Mechanical Engineering and Diagnostics groups of Soleil

RETRACTABLE ABSORBER (MASK) AND WHITE BEAM IMAGER DIAGNOSTIC FOR CANTED STRAIGHT SECTION

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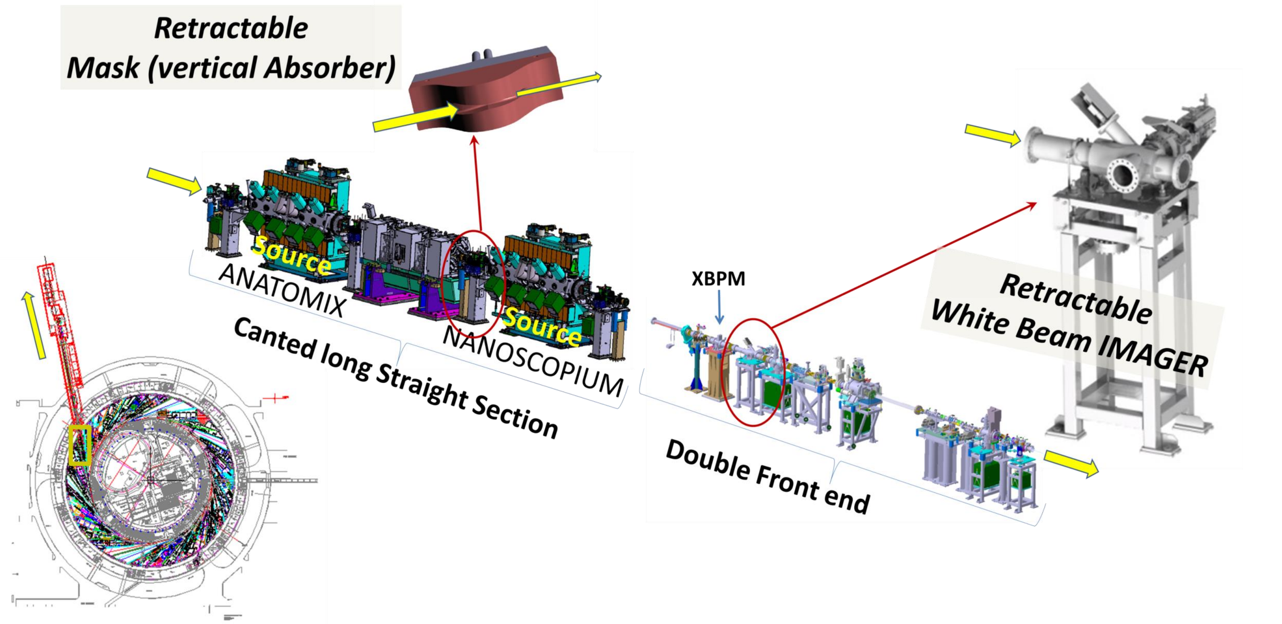
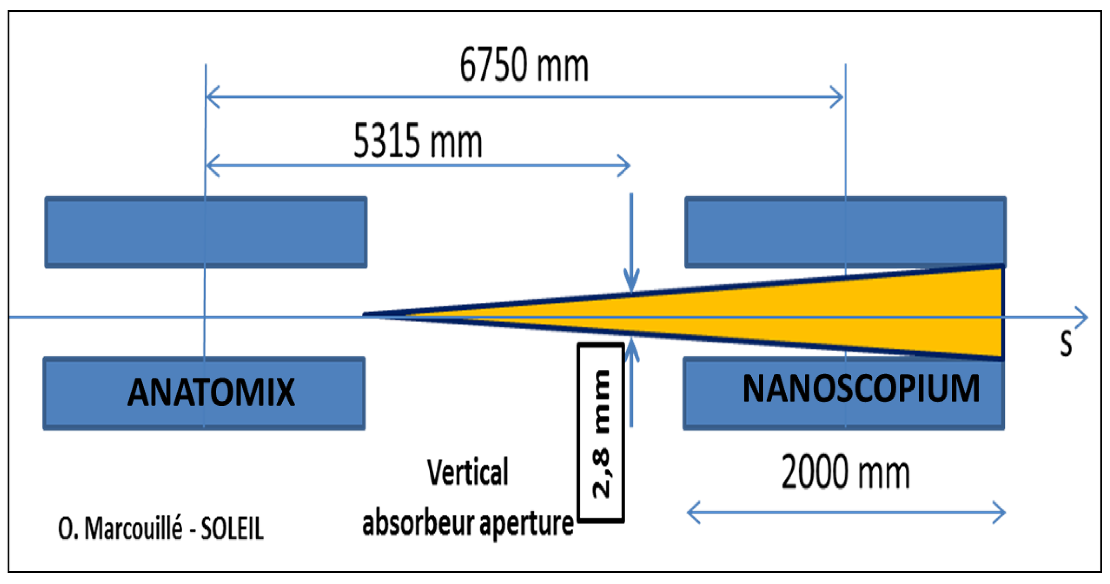
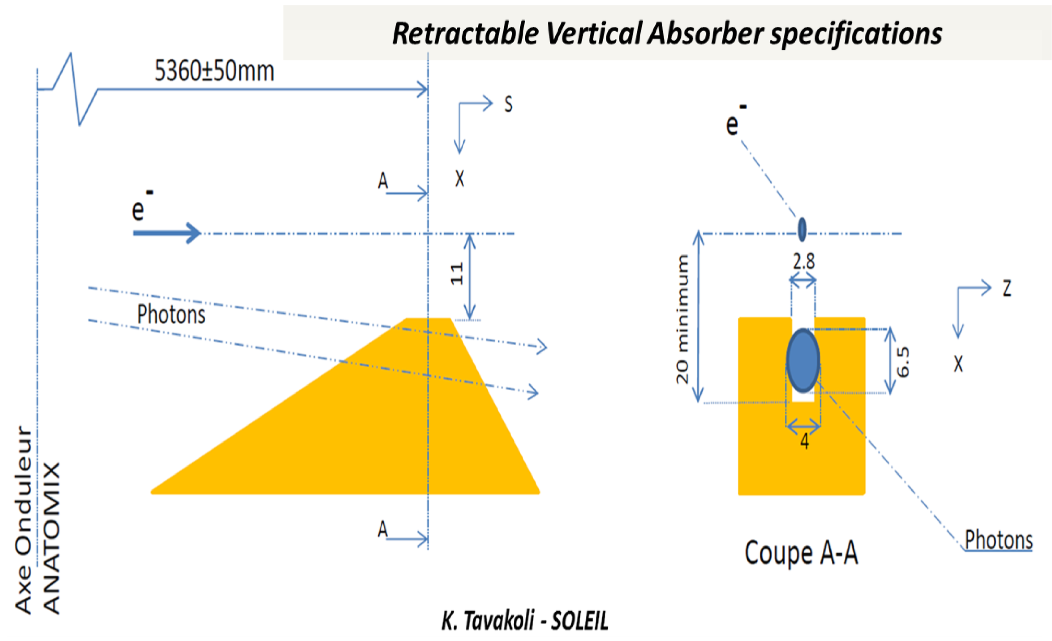
Introduction / Background :

At the SOLEIL synchrotron, as in other accelerators, two canted sources can coexist on the same straight section for space and economic reasons and have to be capable to operate simultaneously. In one of the long straight sections of SOLEIL, SDL13, two insertion devices, canted in the horizontal plane, have been installed for X-rays delivery to the ANATOMIX (upstream) and NANOSCOPIUM (downstream) independent long beamlines. The canting angle remains small, so that the upstream ID radiation passes through the downstream ID. That implies to take into account the degradation risk management of equipment, due to radiation. As the beam power deposition from the upstream undulator can seriously degrade the downstream one, or even other equipment. To handle these risks, Soleil first designed and installed in 2016 a retractable vertical absorber between both insertions to shadow the downstream ID magnets from the upstream one. But the efficiency of this mask relies on an accurate relative alignment of the upstream ID, the mask itself and the downstream ID. Those diagnostics to do the survey are mandatory. An XBPM in the beamlines front-end is in operation since 2016. But to ensure a redundancy in the measurements, it was decided in 2017 to add nearby a white imager. For the vertical absorber as for the white beam imager Soleil had to meet some interesting technological and manufacturing aspects that we propose to present here.





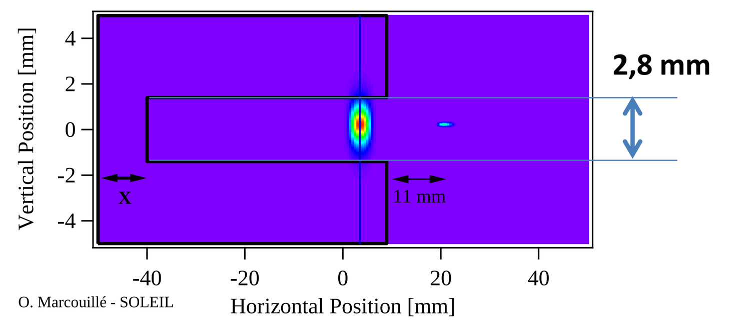
(Canted long Straight Section)

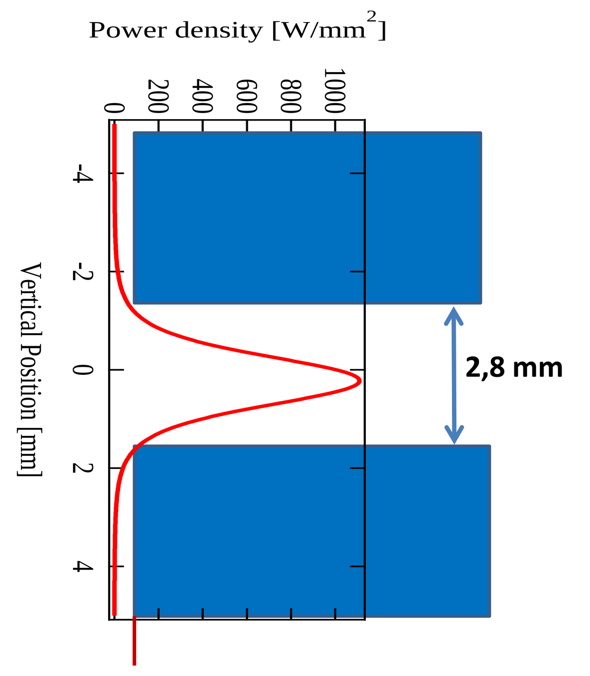


The Absorber:

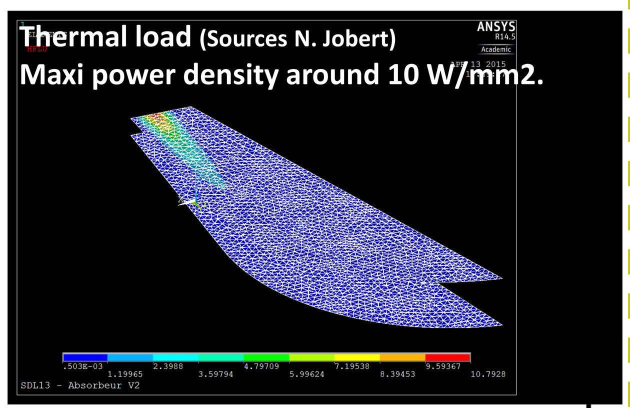
Installed at SOLEIL Synchrotron in the beginning of 2016, the absorber (a cooled mask) first aim was to shadow the downstream ID magnets from the upstream ID radiation. Installed in between the two IDs, this gave a vertical aperture of 2.8 mm. Detailed studies were then carried out to define its geometry in order not to jeopardize the performance of the storage ring in terms of collective effect induced instabilities, beam losses, injection efficiency and beam time. The absorber is piece of OFHC (Cuc2) copper with an asymmetric 90 degree U-shape. It encloses the photon beam produced upstream while the electron beam is located at -11 mm from the U-border of the absorber. The absorber is maintained inserted in between the IDs using a spring based system. For security reason, the stage is by default inserted. It can be retracted when needed, thanks to a remote controlled jack.

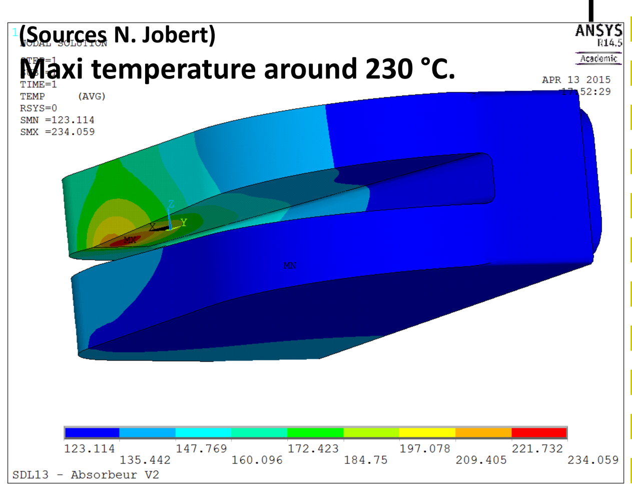
The design of the absorber makes it possible to completely protect the insertion downstream of section SDL13. Its cooling is sized to evacuate an upstream power of ***460 W****, including deposition.*

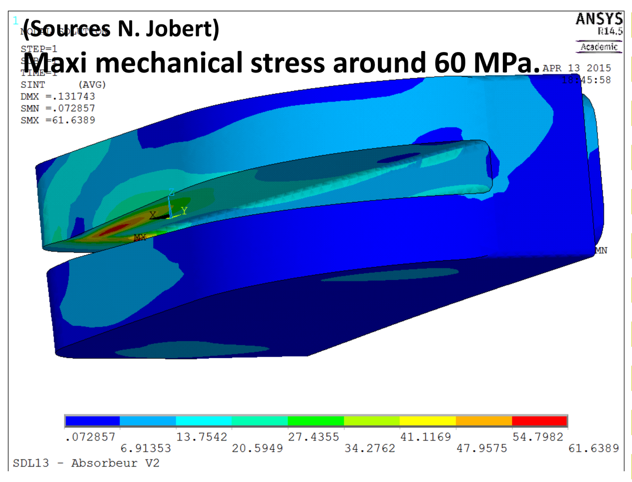


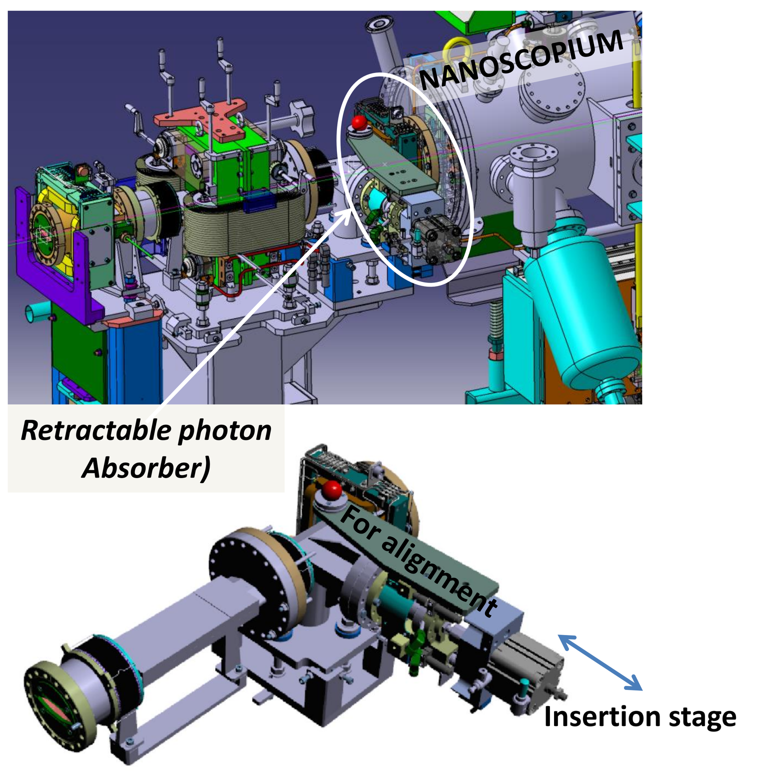


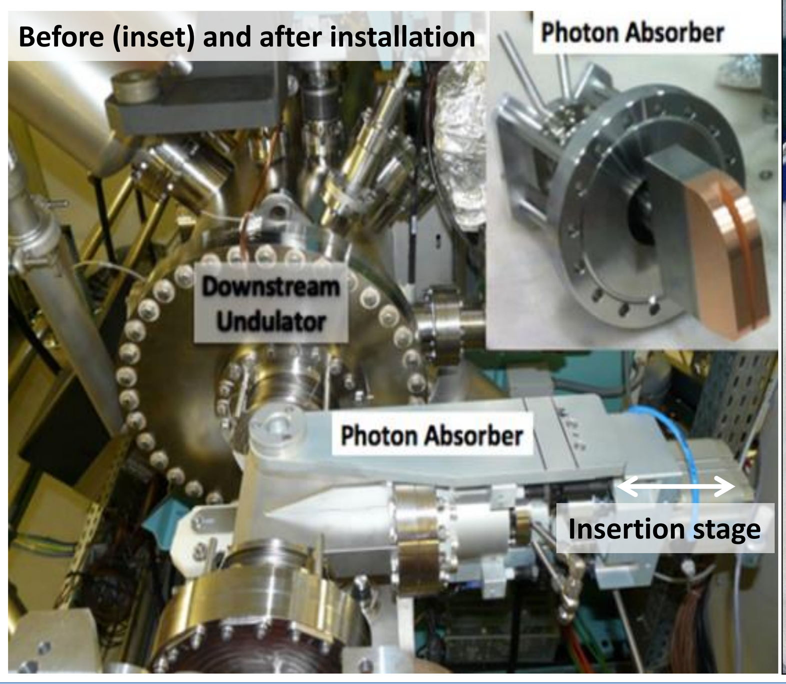
Maximum power density (in the perpendicular plane to the photon beam) seen by absorber less than 100 W/mm2
➔ Absorber designed with low incidence angles in relation to intercepted beam, reduces **power density around 10 W/mm2.**

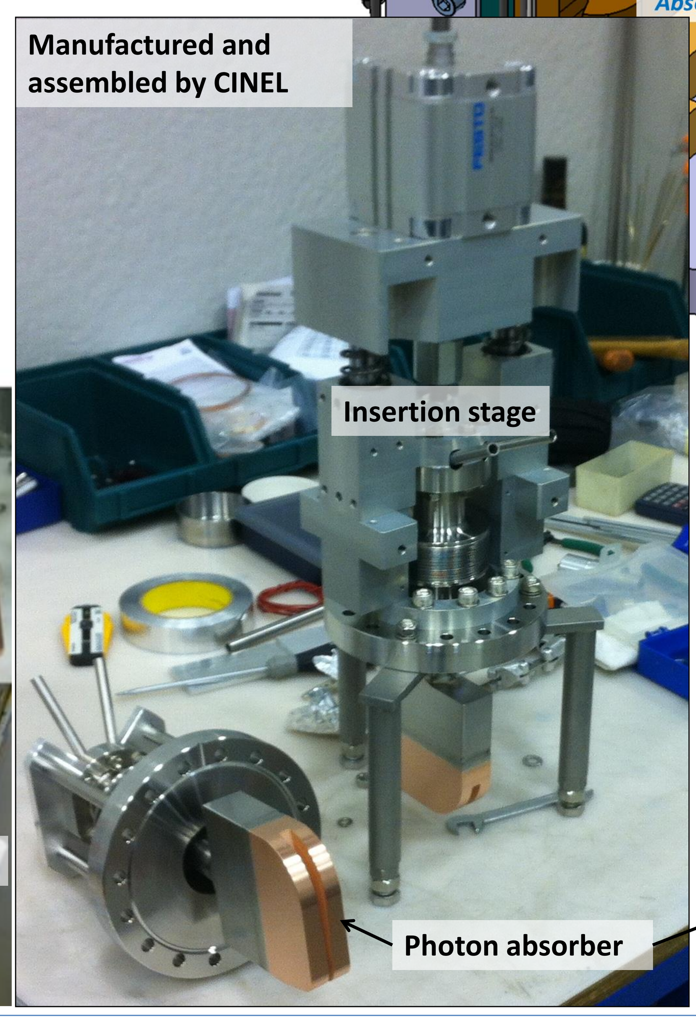


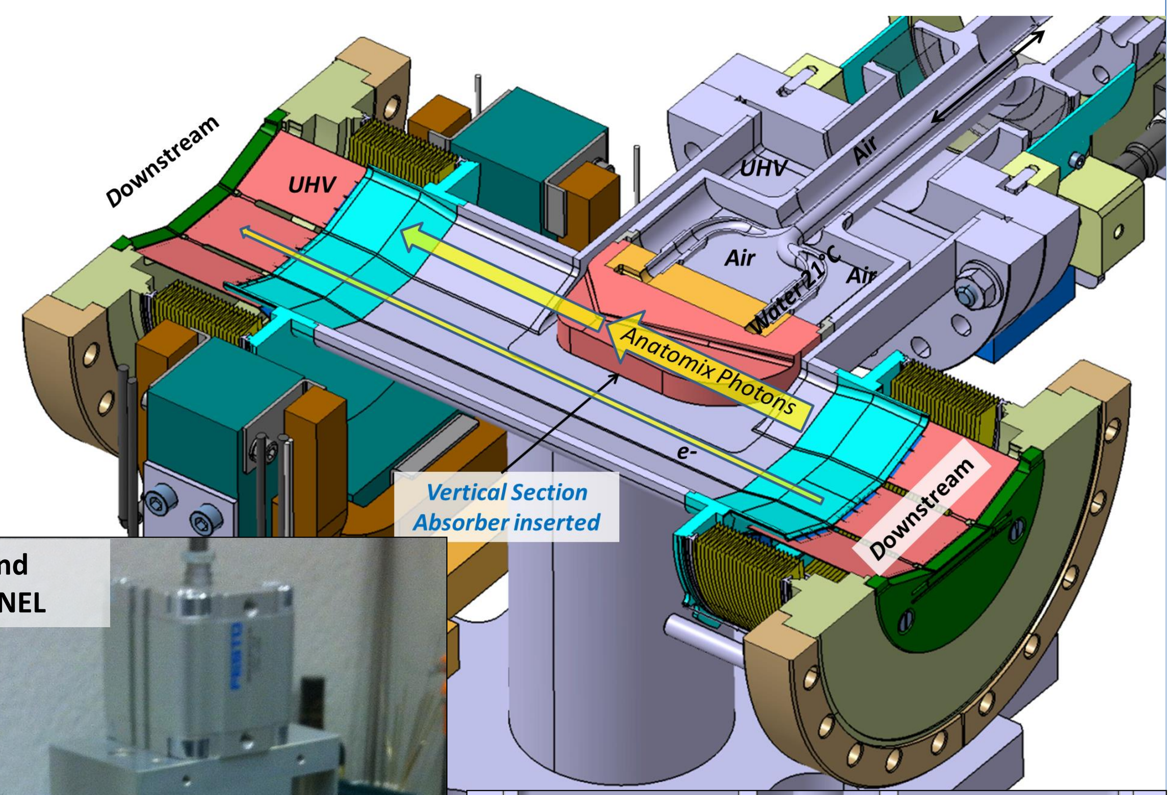


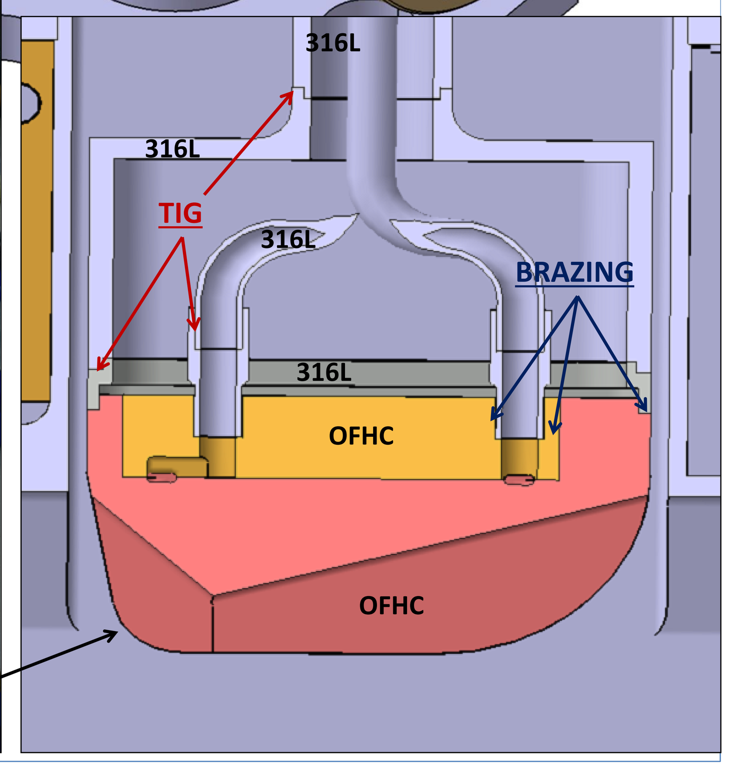












The white imager:

The white imager first aim is to check the relative alignment of the upstream ID, the absorber and the downstream ID. Its principle is the following: a diamond disk is inserted on the upstream ID photon beam path after passing through the downstream ID. The photon beam hits diamond imperfections (Cuc2) causing scintillation of the diamond in the visible range. This scintillating pattern is then imaged on a CCD. It is then checked on this image that the upstream radiation is correctly "clipped" by the absorber, meaning that the downstream ID magnets are protected.

The diamond

Given the upstream ID radiation pattern dimensions together with the absorber shadow geometry in the imager plane, the diamond disk had to reach a minimum diameter of 26 mm: a clear aperture of 28 mm was chosen. To ensure sufficient light collection but also to limit the expected temperature elevation to +40°C, the diamond thickness was chosen to be 0.3 mm. Because the incident power on the diamond is of the order of 10 W/mA, it can only be inserted at low (<10 mA) currents. To enable the water cooling of the diamond, it was brazed on a copper ring. A 30 µm silver coating was deposited on the diamond surface to increase its thermal conductivity. The whole system (diamond + ring) was realized by Diamond Materials.

The diamond holder and cooling system

The diamond is mounted on a holder which ensures both the diamond supporting and cooling. The diamond copper ring is hold by a refined pressuring system using Belleville rings to ensure a homogeneous stress on the ring. To evacuate the heat load on the diamond, water flows through the holder in and out around the copper ring with a limited speed to prevent vibrations.

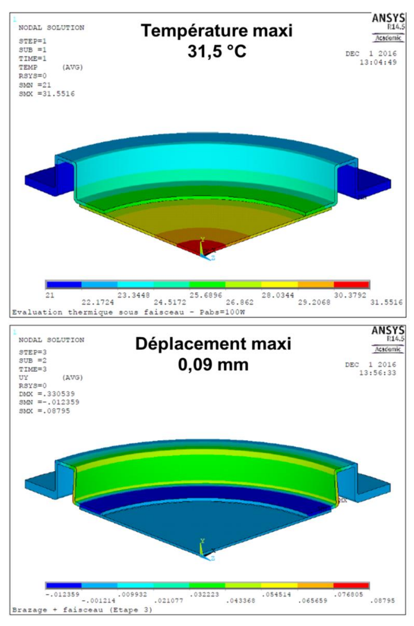
The diamond insertion stage

The insertion of the diamond in its holder on the photon beam path is enabled by a pneumatic jack. For machine and diamond security reasons, the diamond has to be by default extracted: this was ensured using two strong springs that have to be compressed by the jack for diamond insertion.

The imaging system

In order to image the scintillation pattern on the diamond disk, an imaging system is mounted behind an UHV window on the top of the diamond vacuum chamber. This imaging system simply consists in an objective with extender and of a CMOS camera. The photon pattern is demagnified by about a factor 0.55 which allows a spatial resolution better than 10 µm.

Mechanical behaviour of CVD when brazing and with electrons beam current 10 mA ➔ Thermal load of 100 W
Sources N. Jobert note AI-CI-NT-I-0214-SDL13 - IMAGEUR

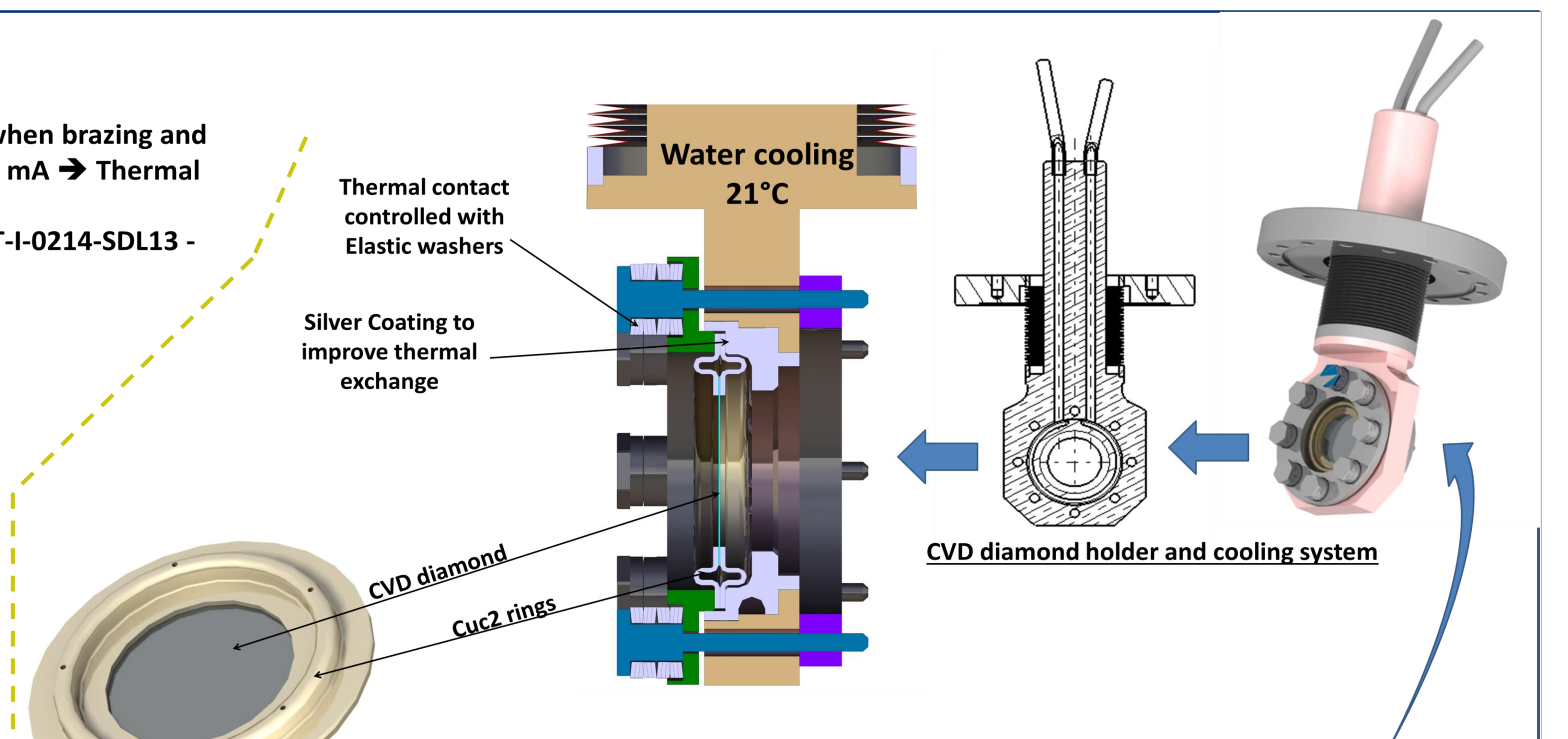


Contraintes

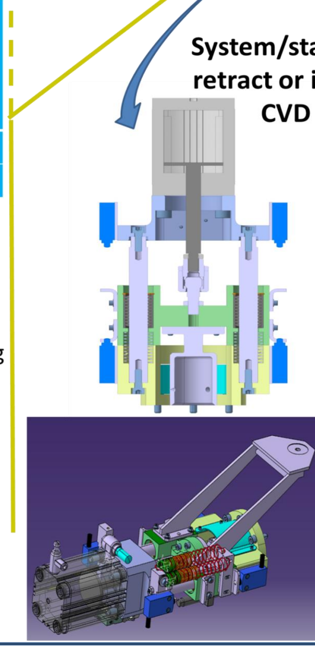
Shear stress at the CVD / Cuc2 interface	Stress in CVD	Cuc2 (braszing)	Cuc2 (brazing + beam load) (%)
173 MPa	50 MPa	10 %	10%
		Elongation limit at break > 20%	

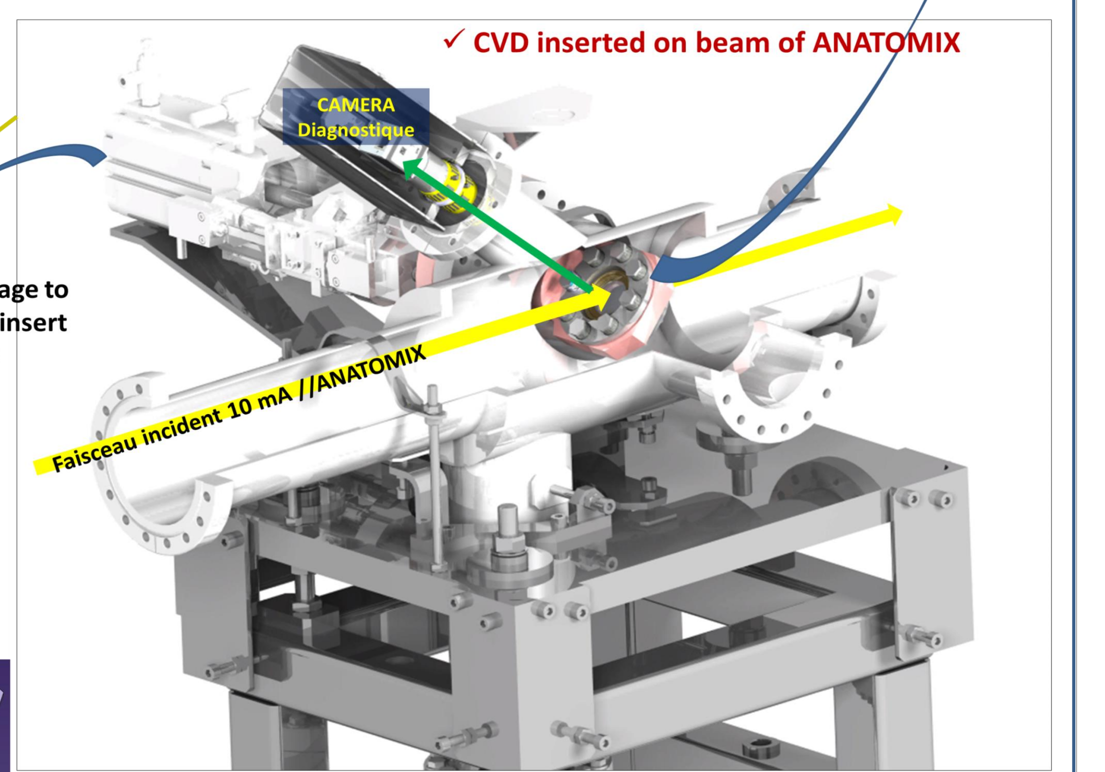
Selected criteria :

- **Shear stresses during brazing < 200 MPa**
- Main **tensile** stresses in **CVD < 350 MPa**
- No excessive deformation of Cuc2 rings **(ε<20%)** during brazing
- Mechanical fatigue of Cuc2 (N_{cycles} > 1000 ➔ Extent of total deformation < 0.5%)
- Elastic limit of CuC2, function of temperature :
  ➔ 21°C: Elastic limit = 60 MPa // Plastic limit = 700 Mpa
  ➔ 400°C: Elastic limit = 20 MPa // Plastic limit = 50 MPa
  ➔ 800°C: Elastic limit = 2 MPa // Plastic limit = 30 MPa



CDV diamond disk brazed on its 2 symmetrical and flexible copper (Cuc2) rings





Absorber and imager operation, and Conclusion:

The absorber was successfully installed and commissioned in 2016. In users operation, it is systematically inserted to allow the simultaneous operation of the SDL13 beamlines. It is only extracted during specific machine studies.
The white imager was successfully installed and commissioned in 2017. It was found out that using a current of 6 mA is already sufficient in terms of photon flux to operate the diagnostics. The white imager is used after each machine shutdown and after each extraction/insertion of the absorber. It gives complementary information to the XBPM measurements and even revealed more straight forward and easy to use. Finally, the absorber and the white imager were designed at SOLEIL to secure the operation of two canted IDs. Both rely on simple thus robust mechanical concepts which rend their commissioning easy and straight forward. The are now successfully used to operate routinely ANATOMIX and NANOSCOPIUM beamlines simultaneously.

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