

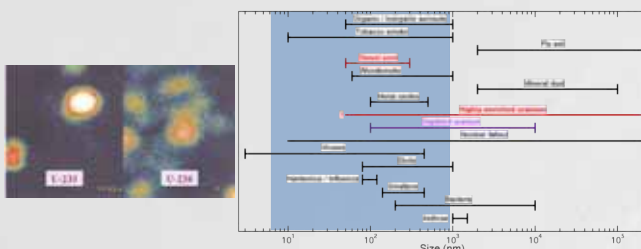
# Novel Instrumentation for Selective Photo-Ionization and Trapping of Fine Particles

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## Problem

Lack of methods for collection and *in situ* analysis of fine particles for evidence of proliferation activities  
Without selective collection, finding trace quantities of uranium is the proverbial "needle-in-a-haystack" problem



Uranium enrichment can produce fine atmospheric particles, providing an indicator of proliferation activities. These particles are difficult to detect because of (1) low ambient concentrations, (2) small size (<1  $\mu\text{m}$ ), (3) high concentrations of other particles.\* Fine particles are difficult to trap (i.e., follow gas flow and are aerodynamically "slippery") and difficult to sort. Enriched uranium particles will likely be <1  $\mu\text{m}$ , nonspherical, dense uranium oxide or uranyl fluoride.



Our technique is designed to solve the "needle-in-a-haystack" problem.

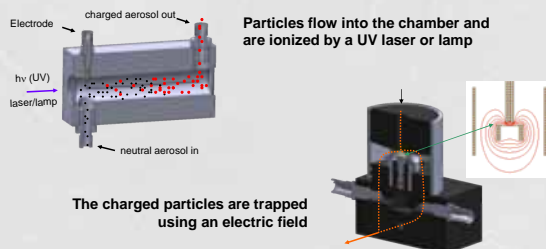
## Approach

We are using ultraviolet light from lasers and lamps to select between the target and background particles.

- Ultraviolet (UV) light can impart a charge to a particle — "photoionization"
- By carefully selecting the light source and intensity, different particles in a mixture can be charged to different degrees.
- The efficiency of the particle charging depends on the intensity of the light.
- Lasers and lamps can be used to produce the desired light.
- A brief voltage pulse can help sweep away electrons, preventing recombination with the ions.

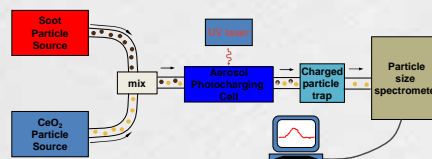
An electric field can be used to move the charged particles to a trap.

- Smaller charged particles and particles with more charges on them move more easily in an electric field.
- Uncharged or insufficiently charged particles are not trapped.

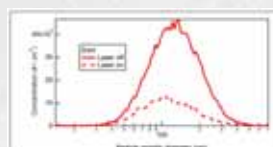


## Results

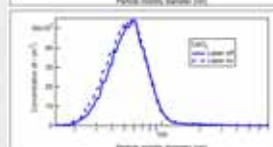
Particle separation experiment schematic drawing



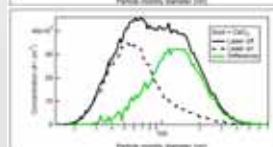
- Soot source:** ethylene flame followed by particle diffusion-dryer
- CeO<sub>2</sub> source:** aerosol atomizer using CeO<sub>2</sub> powder suspended in H<sub>2</sub>O and dryer
- UV source:** 243 nm produced by frequency conversion using 1064 nm Nd:YAG laser and 630 nm dye tunable laser
- Charged particle trap:** parallel plate electrostatic trap
- Particle size spectrometer:** scanning mobility particle sizer (TSI)



Soot has a size peak at ~140 nm and is significantly ionized and trapped when the 243 nm (UV) light is turned on. High concentrations used for this demonstration reduce trapping efficiency. Greater than 95% trapping has been demonstrated using concentrations closer to ambient.



CeO<sub>2</sub> has a size peak at ~60 nm and does not ionize at 243 nm and, therefore, is not trapped. Using shorter wavelengths, CeO<sub>2</sub> can be ionized and trapped.



The mixed aerosol of soot and CeO<sub>2</sub> shows the expected bimodal distribution with the laser off. With the laser on selective trapping of soot is clearly evident.

## Significance

Our technique is versatile and could be used for:

Nuclear nonproliferation and forensics to detect enriched uranium particles

- Revealing covert activities
- Monitoring for treaty verification



U<sub>3</sub>O<sub>8</sub> with platelets of PuO<sub>2</sub>\*

Explosives detection

Chem / bio warfare detection



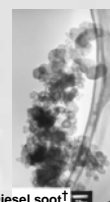
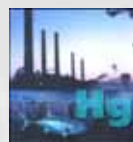
Smallpox



Ebola virus

Energy R&D

- Fossil fuel / biofuel particle sampling for engine development
- Coal power plant toxic emissions monitoring



Diesel soot†

\*Tamborini & Betti, *Mikrochimica Acta* 132, 411 (2000).

†Clague et al., *Carbon* 37, 1553 (1999).