N. Al-Saokal, J. Kühn, M. Buerger, M. Dirsat, A. Frahm,
A. Jankowiak, T. Kamps, G. Klemz, S. Mistry, A. Neumann, H. Ploetz
Helmholtz-Zentrum Berlin (HZB) für Materialien und Energie, Germany

HZB Helmholtz Zentrum Berlin
bERLinPro
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THERMAL LOAD STUDIES ON THE PHOTOCATHODE INSERT WITH EXCHANGEABLE PLUG FOR THE BERLINPRO SRF-PHOTOINJECTOR

ABSTRACT

- **thermal contact experiment (TCX) was set up of the photocathode cooling system based on the original components**
- **thermal load studies were carried out to investigate the cooling performance**
- **two cathode inserts and two RF-filters were characterized and optimized**
- **Thermal limits, heat transfer coefficients of the interfaces and temperature dependent insert motion have been identified**

INTRODUCTION

- since 2012 the Helmholtz Zentrum Berlin is working on the Berlin Energy Recovery Linac Prototype as one of its future projects led by the Institute of Accelerator Physics and the Institute of SRF - science and technology (1)
- Mile stone: commissioning of the SRF photoinjector and the first electron fired from a copper photocathode in 2018 (2,3,4)
- after decommissioning of the SRF photoinjector for the refurbishment of the gun cavity the photocathode insert was damaged due to high thermal load based on RF losses during operation
- Photocathode plug holding mechanism was improved and had to be tested
- study is motivated to ensure a safe operation of the bialkali antimonide semiconductor photocathodes and to avoid the contamination of the SRF cavity of the photoinjector when bERLinPro is commissioned

SRF PHOTOINJECTOR

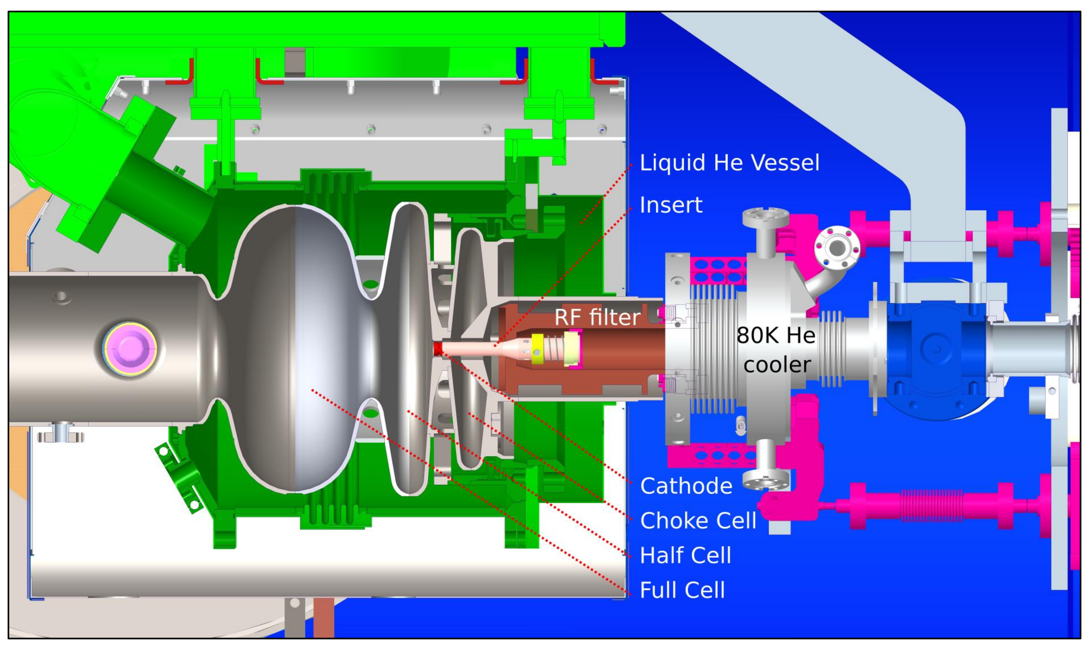

Figure 1: Cross section of the SRF photoinjector showing the cavity geometry together with the cathode section (courtesy of M. Schmeisser).

- for the bERLinPro SRF photoinjector a Cs-K-Sb photocathodes will be used as electron source
- inside the module the cathode insert is cooled down to 80K by gaseous helium
- the cathode insert carries the photocathode plug which will be aligned in the RF-filter with respect to the back wall of the cavity
- cathode position is crucial for the heat load, 1mm behind the back wall **5W** can be expected
- during operation the photocathode is illuminated with a 515nm drive laser - for a 100mA current and 1% QE is **25W** laser power required
- in total a heat load of about **30W** was estimated for high current scenario with a retracted photocathode

THERMAL CONTACT EXPERIMENT

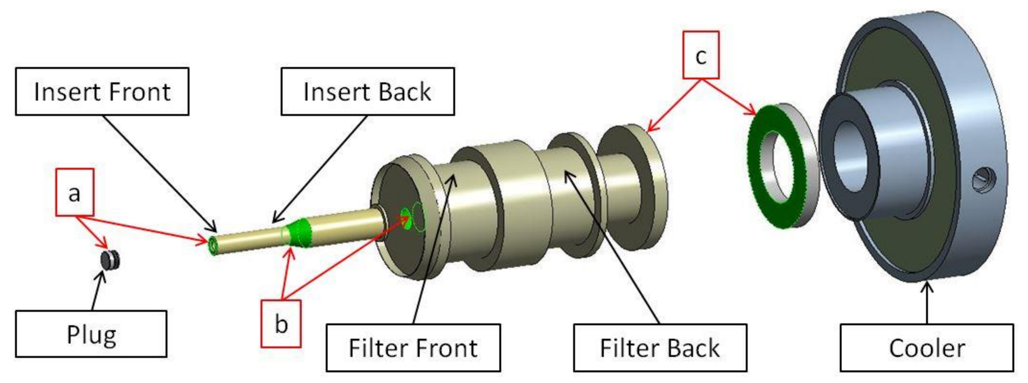

Figure 2: Three interfaces: a-plug/insert, b-insert/RF-filter, c - RF-filter/cooler.

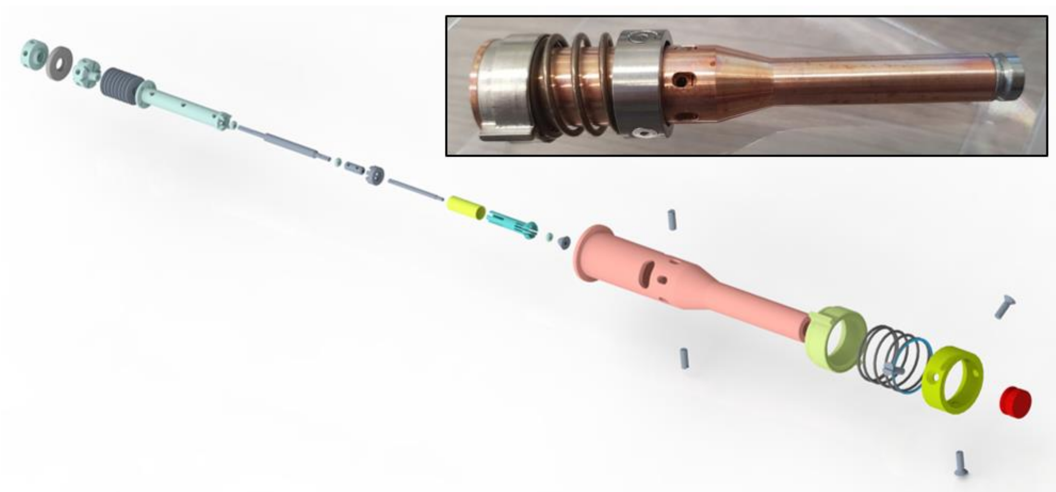

Figure 3: A photograph of the assembled 7111 cathode insert for the SRF photoinjector and the exploded drawing.

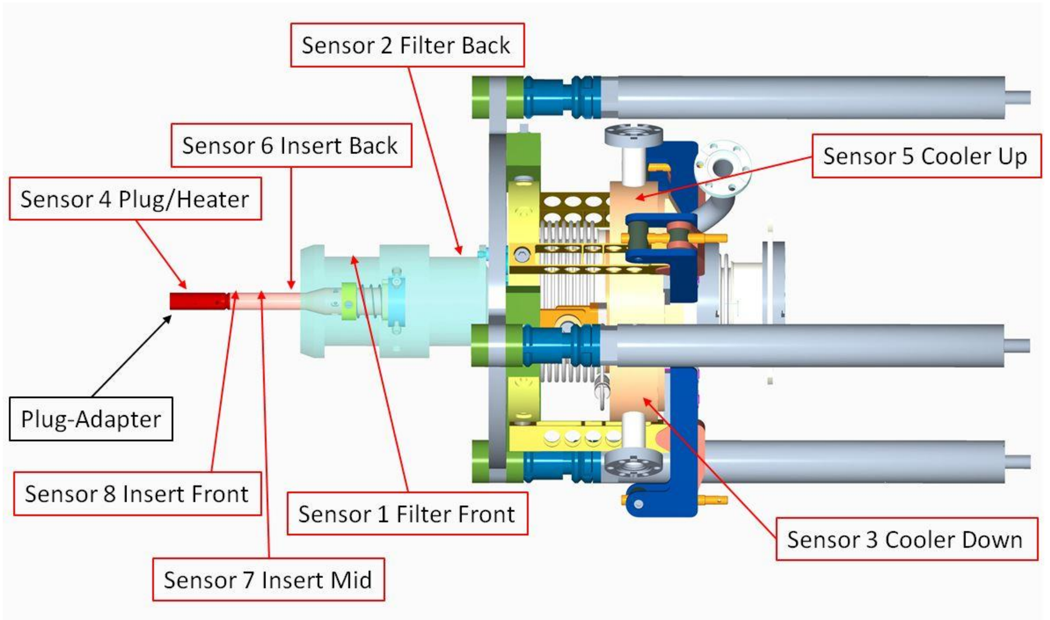

Figure 4: 3D-drawing of the thermal contact experiment.

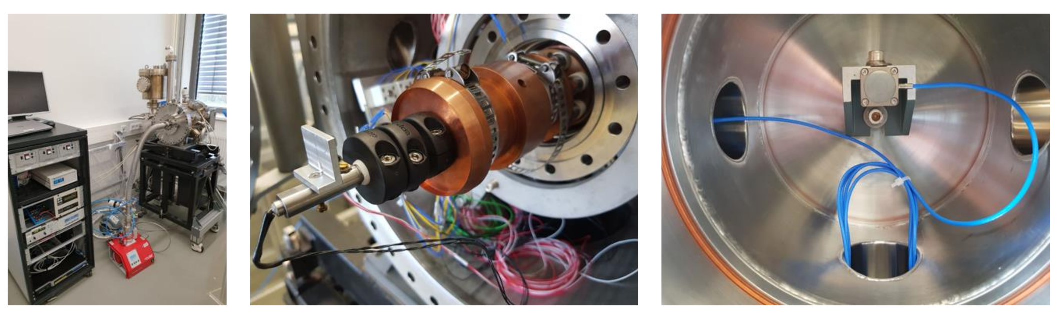

Figure 5: Overview of the TCX-setup: (left) Vacuum chamber, (center) Insert inside the RF-filter with heater and sensors and position marker for distance measurement, (right) distance sensor.

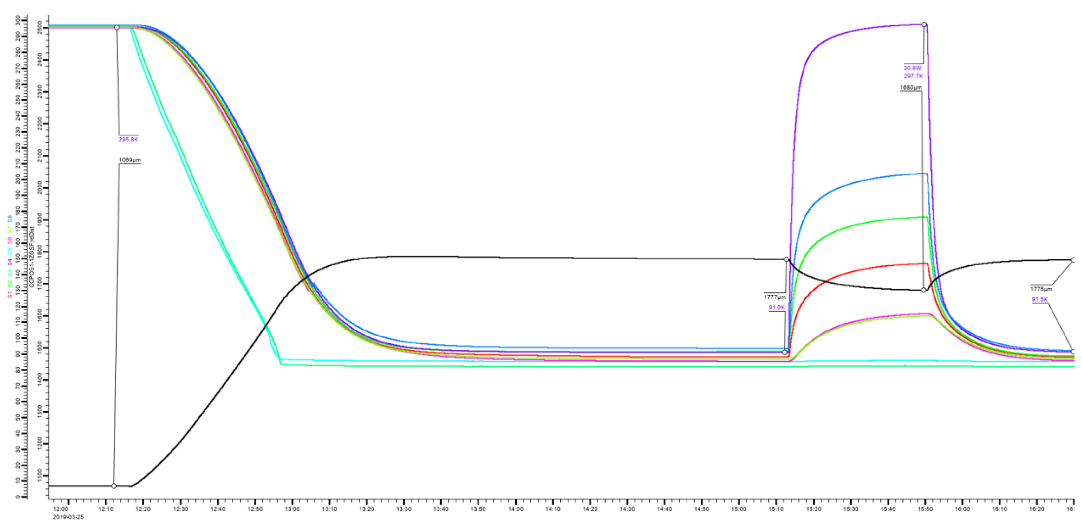

Figure 6: An example plot of the thermal contact measurement procedure. First the experiment is cooled down with liquid nitrogen until the equilibrium is reached. The movement of the cathode insert can be followed via the signal from the distance sensor (black). After the equilibrium is reached, the power of the heater was raised until room temperature is reached at the plug, which also causes movement in the opposite direction.

RESULTS

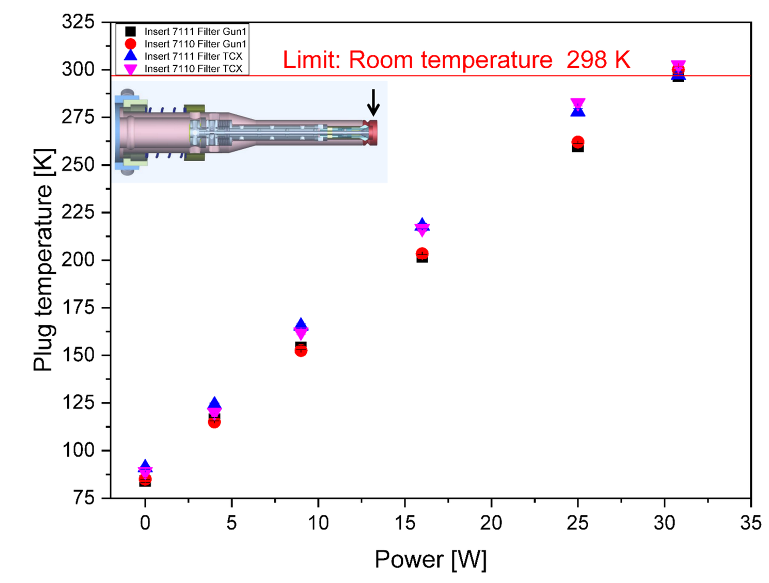

Figure 7: Different plug temperatures at different powers for two inserts and two RF-filters, temperature on the plug reaches room temperature at 30.8W heat load

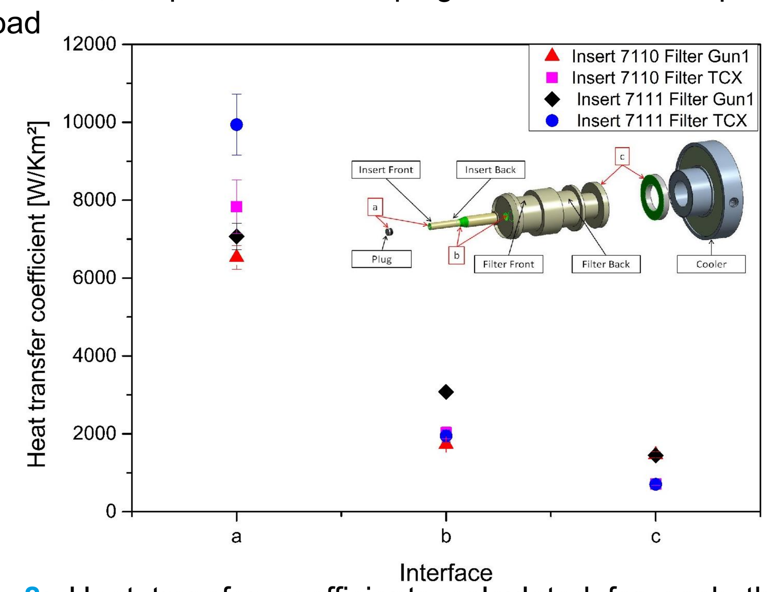

Figure 8: Heat transfer coefficients calculated for each thermal contact, Even if the observed plug temperatures are similar the heat transfer coefficients for the plug/insert interface differ from about 6500 W/Km² up to 9900 W/Km²

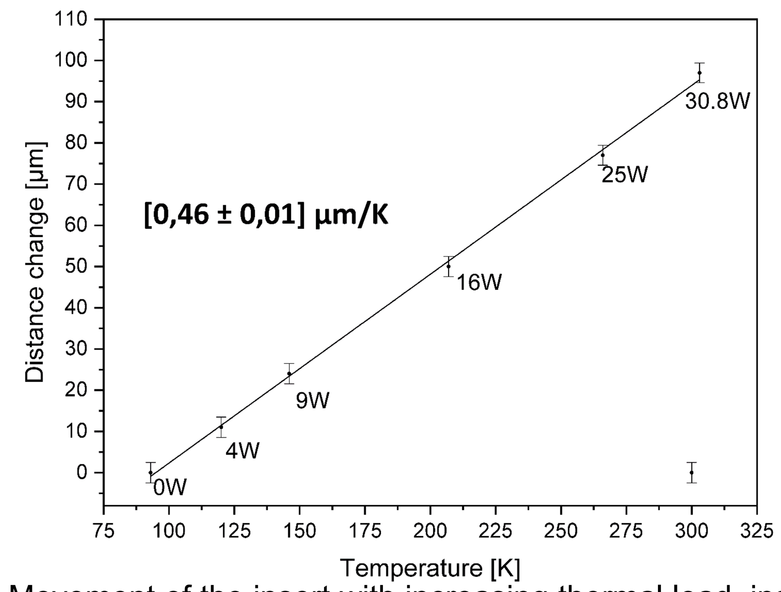

Figure 9: Movement of the insert with increasing thermal load, insert moves reversible about 100µm when it is heated

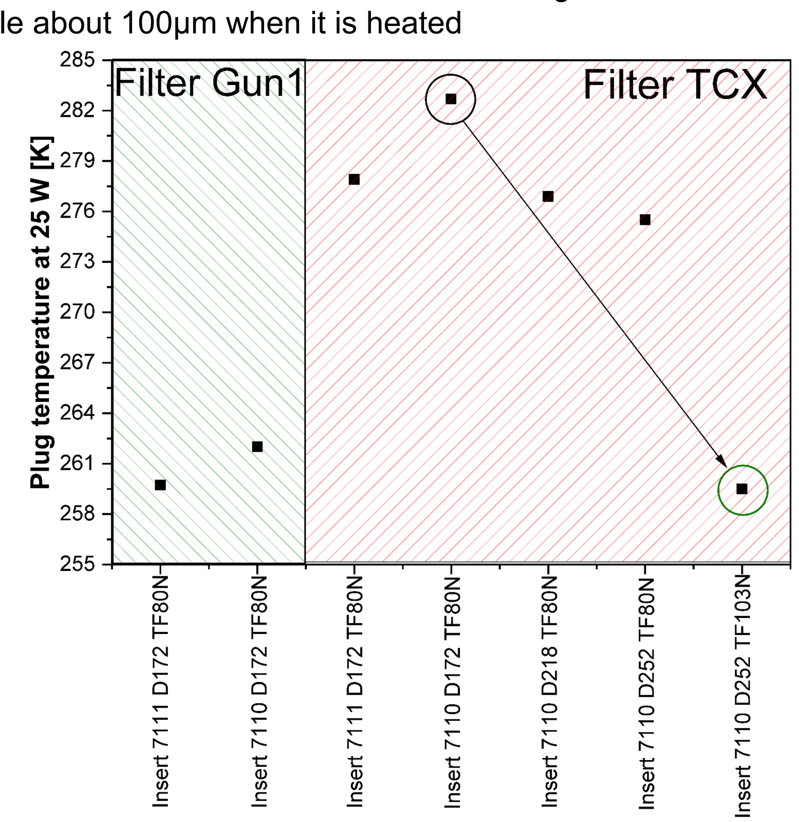

Figure 10: Different spring configurations for a heat load of 25 W with respect to the plug temperature, arrow shows the improvement due increasing spring forces of the plate spring (TF) from 80N to 103N and bayonet spring (D) from 1.72N/mm to 2.52N/mm

REFERENCES

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(4) J. Kuehn *et al.*, "UHV photocathode plug transfer chain for the bERLinPro SRF-photoinjector," Proceedings of IPAC2017, Copenhagen, Denmark, paper TUPAB029.

PRESENTER

Nawar Al-Saokal
Nawar.Al-Saokal@helmholtz-berlin.de
Fon: 0049 / 30 / 8062 - 12923

CONCLUSION

- cathode insert can handle a thermal load of about 30W and the plug exchange mechanism is still working after several iterations of heating and cooling
- with the goal of operating bERLinPro in the first stage at a lower current, we expect that we can use the cathode insert without any damage and harm for the gun cavity
- to get closer to the operating conditions of the SRF photoinjector experiments with the 80 K He(g) cooling system are planed