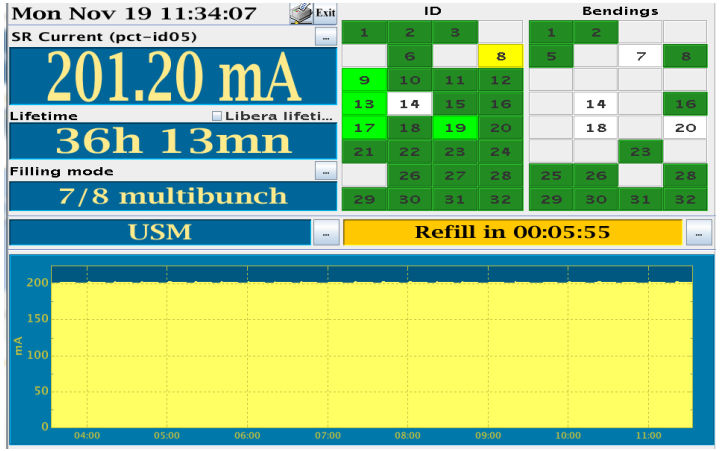
XXVI ESLS WORSHOP

Krakow, 26-28 November 2018

ESRF operation and upgrade status

JL Revol

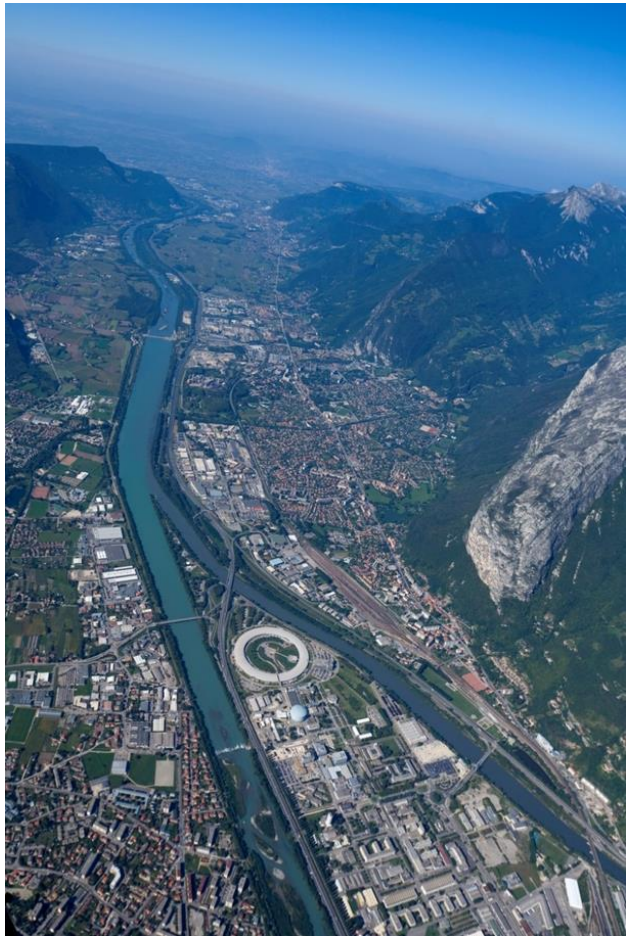
On behalf of the ASD division and the EBS Accelerator Project Team



ESRF | The European Synchrotron

SOLARIS
NARODOWE CENTRUM PROMIENIOWANIA SYNCHROTRONOWEGO

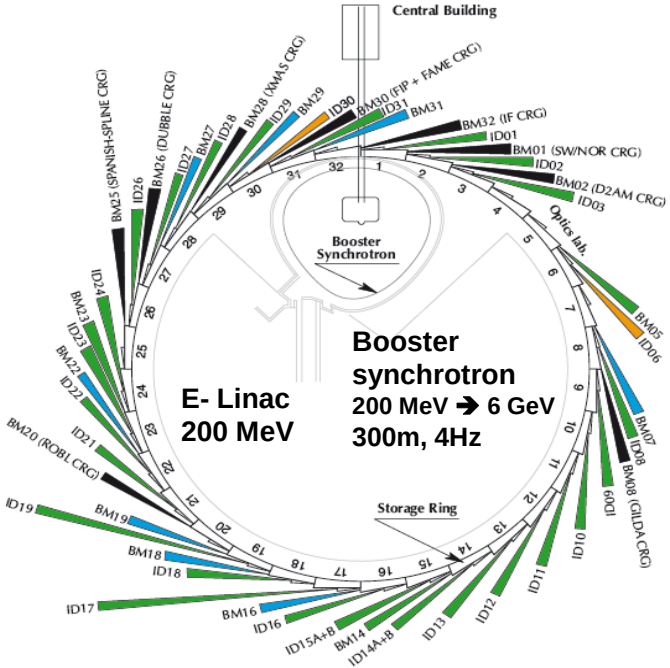
OUTLINE



- The ESRF in brief
- Operation
- Top-up

- EBS project overview
- Procurement & Assembly
- Installation & commissioning

ESRF IN BRIEF



844 m circumference storage ring
DBA lattice, 32 straight sections

42 Beamlines
(including 12 on Bending Magnets)

Third generation light source

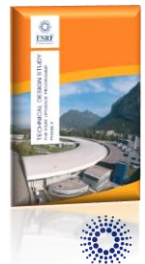
Location:	Grenoble, France
Cooperation:	22 partner nations
Annual budget:	100 million €
Staff:	630
Created:	1988 *(30 years anniversary)*
Start User Mode	1994

Energy	**6.04**	**GeV**
Multibunch current	**200**	mA
Horizontal emittance	**4**	nm.rad
Vertical emittance	**4**	pm.rad

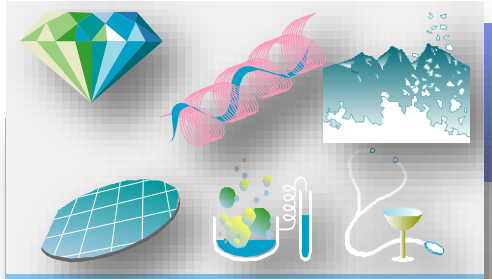
- 9,000 scientific visits every year
- 1800 publications every year

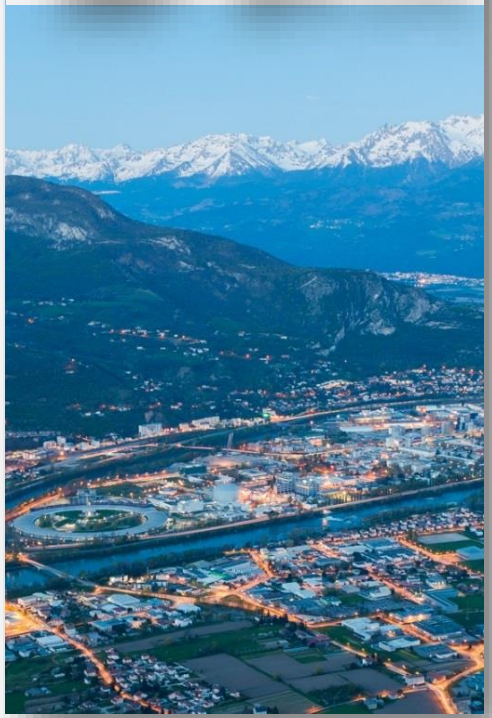
2009-2015 Upgrade PHASE I – 180 M€

2015-2022 – ESRF-EBS -150 M€



OPERATION: MACHINE STATISTICS FOR 2015-2018





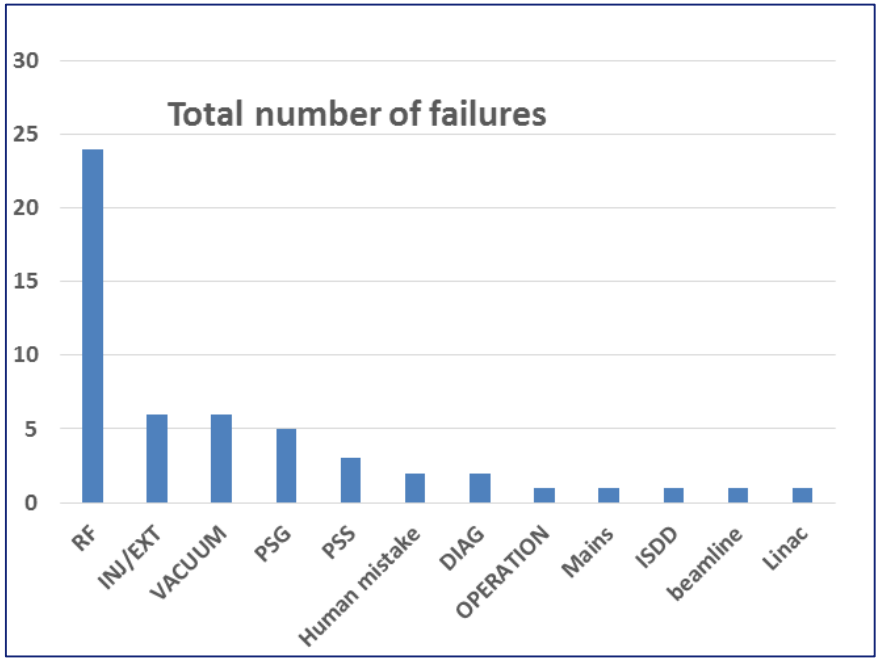
5407 hours of beam delivered out of 5502 scheduled in 2017.
Overall 2017 availability of 98.28 %

	2015	2016	2017	October 2018
Availability (%)	98.53	99.06	98.28	**98.57**
Mean Time Between Failures (hrs)	93.6	93.8	64.27	**110.7**
Mean duration of a failure (hrs)	1.37	0.88	1.11	**1.58**

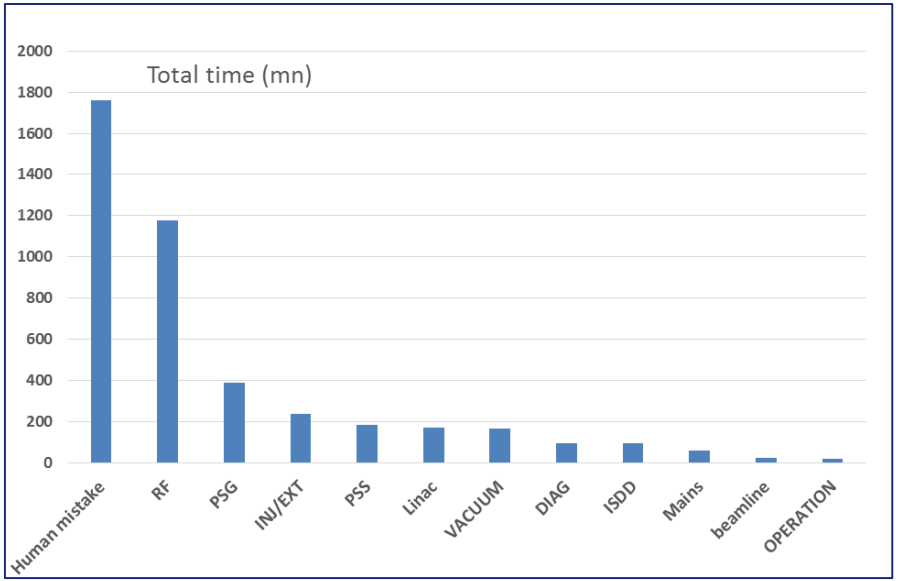
Until 08 October 2018

2015: 59 Failures / 2016: 59 Failures / 2017: 85 Failures / 2018: 45 Failures until 15/11/18.

STATISTICS



2018: Failure distribution in time



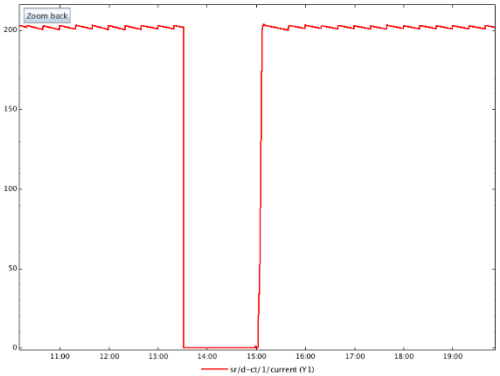
2018: Failure distribution in number

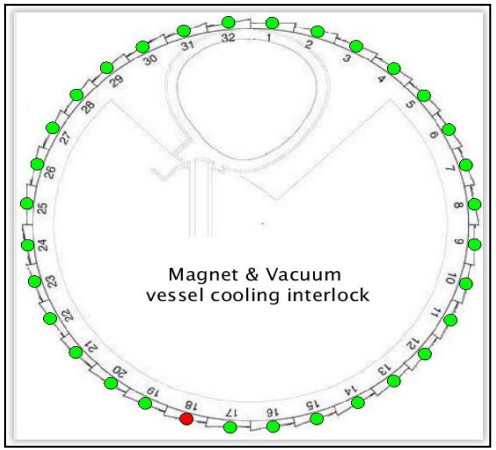
WATER LEAK IN CELL 19 (18 JULY)

Leak on a rubber tube, cooling down the upstream absorber of ID19 (only 4 years old).

Despite that since the end of the rubber hose exchange campaign, visual inspection of the tubes for one day during each shutdown.

98 mn lost

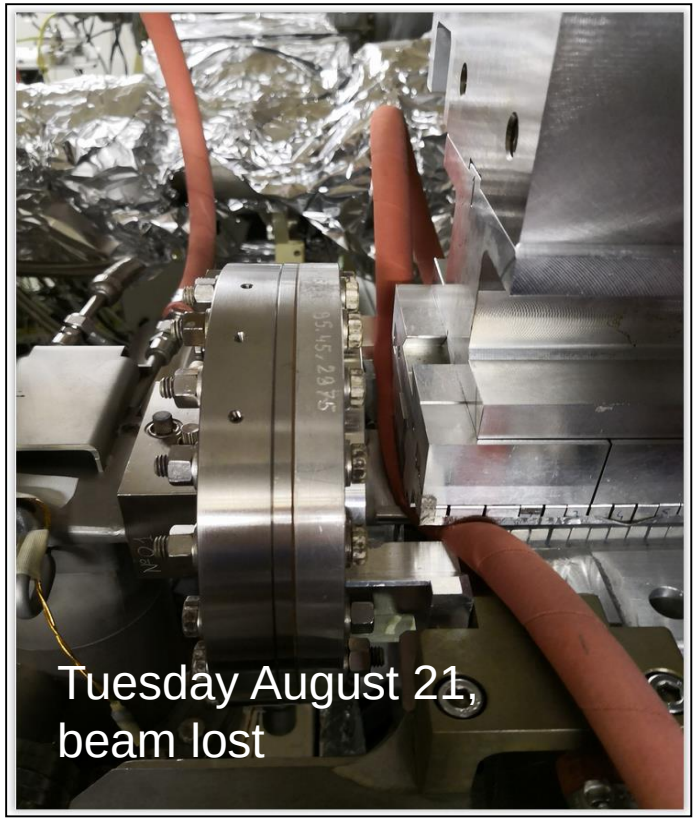


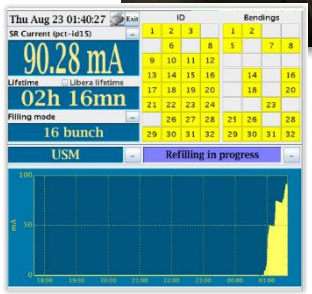


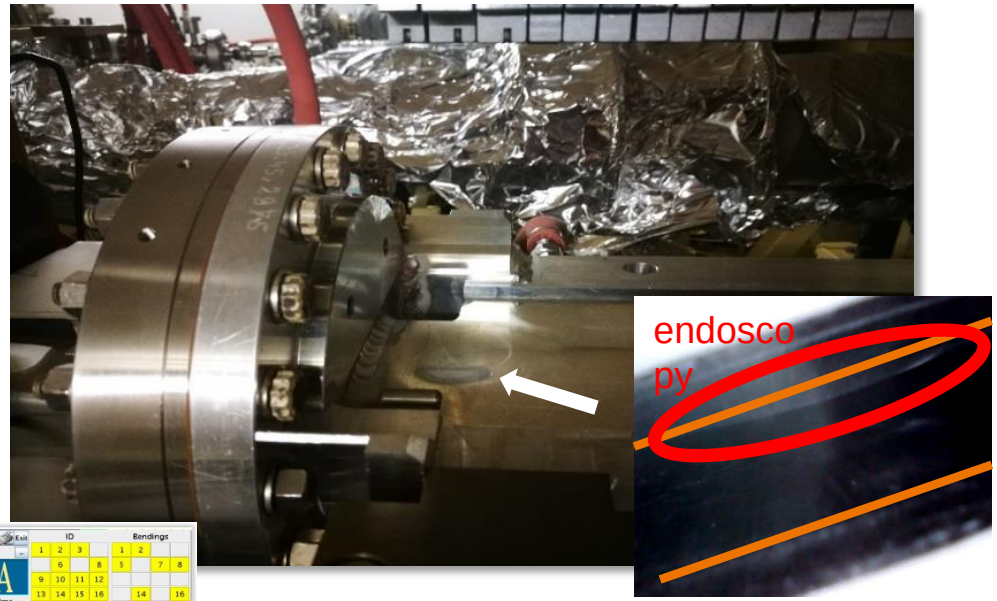
INCIDENT ON ID19 CV5000

Half day of user mode after the summer shutdown, the beam was lost when the in air undulator of ID19 was closed.

- *A water hose is found stuck between the 5 m ID chamber and the magnetic jaw !*





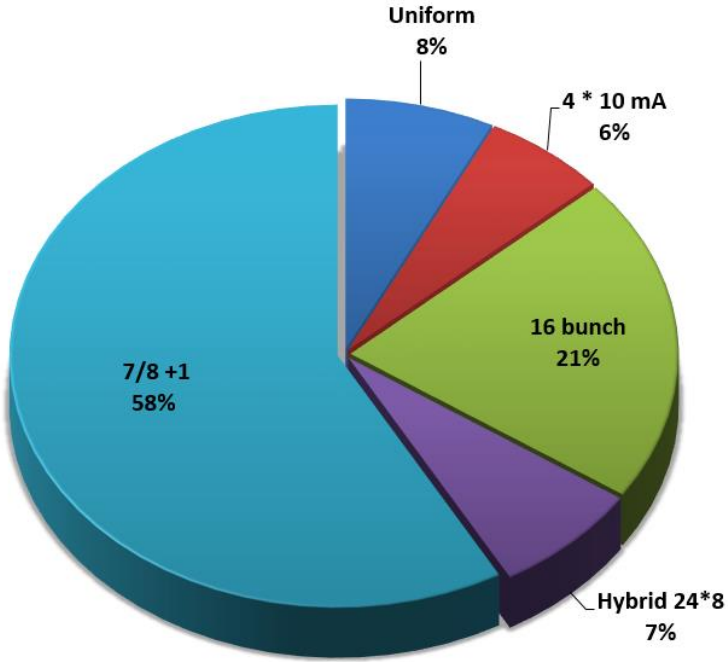


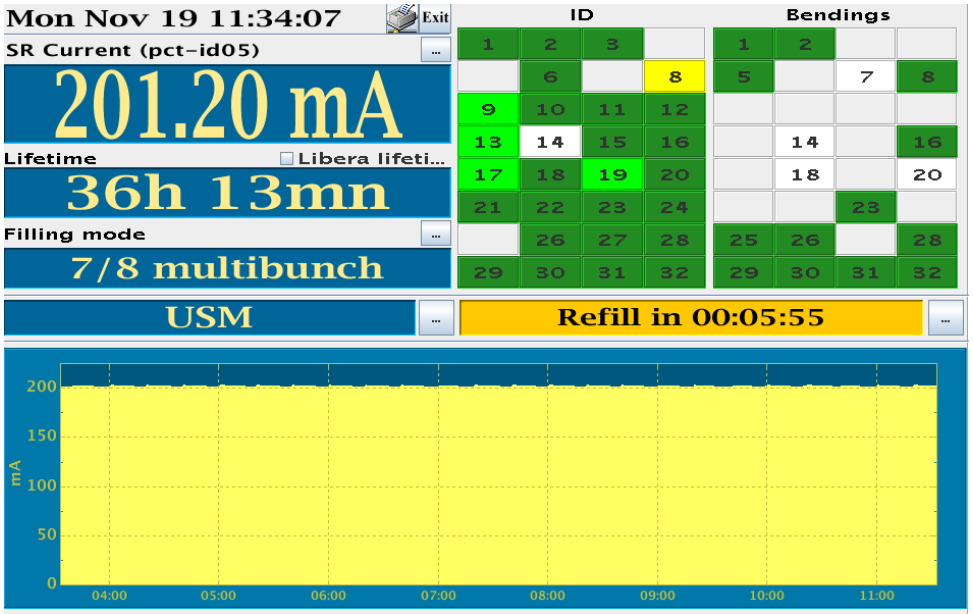
The chamber was exchanged
➔ beam back on Thursday at 02:00

OPERATION: MACHINE – TOP-UP OPERATION IN 7/8+1

16 Bunch in top-up since 26 April 2016 ➔ **High brightness**
I max = 90 mA, Refill every 20 mins, delta I = 5 mA, Vertical emittance: 10 pm

Top-up routinely in operation in 7/8+1 since 6 June 2018
Refill every 20 mins, delta I=2 mA

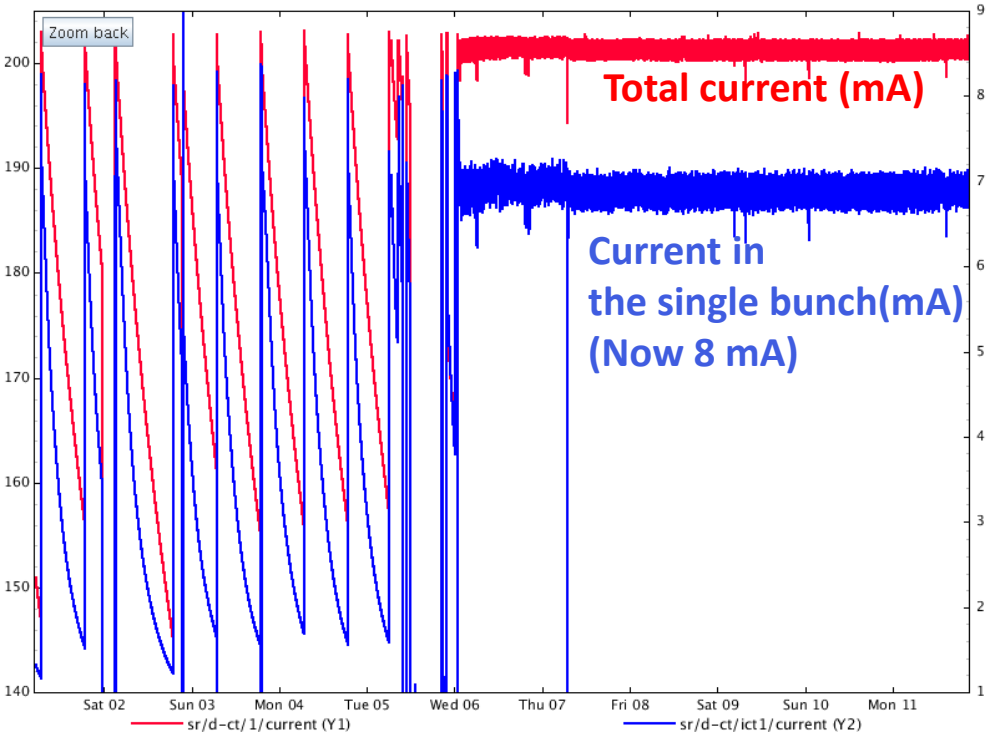


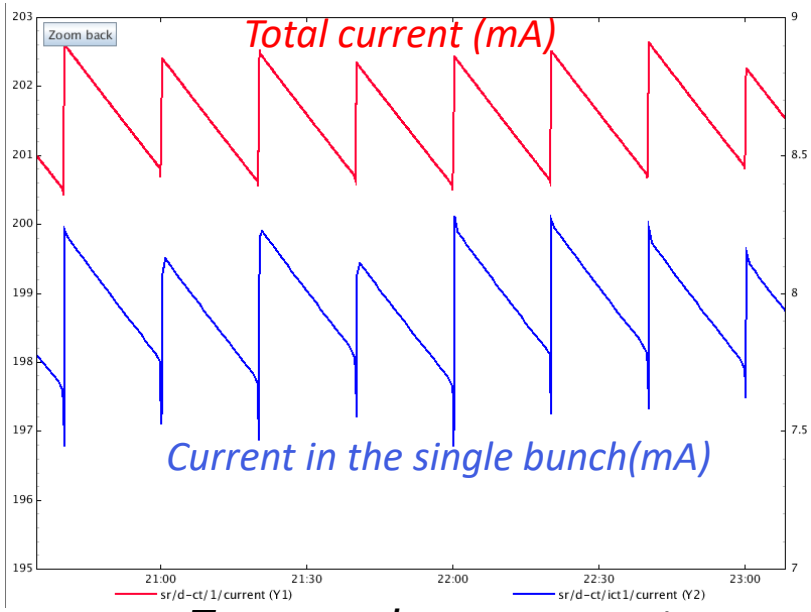


OPERATION: MACHINE – TOP-UP OPERATION IN 7/8+1

Before 6 June

After 6 June

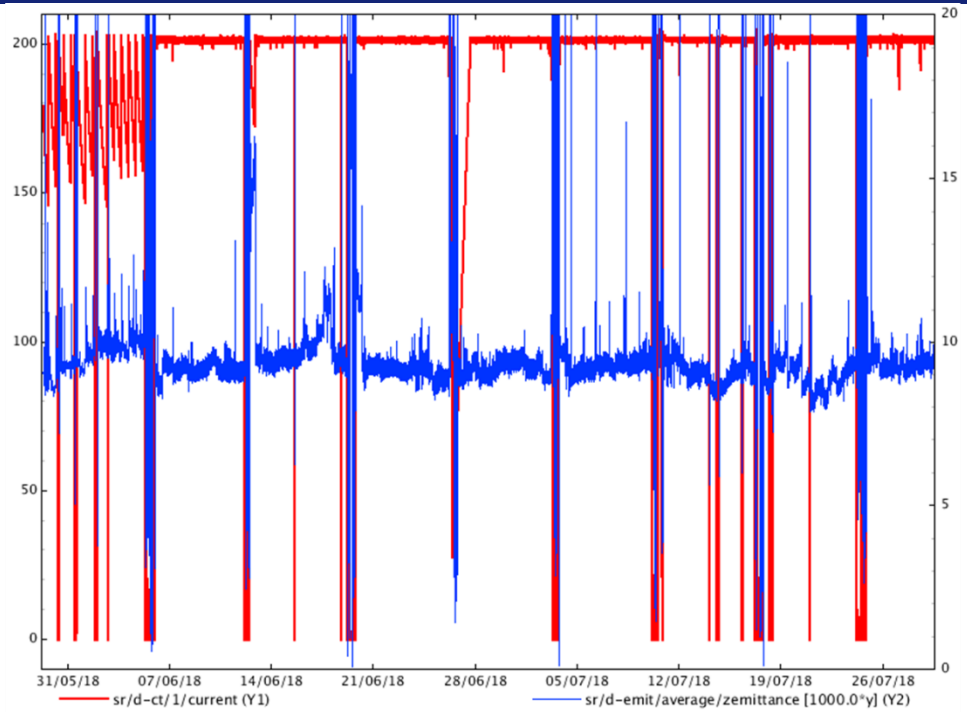




Zoom on beam current

OPERATION: MACHINE – TOP-UP OPERATION IN 7/8+1

CURRENT (mA)



VERTICAL EMITTANCE (pm)

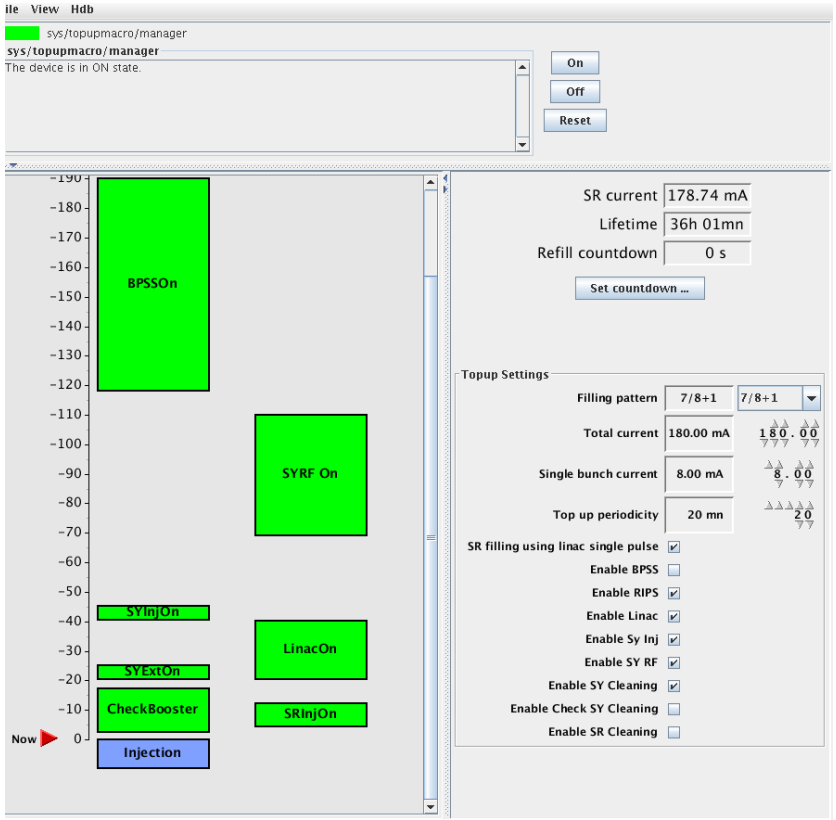
Better stability of the beam parameters

To minimize perturbation to users:
disturbance of the beam trajectory during injection reduced *(Eric Plouviez talk)*

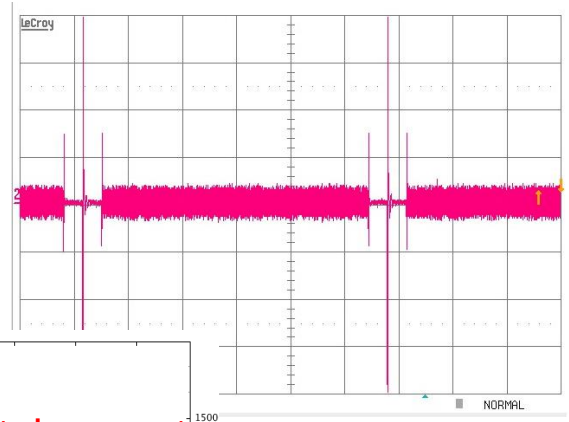
- with improvement of the injection kicker system
- with addition of several active cancellation systems

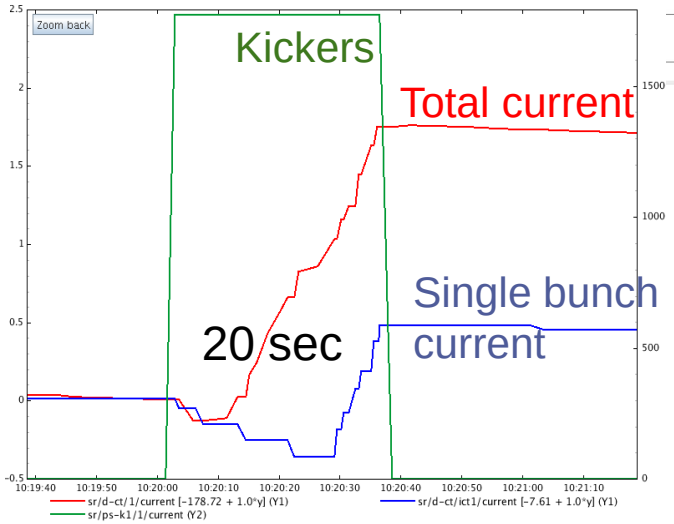
OPERATION: MACHINE – TOP-UP OPERATION IN 7/8+1

Tango Sequencer

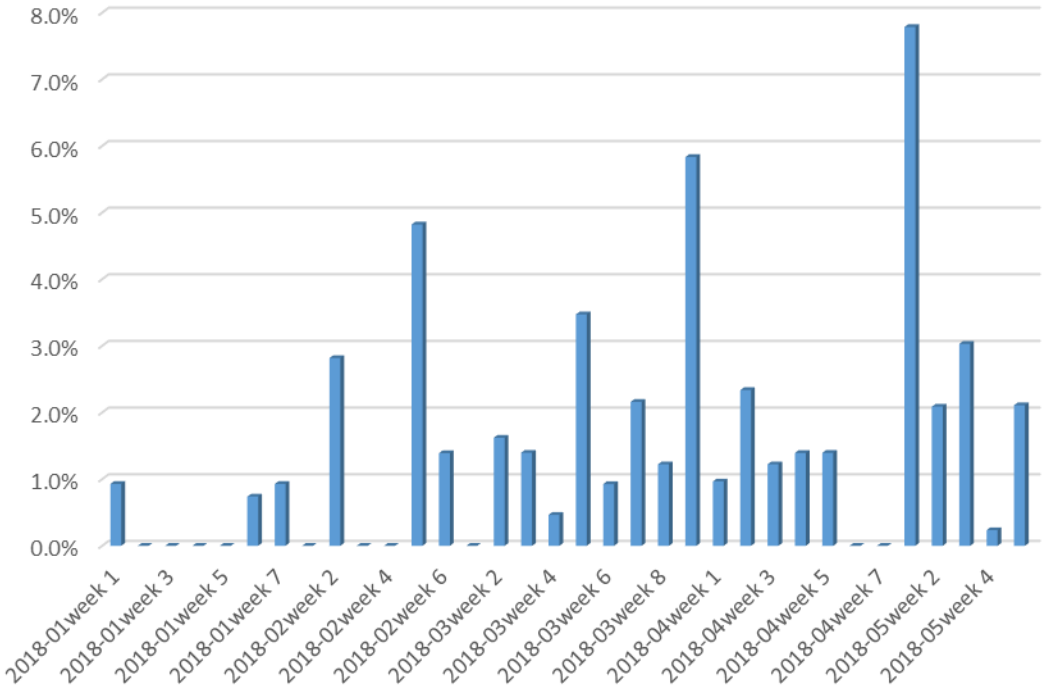


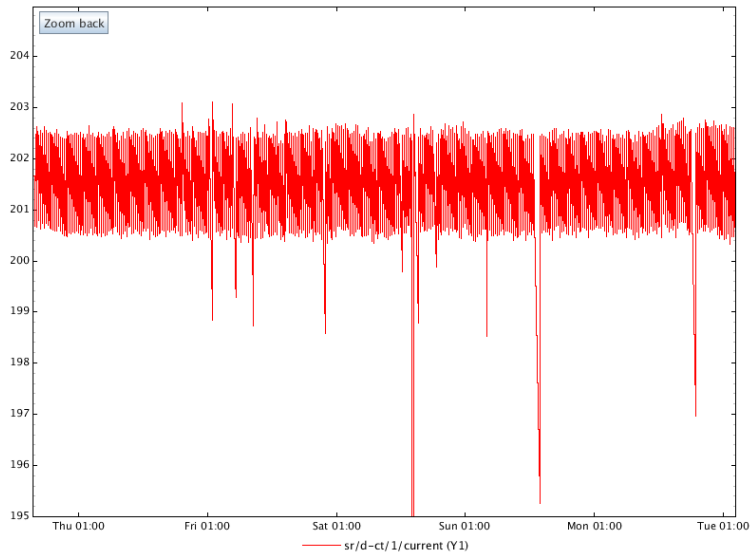
Refill performed in single bunch using a measurement of the filling pattern to improve the flatness





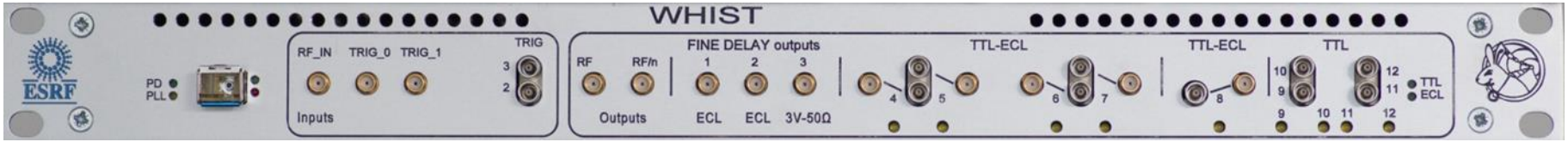
RELIABILITY OF THE INJECTOR



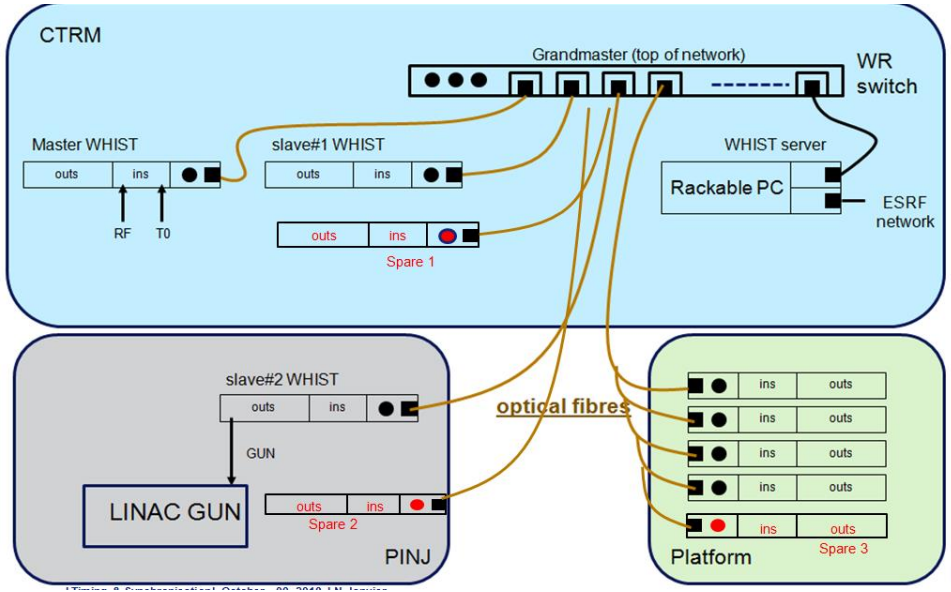


A large part of the missed injection were due to the booster power supply in fault are solved since week 3 of run 5,
Remaining problem are with injection/extraction kicker control, to be rebuilt during the long shutdown

NEW TIMING SYSTEM

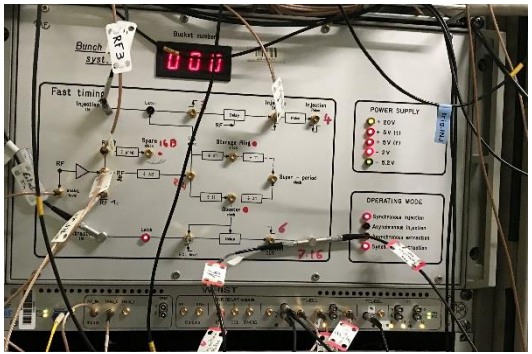


- In house development based on CERN white rabbit technology and RF over Ethernet distribution
- Bunch clock replacement done successfully in October
- Main machine timing system equipment upgraded



Old bunch clock

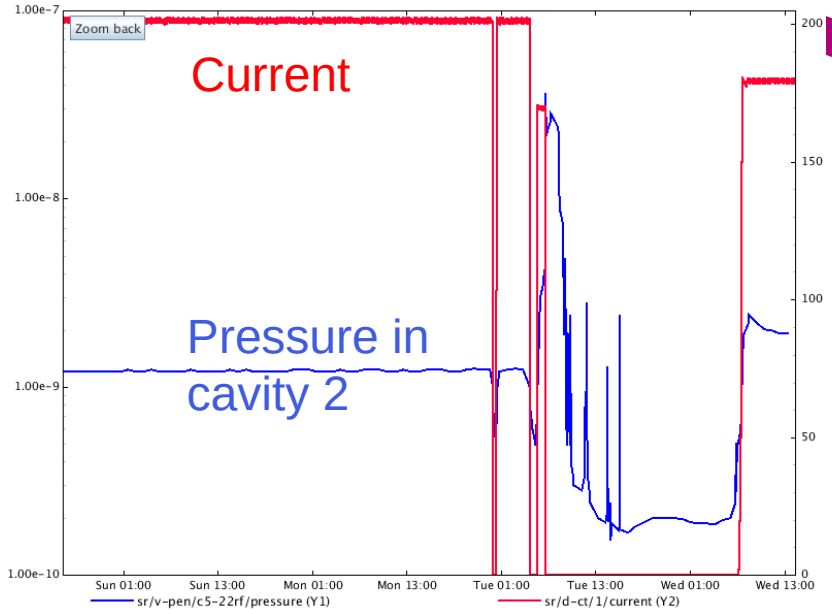
New bunch clock

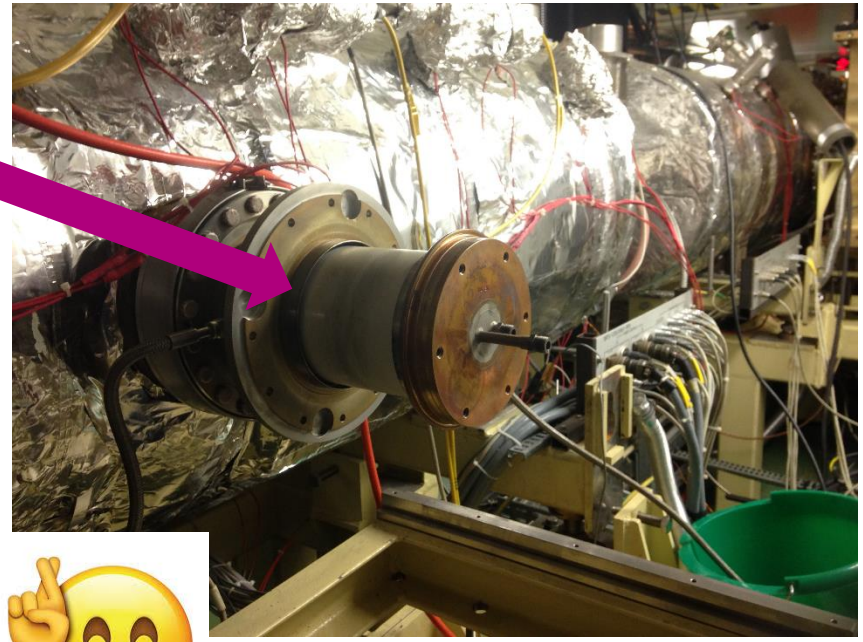


Timing distribution for diagnostics

Machine shut down on 10 December at 8:00

But … operation is still there…
And we have to finish with a varnished leaking cavity coupler which re-opened last Tuesday…and was re-varnished.

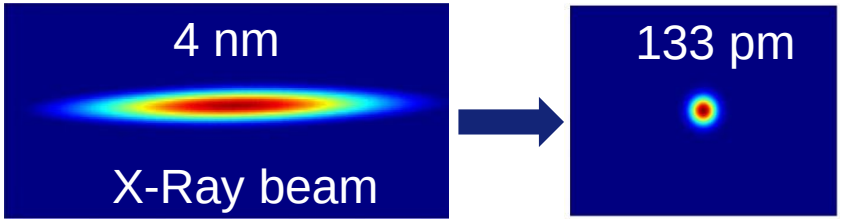




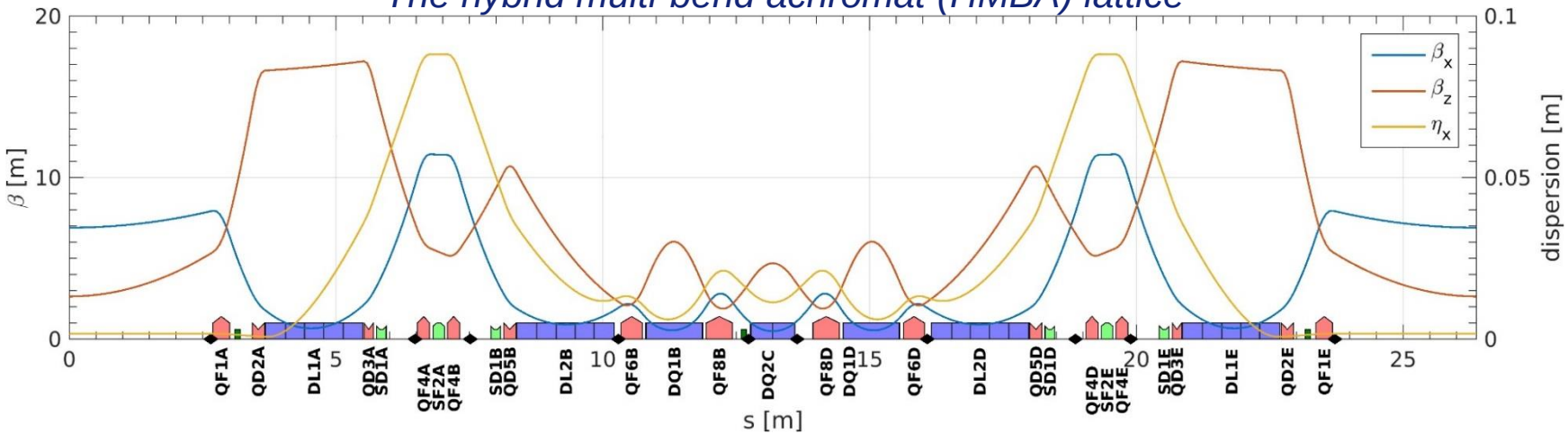
EXTREMELY BRILLIANT SOURCE: ACCELERATOR UPGRADE

The accelerator Upgrade Phase II aims to:

- ✓ Substantially decrease the Storage Ring Equilibrium Horizontal Emittance
- ✓ Increase the source brilliance
- ✓ Increase its coherent fraction



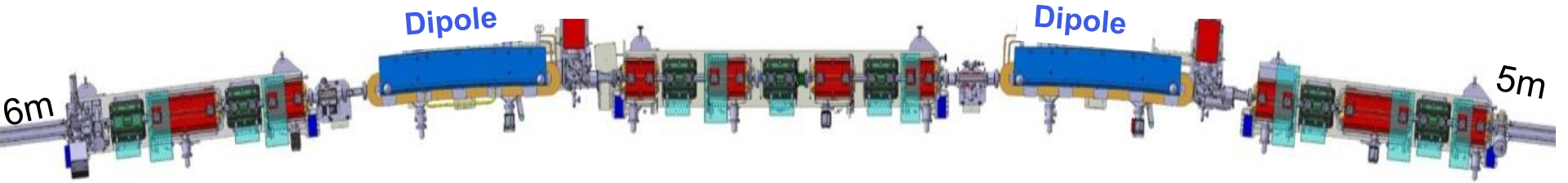
The hybrid multi-bend achromat (HMBA) lattice



NEW LATTICE VS PRESENT ESRF LATTICE

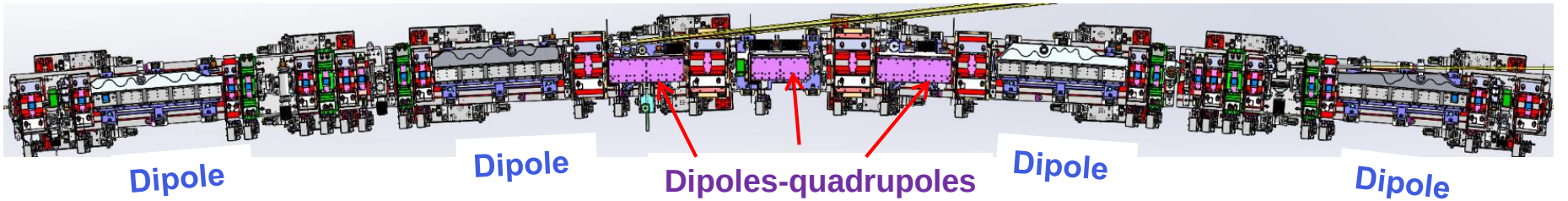
▪ Present ESRF lattice

32 cells, Double Bend Achromat = (2 dipoles + 8 quad. 7sext.) per cell
ID length = 5 m (standard) / 6m / 7m



▪ ESRF EBS lattice

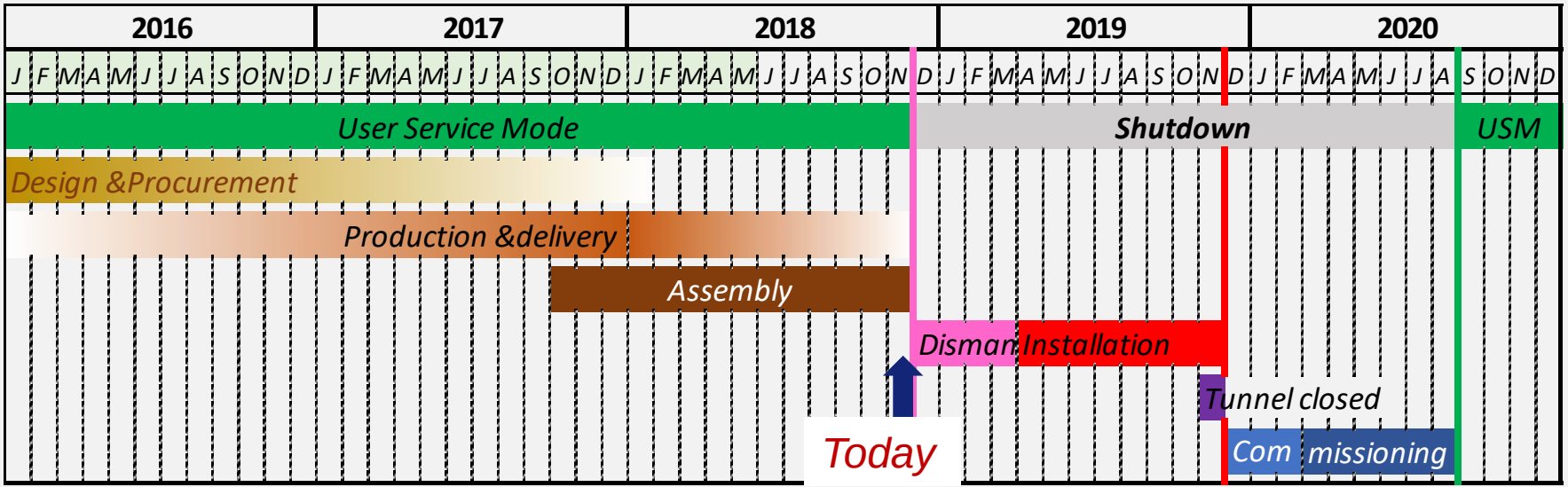
Hybrid 7 Bend Achromat = (4 dipoles + 3 dipoles-quad + 16 quad., 6 sext., 2 oct.) per cell
32 identical arcs 21.2 m long, ID length = 5 m



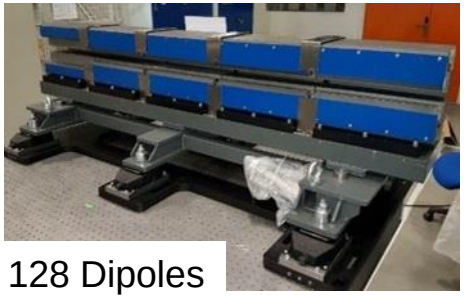
31 magnets per cell instead of 17 currently
*Free space between magnets (total for one cell): **3.4m** instead of **8m** today*

PLANNING

October	2017	Start of the girder assembly *(12 months)*
10 December	2018	Start of the long shutdown *(18 Months)*
		Dismantling *(3 months)* and Installation *(9 months)*
8 November	2019	Tunnel closed Equipment test
2 December	2019	Accelerator commissioning
March	2020	Beamline commissioning
25 August	2020	Back to USM

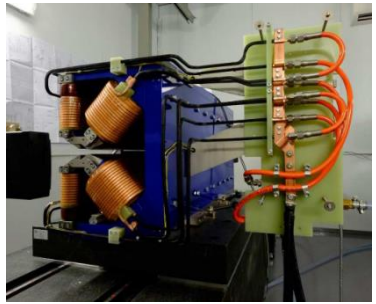


MAGNET SYSTEM: ALL DELIVERED



128 Dipoles

Assembled in house



96 Dipole-quadrupoles

96 Correctors

DC-DC converters in production to power each magnet individually

.

More than 1000 Magnets procured in less than 3 years

512 Quadrupoles
(128 HG, 384 MG)

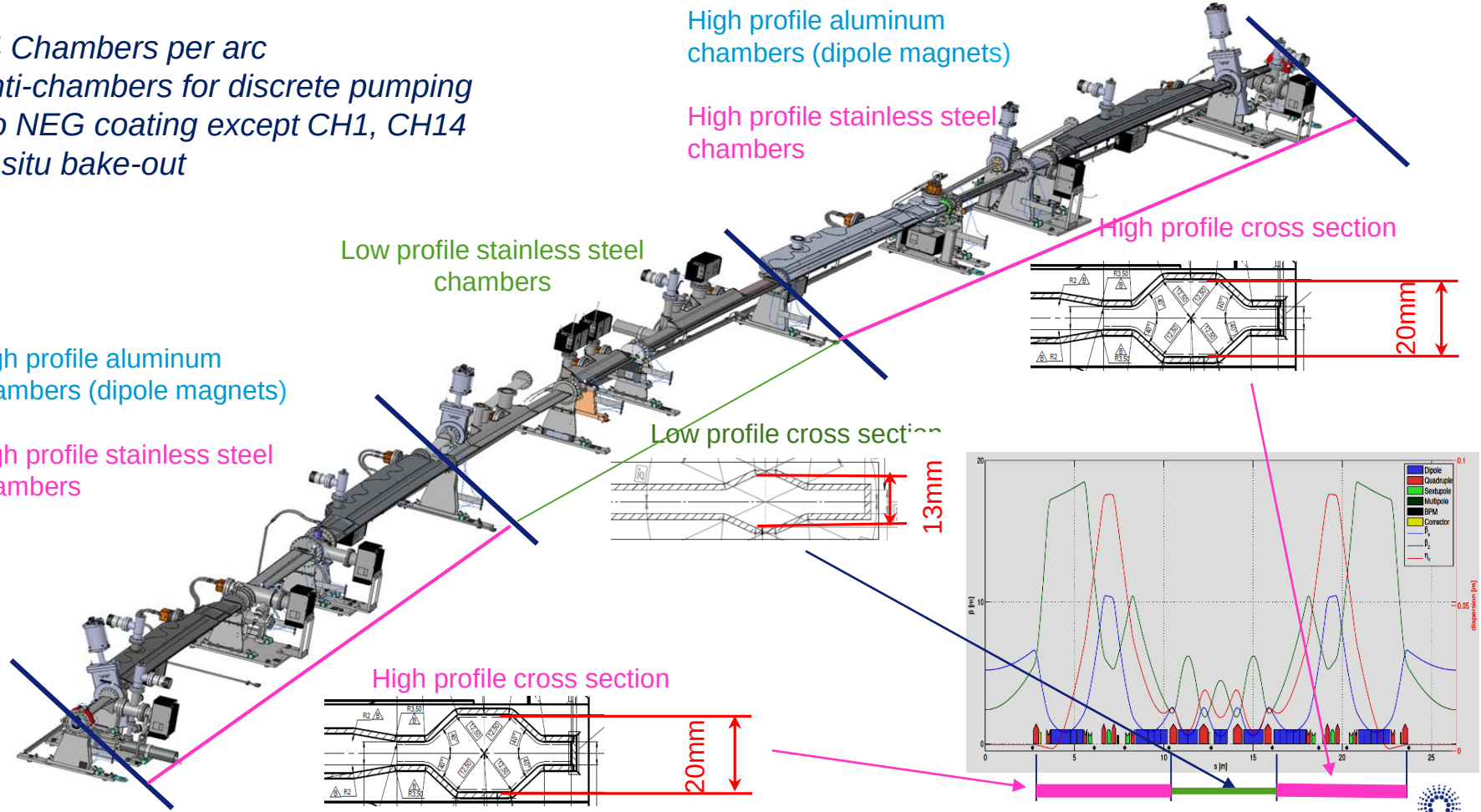
192 Sextupoles

64 Octupoles

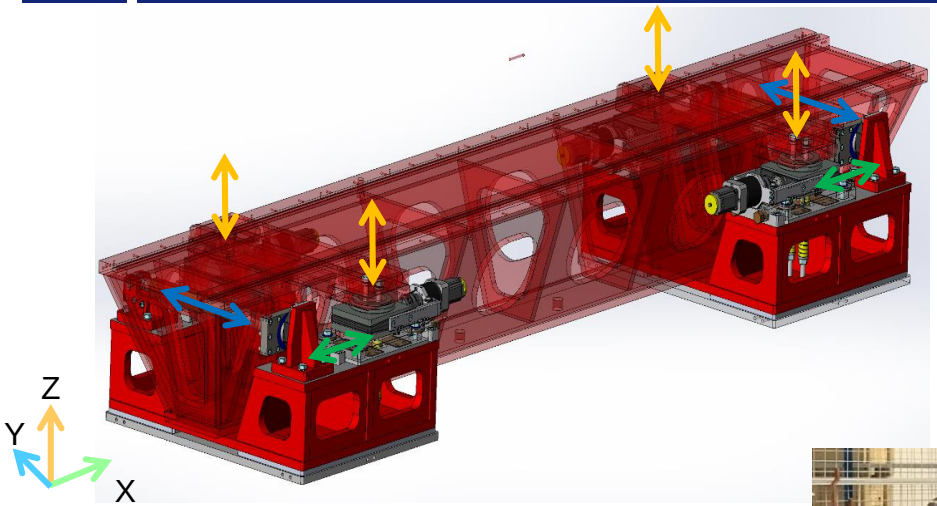
See talk Loic

VACUUM SYSTEM: MOSTLY DELIVERED

14 Chambers per arc
Anti-chambers for discrete pumping
No NEG coating except CH1, CH14
In situ bake-out

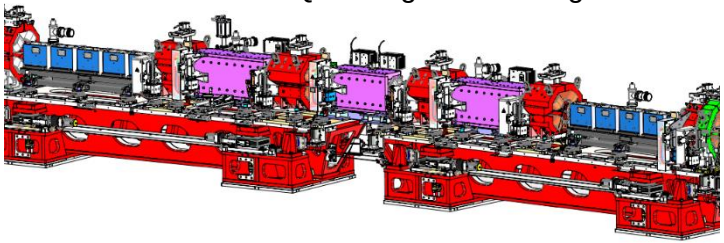


GIRDERS & SUPPORTS: ALL DELIVERED



4 girders per cell

Central DQ2 sitting between 2 girders

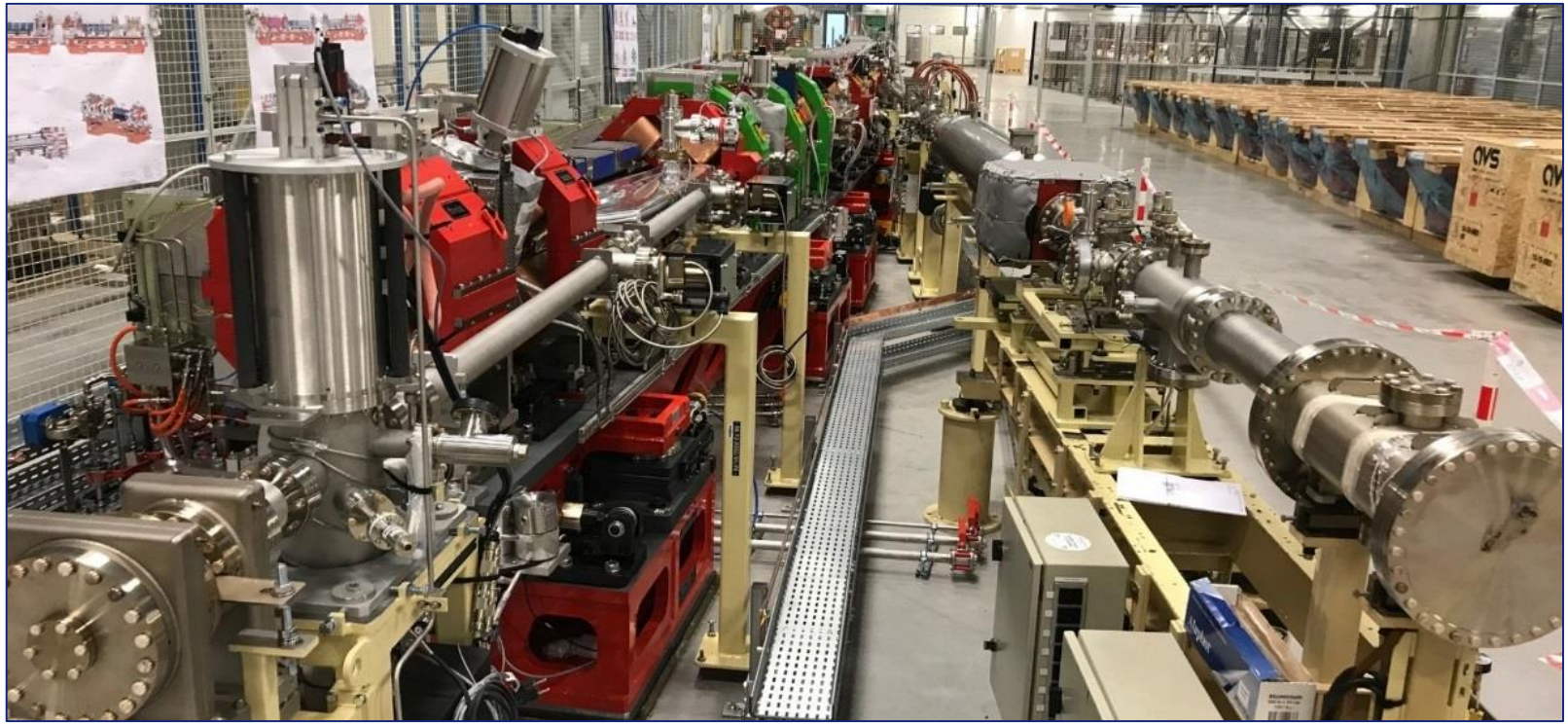


- Girder supported by 4 adjustable Z feet made of motorised wedges
- Y adjustment by 2 manual jacks pushing the girder
- 1st natural frequency: 49 Hz measured

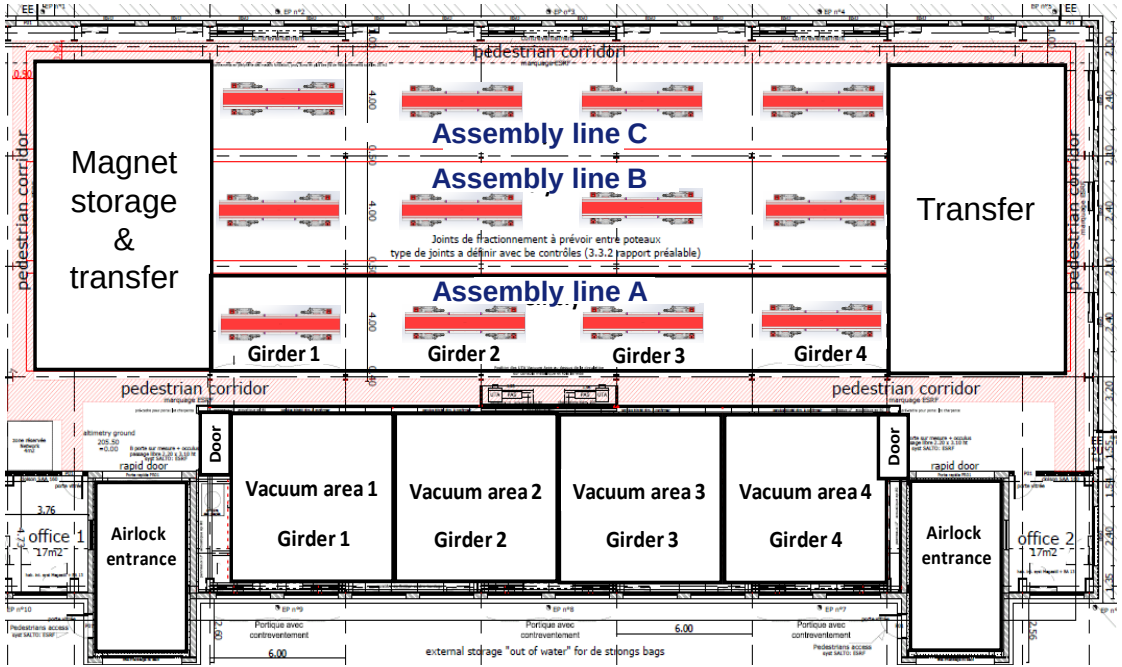
MOCK-UP

Sept. 2017: One full cell assembled *including straight section, front-ends and services (Cables trays, connection boxes, cooling pipes, ….)*

- ✓ Validation of the engineering prior series production
- ✓ validation of the assembling and installation procedures



ASSEMBLY



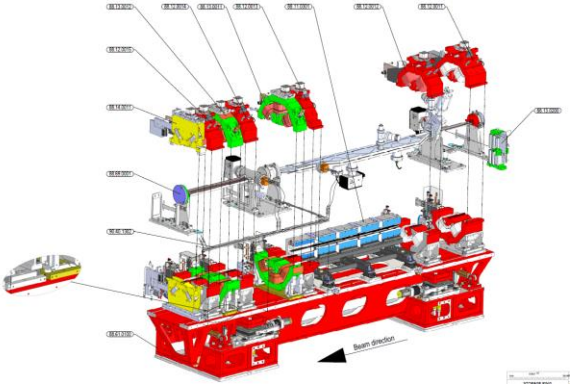
Week 1:
- Position girders
- Install magnets & align
- Open magnets

Week 2:
- Install pre-assembled chambers
- Align BPM's & chambers
- Close magnets

Week 3:
- Cooling installation
- Final alignment
- Move girder outside

Each week:
- Vacuum chambers preparation

GIRDER ASSEMBLY IN FULL SWING



- Assembly building delivered in October 2017
- 3 assembly lines + 1 vacuum preparation line
- 3 to 4 girders assembled per week
- 128/128 girders assembled with magnets
- 112/128 fully assembled with chambers

LOGISTICS & STORAGE

12 Cavity assembled and stored

Assembled girders handling

Storage and logistics are key issues for an upgrade

Components storage

Assembled girders storage

Assembled girders storage

SR INSTALLATION – ENTERING GIRDERS

Loading/unloading from trucks

Assembled girders (12T) are too heavy for the 3 overhead cranes (6.3T)

3 entry points with fixed gantries to lift the girders above the tunnel wall

Transport modules to moved the girders inside the tunnel for final installation

DISMANTLING + INSTALLATION: DEC 2018 – NOV 2019

Dismantling

Civil works

Girder entry
Vacuum connection

Piping
Cabling

FE
Straights Sections
Bakeout

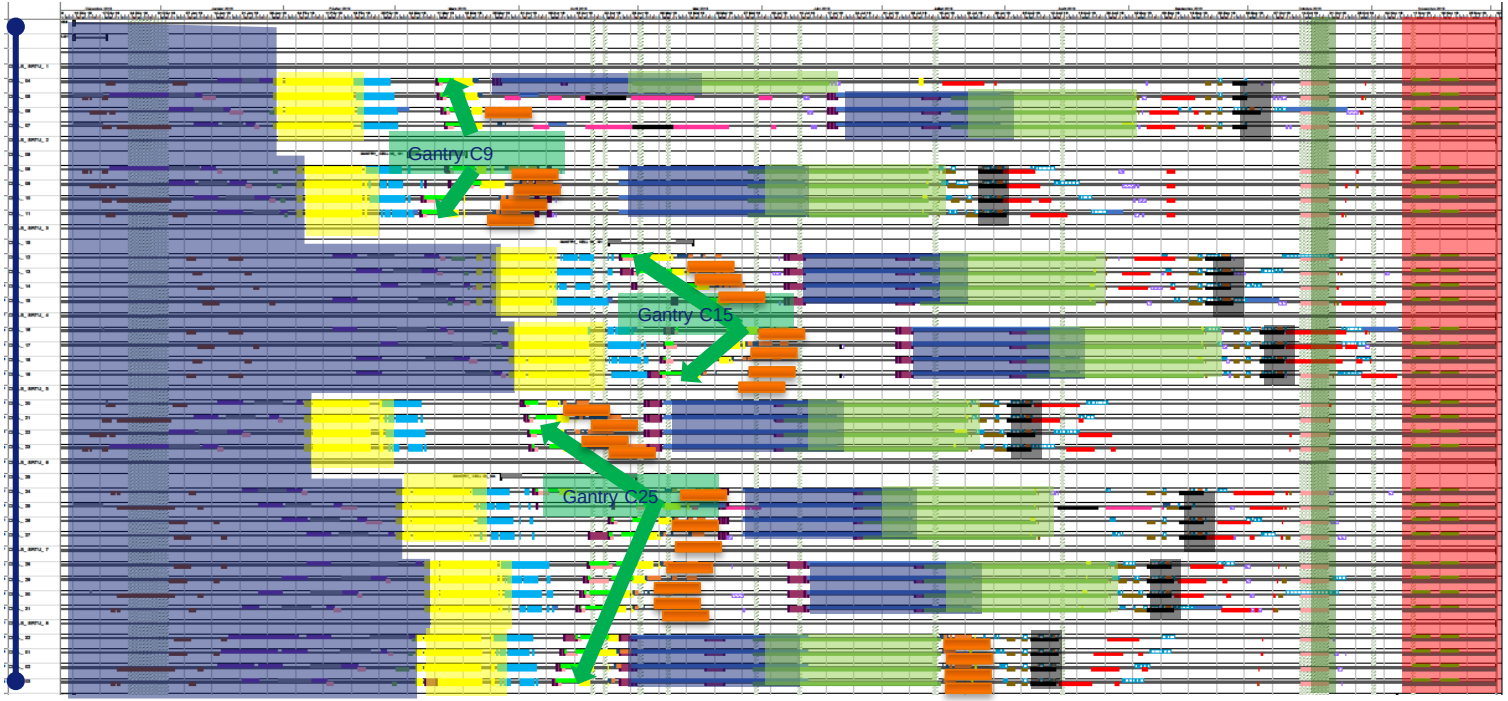
IDs
Equipment test

PSS test

Alignment &
Global tests

Dec 2018 — ***Nov 2019***

32 cells



+ all the activities in the technical areas

GLOBAL TESTS

	November 2019		
	Morning	*Afternoon*	*Night*
Fri 01	s	s	s
Sat 02	s	s	s
Sun 03	s	s	s
Mon 04	s	s	s
Tue 05	s	s	s
Wed 06	s	s	s
Thu 07	s	s	s
Fri 08	s	s	
Sat 09			
Sun 10			
Mon 11	A	*ITLK*	
Tue 12	A+L	*ITLK + RF&PS*	
Wed 13	A+L	*PS + RF*	
Thu 14	A+L	*RF + PS*	
Fri 15	A	*B + PS&RF*	
Sat 16			
Sun 17			
Mon 18	A+L	*PS + RF*	
Tue 19	A+L	*RF + PS*	
Wed 20	A	*PS + RF&B)*	
Thu 21	A	*RF + PS&B)*	
Fri 22	A	*B + PS&RF*	
Sat 23			
Sun 24			
Mon 25	Equip Test	Equip Test	
Tue 26	Diag	*B + PS&RF*	
Wed 27	FE & ID	*B + PS&RF*	
Thu 28	*PS + RFB)*	*B + PS&RF*	
Fri 29	Equip Test	*B + PS&RF*	
Sat 30			

Week -3

Week -2

Week -1

Priority shift in red

- **All equipment ready to inject into TL2 & SR** on 2 December 2019
- SR and booster tunnel closed on 8 November 2019
- Week -2&-3 morning shifts for survey and Alignment with stable condition *(roof beam closed,..),*
  ➔ *LINAC could be tested in parallel.*
- Week -2&-3 afternoon shift dedicated to Machine protection tests (ITLK), SR-RF in the cavities, SR Cavity conditioning, SR-PS global tests, Booster equipment test. *(in principle activities could be done in parallel, but priorities are predefined)*
- Week -1 Morning dedicated to equipment test and intervention
- Week -1 A afternoon shift dedicated to Booster commissioning & SR Cavity conditioning.
- No activities foreseen during night and weekend (Buffer time)

TEST & COMMISSIONING

- Tests before commissioning:

  All equipment will be fully tested for both Hardware, Control software

  The new SR will benefit from the existing control system (TANGO) and from the running infrastructure

  Avoid as much as possible modification of equipment tested and running before the shutdown:
  - Injector
  - New timing system
  - BPMs: 60% of the hardware is kept, new hardware already installed and tested, software upgraded,
  - Loss monitors: new system already operational to get references

  High level commissioning procedures tested on the TANGO accelerator simulator

  The magnet power supply system *(completely new architecture)* is a critical element

- Accelerator commissioning:

  Allocated time : 3 months, starting: Monday December 2th, 2019
  - Month 1 : debugging of equipment and software, 1st turn, initial tuning at low current
  - Month 2 : Current ramping, finer optics tuning
  - Month 3: Contingency, stabilisation of the beam delivery

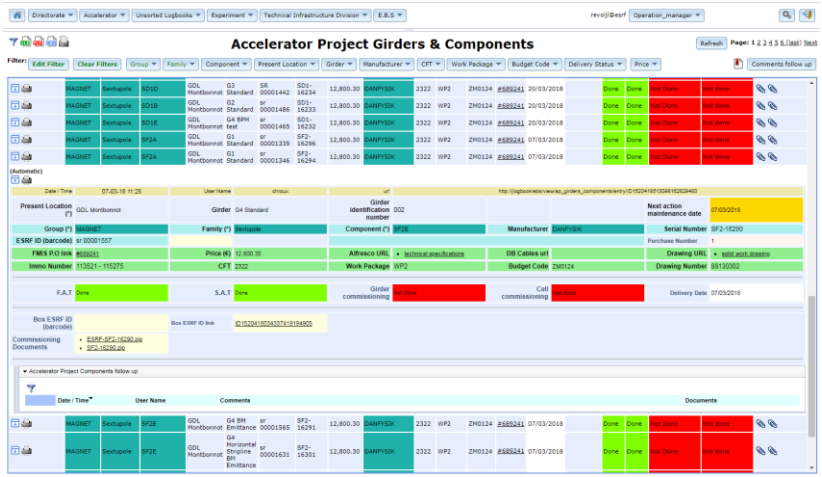
  2 shutdowns are scheduled in that period for heavy interventions and the installation of the sources for bending magnet beamlines *(Single-pole magnet, Two-pole wigglers, Three-pole wiggler)*

FOLLOW-UP

The follow-up of the equipment installation and commissioning will be done using:

- The EBS-installation data base
  ➔ Overall progress of the tasks

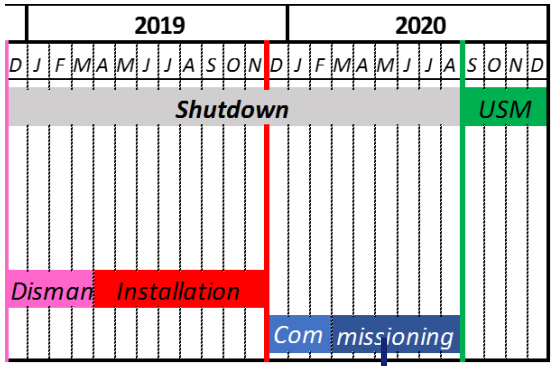
- The equipment database already used to follow-up the procurement and the assembly
  ➔ The data base is already prepared to follow-up each equipment during installation and commissioning



CONCLUSION

- **EBS project running in parallel with ESRF operation**
  - **No impact on user operation**
  - **Continuation of the development of the existing machine**
    (injector upgrade, top-up, cryo-undulators,…)

- **Project execution progression as of today:**
  - **Engineering Design completed**
  - **Procurement completed**
  - **Delivery of main components close to completion**
  - **Mock-up cell completed**
  - **Assembly close to completion**
  - **Dismantling/installation/commissioning planning ready**
  - **At this stage of the project, no show stopper identified.**



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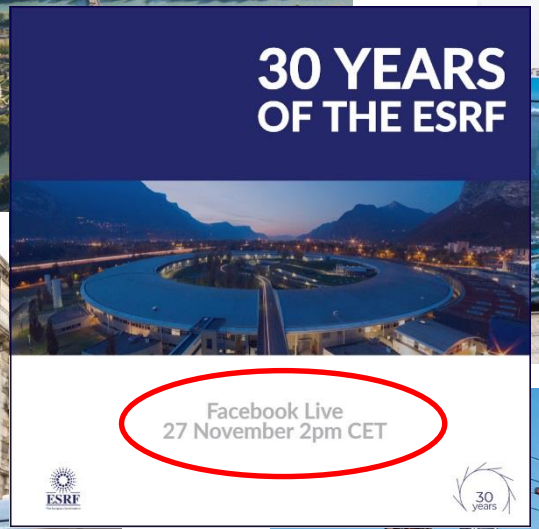
MANY THANKS FOR YOUR ATTENTION