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CRYSTAL Simulation Code and New Coherent Effects in Bent Crystal at the LHC

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Both long-lasting UA9 studies and coming Large Hadron Collider collimation and extraction experiments strengthen the need to develop reliable codes for the modelling of the proton interaction with bent crystals.

A CRYSTAL simulation code [1] for particle tracking in crystal is introduced. Its essence consists in both adequate and fast evaluation of proton trajectories in crystals with all the peculiarities of incoherent scattering in order to provide correct predictions for the wide range of charged particle energies up to 7 TeV and above.

The new effects of dechanneling peaks in the deflection angle distribution and of excess of the amorphous level of ionization losses in the channeling mode will be observed for the LHC case.

The dechanneling peaks appear due to the continuously conserving phase correlations of transverse motion of near-barrier channelling particles which dechannel mainly after their scattering near the atomic planes where the nuclei and electron densities are high. These particles give rise to the peaks in angular distribution if the typical inter-peak separation angle exceeds the r.m.s. Coulomb scattering angle at the crystal length. This condition is easier to satisfy when crystal bending radius does not exceed much the critical crystal bending radius. Since this situation is typical for the LHC 7 TeV case, the dechanneling peaks were accidentally found in the simulations. At the same time, as is known, such peaks have not been observed in the multiple SPS experiments conducted earlier [2]. Nevertheless, we found them at 400 GeV, when the tested crystal curvature was increased.

The second effect of the excess of channelling particle ionization losses over the amorphous level arises at highest amplitudes of channeling oscillations. This effect arises at the close approach of particles to the crystal planes where the electron density and local ionisation loss rate are high and reaches observable values due to the nuclear dechanneling length increase at the LHC energy.

A comprehensive study of the 7 TeV beam deflection peculiarities is provided. In addition the single-pass deflection efficiency of the channeling mode is compared with the multiple volume reflection in one bent crystal effect and its modifications [3] for different angular divergences of the incident beam.

References

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