RF Design of a High-Frequency RFQ Linac for PIXE Analysis

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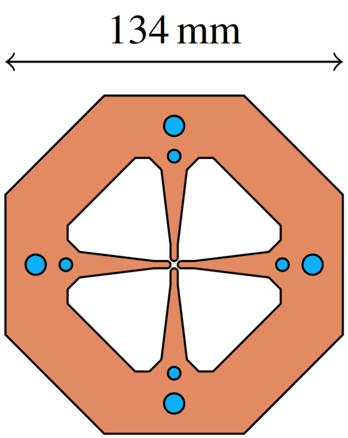
The PIXE RFQ

PIXE = particle/proton-induced X-ray emission

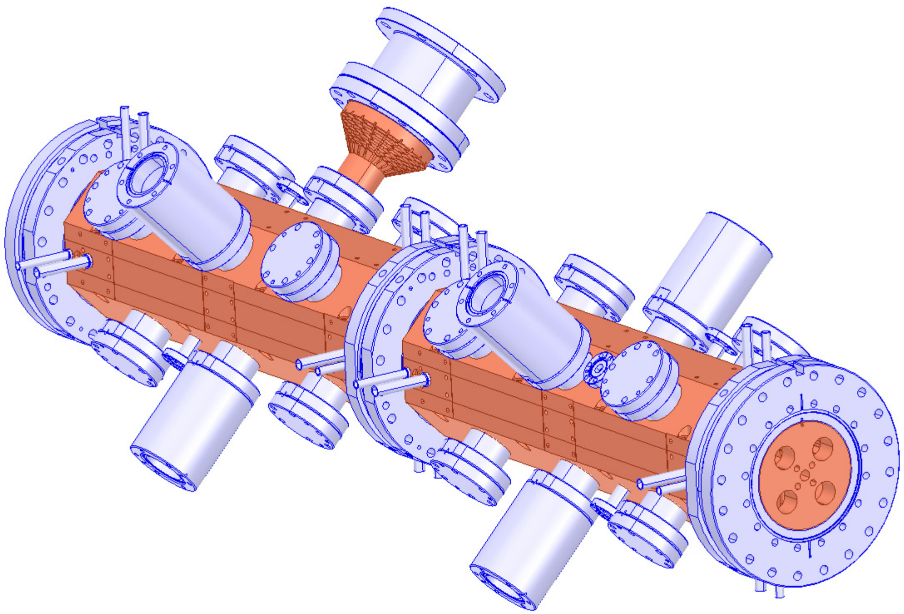
- low energy ion beam excites X-ray in specimen atoms
- spectrum allows for non-destructive analysis of artefacts, cultural heritage (among others)

PIXE RFQ

- 750 MHz RFQ provides 2 MeV protons over only one meter
- goal: first transportable system for *in situ* ion beam analysis



Input energy	20	keV
Output energy	2	MeV
RF frequency	749.48	MHz
RFQ length	1072.938	mm
Vane voltage	35	kV
Min. aperture	0.7	mm



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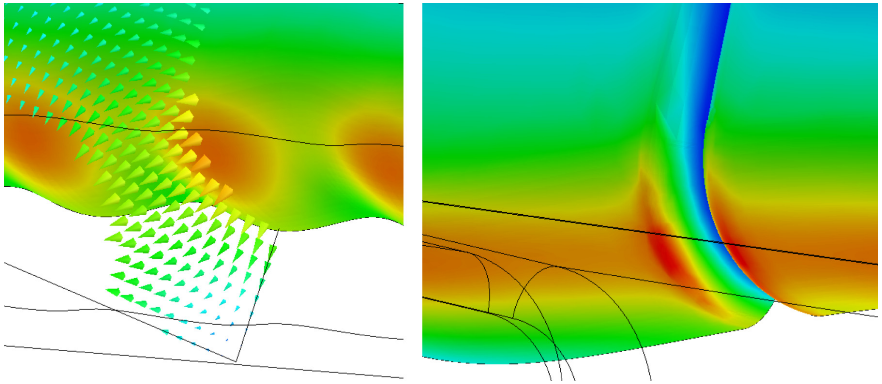
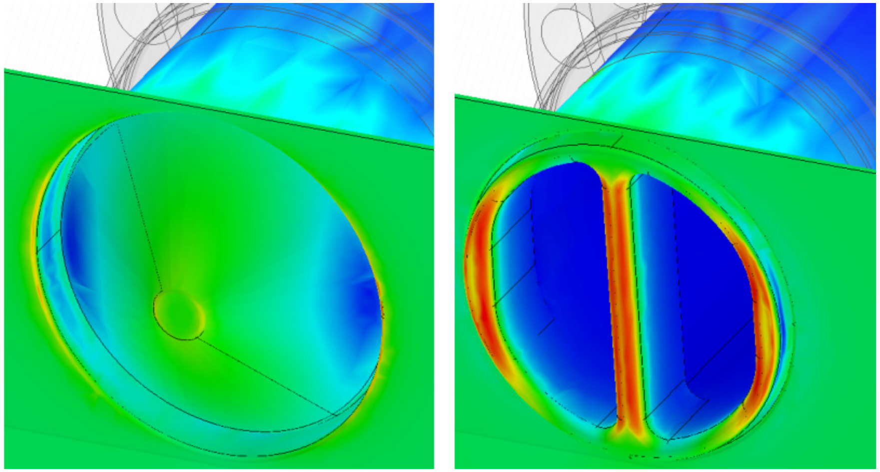
RF Design

- optimisation for 749.48 MHz and maximum Q factor
- end plates with bead pull holes and dipole stabilisation rods



- maximum surface electric field: 39.1 MV/m at module gap



- 16 copper slug tuners with conical tip
- 7 vacuum ports with crossbar

RF Design

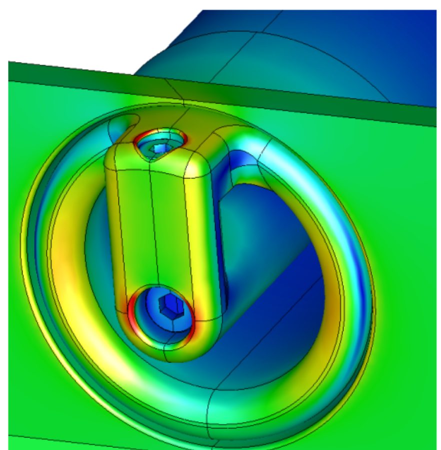
- power loss can be calculated from decomposition into segments

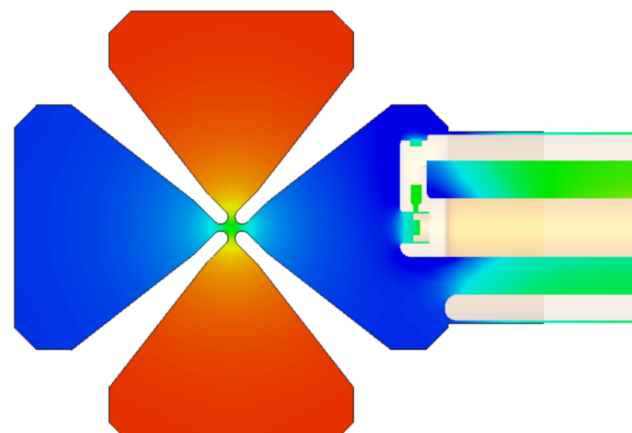
$$P_0 = \frac{\omega_0 V^2}{2} \sum_s \frac{1}{Q_{0,s}} \int_{Seg.\,s} C'(z)dz$$

without simulating full model

Loss factor	6000	
Capacitance	125	pF/m
Stored energy	82	mJ
RF power loss	64.5	kW
Max. surface field	39.1	MV/m

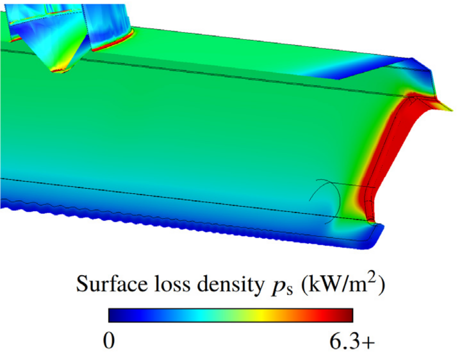
- one input power coupler (coaxial magnetic loop antenna) mounted on rotatable flange

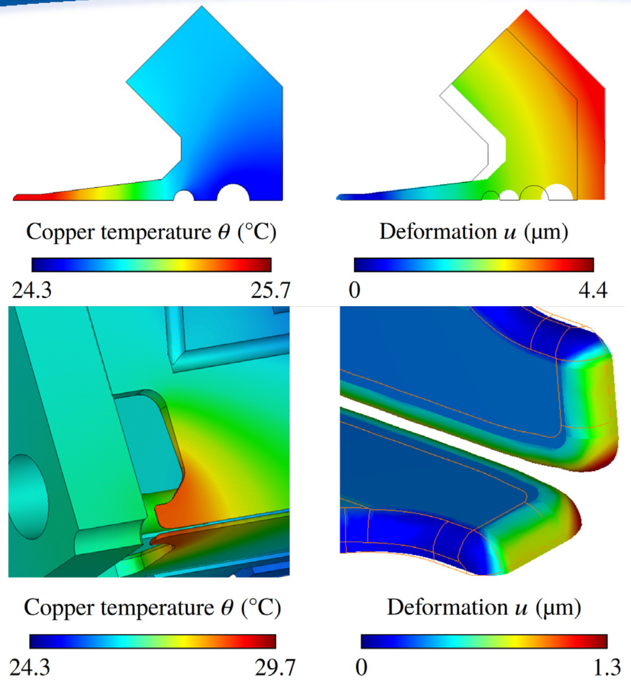


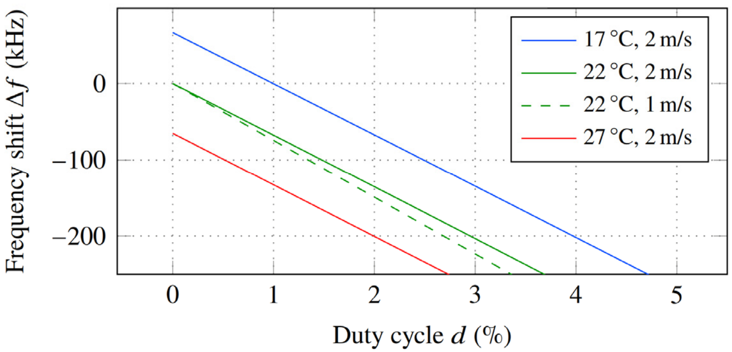


Thermal Simulation

- RF power loss raises RFQ temperature, thermal expansion results in deformation and frequency shift
- study frequency shift in dependence of duty cycle and water cooling properties

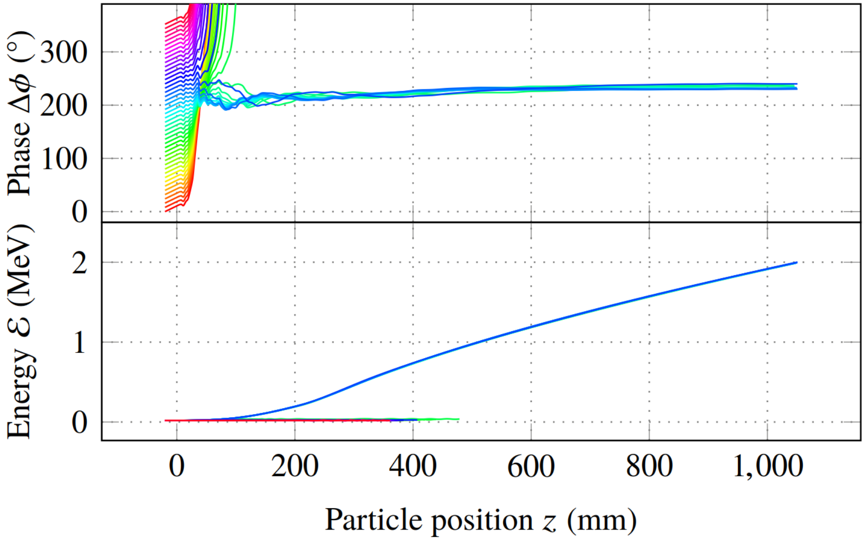


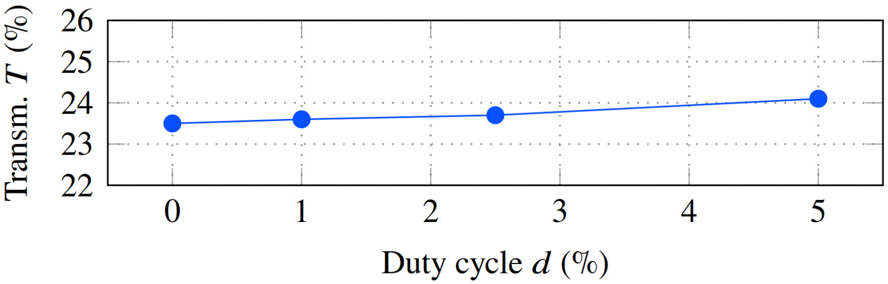




1D Particle Tracking

- validate RF design by tracking particles through RF field
- so far: longitudinal tracking only
  0..2π start phases 20 keV → 2 MeV x = y = 0





- Frequency shift due to RF heating acceptable for transmission

Conclusion

- RF design done for cavity, tuners, pumping ports, power coupler
- thermal simulation conducted to obtain requirements on cooling circuit
- first tracking results: deformation due to RF heating acceptable
- current state: machining, first brazing expected Oct 2018

Thank you!

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