VACUUM SYSTEM FOR THE SWISS LIGHT SOURCE

G. Heidenreich, L. Schulz, P. Wiegand
Paul Scherrer Institut, 5232 Villigen PSI, Switzerland

Abstract

The Swiss Light Source (SLS) is a dedicated high brightness Synchrotron Radiation Source with a circumference of 288 m, an electron energy of 2.4 GeV and a nominal current of 400 mA. A vacuum chamber design with an antechamber is foreseen with discrete absorbers and lumped pumps. This will minimize the area exposed to synchrotron radiation leading to a higher rate of conditioning and reduce the thermal stress which may lead to current-dependent chamber movements. The vacuum chambers will be made of stainless steel. Each magnet sector (1/12 of the ring) will form a separate vacuum section with gate valves at both ends of the straight sections. The vacuum sections are assembled outside the ring, baked at 300°C, and then lifted in place and installed on the girders. No in situ bakeout and no bellows in the magnet arcs are foreseen.

1 INTRODUCTION

The vacuum system for the Swiss Light Source (SLS) will provide the required working condition for an electron energy of 2.4 GeV and a beam current of 400 mA. The residual gas scattering beam lifetime has to be in the range of 10 hours which implies an averaged pressure of 1 nTorr for the vacuum system.

To achieve the required pressure after a short operation time an antechamber design is foreseen for the vacuum system so that the total photon flux will hit only the discrete photon absorbers. A design with discrete absorbers has two main advantages: (i) the pumps may be mounted close to the photon absorbers (the main source of the gas load) and (ii) a short 'conditioning time' due to a high photon flux on the desorbing surfaces. With this concept the beam cleaning effect is faster than if the synchrotron radiation is distributed along the chamber.

2 CHAMBER DESIGN

The electron channel has the same cross section in all vacuum chambers and has a keyhole profile (Fig. 1). The synchrotron radiation exits the electron channel through the gap between the electron channel and the antechamber and hits the discrete photon absorbers located within the antechamber. The gap has a vertical size of 10 mm. This is a good compromise between a low chamber impedance and an unrestricted exit of the synchrotron radiation.

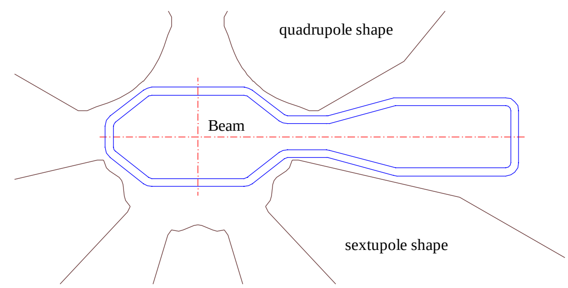

Figure 1: Chamber Cross Section

3.1 Dipole Chamber

Due to the long distance between the bending magnets a fraction of 0.5% of the photons hit the walls of the slot between the electron channel and the antechamber. As a result a significant amount of the radiated power is distributed within the dipole chambers (Fig. 2). This amount will even be increased by the photon fan of insertion devices especially of the insertion devices for circular polarized synchrotron radiation which has a larger vertical opening angle. This leads to high local thermal stresses because of the low thermal conductance of the stainless steel chamber.

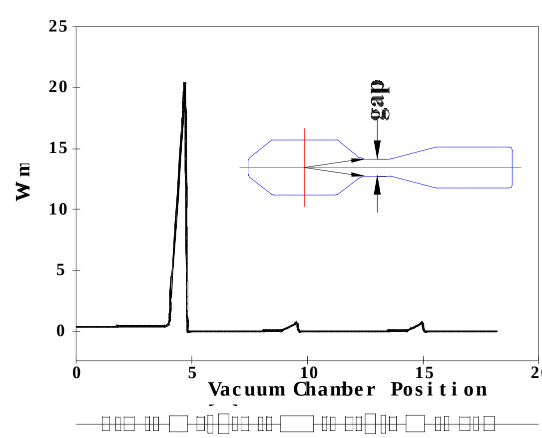

Figure 2: Power Distribution of the Vacuum Chamber at 2.4 GeV and 400 mA for a Magnet Section

To solve this problem the SLS dipole chamber has a stainless steel body with an inserted water cooled copper shield to separate electron channel and antechamber (see

Fig. 3). The shield will be inserted in two parts through the entrance flange into the completed chamber and will be fixed with screws to the flanges at both ends of the chamber.

The water feedthrough of the closed cooling-pipe will afterwards be welded to the chamber wall. Several clamps in the chamber hold the copper shields in place.

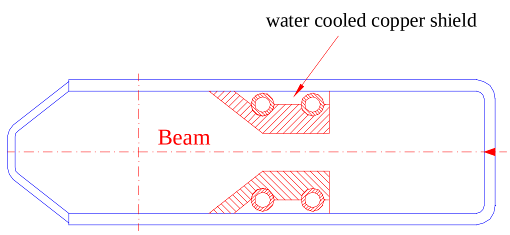

Figure 3: Dipole chamber cross section

3.2 Quadrupole Chamber

Each quadrupole chamber is equipped with one or two beam position monitors. The beam position monitor stations (BPM) will be solid stainless steel blocks which contain the pick up electrodes. The vacuum chamber is fixed at each BPM-station with supports to the magnet girders.

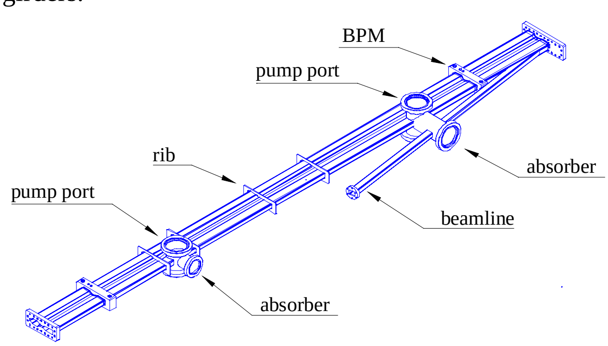

Figure 4: Quadrupole chamber

If no bellows are installed in the vacuum sections the following measures are necessary:

- To compensate the ground movements of the magnet girders the girders have to be equipped with a permanent measuring and alignment system [1].
- For the fabrication of the vacuum chambers it is important that the tolerances of the overall length and the angles of the flanges stays within small limits. All chambers are equipped with flat seal flanges which have the advantage that their final processing can be done after the welding process of the chambers has been finished. A further advantage is that flat seal flanges have no gaps between gasket and flange which results in a low chamber impedance [2].

Finite element calculations have been performed to study the influence of the thermal expansion due to HF-losses and scattered photons which leads to forces having an effect on the chamber supports. The resulting reaction forces are below 170 N and have no influence on the alignment of the magnet girders.

To compensate errors in the BPM system caused by small chamber motions which are in the range of several microns it is foreseen to measure the transverse position of each BPM block with an optical measuring system [3].

3 GAS LOAD AND PUMPING

The main gas loads will be produced by photon induced desorption from the absorbers and the photon exposed surfaces of the electron channel. A total gas load of 40000 nTorr l/s is expected after a beam dose of 100 Ah. The photon distribution from the bending magnets has been used to calculate the gas load and the corresponding CO partial pressure distribution along the vacuum chamber which is shown in Fig. 5 .

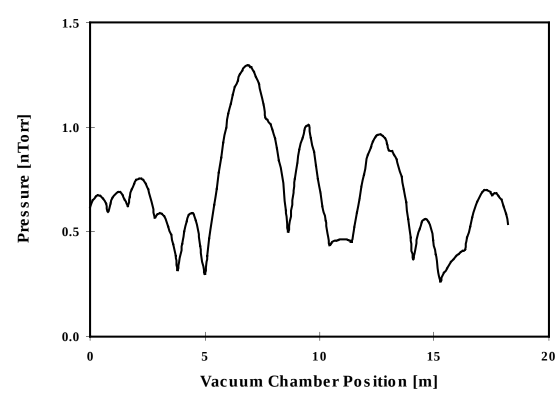

Figure 5: CO Pressure Distribution for a Magnet Section (2.4 GeV, 400 mA, 100 Ah)

4 VACUUM CONDITIONING

A bakeout of the vacuum chambers before the first start up clearly reduces the commissioning time of the light source. Although it has been suggested to leave out any bakeout completely, the fact is undisputed that the higher the bakeout temperature for a vacuum system is, the lower is the resulting desorption rate and the corresponding base pressure.

After commissioning there is no need for in-situ bakeout. If only a few vacuum sections are vented during service and maintenance, operation can normally be started again without a following bakeout [4].

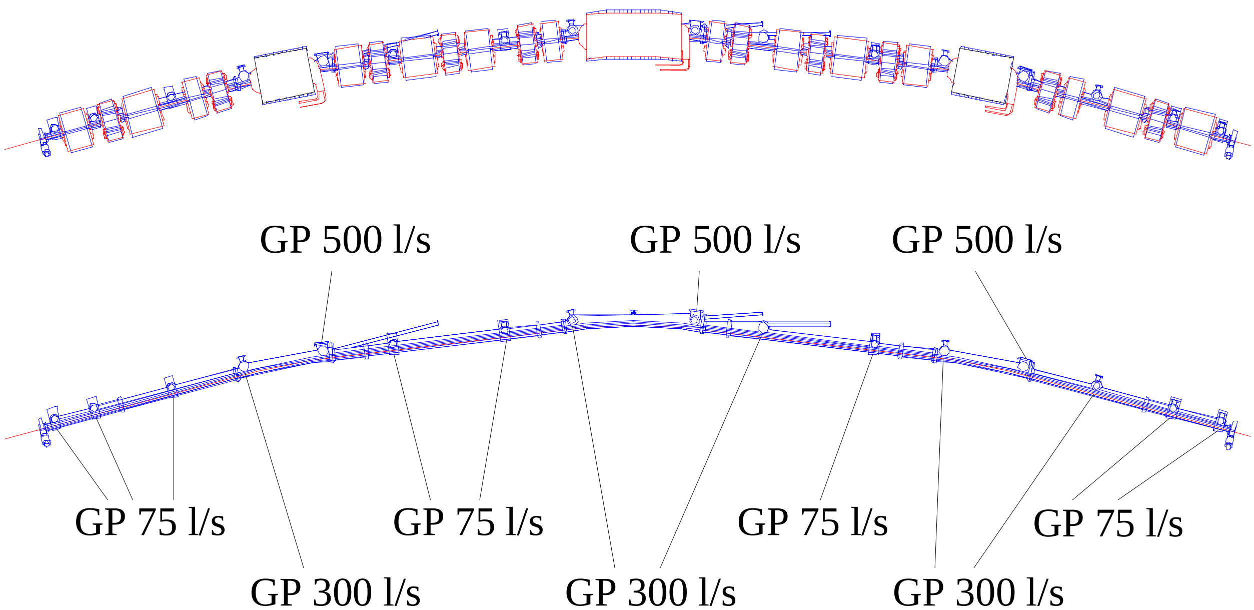

Figure 6: Storage Ring Section

A bakeout of the vacuum chambers before installation is therefore intended while an in-situ bakeout for the SLS vacuum system is not foreseen. Before installation into the ring the vacuum sections will be assembled outside the magnet girders, equipped with all vacuum components, evacuated and baked out. Each magnet sector (1/12 of the lattice) will form a separate vacuum section (Fig. 6) with gate valves at both ends of all straight sections. In the storage ring all magnets (dipoles, quadrupoles, and sextupoles) can split in the midplane. The upper yokes of all magnets can be removed from the aligned girders so that the already baked out and evacuated chambers can be lifted in place and installed on the girders.

This concept results in a more complicated assembly but it has the following advantages:

- It saves the considerable costs for an in-situ bakeout system consisting of heating jackets, thermal insulation and heating control.
- The aperture of the magnets can be reduced because no additional space is necessary between chamber wall and magnet pole for heating jacket and insulation.
- The vacuum chambers are not constrained during the bakeout so that chamber lengthening does not have to be compensated by the bellows.

REFERENCES

[1] M. Böge, L. Rivkin, M. Rohrer, R. Ruhland, A. Streun, L. Tosi, P. Wiegand, SLS Lattice Finalization and Magnet Girder Design, this Conference

[2] B. Hippert and N. Marquardt, The DELTA Vacuum System, EPAC'96, Page 364, 1996

[3] C. Herbeaux, P. Marin, V. Baglin, O. Gröbner, "In Situ" / No "In Situ" Bake Out for Future S.R. Sources-Measurements on a Test Stainless Steel Chamber at DCI, Lure RT/97-03, 1997

[4] M. Dehler, A. Jaggi, V. Schlott, R. Ursic, Electron Beam Diagnostics for the Swiss Light Source, this Conference