Study, Design and Optimization Analysis of the ALBA LOREA Dipole Vacuum Chamber and Crotch Absorbers Based on Finite Element Analysis

Marcos Quispe, Josep Campmany, Joan Casas, Carles Colldelram, Alejandro Crisol, Jordi Marcos, Gabriel Peña,

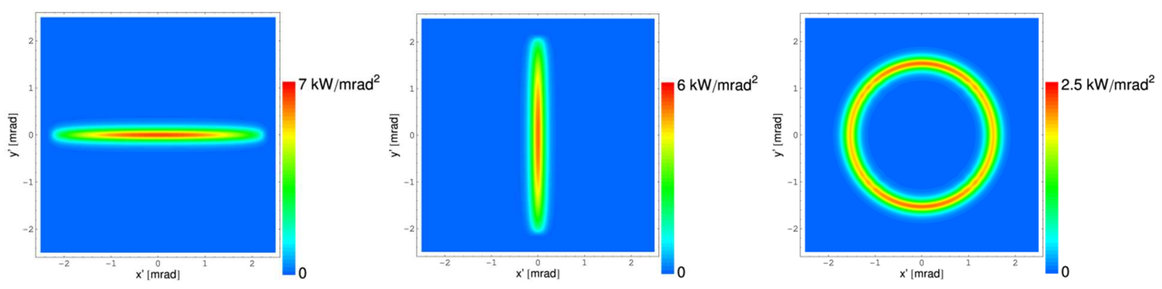
Massimo Tallarida

ALBA-CELLS Synchrotron, 08290 Cerdanyola del Vallès, Spain

Abstract

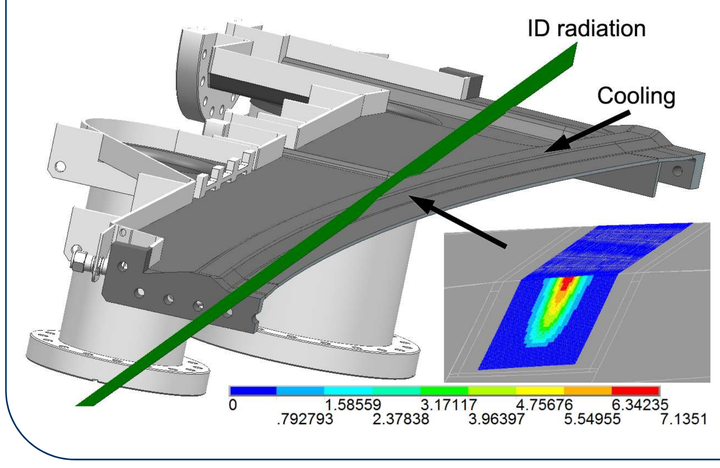
This work deals with the FEA study, design and optimization of the LOREA dipole vacuum chamber and Glidcop Al-15 crotch absorbers. At present LOREA is the ninth beamline being designed at ALBA with an Insertion Device (ID) consisting of an Apple II-type helical undulator. For the standard dipole chamber the vertical polarized light hits the walls because of the very narrow vertical aperture between the cooling channels. In vertical mode the ID vertical divergence equals +/- 2.2 mrad and the peak power density and total power are 5.6 kW/mrad² and 5.5 kW, respectively. Due to the high power a temperature as high as more than 600 ºC is calculated. In consequence the dipole chamber has to be modified and the absorbers have to withstand the Bending Magnet (BM) and ID radiation. The new absorbers have to be thicker and its cooling channels are farer from BM power deposition than the standard absorbers. The thermal mechanical simulations show good results, the new absorbers are in a safe range, the maximum temperature, stress and strain are 309.2 ºC, 164.2 MPa and 0.14%, respectively. The main ALBA Storage Ring design parameters used in the simulations are: 3 GeV, 400 mA and 1.42 T (BM).

LOREA Insertion Device: EU125



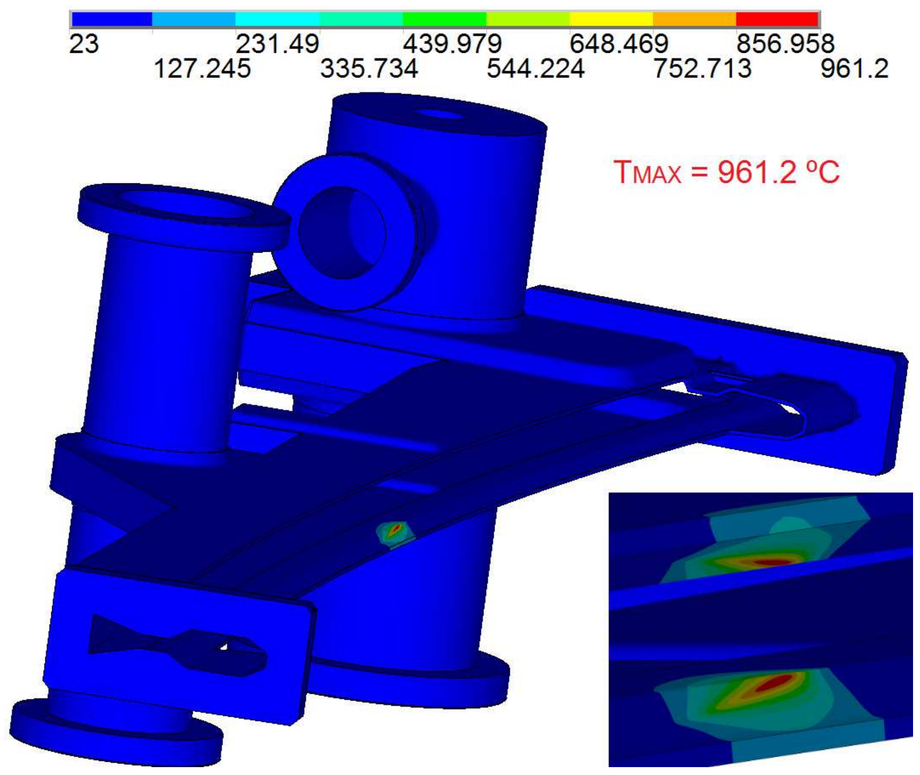
Horizontal Mode | Vertical Mode | Circular Mode

Vertical Mode Interference



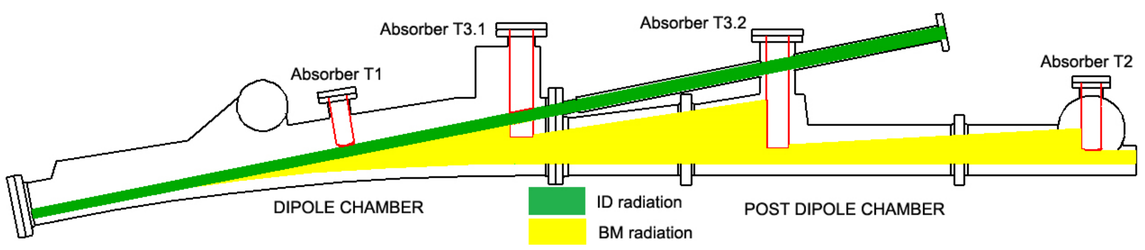
Schematic cross-sectional view of standard dipole vacuum chamber, displaying the lower longitudinal cooling channel and ID radiation interference for vertical mode polarization. The footprint is in W/mm².

FEA Studies for Standard Dipole Chamber

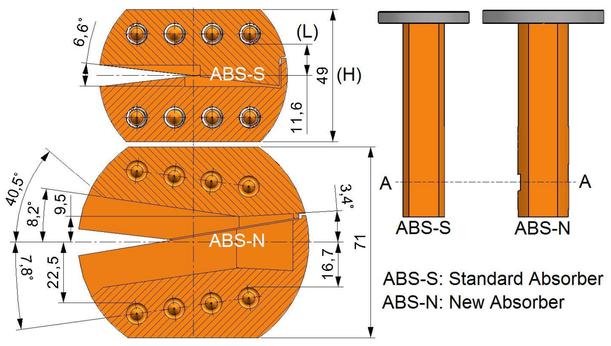


Temperature reached on the dipole chamber (upper and lower cooling channels) due to interference of ID radiation in vertical mode. The maximum temperature is 961.2 ºC. The current working point of water has been imposed as boundary condition: h = 1500 W/m²K at 23ºC.

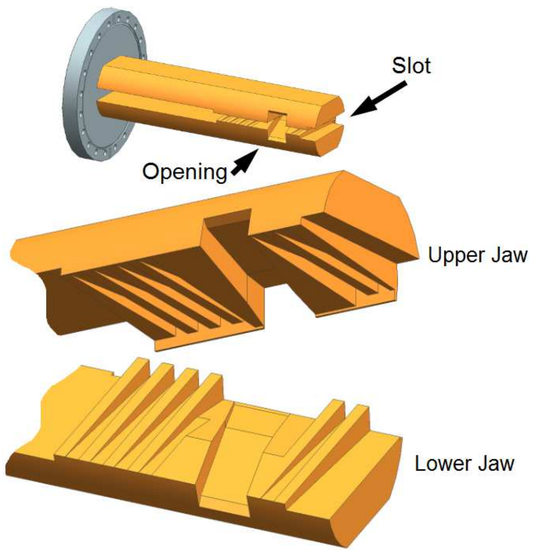
Ray Tracing



New Glidcop Crotch Absorber

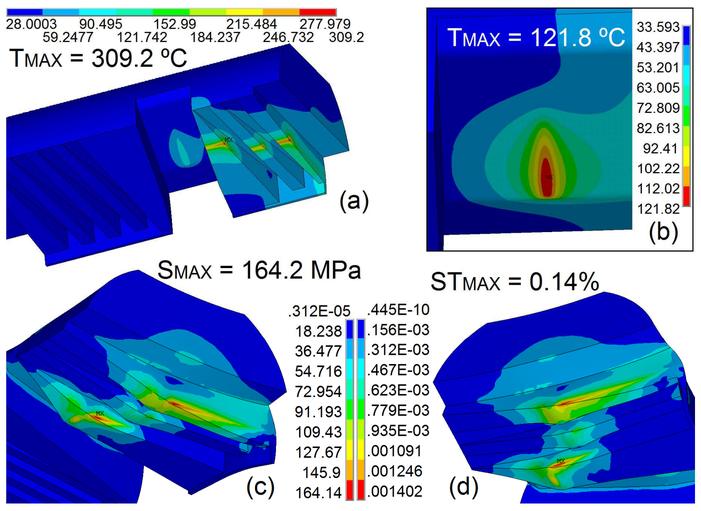


Comparative study between the dimensions of standard (ABS-S) and new crotch absorber (ABS-N). View for the cross section A–A. Dimensions are in mm.



The assembly and two jaws of new Glidcop Al–15 crotch absorber for LOREA dipole chamber.

Glidcop Crotch Absorber FEA Results



The temperature, stress and strain distribution have been calculated based on linear elastic analysis. The thermal mechanical simulations show good results, the new absorber is in a safe range according to the design criteria. The maximum temperature, stress and strain are 309.2 ºC, 164.2 MPa and 0.14%, respectively.

Conclusions

The study confirms the necessity to do a modification of the dipole vacuum chamber. From the ray tracing it resulted that the post-dipole vacuum chamber should not be modified, but the two Glidcop Al-15 crotch absorbers (T3.1 and T3.2) should be designed anew. The new absorber T3.2 has to be modified following the same design criteria for absorber T3.1. The FEA results of the new crotch absorber show a good performance according with the limits of the design criteria.