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Axial channeling of high-energy protons in bent crystals as a tool for beam steering or splitting in high-energy hadron accelerators

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As a charged particle beam is aligned with one of the main axes of a slightly bent crystal, most of the particles follows the crystal curvature due to multiple scattering with bent crystal atomic strings, the so called stochastic deflection. Indeed, in the case of positively charged particles, a portion of the beam may escape from the axial confinement to planar channeling. We investigated such mechanism at the external line H8 of CERN SPS with 400 GeV/c protons [1]. Two bent crystals were selected for the purpose, the first to meet the condition for stochastic deflection, the second, with a smaller bending radius, not to meet it.
We individuated a necessary condition for the exploitation of axial confinement for particle beam manipulation in high-energy accelerators. In the first mode exploited for the first bent crystal tested, total relaxation from axial to planar channeling is prevented and a bent crystal may be used as an efficient deflector for the whole beam. This first mode can be exploited to improve the beam collimation in the LHC, but also in future FCC-hh through an efficient deflection of the beam halo.
In the second regime used for the second crystal, escape of particles to the skew planar channels is favored and a short (few mm) Si crystal can be exploited to efficiently split the beam into two separated beams with adjustable intensity. This regime can be used in hadron accelerators, such as FCC-hh, for realization of both beam extraction and layout of the extracted beam to several beam lines by means of one passive and space-saving device.

References

[1] L. Bandiera et al., Eur. Phys. J. C 76 (2016) 80 (1-6).

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