Study of Visible Synchrotron Radiation Monitor on SOLEIL Booster

IBIC 2023

A. Moutardier *, G.Cauchon, M. Chevrot, Z. Fan, N. Hubert, S. Kubsky, M. Labat, M. Thomasset, Synchrotron SOLEIL, Gif-Sur-Yvette, France
*alexandre.moutardier@synchrotron-soleil.fr

Abstract

In the scope of SOLEIL II, the booster must also be upgraded to reduce from 130 to 5 nm.rad the emittance of the beam delivered to the ring. Control of the emittance in the booster will become crucial to ensure the nominal performance of the storage ring injection. The SOLEIL I booster is already equipped with a Visible Synchrotron Radiation Monitor (MRSV). This equipment, made of an extraction mirror and a simple optical system, was originally planned to be used only for beam presence verification but has not been used routinely for operation since the commissioning in 2005. The control and acquisition systems had to be refreshed to be usable again and allow the beam size measurement along the booster energy ramp. The extraction mirror was replaced due to unexpected degradation leading to a second spot appearing on the camera. This paper traces back the MRSV upgrades from understanding the cause of mirror degradation until mirror replacement and the first proper beam visualisation, achieved at the beginning of 2023.

MRSV theory

MRSV : **V**isible **S**ynchrotron **R**adiation **M**onitor

MRSV design

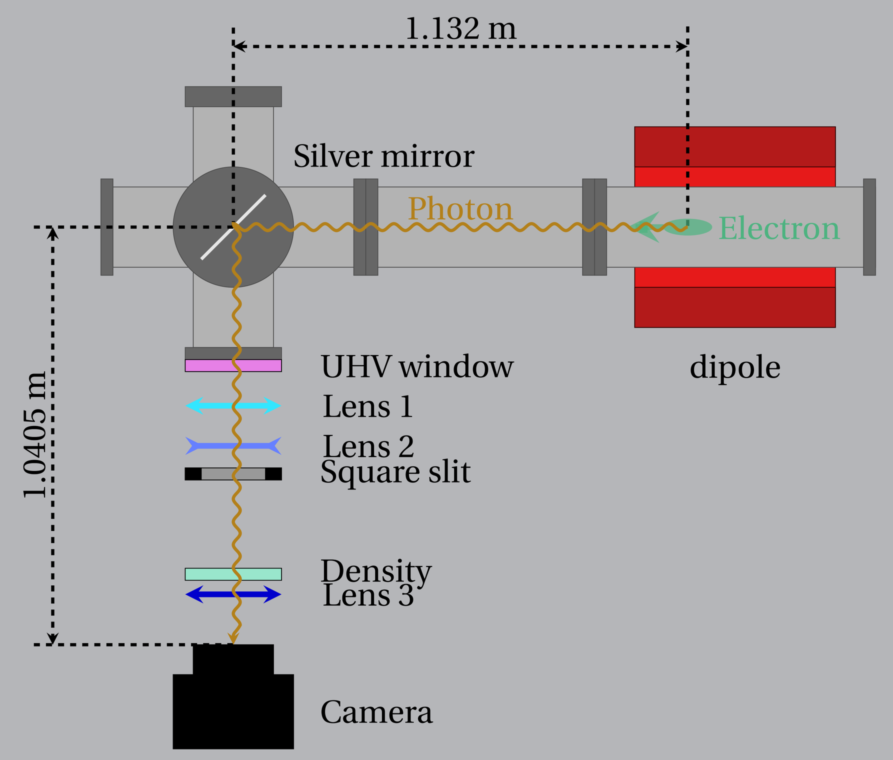

Figure 1: MRSV design.

Measure

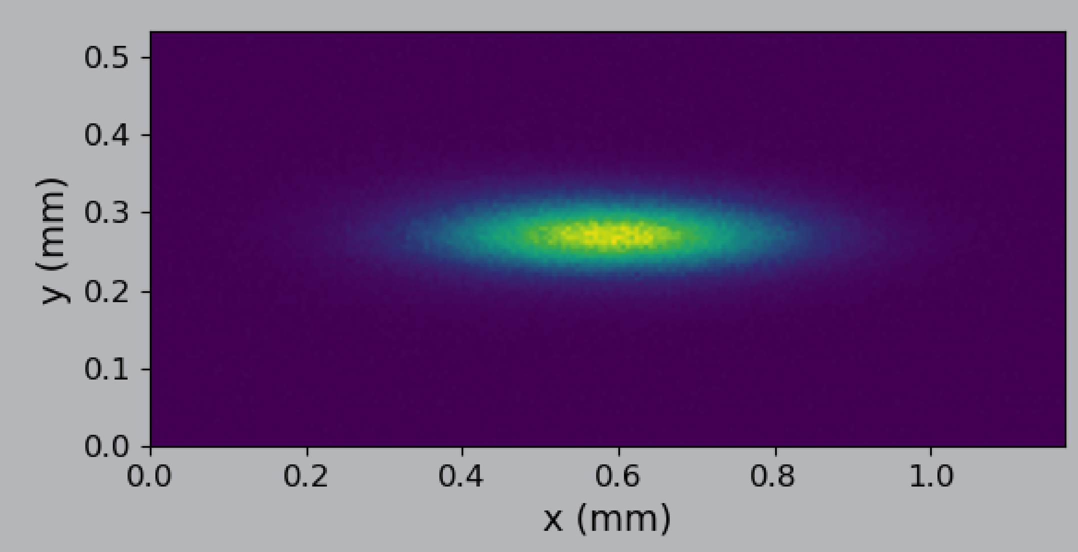

Figure 2: Image of synchrotron radiation taken during commissioning of a new mirror.

Beam profile at the end of the booster ramp coherent with simulations.

Point-Spread-Function (PSF)

i.e. light emission by an unique electron

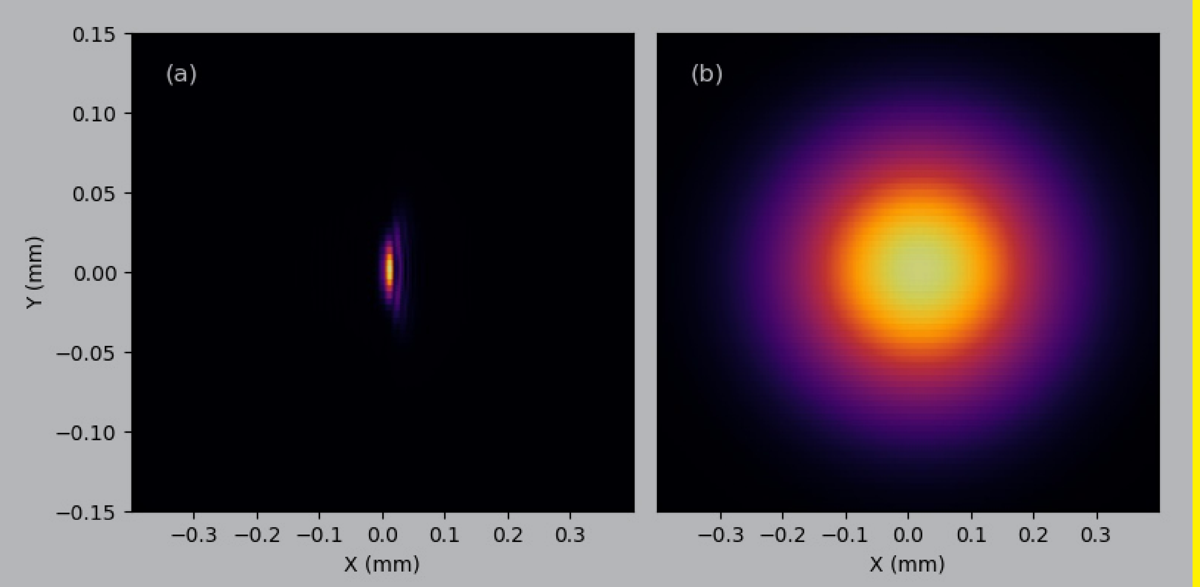

Figure 3: SRW [3] simulations of synchrotron radiation for a) one electron (PSF), b) a beam.

Image spot size = convolution of real electron beam size and PSF

Double spot issue

- **2005** : SOLEIL commissioning
- **2006** : Second spot on MRSV images :

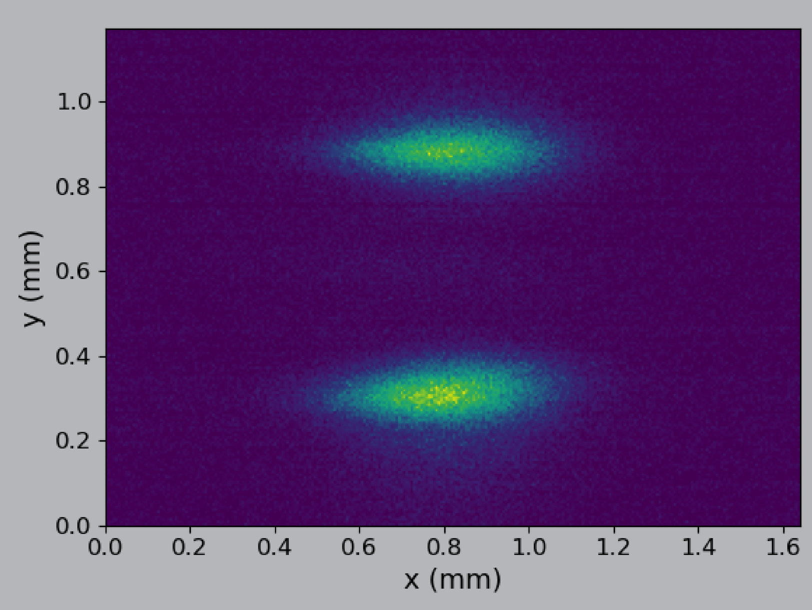

Figure 4: MRSV image 18 years after the SOLEIL commissioning.

- **2023**: extraction mirror replace ⇒ **Fig. 2**
- **2 weeks after**: Image already distorted

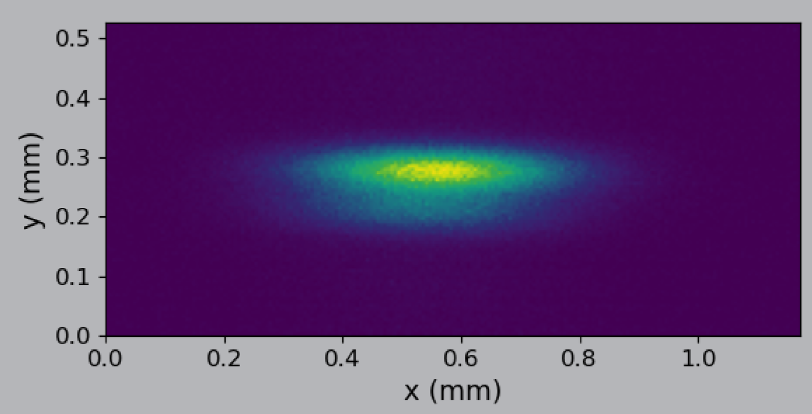

Figure 5: MRSV image 2 weeks after mirror exchange.

Mirror study

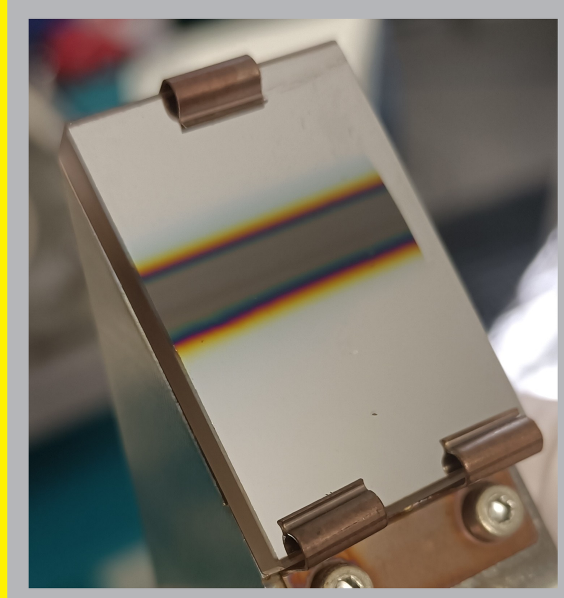

Figure 6: Booster's MRSV extraction mirror, after nearly 18 years of operation.

Damaged mirror

← **Iridescence** = Heat damage

← **Black strip** = carbon deposition

For mirror surface study, the carbon deposition was removed using a O_2 plasma chamber [4].

Thermal study

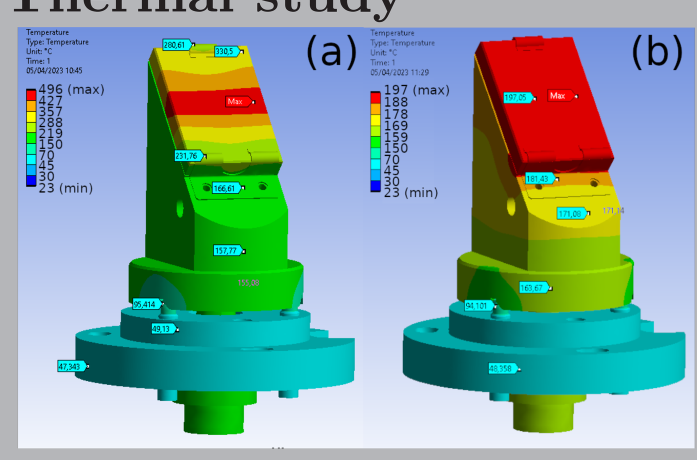

Figure 7: Ansys [6] thermal simulation of Pyrex mirror (a) and copper one (b), both silver coated.

Mirror surface study

- 4 µm deep valley
- Melt silver down valley
- Mirror deformation :

  Angle between upper and lower half of the mirror

Black strip + mirror deformation ⇒ 2 spots on images

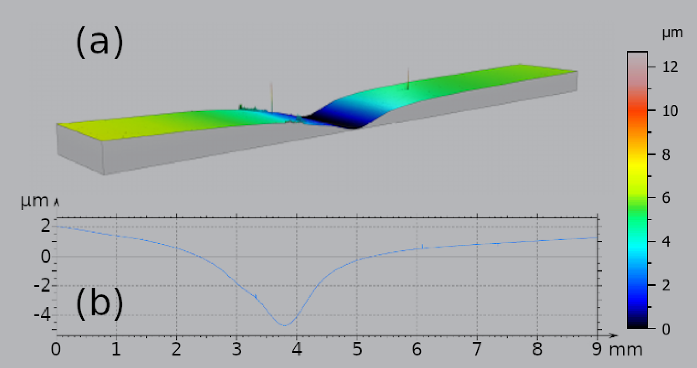

Figure 8: Interferometry [5] of MRSV extraction mirror surface. (a) 3D map, (b) line cut along top image.

On the mirror :

- Total average power : 6 W
- Average power density : $0.26\,\mathrm{W\,mm^{-2}}$

	(a)	(b)
Mirror heat transfer ($\mathrm{W\,m^{-1}\,K^{-1}}$)	1.2	400
Max heat	496°	197°
Without coating	1000°	-

Conclusion

- Double spot issue comes from mirror degradation
- Those degradations are due to overheating because of poor heat transfers of Pyrex glass
- A copper-based mirror is installed to increase heat transfers and hopefully prevent mirror degradation
- MRSV can be used to measure electron beam size, hence beam emittance
- This work is useful for the SOLEIL booster upgrade and associated diagnostics design.

References

[1] acA1920-50gm Basler ace GigE camera, *https://docs.baslerweb.com/aca1920-50gm*
[2] Å. Andersson and al., *Determination of a small vertical electron beam profile and emittance at the Swiss Light Source*, NIM A 591 (3), 437 - 446 (2008).
[3] O. Chubar and P. Elleaume, *Accurate and efficient computation of synchrotron radiation in the near field region*, Proceedings of EPAC'98, Stockholm, Sweden, 1998, 88.
[4] *DIENER Pico* Diener Plasma GmbH & Co. KG, Ebhausen, Germany.
[5] *firebolt*, (GBS) mbH, Ilmenau, Germany
[6] *Ansys® Academic Research Mechanical*, Release 2020R2, 2020.

Acknowledgements

S. Morand, M.-A. Tordeux (SOLEIL).