Vertical Beam Size Measurement at CesrTA Using Diffraction Radiation

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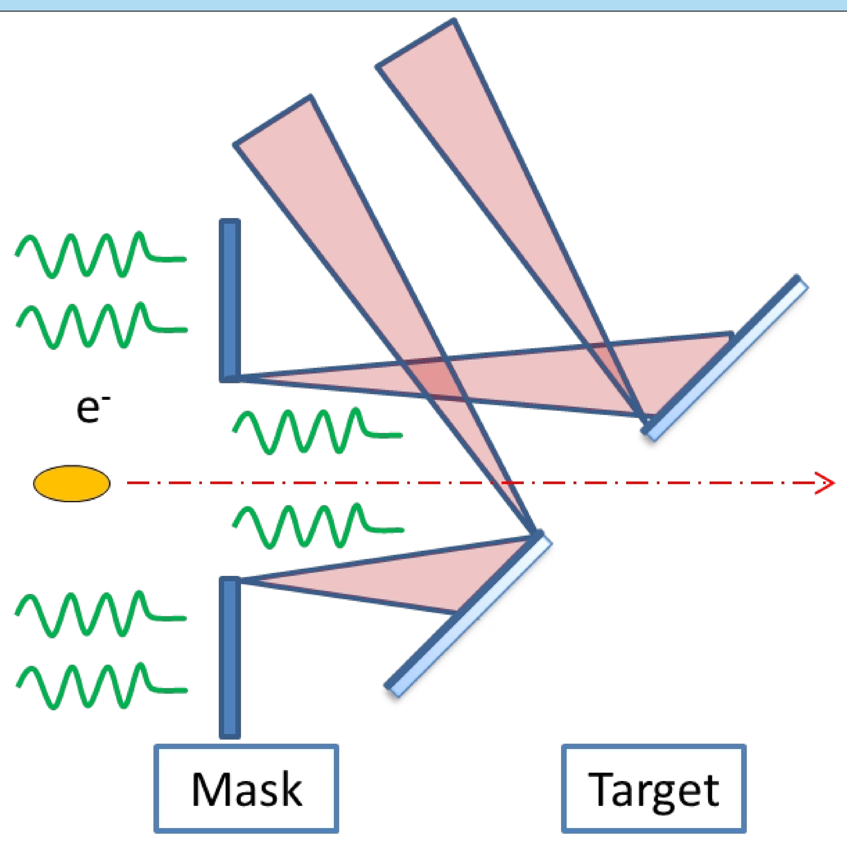
ABSTRACT

Over recent years the first Diffraction Radiation (DR) beam size monitor has been tested on a circular machine. At CesrTA, Cornell University, USA, the sensitivity and limitations of the DR monitor for vertical beam size measurement has been investigated. DR emitted from 1 and 0.5 mm target apertures was observed at 400 and 600 nm wavelengths. In addition, interference between the DR signals emitted by the target and mask has been observed. In this report, we present the recent observations and discuss areas for improvement.

DIFFRACTION RADIATION

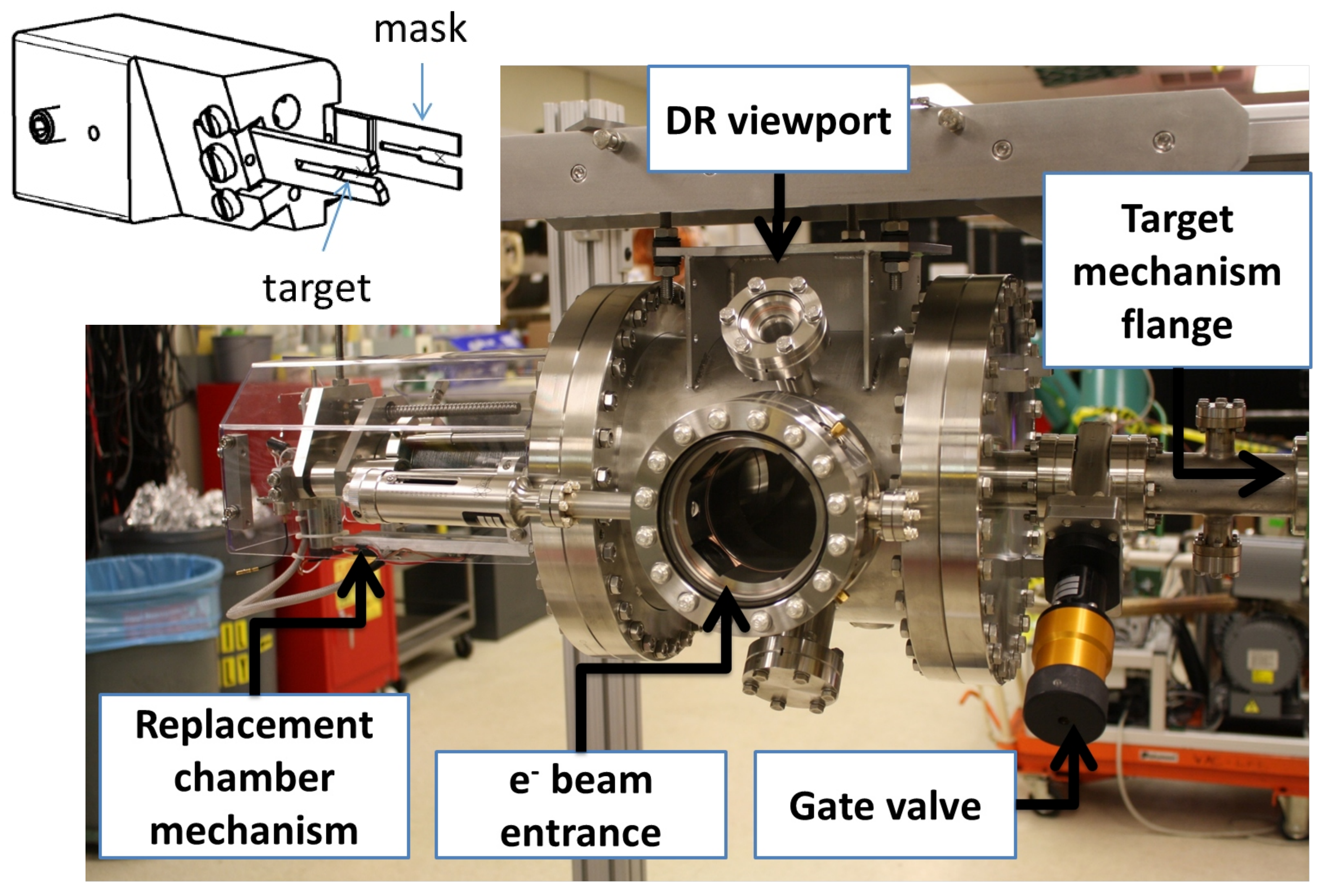
1. Electron bunch moves through a high precision co-planar slit in a conducting screen.
2. Electric field of the electron bunch polarizes atoms in the screen surface which emit radiation in two directions:
   - along the particle trajectory called "Forward Diffraction Radiation" (FDR).
   - in the direction 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.

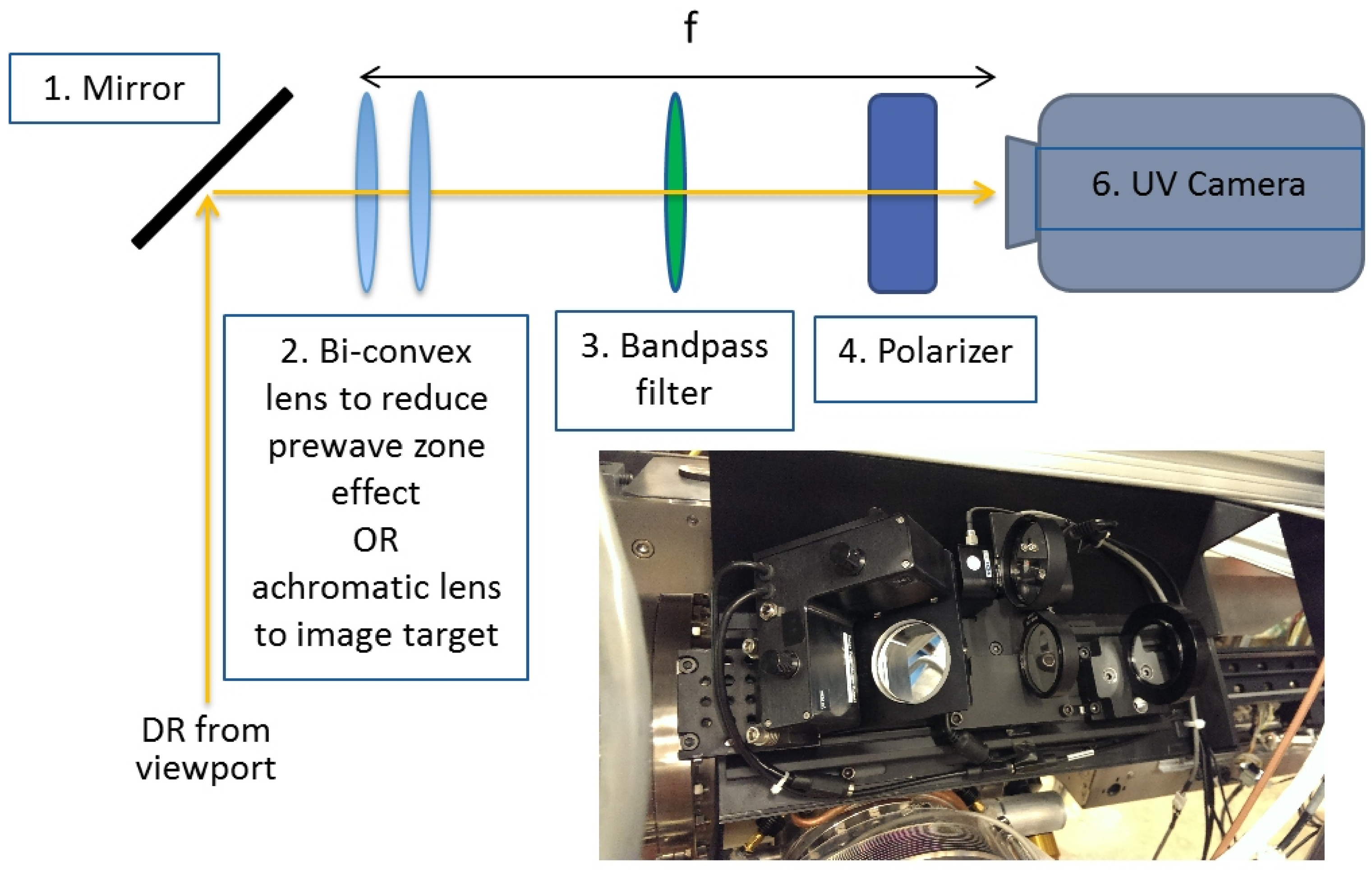
Parameters:
- E = 2.1 GeV
- Single bunch electron beam in storage ring
- I ~ 1 mA
- Mask apertures = 1 mm (ODRI) and 2 mm (ODR)
- Target aperture = 0.5 mm



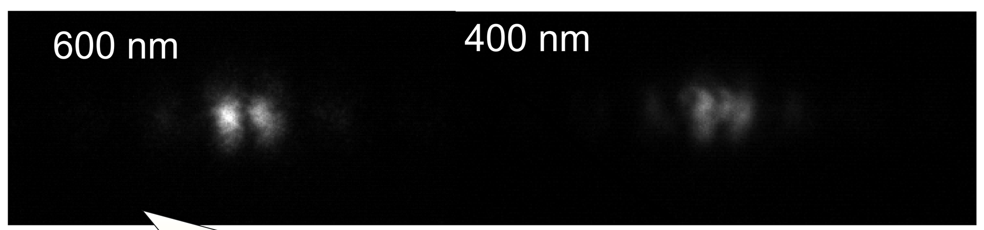
[1]

EXPERIMENTAL SETUP

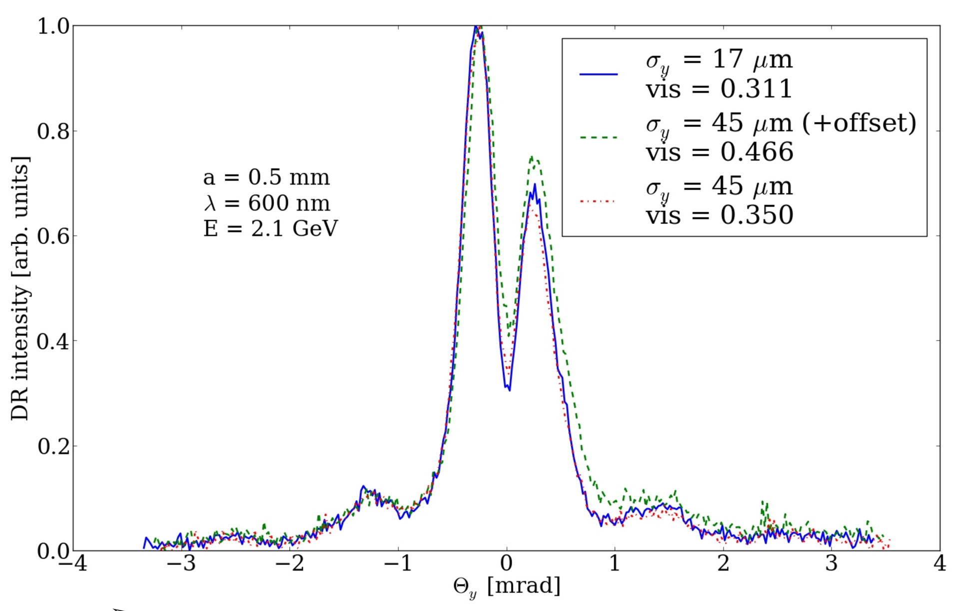




ODR WITH PVPC TECHNIQUE

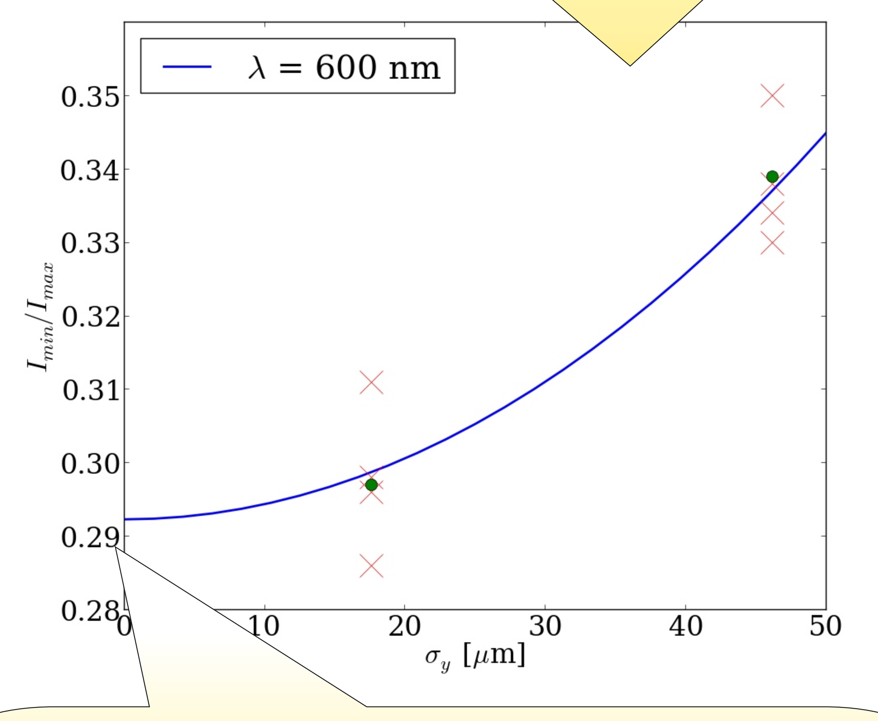


DR angular distributions using **0.5mm** target and **2mm** mask.



A comparison of projected vertical polarisation components (PVPCs) for different beam sizes.

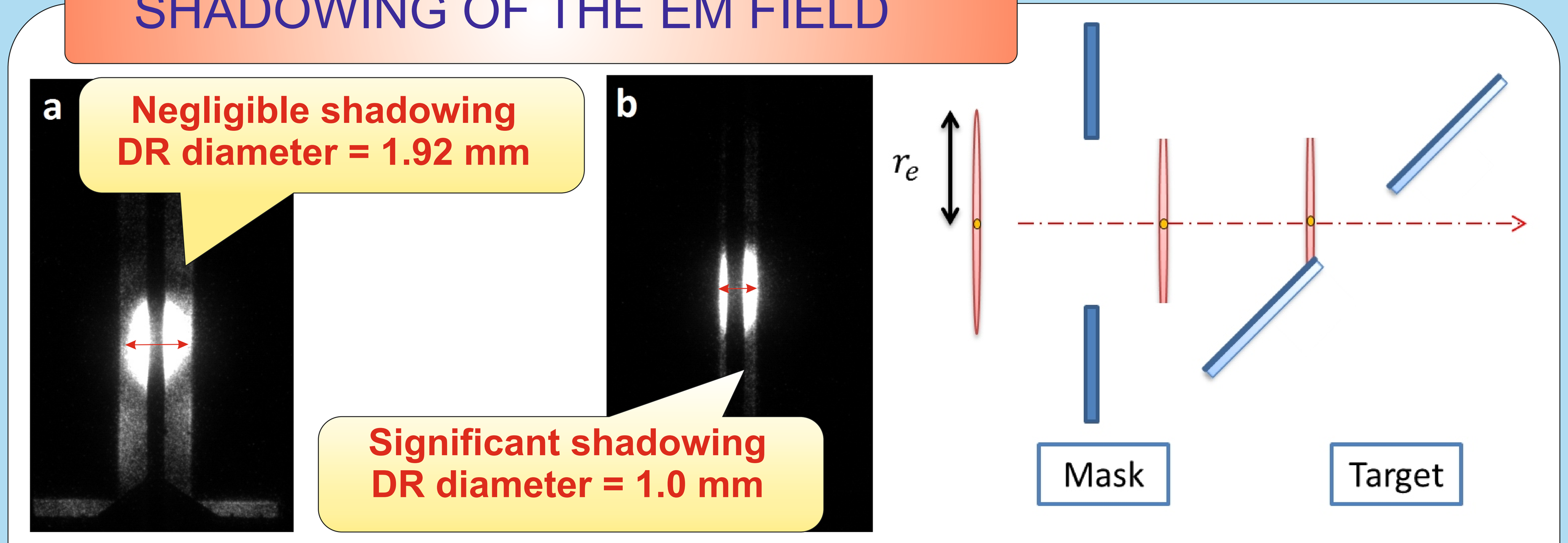
Resultant visibility curve from the least squares fit of the average visibility (green circles) at different beam sizes from individually measured visibilities (red crosses) corresponding to separate images.



SR background contribution to visibility measurement = 0.292

Refer to [2,3] for details of the ODR model and PVPC technique.

SHADOWING OF THE EM FIELD

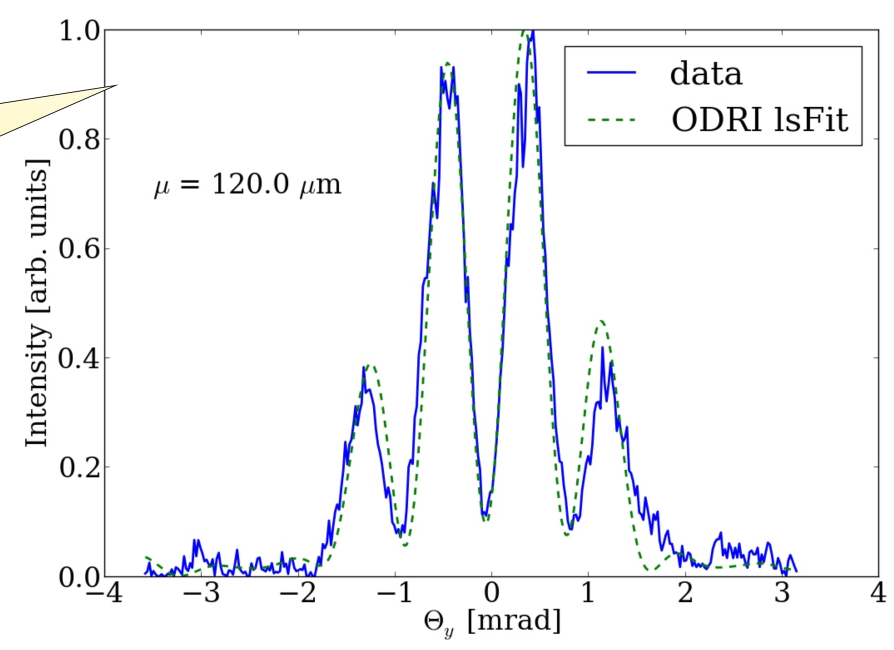


The electric field associated with the electron beam is considered to consist of quasi-real photons. Scattering of the Coulomb field by the mask gives rise to FDR. Positioned downstream, the target is in the shadow of the mask. Thus it emits almost no radiation. The Coulomb field is gradually "repaired" during the formation zone [5].

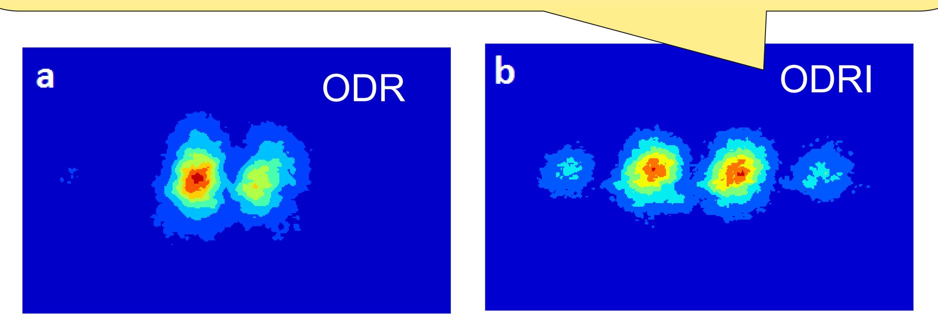
The mask is separated from the target and the optical system only images the target surface. Therefore although it is expected that SR cannot extend into the shaded regions of the target due to being blocked by the mask positioned upstream, DR emitted by the target should not have this boundary unless as a result of shadowing.

ODRI

A beam offset of 120 μm obtained using a least squares fit for ODRI data given parameters: σ_y= 17.6 μm, σ'_y= 4.08 μrad and coplanarity offset 40 nm.



Contour plots of ODR vs ODRI show the enhancement of the side fringes due to interference.



Refer to [4] for details of the ODRI model.

CONCLUSION

The vertical beam size measurements from the Diffraction Radiation monitor installed at CesrTA are presented. Using a 0.5 mm target and 600 nm wavelength, interference effects in the angular distribution between the mask and target have been investigated. Further study of these interference effects have been explored via direct imaging of the target surface. These observations show evidence for the presence of shadowing.

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REFERENCES

[1] A. Potylitsyn et al., *Diffraction Radiation from Relativistic Particles*, Springer, Berlin Heidelberg, 2010.
[2] M. Castellano, "A new non-intercepting beam size diagnostics using diffraction radiation from a slit", Nucl. Instr. and Methods in Phys. Res. Sec. A: Accelerators, Spectrometers, Detectors and Associated Equipment, 394, 3, (1997), p.275-280.
[3] P. Karataev et al., "Application of optical diffraction radiation to a non-invasive low-emittance high-brightness beam diagnostics", QUANTUM ASPECTS OF BEAM PHYSICS. SINGAPORE : WORLD SCIENTIFIC PUBL CO PTE LTD, (2004) p.111-118.
[4] A. Cianchi et al., "Nonintercepting electron beam size monitor using optical diffraction radiation interference", Phys. Rev. ST Accel. Beams, 14, (2011), 10, p.102803-102812.
[5] G. Naumenko et al., "Shadowing of the electromagnetic field of relativistic charged particles", Journal of Physics: Conference Series, 236, (2010), 1, p.012004.