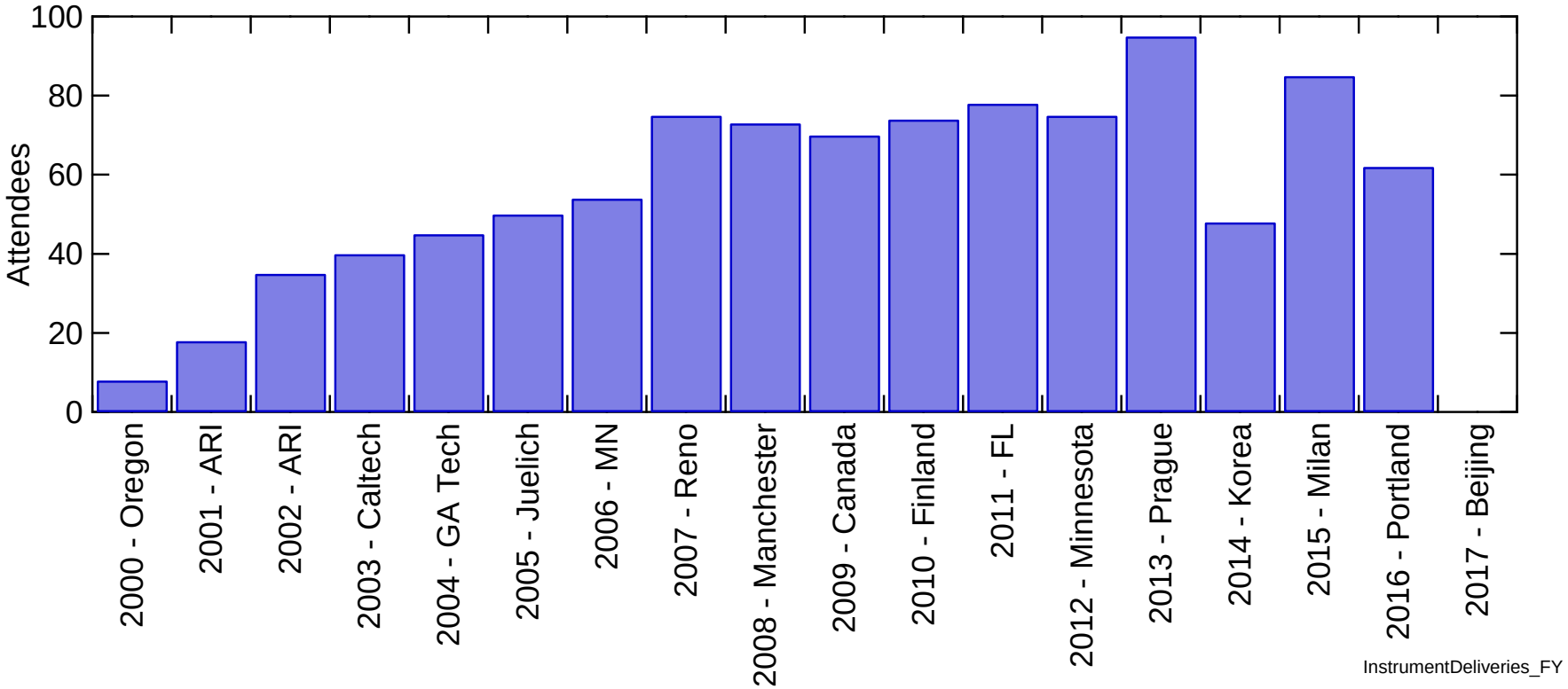
# Friday 14:40
# Instruments Overview

17th Users Meeting
Portland, OR
Oct 21-23, 2016

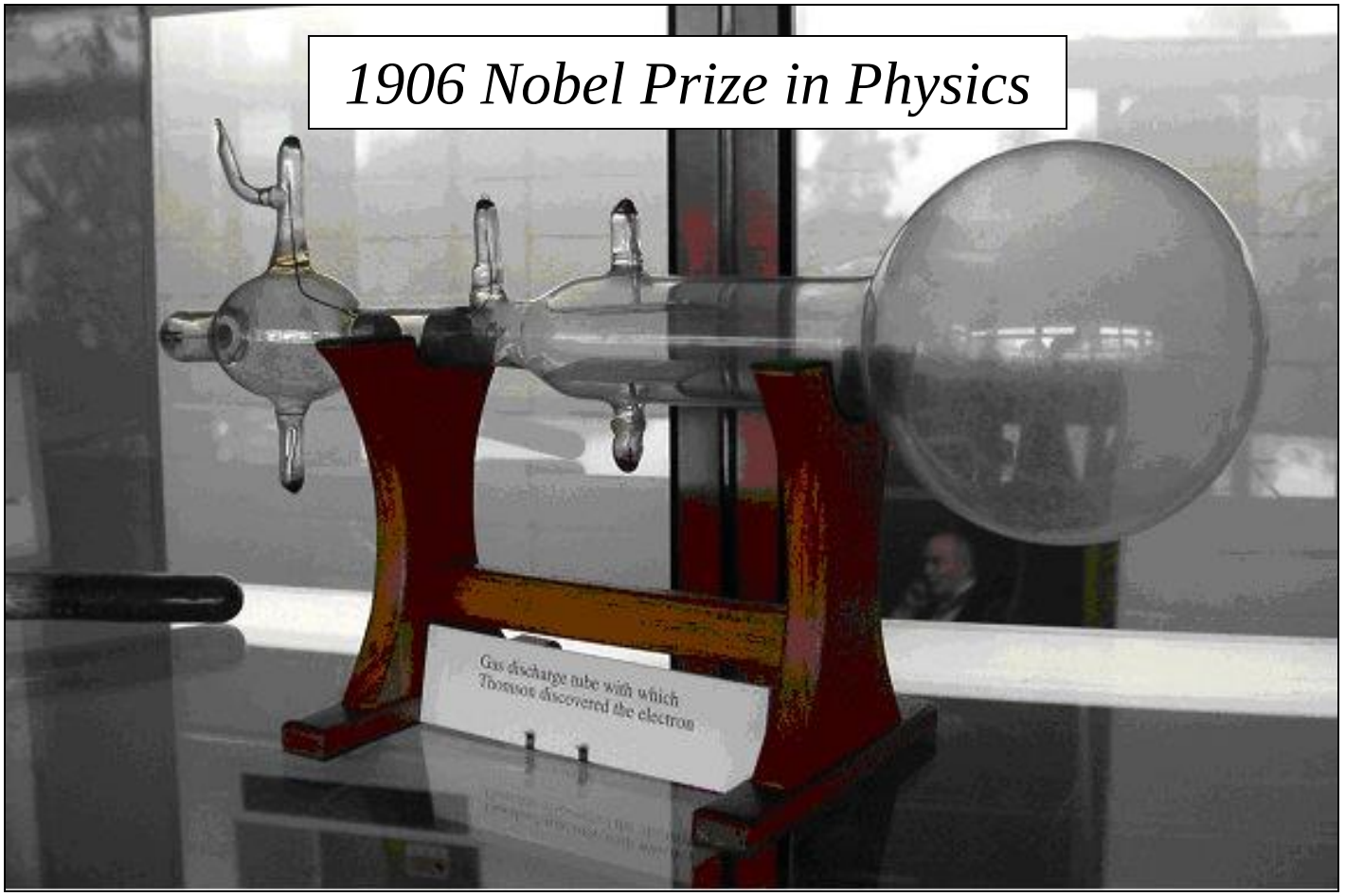
# AMS Users Community
# Annual Meeting Attendance




*895+ Published Articles to date*

*http://cires1.colorado.edu/jimenez/ams-papers.html*

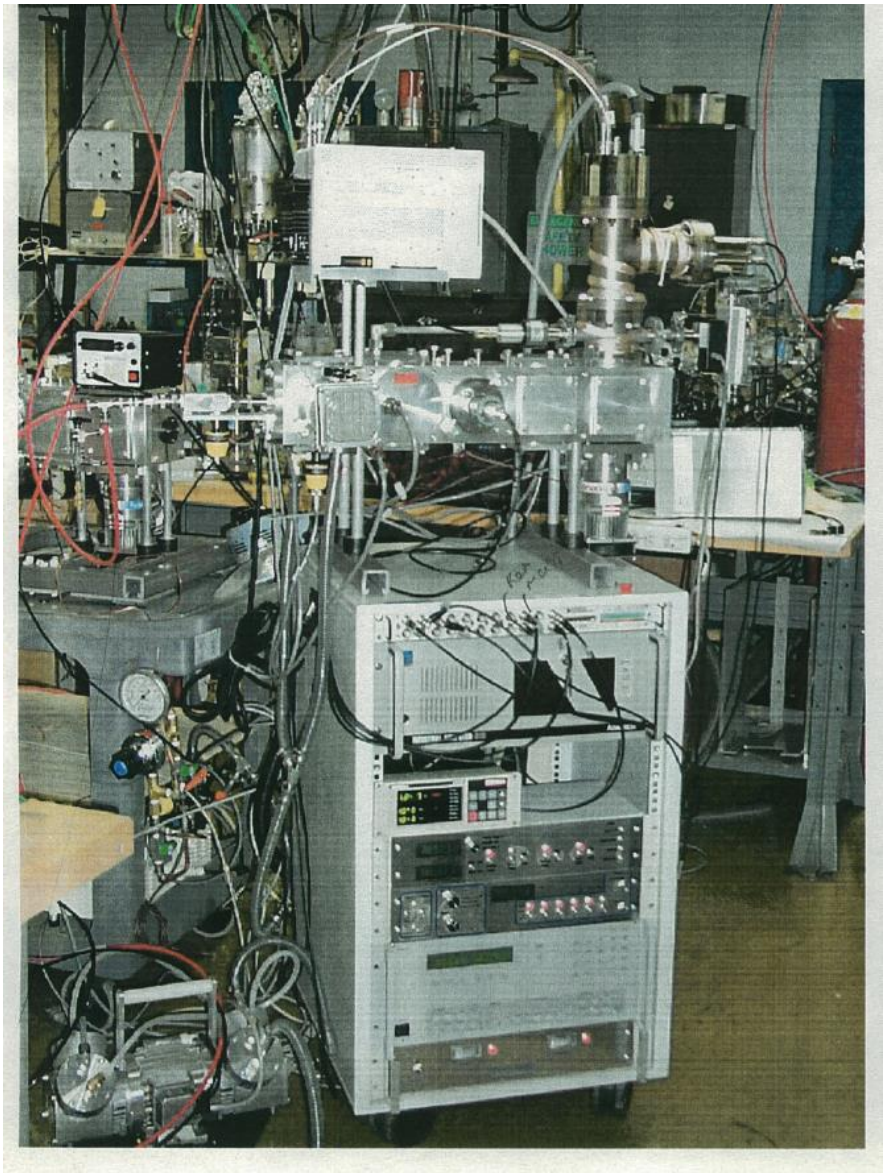
# Apparatus that J. J. Thomson used in the ‘discovery of the electron’




Thomson’s work promoted the basic physics underlying the development of the mass spectrometer

http://msr.dom.wustl.edu/history-mass-spectrometry/

# Something we may have delivered to the Manchester Group!



s/n: 255-002
June 2000

# Chronology of AMS systems

| | |
|---|---|
| ~~QAMS~~ | 1995 – 2000+ |
| CTOF AMS | 2001 |
| HTOF AMS | 2002 |
| QACSM | 2004 – 2009+ |
| SP HTOF AMS | 2007 |
| eTOF ACSM | 2010 |
| CTOF mAMS | 2011 |
| HTOF mAMS | *TBD* |
| *HTOF ACSM* | *TBD* |
| ***LTOF AMS*** | ***2015*** |

*1st Api TOF*

*Different colors are different vacuum systems*

# Instruments and Developments

*AMS, SP AMS, mini AMS*
*QACSM, ToF ACSM*

*CIMS and FIGAERO CIMS*
*TAG and GC HTOF*
*IMS TOF*

*PM2.5 lens and Capture Vaporizer*
*ePTOF Multiplex chopper, Data Acquisition*

*Thermal Denuder, PAM Reactor, Aerosol Dryer and Sampling System*

# Long (L) TOF AMS

2x the resolution of HTOF (Vmode) with the same sensitivity.

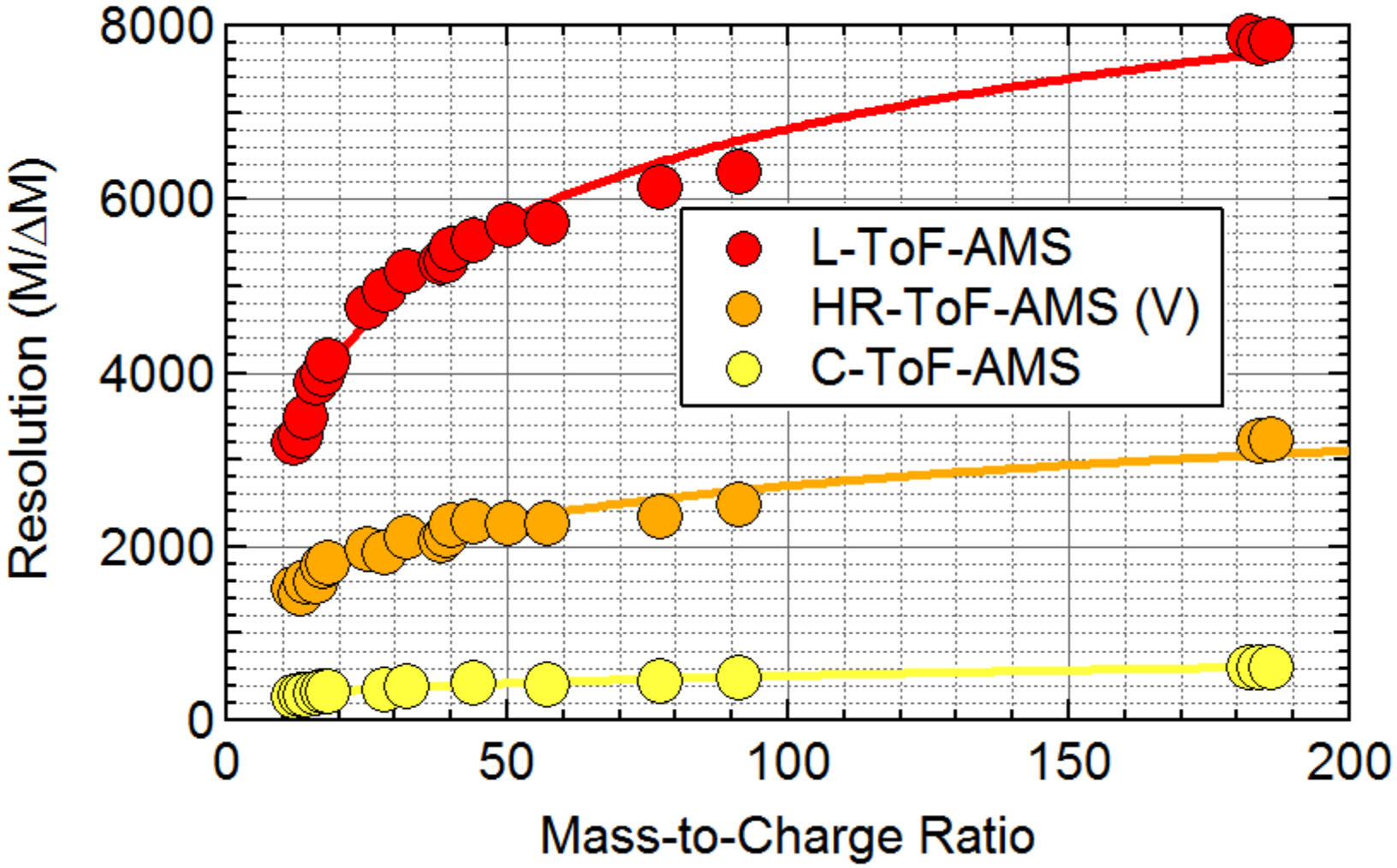
2x the length of the HTOF

4 systems in use

Note use of Pfeiffer turbo pumps

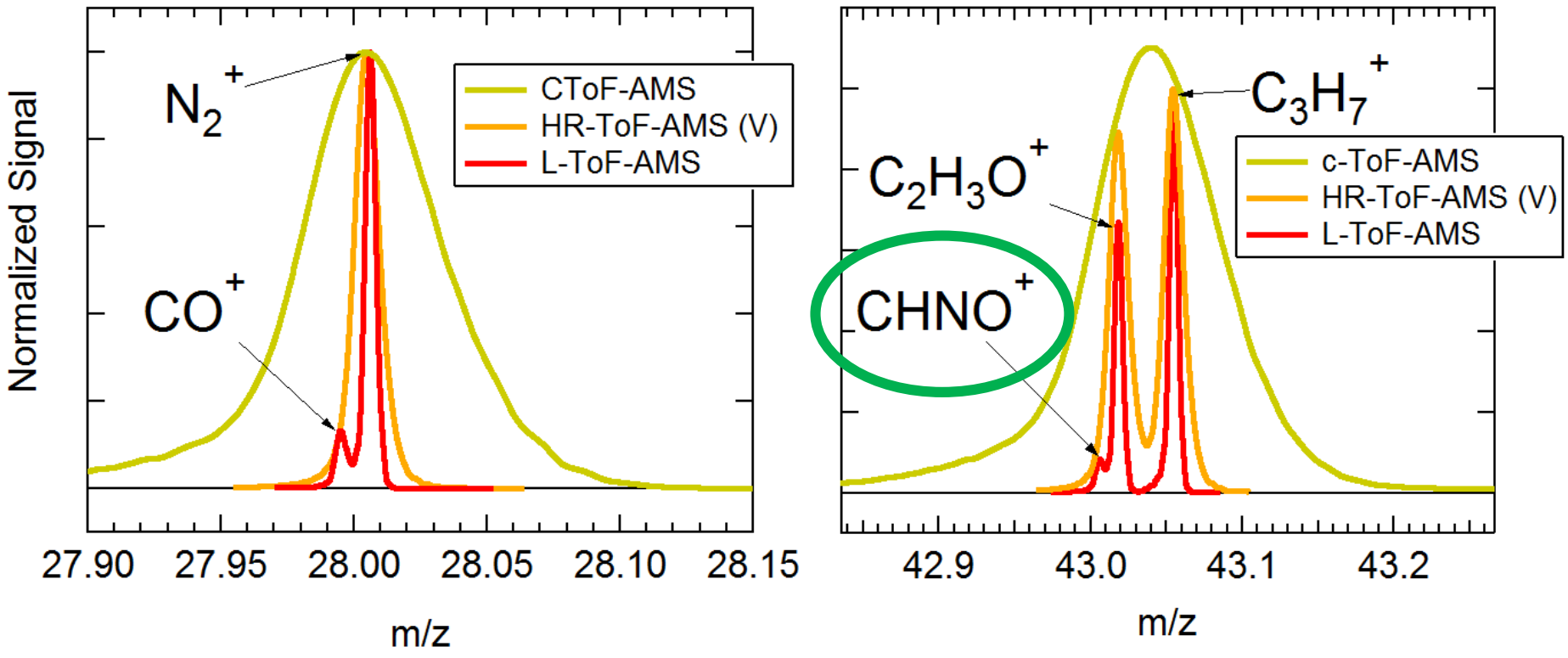
55” L x 24” D x 27” H, 275 lbs.
[139.7 cm x 60.9 cm x 68.6 cm, 124.7 kg]

# LTOF Resolution Compared to C- and HTOF




*Andy Lambe*

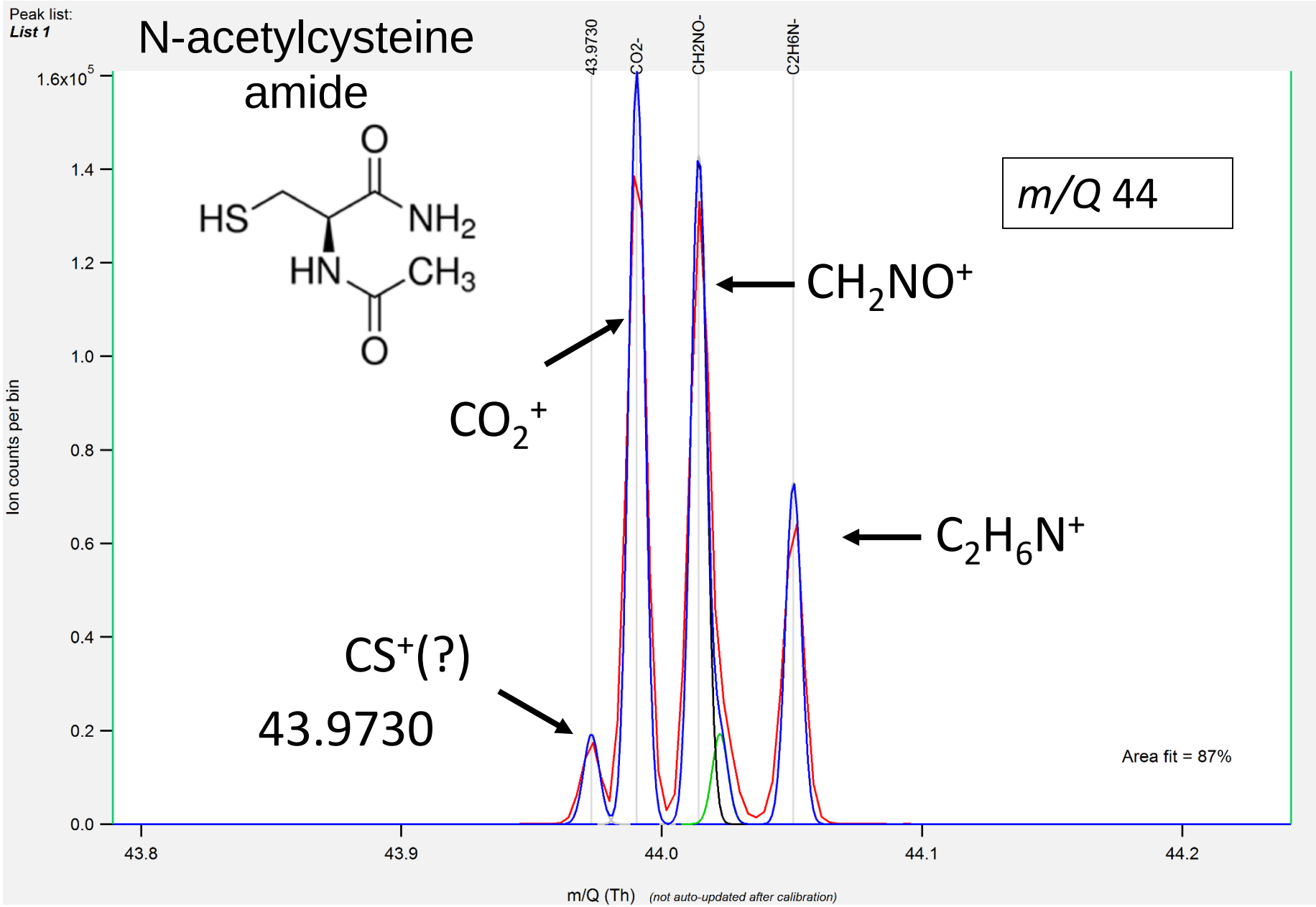
# LTOF Qualitative Comparison to C- and HTOF



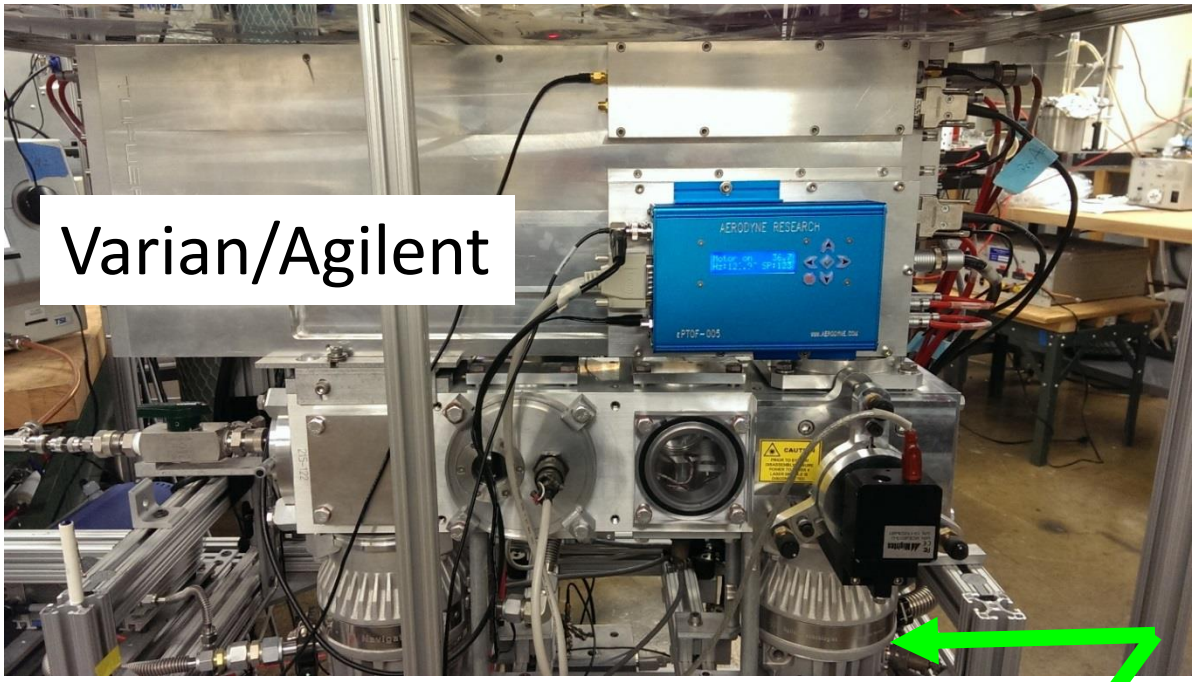

*Improved ability to report on elemental Nitrogen.*

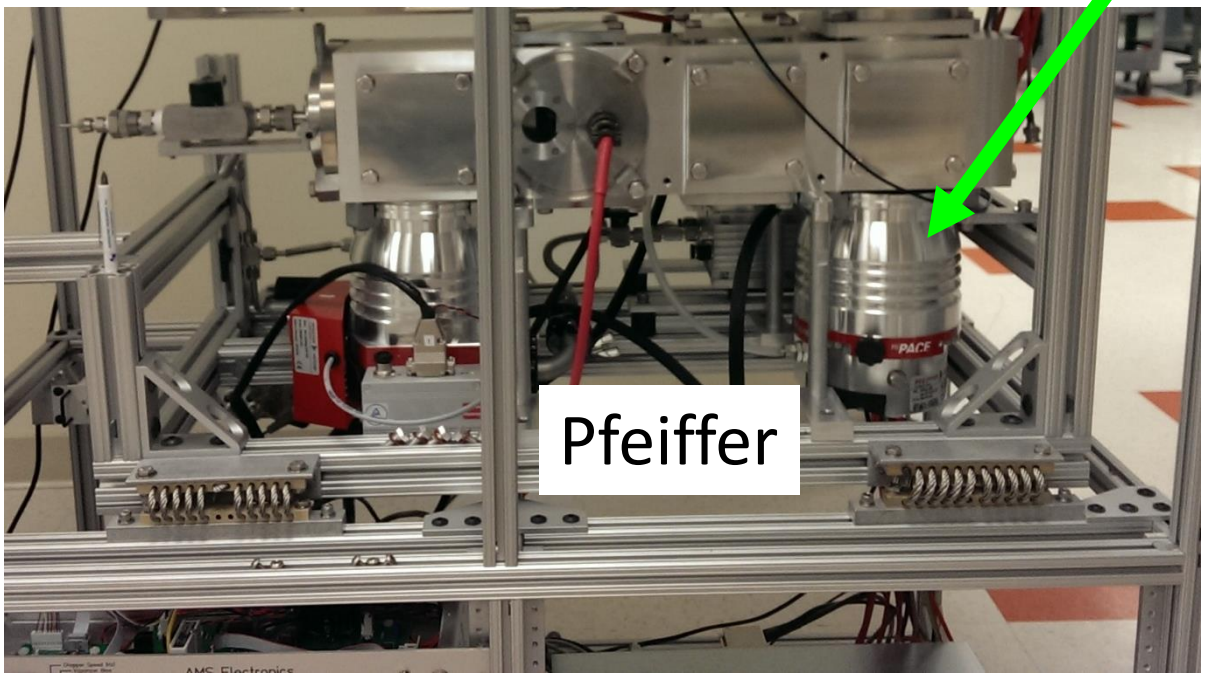
*Andy Lambe*

# L-TOF: High Resolution separation of N containing ions



# AMS Vacuum System



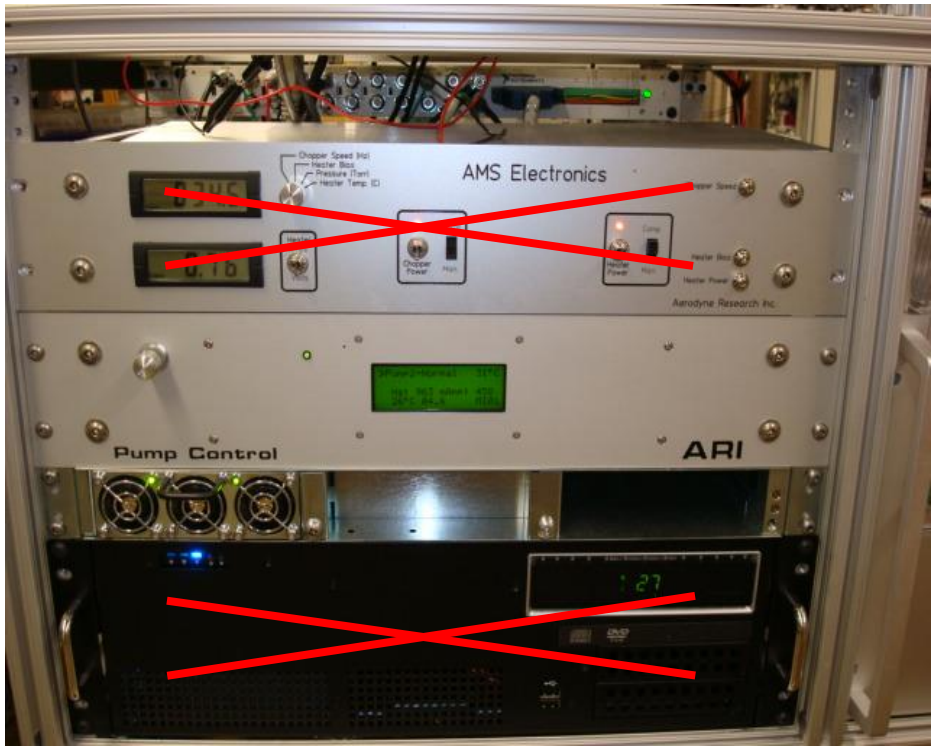




New systems are being built with Pfeiffer turbo pumps.

Better reliability but not well suited for mobile applications.

Discussion and evaluation of new Agilent pumps presented during Hardware Session.

# Updates on AMS Control System





-Ebox eliminated.
-Rack mount PC replaced with small form factor PC.
-Simplified cabling

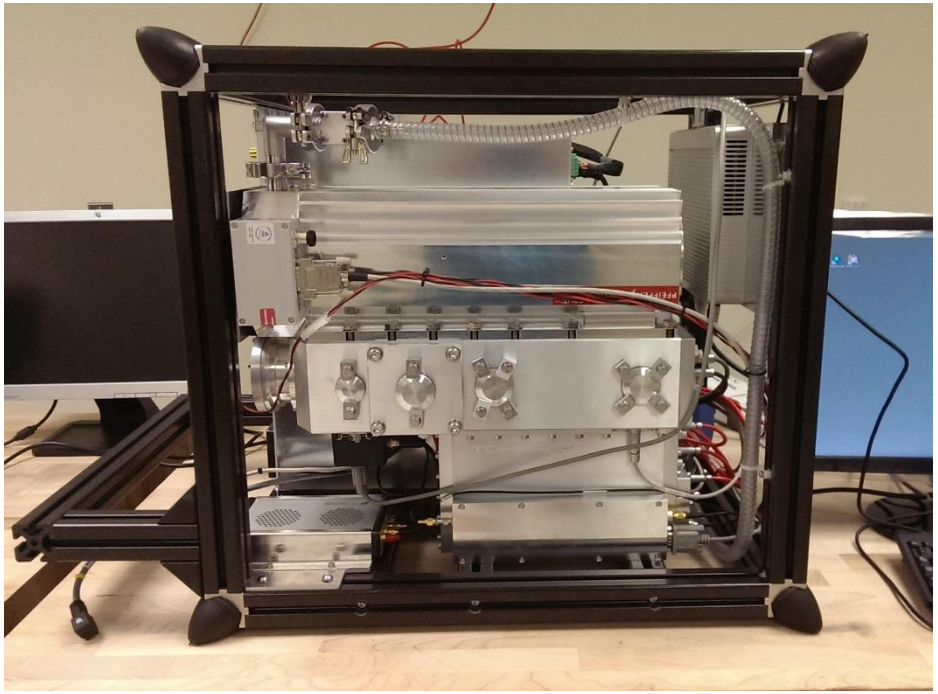
Pump Control Box  now manages:
-Heater power
-Heater temperature display
-Communication/control with AMS DAQ
-Control for AutoInlet valve and backing pump isolation valve

Coming:
-Pump control via DAQ5

# QACSM and ToF ACSM Systems

QACSM

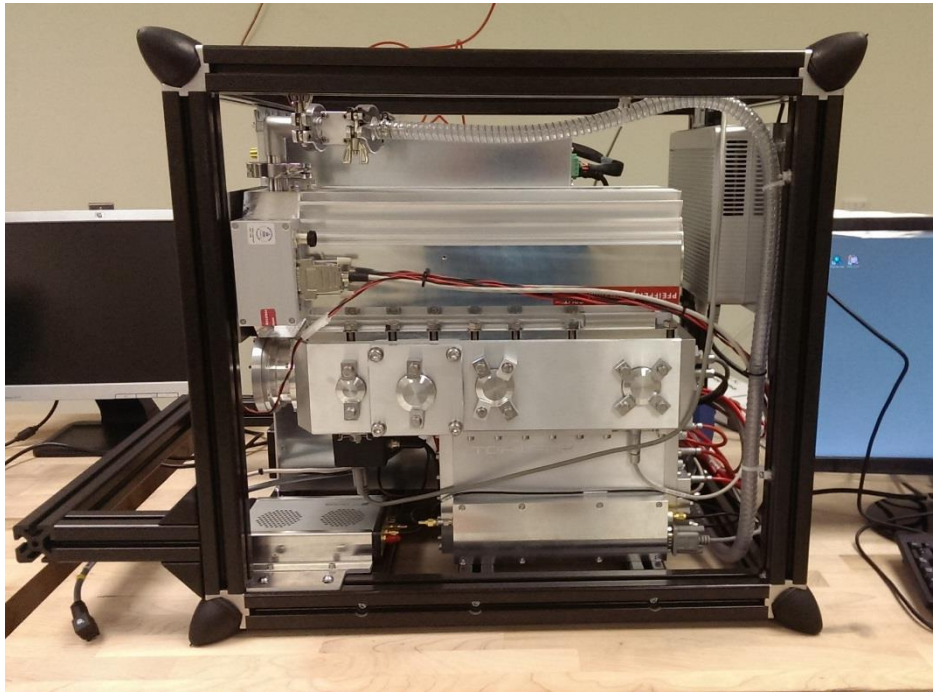

eTOF ACSM



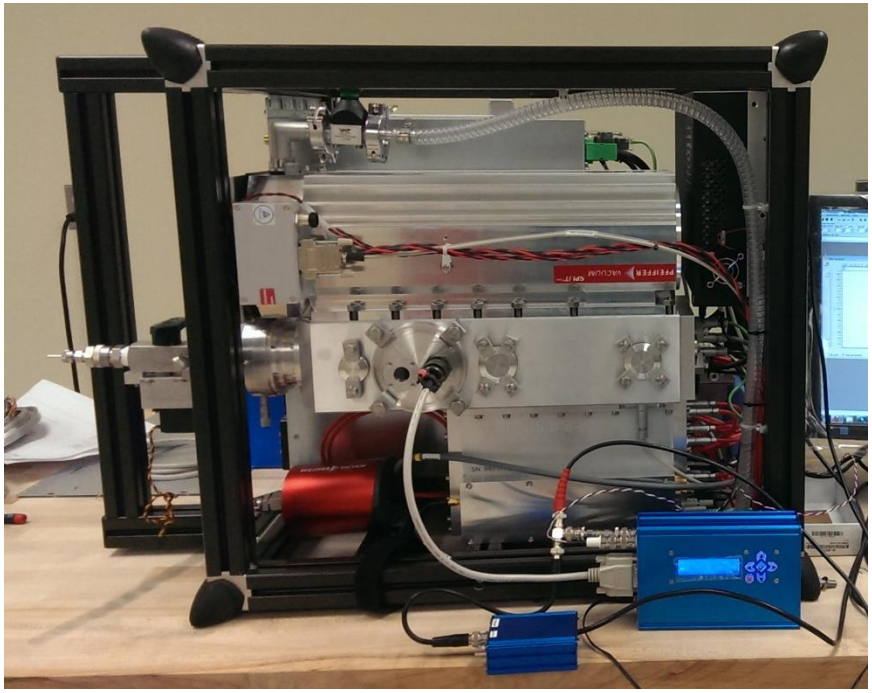
Second intercomparision of ACSMs took place in Paris, March 2016

# mini-AMS and ToF ACSM Systems

eTOF ACSM

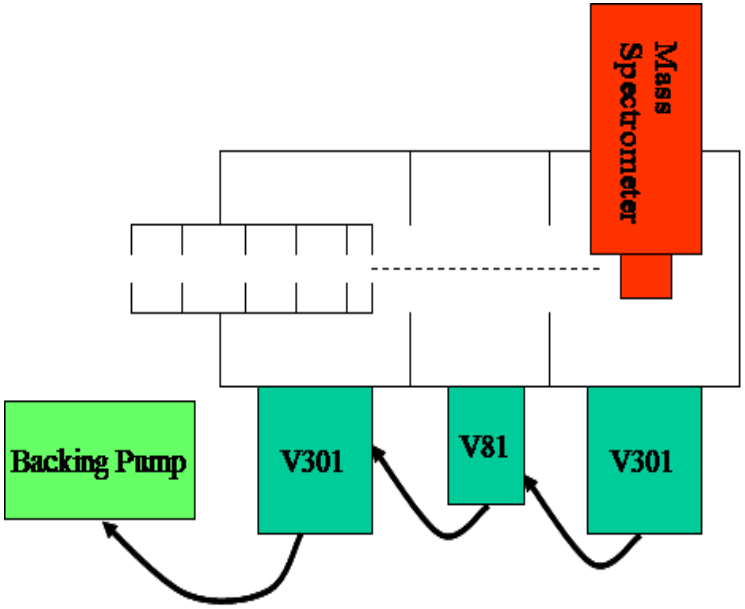


cTOF mAMS

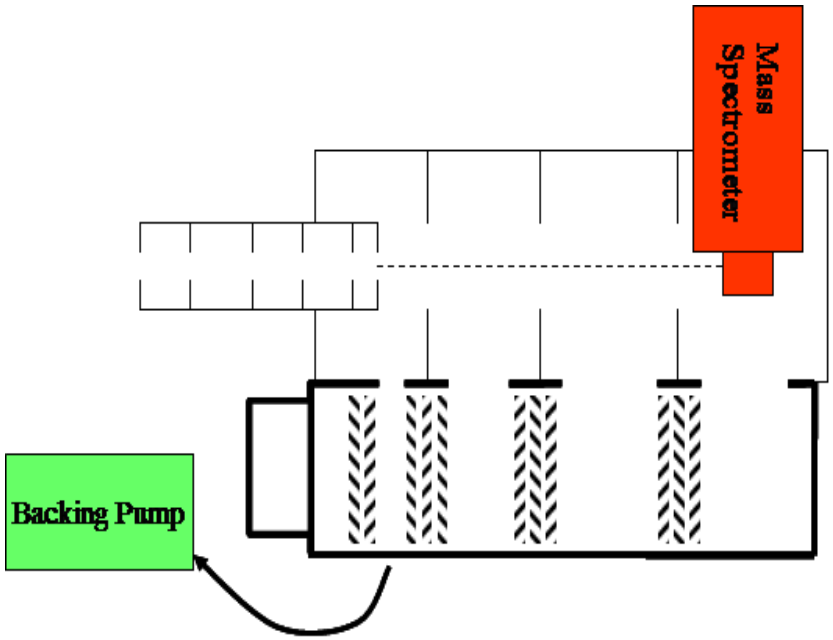


*Differences between ACSM and mAMS are the chopper and the DAQ system*

# Two Different ACSM Vacuum System Designs




QACSM
discrete turbos



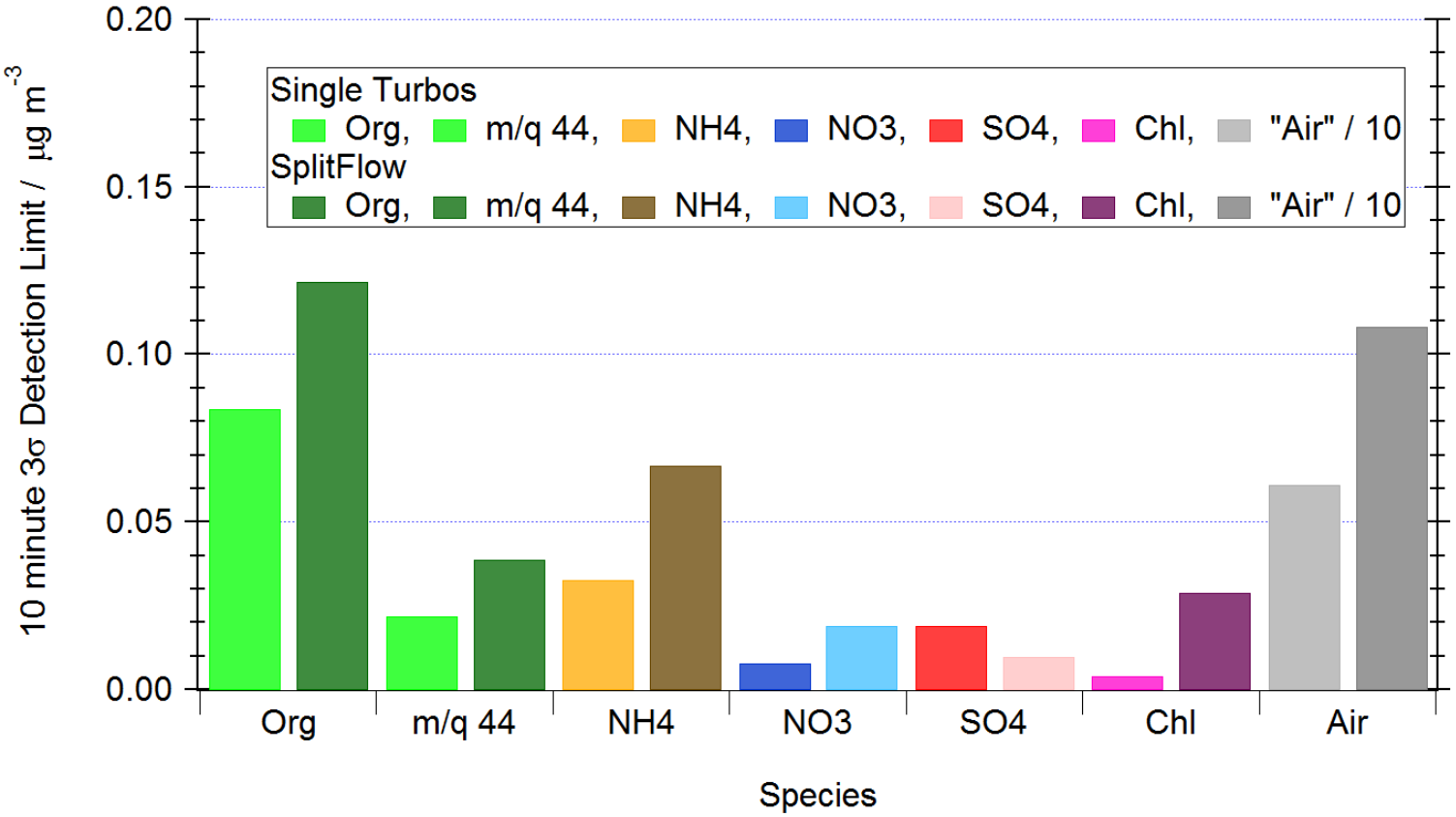

TOF ACSM and mAMS
Split flow turbo

**Pumping speeds (L/s)**

**300 80 300**

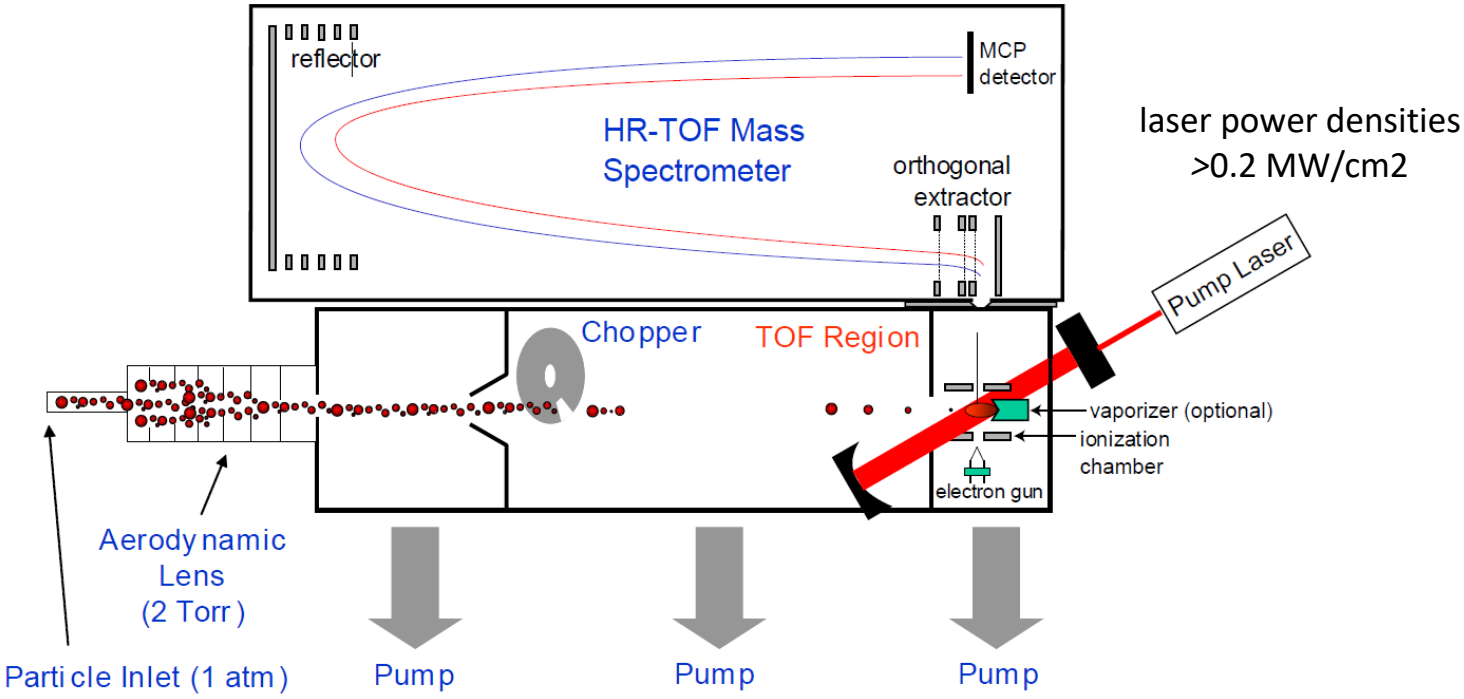
**40 170 135 160**

# Comparison of Single Turbos and Split Flow Turbo Vacuum System Designs




*More about this in Phil's talk later*

# Soot Particle (SP) AMS

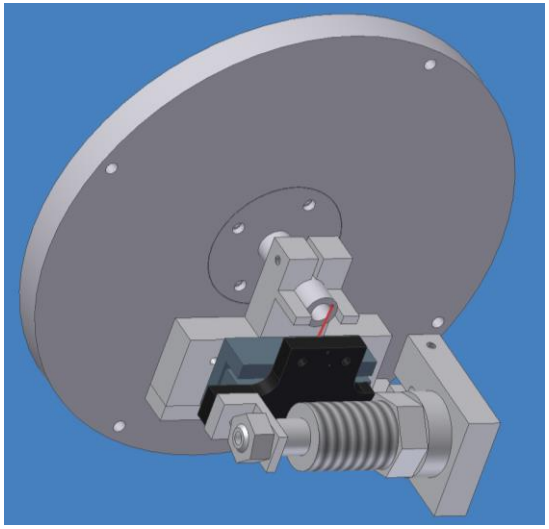


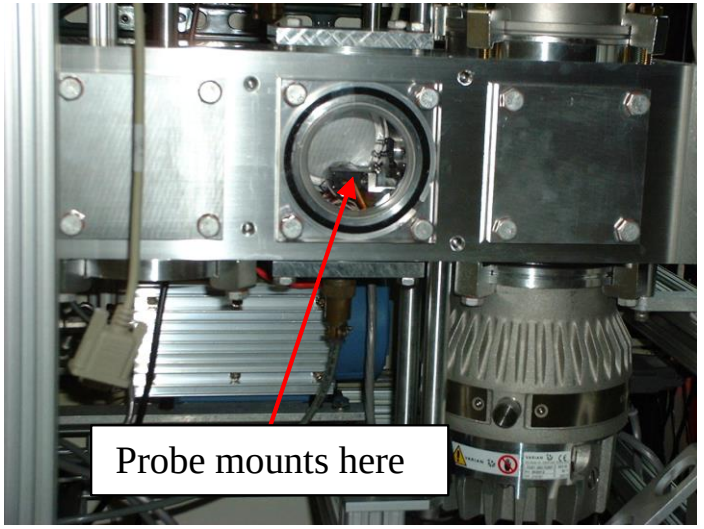

Addition of intra-cavity laser (1064 nm) to the AMS allows vaporization and detection of **black carbon** containing particles.

Work is focused on quantification of BC signals.

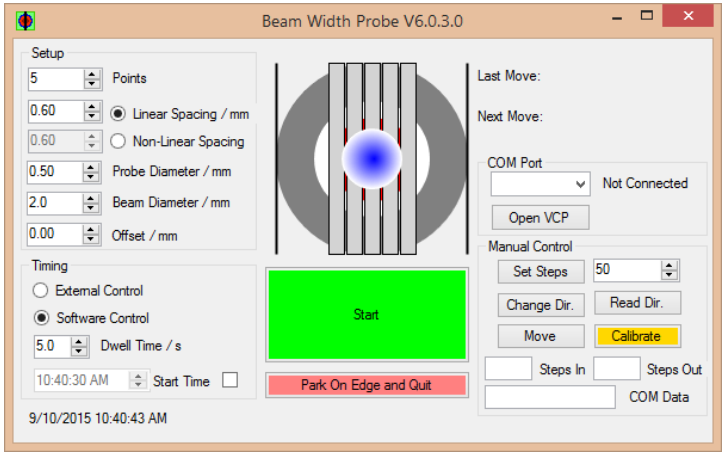
*Onasch et al. AS&T 2012*
*Onasch et al. AS&T 2015*

# Beam Width Probe Revived
# Important for characterization of SP AMS






- Updated electronics.
- Software rewritten for new hardware.




*Phil Croteau, Bill Brooks, Tim Onasch*

# Efficient Particle Time-of-Flight
# ePTOF

## Application of a higher throughput chopper wheel

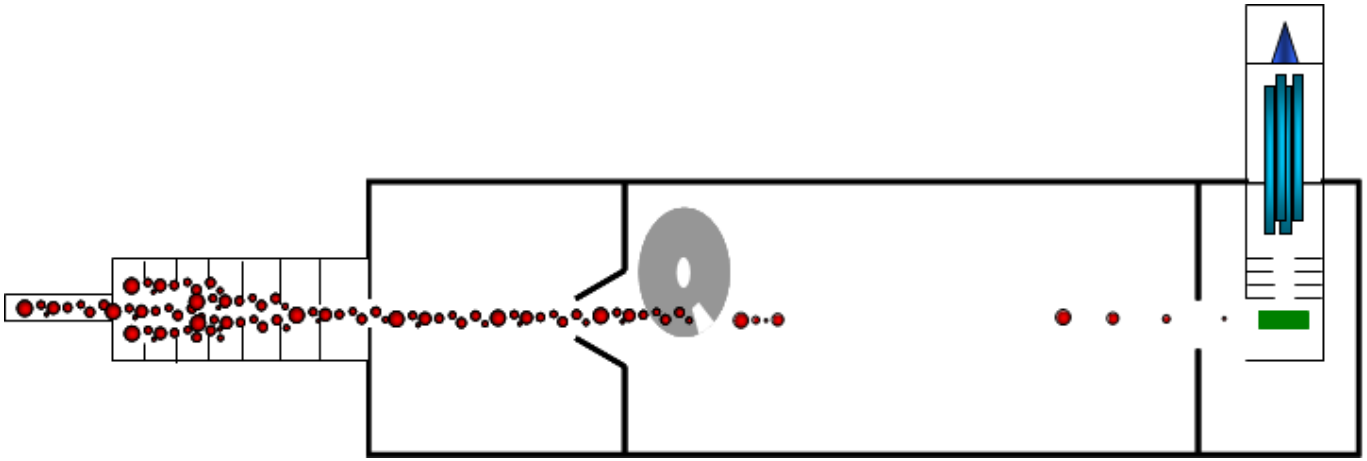
## Performance enhancements in size resolved measurements with the AMS

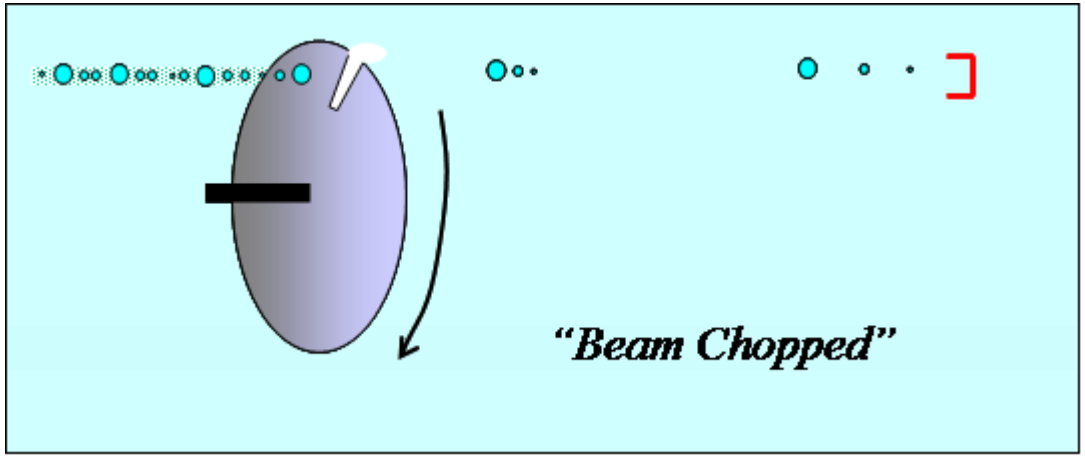
*ARI/Tofwerk*
*J. Jayne, J. Kimmel, R. Knokumuss, M. Cubison, M. Gonin*

*CU/Boulder*
*P. Campuzano Jost, D. Day & Weiwei Hu, Harald, Donna, Jose*

*Florian Rubach, Mainz (mAMS)*

# Size measurement in the AMS

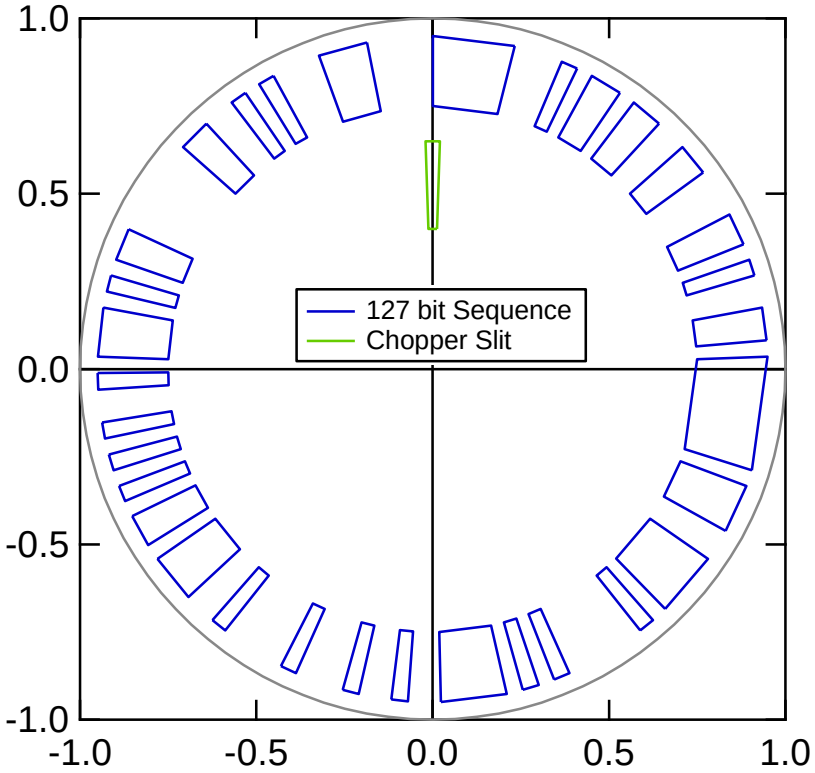


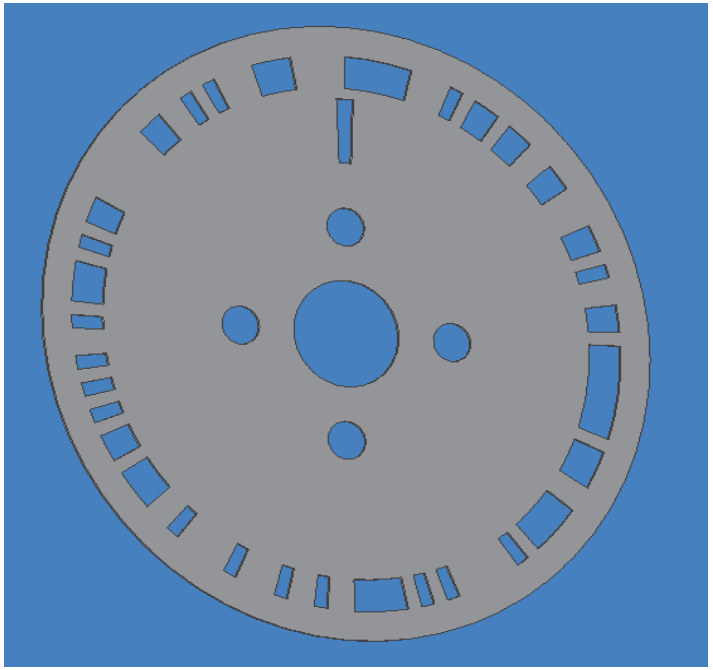



Single slit chopper limits throughput to 2%

# Multi-slit wheel for 50% aerosol throughput

## Deconvolution procedure to obtain size information



4-positions
open, closed, blocked, chop

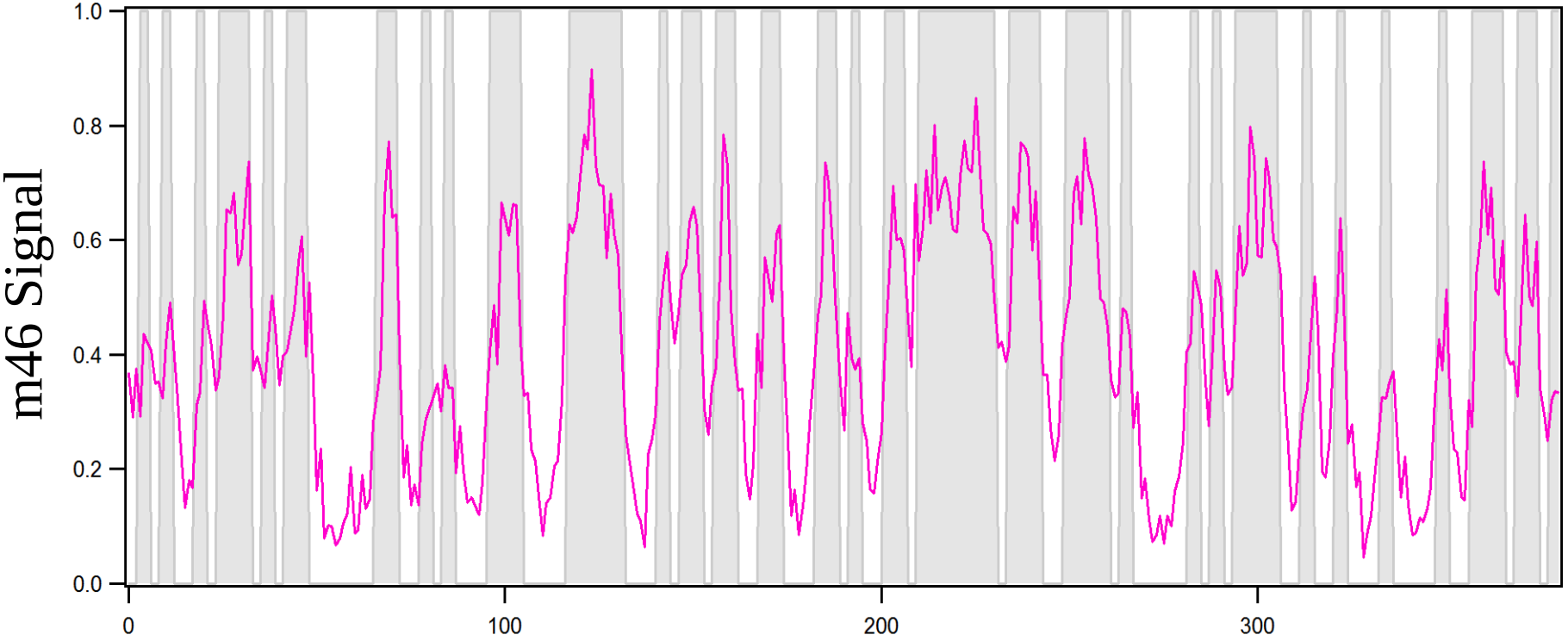
- 3-phase brushless DC motor
- wheel velocity regulated

*DAQ5 and Squirrel - Joel, Donna, Harald*

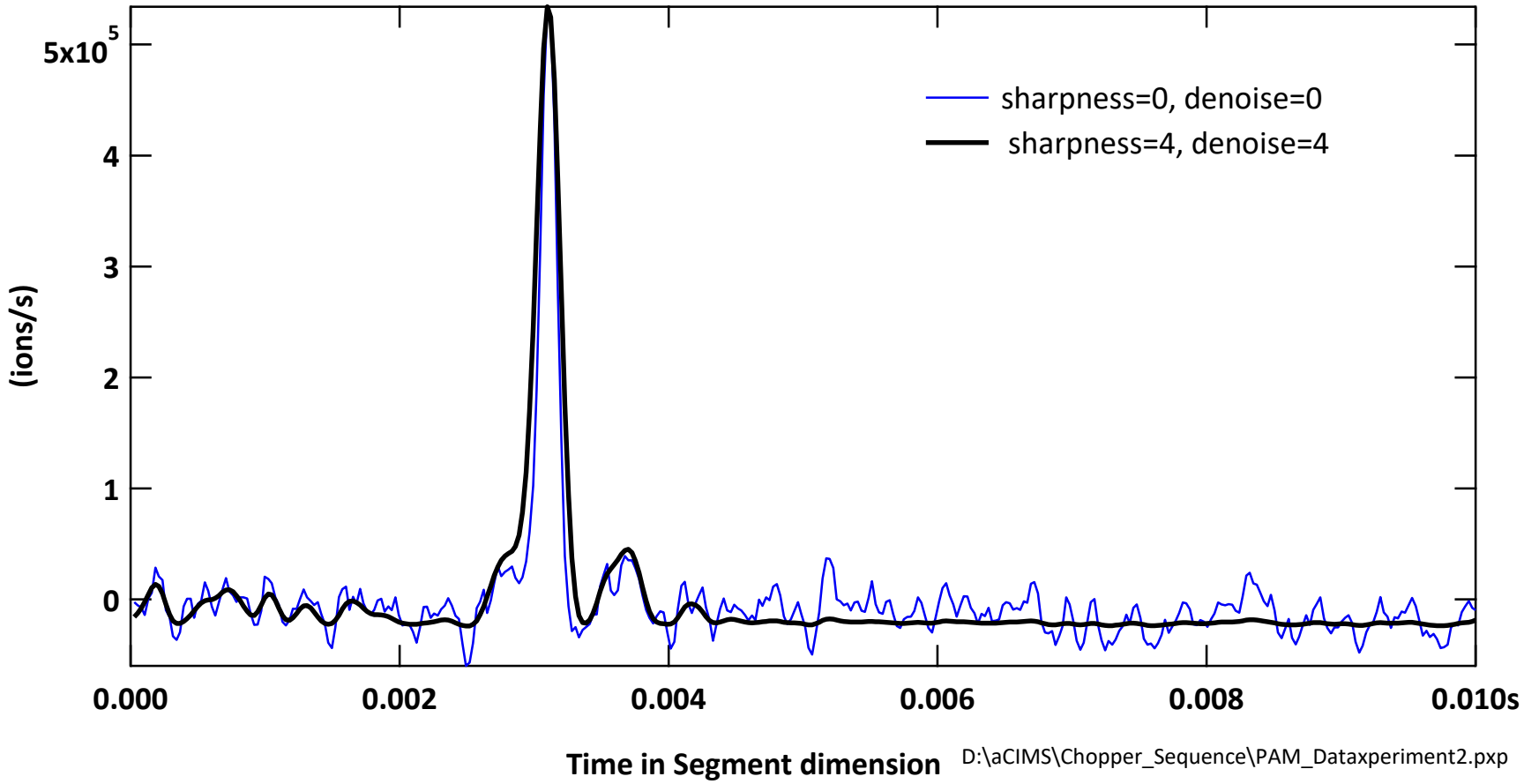
*Mike Cubison, Richard Knochenmuss - TW*

# 300 nm $NH_4NO_3$ Raw Data

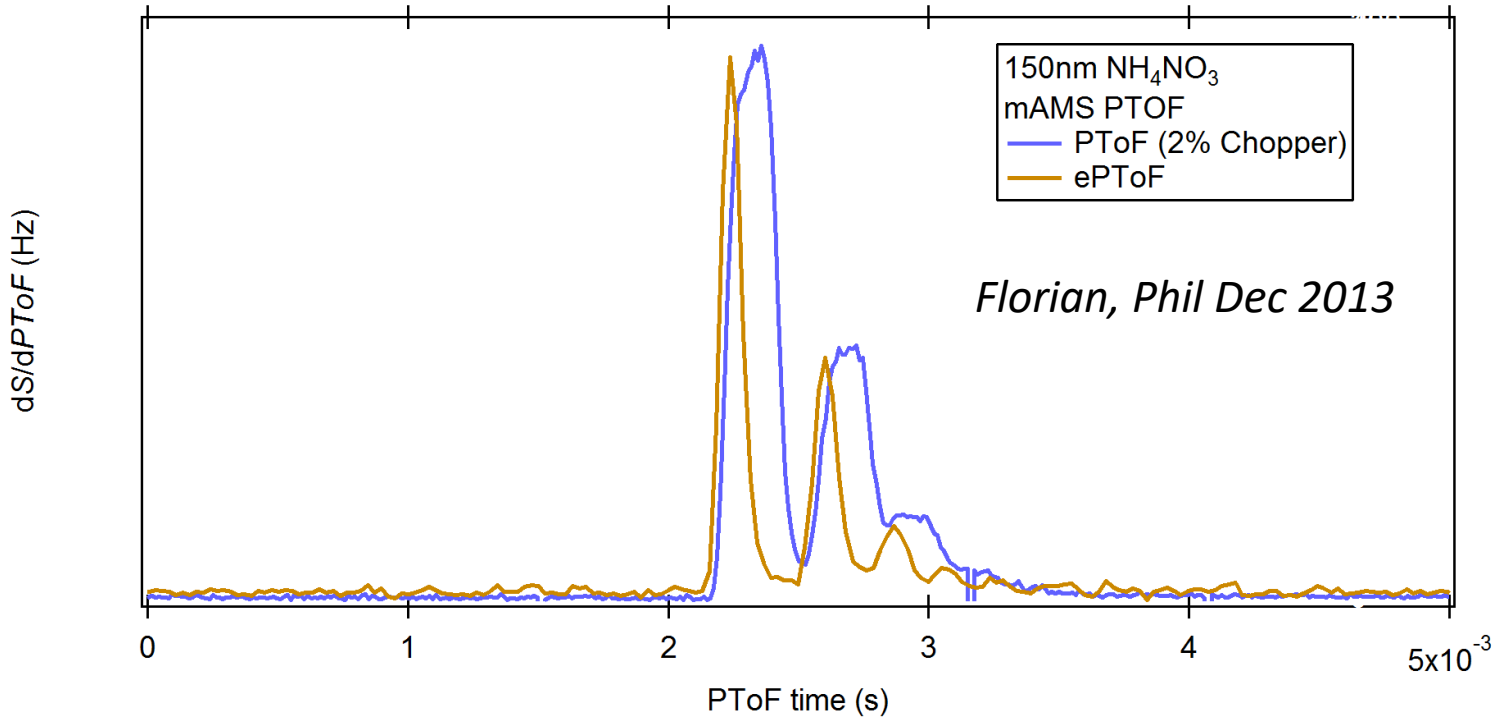
## Recorded with multi-slit wheel



# 300 nm NH4NO3 Data De-Multiplexed



# PTOF & ePTOF resolution comparison on Mini-AMS (24.5cm flight path)




ePTOF has higher resolution - 127 bit sequence → 1/127 = 0.78% (effective slit width) vs 2%

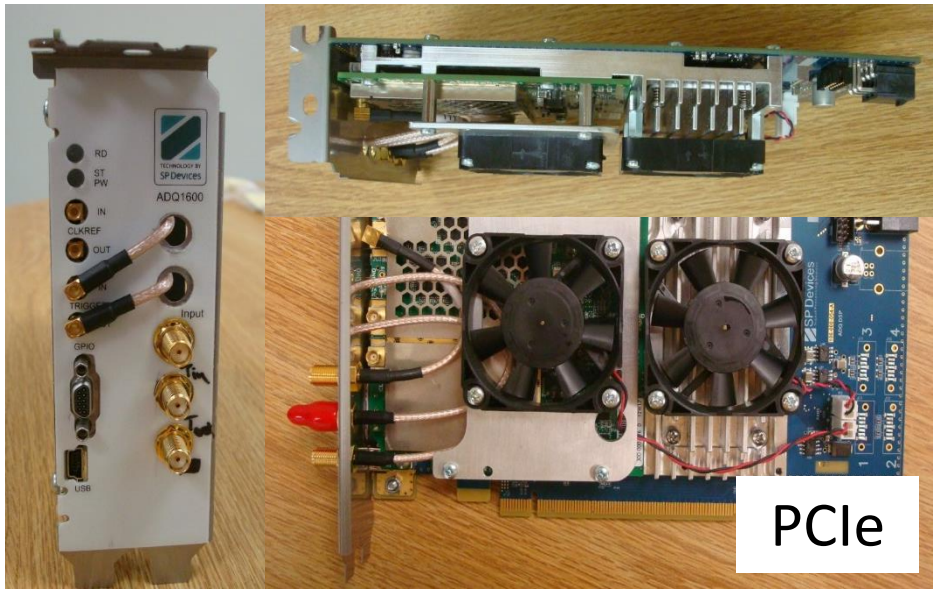
# ePTOF Hardware


- *Plans are underway for communication with AMS DAQ*
- *Improvements to speed regulation*
- *Updates from Florian, Pedro/ Donna/Joel*

Can be built on NW63 and NW100 flanges (AMS, mAMS compatible). 17 systems delivered.

# New Data Acquisition Card

## SP Devices ADQ1600





- Replaces AP240 (8 bit, 1 GS/sec; now discontinued)
- Fast with extended ADC range, 1.6 GS/sec,14 bit
- Custom firmware for AMS, ePTOF, event trigger modes.
- PCIe version replaced by USB-3 version → Can use smaller PC

# New Data Acquisition Card

## SP Devices ADQ1600

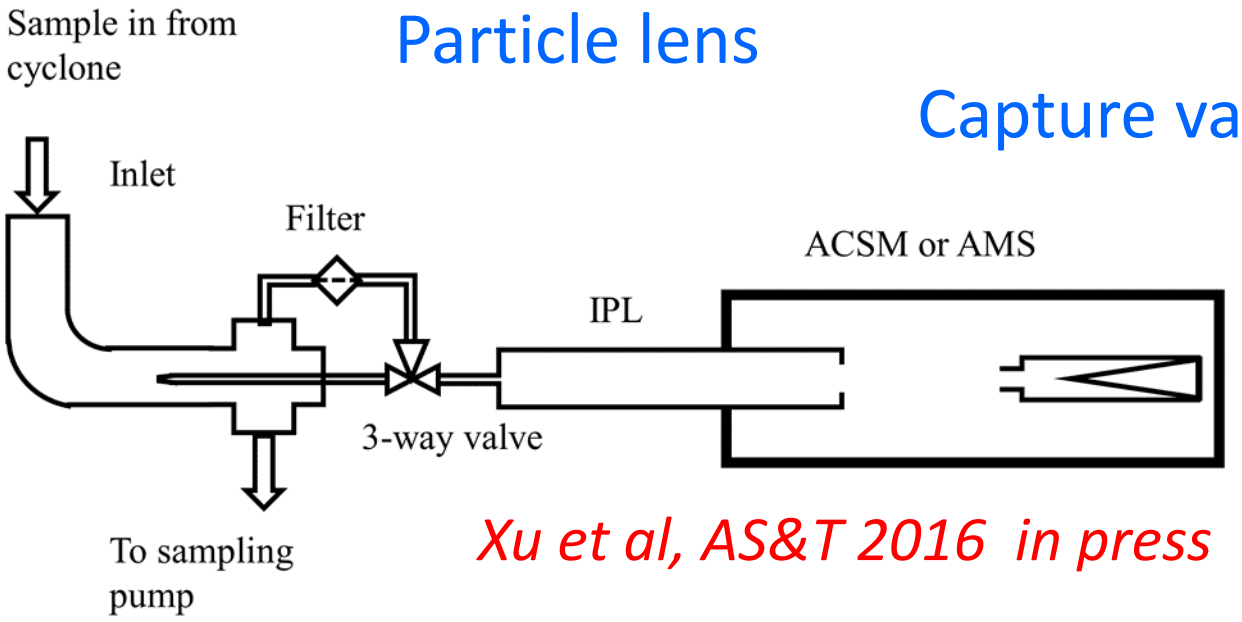
- Supports ePTOF acquisition mode.
- Single particle – Event Trigger mode
- Requires AMS DAQ V5,  strategic break point for AMS software. Joel will provide update on new AMS DAQ V5

# PM2.5 Capability

Sampling system,
inlet plumbing

Particle lens

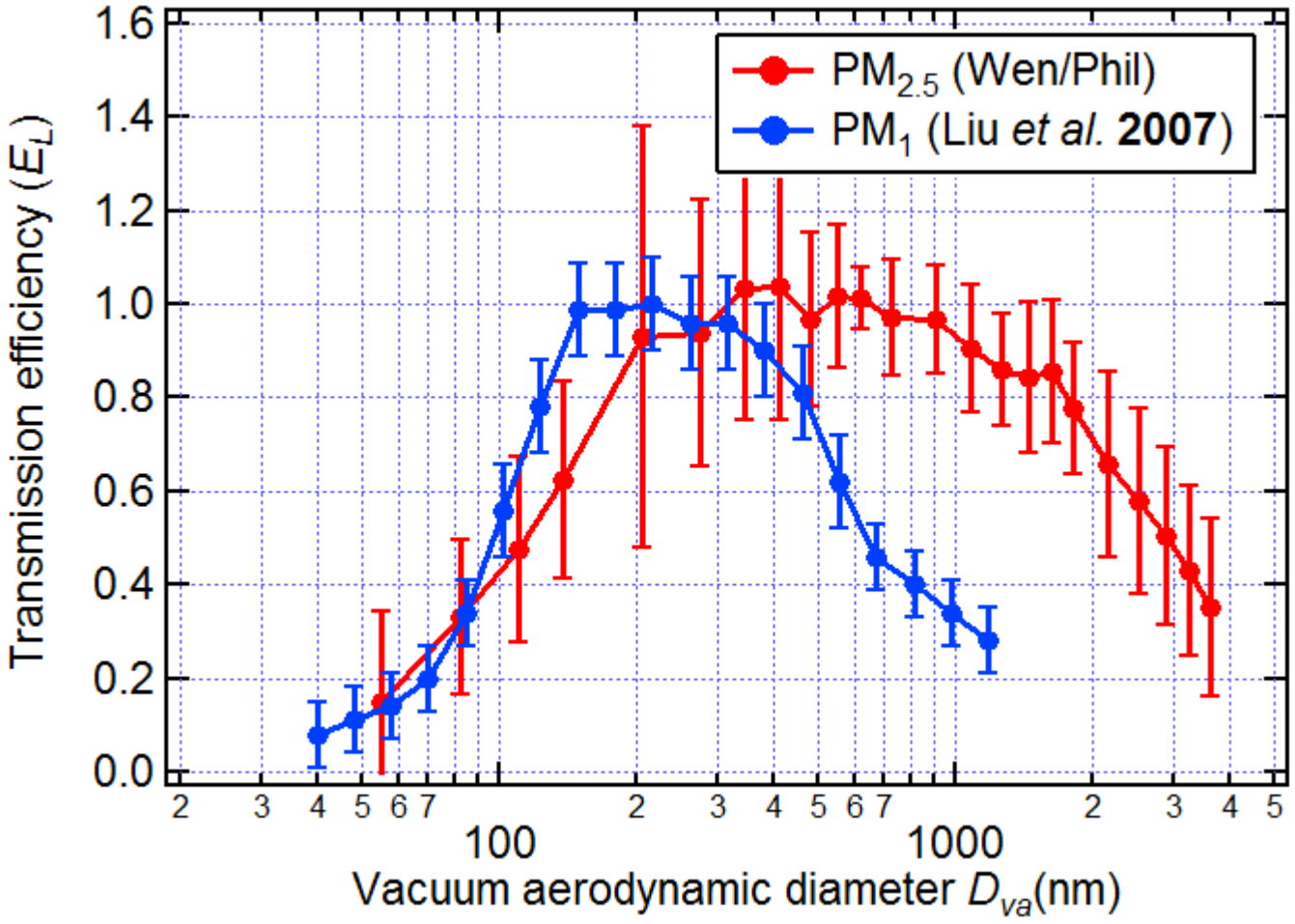
Capture vaporizer




*Xu et al, AS&T 2016 in press*

*First PM2.5 ACSM instrument - China deployments.*
*Updates from Phil, Yungjiang, Ping during ACSM session.*

# PM2.5 Lens Transmission

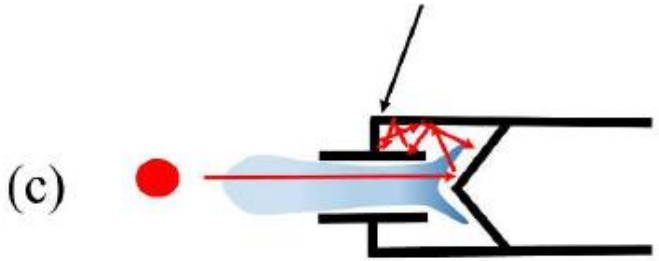



We have a design, making copies

# Evaluation of Particle Vaporizer Types

SV - Standard Vaporizer


CV - capture Vaporizer



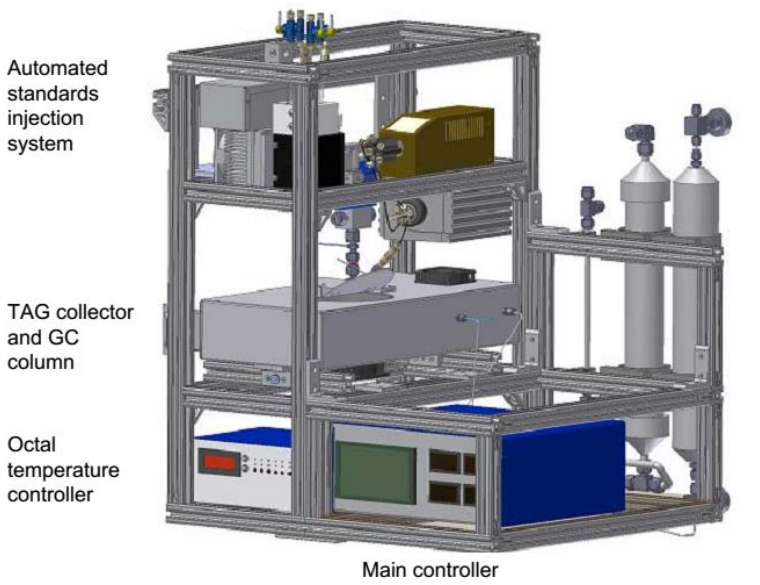

*Xu et al., AS&T in press 2016*
*Hu et al, submitted AMTD, 2016*

# TAG-AMS Updates

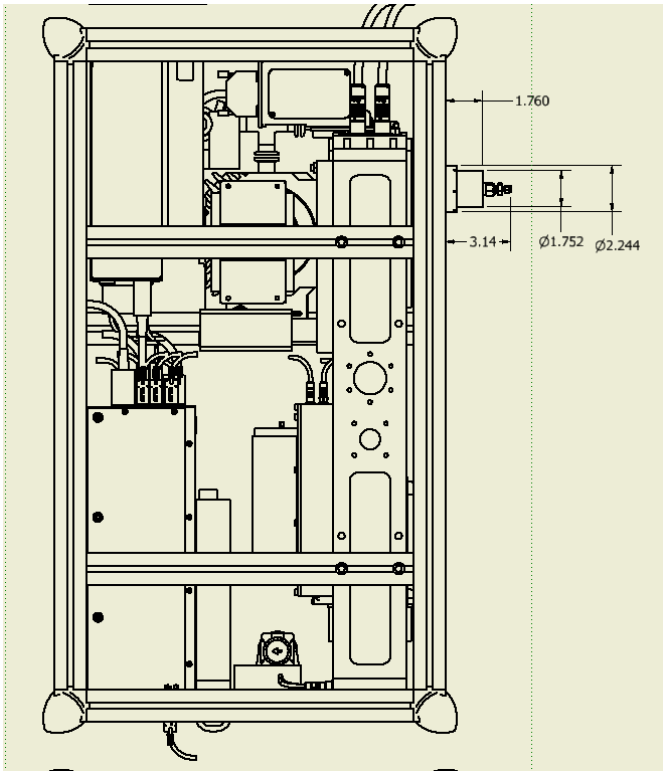
*Collaboration with UC Berkeley and ADI*

Thermal Desorption Aerosol GC/MS

## Molecular identification for organic aerosol constituents



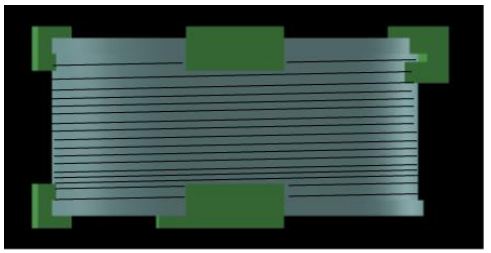

TAG Collector Module

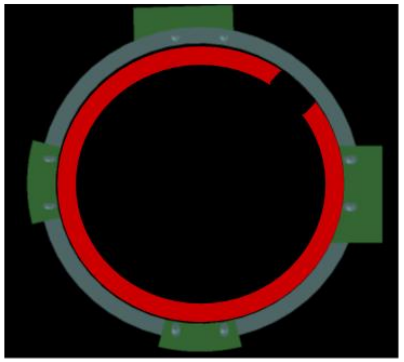


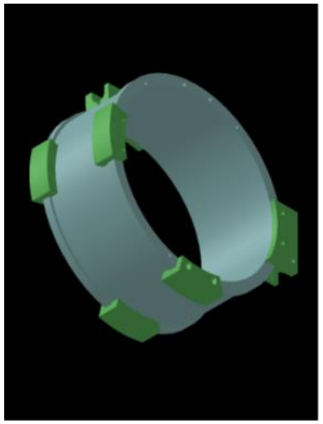

GC HTOF

# Mini GC “Oven”

*Nathan Kreisberg, ADI*



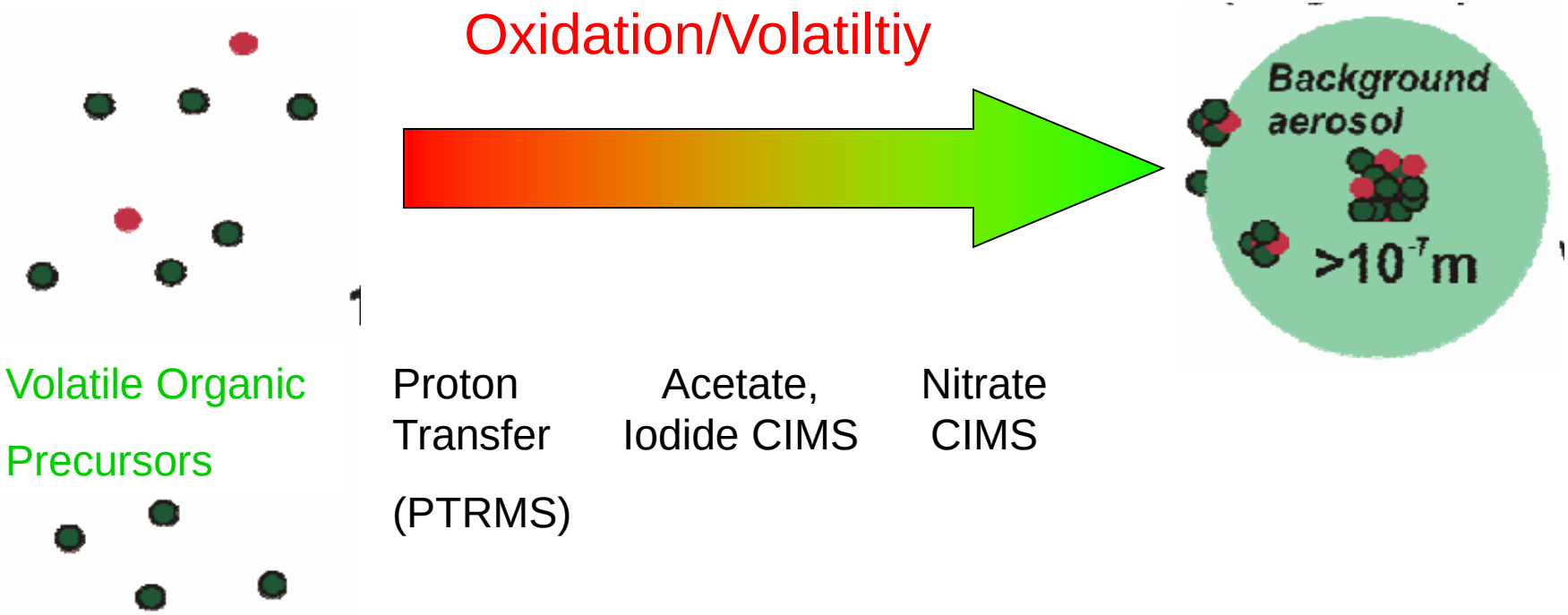




- Simple aluminum 8 cm OD hub for wrapping column
- Hub is heated by an expanding band heater (150W)

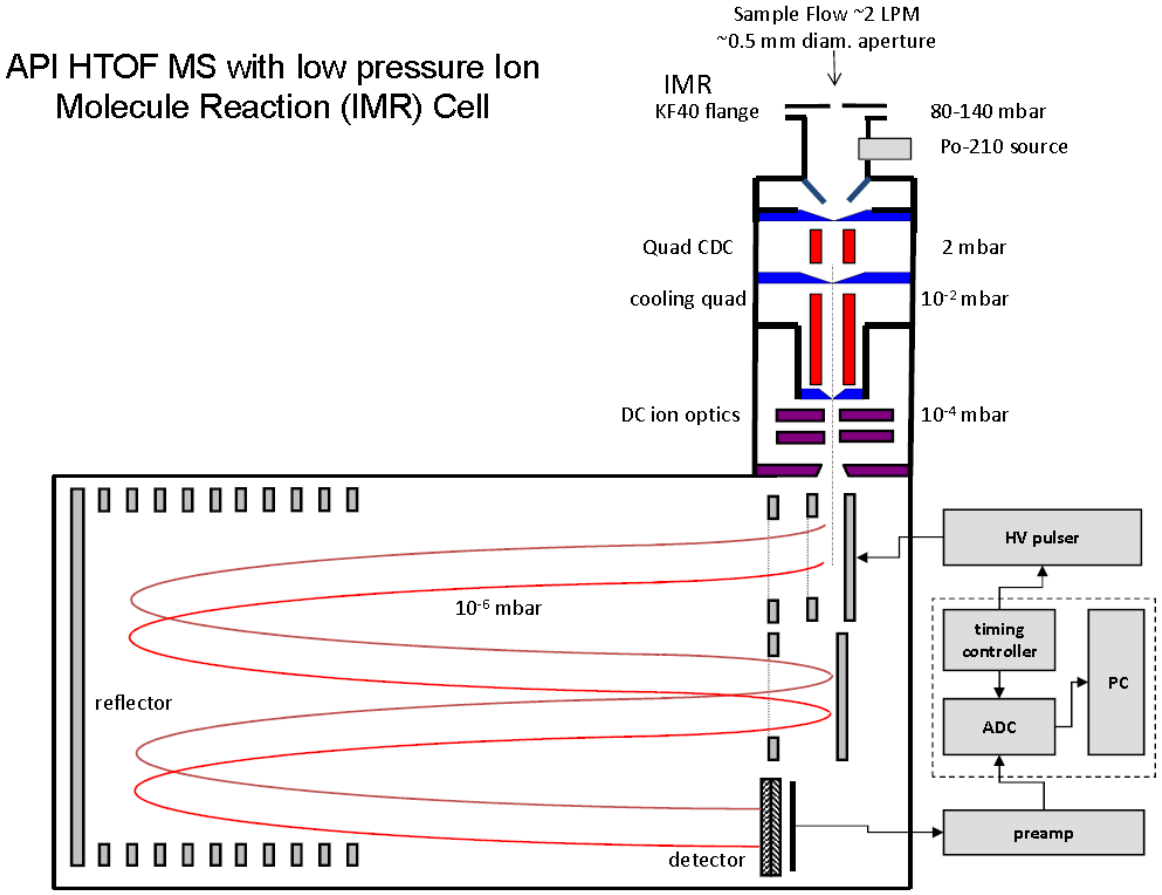
Replaces the Vici coated column which previously replaced the ‘conventional’ GC box oven

# Increasing Focus on Detection of Gas Phase Oxidized Organic Compounds



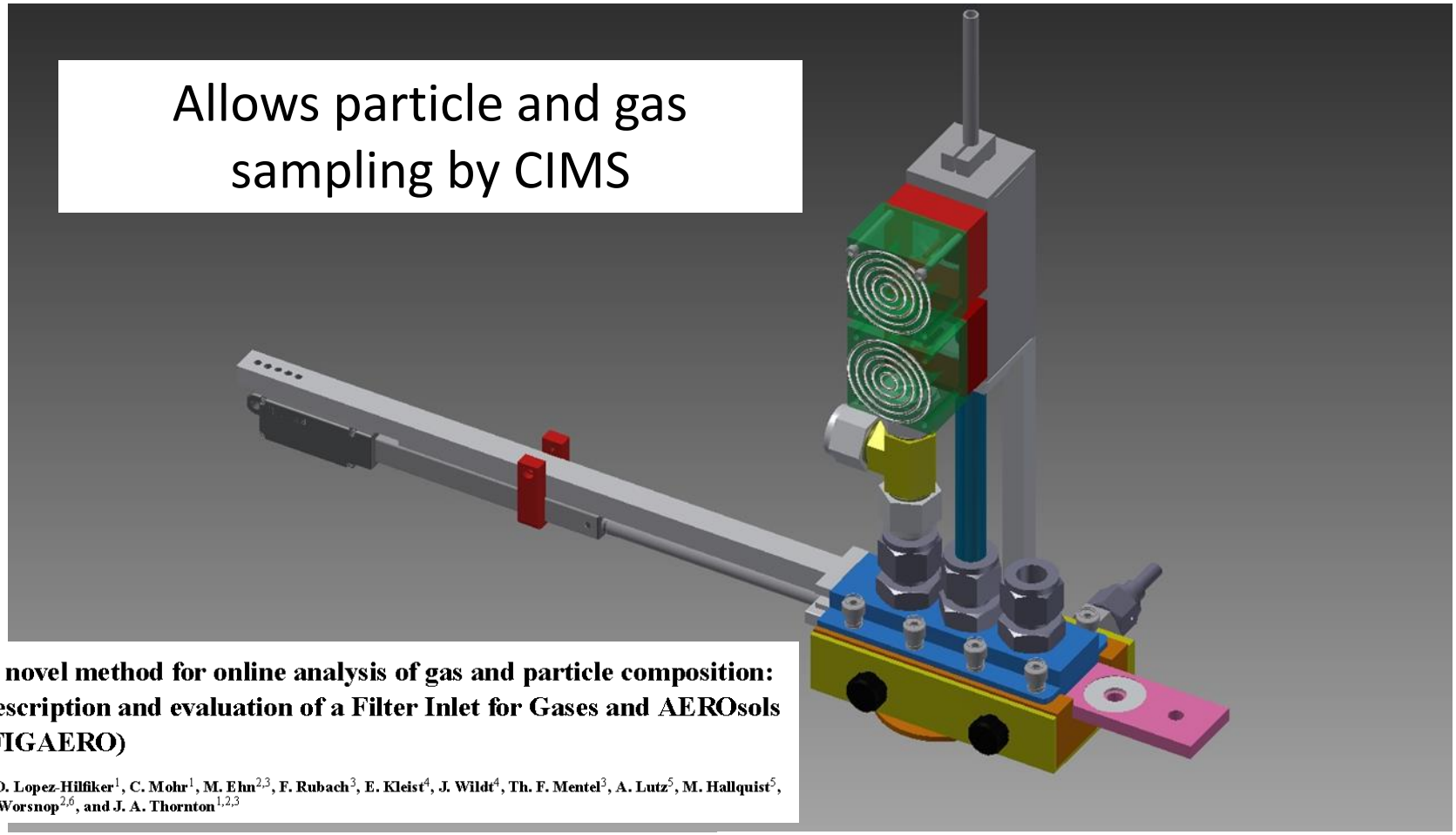

- Chemical Ionization Mass Spectrometry (CIMS)
- High sensitivity and selectivity (molecular identification
- GOAL: Connect gas phase aerosol precursors with AMS particle data

# High Resolution Chemical Ionization Mass Spectrometer - CIMS




- Can be configured with various reagent ionization sources.
- Can also detect naturally occurring ambient ions - Api-TOF

# FIGAERO
# Jointly developed with Thornton Group UW
# Modelled after Lopez-Hilfiger et al, 2014



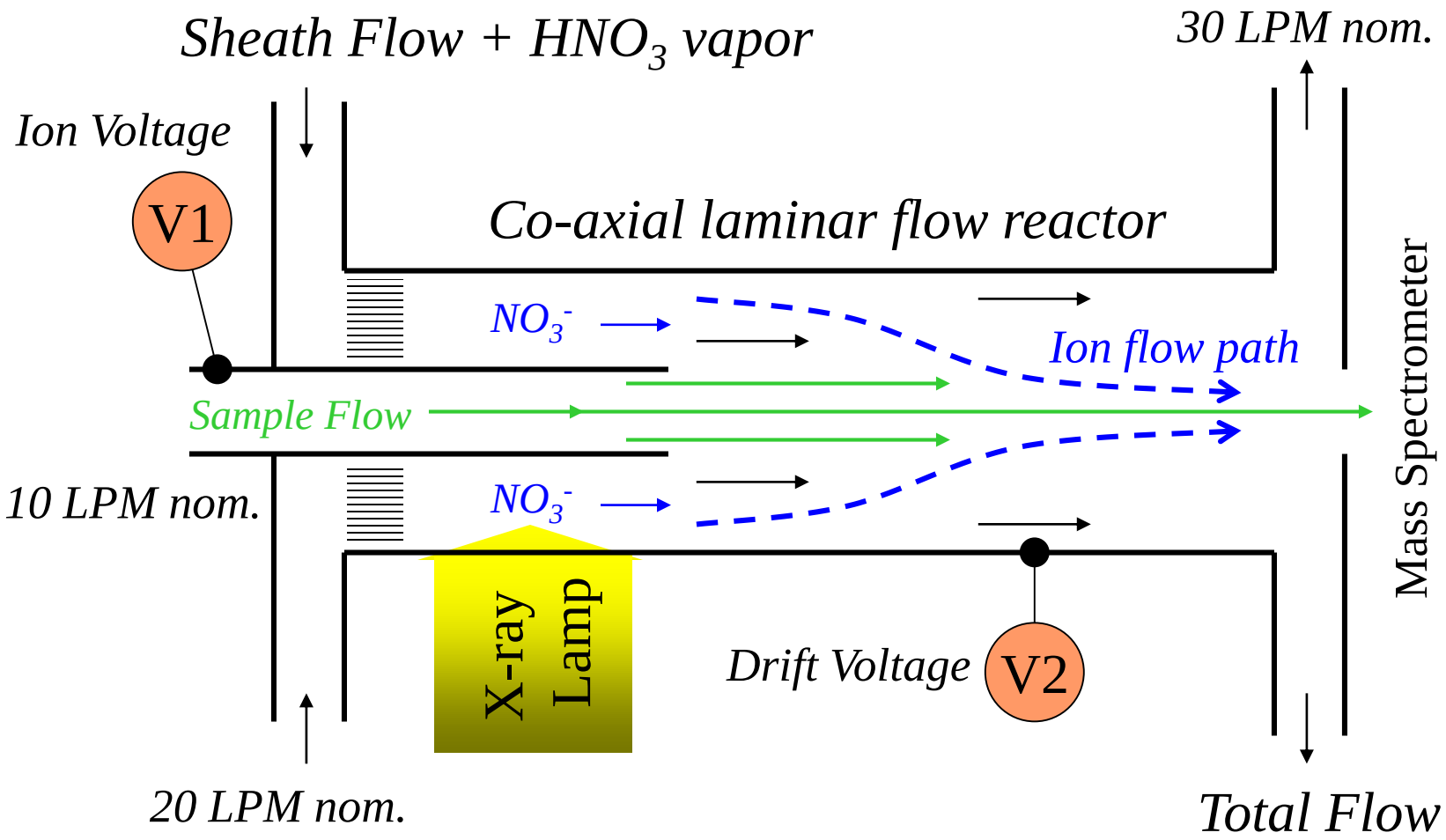

**A novel method for online analysis of gas and particle composition: description and evaluation of a Filter Inlet for Gases and AEROsols (FIGAERO)**

F. D. Lopez-Hilfiker[1], C. Mohr[1], M. Ehn[2,3], F. Rubach[3], E. Kleist[4], J. Wildt[4], Th. F. Mentel[3], A. Lutz[5], M. Hallquist[5], D. Worsnop[2,6], and J. A. Thornton[1,2,3]

Atmos. Meas. Tech., 7, 983–1001, 2014
www.atmos-meas-tech.net/7/983/2014/
doi:10.5194/amt-7-983-2014

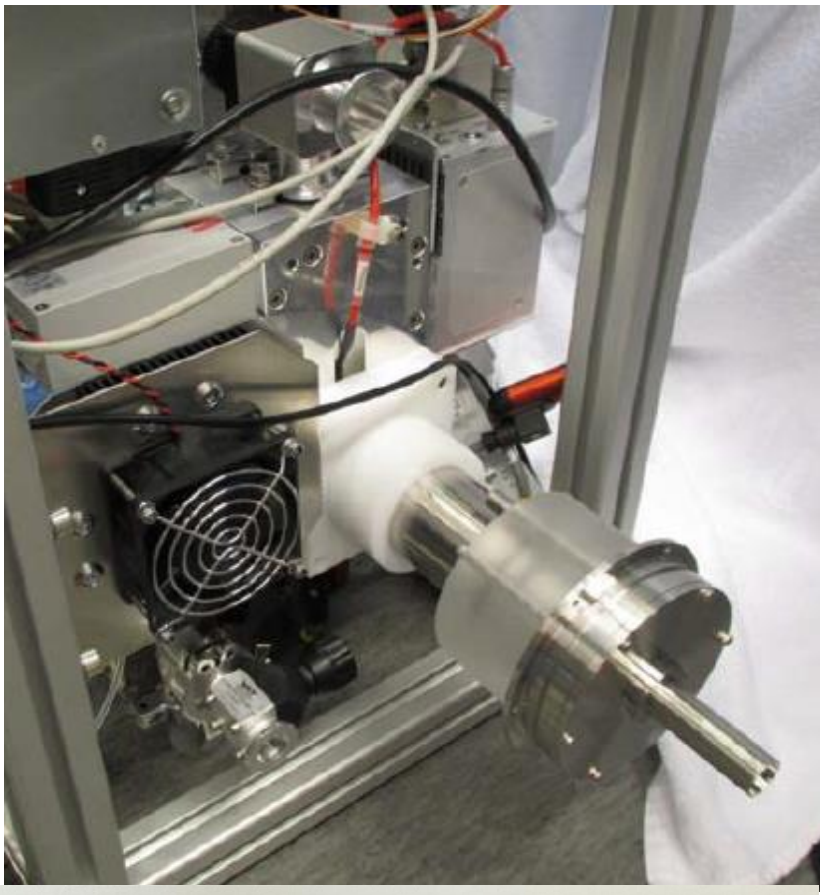

Atmospheric Measurement Techniques
Open Access

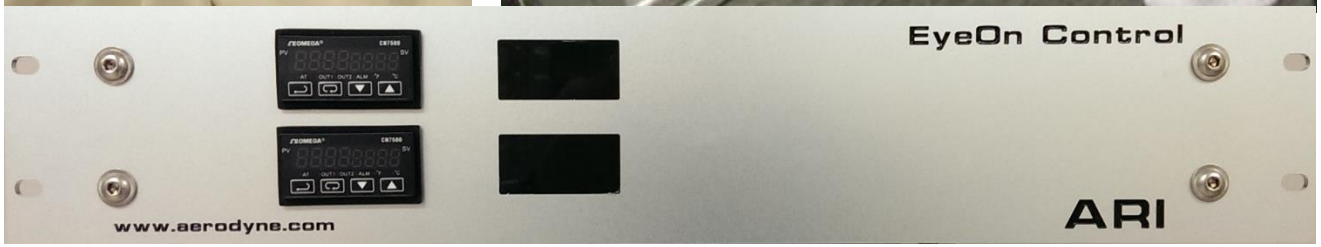
# Nitrate Ion Chemical Ionization Source for API-TOF Mass Spectrometer System




*Eisele, F. and Tanner, D. Measurement of the gas phase concentration of H2SO4 and methane sulfonic acid and estimates of H2SO4 production and loss in the atmosphere, J. Geophys. Res., 98(D5), 9001–9010, 1993.*

# Nitrate Ion Source and Installation on Mass Spectrometer with EyeOn Control System

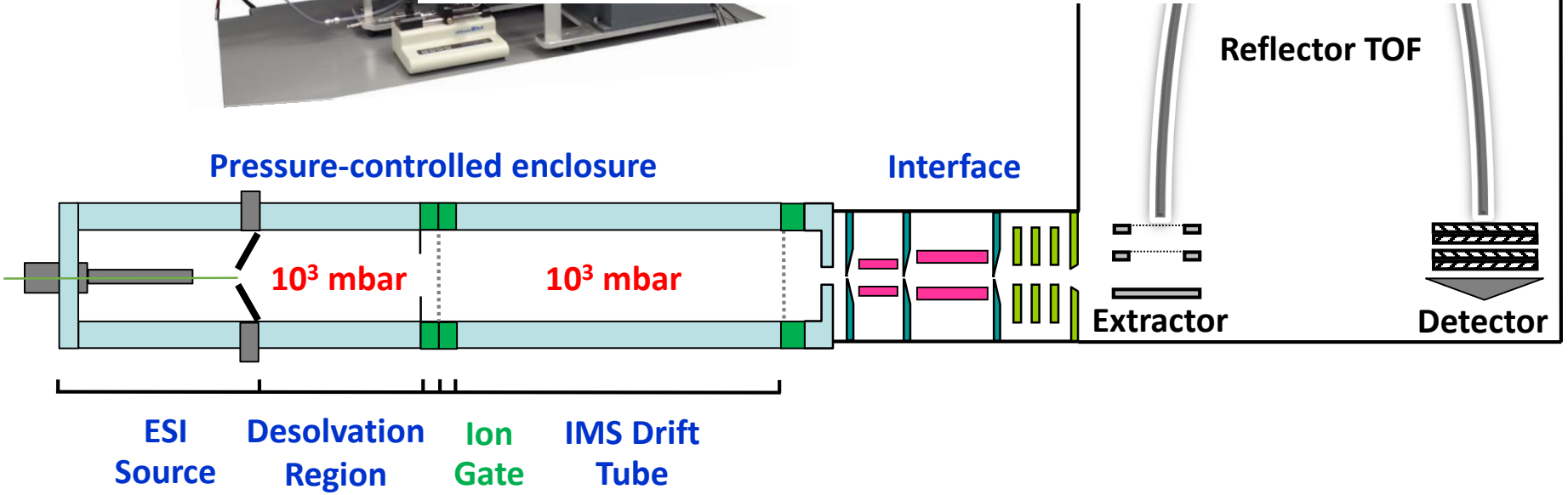




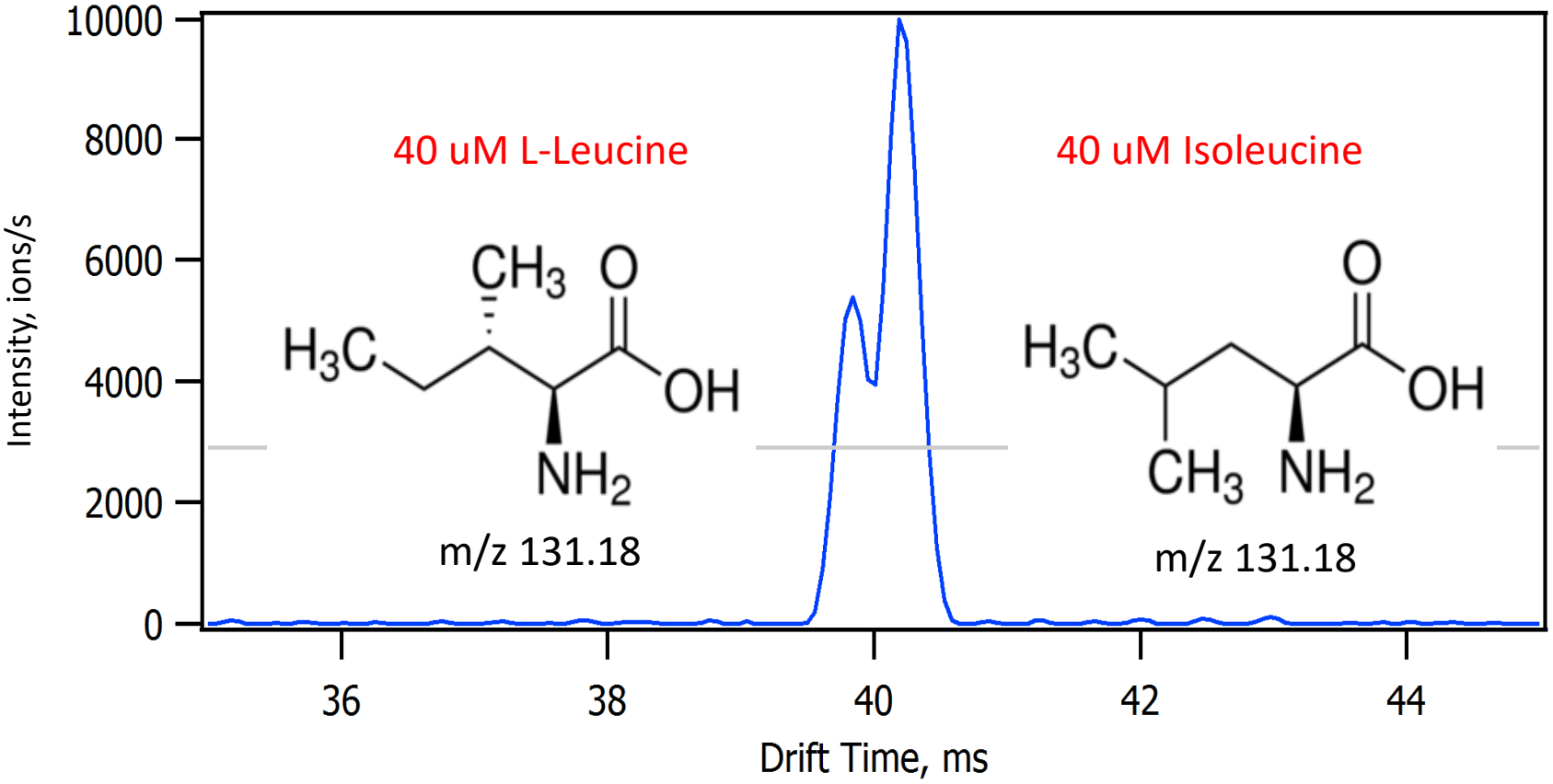
# What is next? Ion Mobility TOF MS Structures, More than just Chemistry

**Low field Drift Tube**
P = 1 atm
T = 50 – 150 °C
Resolution > 100
Multiplexing

- Separation of structurally similar isobaric compounds.
- High pressure drift tube == high resolving power in compact instrument
- ESI-ElectroSpray Interface for application to PM filter extracts.
- Will soon be testing a gas phase source.

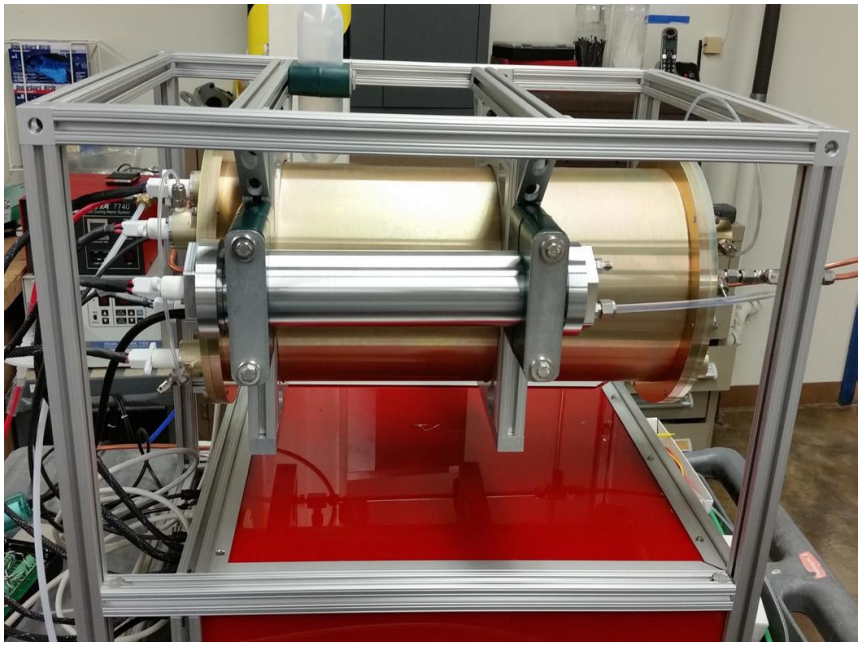


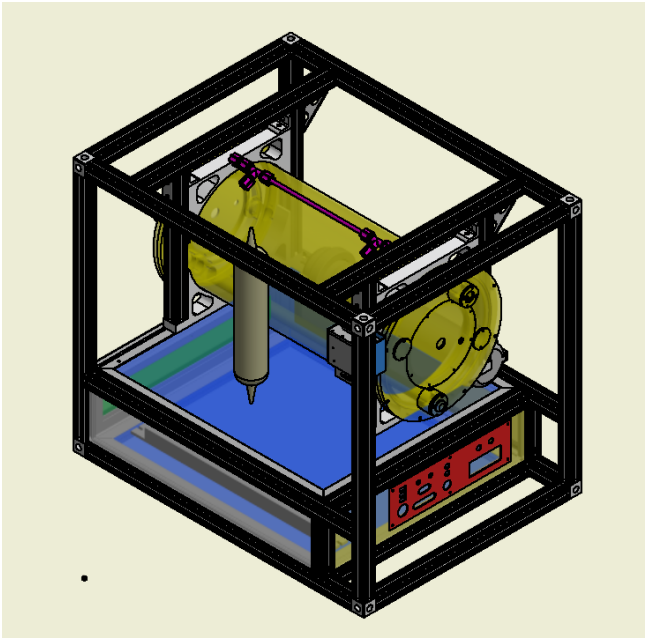
# Isomer separation by Ion Mobility Mass Spectrometer




Xuan Zhang, Manjula Canagaratna

# Potential Aerosol Mass (PAM) Oxidation Flow Reactor



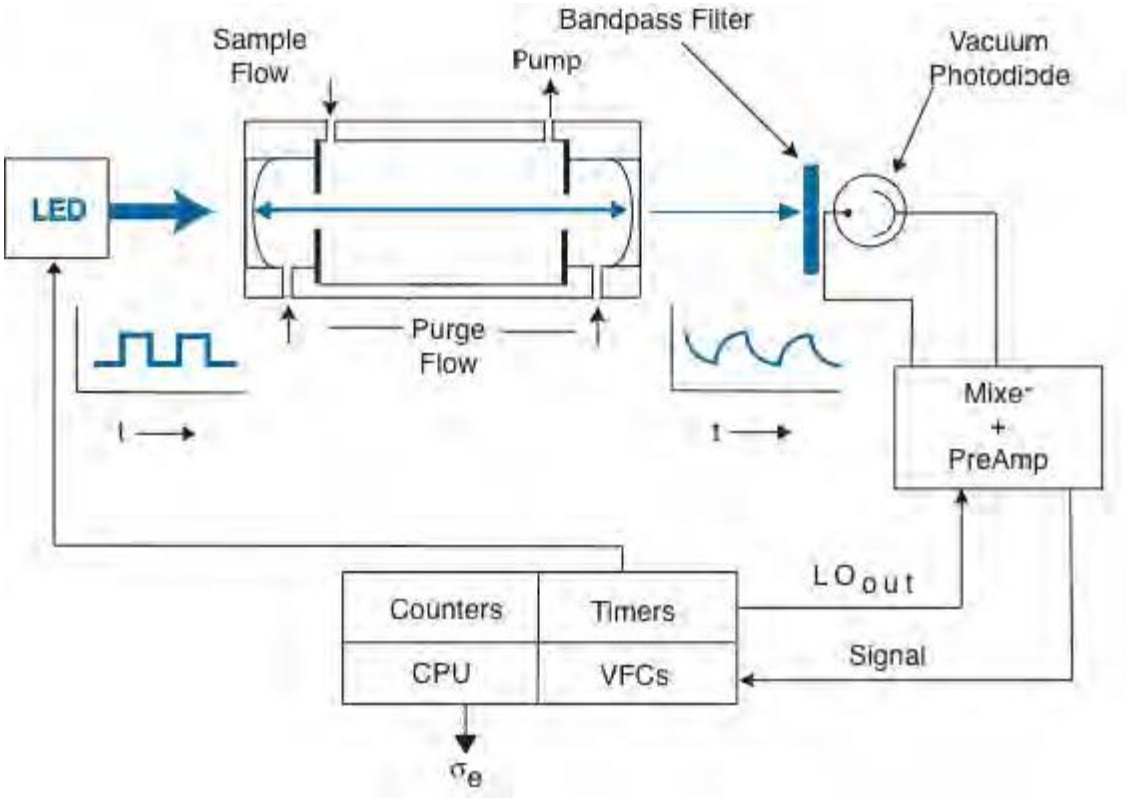


A. Lambe, J. Jayne, W. Robinson, X. Cabral, S. Prescott
Aerodyne Research, Inc.
Bill Brune, Pennsylvania State University

Kang et al. (2007), Lambe et al. (2011)

# CAPS Pmex and SSA Monitors

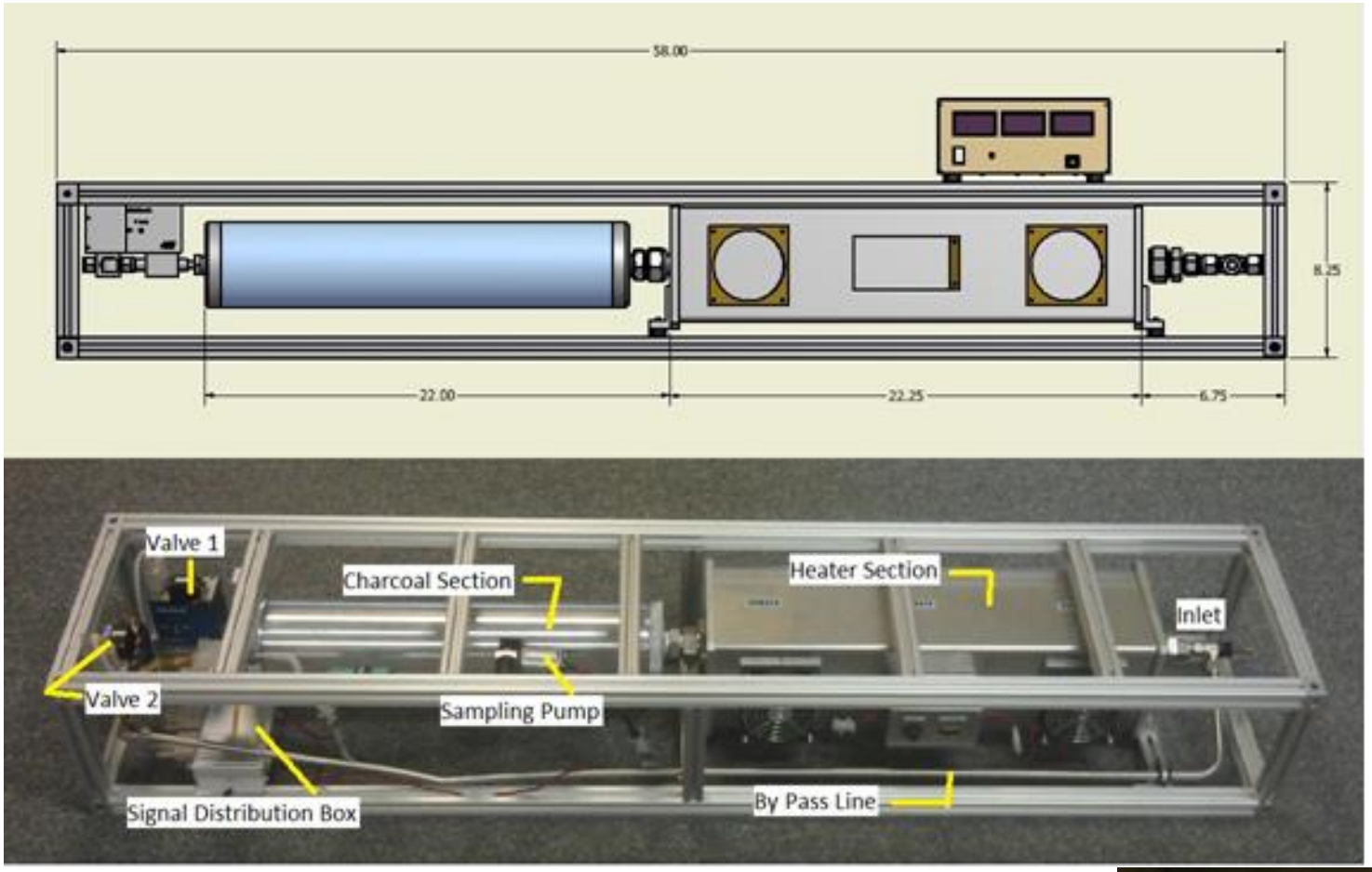
## Particle Extinction and Single Scattering Albedo




3-wavelength version now available

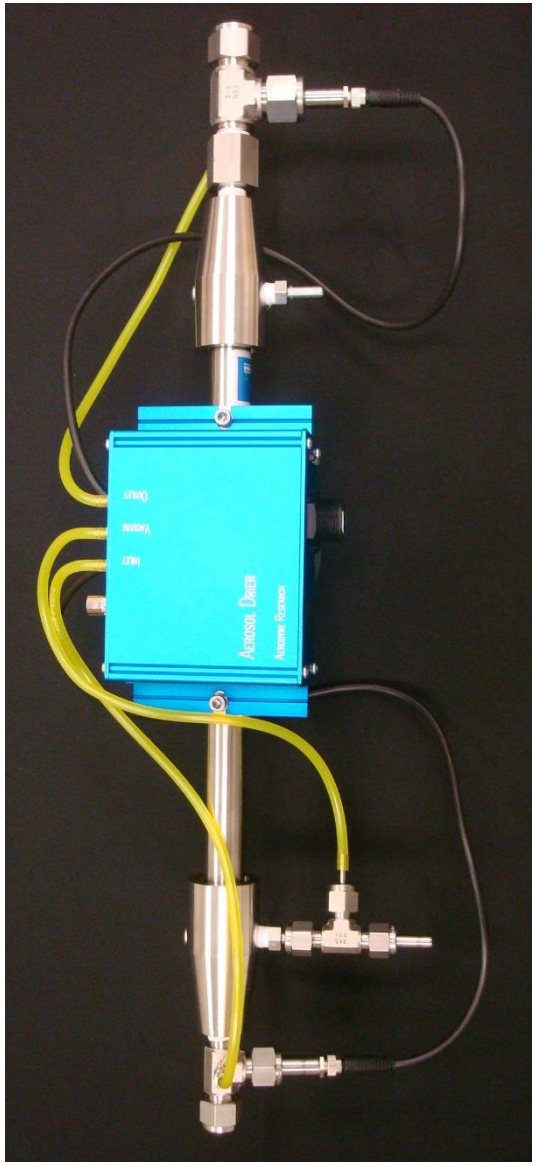
*Andy Freedman/Tim Onasch*

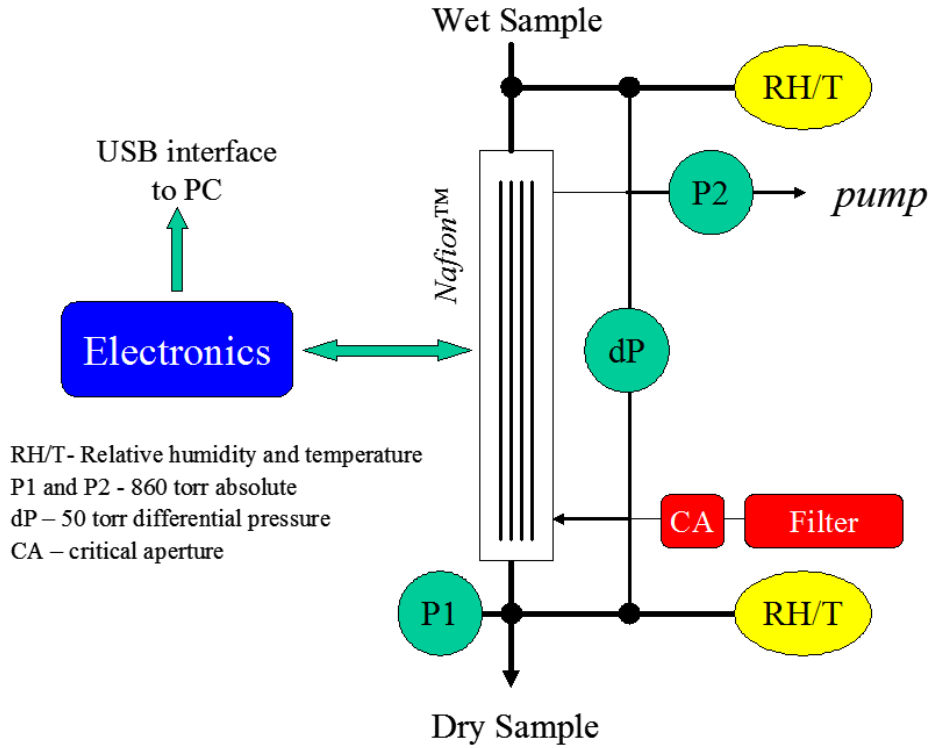
# Thermal Denuder System

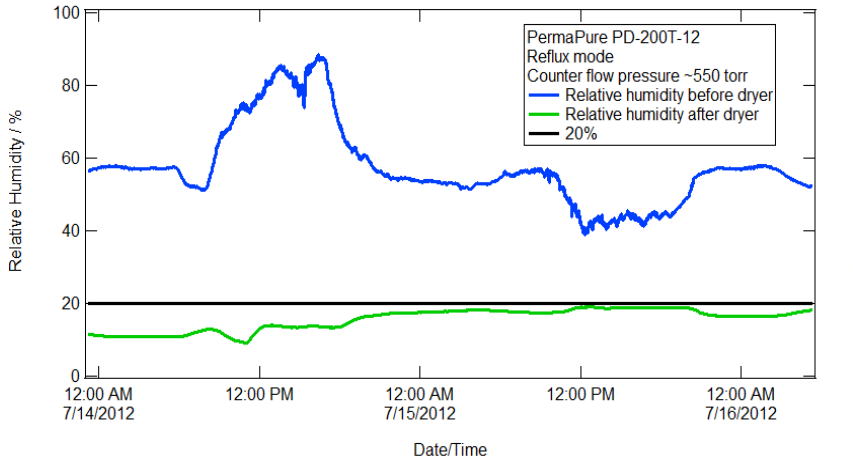



For aerosol volatility studies

# Aerosol Sample Dryer System

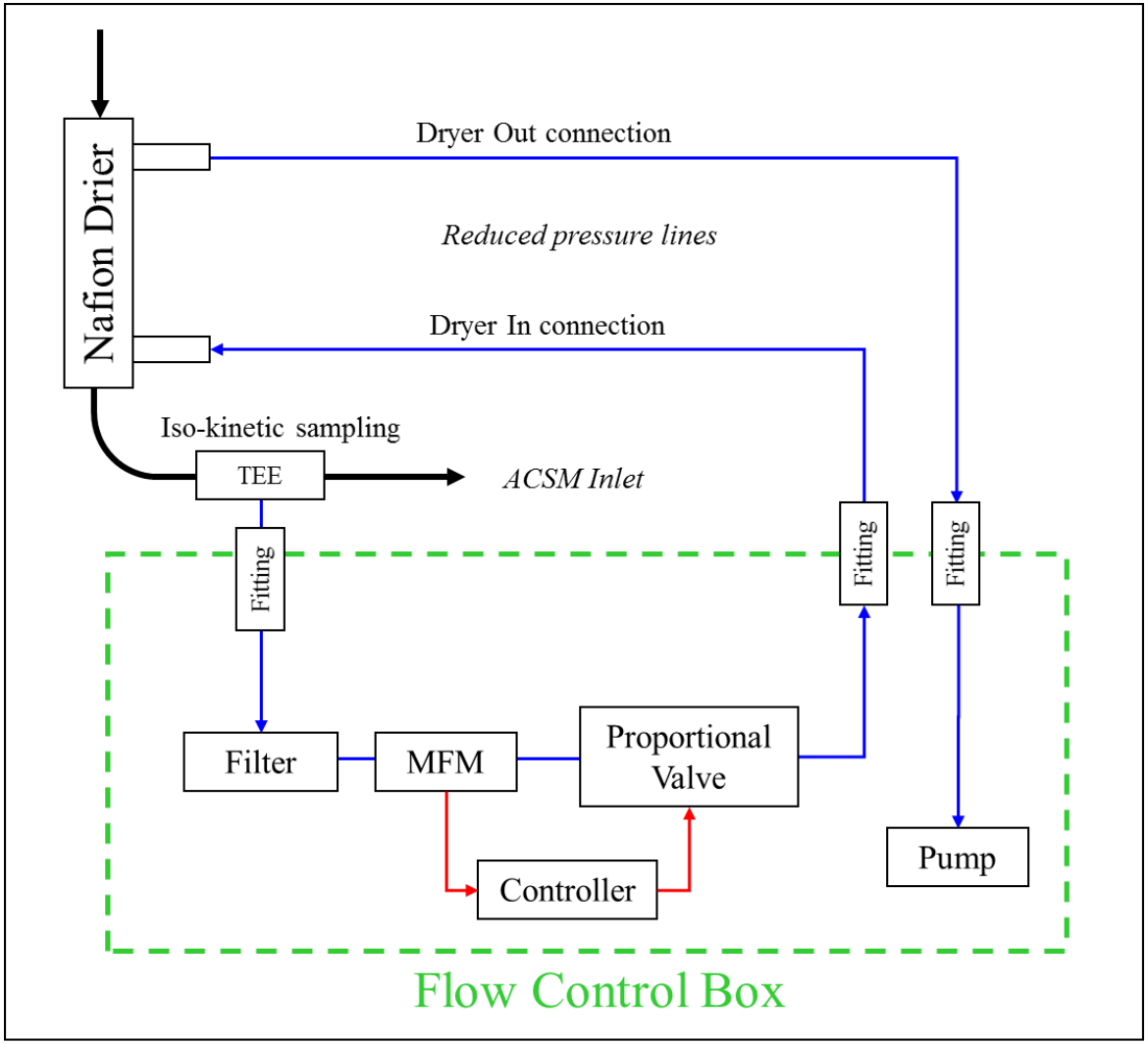




# Sample Line Flow Controller System


- Light weight, low power (24V)
- Up to 10 LPM
- Compatible with Dryer system



# ARI Autovalve

*Electrically actuated valve driver for automated sampling applications*

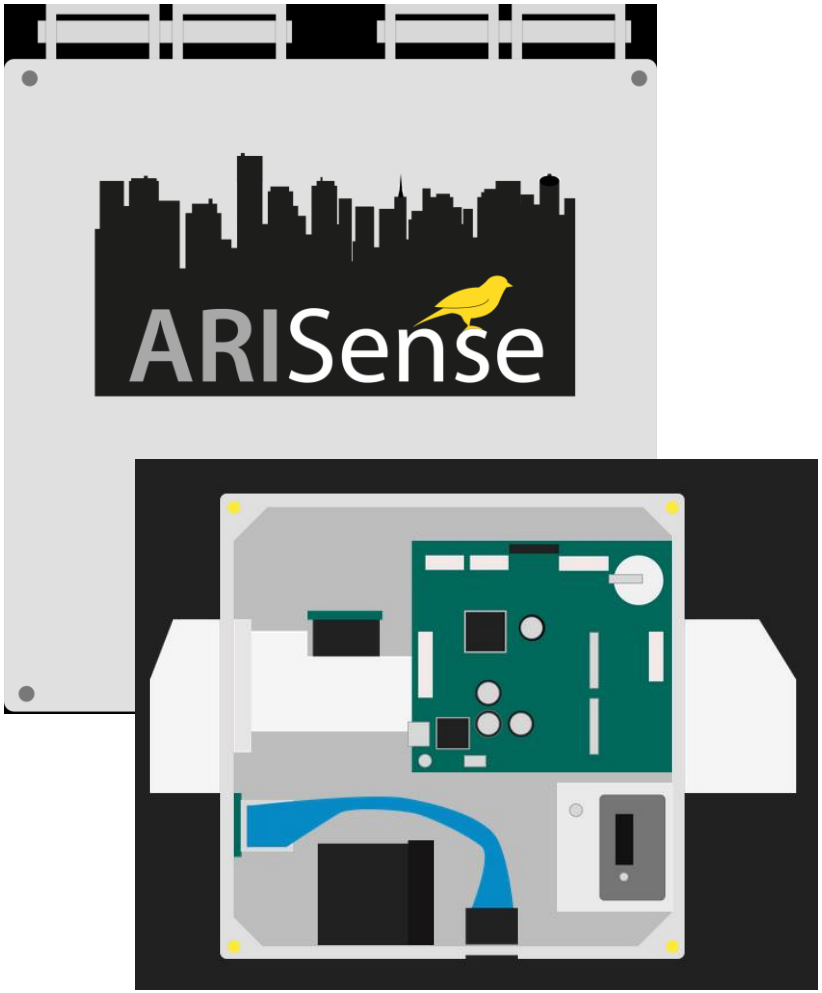

*Swagelok SS-44S6*

- Adaptable for 40 and 40G series on-off and 3-way valves. Also have drivers for Nupro ¼-turn plug valves.
- Fast switching (< 1 second).
- Low power (~10W) DC voltage (7.5 – 24V) operation.
- No heating of valve body.
- Limit switches for position sensing.
- Servo driven for precise positioning.
- Manual and remote (TTL) control.
- Lifetime testing on-going.

Also being used on the TD, MOVI and TAG systems

# ARISense
# Low Cost Air Quality Sensor System

*Eben Cross*




16 Measurements

- CO, NO, NO2, Ox, CO2
- Particle size ~(0.4 -17) um, 16 bins
- PM1, 2.5, 10
- Wind speed, Wind direction
- Solar
- Sound/noise
- Barometric pressure
- Relative Humidity
- Temperature

Data saved locally and to the web.

END