

What are We Breathing on Shaw Avenue?

Understanding the Chemical Makeup and Health
Implications of Individual Particles

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Many Thanks to

Keith Bein, UC Davis

Yongjing Zhao, UC Davis

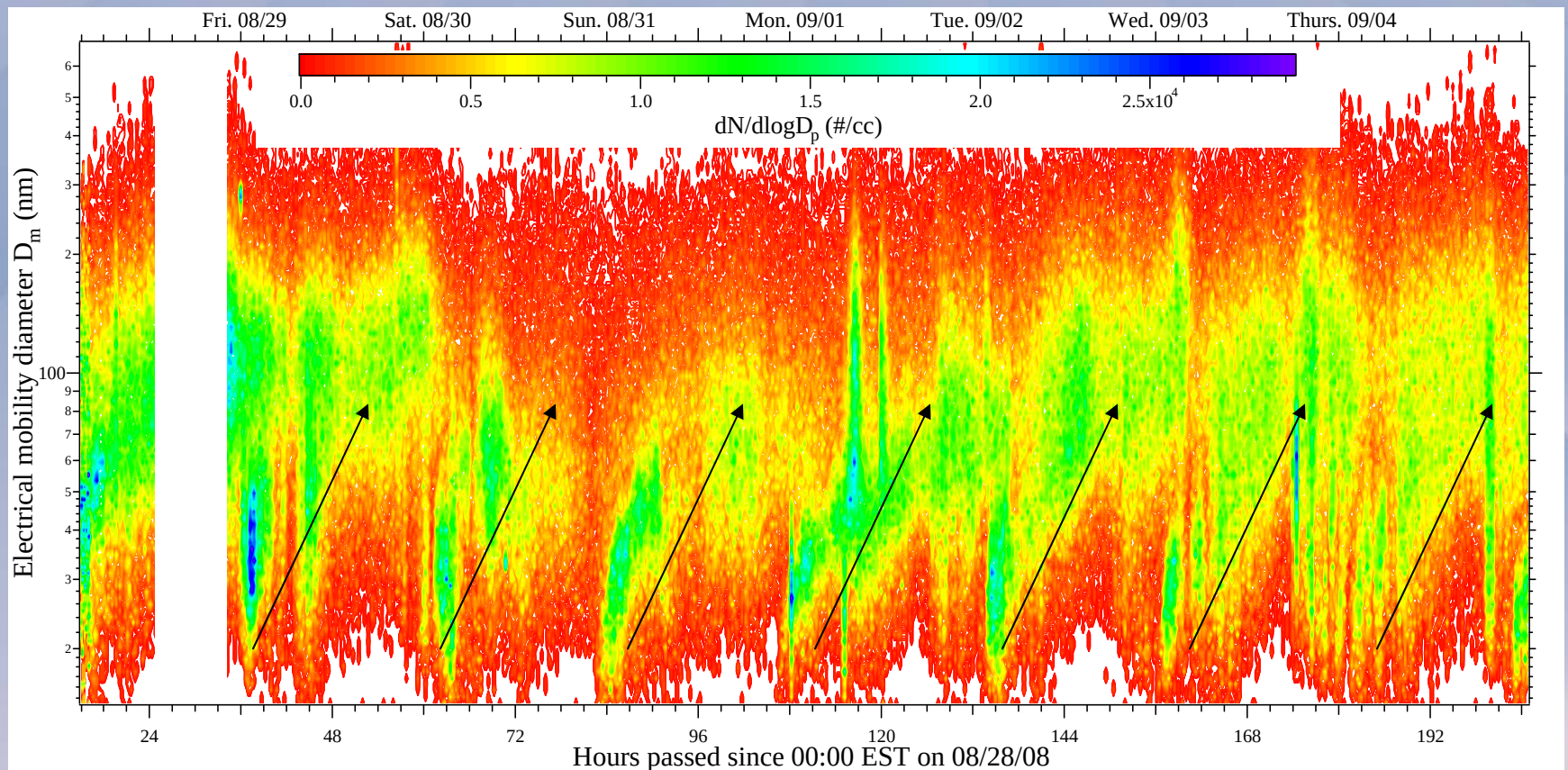
Kent Pinkerton, UC Davis

A Particle Number View

Repeated Patterns of Particle Number
Single-Particle Composition
Source-Oriented Sampling

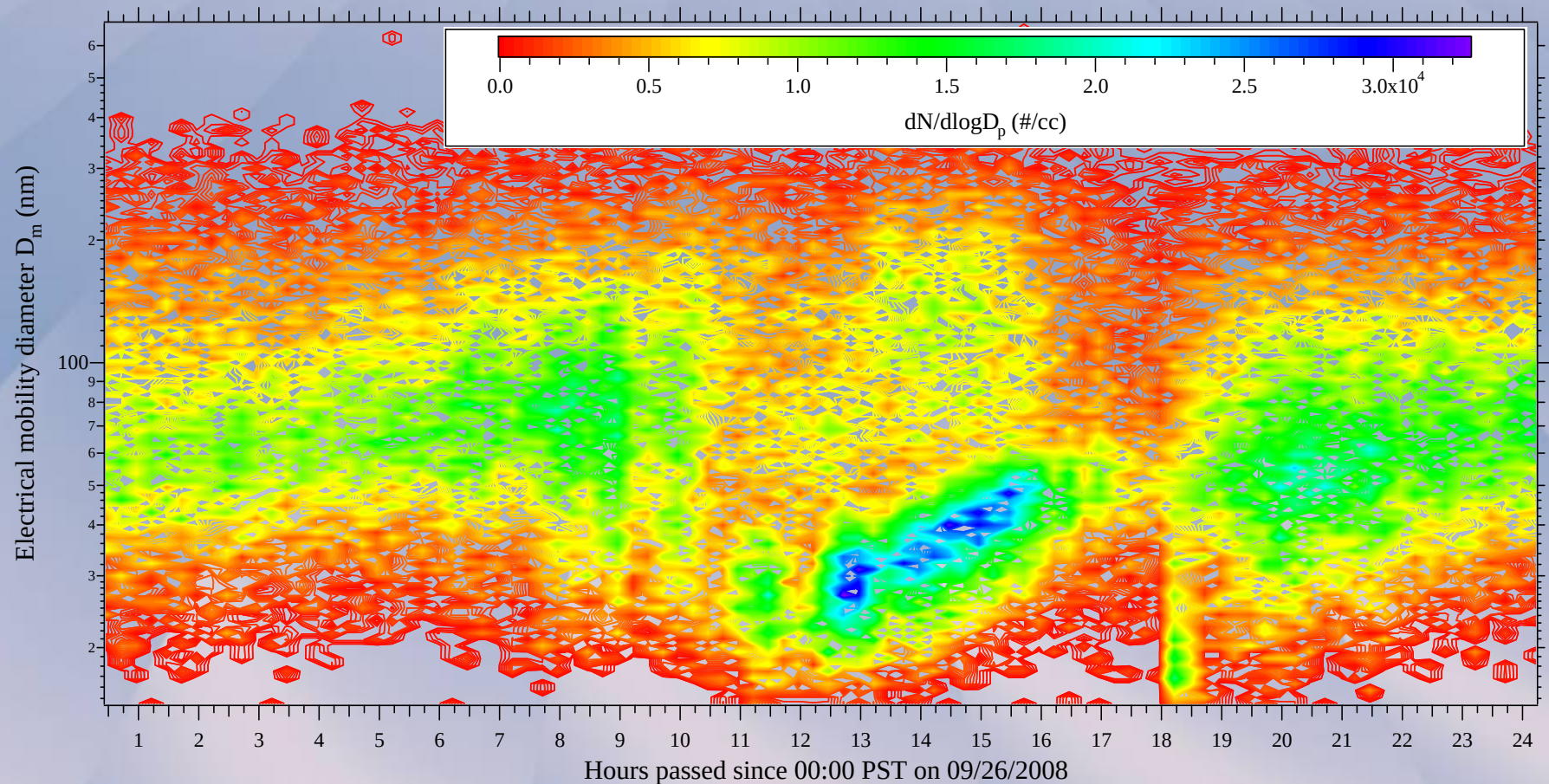
Summertime Diurnal Variation in Particle Number Size Distribution

Fresno, CA 08/29/2008-09/04/2008

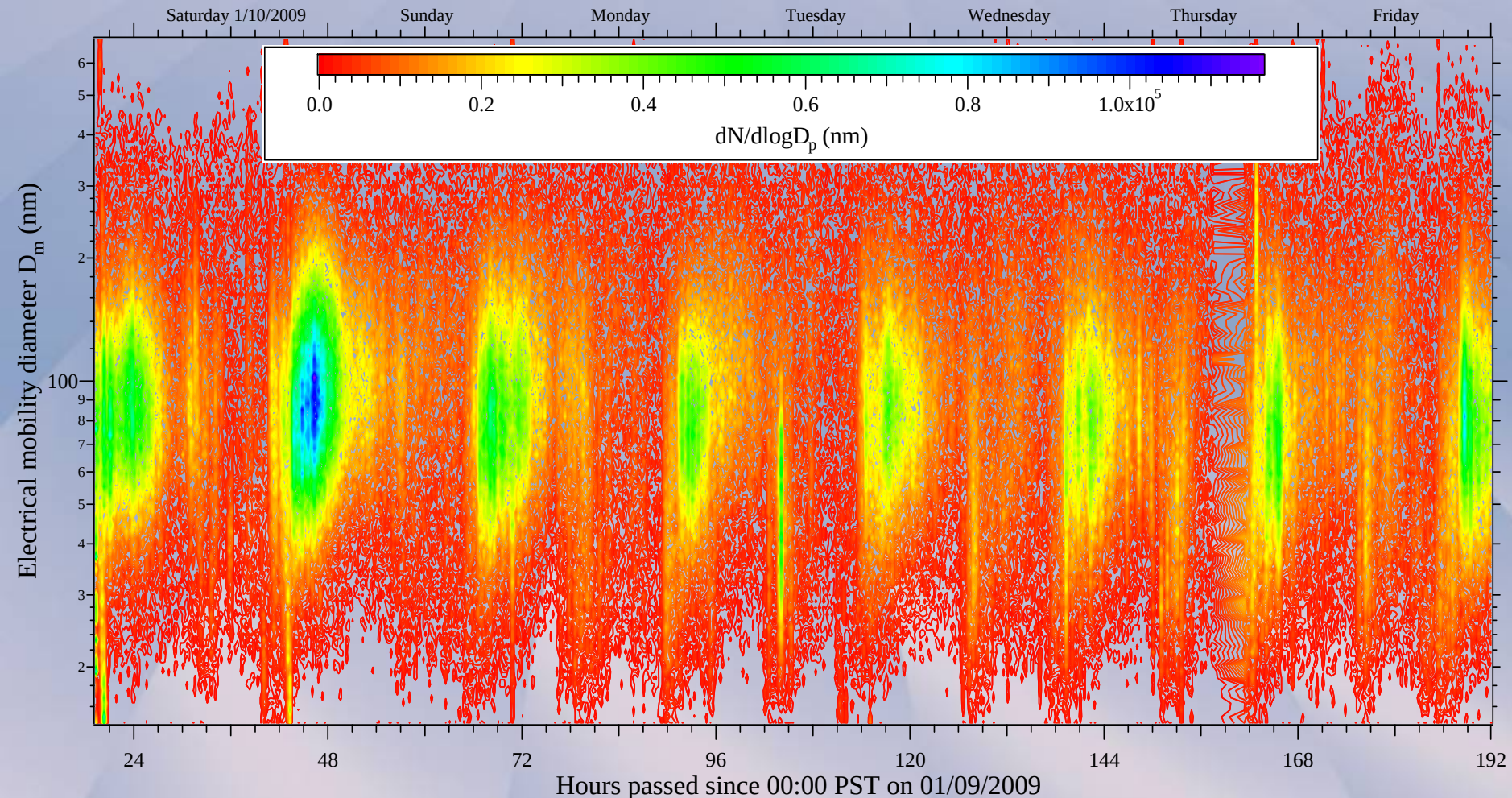


Summertime Diurnal Variation in Particle Number Size Distribution

Fresno, CA 09/26/2008

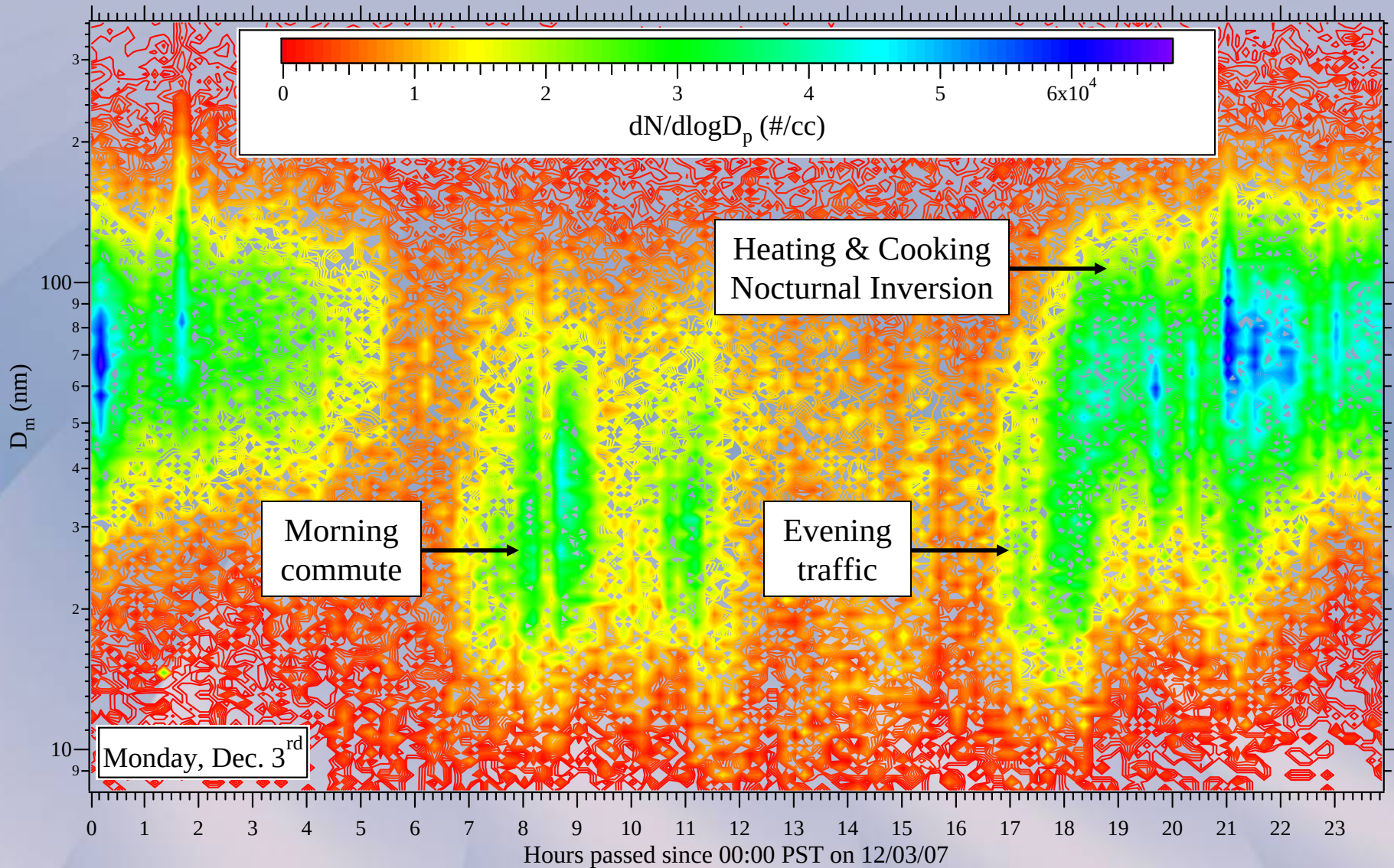


Wintertime Diurnal Variation in Particle Number Size Distribution Fresno, CA 01/09/2009-01/16/2009



Typical Wintertime Sources

Fresno, CA 12/03/2007

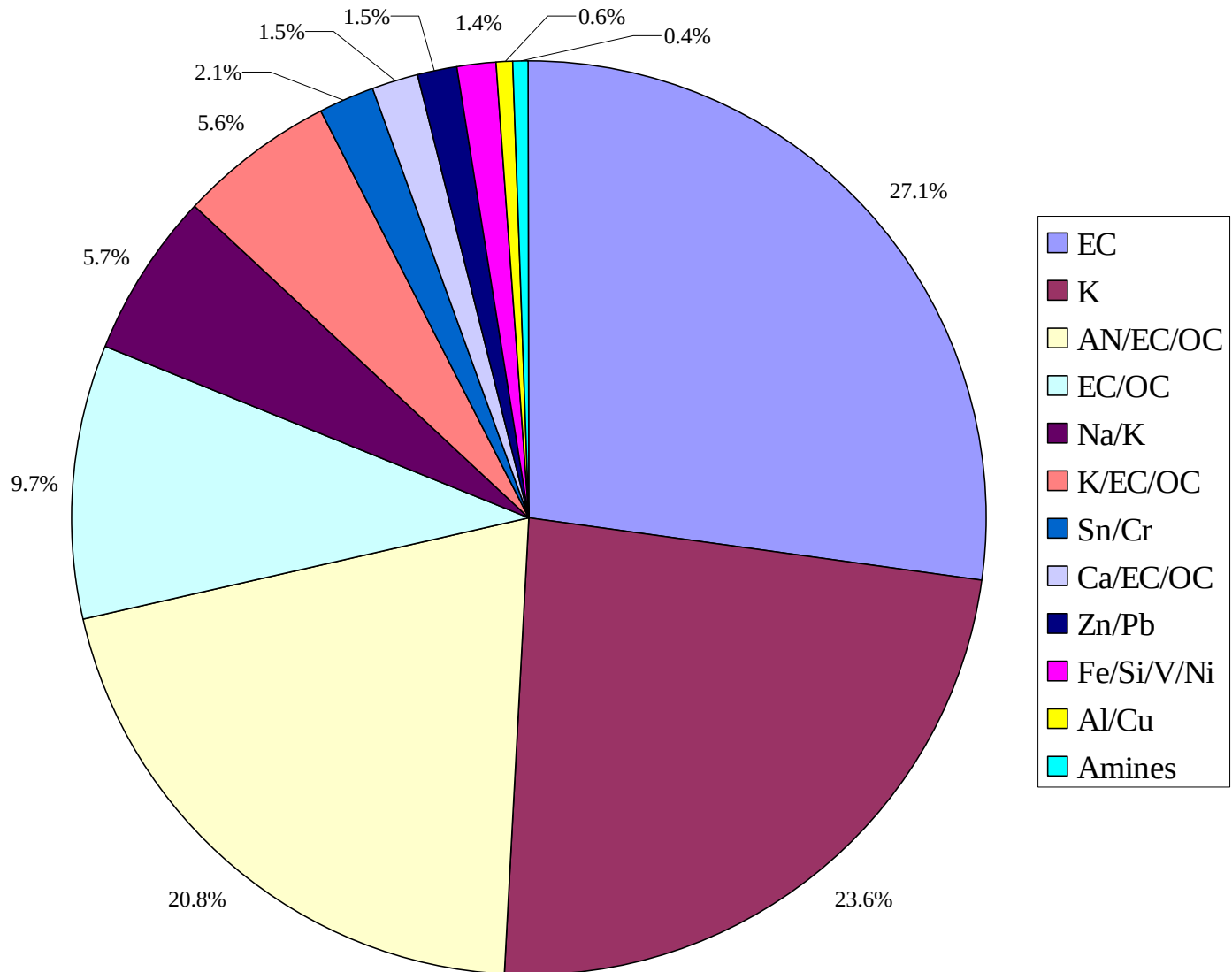


RSMS-II



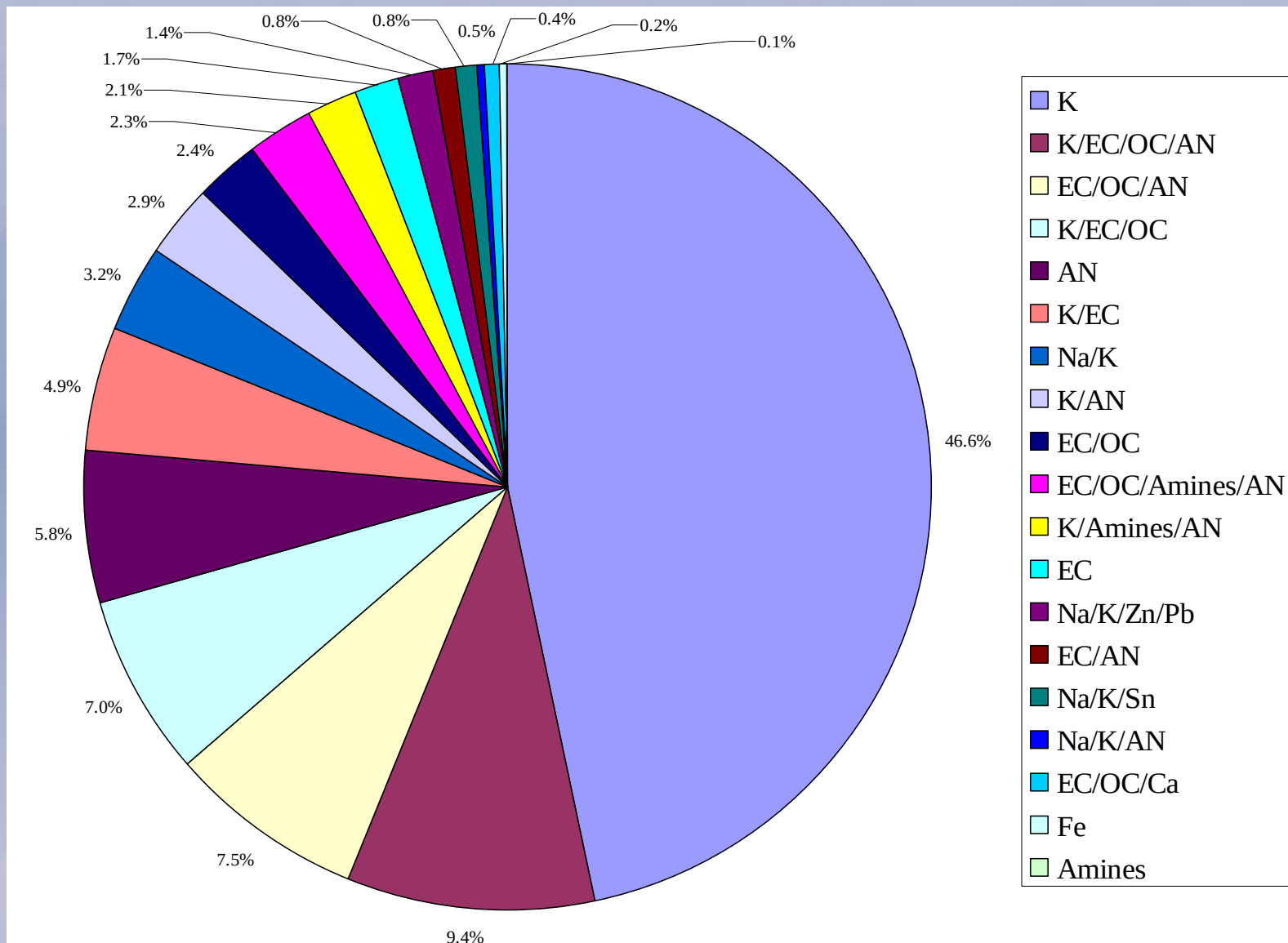
Summer Particle Class Distribution

Fresno, CA 08/13/2008-08/30/2008

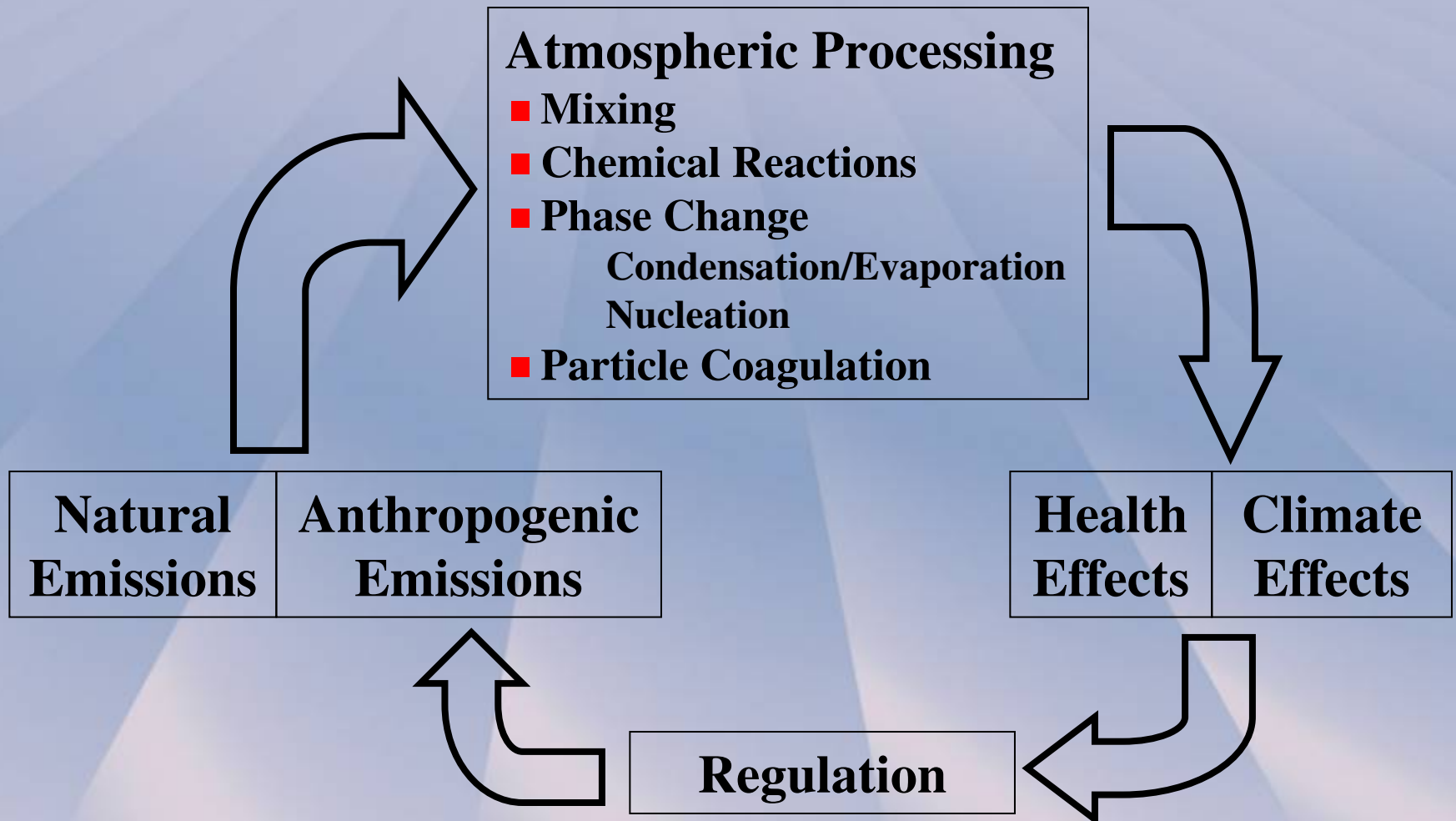


Winter Particle Class Distribution

Fresno, CA 11/16/2007-12/06/2007



The Air Pollution Life Cycle



Future Regulatory Imperatives

Is all PM created equal?

Is some PM more equal than others?

(apologies to George Orwell)

- Do sea spray and diesel exhaust have same toxicity?
- Current mass-based NAAQS treats them the same
- More cost-effective to regulate more toxic emissions

Source-based Regulation may be the future

Future Regulatory Imperatives

How do we deduce health effects of different sources?

Epidemiologically

- Kids growing up near freeways
- Kids growing up downwind of coal fired power plants
- Many other studies
- But correlation, not causative

Future Regulatory Imperatives

How do we deduce health effects of different sources?

Toxicologically directly from sources

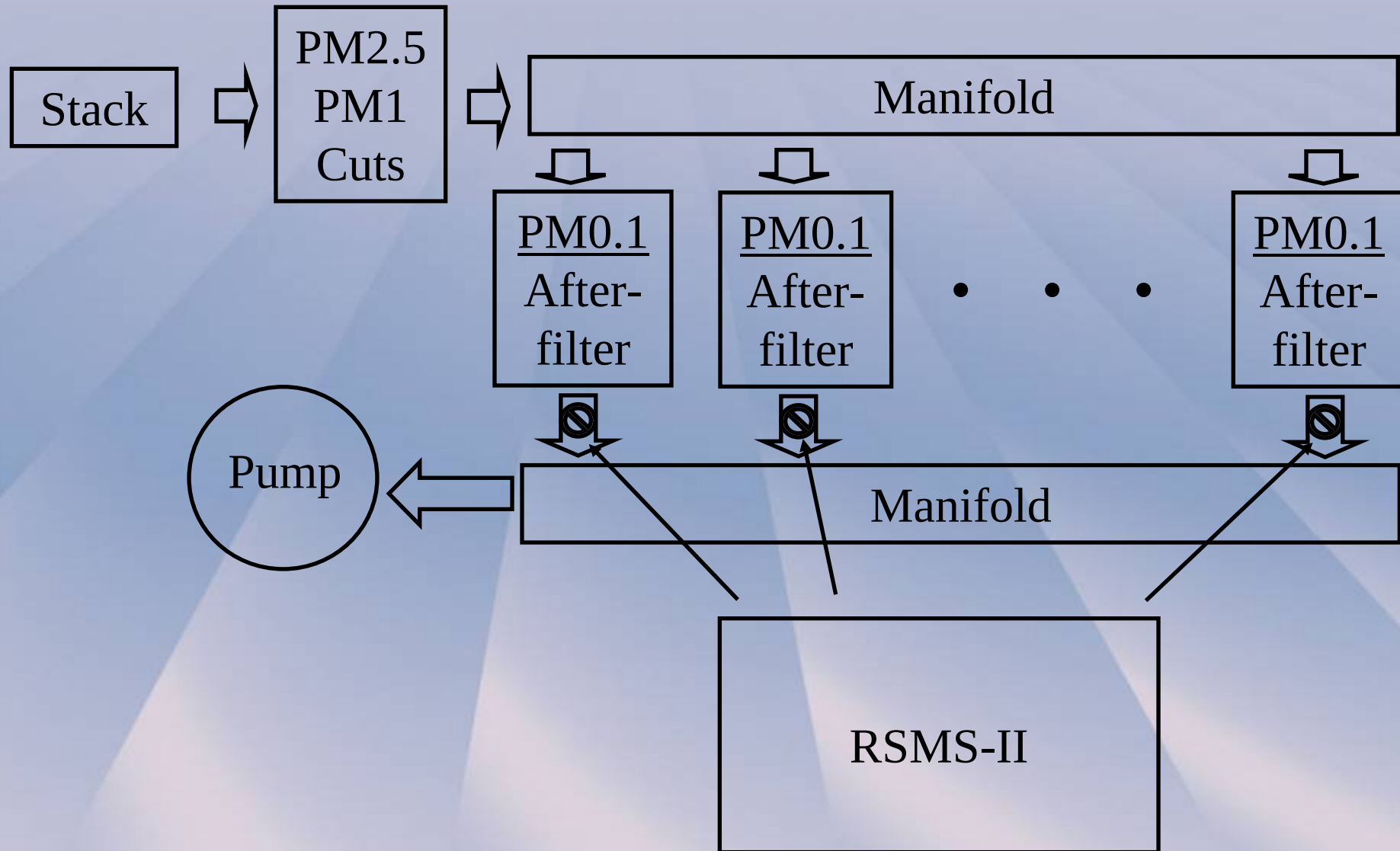
- Well how about those nasty secondary compounds?
- And how about the atmosphere changing the toxicity?
- Can we collect source-oriented PM from the atmosphere?
- Isn't the atmosphere well mixed?

Source-Oriented Sampling

So what's the big idea?

- Run a single particle mass spectrometer to characterize the mixing state of the atmosphere
- Assign prevailing sources or source combinations to each of 10 high-volume ChemVol samplers
- Use the single particle mass spectrometer to select which ChemVol samples depending on the sources or source combinations affecting the site

Conditional Source-Oriented Sampling

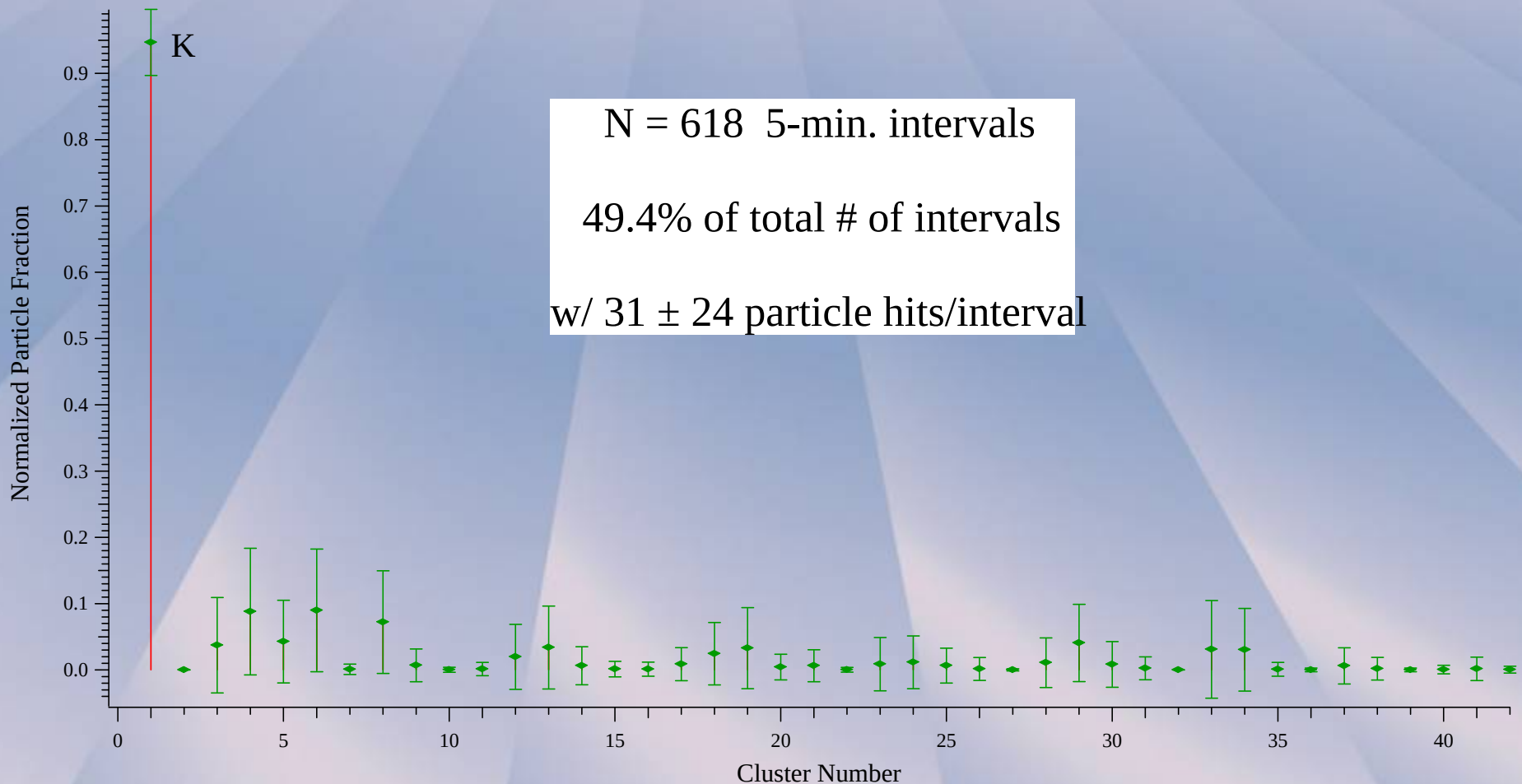


Sampling Train



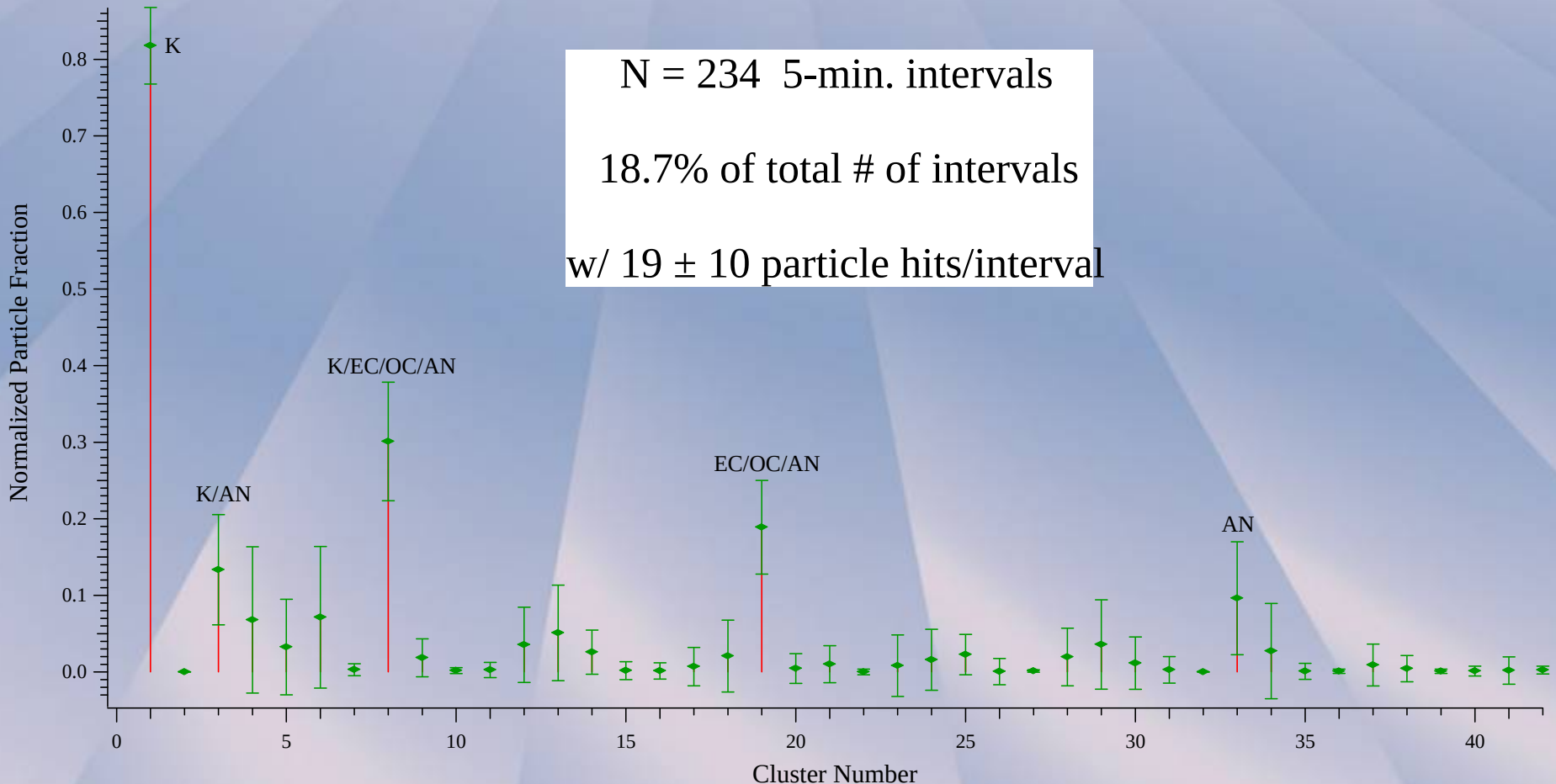
Source Combination 1 ($D_p \sim 70\text{-}93\text{ nm}$)

Relatively clean separation of primary wood smoke emissions



Source Combination 2 ($D_p \sim 70-93$ nm)

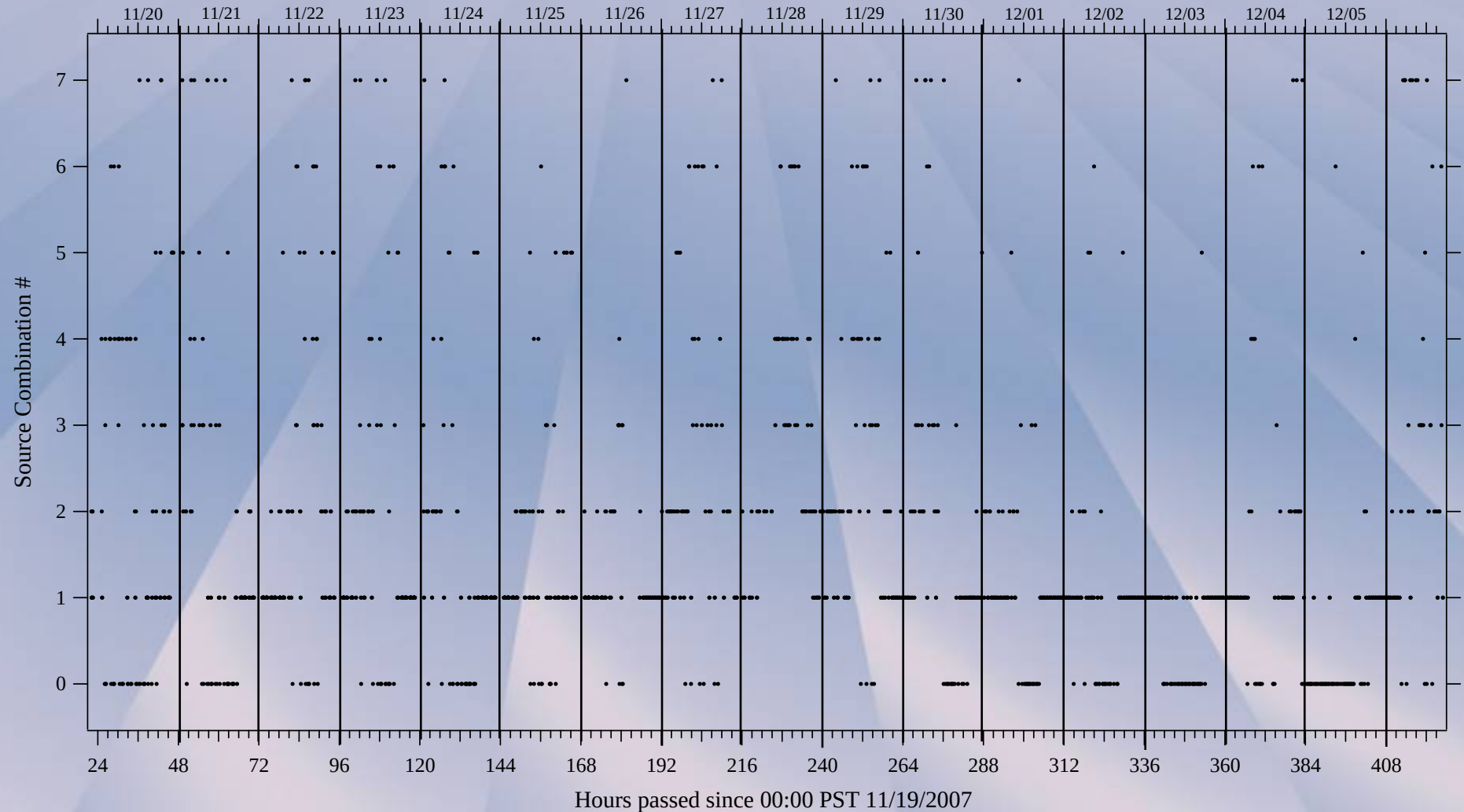
Mixture: wood smoke emissions (primary and w/ammonium nitrate), carbonaceous aerosol, and ammonium nitrate (AN) particles



Temporal Trend in Source Combinations

Source combinations are temporally separated

Seven source combinations account for 91% of the 5-min intervals.



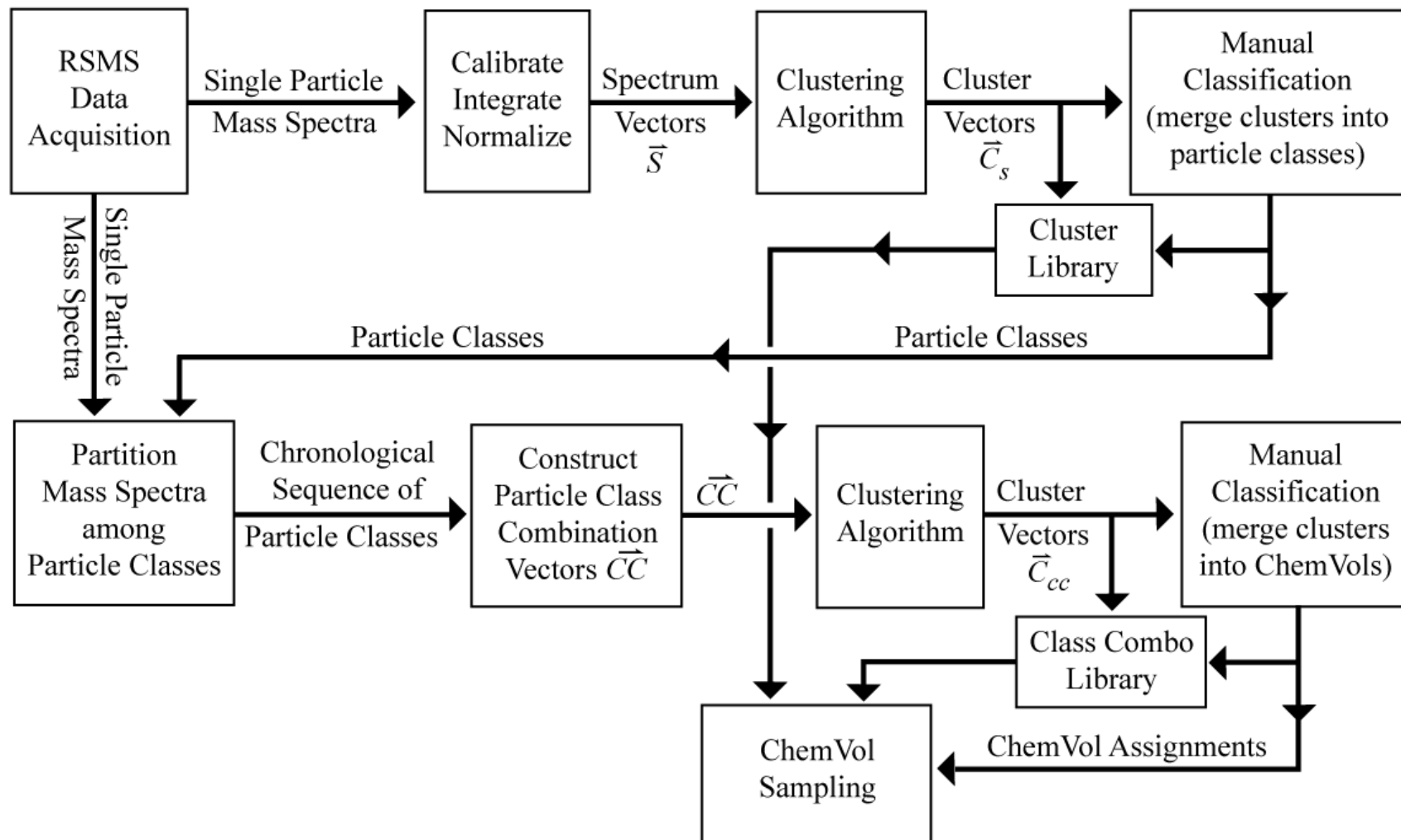
Thanks to

- Keith Bein for building the instrument, developing the algorithm and basically doing all the interesting stuff
- Yongjing Zhao for helping to run everything and keep the single particle mass spectrometer operating
- You for staying awake
- CARB and EPRI for financial and moral support

Questions?

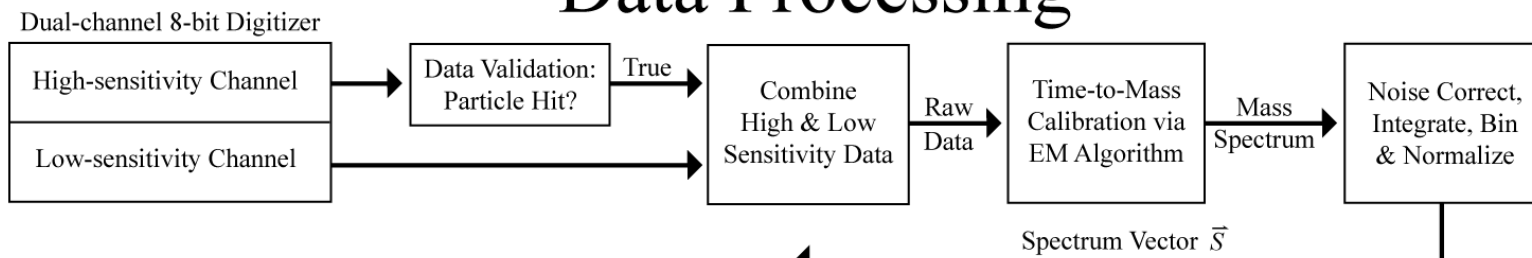
Extra Slides for Q & A

Pre-study Data Analysis

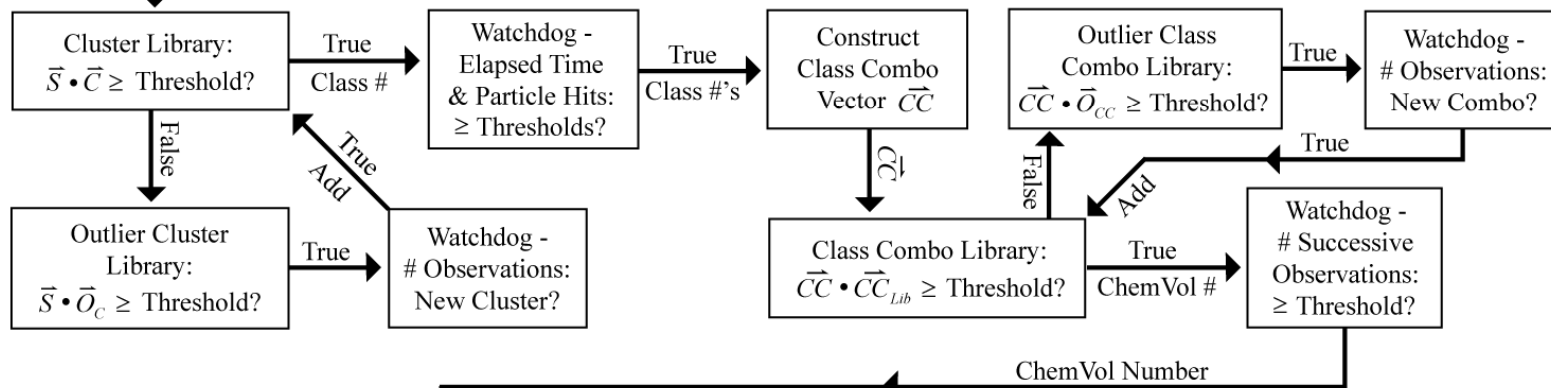


Real-time Data Flow

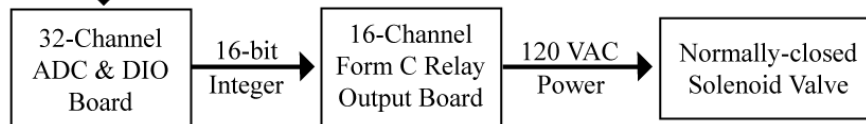
Data Processing



Clustering Algorithms



Hardware Interface



Single Particle Summary Statistics

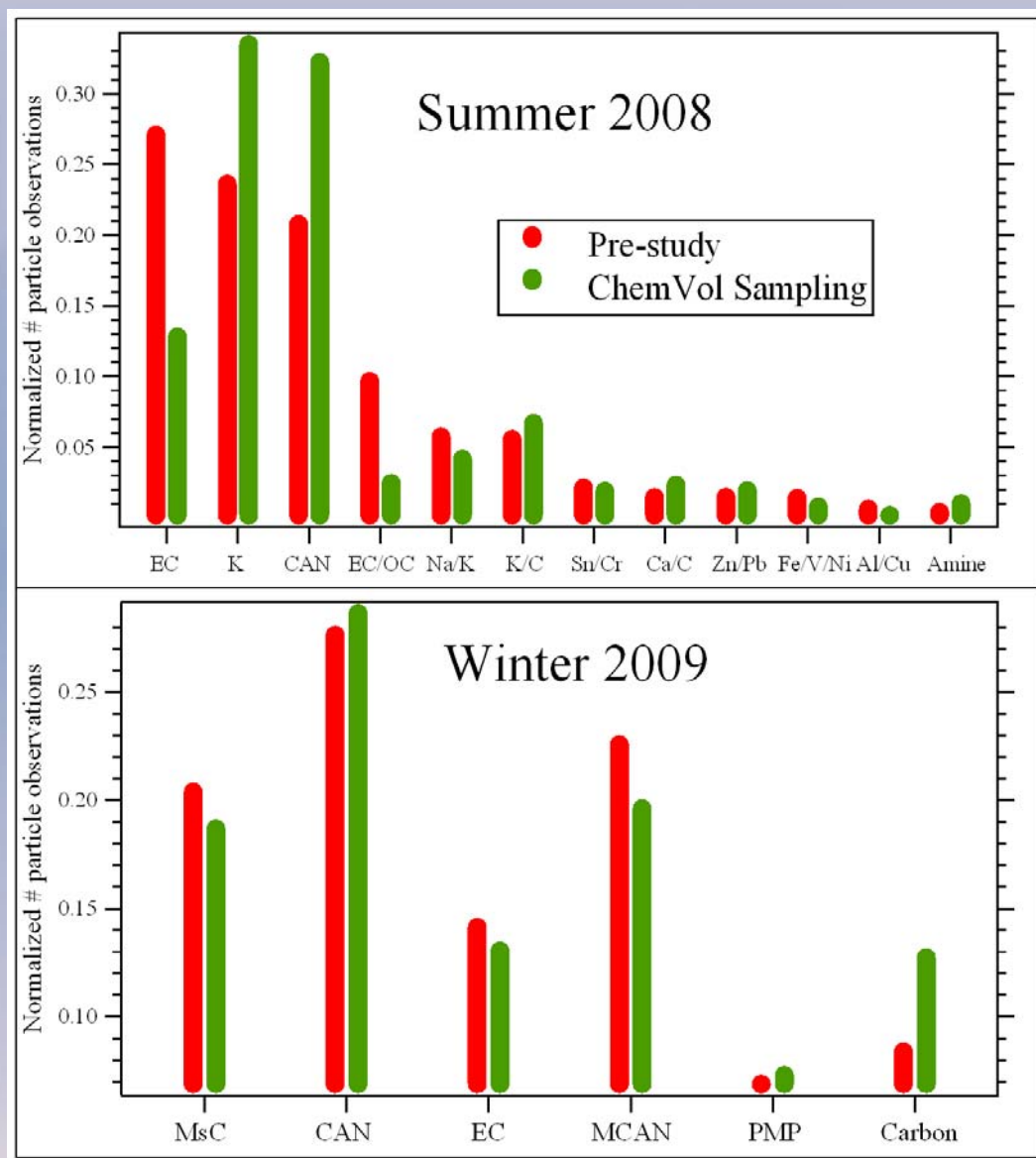
Summer 2008 Experiment

ChemVol	Total Sampling Time (hrs)	Total # Particle Hits	Total # Sampling Intervals	Class Combo Vectors		Scaled Estimates – Collected Mass (mg)	
				Total #	Average # Particles/	Ultrafine	Fine
1	85.55	15283	991	4327	14 ± 8	14 ± 3	36 ± 10
2	63.69	13304	742	3844	24 ± 20	12 ± 2	41 ± 12
3	2.60	426	62	83	7 ± 2	0.42 ± 0.08	1.3 ± 0.4
4	2.26	400	61	76	8 ± 3	0.41 ± 0.07	1.1 ± 0.3
5	0.51	88	13	18	8 ± 3	0.10 ± 0.02	0.21 ± 0.06
6	5.85	1106	133	242	11 ± 6	1.1 ± 0.2	2.9 ± 0.8
7	1.45	240	38	45	7 ± 3	0.16 ± 0.03	0.4 ± 0.1
9	139.60	-	29	-	-	17 ± 3	47 ± 14
10	468.27	4419	1344	139	8 ± 7	63 ± 11	197 ± 56
Totals:	770	35266	3413	8785	-	109 ± 12	328 ± 60

Single Particle Summary Statistics

Winter 2009 Experiment							
ChemVol	Total Sampling Time (hrs)	Total # Particle Hits	Total # Sampling Intervals	Class Combo Vectors		Measured Mass (mg)	
				Total #	Average # Particles/	Ultrafine	Fine
1	6.91	7478	477	2148	12 ± 7	2.58 ± 0.06	3.21 ± 0.04
2	6.04	4087	402	1479	7 ± 2	1.30 ± 0.05	3.02 ± 0.03
3	4.41	3605	363	1239	8 ± 5	1.01 ± 0.08	2.0 ± 0.5
4	1.65	1879	137	536	11 ± 5	0.73 ± 0.04	0.8 ± 0.2
5	4.72	4423	422	1421	8 ± 3	1.33 ± 0.06	1.66 ± 0.08
6	1.98	2519	191	691	11 ± 7	0.88 ± 0.07	1.23 ± 0.04
7	8.75	-	3	-	-	1.07 ± 0.06	1.88 ± 0.06
8	92.49	-	32	-	-	11.26 ± 0.06	15.48 ± 0.05
9	257.82	-	33	-	-	27.22 ± 0.07	32.82 ± 0.08
10	356.51	22295	2081	2760	6 ± 1	37.16 ± 0.07	47.26 ± 0.09
Totals:	741	46286	4141	10274	-	85	107

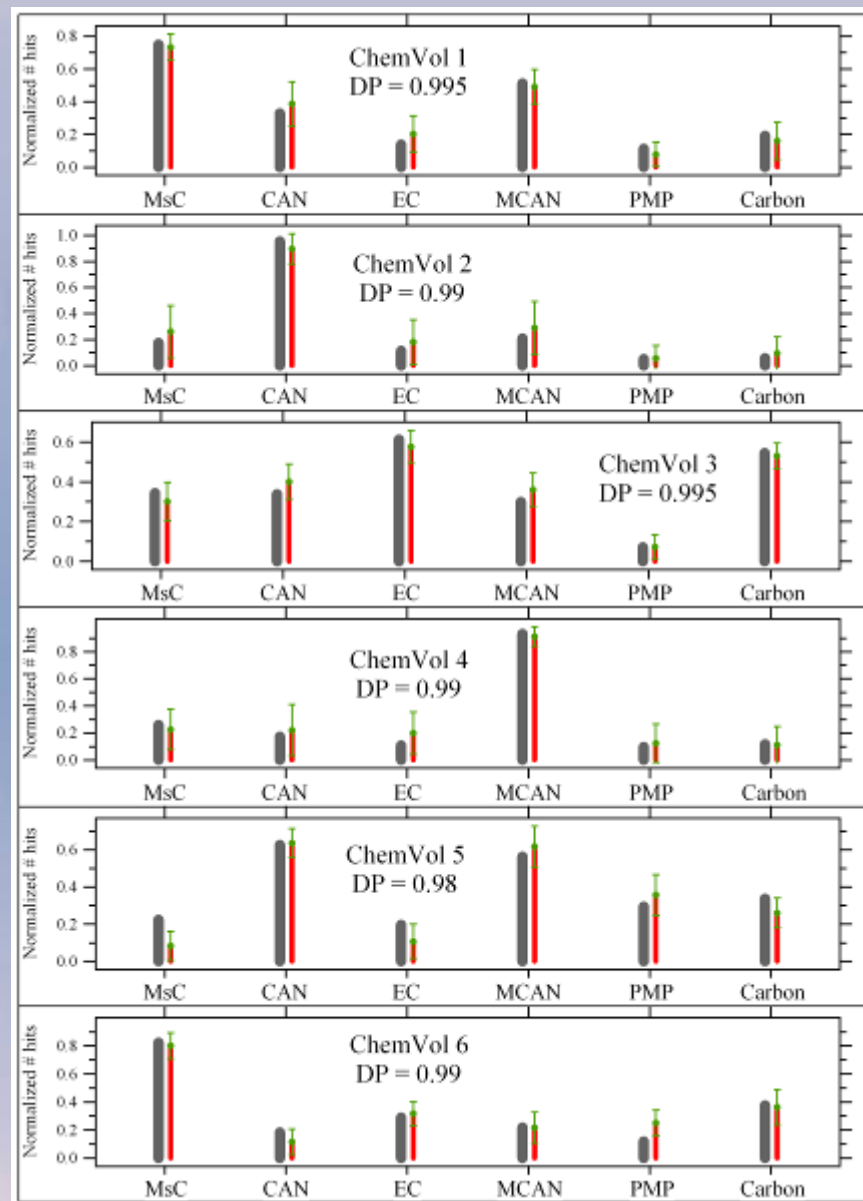
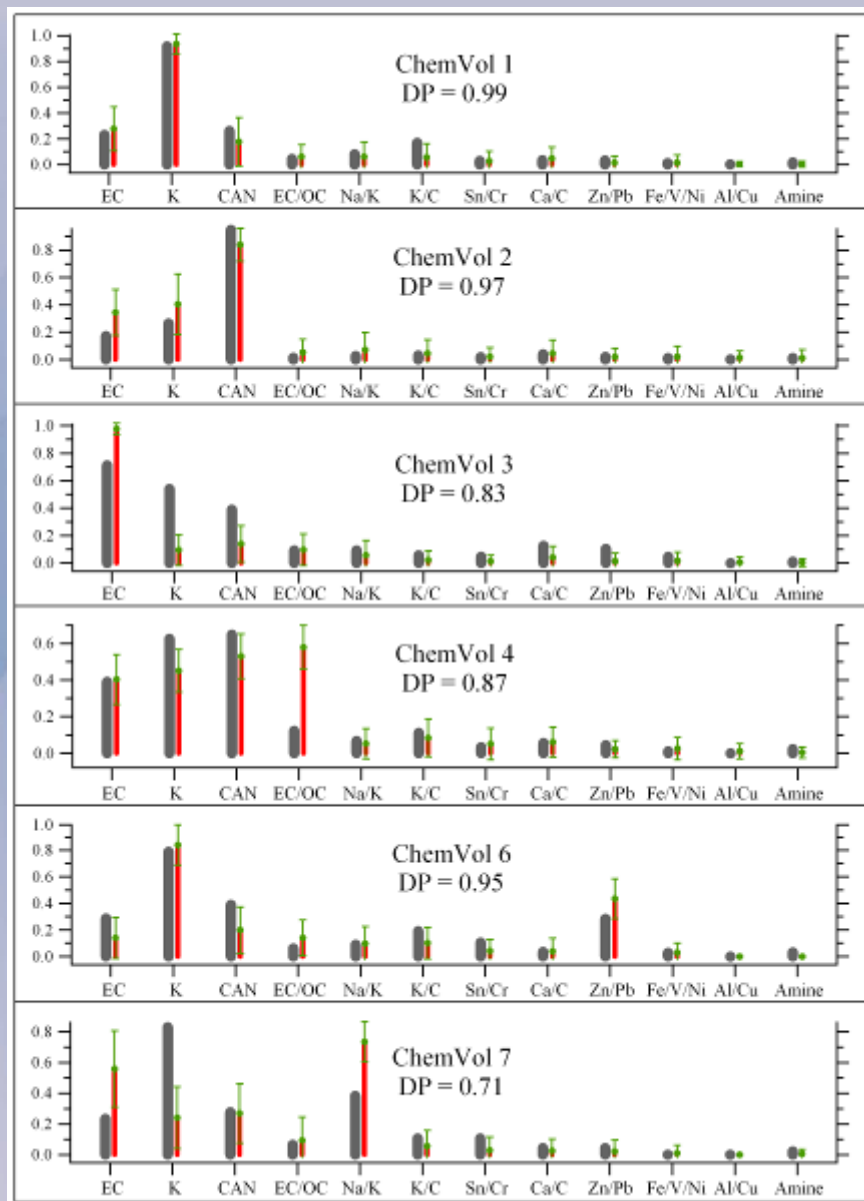
Particle Class Distributions



Fidelity

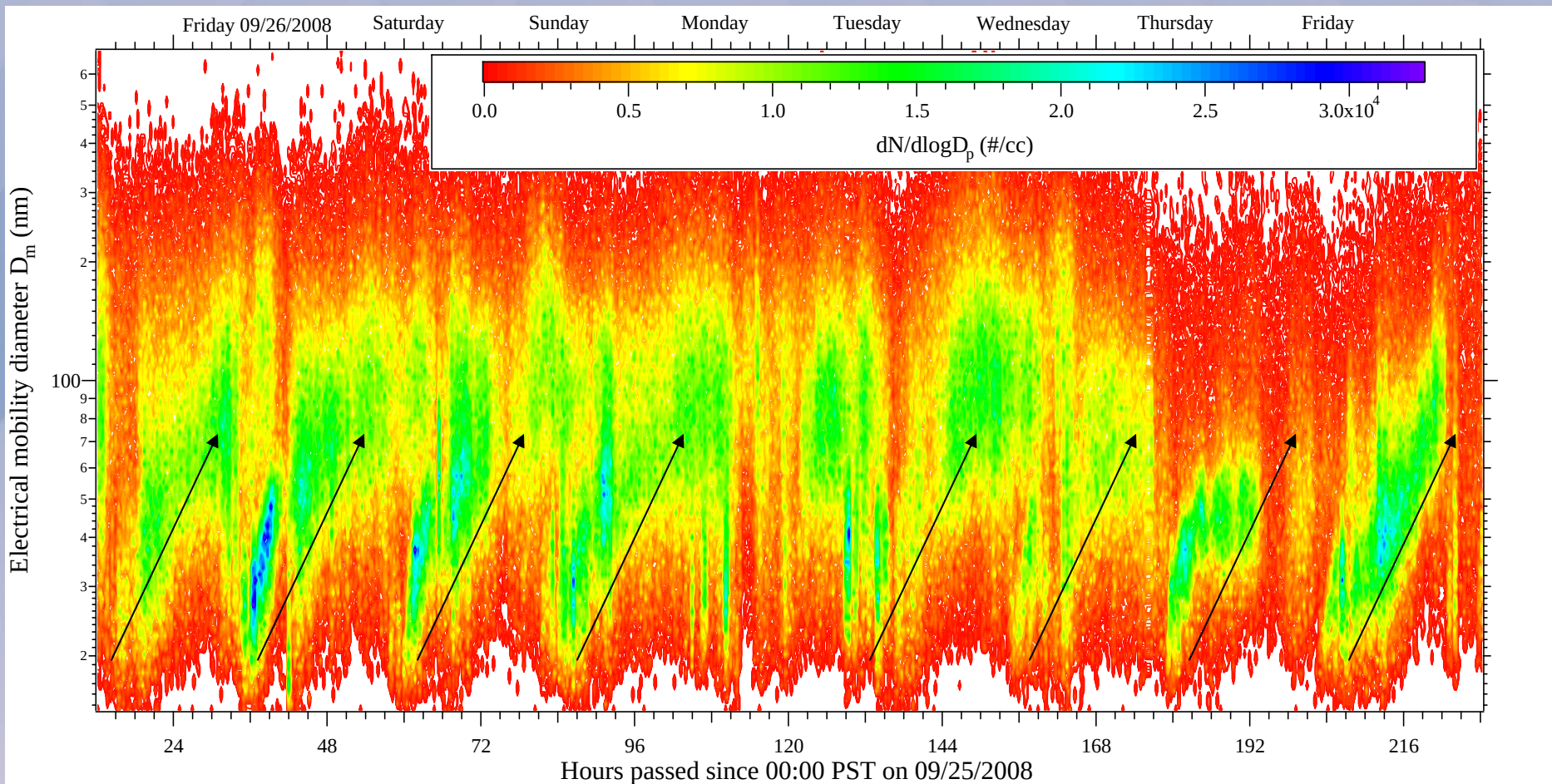
Summer 2008

Winter 2009



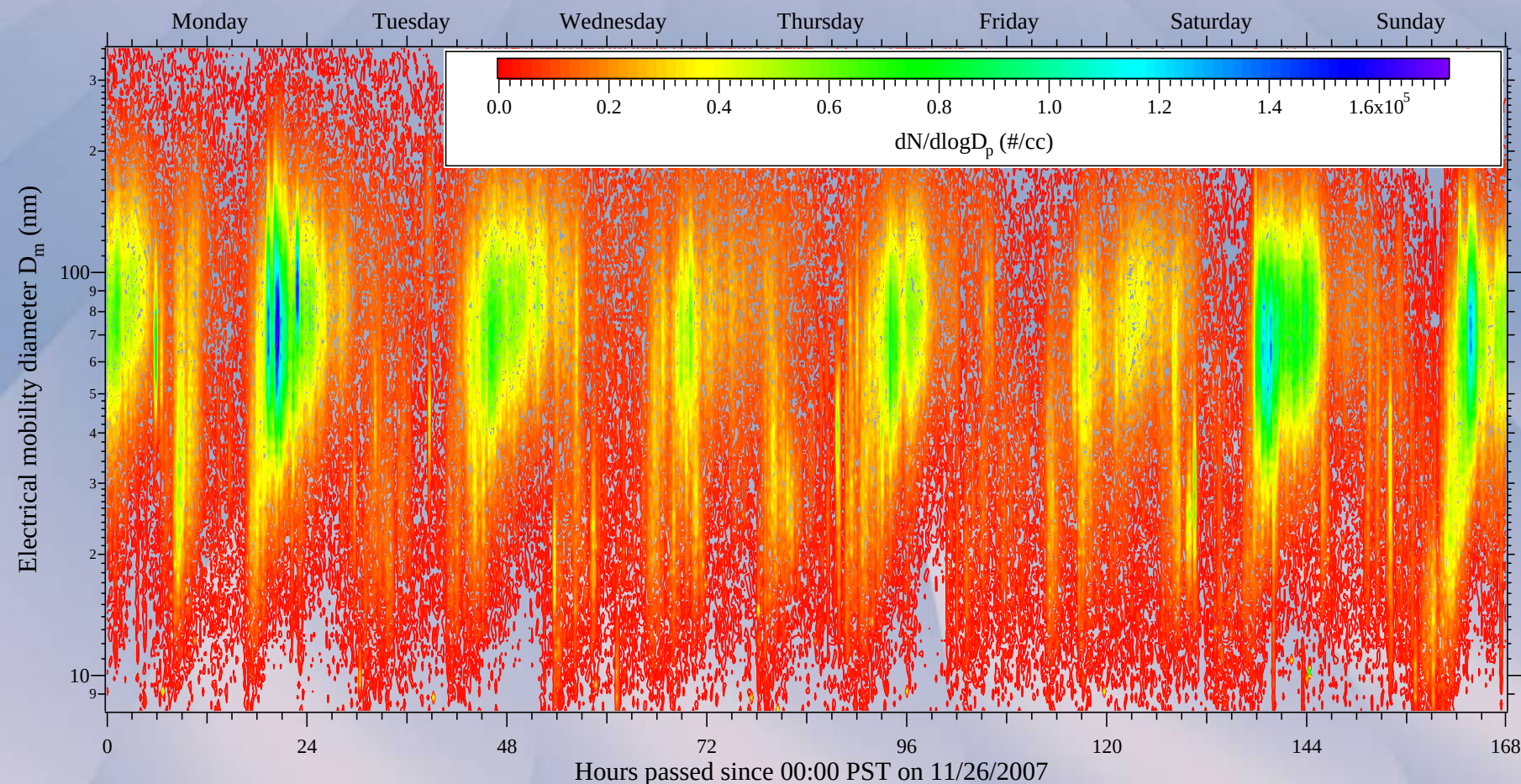
Summertime Diurnal Variation in Particle Number Size Distribution

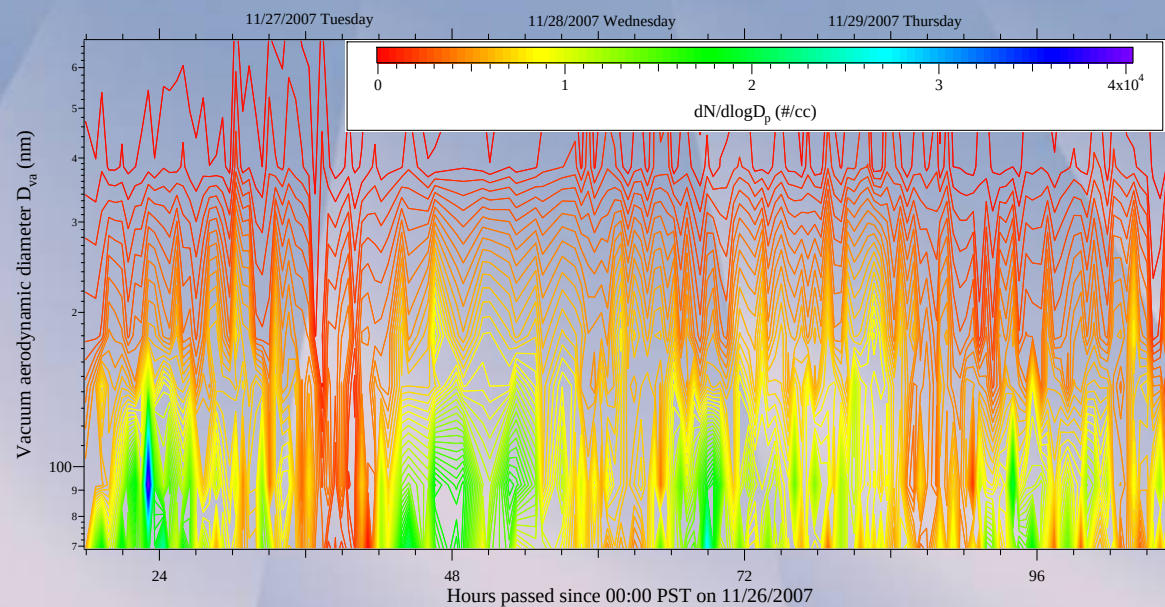
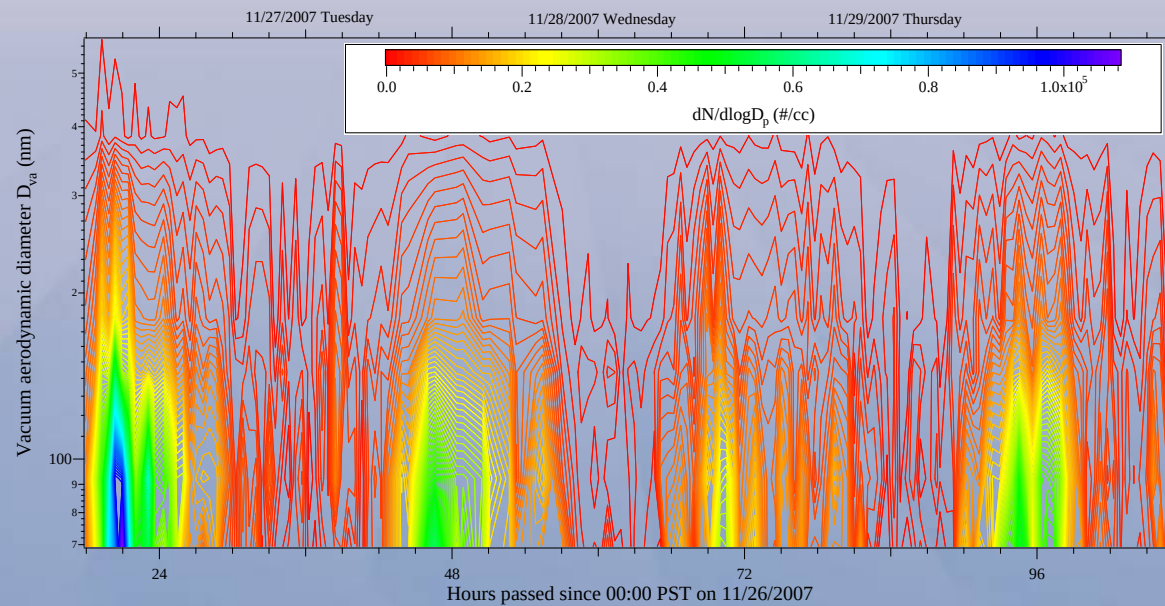
Fresno, CA 09/25/2008-10/04/2008

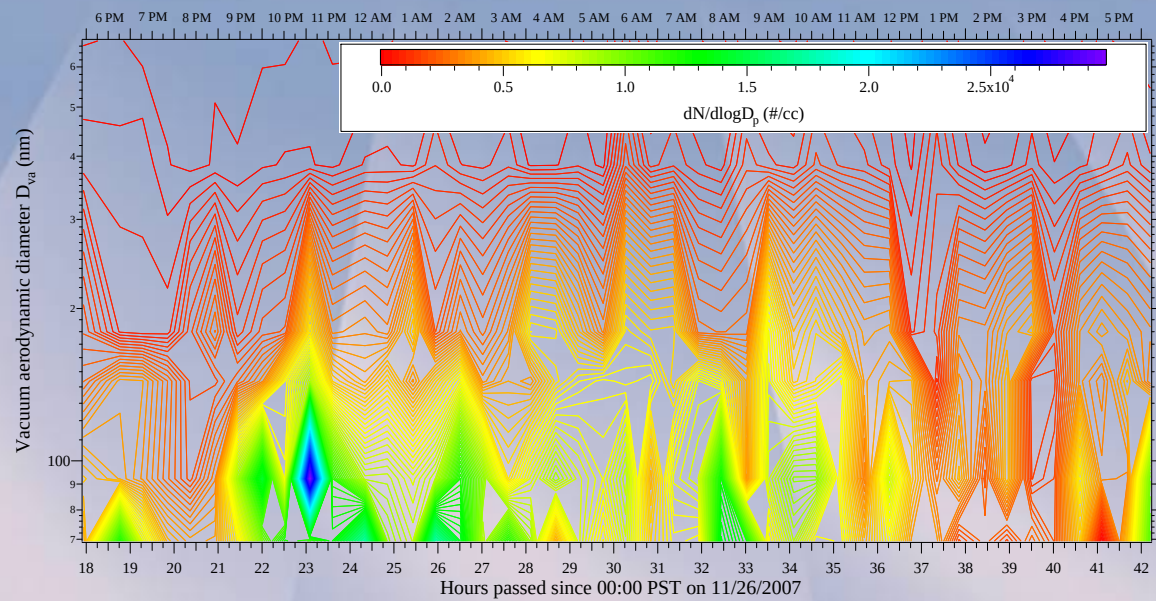
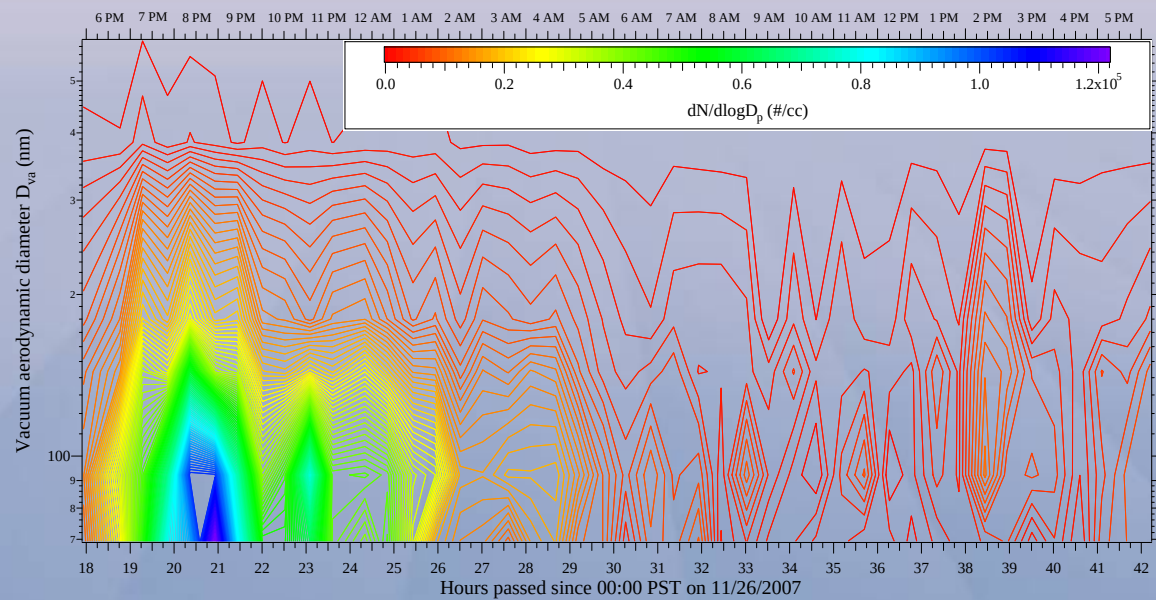


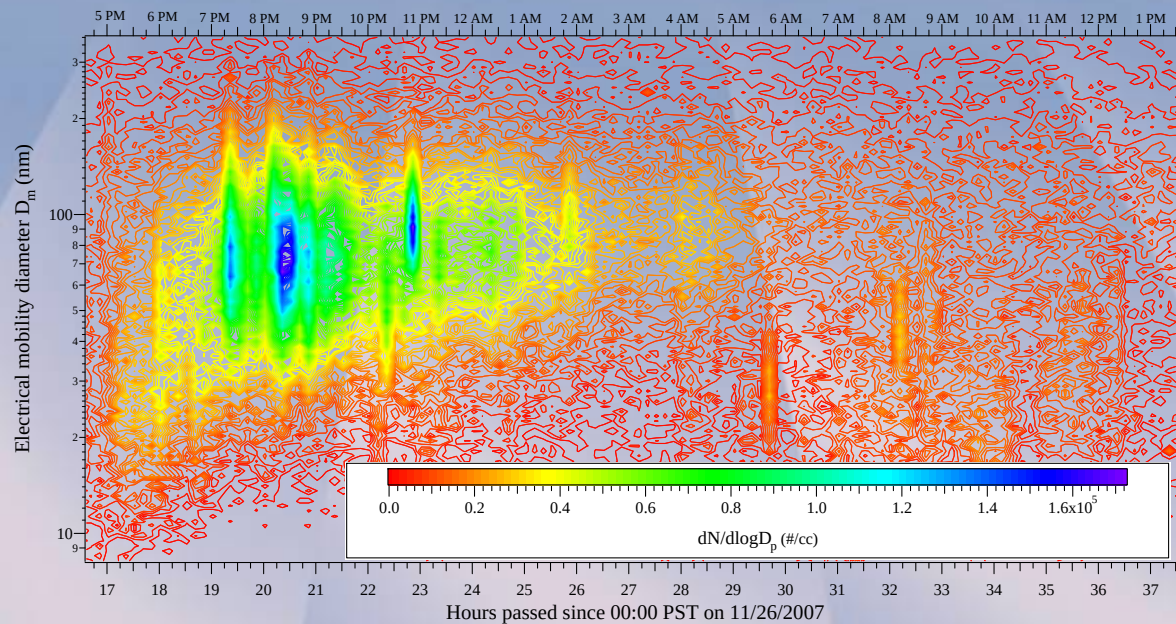
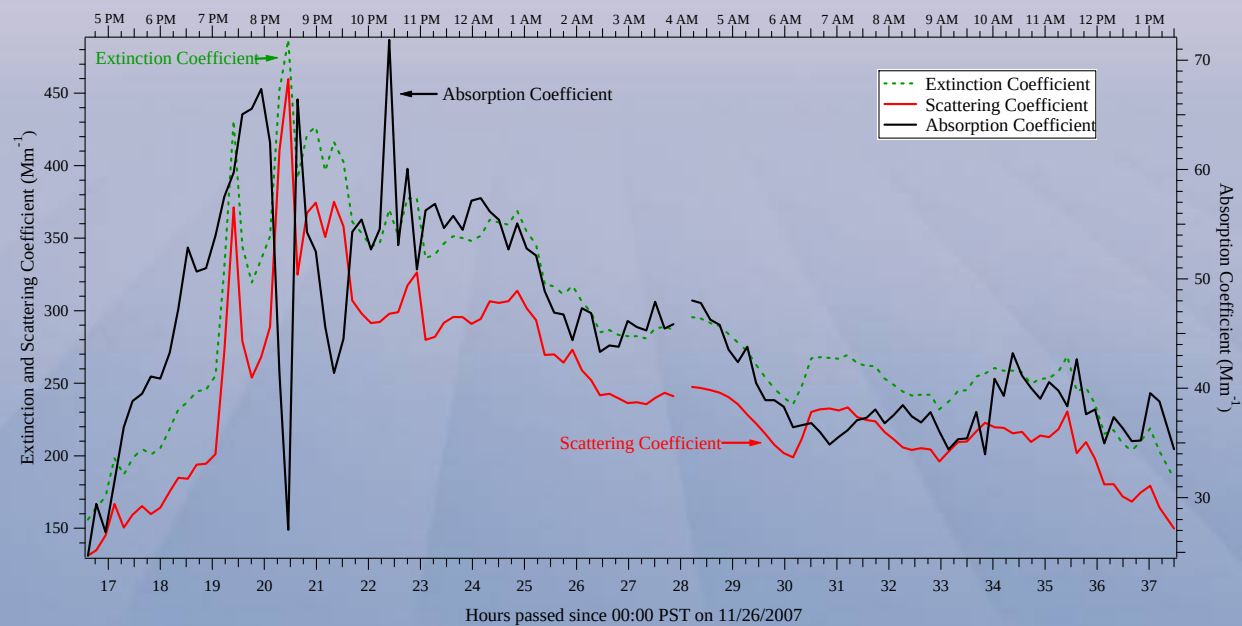
Wintertime Diurnal Variation in Particle Number Size Distribution

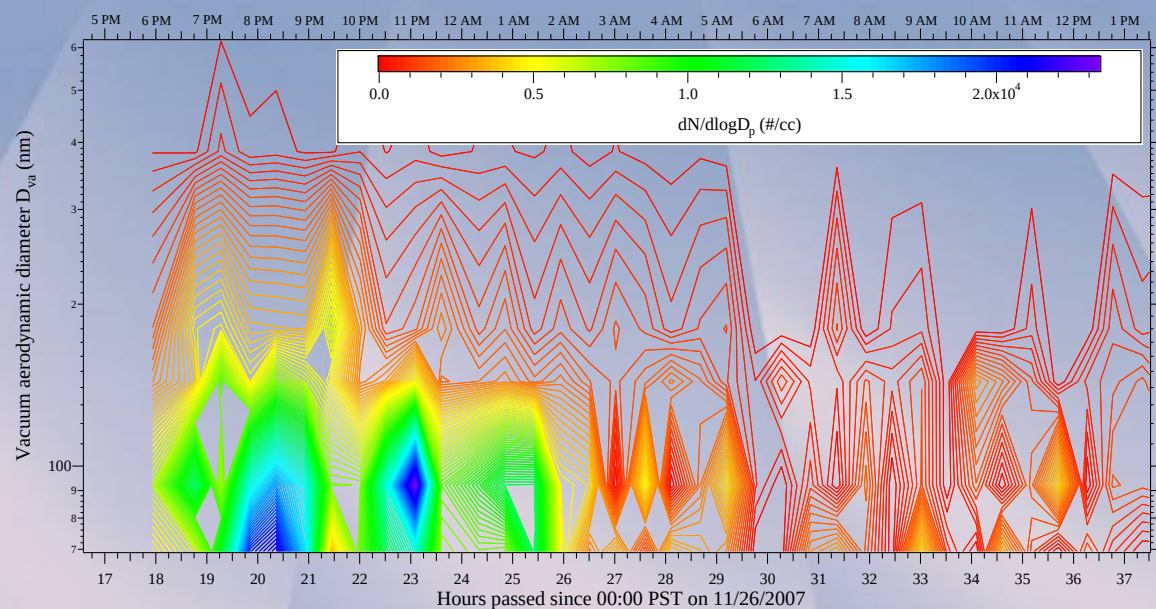
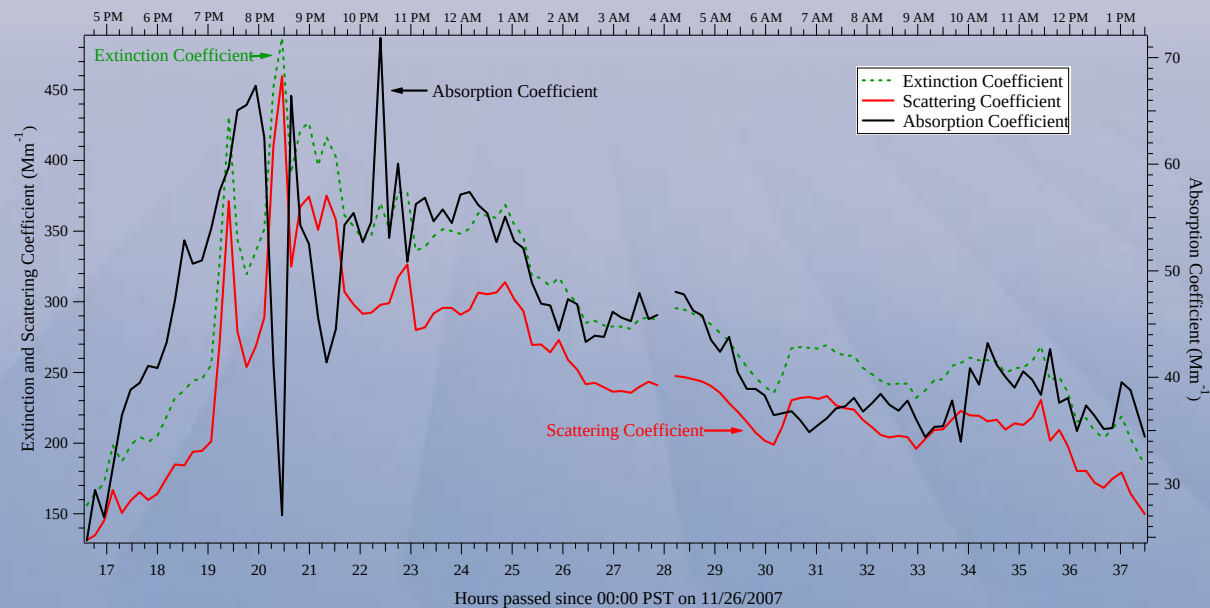
Fresno, CA 11/26/2007-12/02/2007

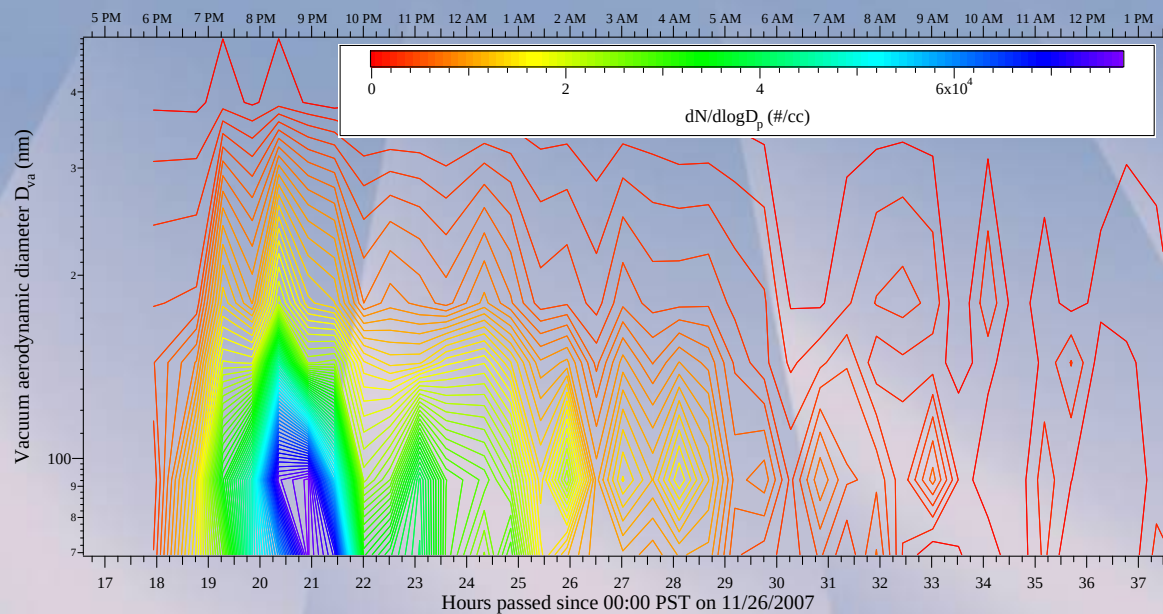
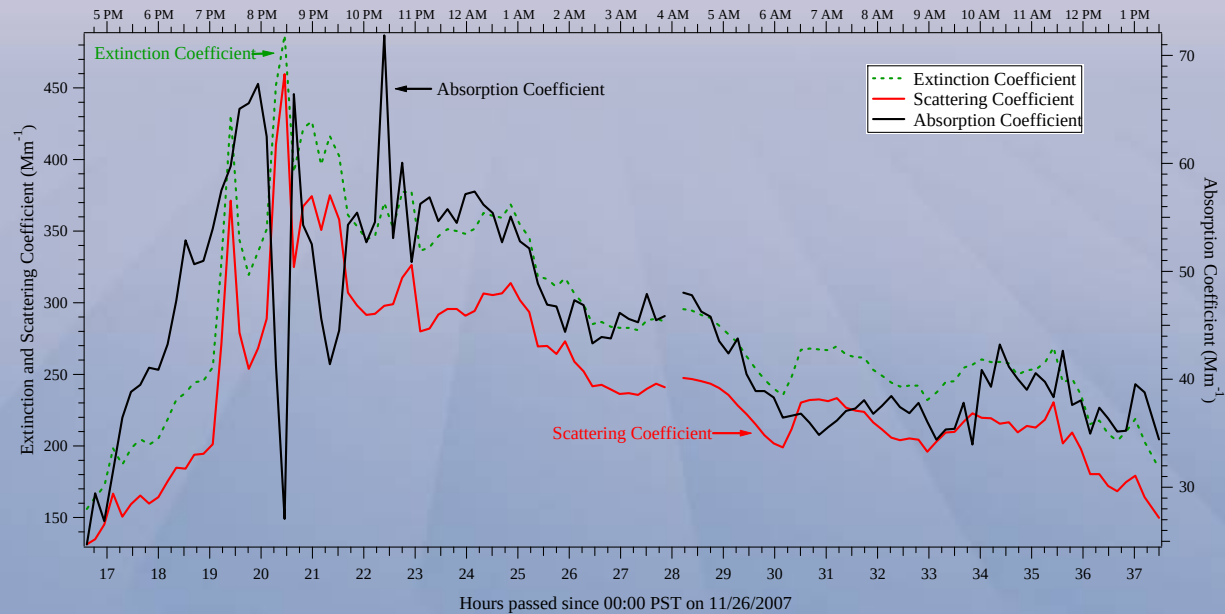


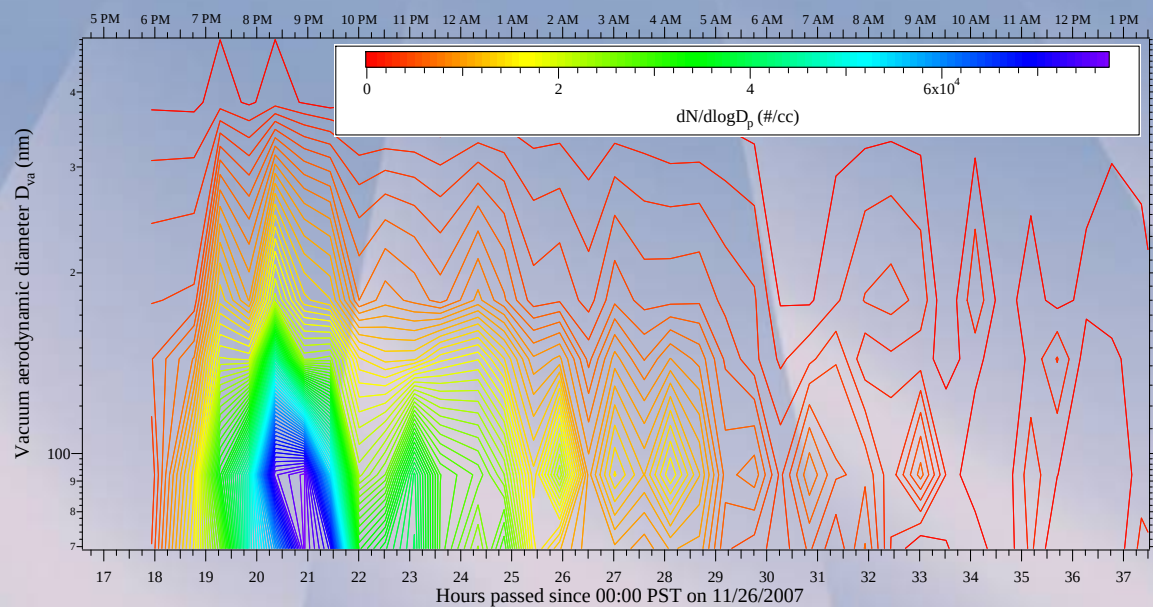
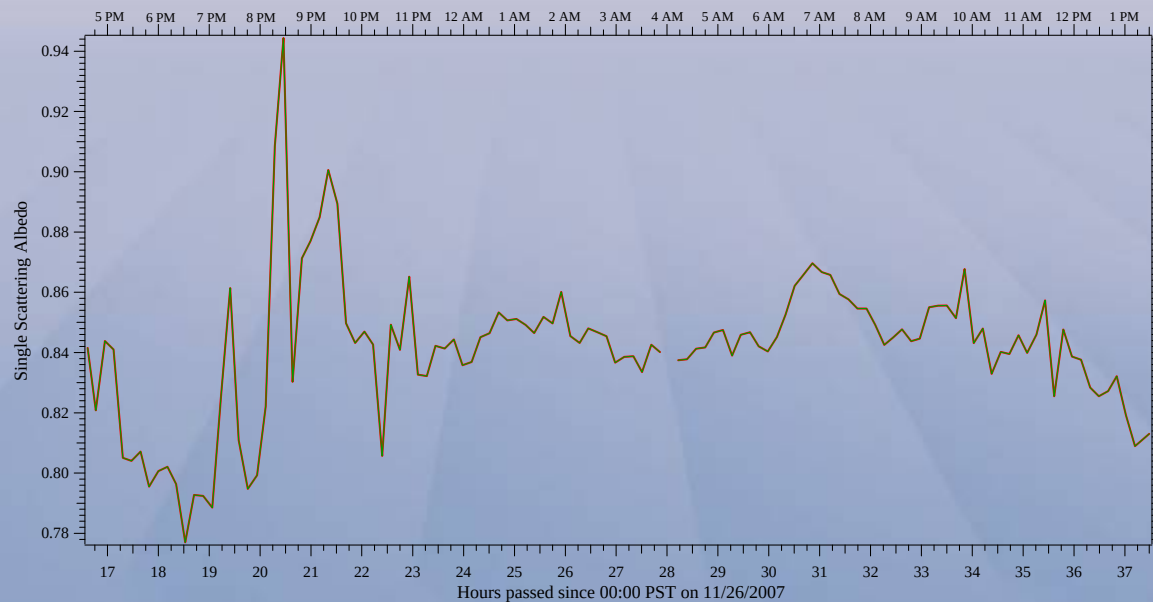












Inlet:
Focus Particles into a Beam
Size the Particles

Source Region:
Ablate/Ionize Particles to Form Ions

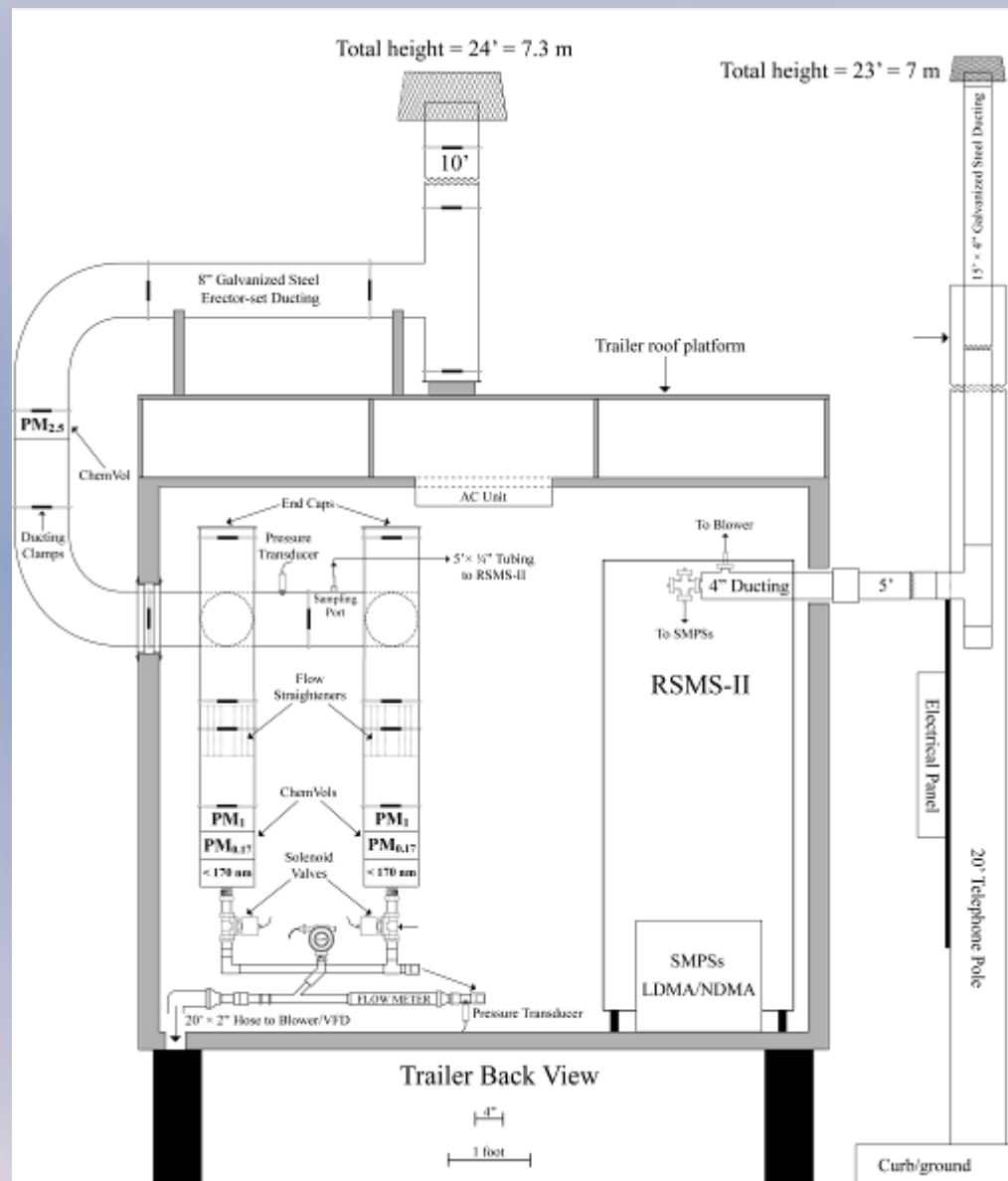
Thermal or Radiative
Energy Source

Mass Spectrometer:
Analyze Ion Masses

Computer:
Digitize and Store Spectra
Categorize Spectra



Sampling Train Schematic

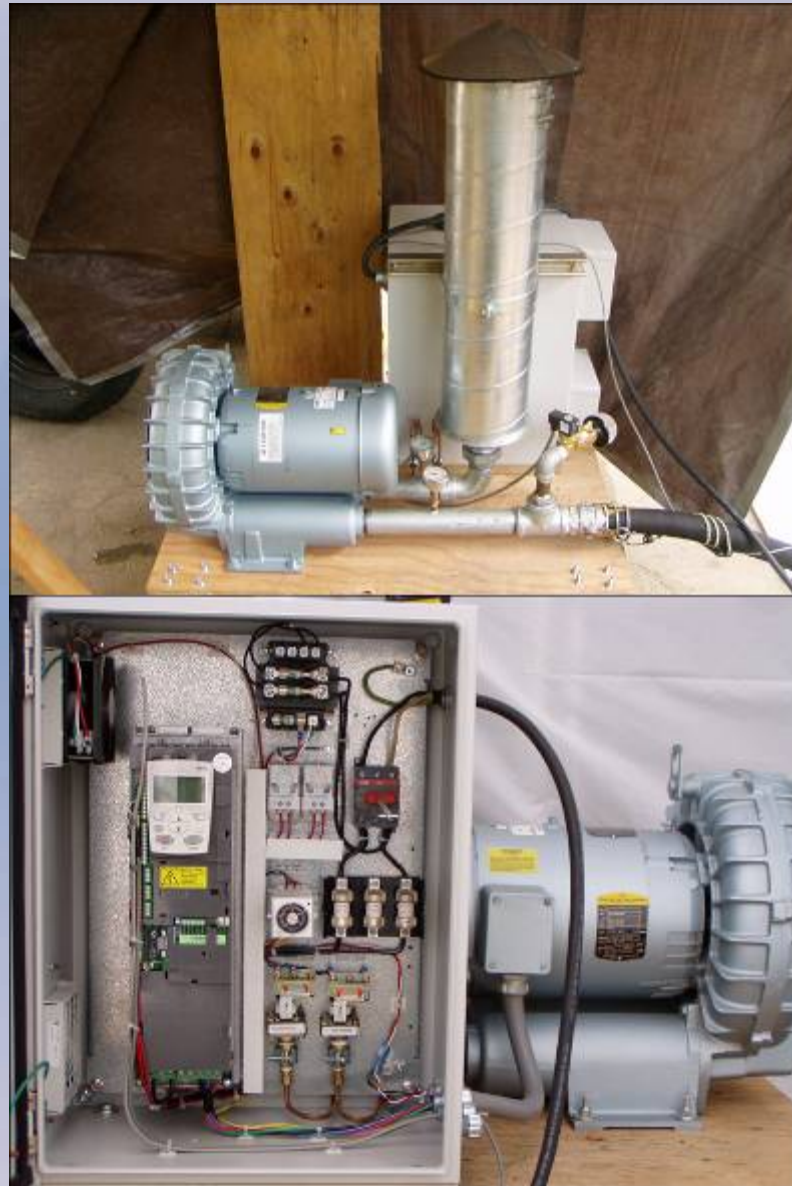


Source-Oriented Sampling

The atmosphere is not well mixed on short time scales

- Consider plumes hitting a sampling site
- Single particle mass spectrometer observations in Atlanta, Houston, Baltimore and Pittsburgh

Blower Assembly



Fresno Metadata

Experiment		Start Date	End Date	Total Sampling Hours	Total # Mass Spectra	Total # Particle Classes	Total # Class Combination Vectors
Summer 2008	Pre-study	8/13/2008	9/2/2008	446	21,906	12	4689
	ChemVol Sampling	9/11/2008	10/21/2008	741	35,266		8785
Winter 2009	Pre-study	1/9/2009	2/11/2009	522	100,242	6	30,810
	ChemVol Sampling	3/1/2009	4/6/2009	712	46,286		10,274