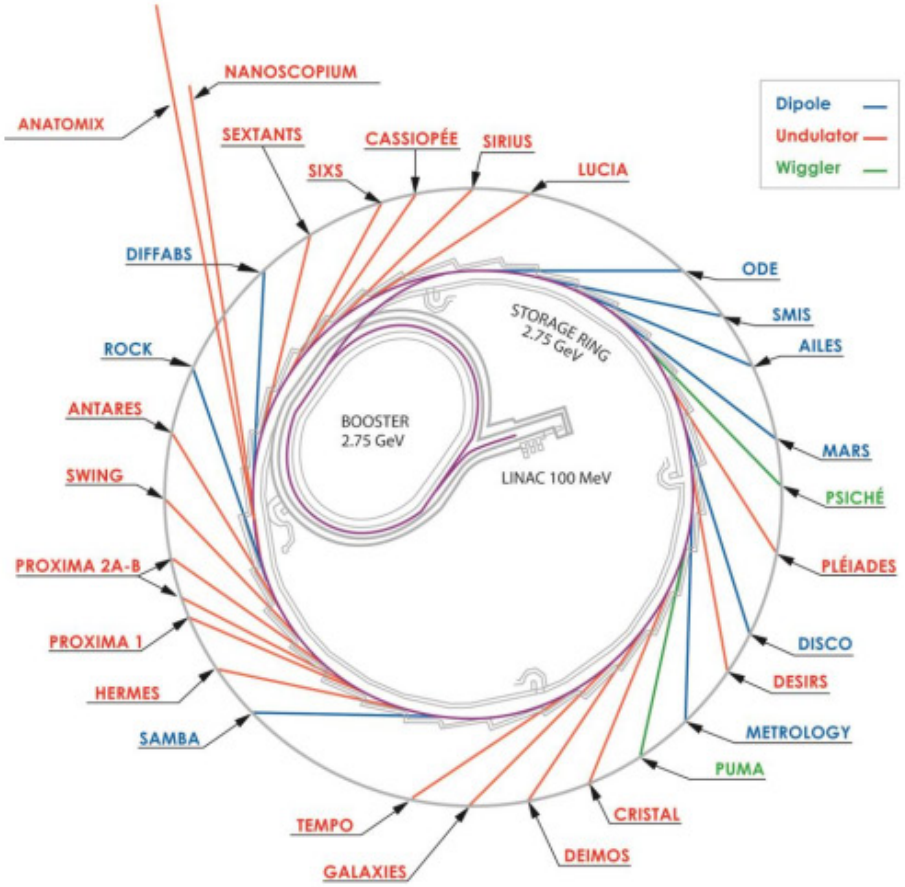
SOLEIL-II Mechanical Engineering Challenges

Keihan TAVAKOLI

SOLEIL Today

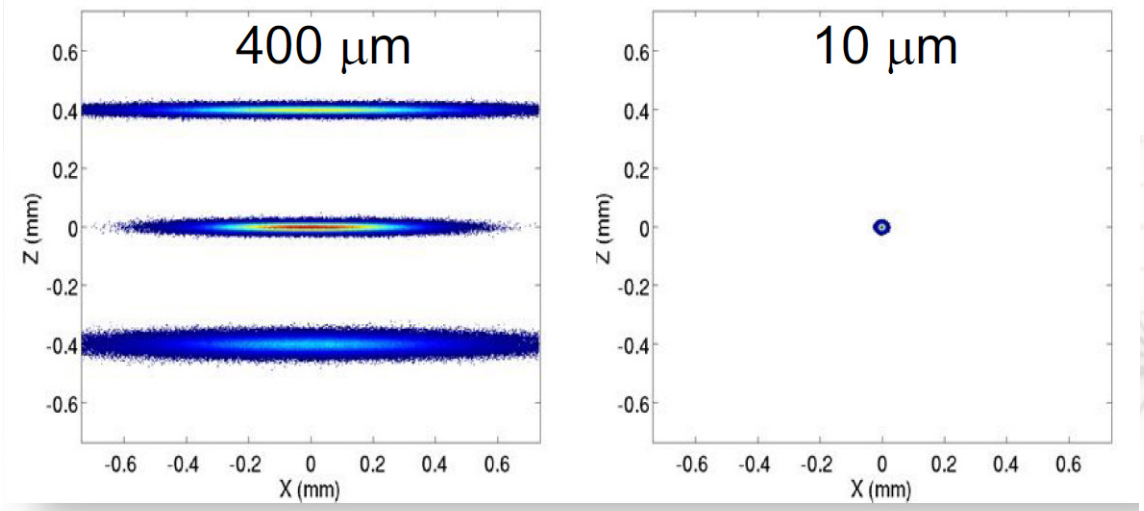
72%

28%



- Storage ring 354m, 2.75GeV
- 29 beamlines
- Open to external users in 2008
- Overall construction budget (full cost) ~600 M€
- Annual budget ~63 M€
- ~ 450 staff members

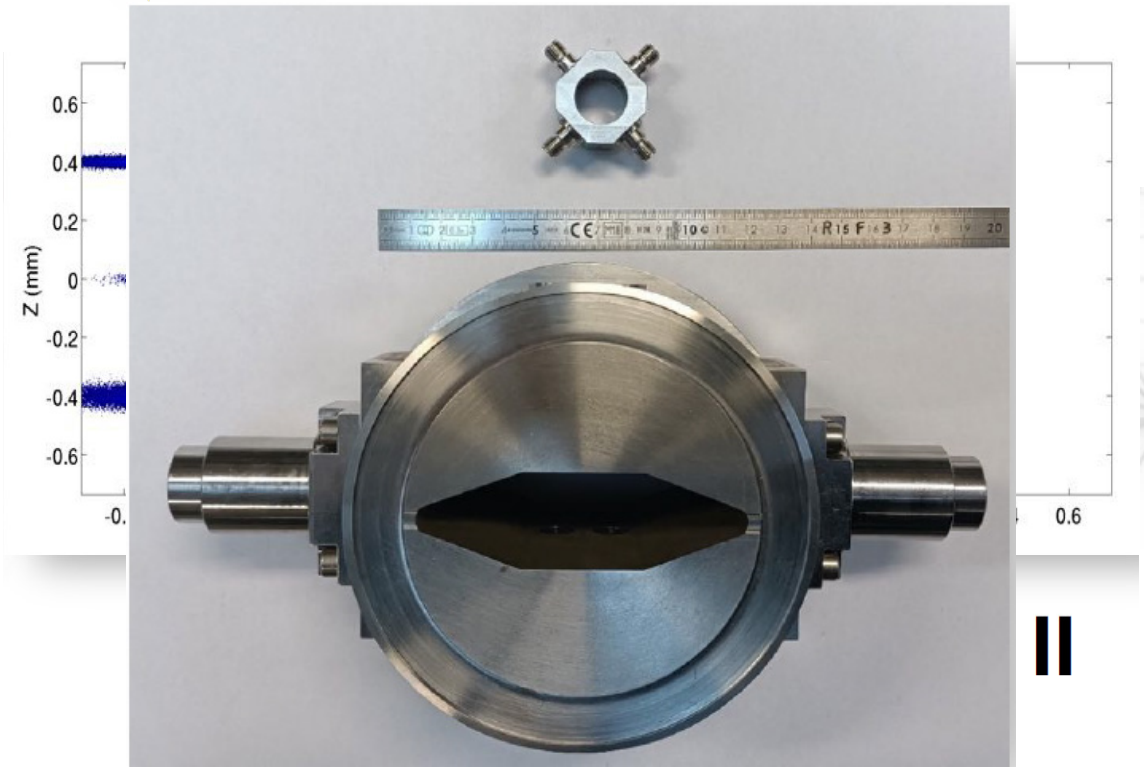
SOLEIL tomorrow: SOLEIL-II project



SOLEIL → SOLEIL II

1. Non-standard MBA lattice: 12 x 7BA + 8 x 4BA.
2. 85 pm.rad (63 pm.rad with IDs) / 2.75 GeV / 354 m.
3. 20 straight sections (4 of ~8 m; 4 of ~4.2 m ; 4 of ~3.6 m and 8 of ~3.0 m).
4. Large photon spectrum (far IR to hard X-rays).
5. NEG coated very small vacuum chamber diameter = 12 mm.
6. Extensive use of permanent magnets (All Dipoles, all RB and all main quadrupoles).
7. Miniaturization.
8. Off-axis injection.
9. High performance Multipole Injection Kicker (MIK).
10. Energy Savings.

SOLEIL tomorrow: SOLEIL-II project



II

1. Non-standard MBA lattice: 12 x 7BA + 8 x 4BA.
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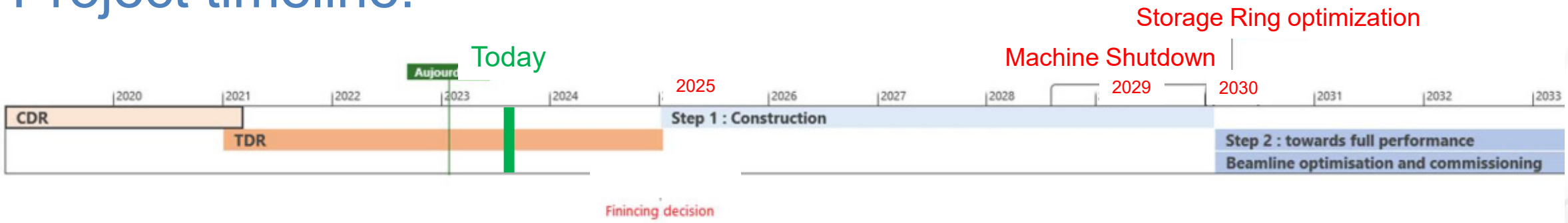
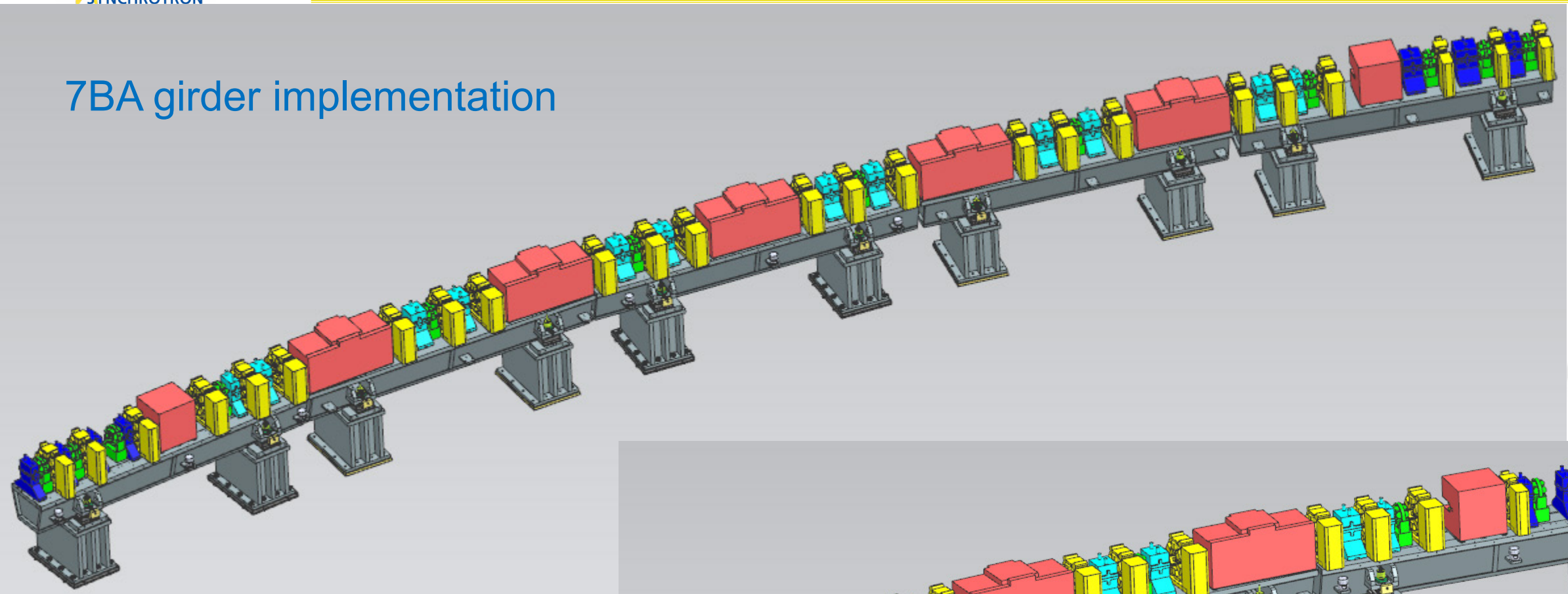
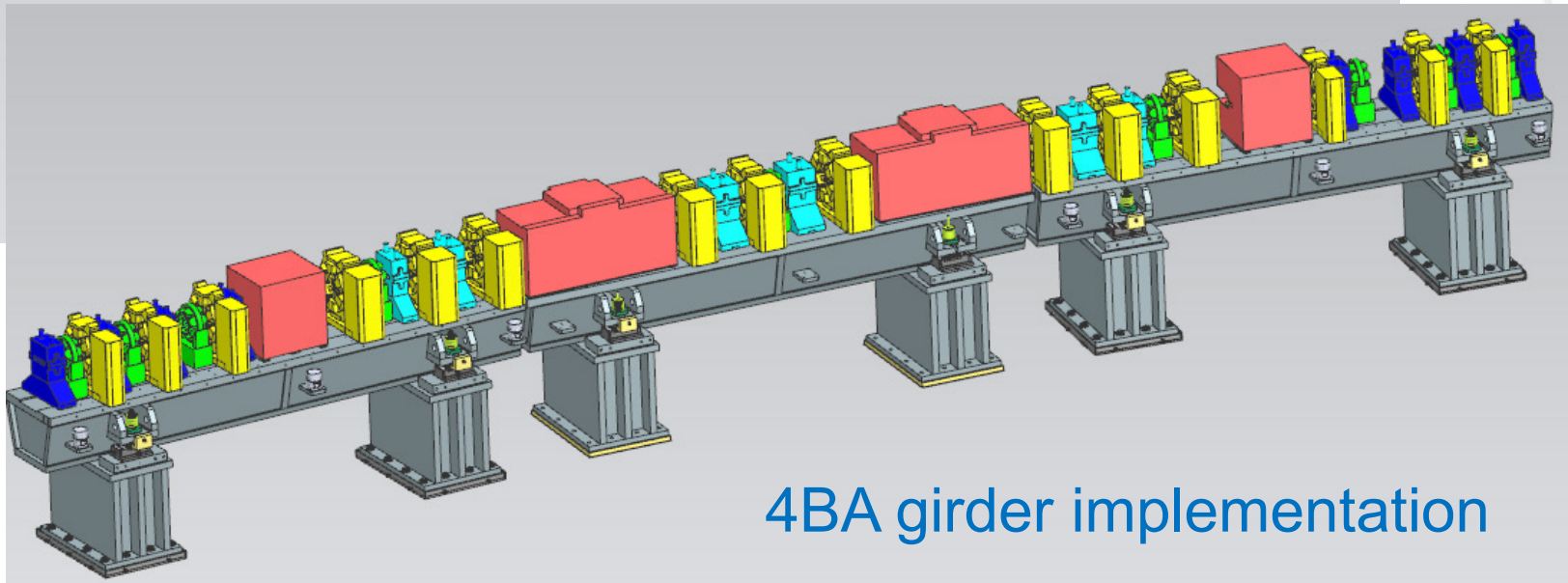
Project timeline:



Layout and general Implementation

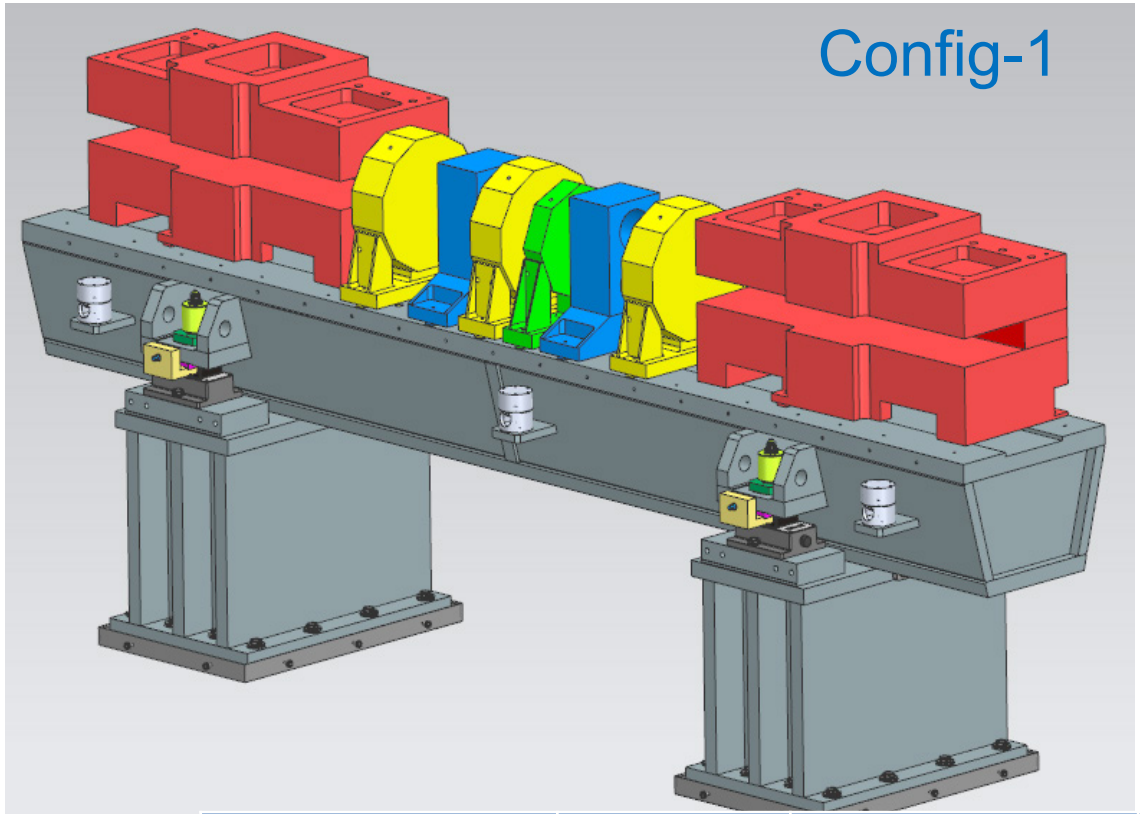
7BA girder implementation

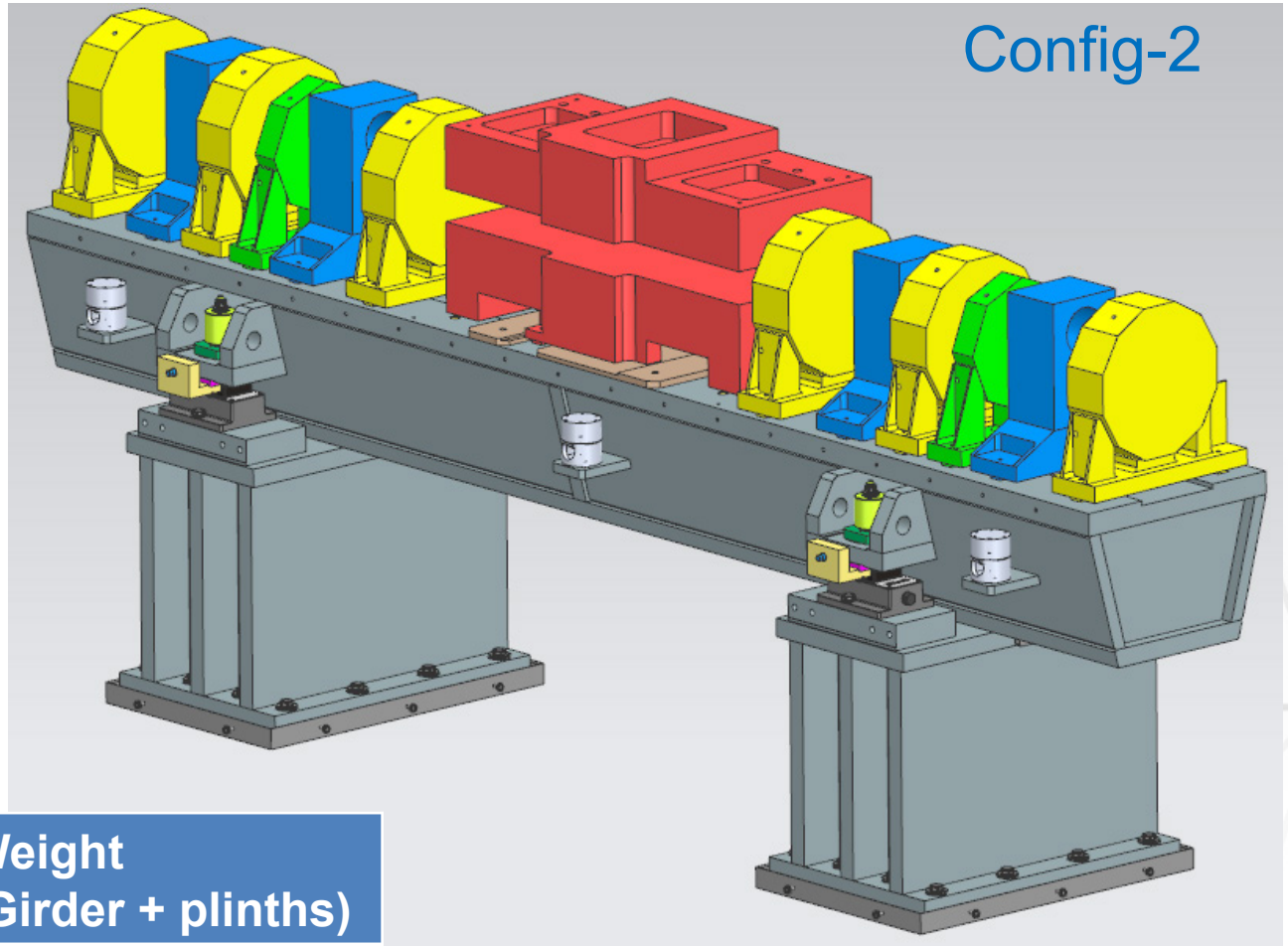




4BA girder implementation

Girder Design



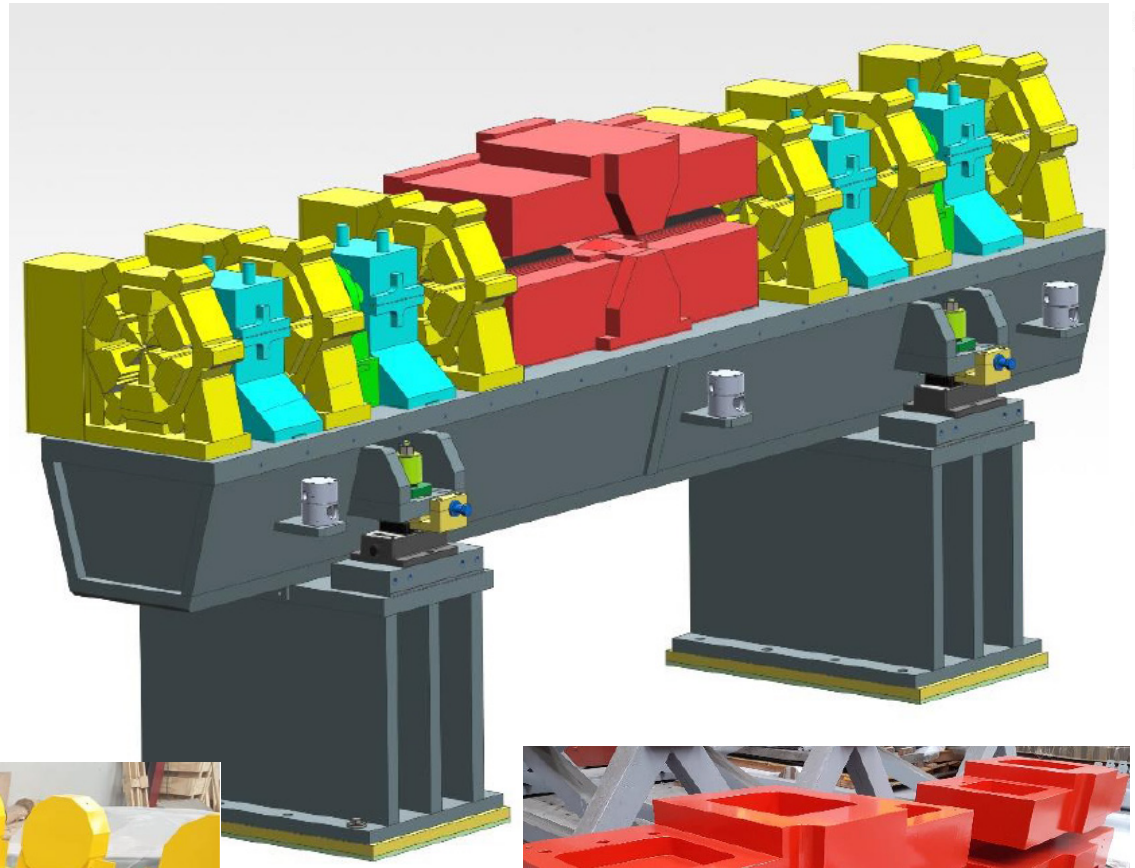


Type	Number	Length (mm)	Weight (Girder + plinths)
1 (Long)	12	3350	2700 kg
2 (Average)	36	3125	2600 kg
3 (Short)	36	3050	2500 kg
Triplet support	2	~1000	To be defined

Refer to poster THPPP038 (J.DASILVACASTRO) for more information about girder design

Girder Prototype

1st modal frequency 49,1 Hz

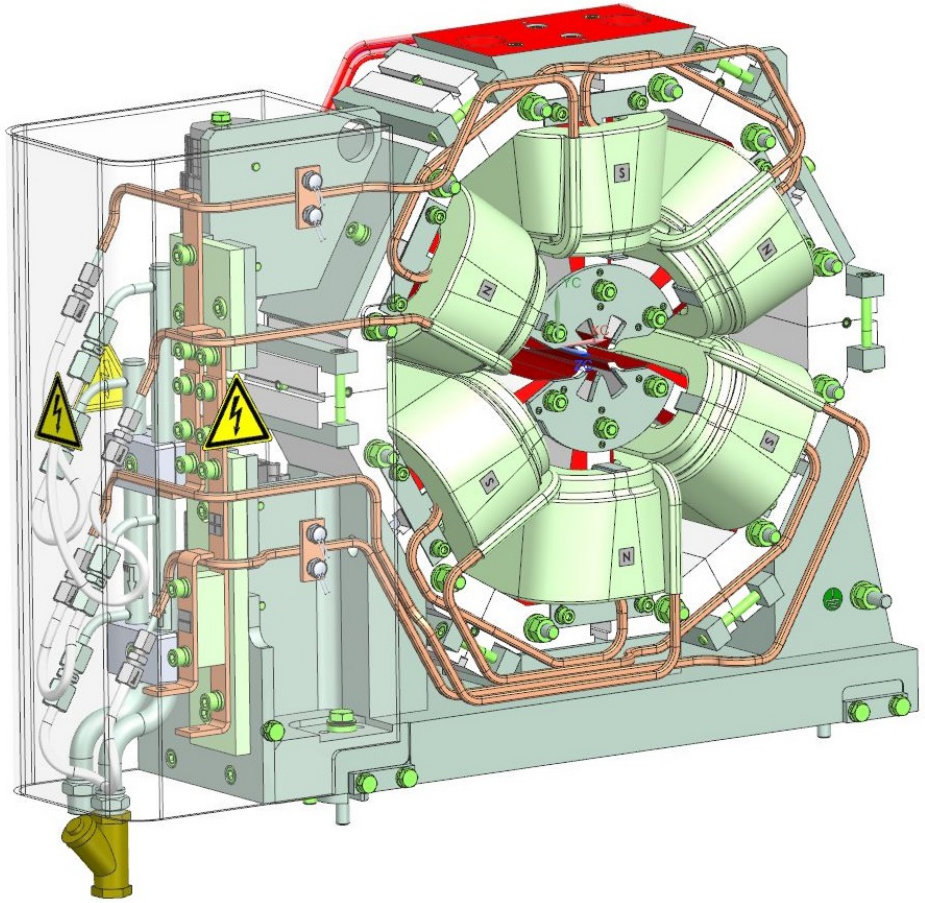


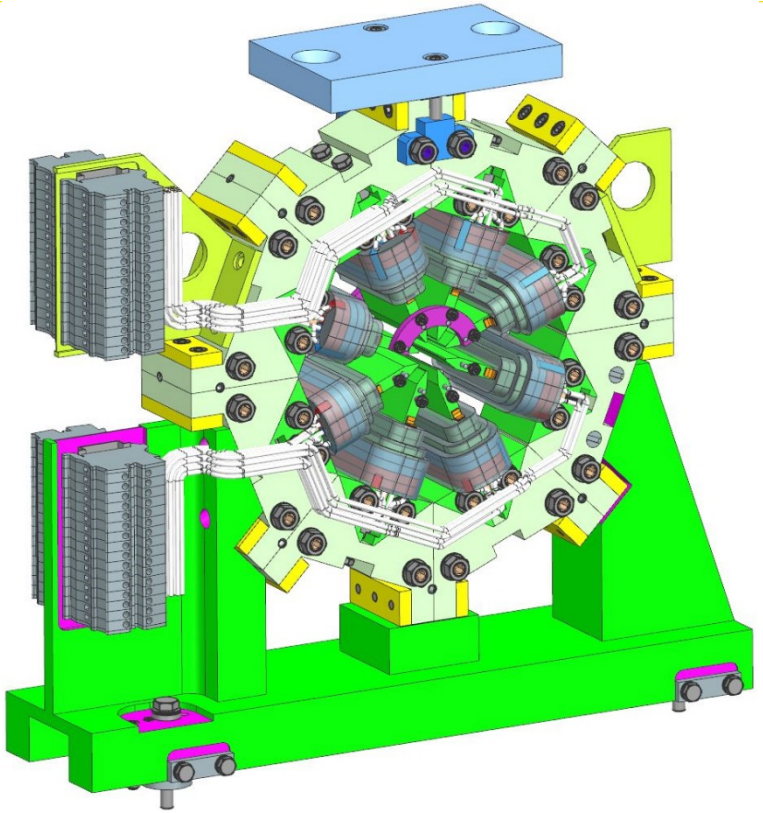
2nd modal frequency 58,7 Hz

Refer to poster THPPP038 (J.DASILVACASTRO) for more information about girder design

Magnet design

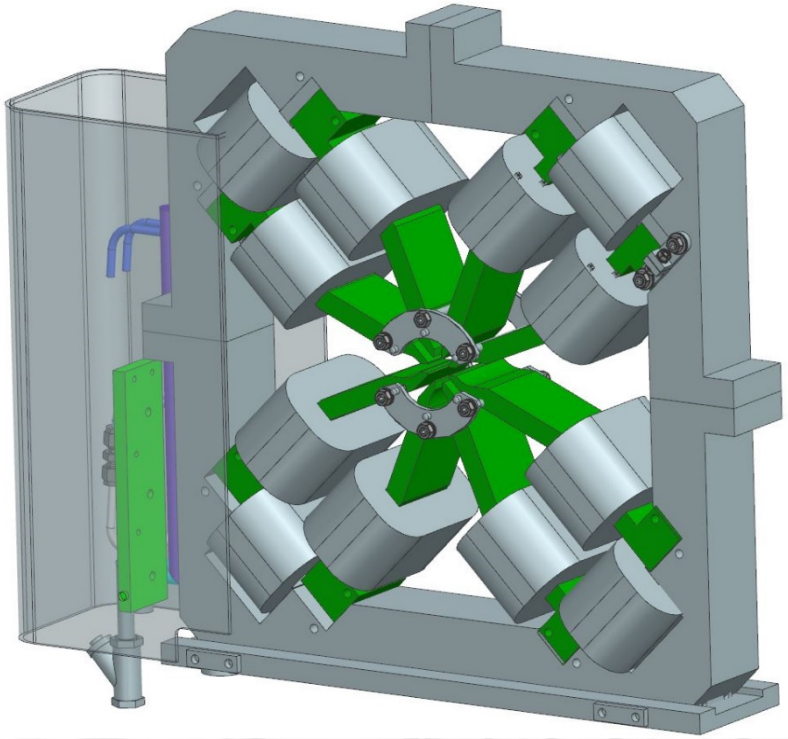
Sextupole magnet prototype entirely designed in house





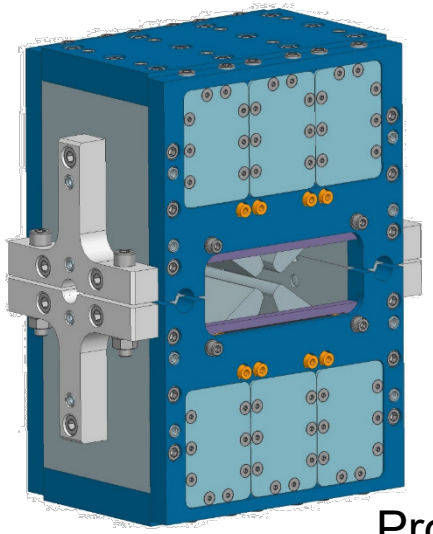
First attempt for octupole design but issues with photon extraction

A new version of octupole is under study

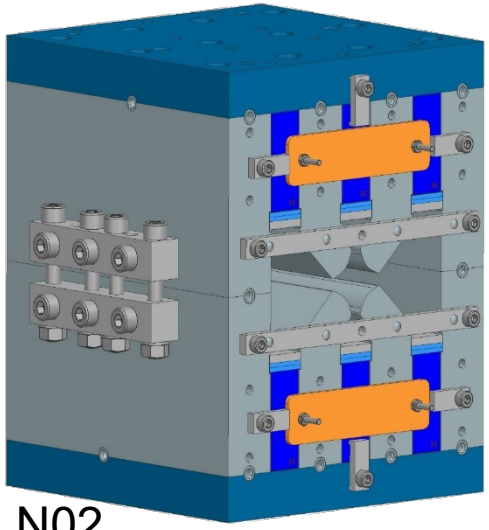


Courtesy of V. Pinty – S. Thoraud - GMI

PM Quadrupole design and prototyping

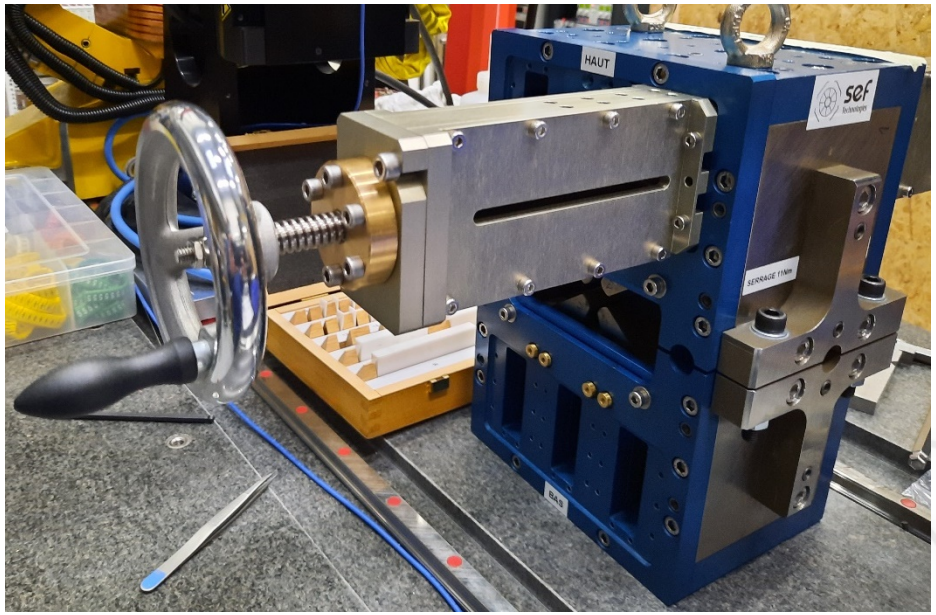


- Pole tip shape
- No coils
- More space for thermo-shim
- Less parts
- Shunt between poles
- Simpler clamps



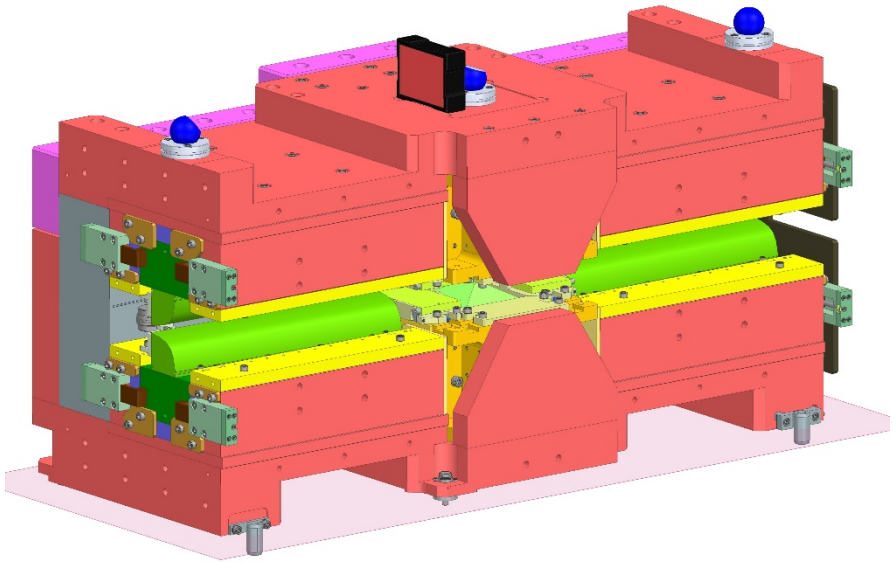
Prototype N01
L=100 mm

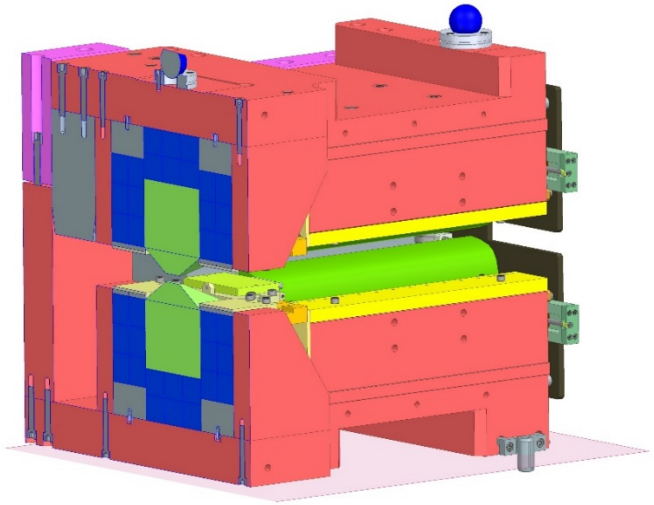
Prototype N02
L=180 mm



Courtesy of A. Berlioux – A. Mary - GMI

Superbend 3T and dipole retracting system

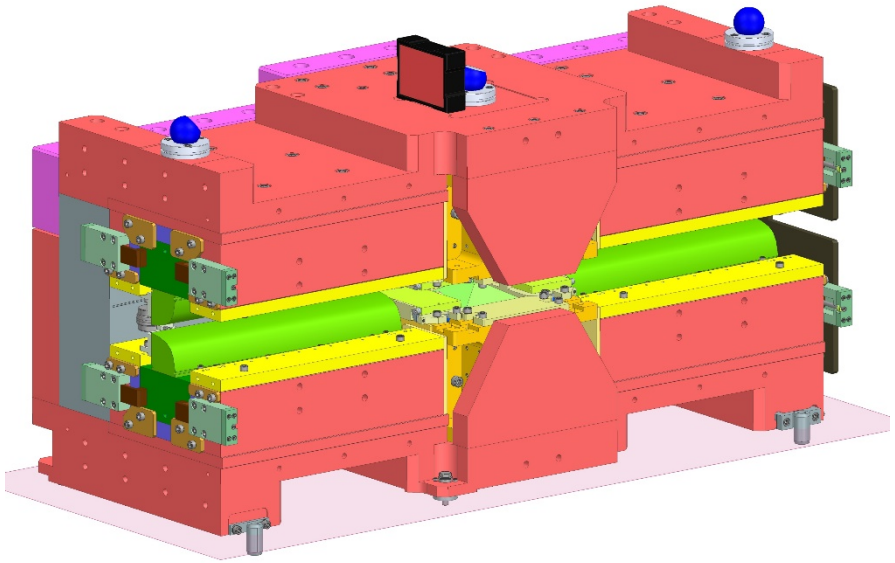


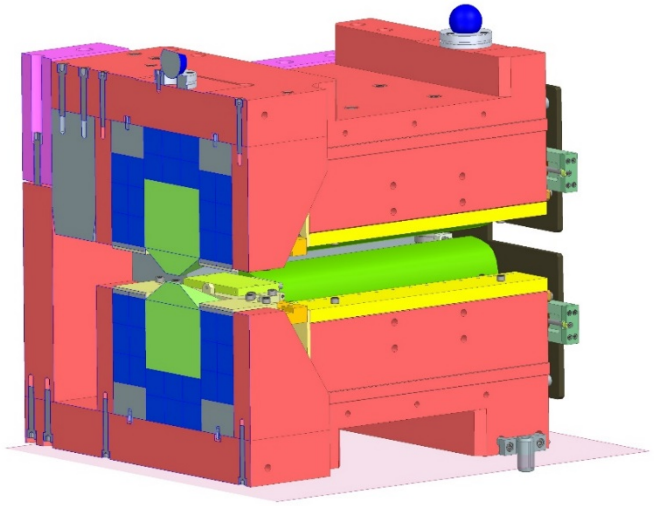


Refer to poster WEPPP058 (A.BERLIOUX) for more information about magnet design

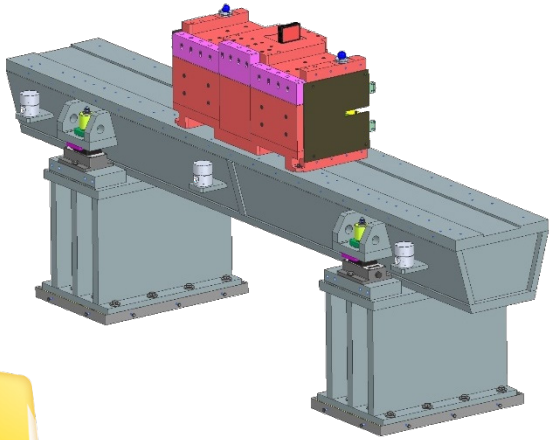
Courtesy of A. Berlioux – E. Raimon - GMI

Superbend 3T and dipole retracting system

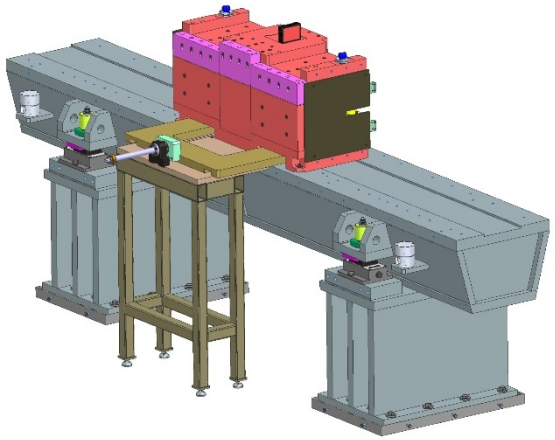




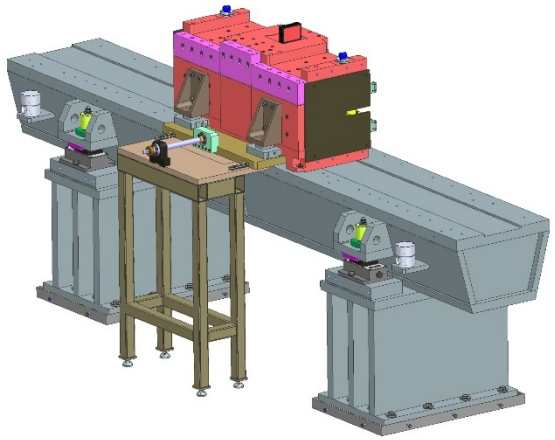
Refer to poster WEPPP058 (A.BERLIOUX) for more information about magnet design



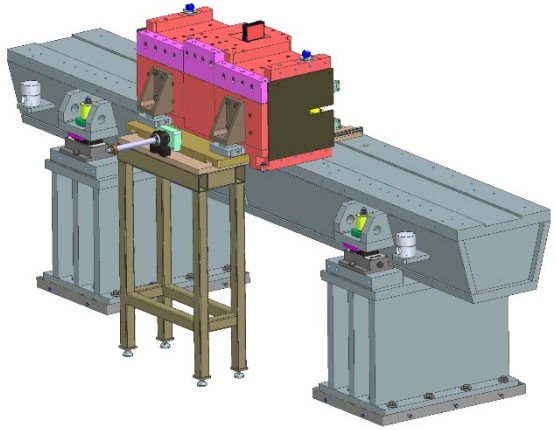
Initial position



Extraction tooling assembly



Insert wedges between dipole and moving plate



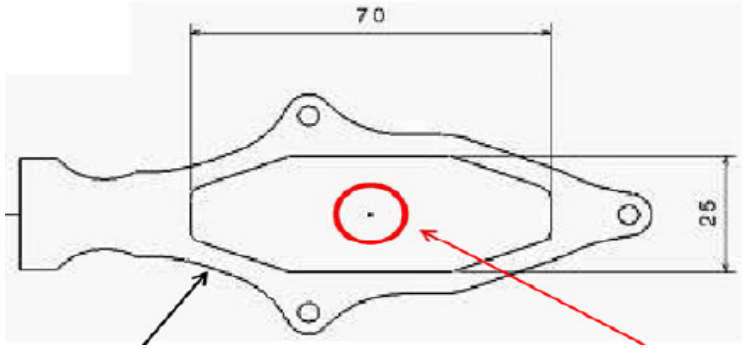
Lifting and dipole extraction

Courtesy of A. Berlioux – E. Raimon - GMI

Vacuum System Main Features and Targets

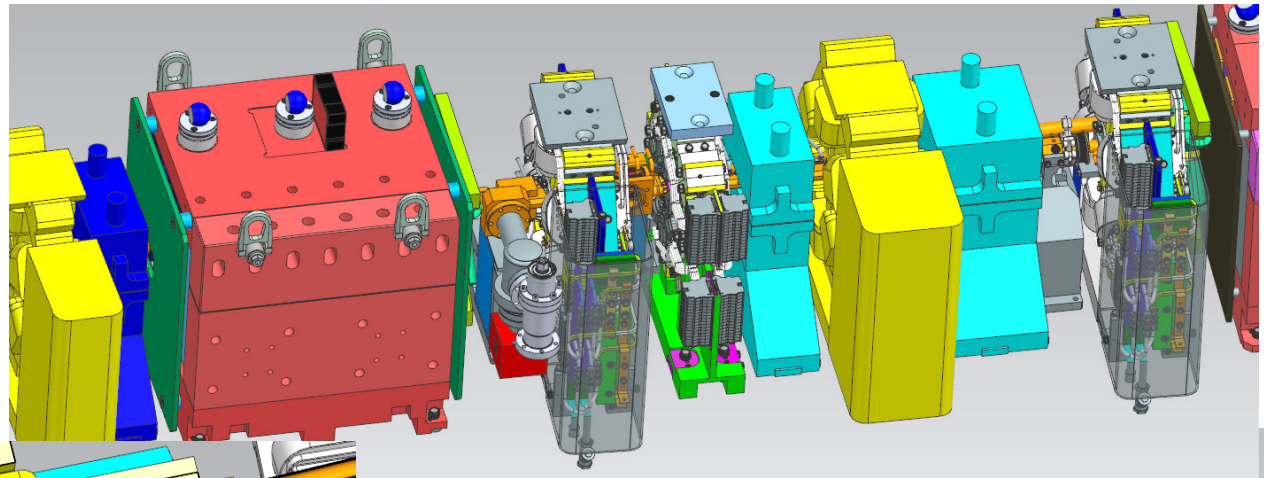
- 100% Full distributed Ti-Zr-V NEG coating / from 0.5 µm to 1 µm max. average thickness
- 1 standard pump [Getter/SIP] after each Dipole
- Ex-Situ bakeout

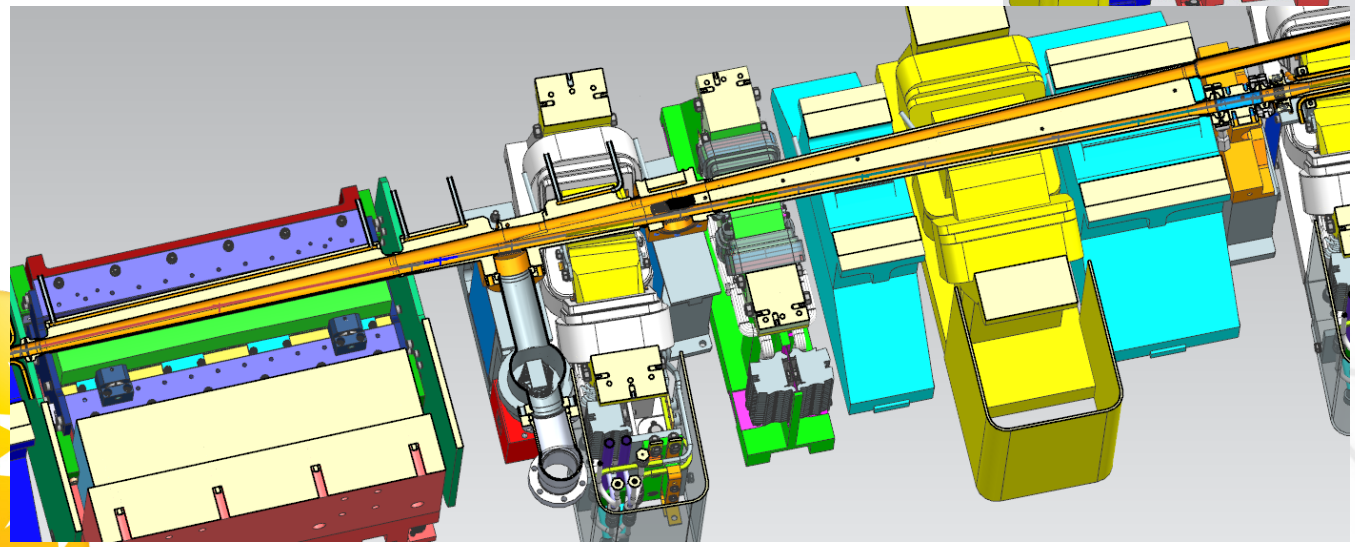
Pressure Target < 10^{-9} mbar @ 500 mA - Integrated dose 100 A.h

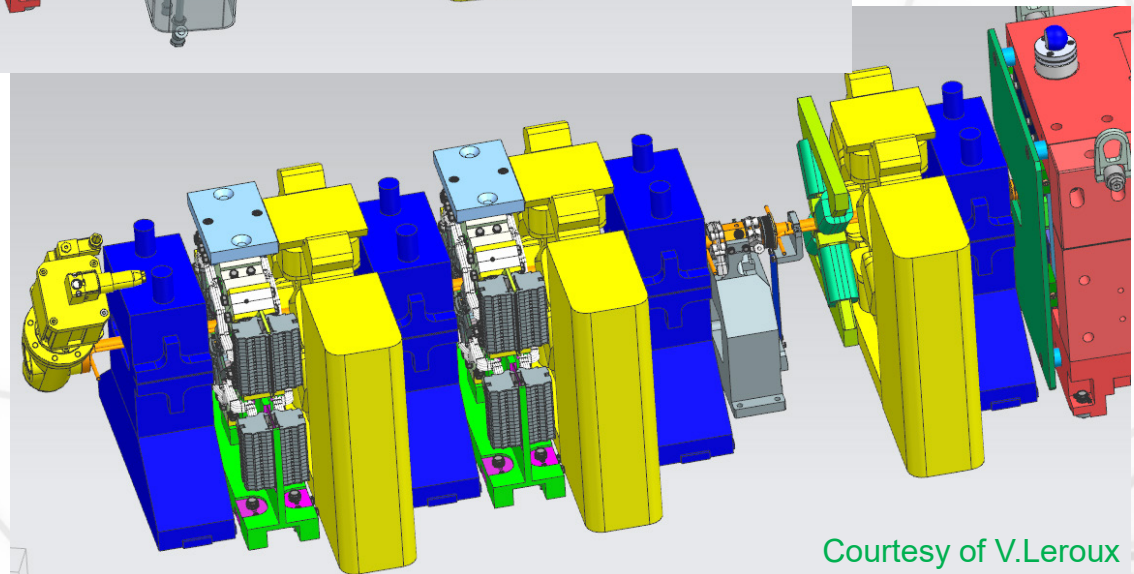


SOLEIL today

SOLEIL-II (Ø12 mm)







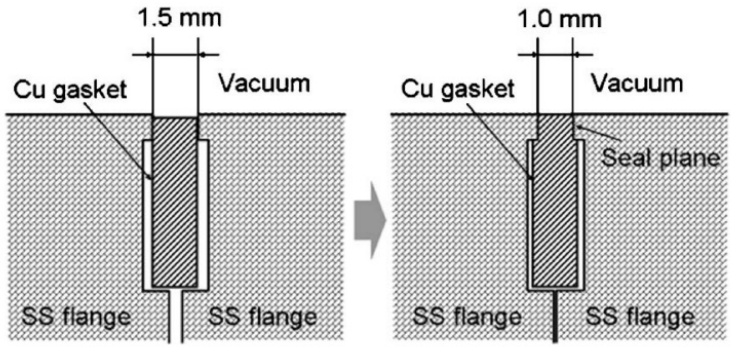
Courtesy of V.Leroux

Flanges and gasket type

RF continuity and the vacuum seal are made by the same gasket

‘MO type seal flange’

1

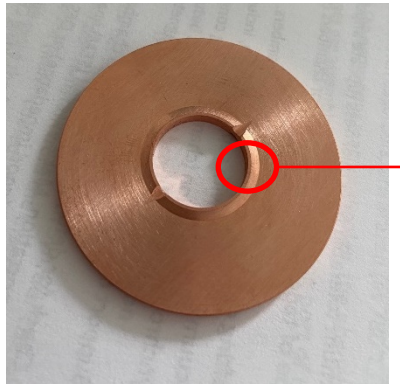


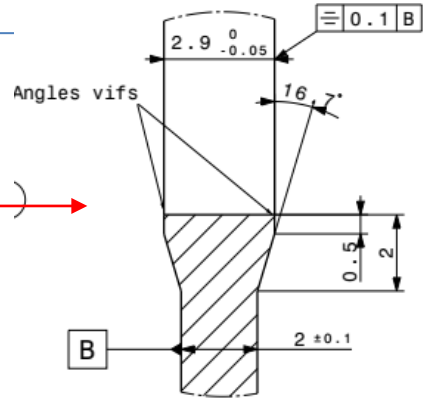
Y. Suetsugu, M. Shirai, M. Ohtsuka “*Application of a Matsumoto-Ohtsuka-type vacuum flange to beam ducts for future accelerators*” **J. Vac. Sci. Technol. A 23 (6), Nov/Dec 2005**

Connection between chambers down to a DN12 opening

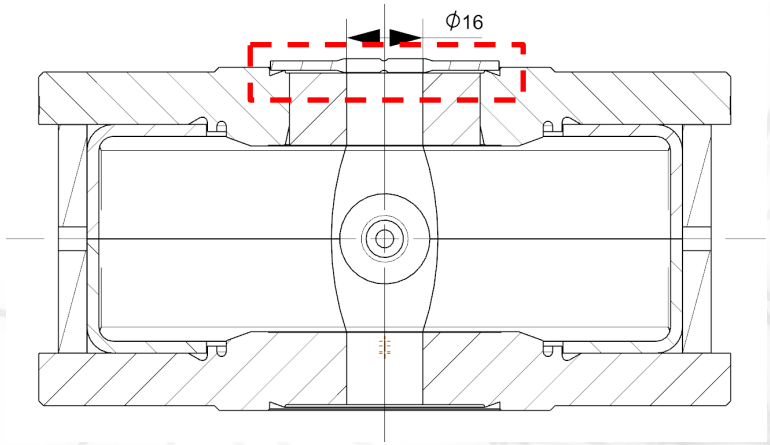
‘CF/RF seal flange’

2



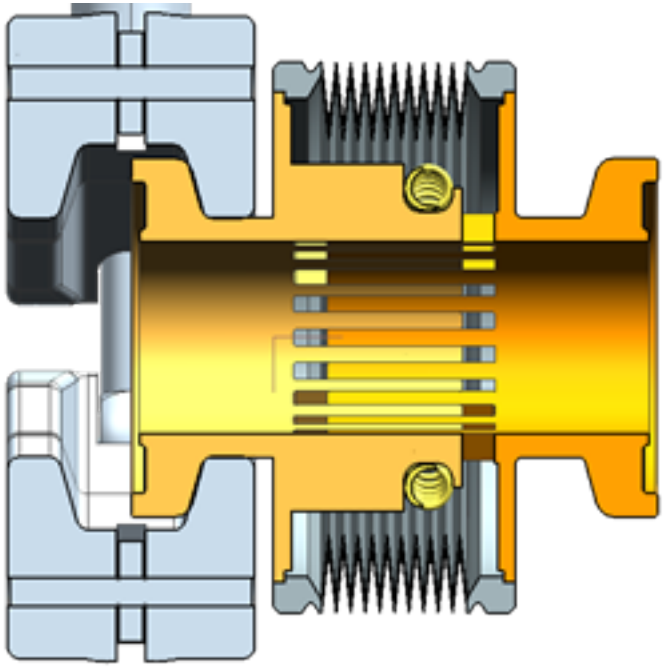


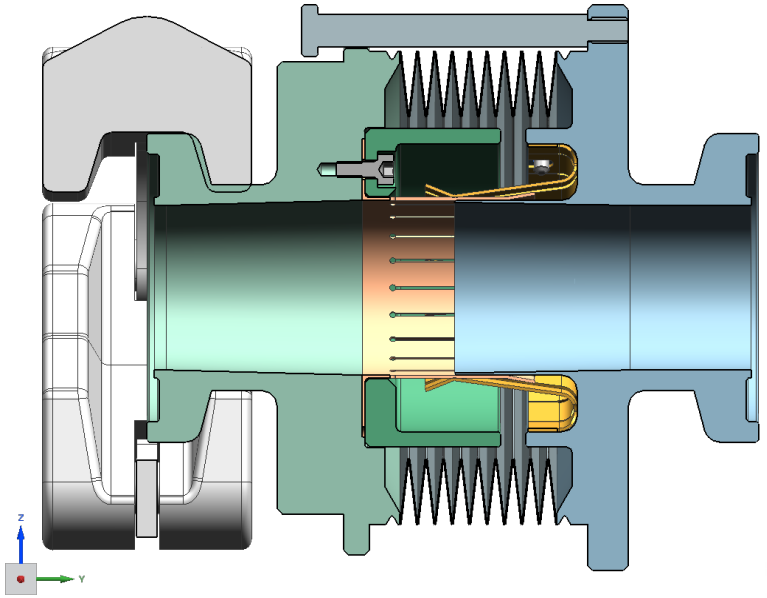
RF gate valve and DN16+ opening



Courtesy of V.Leroux, N.Bechu, F. Alves

Ultra compact bellows





Prototype of a “COMB type” bellow for the ACHROMAT

→Small stroke

→Impedance optimized

Prototype of a “RF finger type” bellow for the Straight Sections

→ more standard design but ‘narrowed’

→Larger stoke

Courtesy of V.Pinty, V.Leroux

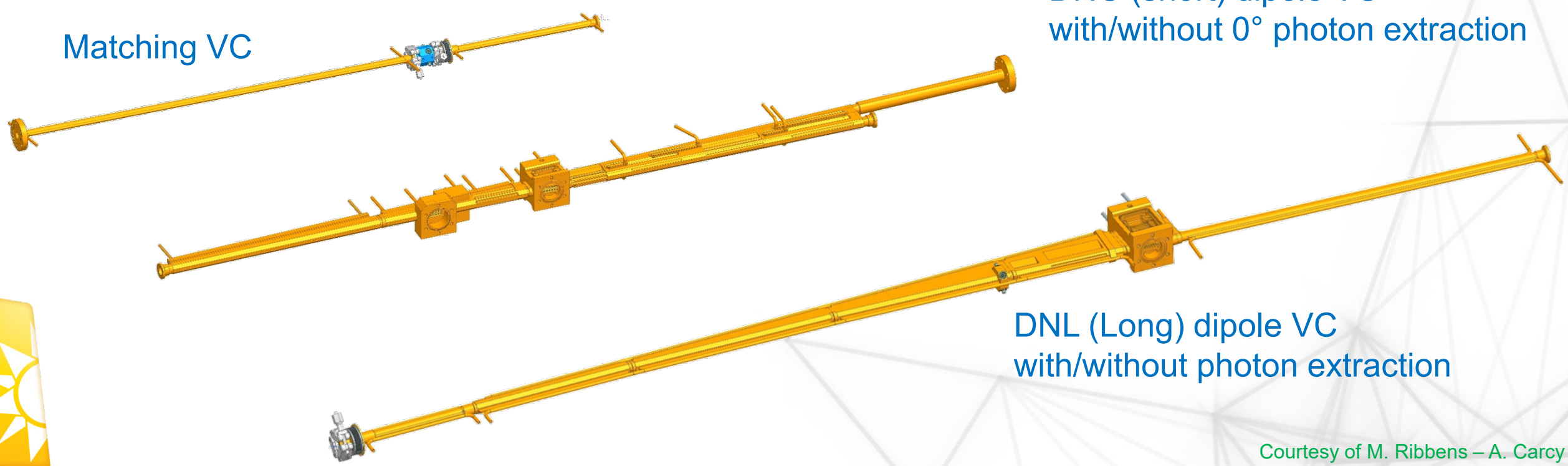
Vacuum chamber design

The vacuum system on an arc is composed of three main components:

- Matching vacuum chamber at entrance and exit of the arc
- Short Dipole (DNC) vacuum chamber
- Long Dipole (DNL) vacuum chamber

Matching VC

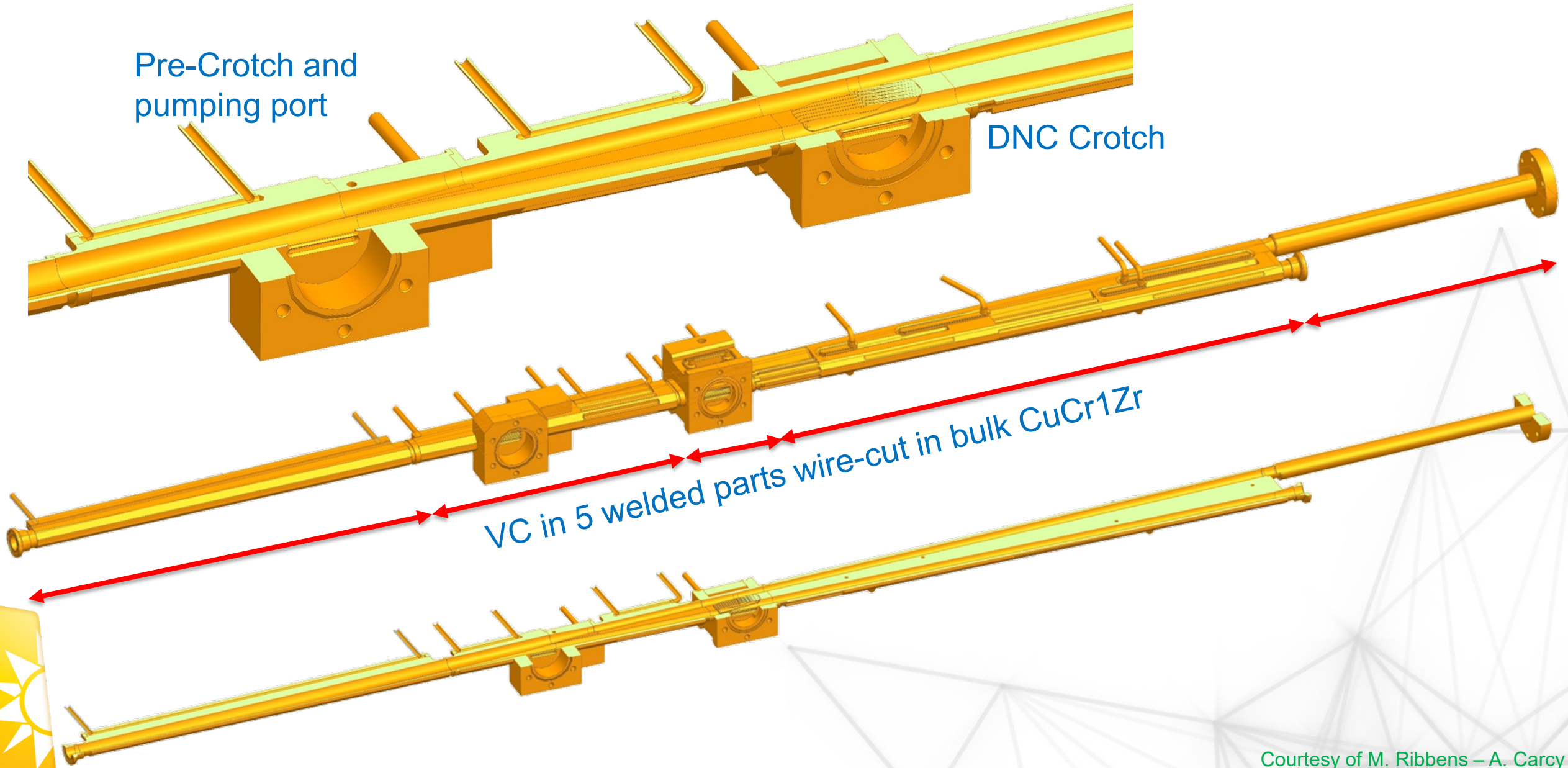
DNC (short) dipole VC
with/without 0° photon extraction



DNL (Long) dipole VC
with/without photon extraction

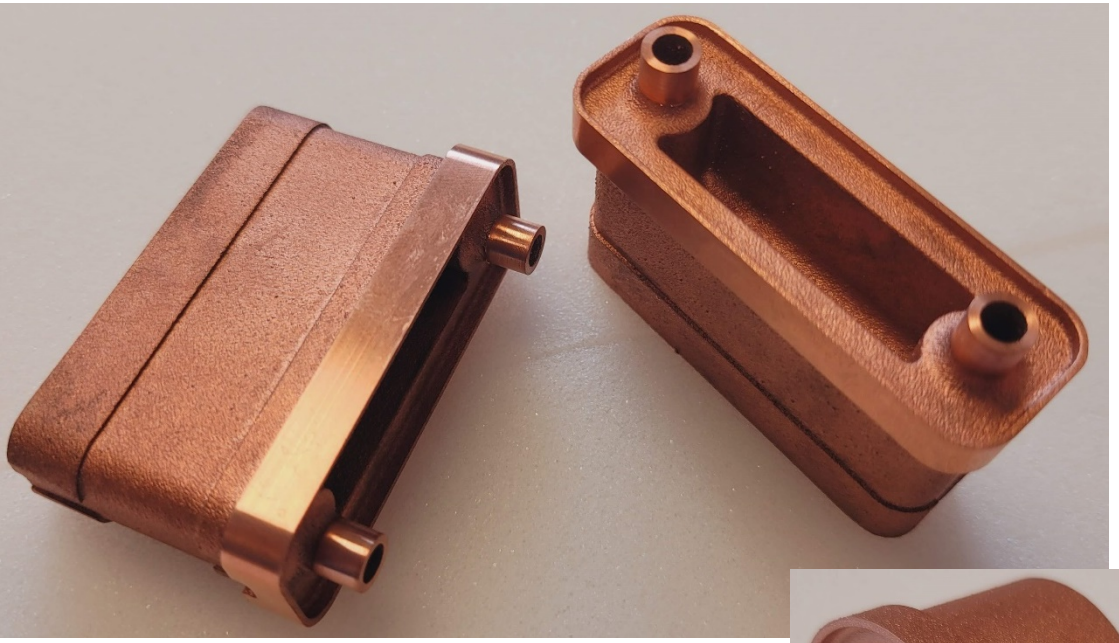
Courtesy of M. Ribbens – A. Carcy

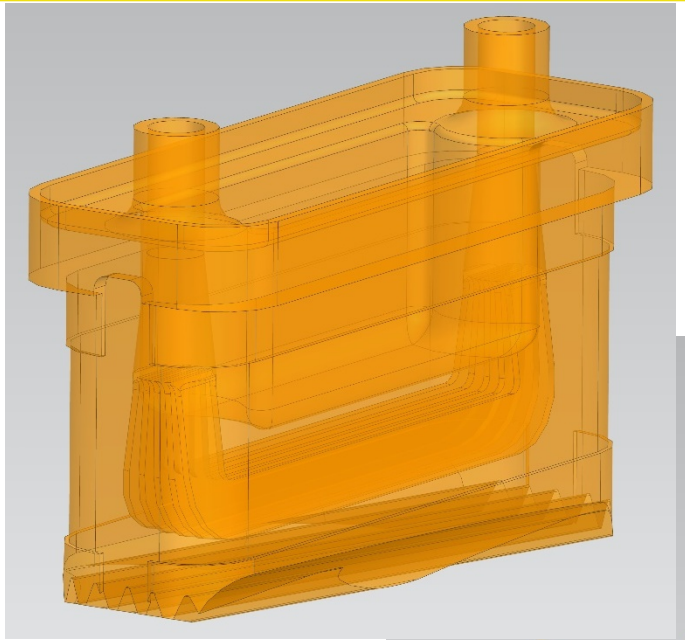
Short Dipole (DNC) Vacuum chamber design

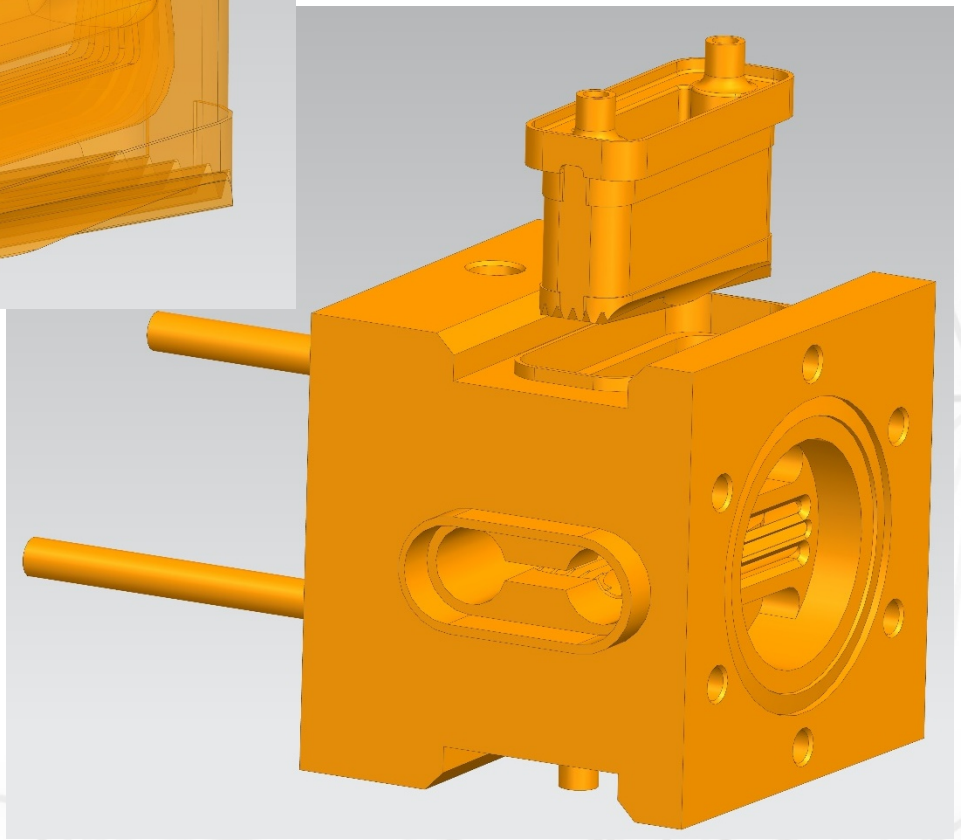


Courtesy of M. Ribbens – A. Carcy

Short Dipole (DNC) Vacuum chamber design



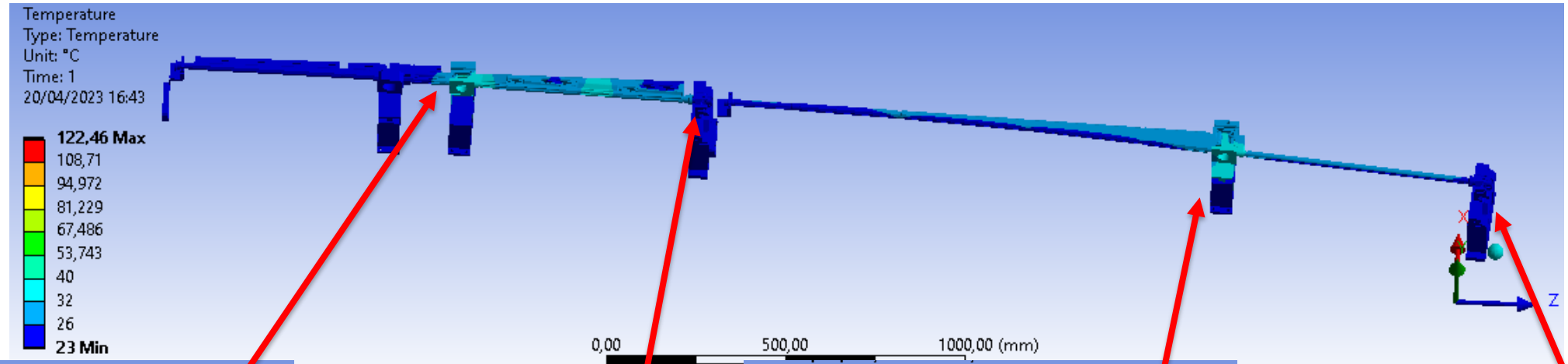


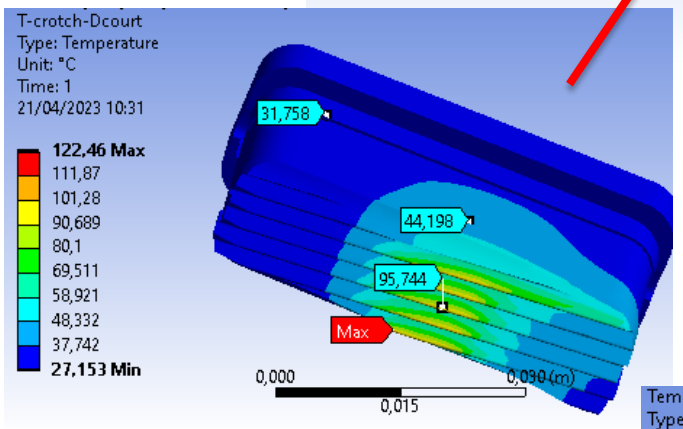


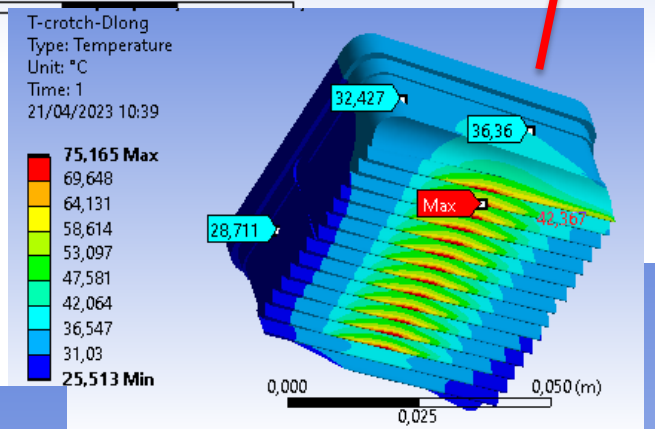
Crotch absorber prototype in Additive manufacturing (AM)

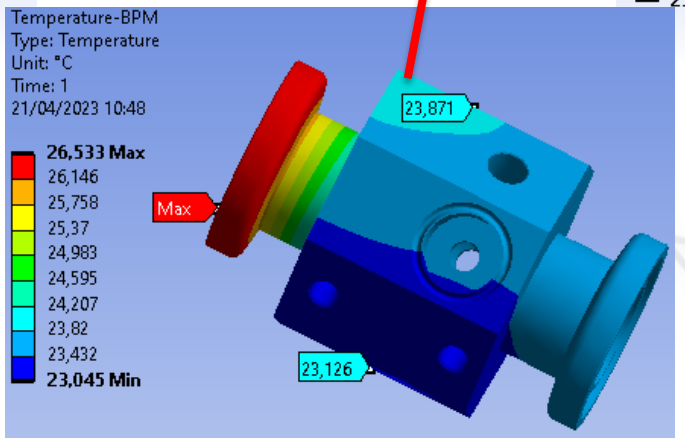
Welding samples in AM for procedure approval

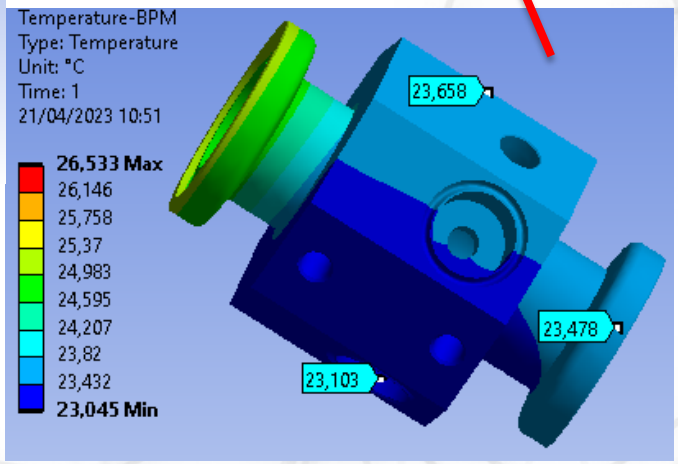
Vacuum chamber design: Temperature distribution









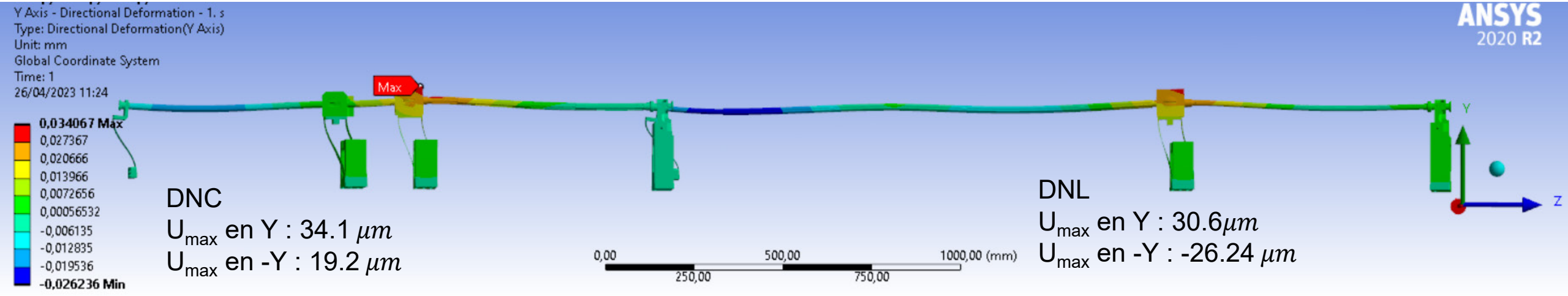


The maximum temperature on the crotch is reduced by 32° on the AM version

Courtesy of Z. Fan

Vacuum chamber design: deformations

Vertical displacement with ideal bellows:



DNC

U_{max} en Y : 34.1 μm

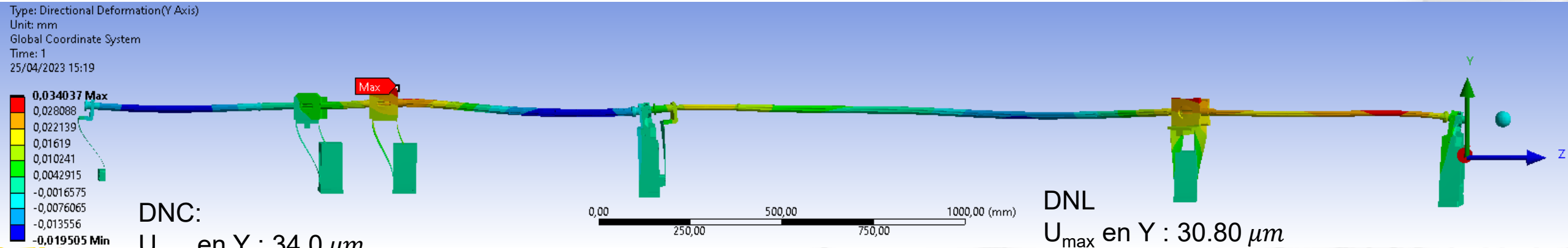
U_{max} en -Y : 19.2 μm

DNL

U_{max} en Y : 30.6μm

U_{max} en -Y : -26.24 μm

Vertical displacement without bellows:



DNC:

U_{max} en Y : 34.0 μm

U_{max} en -Y : 19.5 μm

DNL

U_{max} en Y : 30.80 μm

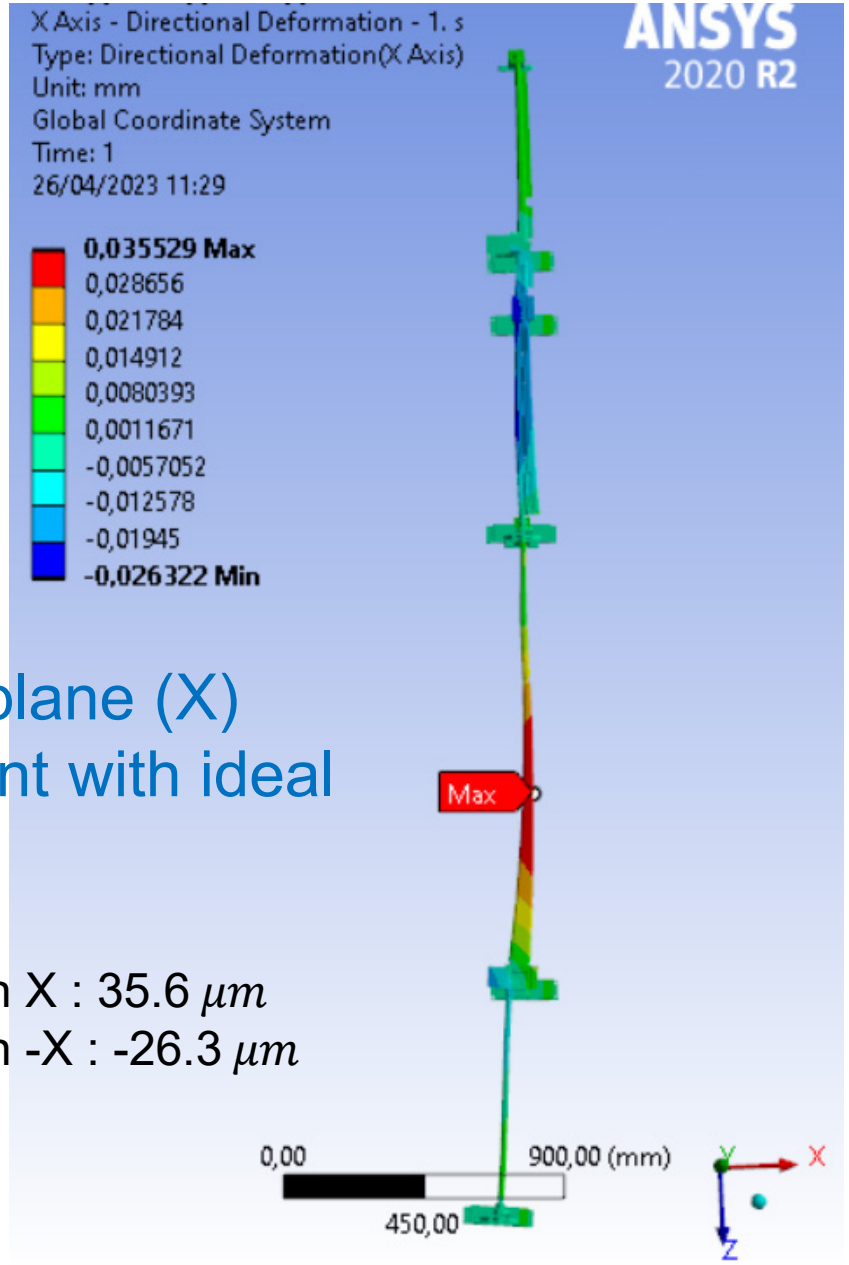
U_{max} en -Y : -15.03 μm

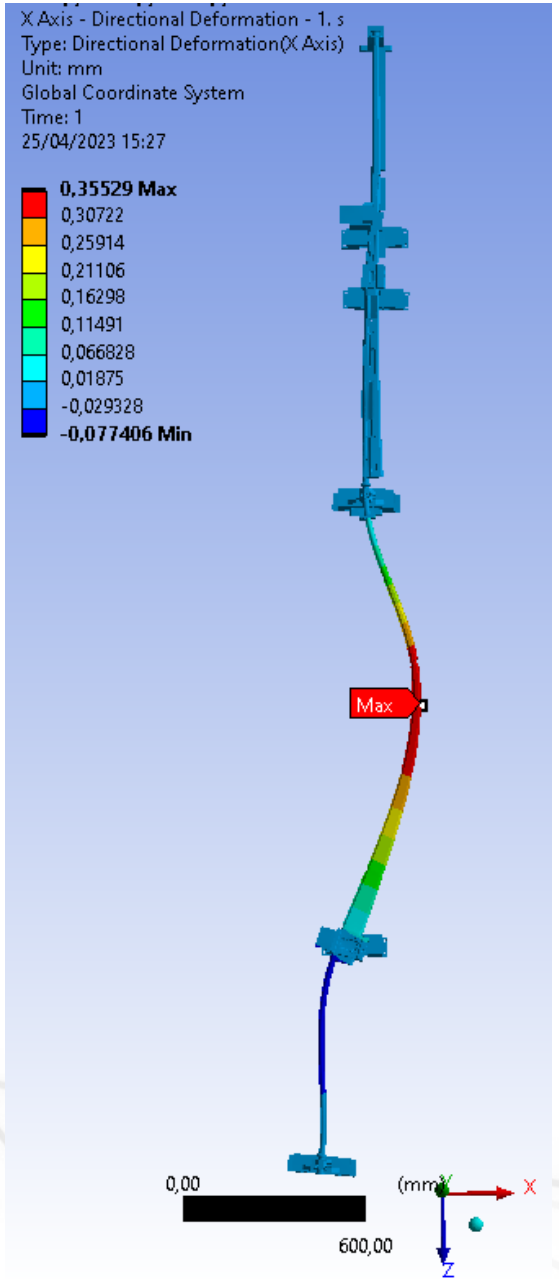
Courtesy of Z. Fan

Vacuum chamber design: deformations

Horizontal plane (X) displacement with ideal bellows

U_{max} in X : 35.6 μm
U_{max} in -X : -26.3 μm





Horizontal plane (X) displacement without bellows

U_{max} in X : 355.3 μm
U_{max} in -X : -77.4 μm

<u>No impact on the beam:</u>

Beam Stay Clear < 12 mm for a Ø16 mm DNL vacuum chamber

Courtesy of Z. Fan

Conclusion

- SOLEIL-II is a very challenging project,
- The lattice has only a symmetry of 2 including two different type of cells (7BA & 4BA), independent design for each cell is required….
- The lack of space between multipoles forces us to miniaturize all elements,
- The vacuum chambers act also as photon absorbers!
- The crosstalk between all magnets needs to be taken into consideration

Acknowledgment

On behalf of all my colleagues:

Mechanical Engineering and FE:

- Filipe ALVES
- Gil BARANTON
- Youness BENYAKHLEF
- Anthony BERLIOUX
- Jose DASILVA CASTRO
- Zhengxuan FAN
- Antoine LEJOLLEC
- Victor PINTY
- Marc RIBBENS

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- Jessy BOUILLAUD
- Carlos DE OLIVEIRA
- Armindo MARQUES
- Pascal PROUT

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- François LEPAGE
- Arnaud MARY
- Stephanie PAUTARD
- Emmanuelle RAIMON
- Serge THORAUD