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Author: Luciano Catani, INFN

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DESIGN OF A MOVABLE EMITTANCE METER FOR SPARC

Contact person: Luciano.Catani@roma2.infn.it

INTRODUCTION

The SPARC Movable "Emittance-meter" ("SPARC e-meter" shortly) has been conceived to perform a detailed study of the emittance compensation process in the SPARC photo-injector and to optimize the RF-gun and the accelerator working point. It consists of a movable emittance measurement system installed between two long bellows with the possibility to scan a region 1.2 m long downstream the RF-gun.

The technique that will be employed for the emittance measurement consists in the use of a double system of emittance slit-arrays, horizontal and vertical, to measure the emittance and the Twiss parameters in both planes.

DESIGN AND PERFORMANCES

General Layout

For the general layout of the SPARC e-meter refer to Fig.1. The measurement device is installed on top of a table with the possibility to adjust the height of the beamline by means of legs extenders (not present in Fig.1). As alternative it can be installed on top of a girder as shown in Fig.1.

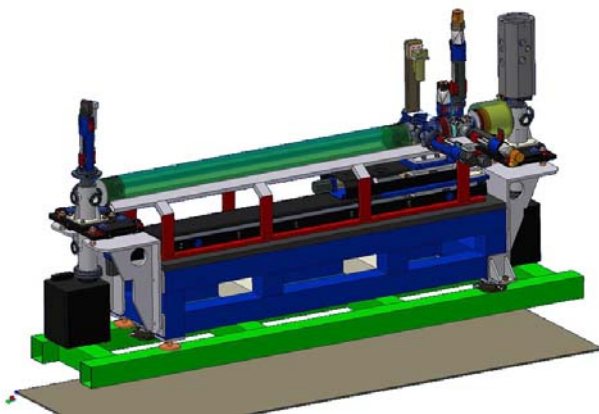


Figure 1. 3D mechanical drawing of the SPARC e-meter. In this drawing are also included one of the two alignment tools, to be installed during alignment on top of the end flanges (grey cylinders), and the girder (green structure).

The measurement system, installed in two crosses placed between two long bellows, consists of two

slits mask mounted on two independent holders 90° with respect to each other and a radiator screen where the beamlets, emerging from the upstream slits mask, will be measured. The cross housing the two slits mask can be tilted around both x and y-axes to adjust the alignment of the slits with respect to the beam direction. A stepper motor having 200 steps per turn moves each stage. Resolutions of these movements is $\Delta\theta < 2.5 \mu\text{rad}$.

Two linear actuators, connected to brushless motors, are used to move longitudinally the complete measurement system located between the two long bellows and to change the distance between the two crosses housing the slits mask and the screen.

Magnetic steerers are installed at the beginning of the system, clamped around the upstream flange. They can be used to adjust the direction of the electron beam in the x and y plane.

Slits Mask

Each slits mask is assembled stacking single pieces made of 2 mm thick tungsten with a well defined profile. Once assembled these pieces form a mask with, in the upper part, two single slits 50 μm and 100 μm respectively and, in the lower part, an array of 7x50 μm slits separated by 500 μm .

The single slits will be used for multi-shot measurements, scanning transversally the beam and collecting together the images from different positions (Fig.2).

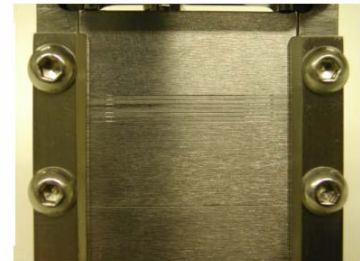
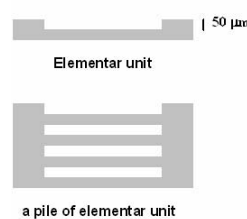


Figure 2: Slit mask design

Screens and imaging system

Ce:YAG radiators will be used to measure the transverse distribution of low-charge beamlets emerging from the slit-mask. They offer good resolution and high efficiency (Fig.3).

We collect forward radiation emitted from Ce:YAG crystal with a mirror at 45° downstream the radiator. As result the radiator is observed at 90° with respect to the rear face thus minimizing the degradation of spatial resolution due to the non-negligible thickness of transparent crystal.

Imaging system includes a digital CCD cameras and a 105mm “macro” type objective. Resolution better than 11 μm can be achieved (Fig.4).

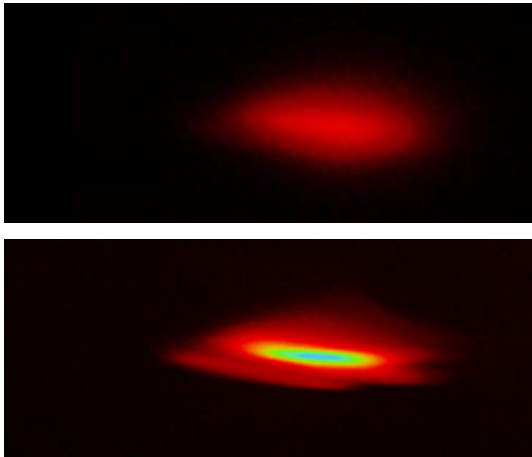


Figure 3. Comparison of Cr-oxide (top) and Ce-doped YAG radiators (bottom). Electronic gain of the CCD camera was approximately three times higher in the case of Cr-oxide screen to get comparable pixel values with the Ce:YAG.

Controls and Analysis Software

The SPARC e-meter has its own control and acquisition system. Two PCs in the control room run control panels and measurements programs. Motors are controlled via CAN bus or RS232 serial interfaces. PCs running control panels communicate with motor controllers via network using a network serial-port server.

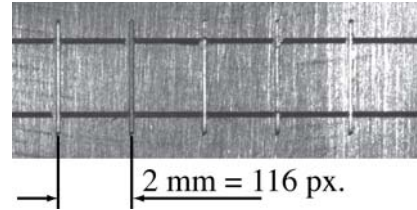


Figure 4. Measurement of resolution of the optical system using the calibration marks on the screen holder.

To connect a PC in the control room with digital cameras in the accelerator tunnel, because of limitation of the maximum cable length (4.5 meters), we use a fiber-optic firewire extender.



Figure 5. Control Panel for remote control of motors and actuators and digital camera.