



The European Synchrotron

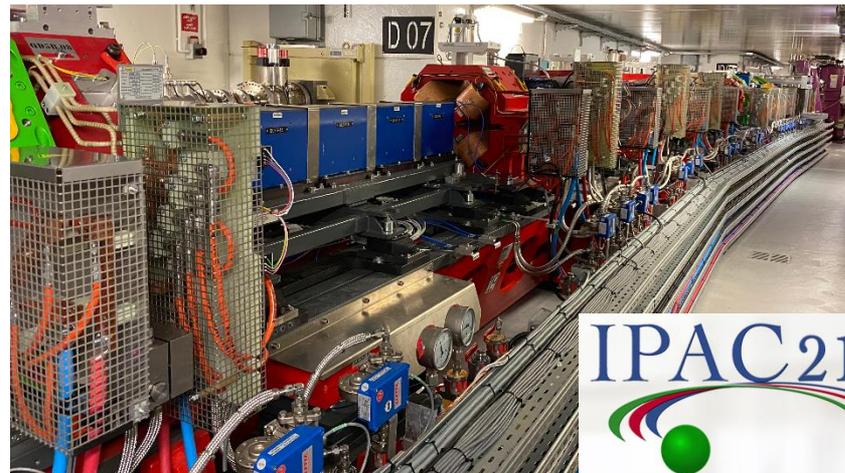


# ESRF-EBS: IMPLEMENTATION, PERFORMANCE AND RESTART OF USER OPERATION

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*on Behalf of the project team*



12th International Particle Accelerator Conference -  
IPAC'21, May 24-28, 2021  
Campinas, Brazil.



# ESRF FACT AND FIGURES

Light source in operation since 1994

Located in Grenoble France

22 partner nations

Annual budget: 100 million euros

Staff: 650 people

Purple Book  
January 2008





Orange Book  
January 2015



**ESRF UPGRADE PHASE I**  
180 M€ (2009-2015):  
ESFRI ROADMAP 2006-2016  
ON TIME – WITHIN BUDGET

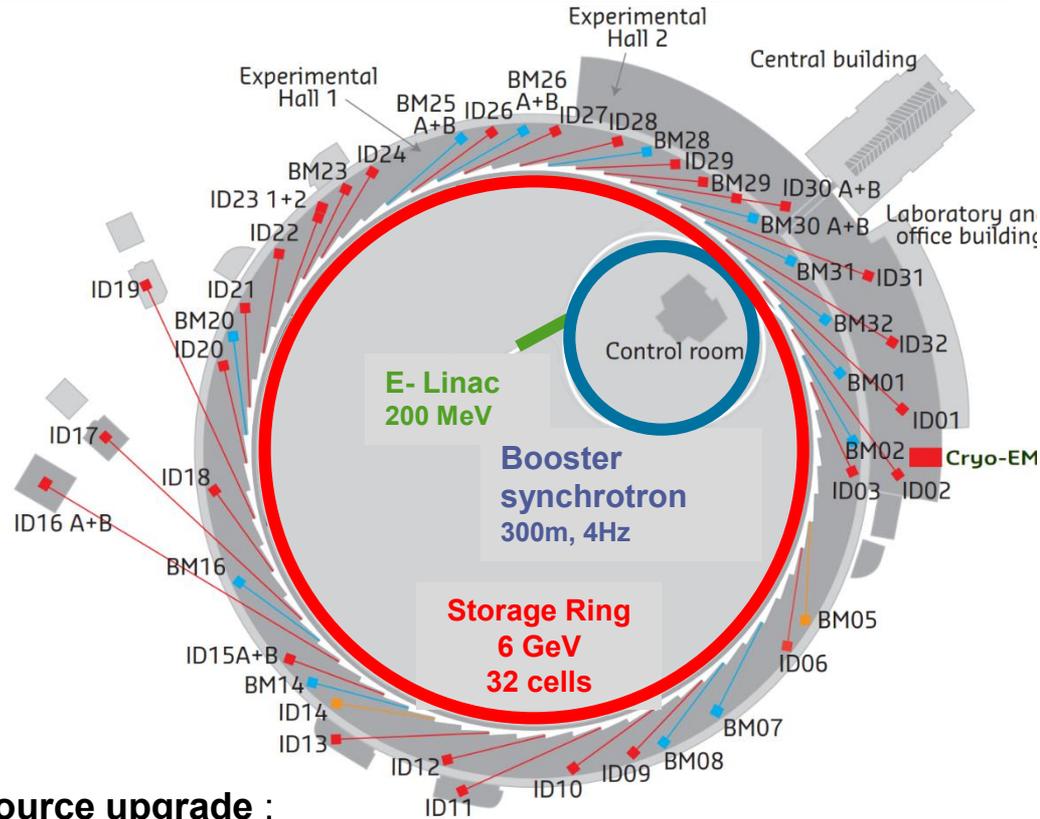
- 19 new beamlines, many specialised in *nano*-beam science
- Upgrade and renewal of facilities and support laboratories

**ESRF-EBS**  
Extremely Brilliant Source  
150 M€ (2015-2022):  
ESFRI LANDMARK (2016)

Revolutionary design  
for a new generation of  
synchrotron source storage rings

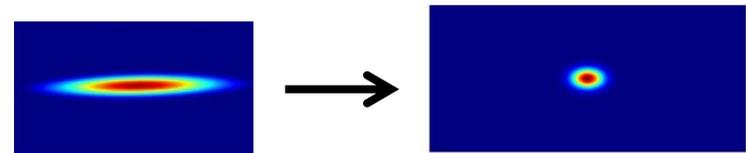


ESRF  
European Commission

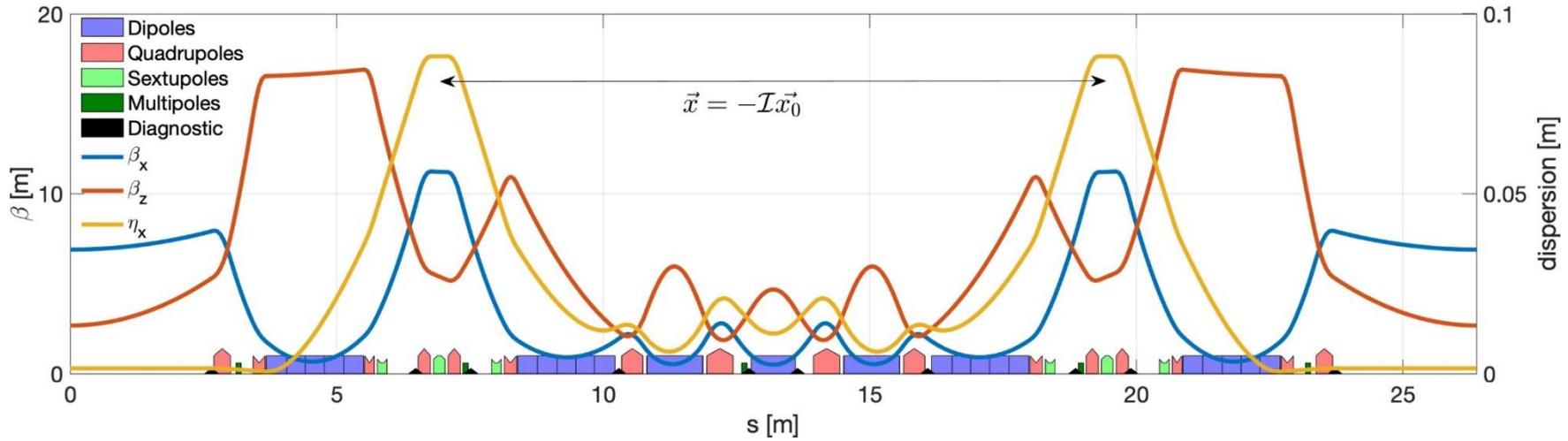


The **ESRF Extremely Brilliant Source** upgrade :

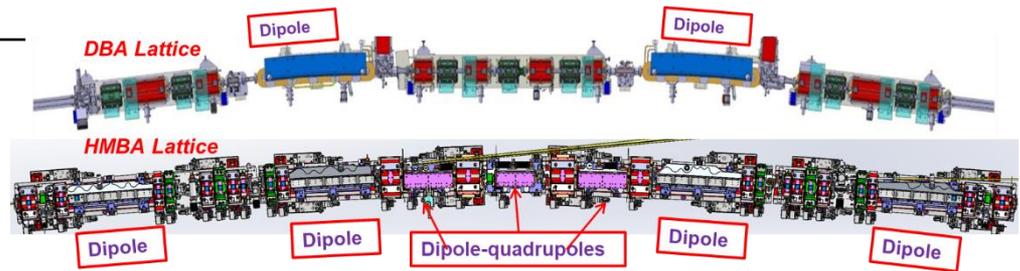
- Decrease the horizontal emittance
- Increase the source brilliance
- Increase the source coherence



# THE ESRF-EBS UPGRADE

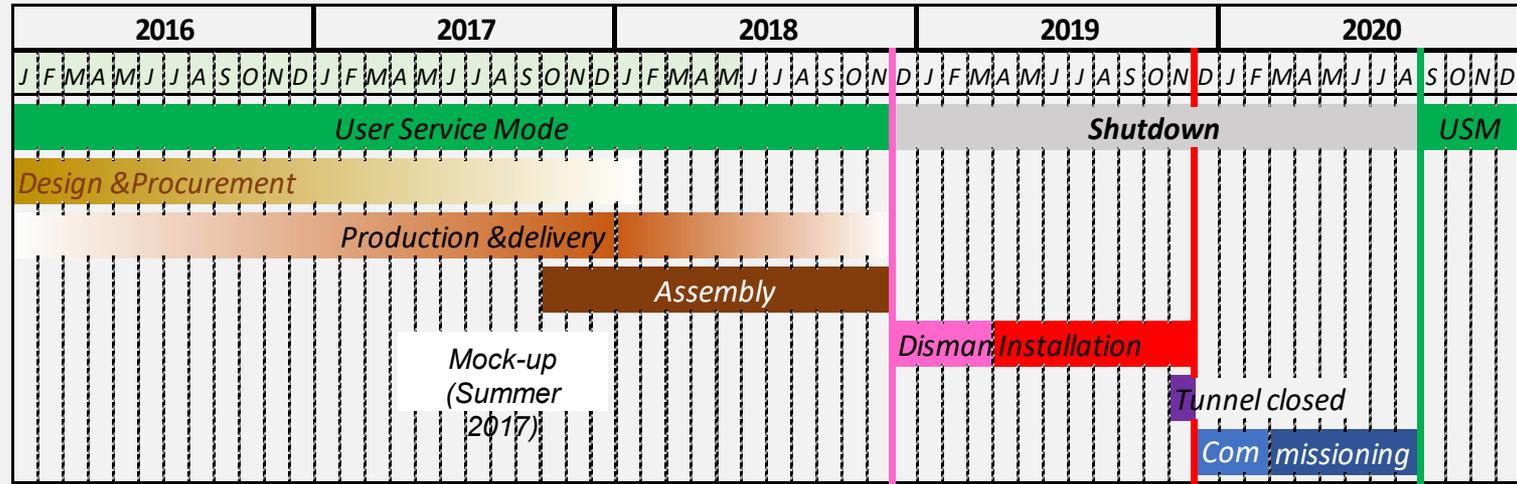


	<i>Units</i>	ESRF	ESRF-EBS
Energy	<i>GeV</i>	6	6
Circumference	<i>m</i>	844.4	844
Lattice		DBA	HMBA
Current	<i>mA</i>	200	200
Lifetime	<i>h</i>	50	25
Emittance H	<i>pm.rad</i>	4000	133
Emittance V	<i>pm.rad</i>	4	10*



31 magnets per cell instead of 17

# ESRF-EBS PROJECT IMPLEMENTATION



Old ESRF-Storage Ring



- October 2017** Start of girder assembly
- 10 December 2018** End USM, start shutdown
- Dismantling**
- Installation**
- 8 November 2019** Tunnel closed
- Test & Injector restart**
- 28 November 2019** Accelerator commissioning
- 2 March 2020** Beamlines commissioning
- 25 August 2020** Start User Mode Operation

ESRF-EBS



# ESRF-EBS: INSTALLATION IN THE TUNNEL



Dismantling



Entering girders



Interconnection & alignment



Radiofrequency



Dismantling



Moving girders



Piping

Cabling



Straight section for IDs



Civil work



Girder in place

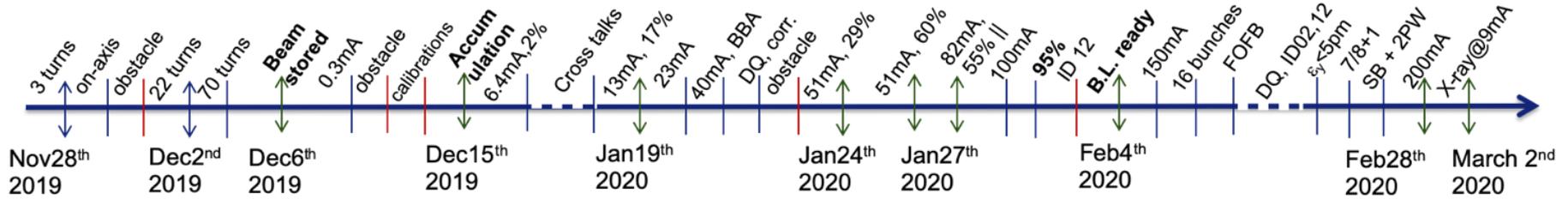


Injection zone

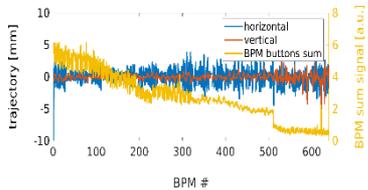
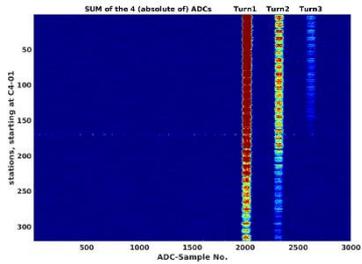


Front ends

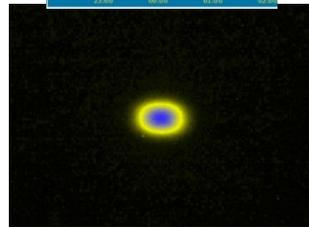
# ESRF-EBS COMMISSIONING



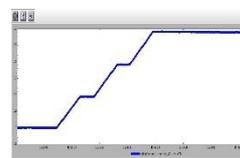
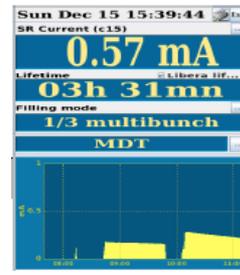
November 28<sup>th</sup>  
First turns



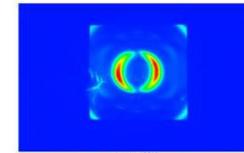
December 6<sup>th</sup>  
Beam stored



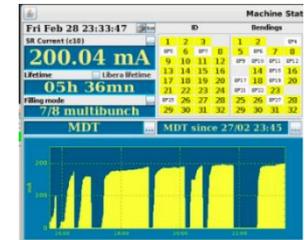
December 15<sup>th</sup>  
Accumulation



January 30<sup>th</sup>  
First Beam on  
26 Beamlines

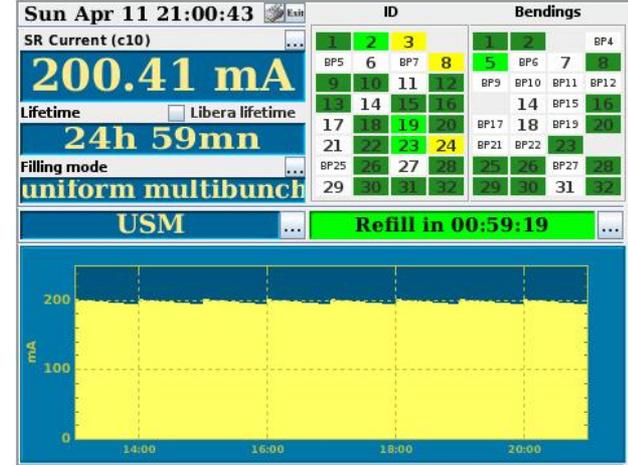
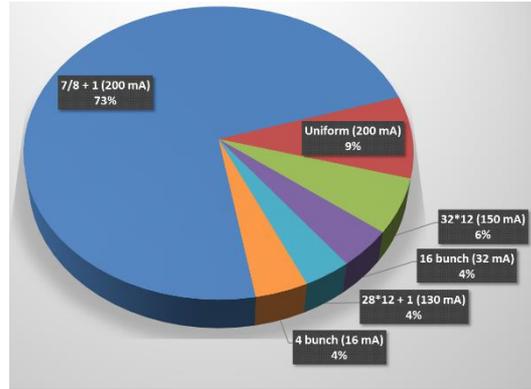
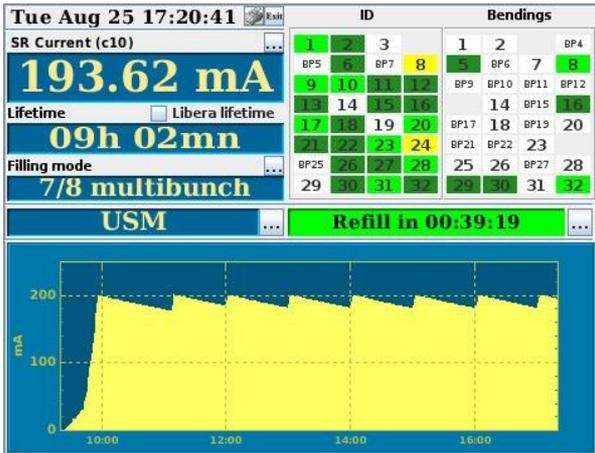


February 28<sup>th</sup>  
200 mA achieved



3 physical obstacles on the beam path and poor vacuum in a few ID NEG coated chambers slowed down the overall commissioning.

# ESRF-EBS: USER MODE OPERATION

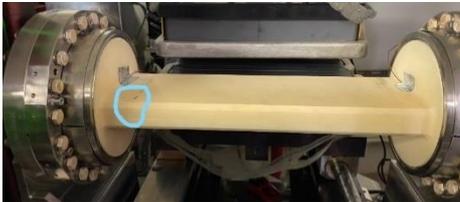


**USM resumed on  
25<sup>th</sup> August 2020 at 8:00  
as initially planned**

	7/8 + 1	Uniform	32*12	16 bunch	28*12+1	4 bunch
First time	25/08/2020	24/11/2020	01/12/2020	10/03/2021	04/05/2021	11/05/2021
$I_{max}$ (mA)	196+4 * (192+8)	200	150 * (200)	35* (90)	125+3* (200)	20* (40)
Lifetime (hours)	> 22	> 25	> 22	~ 8	> 23	~ 5
$\varepsilon_v$ (pm) *	10	10	20	20	20	20

\* Intensity limitation due to mechanical weakness of the kickers ceramic chambers

\* Vertical emittance artificially increased from 1 to 10 pm rad for an operational lifetime



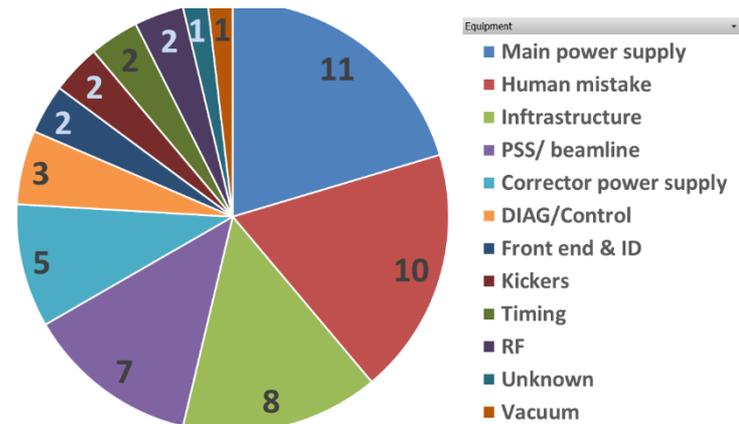
# RELIABILITY AND IMPACT OF COVID-19 PANDEMIC

	2017	2018	2020	2021
			EBS	EBS
Availability (%)	98.3	98.5	96.1	97.9
Mean time between failures (hrs)	64.3	104.3	46.0	103.5
Mean duration of a failure (hrs)	1.11	1.60	1.80	2.13

- Overall reliability comparable to that of the old source
- Magnet power supply system was the most complex hardware to develop and commission
- Operation disturbed by a few long failures from sub-systems not linked to EBS design
  - ✓ *aluminum NEG coated ID vacuum chambers RF master source*
  - ✓ *20 KV high voltage cable defect*

- Commissioning of the SR completed when the first lockdown was declared in France.
- The two-month restrictions impacted heavily the beamline commissioning.
- During the second and third lockdowns, number of user shifts reduced.

• *Limited access to the site*  
 → *opportunity to implement tools for remote control*  
*Development shift/interventions often performed via video-conferencing*



- Despite the impact of Covid-19 pandemic, users received back the beam on the scheduled day.
  - Main performances achieved (beam current, lifetime, emittances, stability)
  - Excellent reliability of the equipment
- Beamlines are now progressing and upgrading to take full benefit from the source.
- Hot-swap system for magnet power supply DC-DC converters in commissioning
  - Intensity limitation in time-structured mode of operation due to weakness of the kicker ceramic chambers → New design chambers being manufactured
  - Large perturbation of the closed orbit during top-up injections despite the compensation system
    - Injection every 1 hour instead of 20 mn
    - New kicker power supplies commissioning in progress