UV/X-ray Diffraction Radiation for Non-intercepting Micron-scale Beam Size Measurement

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Aim

To design and test at the CesrTA@Cornell an instrument to measure on the micron-scale the transverse (vertical) beam size for the Compact Linear Collider (CLIC) using incoherent Diffraction Radiation (DR).

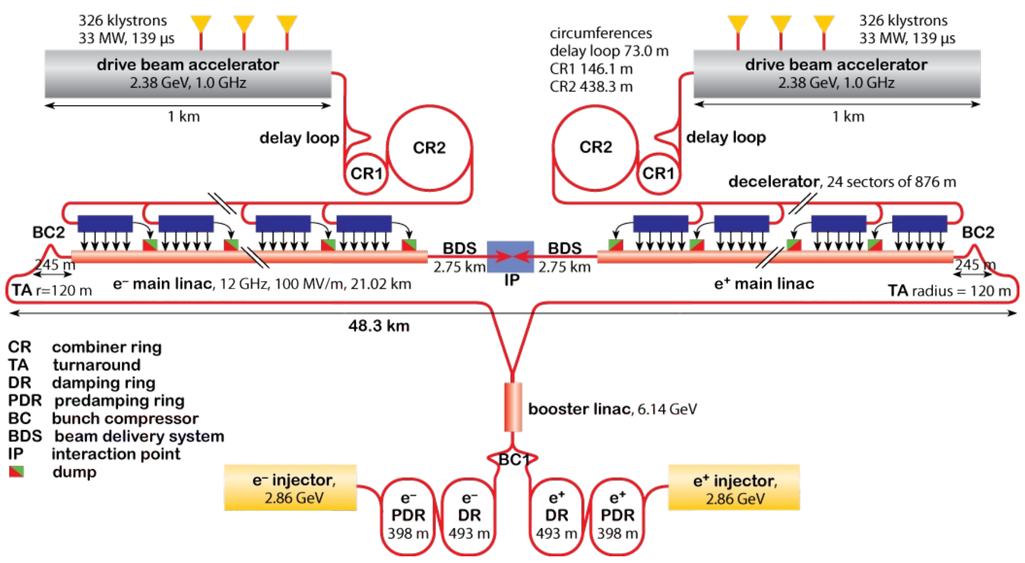

Figure 1: Overall layout of CLIC (3 TeV) [1].

Design

The tank has 2 modes of operation because we are using a circular machine:

- to perform the DR beam size measurement
- or to allow normal operation of Cesr using the replacement chamber.

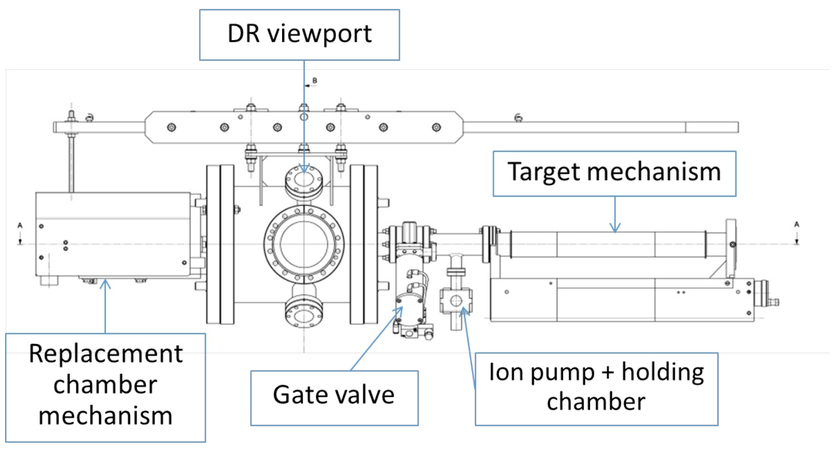

Figure 3: Layout of the DR vacuum assembly. (Electron beam direction into page).

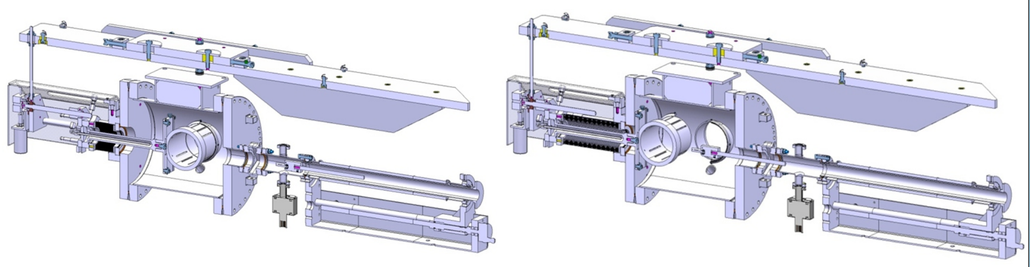

Figure 4: Cross-section of the vacuum tank: Cesr operation (left) and DR experiment (right).

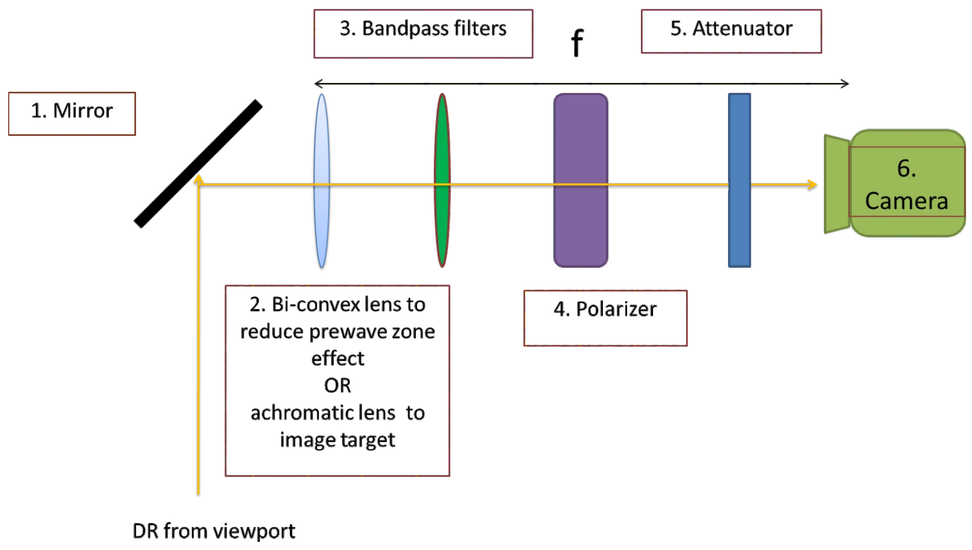

Figure 5: Schematic of the optical system.

Introduction

CLIC is a next generation electron/positron collider consisting of two linacs with a combined length exceeding 40 km. Currently, laser wire scanners (LWS) are the only non-invasive high resolution devices for transverse beam size measurements. However LWS are complex and expensive. An alternative device for non-invasive beam size measurements is needed- DR offers one such alternative. DR devices could be used both from the damping ring exit to the entrance of the main beam linac and in the CLIC drive beam complex (2.4 GeV).

Principle of DR transverse beam size measurement:

1. Electron bunch moves through a high precision co-planar slit in a conducting screen (Si + Al coating).
2. Electric field of the electron bunch polarizes atoms in the screen surface which emit radiation in two directions:
   - along the particle trajectory called "Forward Diffraction Radiation" (FDR).
   - in the direction of specular reflection called "Backward Diffraction Radiation" (BDR).
3. Visibility of the vertical polarization component of the DR angular distribution is sensitive to vertical beam size.

DR Angular distribution

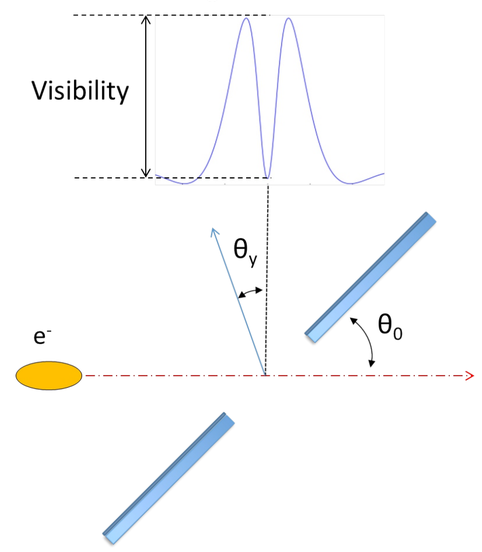

Figure 2: A diagram to show the production of DR.

Simulations

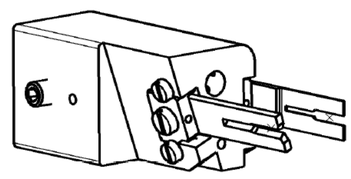

Figure 6: Target and mask assembly.

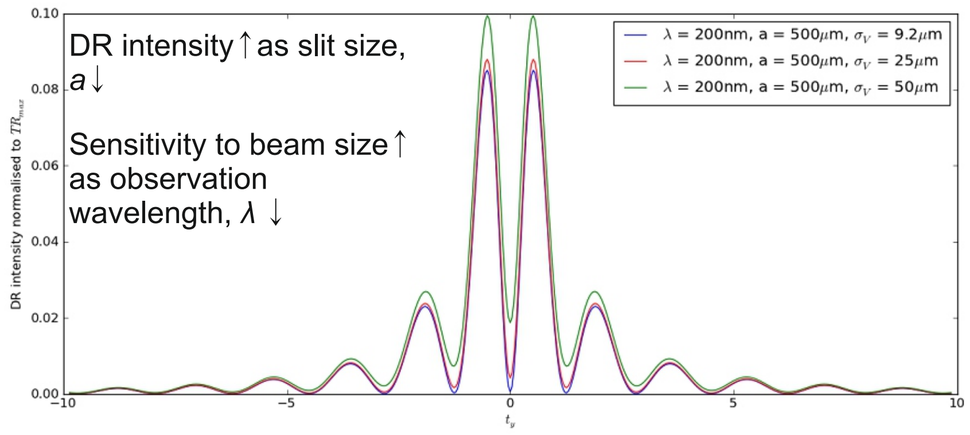

Figure 7: DR angular distributions at different beam sizes for 0.5 mm slit size, 200 nm wavelength and 2.1 GeV beam energy.

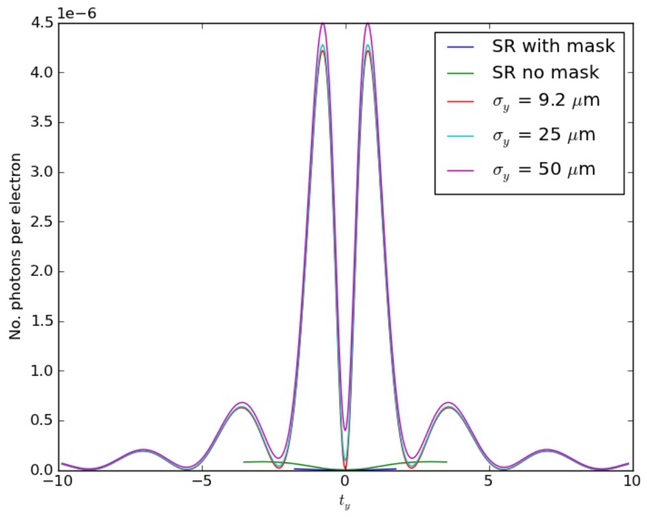

Figure 8: Background considerations from Synchrotron Radiation (SR).

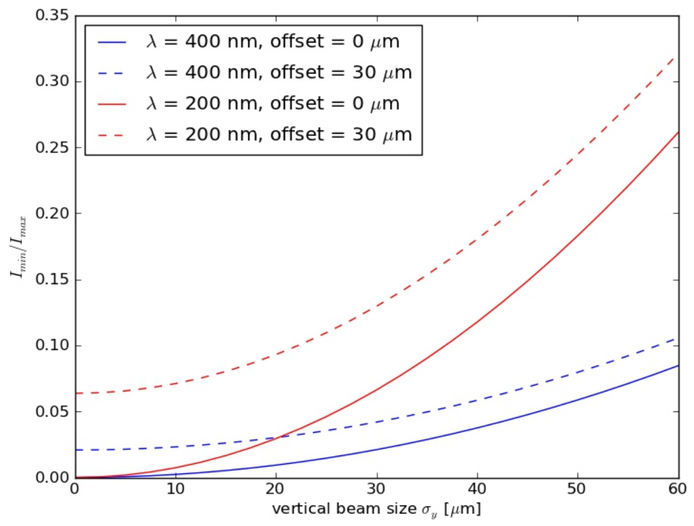

Figure 9: Sensitivity to beam size with/without beam jitter.

Conclusion

Currently the DR vacuum chamber is being assembled at CERN to be tested at the CesrTA@Cornell University later this year. Based on the results from simulations, slit sizes of 1 mm and 0.5 mm have been chosen for our target. The beam lifetime is reasonable for these apertures allowing us time for both the alignment of the target and measurement of the vertical beam size using DR. The observation wavelengths for this first experimental phase are 400 nm and 200 nm.
The second experimental phase is foreseen for the summer 2013. This test will aim to measure the vertical beam size using wavelengths in the soft X-ray range.

References

1. *CLIC study,* http://clic-study.web.cern.ch/clic-study/Layout/OverallCLIC3.html
2. *Cornell Electron Storage Ring Test Accelerator (CesrTA) Collaboration*, https://wiki.lepp.cornell.edu/ilc/bin/view/Public/CesrTA/

All technical drawings by N. Chritin.

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