PM2.5 ACSM System

AEROSOL SCIENCE AND TECHNOLOGY
2017, VOL. 51, NO. 1, 69–83
http://dx.doi.org/10.1080/02786826.2016.1241859

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Laboratory characterization of an aerosol chemical speciation monitor with $PM_{2.5}$ measurement capability

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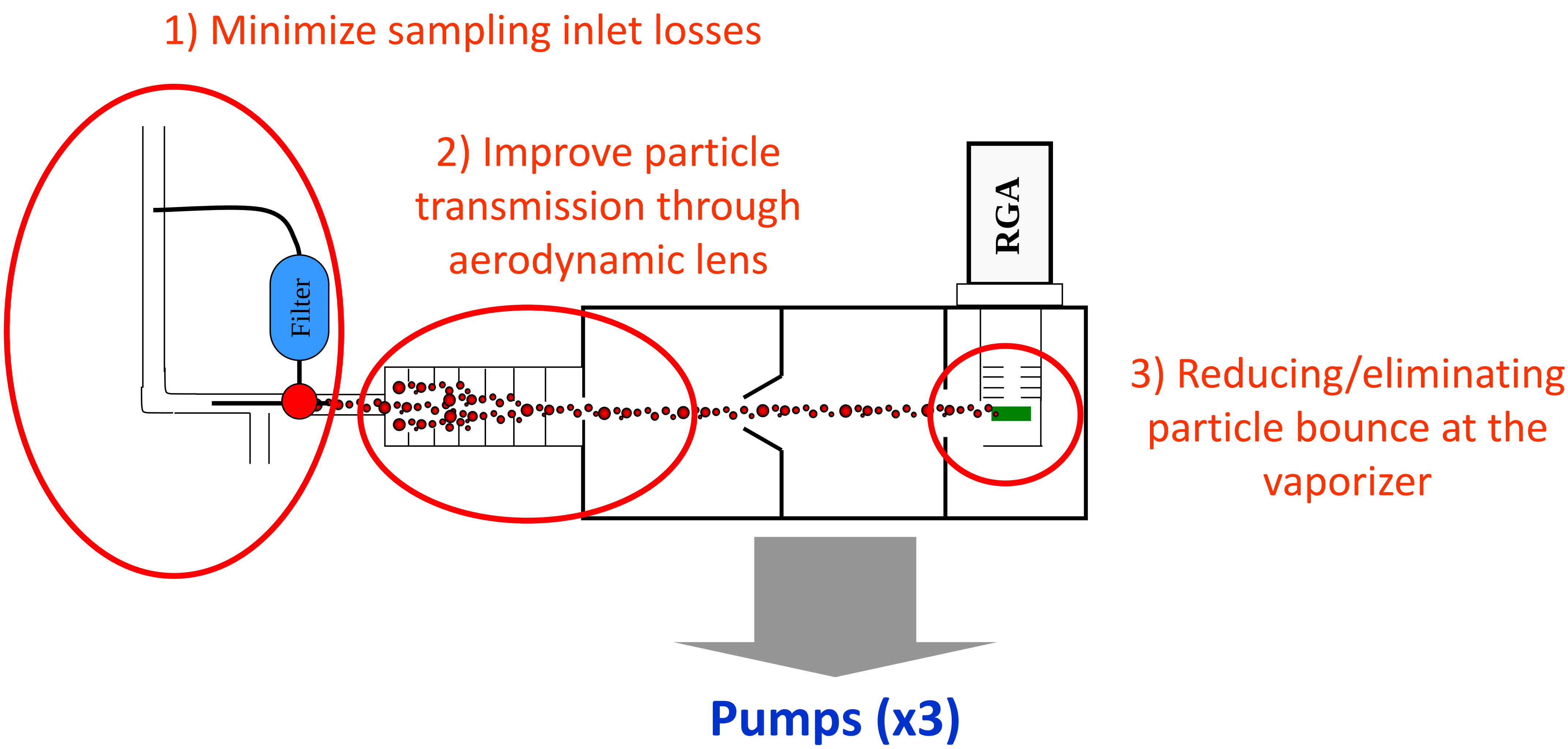
Motivation and Study Overview

- Develop an ACSM capable of measuring $PM_{2.5}$

- It's not just the lens!

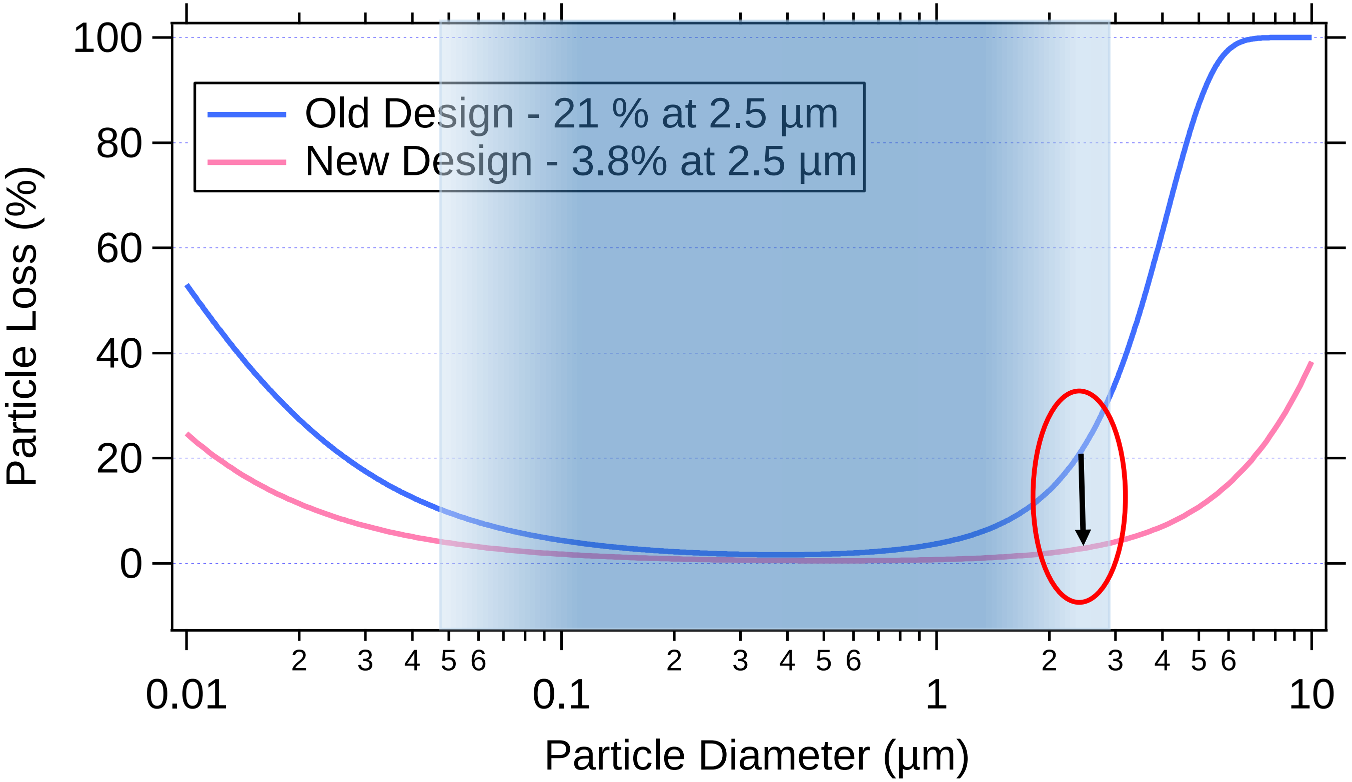
- Three fundamental challenges (Our solutions)
  - Sampling inlet for $PM_{2.5}$ - New style minimizes losses of large particles
  - Delivery of $PM_{2.5}$ through the lens to the detector - New aerodynamic lens
  - Detection of the mass from particles - "Capture" vaporizer
- Experimental Methods
- Results of laboratory measurements characterizing the performance of the $PM_{2.5}$ ACSM
  - Particle loss calculation in ACSM sampling inlet
  - Lens transmission results
  - Capture vaporizer detection efficiency
  - Comparison of $PM_{2.5}$ ACSM with $PM_{1.0}$ ACSM and Marga measurements

PM2.5 Capable ACSM Instrument – Required Development



Calculated Particle loss for “old” and “new” ACSM sampling inlet designs

New inlet design shows <5% loss over the expected size range. Eliminated two 90 deg and one 150 deg bends.



“Particle Loss Calculator”

von der Weiden, S. L., et al. (2009). Atmos. Meas. Tech. **2**(2): 479-494.

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- **Experimental Methods For Lens Development/Characterization**
- Results of laboratory and ambient measurements characterizing the performance of the $PM_{2.5}$ ACSM
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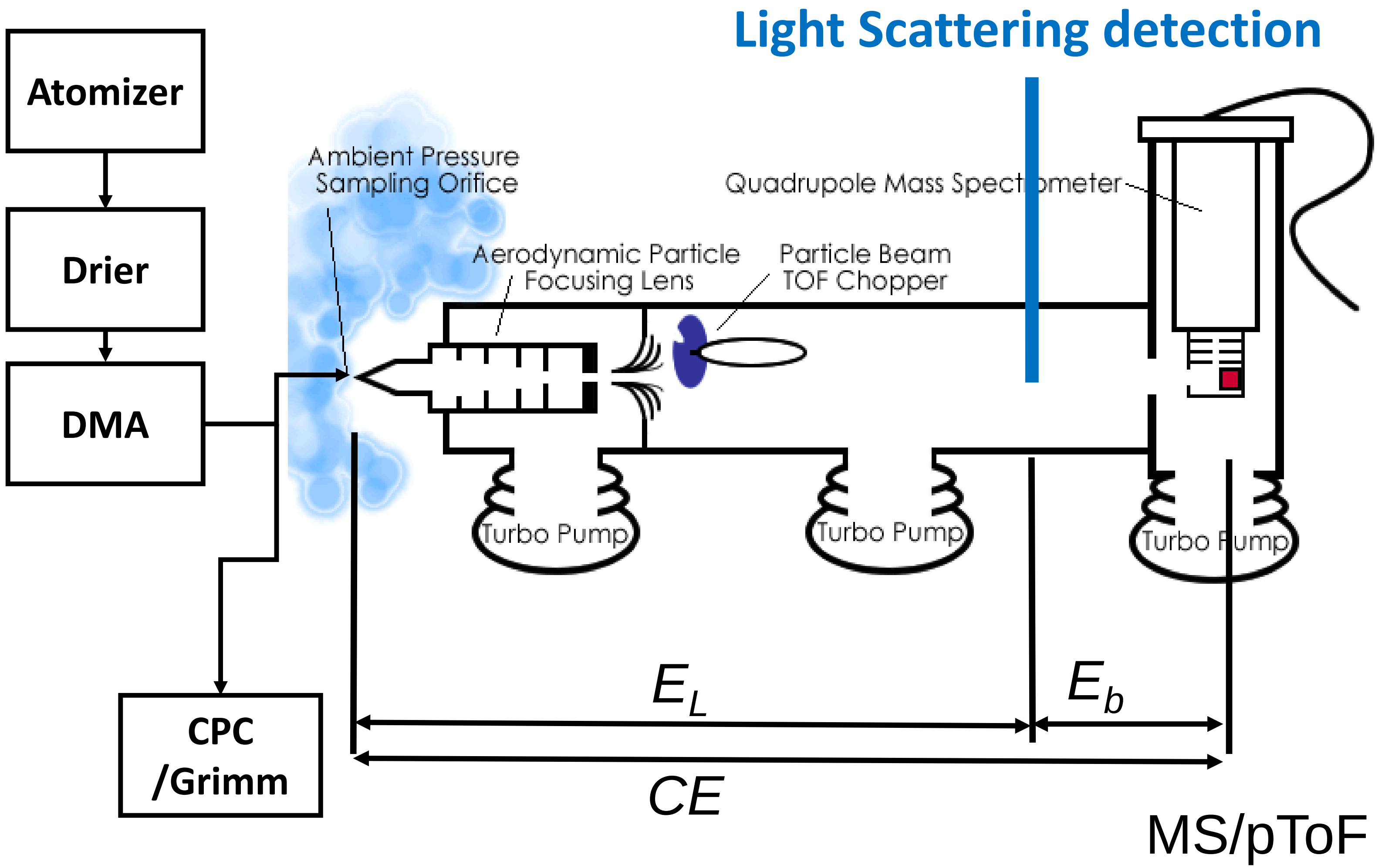
Lab measurements characterizing new lens and vaporizer requires the use of an AMS



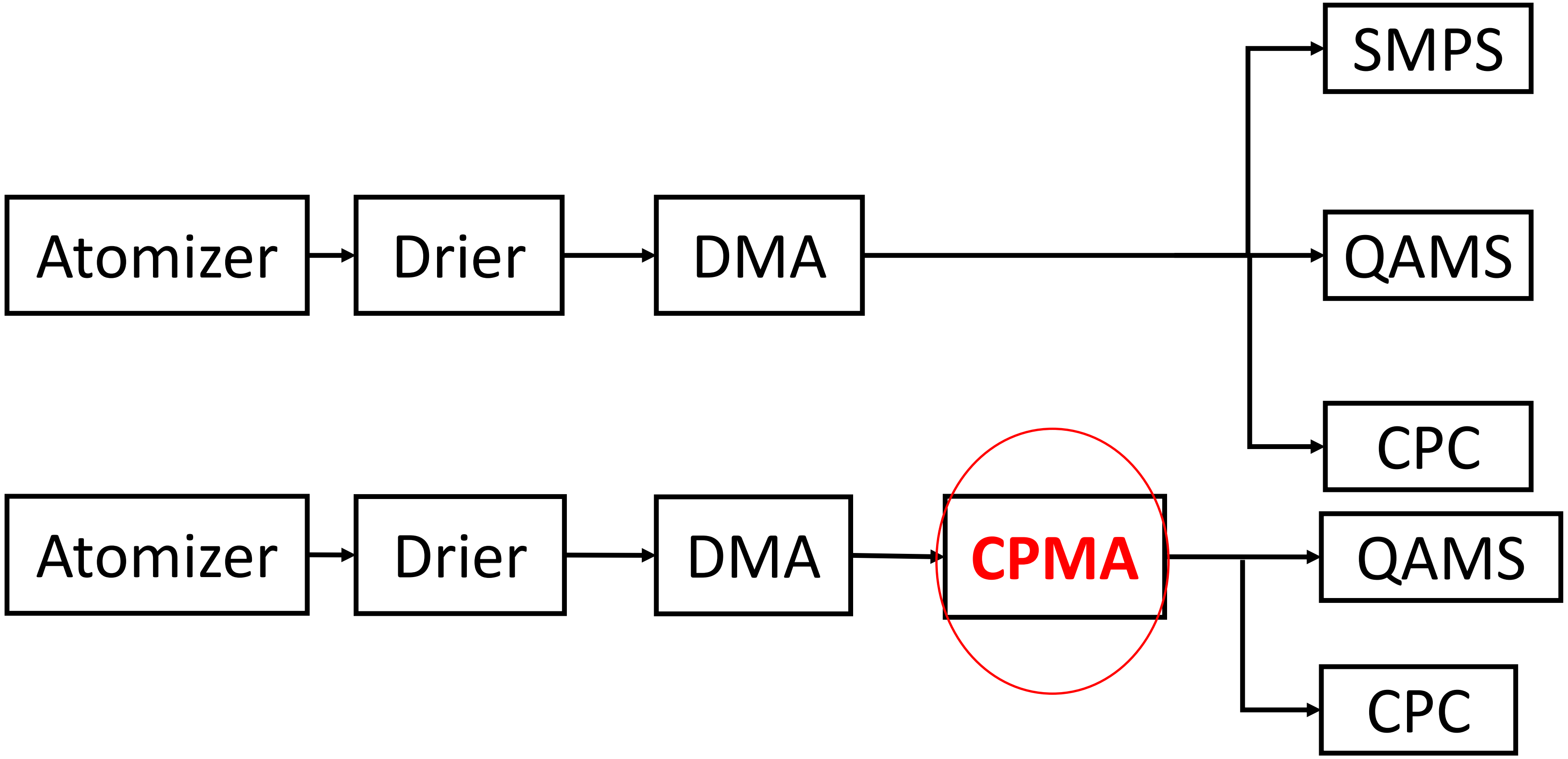
$$d_{va} = d_{mob} \times \rho_p \times JS$$
$$\rho_{AN} = 1.72\ g/cc$$
$$\rho_{SN} = 2.26\ g/cc$$

$$d_{mob} > 300\ nm$$
$$E_L(d_{va}) = \frac{Count_{LS}(d_{va})}{Count_{CPC}(d_{va})}$$

$$d_{mob} \leq 300\ nm$$
$$E_L(d_{va}) = \frac{Mass(QAMS)(d_{va})}{Mass(CPC)(d_{va})}$$

http://cires.colorado.edu/~jjose/ams.html

Lens transmission efficiency measurement



CPMA = Centrifugal Particle Mass Analyzer

NO multiply charged particles

$$E_L(d_{va}) = \frac{Mass(pToF46)(d_{va})}{Mass(CPC)(d_{va})} \Big/ \frac{Mass(pToF46)(300nm)}{Mass(CPC)(300nm)}$$

$d_{mob} \leq 300\ nm$

$$E_L(d_{va}) = \frac{Mass(MS)(d_{va})}{Mass(CPC)(d_{va})} \Big/ \frac{Mass(MS)(300nm)}{Mass(CPC)(300nm)}$$

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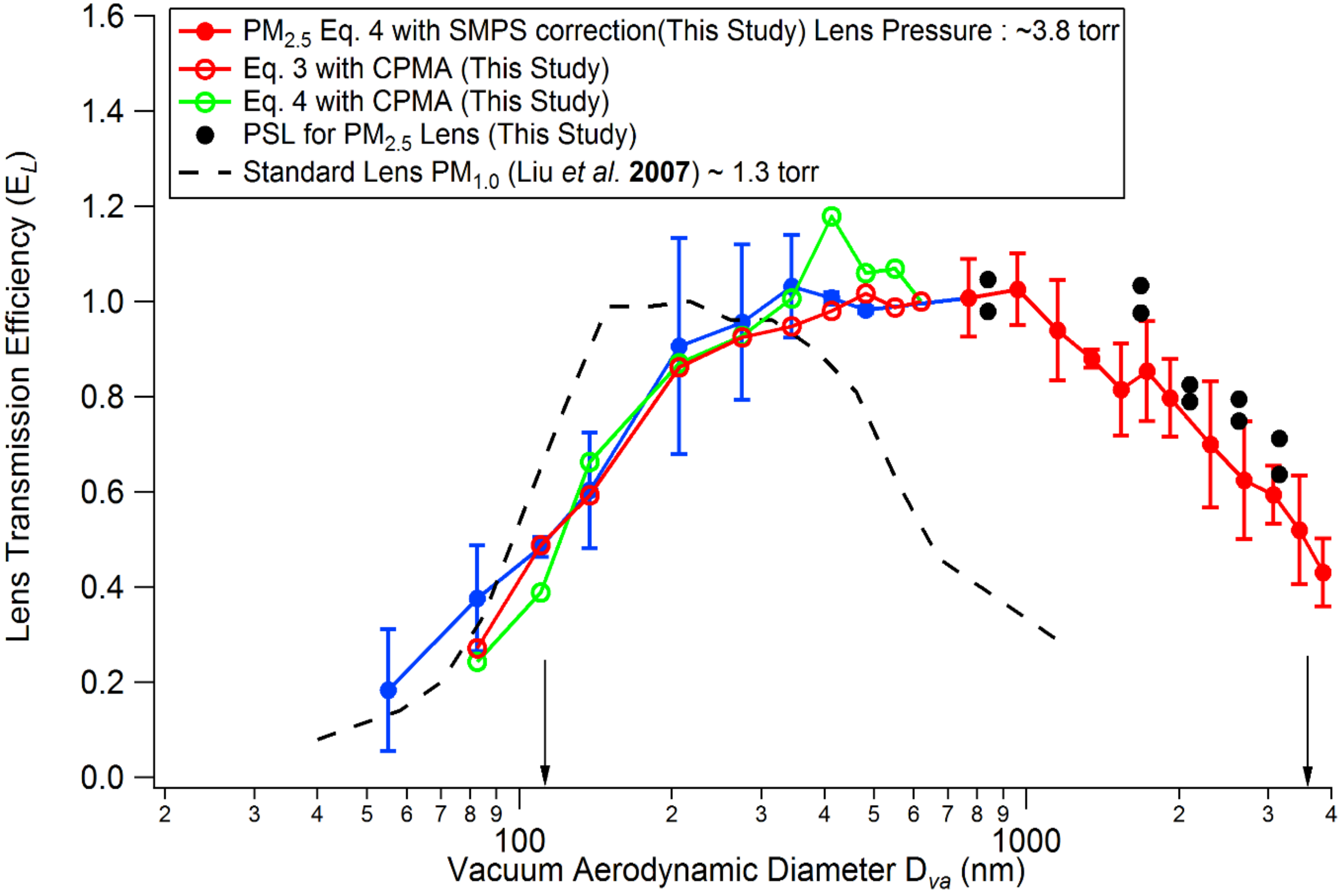
Average transmission for PM2.5 lens



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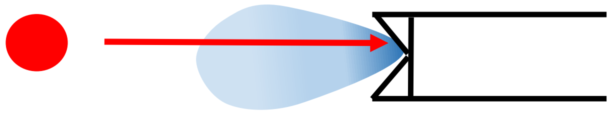
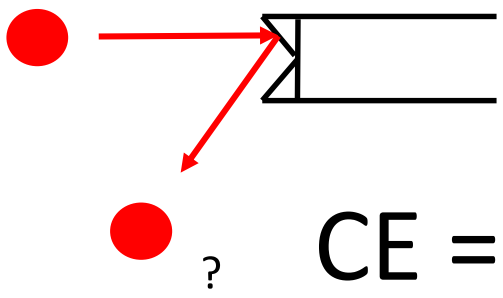
“Standard” vaporizer vs “Capture” vaporizer

“Flash Vaporization”

Standard Vaporizer:



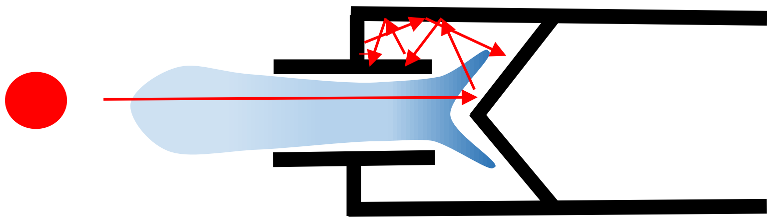
“Bounce”



CE = ~0.5

“Trapped” and “Delayed Vaporization”

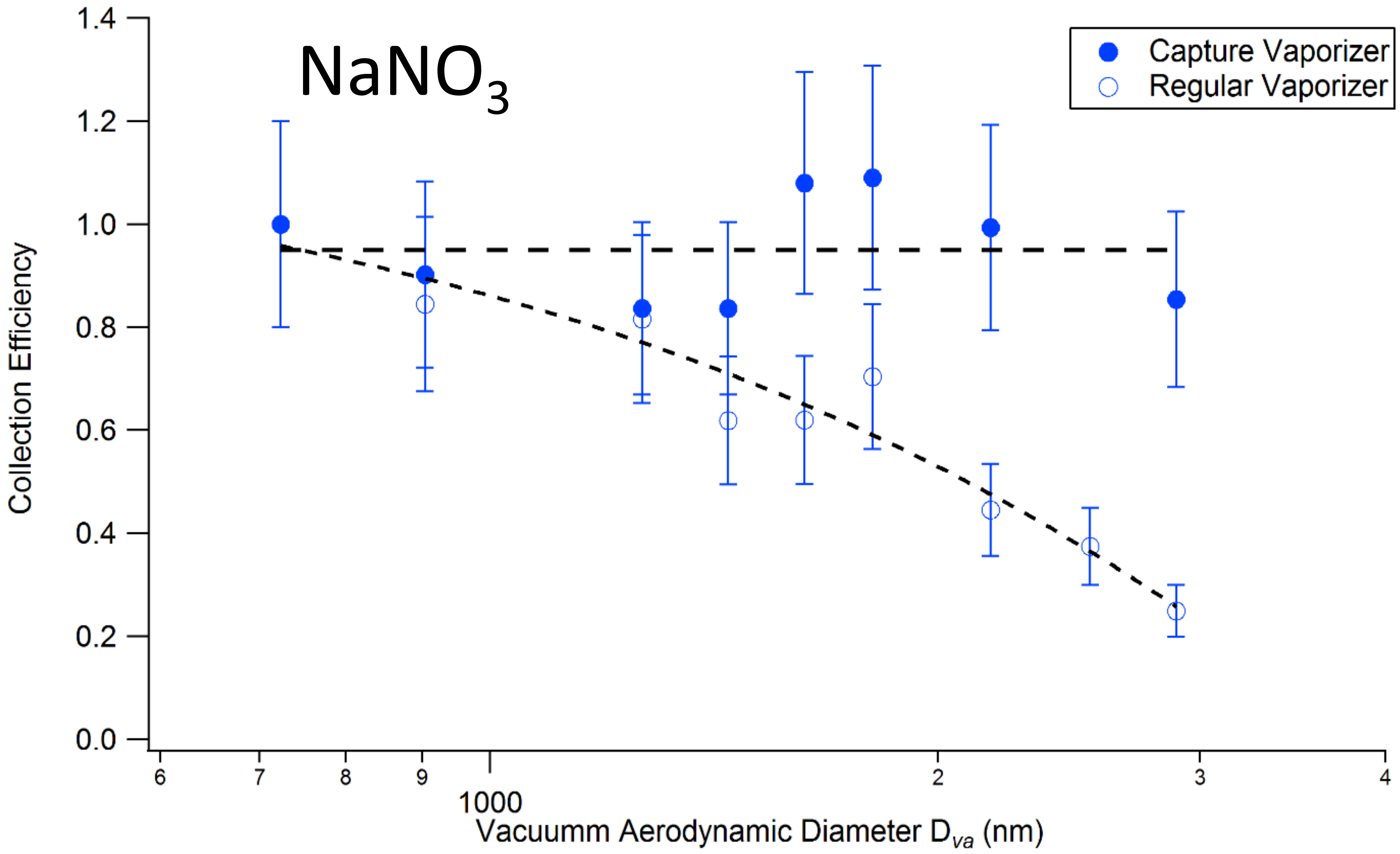
Capture Vaporizer:



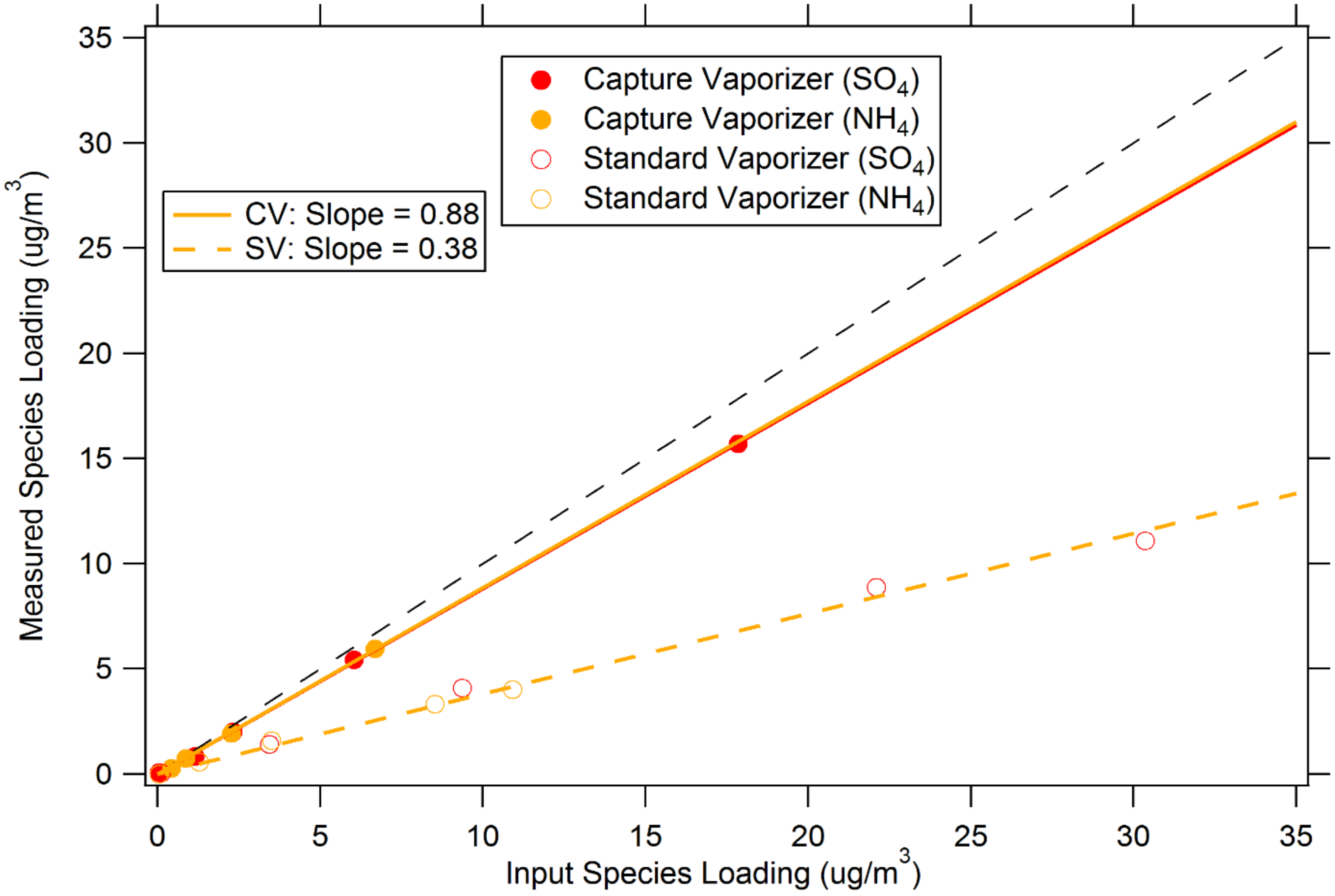
CE = 1

Jointly characterized with University of Colorado, Boulder
SOAS deployment – side-by-side AMS with and without CapVap

Reduced particle bounce by “Capture” Vaporizer



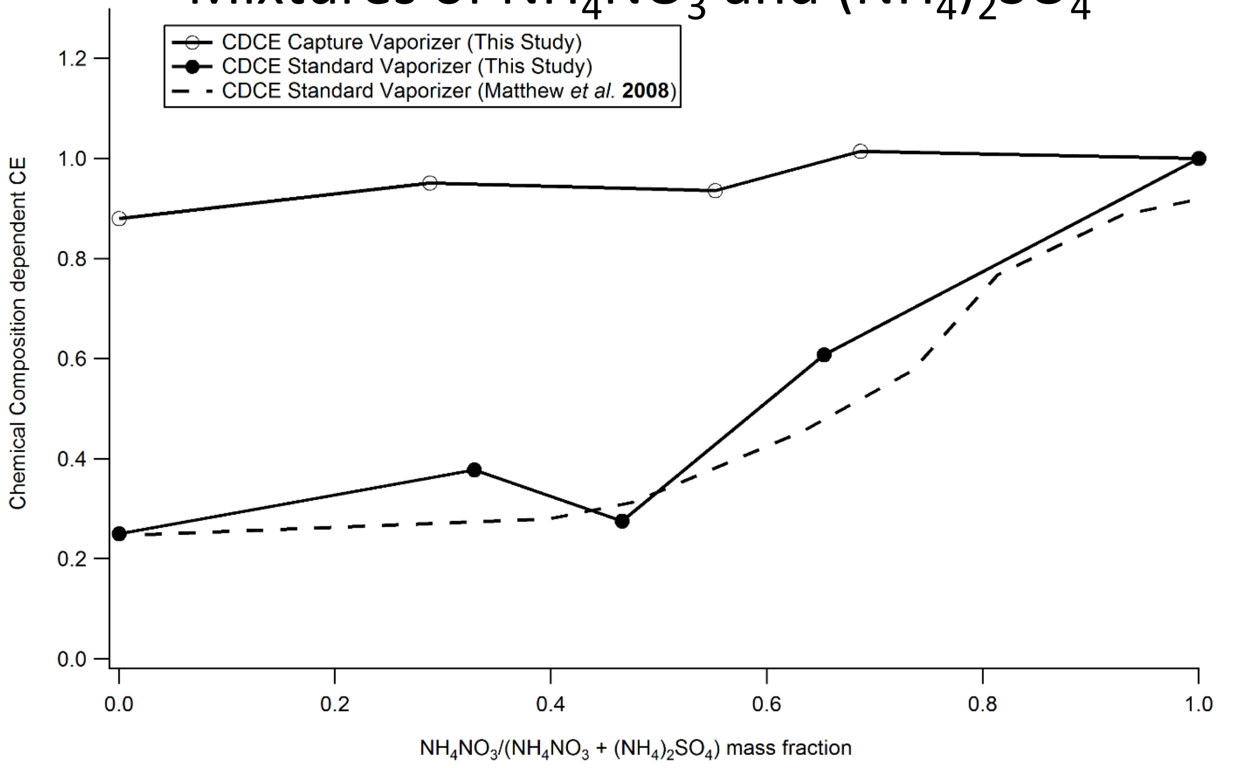
$(NH_4)_2SO_4$ Calibration



Chemical Composition Dependent CE

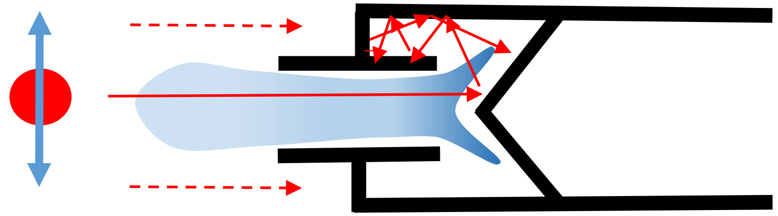
Mixtures of NH_4NO_3 and $(NH_4)_2SO_4$

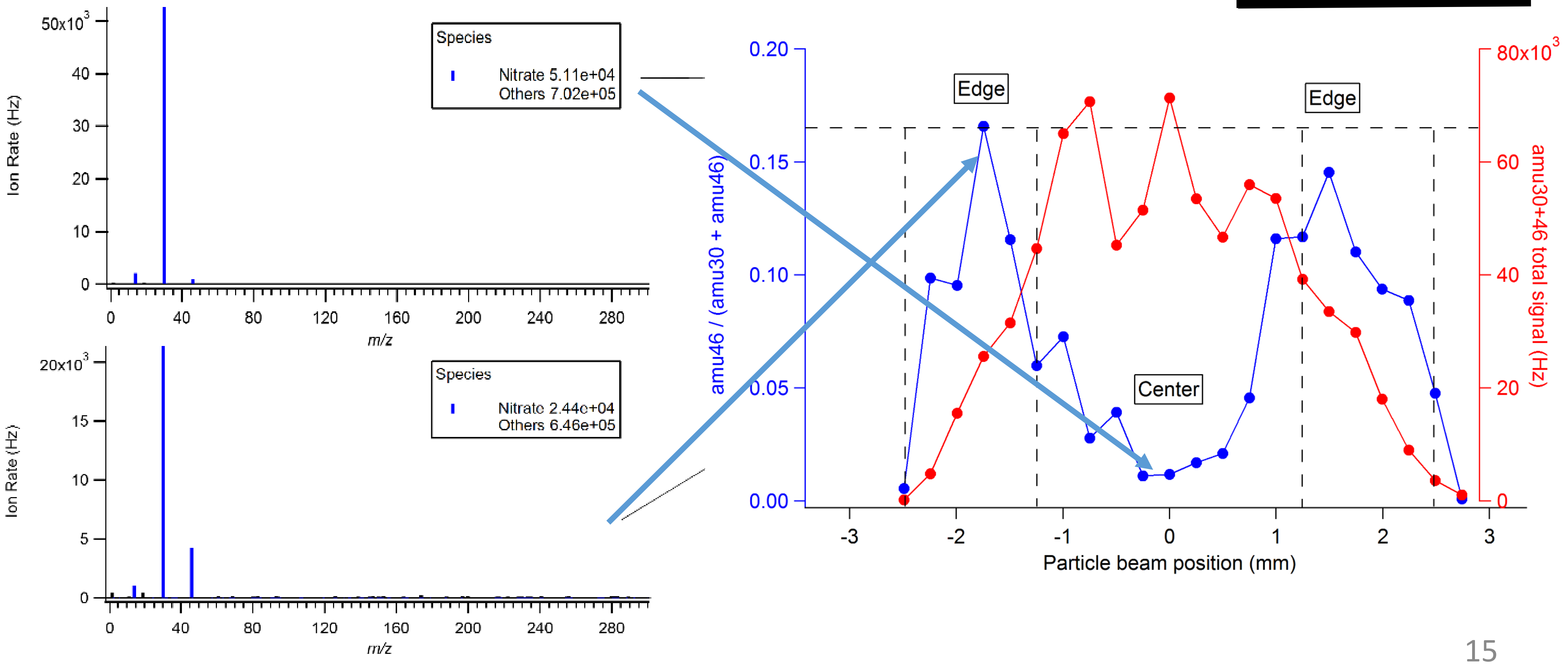
CE



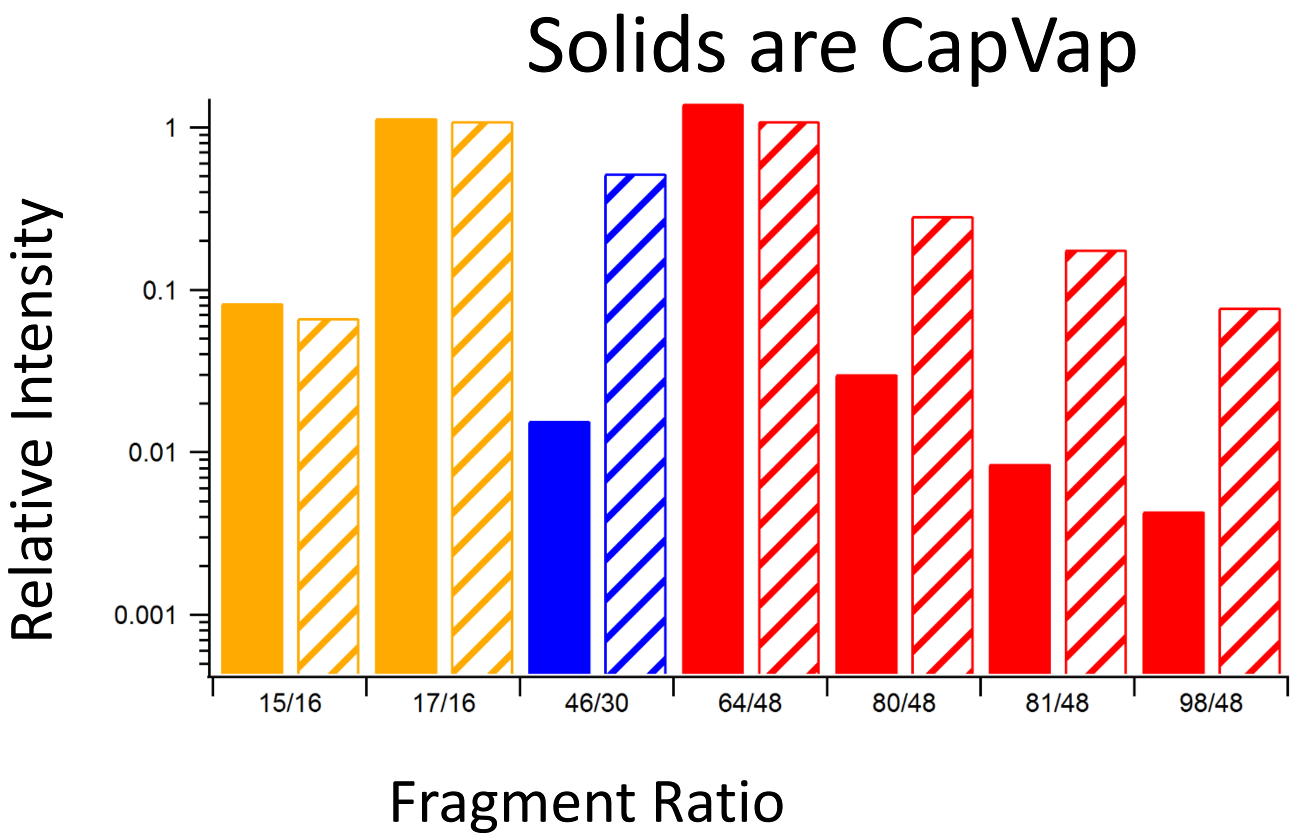
Increasing NH_4NO_3 Fraction

Lens alignment and 2-dimensional mapping of Capture Vaporizer





Fragmentation Pattern Changes with Capture Vaporizer



New fragmentation table entries for SO4 with CV

Table 2(a). Modified fragmentation table entries for sulfate for the CV. The frag_NO_3 is unchanged, although the *m/z* 46/30 ratio has changed.

m/z	frag_sulfate	frag_H_2SO_4	frag_SO_3
18	frag_SO_3[18]		0.938*frag_SO_3[64], 0.938*frag_SO_3[48]
32	frag_SO_3[32], frag_H_2SO_4[32]	0.034*frag_H_2SO_4[81], 0.034*frag_H_2SO_4[98]	0.105*frag_SO_3[48], 0.105*frag_SO_3[64]

(b). Corresponding standard frag table for the SV.

m/z	frag_sulfate	frag_H_2SO_4	frag_SO_3
18	frag_SO_3[18]		0.67*frag_SO_3[64], 0.67*frag_SO_3[48]
32	frag_SO_3[32], frag_H_2SO_4[32]	0.068*frag_H_2SO_4[81], 0.068*frag_H_2SO_4[98]	0.21*frag_SO_3[48], 0.21*frag_SO_3[64]

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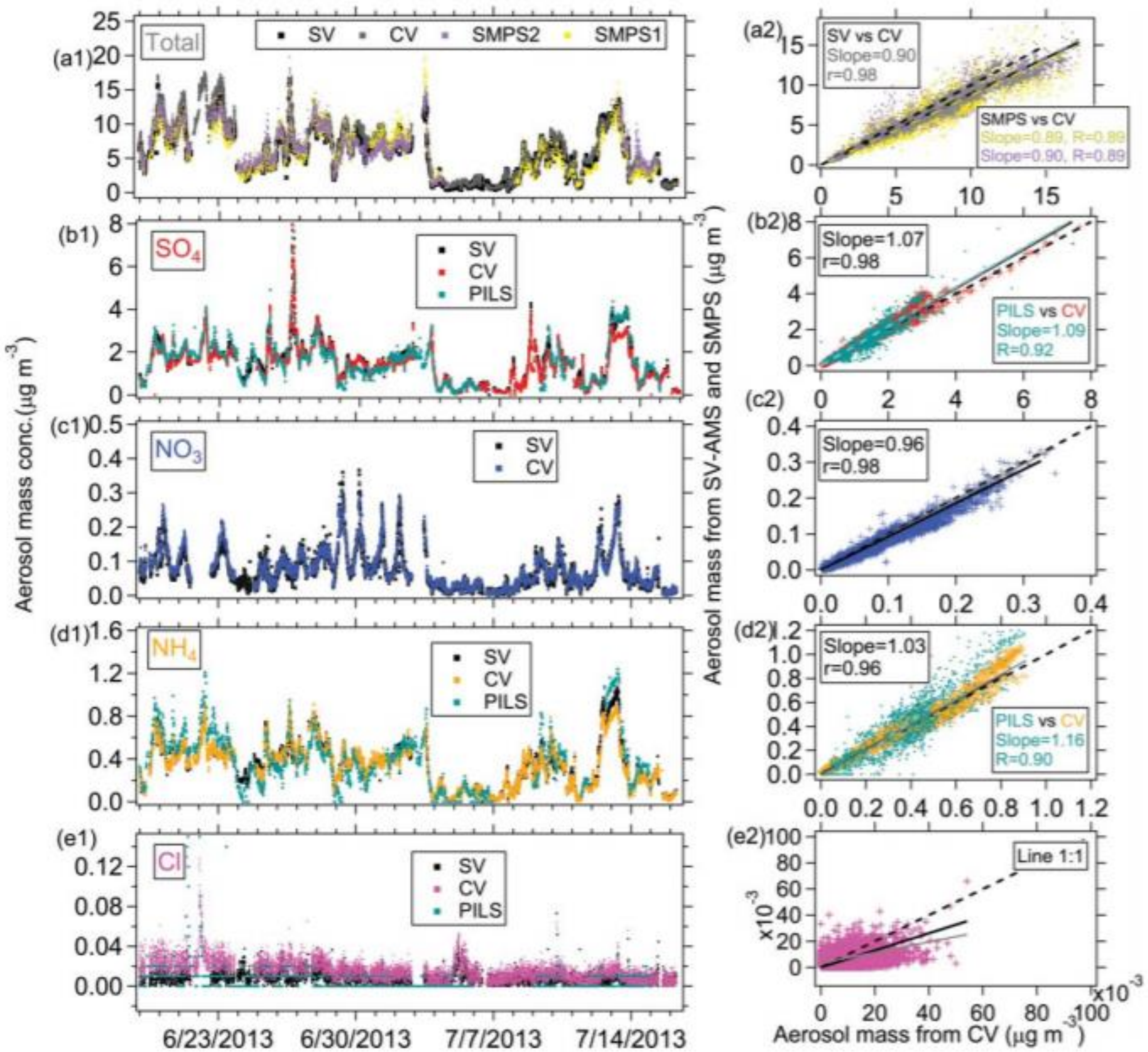
Comparison of CV and SV at SOAS campaign, 2013



Evaluation of the new capture vaporizer for aerosol mass spectrometers (AMS) through field studies of inorganic species

Weiwei Hu, Pedro Campuzano-Jost, Douglas A. Day, Philip Croteau, Manjula R. Canagaratna, John T. Jayne, Douglas R. Worsnop & Jose L. Jimenez

To cite this article: Weiwei Hu, Pedro Campuzano-Jost, Douglas A. Day, Philip Croteau, Manjula R. Canagaratna, John T. Jayne, Douglas R. Worsnop & Jose L. Jimenez (2017) Evaluation of the new capture vaporizer for aerosol mass spectrometers (AMS) through field studies of inorganic species, Aerosol Science and Technology, 51:6, 735-754, DOI: 10.1080/02786826.2017.1296104