Testing and Calibration of the NASA COR1 Coronagraph for the Solar Terrestrial Relations Observatory (STEREO)

NCAR Proposal 2001-092
NASA Grant NAG5-12049
Principal Investigator: J.T. Burkepile

Overview

This proposal is for a no cost extension on the period of performance of the existing grant. The period of performance shall be extended to the end of FY 2003. This extension is required due to schedule changes in the COR1 program. Funding for Phase II and Phase III of this grant has been obtained. This unsolicited proposal was for scientific and engineering collaboration between NASA's Goddard Space Flight Center (GSFC) and HAO. Performance testing of the COR1 engineering test unit has been partially completed. The COR1 coronagraph engineering test unit requires further testing at NASA's GSFC and the National Center for Atmospheric Research (NCAR) Mauna Loa Solar Observatory (MLSO), operated by the High Altitude Observatory (HAO).

HAO personnel have recently supported efforts to test component and breadboard versions of the COR1 using the NCAR Vacuum Tunnel Facility (NVTF). HAO personnel will continue to work closely with scientists and engineers at NASA/GSFC in the development, design, assembly, testing, and operation of this key element of NASA's Solar Terrestrial Relations Observatory (STEREO) mission. The element is an internally-occulted coronagraphic telescope, and the design and development effort is already underway at GSFC.

Background

One of the scientific goals of NASA's STEREO project is to obtain information about coronal mass ejections (CMEs) from the Sun. These ejections interact with Earth and are responsible for the most severe geomagnetic storms. The primary method to detect and to characterize CMEs is through coronagraphic telescopes. Specific coronagraph designs can be made to work at high altitude groundbased observatories such as Mauna Loa, which is operated by HAO. But optimal performance can only be achieved when scattered light from the sky is removed completely, as on a spacebased platform. HAO investigators have a documented track record in obtaining and analyzing coronagraphic CME observations, and they will work closely with GSFC scientists, engineers, and managers to achieve the goals of the STEREO mission.

Specific Goals to be Accomplished During FY 2003

The optical telescope effort is underway, with science and engineering teams actively working toward an ambitious schedule to complete the optical section rearward of the bandpass filter and test the entire engineering unit. The Phase I testing of the higher fidelity instrument model (from the objective lens to the bandpass filter) was completed in November of 2002 at the NVTF. A detailed description of the remaining activities funded under this grant is included below:

Phase I consists of a two-week initial testing at the NVTF to advance the COR1 Breadboard assembly to a higher level of fidelity.

Phase I completed. November, 2002.

Phase II will build on the testing in Phase I by use of the COR1 engineering unit fitted to the HAO Carroll spar at the Goddard Space Flight Center (GSFC). Testing will include pointing an engineering model of the instrument at the Sun to see how it performs as a ground-based telescope.

- Testing and any needed maintenance to the HAO Carroll spar.
- Designing and building packing crates for the Carroll spar.
- Shipping the Carroll spar to GSFC.
- Test fitting and checkout of the COR1 Breadboard with the Carroll spar at GSFC. HAO engineering time will be available for consultation on spar setup and operation.

Phase III. After the initial testing phases have been completed, Phase III will focus on field testing of the instrument at HAO's MLSO in Hawaii. This field test will be used for the purpose of taking coronal data. The MLSO facility is situated in a location where the scattered light from sky conditions is considered to be the lowest in the world and is therefore the optimal test site. HAO operates the MKIV Coronagraph at MLSO on a full time basis and the data from this instrument will be used for comparison purposes.

- Shipping the Carroll spar from GSFC to Boulder.
- Shipping the Carroll spar from Boulder to MLSO with other HAO support equipment.
- Testing of the COR1 Breadboard mounted to the HAO Carroll Spar at MLSO with the assistance of the HAO staff.
- Supporting the logistics and operations for obtaining data with the advanced COR1 Breadboard assembly at MLSO.
- After the experiment, shipping the Carroll spar back to HAO in Boulder, Colorado.

Proposed Period of Performance:

Planned Start Date: 01 March 2002
Planned End Date: 30 September 2003

Ball Aerospace & Technologies Corp.

Testing and Analysis
P.O. Box 1062, Boulder, Colorado 80306-1062 USA
Telephone (303) 939-5419 Fax (303) 939-5062 e-mail mpirkey@ball.com

To: National Center for Atmospheric Research
PO Box 3000
Boulder, CO 80307-3000
Attn: Gregory L. Card

Date: October 25, 2002
Ref.
BATC 31200.02.770

Samples: Samples were taken on October 23, 2002 at 1630 hours with Gregory Card present. The samples we described and labeled as follows:

1. Rinsate of 3/4" and 5/8" wrench, total area 20 in^2
2. Rinsate of ESD mat, total area 1 ft^2.

Procedure: Each sample was obtained by rinsing the sample area with approximately 20 mL distilled heptane – isopropanol azeotrope. Each rinsate was quantitatively transferred to a scintillation vial(s) at the sampling site. Quantification of the nonvolatile residue was achieved by evaporation of the solvent at 105°C. The residue was identified using a Bio-Rad FTS 40 Fourier Transform Infrared Spectroscopy (FTIR) coupled with a UMA 500 microscope in accordance with ASTM E 334-99, "Standard Practice for General Techniques of Infrared Microanalysis".

Results: The results of the testing are summarized in the table below.

Sample Identification	NVR (mg/ft^2)	FTIR results
Wrench rinsate	0.22*	Aliphatic hydrocarbon, aliphatic ester, silicone (5-10%)
ESD mat rinsate	38.79	Dioctyl phthalate

* at or near the detection limit of the method

Discussion: The NVR for the wrench rinsate is at or near the detection limit of the method. The small sample area may cause the NVR value of 0.22 mg/ft^2 to be erroneously high. The presence and relative proportions of the identified contaminants in the residue has been historically observed at BATC. In general, the level and composition of the contamination on the wrenches is expected and acceptable.

The analysis indicates that the rinsate from the ESD mat contains 38.79 mg/ft^2 of dioctly phthalate, a common plasticizer used in vinyl. Care should be taken to limit mechanical transfer of the contaminant to hardware and optics. It should also be noted that dioctyl phthalate is sufficiently volatile and will transfer via evaporation/condensation. Although over the short term the ESD mat will most likely not pose a significant source of contamination, it is recommended that for the long term this ESD mat be removed from the cleanroom, replaced with a clean ESD mat, and the bench thoroughly cleaned.

Report Prepared by:

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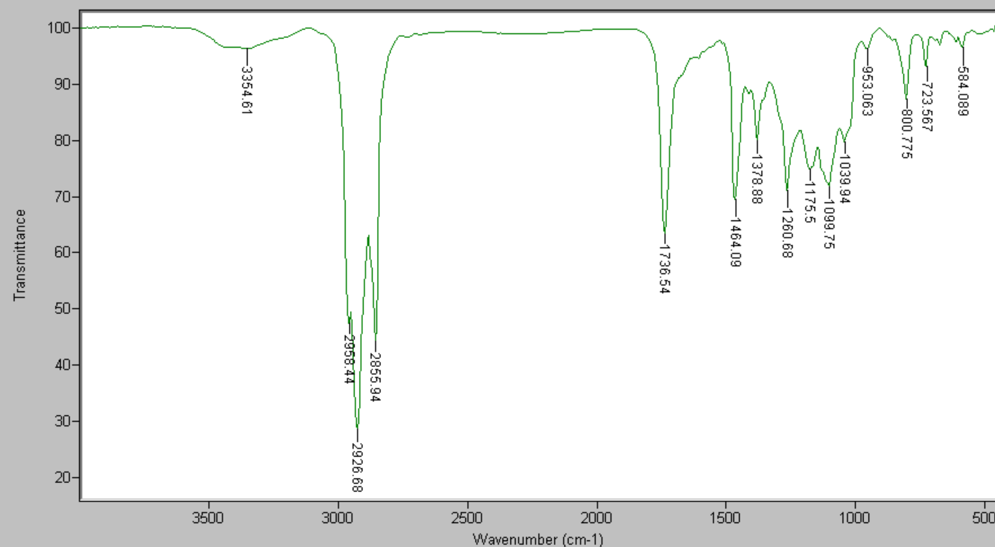
Michael S. Pirkey
Senior Engineer

cc: to file



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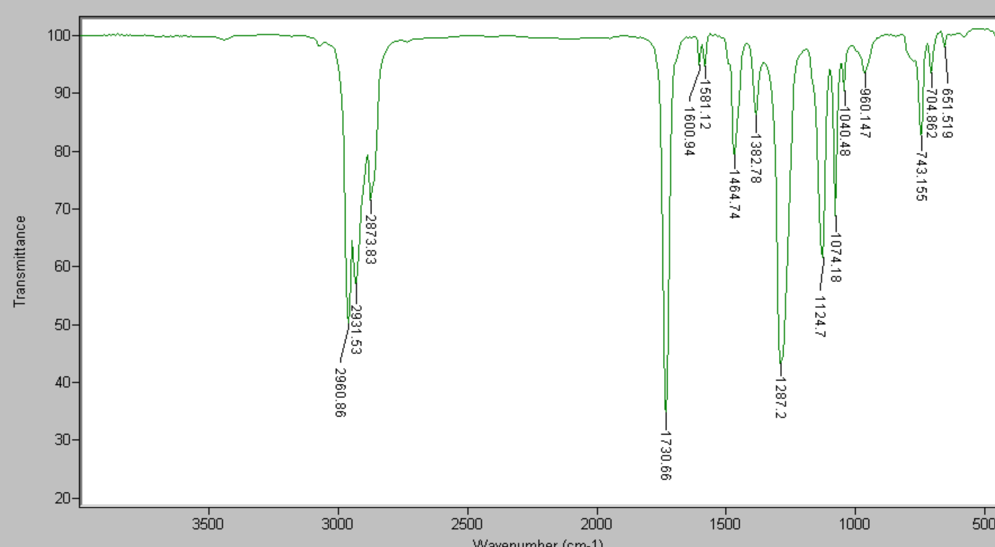

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Comment: 31200 NCAR 3M ESD MAT 38.79 MG/FT^2 10/23/02 AGCL

Ball Aerospace & Technologies Corp.

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P.O. Box 1062, Boulder, Colorado 80306-1062 USA
Telephone (303) 939-5419 Fax (303) 939-5062 e-mail mpirkey@ball.com

To: National Center for Atmospheric Research
PO Box 3000
Boulder, CO 80307-3000
Attn: Gregory L. Card

Date: December 9, 2002
Ref.
BATC 31200.02.770

Samples: Three Molecular Contamination Witness Plates and two Settle Particle Witness Plates were placed in the cleanroom and chamber on October 23, 2002. All plates were sampled on November 14, 2002 with Gregory Card present. The samples were described and labeled as follows:

1. NCAR NVR plate over table
2. NCAR NVR plate in Chamber – Vertical
3. NCAR NVR plate in Chamber – Horizontal
4. NCAR PC plate in Chamber
5. NCAR PC plate on Top of Flow Bench

Procedure: Molecular Contamination Witness Plates (BPS 27.43)

Each sample was obtained by rinsing the witness plate (1 ft^2) with approximately 20 mL distilled heptane – isopropanol azeotrope, directly collecting each rinsate into a scintillation vial at the sampling site. Quantification of the nonvolatile residue was achieved by evaporation of the solvent at 105°C. The residue was identified using a Bio-Rad FTS 40 Fourier Transform Infrared Spectroscopy (FTIR) coupled with a UMA 500 microscope in accordance with ASTM E 334-99, "Standard Practice for General Techniques of Infrared Microanalysis".

Settle Particle Witness Plates (BPS 27.43)

Each sample was obtained by rinsing the witness plate (1 ft^2) with approximately 100 mL isopropyl alcohol (filtered). Each rinsate was filtered onto a gridded filter membrane. Particles above 25 μm were counted and size ranged.

Results: The results of the Molecular Contamination Testing are summarized in the table below. The FTIR spectra for each of the residues are attached.

Sample Identification	NVR (mg/ft^2)	FTIR results
NCAR NVR Plate Over Table	0.10	Alkylarylsulfonate surfactant
NCAR NVR Plate in Chamber – Vertical	0.11	Aliphatic hydrocarbon, aromatic ester (Dioctyl phthalate-like), silicone (5-10%), trace of amide
NCAR NVR Plate in Chamber – Horizontal	0.26	Aliphatic hydrocarbon, aromatic ester (Dioctyl phthalate-like), silicone (5-10%)

The results of the Settle Particle Testing are summarized in the attached data sheets.

Discussion: The amount and identity of the molecular contamination in the chamber is expected (See report issued on 10/25/02). However, the presence of the alkylarylsulfonate surfactants on the witness plate was not expected. Such compounds are anionic surfactants used in cleaning products.

Report Prepared by:

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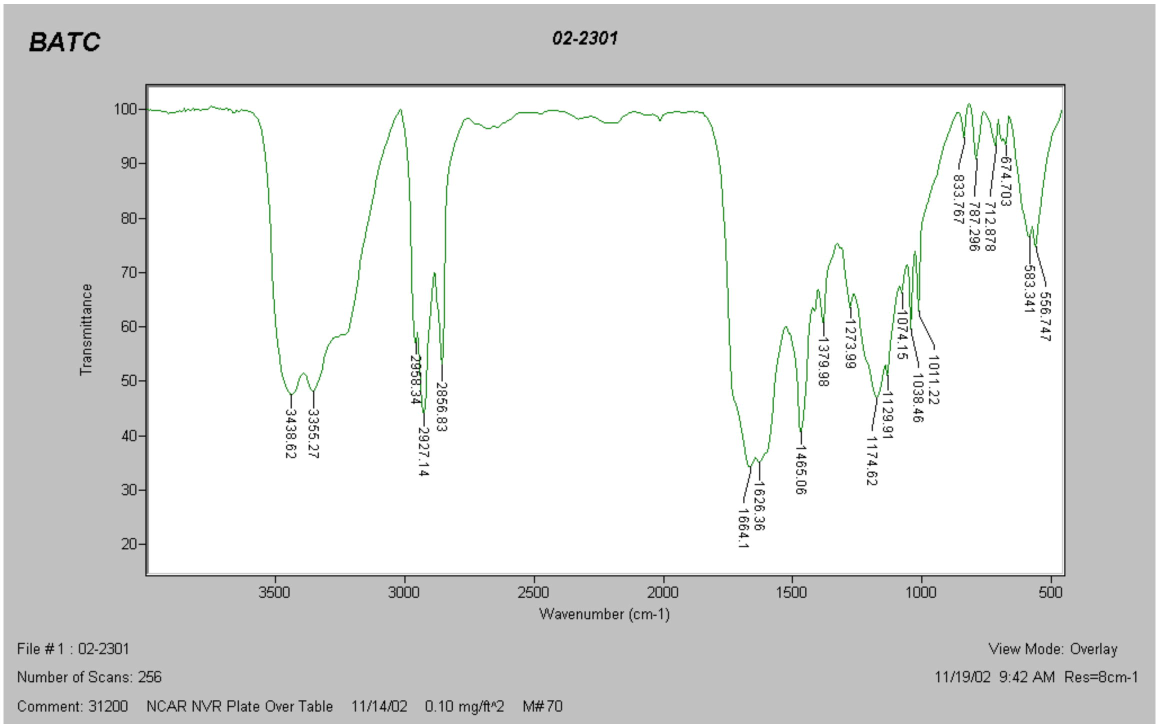
Michael S. Pirkey
Senior Engineer

Attachments
cc: to file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02-2301
Transmittance
Wavenumber (cm-1)
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1626.36
1465.06
1379.98
1273.99
1174.62
1129.91
1074.15
1038.46
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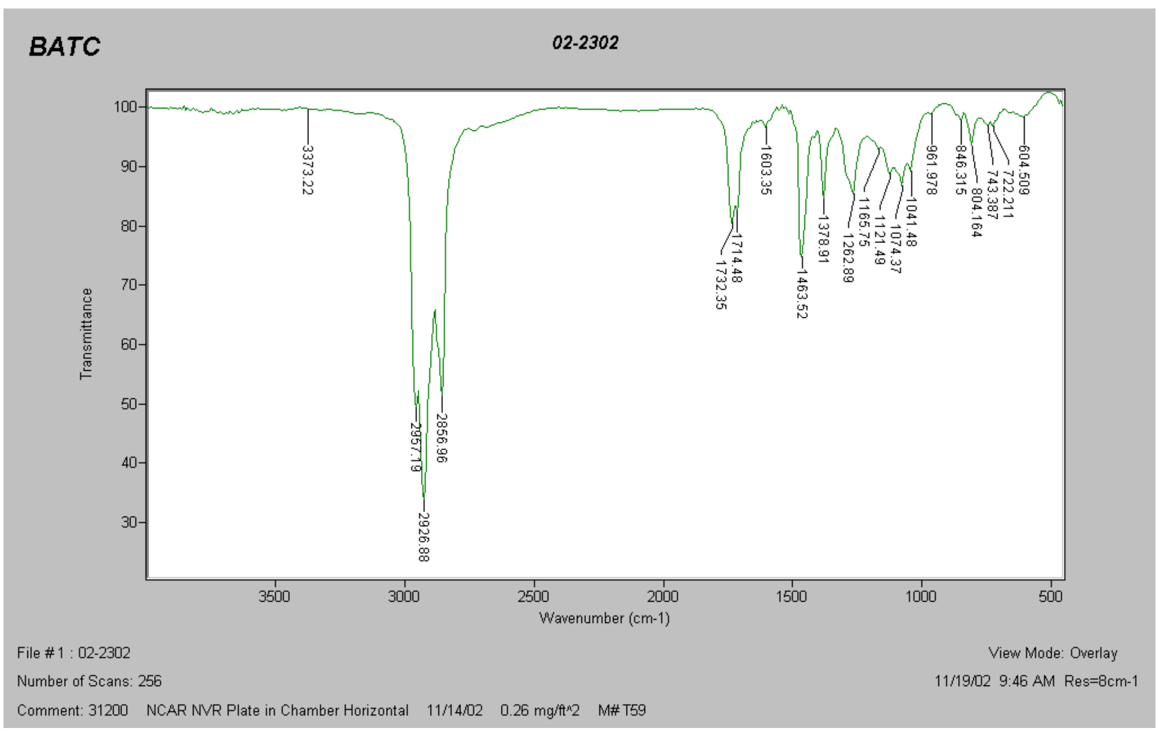
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02-2302
Transmittance
Wavenumber (cm-1)
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1603.35
1463.52
1378.91
1262.89
1165.75
1121.49
1074.37
1041.48
961.978
846.315
804.164
743.387
722.211
604.509
File # 1 : 02-2302
View Mode: Overlay
Number of Scans: 256
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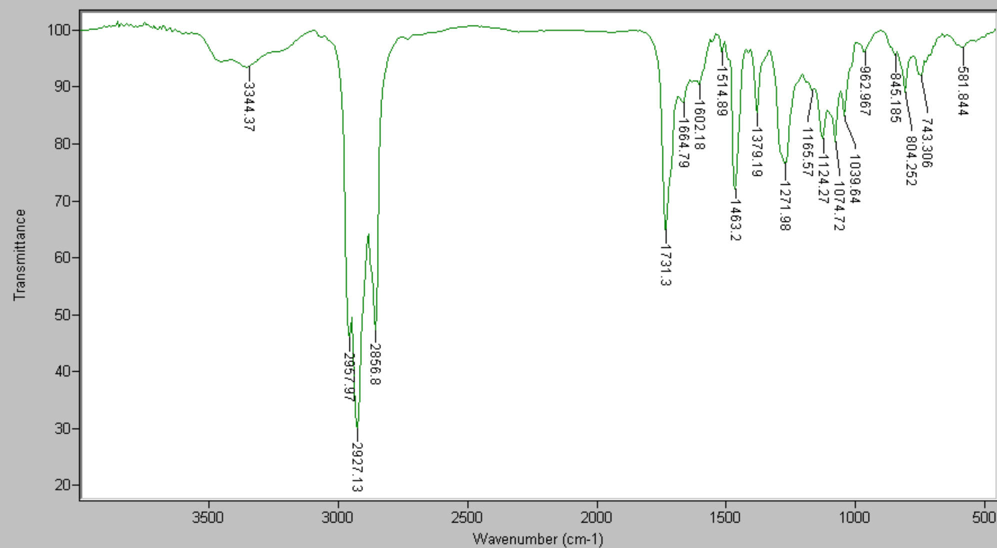
BATC **02-2303**



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Number of Scans: 256 11/19/02 9:50 AM Res=8cm-1

Comment: 31200 NCAR NVR Plate in Chamber Vertical 11/14/02 0.11 mg/ft^2 M# 30

PARTICLE COUNT TALLY SHEET

PC# 02-102

Source description:	NCAR Cleanroom	Project:	NCAR
Particle Plate On Top Of Flow Bench		Project No.	31200.02.770
		Production No.	
Inspector:	LC	Sample liquid:	IPA
Date:	11/14/02	Sample volume:	~ 100 ml
Requested by:	M. Pirkey / NCAR	Sampled area:	1 Ft ^2

PARTICLE SIZE RANGE micrometers		PARTICLE COUNTS IN GRID SQUARES OF PARTIAL FILTER AREA A	B	C	D	E	Total Count for rep. filter area	Extrapolated count for sampled area	Particle Types Per sq. ft.	Particles per sq. ft. Total
6-12	f									
	m									
	o									
13-15										
26-50									0	
									2	43
									41	
51-100									0	
									0	21
									21	
101-250									10	
									0	30
									20	
250-500									20	
									0	22
									2	
>500									38	
									0	38
									0	

PARTICLE SIZE micrometers	CONTAMINATION LEVEL 25	50	100	500				Metal Particles per sq. ft.	Sample Particles per sq. ft.
>~12.5	5	36	389						
>25	1	7	78	86252				2	154
>50		1	11	11817				0	111
>100			1	1100				0	90
>250				26				0	60
>500				1				0	38
NVR=		NVR#		IR#					

The Contamination Level table shows the maximum number of particles per square foot of sampled area for each level. See BPS 27.43 for definitions and other details.

COMMENTS

Particle types within size ranges: Fibers f

Metals m

Other o

PARTICLE COUNT TALLY SHEET

PC# 02-103

Source description: NCAR Cleanroom		Project:	NCAR
Particle Plate In Chamber		Project No.	31200.02.770
		Production No.	
Inspector: LC		Sample liquid:	IPA
Date: 11/14/02		Sample volume:	~ 100 ml
Requested by: M. Pirkey / NCAR		Sampled area:	1 Ft^2

PARTICLE SIZE RANGE micrometers	PARTICLE COUNTS IN GRID SQUARES OF PARTIAL FILTER AREA A	B	C	D	E	Total Count for rep. filter area	Extrapolated count for sampled area	Particle Types Per sq. ft.	Particles per sq. ft. Total
6-12 f									
m									
o									
13-15									
26-50								0	
								2	46
								44	
51-100								0	
								3	20
								17	
101-250								8	
								1	23
								14	
250-500								15	
								0	16
								1	
>500								12	
								0	12
								0	

PARTICLE SIZE micrometers	CONTAMINATION LEVEL 25	50	100	500				Metal Particles per sq. ft.	Sample Particles per sq. ft.
>~12.5	5	36	389						
>25	1	7	78	86252				6	117
>50		1	11	11817				4	71
>100			1	1100				1	51
>250				26				0	28
>500				1				0	12
NVR=		NVR#		IR#					

The Contamination Level table shows the maximum number of particles per square foot of sampled area for each level. See BPS 27.43 for definitions and other details.

COMMENTS

Particle types within size ranges:

Fibers	f
Metals	m
Other	o

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To: National Center for Atmospheric Research
PO Box 3000
Boulder, CO 80307-3000
Attn: Gregory L. Card

Date: December 27, 2002
Ref.
BATC 31200.02.770

Samples: Three Molecular Contamination Witness Plates and two Settle Particle Witness Plates were sampled on November 14, 2002 and data were reported on December 9, 2002. A final sampling of all plates occurred on December 20, 2002 with Gregory Card present. The samples were described and labeled as follows:

1. NCAR NVR plate in cleanroom
2. NCAR NVR plate in Chamber – Vertical
3. NCAR NVR plate in Chamber – Horizontal
4. NCAR Chamber Particle Plate
5. NCAR Cleanroom Particle Plate

Procedure: Molecular Contamination Witness Plates (BPS 27.43)

Each sample was obtained by rinsing the witness plate (1 ft^2) with approximately 40 mL distilled heptane – isopropanol azeotrope, directly collecting each rinsate into a scintillation vial at the sampling site. Quantification of the nonvolatile residue was achieved by evaporation of the solvent at 105^{o}C. The residue was identified using a Bio-Rad FTS 40 Fourier Transform Infrared Spectroscopy (FTIR) coupled with a UMA 500 microscope in accordance with ASTM E 334-99, "Standard Practice for General Techniques of Infrared Microanalysis".

Settle Particle Witness Plates (BPS 27.43)

Each sample was obtained by rinsing the witness plate (1 ft^2) with approximately 100 mL isopropyl alcohol (filtered). Each rinsate was filtered onto a gridded filter membrane. Particles above 25 μm were counted and size ranged.

Results: The results of the Molecular Contamination Testing are summarized in the table below. The FTIR spectra for each of the residues are attached.

Sample Identification	NVR (mg/ft^2)	FTIR results
NCAR NVR Plate in cleanroom	0.09	Alkylaryl sulfonate, aromatic ester
NCAR NVR Plate in Chamber – Vertical	0.03	Aliphatic hydrocarbon, aromatic ester, silicone (5%), trace of amide
NCAR NVR Plate in Chamber – Horizontal	0.05	Aliphatic hydrocarbon, aromatic ester, silicone (5%), trace of amide

The results of the Settle Particle Testing are summarized in the attached data sheets.

Discussion: The spectra of these samples are consistent with those previously observed and reported. (See report issued on 12/9/02). However, the level of molecular contamination in the chamber is 40-70% less than previously reported. The source of the alkylaryl sulfonate is still unknown at this time.

Report Prepared by:

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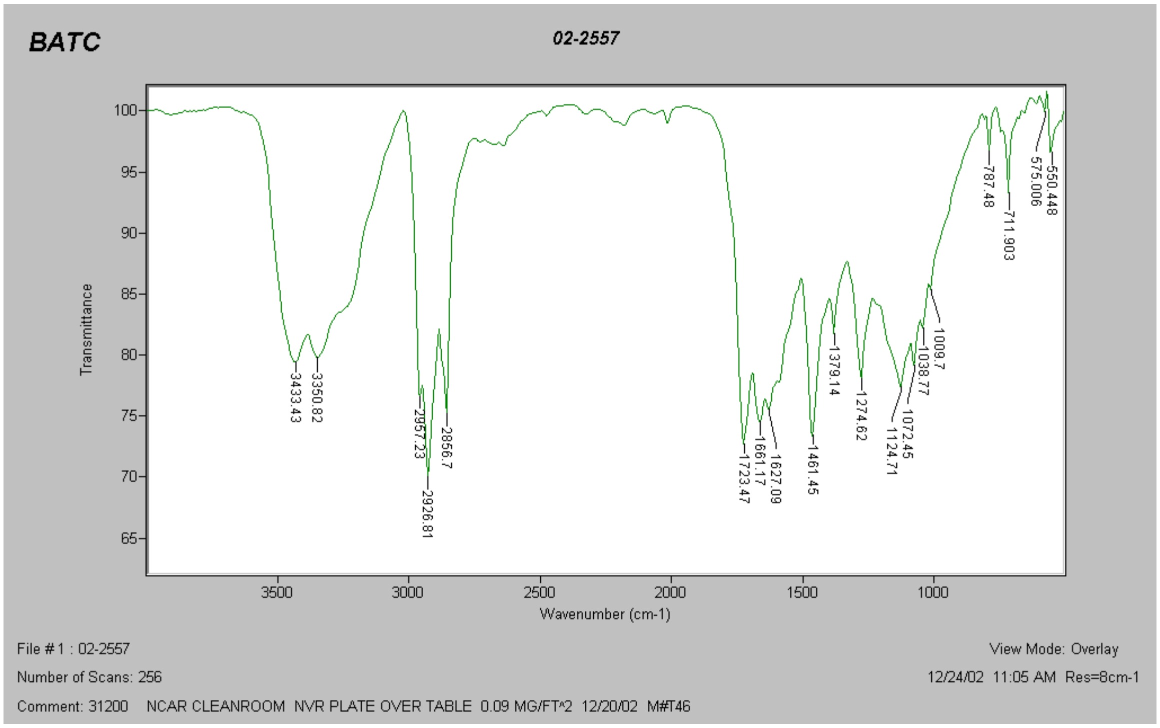
Michael S. Pirkey
Senior Engineer

Attachments
cc: to file


BATC
02-2557
Transmittance
Wavenumber (cm-1)
3433.43
3350.82
2957.23
2926.81
2856.7
1723.47
1661.17
1627.09
1461.45
1379.14
1274.62
1124.71
1072.45
1038.77
1009.7
787.48
711.903
575.006
550.448
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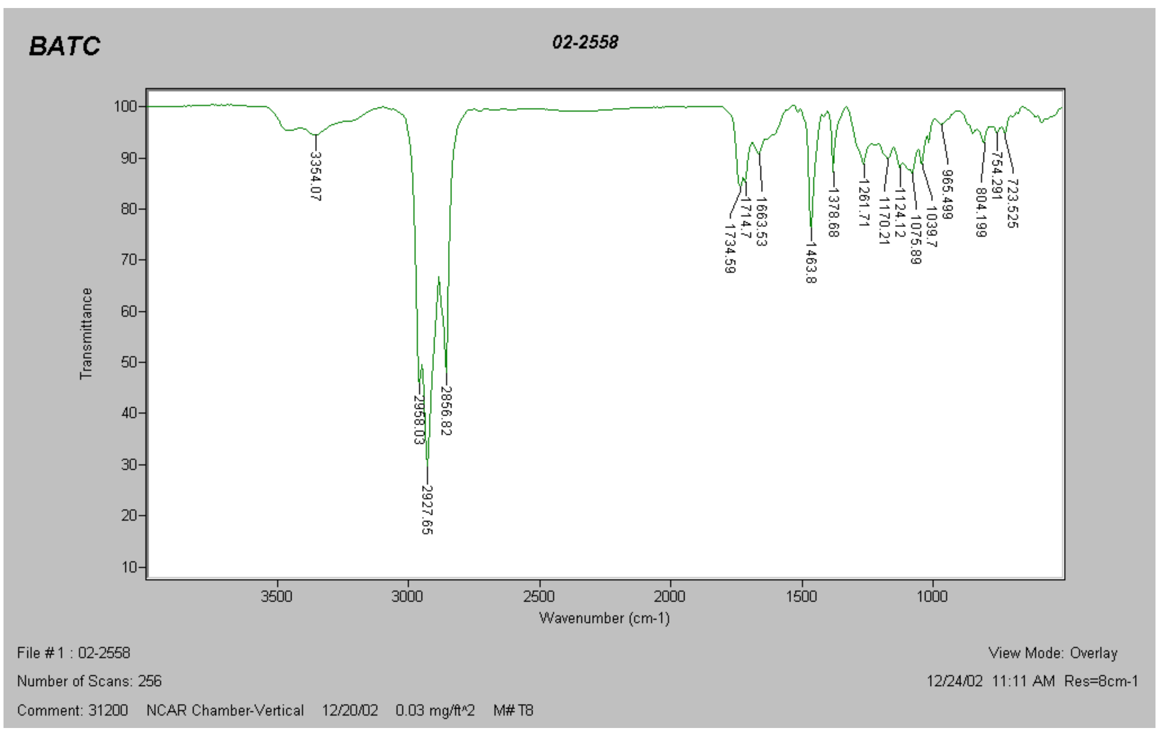
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02-2558
Transmittance
Wavenumber (cm-1)
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2958.03
2927.65
2856.82
1734.59
1714.7
1663.53
1463.8
1378.68
1261.71
1170.21
1124.12
1075.89
1039.7
965.499
804.199
754.291
723.525
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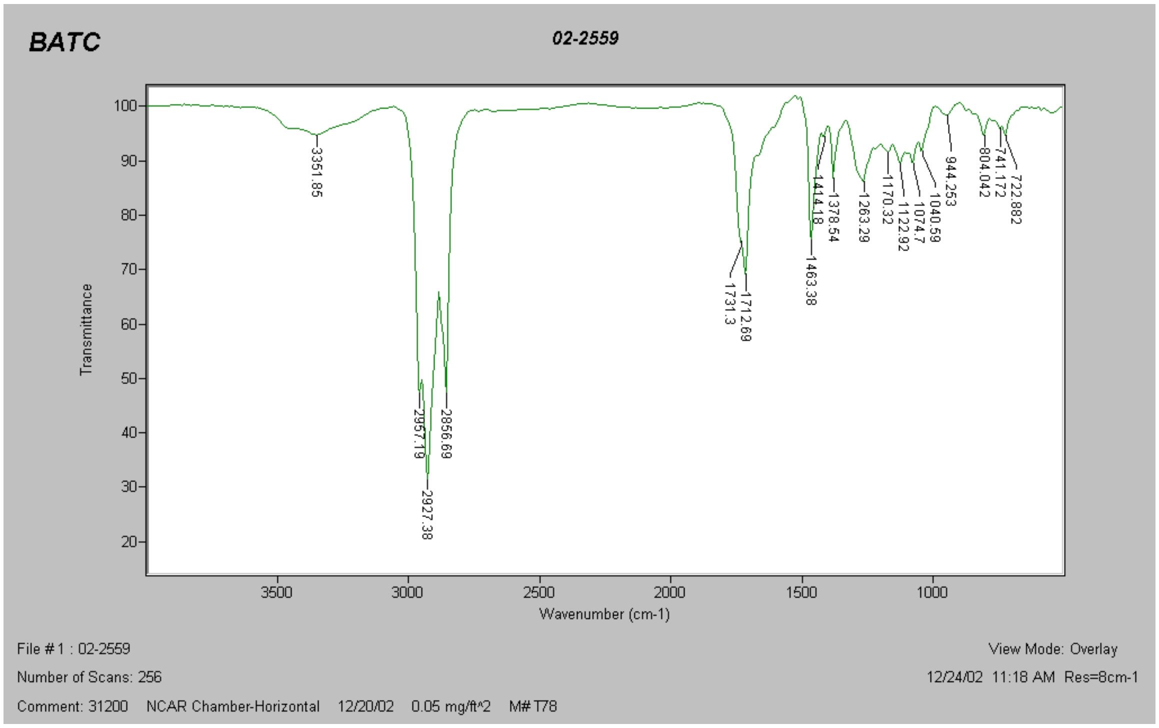

BATC
02-2559
Transmittance
100
90
80
70
60
50
40
30
20
3500
3000
2500
2000
1500
1000
Wavenumber (cm-1)
3351.85
2957.19
2927.38
2856.69
1731.3
1712.69
1463.38
1414.18
1378.54
1263.29
1170.32
1122.92
1074.7
1040.59
944.253
804.042
741.172
722.882
File # 1 : 02-2559
View Mode: Overlay
Number of Scans: 256
12/24/02 11:18 AM Res=8cm-1
Comment: 31200 NCAR Chamber-Horizontal 12/20/02 0.05 mg/ft^2 M# T78

PARTICLE COUNT TALLY SHEET

PC# 02-132

Source description:	NCAR Cleanroom	Project:	NCAR
Particle Plate On Top Of Flow Bench		Project No.	31200.02.770
		Production No.	
Inspector:	EG	Sample liquid:	IPA
Date:	12/20/02	Sample volume:	~ 100 ml
Requested by:	M. Pirkey / NCAR	Sampled area:	1 Ft ^2

PARTICLE SIZE RANGE micrometers	PARTICLE COUNTS IN GRID SQUARES OF PARTIAL FILTER AREA A	B	C	D	E	Total Count for rep. filter area	Extrapolated count for sampled area	Particle Types Per sq. ft.	Particles per sq. ft. Total
6-12 f									
m									
o									
13-15									
26-50								0	
								1	9
								8	
51-100								3	
								1	13
								9	
101-250								2	
								0	3
								1	
250-500								2	
								0	3
								1	
>500								1	
								0	1
								0	

PARTICLE SIZE micrometers	CONTAMINATION LEVEL 25	50	100	500				Metal Particles per sq. ft.	Sample Particles per sq. ft.
>~12.5	5	36	389						
>25	1	7	78	86252				2	29
>50		1	11	11817				1	20
>100			1	1100				0	7
>250				26				0	4
>500				1				0	1

NVR= NVR# IR#

The Contamination Level table shows the maximum number of particles per square foot of sampled area for each level. See BPS 27.43 for definitions and other details.

COMMENTS

Particle types within size ranges: Fibers f
Metals m
Other o

PARTICLE COUNT TALLY SHEET

PC# 02-133

Source description: NCAR Cleanroom		Project:	NCAR
Particle Plate In Chamber		Project No.	31200.02.770
		Production No.	
Inspector: EG		Sample liquid:	IPA
Date: 12/20/02		Sample volume:	~ 100 ml
Requested by: M. Pirkey / NCAR		Sampled area:	1 Ft^2

PARTICLE SIZE RANGE micrometers	PARTICLE COUNTS IN GRID SQUARES OF PARTIAL FILTER AREA A	B	C	D	E	Total Count for rep. filter area	Extrapolated count for sampled area	Particle Types Per sq. ft.	Particles per sq. ft. Total
6-12 f									
m									
o									
13-15									
26-50								0	
								0	11
								11	
51-100								1	
								0	9
								8	
101-250								1	
								0	2
								1	
250-500								1	
								0	2
								1	
>500								4	
								0	4
								0	

PARTICLE SIZE micrometers	CONTAMINATION LEVEL 25	50	100	500				Metal Particles per sq. ft.	Sample Particles per sq. ft.
>~12.5	5	36	389						
>25	1	7	78	86252				0	28
>50		1	11	11817				0	17
>100			1	1100				0	8
>250				26				0	6
>500				1				0	4
NVR=		NVR#		IR#					

The Contamination Level table shows the maximum number of particles per square foot of sampled area for each level. See BPS 27.43 for definitions and other details.

COMMENTS

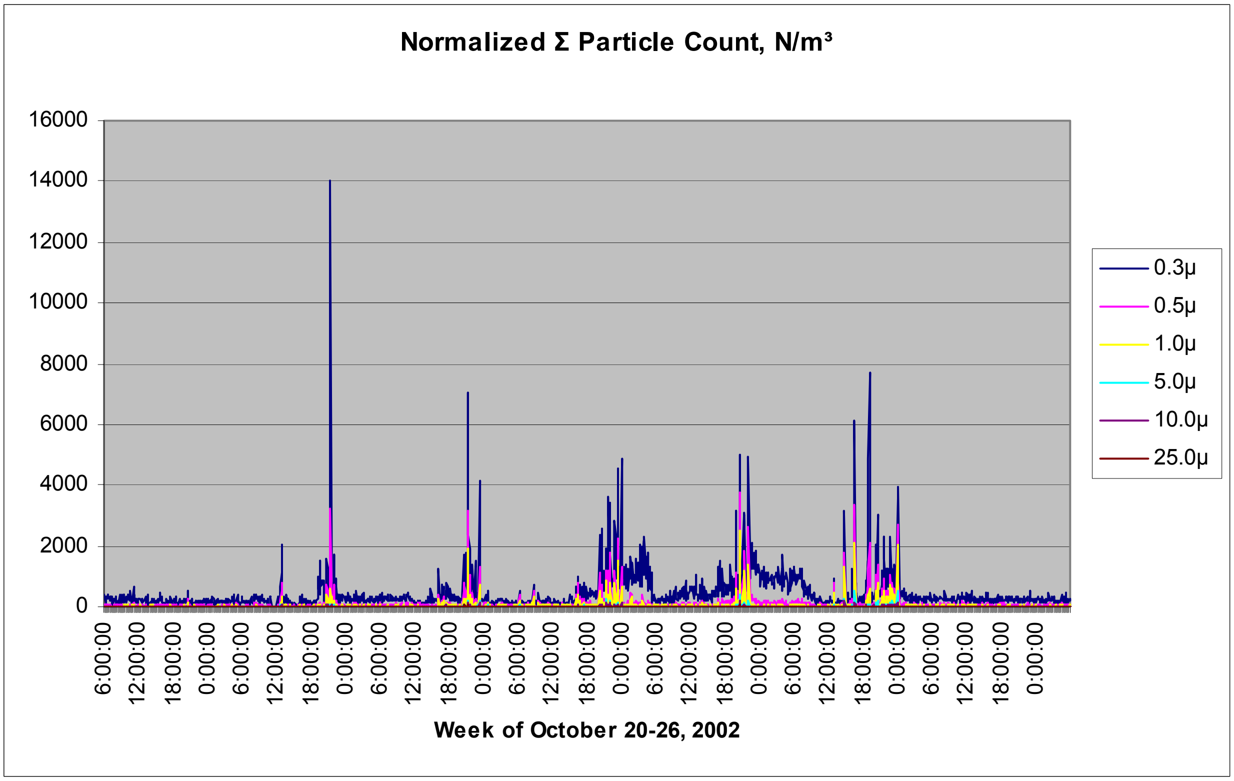
Particle types within size ranges: Fibers f

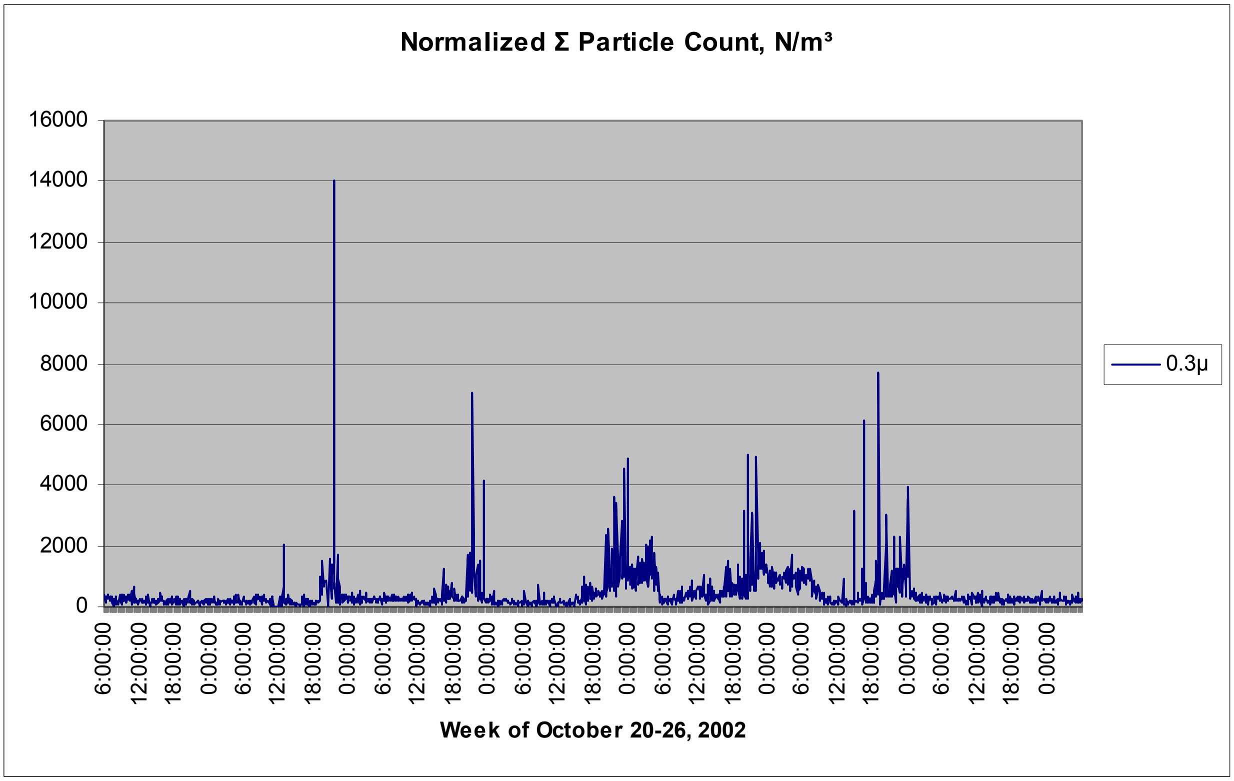
Metals m

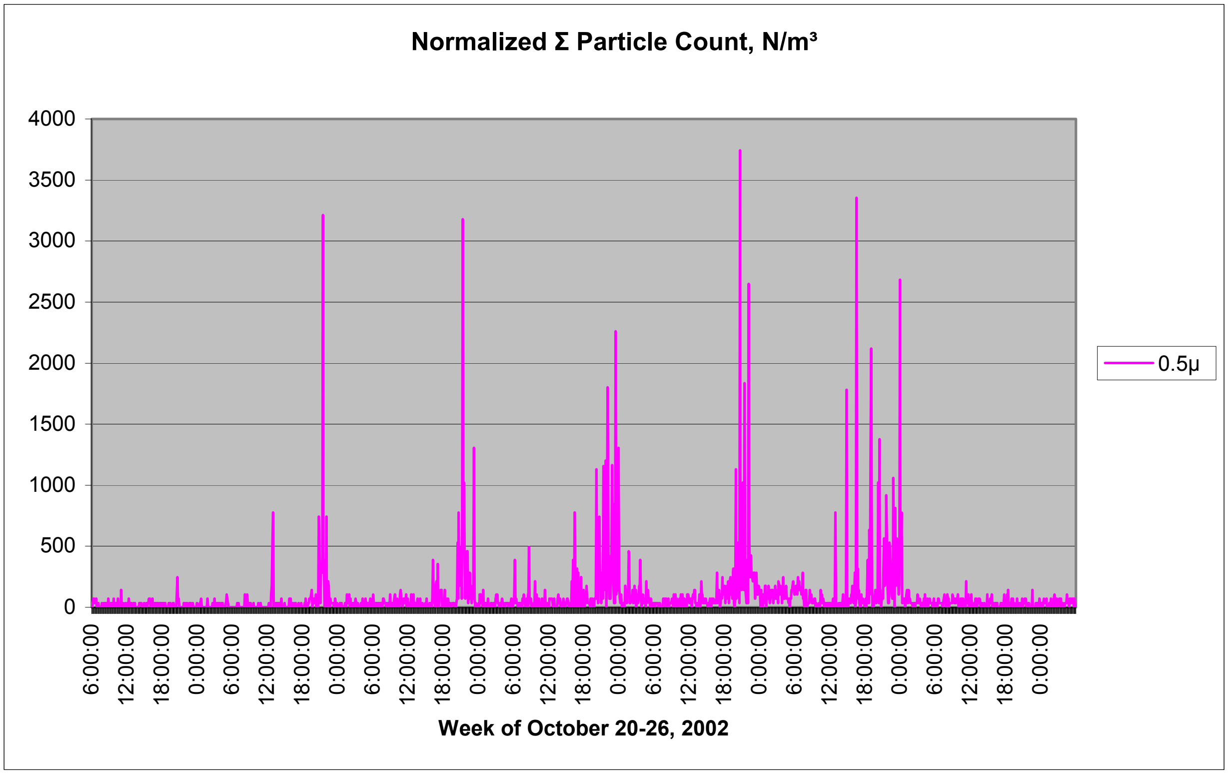
Other o

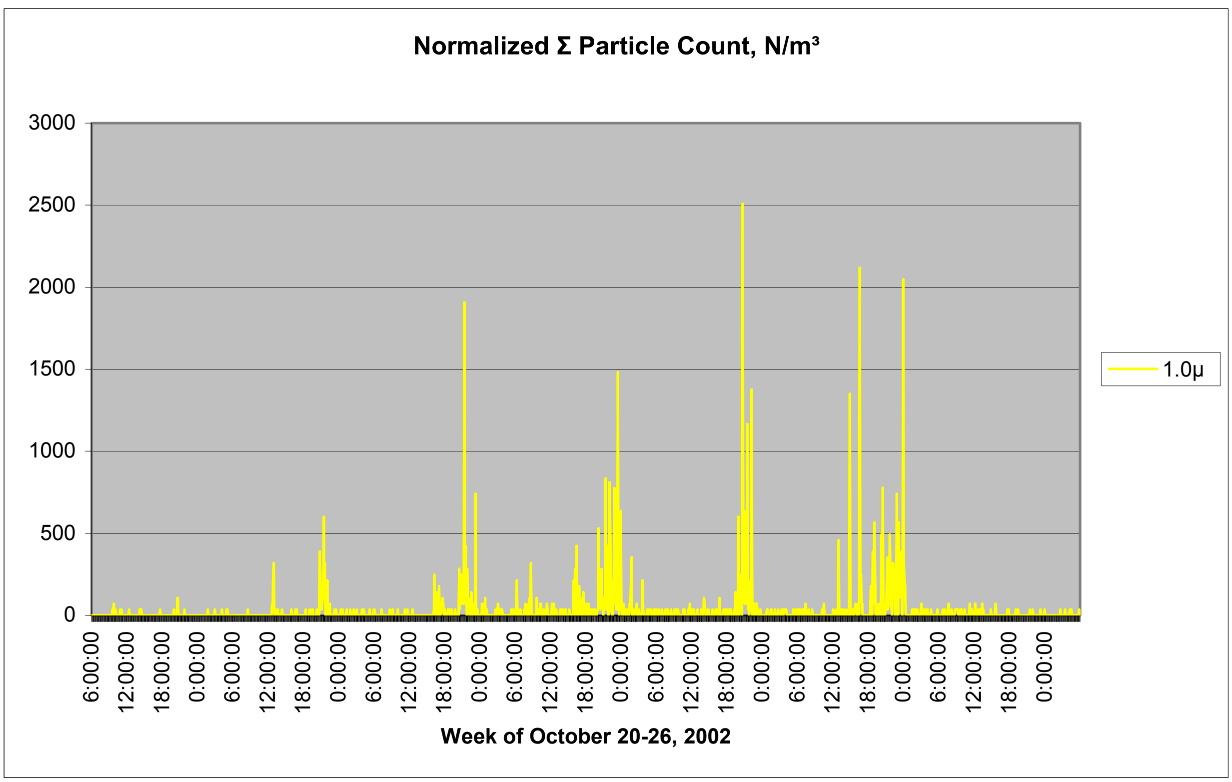
Cleanroom Particle Counts, Temperature and Relative Humidity
October 20 – December 21, 2002

Note: All times are in UT.






Normalized Σ Particle Count, N/m³
4000
3500
3000
2500
2000
1500
1000
500
0
0.5μ
6:00:00
12:00:00
18:00:00
0:00:00
Week of October 20-26, 2002


Normalized Σ Particle Count, N/m³
3000
2500
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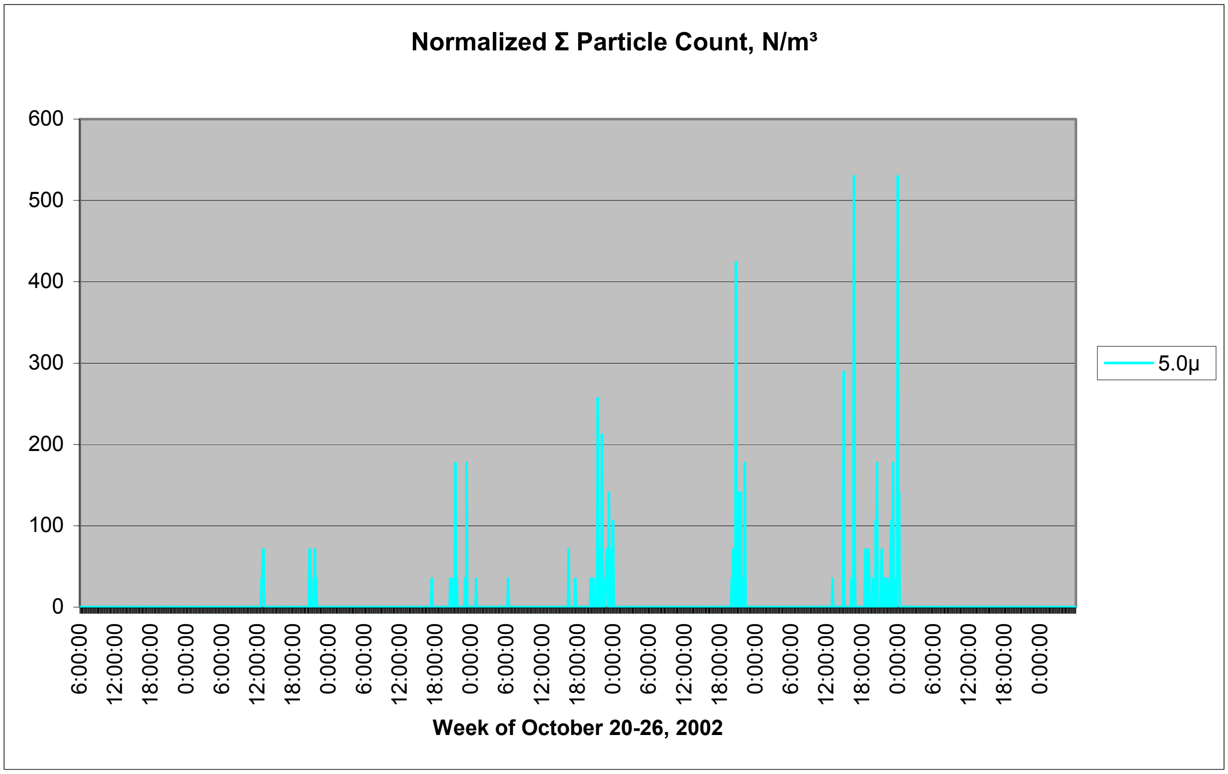
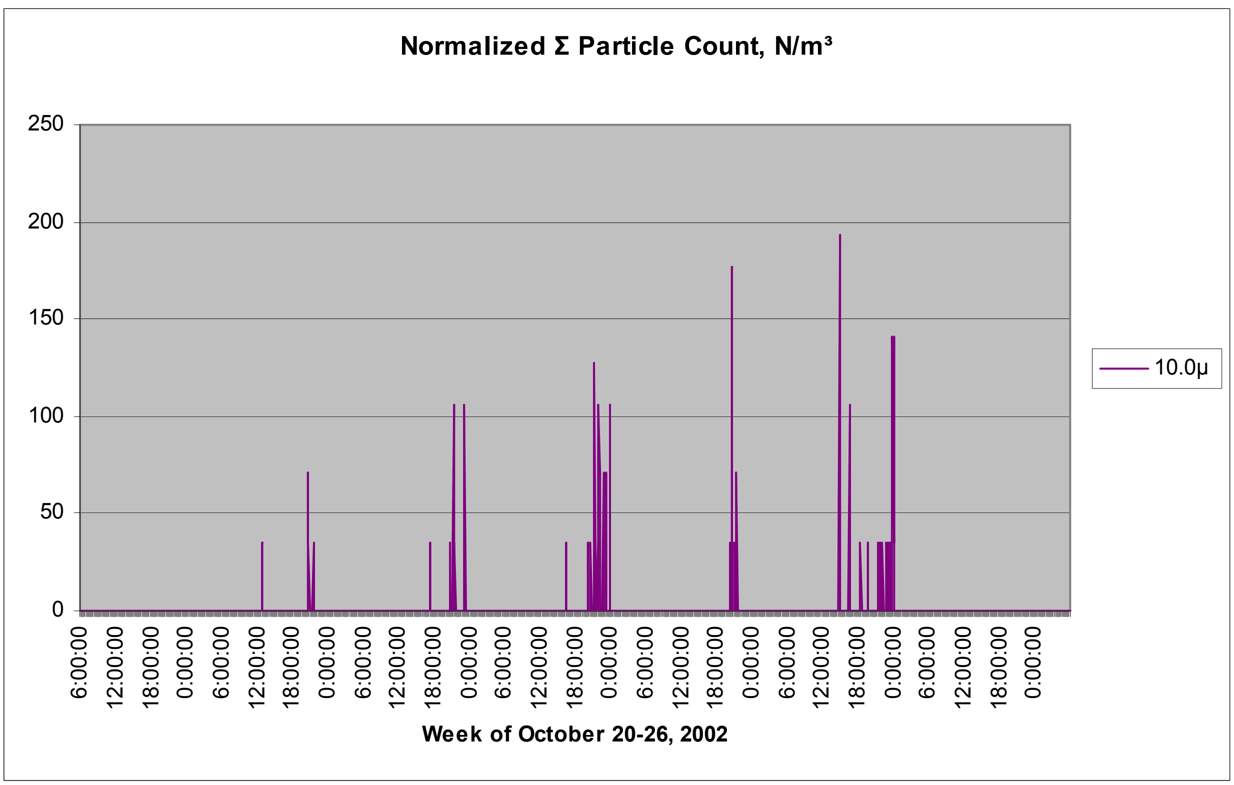
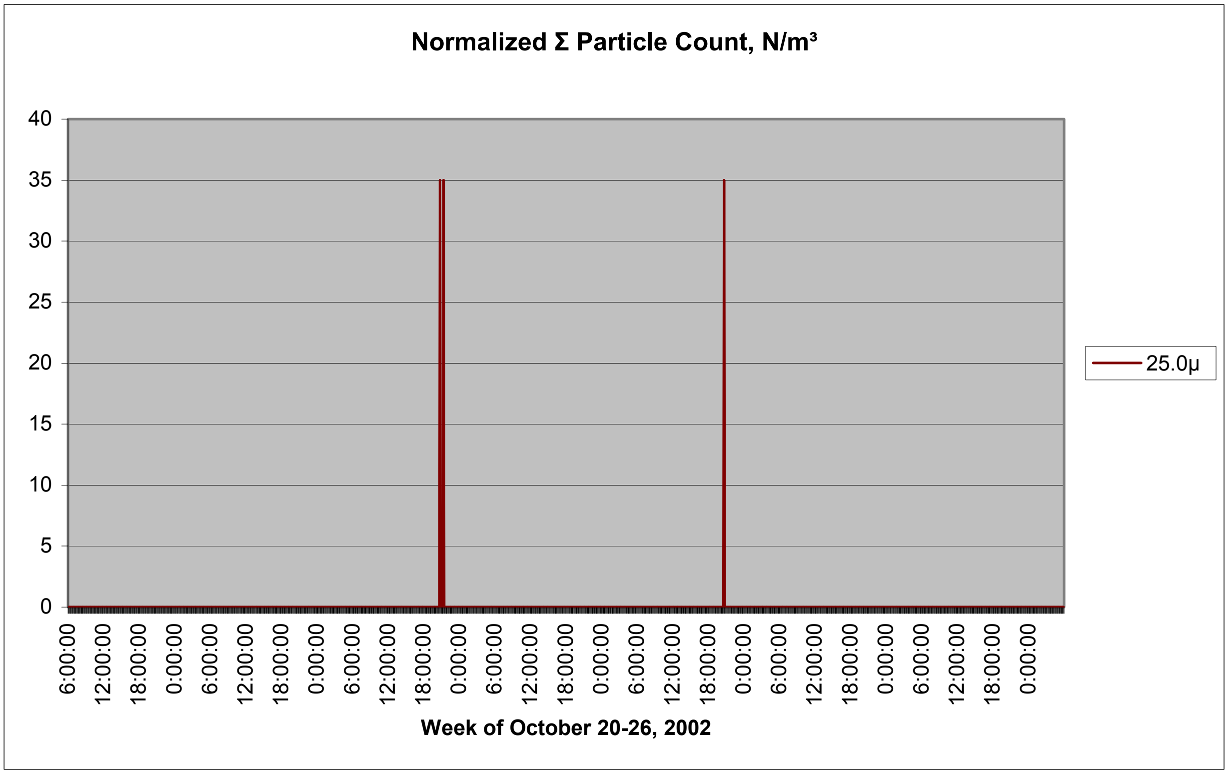
12:00:00
18:00:00
0:00:00
Week of October 20-26, 2002

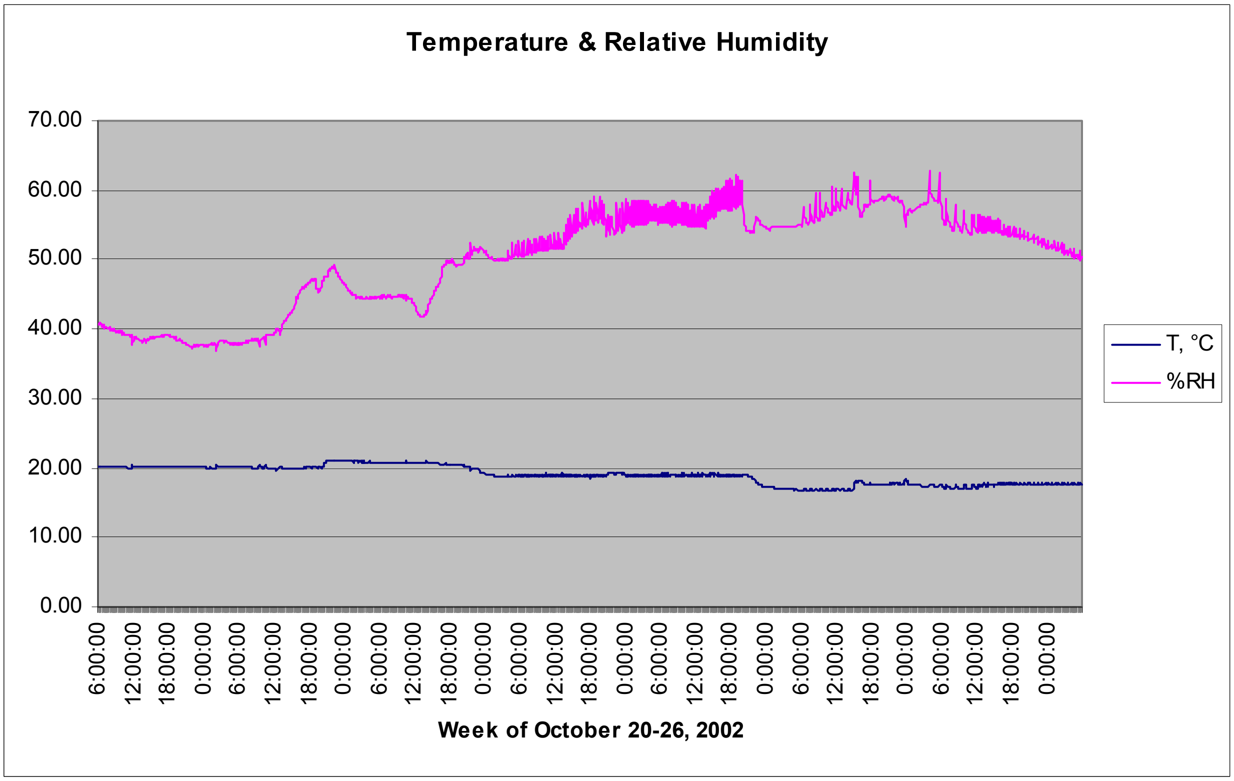


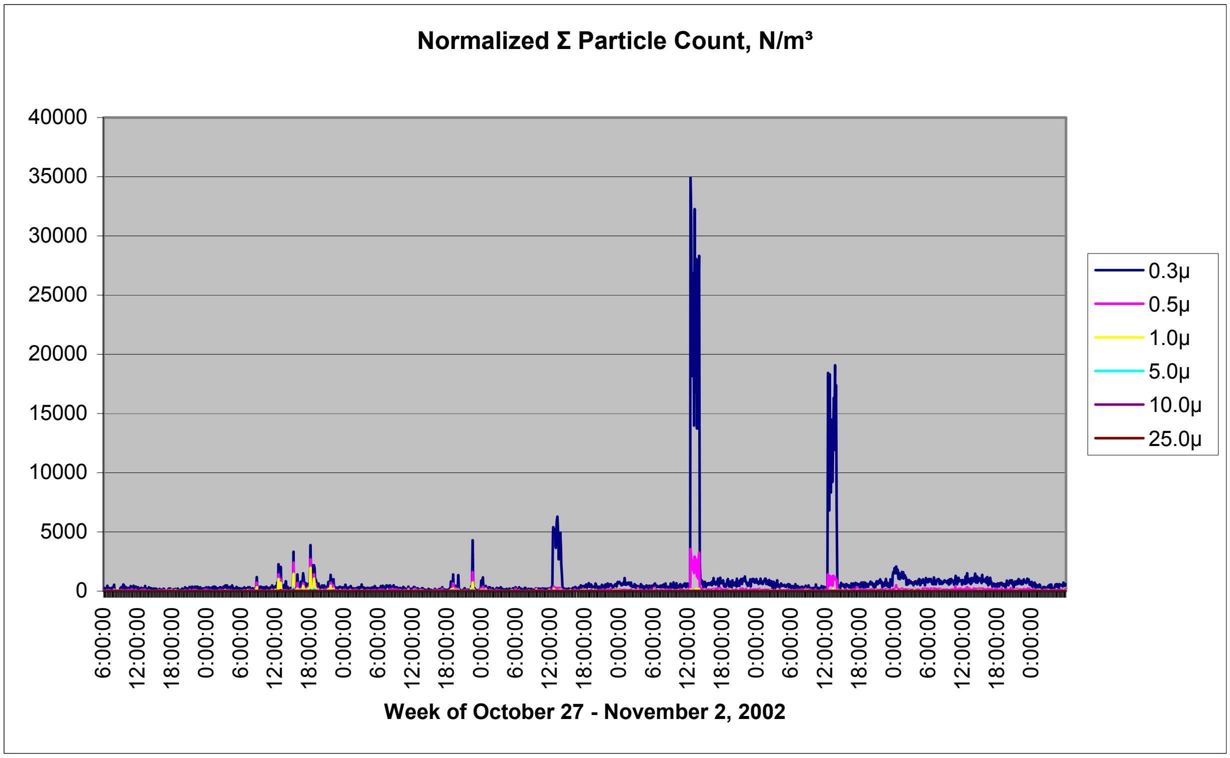
Normalized Σ Particle Count, N/m³
600
500
400
300
200
100
0
5.0μ
6:00:00
12:00:00
18:00:00
0:00:00
Week of October 20-26, 2002



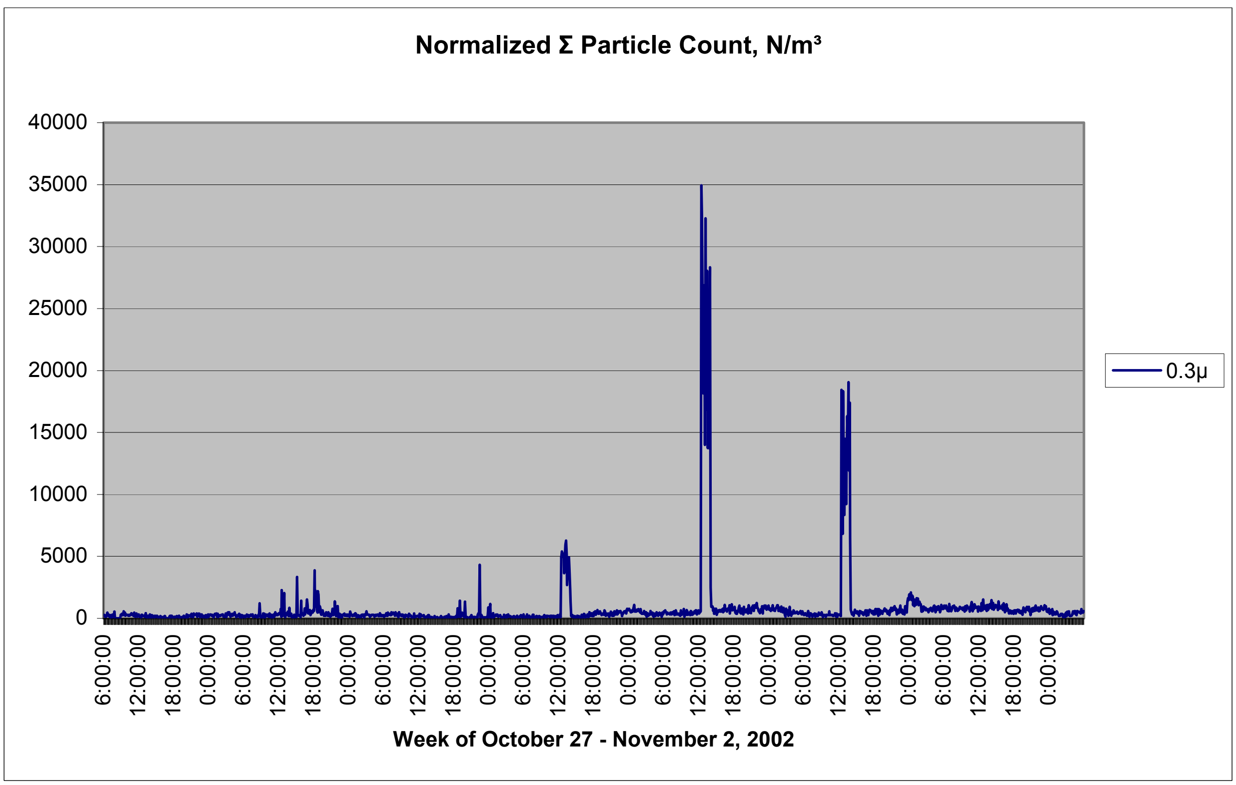
Normalized Σ Particle Count, N/m³
250
200
150
100
50
0
10.0μ
6:00:00
12:00:00
18:00:00
0:00:00
Week of October 20-26, 2002


Normalized Σ Particle Count, N/m³
40
35
30
25
20
15
10
5
0
25.0μ
6:00:00
12:00:00
18:00:00
0:00:00
Week of October 20-26, 2002

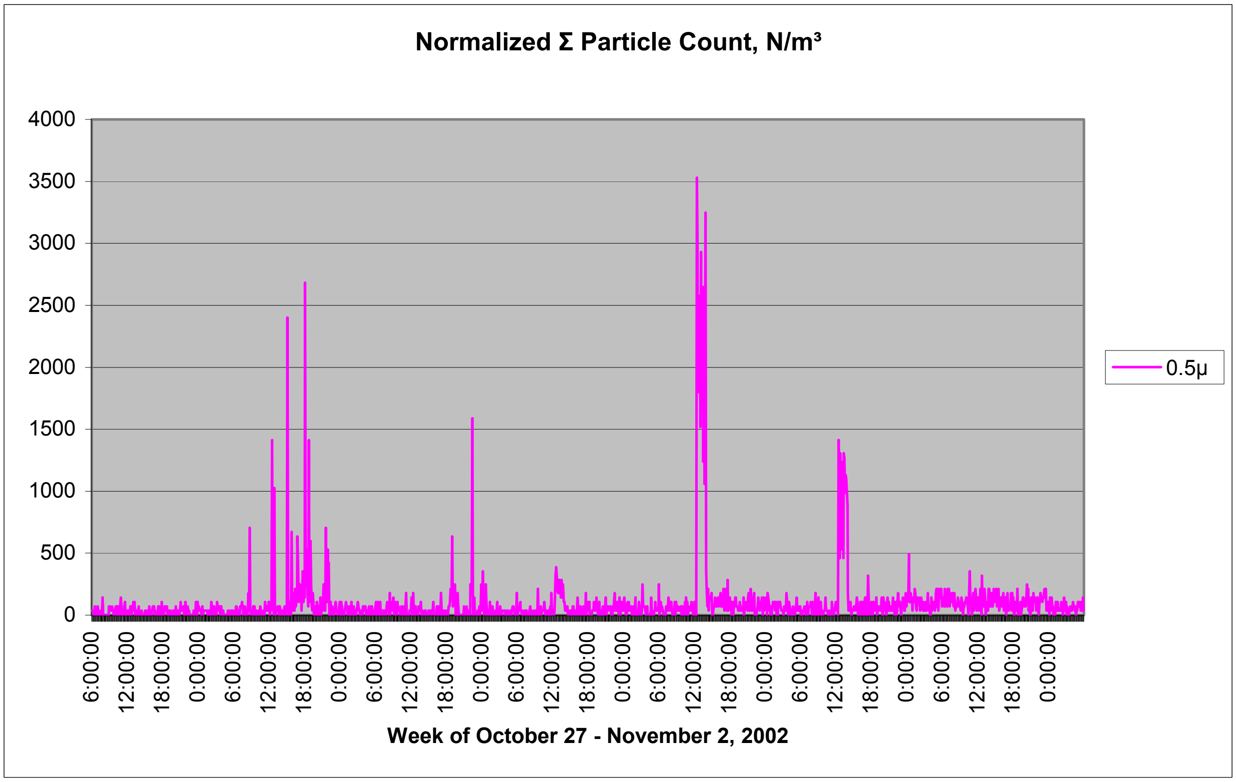

Temperature & Relative Humidity
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
T, °C
%RH
6:00:00
12:00:00
18:00:00
0:00:00
Week of October 20-26, 2002



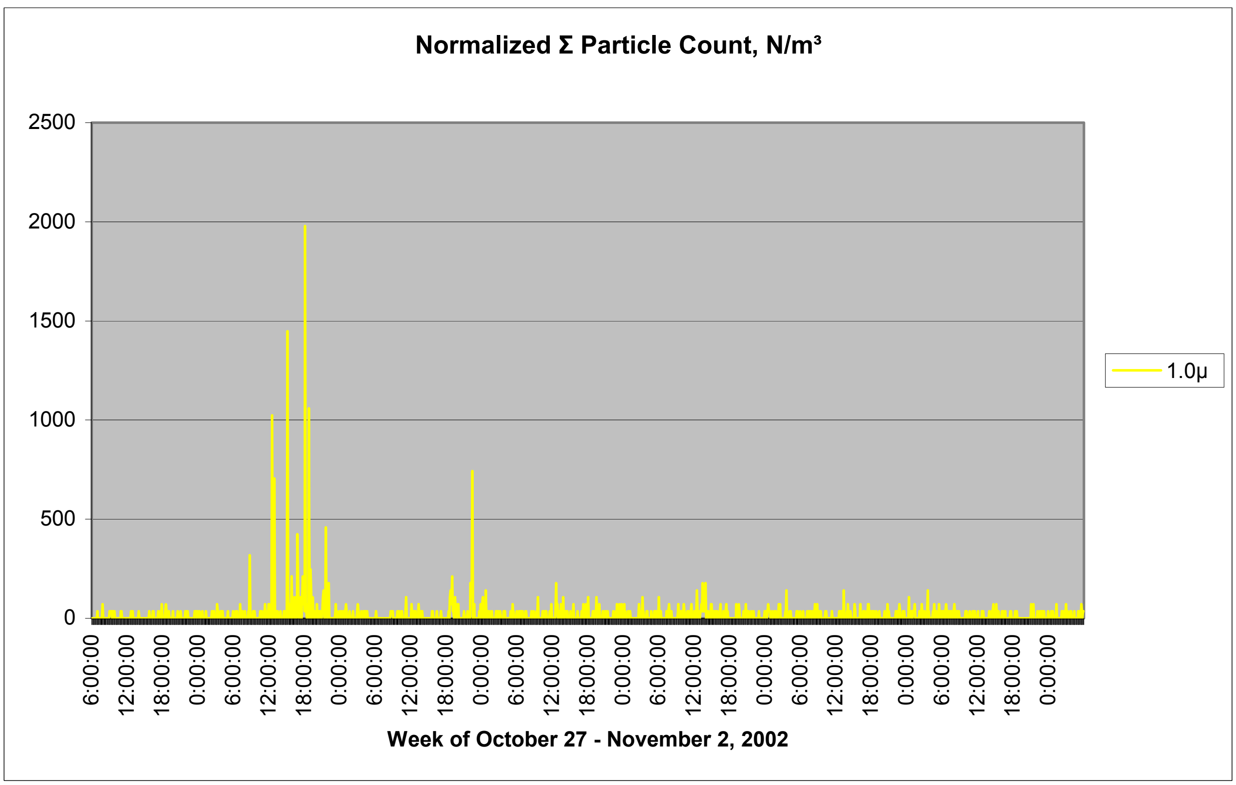
Normalized Σ Particle Count, N/m³
40000
35000
30000
25000
20000
15000
10000
5000
0
0.3µ
0.5µ
1.0µ
5.0µ
10.0µ
25.0µ
6:00:00
12:00:00
18:00:00
0:00:00
Week of October 27 - November 2, 2002



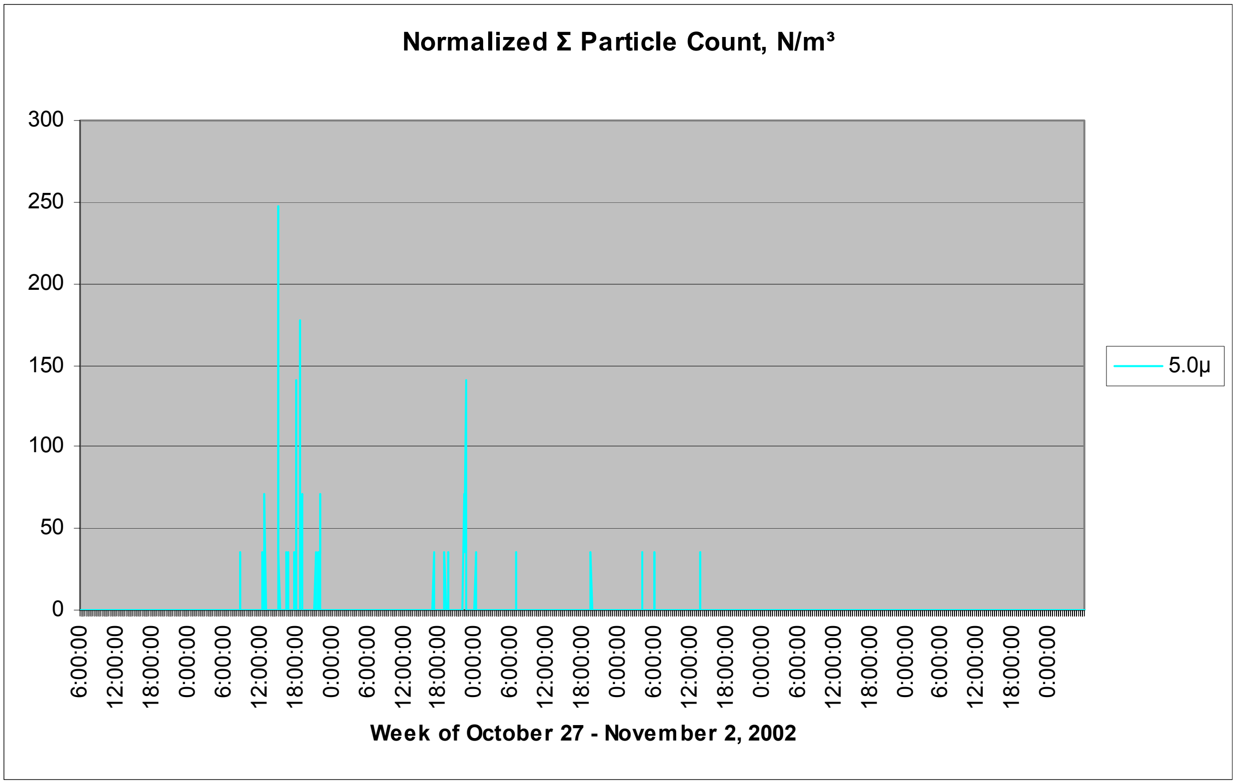
Normalized Σ Particle Count, N/m³
40000
35000
30000
25000
20000
15000
10000
5000
0
0.3µ
6:00:00
12:00:00
18:00:00
0:00:00
Week of October 27 - November 2, 2002

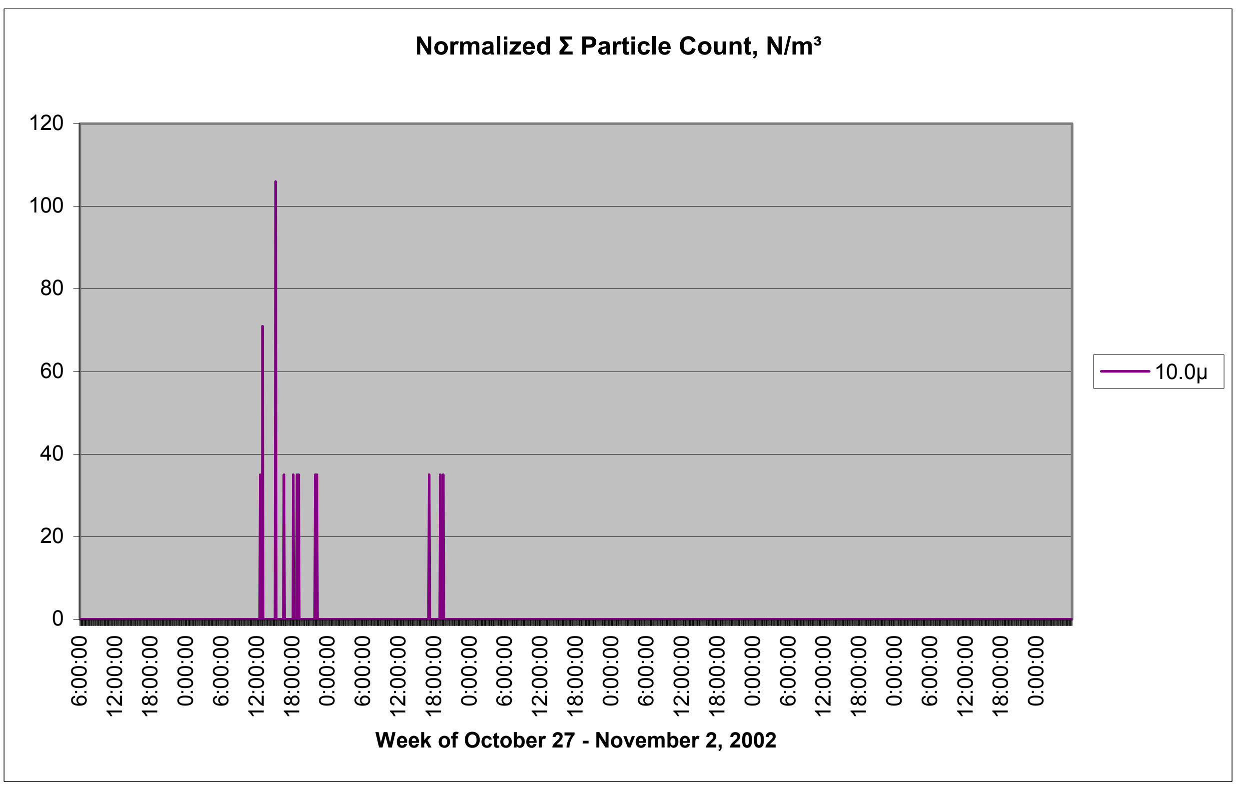


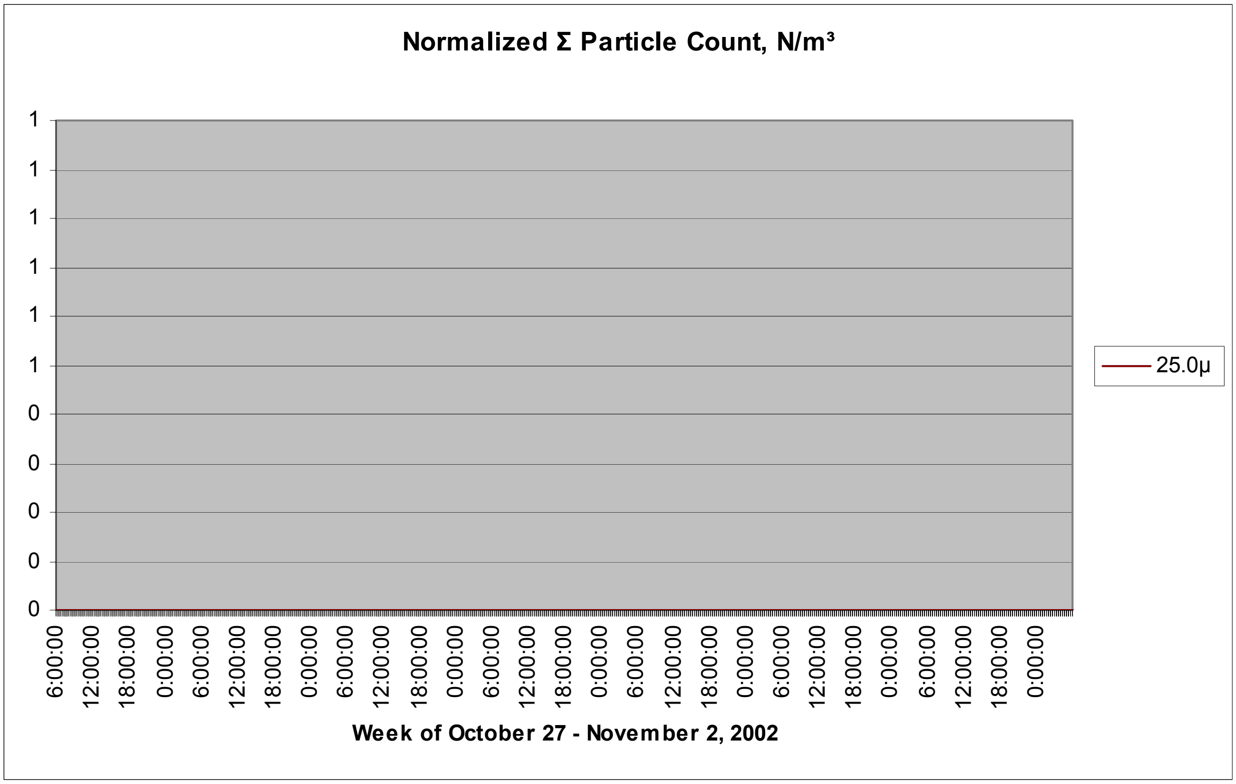
Normalized Σ Particle Count, N/m³
4000
3500
3000
2500
2000
1500
1000
500
0
6:00:00
12:00:00
18:00:00
0:00:00
Week of October 27 - November 2, 2002
0.5μ



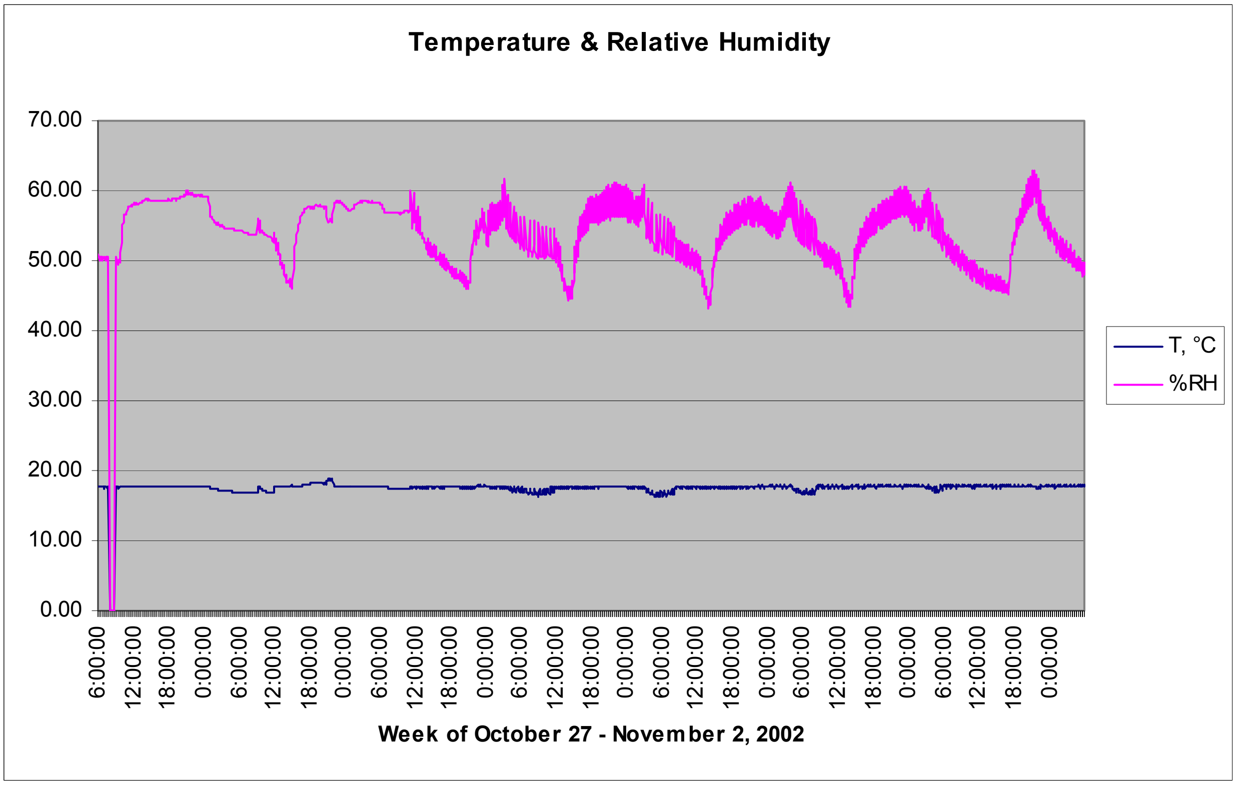
Normalized Σ Particle Count, N/m³
2500
2000
1500
1000
500
0
6:00:00
12:00:00
18:00:00
0:00:00
Week of October 27 - November 2, 2002
1.0μ


Normalized Σ Particle Count, N/m³
300
250
200
150
100
50
0
5.0μ
6:00:00
12:00:00
18:00:00
0:00:00
Week of October 27 - November 2, 2002

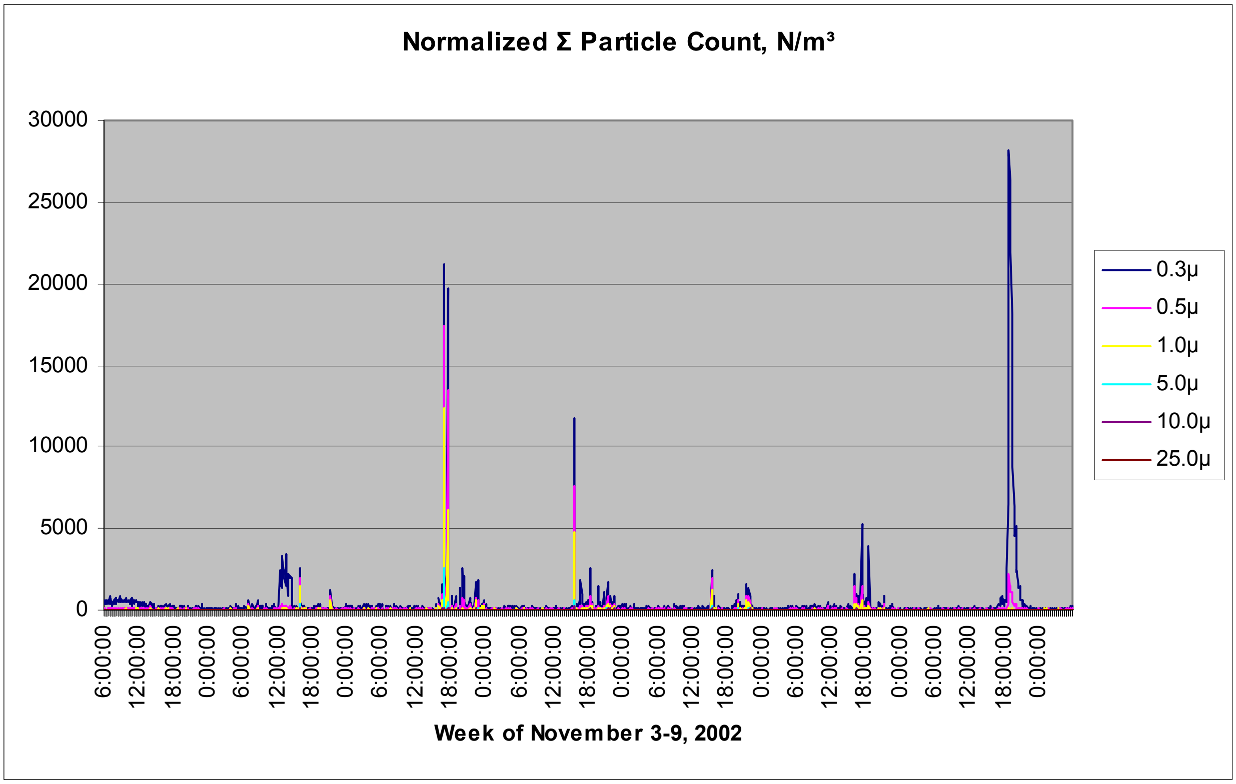

Normalized Σ Particle Count, N/m³
120
100
80
60
40
20
0
10.0μ
6:00:00
12:00:00
18:00:00
0:00:00
Week of October 27 - November 2, 2002

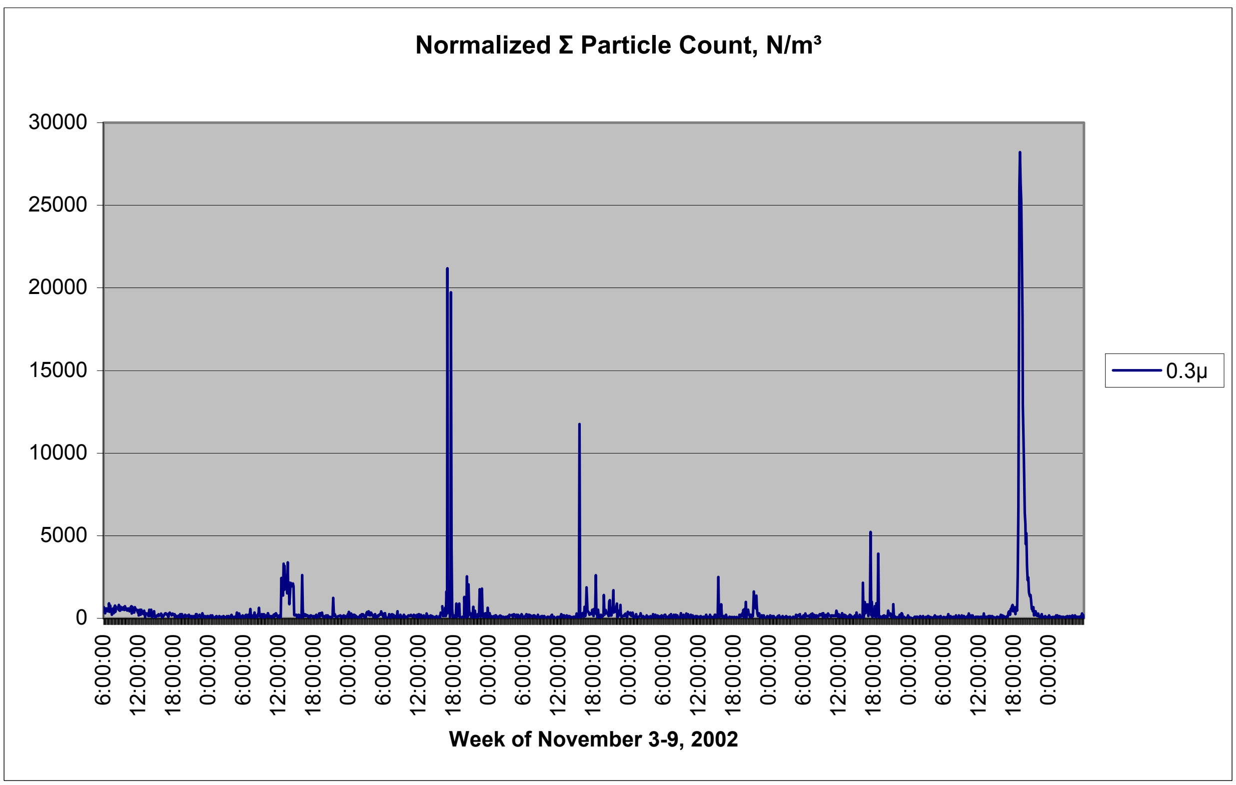


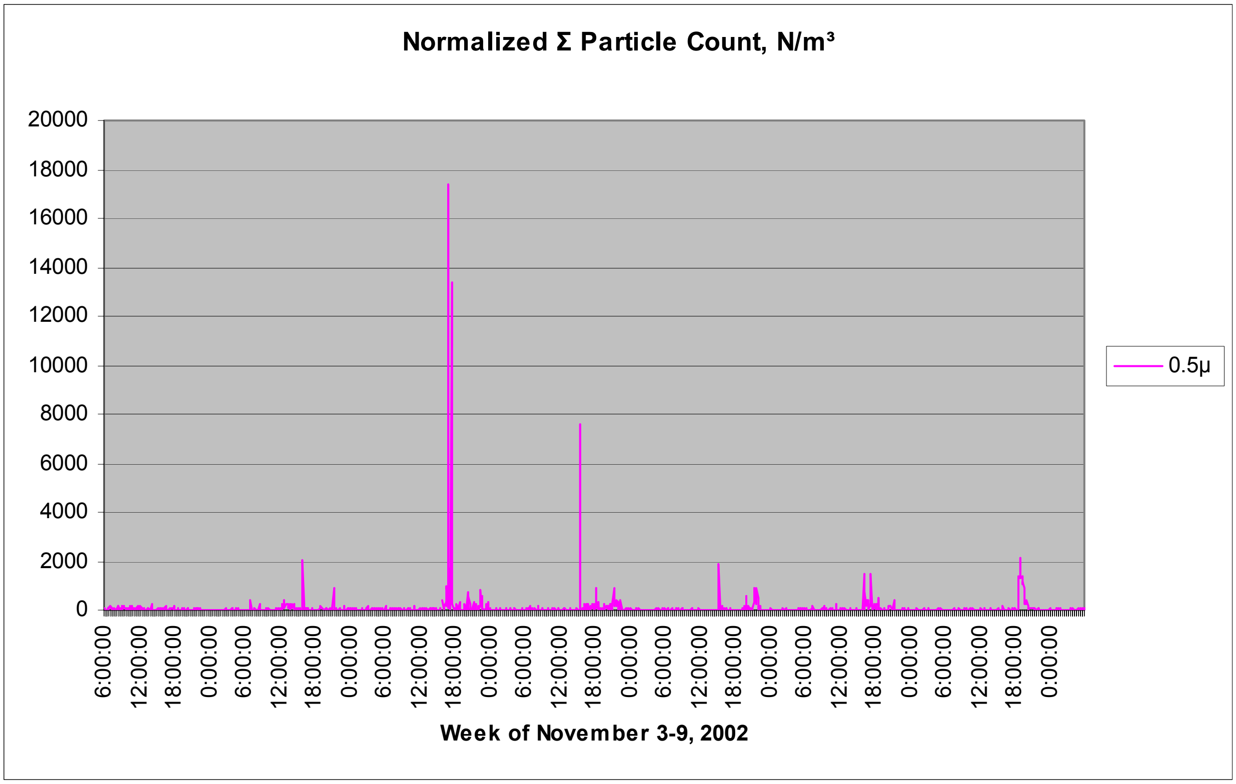
Normalized Σ Particle Count, N/m³
1
1
1
1
1
1
0
0
0
0
0
25.0µ
6:00:00
12:00:00
18:00:00
0:00:00
Week of October 27 - November 2, 2002

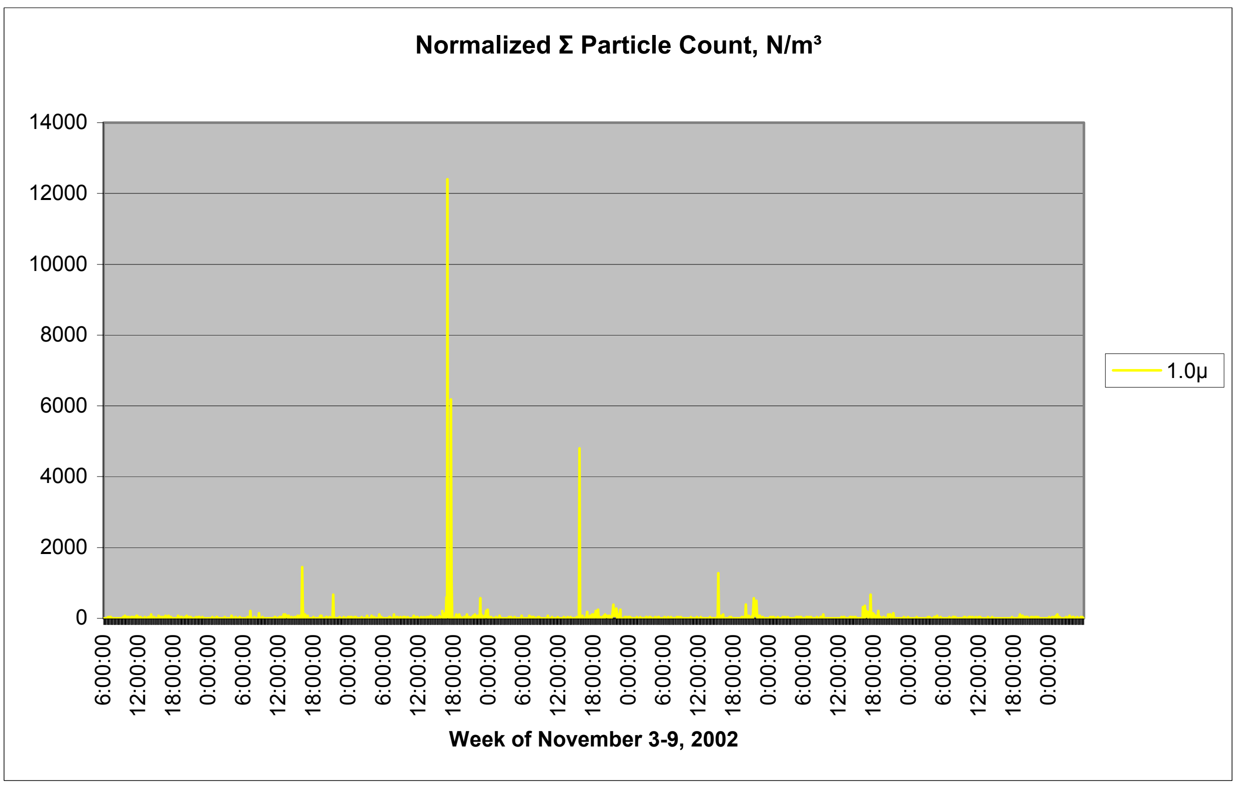


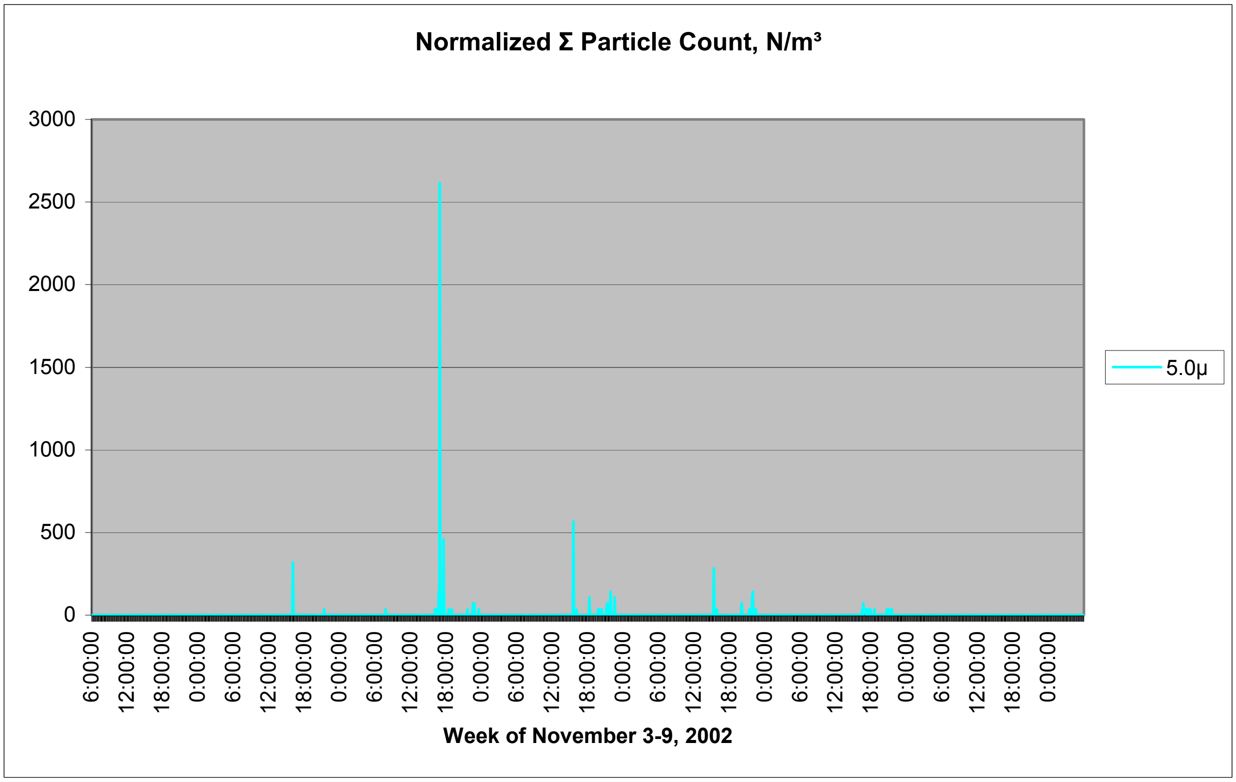
Temperature & Relative Humidity
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
T, °C
%RH
6:00:00
12:00:00
18:00:00
0:00:00
Week of October 27 - November 2, 2002

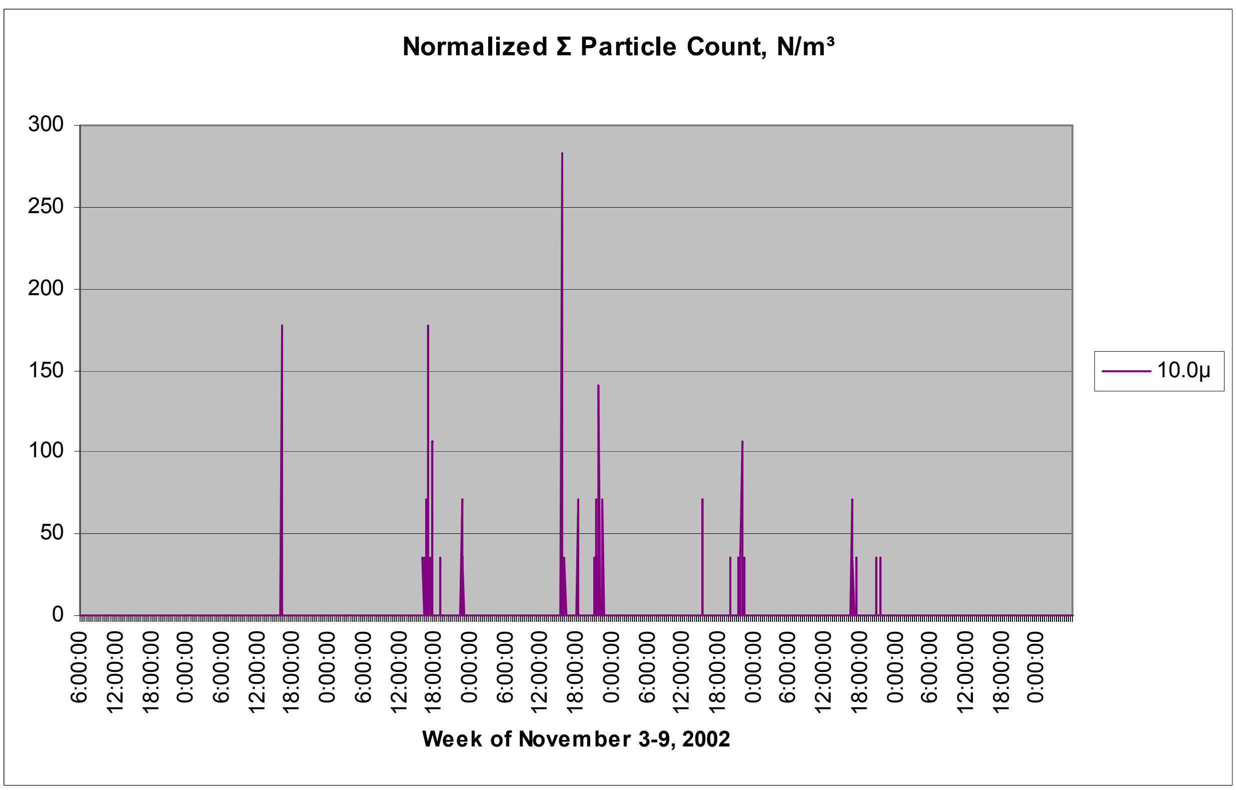

Normalized Σ Particle Count, N/m³
30000
25000
20000
15000
10000
5000
0
6:00:00
12:00:00
18:00:00
0:00:00
Week of November 3-9, 2002
0.3μ
0.5μ
1.0μ
5.0μ
10.0μ
25.0μ

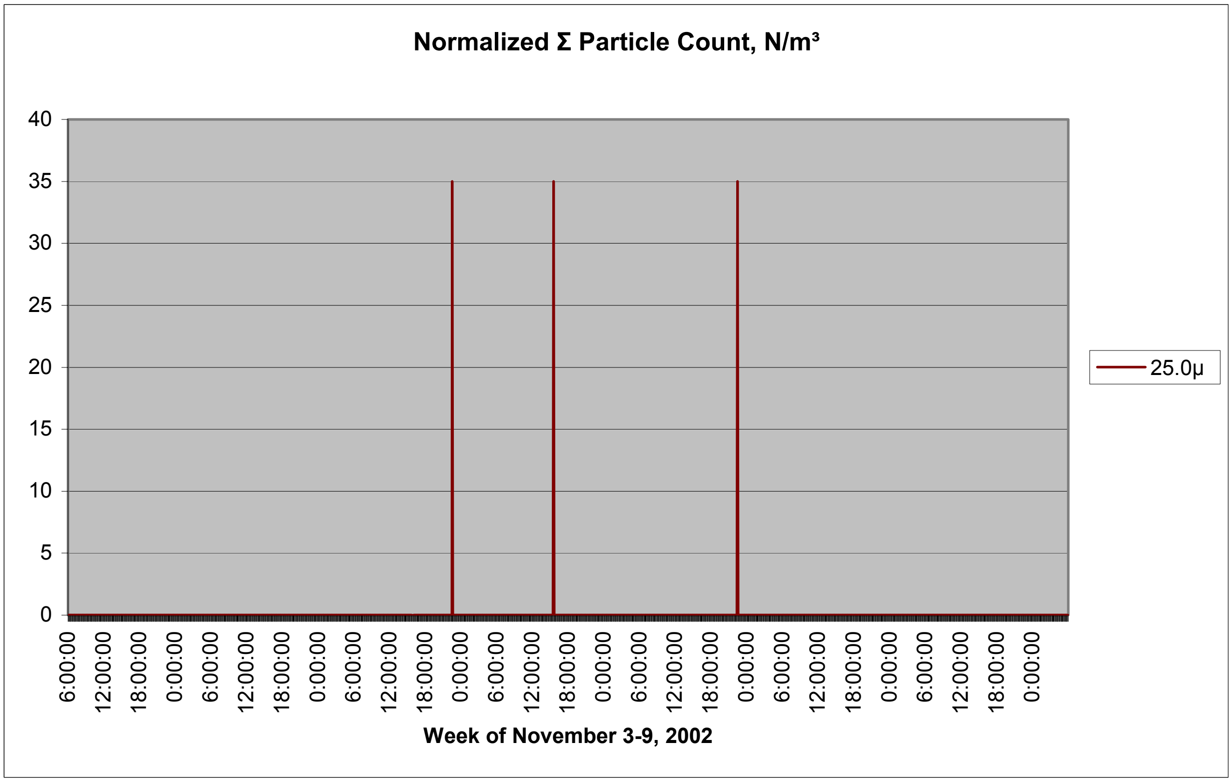

Normalized Σ Particle Count, N/m³
30000
25000
20000
15000
10000
5000
0
6:00:00
12:00:00
18:00:00
0:00:00
Week of November 3-9, 2002
0.3μ


Normalized Σ Particle Count, N/m³
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
0.5µ
6:00:00
12:00:00
18:00:00
0:00:00
6:00:00
12:00:00
18:00:00
0:00:00
6:00:00
12:00:00
18:00:00
0:00:00
6:00:00
12:00:00
18:00:00
0:00:00
6:00:00
12:00:00
18:00:00
0:00:00
6:00:00
12:00:00
18:00:00
0:00:00
6:00:00
12:00:00
18:00:00
0:00:00
Week of November 3-9, 2002

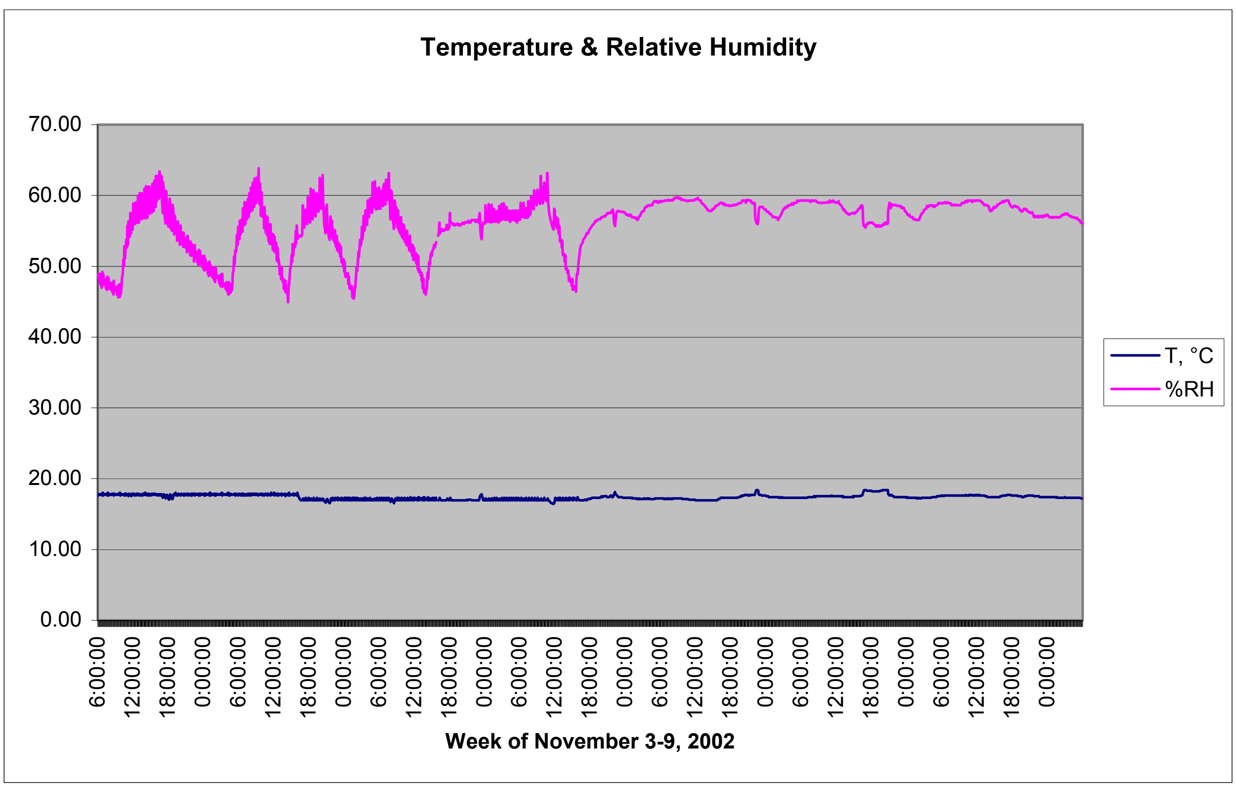

Normalized Σ Particle Count, N/m³
14000
12000
10000
8000
6000
4000
2000
0
1.0µ
6:00:00
12:00:00
18:00:00
0:00:00
6:00:00
12:00:00
18:00:00
0:00:00
6:00:00
12:00:00
18:00:00
0:00:00
6:00:00
12:00:00
18:00:00
0:00:00
6:00:00
12:00:00
18:00:00
0:00:00
6:00:00
12:00:00
18:00:00
0:00:00
6:00:00
12:00:00
18:00:00
0:00:00
Week of November 3-9, 2002


Normalized Σ Particle Count, N/m³
3000
2500
2000
1500
1000
500
0
5.0µ
6:00:00
12:00:00
18:00:00
0:00:00
Week of November 3-9, 2002

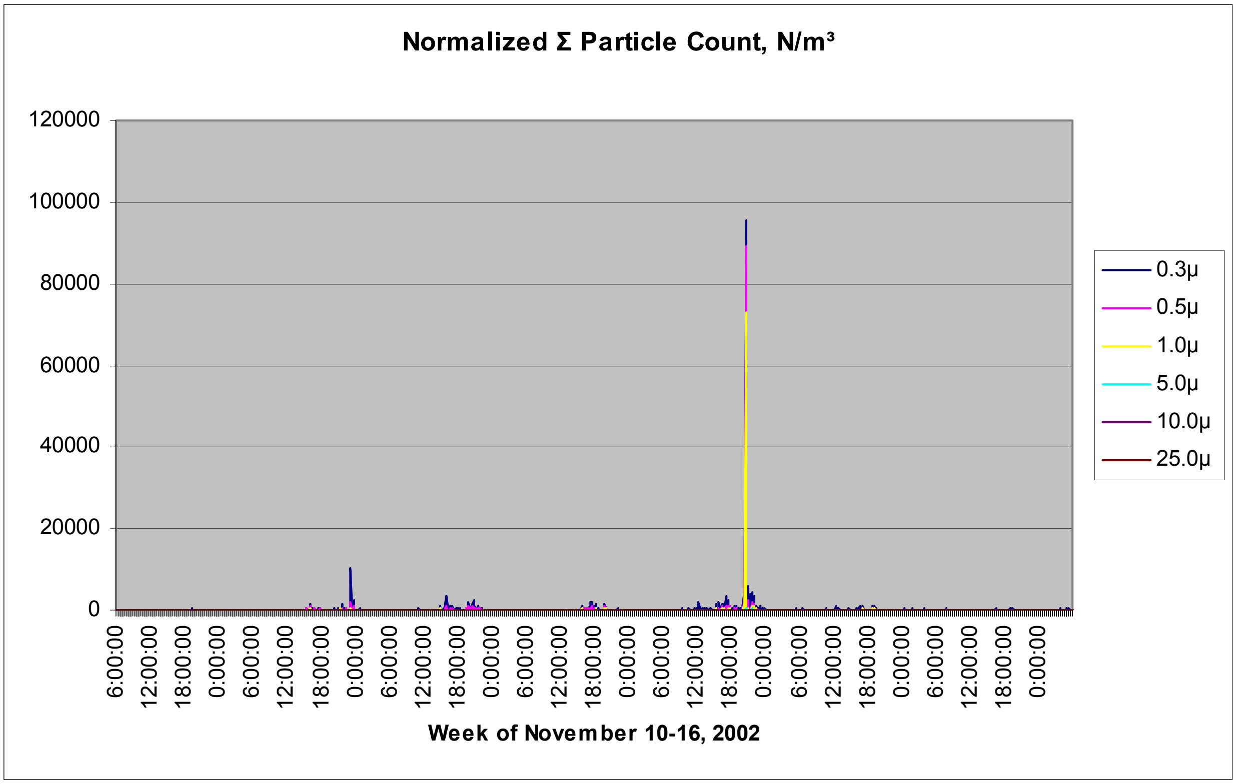

Normalized Σ Particle Count, N/m³
300
250
200
150
100
50
0
10.0µ
6:00:00
12:00:00
18:00:00
0:00:00
Week of November 3-9, 2002

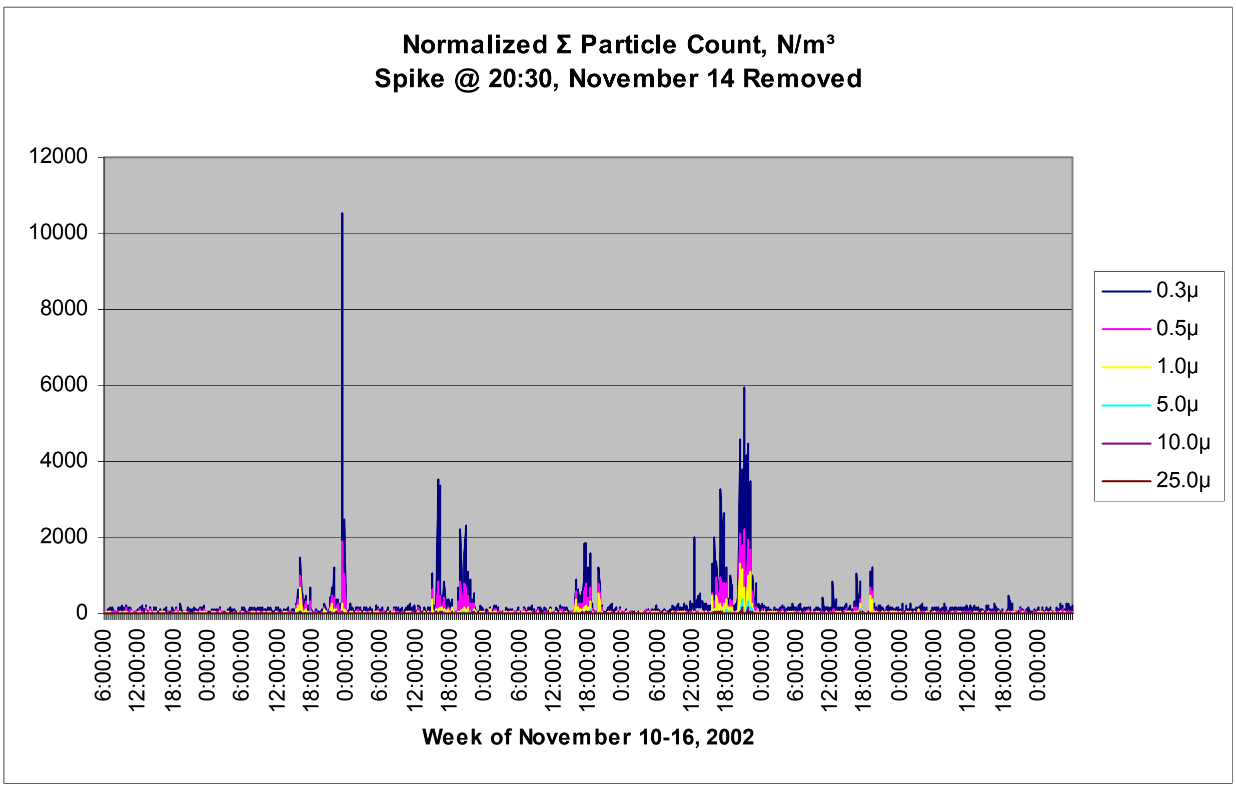


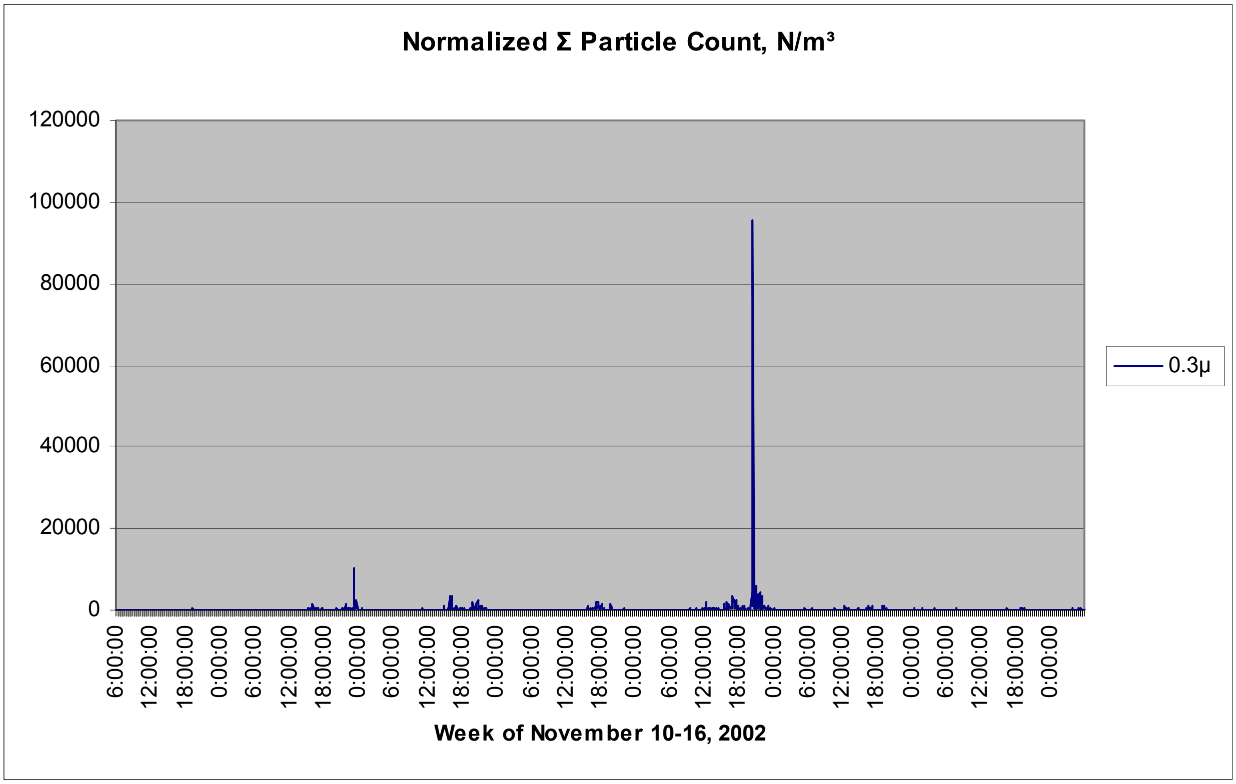
Normalized Σ Particle Count, N/m³
40
35
30
25
20
15
10
5
0
25.0μ
6:00:00
12:00:00
18:00:00
0:00:00
Week of November 3-9, 2002

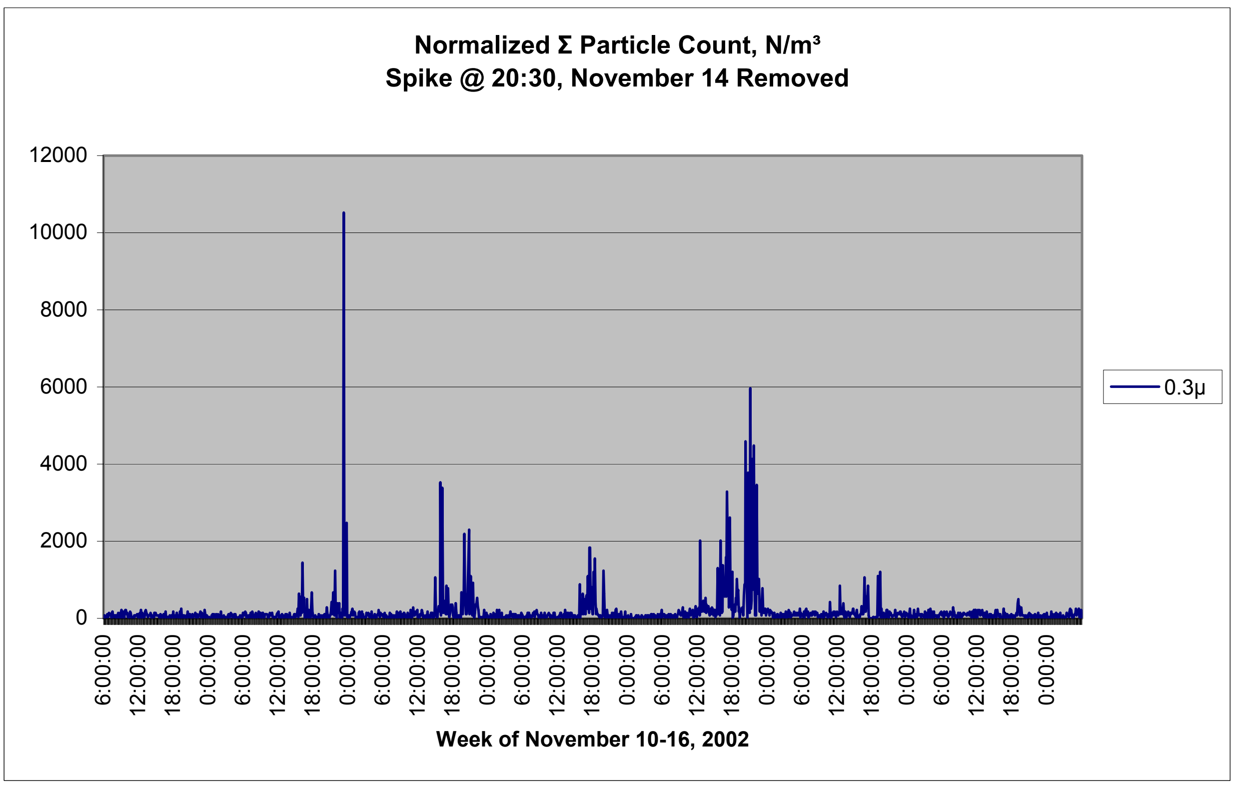


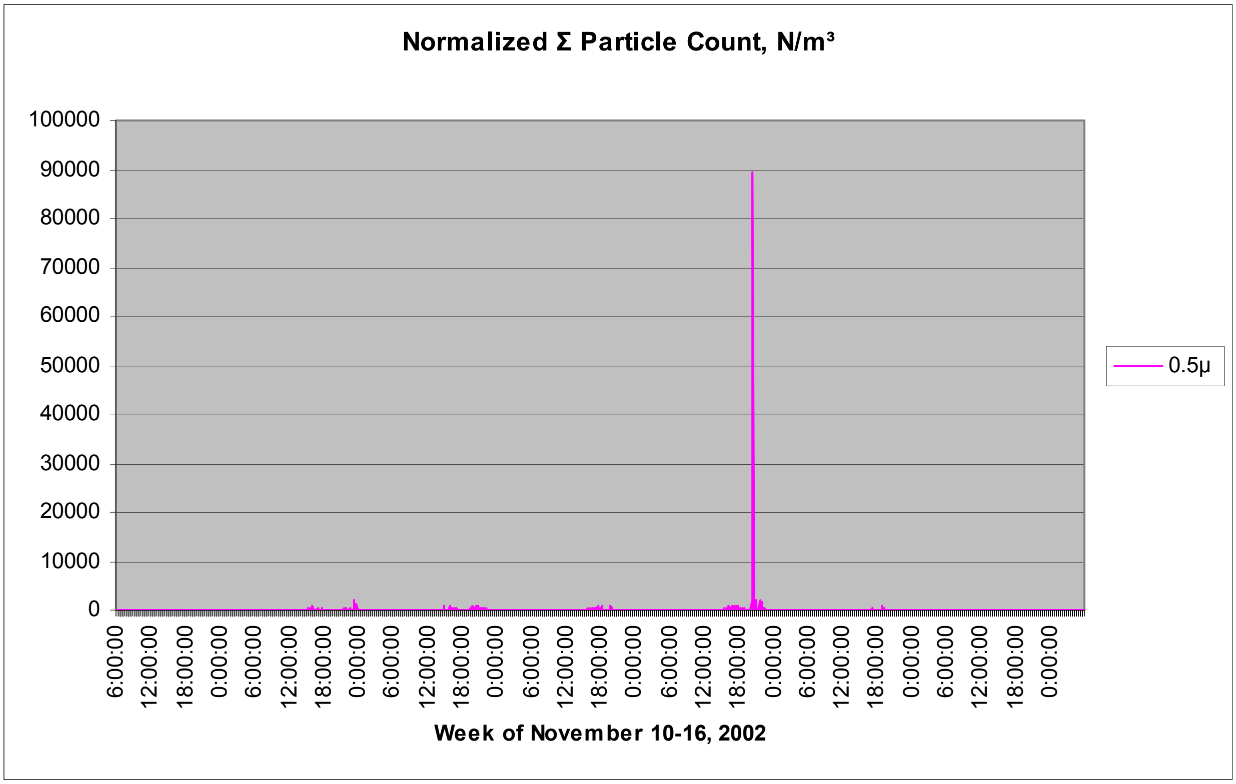
Temperature & Relative Humidity
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
T, °C
%RH
6:00:00
12:00:00
18:00:00
0:00:00
Week of November 3-9, 2002

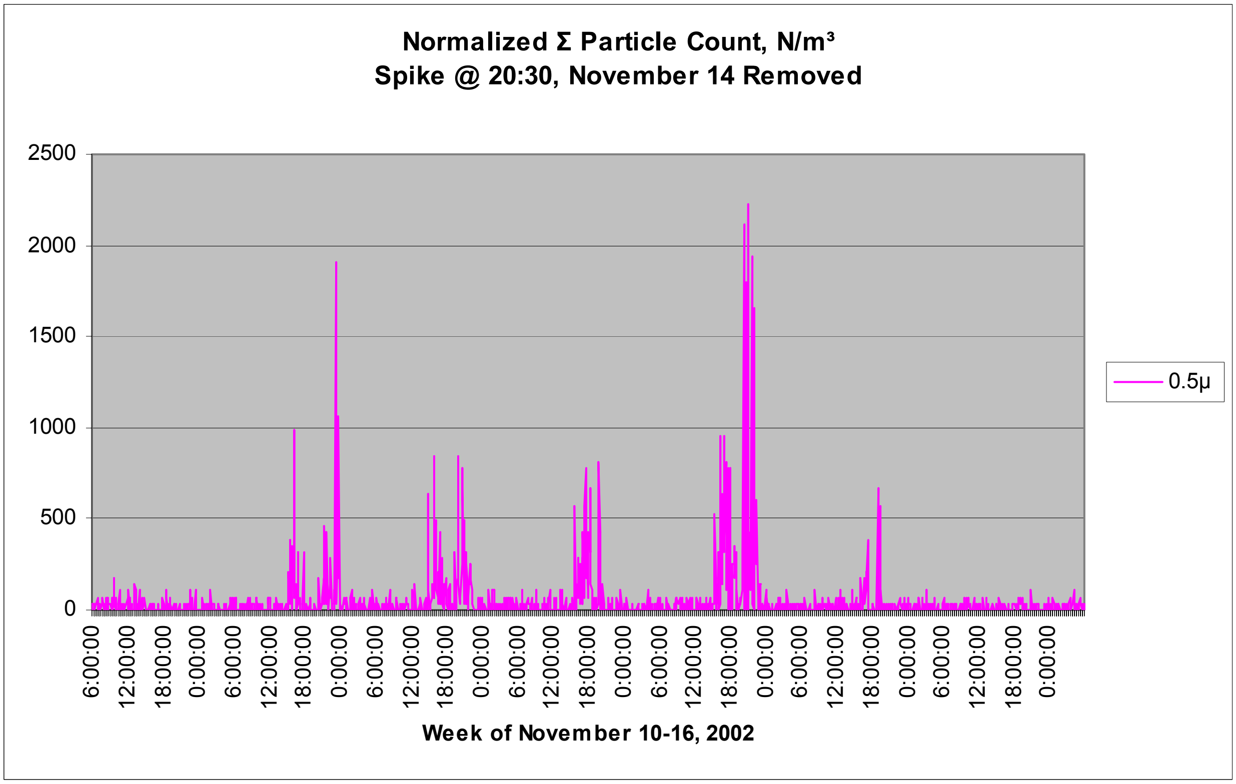

Normalized Σ Particle Count, N/m³
120000
100000
80000
60000
40000
20000
0
0.3µ
0.5µ
1.0µ
5.0µ
10.0µ
25.0µ
6:00:00
12:00:00
18:00:00
0:00:00
Week of November 10-16, 2002

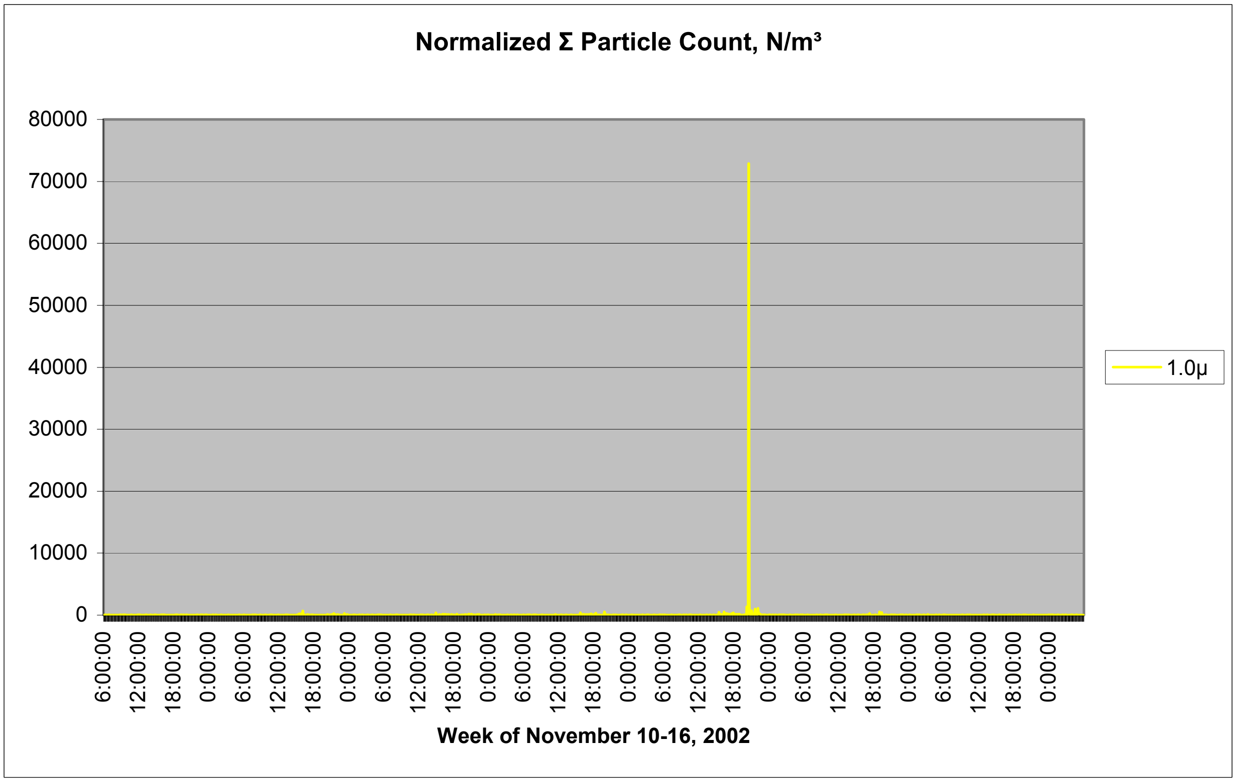

Normalized Σ Particle Count, N/m³
Spike @ 20:30, November 14 Removed
12000
10000
8000
6000
4000
2000
0
0.3µ
0.5µ
1.0µ
5.0µ
10.0µ
25.0µ
6:00:00
12:00:00
18:00:00
0:00:00
Week of November 10-16, 2002

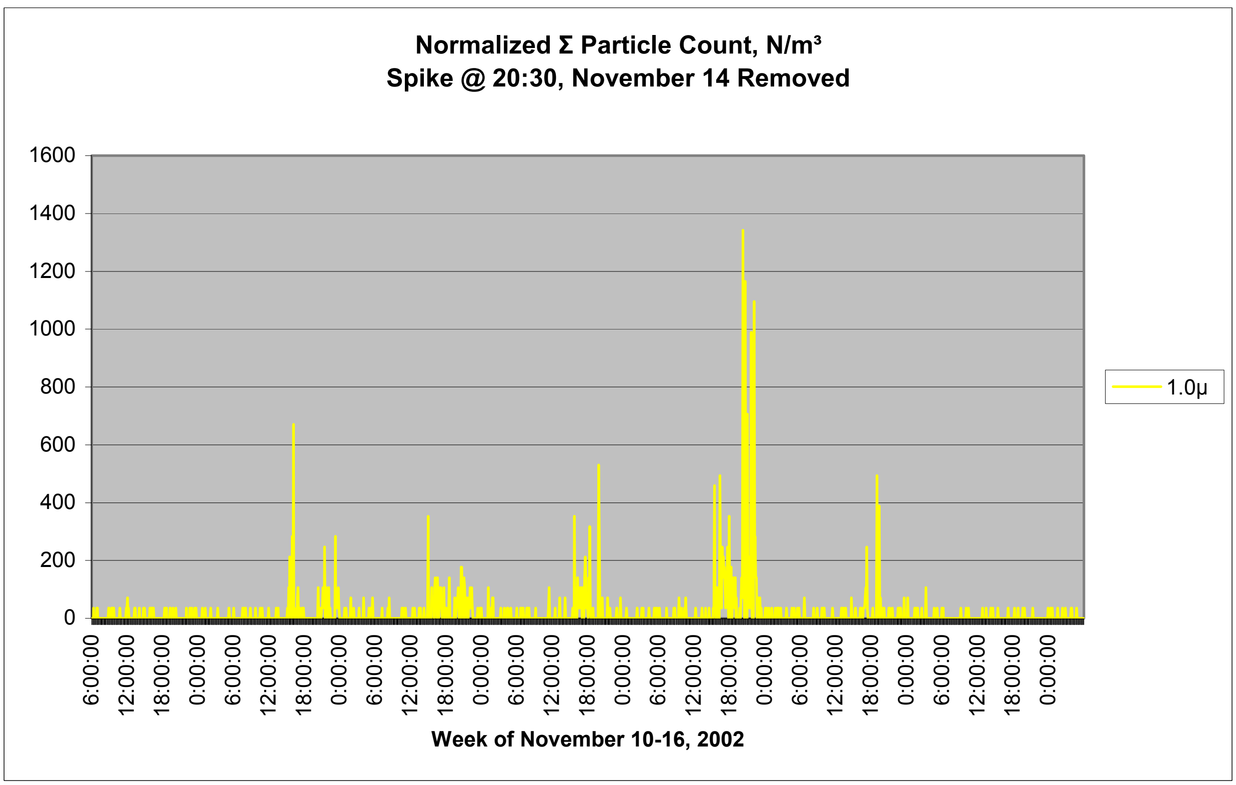

Normalized Σ Particle Count, N/m³
120000
100000
80000
60000
40000
20000
0
0.3µ
6:00:00
12:00:00
18:00:00
0:00:00
Week of November 10-16, 2002

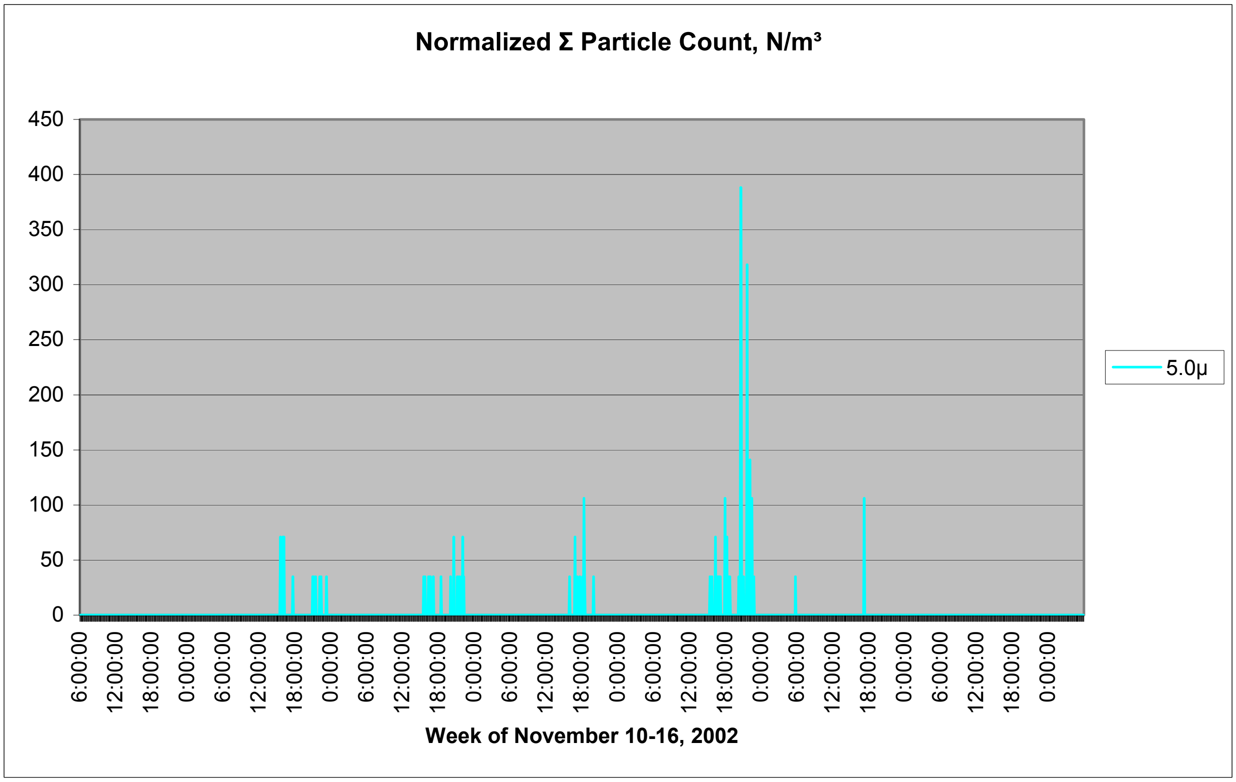

Normalized Σ Particle Count, N/m³
Spike @ 20:30, November 14 Removed
12000
10000
8000
6000
4000
2000
0
0.3µ
6:00:00
12:00:00
18:00:00
0:00:00
Week of November 10-16, 2002

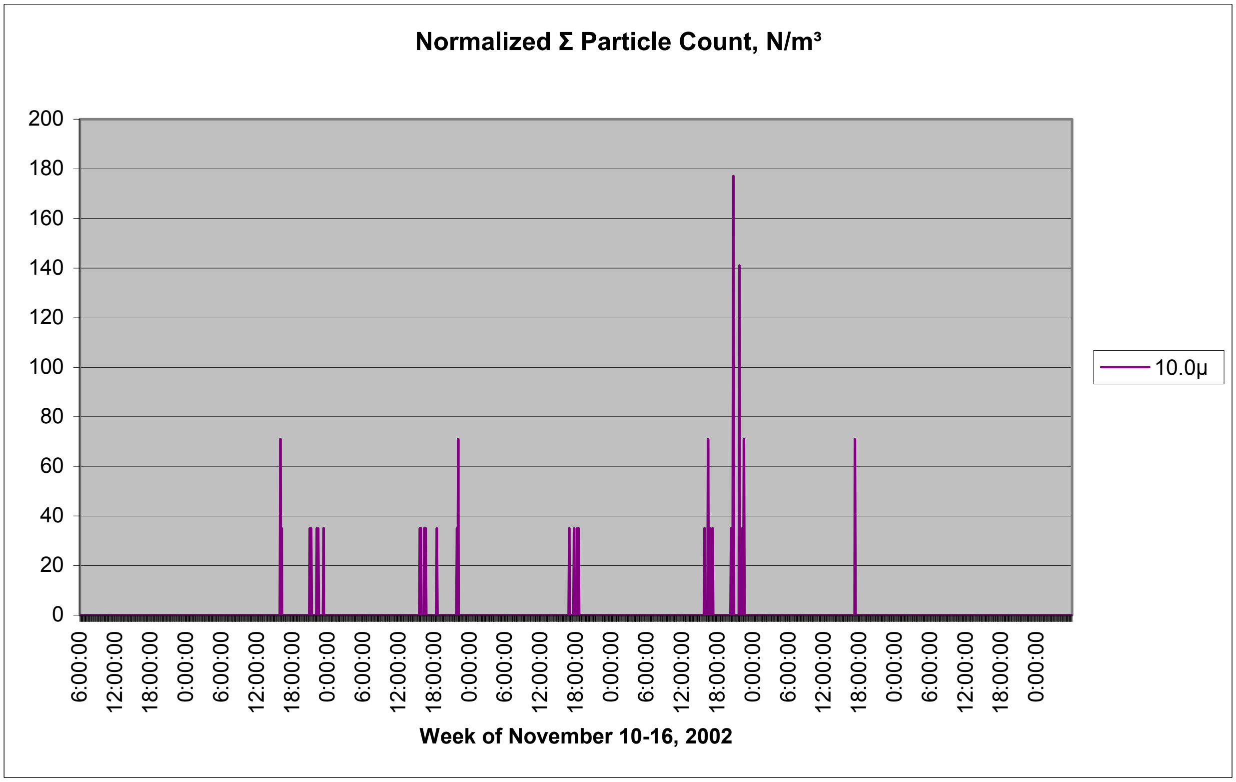

Normalized Σ Particle Count, N/m³
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
6:00:00
12:00:00
18:00:00
0:00:00
Week of November 10-16, 2002
0.5μ

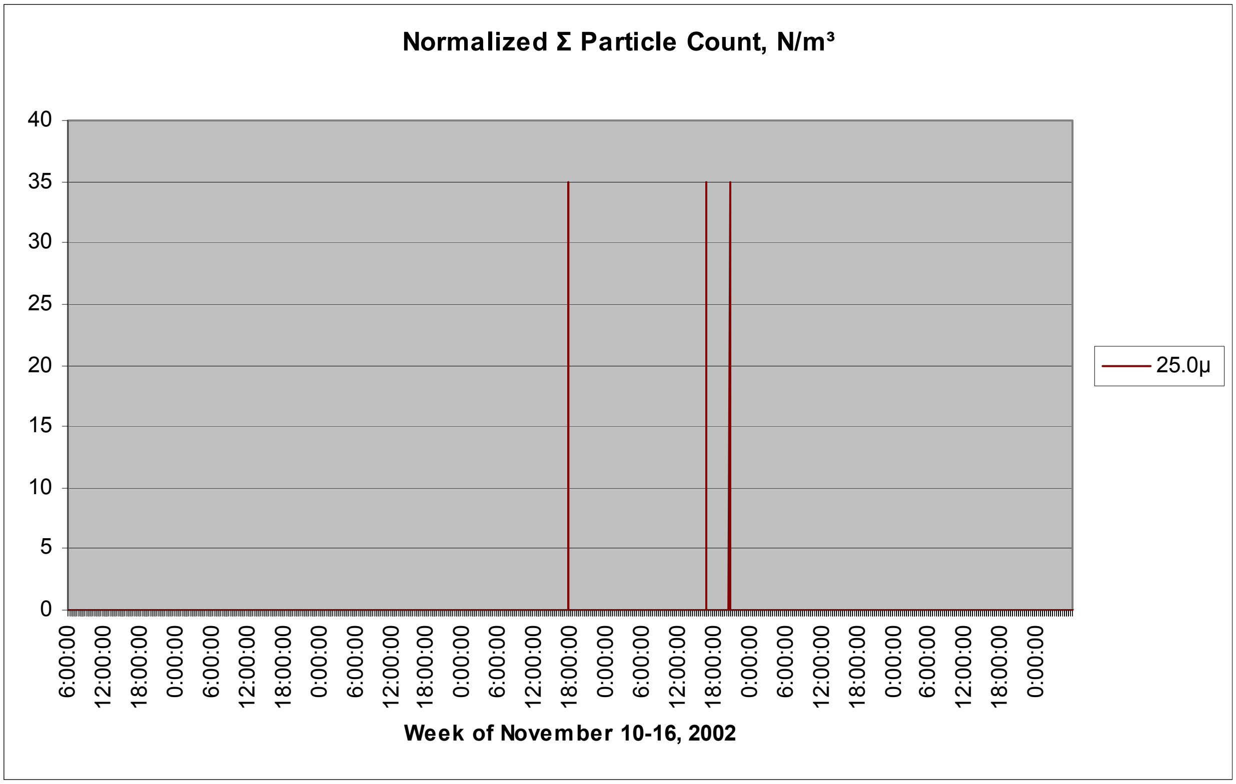

Normalized Σ Particle Count, N/m³
Spike @ 20:30, November 14 Removed
2500
2000
1500
1000
500
0
6:00:00
12:00:00
18:00:00
0:00:00
Week of November 10-16, 2002
0.5μ

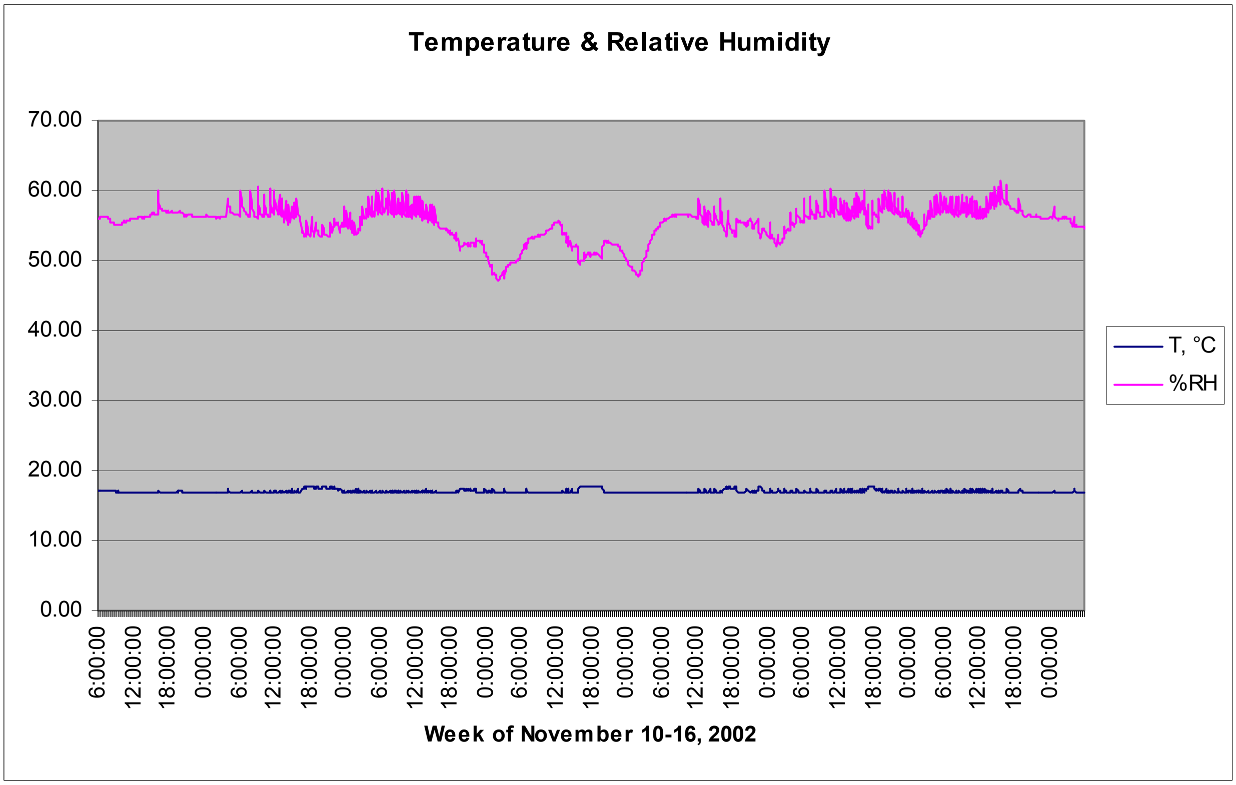

Normalized Σ Particle Count, N/m³
80000
70000
60000
50000
40000
30000
20000
10000
0
6:00:00
12:00:00
18:00:00
0:00:00
Week of November 10-16, 2002
1.0μ

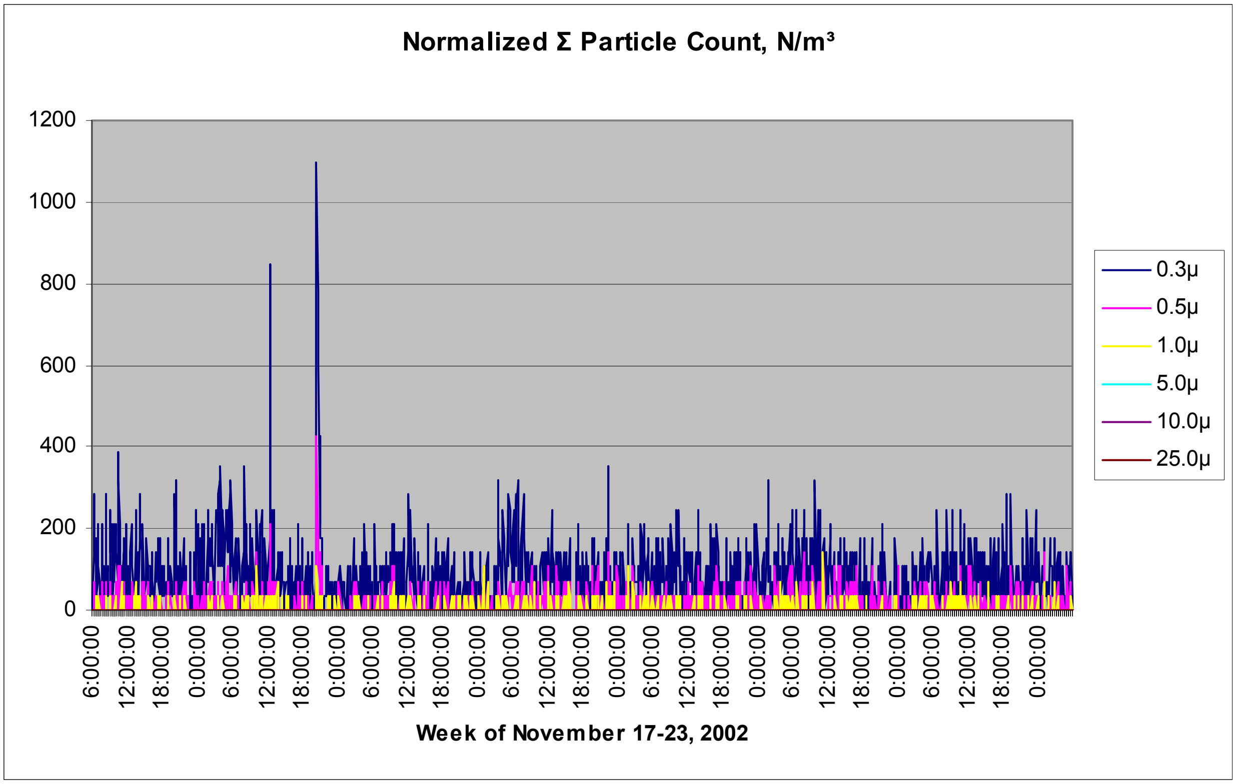

Normalized Σ Particle Count, N/m³
Spike @ 20:30, November 14 Removed
1600
1400
1200
1000
800
600
400
200
0
6:00:00
12:00:00
18:00:00
0:00:00
Week of November 10-16, 2002
1.0μ

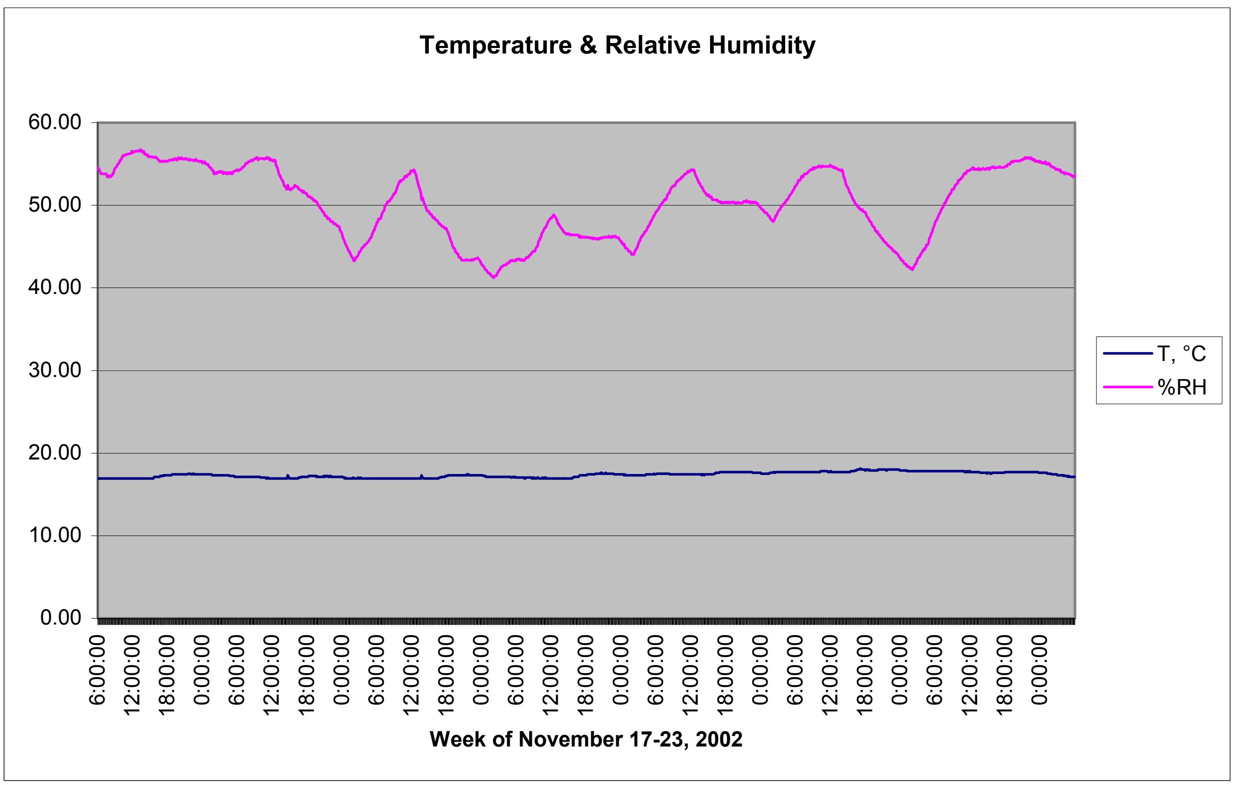

Normalized Σ Particle Count, N/m³
450
400
350
300
250
200
150
100
50
0
5.0μ
6:00:00
12:00:00
18:00:00
0:00:00
Week of November 10-16, 2002

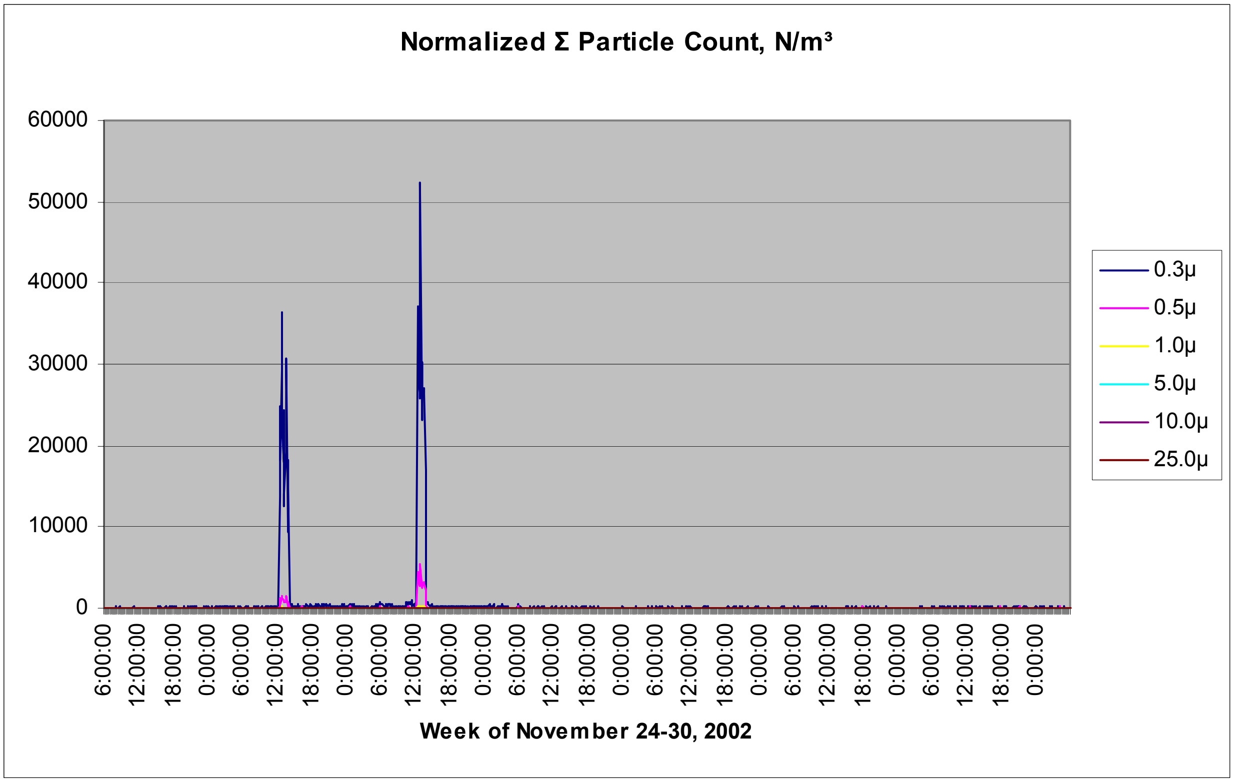

Normalized Σ Particle Count, N/m³
200
180
160
140
120
100
80
60
40
20
0
10.0μ
6:00:00
12:00:00
18:00:00
0:00:00
Week of November 10-16, 2002

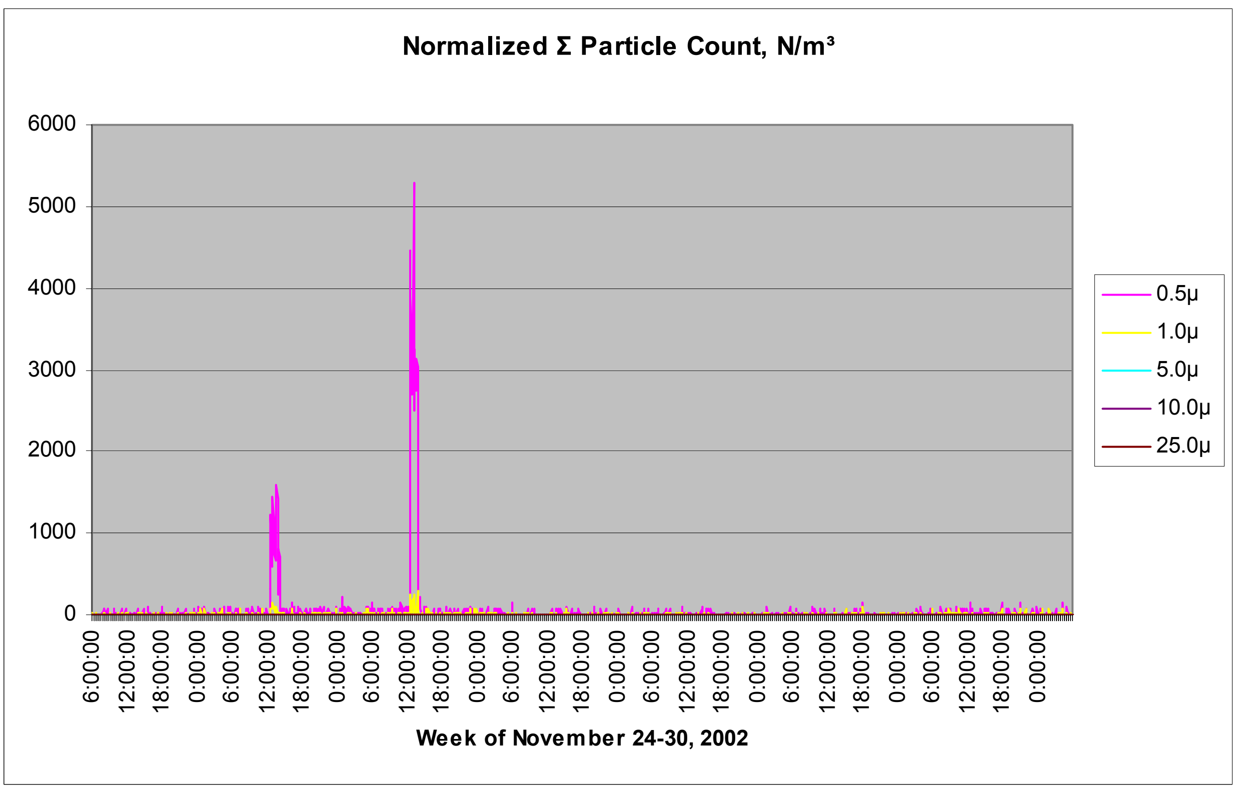

Normalized Σ Particle Count, N/m³
40
35
30
25
20
15
10
5
0
25.0µ
6:00:00
12:00:00
18:00:00
0:00:00
Week of November 10-16, 2002

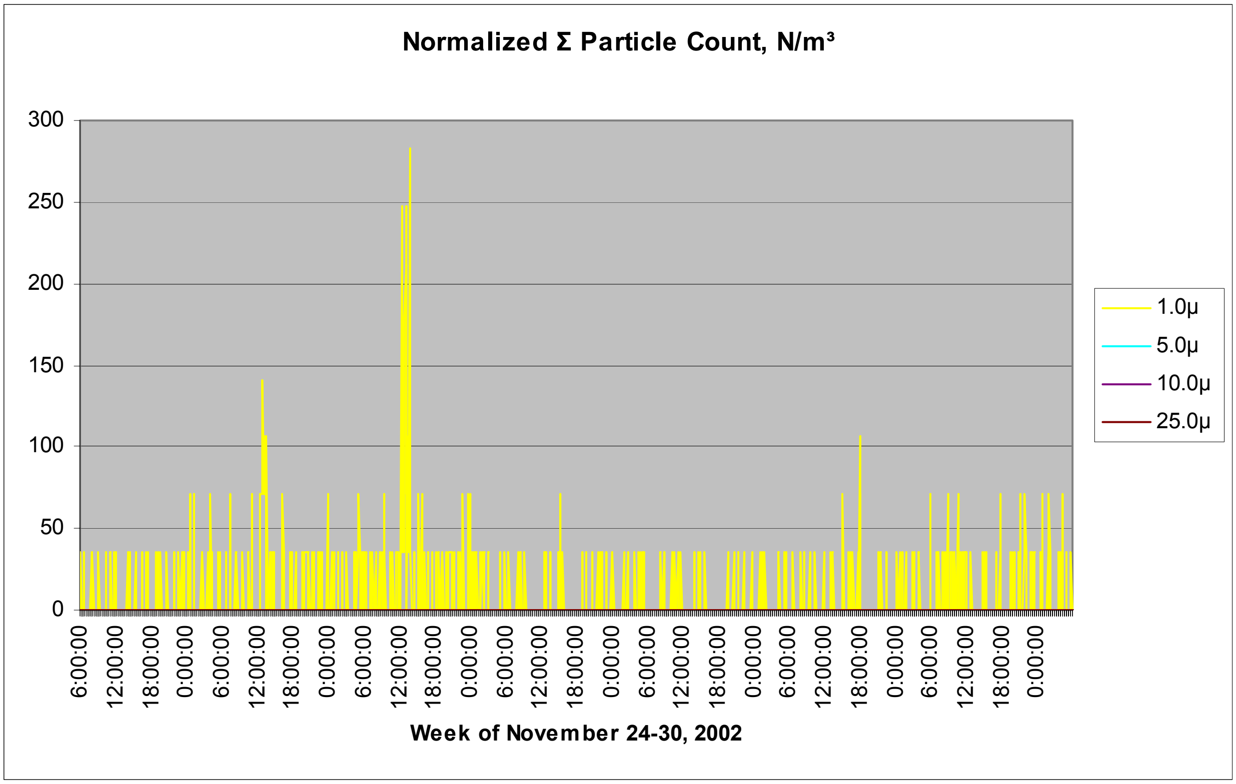

Temperature & Relative Humidity
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
T, °C
%RH
6:00:00
12:00:00
18:00:00
0:00:00
Week of November 10-16, 2002

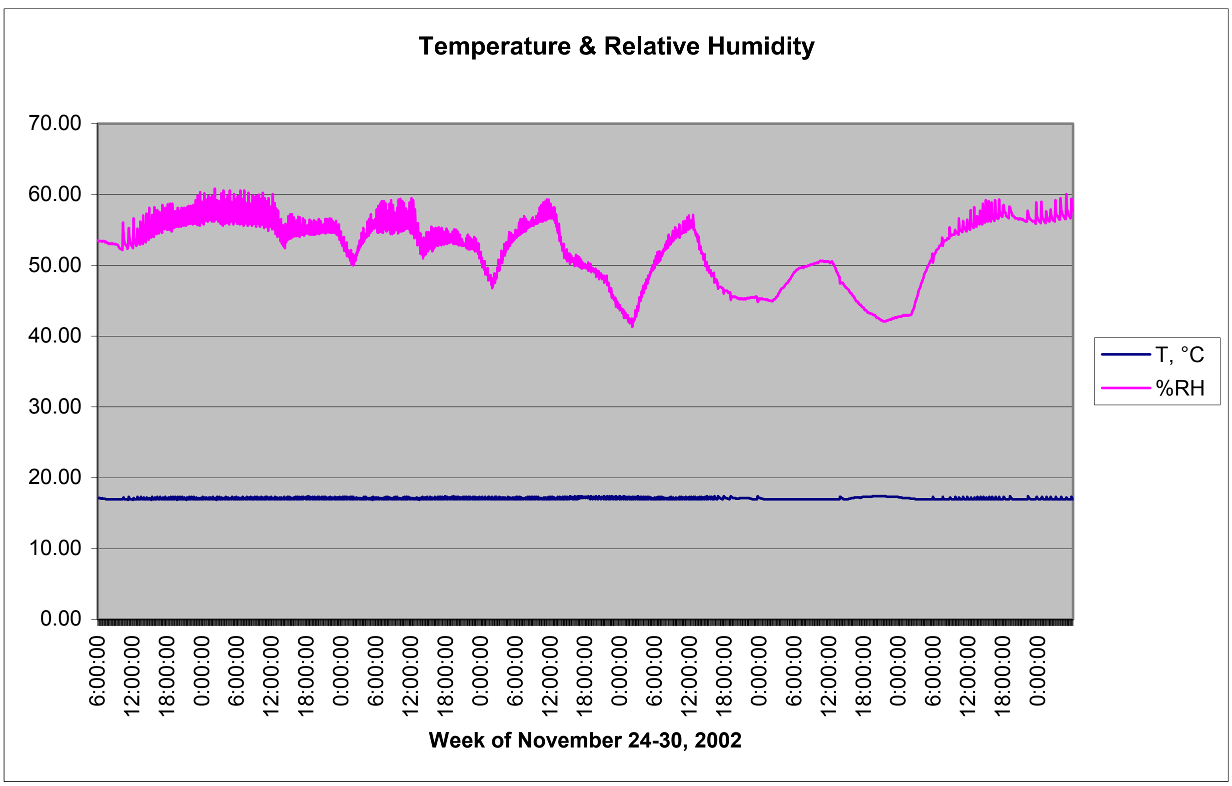

Normalized Σ Particle Count, N/m³
1200
1000
800
600
400
200
0
0.3µ
0.5µ
1.0µ
5.0µ
10.0µ
25.0µ
6:00:00
12:00:00
18:00:00
0:00:00
Week of November 17-23, 2002

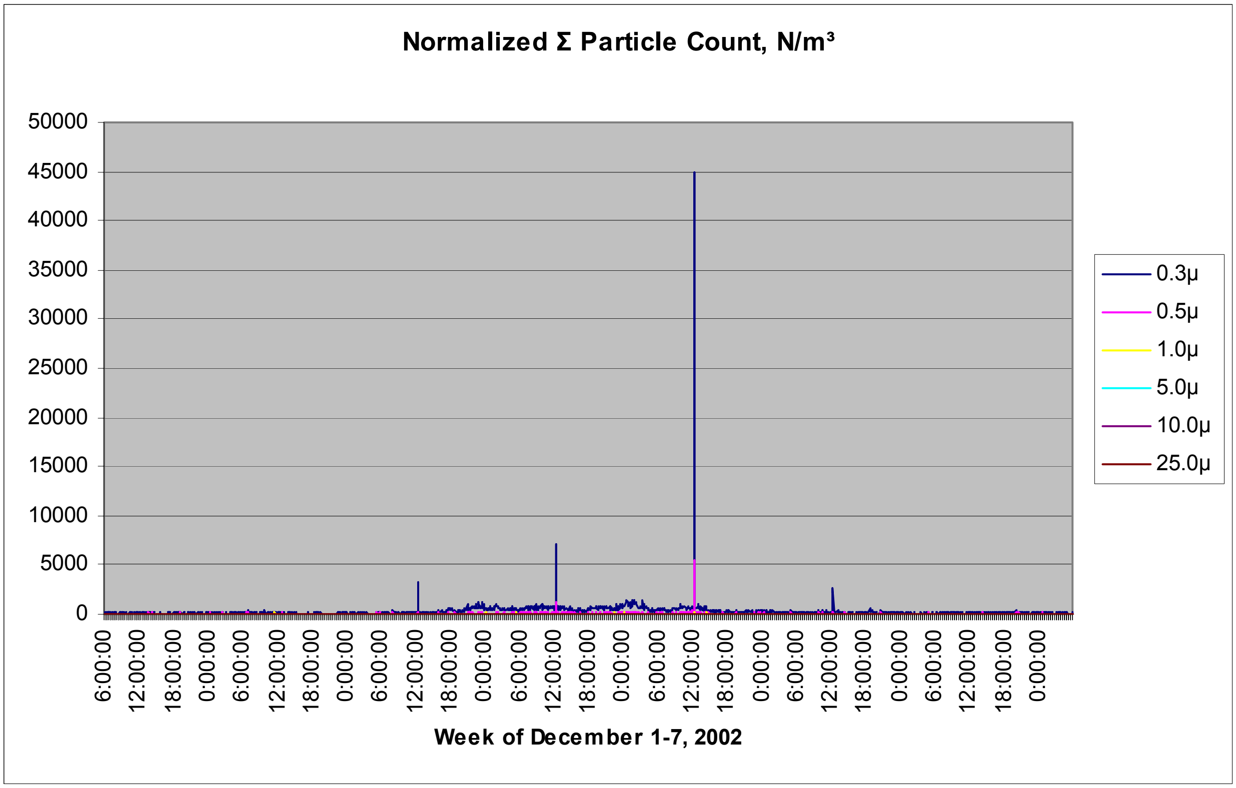

Temperature & Relative Humidity
60.00
50.00
40.00
30.00
20.00
10.00
0.00
T, °C
%RH
6:00:00
12:00:00
18:00:00
0:00:00
Week of November 17-23, 2002

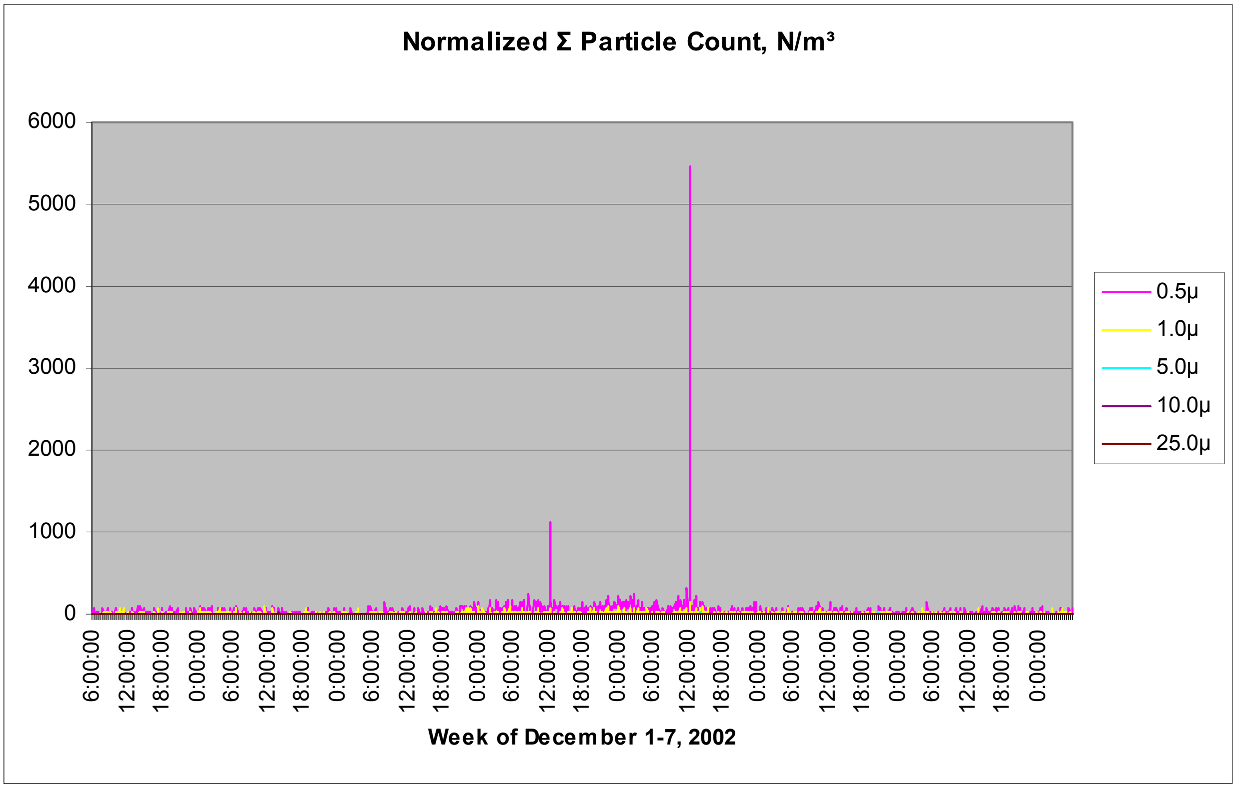

Normalized Σ Particle Count, N/m³
60000
50000
40000
30000
20000
10000
0
0.3μ
0.5μ
1.0μ
5.0μ
10.0μ
25.0μ
6:00:00
12:00:00
18:00:00
0:00:00
Week of November 24-30, 2002

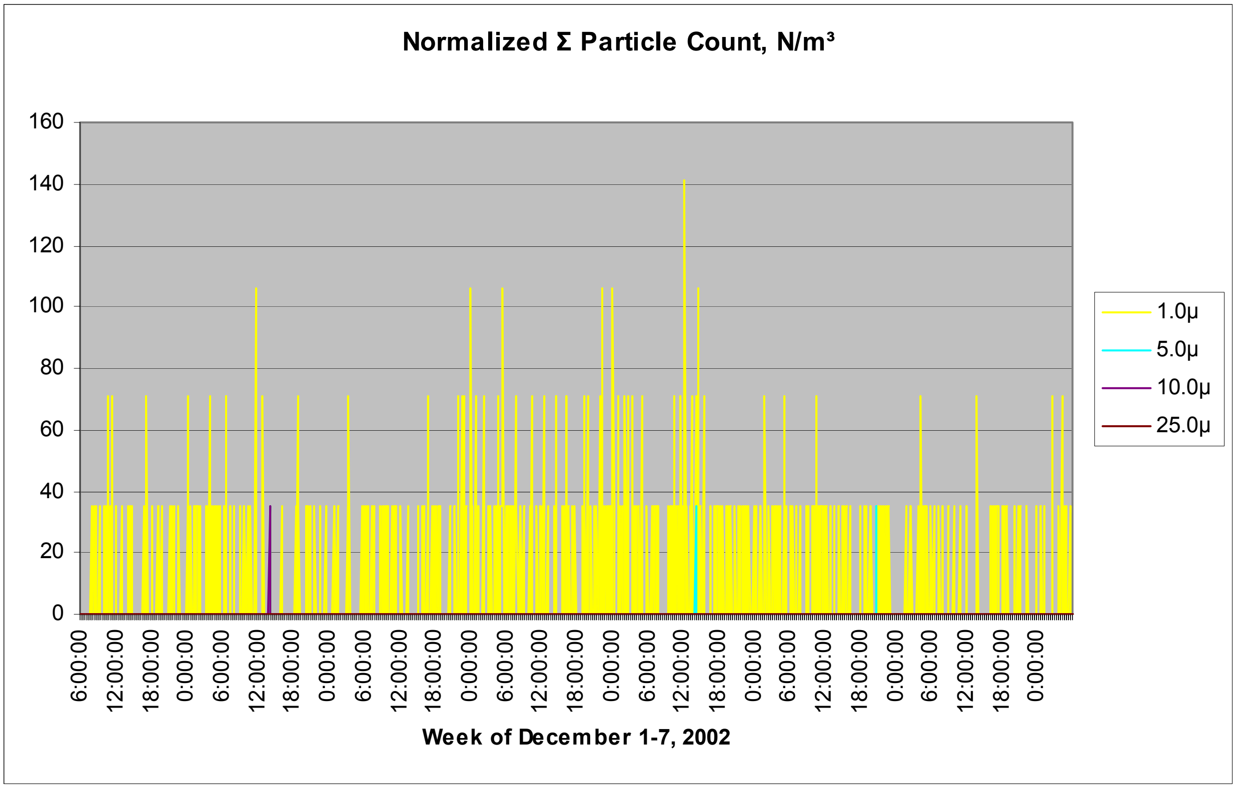

Normalized Σ Particle Count, N/m³
6000
5000
4000
3000
2000
1000
0
0.5μ
1.0μ
5.0μ
10.0μ
25.0μ
6:00:00
12:00:00
18:00:00
0:00:00
Week of November 24-30, 2002

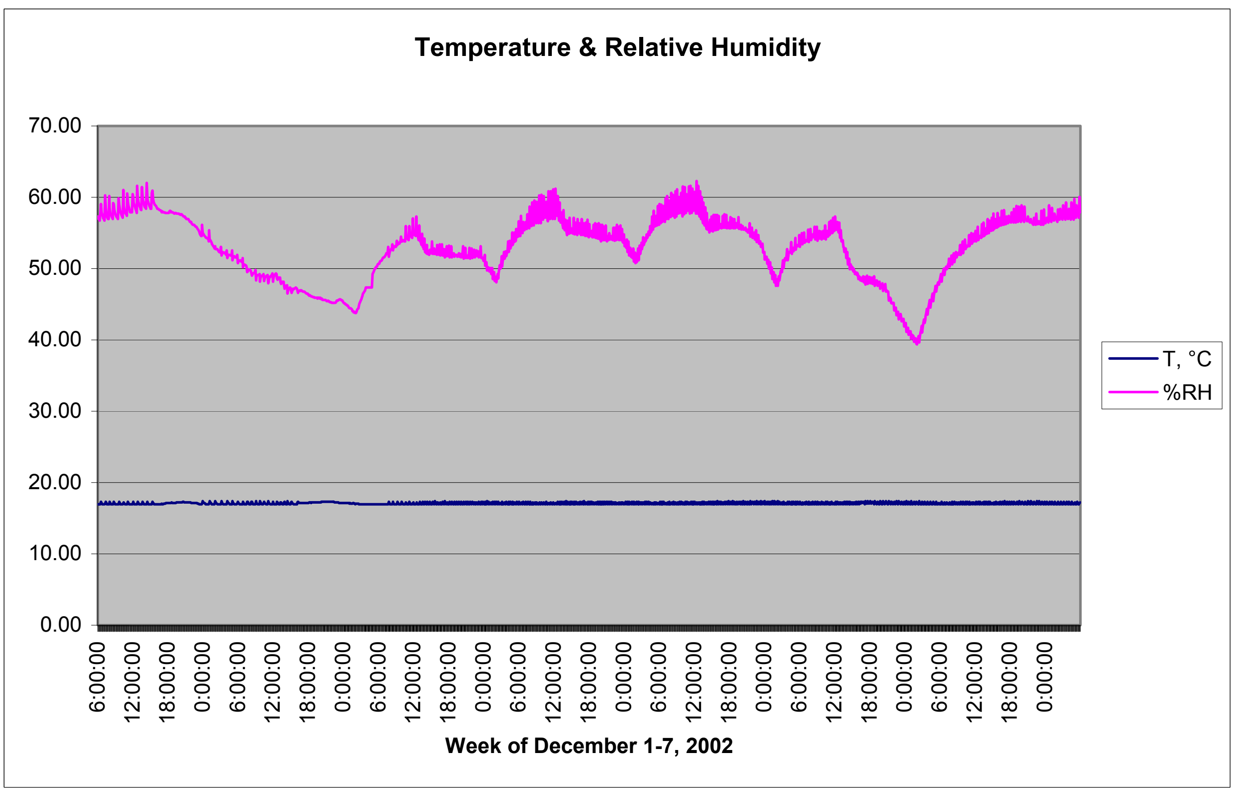

Normalized Σ Particle Count, N/m³
300
250
200
150
100
50
0
6:00:00
12:00:00
18:00:00
0:00:00
Week of November 24-30, 2002
1.0µ
5.0µ
10.0µ
25.0µ

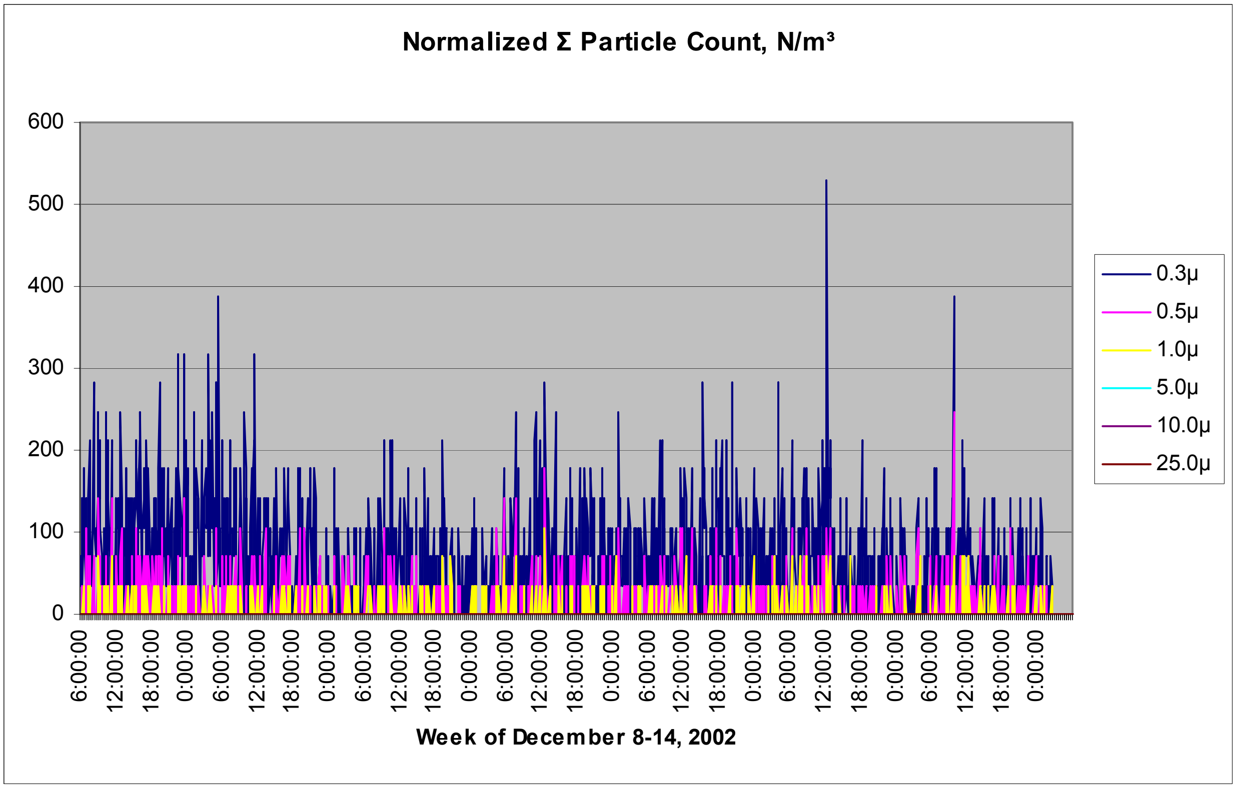

Temperature & Relative Humidity
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
6:00:00
12:00:00
18:00:00
0:00:00
Week of November 24-30, 2002
T, °C
%RH


Normalized Σ Particle Count, N/m³
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
0.3µ
0.5µ
1.0µ
5.0µ
10.0µ
25.0µ
6:00:00
12:00:00
18:00:00
0:00:00
Week of December 1-7, 2002

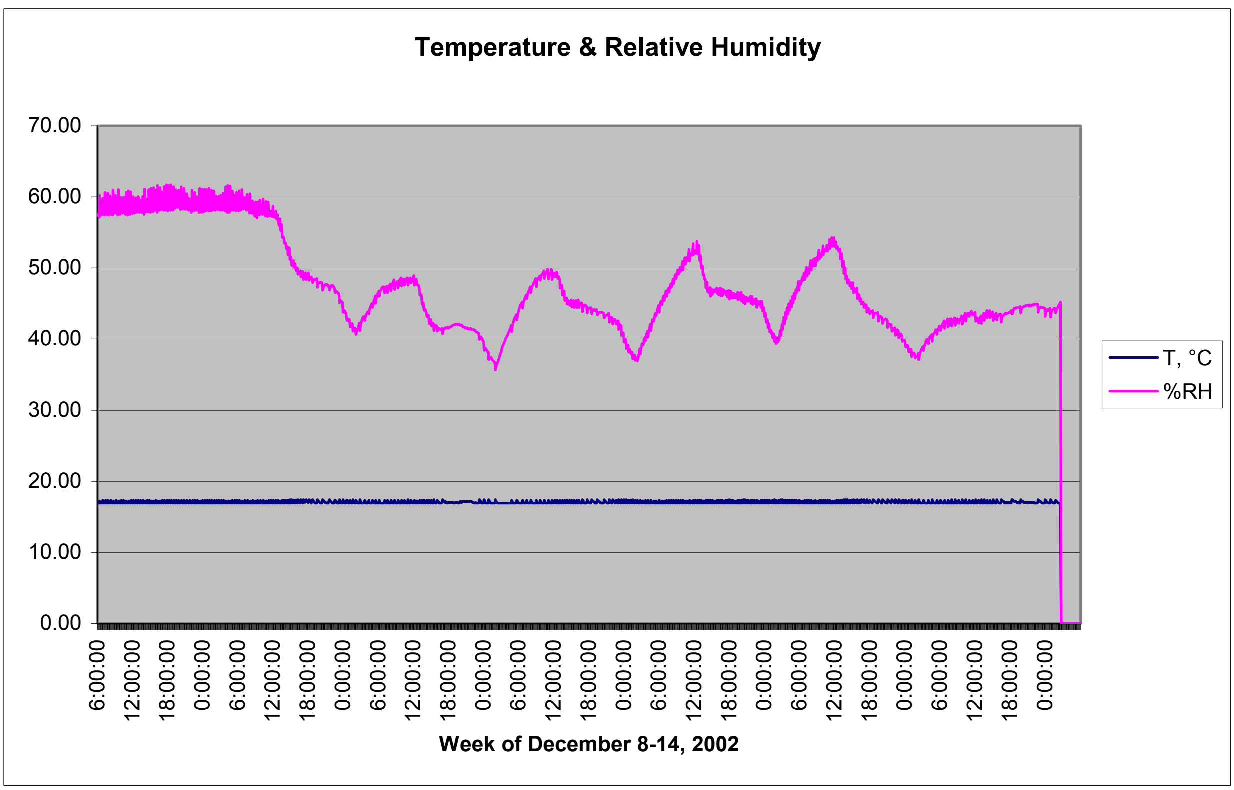

Normalized Σ Particle Count, N/m³
6000
5000
4000
3000
2000
1000
0
0.5µ
1.0µ
5.0µ
10.0µ
25.0µ
6:00:00
12:00:00
18:00:00
0:00:00
Week of December 1-7, 2002


Normalized Σ Particle Count, N/m³
160
140
120
100
80
60
40
20
0
6:00:00
12:00:00
18:00:00
0:00:00
Week of December 1-7, 2002
1.0µ
5.0µ
10.0µ
25.0µ

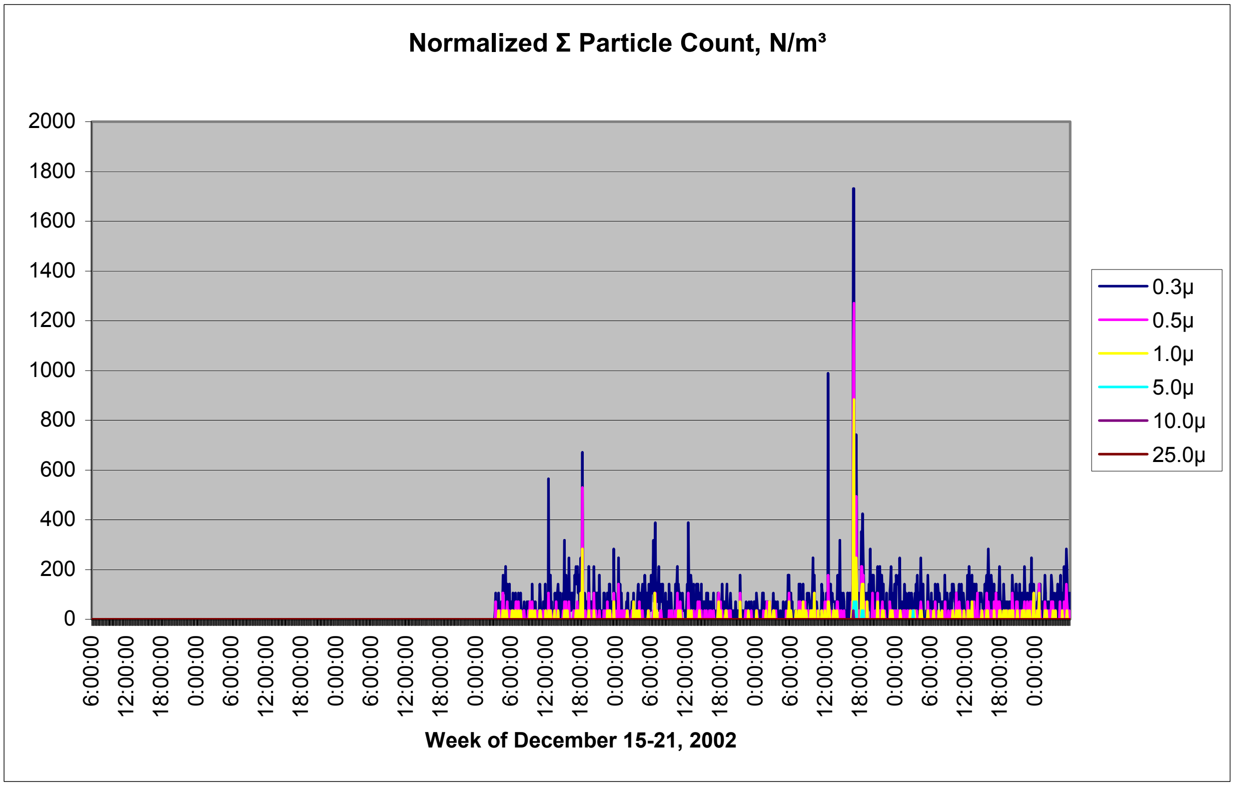

Temperature & Relative Humidity
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
6:00:00
12:00:00
18:00:00
0:00:00
Week of December 1-7, 2002
T, °C
%RH

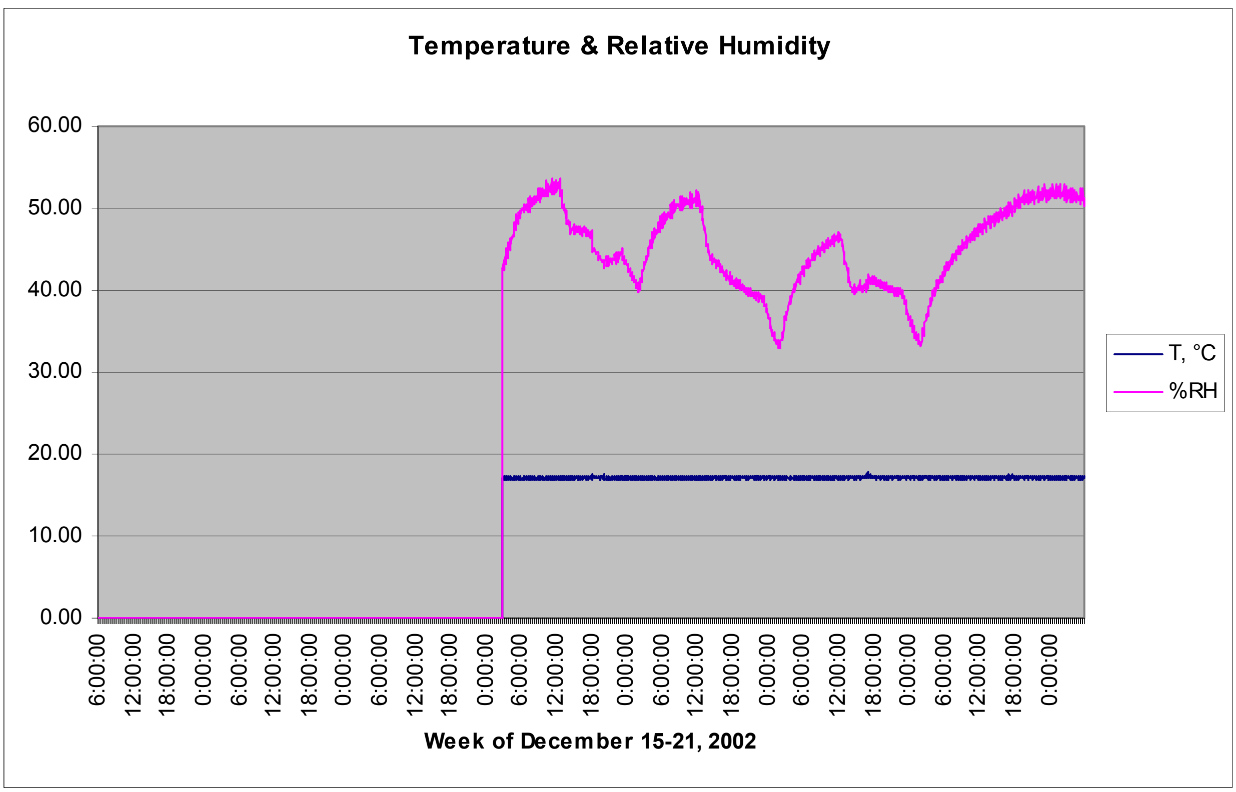


Normalized Σ Particle Count, N/m³
600
500
400
300
200
100
0
0.3µ
0.5µ
1.0µ
5.0µ
10.0µ
25.0µ
6:00:00
12:00:00
18:00:00
0:00:00
Week of December 8-14, 2002



Temperature & Relative Humidity
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
T, °C
%RH
6:00:00
12:00:00
18:00:00
0:00:00
Week of December 8-14, 2002


Normalized Σ Particle Count, N/m³
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0.3µ
0.5µ
1.0µ
5.0µ
10.0µ
25.0µ
6:00:00
12:00:00
18:00:00
0:00:00
Week of December 15-21, 2002


Temperature & Relative Humidity
60.00
50.00
40.00
30.00
20.00
10.00
0.00
T, °C
%RH
6:00:00
12:00:00
18:00:00
0:00:00
Week of December 15-21, 2002

Delivered-To: card@ucar.edu
Date: Fri, 06 Feb 2004 12:00:29 -0500
From: William Thompson <William.T.Thompson.1@gsfc.nasa.gov>
User-Agent: Mozilla/5.0 (X11; U; Linux i686; en-US; rv:1.4) Gecko/20030624 Netscape/7.1
X-Accept-Language: en-us, en
To: Nelson Reginald <reginald@stars.gsfc.nasa.gov>,
Tom Moran <moran@orpheus.nascom.nasa.gov>
Cc: Mauna Loa Solar Observatory <mlso@hao.ucar.edu>,
Joe Davila <davila@stars.gsfc.nasa.gov>,
"Chris St.Cyr" <cstcyr@grace.nascom.nasa.gov>, Kim Streander <kvs@ucar.edu>,
Greg Card <card@ucar.edu>
Subject: Congratulations

Tom, Nelson:

Congratulations! I really do think you're seeing the corona.

Here's my analysis of the data you took on Wednesday. On the far left is the worst-case instrumental noise, based on analysis of image triplets of fixed polarizer position. In the middle is the average polarized brightness taken from polarizer angles 0,120,240, and on the right is the standard deviation of the same data. Since the features seen in the middle image are only seen when the polarizer is moved, the most likely explanation is that we're seeing polarized light. As you folks pointed out, it does have a certain resemblence to the Mk4 data (also attached), although at an angle. The P0 angle was -13.4 degrees when the data were taken, but it seems that the image is rotated by more than that.

Once again, congratulations! And thanks! I know that conditions were difficult up there, and that it took a lot of hard work.

Bill

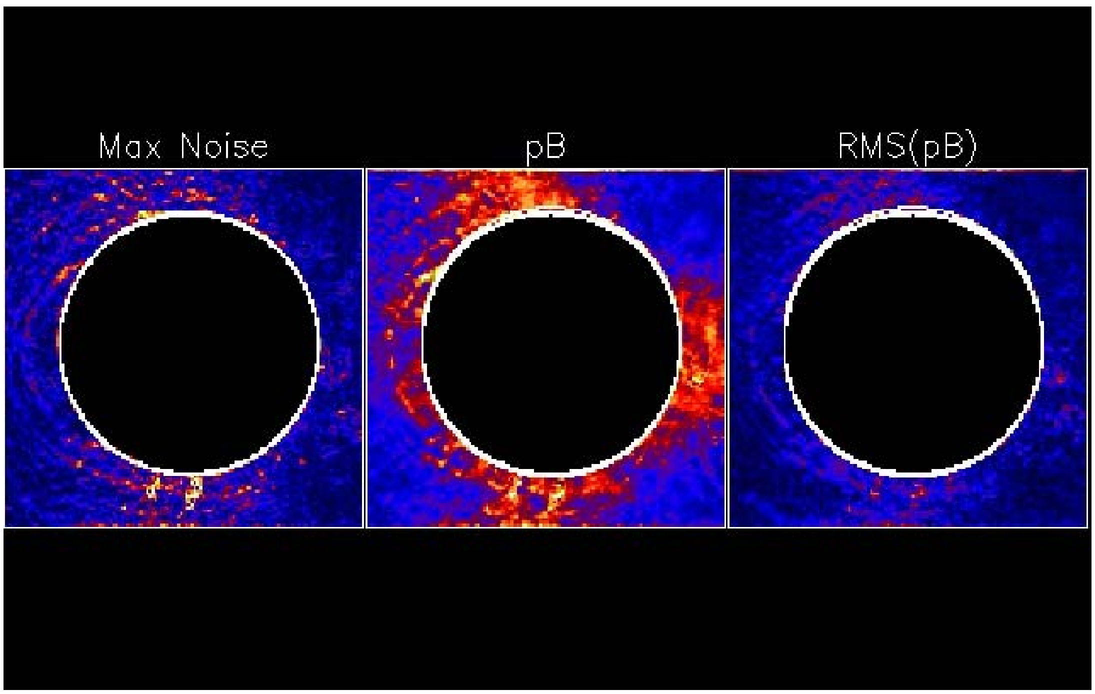
--
William Thompson
NASA Goddard Space Flight Center
Code 682.3
Greenbelt, MD 20771
USA

301-286-2040
William.T.Thompson.1@gsfc.nasa.gov

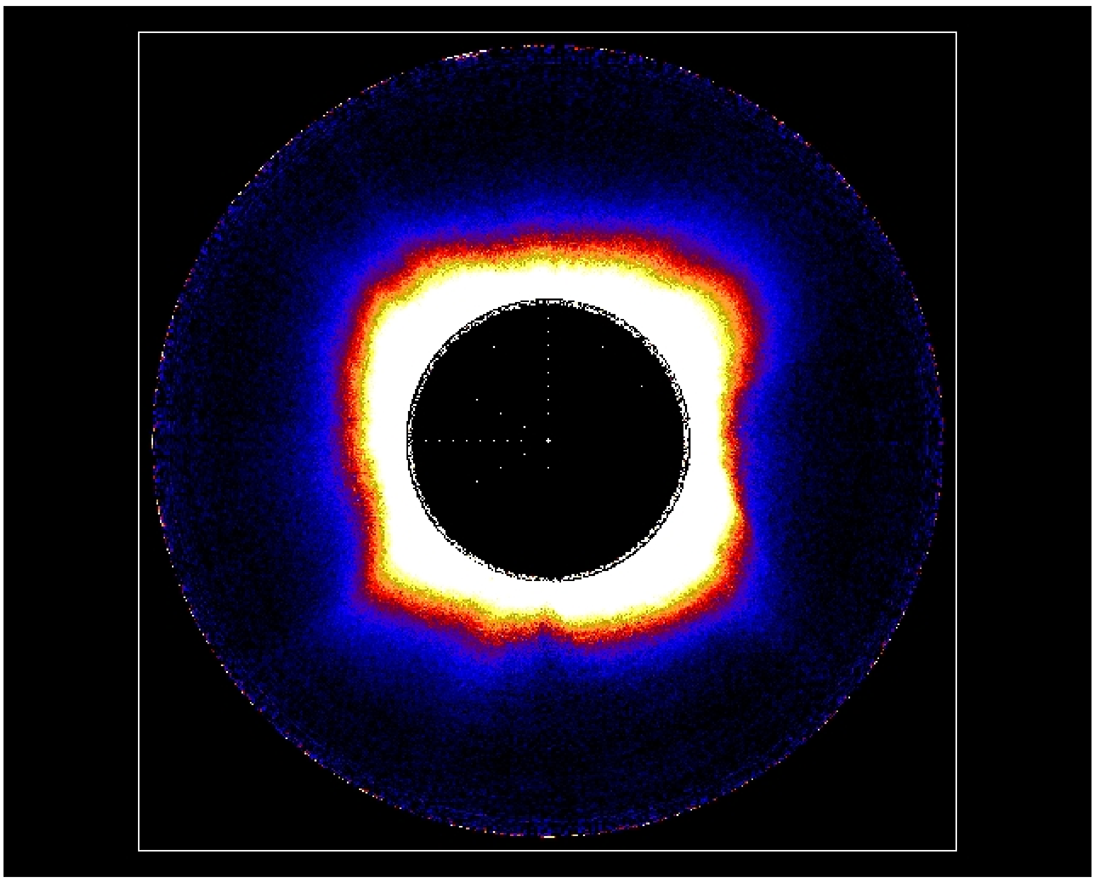
(Please note changed email address.)

comparison.jpg

mk4.jpg



comparison.jpg



mk4.jpg