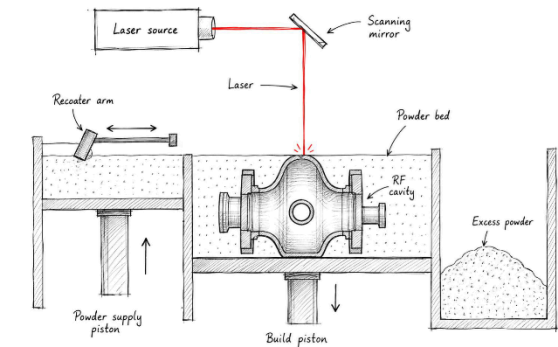
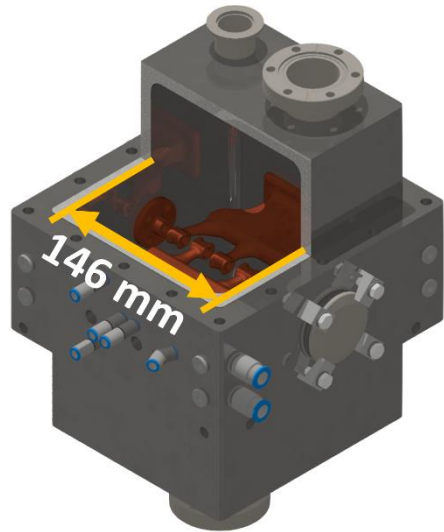


Recent progress in additive manufacturing of linear accelerator components

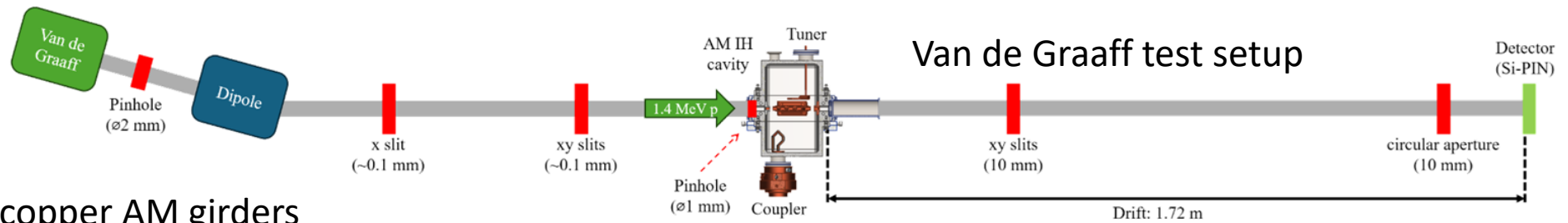
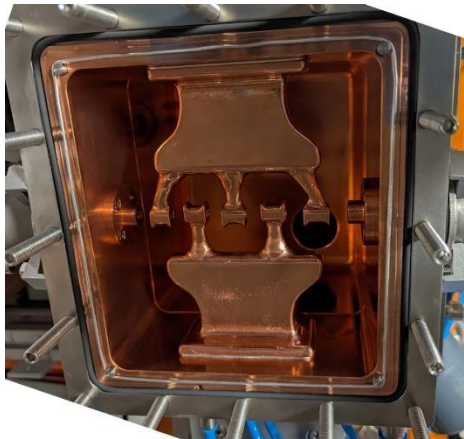
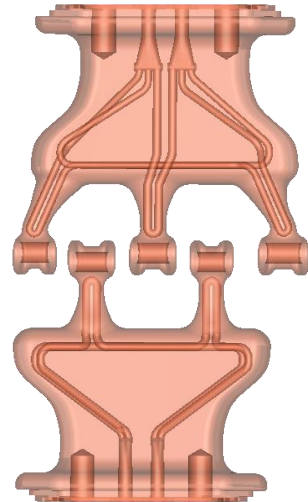


First beam test with 433 MHz IH-mode Linac structure

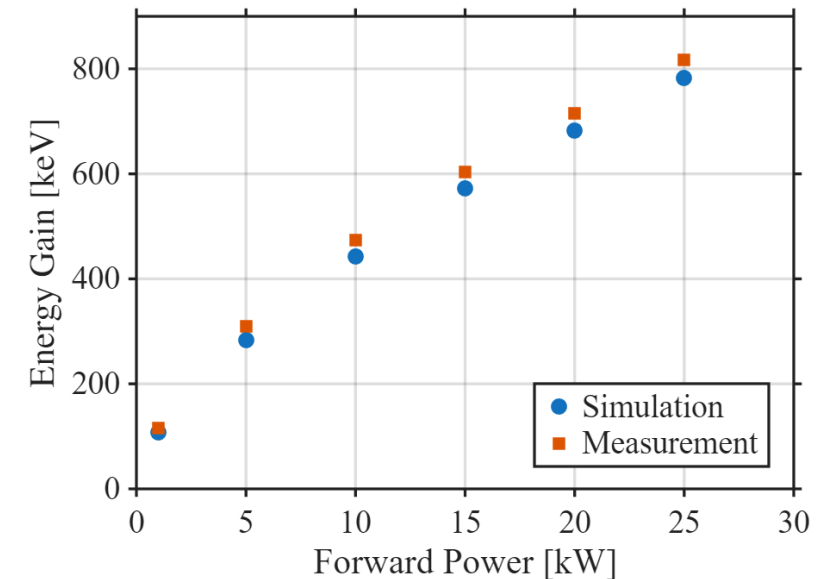
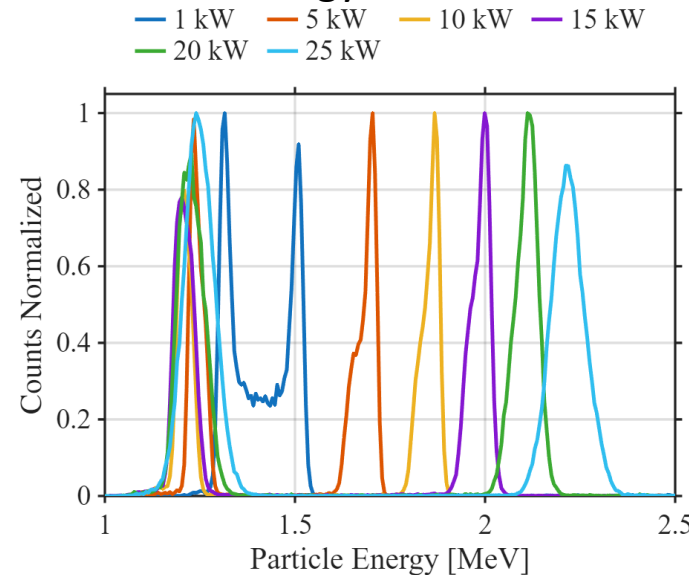
IH-mode RF cavity



Pure copper AM girders



Particle energy distribution at detector

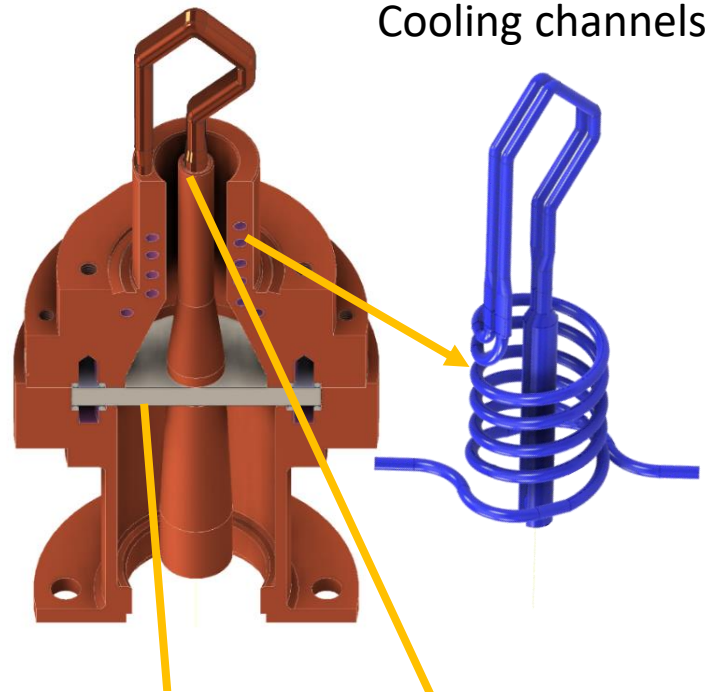


- $Q/Q_{sim} > 90\%$
- 25 kW at 2% duty cycle
- Peak E-field: 66.8 MV/m (3.3 KP)

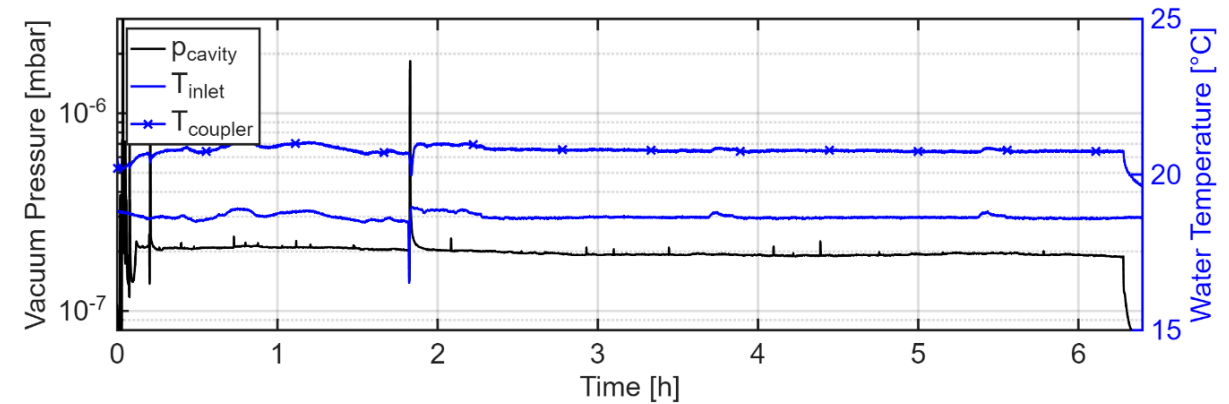
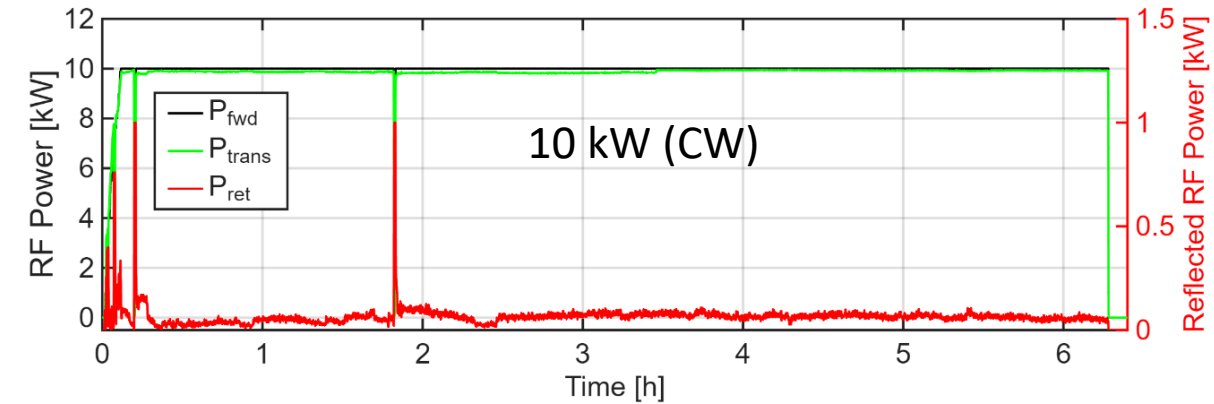
- Eff. shunt impedance: 186 MΩ/m
- No significant breakdown or field emission

A compact CF40 RF coupler

Coupler assembly



Ceramic insulator Brazed joints



- Successfully tested with RF cavity setup:
 - 10 kW CW
 - 25 kW at 2% duty cycle
- No significant breakdown or field emission

Multi-material Laser powder bed fusion (MM-LPBF)

➤ Allows monolithic components made from different materials

Matrix of possible material combinations

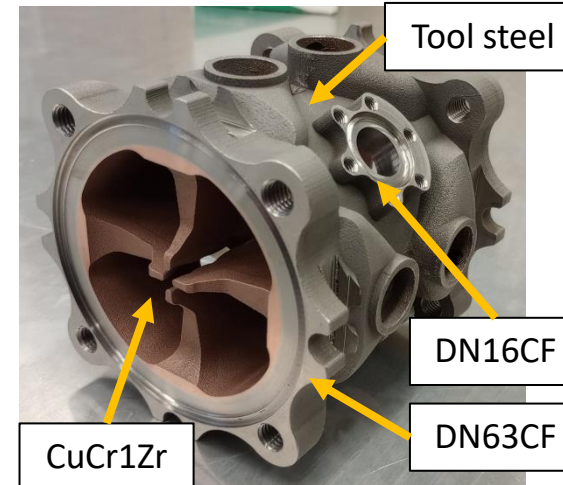
RFQ prototype demonstrates integration of CF flanges

	Qualification ongoing																Qualified on prototype							
AISI10Mg																								
Ti6Al4V																								
1.4404																								
1.2709																								
420SS																								
Inconel 625																								
Inconel 718																								
Hastelloy X																								
WC-Co																								
CuCrZr																								
GRCop-42																								
CuZr																								
CuSn10																								
Cu																								
Ti																								
Ta																								
W																								
Ceramics																								
AISI10Mg																								
Ti6Al4V																								
1.4404																								
1.2709																								
420SS																								
Inconel 625																								
Inconel 718																								
Hastelloy X																								
WC-Co																								
CuCrZr																								
GRCop-42																								
CuZr																								
CuSn10																								
Cu																								
Ti																								
Ta																								
W																								
Ceramics																								

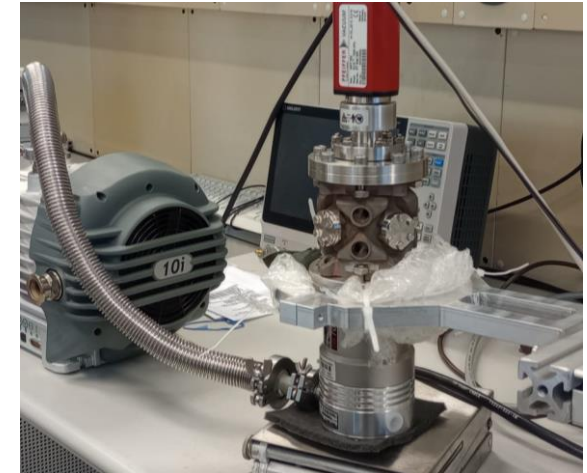
MM-LPBF process



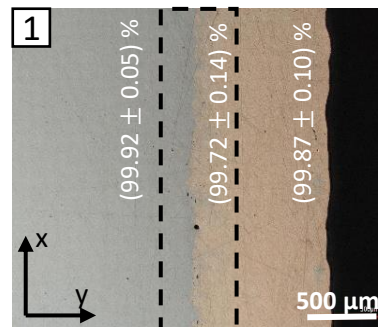
RFQ prototype



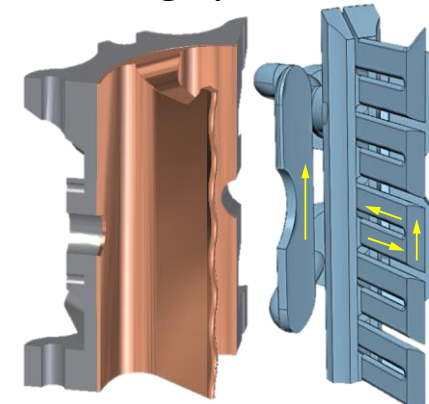
Vacuum test



Material density



Cooling system

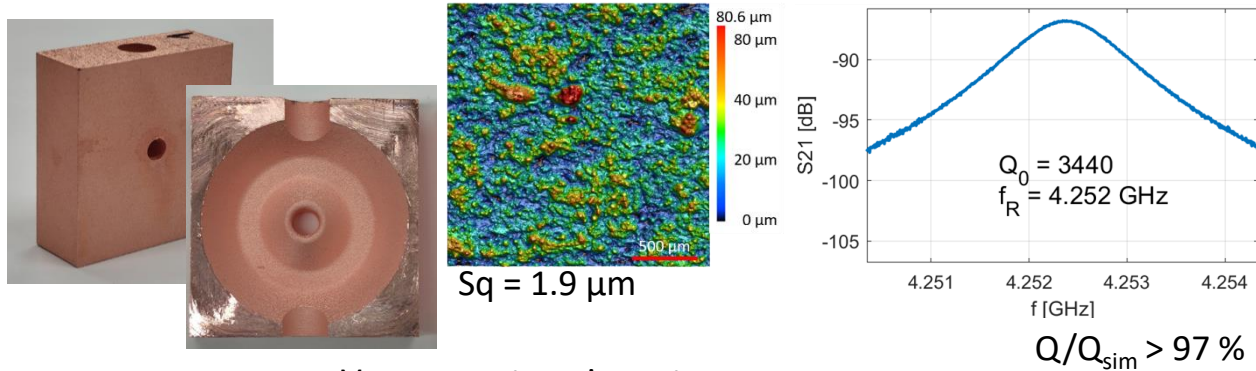


- Material density > 99.7 %
- Internal pressure < $5 \cdot 10^{-9}$ mbar
- Helium leak rate < $1 \cdot 10^{-8} \frac{\text{mbar L}}{\text{s}}$
- $Q/Q_{\text{sim}} > 75 \%$

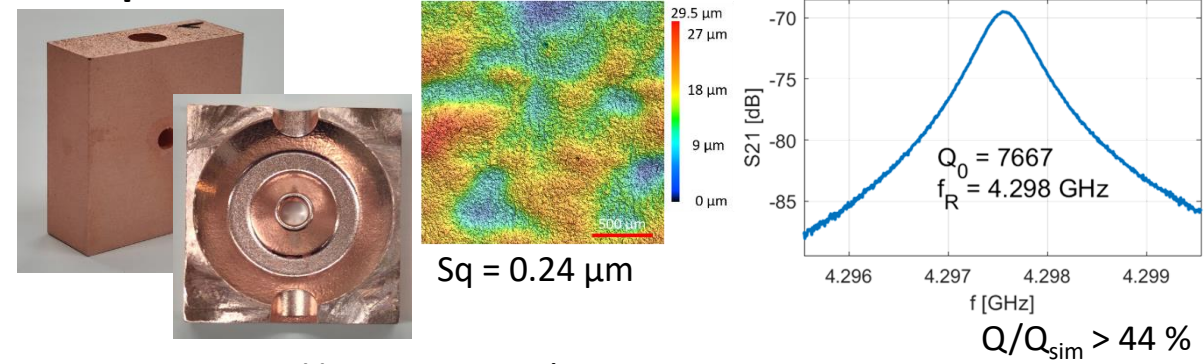
Vacuum quality of fully AM components

- LPBF → High surface roughness ($S_q > 1 \mu\text{m}$) → e.g. high RF conductivity → Post-processing
- Fully AM components → CNC machining not possible → **Chemical post-processing approach (Hirtisation)**

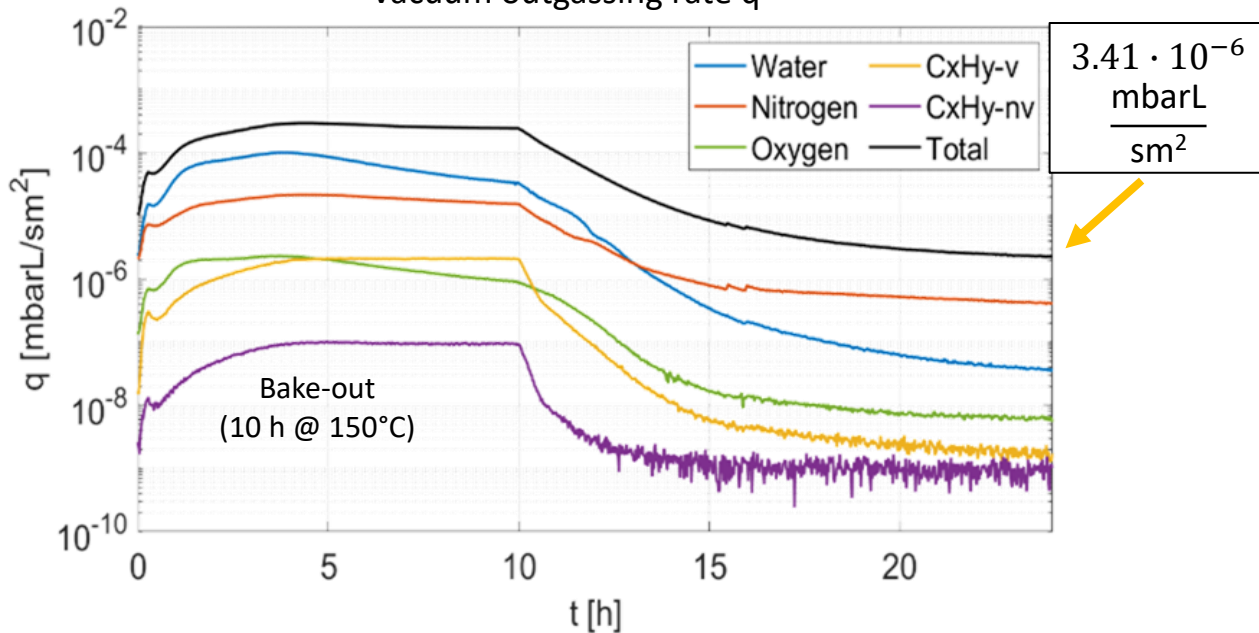
As-built



Post-processed



Vacuum outgassing rate q



Vacuum outgassing rate q

