SPEC inc

Participation in ICE-T with the SPEC Learjet

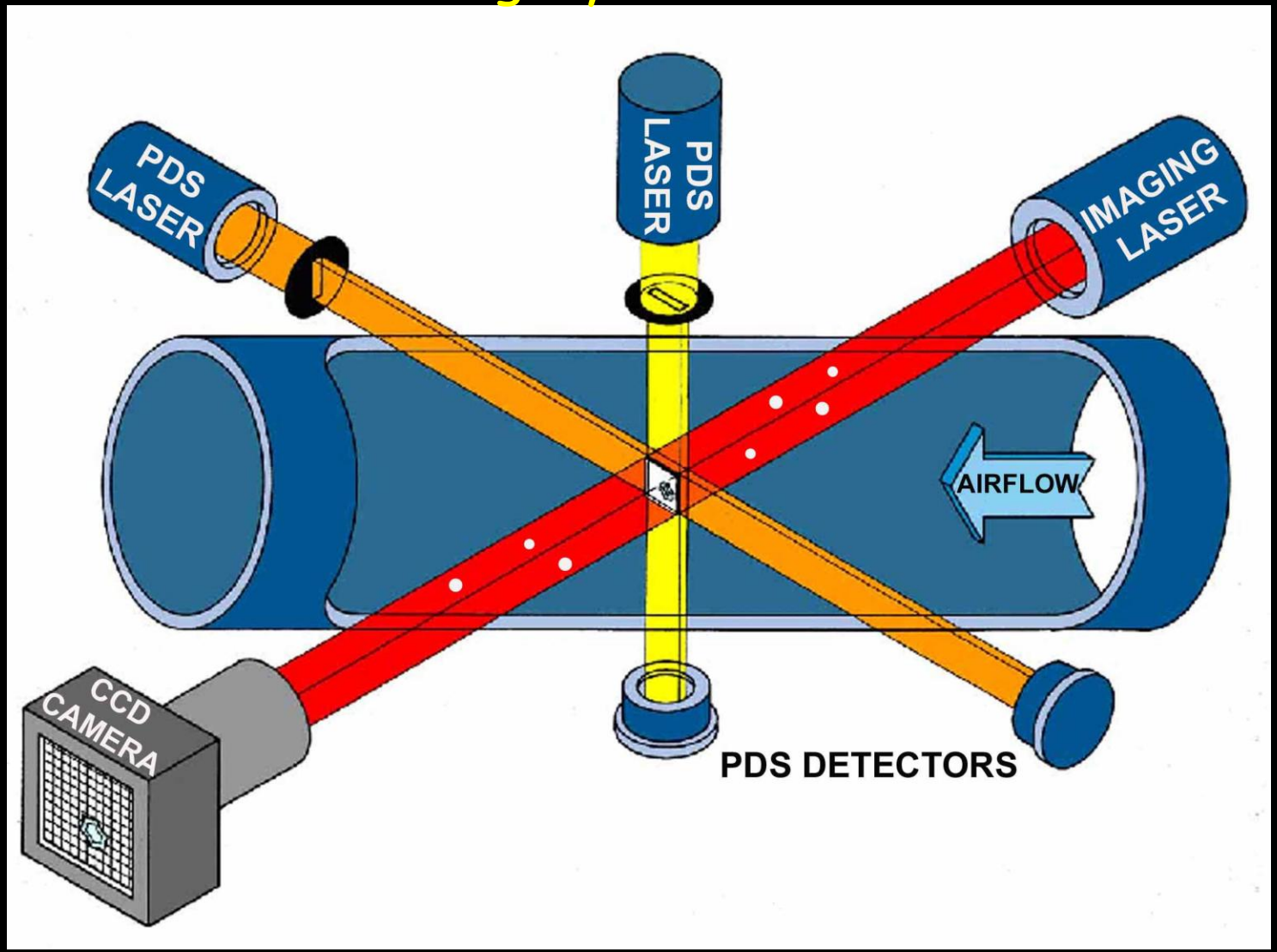
Mid-Project Science Report

CPI

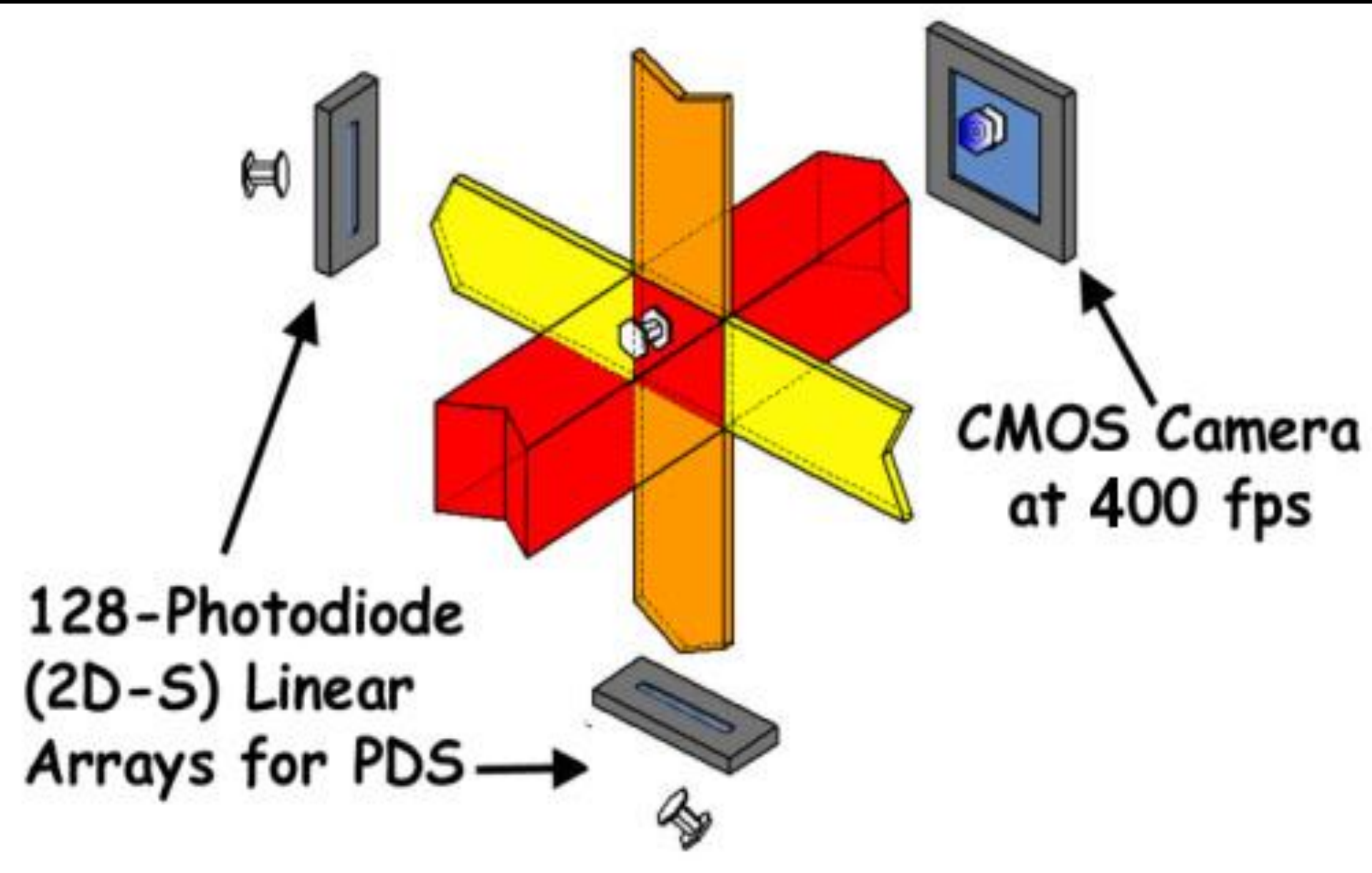
PDS LASER
PDS LASER
IMAGING LASER
AIRFLOW
CCD CAMERA
PDS DETECTORS

Airflow

When a Particle Enters the Rectangular Region Defined by the Continuous PDS Beams, the High-Power Imaging Laser is Pulsed and Freezes the Image with 2.3 μm Pixel Resolution and 256 gray levels on a CMOS Camera.

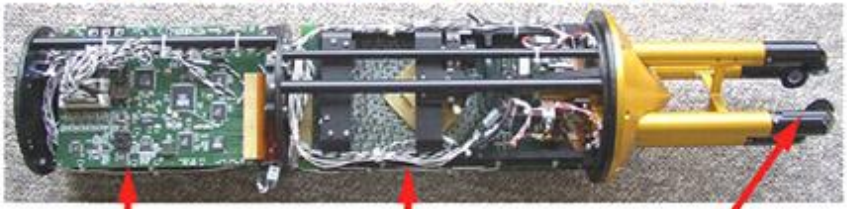


3V-CPI Electro-optics



The 2D-S is Two Identical Probes in one Canister. Each Probe has a Laser that Illuminates a Linear Array of 128 Photodiodes with True 10-µm Pixel Resolution.

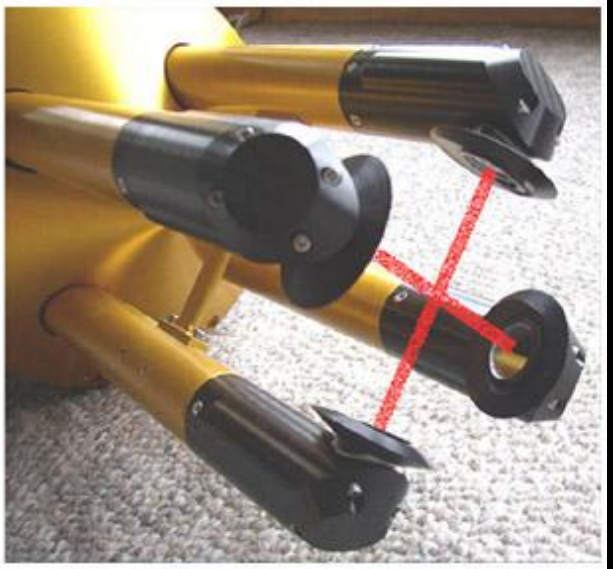
SPEC 2D-S Probe

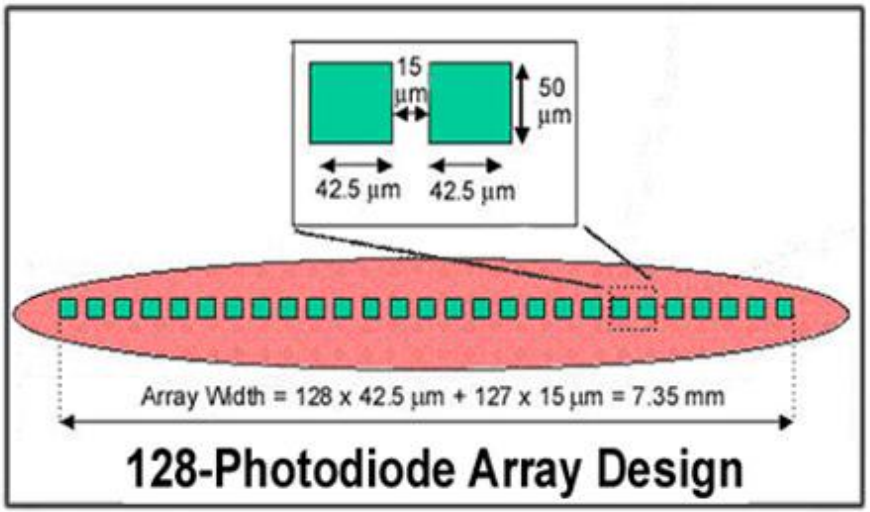


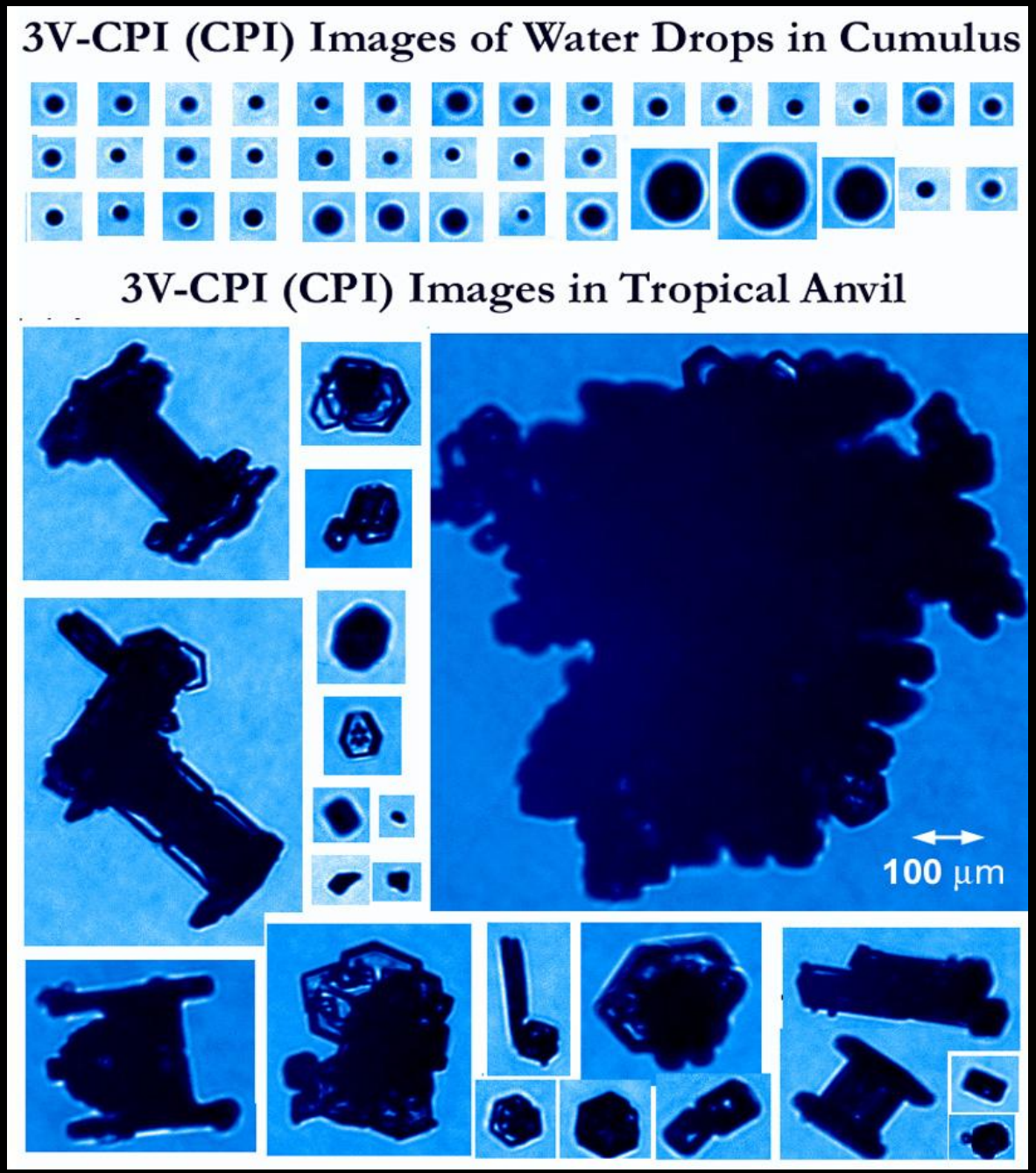
DSP Control Board with Hardware Data Compression

128-Photodiode Array Board with 2-Stage Amplifier and Comparators (1 of 2 Boards)

Heated Sapphire Windows with Knife-Sharp Leading edges

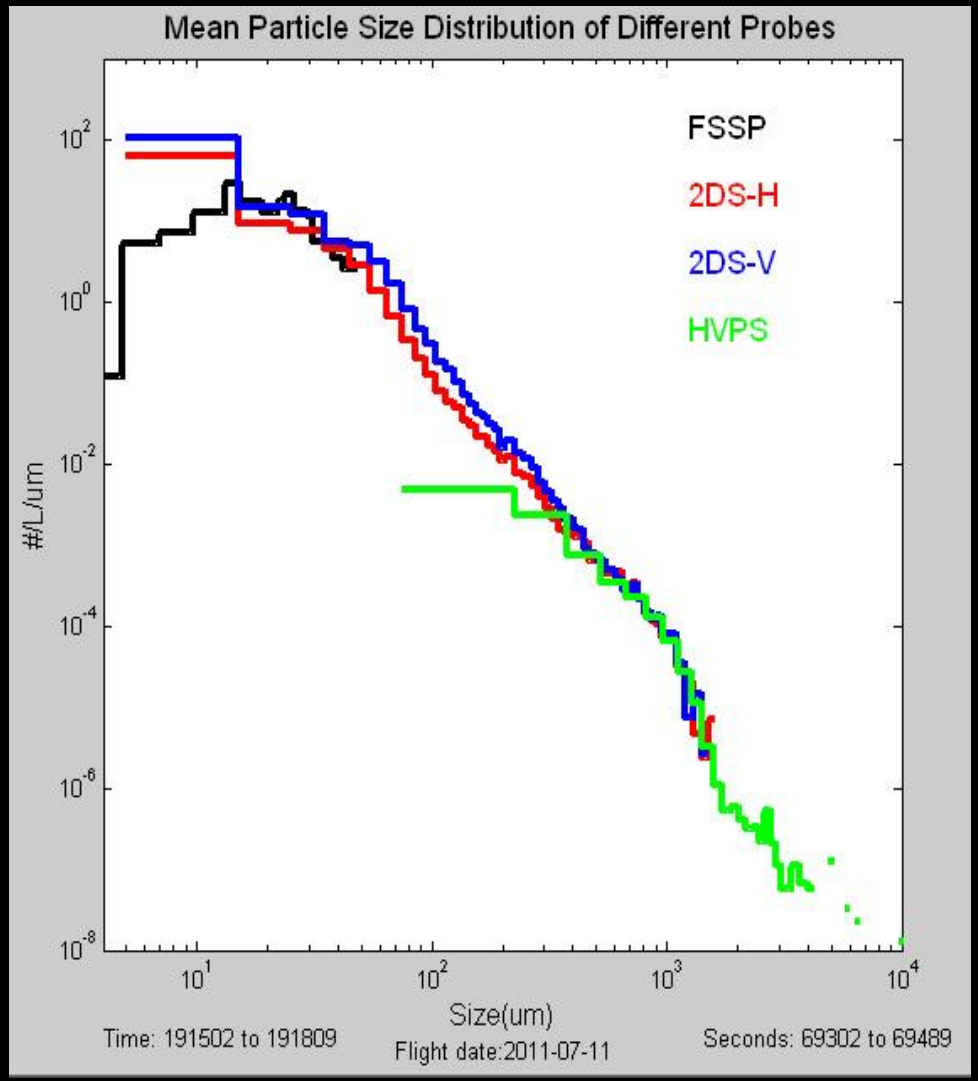


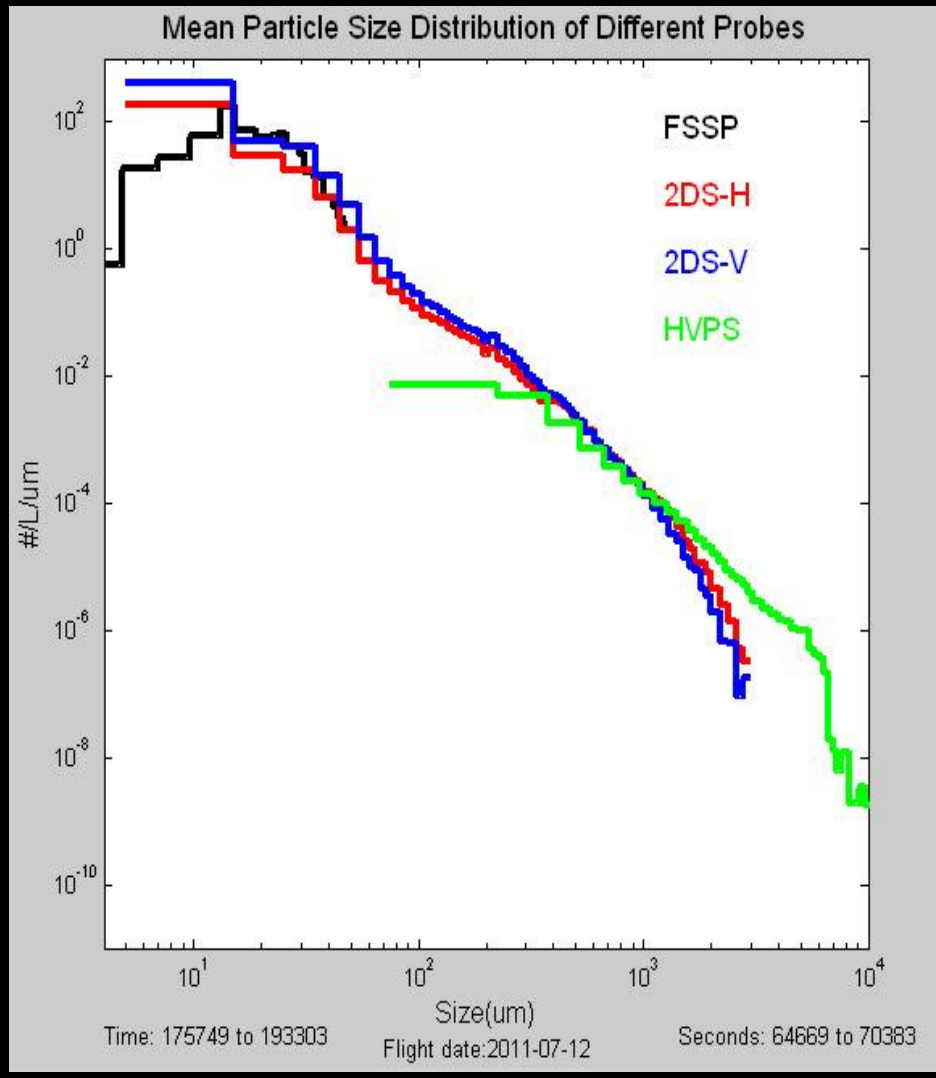



3V-CPI (CPI) Images of Water Drops in Cumulus
3V-CPI (CPI) Images in Tropical Anvil
100 µm

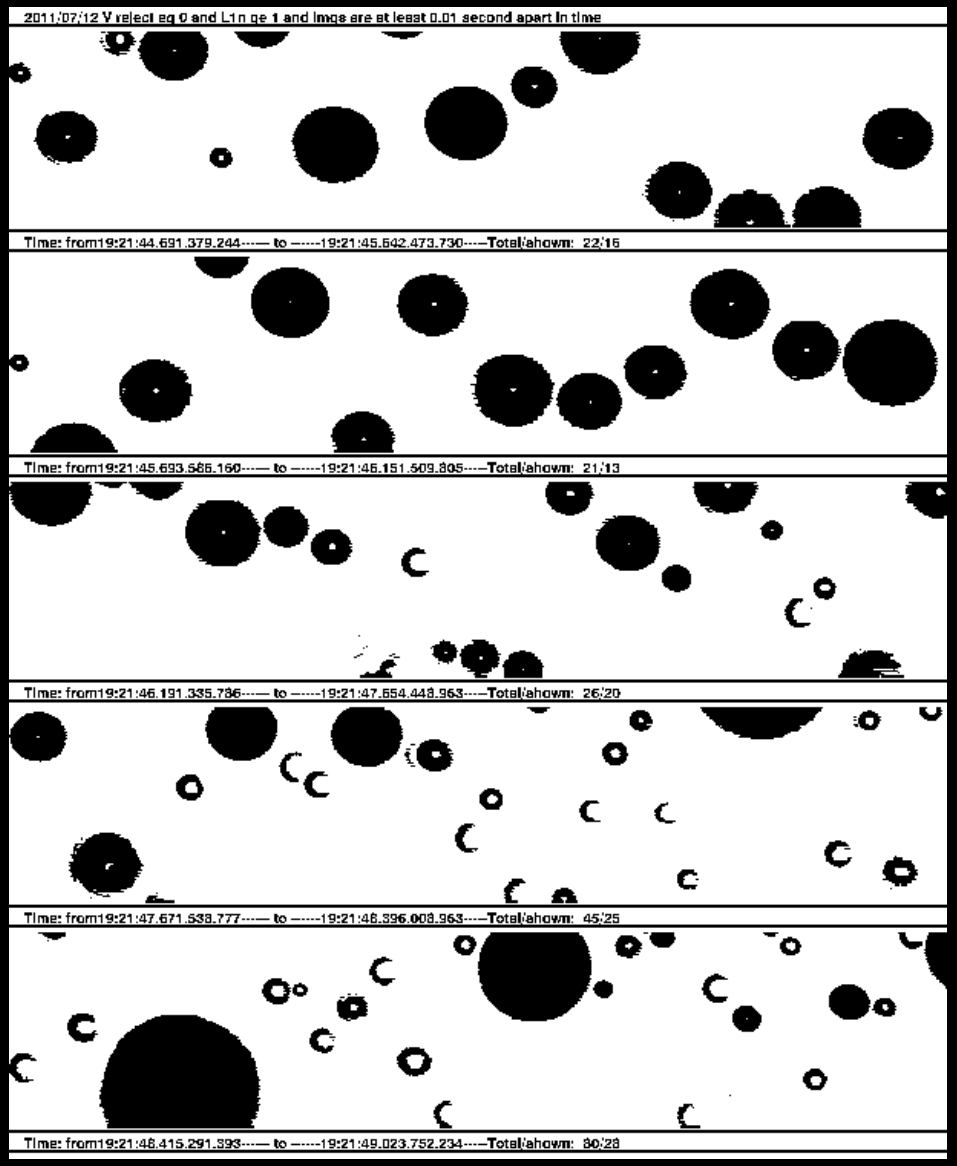
3V-CPI Installed on the NSF/NCAR GV

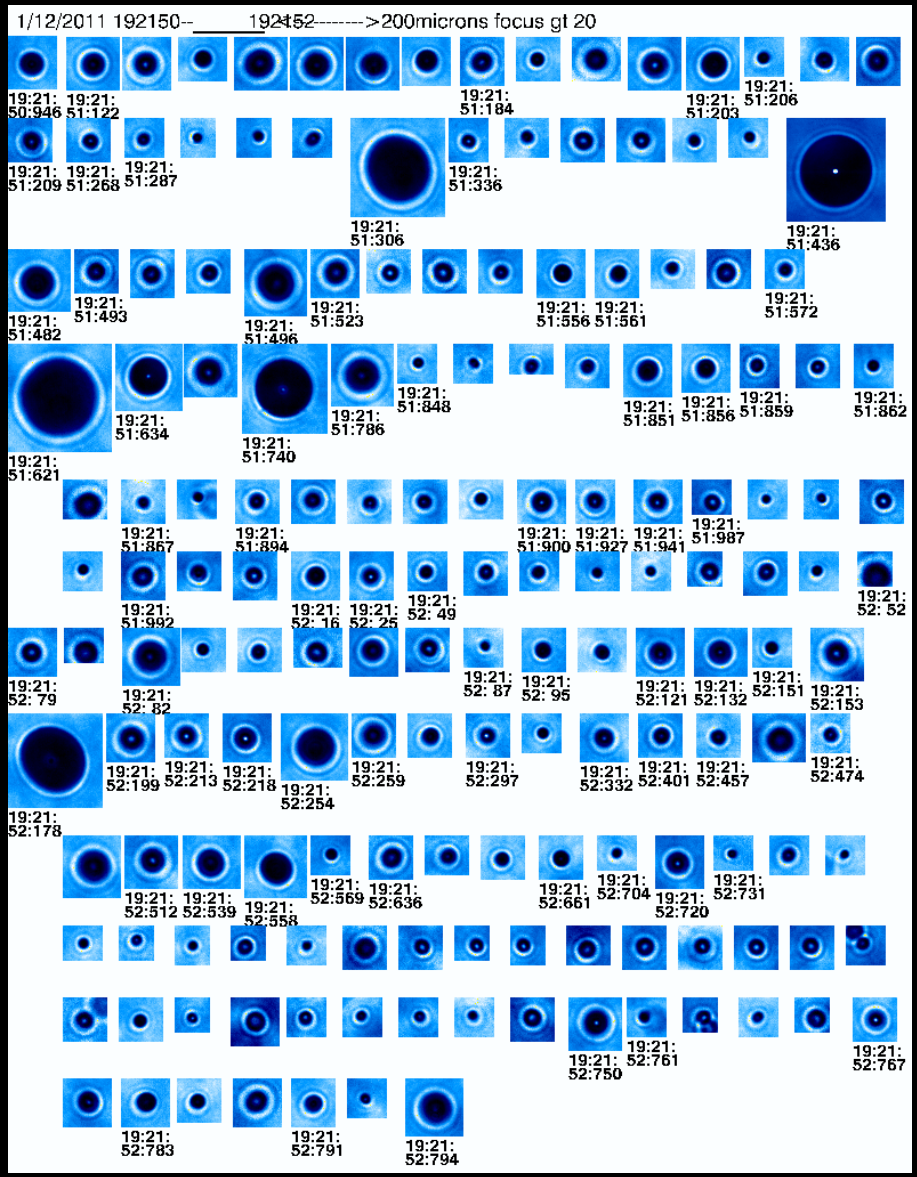
Lear Cloud Particle Probes



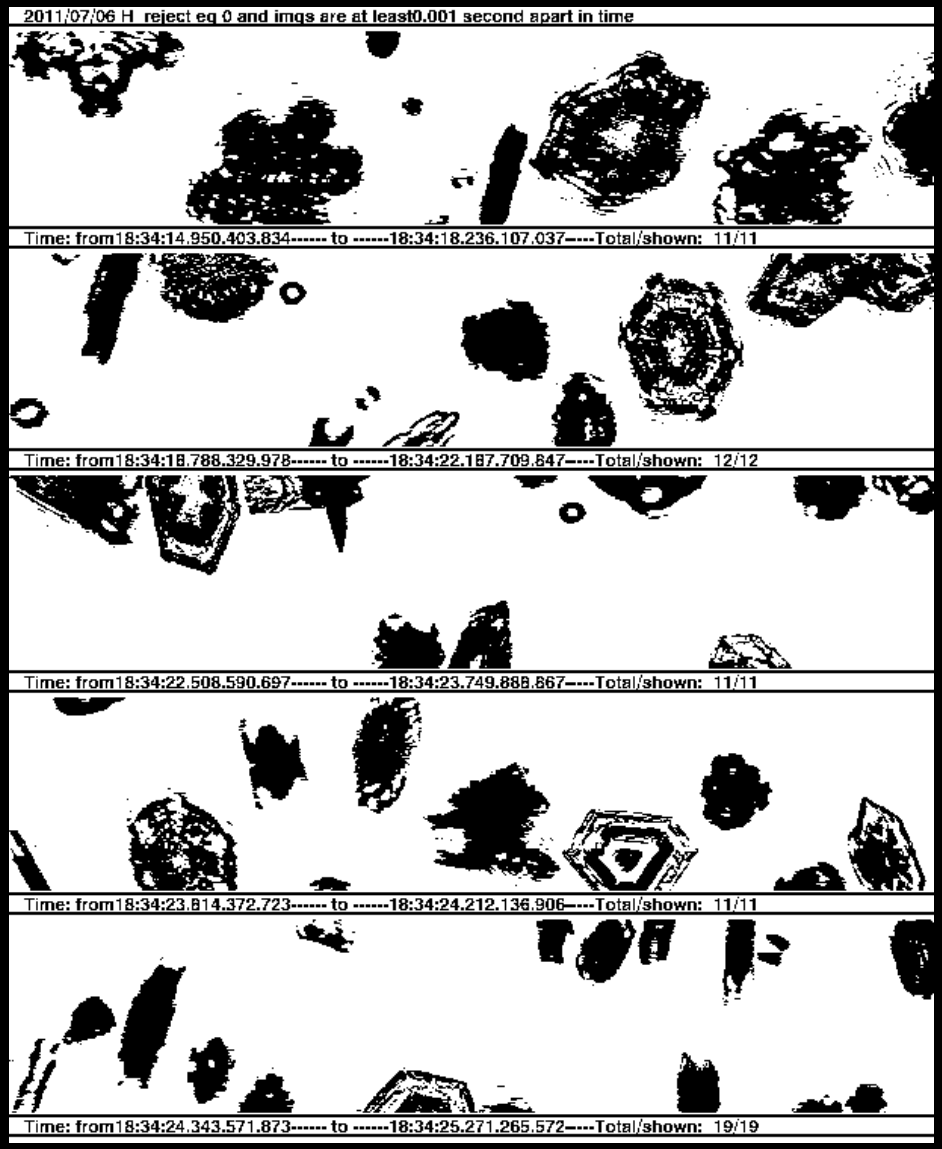


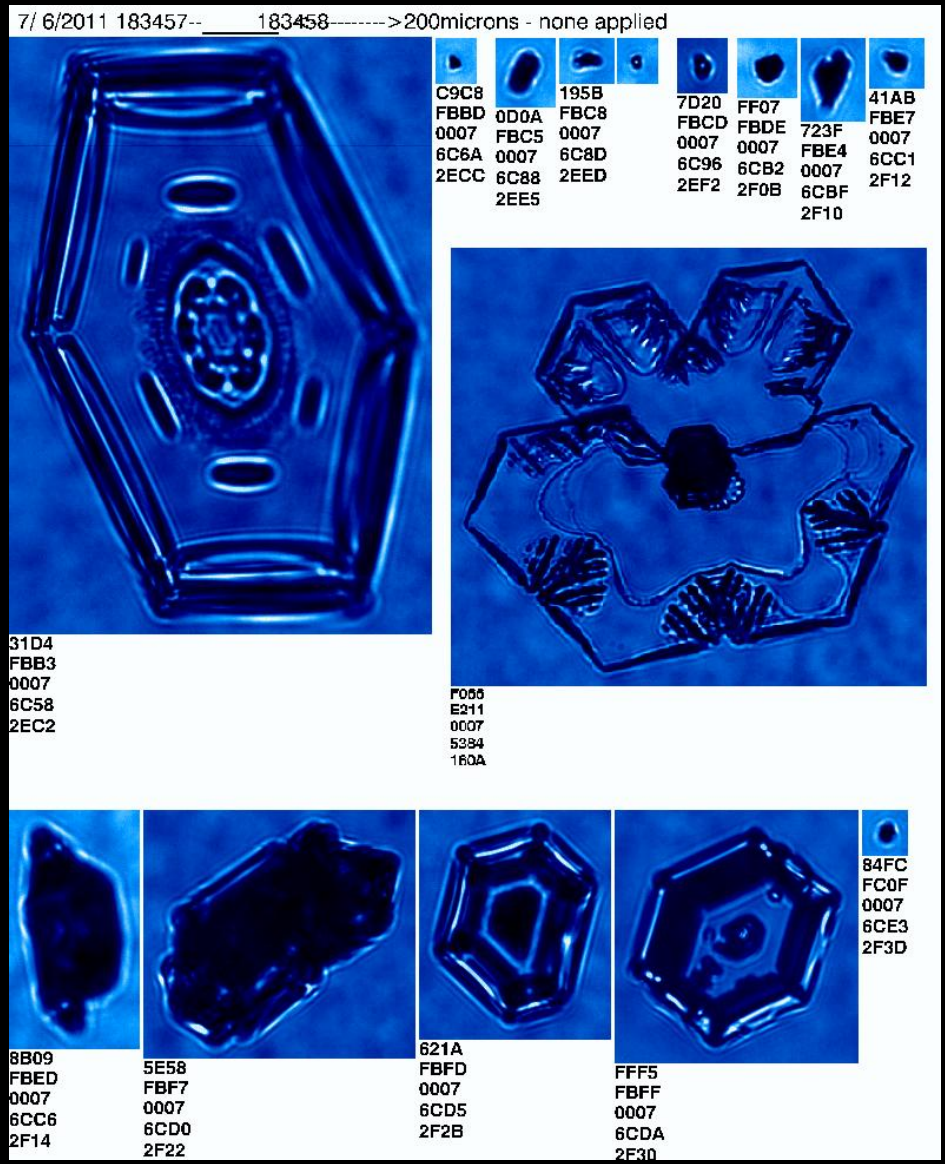
2D-S and CPI Images on 12 July in Warm Cloud at +25 C



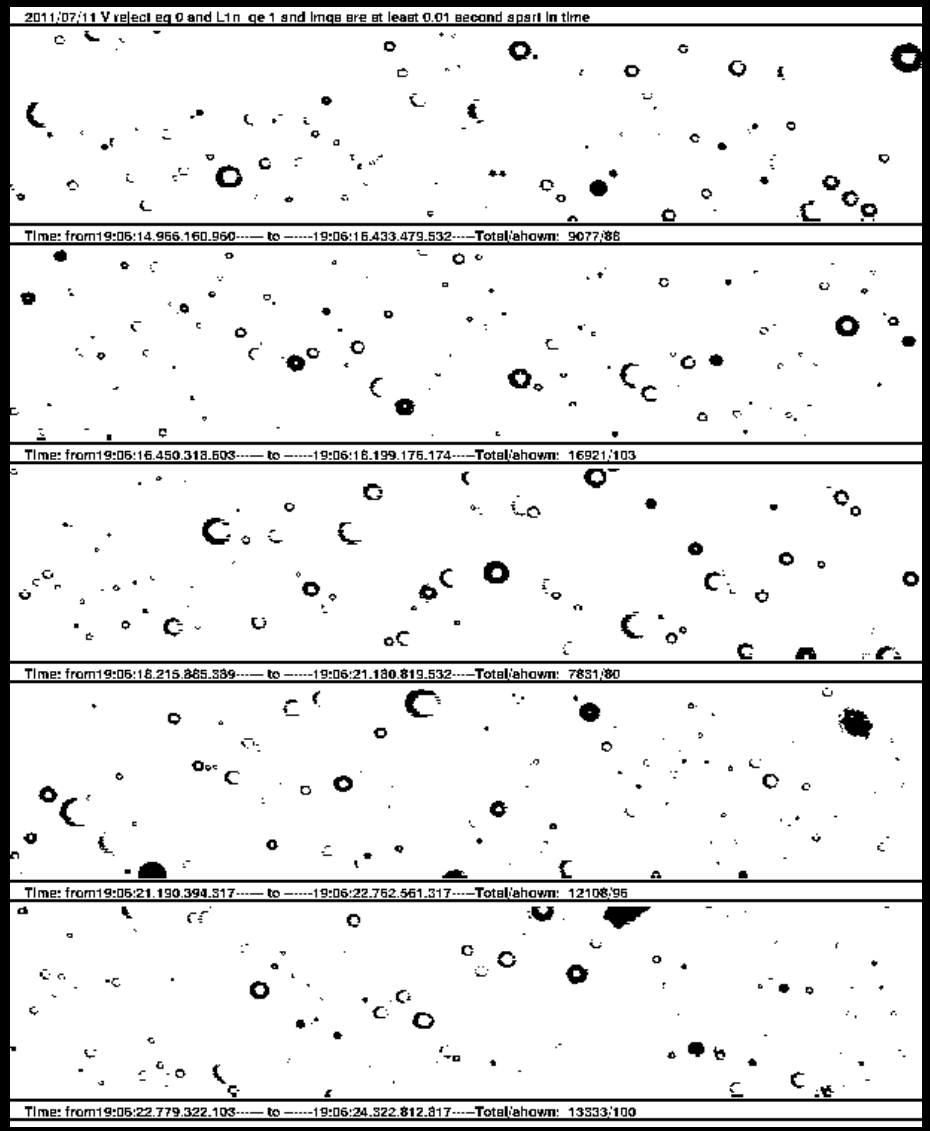


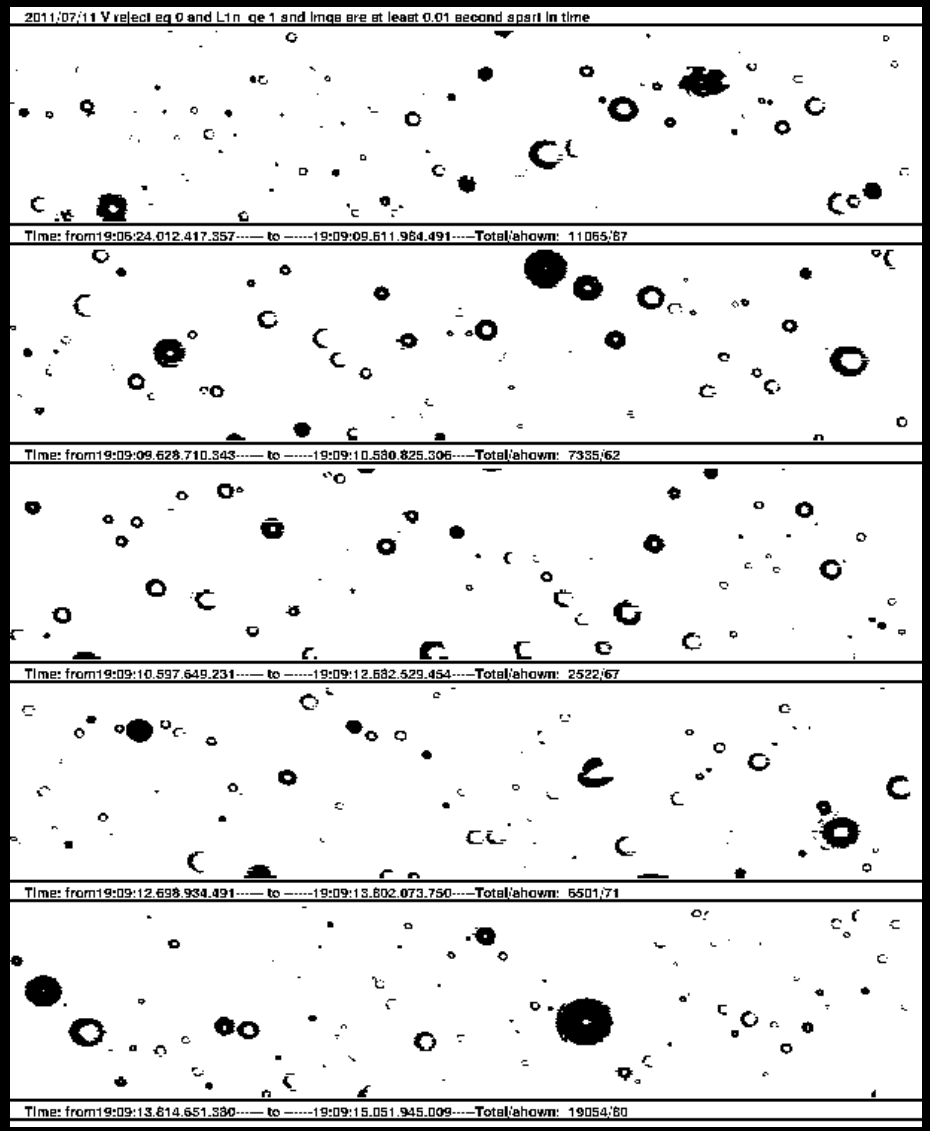
2D-S and CPI Images on 6 July in Ice Cloud at - 12 C



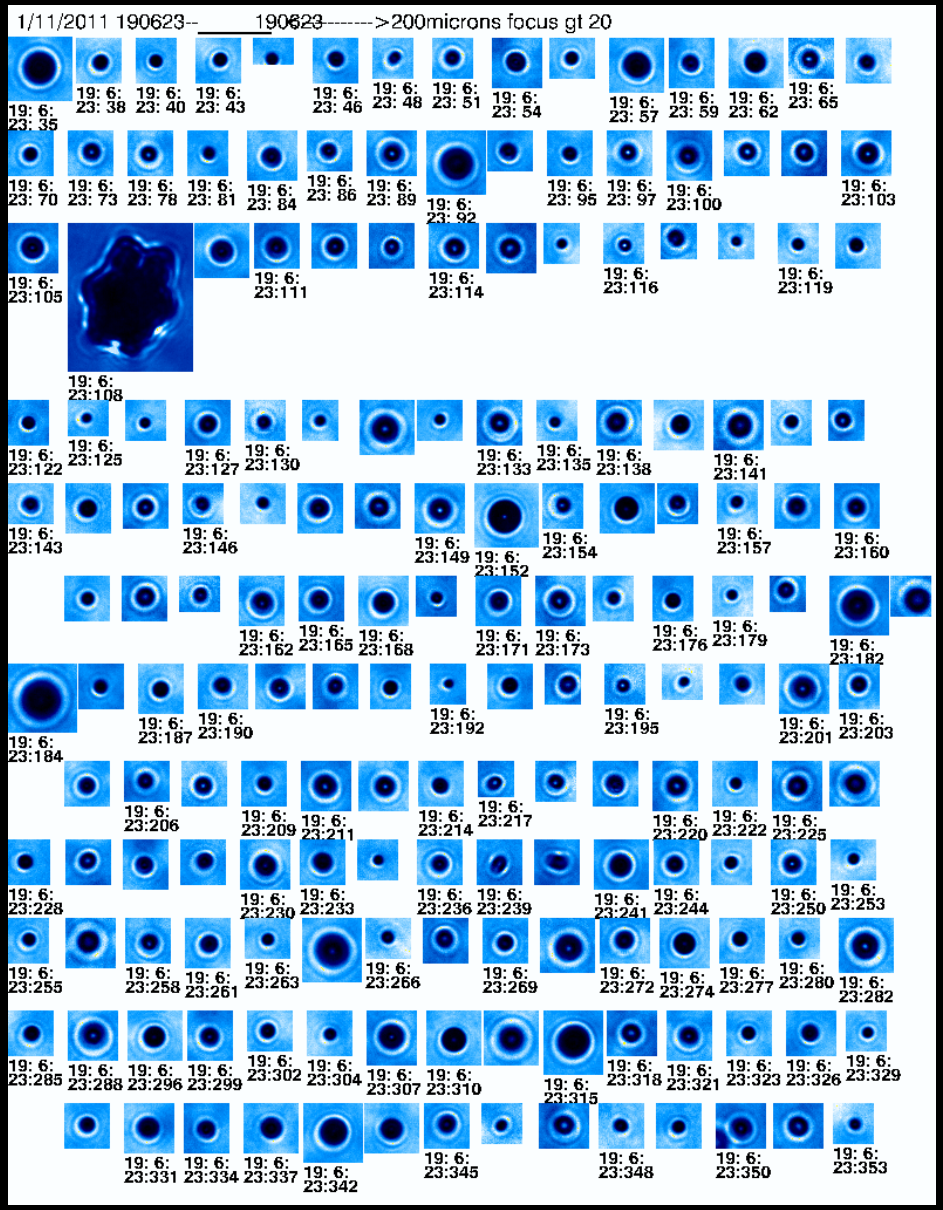


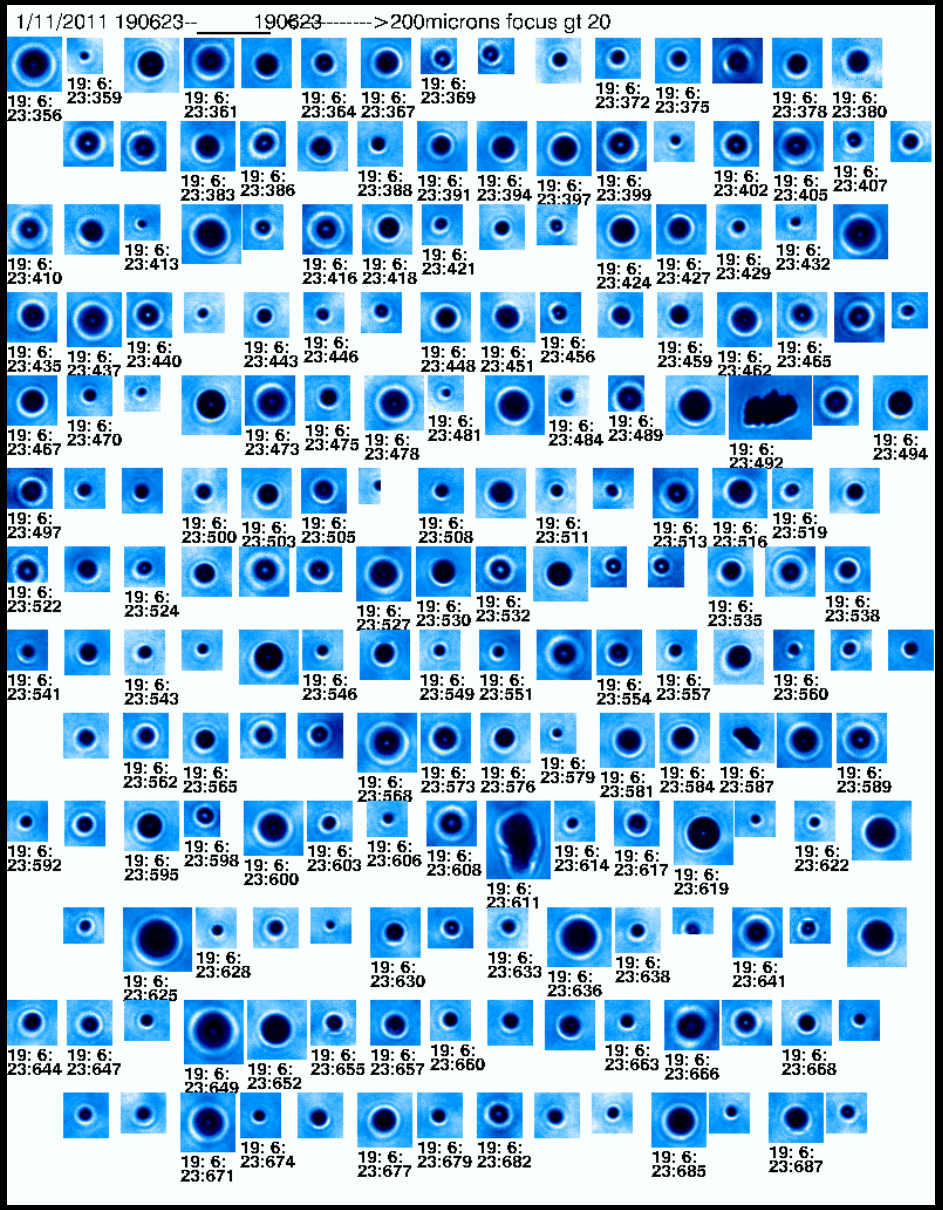
2D-S Images on 11 July at - 12 C



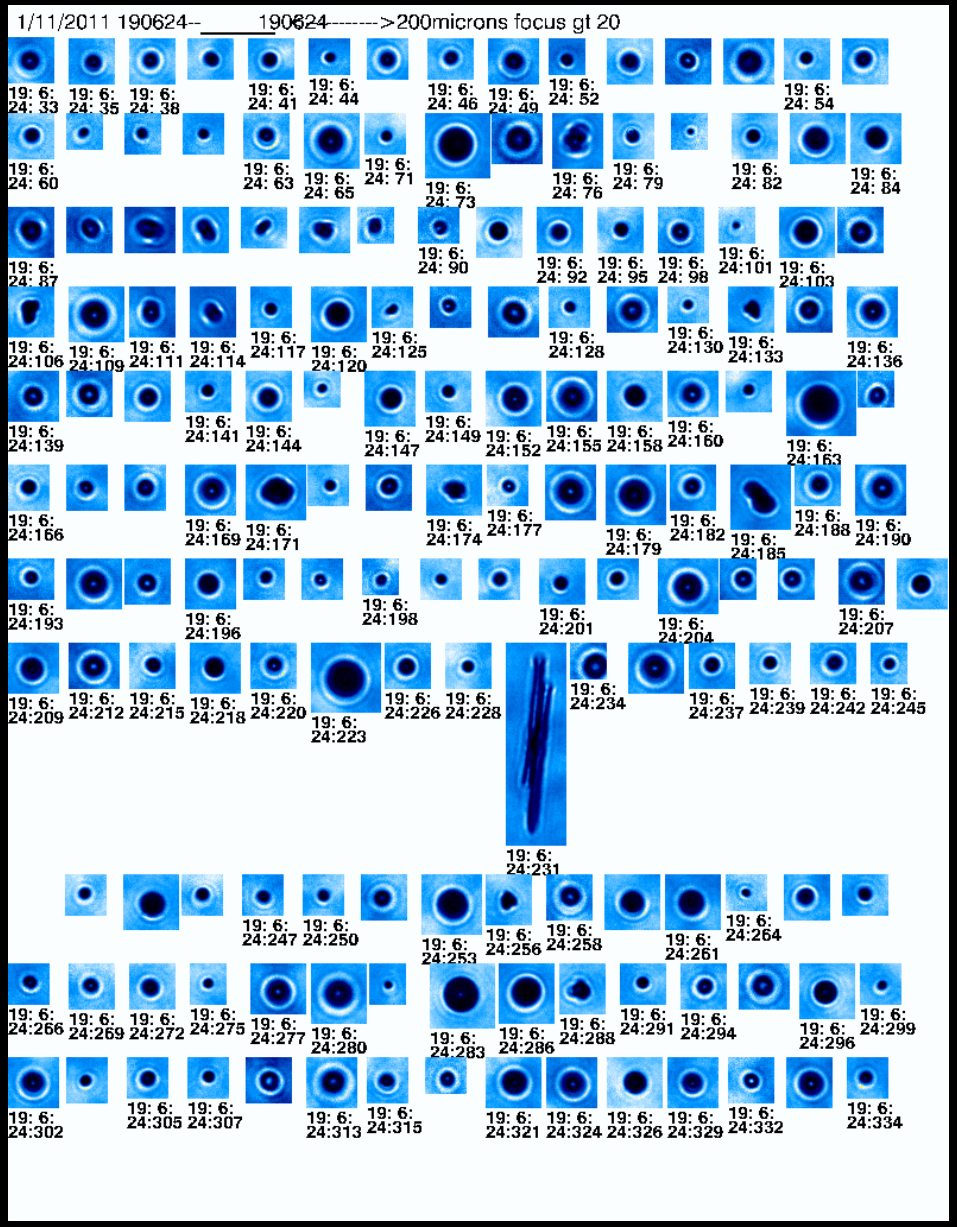


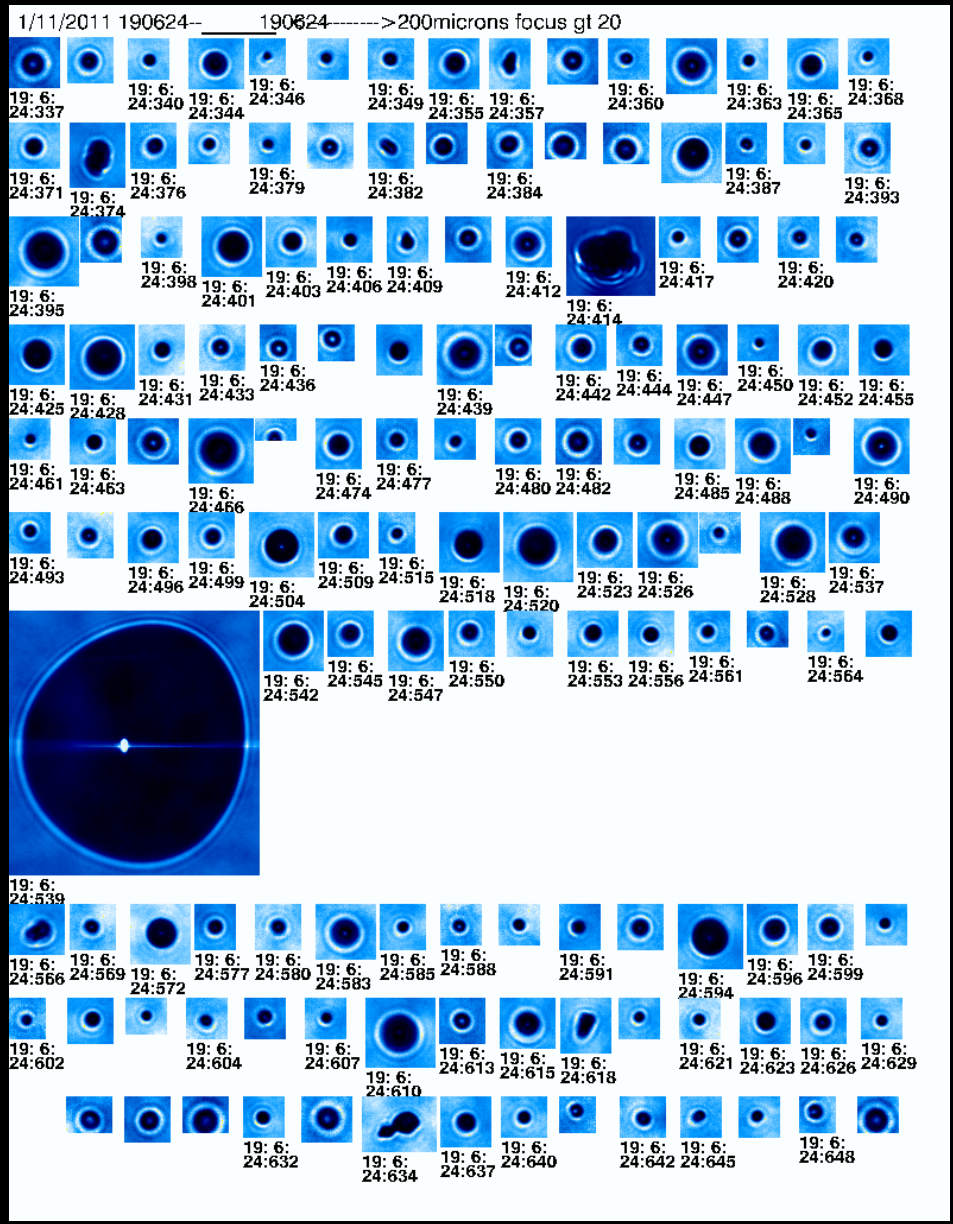
CPI Images on 11 July at - 12 C



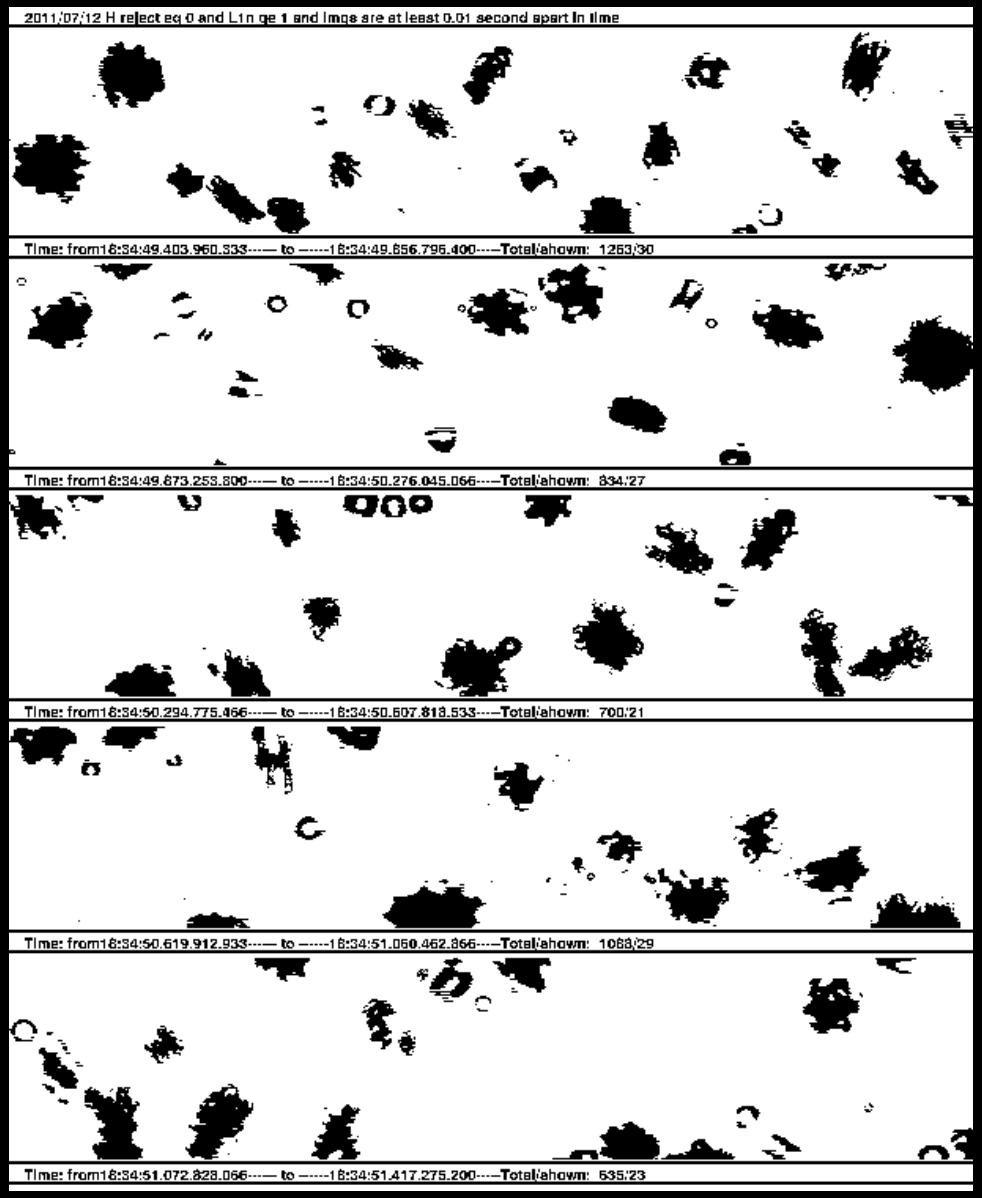


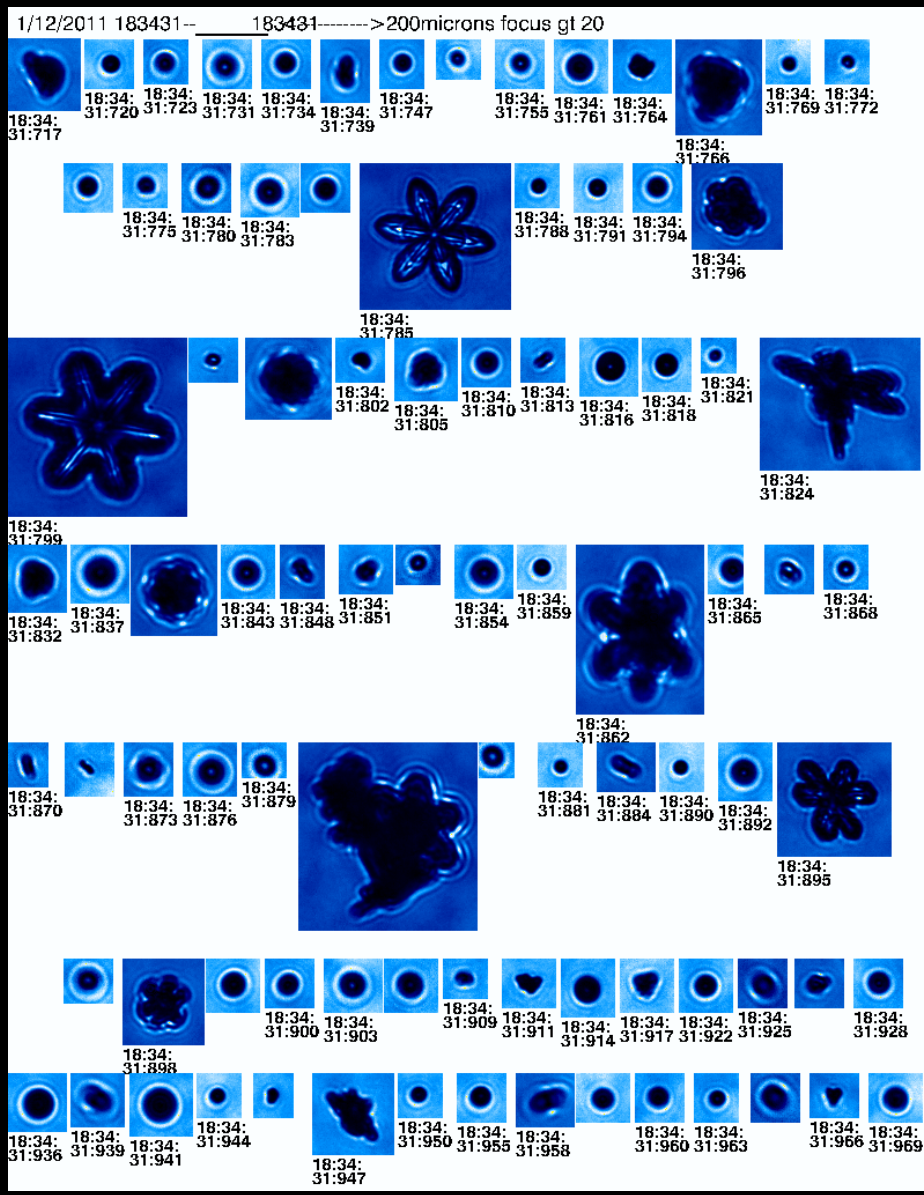
CPI Images on 11 July at - 12 C



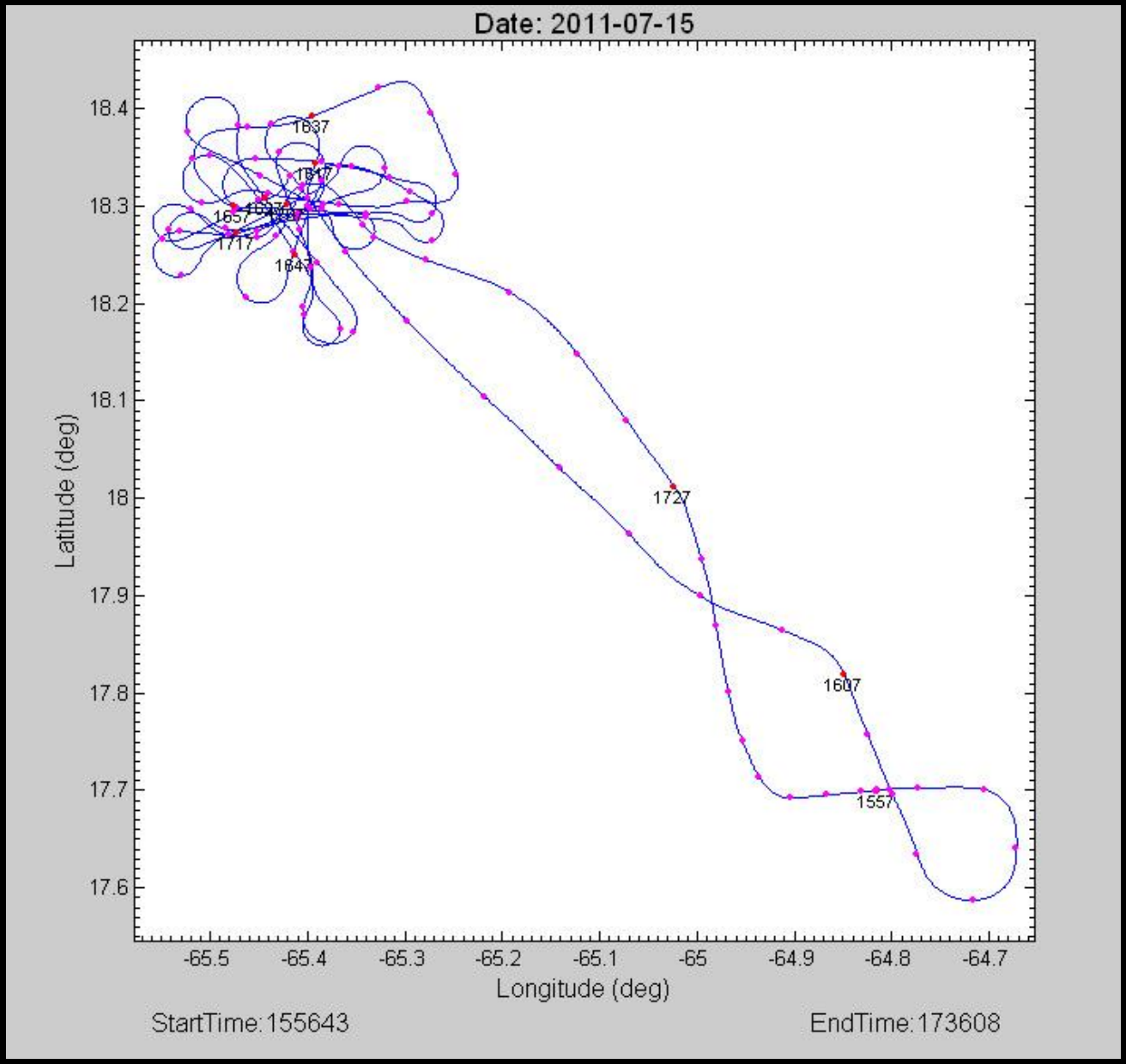


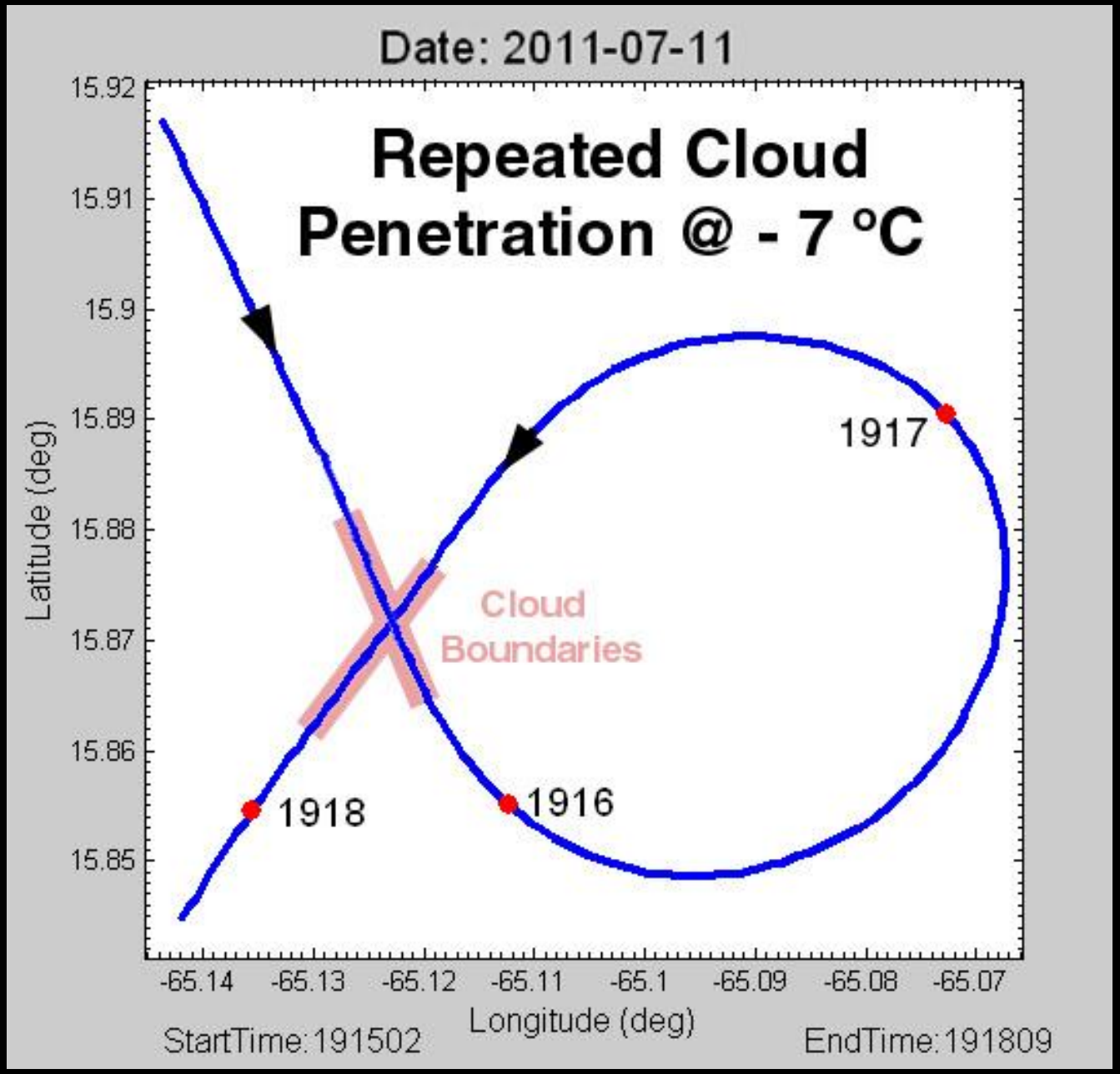
2D-S Images on 11 July at - 20 C



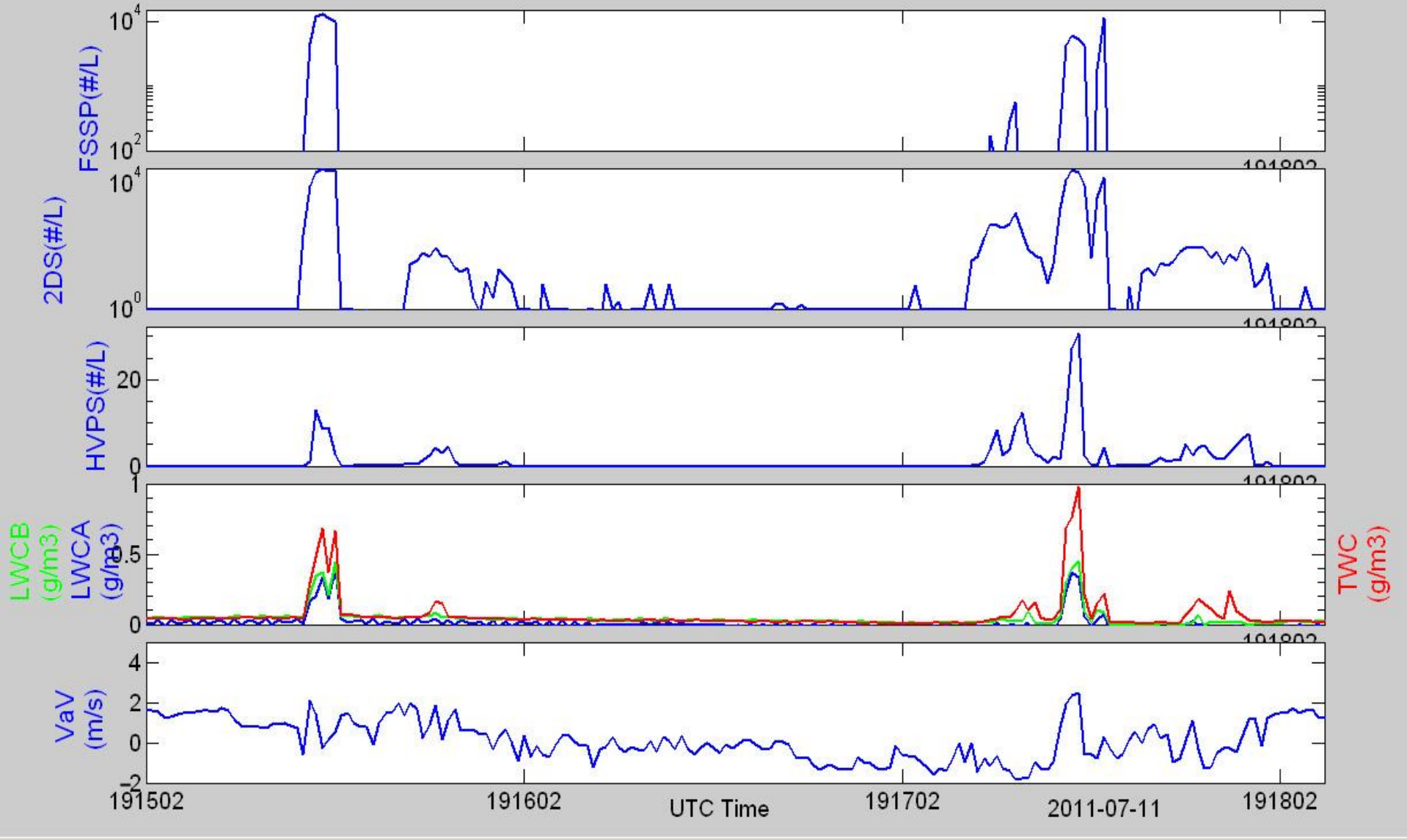


Lear Flight Track on 15 July




Date: 2011-07-11
Repeated Cloud Penetration @ - 7 °C
Latitude (deg)
15.92
15.91
15.9
15.89
15.88
15.87
15.86
15.85
1917
1916
1918
Cloud Boundaries
-65.14
-65.13
-65.12
-65.11
-65.1
-65.09
-65.08
-65.07
Longitude (deg)
StartTime:191502
EndTime:191809

Lear Flight Track on 15 July



Preliminary Observations

- Regions of all water & all ice observed at T ≅ - 12 C, as well as mixed-phase.
- Significant SLWC observed at T = - 20 C, may extend to colder temperatures but not yet investigated.
- Clouds are composed of bubbles. Repeated penetration at - 7 C within 2 min in the same "cloud region" show that regions with all water changed to mixed-phase with large drops, graupel and 300 micron columns that could not have grown to those sizes via H-M.
- Because cloud bubbles are short-lived and intimately connected within cloud systems, it is unlikely that any Lagrangian study of the development of "first ice", primary nucleation and secondary ice processes will be tractable.
- Quantitative estimates of water and ice in mixed-phase require high-resolution (CPI) images, or perhaps SID data.

Suggestions

- Radar could help fill in the gaps inherent from in situ sampling using particle probes. Coincident radar and in situ observations will help to validate radar – anticipate that this will be challenging to coordinate.
- Learjet should make rapid repeated penetrations and investigate regions T < - 20 C in vigorous turrets.
- Forward video from both aircraft should be used extensively in post analysis to document evolution of bubbles, with attempts made to estimate origin and age of bubbles based on video (perhaps radar) and in situ measurements (i.e., LWC, drop concentration, updraft velocity, degree of mixing and homogeneity). Analysis should focus on a case study approach, with synthesis of case studies to be used for comparison with models.