Status and Operation of SOLEIL
The Upgrade Project

C. Herbeaux, L. Nadolski, A. Nadji

Outline

- Operation
  - Key Performance Indicators (KPI's)
  - Operational metrics
  - Major Incidents
- Major R&D Projects
  - Multipole Injection Kicker
  - Superbend Project
- Conceptual Design for a Major Upgrade
  - Overview
  - Salient features
  - R&D

Operation

Lattice

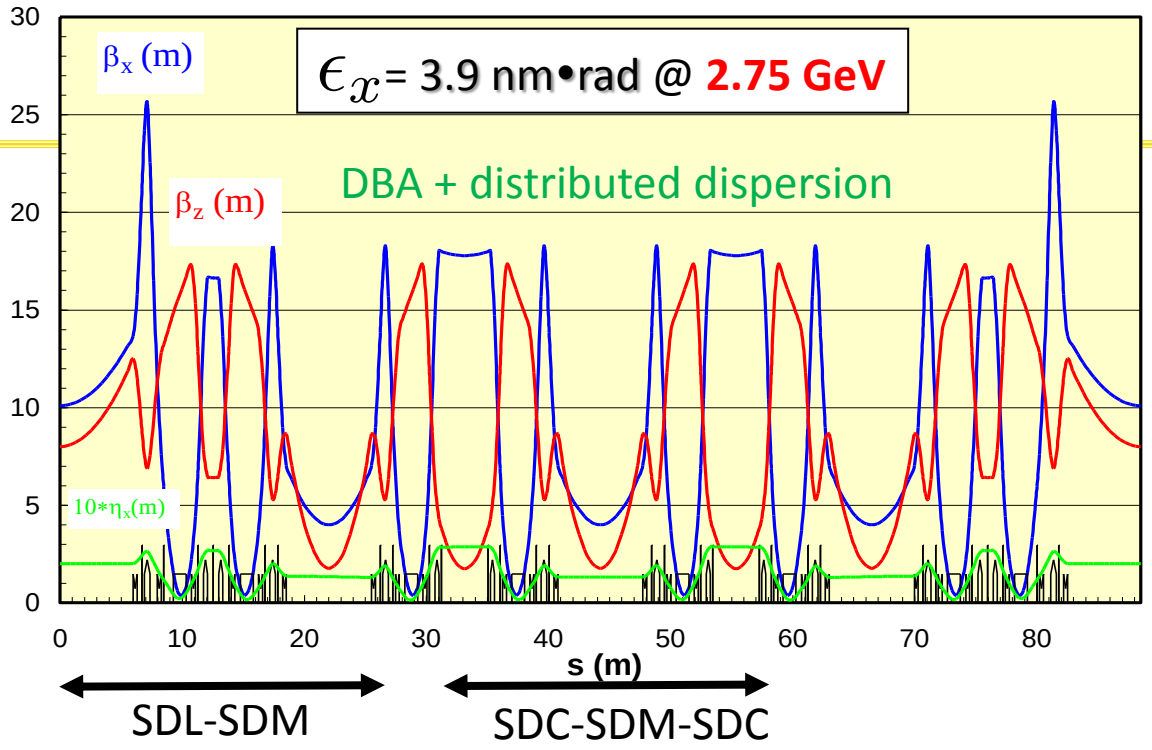
Location: France

Circumference: **354 m**

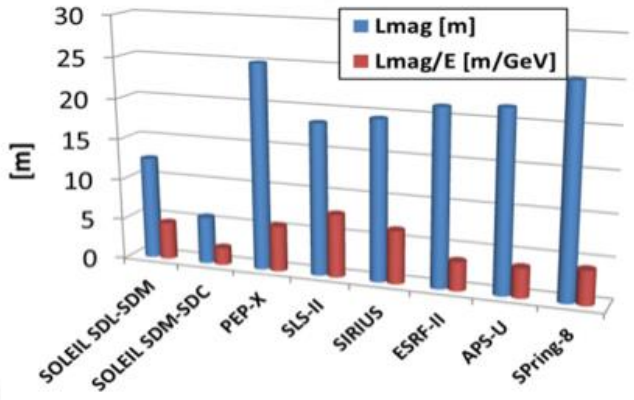
24 straight sections

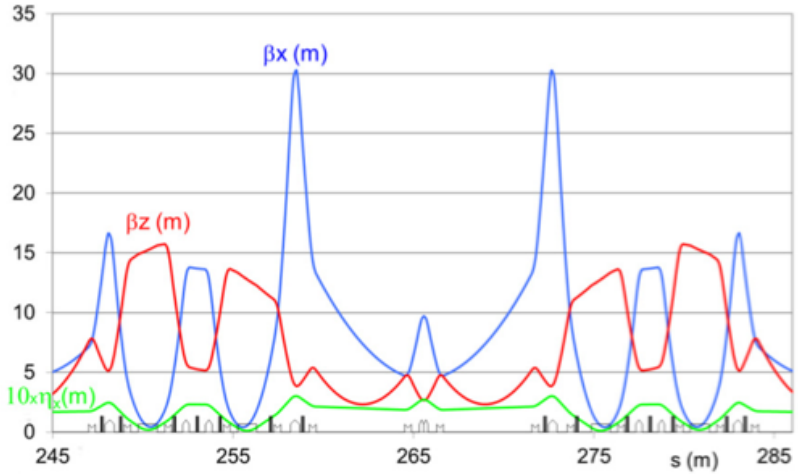
(variable length)

SDL: 4 x 12 m
SDM: 12 x 7 m
SDC: 8 x 3.6 m



Very compact magnetic structure





One long straight section (SDL13, accommodating 2 canted long beamlines) has been modified

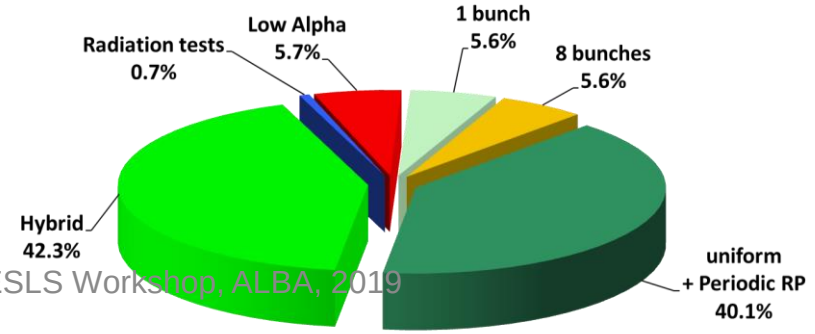
C. Herb

Beam Time Schedule in 2019

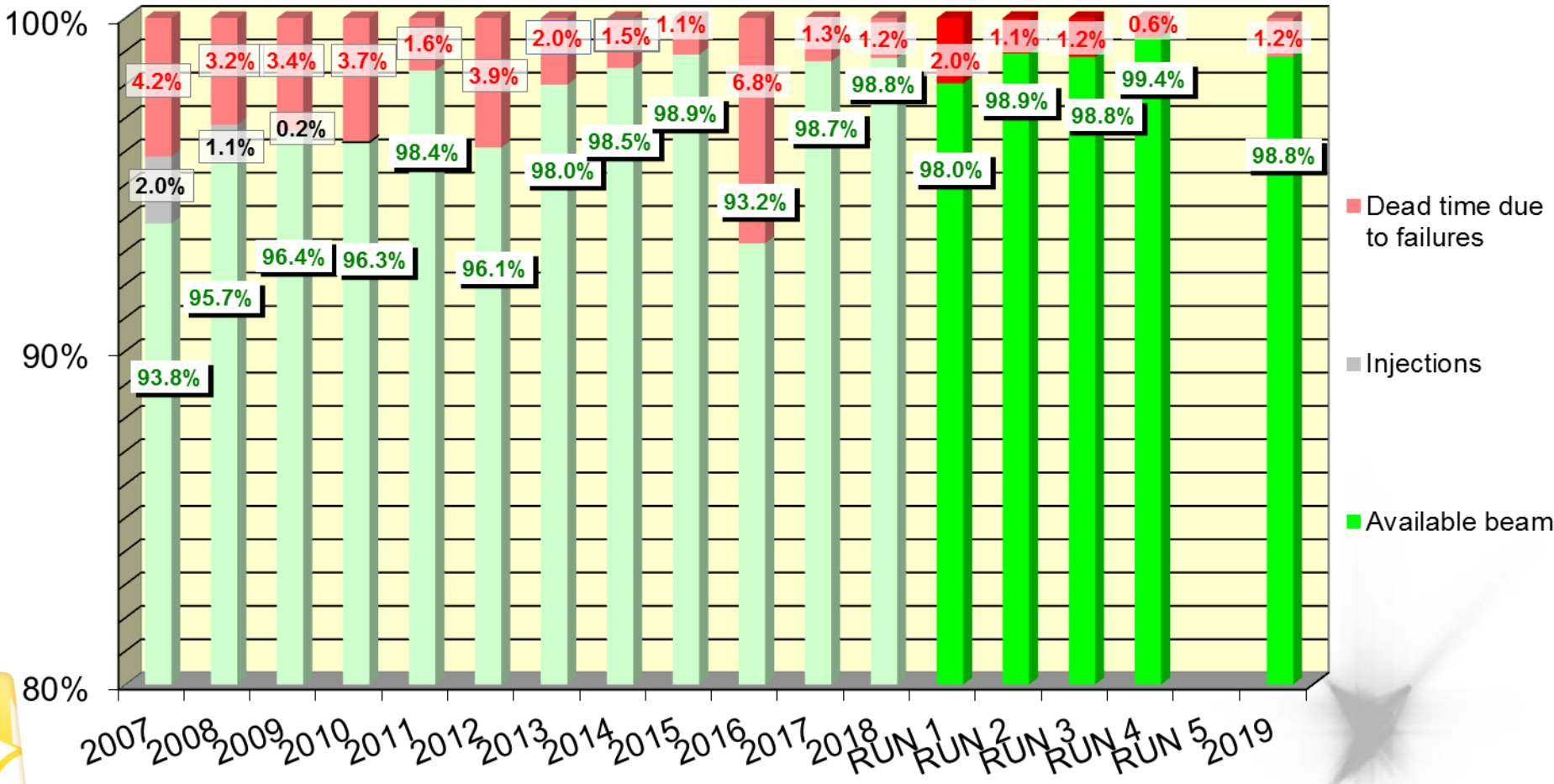
janv 2019				févr 2019				mars 2019				avr 2019				mai 2019				juin 2019				juil 2019				août 2019				sept 2019				oct 2019				nov 2019				déc 2019			
mar 01	.	.	.	ven 01	H	H	H	ven 01	.	.	.	lun 01	A	A	Tv	mer 01	.	.	.	sam 01	U	U	U	lun 01	A	A	A	jeu 01	.	.	.	dim 01	A	A	A	mar 01	B	B	B	ven 01	S	S	S	dim 01	H	H	H
mer 02	.	.	.	sam 02	H	H	H	sam 02	.	.	.	mar 02	B	B	B	jeu 02	.	.	.	dim 02	U	U	U	mar 02	Cp	Cp	B	ven 02	.	.	.	lun 02	A	A	A	mer 02	H	H	H	sam 02	S	S	S	lun 02	A	A	Tv
jeu 03	.	.	.	dim 03	H	H	H	dim 03	.	.	.	mer 03	H	H	H	ven 03	.	.	.	lun 03	A	A	A	mer 03	U	U	U	sam 03	.	.	.	mar 03	B	B	B	jeu 03	H	H	H	dim 03	S	S	S	mar 03	B	B	B
ven 04	.	.	.	lun 04	A	A	Tv	lun 04	.	.	.	jeu 04	H	H	H	sam 04	.	.	.	mar 04	L	L	L	jeu 04	U	U	U	dim 04	.	.	.	mer 04	U	U	U	ven 04	H	H	H	lun 04	A	A	Tv	mer 04	H	H	H
sam 05	.	.	.	mar 05	B	B	B	mar 05	.	.	.	ven 05	H	H	H	dim 05	.	.	.	mer 05	L	L	L	ven 05	U	U	U	lun 05	.	.	.	jeu 05	U	U	U	sam 05	H	H	H	mar 05	B	B	B	jeu 05	H	H	H
dim 06	.	.	.	mer 06	H	H	H	mer 06	.	.	.	sam 06	H	H	H	lun 06	.	.	.	jeu 06	L	L	L	sam 06	U	U	U	mar 06	.	.	.	ven 06	U	U	U	dim 06	H	H	H	mer 06	U	U	U	ven 06	H	H	H
lun 07	.	.	.	jeu 07	H	H	H	jeu 07	.	.	A	dim 07	H	H	H	mar 07	.	.	.	ven 07	L	L	L	dim 07	U	U	U	mer 07	.	.	.	sam 07	U	U	U	lun 07	A	A	A	jeu 07	U	U	U	sam 07	H	H	H
mar 08	.	.	.	ven 08	H	H	H	ven 08	A	A	A	lun 08	A	A	Tv	mer 08	.	.	.	sam 08	L	L	L	lun 08	A	A	Tv	jeu 08	.	.	.	dim 08	U	U	U	mar 08	L	L	L	ven 08	U	U	U	dim 08	H	H	H
mer 09	.	.	.	sam 09	H	H	H	sam 09	A	A	A	mar 09	B	B	B	jeu 09	.	.	.	dim 09	L	L	L	mar 09	B	B	B	ven 09	.	.	.	lun 09	A	A	Tv	mer 09	L	L	L	sam 09	U	U	U	lun 09	A	A	A
jeu 10	.	.	.	dim 10	H	H	H	dim 10	A	A	A	mer 10	U	U	U	ven 10	.	.	.	lun 10	A	A	Tv	mer 10	H	H	H	sam 10	.	.	.	mar 10	8	8	8	jeu 10	L	L	L	dim 10	U	U	U	mar 10	A	A	Tv
ven 11	.	.	.	lun 11	A	A	Tv	lun 11	A	A	A	jeu 11	U	U	U	sam 11	.	.	.	mar 11	B	B	B	jeu 11	H	H	H	dim 11	.	.	.	mer 11	8	8	8	ven 11	L	L	L	lun 11	A	A	A	mer 11	U	U	U
sam 12	.	.	.	mar 12	B	B	B	mar 12	B	B	B	ven 12	U	U	U	dim 12	.	.	.	mer 12	U	U	U	ven 12	H	H	H	lun 12	.	.	.	jeu 12	8	8	8	sam 12	L	L	L	mar 12	Cp	Cp	B	jeu 12	U	U	U
dim 13	.	.	.	mer 13	U	U	U	mer 13	U	U	U	sam 13	U	U	U	lun 13	.	.	.	jeu 13	U	U	U	sam 13	H	H	H	mar 13	.	.	.	ven 13	8	8	8	dim 13	L	L	L	mer 13	U	U	U	ven 13	U	U	U
lun 14	.	.	.	jeu 14	U	U	U	jeu 14	U	U	U	dim 14	U	U	U	mar 14	.	.	.	ven 14	U	U	U	dim 14	H	H	H	mer 14	.	.	.	sam 14	8	8	8	lun 14	.	.	.	jeu 14	U	U	U	sam 14	U	U	U
mar 15	.	.	.	ven 15	U	U	U	ven 15	U	U	U	lun 15	A	A	Tv	mer 15	.	.	.	sam 15	U	U	U	lun 15	A	A	Tv	jeu 15	.	.	.	dim 15	8	8	8	mar 15	.	.	.	ven 15	U	U	U	dim 15	U	U	U
mer 16	.	.	A	sam 16	U	U	U	sam 16	U	U	U	mar 16	B	B	B	jeu 16	.	.	A	dim 16	U	U	U	mar 16	B	B	B	ven 16	.	.	.	lun 16	A	A	Tv	mer 16	.	.	.	sam 16	U	U	U	lun 16	U	U	U
jeu 17	A	A	A	dim 17	U	U	U	dim 17	U	U	U	mer 17	H	H	H	ven 17	A	A	A	lun 17	A	A	Tv	mer 17	H	H	H	sam 17	.	.	.	mar 17	B	B	B	jeu 17	.	.	.	dim 17	U	U	U	mar 17	U	U	U
ven 18	A	A	A	lun 18	A	A	Tv	lun 18	A	A	Tv	jeu 18	H	H	H	sam 18	A	A	A	mar 18	B	B	B	jeu 18	H	H	H	dim 18	.	.	.	mer 18	U	U	U	ven 18	.	.	.	lun 18	A	A	Tv	mer 18	.	.	.
sam 19	A	A	A	mar 19	B	B	B	mar 19	B	B	B	ven 19	H	H	H	dim 19	A	A	A	mer 19	H	H	H	ven 19	H	H	H	lun 19	.	.	.	jeu 19	U	U	U	sam 19	.	.	.	mar 19	B	B	B	jeu 19	.	.	.
dim 20	A	A	A	mer 20	U	U	U	mer 20	U	U	U	sam 20	H	H	H	lun 20	A	A	A	jeu 20	H	H	H	sam 20	H	H	H	mar 20	.	.	.	ven 20	U	U	U	dim 20	.	.	.	mer 20	H	H	H	ven 20	.	.	.
lun 21	A	A	A	jeu 21	U	U	U	jeu 21	U	U	U	dim 21	H	H	H	mar 21	S	S	S	ven 21	H	H	H	dim 21	H	H	H	mer 21	.	.	.	sam 21	U	U	U	lun 21	.	.	.	jeu 21	H	H	H	sam 21	.	.	.
mar 22	B	B	B	ven 22	U	U	U	ven 22	U	U	U	lun 22	A	A	Tv	mer 22	S	S	S	sam 22	H	H	H	lun 22	A	A	Tv	jeu 22	.	.	.	dim 22	U	U	U	mar 22	.	.	.	ven 22	H	H	H	dim 22	.	.	.
mer 23	H	H	H	sam 23	U	U	U	sam 23	U	U	U	mar 23	8	8	8	jeu 23	S	S	S	dim 23	H	H	H	mar 23	B	B	B	ven 23	.	.	.	lun 23	A	A	Tv	mer 23	.	.	.	sam 23	H	H	H	lun 23	.	.	.
jeu 24	H	H	H	dim 24	U	U	U	dim 24	U	U	U	mer 24	8	8	8	ven 24	S	S	S	lun 24	A	A	Tv	mer 24	U	U	U	sam 24	.	.	.	mar 24	B	B	B	jeu 24	.	.	A	dim 24	H	H	H	mar 24	.	.	.
ven 25	H	H	H	lun 25	.	.	.	lun 25	A	A	A	jeu 25	8	8	8	sam 25	S	S	S	mar 25	B	B	B	jeu 25	U	U	U	dim 25	.	.	.	mer 25	H	H	H	ven 25	A	A	A	lun 25	A	A	Tv	mer 25	.	.	.
sam 26	H	H	H	mar 26	.	.	.	mar 26	Cp	Cp	B	ven 26	8	8	8	dim 26	S	S	S	mer 26	H	H	H	ven 26	U	U	U	lun 26	.	.	.	jeu 26	H	H	H	sam 26	A	A	A	mar 26	B	B	B	jeu 26	.	.	.
dim 27	H	H	H	mer 27	.	.	.	mer 27	U	U	U	sam 27	8	8	8	lun 27	A	A	Tv	jeu 27	H	H	H	sam 27	U	U	U	mar 27	.	.	.	ven 27	H	H	H	dim 27	A	A	A	mer 27	H	H	H	ven 27	.	.	.
lun 28	A	A	Tv	jeu 28	.	.	.	jeu 28	U	U	U	dim 28	8	8	8	mar 28	B	B	B	ven 28	H	H	H	dim 28	U	U	U	mer 28	.	.	A	sam 28	H	H	H	lun 28	A	A	A	jeu 28	H	H	H	sam 28	.	.	.
mar 29	B	B	B					ven 29	U	U	U	lun 29	.	.	.	mer 29	U	U	U	sam 29	H	H	H	lun 29	.	.	.	jeu 29	A	A	A	dim 29	H	H	H	mar 29	S	S	S	ven 29	H	H	H	dim 29	.	.	.
mer 30	H	H	H					sam 30	U	U	U	mar 30	.	.	.	jeu 30	U	U	U	dim 30	H	H	H	mar 30	.	.	.	ven 30	A	A	A	lun 30	A	A	Tv	mer 30	S	S	S	sam 30	H	H	H	lun 30	.	.	.
jeu 31	H	H	H					dim 31	U	U	U					ven 31	U	U	U					mer 31	.	.	.	sam 31	A	A	A					jeu 31	S	S	S					mar 31	.	.	.

Maintenances

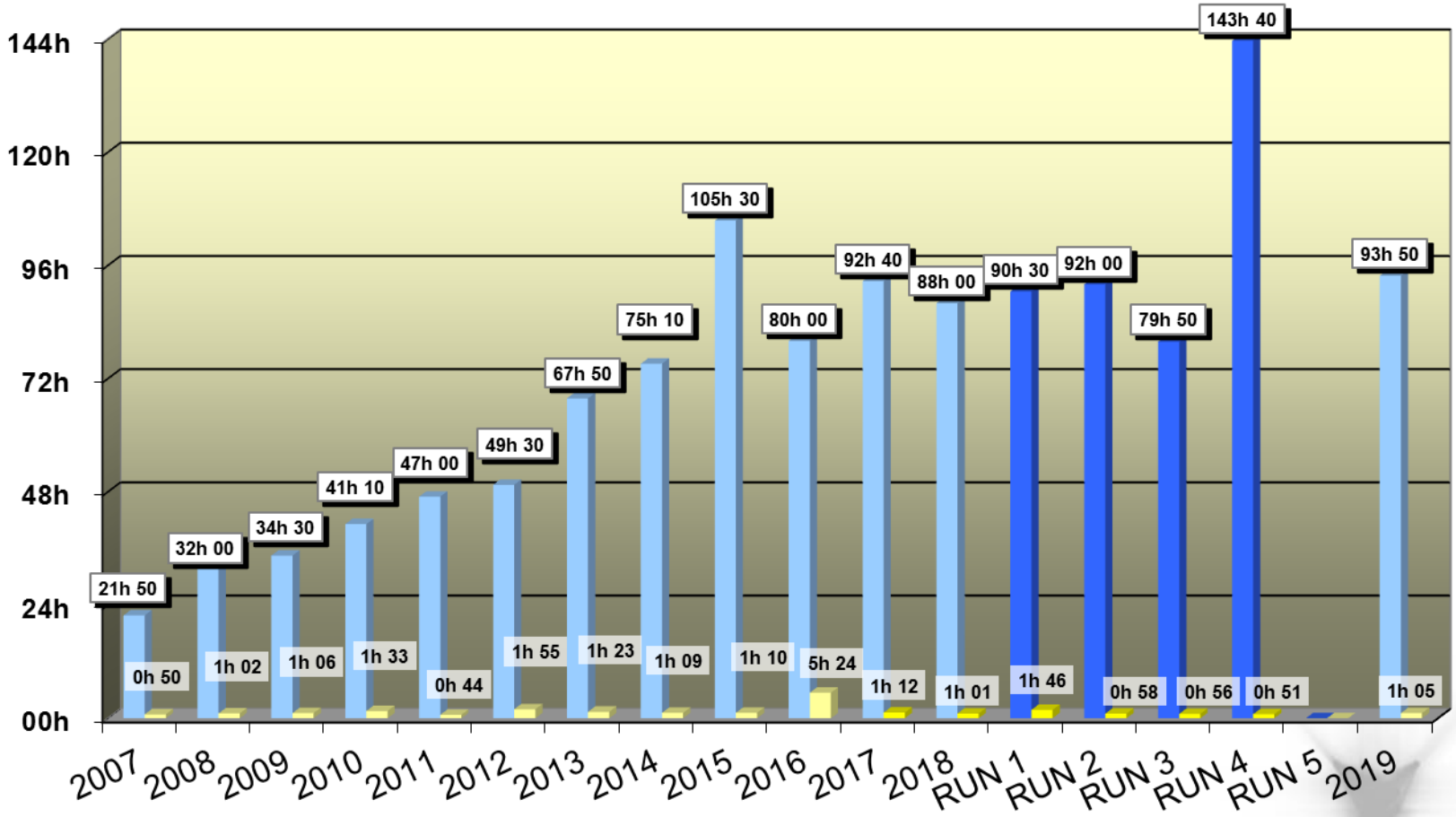
U	Uniform
H	Hybrid
8	8 bunches
S	1 bunch
L	Low -Alpha
B	Beamlines
Cp	Periodic radiation safety checks
Tv	Radation safety validation
A	accelerators
.	Shutdow n



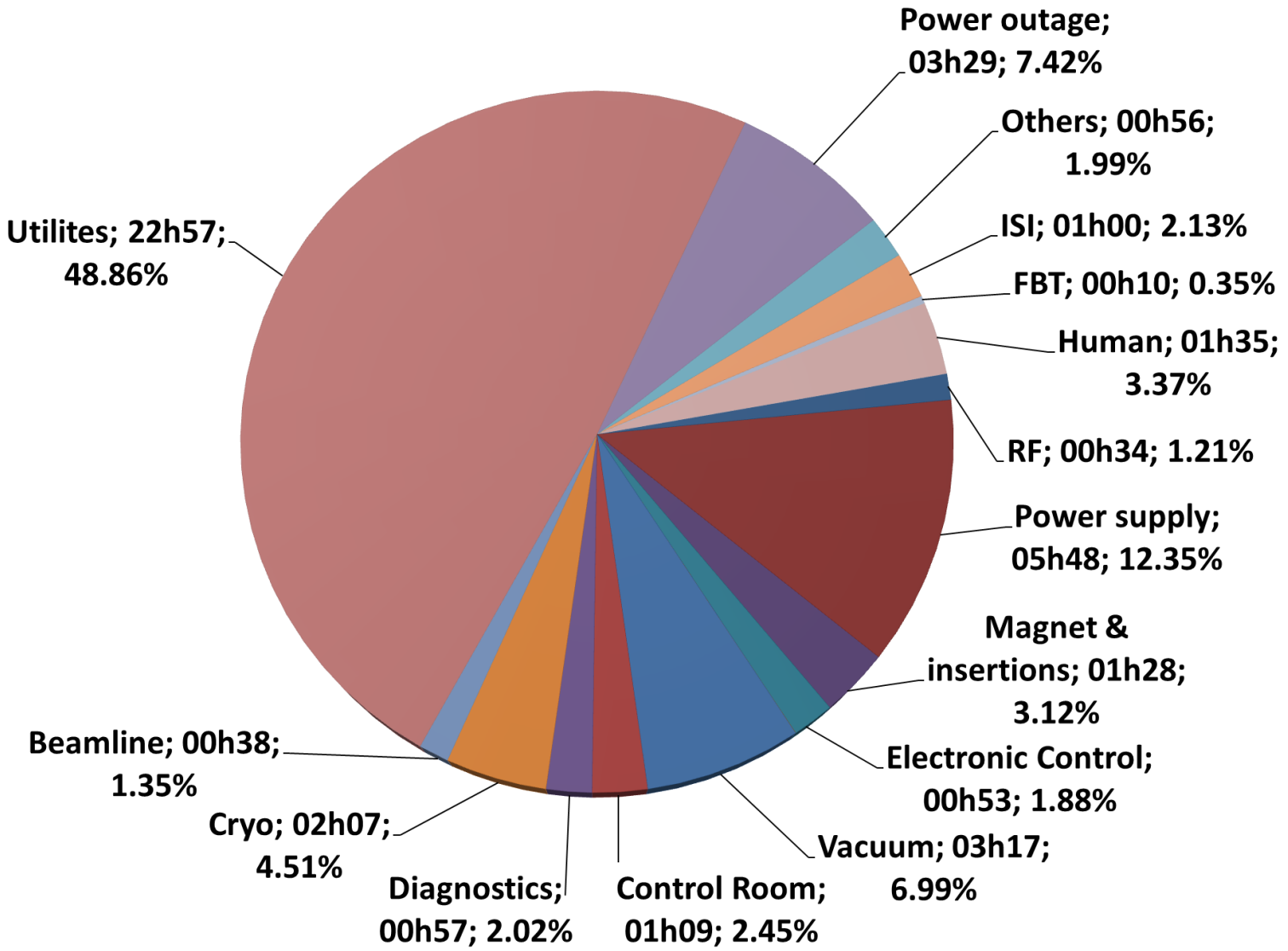
Efficiency during beamlines and RP sessions in 2019
3989 hours of beamtime delivered
represent a beam availability of 98,8 %



MTBF: Meantime between failures (93h50) and MTTR: MeanTime To Recovery (01h05) during beamlines and RP sessions in 2019



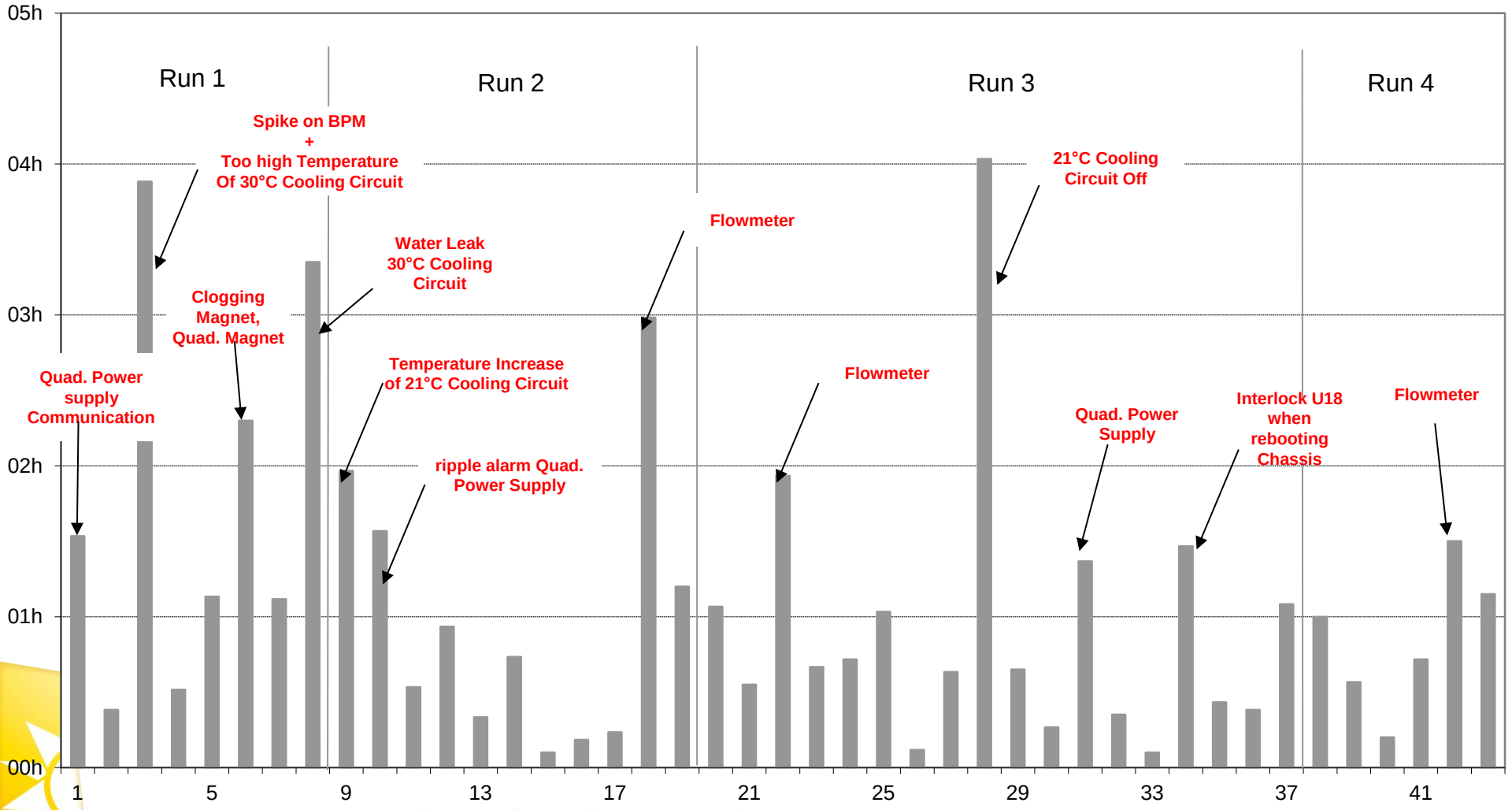
Origin of the 47 hours of Downtime in 2019 (RUN1 to RUN4)



Duration of every beam trip (Run 1 to 4)

Total 46:58
Min 00:06
Max 04:02
Mean 01:05
RMS 00:58

Time duration of the 43 beam interruptions (beam losses or equipmentfailures) impacting the beamline or Radiation Safety Tests



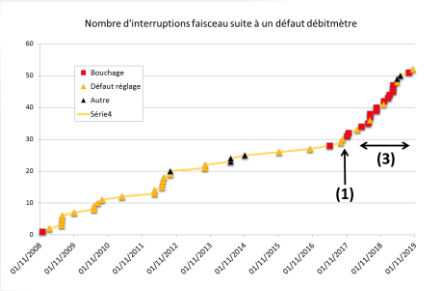
21°C Cooling Circuit Leaks on Brazing Joints and Clogging

- **Since April 2017, 5 leaks on brazing joints**
  - 2 on HU640 10 m long ID
  - 2 on SR sextupole and 1 SR quadrupole
- **Significant increase of clogging events**
  - @filters, @pressure reductor at BPM locations, etc.
  - Cu oxide residues, whitish precipitations

brazing joint

- **January 2019, 12 anomalies corrected**:
  - 3 brazing joints secured, 8 threaded connections disassembled, clean-up.

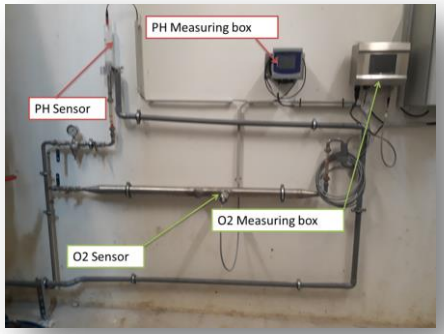
- **Concern about aging of the 21°C cooling circuit**
  - **Regime of high DO regime (4000 ppb, pH~6.5-7.5)**
  - **Survey/**experience of other facilities on similar issues
  - Improve **on-site brazing expertise** and training (4 people)
  - Revisiting **erosion/corrosion process** and water chemistry
  - **Online measurement capability** (pHmeter, dissolved oxygen)
  - **Identification** of **sensitive Waterflow meters**. Fine adjustments of trigger thresholds (how: reducing the water pumps regime);
  - **Campaign to clean-up the water flow reducer** and filters (over 6 shutdown periods > 1 year);
  - **Expertise with CEA** (service de la corrosion et du comportement des matériaux dans leurs environnements)



Clogging @ Filter

In Situ brazing/ welding/soldering:

A 4 Hour Operation

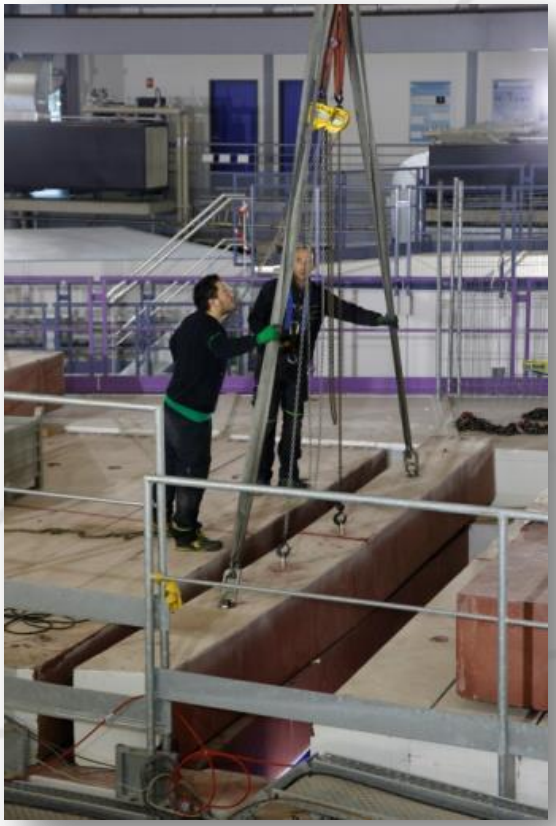


An incident with the handling of a Bean Roof

When handling one slab of the storage ring roof, the system malfunctioned and the slab hit the wall and broke.

Set up protections on machine equipment located just below. Left until the change of the slabs.

After analysis, technical expertise, added 4 additional anchor points.
Repositioning the slabs, without any problem.

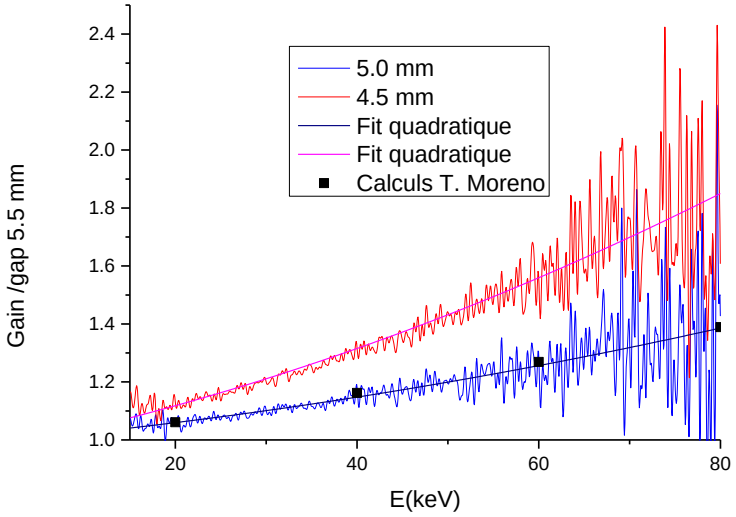


ZERO impact on the beam time.
Restarting of the beam as scheduled.
Replacement August 2019 & Spring 2020

Major R&D Projects

Increase of the photon flux for the PSICHÉ beamline

Reducing the WSV50 wiggler gap from 5.5 mm to 4.5 mm

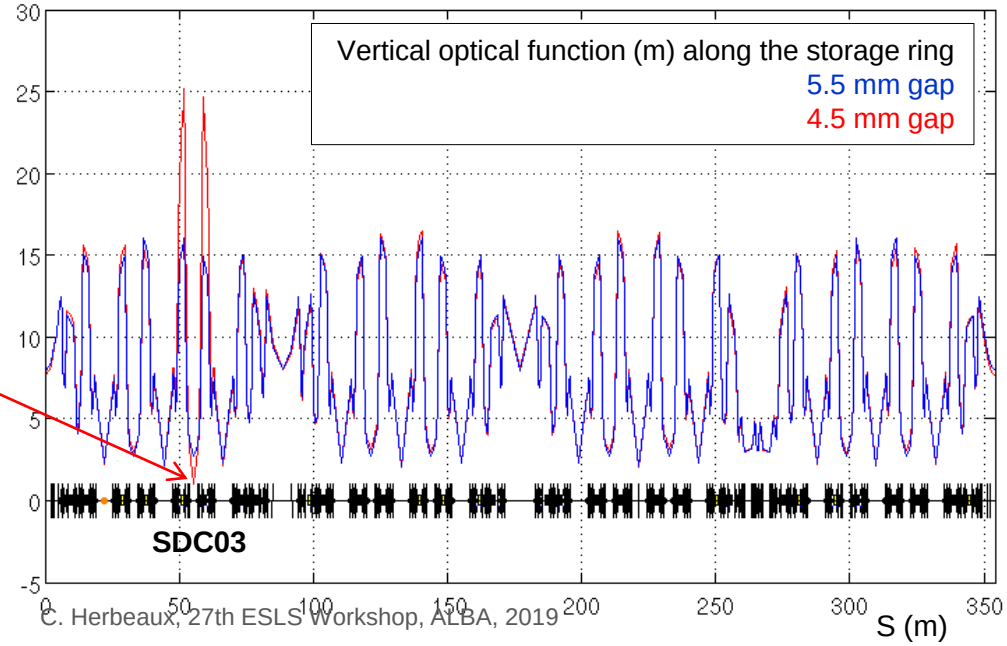


Measurement on air diffusion with a Ge solid detector (2015, June, 29th)

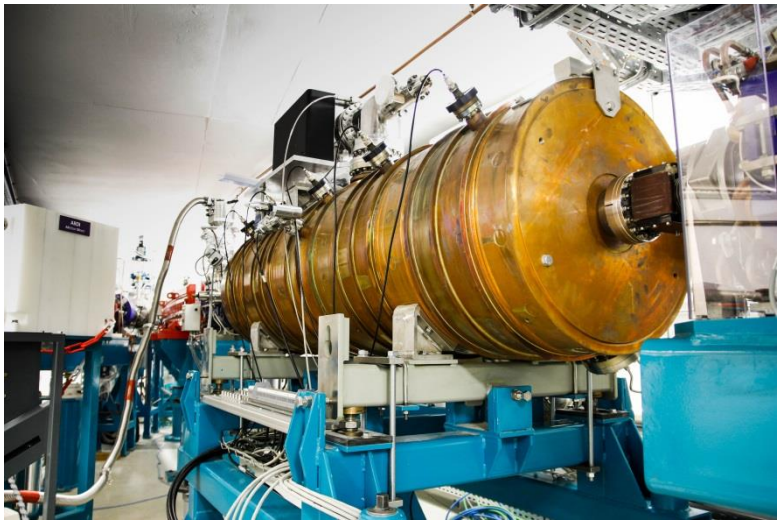
Intensity gain (as referred to 5.5 mm gap case) versus photon energy and comparison to calculations made by T. Moreno

The smaller gap leads to a local reduction of the physical aperture

A new optics was optimized to locally increase the vertical focusing and is **in operation since February 2019.**



Main RF activities in 2019



- ❑ **Installation of a 2nd Booster RF Cavity :**
- ✓ *In operation since beginning of 2018*
  → *Injection efficiency enhancement from 19 up to **35% in low-a mode***
- ✓ *redundancy in all the other modes of operation.*
- ❑ **Validation of the new Transverse Feedback (FBT) processor (SPring8/TED/SOLEIL)**
- ❑ ***Ongo*ing upgrades of the Storage Ring RF system**

  - Solid state power amplifiers (SSPA) → New transistors + improvement of the power combiners
    → Full completion scheduled for the 1st quarter of 2020.

  - New cavity input power couplers (P : 200 → 300 kW)

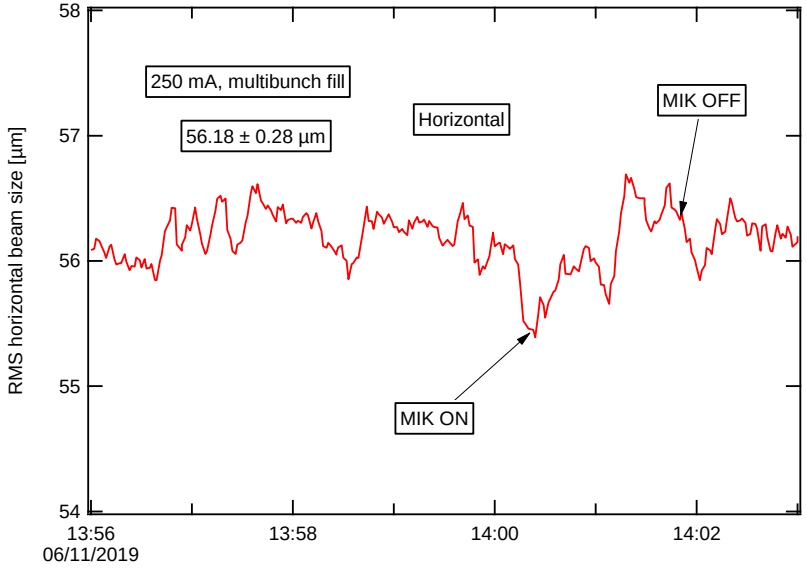
  - Modification of the wave guide network with the insertion of « Magic Switches »

At this stage, it is possible to store 450 mA with 1 of the 4 RF stations out of use.
After completing of the SSPA refurbishment (1st quarter 2020) → 500 mA with 1 of the 4 RF stations out of use or 450 mA using a single cryomodule and combing 2 SSPA on each cavity.

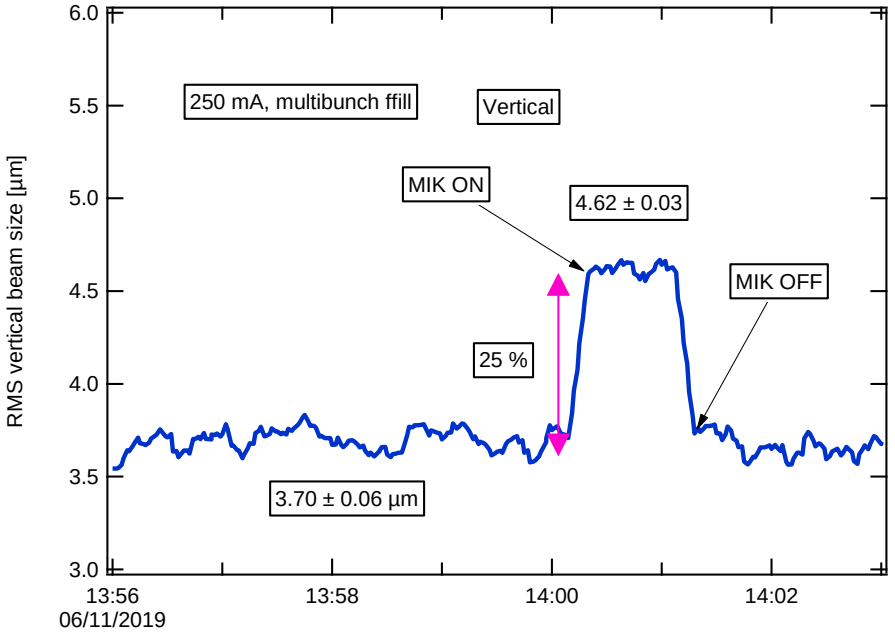
SOLEIL MIK @ MAXIV: Residual Stored Beam Perturbations

Transverse beam profile measured at diagnostic beamline while pulsing the MIK.

Values scaled to the centre of the long straight



Horizontal transparency $\lesssim$ **0.3 µm / 0.5 % σ**

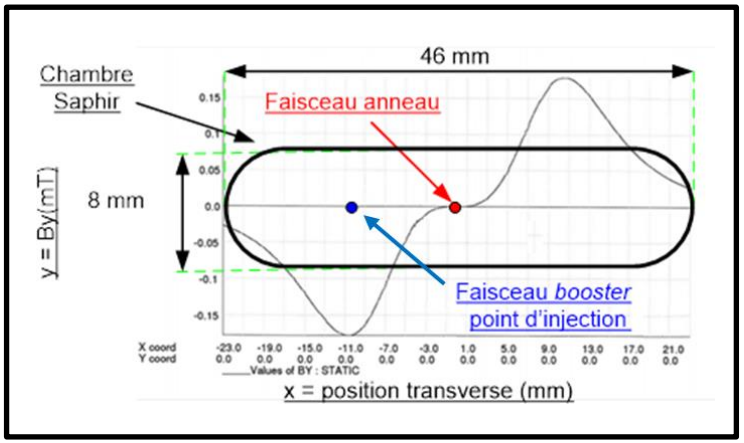


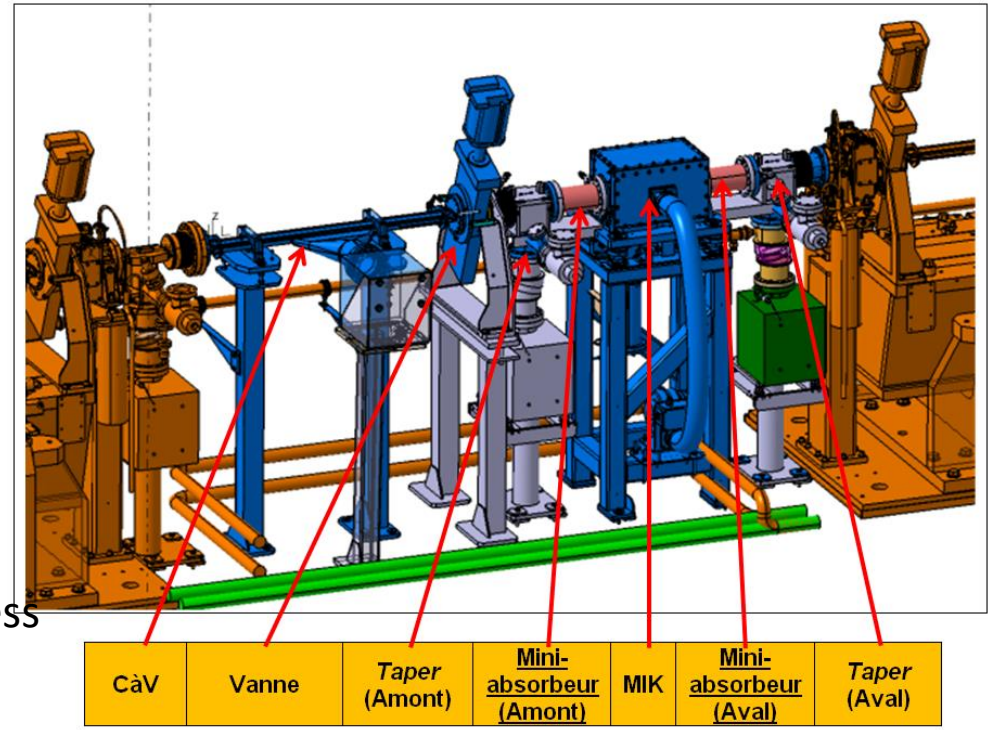
Vertical transparency $\lesssim$ **0.9 µm / 25 % σ**

Courtesy Pedro Tavares (MAX IV)

Installation of the MIK @ SOLEIL

Installation of the MIK in an available Short Straight Section.





Feedback from MAX IV

- Good Efficieincy
- Sustainable heating vs Ti coating thickness

Same geometry as the on installed at MAX IV

Objective :

Test the MIK concept on SOLEIL : efficiency, orbit perturbation.

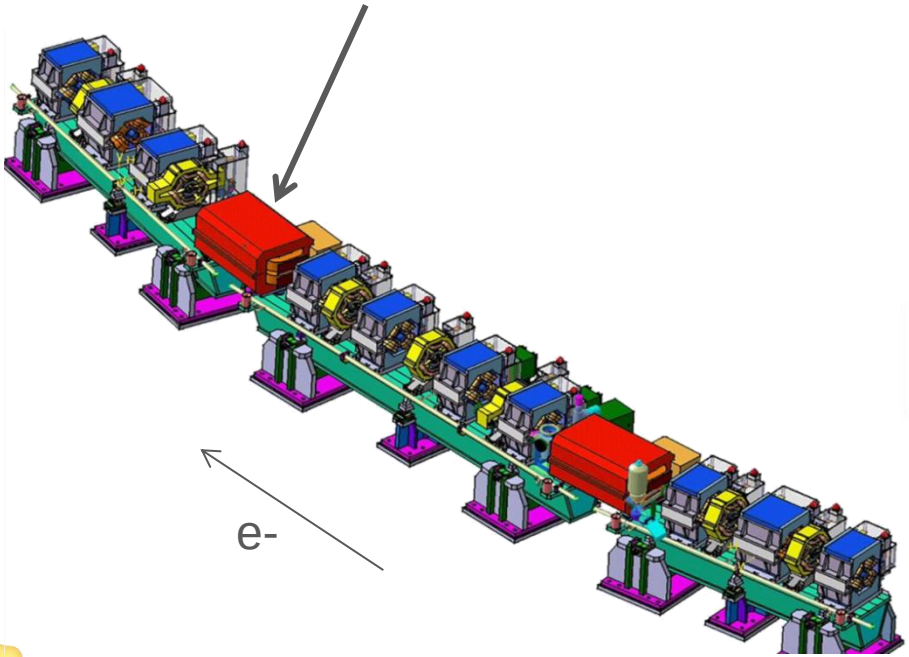
Test of injection schemes in the framework of the upgrade studies

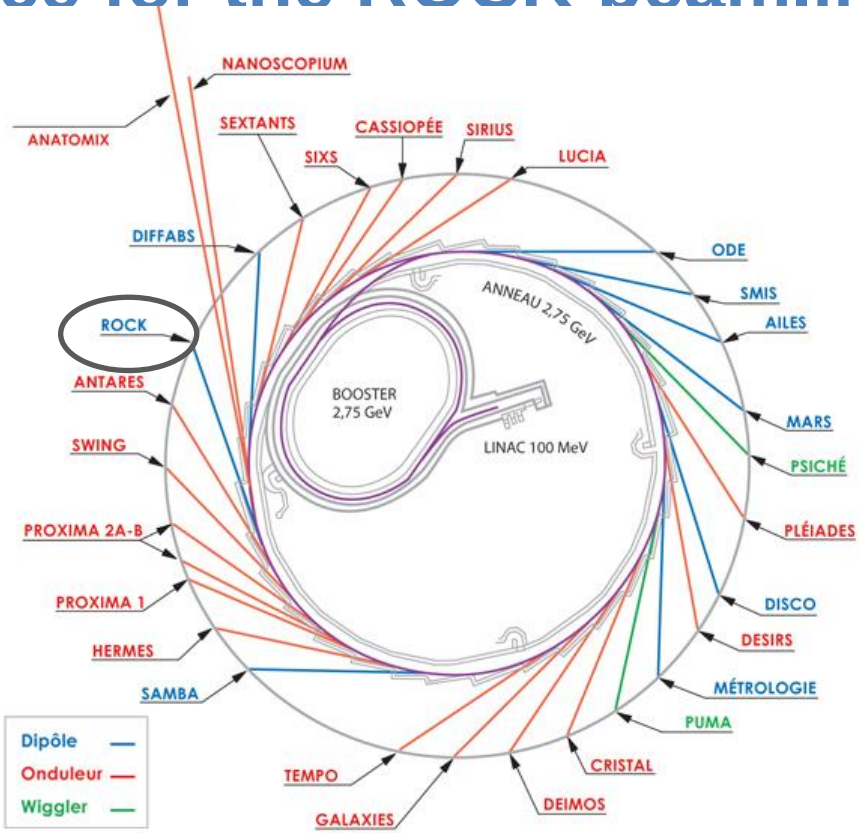
On axis Injection with Transverse kick combined with longitudinal kick with the RF

Courtesy of Rachid Ben El-Kefih

New photon source for the ROCK beamline

Present source : Bending magnet 1.7 T
Horizontal aperture 1.5 mrad

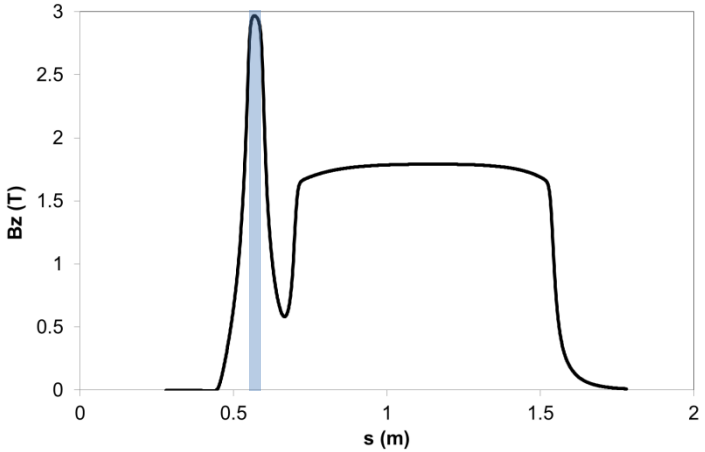


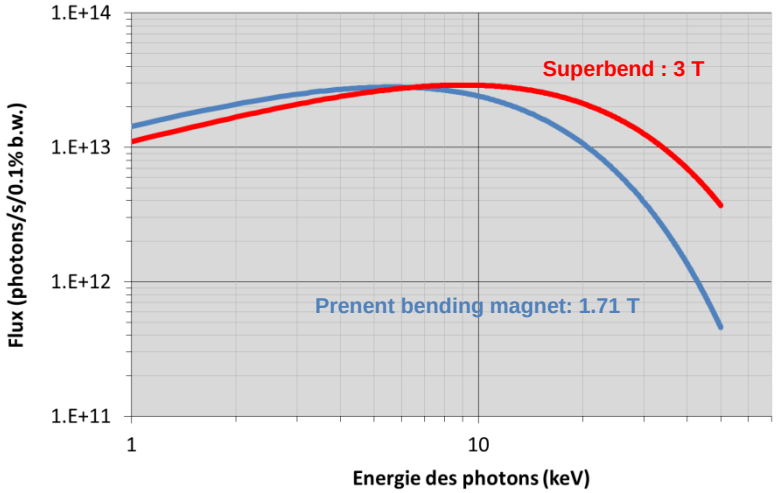


3T Superbend Project

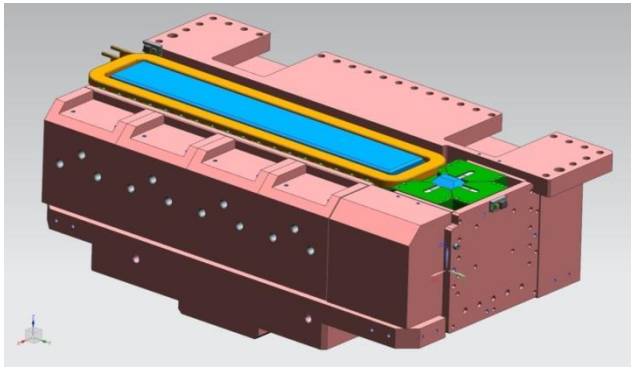
Permanent magnet dipole(NdFeB)

Length 1.260 m

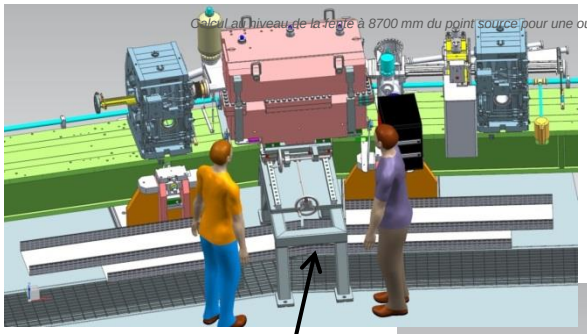




Gap **16.1 mm** B = **2.84 T**	Gap **23 mm** B = **1.81 T**



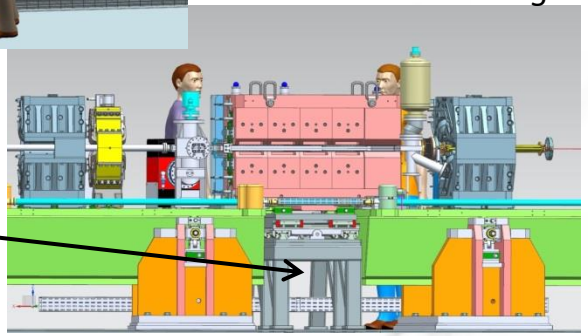
Courtesy of Pascale Brunelle



Inside storage ring

A C shape yoke which allow the removal of the magnet for bake out

Outside the storage ring



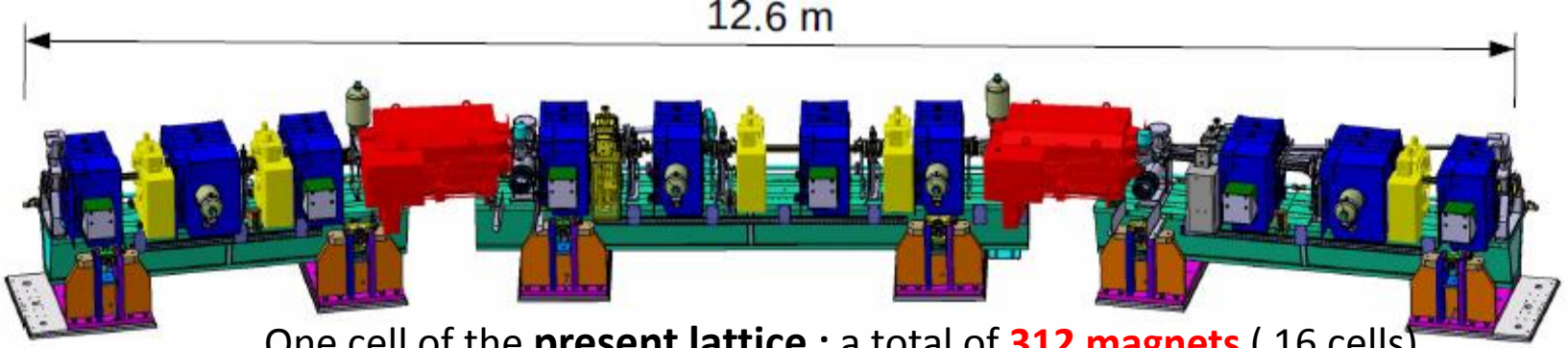
Magnet remove devide for bake out

Conceptual Design for A Major Upgrade

C. Herbeaux, 27th ESLS Workshop, ALBA, 2019

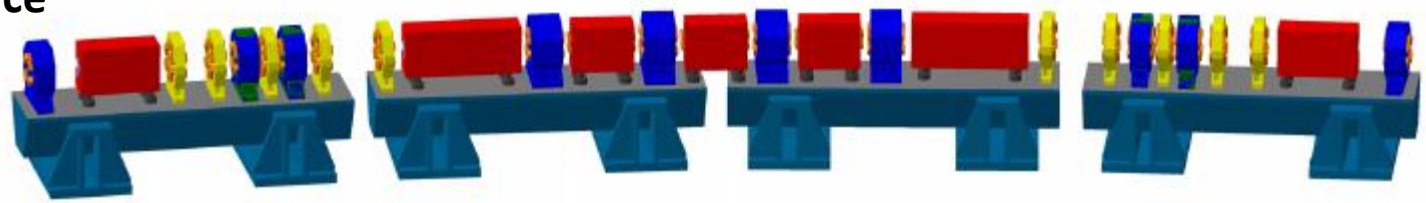
Boundary Conditions and Constraints

- Reduce by more than a **factor 30 or 40** the horizontal electron beam emittance (in the order of **100 pm.rad**).
- **Reuse** of the existing tunnel and its **radiation shielding wall**.
- Maintain the existing insertion device source points **as much as possible**.
- Keep a storage ring energy that covers a **very broad photon energy range**.
- Preserve a current of **500 mA** in multibunch operation.
- Preserve **time structure** and **time resolved** operations.
- **Reuse** as much as possible of the **injector complex**: linac and booster.
- **Reuse** much of the **technical infrastructure**.
- Provide alternative radiation sources for the existing **bending magnet based beamlines.**
- **Innovative insertion devices** to cover low to high energy spectrum (IVU: ≤ 4mm full gap)
- Preserve **Infra-Red (IR) beamlines**
- Preserve the location of the **MARS radioactive beamline**
- Preserve the location of **long canted beamlines (150/200 m long BL)**
- Limit downtime to a **maximum of two years**.
- **Minimize operation costs**, in particular the wall-plug-power.



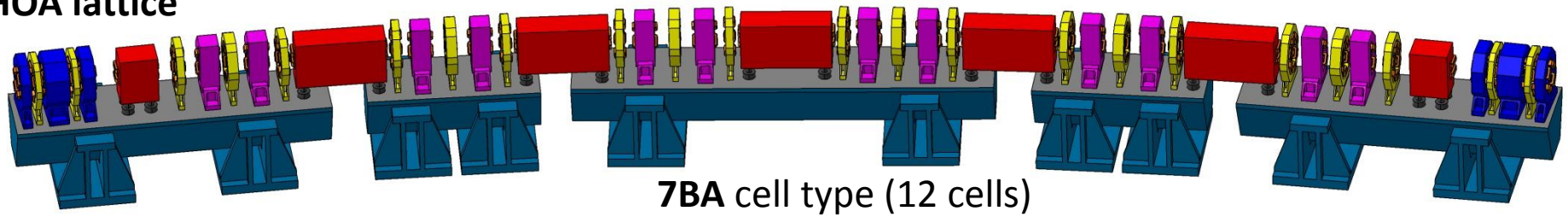
One cell of the **present lattice :** a total of **312 magnets** (16 cells)

HYBRID lattice

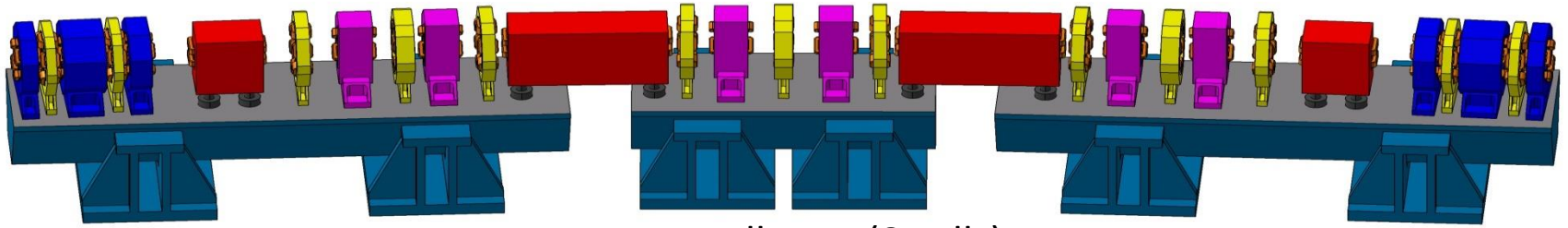


One cell of the **7BA Hybrid** : a total of ~**620 magnets** (20 cells)

HOA lattice



7BA cell type (12 cells)



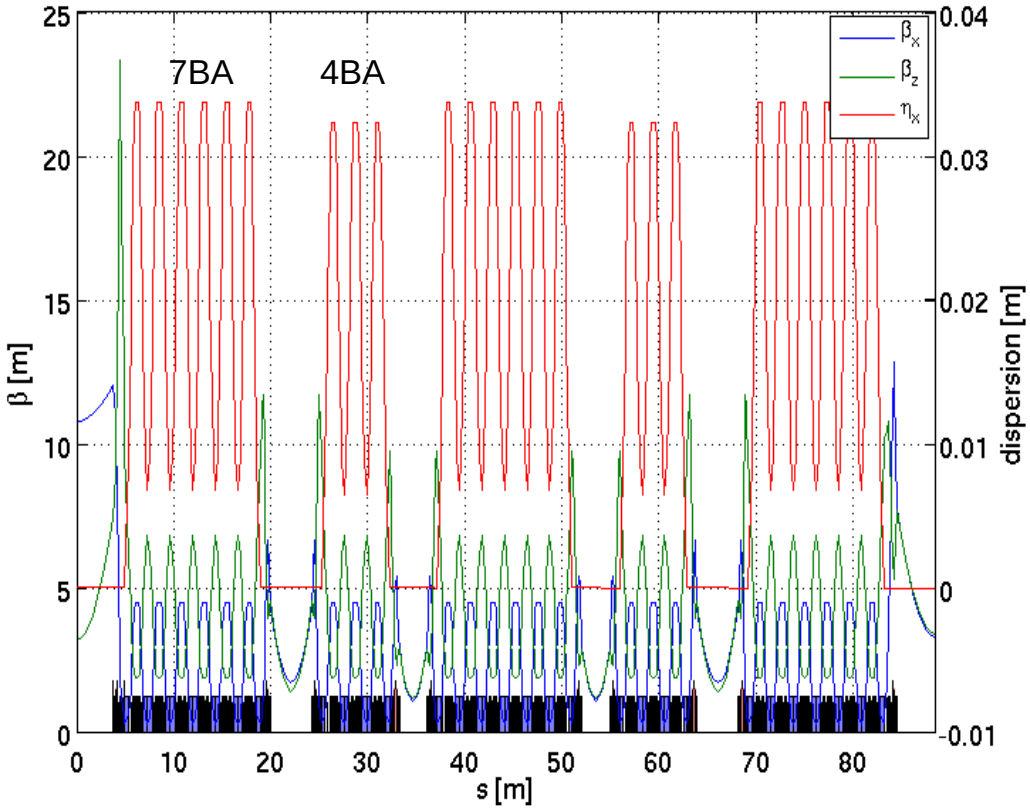
4BA cell type (8 cells)

A total of ~ **1200 magnets**

Lattice: Combinaison of 4BA and 7 BA

- **Strong Geometry Constraints**
  - ✓ **No modification** of the shielding walls.
  - ✓ **All hutches** are preserved.
  - ✓ Zero radial offset for the three beamlines from the long straight sections (canted insertions).
  - ✓ Radial shift for the other beamlines on insertion devices: (**still on progress**)
    - -114 mm (4 beamlines)
    - +/- 37 mm or 42 mm (10 beamlines)

1/4 of the ring



- **Symmetry 2**, 20 straight sections
  - 8 x 2.8 m
  - 8 x 4.2 m
  - 2 x 7.7 m and 2 x 7.3 m

R&D to Alleviate Any Technological Showstopper

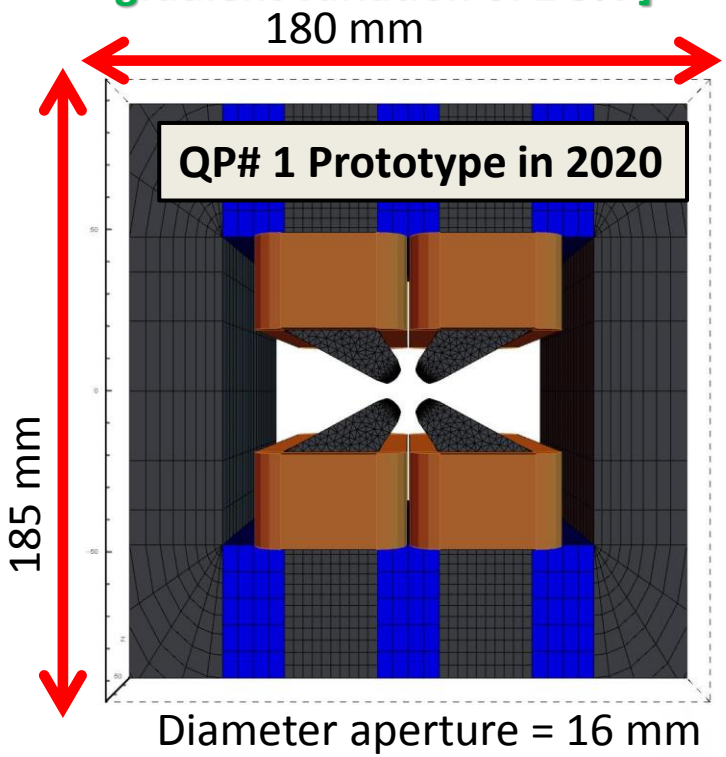
- Magnet (PM, 100 T/m quadrupole, 7OOO T/m² sextupole)
- Vacuum System (10 mm tube, desorption / NEG)
- Low-energy Undulator (5 eV-40eV)
- RF system (fundamental and harmonic)

Magnet Strategy

Modular Approach
Inspired by N'Gotta PhD Dissertation

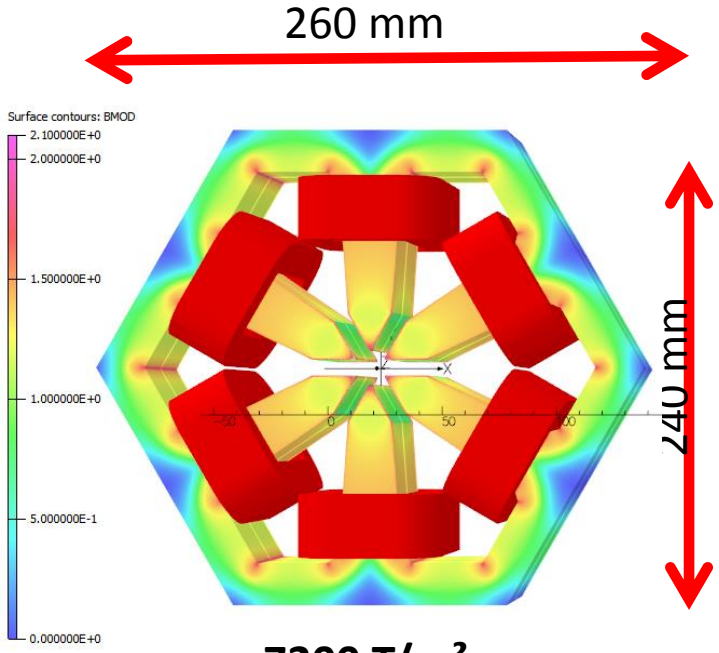
- **Use of permanent magnets beyond dipole: dipole, quadrupole, reverse bend**
- **Reduce Power on plug.**

[Permanent Magnet with coil allowing gradient variation of ± 5%]



Diameter aperture = 16 mm

[Sextupole: Electromagnetic]



7200 T/m²

Prototype in 2021

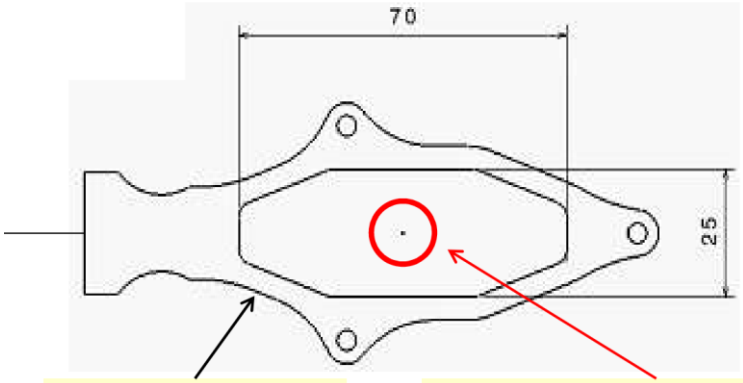
Magnet	QP #1	QP # 2	QP #3	QP #4	QP #5	QP #6
L meca (mm)	54.9	73.2	91.5	134.2	189.1	195.2
G int (T)	6.18	8.55	10.93	16.48	23.62	24.41
G (T/m)	96.5	104.2	109.3	116.1	120.6	120.9
Diff. with spec. (%)	-0.68	0.29	0.11	0.51	-0.76	-0.27

÷ 6.1m

Permanent magnet size: 20 mm x 49 mm x 6.1 mm

Vacuum System

Drastic reduction of the size of the vacuum chambers



SOLEIL today
Standard vac. Chamber
Qpole, Spole

SOLEIL UPGRADE project
center achromat
ø 10 mm internal diameter

- *Traditional linear distributed pumping not possible.*
- *Less « standard » pumping space available (only few ionic pumps along the ring!).*
- *More than **95 %** of the ring chambers must be NEG coated.*
- ***10 mm** inner diameter chambers foreseen along the lattice (not only on straight section).*

Comparison with new Synchrotron Light Sources *worldwide*

Facility	Mag. Bore(mm)	Chamber Material	Baking Method
MAX-IV (Sweden)	25	OFS Cu (100% NEG Coating)	Ex-situ
SIRIUS (Brazil)	28	OFS Cu (100% NEG Coating)	In-situ
EBS (France)	26	SST/Al (Partial NEG Coating)	In-situ
SPring-8_U (Japan)	26	SST (No NEG Coating)	Ex-situ
APS_U (USA)	26	OFS Cu/Al (Partial NEG Coating)	Ex-situ

*P. He, Proceedings of **IPAC2017**, Copenhagen, Denmark*

SOLEIL UPGRADE project and challenges:

Magnetic bore of 16 mm needed for high gradient magnets required for targeted emittance

Balance between Photon Stimulated Desorption yield η & the NEG Pumping speed / saturation-capacity

→ For 10 mm diameter chamber ←

What would be the dynamic pressure and its evolution with the photon DOSE

↓

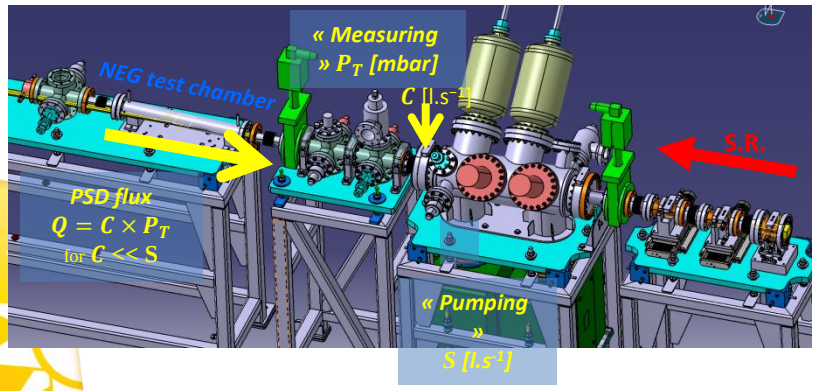
2 TEST BENCH launched @SOLEIL

On the ring

PSD η / ***Dose*** of photons

- Activation NEG with SR ?
- Pumping CH4?

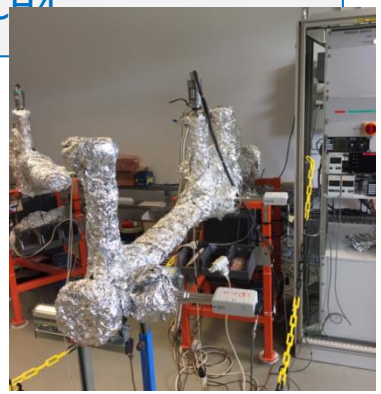
(First measurements in June 2020)



In the LAB

- **Intrinsic pumping speed of the NEG S^{NEG}**
- **Capacity/saturation**

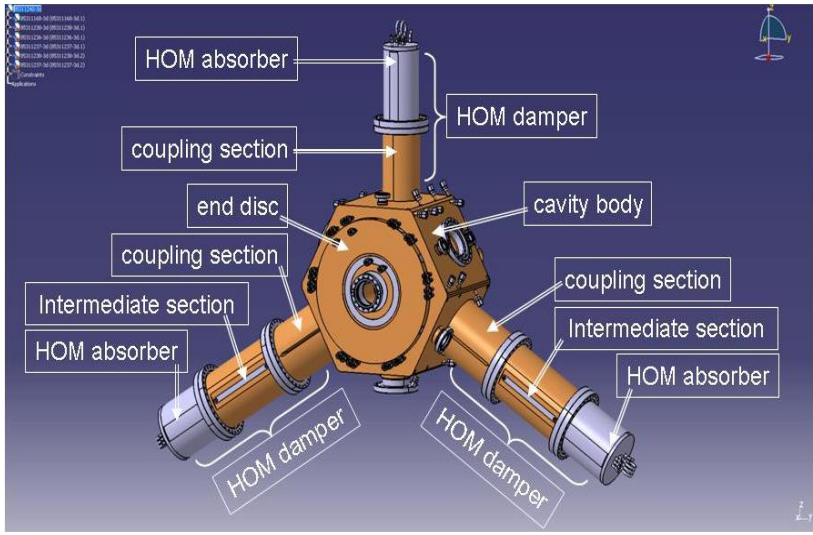
with Injection gaz pur/µleak H2, CO, CO2, CH4

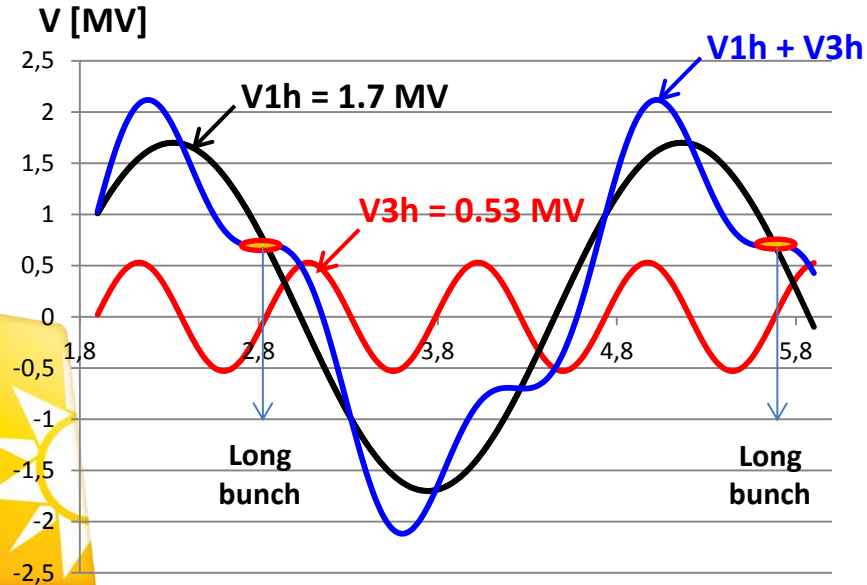


RF System

- **Main RF cavity**: use 4 Normal Cavities (ESRF-EBS type is a good candidate) in a 4.2 m straight → P_{RF} = 4 x 75 kW
- Redundancy : one can easily meet the requirements with only 3 of the 4 cavities in use.

- **Harmonic RF system**: h = 3, 4 or 5. The favored one is presently a passive SC system, based on the Super3HC CM.





Super3HC CM.

A Tentative Schedule for An Upgrade

Date	Phase
Dec. 2016	Council meeting, presentation of the first proposal for an upgrade.
2017 - 2019	Discussions regarding the definition of the project (beamlines and storage ring); definition of objectives. Baseline Lattice defined.
2018 - 2019	Continuation of discussions and prototyping to assess feasibility of key options.
2019	**Decision to launch a Conceptual Design Report (CDR).**
2019-2020	CDR based on preliminary studies and prototyping. New Baseline Lattice.
2021	**Decision to launch a Technical Design Report (TDR).**
2021-2022	Technical Design Report.
2023	**Decision to start the project.**
2023-2026	Reconstruction of storage ring and beamlines.
2027	Restart of user operation.

CONCLUSION

- The main metrics of the machine operation: availability of the beam for the users (98.8%), mean time between failures (95h) and mean time to recover (1h) are all at a very good level and among the best light sources.

- Ambitious and innovative R&D projects are conducted either to enhance the performances of the present Machine (second RF cavity
in the Booster), to improve the flux at high photon energy (Rock and Psiche beamlines) or to validate new schemes for the upgrade (injection scheme).

- The upgrade of Soleil is in its CDR phase. The definition of the baseline lattice, the first engineering studies and prototyping are under progress.

Thank you for your attention

Questions?

Annexes

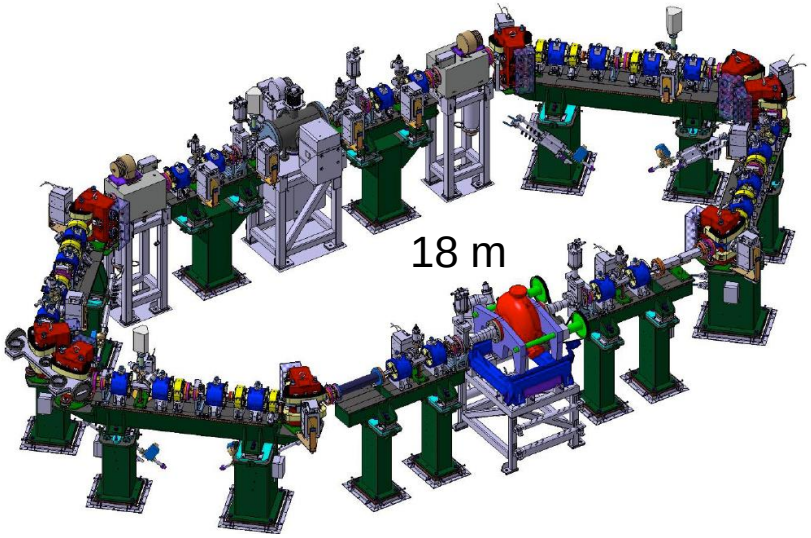
Courtesy of A. Loulergue

Compton Back Scattering X-ray Source

Electron: 1 bunch, 1 nC, 20 to 70 MeV max
Rep = 20 MHz in a ring

Laser: 1 pulse, 10 – 30 mJ max
Rep = 40 MHz in FP cavity

X-Flux: up to 90 keV
up to 10^{13} Photon/s



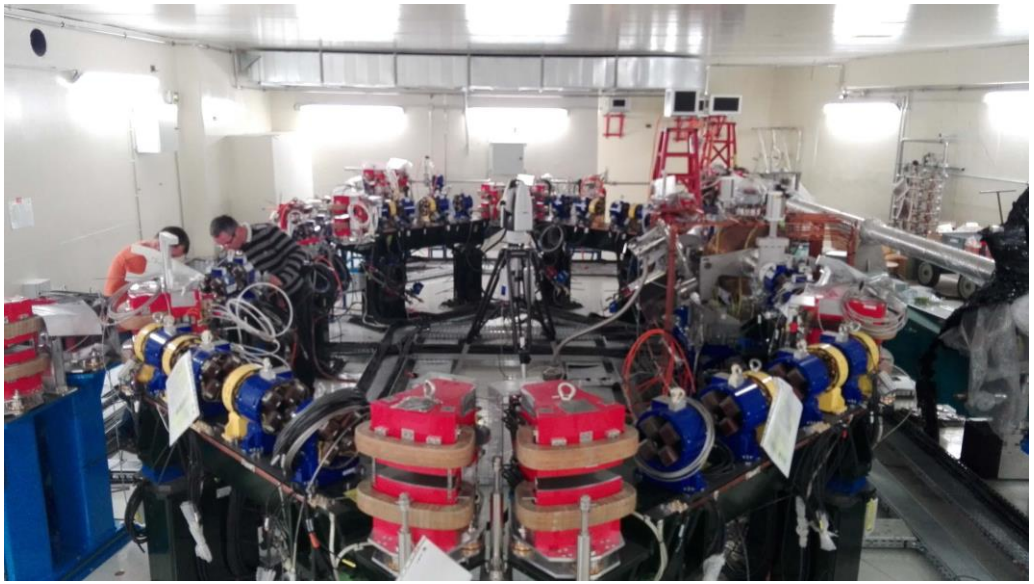
Status

All installation should end by March-2020

Commissioning: (Show-stopper ASN)

Linac	**March – 2020**
Fabry-Perot cavity	**April – 2020**
Ring	**Spring – 2020**

First photon by end of 2020



Installation almost completed
Missing pulsed magnets and few connecting pipes