Vertical Beam Size Measurements in the SPEAR3 Accelerator at SLAC

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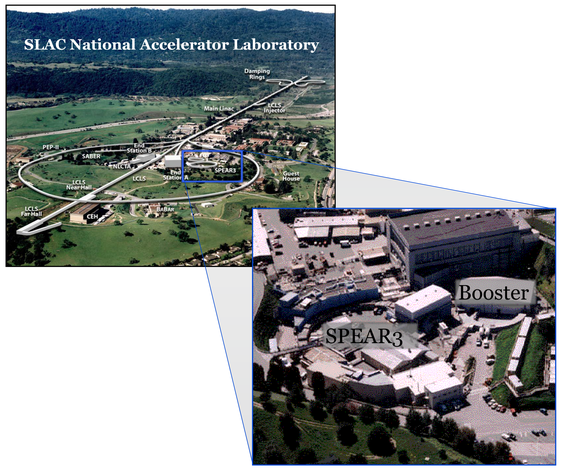
Introduction

Synchrotron radiation is a powerful tool used in many fields of science ranging from materials characterization to structural biology. Each year thousands of scientists travel to SLAC National Accelerator Laboratory to use high-resolution x-rays emitted from a relativistic electron beam circulating in the SPEAR3 synchrotron light source.



The electron beam is manipulated by SPEAR3 operators depending on the research being done. By changing the beam's characteristics, the height of the beam is affected. Knowing the correct height enables the most beneficial results.

In this project, we:

1. Constructed a visible-light interferometer to measure the height of the relativistic electron beam

2. Measured the contrast of the interference pattern as a function of the vertical slit separation

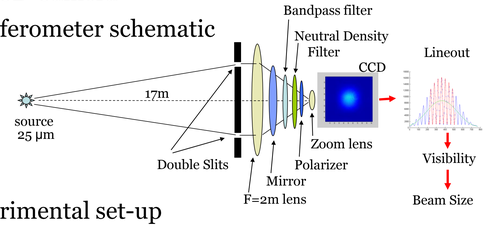
3. Measured changes in the vertical beam size while keeping the slit separation fixed

Methods

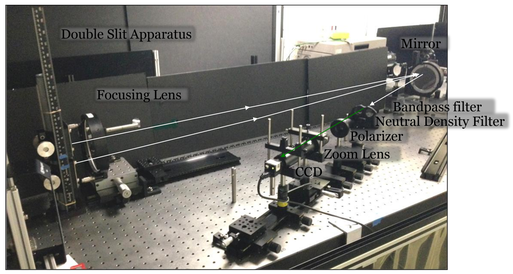
To measure the vertical beam size, an interferometer was constructed. It consists of:

- Adjustable two-slit apparatus
- 2 m Focusing lens
- Retro-mirror
- 550 nm Bandpass filter with width of 10 nm
- Neutral density filter
- Glan-Thompson polarizer
- 0.4-4x Zoom lens
- CCD Camera

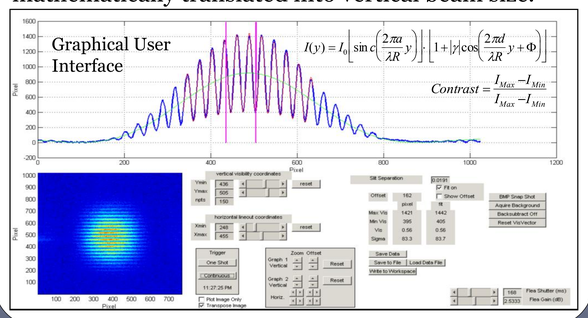
Interferometer schematic



Experimental set-up

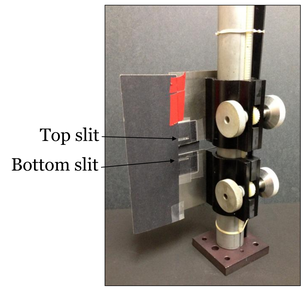


The contrast, or *visibility*, of the interference pattern is then numerically fit to a model and mathematically translated into vertical beam size.



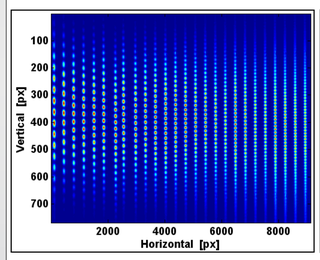
Experimental Results

Measured change in contrast as a function of interferometer slit separation.

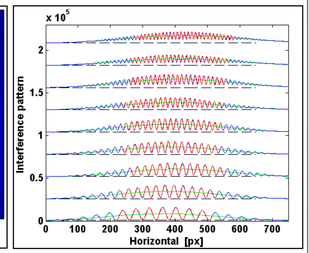


Young's two-slit apparatus

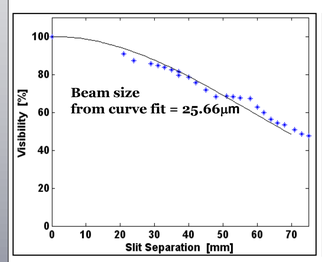
Thomas Young, English scientist



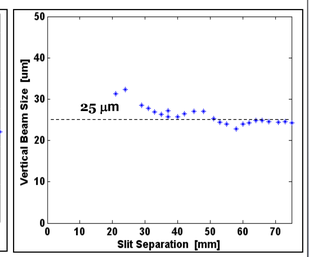
Raw camera images vs. slit separation



Interference pattern vs. slit separation



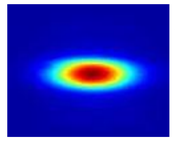
Contrast as a function of slit separation



Calculated beam size for different slit separations

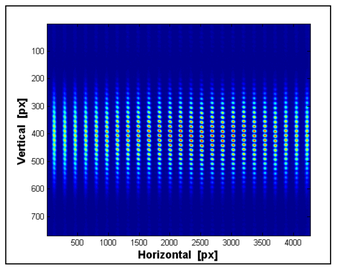
Results (cont'd)

Measured change in beam size while maintaining constant slit separation by adjusting skew quad coupling magnets.

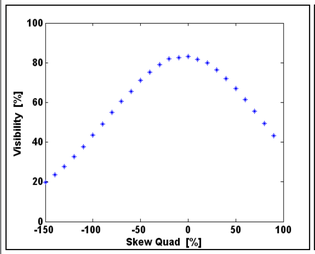


Full coupling

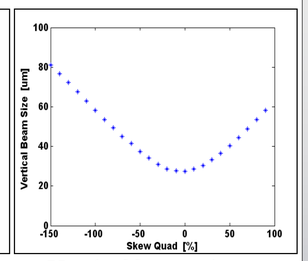
Minimum coupling



Raw camera images vs. skew quad adjustment



Contrast vs. skew quad adjustment



Vertical beam size vs. skew quad adjustment

Conclusions

The visible-light interferometer can measure beam size of an incoherent light source with a height of 25 µm located 17 meters away. The interferometer will remain in SPEAR3 as an on-line beam diagnostic . For example, with a few minor adjustments, the interferometer can be applied to measure the horizontal beam size.

This material is based upon work supported by the S.D. Bechtel, Jr. Foundation, National Marine Sanctuary Foundation, Carnegie Corporation of New York, and/or National Science Foundation under Grant Nos. 0952013 and 0833353. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the funders.

The STAR program is administered by the Cal Poly Center for Excellence in Science and Mathematics Education (CESaME) on behalf of the California State University.