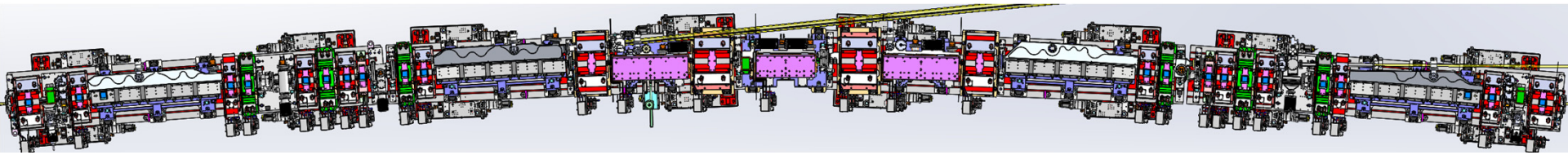


THE ESRF ACCELERATOR UPGRADE: THE EXTREMELY BRILLIANT SOURCE (EBS) PROJECT VACUUM CHAMBERS – RF FINGERS

Loys Goirand, Philippe Marion, Jean-Claude Biasci, Pierre Van Vaerenbergh, Filippo Ciancesi,
Joel Pasquaud, Thierry Brochard, Jacques Borrel, Philipp Brumund.
goirand@esrf.fr

EBS VACUUM CHAMBERS

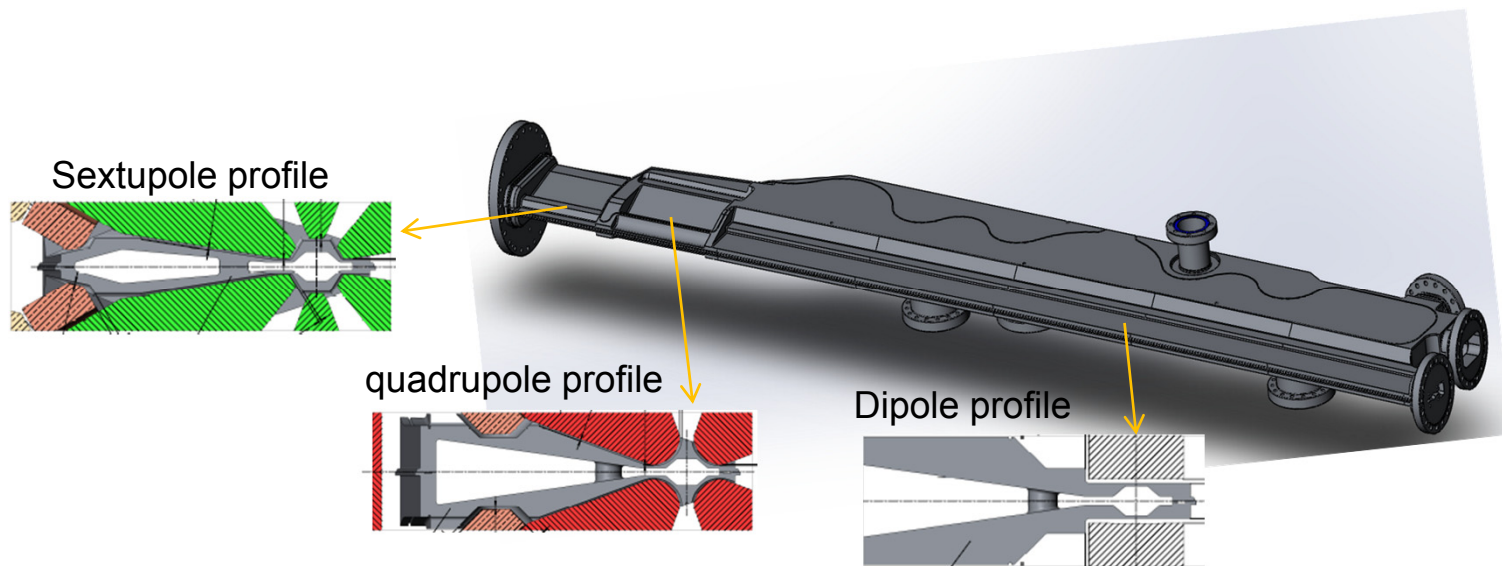
- **Principles & Constraints:**
 - Mechanical
 - Beam
 - Vacuum
 - RF
- **Vacuum Chambers Families:**
 - Aluminium Chambers
 - Stainless Steel Chambers
 - Diagnostic Chambers
- **RF Fingers:**
 - RF Fingers
 - RF GasKets
- **Conclusion**

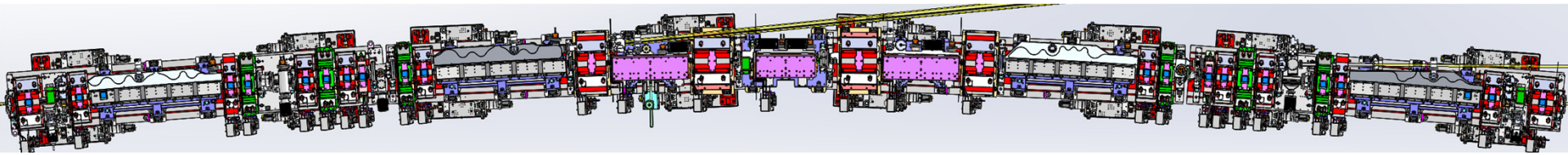


Free space between magnets (total for one cell): **3.4m** instead of **8m** today
31 magnets per cell instead of 17 currently

✓ Very limited space available between magnets for flanges, valves, bellows, BPMs

Several chambers have different successive external cross sections to pass through several different magnets.



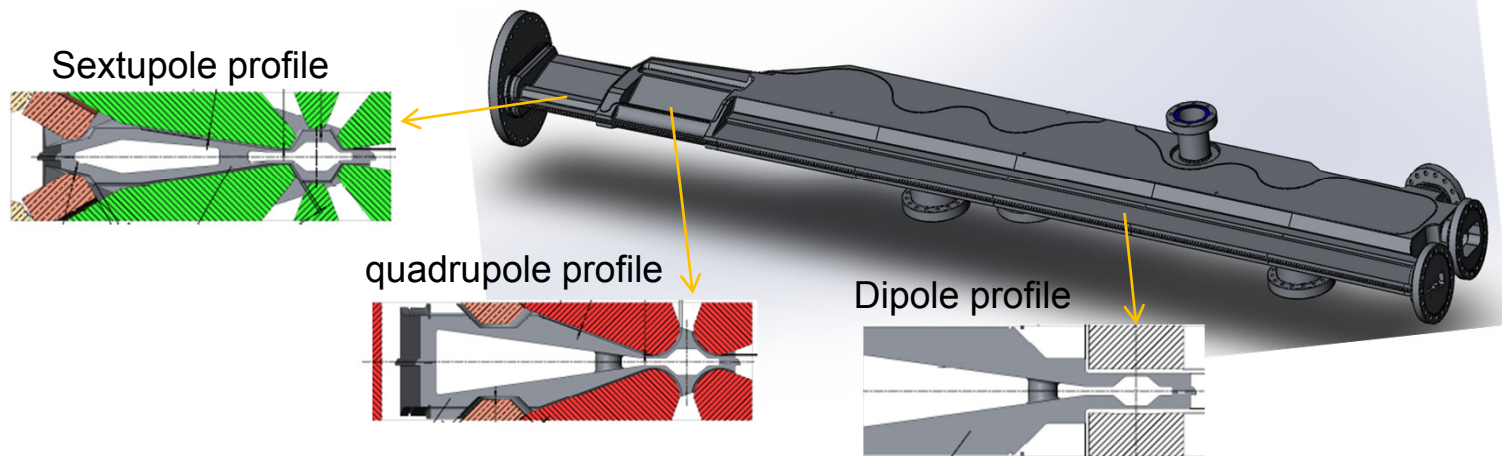


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Several chambers have different successive external cross sections to pass through several different magnets.

Such chambers are difficult to manufacture by extrusion or by folding
=> several chambers made of welded assemblies of machined parts

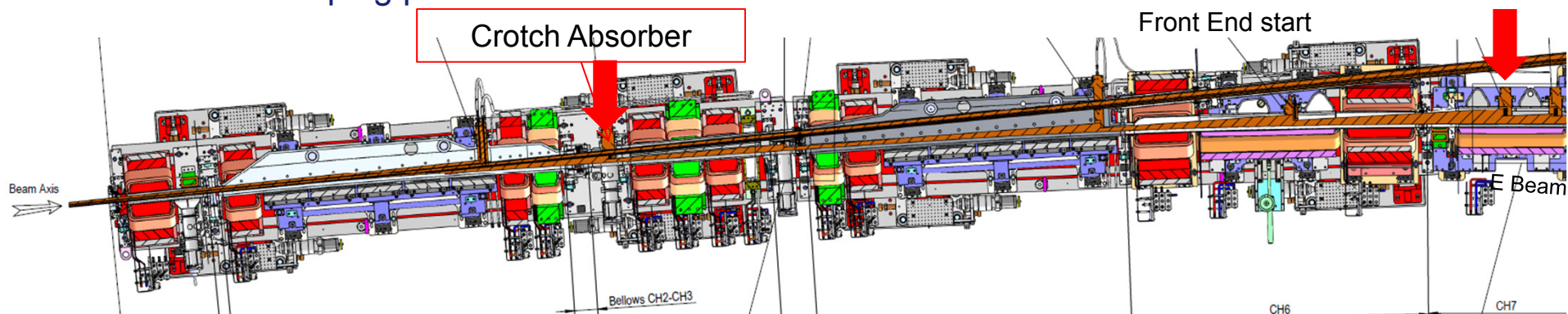


The Electrons and Photons beams need a long distance before being in separate chambers

Chambers with ante-chamber where the photon beam can circulate

=> Lumped absorbers

=> Pumping ports close to absorbers on the ante-chamber

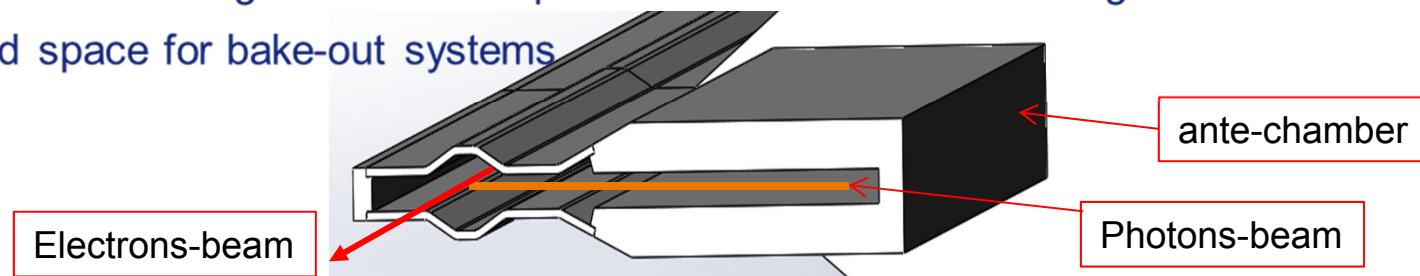


Very little space available between poles and e- beam stay clear zone for chamber and bake out systems

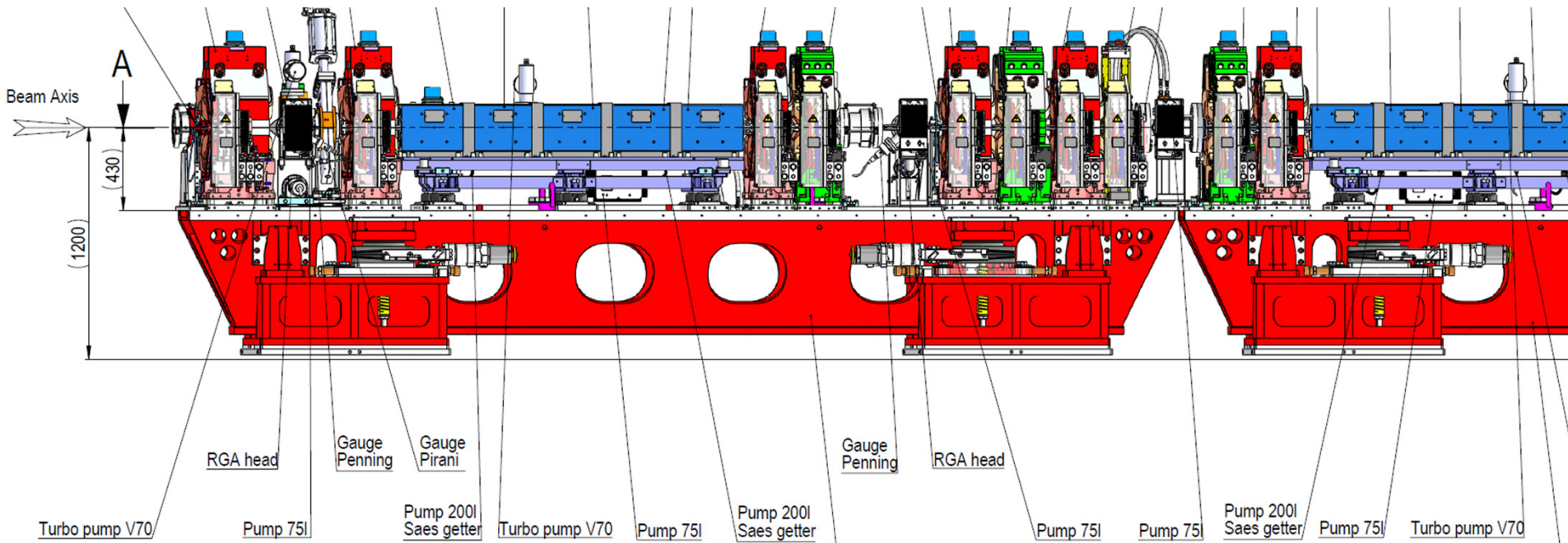
=> Small chamber thickness around e- beam. A thick ante-chamber acts as a stiffener. Several design iterations to obtain acceptable stress and strain

=> Tight manufacturing tolerances required. Difficult to obtain on long chambers

=> Limited space for bake-out systems



- ✓ Pumping mainly by lumped pumps (Ion pumps or NEG pumps fitted on pumping ports)
- Only 2 chambers (CH1 and CH14) from 14 will be NEG coated.

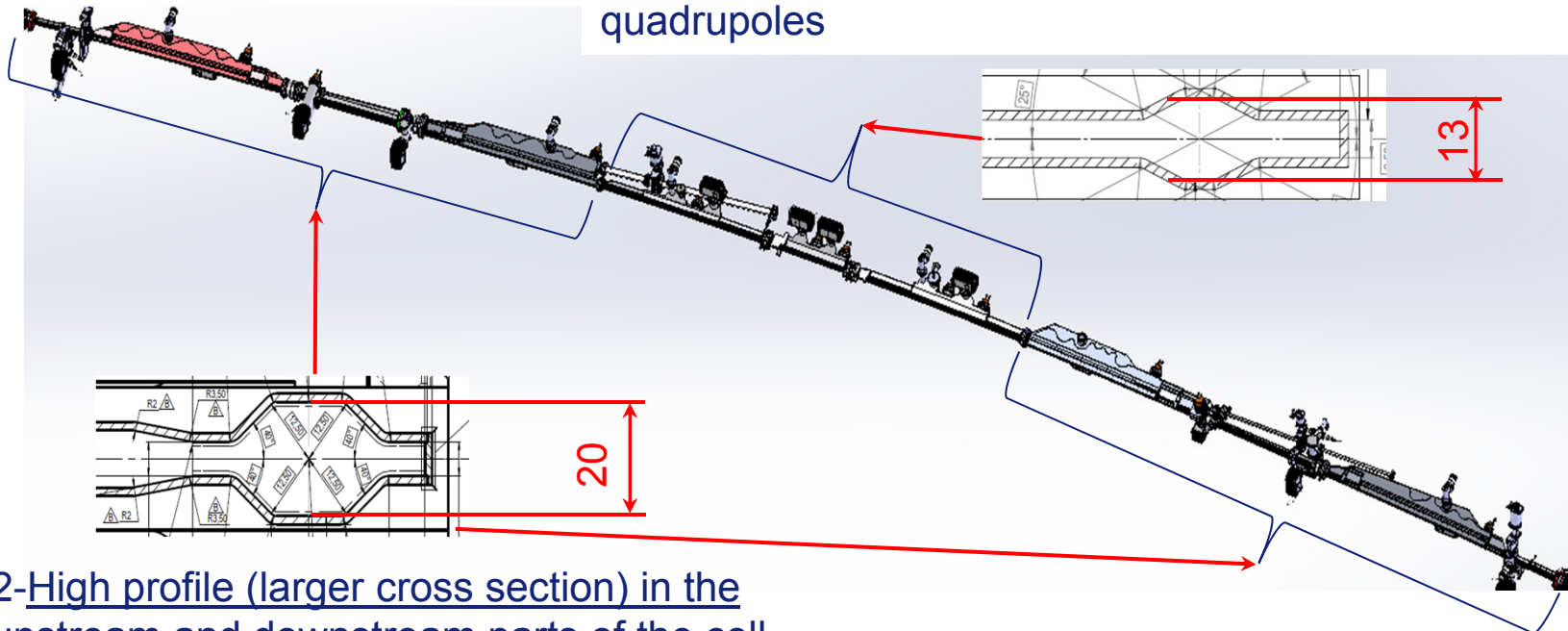


IP & NEG Pumps		CH 1	CH 2	CH 3	CH 4	CH 5	CH 6	CH 7	CH 8	CH 9	CH 11	CH 12	CH 13	CH 14
IP	55 L/s-1							2				1		
	75 L/s-1	1	1	1	1	1	1		1	2		1	1	1
NEG	GP100						1							
	GP200		2			2			1	2			2	

Pumping and pressure calculations done by Hugo Pedroso-Marques.

2 different sizes for inside profile around the e-beam

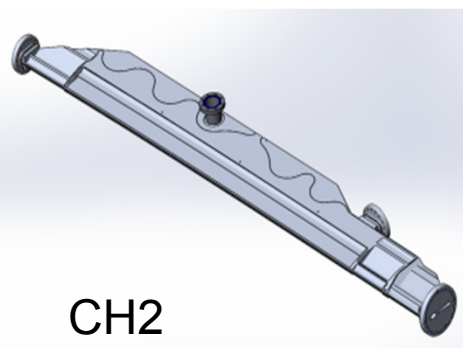
1-Low profile (small cross section) in central part of the cell Inside dipole-quadrupoles and HF quadrupoles



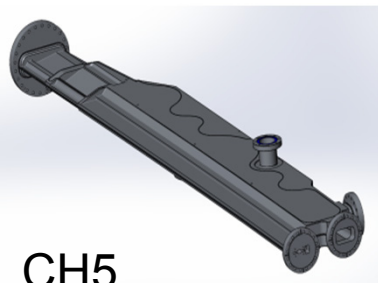
2-High profile (larger cross section) in the upstream and downstream parts of the cell



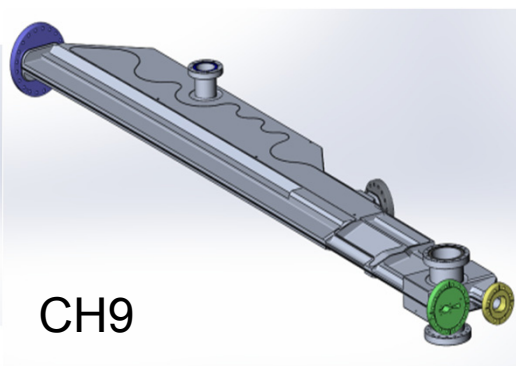
4 dipole chambers per cell made of Aluminum alloy



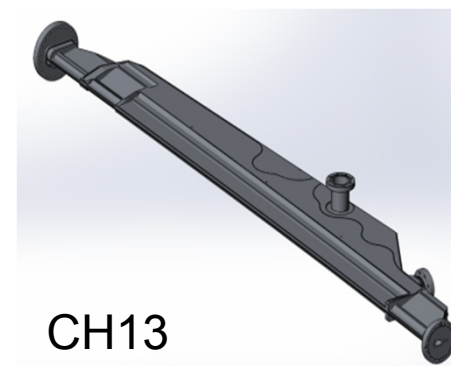
CH2



CH5



CH9



CH13

Dipole chambers are in Aluminum alloy 2219 T87

- easy to machine
- lightweight
- weld-able
- good mechanical properties

Designed in collaboration with INFN Frascati

ESRF engineer: Filippo Cianciosi

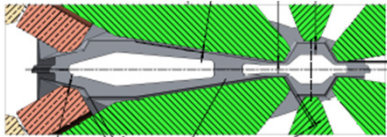
Aluminium cheaper and easier to machine than stainless steel
=> well adapted for complex shapes.

Flanges:

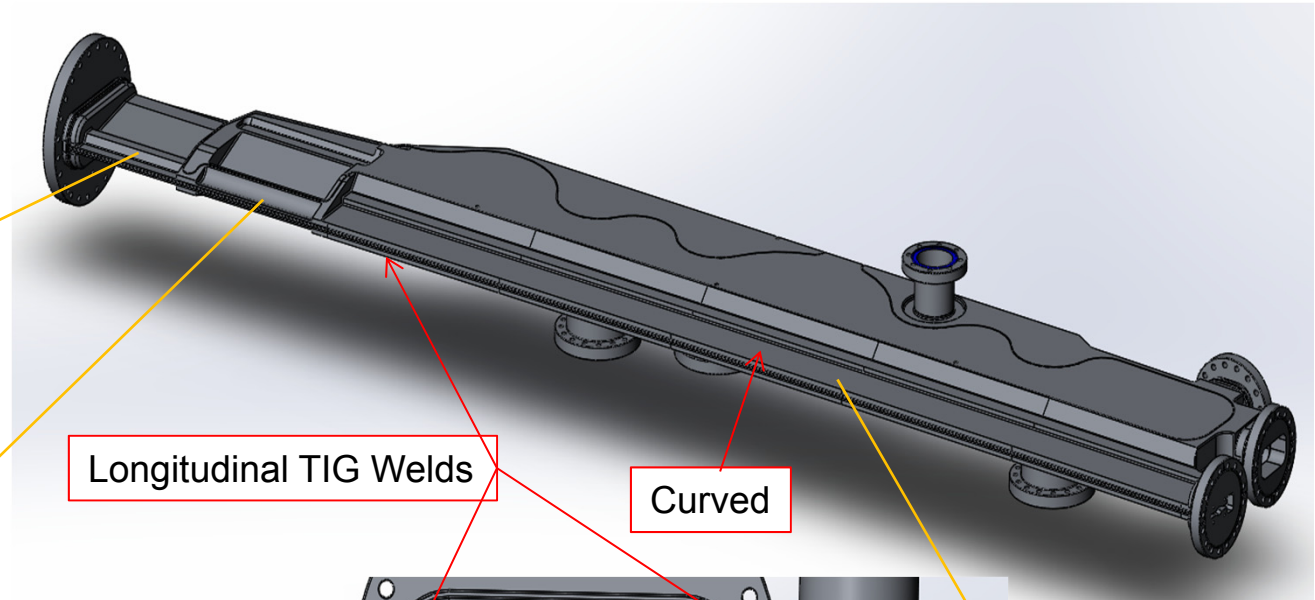
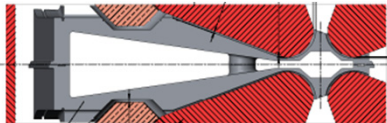
- Bi-metallic CF flanges

Outside profiles

Sextupole profile



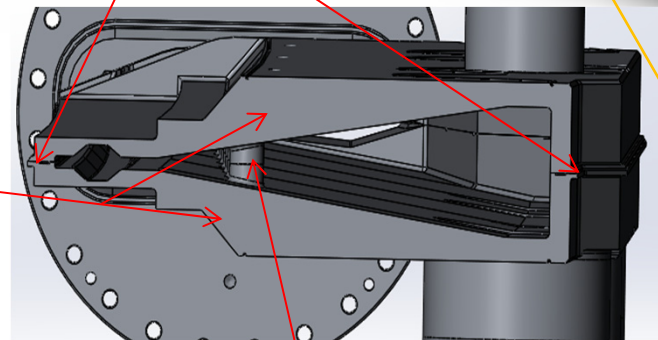
Quadrupole profile



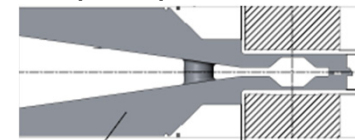
Longitudinal TIG Welds

Curved

Upper / lower half part
shaped by machining



Dipole profile



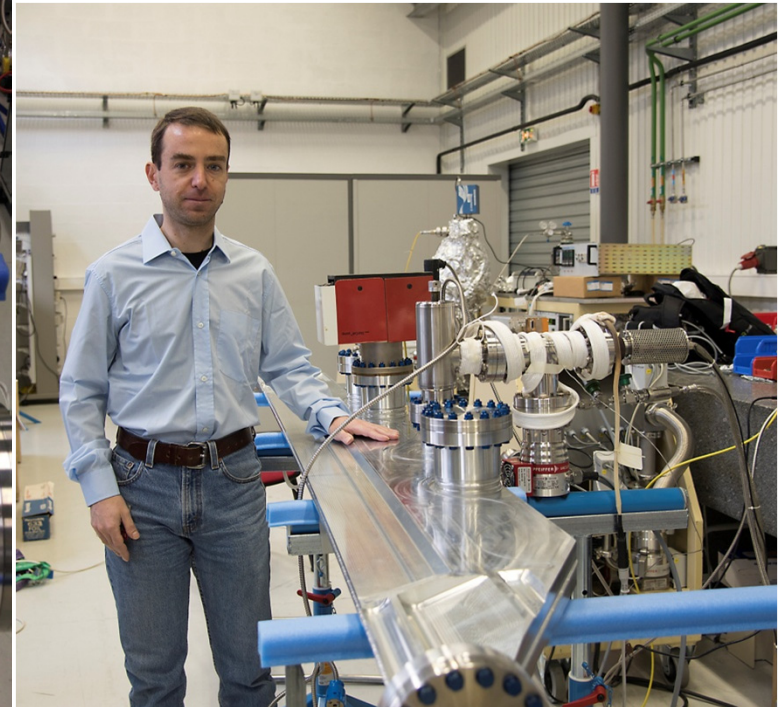
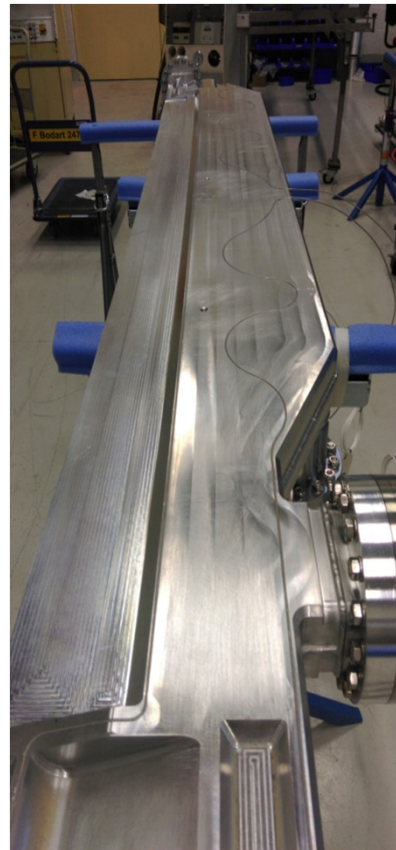
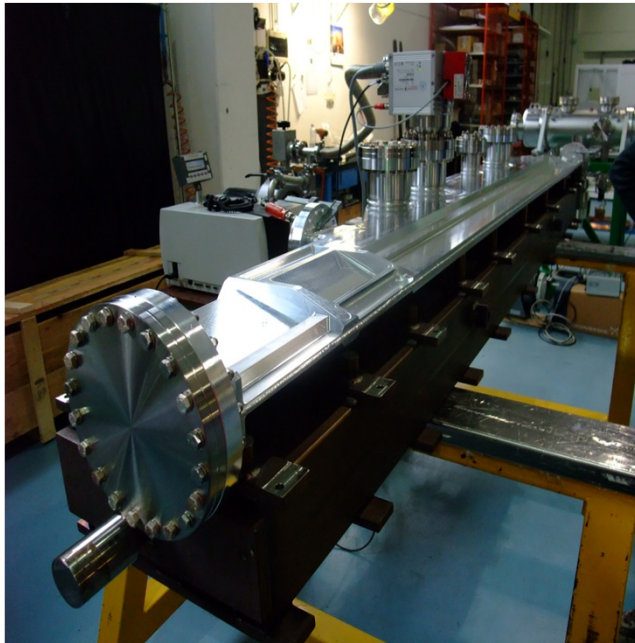
Integrated spacers to reduce stress and strain

**Designed in collaboration
with INFN Frascati**

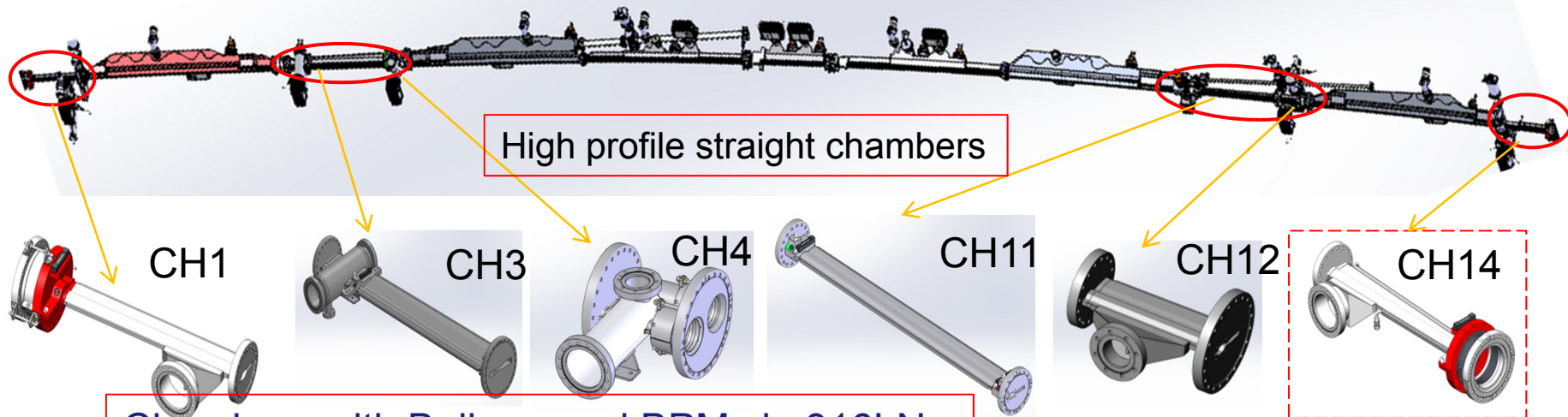
ESRF engineer: Filippo Cianciosi

A prototype aluminum chamber was produced to validate the manufacturability
Call for tender for the series production in progress

Precision achieved : on the profile / on straightness: 0.1mm



ESRF engineer: Filippo Ciansiosi



High profile straight chambers

CH1

CH3

CH4

CH11

CH12

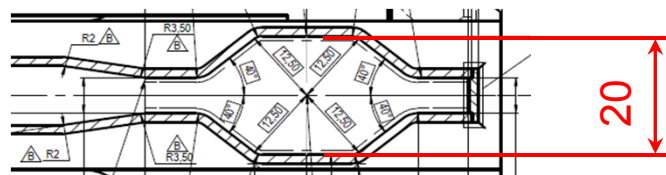
CH14

Chambers with Bellows and BPMs in 316LN and 316L stainless steel.

- easy to weld
- non-magnetic
- good mechanical properties

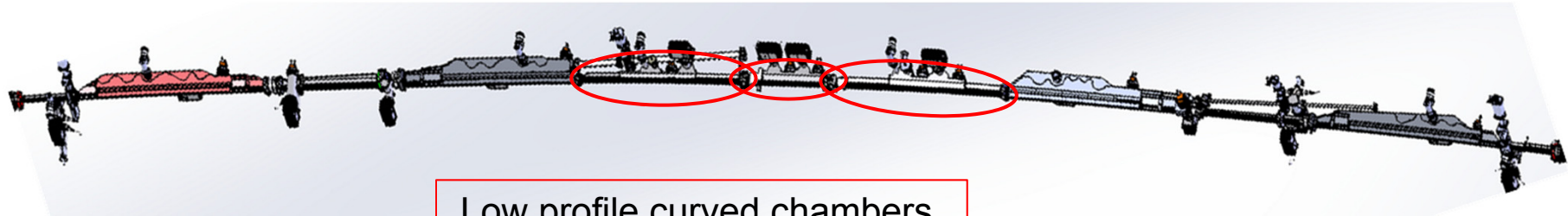
Copper integrated in the chamber body (explosion bonding), water-cooling through the chamber wall

High profile cross section

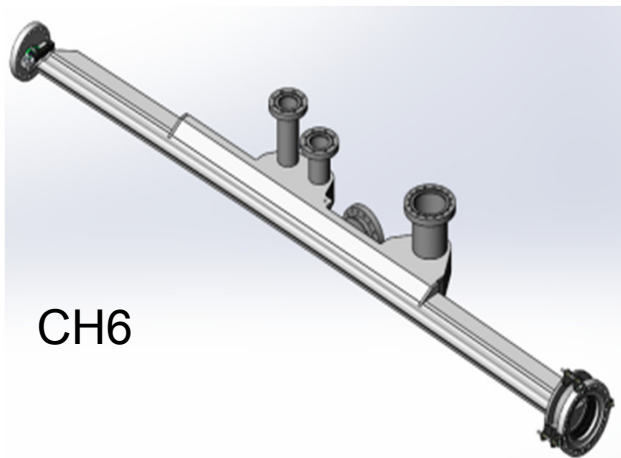


Pierre Van Vaerenbergh

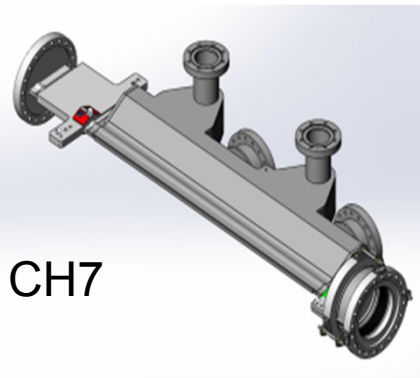
Joachim Leonardon, Thibault Ducoing



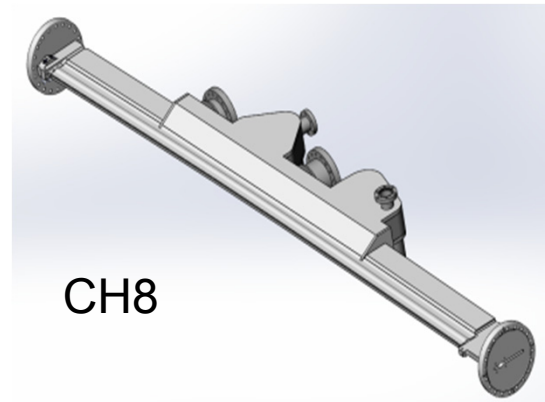
Low profile curved chambers



CH6



CH7

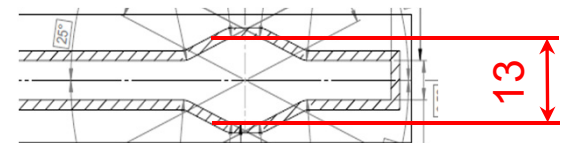


CH8

Chambers with Bellows and BPMs in 316LN and 316L stainless steel

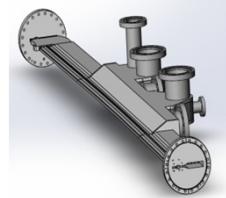
- easy to weld
- non-magnetic
- good mechanical properties

Low profile cross section (inside dipole-quadrupoles and HF quadrupoles)

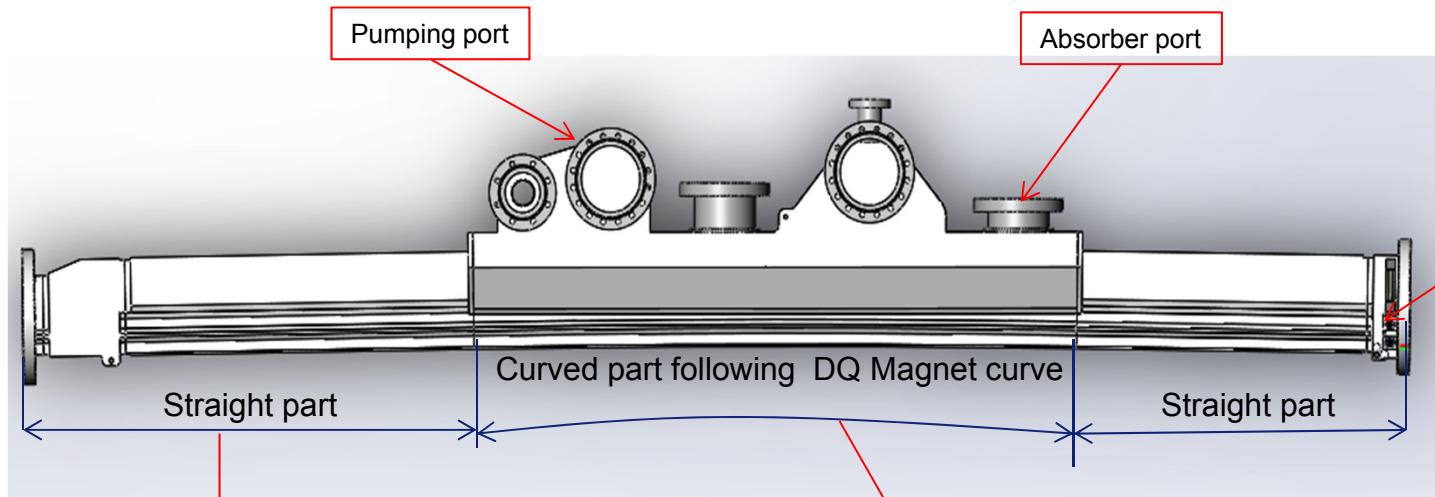
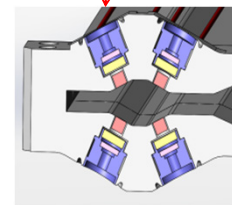


Courtesy of Joel Pasquaud

Material : 316 LN & 316L



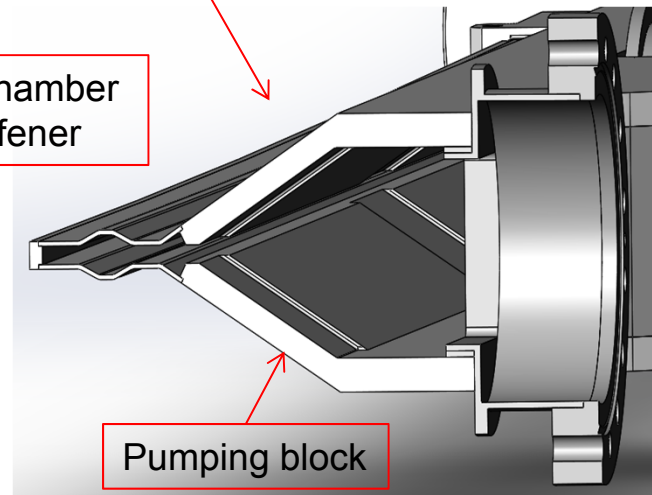
BPM Block



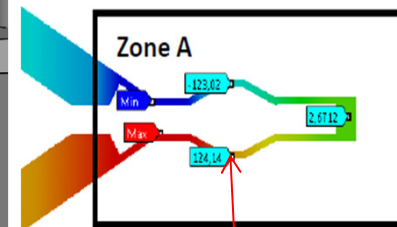
EB Welding

Thick ante-chamber acting as stiffener

1,5mm sheet



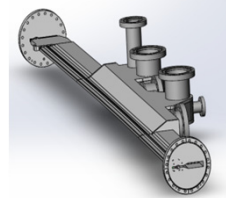
Pumping block



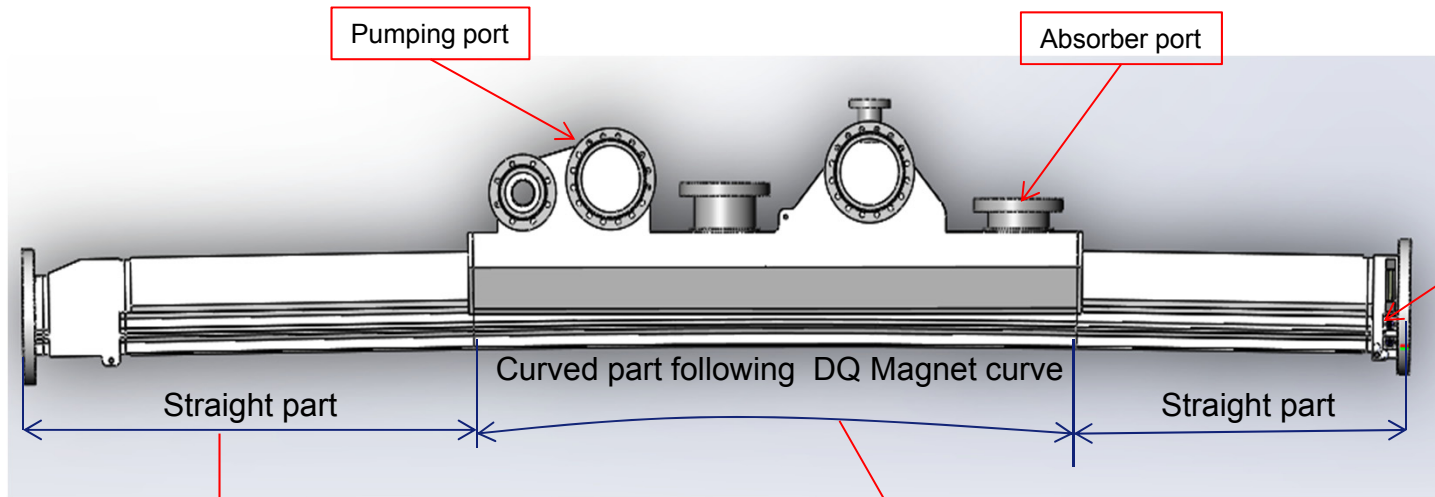
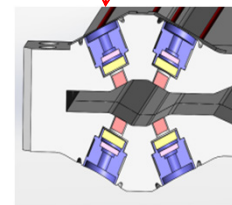
Deformation at the Beam area
0.125mm

Courtesy of Joel Pasquaud

Material : 316 LN & 316L



BPM Block

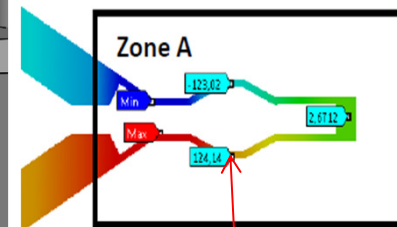
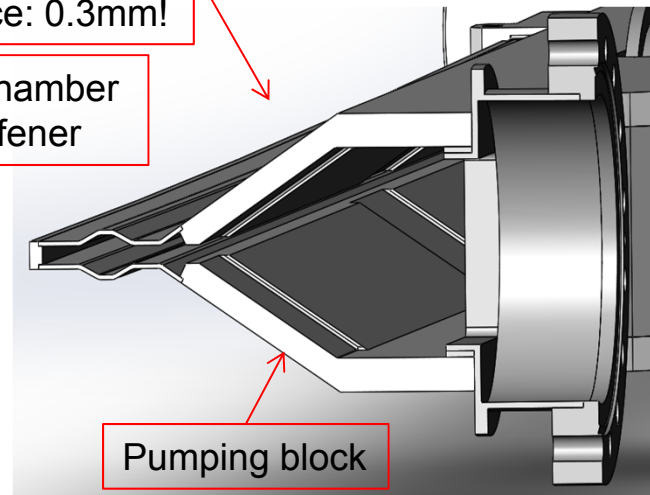


Requested shape tolerance: 0.3mm!

Thick ante-chamber acting as stiffener

EB Welding

1,5mm sheet

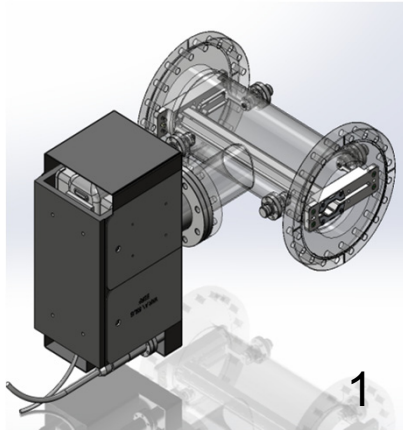


Deformation at the Beam area 0.125mm

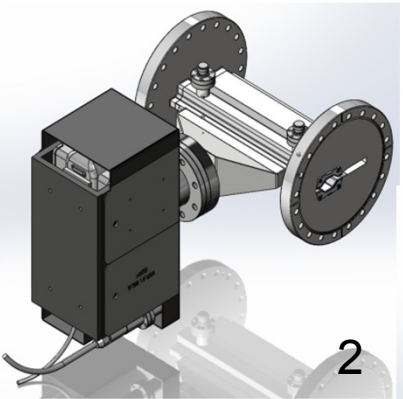
Courtesy of Joel Pasquaud

CH12 DIAGNOSTICS

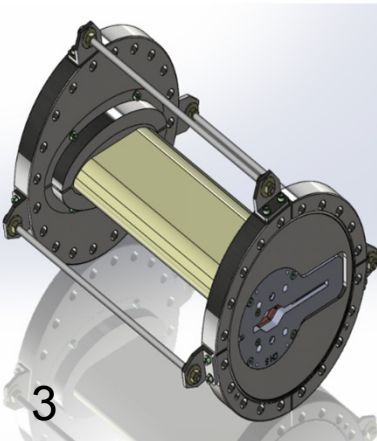
1. H Stripline
2. V Stripline
3. Shaker
4. Current transformer
5. Beam Killer
6. Beam losses collimator
New device associated with
a iron shielding



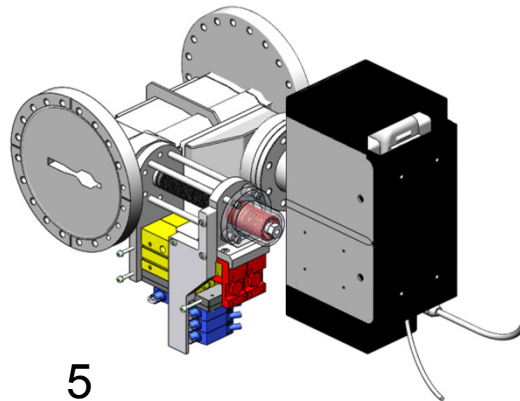
1



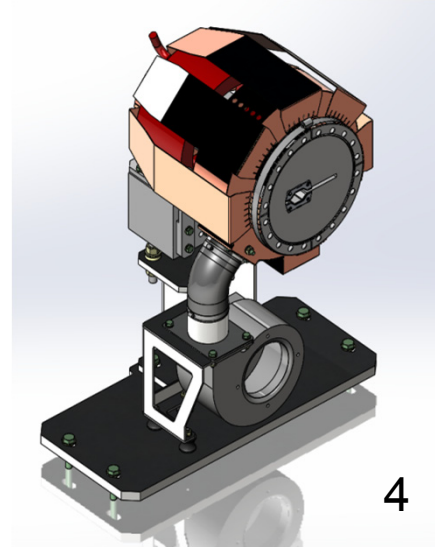
2



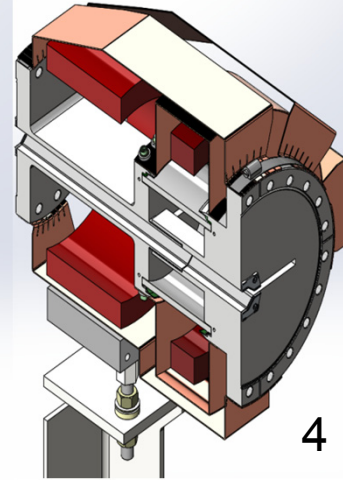
3



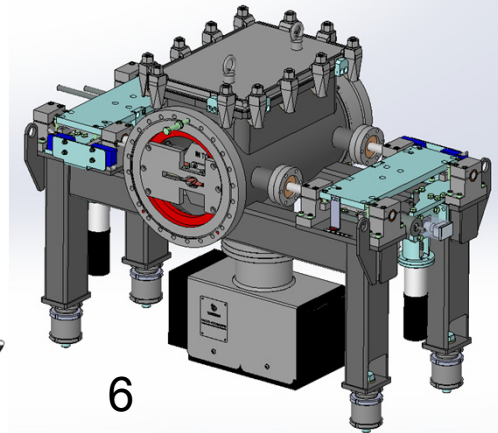
5



4



4



6

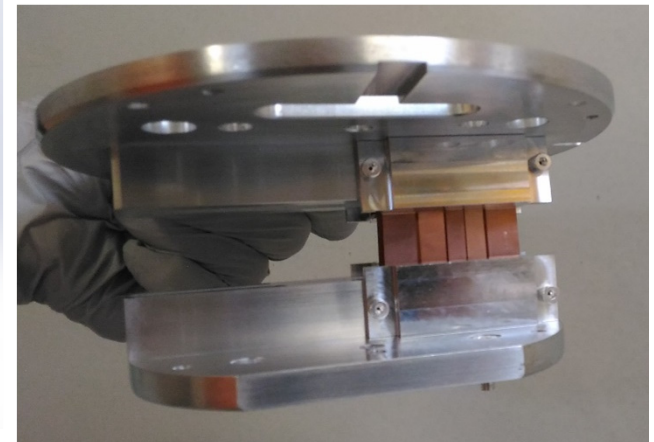
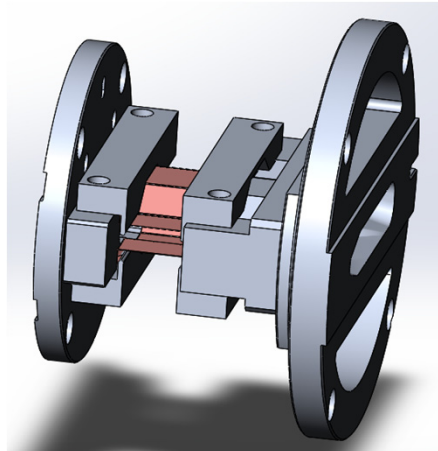
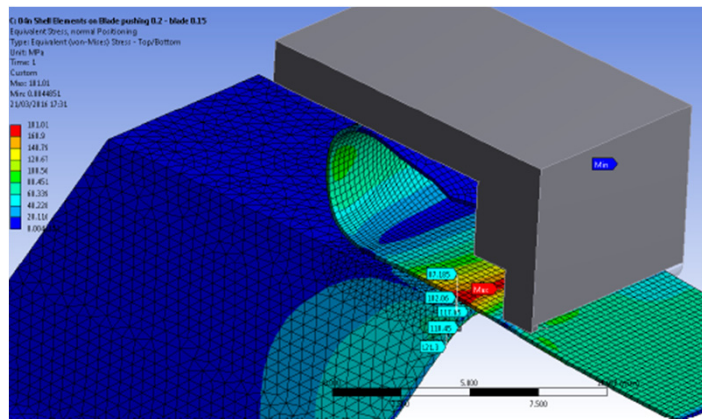
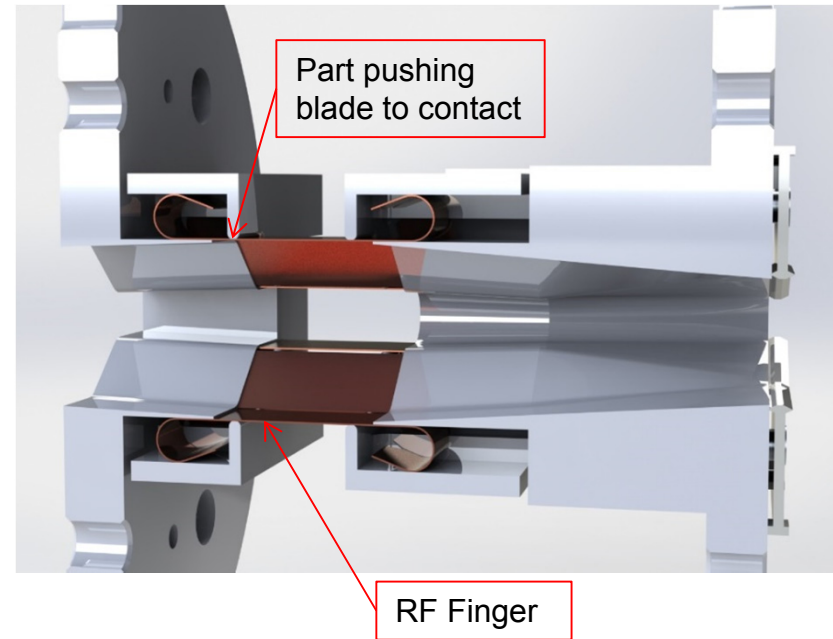
J Borrel

RF impedance has a direct effect on the beam quality (brilliance & stability).

To minize it:

- Smooth transitions between profiles
- No change of the profile inside the RF fingers
- RF gasket between flanges

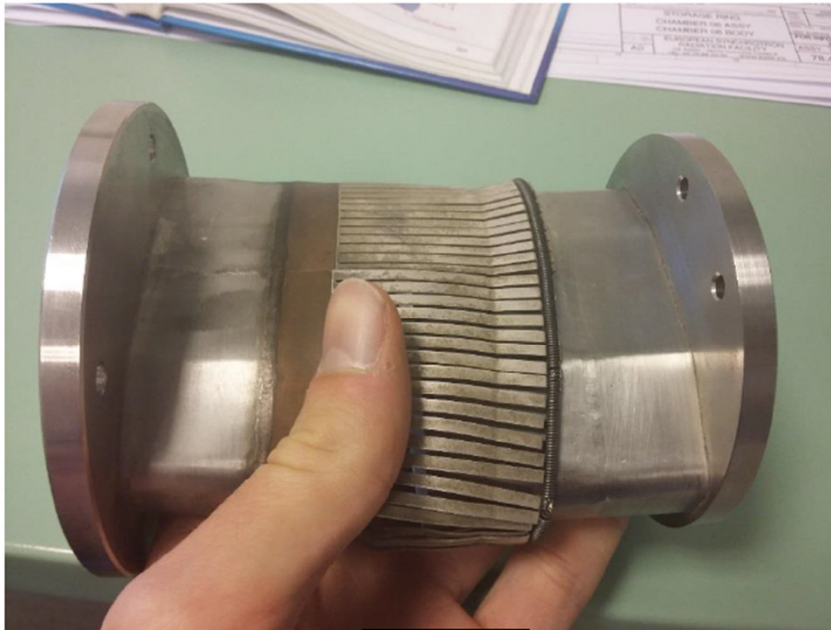
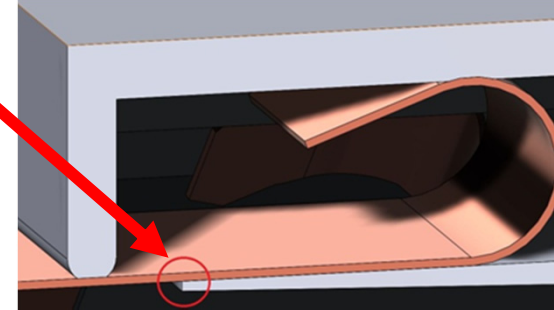
- ❑ 2 different profiles = 2 different sizes of RF Fingers.
- ❑ FEA model for mechanical and RF
- ❑ Prototype tested,
- ❑ Patent Pending



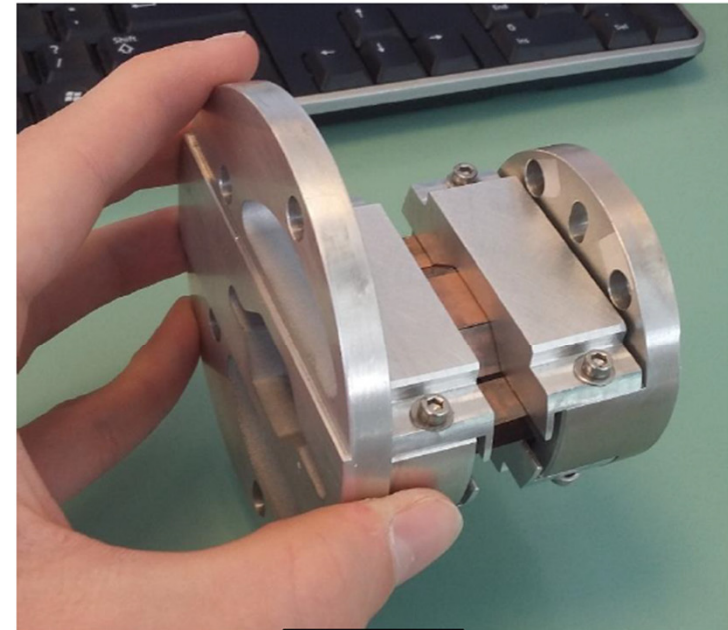
P Brumund, T Brochard, L Goirand, J Pasquaud, Simon White

Comparison to old design

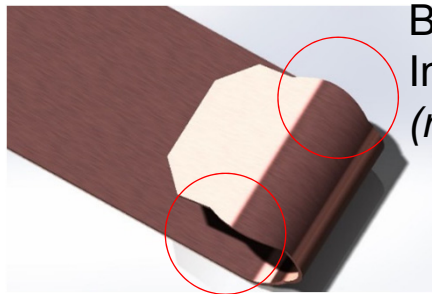
- Old design simpler but improper for new profile
- In new design the electrical contact pressure is better distributed
- The electrical contact is on the edge of the sleeves
- No welding or brazing
- Parts replaceable
- Compact but allowing high lateral and vertical offsets
- No risk of finger falling into the beam area



Old design



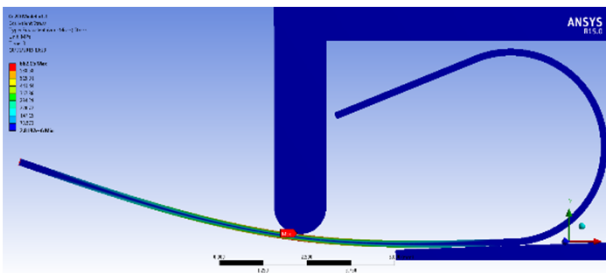
New design



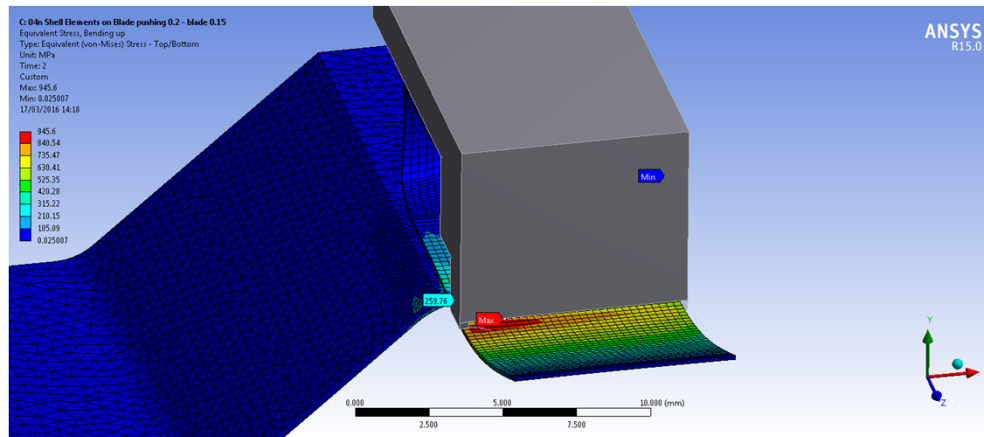
Blade Geometry Improvement
(rounded edges)

- Improvement of Rf impedance, lateral blades added
- Improvement of blade geometry for more flexibility
- Calculations (2D/3D) performed with goals:
 - Validation of concept
 - Optimization of design to obtain good flexibility and contact behavior

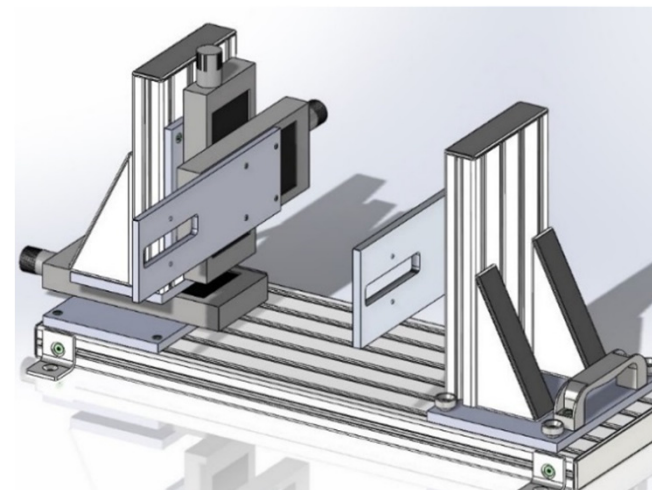
2D FE Model

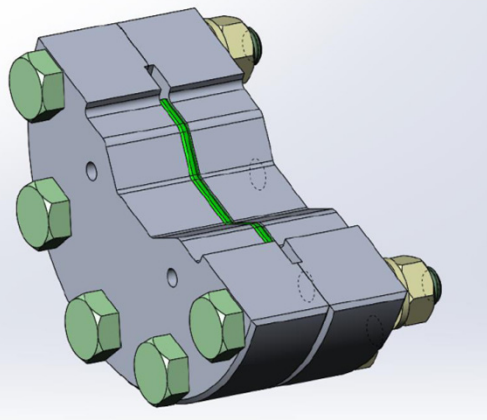


3D FE Model



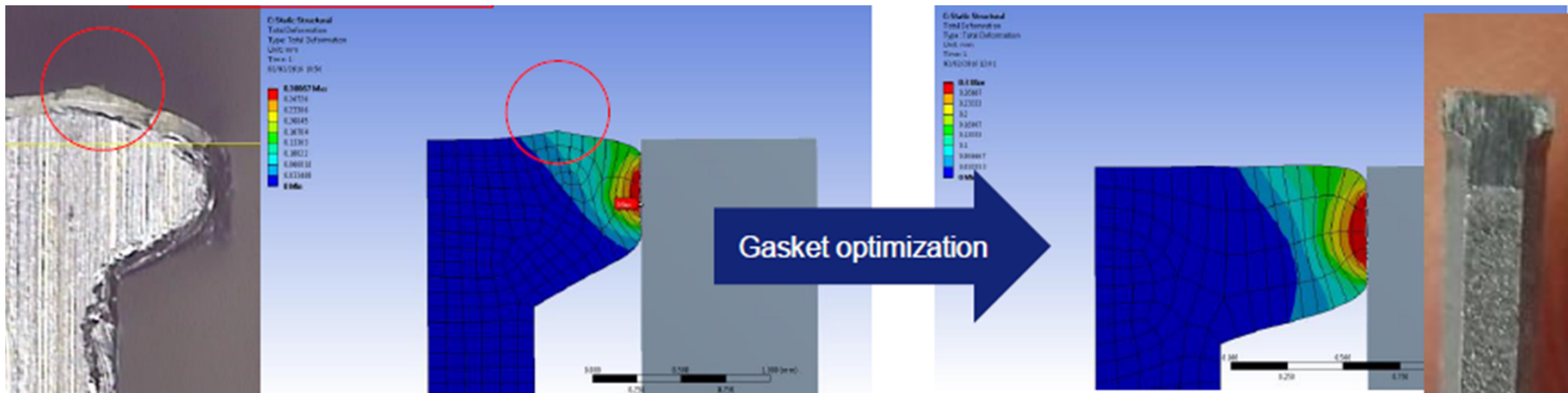
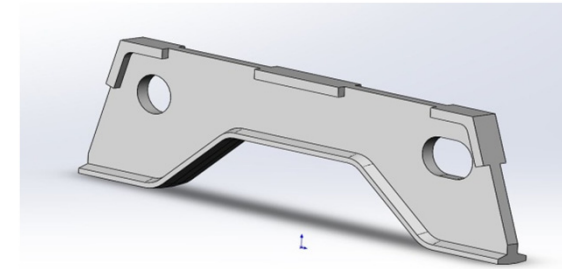
Test Bench





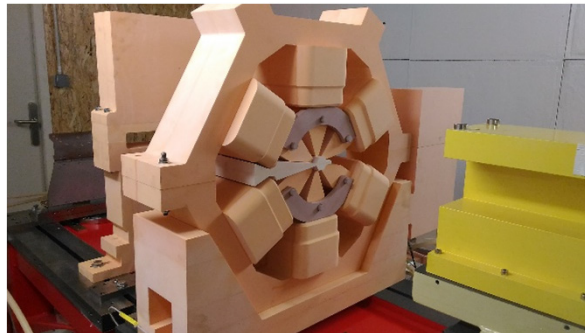
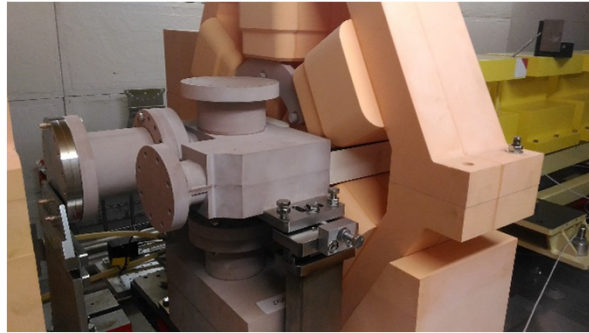
RF Gasket design

- First prototypes showing bump
- FE Model simulation
- Dimensions were optimized using the FE model
- New prototype test showed good results



P Brumund, T Brochard

Test assembly with mock-up to scale

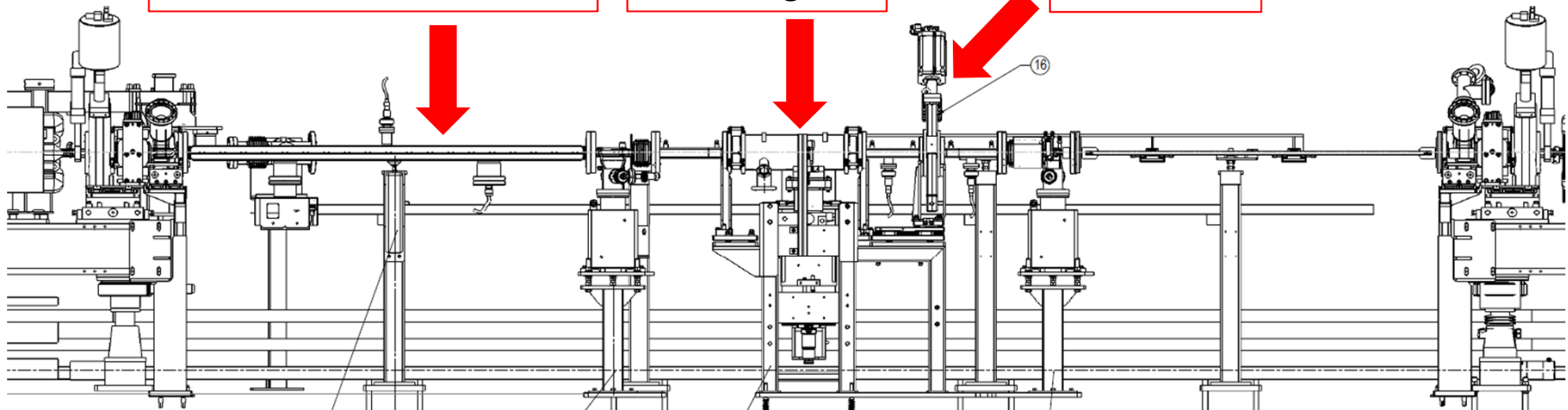


Vacuum and RF test of different devices on the existing machine

Aluminium Chamber

RF Fingers

RF Valve



The EBS lattice is technically demanding
We combined different technical solutions:

Material :

- Aluminium
- Stainles-steel

Manufacturing:

- Machined from block
- Welded assembly
- Folding (thin 1.5mm and thick 12mm)
- Stamping.

Vacuum:

- Ion pump
- Neg pump
- Neg coating

Absorber:

- Lumped absorber
- Distributed absorber

RF:

- New RF finger device
- RF gasket

Design: Mechanical, Vacuum, RF, Thermal, Cost constraints

- Many iterations to finalize dimensions & drawings
- Material choice
- FEA modelling
- Photon absorbers integration
- Magnets interferences
- Supports interface
- Ante-chamber internal profile ajustement

Contracts phase 1: Design review

- Manufacturers requirement
- Many iterations to finalize dimensions & drawings
- FEA modelling when thickness
- Magnets and correctors interferences verification
- Raw material dimensions modification

Contracts phase 2: Pre serie:

- End 2016



Now

THANK YOU FOR YOUR ATTENTION