THE VACUUM SYSTEM FOR THE SPANISH SYNCHROTRON LIGHT SOURCE (ALBA)

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Abstract

ALBA is a 3rd generation synchrotron light facility to be built near Barcelona (Spain). The design phase of ALBA is almost completed and the first components (including the vacuum chambers for the storage rings) have been ordered. ALBA consists of a 100 MeV Linac injecting into a 249.6 m circumference booster synchrotron and a 3 GeV, 268.8 m storage ring with DBA structure. The storage ring has a four fold symmetry with 32 bending magnet, 4 long, 12 medium and 8 short straight sections. The stainless steel vacuum chamber (VC) of the storage ring has been designed with the concept of the antechamber where crotch absorbers will be placed. Pumping will be by sputter ion pumps (SIP) and NEG pumps, with an overall pumping speed from SIP of around 57000 l/s. This will maintain an average dynamic pressure of around 1.10^{-9} mbar to achieve a beam lifetime >15 hours at the designed current (400mA).

INTRODUCTION

The lattice of the storage ring is based on an extended DBA structure and has a nominal emittance of 4.3 nm.rad. The main parameters of ALBA storage ring which characterize the vacuum system are shown in Table 1 [1].

ALBA will contain several straights: 4 long straight section (LSS) of 8 m, 12 medium straight sections (MSS) of 4.2 m long and 8 short straight sections (SSS) of 2.6 m.

Table 1: ALBA storage ring main parameters which characterize the vacuum system.

Parameter	**Unit**	**Value**
Beam Energy, E	GeV	3
Nominal/Design current, I_{nom}.	mA	250/400
Circumference, C	m	268.8
Dipole magnetic field, B	T	1.42
Dipole magnets radius of curvature, ρ	m	7.047
Total photon flux from bending magnets at the design current, Γ	Ph/sec	$9.7\cdot10^{20}$
Total power from bending magnets at the design current, P_T	kW	407

THE STORAGE RING VACUUM SYSTEM

The storage ring is divided into 16 vacuum sections. By the means of ultra high vacuum (UHV) valves, the vacuum layout will follow the definition of the matching cell and the unit cell, see Figure 1 [1]. The unit cell has an overall length of 13.6 m, and includes the short straight section (SSS) and two bending magnets. The matching cell has also two dipole with an overall length of 11.0 m.

The VC will be of 3 mm thickness stainless steel 316LN and has a key-hole profile. The standard profile of the vacuum chamber consists of the e-beam channel (width 72 mm, height 28 mm) connected by a 10 mm height slot (15 mm for the dipole VC) to the so-called antechamber, which has the same height as the e-beam chamber. The dipole vacuum chamber has a different profile: the chamber has a tapering to follow the pole profile of the dipole magnet; moreover it has all stainless steel external cooling (see Figure 2).

With the concept of the antechamber, it is possible to absorb the unwanted synchrotron radiation (SR) by lumped absorbers, which has several advantages: higher doses of SR will reach the absorbers, leading to a fast conditioning. In addition, the antechamber will increase the overall conductance of the vacuum chamber, and will allow better connection of the pumps; this will lead to a more efficient pumping from the pumps installed.

The vacuum chambers will be connected to each other using flat seal flanges which will permit a very small gap facing the e-beam which will give a small contribution to the impedance budget of the machine, also will allow possible manufacturing correction for the chamber length (by machining) after welding it to the chamber.

The crotch absorbers

The absorbers are distributed all over the circumference to absorb the non used SR. The total power from the dipoles is 407 kW (for the design current), the maximum total power on the main absorbers is around 6.8 kW, the maximum linear power density is 64.4 W/mm and the maximum surface power density (with normal incidence) is 246 W/mm^2 (37 W/mm^2 at the 8.8° the inclination angle of the absorber's teeth).

The ANKA/SLS design for the absorbers has been adapted to ALBA with some updates [2]. FEA has been performed to estimate the maximum stress, stain and temperature on the absorber, in order to estimate the cycles that the absorbers can withstand before failure. The results of this analysis (for the critical absorber) are: the maximum stress is 193 MPa, the maximum strain is 0.17% and the maximum temperature is 285 °C; the results are within the design criteria of the absorbers. Glidcop® will be used for the absorbers; Figure 3 shows the strain results for the critical absorber.

The pumping system and instrumentation

Mobile roughing stations will be used to pump down the storage ring into 10^{-6} mbar; SIP will be the main UHV pumps in the storage ring, different pumping speeds for the SIP have been selected where pumps with the highest pumping speed will be installed close to the main absorbers (high outgassing). The overall nominal pumping speed for the storage ring is 57000 l/s. Furthermore, in the places with high outgassing (and also at the locations with limited space) NEG pumps will be fixed (see Figure 1).

The pumping ports have large openings and are located on the antechamber and as close as possible to the locations of the high outgassing. With this arrangement the effective pumping speed is reasonable.

ALBA will use Pirani gauges to measure the pressure from atmospheric down to 10^{-3} mbar range and inverted magnetron gauges (IMG) will be used for UHV pressure measurements and also for interlock purposes. Residual gas analysers (RGA) will be used to measure the partial pressure around the ring, they will be a good tool to predict vacuum failures and for leak chasing purposes.

The average dynamic pressure.

The main source of outgassing in the storage ring is due to the thermal and the photon stimulated desorption (PSD). The PSD outgassing is determined by the PSD yield (η_{PSD}) and its reduction with the accumulated photon dose. This phenomena has been studied extensively [3], [4]. The base pressure without beam is determined by the thermal outgassing of the vacuum chamber facing vacuum. The thermal outgassing rate used for ALBA simulations was $1\cdot10^{-11}$ mbar.l/(sec.cm^2).

In order to determine the PSD yield values, the photon flux around the ring and on the absorbers must be calculated. The flux values on the absorbers are determined by the angle of the SR fan each absorber will cover. The values of the PSD yield used for the pressure profile calculations for pre-baked (not in-situ) and for in-situ baked vacuum chamber for CO are given in ref. [5].

The average pressure (for CO) has been calculated for ALBA storage ring by Monte-Carlo simulations using Molflow program [6]. The average base pressure being calculated is $7.0\cdot10^{-10}$ mbar see Figure 4. For the PSD results, several cases have been calculated, depends on the machine operation (all at 3GeV):

Case 1: First injection (10 mA).

Case 2: With beam current of 100 mA after 100 Ah.

Case 3: Operation with the nominal current (250 mA) after 500 Ah.

Case 4: With the design current (400mA) after 1000Ah.

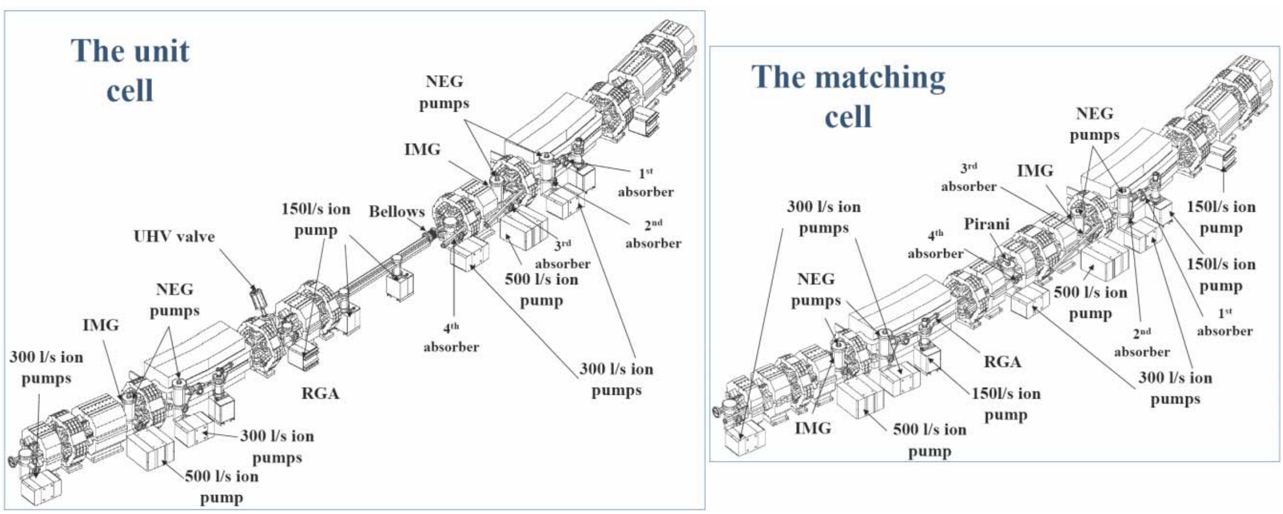

Figure 1: The unit cell and the matching cell of ALBA storage ring, respectively.

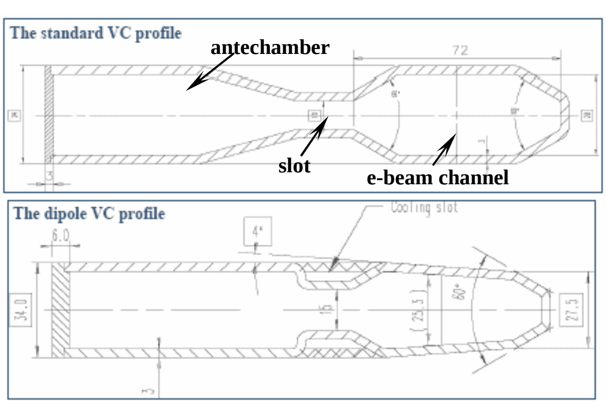

Figure 2: Cross sections of the standard profile and for the dipole chamber profile, respectively.

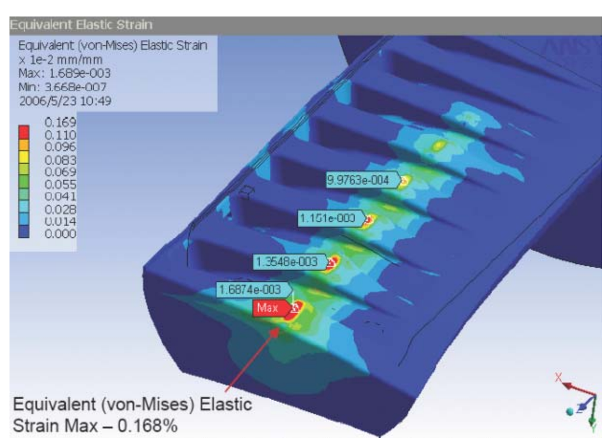

Figure 3: the equivalent von-Mises strain for the critical absorber (Glidcop®).

An assembly procedure (similar to SLS approach) will be adopted to ALBA in order to achieve results for the average pressure similar to those for an in-situ baked vacuum chamber, which leads to a fast conditioning [7].

Table 2: The pressure (mbar) due to PSD and the total pressure for per-baked VC and for in-situ baked VC.

	Pre-baked VC		In-situ baked VC	
Case #	PSD	Total	PSD	Total
1	$5.23\cdot10^{-8}$	$5.3\cdot10^{-8}$	$2.62\cdot10^{-9}$	$3.35\cdot10^{-9}$
2	$1.21\cdot10^{-9}$	$1.94\cdot10^{-9}$	$7.92\cdot10^{-10}$	$1.52\cdot10^{-9}$
3	$1.31\cdot10^{-9}$	$2.04\cdot10^{-9}$	$9.86\cdot10^{-10}$	$1.71\cdot10^{-9}$
4	$1.04\cdot10^{-9}$	$1.77\cdot10^{-9}$	$7.87\cdot10^{-10}$	$1.51\cdot10^{-9}$

THE BOOSTER VACUUM SYSTEM

The booster has 32, 10° dipoles of around 2 m length, and 8, 5° dipoles of around 1m length. The profile of the vacuum chamber inside the dipole is elliptical of 17.6*46mm (inside) this will leave a clearance with the poles of the dipole of 1.5 mm, while the profile inside the quadrupole is circular with an inside diameter 29 mm, this will leave a clearance of around 2 mm with the quadrupoles as well as for the other magnets.

The booster is divided into arcs where each arc consists of one dipole, a quadrupole, correctors and BPM. This is what is called a "unit cell". The length of the unit cell is around 6m and consists of one vacuum chamber with a bend for the dipole and on each side of the unit cell there are bellows to ease the assembly. The change of the profile of the chamber from elliptical into the circular is done by a step. 3, 20 l/s SIP have been used to pump down the unit cell (See Figure 5).

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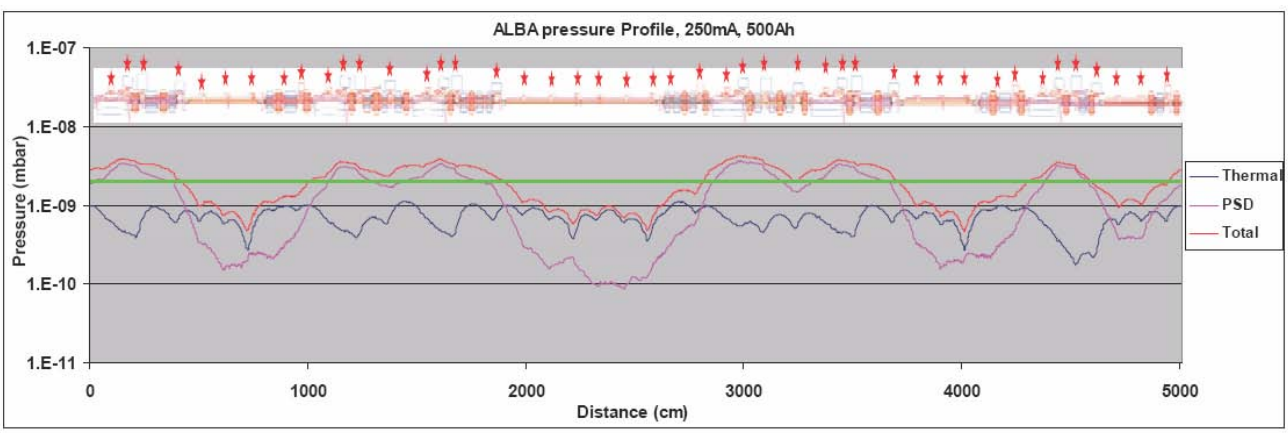

Figure 4: The pressure profile of ALBA storage ring at nominal current 250 mA after 500 Ah.

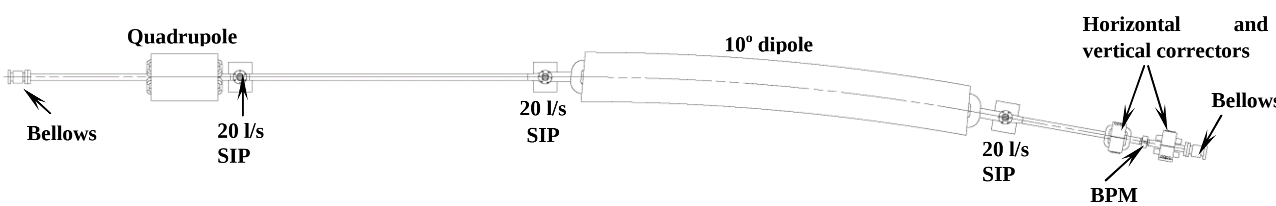

Figure 5: the vacuum layout of the unit cell of the booster synchrotron