ISBN: 978-3-95450-207-3 doi:10.18429/JACoW-MEDSI2018-WEPH24

DESIGN OF AN INTEGRATED CROTCH ABSORBER FOR ALBA SYNCHROTRON LIGHT SOURCE

M. Quispe†, J. Campmany, A. Gevorgyan, J. Marcos
ALBA – CELLS Synchrotron, 08920 Cerdanyola del Vallès, Spain

Abstract

This paper presents the design of an Integrated Crotch Absorber for the new beamline LOREA (Low-Energy Ultra-High-Resolution Angular Photoemission for Complex Materials at ALBA). The LOREA Insertion Device (ID) consists of an Apple II undulator with a period of 125 mm.

For the current ALBA dipole chamber the ID vertical polarized light hits the upper and lower walls because of the very narrow vertical aperture between the cooling channels. To solve this problem some modifications must be implemented both in the dipole chamber and in the crotch absorber located inside of the dipole.

The new crotch absorber, named Integrated Crotch Absorber, must absorb a significant part of the ID vertical polarized light in order to avoid radiation impinging at the post dipole chamber.

The geometry of the Integrated Crotch Absorber is a combination of the conventional crotch and the distributed absorber done at PSI for ANKA. The design has been optimized taking into account the standard thermo-mechanical design criteria as well as the reflective effects of the ID radiation from the opening towards the walls of the dipole chamber.

INTRODUCTION

The ALBA synchrotron light source is currently installing the new beamline LOREA, for Low-Energy Ultra-High-Resolution Angular Photoemission for Complex Materials. It will operate in the range of 10 – 1500 eV and will use polarized light. To produce the light an Insertion Device Apple II undulator with a period of 125 mm has been chosen. The device can operate as an undulator at low energies and as a wiggler at high energies, reaching a wide energy range.

For the vertical polarization mode, the photon beam emitted by the ID at low photon energies has a large aperture angle of ±2.2 mrad, which is the worst case. Because of the very narrow vertical aperture between the cooling channels of the conventional ALBA dipole chamber, the ID vertical polarized light hits the chamber. To solve this problem two main modifications have to be introduced:

- Modification of the dipole chamber. The longitudinal cooling channels have to be removed to increase the vertical aperture.
- Modification of the Glidcop Crotch Absorber. Part of the ID radiation must be absorbed by the opening of the new crotch absorber in order to protect the post dipole chamber from any collision.

† mquispe@cells.es

This paper is dedicated to the design of a new Glidcop Crotch Absorber. For ALBA this new absorber is non-conventional because the device must face the Bending Magnet (BM) and ID radiation at the same time. We name this new absorber as Integrated Crotch Absorber because its geometry is a combination of the conventional crotch absorber and the distributed absorber made at PSI for ANKA [1].

Design aspects of the geometry, the effects of the ID beam reflection from the absorber to the walls of the vacuum chamber and FEA simulations of the Integrated Crotch Absorber are included in this paper.

BASIC DESIGN

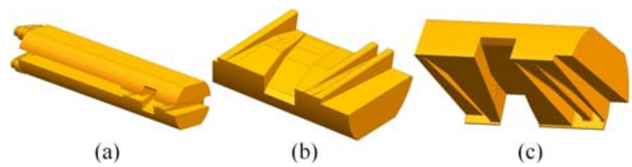

Figure 1: (a) Assembly of the Integrated Crotch Absorber, (b) The lower jaw and (c) The upper jaw.

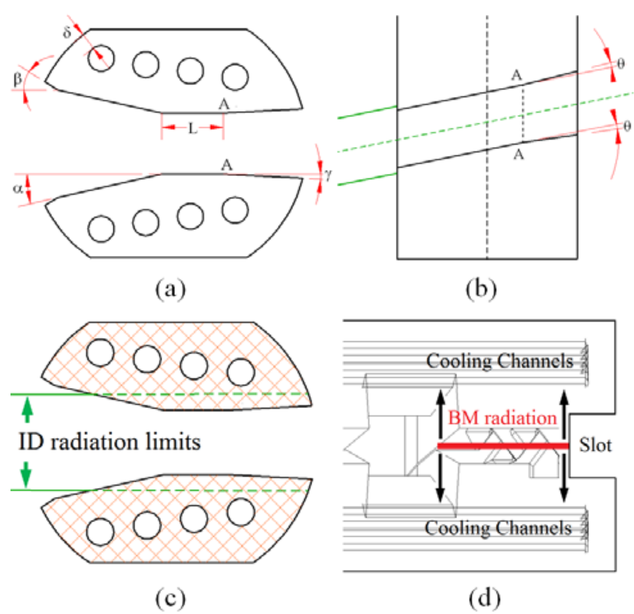

Figure 2: (a) Cross section view in the middle of the opening, (b) Details of the opening from the top view, (c) Details of the beam limits with respect to the cooling channels and (d) Position of the cooling channels with respect to the BM radiation on the teeth.

.

ISBN: 978-3-95450-207-3 doi:10.18429/JACoW-MEDSI2018-WEPH24

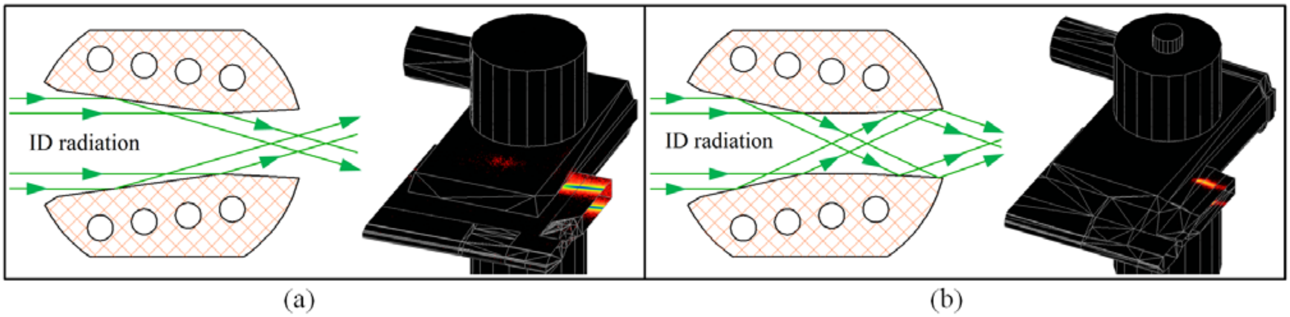

Figure 3: Collision and reflection of the ID radiation vertical mode in a cross section view of the opening. (a) The radiation hits the absorber and is reflected directly to the walls of the dipole vacuum chamber. (b) After the collision on the absorber the reflected ID radiation hits the internal walls of the Integrated Crotch Absorber.

Figure 1 shows the updated version of the Integrated Crotch Absorber presented in a previous work [2]. It consists of two jaws. A special opening has been designed in order to absorb the ID radiation in vertical mode. At the end of the absorber a slot also has been included as part of the thermal mechanical optimization.

The geometrical model is based on the following design criteria as is showed on Fig. 2:

- The inclination of the surface where the ID radiation is deposited, defined by the angle α (Fig. 2a), has been chosen under the following conditions: (i) get the lower power density distribution and (ii) capture the ID radiation reflected inside of the same absorber.
- At the entrance of the opening an additional safe angle is included, the angle β (Fig 2a), with the aim to avoid any perpendicular collision of the beam on the absorber in case of beam misalignments.
- A horizontal surface has been included in the halfway of the opening, defined by the length L (Fig 2a), in order to capture the reflection of the radiation inside of the absorber.
- With the aim to guarantee that all the ID radiation is always deposited below of the cooling channels, the angles θ and γ have been included in this design. In this way the end point for the first collision of the radiation will be always the point "A" (Fig 2a and 2b).
- A minimal thickness of $\delta = 5$ mm has been defined in between the water cooling channels and the vacuum zone (Fig 2a).
- In order to avoid any possibility of corrosion induced by radiation, the position of the cooling channels are separated from the fan of the ID radiation (Fig 2c).
- At the end of the absorber a slot has been included. In this way the region with BM radiation is always below of the position of the cooling channels (Fig 2d).

Photon Reflection as Design Parameter

The effect of the reflection of the ID radiation from the opening of the absorber to the dipole vacuum chamber has been investigated. This analysis has been done by using the Monte Carlo software SynRad+ [3].

The radiation of the Apple II undulator has been approximated as a Wiggler by applying the function sin/cos for the magnetic field with the appropriated parameters in order to approximate the Gaussian profile of the ID radiation.

Figure 3 shows two types of reflections as a function of the internal geometry of the opening. For the first case, Fig 3a, after the collision the photons are reflected directly to the wall of the chamber as is showed in the illuminated part. It is calculated a maximum power of 3.4 W and a peak of power density of 7 W/cm^2. In the second case, Fig. 3b, the previous geometry has been optimized and now the reflection after the collision hits directly the same opening of the absorber and the following reflections hit the walls of the dipole chamber. For this new case the maximum power and peak power density has been reduced to 0.6 W and 0.8 W/cm^2.

Figure 4 shows the SynRad+ simulations made for the Integrated Crotch Absorber based on the geometry of Fig. 3 (b). The green lines represent the photon beam coming from the ID and BM sources. The SynRad+ model allows to see the effect of the internal reflection on the opening of the absorber (Fig.4 a).

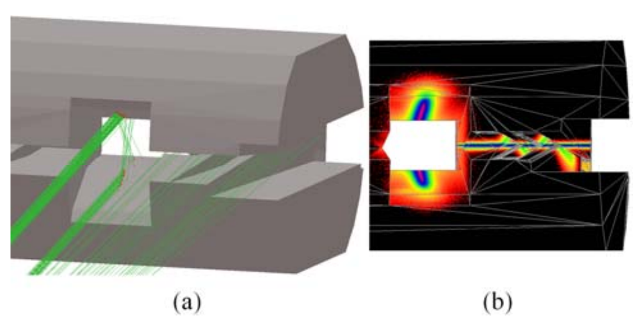

Figure 4: Absorber simulated by using SynRad+. (a) Details of the photon beam trajectory. (b) The footprint of the ID and BM radiation.

SIMULATIONS

Boundary Conditions

The main parameters which characterize the LOREA ID (vertical mode) and BM power on the absorber are shown in Tables 1 and 2.

For the ID power deposition the vertical misalignments, angular (+/- 0.11 mrad) and displacement (+/- 0.16 mm), have been imposed. For these conditions the ID power on

ISBN: 978-3-95450-207-3 doi:10.18429/JACoW-MEDSI2018-WEPH24

the upper and lower jaws are 610.7 and 296.2 W, respectively, and the ID peak power density is 19.8 W/mm^2.

The total power (ID and BM) on the upper jaw is 2729 W and the maximum power density is because of BM radiation: 43 W/mm^2.

The crotch absorber is cooled by water at 23 ºC inlet temperature. The velocity in the cooling channels is kept at 3 m/s and the calculated convective heat transfer coefficient is 15000 W/m^{2}K.

For all the FEA studies only the upper jaw is simulated. This jaw is subjected to the maximum power load conditions, in comparison with the lower jaw.

The material for the absorber is Glidcop Al-15.

Table 1: Main parameters of Insertion Device for LOREA (vertical mode). The emitted power and power density are computed for an electron beam current of 400 mA.

Parameter	Magnitude
Maximum magnetic field	1.06 T
K	12.37
Power density	5.6 kW/mrad^2
Total power	5.5 kW

Table 2: Main parameters for ALBA Storage Ring

Parameter	Magnitude
Beam energy, E	3 GeV
Design current, I	400 mA
Dipole magnetic field, B	1.42 T

Results

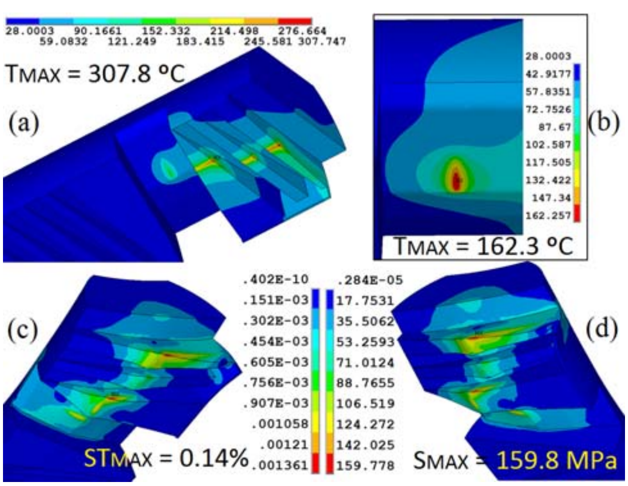

Figure 5: FEA results for the Glidcop Al–15 Integrated Crotch Absorber in the dipole chamber: (a) Temperature map, (b) Local detail of the temperature distribution at the ID power deposition, (c) Strain map, and (d) Stress map.

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 [4]. The maximum temperature, stress and strain are 307.8 ºC, 159.8 MPa and 0.14%, respectively (Fig. 5). The maximum temperature because of the ID radiation equals 162.3 ºC, at the upper wall of the opening.

Figure 6 shows the Integrated Crotch Absorber for ALBA manufactured by CINEL company [5] according with the ALBA specifications.

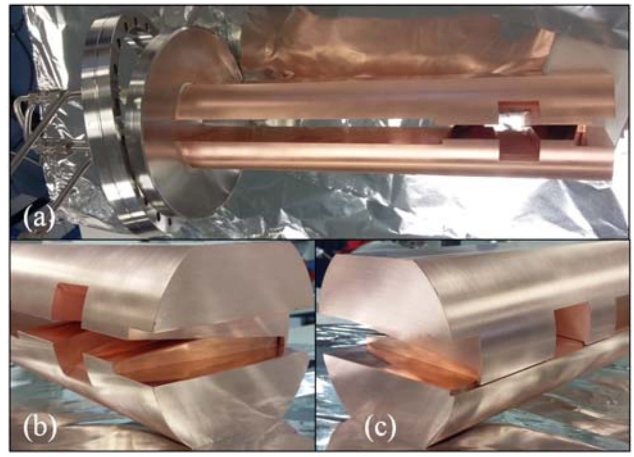

Figure 6: Integrated Crotch Absorber for LOREA. (a) The complete absorber. (b) Opening inlet reference. (c) Opening back reference.

CONCLUSIONS

Details of a non-conventional absorber at ALBA are presented. This new Glidcop Al-15 absorber is named Integrated Crotch Absorber because we combine two types of geometries: the conventional crotch absorber and the distributed type. Its optimization is based on geometrical aspects in order to have an optimal thermal mechanical behavior and also with the aim to capture the ID radiation reflected inside of the same absorber. The final design meets the thermal mechanical design criteria for the absorbers and reduces the effects of the ID photon reflection on the dipole vacuum chamber.

REFERENCES

[1] S. Hermle *et al.*, "Layout of the absorbers for the synchrotron light source ANKA", in *Proc. PAC99*, vol. 2, New York City, New York, USA, March-April 1999, pp.1360-1362.

[2] M. Quispe *et al.*, "Study, Design and Optimization Analysis of the ALBA LOREA Dipole Vacuum Chamber and Crotch Absorbers Based on Finite Element Analysis", in *Proc. MEDSI2016*, Barcelona, Spain, Sep. 2016, paper TUPE14, pp. 191–103, DOI: 10.18429/JACoW-MEDSI2016-TUPE14

[3] SynRad, https://molflow.web.cern.ch.

[4] E. Al-Dmour *et al.*, "The conceptual design and thermal analysis of ALBA crotch absorbers", in *Proc. PAC07*, Albuquerque, NM, USA, June 2007, paper MOPAN065, pp. 299–301, DOI: 10.1109/PAC.2007.4440191.

[5] CINEL, https://www.cinel.com.