Hygroscopicity and Mixing State

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The Desert Research Institute (DRI) CCN spectrometers with 100+ channels of critical supersaturation, (S_c) resolution and greater, mainly low S_c range can resolve bimodality.

When compared with simultaneous dry particle spectra from a DMA/SMPS kappa can be determined.

This is done by overlaying the two spectra by transposing size to S_c by applying kappa. Kappa is then tuned to provide the best fit of the two spectra. This fit may vary over the S_c/size range.

But sometimes they cannot agree, especially at high S_c where some particles are too small or not hygroscopic enough to be detected by the CCN.

The difference between the spectra indicates external mixing. Agreement of the spectra indicates internal mixing or pure substance.

These measurements have time resolution of seconds, continuously.

The entire spectra are determined simultaneously in the DRI CCN spectrometers.

We present surface data from SGP, May 2003

Aircraft data from MASE, off central California,
July 2005

ICE-T Caribbean, July 2011

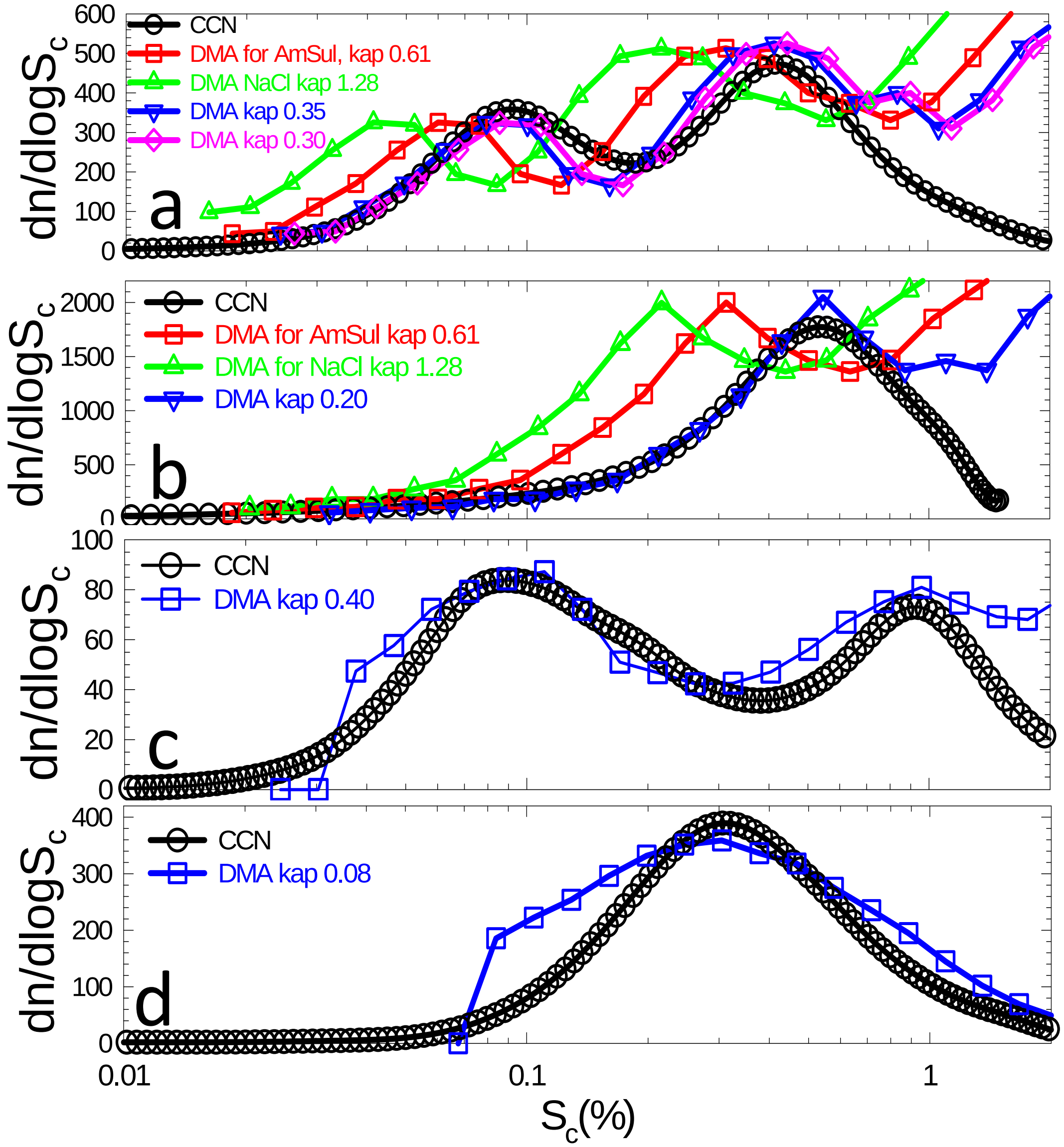
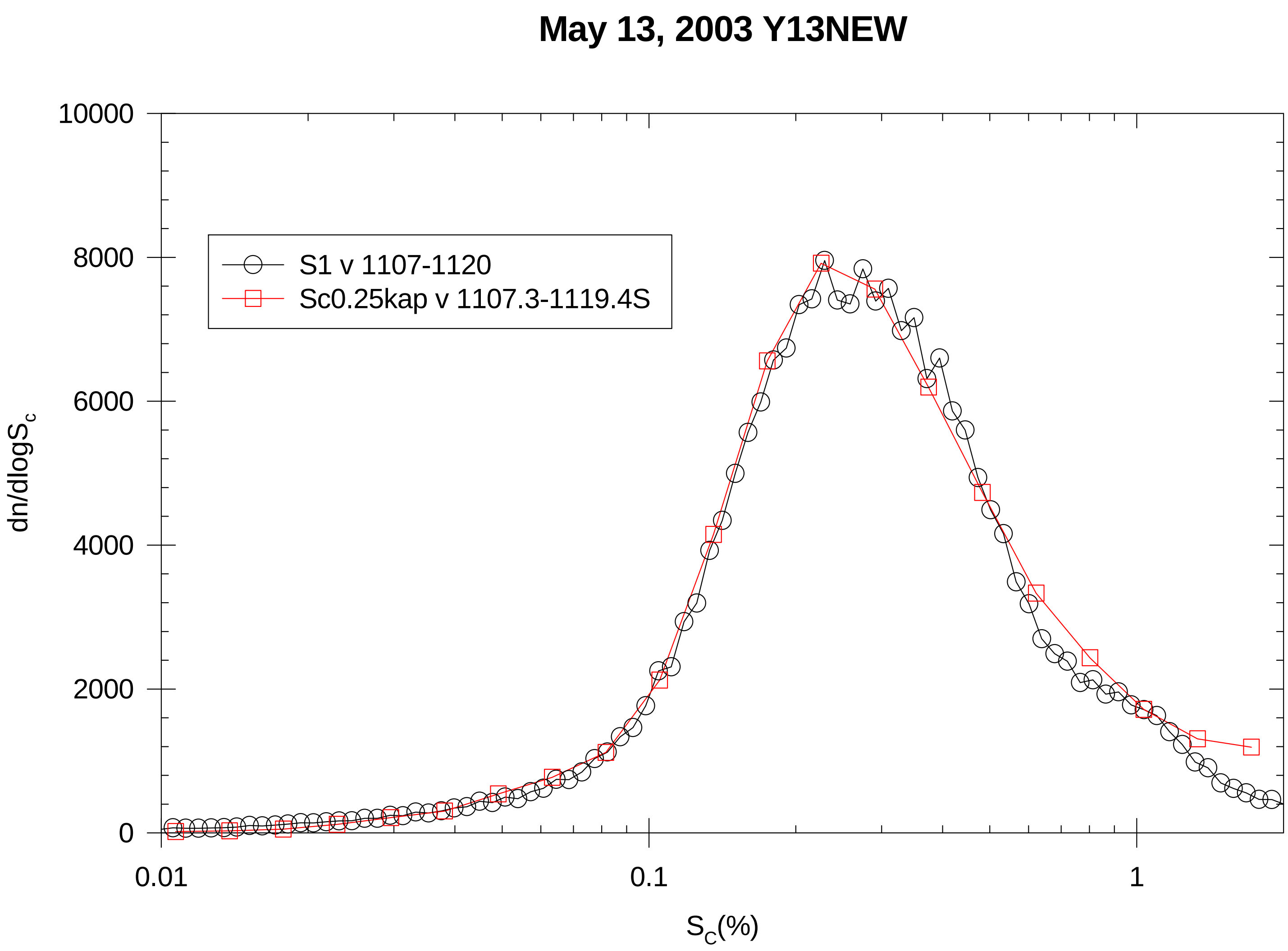
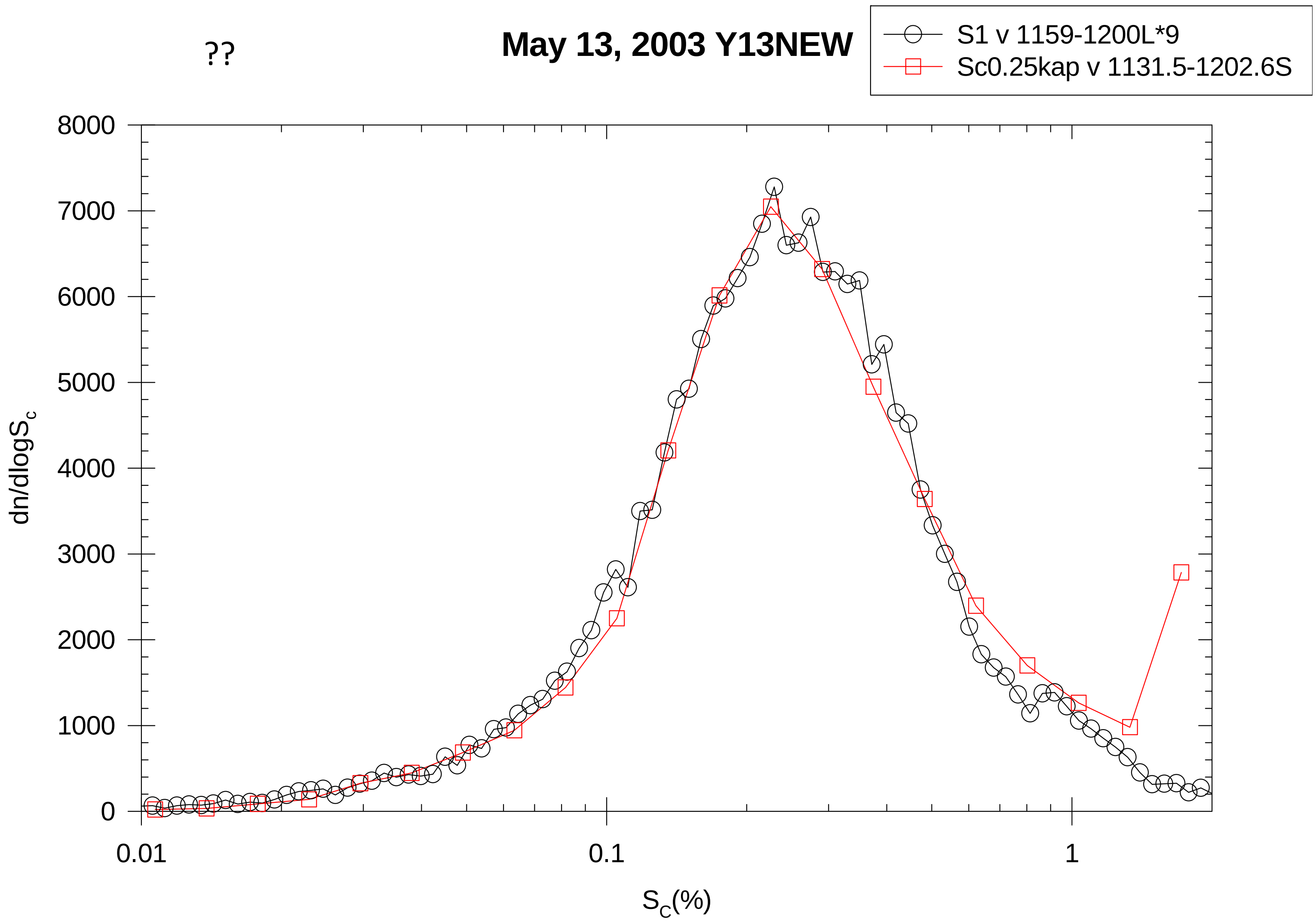
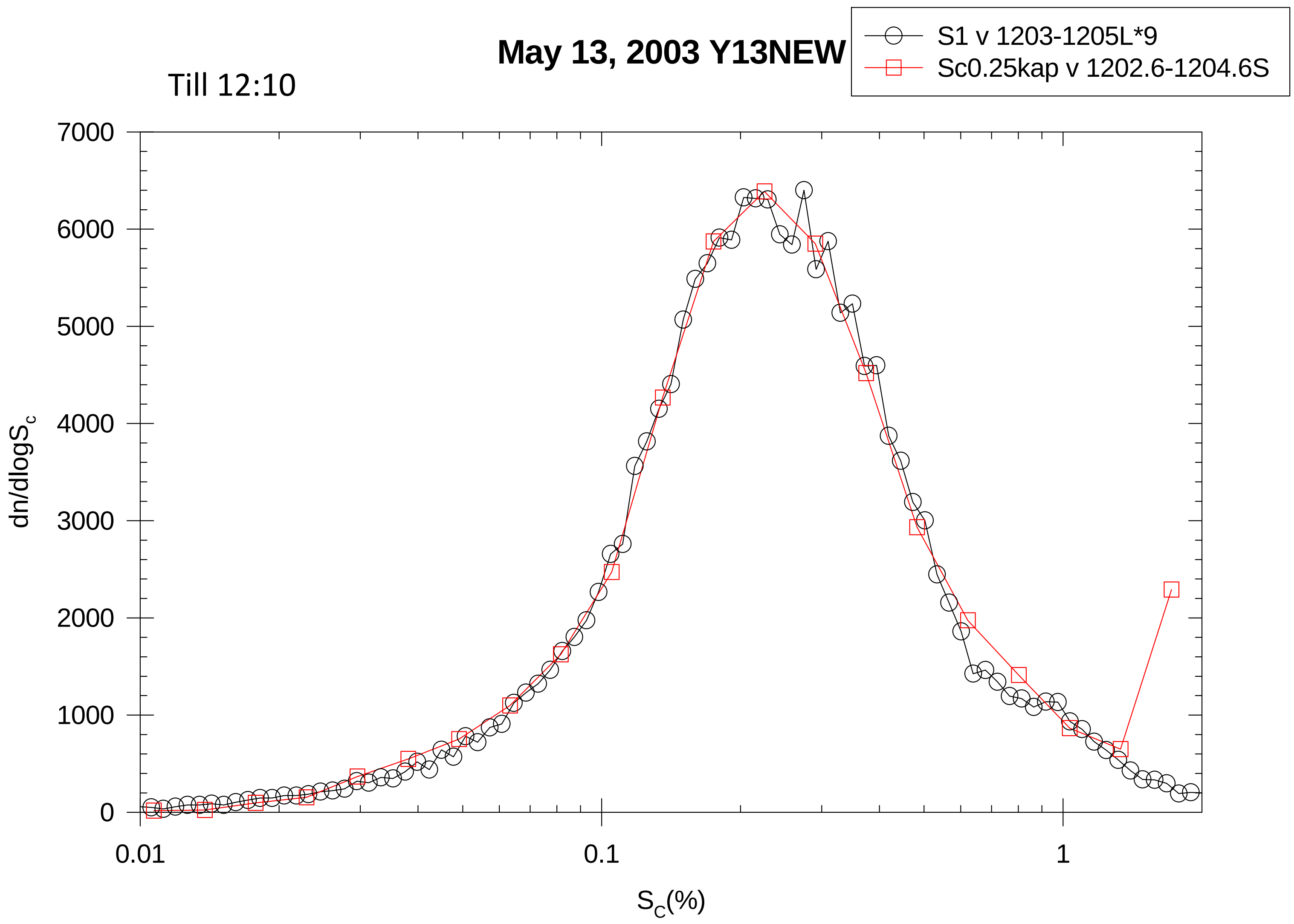


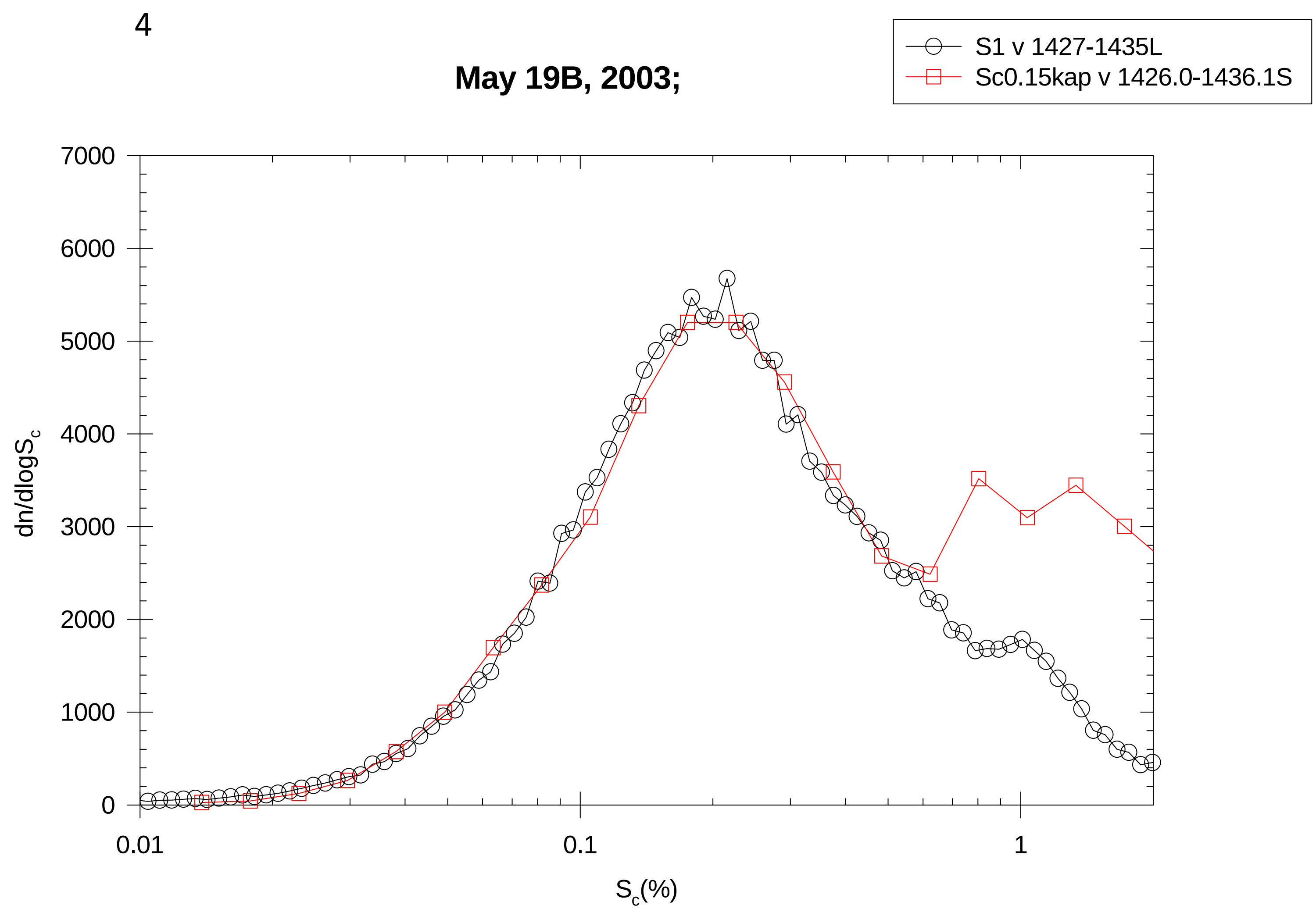
Fig. 1. Differential CCN and DMA concentrations plotted against critical S (S_c). DMA sizes transposed to S_c by assuming a κ (kap). **a and b** show measurements under polluted stratus clouds off the central California coast; MASE. Panel a shows a bimodal spectrum where κ 0.35 provides the best fit of the DMA data with CCN spectra for the higher S_c mode (right), whereas κ 0.30 provides the best fit for the lower S_c mode (cloud-processed). Hoppel minimum indicates S_{eff} 0.20. Panel b shows a monomodal spectrum where κ 0.20 provides the best agreement with the CCN data. **c and d** are associated with Caribbean cumuli; ICE-T. Hoppel minimum indicates S_{eff} 0.40% in panel c.

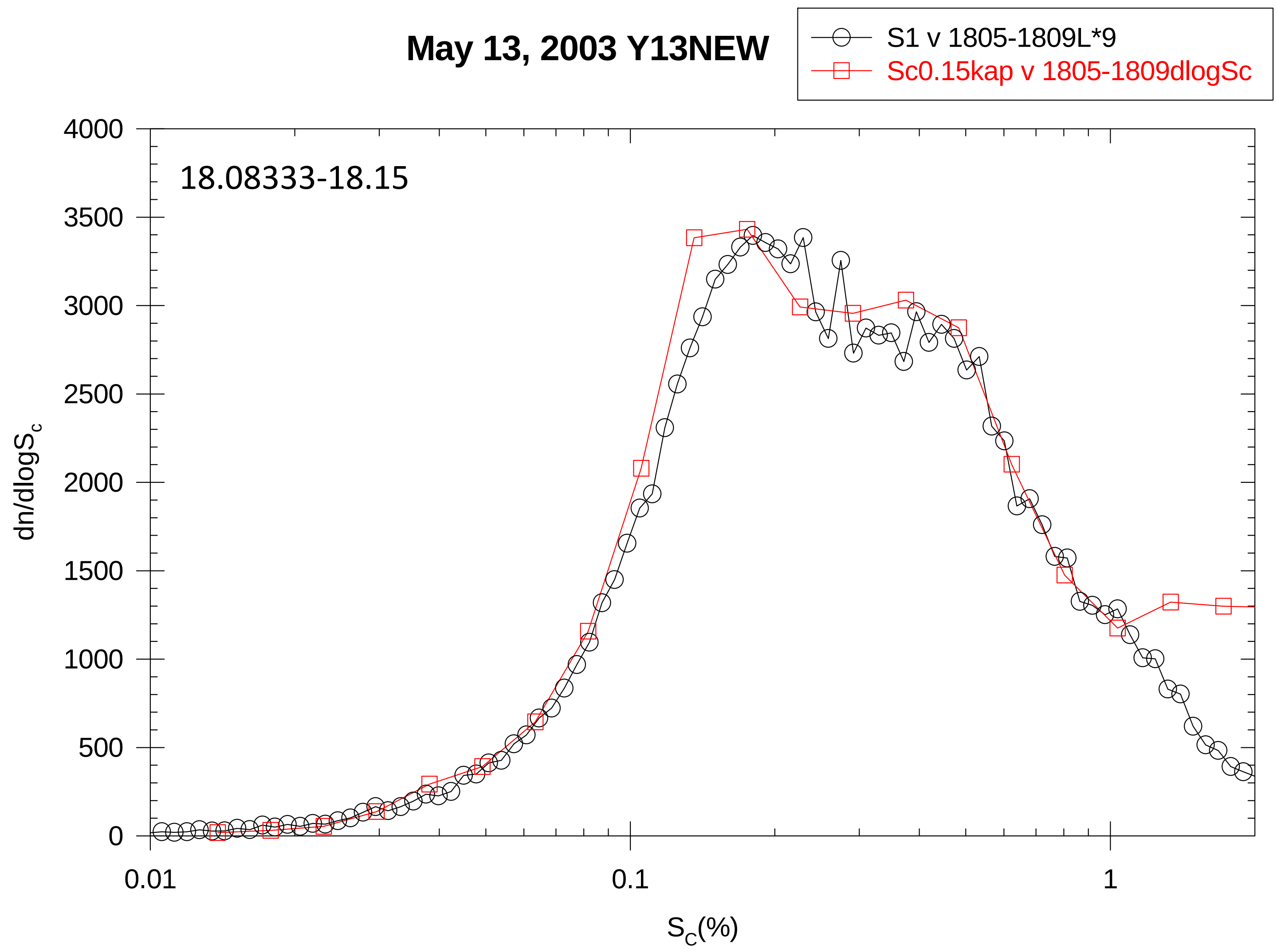

May 13, 2003 Y13NEW
S1 v 1107-1120
Sc0.25kap v 1107.3-1119.4S
dn/dlogS_c
S_C(%)
10000
8000
6000
4000
2000
0
0.01
0.1
1


??
May 13, 2003 Y13NEW
S1 v 1159-1200L*9
Sc0.25kap v 1131.5-1202.6S
dn/dlogS_c
0
1000
2000
3000
4000
5000
6000
7000
8000
0.01
0.1
1
S_C(%)

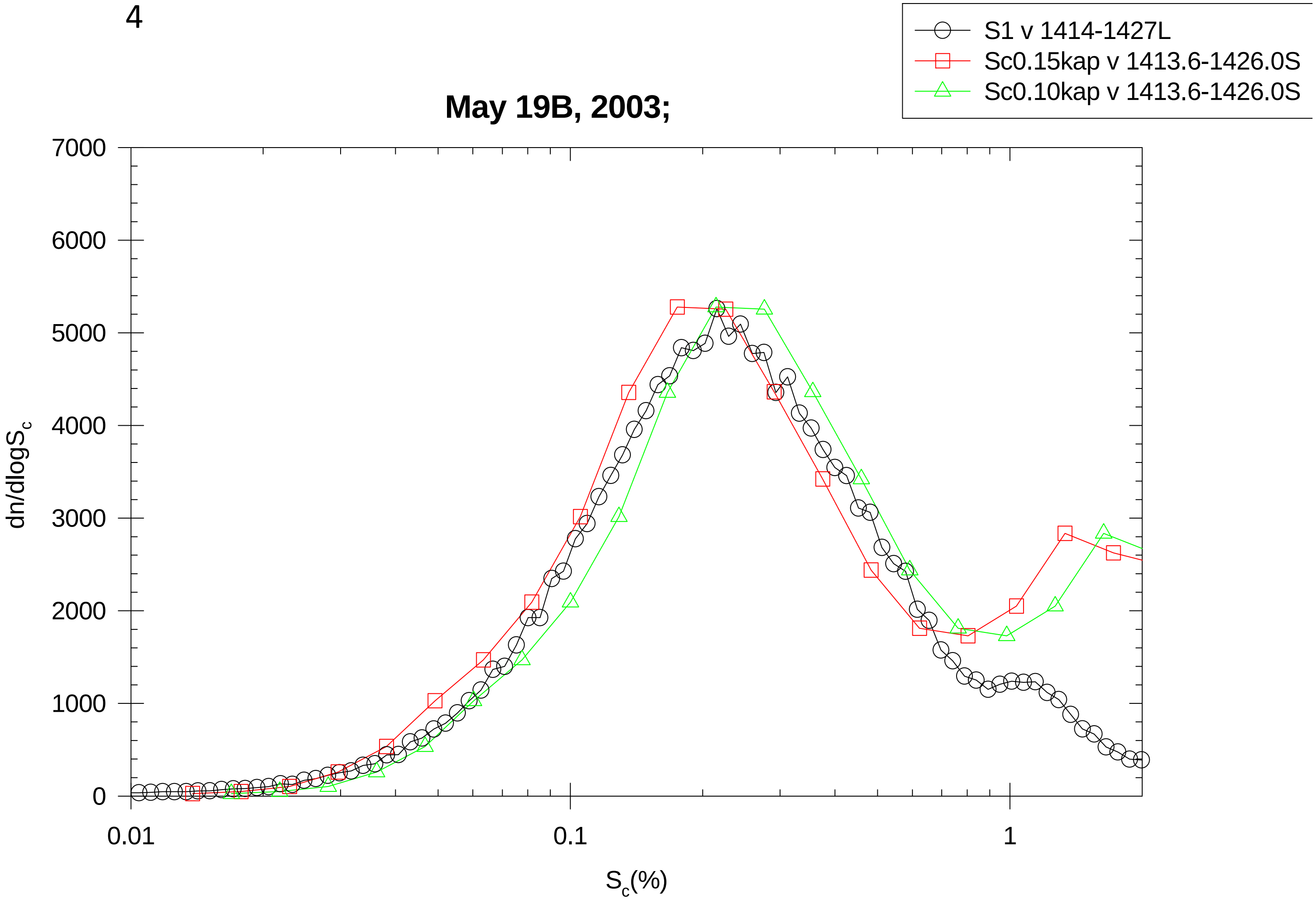


May 13, 2003 Y13NEW
Till 12:10
S1 v 1203-1205L*9
Sc0.25kap v 1202.6-1204.6S
dn/dlogS$_c$
S_C(%)
7000
6000
5000
4000
3000
2000
1000
0
0.01
0.1
1


4
May 19B, 2003;
S1 v 1427-1435L
Sc0.15kap v 1426.0-1436.1S
7000
6000
5000
4000
3000
2000
1000
0
dn/dlogSc
0.01
0.1
1
Sc(%)

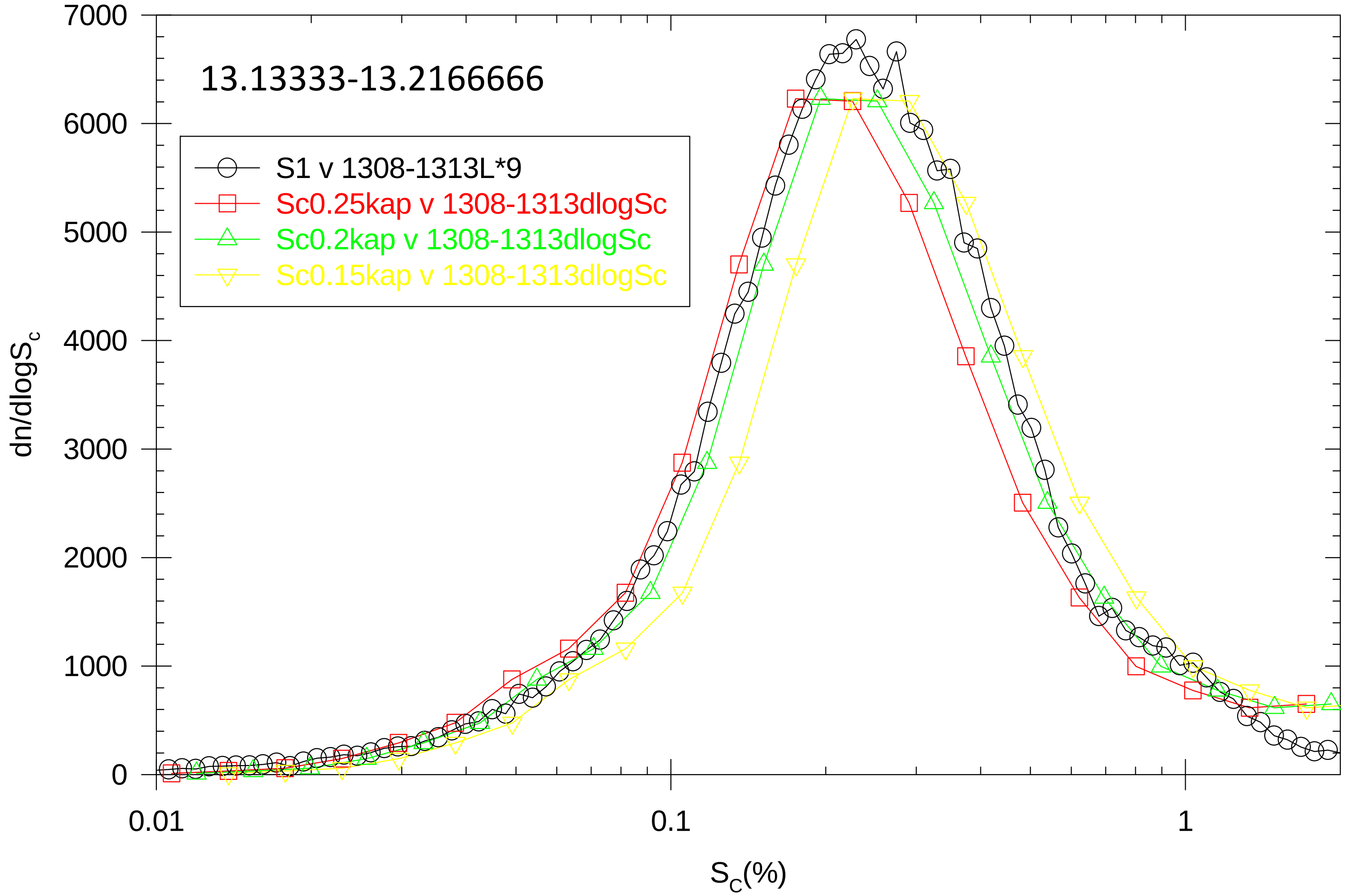

May 13, 2003 Y13NEW
S1 v 1805-1809L*9
Sc0.15kap v 1805-1809dlogSc
18.08333-18.15
dn/dlogSc
Sc(%)
4000
3500
3000
2500
2000
1500
1000
500
0
0.01
0.1
1

4

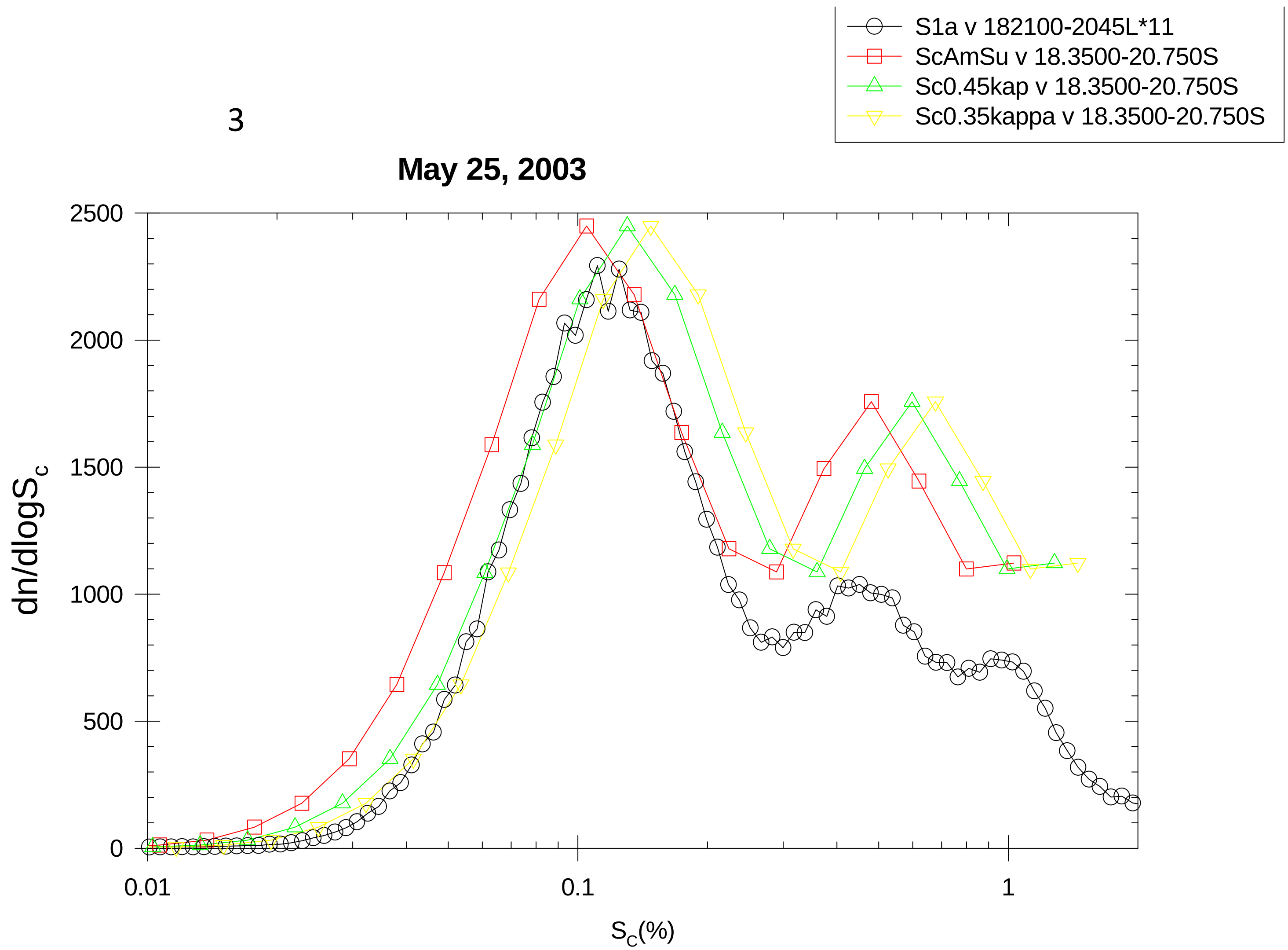


May 19B, 2003;
S1 v 1414-1427L
Sc0.15kap v 1413.6-1426.0S
Sc0.10kap v 1413.6-1426.0S
dn/dlogSc
0
1000
2000
3000
4000
5000
6000
7000
0.01
0.1
1
Sc(%)

May 13, 2003 Y13NEW

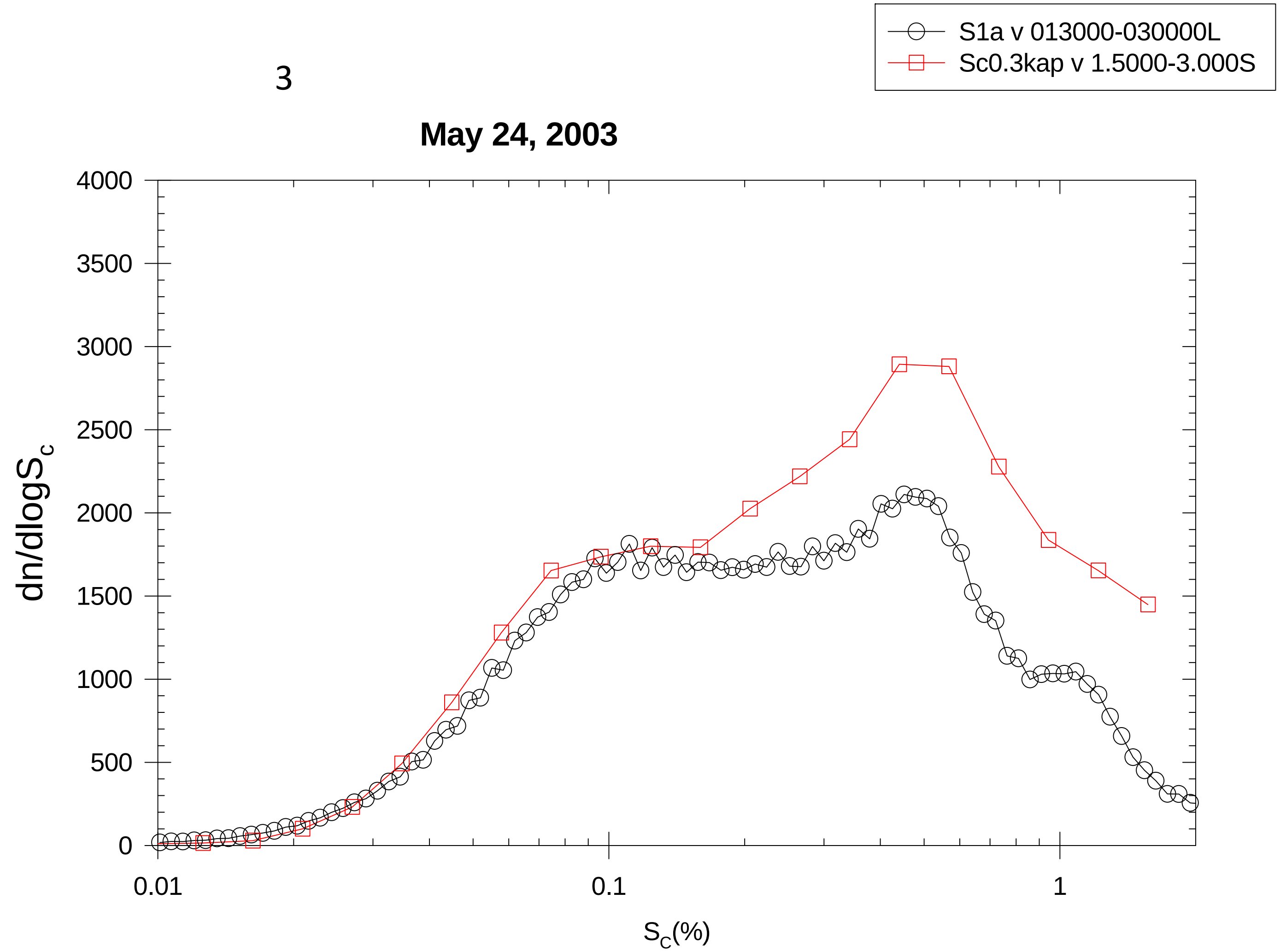


3

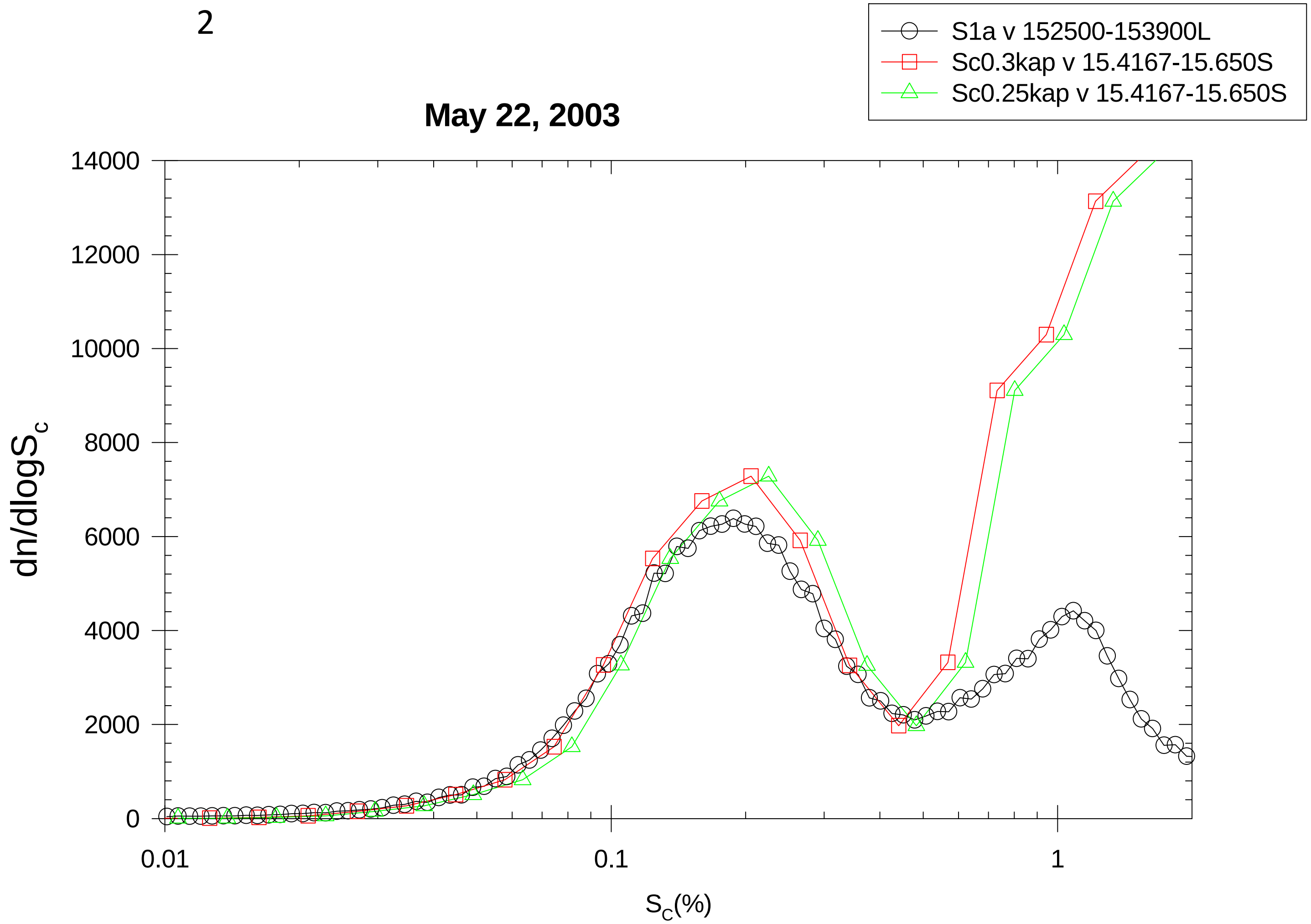


May 25, 2003
S1a v 182100-2045L*11
ScAmSu v 18.3500-20.750S
Sc0.45kap v 18.3500-20.750S
Sc0.35kappa v 18.3500-20.750S
2500
2000
1500
1000
500
0
dn/dlogS$_c$
0.01
0.1
1
S$_C$(%)

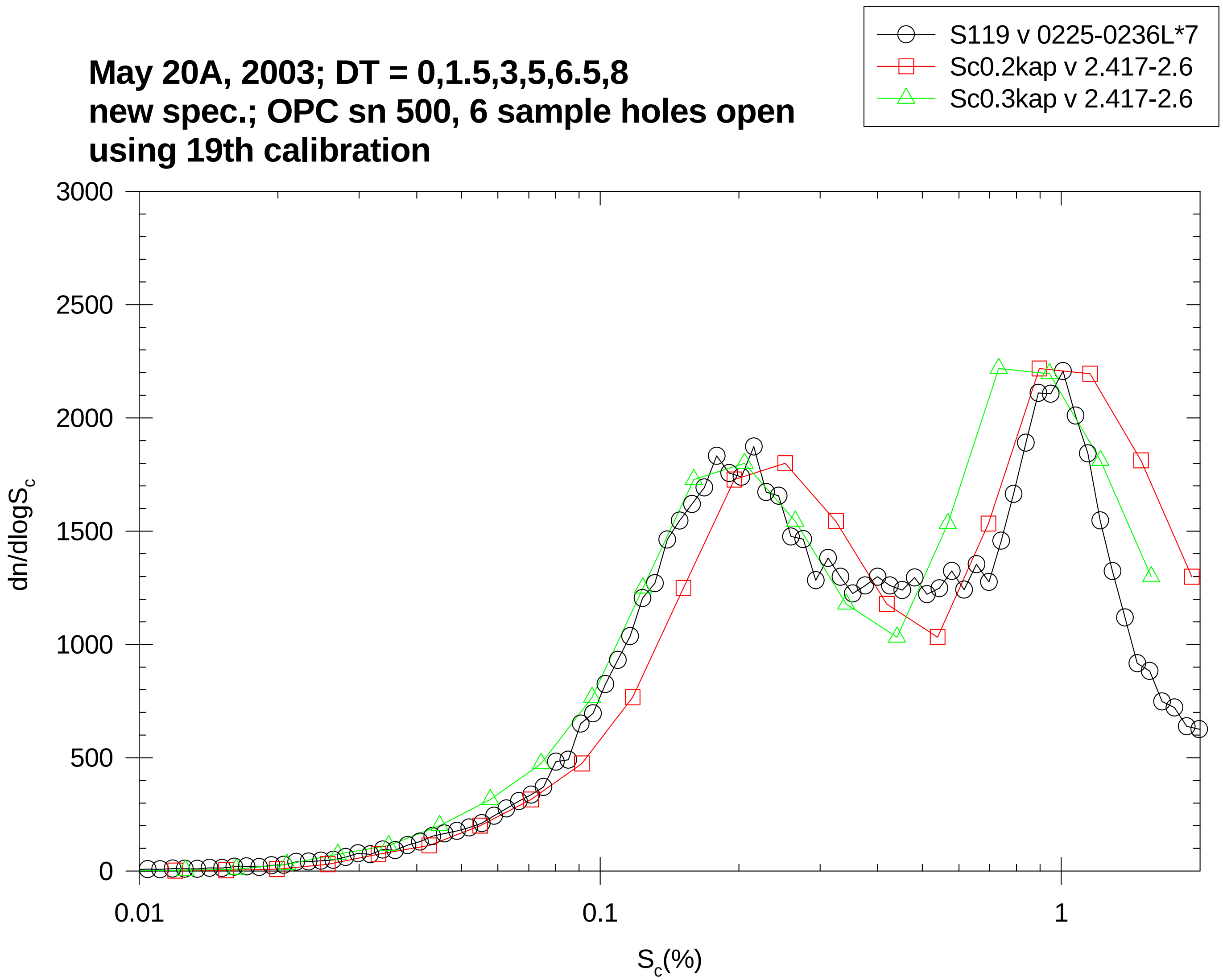
3

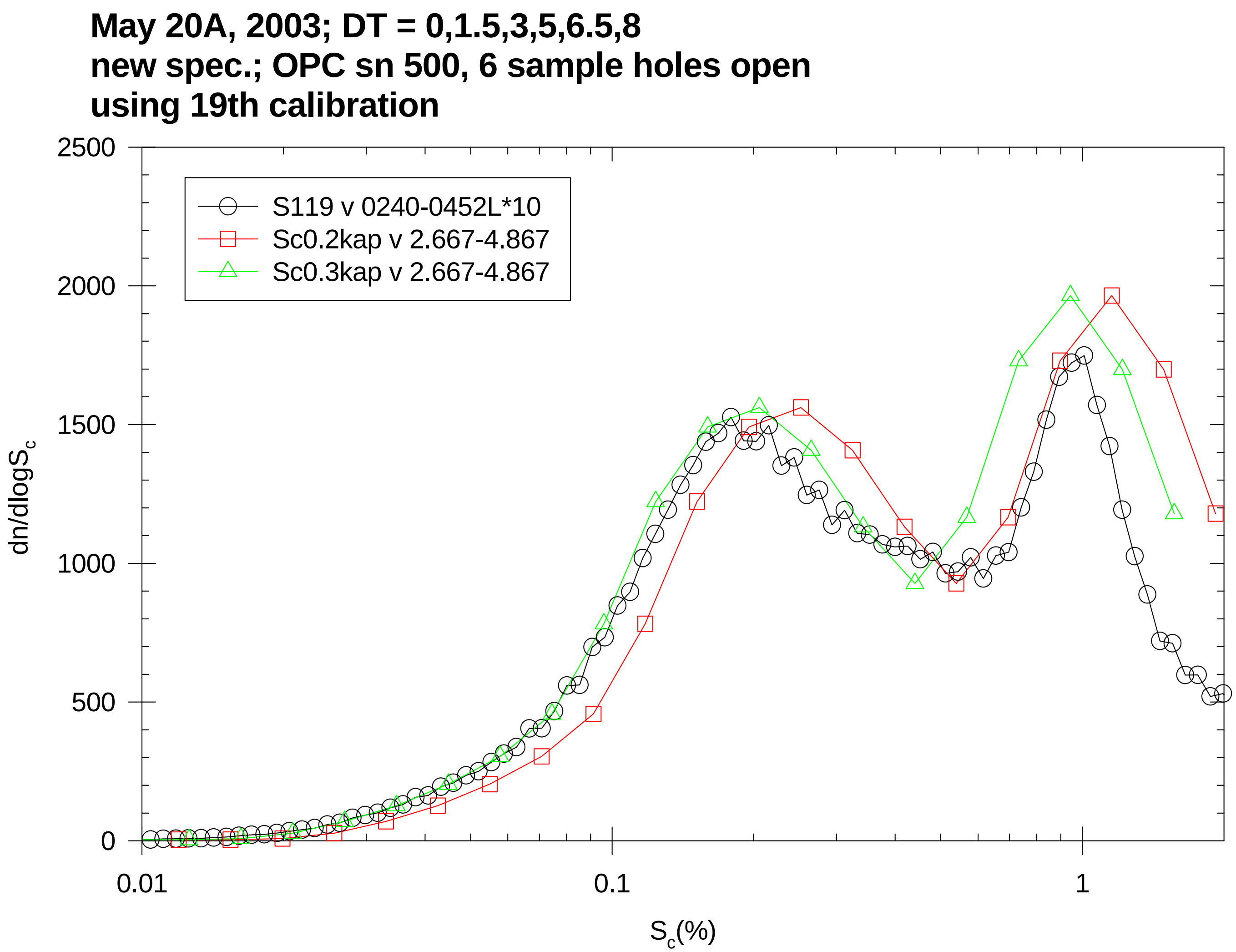

S1a v 013000-030000L
Sc0.3kap v 1.5000-3.000S
May 24, 2003
dn/dlogS$_c$
4000
3500
3000
2500
2000
1500
1000
500
0
0.01
0.1
1
S$_C$(%)

2



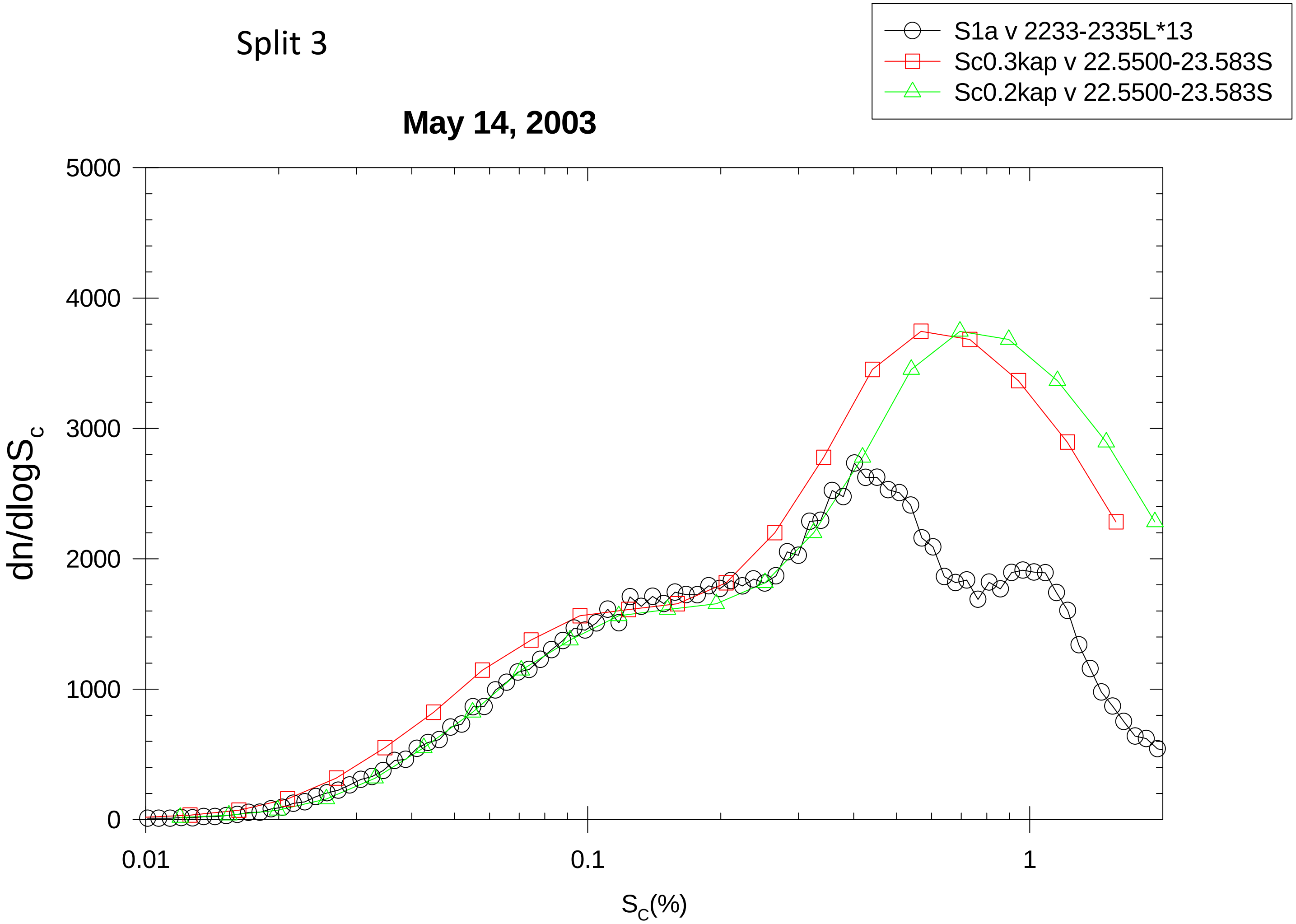
S1a v 152500-153900L
Sc0.3kap v 15.4167-15.650S
Sc0.25kap v 15.4167-15.650S
May 22, 2003
14000
12000
10000
8000
6000
4000
2000
0
dn/dlogS$_c$
0.01
0.1
1
S$_C$(%)


May 20A, 2003; DT = 0,1.5,3,5,6.5,8
new spec.; OPC sn 500, 6 sample holes open
using 19th calibration
S119 v 0225-0236L*7
Sc0.2kap v 2.417-2.6
Sc0.3kap v 2.417-2.6
dn/dlogS$_c$
S$_c$(%)
3000
2500
2000
1500
1000
500
0
0.01
0.1
1

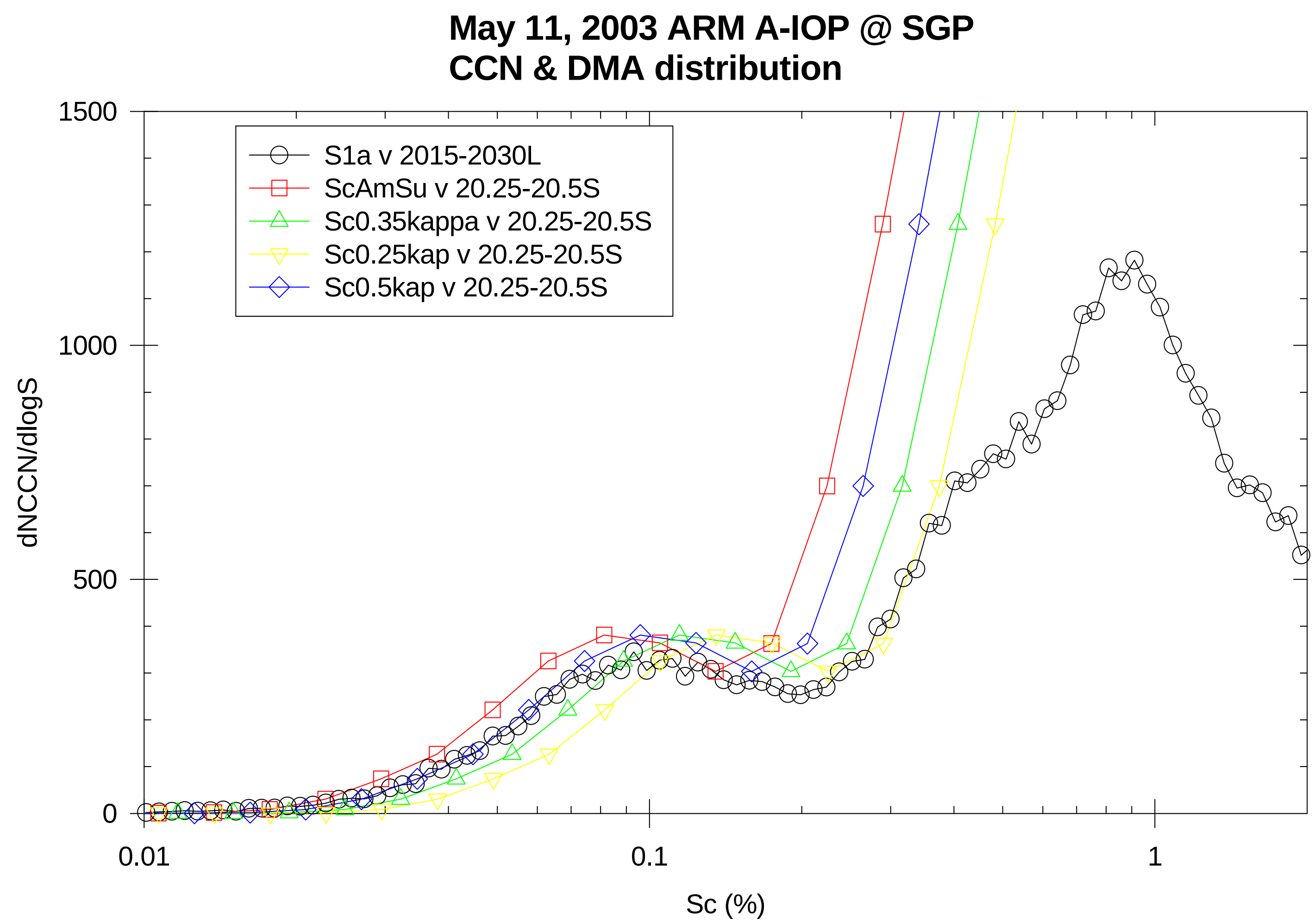


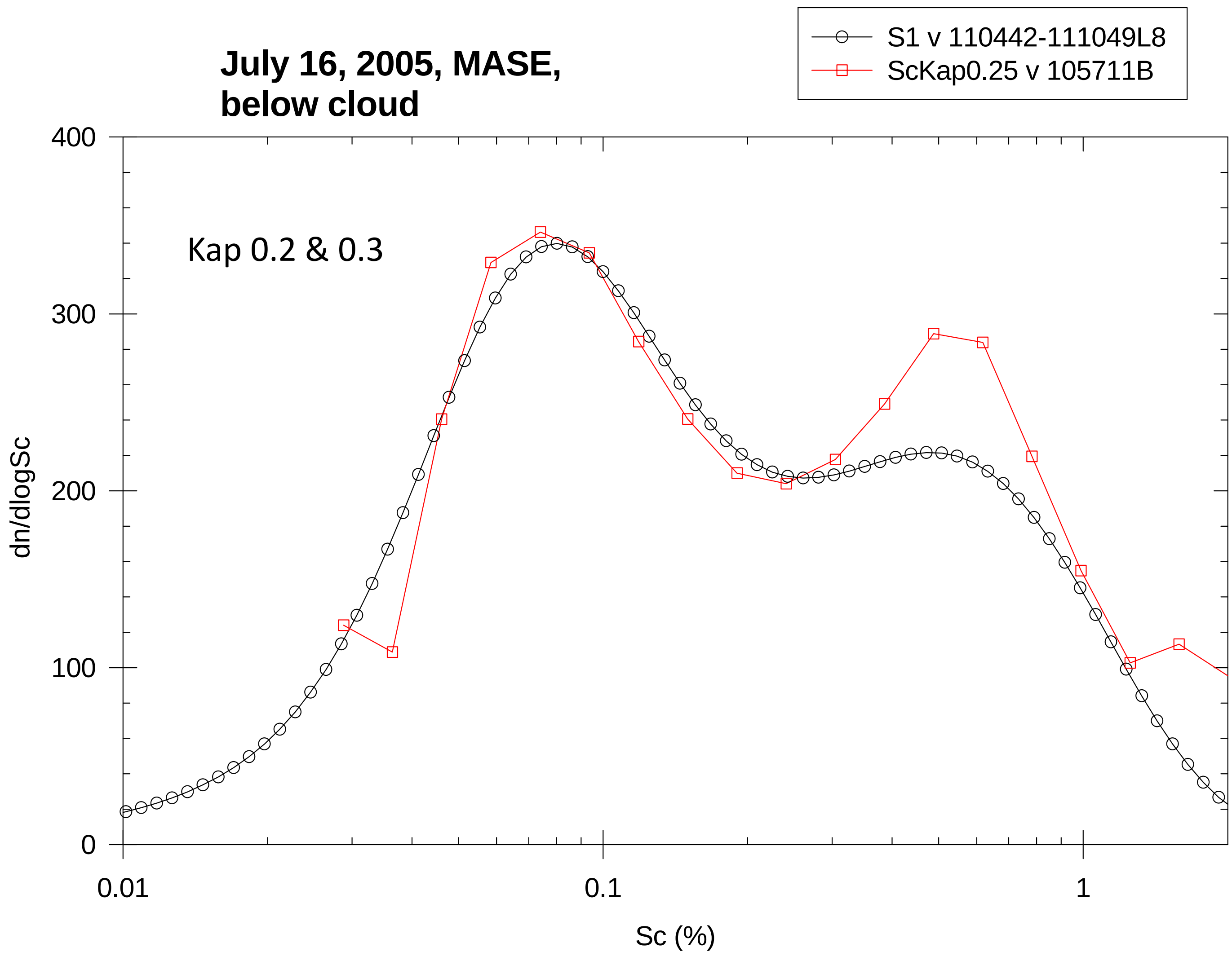
May 20A, 2003; DT = 0,1.5,3,5,6.5,8
new spec.; OPC sn 500, 6 sample holes open
using 19th calibration
S119 v 0240-0452L*10
Sc0.2kap v 2.667-4.867
Sc0.3kap v 2.667-4.867
dn/dlogS$_c$
S$_c$(%)
2500
2000
1500
1000
500
0
0.01
0.1
1

Split 3



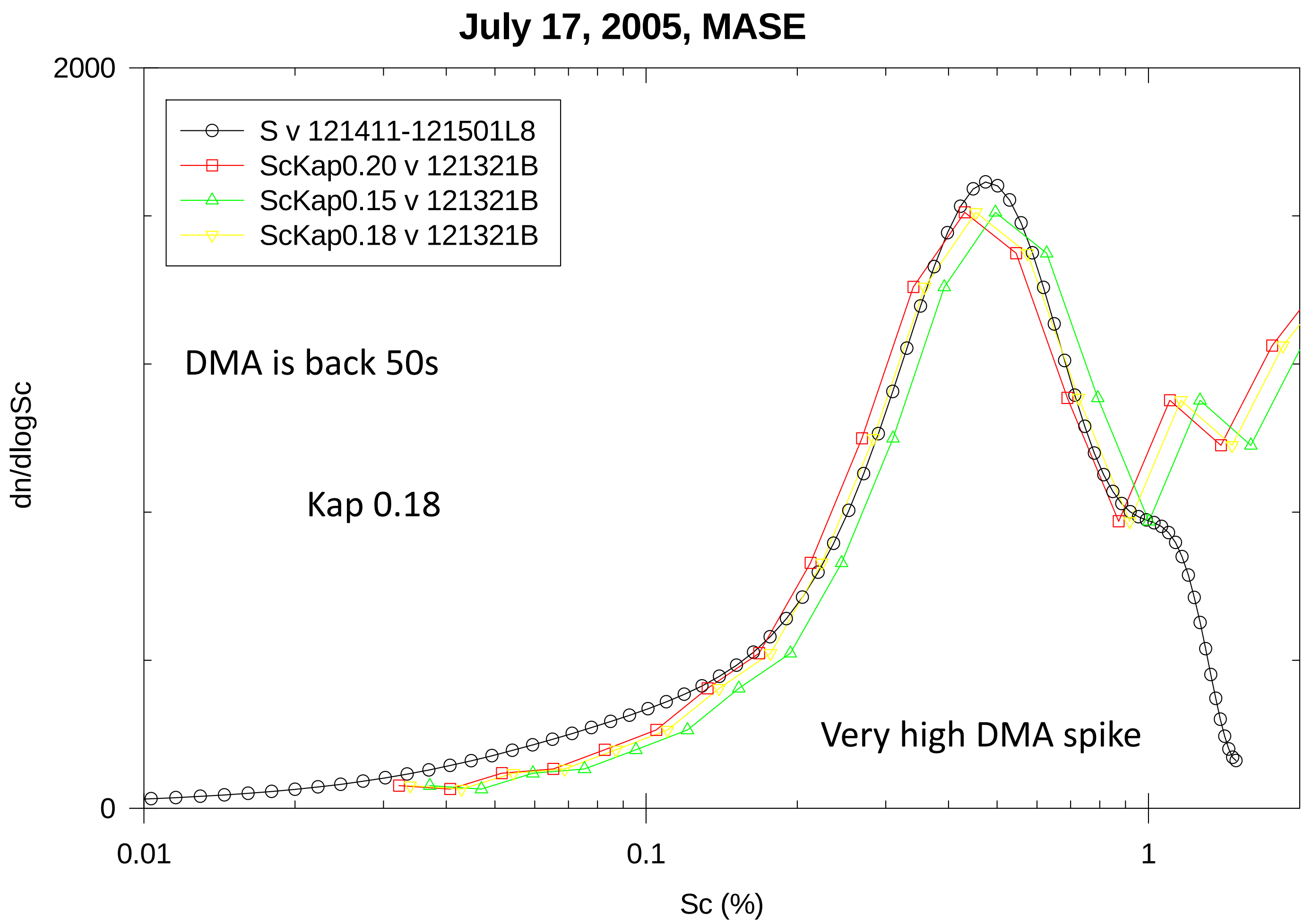
May 14, 2003
S1a v 2233-2335L*13
Sc0.3kap v 22.5500-23.583S
Sc0.2kap v 22.5500-23.583S
5000
4000
3000
2000
1000
0
dn/dlogS$_c$
0.01
0.1
1
S$_C$(%)


May 11, 2003 ARM A-IOP @ SGP
CCN & DMA distribution
S1a v 2015-2030L
ScAmSu v 20.25-20.5S
Sc0.35kappa v 20.25-20.5S
Sc0.25kap v 20.25-20.5S
Sc0.5kap v 20.25-20.5S
dNCCN/dlogS
Sc (%)
1500
1000
500
0
0.01
0.1
1



July 16, 2005, MASE,
below cloud
S1 v 110442-111049L8
ScKap0.25 v 105711B
Kap 0.2 & 0.3
400
300
200
100
0
dn/dlogSc
0.01
0.1
1
Sc (%)

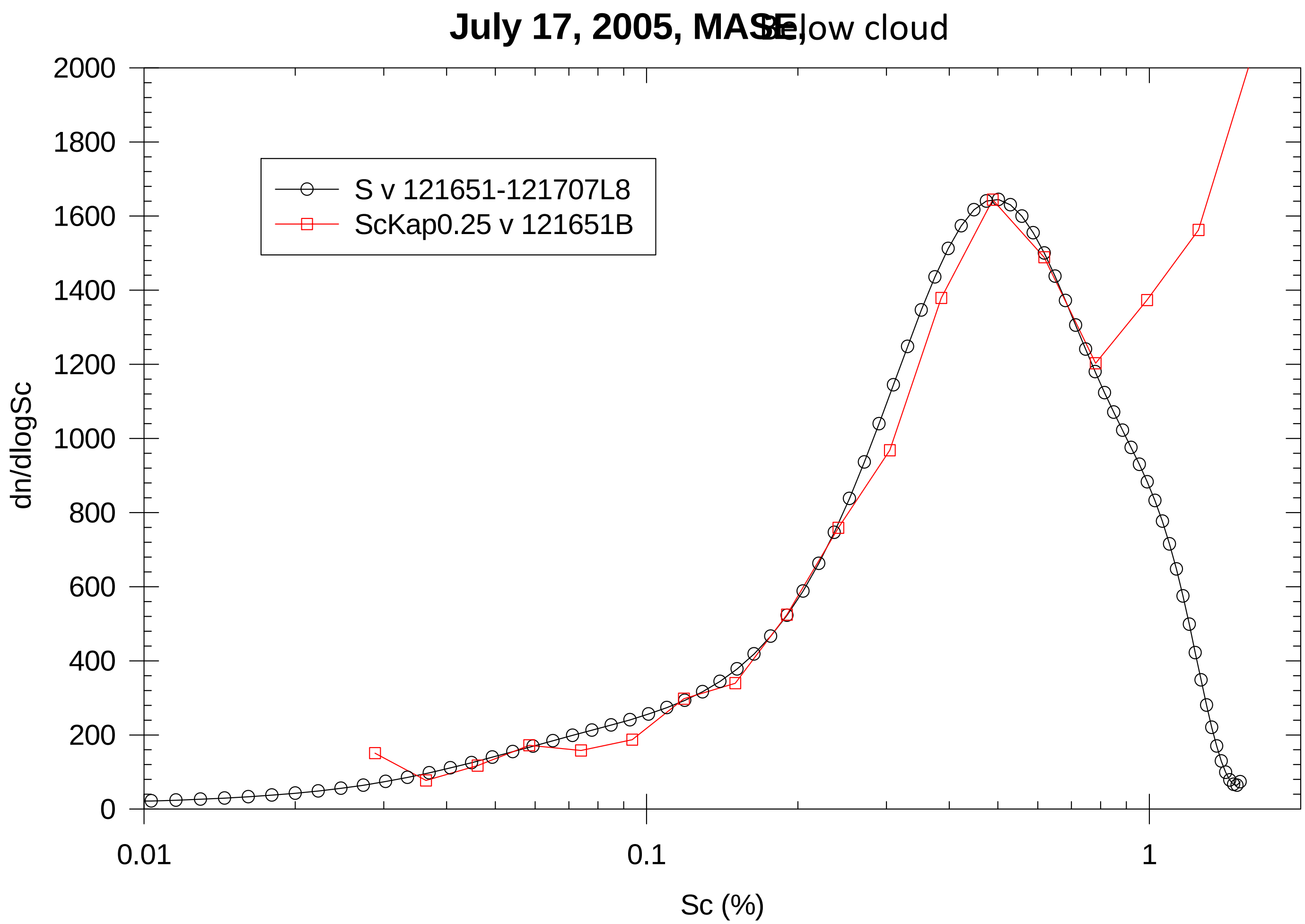
Below cloud



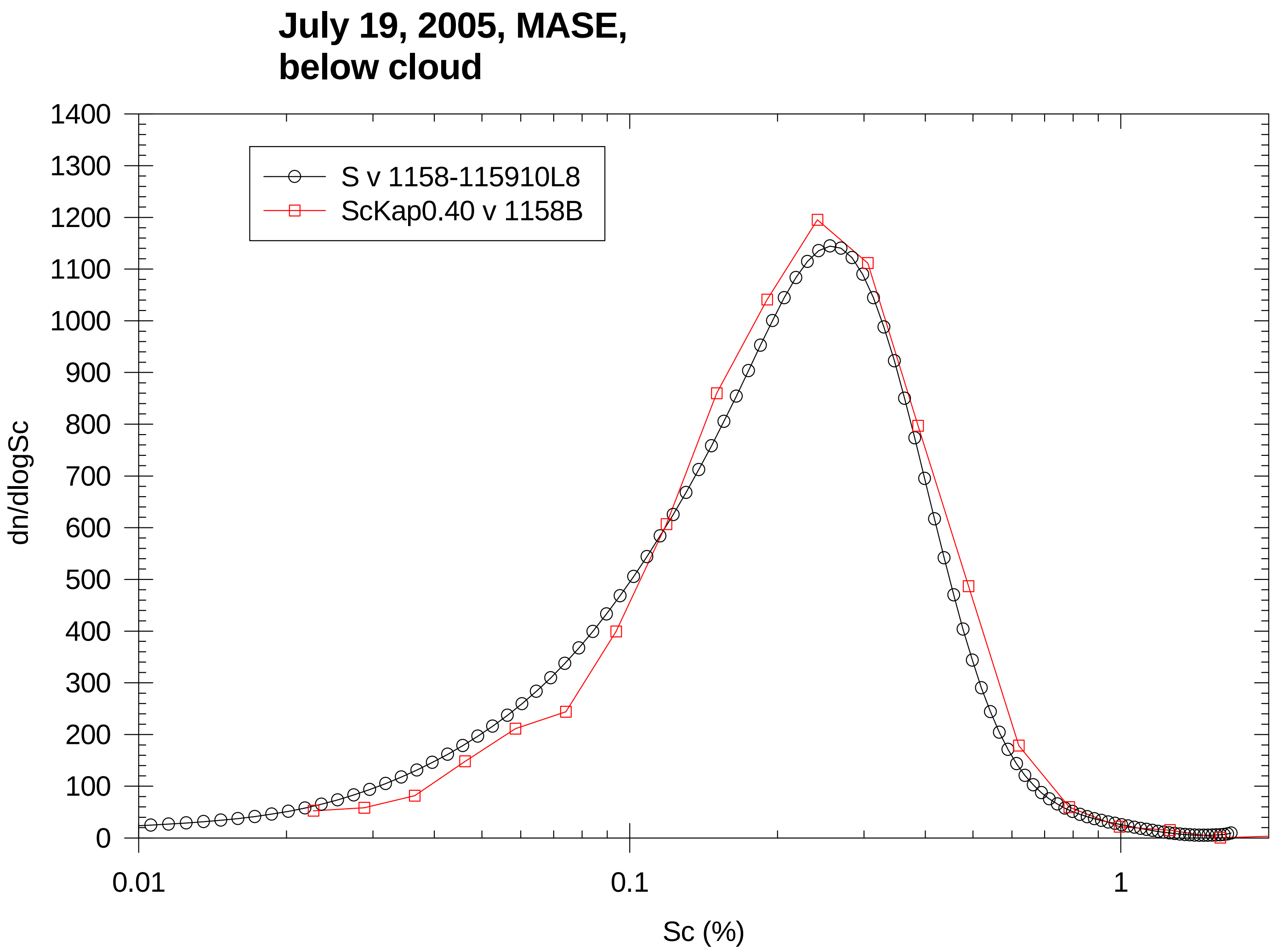
DMA is back 50s

Kap 0.18

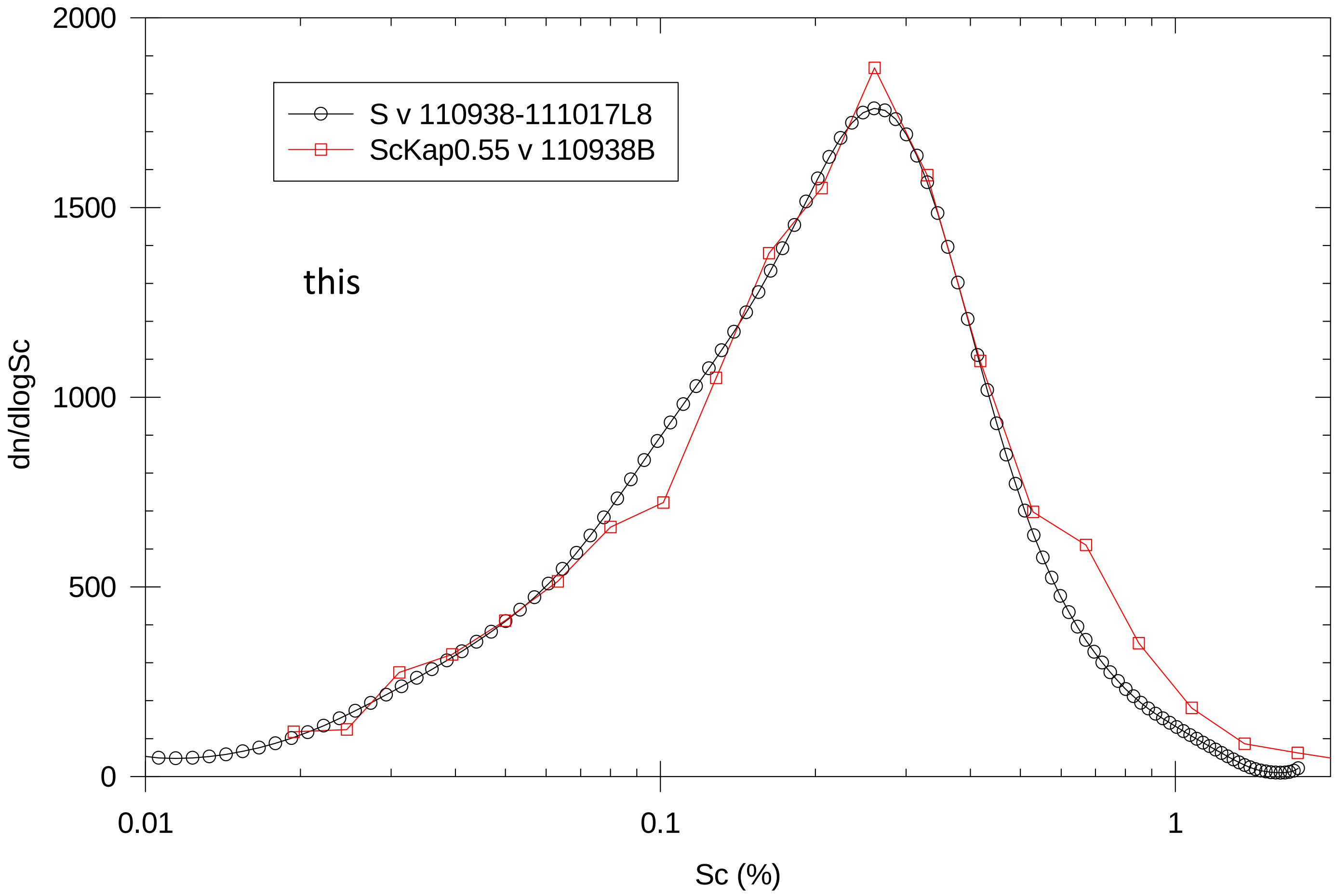
Very high DMA spike



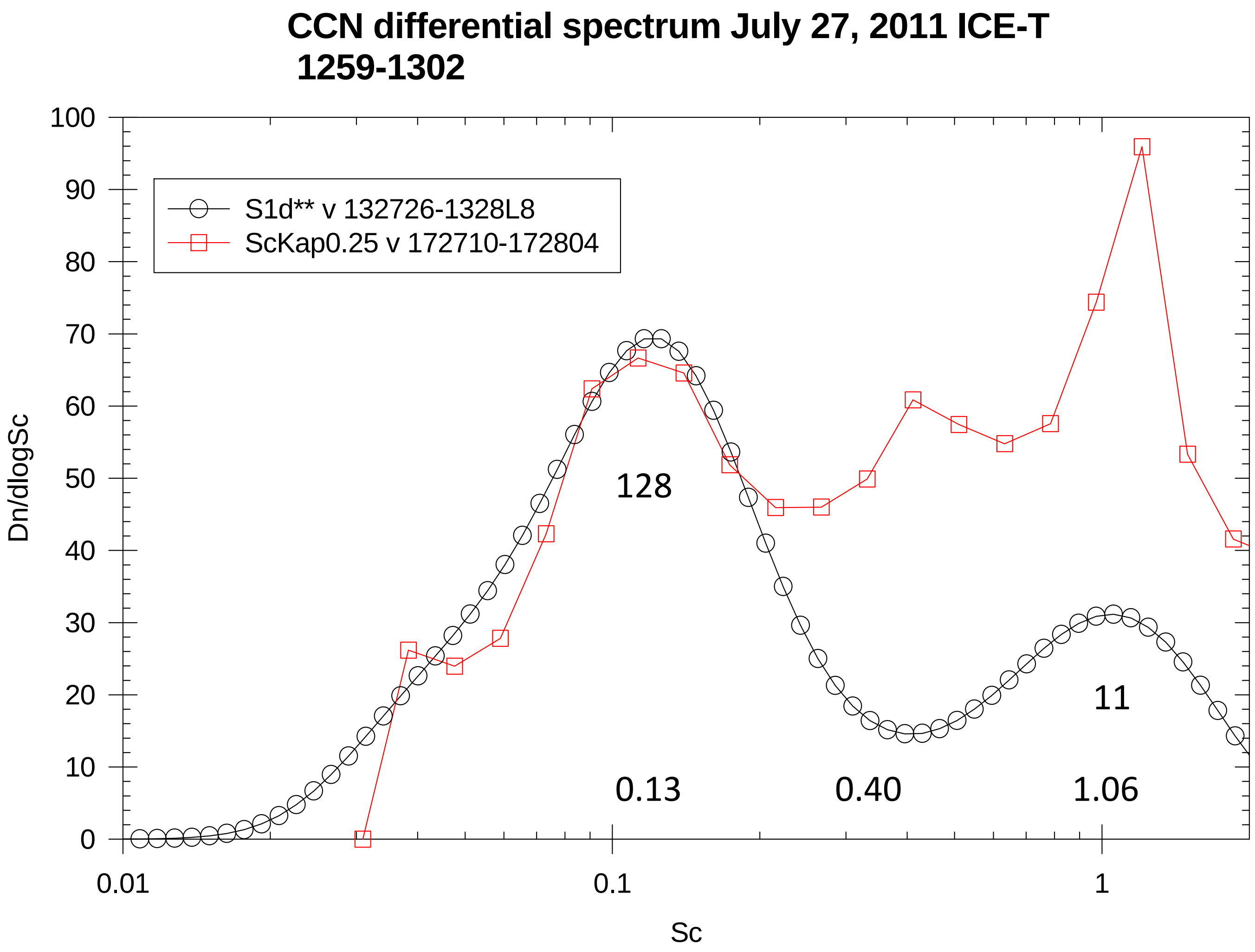
July 17, 2005, MASE, Below cloud
2000
1800
1600
1400
1200
1000
800
600
400
200
0
S v 121651-121707L8
ScKap0.25 v 121651B
dn/dlogSc
0.01
0.1
1
Sc (%)


July 19, 2005, MASE,
below cloud
S v 1158-115910L8
ScKap0.40 v 1158B
dn/dlogSc
Sc (%)
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
0.01
0.1
1

July 23, 2005, MASE,
below cloud



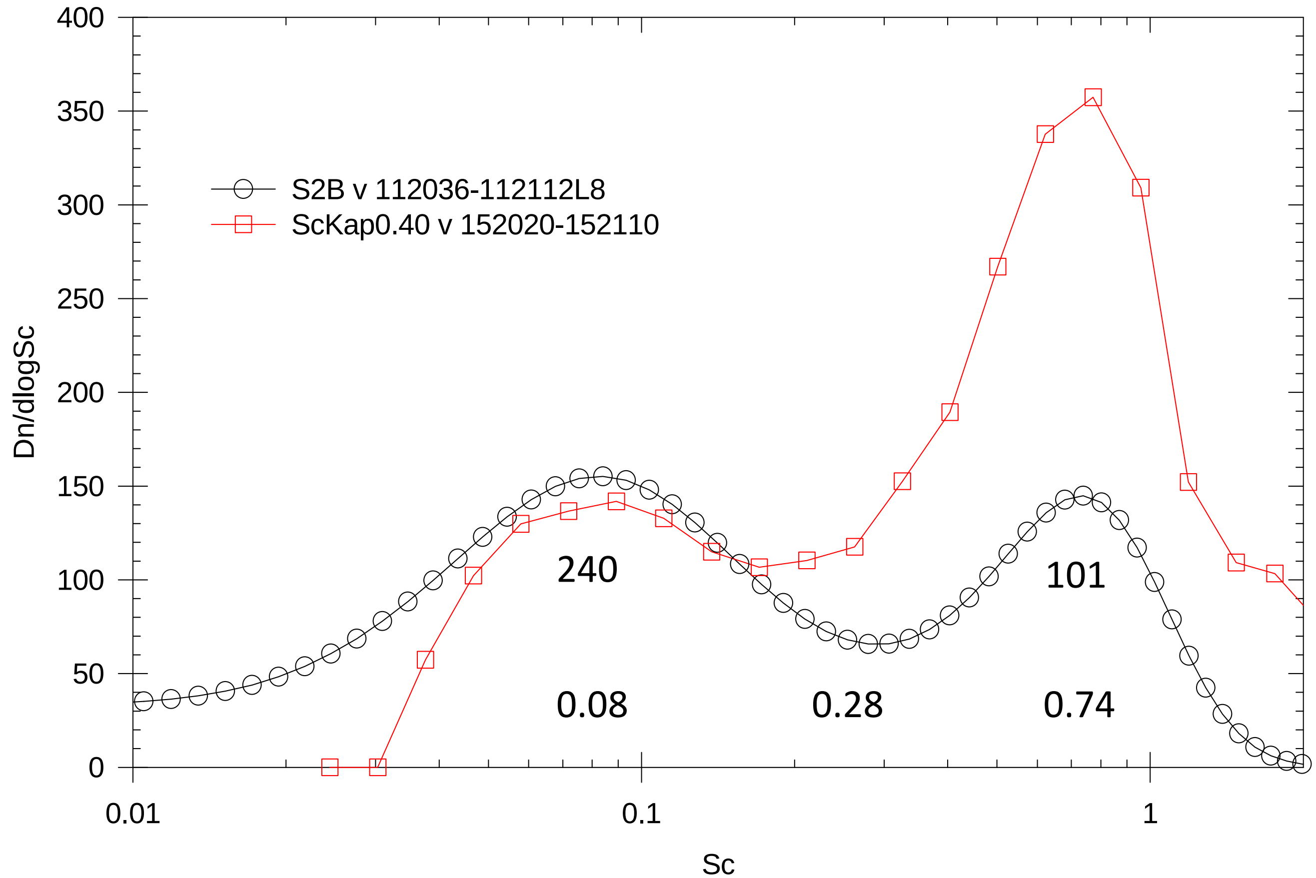
1



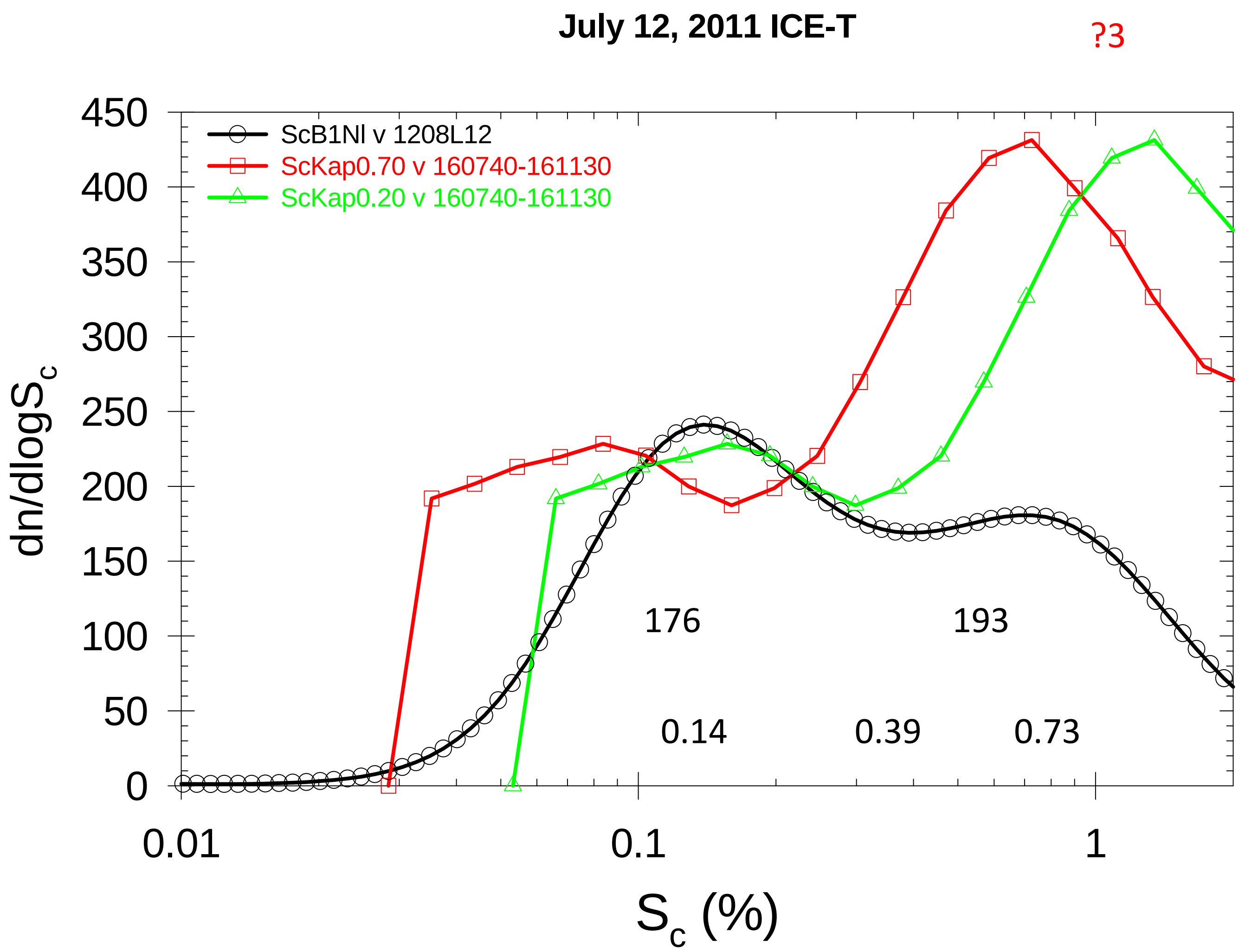
CCN differential spectrum July 27, 2011 ICE-T
1259-1302
S1d** v 132726-1328L8
ScKap0.25 v 172710-172804
Dn/dlogSc
100
90
80
70
60
50
40
30
20
10
0
0.01
0.1
1
Sc
128
11
0.13
0.40
1.06

1

CCN differential spectrum July 30, 2011 ICE-T RF13



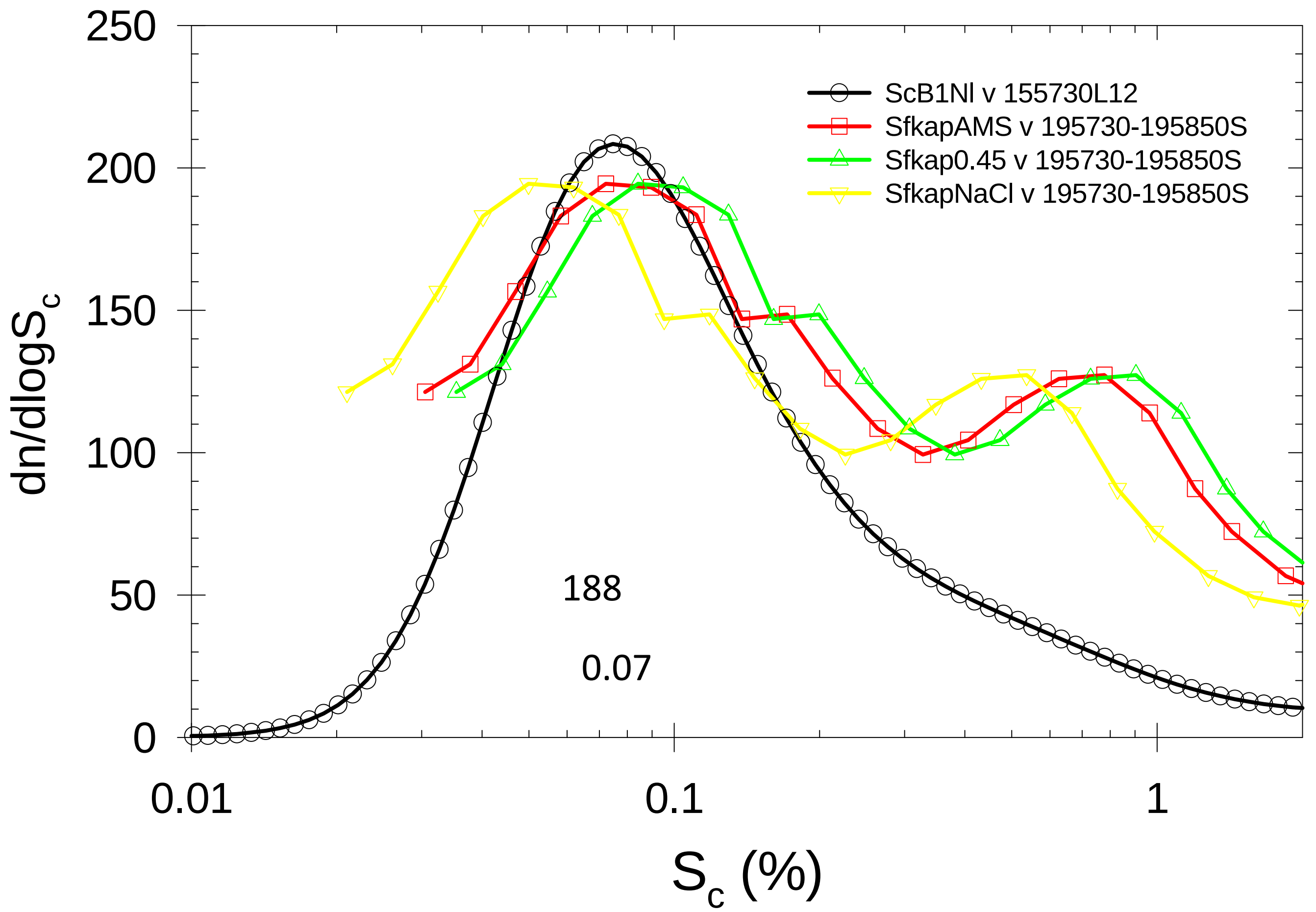
2



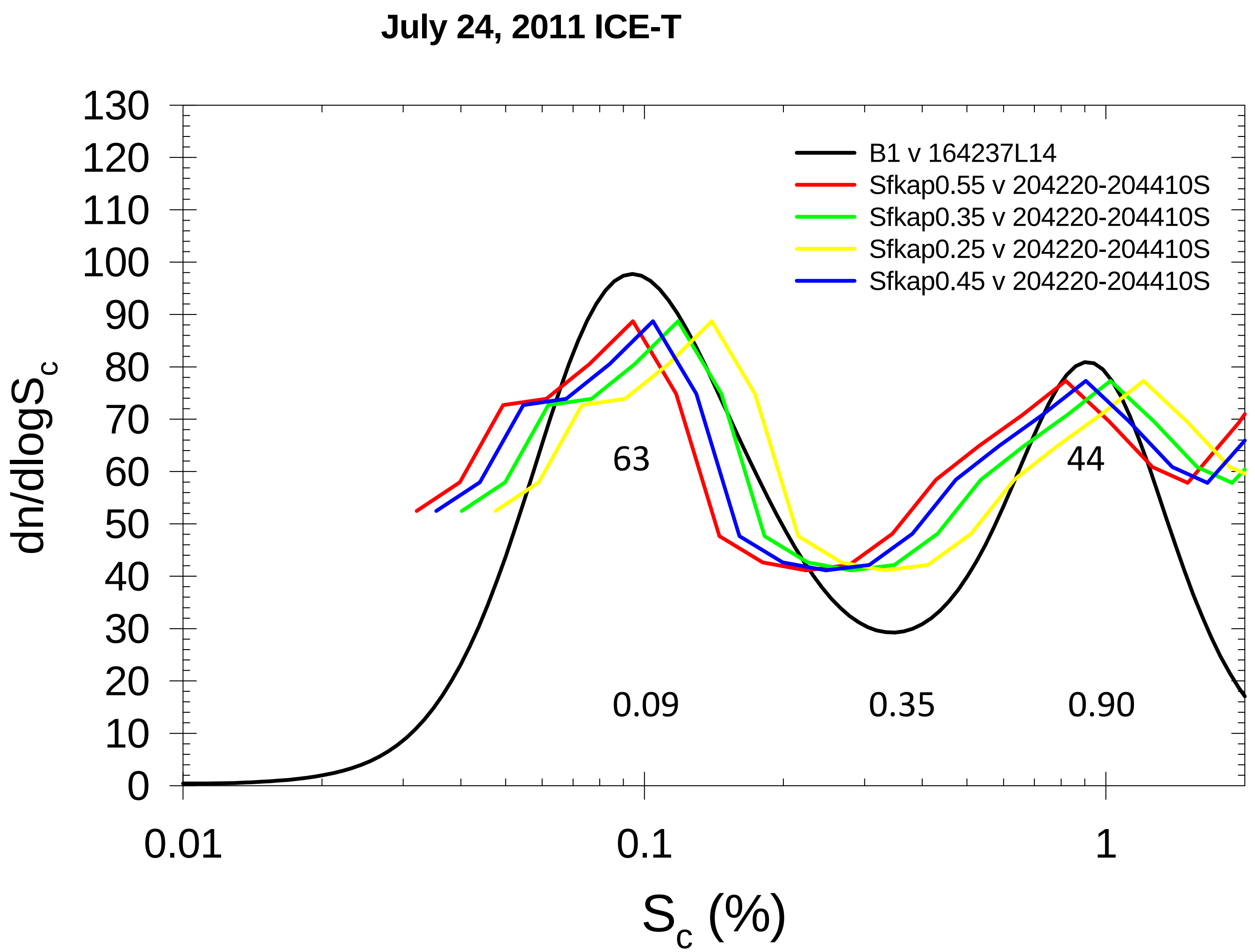
July 12, 2011 ICE-T
?3
ScB1Nl v 1208L12
ScKap0.70 v 160740-161130
ScKap0.20 v 160740-161130
dn/dlogSc
Sc (%)
176
193
0.14
0.39
0.73
0.01
0.1
1
0
50
100
150
200
250
300
350
400
450

7

July 12, 2011 ICE-T

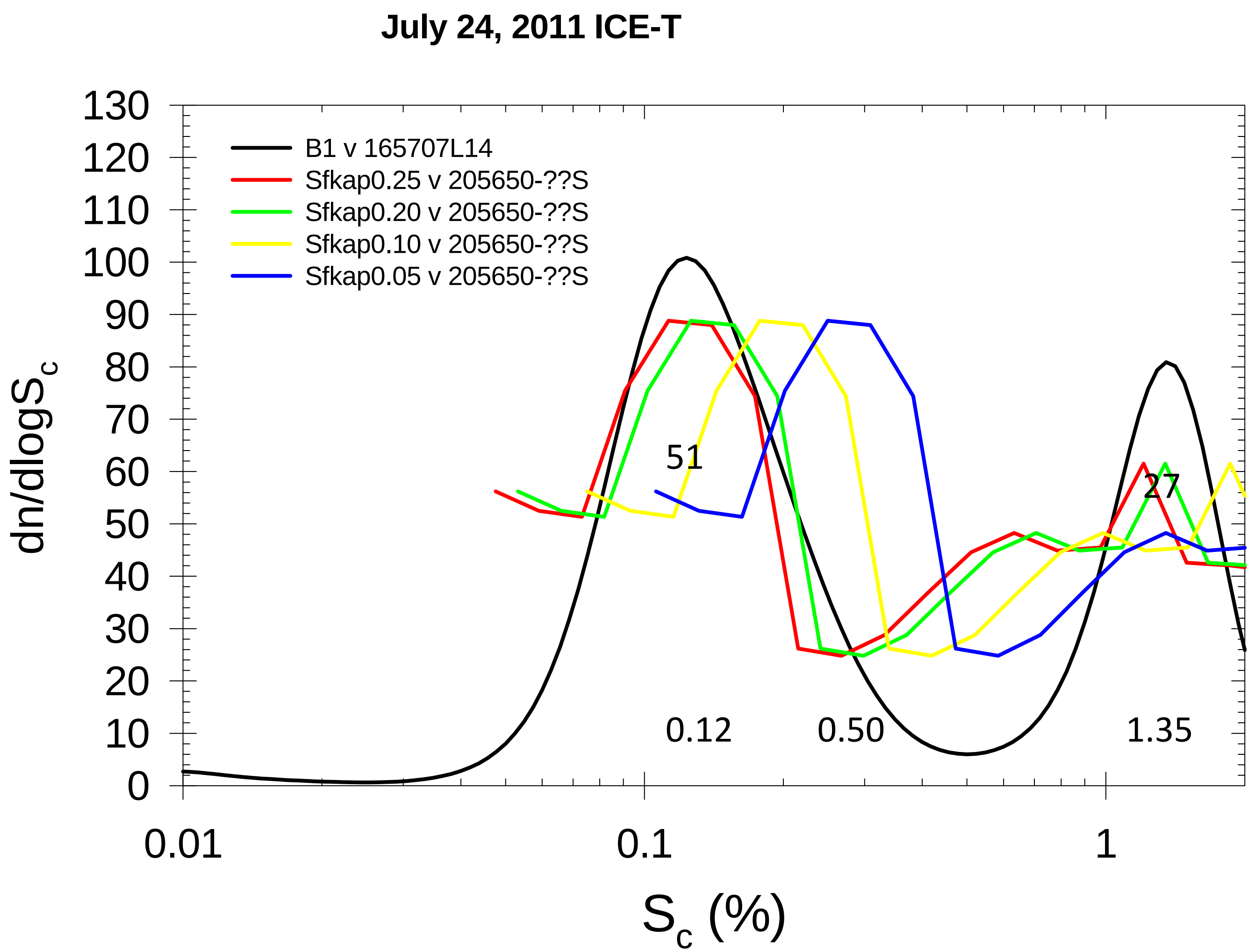


1

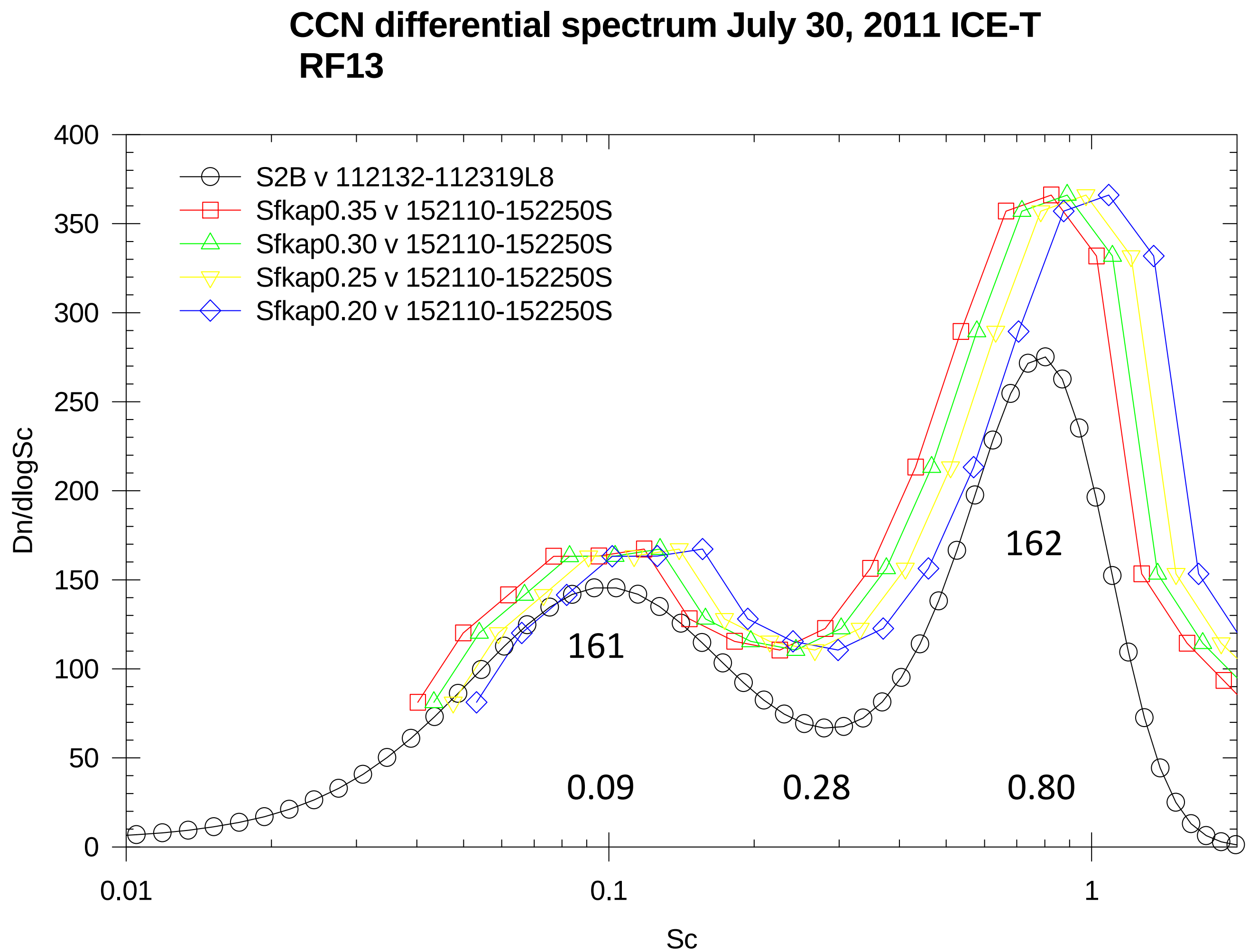


July 24, 2011 ICE-T
B1 v 164237L14
Sfkap0.55 v 204220-204410S
Sfkap0.35 v 204220-204410S
Sfkap0.25 v 204220-204410S
Sfkap0.45 v 204220-204410S
dn/dlogS$_c$
S$_c$ (%)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
0.01
0.1
1
63
44
0.09
0.35
0.90

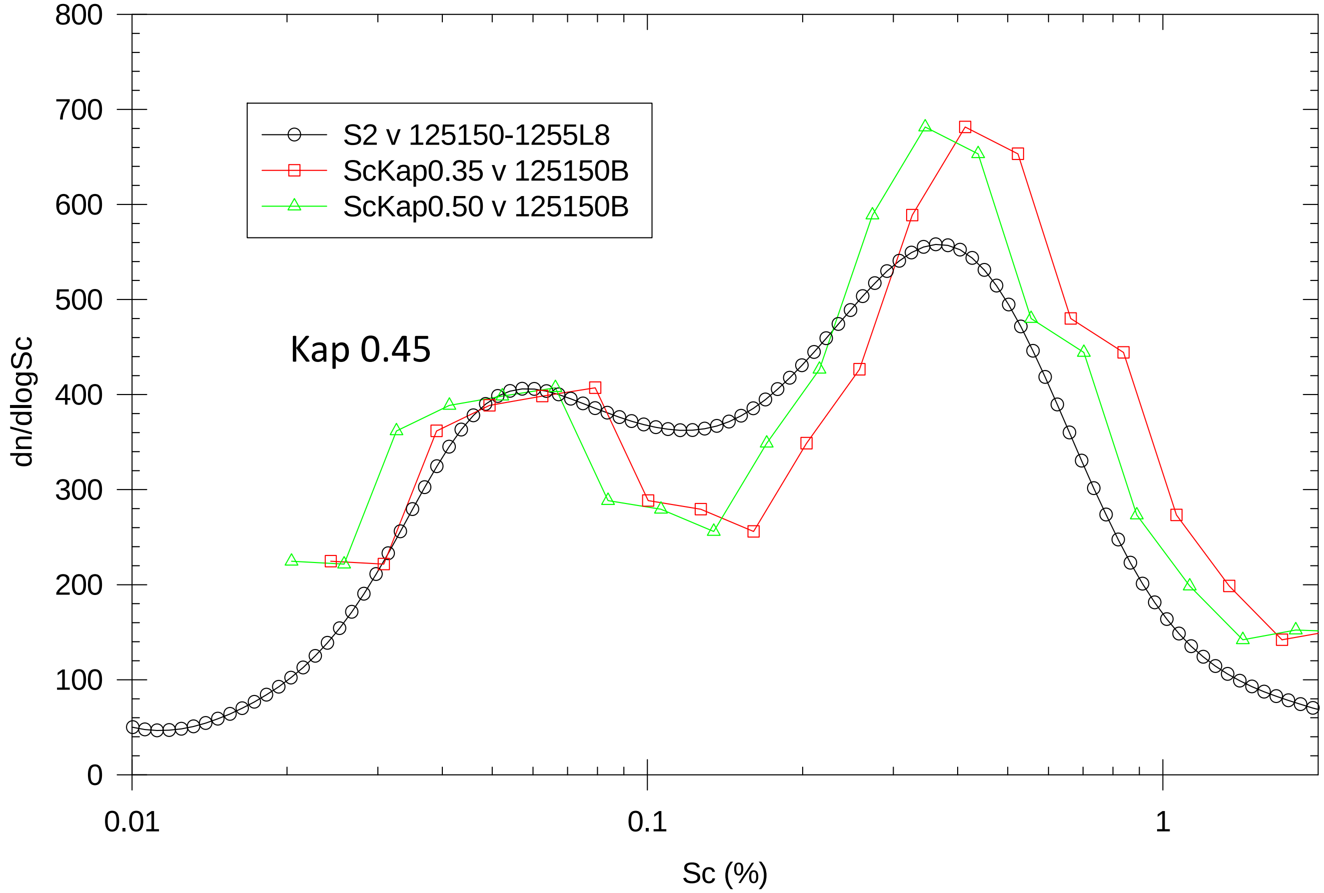
1

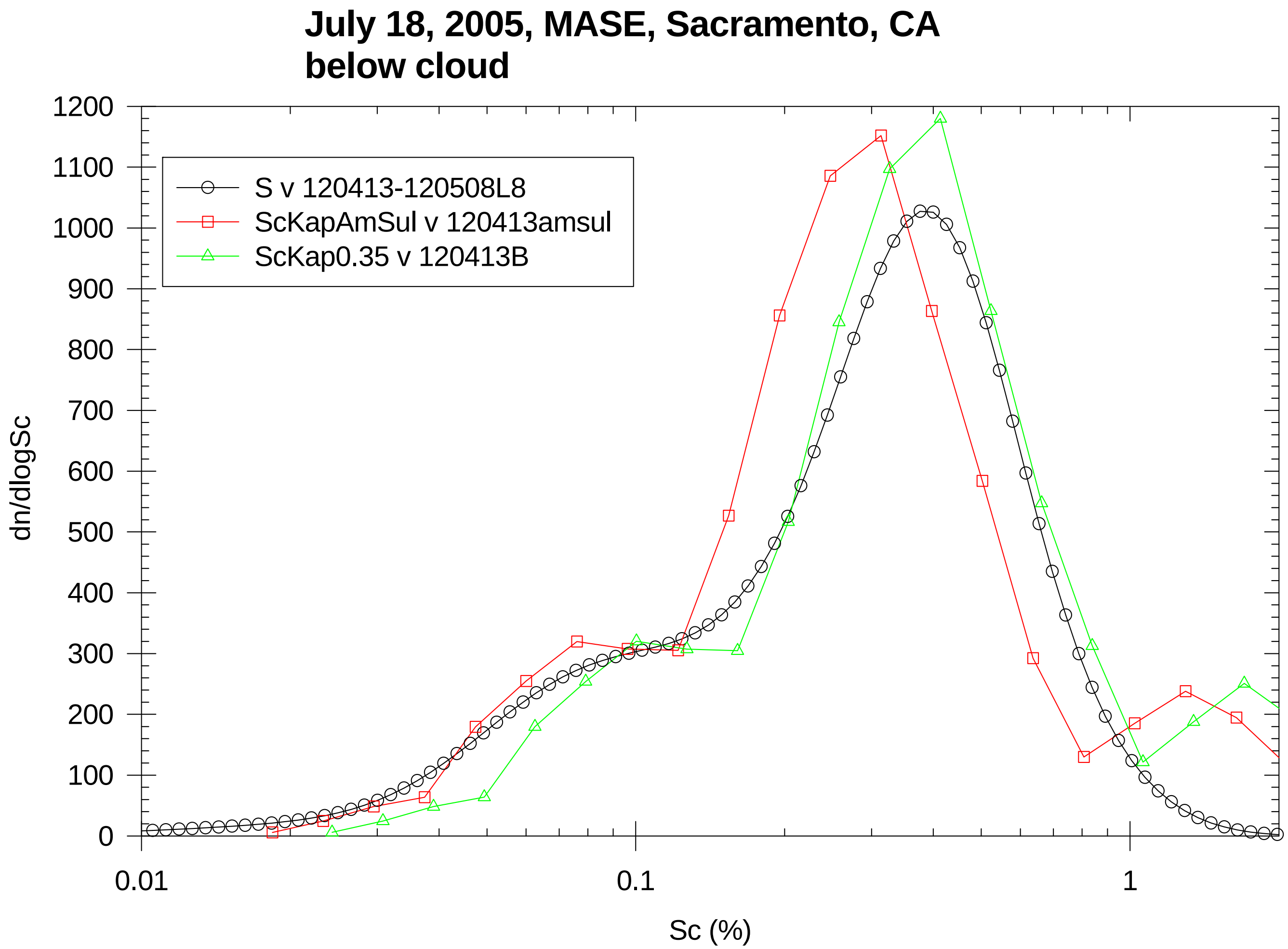

July 24, 2011 ICE-T
B1 v 165707L14
Sfkap0.25 v 205650-??S
Sfkap0.20 v 205650-??S
Sfkap0.10 v 205650-??S
Sfkap0.05 v 205650-??S
51
27
0.12
0.50
1.35
130
120
110
100
90
80
70
60
50
40
30
20
10
0
0.01
0.1
1
dn/dlogSc
Sc (%)

1

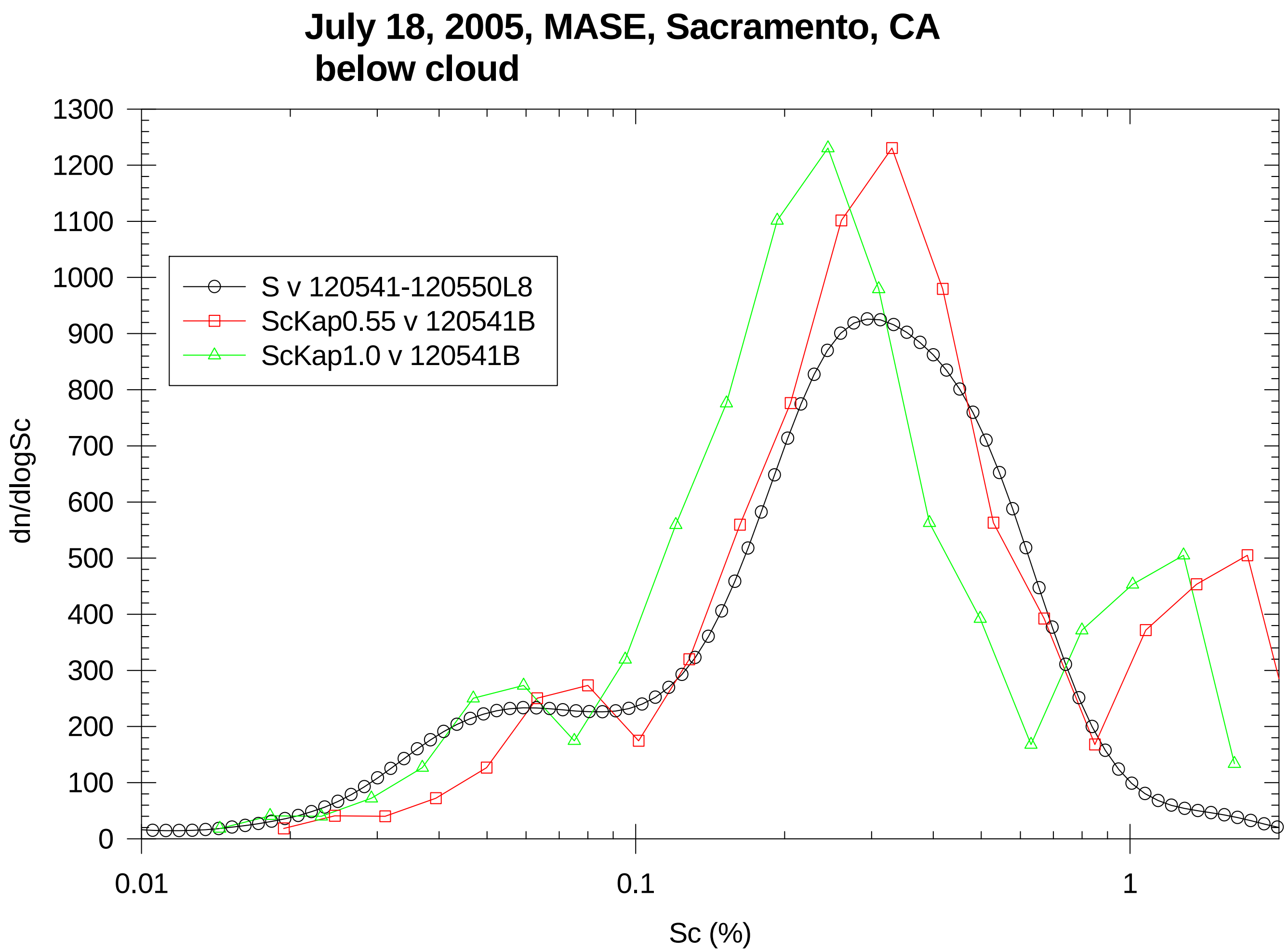

CCN differential spectrum July 30, 2011 ICE-T
RF13
S2B v 112132-112319L8
Sfkap0.35 v 152110-152250S
Sfkap0.30 v 152110-152250S
Sfkap0.25 v 152110-152250S
Sfkap0.20 v 152110-152250S
Dn/dlogSc
Sc
161
162
0.09
0.28
0.80
0
50
100
150
200
250
300
350
400
0.01
0.1
1

July 16, 2005, MASE, Sacramento, CA
new spec. using 1201-1325 linear calibration,
L16m10.out jul16kew.spw
below cloud

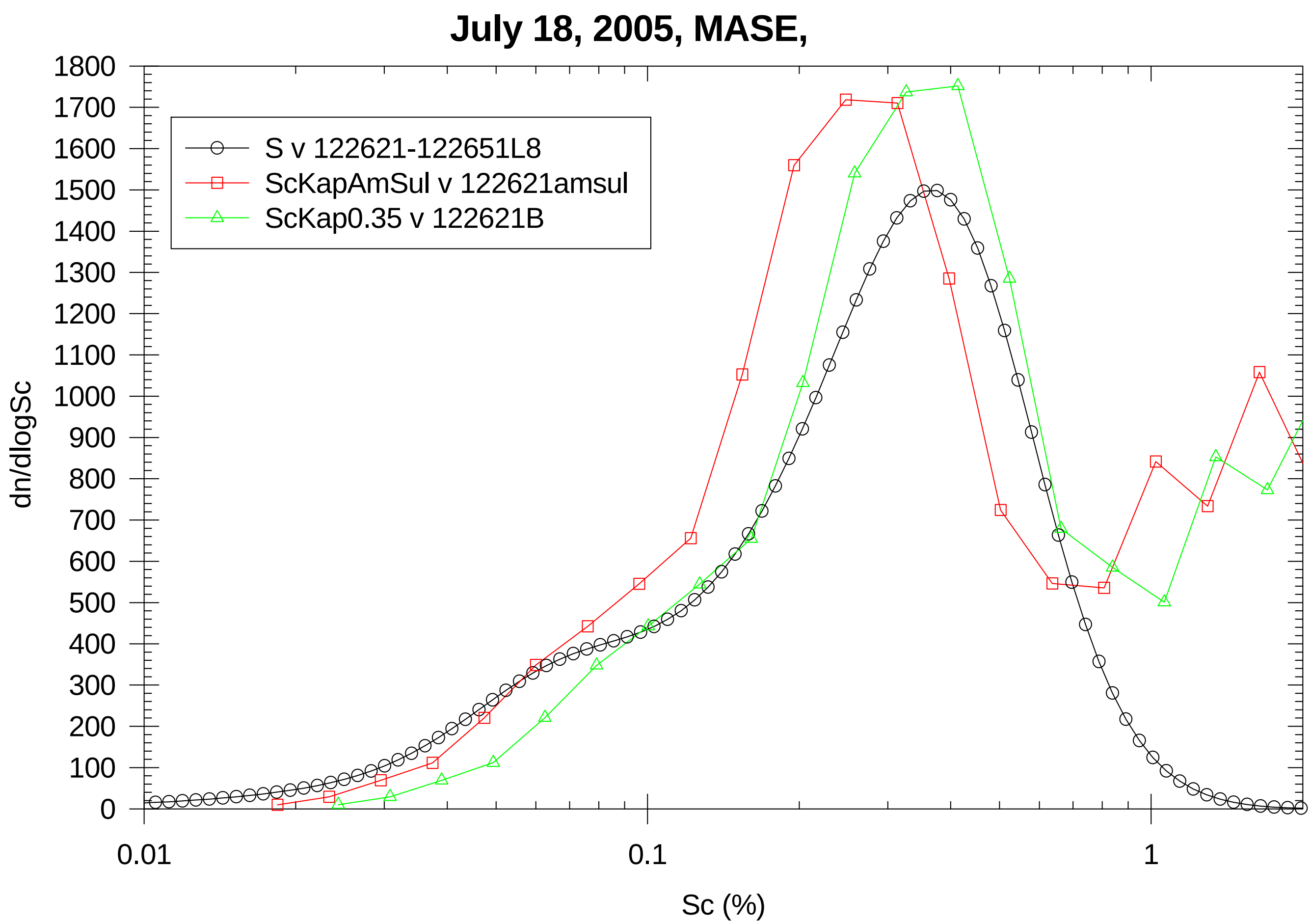




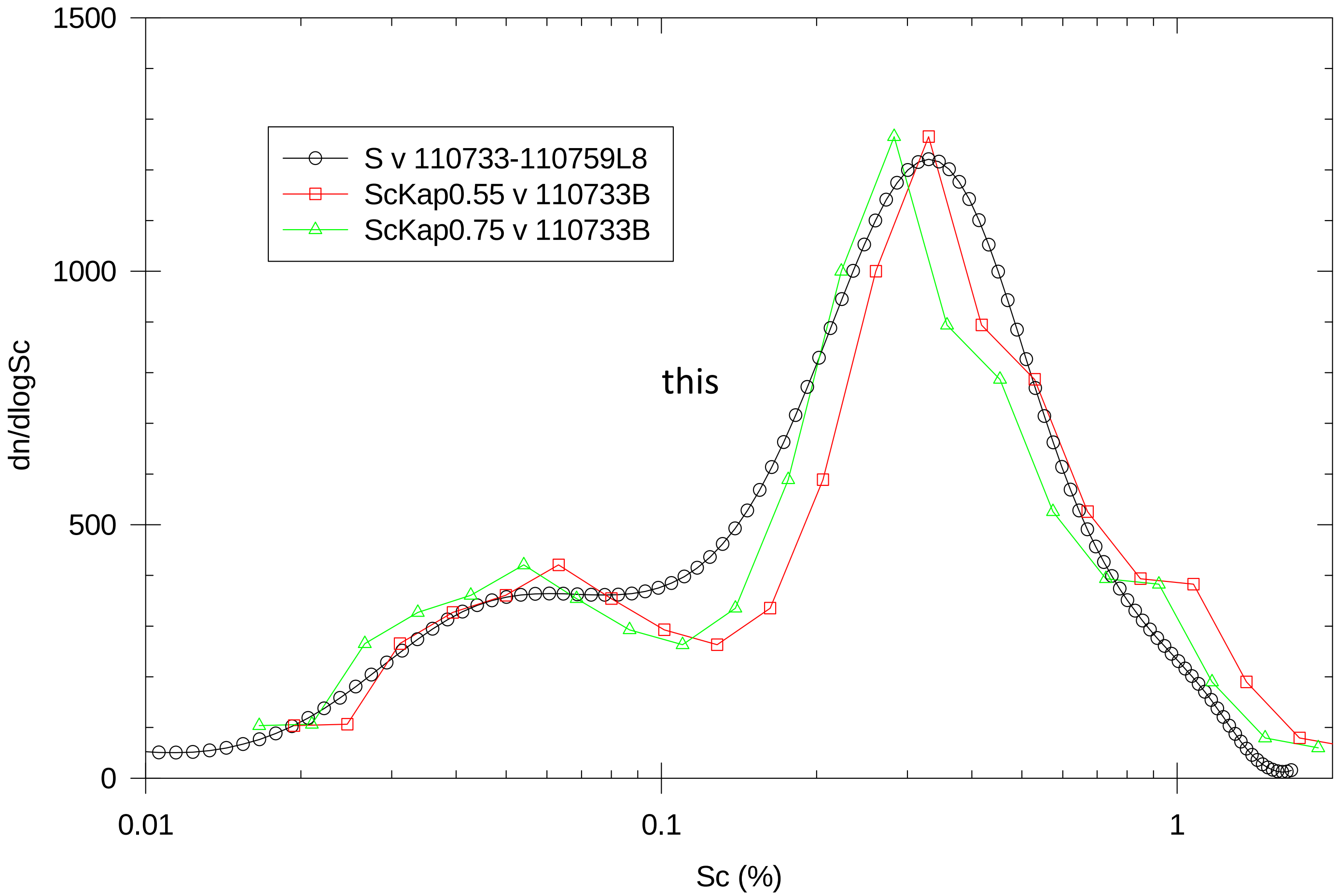
July 18, 2005, MASE, Sacramento, CA
below cloud
S v 120413-120508L8
ScKapAmSul v 120413amsul
ScKap0.35 v 120413B
dn/dlogSc
Sc (%)
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
0.01
0.1
1



July 18, 2005, MASE, Sacramento, CA
below cloud
S v 120541-120550L8
ScKap0.55 v 120541B
ScKap1.0 v 120541B
dn/dlogSc
Sc (%)
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
0.01
0.1
1


July 18, 2005, MASE,
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
dn/dlogSc
S v 122621-122651L8
ScKapAmSul v 122621amsul
ScKap0.35 v 122621B
0.01
0.1
1
Sc (%)

July 23, 2005, MASE, below cloud



	flts	cases	secs	κ
MASE below	9	135	7509	0.40±0.20
MASE above	9	92	1657	0.24±0.16
ICE-T	8	50	6162	0.34±0.22