

Cloud Chamber Experiments to Determine Ice Production as a Function of Temperature



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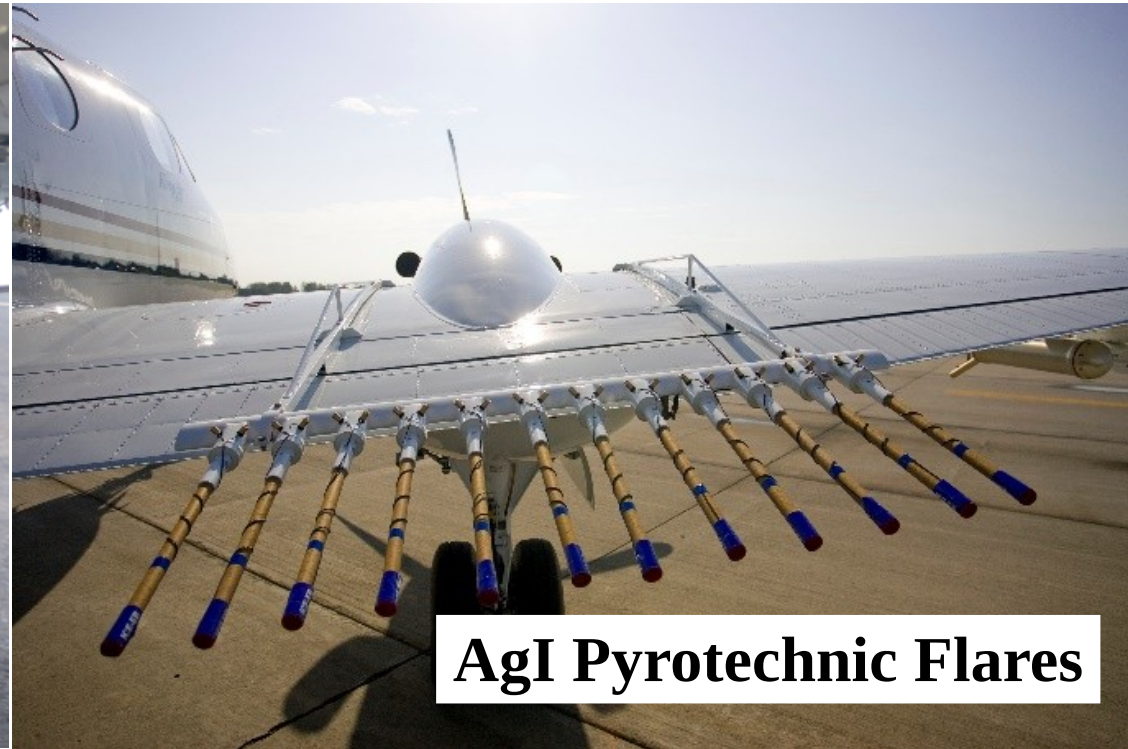
Weather Modification Motivation

- **Water is critically important for many human and economic activities.**
 - **The largest issues facing society are energy and water (Professor Richard Smalley – Our Energy Challenge)**
- **Weather modification has a low cost to benefit ratio if it can increase precipitation on the order of 10 percent.**
- **Weather modification has not been rigorously proven; however, there have been positive scientific results.**

Weather Modification Methods



Ejectable Flares



AgI Pyrotechnic Flares



Ground Generator



Hygroscopic Flares

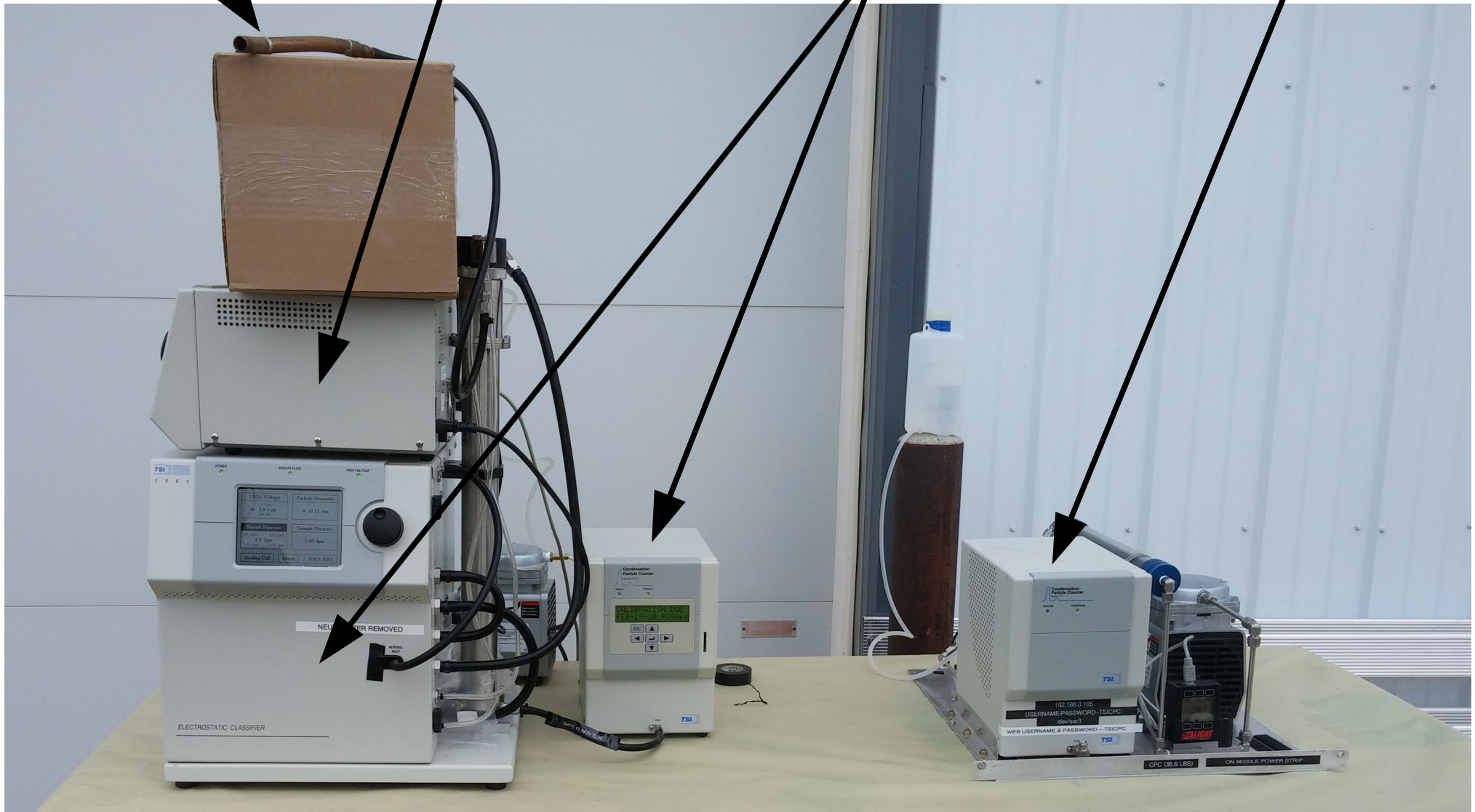
Preliminary Research Measurements

Shared
Inlet

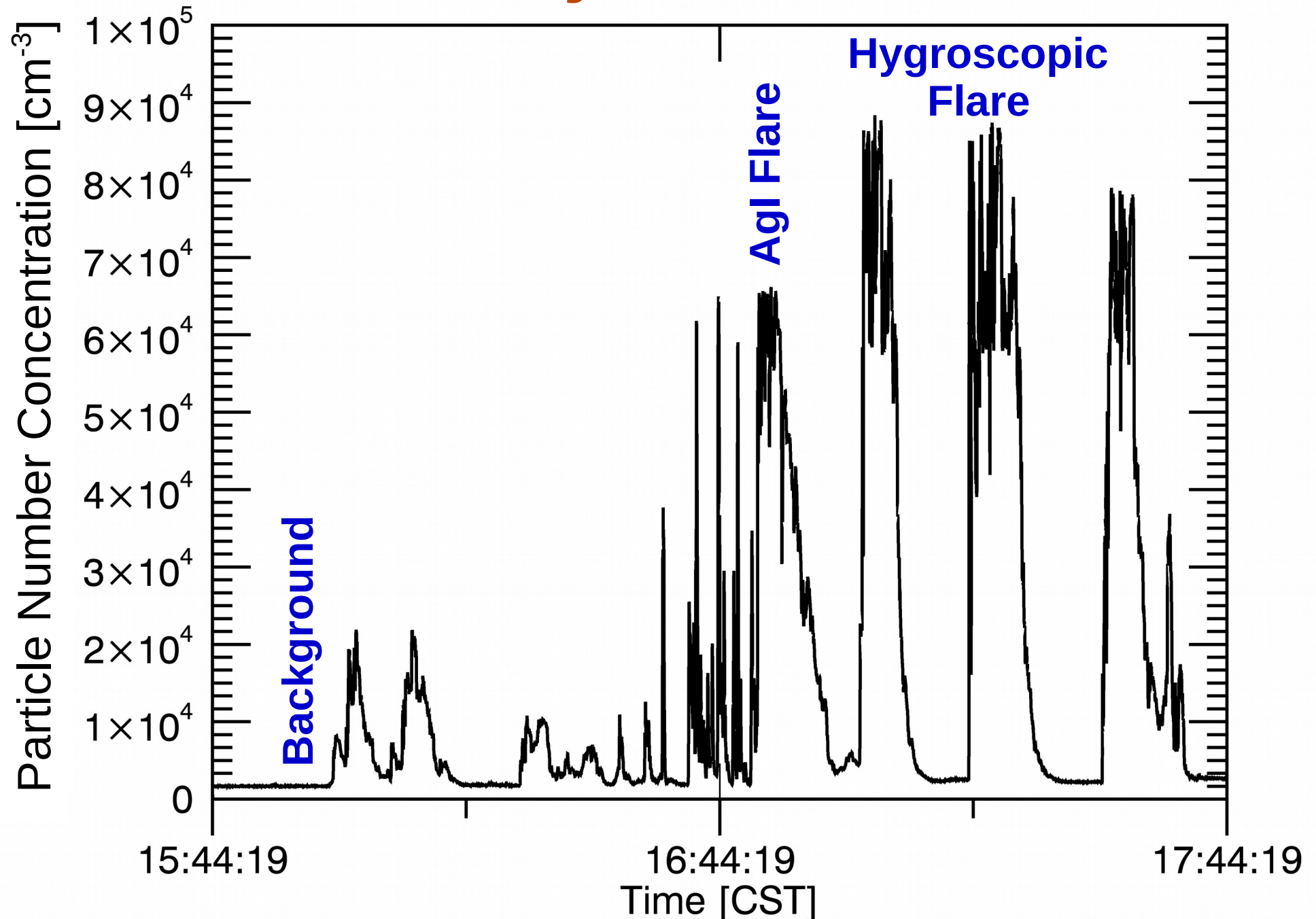
APS
(0.5-20 μm)

SMPS
(10-500 nm)

CPC
(> 10 nm)



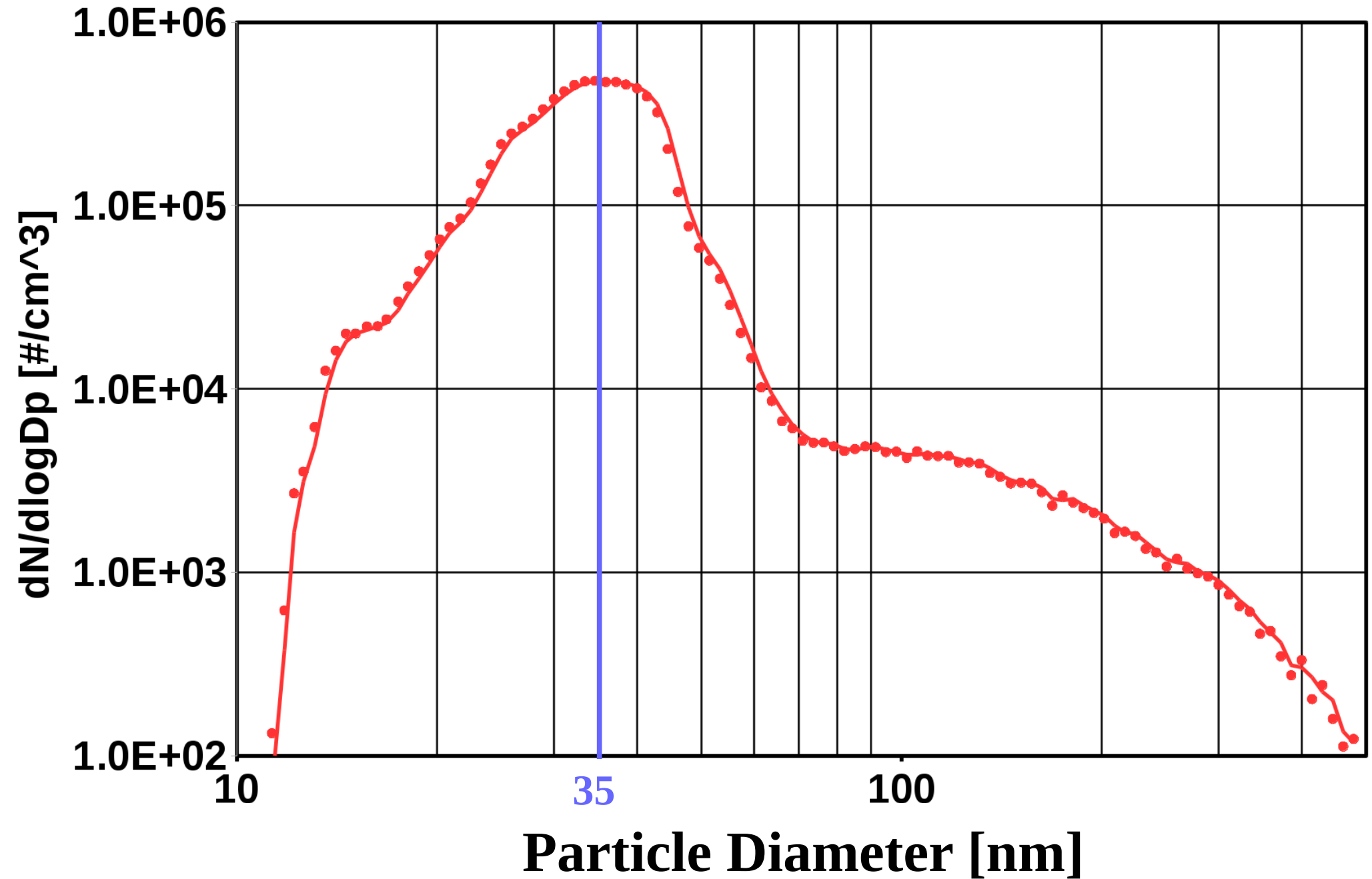
Preliminary Research Data



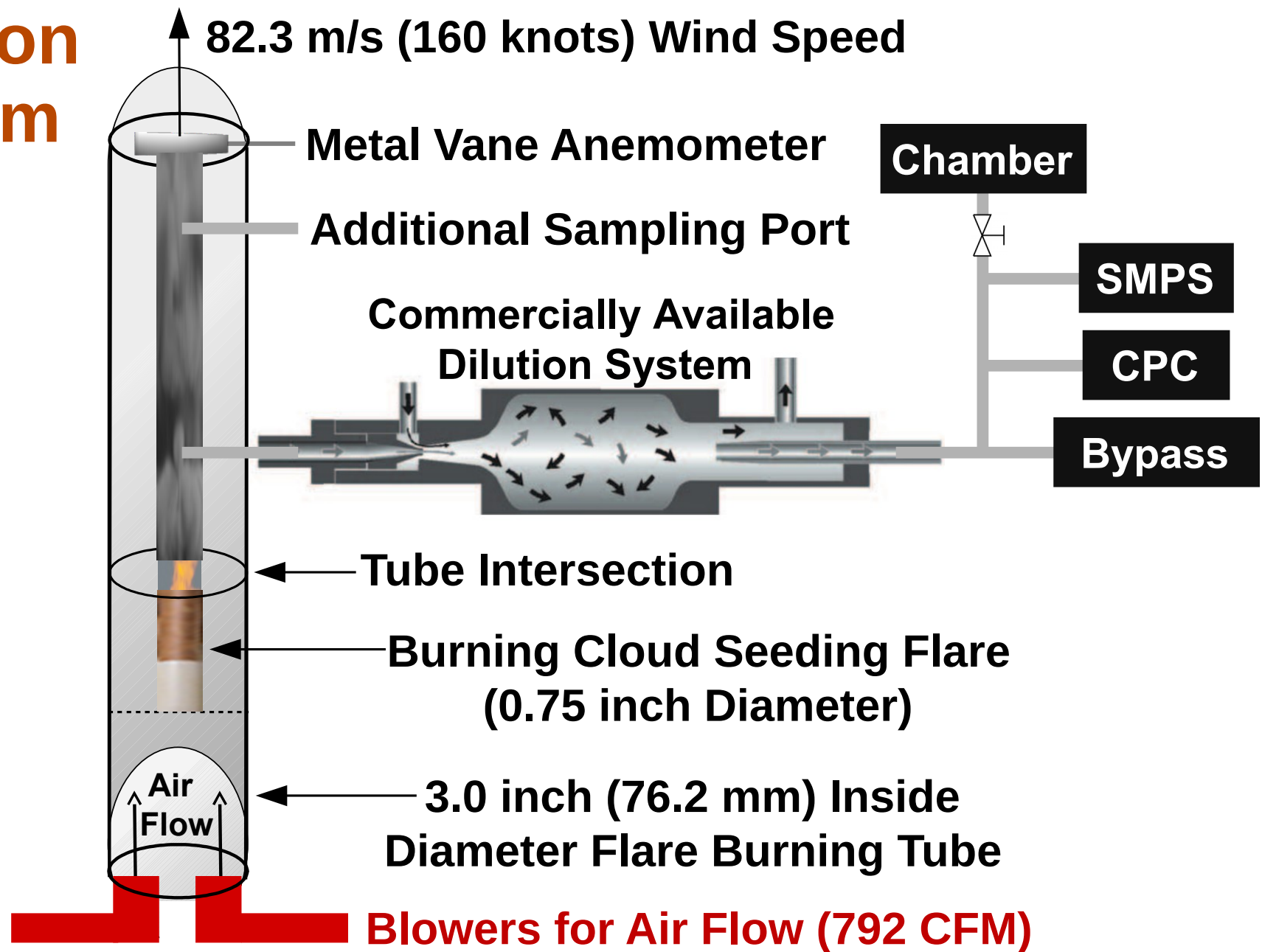
Aerosol (> 10 nm) Time Series: 4 November 2015

Agl Seeding Flare

(4 November 2015, 13:53:40 – 13:54:59 CST)

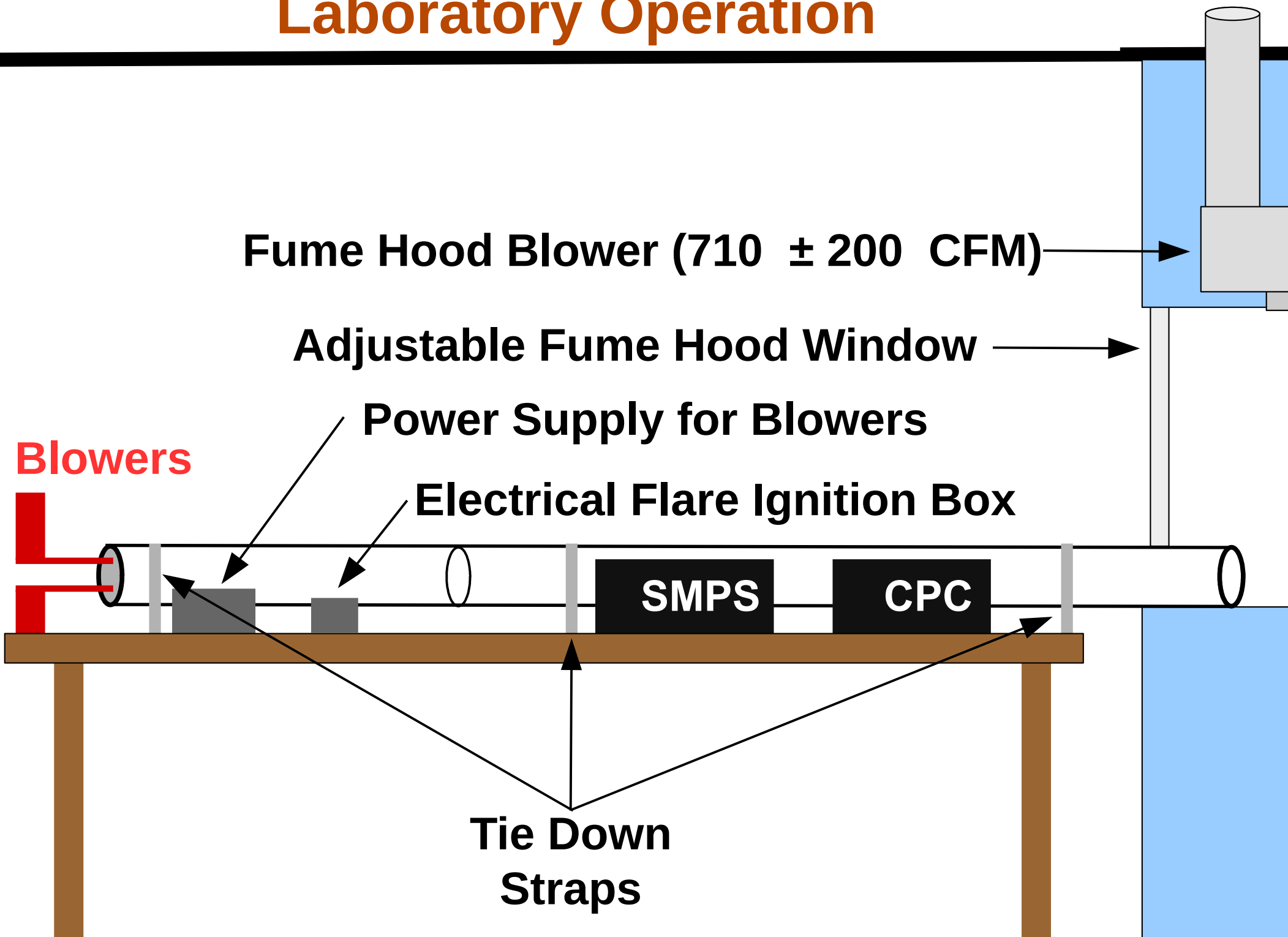


Injection System



Schematic of the cloud-nuclei injection system for burning flares that enables sampling with a scanning mobility particle sizer (SMPS) and a condensation particle counter (CPC), along with injection of cloud nuclei into a chamber.

Laboratory Operation



Research Plan

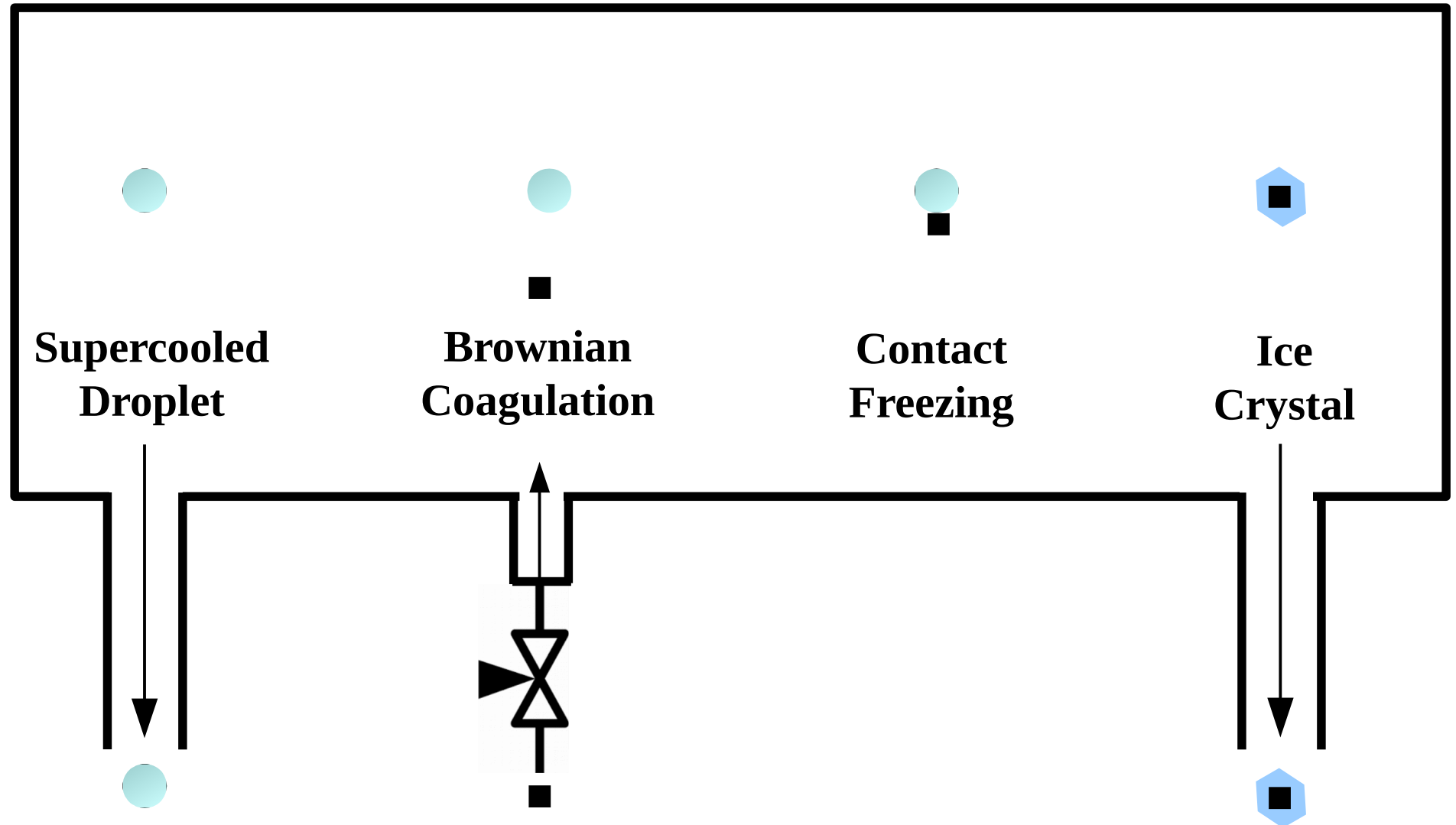
- Develop Ice Nuclei Injection System
 - Design system that works with the π Cloud Chamber.
 - Build the cloud-nuclei injection system.
 - Determine particle concentration range produced by the cloud-nuclei injection system.
- Conduct Experiments
 - Test injection system at University of North Dakota.
 - Conduct test in the π Cloud Chamber.



Isothermal Cloud Chamber Setup

Fixed Temperatures (-4, -6, -8, -10, -12 ± 0.2 °C)

Fixed Liquid Water Content (0.5 ± 0.1 g m⁻³)



Droplet, Nuclei and Crystal Continuous Measurements

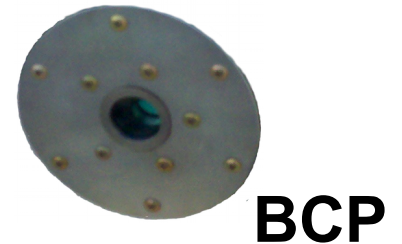
Chamber Measurements

- **Nuclei**

- Scanning Mobility Particle Sizer (SMPS) and Condensation Particle Counter (CPC)

- **Cloud Droplets**

- Cloud Droplet Probe (CDP) or Forward Scattering Spectrometer Probe (FSSP) or Back-scattering Cloud Probe (BCP) (10 m/s)

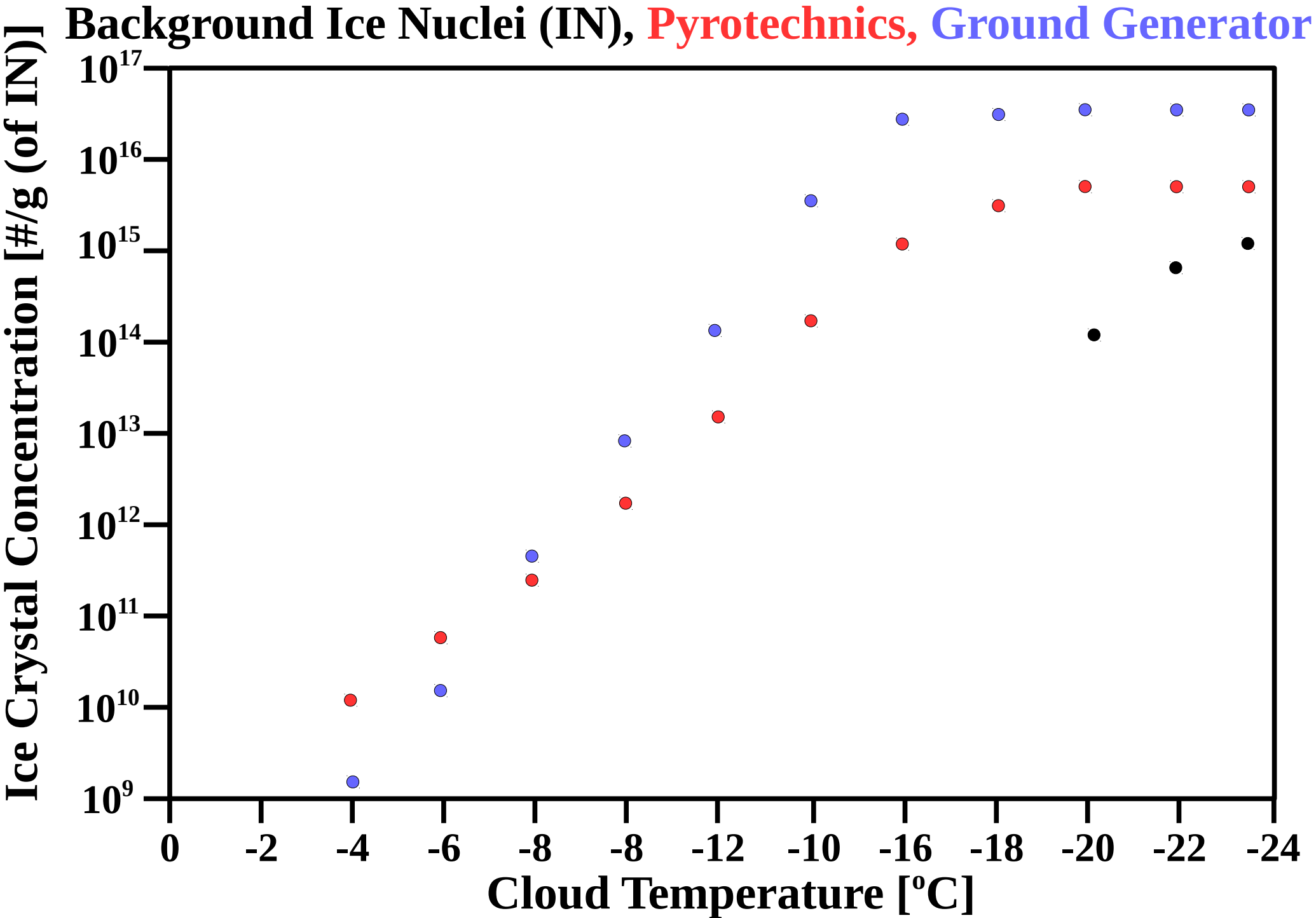


- **Ice Crystals**

- Video Ice Particle Sampler
 - Carl Schmitt / Andrew Heymsfield
 - Used in AIDA Chamber
 - 10-20 L/min



Expected Results: Ice Nucleus Effectiveness



Questions
Comments
Discussion



Ice Nucleation Mechanisms

Homogeneous
Freezing

Deposition
Nucleation

Immersion
Freezing

Contact
Freezing

