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THE GIRDER SYSTEM PROTOTYPE FOR ALBA II STORAGE RING

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Abstract

The main goal of the upgrade of ALBA Synchrotron Light Facility into ALBA II is the transformation of the current accelerator into a diffraction limited storage ring, which implies the reduction of the emittance by at least a factor of twenty. The upgrade will be executed before the end of the decade and will be profiting at maximum all existing ALBA infrastructures, in particular the building. The whole magnet layout of the lattice has to be supported with a sequence of girders for their positioning with respect to another located in an adjacent girder with an accuracy of 50 µm to ensure the functionality of the accelerator. Besides the girders must enable the remote repositioning the magnets against the overall deformation of the site while ensuring the vibrational stability of the components on top. Easiness of assembling and installation of the different subsystems of the machine on top of the girder has to be considered also as a design requirement, in order to minimize the installation time. Two prototypes are planned to be built next year in order to check its full functionality.

FROM ALBA TO ALBA II

ALBA current storage ring is composed by 264 magnets, which are distributed in 16 cells in an array of 2 girders of 6 meters for each cell. ALBA II proposed layout is composed by 592 magnets, in the same arc length as current ALBA storage ring [1], meaning that the compactness ratio has increased by a factor of 2 in the new projected storage ring with respect to the old one. In Fig. 1 is represented an overall distribution of one sector for the current and new storage ring, where the reduction of free space can be appreciated.

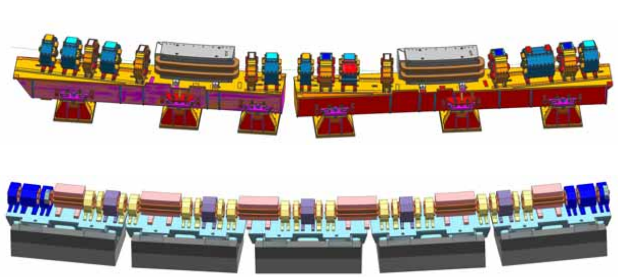

Figure 1: Current magnetic distribution of ALBA (top) and ALBA II cell layout (bottom).

As it can be seen on Table 1, the tolerances for positioning the girder will thus need to be tighter corresponding to a low emittance new machine, where the emmitance is reduced by a factor of 20 [2].

Table 1: Sizes Comparison

Dimension	ALBA	ALBA II
Compactness grade	49 %	80 %
Vacuum chamber size	28×56 mm	18 mm
Dynamic aperture	50 mm	6 mm
Beam Size	60 µm	5 µm

A NEW GIRDER DESIGN

In order to support the magnetic arrays, a new girder design is required. Taking into consideration the deformation of ALBA slab in the last 12 years, motorization for vertical positioning may be considered as a demand to be able to automatically compensate the small incremental vertical deformations and maintain electron beam stable in dynamic aperture.

The chosen strategy for conditioning the vacuum cell, will lead to a determinate vacuum section design, but according to the actual design status there are two possible layouts, which differ on the number and length of girders. That's why it is foreseen to prototype a girder design that will be fabricated in two different lengths, considering the ALBA II cell nowadays possible configurations. Apart from that, the girder design has to be modular enough in order to facilitate a full assembly outside the tunnel, together with the magnets and interfaces to minimize the installation time. In Table 2 the specifications for the girders prototype are summarized, in Fig. 2 the architecture and the main axes of movements are represented.

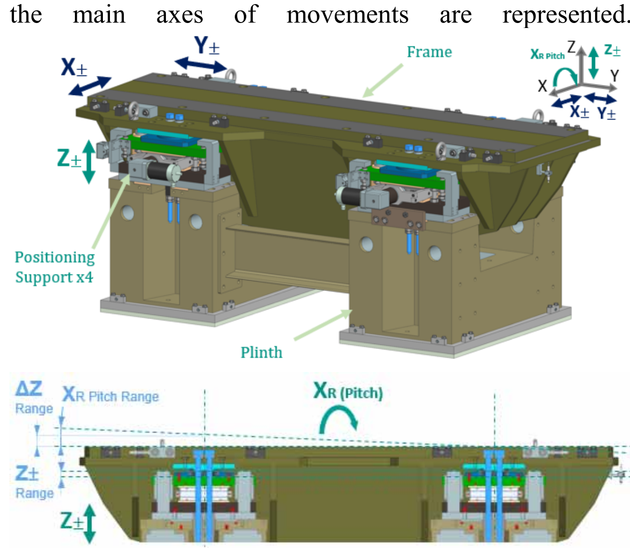

Figure 2: Motion axes and architecture.

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Table 2: Prototype Specifications

Specification	Value	Comments
Length	2.6 m /4 m	Extreme possible lengths.
eBeam height	1400 mm	Girder interface height about 1 m, defined by magnet design.
Eigenmodes	> 50 Hz	By design.
XY adjustment Resolution	20 µm	Manual.
Z range manual	+/- 5 mm	Manual.
Z range motorized	+/- 1 mm	Value determinate by the final assembly architecture.
Z resolution	5 µm	Motorized axis.
Assembly weight	< 12 Tn	Considering magnet assembly.
Magnet positioning tolerance	50 µm	Considering magnets of consecutive girders.

DIMENSIONING AND ARCHITECTURE

As it is shown in Fig. 2, the girder is divided in 3 main parts. The plinth, acting as a support, the positioning system, which consists on the mechanics for the vertical and pitch positioning, and the frame, which is the moving part that supports the full arrange of magnets.

The plinth is designed to be screwed to a grinded steel plate which is epoxy-glued to the floor. This plinth will support the Z positioning system, together with the electrical interfaces. For the prototype it is still being considered whether the plinth will be steel welded or fabricated from a block of granite. After evaluation of the cost and performance, manufacturing strategy will be decided for the series production. Figure 3 shows a front view of the girder with dimensions of the most relevant magnets of the array.

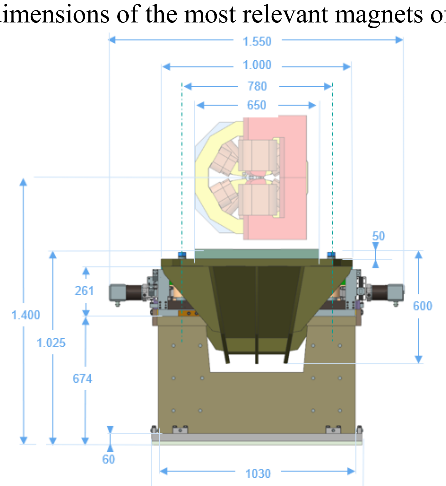

Figure 3: Front view and dimensioning.

THE MOTION SYSTEM

The motion system consists mainly on four actuators composed by motorized commercial wedge mounts, similar to the girder for the ESRF-EBS upgrade [3]. Wedge mounts are considered as the stiffest and coherent positioning system for such application, were tones of weight have to be positioned

The commercial wedge mount performs a precise vertical positioning but unguided, generating uncertainty in the horizontal position when it is actuated. That is why the system proposed is foreseen to be guided with a die press like system, where the top plate of the wedge is guided with respect to the bottom one with two linear bushings. Each actuator, composed by the motorized wedge and the guiding system, will include an absolute encoder and limit switches to control and limit its range.

Apart from that, in order to increase the rigidity of the system, a set of preloaded elastic elements are implemented. It is assumed a maximum reaction force of 40 kN in each actuator. This reaction force includes the weight of the magnetic array, the weight of the frame and the preload force that has been considered. This reaction force has been considered to calculate the input torque needed on the screw of the wedge mount to move the system. With that, the stepper motor and the reducer are sized.

In the next Fig. 4 the mentioned elements are shown as well as some selected references for the first prototype. A spherical contact as interface between the wedge mount and the top plate of the die press (in green) is foreseen.

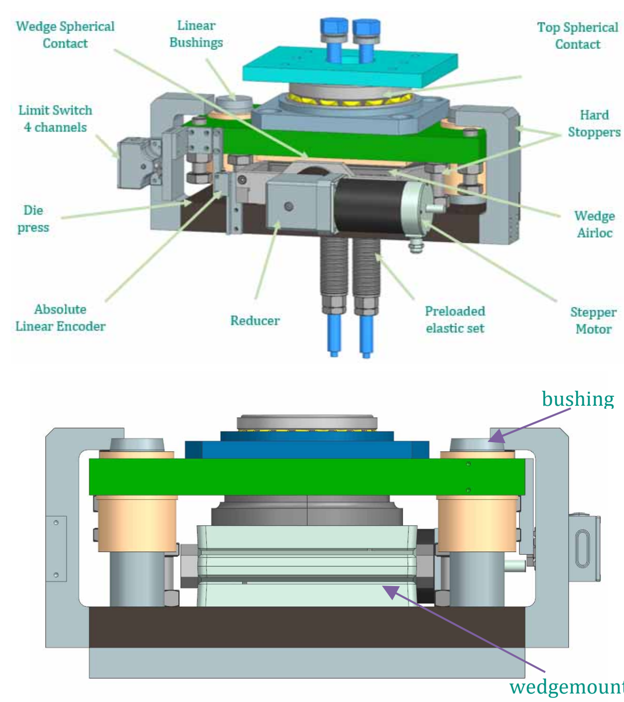

Figure 4: Positioning system detail. Top details of all the parts, bottom the wedge mount guided by the linear bushings is appreciated.

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The girder frame is linked to the positioning system by means of spherical contacts (in Fig. 4 are represented as actuator top spherical contact). These will be axial roller conical bearings or precision spherical washers that will be interchangeable in order to test their performance. Three types of spherical contacts are foreseen to be evaluated in the prototype.

The wedge mount is able to be manually actuated by uncoupling the motor or acting on the second motor axis located in the back of the motor. This manual adjustment is needed to position and align the girder in a nominal position in height and pitch when being installed for first time in the machine.

THE FRAME

The frame will be manufactured by continuous welded steel and it has been optimized in shape and weight by FEA analysis in order to minimize deformations and maximize vibrational stability. The most optimal geometry found, based on welded plates is to distribute them in a triangular shape as it is shown in Fig. 5.

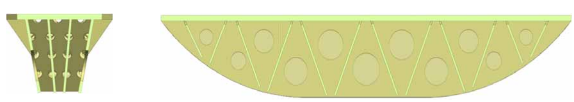

Figure 5: Shape of the optimized frame.

First eigenmodes and static deformation have been calculated by FEA, with the following boundary conditions: a fixation on the 4-frame supports and the inclusion of a model of the magnets as masses. When the frame shape was optimized, the full girder model with all the parts included in the model were simulated. The results of the FEA analysis are shown in Fig. 6.

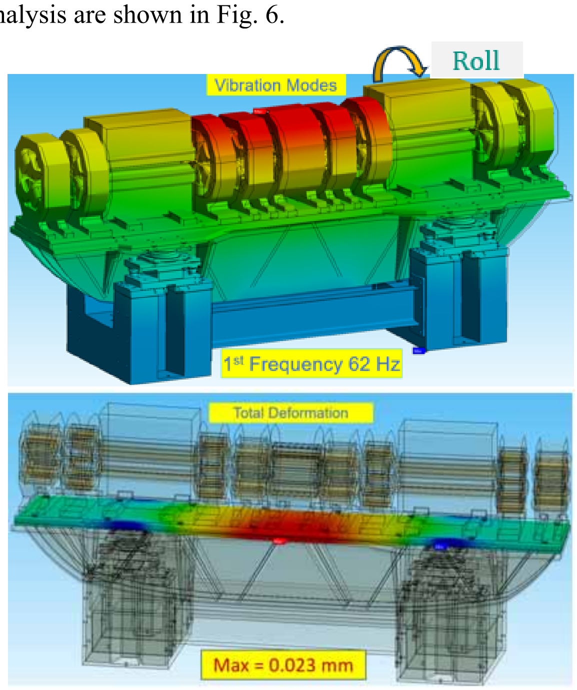

Figure 6: FEA results.

The horizontal alignment is foreseen to be implemented by a plate that will be adjusted in XY position on top of the frame by means of a push pull system with fine thread screws. Apart from that, it is foreseen a control of the relative position between girders by means of LVDT absolute encoders and limit switches. This is considered to be a need, as the stay clear area between the vacuum chamber and the yoke is very tight, and an interference can lead to stresses into in the vacuum pipe. The allowed range for this relative movement will have to be determined during the mock up phase, as it mainly depends on the design of the vacuum pipe.

TESTING OF THE PROTOTYPE

The objectives of developing this prototype are to evaluate the performance of the positioning system and the stability of an entire girder module, measuring ground vibration and vibrations induced by external excitation.

The prototype is designed in a modular way to be able to interchange spherical contacts, and leave sliding surfaces or impose mechanical restrictions between the plinths and the motion system, in order to evaluate the best performance of it. Assembly feasibility and easiness of transportation will also be evaluated as well for this prototype to learn from it and to optimize the assembly period of the full arrays of the new ALBA II machine.

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