The Kanomax Model 3650 FastCPC:

Design and performance of a compact, high sensitivity, ultra-fast Condensation Particle Counter

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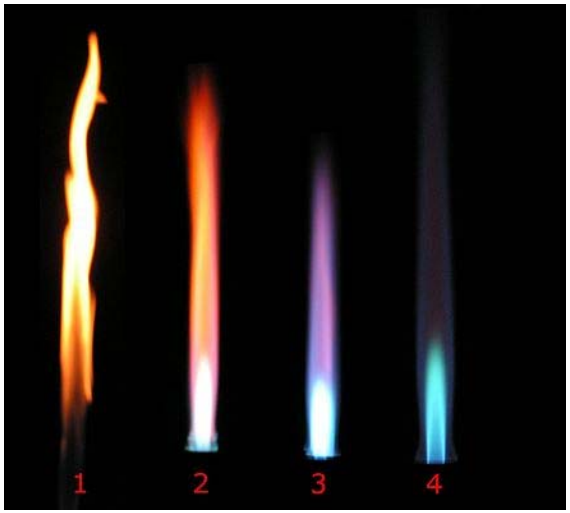
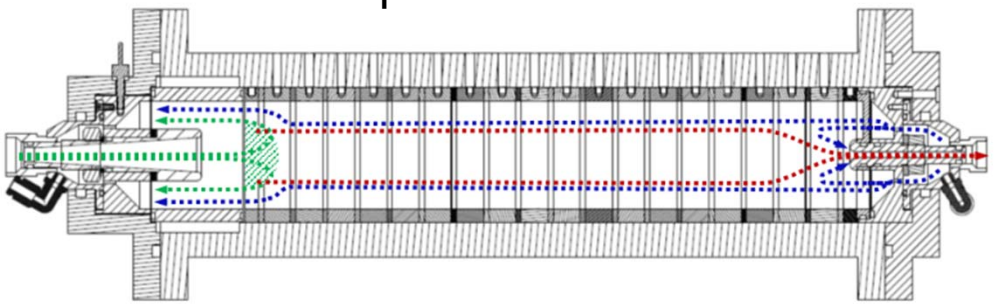
Motivation: Why develop the FastCPC?



Resolve particle concentration in dynamic processes

Flooded optics are annoying

Couple to high performance particle spectrometers



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Background: Design Goals

- Short delay time
  - Minimize settling time for size spectrometers
- Fast 10%-90% response
  - Resolve fast changing concentrations
- High sensitivity
  - 50% detection efficiency < 2nm
- Short aerosol path
  - Minimize diffusion losses
- Robust
  - Reduce flooding

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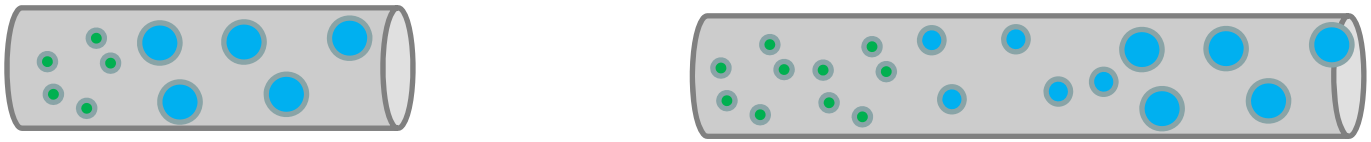
Design considerations for diabatic CPCs

Cylindrical condensation region

- Response time and droplet size increase with tube diameter

- Maximum flowrate (Q_{max}) increases with length



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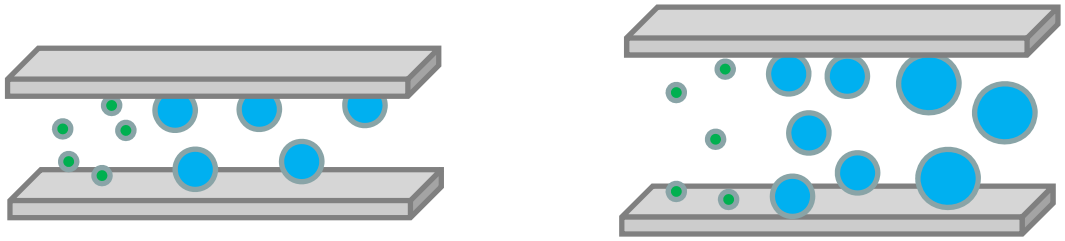
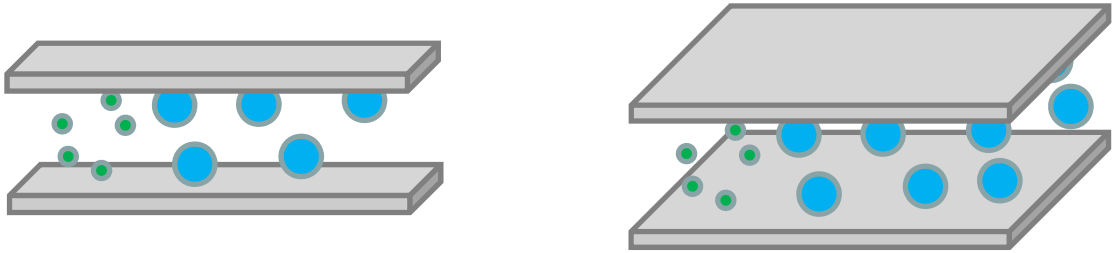
Design considerations for diabatic CPCs

Rectangular / Parallel Plate condensation region

- Response time and droplet size increase with gap distance



- Maximum flowrate (Q_{max}) increases with channel width



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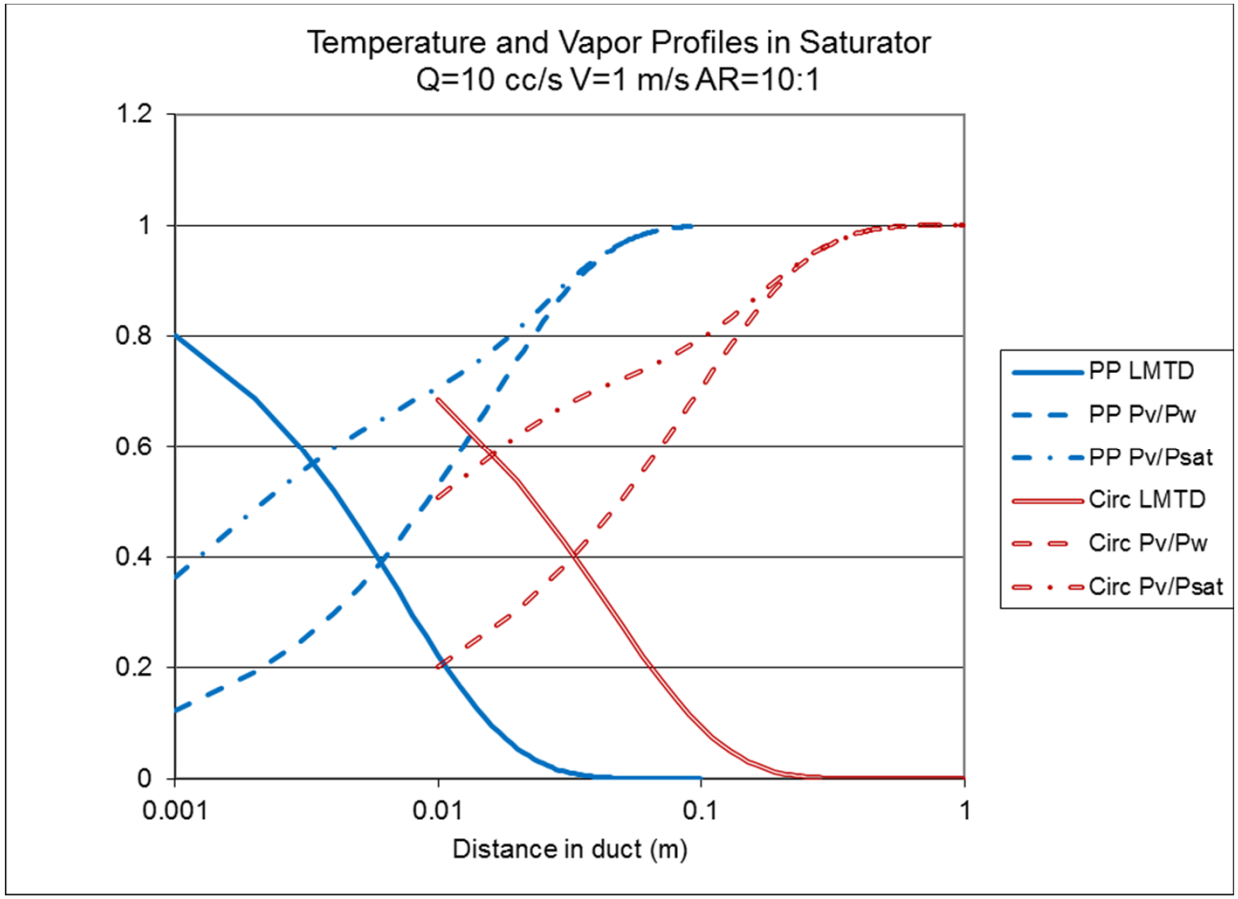
Saturator Vapor and Temperature Profiles



- Required axial length for Parallel Plate significantly shorter than Circular
- In FastCPC, S~0.9 leaving saturator

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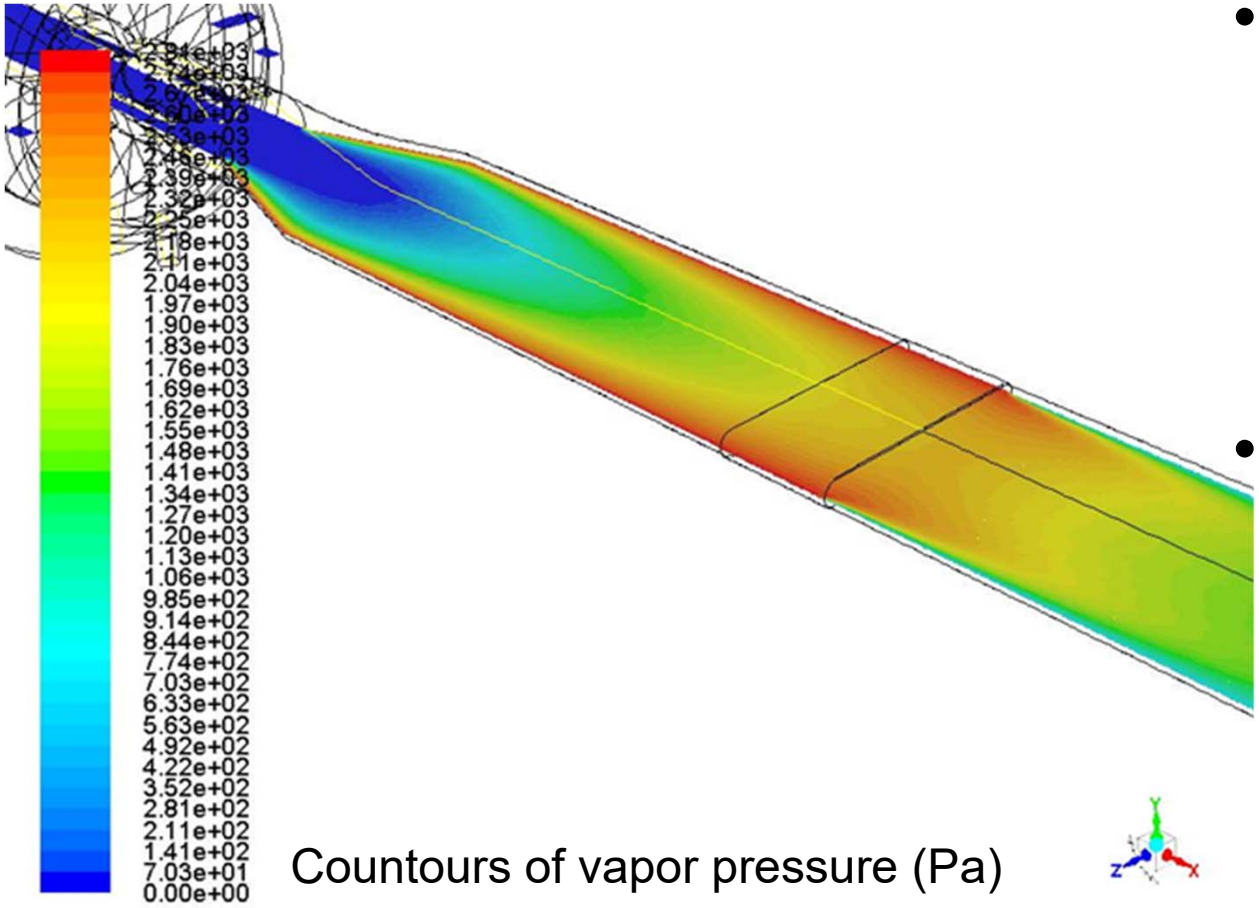
FastCPC Saturator Design



Countours of vapor pressure (Pa)

- Abbreviated saturator length reduces centerline vapor pressure
- Allows for higher average saturation ratio without homogenous nucleation

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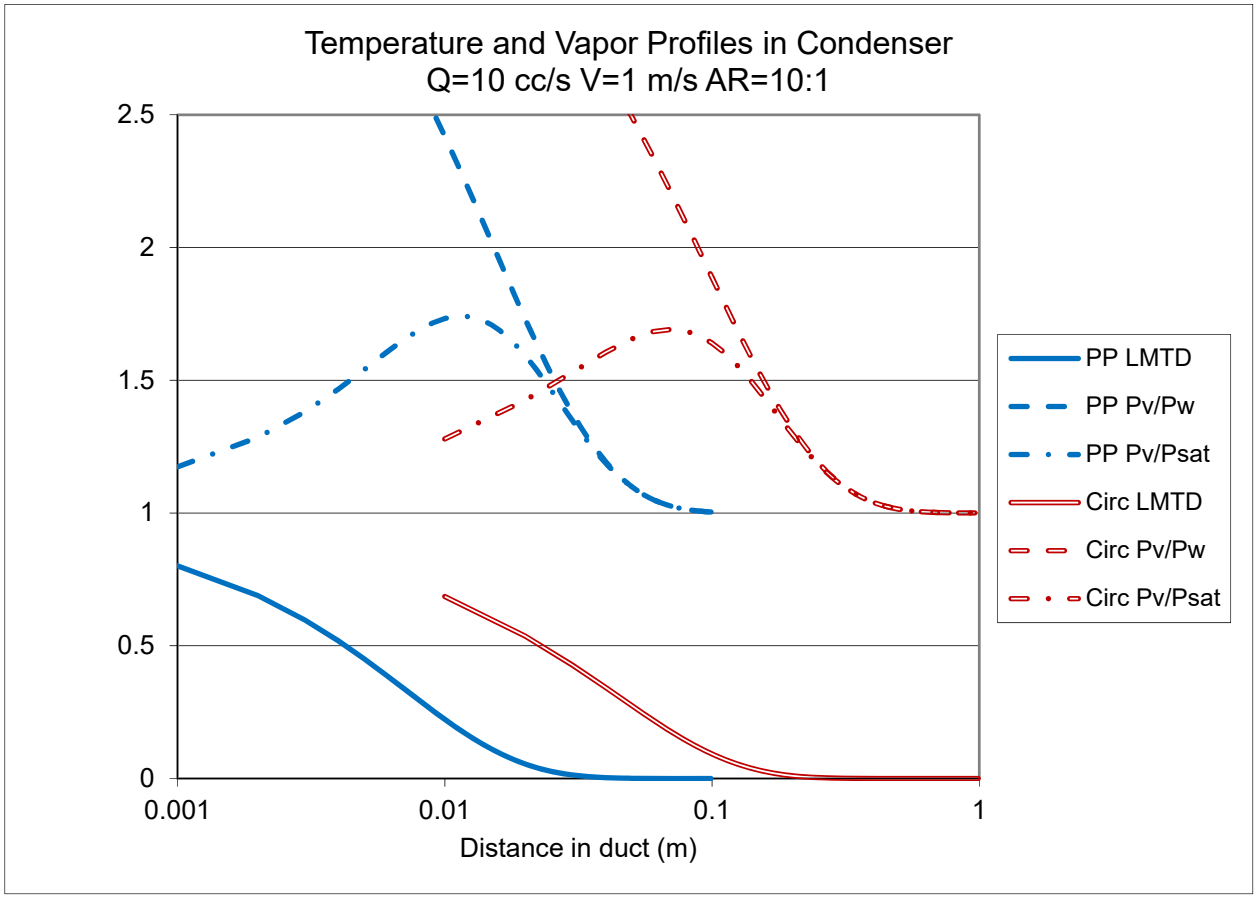
Condenser Vapor and Temperature Profiles



- Parallel plate design leads to higher average saturation ratio

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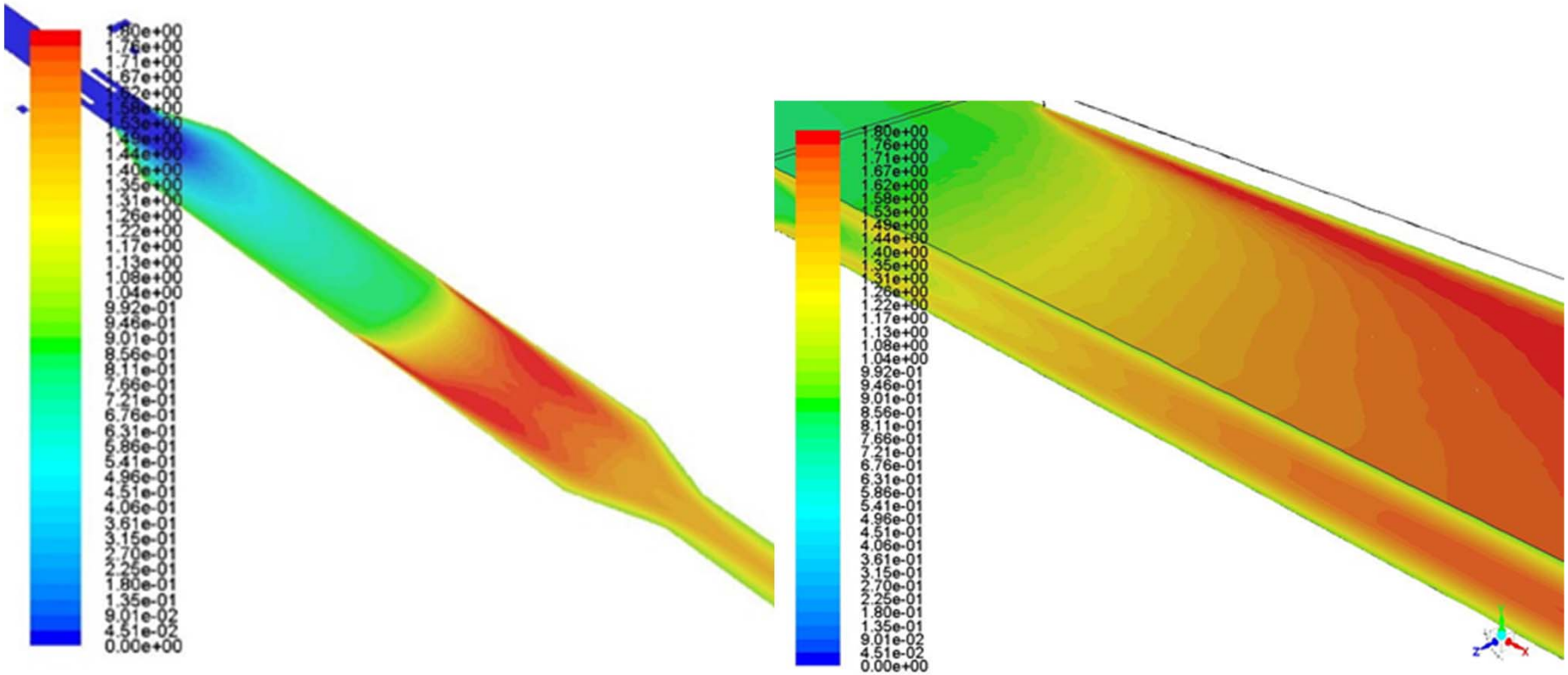
Fast CPC Condenser Design

- Peak Saturation ratio evenly distributed across flow



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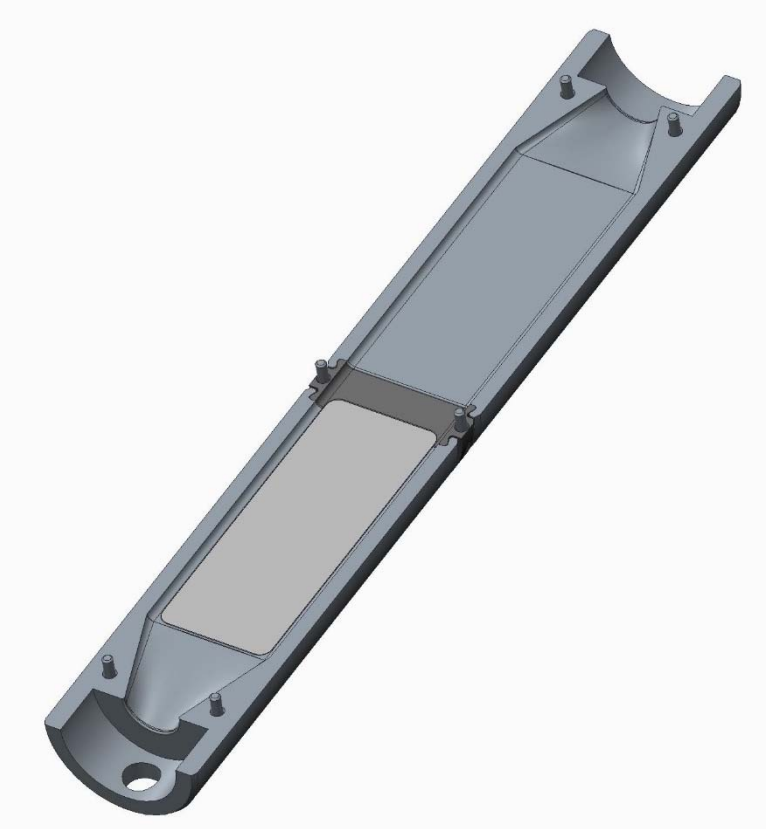
FastCPC saturator-condenser design

- Sheathing and optical detection much easier to accomplish with cylindrical flow conduits
- Transitions designed to limit flow separation



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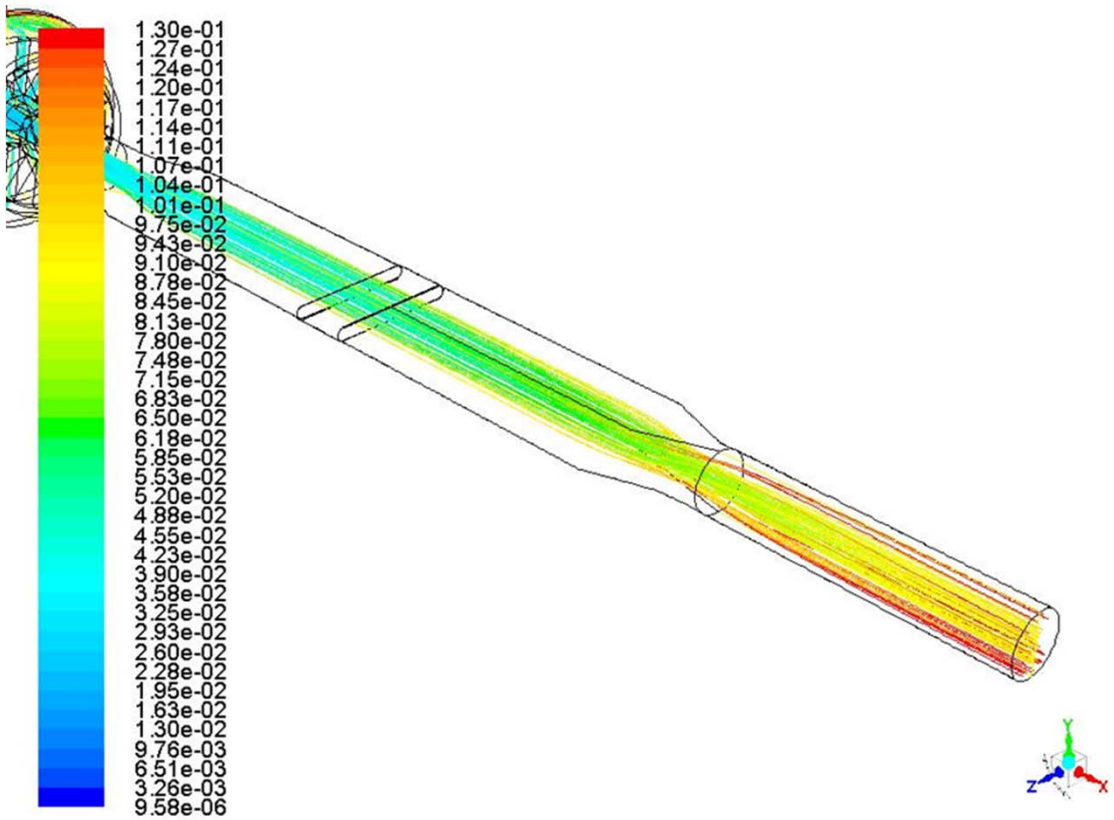
Fast CPC Flow

- Sample flow is sheathed with filtered air at a 1:1 ratio
- Reduce time smearing due to boundary layer effect
- Reduce smearing of detection efficiency curve caused by particles in low saturation regions near the condenser walls



Pathlines colored by transit time (s)

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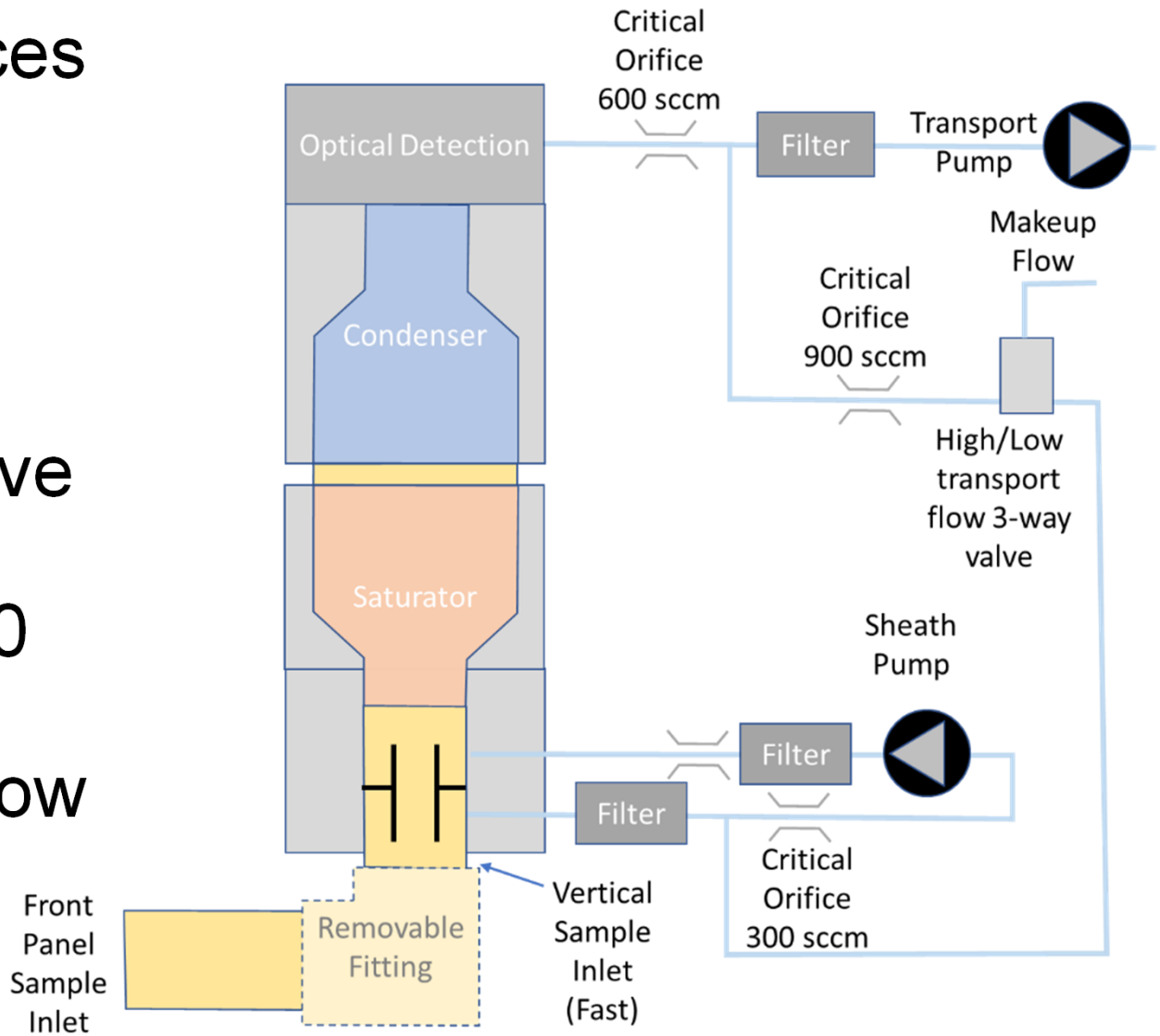
FastCPC Flow Schematic

- Critical orifices regulate volumetric flowrate
- Transport solenoid valve to switch between 600 and 1500 sccm inlet flow



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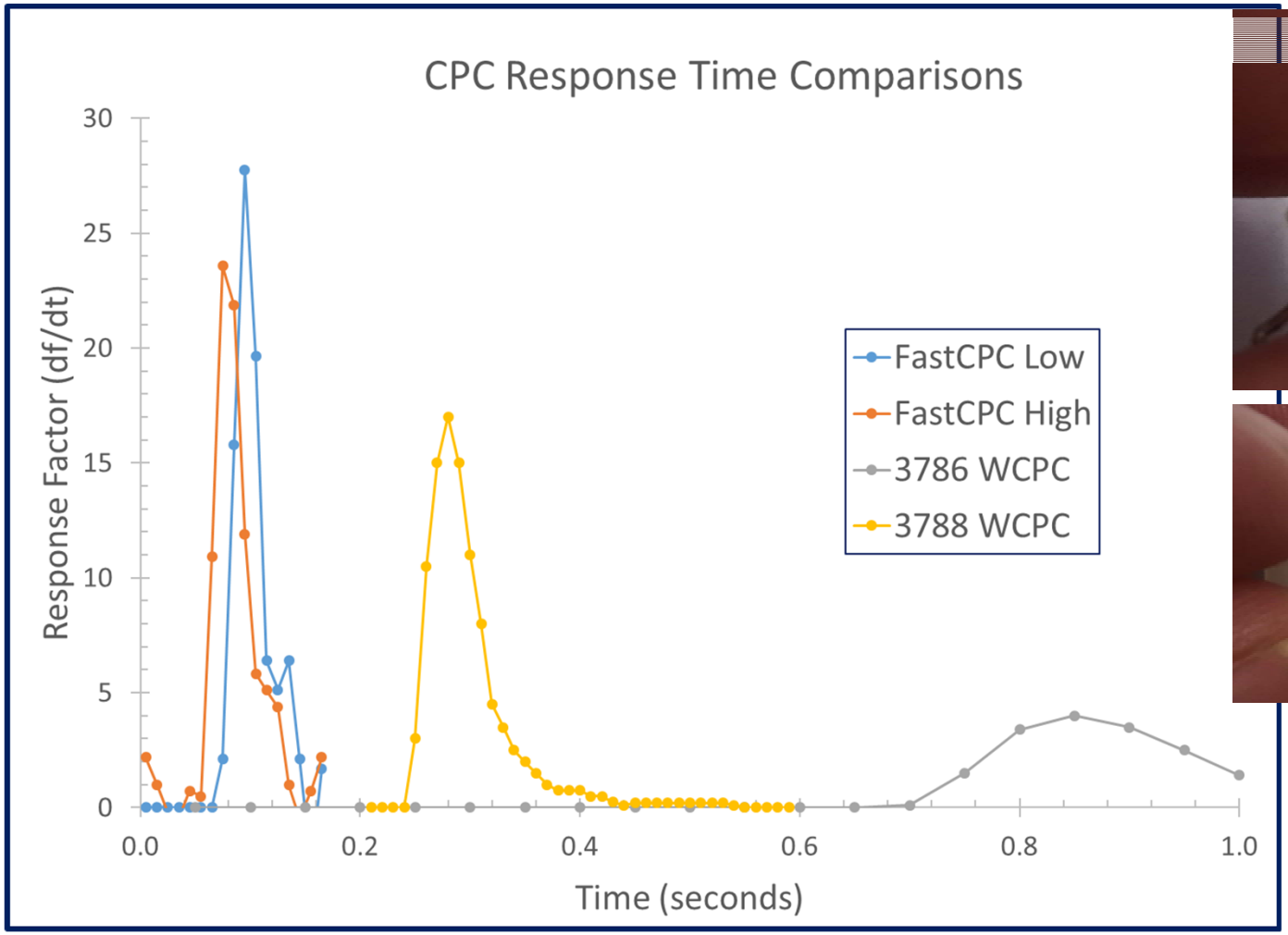
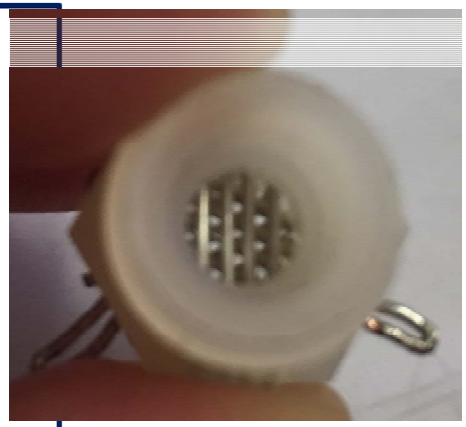
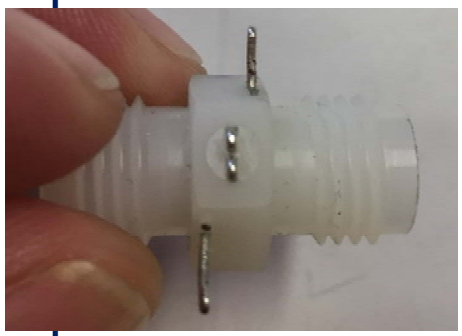
Fast CPC Performance – Response Time







Custom Tyndall type Ion-shutter

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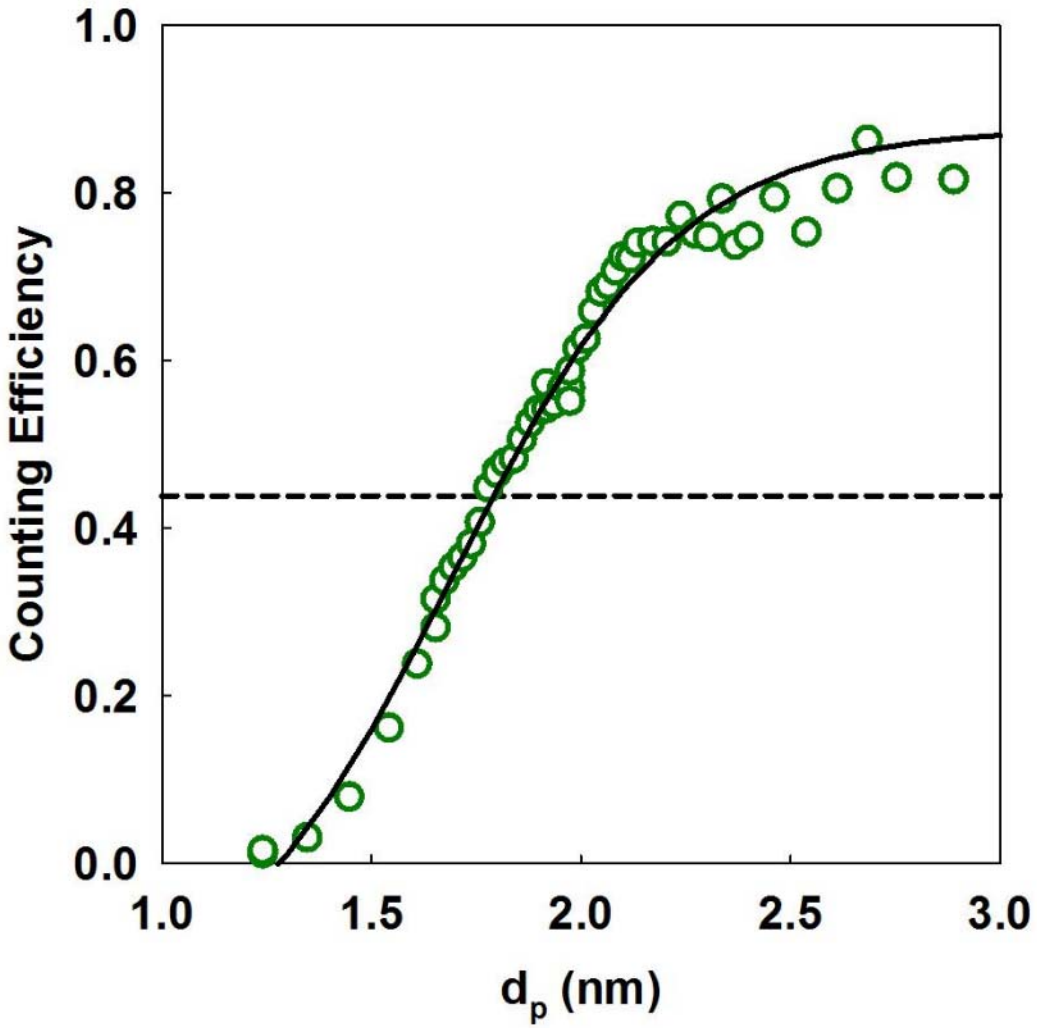
Derek R. Oberreit , Peter H. McMurry & Christopher J. Hogan Jr. (2014) Mobility Analysis of 2 nm to 11 nm Aerosol Particles with an Aspirating Drift Tube Ion Mobility Spectrometer, Aerosol Science and Technology, 48:1, 108-118, DOI: 10.1080/02786826.2013.861893

Fast CPC Detection Efficiency



From: David Buckley, University of Minnesota 2017

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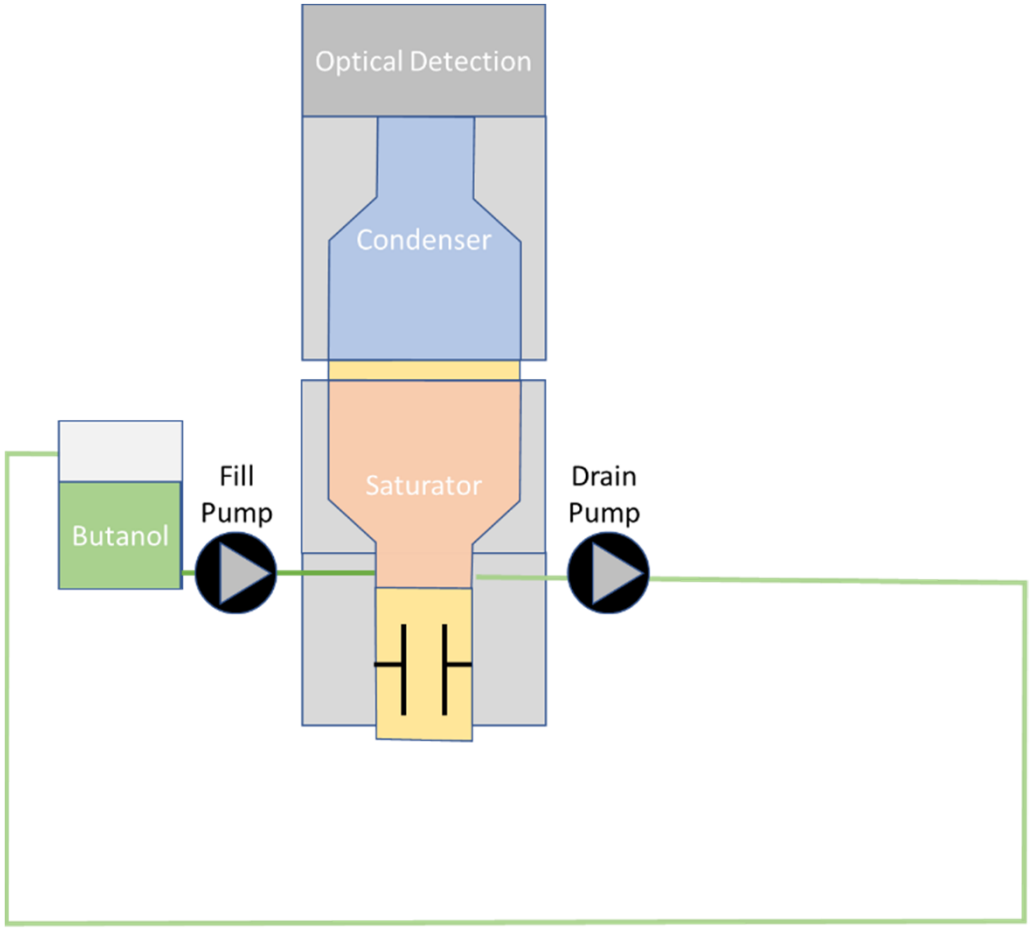
How did we reduce flooding?

- Solenoid pumps inject and extract working fluid
- Working fluid reservoir not required



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Fast CPC Specifications

- **Weight**
  15 lbs (6.8 kg)
- **Dimensions L x W x H**
  8.5” x 7.5” x 8.5”
  (21.6 cm x 19 cm x 21.6 cm)
- **Power requirements**
  50/60 Hz, 100-220 VAC, 75 Watts
- **I/O**
  RJ-45 with Ethernet, 9 pin D-subminiature connector with RS-232 serial communication, pulse output and user selectable analog output
- **Working fluid**
  n-Butyl alcohol
- **Flow control**
  Critical orifice for sheath and transport flows, internal transport and sheath pumps
- **Aerosol Flow**
  300 ccm
- **Inlet Flow**
  600 or 1500 ccm (use selectable)
- **Aerosol Inlet**
  Front panel or vertical on right side of instrument

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