Study of Atmospheric Aerosols by Laser Post Ionization Time-of-Flight Mass Spectrometry at the Argonne Free Electron Laser Facility

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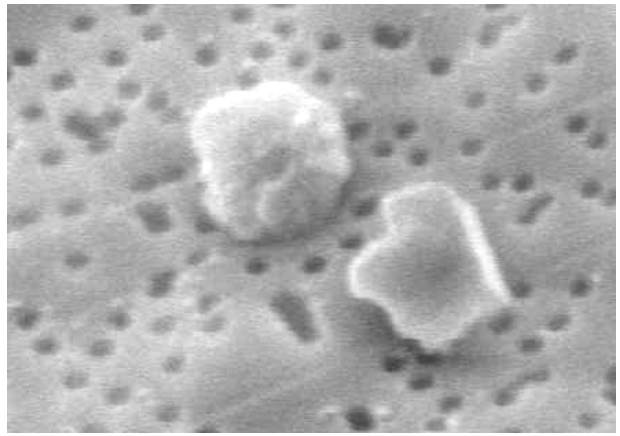
Aerosols



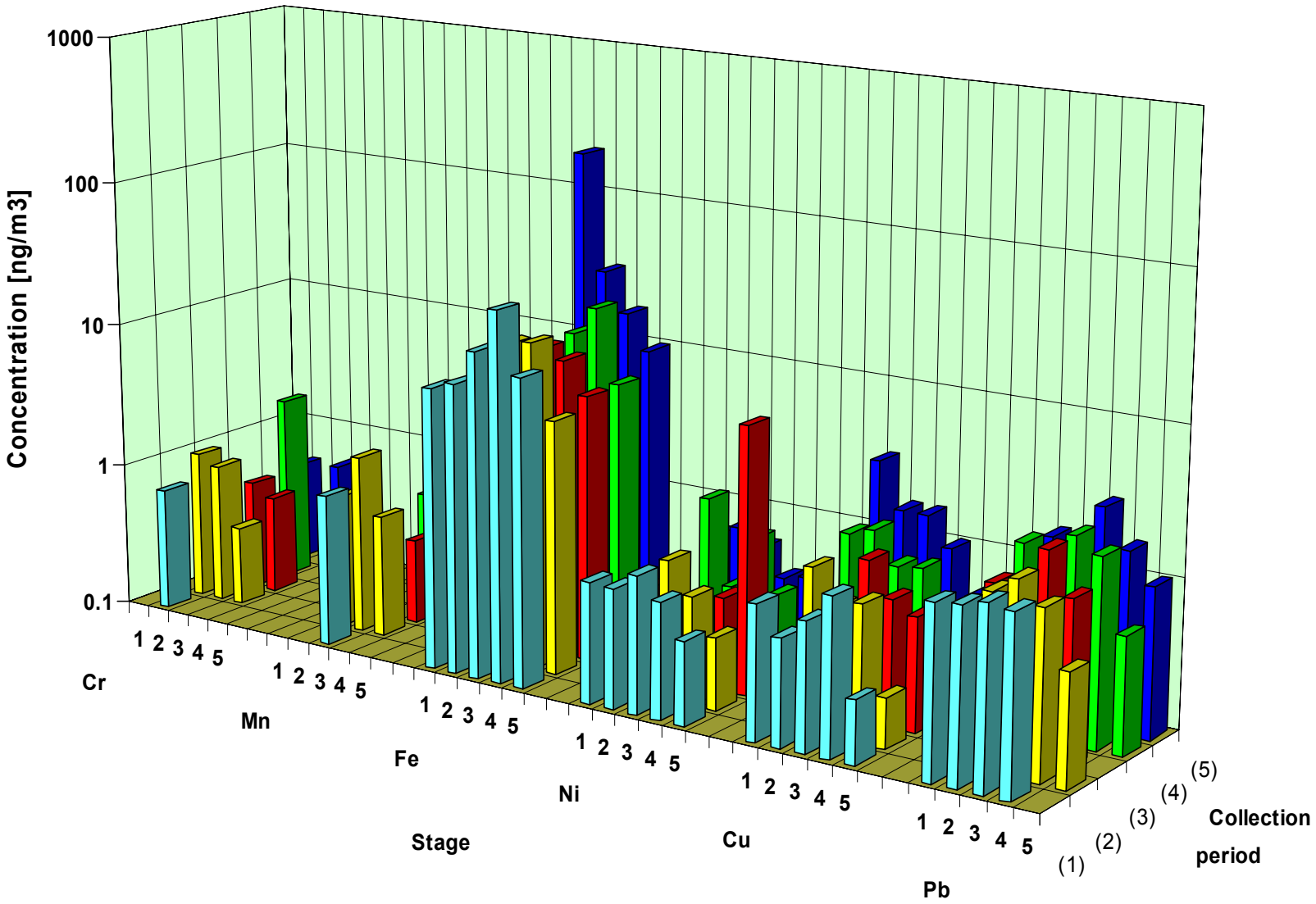
⇨ are solid particulates suspended in air

⇨ have different sizes

⇨ show different chemical composition

Both, size and composition change frequently and rapidly.

Diurnal Variation Urban Aerosol



Aerosols

Courtesy USGS

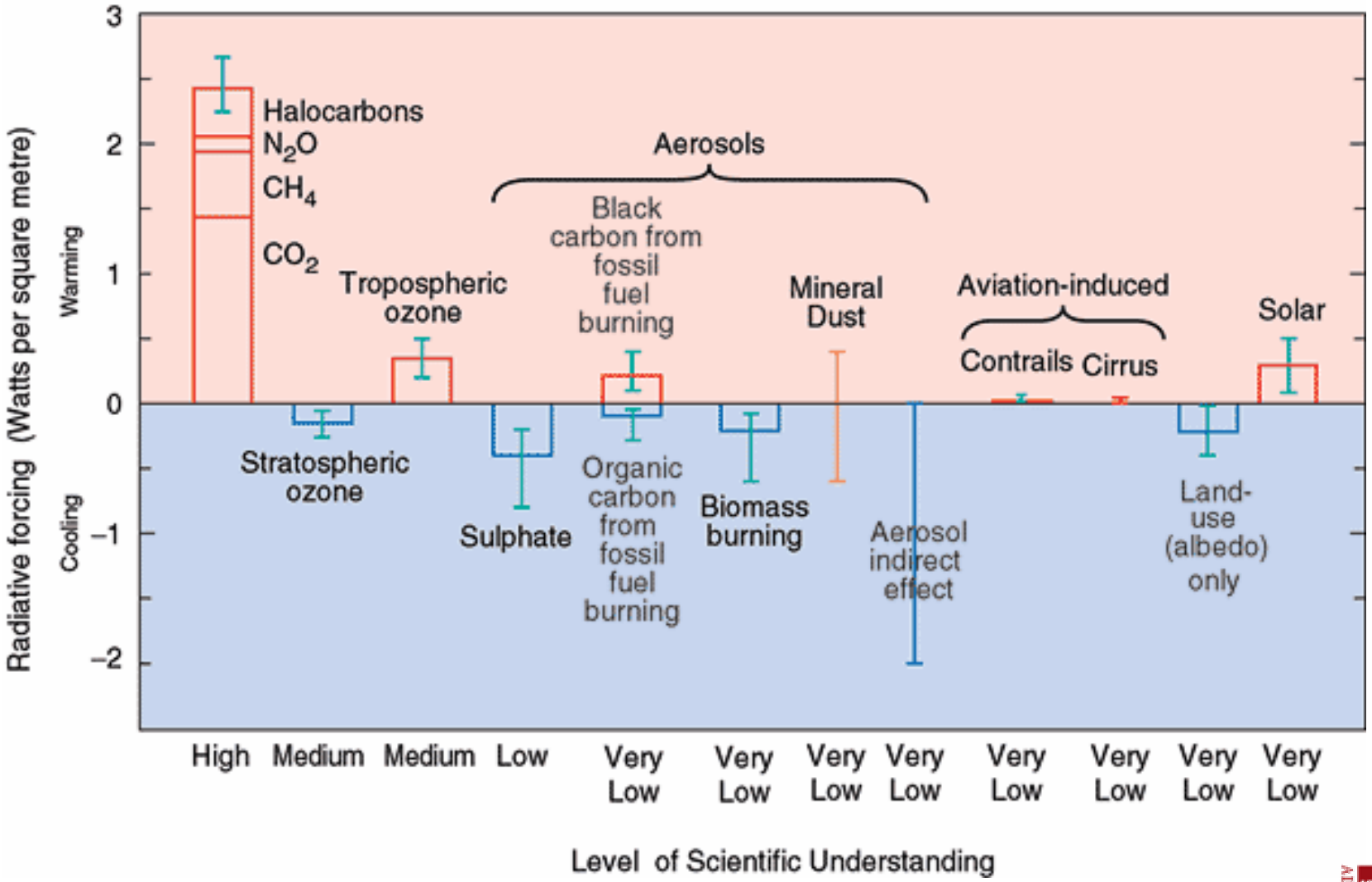
are responsible for:

- ⇨ **low visibility and haze**
- ⇨ **urban air pollution**
- ⇨ **respiratory and other diseases**
- ⇨ **climate forcing - directly and indirectly**

Until now, little is known about the magnitude of aerosol contribution to climate. The IPCC 2001 states:

“Large uncertainties in anthropogenic forcing are associated with the effects of aerosols.”

The global mean radiative forcing of the climate system for the year 2000, relative to 1750



IPCC, 2001

Highest uncertainties originate from:

- ⇨ the complex nature of aerosols
- ⇨ their rapid change in size and composition
- ⇨ are associated with the carbonaceous fraction of the aerosol
- ⇨ lack of instrumentation to study aerosols with satisfactory resolution

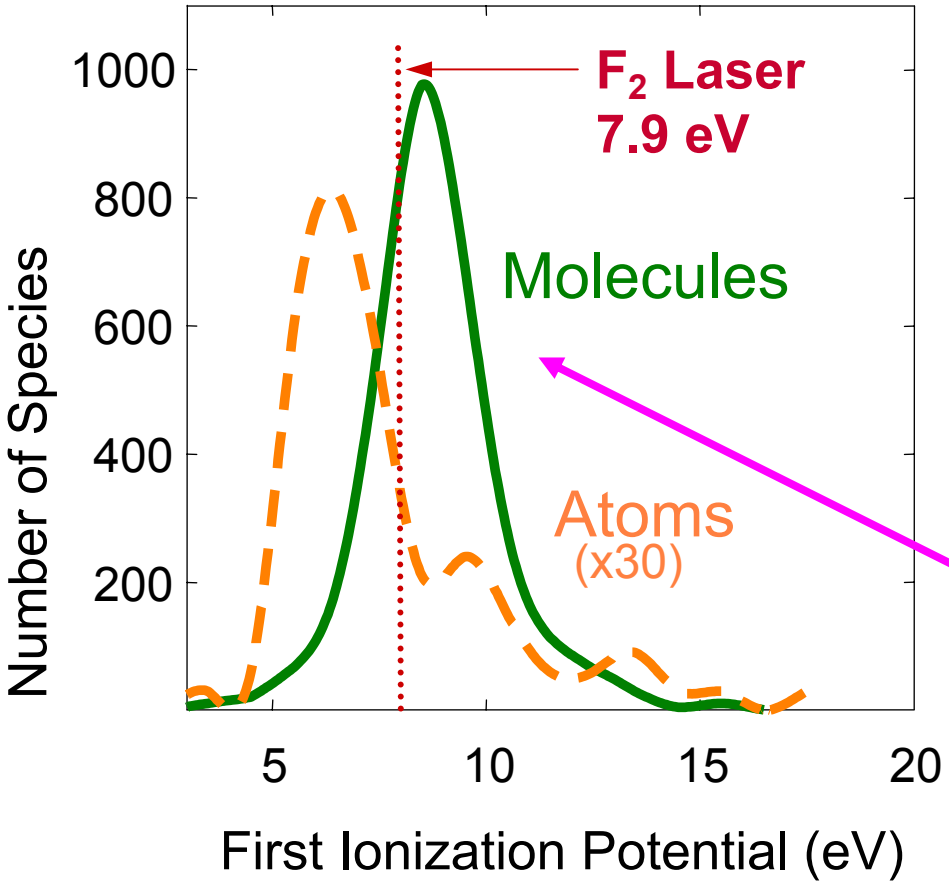
Comparison of Instrumentation for aerosol analysis

* **SEM/TEM –** size information, but only limited composition, single particle analysis
* **PIXE/XRF –** need size classified collection; need high sample mass, quantitative, but no light elements
* **ATOFMS –** size information, single particle analysis but not quantitative, poor detection limits
* **TXRF –** light elements excluded, needs size classified collection, but needs only small sample mass and is quantitative

LPI TOF MS

- ⇨ single particle analysis
- ⇨ chemical speciation possible
- ⇨ quantification possible
- ⇨ depth profiling – bulk and surface analysis possible

Distribution of First Ionization Potentials



The new VUV FEL with the photon energy tunable up to 22.54 eV and 100 μJ/pulse will make possible saturation of the resonance SPI for almost every species!

Including
organic molecules

Courtesy of I. Veryovkin

Strength of LPI TOF MS

⇨ depth profiling

- ⇨ provides information about surface and bulk of particle
- ⇨ this information is critical to identify whether a particle is internally or externally mixed
- ⇨ internally mixed particles have different radiative properties than externally mixed ones

⇨ determination of organic species

How will we proceed?

Collection

- Size classified collection at Loyola University Chicago Air Station (LUCAS)
- use of collection substrate to permit bulk and single particle analyis

Loyola University Chicago Air Station - LUCAS

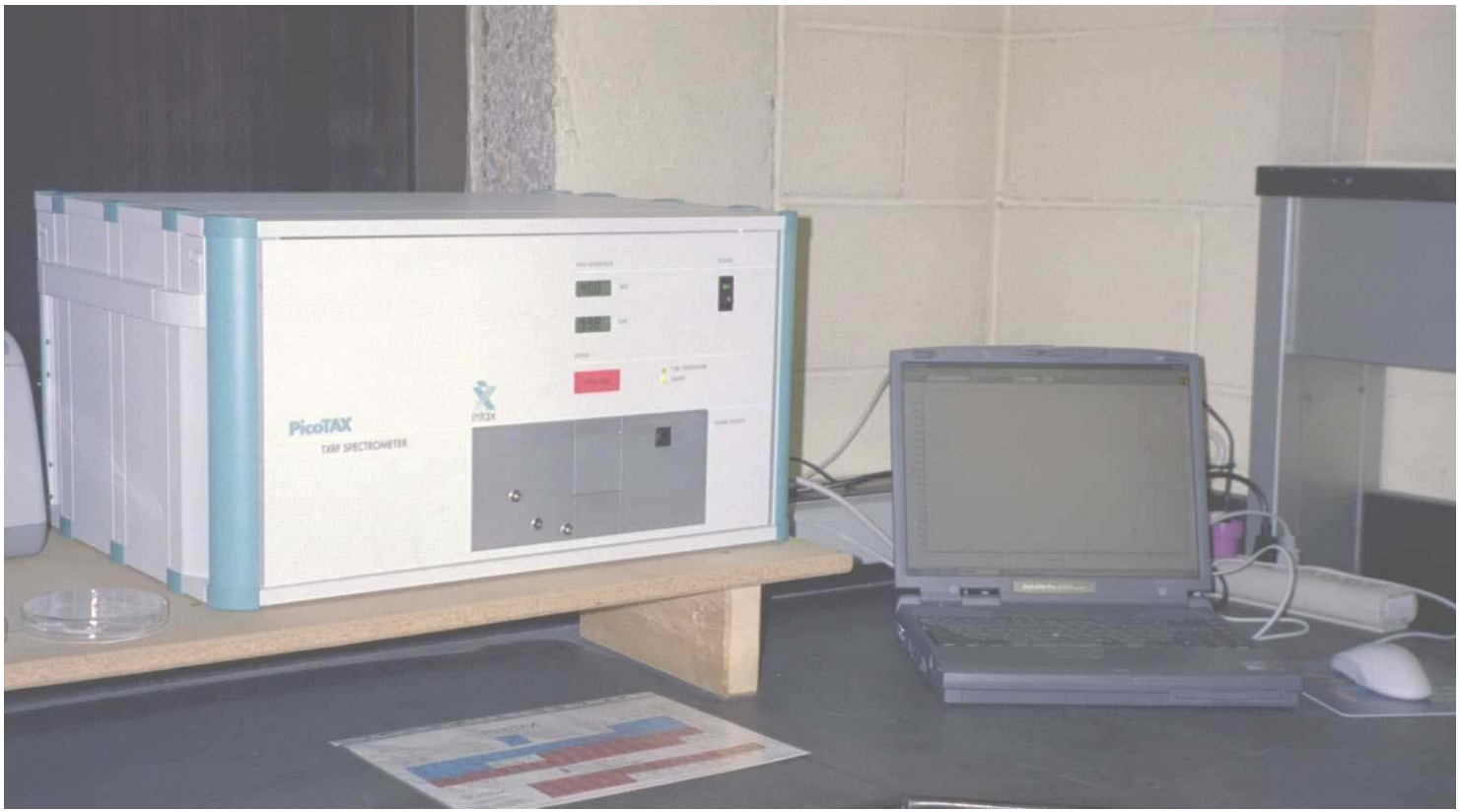
Analysis

- non- destructive bulk analysis by
  Total Reflection X-ray Fluorescence Analysis (TXRF)
  at Loyola University Chicago

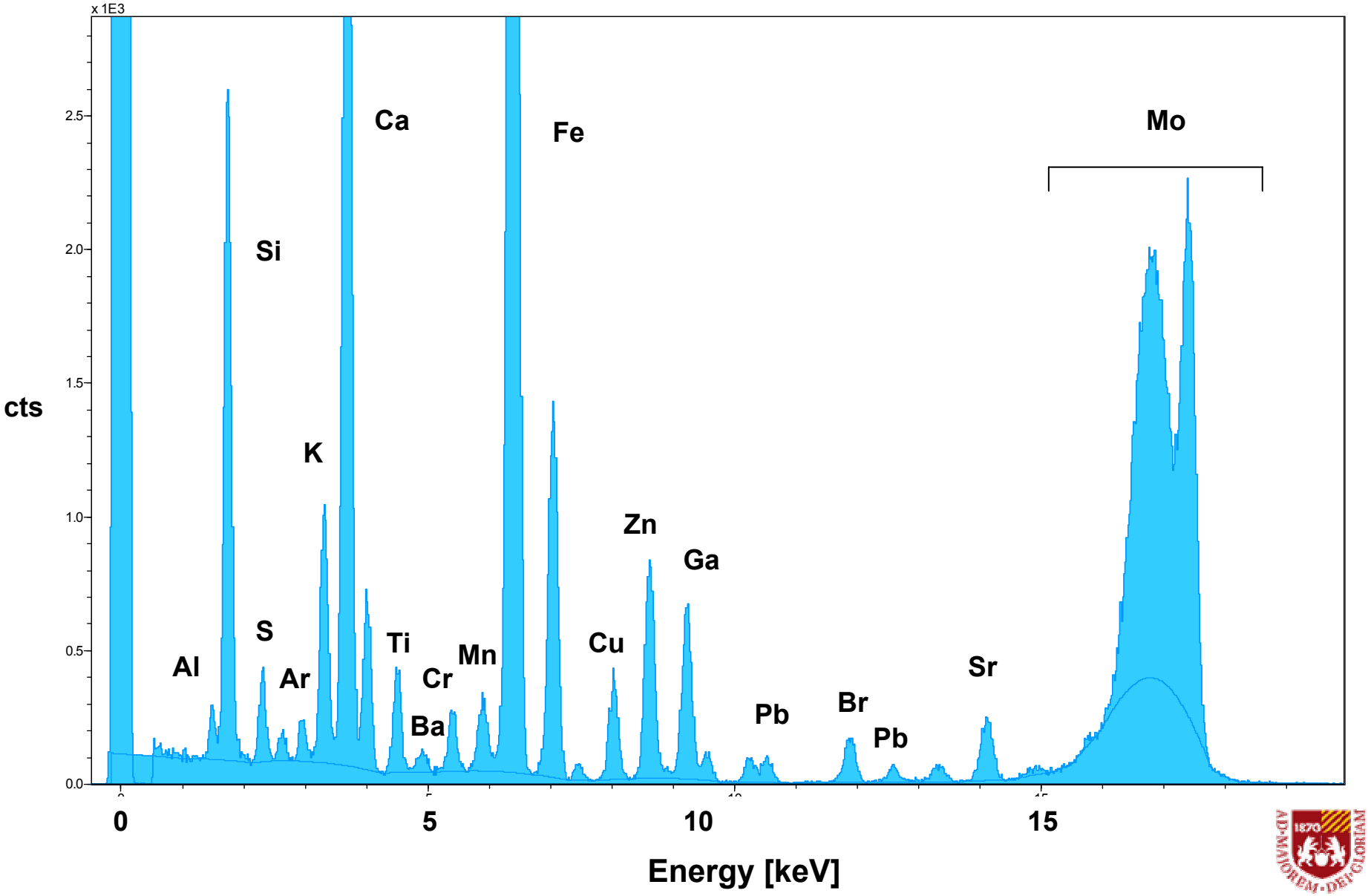
- single particle analyis of the same sample with
  LPI TOF MS (SPIRIT) at FEL

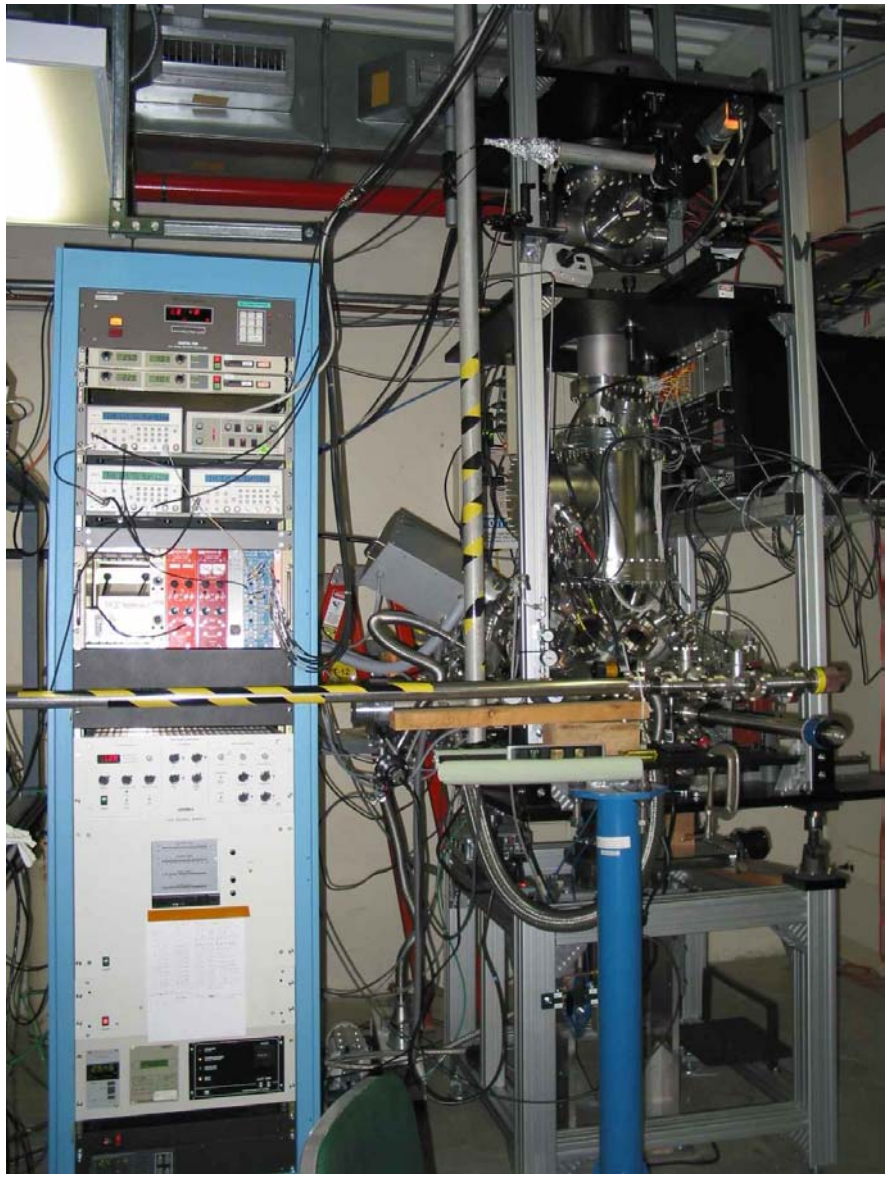
- development of an analysis procedure for UHV conditions

PicoTax Total Reflection X-ray Fluorescence Spectrometer

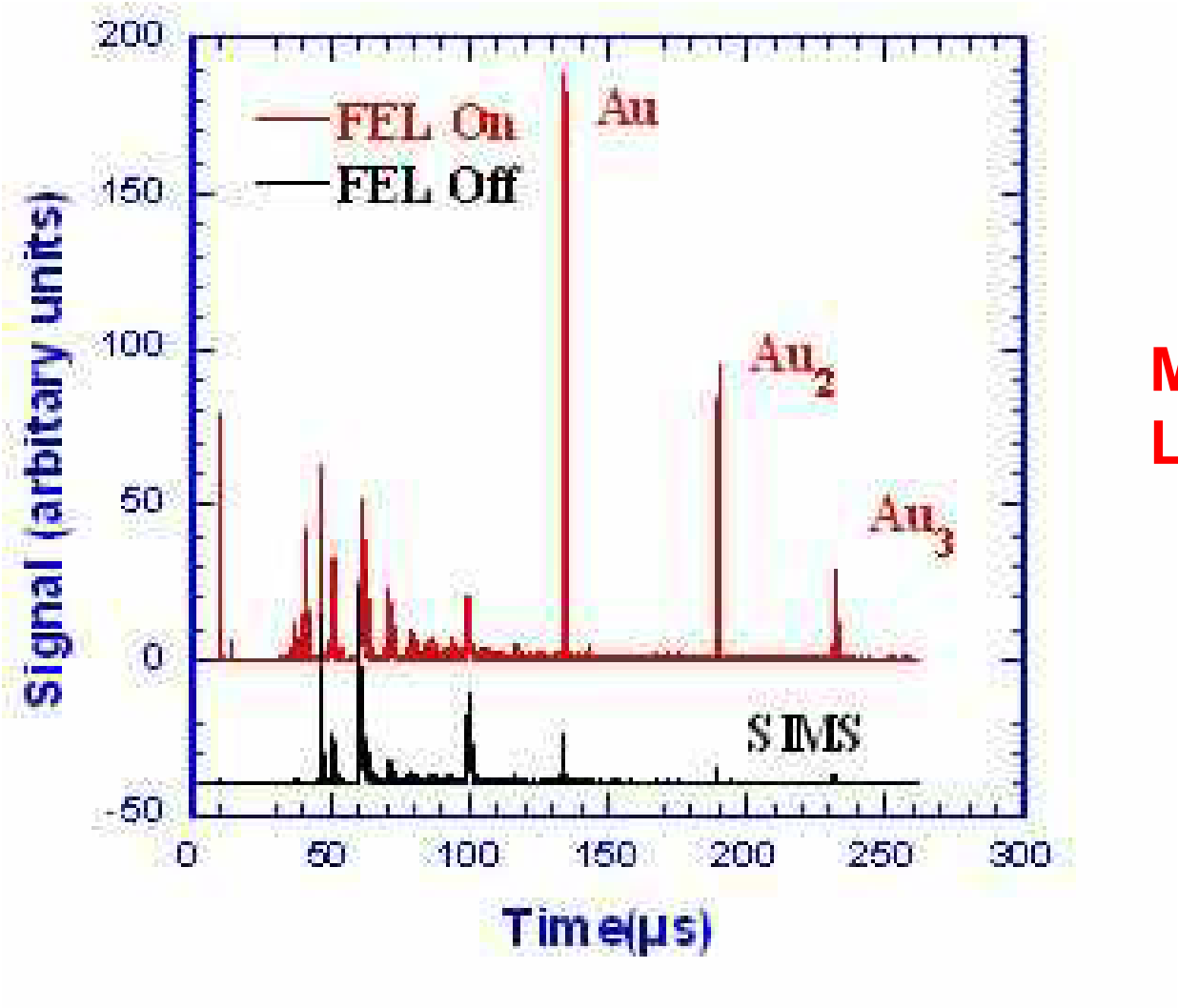


Typical Bulk Aerosol Chemical Composition by TXRF





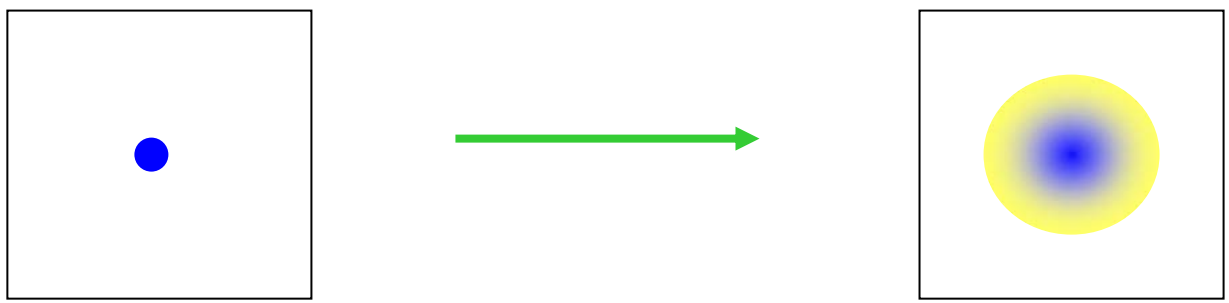
LPI TOF MS at APS



Mass Spectrum
LPI TOF MS

Laboratory Produced Particulates

- ⇨ generation of aerosols with defined sizes
- ⇨ exposing this aerosols to different atmospheric conditions
- ⇨ observe their evolution and growth at different development stages by LPI TOF MS



Projected Outcome

- information about single particle composition
  - ⇨ surface and bulk composition, provides insight whether internally or externally mixed
  - ⇨ surface coating?
  - ⇨ reaction potential of the particle

- together with bulk chemical composition, radiative properties can be estimated