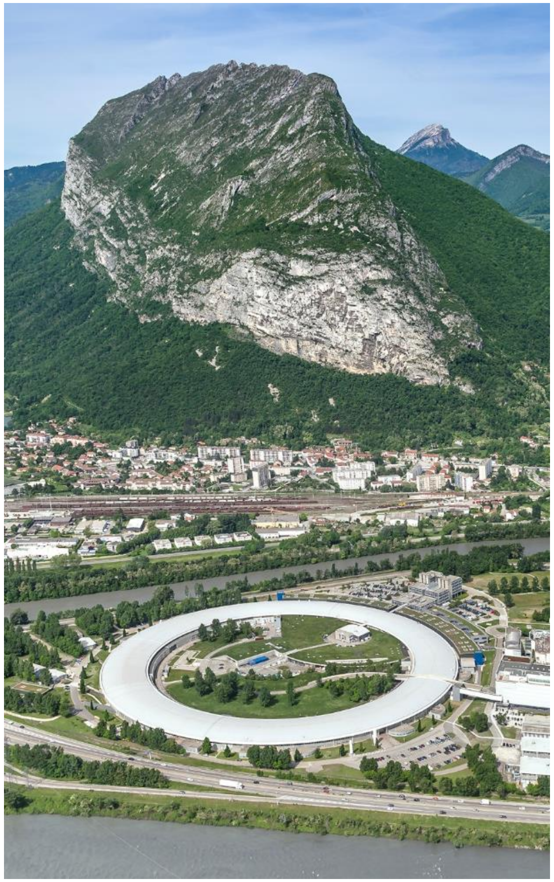
ESRF | The European Synchrotron



1) General presentation

2) The ESRF today

3) The ESRF-EBS Upgrade

Friday 31 January 2020
JUAS 2020 Revol Jean-Luc

A MODEL OF INTERNATIONAL COOPERATION: 22 PARTNER NATIONS

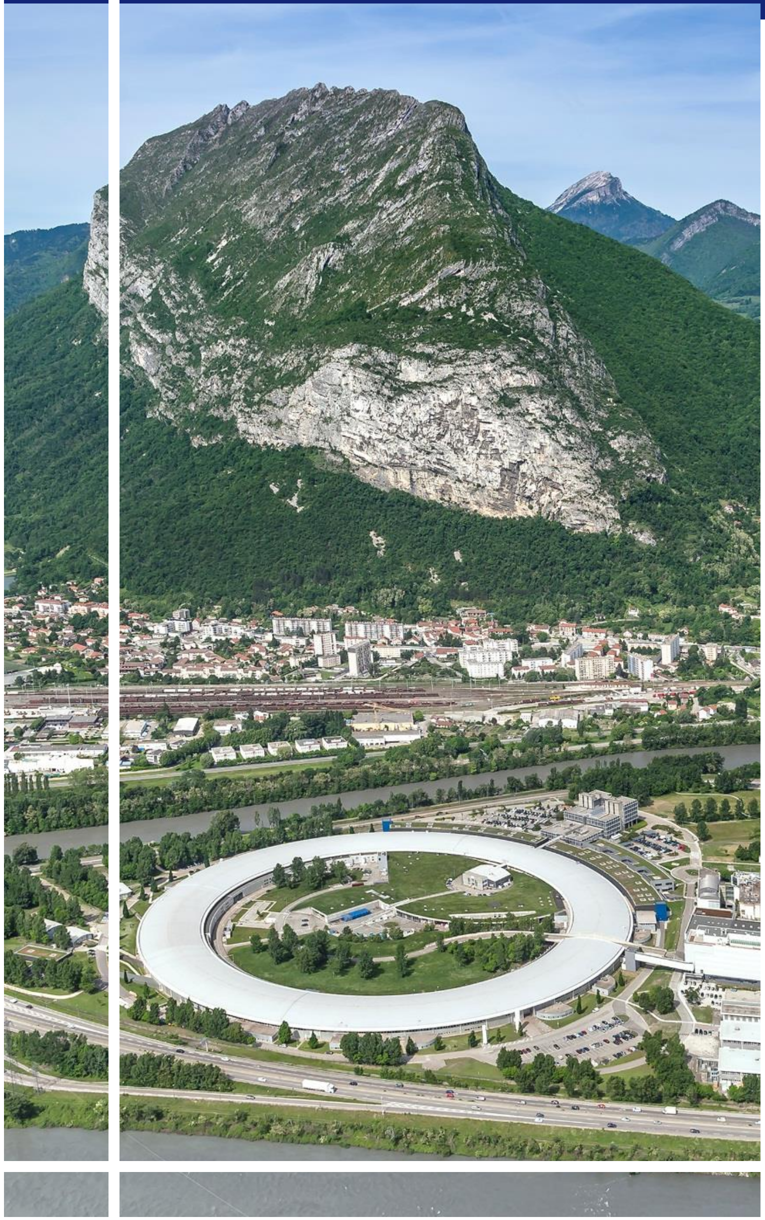
13 Member states:

France	27.5 %
Germany	24 %
Italy	13.2 %
United Kingdom	10.5 %
Russia	6 %
Benesync (Belgium, The Netherlands)	5.8 %
Nordsync (Denmark, Finland, Norway, Sweden)	5 %
Spain	4 %
Switzerland	4 %

9 Associate countries:

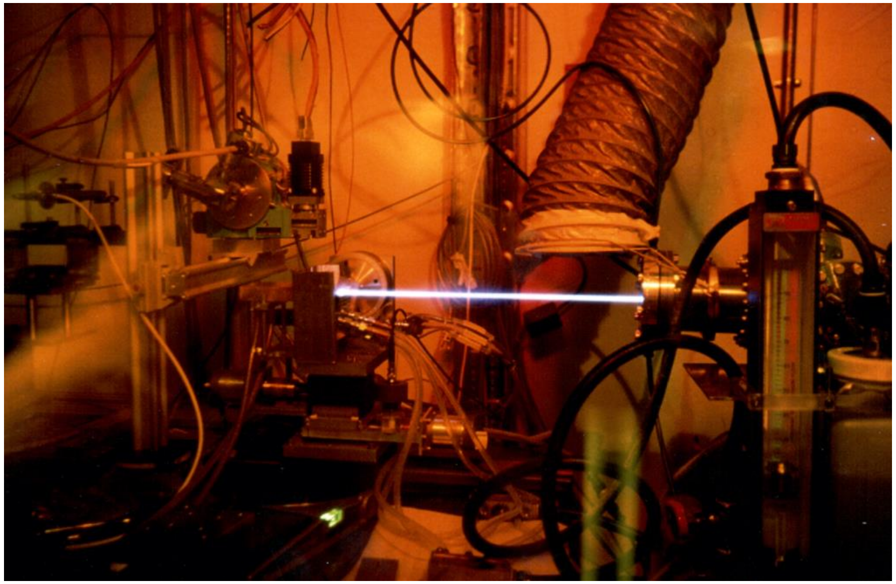
Israel	1.5 %
Austria	1.3 %
Centralsync (Czech Republic, Hungary, Slovakia)	1.05 %
Poland	1 %
Portugal	1 %
India	0.66 %
South Africa	0.3 %

22 partner nations
Annual budget: **100 million euros**
Staff: **630 people, 40 different nationalities**
Legal status: **Private civil company subject to French law**



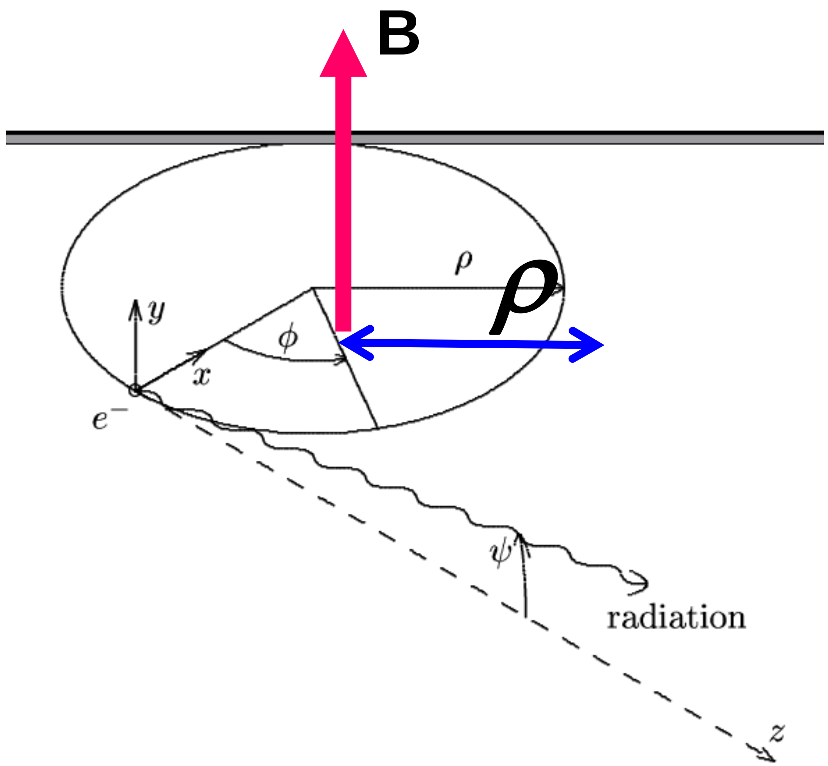
ESRF
The European Synchrotron

The ESRF yesterday



PRINCIPLE

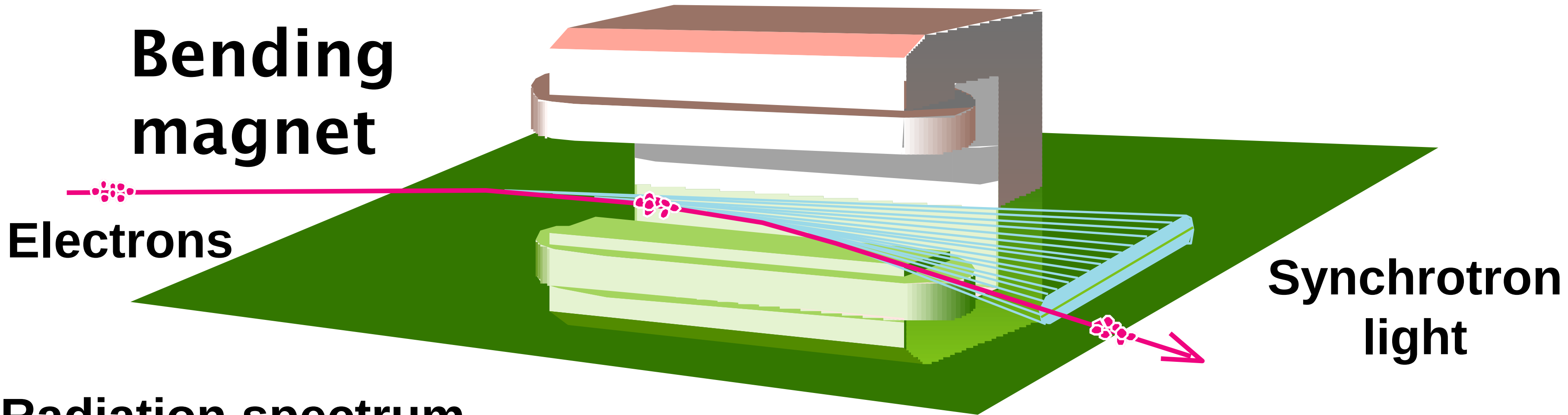
- When a charged particle is deviated in a magnetic field, it loose energy by emitting electromagnetic radiation (photons),call synchrotron radiation, tangent to the trajectory.



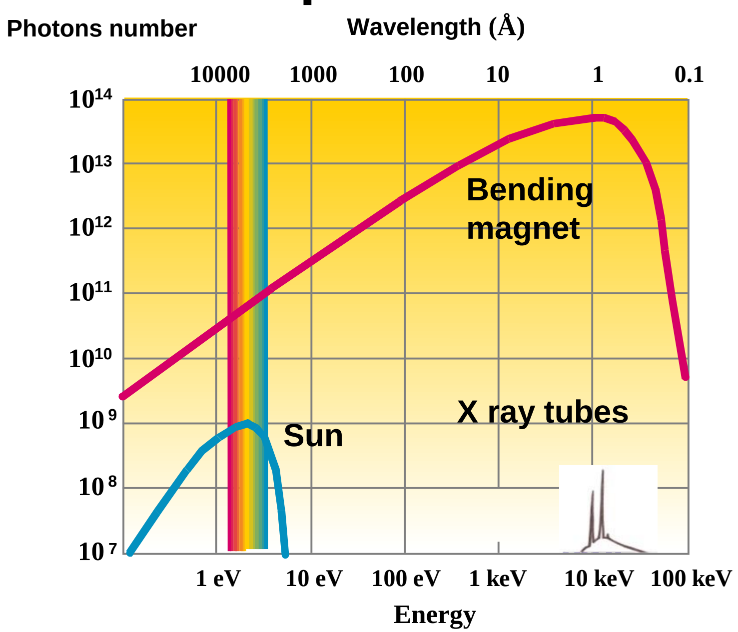
$$P \propto \left(\frac{E}{mc^2}\right)^4 \frac{I}{\rho}$$

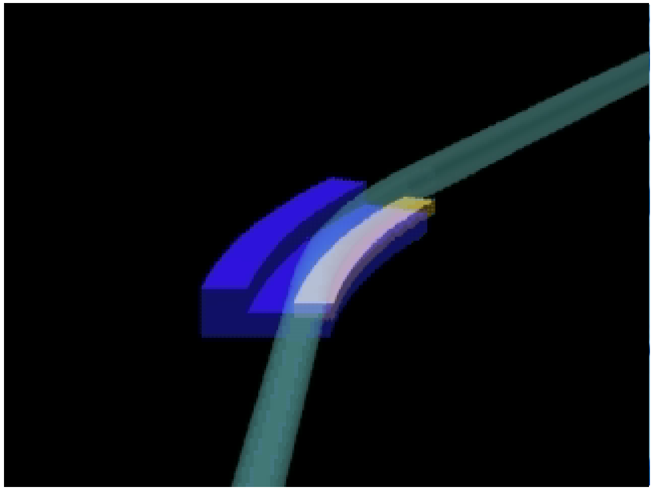
Large difference between electrons and protons !

Scale with the square of the energy!



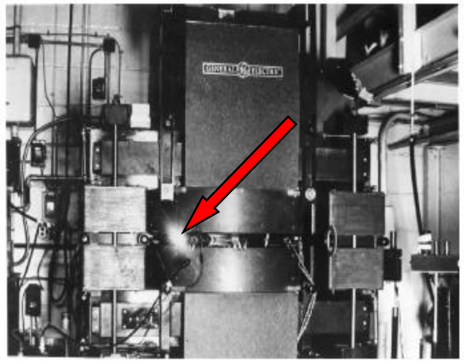
Radiation spectrum



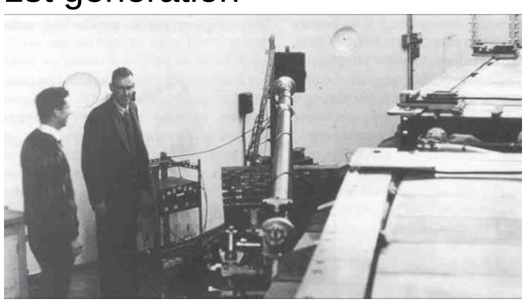


FROM PARASITIC USE TO DEDICATED USER FACILITY

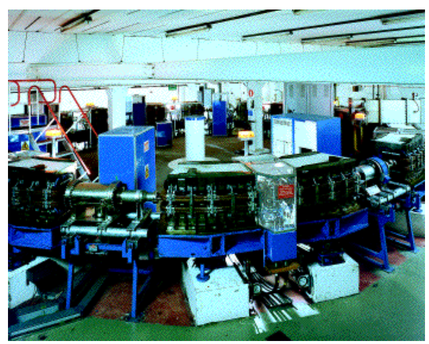
1947: First observation of synchrotron radiation



« Nina », first beamline at Daresburry in1966 (synchrotron 6 GeV électron). 1st generation

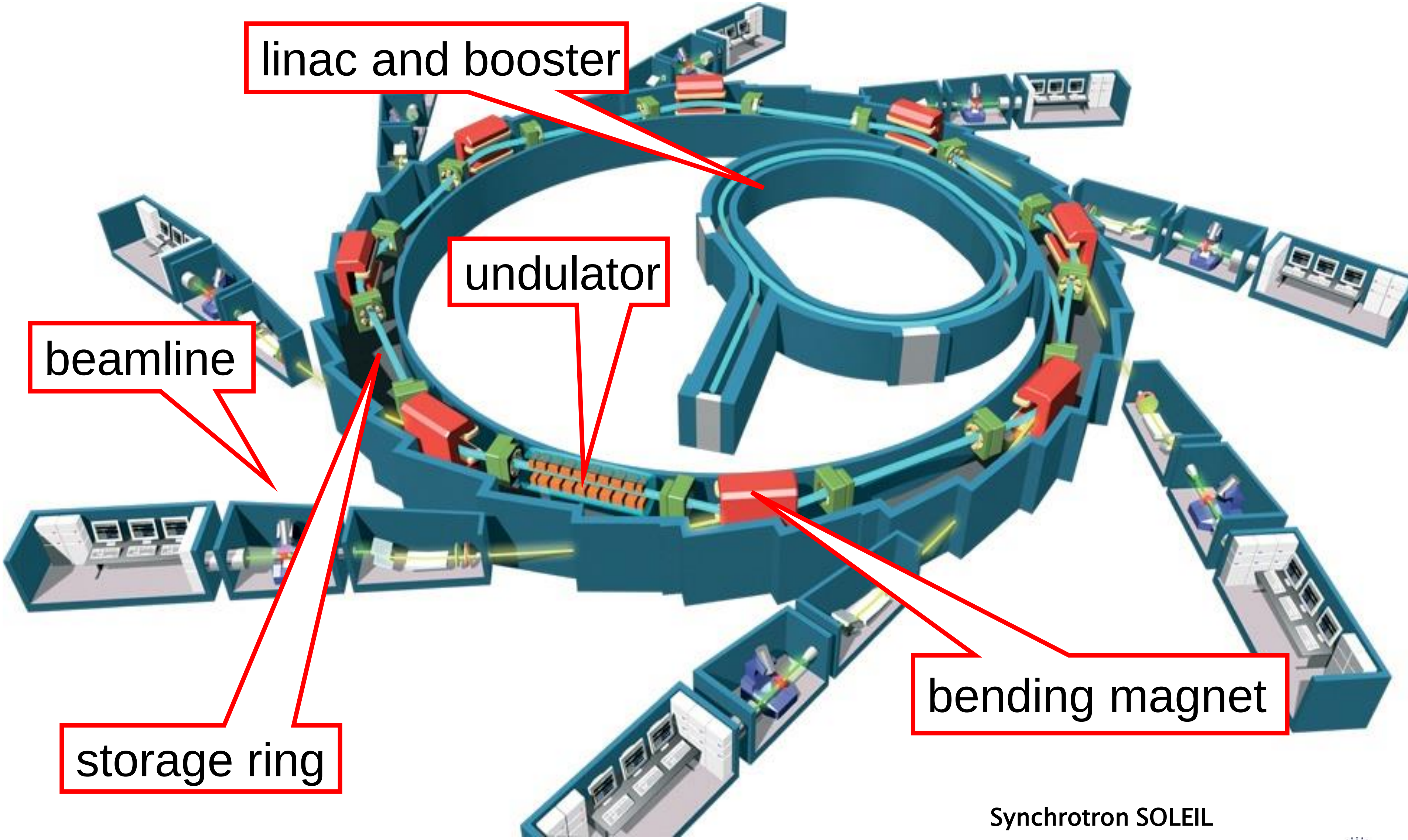


1981: SRS (UK) 1st dedicated X ray light source
2nd generation



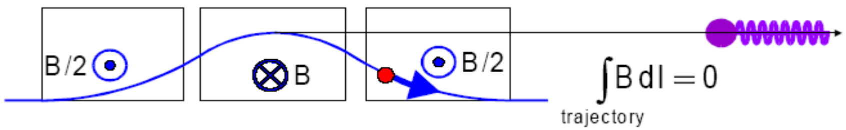
1994: Inauguration of the l'ESRF, The first X ray light source of the 3rd generation

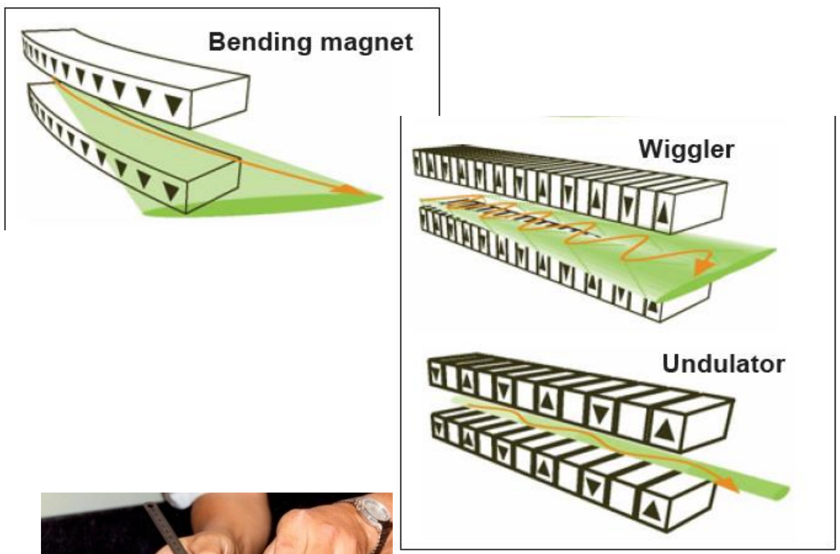
A TYPICAL USER FACILITY

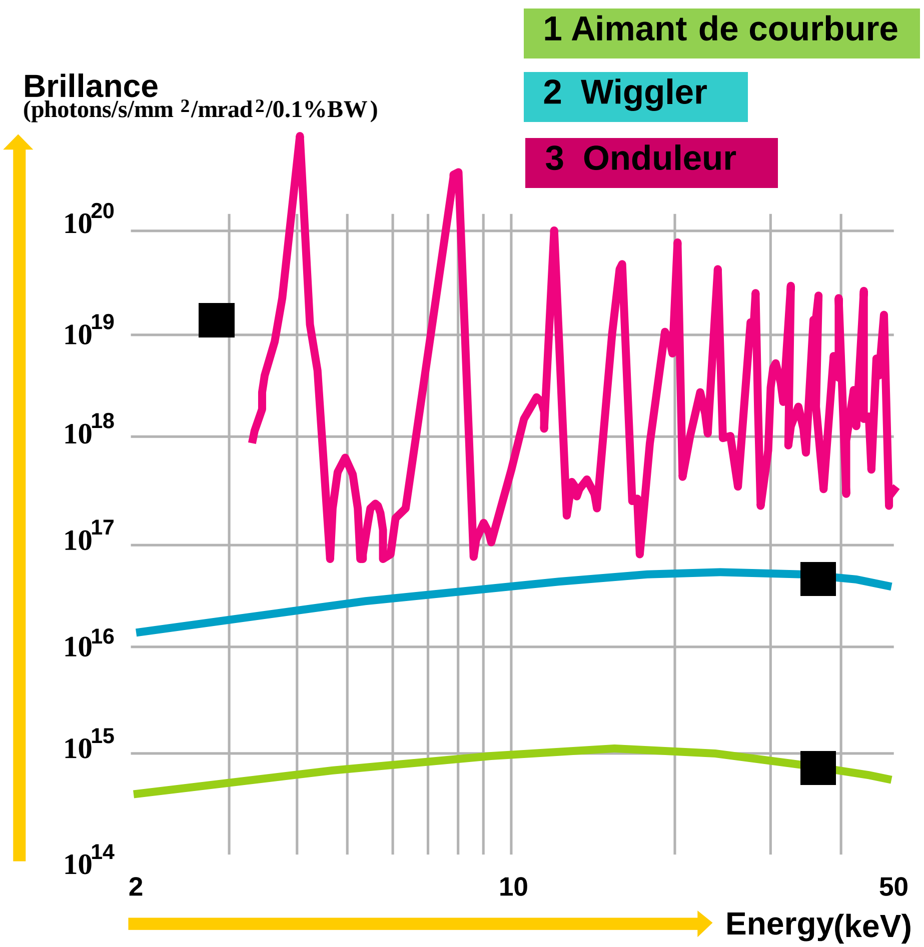


Synchrotron SOLEIL

Insert permanent magnets to provide an alternative magnetic field to bend the trajectory.







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BRILLIANCE OF LIGHT SOURCES

Progress of X ray light sources are summarized in the evolution of the brilliance

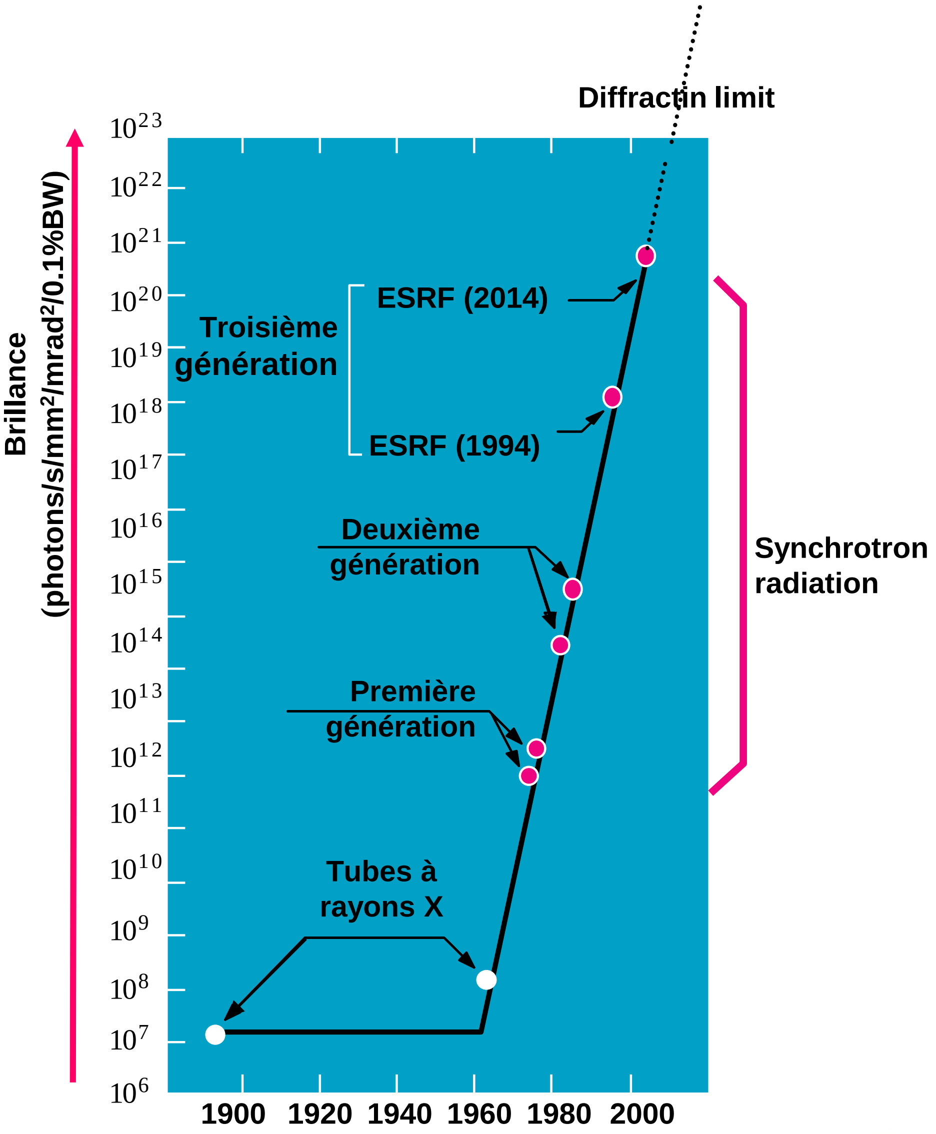
Brilliance =
photons /s / mm² /mrad² /0.1% bandepassante

Number of photons per second

Size horizontale*vertical

Divergence horizontal *vertical

In a bandwith of 0.1 % around the considered energy.



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MORE THAN 50 SYNCHROTRON LIGHT SOURCES AROUND THE WORLD

DIFFERENT TYPE OF SOURCES

Many Medium energy rings :2.7-3.5 GeV

SOLEIL, DIAMOND, CLS, ALBA, SSRF, TPS ,Australian Synchrotron, NSLS II, MAXIV …

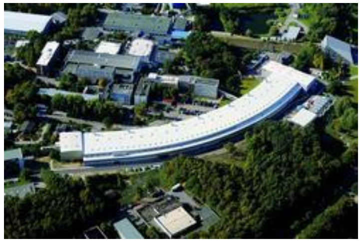
High energy rings (≥ 6.GeV)

SPRING 8

ESRF Upgrade

APS Upgrade

Petra III



X FELs (4th ~~generation light sources~~)

- LCLS (Stanford)
- SACLA (SPRING8)
- Flash, European XFEL (Hamburg)
- Fermi@ elettra
- …..

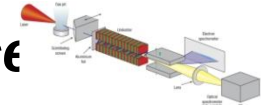
LCLS

SACLA

European XFEL

Fermi

Laser plasma acceleration: 5th generation light source



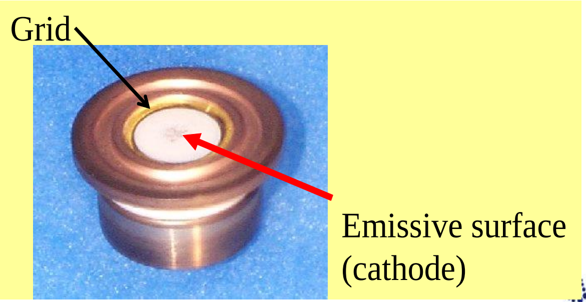
THE ACCELERATOR COMPLEX

THE LINEAR ACCELERATOR

The Linac consists in one **TRIODE** (cathod – anod – grid) powered with 100 KV. Electrons produced have then an energy of 100 keV.

The electrons are then accelerated in 2 sections (each section = 6 meters), accelerating the beam by 100 MeV, i.e., a total of 200 MeV.

Operation mode	Long pulses	Short pulses
Peak current	25 mA	250 mA
Pulse length	1µs	2ns
Energy spread	+/- 1%	+/- 0.5%



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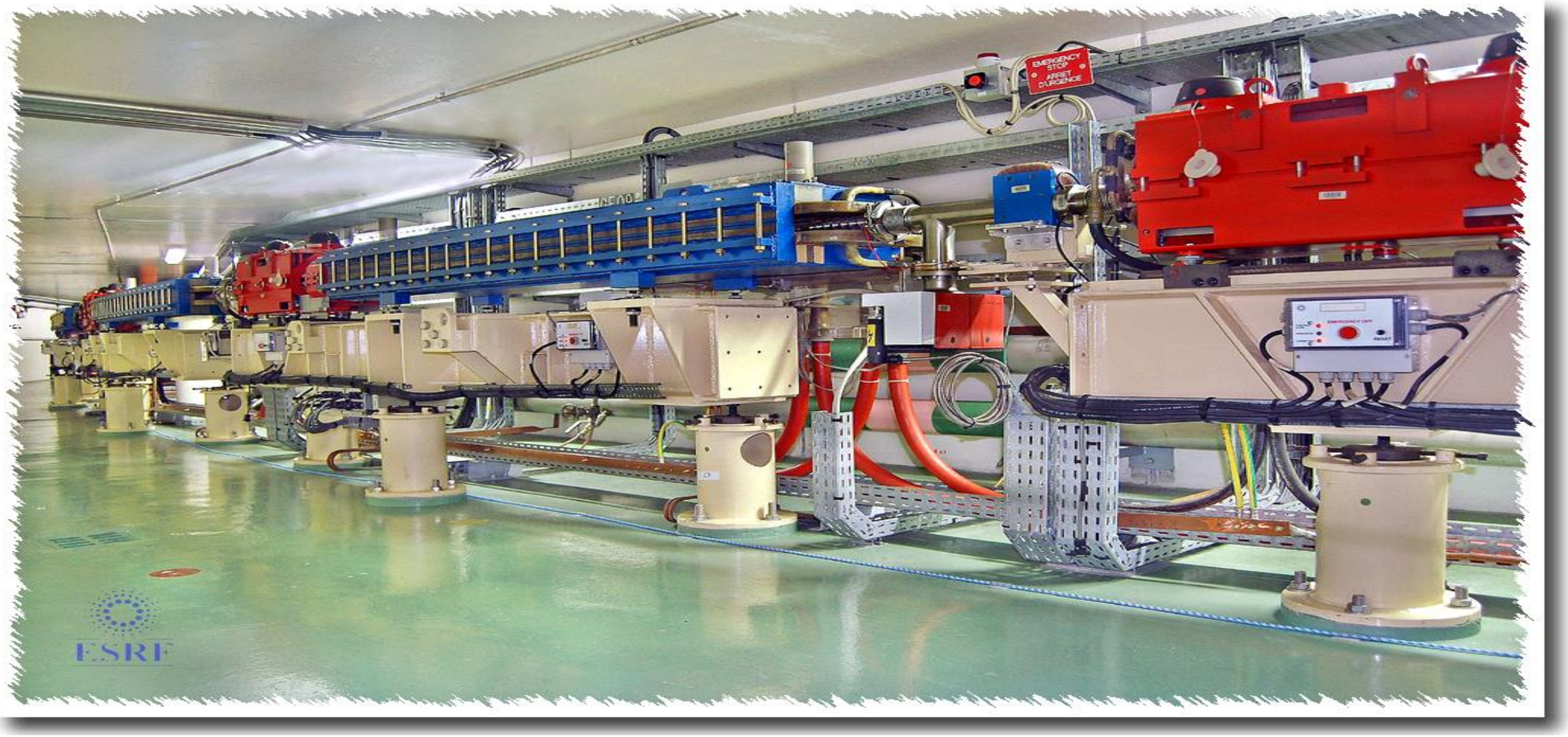
THE TRANSFER LINE FROM THE LINAC TO THE BOOSTER: TL1

- Length: 16 metres
- Main components: 2 bending magnets, 7 quadrupoles, 2 pairs of steerers
- Diagnostics: insertable screens + synchrotron radiation

screens

THE SYNCHROTRON (OR BOOSTER)

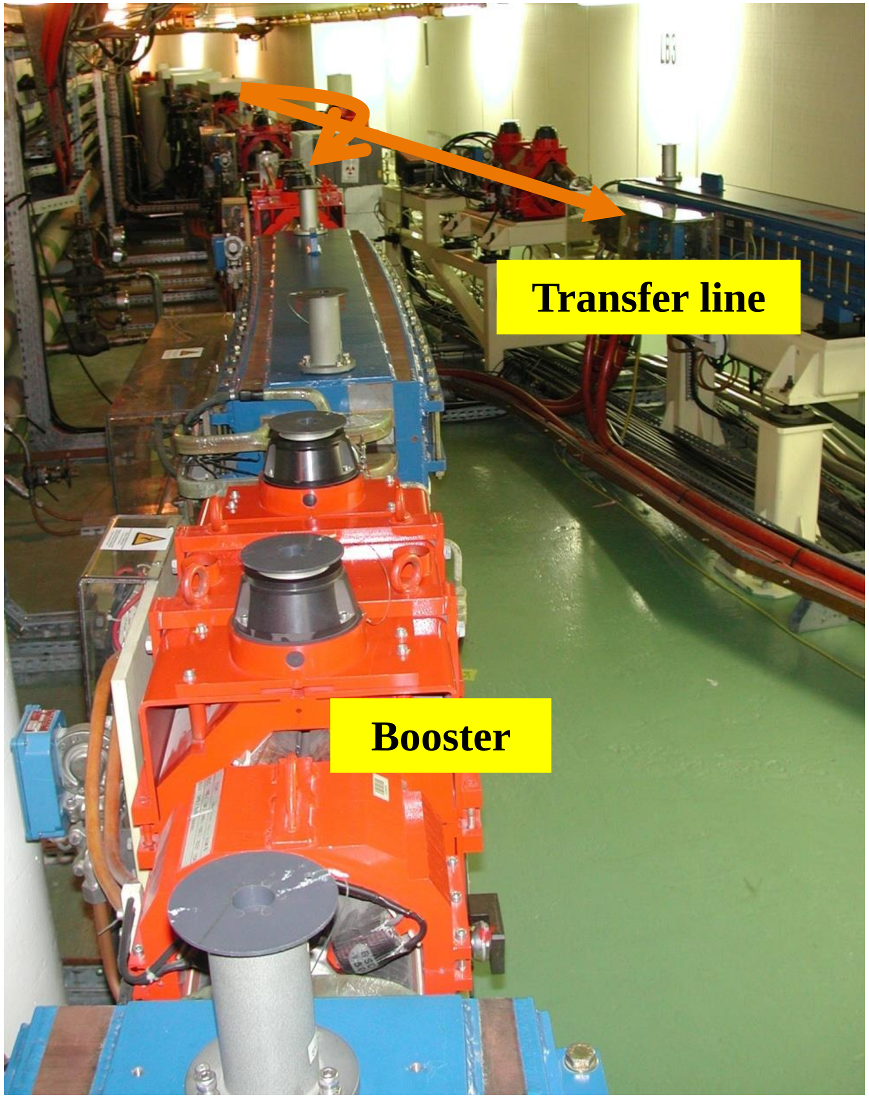


Goal: Accelerate the electrons from 200 MeV to 6 GeV

Cycle: period of 250 msec

Length: 300 metres

THE TRANSFER LINE FROM THE BOOSTER TO THE STORAGE RING: TL2



Goal:

Transfer the 6 GeV electrons from the Synchrotron to the storage ring:

- 5 bending magnets (powered in serie with Booster dipoles)
- 14 quadrupoles
- 9 insertable screens
- Beam Position Monitors
- Synchrotron radiation screens (1 screen / dipole)
- Length: 65 metres

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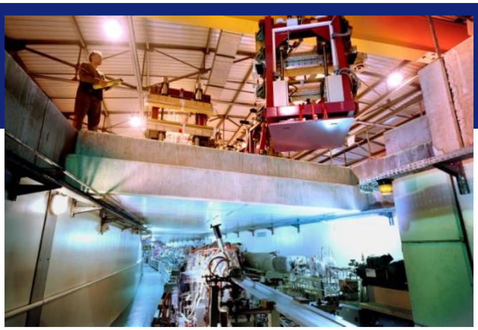
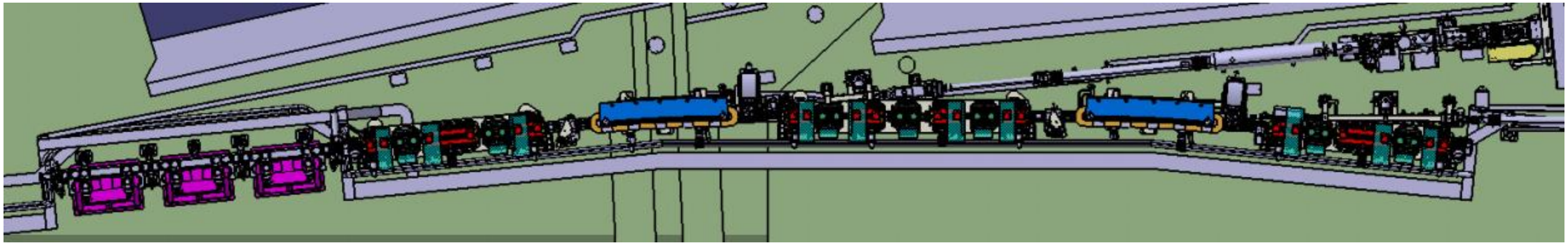
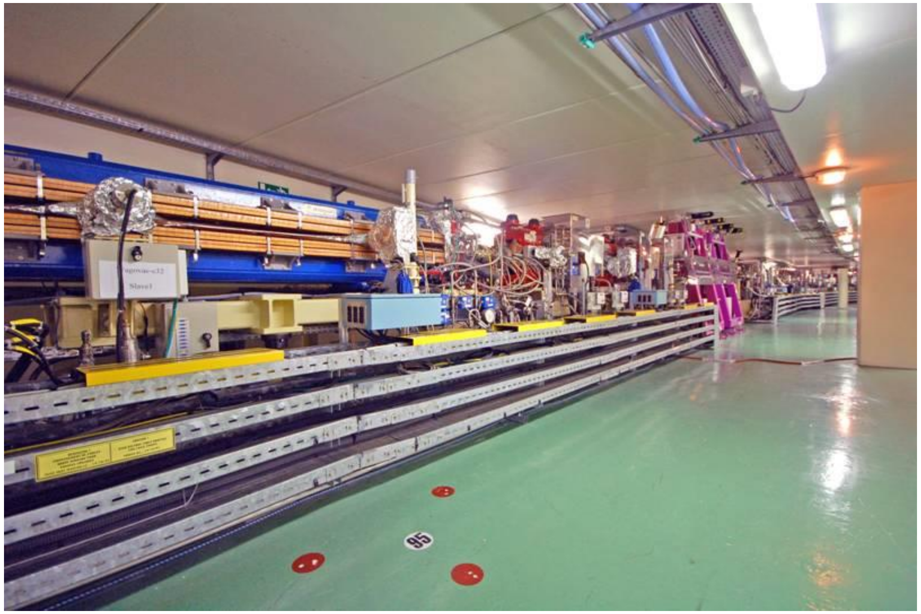
THE STORAGE RING YESTERDAY



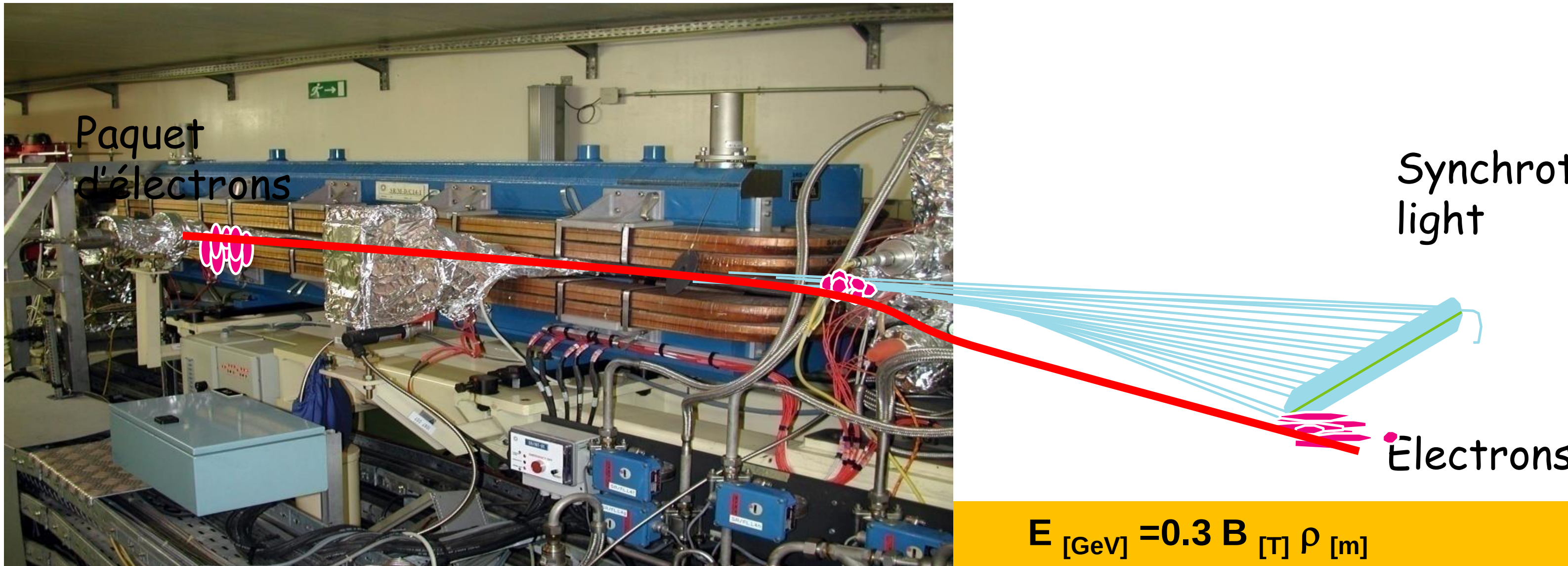


- Circumference: 844 metres
- 16 super-periods of 2 mirror cells➔ 32 cells
- Energy: 6 GeV
- Nominal intensity: 200 mA
- Emittance: 4nm rad
- Usual coupling : 0.1 %



THE STORAGE RING BENDING MAGNETS

64 bending magnets (dipoles)



$E_{[GeV]} = 0.3\, B_{[T]}\, \rho_{[m]}$

$B = 0.8$ T $\rho = 25$ m

Energy lost per turn of ring by one electron

$$\Delta E_{[keV]} = 88.5 \frac{E^4_{[GeV]}}{\rho_{[m]}} = 4.6 \text{ MeV}$$

The power radiated around the length of the ring bending magnets by a current of 200 mA = 920 kW

Numbers :	64 (2 per cells)
Bending angle :	5.625 °
Magnetic field :	0.8612 Tesla
Number of family :	1
Nominal intensity :	714.993 A

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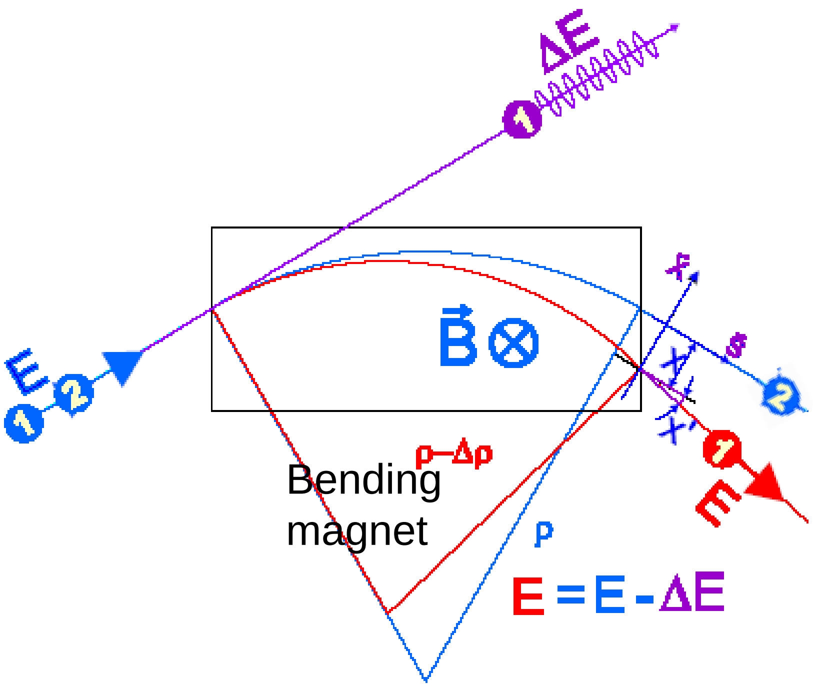
GENERATION OF AN HORIZONTAL EMITTANCE BY RADIATION



Electron 2 emits Δe at the exit of the bending magnet.

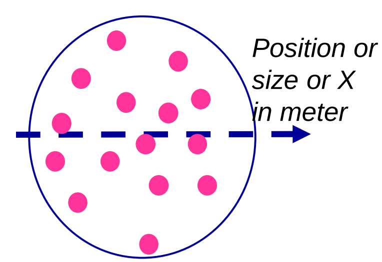
- ➔ *same energy when crossing the magnet*
- ➔ *stay on the reference trajectory*

Electron 1 emits ΔE at the entrance of the bending magnet.

- ➔ *lower energy when crossing the magnet*
- ➔ *larger curvature*

A horizontal beam size and divergence (or emittance) and an energy spread is created.

The beam emittance is the **surface** occupied by the beam in size and divergence.



$$\varepsilon_{x[m*rad]} = \frac{1}{\pi}\oiint dx\,dx'$$

THE STORAGE RING QUADRUPOLE MAGNETS

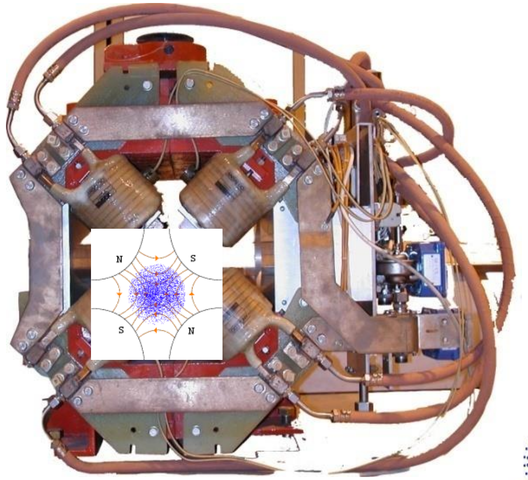
256 quadrupoles shared in 6 families

Name	Number
QF2	32
QD3	32
QD4	64
QF5	64
QD6	32
QF7	32

The goal of the **quadrupoles** is to focus the electron beam so as to maintain its size as small as possible

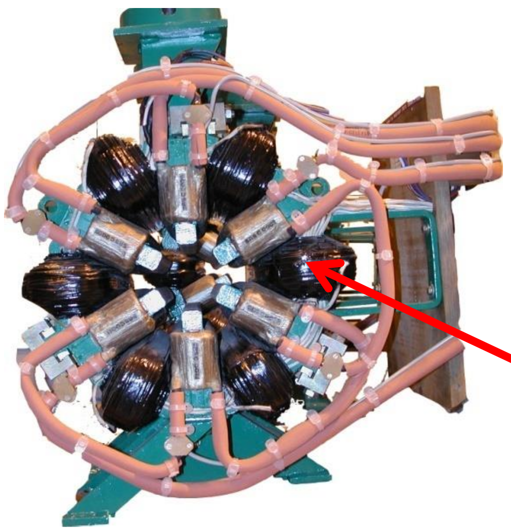
The quadrupole settings are also important for:

- the tune values,
- the beam size,
- the injection efficiency,
- the betatronic resonances,   etc



THE STORAGE RING SEXTUPOLE MAGNETS

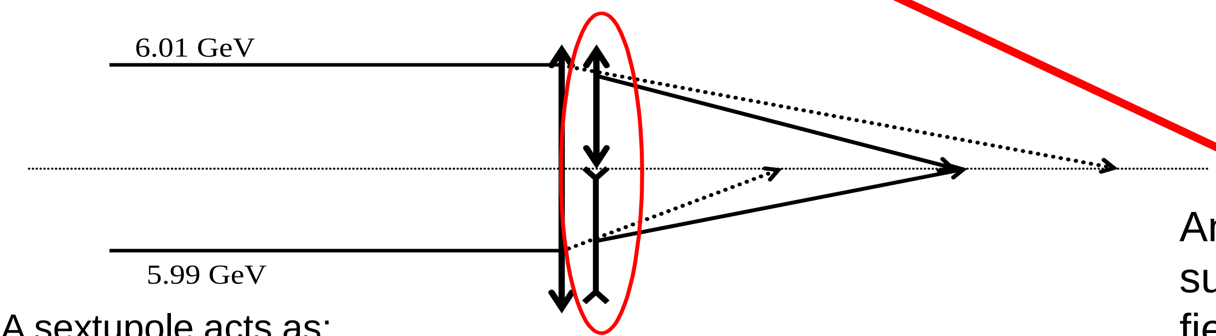
224 sextupoles shared in 7 families



Name	Number
S4	32
S6	32
S13	32
S20	32
S19	32
S22	32
S24	32

Their settings are important for:

- the chromaticities,
- the betatronic resonances
- the dynamic aperture,
- and therefore the beam lifetime



And steerers (3 power supplies to get a H or V field)

A sextupole acts as:

- A focusing quadrupole for the electrons which have a higher energy

- A defocusing quadrupole for the electrons which have a lower energy

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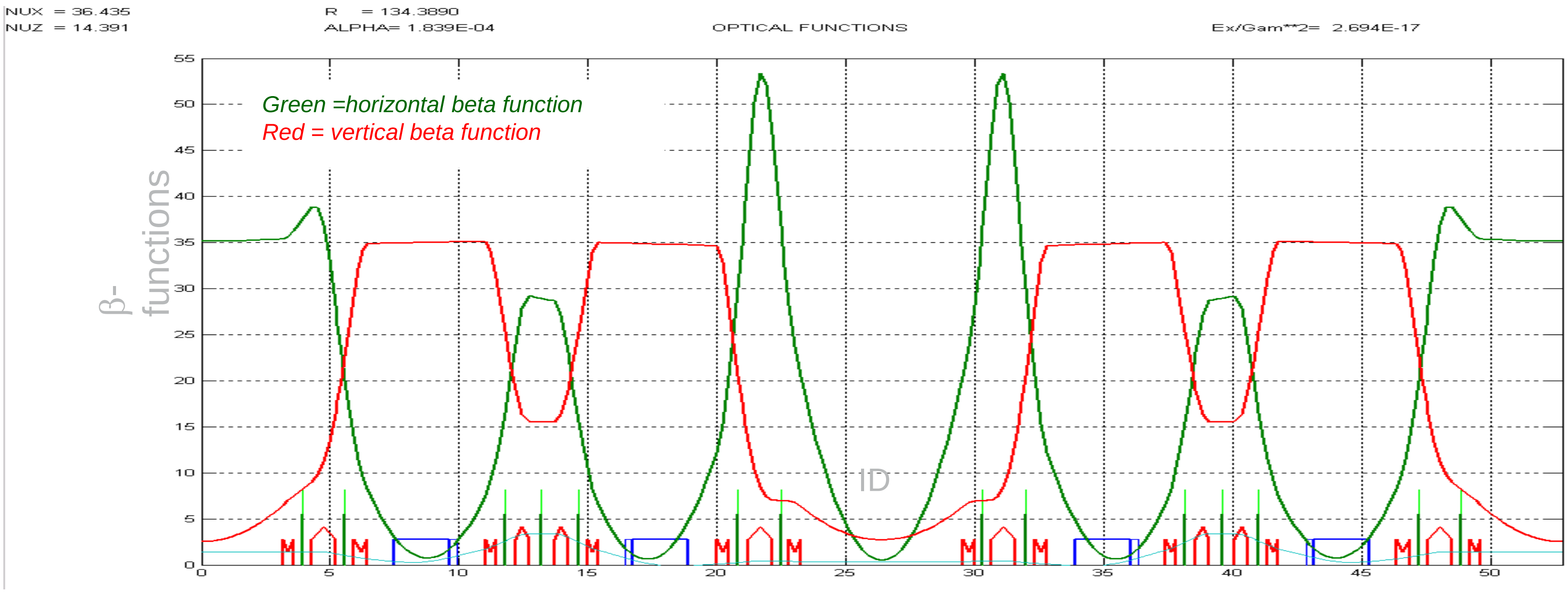
THE ESRF STORAGE RING LATTICE

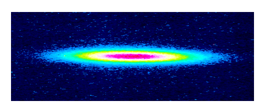


5 m

5 m

5 m

Even cells



Odd cells

ESRF Horizontal emittance = 4 nm.rad

ESRF vertical emittance = 5pm

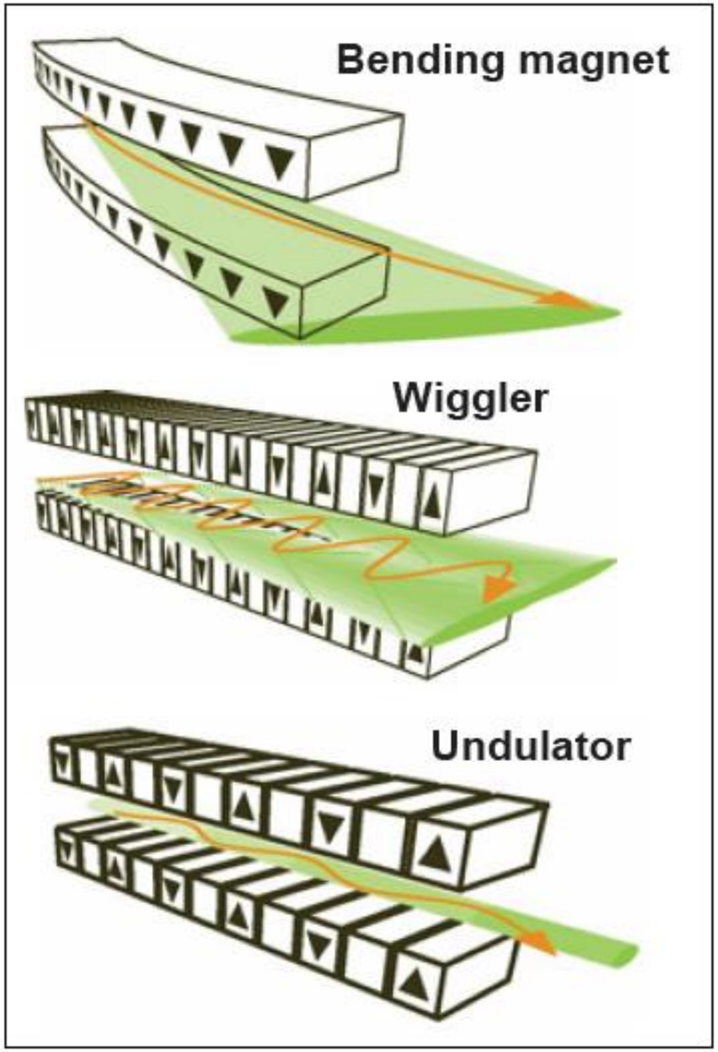
Vertical emittance is determined by the coupling to the horizontal motion due to magnet or alignment imperfections.

$$\sigma_x = \sqrt{\varepsilon_x \beta_x} \qquad \sigma'_x = \sqrt{\varepsilon_x / \beta_x}$$

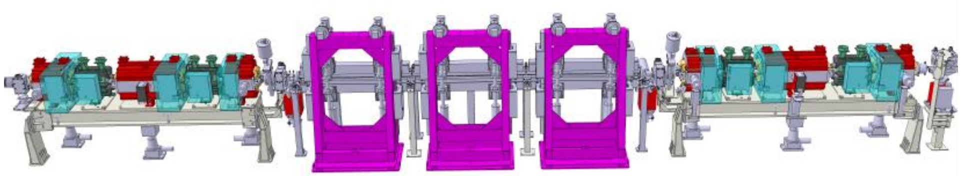
$$\sigma_y = \sqrt{\varepsilon_y \beta y} \qquad \sigma'_y = \sqrt{\varepsilon_y / \beta_y}$$

Taille *Divergence*

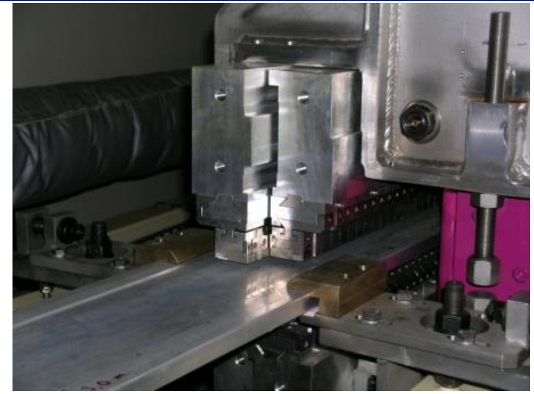
INSERTION DEVICES

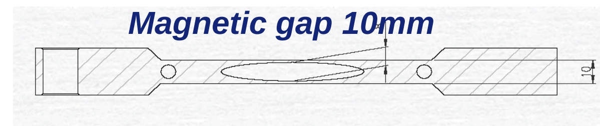


<u>Goal</u>: produce X-rays with specific properties which are different from those emitted by the dipoles, for example, tuneable energy spectrum, polarisation, higher brilliance...



<u>In-air</u> *length =1.64 m*





<u>In-vacuum</u>

Length=2.4 m

(2.4 m flenge to flange , 2m magnetic asembly)

Power generated by one undulator (1.6 m) = 3kW

Available power = 250 kW

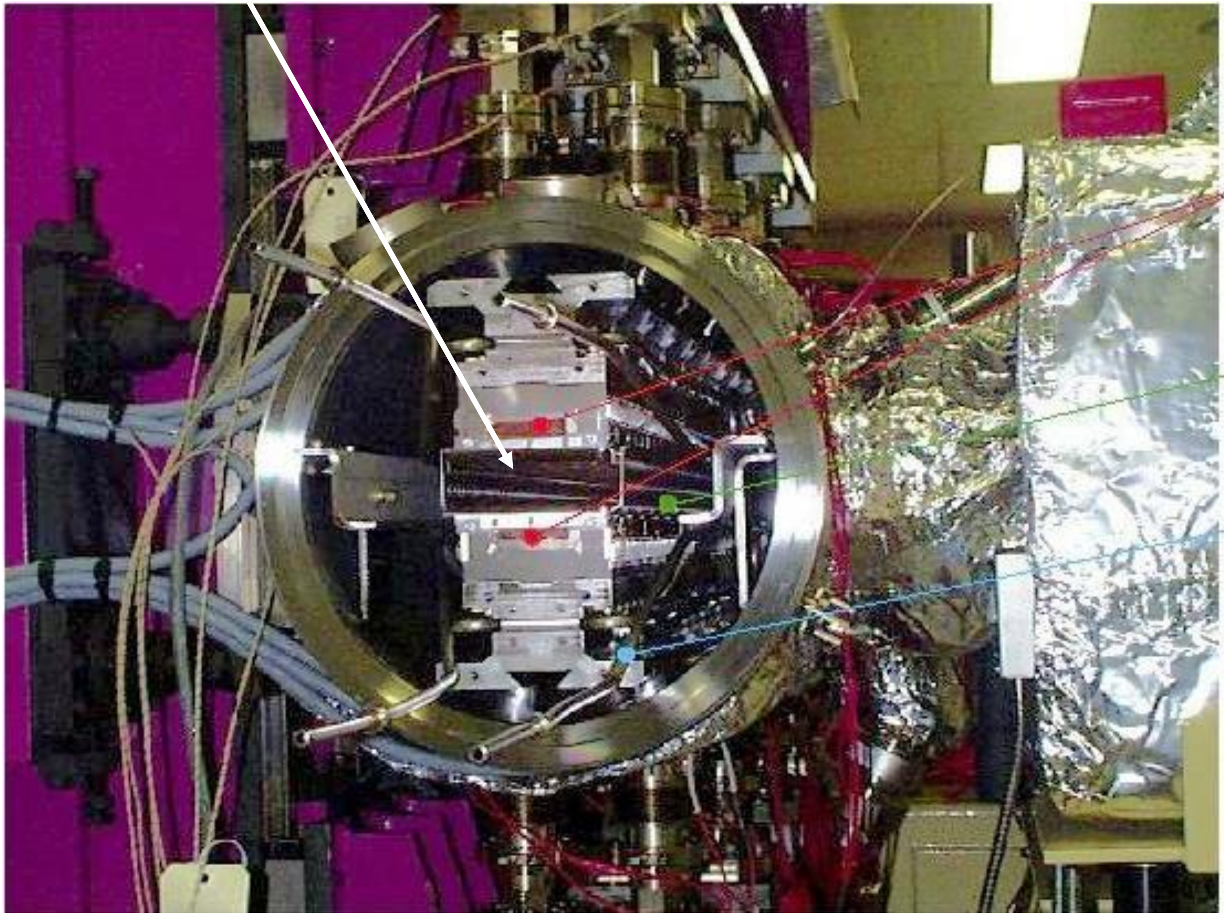
But less than 100 kW is used!!

2kW/mm^2 at 200 mA

8000 kW of Electrical power is needed to produce it!! Efficiency: 2% !

IN-VACUUM UNDULATORS

The jaws of the in-vacuum undulators can be closed down to 5 mm

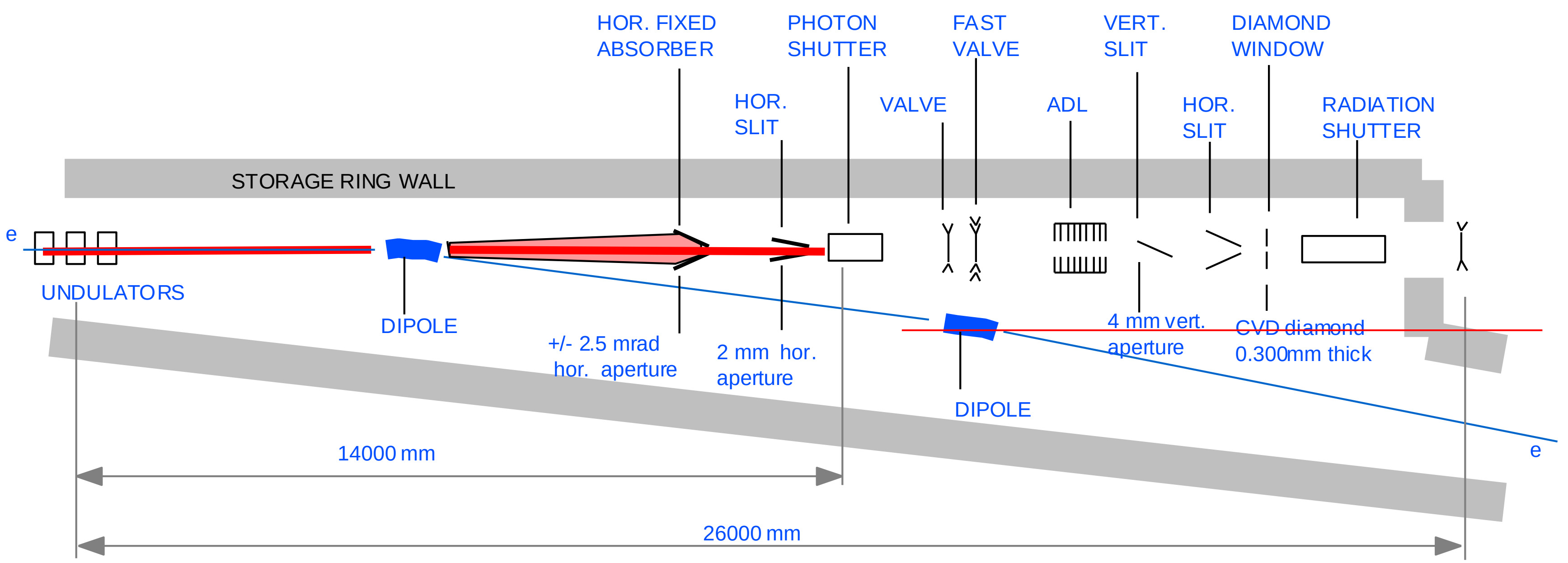


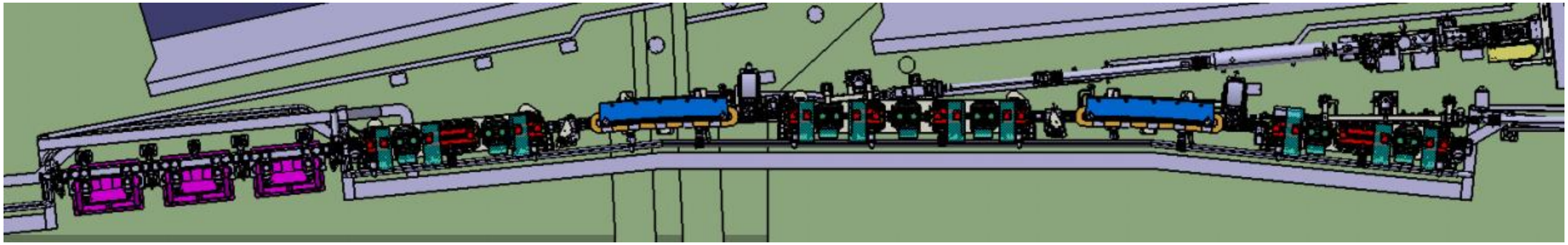
Permanent Magnets
(Sm_2Co_{17}) + Cu-Ni sheet

RF Masks

Cooling Pipes

THE STORAGE RING FRONT ENDS





Goal: Drive the X-rays produced either by the dipoles, or by the insertion devices, from the storage ring to the beam line.

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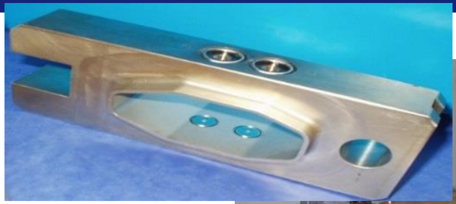
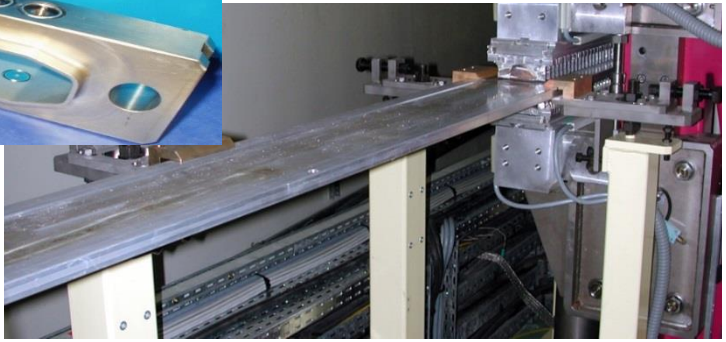
THE VACUUM SYSTEM



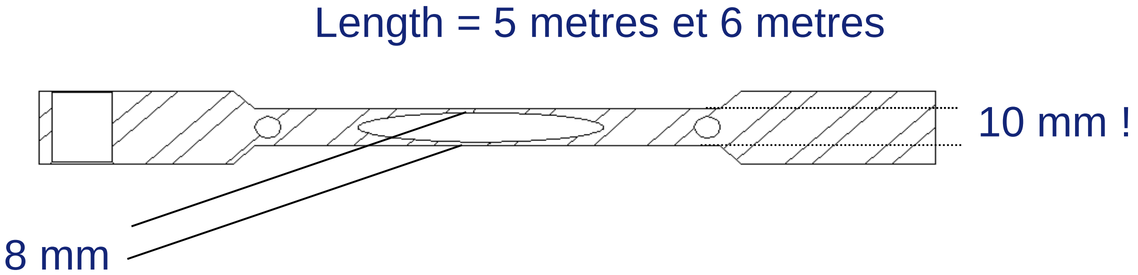


Goal: control and maintain an excellent vacuum level in the storage ring:

10^{-10} mbar without beam (static pressure)
10^{-9} mbar with beam (dynamic pressure)

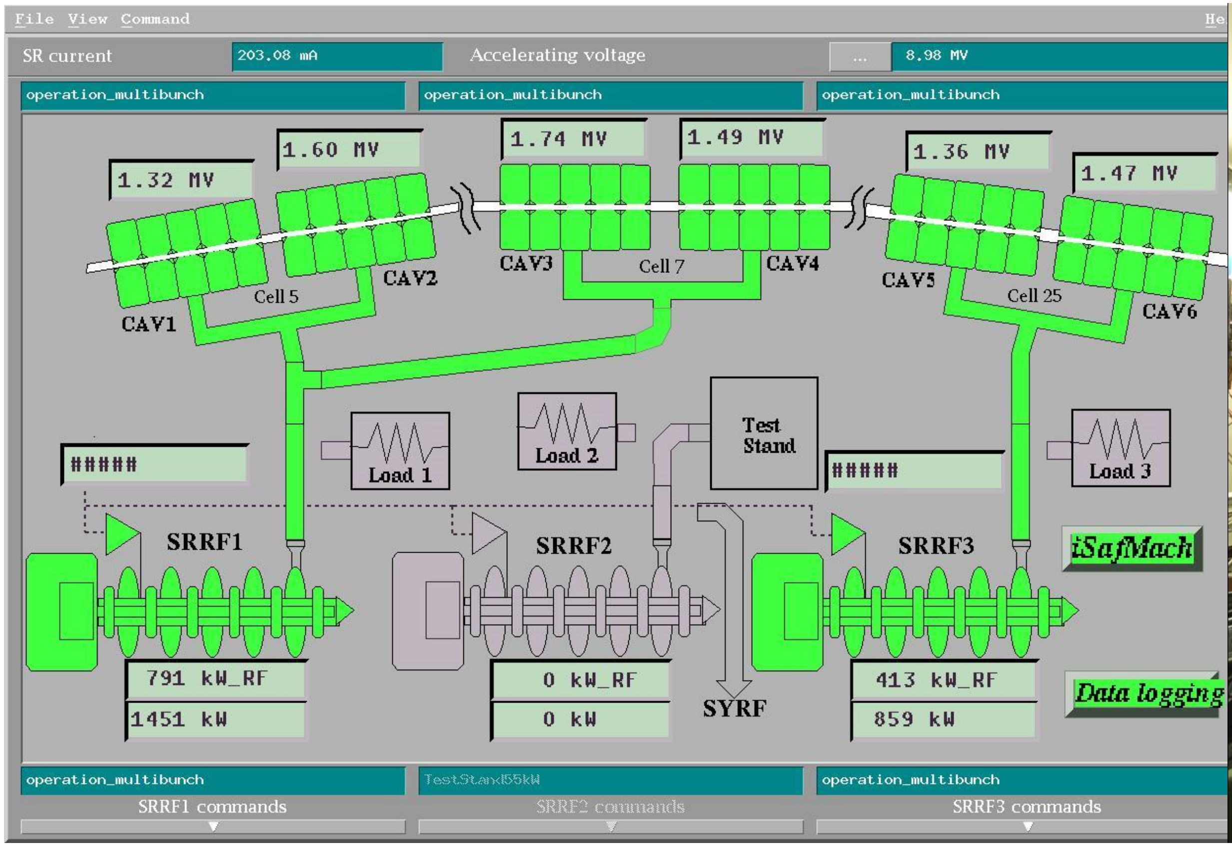
- This vacuum level is ensured by the ionic pumps, NEG coating
- The pressure control is done with Penning gauges.

ID chambers



- Extruded aluminium
- The internal side of these vacuum vessels is covered with a thin coat of NEG material (Non Evaporable Getter) made of an alloy of Titanium, Zirconium, Vanadium. The particularity of this alloy is to trap chemically certain molecules (mainly CO and CO2) acting as vacuum pumps.

THE STORAGE RADIOFREQUENCY SYSTEM



Goal: compensate the energy loss turn / turn by the electrons, following the synchrotron radiation emission, i.e., 4.8 MeV (with all insertion devices)

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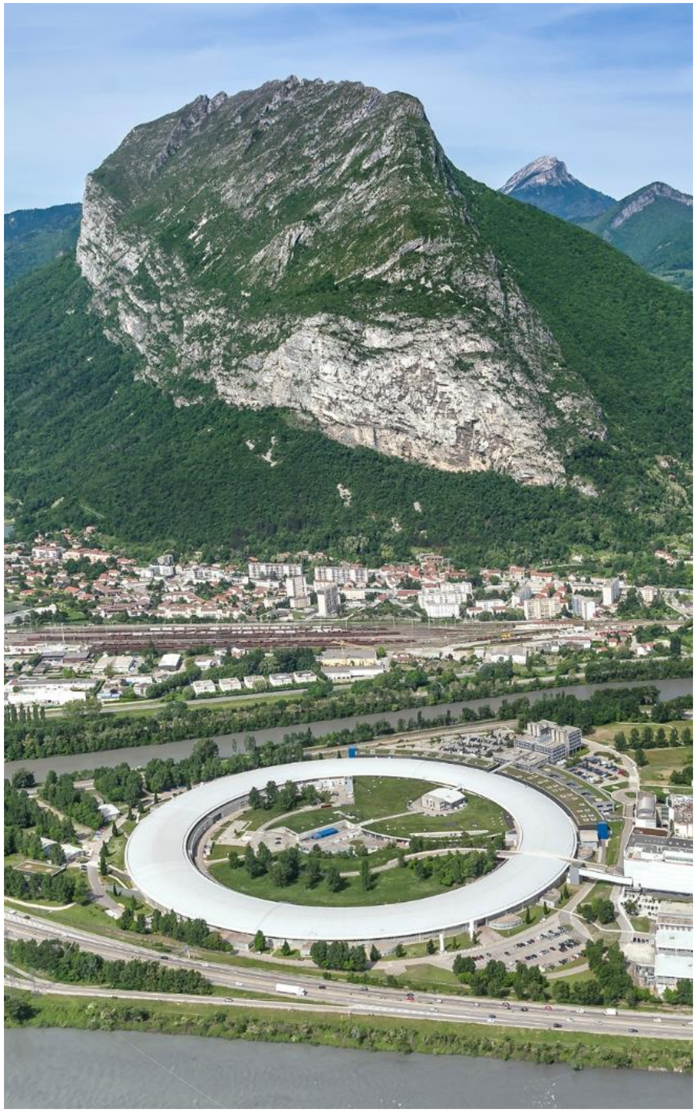
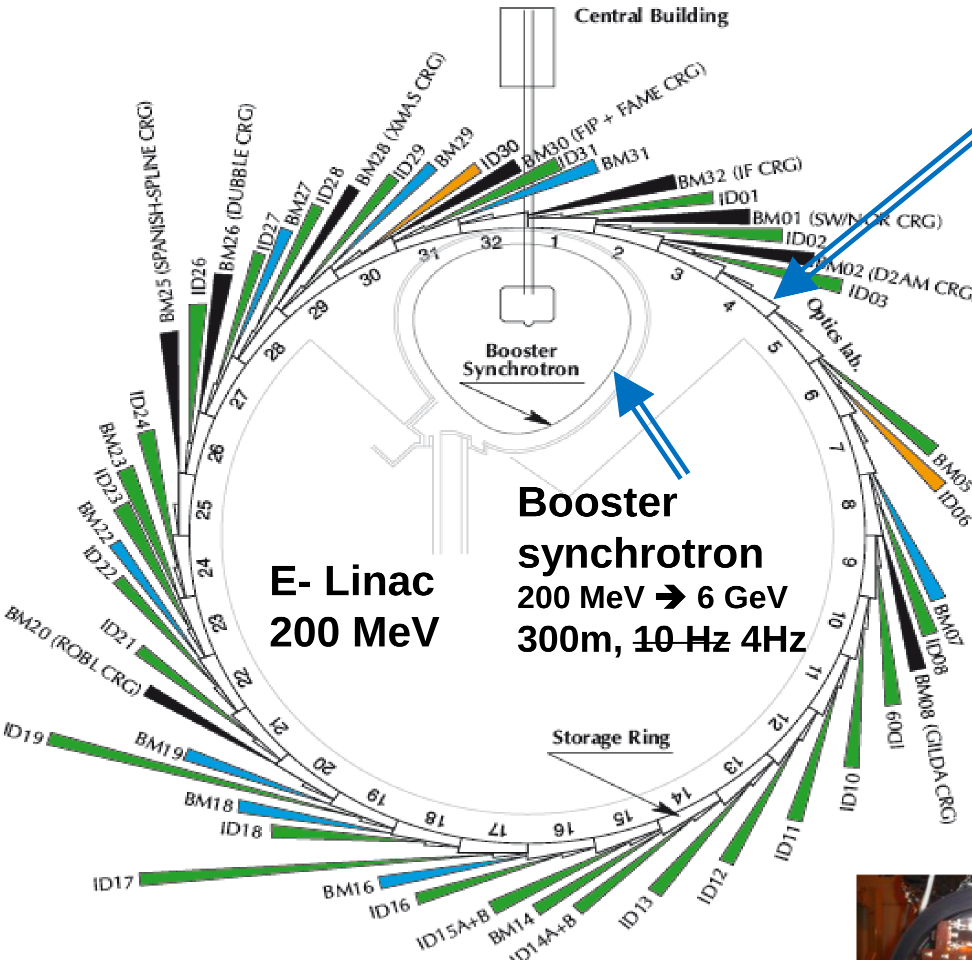
THE ESRF TODAY



ESRF

Operation



Storage ring
6GeV, 844 m

Booster synchrotron
200 MeV → 6 GeV
300m, ~~10 Hz~~ 4Hz

E- Linac
200 MeV

Energy	GeV	6.04
Multibunch Current	mA	200
Horizontal emittance	nm	4
Vertical emittance	pm	4

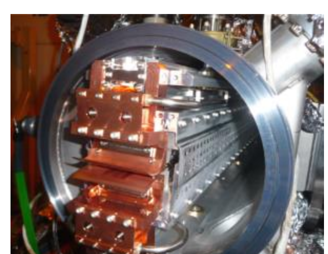
32 straight sections

DBA lattice

42 Beamlines

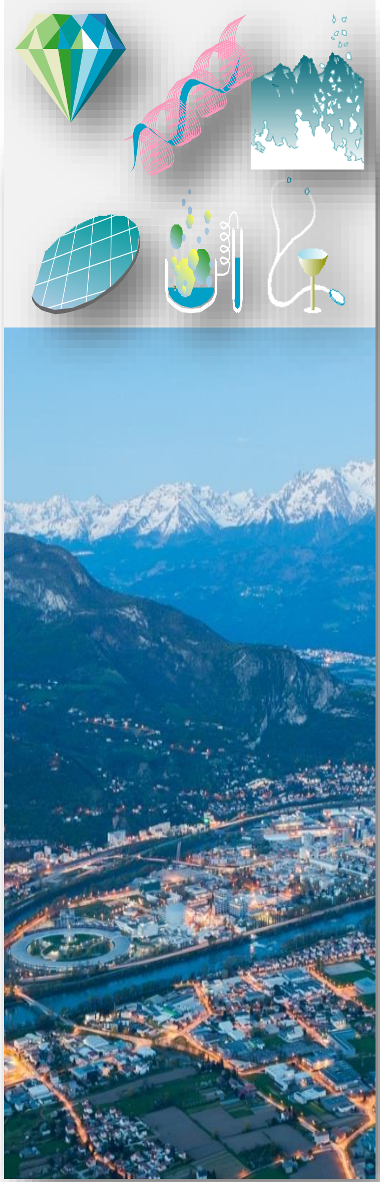
12 on dipoles

30 on insertion devices



72 insertion devices:
55 in-air undulators, 6 wigglers,
10 in-vacuum undulators,
including 3 cryogenic

OPERATION : MACHINE STATISTICS FOR 2015-2018

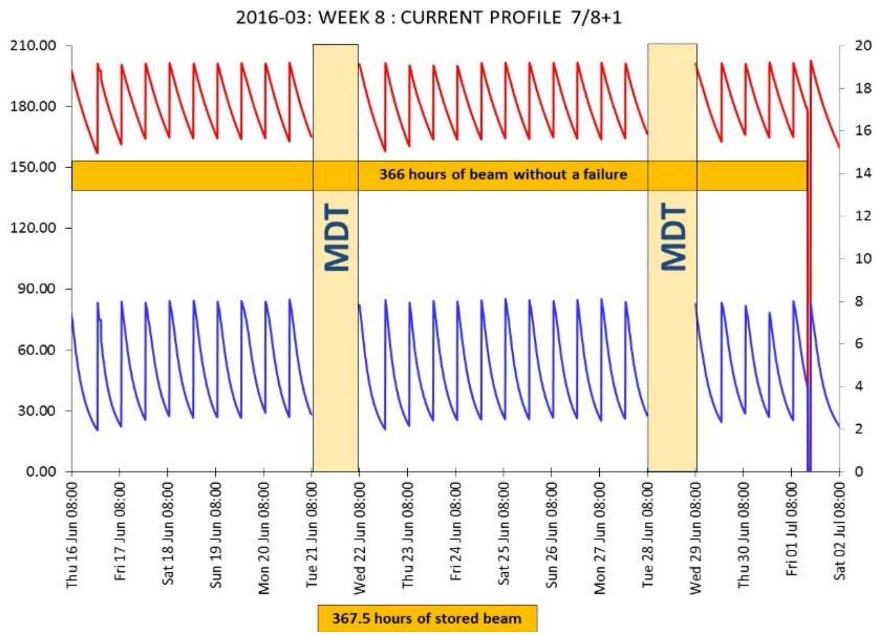


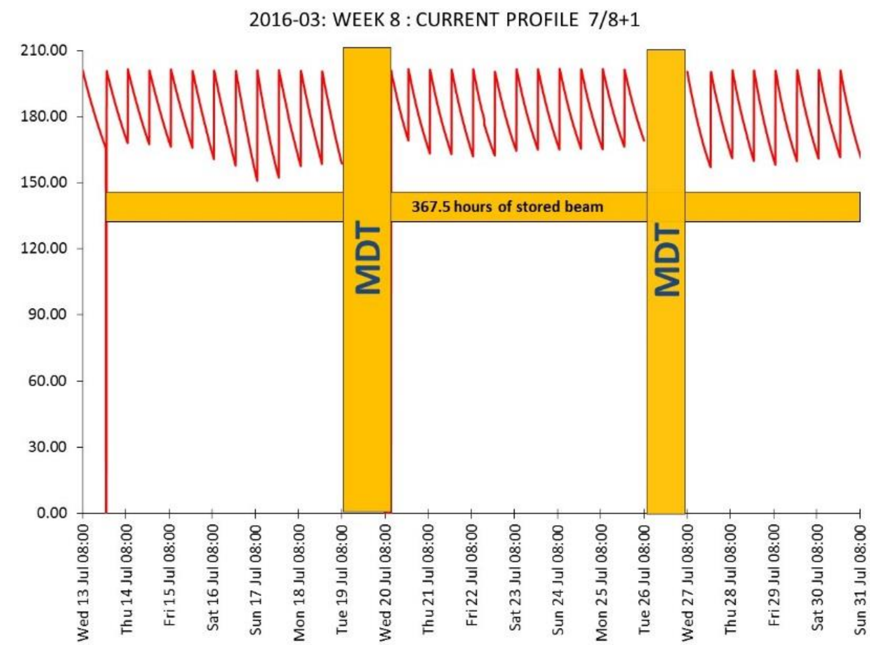
5442 hours of beam delivered out of 5527 scheduled in 2018.
Overall 2018 availability of 98.47 %

	2015	2016	2017	2018
Availability (%)	98.53	99.06	98.28	**98.47**
Mean Time Between Failures (hrs)	93.6	93.8	64.27	**104.3**
Mean duration of a failure (hrs)	1.37	0.88	1.11	**1.6**

2015: 59 Failures / 2016: 59 Failures / 2017: 85 Failures / 2018: 53 Failures.

JUNE – JULY 2016: long periods of deliveries without any failures





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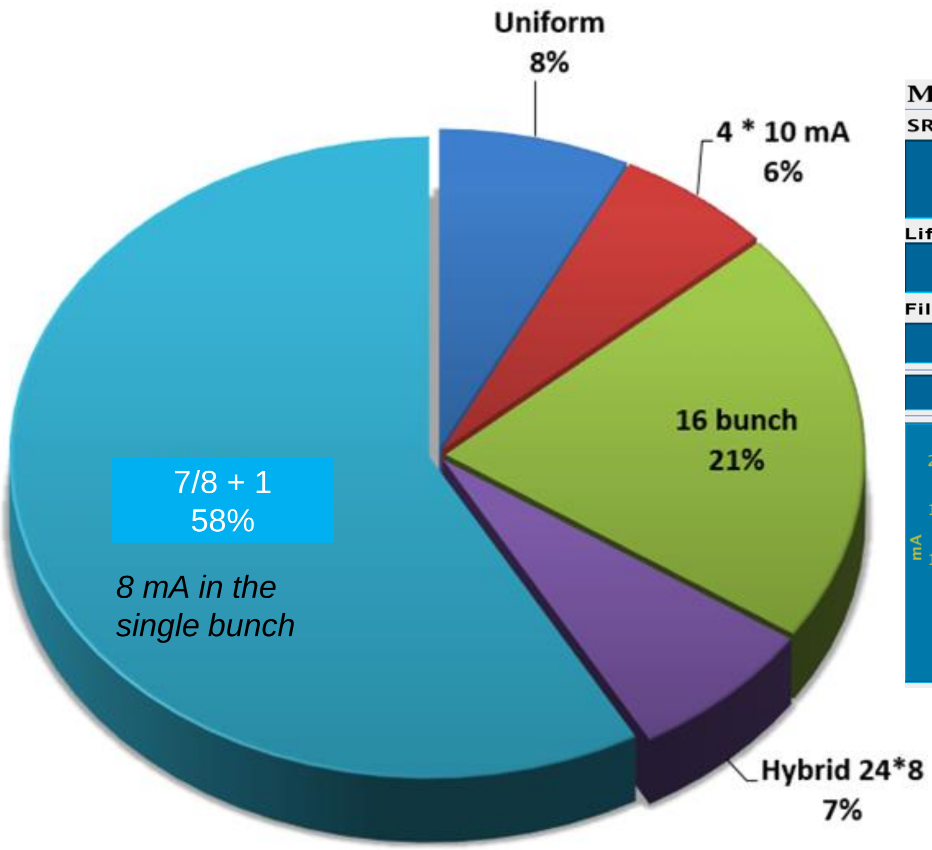
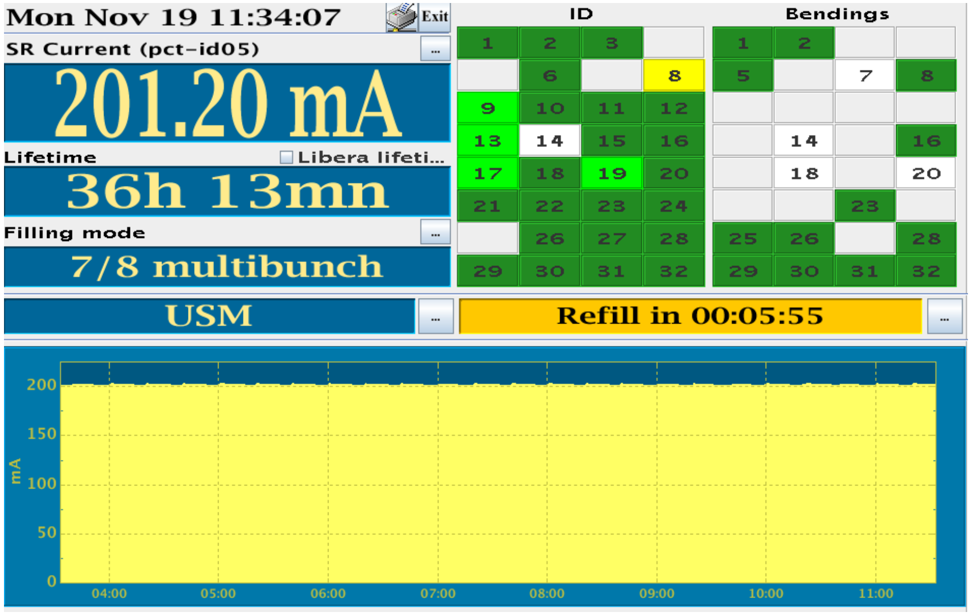
OPERATION: FILLING MODES IN 2018

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





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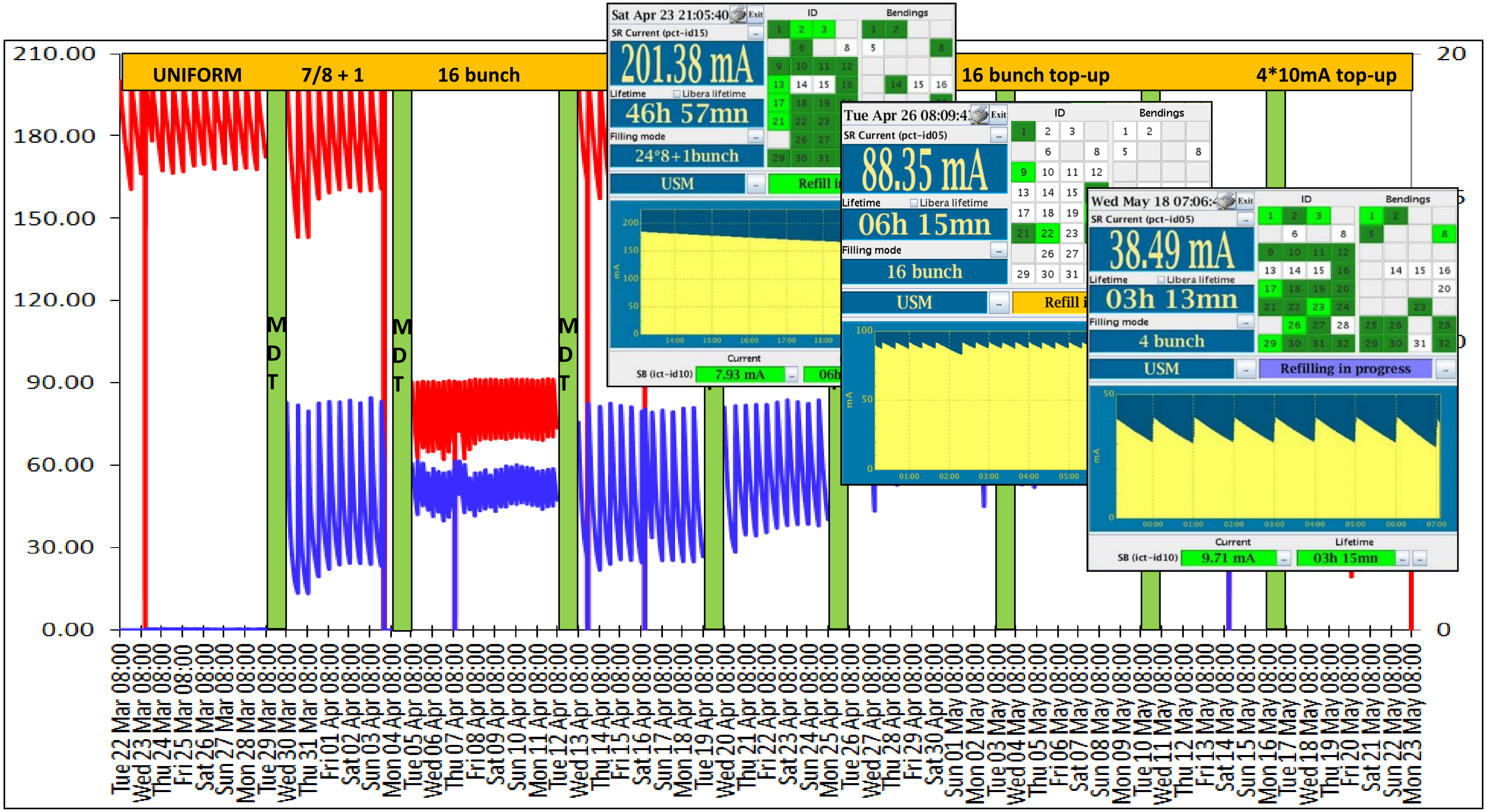
OPERATION : MACHINE



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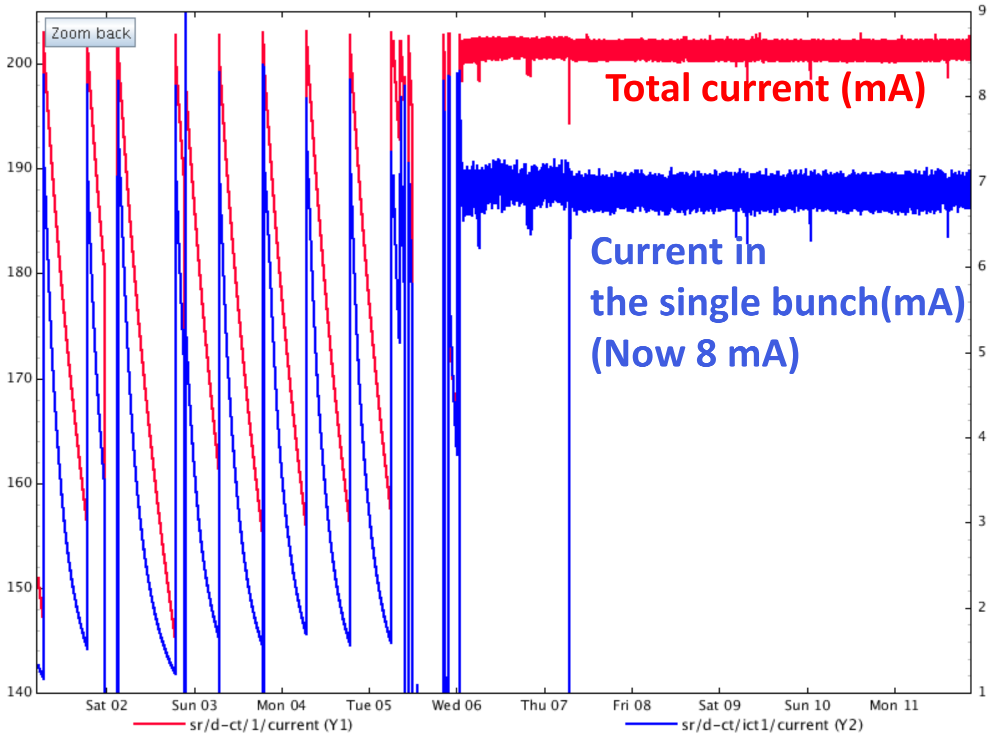
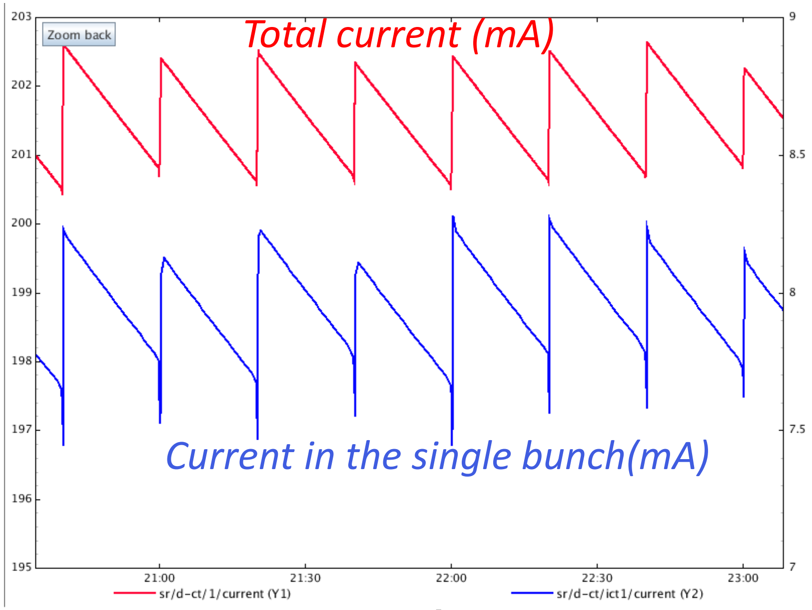
OPERATION: MACHINE – TOP-UP OPERATION IN 7/8+1

Before 6 June

After 6 June





Zoom on beam current

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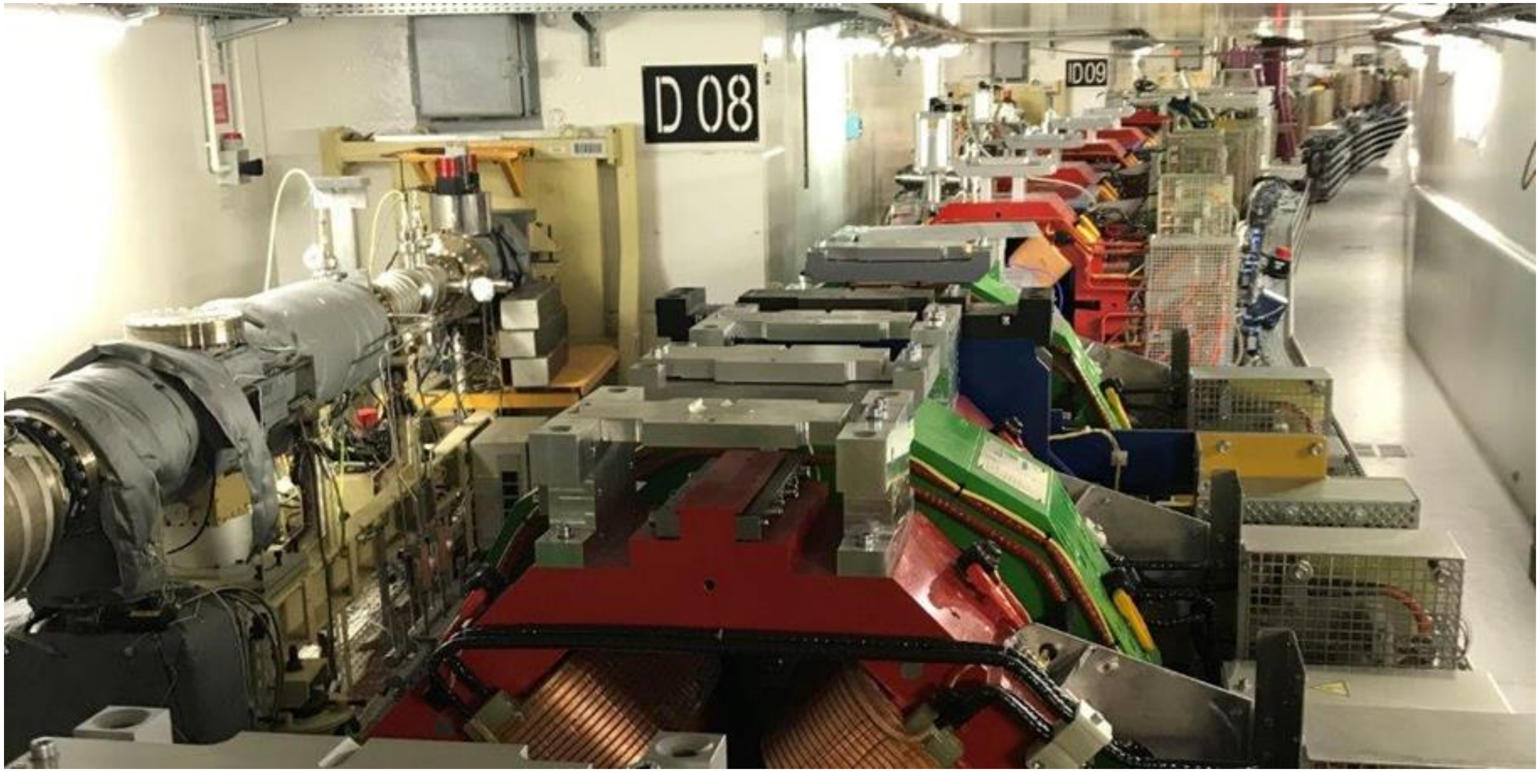
ESRF-EBS: The Extremely Brilliant Source Project

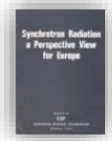


ESRF-EBS
Extremely Brilliant Source

ESRF | The European Synchrotron

ESRF: MORE THAN 20 YEARS OF SUCCESS AND EXCELLENCE




- **1988** 11 member states sign the creation of the ESRF
- **1992** 1st electron beam in the storage ring
- **1994** Inauguration: 15 beamlines on time and within budget
- **1998** 40 beamlines on time and within budget

- **2009-2015** Upgrade Programme Phase I on time and within budget

- **2012** New design for the storage ring

- **2015** Upgrade Programme Phase II: ESRF-EBS

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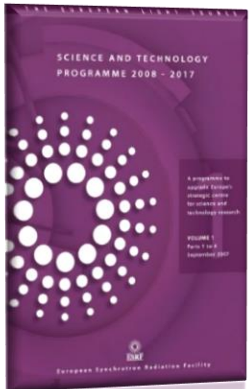
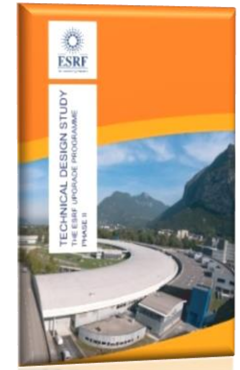
ESRF UPGRADE PROGRAMME: AN AMBITIOUS PROGRAMME TO PREPARE THE FUTURE

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

ESFRI

European Commission

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

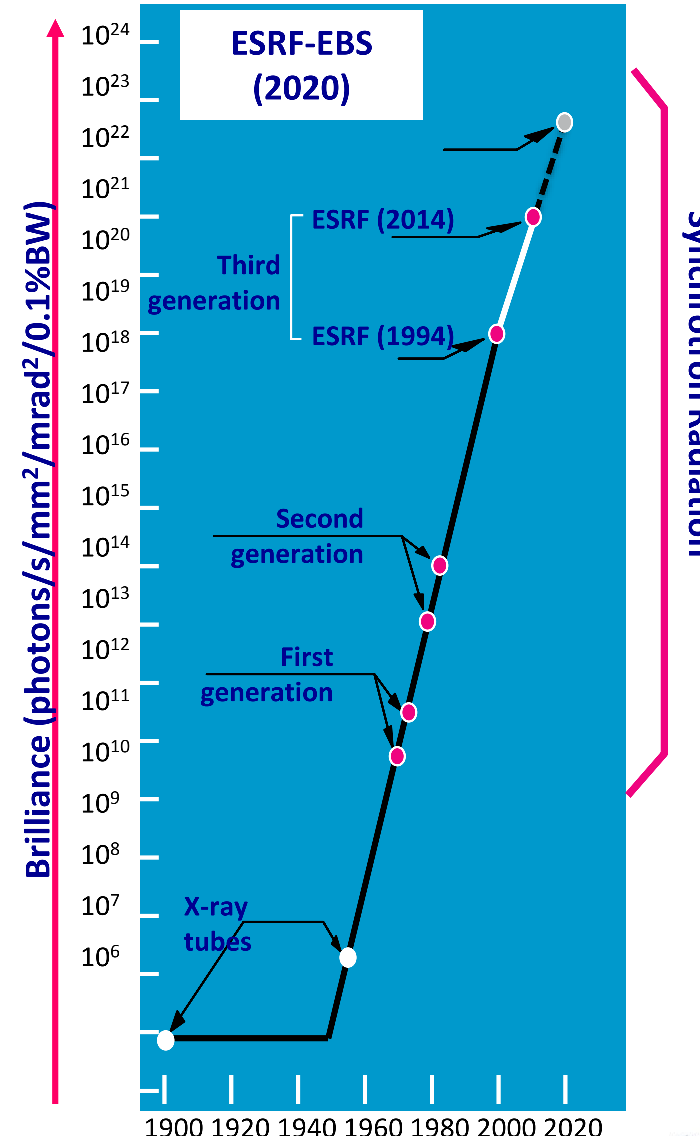
Revolutionary design
for a new generation of
synchrotron source storage rings

ESRF-EBS: AN AMBITIOUS NEW STANDARD FOR SYNCHROTRON STORAGE RINGS

ESRF Extremely Brilliant Source
ESRF-EBS – 150 M€ (2015-2022)

ESRF-EBS
Extremely Brilliant Source

- ~100 times more brilliant and coherent X-rays
- Programme to exploit the qualities of this new and unique extremely brilliant X-ray source:
  - Creation of new beamlines
  - Innovative detector programme
  - « Data as a Service » strategy



Budget for the source only: 104 M€

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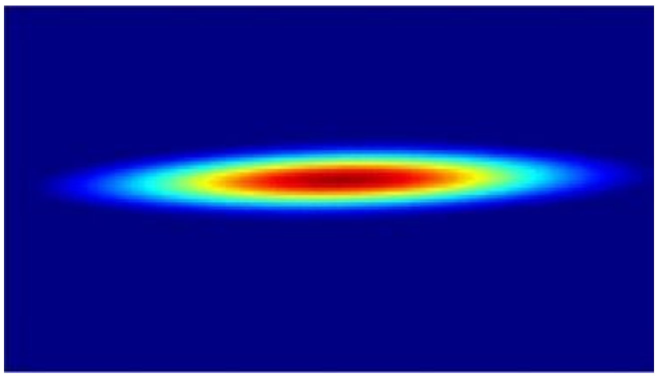
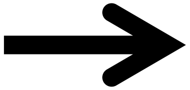
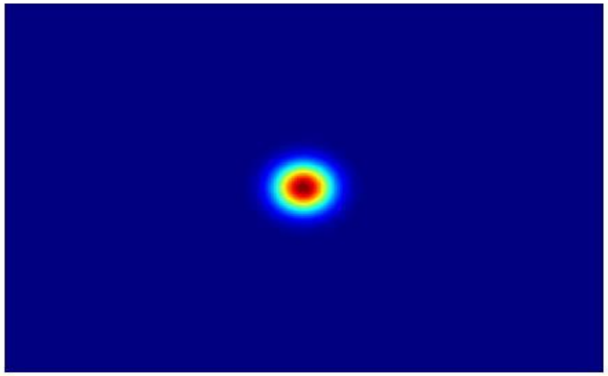
Reduce the **horizontal** emittance from **4nm** to **0.14nm**







Beam-line experiments can benefit from :

an increase in brilliance

an increase of coherence

(the coherent fraction, in hor. plane)

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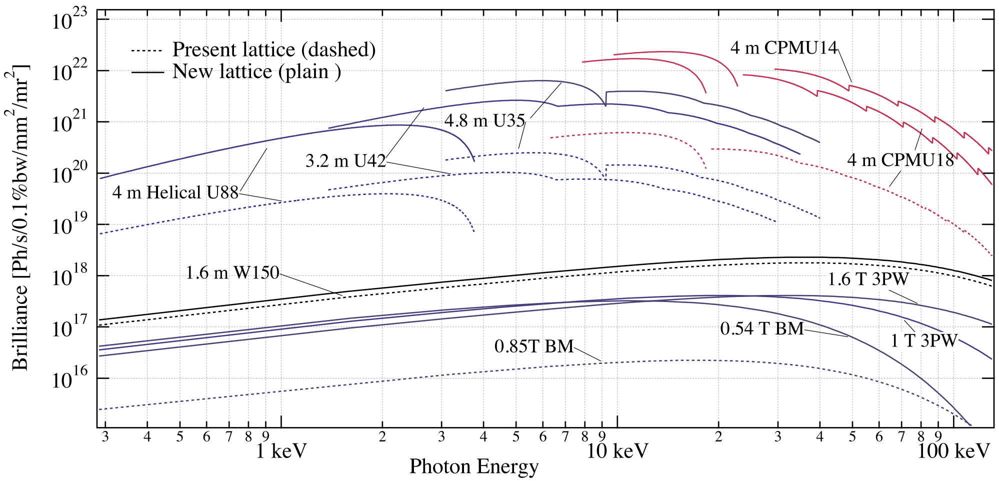
BRILLIANCE AND COHERENCE INCREASE

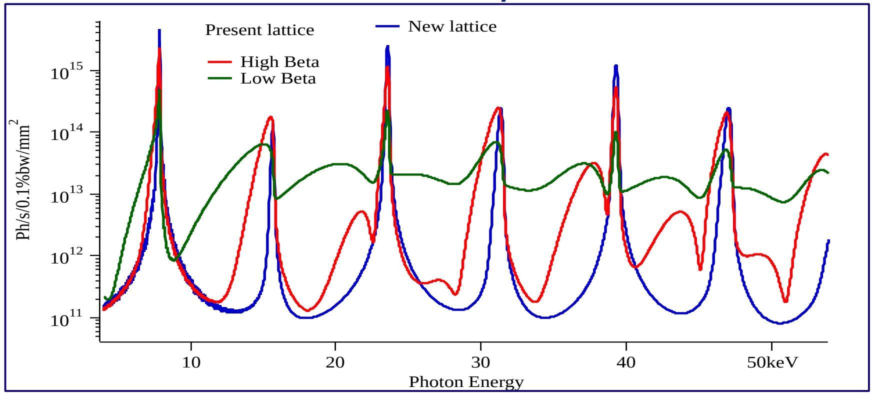
Brilliance



Hor. Emittance [nm]	4	0.135
Vert. Emittance [pm]	4	5
Energy spread [%]	0.1	0.09
β_x[m]/β_z [m]	37/3	6.9/2.6

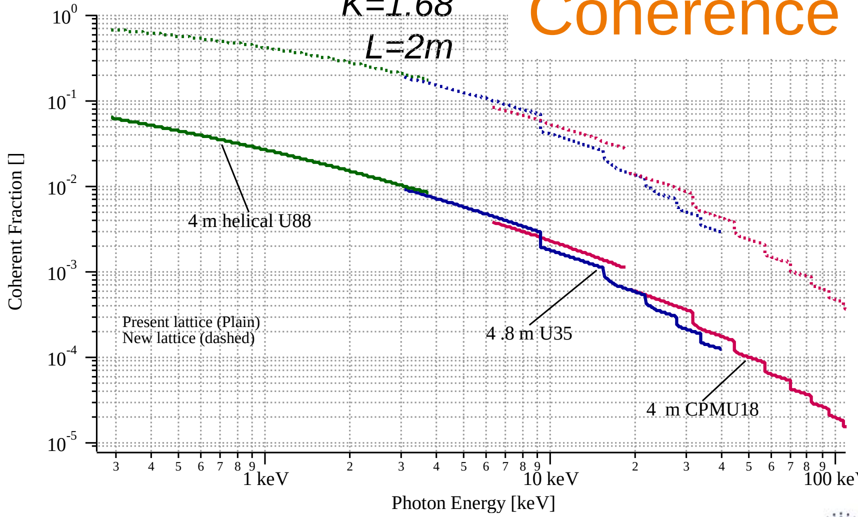
Source performances will improve by a factor 50 to100

18mm Undulator spectrum

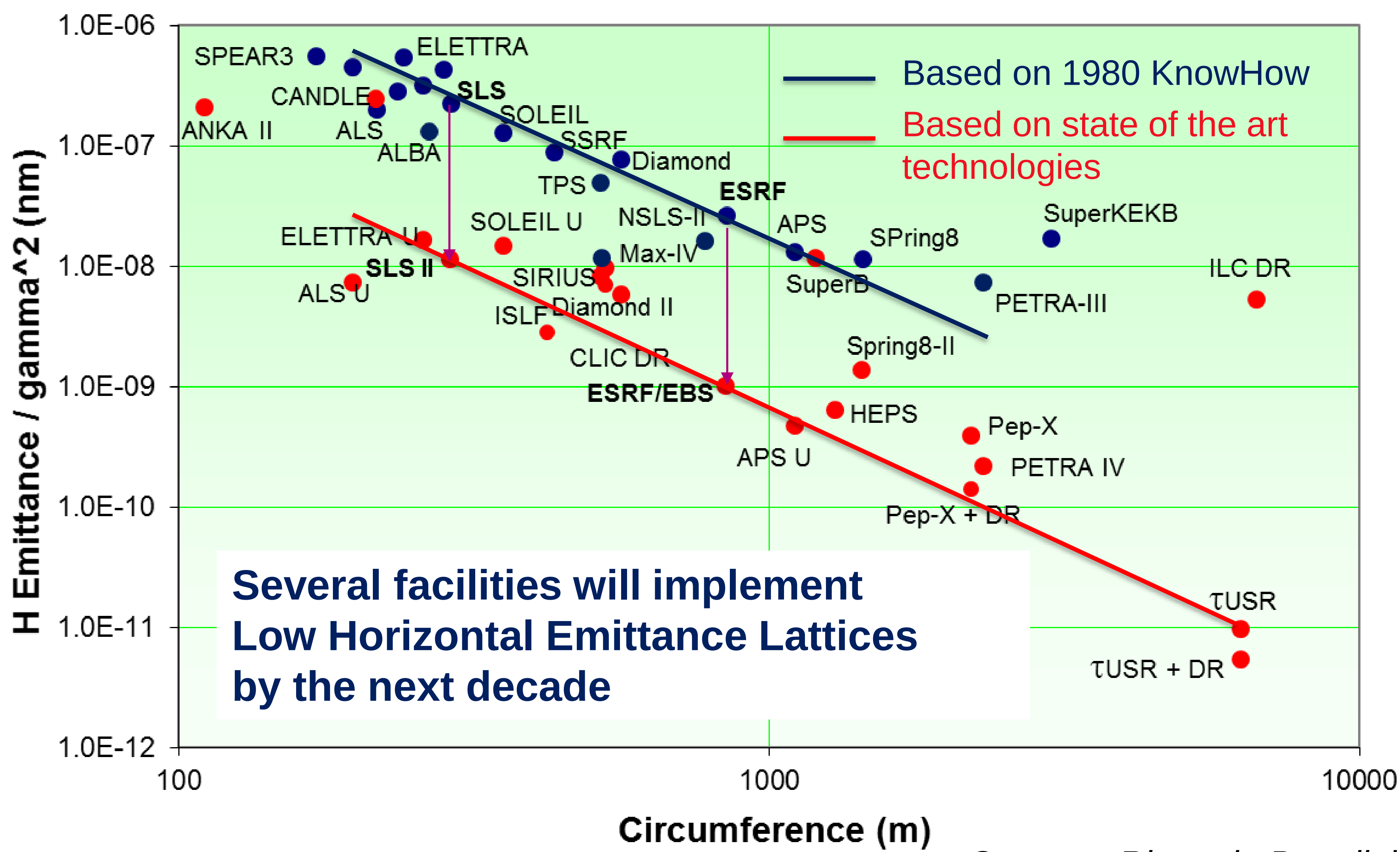


Undulator: CPMU18, K=1.68 L=2m

Coherence



LOW EMITTANCE RINGS TREND



Courtesy Riccardo Bartolini

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DECREASING THE HORIZONTAL EMITTANCE

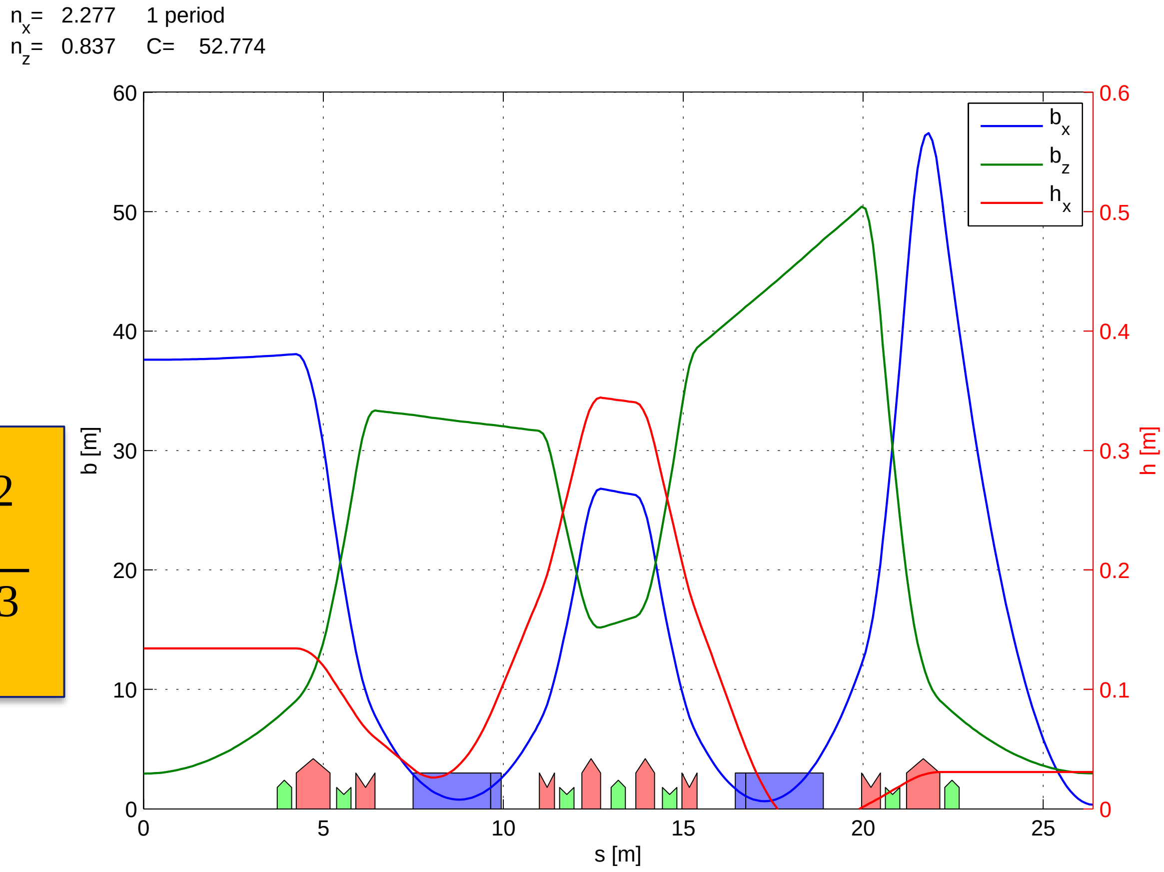
Low emittance:
Careful tuning of β_x and η_x in the dipoles (where the radiation occurs)
β_x: envelope function
η_x: dispersion

How clever we are

Energy

$$\varepsilon_x = F(Lattice)\frac{E^2}{N^3}$$

Number of identical dipoles



Emittance reduction ➔ large number of bending magnets

- Increase the number of cells
  ➔ Large circumference
- Put more dipoles per cell
  ➔ Compact machine

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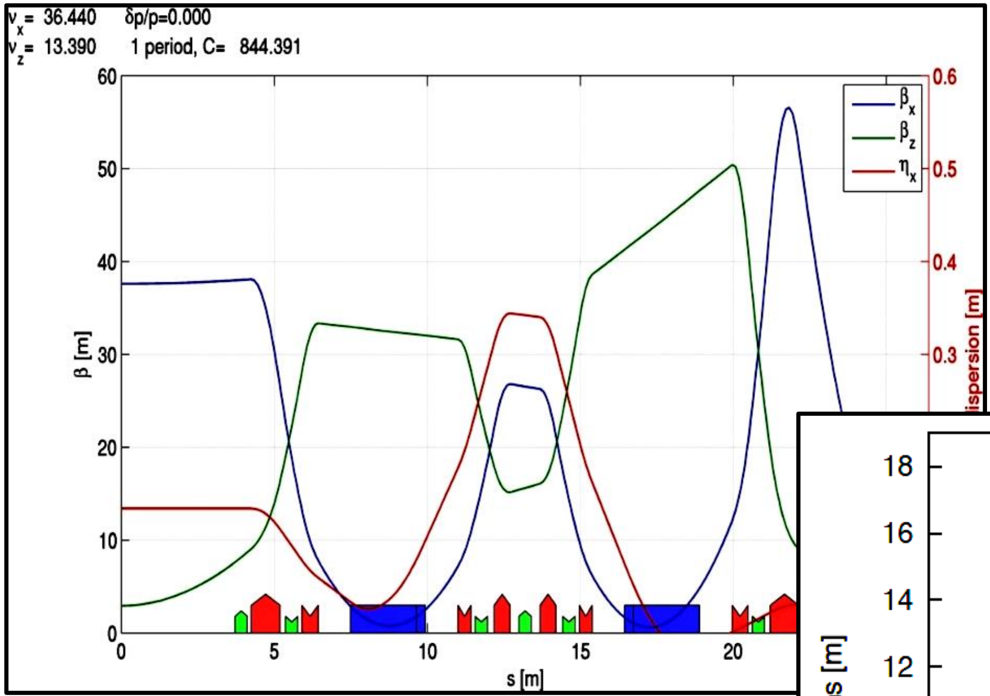
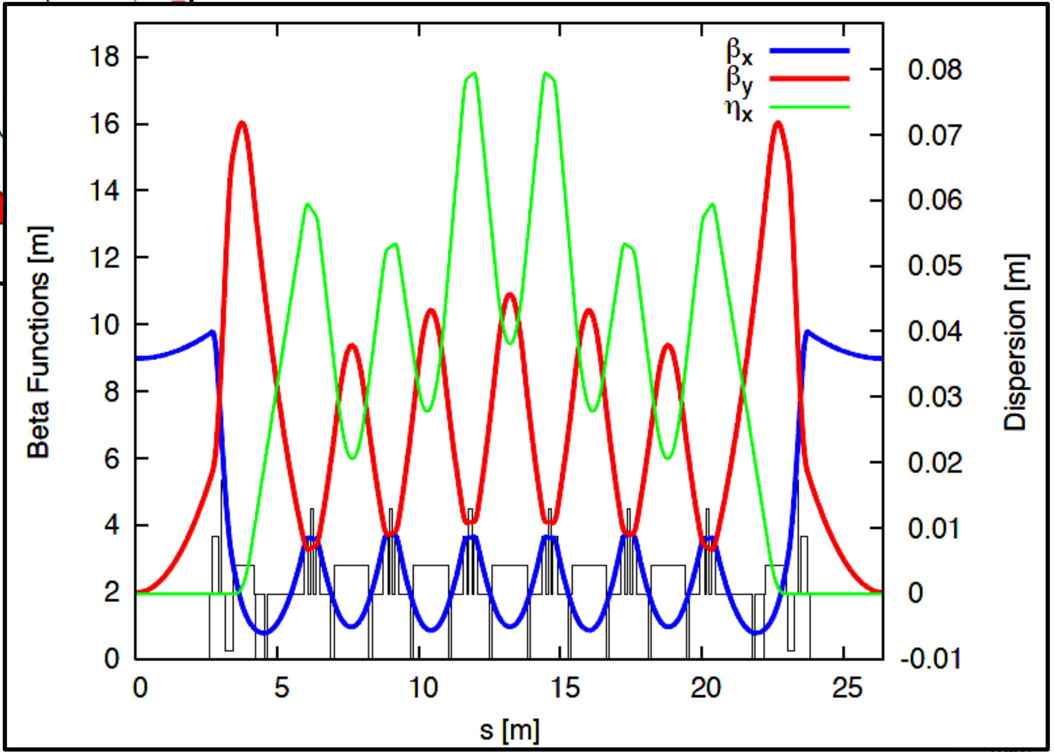
THE EVOLUTION TO MULTI-BEND LATTICE



Double-Bend Achromat (DBA)

- Many 3rd gen. SR sources
- Local dispersion bump (originally closed) for chromaticity correction



Multi-Bend Achromat (MBA)

- MAX IV and other USRs
- No dispersion bump, its value is a trade-off between emittance and sextupoles (DA)

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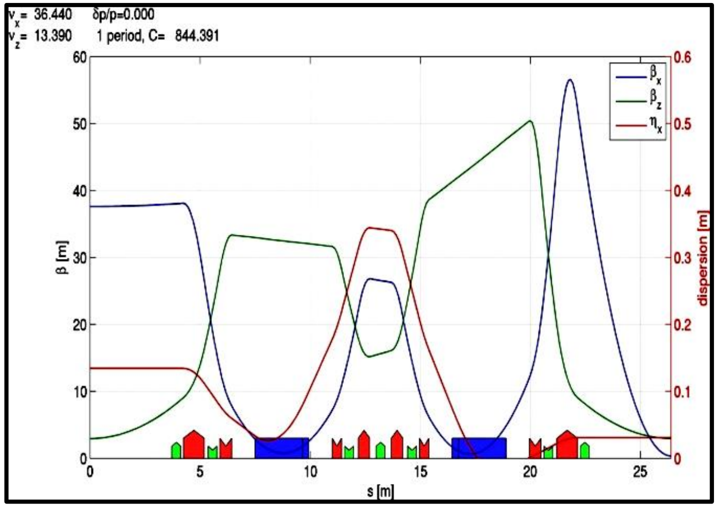
THE HYBRID MULTI-BEND (HMB) LATTICE

ESRF existing DBA cell

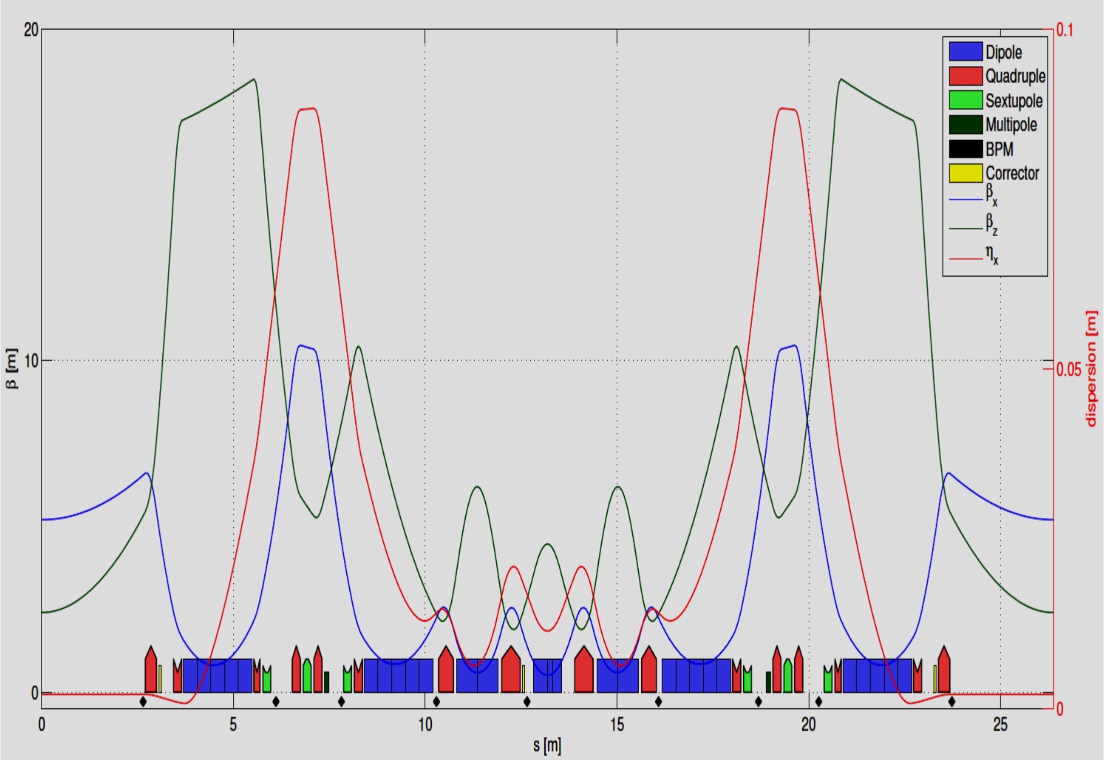
- Ex = 4 nm•rad
- tunes (36.44,13.39)
- nat. chromaticity (-130, -58)



- **Multi-bend for lower emittance**
- **Dispersion bump for efficient chromaticity correction => "weak" sextupoles (<0.6kT/m)**
- **Fewer sextupoles than in DBA**
- **Longer and weaker dipoles => less SR**
- **No need of "large" dispersion on the inner dipoles => small *H*x and Ex**

ESRF HMB cell

- Ex = 140 pm•rad
- tunes (76.21, 27.34)
- nat. chromaticity (-99, -82)



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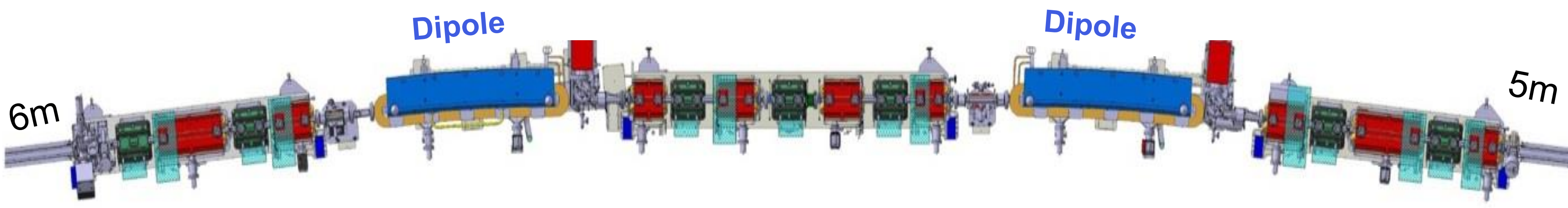
NEW LATTICE VS PRESENT ESRF LATTICE

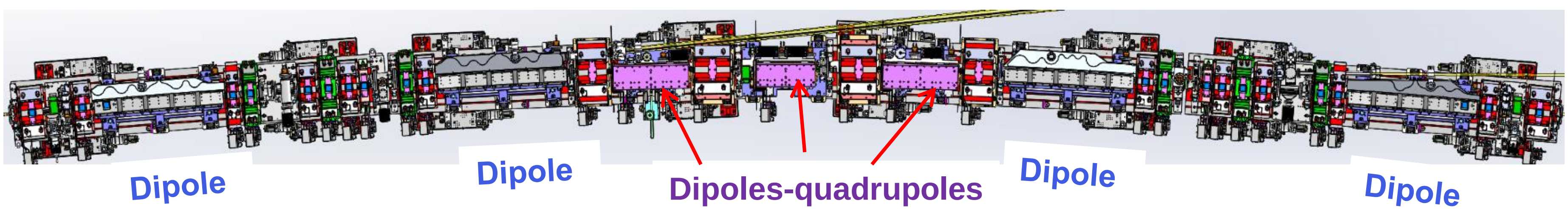
- **Present ESRF lattice**

32 cells, Double Bend Achromat = (2 dipoles + 15 quad. sext.) per cell
ID length = 5 m (standard) / 6m / 7m



- **ESRF EBS lattice**

Hybrid 7 Bend Achromat = (4 dipoles + 3 dipoles-quad + 24 quad., sext., 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 !!

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EXTREMELY BRILLIANT SOURCE: ACCELERATOR UPGRADE

The Extremely Brilliant Source Project aims to:

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

- Must fit in the same tunnel: same circumference as much as possible
- Keep the electron energy (6 GeV)
- IDs at same locations: keep Beamlines where they are
- Maintain the existing bending magnet beamlines
- Preserve the time structure operation and a multibunch current of 200 mA
- Re-use injector complex
- Limit the downtime for <u>installation and commissioning to less than 18 months</u>

Maintain standard User-Mode Operations until the day of shut-down for installation

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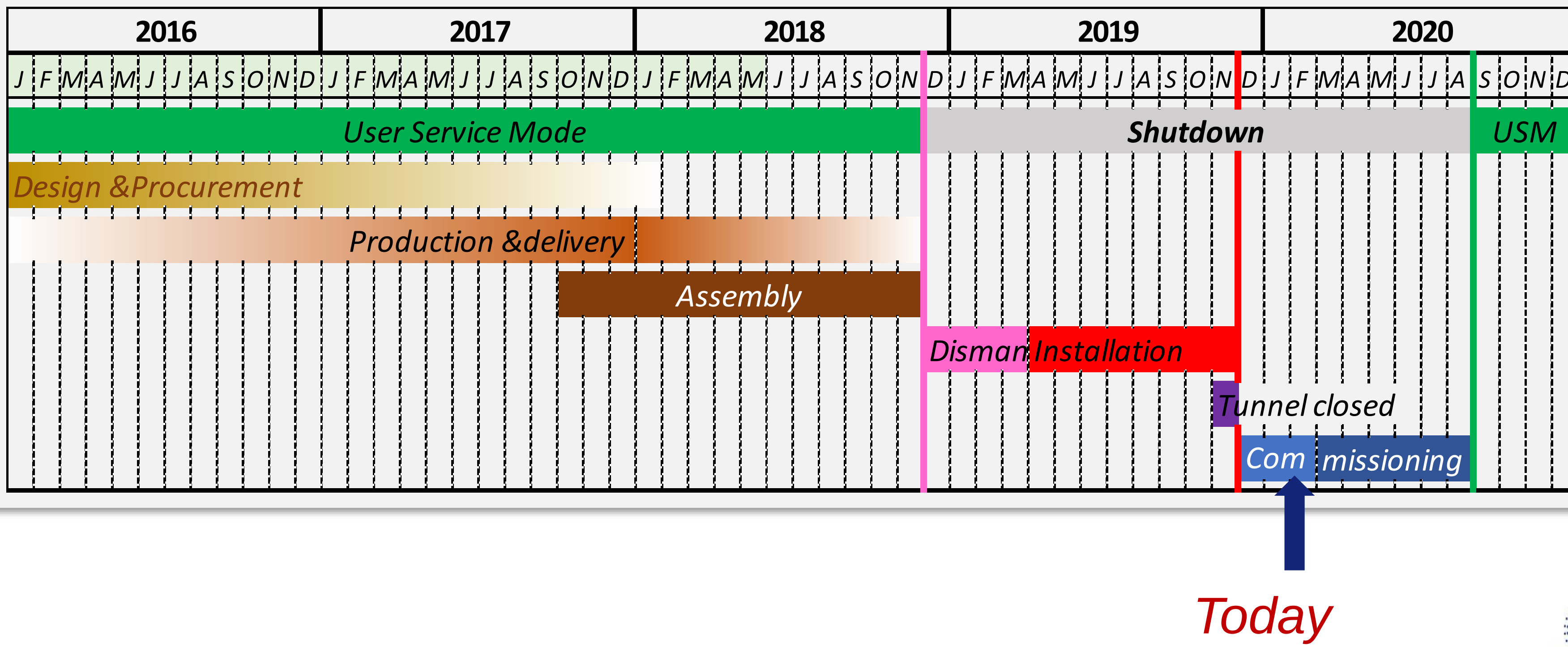
OPERATION AND EBS PROJECT PLAN (2015-2020)

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



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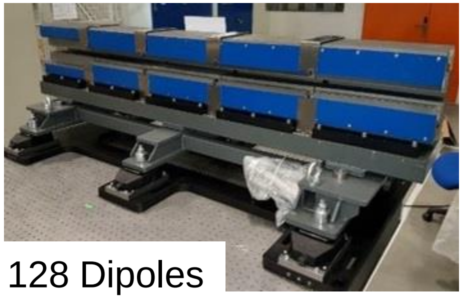


128 Dipoles

Assembled in house

96 Dipole-quadrupoles

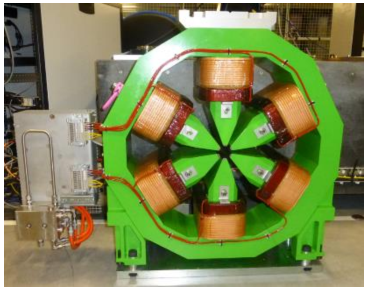
96 Correctors

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

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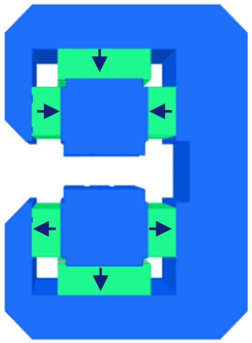
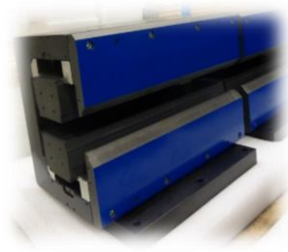
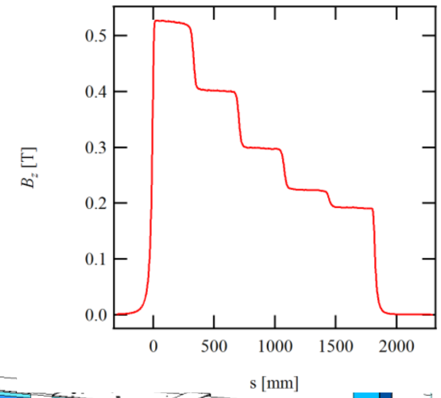
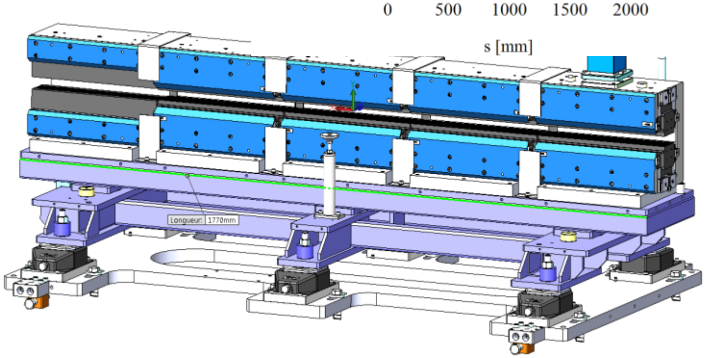
DIPOLES WITH LONGITUDINAL GRADIENT [132]

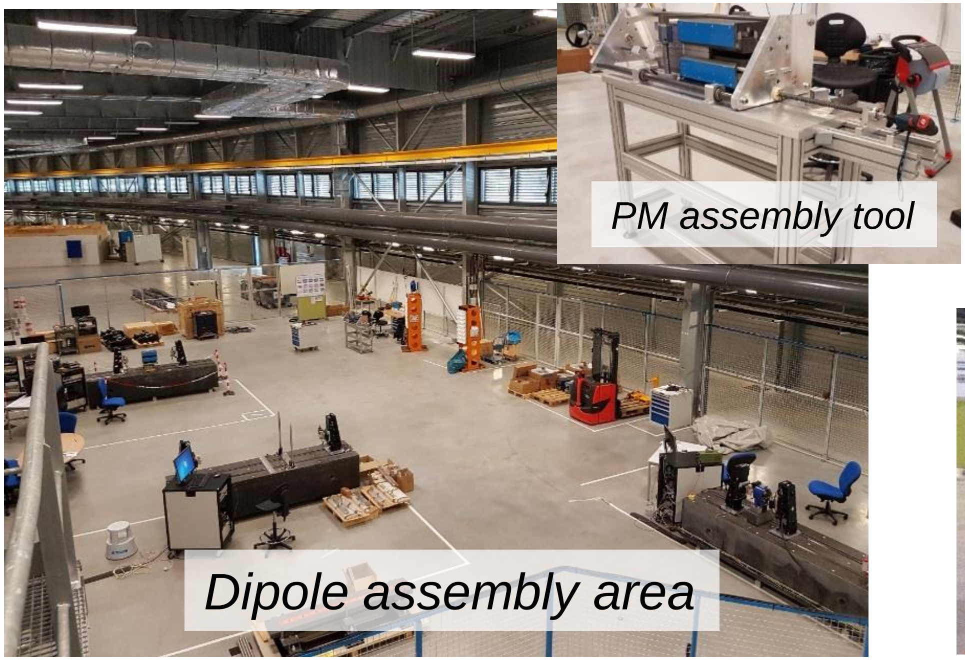
- Each dipole based on 5 PM modules
- Strength 0.67-0.17 T &
- Iron length 1788 mm
- 25.5 – 30.5 mm GAP
- Iron: Pure Iron
- Permanent magnet Sm_2Co_{17}











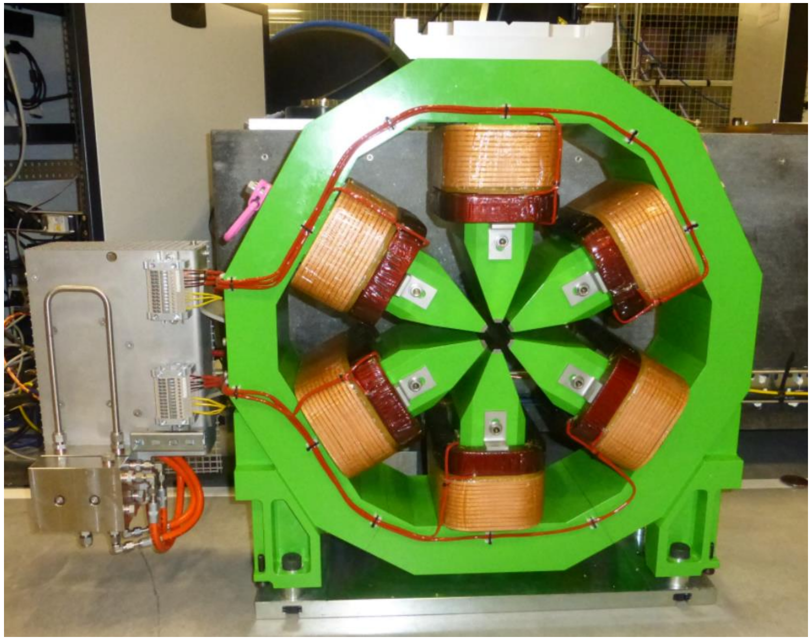
Dipole assembly area

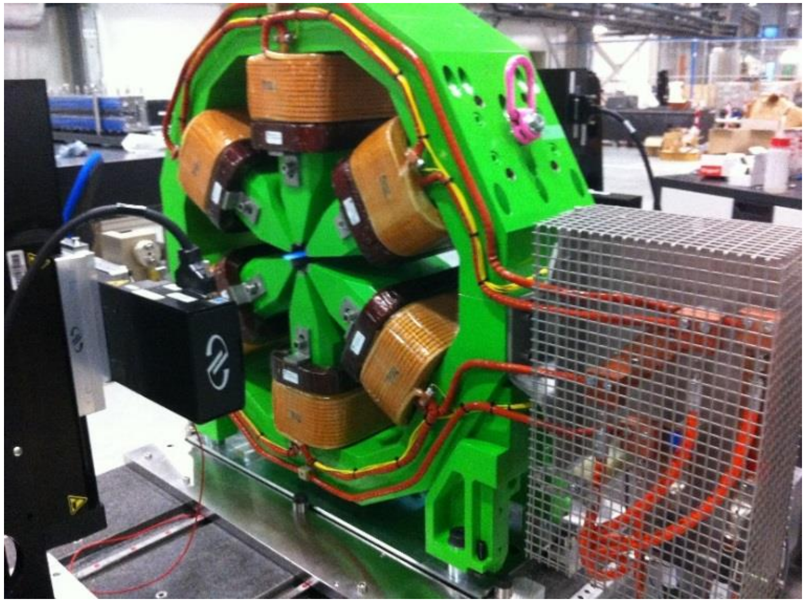
PM assembly tool

Around 6000kg of PM, 660 Iron modules,

SEXTUPOLES [196]

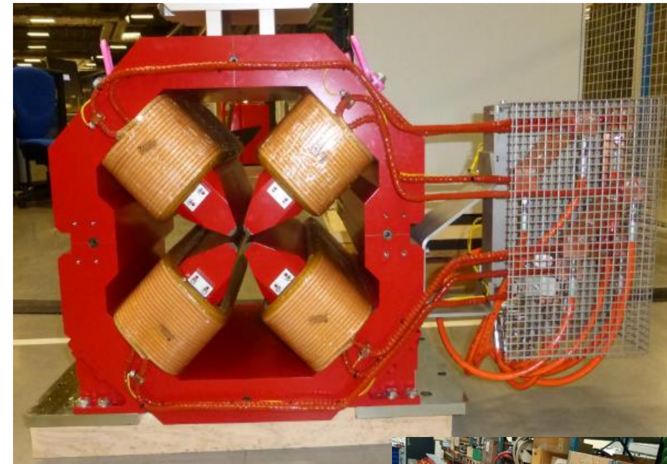
- 2 types
- 1700 T/m² gradient, 166 – 200 mm length
- 19.2 mm bore radius
- 0.5 kW power consumption
- Including additional correction coils





QUADRUPOLES

High Gradient *[130]*



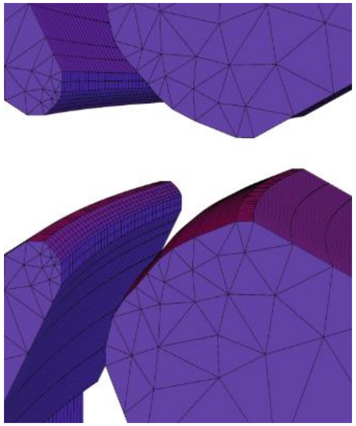
- 2 types
- 89 & 87 T/m gradient
- 388 – 484 mm length
- 12.7 mm bore radius
- 1.9 & 1.7 kW power consumption

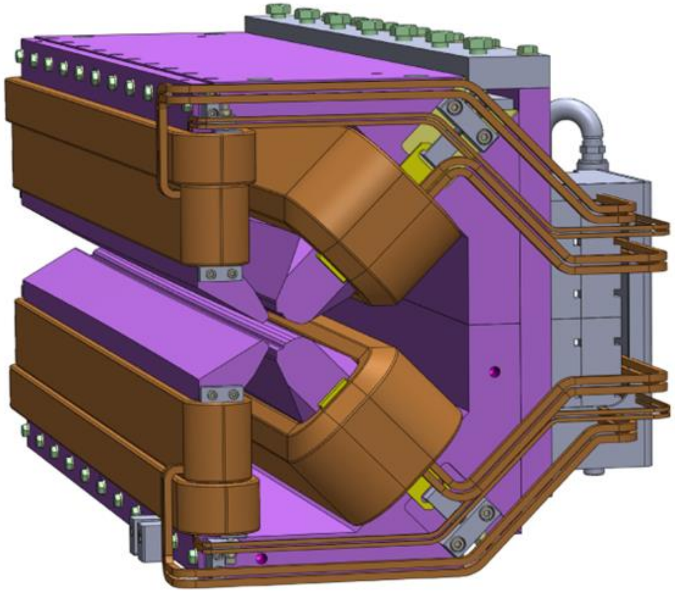
Moderate Gradient *[398]*

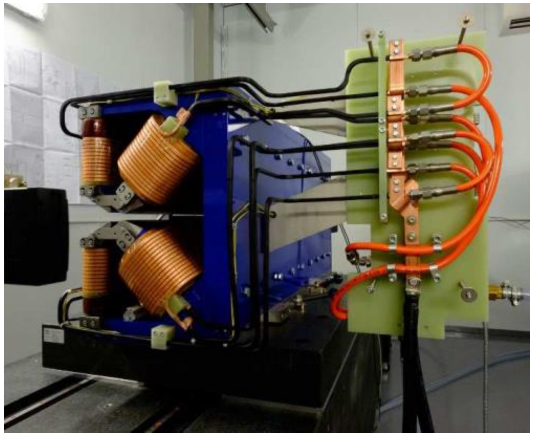
- 4 types
- Up to 54 T/m gradient, 162– 295 mm length
- 16.4 mm bore radius
- 0.7 – 1.1 kW power consumption

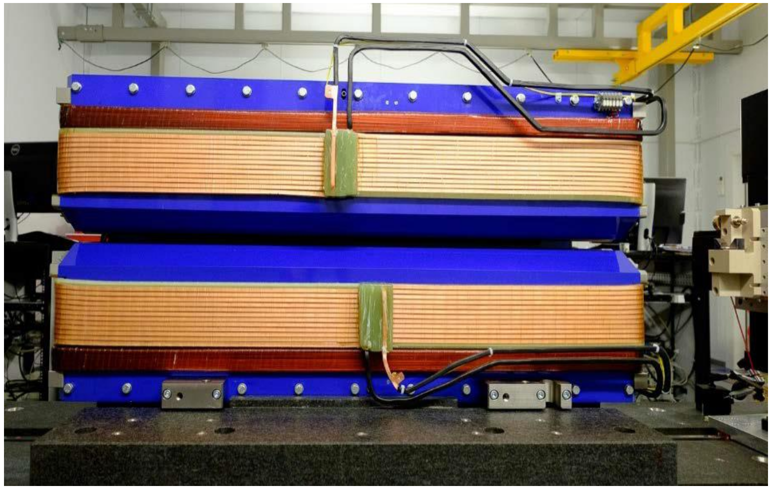
DIPOLE QUADRUPOLES [99]

- 2 types
- Nominal dipole 0.55 – 0.39 T
- Nominal gradient 36-39 T/m
- 1028-800 mm
- 18.6 mm bore radius
- 1.6- 1.2 kW power consumption
- Poles longitudinally curved



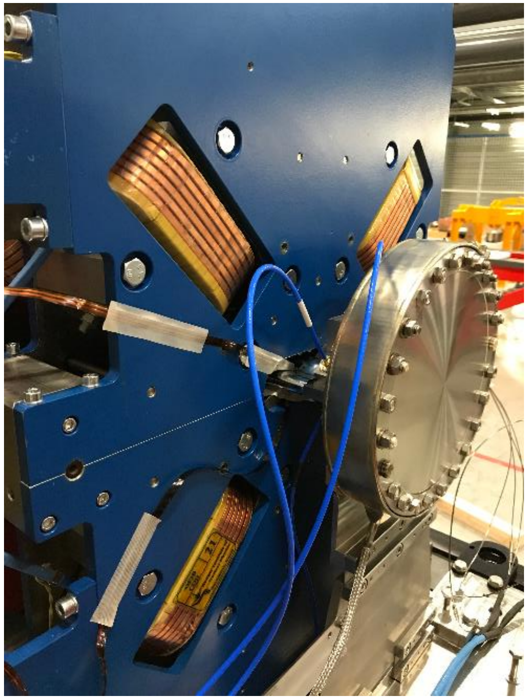


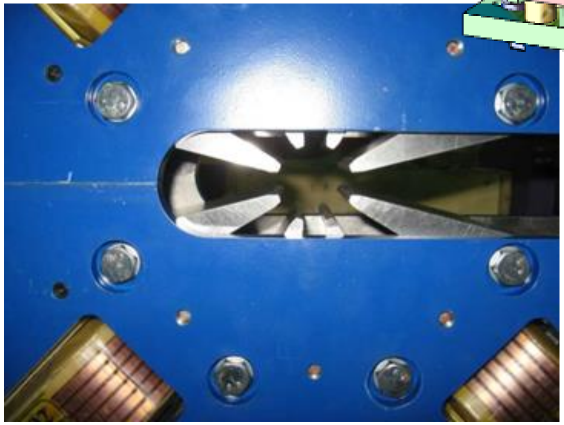


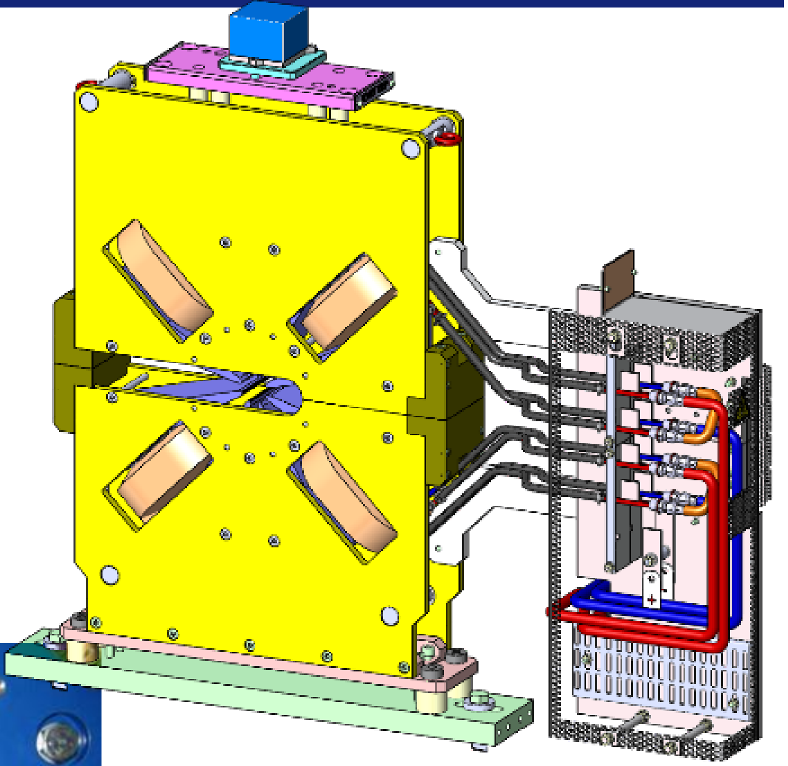


OCTUPOLES [66]

- 36900 T/m3 gradient, 90 mm length
- 18.6 mm bore radius
- 0.1 kW power consumption
- Allows the required stay clear for Synchrotron radiation fan

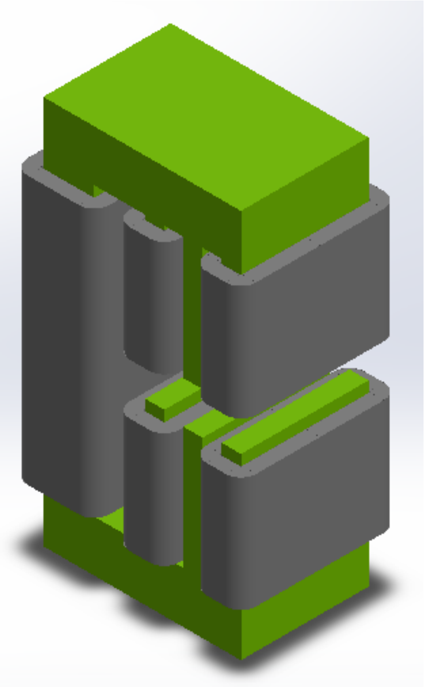






CORRECTORS [100]

- Horizontal: 0.1 T.mm
- Vertical 0.1 T.mm
- Skew quadrupole: 0.12 T
- 25.5 mm gap mm bore radius



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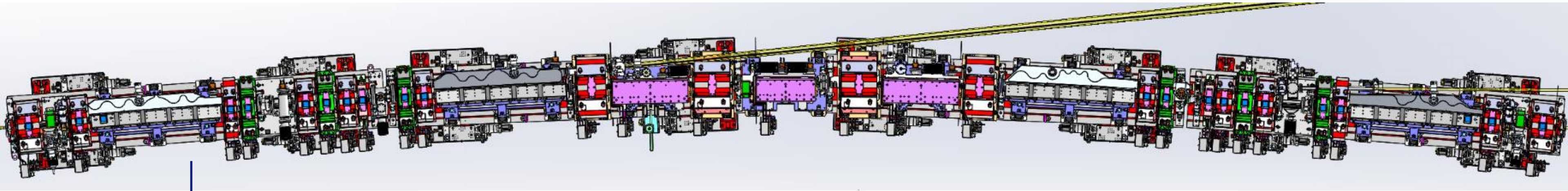
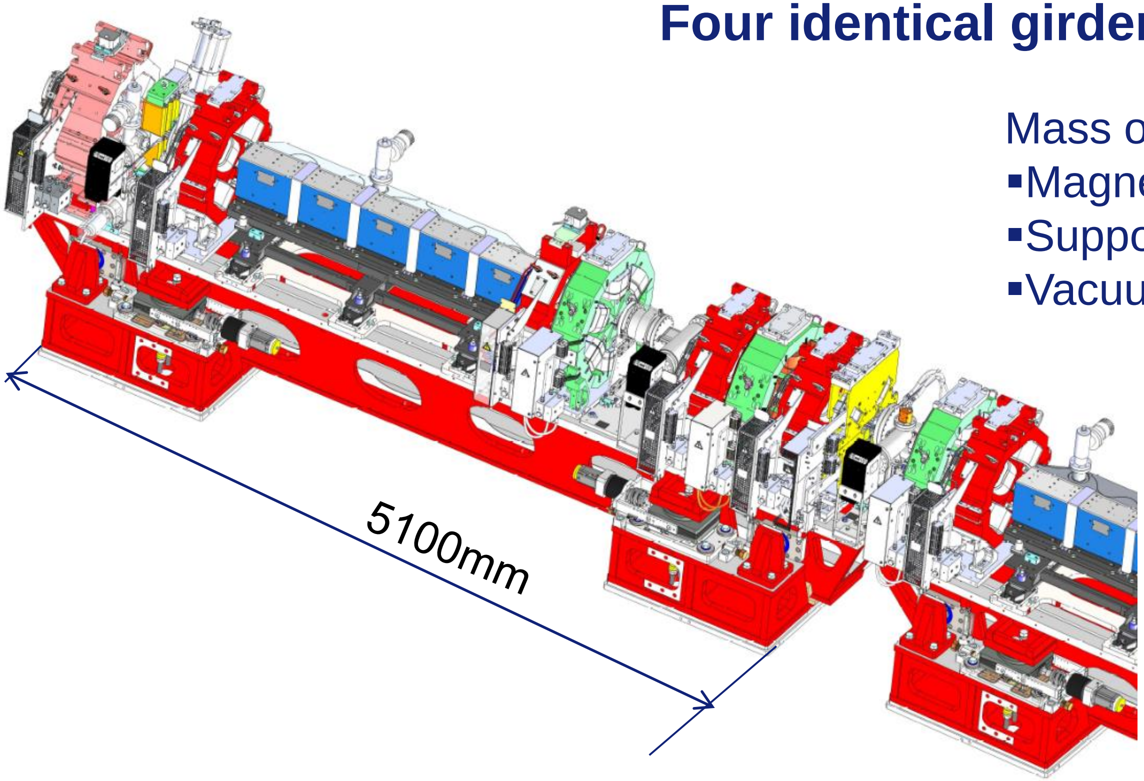
GIRDERS





Four identical girders per cell

Mass of:
- Magnetic elements
- Supports
- Vacuum equipements

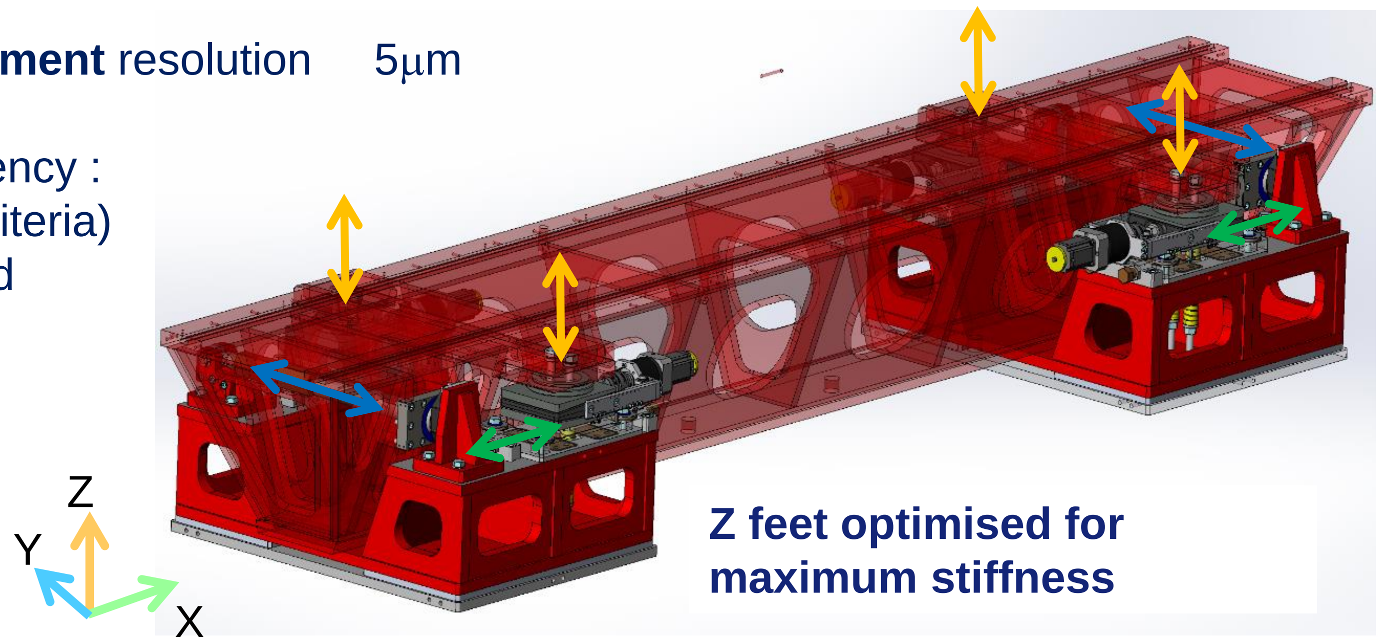
6-7T/girder

GIRDERS

- Girder supported by 4 adjustable Z feet made of motorised wedges
- Y adjustment by 2 manual jacks pushing the girder

	HORIZONTAL (Y)	VERTICAL (Z)
Girder to girder	50 µm	50 µm

- **Motorized Z adjustment** resolution 5µm
- **Manual Y adjustment** resolution 5µm
- 1st natural frequency :
  - 50Hz (design criteria)
  - 49 Hz measured



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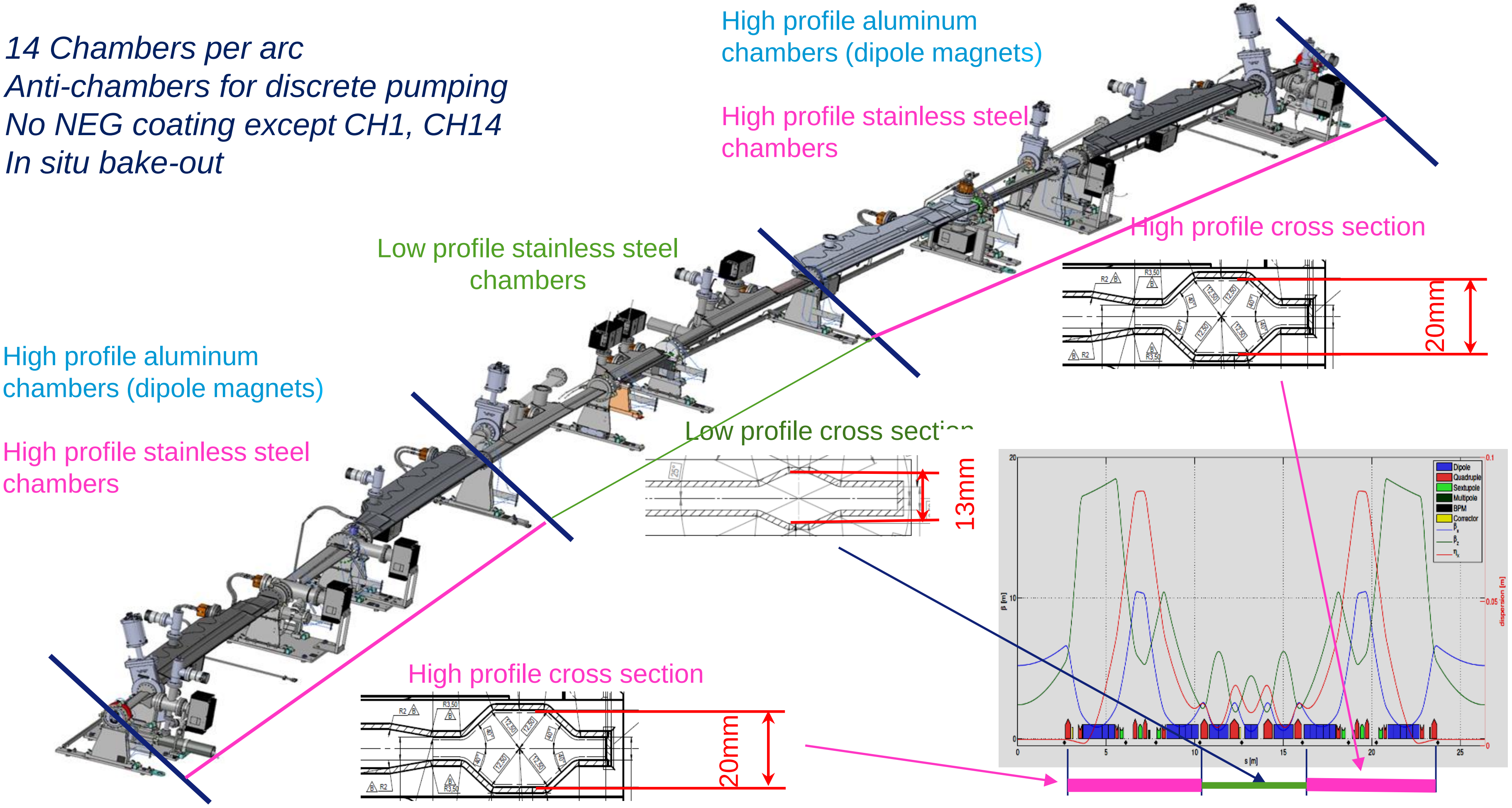
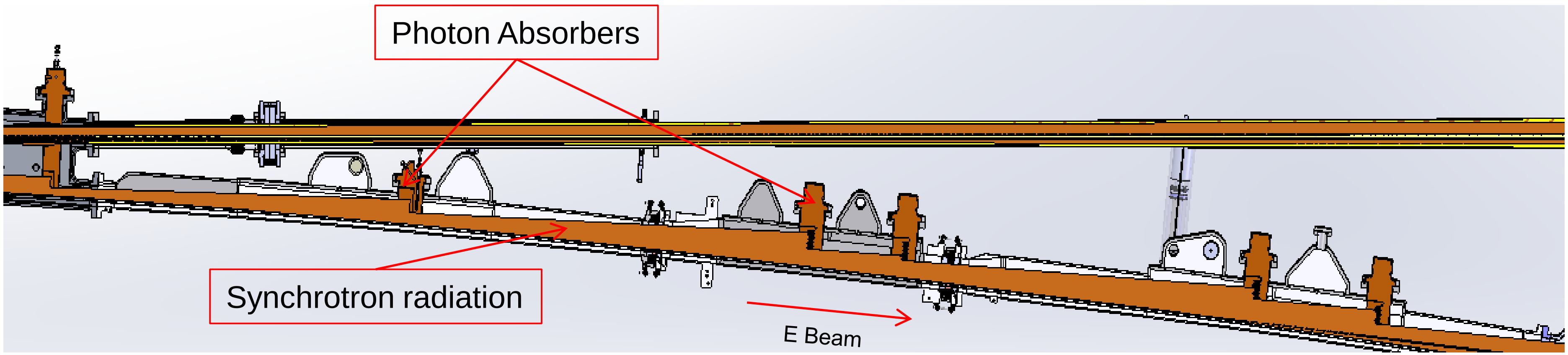
VACUUM CHAMBERS

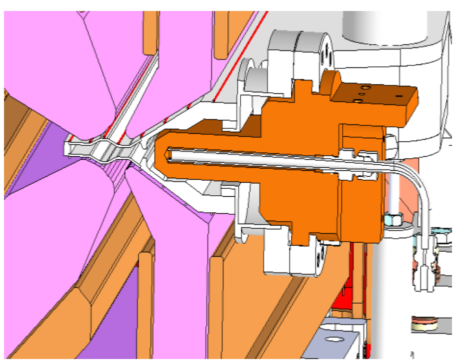
14 Chambers per arc
Anti-chambers for discrete pumping
No NEG coating except CH1, CH14
In situ bake-out



PHOTON ABSORBERS

- ~391 absorbers (including crotch absorbers, without injection cell specials)
- Total power to be absorbed: 504.5 kW (30 x 15.795 kW + 2x 15.314) kW
- Power density: 10 to 110 W/mm2 (normal to beam)
- => moderate power parameters compared to current ESRF
- Scattered radiation blocked in the absorber to avoid chamber cooling





-CuCr1Zr as an alternative to Glidcop

- Integrate the CF flange in the CuCr1Zr absorber body (Sharma Sushil idea)

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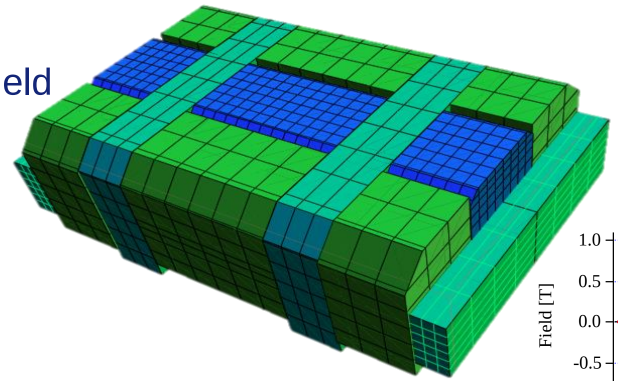
BENDING MAGNETS SOURCE: 1- POLE BM, 2-POLE & 3-POLE WIGGLERS

All new projects of diffraction limited storage rings have to deal with:

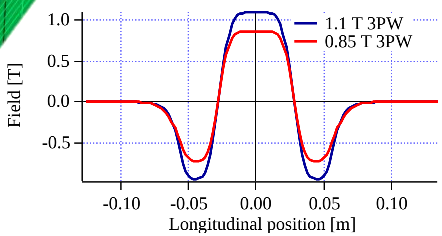
Increased number of bending magnets / cell => BM field reduction

Conflict with hard X-ray demand from BM beamlines

ESRF will go from 0.85 T BM to 0.54 T BM



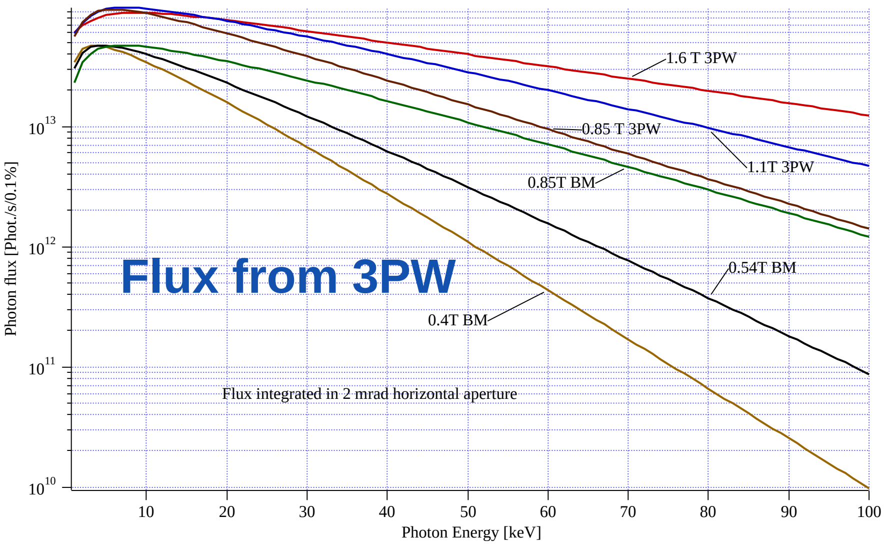
Half assembly



The BM Sources will be replaced by dedicated 1-Pole short super bend, 2-Pole or 3-Pole Wigglers

- Field Customized
- Large fan with flat top field
- 2 mrad feasible for 1.1 T 3PW
- Mechanical length ≤ 150 mm

- Source shifts longitudinally by ~3m
- Source shifts horizontally by ~1-2cm



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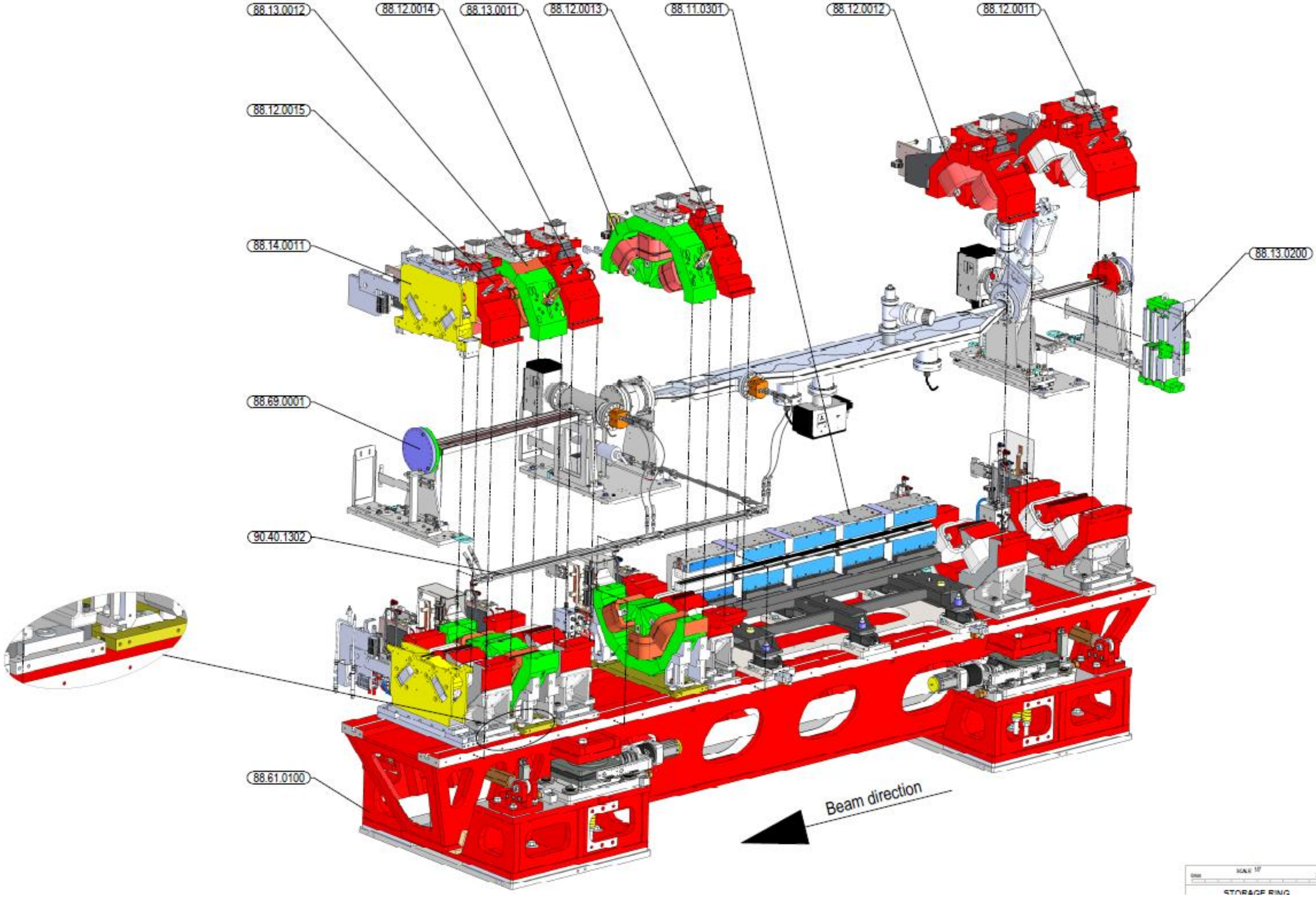
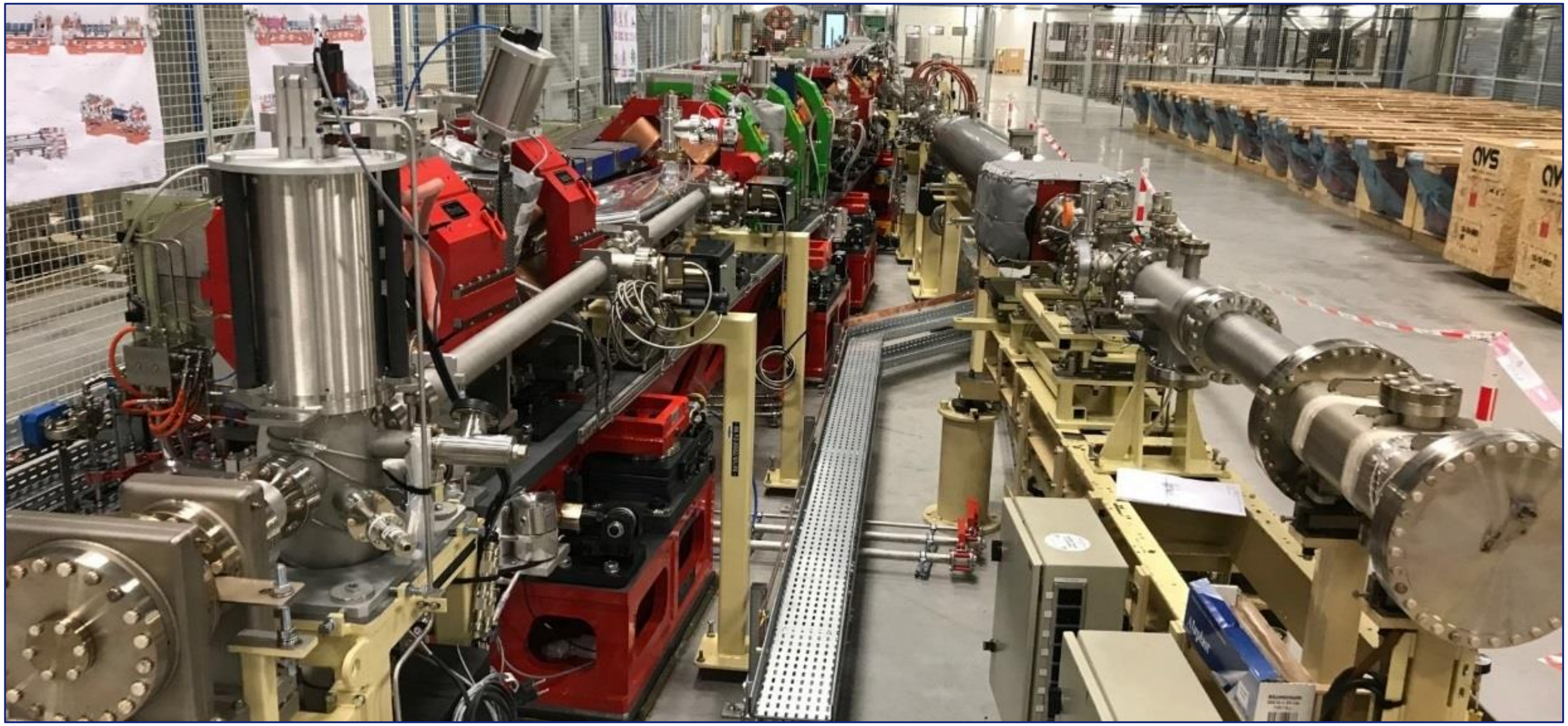
COMPLETE GIRDER DISASSEMBLED VIEW



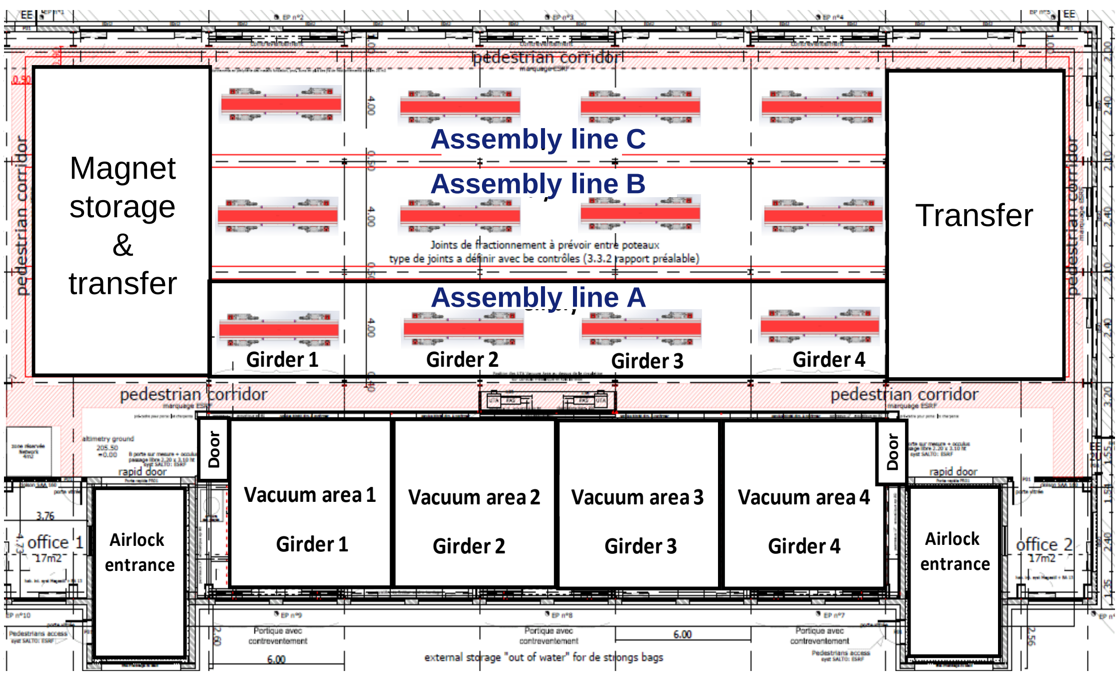
MOCK-UP

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

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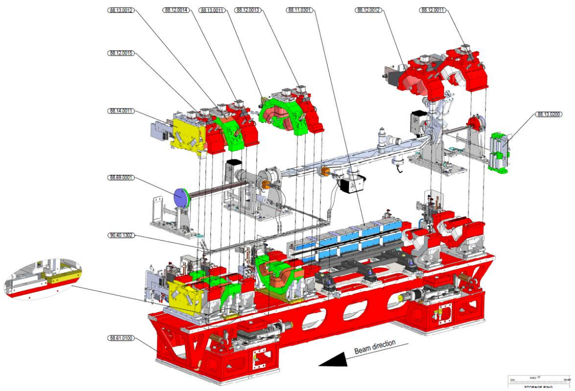
GIRDER ASSEMBLY IN FULL SWING



- 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

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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

DISMANTLING + INSTALLATION: DEC 2018 – NOV 2019

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

32 cells

Old machine storage building for radioprotection control

\+ all the activities in the technical areas

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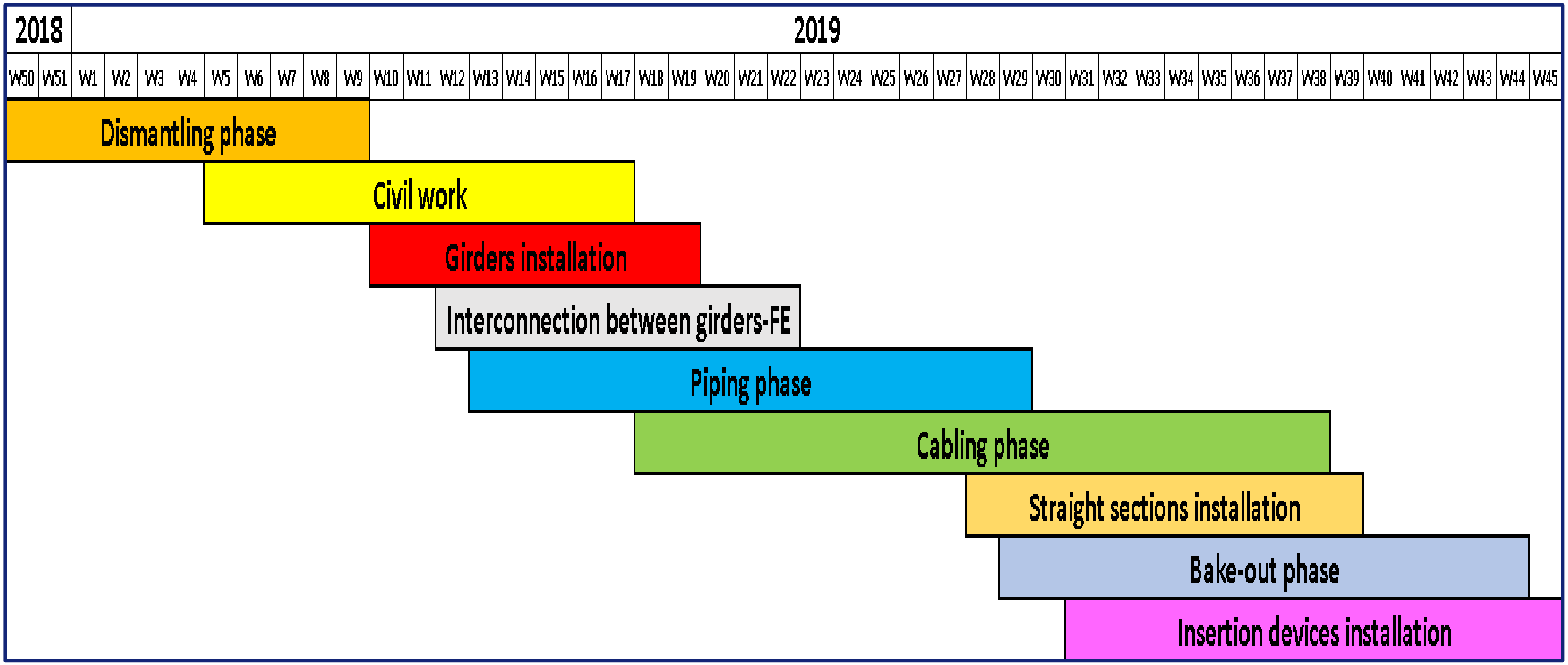
INSTALLATION

Name	Start
MILESTONES	10-Dec-18
* Start ESRF-EBS Big shutdown	10-Dec-18

11 months after …

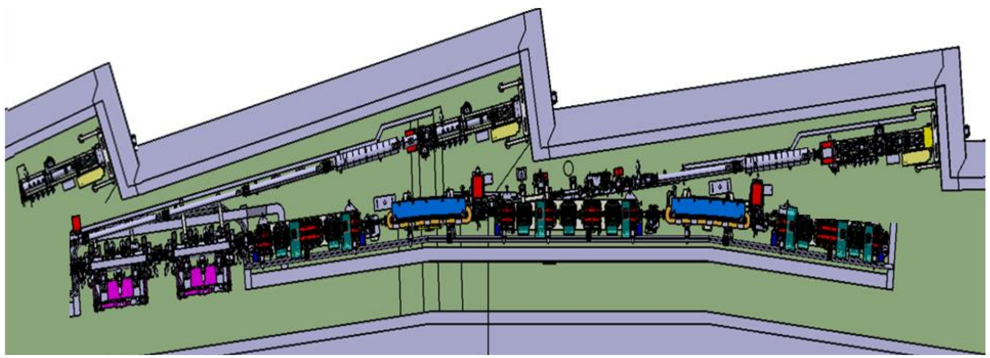
INSTALLATION



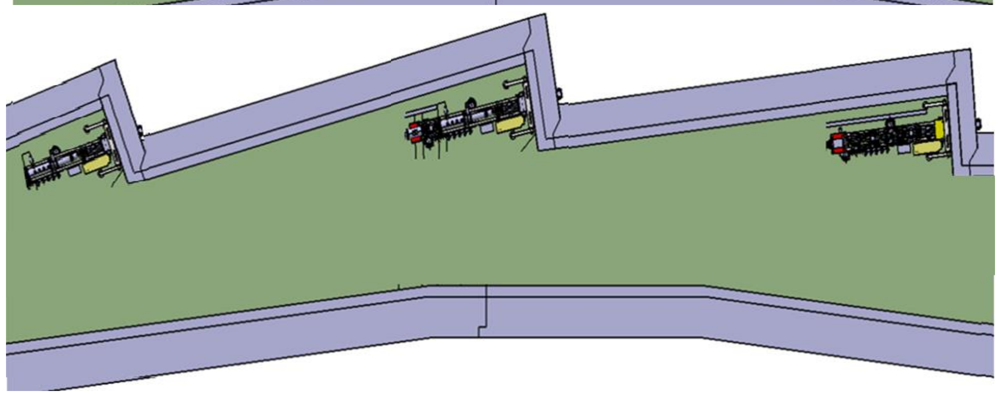
DISMANTLING PHASE : 11 WEEKS

2018		2019																																												
W50	W51	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45
Dismantling phase																																														

BEFORE



AFTER



1. Cables
2. Pipes
3. Girders & ALL

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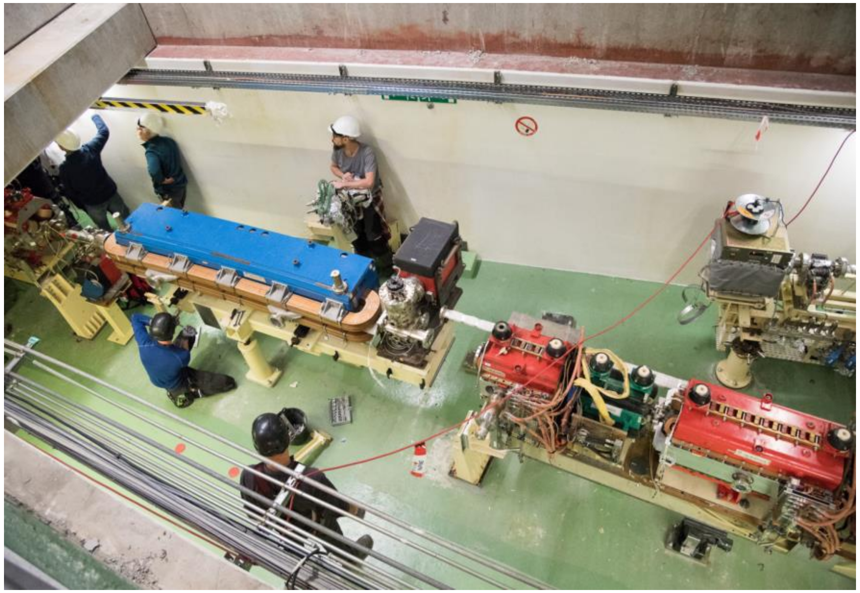
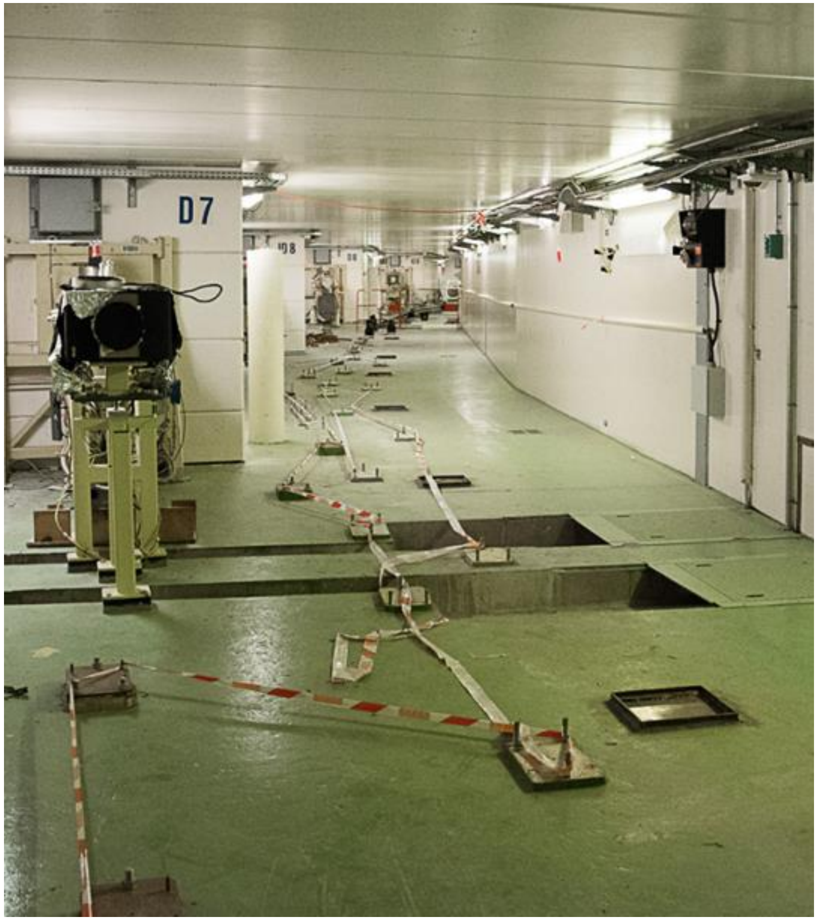
DISMANTLING PHASE : CABLES

DISMANTLING PHASE : FRONT-END PARTS REMOVAL



DISMANTLING PHASE : AT THE END …



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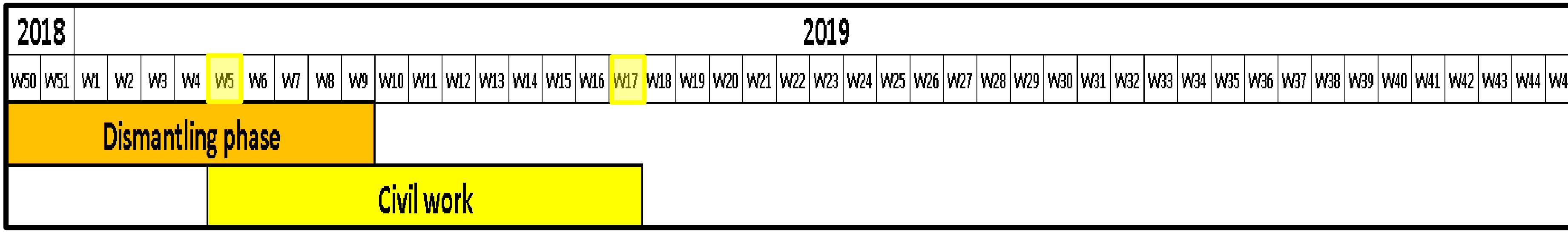
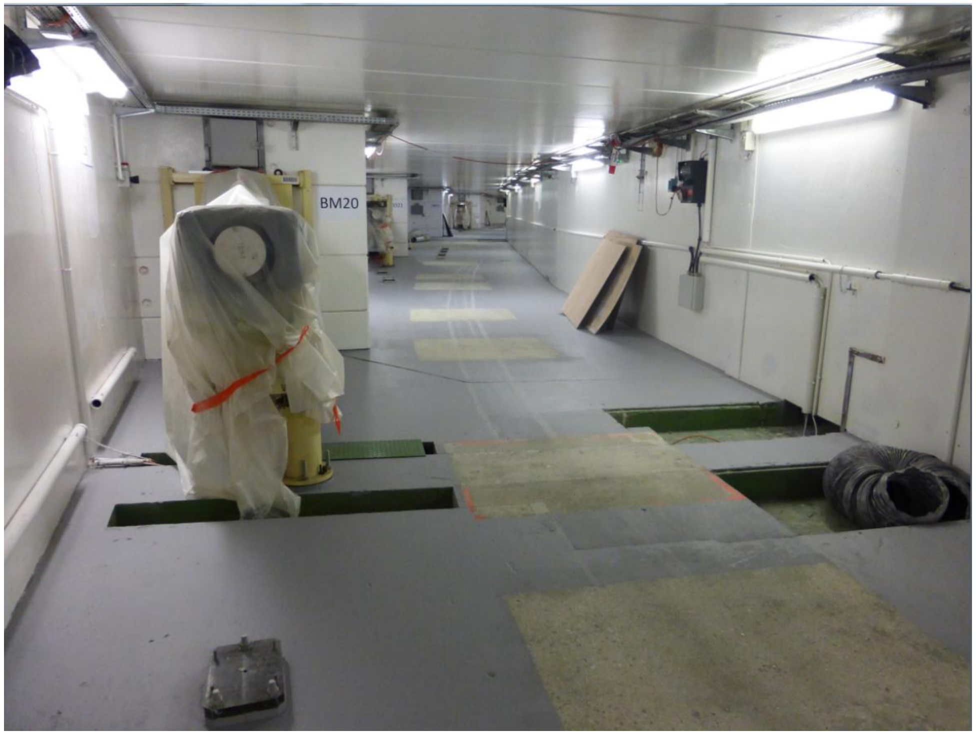
CIVIL WORK PHASE : 13 WEEKS



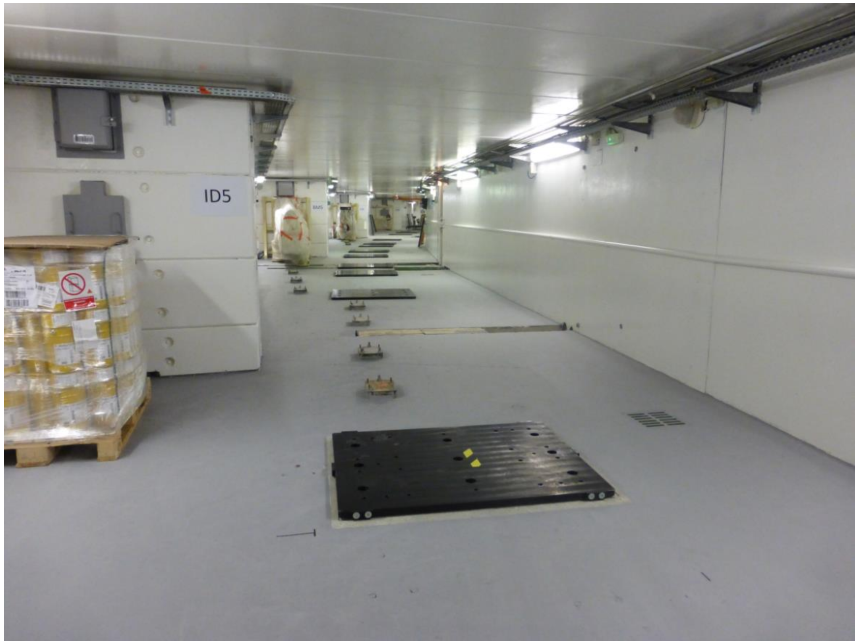
CIVIL WORK PHASE : IN PROGRESS

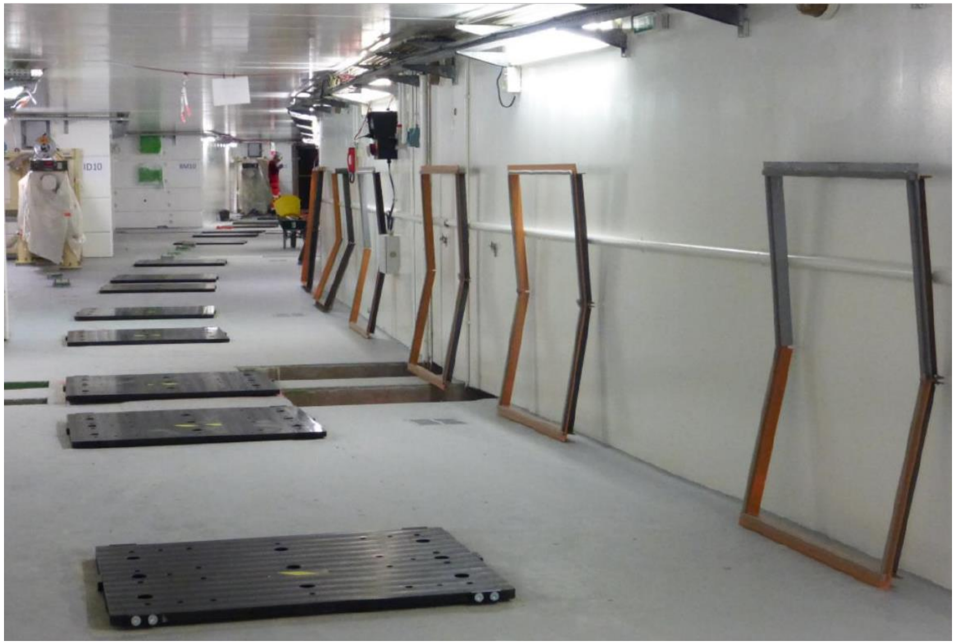
CIVIL WORK PHASE : PREPARATION FOR THE PAINTING

CIVIL WORK PHASE : LOCATION OF THE GIRDERS PLATES

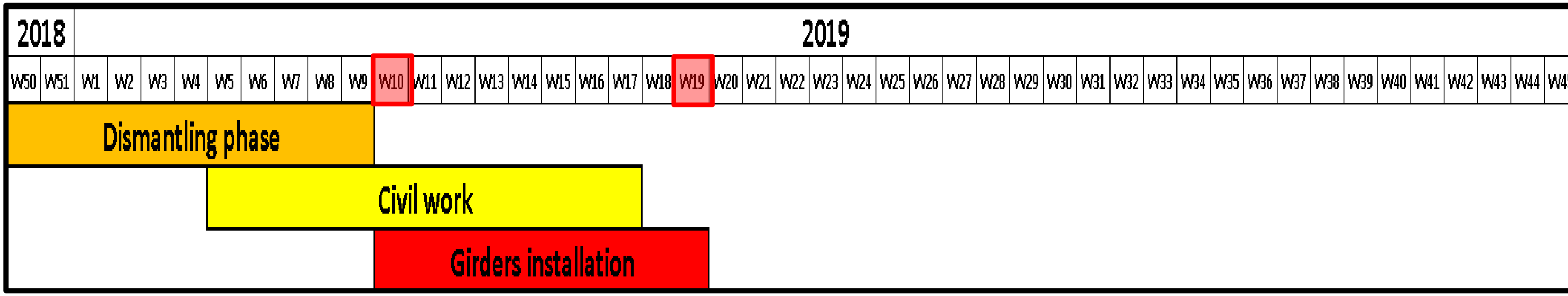


CIVIL WORK PHASE : CASING OF GIRDERS PLATES





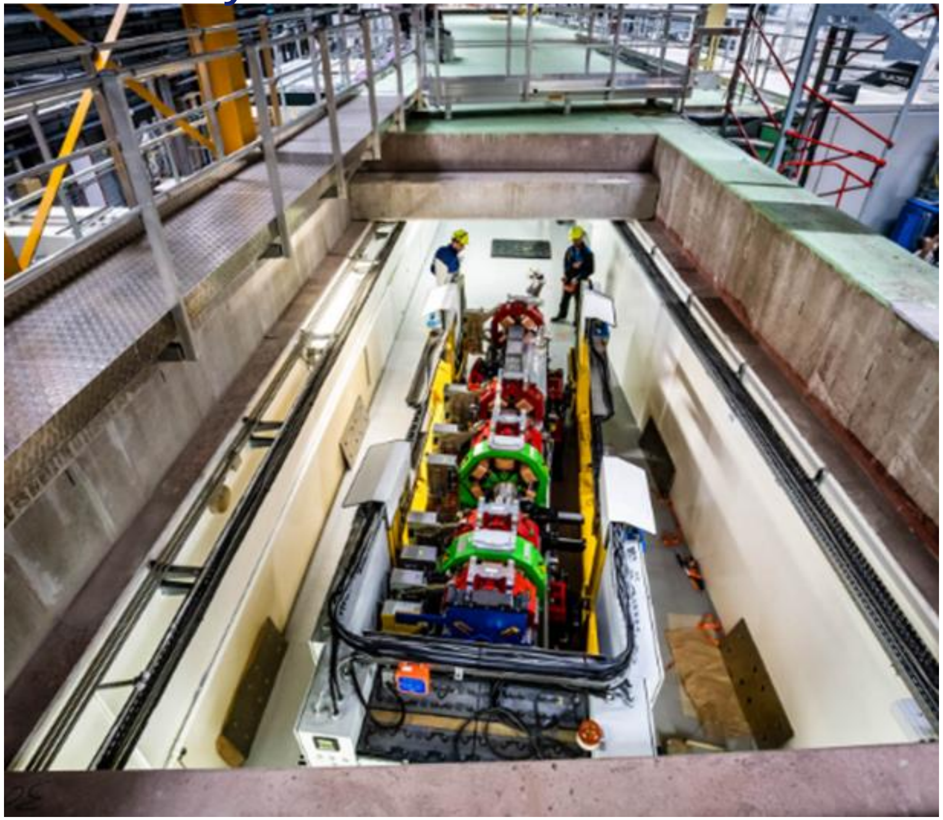
GIRDERS INSTALLATION : 10 WEEKS



GIRDERS INSTALLATION : LIFTING

Girder lifted from the EXPH into SRTU

Girder inserted into the module
Ready for its final destination



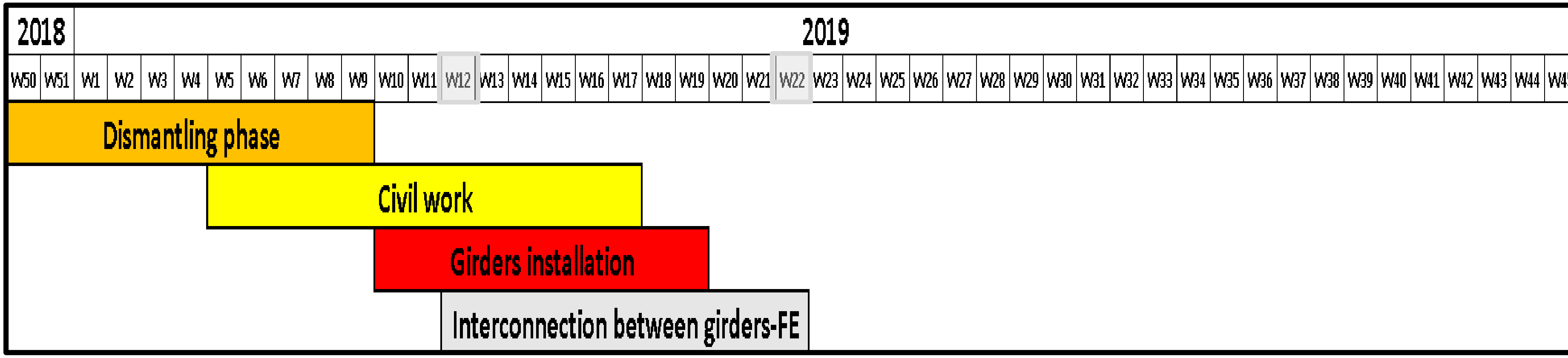
GIRDERS INSTALLATION : ROLLING

No much space for the module during displacements

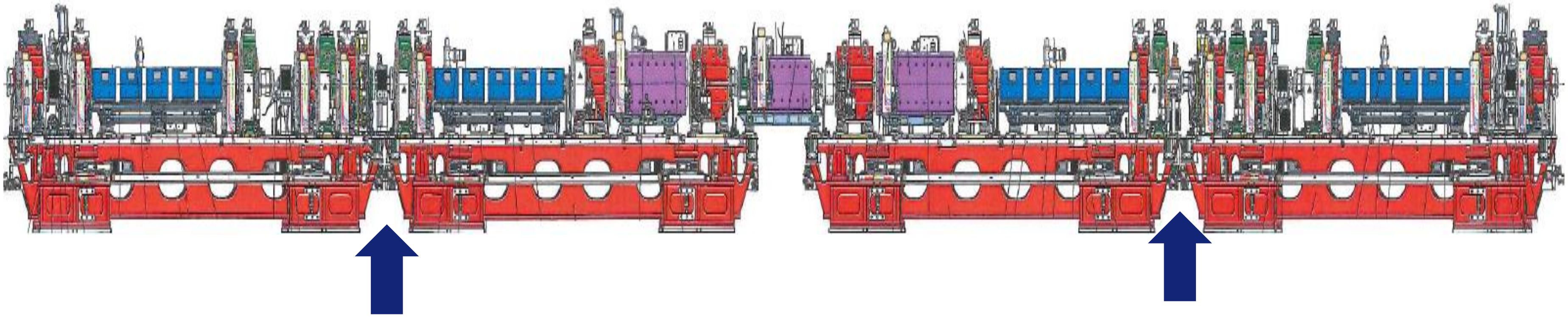
GIRDERS INSTALLATION : RECORD

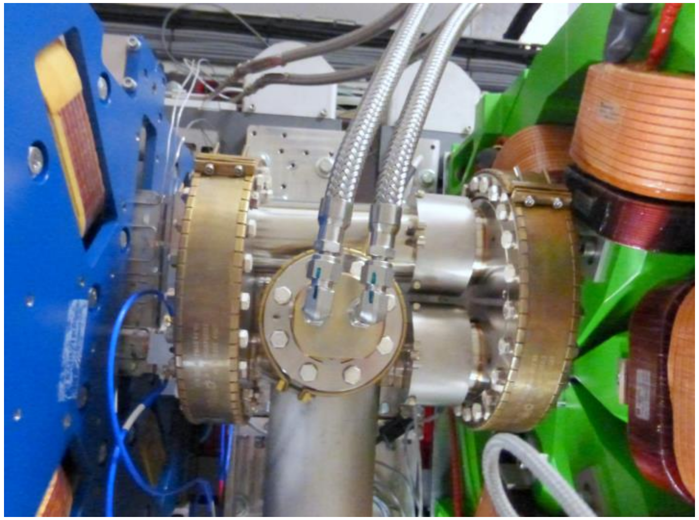
16/04/2019
9 girders
installed

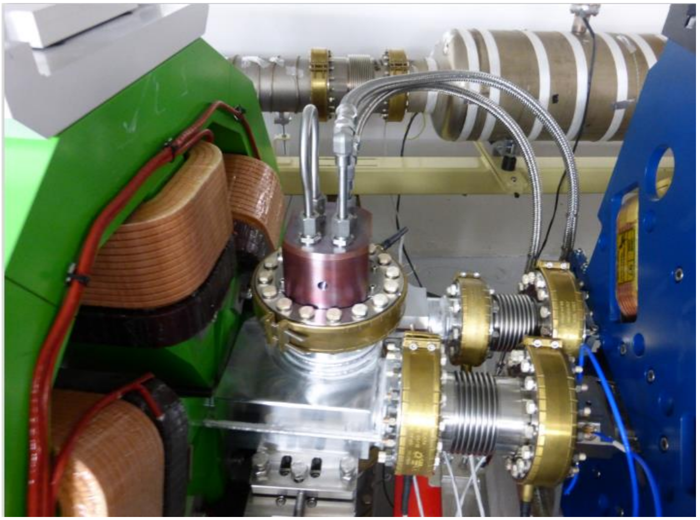
INTERCONNECTIONS PHASE : 11 WEEKS



INTERCONNECTIONS PHASE : G1-G2 & G3-G4



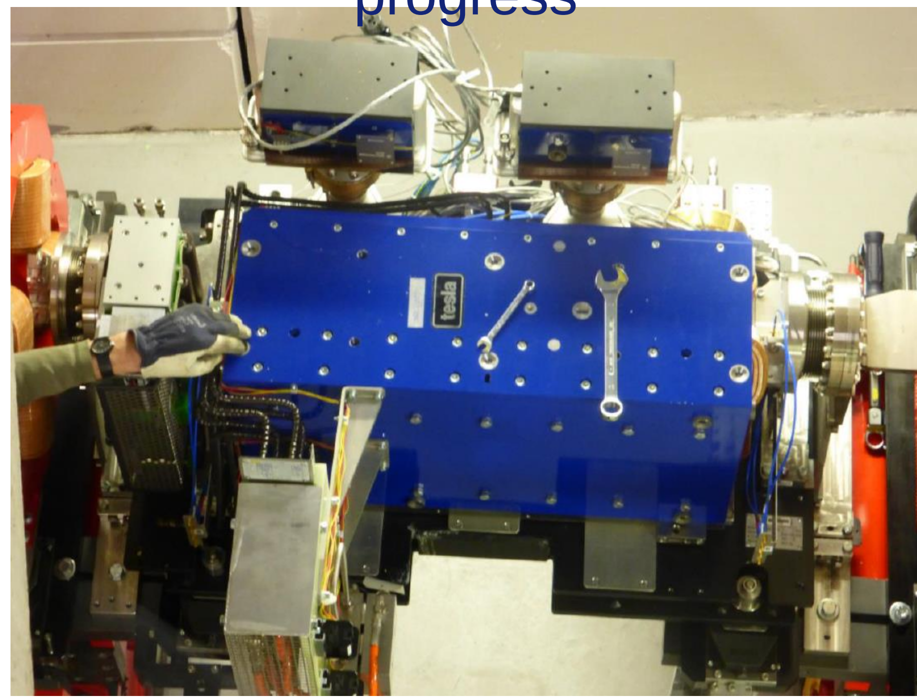




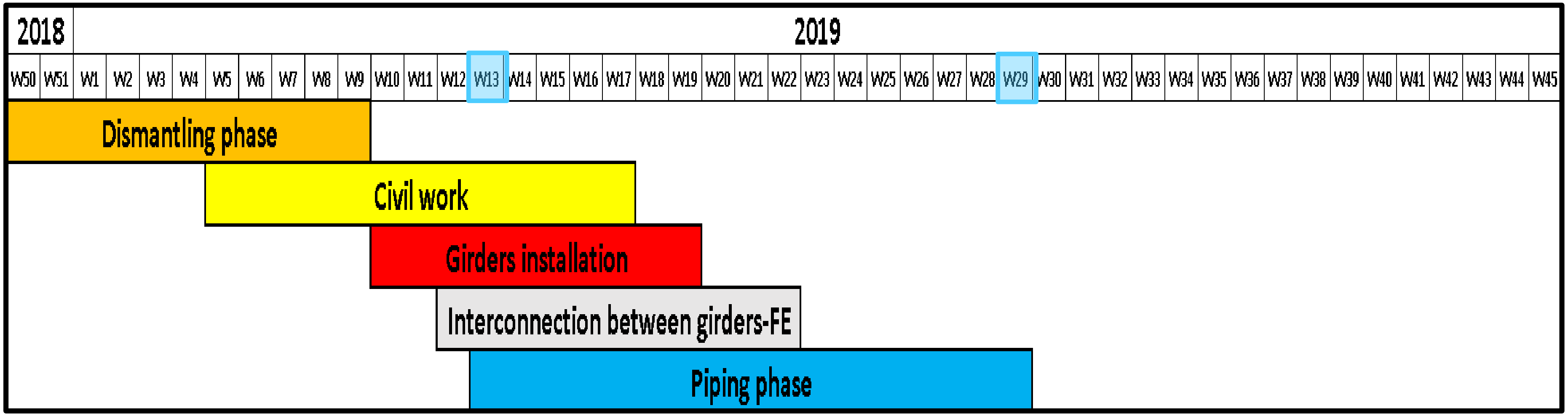
INTERCONNECTIONS PHASE : G2-G3 => DQ2 INSTALLATION

DQ2 ready to be inserted into the SRTU

DQ2 in place, alignment in progress



PIPING PHASE : 17 WEEKS



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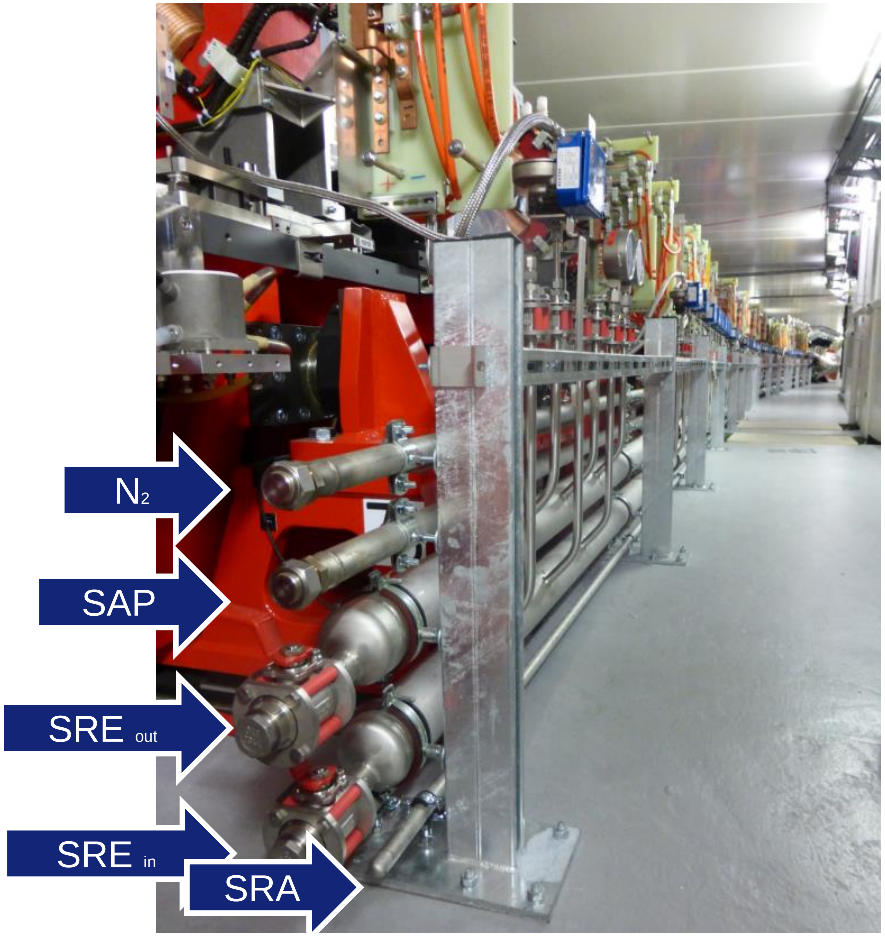
PIPING PHASE : PREPARATORY WORK AT THE SUBCONTRACTOR'S

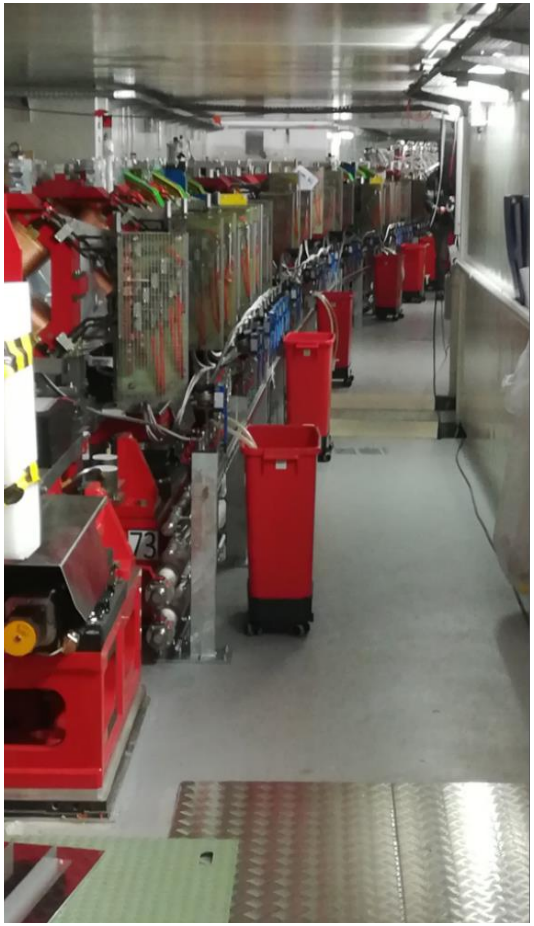
Pipes pre-assembled and tested

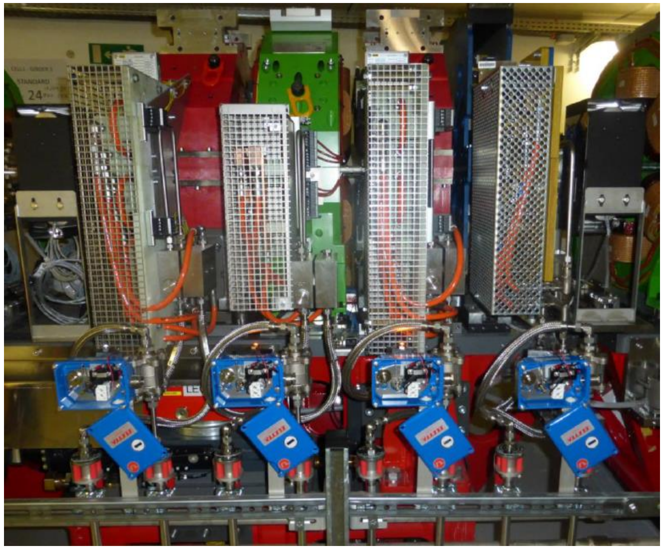
Pipes packaged for delivery

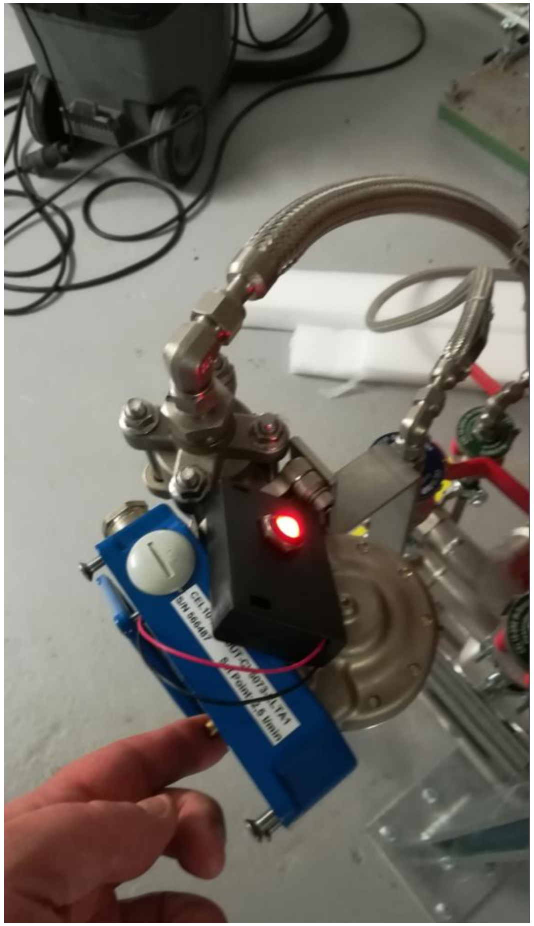
PIPING PHASE : INSTALLATION



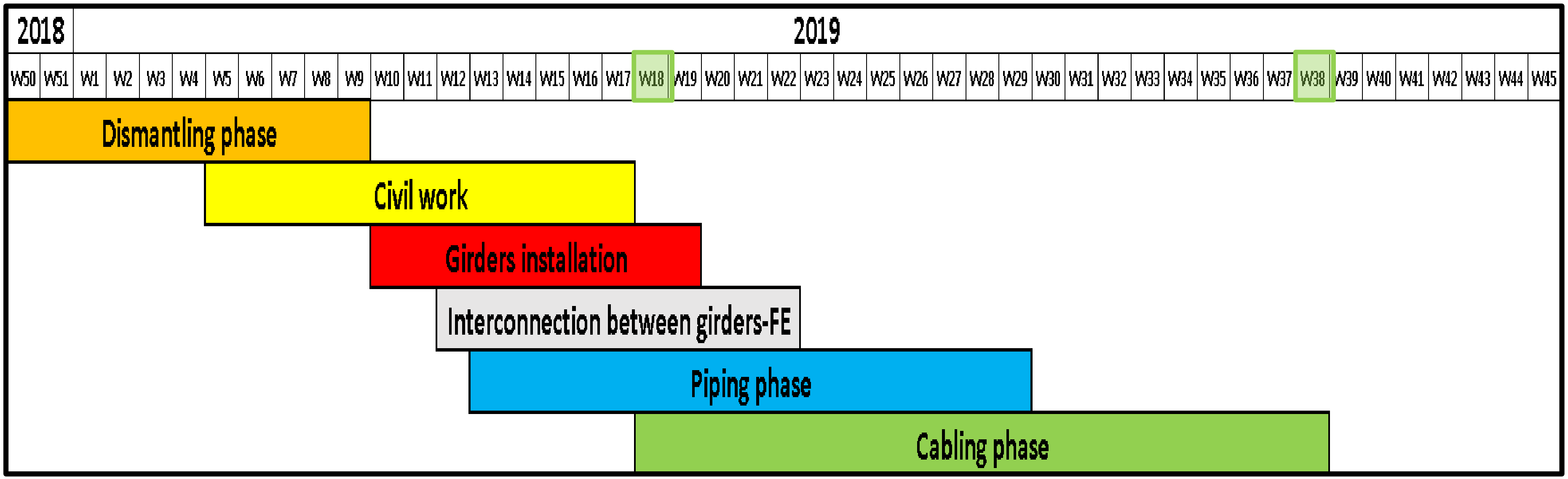
PIPING PHASE : COMMISIONING





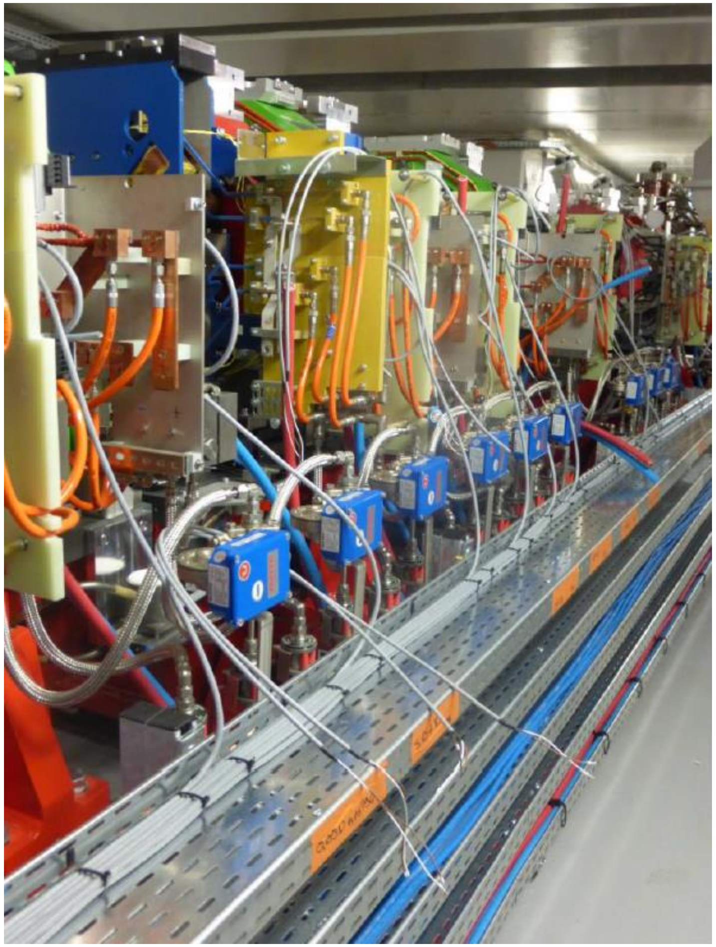


CABLING PHASE : 21 WEEKS



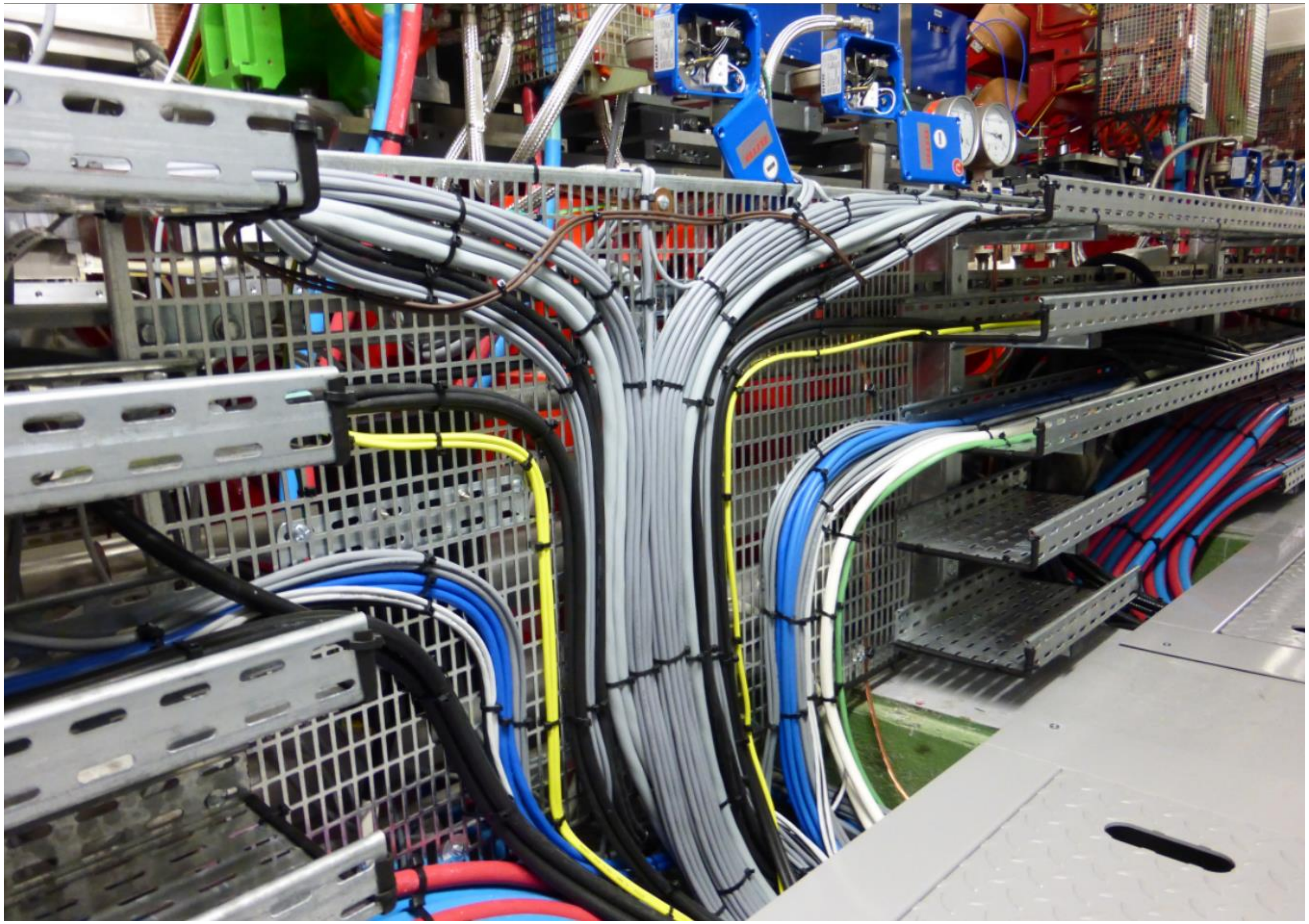
- Around 60 000 h of work
- 220 electricians all along with the project
- More than 100 electricians at the peak load
- Around 14 000 cables installed
- 360 km of cables pulled
- 15 500 connectors
- Less than 100 cables found faulty during the commissioning phase

CABLING PHASE : INSTALLATION

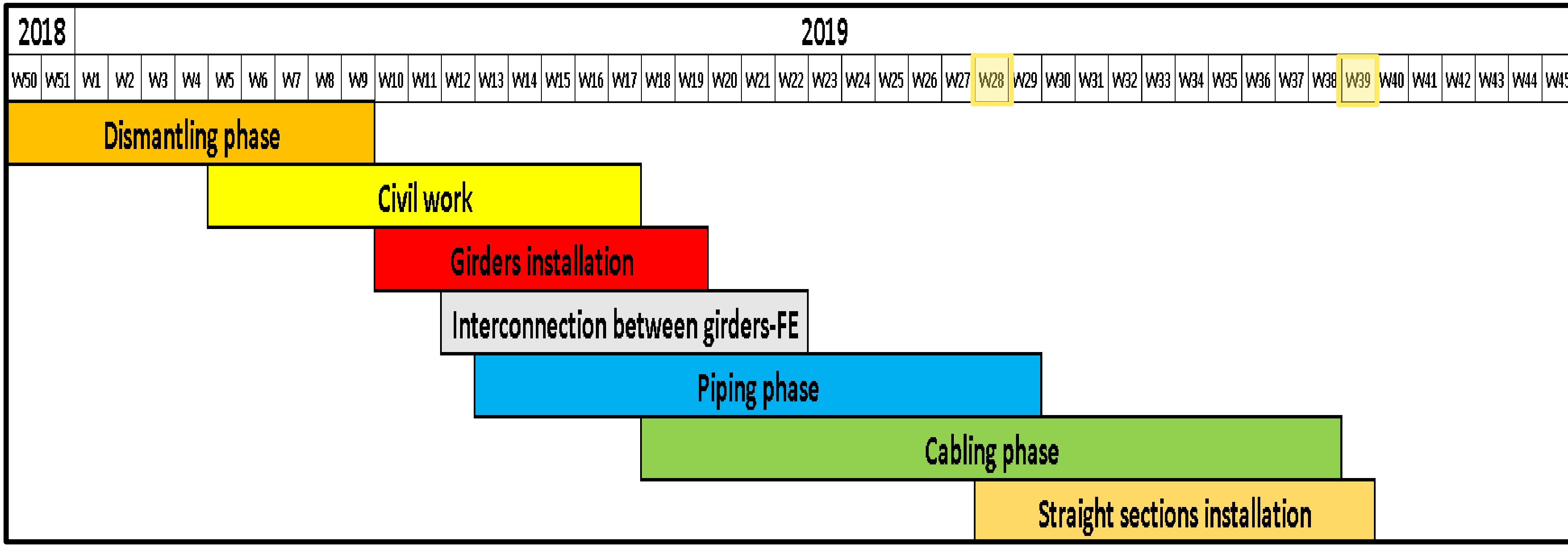


JUAS, 21 January 2020, ESRF operation -EBS project Jean-Luc Revol

CABLING PHASE : CELL COMPLETED



STRAIGHT SECTIONS INSTALLATION : 12 WEEKS



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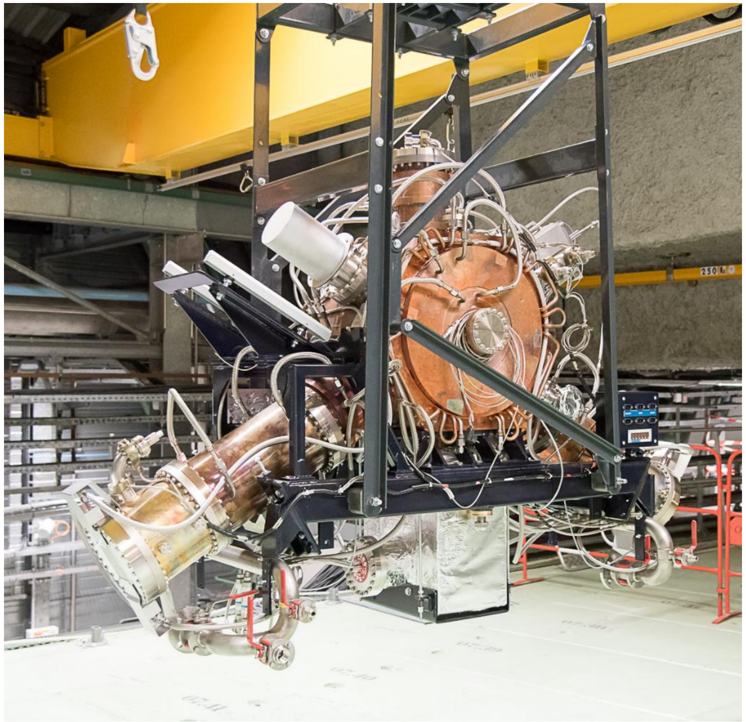
STRAIGHT SECTIONS INSTALLATION

4	G0	
5	RF cavities	RF
6	IVU01-CV2378	INVAC
7	RF cavities	RF
8	CV5073	
9	CV2378 + IVP02	INVAC
10	CV5073	
11	IV091 + IVR02	INVAC
12	CV5073	
13	CV2378 + IVP04	INVAC
14	CV5073	
15	CV2000-IVR03	INVAC
16	IVW1-CV2378	INVAC
17	CV5073	
18	CV5073	
19	CV5073	
20	CV5073	
21	CV5073	
22	CV2378-IVO01	INVAC
23	CV5073	
24	CV5073	
25	RF cavities	RF
26	CV5073	
27	CV5073	
28	CV5073	
29	CV2378-IVP03	INVAC
30	CV5073	
31	CV1140-IV092-CV1140	INVAC
32	CV5073	
1	CV5073	
2	CV5073	
3	CV5073	

RF cavities installed in phase advance in April & May



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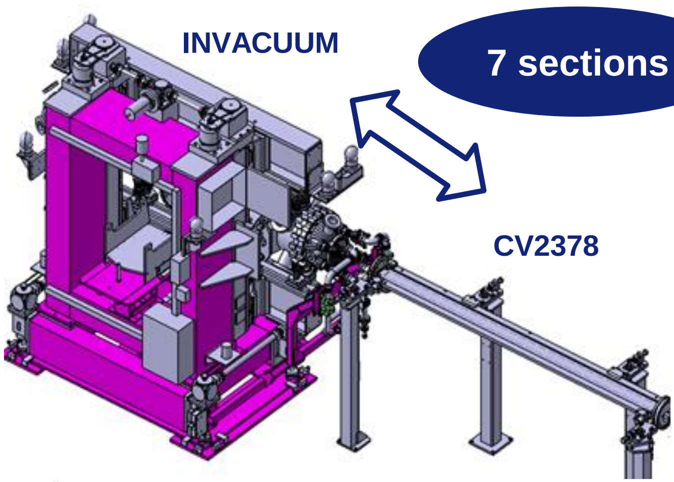
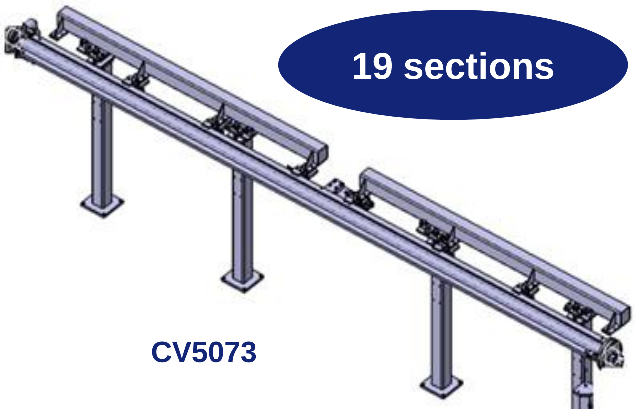
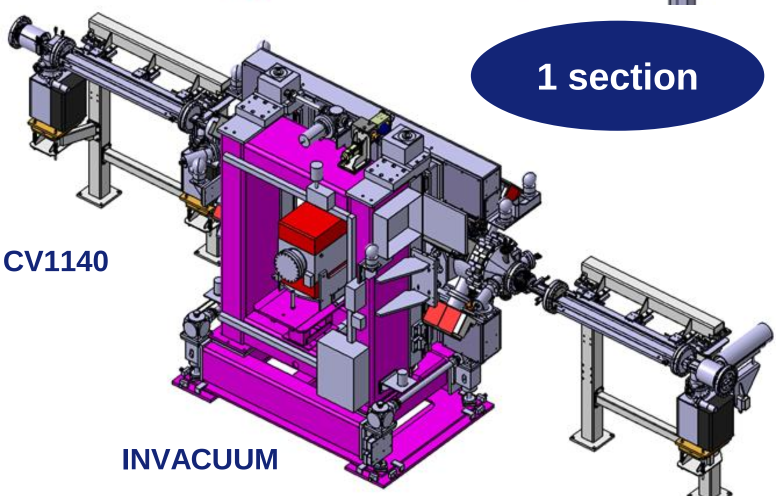
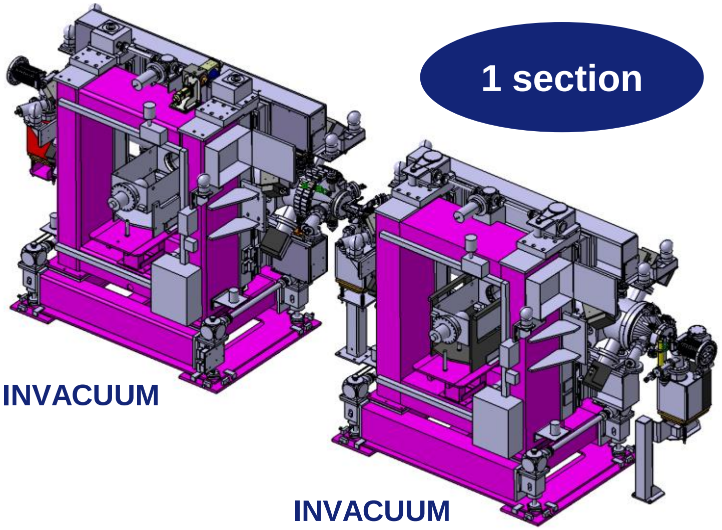
STRAIGHT SECTIONS INSTALLATION : 4 TYPES

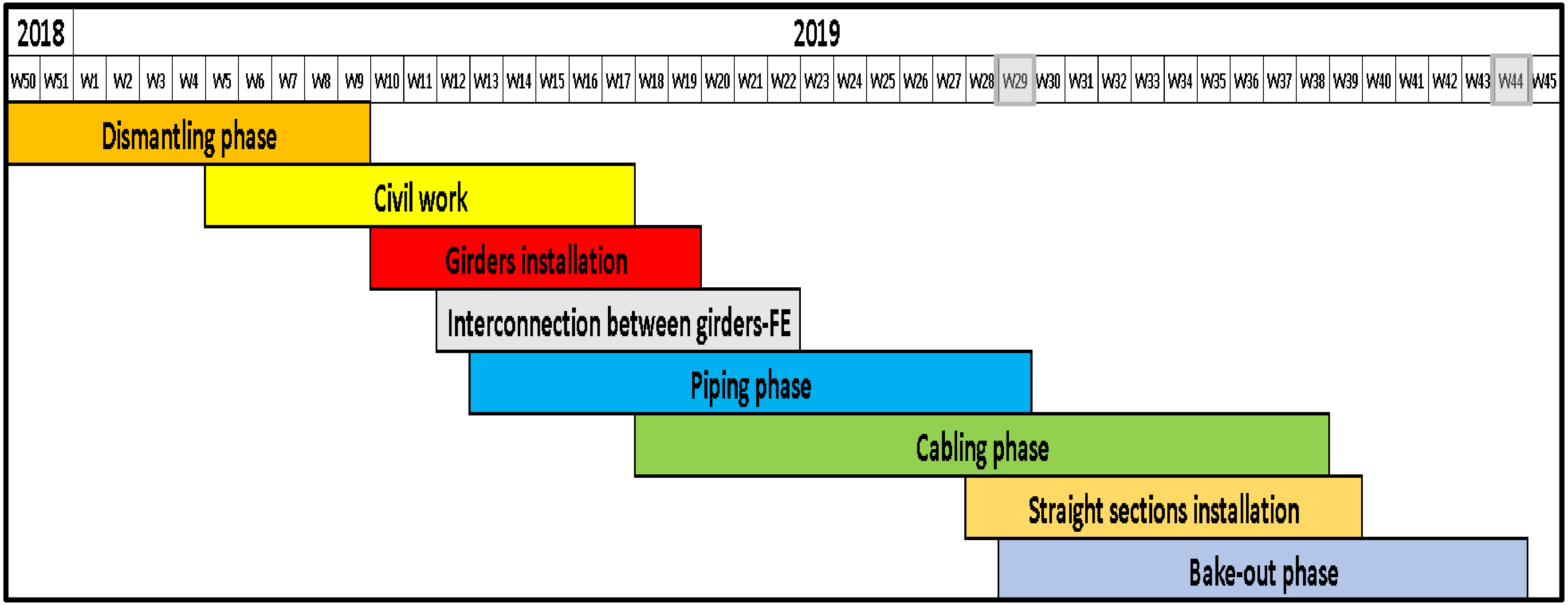




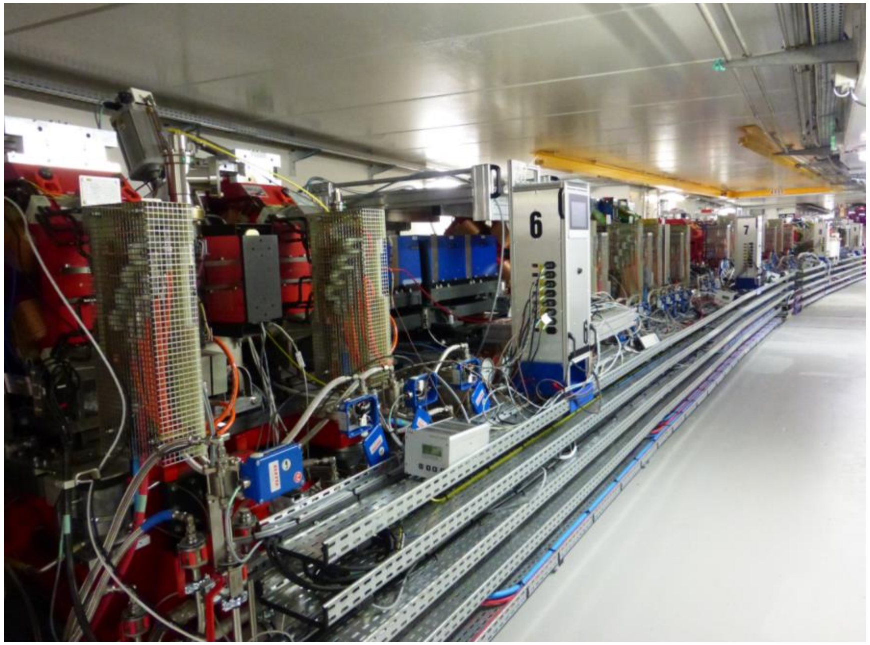




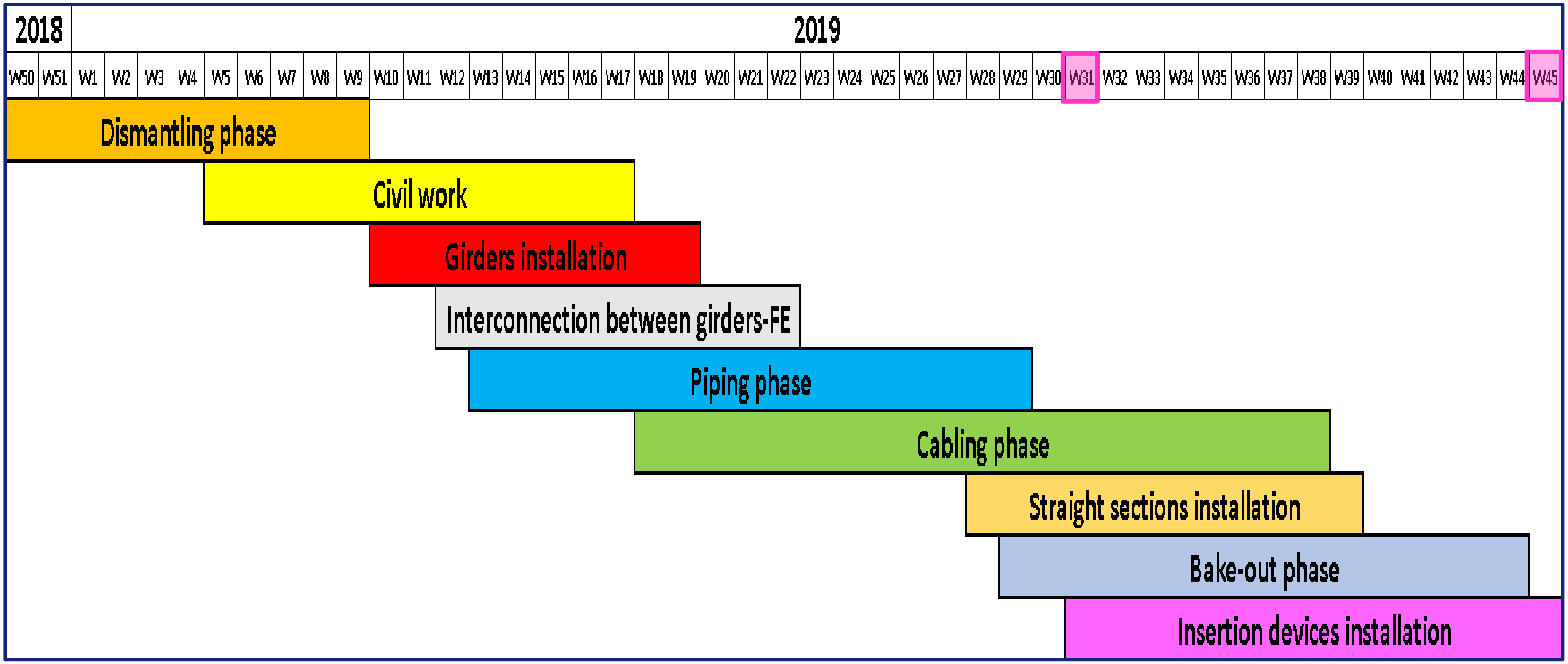
BAKE-OUTS PHASE : 16 WEEKS



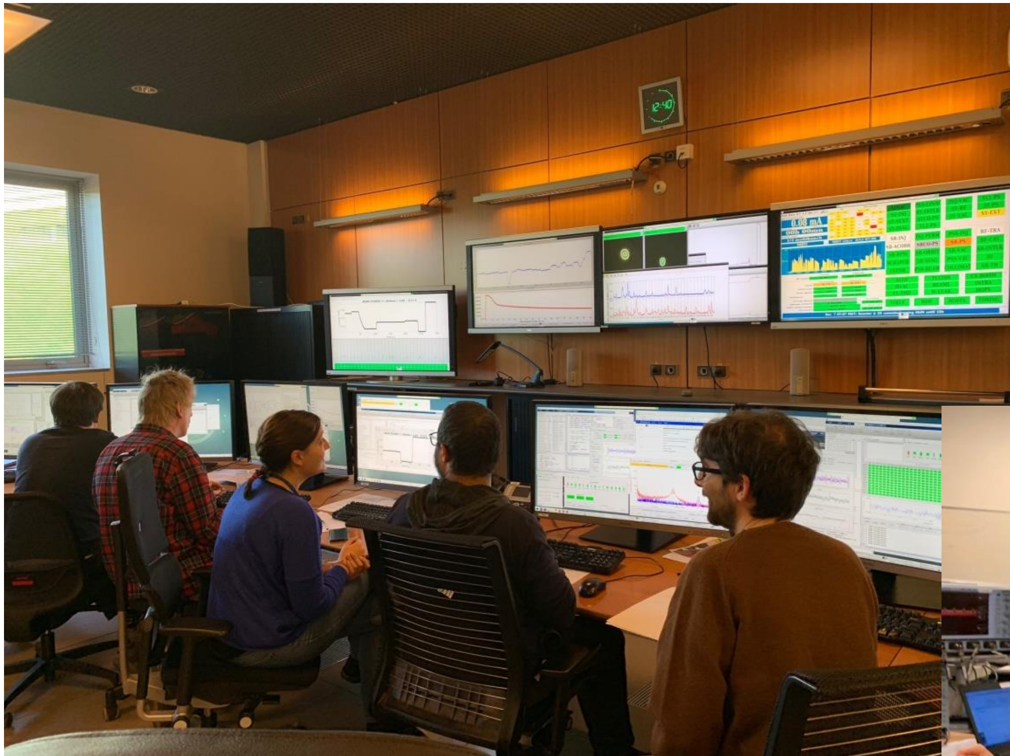
BAKE-OUT PHASE : ARC READY TO BE BAKED

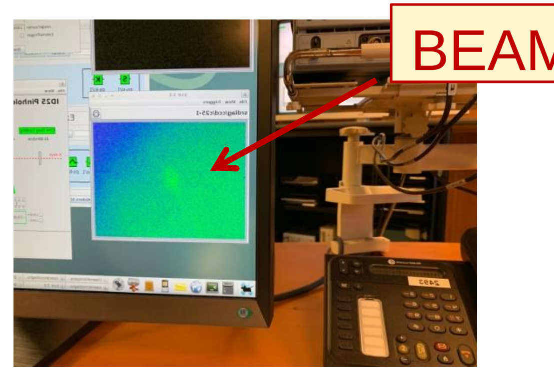


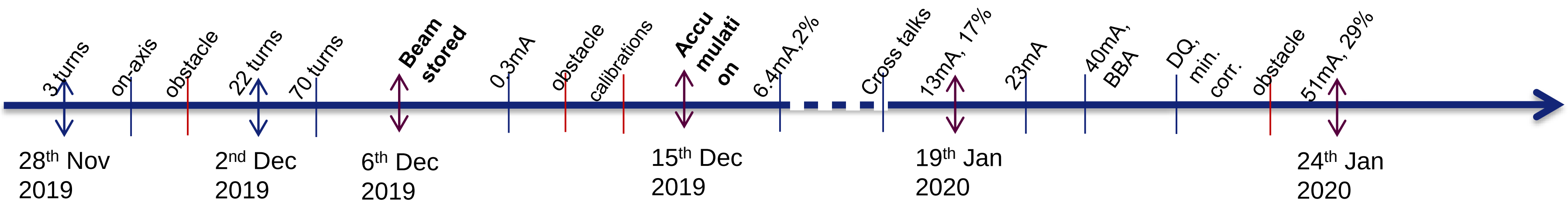
INSERTION DEVICES INSTALLATION : 15 WEEKS



BEAM STORED: A MAGIC MOMENT!







Optics commissioning results and plans

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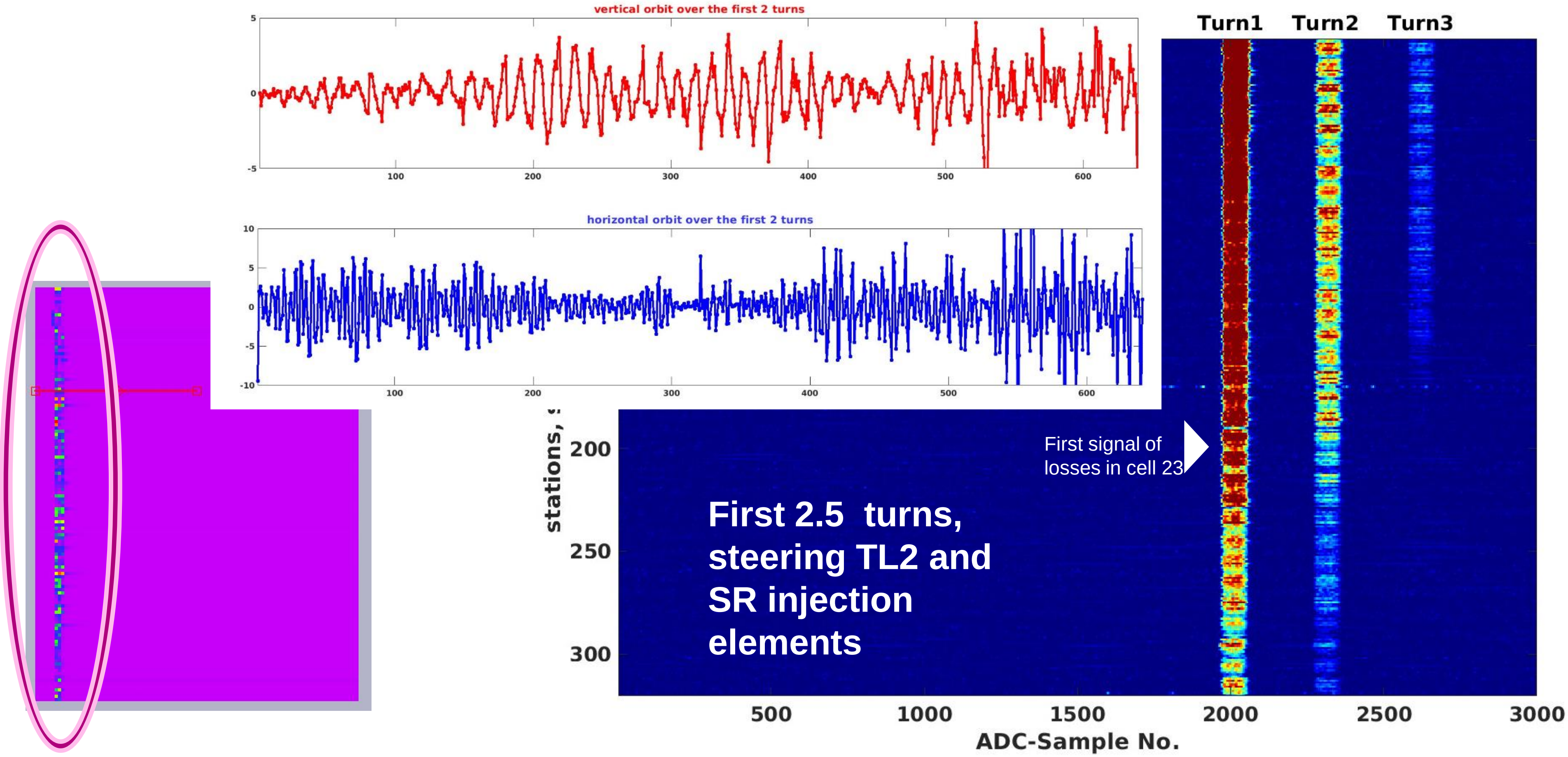
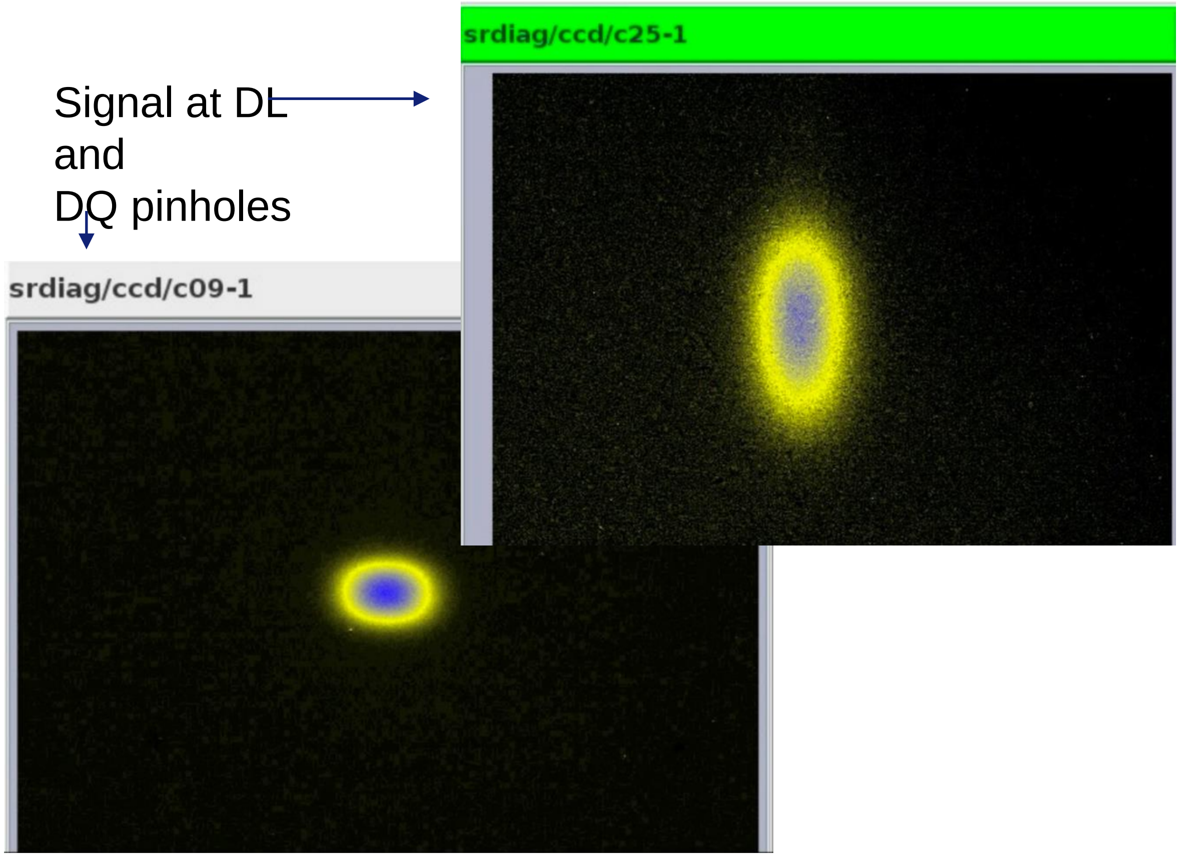
2019 NOVEMBER 28TH AT 19.00: FIRST TURNS IN EBS-SR

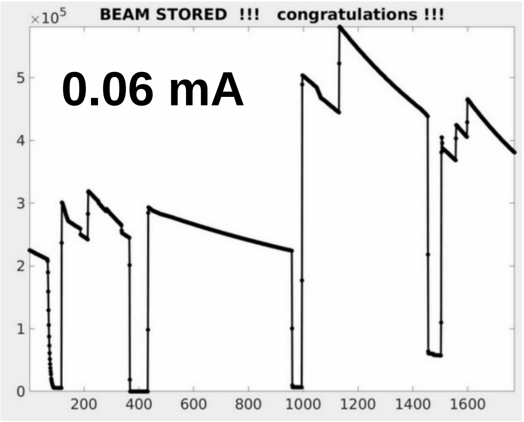


First 2.5 turns, steering TL2 and SR injection elements

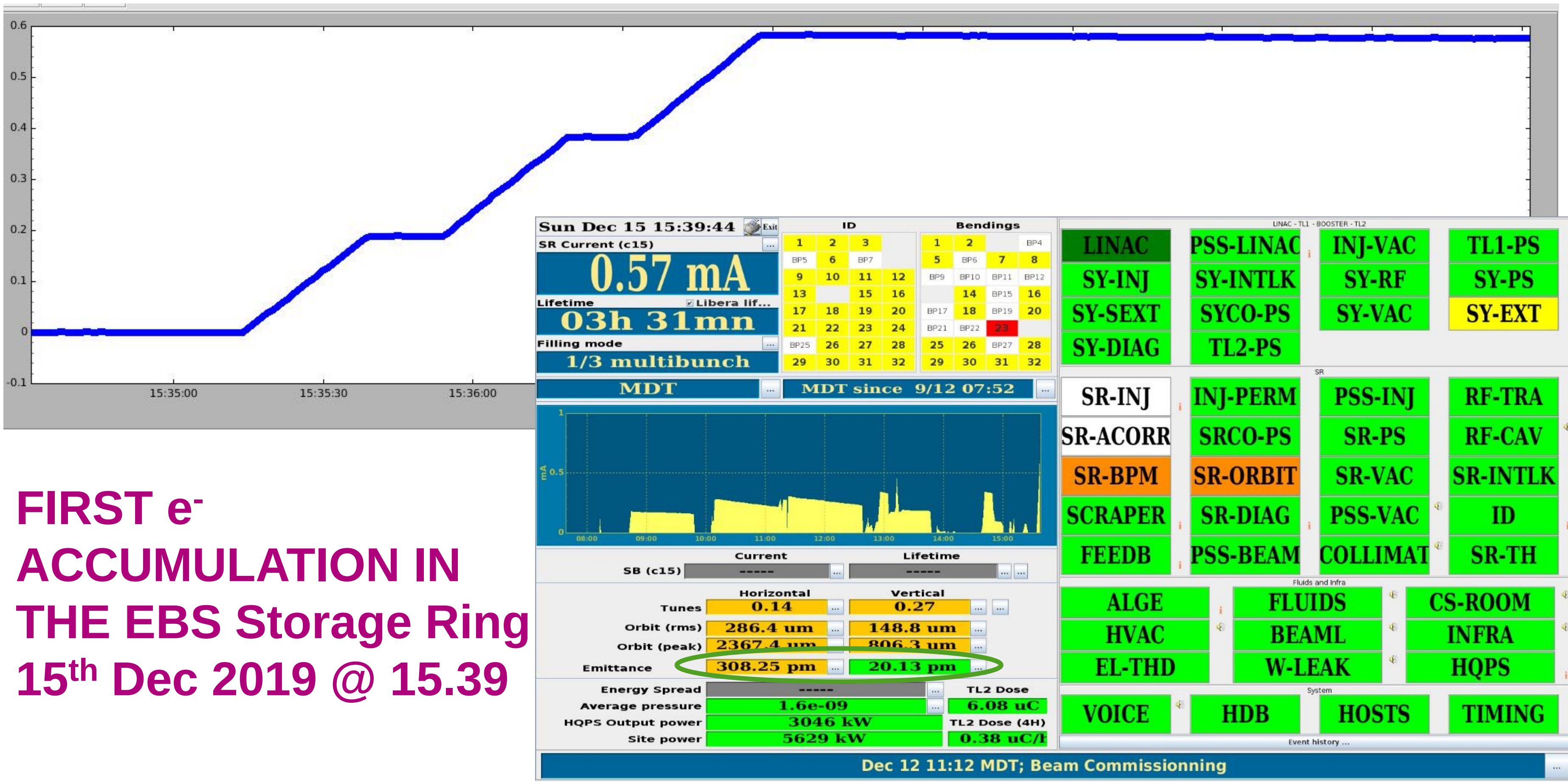
2019 DECEMBER 6TH : BEAM STORED AT 12.30, PINHOLE LIGHT AND TUNE MONITOR

Signal at DL
and
DQ pinholes



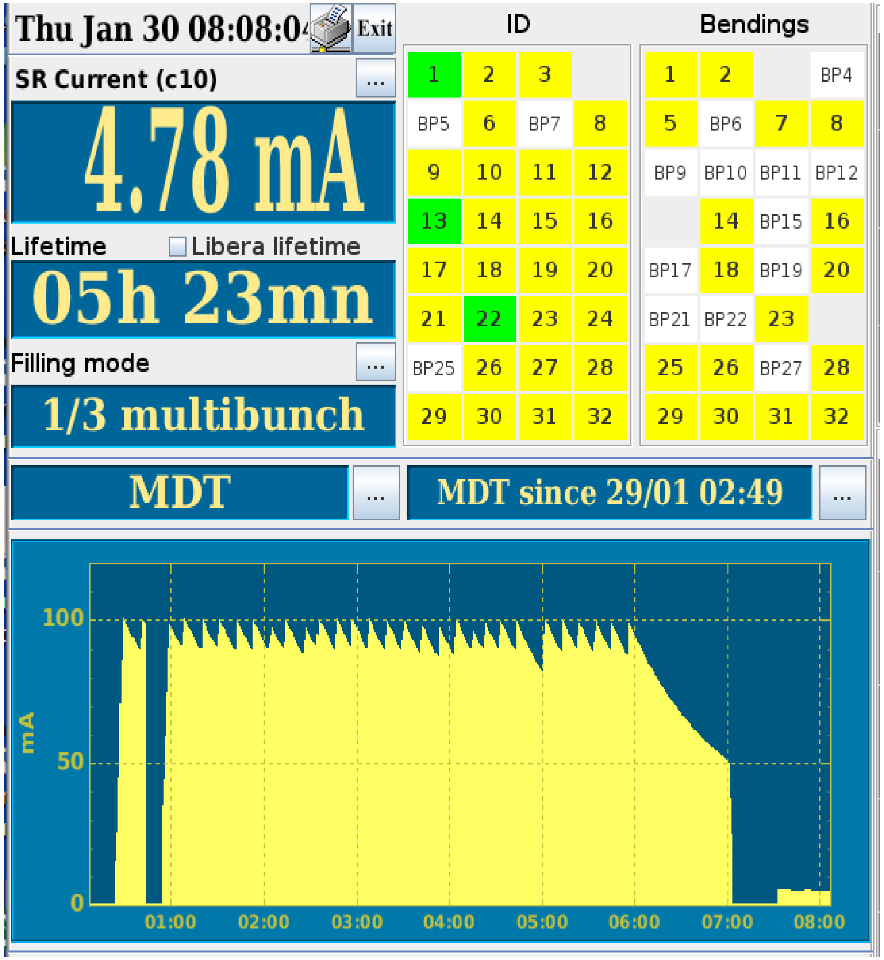


2019 DECEMBER 15TH : FIRST ACCUMULATION



FIRST e$^-$ ACCUMULATION IN THE EBS Storage Ring 15th Dec 2019 @ 15.39

PRESENT STATUS ON 30TH JANUARY

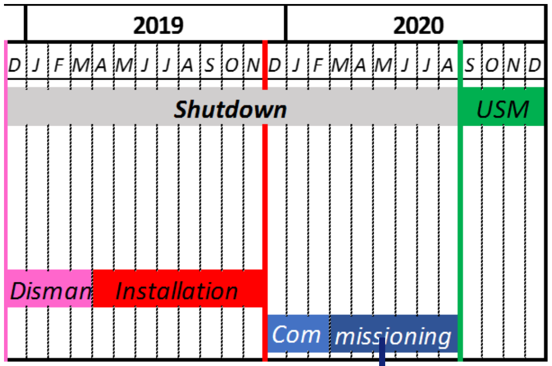


- 100 mA reached
- Delivery to beamline for alignment check

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 :
  - Engineering Design completed
  - Procurement completed
  - Delivery of main components completed
  - Mock-up cell completed
  - Assembly clompleted
  - Dismantling/installation completed
  - Commissioning well progress
  - Delivery to users close to be performed
  - No show stopper to be back to operation with users in August



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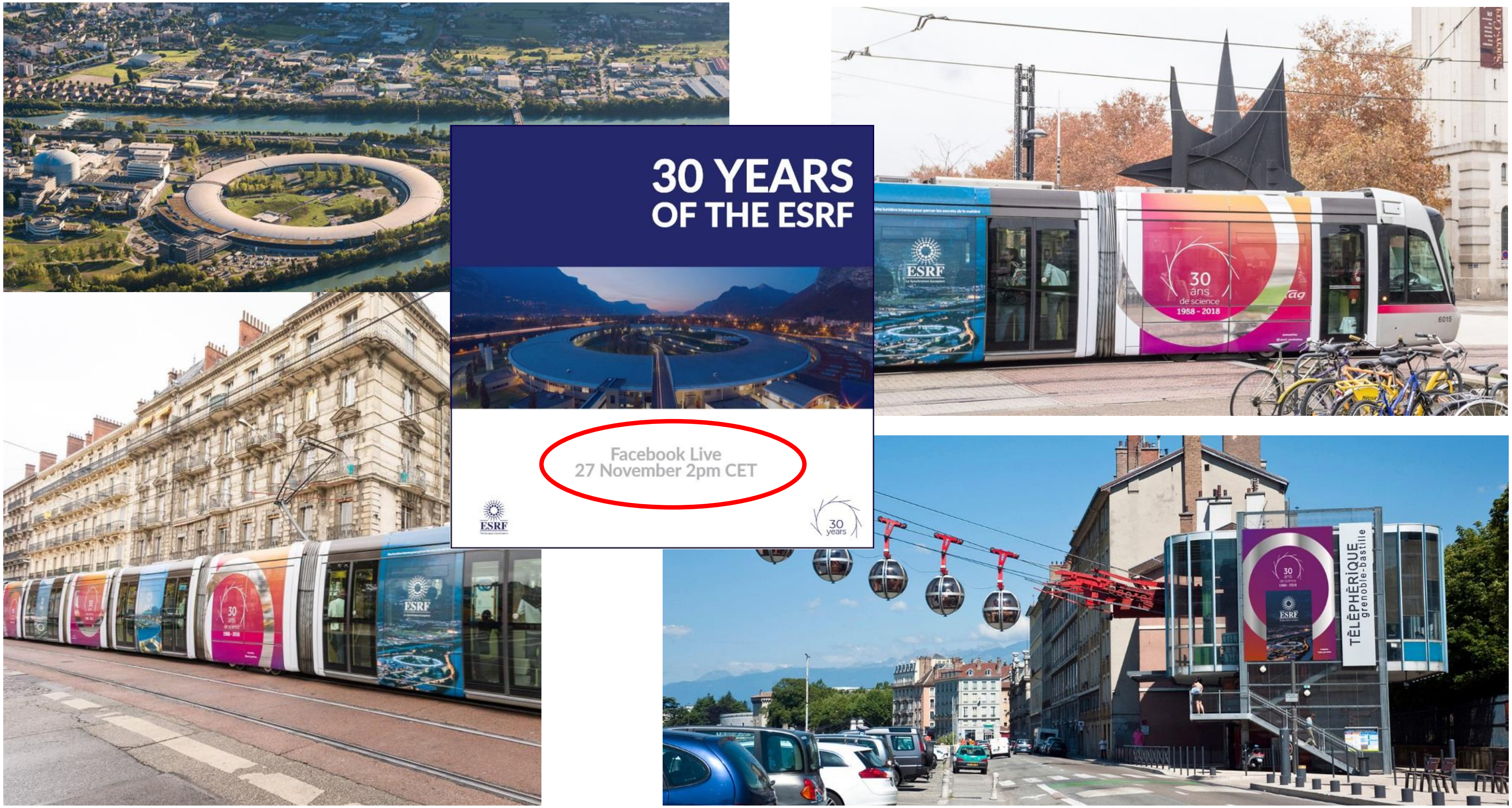
MANY THANKS FOR YOUR ATTENTION



MANY THANKS FOR YOUR ATTENTION