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Crystal-assisted HEP

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In a crystal, atoms arranged in a precise and periodic pattern interact together as planes or axes with incoming charged particles. Thus, is possible to substitute the random incoherent scattering of each atom with continuum potentials and fields. These planar and axial fields are extremely intense (up to ˜1E9 V/cm for Si, up to 1E12 V/cm for heavier elements) and exceed artificial ones. Several phenomena could be efficiently exploited to assist HEP application.

Planar channeling occurs when charged particles impinges crystal planes within a critic angle: positive charged particles are confined between planes away from nuclei and undergo strongly reduced scattering. When a crystal is bent, the particles channeled along the planes follow the curvature and change trajectory accordingly. This is a powerful mean for beam steering: a silicon bent crystal can achieve in few millimeters the effect of hundreds tesla magnetic dipole. A bent crystal could efficiently separate the beam particle halo from the primary beam in a controlled manner, increasing collimation efficiency. The same deflected particles could be exploited as an extracted beam instead of being lost. Recently it has been proposed to exploit the bent trajectory inside crystal to induce precession of MDM and EDM in fast decay particles, whose short life do not allow use of magnetic dipole. In case of axial alignment, the stronger effect of stochastic deflection is possible. In this case is possible to deflect also negative particles.

Crystal can be unique sources of radiation as well. A sinusoidally bent crystal can perform as free electron laser crystalline undulator, similar to traditional one but with period reduced of 2-3 order of magnitude. Either undulator or synchrotron radiation is emitted by channeling radiation, while the particle is channeled.

Axial potential exceeds the planar case, so much that is some cases critical field condition is achieved, which results in enhanced emission of hard radiation or emission of e+/e- couples. Such effects are Lorentz-boosted, hence intensify as projectile momentum increases. This effect enables novel design of gamma sources for hybrid positron production, “smart”gamma converter to clean photons from a neutral beam, compact electromagnetic calorimeters for forward detectors or satellites.

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