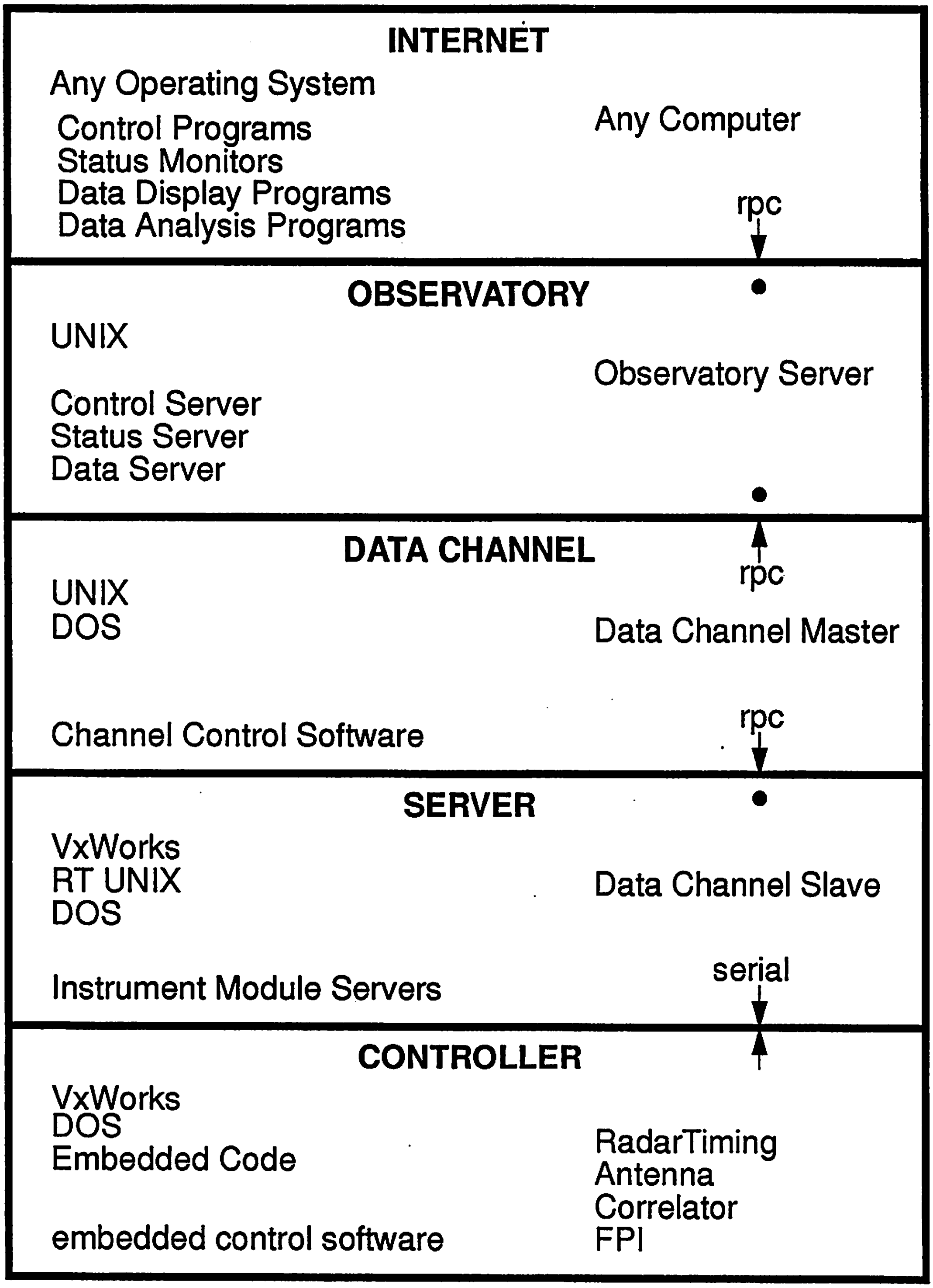
1994 CEDAR Workshop
Boulder, Colorado
June 20-25, 1994

Telescience Tutorial Section

by John Holt
MIT/Haystack

Telescience at Millstone Hill

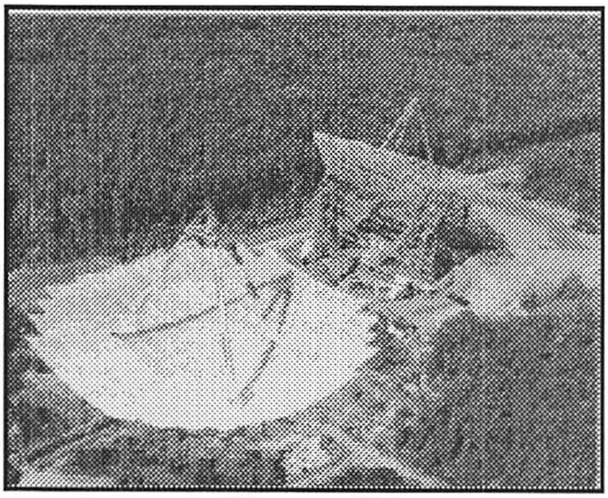
OBSERVATORY SOFTWARE MODEL



The Worldwide Web is an Internet information access tool which organizes Internet information resources as a set of hypertext documents. The user traverses the network by moving from one hypertext document to another via links that are implemented between them.

Many different types of documents may be accessed in this fashion, for example, text files, postscript files, audio files, images, movies and native WWW documents which may contain links to other documents anywhere on the Internet.
+ HDF, netCDF

Mosaic is a particularly popular WWW viewer which features a point-and-click interface and inline images, and supports an extensible set of document types by means of separate viewers.
And - Mosaic is free and runs on workstations, PCs and Macs.



Millstone Hill Observatory

The Millstone Hill Observatory, located in Westford Massachusetts, is a broad–based atmospheric sciences research facility owned and operated by the Massachusetts Institute of Technology. The Atmospheric Sciences Group, which staffs and manages the observatory, is a part of M.I.T's Haystack Observatory, a basic research organization whose focus is radio wave and radar science, instrumentation and techniques.

The following resources may be of interest. EISCAT is a particularly good source of data and useful information. See, for example, incoherent scatter radar and magnetosphere.

- Millstone Hill Observatory: Information, data, etc., including real–time radar status and data when the radar is operating.
- Haystack Young Scholars Program: Haystack's annual summer program for middle school students.
- Incoherent Scatter Radar Stations: Interactive map of incoherent scatter radars.
- EISCAT: European Incoherent Scatter Association.
- Arecibo: National Astronomy and Ionosphere Center (NAIC) Arecibo Observatory.
- JRO: Jicamarca Radio Observatory.
- Poker Flat Research Range: Scientific, rocket launching facility owned by the University of Alaska.
- CASS: The Center for Atmospheric and Space Sciences at Utah State University.
- NCAR: National Center for Atmospheric Research.
- NSF: National Science Foundation Gopher server, NSF forms, etc.
- NASA: National Aeronautics and Space Administration.
- NGDC: National Geophysical Data Center.
- Internet Resources Meta–Index: Starting point for Internet exploration.

This service is under development and may not always work as expected. Suggestions and comments should be directed to John M. Holt. Usage statistics for this service are here.

Millstone Hill Observatory / jmh@chaos.haystack.edu

NCSA Mosaic: Document View

File Options Navigate Annotate Help

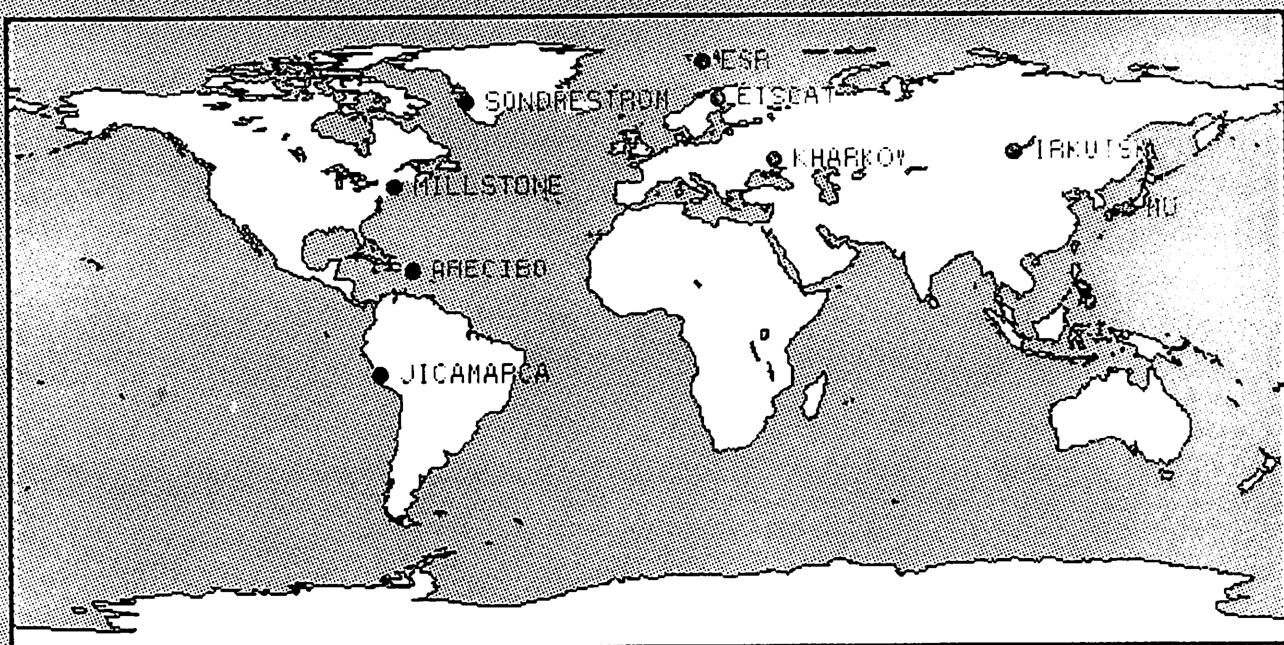
Document Title: Millstone Hill Observatory URSI Incoherent Scatter Working Group

Document URL: http://hyperion.haystack.edu/iswg/iswg.html

URSI Incoherent Scatter Working Group

Incoherent Scatter Radars

This map shows all of the world's operational incoherent scatter radars (The EISCAT Svalbard Radar will begin operations in December, 1995). If a radar has a WWW server, you can access it by clicking on the red dot.



- List of Operational Incoherent Scatter Radars
- Working Group Report: 1991-1993
- Incoherent Scatter Coordinated Observation Days for 1994

Data transfer complete.

Back | Forward | Home | Reload | Open... | Save As... | Clone | New Window | Close Window

NCSA Mosaic: Document View

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Document Title: Millstone Hill Observatory

Document URL: http://hyperion.haystack.edu/cgi-bin/mhrobs_cgi

Millstone Hill Observatory

An Introduction to the Millstone Hill Observatory

- Introduction
- History (1960-1988)
- Capabilities
- Instrumentation
- Recent Scientific Emphasis
- New Initiatives
- Bibliography

An Introduction to Incoherent Scatter Radar

(Under Development)

Documents and Data

- News
- Schedules
- Documents
- Computing Systems
- MIDAS Data Acquisition System
- OASIS Incoherent Scatter Analysis (under construction)
- CEDAR Database
- URSI Incoherent Scatter Working Group
- Address List
- Staff

Radar Status – Tue Jun 14 10:20:16 1994

ON

Fabry-Perot Coordinated Observations (local 10 position)
MISA - Idle
ZENITH - 300 usec single pulse calibration
UHF Peak Power = 0.0 MW
MISA azimuth, elevation = 177.9, 1.2 deg

Here is a plot of the most recent raw data record (autocorrelation functions, signal-to-noise ratios and spectra), and here is a plot of the most recent ionospheric parameters. During development periods these may be rather meaningless (see the schedule)

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File Options Navigate Annotate Help

Document Title: Millstone Hill Observatory MIDAS Wide Coverage 1

Document URL: http://hyperion.haystack.edu/midas/wide_coverage_1.html

MIDAS Wide Coverage 1

WIDE_COVERAGE_1

EXPERIMENT CYCLE TIME: 47 minutes

SEQUENCE OF POINTING DIRECTIONS:

AZ	EL	Antenna	Mode	Duration
180	88	Zenith	s640.20z	120 sec
270	60	MISA	s640.20m	120 sec
180	88	Zenith	s640.20z	120 sec
0	60	MISA	s640.20m	120 sec
0	75-4.2	MISA	s640.20m	35 sec * 12 elevation
180	88	Zenith	s320.20z	120 sec
180	88	Zenith	s40.20z	120 sec
180	88	Zenith	s640.20z	120 sec
90-270	6	MISA	s2000.20m	35 sec * 36 azimuths

MODE SPECIFICATIONS:

s640.20z

640 usec	Single pulse
Sample Rate	20 usec
Altitude	135 - 1031 km
RF Duty Cycle	5.52%
Beam Duty Cycle	5.94%
PRF	86.21 pulses/sec
Freq Commutate	No
Clutter Subtract	No

s640.20m

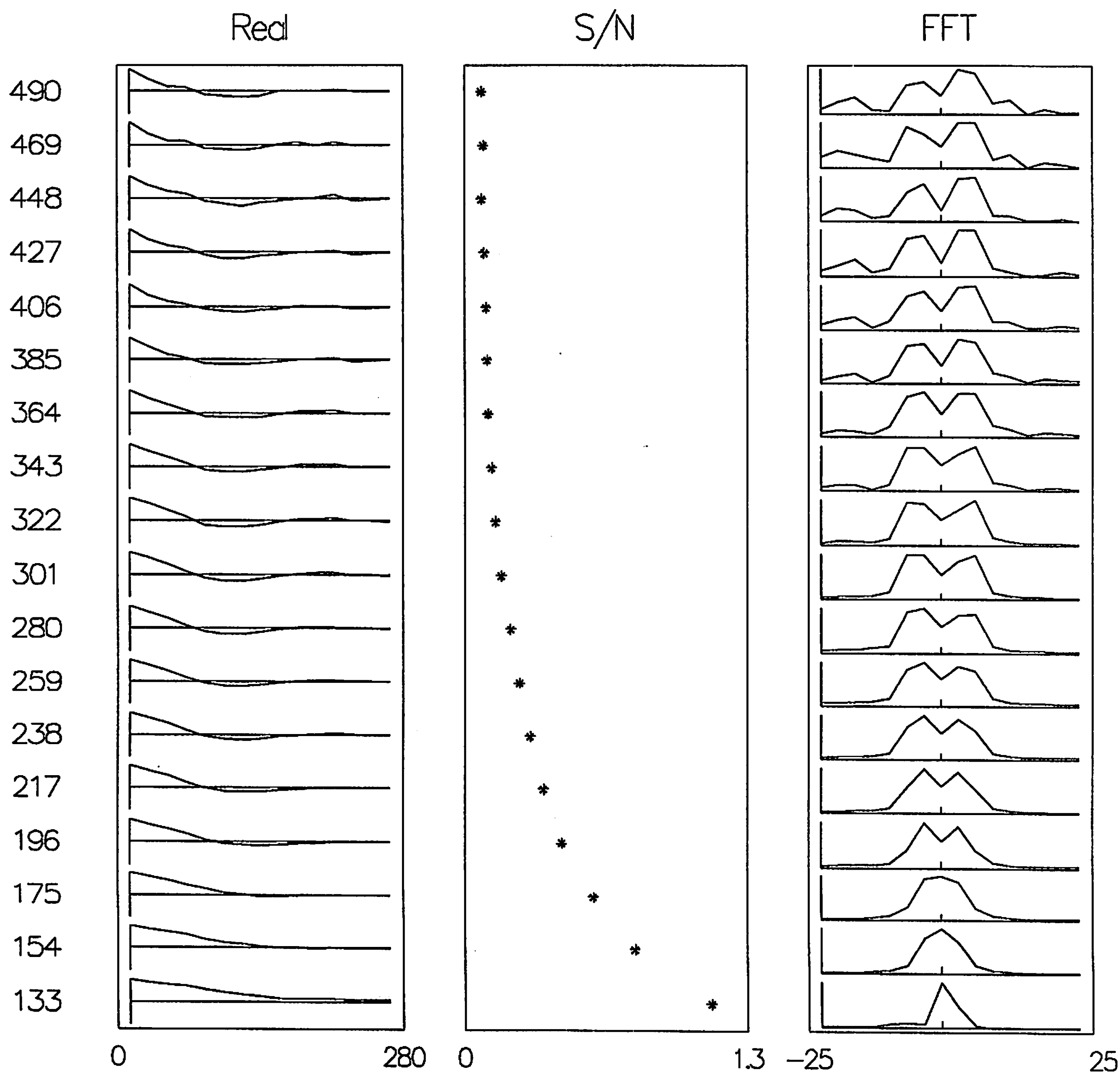
640 usec	Single pulse
Sample Rate	20 usec
Altitude	135 - 1031 (60 deg el). See table for
RF Duty Cycle	5.52%
Beam Duty Cycle	5.94%
PRF	86.21 pulses/sec

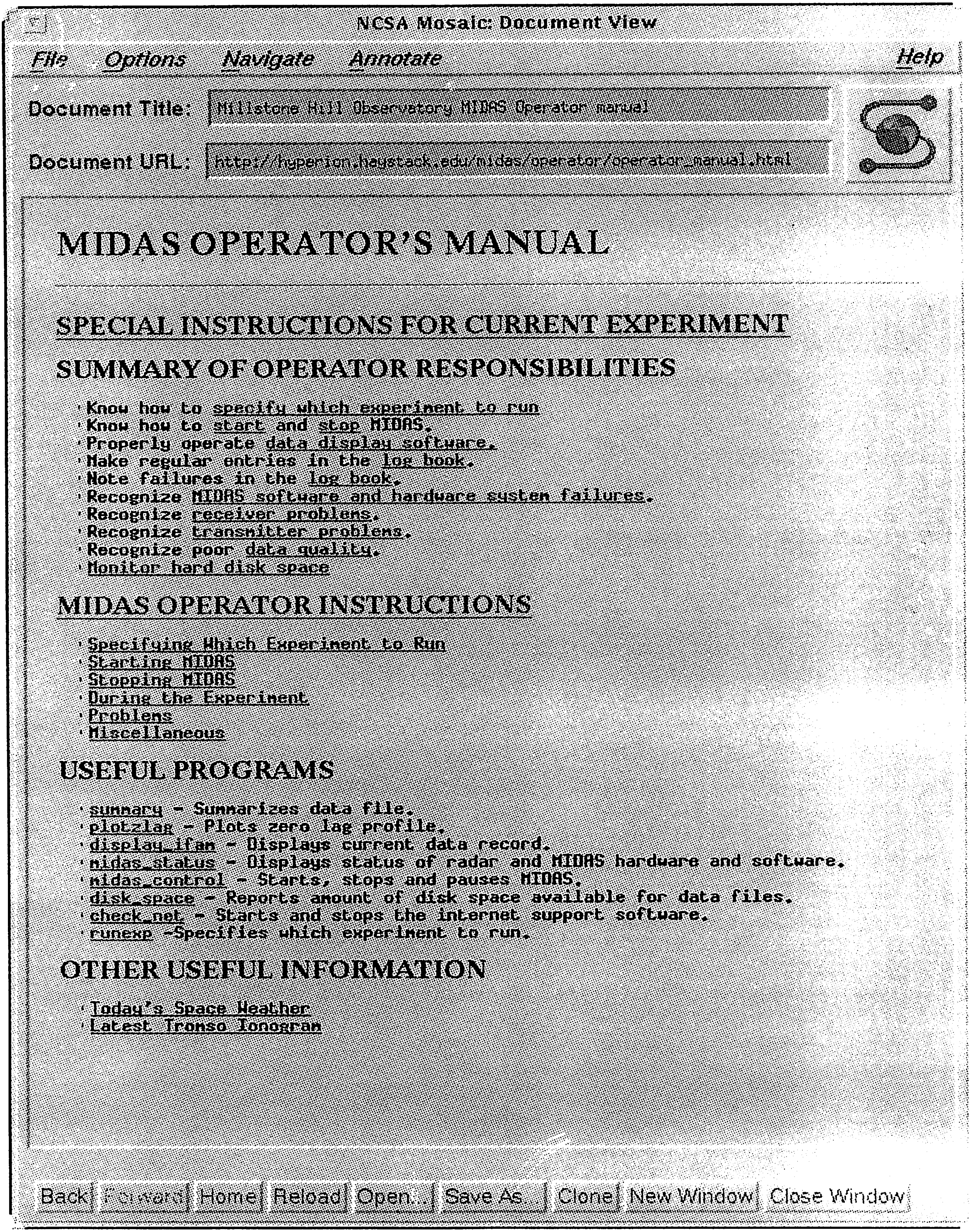
Back Forward Home Reload Open... Save As... Clone New Window Close Window

6/9/1994 17:46:51 17:47:49 177.9 177.9 88.0 88.0

MSA 2.31MW 442.4K 431.7K

waveform: 300 usec, baud: 300 usec





MIDAS OPERATOR'S MANUAL

SPECIAL INSTRUCTIONS FOR CURRENT EXPERIMENT

SUMMARY OF OPERATOR RESPONSIBILITIES

- Know how to specify which experiment to run
- Know how to start and stop MIDAS.
- Properly operate data display software.
- Make regular entries in the log book.
- Note failures in the log book.
- Recognize MIDAS software and hardware system failures.
- Recognize receiver problems.
- Recognize transmitter problems.
- Recognize poor data quality.
- Monitor hard disk space

MIDAS OPERATOR INSTRUCTIONS

- Specifying Which Experiment to Run
- Starting MIDAS
- Stopping MIDAS
- During the Experiment
- Problems
- Miscellaneous

USEFUL PROGRAMS

- summary - Summarizes data file.
- plotzlag - Plots zero lag profile.
- display_ifam - Displays current data record.
- midas_status - Displays status of radar and MIDAS hardware and software.
- midas_control - Starts, stops and pauses MIDAS.
- disk_space - Reports amount of disk space available for data files.
- check_net - Starts and stops the internet support software.
- runexp -Specifies which experiment to run.

OTHER USEFUL INFORMATION

- Today's Space Weather
- Latest Tromso Ionogram

This is a simplified introduction to the incoherent scatter radar technique used at the Millstone Hill Observatory. As time goes on, links to more detailed and advanced material will be added. For example, another introduction to incoherent scatter radar is here. This is a dynamic document which is illustrated by near–real–time data when the radar is running. The daemon which updates this document attempts to screen out bad data, but on occasion it may fail, and the figure may not make the desired point. Next to each figure there is a link to a prescreened illustration, which you may want to view if the figure in the document seems wrong.

RADAR (RAdio Detection And Ranging) is a technique for detecting and studying remote targets by transmitting a radio wave in the direction of the target and observing the reflection of the wave.

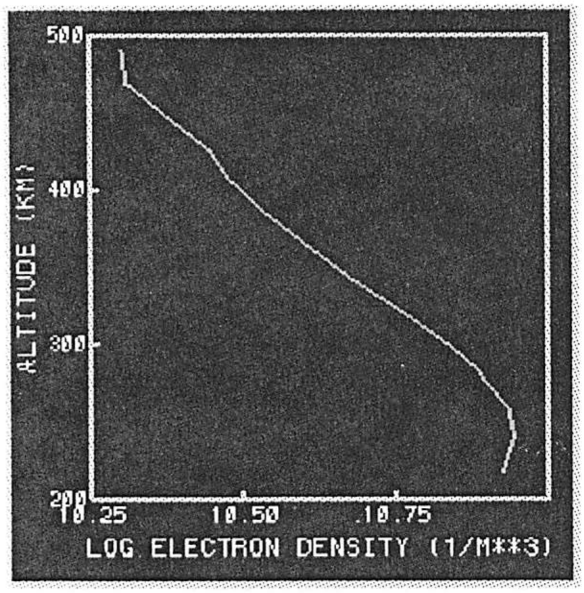
The most basic property of a target which can be measured by radar is its distance from the radar, known as the range. This is accomplished by transmitting short bursts, or pulses, and measuring the time between the transmission and the reception of the echo. Since radio waves travel at the speed of light (c = 300,000 km/sec = 186,000 miles per second), range = c*time/2, where the factor of 2 is because the measured time is for a round trip to and from the target. The range, together with the direction of the target, determine its location, which is what is needed for many radar applications such as air traffic control.

The strength of the received echo can also be measured. This will vary with the distance of the target, its size, its shape and its composition. For example, the echo from a Boeing 747 airliner will be much stronger that the echo from a small commuter aircraft. The echo from a stealth aircraft is much smaller than from a commercial aircraft of the same size because its shape and composition are carefully chosen to minimize radar returns.

The target of the Millstone Hill incoherent scatter radar is electrons in the earth's ionosphere rather than a discrete hard target like an airplane. The ionosphere extends from about 100 km (60 miles) to 1000 km (600 miles) above the earth's surface. High energy ultraviolet radiation from the sun removes electrons from some of the atoms and molecules in this region, and these electrons can scatter radio waves. The density of the electrons ranges from about 10,000 to 1,000,000 per cubic centimeter. Since the amount of energy scattered from each electron is well known, the strength of the echo received from the ionsphere measures the number of electrons in the scattering volume, and thus the electron density or pressure. Thus the radar functions much like a barometer. An example of the variation of electron density with altitude is shown in the following figure.

The data shown in this and the following figures were collected on 06/09/94 at 15:51:44 UT. The pulse–length was 300.0 microseconds, which corresponds to an altitude resolution of 45.0 km. The transmitter power was 2.57 megawatts and the density was measured at 23 ranges between 200 and 500 km above the earth.

Electron Density



PRESCREENED FIGURE

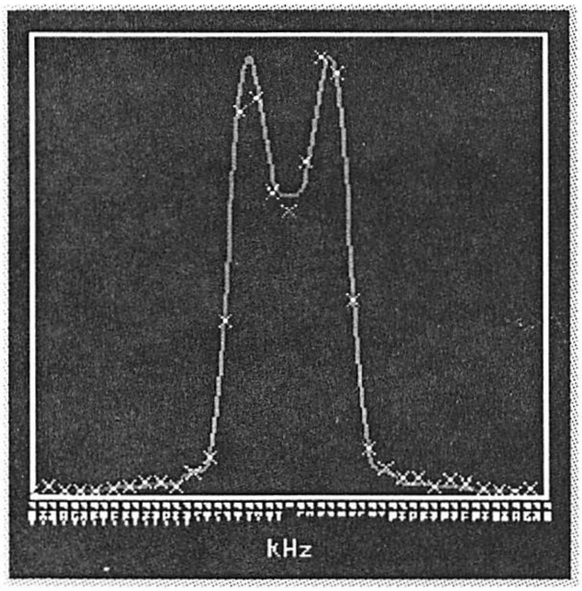
Another important measurement made by some radars is the Doppler shift of the echo. The radar transmits a radio wave of known frequency – 440 MHz in the case of the Millstone Hill Radar. If the target is moving away from the radar, the waves in the reflected signal will be stretched, and the echo will have a lower frequency than the transmitted signal. Conversely, if the target is moving toward the radar, the waves will be compressed and the echo will have a higher frequency. This is how police radar guns work. They just transmit a continuous wave. Since the distance to the target is unimportant, the traffic officer only needs to know which vehicle he is pointing his radar at. The radar gun compares the frequency of the wave reflected from the vehicle to the frequency of the transmitted wave, and displays the vehicle's speed.

An incoherent scatter echo comes from a very large number of electrons. These are not stationary, but rather are in random thermal motion. Thus the echo will not be at a single frequency, but instead will contain a range. or spectrum of frequencies near the transmitter frequency. As the temperature increases, the average velocity of the electrons increases, and the range of velocities increases. Put another way, the width of the spectrum increases. The width of the spectrum is then a measure of the temperature of the ionosphere, and the incoherent scatter radar functions as a thermometer. In fact, it turns out that there are two temperatures in the ionosphere. When an electron is removed from an atom, the remaining atom, which is now missing an electron, is known as an ion. The ion gas may have a different temperature from the electon gas. As a result of electrical interactions between the ions and electrons, the width of the spectrum measures the ion temperature. However, the spectrum usually has two peaks, or wings, and the height of these wings measures the electron temperature. The electron/ion mixture is known as a plasma, and in addition to the thermal motions, the entire plasma is usually in motion. In other words, there is a plasma wind. As a result, the entire spectrum will be shifted instead of being centered on the transmitter frequency. Thus an incoherent scatter radar also functions as a wind speed meter. An example of a spectrum is shown in the following figure.

The yellow crosses are the measured spectrum from 258.9 km. The red curve is a theoretical spectrum corresponding to an ion temperature of 913.1 degrees Kelvin, an electron temperature of 2104.3 degrees Kelvin, and an drift velocity (wind) of 17.5 meters/second.

Incoherent scatter spectra are analized by finding the temperatures and velocity which yield a theoretical spectrum which most closely matches the measured spectrum.

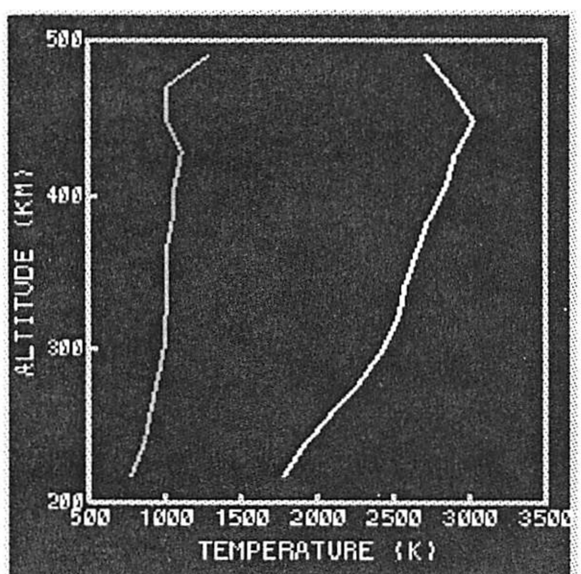
Measured and Fit Spectra



PRESCREENED FIGURE

The next figure show the ion temperatures (red) and electron temperatures (yellow) derived from the width of the spectrum and the height of the wings of the spectrum.

Ion and Electron Temperature



PRESCREENED FIGURE

The final figure shows the line–of–sight drift determined from the offset of the spectrum from the transmitter frequency.

Line–of–sight Ion Drift

NCSA Mosaic: Document View

File Options Navigate Annotate Help

Document Title: Millstone Hill Observatory CEDAR Database System

Document URL: http://hyperion.haystack.edu/madrigal/madrigal.html

CEDAR Database

MADRIGAL

MADRIGAL is an interactive interface to the CEDAR Database. It was developed at the Millstone Hill Observatory. For further information, contact Steve Cariglia. WEB access to several MADRIGAL utilities will be available soon.

- MADRIGAL Manual
- Current on-line database holdings at Millstone Hill

CEDAR Database documents

These are also available by anonymous ftp from NCAR.

- The CEDAR Access Form. Use this once a year to affirm your commitment to the 'Rules of the Road'. Questions about past use and future desires. Is also the form to request a login to the cedar machine.
- A list of the database contents ordered by data volume name.
- The Experiment Listing by Station. Perhaps more recent than the Catalogue version, this is the most detailed inventory listed in order by station number (KINST) and date.
- The CEDAR Data Request Form. Use this to order data, models, or documents.
- The Combined Daily Listing for Fabry-Perot Interferometers. Also printed in the catalogue, this indicates dates on which Fabry-Perot data are available. Daily Ap values are also provided.
- Analogous to the Fabry-Perot table, this is for Incoherent Scatter (IS) Radar data. If Fabry-Perot data at an IS site is available in the Data Base on the same day, it is denoted in this table with an 'F'.
- A listing of all instruments in the database showing the number of months with data for each year.
- A list of parameter codes used in the database.
- Special parameter codes definitions for Sondre Stromfjord and Chatinika I.S. Radar data (3000 and 30000 series codes).
- A postscript version of the CEDAR Database User Guide.

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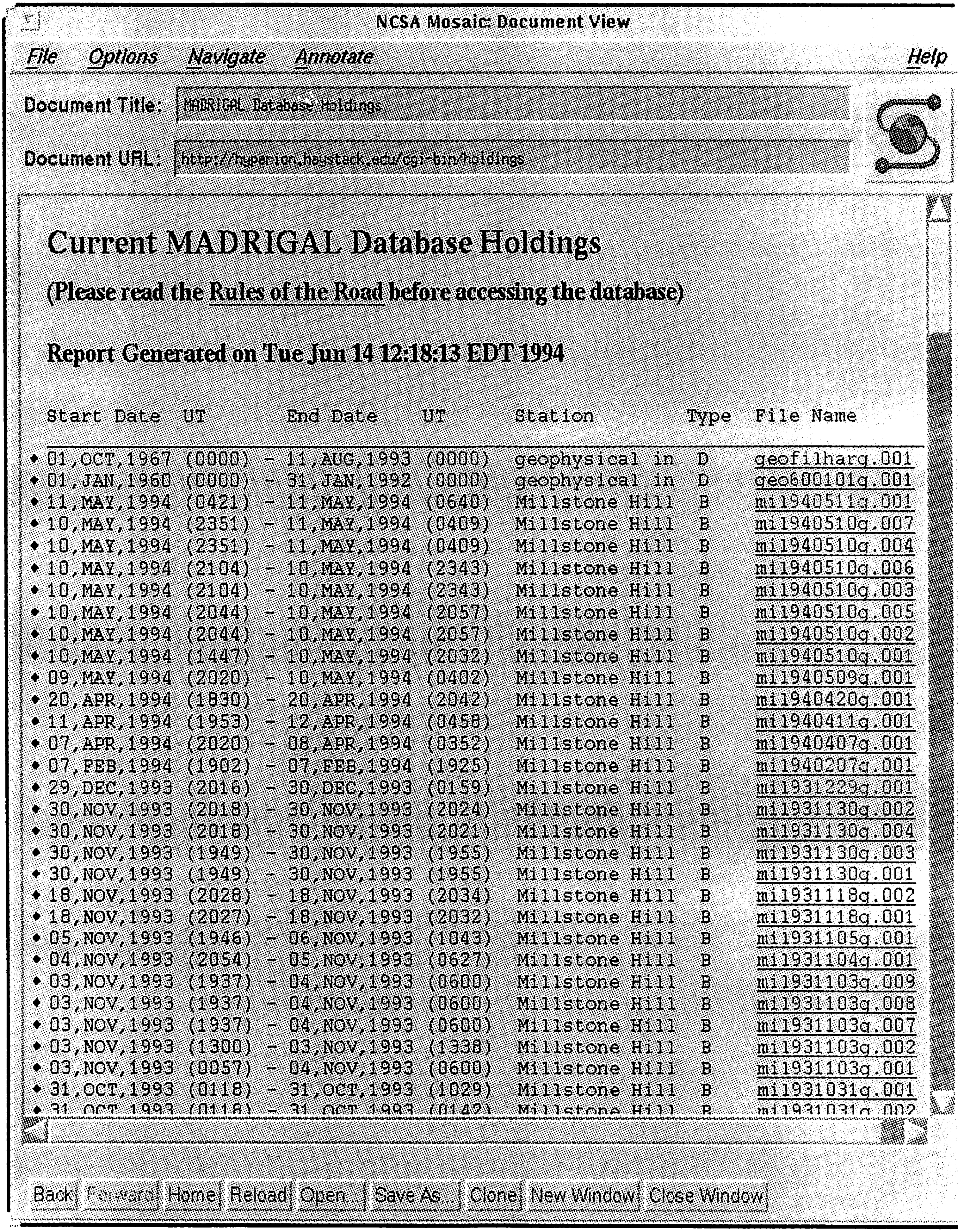

Current MADRIGAL Database Holdings

(Please read the Rules of the Road before accessing the database)

Report Generated on Tue Jun 14 12:18:13 EDT 1994

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01,JAN,1960	(0000)	-	31,JAN,1992	(0000)	geophysical in	D	geo600101g.001
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10,MAY,1994	(2104)	-	10,MAY,1994	(2343)	Millstone Hill	B	mil940510g.006
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09,MAY,1994	(2020)	-	10,MAY,1994	(0402)	Millstone Hill	B	mil940509g.001
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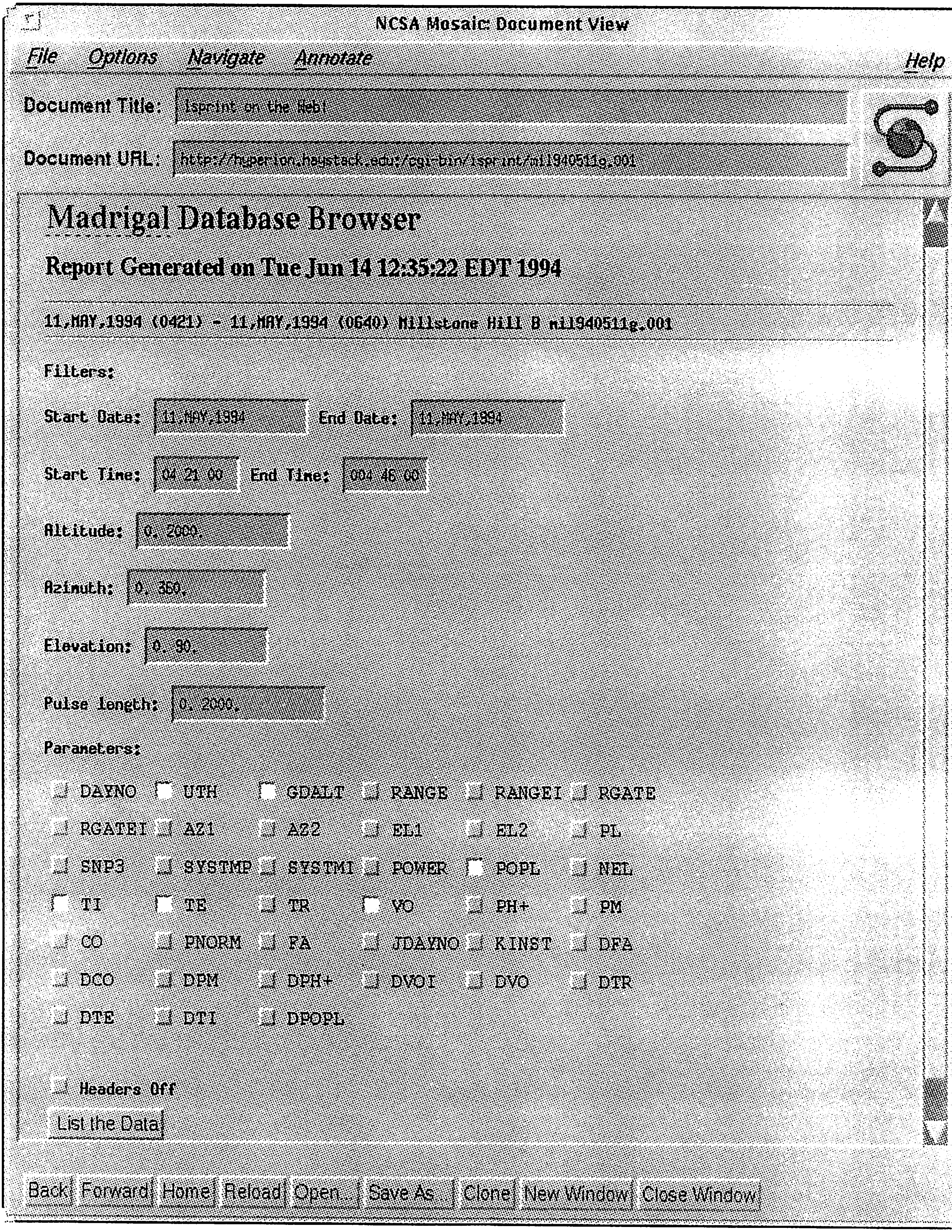
NCSA Mosaic: Document View
File Options Navigate Annotate Help
Document Title: isprint on the Web!
Document URL: http://hyperion.haystack.edu/cgi-bin/isprint/mil940511g.001
Madrigal Database Browser
Report Generated on Tue Jun 14 12:35:22 EDT 1994
11,MAY,1994 (0421) - 11,MAY,1994 (0640) Millstone Hill B mil940511g.001
Filters:
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Start Time: 04 21 00 End Time: 004 46 00
Altitude: 0, 2000.
Azimuth: 0, 360.
Elevation: 0, 90.
Pulse length: 0, 2000.
Parameters:
DAYNO UTH GDALT RANGE RANGEI RGATE
RGATEI AZ1 AZ2 EL1 EL2 PL
SNP3 SYSTMP SYSTMI POWER POPL NEL
TI TE TR VO PH+ PM
CO PNORM FA JDAYNO KINST DFA
DCO DPM DPH+ DVOI DVO DTR
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Headers Off
List the Data
Back Forward Home Reload Open... Save As... Clone New Window Close Window

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Document Title: Isprint on the Web!

Document URL: http://hyperion.haystack.edu/cgi-bin/isprint/mil940511g.001

ISprint Output:

Report Generated on Tue Jun 14 12:41:06 EDT 1994

This is preliminary data which has not been fully verified. Please contact the Millstone Hill Observatory before using it.

Millst 05/11/94 0421:56-0422:54 AZ= 179.0- 179.0 EL= 88.0- 88.0 PL= 300

UTH	GDALT	POPL	TI	TE	VO
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4.374	238.01	10.0650	739.0	770.0	-26.0
4.374	258.99	10.2710	757.0	883.4	-26.0
4.374	279.96	10.4130	801.0	937.2	-7.0
4.374	300.93	10.4960	832.0	992.6	9.0
4.374	321.90	10.5220	823.0	1055.1	38.0
4.374	342.87	10.5030	782.0	1122.2	38.0
4.374	363.84	10.4520	712.0	1191.9	30.0
4.374	384.82	10.4260	725.0	1205.0	44.0

Millst 05/11/94 0423:02-0424:00 AZ= 179.0- 179.0 EL= 88.0- 88.0 PL= 300

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4.392	279.96	10.4120	1072.0	801.9	-8.0
4.392	300.93	10.4890	987.0	909.0	-25.0
4.392	321.90	10.5030	984.0	907.2	-12.0
4.392	342.87	10.4760	975.0	961.4	6.0
4.392	363.84	10.4300	998.0	1048.9	4.0
4.392	384.82	10.3610	943.0	1154.2	-15.0

Millst 05/11/94 0425:46-0427:45 AZ= 165.7- 165.4 EL= 68.5- 68.5 PL= 300

UTH	GDALT	POPL	TI	TE	VO
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4.446	241.59	10.5410	965.0	619.5	-42.0
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4.446	280.84	10.9200	1009.0	730.5	-6.0
4.446	300.48	10.9960	947.0	759.5	-17.0
4.446	320.12	11.0180	975.0	834.6	-13.0
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4.446	359.44	10.9800	1144.0	832.8	5.0
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