T 27: Muon Detectors

Time: Tuesday 16:15–18:15 Location: KH 00.023

T 27.1 Tue 16:15 KH 00.023

Development of a test bench for the MDT front-end electronics and L0 MDT Trigger Processor full-slice tests at the expected HL-LHC rates — •Georgios Lamprinoudis, Gia Khoriauli, Raimund Ströhmer, and Thomas Trefzger — Julius-Maximilians-Universität Würzburg

The new electronic readout of the Muon Drift Tube (MDT) chambers is a key component of the ATLAS Phase 2 upgrade for HL-LHC. The system will incorporate new mezzanine boards and chamber service modules of the MDT front-end electronics in conjunction with the new L0 MDT Trigger Processor. The development of this electronic chain requires continuous quality control and assessment. The test bench is being designed to fulfil both of these tasks by using simulated muon samples to emulate the operation and performance of the full-slice MDT readout and to optimize the muon L0 trigger.

T 27.2 Tue 16:30 KH 00.023

Small-Diameter Muon Drift Tube Detector Chambers for the ATLAS Phase-II Upgrade: Performance and Certification with Final Readout Electronics — •Elena Voevodina, Oliver Kortner, Hubert Kroha, Nick Meier, and David Weber — Max Planck Institut für Physik - Werner Heisenberg Institute Boltzmannstr. 8 - 85748 Garching, Germany

To meet the High-Luminosity LHC (HL-LHC) requirements, the Muon Drift Tube (MDT) chambers in the ATLAS Muon Spectrometer's inner barrel layer (BIS) are being replaced by small-diameter MDT (sMDT) chambers. The new sMDT stations will be integrated with triplets of thin-gap Resistive Plate Chambers (RPCs) to increase geometric acceptance and strengthen the barrel muon trigger. Between January 2021 and September 2023, 102 sMDT chambers were produced at two sites; 50% with some spares were built at the Max Planck Institute for Physics (MPI), Munich. All detectors from both production sites have been shipped to CERN for final validation. Following the production of ˜3,600 stacked readout mezzanine cards and their QC/QA testing at the University of Würzburg, the cards were installed on the BIS1-6 sMDT chambers at CERN in 2025. In this contribution, we present the certification methodology and performance results for detectors equipped with the final electronics at the CERN BB5 facility*covering gas tightness, electronic noise, muon detection efficiency, and spatial resolution*and compare them with the outcomes of the initial quality-assurance campaign conducted at MPI.

T 27.3 Tue 16:45 KH 00.023

Integration of an SiPM-Based Scintillation Detector into the Readout Chain of a Cosmic Muon Test Stand with a CMS Drift Tube Chamber — Erik Ehlert, Dmitry Eliseev, •Nils Jonathan Esper, Thomas Hebbeker, Kerstin Hoepfner, Markus Merschmeyer, Carsten Presser, and Alexander Schmidt — III. Physikalisches Institut A, RWTH Aachen University

The III. Physics Institute A at RWTH Aachen University operates a cosmic test stand with a fully functional Drift Tube (DT) chamber and all necessary peripherals, which is similar to the chambers used in the Compact Muon Solenoid (CMS) experiment. Recently, the chamber was equipped and recommissioned with the readout electronics that will be used in the Phase-2 upgrade of CMS. In addition, a scintillation detector with Silicon Photomultiplier (SiPM) readout has been constructed at our institute. With the goal of integrating the readout of the scintillator into the chamber backend system, new electronics and corresponding firmware have been developed. These electronics feature the Low Power Gigabit Transceiver (lpGBT) chip, a serializer-deserializer device developed at CERN. It allows to inject the detector data into the backend system, and maintains synchronization with the global clock. This talk presents the newly developed scintillator readout chain and first recorded data. The data is compared to the independently reconstructed tracks from the DT chamber.

T 27.4 Tue 17:00 KH 00.023

Integration of Upgraded MDT Readout Electronics in the LMU Cosmic Ray Facility — •Lilla Schneider, Otmar Biebel, Valerio D'Amico, Ralf Hertenberger, Eshita Kumar, Nick Schneider, Chrysostomos Valderanis, and Fabian Vogel — LMU München

The Phase-II upgrade of the ATLAS Muon Spectrometer for the High Luminosity LHC (HL-LHC) involves the implementation of a more advanced trigger and readout system for the Monitored Drift Tube (MDT) chambers. The Cosmic Ray Facility (CRF) at Ludwig-Maximilians University Munich, equipped with two fully operational ATLAS series production, 8 m^2 sized MDT chambers enclosed by a scintillator hodoscope for triggering, is an optimal location for the testing and evaluation of these systems. Integrating the new readout electronics into the existing reconstruction chain in the CRF is a crucial step in this evaluation process. It allows for detailed studies of any differences between the legacy electronics and the upgraded system. This talk will present the current status of this project and show a comparison between the performance of the old system and the new Phase-II electronics.

T 27.5 Tue 17:15 KH 00.023

Simulation of a calorimetric muon detector using liquid organic media for imaging of nuclear materials — •Nicolas Andreas Schwarz, Yan-Jie Schnellbach, and Sarah Friedrich — Technische Universität Darmstadt, Darmstadt, Germany

The Treaty on the Non-Proliferation of Nuclear Weapons (NPT) aims to ensure the exclusively peaceful civilian use of nuclear technology in energy generation and disarmament. Nuclear safeguards are technical measures to support non-proliferation. This contribution presents a conceptual muon detector that could prove itself useful as a safeguard for the purpose of (re-)verification. The energy loss of cosmic muons as charged particles is described by the Bethe-Bloch formula. They belong to minimally ionizing particles (MIPs) and thus the mean energy loss is a function of the momentum alone for given material charge densities in the Bethe region. The proposed detector concept studied in this work is a two-sided hybrid muon detector, that uses a PVT scintillator hodoscope for muon track reconstruction, and a liquid organic TPC for calorimetric energy loss measurement since the muon ionizes the medium, producing drift electrons proportional to the deposited energy. Multiple Coulomb Scattering implies a near Gaussian distribution of scattering angles. Combining both information, simulation-based feasibility studies have been conducted to yield density images and show that a differentiation of heterogeneous materials is possible. The insights gained from this analysis will be further developed to apply them to the context of Spent Nuclear Fuels.

T 27.6 Tue 17:30 KH 00.023

Simulations regarding the water tank instrumentation for LEGEND-1000 — •Eric Esch — University Tübingen

In order to reach the challenging background goal of less than 10^{-5} cts/(keV*kg*yr) targeted by the next phase of the Large Enriched Germanium Experiment for Neutrinoless $\beta\beta$ Decay (LEGEND), new detector systems have to be planned and optimized. Previous Monte Carlo studies have revealed that the in-situ production and delayed decays of ^{77}Ge and its metastable state ^{77m}Ge constitute a significant cosmogenic background. This talk will present recent simulations exploring the instrumentation of the water tank, aimed at mitigating these contributions. Specifically, the instrumentation seeks to identify and veto events produced by neutron-showering muons, the key source of $^{77(m)}$Ge background.

T 27.7 Tue 17:45 KH 00.023

Development of new measurement methods of particle track dE/dx and time slew corrections to drift times for the ATLAS MDT detectors — •Jens Ledermann, Thomas Trefzger, Raimund Ströhmer, Gia Khoriauli, and Georgios Lamprinoudis — Julius-Maximilians-Universität Würzburg

The Monitored Drift Tube detectors (MDT) of the ATLAS Muon Spectrometer will be equipped with a new front-end electronics system after the ATLAS Phase-2 upgrade for an operation at the HL-LHC. The new 24-channel front-end mezzanine cards are designed for a precise time measurement of MDT hits at the expected HL-LHC particle rates. Comprehensive quality assessment and control tests of the mezzanine cards are performed using the tester hardware tool developed at the University of Würzburg. The test data of the mezzanine cards can be used for a calibration of a measurement of MDT ionisation charge and hence, dE/dx of charged tracks for a particle identification. Besides

that, the time slew corrections for measurements of MDT hit drift times can be derived using the test data. Corresponding new methods are currently being developed. The development progress and the application of the new methods using cosmic data collected at the MDT Cosmic Ray Facility at the LMU Munich are presented in this work.

T 27.8 Tue 18:00 KH 00.023

Activities towards Phase-II upgrade of the CMS Drift Tube detector — •Dmitry Eliseev, Nils Esper, Carsten Presser, Markus Merschmeyer, Alexander Schmidt, and Thomas Hebbeker — III. Physikalisches Institut A, RWTH Aachen University

The Compact Muon Solenoid (CMS) experiment is currently preparing for its Phase-2 Upgrade, which includes major improvements to the electronics of the Drift Tube (DT) muon detectors. A central part of this upgrade is the replacement of the legacy on-chamber minicrates with newly developed and recently produced units.

Large-scale production of the new components has been completed, and the project has now entered the assembly and quality-assurance phase. Our group has played a significant role not only in the development and production of the new electronics but also in establishing of the quality assurance of the new DT electronics. Together with the CMS DT collaboration, the group has developed and deployed a software framework designed for testing and validating the new electronics, enabling consistent operation at multiple collaboration sites.

This talk reviews the ongoing CMS DT upgrade activities, and also summarizes the latest results from the current validation program. The upcoming steps on the path toward the CMS DT Upgrade are discussed as well.