2.6 SLS VACUUM SYSTEM

The gas pressure in a synchrotron light source is dominated by the synchrotron light induced desorption. The desorption is for a very small part induced by photons which impinge on the vacuum chamber wall. The main part is induced by photo electrons. These photo electrons can desorb residual gas molecules twice, once when leaving the chamber surface and once when striking the vacuum chamber again. The desorption rate typically is time dependent and decreases with an increasing photon dosis.

The on residual gas scattering depending beamlifetime has to be in the range of 10 hours at an electron energy of 2.4 GeV and a beamcurrent of 400 mA which implies an averaged pressure of 1 nTorr for the SLS vacuum system. It is especially important for the design of the vacuum system that this pressure will be reached after a short operation time.

To achieve the required pressure after an short operation time the vacuum system has been designed so that the total photon flux will hit only on lumped absorbers. Recent investigations and experiences made at other synchrotron light sources have shown that with this concept of high photon density on the absorber surfaces the beam cleaning effect is faster as when the synchrotron radiation is distributed on the total circumference. The range of the photo electrons can be reduced and the beam cleaning effect increased by a suited absorber design and/or a superposition of low magnetic fields [1].

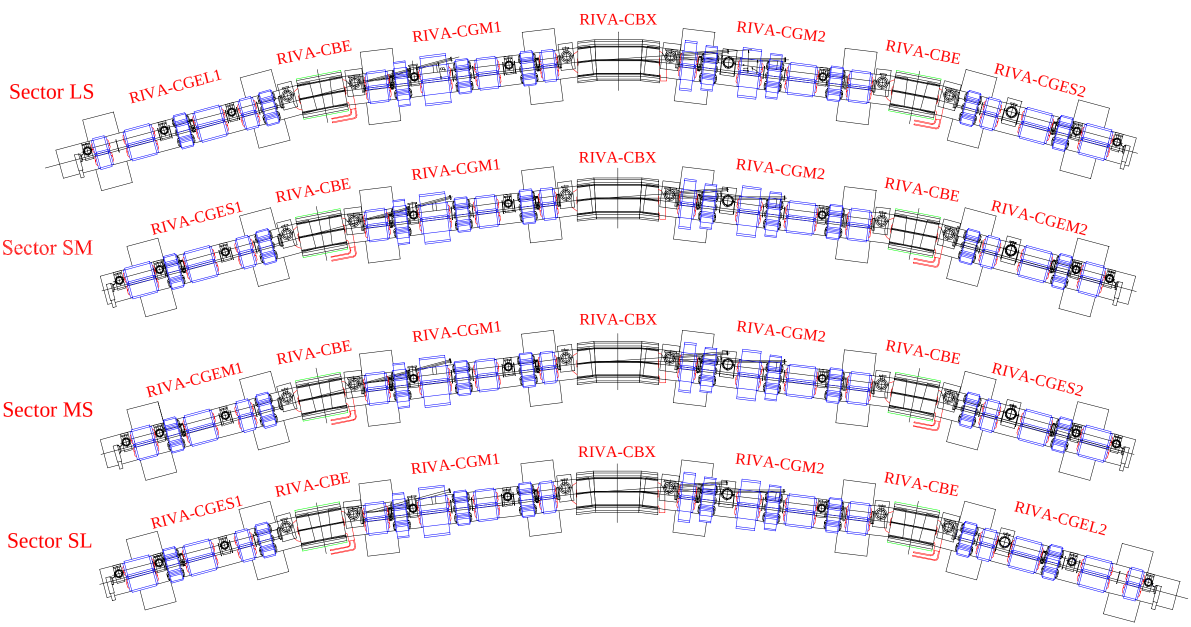

Figure f26_a: **Storage ring cells LS, SM, MS, and SL with vacuum system**

The required pressure of 1 nTorr at a beam current of 400 mA can only be realized if the base pressure without beam is in the 0.1 nTorr range. The base pressure depends on the installed pumping speed and the thermal desorption rate of the vacuum chamber. The beam cleaning effect is very high around the lumped absorbers but accordingly low in the other areas. The in UHV technic common desorption rates of =0.1 nTorr l /(s m^2) must be realized and UHV standards must be kept. Additional to a standard cleaning and vacuum firing of the chambers a sufficient bakeout is required at least before the first start up.

2.6.1 CHAMBER DESIGN

Fig. f26_a shows the vacuum section of a SLS storage ring cell. Each of the straight sections containing quadrupoles and sextupoles is equipped with one continuous vacuum chamber. In the dipole magnets the vacuum chambers are bent. The dipole and quadrupole chambers are connected by flanges. This gives the possibility to exchange single dipoles with supra conducting magnets later on.

The electron channel has the same cross section in all vacuum chambers and has a keyhole profile (Fig. f26_b). 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.

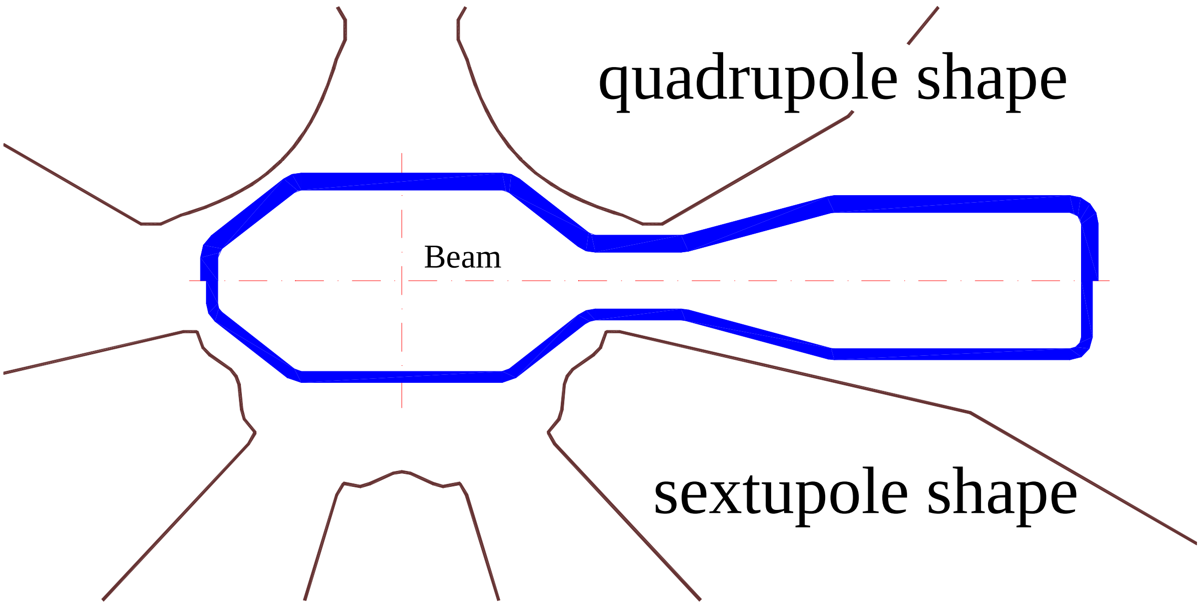

Figure f26_b: **Chamber cross section with quadrupole and sextupole shape**

The vacuum chamber materials for synchrotron radiation sources usually are aluminum or stainless steel. The advantages and disadvantages of both materials have been sufficiently described. For a synchrotron light source as the SLS with its complex chamber geometries the advantages of aluminum (high electrical and thermal conductivity, no magnetic permeability) are compensated by the technologically more complicated manufacturing process resulting in higher costs. Therefore the SLS vacuum system will be made of stainless steel 316 LN.

Each vacuum section consists of 3 dipole chambers (see Fig. f26_c) and 4 straight chambers for the quadrupoles and sextupoles (see Fig. f26_d). The dipole chambers will be manufactured of 3 mm thick stainless steel 316 LN. The greatest chamber width will be about 250 mm. The chambers will have to be reinforced with ribs so that they can withstand the air pressure. FEM calculations have shown, that the max. displacement is in the range of 0.5 mm.

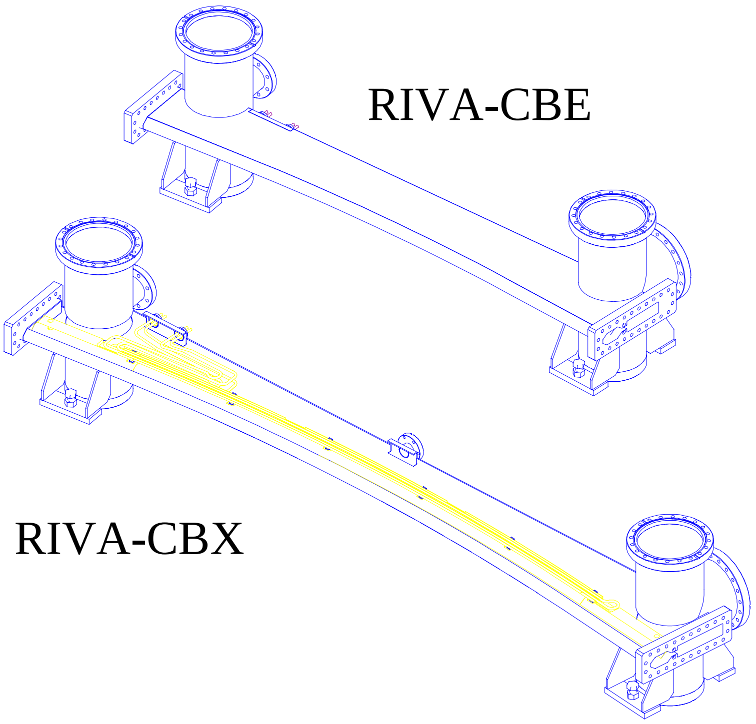

Figure f26_c: **Dipole chamber RIVA-CBE for dipole BE and RIVA-CBX for dipole BX**

The absorbers for the synchrotron radiation will be made of copper and will have a direct water cooling system. They are fitted into an orifice which is connected with the keyhole of the vacuum chamber (see Fig. f26_d). An ion sputter pump is connected directly under and/or beside the absorber on the same orifice. The maximum synchrotron radiation power with a value of 20.5 kW/m will strike the absorbers in the dipole chambers. This compares to a power density of about 40 W/mm². This value permits the use of OFHC copper as absorber material and the use of glidcop is not necessary.

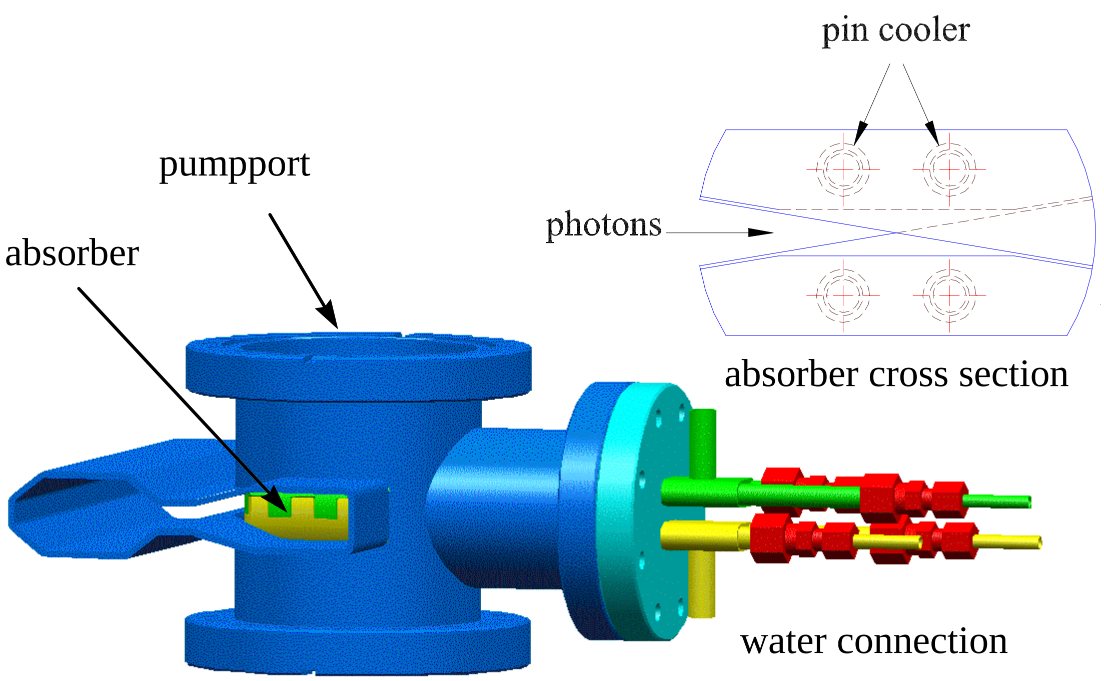

Figure f26_d: **Photon Absorber in the Quadrupole Chamber**

Each magnet sector (1/12 of the lattice) will form a separate vacuum section with gate valves at both ends of all straight sections.
All vacuum sections can be separated from the rest of the ring with all metal gate valves so that while installing insertion devices in the straight sections the adjoining vacuum sections will not be vented. The beamlines can also be closed off with gate valves. The storage ring gate valves are equipped with rf-shields for the open position.
The straight section chambers and especially those with small vertical gap will contribute significantly to the total impedance seen by the beam. The high resistivity of stainless steel might enforce a reconsideration of the material for these vacuum chambers. A low resistivity inner plating of SS chambers could also be considered.

2.6.1.1 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 (see Fig. f26_e). 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.
To solve this problem the SLS dipole chamber has a stainless steel body with an inserted

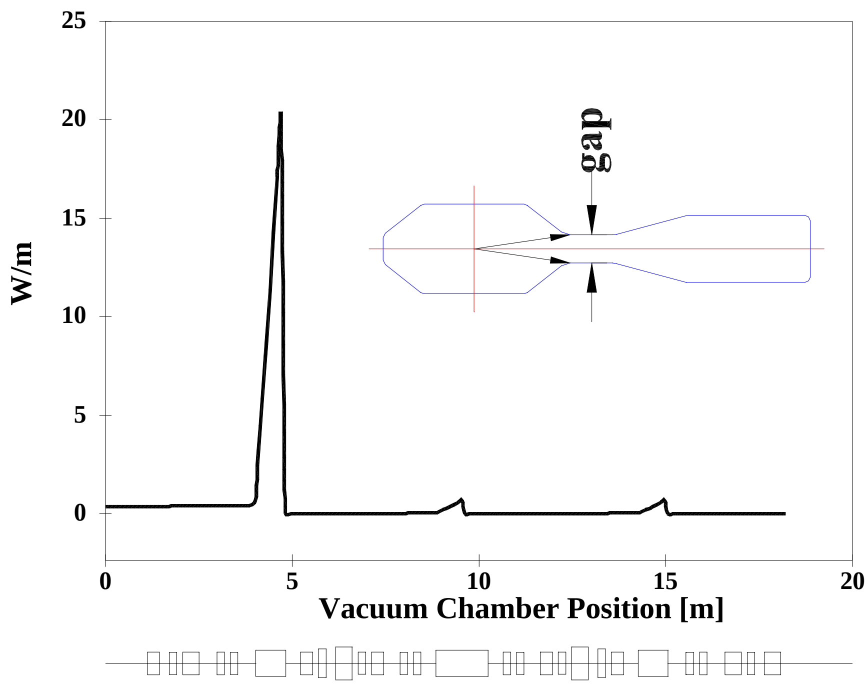

Figure f26_e: **Power Distribution of the Vacuum Chamber at 2.4 GeV and 400 mA for a Magnet Section**

water cooled copper shield to separate electron channel and antechamber (see Fig. f26_f). 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 (see Fig. f26_g).
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.

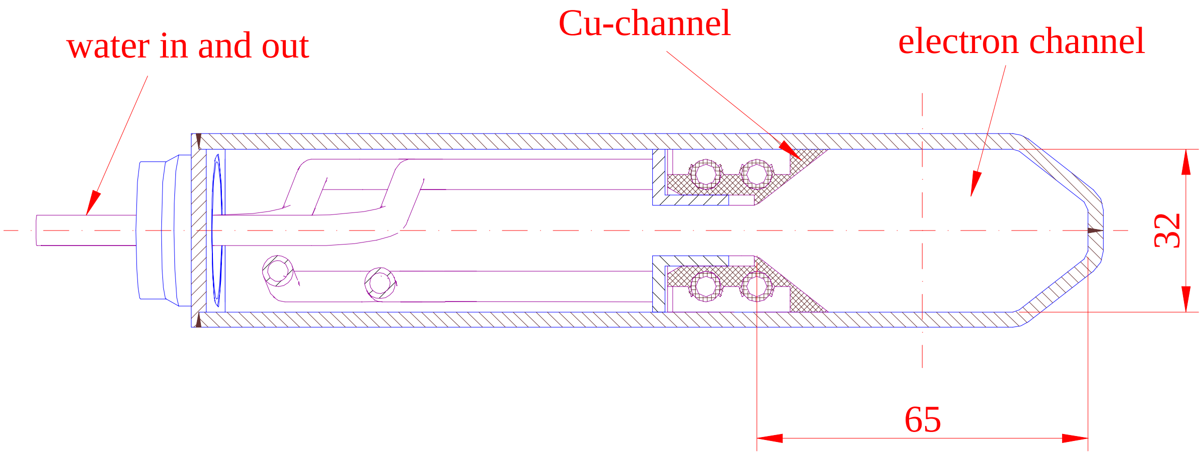

Figure f26_f: **Dipole chamber cross section**

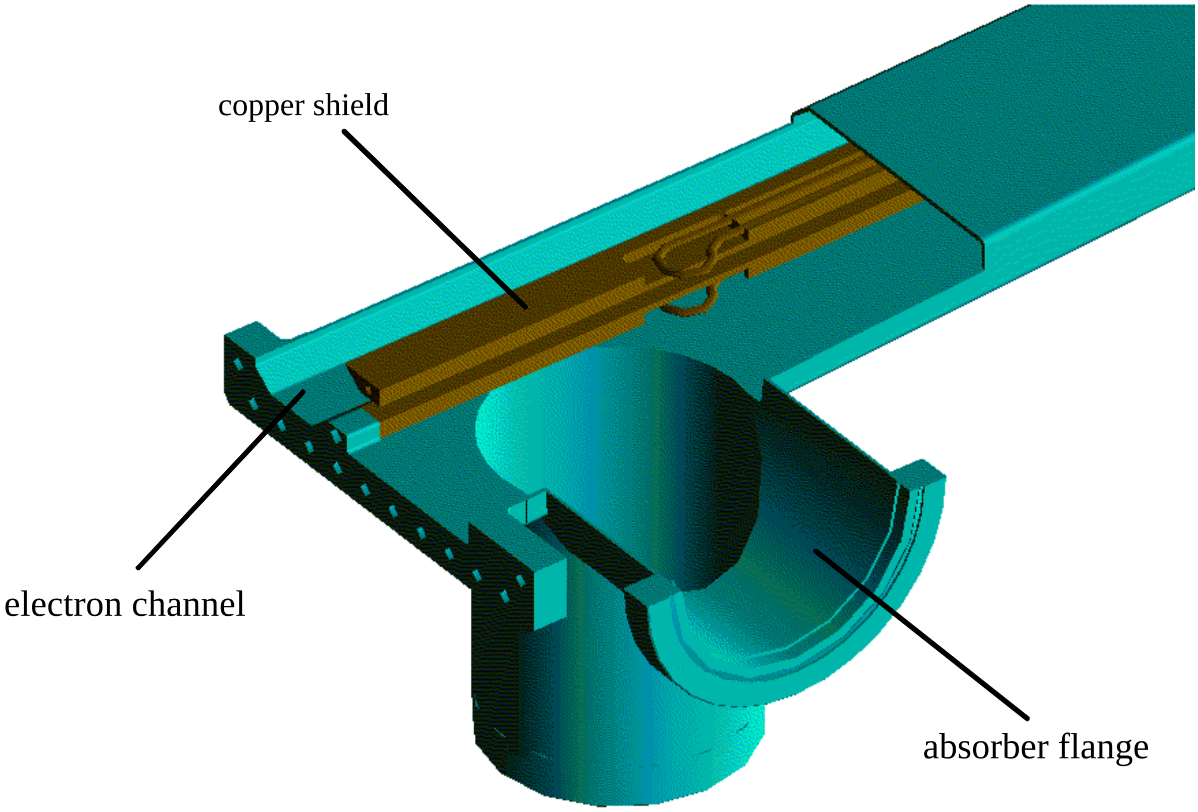

Figure f26_g: **Copper shield in the Dipole chamber**

2.6.1.2 QUADRUPOLE CHAMBER

Each quadrupole chamber is equipped with one or two beam position monitors (see Fig. f26_h). 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.

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.

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.

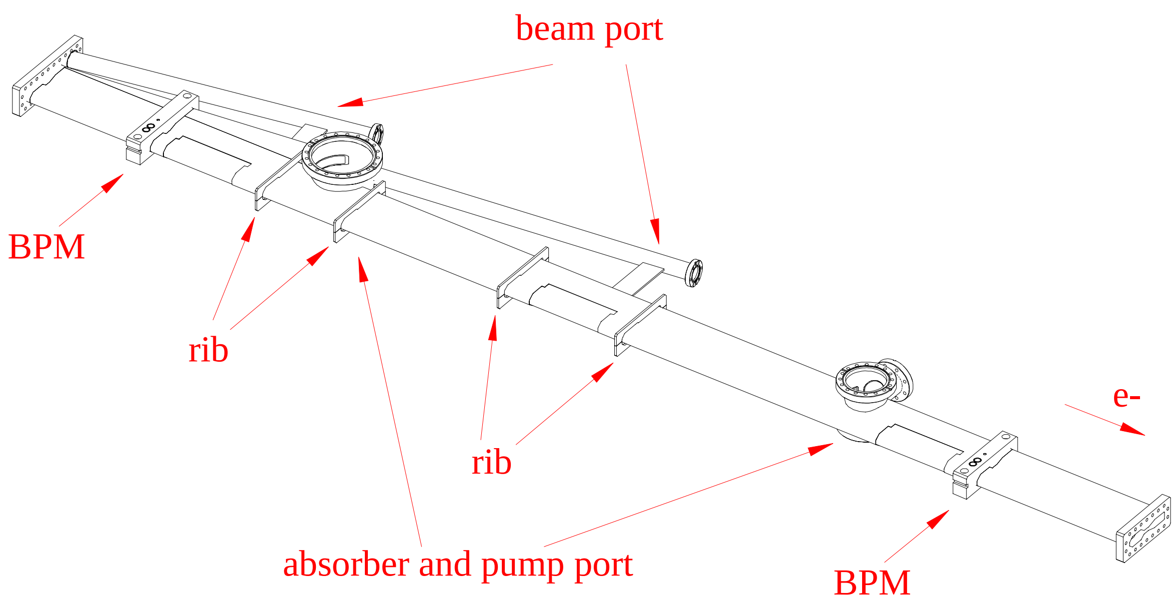

Figure f26_h: **Quadrupole chamber RIVA-CGM2**

2.6.2 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. f26_i .

2.6.2 BAKEOUT SYSTEM

The question whether it is necessary to bake out the SLS-vacuum system before installation can clearly be answered with yes. 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 bake out. If only a few vacuum sections are vented during service and maintenance, operation can normally be started again without a following bakeout [3].

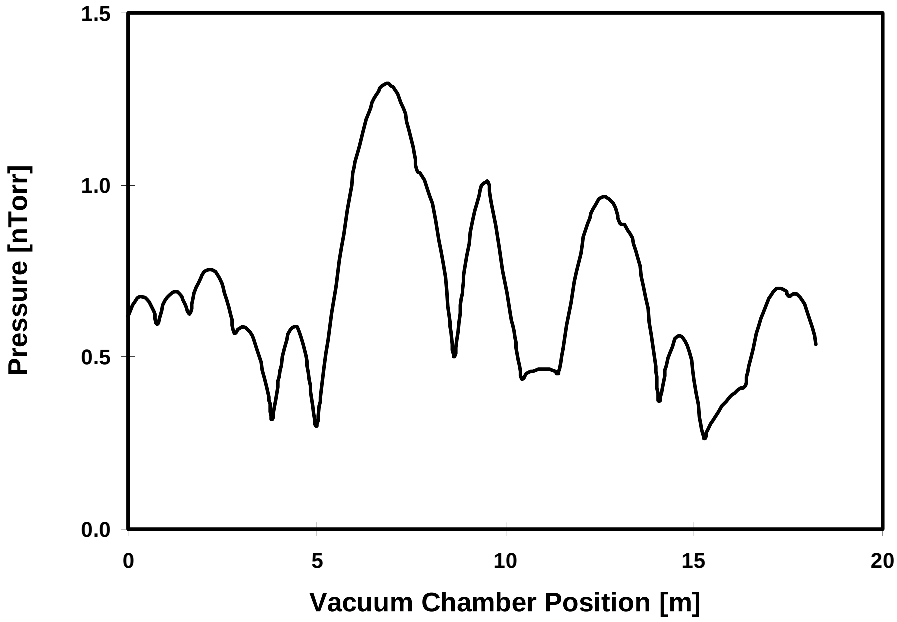

Figure f26_i: **CO Pressure Distribution for a Magnet Section (2.4 GeV, 400 mA, 100 Ah)**

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 chambers will be assembled outside the magnet girders, equipped with all vacuum components, evacuated and baked out with a mobile bakeout system. In the storage ring the upper magnet jokes will be removed from the aligned girders. The dipole magnets are designed as splittable C-magnets and their upper jokes can also be removed so that the already baked out and evacuated chambers can be lifted in place and installed on the girders.

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

1. It saves the considerable costs for an in-situ bakeout system consisting of heating jackets, thermal insulation and heating control.
2. 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.
3. There is no fixture for the vacuum chambers during the bakeout so that chamber lengthening does not have to be compensated by the bellows. If at all required bellows are designed only to compensate the normal chamber fabrication tolerances. This allows the construction of RF-liners with only small movements.
4. The maximum bakeout temperature is not limited by the thermal conductance of the insulation of the heating jacket.

References:

1) Å. Anderson and M. Ericson, Some Experiments on Synchrotron Radiation Induced Desorption at MAX, Vacuum, 46, 757 (1995)

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