Nanoparticle/Ultrafine Monitoring State of the Science

NAAMC Nov. 3 – 5, 2009

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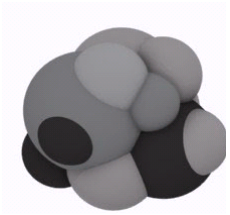
EPA OAQPS

Outline



Concerns – Why is this important?

Nanotechnology Workshop

- Gaps - Recommendations

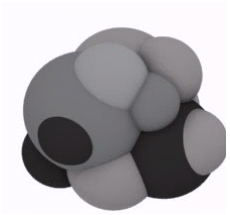
European Union - Status

What’s out there right now?

Getting to the Core of Things

Summary - Acknowledgements

Concerns



Let's put this into perspective: (According to Wikipedia)

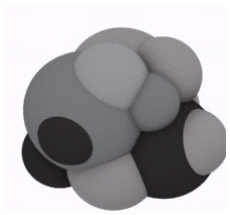
What is a Nano particle?

A particle is defined as a small object that behaves as a whole unit in terms of its transport and properties… Similar to Ultrafine particles, they are sized between 1 to 100 nanometers.

What is an Ultrafine Particle?

Particles in the nanoscale, less than 100 nanometers…There are two main divisions that categorize types of UFPs. UFPs can either be carbon-based or metallic, and then can be further subdivided by their magnetic properties.

Sources of NPs and UFPs



Anthropogenic

Engineered

- Carbon-based Nanotubes, Fullerenes
- Metal Oxides
- Quantum Dots
- Nanotubes
- Nanowires
- Dendrimers

Incidental

Particles from:

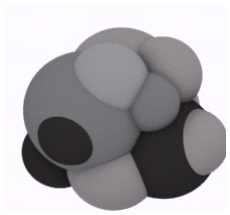
- Combustion
- Industrial Processes
- Vehicles
- Construction

Natural

Particles from:

- Plants, Trees
- Oceans, other water bodies
- Erosion
- Dust

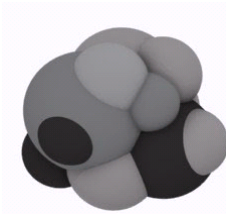
Concerns



There are numerous health effects

- Pulmonary inflammation
- Early interstitial lung fibrosis and granulomas
- Asbestos-like pathogenicity
- Translocation from respiratory tract
  - Oxidative damage in human blood serum
  - Inflammatory and pro-clotting effects in blood

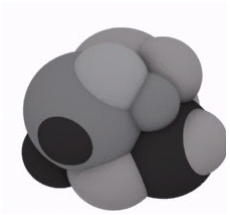
Concerns



What is it that causes these symptoms?

- Size
- Shape
- Composition
- Solubility
- Crystalline structure
- Charge
- Surface characteristic
- Attached functional groups
- Agglomeration
- Impurities

Nanotechnology Workshop



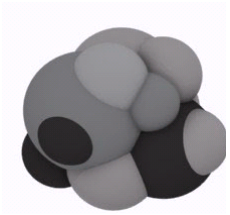
March 3-4, 2009: EPA and Battelle Hosted a Workshop on Monitoring

Technology Needs and Gaps
Implications and Drivers Discussion
Technology Needs Discussion
Path Forward/Actions

EPA – OAQPS' Goal:

- **What are the technology gaps and needs?**
- **What will it take to fill those gaps?**
- **What do we present to EPA management?**

Nanotechnology Workshop Findings



A literature search should be performed to identify all available types of NP air measuring devices.

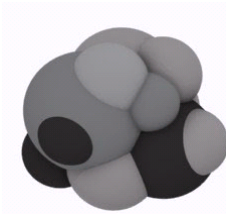
The Agency needs to define whether NPs should be classified as a subset of UFPs or classified independently.

Technology that has been developed for UFPs should be investigated as the "springboard" to launch technology development for NPs. The ability to collect and "count" UFPs is a mature technology.

UFPs and NPs should be regulated in the same manner.

A collaborative group should be formed from different organizations to lead an effort to identify the best available air monitoring .

Nanotechnology Workshop Findings



Individual Particle Techniques

Electron Microscopy
(SPM, SEM, TEM)

Electron Diffraction

Ensemble Techniques

Photon based
Spectroscopy
(FT-IR,NMR)

X-ray
(scattering, spectroscopy)

Mass Spectrometry

Reverse Chromatrography

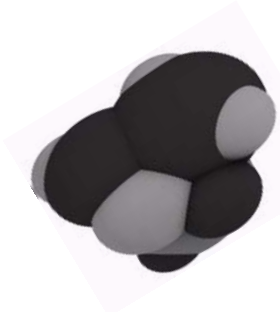
Metrology Standards

3-D Characterization Standards

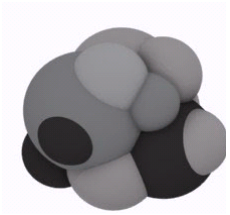
Dispersion and Distribution

Interfacial Interactions

Interphase Properites



European Union UFP's

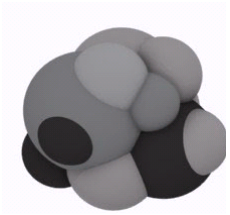


- In 2005 the EU adopted the *"Thematic Strategy on Air Pollution"* - part of the "Clean Air for Europe (CAFE)" program

- EU established a starting point for particle number based limits for emission of UFP's from light duty vehicles with diesel engines

- 6×10^{11} particles/km - phased in - 2010 to 2012

EU-Life UFIPOLNET Project



Objectives

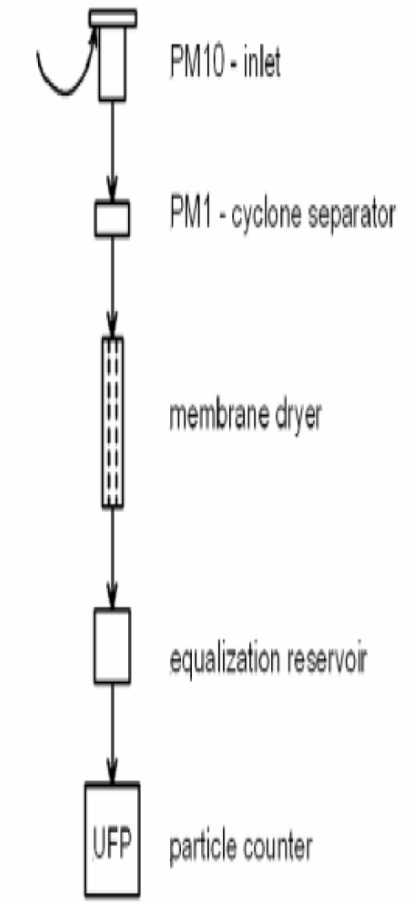
Design a new UFP monitor for air quality networks

- Affordable (initial cost & total cost of ownership)
- Easy to install, use and maintain
- Easy to integrate into existing station data acquisition
- Well suited for continuous monitoring

Four European sites with different particle characteristics were chosen:

- Street Canyon in Stockholm, Sweden (very high PM concentration)
- Street tunnel entrance in Prague, Czech Republic (medium PM concentration)
- Street intersection in Dresden, Germany (medium PM concentration)
- Urban park in Augsburg, Germany (urban background)

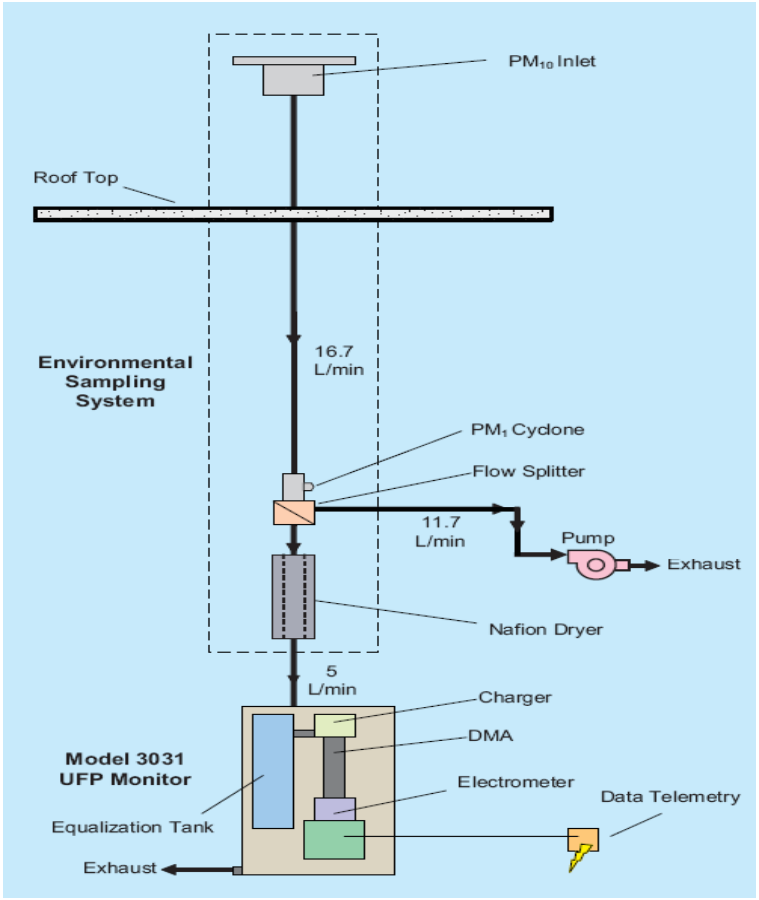
EU TSI UPFs Instrument



Sampling system of UFP 330 implemented at all 4 stations (Hillemann/Wehner)

TSI – UFP 330

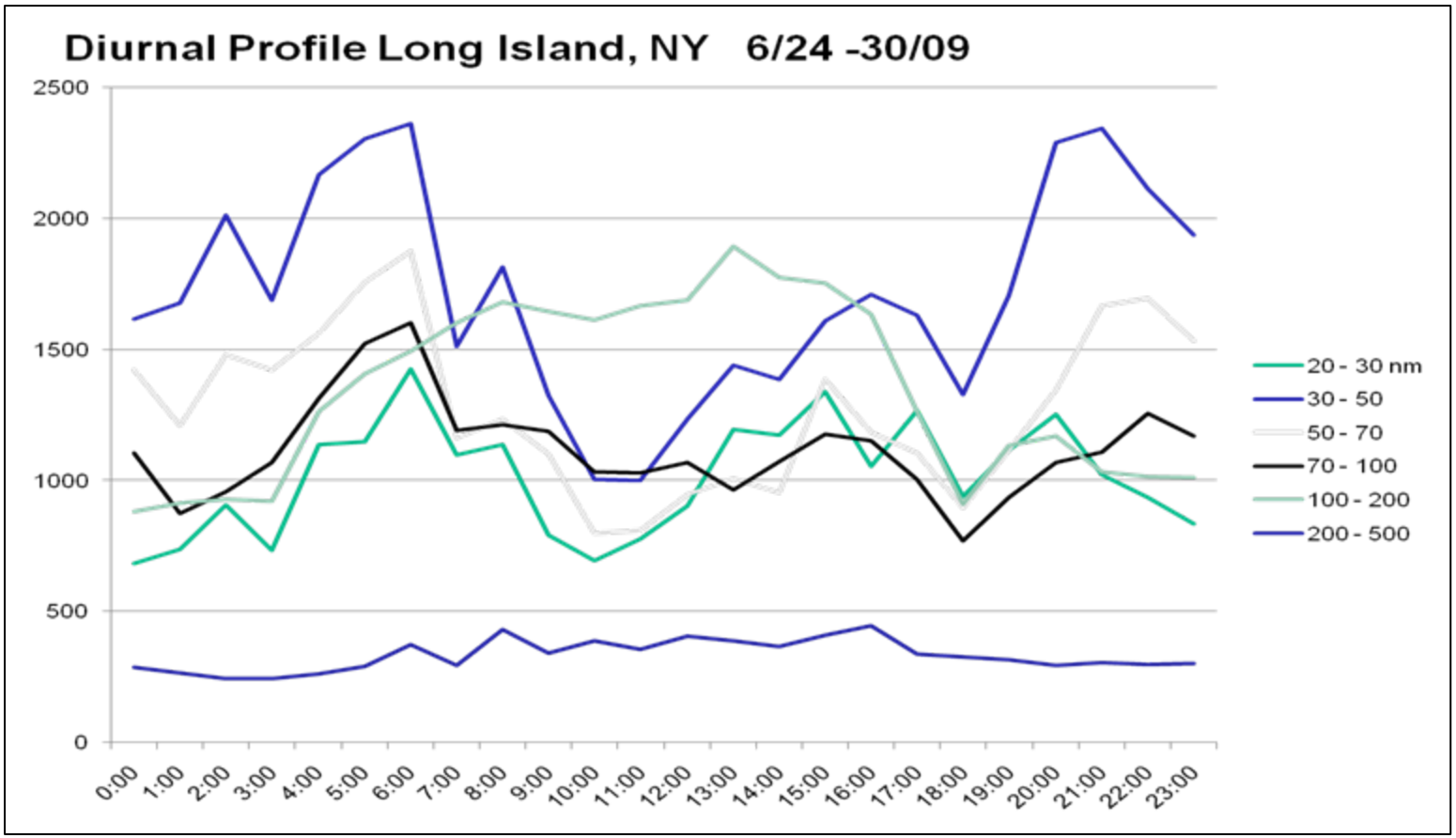
NY UFPs instrument



TSI 3031 Features and Benefits

- Long-term, unattended operation
- Low start-up and operating costs
- No working fluids; no radioactive source
- Convenient data management with remote access via the Internet
- Continuous measurements every 10 minutes
- Optional environmental sampling system

NY UFP Data


Diurnal Profile Long Island, NY 6/24 -30/09
2500
2000
1500
1000
500
0
0:00
1:00
2:00
3:00
4:00
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6:00
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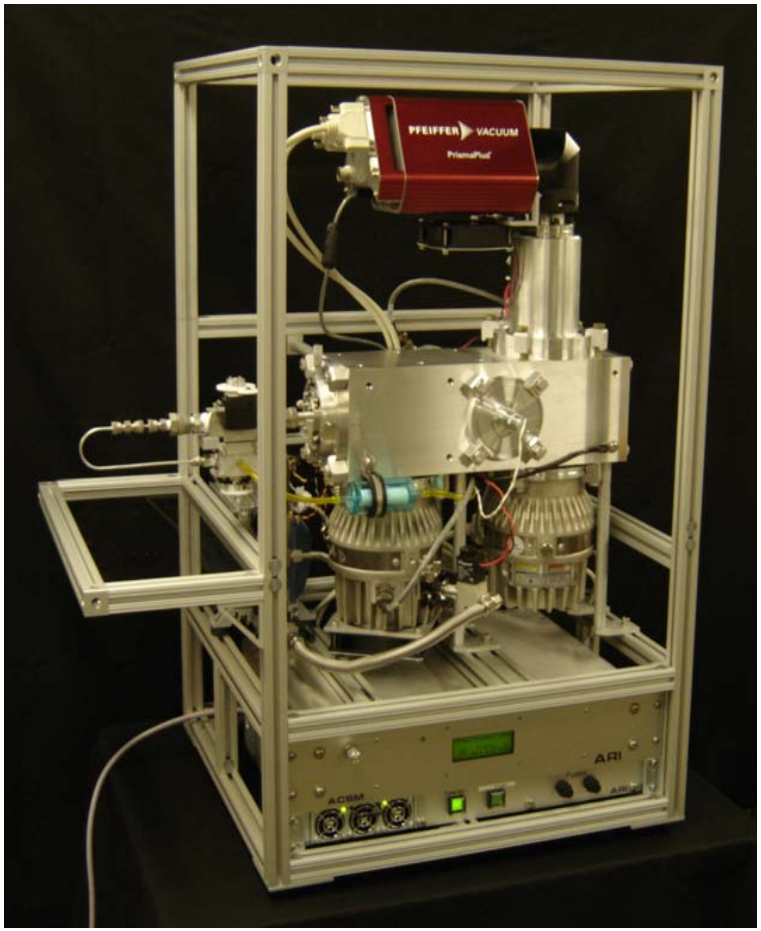
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
20 - 30 nm
30 - 50
50 - 70
70 - 100
100 - 200
200 - 500

Aerodyne Research, Inc.- Aerosol Chemical Speciation Monitor (ACSM)



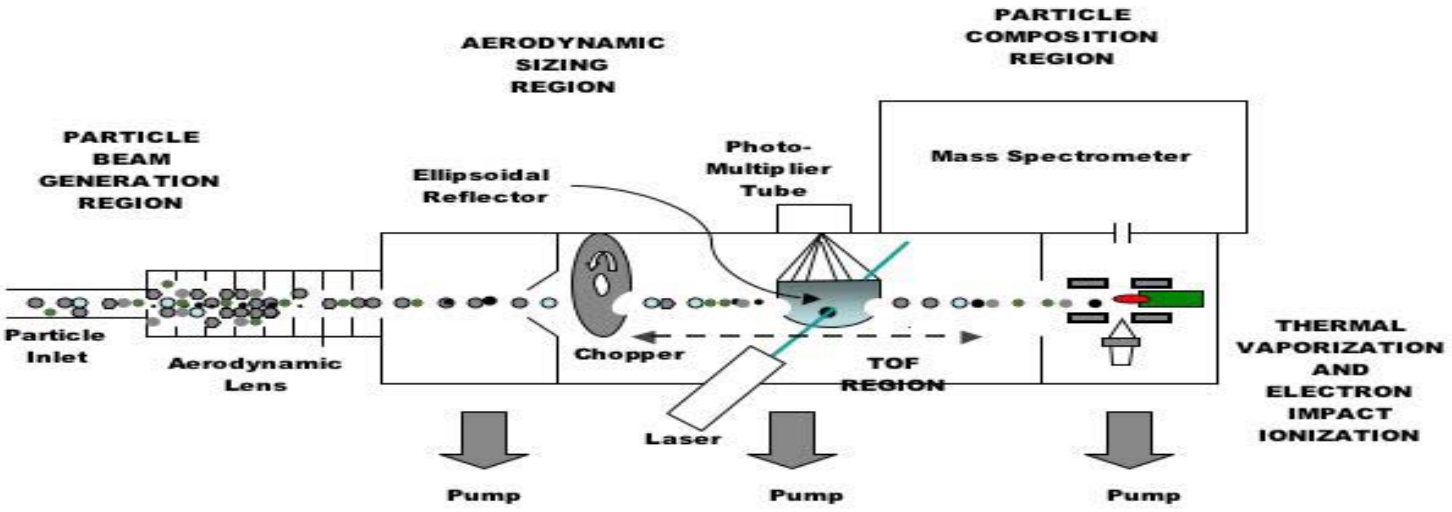
Size: 19”D x 21”W x 33”H

Weight: 140 lbs

Power: 300W

AC power; 120/240 VAC, 50/60hz

What's out there? - ACSM



What's out there? - ACSM

- Continuous monitoring of non-refractory aerosol composition (40-1000 nm) by thermal particle vaporization aerosol mass spectrometry (0-200 amu).

  Sulfate, Nitrate, Chloride, Ammonium, Organics.

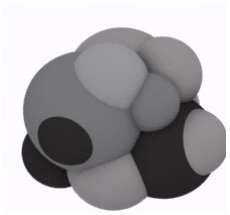
- Builds on ARI Q and ToF AMS concepts

  lower cost, lower sensitivity.

- Designed for long term unattended operation.

- Data acquisition and control via Ethernet connectivity, basic laptop computer is sufficient

Getting to the Core of Things

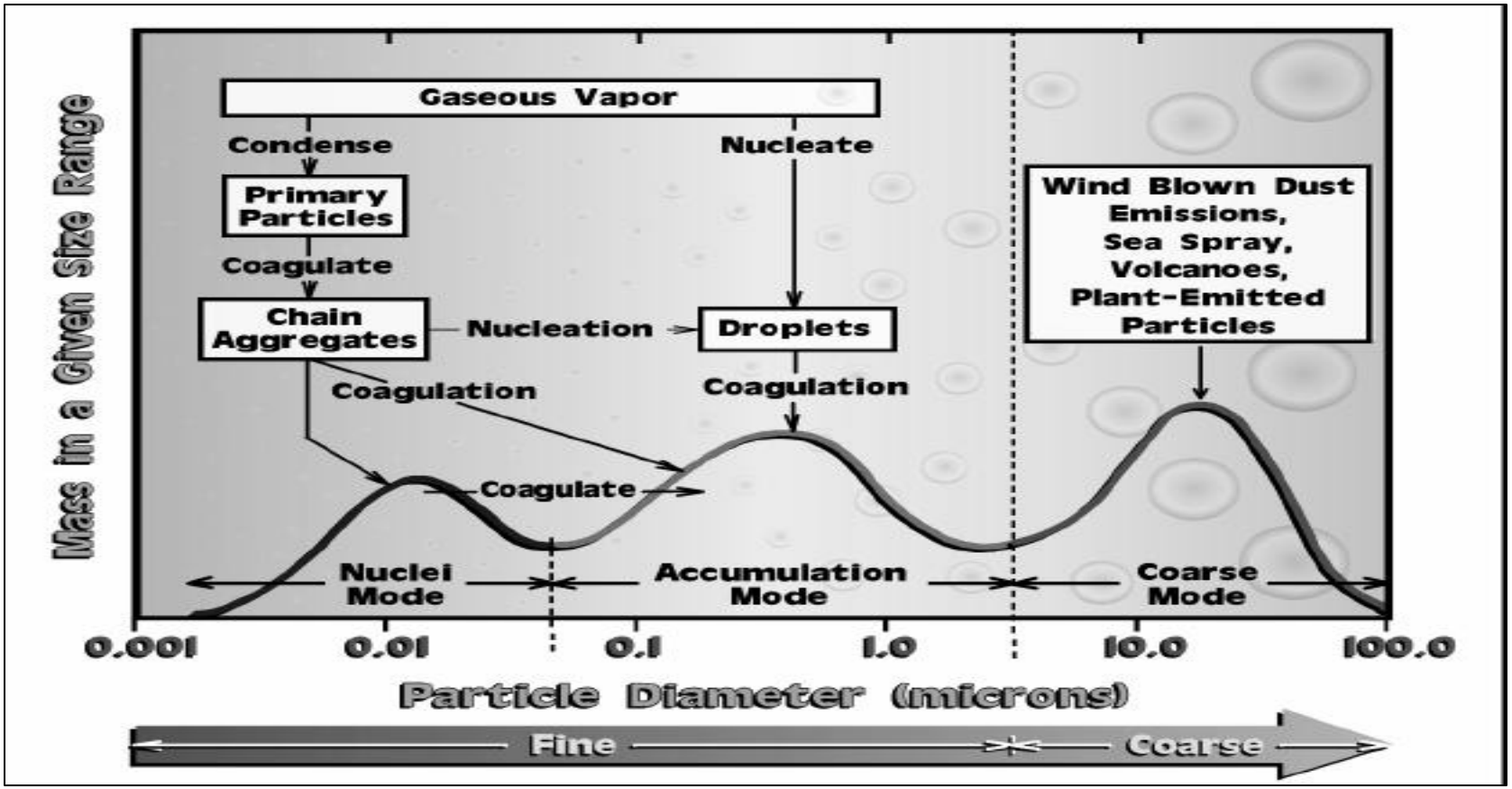


UFPs/NPs can be the core of fine/coarse particles

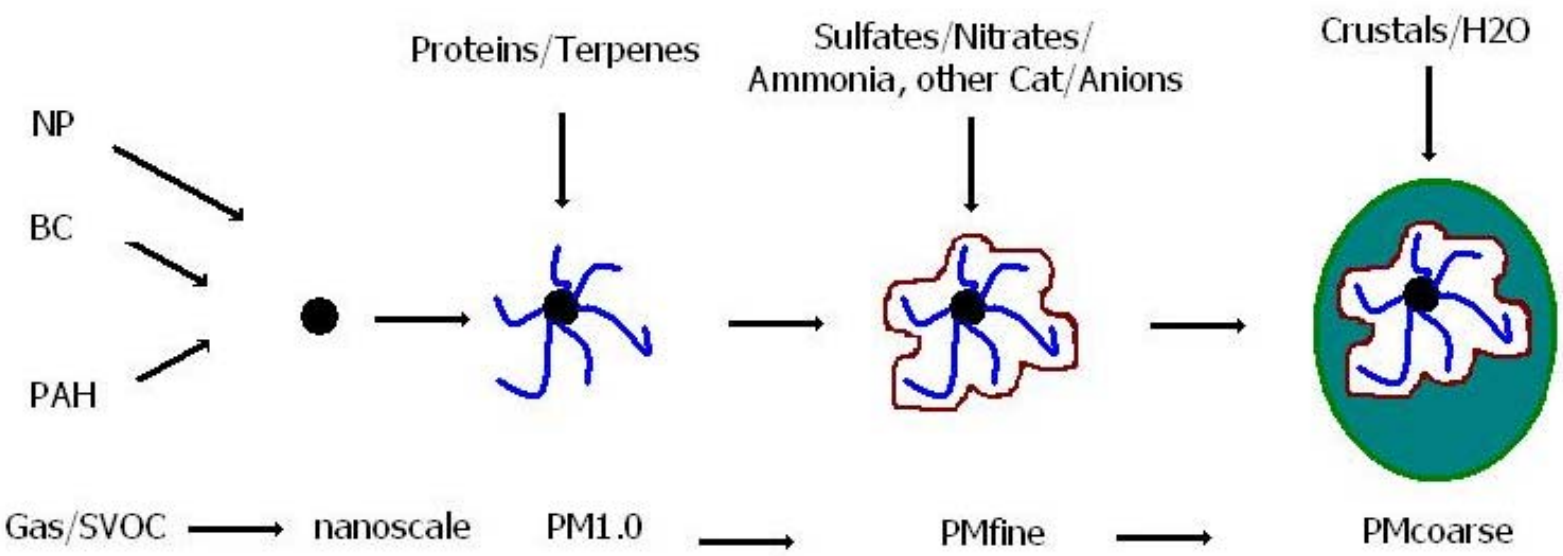
UFP/NPs are generally emitted, not coalesced, fine particles are.

UFPs/NPs can get many different layers and grow over extended time.

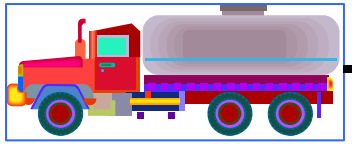
Getting to the Core of Things

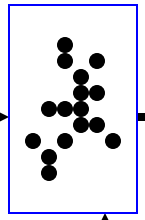


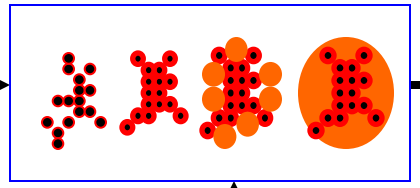
Getting to the Core of Things



CCN-Soot Particle Experiments







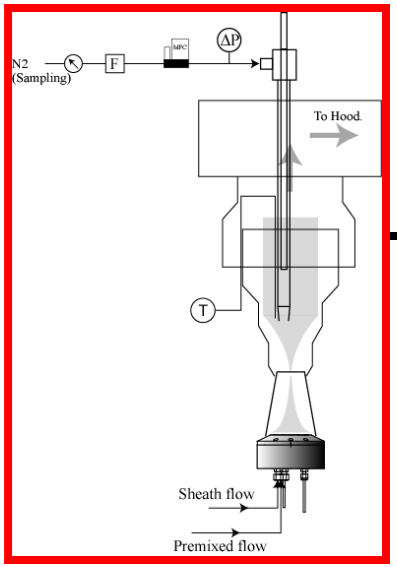
Hydrophilic particles

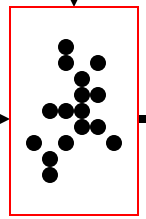
Indirect effect

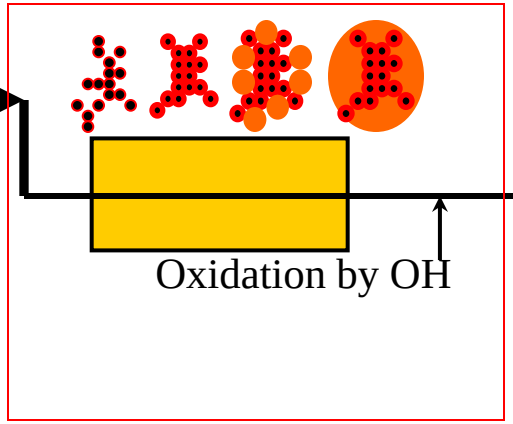
source

nascent soot particles hydrophobic

Atmospheric processing oxidation, coating etc.







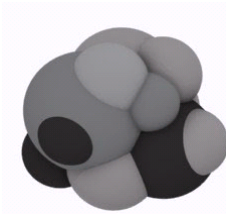
Oxidation by OH

SMPS

CCN counter

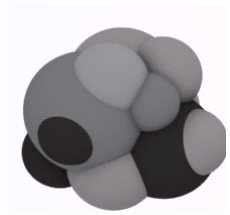
AMS

Summary



- There is a growing concern about NP/UFPs
- From the Workshop many issues were expressed
- There's a plethora of ways to identify/quanitfy NP/UFP
- EU has already instituted a standard and network –Using particle counting
- Instruments, like the TSI 3031/ACSM look promising
- UFPs/NP are at the core of many different monitoring issues: Global Warming, fine and coarse particles
- We need to be able to strip away the fine particles to see what's underneath – Paul Davidotis: Boston College

Acknowledgement



- Tom Kelly, Battelle
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- Dr. Paul Davidovits – Boston College
- Everyone that participated in the Nanoparticle Monitoring Workshop

Thanks everyone!