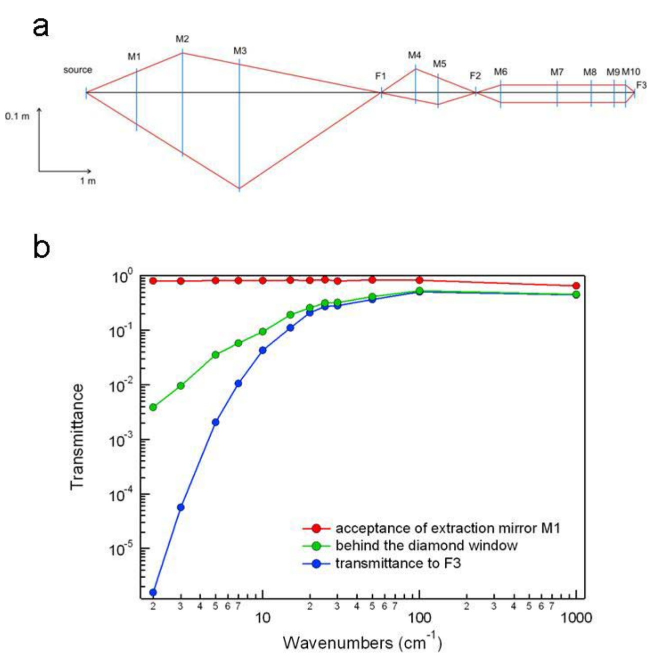
THz Performance of the Infrared Beamline at BESSY

U. Schade[a], M. Ortolani[a, b], J.S. Lee[a]
[a]Berliner Elektronenspeicherringgesellschaft für Synchrotronstrahlung m.b.H., Berlin, Germany,
[b]Istituto di Fotonica e Nanotecnologie IFN-CNR, Rome, Italy.

***Abstract*— Spectroscopy with electromagnetic radiation in the frequency range from hundreds of GHz to few THz has attracted considerable interest in the last decade. Scientific cases and applications are abundant. Synchrotron Radiation facilities can play an important role in the next years to develop prototypes of THz instruments and detectors and to perform scientific experiments by providing a well characterized, powerful, broadband coherent synchrotron radiation source. However, the propagation of sub-THz and THz electromagnetic waves through a typical infrared beamline to the end stations is strongly affected by diffraction. This paper presents the THz performance of the infrared beamline at the electron storage ring BESSY II. Results from wave propagation calculations will be discussed and compared to experimental findings.**

I. Introduction And Background

Coherent emission from an electron bunch is a natural process of collective in-phase emission of all electrons occurring for wavelengths longer than the electron bunch length. In most storage rings, bunches are several millimeter long and therefore the coherent emission occurs in the microwave frequency range. The total power emitted from the bunch would then be proportional to the square of the number of electrons in the bunch (typically $10^7 – 10^9$ in a storage ring), and that means amplification of 7 to 9 orders of magnitude compared to conventional single-particle emission.



At the BESSY-II storage ring in Berlin the emission of stable coherent synchrotron radiation was first shown in 2001 by tuning the magnetic optics into a special low-alpha mode[1].

II. The Beamline

The optical design[2] is schematically shown in Figure 1a. All mirrors involved are metal mirrors. The beamline accepts radiation from a bending magnet: ±30 mrad horizontally and ±20 mrad vertically. The first mirror M1, which is planar, is placed at a distance of 900 mm from the source, the first position possible outside the poles of the magnet. The second and third mirrors, M2 and M3, are both cylindrical and focus the radiation vertically and horizontally to an intermediate focus, F1, just behind a wedged window of polycrystalline CVD diamond, which allows a broad transmission from the THz region up to the visible. Additionally, the window separates the ultra high vacuum system of the front end from the fore-vacuum environment of the next part of the optical path. The mirrors M4 and M5, both cylindrical, transfer and refocus the radiation at the second focus F2 before being collimated by the toroidal mirror M6. Then a set of plane mirrors transfer the radiation until it is refocused at the end of the beamline by a parabolic mirror.

III. Results

The wave propagation of the synchrotron radiation from the bending magnet through all optical elements was investigated by means of the SRW[3] code. The Stokes parameters were calculated. The optical transmittance derived at different positions of the beamline is shown in Figure 1b. Due to the finite size of optical elements the transmittance decreases strongly with decreasing photon frequency, starting from energies below 1 THz. As a result of diffraction, the polarization properties of the bending magnet radiation, left-handed and right-handed circularly polarized above and below the ring plan, respectively, can not be conserved by the beamline. Below 1 THz the radiation is linearly polarized with an azimuth angle parallel to the orbit plane, as indicated by the value of the Stokes parameter related to the degree of linear polarization $s_1 = +0.999$. The s-component is completely suppressed. The calculations are confirmed by spectral measurements down to 100 GHz.

References

[1] M. Abo-Bakr et al., *Phys. Rev. Lett*, **8825**, 254801 (2002) and *Phys. Rev. Lett*. **90**, 094801 (2003).
[2] U. Schade et al, *Rev. Sci. Instr*. **73**, 1568 (2002).
[3] O. Chubar, P. Elleaume, proc. of the *EPAC98 Conference*, 1177 (1998).

978-1-4244-2120-6/08/$25.00 ©IEEE.