Two-Dimensional Interferometery at PETRA III and Scintillator Monitors at XFEL

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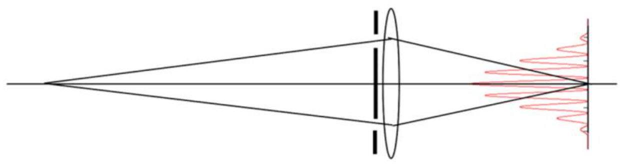
DESY

Two-Dimensional Interferometery

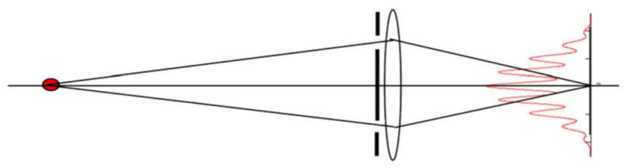
Emittance diagnostics of a modern synchrotron light sources is mainly based on imaging of beam profile in the X-ray region. This region is used for overcoming of a resolution limit caused by diffraction. However there is another way to circumvent this limitation – using of an synchrotron radiation interferometer in the optical spectral region [1]. The light source PETRA III at DESY uses such type of interferometer since several years for determination of vertical beam size. The device is situated behind a 30 m long optical beamline, connecting the accelerator tunnel and the optical hutch. Such length of the beamline brings in an instability of beam size measurement. In order to reduce the instability a new interferometer was commissioned. The new interferometer is also a two dimensional one, it means that it is able to measure vertical and horizontal beam sizes simultaneously. This contribution summarizes the status of the new beamline and the interferometer commissioning.

Principle

Interferogram from a point source



Interferogram from a source with finite sizes



Formula for interferogram fitting is below. In this formula a denotes half of slit width, λ – observed wavelength, R – distance between back principal point of lens and image, y – coordinate, D – distance between slits. From this formula one can define γ and then σ

$$I(y) = I_0 \left[Sinc\left(\frac{2\pi a}{\lambda R} y\right)\right]^2 \left[1 + \gamma\, Cos\left(\frac{2\pi D}{\lambda R} y + \varphi\right)\right]$$

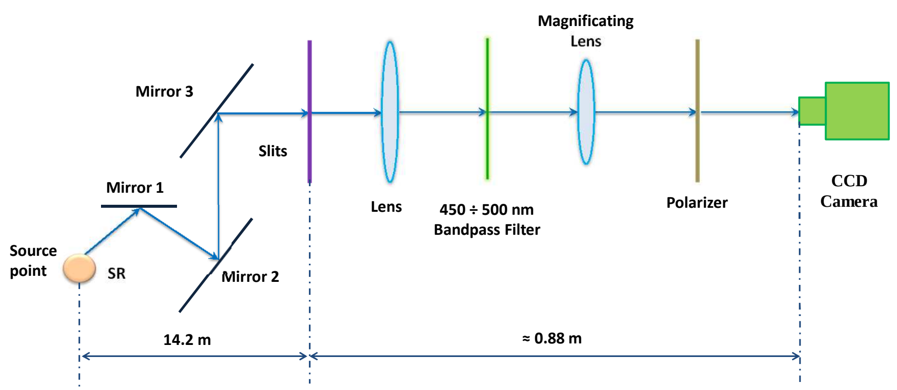
$$\sigma = \frac{\lambda L}{\pi D}\sqrt{\frac{1}{2} ln\left(\frac{1}{\gamma}\right)}$$

Existing Setup

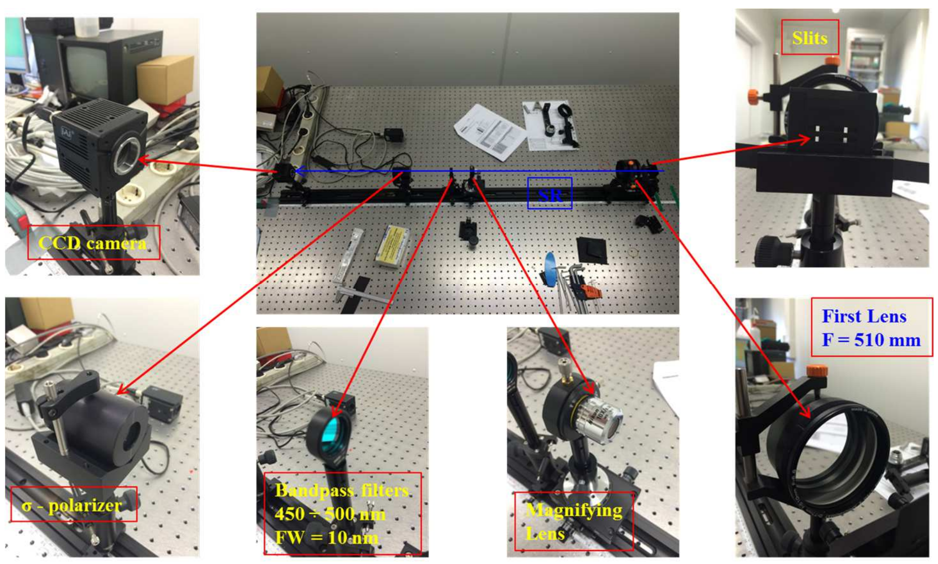
Such an interferometer is already used at PETRA III, but it has some disadvantages:

- Due to the long distance between source point and slits the setup is very sensitive on temperature drifts, a correlation between measured emittance values and ambient temperature is visible.
- The beamline has relay optics and there are additional uncertainties as a result.
- The interferometric setup occupies the place of the streak camera, i.e. simultaneous measurements of vertical and longitudinal beam sizes are not possible.
- The present interferometric setup allows to measure only vertical beam sizes, a simultaneous horizontal interferometric measurement would be preferable.

Interferometric Beamline

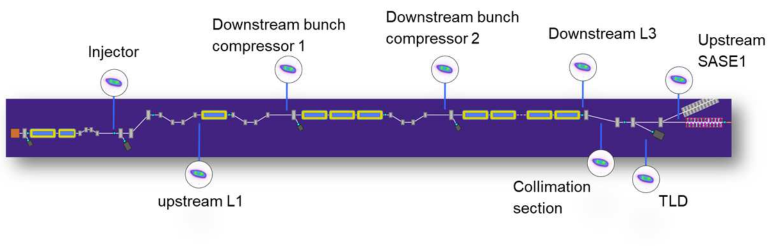


In figure 1 schematic of the new one interferometer is shown. Synchrotron light generated by electron beam in bending magnet and extracted from a tunnel by system of mirrors passes slits and the optical system and then comes to CCD camera.

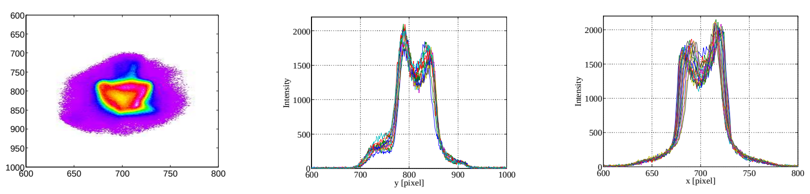


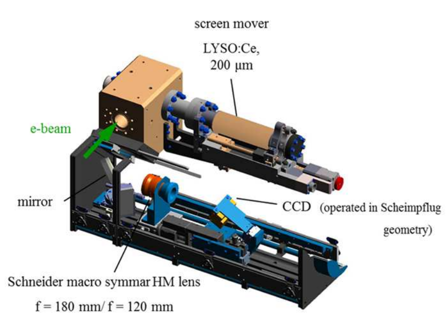
Scintillator Monitors

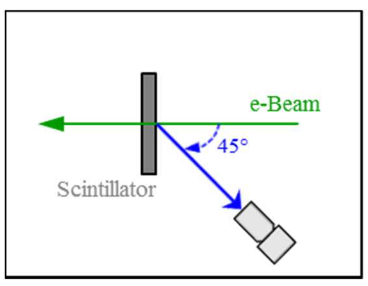
The problem which has appeared at XFEL is a "smoke-ring" shape of a beam profile observed on scintillator monitors. "Smoke-ring" shape means that instead of expected Gaussian shape of a beam it is a shape with a drop in the center of it.



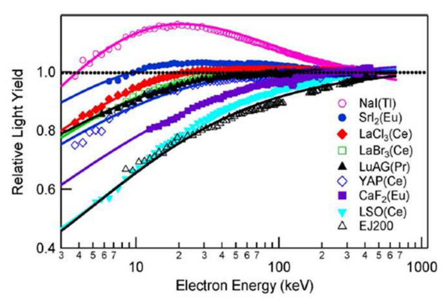
This shape is observed on all scintillator monitors of XFEL. The scintillator monitors use LYSO screens with 0.2 mm thickness. On the figure below the image of a beam from one of the stations with its horizontal and vertical projections is shown.

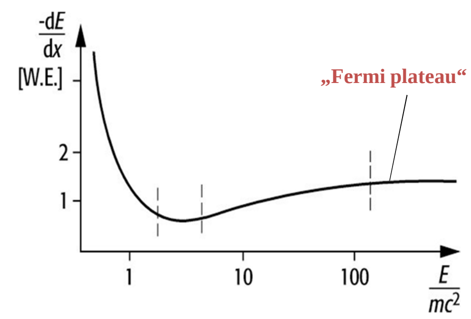






The main idea of where it comes from is a scintillator nonproportionality. The meaning of the effect is a nonlinear dependence of a scintillator light yield on an energy deposited in it by a particle. In other words the higher deposited energy the more e-h are created, and the higher e-h density the more possibility of them to "quench" (recombine nonradiatively).





In our case the deposited energy of one electron isn't high enough (Fermi plateau) but we have high density of electrons in a beam ($N_e \approx 3*10^9$ with Q = 500 pC). Therefore when electrons are very close to each other they also can produce high density of e-h leading to quenching effect.