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A Muon Telescope as Demonstrator of the JUNO Top Tracker Detector

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A four-layer muon telescope has been built employing the equipment and electronics developed for the Top Tracker (TT) detector of the Jiangmen Underground Neutrino Observatory (JUNO). It will serve as a demonstrator of the hardware capabilities in terms of detection efficiency, processing power and system reliability. The entire read out, trigger and acquisition systems have been conceived and build around versatile modular electronics embedding the latest generation of system on chips. A detailed description of the telescope will be given along with the status of the TT electronics and their validation tests.

Summary

Studying neutrino interactions with the JUNO experiment requires dealing with important background signals caused by atmospheric muons traversing the main detector. To reduce the atmospheric muon rate, the experiment will be located underground, but the surrounding rock thickness is not sufficient to shield the detector. To account for the remaining atmospheric muon background, JUNO will be equipped with an external veto system called Top Tracker (TT), made of crossing planes of plastic scintillator strips, which have a high muon detection efficiency to identify and reconstruct these muon tracks. As a small demonstrator of the TT, a muon telescope has been built at the Institut Pluridisciplinaire Hubert CURIEN (IPHC). The detection system of this muon telescope is composed of the same elementary blocks as the TT but arranged in a different configuration. Four tiles of two-layer scintillator strips crossed in a XY lattice are used for precise muon tracking. A 64-anode Photomultiplier Tube (PMT H8804) collects the light of each strip layer and feeds directly the Front-End Board electronics (FEB). The heart of the FEB is a multipurpose ASIC called MAROC3 developed by Omega Microelectronics. It is a 64-channel preamplifier followed by a fast shaper and a discriminator, allowing for fast triggering in parallel with a slow shaper plus two "track and hold"for providing a multiplexed analog charge. A digital version of the latter is also available thanks to an internal Wilkinson ADC (8/10/12 bit). All the infrastructure needed by the PMT and MAROC3 is provided by a Read Out Board (ROB) that configures, controls and reads out the ASIC. The full telescope system is equipped with 8 FEB and ROB cards. A third board called Concentrator (CB) aggregates all the data coming from each ROB and sends them to the DAQ through a GbE optical link. CB provides a timestamp for ROB data with the nanosecond resolution before applying a first level (L1) trigger functionality. A simple coincidence algorithm has been implemented in order to reject the events that do not appear in the same time window in both the X and Y planes of the same detector layer. Finally, CB sends valid events to the DAQ. CB has been implemented as a motherboard that accommodates a daughter card hosting the processing unit. All the connectivity with the ROBs, DAQ, the slow control system, as well as the L2 trigger electronics (present only in JUNO) is provided by the motherboard while the daughter is an embedded high-performance system on module. It hosts a Xilinx system-on-chip of the latest generation (Zynq Ultrascale+) along with a 16Gb DDR4 RAM. Equipping this muon telescope with the readout and trigger electronics that will be deployed in the TT detector allows us to validate the whole readout chain of the future JUNO external veto system.

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