Semiconductor photocathode development for the bERLinPro SRF photoinjector

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OUTLINE

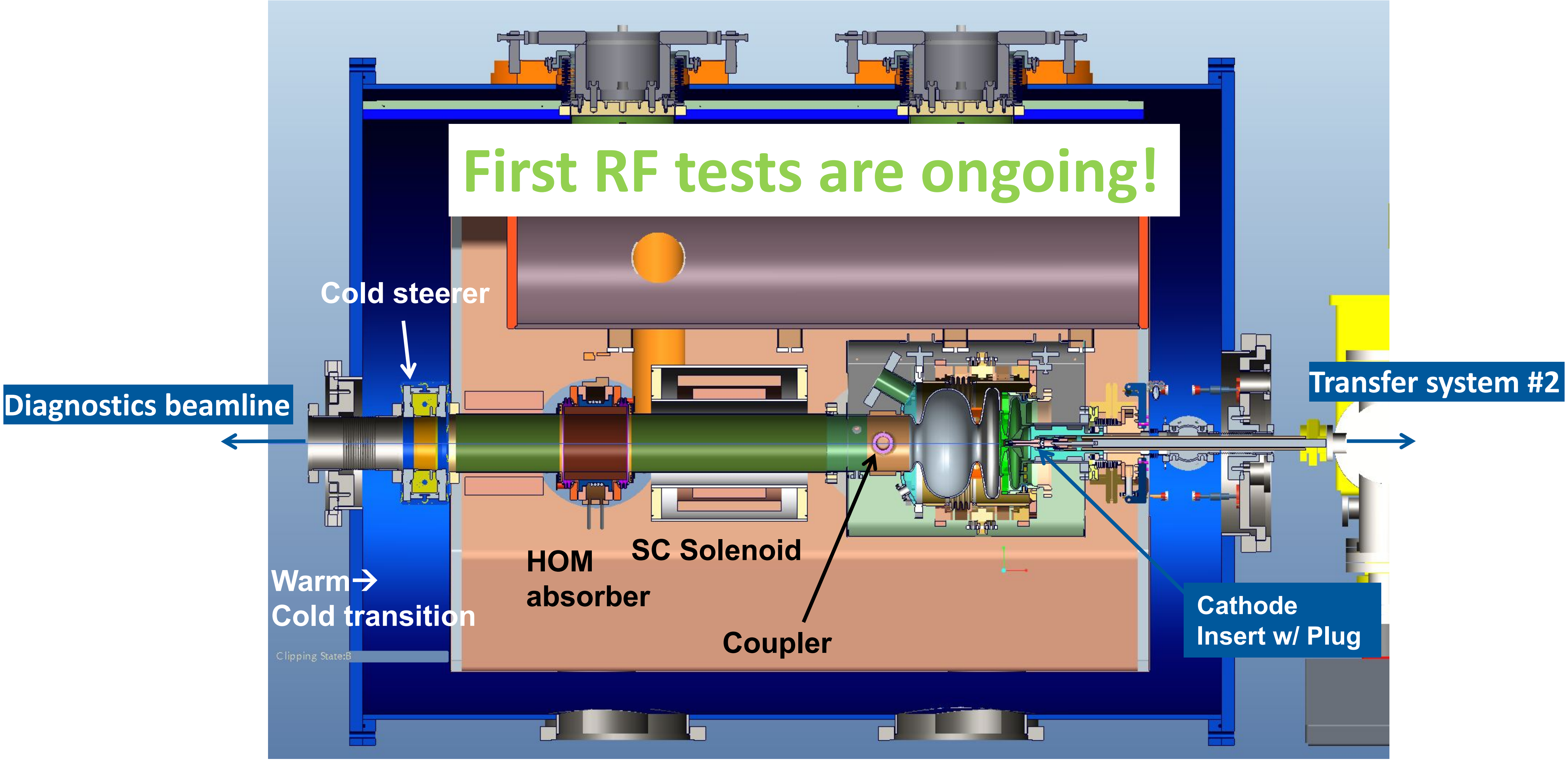
- bERLinPro & GunLab
- Photocathode infrastructure
- Cs-K-Sb photocathode preparation & characterization
- Summary and Outlook

Construction site and accelerator hall (2017-06-12)

A. Jankowiak, Status of the Berlin Energy Recovery Linac Project bERLinPro, Wed 21/06, 8:55

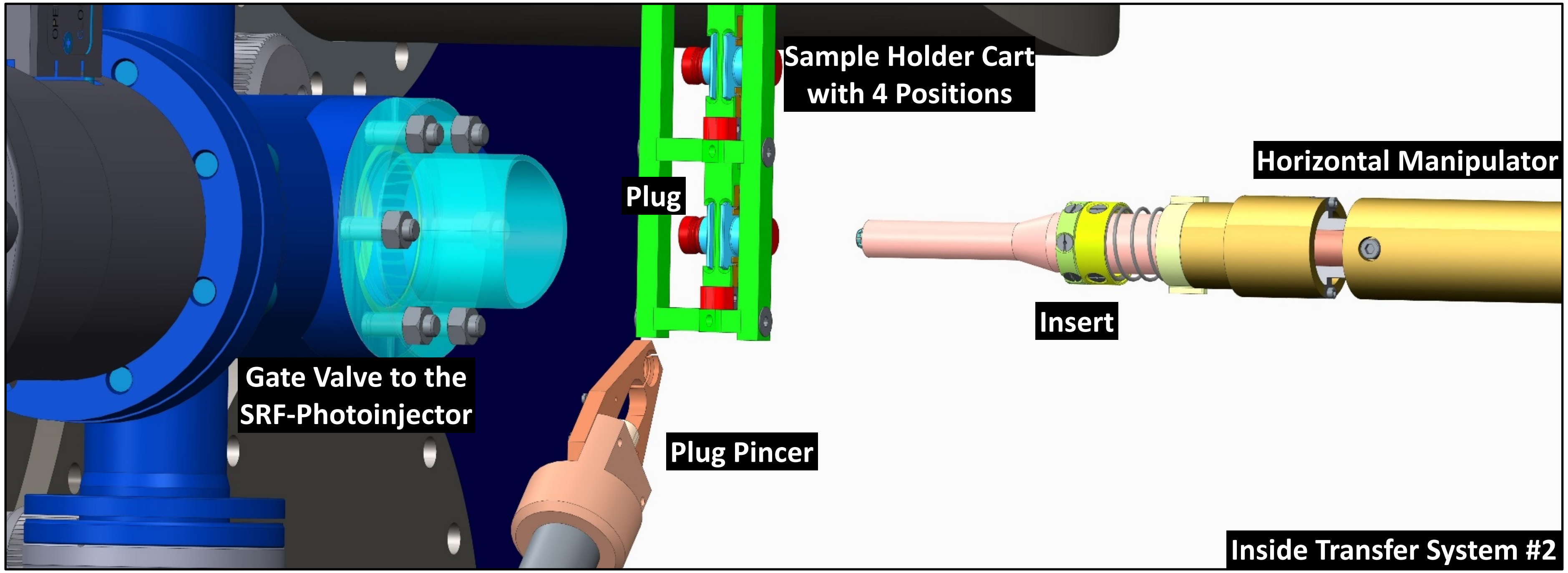
GUNLAB (GUN 1.0) – SRF PHOTOINJECTOR TEST FACILITY

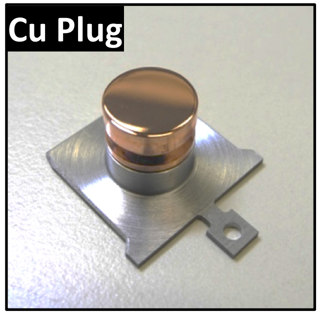
CROSS-SECTION OF THE GUN MODUL



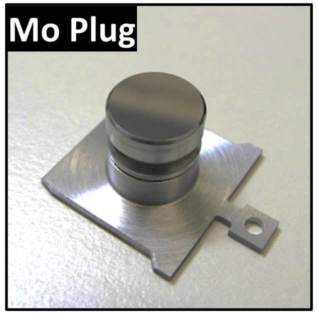
A. Neumann, The bERLinPro SRF Photoinjector system - From design to first RF commissioning results, Wed 21/06, 17:55

INSIDE TRANSFER SYSTEM #2 AT THE SRF-PHOTOINJECTOR MODUL





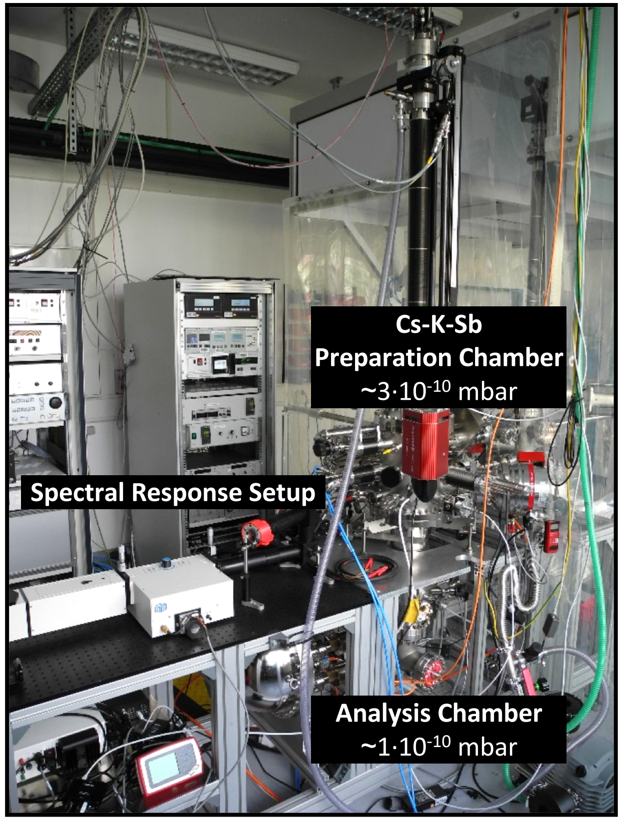
Cu photocathode
for the initial commissioning
of the SRF-phtoinjector
with electrons



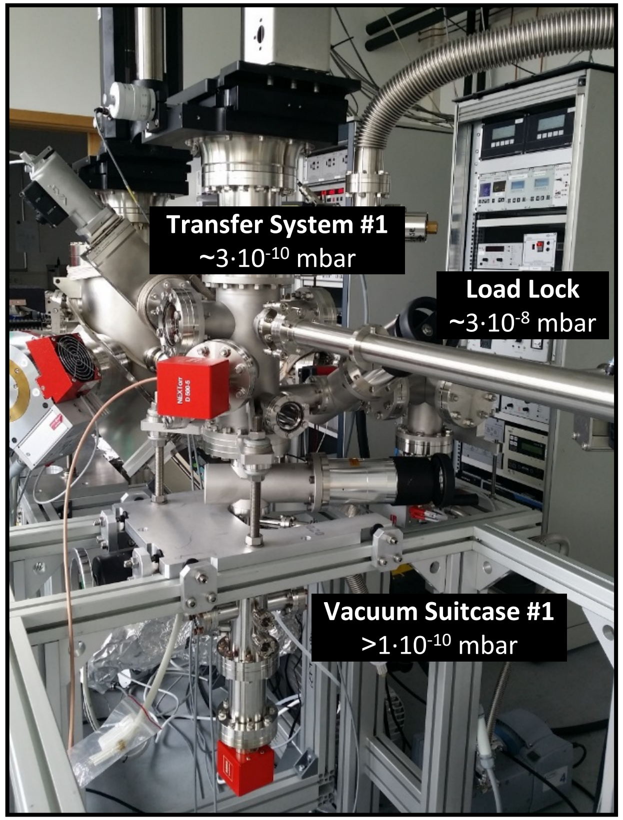
Substrate for
Cs-K-Sb photocathodes

PHOTOCATHODE INFRASTRUCTURE

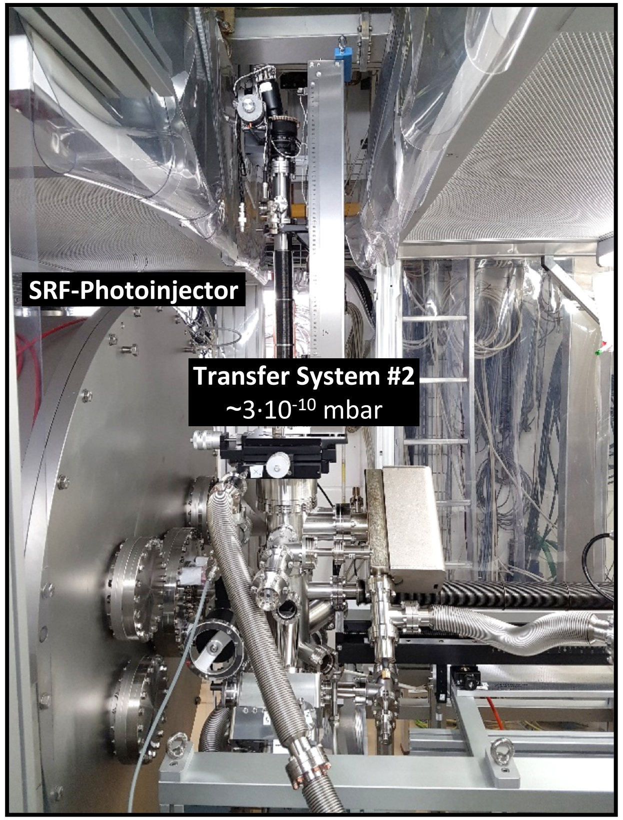
Preparation & Analysis System (PAS) w/ spectral response setup



Transfer system #1 at the PAS w/ vacuum suitcase



Transfer system #2 at the SRF-photoinjector module



in collaboration with HZDR

J. Kuehn *et al*, Proc. of IPAC 2017, **TUPAB029**.

OUR PHOTOCATHODE GOALS

High QE CsK_2Sb photocathodes

- Allow high bunch charge and current 100 mA means 25 W laser power at 1% QE

Smooth substrates and photocathode

- Low emittance, low field emission

Reproducible growth procedure & robust lifetime

- Necessary for operation

STATUS OF THE PHOTOCATHODE LAB

Photocathode History

	No.	QE	λ (nm)
SEQ	P006	4.9 %	532
SEQ	P007	2.3%	515
K,Cs co-dep	P008	1.3%	515
K,Cs co-dep	P009	4.9%	515
K,Cs co-dep	P011	2.9%	515
K,Cs co-dep	P013	7.3%	515
K,Cs co-dep	P014	10.1%	515

Photocathode Preparation and Analysis System (PAS)

Preparation chamber

- effusion cell for Sb, SAES Dispenser for K and Cs
- sequential growth and co-deposition of K and Cs
- bake-out for 72h at 120°C, base p = $3x10^{-10}$ mbar
- carefully degassing of all filaments and dispensers
- monitor the growth process by mass spectrometer and photocurrent

Surface Analysis chamber

- In-situ post-analysis by X-ray photoelectron spectroscopy (XPS)
- Momentatron for emittance measurement (M. Schmeißer, Master Thesis, **2014**)

Spectral response setup H. Kirschner et al, Proc. of IPAC 2017, TUPAB028.

- Spectral response measurement from 370 – 700 nm

Transfer system #1 w/ vacuum suitcase and transfer system #2

- all parts were cleaned and assembled in the clean room
- Vacuum commissioning completed and sample transfer was tested

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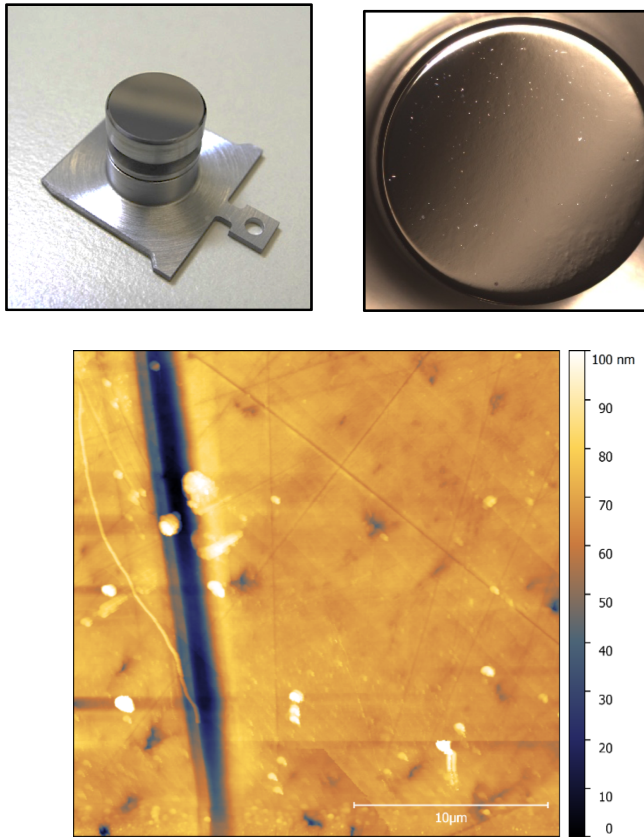
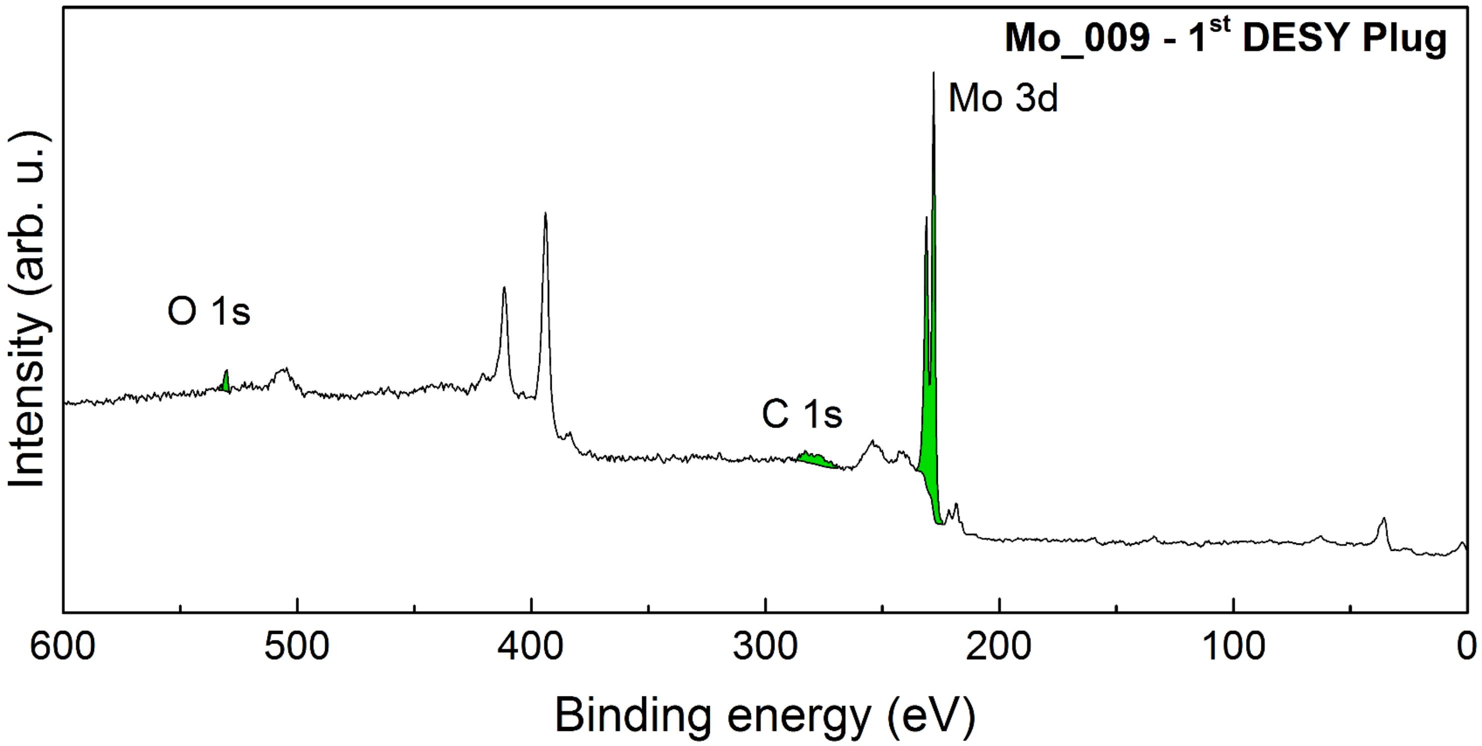
Polished Mo plug (sintered Mo)

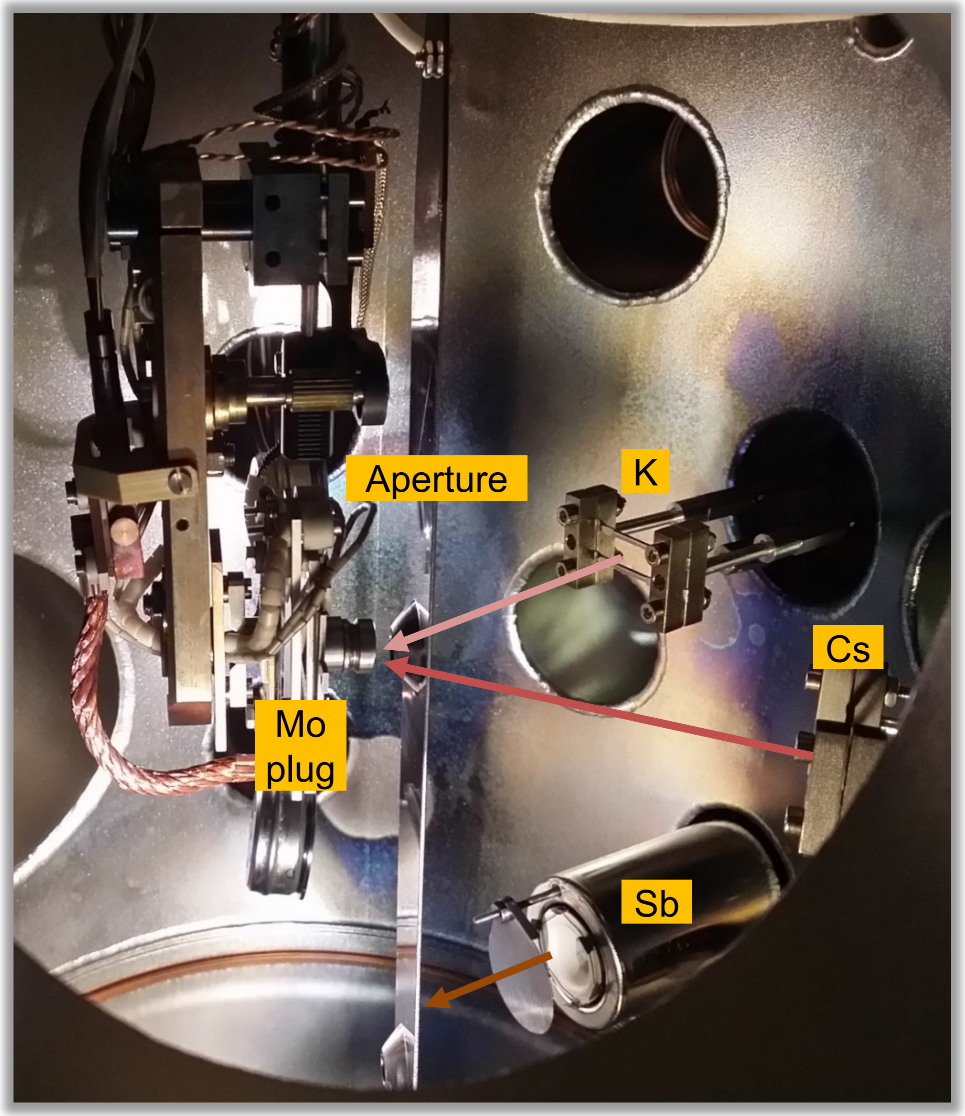


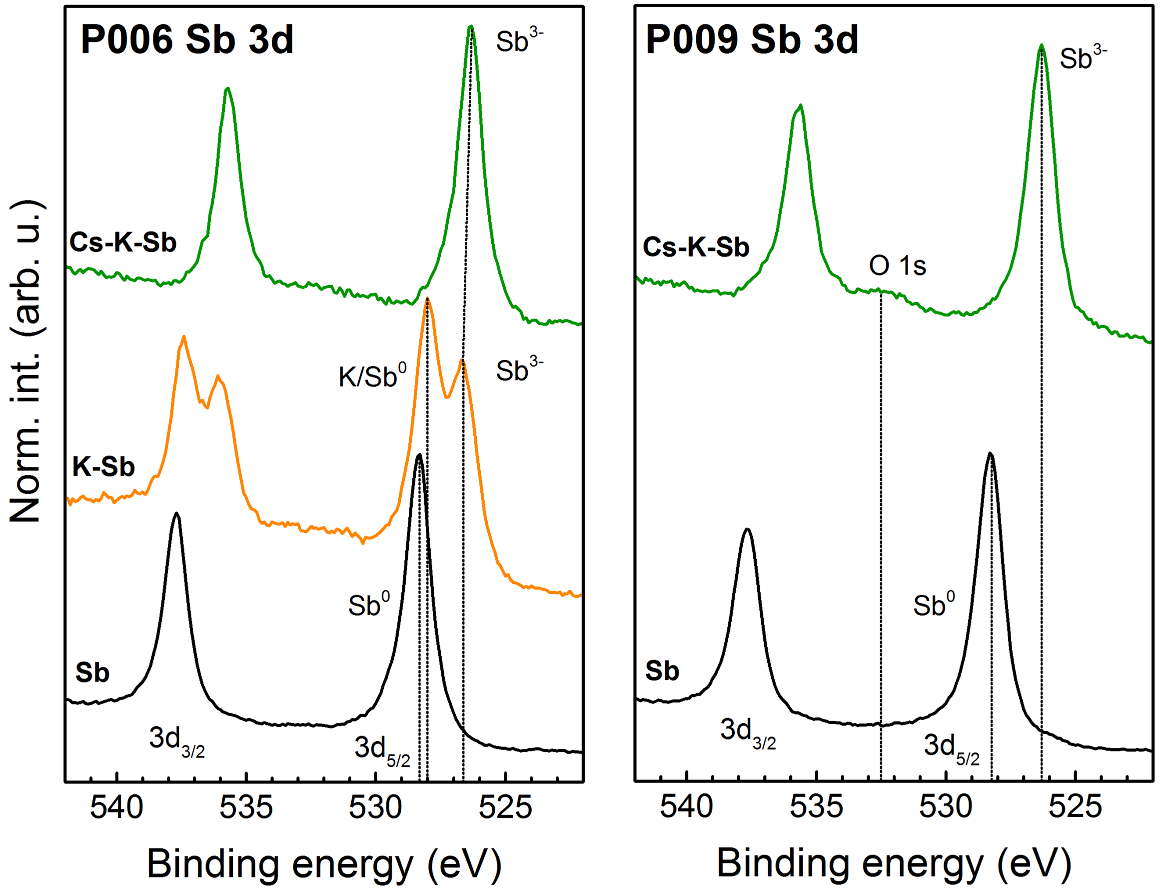
AFM Roughness (rms): 12 nm

X-ray photoelectron survey spectrum

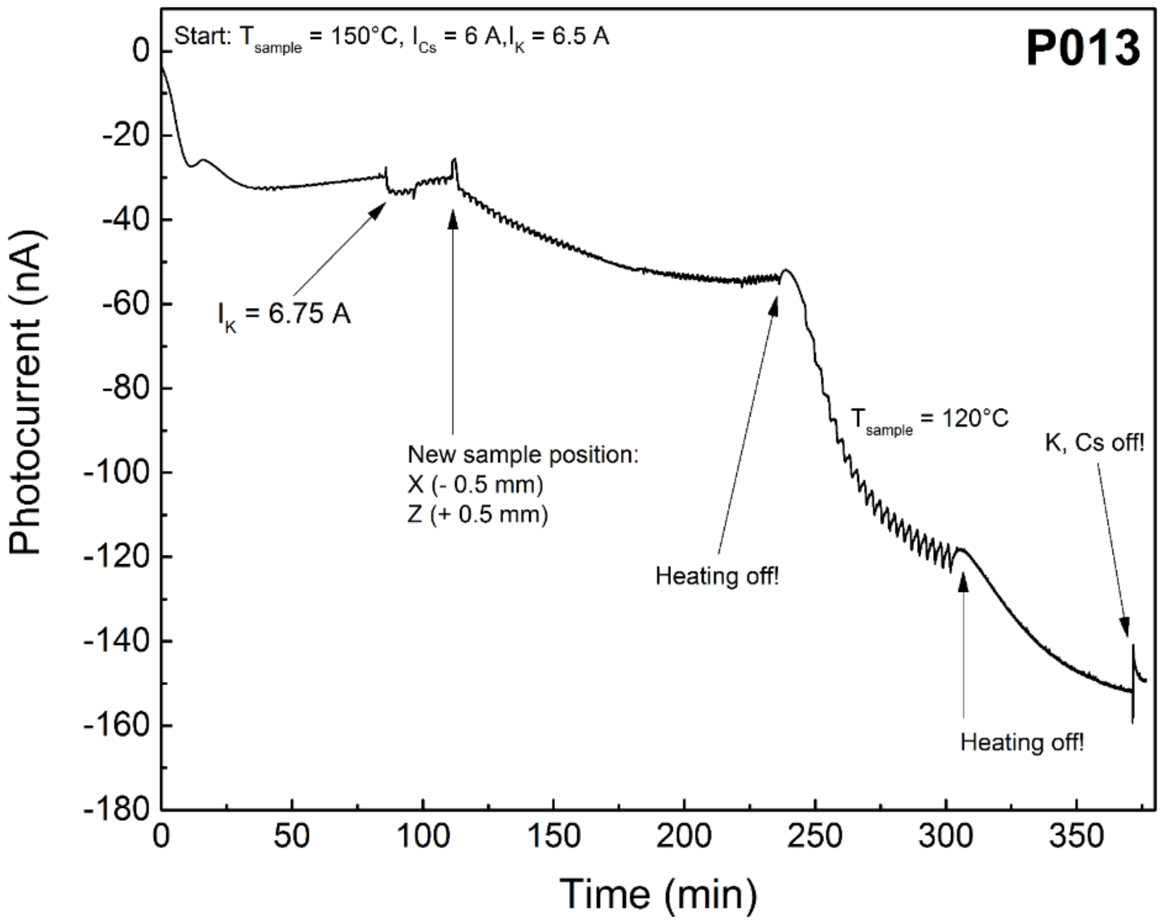


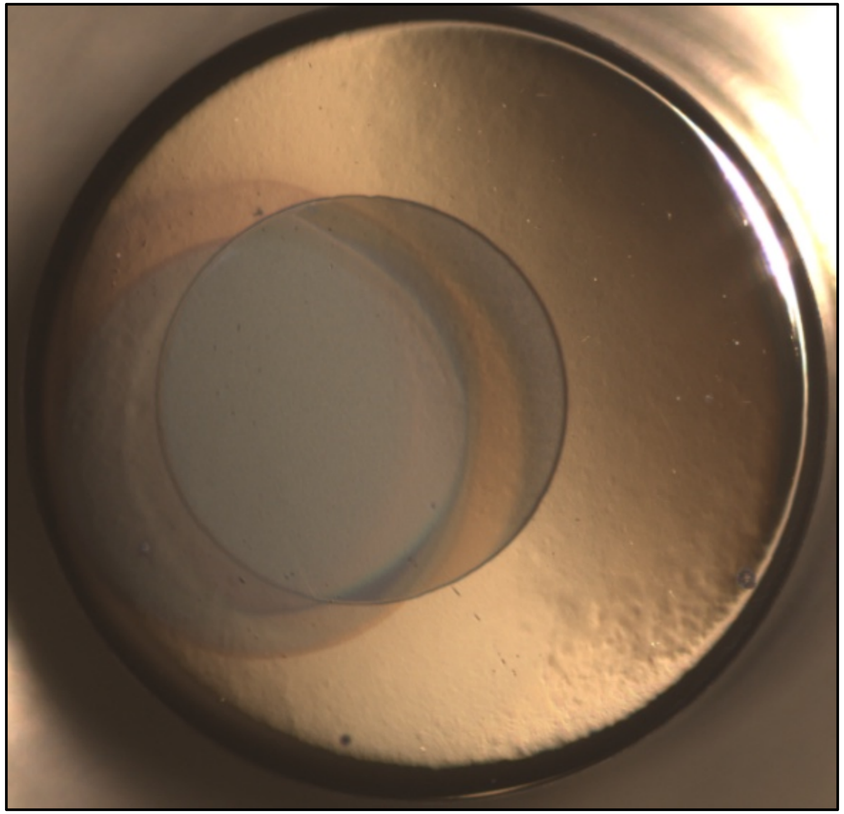
COMPARISON OF SEQUENTIAL AND ALKALI-METAL CO-DEPOSITION GROWTH: P006 VS. P009



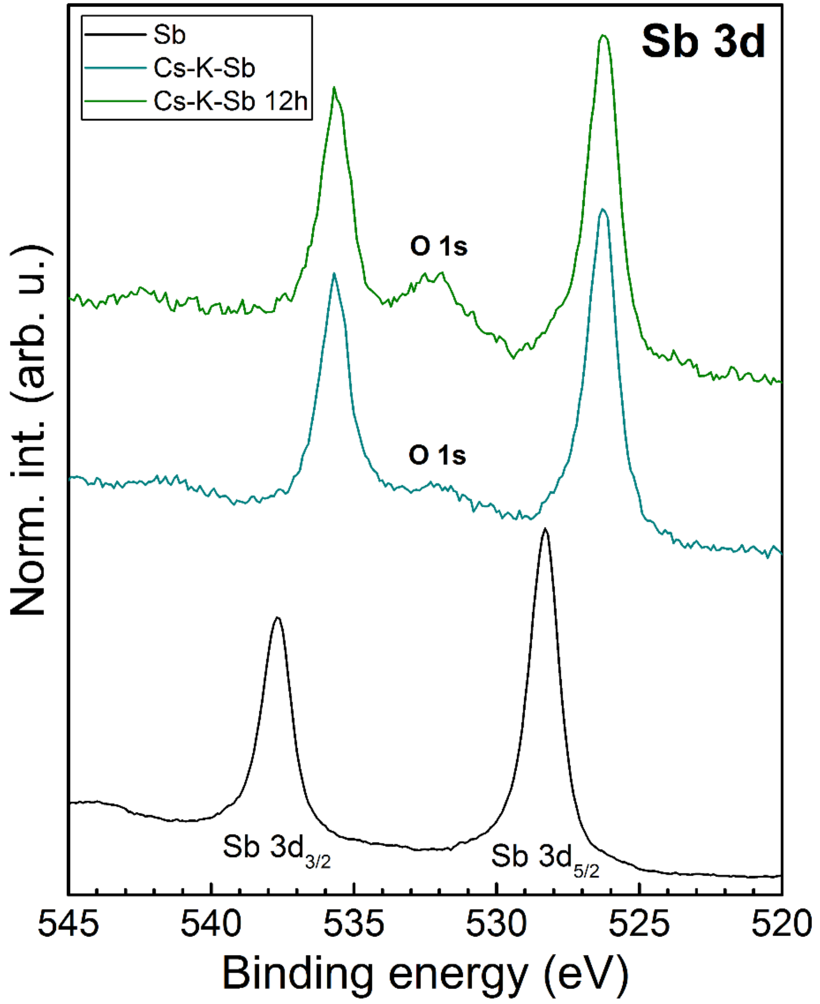


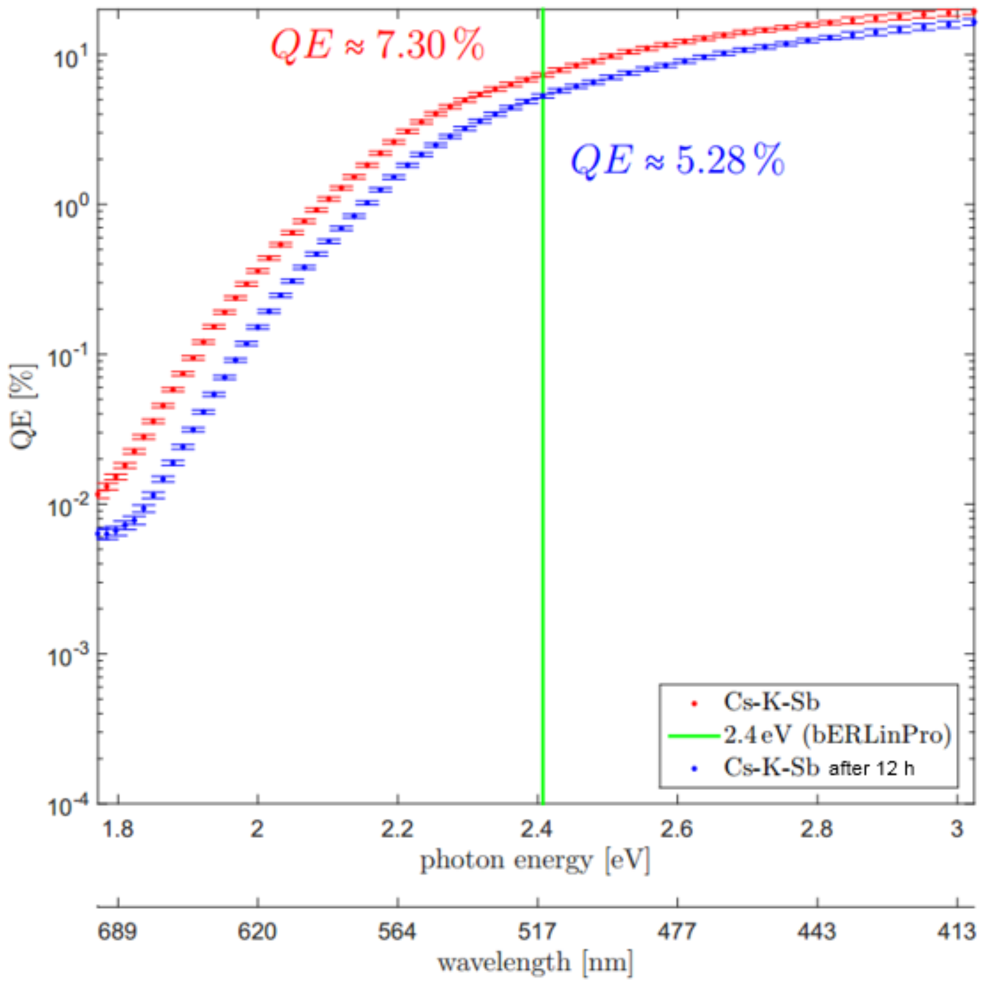
P013: ALKALI-METAL CO-DEPOSITION



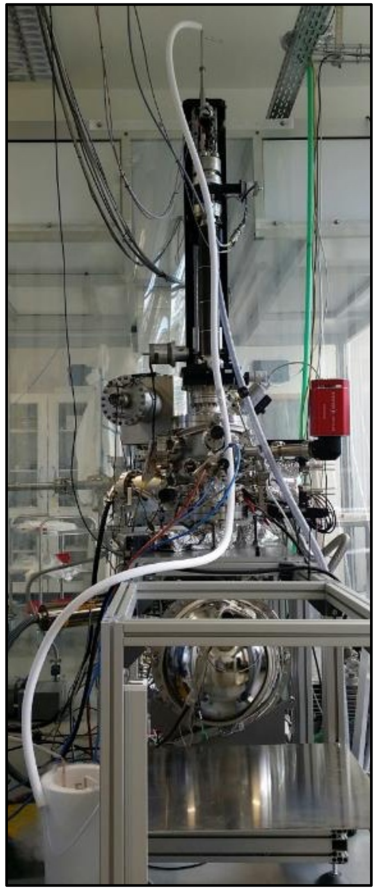


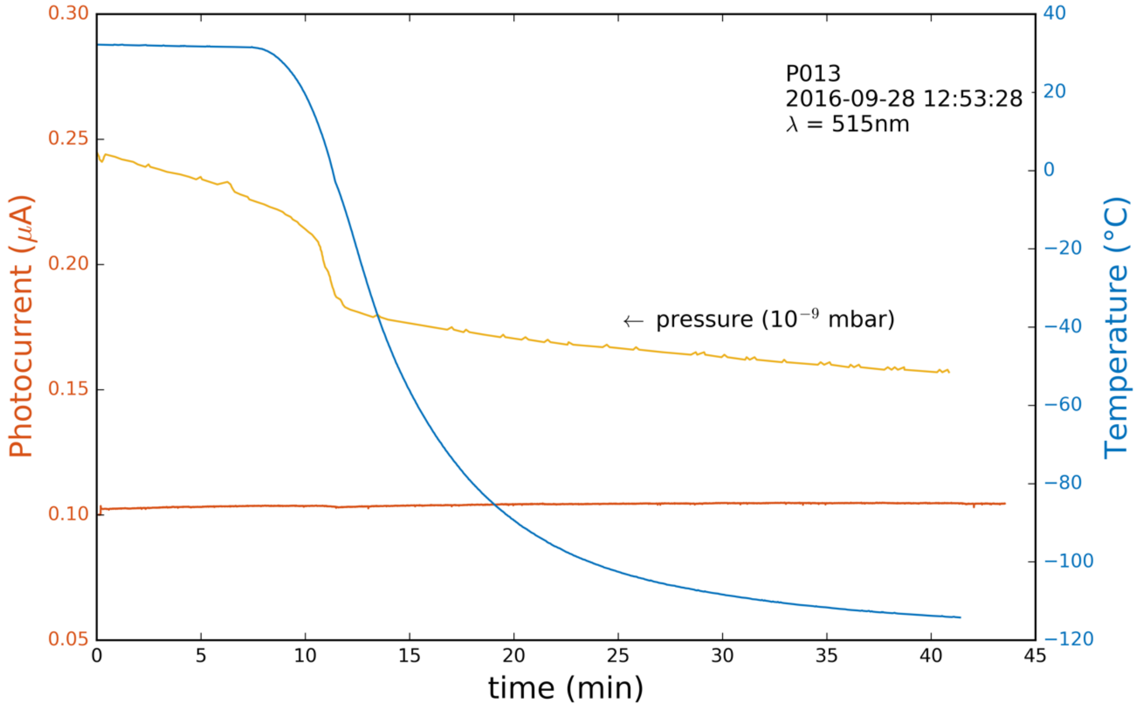
P013: ALKALI-METAL CO-DEPOSITION

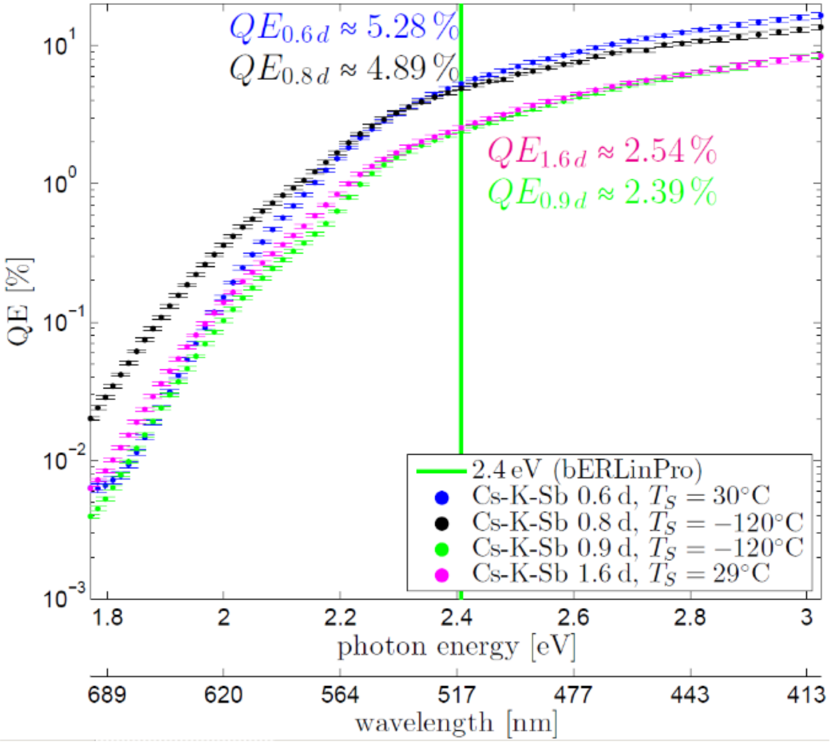




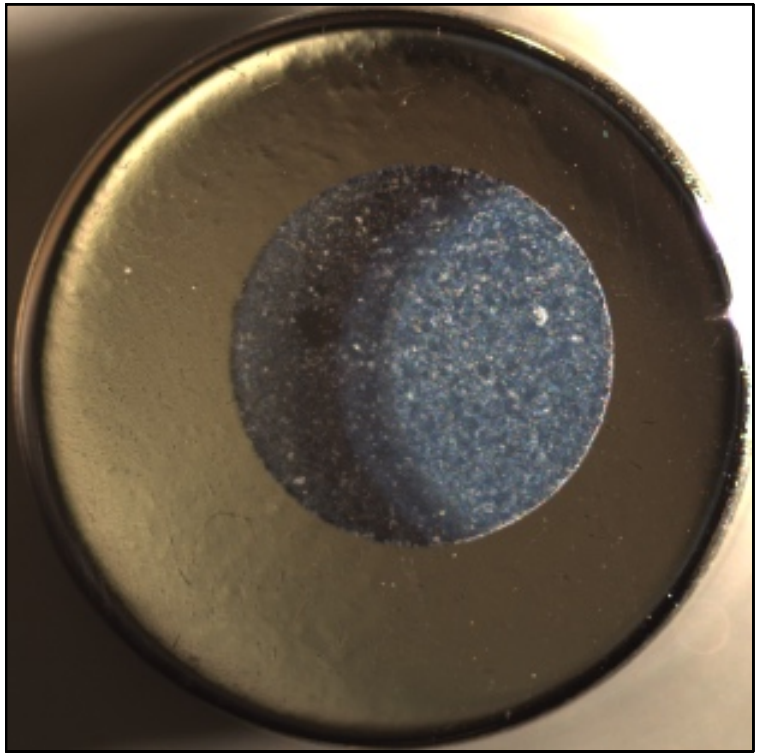
P013: COOL DOWN WITH LN2



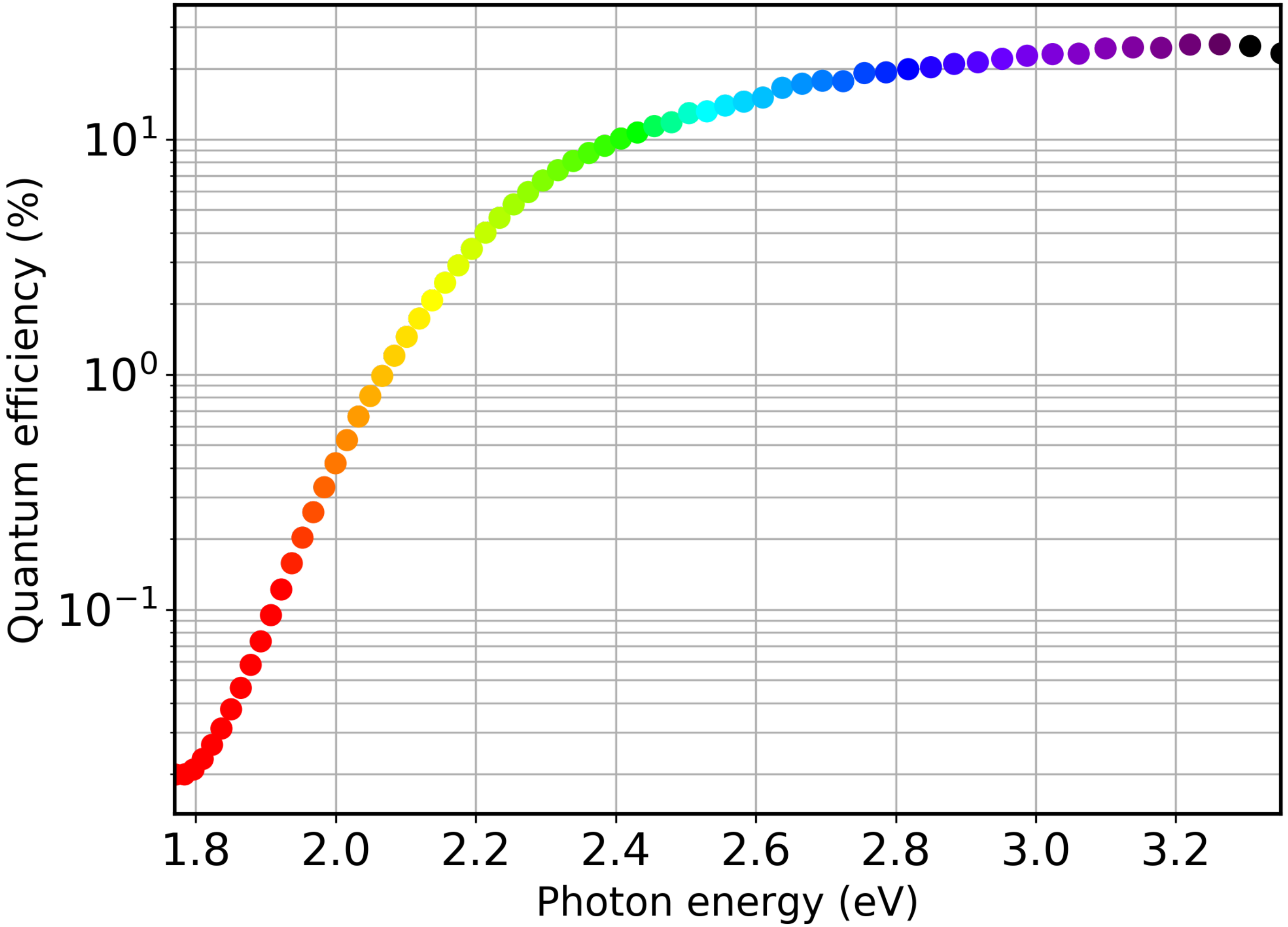




P014: RECORD QE



QE = 10.1 % at 515 nm



SUMMARY

- Setup, testing and vacuum commissioning of the photocathode plug transfer chain completed
- Photocathodes with a QE of 10% at 515 nm grown on Mo plugs by co-deposition of K and Cs on Sb

FUTURE ACTIVITIES PHOTOCATHODE LAB

- Photocathode Growth Control System to synchronize all relevant process data (p, T, I_{photo}, ...)
- Evaluation of single crystal Mo plugs as substrate
- Optimization of Sb film growth in terms of thickness and morphology (influence on QE and life time)
- Test of Cu as a substrate for Cs-K-Sb photocathodes

OUTLOOK GUNLAB

- Operation licence for GunLAB with Cu received
- Finishing the commissioning of the RF-system, the diagnostic beam line and the laser beam line
- Cu photocathode preparation and transfer
- RF commissioning with Cu photocathode

- First Electrons from a Cu photocathode for diagnostic beam line commissioning
- Operation of Cs-K-Sb/Mo Photocathodes in the SRF-photoinjector

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Sven Lederer (DESY)

bERLinPro project team

HZB Helmholtz Zentrum Berlin

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- Programme
- Travel and Accommodation
- Previous Workshops
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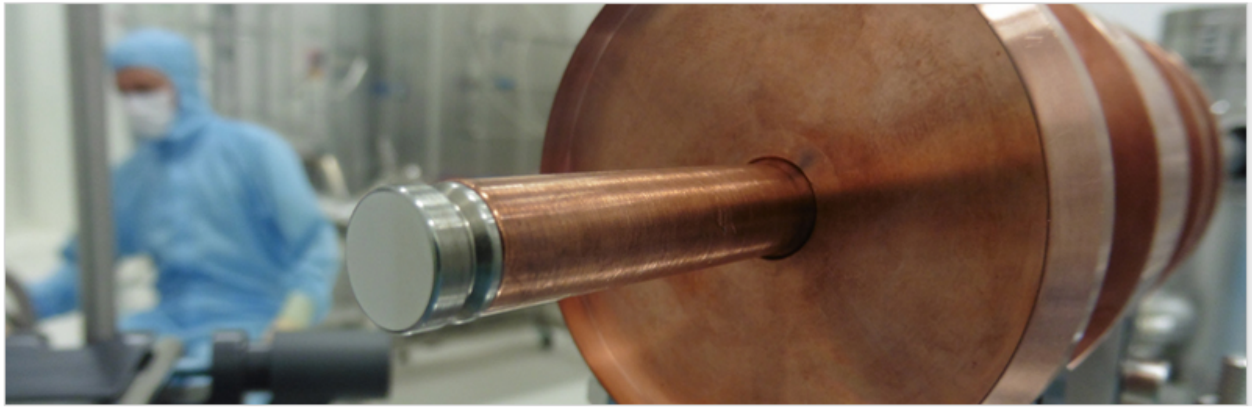
- Abstract Submission



European Workshop on Photocathodes for Particle Accelerator Applications / EWPAA 2017

20-22.09.2017, Helmholtz-Zentrum Berlin, Germany

hz-b.de/ewpaa

EWPAA 2017 – Berlin, 20–22 September 2017

European Workshop on Photocathodes for Particle Accelerator Applications / **EWPAA 2017**

Dear Colleagues,

It is our pleasure to announce that we will hold a

European Workshop on Photocathodes for Particle Accelerator Applications / EWPAA 2017 from **We, 20.09. – Fr, 22.09.2017** at the **Helmholtz-Zentrum Berlin, Germany.**

The workshop will cover recent progress in research and development of photocathodes for accelerator applications. Contributions are invited from all related topics, including operational experience, preparation, and analytical methods including instrumentation as well as theoretical modelling, industrial applications, and novel materials.

Registration and abstract submission will be opened early spring. The Scientific Programme Committee is currently working on a scientific programme. We are planning for invited and contributed oral presentations as well as poster presentations. There will be a special session dedicated for young scientists.

Register now

Submit your Abstract

EWPAA 2017 Announcement

PDF

THANK YOU FOR YOUR ATTENTION!