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## Quality control and reliability testing of the front-end electronics production for the upgrade of the LHCb RICH detectors

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The Ring Imaging Cherenkov detectors are key components for particle identification in LHCb experiment at CERN. The present RICH photodetectors will be replaced by multi-anode photomultiplier tubes and front-end electronics capable of operating at a 40MHz input rate. About 33.000 CLARO8 packaged ASICs have been manufactured and tested on a dedicated automatic pick-and-place station. About 4200 Front-End (FEB) and 1300 Back (BkB) boards hosting and connecting the ASICs are being checked with test setups which are going to be used also to characterize the fully assembled Photon Detector Modules. This presentation describes the dedicated test systems, procedures and results.

### Summary

With the aim to spread the potential for discovery of new physics phenomena at the LHCb experiment, an upgrade of the detector is outlined for Run III. One of the main goals of the upgrade is to allow the detector readout at every bunch crossing, i.e., a sampling rate of 40 MHz.

Therefore, the current RICH photon detectors (Hybrid Photon Detectors) will have to be replaced, together with their DAQ system, by Multi-anode Photo-Multiplier Tubes (MaPMT) and a readout system rated for 40MHz input rate (at an average occupancy of about 30%).

MaPMT photosensors convert single photons into charge signals which are fed to the input channels of the CLARO8 ASICs.

The CLARO8 Application Specific IC is designed to process input signals ranging from 30 ke–up to 20 Me–. About 33.000 CLARO8 will be exploited in the instrumentation of the upgraded RICH detectors during the Long Shutdown 2 (2019–2020).

The basic unit of the photon detector assembly is the Elementary Cell (EC) comprising 4 MaPMTs and the associated front-end electronics. An EC consists of:

- one baseboard (BB) with custom sockets to house either four 1-inch or one 2-inch MaPMT and connect their anodes to the CLARO8 input channels.
- four (two in the case of the 2-inch MAPMT) Front-End Boards (FEB), each equipped with eight CLARO8.
- one backboard (BkB), whose purpose is to interface the FEBs to the downstream Digital Board (PDM-DB) which is capable of configuring and reading out up to four ECs.

The Physics and Earth Science Department of the University of Ferrara and the Ferrara site of INFN have developed dedicated test setups to verify the functionality of the individual EC components, from the CLARO8 to the FEB and BackBoards, as well as of the fully assembled EC.

The CLARO8 ASIC test system uses a 3-axis motion control system to pick an IC from its tray, place it onto a socketed test board and then, after the test, place it either back in its tray or in an error tray, according to the result. The test is carried out through an FPGA implementing the lower level of the configuration and readout protocols, connected via Ethernet TCP/IP to the host

computer running the full test program written in NI LabVIEW. About 18.000 CLARO8 from the engineering run have been tested so far.

The FEB Quality Control system is equipped with connectors similar to those on the PDM-DB to which the operator plugs into the FEB and BkB under test. Test pulse injectors are foreseen to excite the CLARO8 inputs. The FEB\_QC System is based on FPGA (Intel-ALTERA MAX10) devices implementing the lower level of the configuration and readout protocols. These are connected via a dedicated serial protocol to the FEB\_QC\_system controller, based on an Intel-ALTERA CycloneV development kit and connected via Ethernet UDP to the host computer running LabVIEW program. About 500 FEBs and the associated Backboards have been tested so far.

Further details on the test systems, test procedures and results are highlighted.

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