Nanoparticle Size Distribution (2.7-10 nm) Measured by UCPC Pulse Height Analysis

-- New Start --

R. Weber

Brookhaven National Lab. Bldg 815E Upton NY 11973, rweber@bnl.gov

D. Lappen, V. Terpougov, and P. McMurry

University of Minnesota Dept of Mechanical Engineering Minneapolis MN 55455, dlappen@me.umn.edu, terpugov@me.umn.edu, mcmurry@me.umn.edu

Research Goal

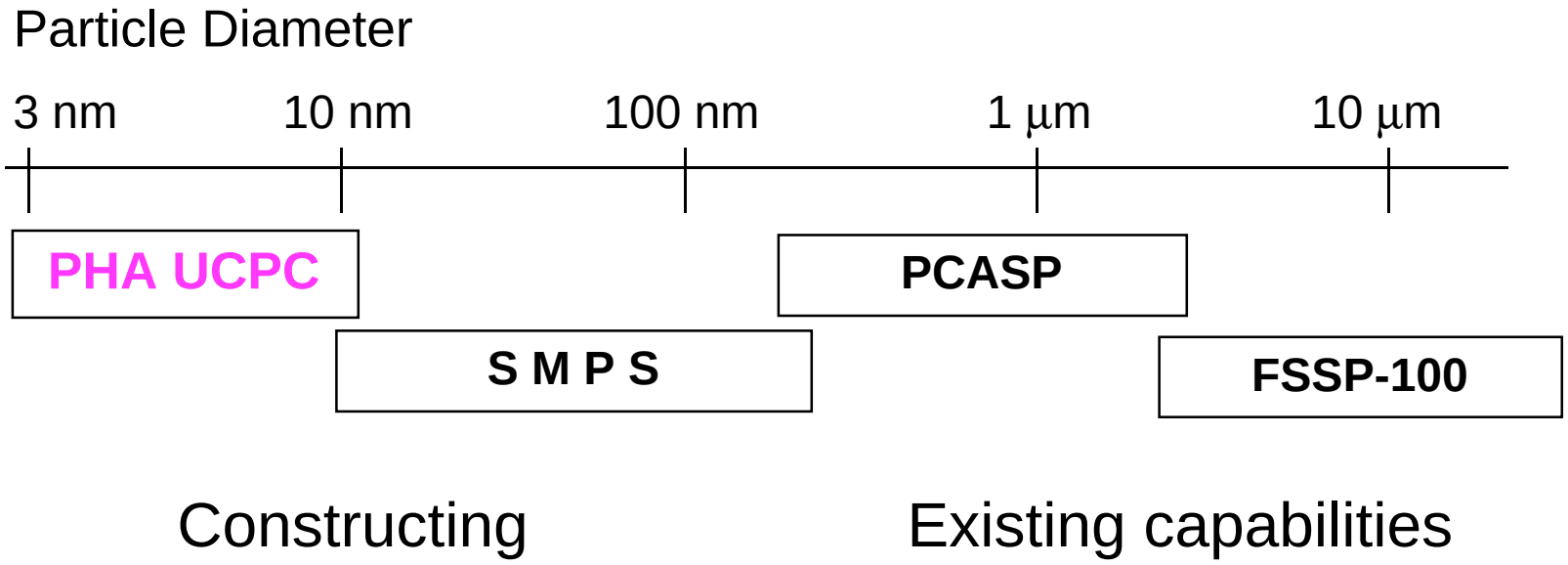
- To develop a new Ultrafine Condensation Particle Counter (UCPC) optimized for airborne measurements of nanoparticle size distributions (2.7 - 10 nm) by pulse height analysis (PHA).

Tasks

1. Modify TSI 3025 UCPC for PHA.
2. Experimental studies to optimize 3025 UCPC for PHA. Studies will focus on:
   - Improving resolution.
   - Influence of particle concentration on pulse heights.
3. Assess PHA technique and new PHA UCPC by instrument inter-comparison study.

Integration with BNL Environmental Chemistry Research Program

- Goal is to assemble instrument suite for airborne measurements of complete aerosol spectra, 3 nm to 47 μm diameter.

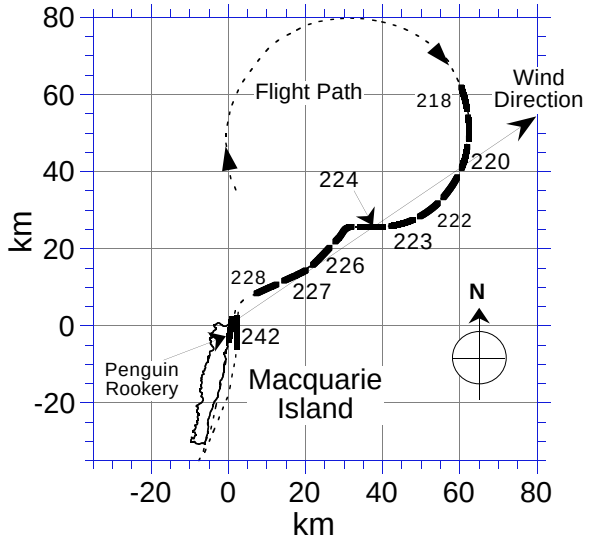


Motivation: Why PHA Technique

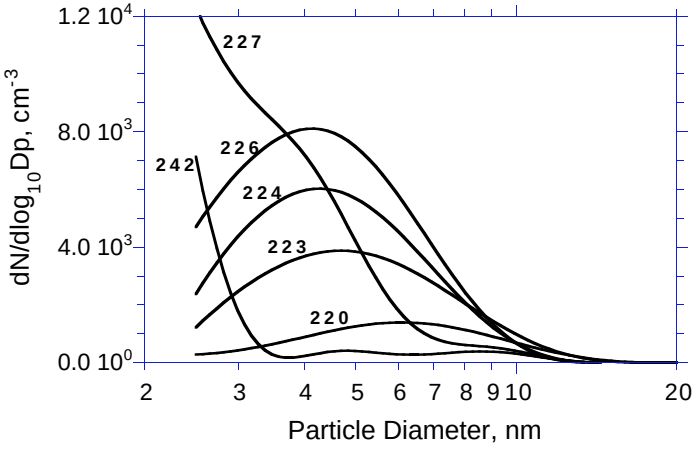
- Only nanoparticle measurement technique which sizes all particles simultaneously, leads to fast measurement.
- Instrument is small, light weight, and robust, suitable for airborne measurement platforms.

Example: A Study of Nucleation and Growth With Prototype UCPC-PHA

- Position of airborne measurements downwind of penguin rookery on Macquarie Island measured during ACE 1.



- Evolution of UCPC-PHA measured nanoparticle size distribution with distance from rookery. Evidence of nucleation and growth.



Evidence for nucleation involving ammonia?

(R. Weber et al., J. Geophys. Res., in press 1998)

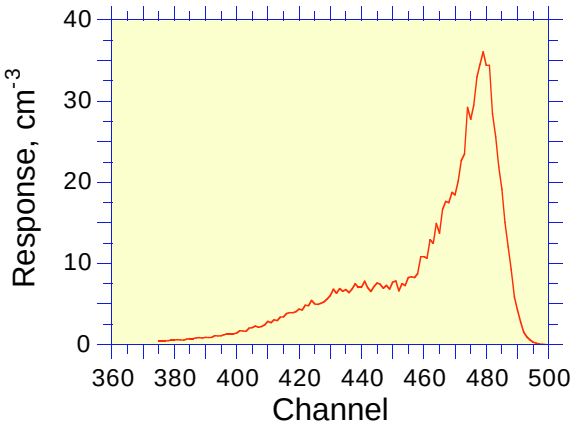
Why a New Pulse Height UCPC?

- Studies with prototype UCPC demonstrate utility of PHA technique.
- Prototype UCPC based on early CNC design, instrument is outdated compared to TSI 3025 UCPC.
- Simple modifications to TSI 3025 UCPC will make PHA technique available to other investigators.

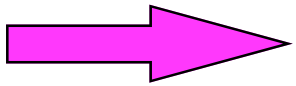
Background: Nanoparticle Spectra from UCPC Pulse Heights

Nanoparticle size distributions are obtained from measured pulse height distributions using an inversion algorithm and kernel functions.

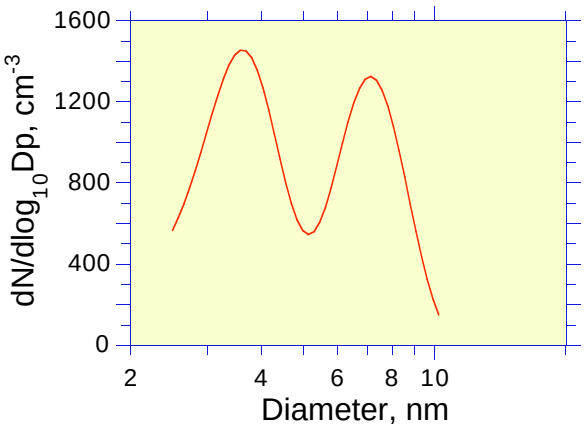
Measurement



Inversion with Kernels



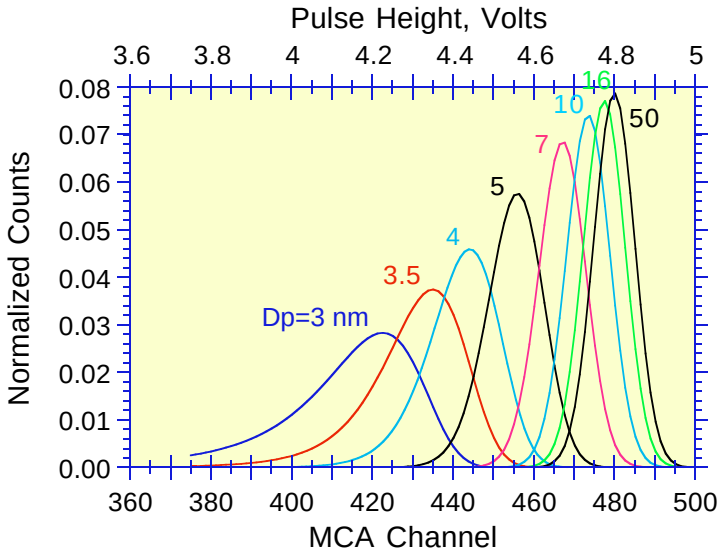
Solution



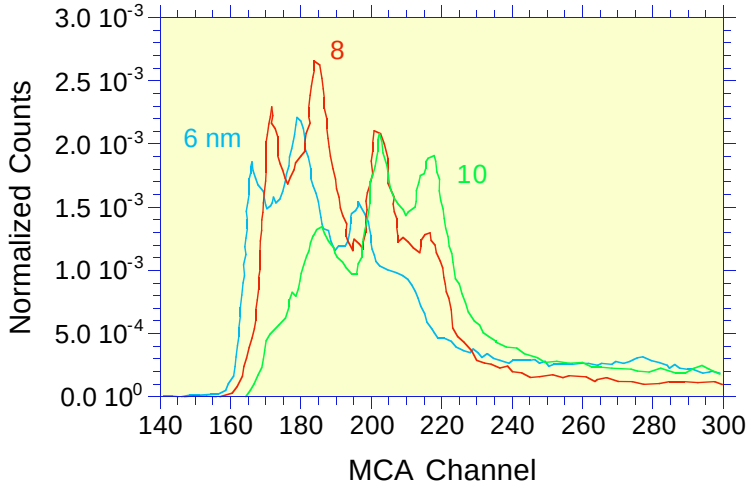
Pulse height distributions are measured with a Multichannel Analyzer

Background: Why New Optics for the TSI 3025 UCPC

Kernel From White Light (prototype) UCPC



Kernel From TSI 3025 UCPC (laser diode)

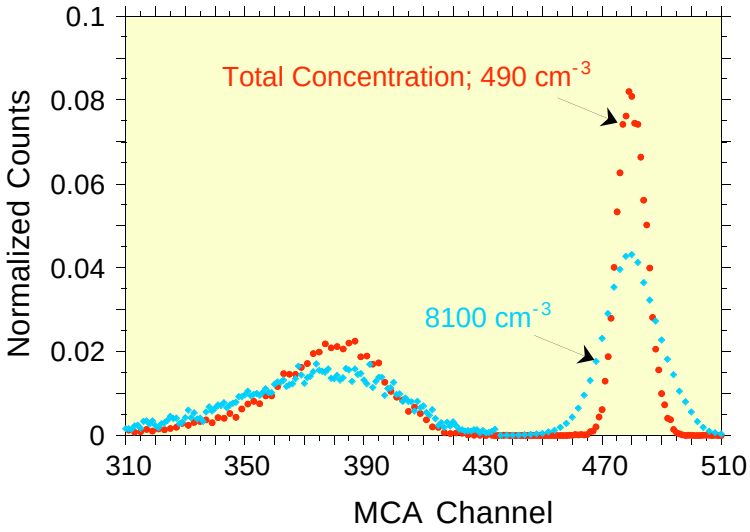


Pulse Height Analysis prohibited with TSI 3025. Models suggest cause is laser light source.

Background: Influence of Aerosol Concentration on Pulse Heights

- Spread in pulse height distributions increases with particle concentration.
- Can't assume kernel functions are invariant with concentration.
- Studies will aim to understand and quantify the effect to remove influence.

Measured pulse height distributions for different aerosol concentrations



Preliminary Work on Modifying TSI 3025 UCPC for PHA

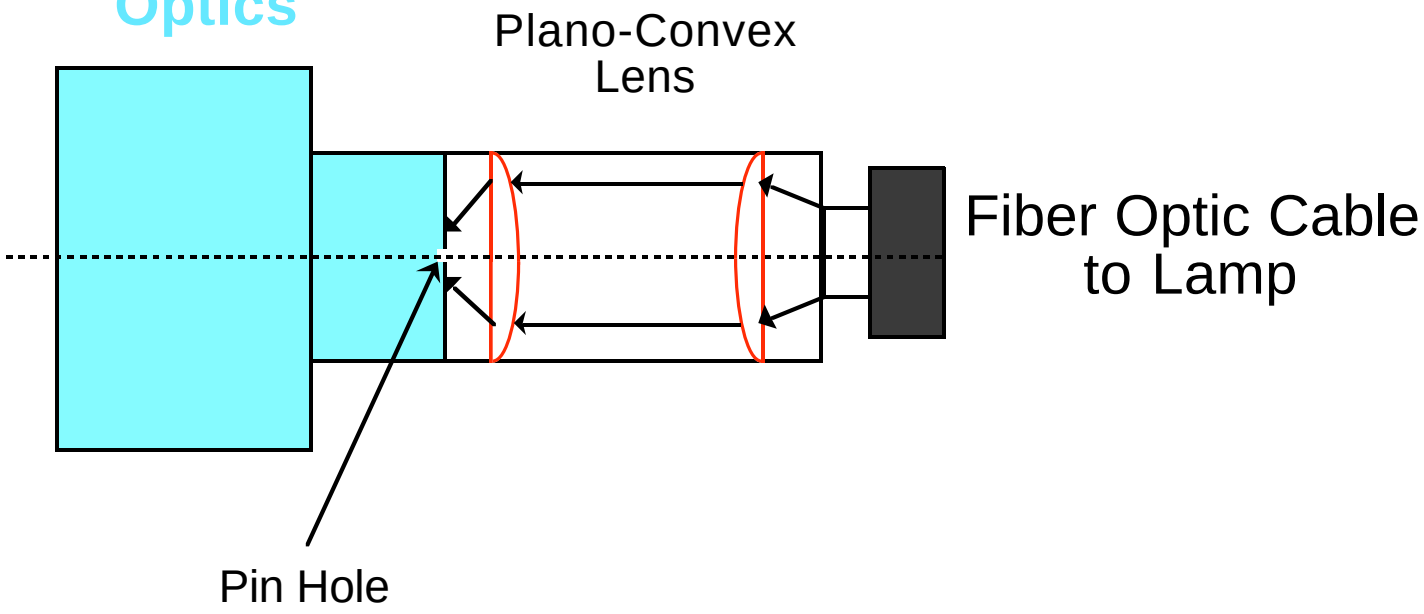
- Design criteria:
  - » Minimize alterations to TSI 3025 UCPC.
  - » Utilize existing photo detector and optics where possible.
  - » Small, light weight, and rugged design suitable for aircraft operation.

Optics Experiments to Date

- LED light source:
  - » Failed from inability to sufficiently focus beam.
- Current Design:
  - » External lamp coupled to a lens train pin-hole arrangement via fiber optic cable.

Preliminary Optics Design

Original TSI 3025 Optics



Generation of a point-source white light using a tungsten filament lamp, fiber optic cable,lenses, and pin-hole.