SESAME MICROTRON AND BOOSTER DIAGNOSTIC STATUS

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Abstract

SESAME* light source is a 2.5 GeV 3rd generation synchrotron facility which still under construction at Allan (Jordan), it consists of a 22.5MeV Microtron as pre-injector and 800 MeV Booster. The pre-injector and booster are originally BESSY-I machine with some major changes within power supplies and diagnostics tools. As all machine; SESAME diagnostics tools are the deflection tube inside the pre-injector, FOM screens, BPMs, visible beam line, DCCT and FCT. Booster commissioning had started lately, our experience with the diagnostics tools outputs will be highlighted and commented within this paper.

INTRODUCTION

SESAME microtron (MM22) generates an electron beam suitable for injection through transfer line 1(TL1) into the booster synchrotron. The timing system relies on the 499.654MHz master oscillator, Microtron operation is synchronised to the low speed clock of 1Hz repetition frequency. Different diagnostics tools and instruments are installed in injector, as the whole injector was from BESSY-I machine some upgrades have been made for the diagnostics instruments especially in the booster synchrotron.

MICROTRON DIAGNOSTIC

The microtron diagnostic tool is deflection tube (DT) figure 1. Deflection tube is magnetic shielded tube located inside the microtron magnet gap which provides a free magnetic field passage through the electron trajectory. DT is controlled via DC motor to be placed on successive electron orbits inside the microtron. The tube signal is transferred outside the microtron via a matched impedance coaxial cable for monitoring on an oscilloscope. The scope is Agilent X2014A 100MHz.From the signal provided by DT the electron acceleration inside the microtron and used as a current monitor once the beam pass inside [1] figure 2.

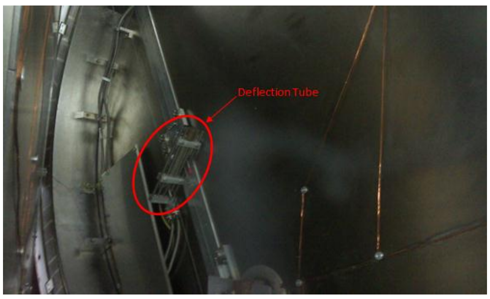

Figure 1: Deflection tube inside microtron

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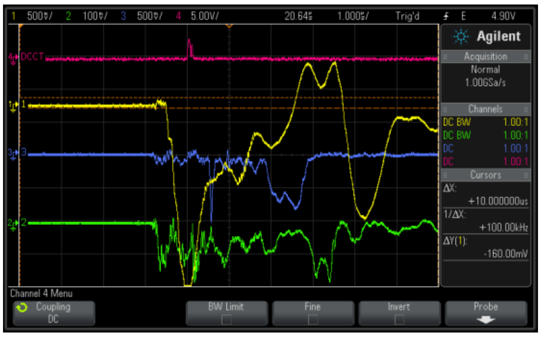

Figure 2: Microtron Signals (Gun Current(Yellow),Deflection tube (Blue) and RF Reflected Power (Green))

TRANSFER LINE 1 DIAGNOSTIC

Transfer line 1(from microtron to booster) has two diagnostics tools:

1. FOM Screens.
2. FCT

FOM Screen

For the Monitor (FOM) screen initially Aluminium Oxide AF995R had been used, but turned out to have a long decay time (up to 1 min) and had been changed to in house made by phosphorus powder and suitable glue which gave a decay time in microns. The next plan is to upgrade this screen to YAG:Ce screen. Triggered IP CCD camera (Balser acA1300-gm) is installed; it can observe the screen in control room easily, to protect the camera from the radiation an optical tubes and mirror will be added to the system to move the camera from radiation plane as much as possible with surrounded lead shield as lustrated in figure 3.

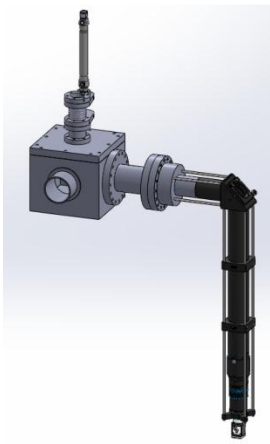

Figure 3: TL1 FOM

By this configuration the emittance of microtron was measured. Quadruple scan method was used for emittance measurements in TL1. Figure 4 shows the results of measurements for horizontal and vertical emittance. Due to screen quality and calibration of quadruple magnets results are only preliminary.

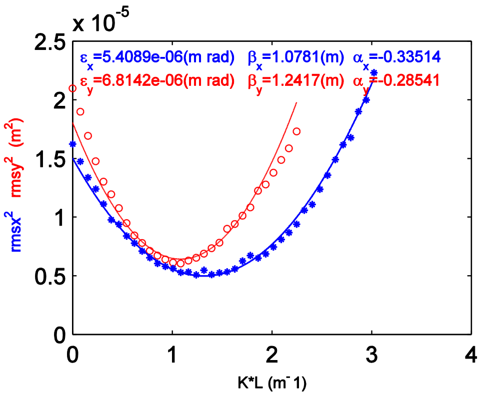

Figure 4: Emittance Measurement

FCT

The fast current transformer (FCT) is a commercial one (Bergoz) which has a sensitivity of 1.25V/A, The FCT is installed after the FOM, it has a ceramic break with a bypass shield, the FCT is directly connected to an oscilloscope (Agilent X2014A) by coaxial cable (LMR200). Figure 5 shows the output pulse of the microtron via FCT.

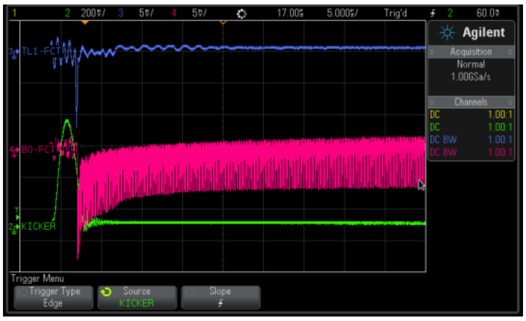

Figure 5: TL1 FCT Output and Booster FCT (Multiturn) Output

BOOSTER DIAGNOSTIC

SESAME booster is FODO lattice with 38.4 m circumference the main parameters are listed in table 1. Different diagnostic instruments installed in booster ring, which are FOMs, BPMs, FCT, DCCT and VBL most of them are from BESSY-I machine and the other are completely new .

FOMs

There are 3 FOMs in booster ring which have an Aluminium Oxide screens and an analog camera connected to signal switcher which allow monitoring one camera on the TV monitor in control room. All the FOMs work by pneumatic technique. Booster future upgrade includes the replacement of the analog cameras to triggered IP Cams and the pneumatic motion mechanism of FOM to be driven by a stepper motors.

BPMs

There are 6 beam position monitor (BPM) in booster ring, 4 of them are strip line and the other are button type. One BPM block geometry enables it to be used as a shaker (beam exciter) for tune measurement purpose. 15 cm length strips designed for 500 MHz and its odd harmonics. Since the booster BPM block diameter is relatively large (150mm) compared to the beam displacement, and on the other hand the electrode locations in horizontal and vertical planes are symmetric, we expect a linear response from the BPM difference over sum values and in the same time a small sensitivity to the beam displacement [1] (figure 6).

Table 1: Booster Main Parameter

Circumference (m)	38.4
RF frequency (MHz)	499.654
Revolution freq. (MHz)	7.807
Repetition freq.(Hz)	1
Ramping time (ms)	450
Injection/Extraction Energy (MeV)	20/800
Beam Current (mA)	7
H/V Tunes υ_x/υ_y	2.22/1.31
H/V Emittances $\varepsilon_x/\varepsilon_y$ (nm.rad)	155/16
Straight sections β-func.(H/V) (m)	5.2/2.9

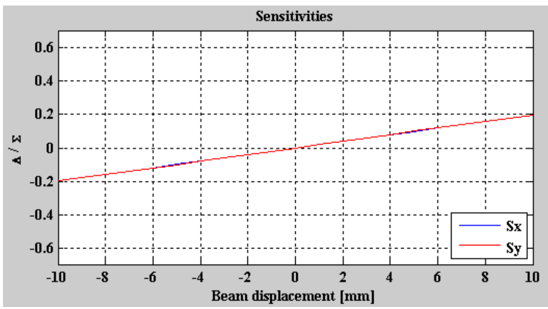

Figure 6: BPM Sensitivity

All BPMs are connected to Libera electron to analyze and calculate the exact position and detailed machine study. BPMs are connected to Libera's by calibrated and phase matched coaxial cable LMR 198 with variety of length (16m-35m) depends on location. All Libera's are controlled via wired LAN and they received a trigger and machine clock from Libera clock splitter, the splitter is connected and synchronized to the timing system.

EPICS driver is used for Libera electron; through it all of Libera modes can be used. Basic mode are used in first turn or first injection to the booster, then data on demand mode is used with AGC and DSC are off with zero attenuation and fixed switching mode (3) , using this mode it can be obtain turn by turn data and it's decimated so we can measure the betatron tune during ramping.

FCT and DCCT

The same type of current transformer is used in the booster and the TL1 (Bergoz) but with different sensitivity 2.5 V/A, furthermore a DCCT with its electronics from the same manufacture (Bergoz). Vacuum chamber is interrupted by thin isolation gasket and both FCT and DCCT are located beside each other in the same cell and its share the bypass shield. The shield was designed in-house; it consist of two cylindrical half's of low carbon steel, three layers of mu metal could be introduced to increase the shielding factor. Figure 7 shows the design of the shield and the already installed DCCT in the booster. Both FCT and DCCT are connected to an oscilloscope via coaxial cables and monitored in the control room (figure 5 & 8).

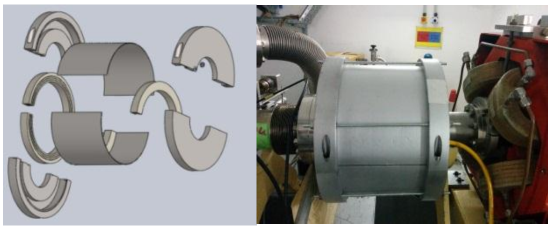

Figure 7: DCCT Shield

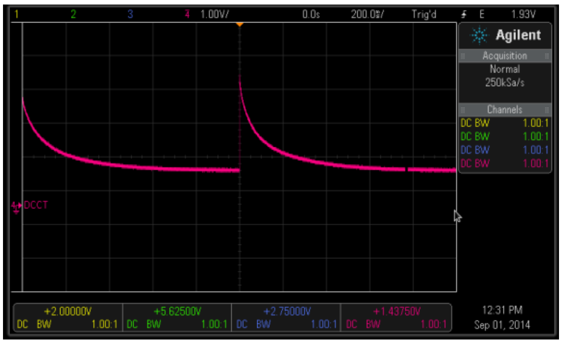

Figure 8: DCCT Reading

VBL

Visible beam line diagnostic system is taking the light coming from a bending magnet to be used to obtain a transverse image of the electron beam. This image is then analysed to infer the horizontal and vertical beam size. The beam transverse sizes depend on the lattice parameters [2]. Figure 9 shows the fluxes produced when an electron beam crosses a bending dipole in the booster.

A completely new vacuum chamber was fabricated for the booster ring, that gave the possibility to fabricate one of the chambers with a glass window for VBL diagnostics, that window is located between the dipole and the quadrupole. VBL located in cell 3 the distance from the glass window to centre of the magnet is 80cm.

The optical system is designed to fit the whole glass window and reflect the light to CCD camera. The optical gages and mirrors are from ThorLabs, tubes and gages are SM2 (2") system with 2 ME2-G01 mirrors, the 1st mirror will reflect the light horizontally directly from the glass window through tubes to 2nd mirror which will reflect the light vertically to CCD camera.

The camera (Basler acA1300-gm) is high resolution camera (1296 x 966) pixel have an external trigger coming from the timing system which is synchronized with beam at that point. The lens is SIGMA lens (F-mount) is mounted on the camera by an adapter to C-mount; the lens is variable focal lens 70-300mm so it can be calibrated depends on camera or working distance figure 10 shows optical structure and camera of VBL.

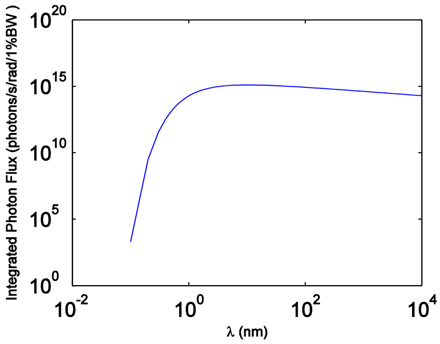

Figure 9: Fluxes along in the booster for beam current 7mA

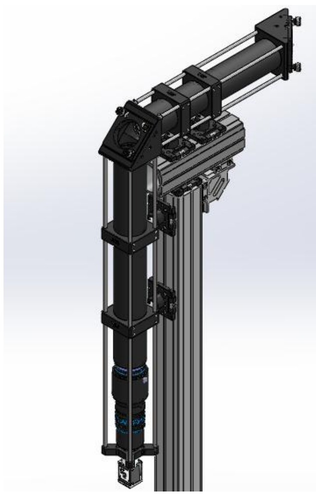

Figure 10: VBL Optical Gage with CCD Camera

Tune Measurement

The booster tune monitor is a diagnostic used to measure the vertical and horizontal transverse resonant frequencies (or betatron tunes) of the beam accelerated in the booster. The beam is accelerated from 20MeV to 800MeV in 450ms. During this ramping cycle, the tunes are not perfectly constant and it’s nescessary to precisely measure them along the cycle.To measure the tune we must excite a beam position oscillation using a shaker, record the beam position oscillation using beam position monitorrs (BPM) by Libera and perform a frequency analysis of these signals in Matlab.

The layout of tune excitation is shown in figure 11. The shaker located in cell 1 which also will works as beam position monior by RF coaxial switch (TELEDYNE CCS-32). Each stripline will have 2 switches one in the upper stream (Libera and 50 Ω dummy load) and the other in down stream (Amlifier and 50 Ω termination) the switching will be controlled by PLC.

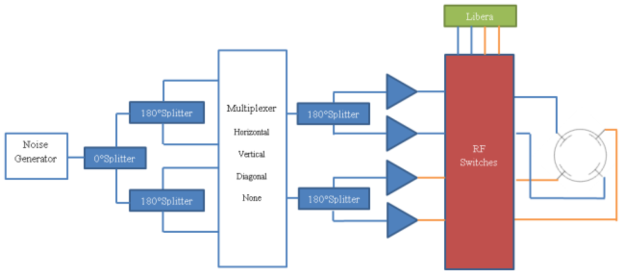

Figure 11: Tune Excitation layout and Switching Between Libera and the Amplifiers

The source of the excitation is white noise generator module with a referance signal coming from function generator to select the center frecuency, the module bandwidth is 4 MHz so it can handle the bandwidth required for fraction tune in the booster.

The amplifer system box consist of amplifers module Modular RF (KMA1040) 50W with frecuency range 200KHz- 50MHz 48dB gain, Mean Well SP-500 power supply and in house design controller board. The whole system are assembled in 3U rack mounted caeses in the lab.

The BPM located in cell 4 which is 90° phase advance respect to cell 1 BPM will pick up the data for tune measurment, this BPM is a strip line BPM so it is more sensetive to the beam than button BPM. Turn by Turn data taken from Libera @revolution frequency then a fourier analysis of the time domain data sampled at every turn yields the tune of the beam, figures 12 and 13 show the horizantal and vertical tune at the injection.

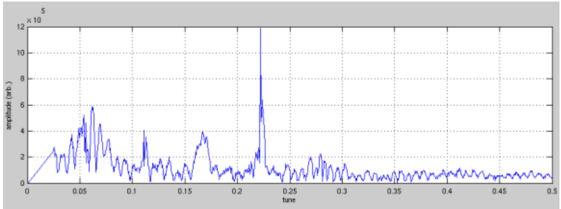

Figure 12 : Horizontal Tune at the Injection

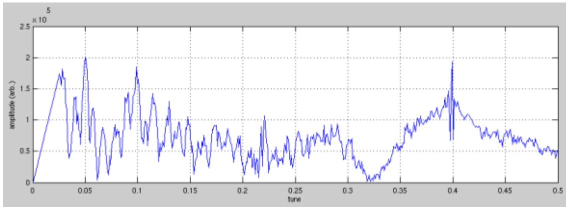

Figure 13 : Vertical Tune at the Injection

CONCLUSION

The set of diagnostics mentioned in this paper performed satisfactorily and allowed a successful booster commissioning. Most diagnostics devices perform with some difficulties specially the old ones problems .Our task now is mainly to perform and upgrade old instruments and make fine adjustments to increase their performance and prepare the new instruments for SR.

ACKNOWLEDGMENT

The authors would like to thank everyone who contributed to this achievement through discussions and suggestions. We are grateful for the support from the entire groups specially control group and special thanks to D. Foudeh (Head of RF&DI Group) for his support and experience to complete this achievement.

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