SOLEIL Operation and Adaptation to the New Common Metrics

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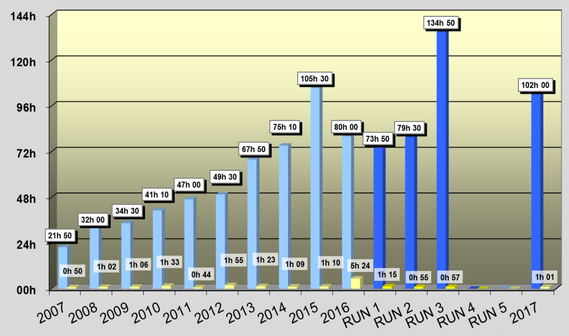
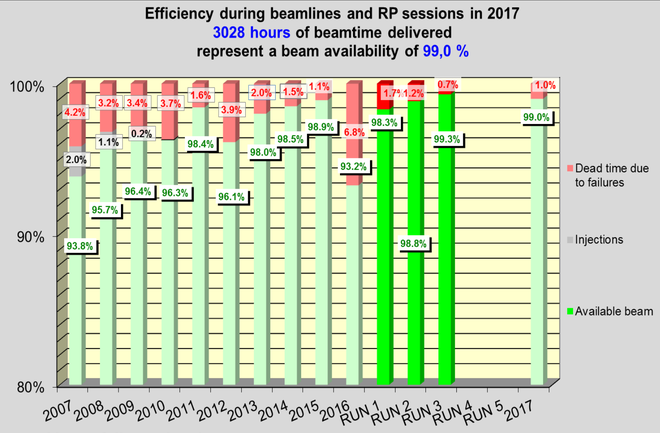
Synchrotron SOLEIL is the 3rd generation French synchrotron light source. In operation since 2007, it provides photon beams to the 29 beamlines. The electron beam intensity can reach up-to 500 mA according to the filling (5 different modes are available all in top-up injection).
After early age failures, the efforts to improve the reliability of the equipment and the availability of the beam contributed to bring us close to the target objectives, namely 99% availability and 100 hours of MTBF. We are going to present the evolution of these results and the major breakdowns that have marked these ten years of operation. Also we did the exercise of adapting our statistics to common metrics shared with other synchrotrons. All these results are accessible from an internal WEB page, thanks to a development carried out by an operator of the group.

Ten Years of Operation: Statistics and Major Breakdowns

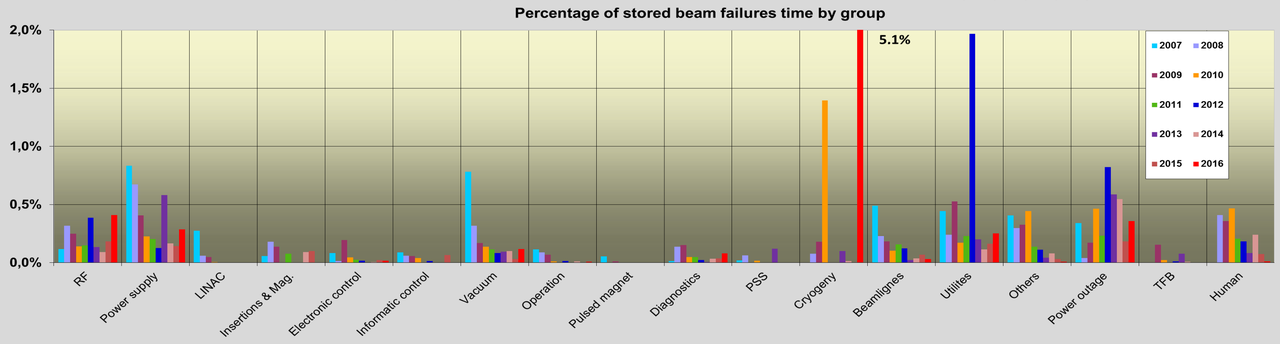
MTBF: Meantime between failures (102h00)
and MTTR: MeanTime To Recovery (01h01)
during beamlines and RP sessions in 2017



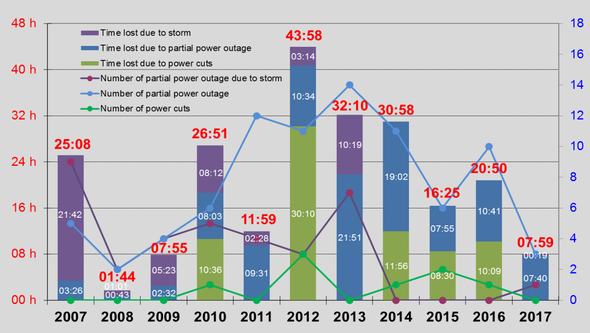
Efficiency during beamlines and RP sessions in 2017
3028 hours of beamtime delivered
represent a beam availability of 99,0 %



Percentage of stored beam failures time by group



Partial power outage and power cuts with impact on the beam availability
Number of interruptions et beam lost time between 2007 and 2017



Power Outage

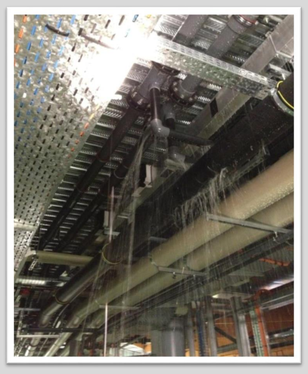
Partial power outage and power cuts are an leading cause of breakdowns. Despite the hardening of the electronics of storage ring RF system and power-supplies, beam losses due to power outages are continually growing till 2014.
In 2015, the installation of an inverter on the control network and low level equipment allows to limit the impact of power cuts. Since 2017, the quality of the electric network has improved and the new construction works close to SOLEIL site are now completed.

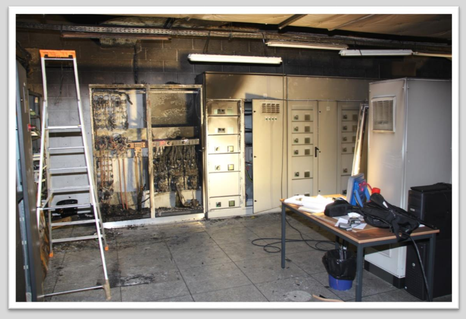
In **2007-2008**, after suffering from quite a few IGBT explosions on 3Hz Booster dipole power supplies, a campaign to upgrade IGBT class (400A to 600A) was the first step. Because the number of operating cycles is much larger than expected. a redesign of these units was decided, especially by oxygenizing the IGBT modules and by improving the cooling system.

In **2013**, a new dipole storage ring power-supply (580A / 610V +/- 10ppm), developed in-house was put in operation. Switching between power supplies takes less than 5 minutes (without beam).
Another spare power supply is under development to be used in case of failure of one storage ring sextupole power supply (10) or dipole power supply of the booster to storage ring transfer line.

In **2016**, Water pollution of the cryogenic station. A two-week shutdown to eliminate the water in the liquefactor in order to avoid breaking its turbines.

By the very end of **2012**, SOLEIL suffered from its longest failure, nearly 60 hours without beam. A tap located on the beamlines cooling system broke. Because of PVC tubing we had to wait until the glue used to repair dried. In 2012, there were more than 100 hours of outage due to cooling system and air compressed problems.



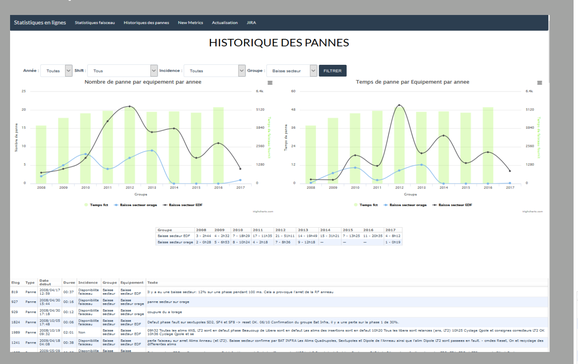


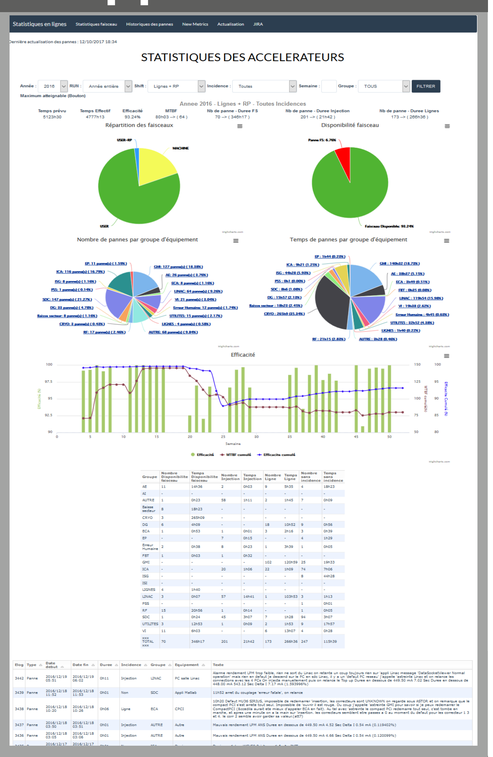
In **2015**, fire in a filtered capacitor of the fluid Main LV board. Three weeks to restore the LV board(expertise, insurance companies visit, decontamination, technical works). Leading to the re-schedule of the calendar beamtime.

Statistic Web Based Application

We developed a web based application to have live beam statistics and to access the statistics of the past years (since 2008).
We can also see incident statistics by equipment and new metrics statistics.

The application is developed in DJANGO (Python web-Framework). The statistics are based on the data entered in the Electronic Logbook (ELOG) by the operator.

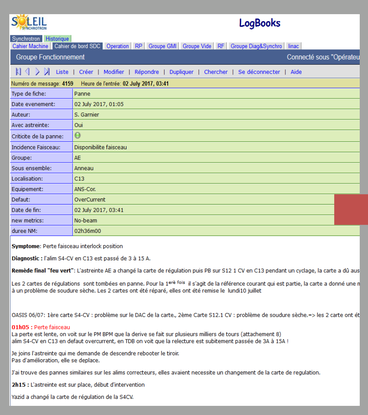


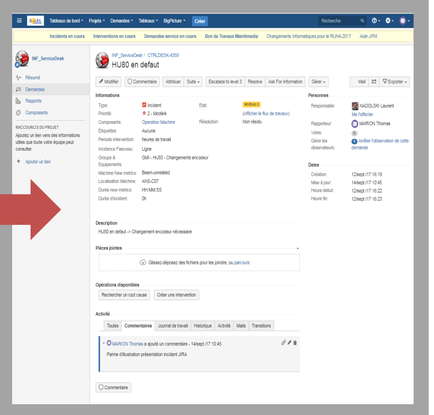


Incident Tracking

Starting January 2018, we will migrate the incident tracking from ELOG to JIRA in order to improve traceability and interaction between groups.

The automatic entries creation that were already used with ELOG based on no-beam and low-beam events will be always present and will be extend to other events (insertion device failures, …)





Adapting our Statistics to Common Metrics

Primary Failure Modes

2016	Stat SOLEIL		Criteria	Comment
	Nb	hours		
No-Beam	**64**	**346,3**	→ Start when I = 0 mA & stop when I = Inominal and Front End unlocked → If beam is less than 7% of nominal current we have to close the Front-Ends to reinject (strict safety rules) → Beam count as No Beam if duration < 30'	A very bad year: A very long interruption due to a failure of the RF CRYO system, and, problems with power supply RF, storage ring power supply, power outage, water leak in the server room.
Top-Up	**201**	**21,9**	→ In multibunch mode, start when the beam current drops below 99.9% of the minimun current. → In single bunch injection, this value is 99,5 %	Many problems with the LINAC (Vaccum, controls, single bunch injection)

2016	News Metrics SOLEIL		Criteria	Comment
	Nb	Hours		
No-Beam	**59**	**345,7**	→Start when I < 20% of I nominal & stop I = Inominal (and FE unlocked) → Close Front-End for reinjection is count as Beam Unrelated → Beam less than 30' is count as Short User Time	5 Front-end closures for reinjection
Low-Beam	**30**	**11,4**	Start when I < 99,5% of I.min for all filling modes & stop when I > I.min (Top-Up regulation threshold)	SOLEIL criteria is much more severe

Secondary Failure Modes

2016	Stat SOLEIL		Criteria	Comment
	Nb	hours		
BeamLines	**173**	**267**	Failures with impact on one or several beamlines → Orbit perturbations: Slow Orbit Feed Back, Fast Orbit Feed-Back, tunnel air-conditioning, cooling water, storage ring or insertion device power supplies, earthquake. → beam size variation: Transverse bunch per bunch Feedback not running, beam excitation (vacuum rise, power supplies default) → Blocking of a front-end opening	Many insertion failures, including one unavailability of several days. One unavailability of several days of the single bunch injection during an hybrid session Many failures of the Fast Orbit FeedBack due to the degraded operation of the informatics control (server out of order after a water infiltration in the server room)

2016	News Metrics		Criteria	Comment
	Nb	hours		
Low-Lifetime	**0**	**0**	→ 4h in multibunch (TAU typical 12h) → 2h in single bunch (TAU typical 4h)	Below the threshold set by the radioprotection, we have to stop TOP-UP injection. Therefore the fault is counted in Low-Beam
Beam Blow-up	**1**	**0,02**	→ +/- 20% of the beam size, more than 10 " (with the FB-Coupling we maintain vertical emittance at +/- 30%)	Some other Beam Blow-Up incidents leads to partial loss of the beam Therefore the fault is counted in Low-Beam
Distorted Orbit	**28**	**10**	Threshold at source point: 5µm in H (10% Beamsize) and 2µm in V (20% Beamsize) if t > 60 " (min time to restart)	24 incidents coming from the Fast-Orbit Feedback including 16 due to the degraded operation of the controls 2 earthquakes (1,7h)
Distorted Filling Bunch Purity	**2**	**105**	→ Distorted filling : No injection in single Bunch, or injection in the wrong bunch → Purity typical between 1E-5 and 1E-4, proposed threshold 1E-3 (user threshold)	
Beam Unrelated	**64**	**133**	Failures do not affect the beam, but affect the user experiments	55 impacted only one beamline
Short User-Time	**0**	**0**	Beam less than 30 minutes	
Orbit FB Outage	**-**	**-**		Orbit feedback outage are recorded if they have an incident on the orbit
Filling FB Outage	**-**	**-**	No Feedback	When we inject in Top-Up (total current below the nominal current threshold), we fill the weakest bunch or quater of ring

User Time

years	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
User Experiment Time	2639	3881	4423	4722	4997	5133	4912	4963	4904	4777
Scheduled User Experiment Time	3096	4056	4580	4881	5077	5341	5015	5041	5200	5124
Spontaneous User Compensation Time (user re-scheduled < 1 month ago)		0	8	24				0	0	0
Scheduled User Reserve Time (user re-scheduled > 1 month ago)		0	0	0				0	192	0
Re-Scheduled User Experiment Time	2313		4588	4905					4959	

Additional time to complete shutdown and to test Beamlines safety system before first opening.

Cryogenic failure, one machine day back to beamlines

Fire in a technical room.
Start of the run delayed by 3 Weeks.
Compensated by eight days.

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