TWEPP 2017 Topical Workshop on Electronics for Particle Physics



Contribution ID: 184

Type: Poster

Readout Electronics for the First Large HV-MAPS Chip for Mu3e

Wednesday 13 September 2017 16:30 (15 minutes)

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Mu3e is an upcoming experiment searching for charged lepton flavor violation in the rare decay mu->eee. A silicon pixel tracker based on 50 um thin high voltage monolithic active pixel sensors (HV-MAPS) in a 1T magnetic field will deliver precise vertex and momentum information. The MuPix HV-MAPS chip combines pixel sensor cells with integrated analog electronics and a complete digital readout. For the characterization of the first large MuPix system on chip a dedicated readout system was developed.

The dedicated readout chain and the first results from the characterization of the large scale MuPix prototype will be presented.

Summary

The Mu3e experiment searches for charged lepton flavor violation in the rare decay $\mu \rightarrow \text{eee}$. In the standard model the decay $\mu \rightarrow \text{eee}$ is extremely suppressed with a BR <10⁻⁵⁴, so that any observation would be a clear sign of new physics. The goal of the first phase of the Mu3e experiment is to reach a branching ratio sensitivity of 10⁻¹⁵, which requires the observation of 10⁸ muons decays per second over several years of runtime. In order to reject both physics and combinatorial background, decay vertex, particle momenta and decay time have to be precisely measured. The hit resolution of the tracking detector of the Mu3e experiment is dominated by multiple Coulomb scattering. Therefore the decay vertex position and the particle momenta are determined with the help of an ultra-thin pixel detector in a 1T magnetic field.

The pixel detector is based on high voltage active monolithic pixel sensors (HV-MAPS) thinned to 50 um. The HV-MAPS developed for the Mu3e experiment, called MuPix, is a system on chip combining sensor diode, digitization including precise time-stamp, zero-suppression, fast on-chip serialization and high speed differential data output. In the last two years the first prototype with full system on chip capabilities was very successfully tested. This year the first large MuPix prototype with full pixel column length will be under investigation. This new MuPix8 has about 1cm times 2cm active area, which is half the area of the final sensor used for the Mu3e experiment.

For the sensor characterization of this complex ASIC, a dedicated readout chain was developed. It's based on an ASIC test board with ultra clean power distribution and a commercial FPGA board. The ASIC test board provides low voltage, high voltage, temperature measurement and test-pulse and is connected to the FPGA card via LVDS links. The FPGA card controls the MuPix chip via a SPI protocol and receives the continuous serial data stream from the MuPix at 1.25 GBit/s. The system has been successfully integrated in laboratory test setups and was used to build test beam telescopes with four to eight MuPix planes.

The dedicated readout chain and the first results from the characterization of the large scale MuPix prototype will be presented.

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Session Classification: POSTER Session

Track Classification: Systems, Planning, Installation, Commissioning and Running Experience