Experimental and Numerical Investigations of Spectral Broadening and the Onset of Precipitation in Warm (RICO) Cumuli

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Presentation Outline

- Briefly mention our objectives
- Briefly mention new instrumentation we will bring
- Briefly mention observations needed to meet our objectives

The overarching scientific objective of this research is to investigate droplet clustering and understand its influence on spectral broadening and the onset of precipitation in warm cumuli.

Our Objectives:

Determine: Are spectral broadening and/or droplet clustering detectable?

If yes,

- then quantify using observations and
- model effects on precipitation formation.

Mystery Echoes. In-situ observations oriented.

Define and review spectral broadening.

- Spectral broadening is real cloud droplet size distributions being broader than predicted by models.

- Questions still remain as to how much broadening really exists and how much is due to uncertainties in the observations.

Define and review droplet clustering.

- We define anomalous clustering of cloud droplets as clustering to a degree greater than expected due to simple random positioning of the particles, and greater than expected due to entrainment and mixing if the droplets were passive tracers.

- If it does occur significantly then it will effect droplet growth by vapor deposition (i.e. cause spectral broadening) and the collision and coalescence process.

- Could be caused by inertial effects however the subject is appropriately mired in controversy.

- Observations (both in-situ and remote) and modeling studies (both laboratory and numerical) hint that clustering could be significant.

- Due to uncertainties in the observations and models, the bottom line is that the jury is still out.

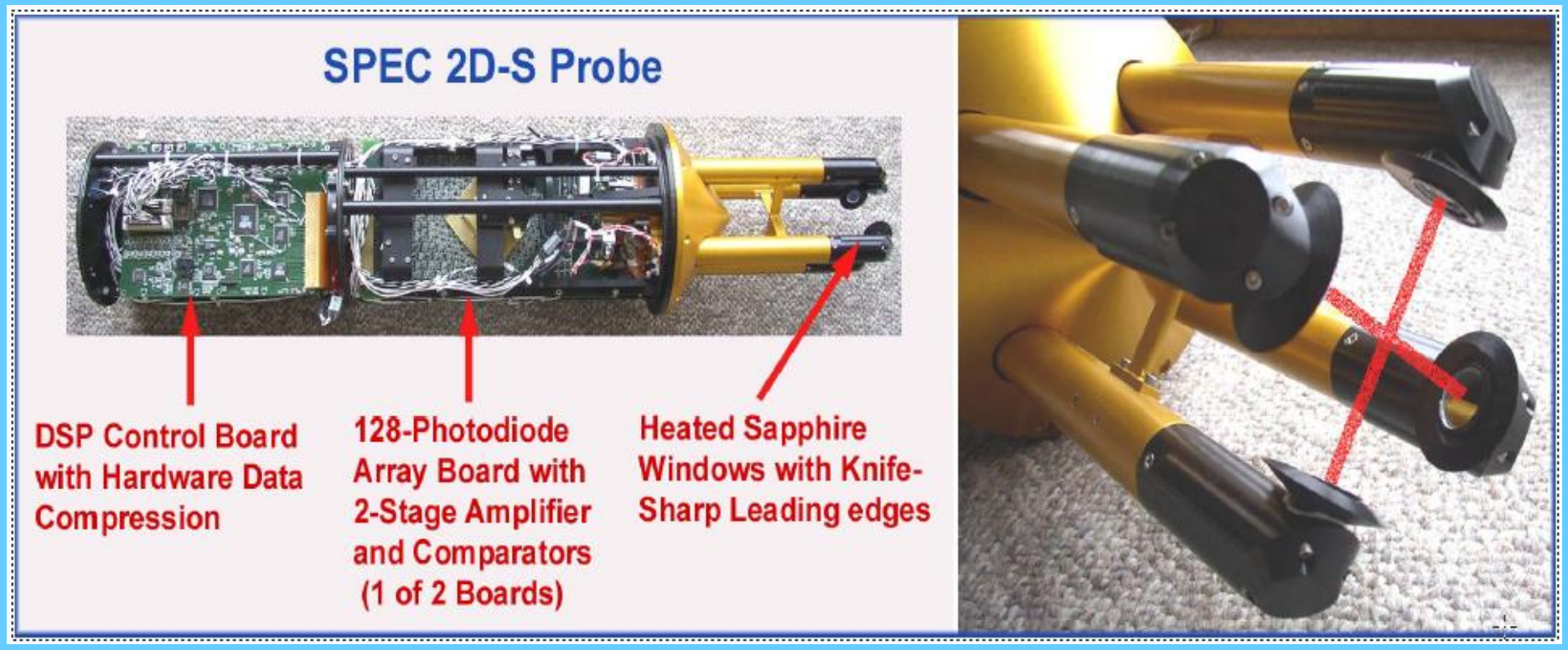
We'll use all the relevant data we can, but for our part we'll bring an improved CPI and the new 2D-S probe.

- Both instruments are designed to accurately measure particle sizes and concentrations in the size range critical for these studies (10 – several 100 microns).

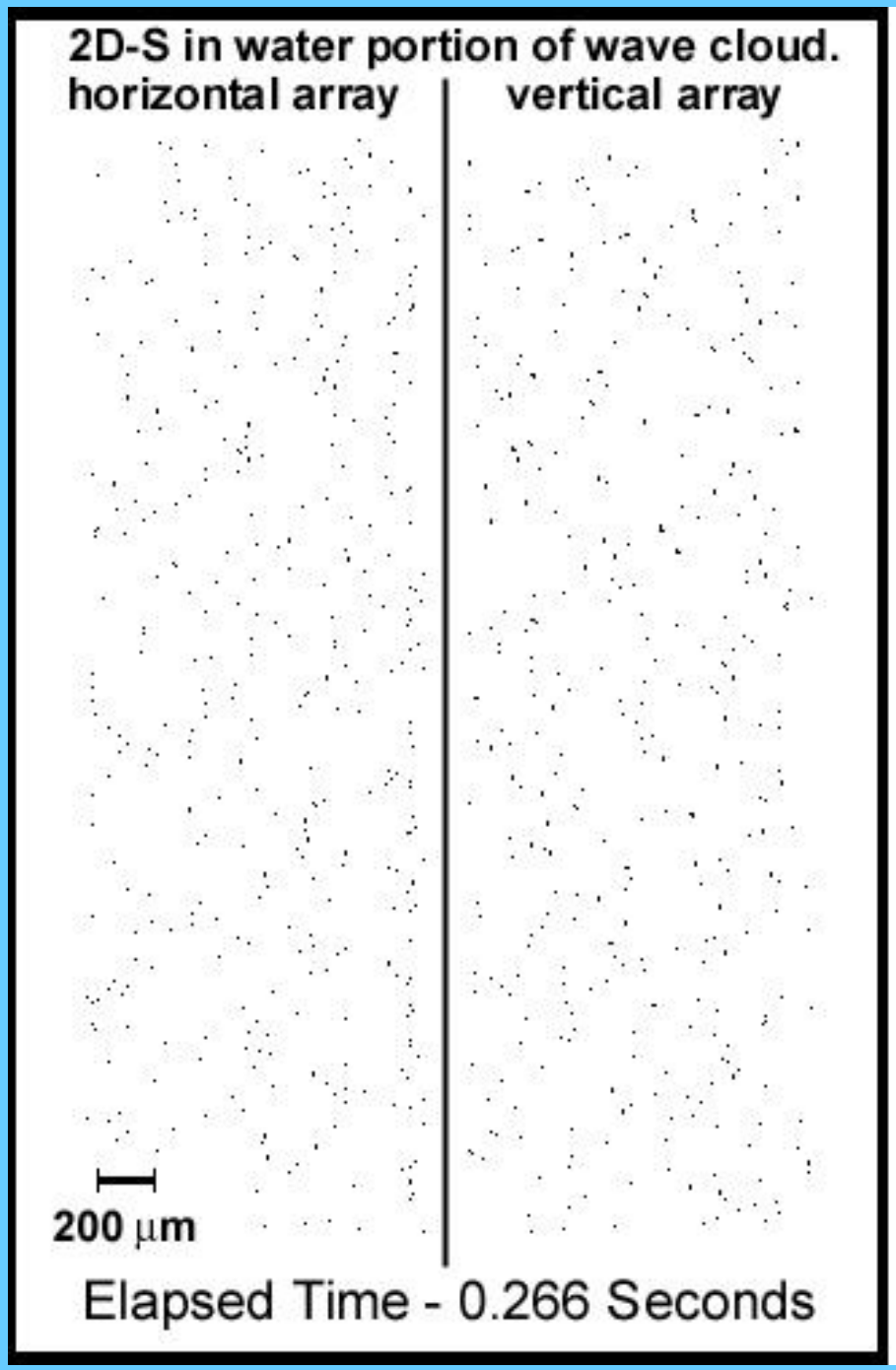
- CPI sizes very accurately but has large uncertainties in concentrations. Improved sampling strategy may help.

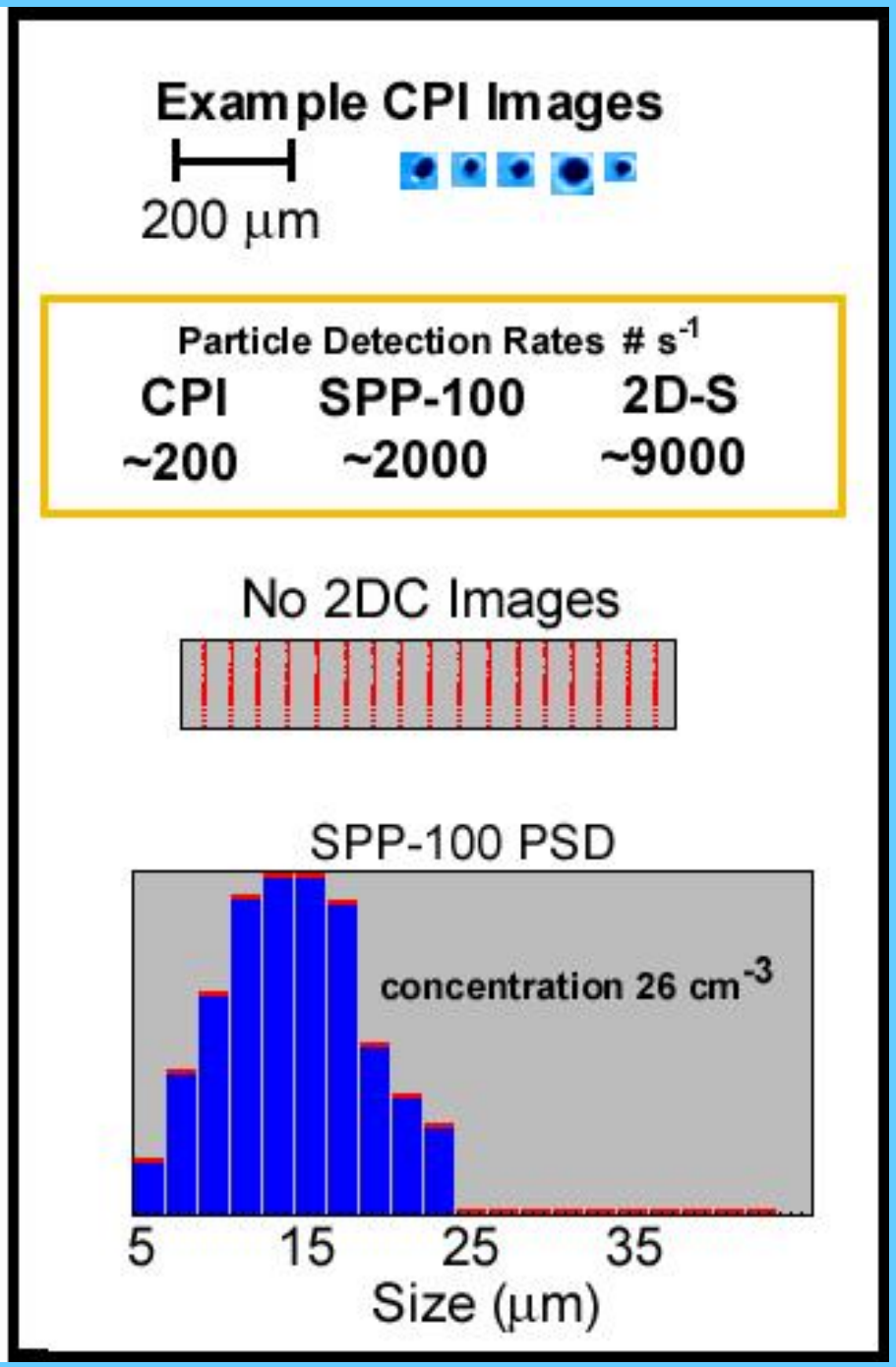
- 2D-S sizes with less resolution than the CPI but should provide unprecedented accuracy for concentrations and also provide droplet position information critical to droplet clustering observations.

S in 2D-S is for Stereographic

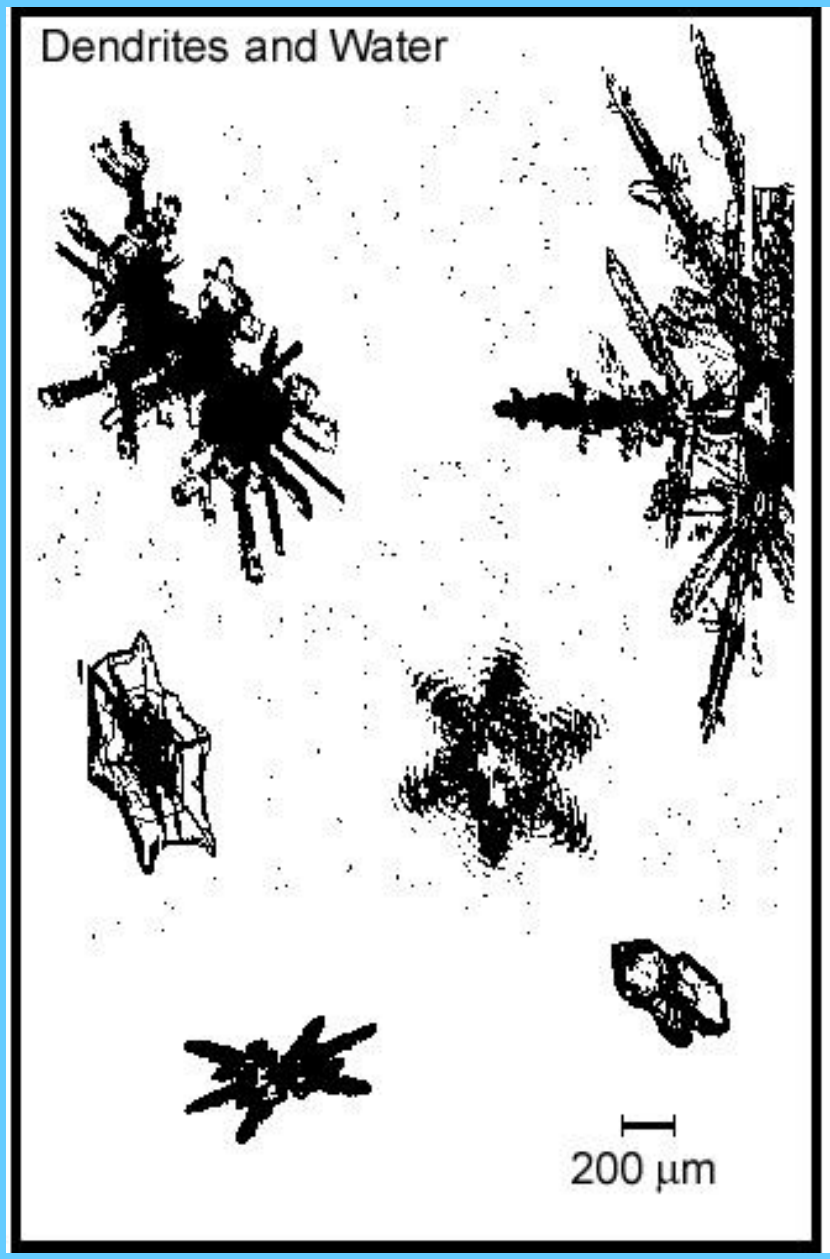


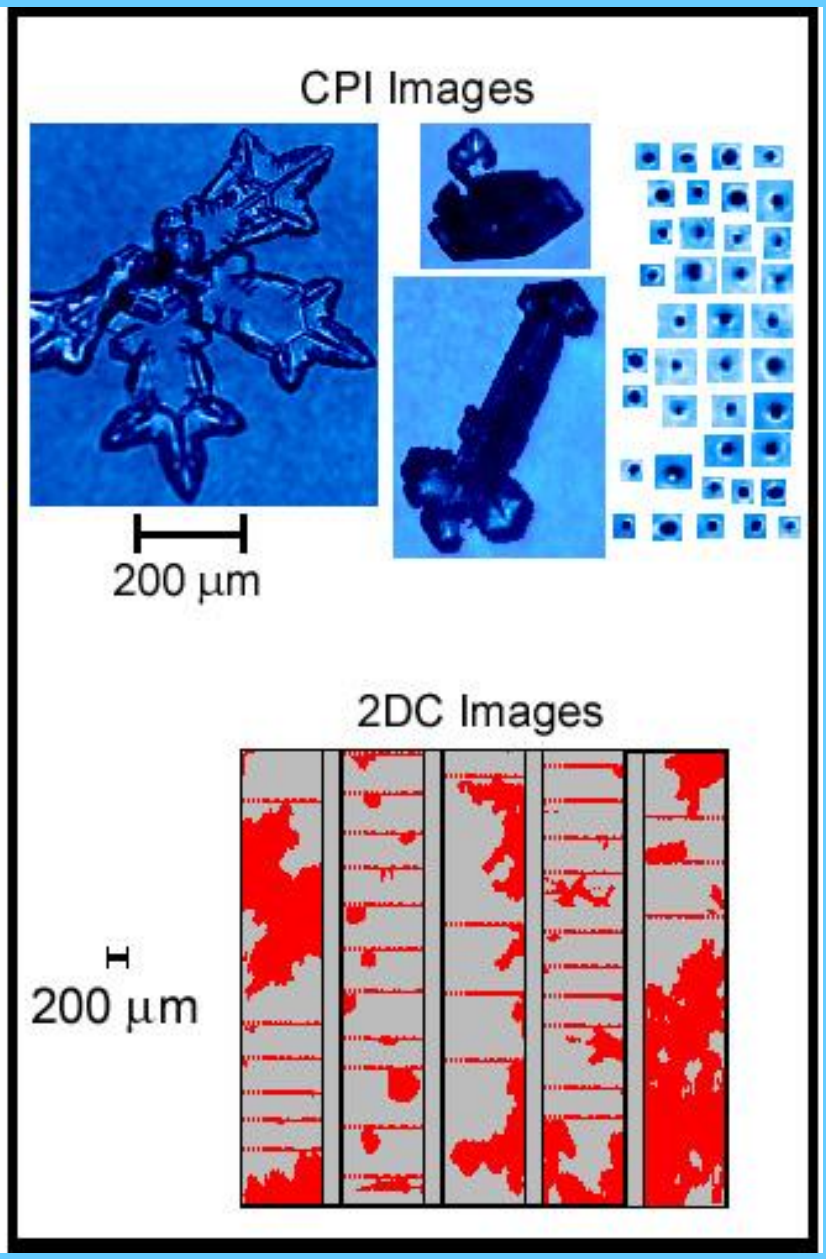
2 high speed 2D probes with overlapping sample areas as shown. Current size resolution is 10 microns. Might be reduced for RICO.


2D-S in water portion of wave cloud.
horizontal array
vertical array
200 μm
Elapsed Time - 0.266 Seconds

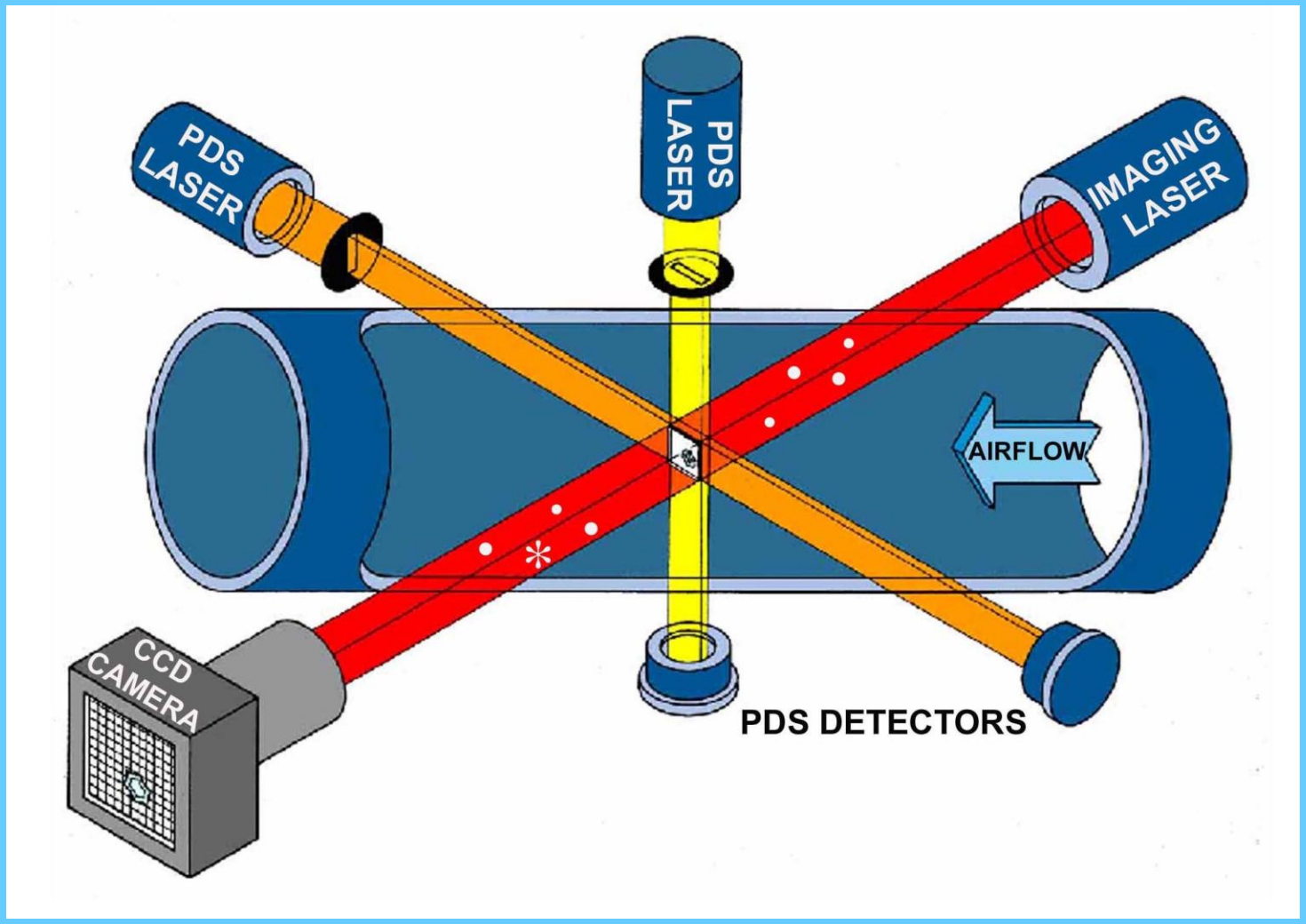

Example CPI Images
200 μm
Particle Detection Rates # s-1
CPI
~200
SPP-100
~2000
2D-S
~9000
No 2DC Images
SPP-100 PSD
concentration 26 cm-3
5
15
25
35
Size (μm)

2D-S in mixed phase cloud



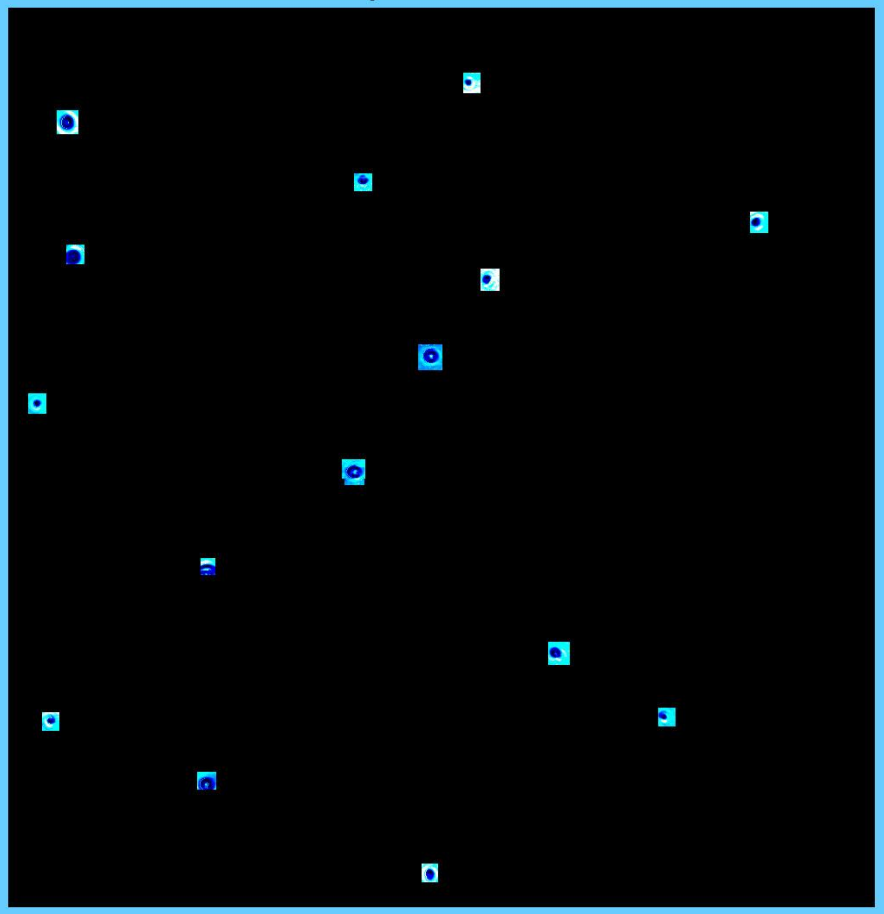


CPI Basics

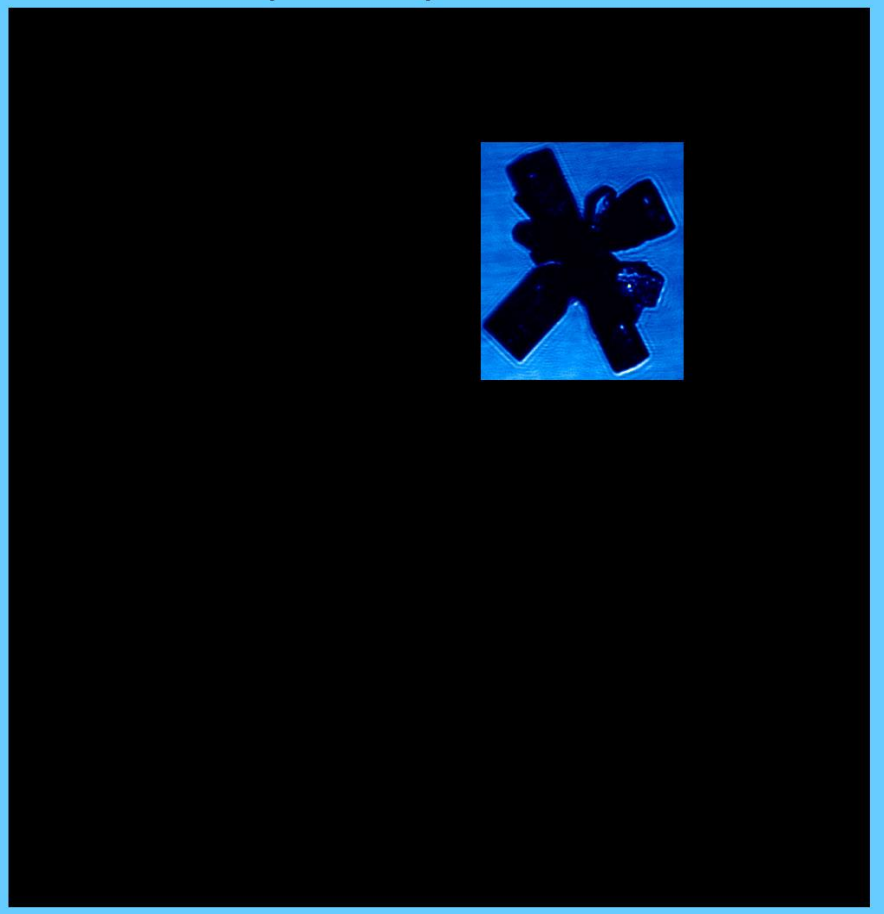


Imaging system (laser and camera), triggered by Particle Detection System (PDS), generates snapshots of particles in a small (0.2 – 0.002 cm^3) volume.

CPI in Water Cloud



CPI in Ice Cloud



CPI Improvements

- Higher frame rate (was 40 s^{-1}, now 70 s^{-1}, might be faster still [>300 s^{-1}] for RICO)
- Hermetically sealed (previous projects in the tropics hampered by condensation inside probe)
- Improved laser and optics
- Non-triggered sampling mode should improve quantification of concentrations and allow statistical analysis for clustering.

Observations Needed

Aircraft will need to make level penetrations at multiple altitudes through the clouds in and near the field of view being observed by the dual wavelength radar.