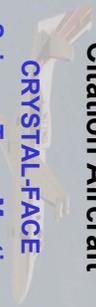


**University of North Dakota
Citation Aircraft**



Science Team Meeting

January 31, 2002

Mike Poellot

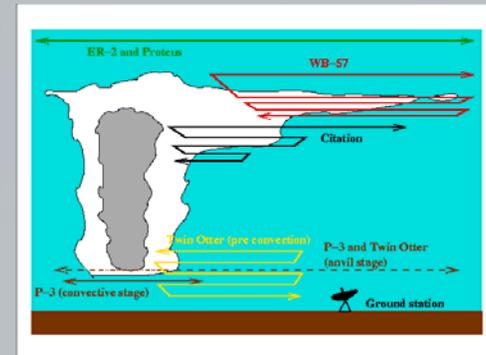
CRYSTAL-FACE: © 2002 University of North Dakota

Citation Co-Investigators

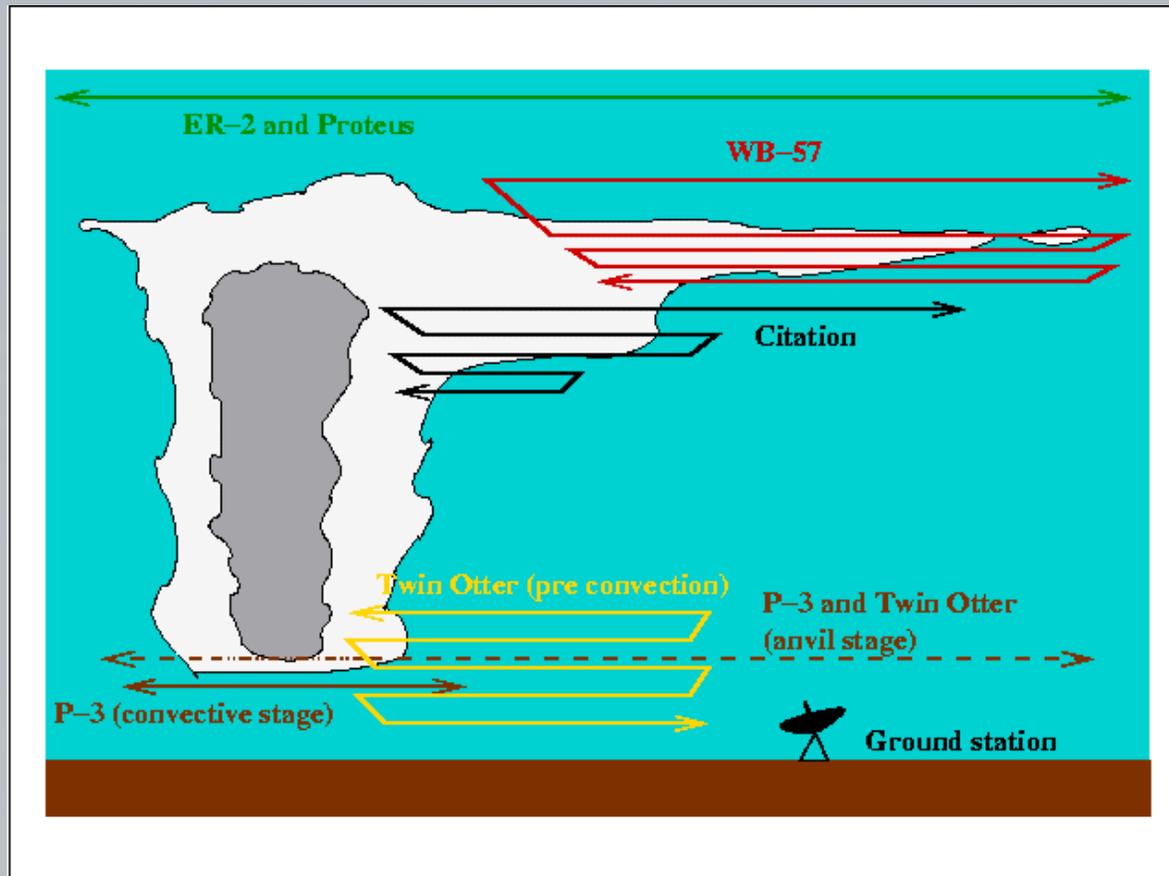
- **Andy Heymsfield (NCAR)**
- **Cindy Twohy (Oregon State University)**
- **Hermann Gerber (Gerber Scientific)**
 - **CVI, HVPS, CPI, CIN**
- **Paul DeMott (Colorado State University)**
- **Dave Rogers (NCAR)**
 - **IN Counter (CFDC)**

Citation Mission Objectives

- Sample lower portions of cirrus anvil and its environment
 - Cloud microphysics
 - Ice and condensation nuclei
 - State parameters
 - Winds



Citation Mission Profile



Science Objectives

- **Anvil Water Budgets**
 - **Microphysical Parameterization Development**
 - **Particle Habit Definition**
 - **Relationship of Optical Properties to Microphysics**
 - **Ice Formation**
- 

UND Citation II



January 30, 2002

CRYSTAL-FACE Science Meeting

Citation Performance

Ceiling	13.1 km (43,000')
Endurance	3.5 hrs (with large C-F payload)
Weight: Empty/Max Ramp	3888/6682 kg
Speed: Cruise/Sampling	170/120 m s⁻¹
Time to Climb: 25,000'/35,000/	13/24 min

Citation Research Power

- **Total Available: 370A 28 VDC**
- **Distribution for CRYSTAL-FACE:**
 - **100 A 28 VDC**
 - **45 A 110 60 Hz AC**

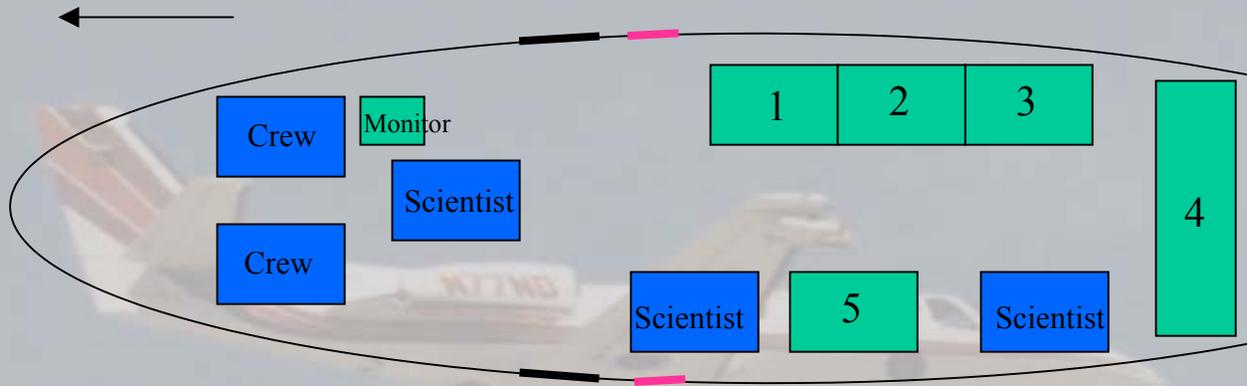
Citation Cabin Plan



January 30, 2002

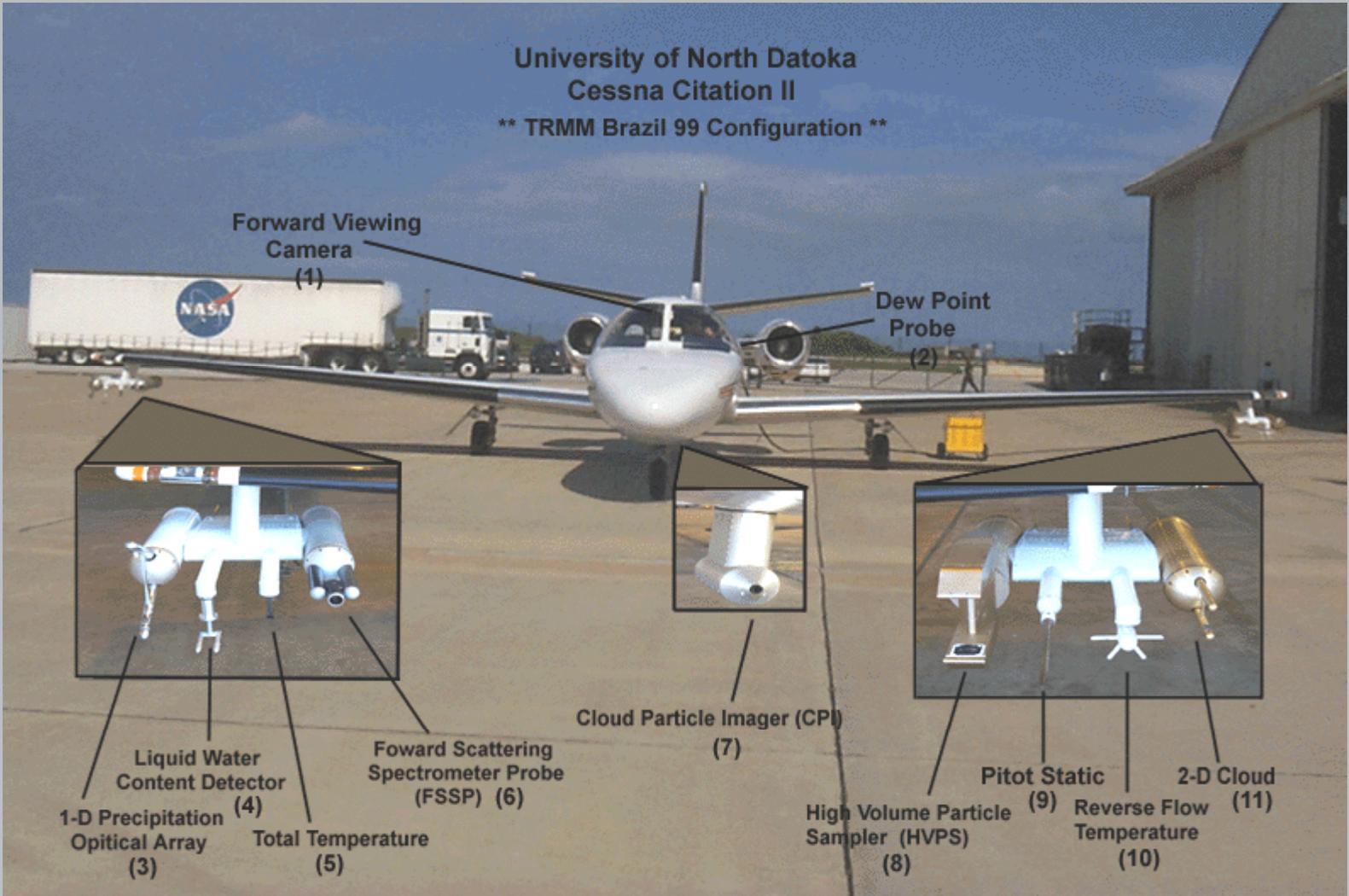
CRYSTAL-FACE Science Meeting

UND Citation Cabin Plan



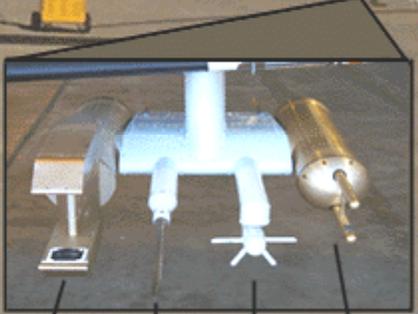
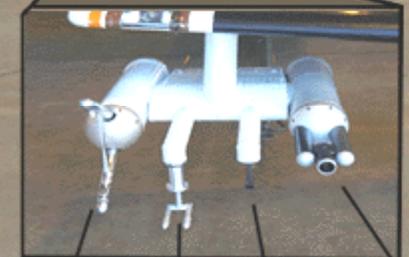
University of North Dakota
Cessna Citation II

** TRMM Brazil 99 Configuration **



Forward Viewing
Camera
(1)

Dew Point
Probe
(2)



Liquid Water
Content Detector
(4)

1-D Precipitation
Optical Array
(3)

Total Temperature
(5)

Forward Scattering
Spectrometer Probe
(FSSP) (6)

Cloud Particle Imager (CPI)
(7)

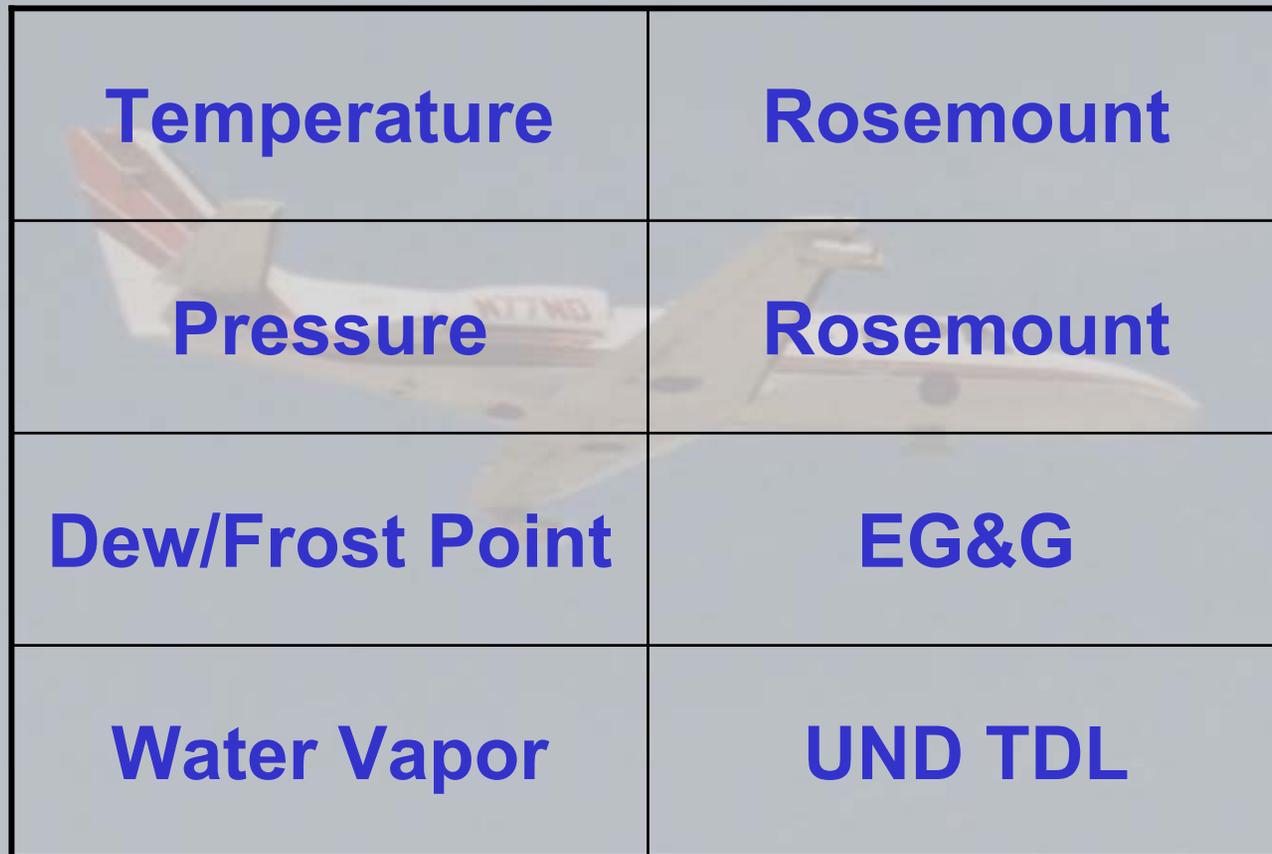
Pitot Static
(9)

High Volume Particle
Sampler (HVPS)
(8)

Reverse Flow
Temperature
(10)

2-D Cloud
(11)

Citation Instrumentation – State Parameters



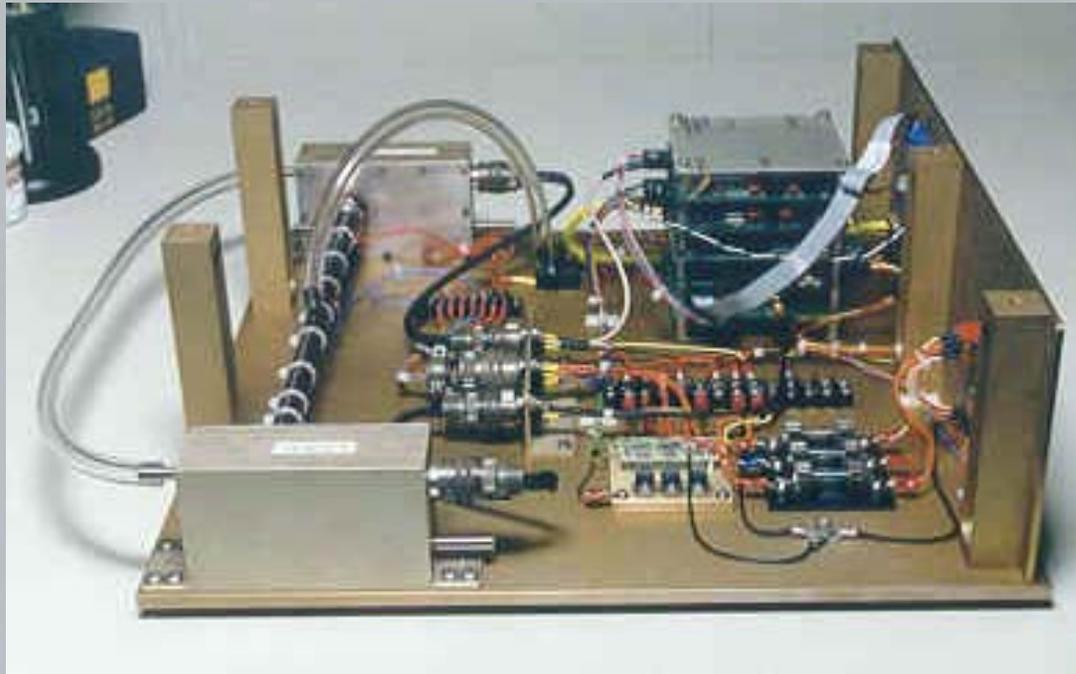
Temperature	Rosemount
Pressure	Rosemount
Dew/Frost Point	EG&G
Water Vapor	UND TDL

Tunable Diode Laser – TDL Water Vapor (Maycomm)

- Optical path length: 4 m multipass
- Lower detection limit: 0.5 ppmv
- Accuracy: +/-3% (troposphere)
- Sample flow rate: 65 cc/s for 1s response time
- Rear-facing inlet



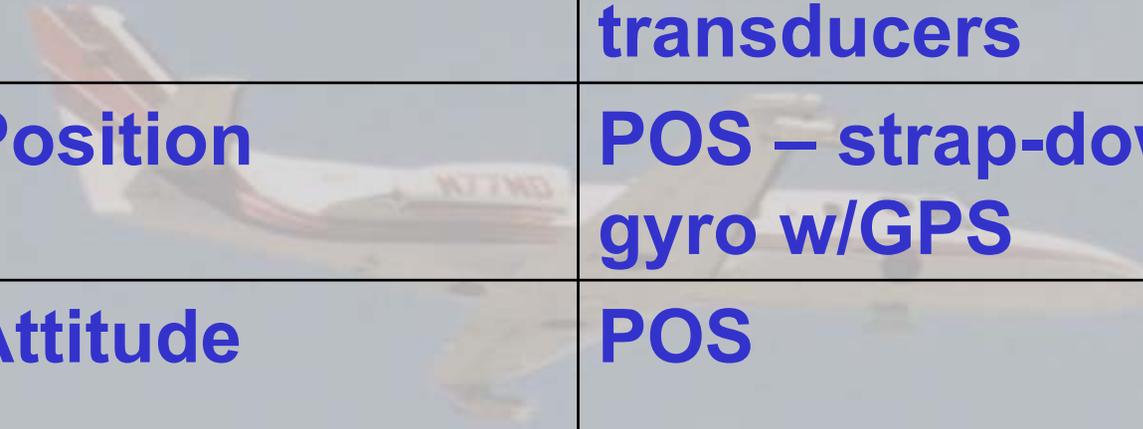
Tunable Diode Laser – TDL Water Vapor (Maycomm)



Citation Instrumentation - Winds

u, v, w	Ported radome, POS
Turbulence ($\varepsilon^{1/3}$)	Pitot-static differential pressure

Citation Instrumentation – Aircraft Parameters



Airspeed	Rosemount transducers
Position	POS – strap-down gyro w/GPS
Attitude	POS
Accelerations	POS
Forward Video	Sony

Citation Instrumentation – Microphysics and Aerosol

Particle Images	CPI, HVPS, 2D-C
Ice Mass	CVI
Bulk Extinction/Scattering	CIN
Small Particle Concentrations	FSSP
Liquid/Supercooled Water	King, Rosemount Ice
Condensation Nuclei	CCN
Ice Nuclei	CFDC

Microphysical Measurements

- Deduce water budgets of anvils
- Develop parameterizations of microphysical and optical properties and retrievals of IWC and r_{eff}
- Characterize particle habits in terms of T, location and radar reflectivity
- Determine relationship of optical properties to microphysics

PMS FSSP

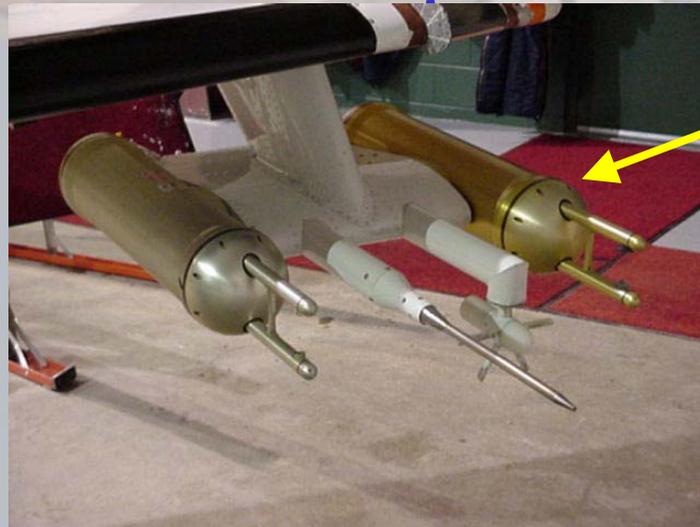
Small Particles

- Forward Scattering Spectrometer
- Assumes liquid spheres – uncertainty in sizing/counting ice particles
- Size range 2 – 47 μm



PMS Optical Array Probe - 2D-C

- Cloud Particle Images
- 30 μm resolution, 32 diodes
- Size range 30 – 960 μm



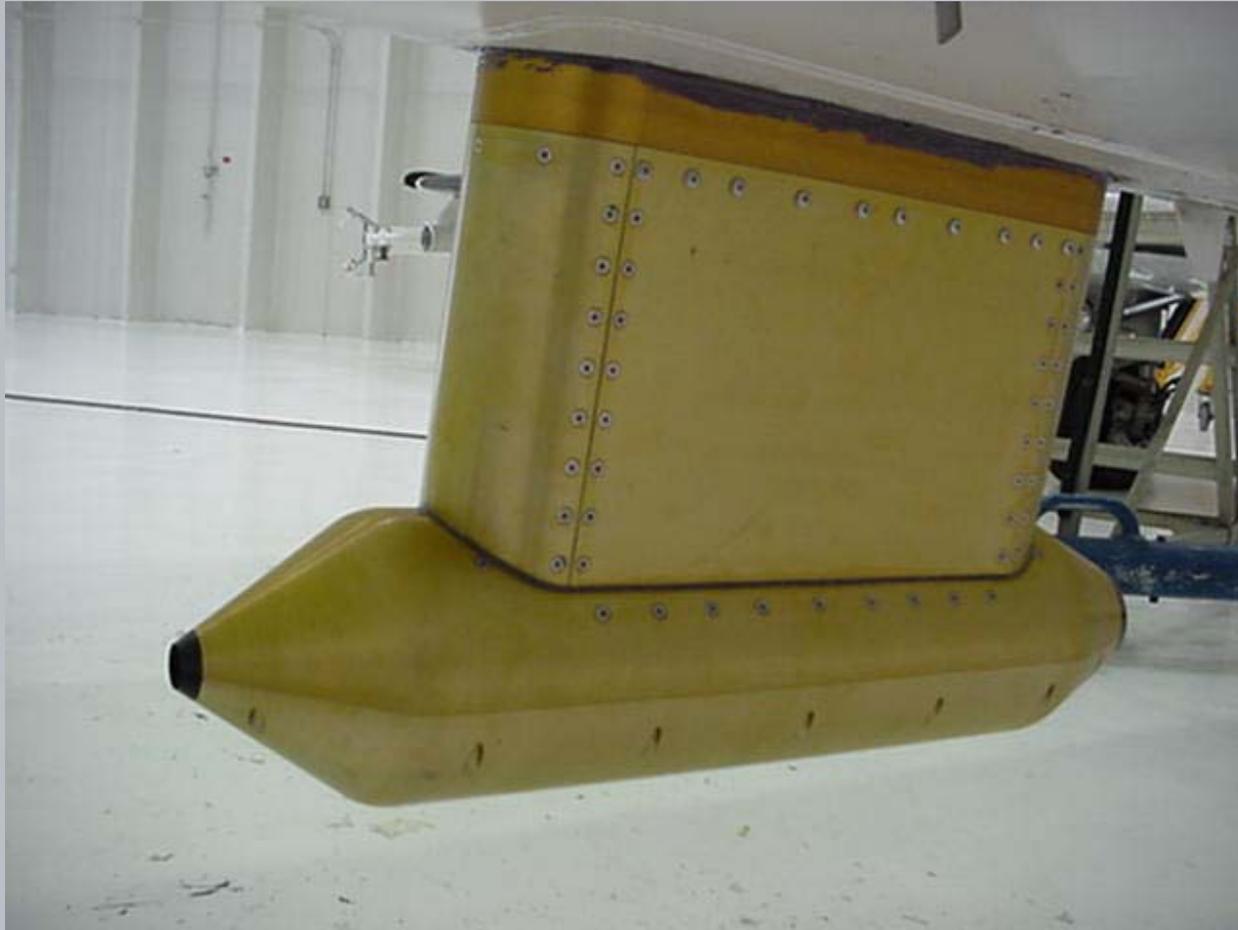
2D-C

PMS 2D-C

- Images can be processed to yield size distribution, ice water content
- Habit recognition limited by low resolution

P 06/24/00	17:49:59.9872	17:50:00.0351	DeltaT:	0: 0.0479	TAS = 117.4
P 06/24/00	17:50:00.2368	17:50:00.2861	DeltaT:	0: 0.0493	TAS = 117.4
P 06/24/00	17:50:00.4864	17:50:00.5312	DeltaT:	0: 0.0448	TAS = 117.4
P 06/24/00	17:50:00.7360	17:50:00.7773	DeltaT:	0: 0.0413	TAS = 117.4
P 06/24/00	17:50:00.9856	17:50:01.0273	DeltaT:	0: 0.0417	TAS = 117.4

Cloud Particle Imager - CPI

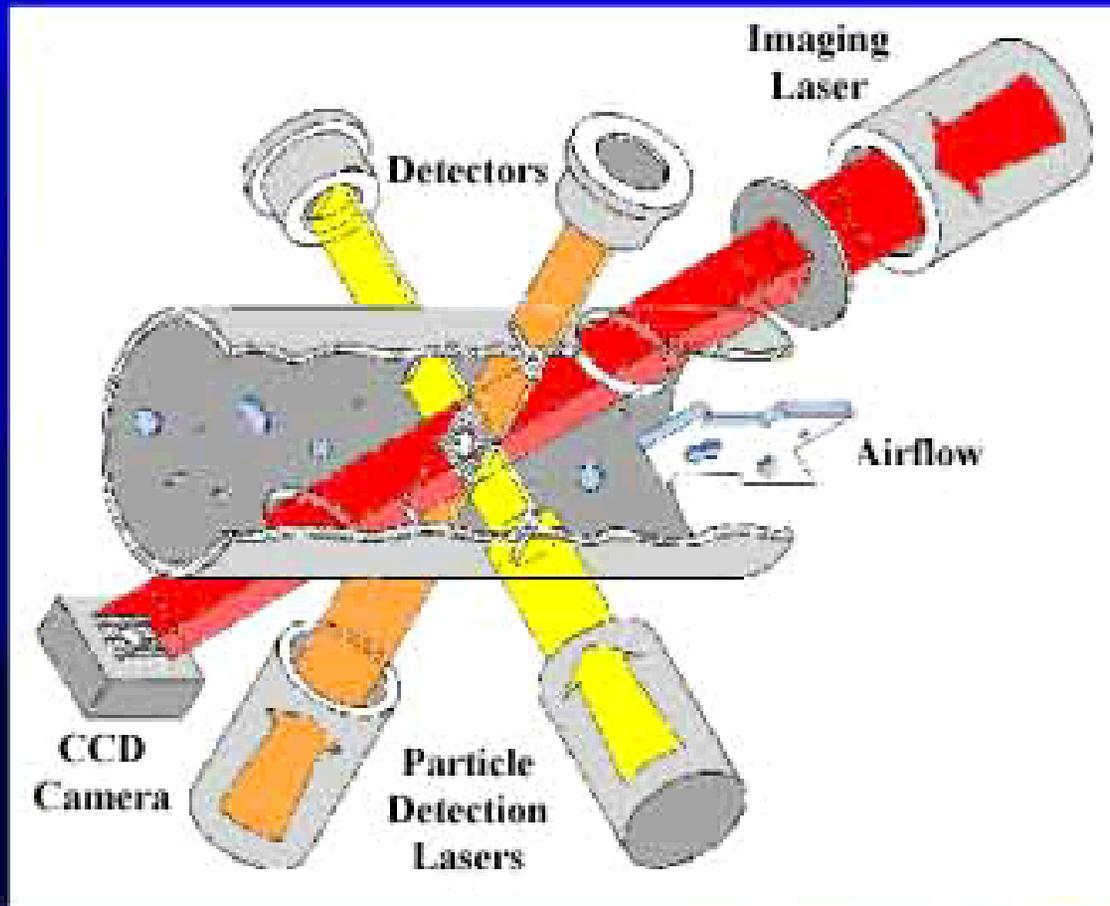


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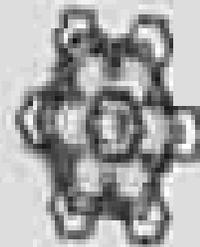
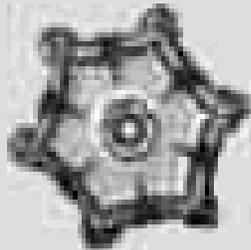
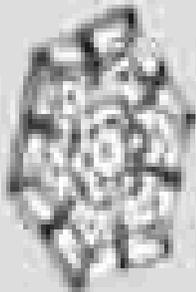
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CLOUD PARTICLE IMAGER (CPI) OPERATION

CPI Electro-Optical System



- 1,000,000 pixel digital CCD camera with 2.3 μm pixel resolution images particles "on the fly"
- Maximum rate of 40 frames per second
- Maximum sample volume of 1 L s^{-1} at 200 m s^{-1}
- Data system sorts multiple particles per frame and sizes them in real time

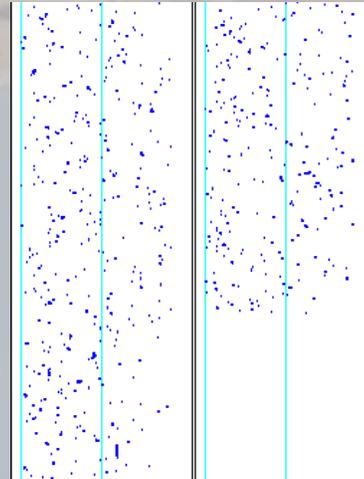


Scale: 100 μm

High Volume Precipitation Spectrometer - HVPS

- Optical Array – 256 pixel, 200 μm resolution
- Size range 200 μm – 5 cm

HVPS



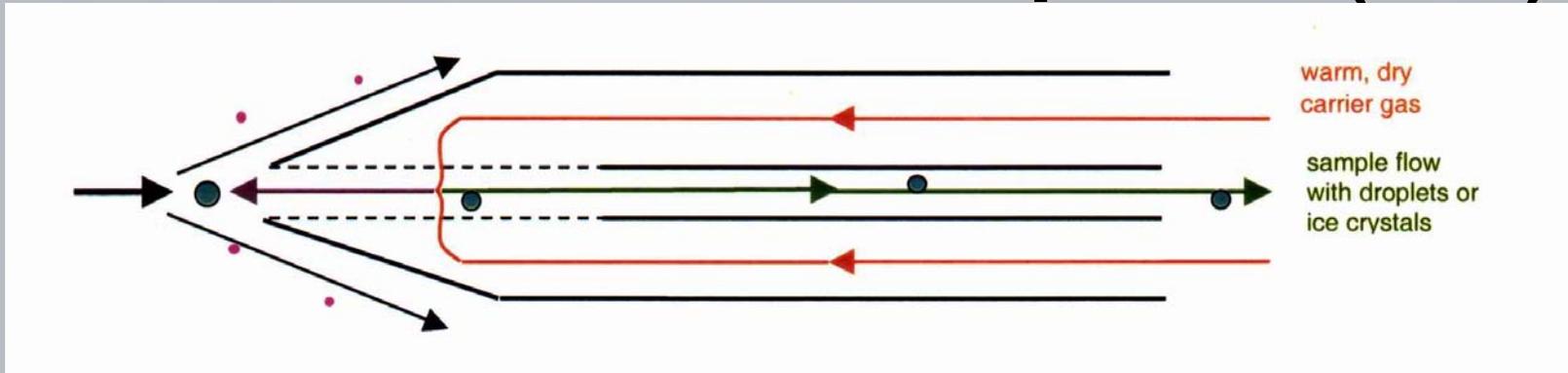
Counterflow Virtual Impactor - CVI



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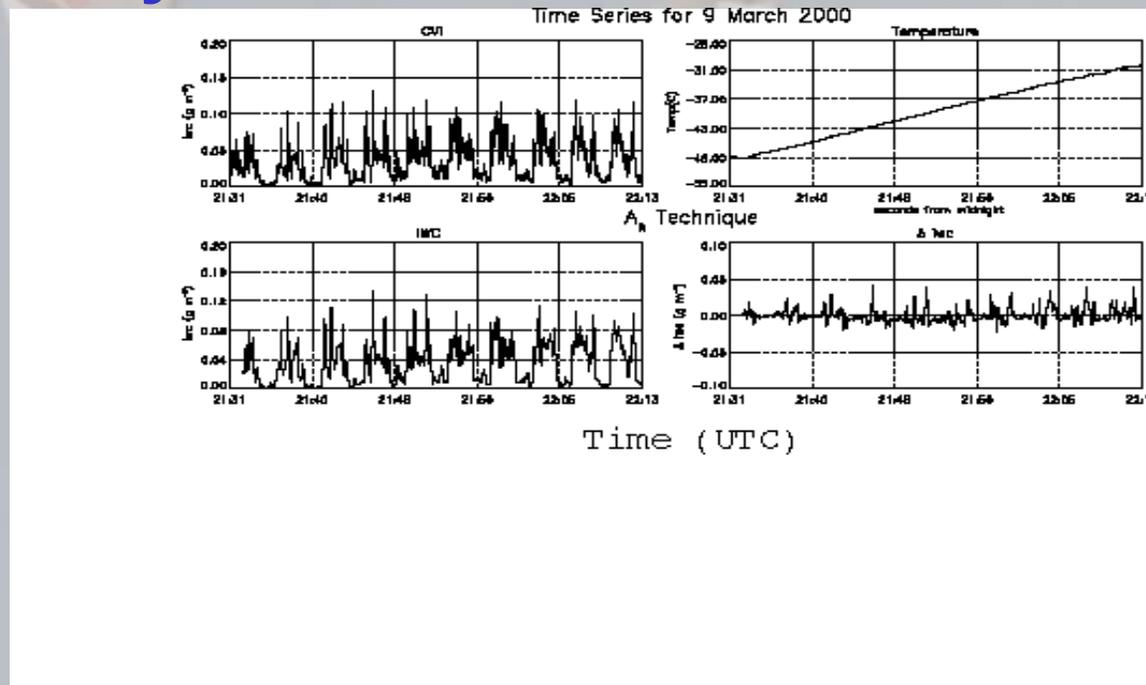
Counterflow Virtual Impactor (CVI)



- System for collecting ice crystals by inertial impaction into dry air while excluding interstitial aerosol and gases using counterflow out tip
- Crystals are evaporated, their non-volatile residual nuclei & volatile gases measured by various techniques.
 - Lyman-alpha & TDL (water content crystals $> 8 \mu\text{m}$)
 - CN counter (ice number; reliable only if no large crystals present)
 - Electron microscope samples (single particle chemical analysis)
 - Ice nuclei (CSU instrument)

CVI

- Primary measurement in CRYSTAL will be ice water content; secondary to study ice chemistry and nucleation

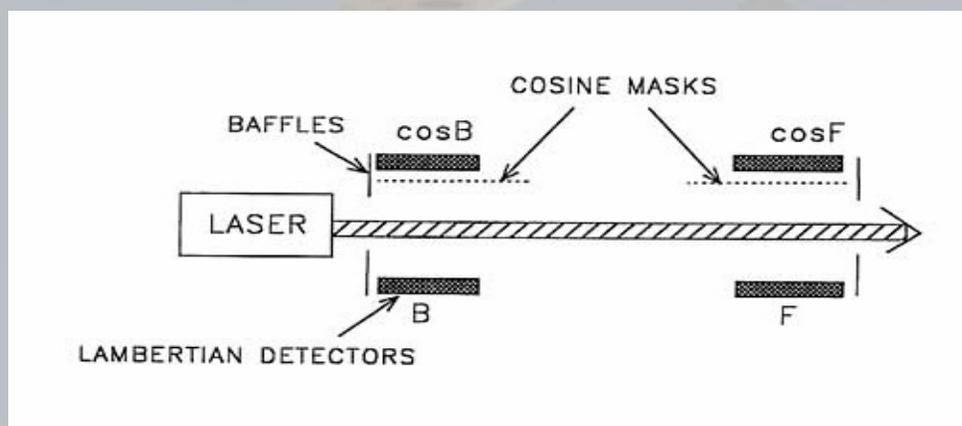


Cloud Integrating Nephelometer - CIN



Cloud Integrating Nephelometer - CIN

- Directly measures asymmetry parameter g , scattering coefficient, backscatter ratio
- Large sample rate – 300 liters/sec

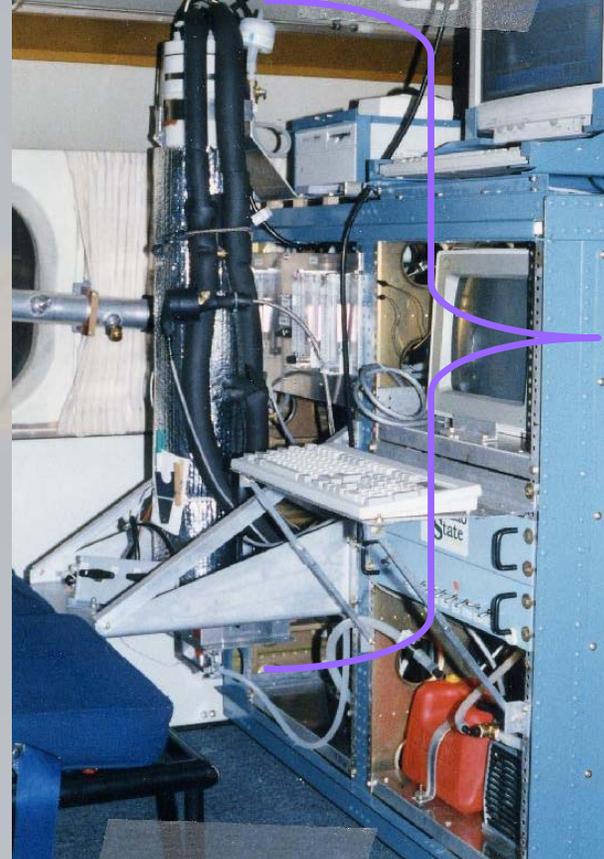


Ice Nucleus Measurements

- Identify fundamental role of ice formation on atmospheric aerosols in determining the microphysical composition of tropical cirrus (anvil cirrus and thin/subvisual cirrus)
- Evaluate role of Homogeneous and heterogeneous ice nucleation
- Provide explicit guidance on ice nucleation for numerical cloud model simulations of tropical cirrus

Continuous Flow Diffusion Chamber – CFDC

CFDC in DC-8 and NCAR Electra

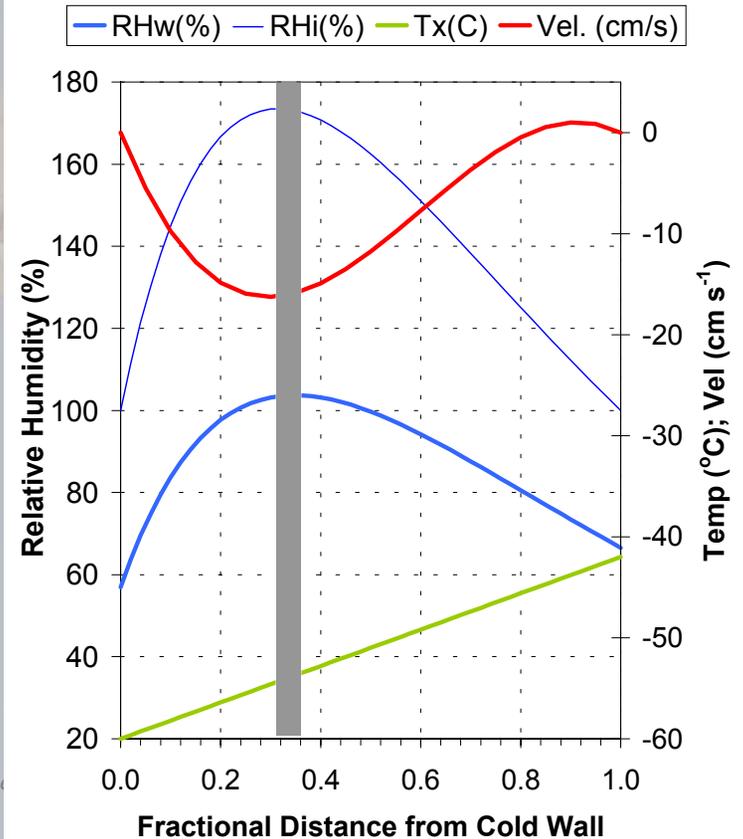
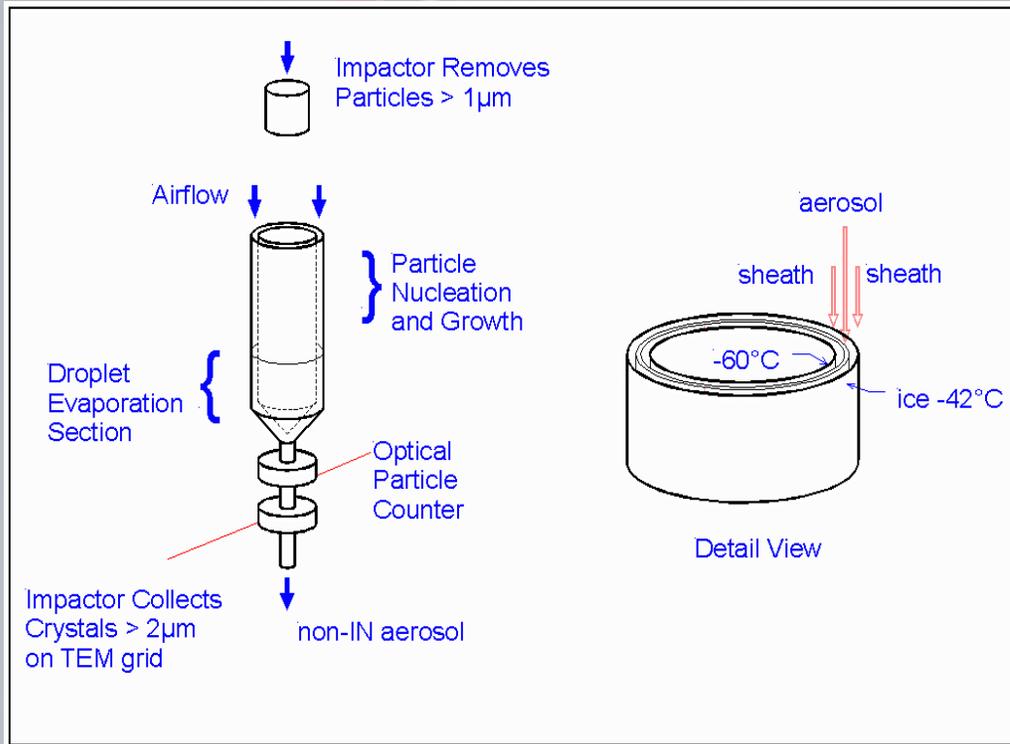


~47"
Just fits
in
Citation!

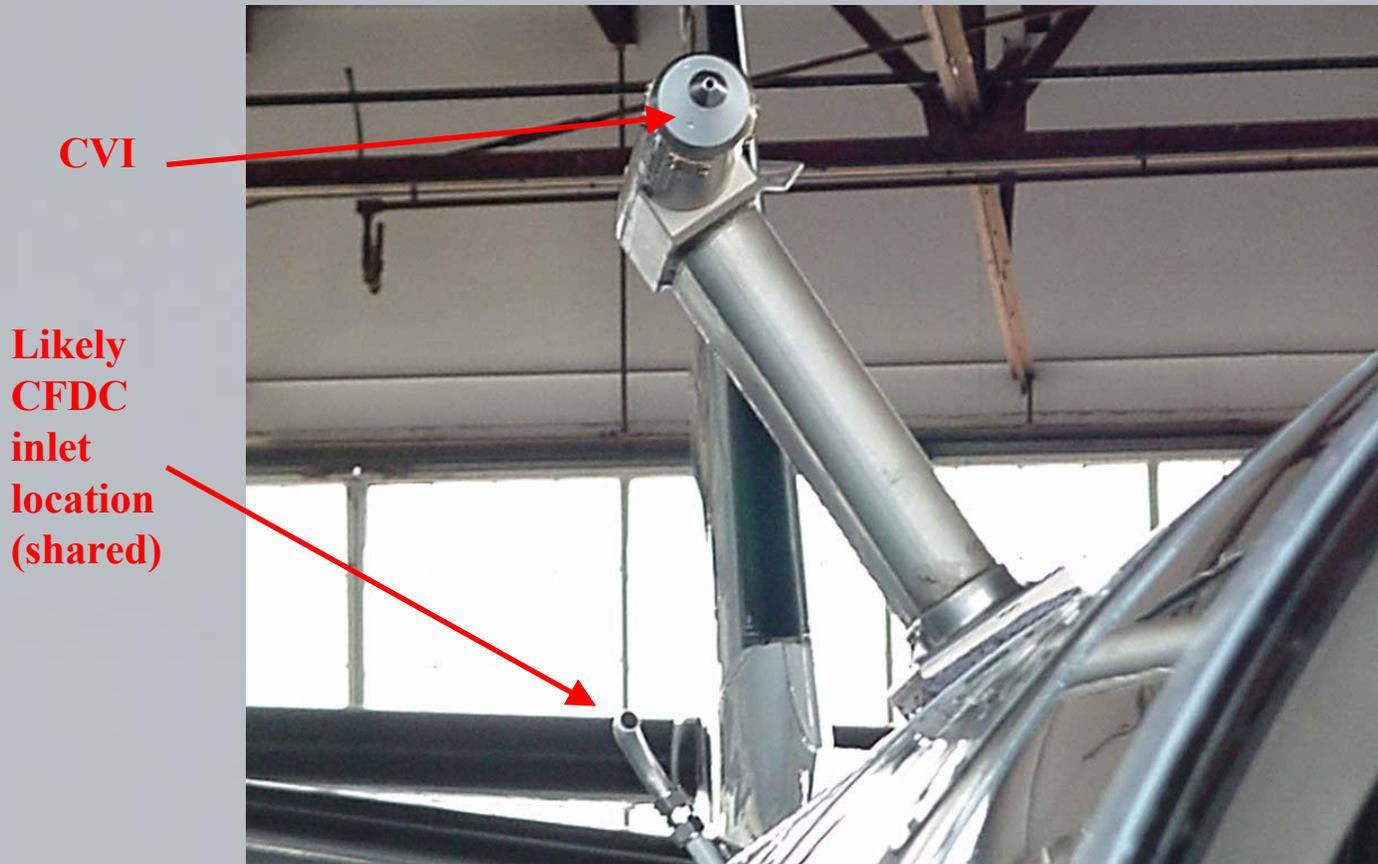
Continuous flow diffusion chamber (CFDC)

Temperature -10 to -65°C
Humidity ice saturation to ~80% SSw
Sample Flow 1 LPM
Total Flow 10 LPM

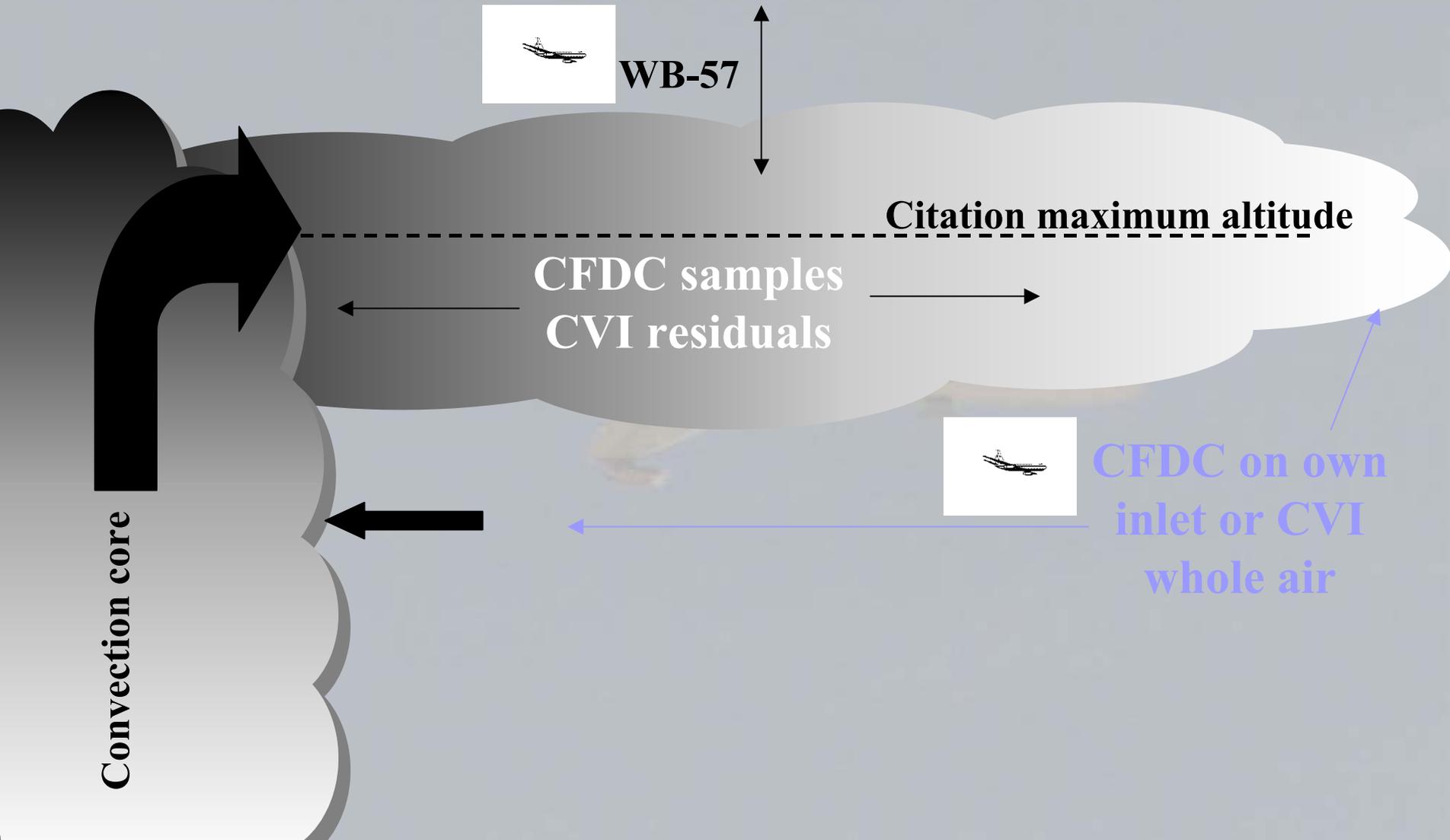
Response Time ~1 second
Ice Nucleus (crystal) detection based on OPC size
Collect IN particles (crystals) with impactor at outlet



Citation Inlets



Scenario for sampling in and around convectively driven cirrus



Scenario for sampling near thin or subvisual cirrus

