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## Optimized optical design of the LHCb RICH detectors for Upgrade-II

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The design of the LHCb/RICH optical systems operating during the current Run-3 data-taking period of the LHC, will be presented with its full characterisation, to set the realistic reference for the similar designs begin developed for the envisaged Upgrade-II, which requires more stringent requirements.

Designs for Upgrade-II are then presented and analytically compared with the reference one (the Run-3 one), based on performance indicators specifically tailored to a RICH detector.

The optical designs are optimised using the OpticaEM<sup>®</sup> optical CAD, a fully flexible and customisable framework for optical (geometric and wave) calculations based on an approach very close to standard HEP codes and built on top of WOLFRAM MATHEMATICA<sup>®</sup>. Several examples of the optimization and performance reporting capabilities are shown.

The performance in terms of Cherenkov angle precision and photo-detection yield is validated through full simulation, which incorporates realistic detector conditions. We will present results obtained using a full simulation framework based on DD4hep for the detector geometry and interfaces to GEANT4 for simulating detector response and optical processes in the RICH detector.

Finally, the performance of the current RICH optics for Run-3 is compared to the expected performance of the optics for Upgrade-II, which is showed to fulfill the requirements imposed by physics.

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