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Development of a Rest Gas Ionisation Profile Monitor for the CERN Proton Synchrotron Based on a Timepix3 Pixel Detector

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A fast non-destructive transverse profile monitor, named PS Beam Gas Ionization monitor (PS- BGI), is under development at CERN for the Proton Synchrotron (PS). This monitor infers the beam profile from the transverse distribution of electrons created by the ionisation of rest gas molecules by the high energy beam particles. The distribution is measured by accelerating the electrons onto a Timepix3 based imaging detector. This detector consist of hybrid pixel detector assemblies mounted on a ceramic printed circuit board and flexible printed cable which have been developed specifically for operation in an ultra high vacuum environment.

Summary

The challenging High Luminosity LHC (HL-LHC) requirements have led CERN to initiate an ambitious improvement program of the full LHC injector chain. As part of this program the transverse emittance monitors in the CERN Proton Synchrotron (CPS) will be upgraded to provide continuous non-destructive bunch-by-bunch measurement of the beam profile.

Measurement of the transverse beam profile is currently performed by fast rotational wire scanners. These scanners cannot provide continuous bunch-by-bunch measurements and the expected future increase of the beam brightness will lead to an accelerated sublimation of the wire. A fast non-destructive transverse profile monitor is currently under development at CERN. This profile monitor, named PS Beam Gas Ionization monitor (PS-BGI), is based on the ionisation of rest gas molecules by the high energy beam particles. The transverse beam profile is inferred from the transverse distribution of the ionisation electrons, the distribution of which is measured by accelerating the electrons onto an imaging detector by means of a guiding electric field. A dipole magnetic field parallel to the electric field maintains the transverse position of the electron by countering diffusive effects.

The imaging detector for the PS-BGI must have a time resolution < 25ns to facilitate bunch-by- bunch measurement of the beam profile and a spatial resolution < 0.1mm. The environment in which the imaging detector must operate is very challenging: it must operate inside the CPS ultra- high vacuum (10ˆ(-9) mbar), in a 10 kGy/yr radiation area and be tolerant to electromagnetic interference caused by the beam. The system must also be sufficiently robust to run reliably for the duration of the annual injector program. To meet these challenging requirements an imaging detector system has been developed which is based on the Timepix3 pixel detector chip, which has been developed in the framework of the Medipix3 collaboration. The imaging detector consists of four pixelated p-on-n silicon sensors bump bonded to four Timepix3 readout chips. The hybrid pixel detector assemblies are mounted on a ceramic Printed Circuit Board (PCB) carrier which has been developed specifically for operation in an ultra high vacuum environment. The ceramic PCB is connected to electrical vacuum feedthroughs by means of a Flexible Printed Cable (FPC) based on a Liquid Crystal Polymer (LCP) substrate. To facilitate the readout of the Timepix3 chips (8 x 320 MHz SLVDS) particular attention has been paid to the signal transmission of the complete readout chain.

This contribution will focus on the development, manufacturing and first functional testing of the readout

system for Timepix3 based imaging detector, with particular emphasis on the requirements, design and manufacturing of the ceramic carrier and flexible interconnect. Finally, first results will be presented on the operation of the Timepix3 chips inside the PS beam pipe vacuum.

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