Test of prototype CBM detector components with proton beams at COSY*

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Teams of the CBM collaboration have performed several in-beam tests of prototype detectors and electronics in 2014. In April at GSI, TOF and TRD detectors were examined in a parasitic ion beam steered onto a target. Prototypes of the TRD, RICH and TOF detectors were under test in a mixed electron-pion beam in November at the CERN-PS. Two campaigns of beamtime took place at COSY, Research Center Jülich, within beam time blocks provided to support FAIR related detector developments. In August, a team spent one week with testing prototype electronics under intense proton irradiation. In December, a week of beam time focused on studies of neutron-irradiated silicon microstrip sensors for the STS detector system, response measurements of a full-size triple-GEM sector for the MUCH detector system, and further studies of radiation effects in FPGA and LDO electronics. We report here on the December test at COSY.

The CBM test bench, 3 m long, is installed in the JESSICA cave into which the proton beam of COSY is extracted. Intensities from minimum 10^4 to maximum 10^9 protons per seconds can serve testing different objects. While detector systems are preferrably tested at lower impinging particle rates, and only for load tests at higher rates, electronics is required to be tested in high beam intensity conditions. The beam can be focused down to about 0.5 cm r.m.s diameter at the objects under test. Beam defocusing to areas of a few cm^2 is possible.

The aim of the beam time campaign was to study the performance of two full-size CBM prototype components, double-sided silicon microstrip sensors for the Silicon Tracking System and a full-size GEM sector for the Muon Chambers, as well as several electronics components for the read-out chains. The double-sided silicon microstrip sensors were produced in two technical versions which were to compare. Prior to the experiment, the sensors had been irradiated at the KIT irradiation facility to 2×10^{14} 1 MeV neutron equivalent fluence matching the integrated “lifetime” exposure expected in CBM running conditions. The detectors were operated in a thermally insulated station at a temperature of -8 °C, achieved with a flow of chilled nitrogen gas. The station was part of a telescope shown in Fig. 1 (top) comprising also two reference stations to define the proton tracks, and one further station with a STS prototype module under test. The full-size prototype GEM sector seen in Fig. 1 (bottom) was produced at CERN from 500 by 471 mm GEM foils in a three-foil stack, segmented into several areas, altogether having 1200 read-out pads with progressively increasing size.

The read-out of both the silicon and the GEM detectors was achieved with n-XYTER based front-end electronics and the DABC data acquisition system. The data collected allowed studying the detector response including charge collection properties.

At the downstream end of the test stand, boards with prototype electronics were placed on the beam. Already during detector operation, tests of FPGA electronics at moderate beam intensities allowed investigating single-event upsets. Dedicated runs at highest intensities were done with analog power regulating electronics (LDO) and memory components, after the conclusion of the detector tests.

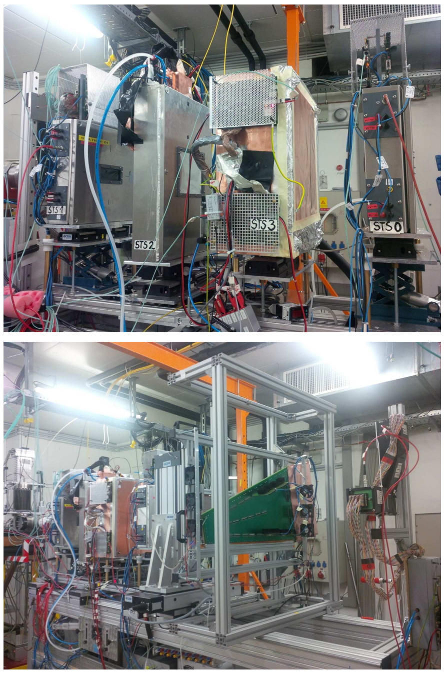

Figure 1: (Top) Telescope with four silicon detector stations. The second to the right operates the irradiated sensors. (Bottom) A full-size prototype GEM sector was installed further downstream comprising a triple-GEM foil stack.

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