Determination Of Real-time Particle Monitor Response To Combustion Derived Particles Under Controlled Experimental Conditions

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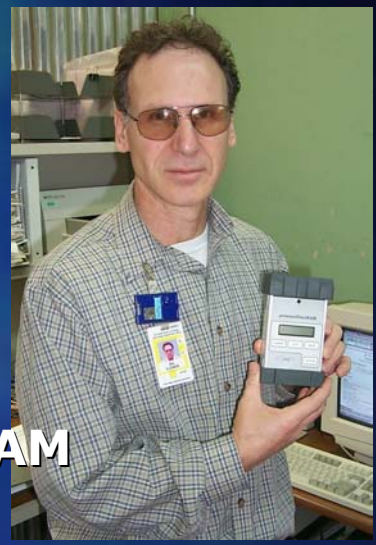
Objective

The purpose of this study was to compare the response of several commercially available instruments to a variety of common matrices (environmental tobacco smoke [ETS], cooking fumes, wood smoke, and propane stove fumes) under controlled laboratory conditions.

Additionally, to perform an evaluation of most “promising” system under real-world conditions.

Real Time Monitoring Systems Evaluated

TSI DustTrak



MIE personal DataRAM

EcoChem PAS 2000 PAH Monitor

TSI PTrak

Laboratory Studies Conducted in a 30 m^3 Controlled Experimental Atmosphere Chamber

Aerosol Generation Systems

- All aerosols generated and monitored under static conditions to minimize particle and other constituent losses.
- Chamber starts at 70° F and 45% RH. Only minor temperature variations (since lights are turned off).
- Small fan running at ca. 200 rpm to stir chamber contents.

Details of Aerosol Generation Systems: Simulated ETS

- Conditioned cigarette smoked at FTC conditions on ADL-II modified to smoke at one puff per minute.
- Sidestream smoke allowed to disperse and dilute
- Mainstream smoke pushed through gas wash bottle filled with water to simulate exhaled mainstream smoke.
- "Exhaled mainstream" comprised 10 – 13% of total particles and was comparable in particle size distribution to human generated mainstream smoke.

Details of Aerosol Generation Systems: Wood Smoke

- Variety of wood species tested. Vast variation in levels of PAH emitted.
- Selected untreated cedar as being mid-range and easily combustible.
- Small pieces of conditioned (60% RH @72^{o} held in forceps and smoldered from both ends to obtain reproducible burning.

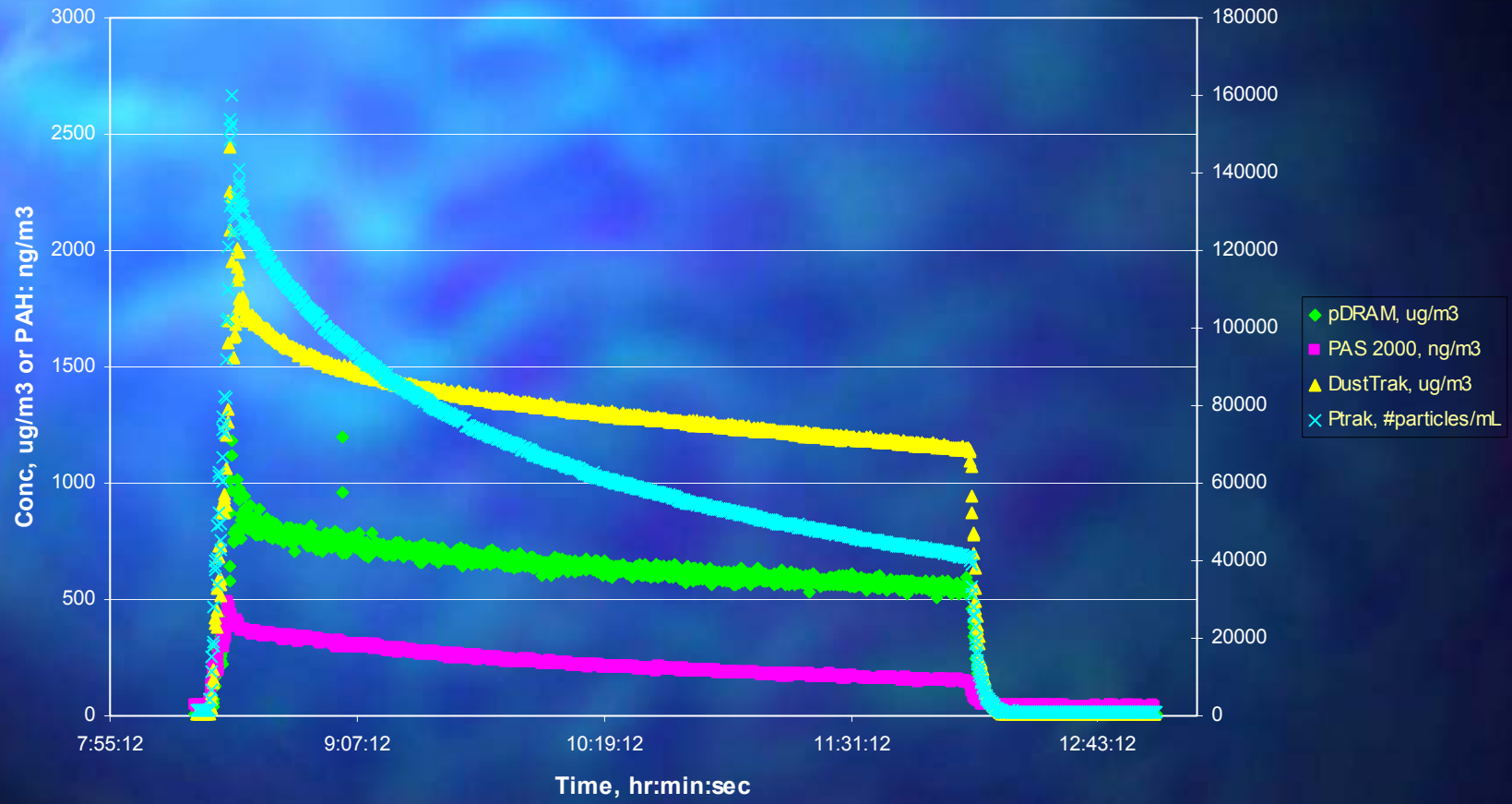
Details of Aerosol Generation Systems: Cooking Oil Fumes

- Cast iron skillet electrically heated to 325°C.
- Known amount of soy-based vegetable soil dispersed on to heated surface.

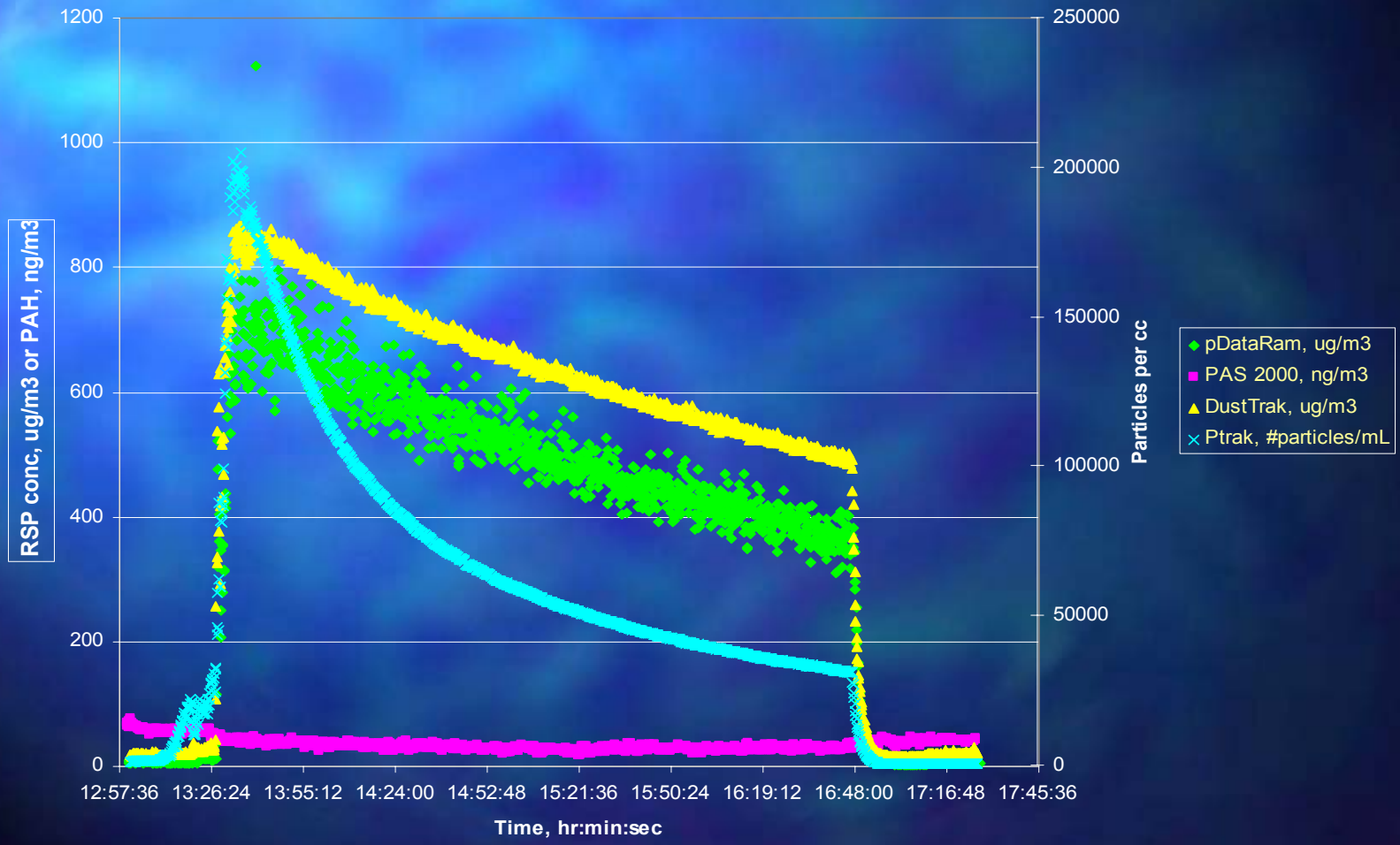
Details of Aerosol Generation Systems: Propane Burner Particles

- Propane stove single burner ignited, and allowed to burn for 3 - 6 minutes.
- Since chamber was under "static" conditions to minimize particle losses, chamber temperatures increased about 5 - 10° F.

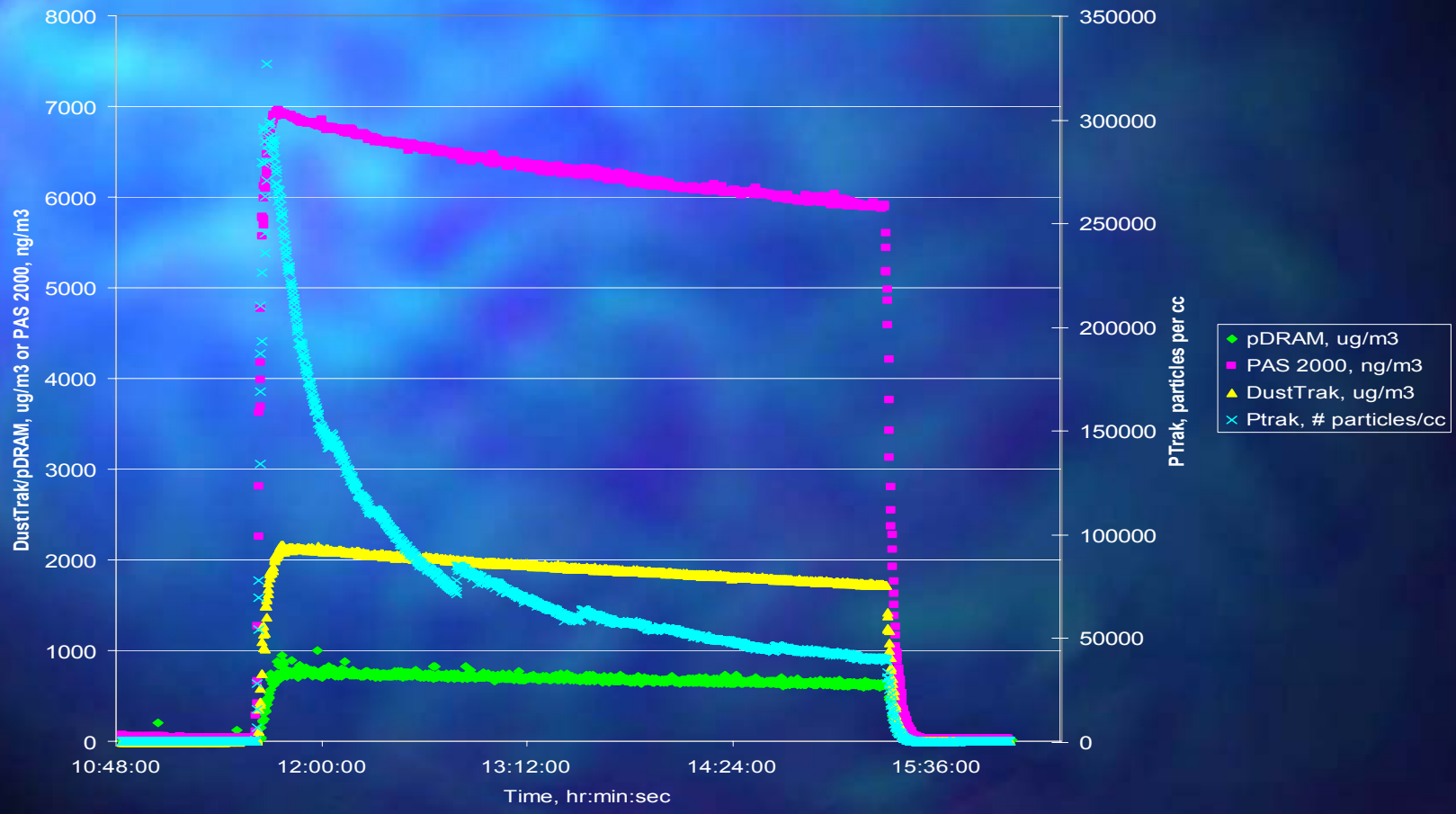
Comparison of Instrument Response as a Fn of Time: Simulated ETS @ 233 μg/m³



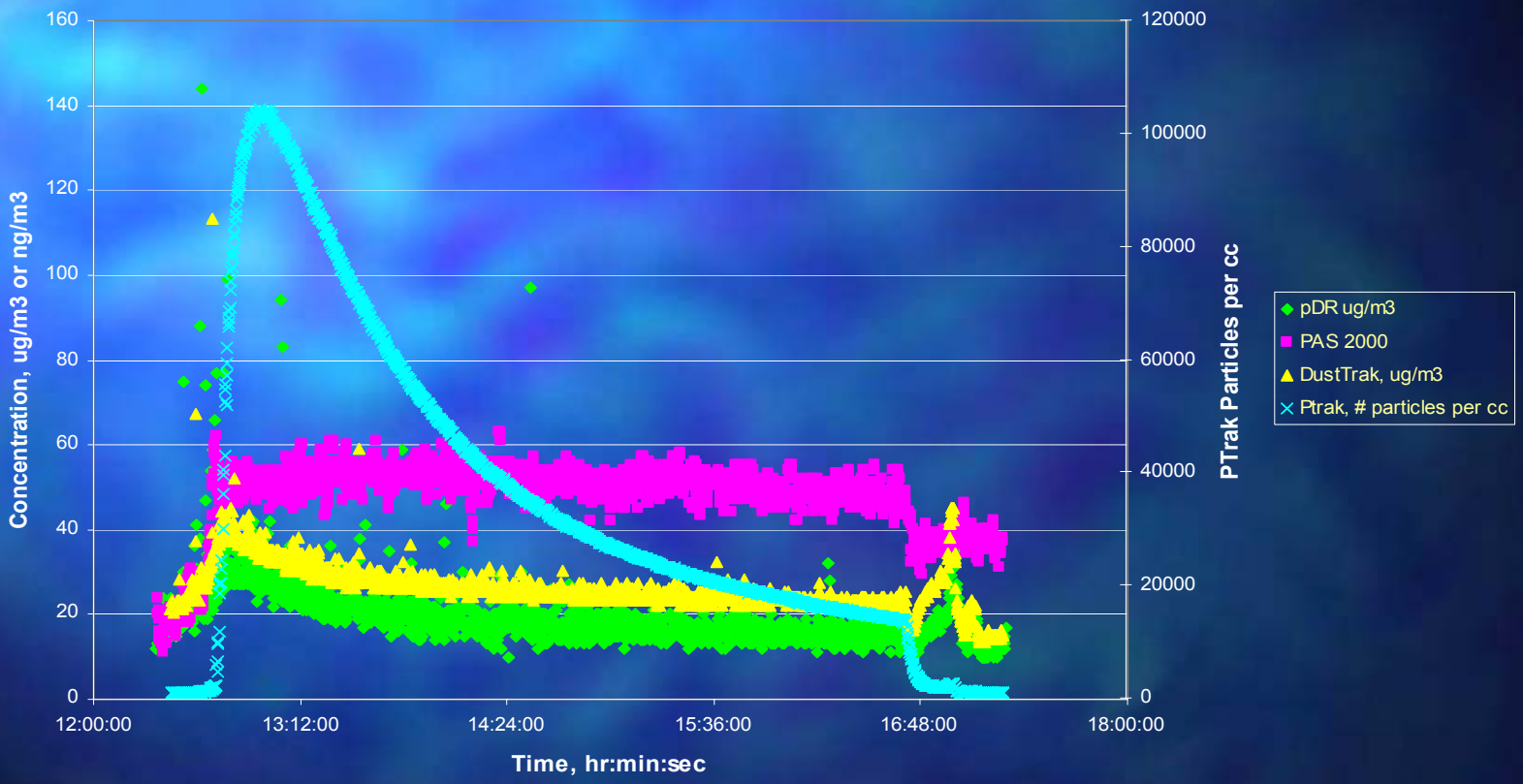
Comparison of Instrument Response as a Fn of Time: Cooking Oil Fumes @ 230 μg/m³



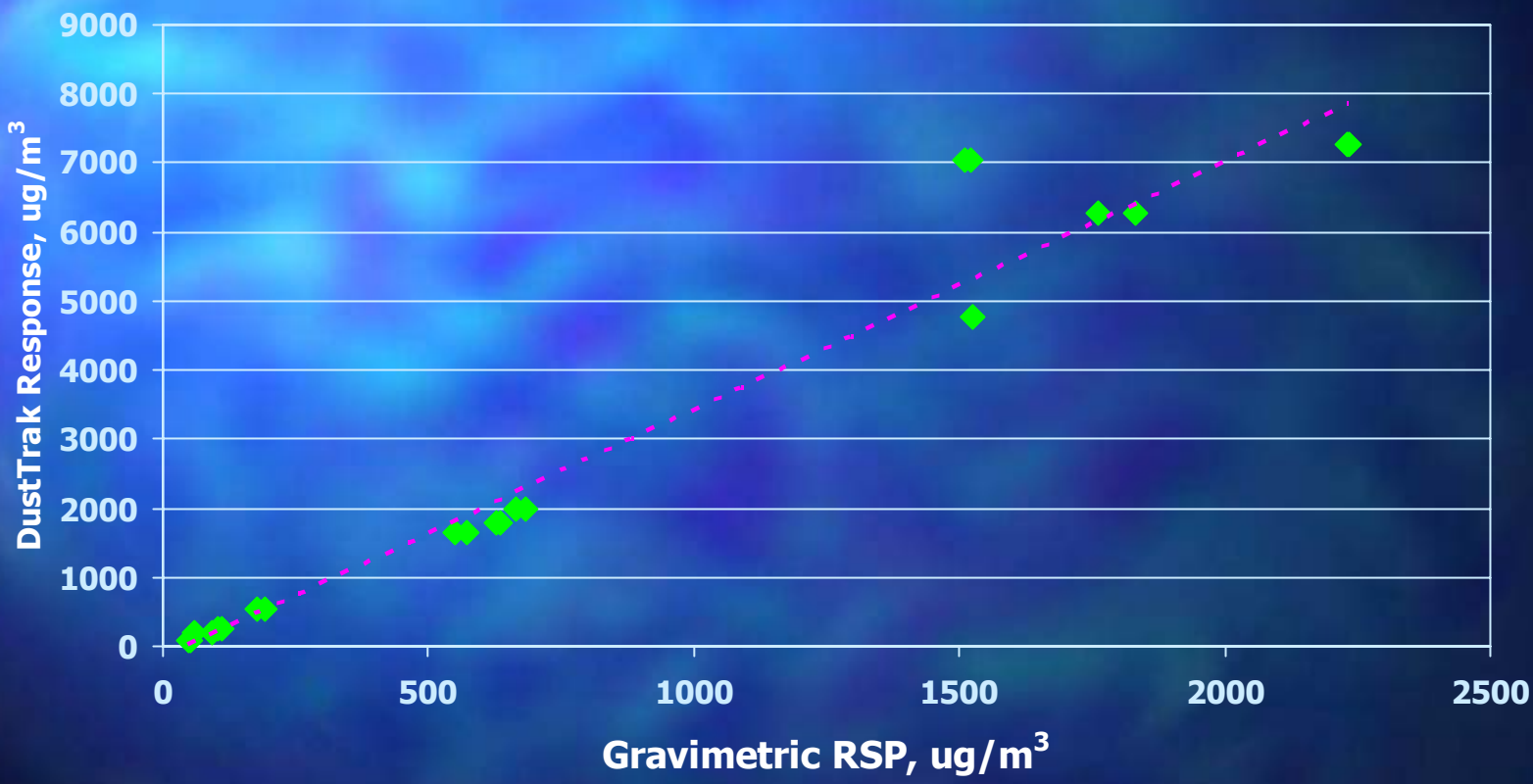
Comparison of Instrument Response as a Fn of Time: Cedar Wood Smoke @ 560 μg/m³



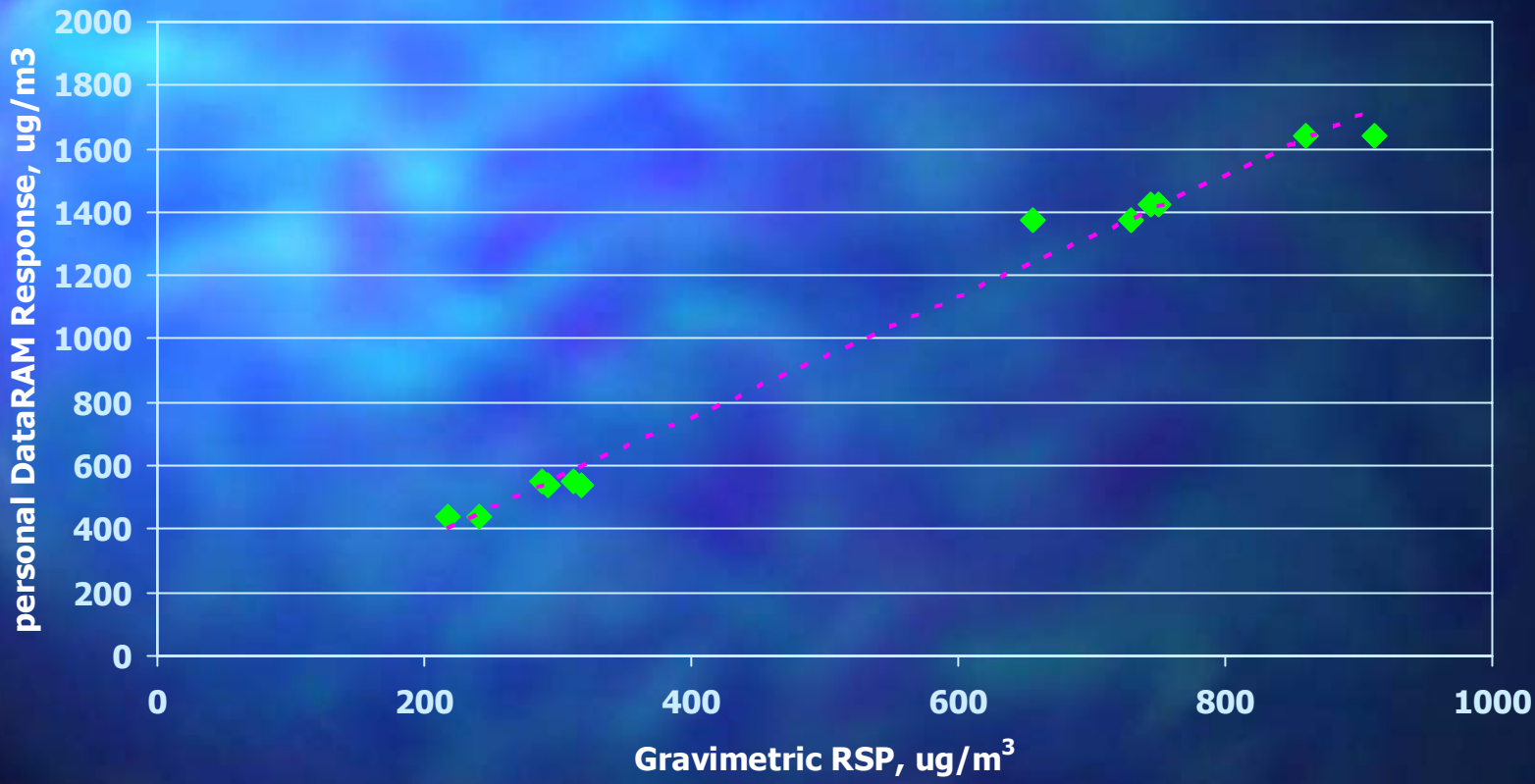
Comparison of Instrument Response as a Fn of Time: Propane Stove Particles @ 30 μg/m³



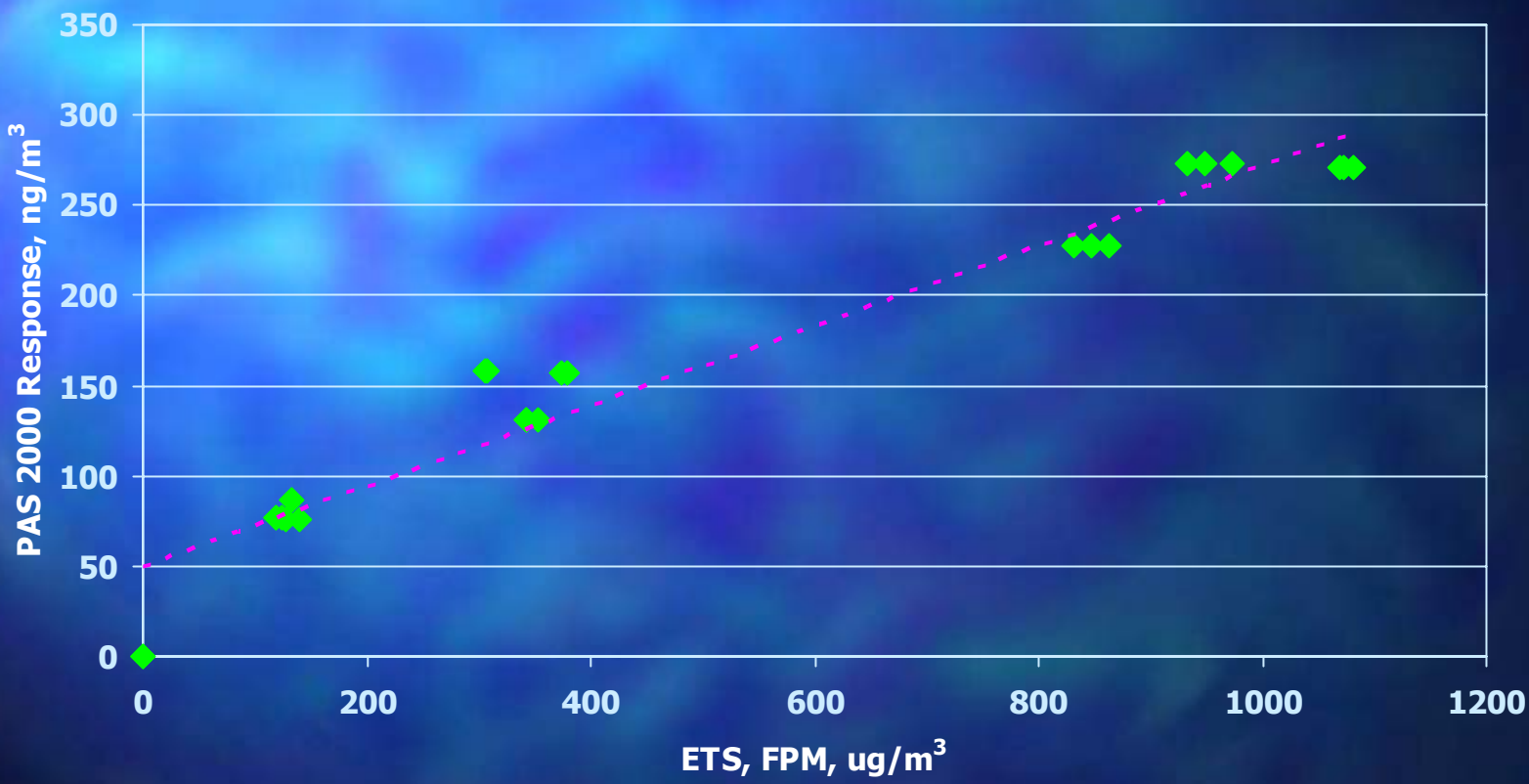
DustTrak Response to Wood Smoke



Personal DataRAM Response to Cooking Oil Fumes



PAS 2000 Response to ETS FPM



Summary of Static Chamber Instrumental Response Factors

(Measured Parameter/Gravimetric RSP, in μg/m^3)

Matrix of Interest	DustTrak, unitless	pDRAM, unitless	PASS 2000, ng/μg	PTrak, particles per cc/μg/m^3
Environmental Tobacco Smoke	4.41 ± 0.68	2.01 ± 0.35	0.54 ± 0.15	229 ± 38
Cooking Oil Fumes	2.25 ± 0.20	1.87 ± 0.16	Does not respond	323 ± 241
Cedar Wood Smoke	3.11 ± 0.63	1.17 ± 0.31	9.95 ± 7.90	157 ± 100
Propane Stove Particles	0.084 ± 0.108	0.016 ± 0.073	0.349 ± 0.327	1508 ± 1002

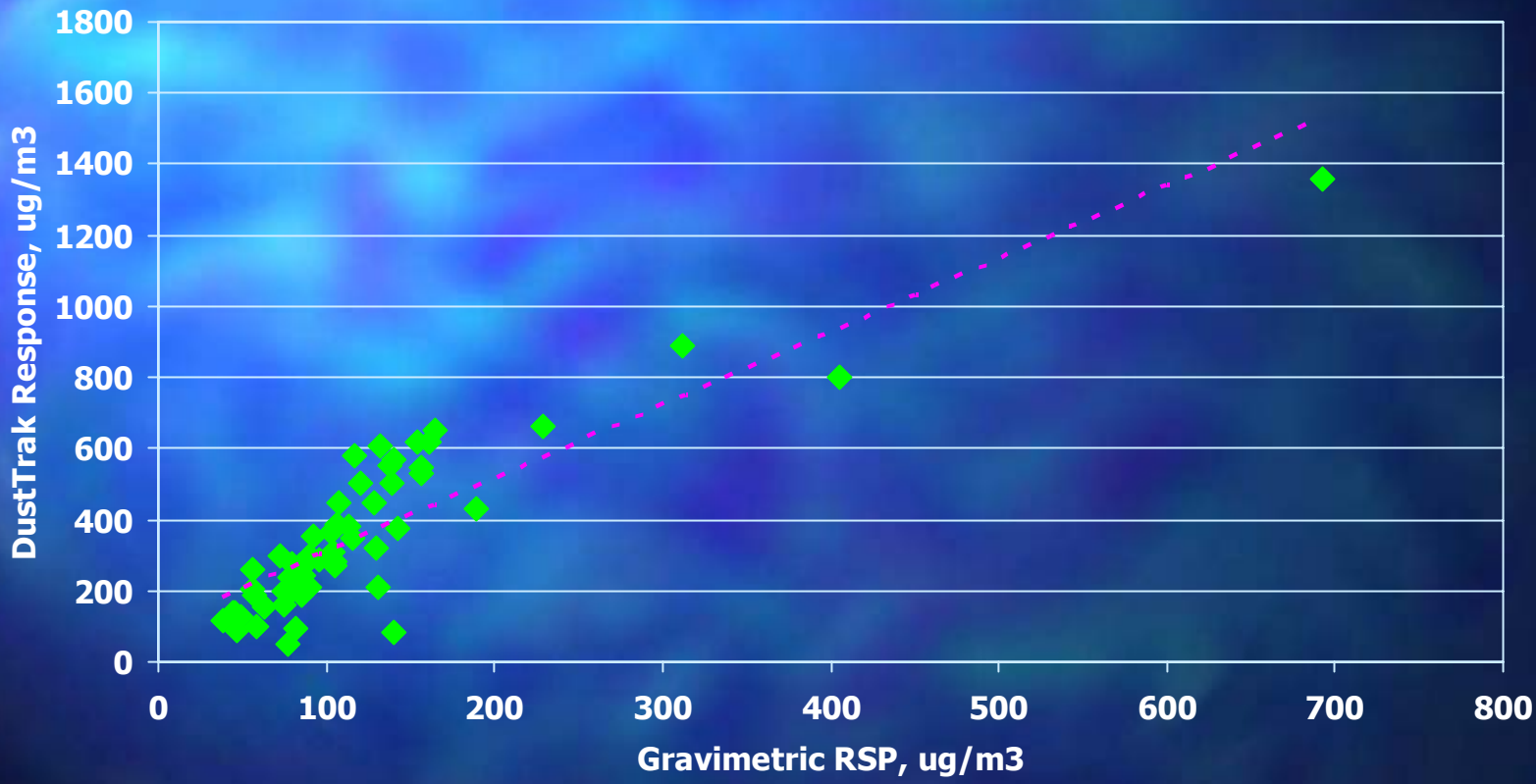
Real World Data from Hospitality Venues

Co-location of TSI DustTrak with ETS Sampler for RSP Collection

Sampling Conditions

- ca. 4 hour samples
- Three different bar/restaurants
- Intimate co-location of RSP sampler and DustTrak
- Range of true time-averaged RSP in smoking sections: 38 – 692 $\mu g/m^3$
- Median fraction of RSP attributable to ETS: 44% in smoking, 34% in non-smoking.
- Total of 37 smoking section samples and 20 non-smoking section samples

DustTrak vs Gravimetric RSP in Hospitality Venues



DustTrak/RSP Response Ratio

- 3.24 ± 0.99 in smoking section
- 2.57 ± 0.61 in non-smoking section
- DustTrak/RSP ratio did not change in a meaningful way with increasing fraction of RSP as ETS RSP. (R^2 = 0.10)
- ETS RSP fraction ranged from 6% to 103% (Median: 39%)

Observations and Conclusions

- Very challenging to generate aerosols that are stable over long periods of time and match real world particle size distributions.
- PTrak is fine for tracking particle sources, but not good for quantitative measurement since it is highly subject to the effects of aerosol coagulation.
- PAS 2000 has much greater response to wood smoke (20x) than ETS.
- DustTrak has slight edge in quantification over pDR, likely due to convective mass transport through the nephalometer.
- DustTrak response to particles in hospitality venues appeared to be an “average” of response to ETS and cooking oil fumes.