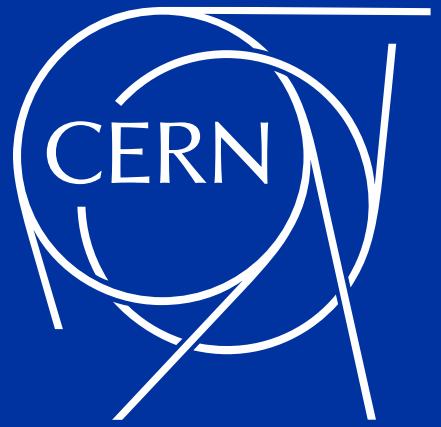


Laser polishing of Additively Manufactured RFQ

Viesturs Lācis

Supervisor: Andris Ratkus

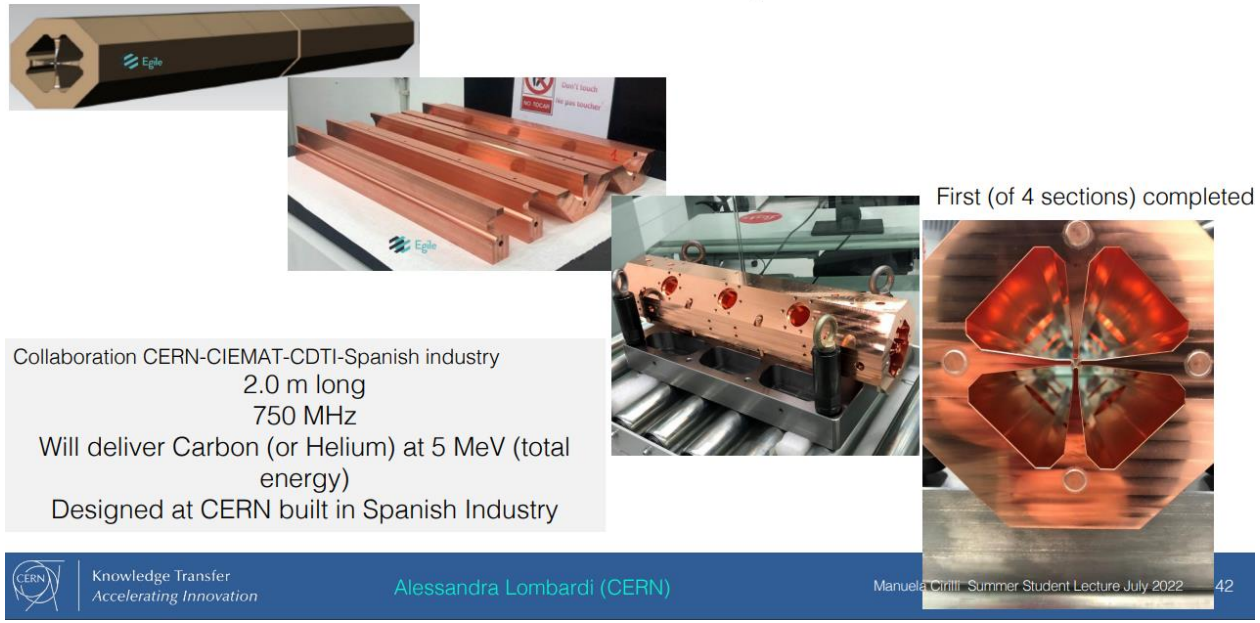
12.10.2022.

What is RFQ

RFQ – Radio Frequency Quadropole

- **Focusing the beam**
- **Bunching the beam in packets**
- **Accelerating the beam**

The RFQ for C^{6+} LINAC option

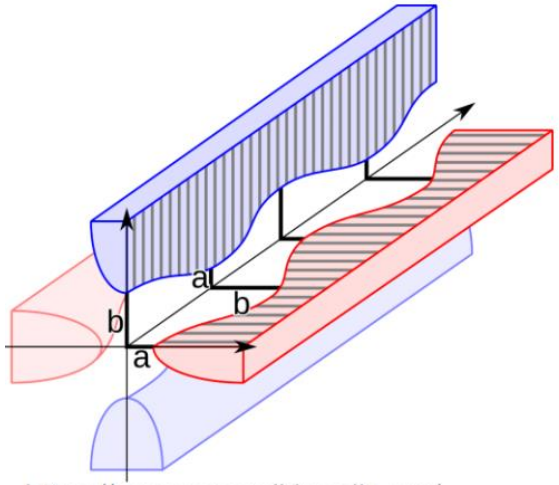


A. Lombardi, CERN

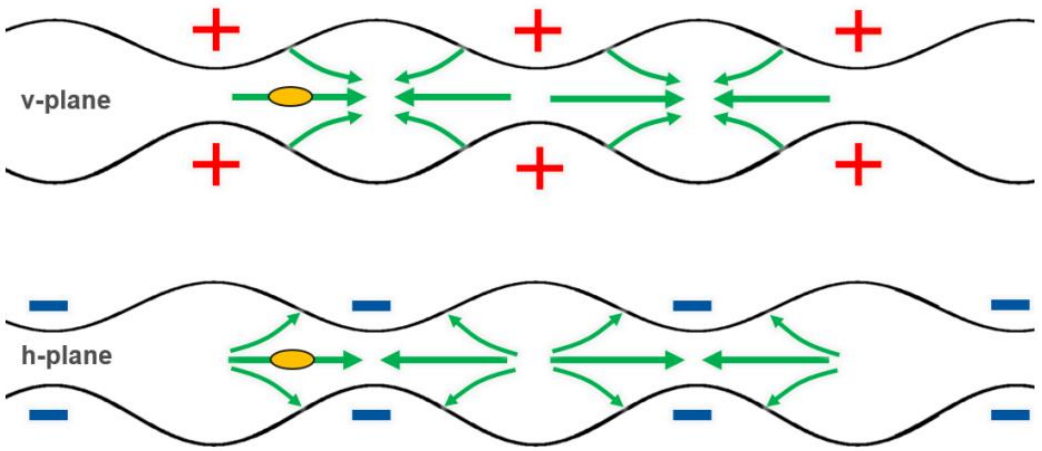
CERN Summer school 2022 lectures

Why is RFQ difficult

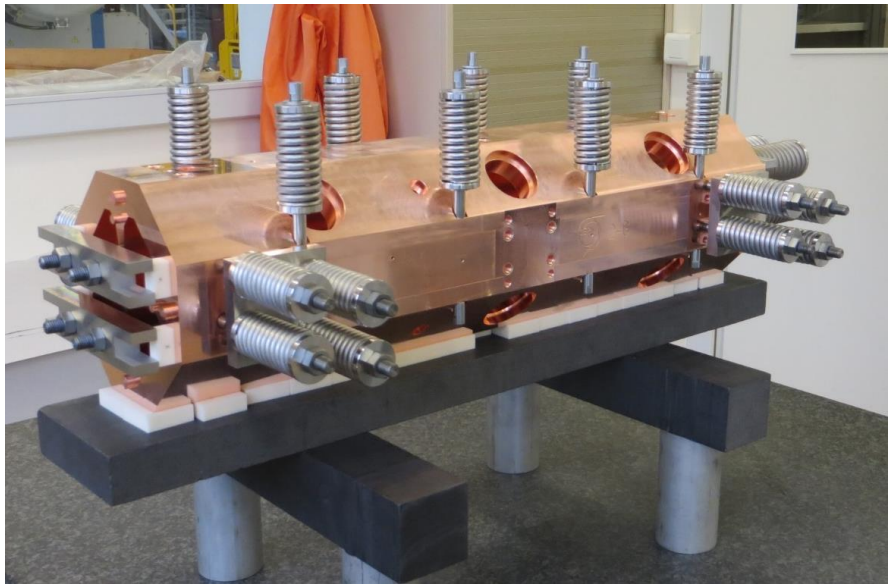
- **Sophisticated geometry**
- **4 separate componets that are brazed together**



https://commons.wikimedia.org/wiki/File:RFQ_accelerator_schematic.svg



Pommerenke et al. 2019



CERN – KT day – S. Mathot

Why is RFQ important

RFQ is crucial for:

- **Minimizing loss of particles**
- **Quality of the beam**

Requirements are demanding:

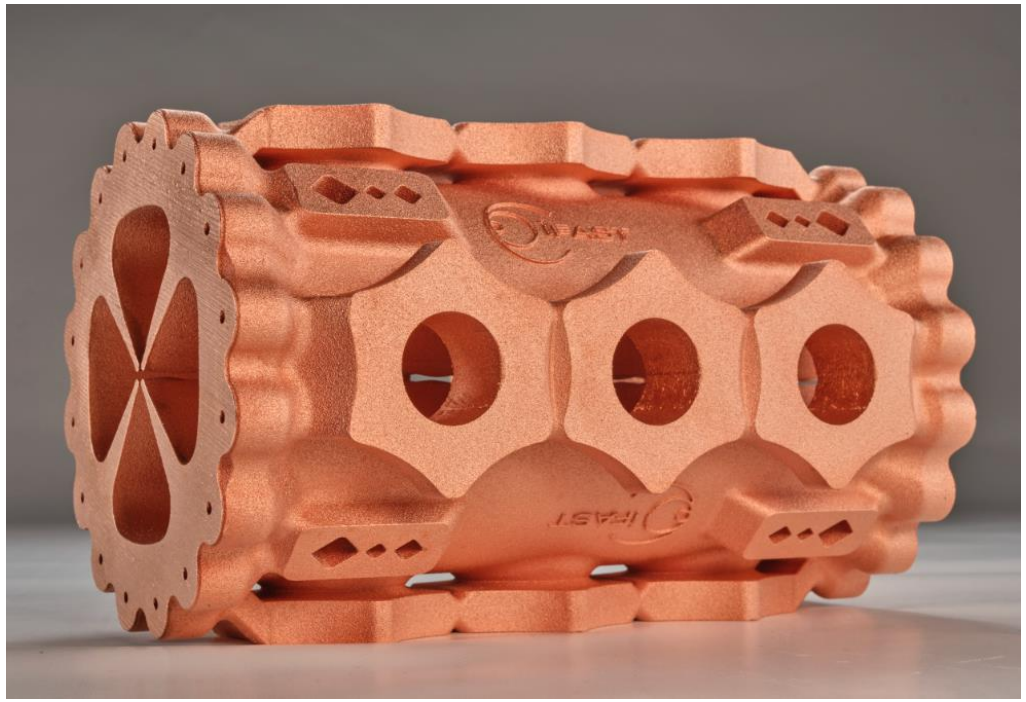
- **Tolerances are tight**
- **Surface roughness: Ra 0,4 µm**
- **Ultra high vacuum: 10^{-7} mbar**

	HF-RFQ – 750 MHz
Vane shape	± 5 µm (± 10)
Vane relative position	± 15 µm
Cavity shape	± 20 µm
Displacement max (X-Y)	± 20 µm
Displacement max. (Z)	± 20 µm
Gap between modules	± 20 µm

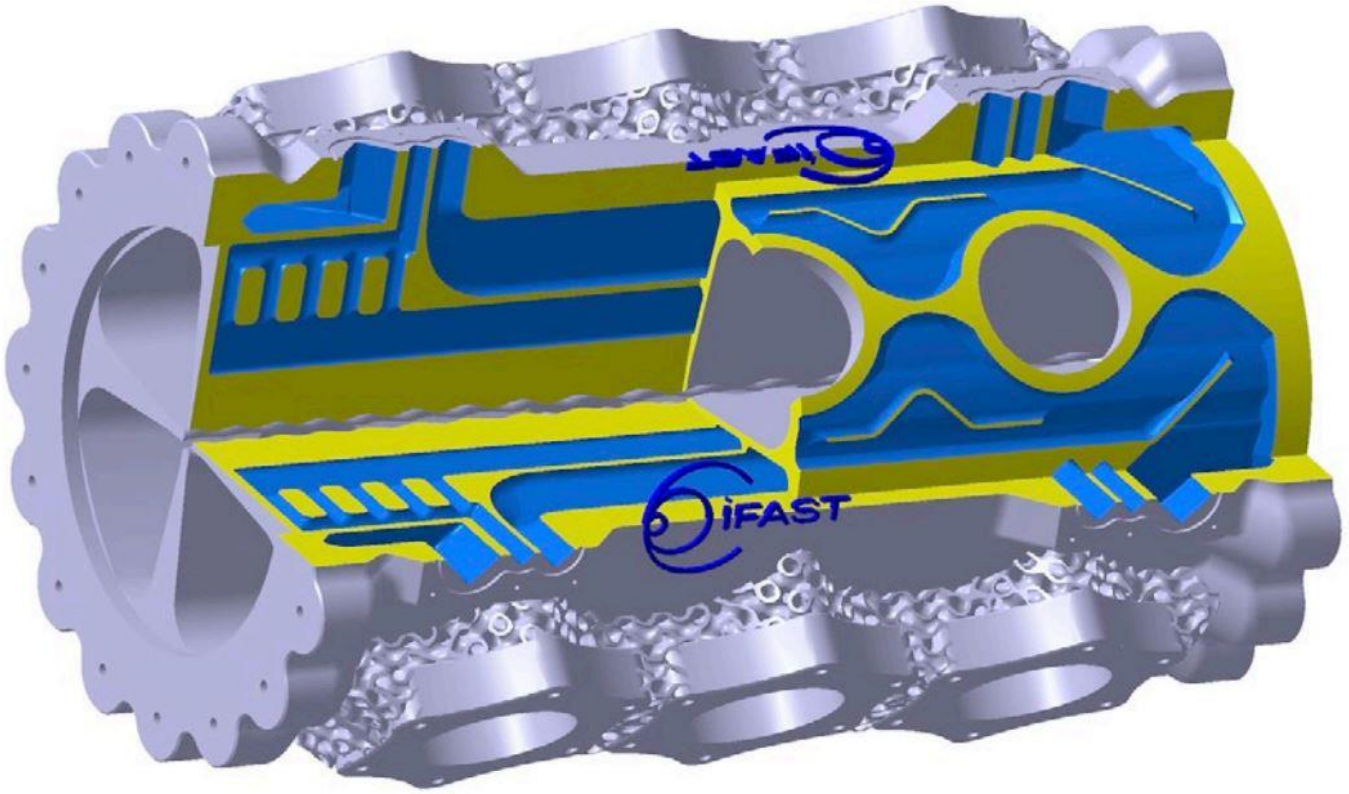
CERN – KT day – S. Mathot

Additively manufactured RFQ prototype

+ **Reduced cost and time**
+ **Improved design**
– **Very high surface roughness**
– **Porosity**



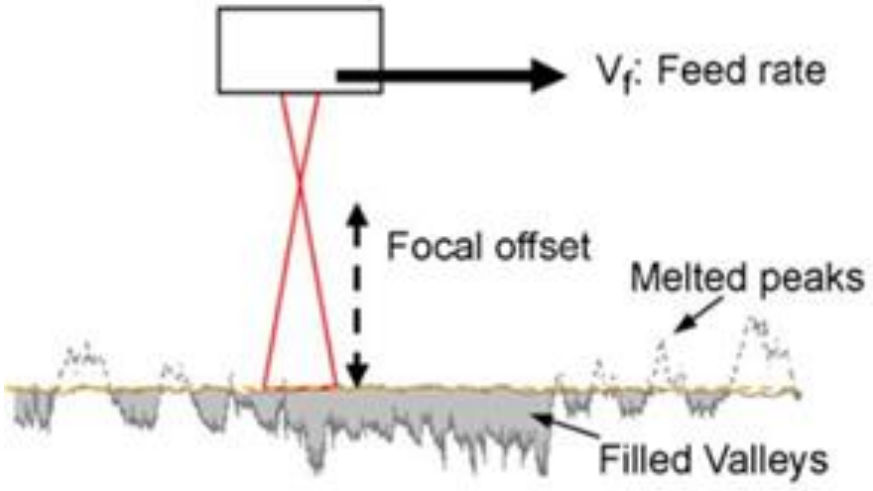
https://cds.cern.ch/record/2811234



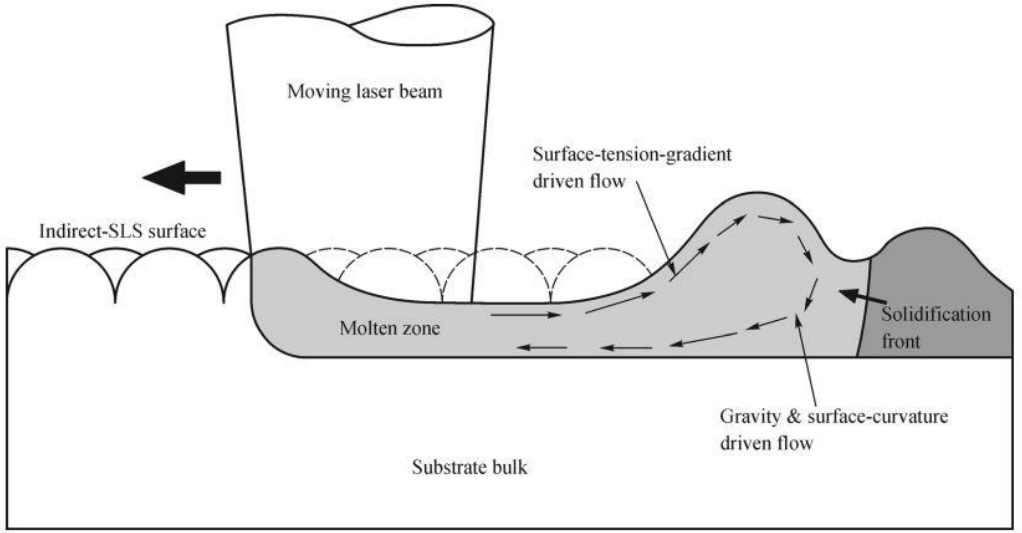
G. Pikurs, CERN

Laser polishing of AM-built RFQ

- **Surface treatment of AM-built RFQ**
  - Reduce roughness
  - Reduce porosity
- **Laser polishing of AM-built copper parts – no evidence found**
- **Analysis of most similar material: Aluminium**



Lamakiz et al. 2007



Alrbaey et al. 2014

Laser polishing of AM-built RFQ

Extracted laser parameters used for laser polishing AM-built aluminium parts

Experiment	No. 1		No. 2		No. 3	No. 4	
Laser mode	PW	CW	PW	CW	PW	PW	CW
Laser wavelength, nm	1030		1030		1030	1030	
Laser power, W	1700	1000	1700	1400	1712	1700	1400
Diameter of laser spot, um	1298	1298	1298	1298	1298	1056	1056
Power density, W/mm^2	1284,72	755,72	1300	1057	1293,79	1940	1600
Energy density, J/mm^2			76,5	42	83,2	76,5	33,6
Pulse duration, ms	0,3	n/a	0,3	n/a	0,41	0,3	n/a
Pulse frequency, Hz	1000	n/a	1000	n/a	2000	1000	n/a
Toolpath overlap, %	95	93,7	94,9	93,7	93,6	93,7	92,1
Scanning velocity, mm/min	8177,4	6000	12000	48000	24000	12000	60000
Feedrate, mm/min	100	100	40	200	100	40	250

Laser polishing of AM-built RFQ

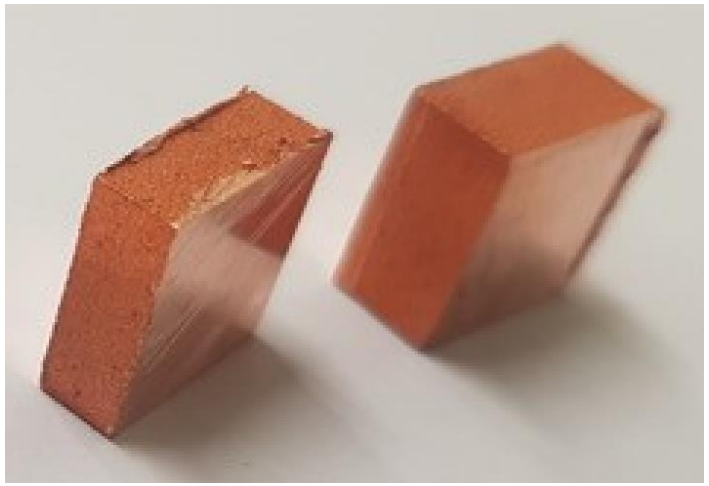
Adjusted laser parameters for different absorption of Cu and laser power

	Initial parameters, adjusted for difference of laser absorption		Parameters adjusted for DU	Parameters adjusted for powder bed fusion printer
Laser mode	PW	CW	CW	CW
Laser wavelength, nm	1060		1060	1060
Laser power, W	1700	1400	1000	250
Diameter of laser spot, um	1300	1300	1300	1300
Pulse duration, ms	0,4	n/a	n/a	n/a
Pulse frequency, Hz	2000	n/a	n/a	n/a
Toolpath overlap, %	94	94	94	94
Scaning speed, mm/min	**6000**	**12000**	**7059**	**1765**

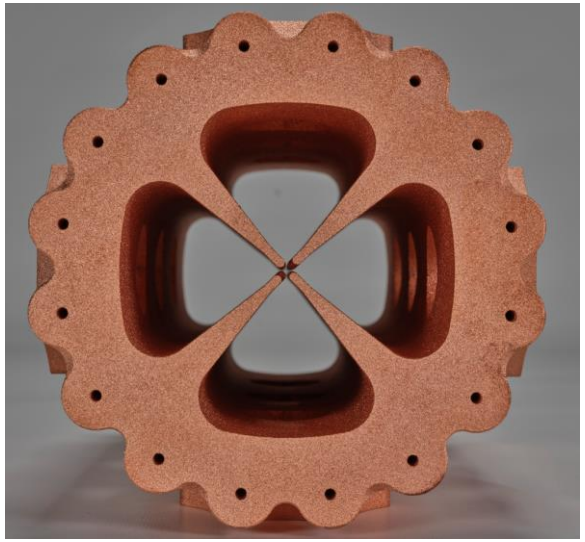
Laser polishing of AM-built RFQ

Future steps:

- **Conduct tests on specimens with flat surface**



- **Conduct tests on specimens with actual RFQ geometry**



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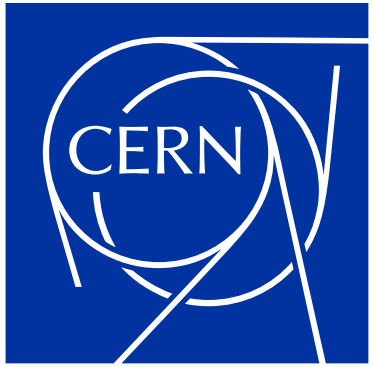

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