Activation studies for GaAs photocathodes at Photo-CATCH*

M. Herbert – J. Enders, M. Engart, M. Meier, J. Schulze, V. Wende, V. Winter

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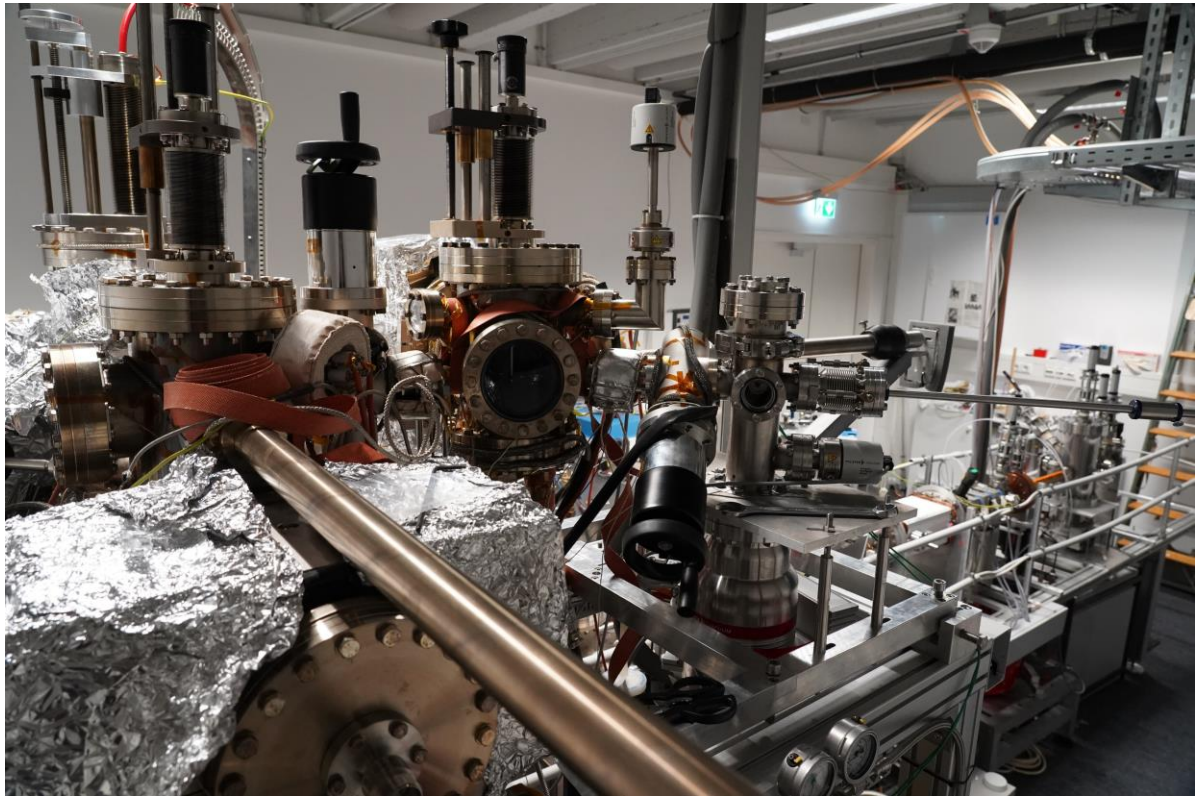
GaAs photocathode research at Photo-CATCH



- Laser-induced photo-emission
- High degree of spin-polarization possible
- XHV required (~ 10^{-11} mbar)
- used in DC HV guns
- low- to medium-intensity electron beams

→ Challenge: high-intensity electron beams

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Emission of polarized electrons from GaAs:

$E_\gamma < 1.76$ eV or $\lambda > 705$ nm

Photoemission threshold for GaAs:

$E_{th} > 5.52$ eV or $\lambda < 225$ nm

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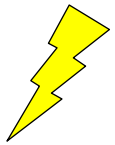

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Activation with NEA layer required to reduce work function!

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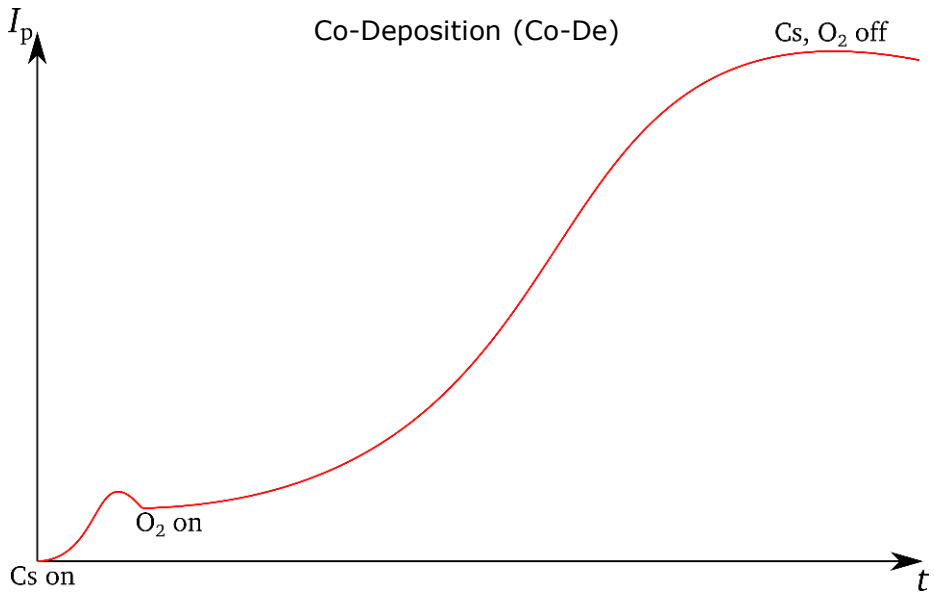

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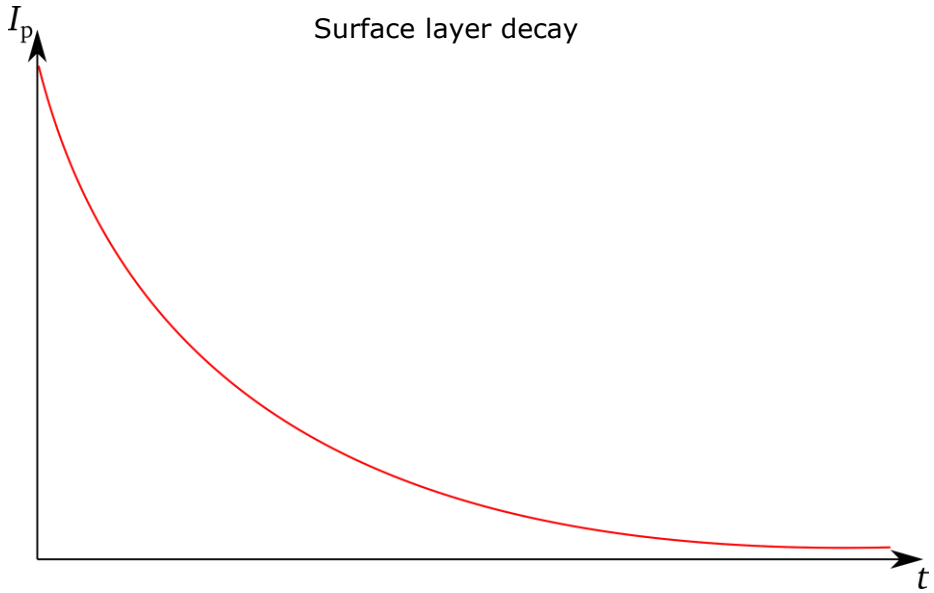

Surface layer decay

Main parameters: η_0, τ, $Q(\tau)$

$$\eta(\lambda) = \left| \frac{hc_0 I_p}{eP_L \lambda} \right| \cdot 100\%$$

$$\eta(t) = \eta_0 \cdot e^{-t/\tau}$$

$$Q(\tau) = I_0 \cdot \tau \cdot \left(1 - \frac{1}{e}\right) \approx 0.63 \cdot I_0 \cdot \tau$$

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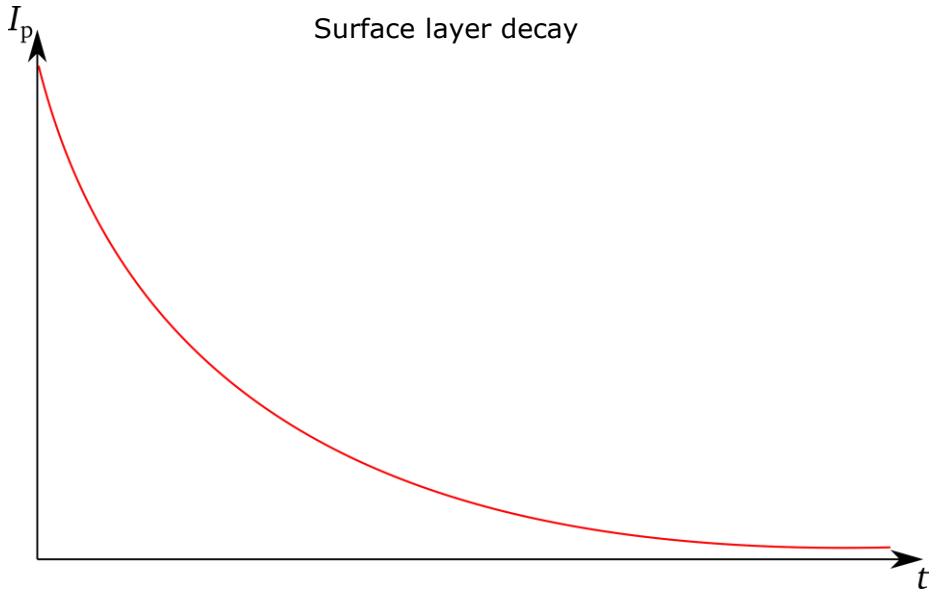

Surface layer decay

Outcome depends on operator input

Dedicated activation studies

Main parameters: η_0, τ, $Q(\tau)$

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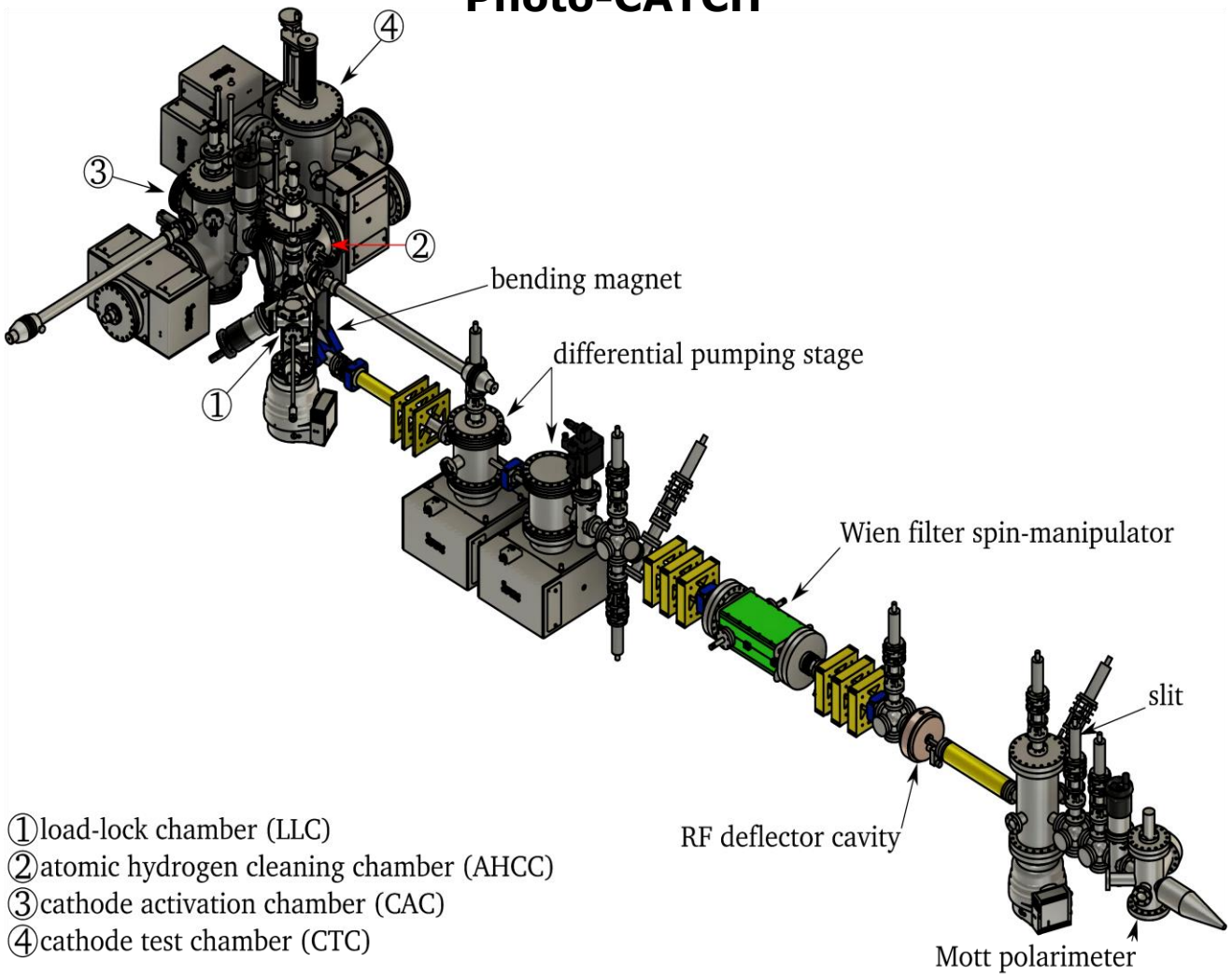

①load-lock chamber (LLC)
②atomic hydrogen cleaning chamber (AHCC)
③cathode activation chamber (CAC)
④cathode test chamber (CTC)

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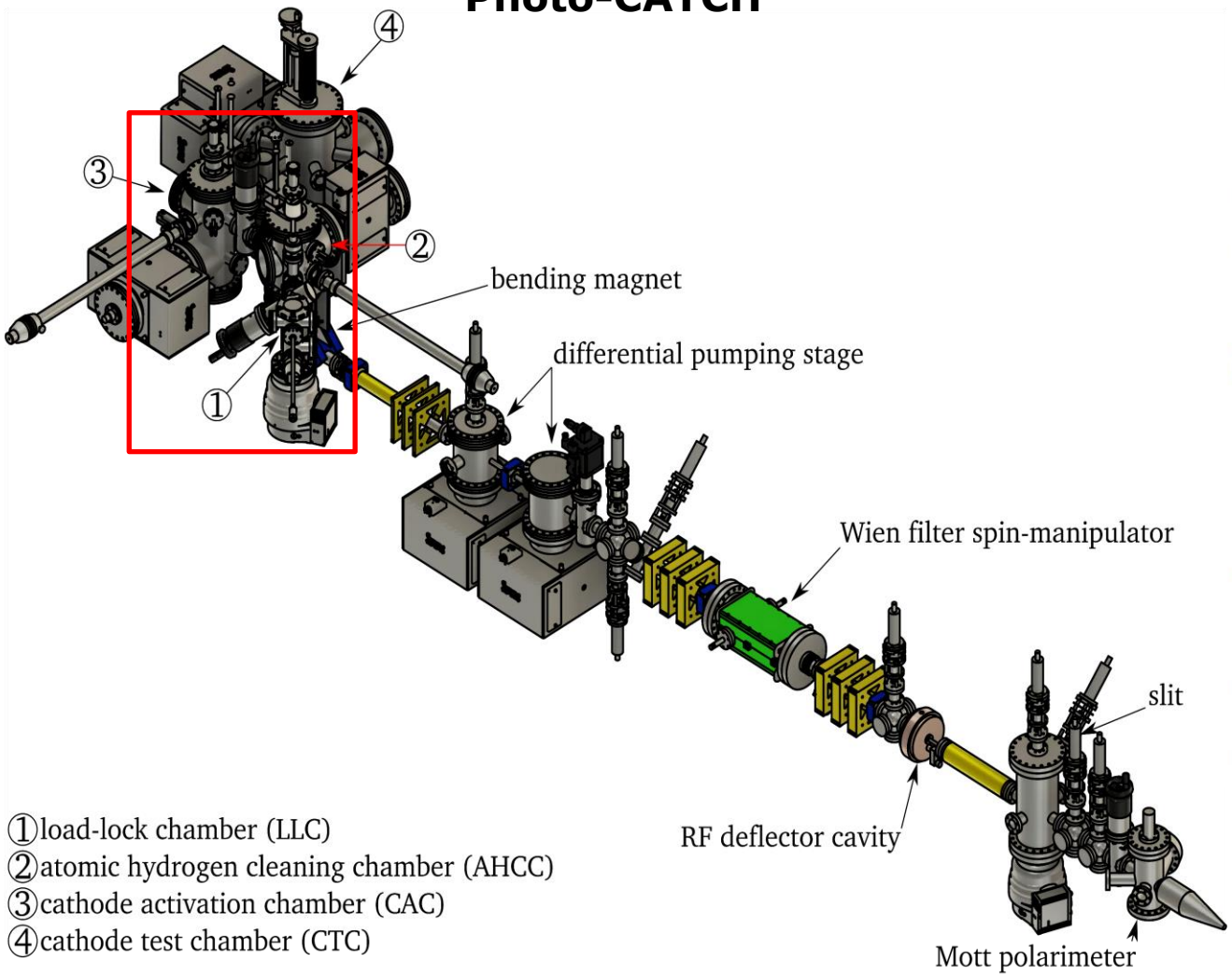

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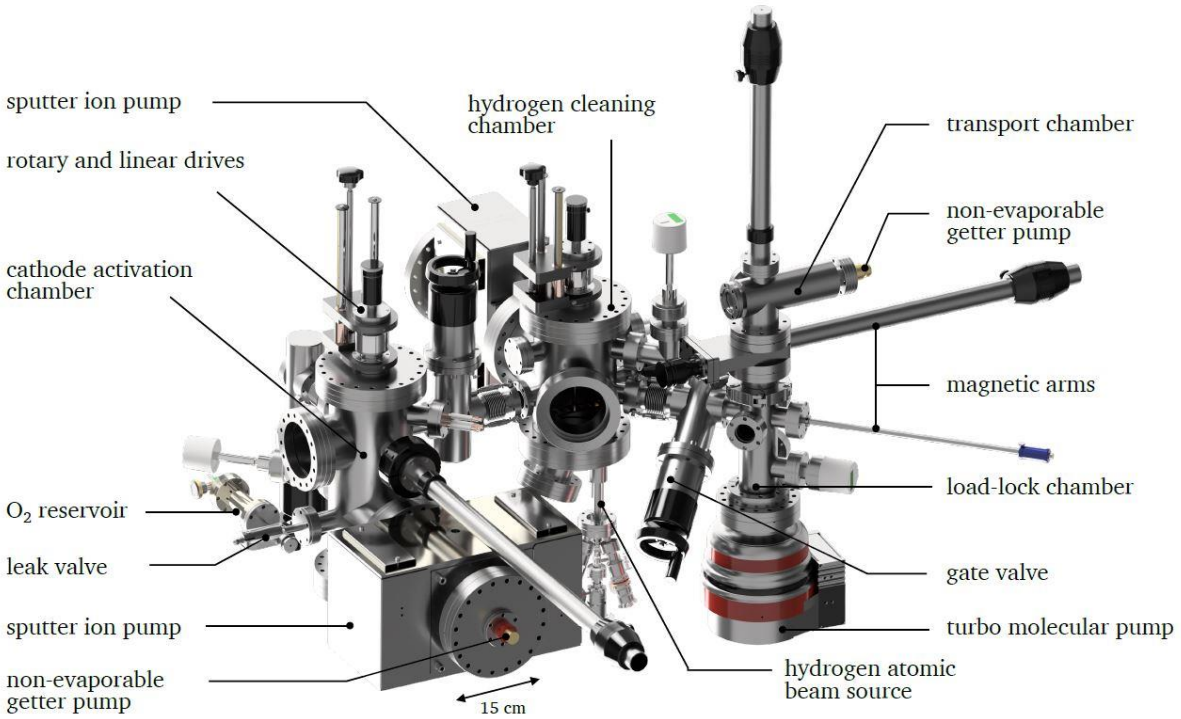
Activation & Cleaning System



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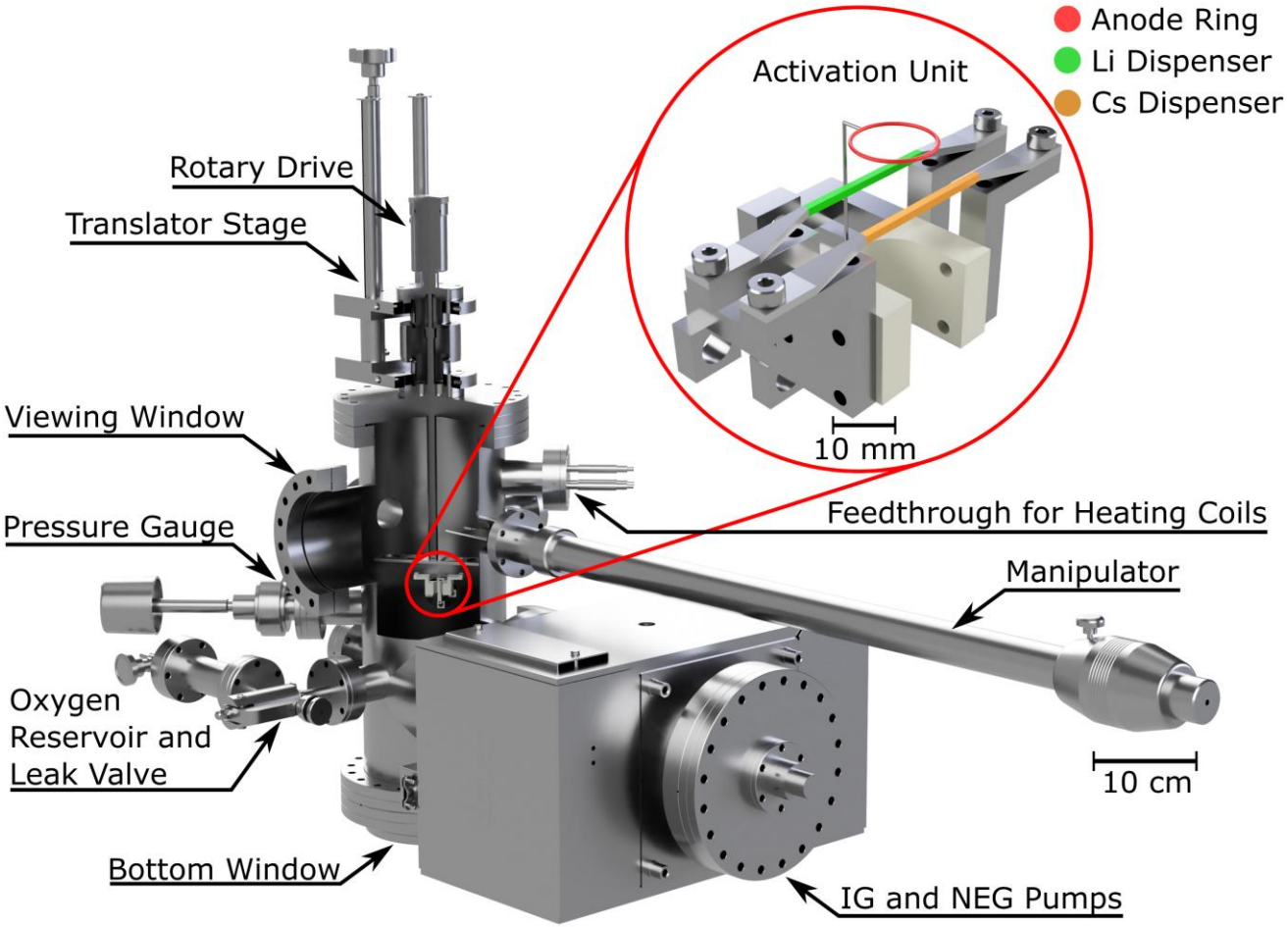
Activation Chamber



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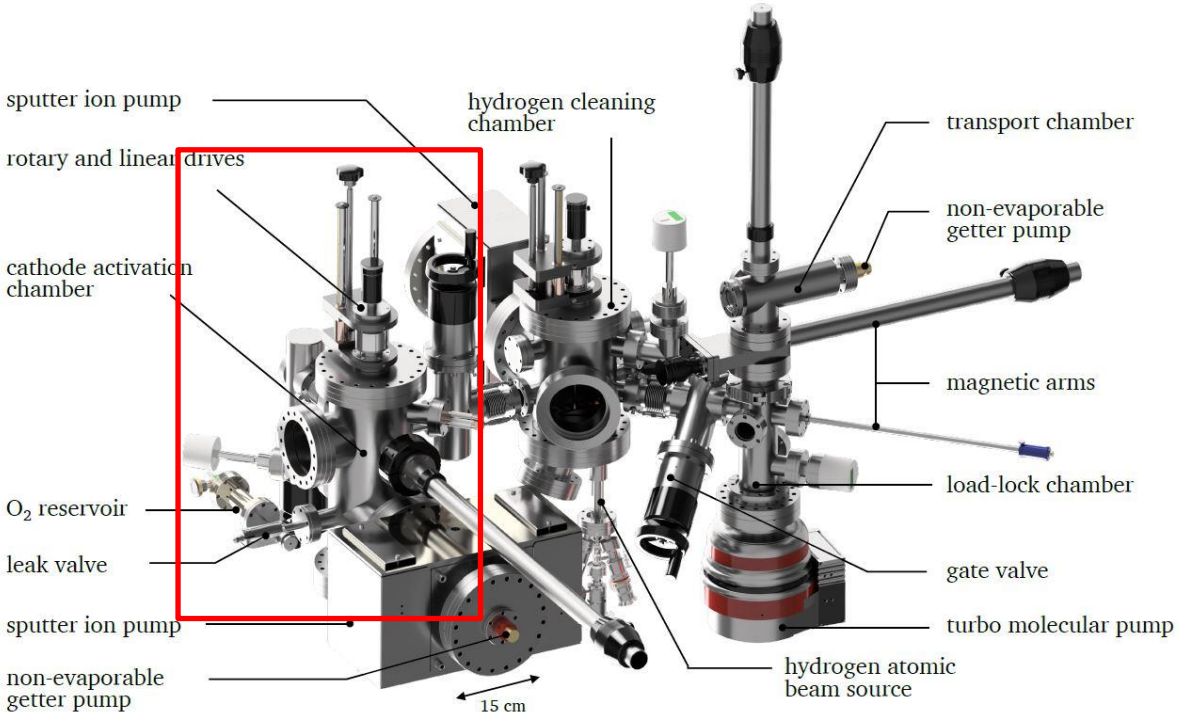

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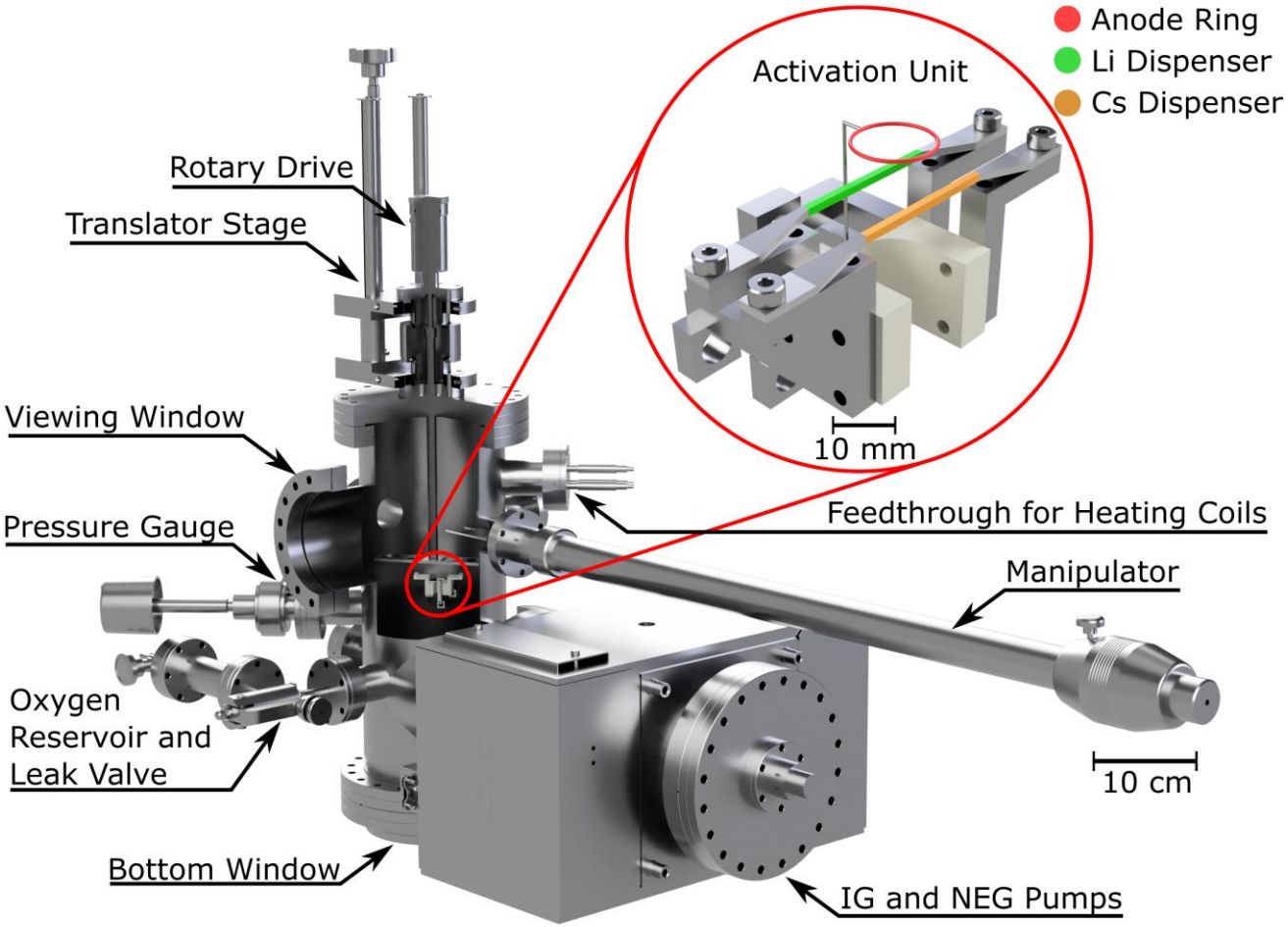
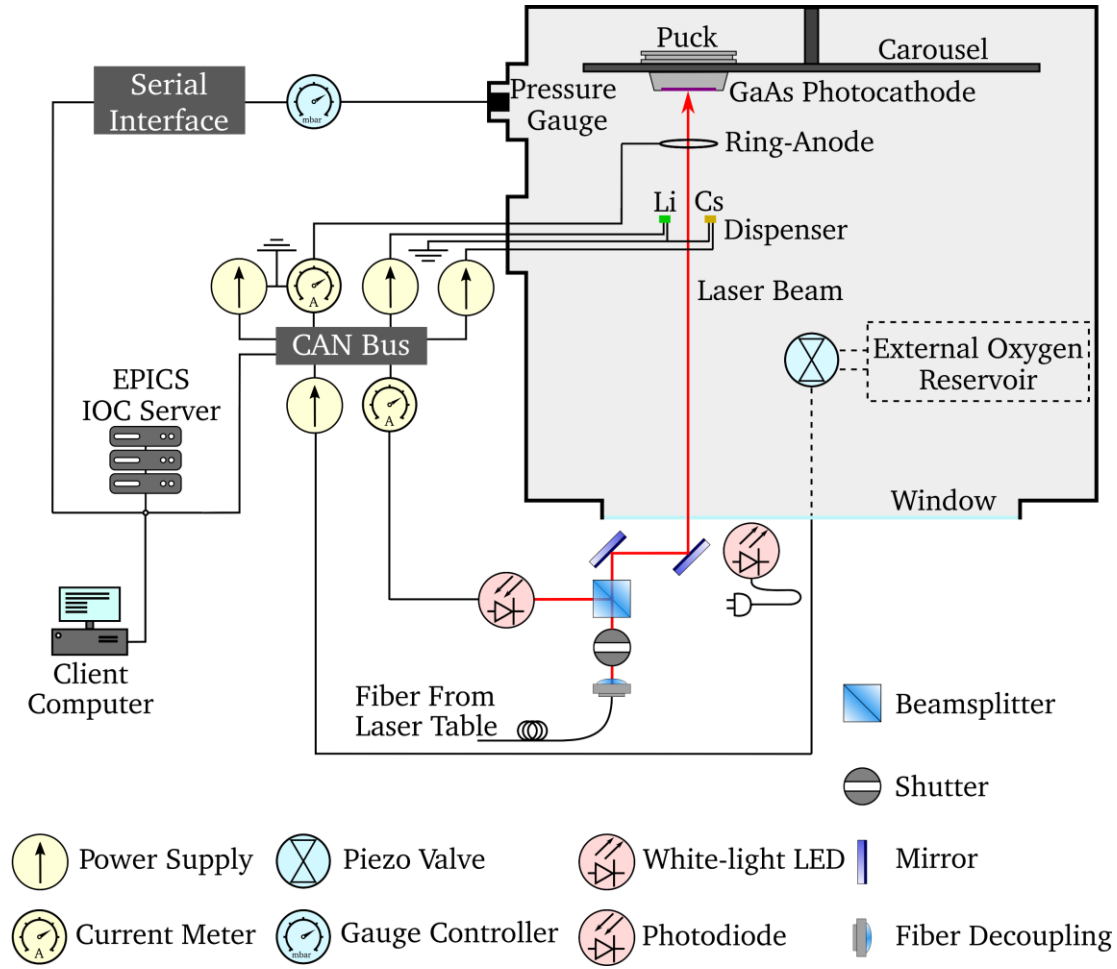


Activation Setup



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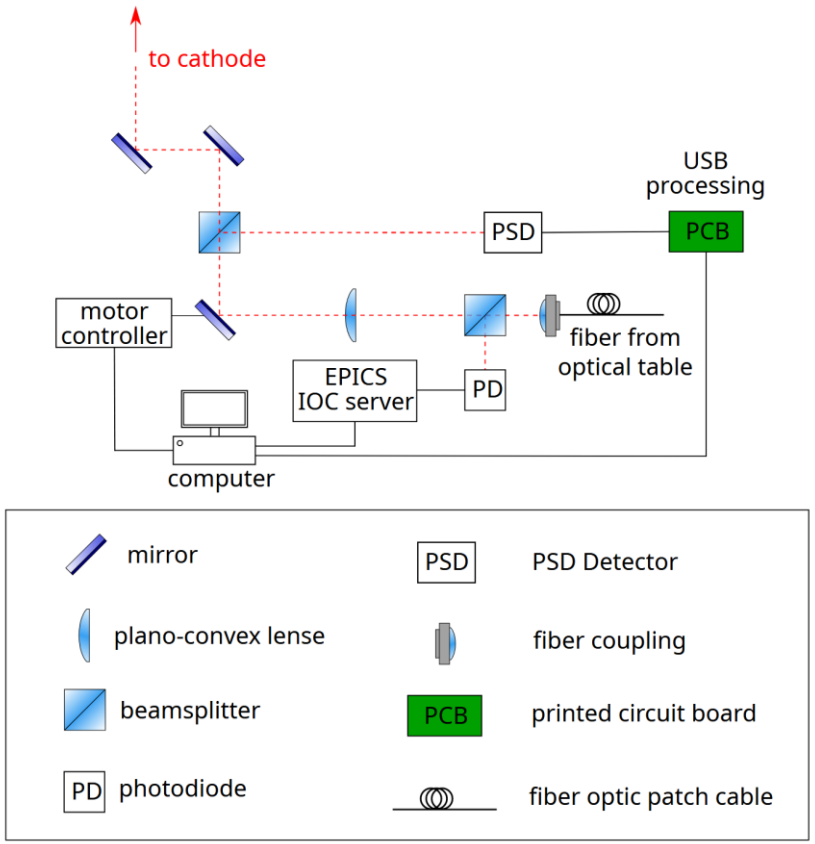
QE scan setup



- Measure QE distribution on photocathode surface
- Dedicated laser beamline below activation chamber
- Move laser-spot using piezo-electric mirror mount
- Feedback position control via position-sensitive diode
- Python-based

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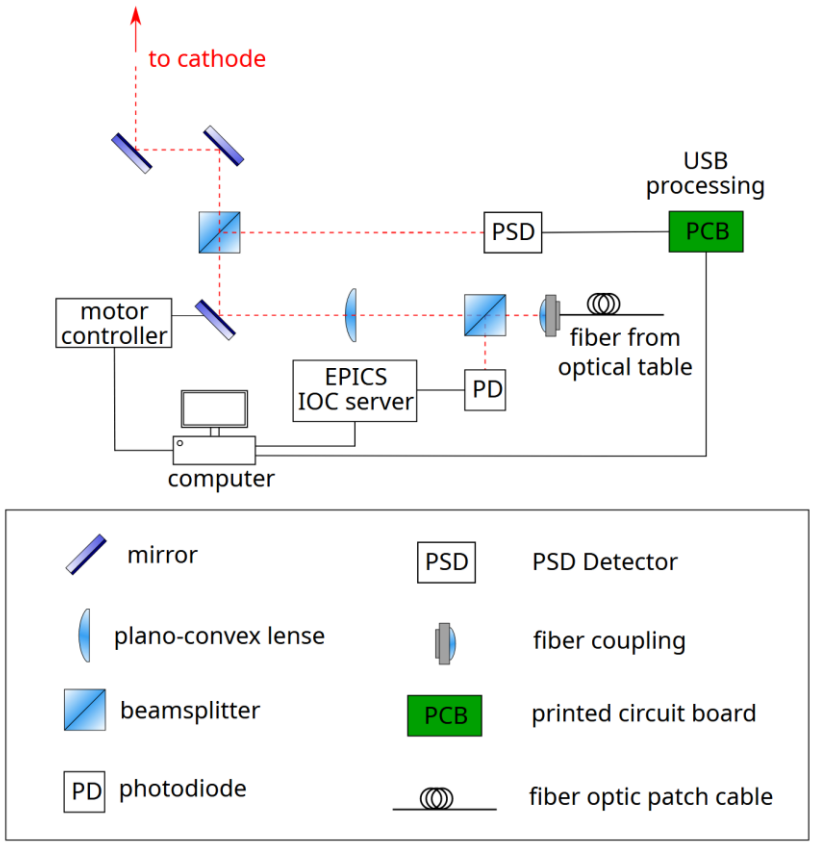

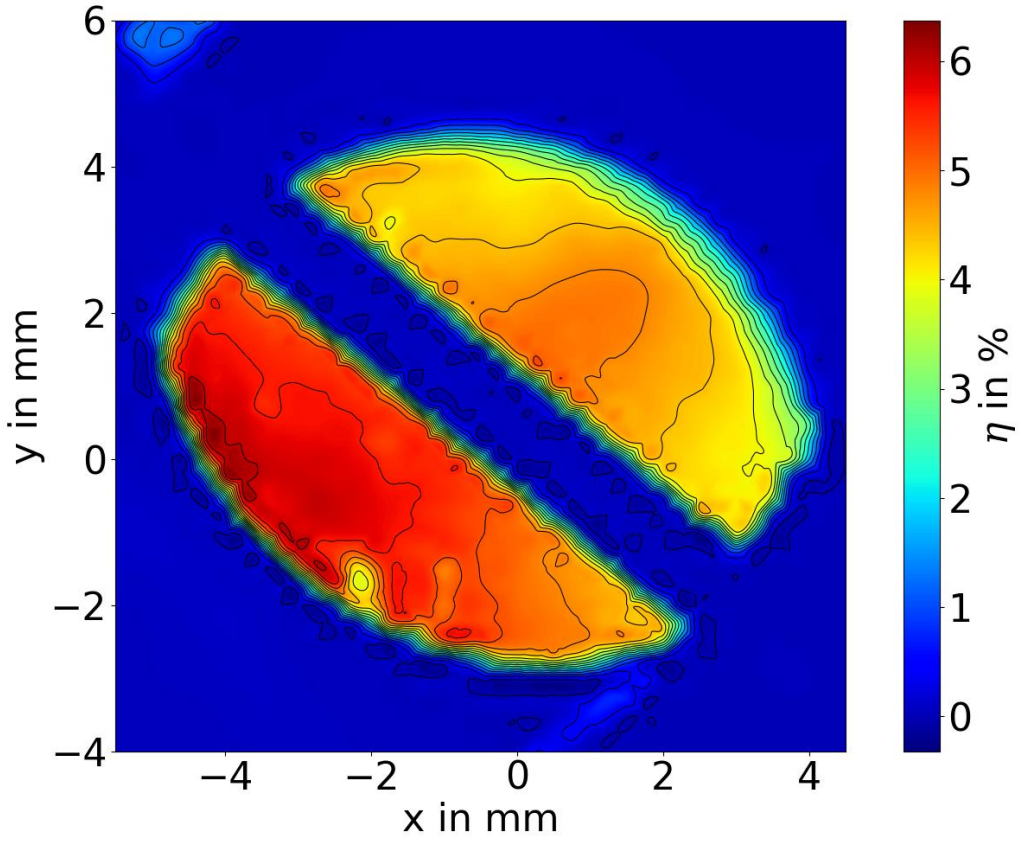

Implementation successful!

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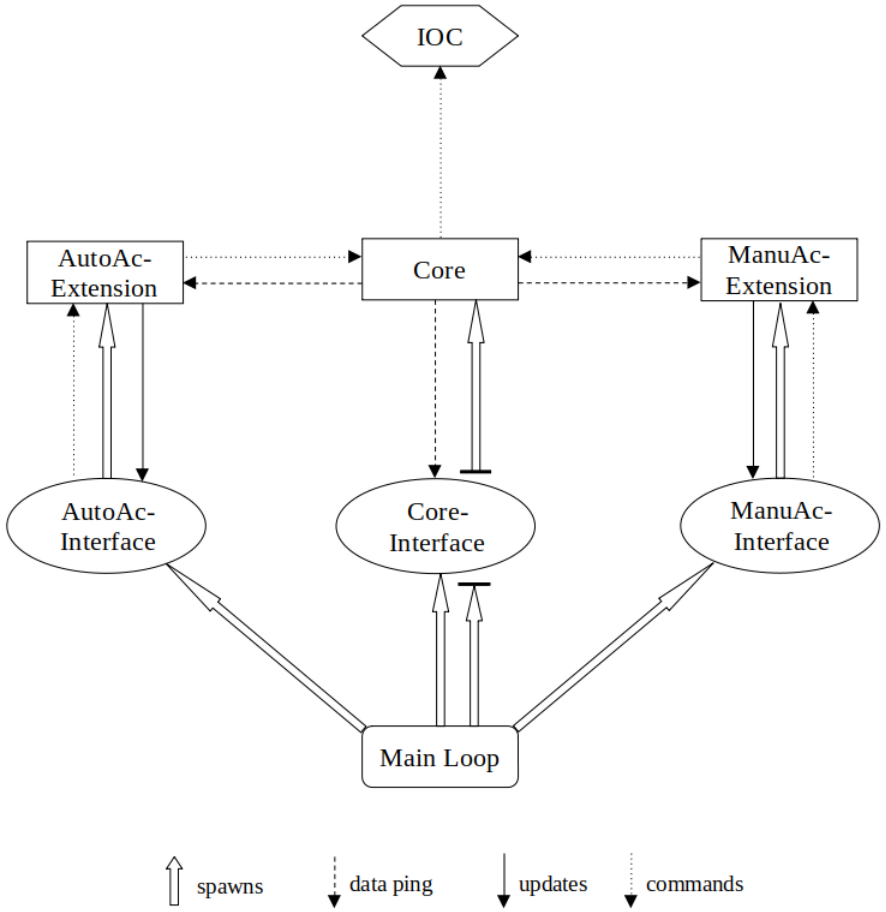
Adaptive Automated Activation using PyCAT

Python Cathode Activation Terminal



- Advanced development following successful preliminary, timer-based tests
- Based on automatic curve analysis (python code)
- Parameters derived in real time during activation process

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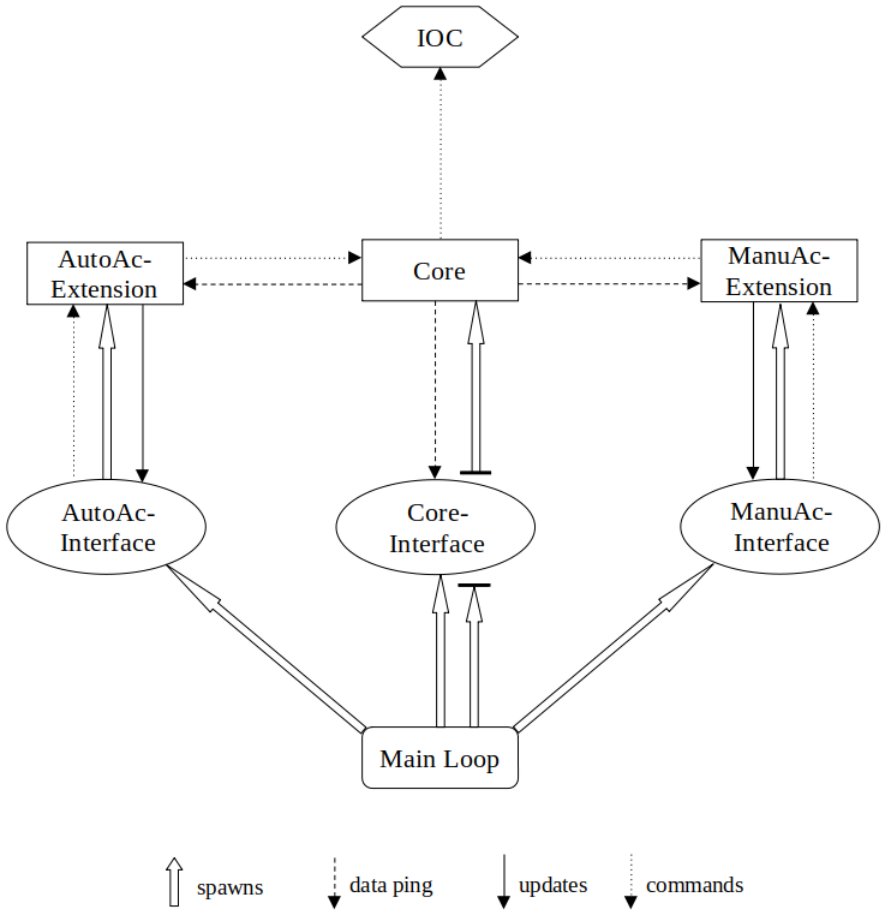
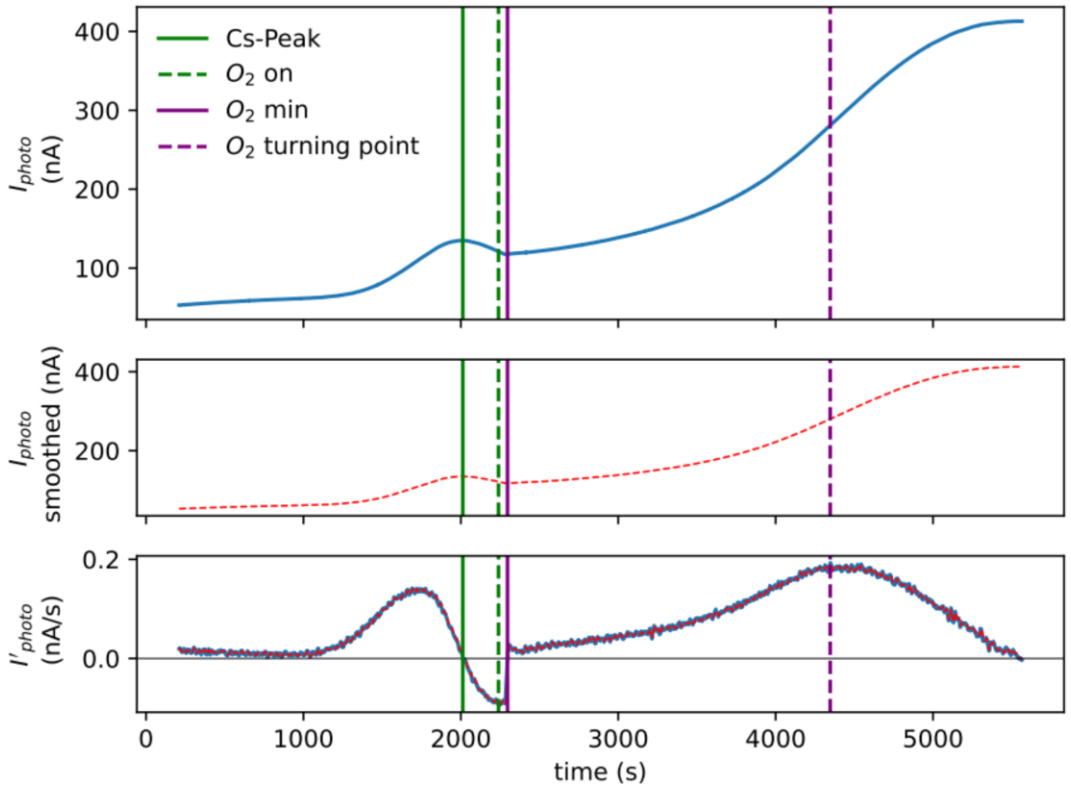
Adaptive Automated Activation

Python Cathode Activation Terminal





first tests successful!

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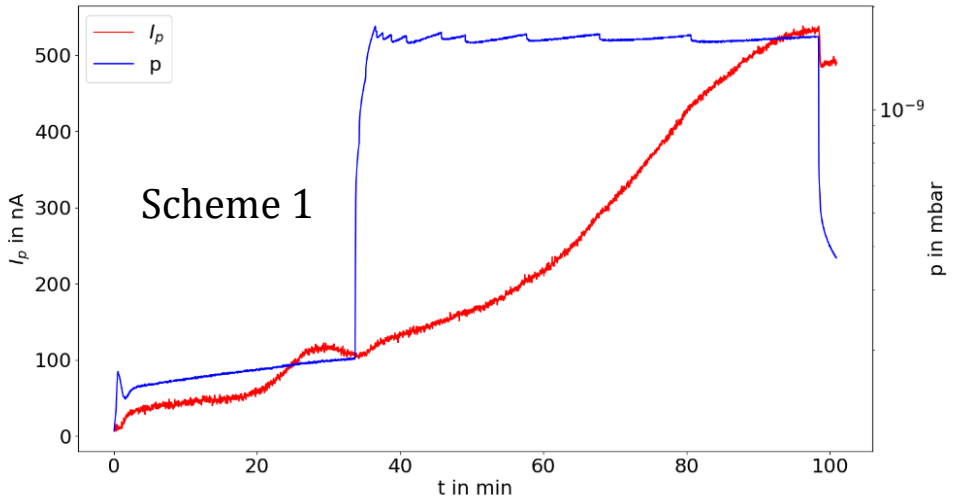
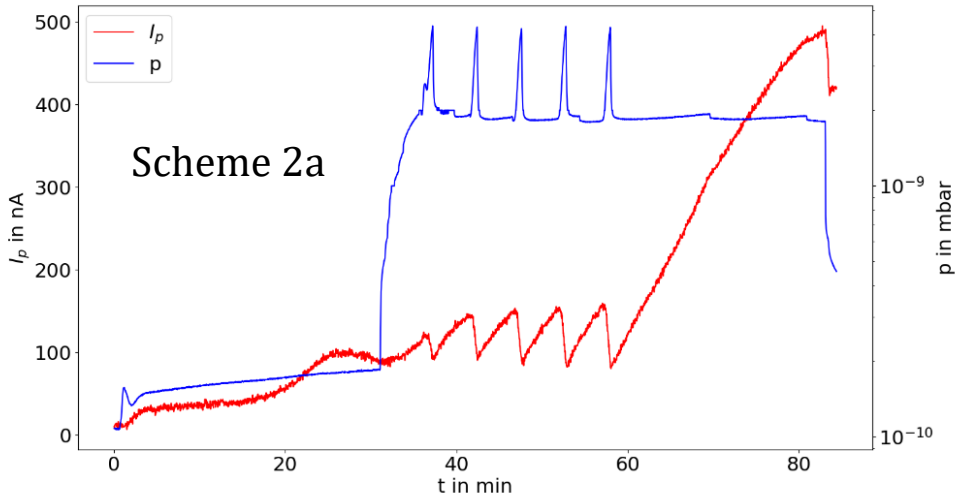
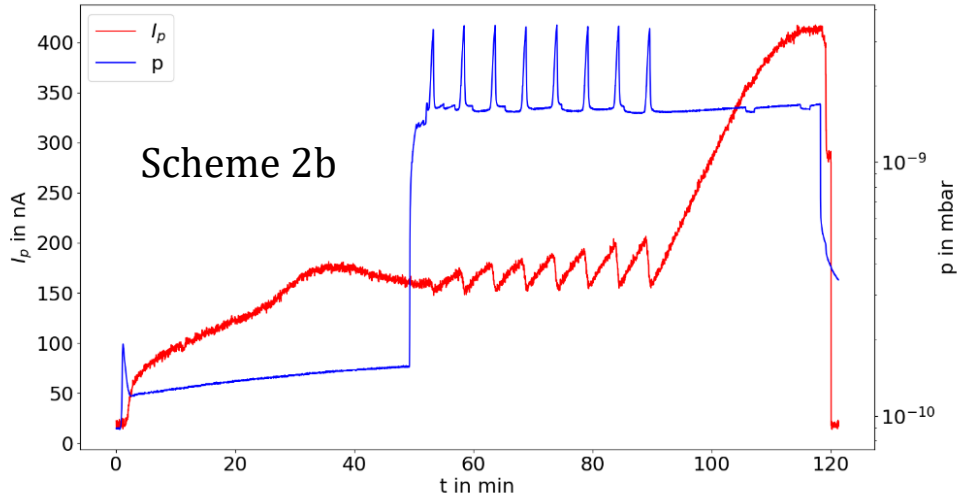
Li-enhanced activation



- Goal: enhanced lifetime
- Co-De with pulsed Li, based on previous study
- Scheme 1: Cs + O_2
- Scheme 2a: Cs + O_2 + Li, 5 pulses
- Scheme 2b: Cs + O_2 + Li, 8 pulses





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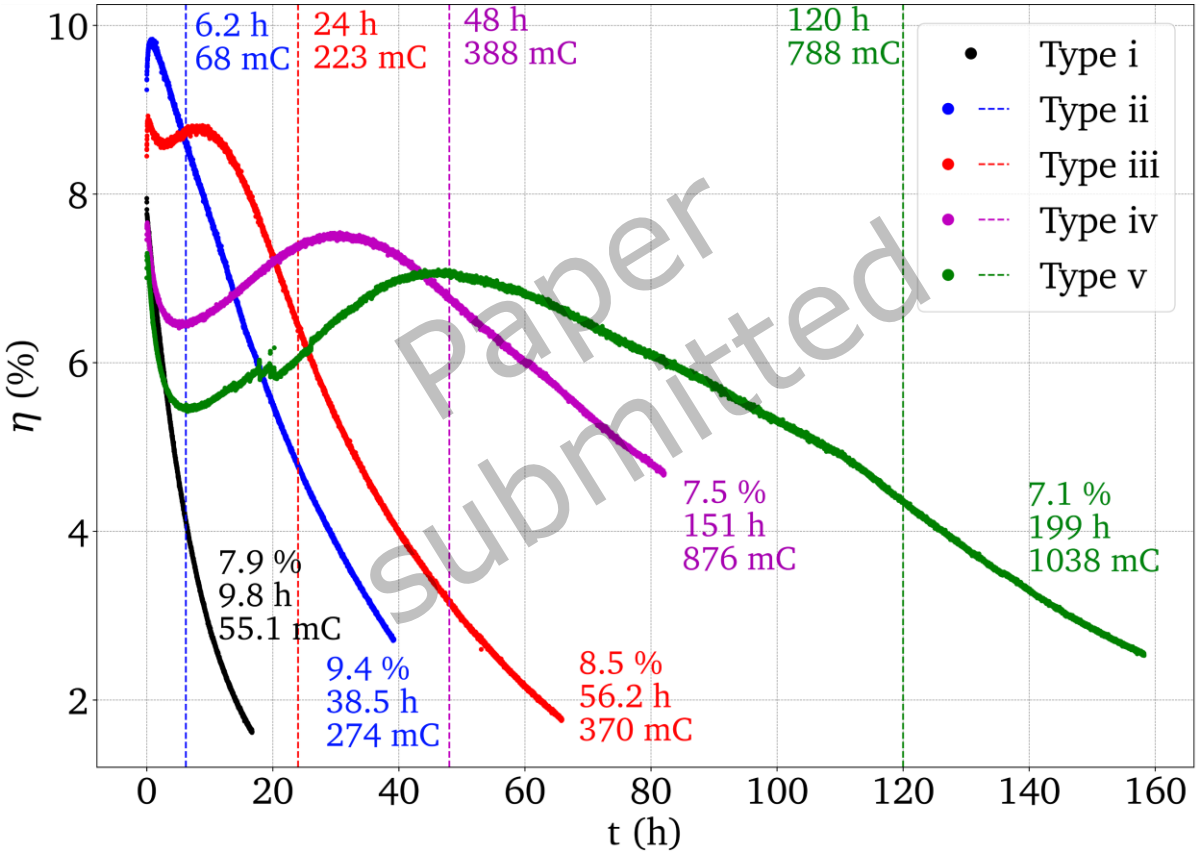

- QE & Lifetime measurements in activation chamber
- P_{laser} = (50 ± 5) µW, λ = (785 ± 2) nm, U_{bias} = 100 V
- 5 types of activations:
  i. Scheme 1, no prior scheme 2
  ii. Scheme 1, subsequent to scheme 2a
  iii. Scheme 2a, subsequent to scheme 1
  iv. Scheme 2b, subsequent to scheme 1
  v. Scheme 2b, subsequent to scheme 2b
- Effect of Li on subsequent activations observed

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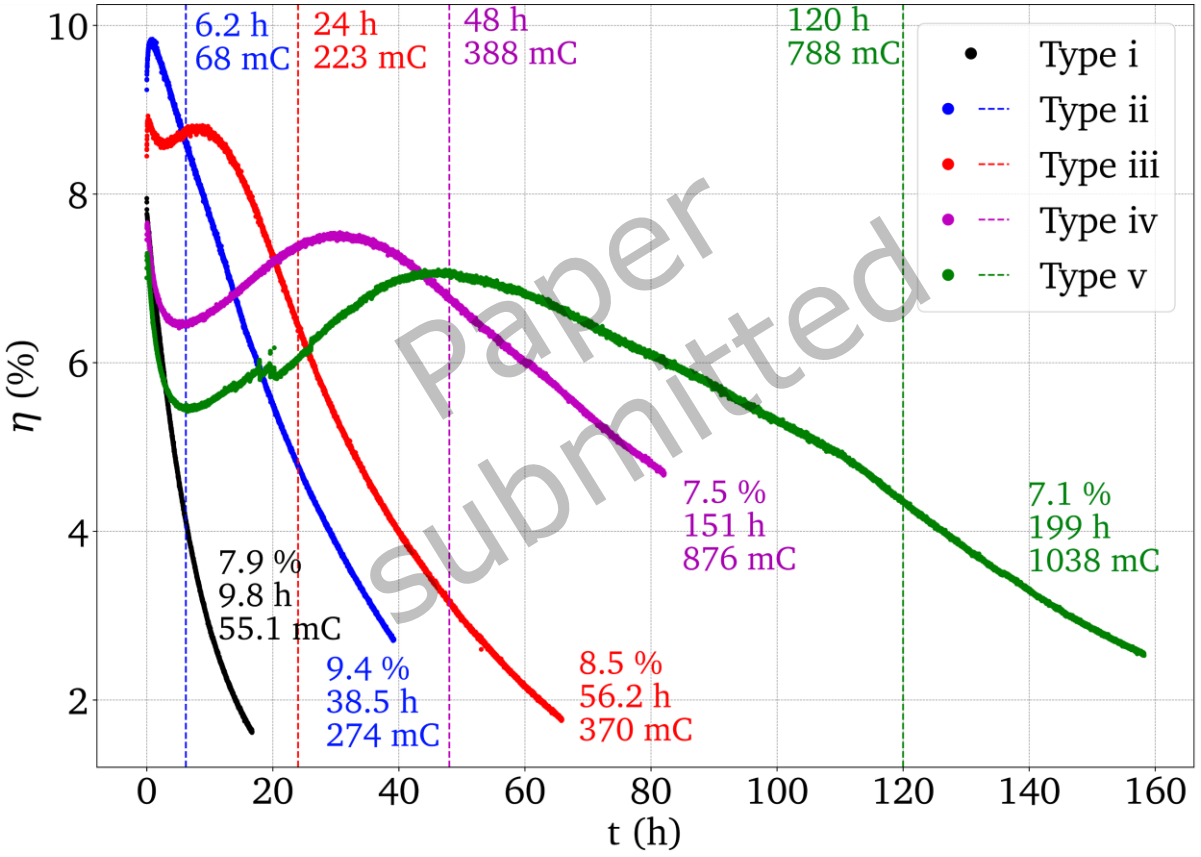
Li-enhanced activation



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Significat increase in τ (up to factor 19) and Q(τ) (up to factor 16.5) observed!

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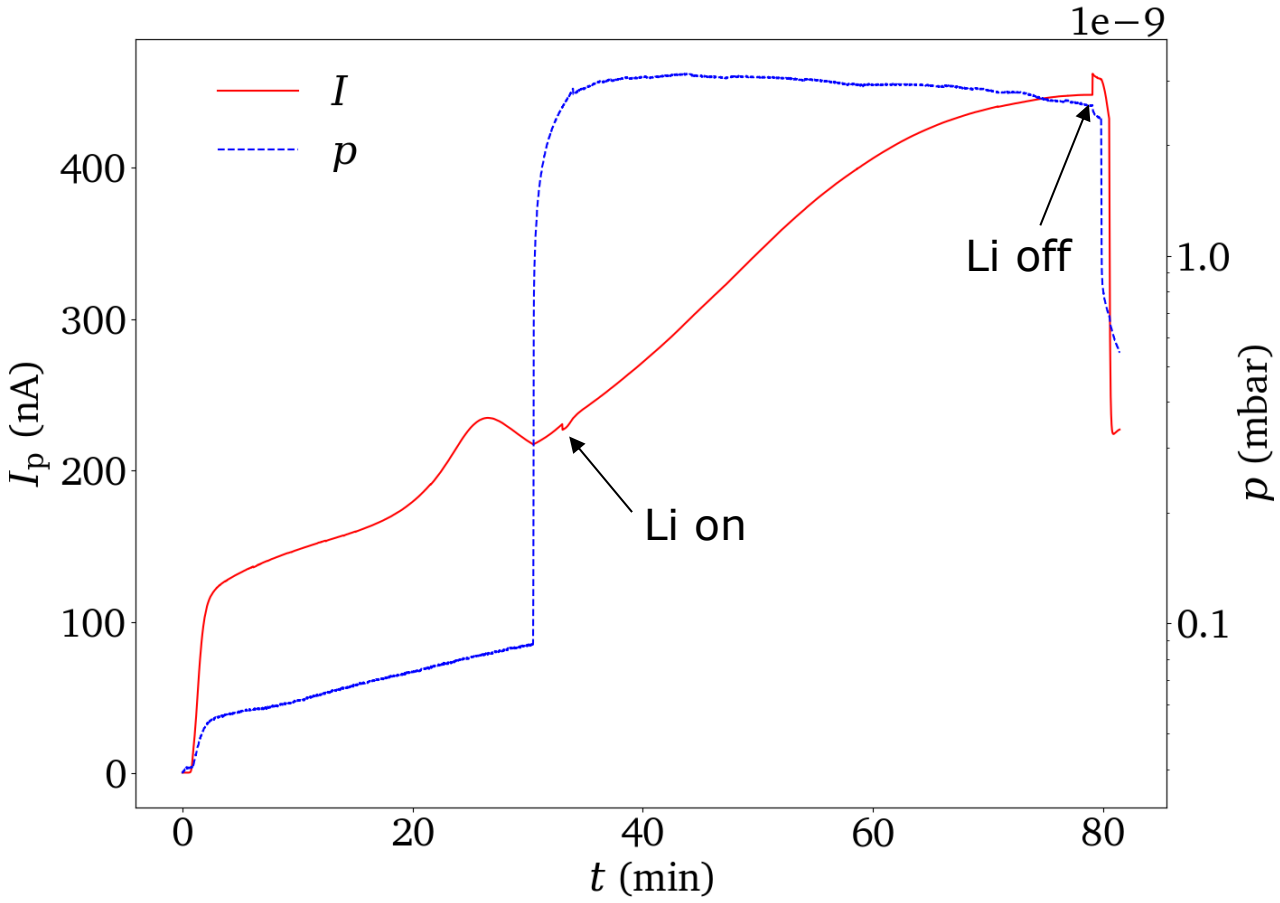
Li-enhanced activation (cont.)



- Idea: simultaneous co-deposition of Li along with Cs and O_2 instead of pulsed Li
- First activation tests successful, QE comparable to Cs+O2 activation
- BUT: first lifetime tests show no improvement
- Additonal tests with higher Li dosage as well as comparison with pulsed scheme ongoing

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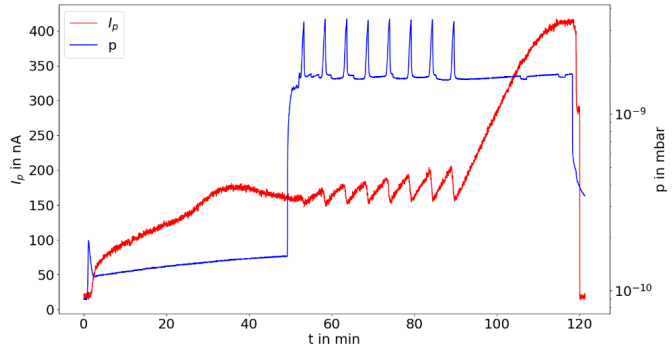
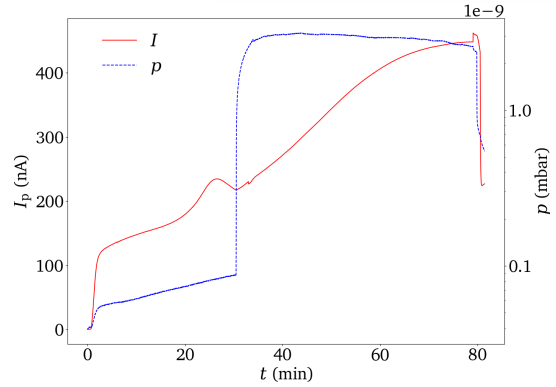
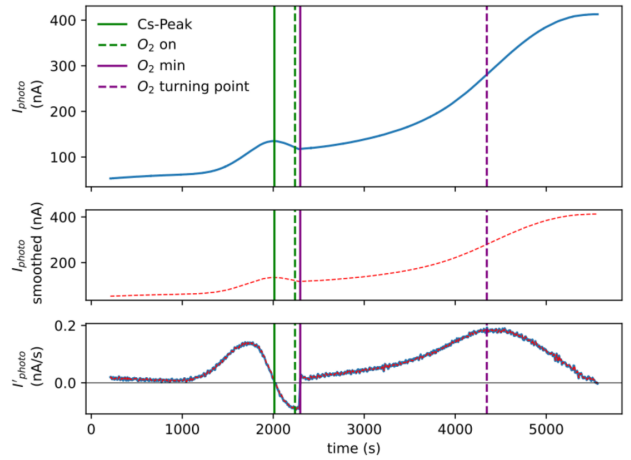
Conclusion

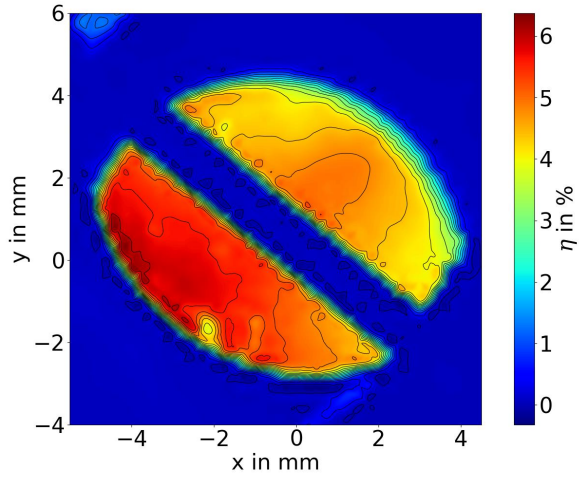
- ✓ Implementation of QE-scan setup
- ✓ Development of automated activation scheme
- ✓ Implementation of Li-enhanced activation yielding significant increase in lifetime

- 🕒 Benchmark automated vs manual activation
- 🕒 Test of Li Co-Deposition
- 🕒 Additional lifetime measurements of Li-enhanced activation









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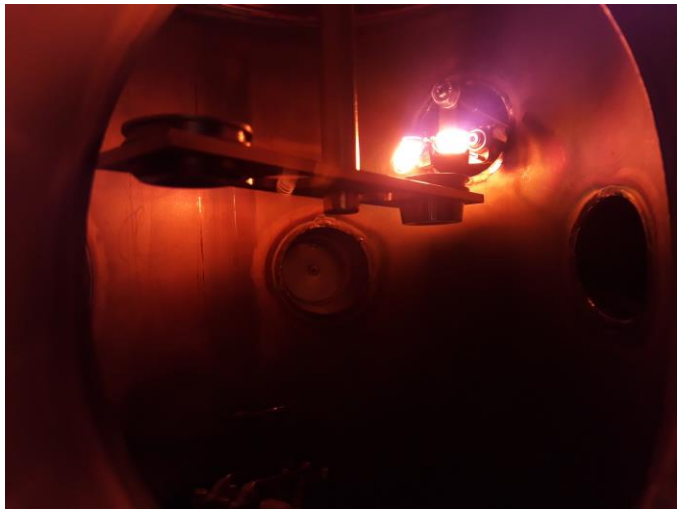
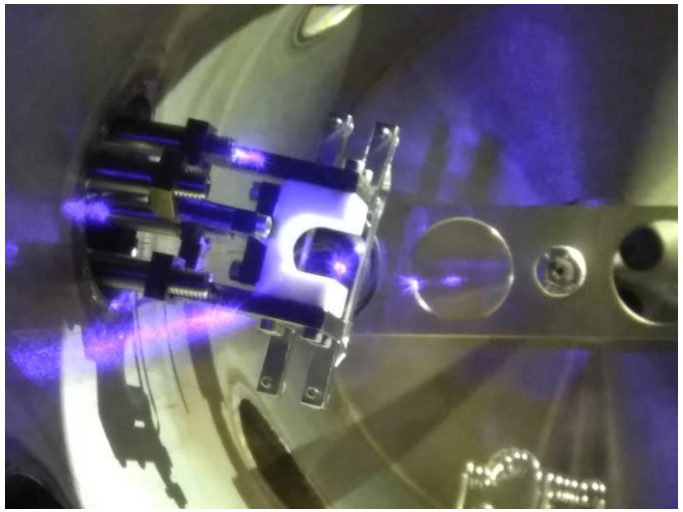
Outlook

- Additional studies with Li-enhanced activation
- Further sophistication of automated activation scheme
- Experiments with Photo-CATCH gun
- High-polarization cathodes
- Cryogenic gun development





THANK YOU!

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S-DALINAC: Ruben Grewe, Felix Heyer
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