3.2.6 BOOSTER SYNCHROTRON DIAGNOSTICS

3.2.6.1 Introduction

This section is intended to be a comprehensive summary about the SLS booster synchrotron beam instrumentation. The design concepts presented here are based on the present status of the respective diagnostics systems. They still might change during the design phase, if more appropriate solutions regarding performance, resource allocation or schedule are found. These issues will be resolved on a case by case basis and are out of the scope of this document. The resource and schedule estimates for each instrument are given in an additional, also updated *SLS Electron Beam Instrumentation* paper. Chapter 3.2.6.2 gives a short overview of the SLS booster synchrotron measurements, which will be nescessary to set up and commission the booster, to measure the machine and beam parameters and to maintain the design performance during routine operation. The following sections go more into detail and provide more or less elaborated design concepts for each instrument.

3.2.6.2 Booster Synchrotron Measurements

Measurement	**Comments**	**Instrument**
Current	Current monitoring while ramping	Modualar Parametric Current Transformer
Position - destructive	Essential device during the commissioning, useful later	OTR and FS
Position - nondestructive	Button pickups	Digital Beam Position Monitor System in closed orbit mode
Tune	Start of measurement at an arbitrary time within the ramping cycle	Booster Tune Monitor
Position and tune - nondestructive	A complementary diagnostic for measuring position and tune	SR Monitor
Radiation	Placed at different locations around the machine	Beam Loss Monitor

3.2.6.3.1 Optical Transition Radiation (OTR) Screens

During commissioning of the booster synchrotron (partly) destructive devices like OTR-screens will be used for monitoring the electron beam position and profile [1]. Therefore two ports will be placed along the injection line of the booster in order to assure proper matching of the electron beam during injection. Moreover two additional OTR-screens (one in each sector of the booster) will be installed to find the correct setting of the synchrotron during the first turns.

Since it is foreseen that the booster synchrotron will not only operate in a ramping mode but in addition also in a storage (damping) ring mode, the impedance contribution of the OTR-screen ports to the total impedance budget of the booster has to be taken into account. Therefore a careful design of the OTR-screen ports will be required.

For linearity and resolution reasons, OTR is preferred over the use of flourescent screens. Still every profile monitor port will be equipped with two selectable stations for an OTR screen

and an optically transperant, but highly sensitive quarz screen. The latter will be used in the low current top up mode of the SLS.

As a special option for advanced control and optimization of the injection process into the storage ring, we are presently investigating the use of very thin (500 nm) Si_3N_4 wafers as OTR-foils. In combination with gateable CCD cameras (< 1 μs gating time), this will allow to observe the position and the matching of the electron beam into the storage ring over serveral (consecutive) turns.

3.2.6.3.2. Modular Parametric Current Transformer (MPCT)

For measuring the current and therefore the injection efficiency in the booster synchrotron with a time resolution of about 1 ms and an absolute accuracy of 1 % at average beam currents of 10 mA a *Bergoz* MPCT [2] would be the appropriate device. The working principle is to compensate the magnetic flux induced by the current flowing through the sensor aperture with a flux in opposite direction. While the total flux is maintained zero, the compensating feedback current is measured in a precision resistor. Therefore the MPCT output is proportional to the voltage developed by this resistor. According to J. Bergoz the MPCT is more suitable for the use in a booster synchrotron than the bandwidth extended *Bergoz* parametric current transformer (PCT), since the precision of both devices at high bandwidth (4.2 kHz) is the same, where as the MPCT is less expensive than the PCT. Although the MPCT is an off the shelf device, delivered from the *Bergoz* company, some effort has to be put into the design and the construction of its installation in the machine, since it is rather sensitive to magnetic stray fields (1 G converts in 100 μA) and temperature changes (1 K converts in 5 μA). Therefore extensive tests and calibration measurements are desirable and will finally pay off as well for the implementation of the PCT in the storage ring (see chapter 2.8.3.2).

3.2.6.3.3 Booster Tune Monitor

The booster tune monitor is described in section 2.8.3.5. of this handbook about tune measurements at SLS.

3.2.6.3.4. Booster Beam Position Monitor System

The booster beam position monitor system is described in section 2.8.3.4. of this handbook, where the newly developed digital BPM system, which will be used in all the SLS accelerators, is described in detail.

3.2.6.3.5. Synchrotron Radiation (SR) Monitors

SR-monitors can be used as a complementary, non-destructive diagnostic device to the OTR-screens mainly during commisioning. During normal operation the SR-monitors will continually deliver electron beam profile pictures to the operator.

When eventually operating the booster as a storage (damping) ring at least one of these monitors could be used for emmittance measurements. In addition fast linear image sensors (CCD or N-MOS) could be installed at these SR-monitors to measure the tunes during ramping.

According to the SLS vacuum group it is conceivable and rather inexpensive to have synchrotron radiation outlets in some of the booster bending magnet chambers. The optical set-up for such SR-monitors could be very much straight forward (outcoupling mirror,

telescope, filter, CCD) since the radiation power level will be rather low (< 1W) and no cooling or absorbers will be required.

3.2.6.4 References

[1] P. Piot, J.-C. Denard, P. Adderley, K. Capek and E. Feldl, *High-current cw beam profile monitors using transition radiation at CEBAF*, Proc. of the 7th workshop on beam instrumentation, Argonne 1996.

[2] Bergoz Precision Beam Instrumentation, Technical Note.