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Channeling in oriented crystals and nanostructures breaking down the challenges in accelerator physics

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Oriented crystals create a unique environment for high-energy charged particles and photons. When charged particles undergo channeling [1], they are guided by atomic electric fields with angstrom-level precision, similar to accelerator optics and achieving effects equivalent to magnetic fields exceeding 100 T. This process also generates intense X-ray and gamma radiation due to transverse e+/e- oscillations and reduces radiation length by up to a factor of 5 [2]. Furthermore, crystals and nanostructures are the key materials for plasma wakefield acceleration in solid-state targets, achieving gradients over 1 TeV/m [3].

These properties enable innovative applications, including instruments for crystal-based beam manipulation and beam focusing; X-ray and gamma sources for cancer radiotherapy, nuclear spectroscopy, and radioisotope production; positron sources for future lepton colliders; compact crystalline calorimeters for HEP experiments; and plasma wakefield acceleration for future colliders.

This presentation offers a comprehensive overview of these applications and introduces the Geant4 G4ChannelingFastSimModel [4], which enables simulation-driven design for their development.

[1] J. Lindhard. Mat. Fys. Medd. Dan. Vid. Selsk. 34(14), 64 (1965).
[2] L. Bandiera et al. Phys. Rev. Lett. 121, 021603 (2018).
[3] M.F. Gilljohann et al. JINST 18, P11008 (2023).
[4] A. Sytov et al. JKPS 83, 132 (2023).

Paper submission Plan

No

Best Presentation

No

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