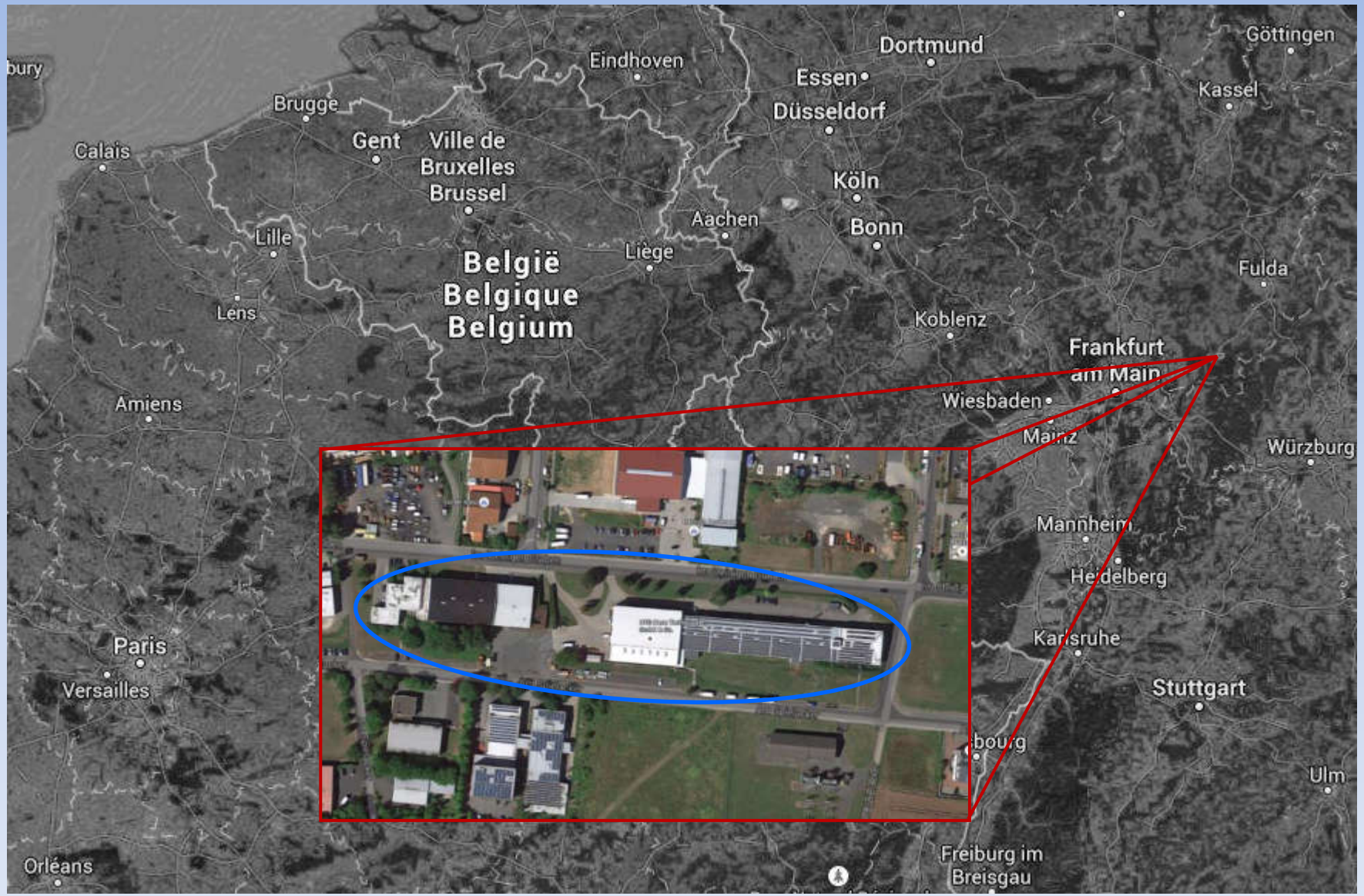
EST. 1968, 100 staff members

LINAC production and commissioning from a company's perspective

Alexander Bechtold

where we are


Eindhoven
Dortmund
Göttingen
Essen
Kassel
Brugge
Düsseldorf
Calais
Gent
Ville de
Bruxelles
Brussel
Köln
Aachen
Bonn
Lille
Liège
België
Belgique
Belgium
Fulda
Lens
Koblenz
Frankfurt
am Main
Amiens
Wiesbaden
Mainz
Würzburg
Mannheim
Heidelberg
Paris
Karlsruhe
Versailles
Stuttgart
Ulm
Orléans
Freiburg im
Breisgau

Looking inside

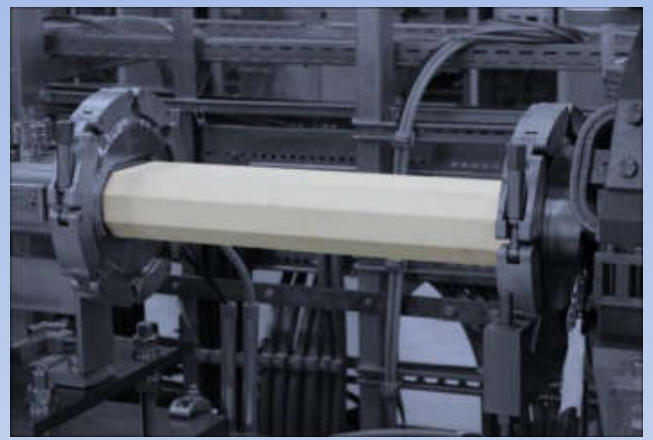
Machines

Deckel-Maho DMC 210 FD

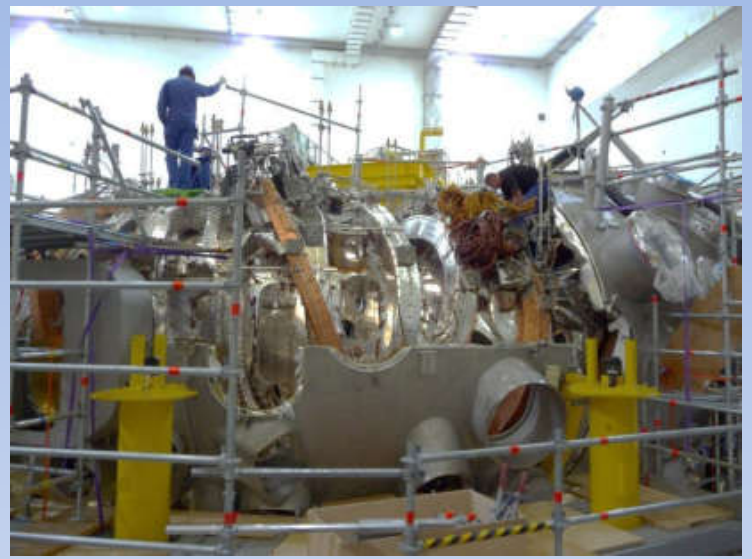
Branches

Vacuum Technology

- Nanotechnology (IBF)
- R&D Projects
- Ceramic to Metal Assemblies
- **Particle Accelerators**
- Beam Diagnostic devices
- Job-Work Production



R & D Projects



Wendelstein WX7

Microwave Mirrors

Microwave Mirror

Cavities

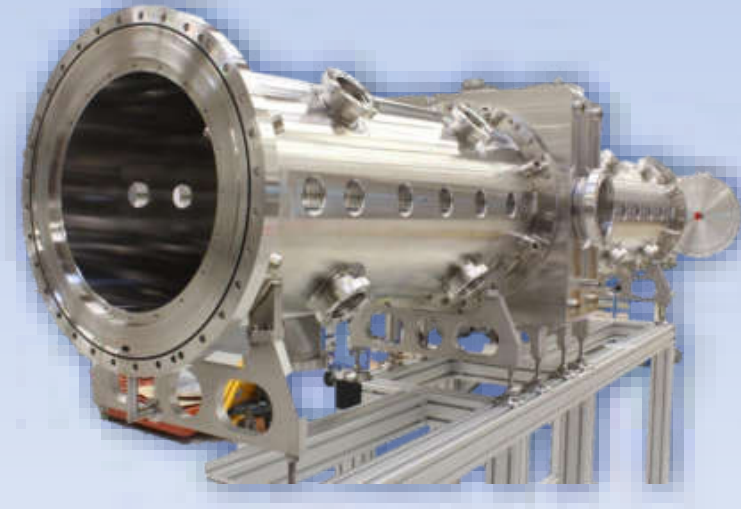
RFQs (e.g. CERN REX-ISOLDE)

MedRFQ

SARAF

DTLs

IH5 VECC

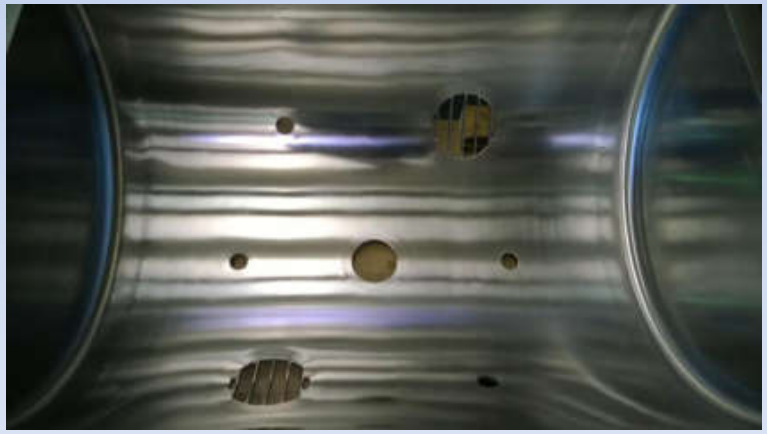


CH-Plinac

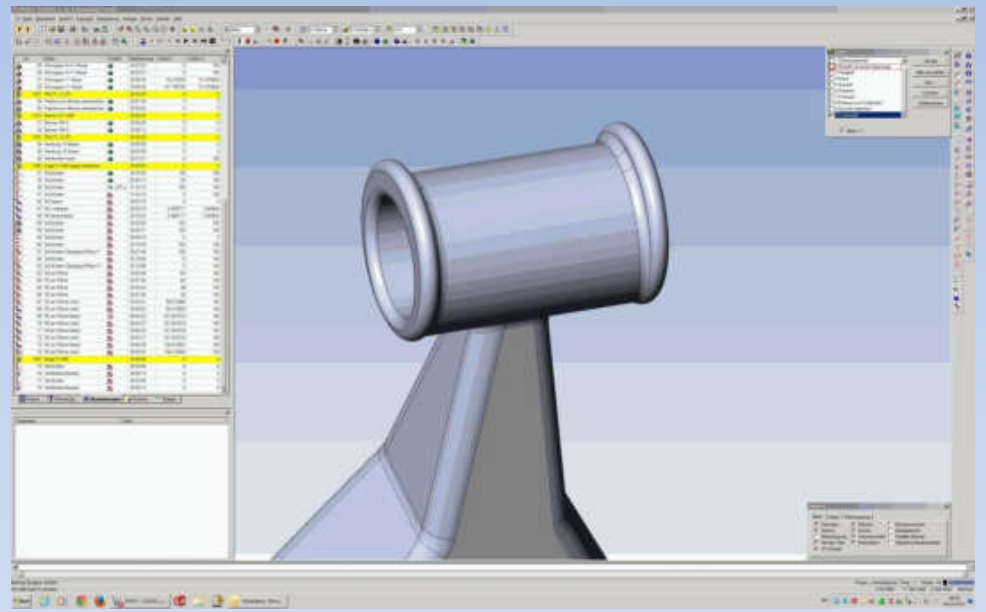
VECC-Linac 5

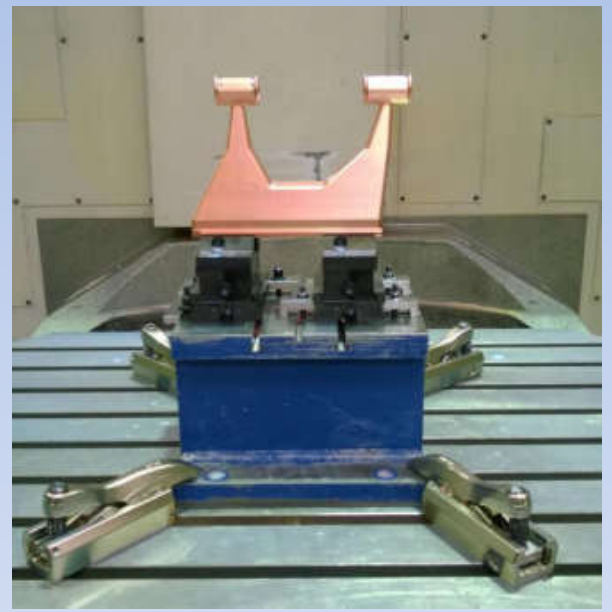
Middle Frame Milling

Half Shell Machining

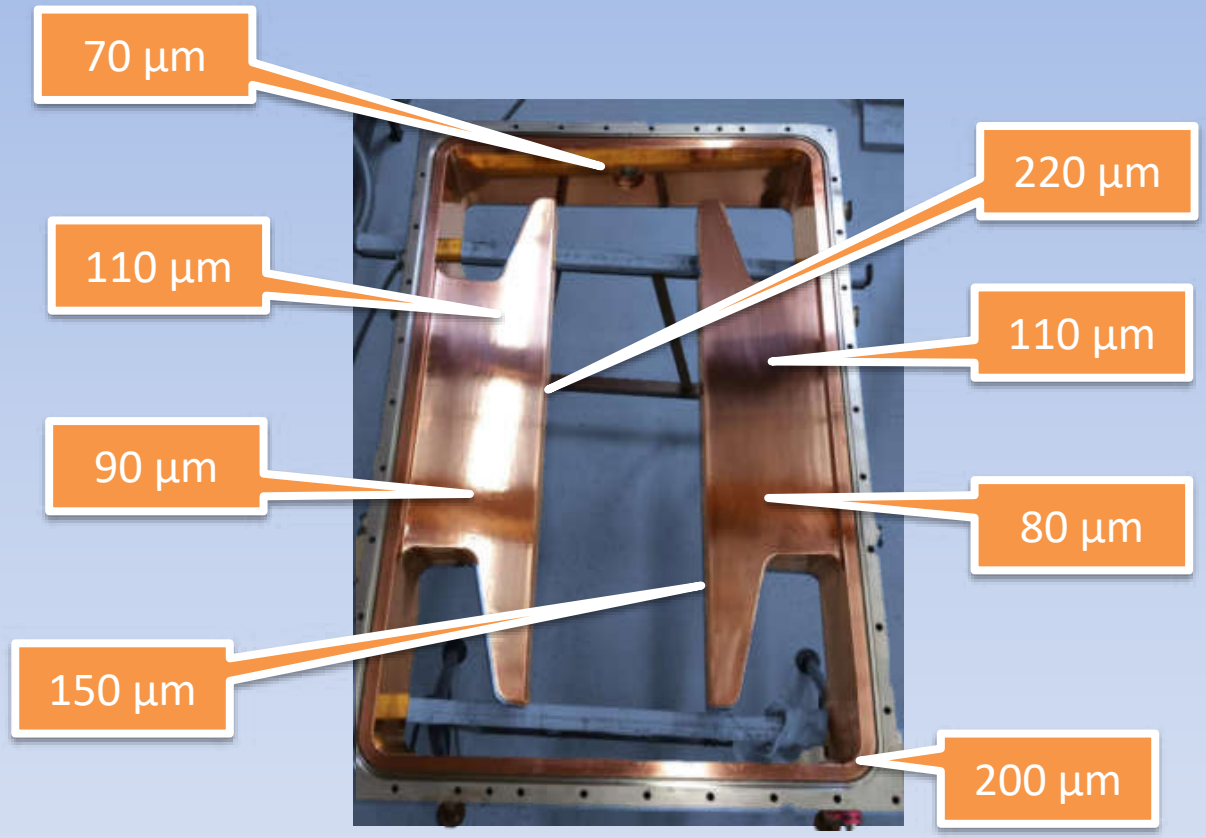


Machining of Drifttubes





Copper Plating

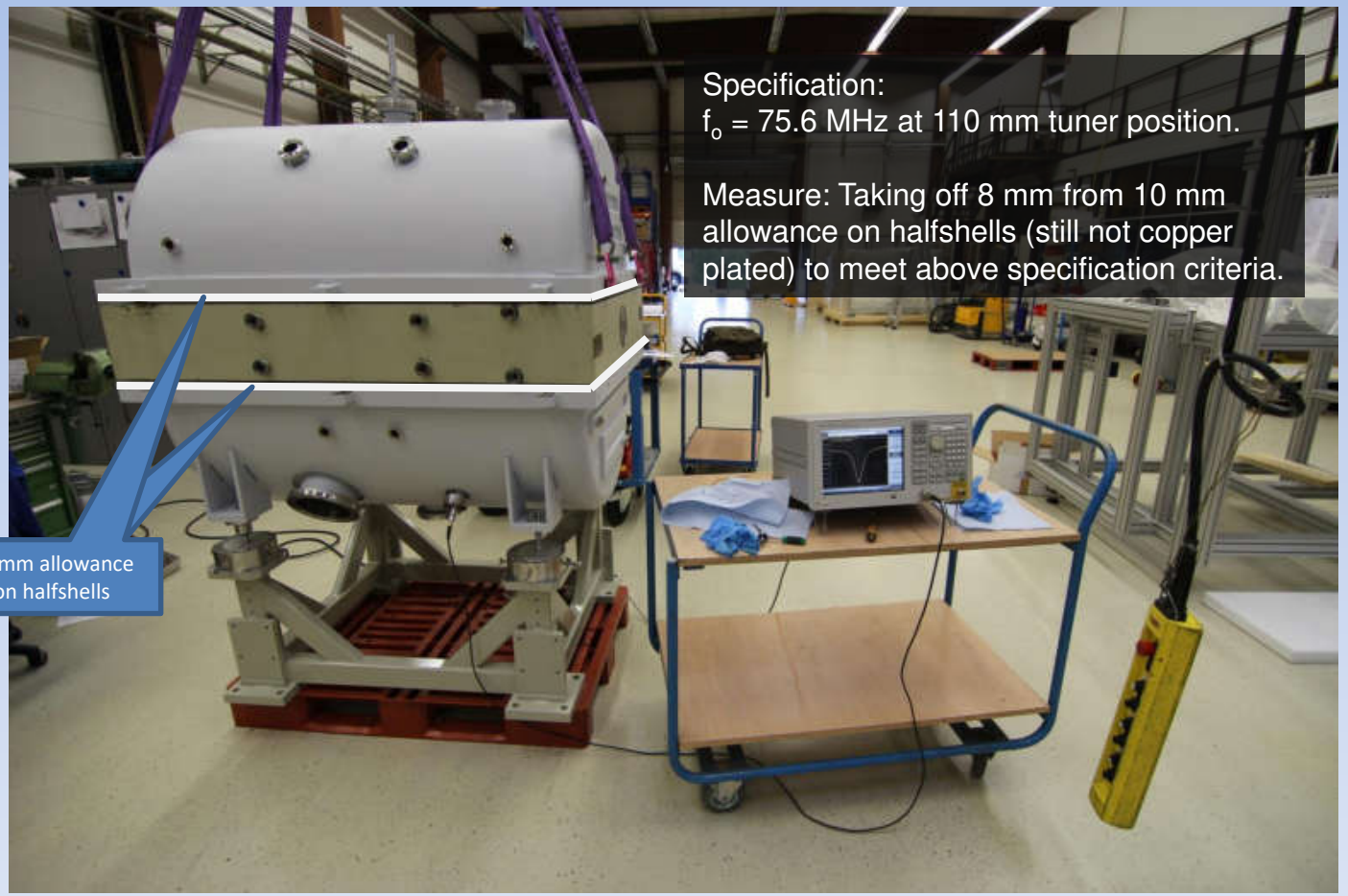


Lower Halfshell: ~ 100 µm

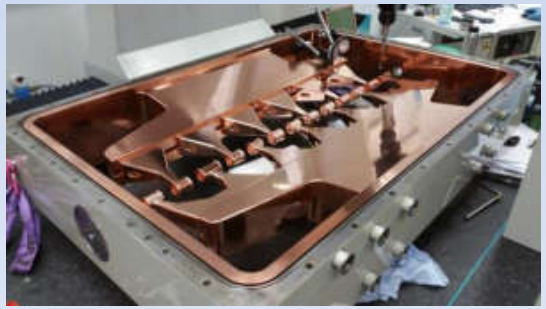
Upper Halfshell: ~ 200 µm

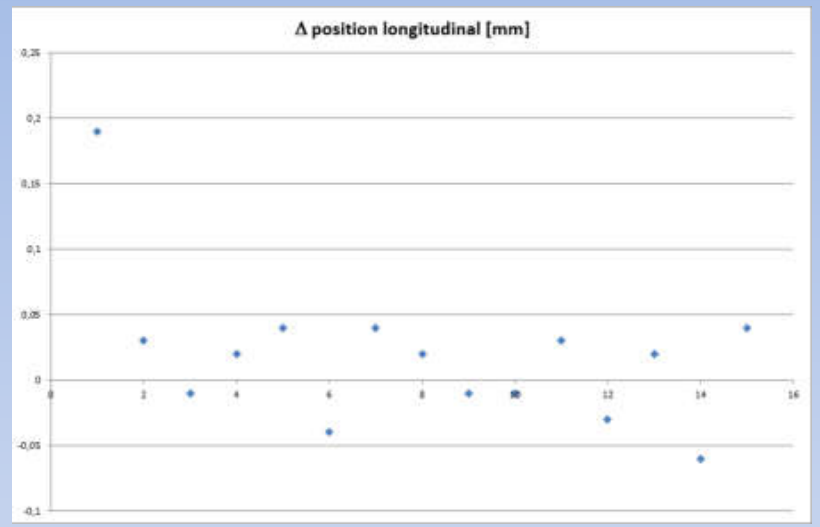
Drifttubes: 20 µm

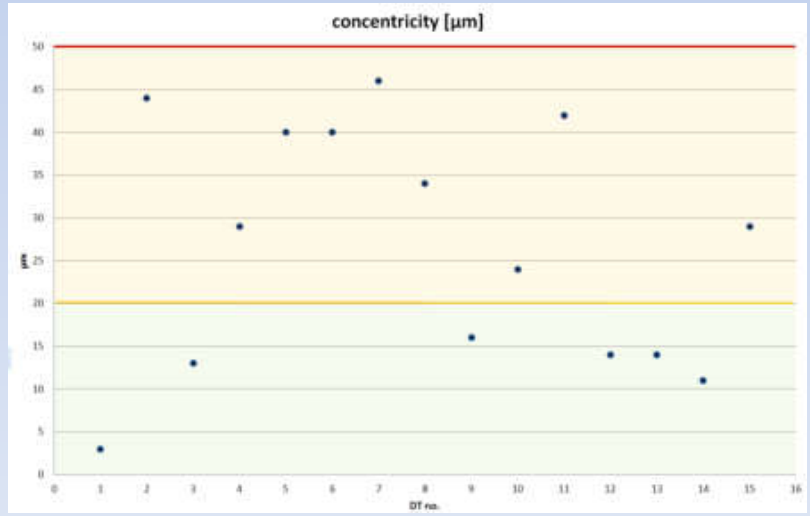
Preliminary RF-Test for matching



Assembling and adjustment of Drifttubes

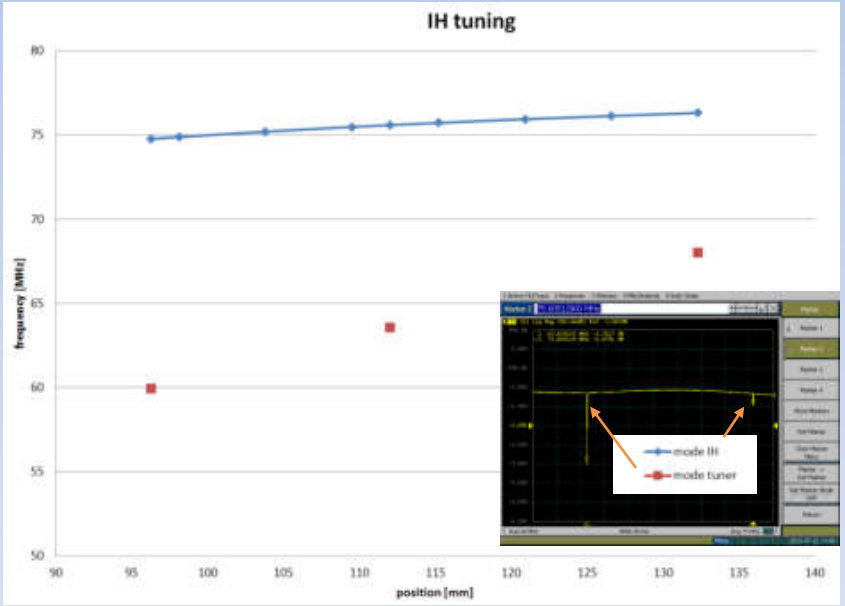


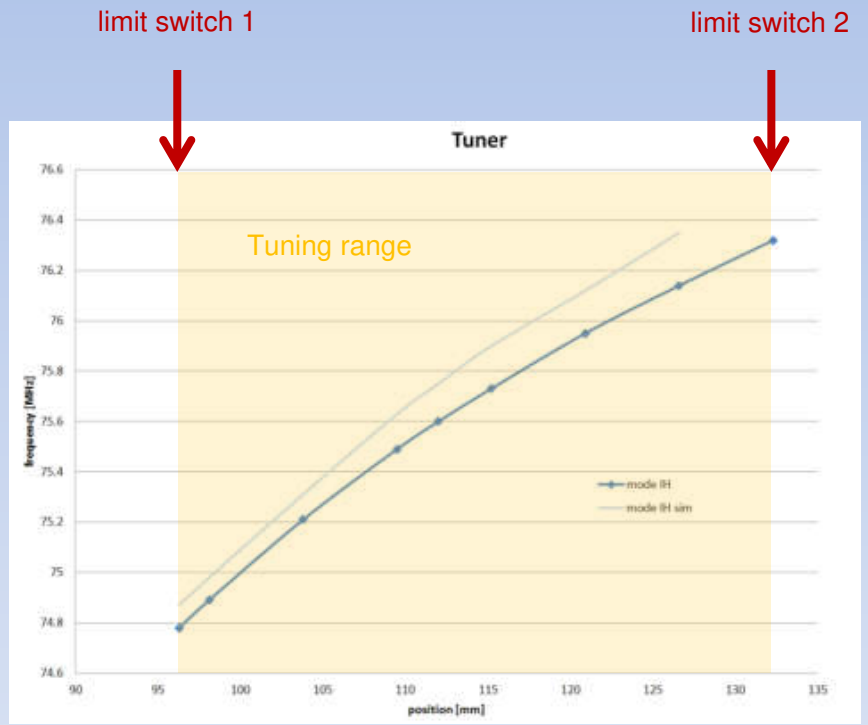




IH Tuning at Atmosphere

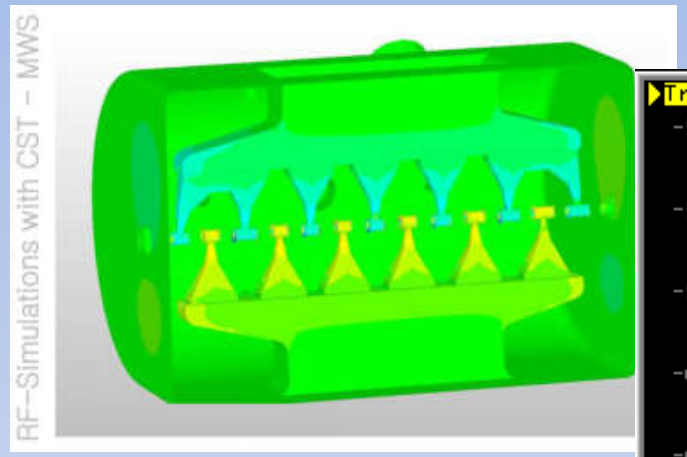
First result: fo = 75.6 MHz at tuner position 112 mm from beam axis.

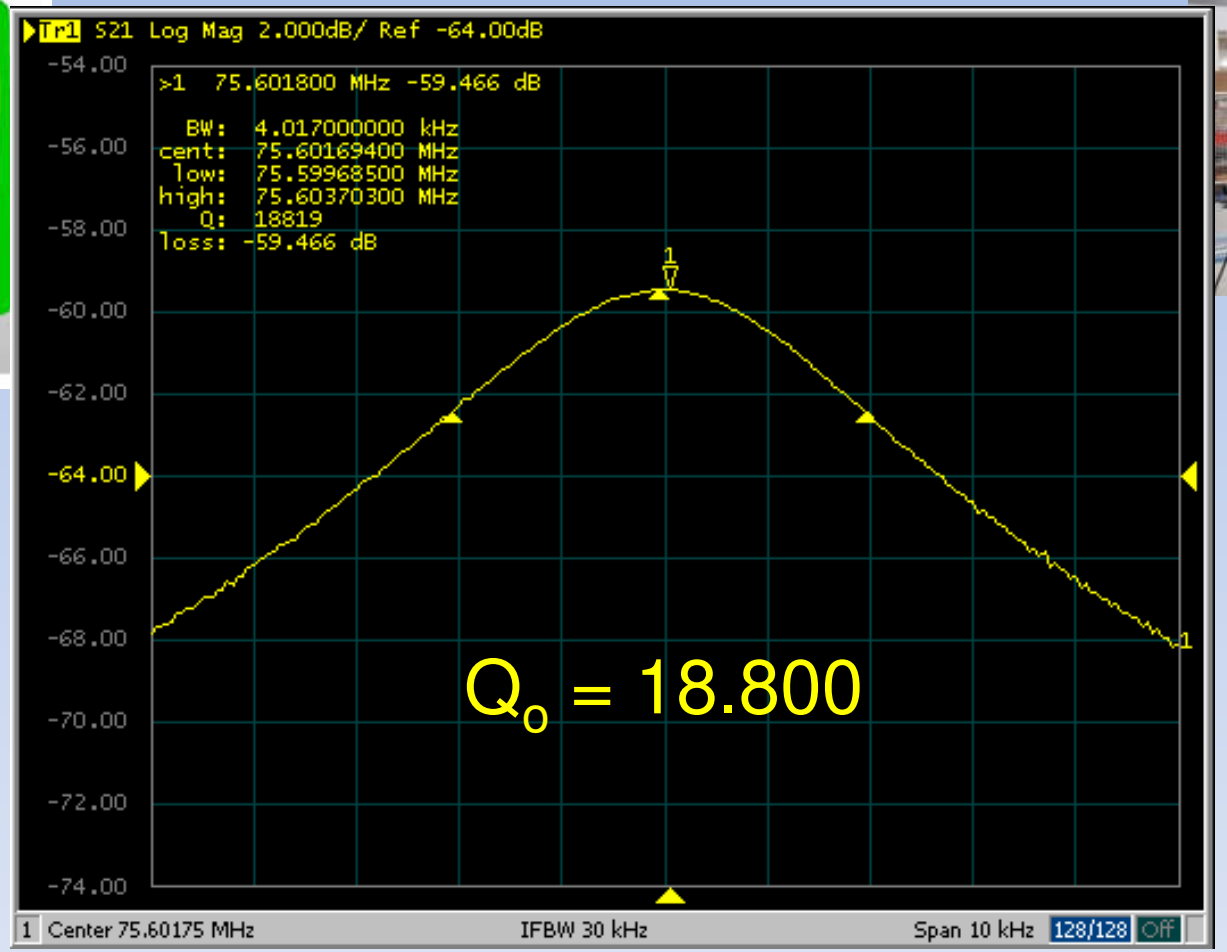


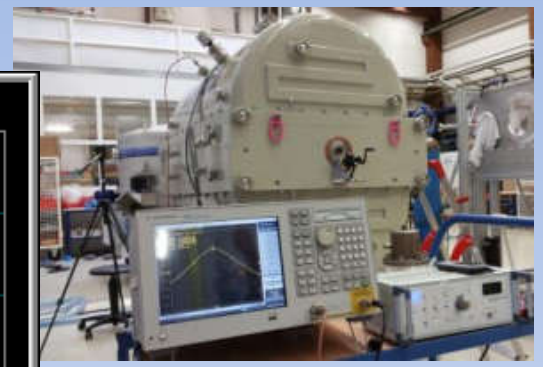


Quality Factor $Q_L \approx Q_o$

Weak coupling on both pickups < 10 mdB



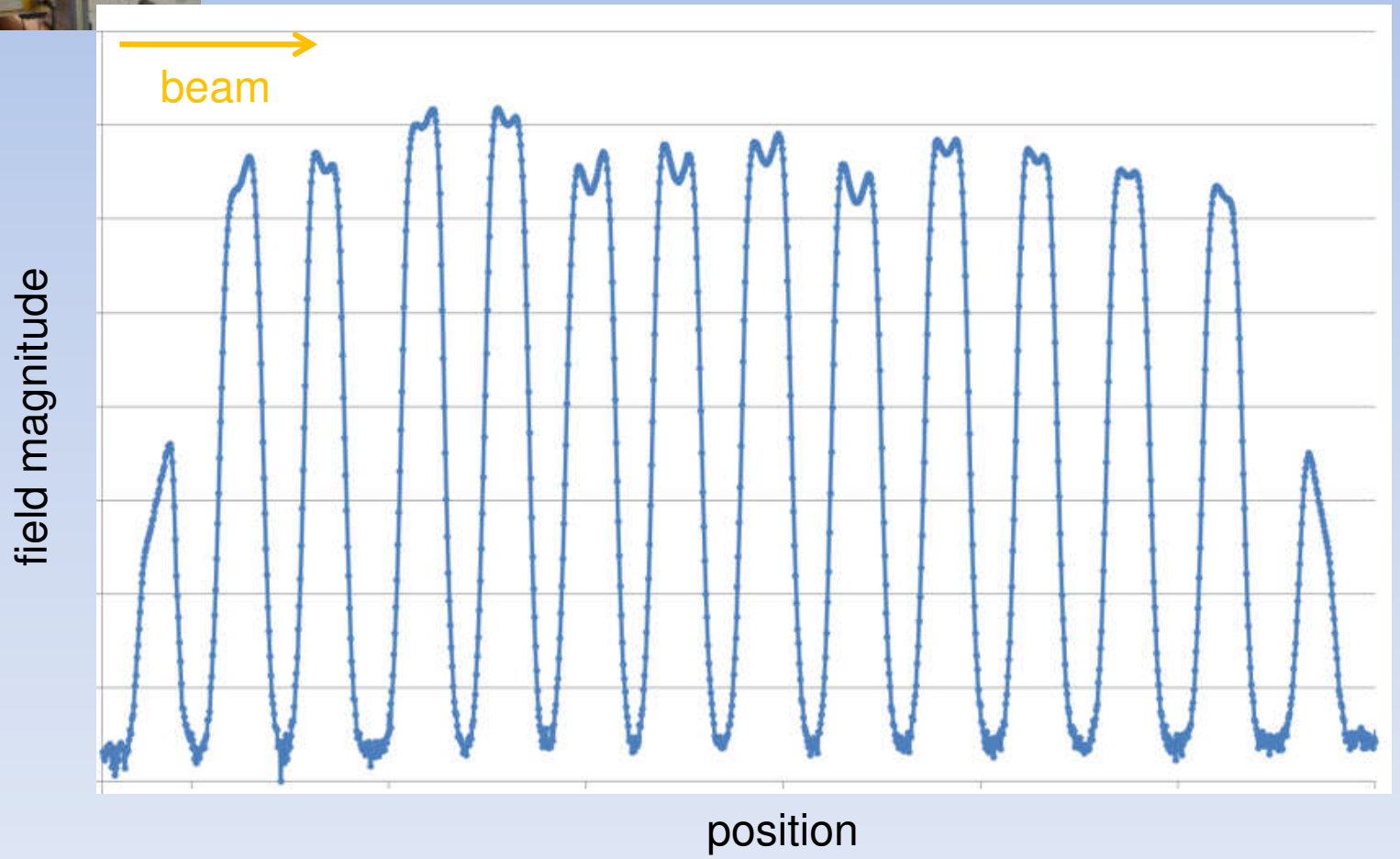




Q_o Remains constant within within tuning range!

Field Distribution

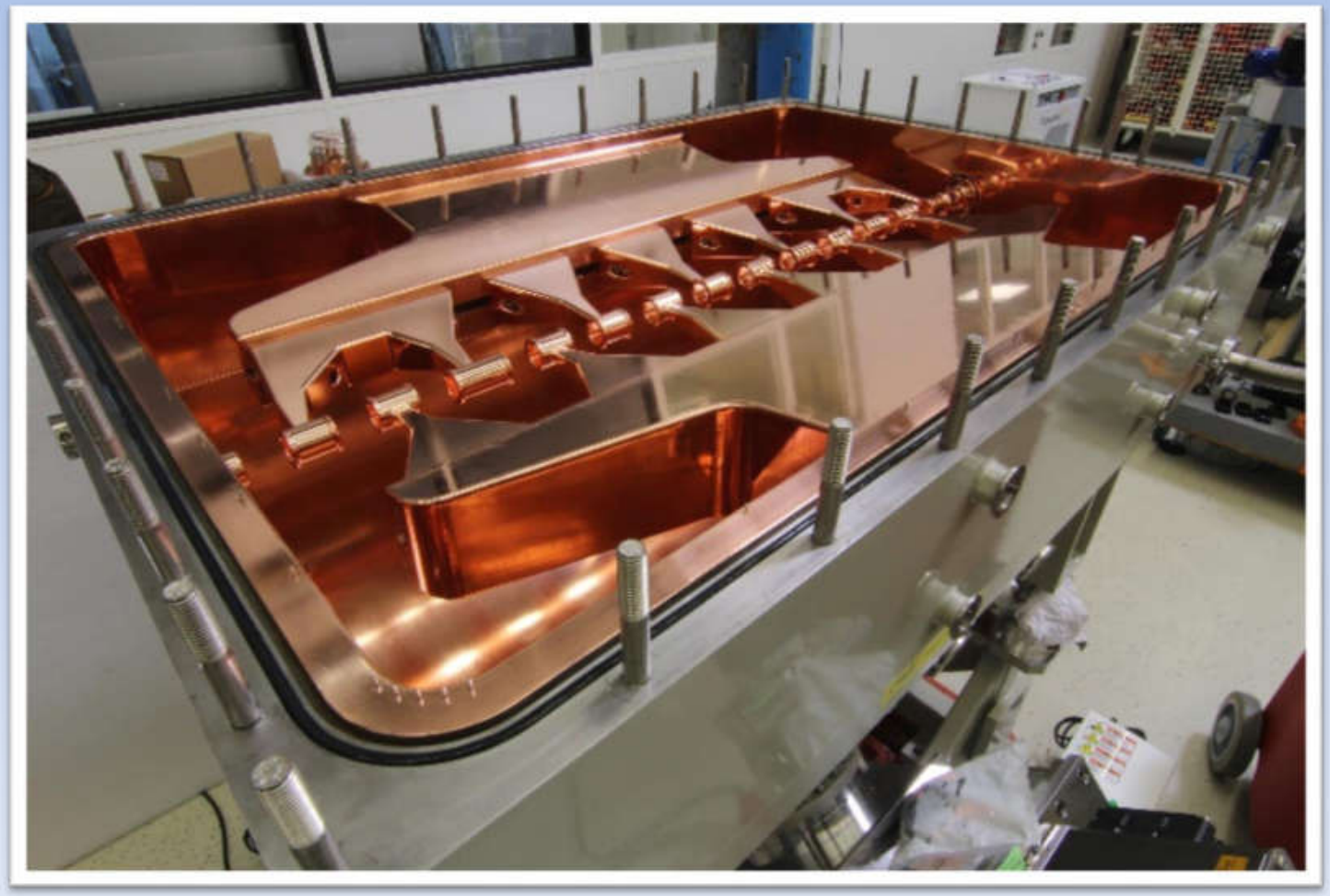
(arbitrary units)



Vacuum

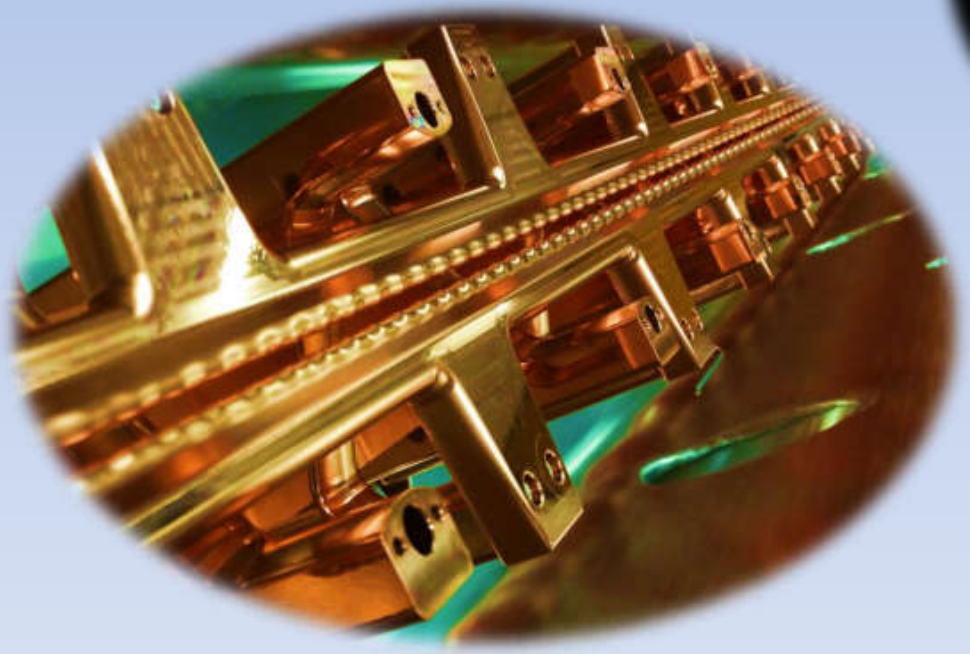
Frequency shift under vacuum: $\Delta f_{o,vac} \approx +100$ kHz

$p = 3*10^{-7}$ mbar after 48h of pumping



High Intensity RFQs

2005 - SARAF 50kW/m



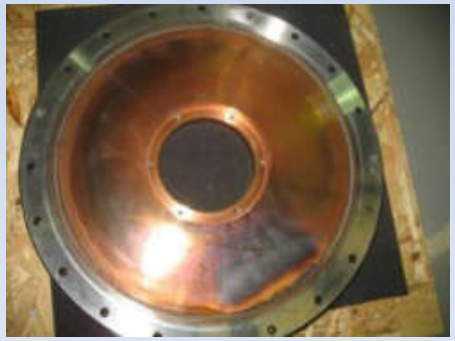
2015 MYRRHA design 25 kW/m

2010 FRANZ 38 kW/m

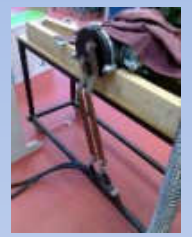
Historical Development: starting point SARAF

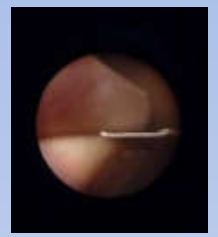
50 kW/m in 2009

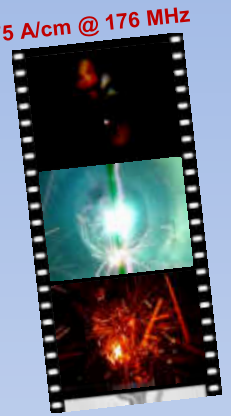
Problem at 100 A/cm with copper plated INCONEL contacts



Experimental Investigation







⇒

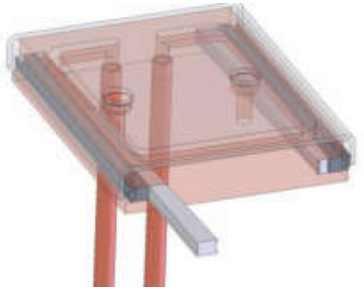
Plungers: Induced eddy currents lead to power losses on the surface in the order of 20 W/cm^2.

⇒

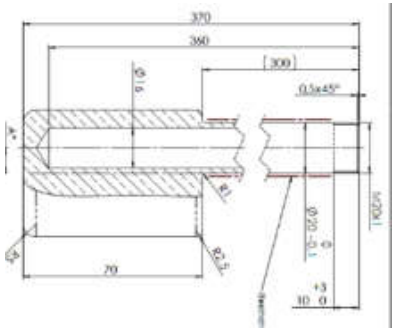
RF penetration can cause **problems in some hidden areas** of the structure.

⇒

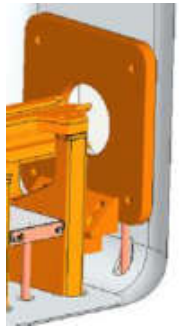
Pure Silver Solution



Improved Cooling



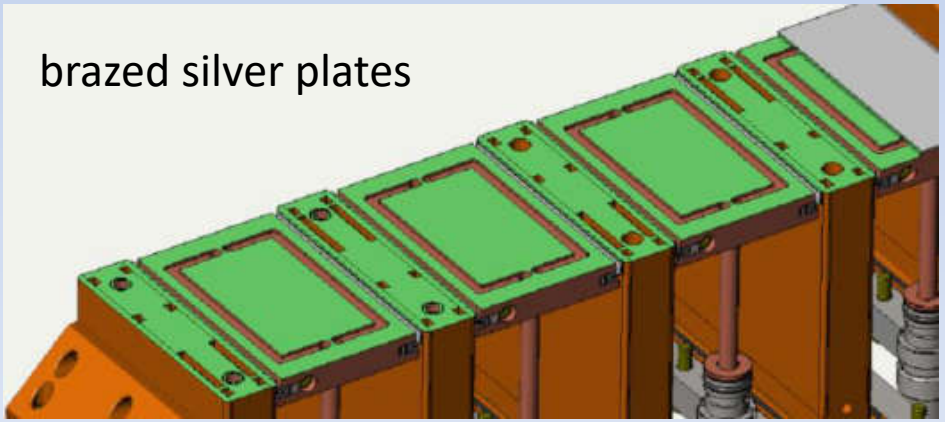
Improved RF-Contacts

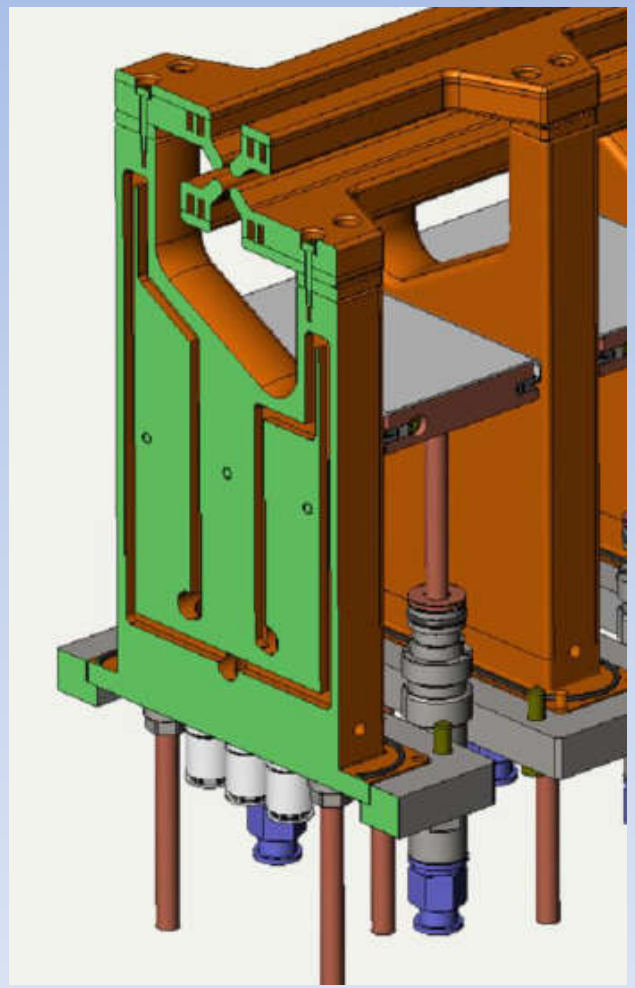


Cooling Concept evolved for FRANZ

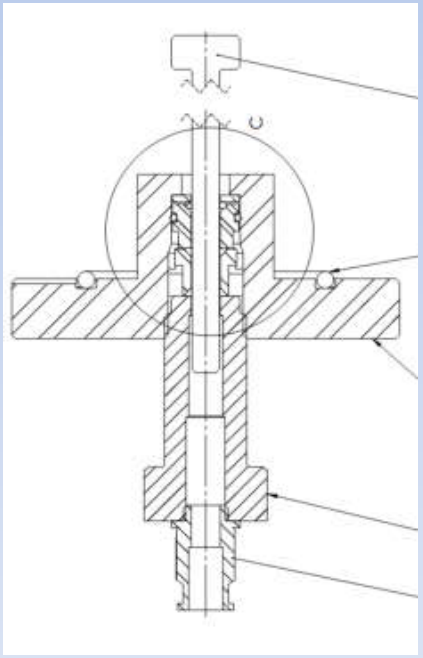
copper electro forming

brazed silver plates



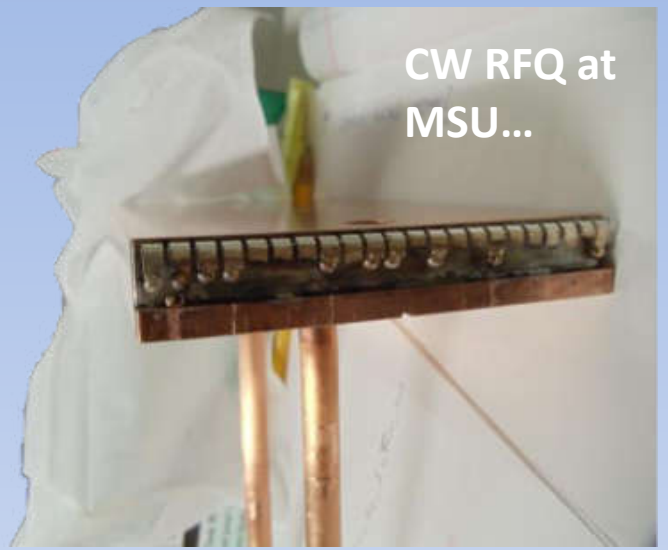


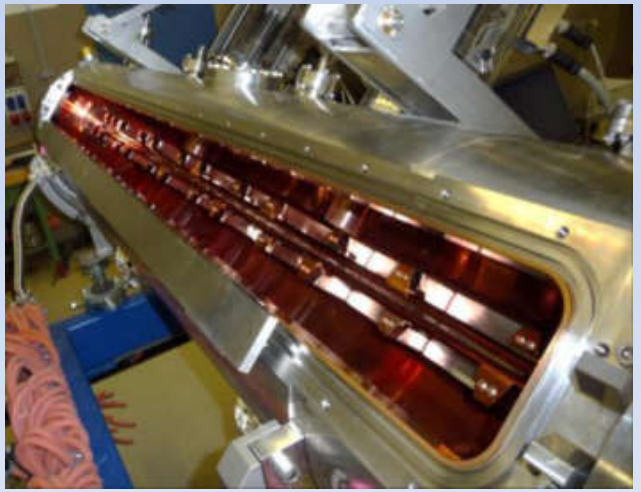
copper electro forming



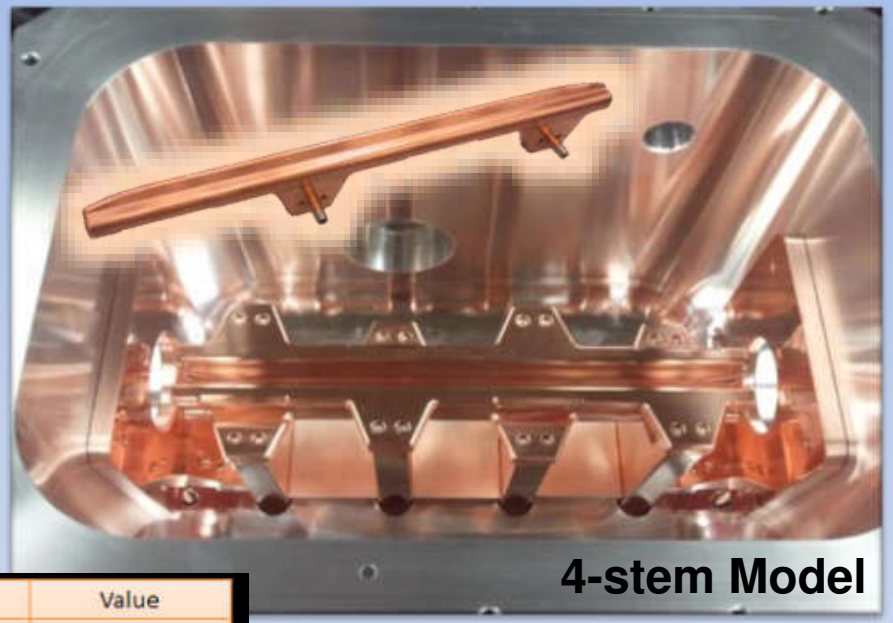
RFQ repair and improvement

Conventional finger contacts made of silver plated copper-beryllium alloys can reliably withstand up to **30 A/cm**. This value can be found in literature and has been repeatedly confirmed by dedicated experimental investigations similar to the ones aside accomplished by NTG at the IAP in Frankfurt and under operational conditions with 4-rod structures.





NEXT GEN HIGH POWER CW-RFQ



Parameter	Value
frequency f_0 [MHz]	175
Q_0	4300
Rp-Value, measured	77 kΩm

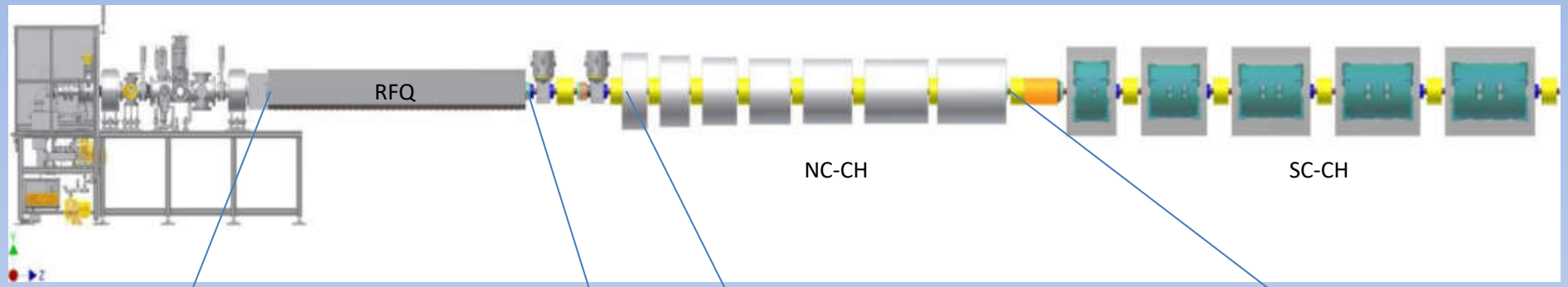
2017

keeps cool at even

130 kW/m, 100 kV

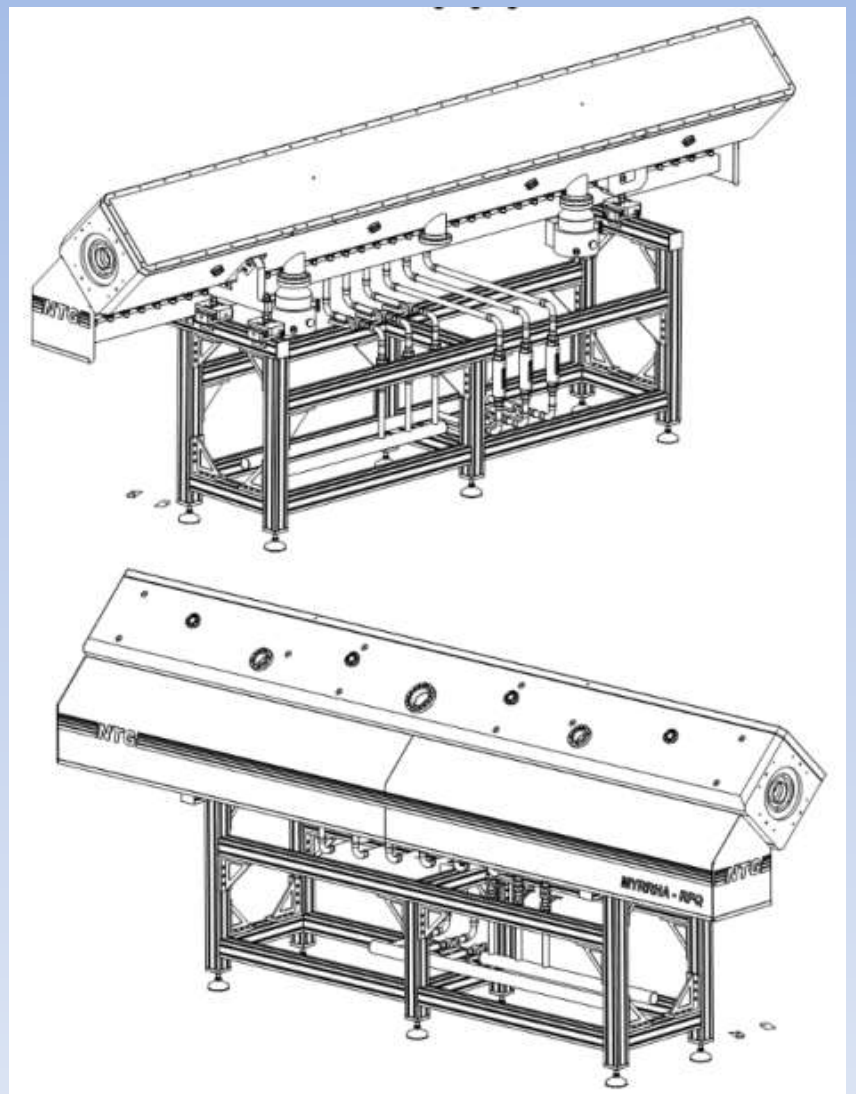
(limit not yet reached)

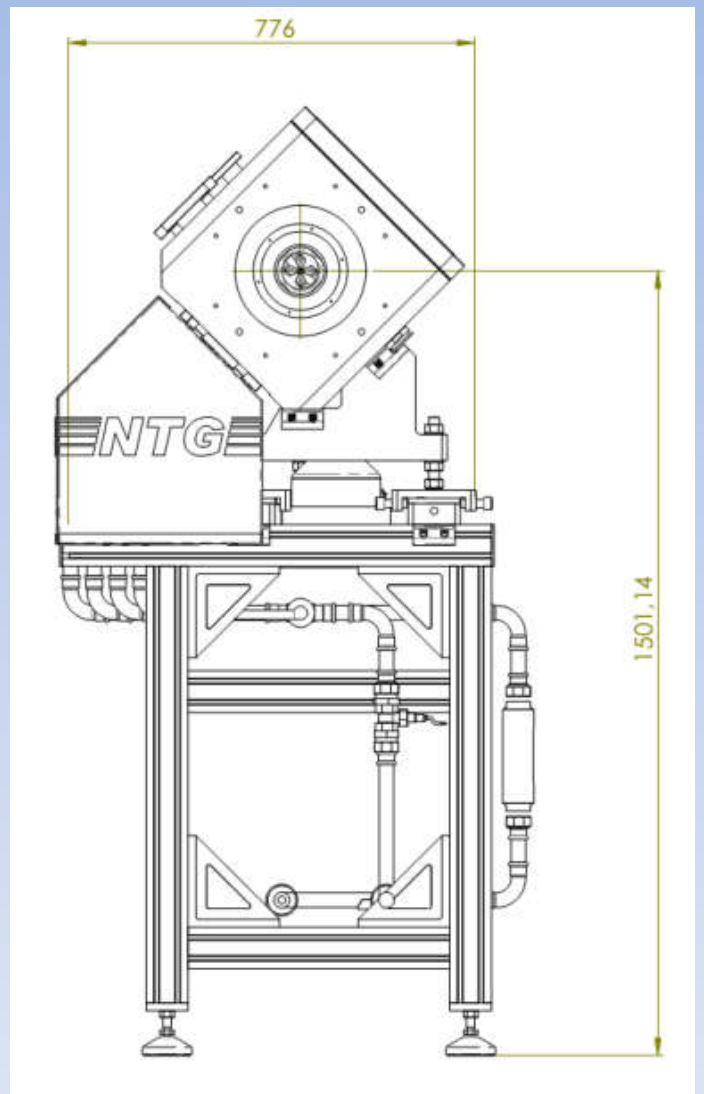
MYRRHA 17 MeV Injector



Parameter	MHYRRA	Unit
RF Structure	4.Rod	---
Frequency	176.1	MHz
Beam current	5	mA
Duty factor	100	%
E_{out}	1.5	MeV
R_p (4-St Model)	77	kΩm
RF Power	108	kW
Specific power	25	kW/m
Voltage	44	kV
Length	4	m

Design & Manufacture of MYRRHA RFQ



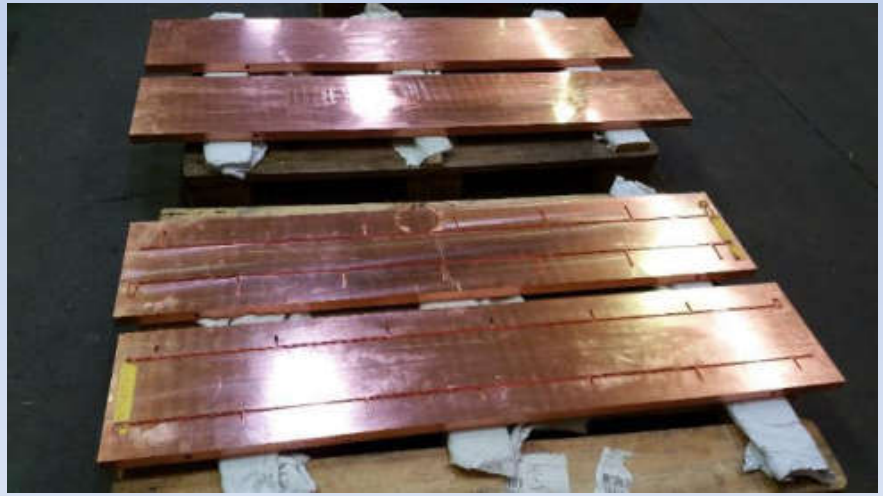


- No. of stems: 40
- Distance of Stems: 100 mm
- No. of electrode sections: 3
- Pumping ports: 2 + 1 DN100CF
- Height of beam axis: 150 cm
- No. of tuner ports: 1 + 1
- Adjustable three-point-support

Starting Manufacture

tank body and lid

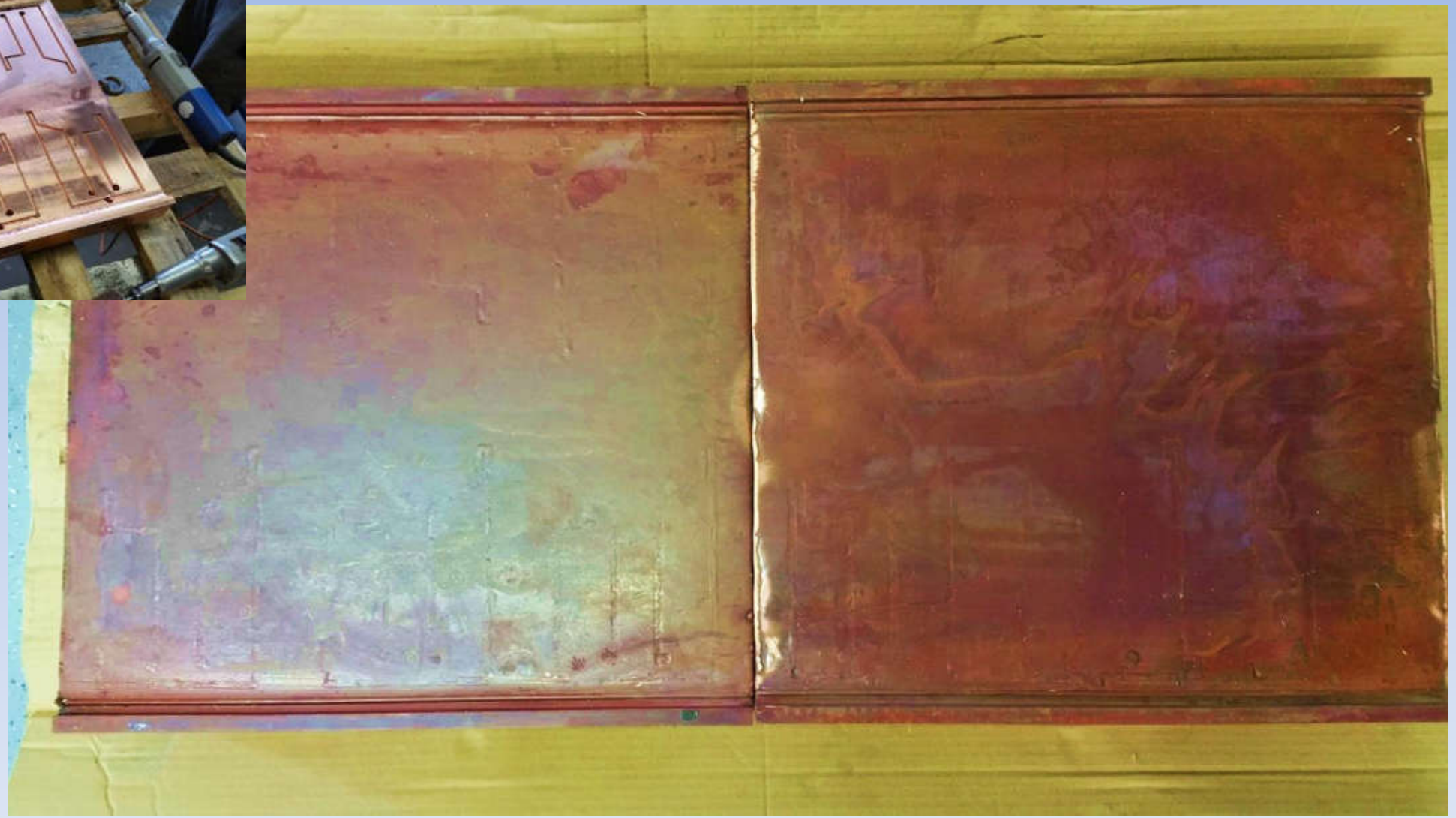
raw material for stems

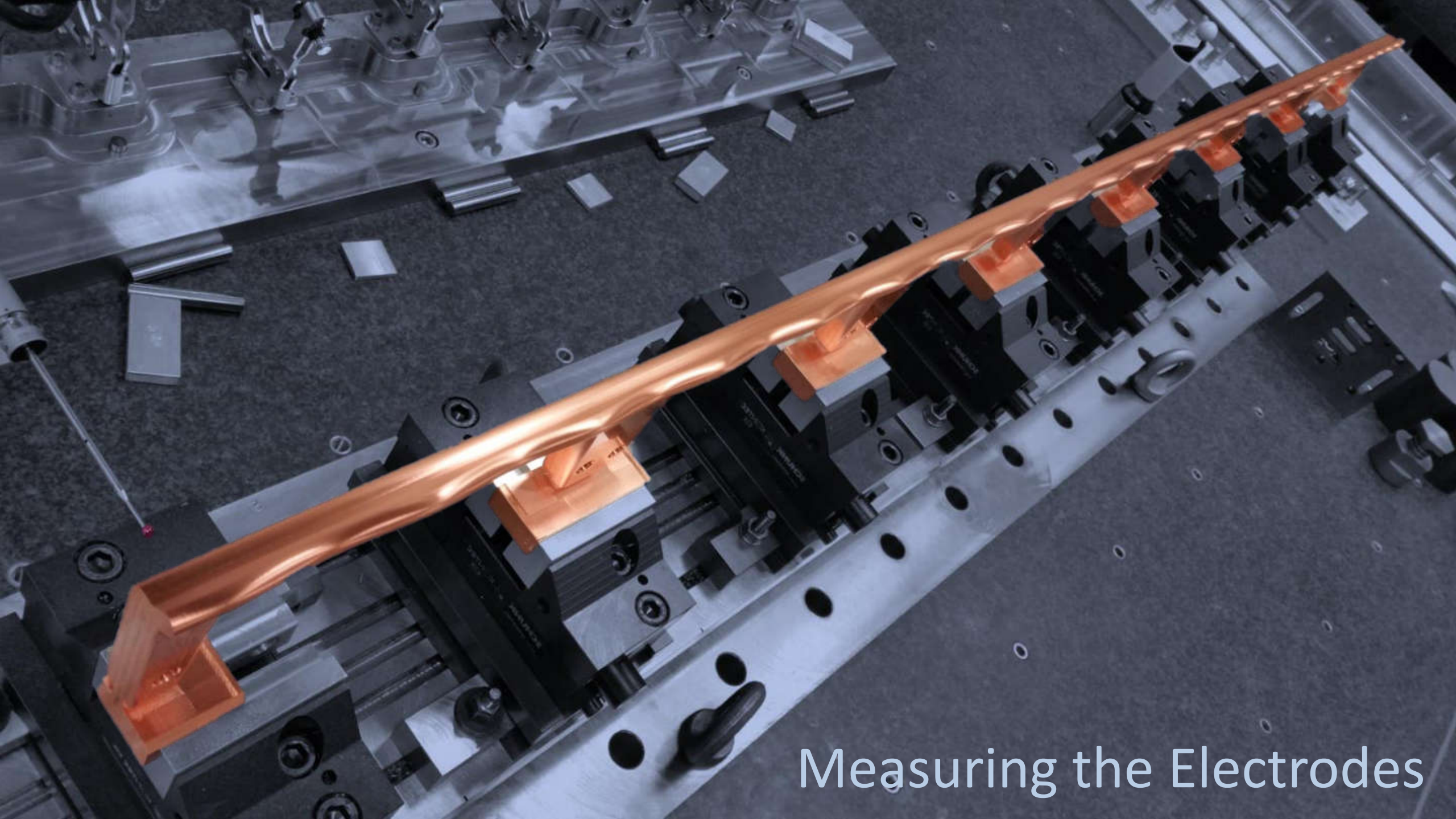


Electrode cooling channels

cooling connections

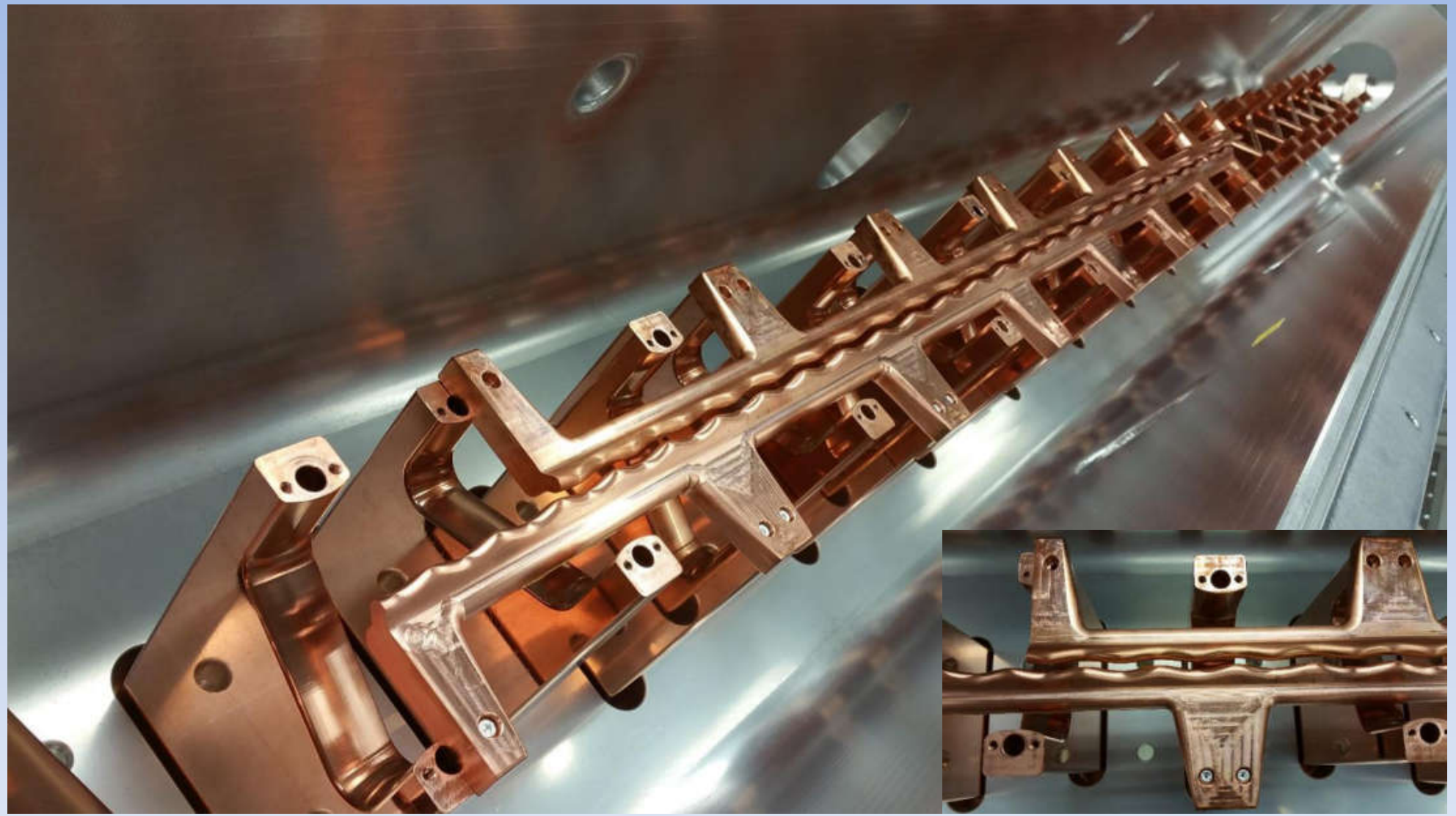
Before and After Copper Plating



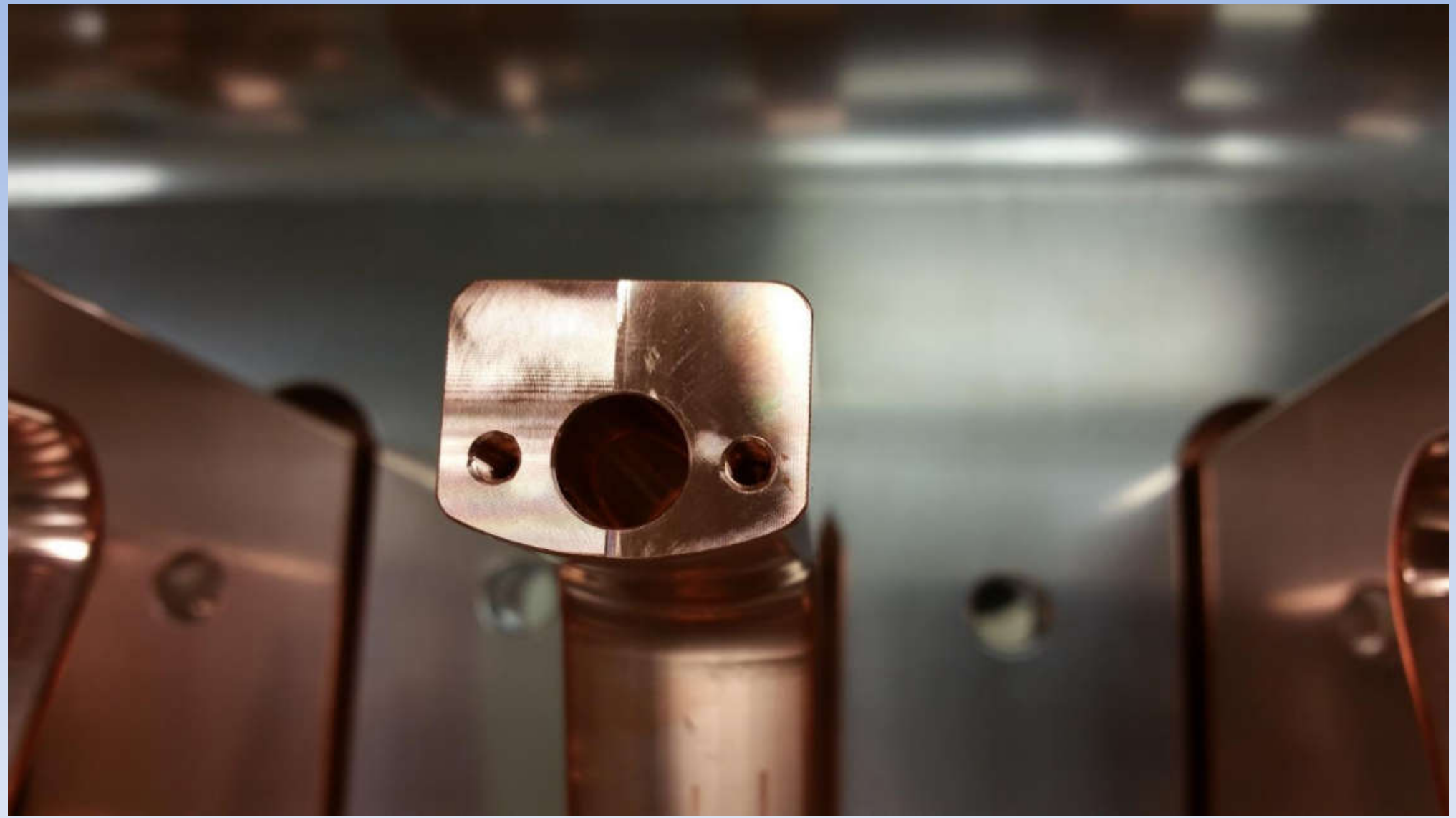


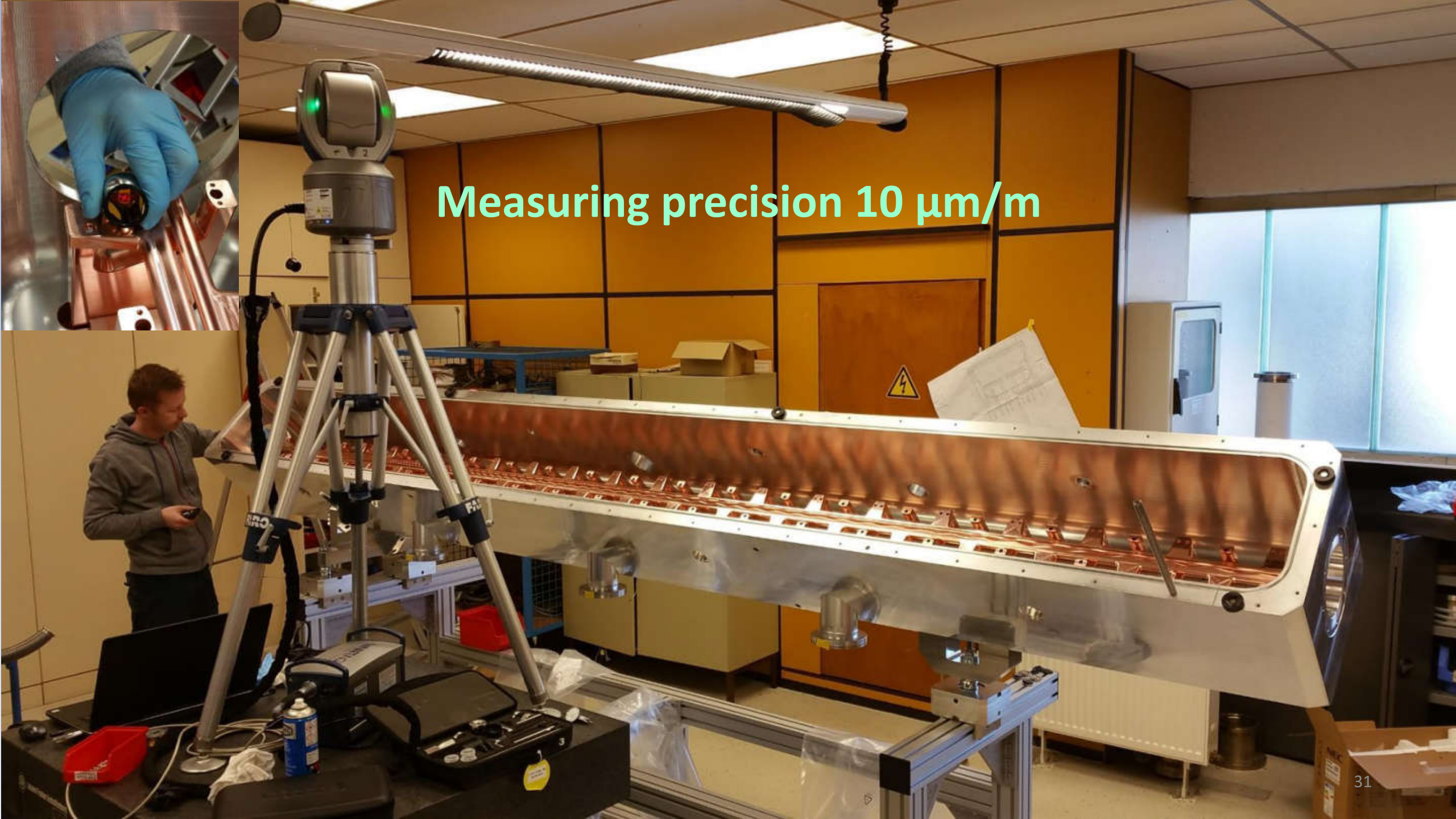
Measuring the Electrodes

Assembly of rods

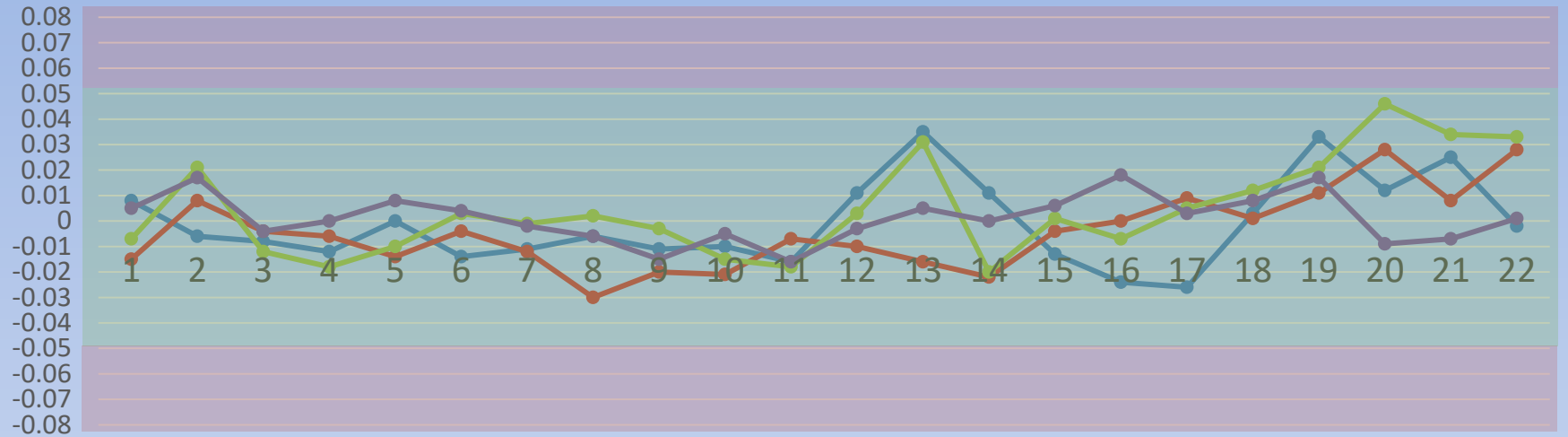


Electrode error compensation at point of transition between segments

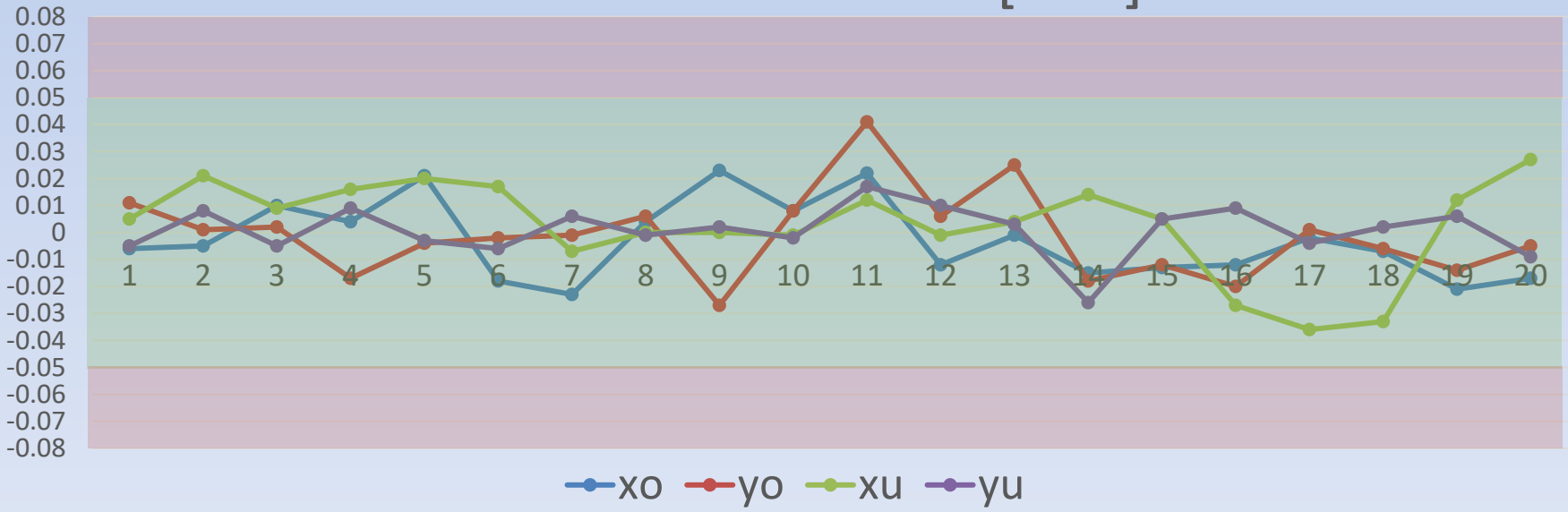


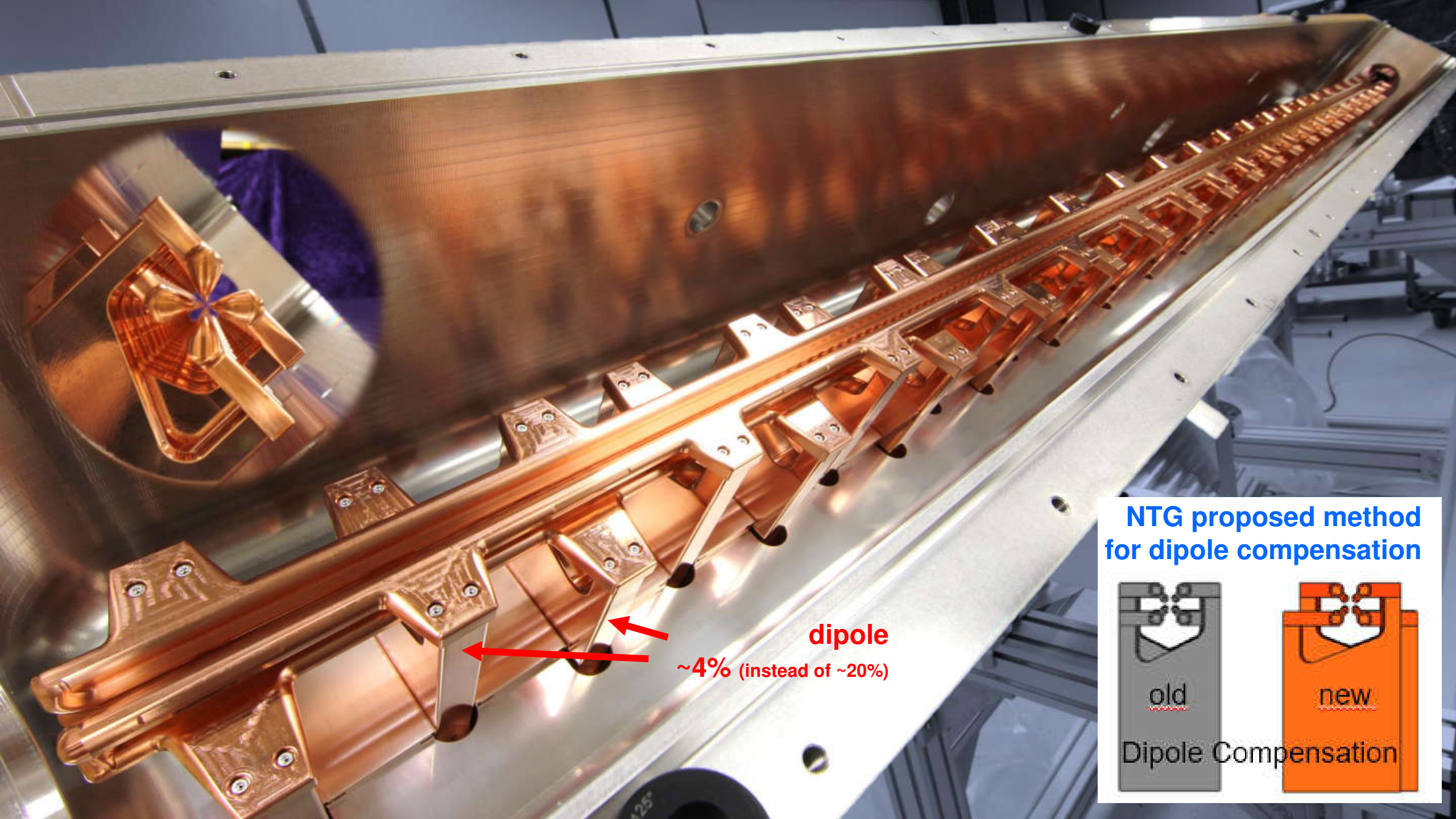

Measuring precision 10 µm/m

vertical deviation [mm]

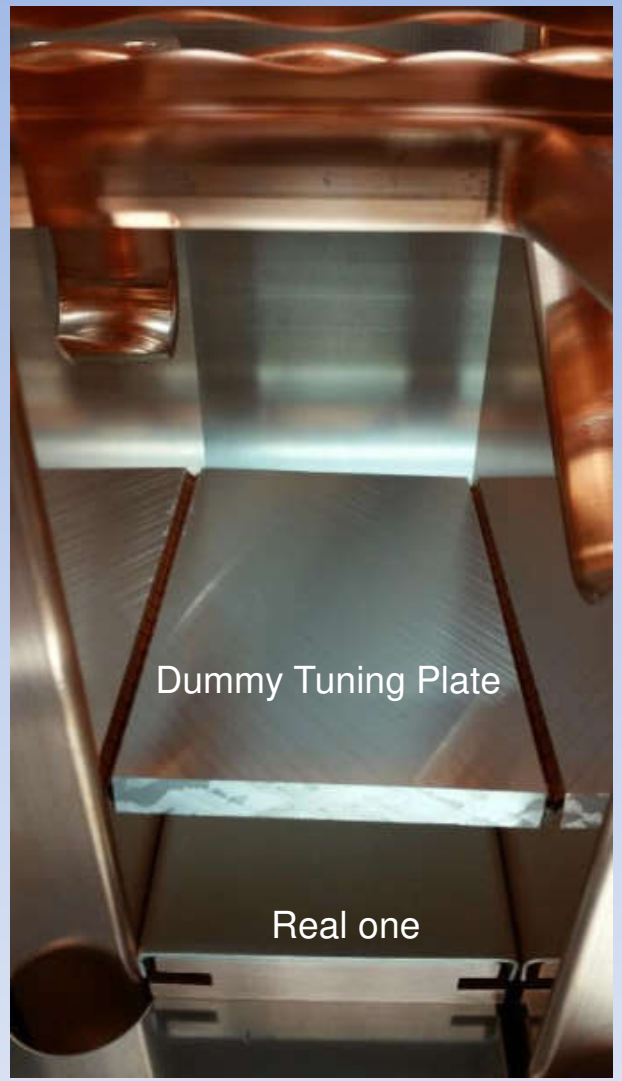


horizontal deviation [mm]

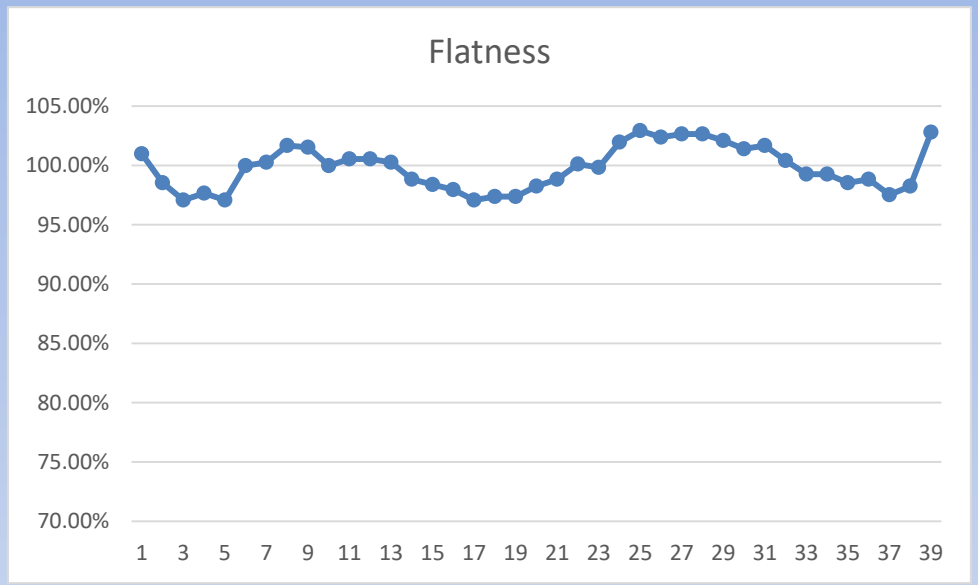


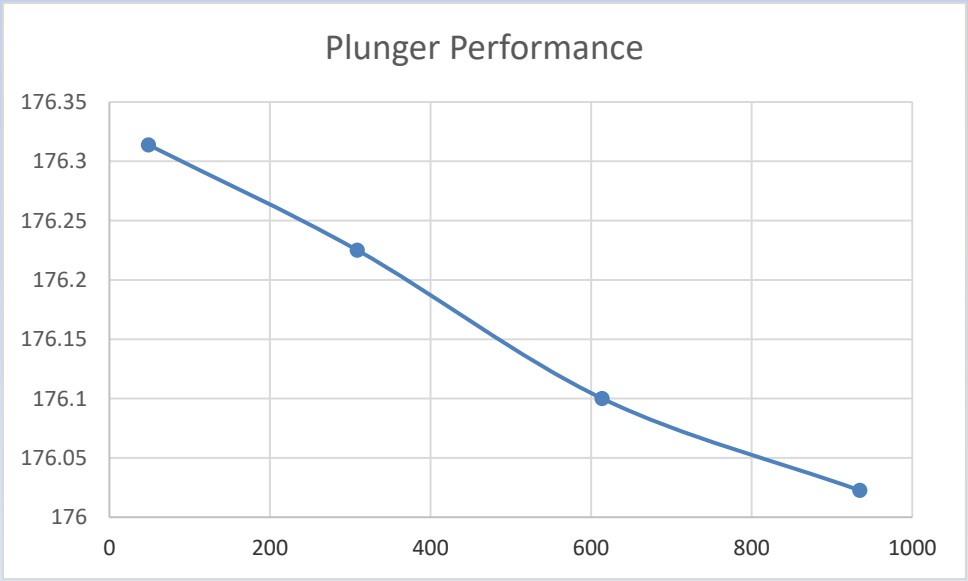

dipole
~4% (instead of ~20%)
NTG proposed method
for dipole compensation
old
new
Dipole Compensation

RF-Tuning

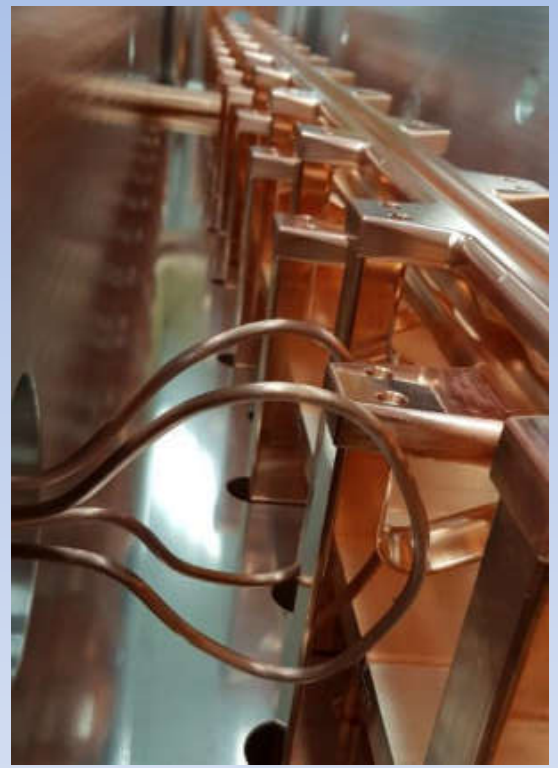


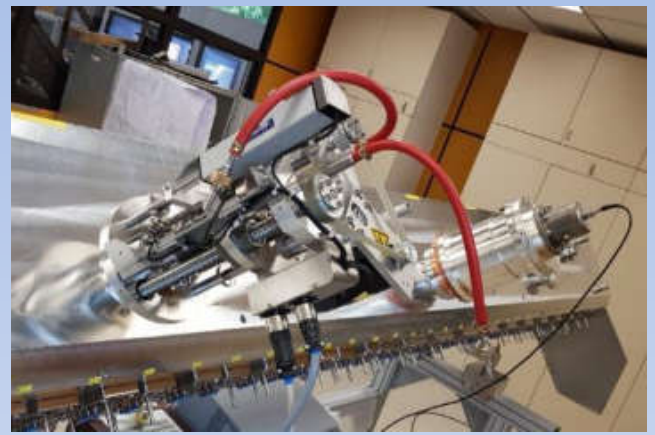
Dummy Pates for RF Tuning





Matching of Coupling Loop





S_{11}< -30 dB

Ready For Shipping

Status at Louvain-la-Neuve on 04.12.2020

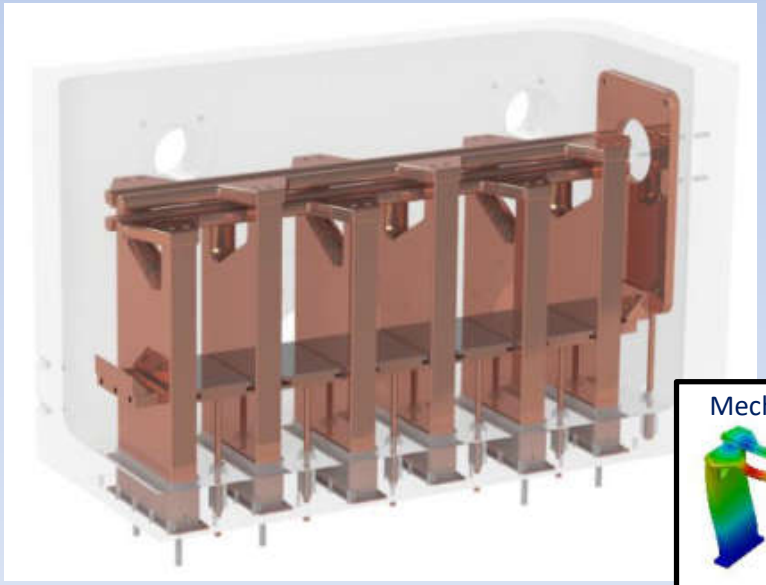
During the last weeks of 2020 the ADT team in Louvain-la-Neuve achieved a new milestone: the 4-rod RFQ, designed by IAP Frankfurt and manufactured by NTG, delivered a characteristic MYRRHA/MINERVA proton beam with the following features:

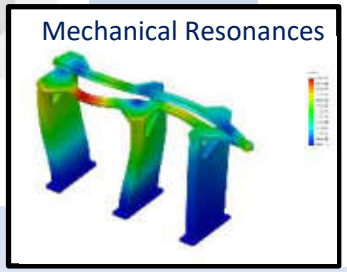
- nominal beam energy of 1.5 MeV (approximate value, to be confirmed and refined by a dedicated measurement).
- nominal beam intensity of **4 mA delivered quasi-continuously**.
- **transmission** through the RFQ **up to 98%**.
- **global duty cycle of 99.75%** (beam holes cut by LEBT chopper).

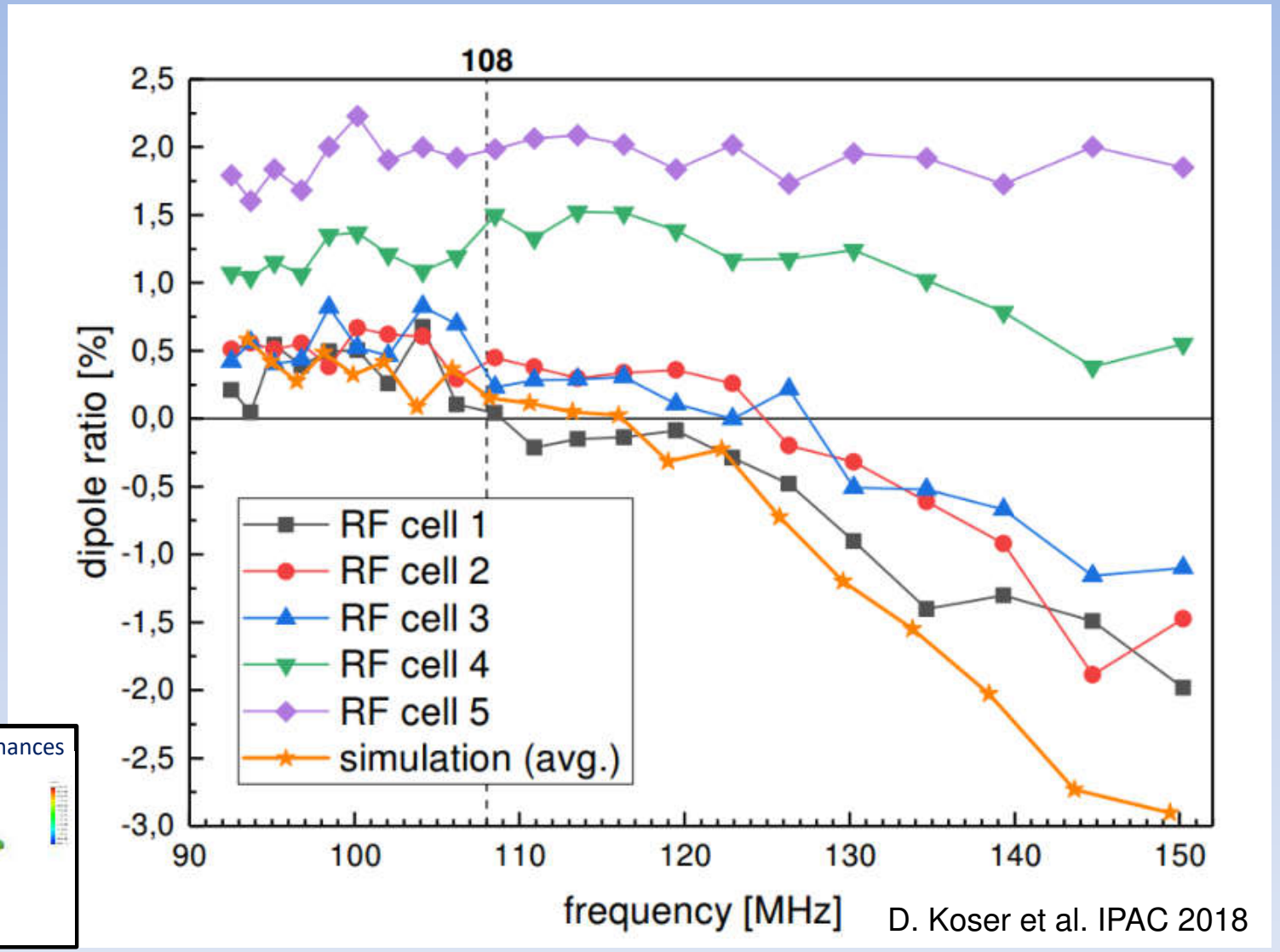
time structure typical for a MYRRHA shared beam application

…to be continued!

HLI 6 Stem Model Dipole Compensation

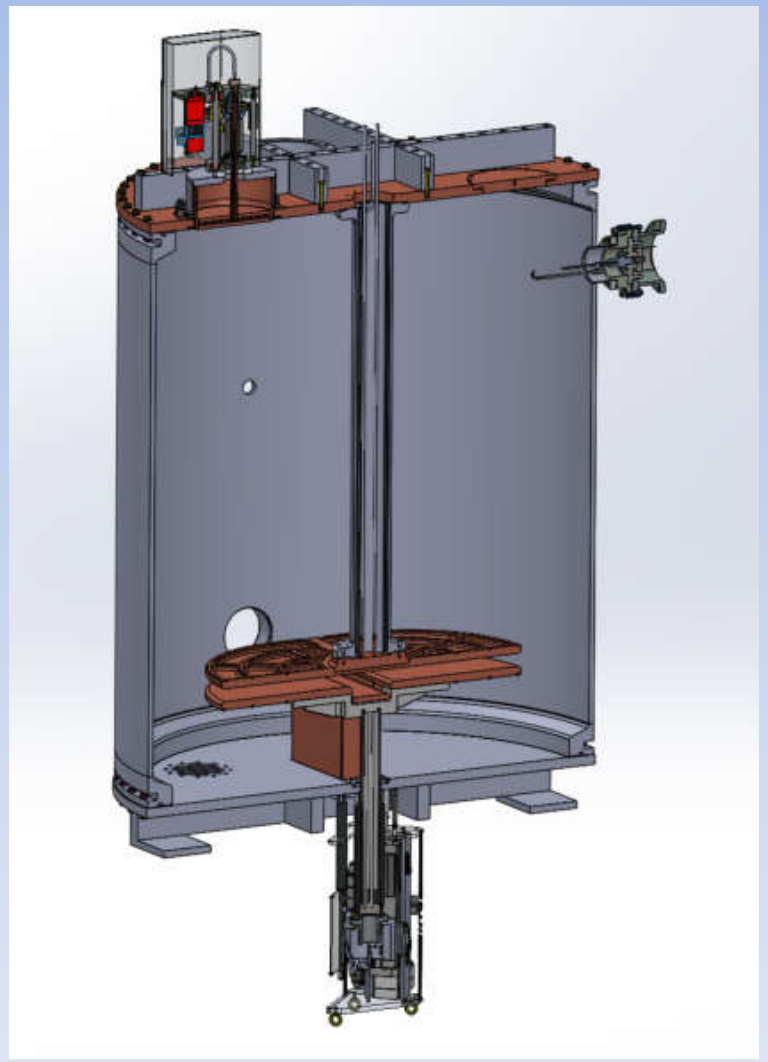


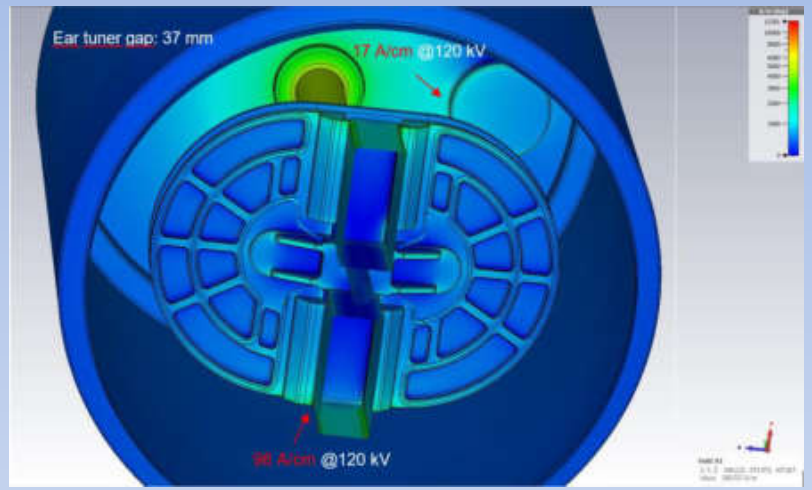


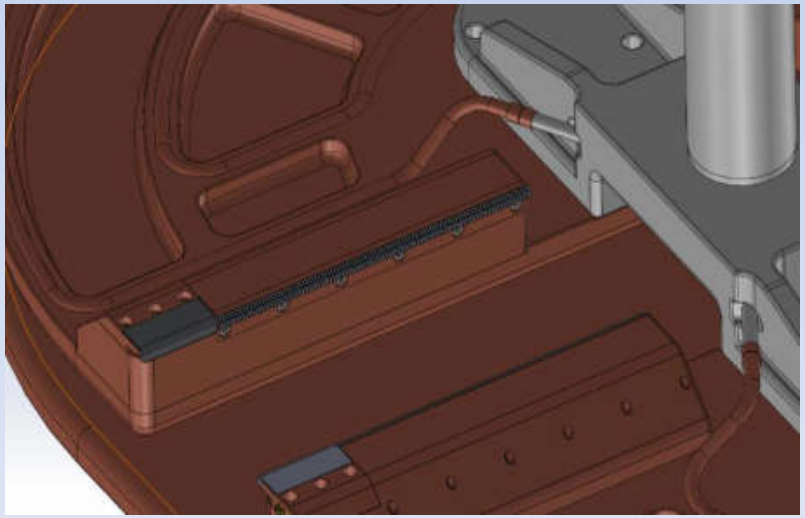


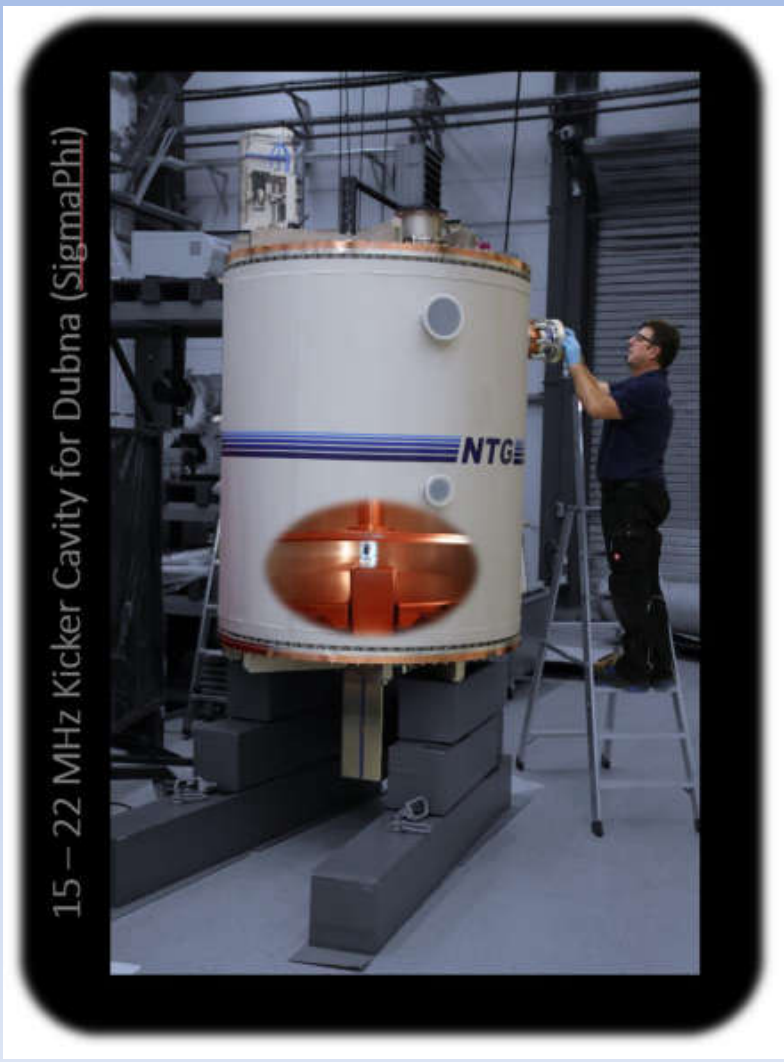
D. Koser et al. IPAC 2018

Kicker Cavity for Acculinna 2, Dubna 17 – 22 MHz (SigmaPhi)





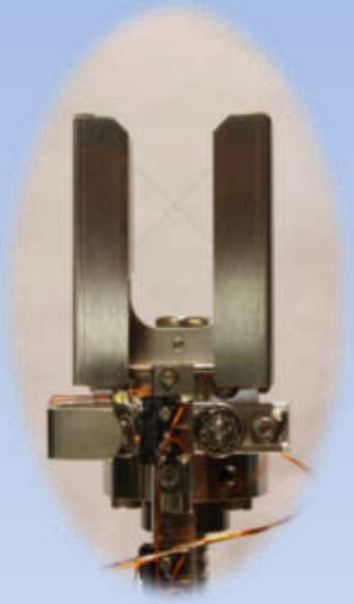




Beam Diagnostics

Allison Scanner

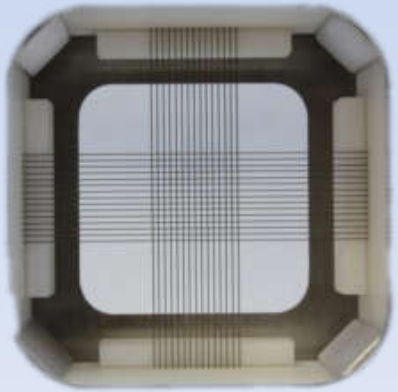
Wire Scanners



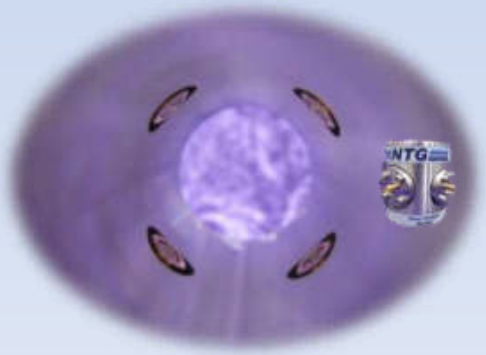
Slit/Grid Emittance Scanner

Chromox Screen

Profile Grids

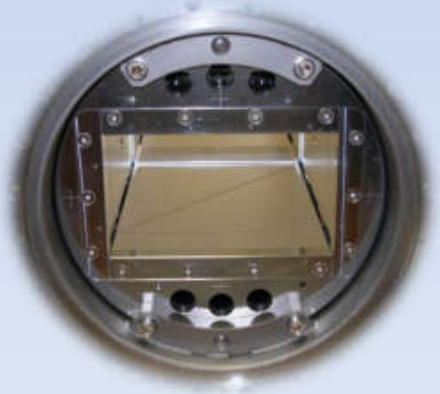


Capacitive BPMs



Beam Tomographyc

BPM linear cut



4d Beam Emittance Analyser ROSE

The ROSE Set-up

Complete ROSE System available at NTG under license of GSI

The detector system ROSE, allowing to perform 4D emittance measurements on heavy ion beams independent of their energy and time structure, has been built and successfully commissioned in 2016 at GSI in Darmstadt, Germany. This method to measure the four dimensional emittance has then been granted a patent in 2017. The inventors together with the technology transfer department of GSI have found with NTG an industrial partner to modify ROSE into a fully standalone, mobile emittance scanner system. The electronics was commissioned at the ECR test bench of the Heidelberg ion therapy facility HIT in June 2019. Currently our main focus is on the development of the 4D software package.


Thank You!
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