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The optics challenges of the LHC Upgrade and a novel concept to reach low beta*

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Increasing the integrated performance of the LHC by a factor of 5 to 6, as requested for the exploitation period 2020-2030, cannot only be achieved by playing with one or two parameters in the luminosity formula, but by pushing all of the them at or beyond the limits. Two of them, beta*and/or the beta* aspect ratio can however reduce the requirements, both on the beam parameters and/or on the new technologies needed for the upgrade (e.g. crab-cavity).
The reduction of beta*, and a fortiori for a flat optics with a beta* even smaller in one of the two planes, was found however very challenging in the LHC due to very simple reasons: working at more less constant L*unless changing completely the detectors, constant length of the final focus system (the so-called matching section for the LHC insertions) unless "displacing the arcs", and a priori constant strength budget for the chromatic correction unless changing 500 two-in-one quadrupoles in the lattice. Under these conditions, and applying the classical approach where low-beta insertions with a squeezable optics are interleaved with arcs of machine to transport the beam at constant optics, the minimum possible beta* was found to be about 30 cm. A novel optics scheme called the "Achromatic Telescopic Squeezing (ATS) Scheme has then be worked out in order to reach much lower beta* and bring a touch of realism for the upgrade parameter lists which were proposed so far.

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