GENERATION AND CHARACTERIZATION OF 5-MICRON ELECTRON BEAM FOR PROBING OPTICAL SCALE STRUCTURES

M. Fedurin #, M. Babzien, V. Yakimenko, BNL, Upton, NY, USA
B. Allen, USC, Los Angeles, CA, USA
P. Muggli, MPI, Muenchen, Germany
A. Murokh, Radiabeam, Santa Monica, CA, USA

Abstract

In recent years advanced acceleration technologies have progress toward combination of electron beam, laser and optical scale dielectric structures. In present paper described generation of the electron beam probe with parameters satisfied to perform test of such optical structures.

GOAL AND SETUP

The work was done at Accelerator Test Facility at Brookhaven National Laboratory on purpose to have setup suitable for experiments with optical scale microstructures. It uses the ICS chamber and permanent magnet quadrupole triplet assembly made by Radiabeam for ICS experiment [1]. Goal of this work was to get 5-micron size electron beam on OTR foil of diagnostic system. Diagnostic system was capable to characterize beam size. ICS chamber has switchable beam profile monitor based on YAG crystal and OTR foil, this BPM was used for rough beam tuning and alignment. For fine measurements

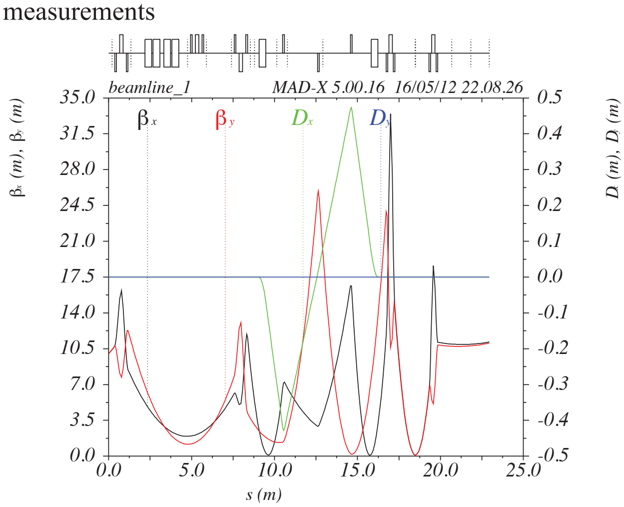

Figure 1: Electron beam optic configuration.

ELECTRON BEAM OPTIC

Usual ATF lattice configuration (Fig. 1) was designed to get optic functions for parallel round beam at the end of beamline where beam could be focused farther with triplet insertion. That gives enough flexibility to tune the beam of desired size.

Triplet esign

Triplet assembly has permanent magnet quadrupoles (PMQ) with gradient ~5 kGs/cm in average (Table 1). Triplet was built for previous experiment [1] and in current setup has redesigned distance between quads. Distance between triplet quadrupoles was found to focus beam with thin lens approximation (Fig 2). So beam transport matrix has a look:

$$\begin{pmatrix} x_{11} & x_{12} & & \\ x_{21} & x_{22} & & \\ & & y_{11} & y_{12} \\ & & y_{21} & y_{22} \end{pmatrix} = \begin{pmatrix} 0.995 & -0.001 & & \\ -4.769 & 1.009 & & \\ & & 1.002 & -0.003 \\ & & -3.908 & 1.013 \end{pmatrix}$$

Horizontal focal length is 21 cm, vertical is 25.6 cm. These values were used in MAD and beta-function values at the waist found as β_y/β_x = 3.5/4.1 mm for 15 m of original betas.

Triplet was installed in the IGS vacuum chamber on two orthogonal movable stages. One stage moves triplet in the transverse direction regards to beam axis, its make beam clear region and allow to operate accelerator for another projects downstream of beamline. Another stage moves triplet along the beam axis to make possible fine beam tuning at focal point. both stages have remote in vacuum control to make operation and tuning fast and pretty flexible

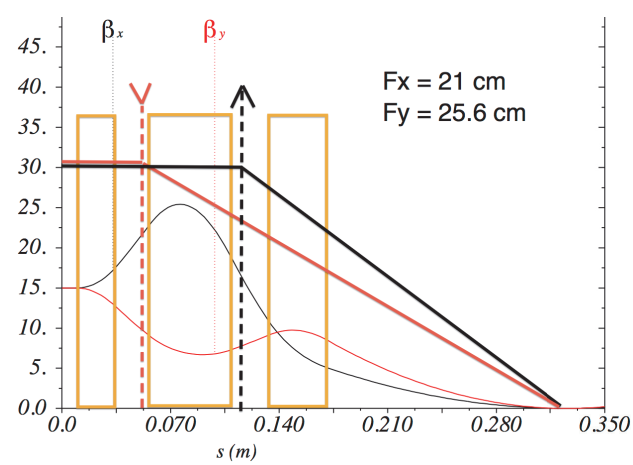

Figure 2: PMQ triplet optic.

#fedurin@bnl.gov

 ISBN 978-3-95450-115-1

Table 1: Triplet Permanent Magnet Quadrupoles

PMQ #	Length, mm	Kx /Ky , kGs/cm
Q1	25.5	+5.130 / -5.110
Q2	54.5	-5.094 / +5.095
Q3	39	+5.186 / -5.133

DIAGNOSTIC SETUP

Diagnostic stage consist of OTR foil, Microscope (25-0506 X15 Reflecting Objective NA 0.28, F=13 mm), mirror and Basler Gigabit camera (scA 1400-17gm, F = 135 mm). OTR foil, mirror and Microscope located on movable stage that moves system in transverse direction refer to the e-beam axis. Remote control of this stage make possible beam clear operation for another experiments downstream beamline. Microscope in turn has adjustable stage to remotely tune it on OTR foil spot. Combination of two optical systems produce 10x image magnification.

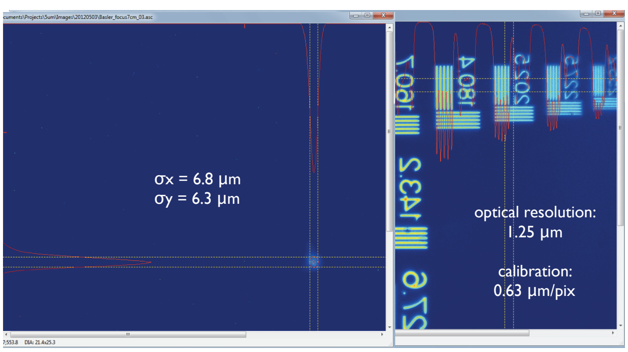

Figure 3: Image from the Basler camera: a) electron beam at OTR foil. b) image of USAF high resolution target.

MEASUREMENTS

During diagnostic setup installation optical resolution and calibration of the system was measured on USAF high resolution target (Fig 3,b). The group of 202.5 pairs per mm was possible to see with 50% min to max ratio. Its gives 1.25 µm optical resolution. Number of pixels per the certain distance gives calibration of 0.63 µm/pixel. On Fig. 6 shown Microscope image on the Basler camera (a) and USATF high resolution snapshot to estimate optical resolution of the system.

At first electron beam of 300 pC bunch charge was tuned in the accelerator to match optic functions shown at Fig. 1 to received large size parallel beam at place of PMQ location. Beam size was monitored by three YAG crystal based Beam Profile Monitors, when required size was reached (11 m beta function was measured), the PMQ triplet was moved in the beam.

To compensate some residual beam divergency at triplet entrance the along beam axis triplet stage was used for fine tuning to localize focal beam point at the OTR foil.

On Fig. 4 shown the search of the triplet focal point by measuring beam sizes on the OTR screen during the triplet position scan.

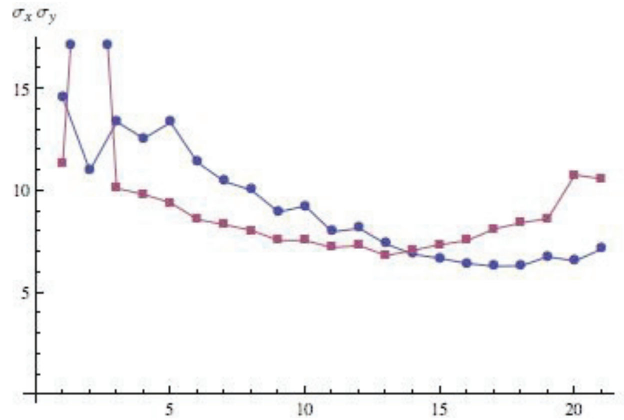

Figure 4: Transverse rms sigmas of beam size in triplet position scan. Bunch charge 300pC.

After optimal PMQ triplet position was found and beam size was fixed at OTR screen, the Microscope fine focus tuning was made by Microscope stage position scan refer to the OTR foil (Fig. 5).

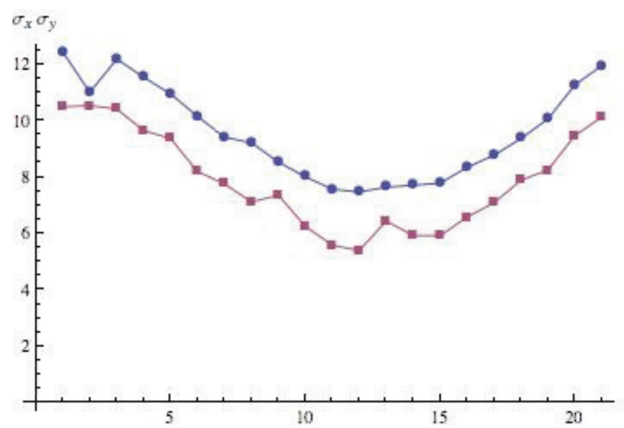

Figure 5: Transverse rms sigmas of beam size in microscope position scan. Bunch charge 300pC.

ACKNOWLEDGMENT

We would like to acknowledge the technical support from ATF staff for skillful work in installation and operation of the experiment.

REFERENCES

[1] A. Murokh et al., “Inverse Compton Scattering Experiment in a bunch train regime using nonlinear Optical Cavity”, THEPPB008, these proceedings.