Study of anomalous heating of the HIE-ISOLDE mobile coupler

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TTC2015 Working Group 4a

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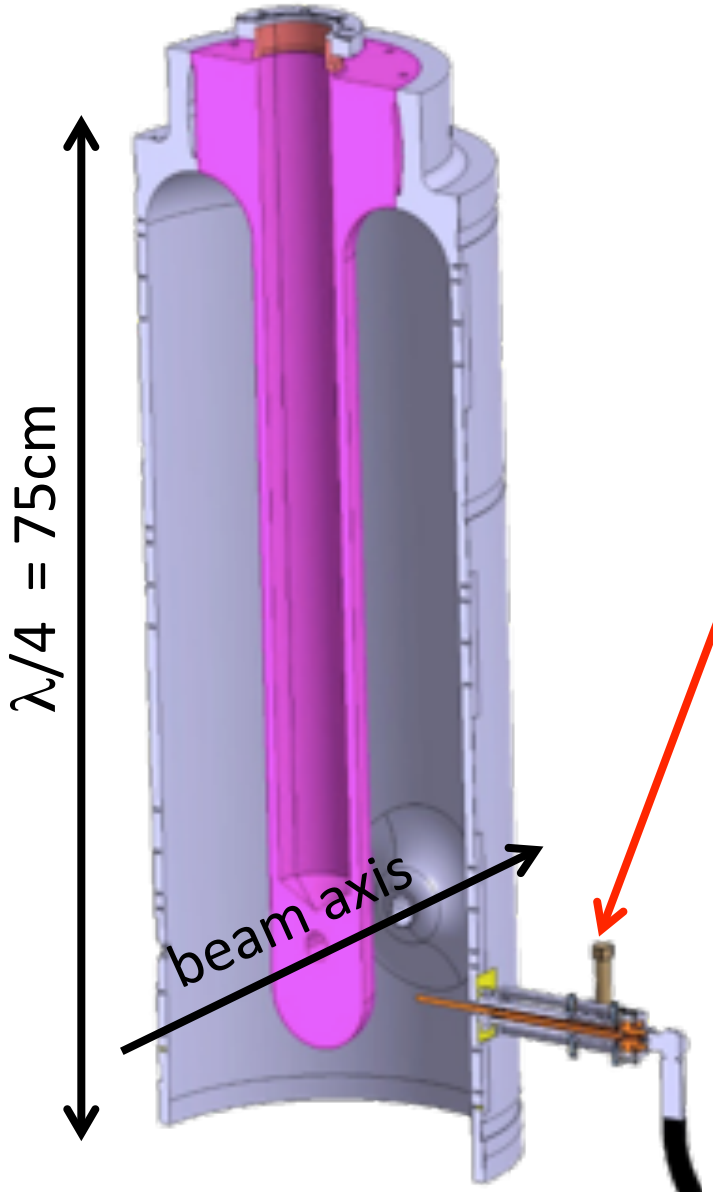
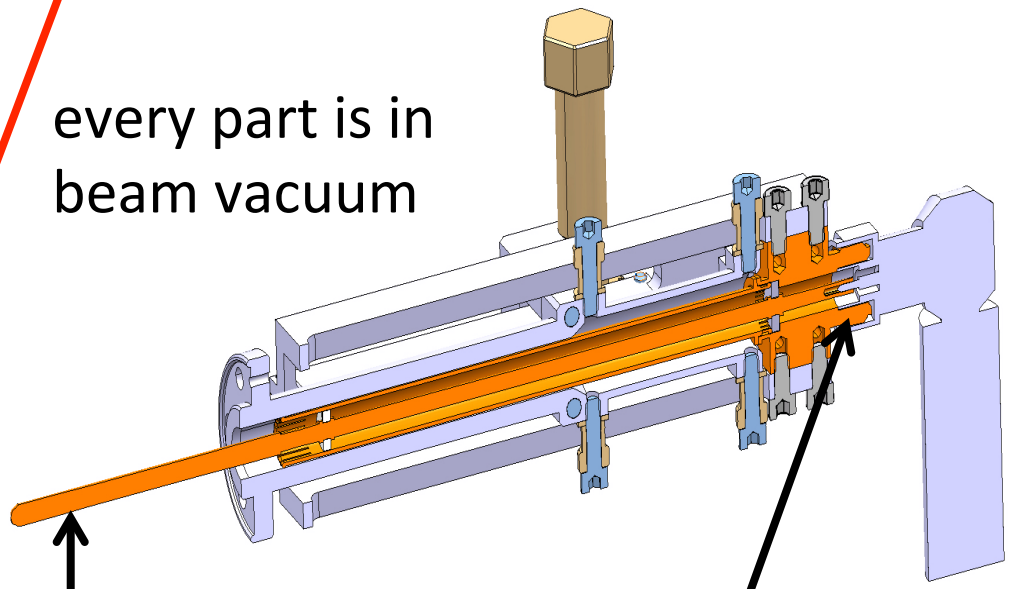
HIE-ISOLDE cavity & mobile coupler

Superconducting quarter-wave resonator for heavy ions (6MV/m, 101MHz)



coaxial mobile coupler (<500W)

every part is in beam vacuum



Bz4

point contact to the inner conductor of the cable

Required band-width (BW)

BW of the resonance is optimized by changing the coupler position

BW [Hz]	Q_{ext}	P_f [W]	P_r/P_f	coupler insertion
0.43	4.3×10^8	10	0	0 mm
3	3.6×10^7	38	74%	4.5 mm
5	2.1×10^7	60	83%	5 mm
17	6.0×10^6	200	95%	8 mm

chosen operational bandwidth, as allowed by the level of microphonics

→ Insert the coupler toward the cavity by a few mm for wider BW

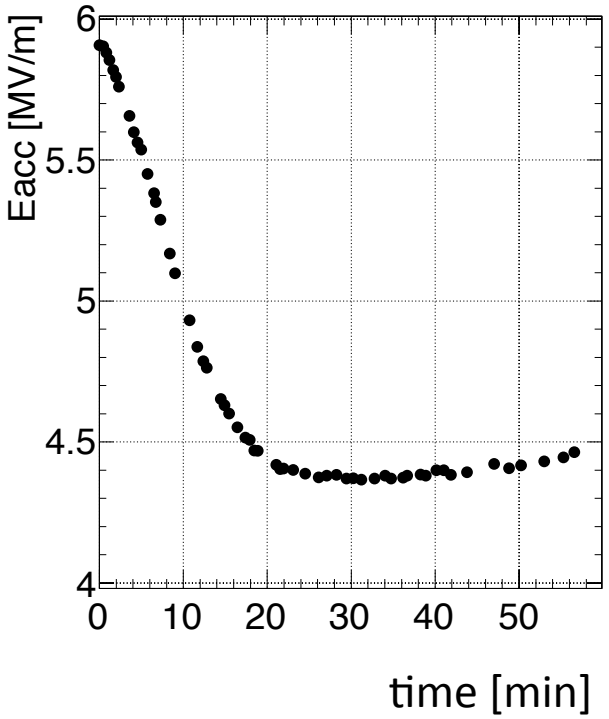
→ The cavity is operated in a strongly over coupled condition

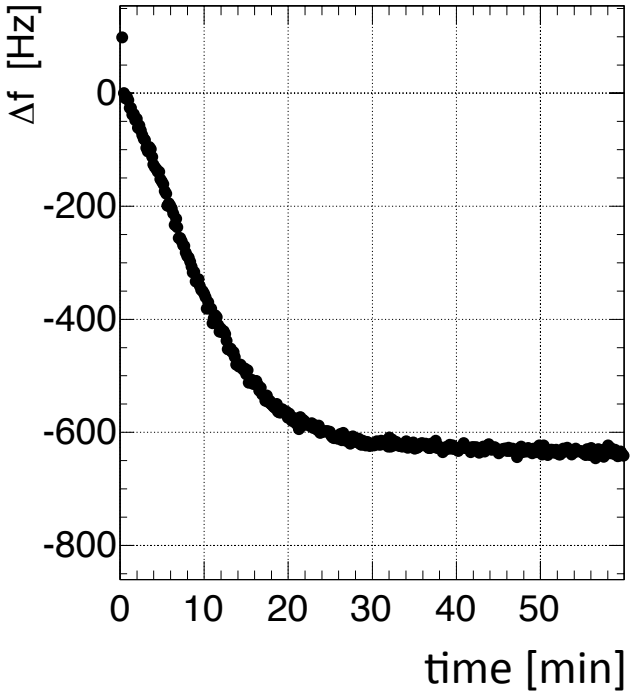
Observed drifts in RF signals in operation

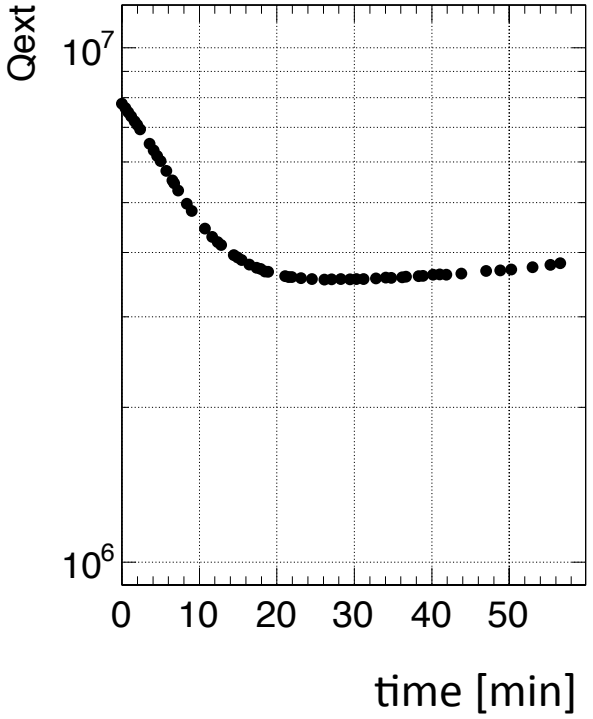
The strongly coupled case was tested during comissioning

→ Eacc, resonance frequency, and Qext decreased in 10 minutes

→ An off-line test was done to investigate this phenomenon





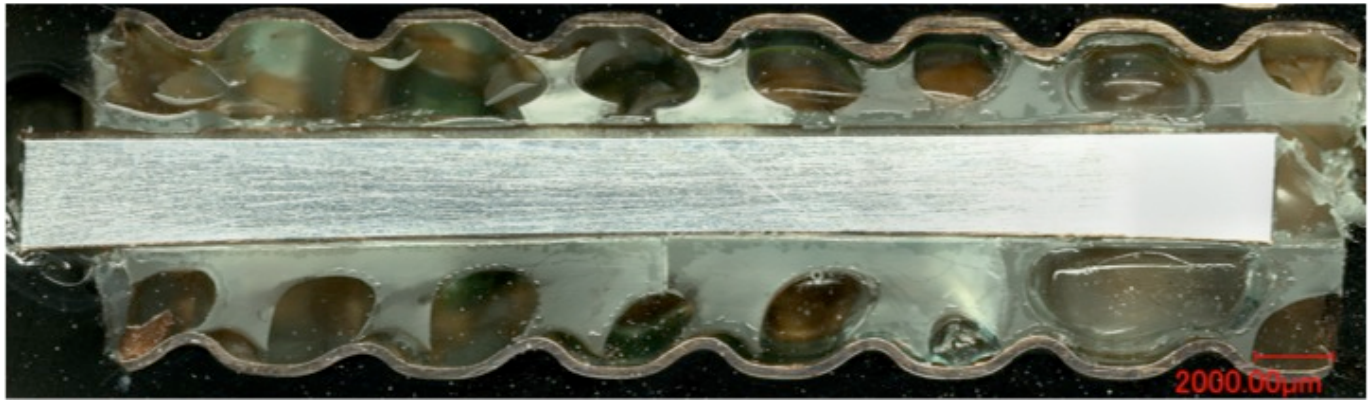


The anomalous phenomenon was reproduced, and…

1h after starting the test, something happened and the cavity was not able to resonate anymore!

coupler and RF cable were melted in off-line test!

→ made short and prevent feeding RF to the cavity after 1h



anomalous heat raised the coupler temperature (>600K)

The acceleration field in the linac is temporarily limited for protection

→ *A dedicated study of this phenomenon was launched*

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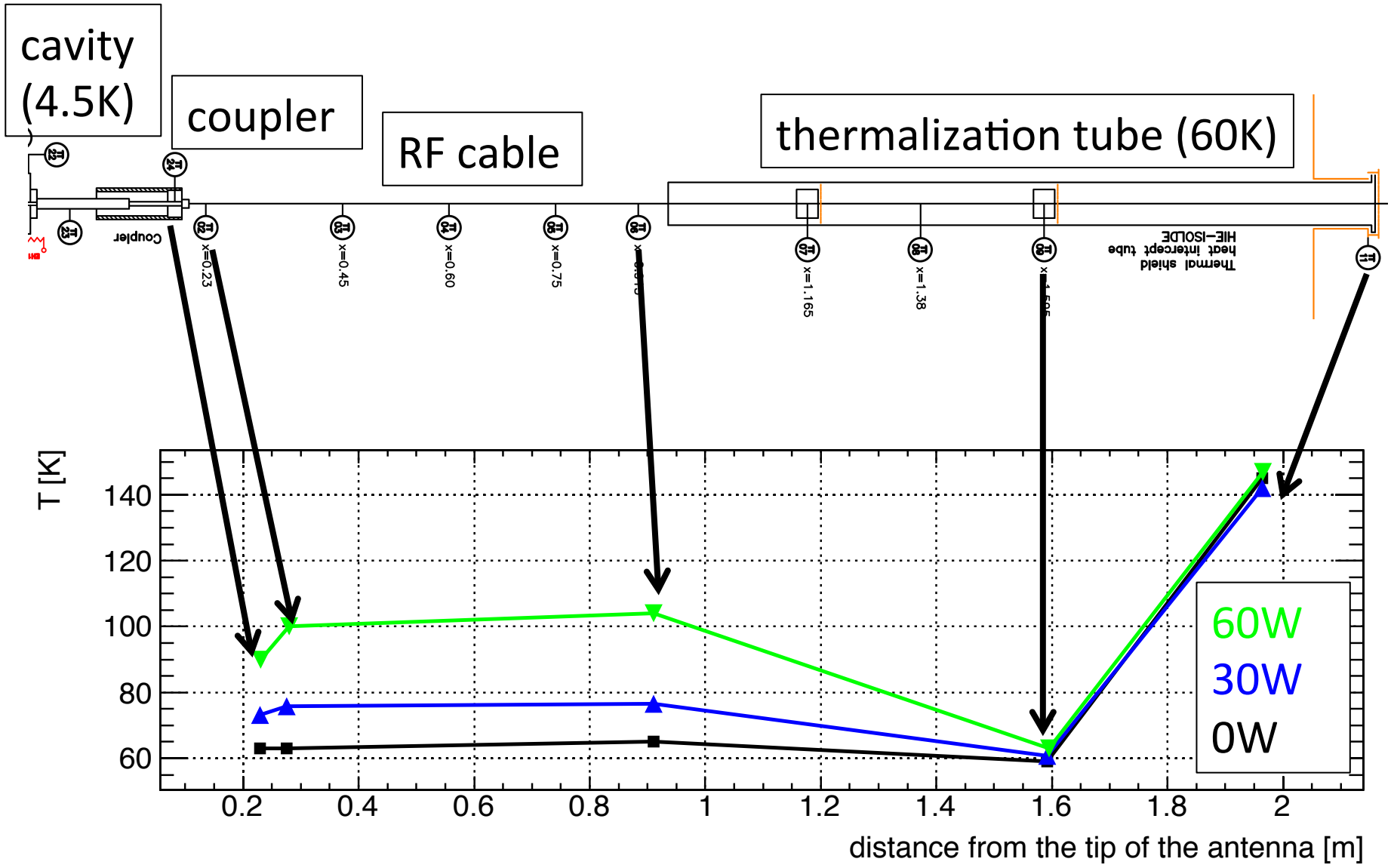
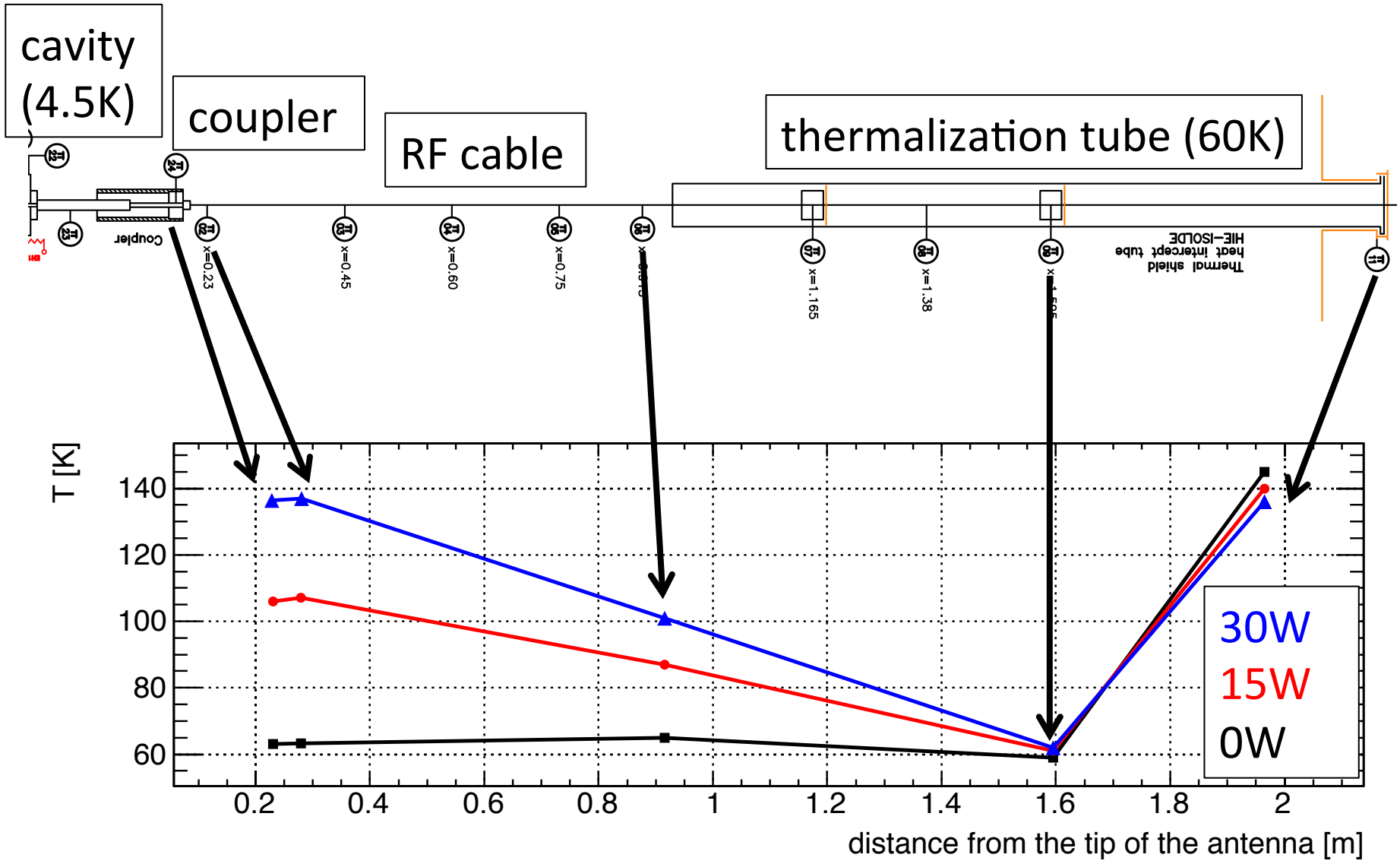
temperature distribution (off-resonance / no cavity)



Without the cavity resonance, the heat is dominated by RF loss in the cable

→ More or less well controlled with the thermalization as designed

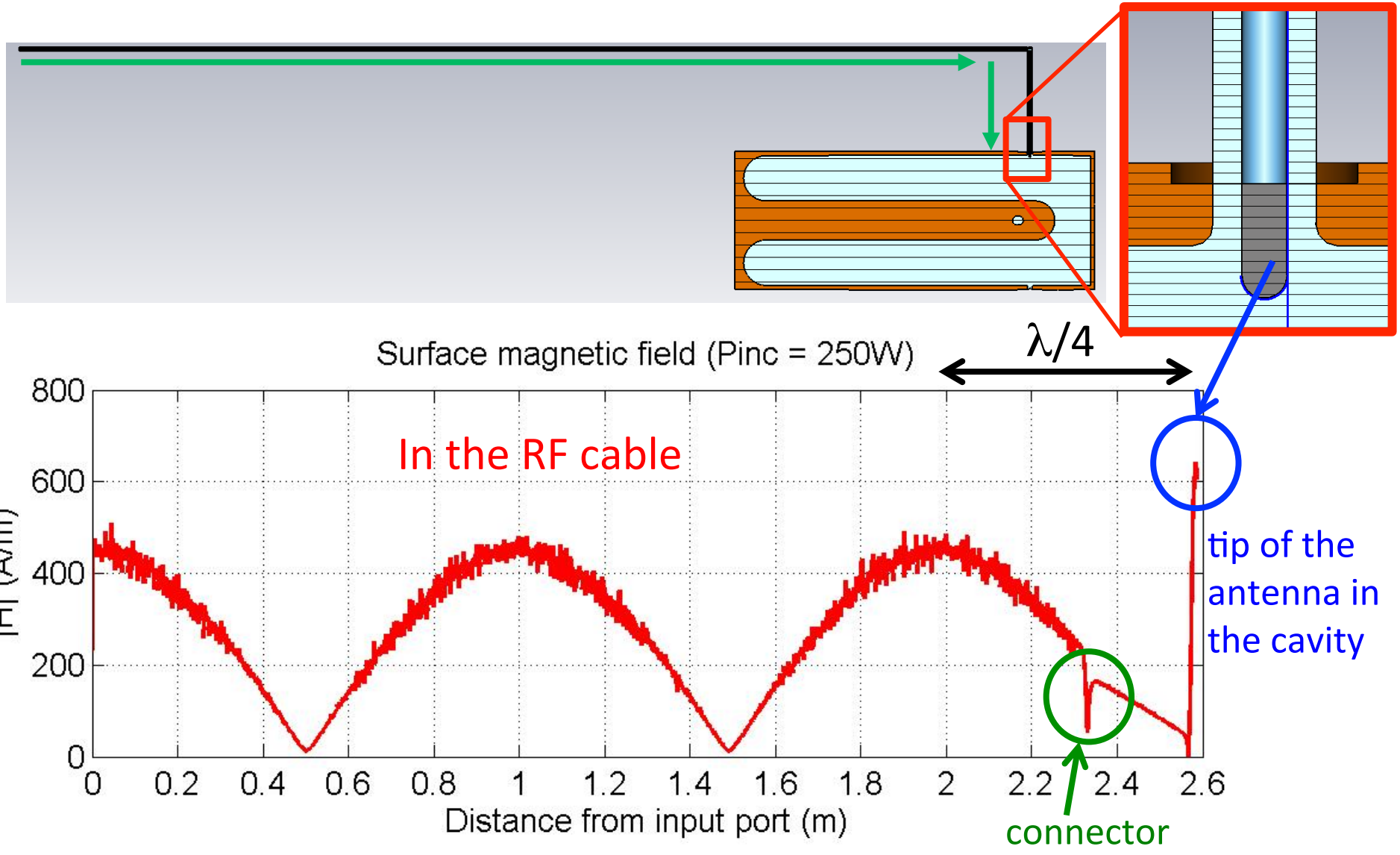
temperature distribution (on-resonance)



There is an additional heat source at the coupler when cavity resonates

→ A RF simulation including *coupler + cavity* is necessary!

RF simulation (H-field)



→ The RF loss at the tip of the antenna should be reduced (Bz4→Cu) !

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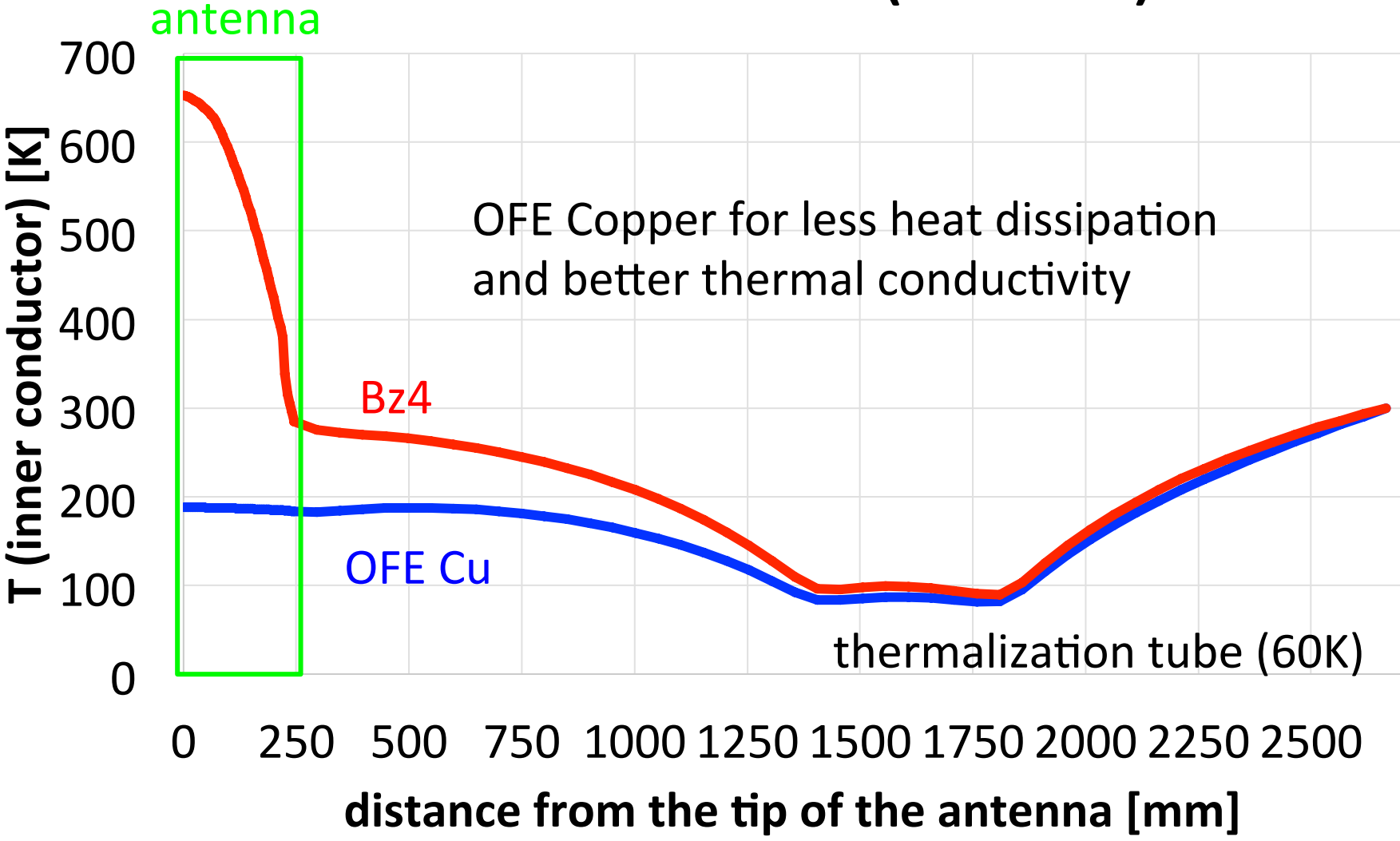
Bz4 → OFE Cu (250W)

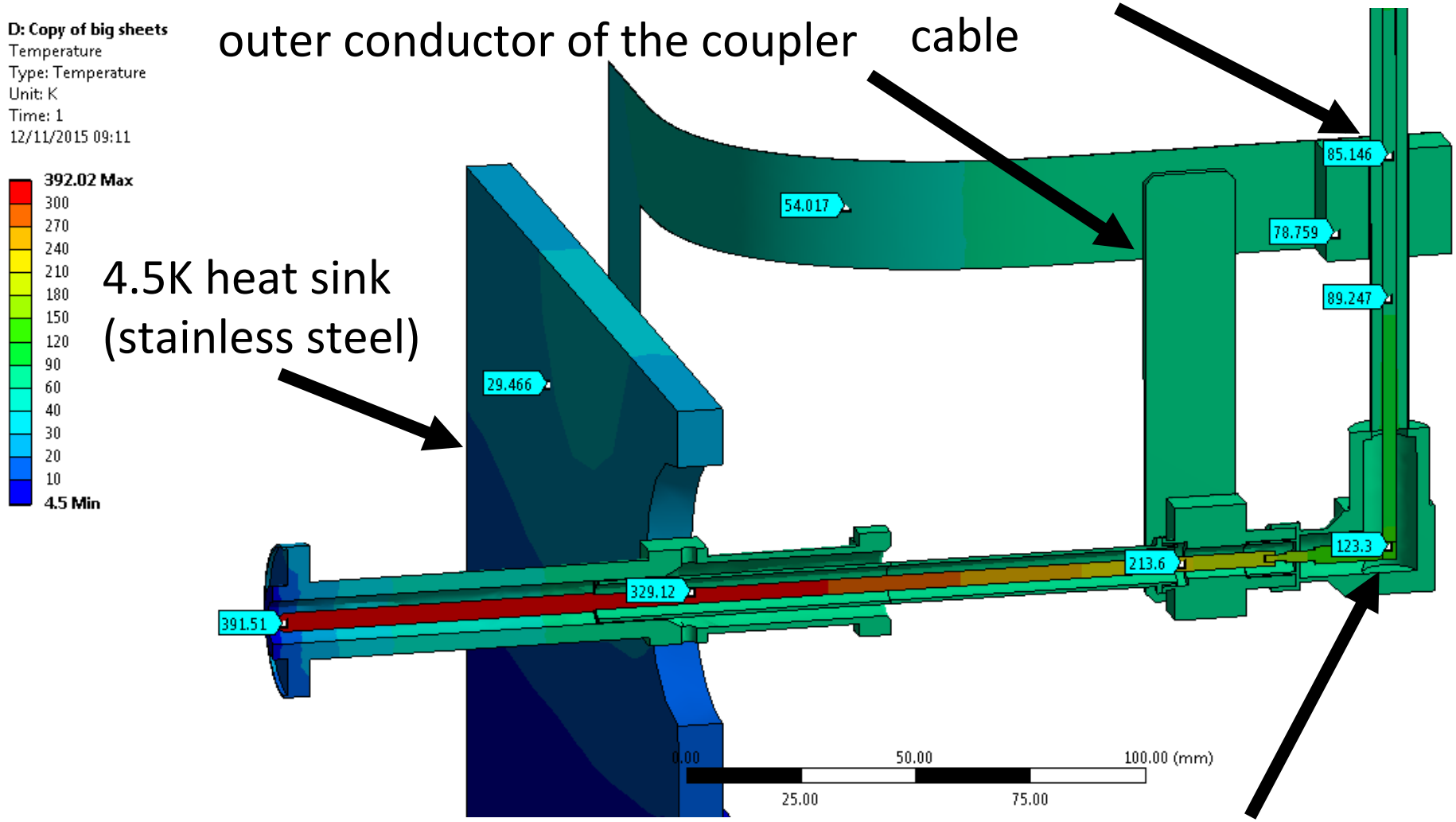


The simulation has *not yet quantitatively* explained the phenomenon
→ A more conservative modification is necessary for safety

Additional thermalization

Additional thermalization1:
outer conductor of the coupler

Additional thermalization2:
cable



The contact between the antenna and the inner conductor of the cable is brazed

Conclusion

- The HIE-ISOLDE cavity is equipped with a variable coupler
- When the coupler is placed at the strongly over-coupled position for wider band-width required by the feedback system, the coupler gets overheated and eventually fails
- We launched a taskforce to investigate this problem in August and have systematically worked for 3 months
- The measurements and simulation at least qualitatively indicate that RF heating on the antenna when the cavity is resonating may explain
- The ideas to mitigate the heat by better electric conductance and cooling power were already proposed and now being tested
- We are still investigating the phenomenon to get better understandings (quantitative consistency, reason of Eacc decrease, etc…)