RL-TR-97-126
Final Technical Report
October 1997

VALIDATION OF POLARIMETRIC RADAR SIGNATURES USING THE 2D-VIDEO DISTROMETER

Colorado State University

V.N. Bringi and J. Hubbert

Rome Laboratory
Air Force Materiel Command
Rome, New York

This report has been reviewed by the Rome Laboratory Public Affairs Office (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS it will be releasable to the general public, including foreign nations.

RL-TR-97-126 has been reviewed and is approved for publication.

APPROVED: Scott M Bolen

SCOTT M. BOLEN
Project Engineer

FOR THE DIRECTOR: Donald W. Hanson

DONALD W. HANSON, Director
Surveillance & Photonics Directorate

If your address has changed or if you wish to be removed from the Rome Laboratory mailing list, or if the addressee is no longer employed by your organization, please notify RL/OCSA, 26 Electronic Pky, Rome, NY 13441-4514. This will assist us in maintaining a current mailing list.

Do not return copies of this report unless contractual obligations or notices on a specific document require that it be returned.

REPORT DOCUMENTATION PAGE	Form Approved OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	Oct 97	Final May 96 - Apr 97

4. TITLE AND SUBTITLE
VALIDATION OF POLARIMETRIC RADAR SIGNATURES USING THE 2D-VIDEO DISTROMETER

5. FUNDING NUMBERS
C - F30602-96-C-0119
PE - 61102F
PR - 2304
TA - E8
WU- PG

6. AUTHOR(S)
V. M. Bringi and J. Hubbert

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Colorado State University
Sponsored Programs
601 South Howes St.
Fort Collins, CO 80523

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Rome Laboratory/OCSA
26 Electronic Pky
Rome, NY 13441-4514

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
RL-TR-97-126

11. SUPPLEMENTARY NOTES
Rome Laboratory Project Engineer: Scott M. Bolen, OCSA, 315-330-7057

12a. DISTRIBUTION AVAILABILITY STATEMENT
Approved for public release, distribution unlimited.

12b. DISTRIBUTION CODE
N/A

13. ABSTRACT *(Maximum 200 words)*

From 10 Jun 96 to 10 Aug 96 a two-dimensional video distrometer was used to collect rainfall measurements at the surface during convective storm events in the North-Eastern Colorado area. More than 20 successful storm events were recorded during the experimental period. The distrometer records two views of all hydrometeors that pass through its measurement area (~10 cm' 10cm) through the use of two CCD (charge coupled device) line scan cameras. The true velocity of the hydrometeors is also measured. This makes possible the calculation of very accurate equi-volumetric spherical diameters, size distributions, and particle non-sphericity and also to distinguish between rain, hail, graupel, and snow. This information can be used to calculate radar measurands via sophisticated scattering models thus validating recorded radar data that may be taken simultaneously with the distrometer measurements. Contained in the final report is a general description of the distrometer, operating procedures, and a compilation of plots of distrometer data collected during the experiment period. The final report can be used to provide an understanding of the data recording methods and the experimental procedure; it can also be used as a index to the recorded data set.

14. SUBJECT TERMS	15. NUMBER OF PAGES
Two-dimensional video distrometer, hydrometeors, equi-volumetric spherical diameters	108
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UL

Table of Contents

Abstract

The CSU-CHILL radar (a National Science Foundation supported facility) is a state-of-the-art weather radar operated by Colorado State University. It is the only S-band radar available to the public sector that is capable of measuring the full scattering matrix of a weather target. Critical to the evaluation of polarimetric measurands is the gathering of reliable, accurate ground truth. This was accomplished in part via the mobile deployment of the 2-D Video Distrometer manufactured by Joanneum Research of Graz, Austria, a non-profit organization, during the the period 10 June to 10 August 1996.

During this period the van "Austria", in which the distrometer is deployed, made more that 20 successful storms intercepts in conjunction with with the CSU-CHILL radar. This distrometer records two views of all hydrometeors that pass through its measurement area (about 10 cm×10 cm) through use of two CCD (charge coupled device) line scan cameras. The true vertical velocity of the hydrometeors is also measured. This makes possible the calculation of very accurate equi-volumetric spherical diameters, size distributions, and particle non-sphericity and makes it possible to distinguish between rain, hail, graupel and snow. It is the only currently available ground based distrometer that has these capabilities. This information can be used to calculate the radar measurands via sophisticated scattering models thus validating the actual recorded radar data.

Contained in this final report are a general description of the the distrometer, operating procedures and a compilation of representative plots of distrometer data gathered of those days. Specifically, the rainrate as a function of time for the events and representative drop size distributions are given. One general conclusion is that for convective rain events, the drop size distributions are frequently are not Marshall-Palmer in character as is typically assumed in the literature. The

larger particles ($D_{eq} \geq 4mm$) frequently occur in greater concentrations than what is predicted by the Marshall-Palmer model. Since reflectivity measurements are very sensitive to larger particles, rainrate estimates based on empirical rain-reflectivity relationships will vary tremendously, i.e., similar reflectivity measurements can correspond to widely varying rainrates. Thus, the data sets contained in this report demonstrate why rainrate estimates base only on reflectivity will likely fail for convective precipitation.

Introduction:

Research Experience For Undergraduates (REU) is program sponsored by the National Science Foundation (NSF) where students can assist Professors, out of the classroom, in various fields and gain valuable experience in labs and on the field. The Electrical Engineering REU this year was sponsored in collaboration with the Department of Electrical Engineering at Colorado State University to design and test various types of instruments that could be used to study the Thunderstorms in Eastern Colorado. There were three Chase Vans used in which these instruments were mounted.

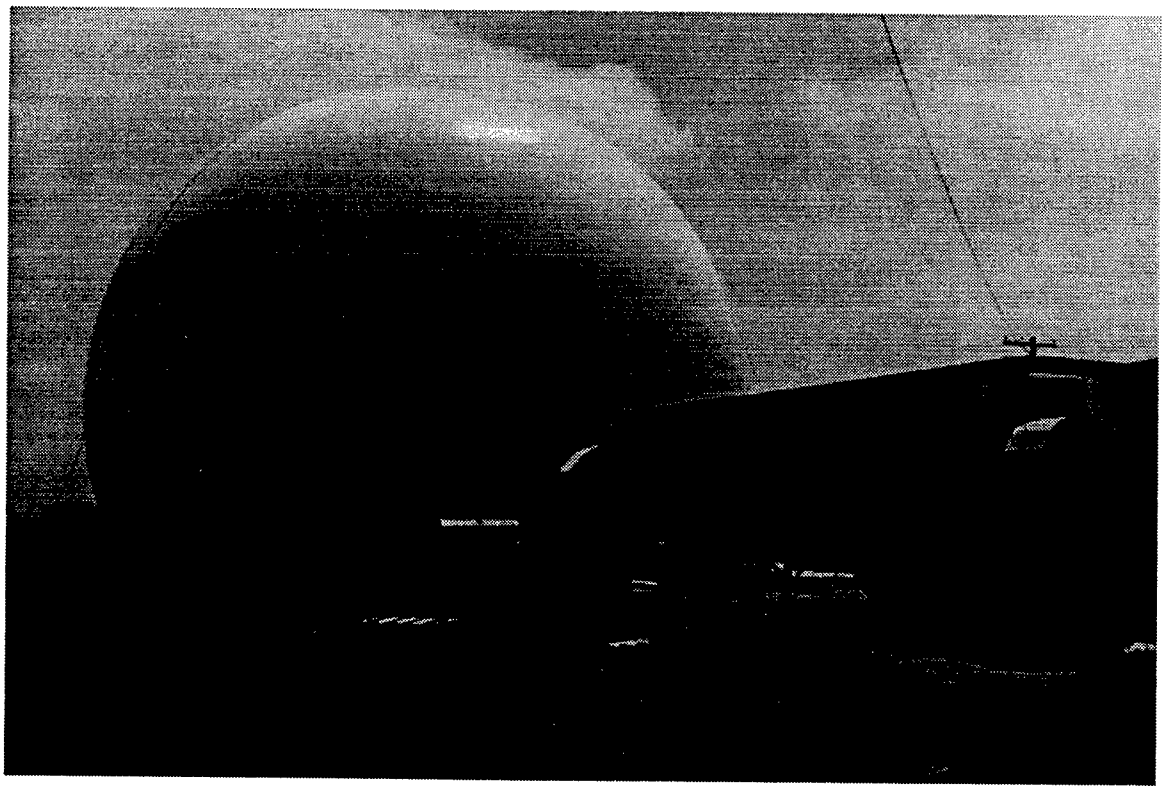
We were involved with the Chase Van Austria. This van got its name from the Austrian instrument mounted inside. Austria, as seen in picture 1, is a 1978 Dodge Ram Sportsman that is equipped with a 2D Video Distrometer (from Austria) and 2 Personal Computers (known as ***Back PC*** and ***Front PC)***, and a GPS (Global Positioning System) tracking system. All the power needed to run these instruments is provided by two 12 Volt battries and an inverter. All the digital data is first collected by the back PC and is then sent to the front PC every 3 seconds where the data is stored.

Picture 1: The infamous CHASE VANS.

CSU-CHILL Polarimetric Radar:

Radar Description:

The CHILL radar has a historic past as it is one of the first radars to utilize polarization diversity. The radar was originally designed and constructed jointly by the University of Chicago and the Illinois Water Survey under the Guidance of Mueller and Atlas. In 1990, the CHILL radar was moved to its present location, outside of Greeley, Colorado, and is now used exclusively as a research radar operated by the Colorado State University under the sponsorship of National Science Foundation. It is a fully Polarimetric S-band radar that can alternately send two Orthogonally polarized signals and simultaneously receive the co- and cross-polarized signals. With recent upgrades made to the radar it now ranks as one of the top radars of its kind.



Picture 2: CHILL Radar

Table: System Characteristics of the CSU-CHILL Radar	
Antenna	
Type:	Fully steerable, focus parabolic reflector
Size:	8.5 m
Feed:	Scalar horn
3 dB beam width:	1.0 degrees
Directivity:	45 dB
Sidelobe level (any φ-plane):	<= -27 dB
Cross-pol. Level (any φ-plane):	<= -30 dB
Polarization radiated:	Horizontal or Vertical
Transmitter	
Type:	Klystron, modernized FPS-18
Wavelength:	10.7 cm
Peak Power:	700 - 1000 kW
Pulse Width:	Steps of 0.1 μs to a max of 1 μs
PRT:	800 - 2500 μs
Max. Unambigu. Range:	375 km
Max. Unambigu. Velocity:	+ – 34.3 m/s
Receiver	
Noise Figure:	0.7 dB
Noise Power:	– 114 dBm
Typical Band Width:	750 kHz
Transfer Function:	Linear
Dynamic Range:	90 dB, 0 - 60 dB IAGC in 12 dB steps
Data Acquisition	
Signal Processor:	SP20 made by Lassen Research
Number of Range Gates:	64 - 2048
Range Gate spacing:	.2 μs or 1μs
Sampling Rate/avg. option:	under micro-code control
Video Digitizer:	12-bit,in the SP20 input card for I,Q & logP
Time series capability:	
Variable Available	
• Reflectivity at H polarization (Z_h)	
• Differential Reflectivity (Z_{dr})	
• Mean Doppler Velocity (υ) and Spectral Width (σ_υ)	
• Differential Phase between H and V states (ψ_{dp})	
• Copolar Correlation Coefficient ($\rho h_\upsilon(0)$)	
• Linear Depolarization Ratio (LDR)	
• Doppler Spectra from FFT processing	
• I, Q and logP for every pulse in time series mode (up to 150 gates)	

Courtesy: Two Year Interim Report by John Beaver, CSU

The Austria Van

The 2D-Video Distrometer, commonly called the Austrian instrument, was designed and built by the Joanneum Institute for Applied Systems Technology Graz, Austria. It has been loaned to Colorado State University by this Institute for the summer to carry out research, and in the process, test the instrument. The main parts of this instrument are:

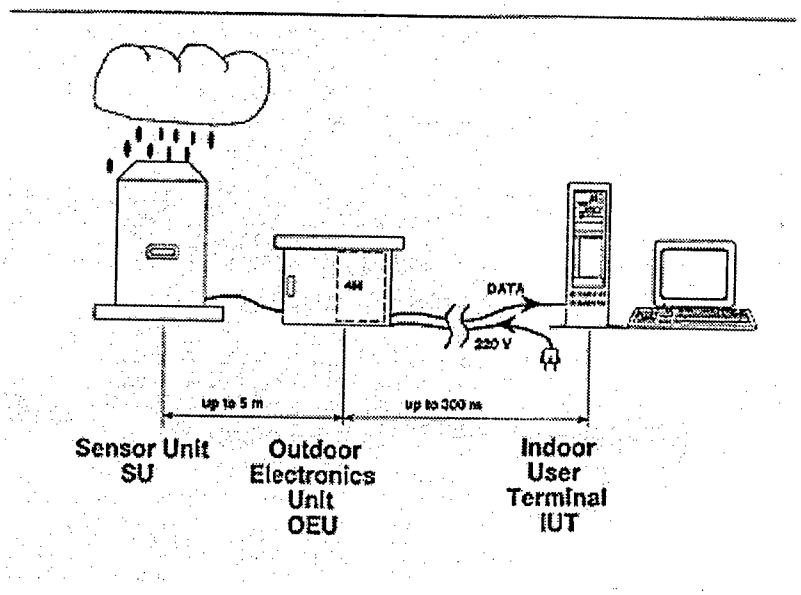
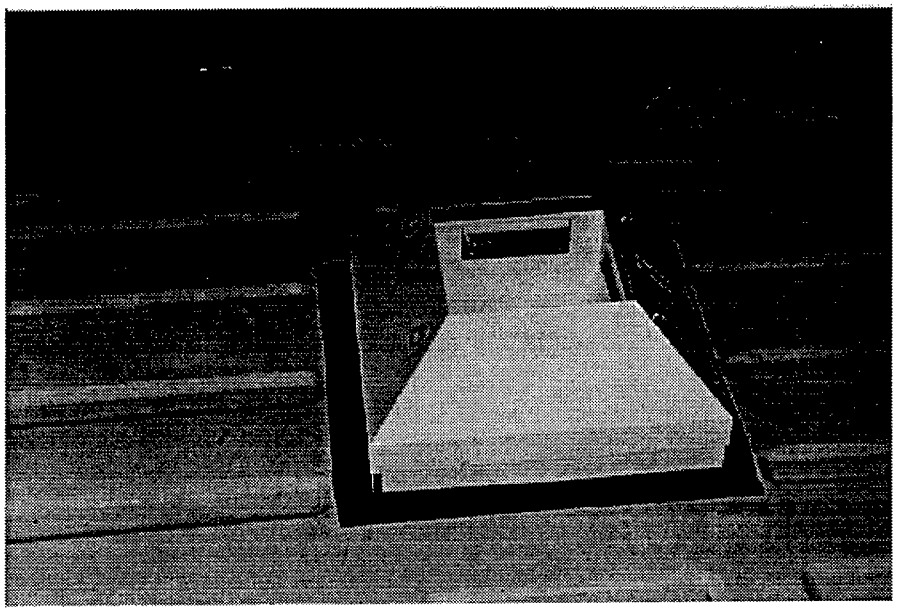


figure 1: Schematic Drawing of the Distrometer

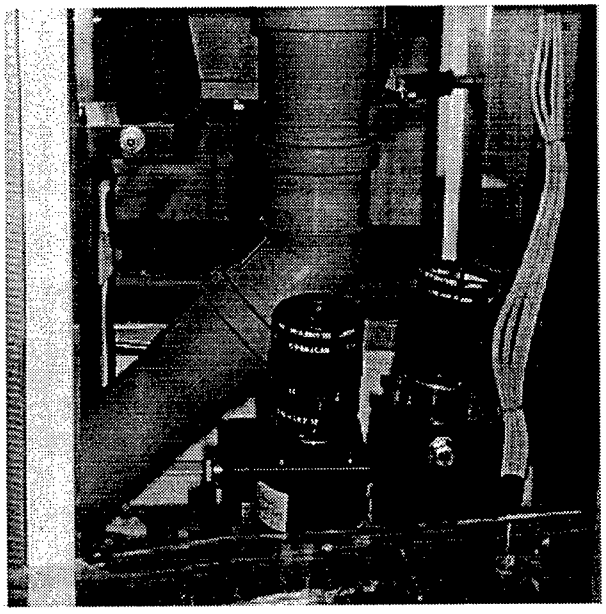
1) ***Sensor Unit (SU)***:

This unit has been mounted on rubber shock absorbers inside the Austria Van. An approximate opening of 18 square inches has been cut from the roof of the van so that the top part of this sensor can face out. The sensor itself has an opening of 10 square cm through which the rain/hail drops fall into the pipe which rains them out from the small opening on the van floor.



Picture 3: Top view of the sensor unit.

Also mounted in the sensor unit are the two Line Scan Cameras, Two Illumination lamps and the Mirrors. (Detailed functions of these are listed in the software and hardware manuals).



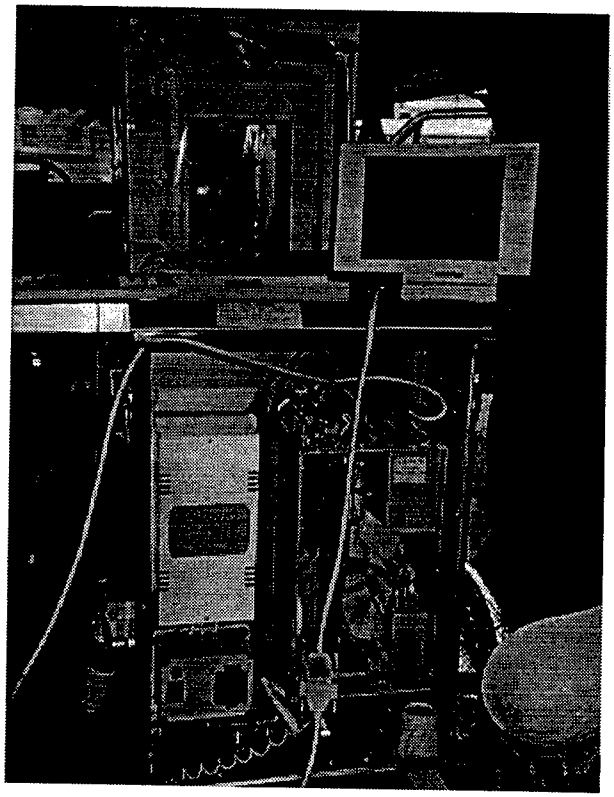
Picture 4: Line scan Cameras

2) ***Indoor User Terminal (IUT):***

The Indoor User Terminal consists of a 120 MHz Pentium PC. This is also commonly referred to as the front PC. This has been mounted behind the drivers seat also on rubber shock absorbers. The monitor for this PC has been mounted in the middle behind the front seats on a wooden table. The main function of the front PC is to receive data sent by the back PC, store it and display it online/offline.

A minor modification was made after IUT was received from Austria. A small 200 Megabyte hard drive was installed inside the Front PC so that data could be backed-up after collection for safety reasons.

3) ***Outdoor Electronics Unit (OEU):***



Picture 5: The Back PC

The OEU is an outdoor unit, but it has been installed inside Austria in order to make the Distrometer mobile. The OEU has been mounted at the rear end of the van. This unit is a steel box inside which a 133 MHz Pentium PC is mounted. This unit is referred to as the Back PC. This unit is directly connected to the SU. It collects data from the SU using the acquisition program provided by Joanneum Research and sends it to the Front PC in small packets every three seconds. A 50 Ohms coaxial cable is used to transfer pre-processed data from the OEU to the IUT.

Overall Plan of the Austria Van Setup:

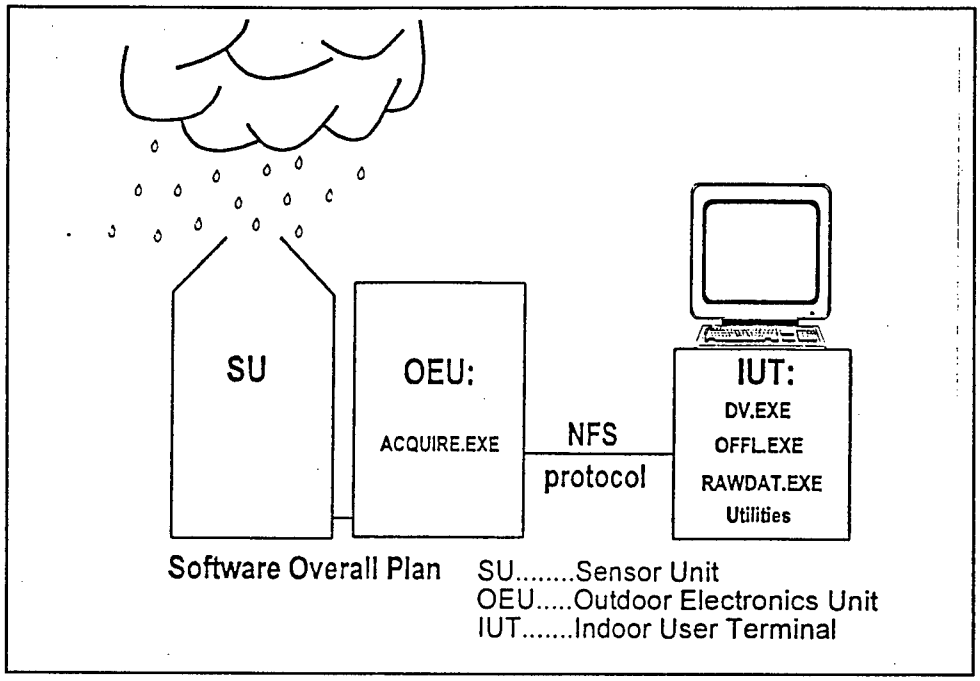


Figure 2: Software overall plan

The overall plan for the 2D-Video-Distrometer software recognizes five main parts:

- Video Control and Data Acquisition:
- Link OEU-IUT: performed via standard NFS protocol.
- Data Storage Manager and Online Display (DV.EXE): This part represents interface to the user.
- Offline Display (OFFL.EXE and RAWDAT.EXE)
- Utilities: several utilities are available for decompressing the recorded data files and for conversion and display of the screendump files.

GPS Unit:

In addition to the 2D-Video Distrometer there is a Global Positioning System (GPS) in the van. The GPS unit allows technicians at the CHILL Radar site to find the van's exact locations. With the movement of the chase vans, the GPS unit is constantly active and

records the location of the van. A program time and date stamps each entry in a data file containing the latitude and longitude of the van. However, these coordinates mean nothing since all the radar data is centered around the radar. Therefore it is important to convert the Lat-Lon reading to the XY coordinates from the radar to make the post analysis of the data easier and more accurate for the user.

A c code has been written for this conversion and the name of the code is azran.c. The exact code for this program can be found in appendix D of Duncan Halstead's report. It reads from a prompted data file and writes to either standard output or a user defined file. There is a DEFINE statement LINES_2_DATA that can be changed to skip bad lines of data, or headers. The program then simply reads until the end of file. When converting the latitude and longitude coordinates, the CHILL Radar has a longitude and latitude of 40.446 degrees and 104.637 degrees respectively, and there are 60.12 nm/degree.

If the format of the data files ever change, all that needs to be modified is the scanf statement that reads in the data. Currently, there is a variable called dummy used to read in the semi-colons between the degrees, minutes and seconds of the latitude and longitude.

Principle Of Operation:

The figure shown below is a schematic drawing illustrating the operating principle of the instrument. The trapezoid black box is the Illumination Device (I.D.), which in principle is an extremely large-diameter optical condenser.

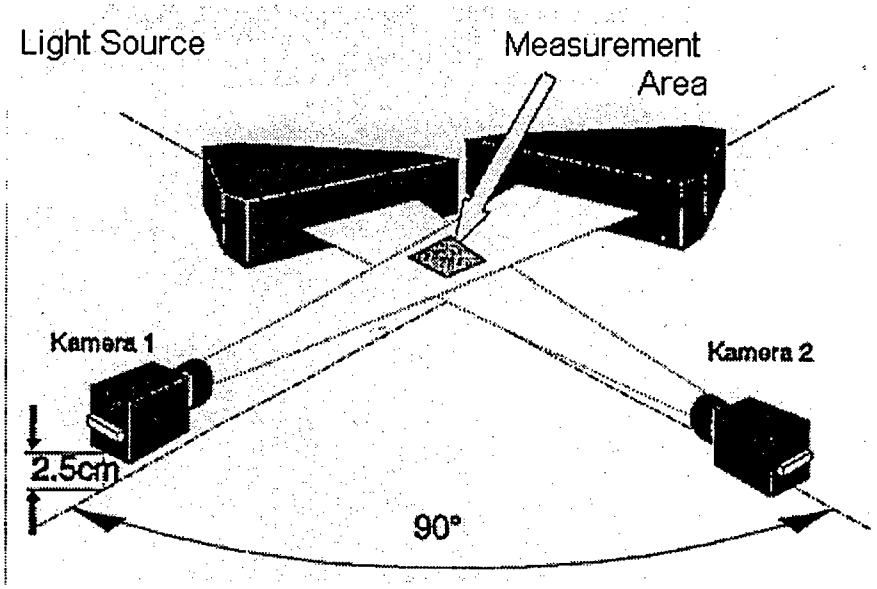


Figure 3: Arrangement of Optical System

Two line scan cameras are directed towards the opening of these illumination devices. The optical system is designed in such a way that (seen thru the camera lens) the slit of the I.D. appears as a relatively even illuminating background of extreme brightness.

To the cameras, any particle falling thru the beam of the light will appear as a dark silhouette against this bright background.

In reality, each of the two optical paths contains two mirrors that are used to "bend" the beam. These are left out here in order to simplify the drawing.

Operating Procedure for Austria:

1) Take out the foam from the top opening of the SU.
2) Turn on the OEU. Wait until the prompt shows up. At the prompt type OPER.

   (Note: This command has already been written in autoexec.bat and does not need to be typed if turned on from the inverter)
3) Once OPER is executed the back PC should go through some processes (like reading the parameters from the file acquire.par) and at the end it should read "data acquisition running"
4) After Data acquisition starts running, turn on the IUT using the switch on the Front PC. Two options will appear on the screen:

   1) Mobile
   2) Docked

   When collecting data the first option should be used, ie. Mobile (The second option is used when uploading saved data to one of the Sun work stations at the Radar Lab. This will be described later on in the report)
5) After the selection is made the screen should read c:\2d-video\oper. At this point type DV. This will take you into an online display.
6) Inside this online display, change the time window to the current time. Make sure that the current time is put in as the data collection is appended to the same file.
7) Once the time is sent, click on run and sit back to see the spectacular work which is being done by the distrometer. Do not forget to take good notes as they are the key to good analysis which leads to good reports.

8) Once the rain event stops, hold escape on both PC's to come out of acquisition.

9) Now is the time to backup the data which has been collected. On the prompt type:

backit xxx y

where:

xxx is the number of days which have passed in the year since January 1 (Julian Date). If in doubt look at the Julian date calendar in the van.

y is the event number of the day. Make sure that the first event of the day is 2, second 3, third 4 and so on.

So the backup procedure for the 5th event on July 7, 1996 will be:

backit 189 6

This procedure saves data on drive f.

10)To minimize the loss of data we backup the data a second time with the same conventions. The command for this is:

backit2 xxx y

This saves data on drive g.

11) Now the system should be turned off and the foam should be put back on.

Important: It is very important to remember that DV should not be run unless the acquisition program on the back PC is running. If this is not done it will corrupt the data files. If DV is accidentally hit, the file delete procedure in the 'problems' part should be followed.

Problems:

Sometimes during the collection of data due to unknown reasons the data acquisition hangs up and the front PC freezes. In this case:

1) First hold escape to get out of acquisition from the back PC.
2) Then try holding escape on the front PC. If this works go to step 4 else go to step 3.
3) Reboot the front PC.
4) At the prompt type:
    a) backit xxx y
    b) backit2 xxx y
    c) del e:\raw\v96xxx_1.*
    d) del e:\hyd\v96xxx_1.*
5) Turn off the Front PC and go to step one of the operating procedure.

Periodic Backup on the Sun Stations in the Radar Lab at the EE building:

Periodically all the data collected should be uploaded to the Everest machine in the radar lab so that it can be put on tapes for permanent safekeeping. Follow the procedure outlined below:

1) Take the van to CHILL radar.
2) Take the coaxial cable from the conference room in the main building. (If in doubt ask Dave)
3) Connect the cable to the ethernet card of the front PC.
4) Start the front PC and go in to 'Docked', the number 2 option.

5) At the prompt type:

a) e:\hyd

b) ftp everest.lance.colostate.edu

c) enter your user name and the password

At the ftp prompt type:

a) the directory where you want to save the data for 1996:

cd ~radar/REU/vivek/chill/96data

b) bin

c) mput v96xxx_*.*

d) lcd ..\raw

e) mput v96xxx_*.*

f) this procedure should be repeated until data for all days is uploaded.

Data Processing:

After the data is collected in the Indoor User Terminal, it can be viewed either online or offline. The online procedure has been discussed in the operating procedure of the Distrometer. There is an offline version of the same software so that the data can be viewed and analyzed at a later date at the user's convenience. The executable for the software is OFFL.EXE, also supplied by Joanneum Research, Austria. The procedure to run this program is listed below:

1) Get the *.hyd file of the date desired to be analyzed from the Sun Station at the radar lab in the EE building.
2) Put the *.hyd in the same directory as OFFL.EXE
3) Type: offl v96xxx_(event number).hyd
4) Right now the program is loaded on the Parnassus PC at the radar lab.
5) *.hyd files have a separate directory under c:\schoe\1996\hyd
6) To run offl type: offl ..\hyd\v96xxx_(event number).hyd

What can we look at by running the offline version?

This simple program provides us with a lot of information. It is hard to believe that a small program like OFFL can provide information about:

a) **Rain Rate versus Time:** The integration interval used for calculating the rainfall rate for this diagram is not a time interval, but a rainfall quantity. The diagram is updated each time a rainfall quantity of 0.1 mm is exceeded. The rainfall rate over the past 30 minutes, counted from the occurrence time of the most recent update, is represented.

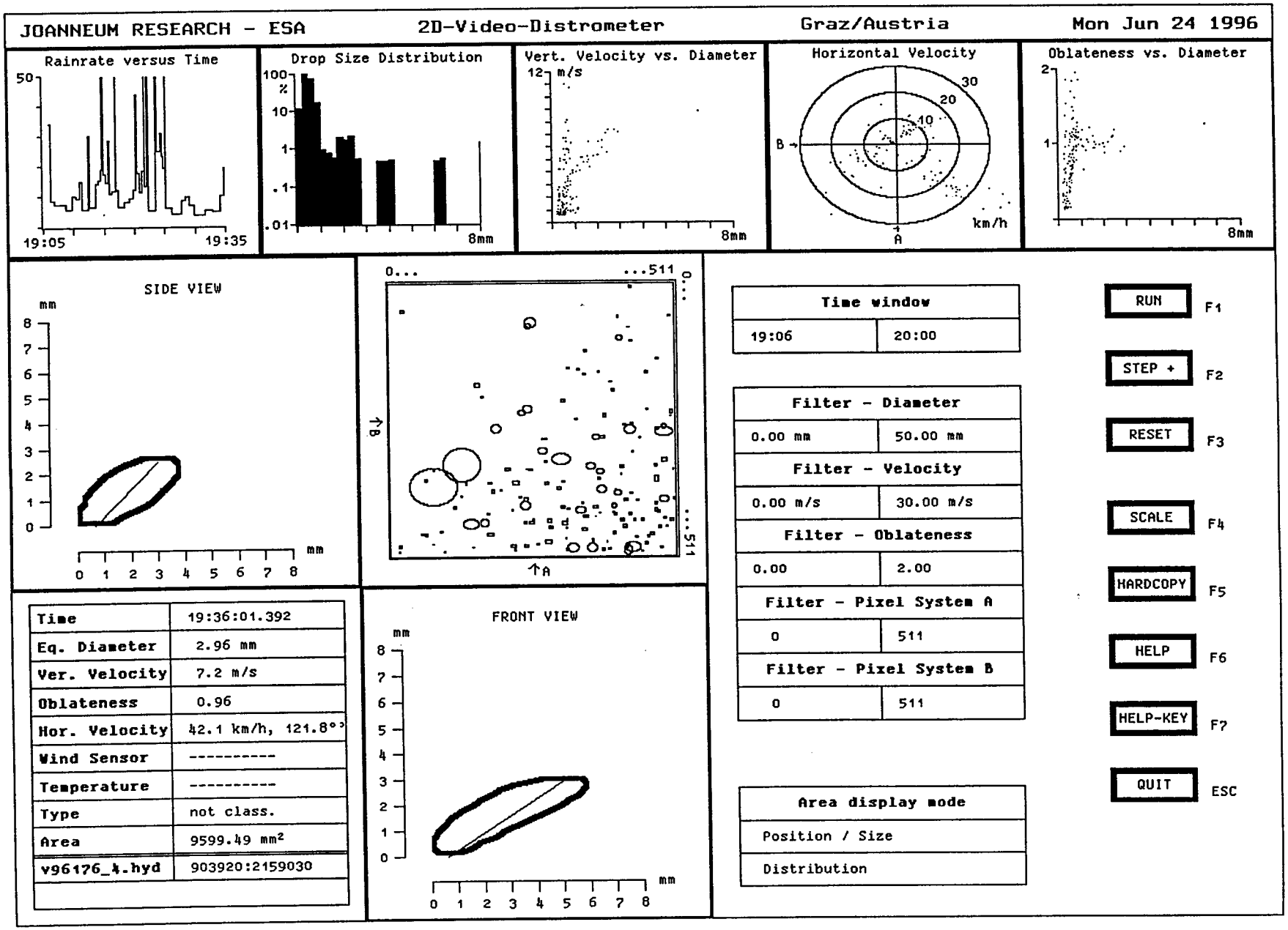
b) **Drop Size Distribution:** The diagram is updated each time a rainfall quantity of 0.1 mm is exceeded. This rainfall quantity is used as an integration interval for calculating the DSD. The diameter class width can be set from 0.25 mm to .05mm.

c) **Vertical Velocity versus Diameter:** This diagram shows hydrometer vertical fall velocity versus equivalent diameter. A dot is set for each hydrometer at the corresponding (diameter, velocity) position. The diagram is updated on each hydrometer. In Run-mode, this diagram is cleared whenever 0.1 mm of rainfall is exceeded.

d) **Horizontal Velocity:** Horizontal velocity is derived from the difference between the center pixel position in the first line and the center pixel position in the last line of a particular drop's shadow area. This difference in center pixel positions is made visible by drawing a "drop axis" into the front/side view of a drop. This result is an approximation method to determine the drop's horizontal velocity. It should be pointed out that the horizontal velocity may be precisely calculated whenever the drop's views are divided into two identical halves. A dot is set for each hydrometer at the corresponding (velocity, direction) position.

e) **Oblateness versus Diameter:** This diagram shows drop oblateness versus equivalent diameter. A pixel is set for each drop at the corresponding (diameter, oblateness) position. The diagram is updated on each drop. Oblateness is calculated by forming the geometric mean value of the two height/width ratios, which can be computed from drop front and drop side view.

f) In addition to the above we can see each drop as it was scanned.


JOANNEUM RESEARCH - ESA
2D-Video-Distrometer
Graz/Austria
Mon Jun 24 1996
Rainrate versus Time
50
19:05
19:35
Drop Size Distribution
100
%
10
1
.1
.01
8mm
Vert. Velocity vs. Diameter
12
m/s
8mm
Horizontal Velocity
30
20
10
B
A
km/h
Oblateness vs. Diameter
2
1
8mm
SIDE VIEW
mm
0 1 2 3 4 5 6 7 8
mm
0...
...511
0...
...511
B
A
Time window
19:06
20:00
Filter - Diameter
0.00 mm
50.00 mm
Filter - Velocity
0.00 m/s
30.00 m/s
Filter - Oblateness
0.00
2.00
Filter - Pixel System A
0
511
Filter - Pixel System B
0
511
RUN
F1
STEP +
F2
RESET
F3
SCALE
F4
HARDCOPY
F5
HELP
F6
HELP-KEY
F7
QUIT
ESC
Time
19:36:01.392
Eq. Diameter
2.96 mm
Ver. Velocity
7.2 m/s
Oblateness
0.96
Hor. Velocity
42.1 km/h, 121.8°
Wind Sensor

Temperature

Type
not class.
Area
9599.49 mm²
v96176_4.hyd
903920:2159030
FRONT VIEW
mm
0 1 2 3 4 5 6 7 8
mm
Area display mode
Position / Size
Distribution

JOANNEUM RESEARCH - ESA | 2D-Video-Distrometer | Graz/Austria | Mon Jun 24 1996

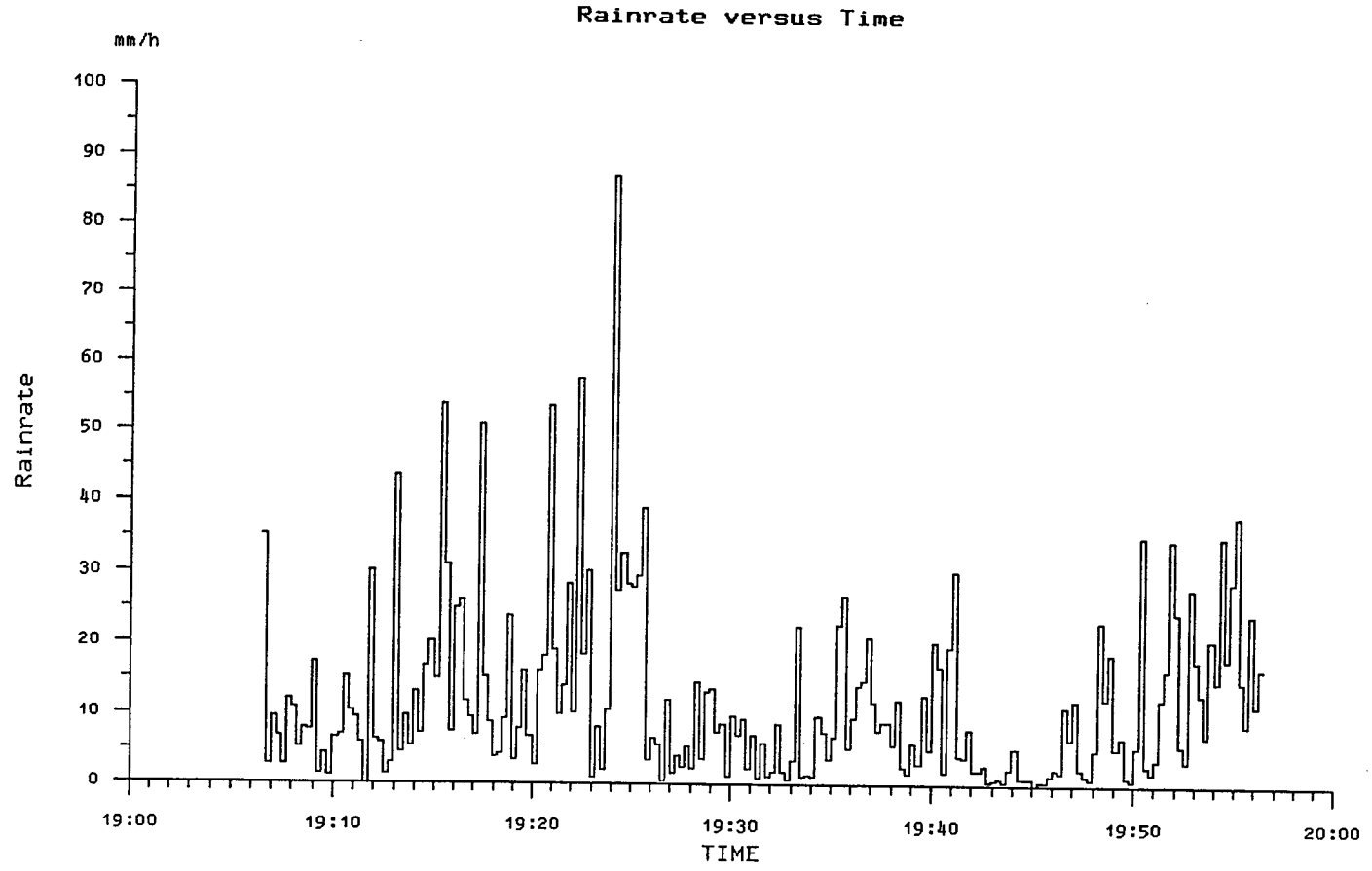
File	v96176_4.hyd	Time	19:00 - 20:00
Int.	19:06:28-19:56:41	Date	Jun 24 1996
Int. Mode	Time (15 sec)		
Rain	9.92 mm		

FILTER

Diameter	0.00 mm	50.00 mm
Velocity	0.00 m/s	30.00 m/s
Oblateness	0.00	2.00
Pixel A	0	511
Pixel B	0	511

RUN F1 | MAIN F2 | HARDCOPY F3 | HELP F4

SCALE < F5 | SCALE > F6 | Integr. F7 | TIP F8

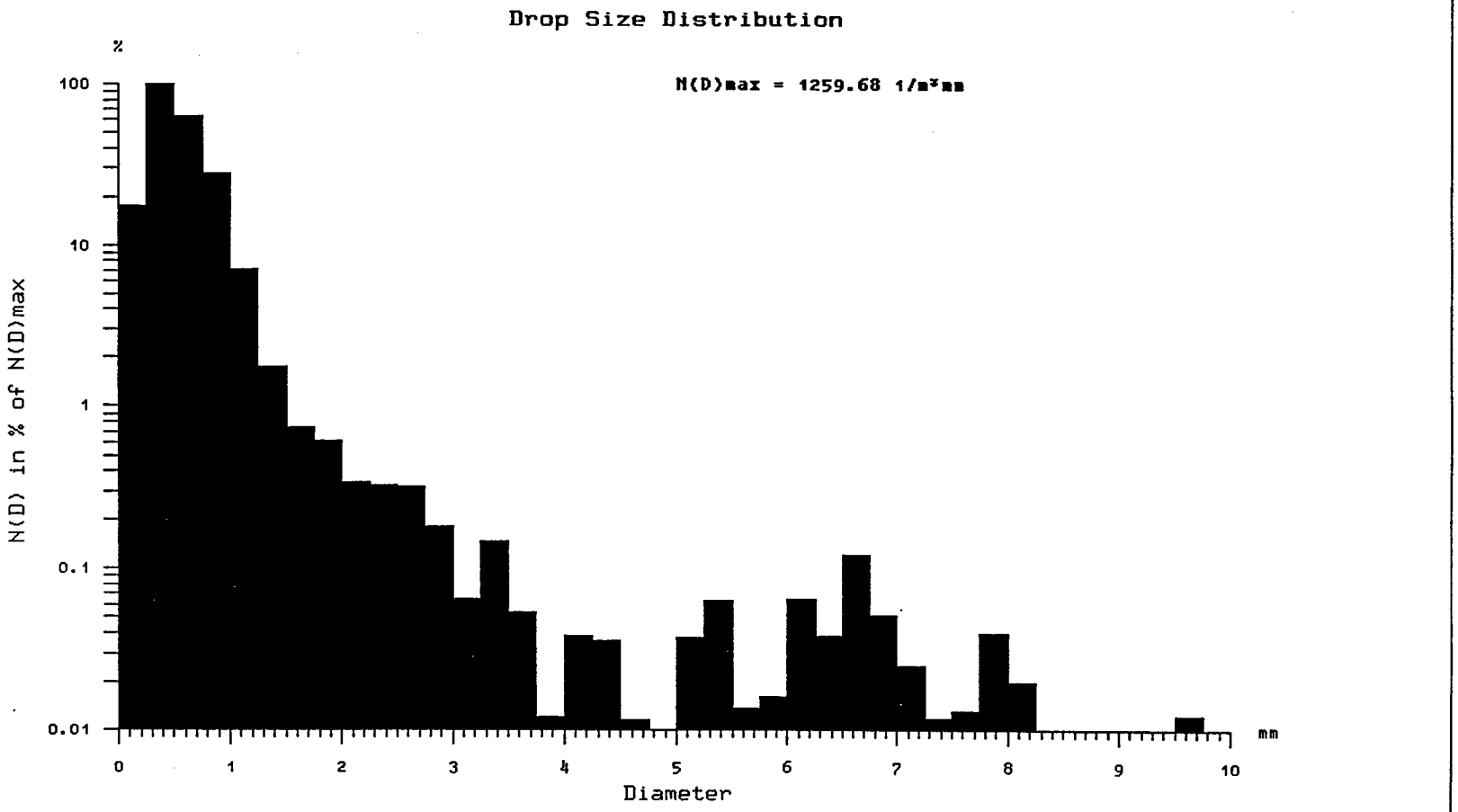


JOANNEUM RESEARCH - ESA | 2D-Video-Distrometer | Graz/Austria | Mon Jun 24 1996

				FILTER			
File	v96176_4.hyd	Time	19:00 - 20:00		Diameter	0.00 mm	50.00 mm
Int.	19:06:00-19:12:00	Date	Jun 24 1996		Velocity	0.00 m/s	30.00 m/s
Rain	0.88 mm				Oblateness	0.00	2.00
Time Int	360.00 s	Rainrate	8.82 mm/h		Pixel A	0	511
Objects	3443	ΔD	0.25 mm		Pixel B	0	511

RUN F1 | MAIN F2 | HARDCOPY F3 | HELP F4

ΔD < F5 | ΔD > F6 | Integr. F7 | COMP F8



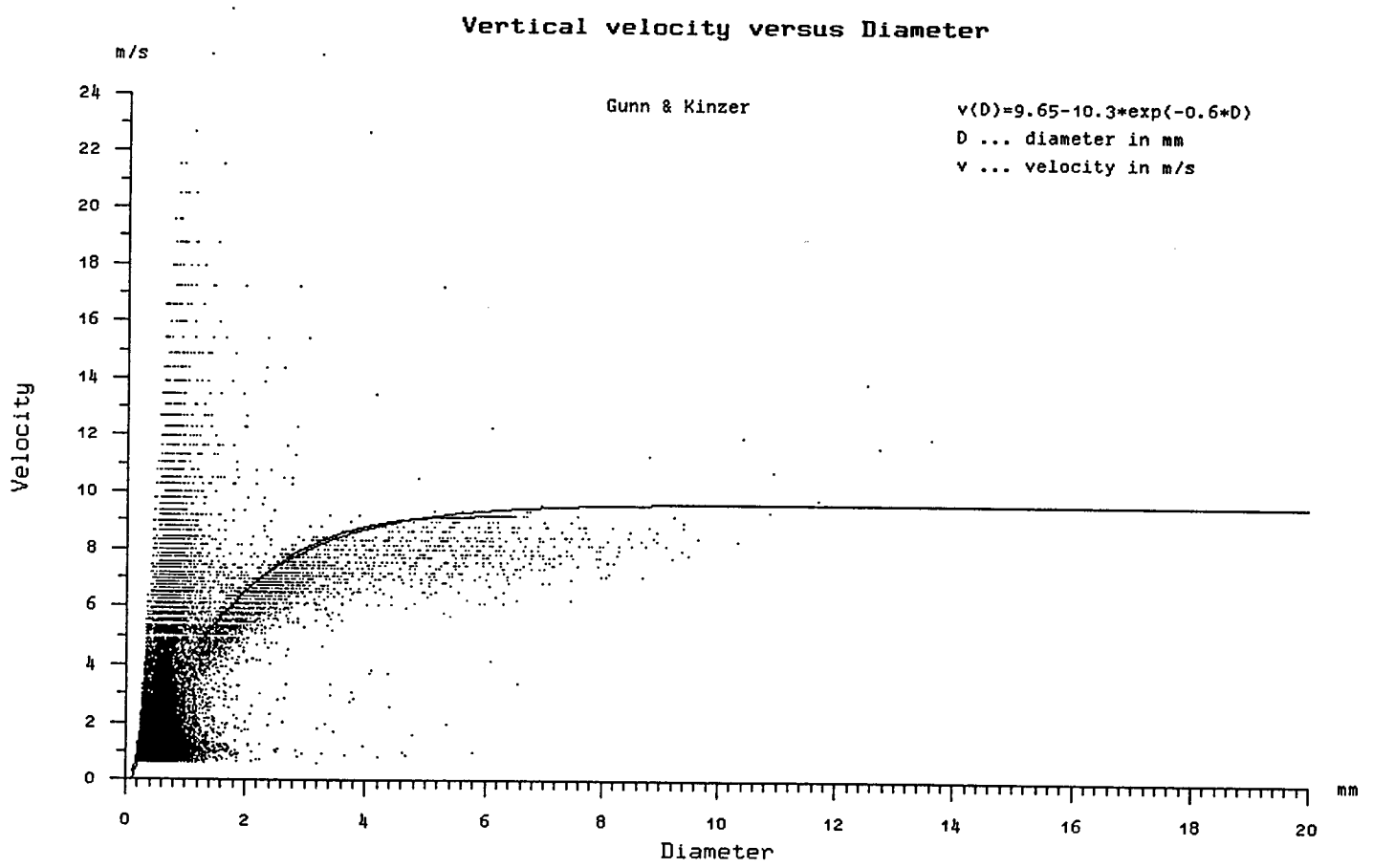
JOANNEUM RESEARCH - ESA | 2D-Video-Distrometer | Graz/Austria | Mon Jun 24 1996

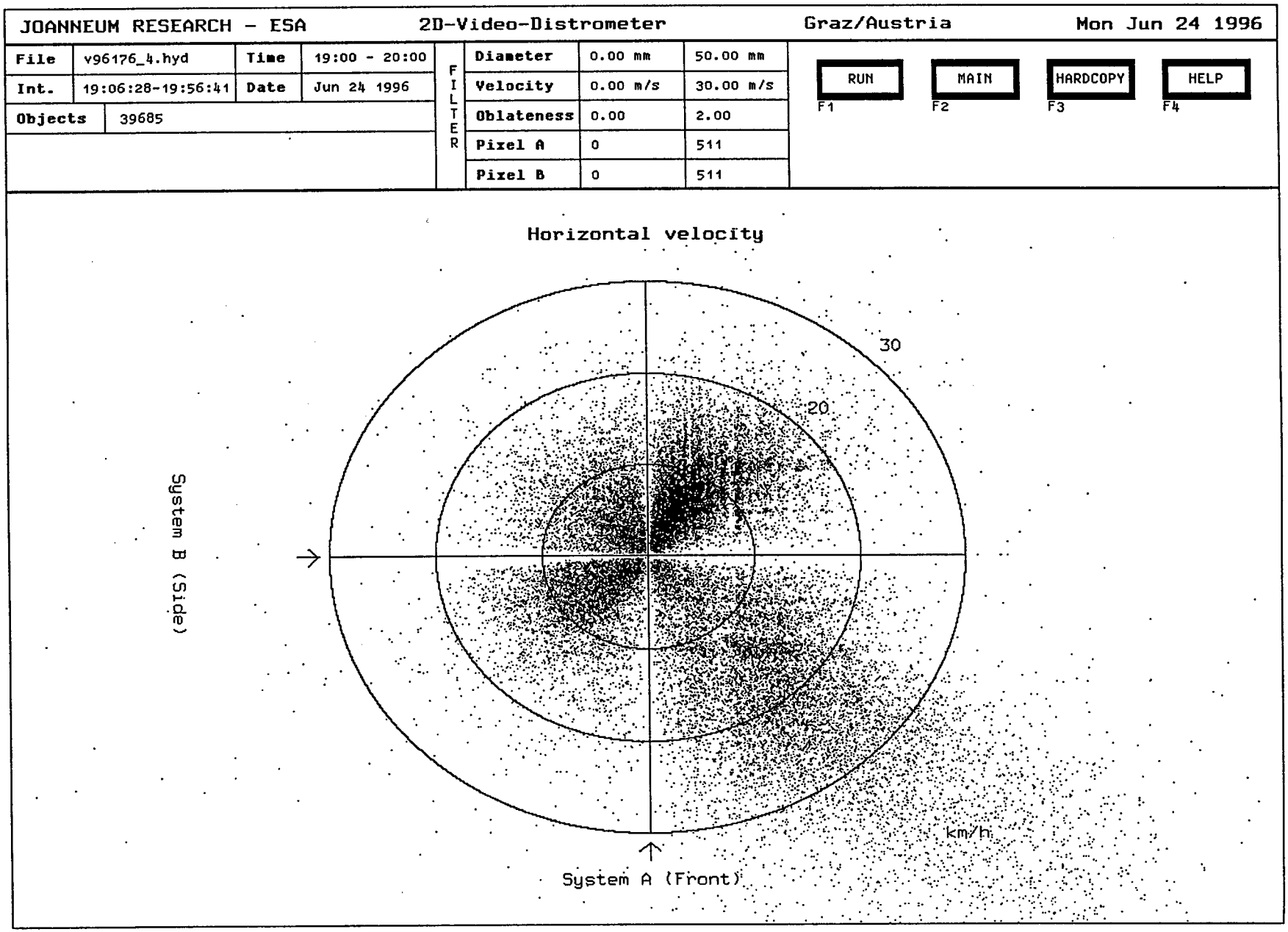
File	v96176_4.hyd	Time	19:00 - 20:00
Int.	19:06:28-19:56:41	Date	Jun 24 1996
Objects	39685		

FILTER

Diameter	0.00 mm	50.00 mm
Velocity	0.00 m/s	30.00 m/s
Oblateness	0.00	2.00
Pixel A	0	511
Pixel B	0	511

RUN F1 | MAIN F2 | HARDCOPY F3 | HELP F4 | COMP F5




JOANNEUM RESEARCH - ESA
2D-Video-Distrometer
Graz/Austria
Mon Jun 24 1996
File
v96176_4.hyd
Time
19:00 - 20:00
Int.
19:06:28-19:56:41
Date
Jun 24 1996
Objects
39685
FILTER
Diameter
0.00 mm
50.00 mm
Velocity
0.00 m/s
30.00 m/s
Oblateness
0.00
2.00
Pixel A
0
511
Pixel B
0
511
RUN
F1
MAIN
F2
HARDCOPY
F3
HELP
F4
Horizontal velocity
30
20
System B (Side)
km/h
System A (Front)

JOANNEUM RESEARCH - ESA | 2D-Video-Distrometer | Graz/Austria | Mon Jun 24 1996

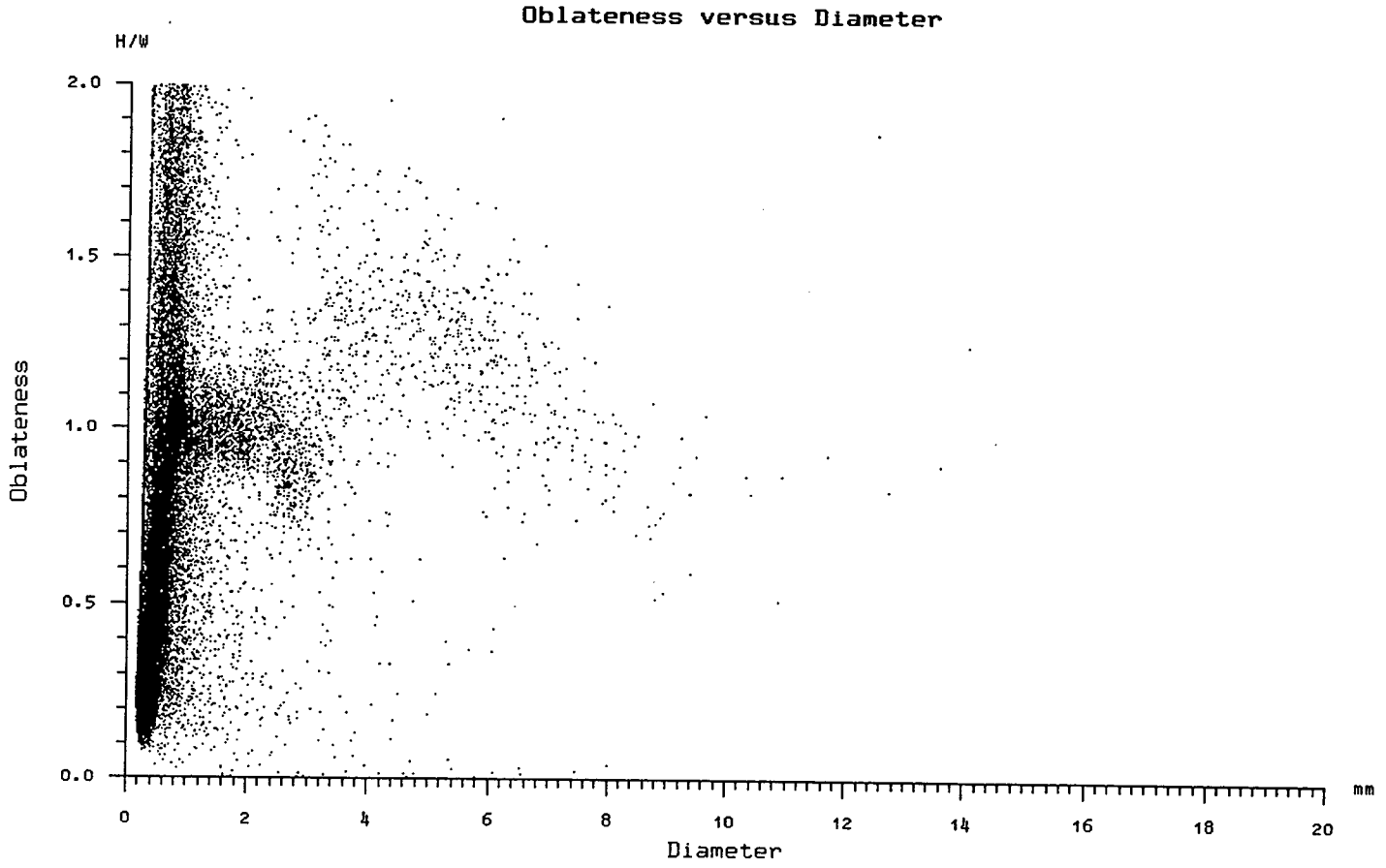
File	v96176_4.hyd	Time	19:00 - 20:00
Int.	19:06:28-19:56:41	Date	Jun 24 1996
Objects	39685		

FILTER

Diameter	0.00 mm	50.00 mm
Velocity	0.00 m/s	30.00 m/s
Oblateness	0.00	2.00
Pixel A	0	511
Pixel B	0	511

RUN F1 | MAIN F2 | HARDCOPY F3 | HELP F4

COMP F5 | GRID F6 | N(H/W) F7



JOANNEUM RESEARCH – ESA 2D-Video-Distrometer Graz/Austria Mon Jun 24 1996

File	v96176_4.hyd	Time	19:00 - 20:00	FILTER	Diameter	5.00 mm	50.00 mm
Hyd. Time	19:10:33.397	Date	Jun 24 1996		Velocity	0.00 m/s	30.00 m/s
Eq.Diam.	9.66 mm	Velocity	8.45 m/s		Oblateness	0.00	2.00
Obl.ness	1.04	Type	not class.		Pixel A	0	511
					Pixel B	0	511

STEP + (F1) MAIN (F2) HARDCOPY (F3) HELP (F4)

STEP - (F5) ASCII (F6) CORR (F7)

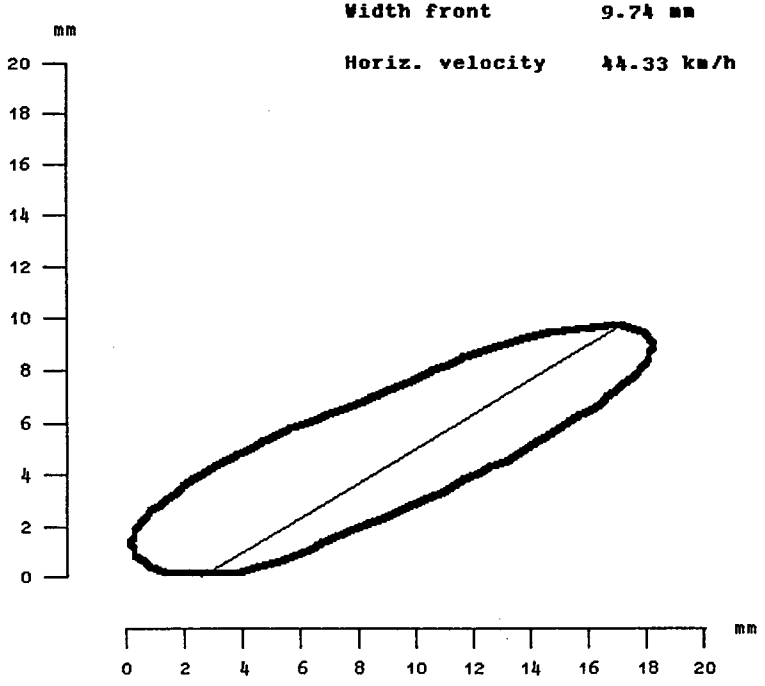
FRONT VIEW

Oblateness front 1.01

Height front 9.84 mm

Width front 9.74 mm

Horiz. velocity 44.33 km/h (→)



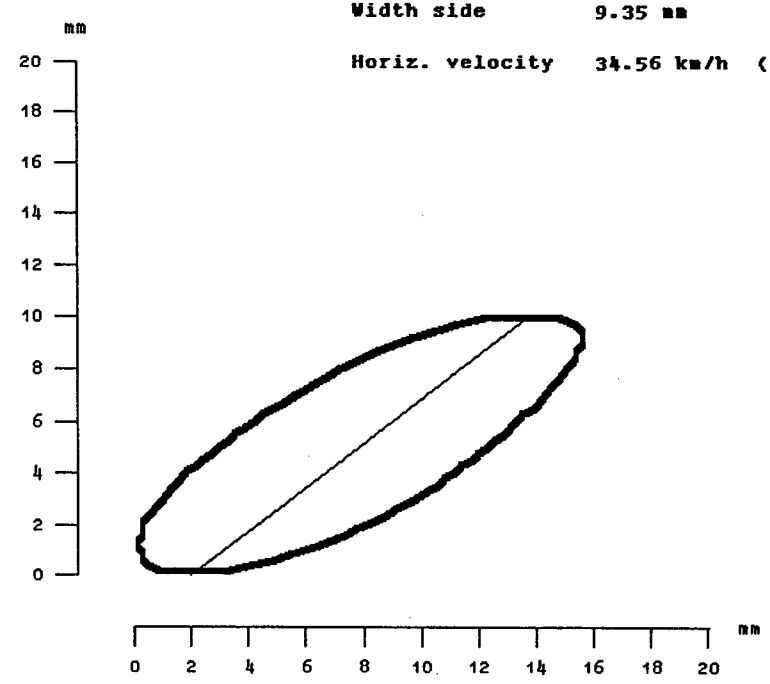
SIDE VIEW

Oblateness side 1.08

Height side 10.08 mm

Width side 9.35 mm

Horiz. velocity 34.56 km/h (→)



Calibration:

Every morning before the van is taken out the Distrometer should be calibrated. There are a few steps which should be followed. These steps are outlined below:

Plane Alignment Program:

Purpose:

PLANE.EXE is a program supplied by Joanneum research to perform the fine adjustment of the optical measurement planes.

Principle of Measurement:

Precision steel balls of 10.0 mm in diameter are dropped through the measuring area at a great number of different positions. The program records the front- and side-view of these objects and then evaluates the following time differences:

Object appears in camera A - Object disappears from camera A

Object appears in camera B - Object disappears from camera B

Object appears in camera A - Object disappears from camera B

Object appears in camera B - Object disappears from camera A

This results in a system of equations that allow to (very accurately) calculate the plane distance for each ball dropped in a particular position. As soon as enough measurement points are available to calculate reliable mean values, the program calculates the "best fit" plane-equation and displays the measured plane distance at 3

corners of the virtual measurement area. The user can then make corrective adjustments to the mechanical components.

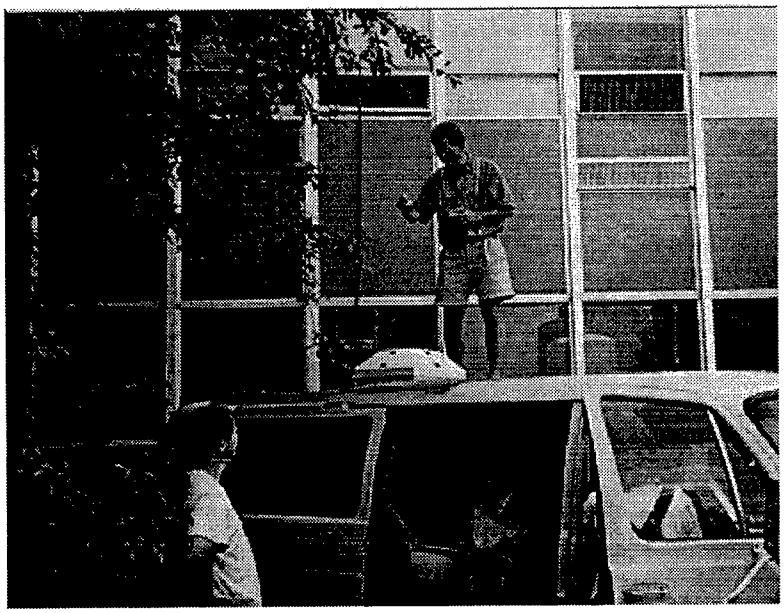
How to use PLANE.EXE to measure plane distances:

At the OEU's command prompt type:

plane

to start the program. The initialization routines are practically the same as the ones used in the data acquisition program ***acquire.***

After initialization has completed, the screen will display a symbolic "top view" of the distrometer orifice. This is oriented "looking from camera A into the respective illumination device".



Picture 6 : Dr. John Hubbert doing calibration

The program now prompts you to throw balls with the message:

Data acquisition running- Throw balls now.....

Drop 10 mm calibration balls into the measurement area. The fall height must not be too great. Ideally, drop the balls from approximately the height of the funnel rim (ie some 5 cm above the plane)

Now go on throwing balls keeping in mind the following:

a) Try not to throw two or more balls at once.

b) Try to distribute your hits evenly across the measurement area.

c) Some of the balls will not appear on the screen (the first never shows up), this is because the program performs a number of integrity checks on the raw data and would rather discard a single measurement point than run the risk of using unreliable data.

d) DO NOT LOOSE THE BALLS THEY ARE 10 US DOLLARS EACH.

Keep throwing the balls until prompted

Enough points -> press 'E' to evaluate...

Pressing the 'E' key will display the plane distance in millimeters at the three corners of the measurement field. A positive value means plane 'A' lies above plane 'B' which is the normal orientation.

Fine adjusting plane distances:

Use ***plane*** to measure plane alignment as described above.

Use fine adjustment screws on the camera tilt table to correct plane distances:

a) Use the long vertical screw to lift and lower the corresponding plane: Turning clockwise will lift the plane as a whole.

b) Use the short horizontal screw to tilt the plane: Clockwise will lower the left and lift the right side of the plane.

c) The short horizontal screw will never be needed for adjustment.

Check plane alignment again using ***plane***. If major mechanical adjustments have been made, it might be necessary to correct the raw video height. Refer to the manual attached.

Repeat the above procedure until average plane distance is:

6.2mm +/- 0.1mm

Put the exact value in the acquire.par file by editing it using the 'b' editor.

APPENDIX A

PROCESSED DATA GRAPHS

Date:	June 10, 1996
Julian Day:	162
Time:	13:39-13:54
Average Rain Rate:	14.22mm\hr
Total Rainfall:	3.79mm
Location:	County road 50 & frontage road Facing east
Contents:	Easterly wind Large drops Water covered ice particles 13:47-13:51: small hail

JOANNEUM RESEARCH – ESA 2D-Video-Distrometer Graz/Austria Mon Jun 10 1996

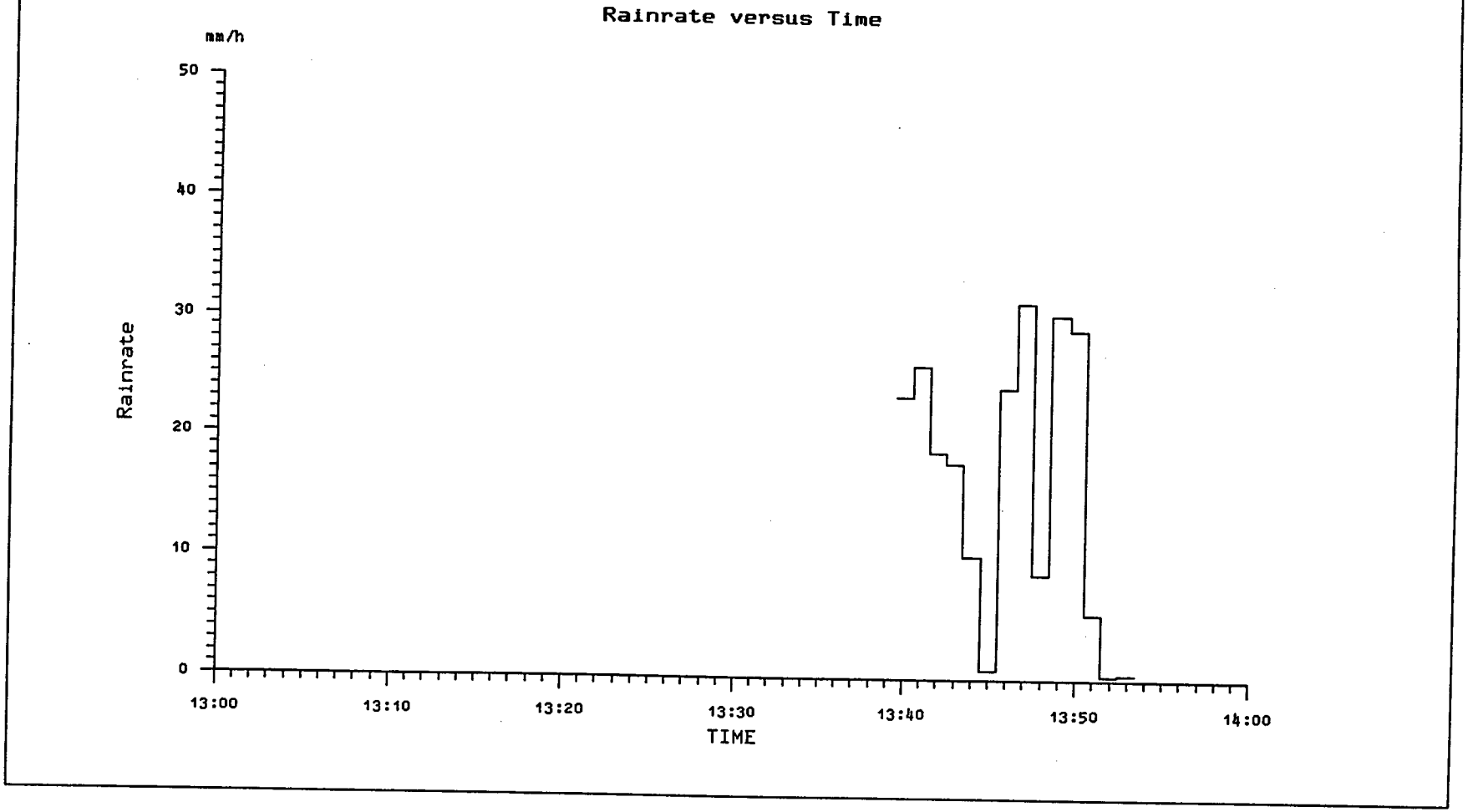
File	v96162_1.hyd	Time	13:00 - 14:00
Int.	13:39:28-13:54:27	Date	Jun 10 1996
Int. Mode	Time (60 sec)		
Rain	3.79 mm		

FILTER

Diameter	0.00 mm	50.00 mm
Velocity	0.00 m/s	30.00 m/s
Oblateness	0.00	2.00
Pixel A	0	511
Pixel B	0	511

RUN F1 | MAIN F2 | HARDCOPY F3 | HELP F4

SCALE < F5 | SCALE > F6 | Integr. F7 | TIP F8



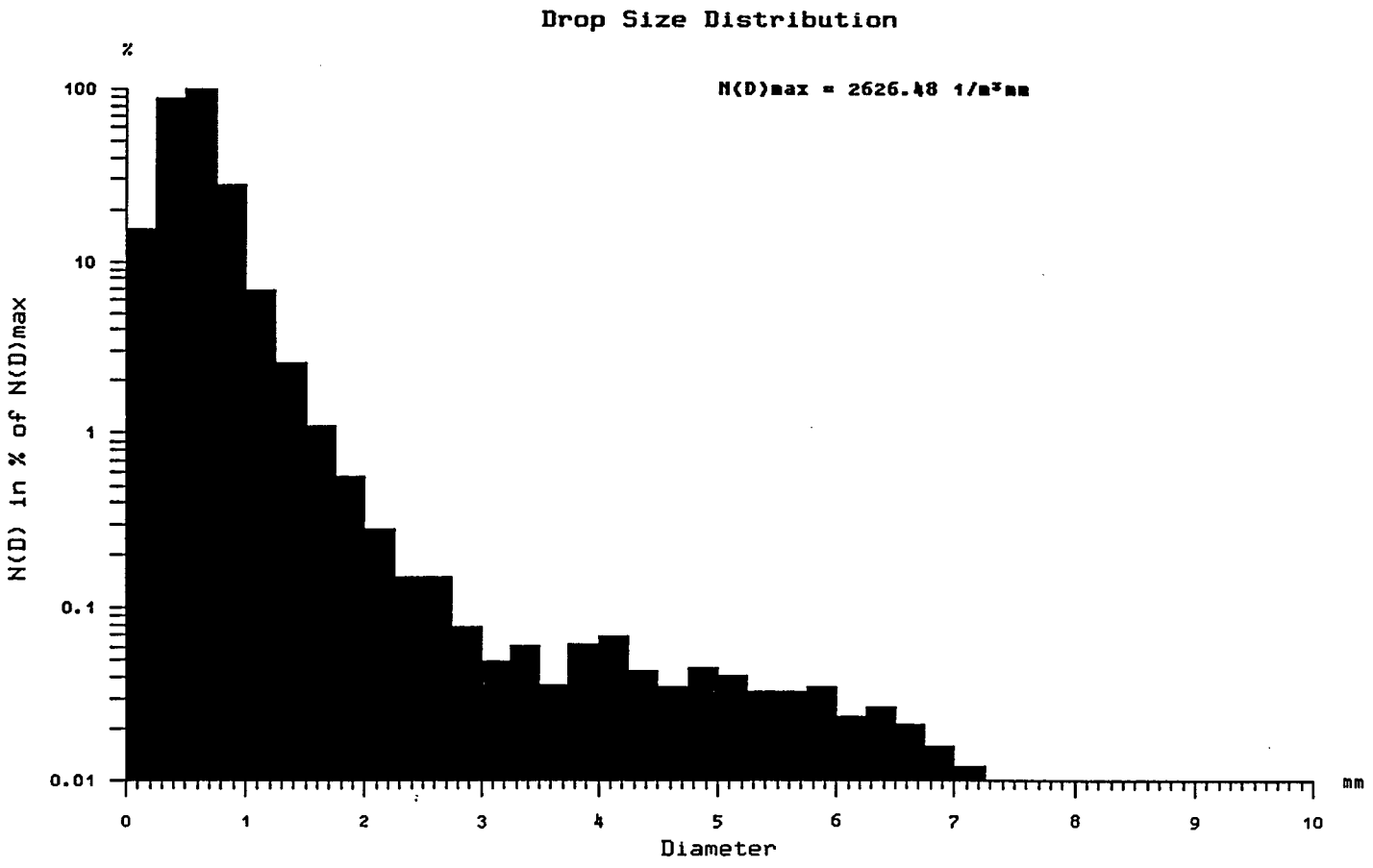
Date:	June 12, 1996
Julian Day:	164
Event:	1
Time:	18:49-18:56
Average Rain Rate:	1.76mm\hr
Total Rainfall:	.21mm
Location:	Highway 34 and County road 47
Contents:	light to moderate rain

JOANNEUM RESEARCH - ESA | 2D-Video-Distrometer | Graz/Austria | Mon Jun 10 1996

File	v96162_1.hyd	Time	13:38 - 14:30	FILTER	Diameter	0.00 mm	50.00 mm
Int.	13:38:00-13:54:00	Date	Jun 10 1996		Velocity	0.00 m/s	30.00 m/s
Rain	3.79 mm				Oblateness	0.00	2.00
Time Int	960.00 s	Rainrate	14.22 mm/h		Pixel A	0	511
Objects	22104	ΔD	0.25 mm		Pixel B	0	511

RUN (F1) | MAIN (F2) | HARDCOPY (F3) | HELP (F4)

ΔD < (F5) | ΔD > (F6) | Integr. (F7) | COMP (F8)

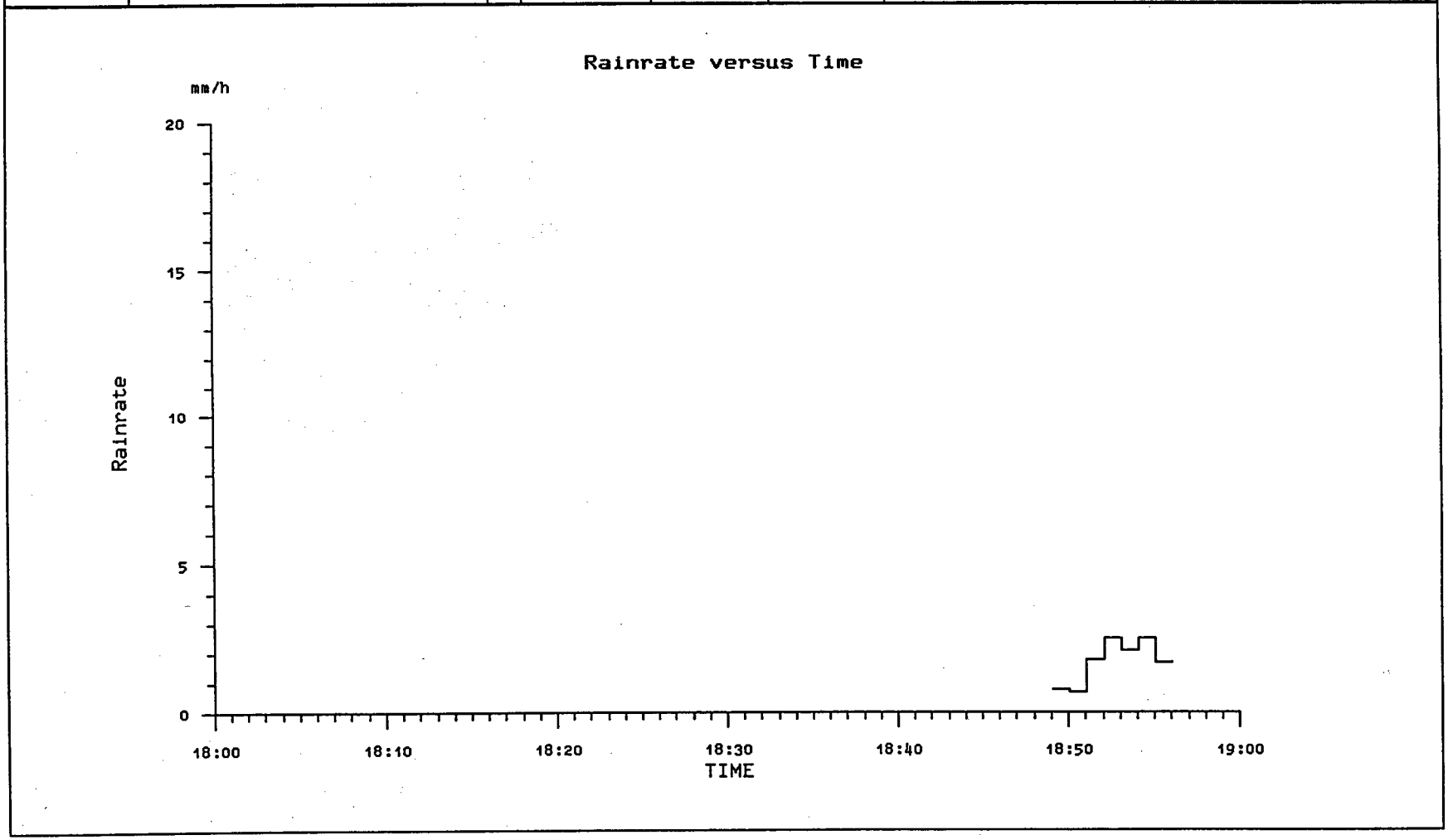


JOANNEUM RESEARCH - ESA | 2D-Video-Distrometer | Graz/Austria | Wed Jun 12 1996

File	v96164_1.hyd	Time	18:00 - 19:00	FILTER	Diameter	0.00 mm	50.00 mm
Int.	18:49:05-18:56:11	Date	Jun 12 1996		Velocity	0.00 m/s	30.00 m/s
					Oblateness	0.00	2.00
Int. Mode	Time (60 sec)				Pixel A	0	511
Rain	0.21 mm				Pixel B	0	511

RUN F1 | MAIN F2 | HARDCOPY F3 | HELP F4

SCALE < F5 | SCALE > F6 | Integr. F7 | TIP F8

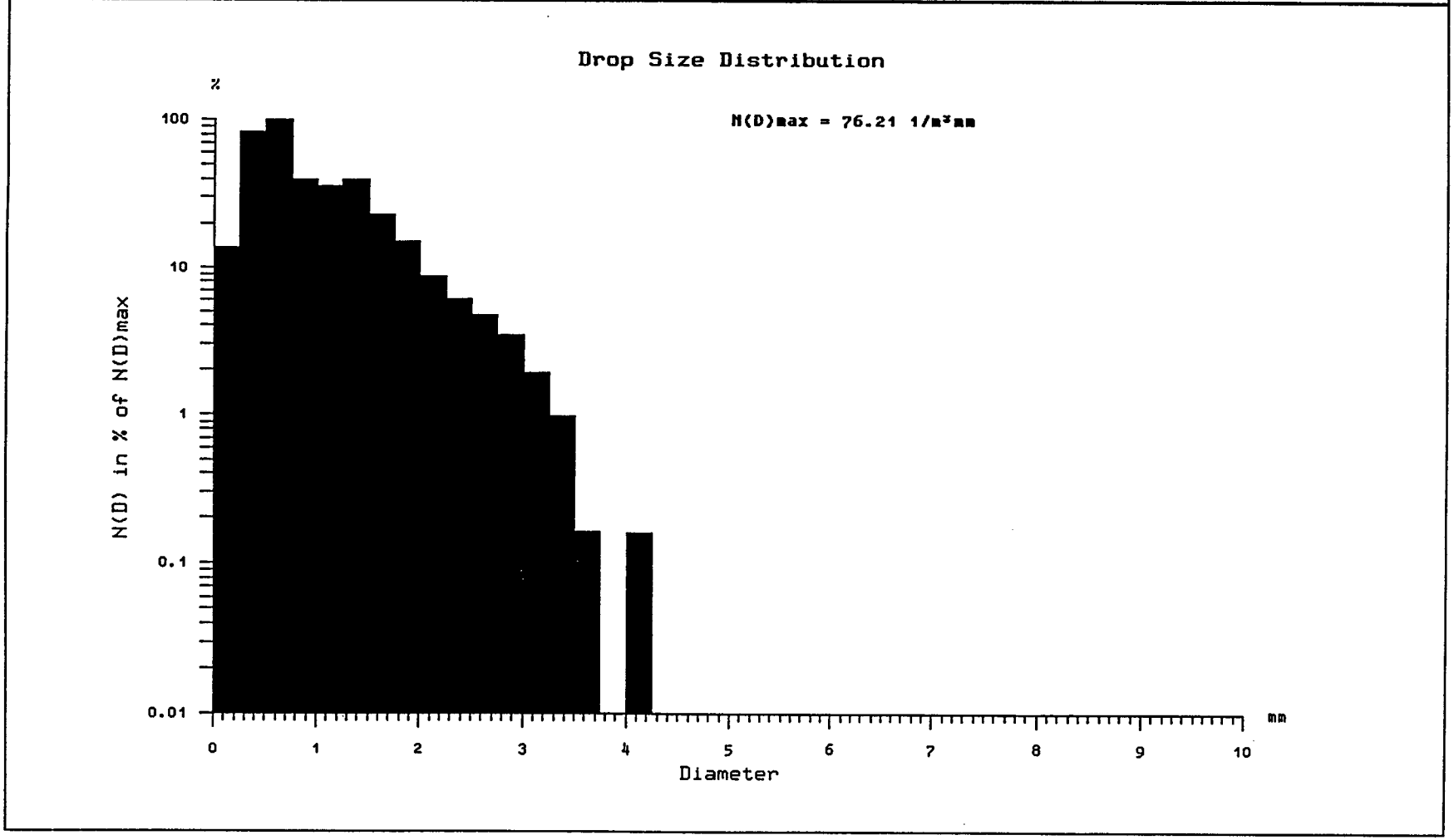


JOANNEUM RESEARCH - ESA | 2D-Video-Distrometer | Graz/Austria | Wed Jun 12 1996

File	v96164_1.hyd	Time	18:00 - 19:00	FILTER	Diameter	0.00 mm	50.00 mm
Int.	18:49:00-18:56:00	Date	Jun 12 1996		Velocity	0.00 m/s	30.00 m/s
Rain	0.21 mm				Oblateness	0.00	2.00
Time Int	420.00 s	Rainrate	1.76 mm/h		Pixel A	0	511
Objects	805	ΔD	0.25 mm		Pixel B	0	511

RUN (F1) | MAIN (F2) | HARDCOPY (F3) | HELP (F4)

ΔD < (F5) | ΔD > (F6) | Integr. (F7) | COMP (F8)



Date:	June 14, 1996
Julian Day:	166
Event:	1
Time:	17:23-17:35
Average Rain Rate:	28.11mm\hr
Total Rainfall:	5.86mm
Location:	Lat.- 40:34:47 Lon.- 104:36:03
Contents:	Little wind Large drops

JOANNEUM RESEARCH - ESA | 2D-Video-Distrometer | Graz/Austria | Fri Jun 14 1996

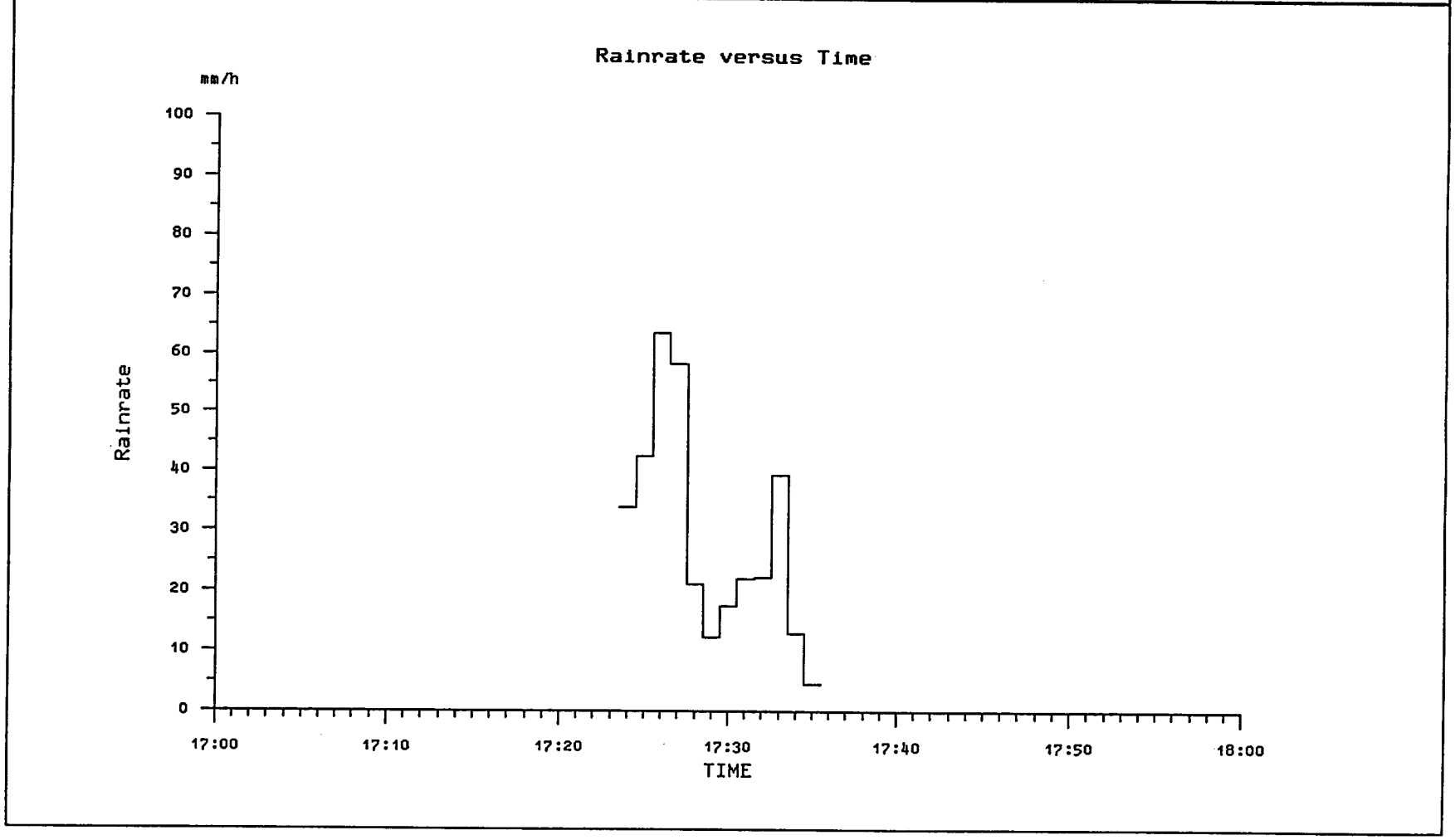
File	v96166_1.hyd	Time	17:00 - 18:00
Int.	17:23:31-17:36:22	Date	Jun 14 1996
Int. Mode	Time (60 sec)		
Rain	5.89 mm		

FILTER

Diameter	0.00 mm	50.00 mm
Velocity	0.00 m/s	30.00 m/s
Oblateness	0.00	2.00
Pixel A	0	511
Pixel B	0	511

RUN F1 | MAIN F2 | HARDCOPY F3 | HELP F4

SCALE < F5 | SCALE > F6 | Integr. F7 | TIP F8

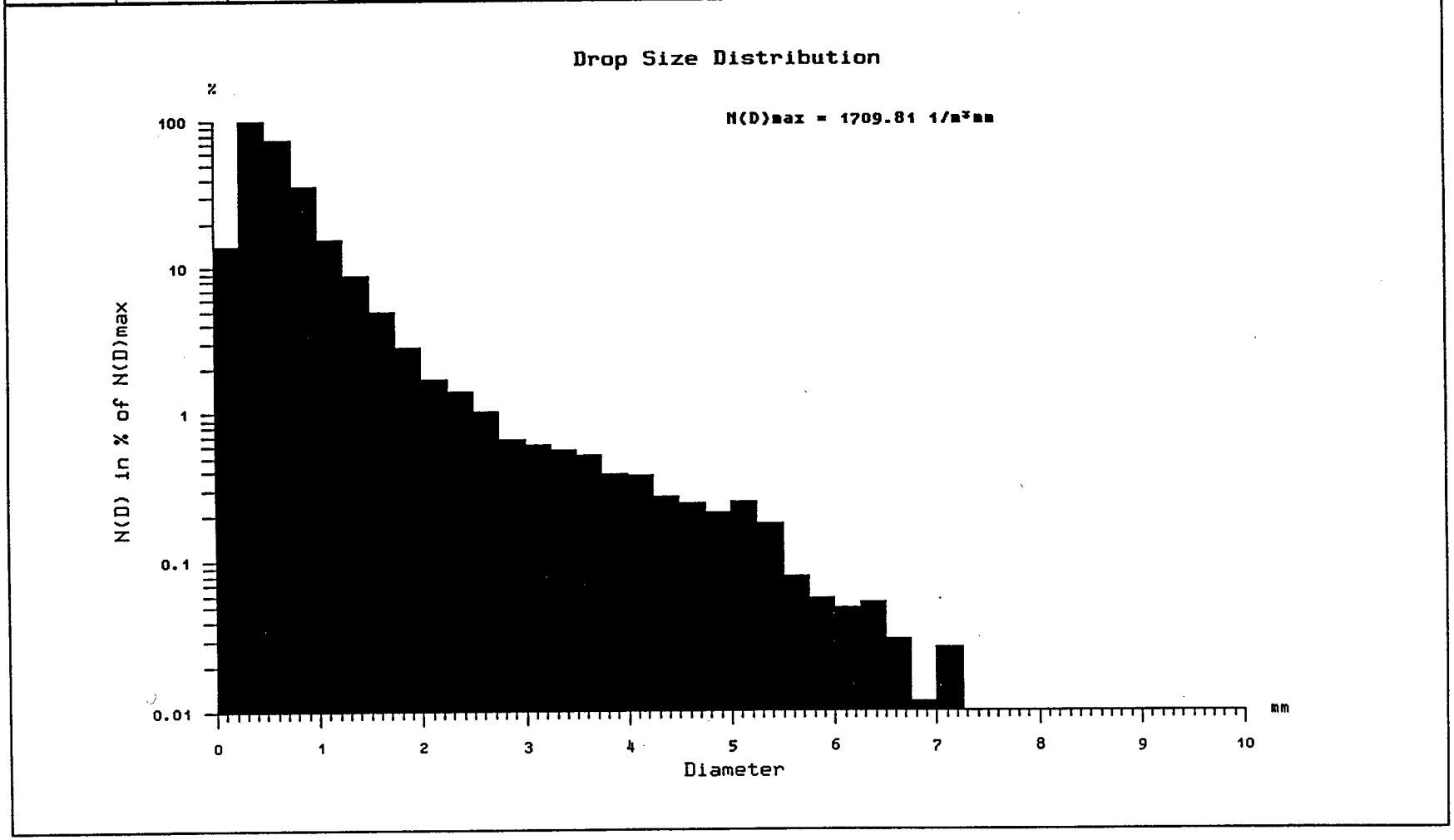


JOANNEUM RESEARCH - ESA | 2D-Video-Distrometer | Graz/Austria | Fri Jun 14 1996

				FILTER			
File	v96166_1.hyd	Time	17:23 - 18:00		Diameter	0.00 mm	50.00 mm
Int.	17:23:00-17:35:30	Date	Jun 14 1996		Velocity	0.00 m/s	30.00 m/s
Rain	5.86 mm				Oblateness	0.00	2.00
Time Int	750.00 s	Rainrate	28.11 mm/h		Pixel A	0	511
Objects	13720	ΔD	0.25 mm		Pixel B	0	511

RUN F1 | MAIN F2 | HARDCOPY F3 | HELP F4

ΔD < F5 | ΔD > F6 | Integr. F7 | COMP F8



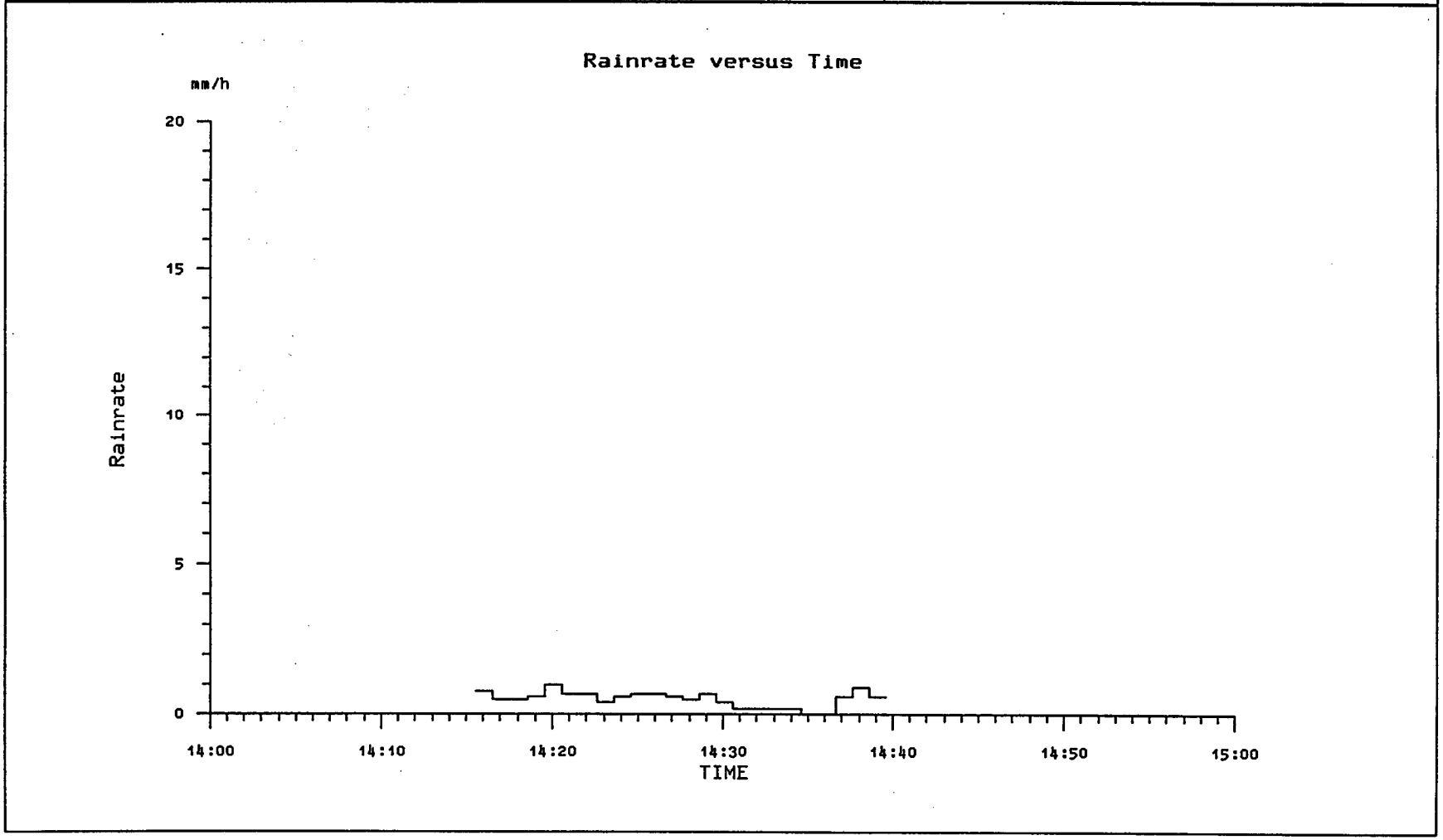
Date:	June 15, 1996
Julian Day:	167
Event:	1
Time:	14:15-14:40
Average Rain Rate:	.56mm\hr
Total Rainfall:	.23mm
Location:	John Hubbert's driveway Lat.- 40:29:51 Lon.- 105:03:35
Contents:	Light rain Good distribution Van scans

JOANNEUM RESEARCH - ESA | 2D-Video-Distrometer | Graz/Austria | Sat Jun 15 1996

				FILTER			
File	v96167_1.hyd	Time	14:00 - 15:00		Diameter	0.00 mm	50.00 mm
Int.	14:15:36-14:40:02	Date	Jun 15 1996		Velocity	0.00 m/s	30.00 m/s
					Oblateness	0.00	2.00
Int. Mode	Time (60 sec)				Pixel A	0	511
Rain	0.23 mm				Pixel B	0	511

RUN F1 | MAIN F2 | HARDCOPY F3 | HELP F4

SCALE < F5 | SCALE > F6 | Integr. F7 | TIP F8

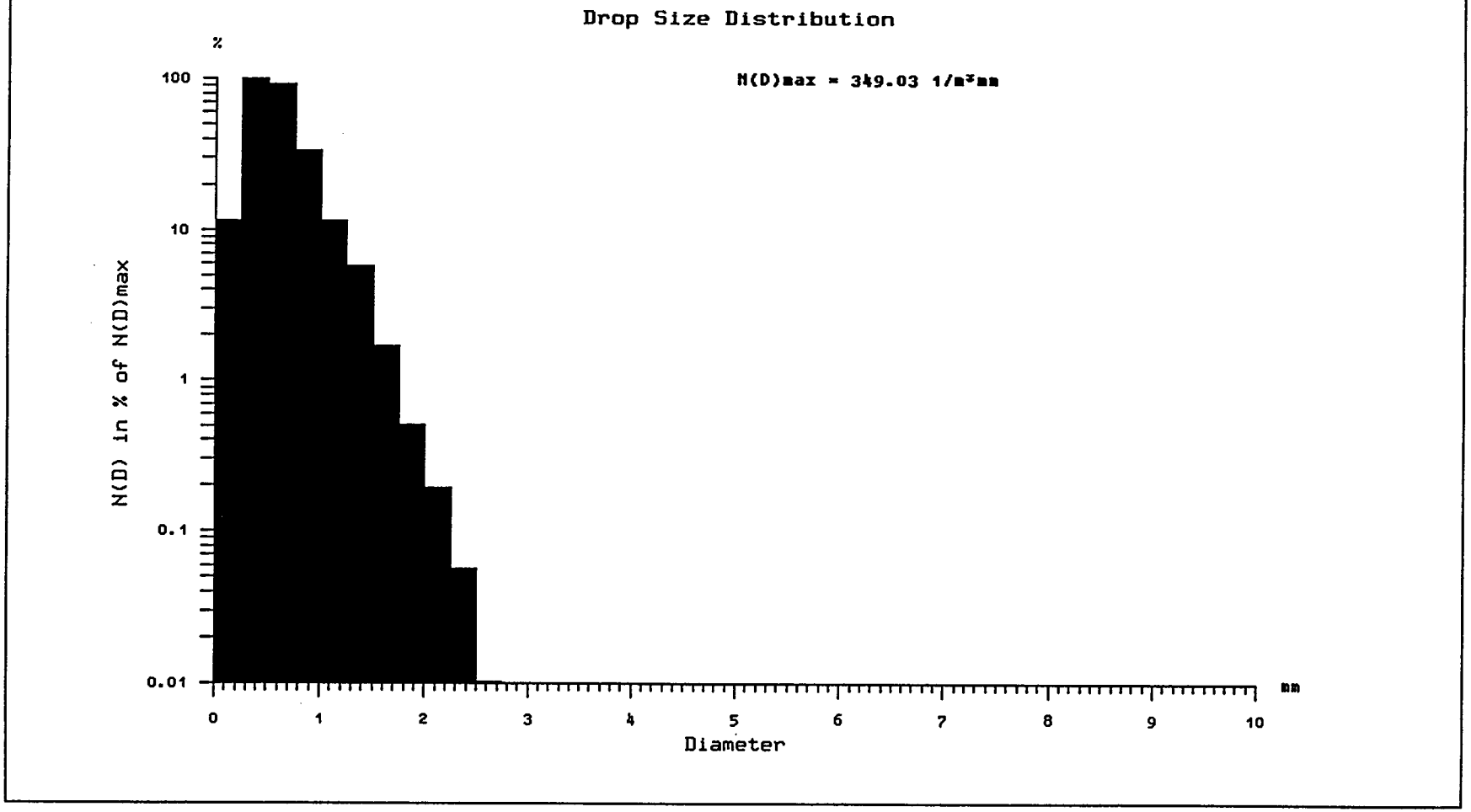


JOANNEUM RESEARCH - ESA | 2D-Video-Distrometer | Graz/Austria | Sat Jun 15 1996

File	v96167_1.hyd	Time	14:15 - 15:00	FILTER	Diameter	0.00 mm	50.00 mm
Int.	14:15:00-14:40:00	Date	Jun 15 1996		Velocity	0.00 m/s	30.00 m/s
Rain	0.23 mm				Oblateness	0.00	2.00
Time Int	1500.00 s	Rainrate	0.56 mm/h		Pixel A	0	511
Objects	6245	ΔD	0.25 mm		Pixel B	0	511

RUN F1 | MAIN F2 | HARDCOPY F3 | HELP F4

ΔD < F5 | ΔD > F6 | Integr. F7 | COMP F8



Date:	June 20, 1996
Julian Day:	172
Event:	1
Time:	19:10-19:17
Average Rain Rate:	.62mm\hr
Total Rainfall:	.07mm
Location:	County road 49 & 22 Lat.- 40:10:29 Lon.-104:36:10
Contents:	Light rain

JOANNEUM RESEARCH - ESA | 2D-Video-Distrometer | Graz/Austria | Thu Jun 20 1996

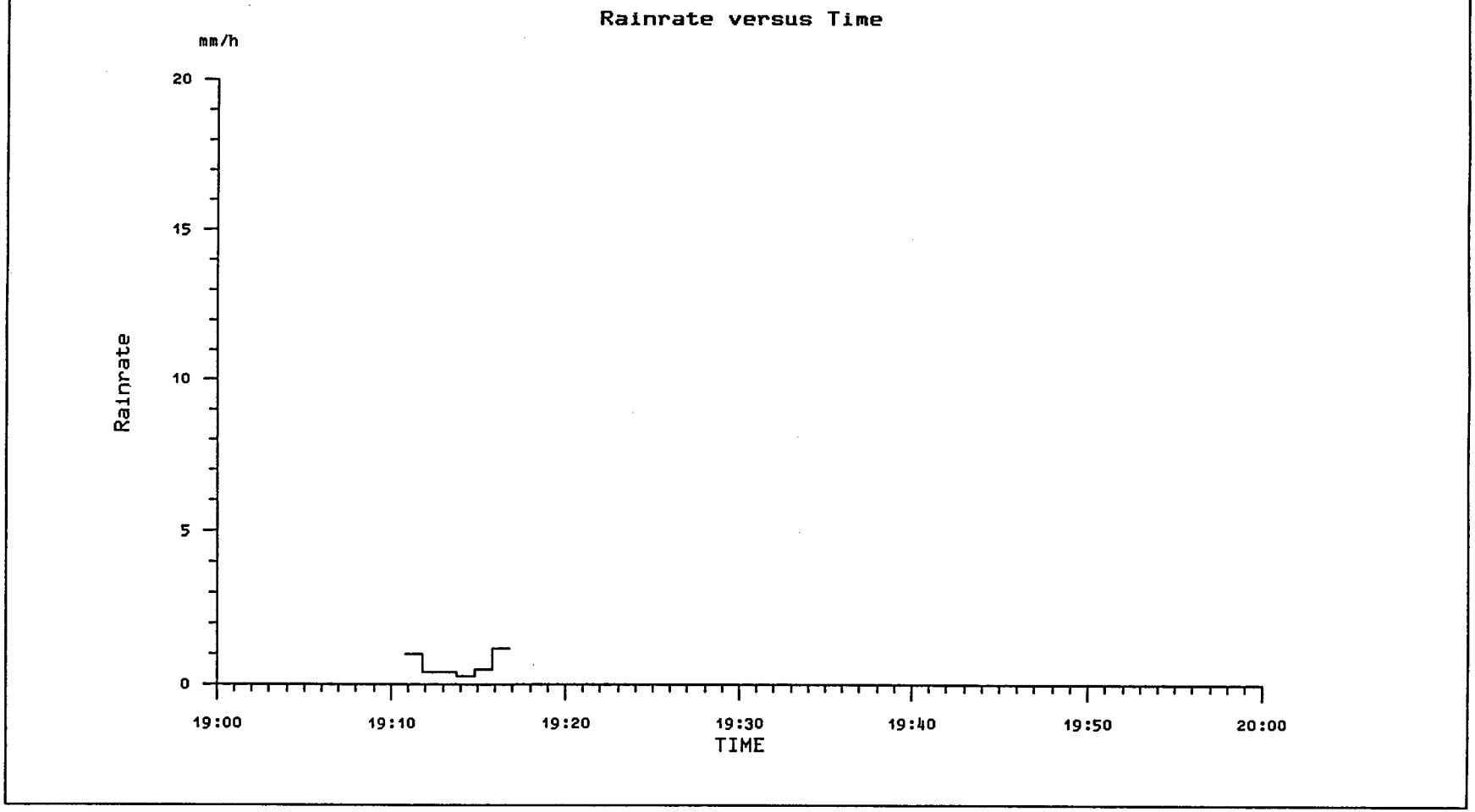
File	v96172_2.hyd	Time	19:00 - 20:00
Int.	19:10:49-19:17:17	Date	Jun 20 1996
Int. Mode	Time (60 sec)		
Rain	0.08 mm		

FILTER

Diameter	0.00 mm	50.00 mm
Velocity	0.00 m/s	30.00 m/s
Oblateness	0.00	2.00
Pixel A	0	511
Pixel B	0	511

RUN F1 | MAIN F2 | HARDCOPY F3 | HELP F4

SCALE < F5 | SCALE > F6 | Integr. F7 | TIP F8

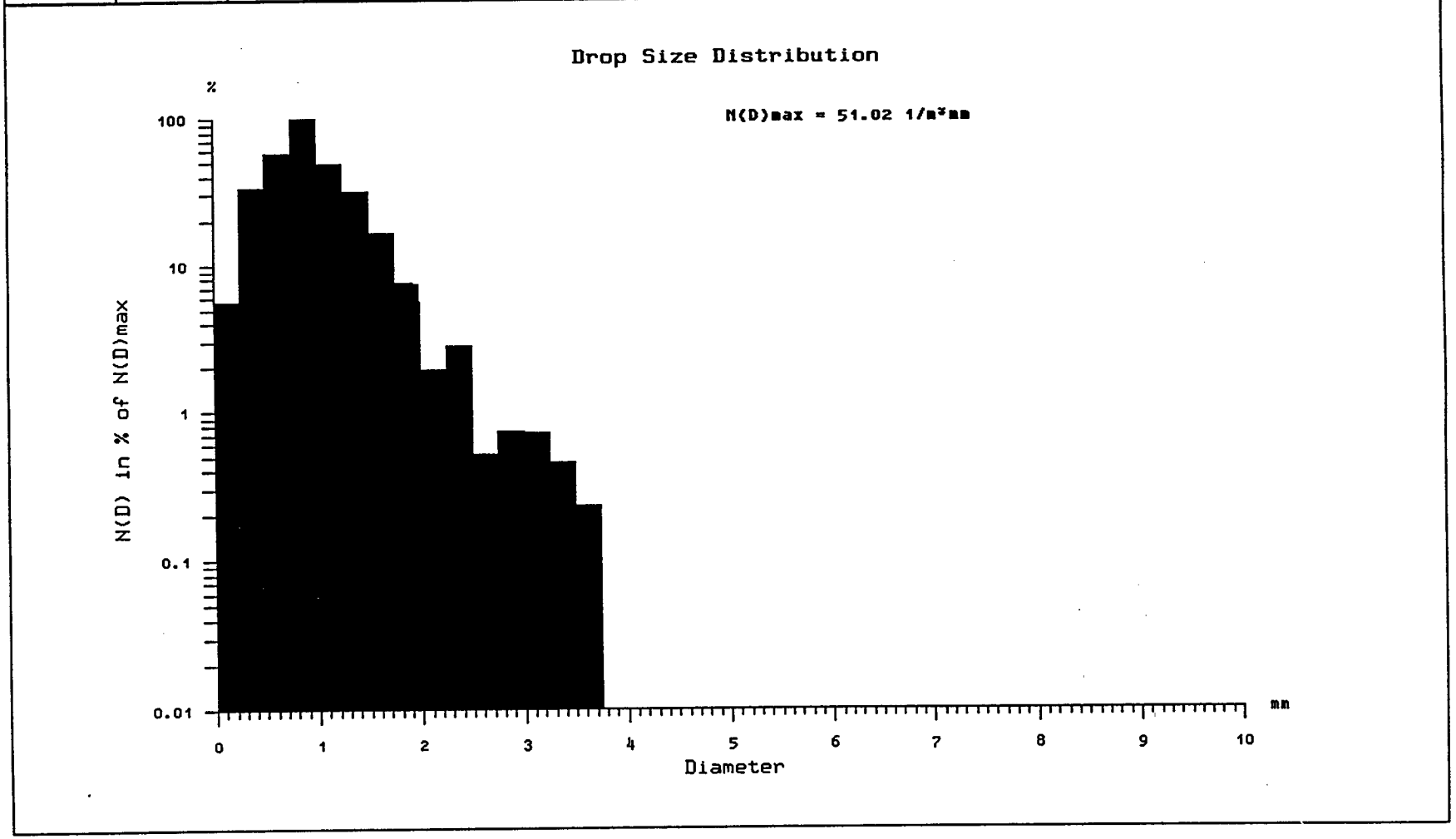


JOANNEUM RESEARCH - ESA | 2D-Video-Distrometer | Graz/Austria | Thu Jun 20 1996

				FILTER			
File	v96172_2.hyd	Time	19:10 - 20:00		Diameter	0.00 mm	50.00 mm
Int.	19:10:00-19:17:00	Date	Jun 20 1996		Velocity	0.00 m/s	30.00 m/s
Rain	0.07 mm				Oblateness	0.00	2.00
Time Int	420.00 s	Rainrate	0.62 mm/h		Pixel A	0	511
Objects	518	ΔD	0.25 mm		Pixel B	0	511

RUN F1 | MAIN F2 | HARDCOPY F3 | HELP F4

ΔD < F5 | ΔD > F6 | Integr. F7 | COMP F8



Date:	June 20, 1996
Julian Day:	172
Event:	2
Time:	20:05-20:14
Average Rain Rate:	18.36mm\hr
Total Rainfall:	2.75mm
Location:	County road 74 & highway 392 Lat.- 40:31:22 Lon.-104:24:50
Contents:	Heavy rain No hail

JOANNEUM RESEARCH - ESA | 2D-Video-Distrometer | Graz/Austria | Thu Jun 20 1996

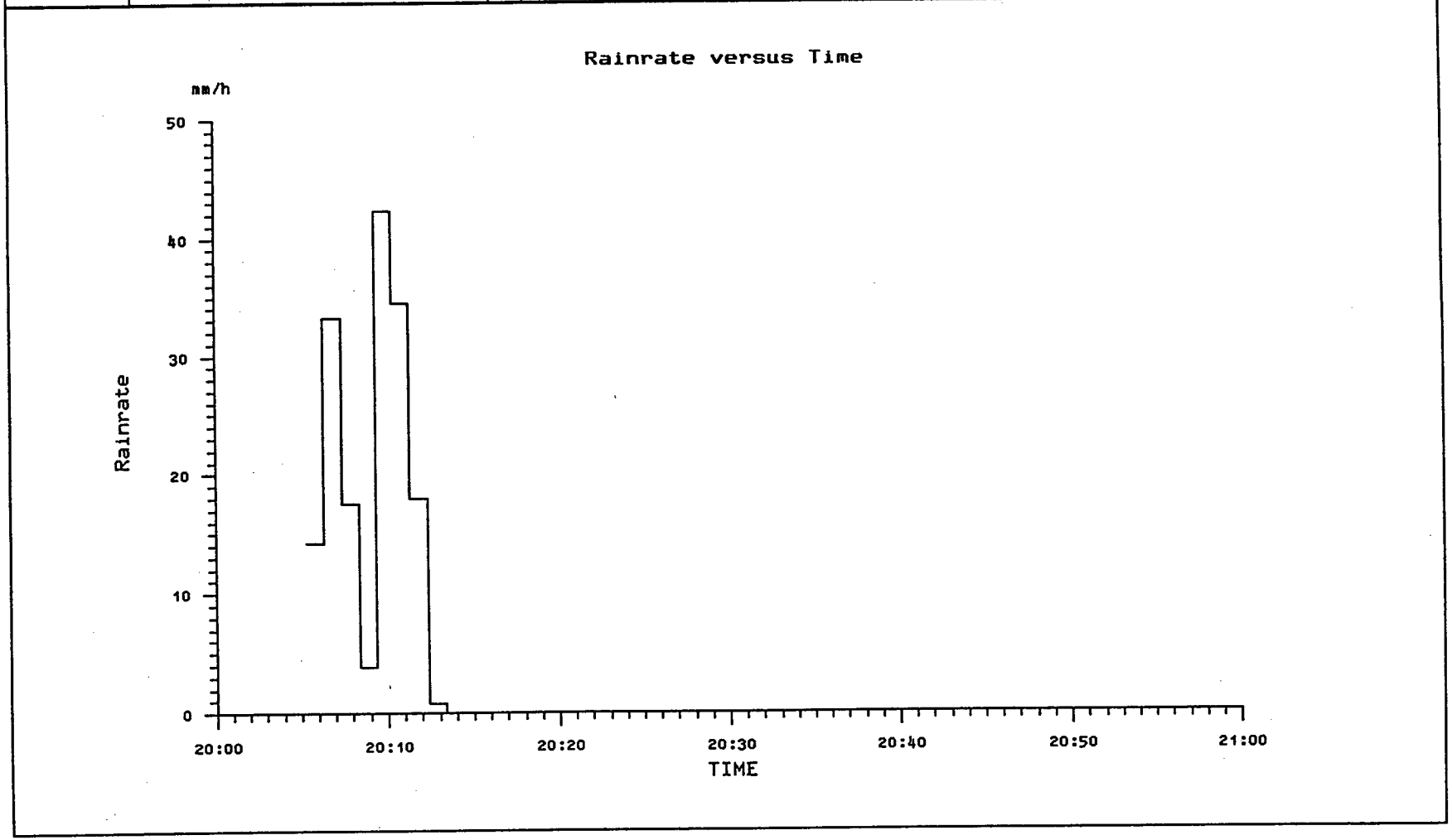
File	v96172_3.hyd	Time	20:00 - 21:00
Int.	20:05:21-20:14:26	Date	Jun 20 1996
Int. Mode	Time (60 sec)		
Rain	2.75 mm		

FILTER

Diameter	0.00 mm	50.00 mm
Velocity	0.00 m/s	30.00 m/s
Oblateness	0.00	2.00
Pixel A	0	511
Pixel B	0	511

RUN F1 | MAIN F2 | HARDCOPY F3 | HELP F4

SCALE < F5 | SCALE > F6 | Integr. F7 | TIP F8

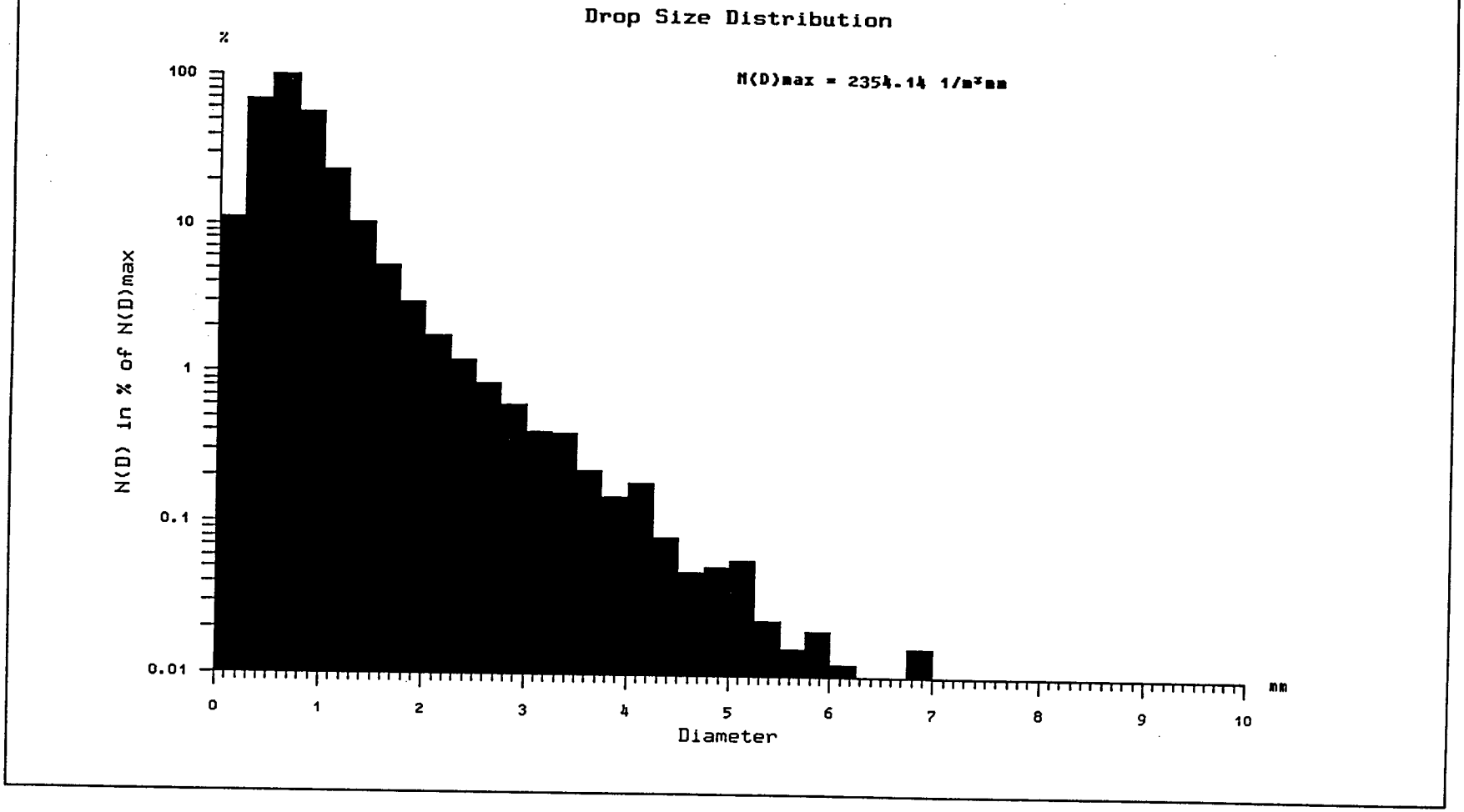


JOANNEUM RESEARCH - ESA 2D-Video-Distrometer Graz/Austria Thu Jun 20 1996

File	v96172_3.hyd	Time	20:05 - 21:00	FILTER	Diameter	0.00 mm	50.00 mm
Int.	20:05:00-20:14:00	Date	Jun 20 1996		Velocity	0.00 m/s	30.00 m/s
Rain	2.75 mm				Oblateness	0.00	2.00
Time Int	540.00 s	Rainrate	18.36 mm/h		Pixel A	0	511
Objects	14637	ΔD	0.25 mm		Pixel B	0	511

RUN F1 | MAIN F2 | HARDCOPY F3 | HELP F4

ΔD < F5 | ΔD > F6 | Integr. F7 | COMP F8



Date:	June 20, 1996
Julian Day:	172
Event:	3
Time:	20:34-20:44
Average Rain Rate:	62.63mm\hr
Total Rainfall:	11.36mm
Location:	highway 14 & 392 Lat.- 40:31:22 Lon.-104:24:50
Contents:	Heavy rain and hail Pea-sized and marble-sized hail Zero visibility Note: File v96172_4.hyd is only two minutes long and was not included Note: File v96172_6.hyd is very short and small also and was not included..

JOANNEUM RESEARCH - ESA | 2D-Video-Distrometer | Graz/Austria | Thu Jun 20 1996

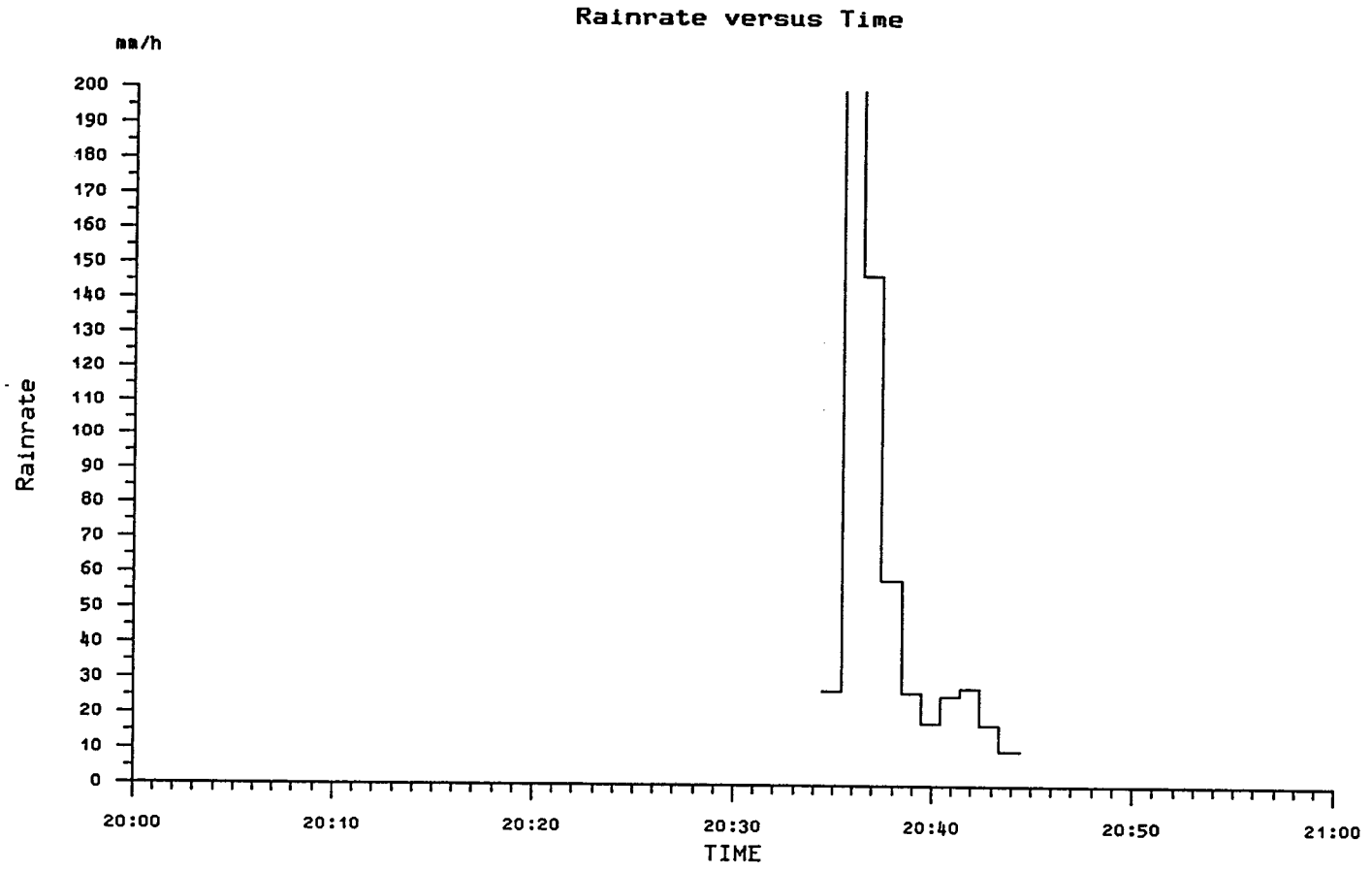
File	v96172_5.hyd	Time	20:00 - 21:00
Int.	20:34:24-20:44:53	Date	Jun 20 1996
Int. Mode	Time (60 sec)		
Rain	11.36 mm		

FILTER

Diameter	0.00 mm	50.00 mm
Velocity	0.00 m/s	30.00 m/s
Oblateness	0.00	2.00
Pixel A	0	511
Pixel B	0	511

RUN F1 | MAIN F2 | HARDCOPY F3 | HELP F4

SCALE < F5 | SCALE > F6 | Integr. F7 | TIP F8

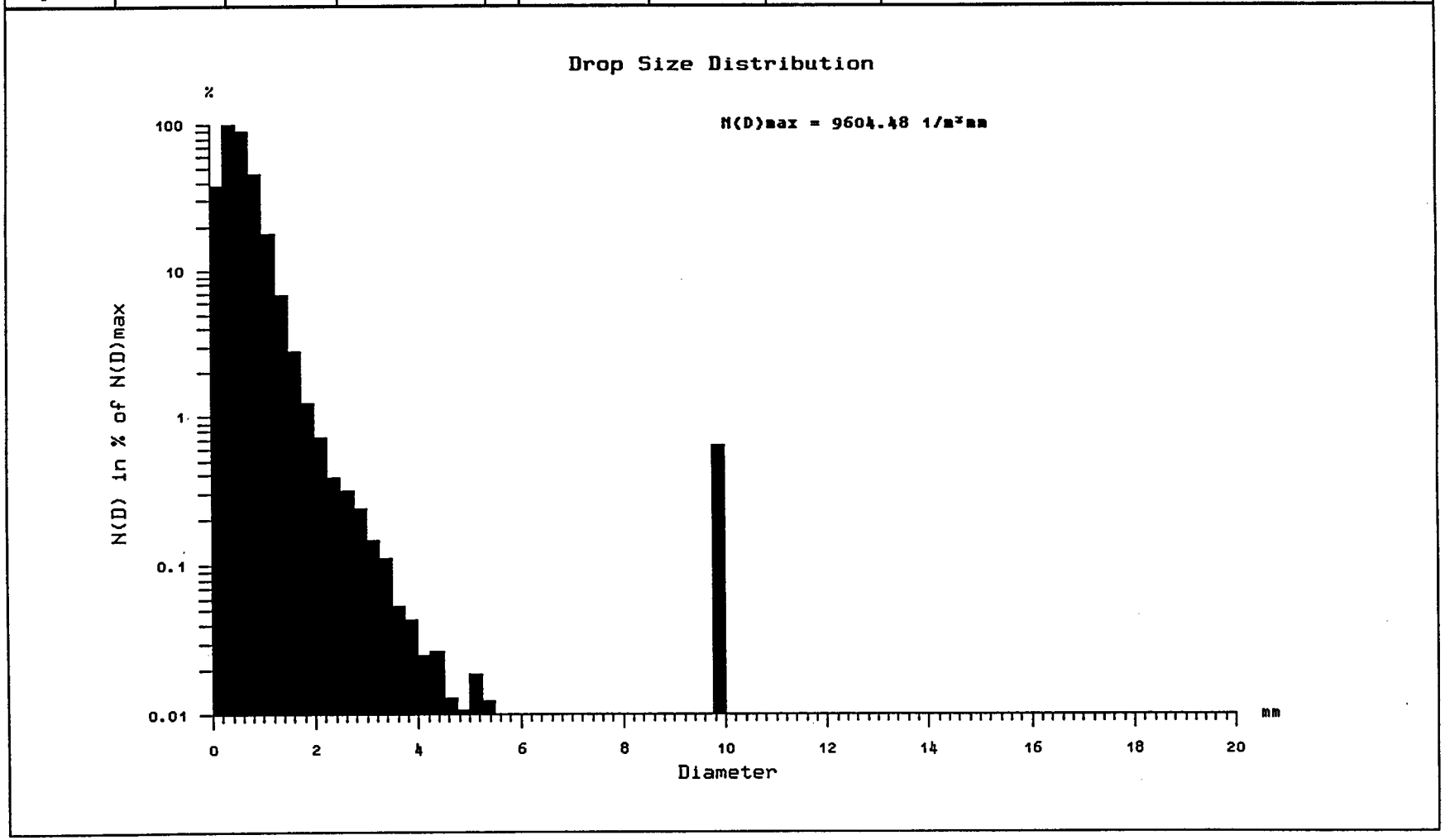


JOANNEUM RESEARCH - ESA | 2D-Video-Distrometer | Graz/Austria | Thu Jun 20 1996

File	v96172_5.hyd	Time	20:34 - 21:00	FILTER	Diameter	0.00 mm	50.00 mm
Int.	20:34:00-20:44:53	Date	Jun 20 1996		Velocity	0.00 m/s	30.00 m/s
Rain	11.36 mm				Oblateness	0.00	2.00
Time Int	653.00 s	Rainrate	62.63 mm/h		Pixel A	0	511
Objects	59629	ΔD	0.25 mm		Pixel B	0	511

RUN F1 | MAIN F2 | HARDCOPY F3 | HELP F4

ΔD < F5 | ΔD > F6 | Integr. F7 | COMP F8



Date:	June 21, 1996
Julian Day:	173
Event:	1
Time:	15:12-15:24
Average Rain Rate:	5.75mm\hr
Total Rainfall:	1.17mm
Location:	County road 43 & highway 14 Lat.- 40:34:39 Lon.-104:39:30
Contents:	Moderate rain

JOANNEUM RESEARCH - ESA | 2D-Video-Distrometer | Graz/Austria | Fri Jun 21 1996

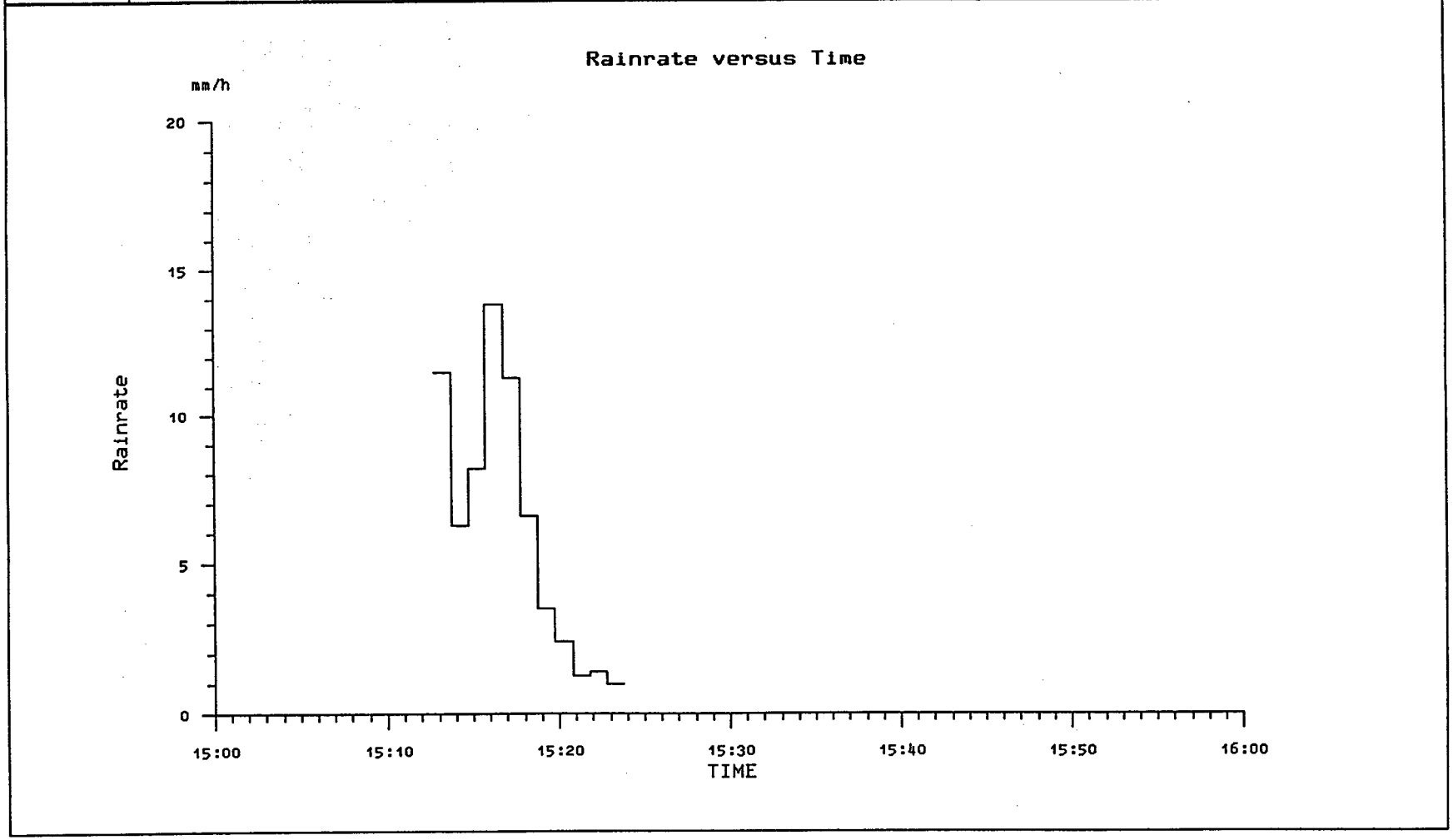
File	v96173_2.hyd	Time	15:00 - 16:00
Int.	15:12:47-15:24:38	Date	Jun 21 1996
Int. Mode	Time (60 sec)		
Rain	1.17 mm		

FILTER

Diameter	0.00 mm	50.00 mm
Velocity	0.00 m/s	30.00 m/s
Oblateness	0.00	2.00
Pixel A	0	511
Pixel B	0	511

RUN F1 | MAIN F2 | HARDCOPY F3 | HELP F4

SCALE < F5 | SCALE > F6 | Integr. F7 | TIP F8

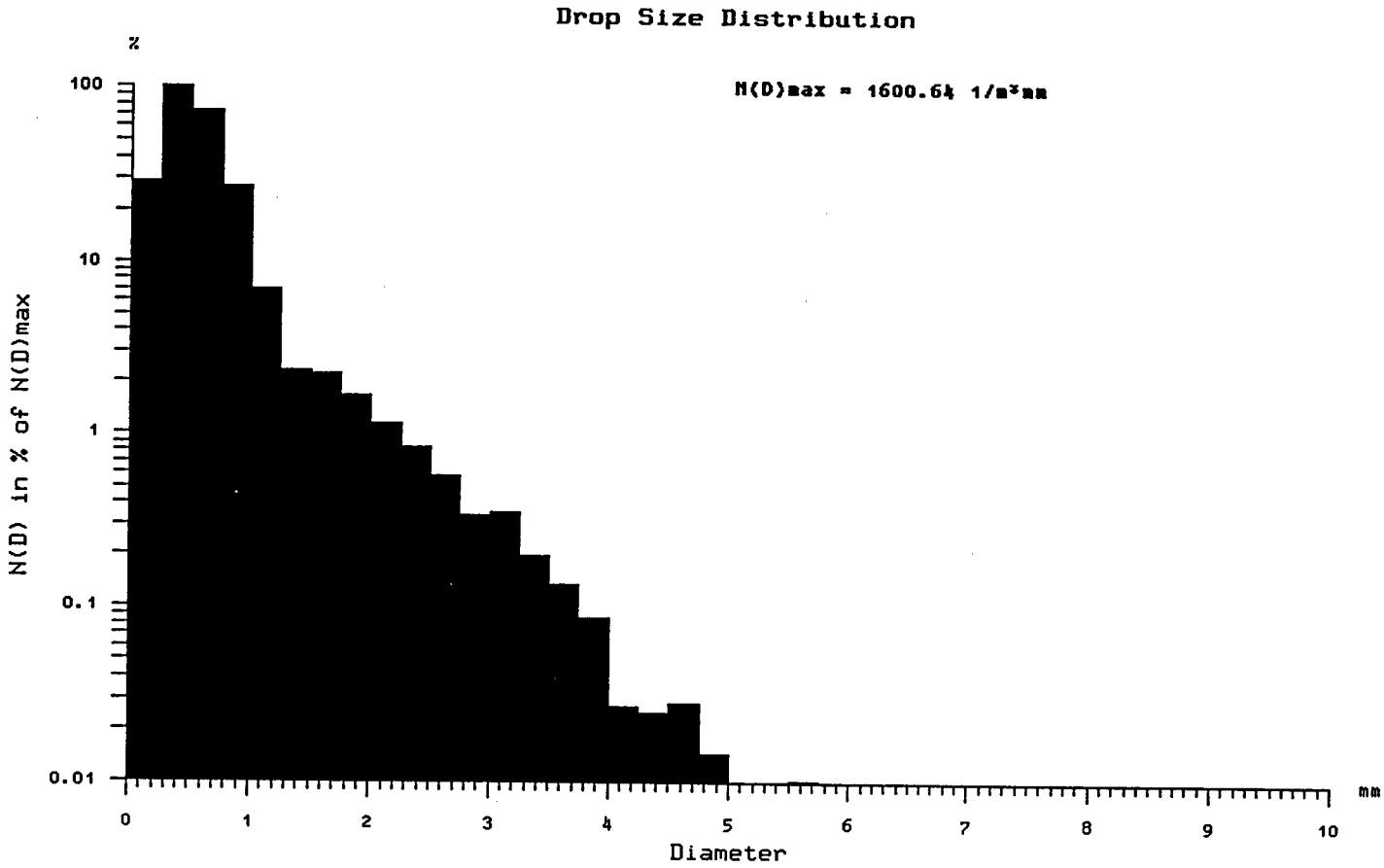


JOANNEUM RESEARCH - ESA | 2D-Video-Distrometer | Graz/Austria | Fri Jun 21 1996

File	v96173_2.hyd	Time	15:12 - 15:30	FILTER	Diameter	0.00 mm	50.00 mm
Int.	15:12:00-15:24:10	Date	Jun 21 1996		Velocity	0.00 m/s	30.00 m/s
Rain	1.17 mm				Oblateness	0.00	2.00
Time Int	730.00 s	Rainrate	5.75 mm/h		Pixel A	0	511
Objects	9562	ΔD	0.25 mm		Pixel B	0	511

RUN (F1) | MAIN (F2) | HARDCOPY (F3) | HELP (F4)

ΔD < (F5) | ΔD > (F6) | Integr. (F7) | COMP (F8)



Date:	June 21, 1996
Julian Day:	173
Event:	2
Time:	15:41-15:50
Average Rain Rate:	8.22mm\hr
Total Rainfall:	1.3mm
Location:	County road 43 & 76 Lat.- 40:31:22 Lon.-104:34:32
Contents:	Light rain

JOANNEUM RESEARCH - ESA | 2D-Video-Distrometer | Graz/Austria | Fri Jun 21 1996

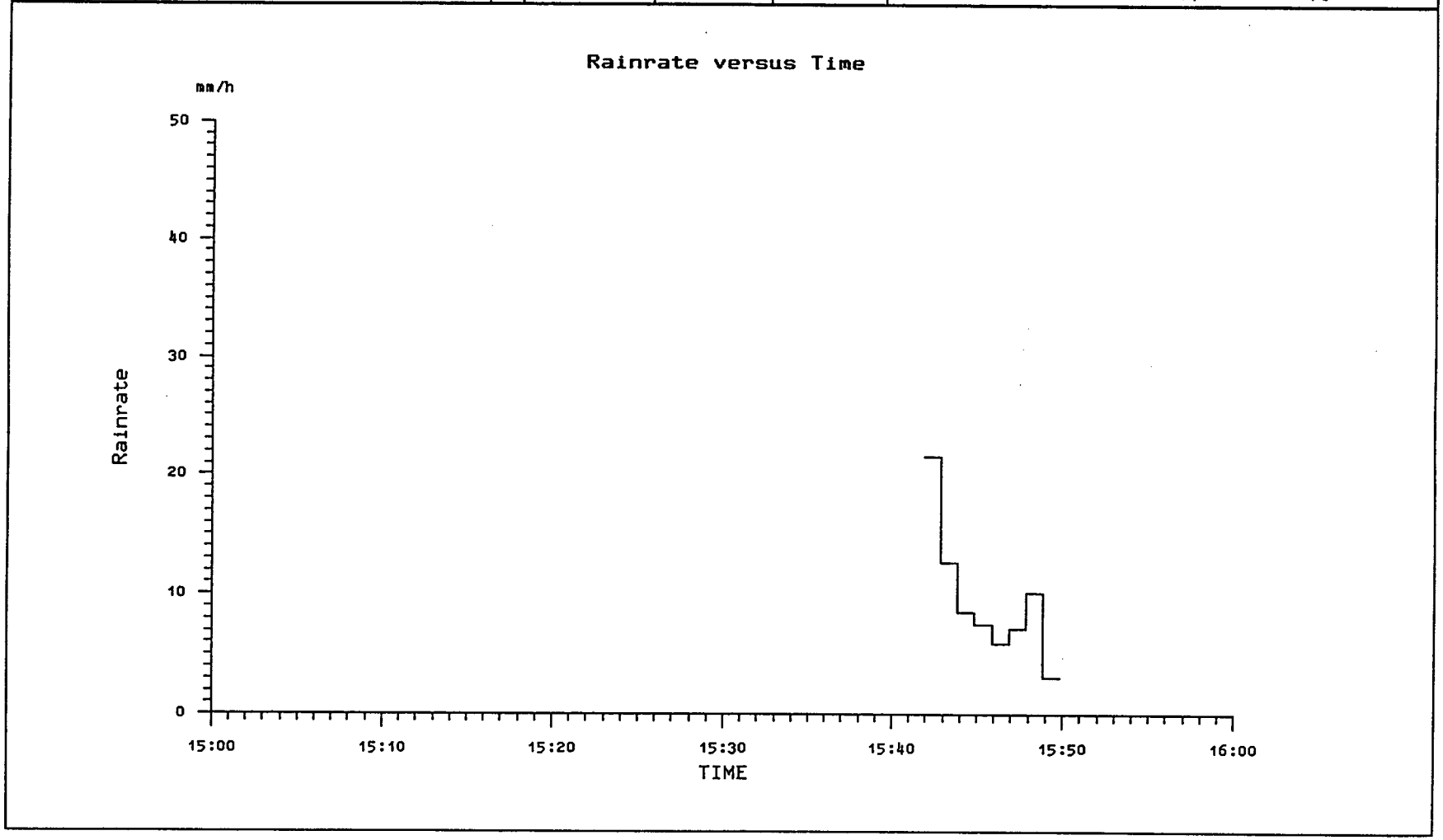
File	v96173_3.hyd	Time	15:40 - 16:00
Int.	15:41:52-15:50:44	Date	Jun 21 1996
Int. Mode	Time (60 sec)		
Rain	1.31 mm		

FILTER

Diameter	0.00 mm	50.00 mm
Velocity	0.00 m/s	30.00 m/s
Oblateness	0.00	2.00
Pixel A	0	511
Pixel B	0	511

RUN F1 | MAIN F2 | HARDCOPY F3 | HELP F4

SCALE < F5 | SCALE > F6 | Integr. F7 | TIP F8

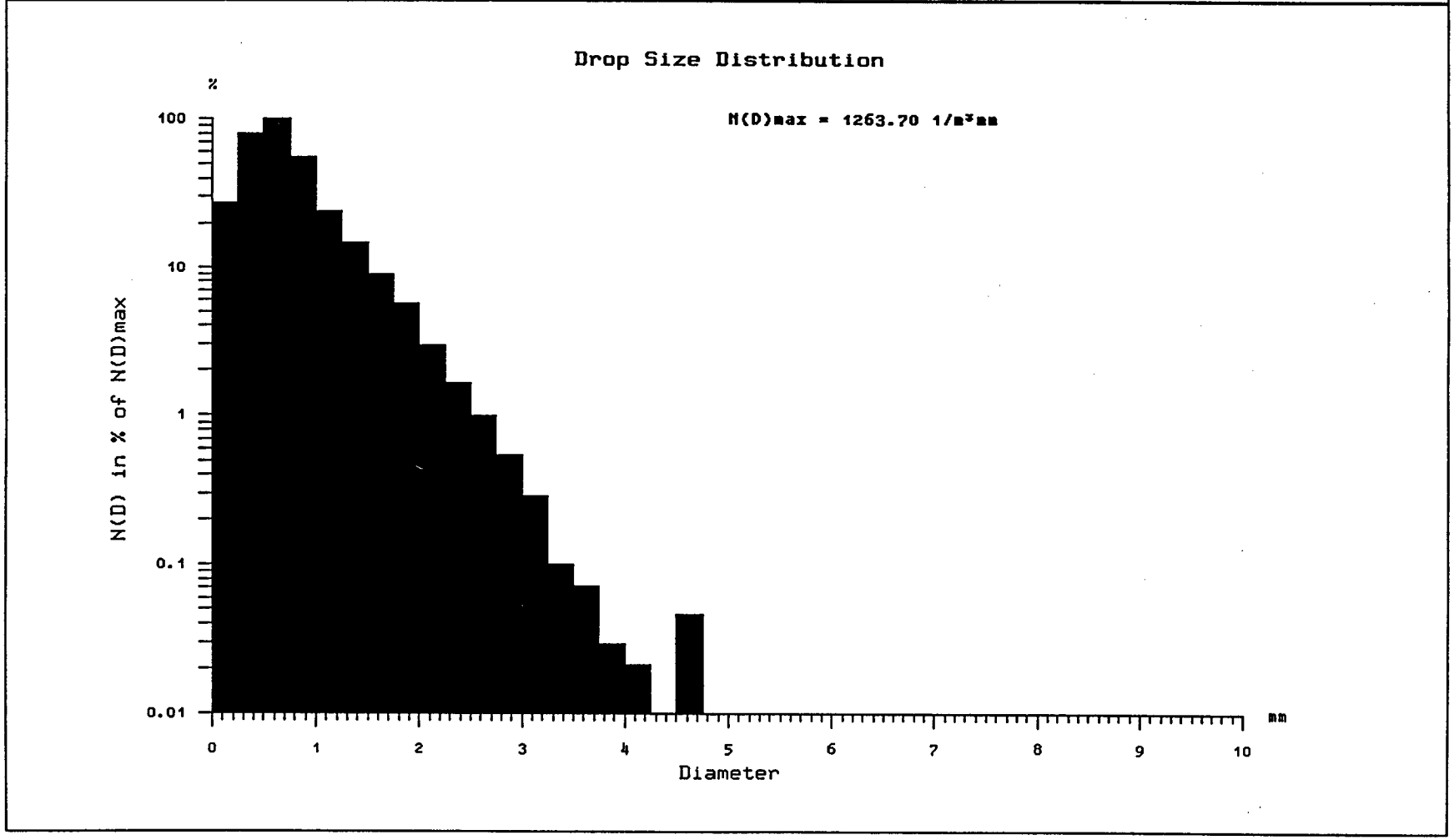


JOANNEUM RESEARCH - ESA | 2D-Video-Distrometer | Graz/Austria | Fri Jun 21 1996

File	v96173_3.hyd	Time	15:41 - 16:00	FILTER	Diameter	0.00 mm	50.00 mm
Int.	15:41:00-15:50:30	Date	Jun 21 1996		Velocity	0.00 m/s	30.00 m/s
Rain	1.30 mm				Oblateness	0.00	2.00
Time Int	570.00 s	Rainrate	8.22 mm/h		Pixel A	0	511
Objects	9310	ΔD	0.25 mm		Pixel B	0	511

RUN F1 | MAIN F2 | HARDCOPY F3 | HELP F4

ΔD < F5 | ΔD > F6 | Integr. F7 | COMP F8



Date:	June 21, 1996
Julian Day:	173
Event:	3
Time:	16:18-16:27
Average Rain Rate:	21.91mm\hr
Total Rainfall:	2.92mm
Location:	Lat.- 40:18:37 Lon.-104:22:39
Contents:	Moderate to heavy rain

JOANNEUM RESEARCH - ESA | 2D-Video-Distrometer | Graz/Austria | Fri Jun 21 1996

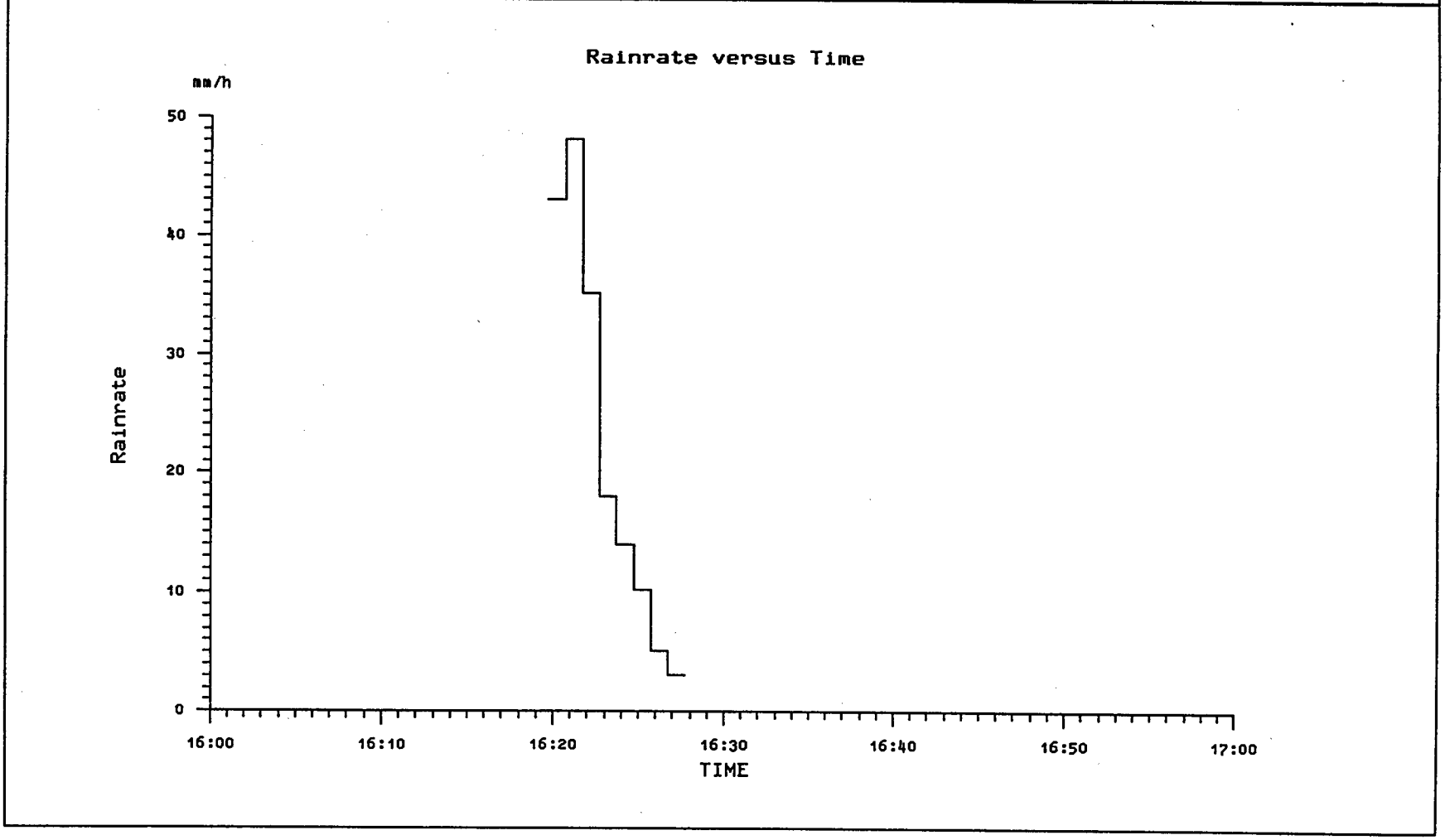
File	v96173_4.hyd	Time	16:00 - 17:00
Int.	16:19:43-16:27:50	Date	Jun 21 1996
Int. Mode	Time (60 sec)		
Rain	2.96 mm		

FILTER

Diameter	0.00 mm	50.00 mm
Velocity	0.00 m/s	30.00 m/s
Oblateness	0.00	2.00
Pixel A	0	511
Pixel B	0	511

RUN F1 | MAIN F2 | HARDCOPY F3 | HELP F4

SCALE < F5 | SCALE > F6 | Integr. F7 | TIP F8

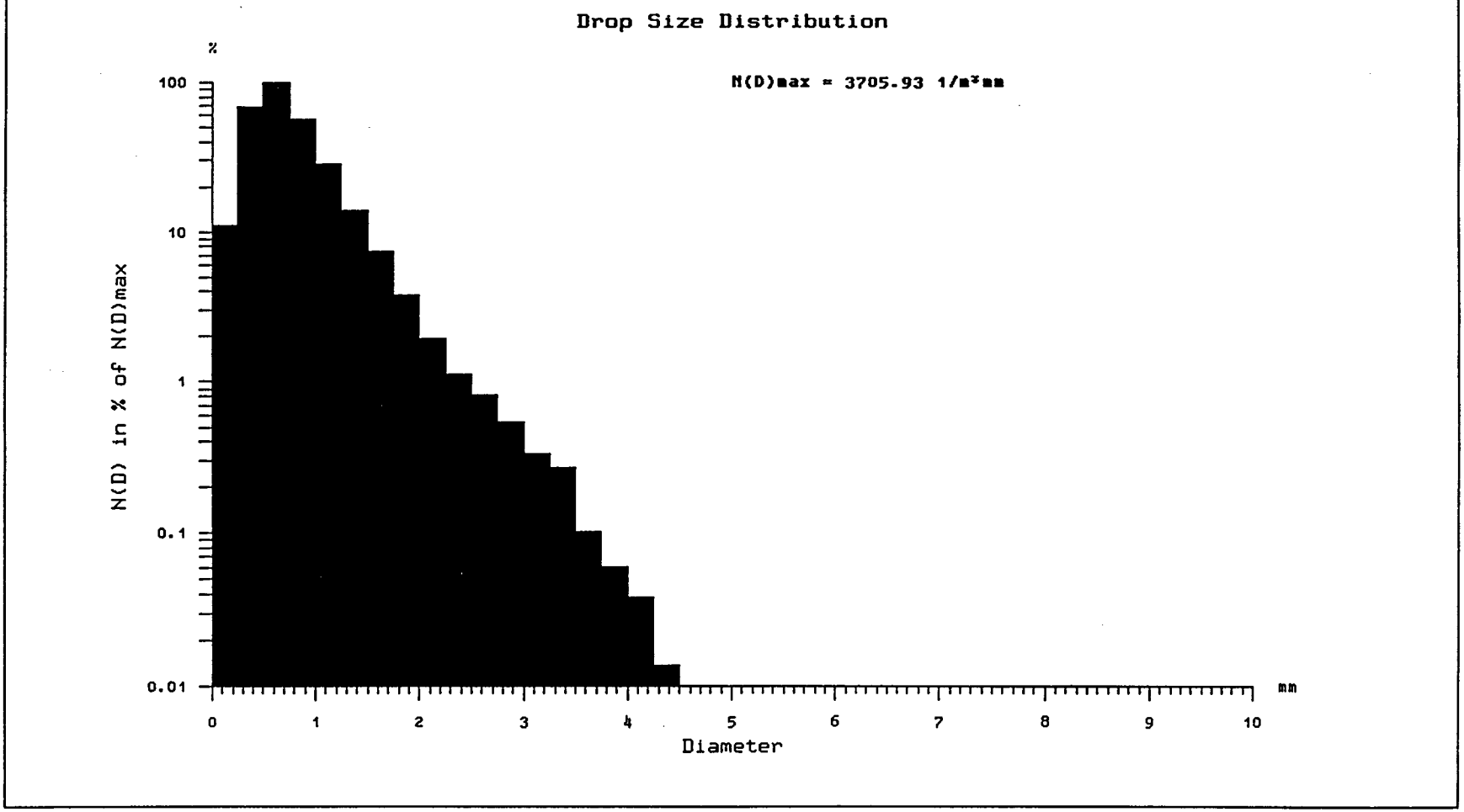


JOANNEUM RESEARCH - ESA | 2D-Video-Distrometer | Graz/Austria | Fri Jun 21 1996

File	v96173_4.hyd	Time	16:19 - 16:30	FILTER	Diameter	0.00 mm	50.00 mm
Int.	16:19:00-16:27:00	Date	Jun 21 1996		Velocity	0.00 m/s	30.00 m/s
Rain	2.92 mm				Oblateness	0.00	2.00
Time Int	480.00 s	Rainrate	21.91 mm/h		Pixel A	0	511
Objects	21162	ΔD	0.25 mm		Pixel B	0	511

RUN F1 | MAIN F2 | HARDCOPY F3 | HELP F4

ΔD < F5 | ΔD > F6 | Integr. F7 | COMP F8



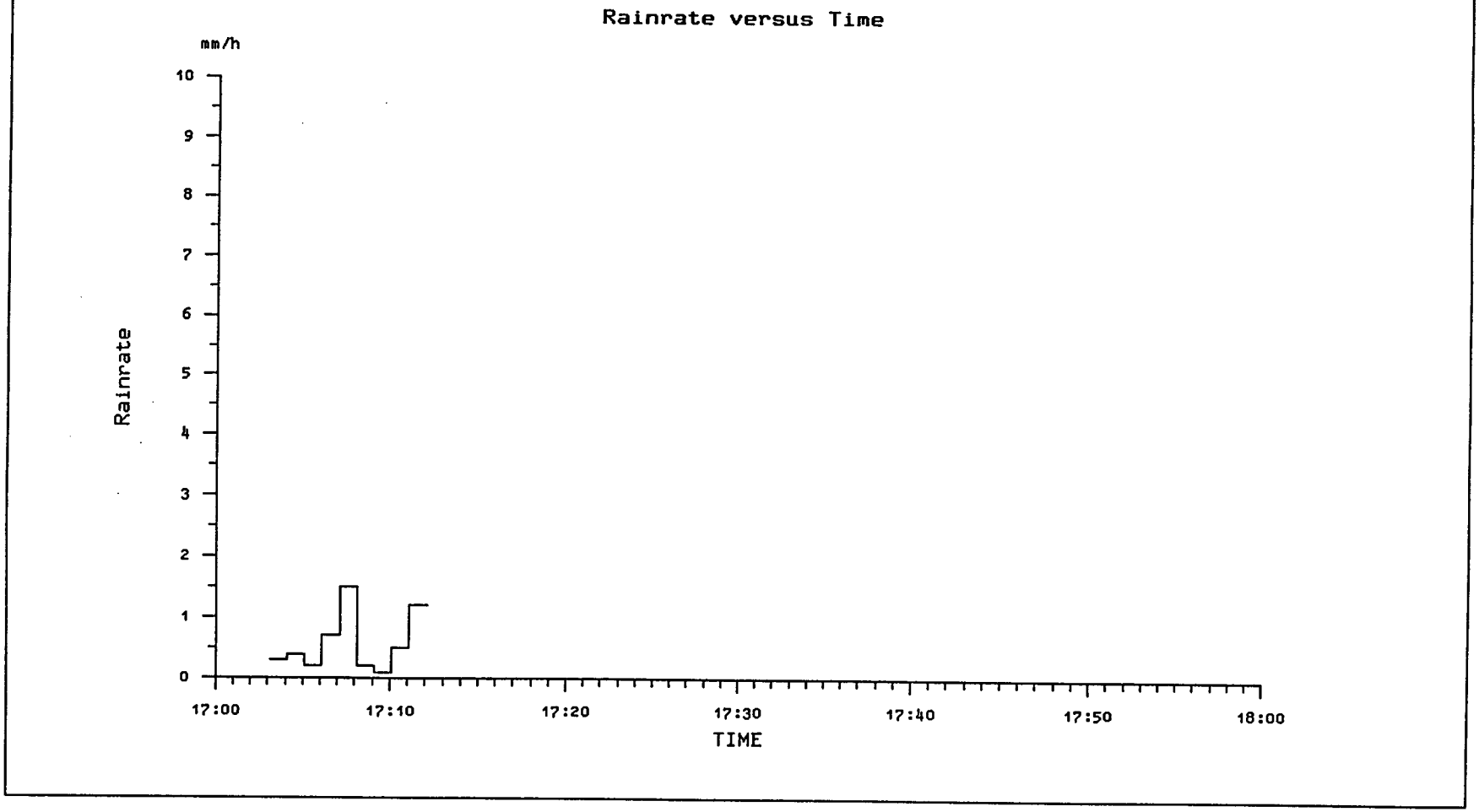
Date:	June 24, 1996
Julian Day:	176
Event:	1
Time:	17:03-17:12
Average Rain Rate:	.58mm\hr
Total Rainfall:	.09mm
Location:	Lat.- 40:17:39 Lon.-104:18:33
Contents:	Almost no rain

JOANNEUM RESEARCH - ESA | 2D-Video-Distrometer | Graz/Austria | Mon Jun 24 1996

				FILTER			
File	v96176_2.hyd	Time	17:03 - 18:00		Diameter	0.00 mm	50.00 mm
Int.	17:03:06-17:12:41	Date	Jun 24 1996		Velocity	0.00 m/s	30.00 m/s
					Oblateness	0.00	2.00
Int. Mode	Time (60 sec)				Pixel A	0	511
Rain	0.09 mm				Pixel B	0	511

RUN F1 | MAIN F2 | HARDCOPY F3 | HELP F4

SCALE < F5 | SCALE > F6 | Integr. F7 | TIP F8

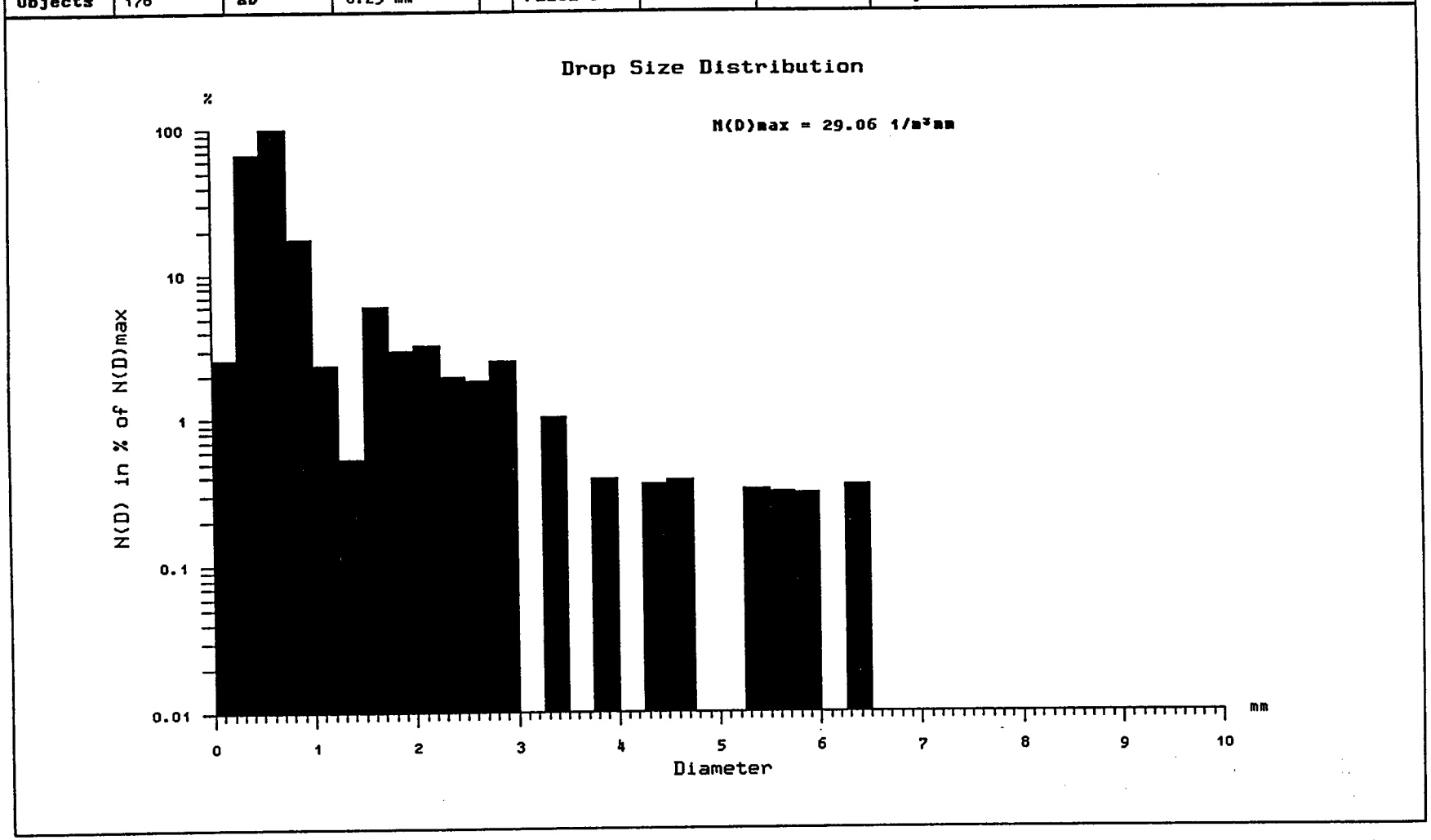


JOANNEUM RESEARCH - ESA | 2D-Video-Distrometer | Graz/Austria | Mon Jun 24 1996

				FILTER			
File	v96176_2.hyd	Time	17:03 - 18:00		Diameter	0.00 mm	50.00 mm
Int.	17:03:00-17:12:40	Date	Jun 24 1996		Velocity	0.00 m/s	30.00 m/s
Rain	0.09 mm				Oblateness	0.00	2.00
Time Int	580.00 s	Rainrate	0.58 mm/h		Pixel A	0	511
Objects	176	ΔD	0.25 mm		Pixel B	0	511

RUN (F1) | MAIN (F2) | HARDCOPY (F3) | HELP (F4)

ΔD < (F5) | ΔD > (F6) | Integr. (F7) | COMP (F8)



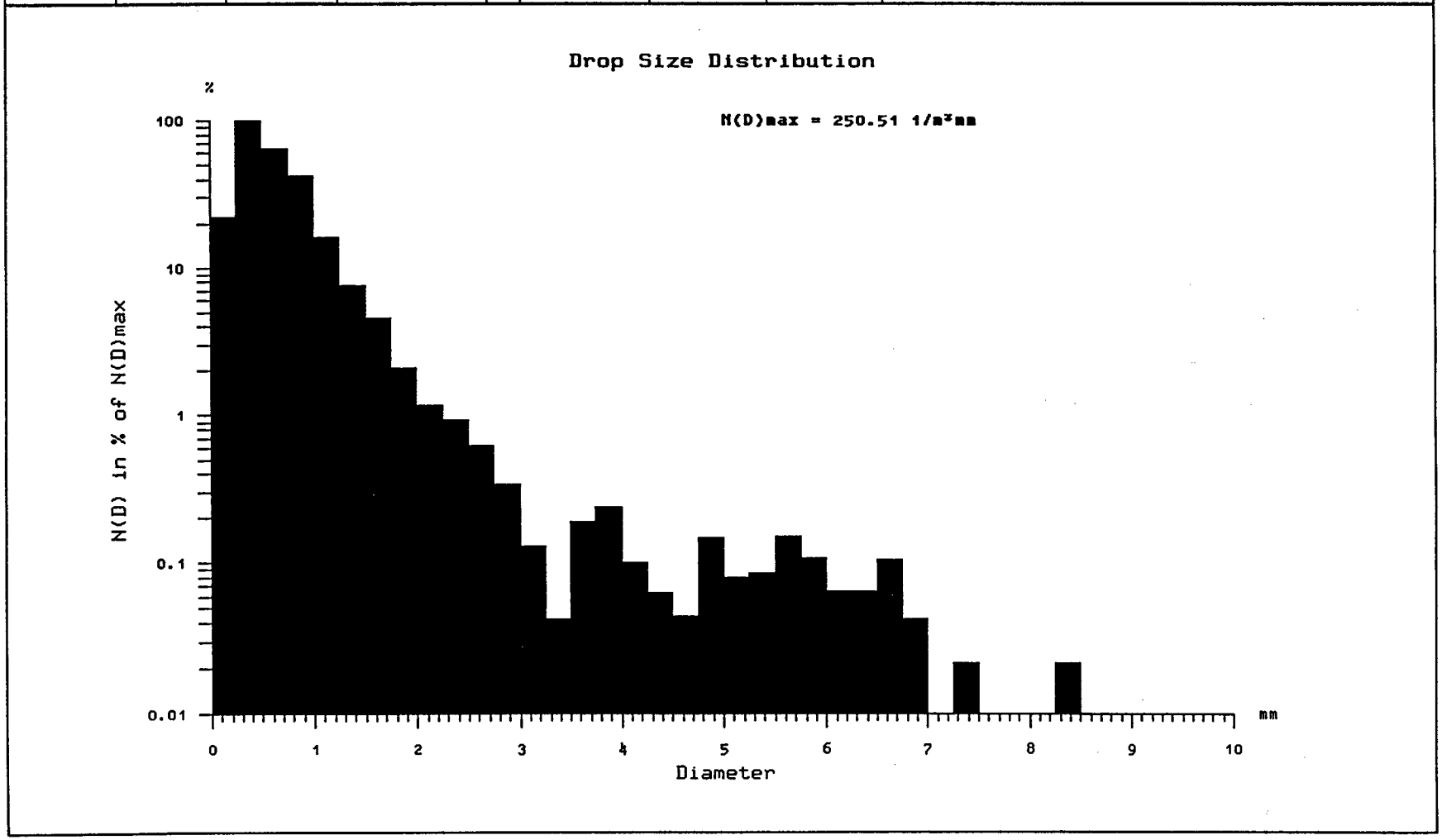
Date:	June 24, 1996
Julian Day:	176
Event:	2
Time:	18:23-18:38
Average Rain Rate:	3.27mm\hr
Total Rainfall:	.84mm
Location:	Lat.- 40:19:35 Lon.-104:33:52
Contents:	Light rain

JOANNEUM RESEARCH - ESA | 2D-Video-Distrometer | Graz/Austria | Mon Jun 24 1996

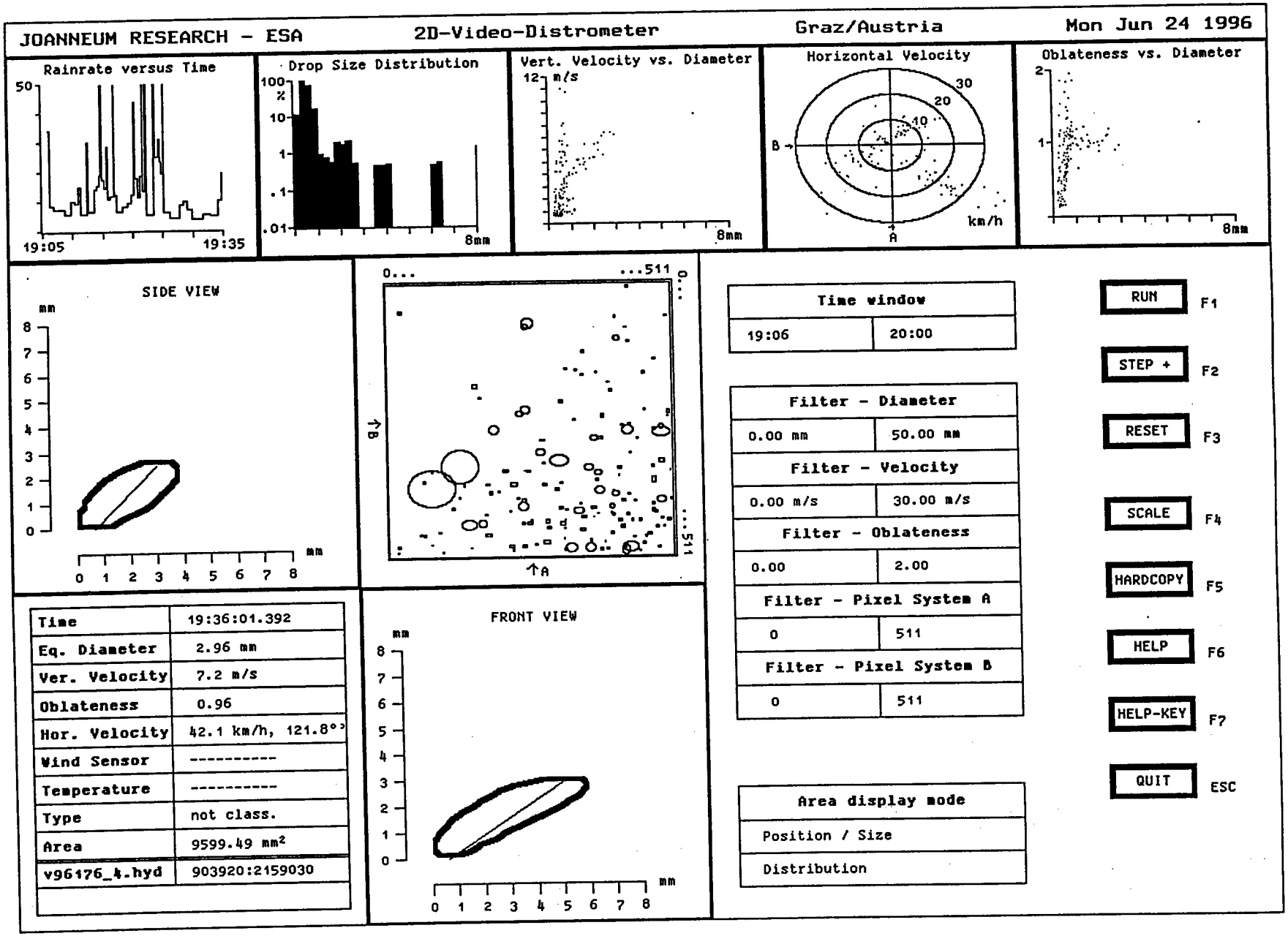
				FILTER			
File	v96176_3.hyd	Time	18:23 - 19:00		Diameter	0.00 mm	50.00 mm
Int.	18:23:00-18:38:30	Date	Jun 24 1996		Velocity	0.00 m/s	30.00 m/s
Rain	0.84 mm				Oblateness	0.00	2.00
Time Int	930.00 s	Rainrate	3.27 mm/h		Pixel A	0	511
Objects	2610	ΔD	0.25 mm		Pixel B	0	511

RUN F1 | MAIN F2 | HARDCOPY F3 | HELP F4

ΔD < F5 | ΔD > F6 | Integr. F7 | COMP F8



Date:	June 24, 1996
Julian Day:	176
Event:	3
Time:	19:06-19:56
Average Rain Rate:	11.75mm\hr
Total Rainfall:	9.79mm
Location:	Lat.- 40:17:08 Lon.-104:33:55 Facing east
Contents:	A lot of hail in the first twenty minutes pea and marble sized hail Heavy rains Southeasterly winds Some van scans


JOANNEUM RESEARCH - ESA
2D-Video-Distrometer
Graz/Austria
Mon Jun 24 1996
Rainrate versus Time
50
19:05
19:35
Drop Size Distribution
100
%
10
1
.1
.01
8mm
Vert. Velocity vs. Diameter
12
m/s
8mm
Horizontal Velocity
30
20
10
B
A
km/h
Oblateness vs. Diameter
2
1
8mm
SIDE VIEW
mm
0 1 2 3 4 5 6 7 8
mm
0...
...511
0...
...511
B
A
Time window
19:06
20:00
RUN
F1
STEP +
F2
Filter - Diameter
0.00 mm
50.00 mm
RESET
F3
Filter - Velocity
0.00 m/s
30.00 m/s
SCALE
F4
Filter - Oblateness
0.00
2.00
HARDCOPY
F5
Filter - Pixel System A
0
511
HELP
F6
Filter - Pixel System B
0
511
HELP-KEY
F7
Time
19:36:01.392
Eq. Diameter
2.96 mm
Ver. Velocity
7.2 m/s
Oblateness
0.96
Hor. Velocity
42.1 km/h, 121.8°
Wind Sensor
Temperature
Type
not class.
Area
9599.49 mm²
v96176_4.hyd
903920:2159030
FRONT VIEW
mm
0 1 2 3 4 5 6 7 8
mm
Area display mode
Position / Size
Distribution
QUIT
ESC

JOANNEUM RESEARCH - ESA | 2D-Video-Distrometer | Graz/Austria | Mon Jun 24 1996

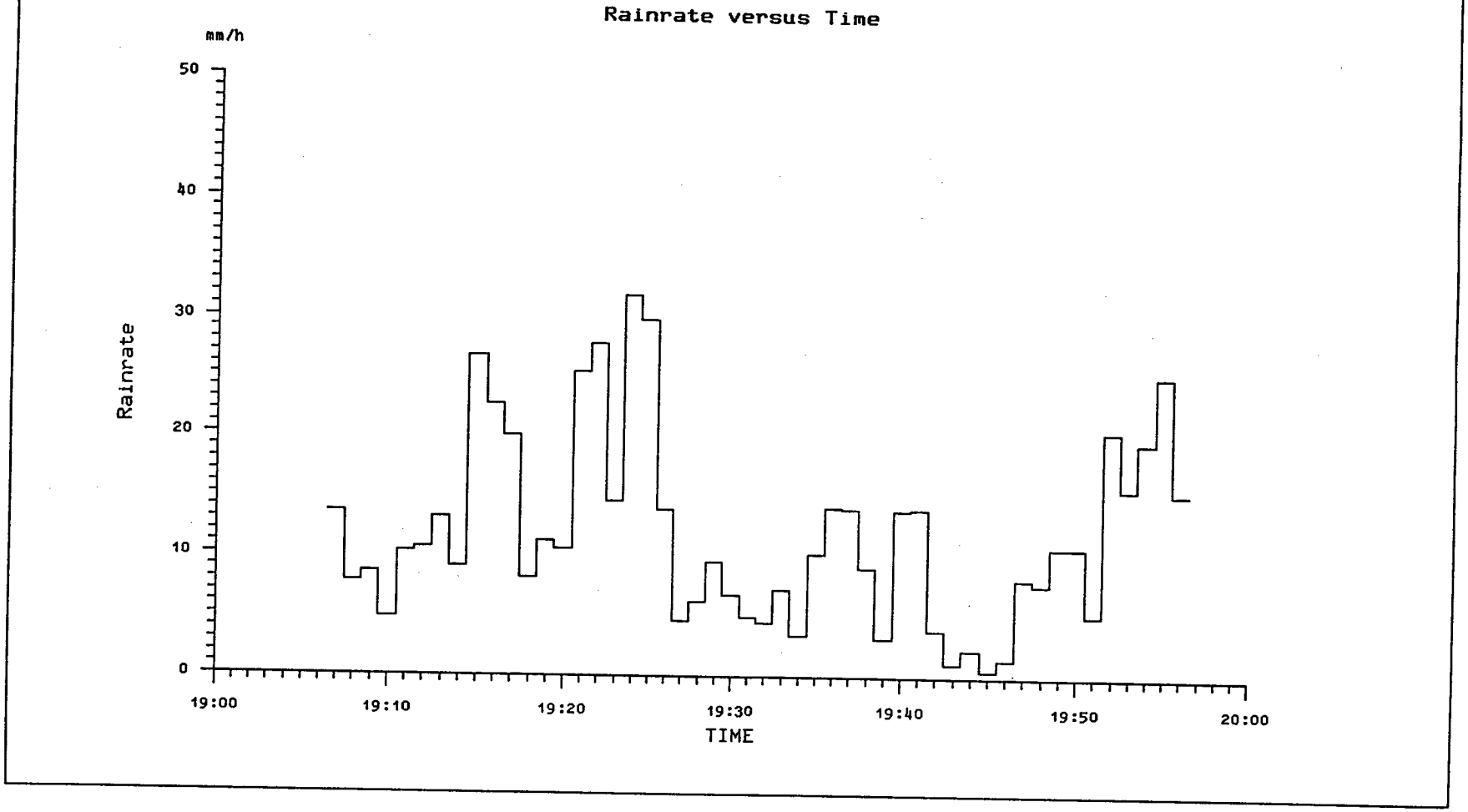
File	v96176_4.hyd	Time	19:00 - 20:00
Int.	19:06:28-19:56:41	Date	Jun 24 1996
Int. Mode	Time (60 sec)		
Rain	9.92 mm		

FILTER

Diameter	0.00 mm	50.00 mm
Velocity	0.00 m/s	30.00 m/s
Oblateness	0.00	2.00
Pixel A	0	511
Pixel B	0	511

RUN F1 | MAIN F2 | HARDCOPY F3 | HELP F4

SCALE < F5 | SCALE > F6 | Integr. F7 | TIP F8



JOANNEUM RESEARCH - ESA | 2D-Video-Distrometer | Graz/Austria | Mon Jun 24 1996

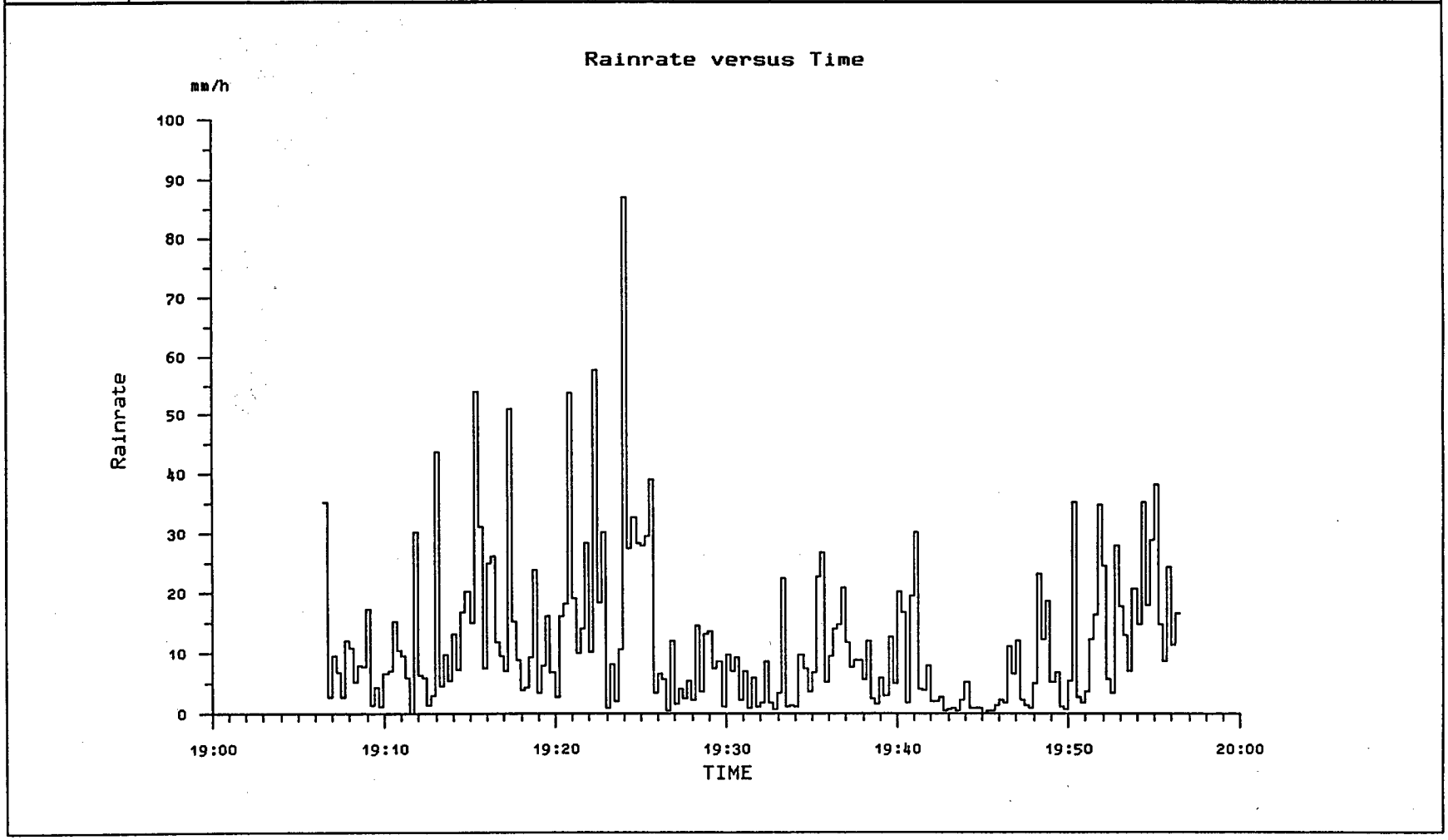
File	v96176_4.hyd	Time	19:00 - 20:00
Int.	19:06:28-19:56:41	Date	Jun 24 1996
Int. Mode	Time (15 sec)		
Rain	9.92 mm		

FILTER

Diameter	0.00 mm	50.00 mm
Velocity	0.00 m/s	30.00 m/s
Oblateness	0.00	2.00
Pixel A	0	511
Pixel B	0	511

RUN F1 | MAIN F2 | HARDCOPY F3 | HELP F4

SCALE < F5 | SCALE > F6 | Integr. F7 | TIP F8

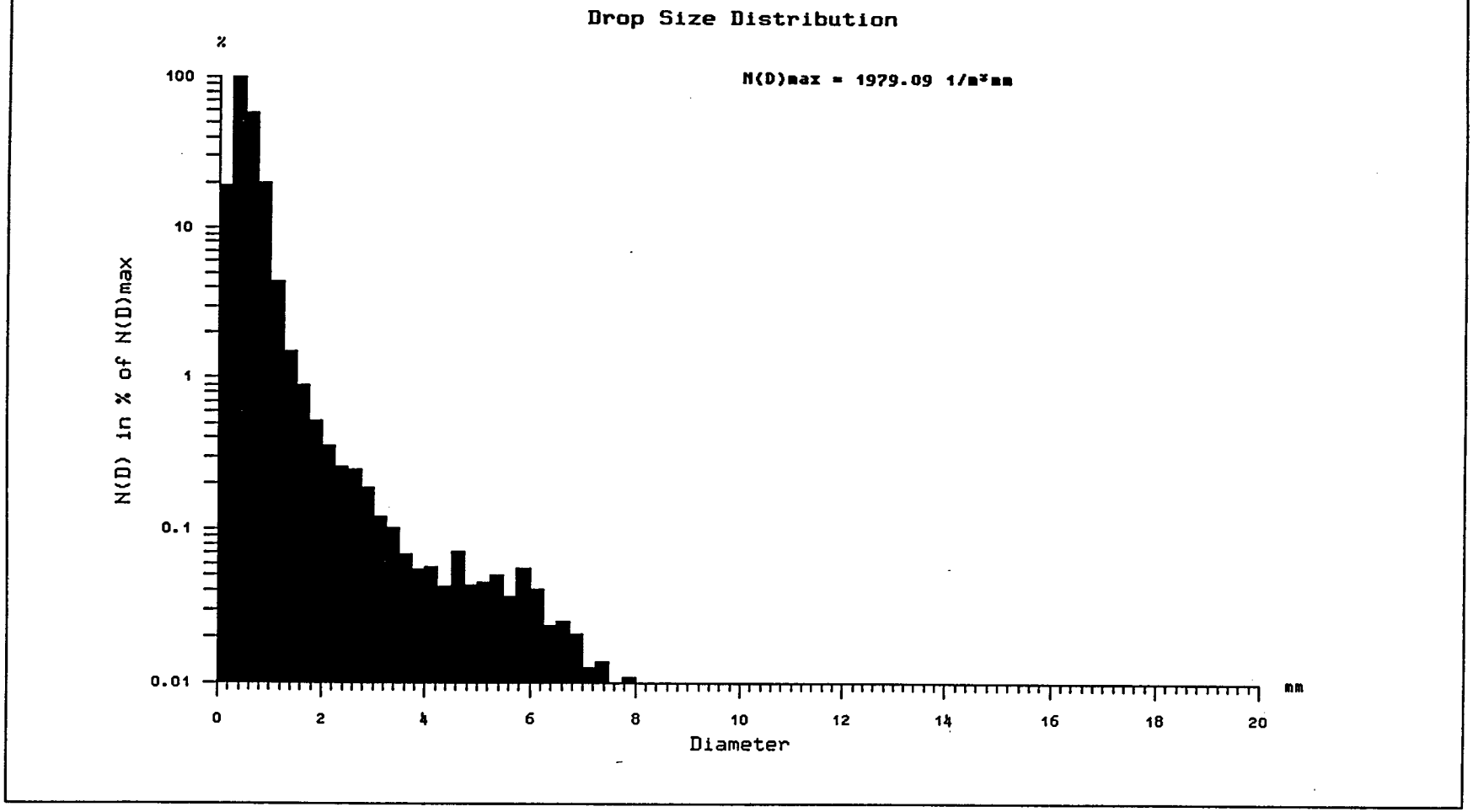


JOANNEUM RESEARCH - ESA 2D-Video-Distrometer Graz/Austria Mon Jun 24 1996

File	v96176_4.hyd	Time	19:06 - 20:00	FILTER	Diameter	0.00 mm	50.00 mm
Int.	19:06:00-19:56:00	Date	Jun 24 1996		Velocity	0.00 m/s	30.00 m/s
Rain	9.79 mm				Oblateness	0.00	2.00
Time Int	3000.00 s	Rainrate	11.75 mm/h		Pixel A	0	511
Objects	39202	ΔD	0.25 mm		Pixel B	0	511

RUN F1 | MAIN F2 | HARDCOPY F3 | HELP F4

ΔD < F5 | ΔD > F6 | Integr. F7 | COMP F8

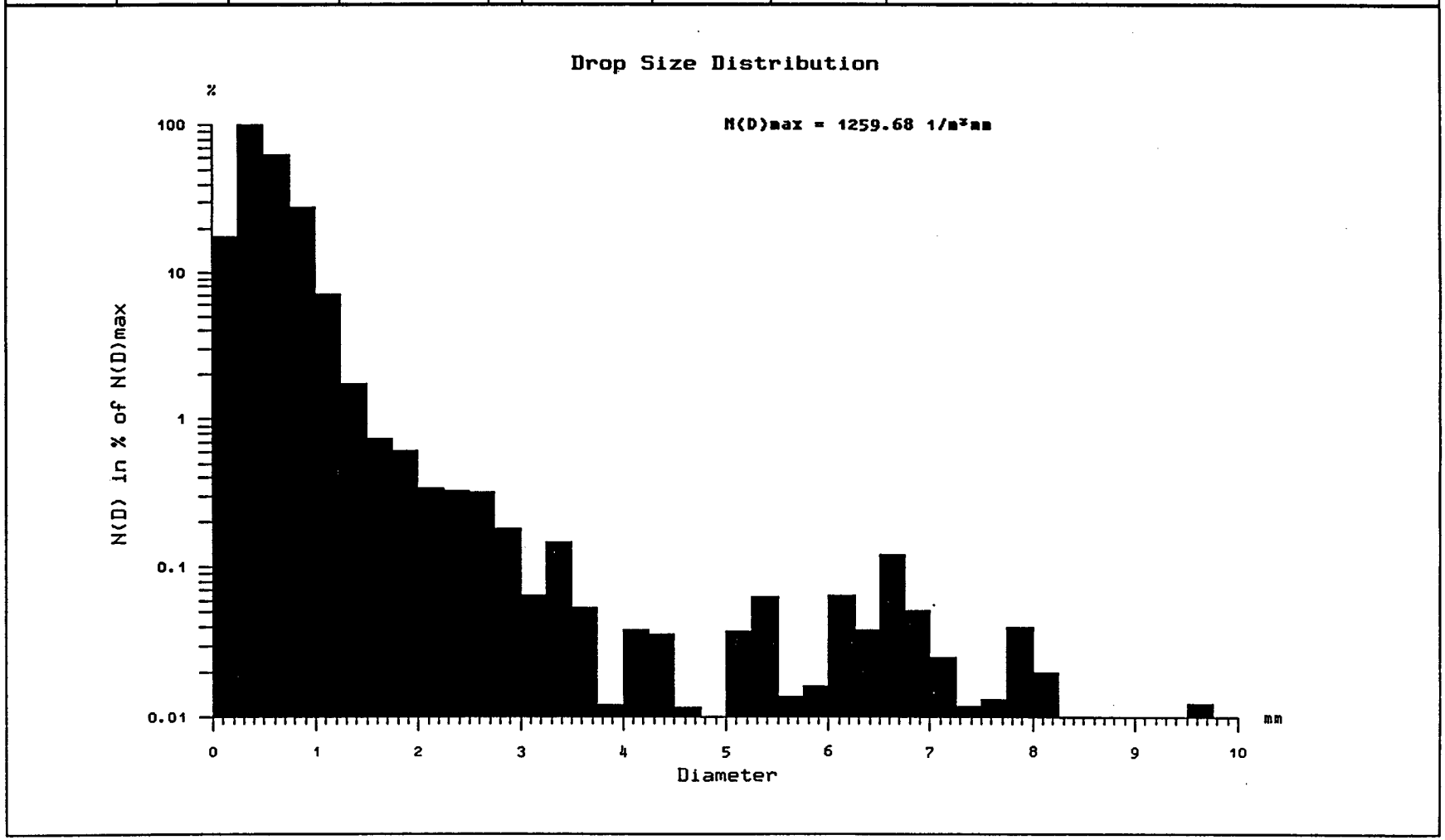


JOANNEUM RESEARCH - ESA | 2D-Video-Distrometer | Graz/Austria | Mon Jun 24 1996

File	v96176_4.hyd	Time	19:00 - 20:00	FILTER	Diameter	0.00 mm	50.00 mm
Int.	19:06:00-19:12:00	Date	Jun 24 1996		Velocity	0.00 m/s	30.00 m/s
Rain	0.88 mm				Oblateness	0.00	2.00
Time Int	360.00 s	Rainrate	8.82 mm/h		Pixel A	0	511
Objects	3443	ΔD	0.25 mm		Pixel B	0	511

RUN F1 | MAIN F2 | HARDCOPY F3 | HELP F4

ΔD < F5 | ΔD > F6 | Integr. F7 | COMP F8



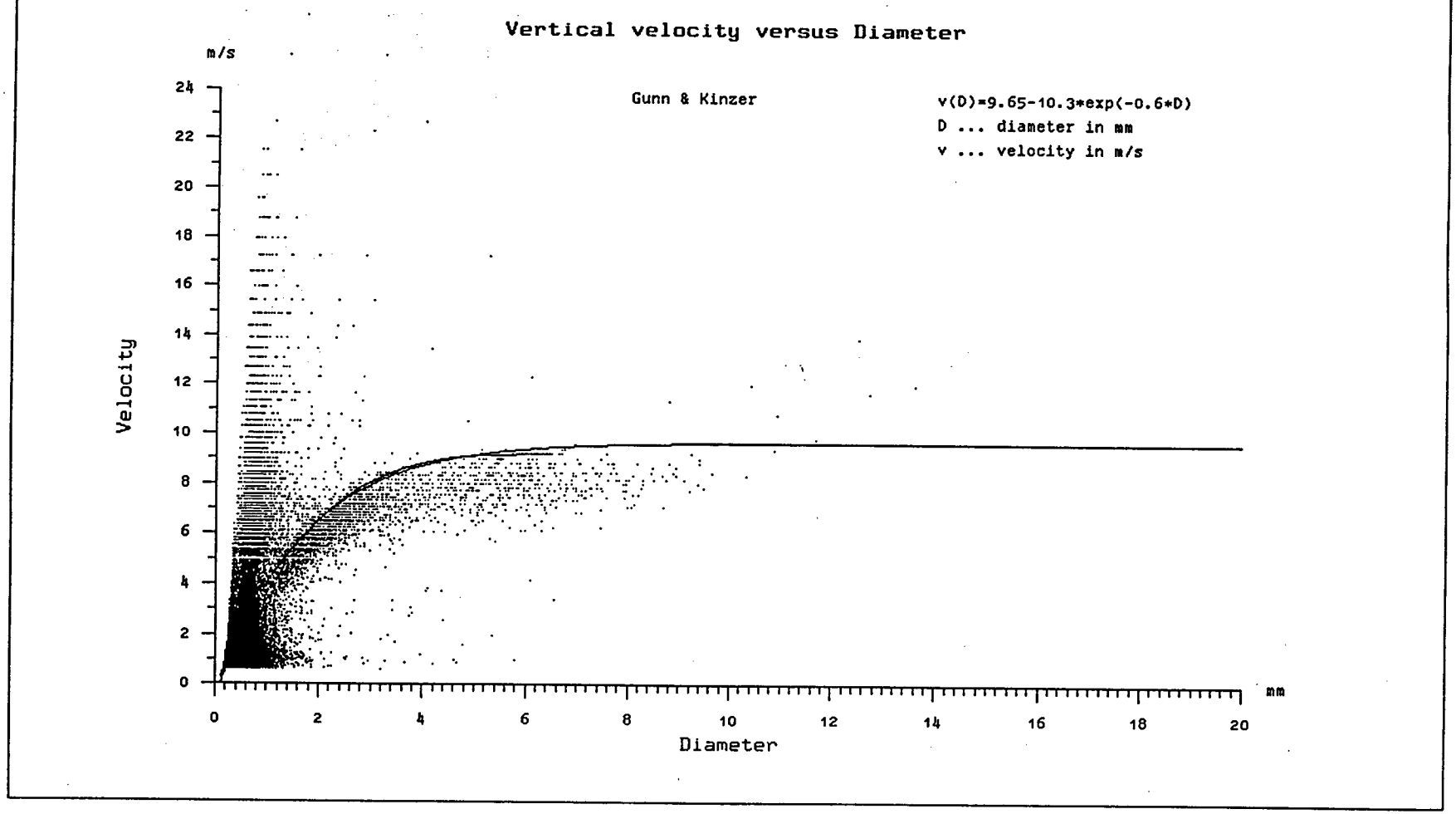
JOANNEUM RESEARCH - ESA | 2D-Video-Distrometer | Graz/Austria | Mon Jun 24 1996

File	v96176_4.hyd	Time	19:00 - 20:00
Int.	19:06:28-19:56:41	Date	Jun 24 1996
Objects	39685		

FILTER

Diameter	0.00 mm	50.00 mm
Velocity	0.00 m/s	30.00 m/s
Oblateness	0.00	2.00
Pixel A	0	511
Pixel B	0	511

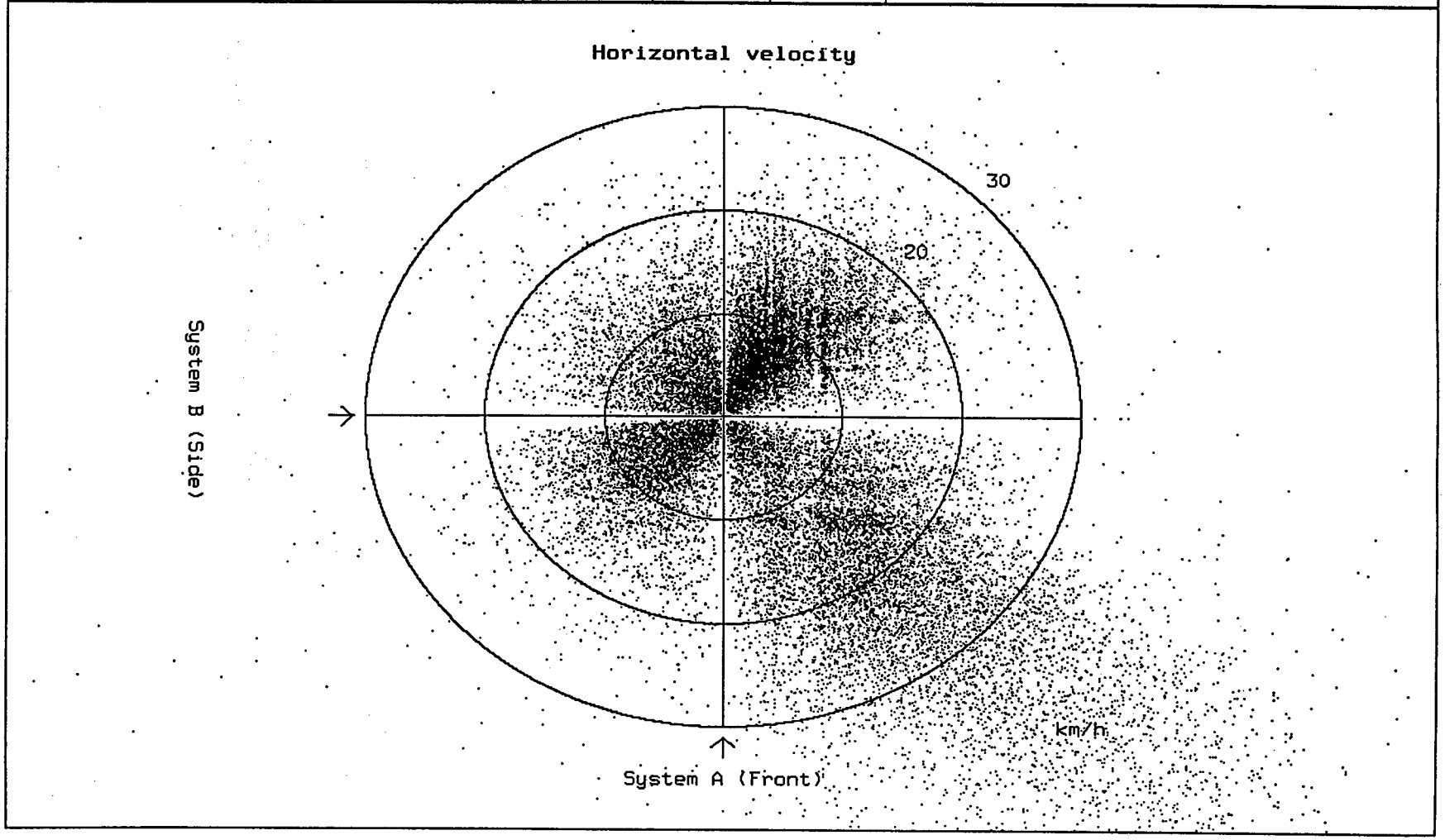
RUN F1 | MAIN F2 | HARDCOPY F3 | HELP F4 | COMP F5



JOANNEUM RESEARCH - ESA | 2D-Video-Distrometer | Graz/Austria | Mon Jun 24 1996

				FILTER			
File	v96176_4.hyd	Time	19:00 - 20:00		Diameter	0.00 mm	50.00 mm
Int.	19:06:28-19:56:41	Date	Jun 24 1996		Velocity	0.00 m/s	30.00 m/s
Objects	39685				Oblateness	0.00	2.00
					Pixel A	0	511
					Pixel B	0	511

RUN F1 | MAIN F2 | HARDCOPY F3 | HELP F4



JOANNEUM RESEARCH - ESA | 2D-Video-Distrometer | Graz/Austria | Mon Jun 24 1996

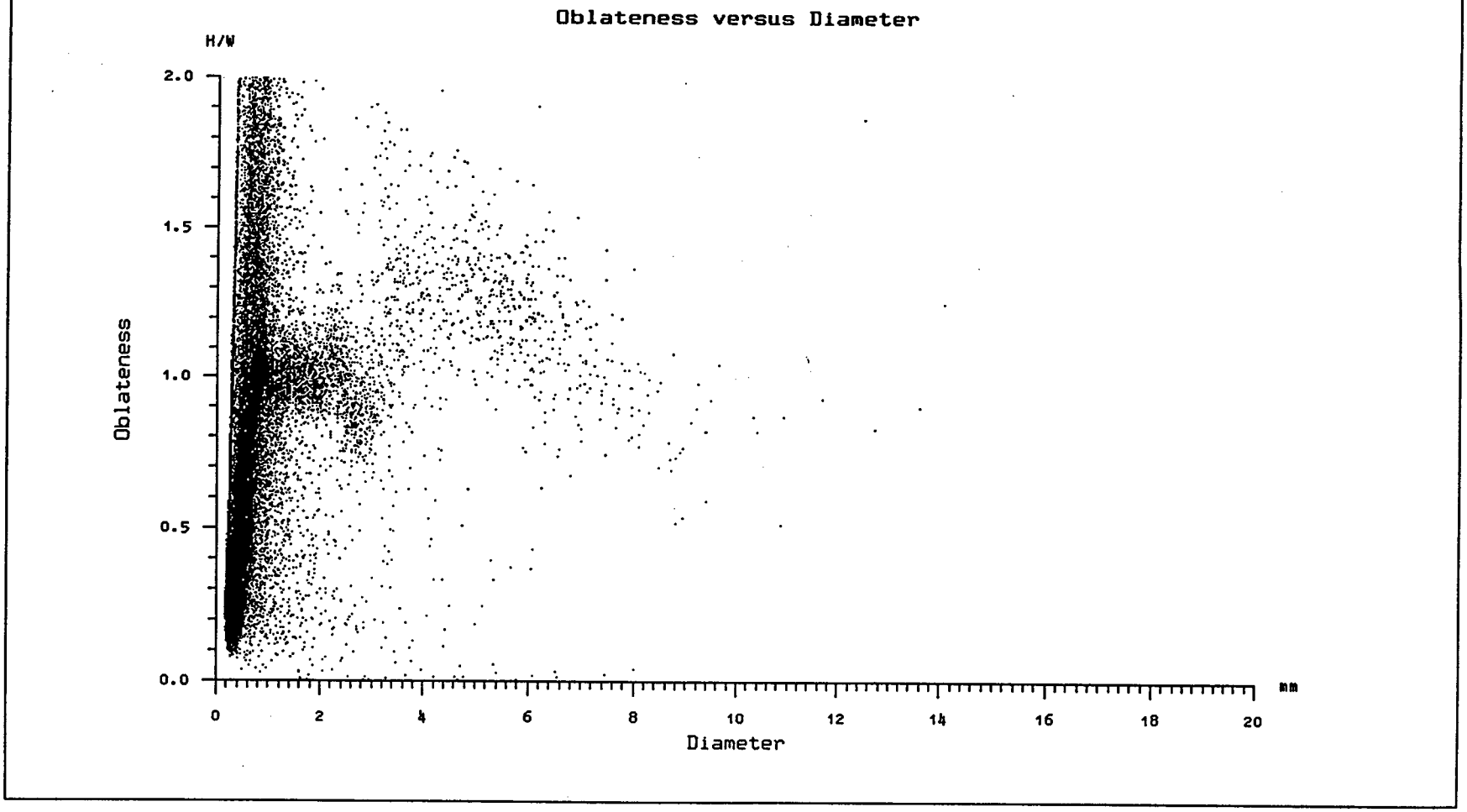
File	v96176_4.hyd	Time	19:00 - 20:00
Int.	19:06:28-19:56:41	Date	Jun 24 1996
Objects	39685		

FILTER

Diameter	0.00 mm	50.00 mm
Velocity	0.00 m/s	30.00 m/s
Oblateness	0.00	2.00
Pixel A	0	511
Pixel B	0	511

RUN F1 | MAIN F2 | HARDCOPY F3 | HELP F4

COMP F5 | GRID F6 | N(H/W) F7



JOANNEUM RESEARCH - ESA 2D-Video-Distrometer Graz/Austria Mon Jun 24 1996

File	v96176_4.hyd	Time	19:00 - 20:00	Diameter	5.00 mm	50.00 mm
Hyd. Time	19:10:33.397	Date	Jun 24 1996	Velocity	0.00 m/s	30.00 m/s
Eq.Diam.	9.66 mm	Velocity	8.45 m/s	Oblateness	0.00	2.00
Obl.ness	1.04	Type	not class.	Pixel A	0	511
				Pixel B	0	511

FILTER

STEP + (F1) MAIN (F2) HARDCOPY (F3) HELP (F4)

STEP - (F5) ASCII (F6) CORR (F7)

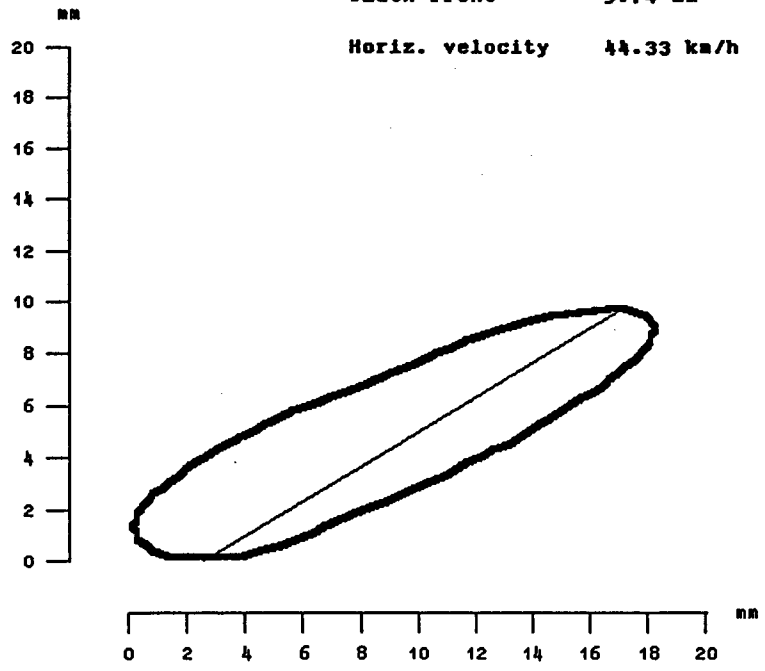
FRONT VIEW

Oblateness front 1.01

Height front 9.84 mm

Width front 9.74 mm

Horiz. velocity 44.33 km/h (→)



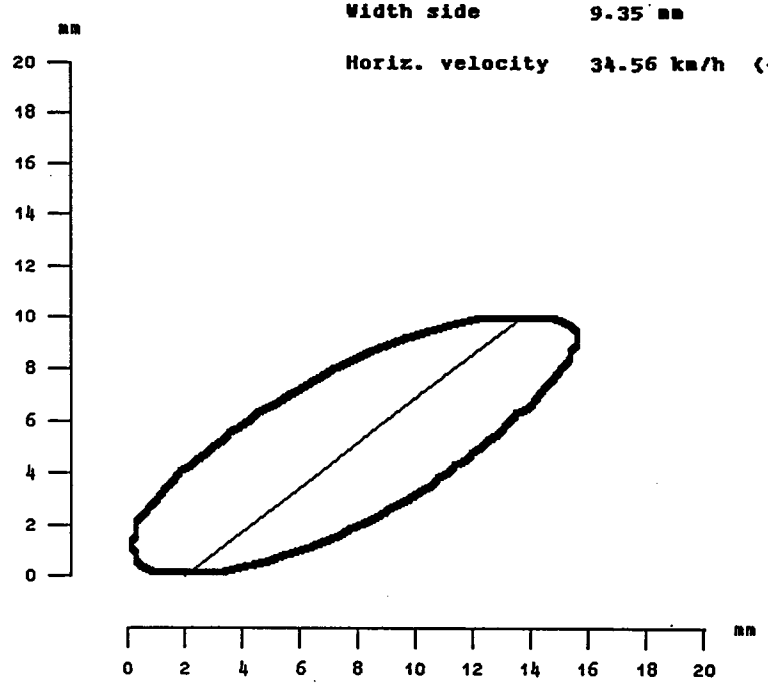
SIDE VIEW

Oblateness side 1.08

Height side 10.08 mm

Width side 9.35 mm

Horiz. velocity 34.56 km/h (→)



JOANNEUM RESEARCH - ESA 2D-Video-Distrometer Graz/Austria Mon Jun 24 1996

File	v96176_4.hyd	Time	19:00 - 20:00	Diameter	5.00 mm	50.00 mm
Hyd. Time	19:10:33.397	Date	Jun 24 1996	Velocity	0.00 m/s	30.00 m/s
Eq.Diam.	9.66 mm	Velocity	8.45 m/s	Oblateness	0.00	2.00
Obl.ness	1.04	Type	not class.	Pixel A	0	511
Views corrected !				Pixel B	0	511

FILTER

STEP + (F1) MAIN (F2) HARDCOPY (F3) HELP (F4)

STEP - (F5) ASCII (F6) CORR (F7)

FRONT VIEW

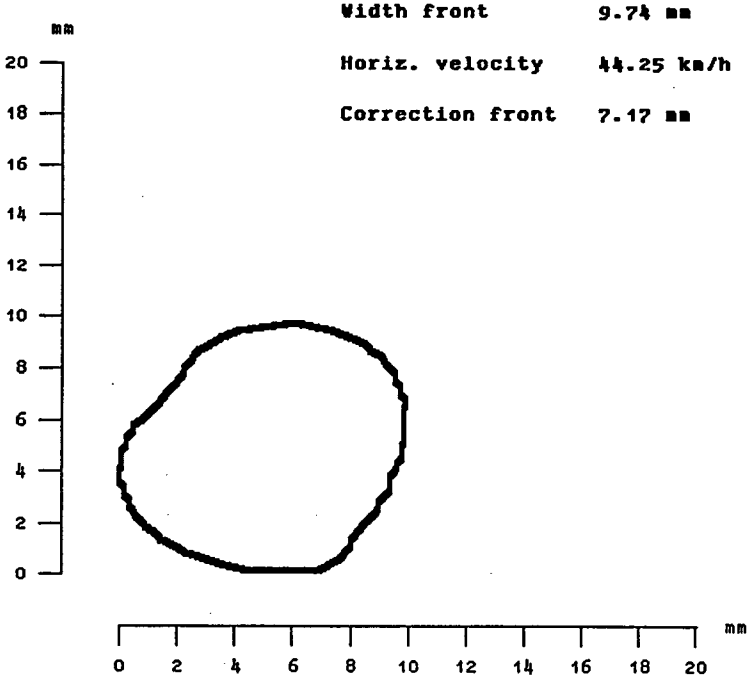
Oblateness front 1.01

Height front 9.84 mm

Width front 9.74 mm

Horiz. velocity 44.25 km/h (→)

Correction front 7.17 mm



SIDE VIEW

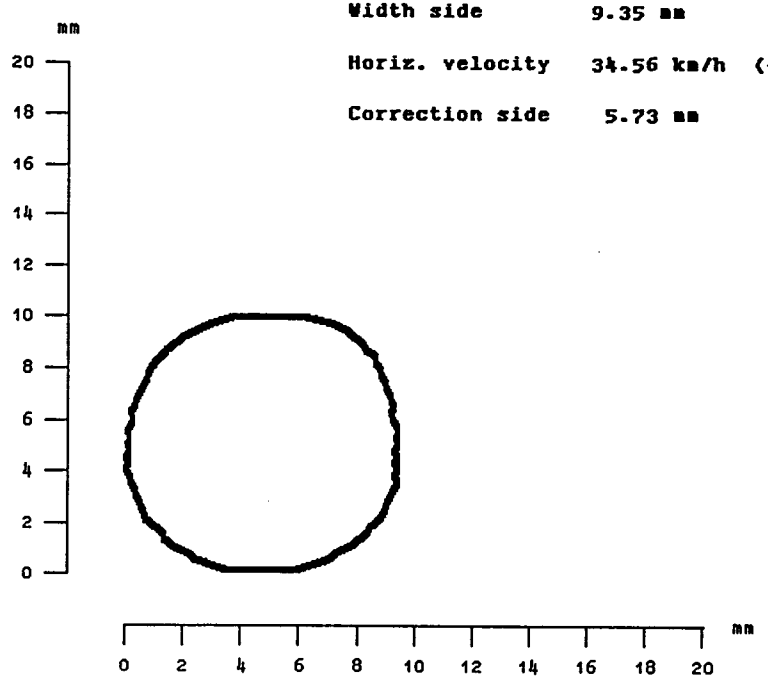
Oblateness side 1.08

Height side 10.08 mm

Width side 9.35 mm

Horiz. velocity 34.56 km/h (→)

Correction side 5.73 mm



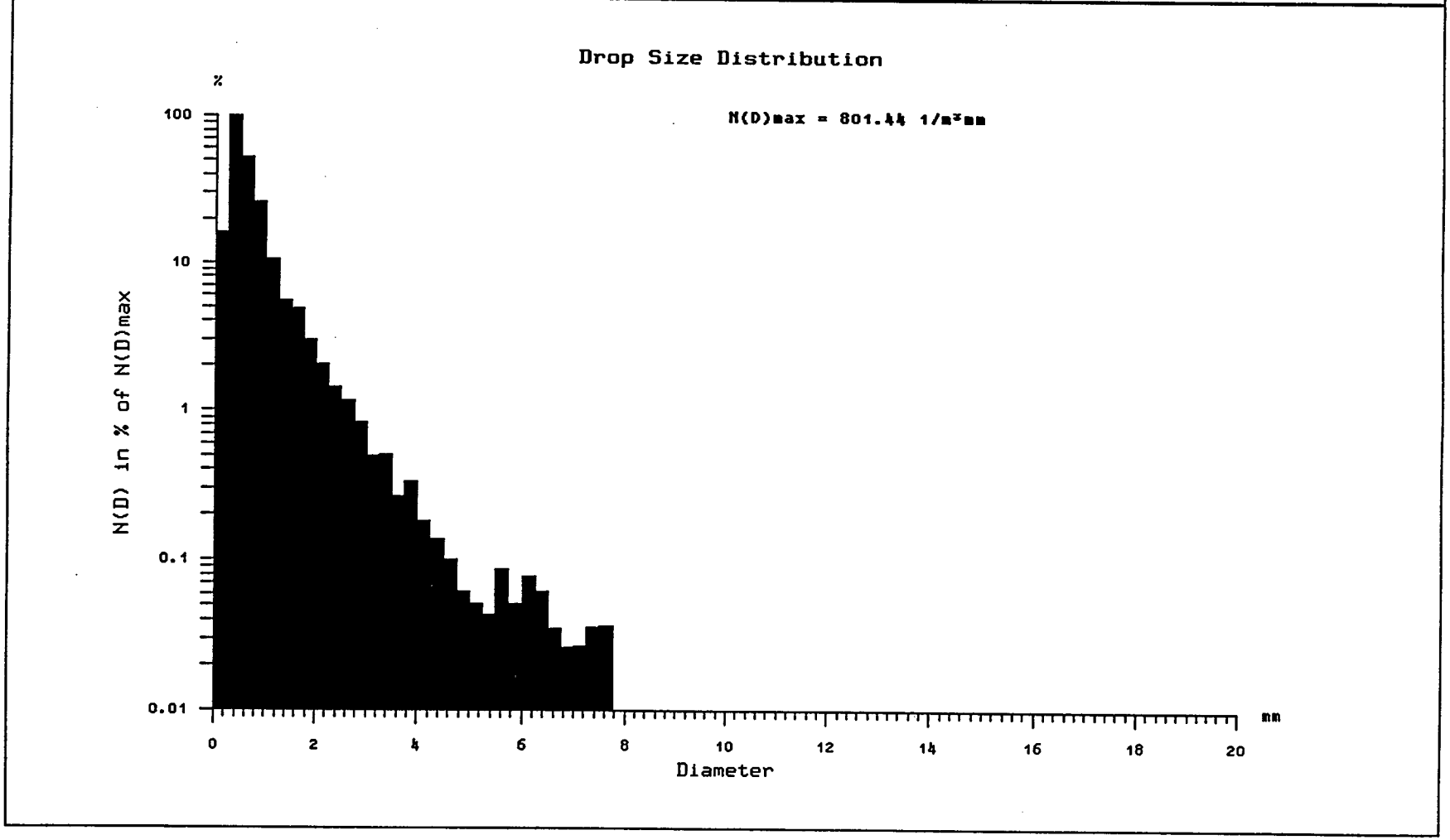
Date:	June 28, 1996
Julian Day:	180
Event:	1
Time:	15:26-15:35
Average Rain Rate:	13.86mm\hr
Total Rainfall:	2.08mm
Location:	I-25 & highway 34 Lat.- 40:24:25 Lon.-104:59:47
Contents:	Moderate rain No large drops

JOANNEUM RESEARCH - ESA 2D-Video-Distrometer Graz/Austria Sat Jul 6 1996

File	v96188_2.hyd	Time	16:18 - 17:00	FILTER	Diameter	0.00 mm	50.00 mm
Int.	16:18:00-16:29:00	Date	Jul 6 1996		Velocity	0.00 m/s	30.00 m/s
Rain	2.29 mm				Oblateness	0.00	2.00
Time Int	660.00 s	Rainrate	12.51 mm/h		Pixel A	0	511
Objects	5260	ΔD	0.25 mm		Pixel B	0	511

RUN F1 | MAIN F2 | HARDCOPY F3 | HELP F4

ΔD < F5 | ΔD > F6 | Integr. F7 | COMP F8



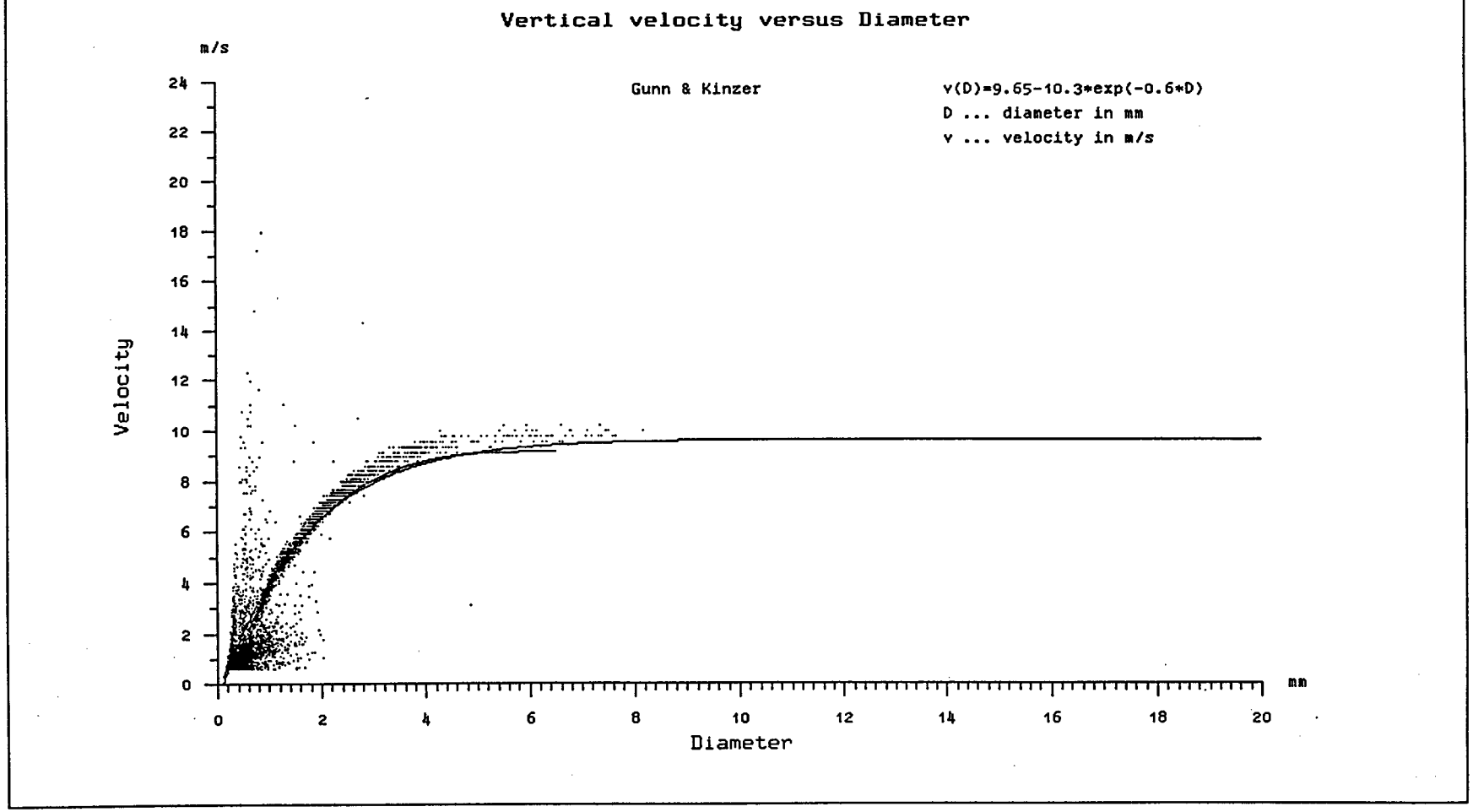
JOANNEUM RESEARCH - ESA | 2D-Video-Distrometer | Graz/Austria | Sat Jul 6 1996

File	v96188_2.hyd	Time	16:18 - 17:00
Int.	16:18:40-16:29:14	Date	Jul 6 1996
Objects	5315		

FILTER

Diameter	0.00 mm	50.00 mm
Velocity	0.00 m/s	30.00 m/s
Oblateness	0.00	2.00
Pixel A	0	511
Pixel B	0	511

RUN F1 | MAIN F2 | HARDCOPY F3 | HELP F4 | COMP F5



JOANNEUM RESEARCH - ESA 2D-Video-Distrometer Graz/Austria Sat Jul 6 1996

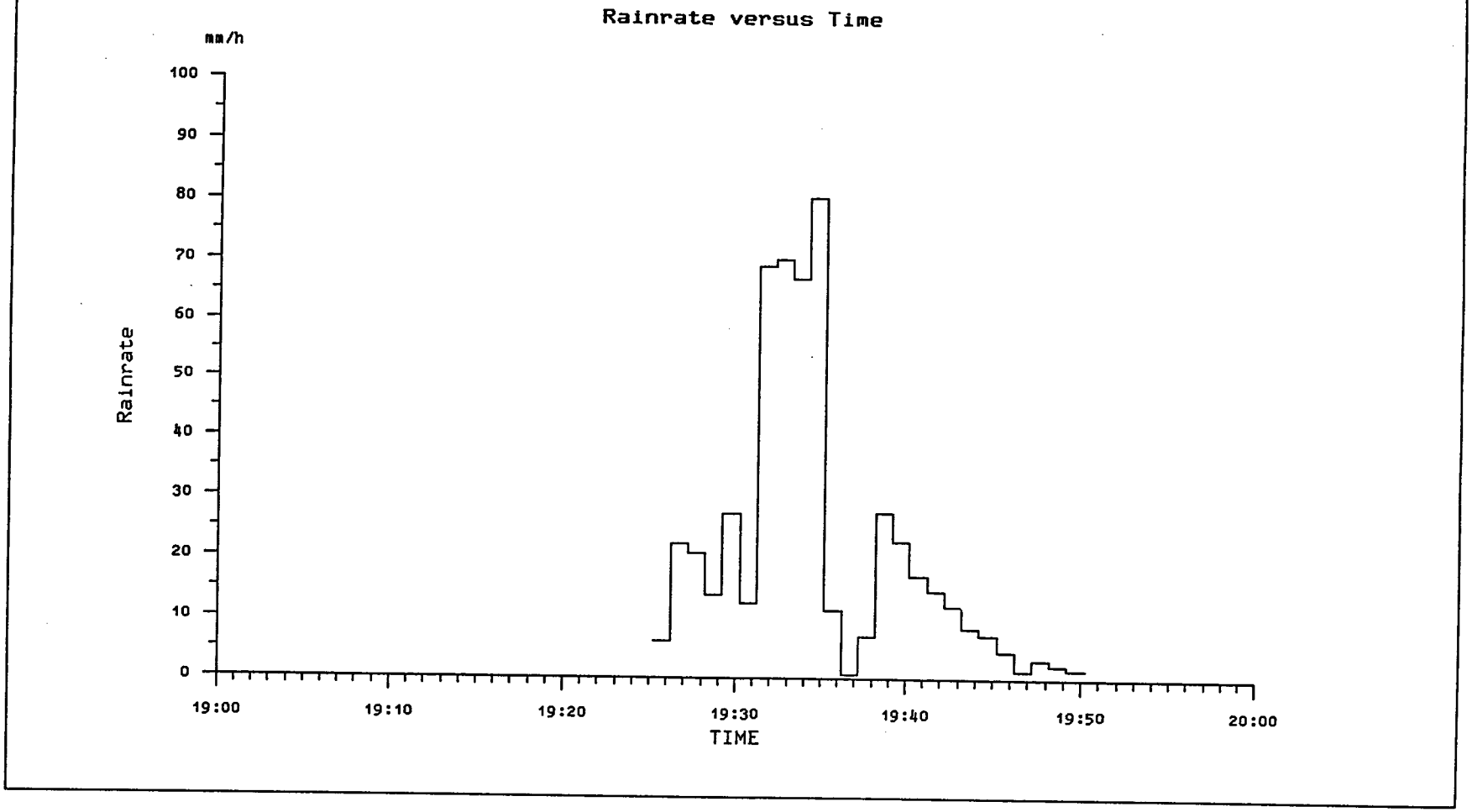
File	v96188_3.hyd	Time	19:00 - 20:00
Int.	19:25:13-19:50:35	Date	Jul 6 1996
Int. Mode	Time (60 sec)		
Rain	8.91 mm		

FILTER

Diameter	0.00 mm	50.00 mm
Velocity	0.00 m/s	30.00 m/s
Oblateness	0.00	2.00
Pixel A	0	511
Pixel B	0	511

RUN F1 | MAIN F2 | HARDCOPY F3 | HELP F4

SCALE < F5 | SCALE > F6 | Integr. F7 | TIP F8

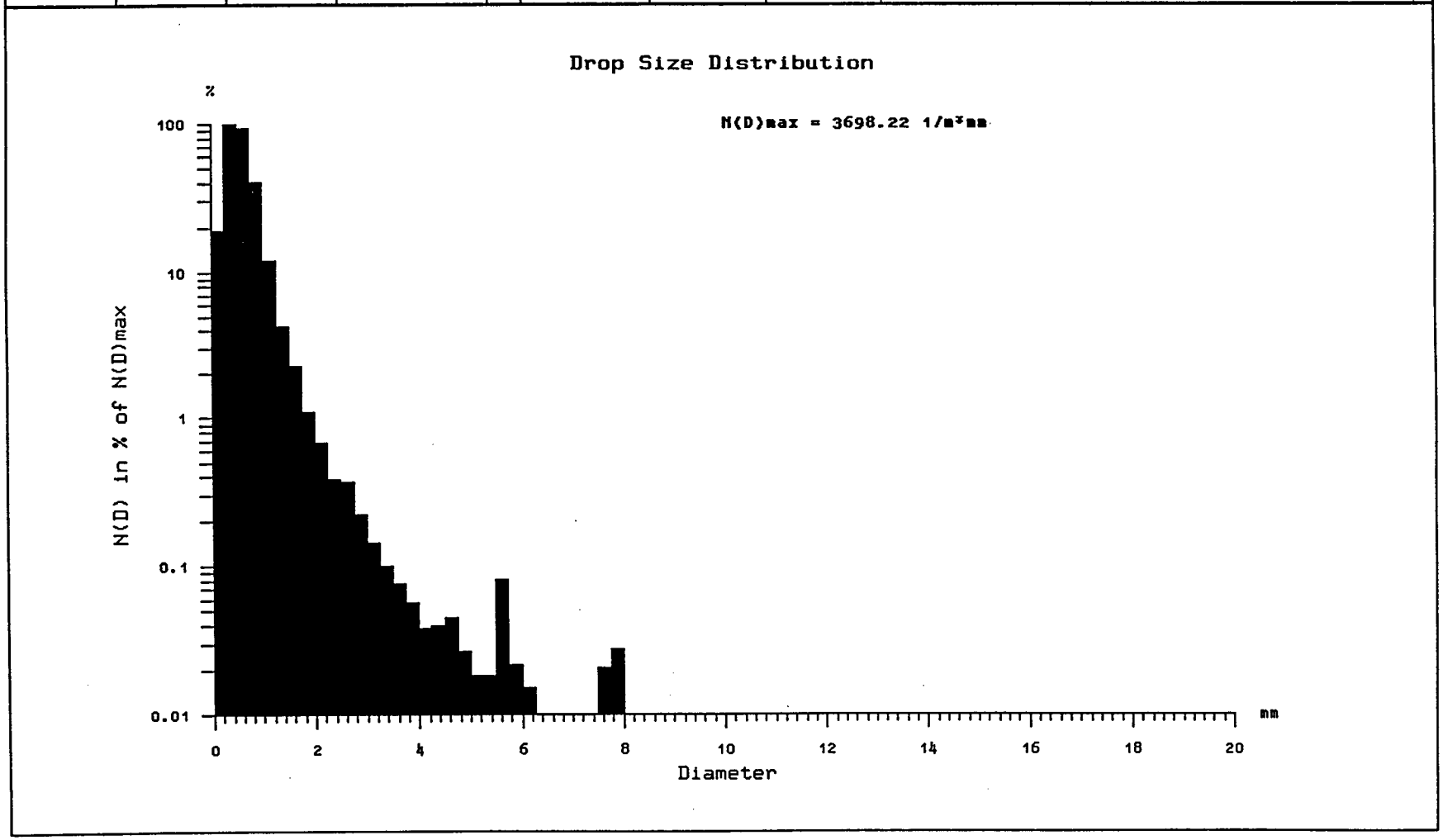


JOANNEUM RESEARCH - ESA | 2D-Video-Distrometer | Graz/Austria | Sat Jul 6 1996

File	v96188_3.hyd	Time	19:25 - 20:00	FILTER	Diameter	0.00 mm	50.00 mm
Int.	19:25:00-19:50:30	Date	Jul 6 1996		Velocity	0.00 m/s	30.00 m/s
Rain	8.90 mm				Oblateness	0.00	2.00
Time Int	1530.00 s	Rainrate	20.95 mm/h		Pixel A	0	511
Objects	50861	ΔD	0.25 mm		Pixel B	0	511

RUN F1 | MAIN F2 | HARDCOPY F3 | HELP F4

ΔD < F5 | ΔD > F6 | Integr. F7 | COMP F8



JOANNEUM RESEARCH - ESA 2D-Video-Distrometer Graz/Austria Tue Jul 9 1996

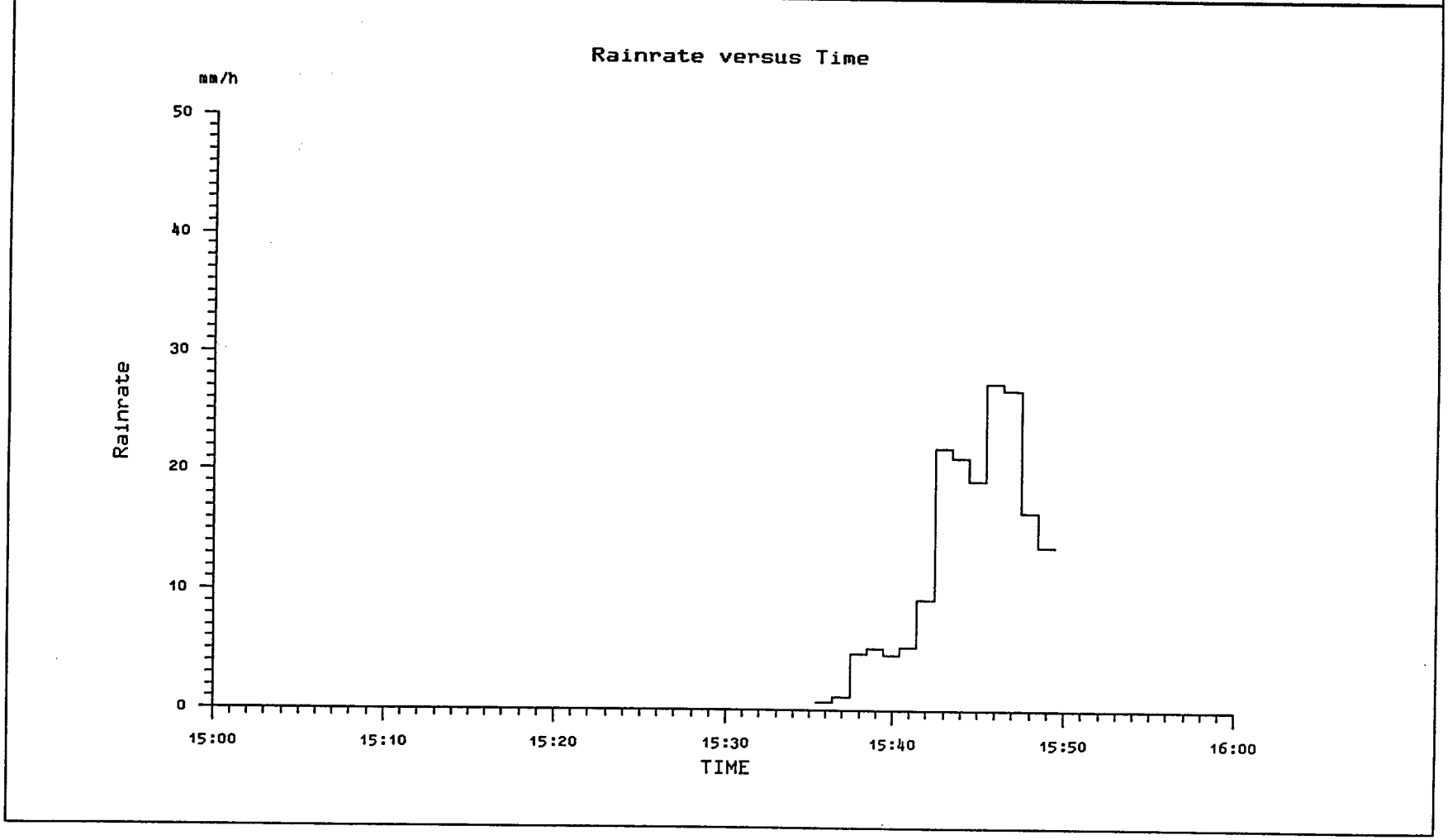
File	v96191_2.hyd	Time	15:00 - 16:00
Int.	15:35:25-15:50:08	Date	Jul 9 1996
Int. Mode	Time (60 sec)		
Rain	3.18 mm		

FILTER

Diameter	0.00 mm	50.00 mm
Velocity	0.00 m/s	30.00 m/s
Oblateness	0.00	2.00
Pixel A	0	511
Pixel B	0	511

RUN F1 | MAIN F2 | HARDCOPY F3 | HELP F4

SCALE < F5 | SCALE > F6 | Integr. F7 | TIP F8



Date:	July 9, 1996
Julian Day:	191
Event:	2
Time:	18:35-19:05
Average Rain Rate:	13.62mm\hr
Total Rainfall:	6.13mm
Location:	Lat.- 40:29:39 Lon.-104:59:58
Contents:	Light drizzle 18:43- moderate rain with large drops 18:45- heavy rain with very large drops

JOANNEUM RESEARCH - ESA | 2D-Video-Distrometer | Graz/Austria | Tue Jul 9 1996

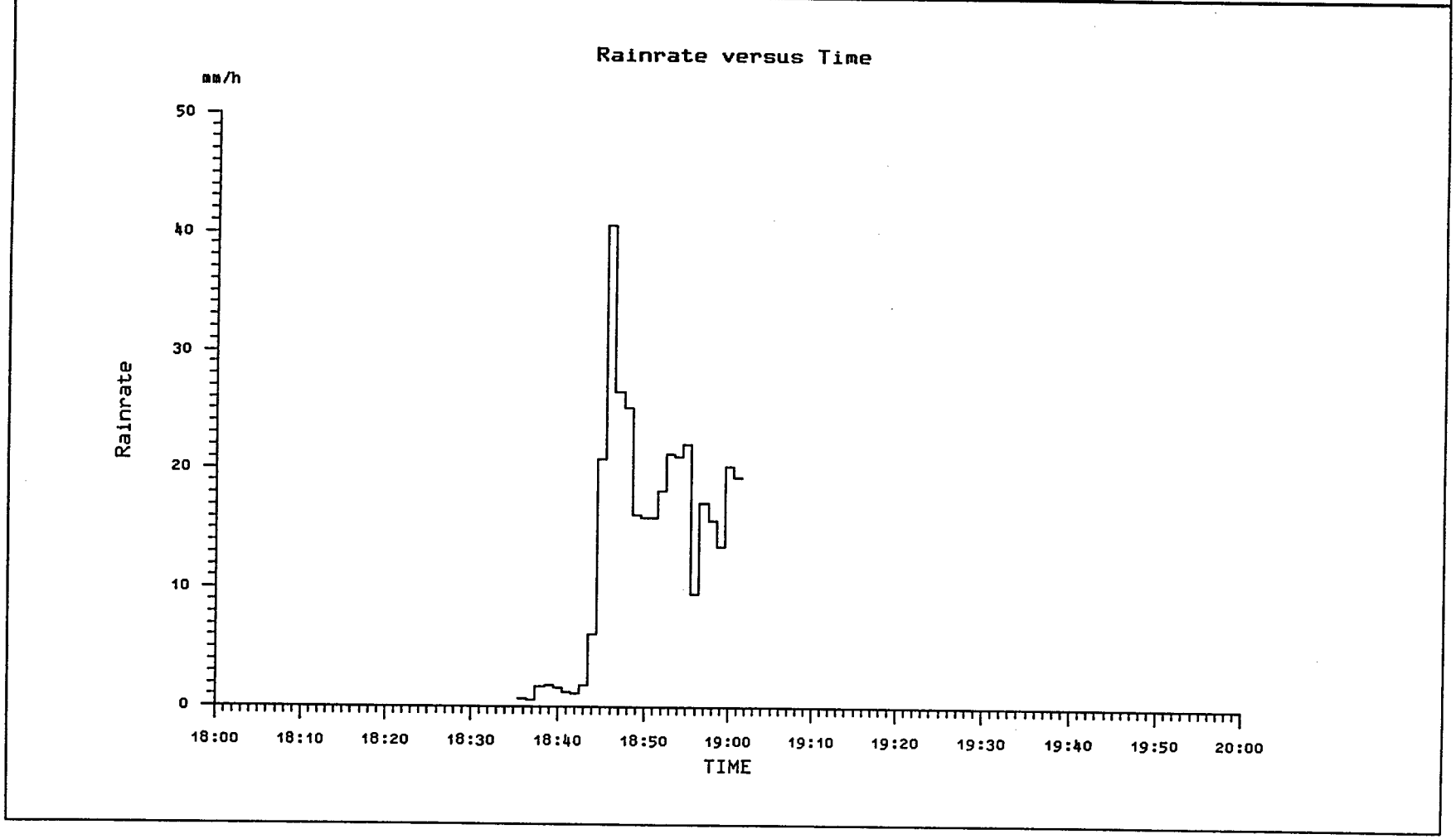
File	v96191_3.hyd	Time	18:00 - 20:00
Int.	18:35:28-19:02:08	Date	Jul 9 1996
Int. Mode	Time (60 sec)		
Rain	6.17 mm		

FILTER

Diameter	0.00 mm	50.00 mm
Velocity	0.00 m/s	30.00 m/s
Oblateness	0.00	2.00
Pixel A	0	511
Pixel B	0	511

RUN F1 | MAIN F2 | HARDCOPY F3 | HELP F4

SCALE < F5 | SCALE > F6 | Integr. F7 | TIP F8

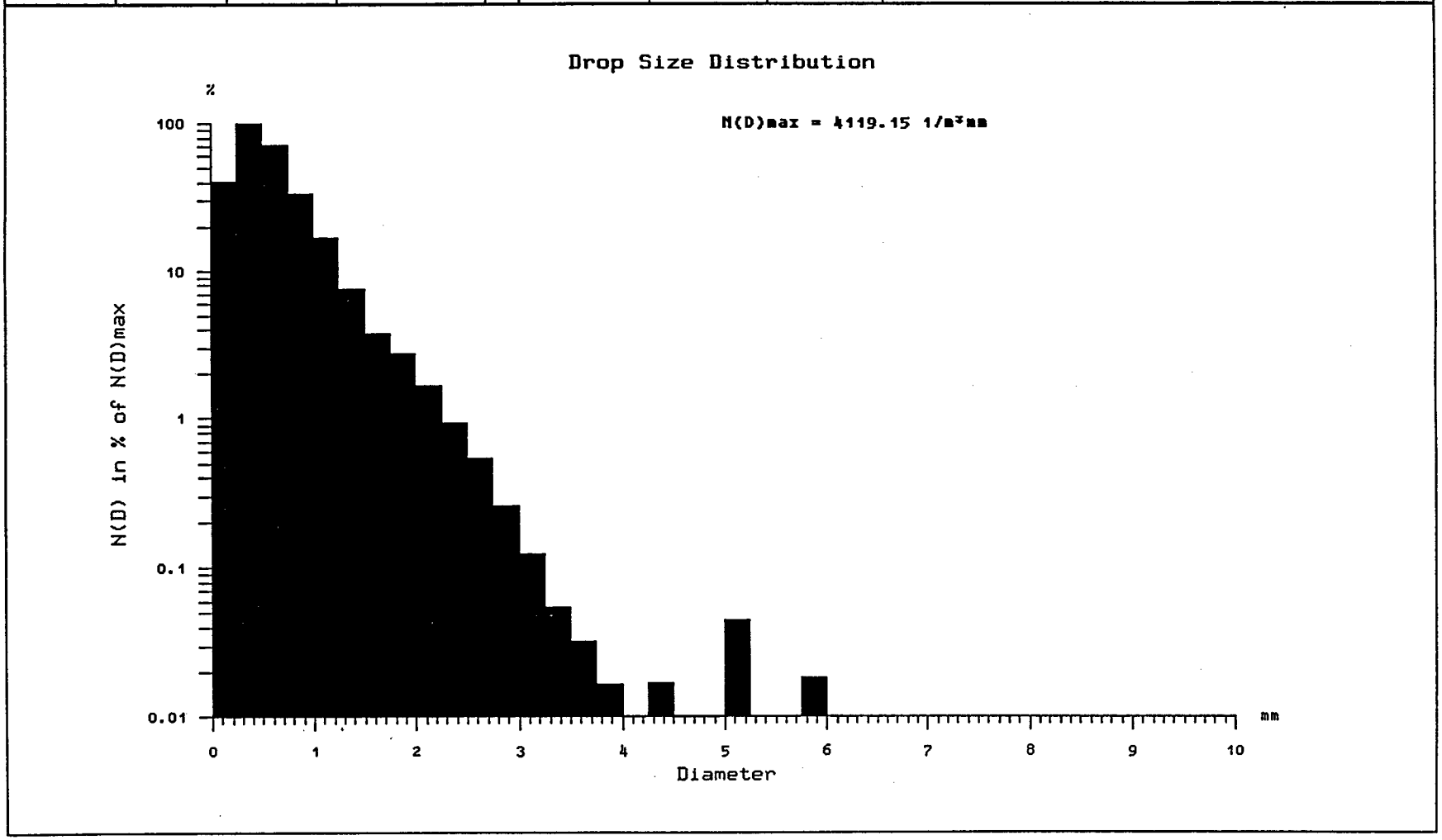


JOANNEUM RESEARCH - ESA | 2D-Video-Distrometer | Graz/Austria | Tue Jul 9 1996

File	v96191_3.hyd	Time	18:35 - 20:00	FILTER	Diameter	0.00 mm	50.00 mm
Int.	18:35:00-19:02:00	Date	Jul 9 1996		Velocity	0.00 m/s	30.00 m/s
Rain	6.13 mm				Oblateness	0.00	2.00
Time Int	1620.00 s	Rainrate	13.62 mm/h		Pixel A	0	511
Objects	64691	ΔD	0.25 mm		Pixel B	0	511

RUN F1 | MAIN F2 | HARDCOPY F3 | HELP F4

ΔD < F5 | ΔD > F6 | Integr. F7 | COMP F8



Date:	July 13, 1996
Julian Day:	195
Event:	1
Time:	14:27-14:50
Average Rain Rate:	22.7mm\hr
Total Rainfall:	8.7mm
Location:	Lat.- 40:42:42 Lon.-104:55:32 Facing east
Contents:	Watered covered ice particles Heavy rain with big drops 14:36- Large hail (marble-sized) with very heavy 14:44- Heavy winds to the northwest

JOANNEUM RESEARCH - ESA | 2D-Video-Distrometer | Graz/Austria | Sat Jul 13 1996

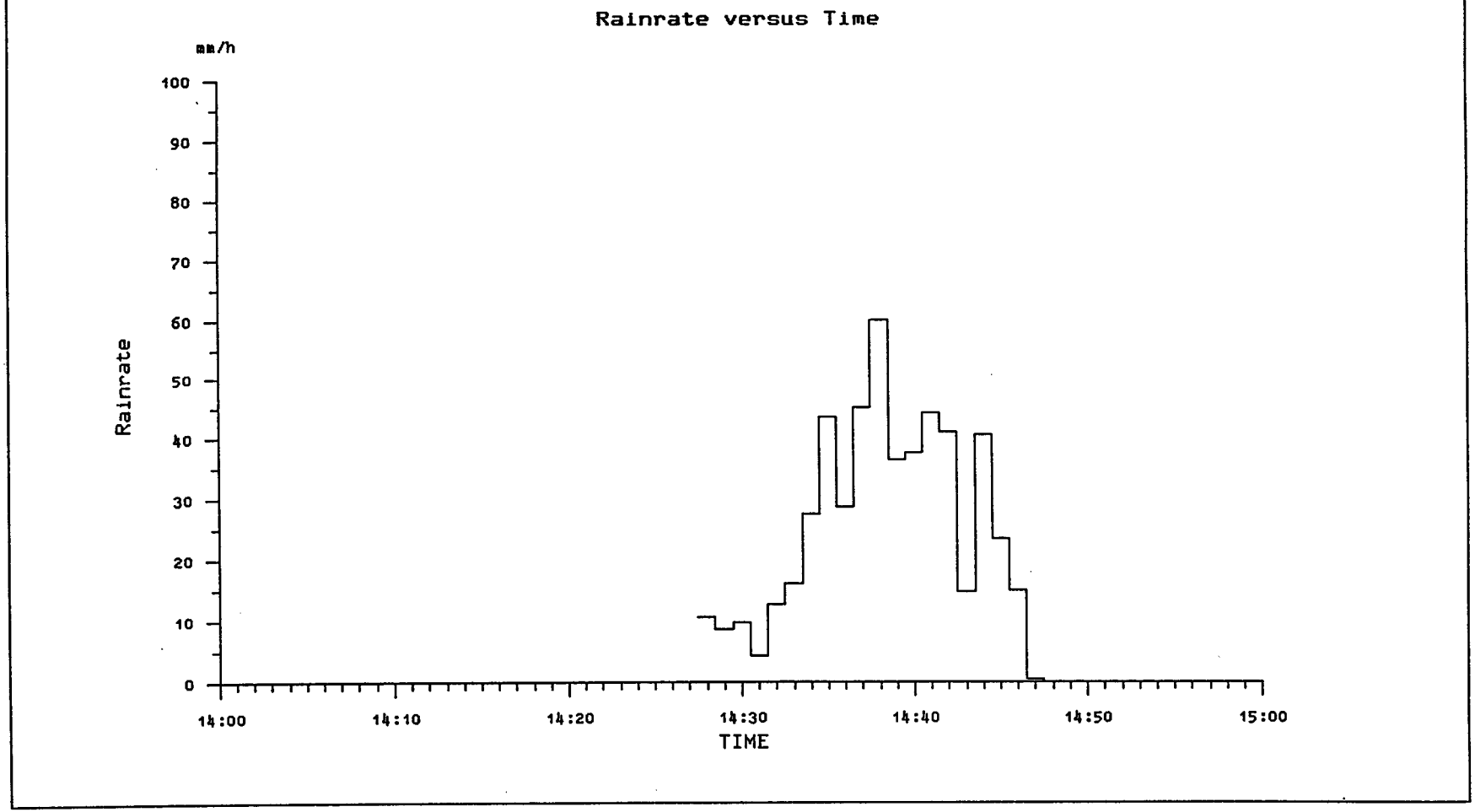
File	v96195_1.hyd	Time	14:00 - 15:00
Int.	14:27:29-14:50:06	Date	Jul 13 1996
Int. Mode	Time (60 sec)		
Rain	8.70 mm		

FILTER

Diameter	0.00 mm	50.00 mm
Velocity	0.00 m/s	30.00 m/s
Oblateness	0.00	2.00
Pixel A	0	511
Pixel B	0	511

RUN F1 | MAIN F2 | HARDCOPY F3 | HELP F4

SCALE < F5 | SCALE > F6 | Integr. F7 | TIP F8

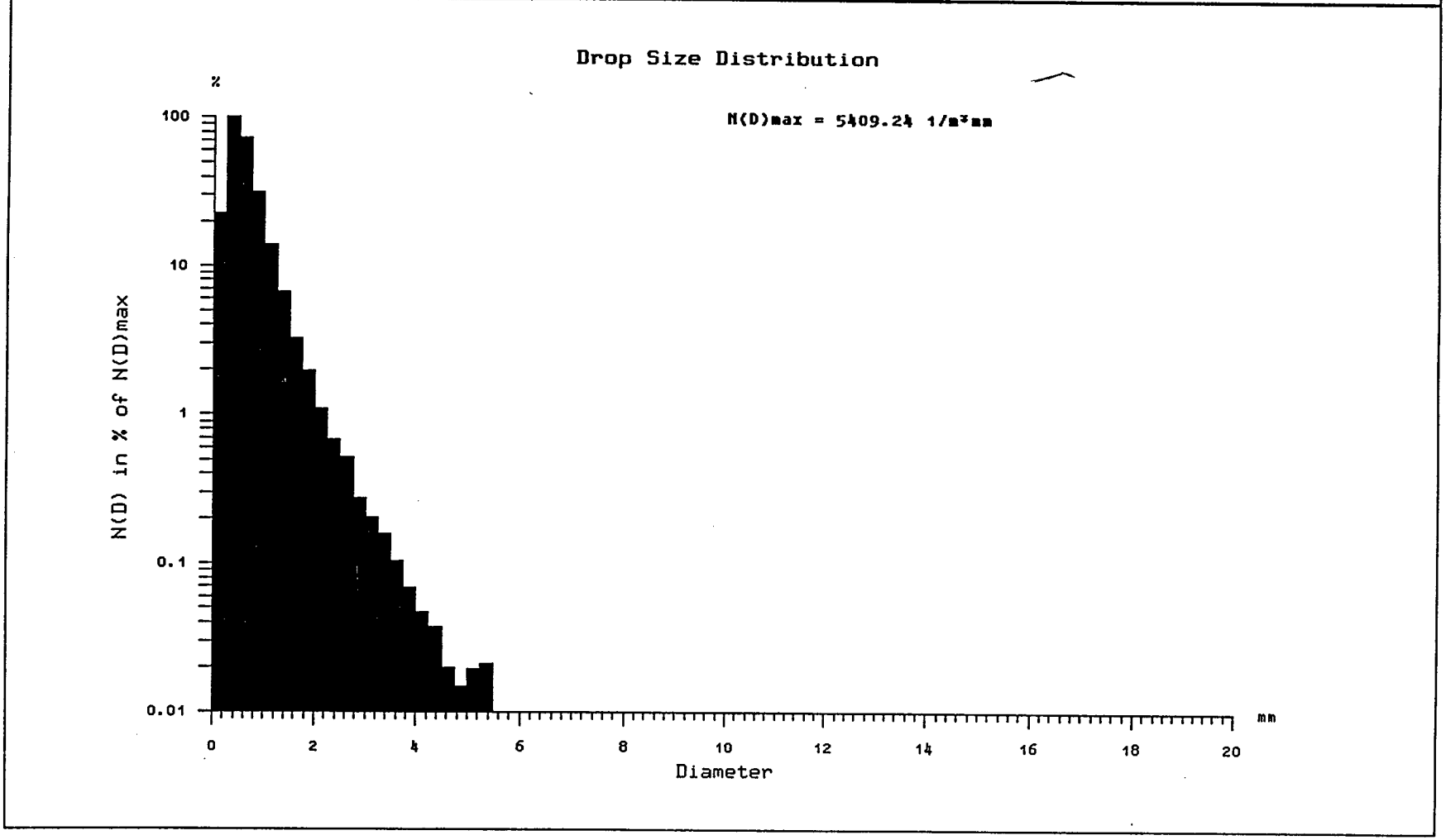


JOANNEUM RESEARCH - ESA | 2D-Video-Distrometer | Graz/Austria | Sat Jul 13 1996

File	v96195_1.hyd	Time	14:27 - 15:00	FILTER	Diameter	0.00 mm	50.00 mm
Int.	14:27:00-14:50:00	Date	Jul 13 1996		Velocity	0.00 m/s	30.00 m/s
Rain	8.70 mm				Oblateness	0.00	2.00
Time Int	1380.00 s	Rainrate	22.70 mm/h		Pixel A	0	511
Objects	64154	ΔD	0.25 mm		Pixel B	0	511

RUN F1 | MAIN F2 | HARDCOPY F3 | HELP F4

ΔD < F5 | ΔD > F6 | Integr. F7 | COMP F8



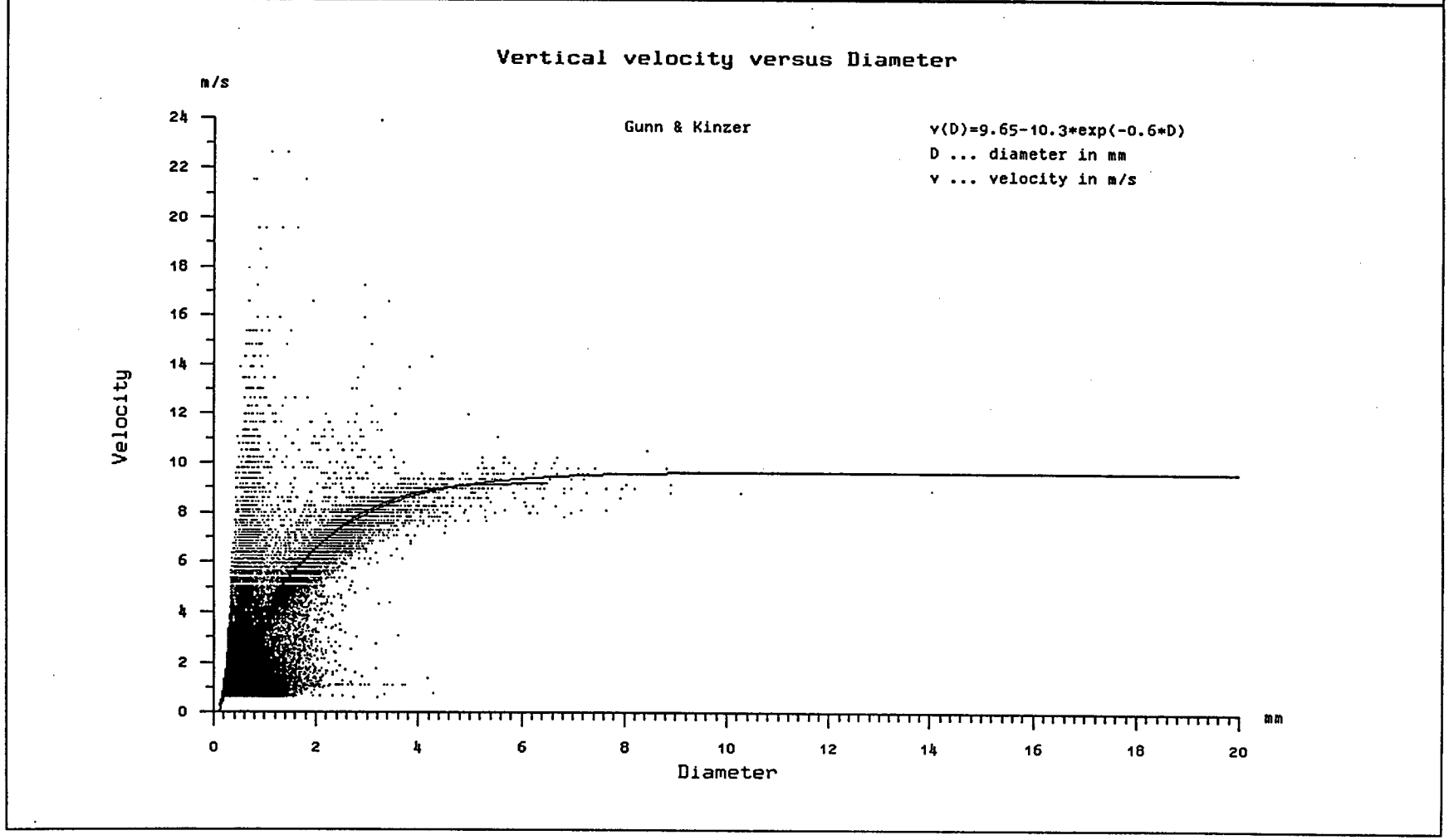
JOANNEUM RESEARCH - ESA | 2D-Video-Distrometer | Graz/Austria | Sat Jul 13 1996

File	v96195_1.hyd	Time	00:00 - 24:00
Int.	14:27:29-14:45:58	Date	Jul 13 1996
Objects	63061		

FILTER

Diameter	0.00 mm	50.00 mm
Velocity	0.00 m/s	30.00 m/s
Oblateness	0.00	2.00
Pixel A	0	511
Pixel B	0	511

RUN F1 | MAIN F2 | HARDCOPY F3 | HELP F4 | COMP F5



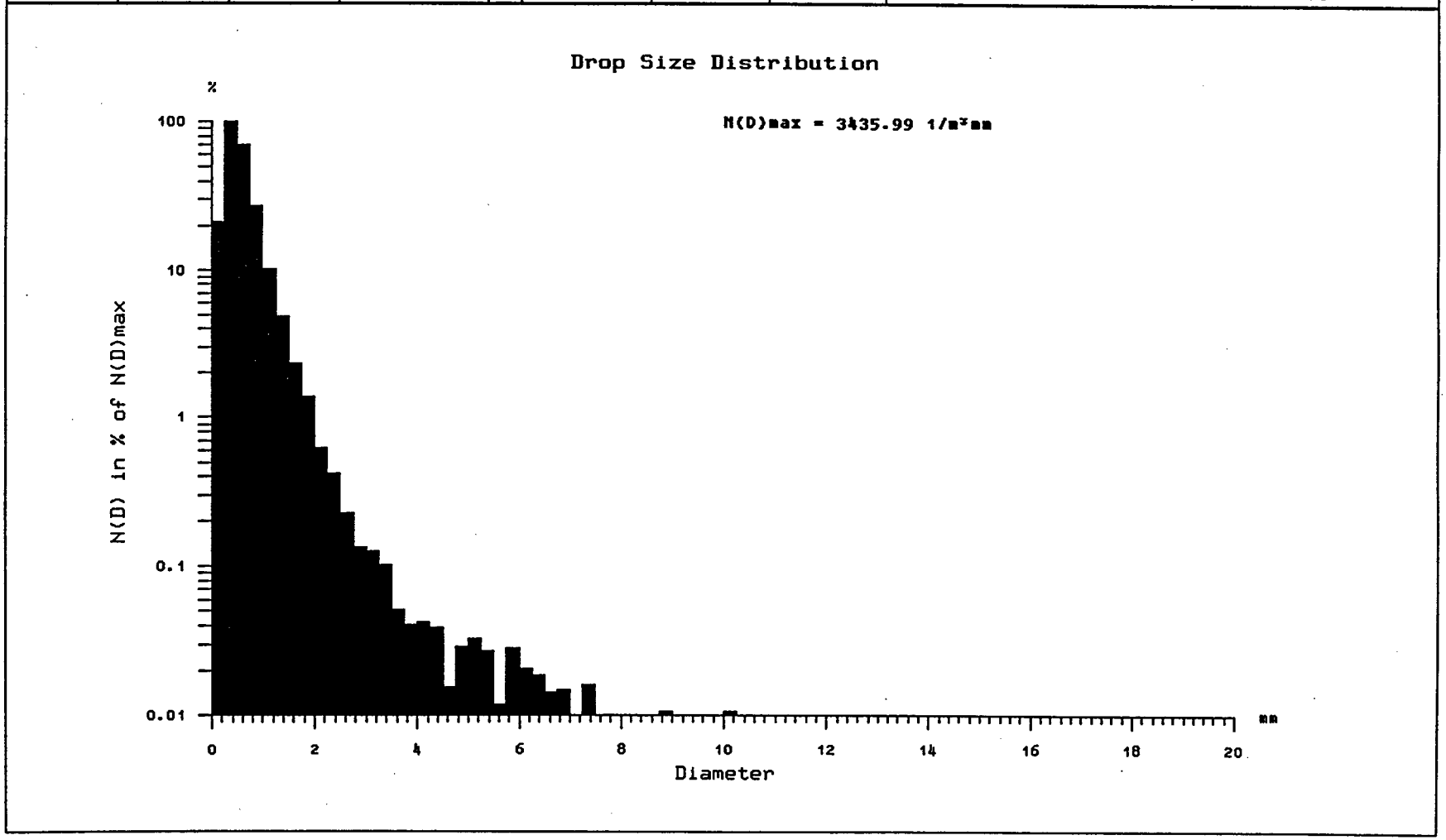
Date:	July 24, 1996
Julian Day:	206
Event:	1
Time:	18:21-18:35
Average Rain Rate:	24.93mm\hr
Total Rainfall:	5.96mm
Location:	Lat.- 40:42:42 Lon.-104:54:13
Contents:	Very little rain during hail event Pea to marble-sized hail

JOANNEUM RESEARCH - ESA | 2D-Video-Distrometer | Graz/Austria | Thu Jan 1 1970

File	v96206_1.hyd	Time	18:21 - 19:00	FILTER	Diameter	0.00 mm	50.00 mm
Int.	18:21:00-18:35:20	Date	Jan 1 1970		Velocity	0.00 m/s	30.00 m/s
Rain	5.96 mm				Oblateness	0.00	2.00
Time Int	860.00 s	Rainrate	24.93 mm/h		Pixel A	0	511
Objects	21310	ΔD	0.25 mm		Pixel B	0	511

RUN F1 | MAIN F2 | HARDCOPY F3 | HELP F4

ΔD < F5 | ΔD > F6 | Integr. F7 | COMP F8



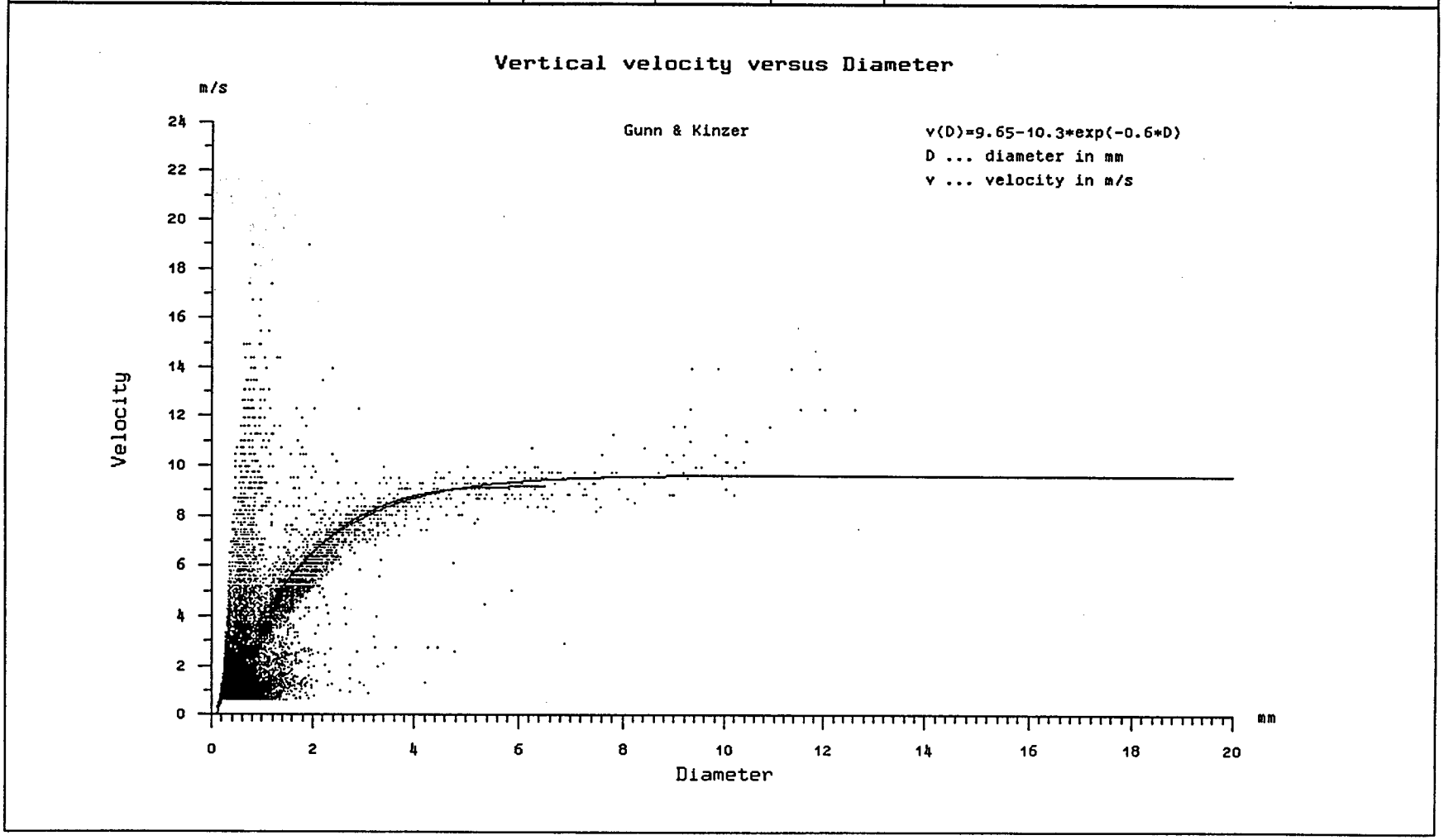
JOANNEUM RESEARCH - ESA | 2D-Video-Distrometer | Graz/Austria | Thu Jan 1 1970

File	v96206_1.hyd	Time	18:00 - 19:00
Int.	18:21:22-18:35:32	Date	Jan 1 1970
Objects	21318		

FILTER

Diameter	0.00 mm	50.00 mm
Velocity	0.00 m/s	30.00 m/s
Oblateness	0.00	2.00
Pixel A	0	511
Pixel B	0	511

RUN F1 | MAIN F2 | HARDCOPY F3 | HELP F4 | COMP F5



JOANNEUM RESEARCH - ESA | 2D-Video-Distrometer | Graz/Austria | Thu Jan 1 1970

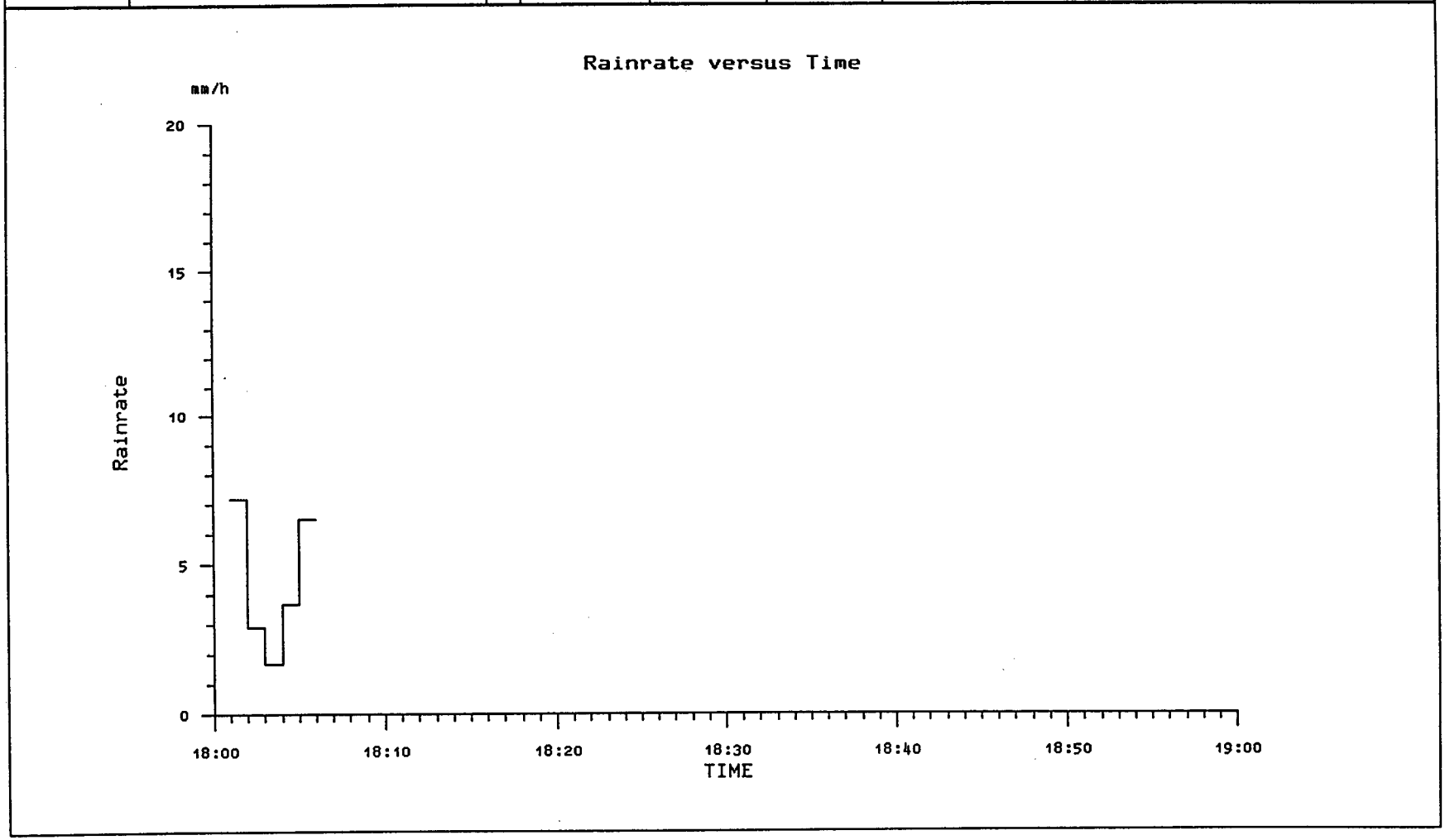
File	v96207_1.hyd	Time	18:00 - 19:00
Int.	18:01:00-18:06:50	Date	Jan 1 1970
Int. Mode	Time (60 sec)		
Rain	0.39 mm		

FILTER

Diameter	0.00 mm	50.00 mm
Velocity	0.00 m/s	30.00 m/s
Oblateness	0.00	2.00
Pixel A	0	511
Pixel B	0	511

RUN F1 | MAIN F2 | HARDCOPY F3 | HELP F4

SCALE < F5 | SCALE > F6 | Integr. F7 | TIP F8

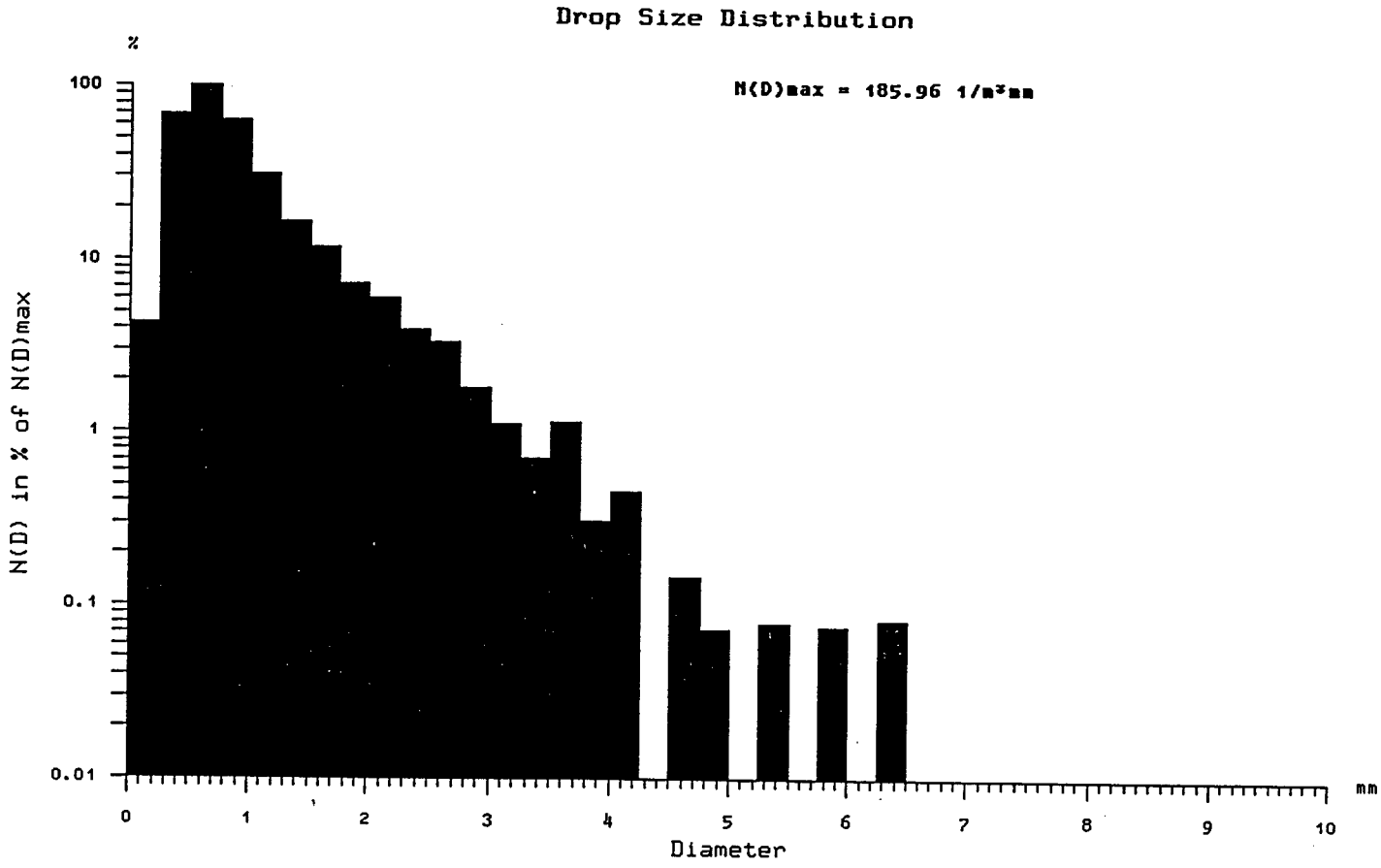


JOANNEUM RESEARCH - ESA 2D-Video-Distrometer Graz/Austria Thu Jan 1 1970

File	v96207_1.hyd	Time	18:01 - 19:00	FILTER	Diameter	0.00 mm	50.00 mm
Int.	18:01:00-18:06:45	Date	Jan 1 1970		Velocity	0.00 m/s	30.00 m/s
Rain	0.39 mm				Oblateness	0.00	2.00
Time Int	345.00 s	Rainrate	4.11 mm/h		Pixel A	0	511
Objects	1169	ΔD	0.25 mm		Pixel B	0	511

RUN F1 | MAIN F2 | HARDCOPY F3 | HELP F4

ΔD < F5 | ΔD > F6 | Integr. F7 | COMP F8



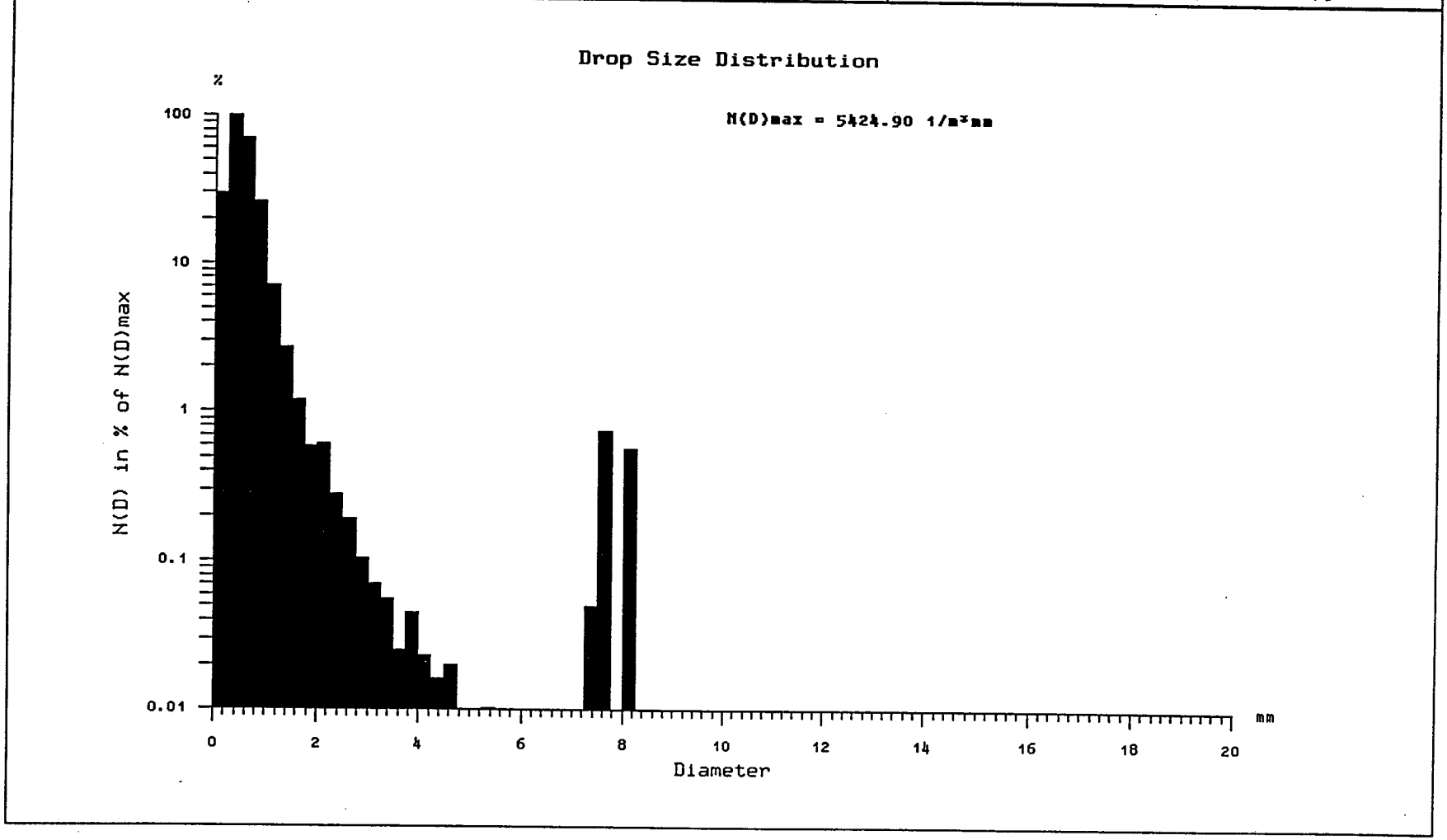
Date:	July 26, 1996
Julian Day:	208
Event:	1
Time:	16:06-16:30
Average Rain Rate:	25.85mm\hr
Total Rainfall:	10.56mm
Location:	16:06-16:12-Lat.- 41:2:17 Lon.- 104:18:47 16:12-16:30-Lat.- 41:3:8 Lon.-104:10:44
Contents:	16:06-16:12-Pea to marble-sized hail and heavy rain Acquired data while moving to new location 16:12-16:30- Heavy rain with no hail

JOANNEUM RESEARCH - ESA | 2D-Video-Distrometer | Graz/Austria | Thu Jan 1 1970

File	v96208_1.hyd	Time	16:06 - 17:00	FILTER	Diameter	0.00 mm	50.00 mm
Int.	16:06:00-16:30:30	Date	Jan 1 1970		Velocity	0.00 m/s	30.00 m/s
Rain	10.56 mm				Oblateness	0.00	2.00
Time Int	1470.00 s	Rainrate	25.85 mm/h		Pixel A	0	511
Objects	54989	ΔD	0.25 mm		Pixel B	0	511

RUN F1 | MAIN F2 | HARDCOPY F3 | HELP F4

ΔD < F5 | ΔD > F6 | Integr. F7 | COMP F8



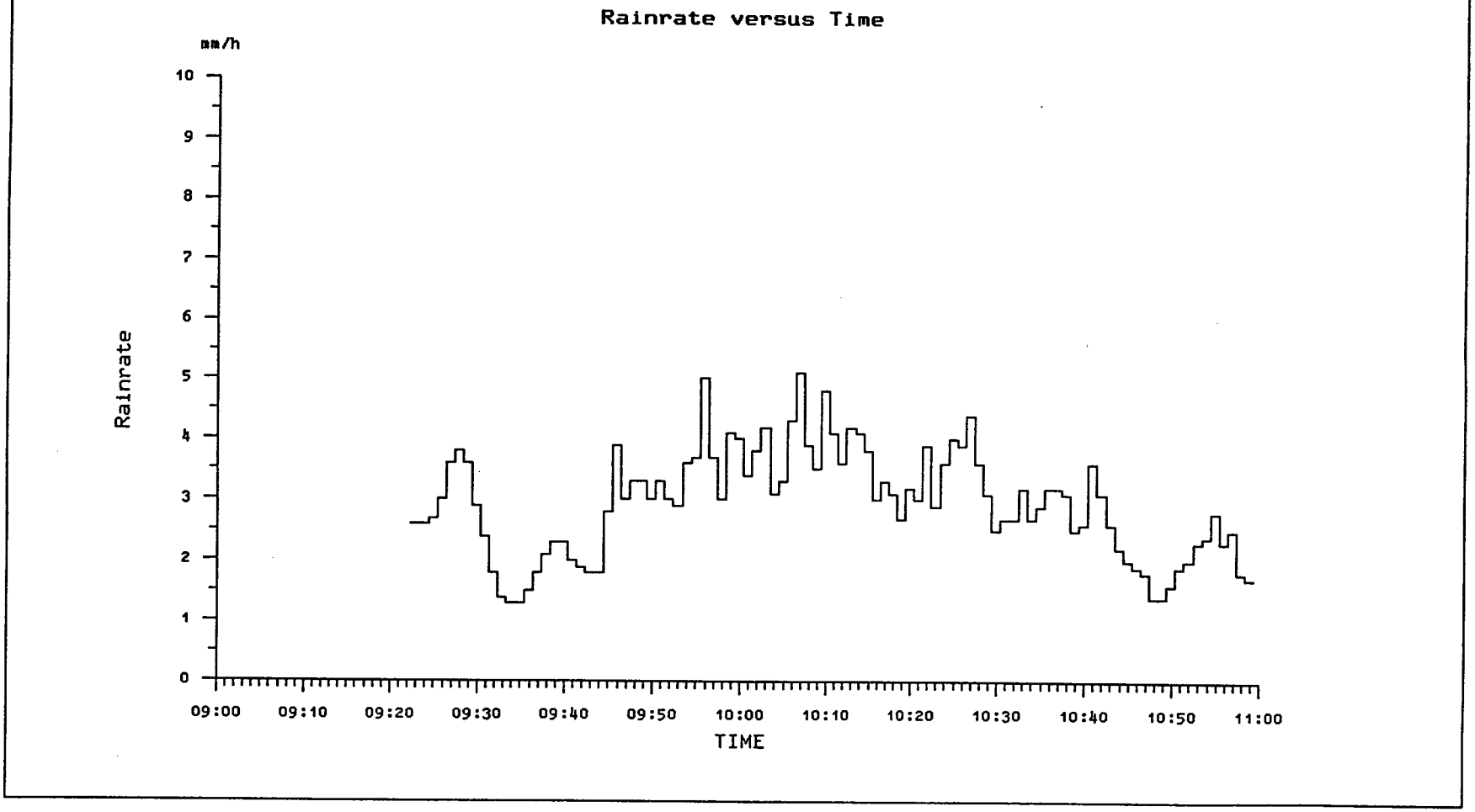
Date:	July 29, 1996
Julian Day:	211
Event:	1
Time:	9:22-11:05
Average Rain Rate:	3.16mm\hr
Total Rainfall:	.25mm
Location:	EE parking lot Lat.- 40:34:35 Lon.-105:05:0
Contents:	Moderate rain Rain had a widespread Very constant Large drops around 10:00 Lighter rain towards the end Van scans

JOANNEUM RESEARCH - ESA | 2D-Video-Distrometer | Graz/Austria | Wed Mar 18 1970

File	v96211_1.hyd	Time	09:22 - 11:00	FILTER	Diameter	0.00 mm	50.00 mm
Int.	09:22:22-10:59:59	Date	Mar 18 1970		Velocity	0.00 m/s	30.00 m/s
					Oblateness	0.00	2.00
Int. Mode	Time (60 sec)				Pixel A	0	511
Rain	4.86 mm				Pixel B	0	511

RUN F1 | MAIN F2 | HARDCOPY F3 | HELP F4

SCALE < F5 | SCALE > F6 | Integr. F7 | TIP F8



MISSION OF ROME LABORATORY

Mission. The mission of Rome Laboratory is to advance the science and technologies of command, control, communications and intelligence and to transition them into systems to meet customer needs. To achieve this, Rome Lab:

a. Conducts vigorous research, development and test programs in all applicable technologies;

b. Transitions technology to current and future systems to improve operational capability, readiness, and supportability;

c. Provides a full range of technical support to Air Force Material Command product centers and other Air Force organizations;

d. Promotes transfer of technology to the private sector;

e. Maintains leading edge technological expertise in the areas of surveillance, communications, command and control, intelligence, reliability science, electro-magnetic technology, photonics, signal processing, and computational science.

The thrust areas of technical competence include: Surveillance, Communications, Command and Control, Intelligence, Signal Processing, Computer Science and Technology, Electromagnetic Technology, Photonics and Reliability Sciences.