Design Project – SIE 2024

Lab Characterization of Aerosol Sampling onto Nanoelectromechanical Resonators

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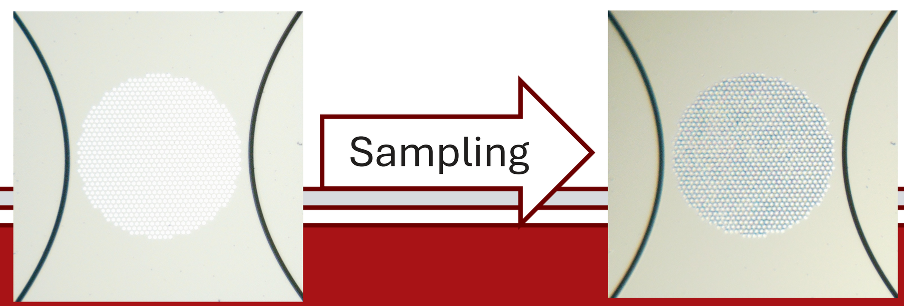
INTRODUCTION

Atmospheric aerosols significantly influence the Earth's radiative balance by affecting cloud properties. The **Arctic region** is particularly impacted as global warming alters air circulation and aerosol scattering properties. However, due to the harsh environment, there is **limited vertical measurement data** and understanding of aerosol mixing during transport. **Unmanned aerial vehicles** (UAVs) like helikites have been used in extreme environments to collect vertical, time-resolved aerosol samples.

Nanoelectromechanical **(NEMS) resonators**, such as the **EMILIE** by Invisible-Light Labs, offer promising capabilities for detecting small masses of aerosols through shifts in resonance frequency.



Before After

OBJECTIVES

To assess the potential of EMILIE in field campaigns by evaluating its sampling efficiency and compatibility of the M1000 (1x1mm) and **M500** (0.5x0.5mm) membranes with current analysis methods.

① **Characterize Detection Limits**: Study how varying aerosol concentration or sampling time affects EMILIE's sampling efficiency.

② **Ease of Adoption for Field Measurements**: Assess the fluctuation in initial unsampled membrane mass to simplify sampling method.

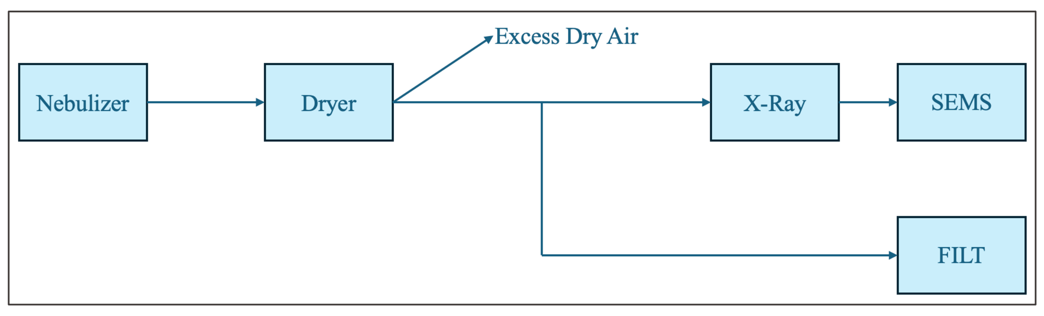
③ **Effect of Particle Size on Sampling Efficiency:** Determine the relationship between sampling efficiency and particle size.

METHODOLOGY

Experimental Approach:

- Ammonium sulfate solution nebulized, passed through a dryer and then to the SEMS or the FILT (containing the EMILIE membranes)
- Measured mass concentration at the SEMS compared to the mass deposited on EMILIE, determined by a change in resonance frequency

① ②



Mass [ng] = Mass Concentration [ng/m^3] × Flow Rate [m^3/min] × Sampling Time [min]

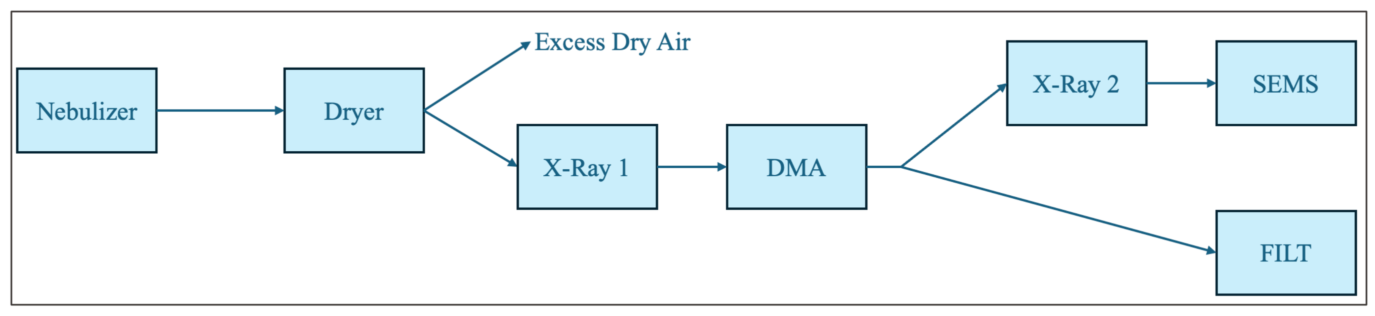
Sampling Time [min]	1	2.5	5	10	20	60	135

& constant mass concentration

Mass Concentration [ng/m³]	1	2.5	5	10	20	60	135

& constant sampling time

③



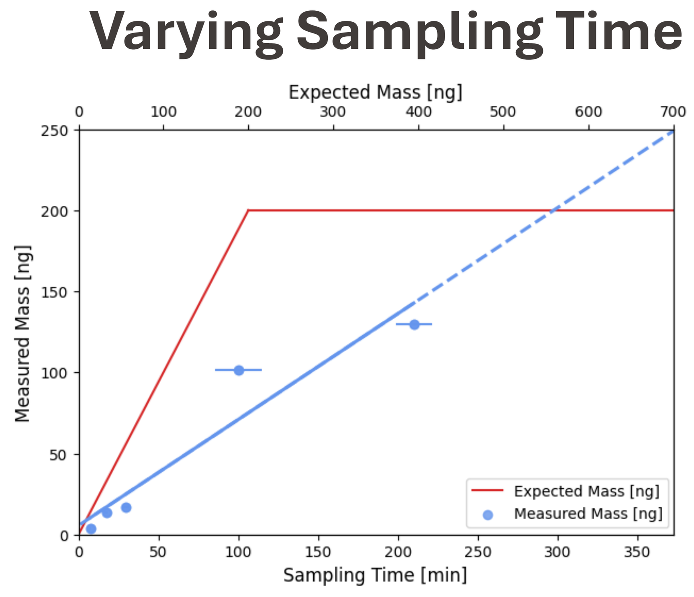
Particle Size [nm]	10	25	50	100	300

Equipment Used :
Aerosol Generator (**Nebulizer**), Scanning Electrical Mobility Spectrometer (**SEMS**), **Dryer**, **X-Rays**, Differential Mobility Analyzer (**DMA**), Filter Sampler Model (**FILT**) containing the EMILIE

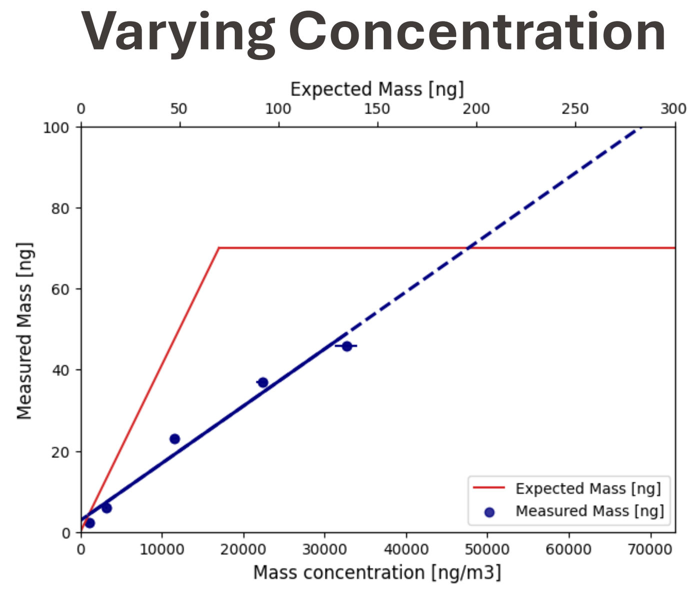
RESULTS

① Characterizing Detection Limits

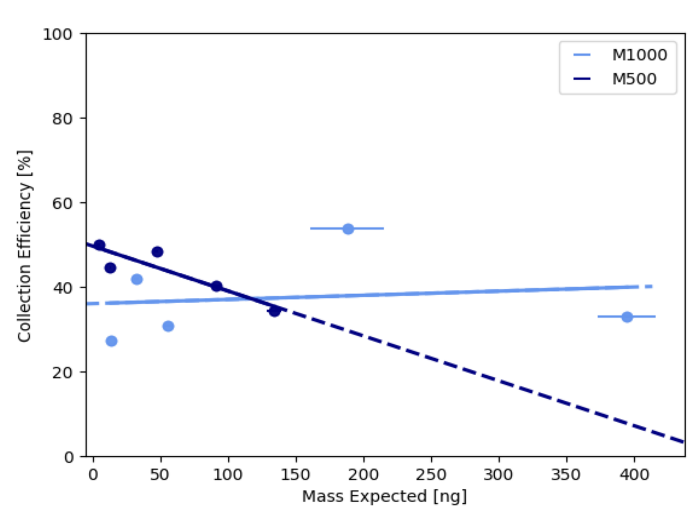
Varying Sampling Time



Varying Concentration

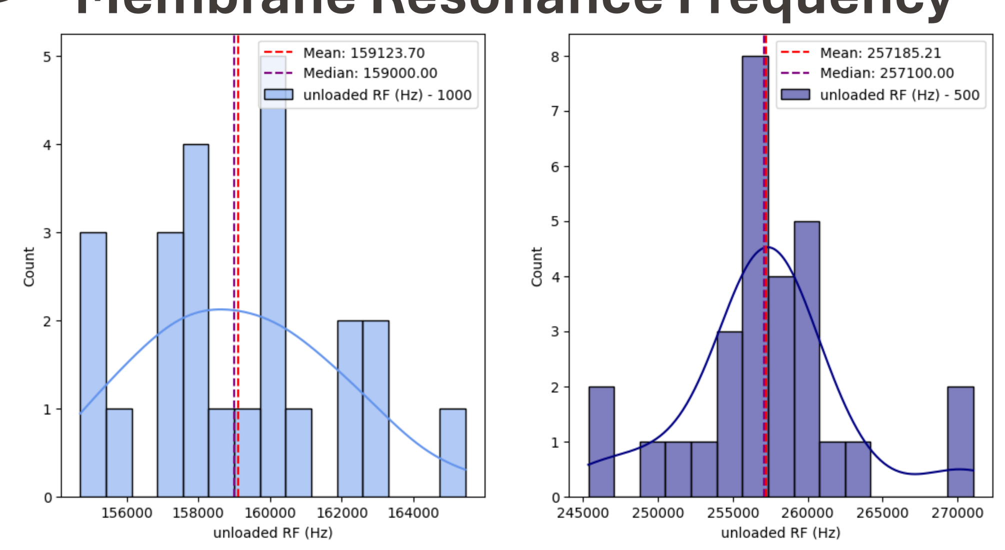


Effect on Efficiency



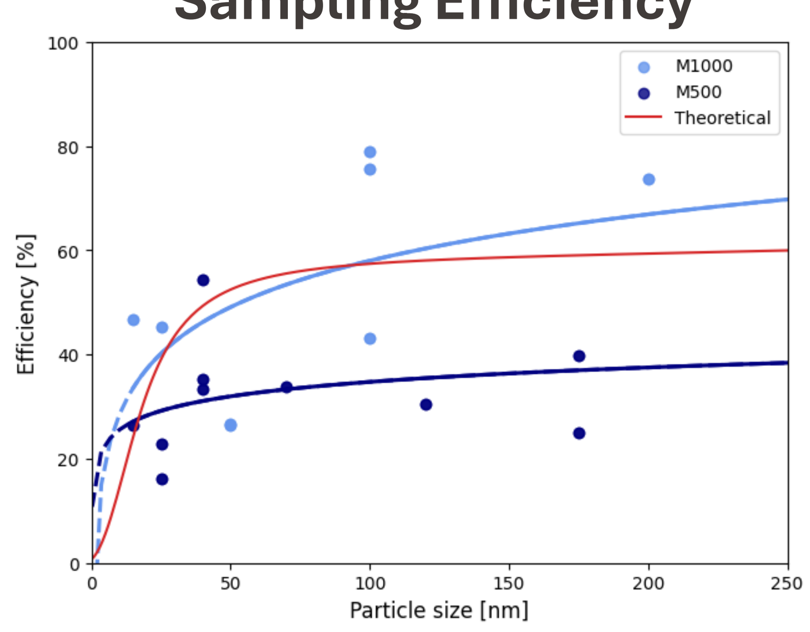
Key Results: same magnitude of linear relationship for M500 and M1000, effect of varying sample time = effect of varying mass concentration, lower range of M1000 tested

② Distribution of Unsampled Membrane Resonance Frequency



Key Results: M500 could follow a normal distribution, too much fluctuation in M1000

③ Effect of Particle Size on Sampling Efficiency



Key Results: Curves follow theoretical trend, small particles harder to sample

CONCLUSION

① General idea of EMILIE's behavior within dynamic range, M1000 lower limit tested

② For accurate measurements, it is still necessary to first measure the initial unloaded frequency

③ Smaller particle size has an impact on efficiency

Limitations

- Need more data points to solidify conclusions
- Lower detection limit of M500 needs to be investigated
- EMILIE membranes are very sensitive, and results highly dependent on mass calculation method

Further Work

Storage experiments and conditions testing
Mechanical tests as well as chemical tests are necessary to determine how physical shocks or exposure/handling would degrade the samples and by how much.

Sciences et ingénierie de l'environnement

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