Two Dimensional Cloud Probe Measurements

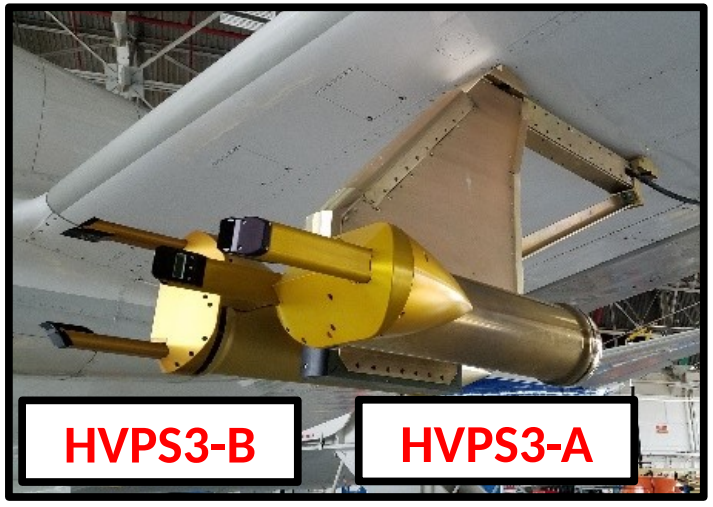
http://vevo.app/

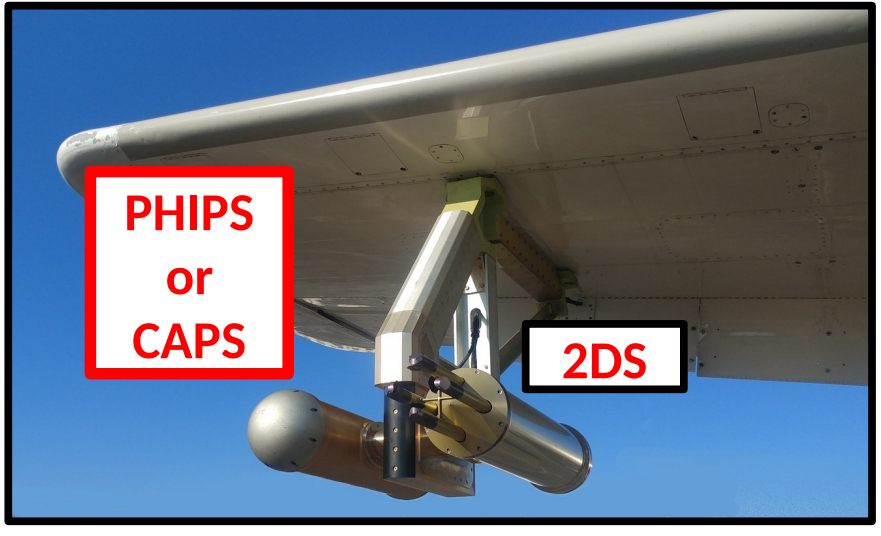
Vevox: 492-809-749

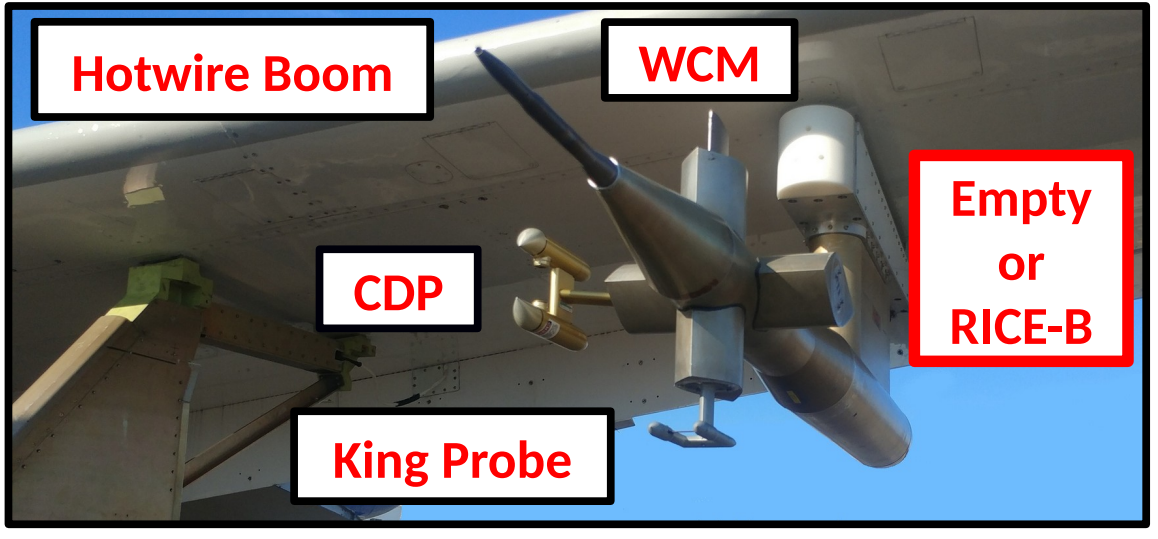
Learning Objectives

- Learners will be able to identify the differences between 2D Probe types, included measurement size ranges.
- Learners will be able to describe the the optical configuration used in 2D Probes.
- Learners will correctly interpret when to use the three particle sizing methods used to process 2D Probe data.
- Learners will correctly interpret the 2D Probe images.
- Learners will be able to conduct quality control and quality assurance of 2D Probe data sets.

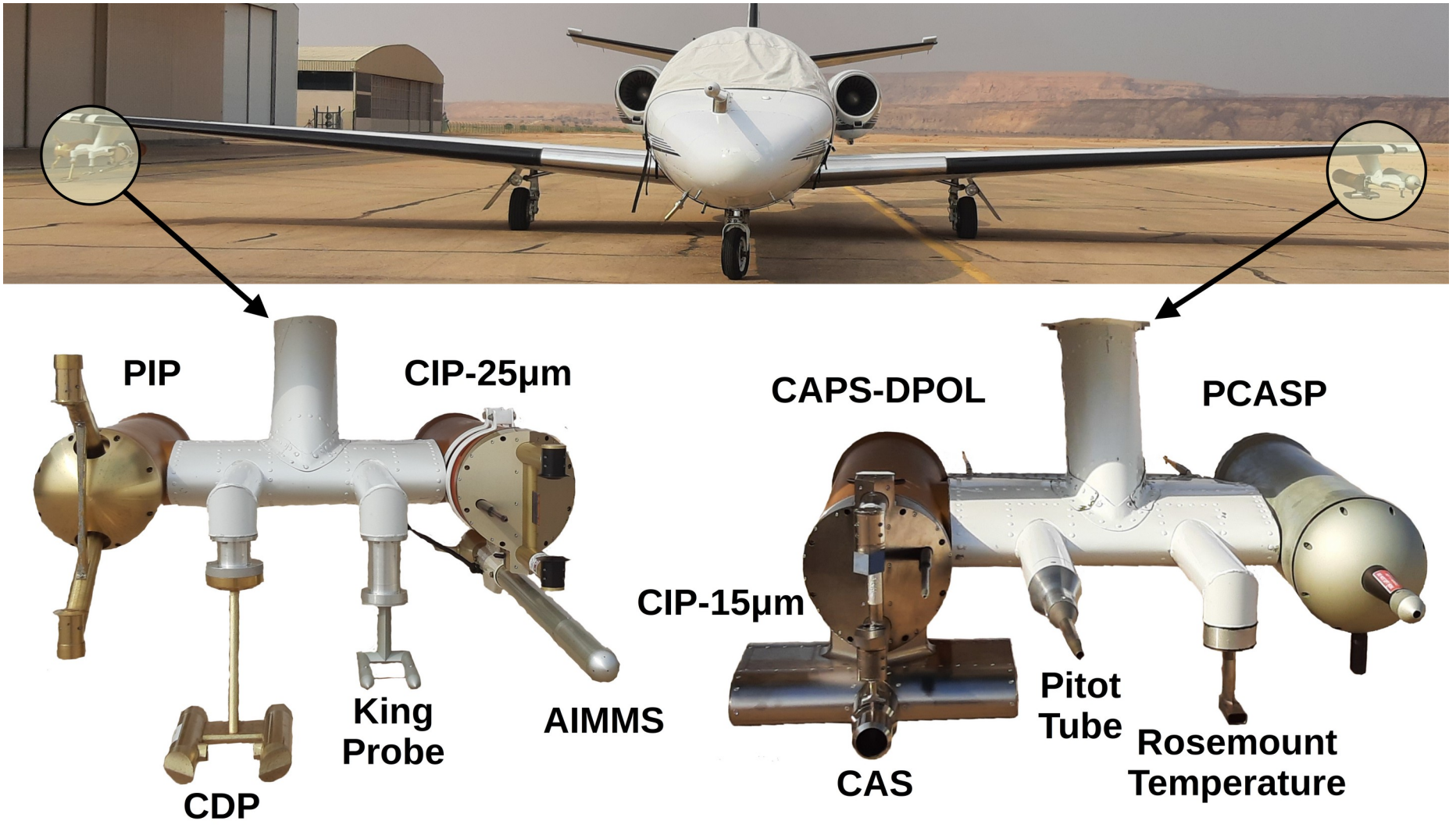
NASA IMPACTS 2022 Cloud Probes



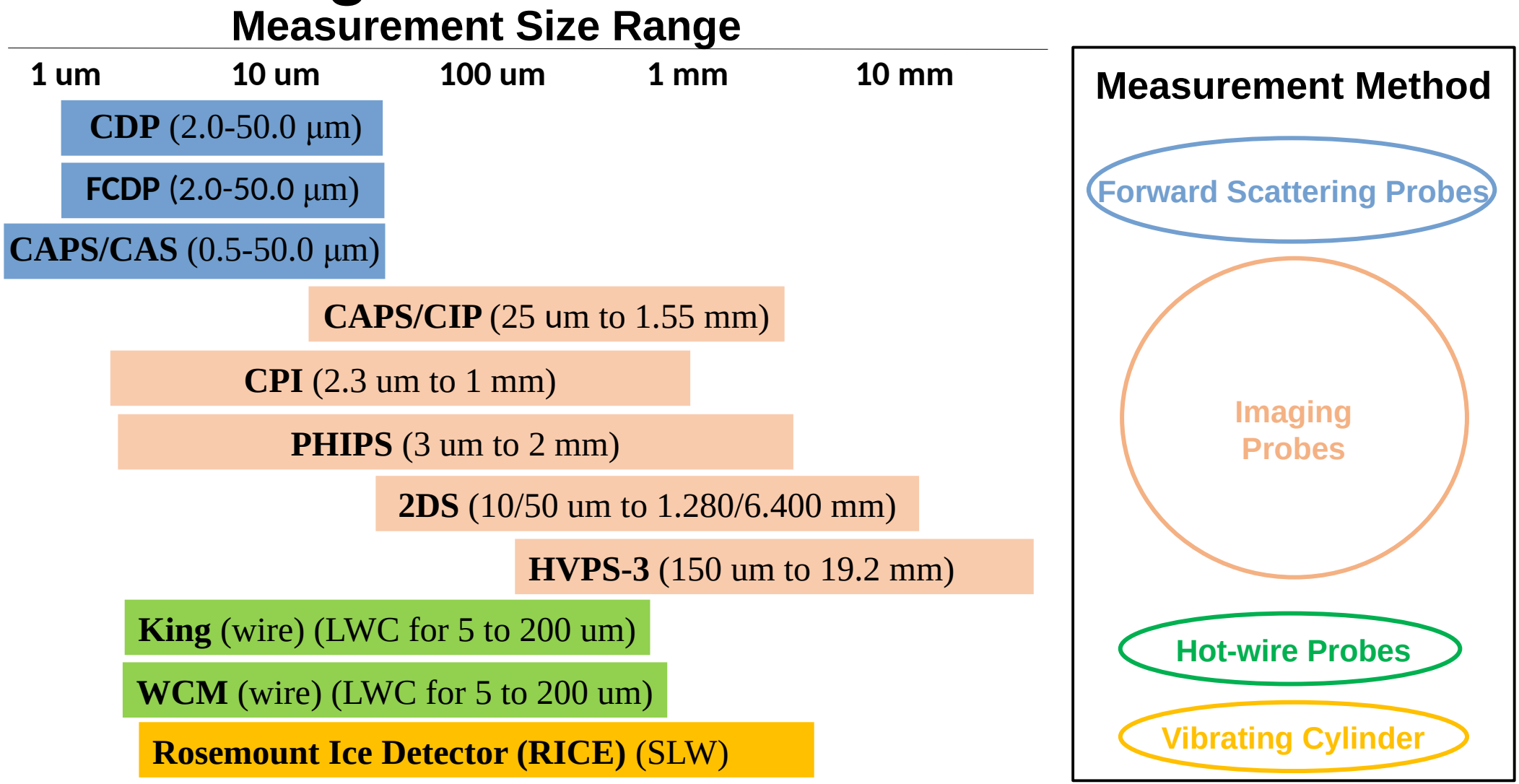




SARPEC Cloud Probes



Size Range Classification: IMPACTS Probes



Polling Question

What is the size range of the 2D-S based on the smallest available diode size to the size of all diodes?

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Two Dimensional Cloud (2D-C) Probe Optics

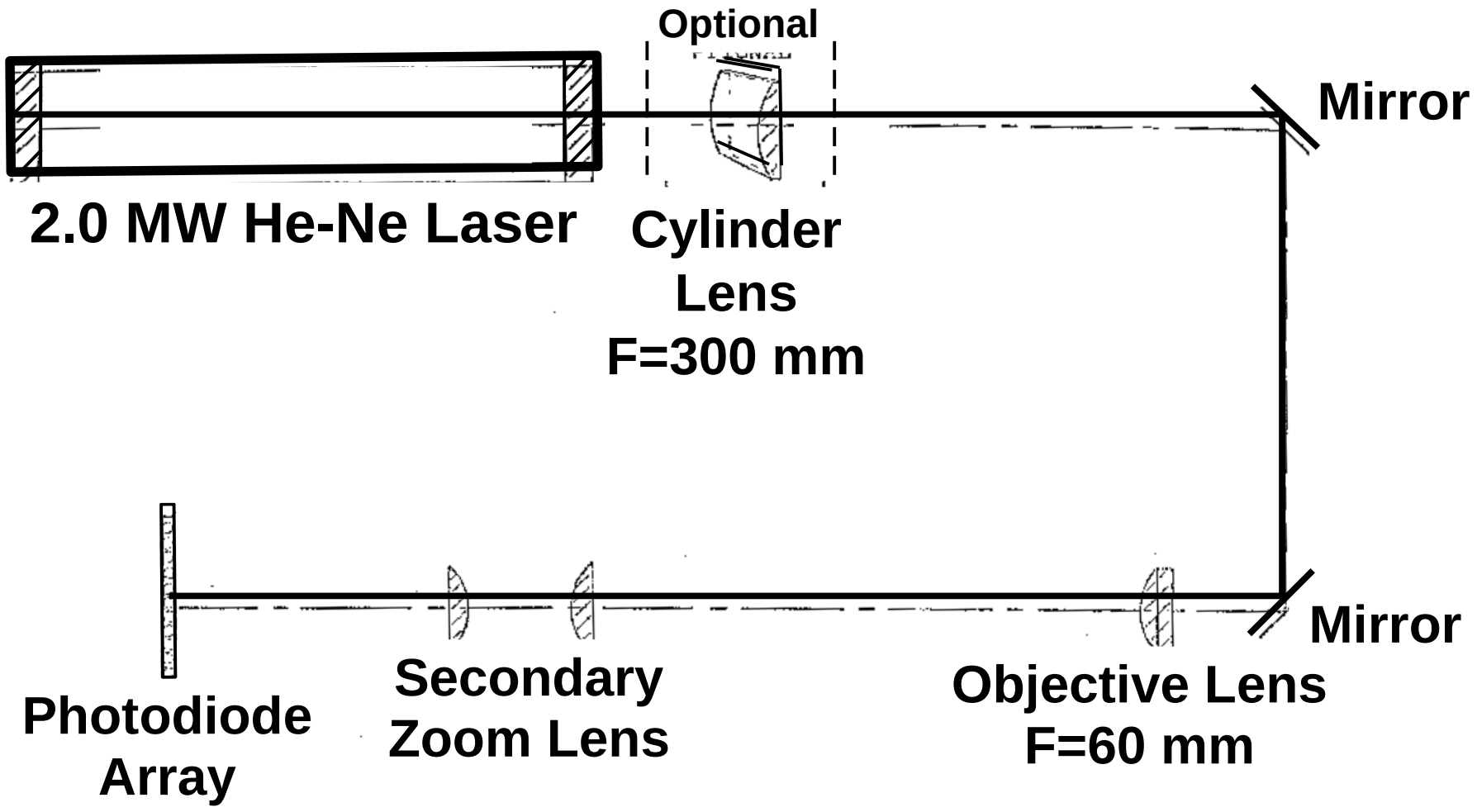


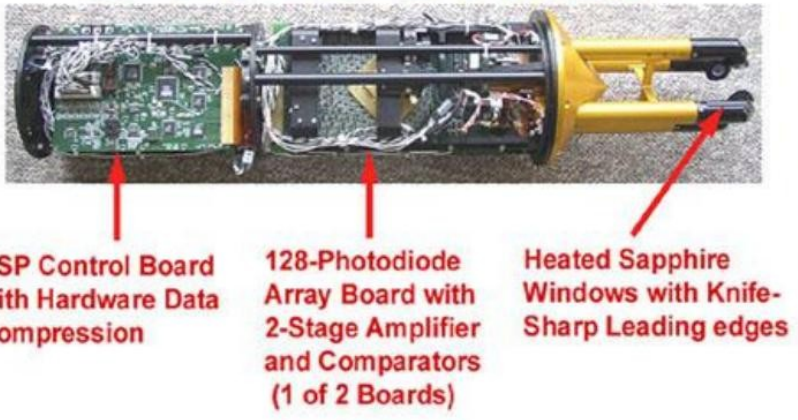
Image Array Elements

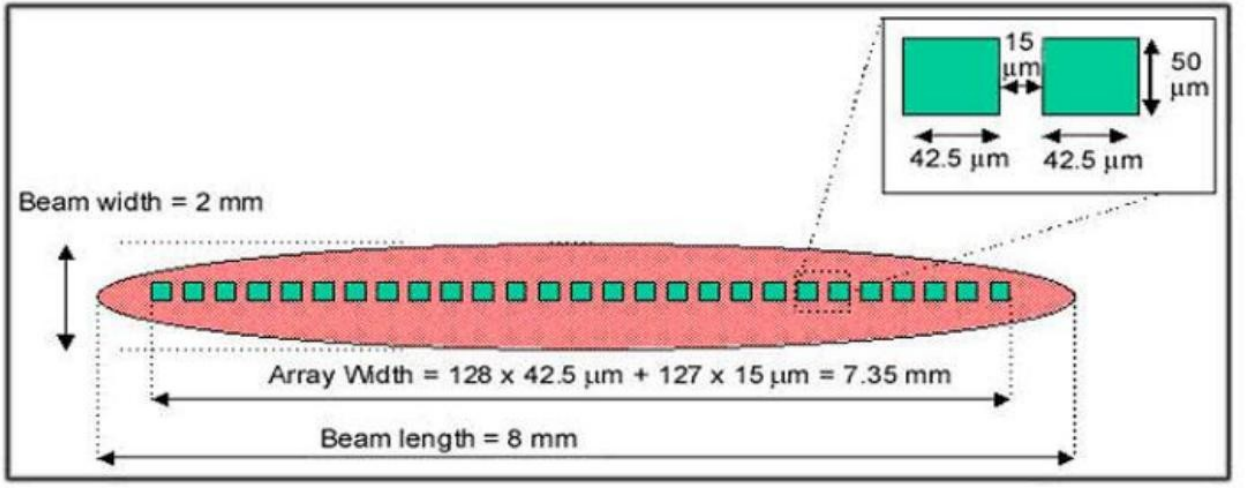
- **The zeros (0) Denote Extinction of a photodiode by 50 %.**
- **The ones (1) Represent less than 50 % extinction.**
- **At 100 m s^{-1} and 25 um resolution along flight path, there are 4 million image slices per second.**

Elements	Time Data Slice All '0' Data	Time Data Slice All '1' Data
32	00111111111111111111111100	
31	10111111111111111111111110	
30	00111111111111111111111100	
29	10111111111111111111111110	
28	00111111111111111111111100	
27	10111111111111111111111110	
26	00111111111110111111111100	
25	00111111111100011111111110	
24	00111111111000001111111100	
23	00111111110000000111111100	
22	00111111100000000011111100	
21	00111111000000000001111100	
20	00111110000000000000111100	
19	00111100000000000000011100	
18	00111000000000000000011100	
17	00110000000000000000001100	
16	00100000000000000000000100	
15	00000000000000000000000100	
14	00000000000000000000000100	
13	10100000000000000000001100	
12	10110000000000000000011110	
11	00111000000000000000111110	
10	00111100000000000001111100	
09	10111110000000000011111110	
08	00111111000000000111111100	
07	00111111100000001111111100	
06	00111111110000011111111110	
05	10111111111000111111111110	
04	00111111111101111111111100	
03	10111111111111111111111110	
02	00111111111111111111111100	
01	10111111111111111111111100	

Two Dimensional Stereo (2D-S) Probe Optics

- Two identical optical channels.
- A single-mode, temperature-stabilized, fiber-coupled 45 mW diode laser produces 1.3 x 61 mm light sheet.
- Magnification to ~ 10 micron pixels in the sample area.
- Image slides are compressed and blocked into frames.





Polling Question

What is the light producing system in the Two Dimensional Stereo (2D-S) Probe?

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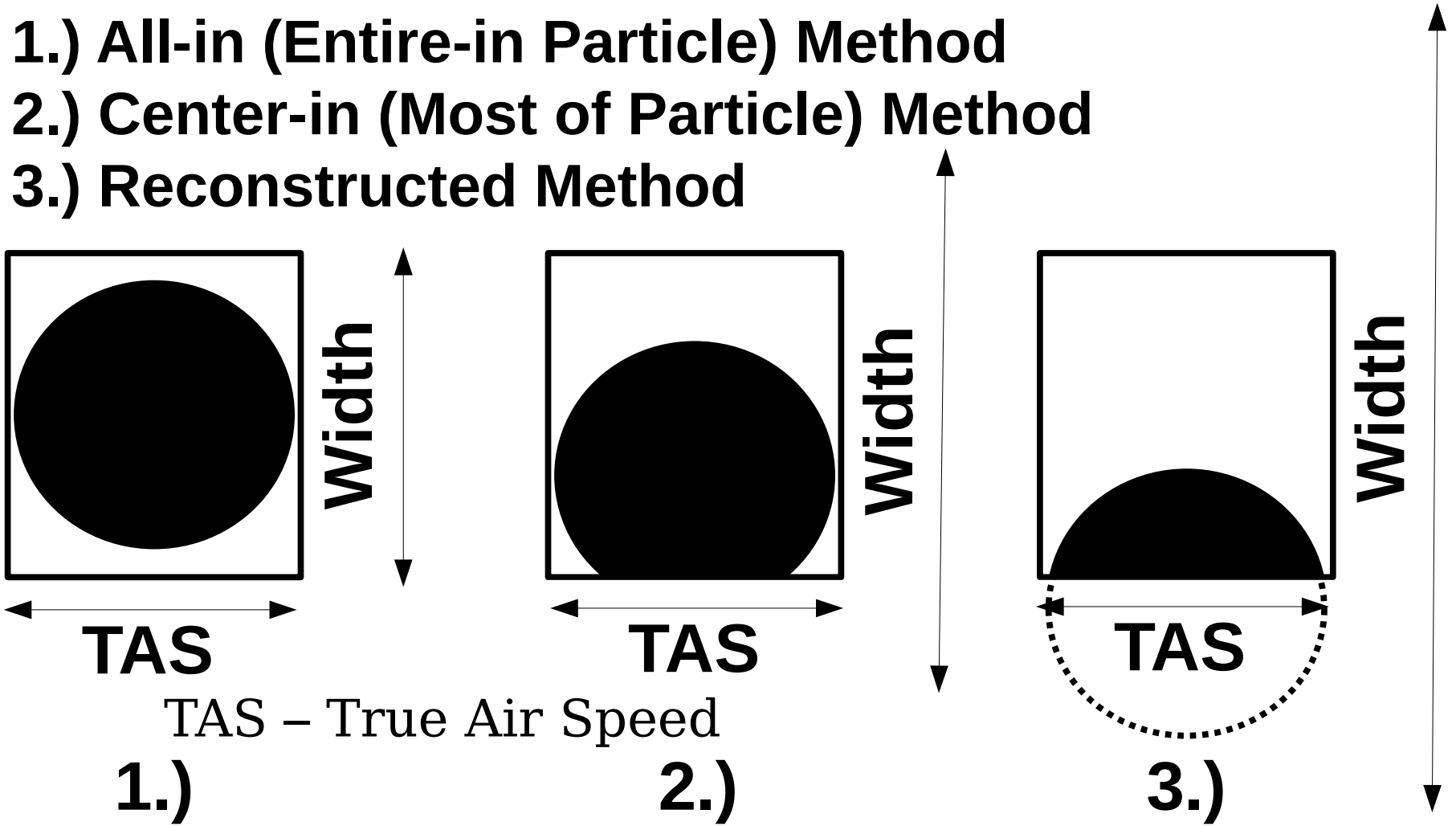
Effective Width of the Array

1.) All-in (Entire-in Particle) Method

2.) Center-in (Most of Particle) Method

3.) Reconstructed Method

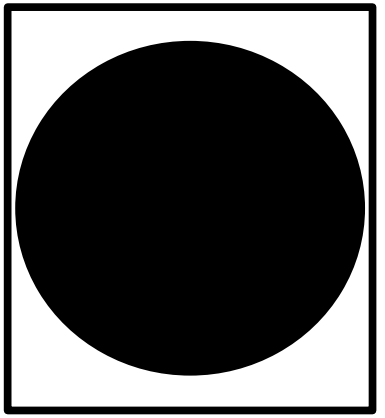


TAS – True Air Speed

All-in (Entire-in) Processing

$$w'(cm) = [RS * (N-1) - (D)] * 10^{-4}$$

$$w'(cm) = [RS * (N-1) - (I * RS)] * 10^{-4}$$



w’ – Effective Width of the Array

D – Diameter of Sphere (um)

N – Number of Array Elements

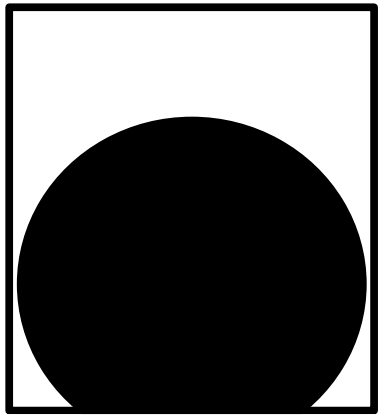
RS – Probe Resolution (um)

I – Number of Diodes Shadowed

$$w'(cm) = RS[31 - I] * 10^{-4}$$

N – 32 for 2-DC

Center-in Processing



$$w'(cm) = [RS * N] * 10^{-4}$$

w – Effective Width of the Array

N – Number of Array Elements

RS – Probe Resolution

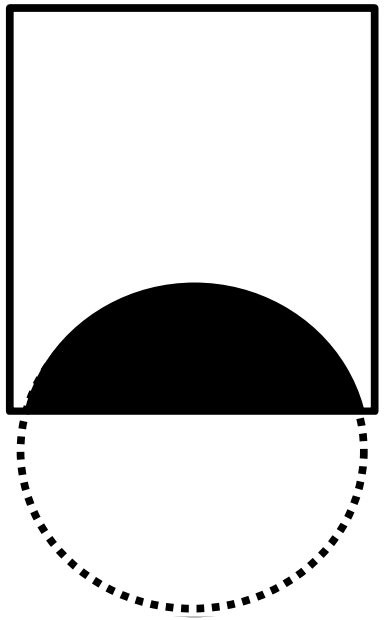
$$w'(cm) = RS * 32 * 10^{-4}$$

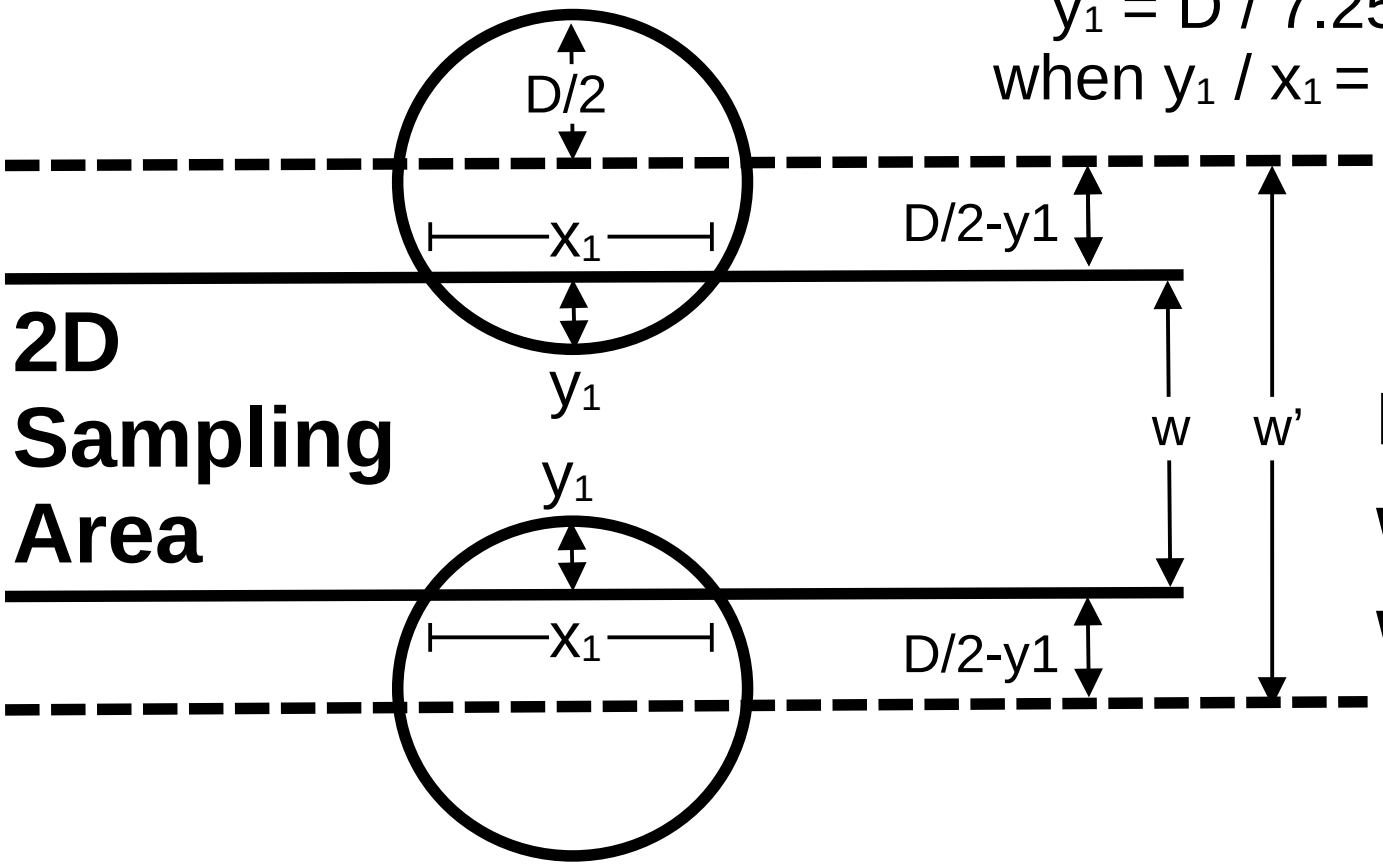
N – 32 for 2-DC

Reconstructed

$$w'(cm) = w + 2 * [(D/2 - y_1)] * 10^{-4}$$

$y_1 = D / 7.25$
when $y_1 / x_1 = 0.2$





2D Sampling Area

D-Diameter

w–Width

w'–Effective Width

Processing Method Sample Volume (SV) Comparison

$$SA = DOF * w'$$

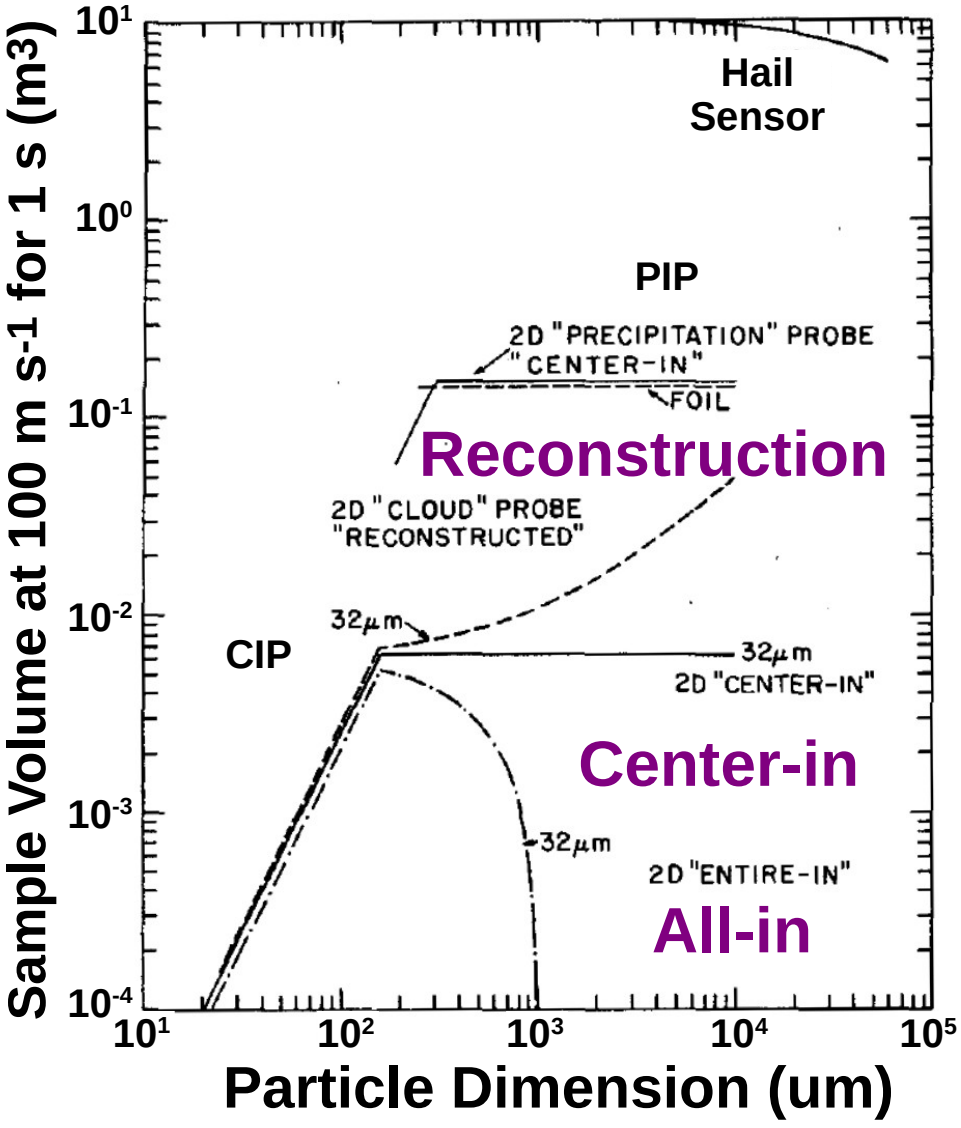
$$SV = SA * TAS * t$$

SA-Sample Area

DOF–Depth of Field

TAS – True Air Speed

T - Time



Polling Question

What two-dimensional data processing method produces a constant sample area for larger-sized particles?

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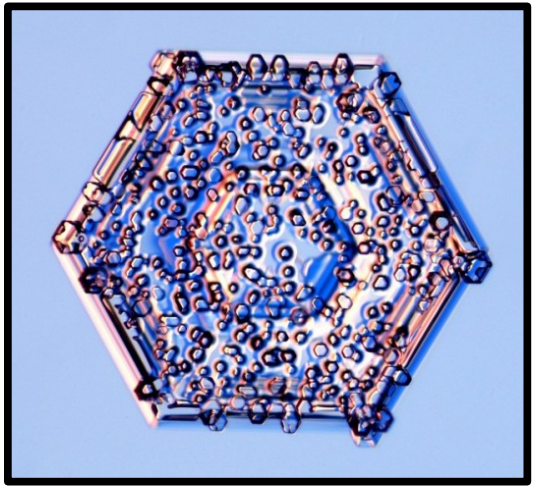
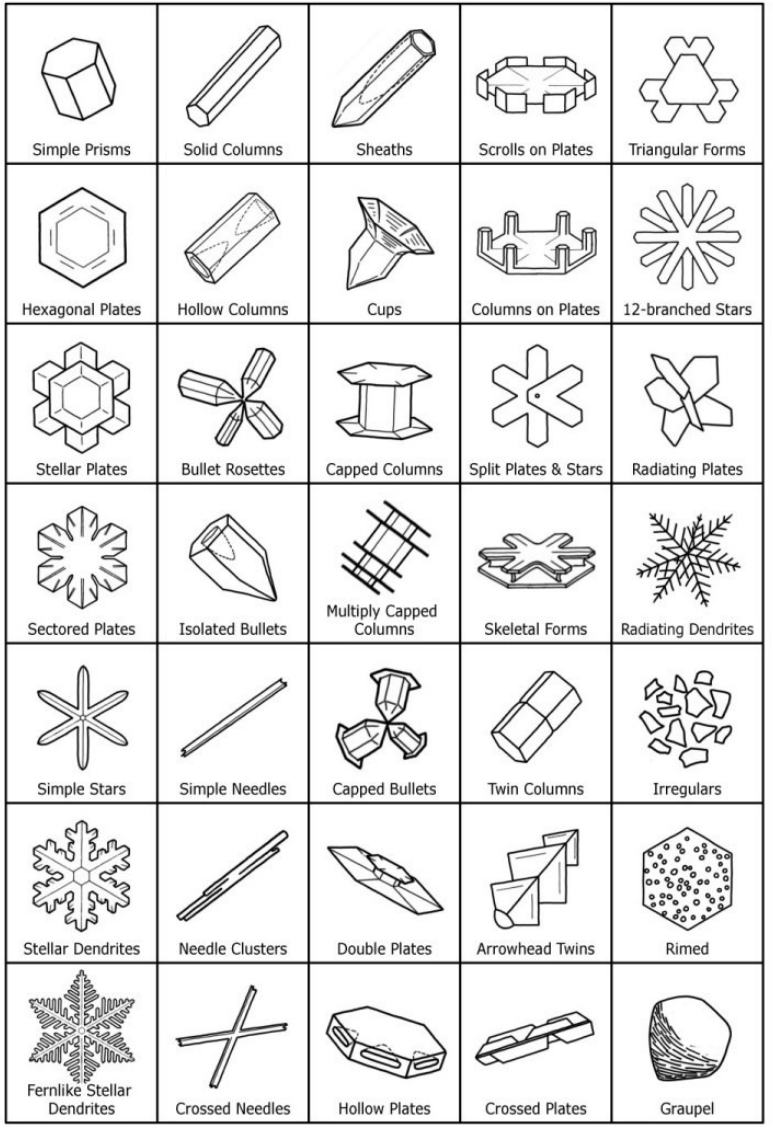
Crystal Shapes

http://www.its.caltech.edu/~atomic/snowcrystals/class/class.htm

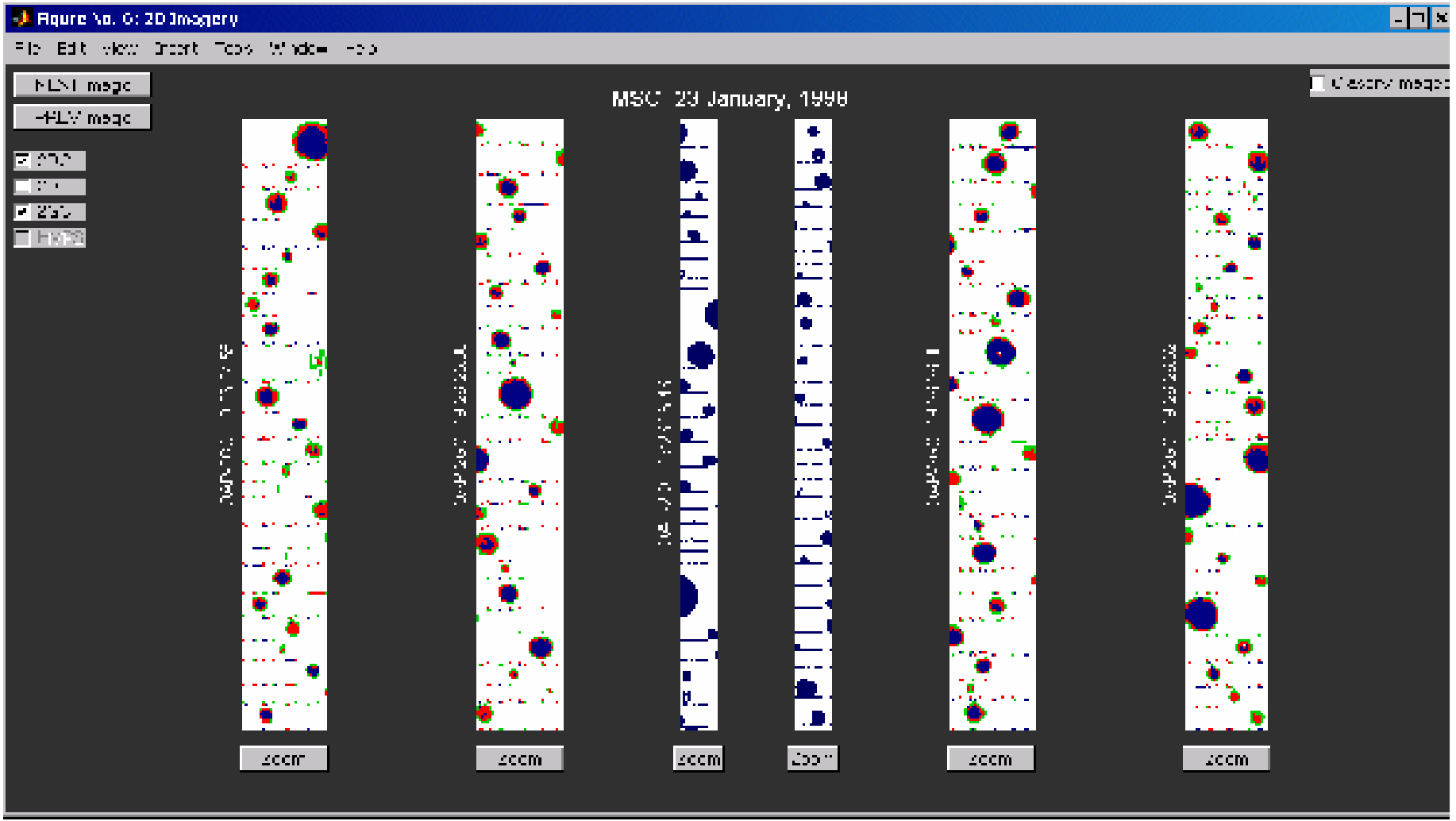
- **Spheres**
- **Needles**
- **Dendrites**
- **Irregulars**



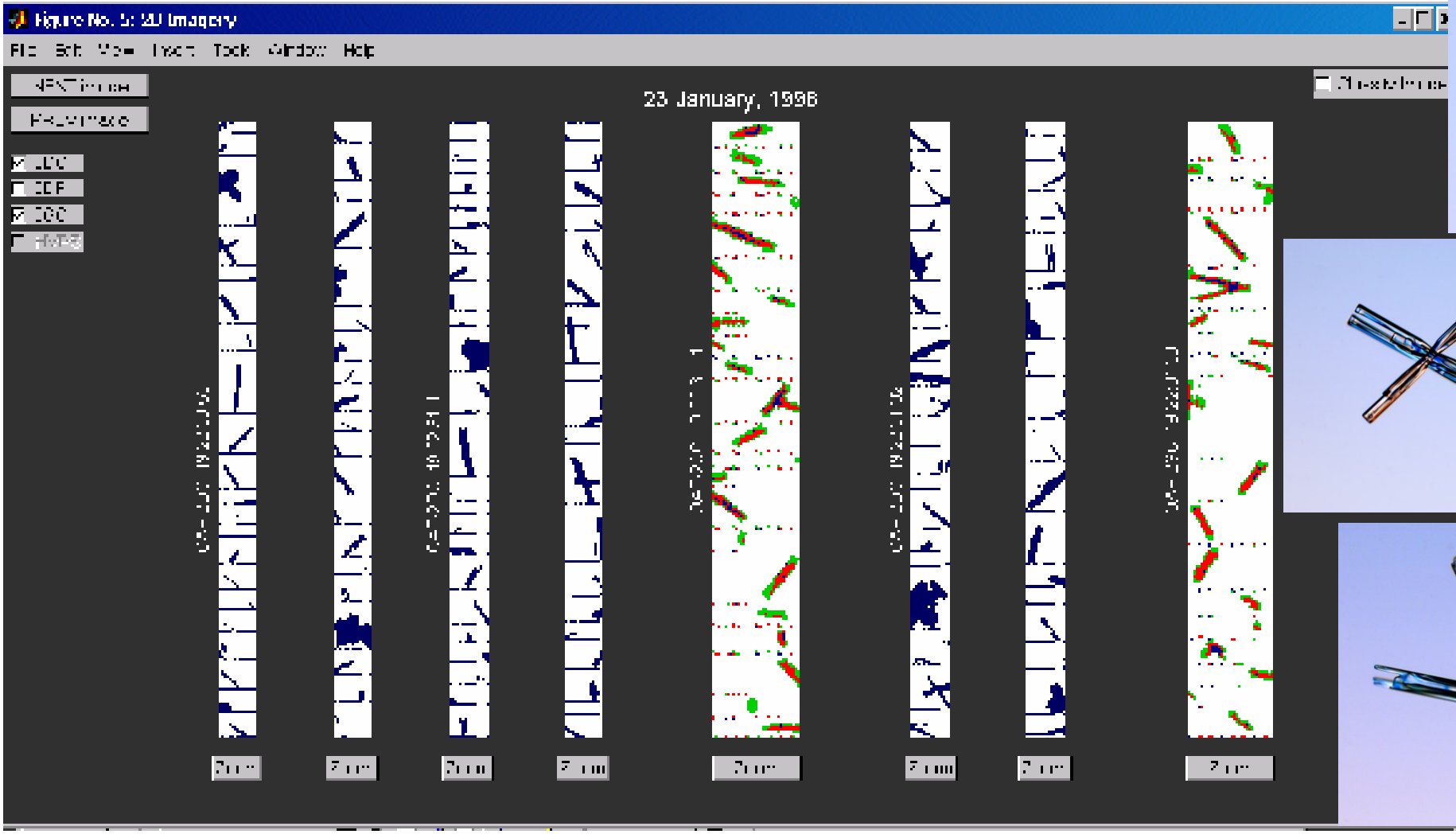
Rimed

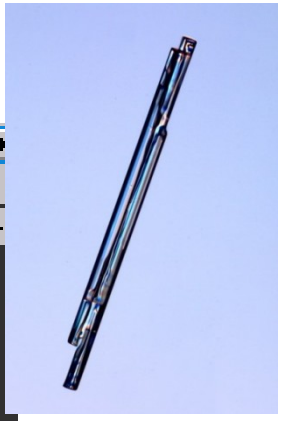


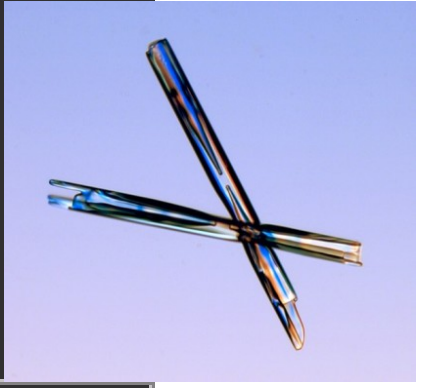
2-DC Probe: Spheres



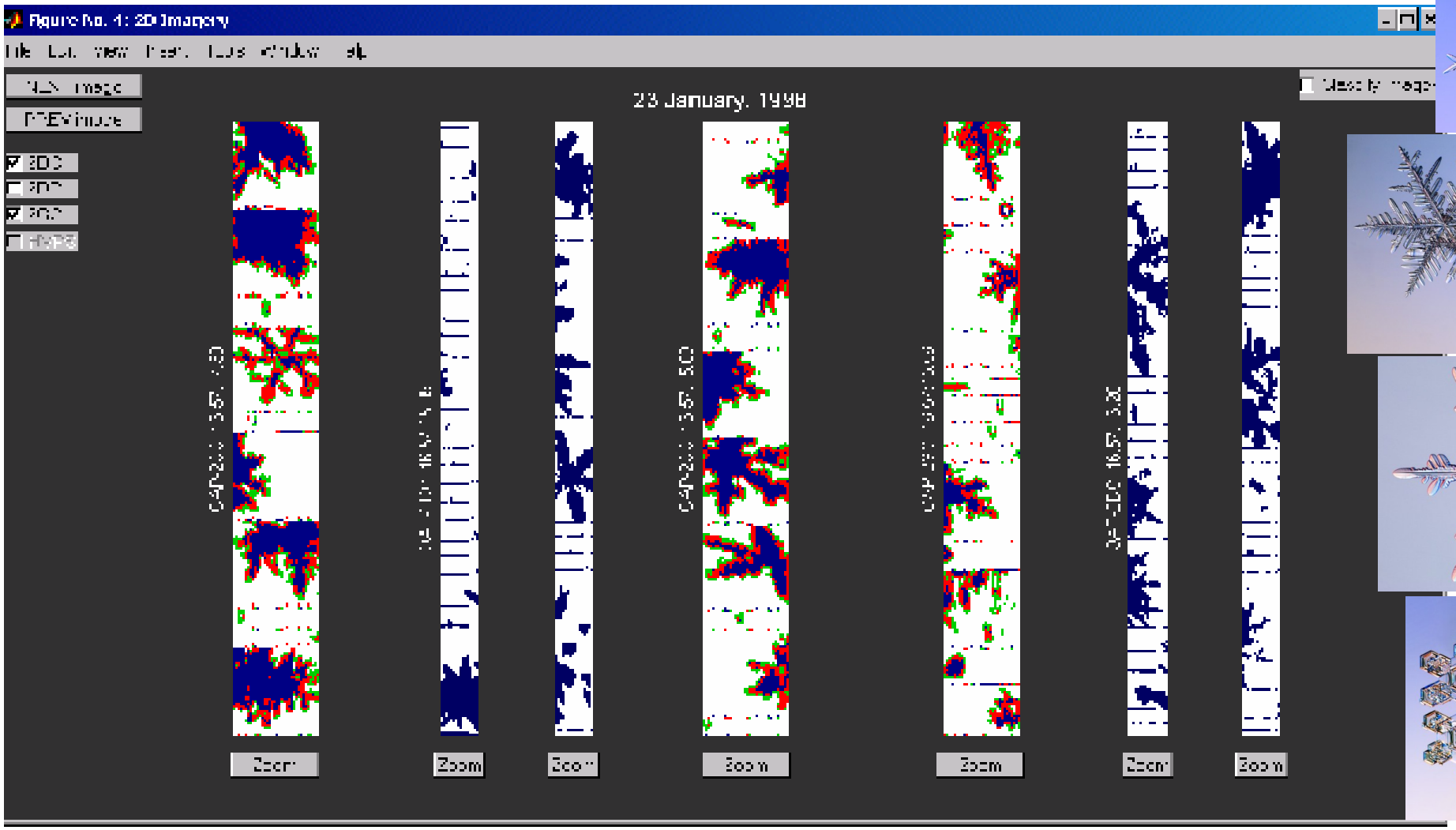
2-DC Probe: Needles



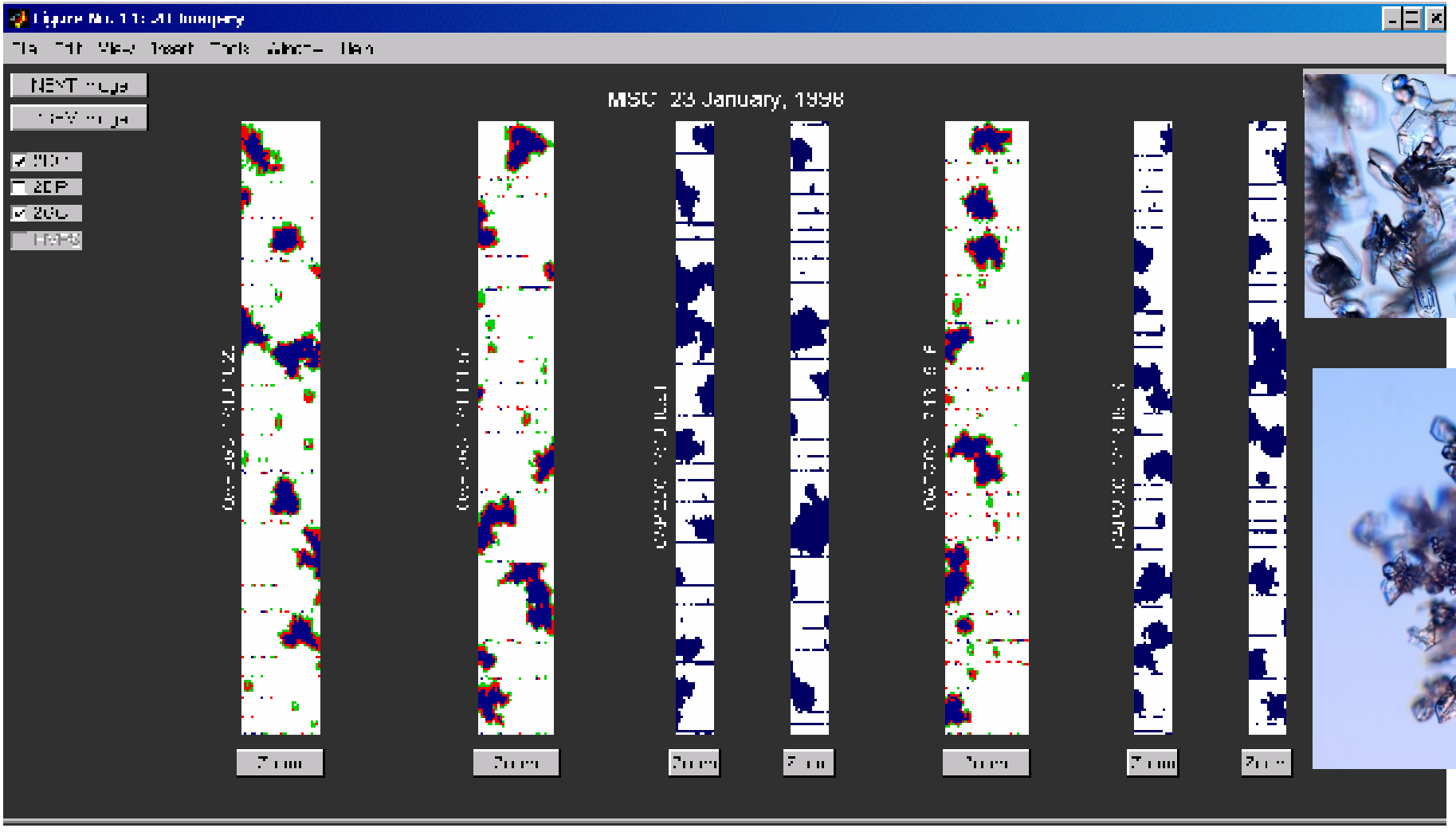


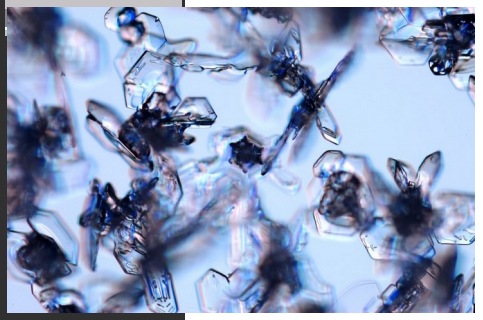


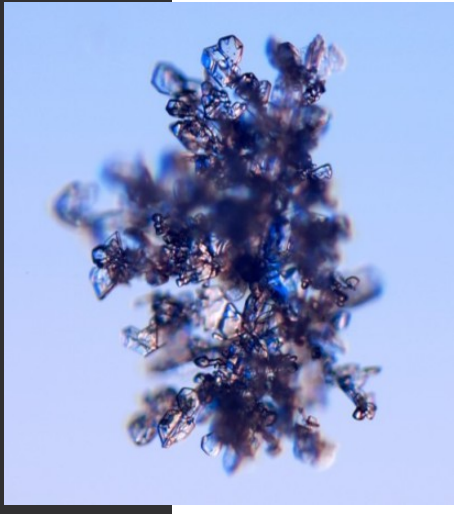
2-DC Probe: Dendrites



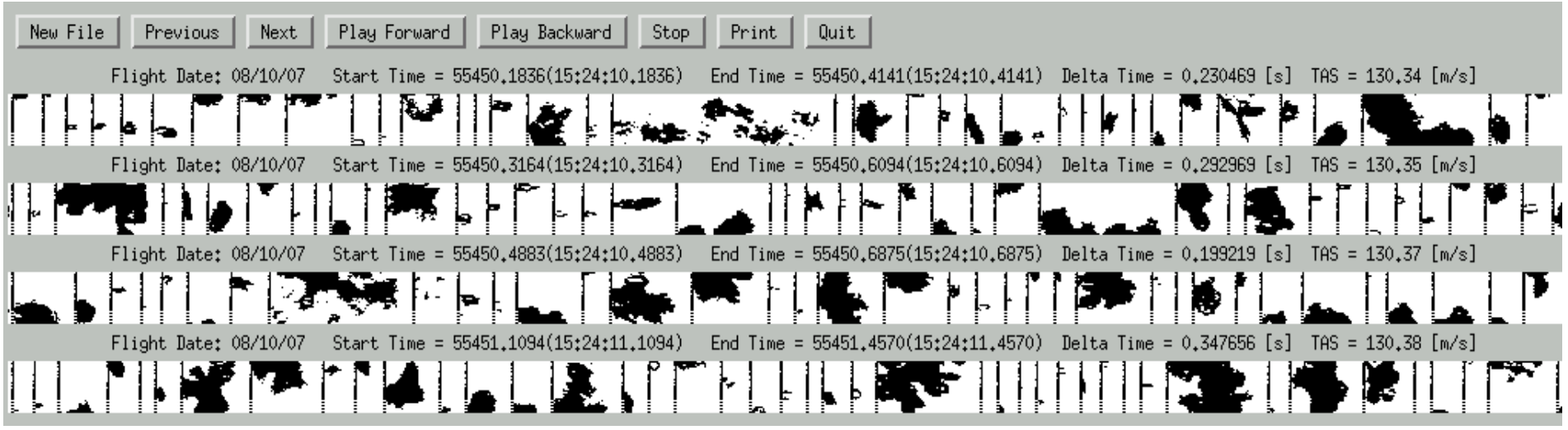
2-DC Probe: Irregulars/Aggregates

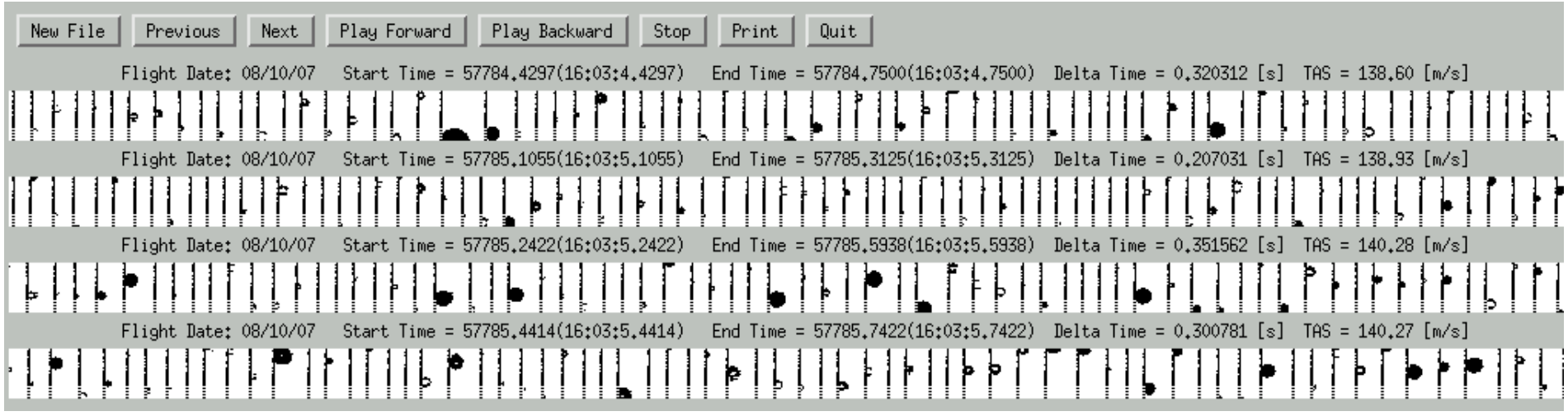






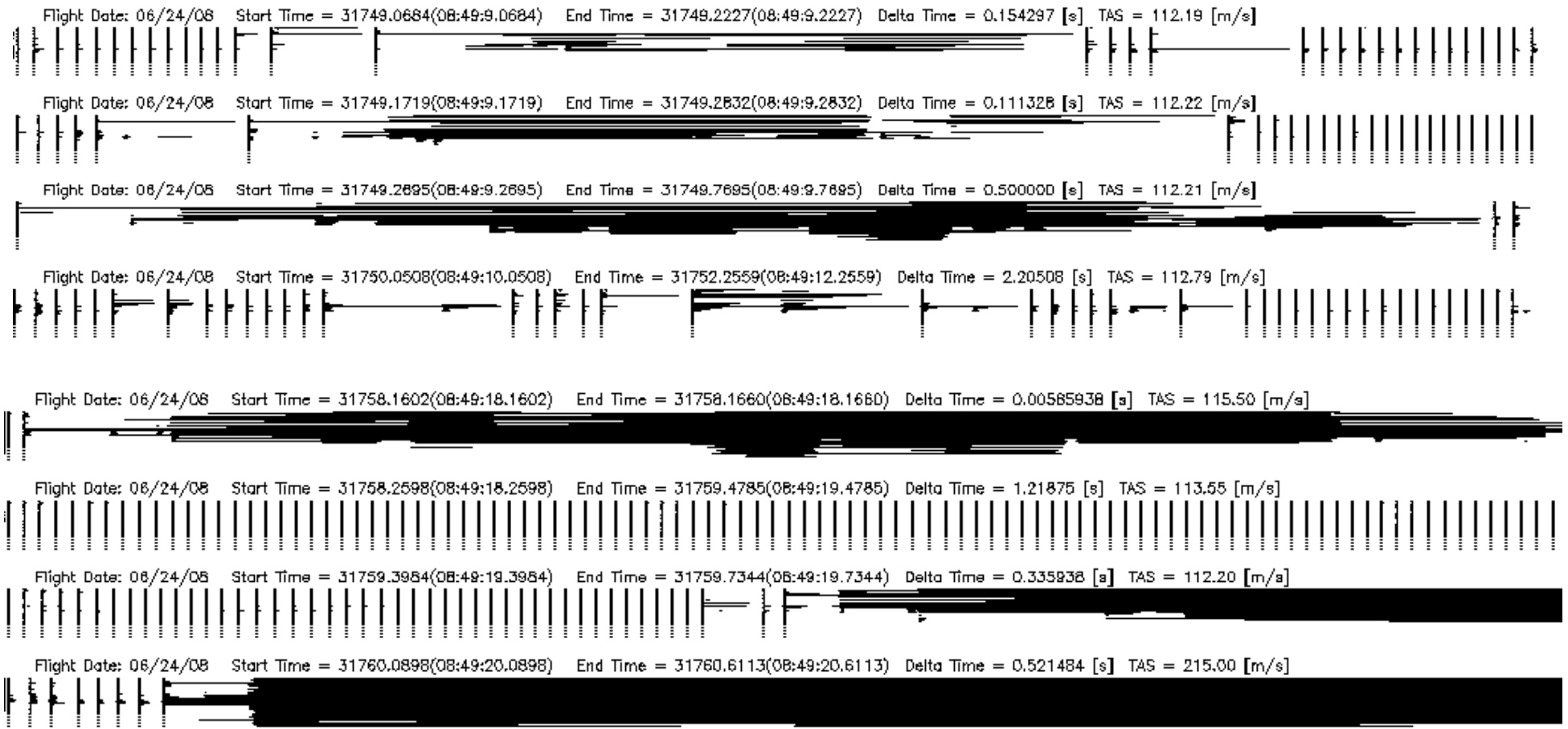
What particles types are in these images?



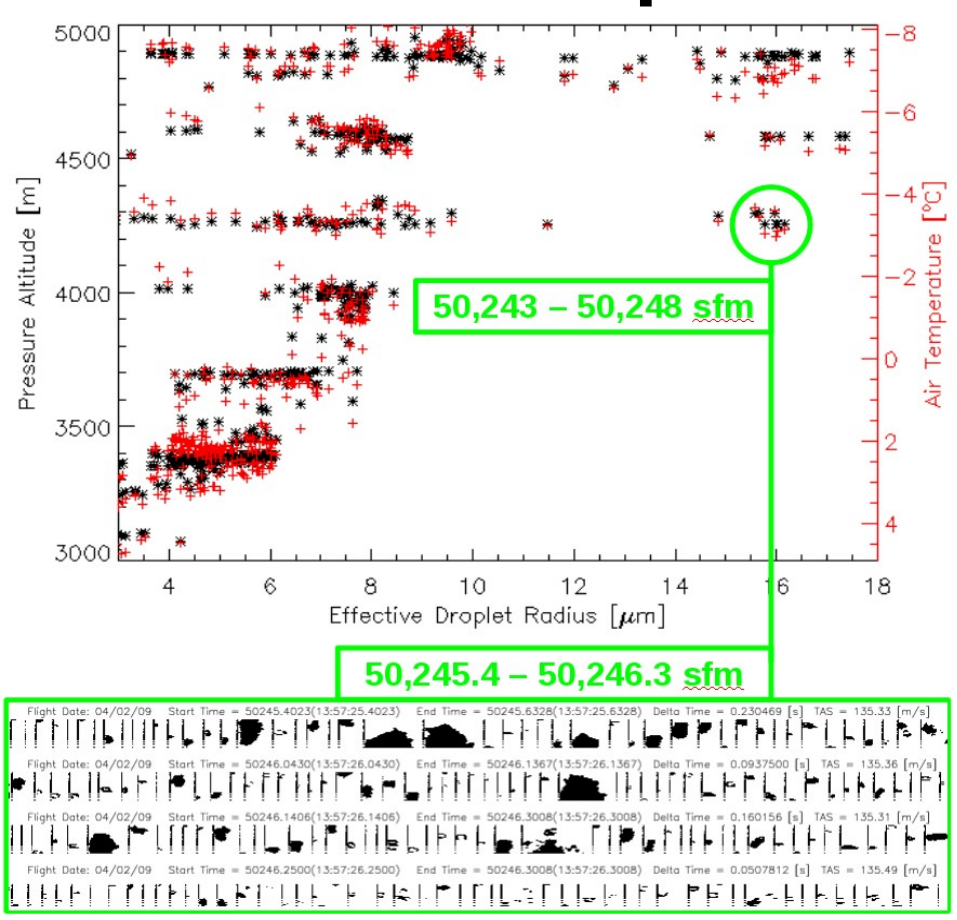


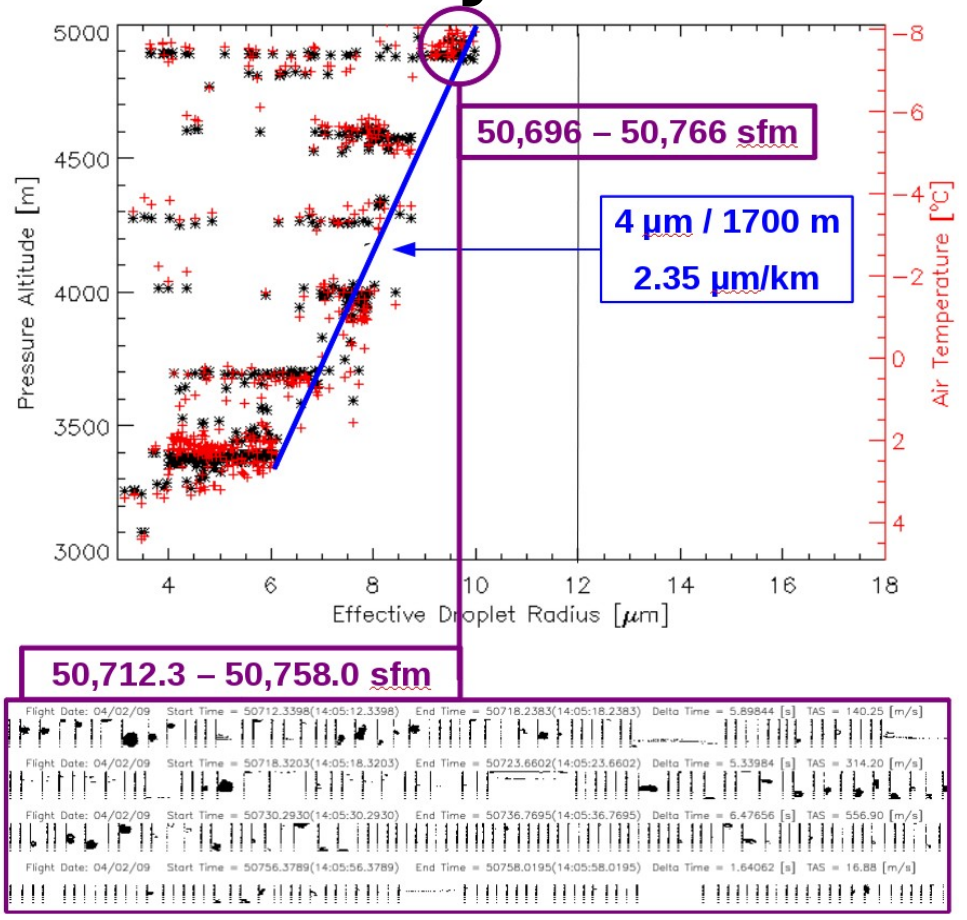
Conclusions

Liquid Droplets are round, ice is generally not.



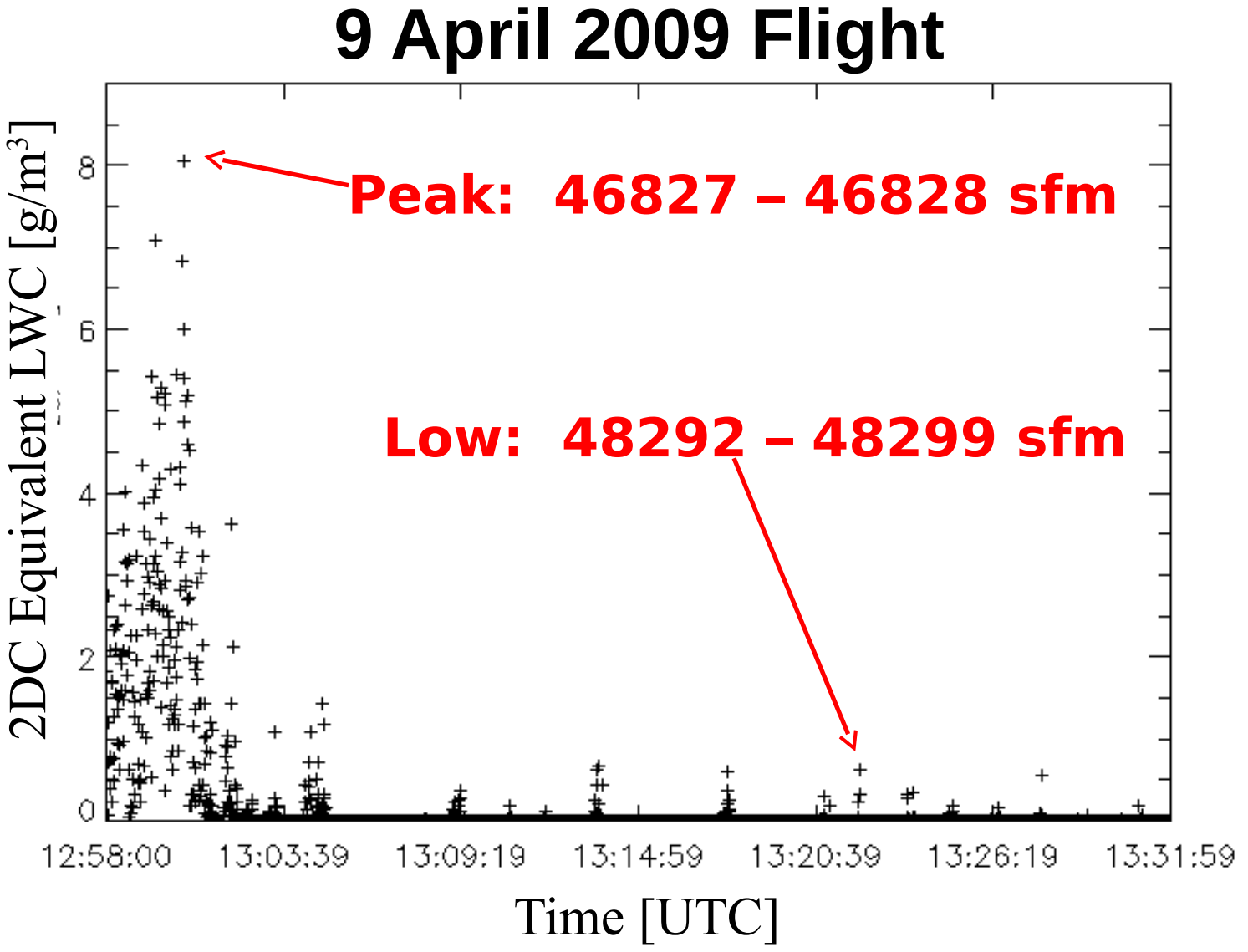
9 April 2009 Case Study



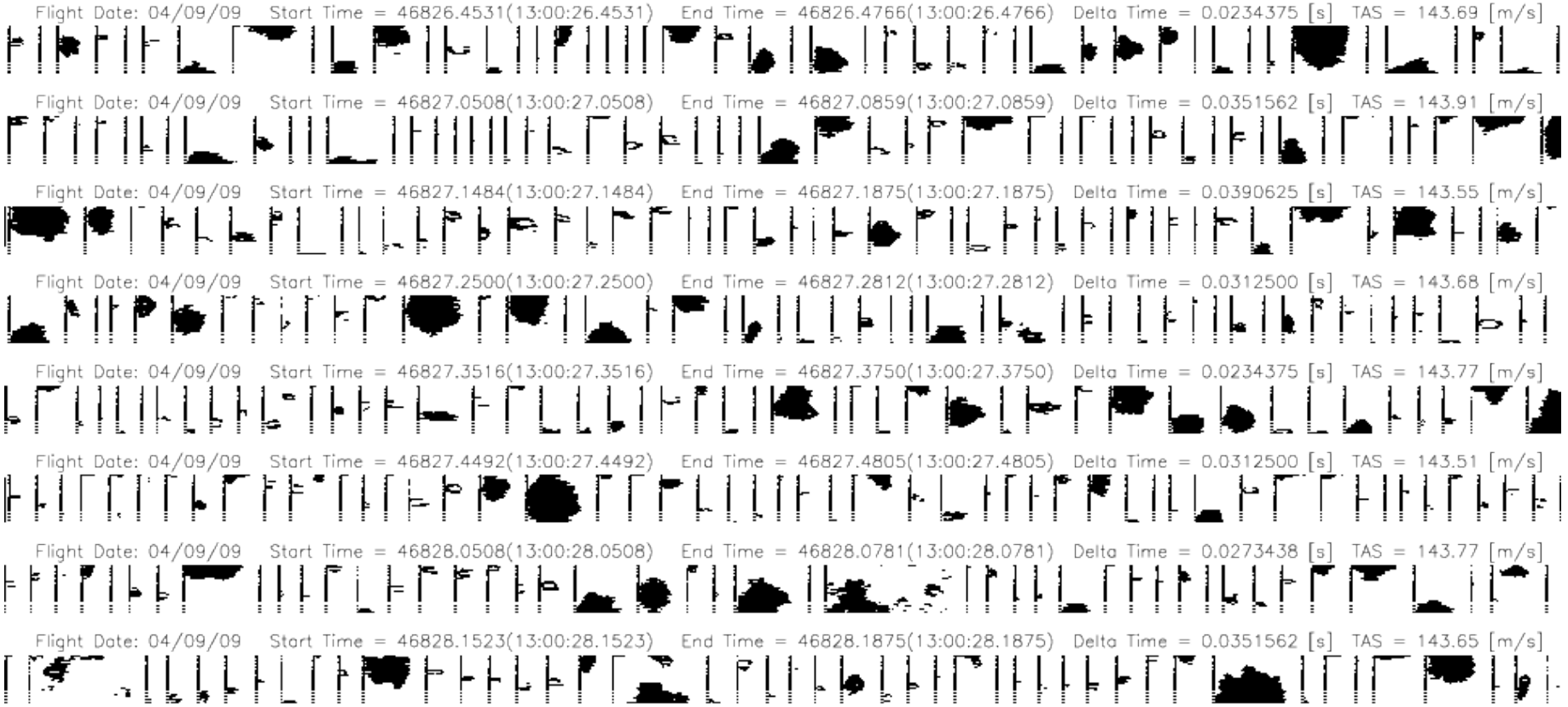


Sampling between cloud base and cloud top during time interval 49,100 to 50,800 sfm on 2 April 2008. Left panel shows all observations, while right panel only includes FSSP concentrations at STP greater than 100 #/cm^3. The blue line is the approximate rate of increase of effective droplet radius with height.

Liquid water content equivalent (1 Hz) at 18,000 ft measured by 2-DC probe on a research flight in Saudi Arabia.

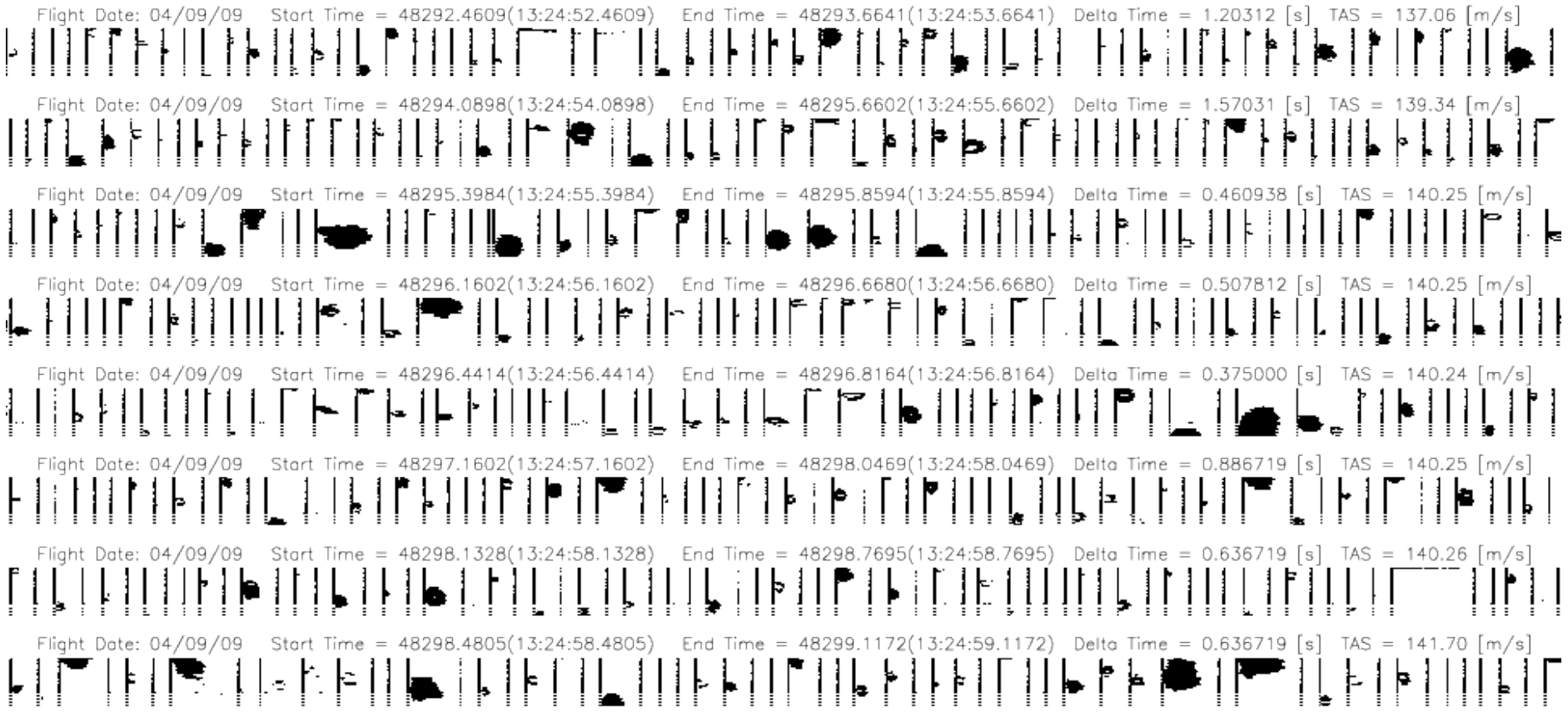


9 April 2009 Flight



Images from the 2-DC between 13:00:26.45 and 13:00:28.19 (less than 2 seconds total) which correspond to the maximum liquid water content equivalent (1 Hz data) measured by 2-DC probe between on 9 April 2009 research flight in Saudi Arabia.

9 April 2009 Flight



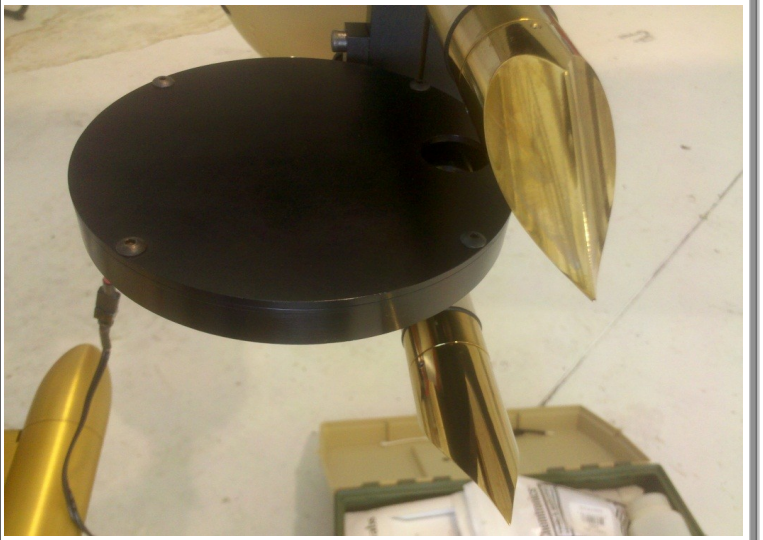
2-DC images between 13:24:52.46 and 13:24.59 (9 seconds total) which correspond to the low liquid water content equivalent (1 Hz data) measured by 2-DC probe on 9 April 2009 research flight in Saudi Arabia.

2-DC
Spinning Disk

txt (0)

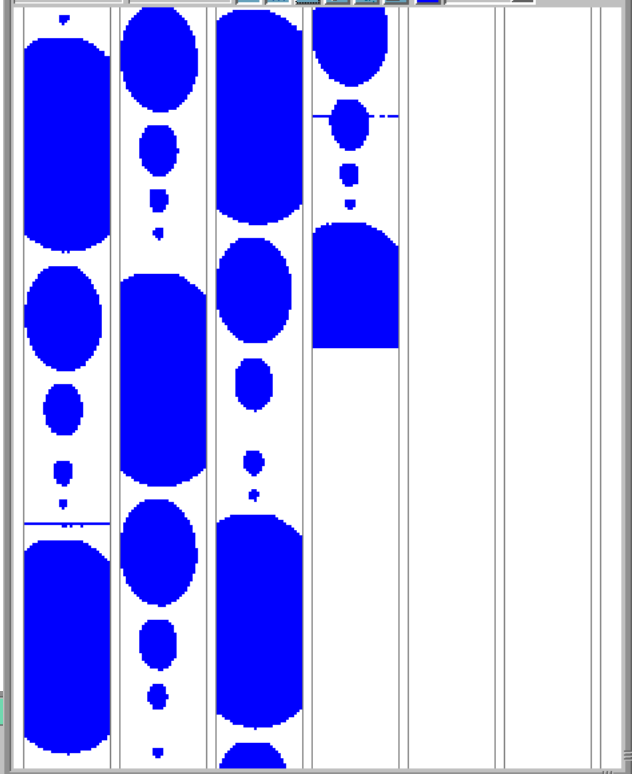
13:13:21.040 2011/12/15 x y

```
TAS                    27 m/s
MulFac                 43
DivFac                  2
TasClk              1.075 MHz
ElapsedTime           191       0.004775 s
ElapsedTas             51     0.00474419 s
ElapsedShwOr           38
ShwOr                7392
House1               1426
House2               1426
House3               1427
House4               1428
House5               1425
House6               1425
House7               1426
House8               1426
        0.0 -   25.0    61.5
       25.0 -   50.0     0.0
       50.0 -   75.0   266.5
       75.0 -  100.0   881.6
      100.0 -  125.0    20.5
      125.0 -  150.0    61.5
      150.0 -  175.0   656.1
      175.0 -  200.0   451.1
      200.0 -  225.0     0.0
      225.0 -  250.0     0.0
      250.0 -  275.0     0.0
      275.0 -  300.0    20.5
      300.0 -  325.0     0.0
      325.0 -  350.0   574.1
      350.0 -  375.0   492.1
      375.0 -  400.0    20.5
      400.0 -  425.0    20.5
      425.0 -  450.0     0.0
      450.0 -  475.0    20.5
      475.0 -  500.0     0.0
      500.0 -  525.0    41.0
      525.0 -  550.0     0.0
      550.0 -  575.0     0.0
      575.0 -  600.0     0.0
      600.0 -  625.0     0.0
      625.0 -  650.0    20.5
      650.0 -  675.0    41.0
      675.0 -  700.0   307.5
      700.0 -  725.0   635.6
      725.0 -  750.0    20.5
      750.0 -  775.0    61.5
      775.0 -  800.0  1271.1
```



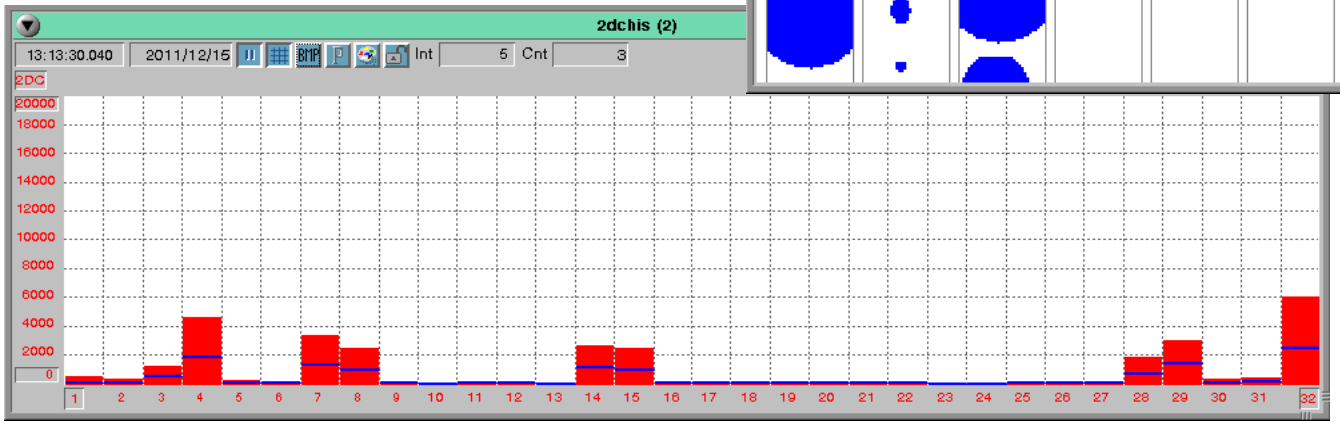
2dc (1)

13:13:18.790 2011/12/15 0x1B00 Timebars

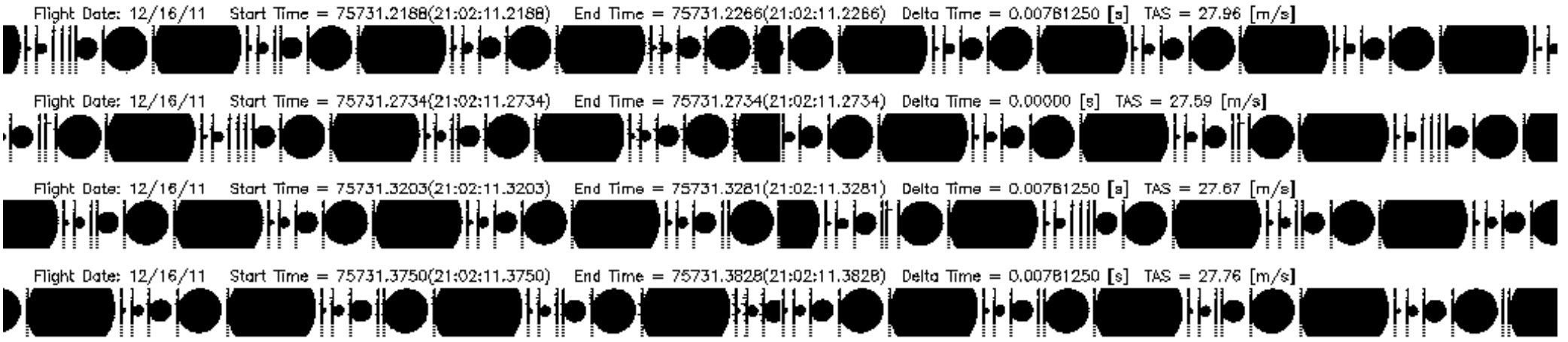


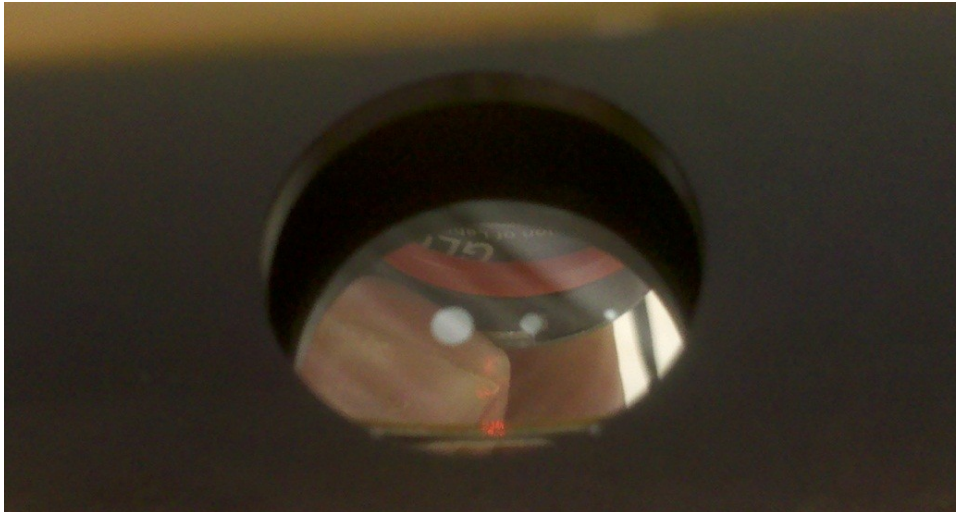
2dchis (2)

13:13:30.040 2011/12/15 Int 5 Cnt 3

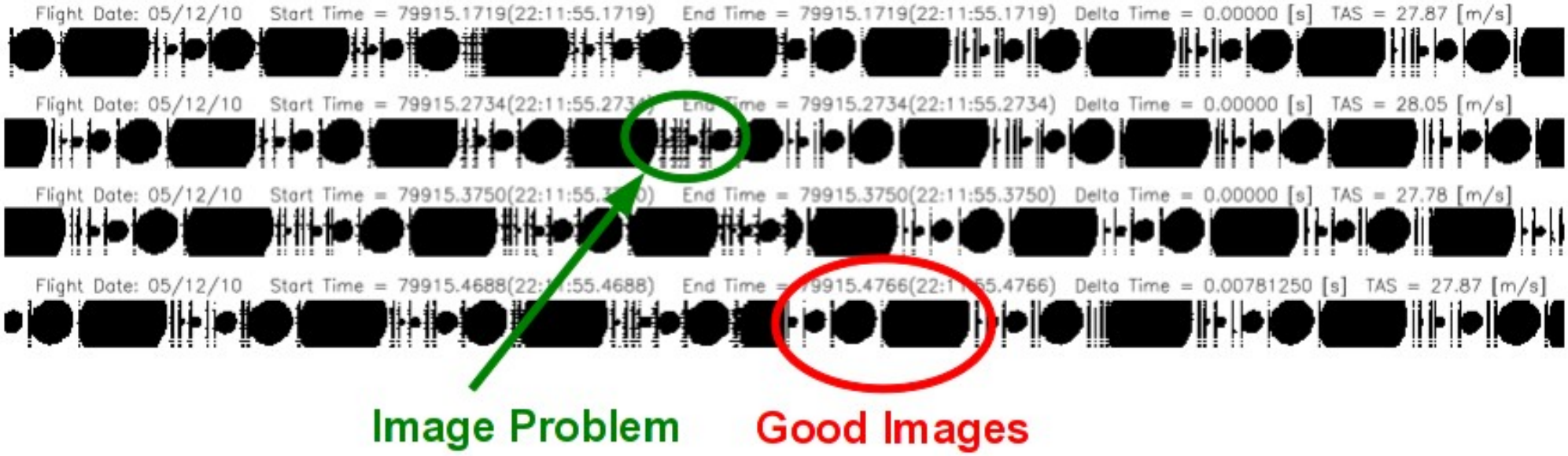


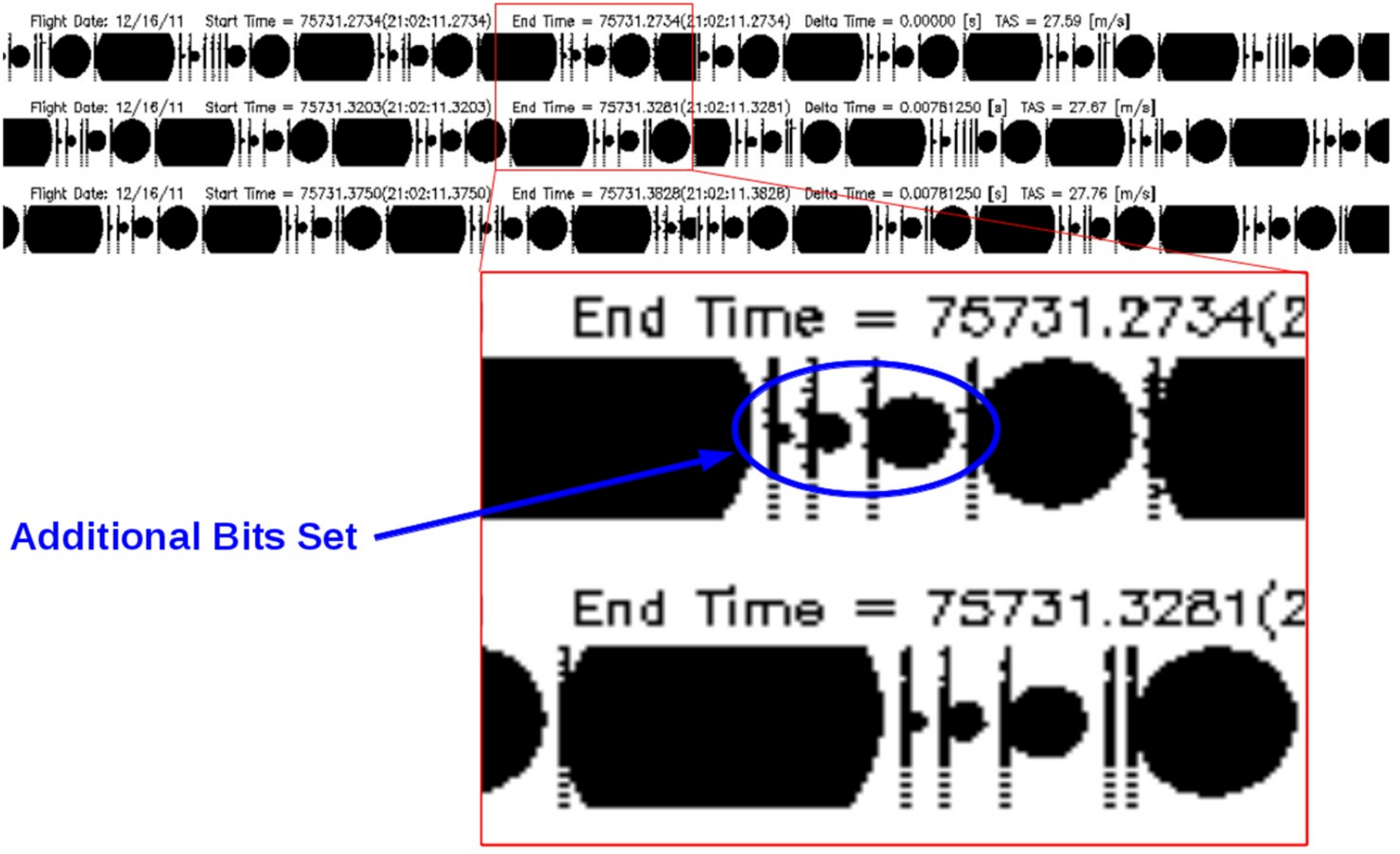
2-DC Spinning Disk



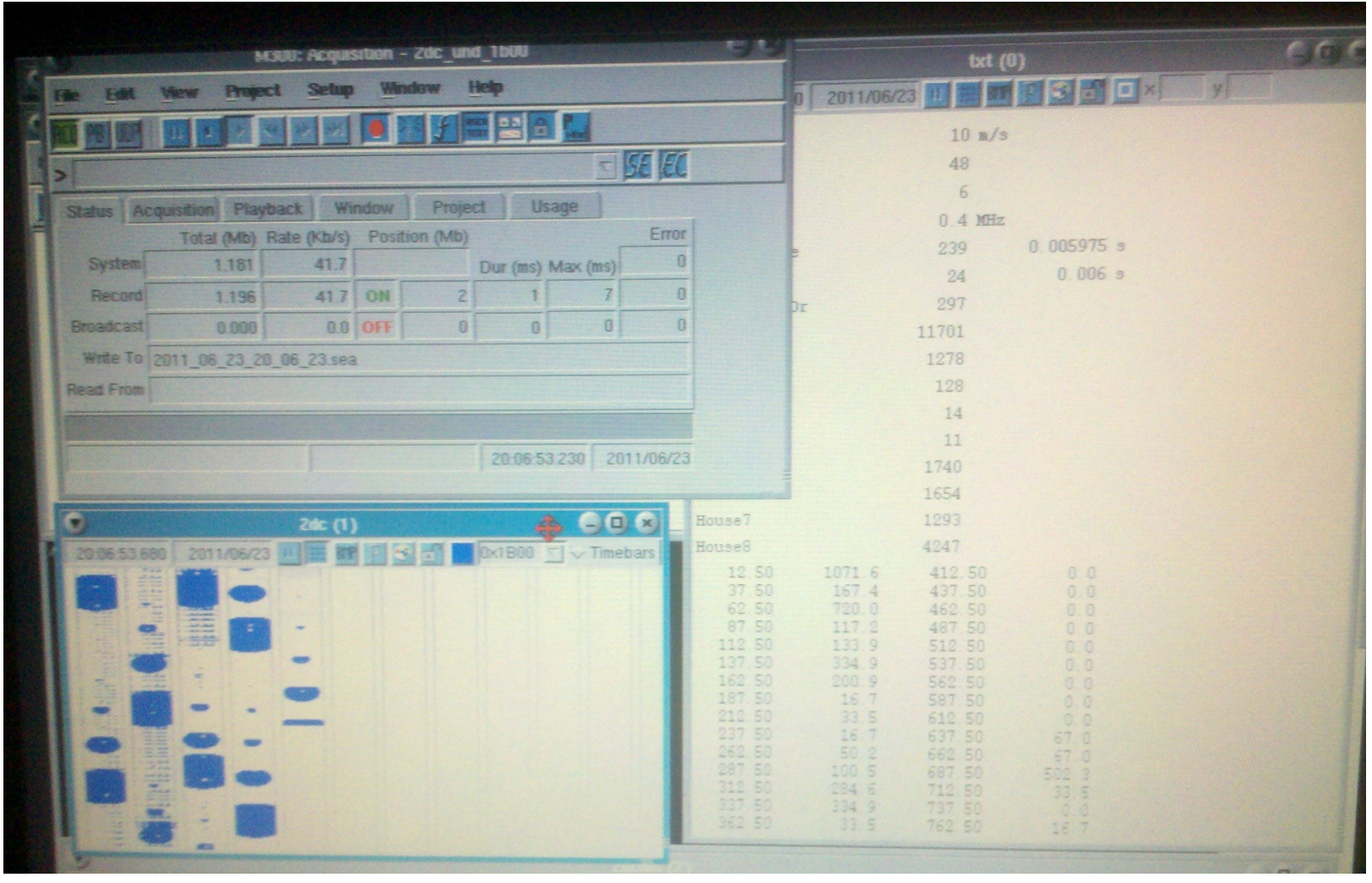


May 12, 2010 Ground Test with Spinning Disk on 2DC Probe

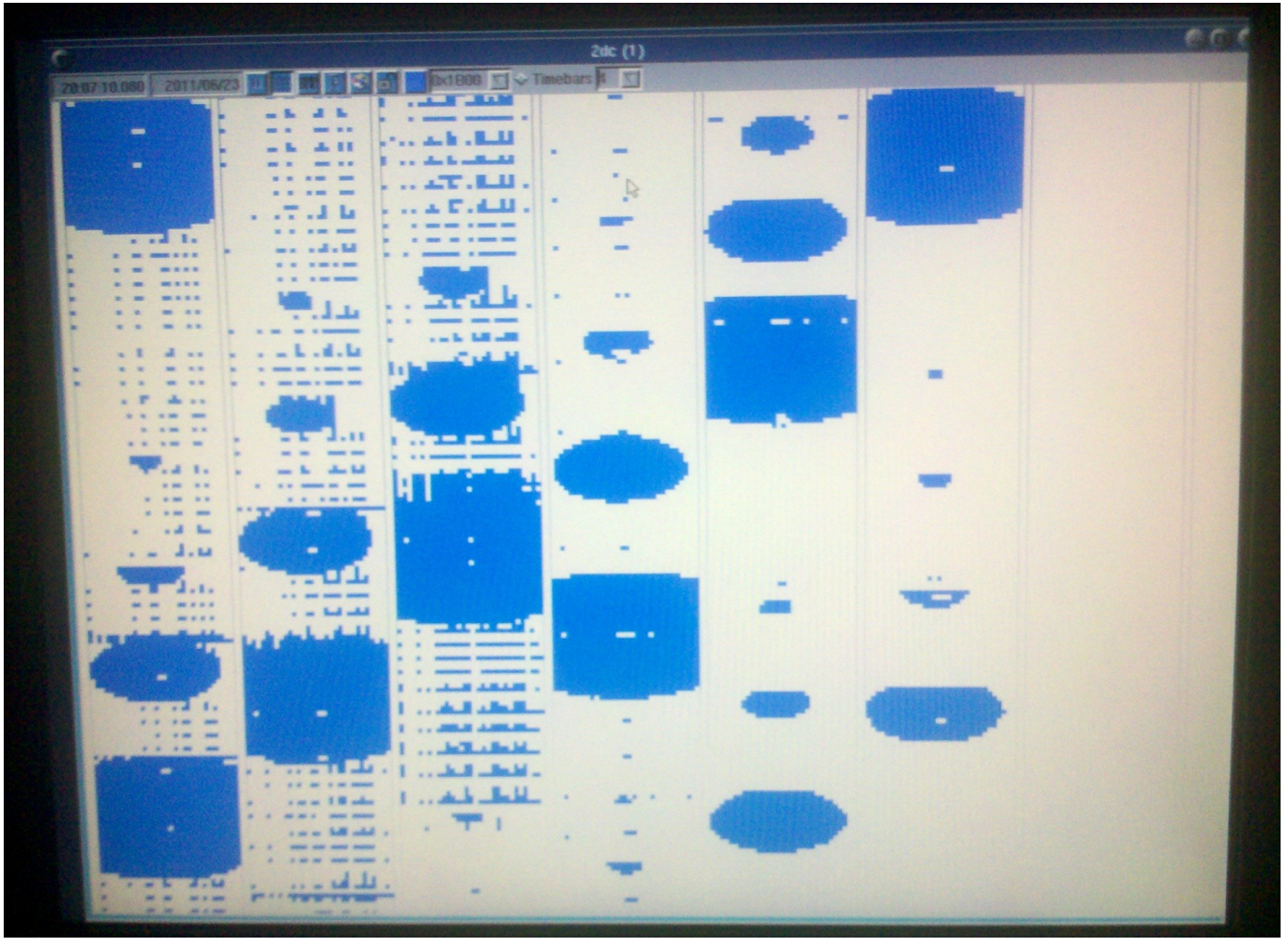



Flight Date: 12/16/11 Start Time = 75731.2734(21:02:11.2734) End Time = 75731.2734(21:02:11.2734) Delta Time = 0.00000 [s] TAS = 27.59 [m/s]
Flight Date: 12/16/11 Start Time = 75731.3203(21:02:11.3203) End Time = 75731.3281(21:02:11.3281) Delta Time = 0.00781250 [s] TAS = 27.67 [m/s]
Flight Date: 12/16/11 Start Time = 75731.3750(21:02:11.3750) End Time = 75731.3828(21:02:11.3828) Delta Time = 0.00781250 [s] TAS = 27.76 [m/s]
End Time = 75731.2734(2
Additional Bits Set
End Time = 75731.3281(2

Images from 2-DC Probe



Images from 2-DC Probe



Conclusions

- It is important to conduct performance test on the using a spinning disk or calibration beads.
- It is important to clean the optics.


Any Questions