Status Of Construction For ESRF EBS

T. Perron on behalf of the EBS Accelerator Project Team

FLS / ShangHai, 05 March 2018

ESRF-EBS
Extremely Brilliant Source

ESRF | The European Synchrotron

Outline

- EBS project presentation
- X-ray beam characteristics
- Hardware description and assembly process
- Installation and commissioning

EBS constraints

Constrains for the new accelerator:

Keep the present injector, tunnel and beam-line configuration to reduce the cost of the project.

- The lattice has to be designed for a machine with the same length.
- Same straight section vacuum chambers will be used and put back at exactly the same place (27 beamlines+2 canted).
- Bending magnet beam line sources have to be reproduced (15 beamlines).
- Increase the brilliance by a factor that justifies investment of ~150 M€.

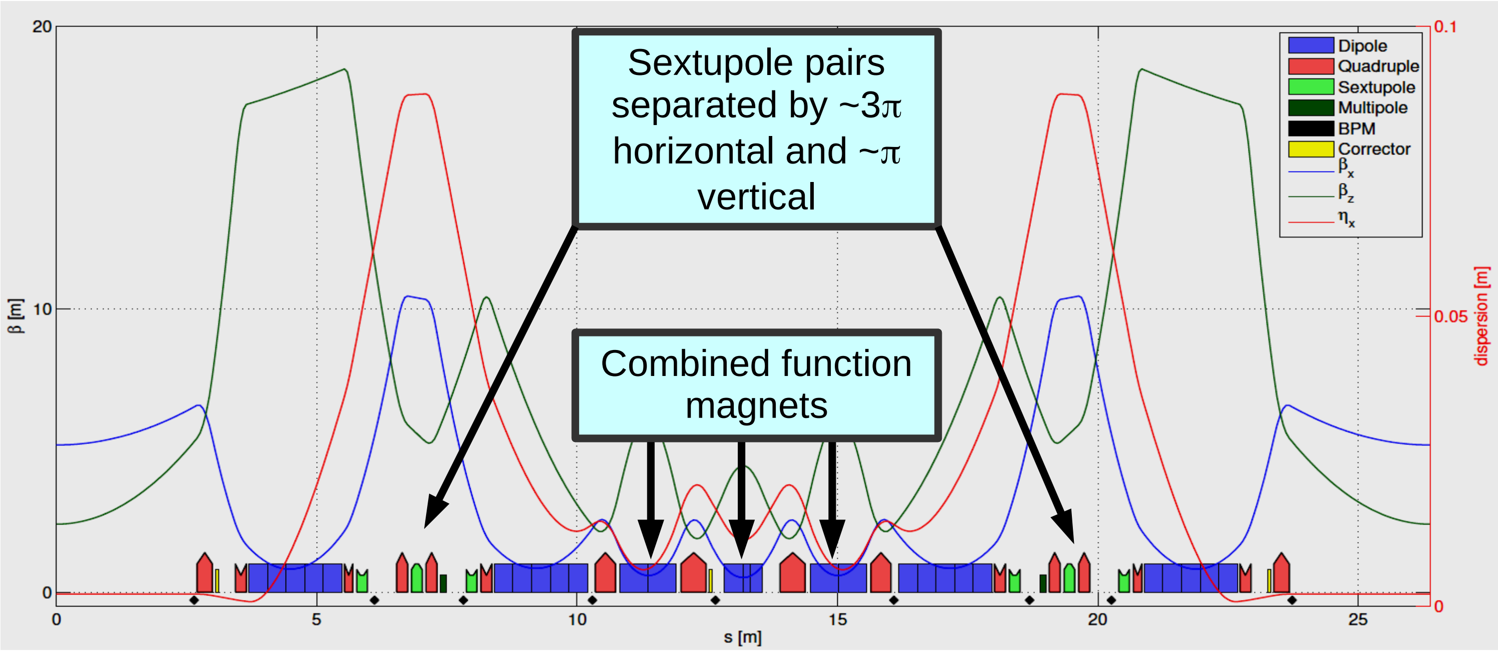
EBS lattice

HMBA lattice:

- Limit the number of sextupole families by having only weak chromatic sextupoles in a dispersion bump, with pairs separated by -I transformation in both planes.
- Add octupoles to compensate for the tune shift with amplitude.
- Use combined function magnets to combine dipoles and defocusing quadrupoles.

⇒ More space available for dipoles at locations with low η_h and low β_h.

40% of the global length compared to 20% today.

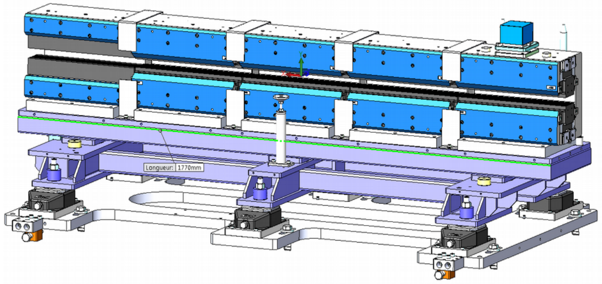


EBS magnets:

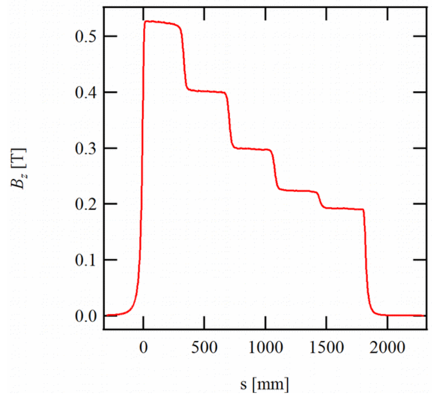
The lattice is mostly based on state of the art normal conducting magnets and cavities and a conservative vacuum system.

Main technological innovations:

- Permanent magnet dipoles with longitudinal gradient and permanent septas.

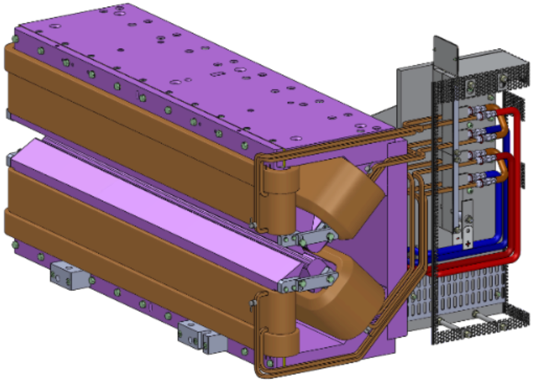


Typical dipole with 5 modules having different strength and longitudinal profile of the resulting field



Combined function magnet with dipole field ~ 0.5T and quad gradient ~37 T/m with a few % tunability.

- Combined function magnets combining a defocusing quadrupole and a dipole.

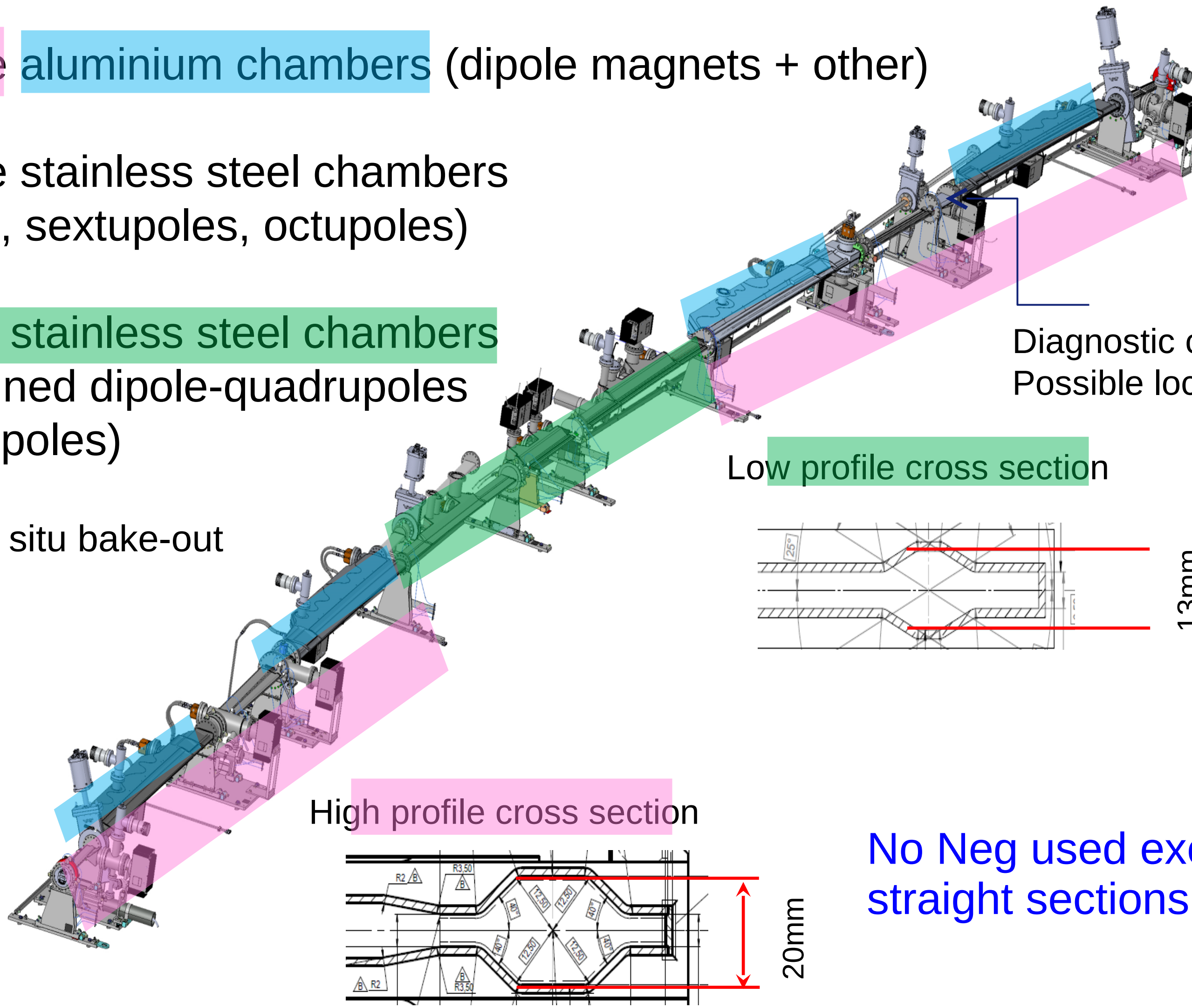


Courtesy J. Chavanne, G. Lebec IDM group

EBS vacuum layout

Three main families of vacuum chambers:

- High profile aluminium chambers (dipole magnets + other)
- High profile stainless steel chambers (quadrupoles, sextupoles, octupoles)
- Low profile stainless steel chambers (inside combined dipole-quadrupoles & HG quadrupoles)



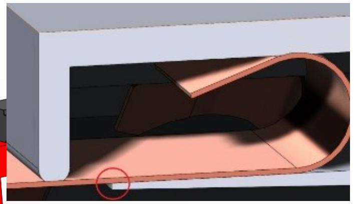
No Neg used except in straight sections.

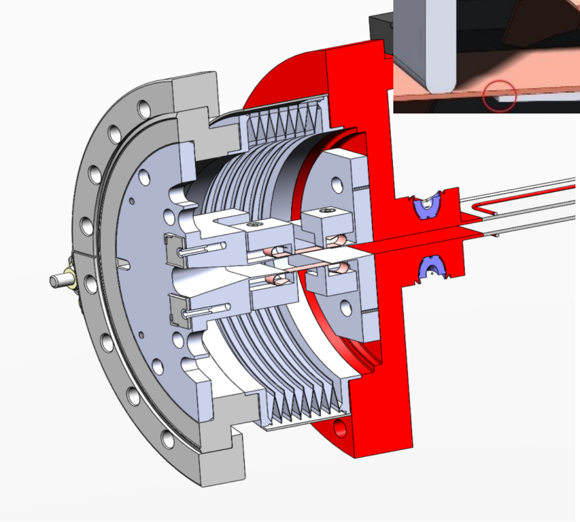
RF fingers

Globally, the vacuum system is conservative even if difficult to produce due to the small dimension of the magnets opening.

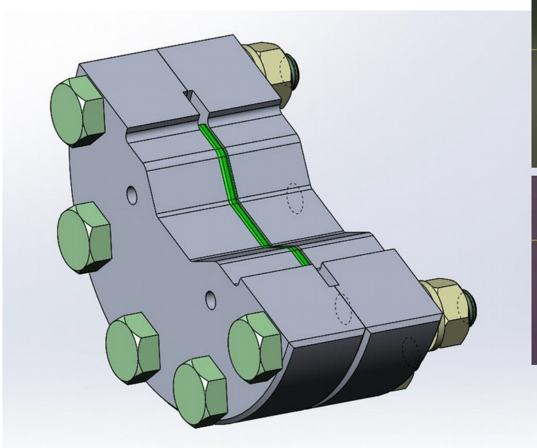
- New in-house design of RF fingers for improved coupling impedance and reliability. Patented last year, first batches delivered.
- T shape aluminum gaskets to improve profile smoothness in flanges and coupling impedance.

Blade contact

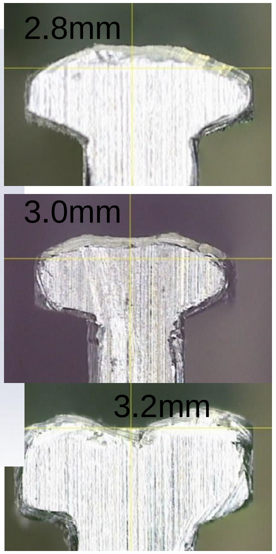




RF finger



T shape gasket



Courtesy T. Brochard, S. White

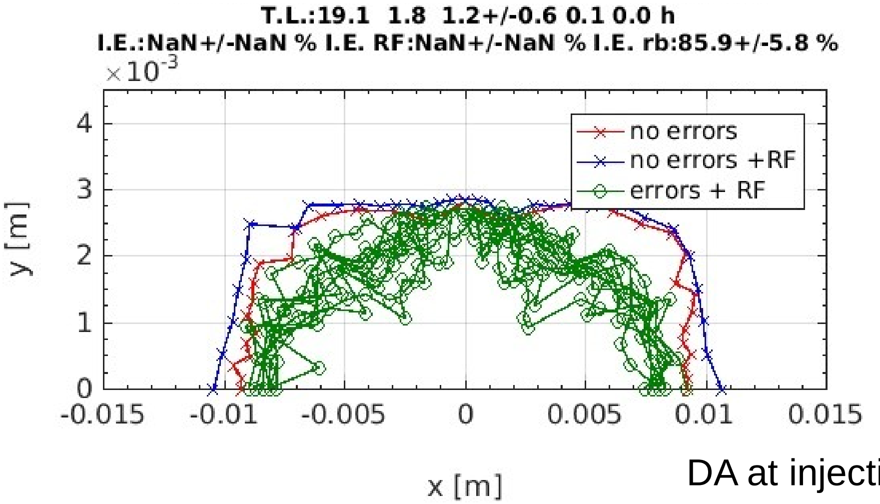
EBS constrains and resulting lattice: Lattice Parameters

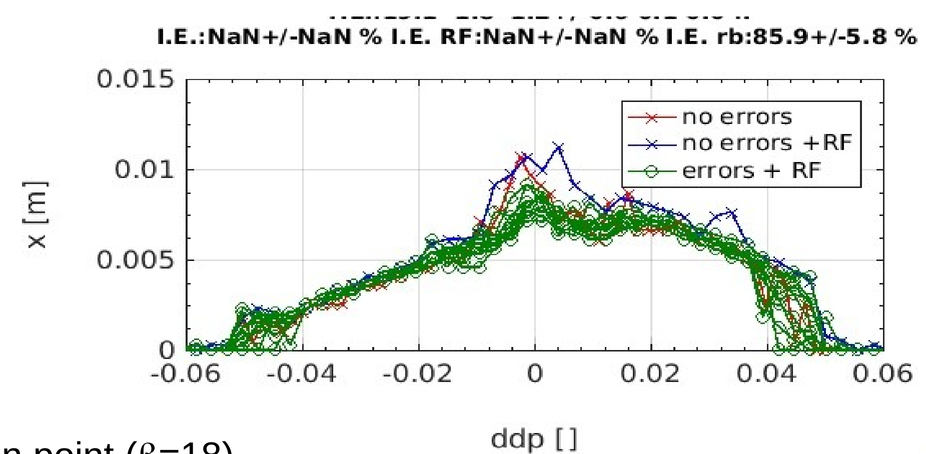
	Now	EBS
Energy (GeV)	6.04	6
Multibunch current (mA)	200	200
Circumference (m)	844.39	843.98
Horizontal emittance (nm.rad)	4	0.133
Vertical emittance (pm.rad)	4	5
Multibunch lifetime (h@200mA)	64	21
Zero current bunch length (ps)	14	10

Gain of a factor 30

Dynamical aperture allows traditional 4 kicker bump injection

Courtesy S.Liuzzo

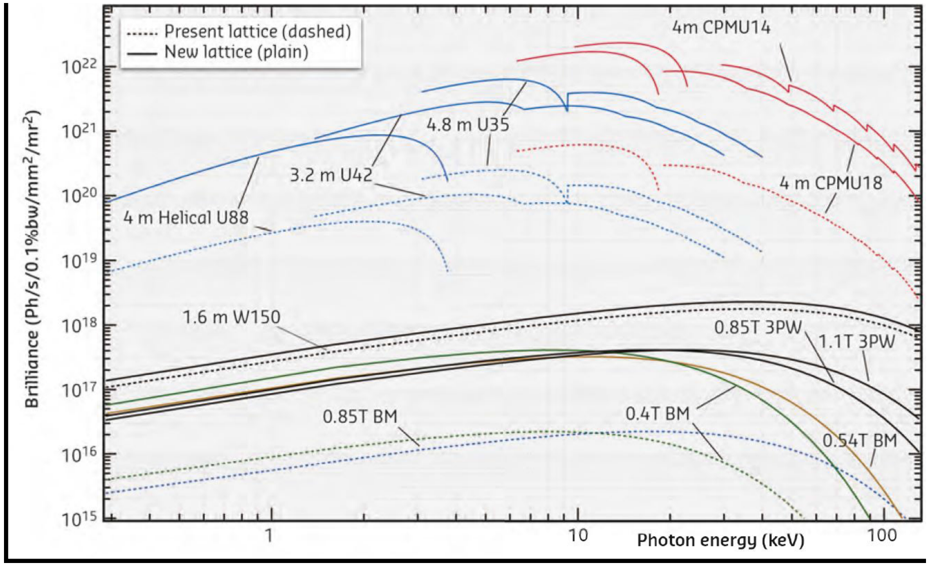


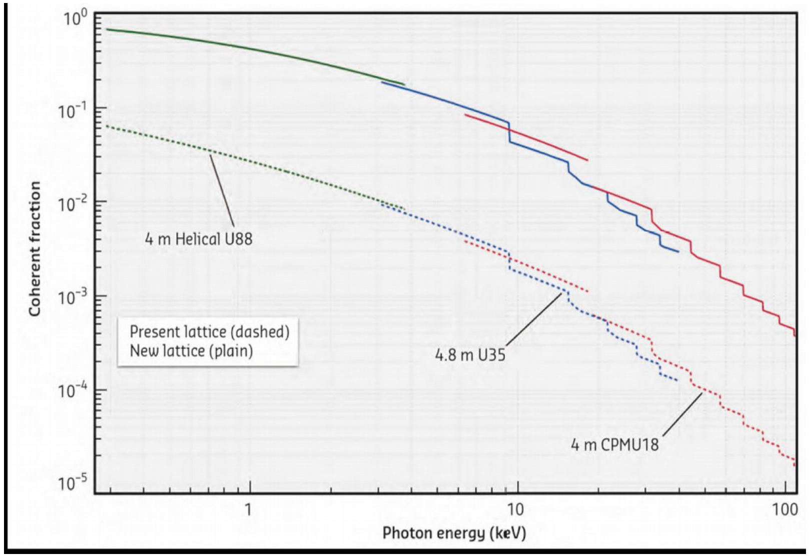


DA at injection point (β=18)

Photon sources: undulators

Present undulators will be re-used and continuous refurbishment program will go on.



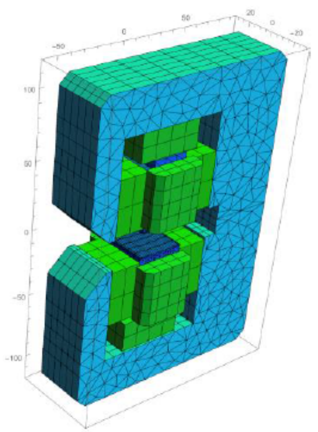


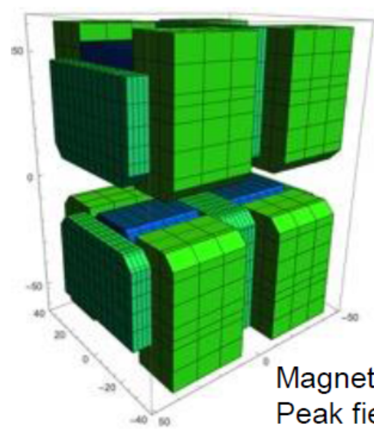
- For a 4m CPMU of 18mm period brilliance and coherence enhanced by a factor ~20 for 10KeV photons.
- Users benefit not only from an increased brilliance but also from increased coherence due to smaller source size.

Courtesy J.Chavanne

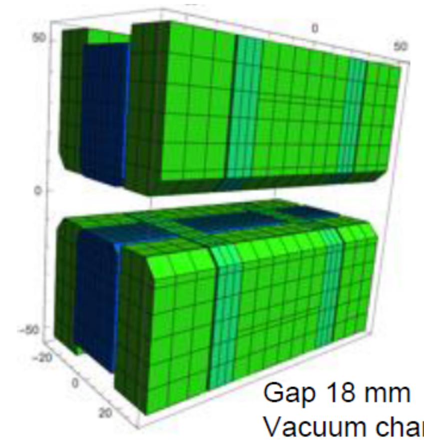
Photon sources: BM beamlines

Bending magnets sources are displaced and weaker (weaker dipoles) for EBS. Dedicated magnets are added next to central DQ to feed all present BM beamlines with increased photon flux:

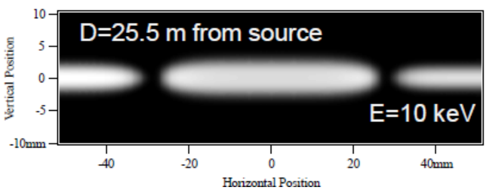


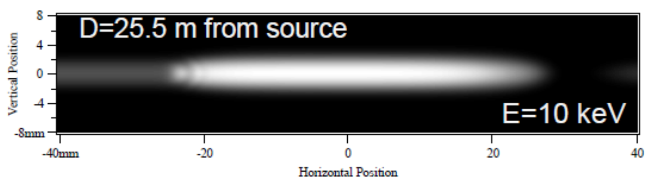


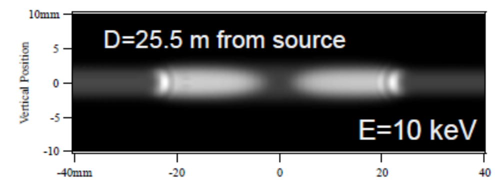
Magnetic gap 18 mm
Peak field: 0.86 T
Magnetic length: 99.1 mm



Gap 18 mm
Vacuum chamber: 16 mm
Magnetic length 110 mm







Short bend of 2.1mrad.Smallest spot size with less background noise. Deflecting angle to be compensated.

2 pole Wiggler, induces an orbit shift of ~100μm. Highest brilliance reached above 15Kev.

3Pole wiggler: better brilliance than 2PW bellow 15Kev. Less orbit distortion but with a dark spot in the center.

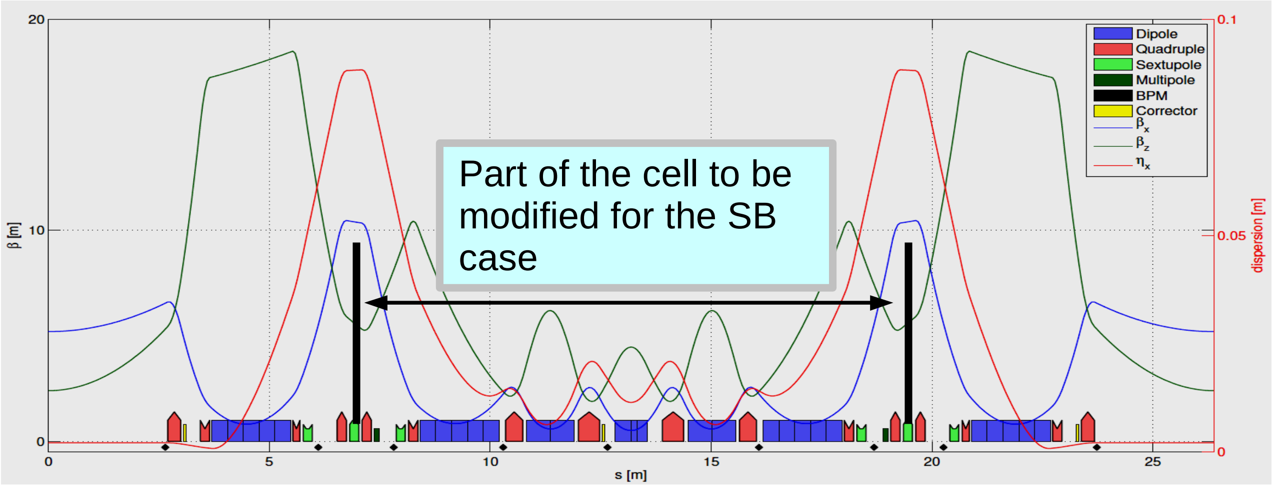
Courtesy J.Chavanne

Photon source: impact on the lattice

Family concept for magnets is abandoned. Because of canting, different bending magnet sources, and specific cells like injection or RF, almost all cells are unique, and each magnet is considered as independent.

Alignment, magnets PS control, tune adjustment, are for example more complicated and symmetry is broken almost at each cell.

Carefully matching dispersion,the phase advance of a cell and the phase advance between sextupoles allows to recover the dynamic aperture of a symmetric machine.



Courtesy S. Liuzzo

Control system

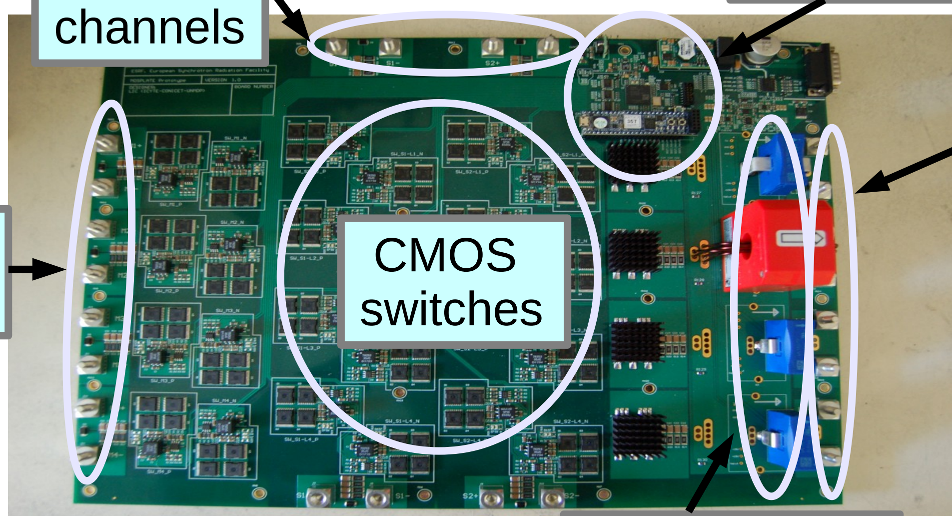
- We will keep the actual TANGO control system for the new machine.
- Writing of devices for the new machine has already started.
- A simulator instance, with an AT structure as input and beam positions, emittance and current as output, is available. It allows to debug devices and higher level applications and to test tools developed for commissioning

View of the EBS orbit correction application tested on the simulator.

Courtesy E. Taurel, S. Liuzzo

Power Supplies

- Magnets are fed with individual power supplies fed by one 360V DC and one 48V DC network.
- Cables for both networks are already installed in technical gallery
- Each cubicle contains 33 power supplies and feeds the 27 magnets of the cell+6 spare channels Spare channels are able to replace a deficient one fast enough to keep the beam in most situations (hot swap).



Hot swap board.
Patented last year.

Courtesy P. Phalaise

RF

RF system consists in 13 single cell HOM damped cavities installed in 3 different straight sections. All cavities are delivered and conditioned.

Cavities are fed by a dual system of klystron and SSA amplifiers, with one SSA amplifier developed in house.

HOM damped single cells cavities

For more details see J. Jacob talk wednsday afternoon

Assembly and Instalation : sequence

Build a mock-up of a full cell including front ends, cable trays etc...

Assembling in house all dipoles

Today

Assemble all girders (magnets+vacuum chamber+connection boxes) and store them on site.

12/2018

Remove old machine from tunnel.

Installation in the tunel

01/2020

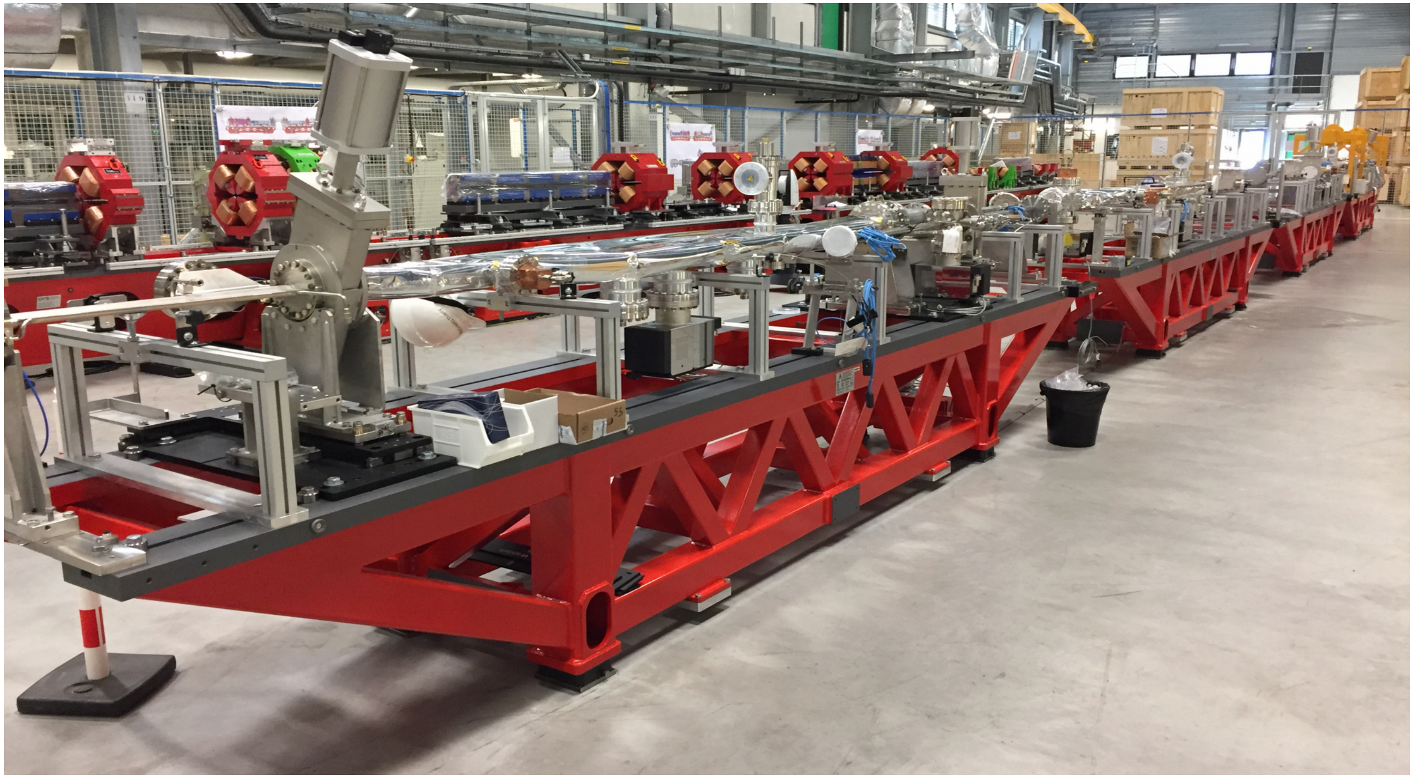
Commissioning

08/2020

USM starts

~20 month of shut-down+commissioning

Mock-up



Magnets are mounted on girders

In parallel, vaccum assembly for each girder is prepared on specific tables.

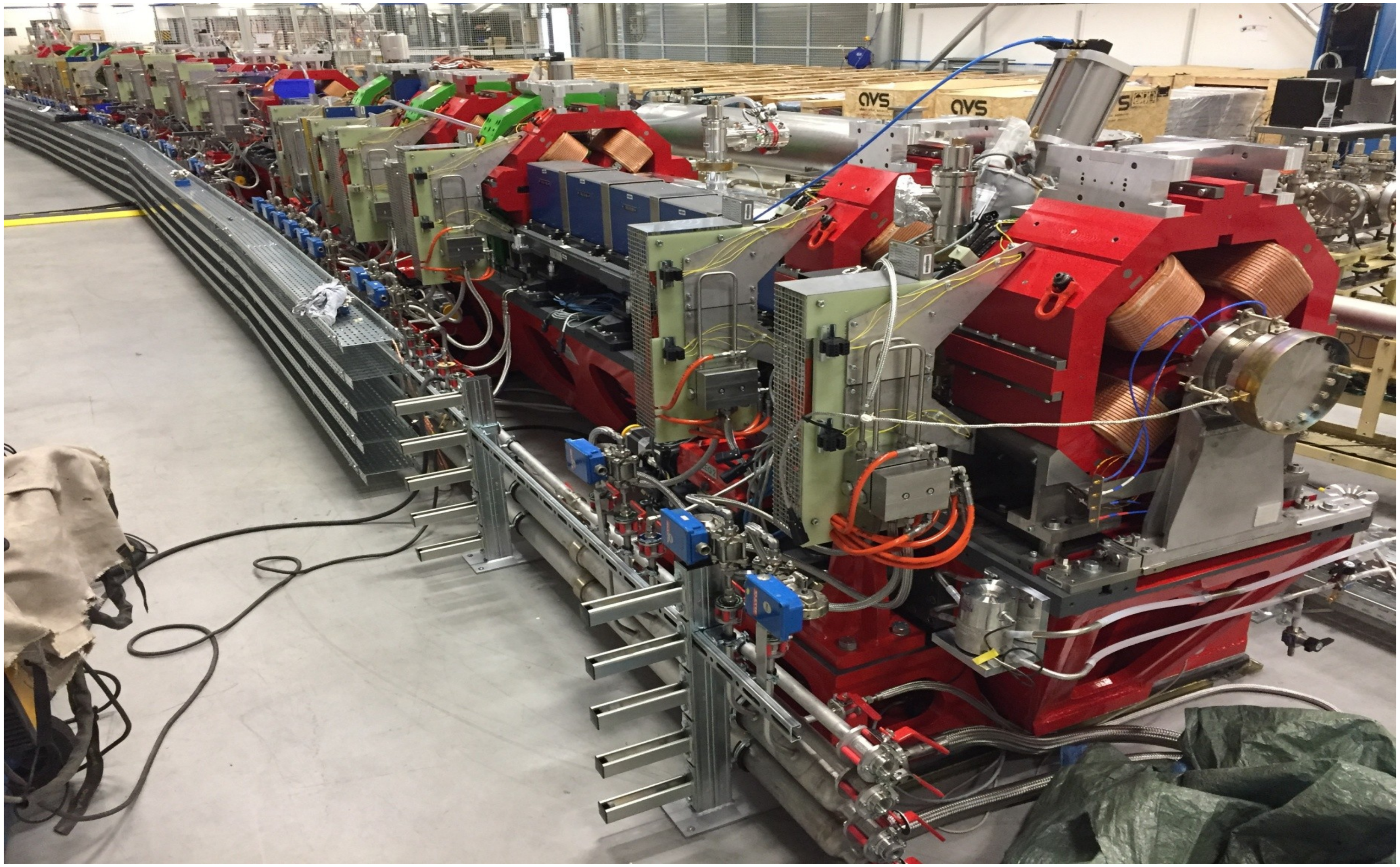
Courtesy L. Eybert

Mock-up

Magnets are opened and the vacuum chamber assembly is mounted on the girder.

Special tooling has been produced to manipulate vacuum chamber.

Mock-up



Full cell mounted with front end, cable trays, cooling pipes, and magnet connection boxes. Assembling sequence of girders finalised during the mock-up assembly.

In-house dipole assembly

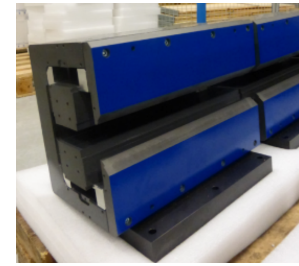
Each dipole based on 5 PM modules.

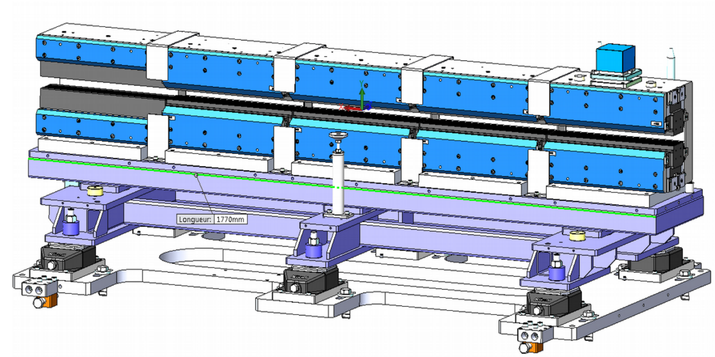
Each module mounted and measured in house.

Modules mounted on support plates and magnet support

Final dipole measured and fiducialised in-house.

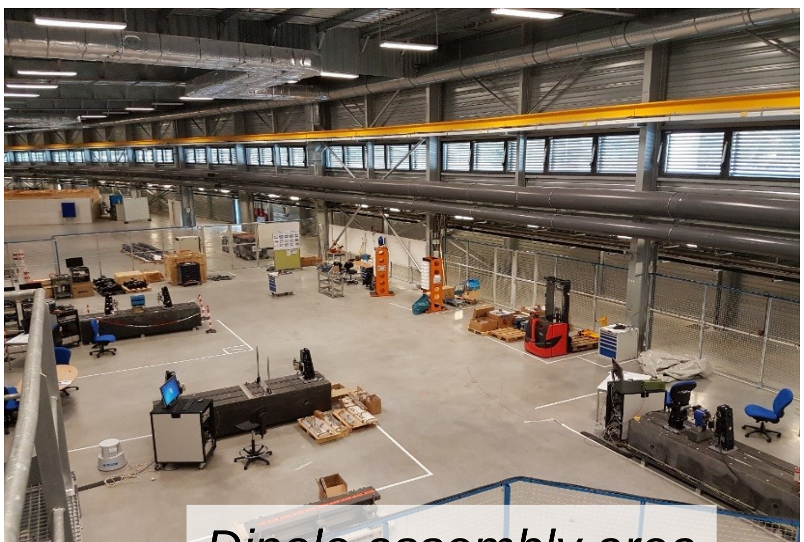
PM assembly tool





Around 6000kg of PM, 660 Iron modules,

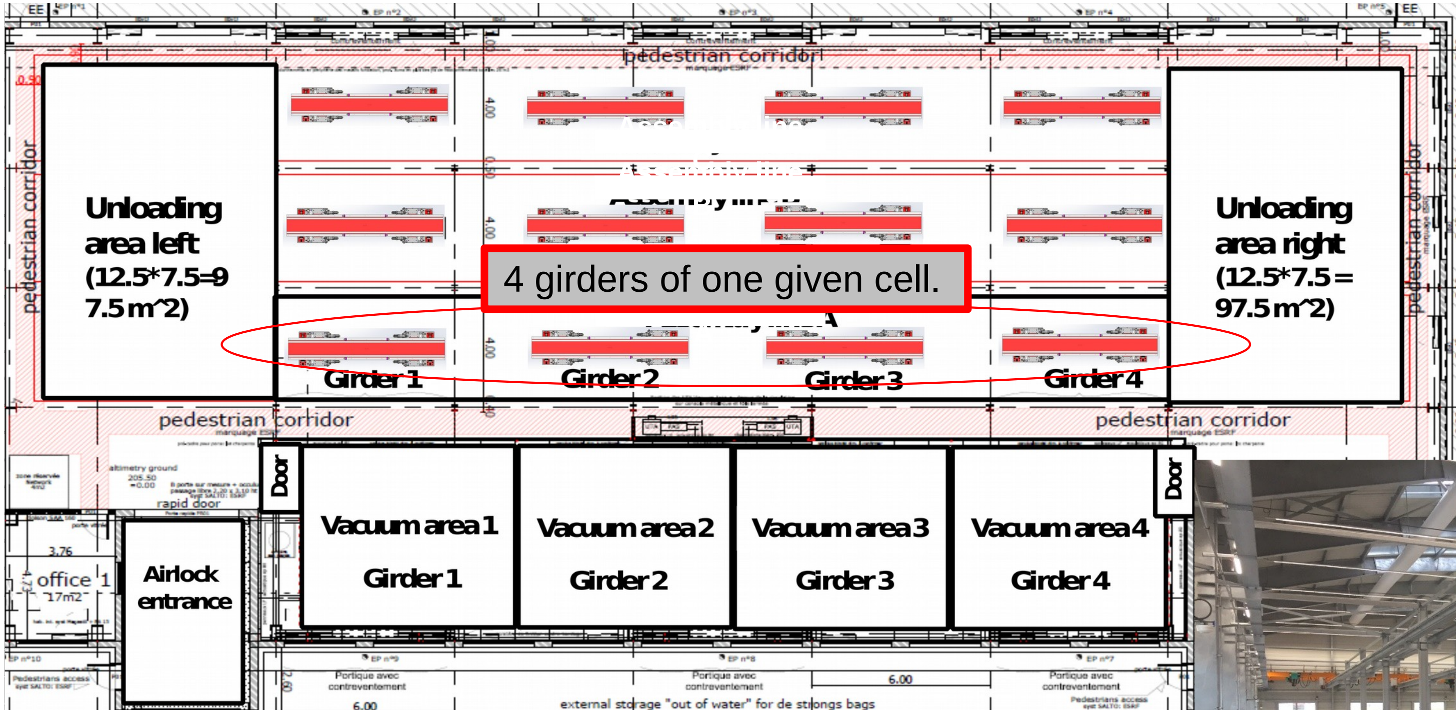
All of the 128 magnets already assembled



Dipole assembly area

Courtesy IDM group

Assembly Building



- New assembly building delivered in fall 2017. Three cells can be worked on in parallel.
- "clean area" for vacuum chamber assembly.

Serial production of girders started beginning of 2018. 9 girders finalized, production of 3 girders per week expected from now on.

Assembly

- For a typical girder, the mounting sequence includes ~130 steps, concerns 4 different groups and requires ~100 pieces of hardware ready for mounting.
- Almost each girder is unique due to diagnostic, canting, injection cells, RF etc...
- Girders production and hardware delivery occur in parallel with almost no margin between delivery and installation for some critical parts.

⇩

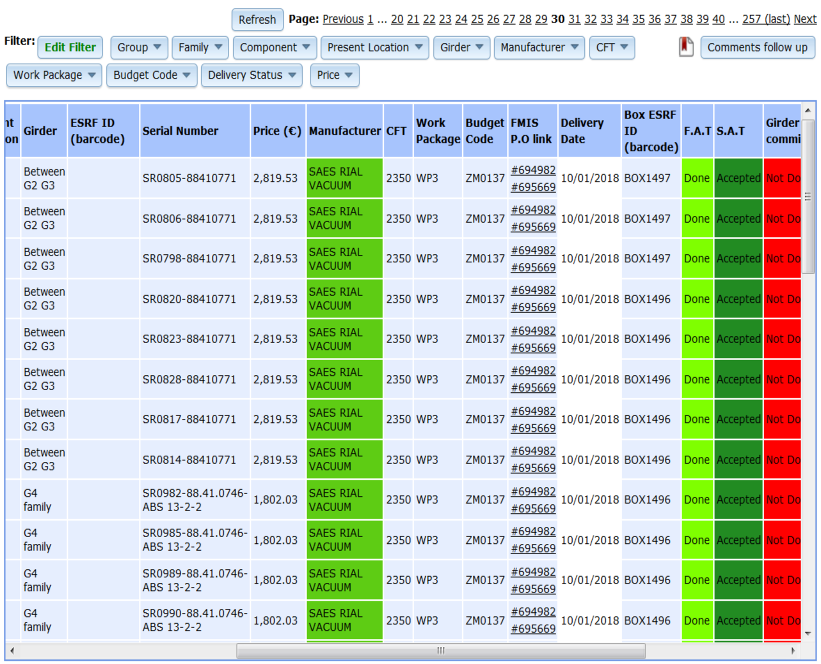
Logistic must be carefully organized in order to:

- Anticipate hardware availability.
- Coordinate the work of the different groups.
- Keep track of hardware once installed and monitor advancement and critical situations.

Assembly: Logistic management

Two interacting databases are used for the supervision:

Low level database for stocks management.


Refresh **Page:** Previous 1 ... 20 21 22 23 24 25 26 27 28 29 **30** 31 32 33 34 35 36 37 38 39 40 ... 257 (last) Next

Filter: Edit Filter | Group | Family | Component | Present Location | Girder | Manufacturer | CFT | Comments follow up | Work Package | Budget Code | Delivery Status | Price

nt on	Girder	ESRF ID (barcode)	Serial Number	Price (€)	Manufacturer	CFT	Work Package	Budget Code	FMIS P.O link	Delivery Date	Box ESRF ID (barcode)	F.A.T	S.A.T	Girder commi
	Between G2 G3		SR0805-88410771	2,819.53	SAES RIAL VACUUM	2350	WP3	ZM0137	#694982 #695669	10/01/2018	BOX1497	Done	Accepted	Not Do
	Between G2 G3		SR0806-88410771	2,819.53	SAES RIAL VACUUM	2350	WP3	ZM0137	#694982 #695669	10/01/2018	BOX1497	Done	Accepted	Not Do
	Between G2 G3		SR0798-88410771	2,819.53	SAES RIAL VACUUM	2350	WP3	ZM0137	#694982 #695669	10/01/2018	BOX1497	Done	Accepted	Not Do
	Between G2 G3		SR0820-88410771	2,819.53	SAES RIAL VACUUM	2350	WP3	ZM0137	#694982 #695669	10/01/2018	BOX1496	Done	Accepted	Not Do
	Between G2 G3		SR0823-88410771	2,819.53	SAES RIAL VACUUM	2350	WP3	ZM0137	#694982 #695669	10/01/2018	BOX1496	Done	Accepted	Not Do
	Between G2 G3		SR0828-88410771	2,819.53	SAES RIAL VACUUM	2350	WP3	ZM0137	#694982 #695669	10/01/2018	BOX1496	Done	Accepted	Not Do
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	G4 family		SR0985-88.41.0746-ABS 13-2-2	1,802.03	SAES RIAL VACUUM	2350	WP3	ZM0137	#694982 #695669	10/01/2018	BOX1496	Done	Accepted	Not Do
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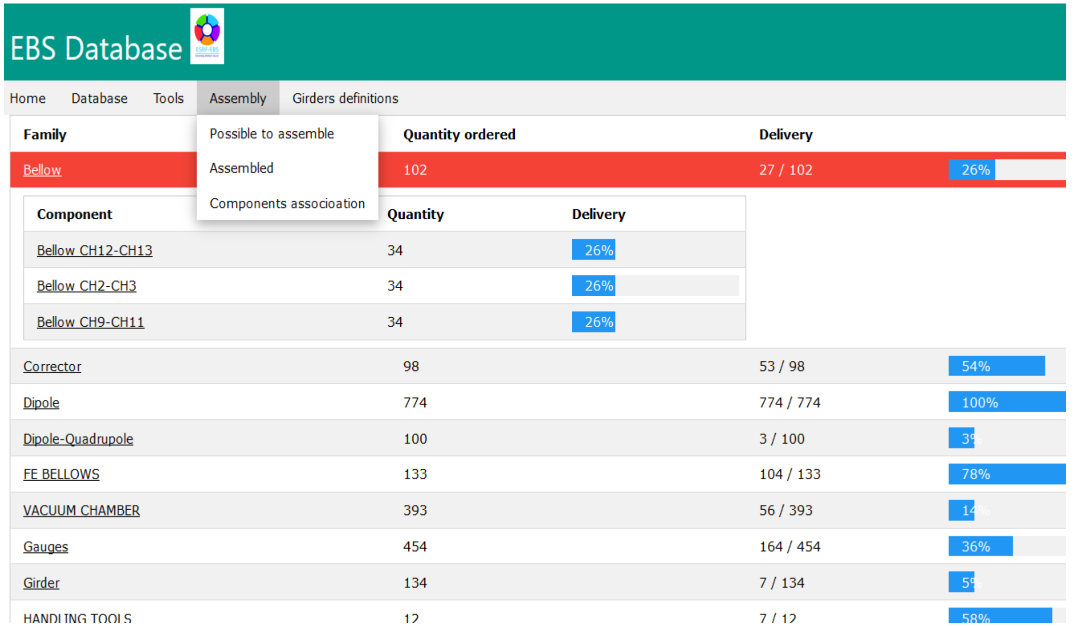
	G4 family		SR0990-88.41.0746-ABS 13-2-2	1,802.03	SAES RIAL VACUUM	2350	WP3	ZM0137	#694982 #695669	10/01/2018	BOX1496	Done	Accepted	Not Do

Higher level database used to monitor girder advancement, request hardware for next girders, monitoring of available stocks for a given girder, coordination of different tasks etc...


EBS Database

Home | Database | Tools | Assembly | Girders definitions

Possible to assemble
Assembled
Components associoation

Family	Quantity ordered	Delivery	
Bellow	102	27 / 102	26%

Component	Quantity	Delivery
Bellow CH12-CH13	34	26%
Bellow CH2-CH3	34	26%
Bellow CH9-CH11	34	26%

Family	Quantity ordered	Delivery	
Corrector	98	53 / 98	54%
Dipole	774	774 / 774	100%
Dipole-Quadrupole	100	3 / 100	3%
FE BELLOWS	133	104 / 133	78%
VACUUM CHAMBER	393	56 / 393	14%
Gauges	454	164 / 454	36%
Girder	134	7 / 134	5%
HANDLING TOOLS	12	7 / 12	58%

Courtesy T. Brochard, L. hardy, G. Chazot, J.C. Biasci

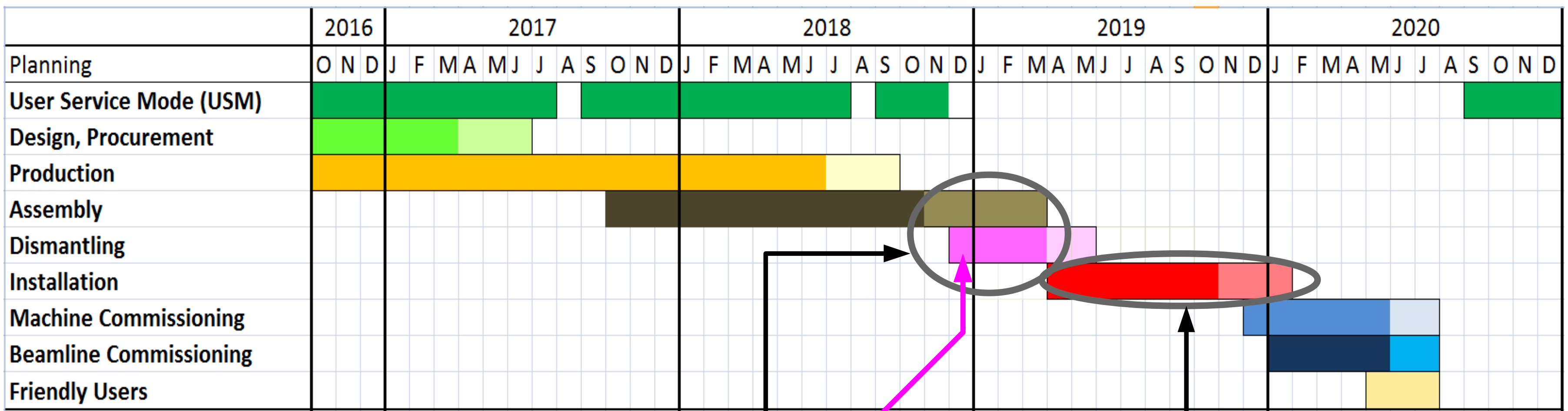
Assembly: Issues

Problems:		Mitigation:
Dedicated tool for girder handling is malfunctioning.	→	Organize transport by truck.
Missing storage area for girders.	→	“Last minute” light building constructed to store girders.
Alignment of girders more difficult than expected (time consuming).	→	Included in updated planning
Fiducialisation of magnets at company was outside tolerances.	→	Fiducialisation done in-house, possible as magnet group is ahead of planning on other posts.
BPM buttons leaking.	→	Change of stainless steel for better material quality. Imaging method to revel defects before vacuum test.
Vacuum assembly faster than foreseen but some chambers may not be available in time because of delays on delivery.	→	Careful monitoring of VC contracts and delivery date. Planning customization

Assembly conclusion

- Mock-up of a full cell allowed to validate and refine mounting procedures.
- Assembly of girders has reached its nominal rate of production of three girders per week.
- Delivery of hardware is progressing well, 90% of the magnets, 70% of magnet supports, 100% of RF cavities, 25% of vacuum chambers, absorbers and front end parts delivery is also in line with planning.
- We are facing a few problems, mainly about logistics, but not severe enough to require major changes in planning or budget.

Installation



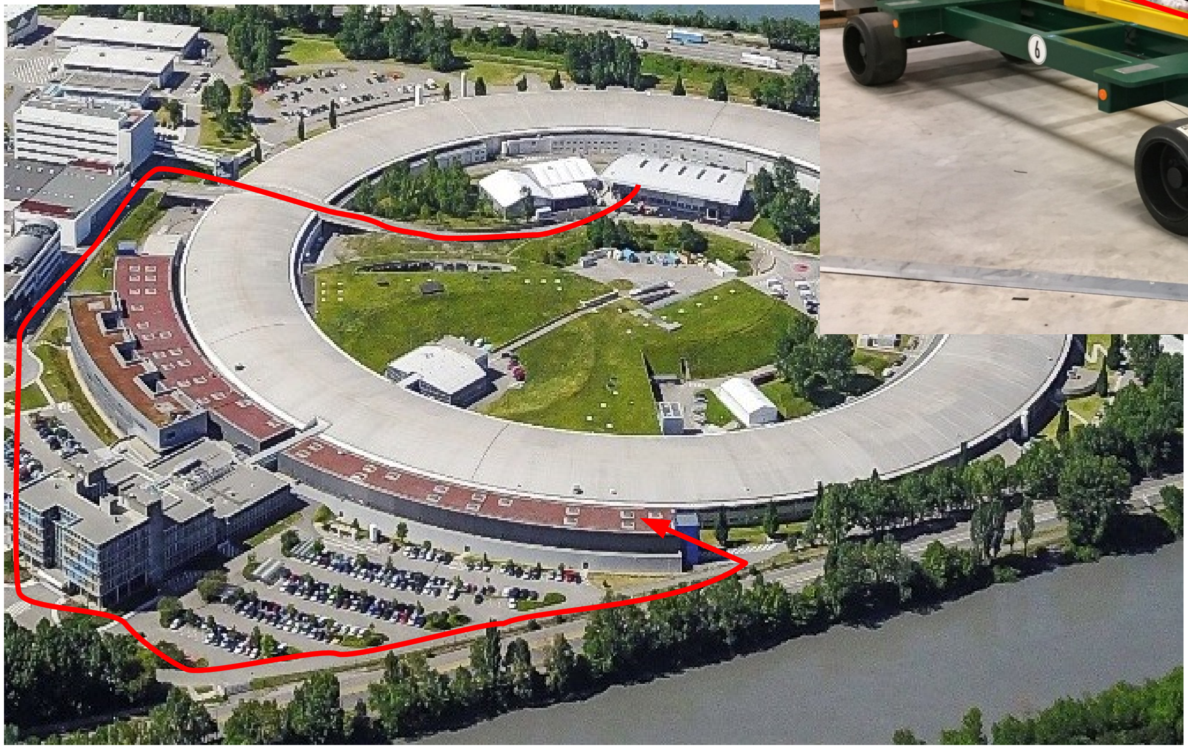
Installation phase should start when all girders are assembled but overlapping is foreseen in case of delay for assembly.

New girders installation in the tunnel including preliminary civil work in the tunnel. Can start slightly before end of dismantling.

Installation starts by dismantling the present machine.

Installation: assembled girder moved to storage area.

Trolley used to move girders inside buildings and inside the tunnel
2 are used but do not fulfil specification. 2 more to be delivered

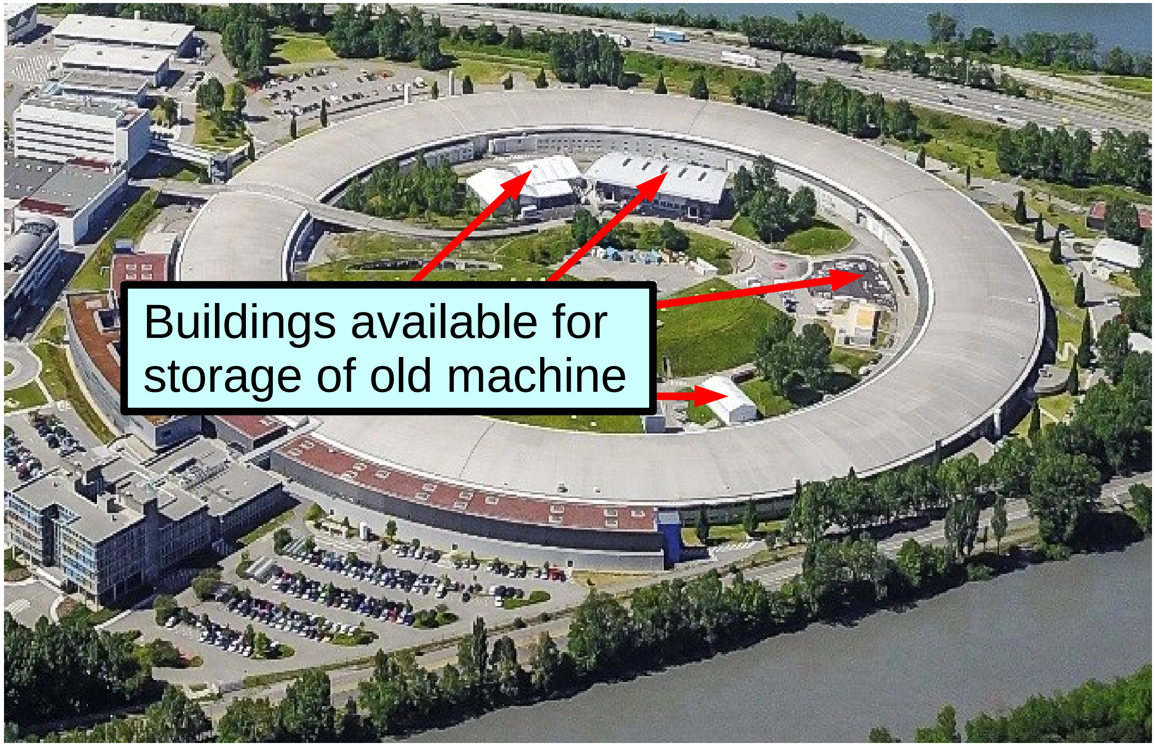


To be moved outside buildings the girders are loaded on a truck trailer.

Installation:Dismantling of old machine.

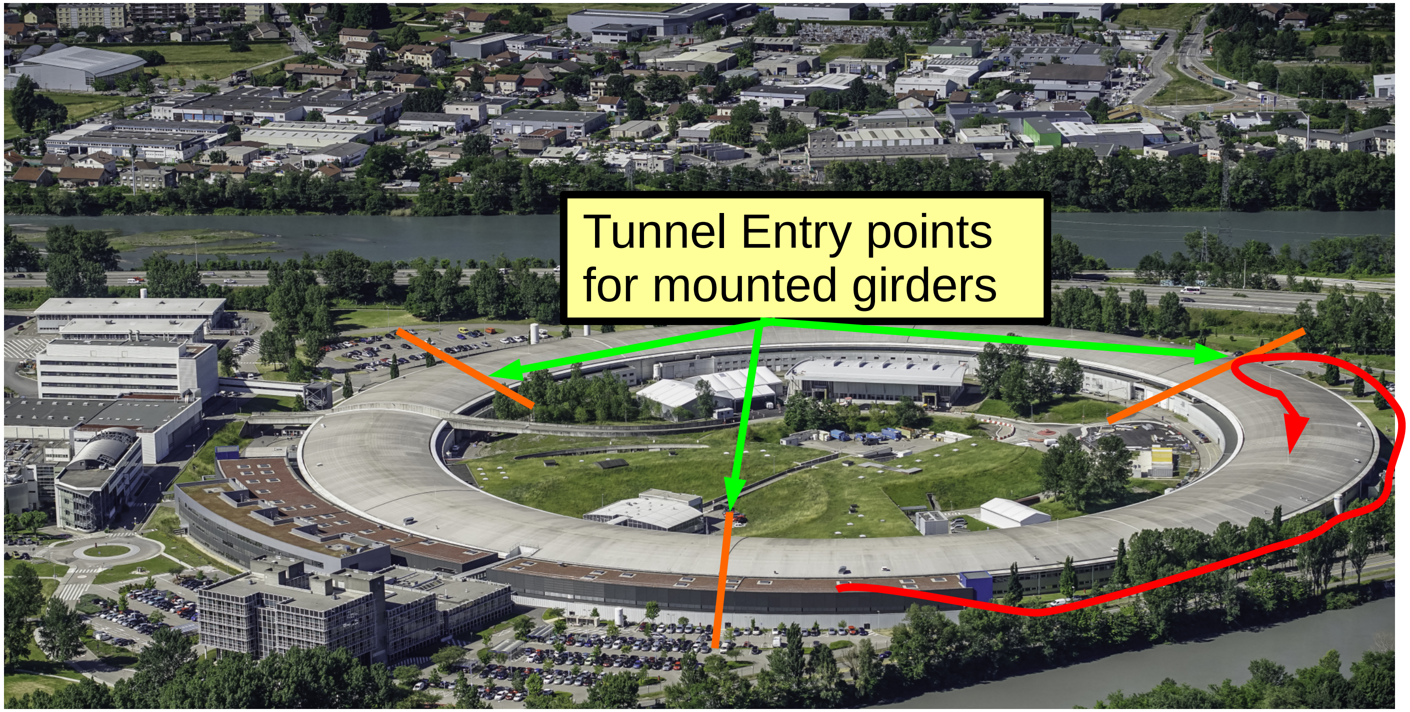
- Except from straight sections VC and Undulators,almost no parts are to be recovered. A “savage “ dismantling is possible, cables included.
- All parts must be stored on site and checked by radio-protection in order to be considered as non activated waste (spreads over 6 years).
- Tunnel emptied by opening the roof and using experimental hall cranes.

Old machine radio protection checks foreseen in the assembly building. If assembly is delayed, other buildings are available for temporary storage.



Installation: preparing cells and bringing new girders in the tunnel

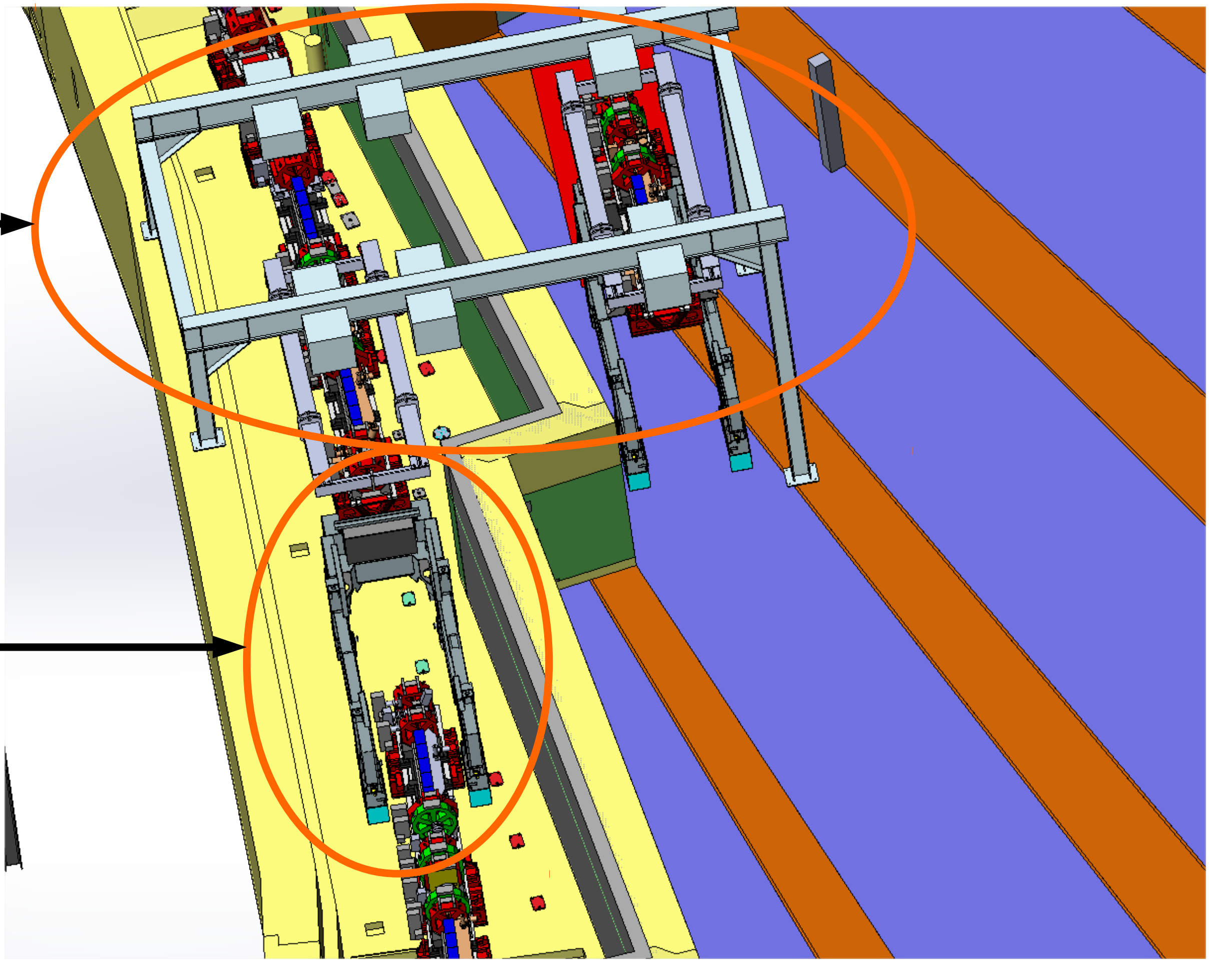
- Once empty, civil work takes place in the tunnel to prepare for the future layout of girders.
- Girders of EBS weight ~12-13 Tonnes, and cannot be handled by existing cranes. Three gantries are foreseen (still to be produced) to pass girders over the tunnel wall at three entry points.
- The girders are then moved in the tunnel using the trolley and connected to each other.



Installation: Tooling View

Fixed gantry used to enter mounted girders in the tunnel

Trolley used to move girders inside the tunnel

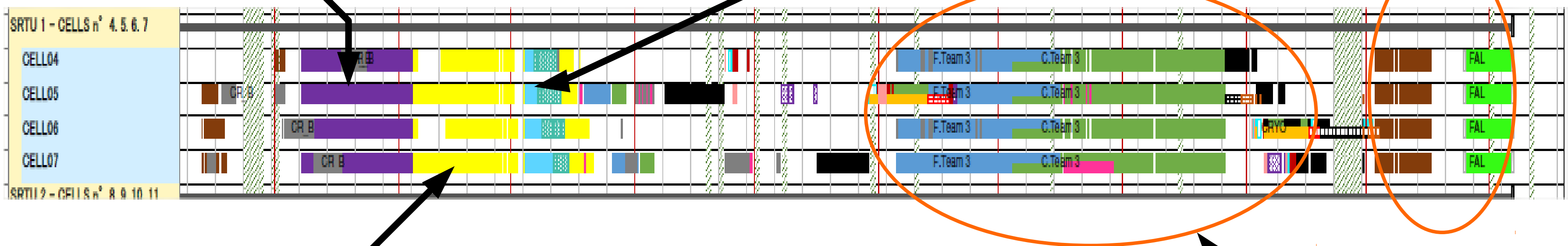


Courtesy P. Renaud

Dismounting sequence governed by crane availability. (4 weeks)

Girders installation Sequence governed by RF activities. (2 weeks)

System tests and final alignment



Civil work in tunnel (3 weeks)

Front end installation, straight section and ID's, cabling, backing.
(12 weeks)

Courtesy P. Renaud

Commissioning

Allocated time: 3 months

Start: Monday December 2nd, 2020

End: Sunday March 1st, 2020

Best case scenario: risk mitigation and alternative scenarios not available now.
All dates are of course provisional, due to the number of unpredictable events which may occur.
We anticipate 3 phases:

- 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

Morning and afternoon shifts are scheduled for interventions and tuning, the night shift will be vacuum conditioning.

2 shutdowns are scheduled in that period for heavy interventions

To ease commissioning, the machine will be started without bending magnet sources.

Courtesy P. Raimondi

Conclusion

- The EBS project has entered its construction phase and no major problems have been encountered for now.
- Assembly process for a full standard cell has been validated and refined during the mock-up assembly.
- New buildings needed for storage and assembly are delivered.
- Delivery of all main components is within schedule and assembly of girders is now entering the production phase.
- Assembling, dismounting and installing the machine before January 2020 is challenging. Buffer is foreseen in case of overlapping tasks, but resources have to be allocated to this contingency
- Detailed commissioning planning is under preparation. Tool for the commissioning are already developed and can be debugged on a simulator.


MANY THANKS FOR YOUR ATTENTION