Channeling, Volume Reflection and Gamma Emission Using 14GeV Electrons in Bent Silicon Crystals

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Presentation Abstract

High energy electrons can be deflected with very tight bending radius using a bent silicon crystal. This produces gamma radiation. As these crystals can be thin, a series of bent silicon crystals with alternating direction has the potential to produce coherent gamma radiation with reasonable energy of the driving electron beam. Such an electron crystal undulator offers the prospect for higher energy radiation at lower cost than current methods. Permanent magnetic undulators like LCLS at SLAC National Accelerator Laboratory are expensive and very large (about 100 m in case of the LCLS undulator). Silicon crystals are inexpensive and compact when compared to the large magnetic undulators. Additionally, such a high energy coherent light source could be used for probing through materials currently impenetrable by x-rays. In this work we present the experimental data and analysis of experiment T523 conducted at SLAC National Accelerator Laboratory. We collected the spectrum of gamma ray emission from 14 GeV electrons on a bent silicon crystal counting single photons. We also investigated the dynamics of electron motion in the crystal i.e. processes of channeling and volume reflection at 14 GeV, extending and building off previous work. Our single photon spectrum for the amorphous crystal orientation is consistent with bremsstrahlung radiation and the volume reflection crystal orientation shows a trend consistent with synchrotron radiation at a critical energy of 740 MeV. We observe that in these two cases the data are consistent, but we make no further claims because of statistical limitations. We also extended the known energy range of electron crystal dechanneling length and channeling efficiency to 14 GeV.

[http://lcls.slac.stanford.edu/
ImageGallery_LCLS.aspx](http://lcls.slac.stanford.edu/ImageGallery_LCLS.aspx)

How can we make a
better undulator?

Crystals

Crystal Lattice Structure

Crystal Lattice From the Top

Bent Silicon Crystal

1. Channeling
2. Volume Reflection
3. Amorphous

Electron Undulator Using Bent Silicon Crystals

Experiment and Analysis

Working to make crystal undulators a reality

T523: Experiment Layout

T523: Experiment Set-up

- Crystal in its scattering chamber
- Rotation on a stage sets crystal orientation
- Beam enters from the top of the screen and exits at the bottom
- Electrons are deflected by the crystal and they produce radiation that we detect

Energy Spectra

Amorphous, Volume Reflection, and Channeling

Energy Spectrum: Amorph

Energy Spectrum: VR

Energy Spectrum: Channeling

Status of the Crystal Energy Spectra

- We saw gamma radiation with signal to noise $\sim 1:1$
- VR is consistent with Synchrotron radiation with $E_c=740\text{MeV}$
- Amorph spectrum is consistent Bremsstrahlung within
- We cannot make statements about the channeling radiation

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Photo of channeling and volume reflection

SLAC graphics