# Emissions of Gas-Phase Low-Volatility Organic Compounds (LVOCs) from Mobile Sources

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MIT CEE and ChE

EPA STAR Kickoff Meeting

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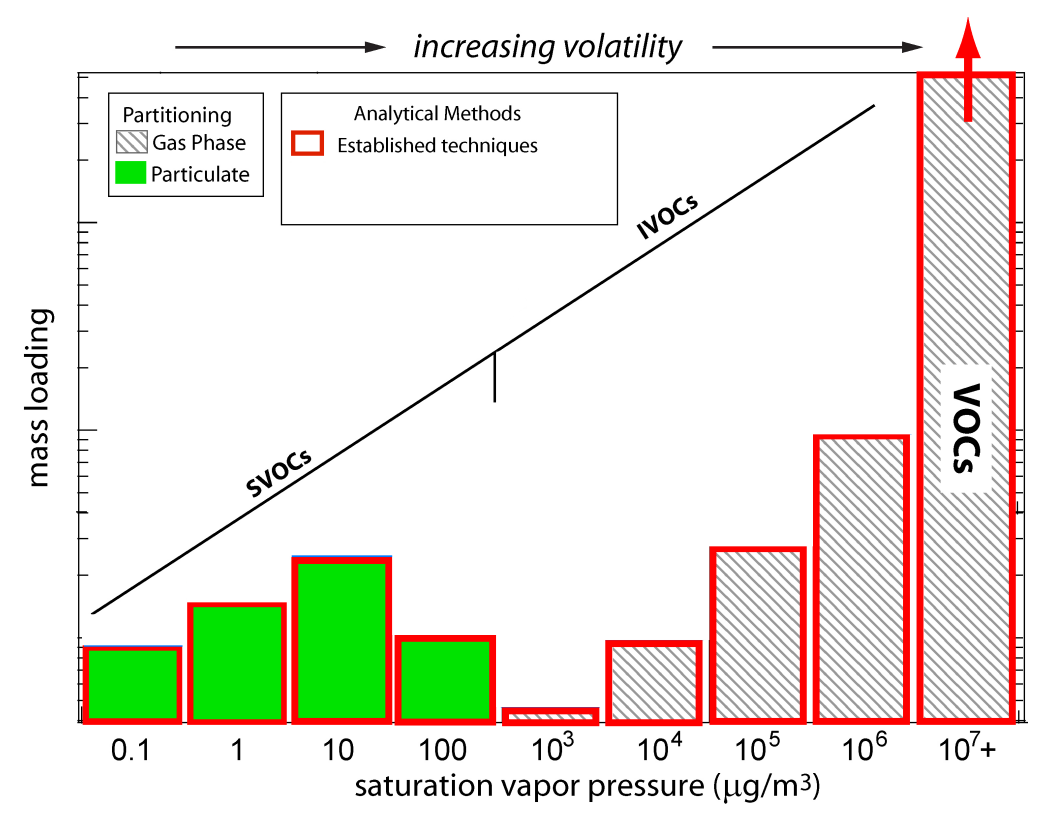
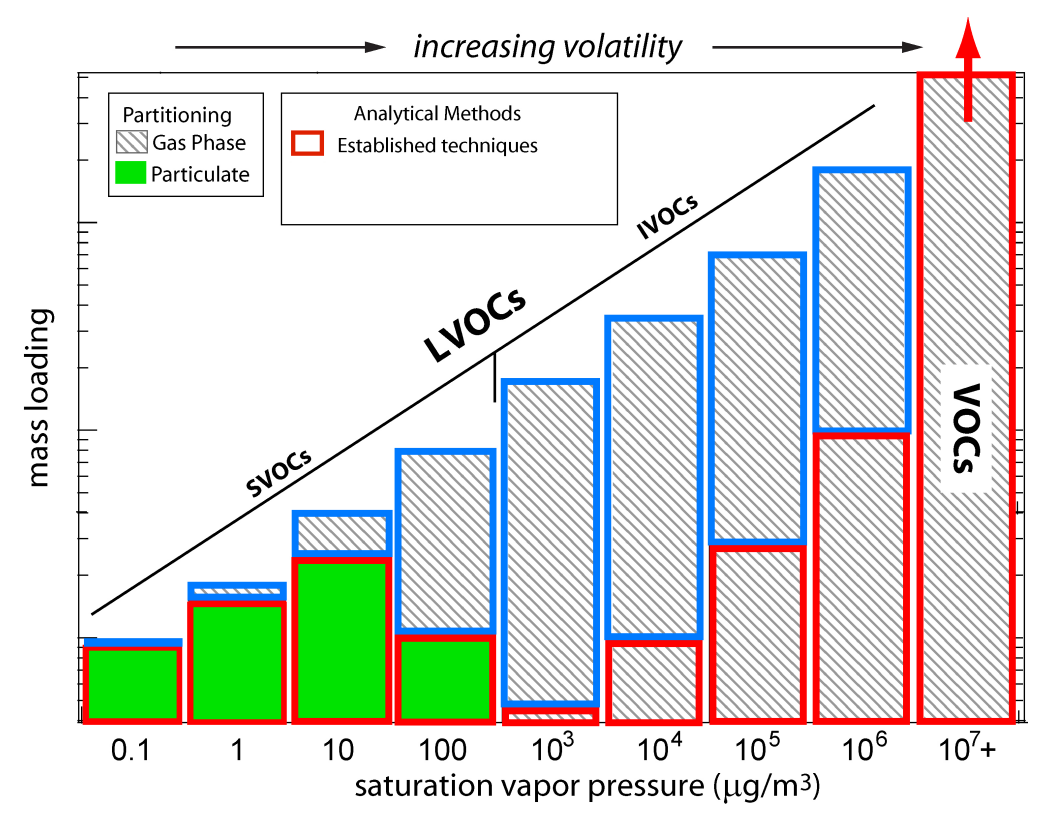
# Emissions of organic species




VOC: volatile organic compounds (gas phase)
IVOC: "intermediate volatility" organic compounds (gas phase)
SVOC: semivolatile organic compounds (gas, particle phase)

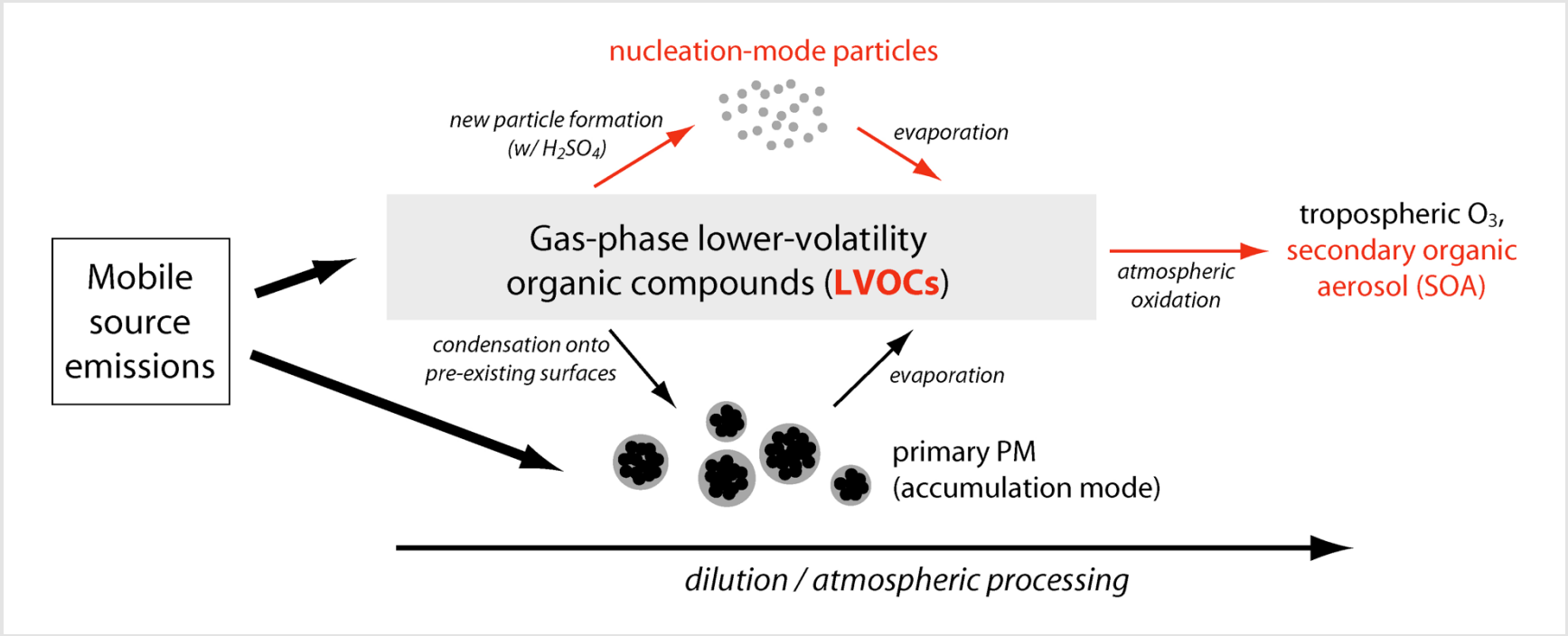
# Emissions of organic species




VOC: volatile organic compounds (gas phase)
IVOC: "intermediate volatility" organic compounds (gas phase)
SVOC: semivolatile organic compounds (gas, particle phase)

**LVOC: lower-volatility organic compounds (IVOC + gas-phase SVOC)**

# Importance of LVOCs



# Measuring LVOCs: Approaches

***1) Speciated*** *(e.g., GC-MS)*

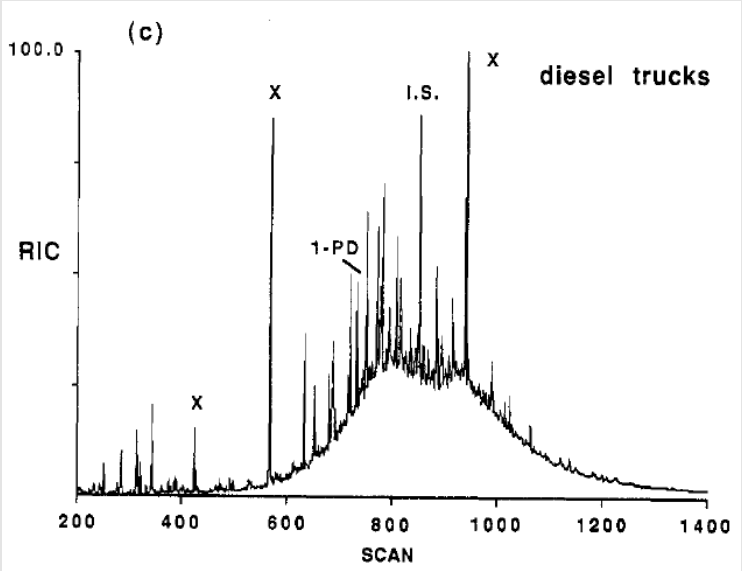
Sensitive and specific
Identifies, quantifies major species

But: *many* minor species
selective?

2) ***Bulk*** *(e.g., FID)*

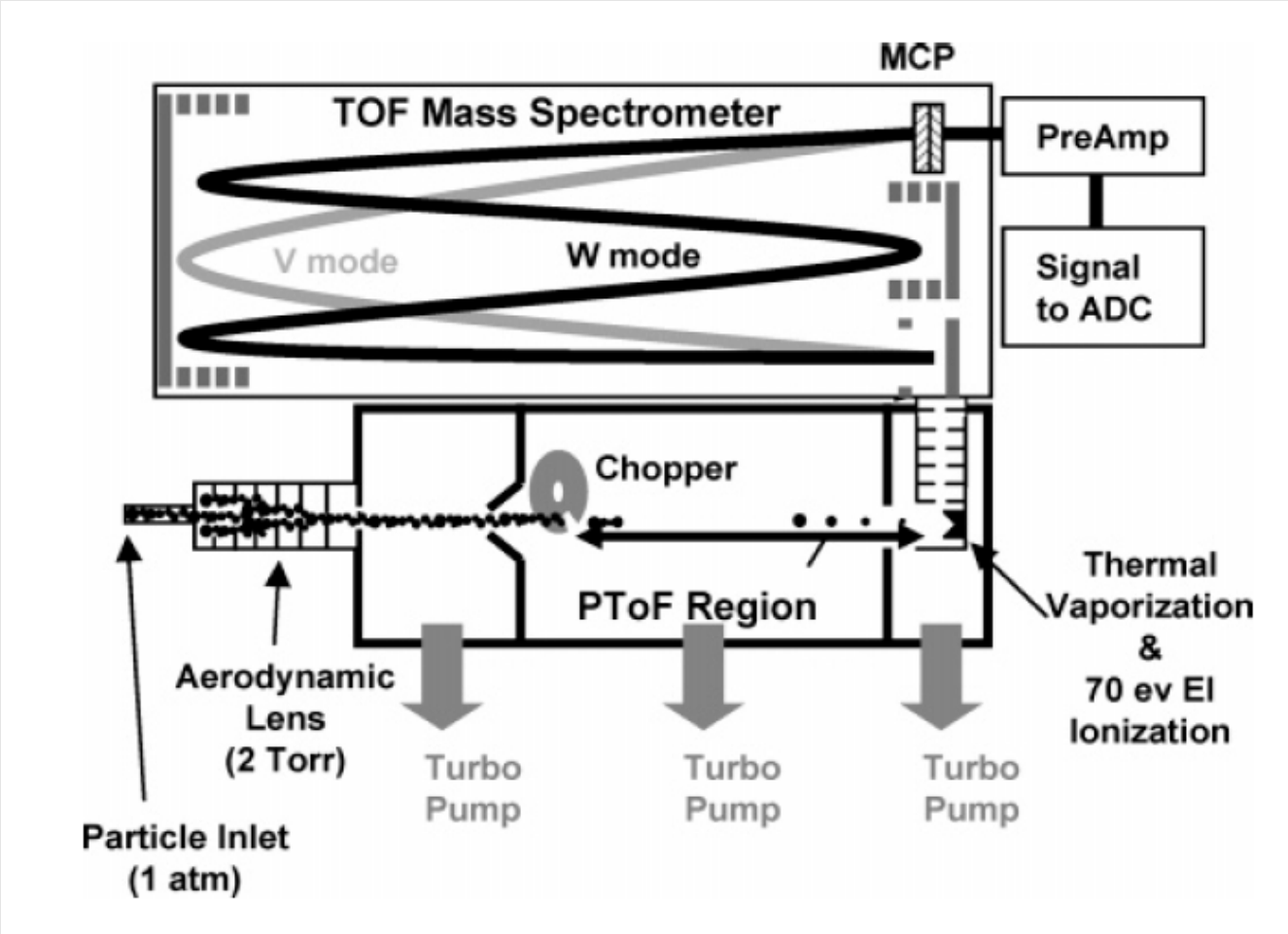
Universal
Detects all carbon

But: no chemical information
no VOC-LVOC differentiation
varying response factors

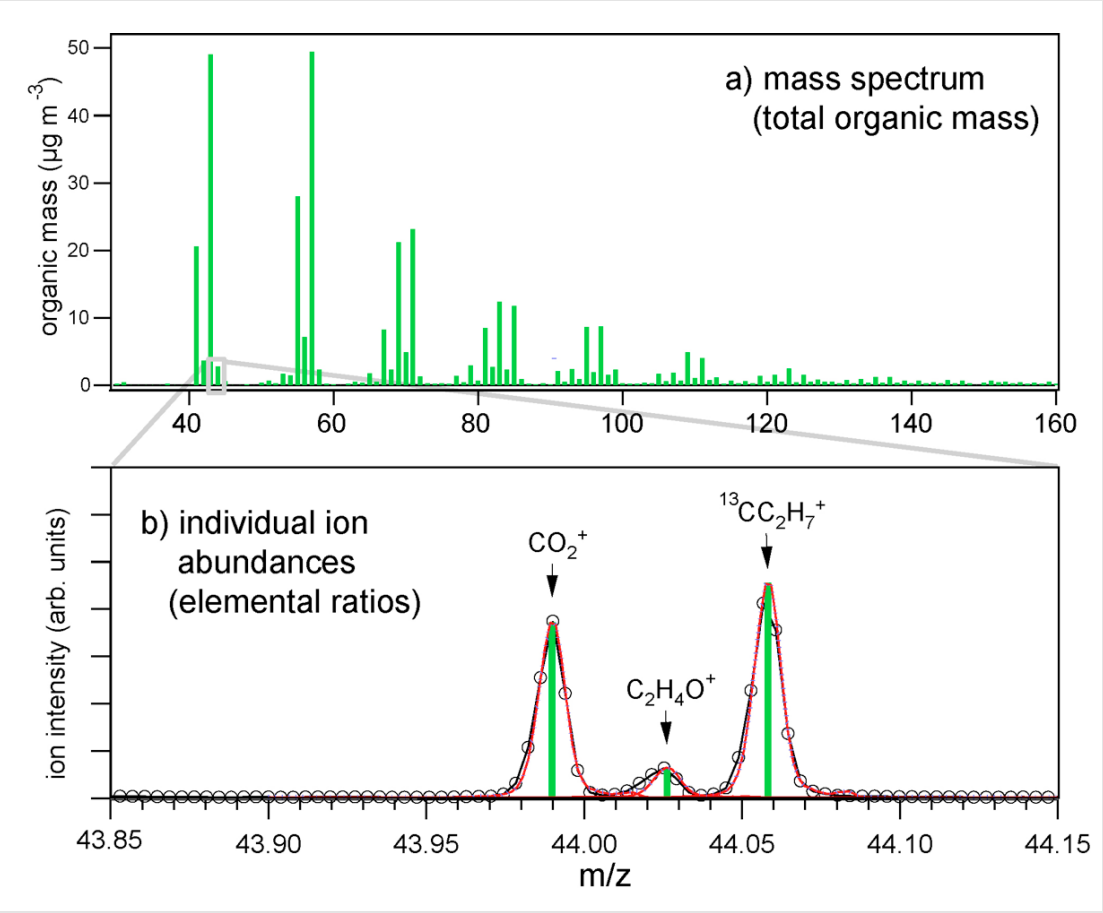



Diesel exhaust PM
(Rogge et al, *ES&T* 1993)

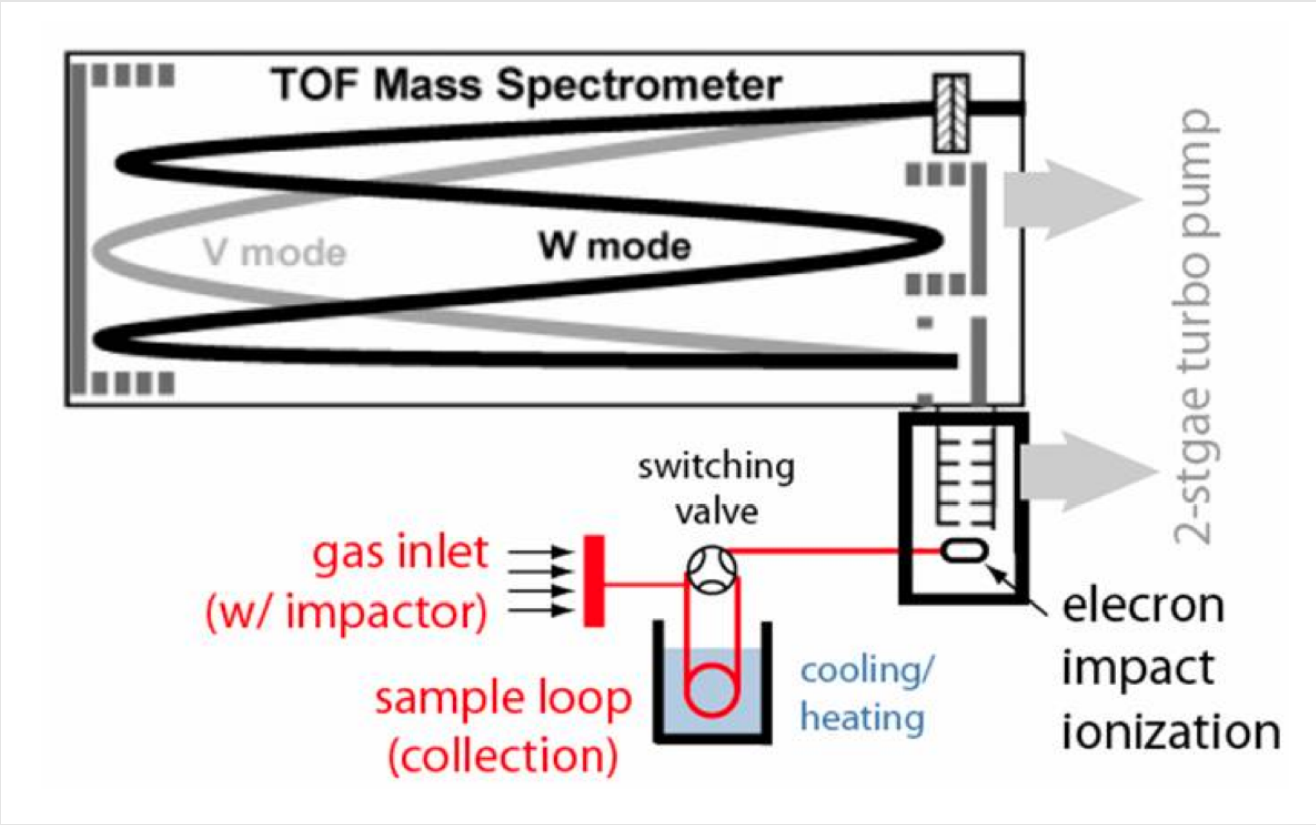
# Aerodyne aerosol mass spectrometer (AMS)



# High-resolution electron impact mass spectrometry

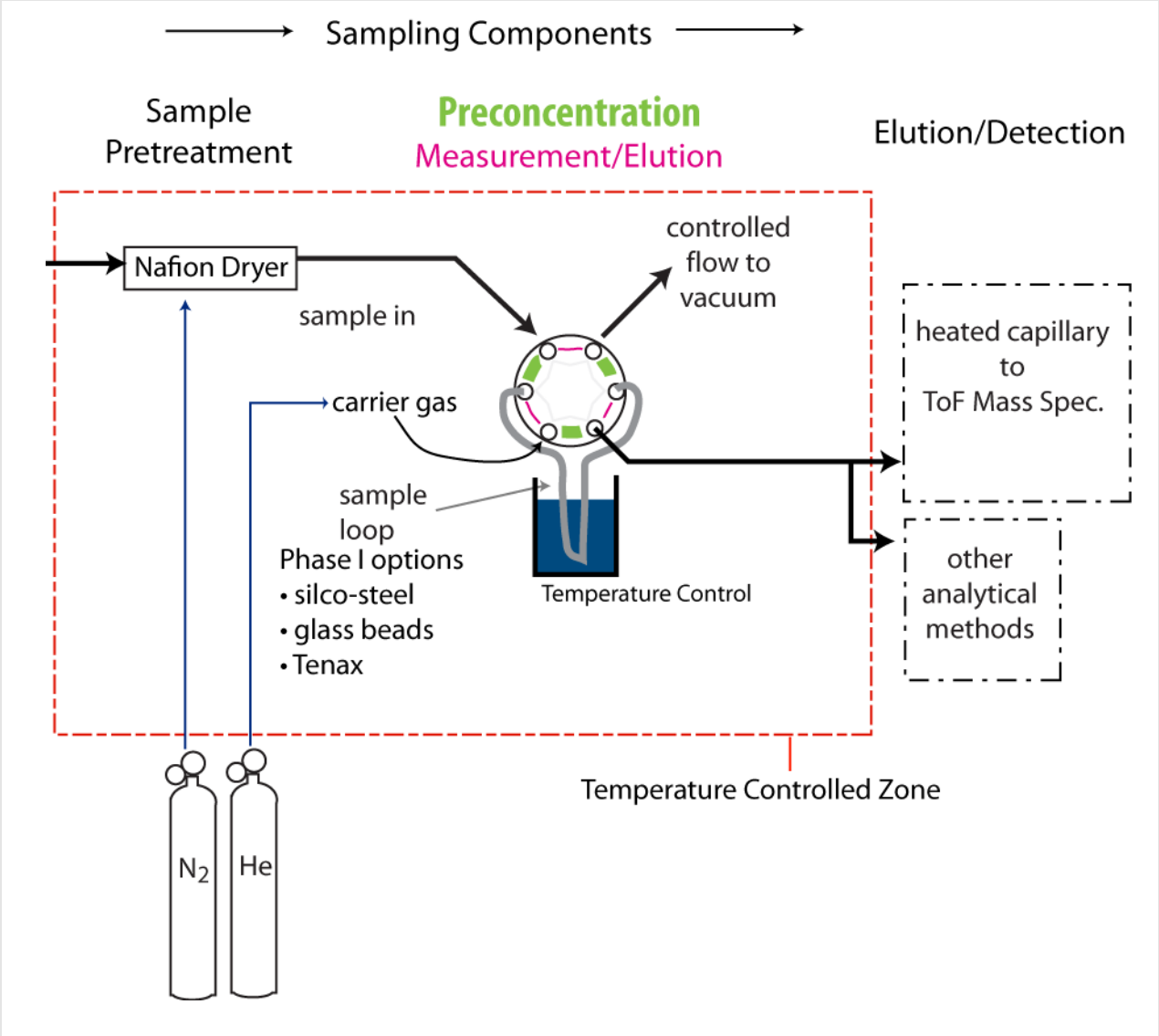


# Total Gas-Phase Organics (TGO) instrument




Developed in collaboration with Aerodyne Research, Inc.

# TGO front end



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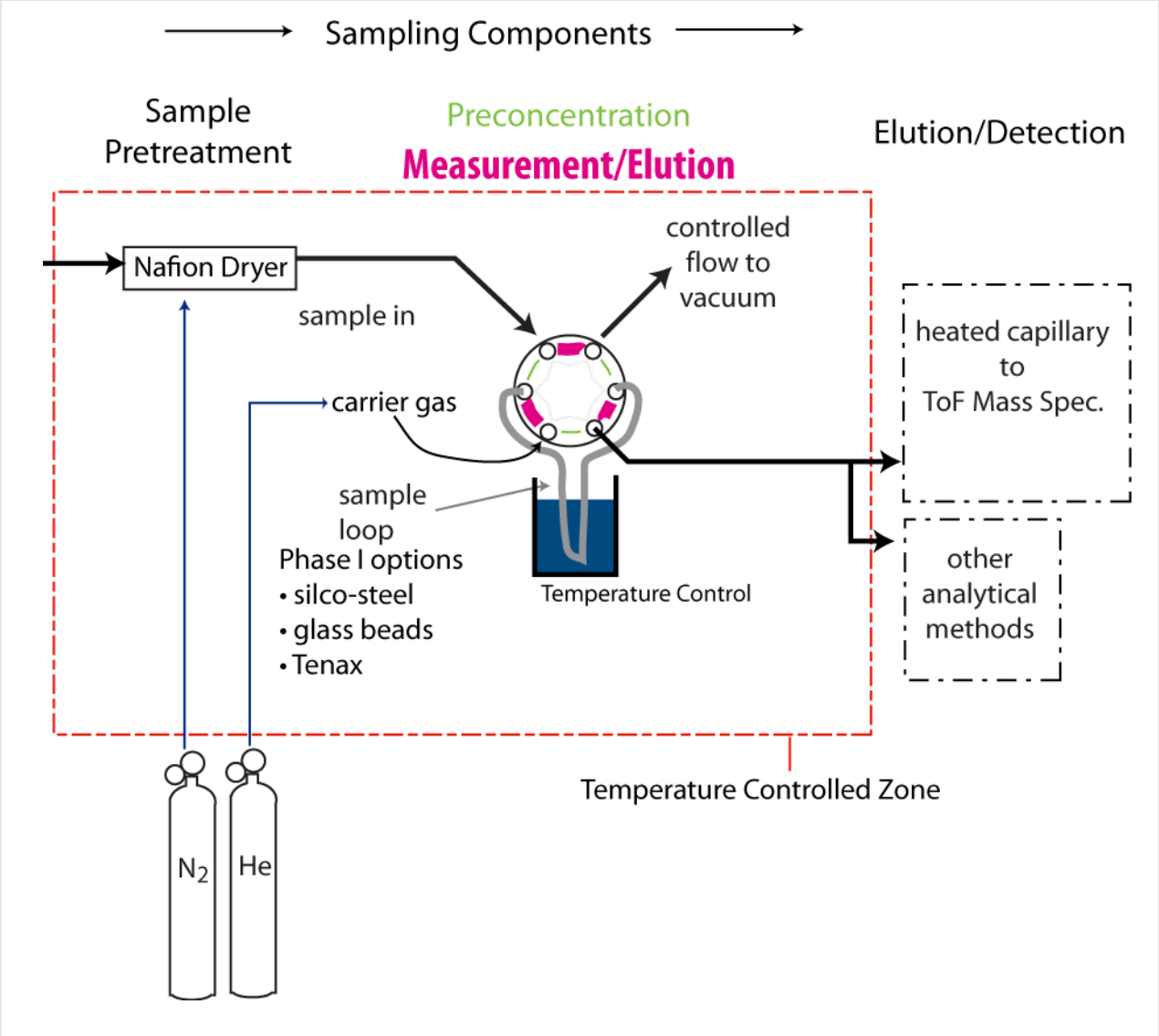
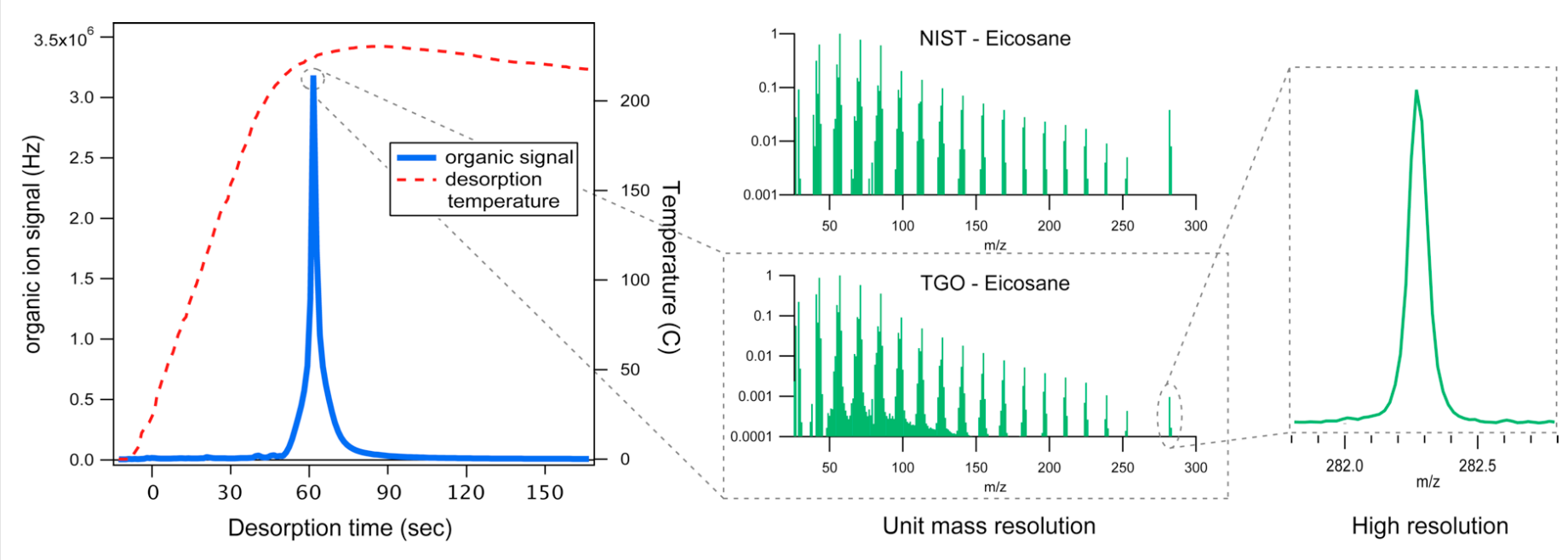
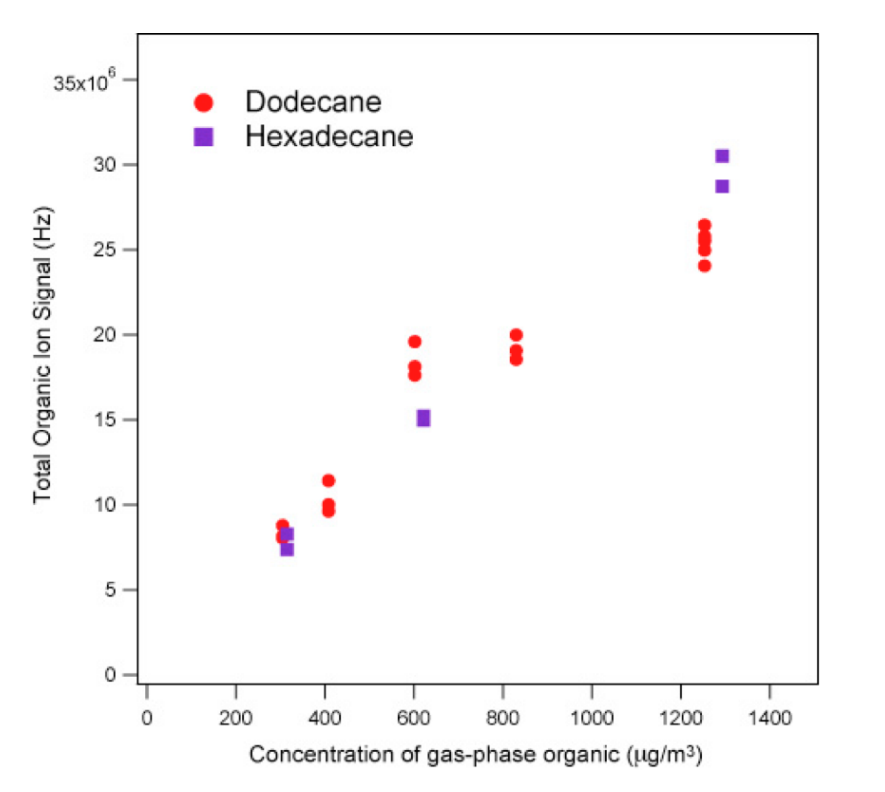


# IVOC: eicosane ($C_{20}H_{42}$)



# Calibration, linearity



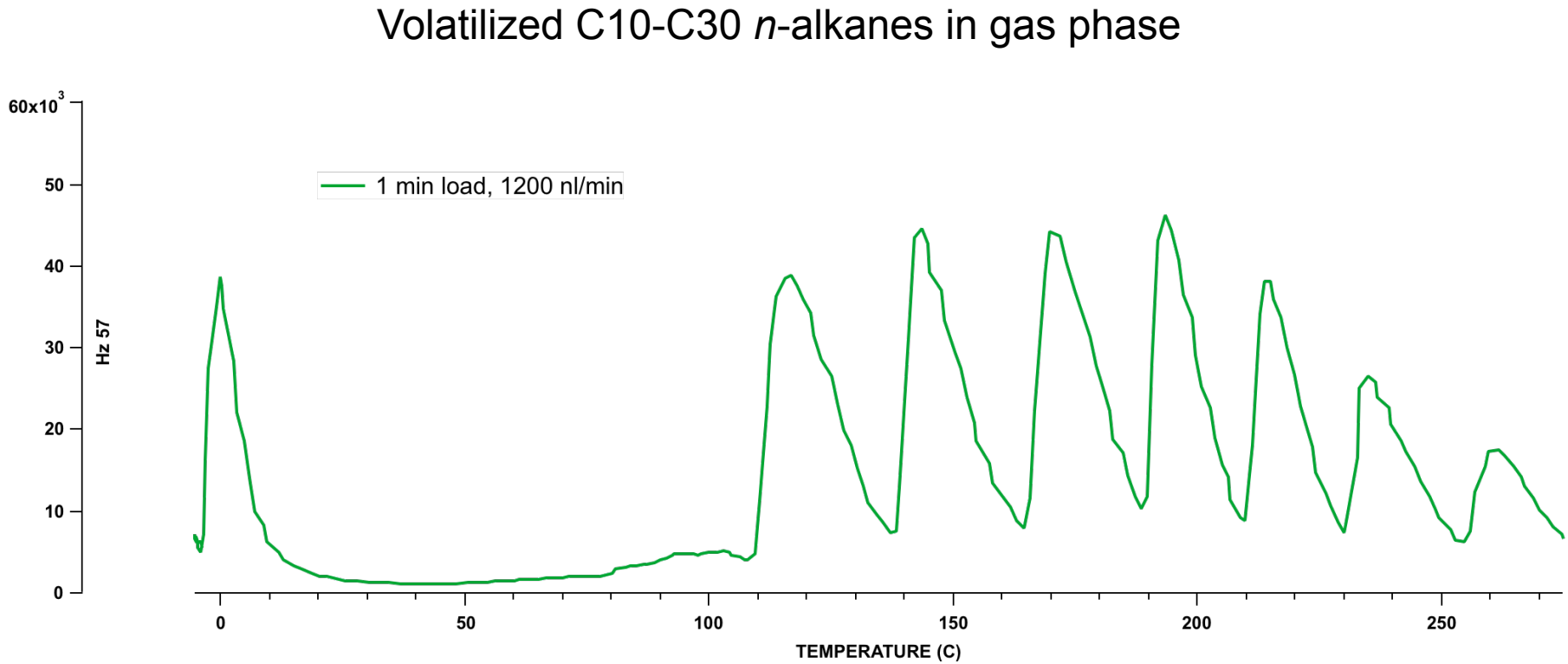
# Objective 1: Volatility-resolved organics

Collected organics will desorb at different temperatures according to their vapor pressures

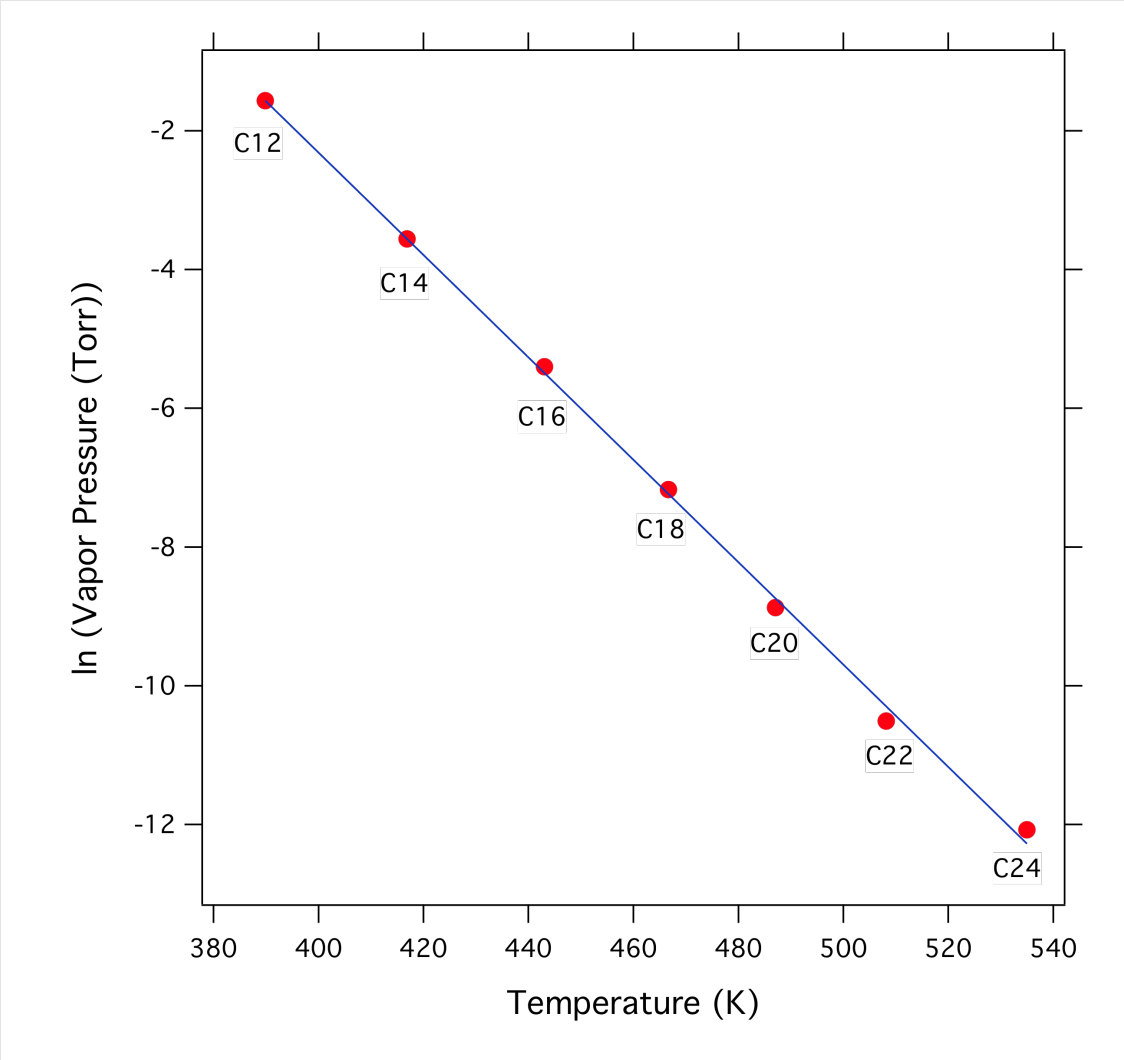
Slow temperature ramp: volatility-resolved measurements

→ Distribution of organics (VOCs vs. IVOCs vs. SVOCs) rather than a bulk average

# Volatility-resolved measurements



# Vapor pressure vs. temperature



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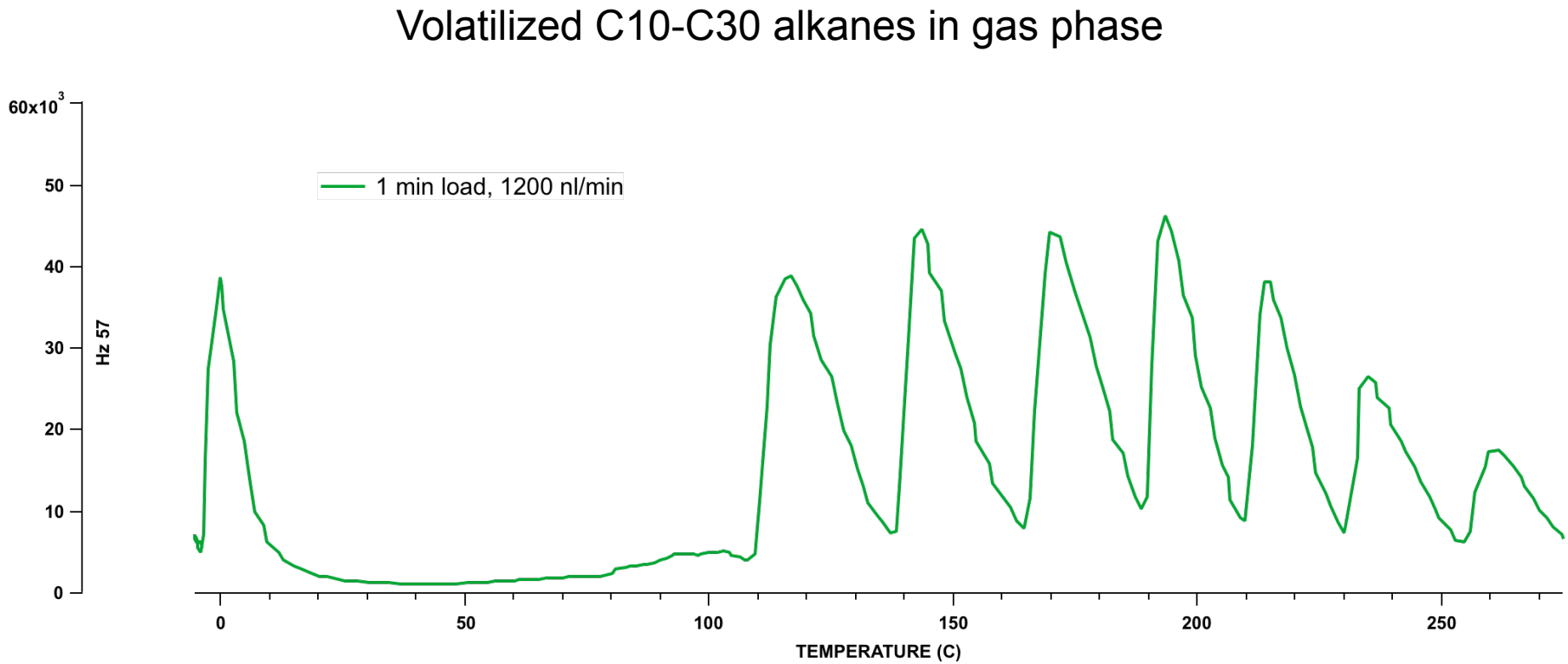

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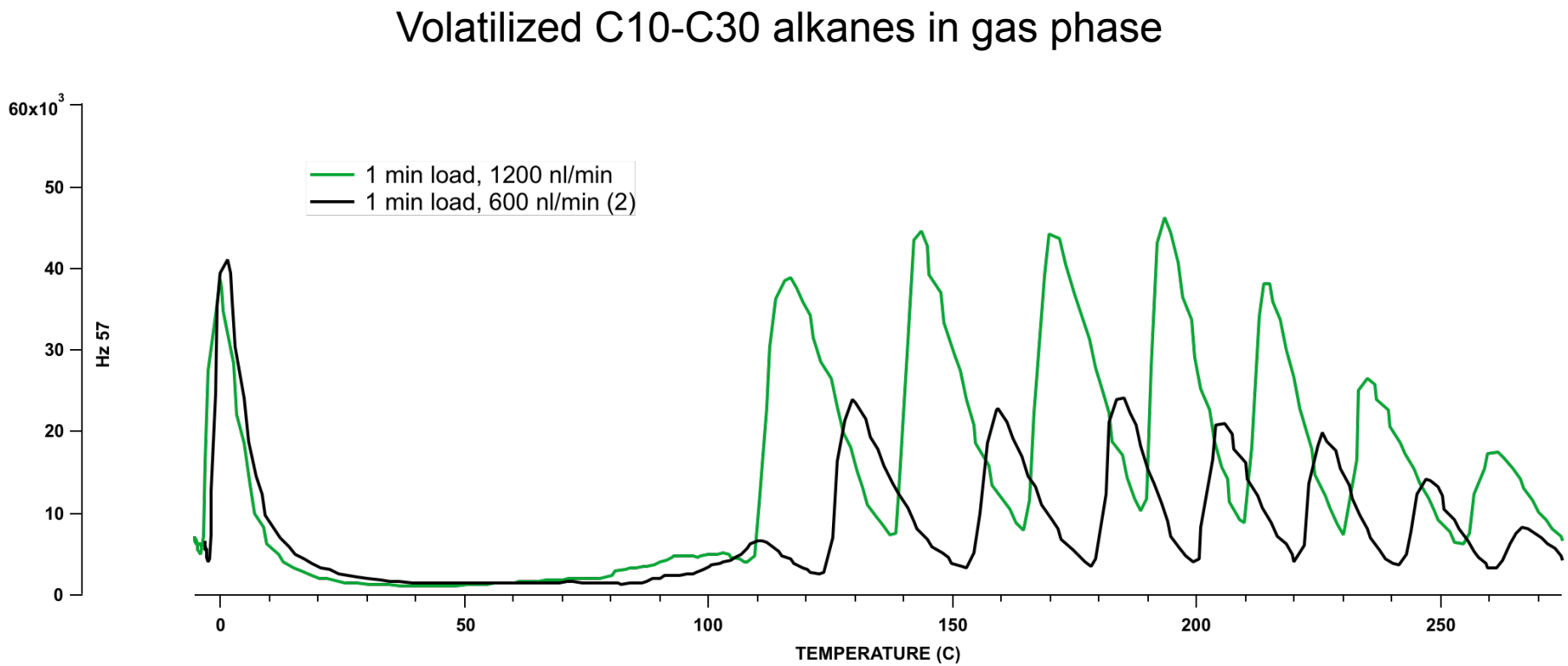

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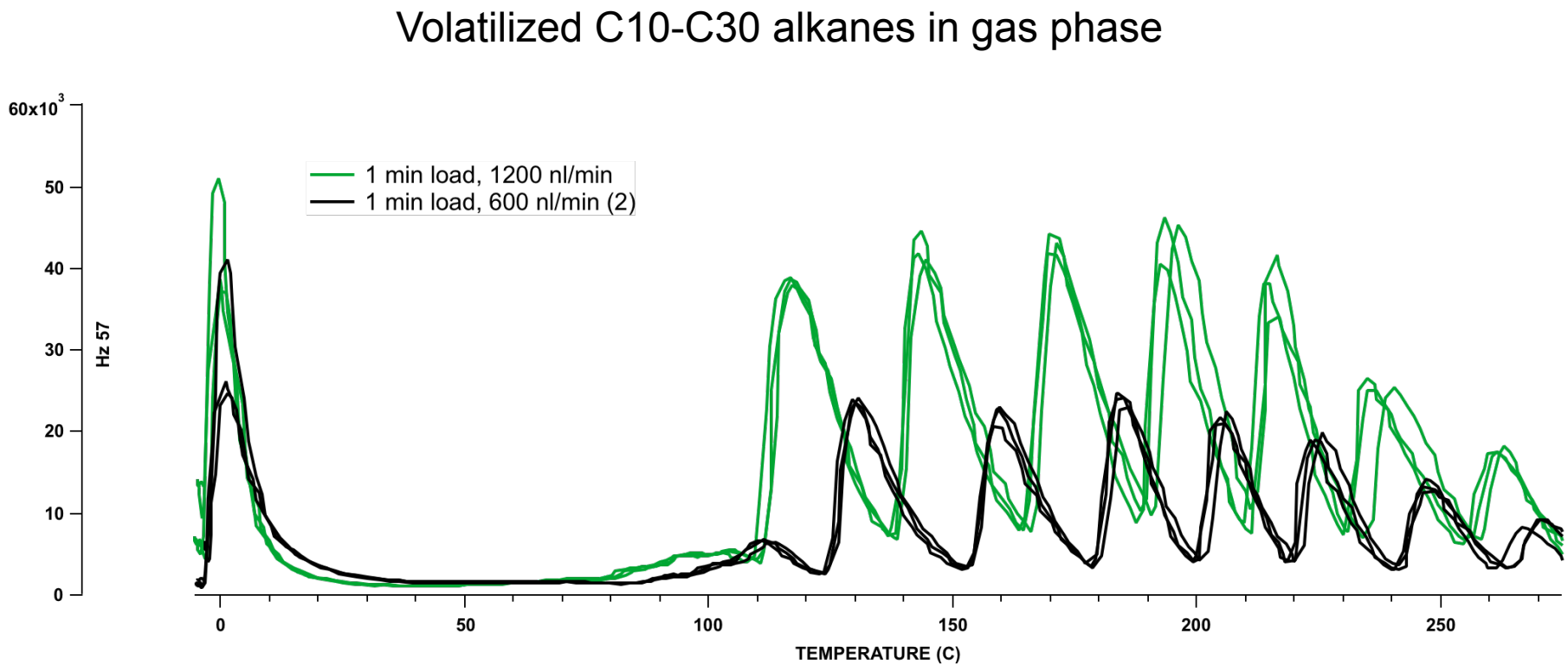
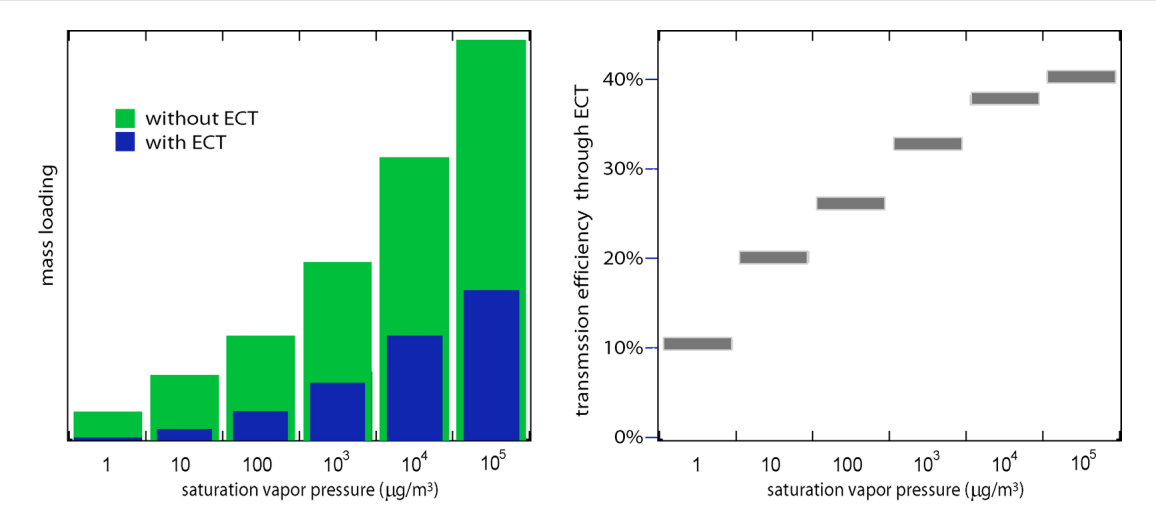


# Objective 2: measurements of LVOCs from engines

LVOCs before and after emissions control technology:




Function of

- after-treatment technology: **DPF**, SCR, etc.
- engine type: **heavy-duty diesel**, spark ignition, HCCI
- engine load/cycle (25%, 50%, 75%, 100%, DPF regeneration)
- fuel (diesel, biodiesel, F-T)

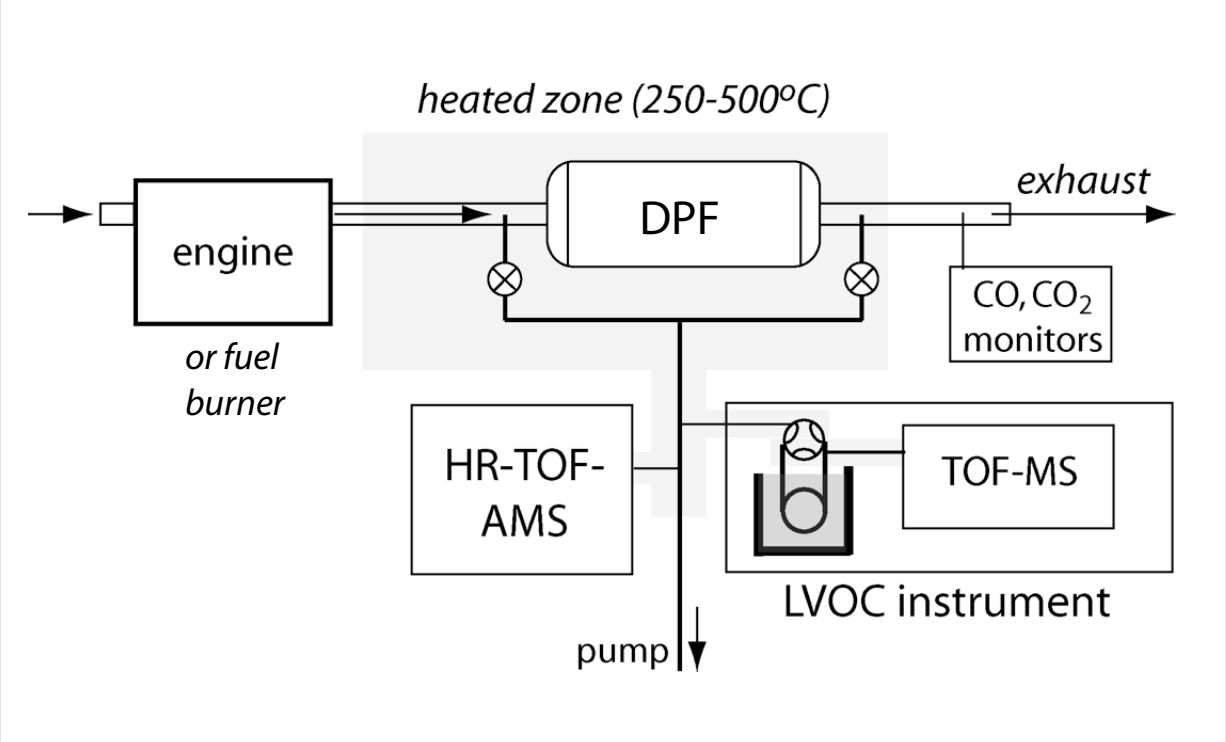
# Engine lab studies


Founded in 1929 (grant from Alfred P. Sloan, Jr., GM CEO)

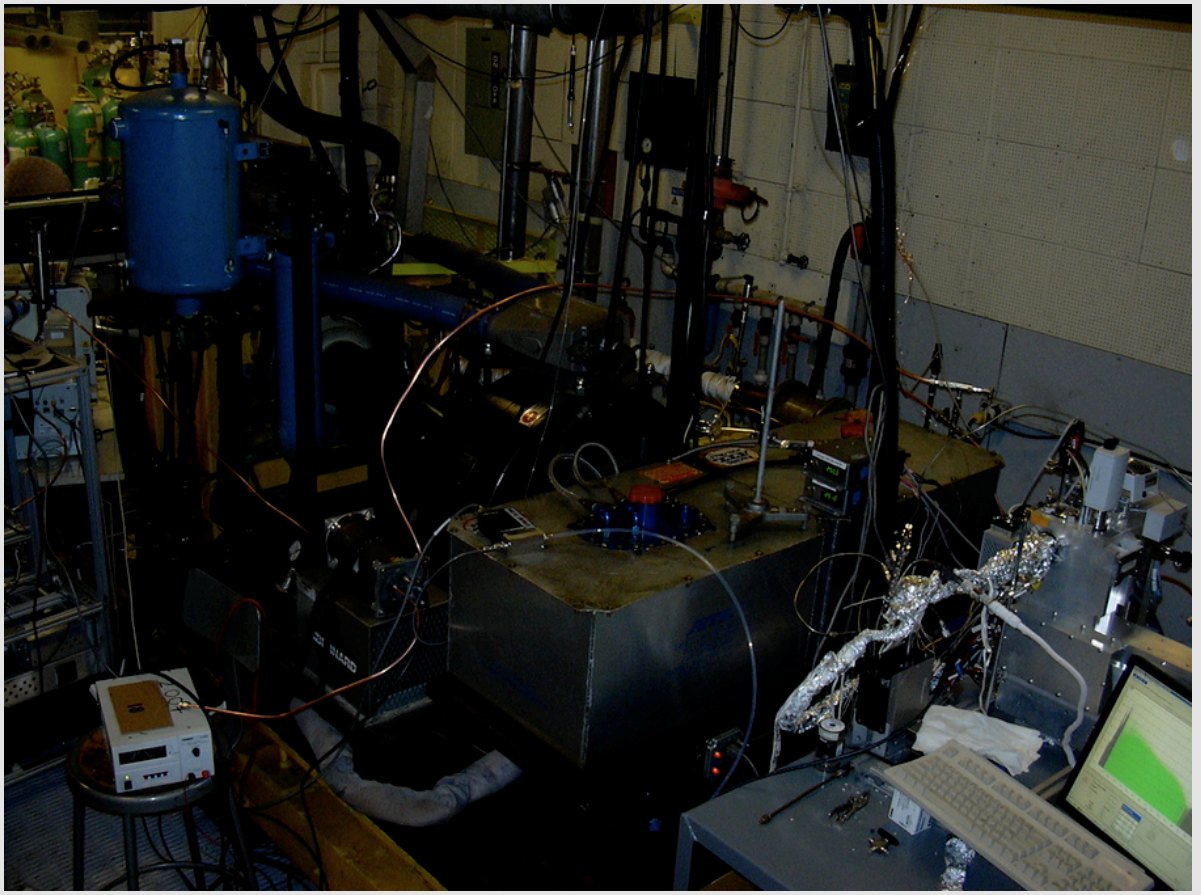
Laboratory objective: “To contribute to future developments in automotive technology through fundamental and applied research on propulsion technology and fuels.”

Collaboration: Victor Wong, Alex Sappok

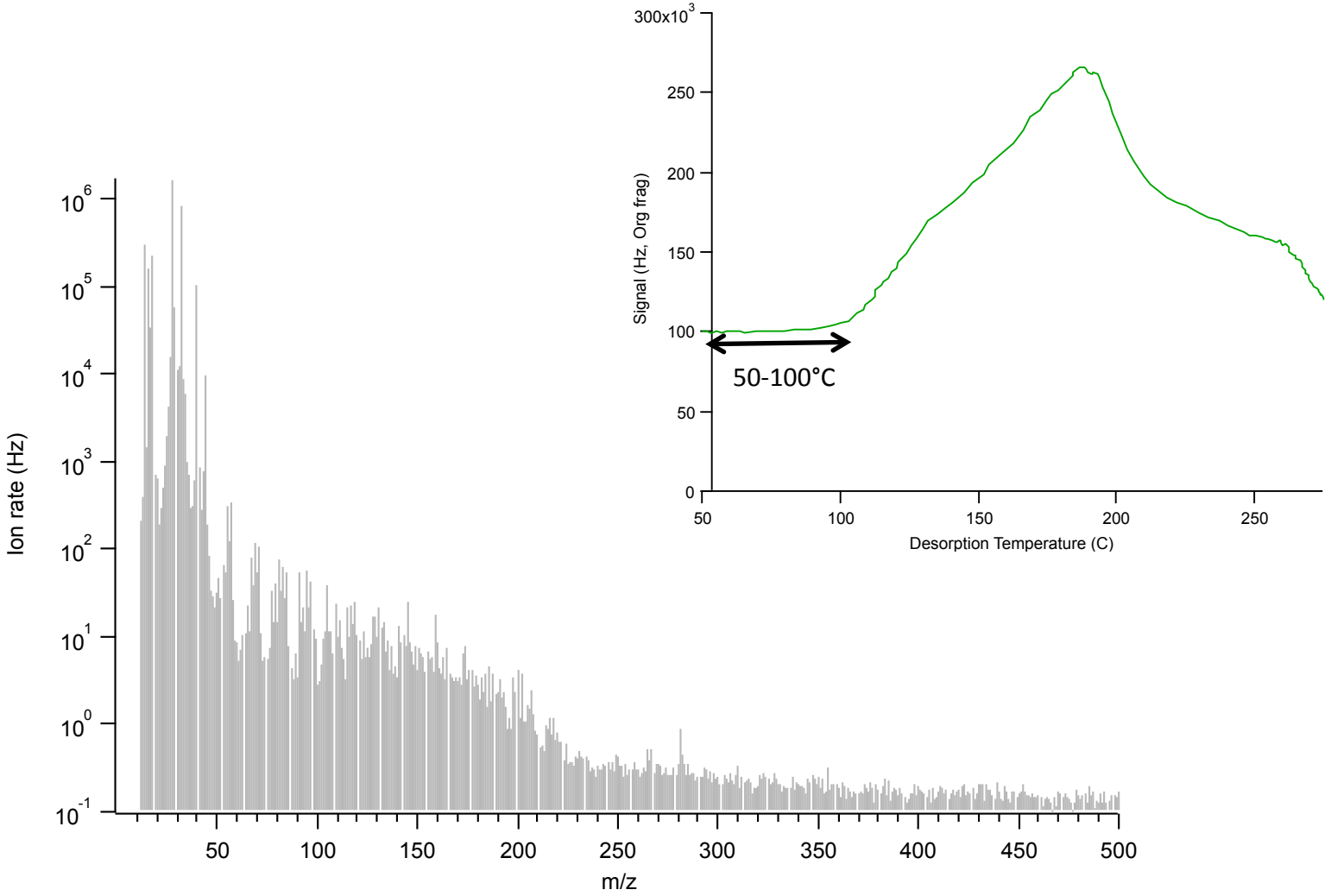
# Experimental setup: Schematic



# Experimental setup: Reality



# Volatility-resolved LVOCs



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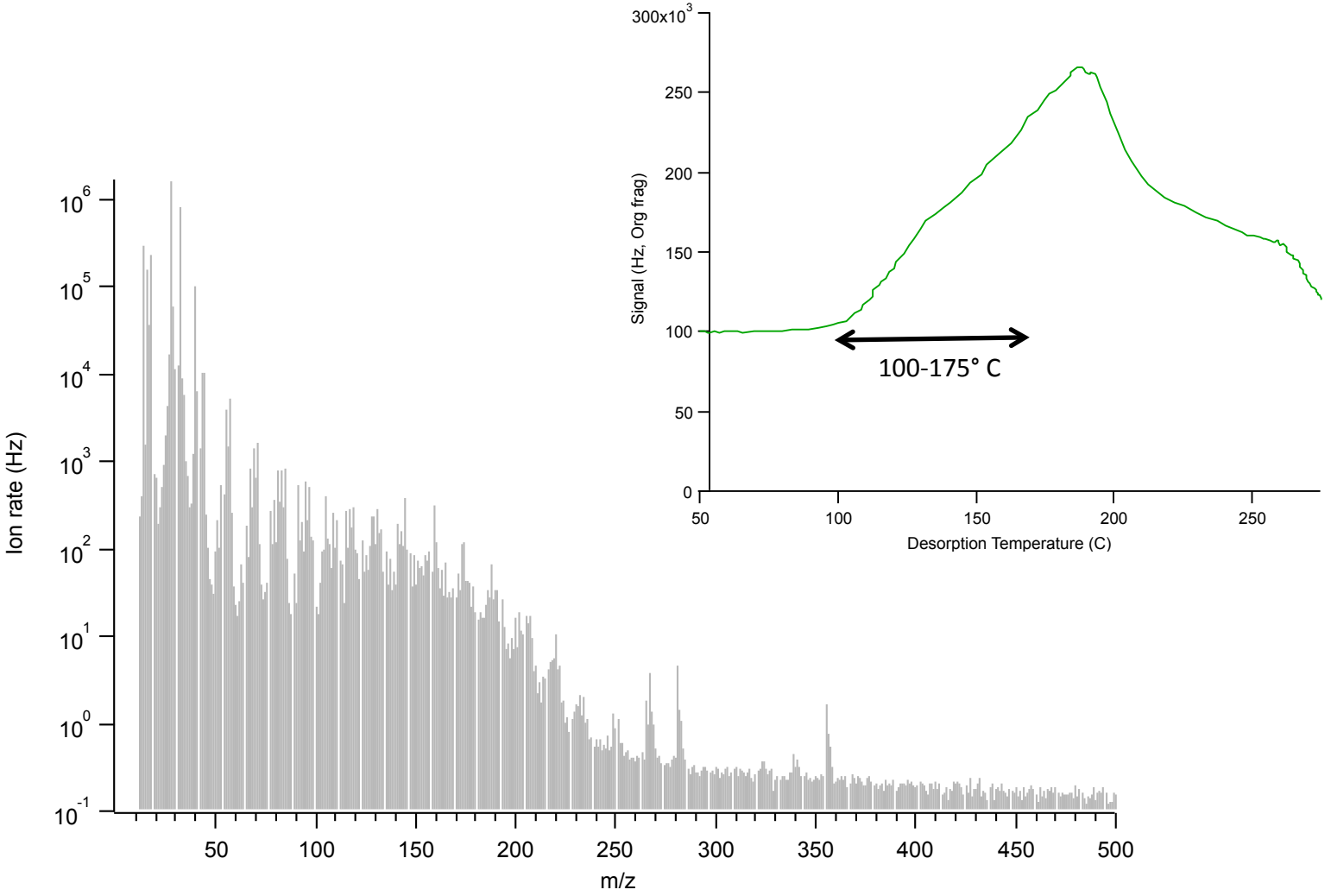

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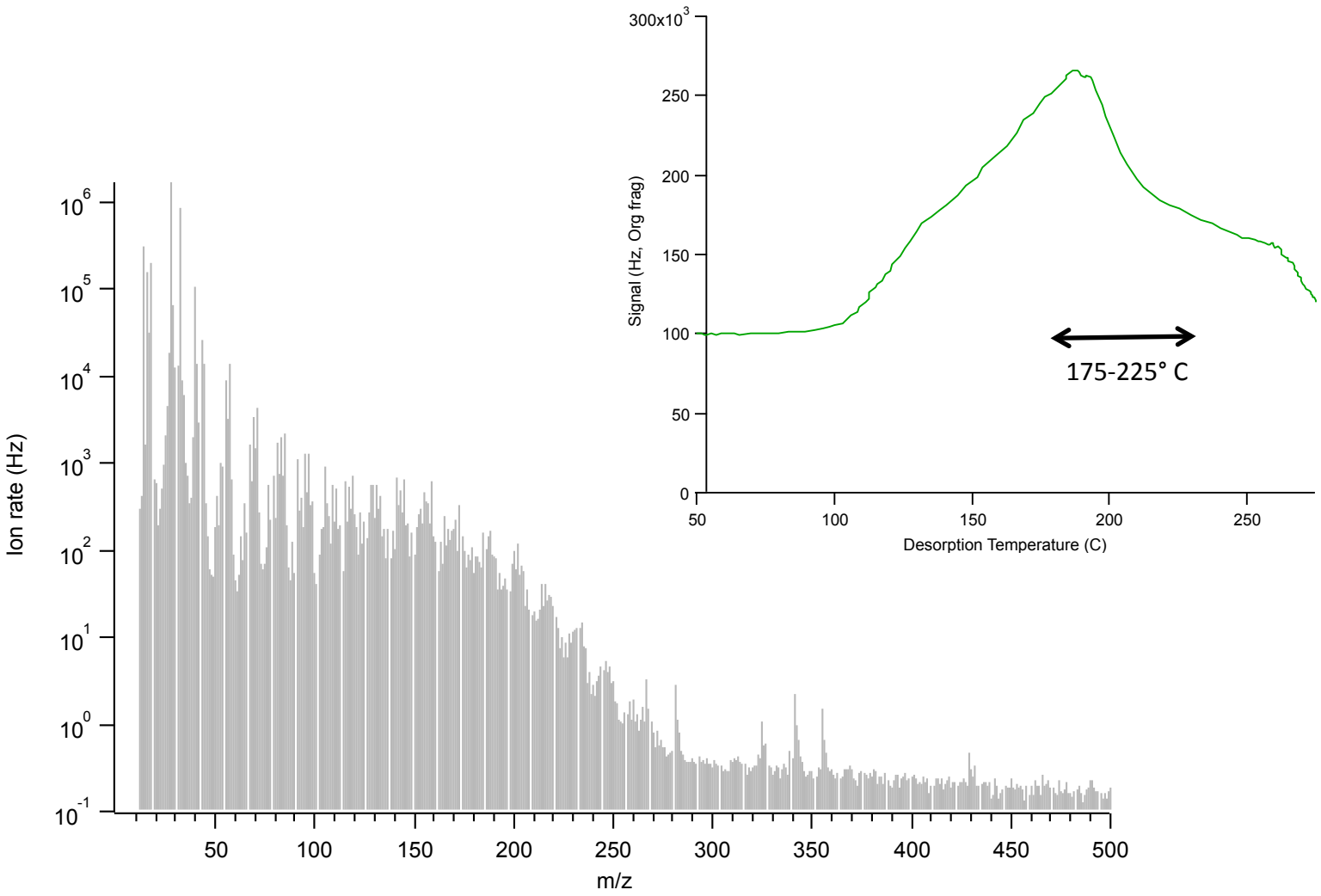

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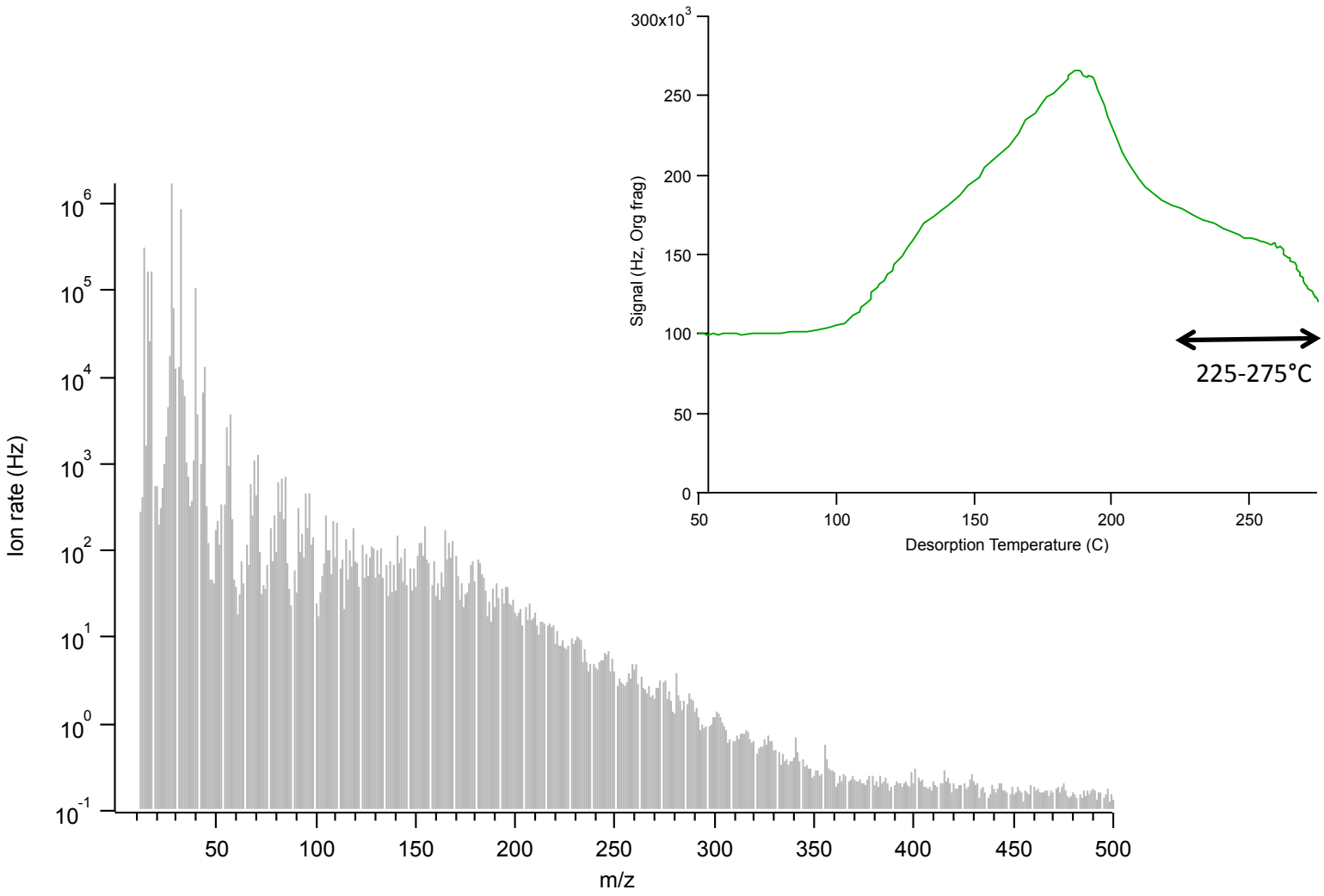
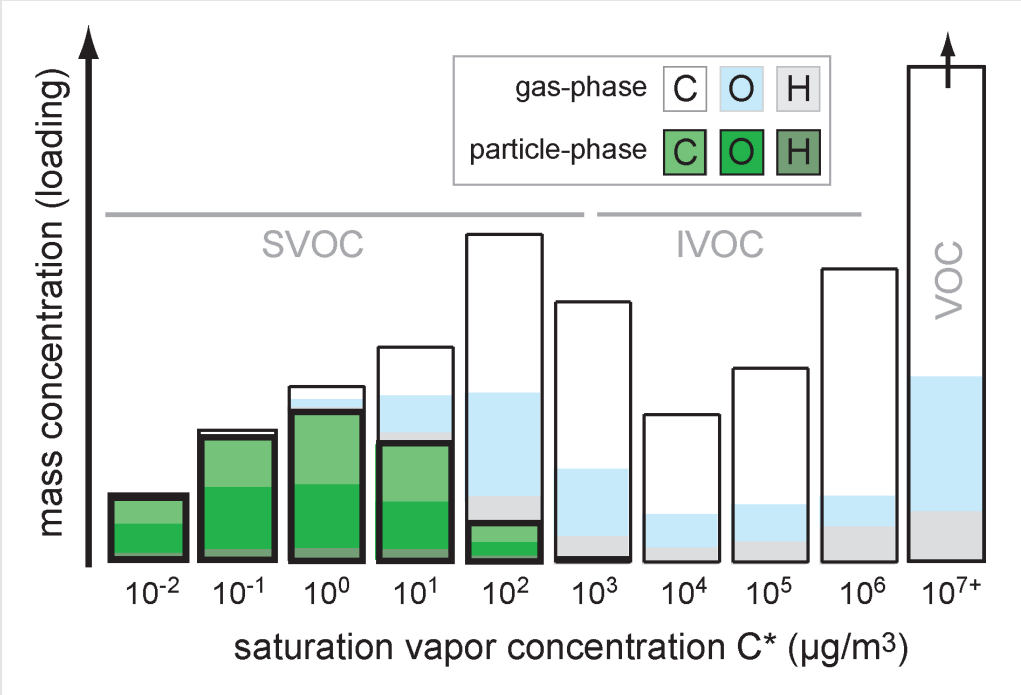


# Objective 3: Ensemble emissions profiles

From laboratory data, can determine key characteristics of emitted LVOCs *as a function of volatility*:

- mass loadings (emission indices)
- elemental ratios (O:C, H:C)
- aromatic vs. aliphatic character
- approximate carbon number?



# Objective 4: Field measurements

*roadside measurements of LVOCs, to measure bulk emissions from in-use vehicles*

- Aerodyne mobile lab: instruments for CO, $CO_2$, VOCs, OA, BC
- LVOC instrument closes major gap in these measurements: *all* emitted carbon

*Real driving conditions vs. laboratory simulations*
*Gas-particle partitioning*