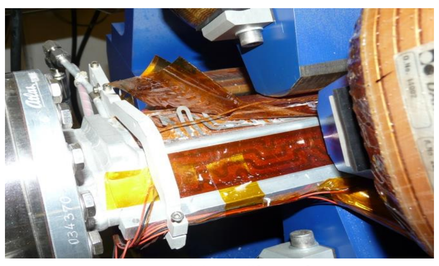
RADIATION DAMAGE AND CHARACTERIZATION IN THE SOLEIL STORAGE RING TUNNEL

N. Hubert*, N. Béchu, K. Desjardins, C. Herbeaux, J-F. Lamarre, F. Marteau, S. Morand, Synchrotron SOLEIL, FRANCE
* nicolas.hubert@synchrotron-soleil.fr

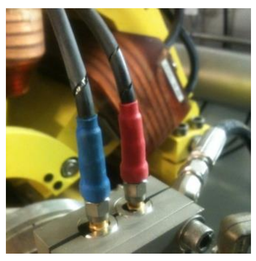
After six years of operation, equipment located close to some vacuum chambers of the SOLEIL storage ring have started to show unexpected damages due to radiation. It has been pointed out that, around the so called “quadrupole” vacuum chambers that intercept the upstream dipole synchrotron radiation, X-rays are emitted. Their energy is too high to be significantly attenuated by the 3 mm aluminum of which the vacuum chamber is made. Diagnostics and means used to understand and characterize this radiation are presented in this poster.

Equipment Damage From Radiations

Sextupole insulators



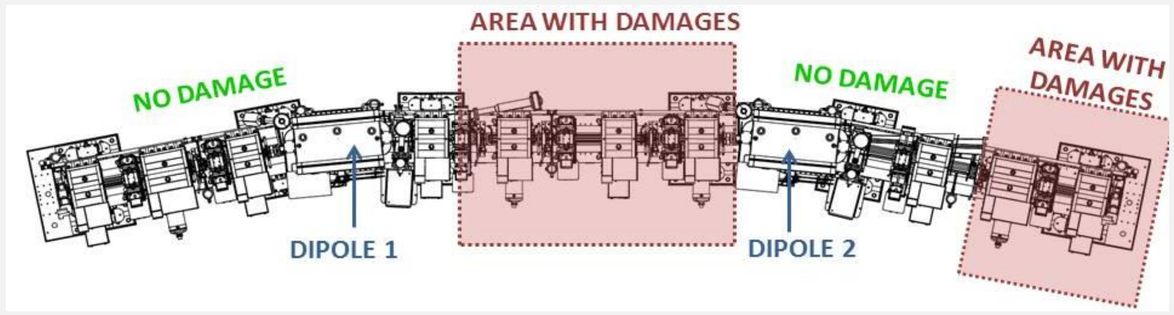
Baking film glue



BPM cable insulators

Premature damages have been observed, for example on some **cables insulators** (magnets, beam position monitors) that became rigid and brittle and on **baking film glue** (making them unusable).

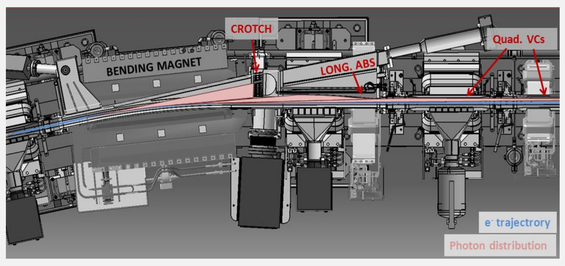
Damage Locations



Damages occur at **very precise locations**: in the arcs, just **downstream the bending magnets,** around the so-called quadrupole vacuum chambers.

Quadrupole vacuum chambers intercept a small fraction of synchrotron radiation emitted in the upstream dipole:

Equipment	RS Intercepted Angle	Absorbed Power
Crotch	102 mrad	7.6 kW
Longitudinal absorber	69 mrad	5.1 kW
Quadrupole vacuum Chamber	25 mrad	1.8 kW

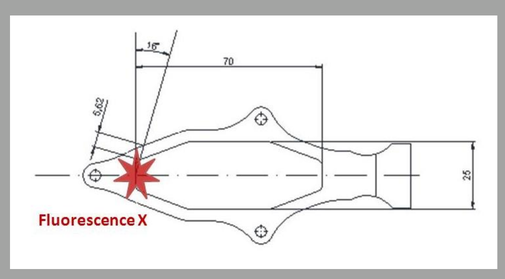


Radiation Characterization

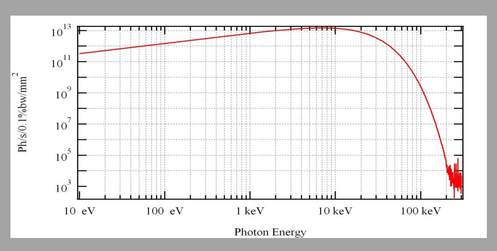
Aluminum Vacuum Chamber

Quadrupole vacuum chambers:

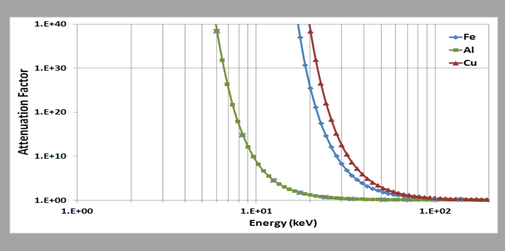
- **made of extruded aluminum** whereas bending magnets ones are made of stainless steel.
- X-rays intercepted inside the chamber spread (secondary emission with isotropic distribution) and are **not enough attenuated by the vacuum chamber material/thickness**.



Profile of the quadrupole type vacuum chamber. Minimum thickness is 3 mm.

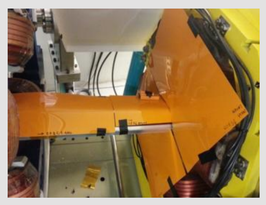


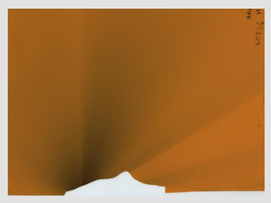
Bending magnet flux: photon energy emitted by bending magnet ranging from 10 eV to 100 keV.



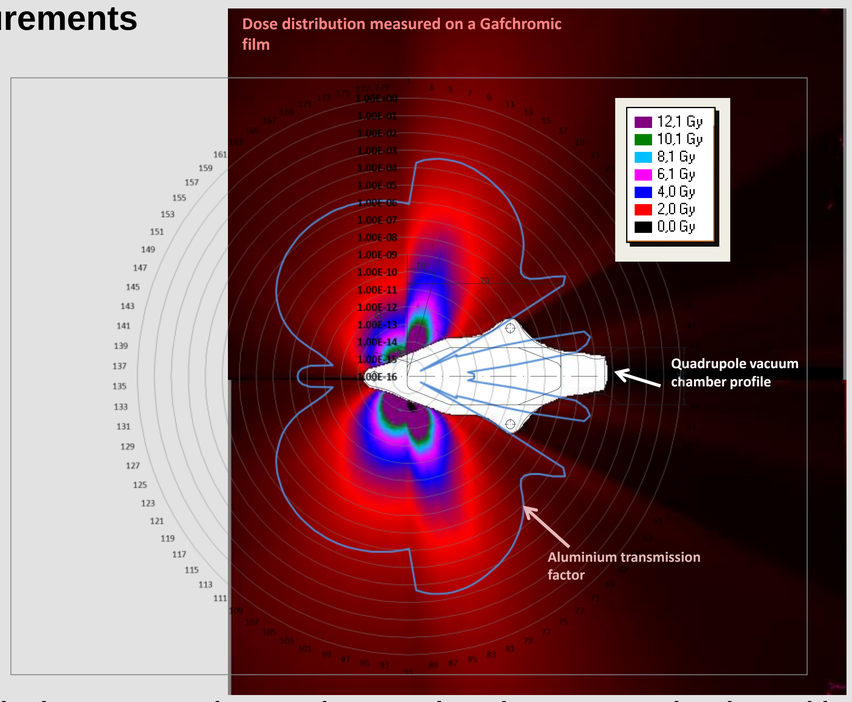
Attenuation factor of 3 mm of Aluminum decrease drastically above 10 keV whereas stainless steel or copper vacuum chamber would be more efficient to damped X-rays spread at the interception point.

Radiation Measurements





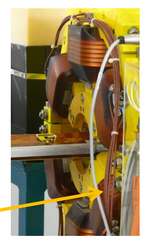
Gafchromics XR-RV3 films used to measure the spatial dose distribution: resulting image (scanned with Epson Perfection V700) is converted to dose based on calibration files.



Transverse dose distribution measured around a quadrupole vacuum chamber with Gafchromics films is perfectly correlated with calculated transmission factor of Aluminum with respect of emission angle and Al thickness.

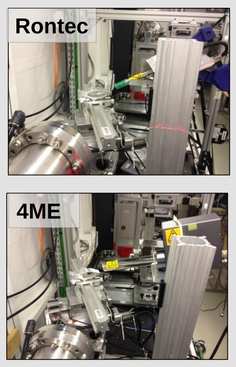
Maintenance

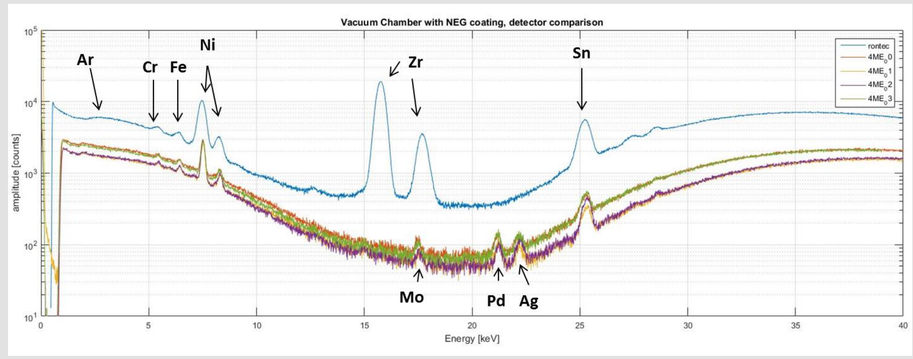
BPM (long) cables have been deported adding 1m long pigtail that is replaced periodically (4 years).



Magnet cable insulators are replaced (or added) periodically with radiation hardened materials.

Tests on radiation hard glues have been carried on. A new glue is now used for baking film that are replaced on demand.





Photon beam energy distribution measurement on the Metrology beamline: comparison of two Silicon Drift Detectors. Radiation spectrum is dominated by the background produced by secondary emission of bending magnet synchrotron radiation. .

Spectrum measurements show lines produced by fluorescence of materials intercepting X rays. Biggest ones are Kα and Kβ from Zirconium are visible only by Rontec detector because it has a Zr collimator inside his head (fluorescence of Zr composing the NEG coating inside the vacuum chamber is not detectable).

Conclusion: Around so-called “quadrupole vacuum chambers” downstream bending magnets, equipment are damaged by radiation more than at other location in the storage ring. Measurements with Gafchromics films and Silicon Drift Detectors have been done to characterize and understand the origin of the radiation: the material (aluminum) of those vacuum chambers is almost transparent to the secondary X-rays that are emitted when the chamber intercept a fraction of synchrotron radiation.

ARW 2017
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