGA. An overview of the firmware is presented with a focus on the muon system showcasing the real-time as well as read-out capabilities of the TDAQi.

T 70.6 Thu 17:30 KH 00.023

The DAQ and Trigger System for the DELight Experiment — •Lea Burmeister for the DELight-Collaboration — Kirchhoff-Institute for Physics, Heidelberg University

While heavy WIMP searches have reached unprecedented sensitivities, the light dark matter (DM) sector remains largely unexplored. Probing light dark matter candidates requires novel detector concepts with ultra-low thresholds. The Direct search Experiment for Light dark matter (DELight) will employ superfluid helium-4 as the target medium monitored with MMC-based large-area microcalorimeters (LAMCALs) operating at mK temperatures, which provide excellent energy resolution with a detection threshold of a few eV.

The DELight experiment requires a data acquisition (DAQ) system capable of detecting extremely small energy depositions without acquiring deadtime. This talk presents ongoing R&D work on the DELight DAQ and trigger system, with focus on its FPGA-based Level-1 (L1) trigger. The L1 trigger will process digitized microcalorimeter waveforms in real time using downsampling, filtering, and flexible threshold logic to distinguish low-energy events from noise. The filtering step will be achieved using an FIR filter whose coefficients resemble a time-domain optimal filter.

T 70.7 Thu 17:45 KH 00.023

Development of a Stand-Alone Drift-Tube-Based Muon Trigger for the ATLAS and CRESST Experiments — •Stefan Eder, Davide Cieri, Oliver Kortner, Sandra Kortner, Federica Petricca, Michele Mancuso, and Alexander Langenkämper — Max Planck Institute for Physics

The upcoming High-Luminosity LHC era will require substantially improved selectivity in the ATLAS first-level muon trigger system. To meet these demands, new FPGA-based trigger processor boards have been developed that, for the first time, incorporate precision tracking information from Monitored Drift Tube (MDT) chambers directly into the Level-0 trigger decision. Before operation in Run 4, the MDT detectors, their readout, and trigger processors must be commissioned using cosmic-ray muons. This requires a dedicated track-finding algorithm that relies solely on information from drift-tube detectors.

This presentation introduces a standalone drift-tube-based muon trigger algorithm designed for this purpose, along with its FPGA gateware implementation and expected performance. In addition to cosmic-ray commissioning, the newly developed standalone track reconstruction algorithm enables trigger decisions during ATLAS operation without input from fast trigger detectors. Beyond its application in ATLAS, the algorithm also opens the possibility of serving as a muon veto in the CRESST dark matter experiment by installing spare ATLAS MDT chambers around the cryogenic CRESST detector setup. The adaptation of the algorithm for this use case will also be discussed.