ALBA Global Stability analysis

M. Llonch Burgos¹, J. Ladrera¹, J. Marcos¹, C. Collidelram¹, M. Pont¹
¹ CELLS-ALBA Synchrotron, Cerdanyola del Vallès, Barcelona, Spain

Abstract

ALBA is a 3rd generation synchrotron with ten years of operation. Along the first operation period, several misalignments have been detected and measured in the ALBA Synchrotron accelerators complex. Facing the future challenges of ALBA II project, which purposes to convert ALBA Synchrotron from 3rd to 4th generation, through the partial replacement of the accelerator and new beamlines construction, a global view on the facility steadiness along its first life period has been considered. The facility alignment drift can be analyzed by means of the historic collected data from the reference networks in the linac, tunnel and experimental area and correlated with some other interesting data like the radio frequency cavities frequency evolution.

Introduction

ALBA is suitably operating along its first life period, although a permanent slowing-down long-term drift is yearly measured through the reference-network periodic measurements. In a few years, ALBA Synchrotron upgrade aims to become a 4th generation machine with a Ultra Low Emittance Ring (ALBA II). ALBA II constraints will involve very high demanding alignment tolerances. First estimations are being calculated and are represented in the next table.

<table>
<thead>
<tr>
<th>Tolerances</th>
<th>Bending magnets</th>
<th>Quadrupoles/Sextupoles</th>
<th>Girders to girder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal</td>
<td>50 µm</td>
<td>50 µm</td>
<td>70 µm</td>
</tr>
<tr>
<td>Vertical</td>
<td>30 µm</td>
<td>30 µm</td>
<td>70 µm</td>
</tr>
<tr>
<td>Longitudinal</td>
<td>50 µm</td>
<td>50 µm</td>
<td>80 µm</td>
</tr>
</tbody>
</table>

ALBA II aims to increase brilliance, resolution and coherence and reduce emittance by more than a factor 10. In addition, three new long beamlines will be constructed in the facility surroundings, connecting the critical slab and external areas. Therefore, for all of this, a global review on the ALBA long-term stability evolution has to be considered to plan the future ALBA II monitoring program.

Survey data analysis

Planimetric evolution

ALBA survey network is measured with a Leica AT-930 Laser Tracker and it is composed by more than 650 reference and support points distributed along the sensitive area. Reference-network survey campaigns are biannual. From the obtained and adjusted annual tunnel datums, planimetric deviations are calculated to analyse the evolution of the circular tunnel ground reference points. The annual datums absolute changes with respect to 2008 are graphically represented with a factor of magnification of 10.000. Next graph shows that the concrete slab has been diametrically extended with maximum deviations of 4 mm in some points since 2008.

Vertical evolution

Vertical drifts are periodically measured with a Trimble DINI 12 Digital Level. Data from Digital Level is adjusted by Baarda’s Test to debug outliers observations and readjust the data set. The graph shows a clear sinking tendency in most of the tunnel network over the years, with the deepest point in 2020 at -6.3 mm. However, there is a sharp and tight profile with a maximum point at 5 mm, gradually increasing.

RF cavities frequency and orbit length

RF frequency fluctuations allow us to track changes in the total length of the accelerator. ALBA RF frequency is 500 MHz, and its total length is 268.8. After 7 years (2012-19), the average RF frequency decreased by 16000Hz.

\[
\Delta f_{RF} = \frac{f_{RF}}{T} \Delta f [\mu m] = -0.54 \Delta f [Hz]
\]

According to previous equations, RF frequency decreasing corresponds to an increase of the electron beam path of +1.9mm. First graph show the frequency decrease tendency, where the pink line represents the polynomial baseline. Second graph represent the reference-network datums long-term perimeter increase, and the RF variation long-term perimeter increase. Two drifts can be reasonably correlated. The evolution is only considering the planimetric differences but vertical variations could have a significant contribution.

Conclusions

- Facing the future ALBA II a first general stability analysis is done to start planning the building settlement monitoring.
- Analysing the planimetric and vertical long term deformations along 14 years (2008-2022), the slab has a maximum deviation of 6.62 mm which represents a displacement of 0.06 mm / 10 m / year. Value that fits the expected maximum long-term deformations.
- An increasing of the machine perimeter is observed in the survey data and supported by the RF frequency decreasing value along last years.
- Storage ring general realignment has not been considered due to our Accelerators scientists criteria and the machine suitable operation.
- Hydrostatic levelling systems and geotechnical instrumentation can be also installed to validate the terrain behaviour hypotheses used during the new facility design.