Portable Aerosol Beam-Focused Laser-Induced Plasma Spectrometer (ABF-LIPS) for Metal Emission Characterization

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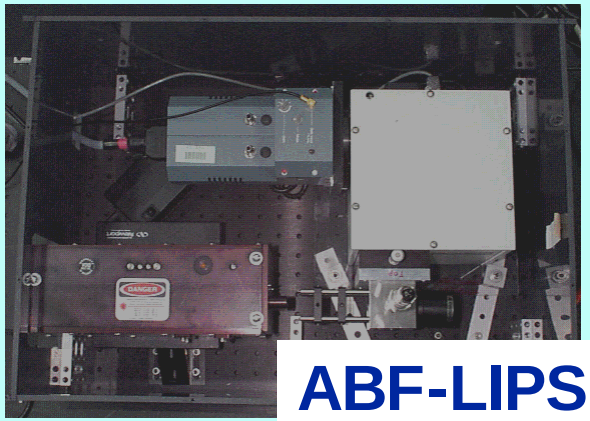
ABF LIPS Metals Measurement

EPA has proposed the continuous emissions monitoring (CEM) of facilities that emit Hazardous Air Pollutants (including toxic metals)



ABF-LIPS

- Pulsed Laser-Induced Plasma
- Time gated emission detection
- Aerosol focusing

TraceAIR

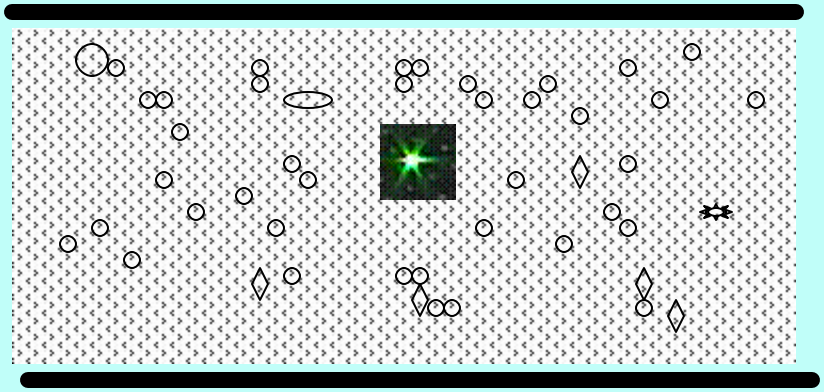
- Inductively Coupled Plasma
- Non-gated emission detection
- No aerosol focusing

ABF LIPS Metals Measurement

- CEM of Various Metals:
  Ag, As, Ba, Be, Cd, Cr, Co, Fe, Hg, Mn, Ni, Pb, Sb, Se, Tl
- ABF-LIPS could be used to monitor various Air Emission Sources including: Plating Shops; Power Plants; Diesel Generators; Waste Combustors and Incinerators.
- Physically Small and Rugged for Field Use/Portable
- Improved Sensitivity achieved by aerosol focusing
- Time-Resolved Analysis Capability for Improved Resolution and Detection

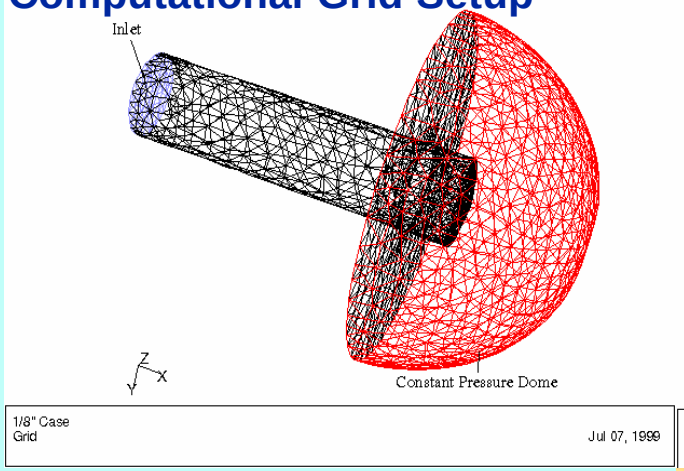
Spectrometric Measurement of Aerosol Chemical Composition in Real Time: Analytical Challenges

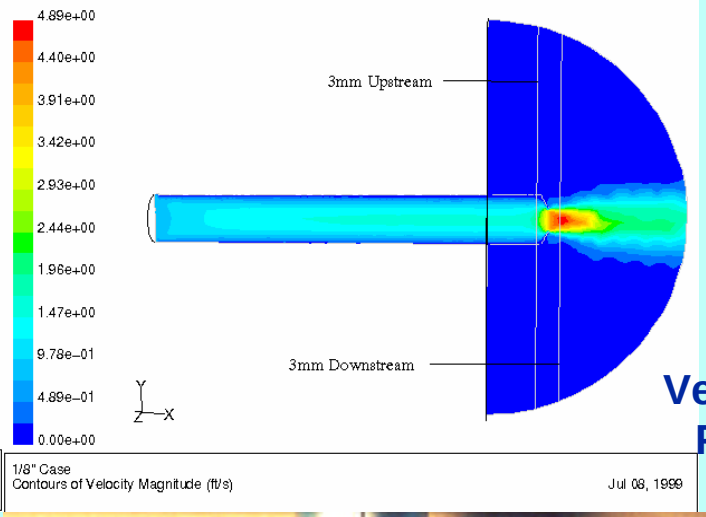
- Non-homogeneous microscale system. Aerosol particles, various size and shape, distributed at random
- No control of the size of particles sampled by each laser-induced plasma
- Sampling uncertainty cannot be confined and determined
- Sample amount or sampling rate not regulated. Analytical determination, quantification, difficult at best



Aerosol Beam Focusing

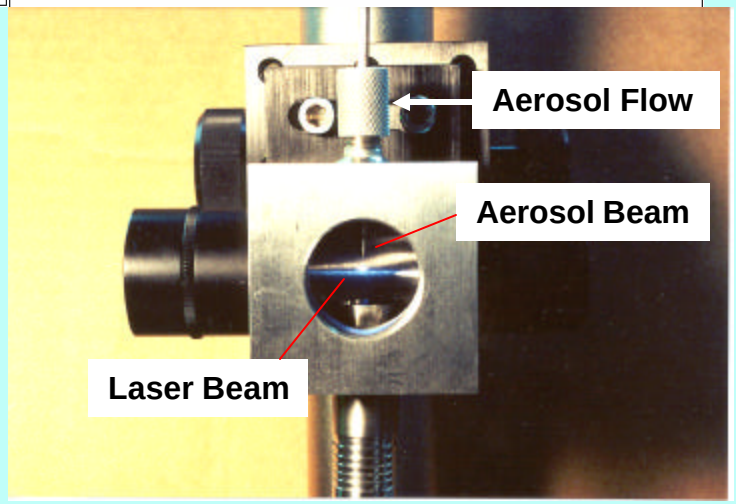
Computational Grid Setup



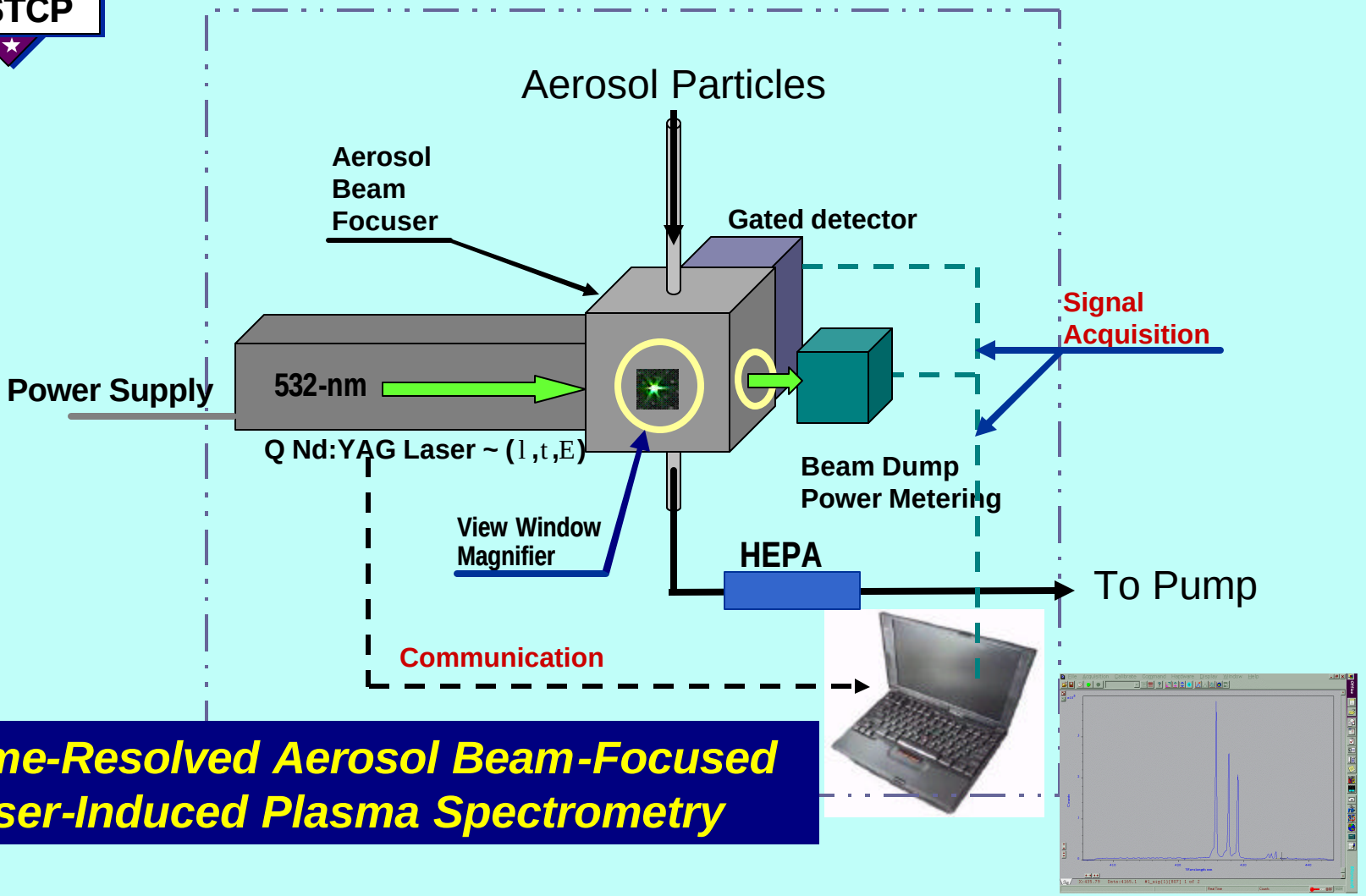


Velocity Field

- Computational Fluid Dynamics simulation used to assist the design of aerosol beam focuser
- Transport behavior of particles in the measurement system investigated
- Several shapes and inner wall geometry tested



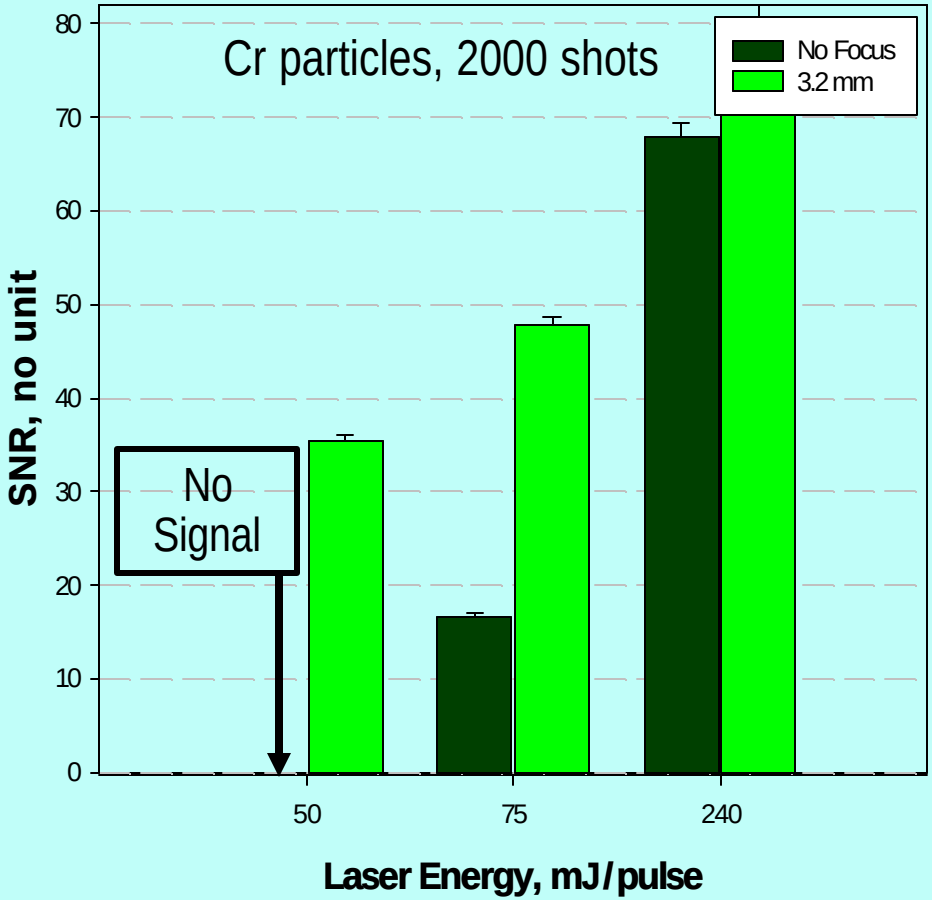
Schematics



Time-Resolved Aerosol Beam-Focused Laser-Induced Plasma Spectrometry

Signal Enhancement by Aerosol Focusing

Aerosol focusing increased signal-to-noise ratio (SNR) substantially at lower laser energy that enables the use of a small compact laser excitation source.



532-nm Nd:YAG

Results from SERDP Studies

- Levels of Detection for some species tested in simple matrix in laboratory environment
- Estimated using data of signal-to-noise ratio $\geq$ 3

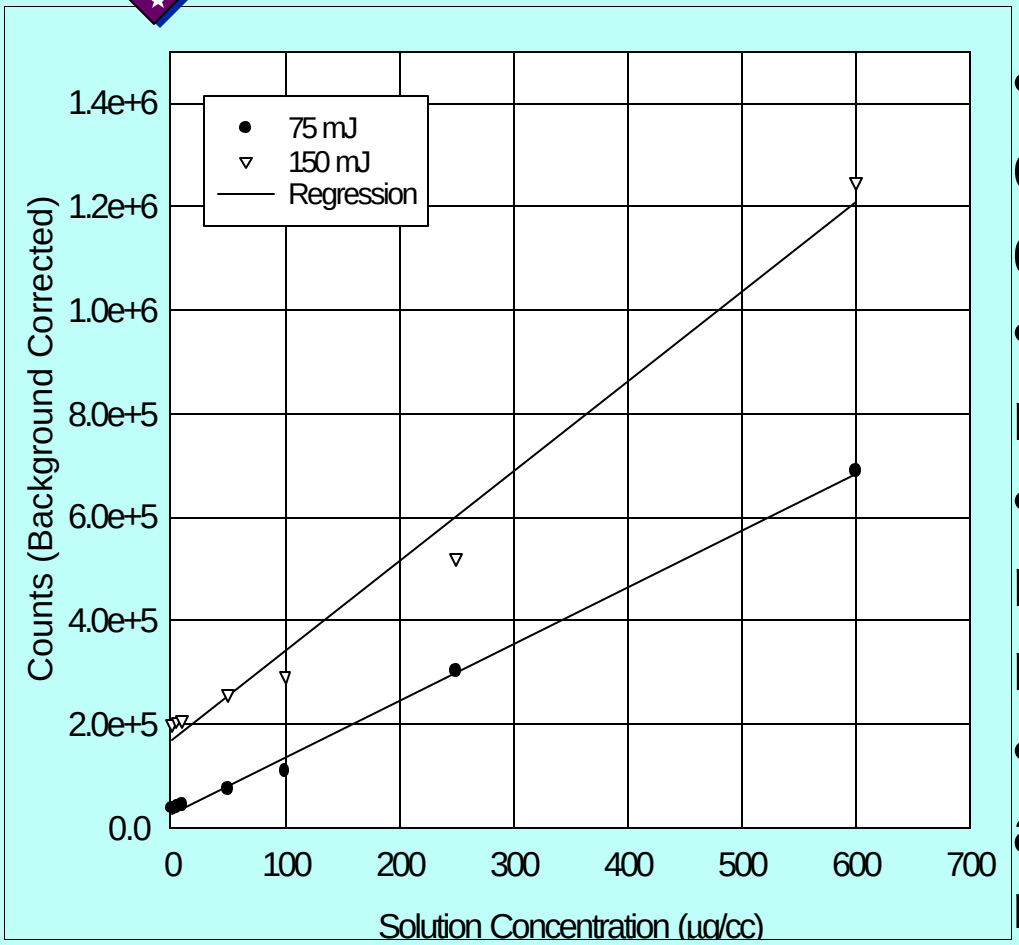
Examples:

Cr: 400 ng m^{-3} or 0.4 $\mu g\ m^{-3}$

Hg: 1000 ng m^{-3} or 1.0 $\mu g\ m^{-3}$

Na: 30 femtograms absolute mass calculated from single particles

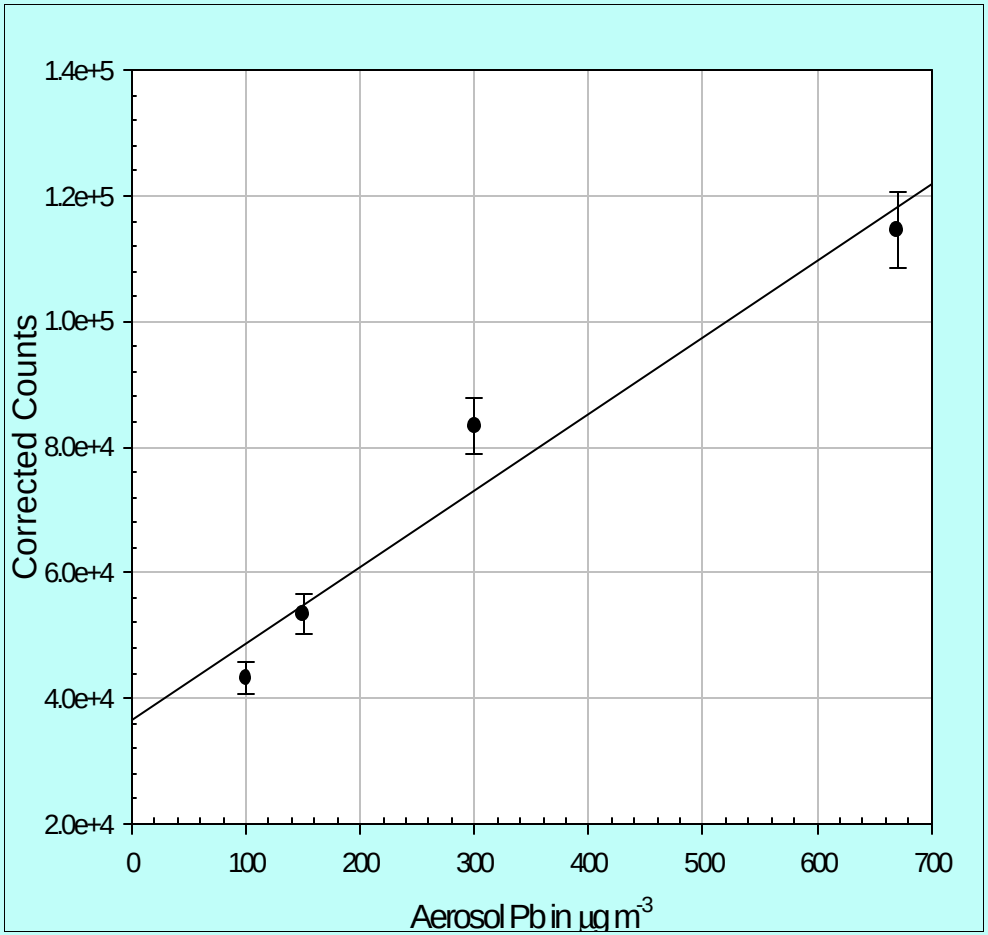
Measurement of Cr-Laden Aerosol



- Minimal aerosol chromium concentration detected: 0.4 µg m^{-3}
- Sample interval: 1.5 minutes
- Good linearity, linear range ~ 3 orders of magnitude
- Shown 1,000 shots accumulated, 10 Hz repetition rate

532-nm Q, 7 ns

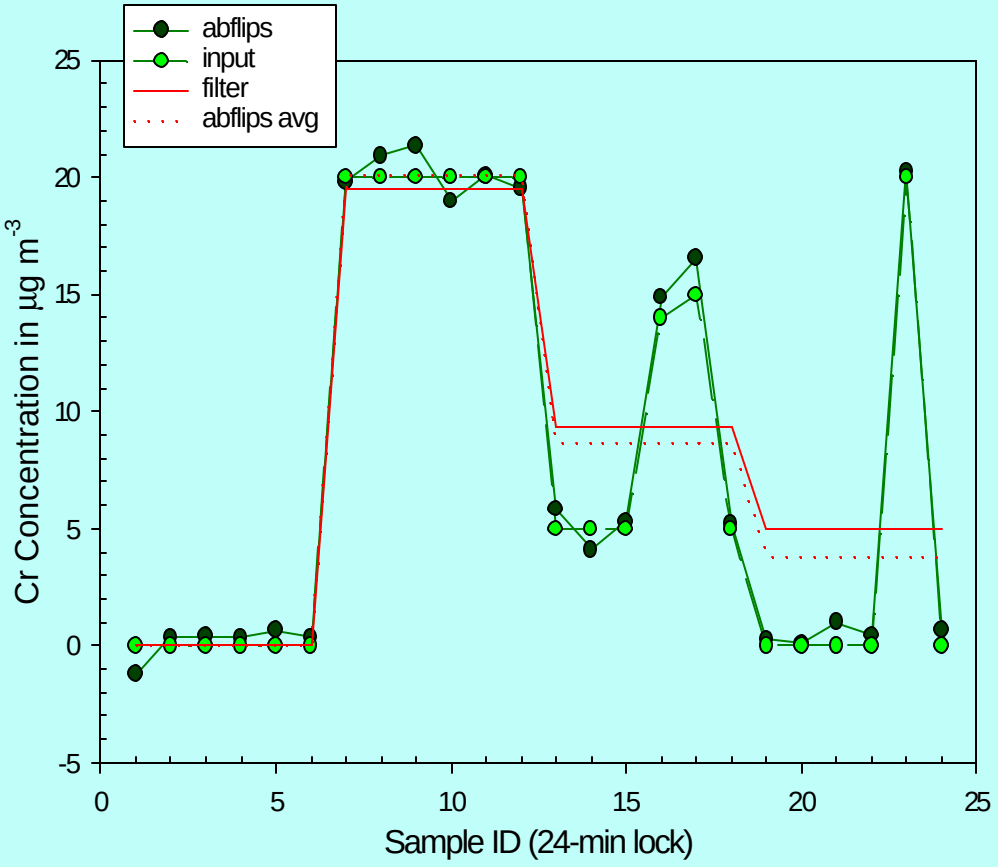
Measurement of Pb-Laden Aerosol



- Aerosol lead detection limit: 60 µg m^{-3} or lower
- Sample interval ~ 4 minutes
- Linear dynamic range ~ 3 orders of magnitude
- Shown 2,500 shots accumulated, 10 Hz repetition rate

Results from SERDP Studies

Cr-laden ($CrCl_3$) Aerosol in Diesel Exhausts *Background Gas Matrix Test of Polydisperse Aerosols*



- 3 different means of monitoring
  - ABFLIPS on-line
  - Separate on-line filter collection
  - Filter collection after aerosol focuser (for diagnostics only, not shown here)
- Averages of both data streams compared reasonably
- Only ABFLIPS reflects the true system variation

Project Description

- SERDP Funded Project selected as Project of the Year in 2000
- Proposing to Dem/Val as a reliable, cost effective real time CEM by comparing with an EPA Approved Sampling Methodology on actual Air Emission Sources (Stack Gas Sampling)
- Dem/Val of the ABF-LIPS will be on a Plating Shop, and Waste Combustor

Method For Verification

Proposed Approach for Field Tests:

- EPA Method 301 for Validation of New Measurement Techniques for Flue Gas
- Performance Specification-10 Multimetals CEM
- Spike the Source Emission w/ 3 Different Metals of Different Concentrations
- Contract for Independent Particle Size and Mass Measurement using traditional Cascade Impactors
- Contract for Method 29 Multimetals Measurement

Collection of Cost And Performance Data

Evaluation of Costs with Potential Commercial Vendor (Comstock, Inc) during the Dem/Val Tests of CEM ABF-LIPS

- Based Upon Actual Field Data Collection/Labor
- Capital Costs
- Operation and Maintenance Costs
- Method 29/Validation Testing
- Cost and Performance Report will be prepared

Test Locations

- **Low (ambient) Temperature Test**
  - Naval Aviation Depot North Island
  - Plating Facility that emits Cr, Ni, and Cd
- **High Temperature Test**
  - Army - Waste Combustor (e.g. Hawthorne Army Depot)
  - Criteria is that it emits Pb, Hg and other metals

Performers

Bryan Harre	NFESC	Principal Investigator
Leslie Karr	NFESC	Co-Investigator
Dr. Mengdawn Cheng	ORNL	Instrument Developer
Bob Weber	Army	Army Site Liaison
John Bosch	EPA	EPA Stakeholder
Dr. William Gibson	Comstock, Inc	Commercial Partner

Acknowledgments

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