UNIVERSITY OF ILLINOIS
AT URBANA-CHAMPAIGN

PLOWS Microphysics

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1867

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Outline

- Motivation
- Cloud Probes
- Shattering Issues
- Quick-Look Products in Field

Motivation

1. μphysics data, together with other data/modeling studies, will identify & quantify instabilities & forcing mechanisms (frontogenesis, gravity waves) associated with bands & relate μphysical evolution of substructures to mesoscale dynamic forcing

2. SDs & bulk μhysics will be used to
   i. Input to mesoscale parameterization schemes
   ii. Knowledge about processes in continental winter cyclones
   iii. Info for characterizing m-Z relations
   iv. Data for placing μphysics in context of radar derived structure of bands (spatial structure & air motions)
   v. Determine how seeder/feeder process evolves within & outside bands
   vi. Determine role of supercooled water in generation of ice particles near cloud top & in subsequent growth as fall through trowal & warm frontal regions

Measurement Needs

- Need to measure SDs over complete range of particle sizes
- Need to measure bulk mass (liquid and ice) to ensure consistency with SDs through closure studies
  - Also required for Z-m relations

Cloud Probes

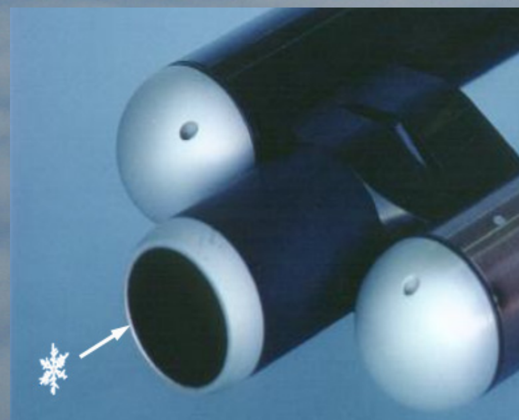
- FSSP-100 (3 to 45 μm), uncertain in ice
- CDP (3 to 45 μm), no inlet/shroud
- 2D-C (125 to 800 μm), shattering for D < 200-300 mm?
- 2D-P (200 to 6400 μm), good for large particles
- CPI (25 to 800 μm), particle images, SDs?
- CSI (measure of bulk water)
- PVM-100 liquid water probe
- PMS King liquid water probe
- TSI 3760 CN counter
- Rosemount icing detector

Shattering Effect: CAS vs CDP vs FSSP

Cloud and Aerosol Spectrometer

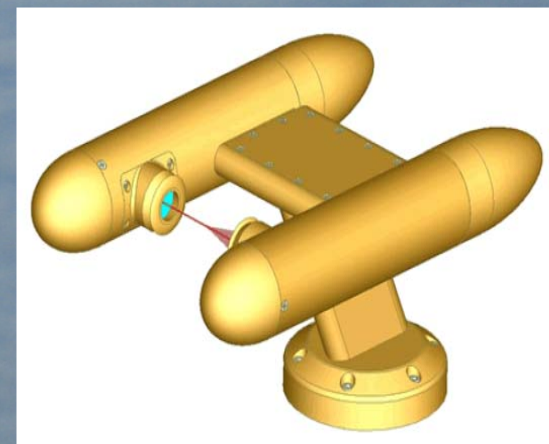
Shroud **Inlet**

Forward Scattering Spectrometer Probe



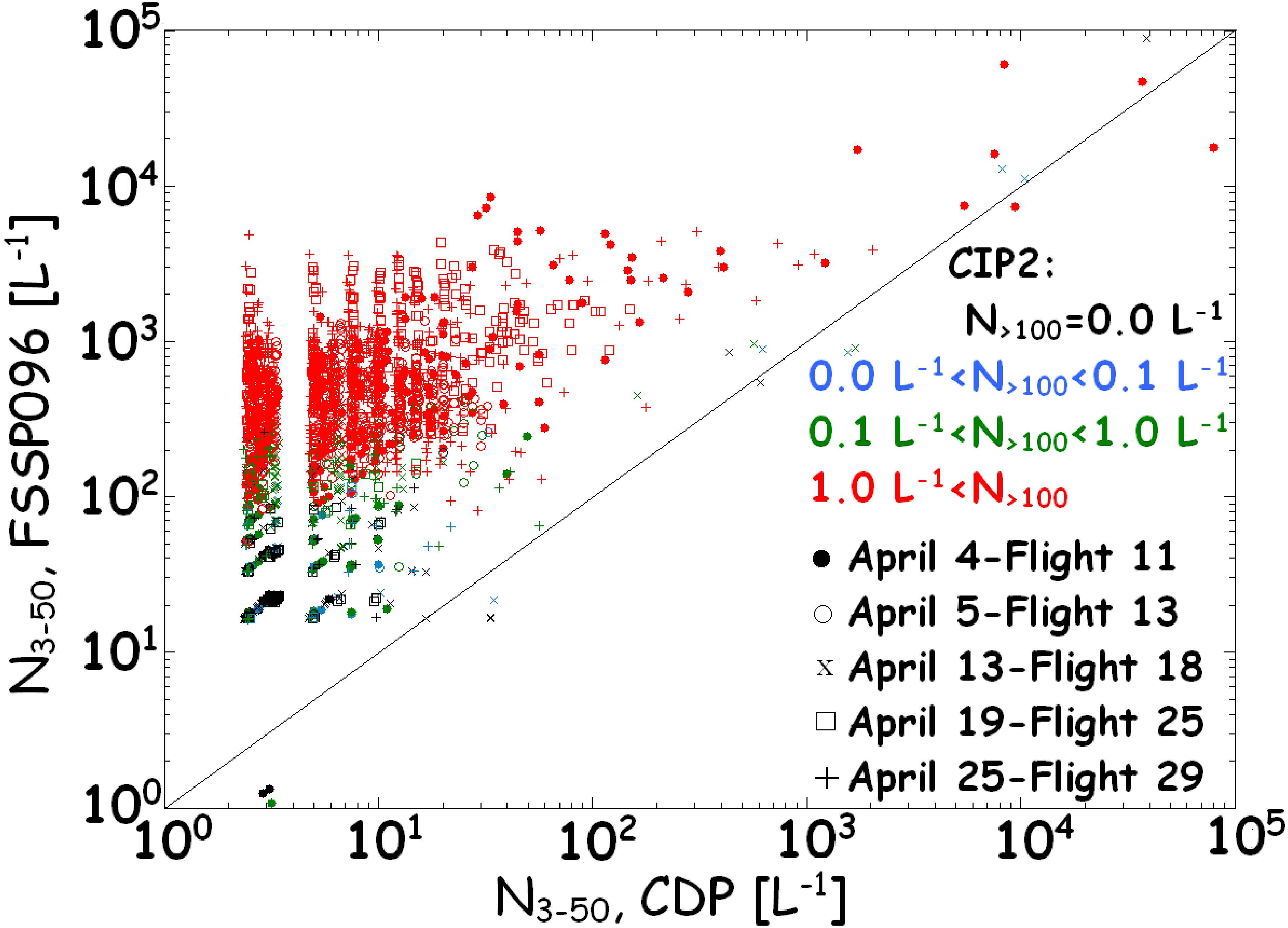
-Surfaces for shattering

Cloud Droplet Probe

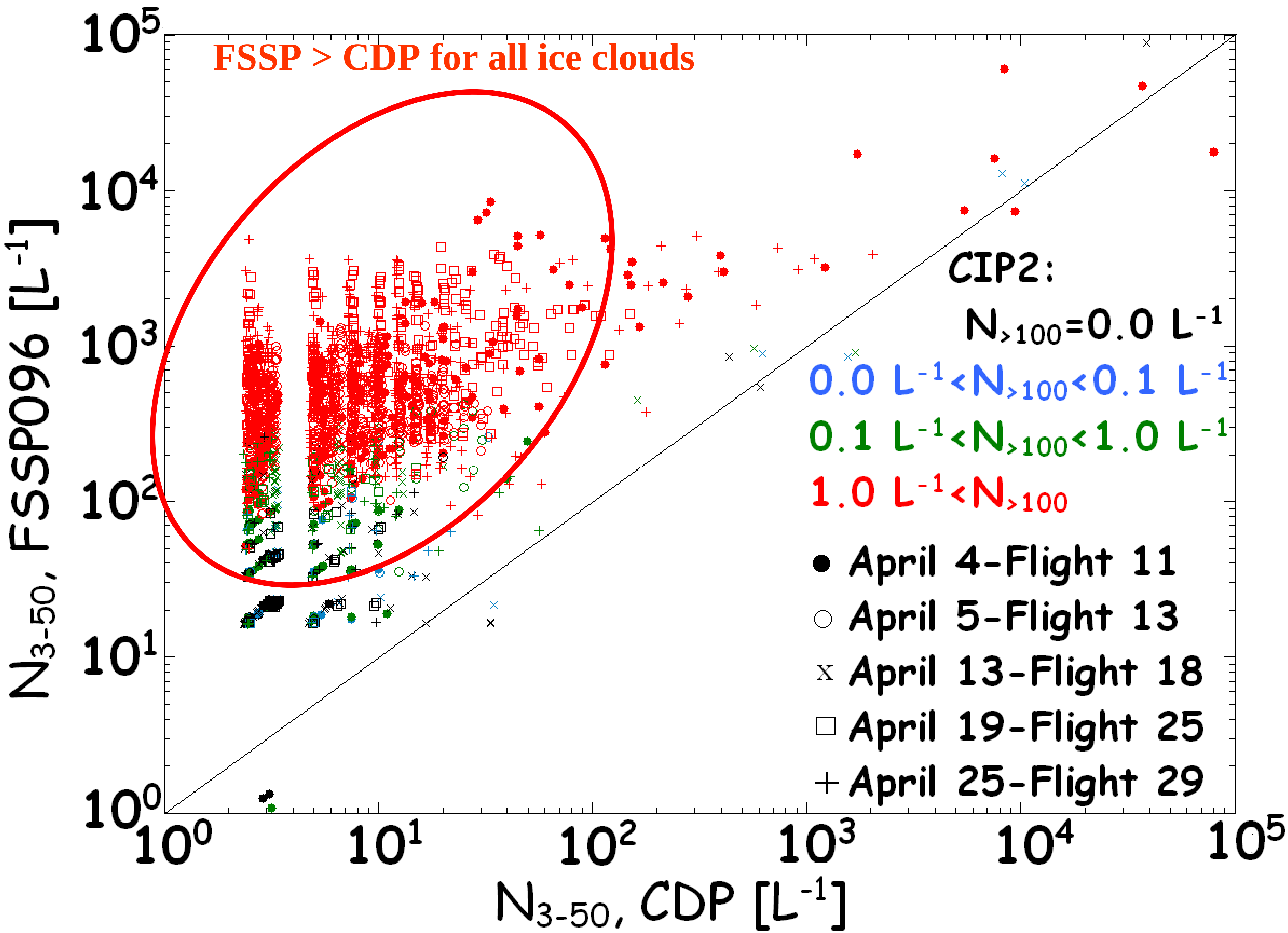


- No inlet or shroud

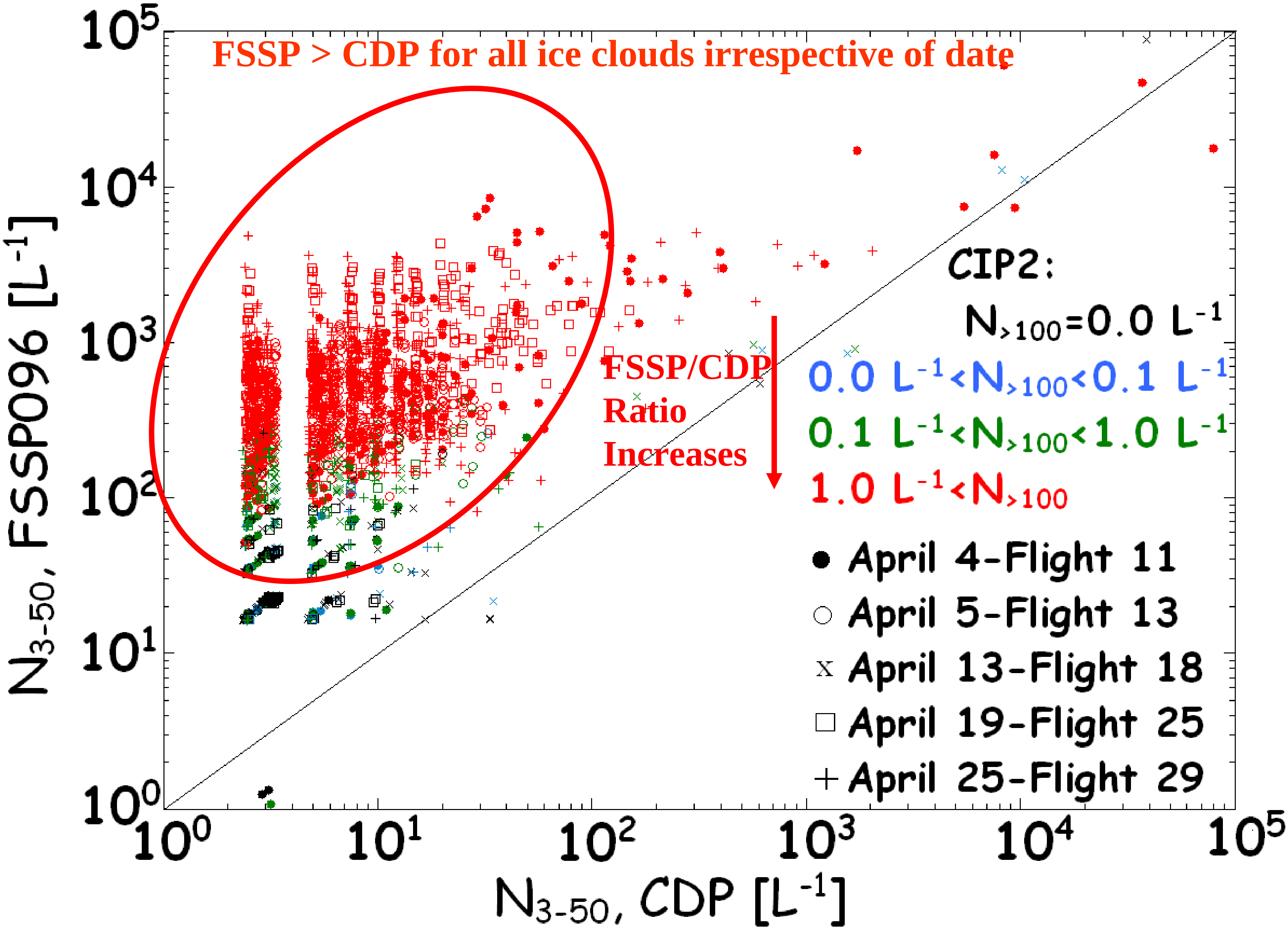
- ✓ **The same working principle and look-up table**
- ✓ **Can we see evidence that shattering on FSSP or CAS amplifies small crystal concentrations?**



CIP2:
N>100=0.0 L-1
0.0 L-1<N>100<0.1 L-1
0.1 L-1<N>100<1.0 L-1
1.0 L-1<N>100
April 4-Flight 11
April 5-Flight 13
April 13-Flight 18
April 19-Flight 25
April 25-Flight 29
N3-50, FSSP096 [L-1]
N3-50, CDP [L-1]
10^0
10^1
10^2
10^3
10^4
10^5

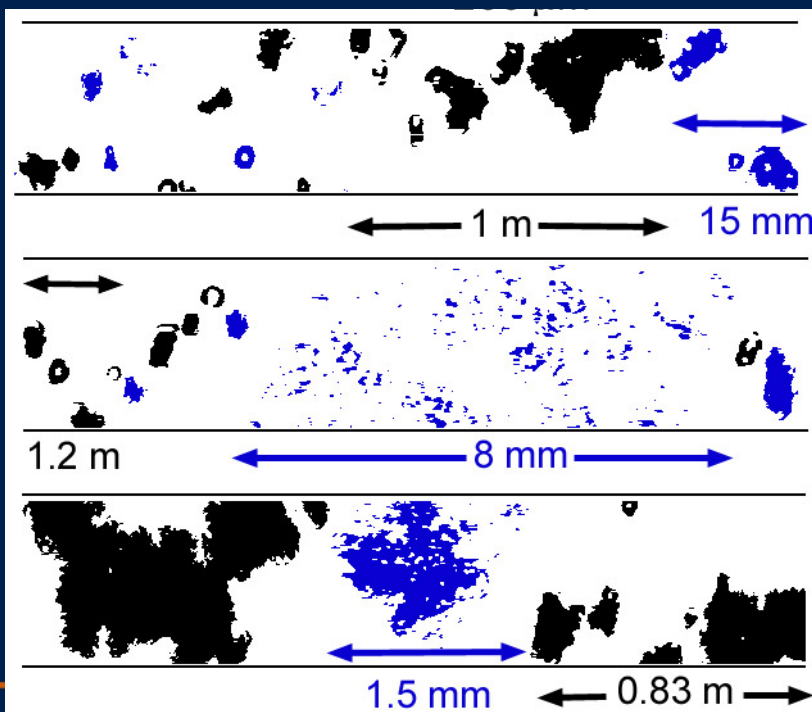


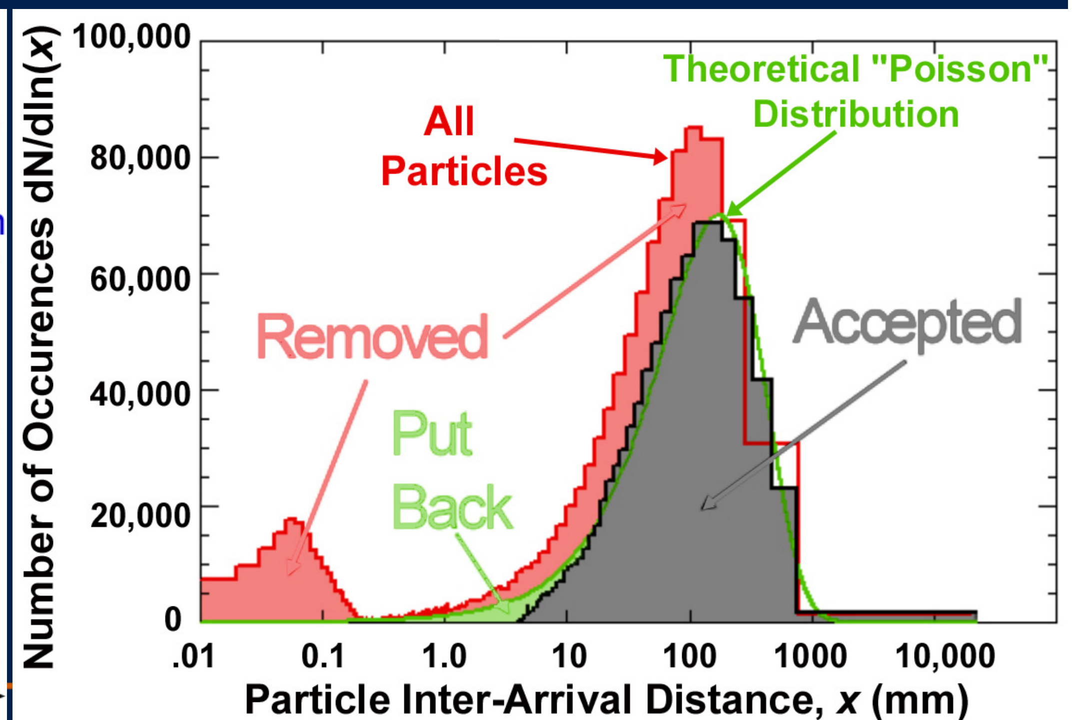
FSSP > CDP for all ice clouds
CIP2:
$N_{>100}$=0.0 L^{-1}
0.0 L^{-1}<$N_{>100}$<0.1 L^{-1}
0.1 L^{-1}<$N_{>100}$<1.0 L^{-1}
1.0 L^{-1}<$N_{>100}$
April 4-Flight 11
April 5-Flight 13
April 13-Flight 18
April 19-Flight 25
April 25-Flight 29
N_{3-50}, FSSP096 [L^{-1}]
N_{3-50}, CDP [L^{-1}]


FSSP > CDP for all ice clouds irrespective of date
FSSP/CDP
Ratio
Increases
CIP2:
$N_{>100}$=0.0 L^{-1}
0.0 L^{-1}<$N_{>100}$<0.1 L^{-1}
0.1 L^{-1}<$N_{>100}$<1.0 L^{-1}
1.0 L^{-1}<$N_{>100}$
April 4-Flight 11
April 5-Flight 13
April 13-Flight 18
April 19-Flight 25
April 25-Flight 29
N_{3-50}, FSSP096 [L^{-1}]
N_{3-50}, CDP [L^{-1}]
10^0
10^1
10^2
10^3
10^4
10^5

Shattering Events

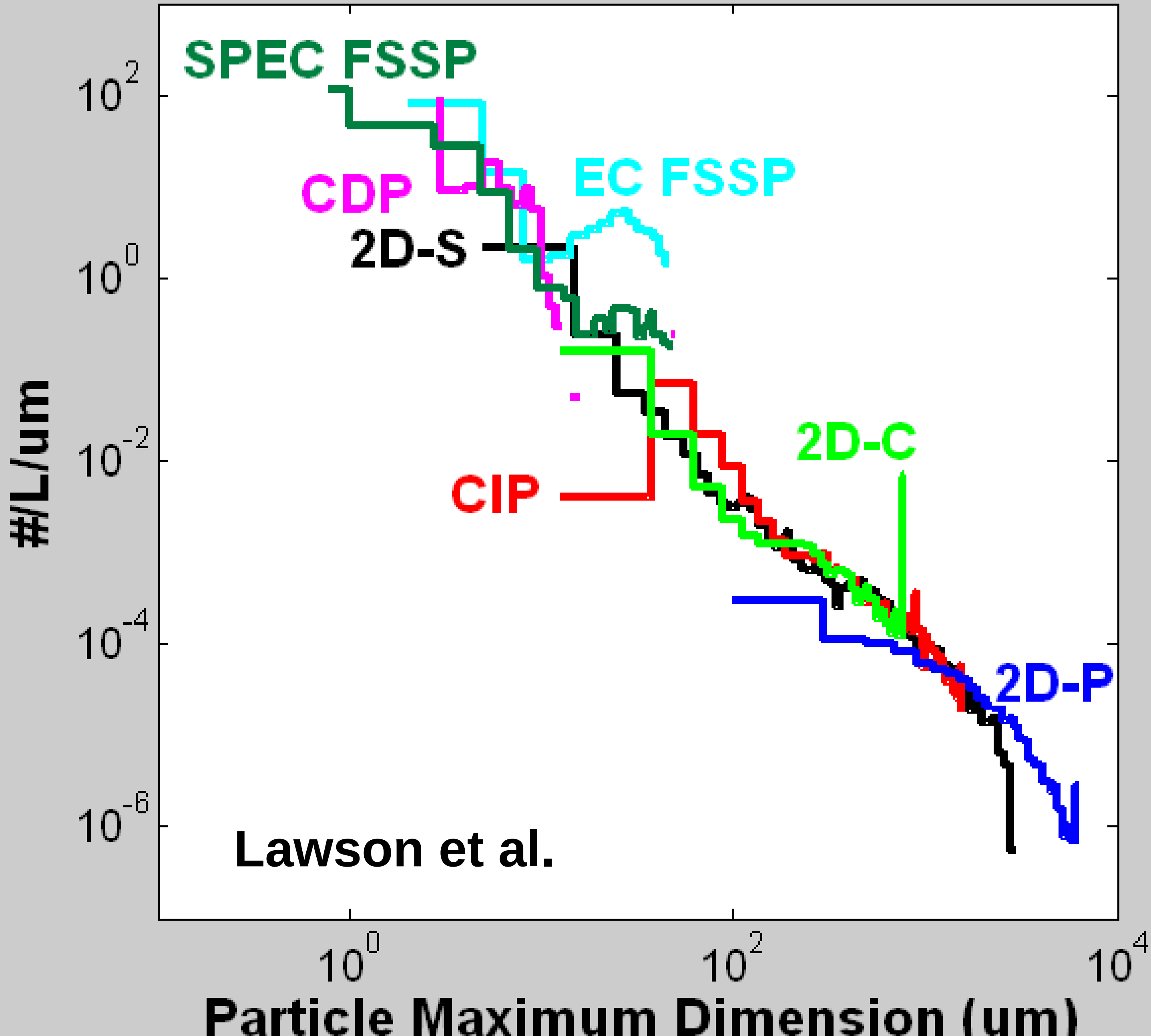
- There is now evidence that 2D-C for D < 200 to 300 μm also contaminated by shattering (Korolev)
  - Shattering events can be identified by interarrival times, # of particles in image and size of fragments



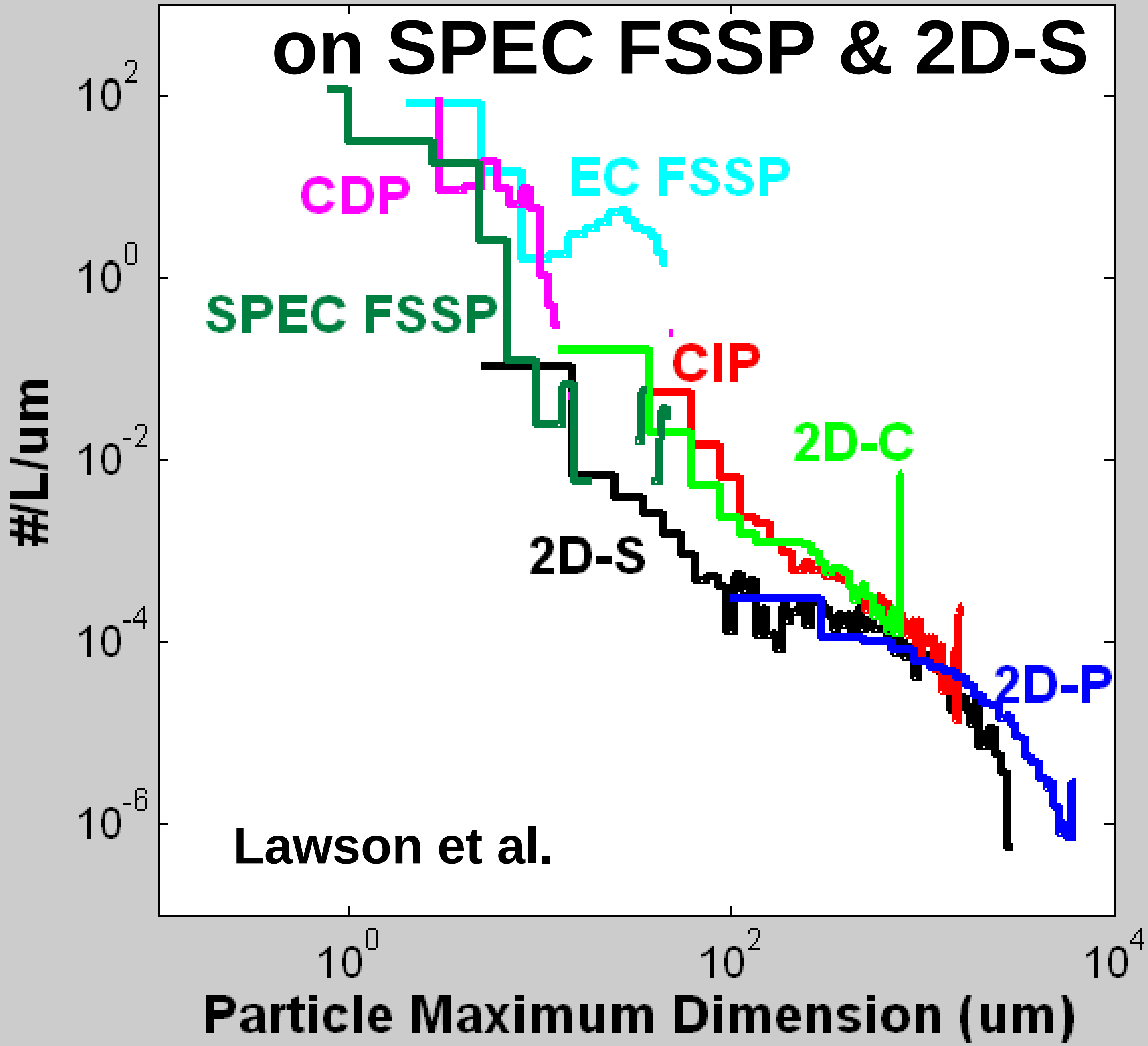


Lawson et al.

Shattered Particles are Included



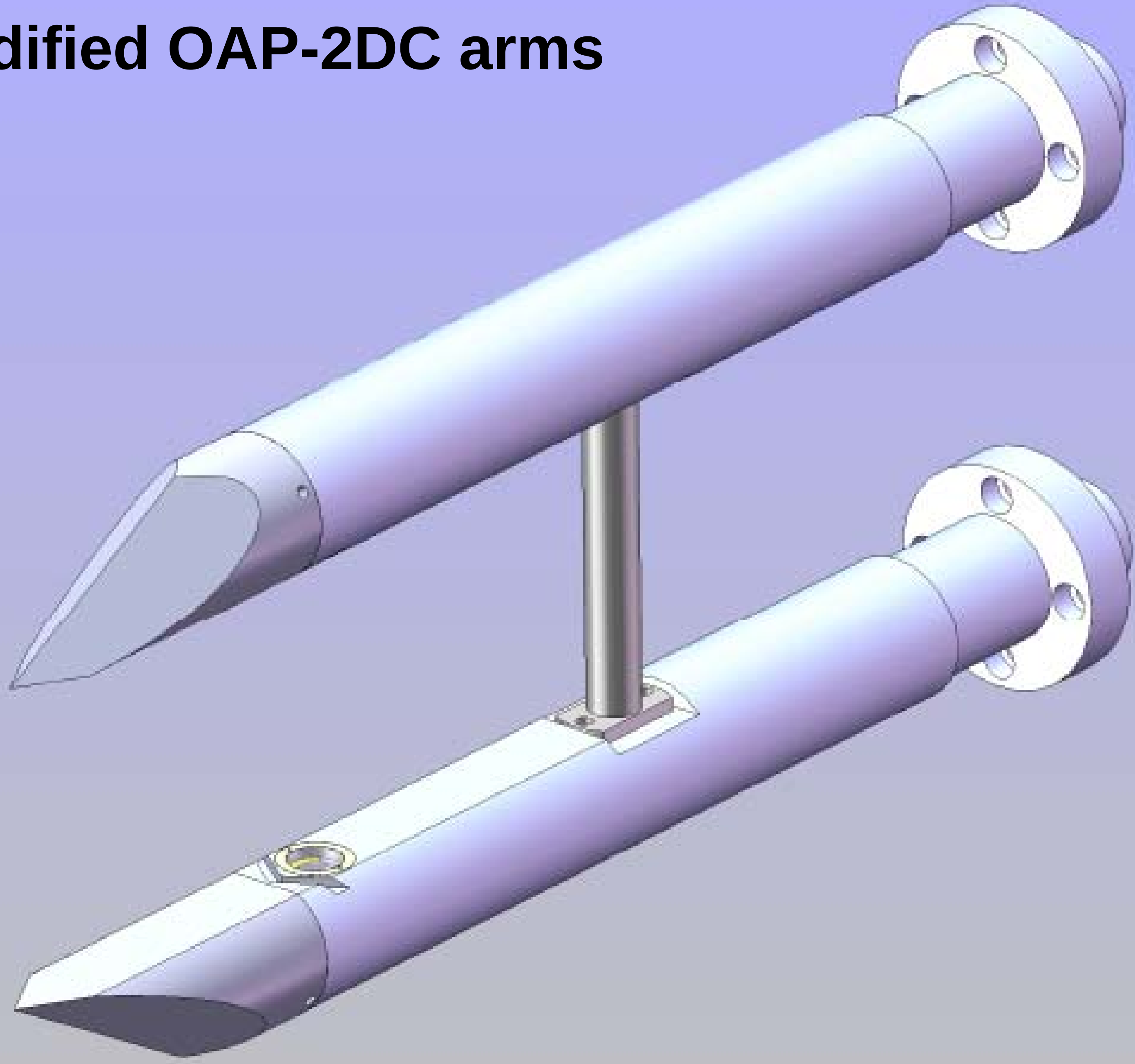
Shattered Particles are Removed on SPEC FSSP & 2D-S



Correcting for Shattering

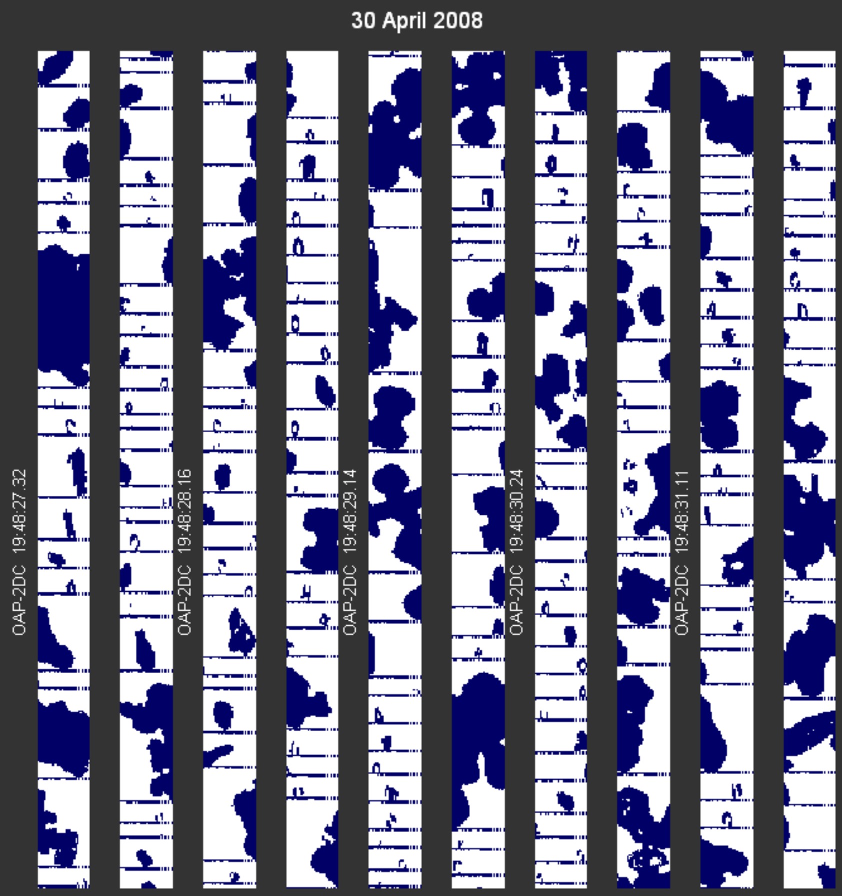
- We will use most sophisticated algorithms to remove shattered artifacts from data
  - BUT, there is some controversy as to whether software alone can do this
  - There are new probe tips (that can be easily exchanged) that can minimize impact of shattering

Modified OAP-2DC arms

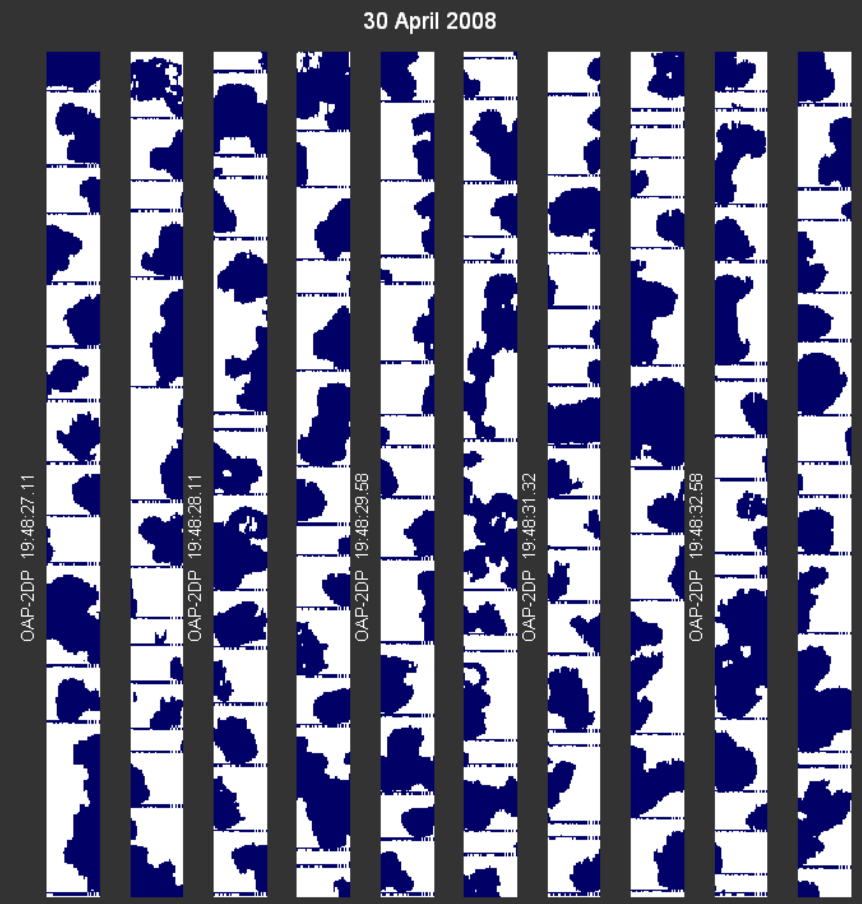


30 April 2008, NRC Convair 580, ISDAC, Fairbanks

Standard OAD-2DC arms



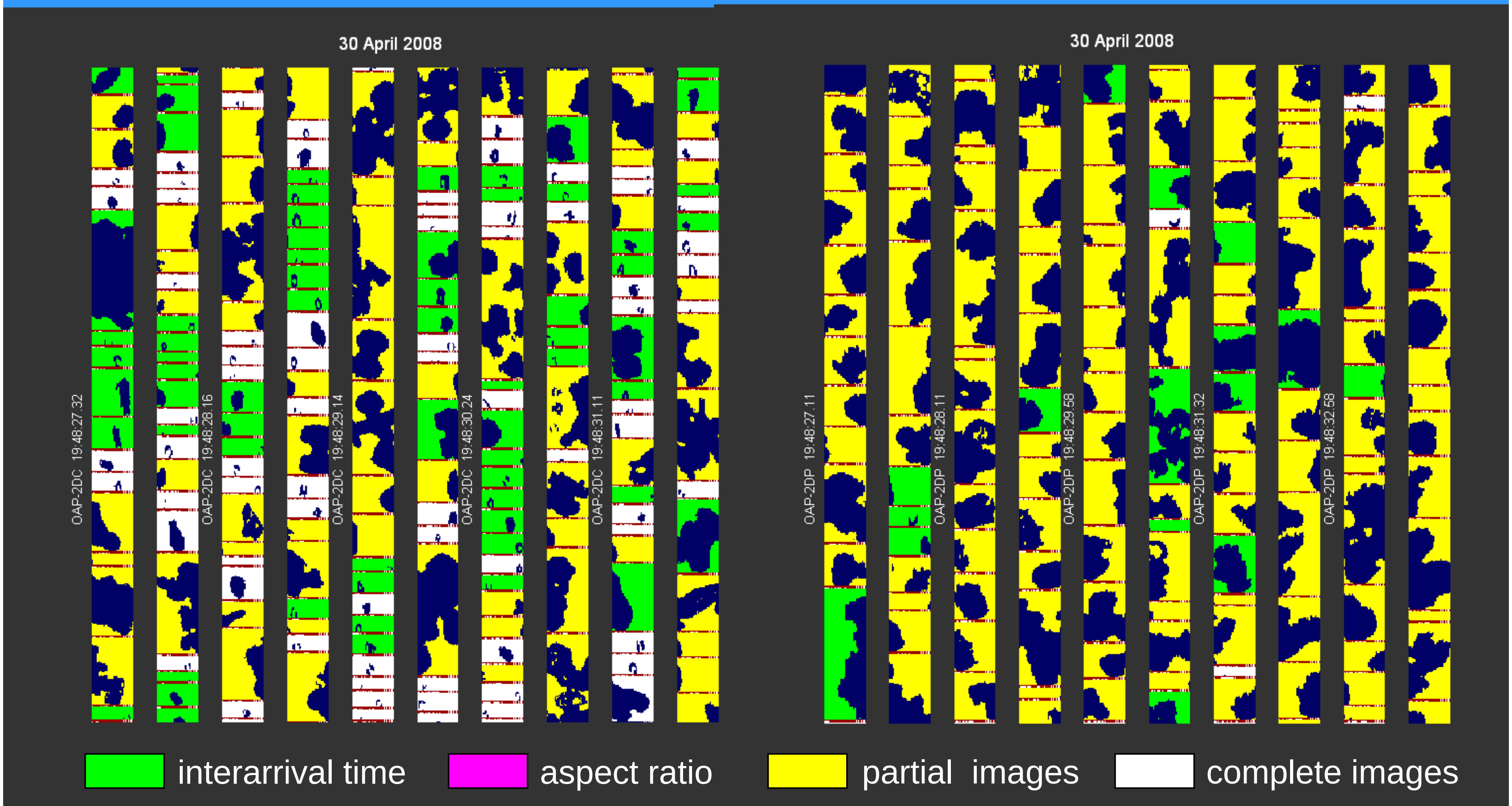
Modified OAD-2DC arms



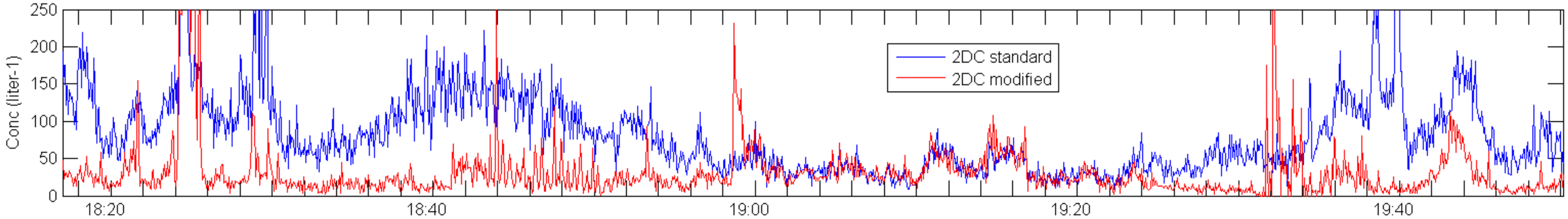
Rejected and accepted OAP-2DC images

τ_{rej}=1000 tics ⇔ ΔX=2.5cm

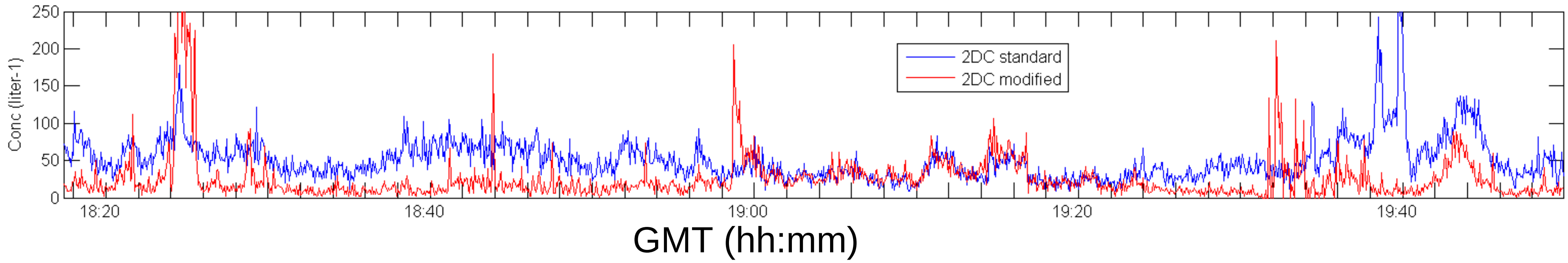
Standard OAD-2DC arms | **Modified OAD-2DC arms**



No corrections on shattering

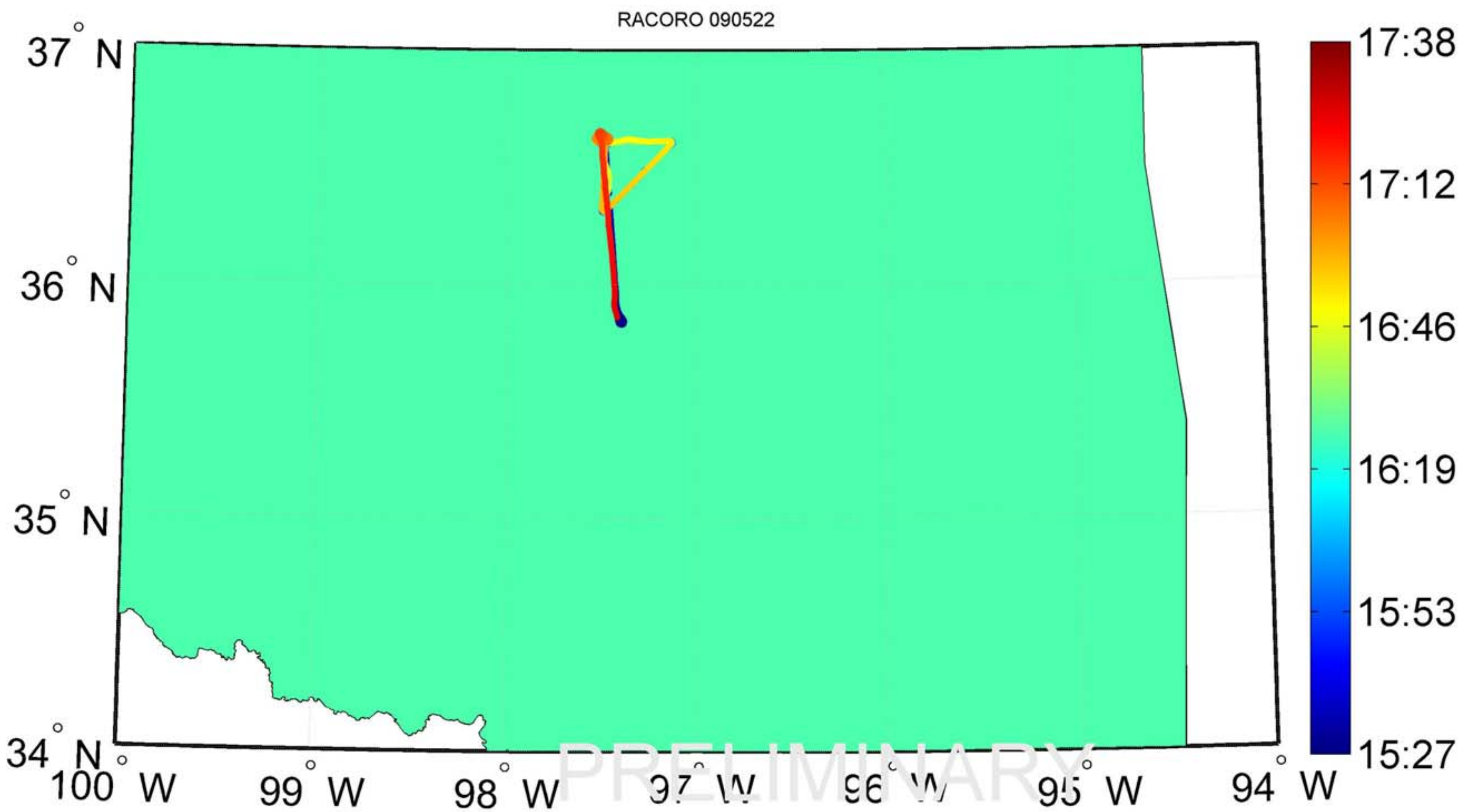


After corrections

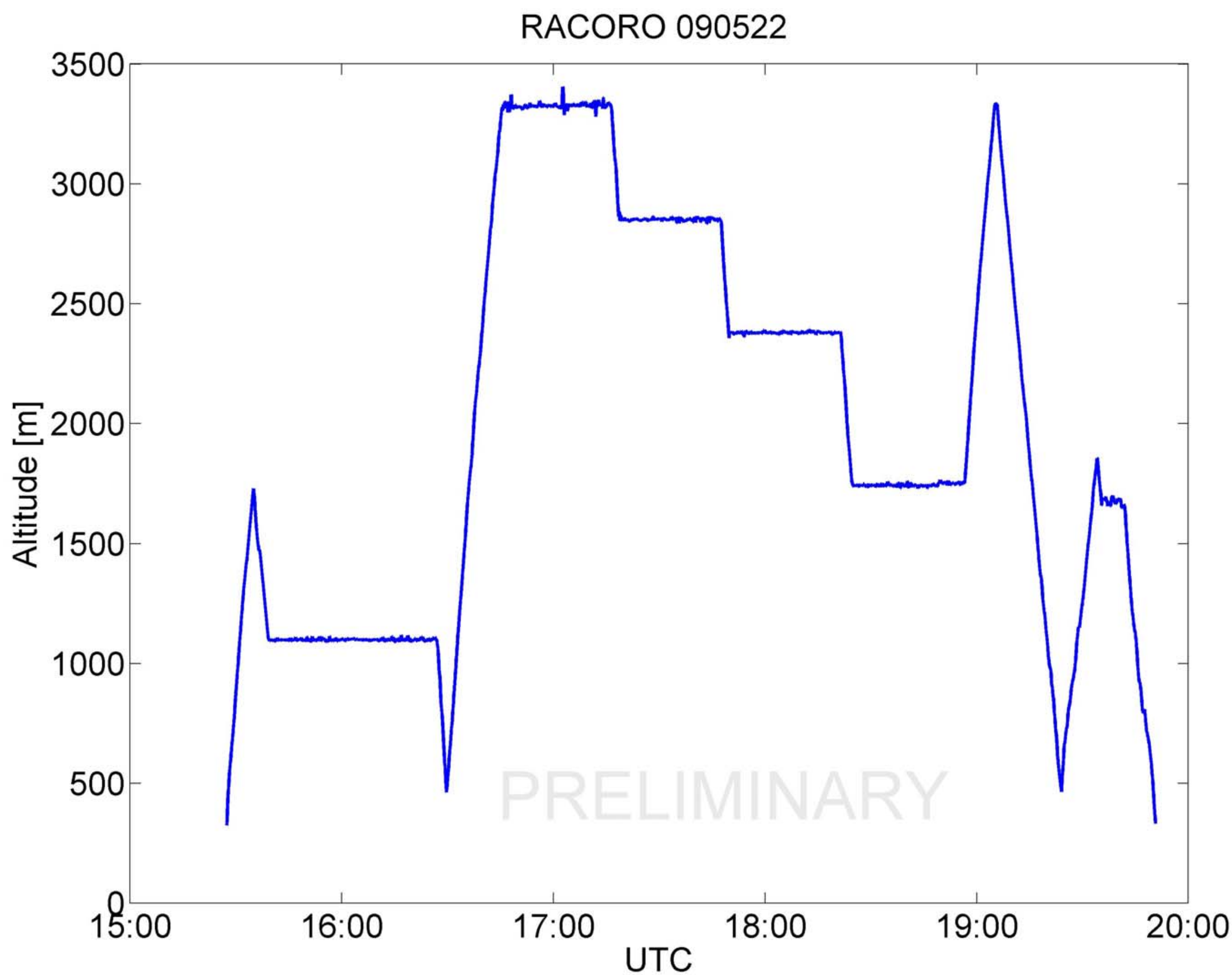


Field Products

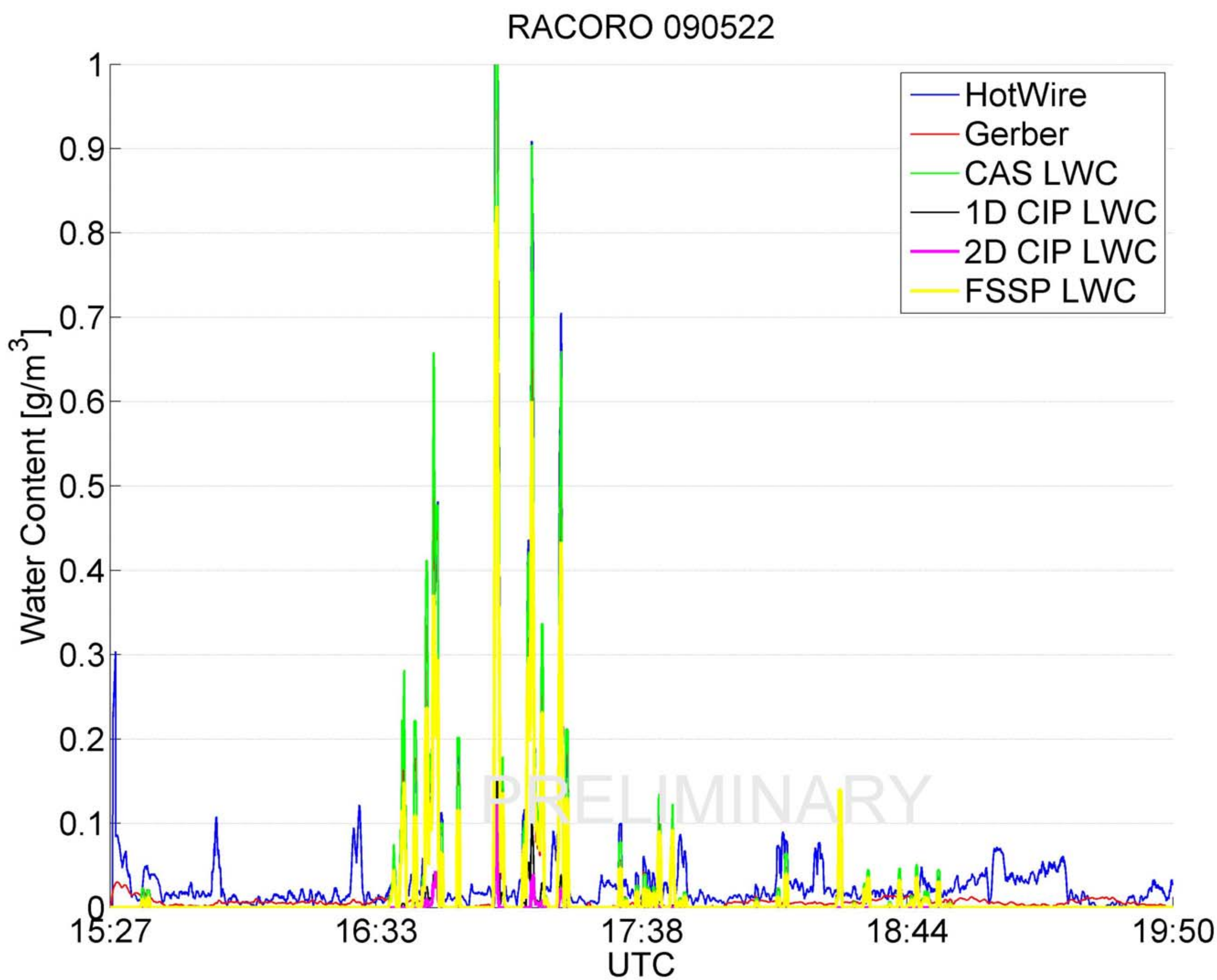
- It is critically important that we examine the data after each flight and report any problems that we see with the probes
- We will be making quick look products available on a web site after each flight



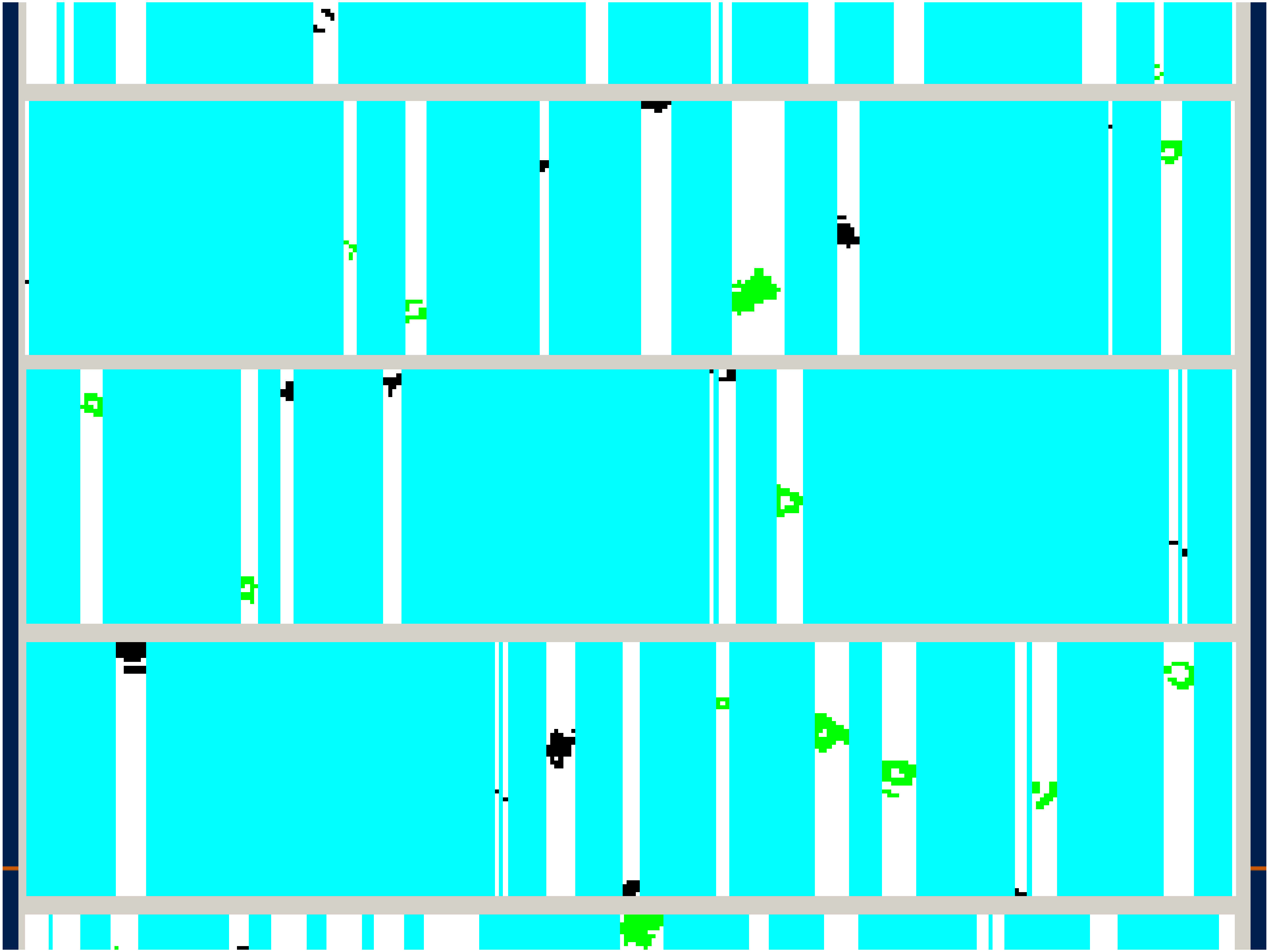
RACORO 090522
37° N
36° N
35° N
34° N
100° W
99° W
98° W
97° W
96° W
95° W
94° W
17:38
17:12
16:46
16:19
15:53
15:27
PRELIMINARY

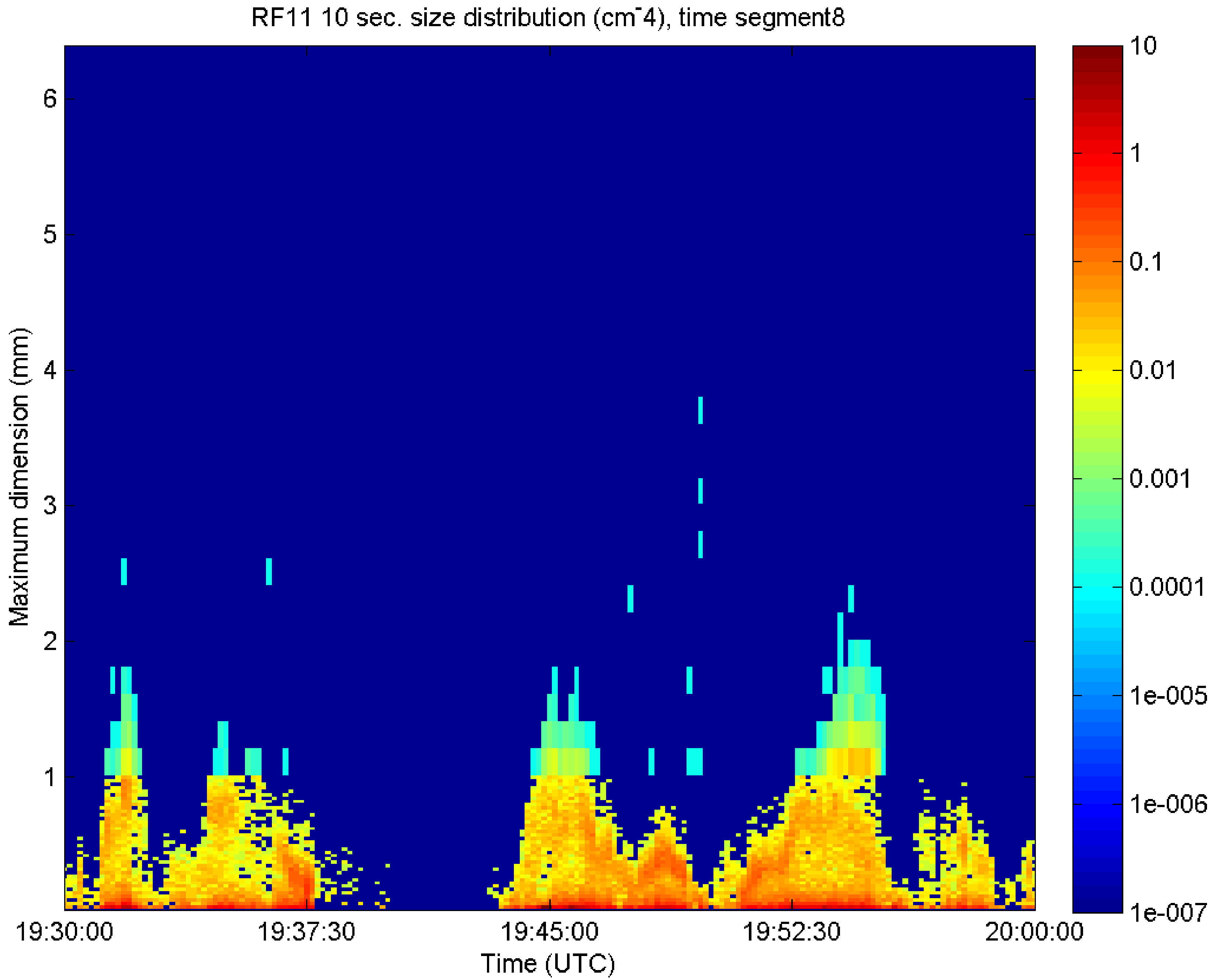


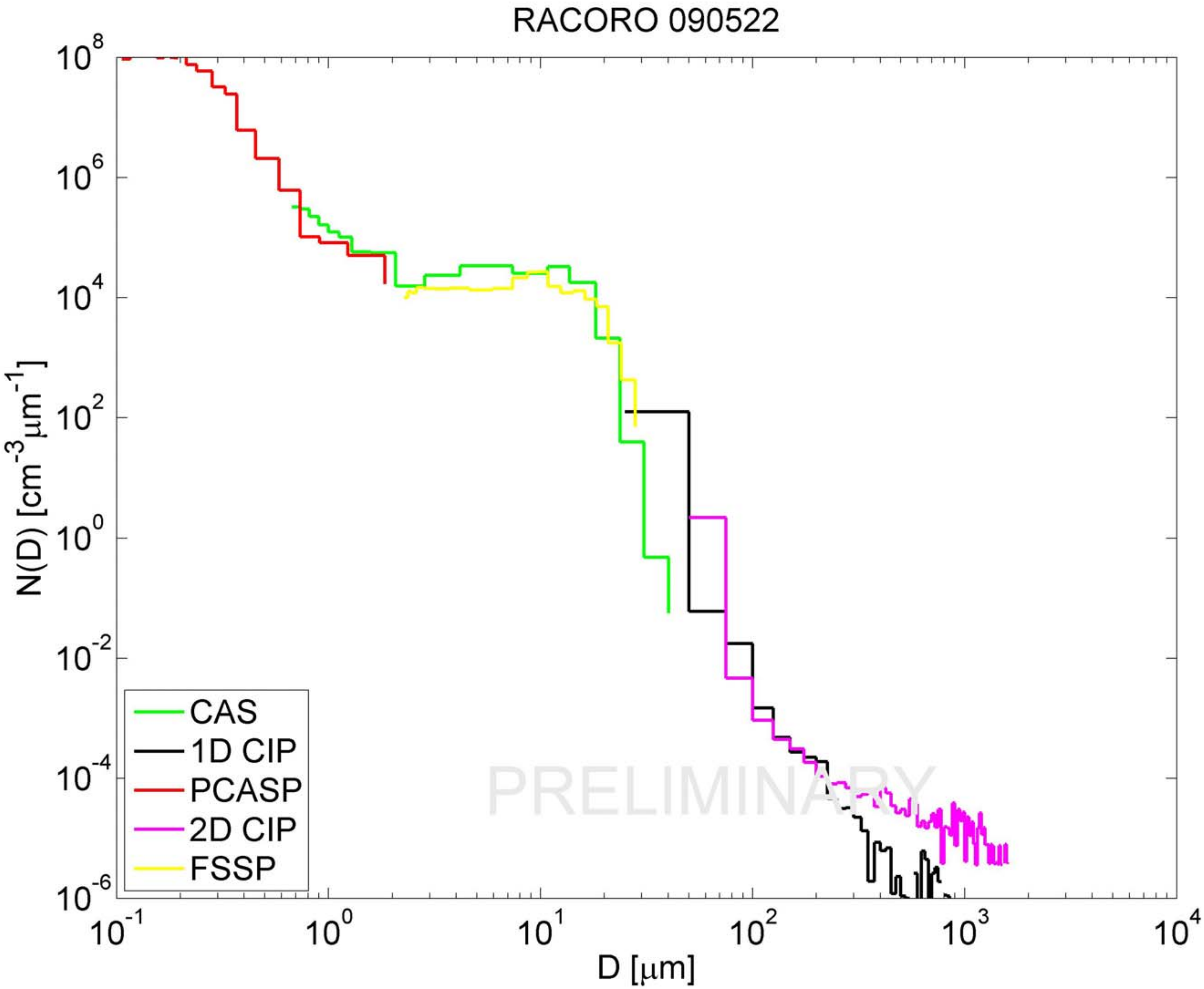
RACORO 090522
Altitude [m]
3500
3000
2500
2000
1500
1000
500
0
15:00
16:00
17:00
18:00
19:00
20:00
UTC
PRELIMINARY



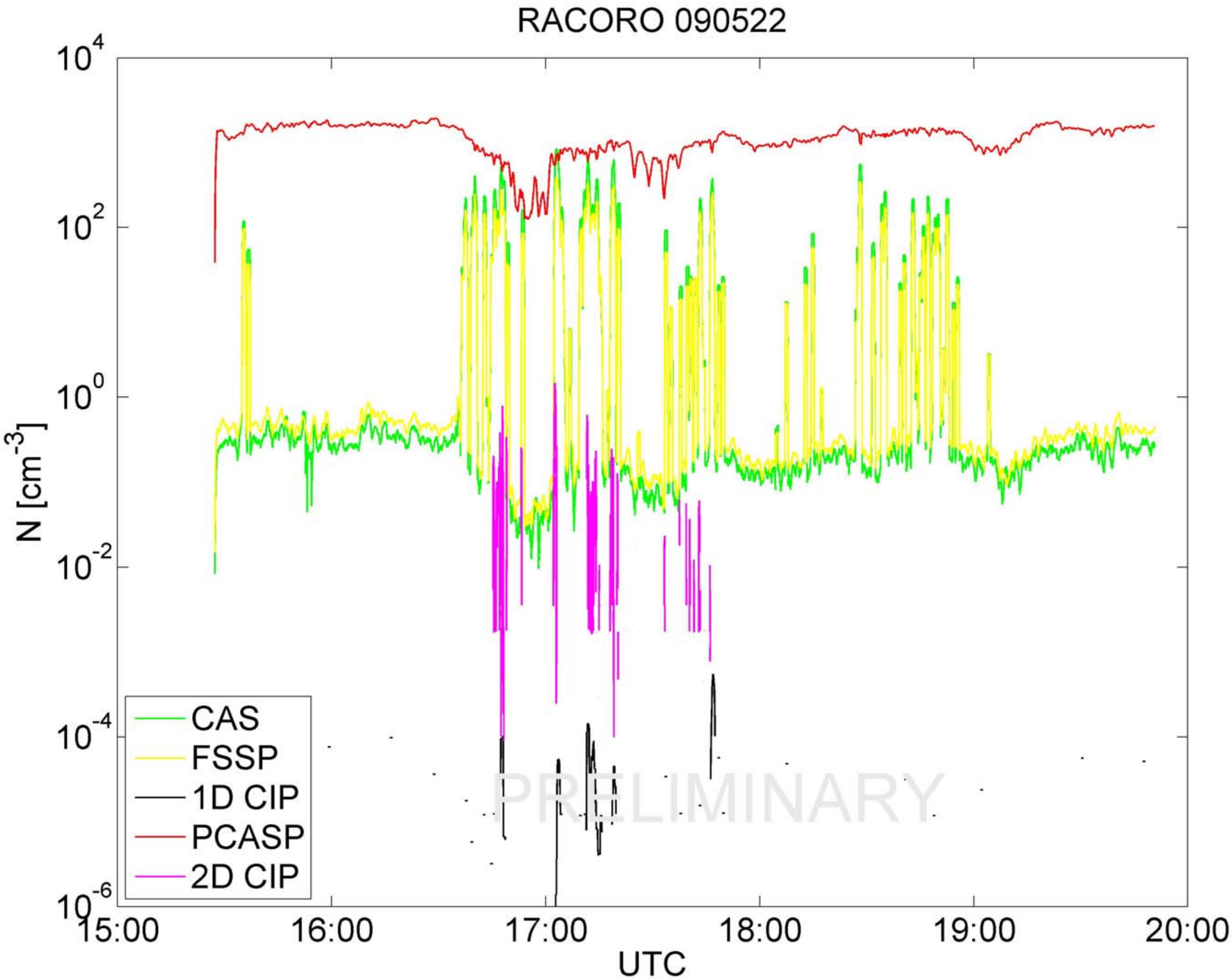
RACORO 090522
Water Content [g/m^3]
UTC
HotWire
Gerber
CAS LWC
1D CIP LWC
2D CIP LWC
FSSP LWC
PRELIMINARY
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
15:27
16:33
17:38
18:44
19:50




RF11 10 sec. size distribution (cm^-4), time segment8
Maximum dimension (mm)
6
5
4
3
2
1
19:30:00
19:37:30
19:45:00
19:52:30
20:00:00
Time (UTC)
10
1
0.1
0.01
0.001
0.0001
1e-005
1e-006
1e-007



RACORO 090522
N(D) [cm^{-3}μm^{-1}]
D [μm]
10^8
10^6
10^4
10^2
10^0
10^{-2}
10^{-4}
10^{-6}
10^{-1}
10^0
10^1
10^2
10^3
10^4
CAS
1D CIP
PCASP
2D CIP
FSSP
PRELIMINARY



RACORO 090522
10^4
10^2
10^0
10^{-2}
10^{-4}
10^{-6}
N [cm^{-3}]
15:00
16:00
17:00
18:00
19:00
20:00
UTC
CAS
FSSP
1D CIP
PCASP
2D CIP
PRELIMINARY