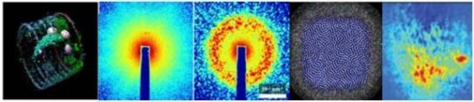
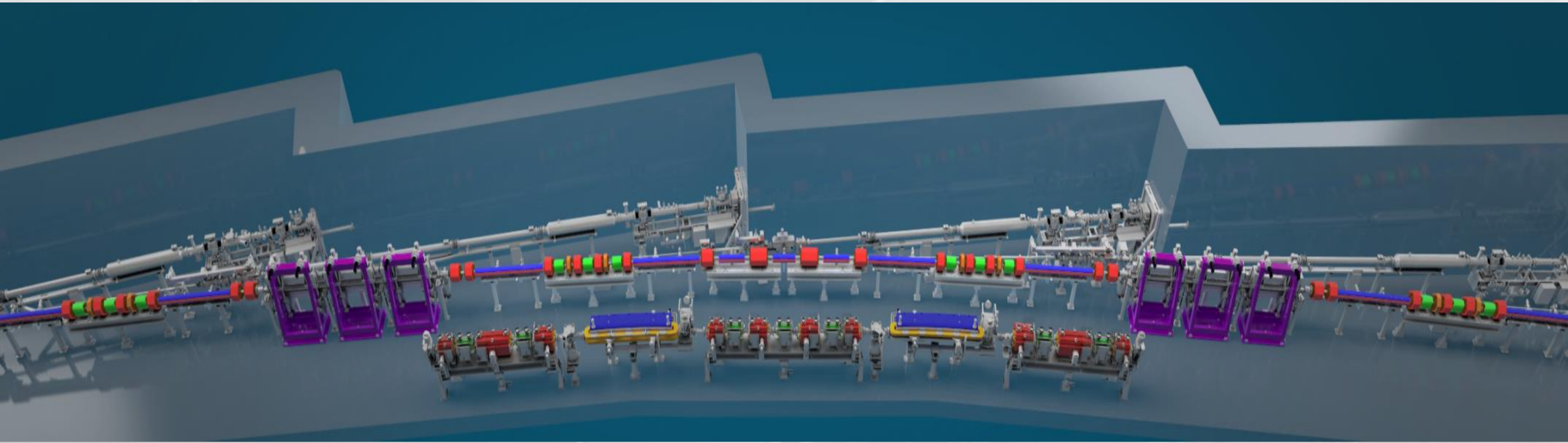


Workshop on Diffraction Limited Storage Rings

9-11 December, 2013

SLAC National Accelerator Laboratory Menlo Park, CA



System Integration and implementation

Jean-Luc Revol, JC Biasci, M Hahn

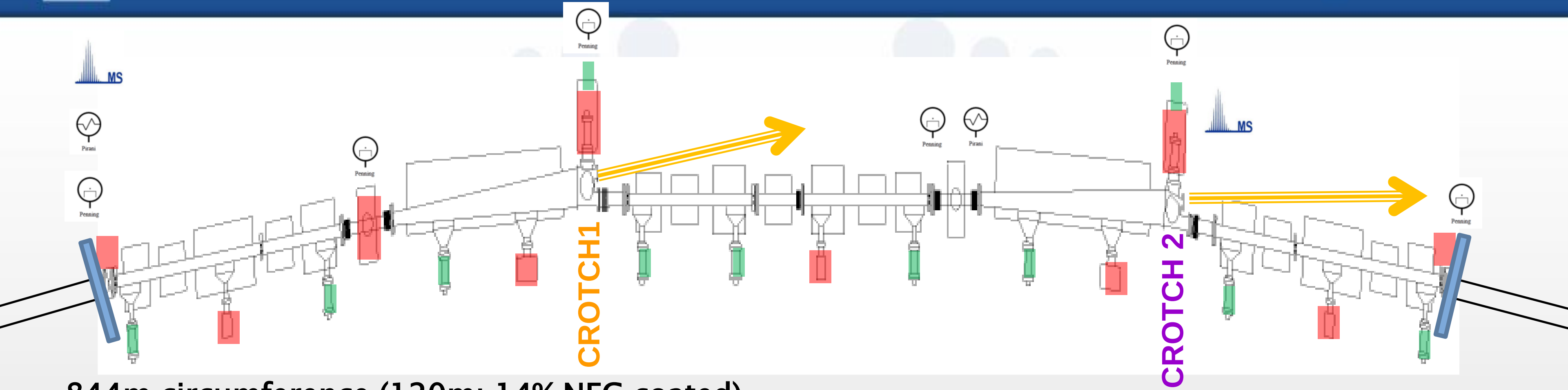
On behalf of the Accelerator Programme Phase II Team

European Synchrotron Radiation Facility

Lattice re-implementation should take in account:

- Expertise gained with the present machine
- Lattice design
- Implementation constraints
- Installation process
- Commissioning & operation aspects
- Maintainability

Vacuum chamber design ➔ Expertise



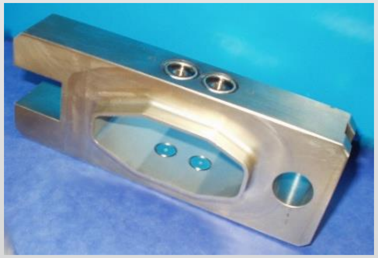
844m circumference (120m; 14% NEG coated)

Bakeable stainless steel 316LN standard cell

Gate valves upstream and downstream each ID section

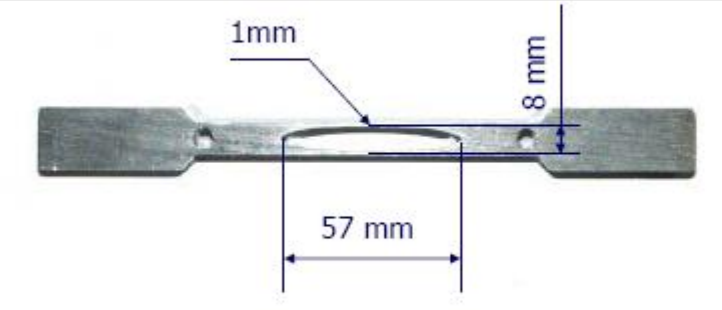
11 NEG pumps (in green)

10 sputter ion pumps (in red)



5 m & 6m

ID chambers NEG coated



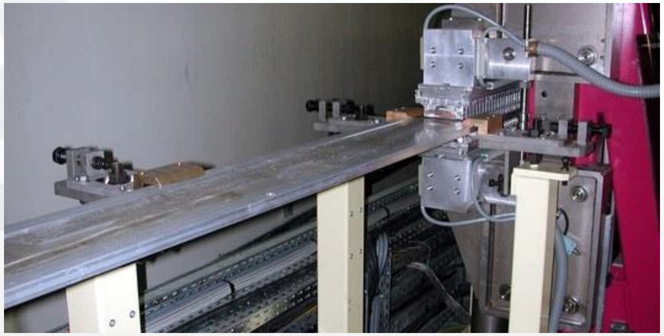
15 Chambers with large conductance
& <u>in situ baking system</u>

➔ **large number eases construction and interventions**

9 RF fingers

➔ **eases longitudinal motion during bake out and transverse motion for alignment**

Vacuum chamber design ➔ Expertise



- All ESRF ID vacuum chambers (5 and 6 meters long, aluminum)
  ➔NEG-coated [Ti Zr V, 0.5 to 1 μm]

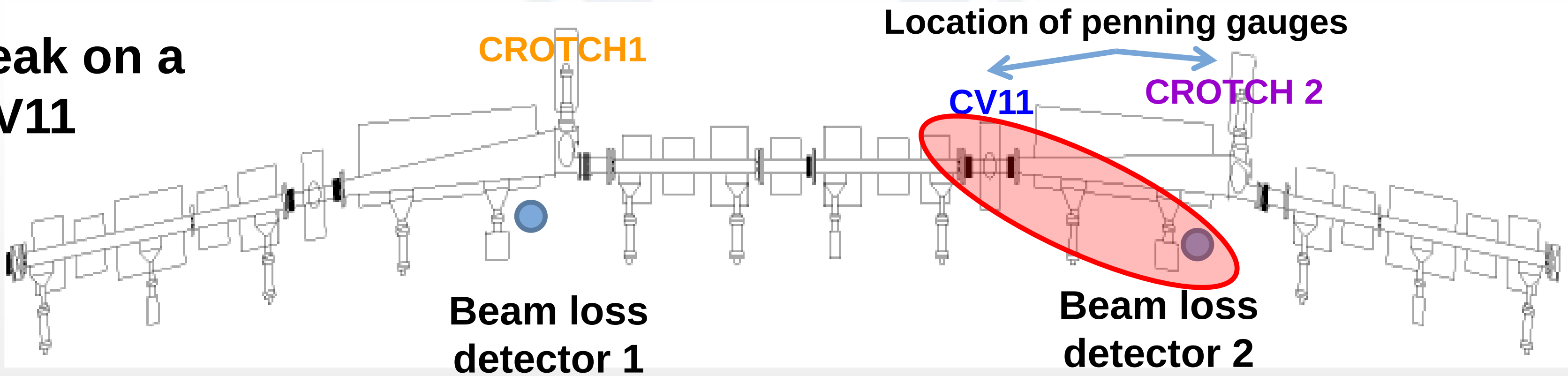
✓ESRF has the knowledge for NEG coating of conductance limited chambers (Al and Stainless Steel)
✓Some R&D necessary for the coating of complicated chambers
✓ESRF has some capacity for the coating of a large number of chambers

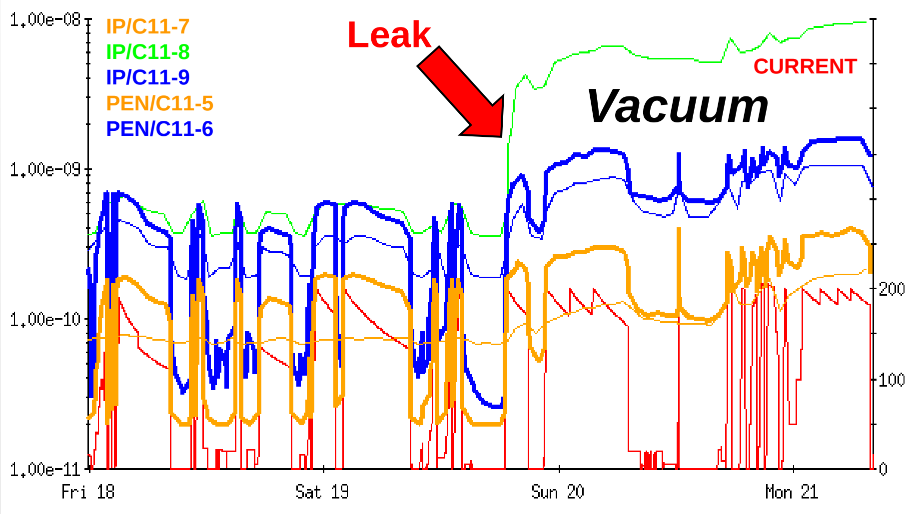
Coating tool 2: 5m chambers and short chambers

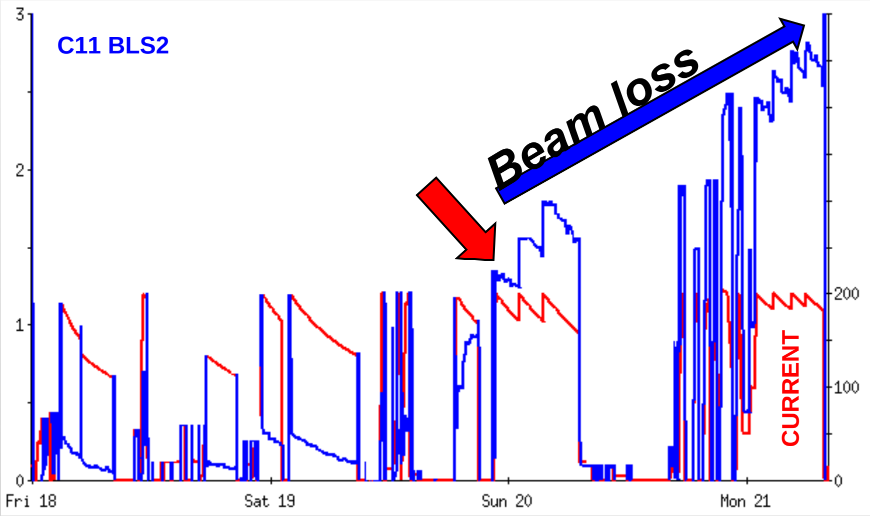
Coating tool 3: constructed in the framework of a collaboration with MaxLab

Vacuum chamber design ➔ Expertise

Leak on a CV11





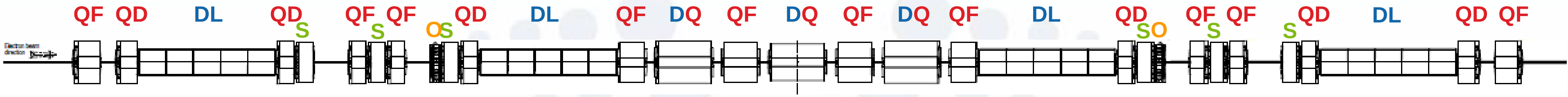


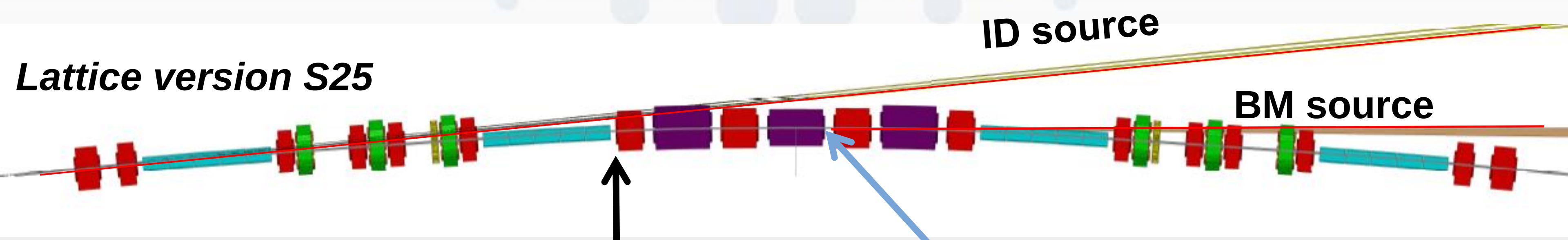
Beam loss often used to detect vacuum leaks at the early stage
➔Advantage: outside the chamber, independent of the conductance

Will be important detectors for low conductance chambers

Courtesy I Leconte

Vacuum chamber design ➔ Constraints

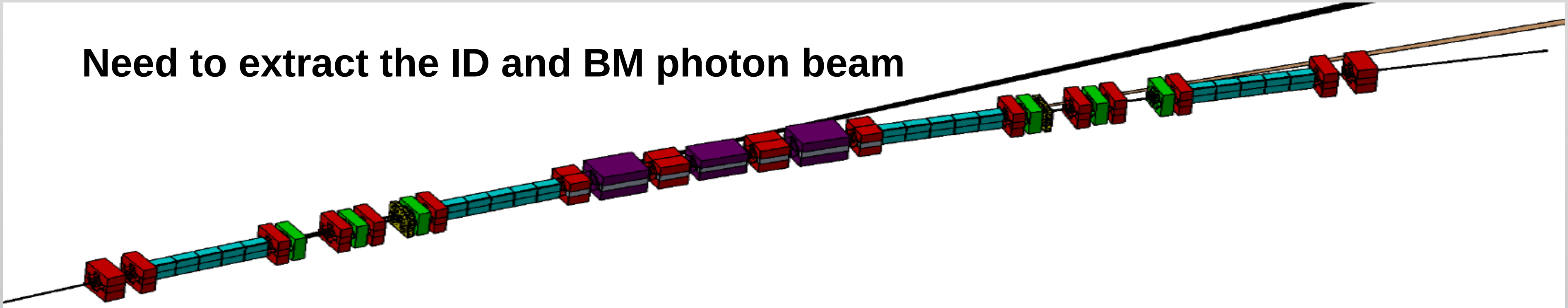




Lattice version S25

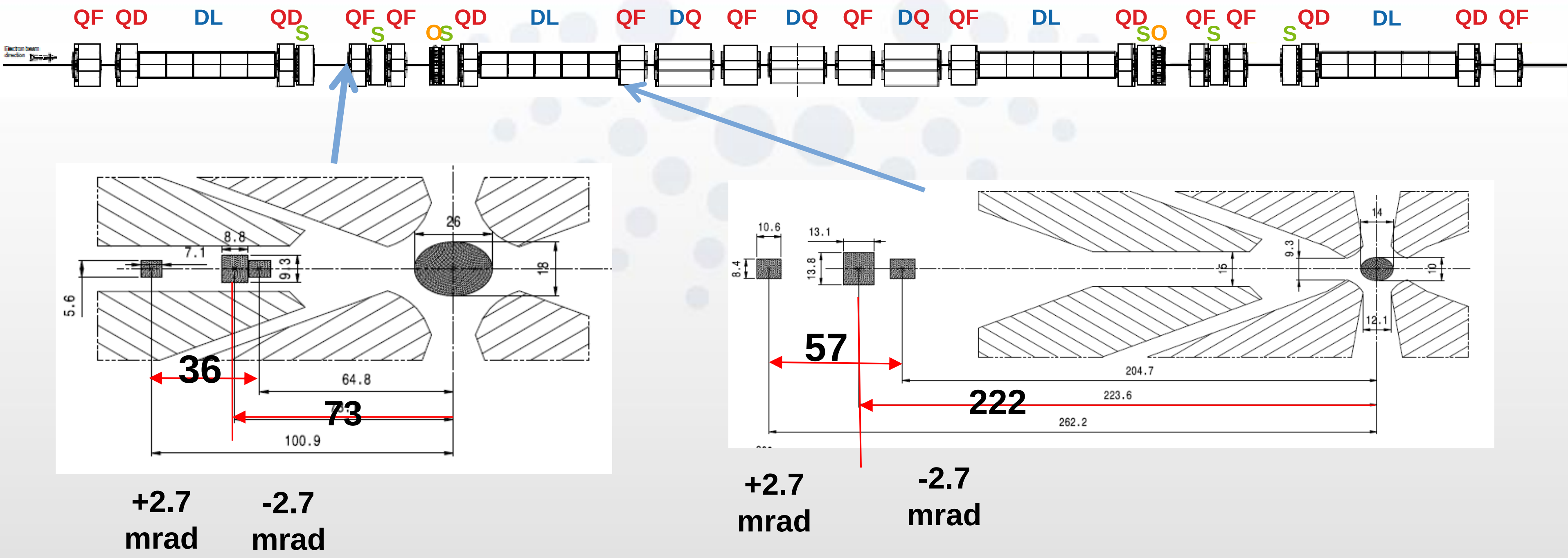
3 pole wiggler in the recent lattice version S28 to be used for the TDS

Only 22 cm between the photon beam [front end] and the electron beam [vacuum vessel] after the second dipole

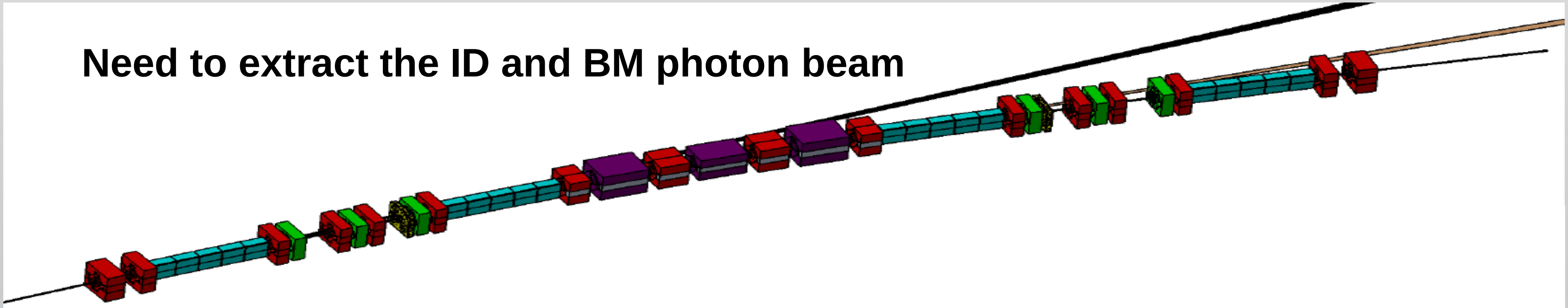


Need to extract the ID and BM photon beam

Vacuum chamber design → Constraints

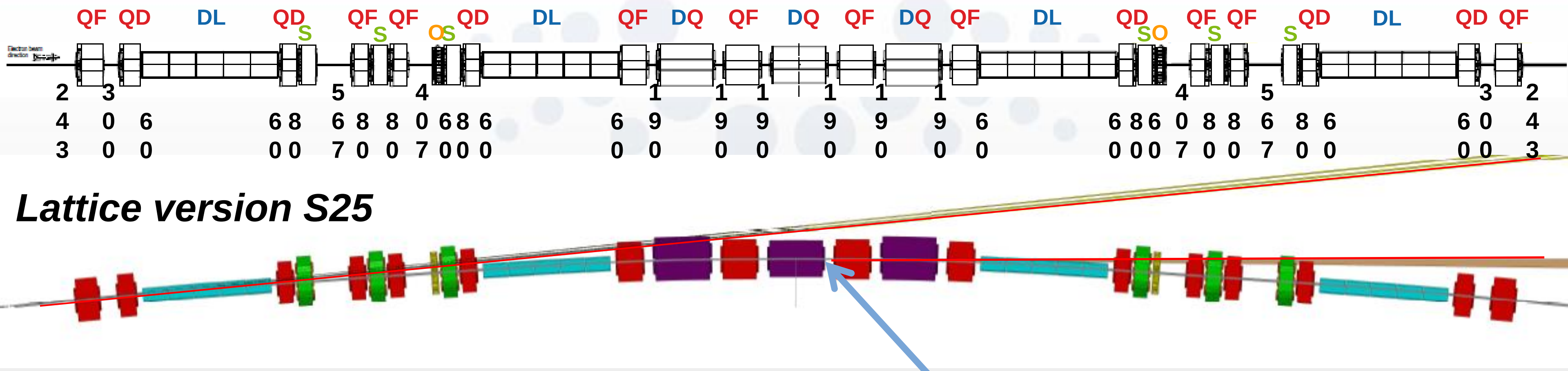


The design should be compatible with the present canted beam line design (max +-2.7 mrad) [3 beamlines today]



Need to extract the ID and BM photon beam

Vacuum chamber design → Lattice design



Lattice version S25

300 mm space created here for the 3 pole wiggler in the recent lattice version S28 to be used for the TDS

5.416 metres of “free space“ outside the 31 magnets and the ID chamber

[S25]
2*567 mm
2*407 mm
2*300 mm
2*243 mm
6*190 mm
8* 80 mm
10* 60 mm

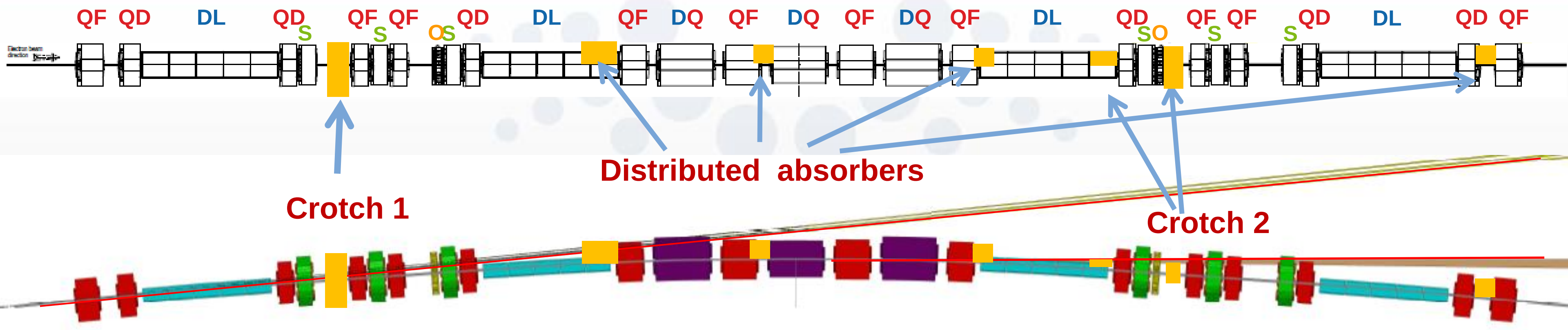
For the rest !

Very compact machine with 32 small and very small portions

(Compared to the present machine 8.4 m distributed over 17 magnets)

[s28]
*2*567 mm*
*2*407 mm*
*4*300 mm*
*2*243 mm*
12 80 mm*
10 60 mm*

Vacuum chamber design → Power absorbers



Crotch 1

Distributed absorbers

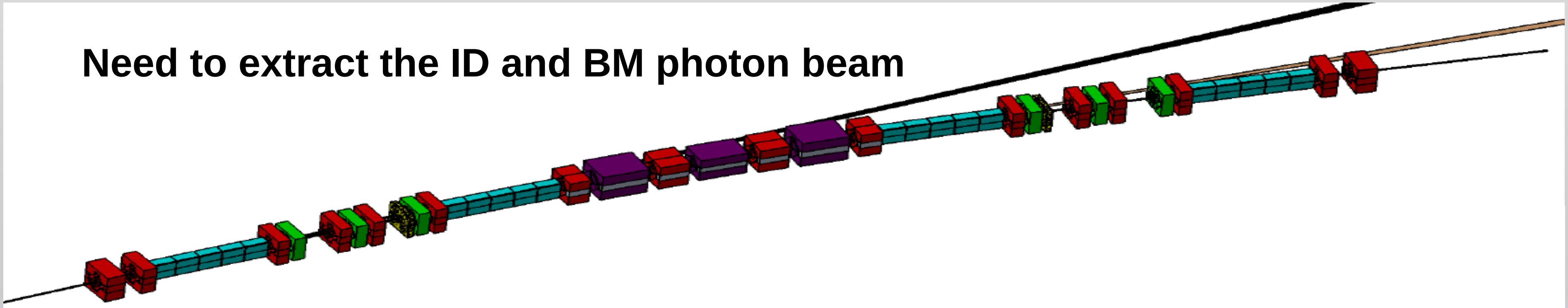
Crotch 2

+ pump
(inner side)
+ gauge

+ pump
(inner side)
+ gauge

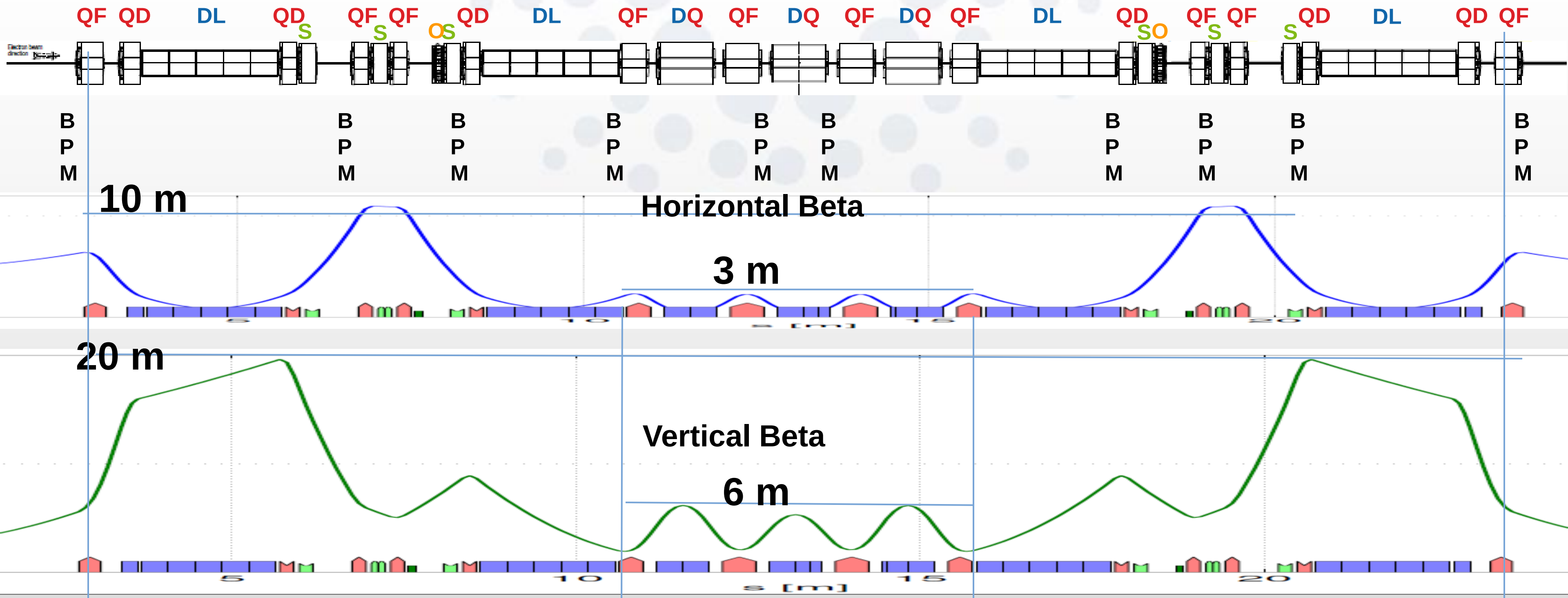
Total BM radiation:

950 kW with the present machine 29kW/cell [8 to 10 kW/ crotch]
560 kW with the new machine 17.5 kW/cell [less than 2kW / crotch]

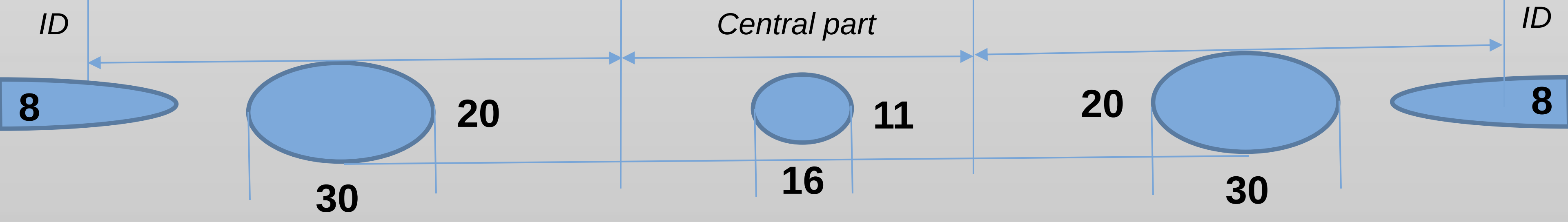


Need to extract the ID and BM photon beam

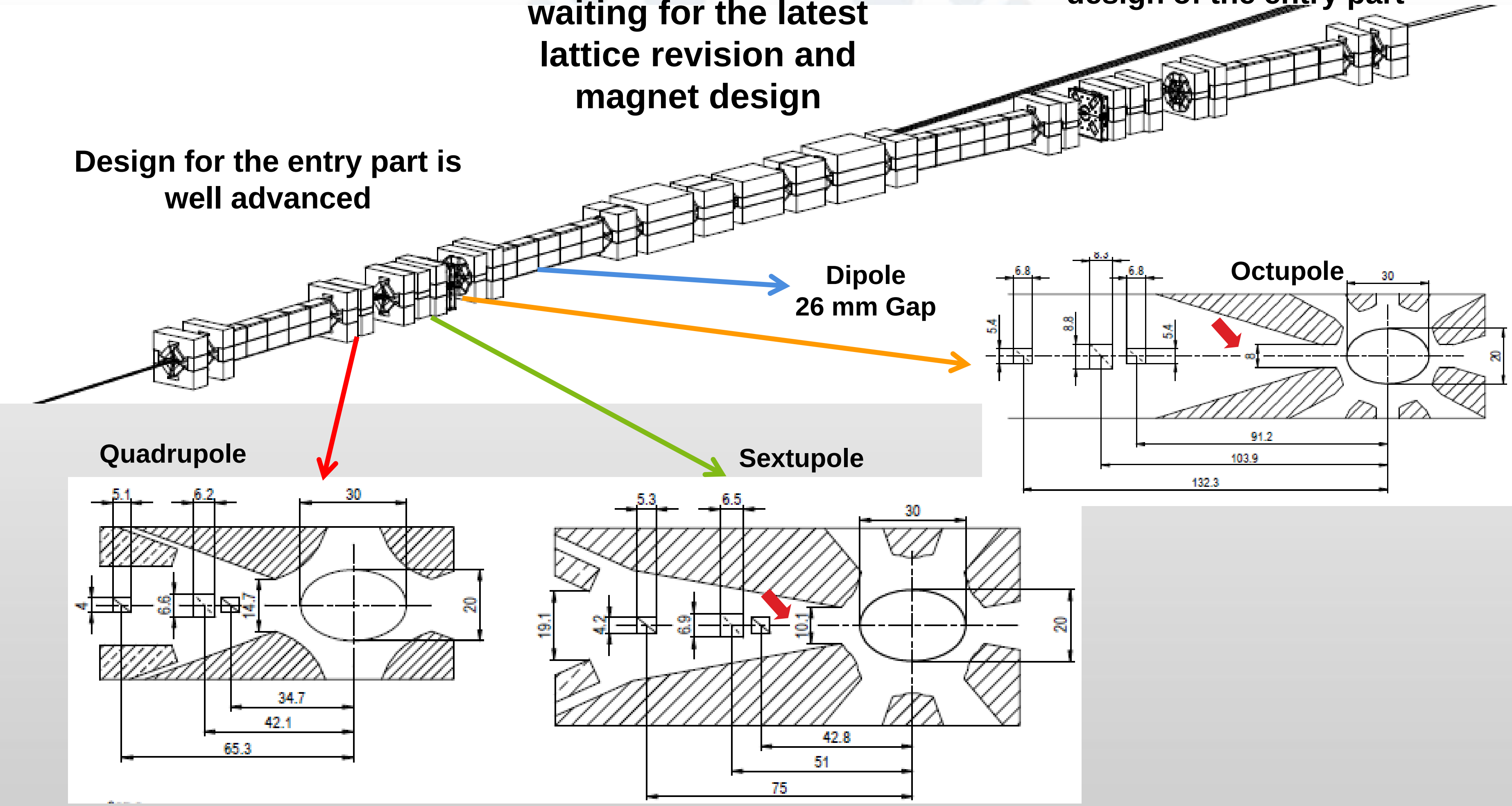
Vacuum chamber design ←→ Lattice design



Beam stay clear (for injection and lifetime)
Scaling based on experience of the present lattice



Vacuum chamber design ←→ Lattice design



Design for the central part very complex, was waiting for the latest lattice revision and magnet design

Design for the outing part is just starting but close to the design of the entry part

Design for the entry part is well advanced

Dipole
26 mm Gap

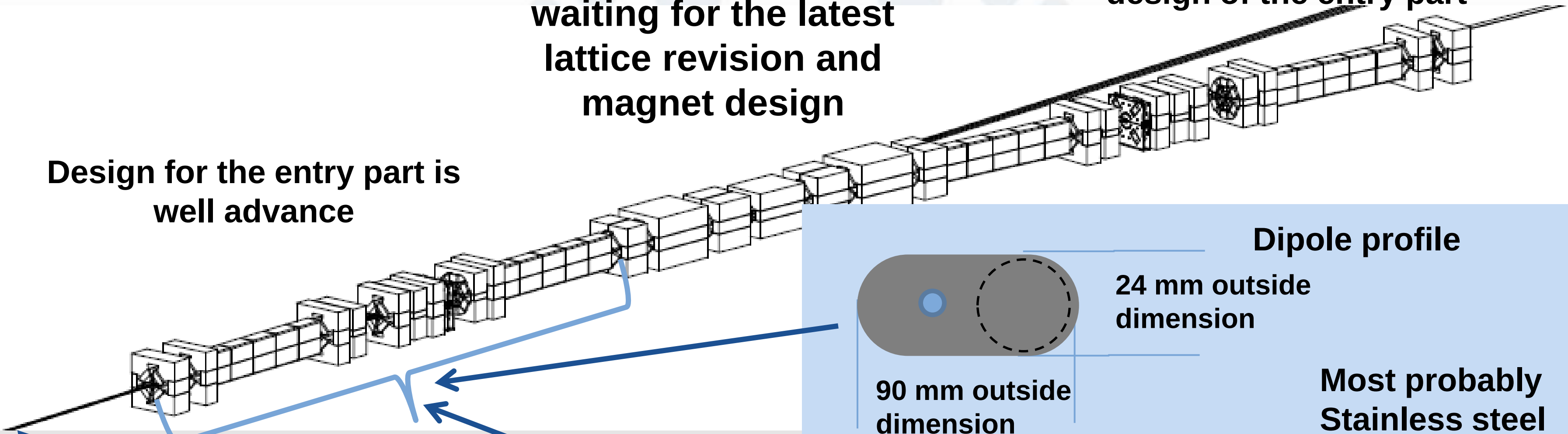
Octupole

Quadrupole

Sextupole

Strong interaction between the magnet designers and the mechanical designers to optimize the apertures and shapes

Vacuum chamber design



Design for the central part very complex, was waiting for the latest lattice revision and magnet design

Design for the outing part is just starting but close to the design of the entry part

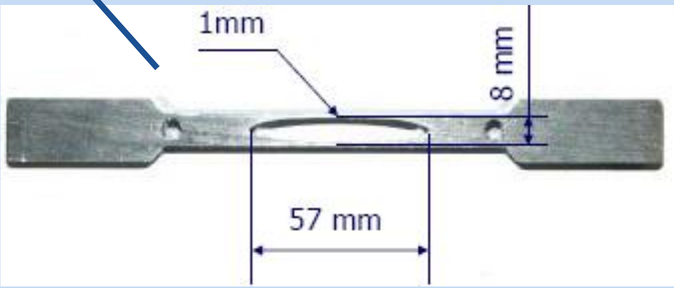
Design for the entry part is well advance

Dipole profile

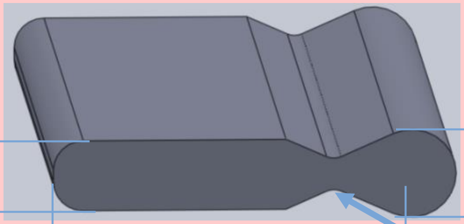
24 mm outside dimension

90 mm outside dimension

Most probably Stainless steel



ID chambers:
Re use the 5073 aluminium NEG coated chambers



Quadrupole, Sextopole, Octupole profile

14 mm outside dimension

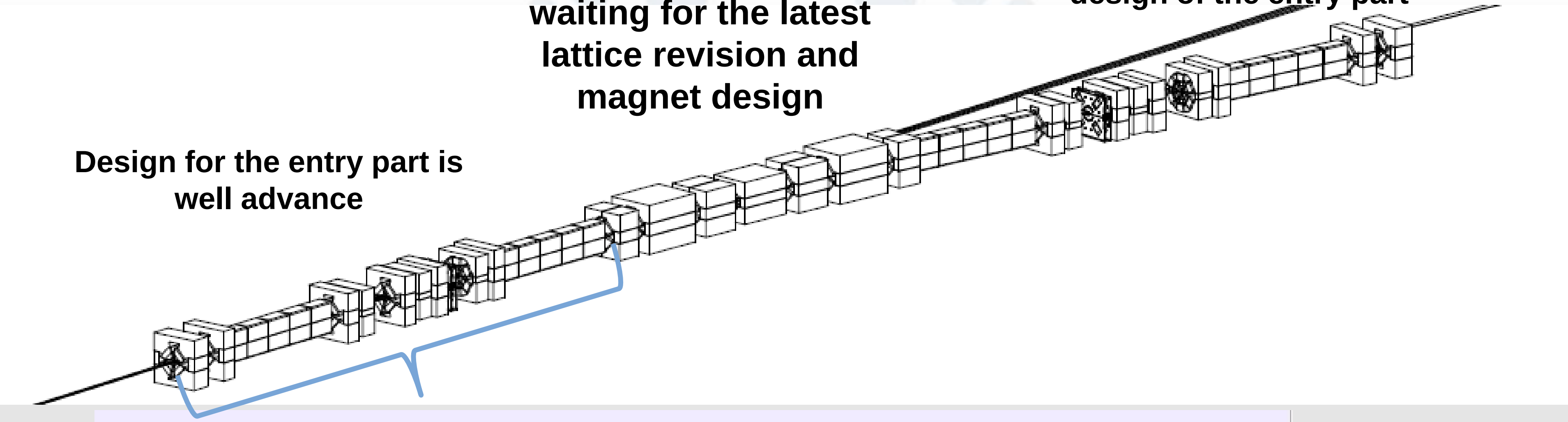
24 mm outside dimension

Restriction: 10 mm outside dimension

Size depends on the requirements for the Photon beam

Most probably Stainless steel to cope with the rigidity needed due to the restriction 2mm thickness

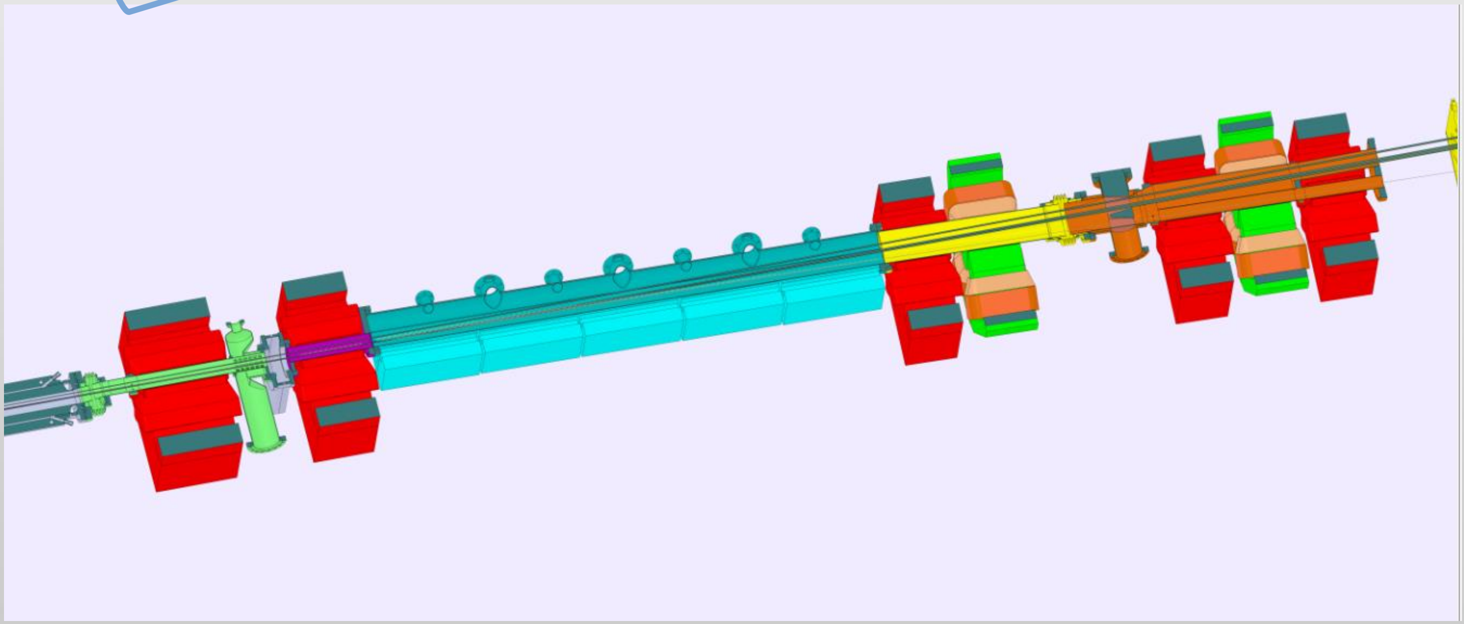
Vacuum chamber design



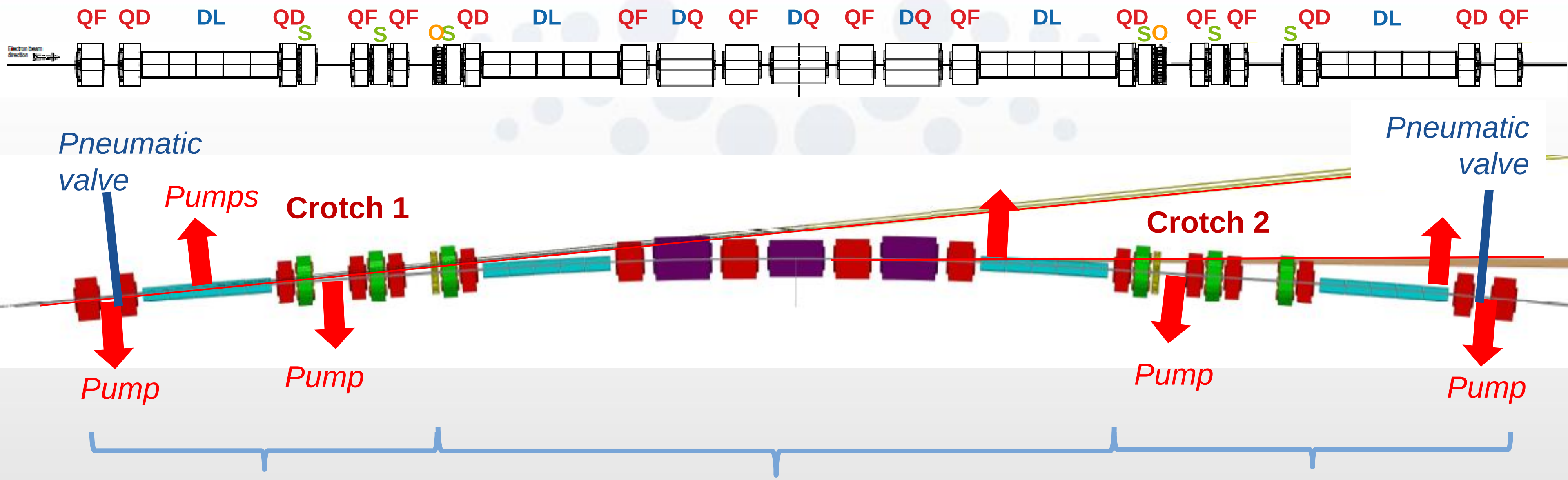
Design for the central part very complex, was waiting for the latest lattice revision and magnet design

Design for the outing part is just starting but close to the design of the entry part

Design for the entry part is well advance



Vacuum chamber design ➔ Pumping



Most power on lumped absorbers
➔Pumps could be installed
➔ Coating provides distributed pumping

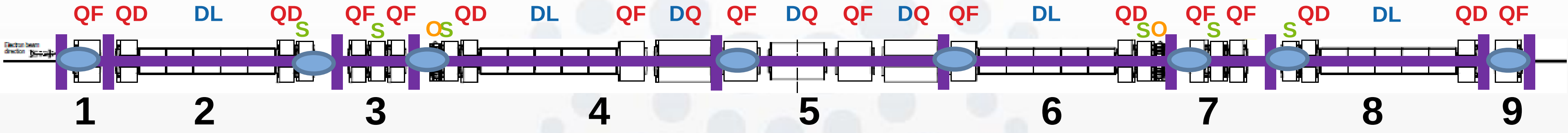
Central part should rely on coating
➔Difficult to install pumps

Most power on lumped absorbers
➔Pumps could be installed
➔ Coating provides distributed pumping

Pressure profile still to be assessed as a function of the design: material, conductance, number of pumps, surface coated, power deposit,...

With 2 objectives:
➔ Get a pressure average in the 10^{-9} mbar (Today 10^{-10}) with beam
➔ Allow the start-up of the machine without saturation of the NEG (in situ baking)

Vacuum chamber design



✓Each cell could be divided into **9 chambers** (ideally 10 to get BPM fix point) with flanges in order to ease the fabrication, the installation and the maintainability.

The flanges may not match the girder transitions (see next slides) due to the lack of space (constraints for installation). Access for intervention due to compactness might be difficult..
(With the s28 lattice version the distribution could be different)

✓In situ bake out after installation or intervention will be used

A permanent baking system with magnet closed is expected using either polyimide foil heater or heating holes

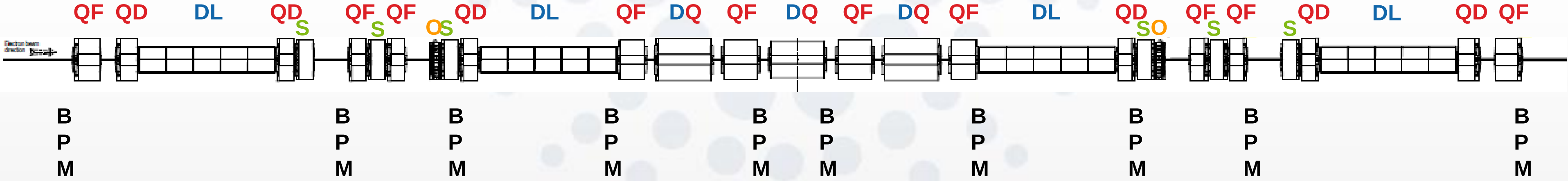
(The permanent magnet dipoles might be slide out during baking)

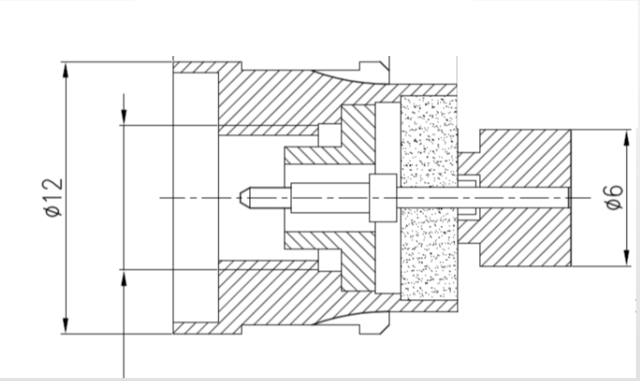
✓ At least 8 RF liners needed to sustain the longitudinal motion during bake out:

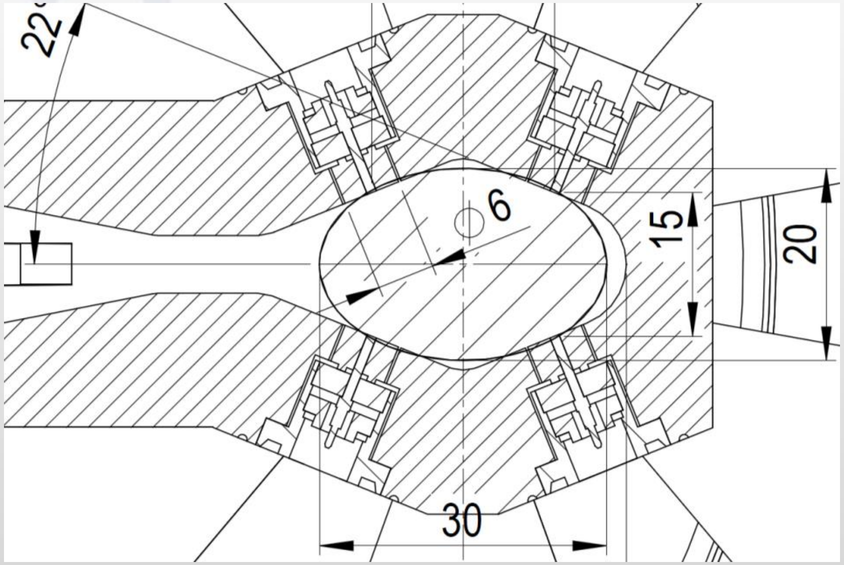
70 mm with stainless (or 110 mm if aluminium)

others could be added to sustain additional transverse motion for alignment

Vacuum chamber design → BPMs





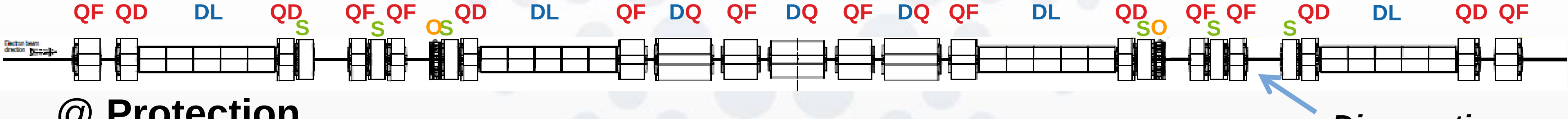


Typical BPM for the new Ring,
only 10 BPMs per Cell instead of 7 today,
8 can be realised with such 6mm buttons,
2 central BPMs need probably 4mm buttons

Due to compactness, the access to the BPM connectors for installation and maintenance will be difficult (could be solved using special intermediate rigid cables).

The ESRF has the expertise for the realisation of BPM blocks for SS but also for Al (prototype)

Vacuum chamber design ➔ Special issues



Diagnostics

@ Protection

Due to the reduction in size of the beam pipe and of the restriction for the multipole magnets, protect the chamber against beam blow up and beam mis-steering (commissioning and operation)

✓dedicated beam blow-up interlock (already existing in the present ring)
✓one or two vertical absorbers well placed ?
✓H&V beam position interlocks on all BPMs

@ Impedance

✓Higher resistivity of stainless steel (factor 25) but corresponds to what we have now
✓Resistive wall impedance function of the reduction of the beta functions and associated the reduction of the beam pipe (*Could be cured by the feedback*)
✓Geometrical impedance could benefit from better design (tapers ,flanges ,..), less flanges and pumping ports,..

@ Radiation damage

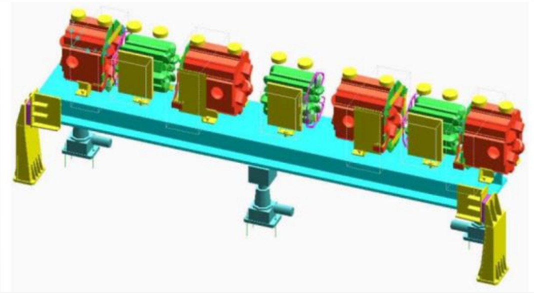
✓SS is better than aluminium for radiation shielding to protect equipment from radiation damage (Soleil and ESRF experience)

@ Space needed also for **diagnostics** equipment:

Current transformers, striplines, scrapers, beam killers

And additional correctors if needed

Girder design ➔ Expertise



Mode	Test (Hz)
1	8.68
2	11.74
3	13.63
4	22.33
5	26.29

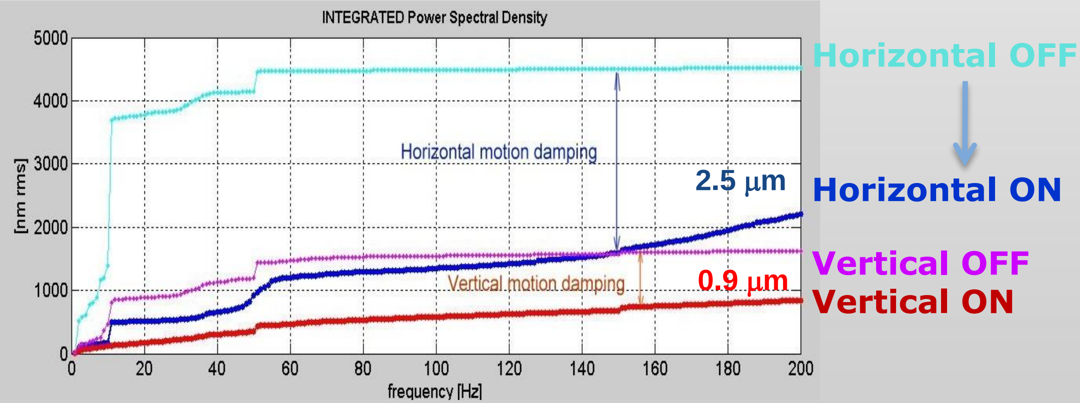
Standard ESRF girder

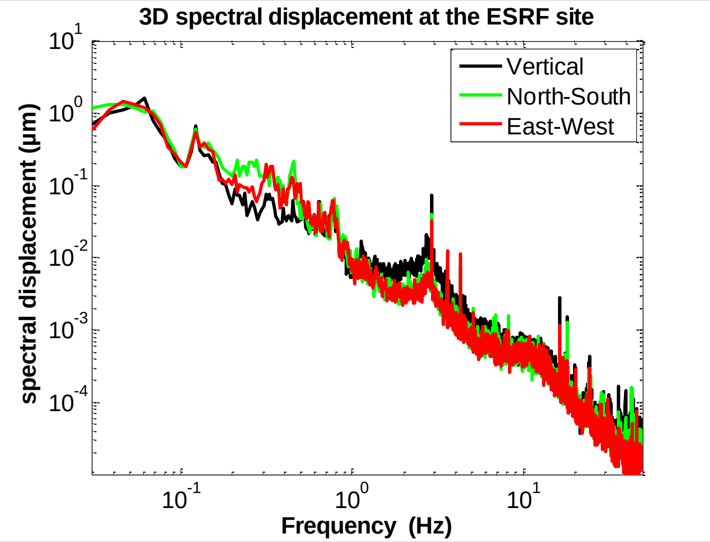
Girder installed for the 7m section in Jan 2013

Damping material is located on each side of the girders to reduce vibration effects

Gain of 3 in the horizontal plane.

Fast orbit correction working from DC to 150 Hz





@ sub μm stability routinely achieved in V
@ μm stability routinely achieved in H

Girder design → Some constraints

Jack system:

- •Good for vertical motion
- •Good for space (cabling)
- •Very bad for horizontal stability
- •Need damping link system
- •Expensive

➡ **Investigating for a new system**

Stability requirement for the new machine:

- •Vertical: same (at least)
- •Horizontal: factor 2 at least

Less space requirement for cabling

Fast orbit feedback system:

- • Efficient to stabilize fast motion (ground, gap change, electrical perturbation,..)

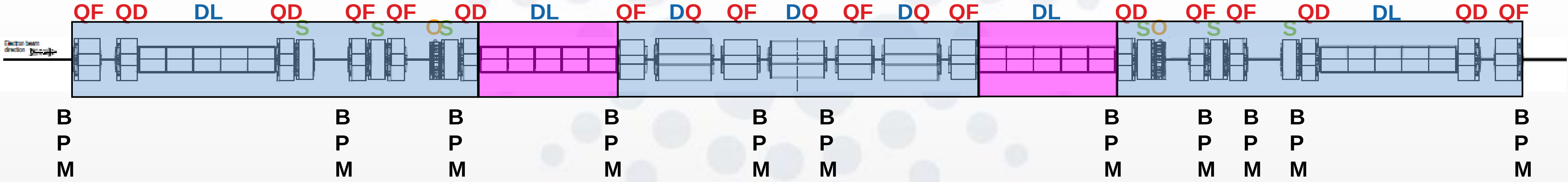
➡ **To be kept for the new machine**

Girder design to be compatible with the installation process

- •Efficient parallel activities using 3 cranes

➡ **Weight < 7T**

Girder design → Objectives



Girder ≈ 5480

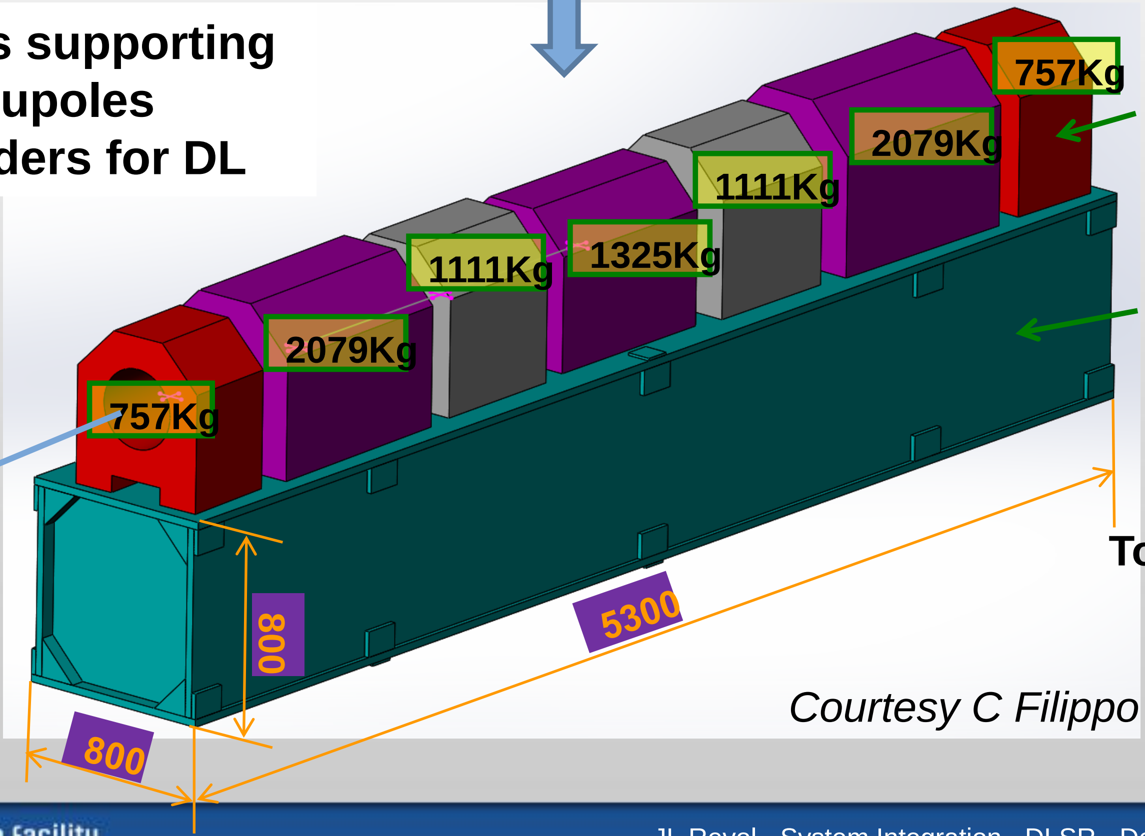
Girder ≈ 1950

Girder ≈ 5126

Girder ≈ 1950

Girder ≈ 5480

3 Long girders supporting
all quadrupoles
2 smaller girders for DL



Total "payload": 9219 Kg

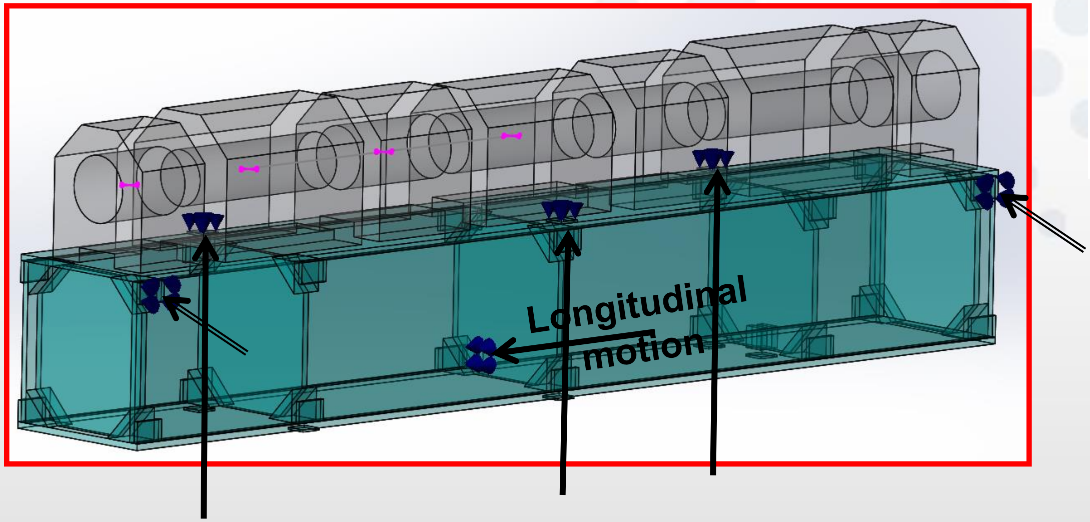
Girder mass: 4755 Kg

Beam axis 1200 mm

Total mass: 14T

Courtesy C Filippo

Girder design ➔ Objectives



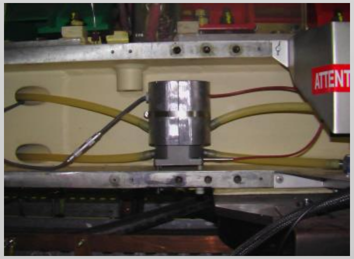
Resonant frequency expected in the 30-40 Hz range

Design for girder motion for alignment is just starting:

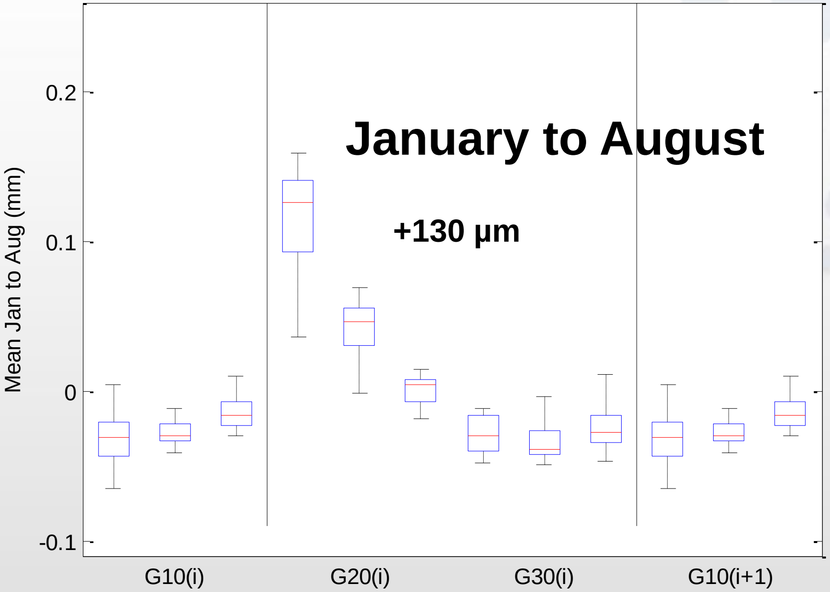
➔looking at an iso-static hexapod system

➔Most probably motorized in the vertical plane to benefit from our Hydrostatic Leveling System (HLS) system

Precision: 1μm
Drift of HLs: 1μm over 1 month



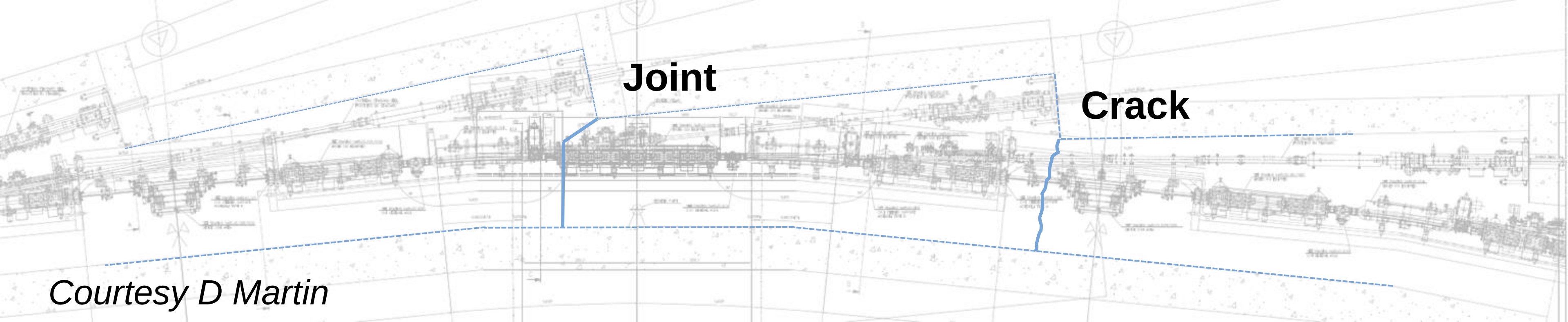
Girder design ➔ Constraints



Inter-Girder - Slab Joint Movements

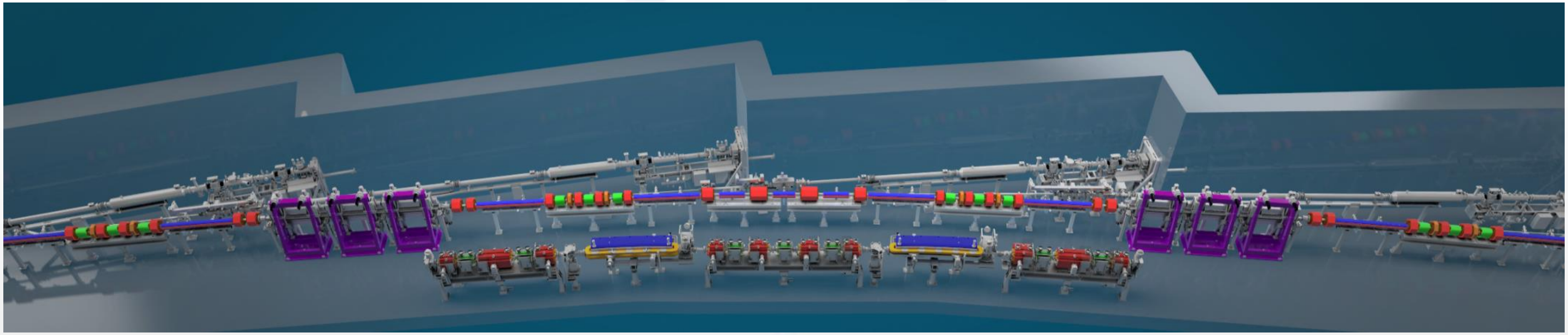
In addition to the overall variation of the alignment envelope (cumulated Δz=5mm over 15 years, 30 realignments), there are movements between adjacent girders of ±150 µm per year following the sinusoidal variation of the temperature of the water under the SR.

To be corrected at least twice a year



Courtesy D Martin

Conclusion and Outlook for the TDS



Since Nov. 2012, preparation of the TDS is progressing

- Capitalising on ESRF & other 3rd Generation SR Sources Know-How,
- Evaluation of different solutions, preliminary design

Critical : resource management

(implementation UP Phase I and operation vs. TDS-UP Phase II)

Next steps:

- Start to prepare the TDS report February 2013 with the S28 lattice as reference
- Progress with detailed design and prototyping of critical components
- Consolidation of the timeline, logistics, budget profile

Many thanks for your attention