High-Voltage Stabilization of MIRACLS' Proof-of-Principle Experiment

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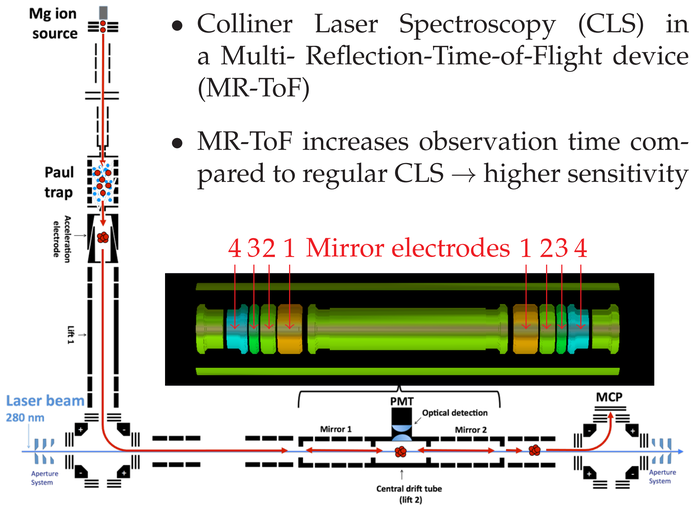
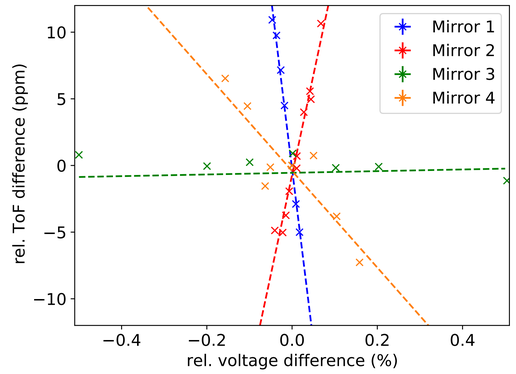
1 Proof-of-Principle Experiment



- Colliner Laser Spectroscopy (CLS) in a Multi- Reflection-Time-of-Flight device (MR-ToF)
- MR-ToF increases observation time compared to regular CLS → higher sensitivity

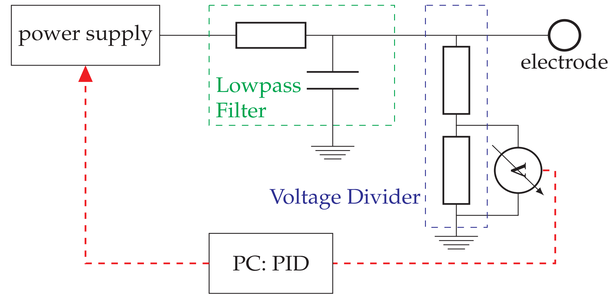
2 Motivation

- CLS linewidth can be broadened by time-of-flight variations of the ion bunch
- Moreover, voltage instabilities lead to ToF fluctuations

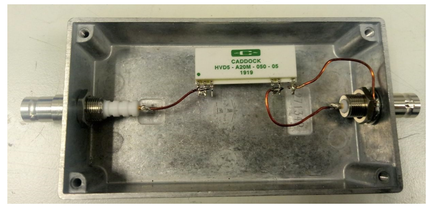


Sensitivity of ToF to mirror potentials

3 Voltage Stabilization Setup

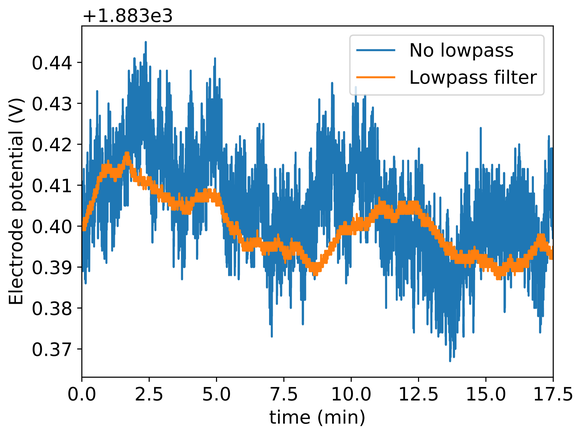


Based on low-cost (50 CHF) voltage divider (TC 5 ppm):



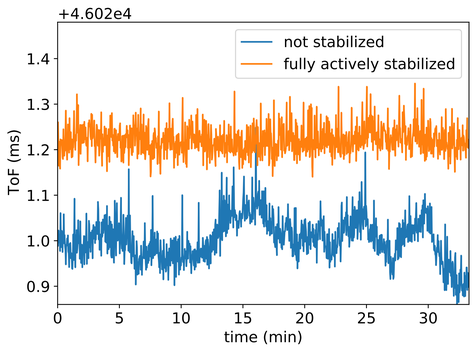
4 Passive stabilization

Lowpass filter with $\tau = R \cdot C = 40\,\mathrm{s}$.
Voltage measured at mirror electrode 4:



5 Active stabilization

Mirror 2 and 4 are stabilized by a lowpass filter and a PID loop, mirror 1 and 3 are only stabilized via a PID loop.



Relative standard deviation of the ToF and voltage signal:

Active stab.	off	on	Improv.
ToF	1.05 ppm	0.67 ppm	36.2 %
Mirror 1	18.16 ppm	16.04 ppm	11.7%
Mirror 2	3.02 ppm	0.66 ppm	78.2%
Mirror 3	8.64 ppm	5.69 ppm	34.1 %
Mirror 4	3.70 ppm	0.56 ppm	84.9 %

The most sensitive mirror (Mirror 1) could not yet be passively stabilized due to its higher potential. A suitable capacitance has now been identified and will be tested soon.

Conclusion:
A significant improvement of the ToF signal stability can be achieved, which reduces the ToF width of an ion signal measured in a longer measurement run. The improvement shown here, can be excelled by stabilizing the most sensitive mirror passively and actively. The passive stabilization enables the active stabilization to work effectively.

References

[1] F. Wienholtz et al. Improved stability of multi-reflection time-of-flight mass spectrometers through passive and active voltage stabilization. *Nucl. Instrum. Methods Phys. Res. B*, 463:348 – 356, 2020.

Outlook

- Comparison to SimION simulations
- Improvement of CLS linewidth due to voltage stabilization
- Implementation into the compactMIRACLS experiment, currently under construction

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