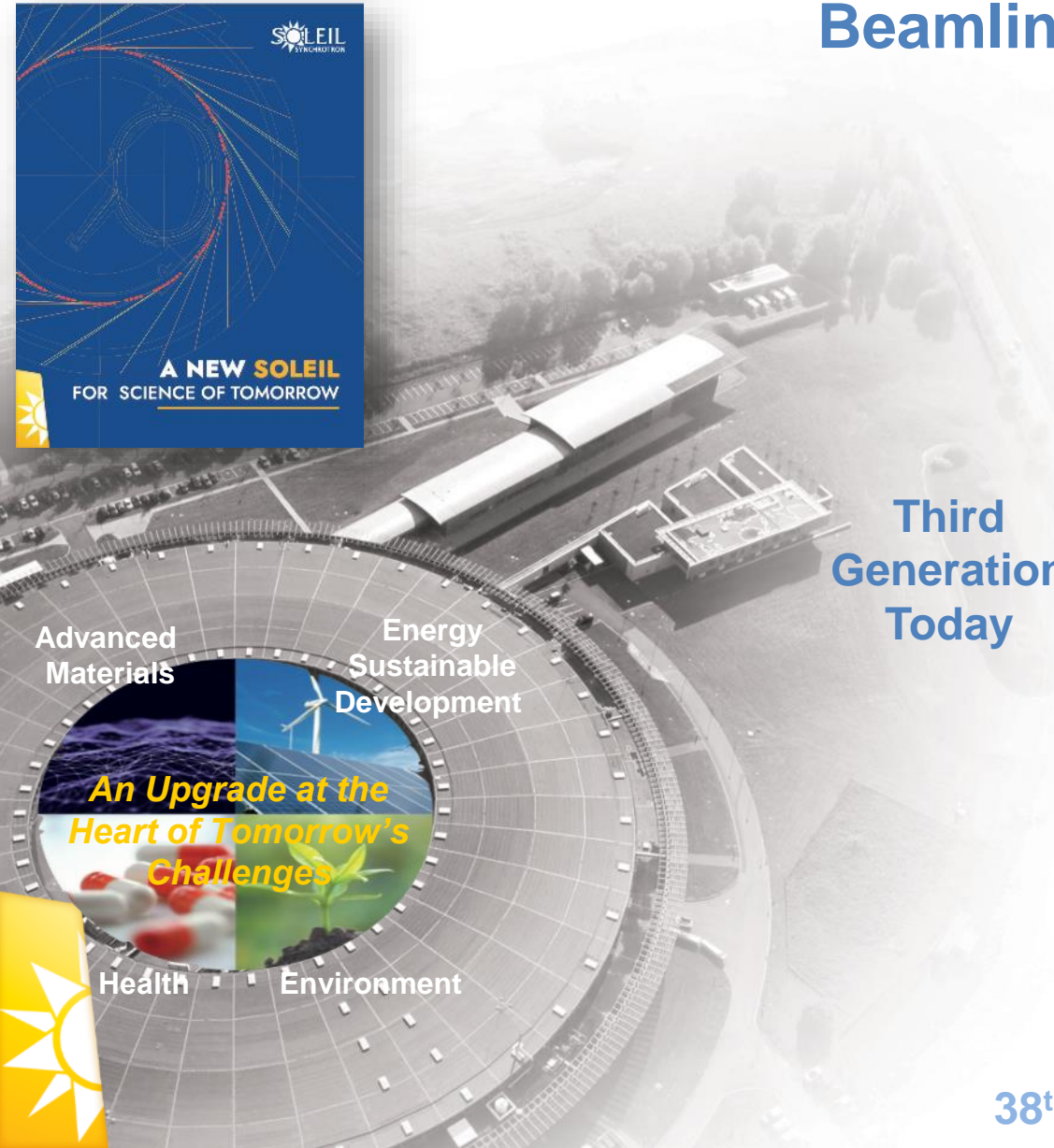
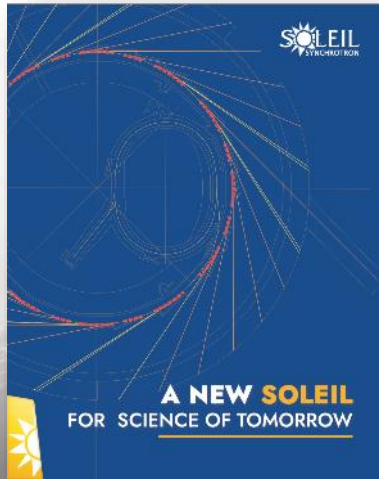
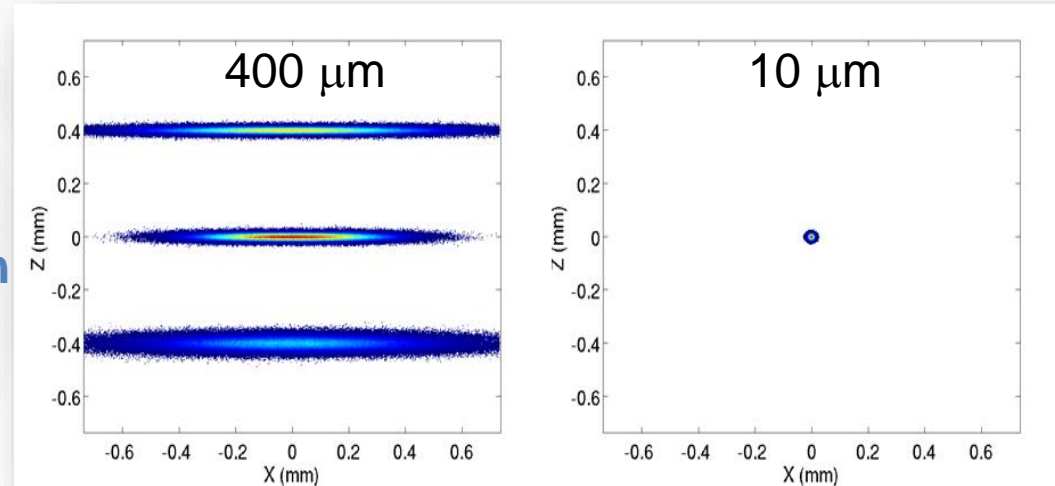


Towards SOLEIL II: An Ambitious Upgrade for Accelerators, Beamlines, Laboratories and Digital Transformation

Amor Nadji



Third Generation Today



Fourth Generation Tomorrow

SOLEIL SOLEIL II

Advanced Materials

Energy Sustainable Development

An Upgrade at the Heart of Tomorrow's Challenges

Health

Environment



- Storage Ring 354 m, 2.75 GeV
- 29 Beamlines
- Open to Users since 2008
- Annual Budget ~63 M€
- ~ 450 employees

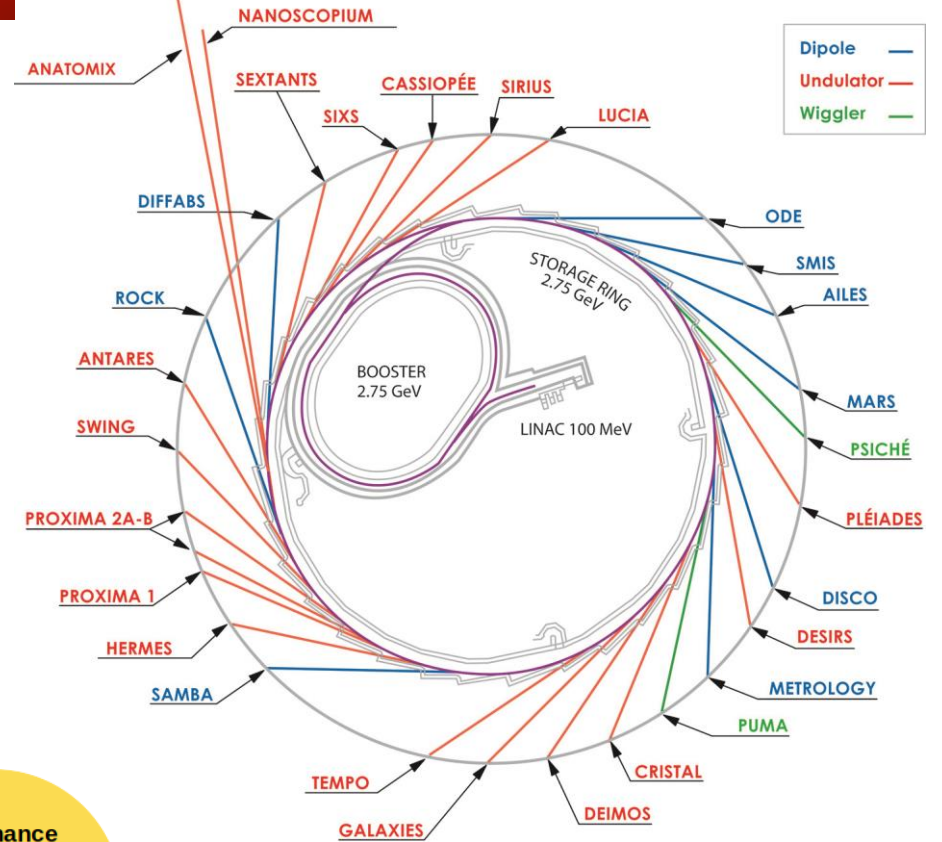
cnrs
dépasser les frontières

72%

DE LA RECHERCHE À L'INDUSTRIE

cea

28%



4 129
passages
d'utilisateurs

2 620
utilisateurs
(individus) par an
venant de ~1000
laboratoires
Plus de 29000
utilisateurs
depuis 2008

**Provenance
des utilisateurs**
65% de France
26% de l'Union Européenne
9% du reste du monde

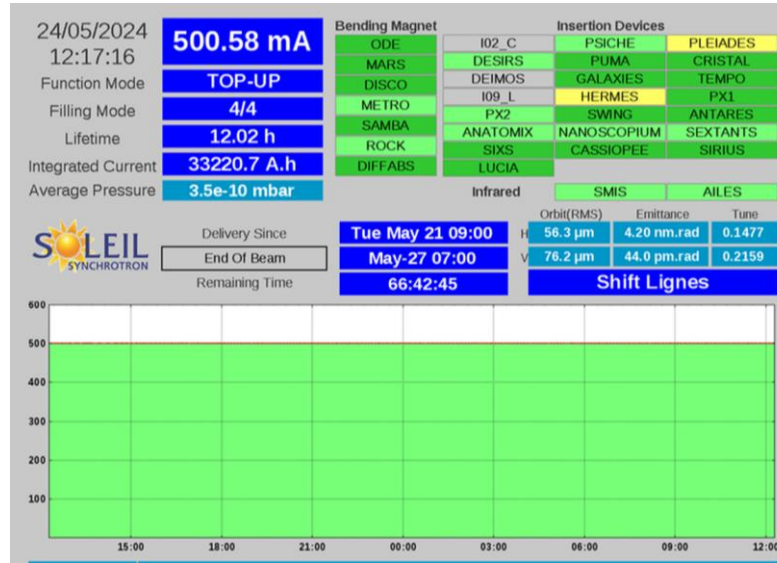
+ 1 CRYO-EM microscope

Beam Schedule in 2024

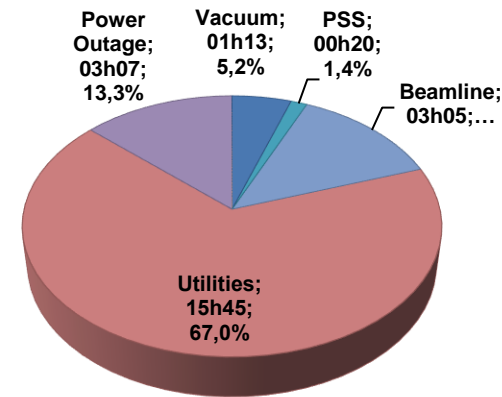
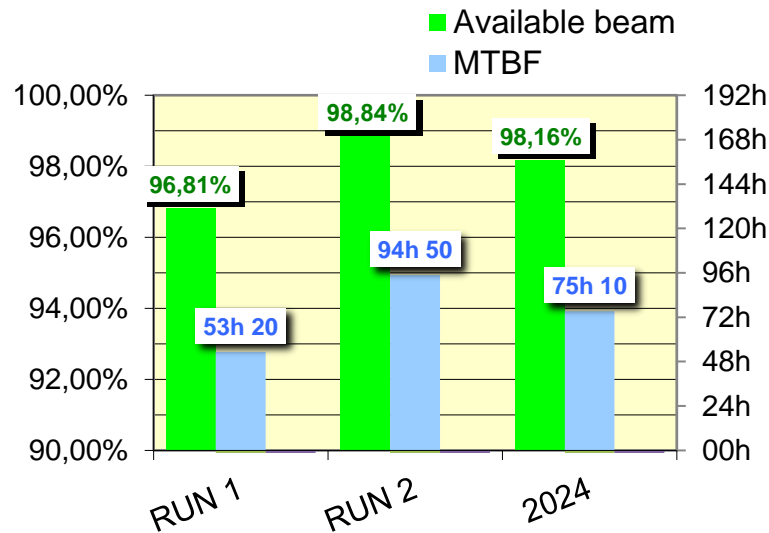
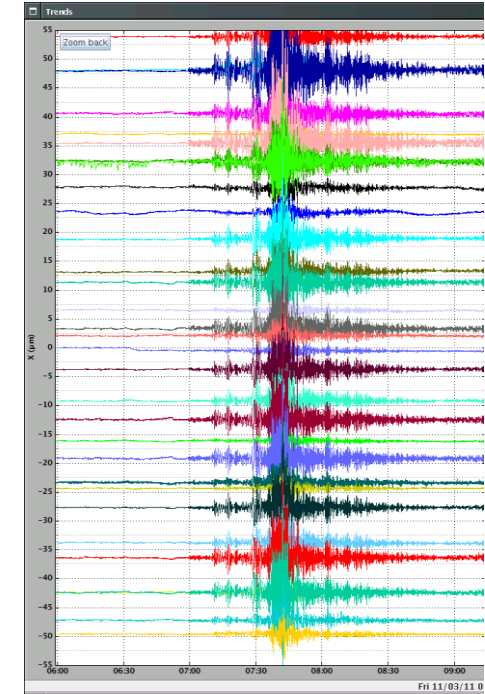
janv 2024	févr 2024	mars 2024	avr 2024	mai 2024	juin 2024	juil 2024	août 2024	sept 2024	oct 2024	nov 2024	déc 2024
dim 01	jeu 01	ven 01	sam 01	dim 01	jeu 01	ven 01	dim 01	jeu 01	ven 01	dim 01	jeu 01
mar 02	dim 02	jeu 02	ven 02	dim 02	jeu 02	ven 02	dim 02	jeu 02	ven 02	dim 02	jeu 02
mer 03	dim 03	jeu 03	ven 03	dim 03	jeu 03	ven 03	dim 03	jeu 03	ven 03	dim 03	jeu 03
jeu 04	dim 04	jeu 04	ven 04	dim 04	jeu 04	ven 04	dim 04	jeu 04	ven 04	dim 04	jeu 04
ven 05	dim 05	jeu 05	ven 05	dim 05	jeu 05	ven 05	dim 05	jeu 05	ven 05	dim 05	jeu 05
sam 06	dim 06	jeu 06	ven 06	dim 06	jeu 06	ven 06	dim 06	jeu 06	ven 06	dim 06	jeu 06
dim 07	dim 07	jeu 07	ven 07	dim 07	jeu 07	ven 07	dim 07	jeu 07	ven 07	dim 07	jeu 07
lun 08	dim 08	jeu 08	ven 08	dim 08	jeu 08	ven 08	dim 08	jeu 08	ven 08	dim 08	jeu 08
mar 09	dim 09	jeu 09	ven 09	dim 09	jeu 09	ven 09	dim 09	jeu 09	ven 09	dim 09	jeu 09
mer 10	dim 10	jeu 10	ven 10	dim 10	jeu 10	ven 10	dim 10	jeu 10	ven 10	dim 10	jeu 10
jeu 11	dim 11	jeu 11	ven 11	dim 11	jeu 11	ven 11	dim 11	jeu 11	ven 11	dim 11	jeu 11
ven 12	dim 12	jeu 12	ven 12	dim 12	jeu 12	ven 12	dim 12	jeu 12	ven 12	dim 12	jeu 12
sam 13	dim 13	jeu 13	ven 13	dim 13	jeu 13	ven 13	dim 13	jeu 13	ven 13	dim 13	jeu 13
dim 14	dim 14	jeu 14	ven 14	dim 14	jeu 14	ven 14	dim 14	jeu 14	ven 14	dim 14	jeu 14
lun 15	dim 15	jeu 15	ven 15	dim 15	jeu 15	ven 15	dim 15	jeu 15	ven 15	dim 15	jeu 15
mar 16	dim 16	jeu 16	ven 16	dim 16	jeu 16	ven 16	dim 16	jeu 16	ven 16	dim 16	jeu 16
mer 17	dim 17	jeu 17	ven 17	dim 17	jeu 17	ven 17	dim 17	jeu 17	ven 17	dim 17	jeu 17
jeu 18	dim 18	jeu 18	ven 18	dim 18	jeu 18	ven 18	dim 18	jeu 18	ven 18	dim 18	jeu 18
ven 19	dim 19	jeu 19	ven 19	dim 19	jeu 19	ven 19	dim 19	jeu 19	ven 19	dim 19	jeu 19
sam 20	dim 20	jeu 20	ven 20	dim 20	jeu 20	ven 20	dim 20	jeu 20	ven 20	dim 20	jeu 20
dim 21	dim 21	jeu 21	ven 21	dim 21	jeu 21	ven 21	dim 21	jeu 21	ven 21	dim 21	jeu 21
lun 22	dim 22	jeu 22	ven 22	dim 22	jeu 22	ven 22	dim 22	jeu 22	ven 22	dim 22	jeu 22
mar 23	dim 23	jeu 23	ven 23	dim 23	jeu 23	ven 23	dim 23	jeu 23	ven 23	dim 23	jeu 23
mer 24	dim 24	jeu 24	ven 24	dim 24	jeu 24	ven 24	dim 24	jeu 24	ven 24	dim 24	jeu 24
jeu 25	dim 25	jeu 25	ven 25	dim 25	jeu 25	ven 25	dim 25	jeu 25	ven 25	dim 25	jeu 25
ven 26	dim 26	jeu 26	ven 26	dim 26	jeu 26	ven 26	dim 26	jeu 26	ven 26	dim 26	jeu 26
sam 27	dim 27	jeu 27	ven 27	dim 27	jeu 27	ven 27	dim 27	jeu 27	ven 27	dim 27	jeu 27
dim 28	dim 28	jeu 28	ven 28	dim 28	jeu 28	ven 28	dim 28	jeu 28	ven 28	dim 28	jeu 28
lun 29	dim 29	jeu 29	ven 29	dim 29	jeu 29	ven 29	dim 29	jeu 29	ven 29	dim 29	jeu 29
mar 30	dim 30	jeu 30	ven 30	dim 30	jeu 30	ven 30	dim 30	jeu 30	ven 30	dim 30	jeu 30
mer 31	dim 31	jeu 31	ven 31	dim 31	jeu 31	ven 31	dim 31	jeu 31	ven 31	dim 31	jeu 31

M Uniforme ou Hybride Top-Up 450 ou 500 mA \ Uniform or Hybrid Top-Up 450 or 500 mA
U Uniforme Top-Up 450 ou 500 mA \ Uniform Top-Up 450 or 500 mA
H Hybride Top-Up 450 mA \ Hybrid Top-Up 450 mA
S 1 paquet Top-Up 16 mA \ 1 bunch Top-Up 16 mA
B Beamlines
Cp Contrôles RP périodiques, 2 mardis de 7h à 23h \ Periodic RP tests, 2 Tuesdays from 7 a.m. to 11 p.m.
Tv Tests RP de validation possibles, faisceau Lignes redonné à 10h \ Radiation test possible, Beam given to Beamlines à 10 a.m.
A Temps Accélérateurs \ Machine tests
Ar Arrêt Machine \ shutdown

Top-up injection



Excellent beam stability.
High sensitivity (effect of earthquake in Japan)



A New Chilled Water Production Station (T7)



- The station is in operation for the accelerators and beamlines since January 2024.
- Installing dry and wet coolers to reduce drinking water consumption by 80% compared to an equivalent capacity tower.
- Reducing energy consumption by using a 'free cooling' operating mode that enable to reduce the station's overall electricity consumption by 35%.

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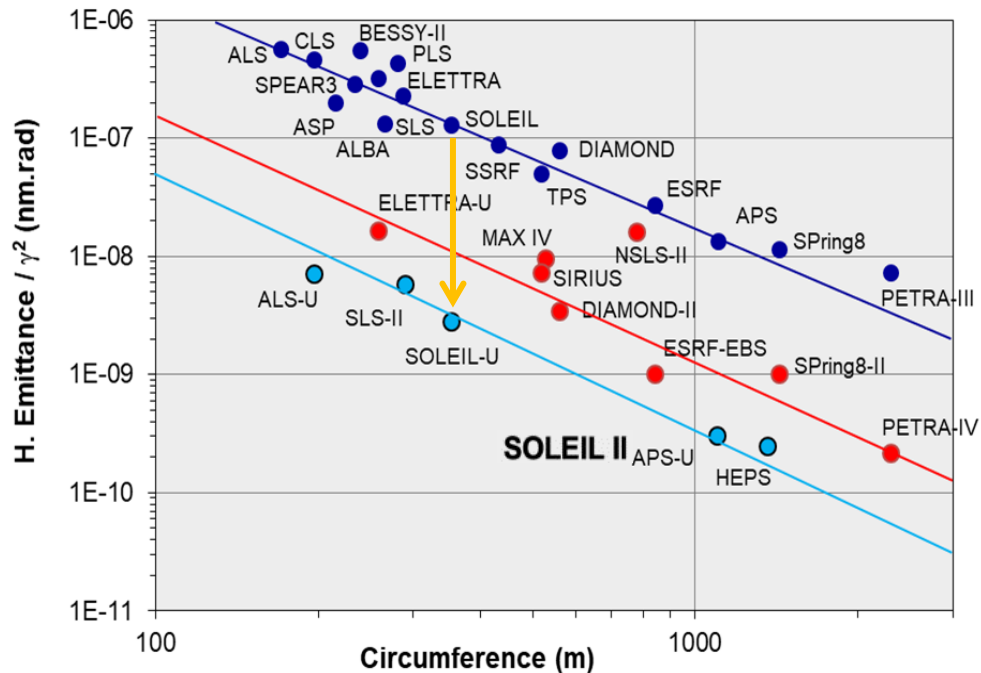


Why moving towards 4th generation SR sources?

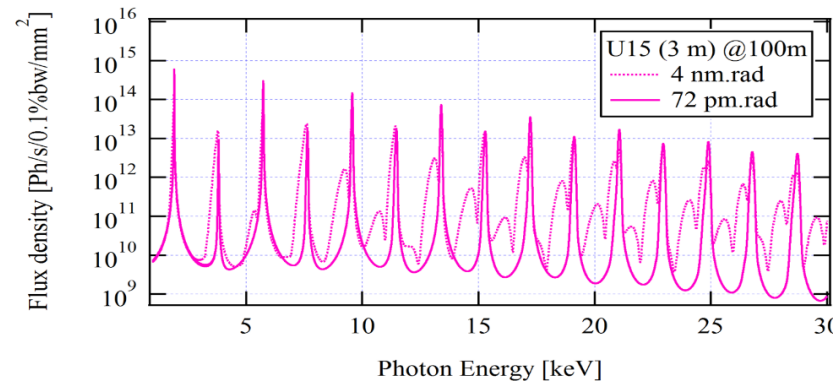
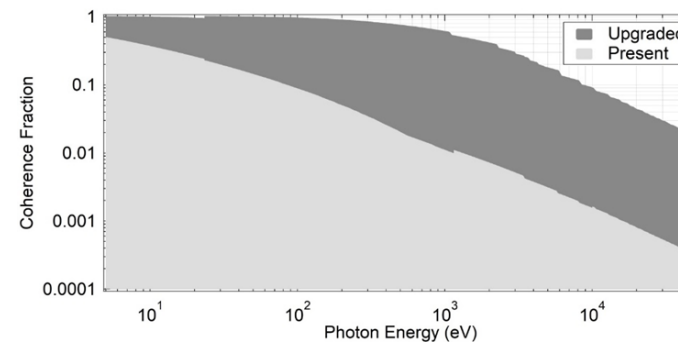
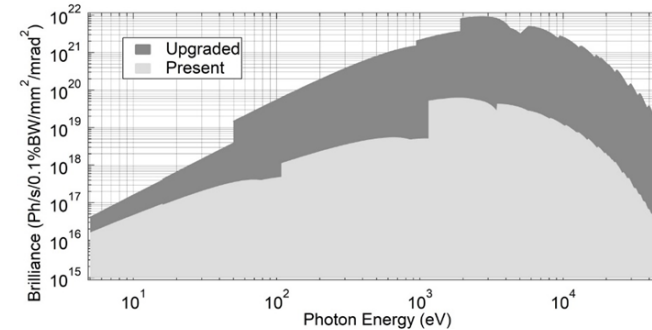
SOLEIL II Performance Expectation

$$B_{avg}(\lambda) \propto \frac{N_{ph}(\lambda)}{(\varepsilon_x(e^-) \oplus \varepsilon_r(\lambda))(\varepsilon_y(e^-) \oplus \varepsilon_r(\lambda))(s \cdot \% BW)}$$

Maximizing the X-ray **Brilliance** and **Coherence** requires minimizing the electron beam emittance!



$$\varepsilon_x \approx F(\text{maille}) \frac{E^2}{N^3}$$



EXPERIMENTS UP TO
10,000 TIMES FASTER

**NANOSCALE
RESOLUTION**

STUDY OF DEVICES
**IN REAL OPERATING
CONDITIONS**

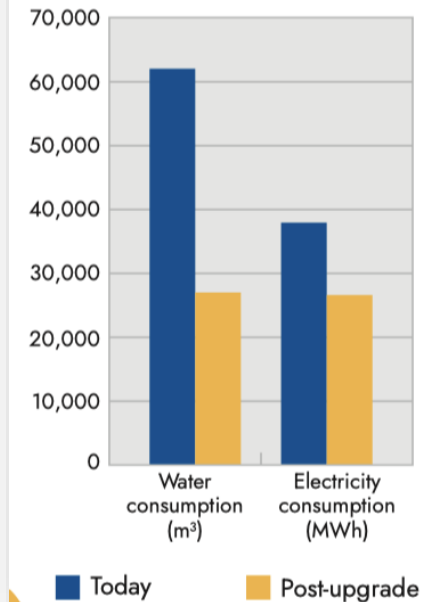
UNIQUE LIGHT SOURCE,
**FROM INFRARED
TO HARD X-RAYS**

EXPERIMENTS UP TO
**1000 TIMES MORE
SENSITIVE**

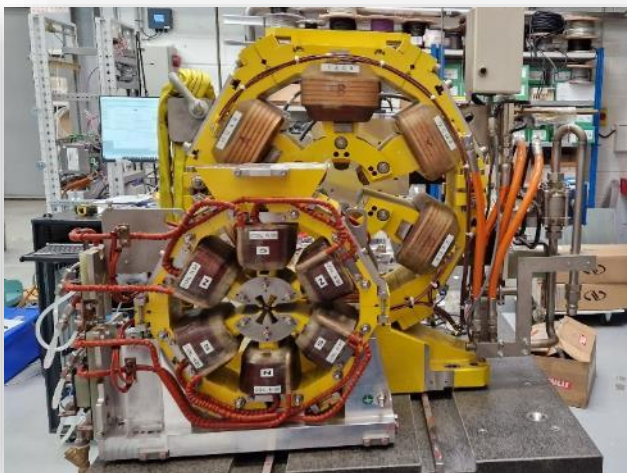
**COMPLEMENTARY
BEAMLINES
AND TECHNIQUES**

1. Non-standard MBA lattice: 12 x 7BA + 8 x 4BA / 2.75 GeV / 354 m / 500 mA
2. ~83 pm.rad (~50 pm.rad round beam as ultimate goal).
3. 22 straight sections (7 different lengths).
4. Large photon spectrum (far IR to hard X-rays).
5. NEG coated very small vacuum chamber diameter (12 mm)
6. Extensive use of permanent magnets (all dipoles, RB and main quadrupoles).
7. Miniaturization.
8. Off-axis injection.
9. High performance Multipole Injection Kicker (MIK).
10. Energy savings and reduced energy footprint.

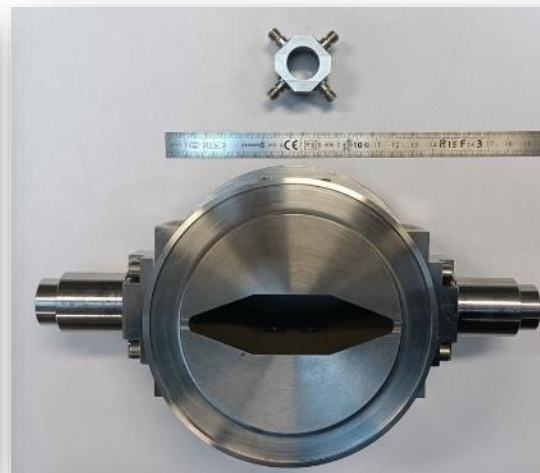
Evolution of electrical and water consumption.



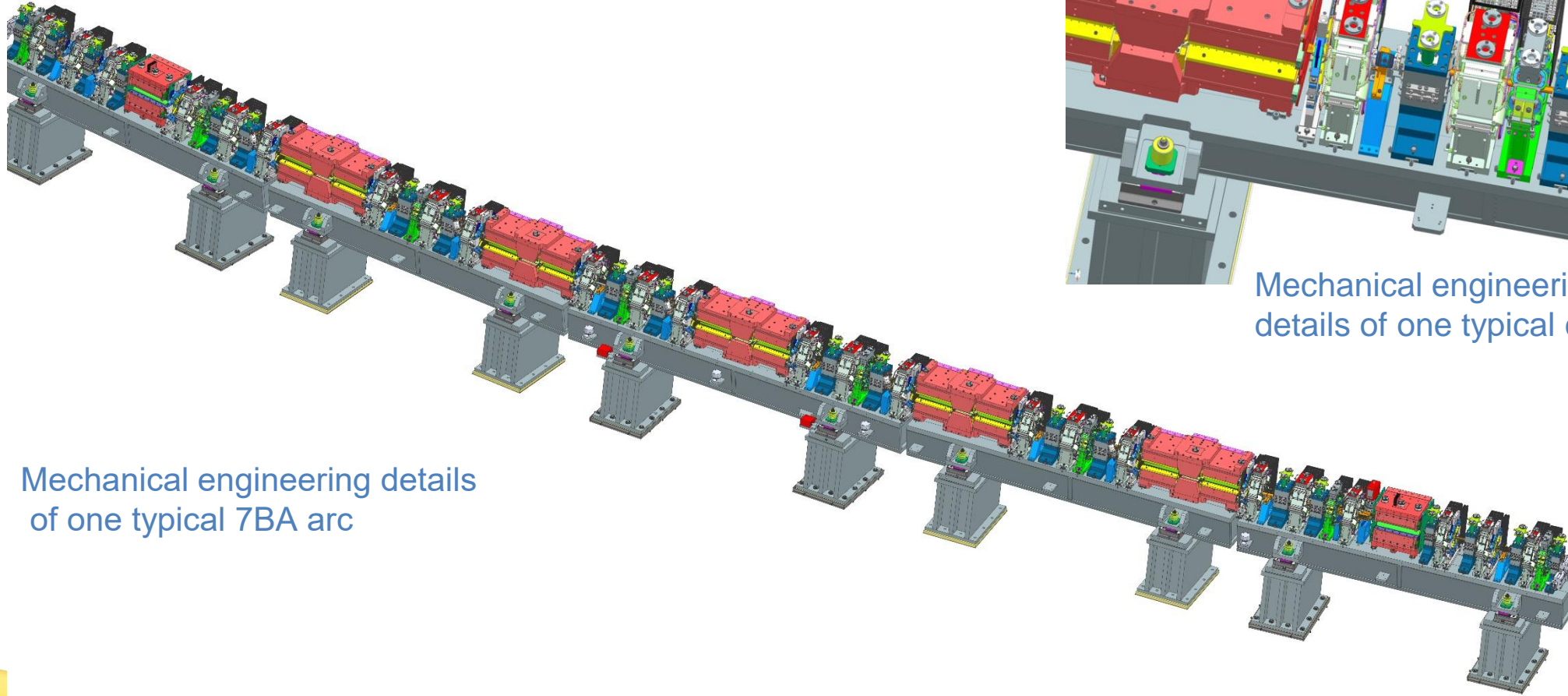
Quadrupole SOLEIL/SOLEIL II



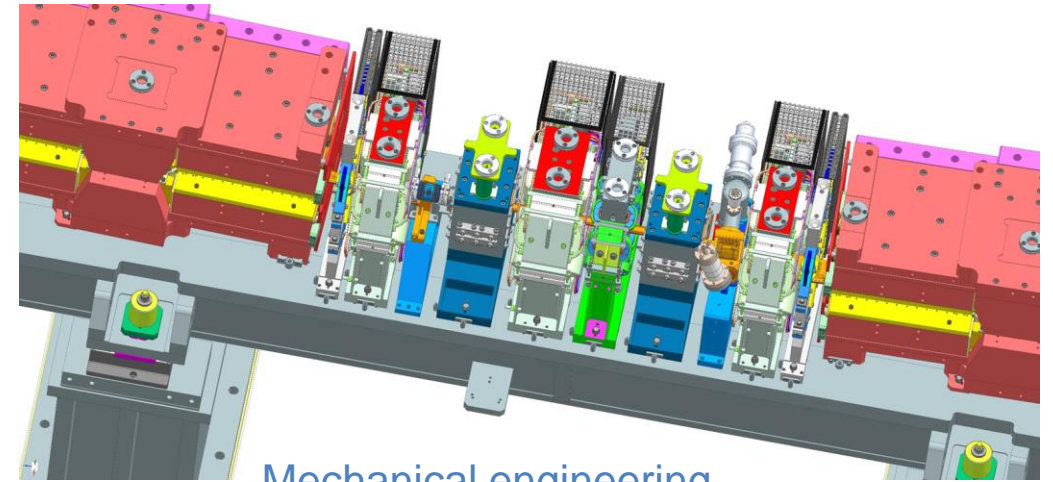
Sextupole SOLEIL/SOLEIL II



BPM vacuum chamber SOLEIL/SOLEIL II



Mechanical engineering details of one typical 7BA arc



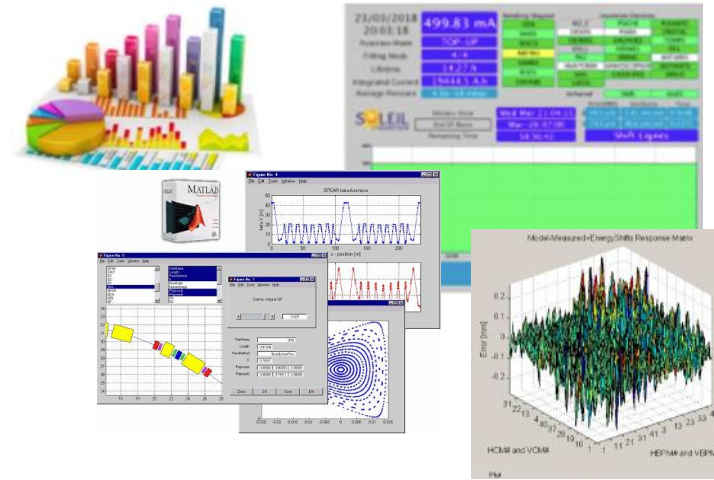
Mechanical engineering details of one typical cell

The end of the TDR phase should result in mechanically integrable machine with detailed specifications ready for tender.

Master schedule SOLEIL II		Phase 1 : Construction																																					
N°	Nom de la tâche	2024				2025				2026				2027				2028				2029				2030				2031				2032					
		T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4	T1					
1	SOLEIL II - Phase 1 Construction																																						
2	Buildings ready for equipment assembly and tests																																						
3																																							
4	IT & Data management																																						
5																																							
6	Accelerators Programm																																						
7	Validation of 150 MeV energy LINAC operation																																						
8	Prototyping																																						
9	Calls for tenders for Booster and Storage Ring																																						
10	Manufacturing, installation and tests																																						
11																																							
12	BeamLines & Laboratories Programm																																						
13	Category 1 Beamlines: reconstruction and modernisation																																						
14	Category 2 Beamlines: adaptation & upgrade																																						
15																																							
16	Interruption of user program																																						
17	Start of the dark period : accelerator shutdown																																						
18	Restart of the LINAC																																						
19	Start of the Booster commissioning with beam																																						
20	Start of the Storage Ring commissioning with beam																																						
21	5mA Beam current ready for Front-end opening																																						
22	Beamline restart commissioning																																						
23	Expert users																																						
24	Restart of user program																																						

IT Support for Accelerators

- Computerization of the professions
- Share and collaborative developments, Agility
- Choice a common development and production platform
- Choice of support software, APIs, GUIs
- Web interfaces
- HW and SW standardization when possible

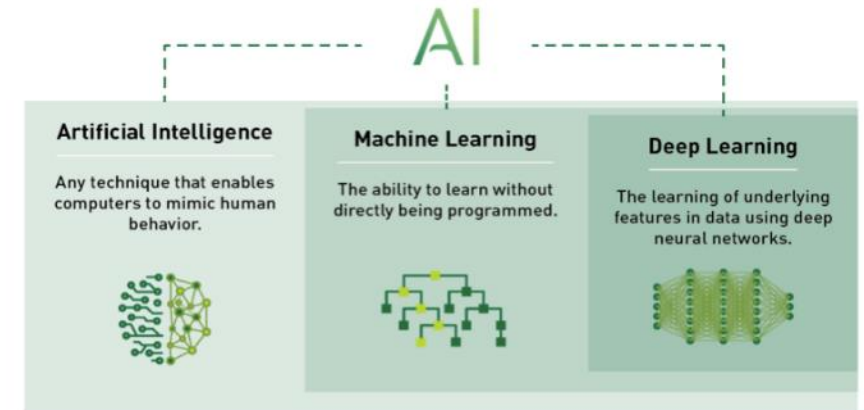


Digital Twins

- IT infrastructure evolution
- Increased connected equipment
- Low latency networks
- Remote access, IT support, operation
- Cybersecurity



- Data historization, storage and databases
- HPC needs for simulation and analysis



- Simulation and online optimization
- Data driven approach
- Reliability-Centered Maintenance
- Augmented operation (automation, AI-aided operation)

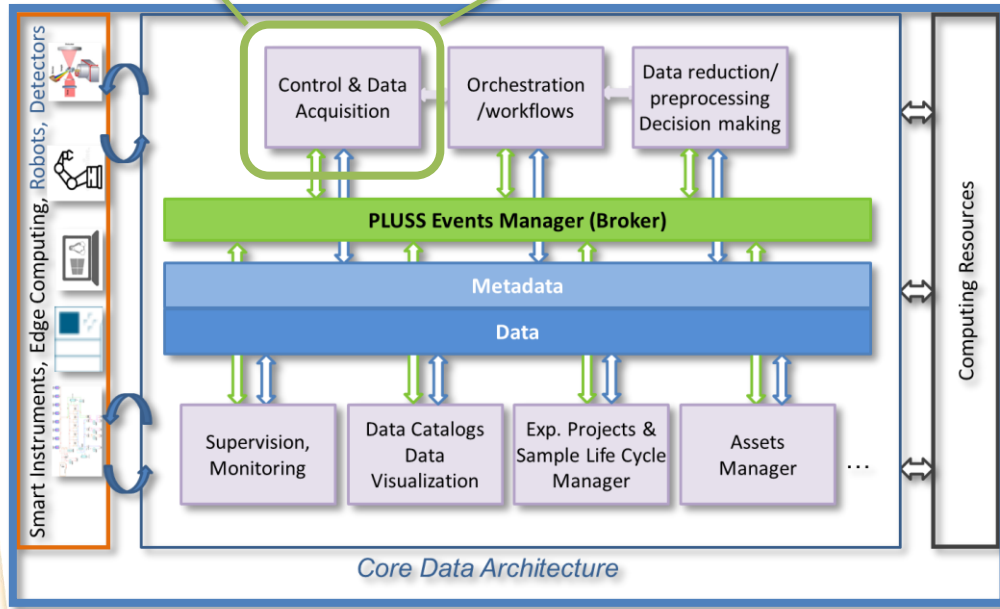


- For SOLEIL II, TANGO control system
 - will remain the Framework for control and data acquisition
 - will be integrated as one of the Data provider service connected with other applications through a Kafka broker or APIs
 - will control more devices on accelerators.
 - 10 times more Data, 10 times faster collection expected on the archiving system
 - will provide new Deviceservers offering advanced processes for automation on the Accelerators and Beamlines

Works in progress

- Upgrading systems in the field of CI/CD, HMI, Archiving, Log Analysis, Data catalog , Log Analysis
- New developments for Fast Orbit Feedback, Power supply, Robotic
- New applications Digital Twin (ESRF based), SciCAT Data catalog, Sample tracking for experiments ...

- Cybersecurity is a critical key topic which is adressed at the Directorate level.



I wish you a very successful meeting!

