

Enhanced GaAs photocathode activations using lithium or automation at Photo-CATCH*

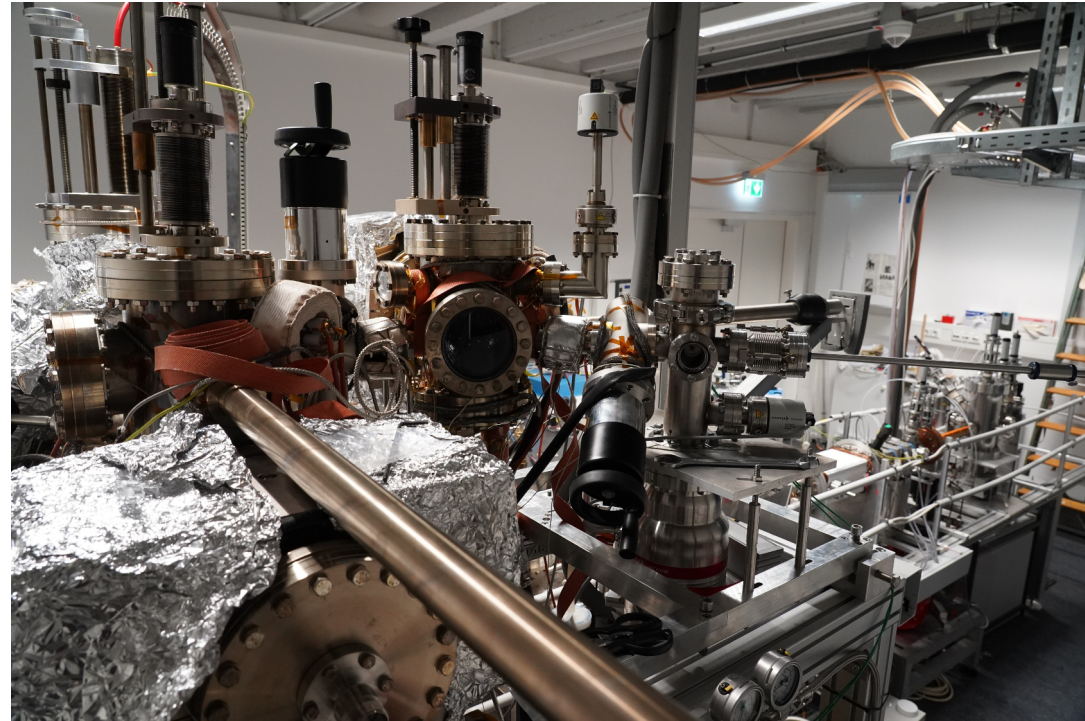
M. Engart – J. Enders, M. Herbert, R. Petry

*Work supported by DFG (Project-ID 499256822 – GRK 2891 'Nuclear photonics').

GaAs photocathodes

- Extraction of polarized electron beams
- Theoretical limit of Polarization $P=1$ using special crystals
- Photo-CATCH: Bulk GaAs
 - $\Rightarrow P_{max}=0.5$
- High Quantum Efficiency with visible light
- Well established cathode material

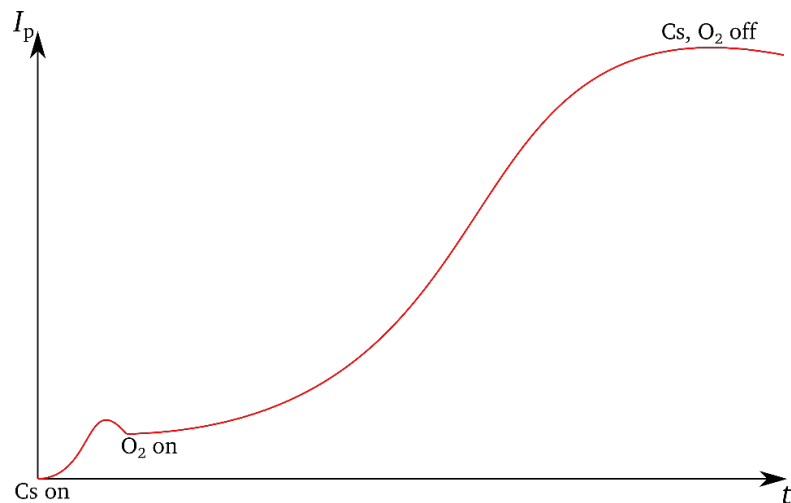
Photo-CATCH





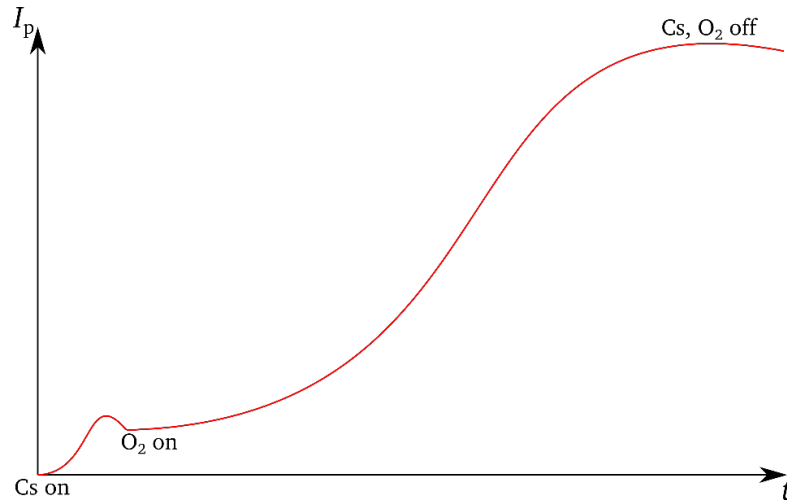
Activation Procedure

Co-Deposition (Co-De)



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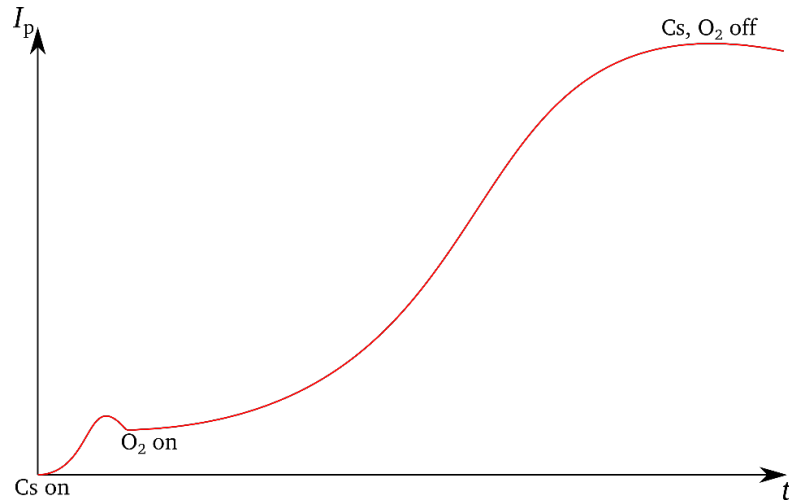
Quantum Efficiency:

$$\eta(\lambda) = \left| \frac{h c_0 I_P}{e P_L \lambda} \right| \cdot 100 \%$$



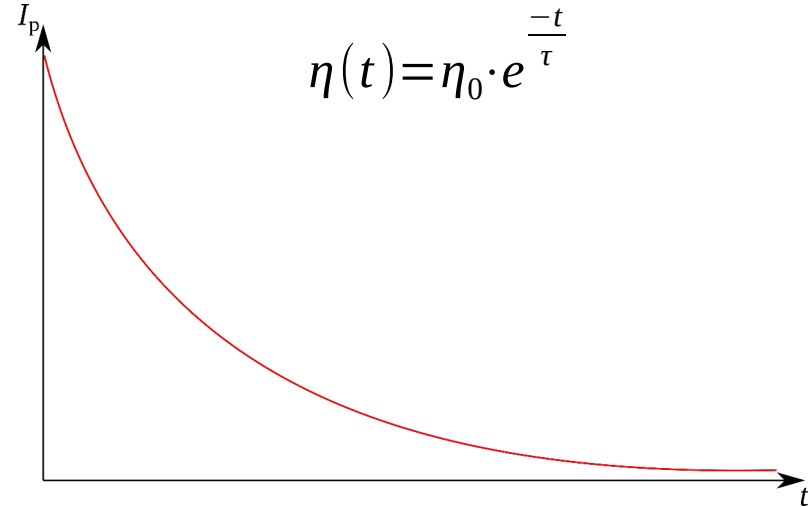
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Lifetime

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



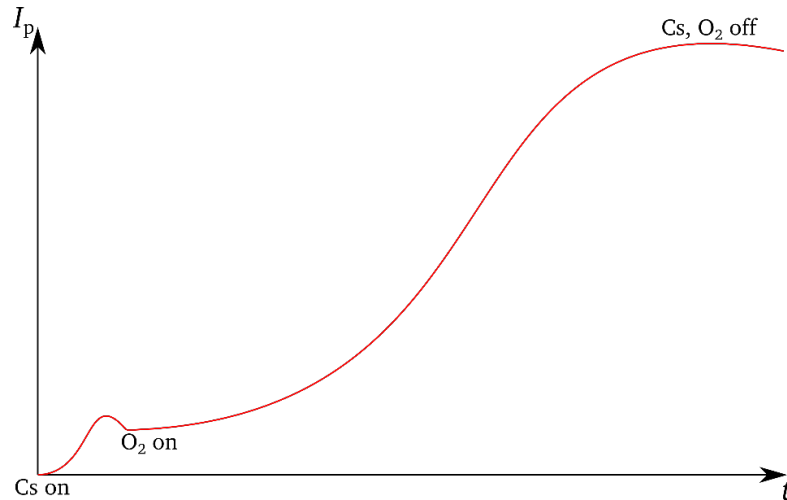
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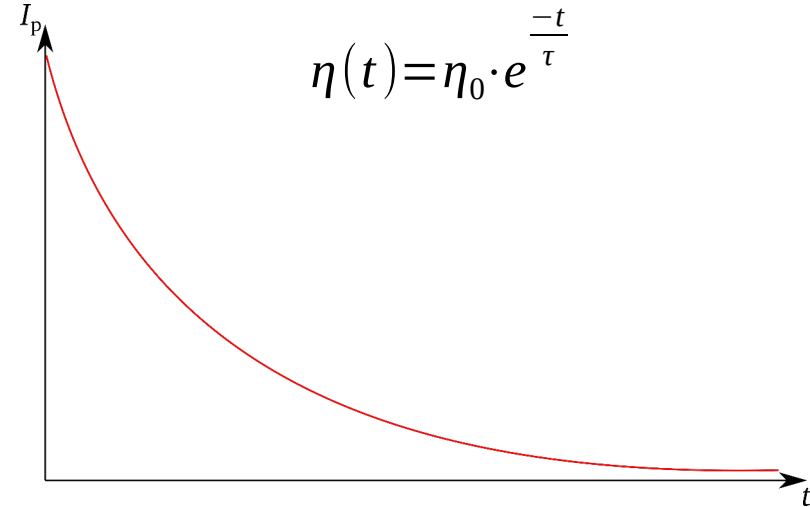
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Lifetime

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Lifetime Charge:

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



Activation Procedure

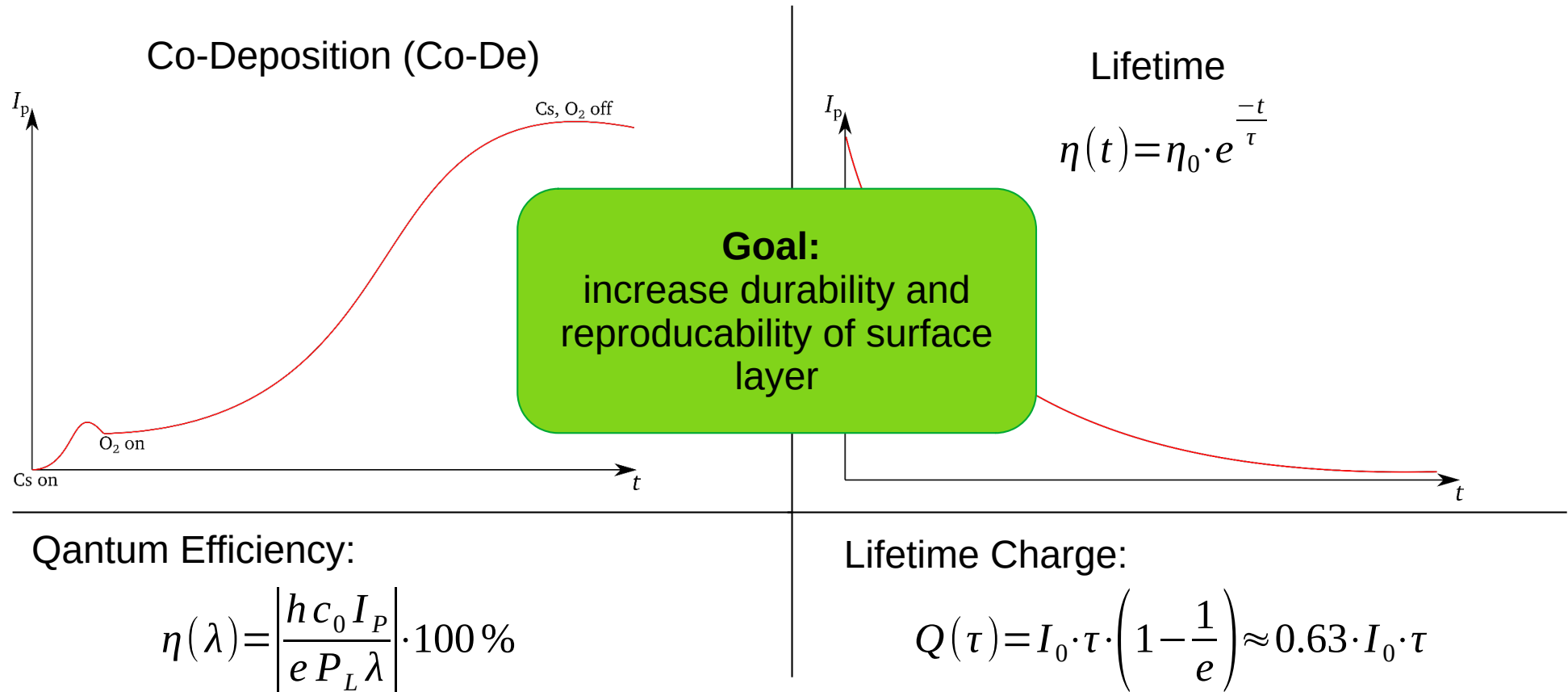


Photo-CATCH

Activation Chamber

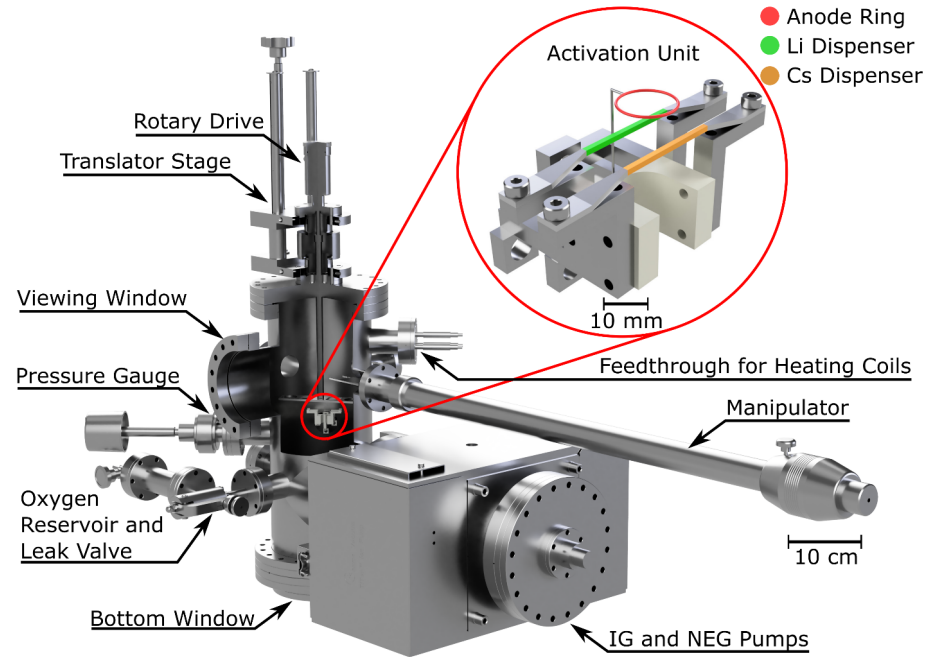
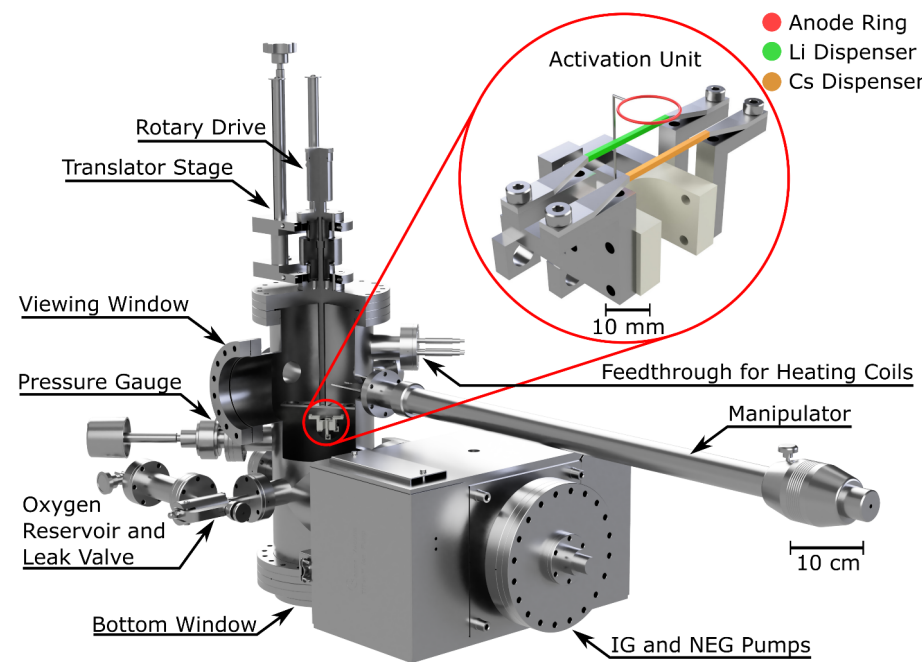
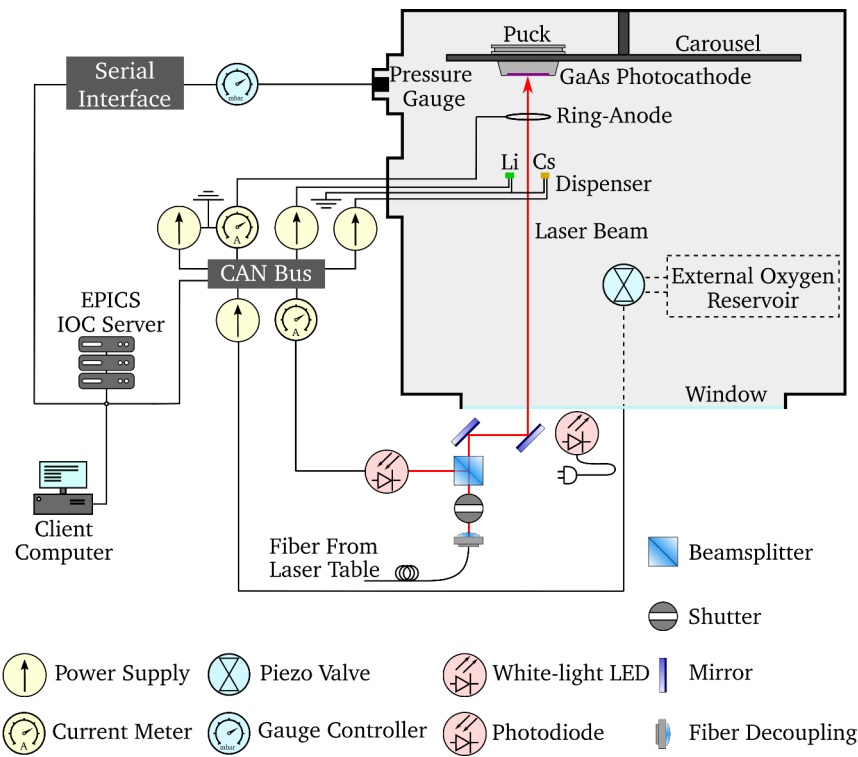


Photo-CATCH

Activation Chamber

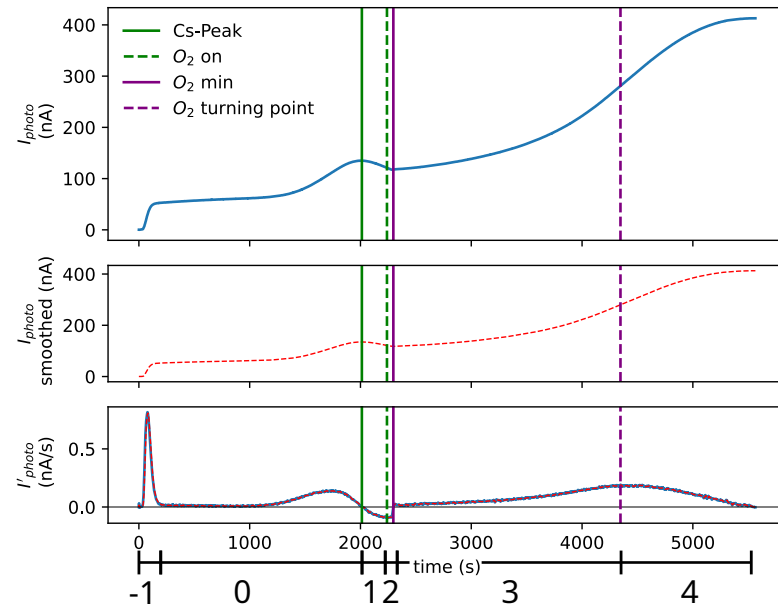


Activation Setup



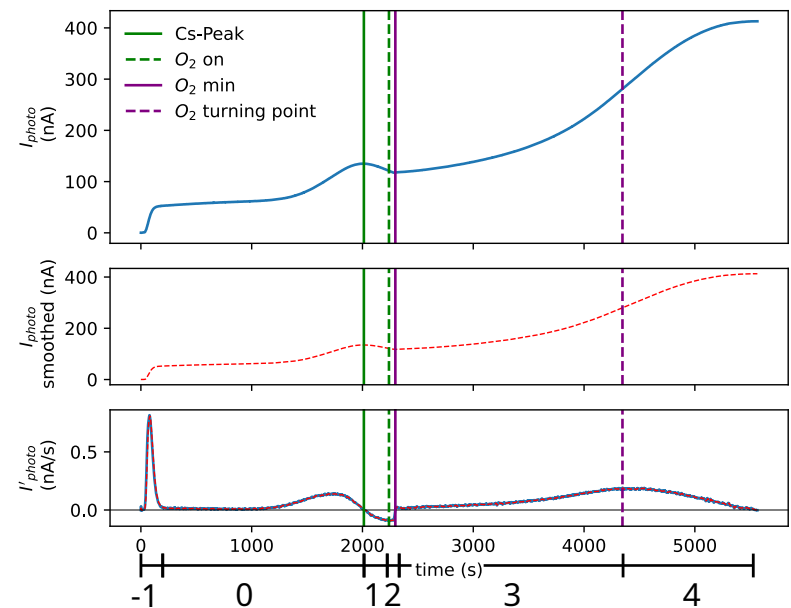
Adaptive Automation

State Based Algorithm

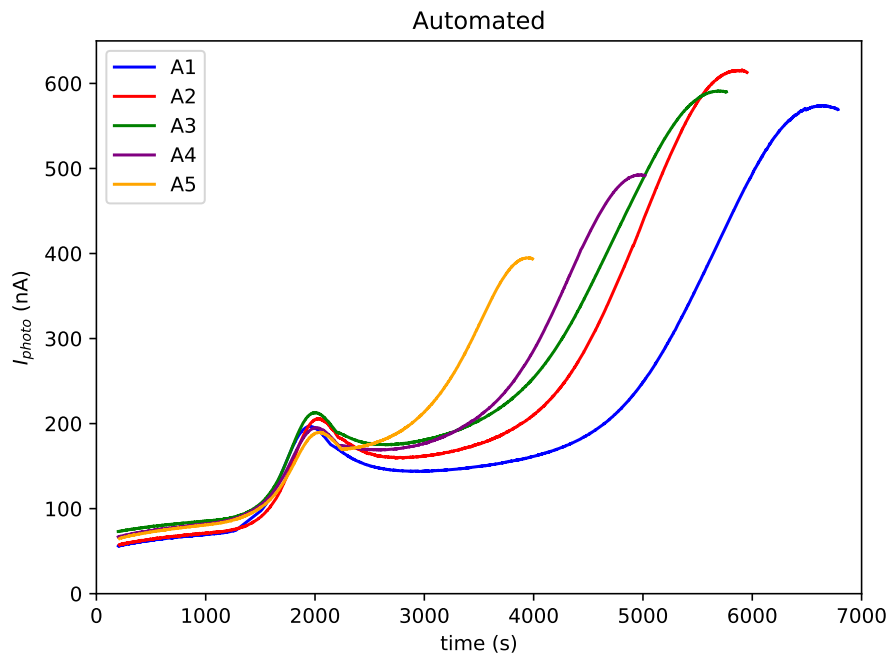


Adaptive Automation

State Based Algorithm

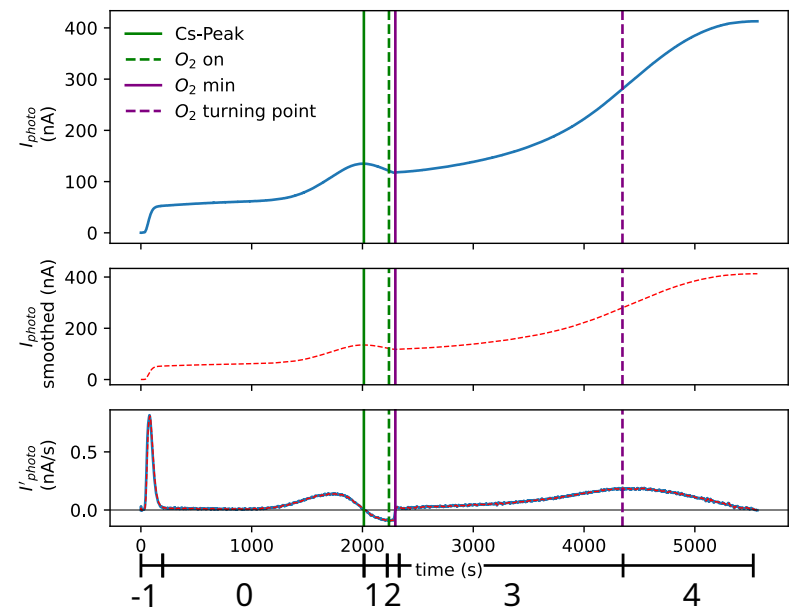


Automated Activations

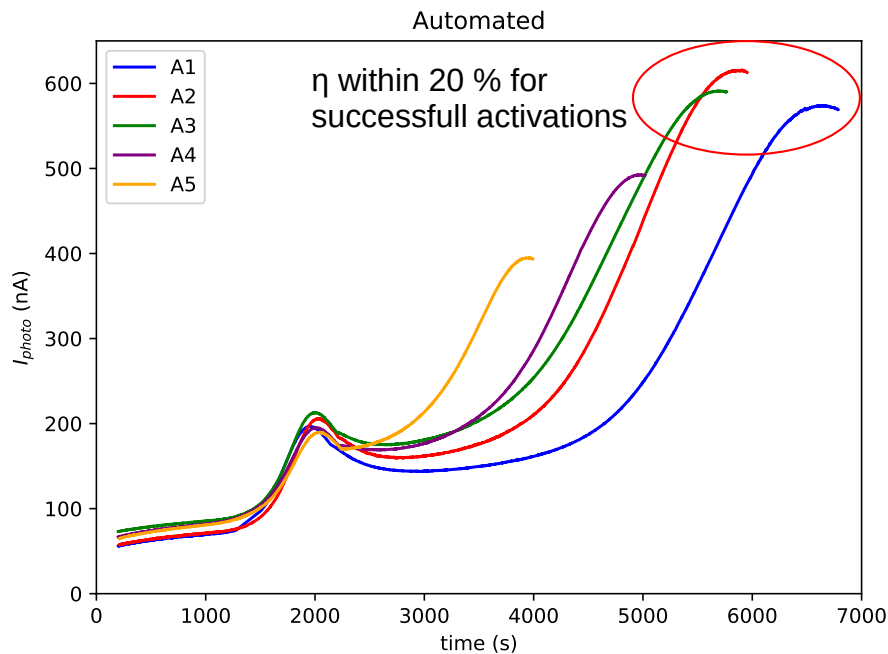


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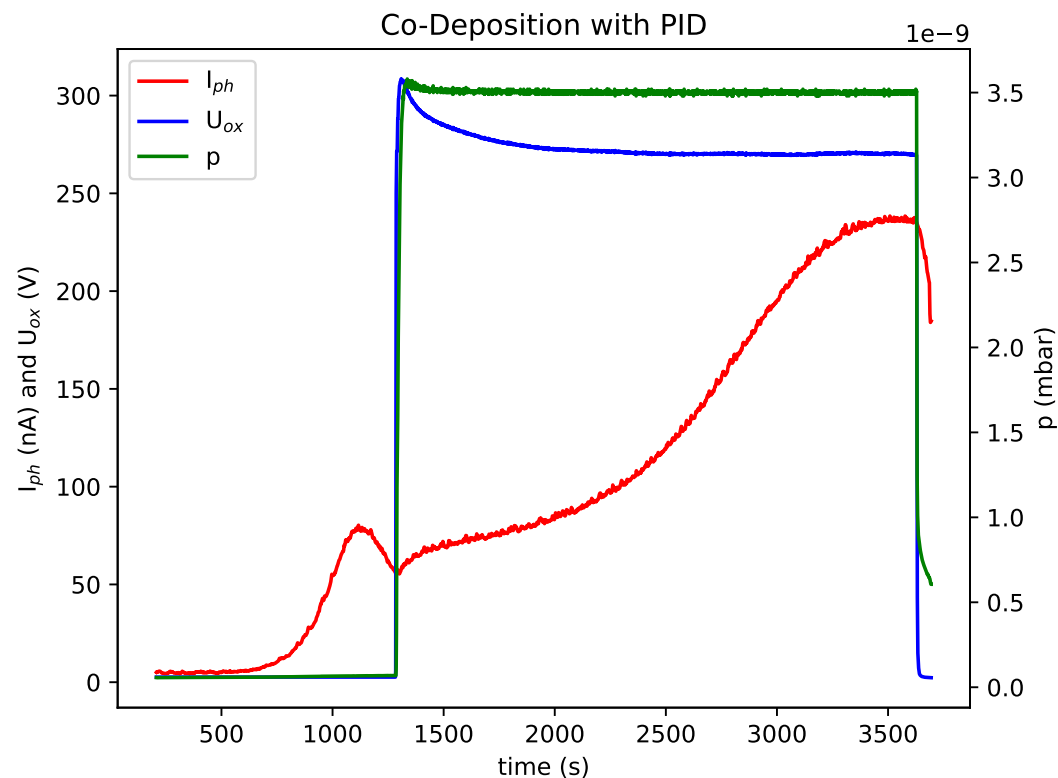
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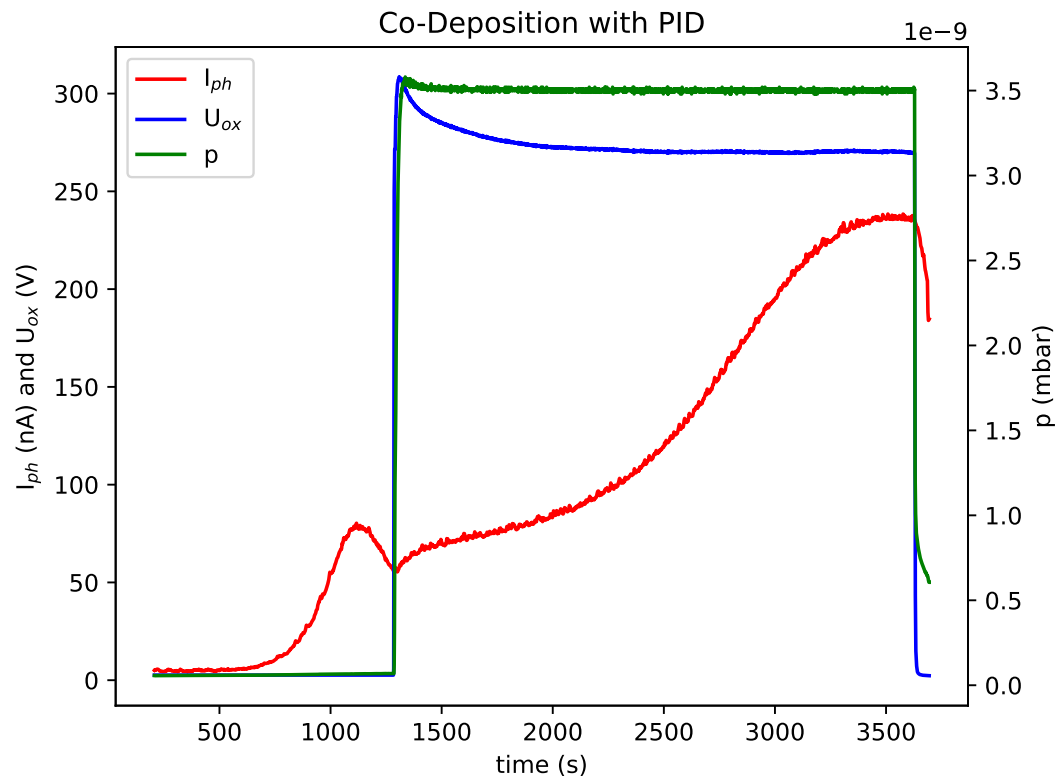
Automated Activations



Oxygen PID Control



Oxygen PID Control



Comparison

Mode	QE (%)	Duration (s)
PID	3.40(8)	3625
Manual	3.33(6)	3800

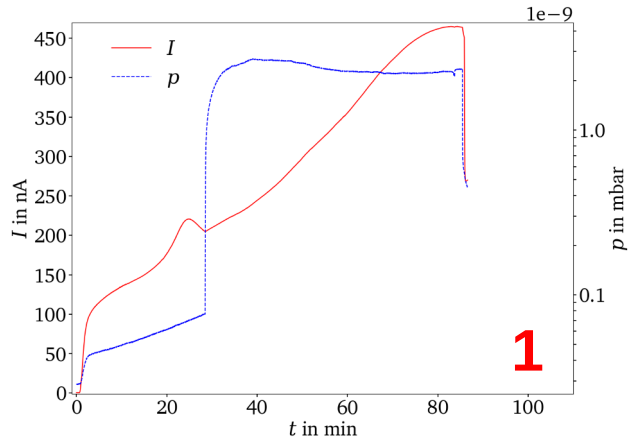


Promising proof of concept

Cs-O₂-Li Activations

Schemes:

1) Cs + O₂

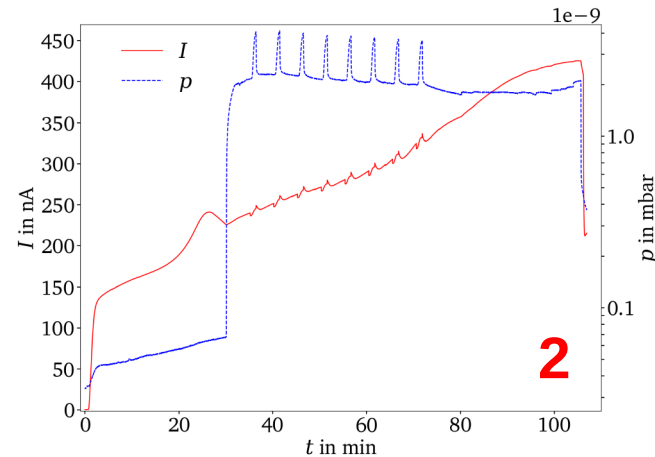
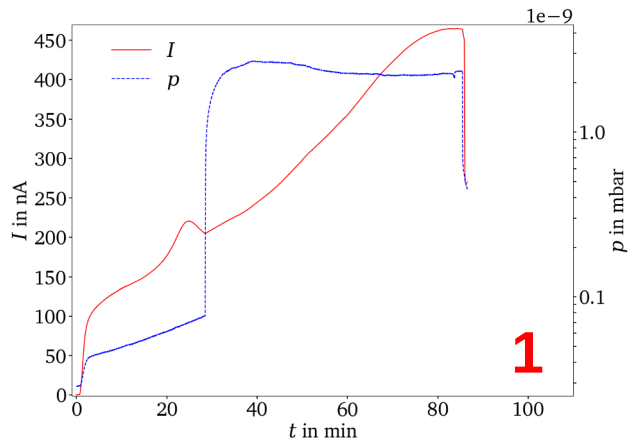


Cs-O₂-Li Activations

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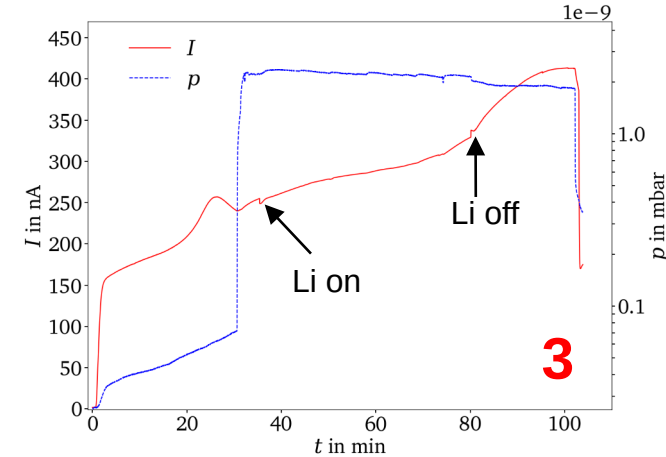
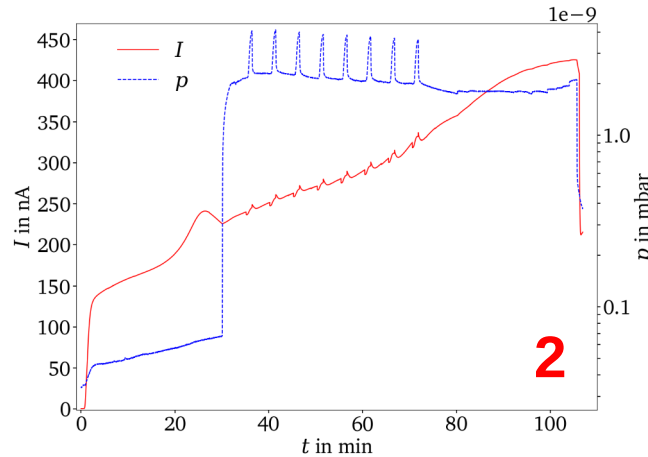
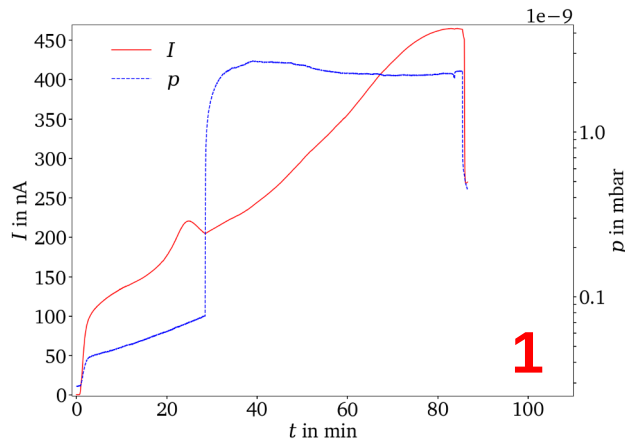
2) Cs + O₂ + Li (8 pulses)



Cs-O₂-Li Activations

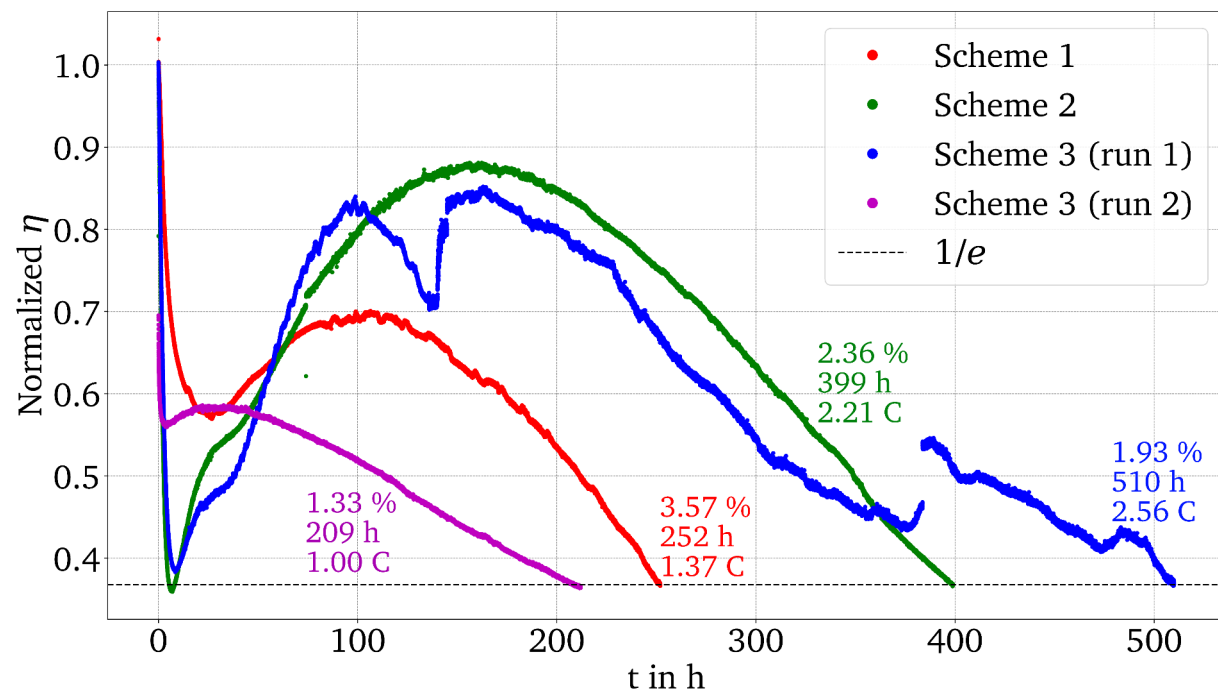
Schemes:

- 1) Cs + O₂
- 2) Cs + O₂ + Li (8 pulses)
- 3) Cs + O₂ + Li (continuous Li during O₂ deposition)



Cs-O₂-Li Lifetime

Lifetime after different Li schemes



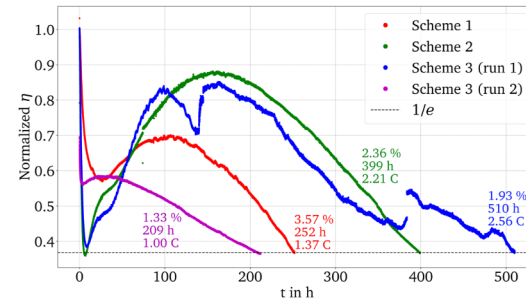
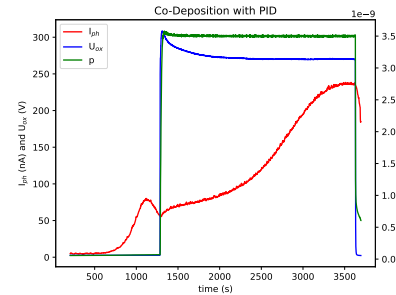
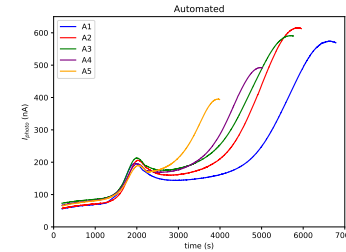
General tendency for Li-enhanced activations:

- lower quantum efficiency
- higher lifetime (factor of 2 for schemes 2 & 3)

M. Herbert et al., PSTP 2024 Proceedings, Proceedings of Science (2025),
<https://doi.org/10.22323/1.472.0055>

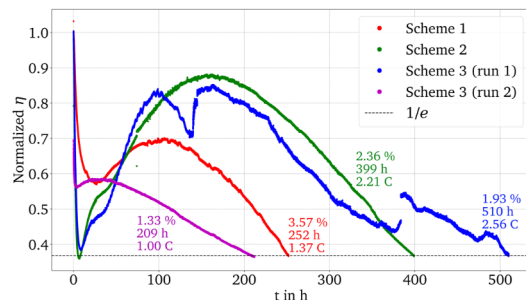
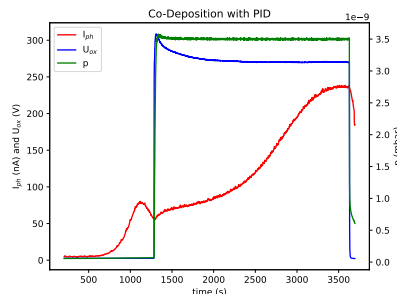
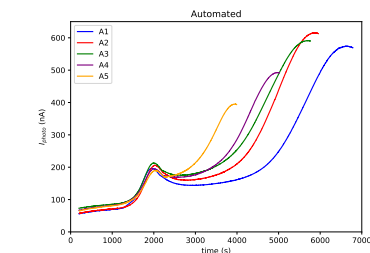
Conclusion

- Adaptive Automation of GaAs Activations
- Oxygen PID operational & promising
- Li-Enhancement greatly increases lifetime



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Outlook

- Integration of oxygen PID into automation
- Automation of Li enhanced activations
- Commissioning of the Photo-CATCH electron gun



Thank you!

AG Enders:

- Joachim Enders
- Maximilian Herbert
- Vincent Wende
- Robin Petry

