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International Atomic
Energy Agency

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ICTP-COST-USNSWP-CAWSES-INAF-INFN
International Advanced School
on
Space Weather
2-19 May 2006

Solar Radiophysics and Space Weather

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34012 Trieste
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New SpW Data Products and Accessibility in the TSRS Coronal Radio Surveillance

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[2] *Dept. of Physics, Trieste University*

in Proc. ESA Space Weather Workshop: Developing a European Space Weather Service Network
3-5 November 2003, ESTEC, Noordwijk, The Netherlands

Scheme of the Talk

- Relevance of Solar Radio Emission to Space Weather
- TSRS – The Trieste Solar Radio System
- TSRS Data Products
- TSRS Data Access
- The TSRS WWW Site
- Conclusions

in Proc. ESA Space Weather Workshop: Developing a European Space Weather Service Network
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Relevance of Solar Radio Emission to SpW

- PROXIES OF SOLAR DRIVERS
  - Type I Bursts (magnetic topology changes)
  - Type II Bursts (propagating shocks; particle beams)
  - Type III Bursts (particle acceleration; particle beams)
  - Type IV Bursts (magnetic reconnection; acceleration)
  - Spikes (energy release fragmentation; acceleration)
  - Precursors (radio signatures preceding flares)
  - 10 cm / 2800 MHz (EUV enhancements)
- DIRECT SOURCE OF GEOEFFECTS
  - Radio Flares (Very Intense Broad Band Radio Noise)

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The Sun as a Radio Noise Source

- The Sun is a radio source
  - non-directional
  - broad band
- Solar radio noise can
  - increase by several orders of magnitude during outbursts
  - persist at high levels for minutes to hours
- Enhanced solar radio noise can perturb
  - HF communications (MIL!)
  - Mobile communications (GSM, GPRS, UMTS!)

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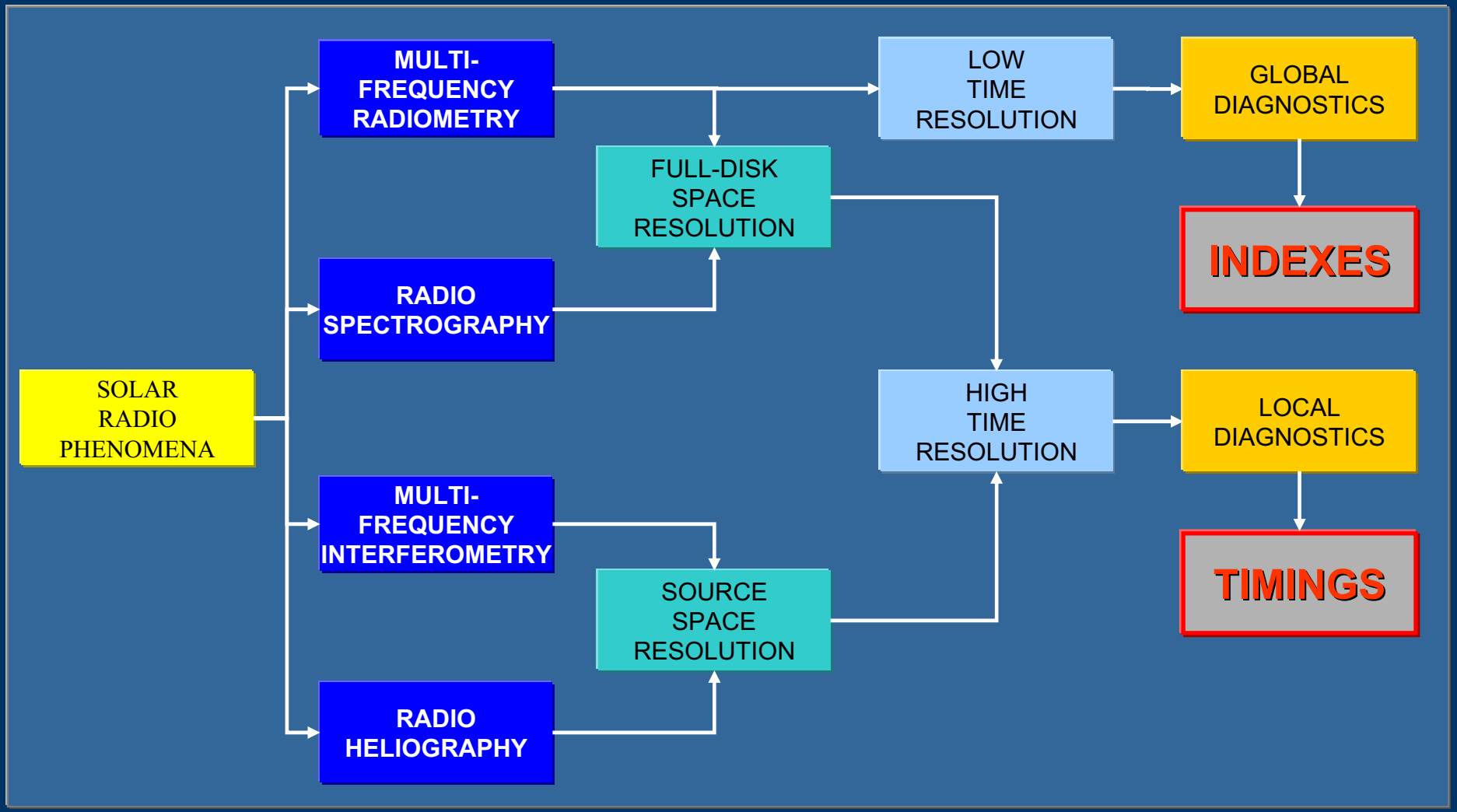
RADIO DIAGNOSTICS RELEVANT TO SPACE WEATHER APPLICATIONS



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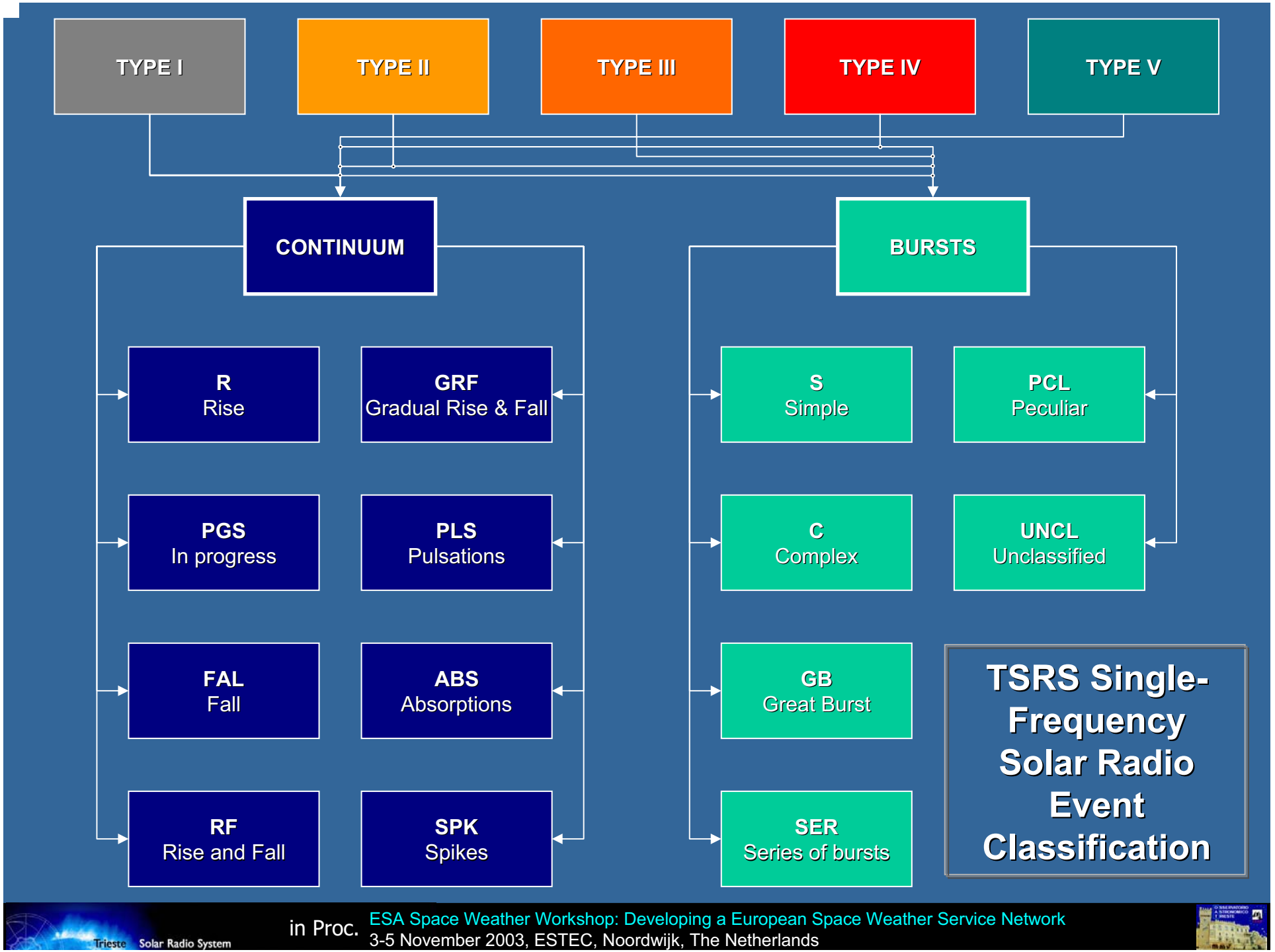

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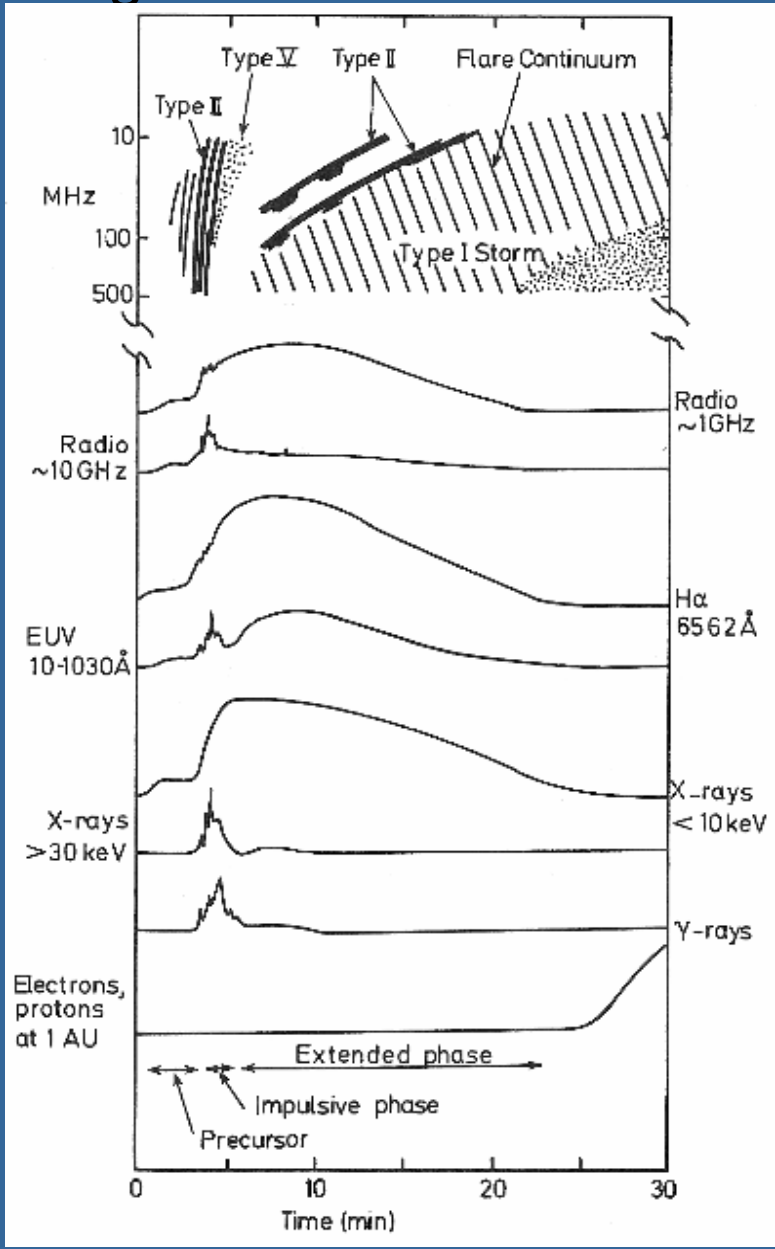
Timing of Flare-Related Events



McLean & Labrum (1985)

SPACE WEATHER
SEC Alerts and Warnings

CATEGORY TYPE	THRESHOLD	ALERT	WARNING
Radio			
245 MHz burst	peak flux ≥ 100 s.f.u.	*	
245 MHz noise storm	peak flux > 5 times background	*	
10 cm burst	peak flux ≥ 100% above background	*	
Type II event	any	*	
Type IV event	any	*	
Particle			
Electron Event	peak flux 10^3 pfu @ > 2 MeV	*	
Suspected Proton Flare	peak flux 10 p.f.u. @ > 10 MeV	*	
P10 Proton event	peak flux 10 p.f.u. @ > 10 MeV	*	*
P100 Proton event	peak flux 100 p.f.u. @ >100 MeV	*	*
SST Radiation Alert	≥ 0.1^{-4} sievert/hour (≥ 10 millirems/hour)	*	*
X-ray			
M5	peak flux ≥ $5*10^{-5}$ W m^{-2}	*	
X1	peak flux ≥ $1*10^{-4}$ W m^{-2}	*	
Geomagnetic			
A Index ≥ 20	running A_B ≥ 20	*	*
A Index ≥ 30	running A_B ≥ 30	*	*
A Index ≥ 50	running A_B ≥ 50	*	*
K Index = 4	K_B = 4	*	
K Index = 5	K_B = 5	*	
K Index ≥ 6	K_B ≥ 6	*	
Atmospheric disturbance			
Stratwarm	stratospheric warming conditions	*	

- Sievert (Sv): effective (equivalent) dose of radiation received by a living organism 1 Sv = 100 rem
- particle flux unit (p.f.u.) [cm^{-2} s^{-1} sr^{-1}]

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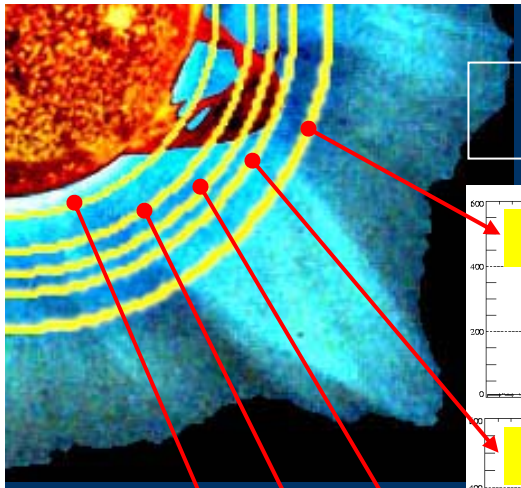
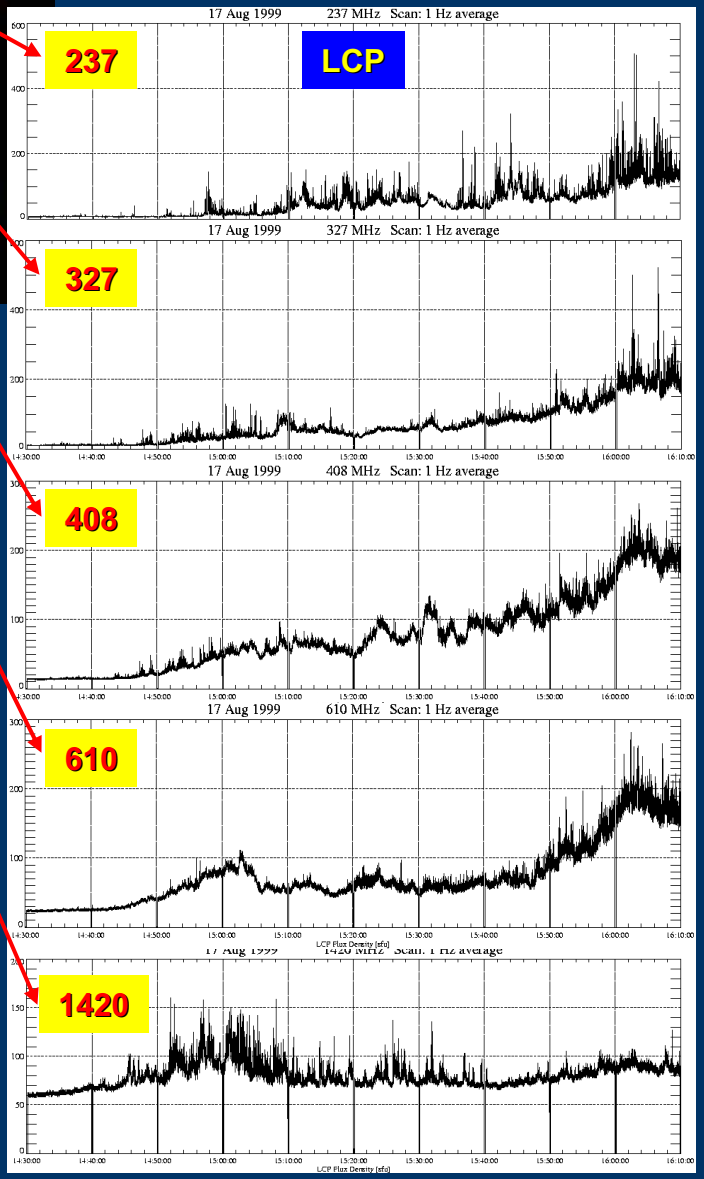
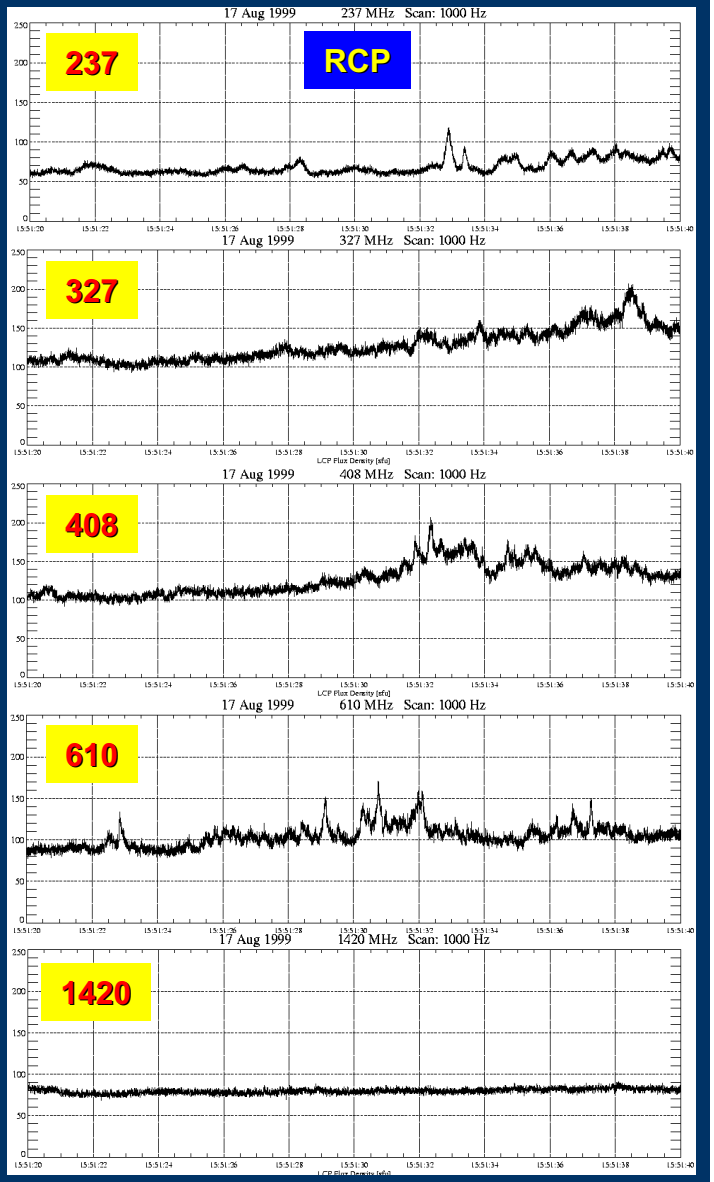
The Trieste Solar Radio System at a Glance

- TSRS (Trieste Solar Radio System)
  - MMSRP (237, 327, 408, 610 MHz)
  - DMMSRP (1420, 2695 MHz)
  - Flux density + Circular polarization
  - High time resolution (1 ms – 0.1 ms)
- Continuous coronal radio surveillance
- Radio indices published on the net in NRT
- SOLRA (SOLar Radio Archive) updated in NRT

Onset of a Strong Type IV Burst







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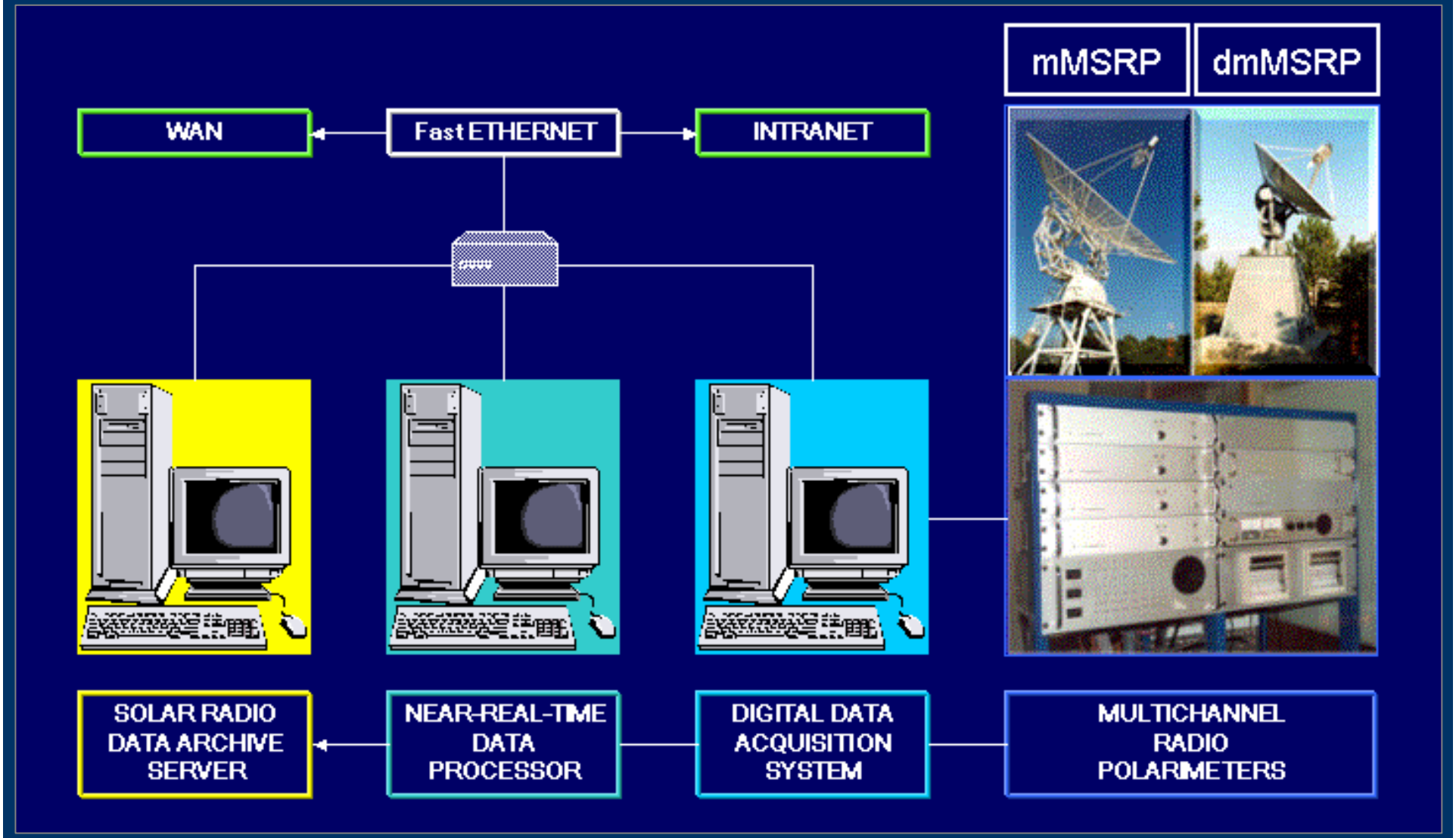
Architecture of TSRS



SWARM

TSRS WWW

DVD Juke-box

SOLRA Server

NRTAnalyzer

TSRS Control System

TSRS CONTROL ROOM

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Scheme of Data Flow: Online and NRT Processing

Rx → LL Drivers → A/D → C Program → NRT → IDL Package

NRT DATA MANAGEMENT IDL PACKAGE

- Transfer Raw Data via Network Share
- Calibrate data on-the-fly
- Compute radio indexes
- Graph synoptic data and radio indexes
- Transfer SpW data to Web server
- Convert calibrated data to FITS format via an Object Library
- Manage data ingestion via an IDL COM (Component Object Model) by means of an ADO (ActiveX Data Object)

Archive → SQL Server

Web → Apache

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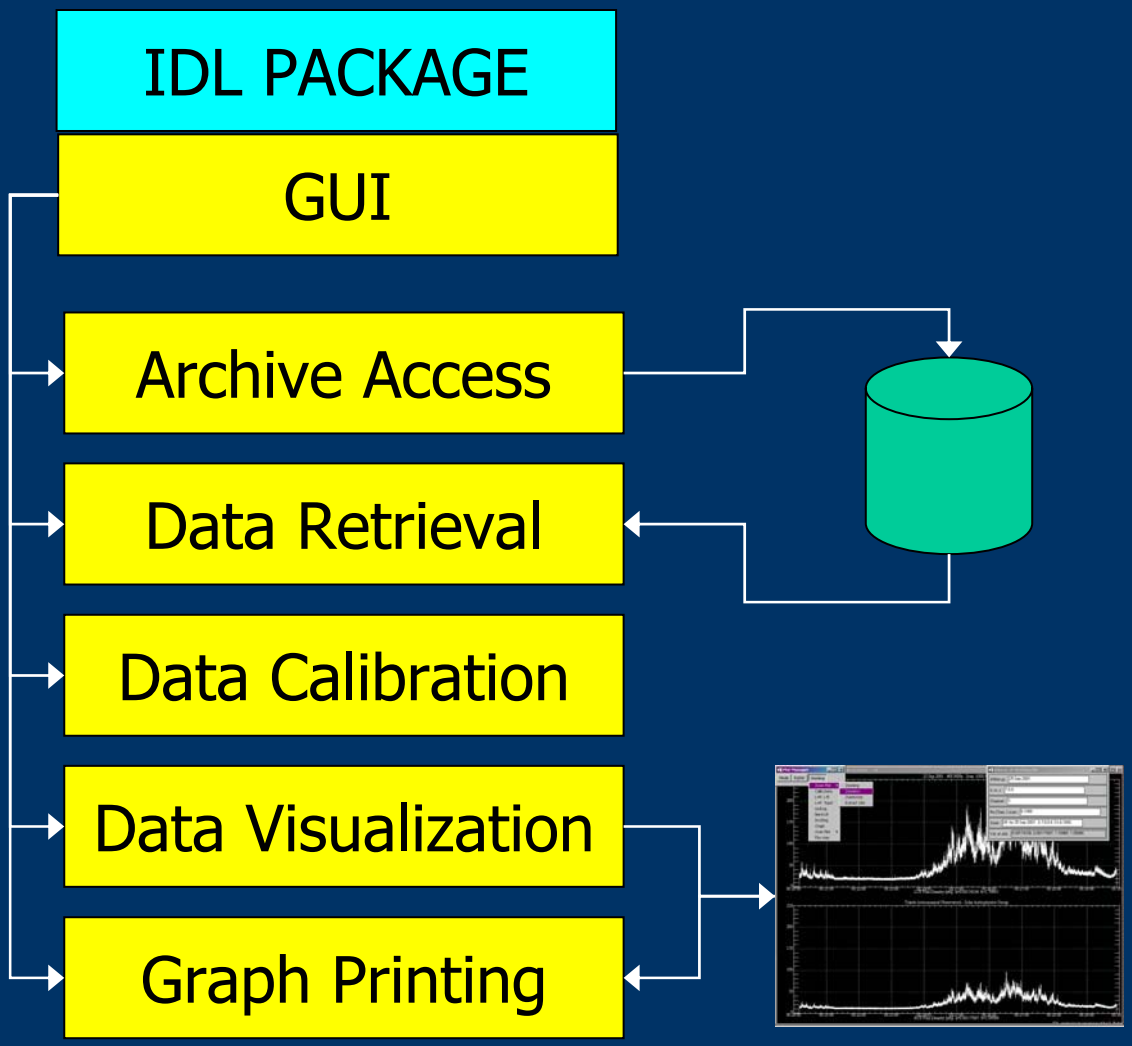
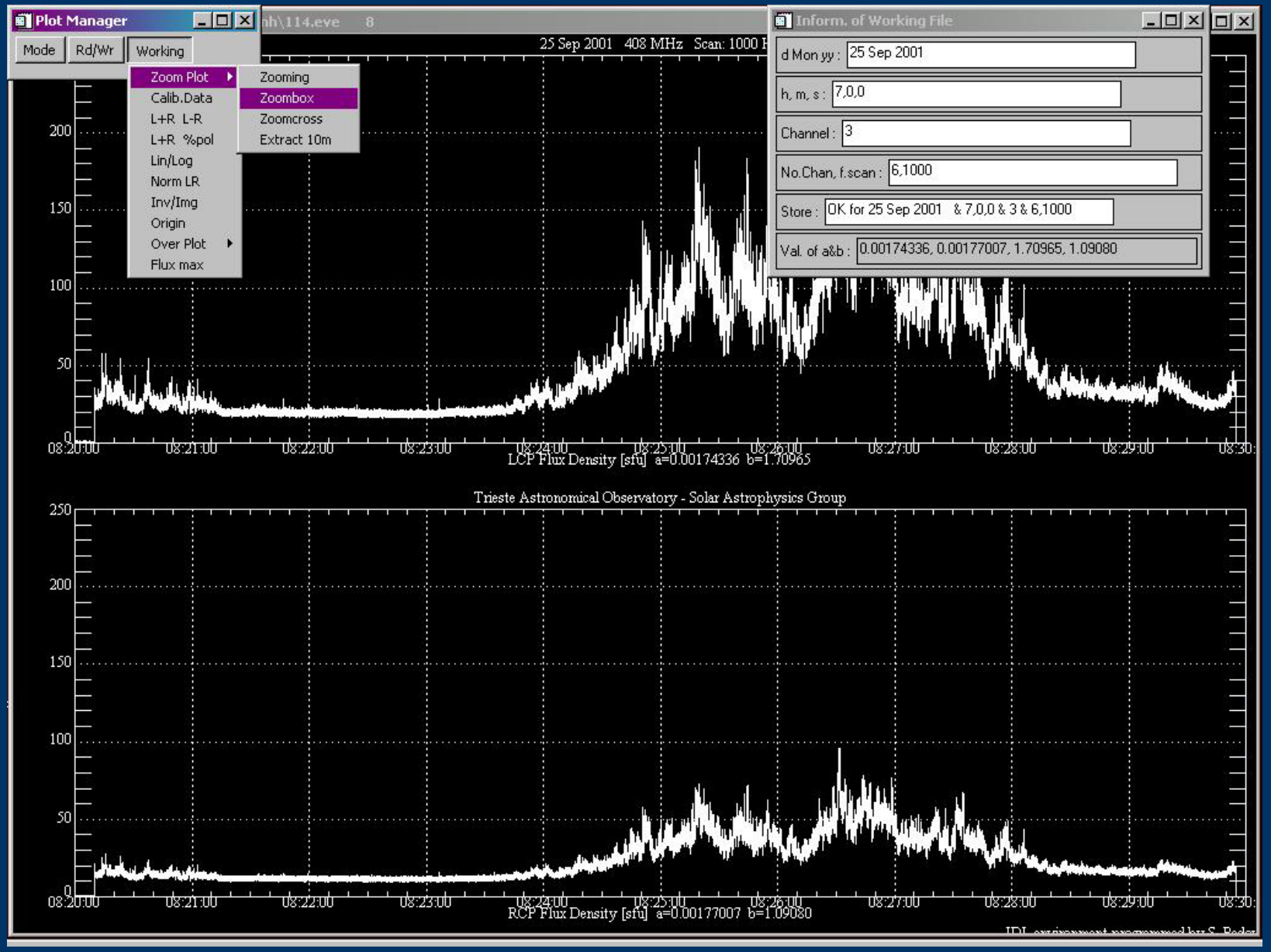
Scheme of Data Flow: Off-Line Analysis



GUI of the Radio Data Processing Package



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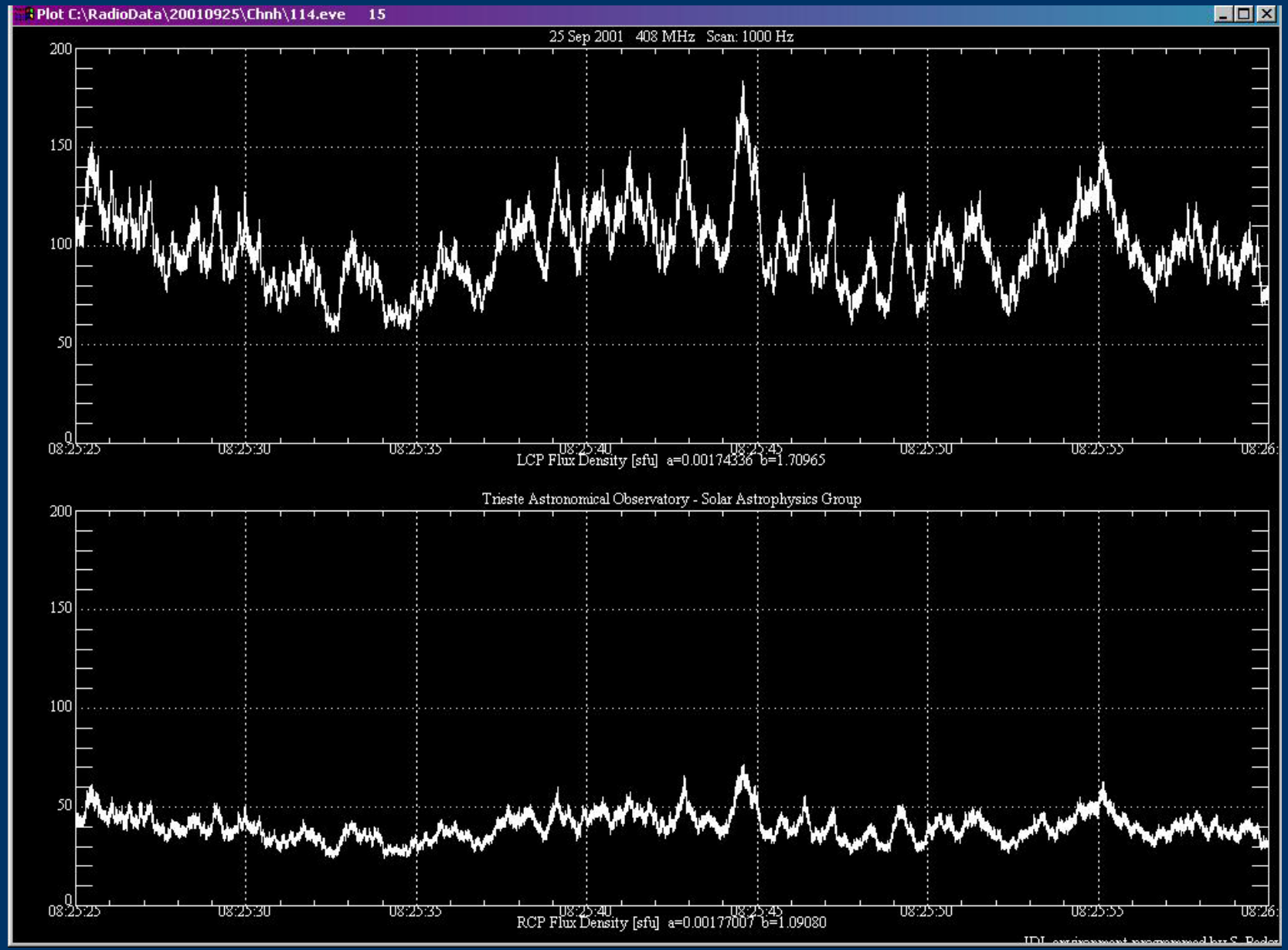
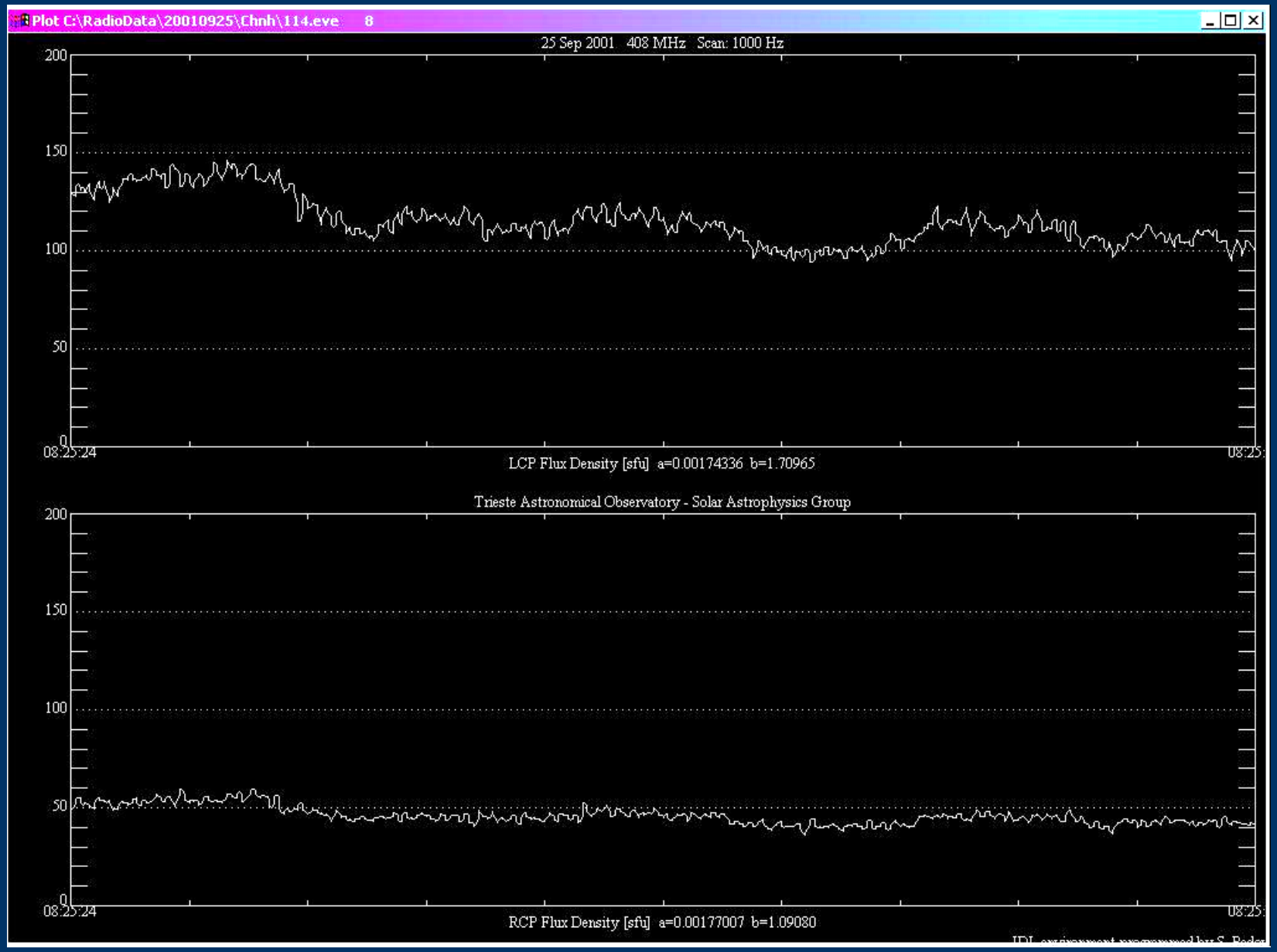
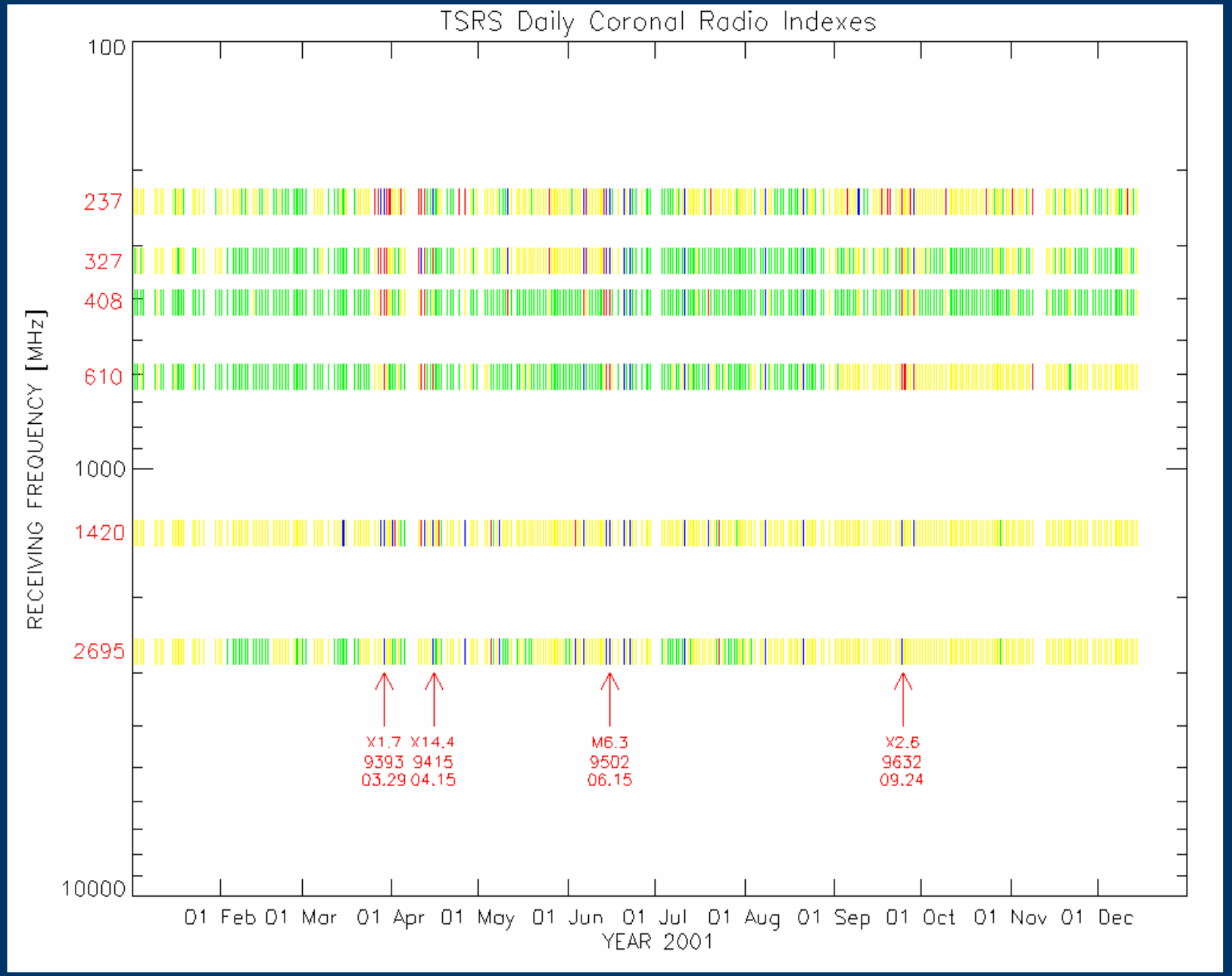
Interactive Selection and Zoom



High Zoom Factor




TSRS Daily Coronal Radio Indexes
RECEIVING FREQUENCY [MHz]
100
237
327
408
610
1000
1420
2695
10000
X1.7 X14.4
9393 9415
03.29 04.15
M6.3
9502
06.15
X2.6
9632
09.24
01 Feb 01 Mar 01 Apr 01 May 01 Jun 01 Jul 01 Aug 01 Sep 01 Oct 01 Nov 01 Dec
YEAR 2001

TSRS Data Products

- High time res. calibrated data files (1kHz; 10min; FITS)
- High time res. uncalibrated data files (1kHz; 10min; BIN)

- 1-sec average calibrated data file (1 Hz; WD; FITS)
- 1-sec average calibrated data file (1 Hz; WD; BIN)

- 1-sec max. calibrated data file (1 Hz; WD; FITS)
- 1-sec max calibrated data file (1 Hz; WD; BIN)

- 1-sec median S+CP multichannel graph (WD; PNG)

TSRS Data Products Specific to Space Weather

- 1-min average radio index
  - whole day index values in text format (WD; TXT)
  - whole day LCP multichannel graph (WD; PNG)
  - whole day RCP multichannel graph (WD; PNG)
  - whole day (LCP+RCP) multichannel graph (WD; PNG)

- 1-min maximum radio index
  - whole day index values in text format (WD; TXT)
  - whole day LCP multichannel graph (WD; PNG)
  - whole day RCP multichannel graph (WD; PNG)
  - whole day (LCP+RCP) multichannel graph (WD; PNG)

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TSRS Data Products Specifications

- Radio indices are derived as 1-min average and 1-min maximum values, which are suitable to properly sample flare-associated emissions
- Indices values are expressed both in Solar Flux Units (SFU) and in dBm/Hz as in radio communications
- A 1-min ahead value of radio indices is derived via an autoregressive model to provide indices prediction
- Indices are computed over 1-min but updated every 10 minutes due to hardware constraints!

TSRS Solar Radio Noise (SRN) Level

- The Solar Radio Noise (SRN) level is derived according to a specific thresholding at each receiving frequency, which is based on the respective Quiet Sun levels via a multiplicative factor as

SRN = (Quiet Sun level) * (Activity Factor)

- SRN is therefore classified as Low, Moderate, High
- Observed and predicted SRN values are published on the web site in NRT

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TSRS Data Access

- All Space Weather Data Products are available online
- HTR FITS files of the last 2 months are online
- The archive is updated in NRT at a cadence of 10 mins
- Data access occurs via web through a simplified GUI
- Data are searchable, displayable and downloadable up to a maximum data volume otherwise sent on physical media upon request

TSRS Dedicated Web Site

- A dedicated web site is available at the URL:

http://radiosun.ts.astro.it

- The site is available also via WAP at the URL:

http://radiosun.ts.astro.it/wap/en.wml

The TSRS WWW Site

- A dedicated web site is available at the URL:

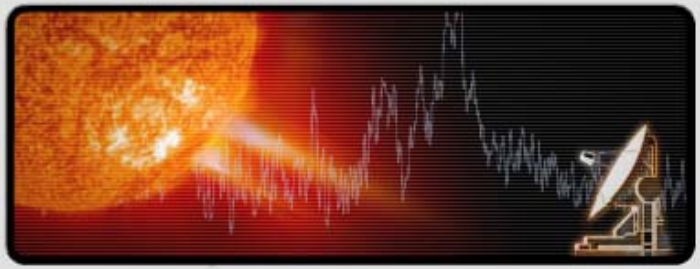
http://radiosun.ts.astro.it

- The site is available also via WAP at the URL:

http://radiosun.ts.astro.it/wap/en.wml

Trieste Solar Radio System

- Monitor
- Indices
- Radio Archive
- Web Cam
- Operational Status



Coronal Radio Surveillance

- News
- Project
- Instrumentation
- Sample Data
- Space Weather
- Italiano

:: Links :: Contacts :: Data policy :: Disclaimer :: Credits

NRT Solar Radio Noise

Freq [MHz]	237	327	408	610	1420	2695
SRN	H	H	H	H	H	H
predicted	H	M	M	M	M	M

Last update: 28 Oct 2003 11:19 UTC

- Details

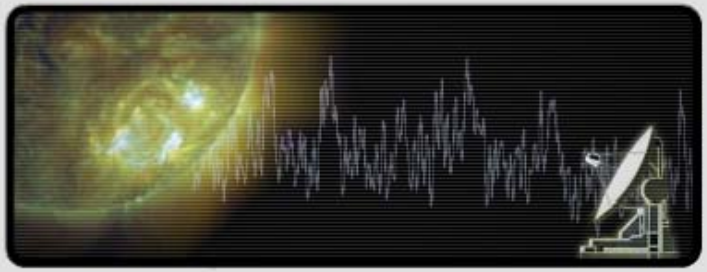
INAF

esa

SWENET

Trieste Solar Radio System

- Monitor
- Indices
- Radio Archive
- Web Cam
- Operational Status



Coronal Radio Surveillance

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NRT Solar Radio Noise

Freq [MHz]	237	327	408	610	1420	2695
SRN	H	H	H	H	M	H
predicted	H	H	H	H	H	H

Last update: 28 Oct 2003 11:38 UTC

- Details

Trieste Solar Radio System

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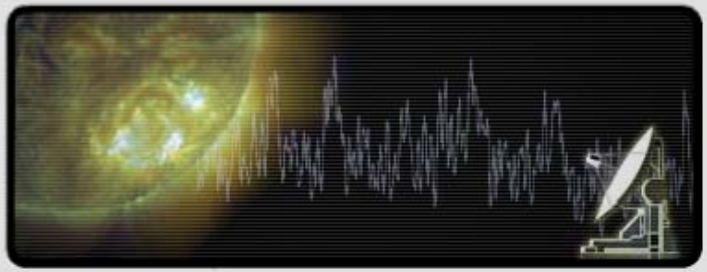

Coronal Radio Surveillance

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NRT Solar Radio Noise

Freq [MHz]	237	327	408	610	1420	2695
SRN	H	H	H	H	M	M
predicted	H	H	H	H	M	M

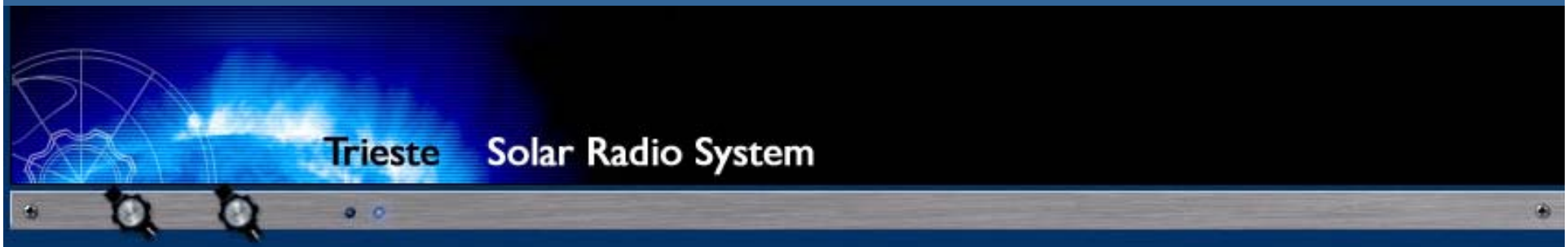
Last update: 28 Oct 2003 13:58 UTC

- Details

INAF

esa

SWENET



Near Real-Time Radio Data

- Monitor
- Indices
- Radio Archive
- Web Cam
- Operational Status

Coronal Radio Surveillance

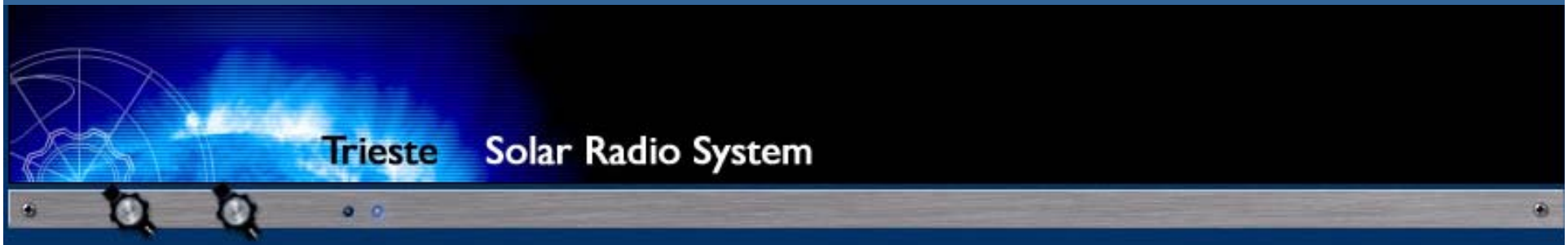
NRT Solar Radio Noise

Frequency [MHz]	Mean [SFU]	Max [SFU]	Mean [dBm/Hz]	Max [dBm/Hz]	SRN	Predicted [SFU]	Predicted [dBm/Hz]	Predicted SRN
237	7101	16222	-183	-179	H	2144	-188	H
327	3103	4072	-189	-188	H	368	-199	M
408	4334	13041	-190	-185	H	174	-204	M
610	4357	8863	-193	-190	H	179	-207	M
1420	3352	6257	-202	-199	H	184	-214	M
2695	4980	8032	-206	-204	H	342	-217	M

Last update: 28 Oct 2003 11:19 UTC

SRN: Solar Radio Noise
Q=Quiet sun
L=Low
M=Moderate
H=High

SFU: Solar Flux Unit



Near Real-Time Radio Data

- Monitor
- Indices
- Radio Archive
- Web Cam
- Operational Status

Coronal Radio Surveillance

NRT Solar Radio Noise

Frequency [MHz]	Mean [SFU]	Max [SFU]	Mean [dBm/Hz]	Max [dBm/Hz]	SRN	Predicted [SFU]	Predicted [dBm/Hz]	Predicted SRN
237	4173	6576	-185	-183	H	6639	-183	H
327	2703	4072	-190	-188	H	4097	-188	H
408	1704	4247	-194	-190	H	830	-197	H
610	947	4828	-200	-193	H	6157	-192	H
1420	591	1241	-209	-206	M	1517	-205	H
2695	1326	3557	-211	-207	H	3859	-207	H

Last update: 28 Oct 2003 11:38 UTC

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Q=Quiet sun
L=Low
M=Moderate
H=High

SFU: Solar Flux Unit

Near Real-Time Radio Data

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Coronal Radio Surveillance

NRT Solar Radio Noise

Frequency [MHz]	Mean [SFU]	Max [SFU]	Mean [dBm/Hz]	Max [dBm/Hz]	SRN	Predicted [SFU]	Predicted [dBm/Hz]	Predicted SRN
237	1840	4694	-189	-185	H	6041	-184	H
327	1409	2239	-193	-191	H	2244	-191	H
408	957	2481	-196	-192	H	2162	-193	H
610	501	1522	-203	-198	H	1117	-199	H
1420	116	185	-216	-214	M	187	-214	M
2695	196	300	-220	-218	M	303	-218	M

Last update: 28 Oct 2003 13:58 UTC

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L=Low
M=Moderate
H=High

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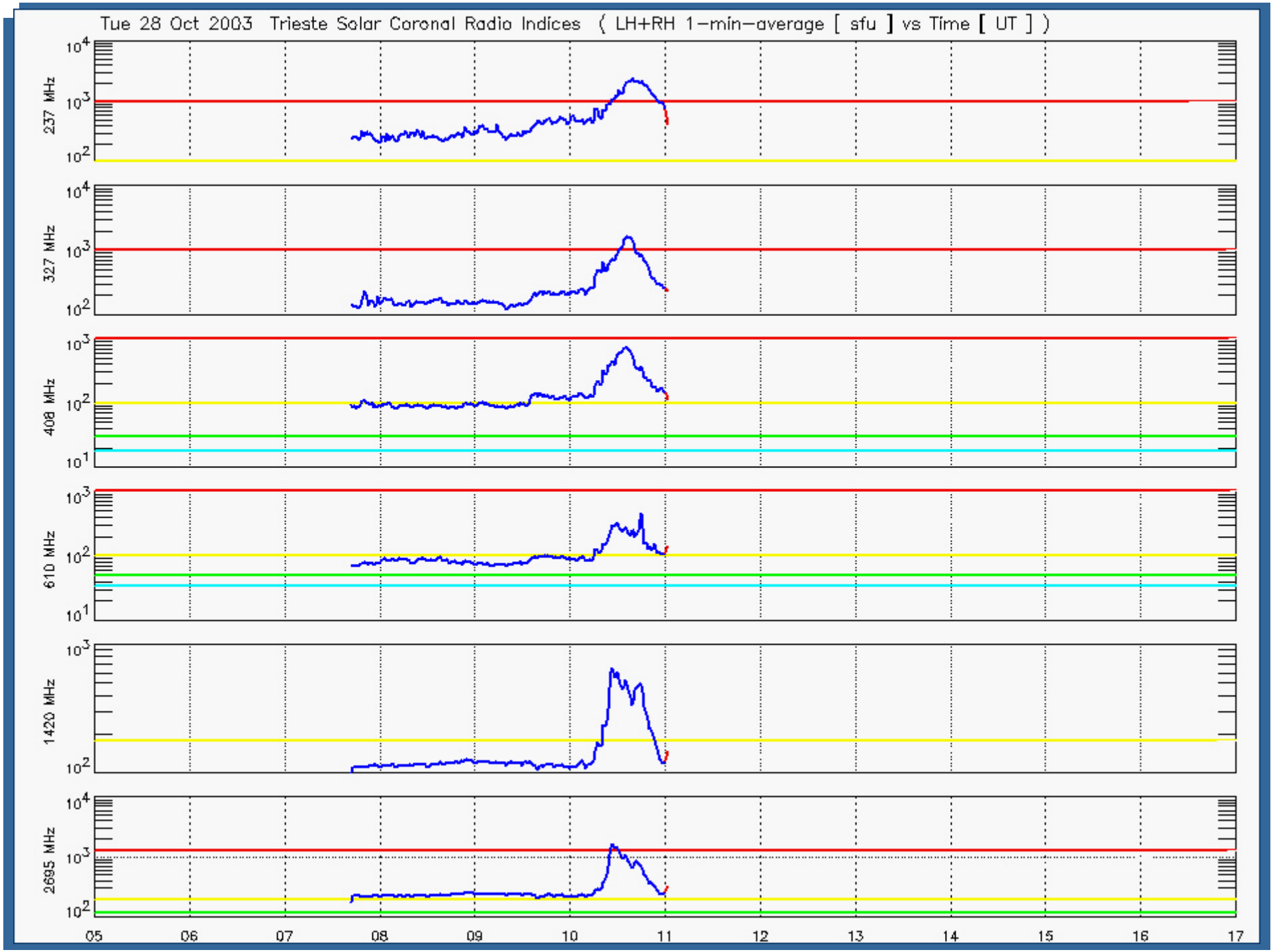
Tue 28 Oct 2003 Trieste Solar Coronal Radio Indices (LH+RH 1-min-average [sfu] vs Time [UT])
237 MHz
327 MHz
408 MHz
610 MHz
1420 MHz
2695 MHz
05
06
07
08
09
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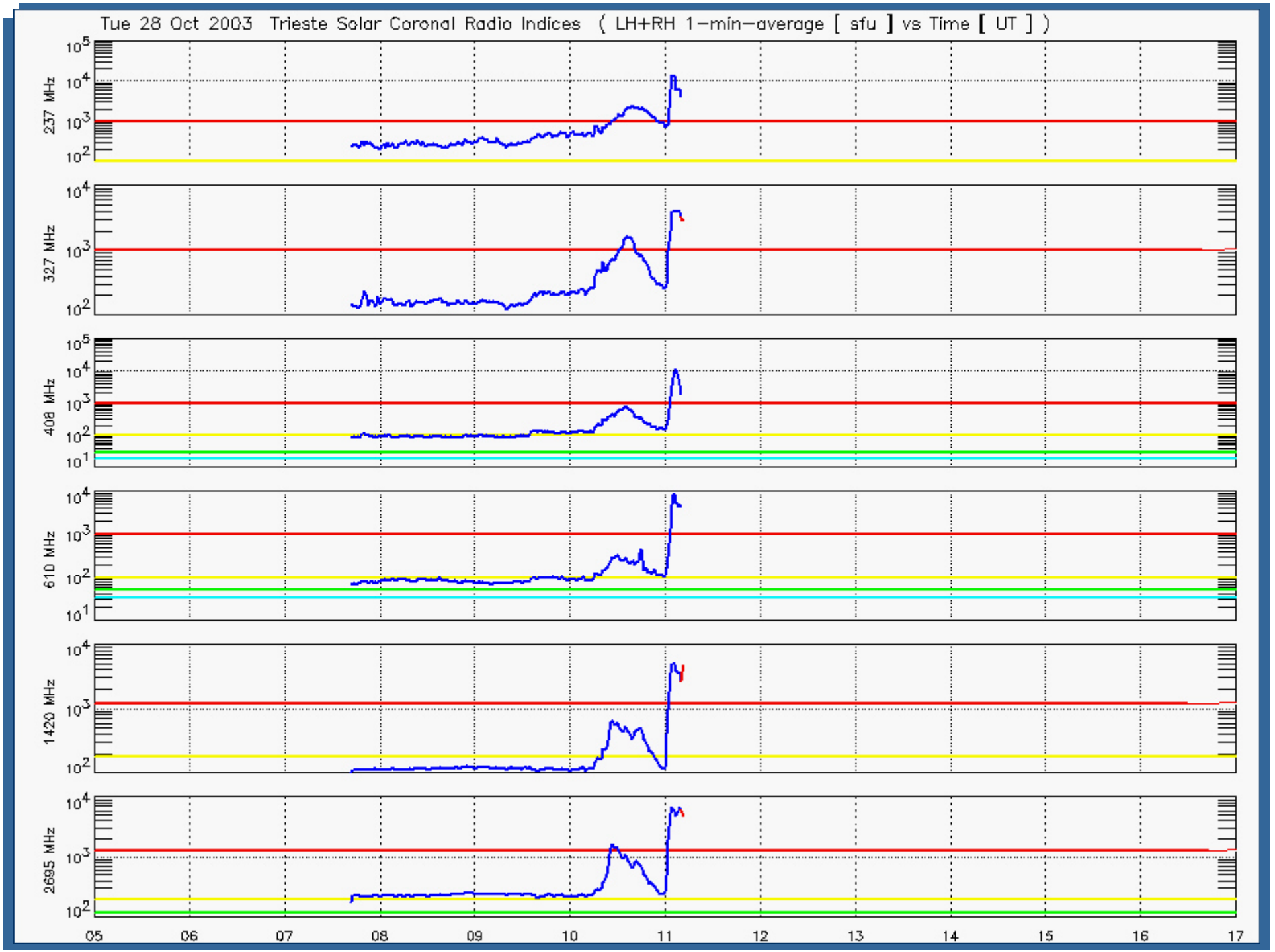
16
17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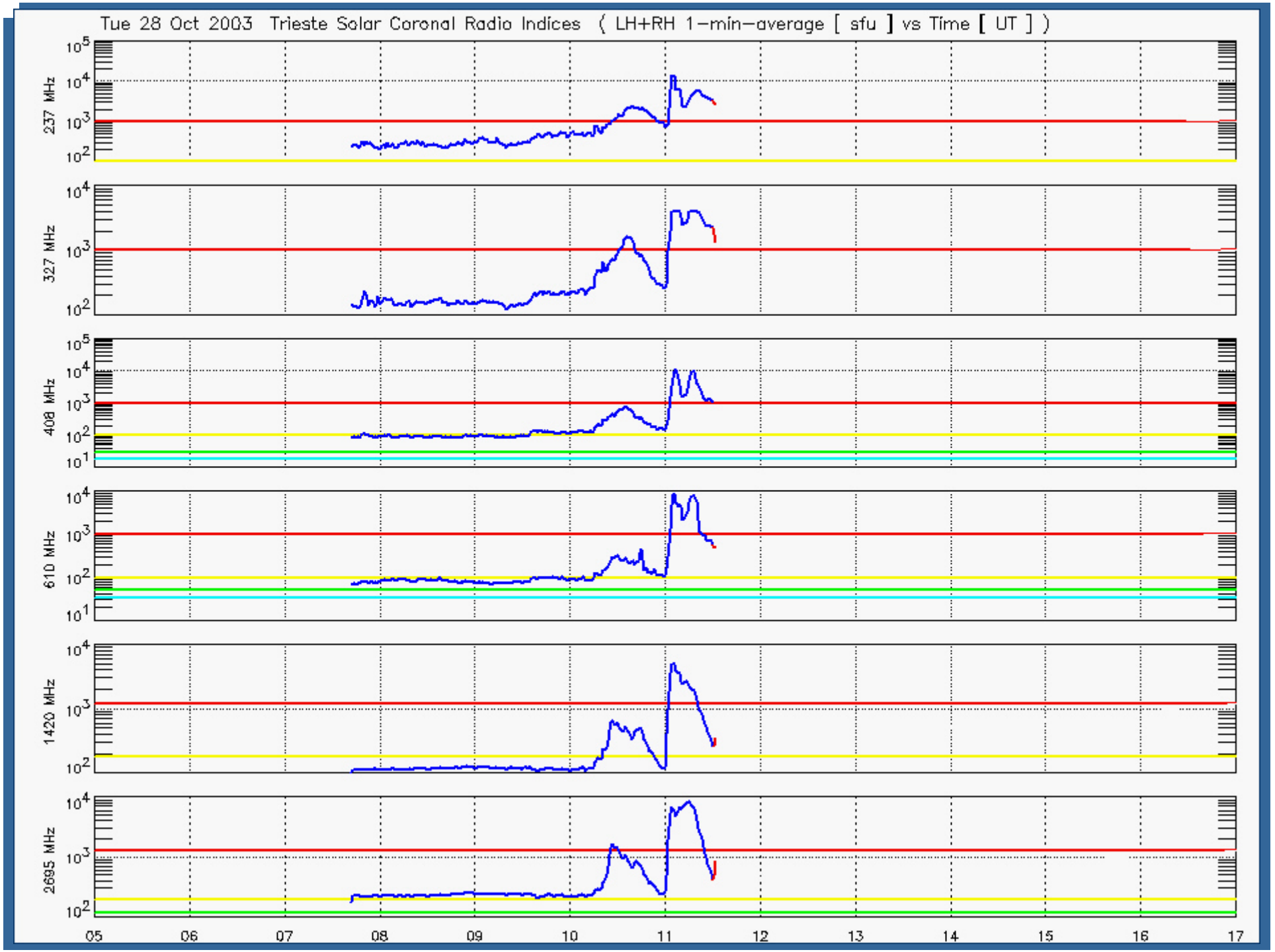
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237 MHz
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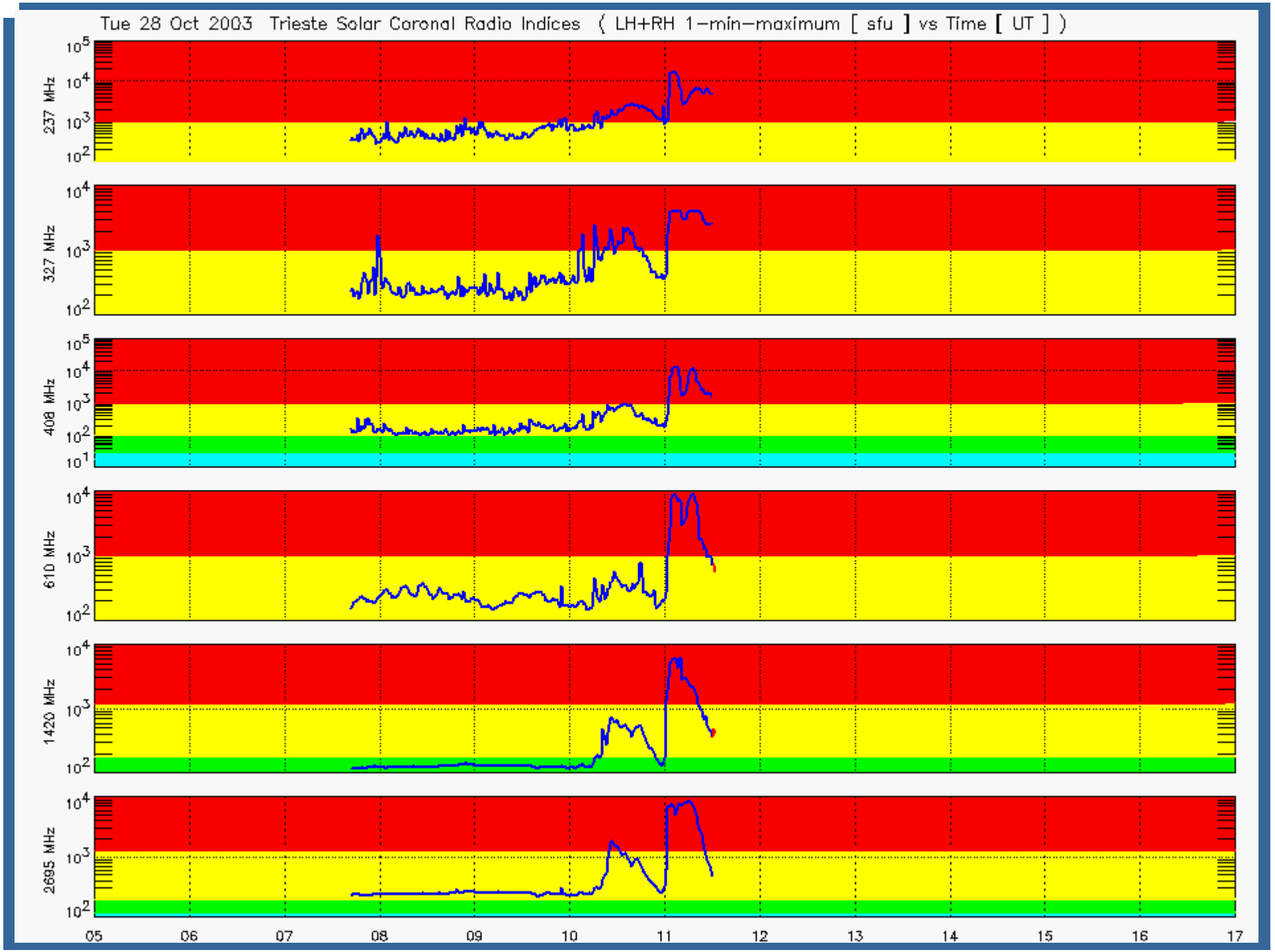
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237 MHz
327 MHz
408 MHz
610 MHz
1420 MHz
2695 MHz
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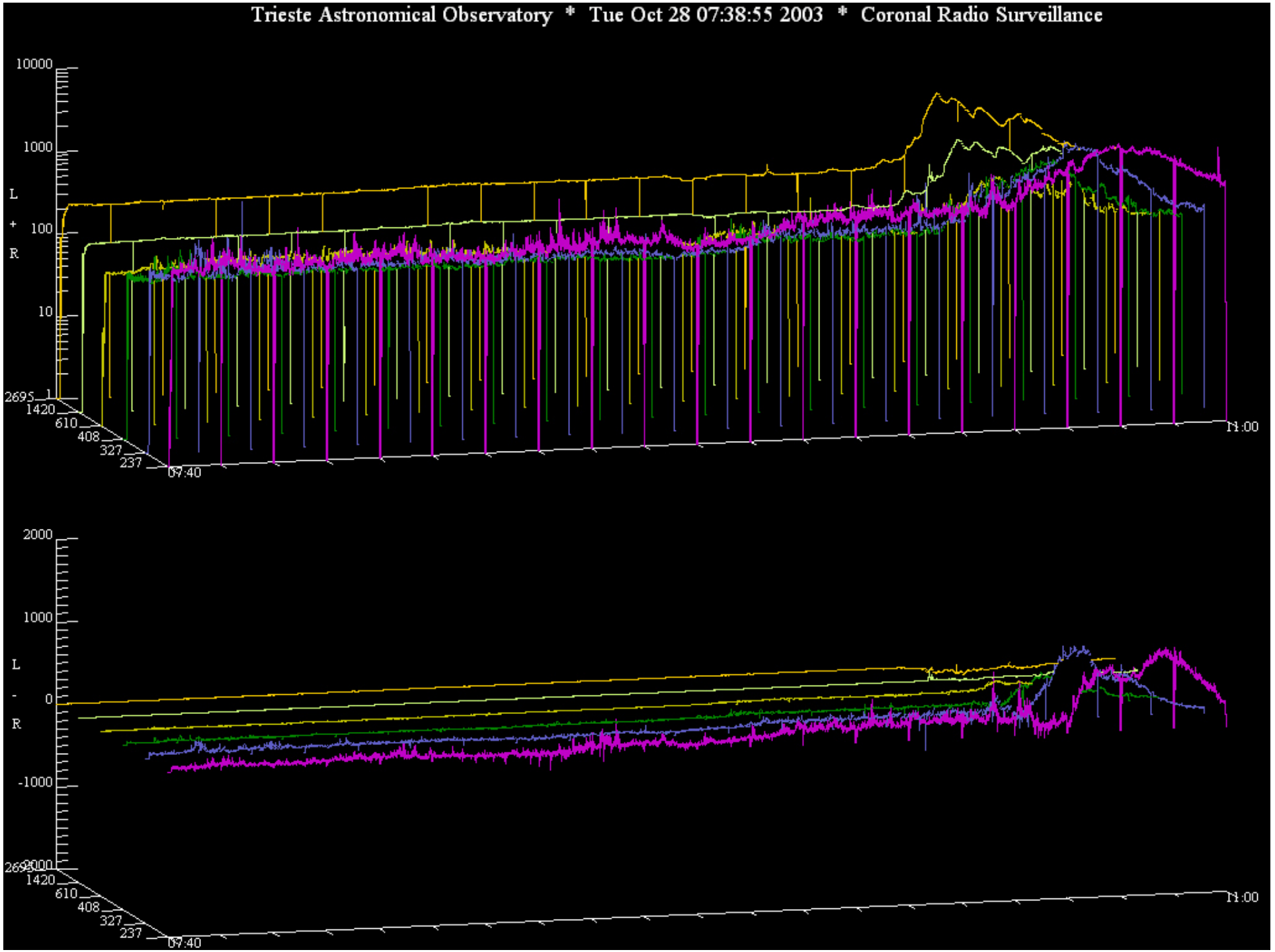
Trieste Astronomical Observatory * Tue Oct 28 07:38:55 2003 * Coronal Radio Surveillance
10000
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+
R
100
10
2695
1420
610
408
327
237
09:40
11:00
2000
1000
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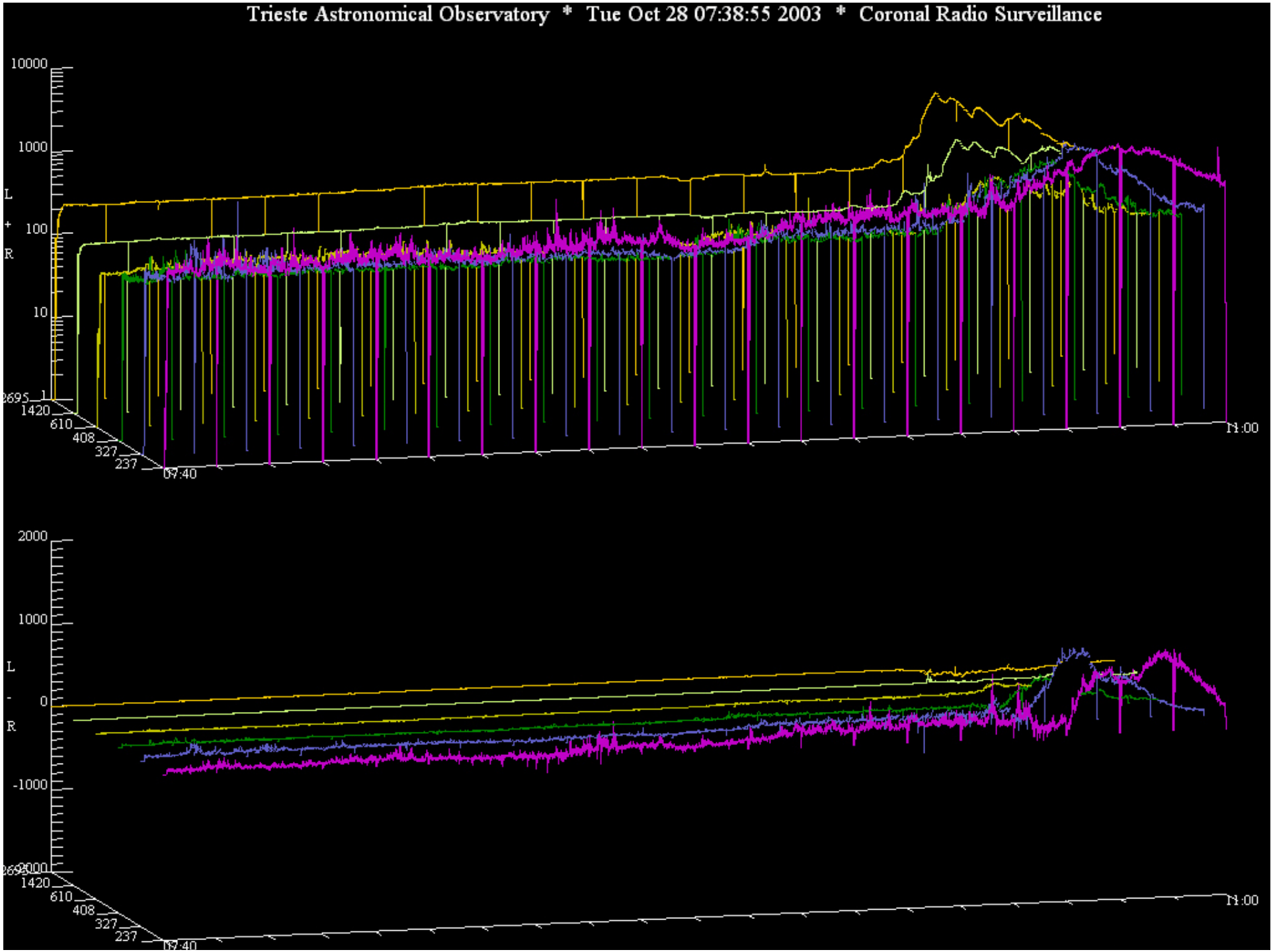
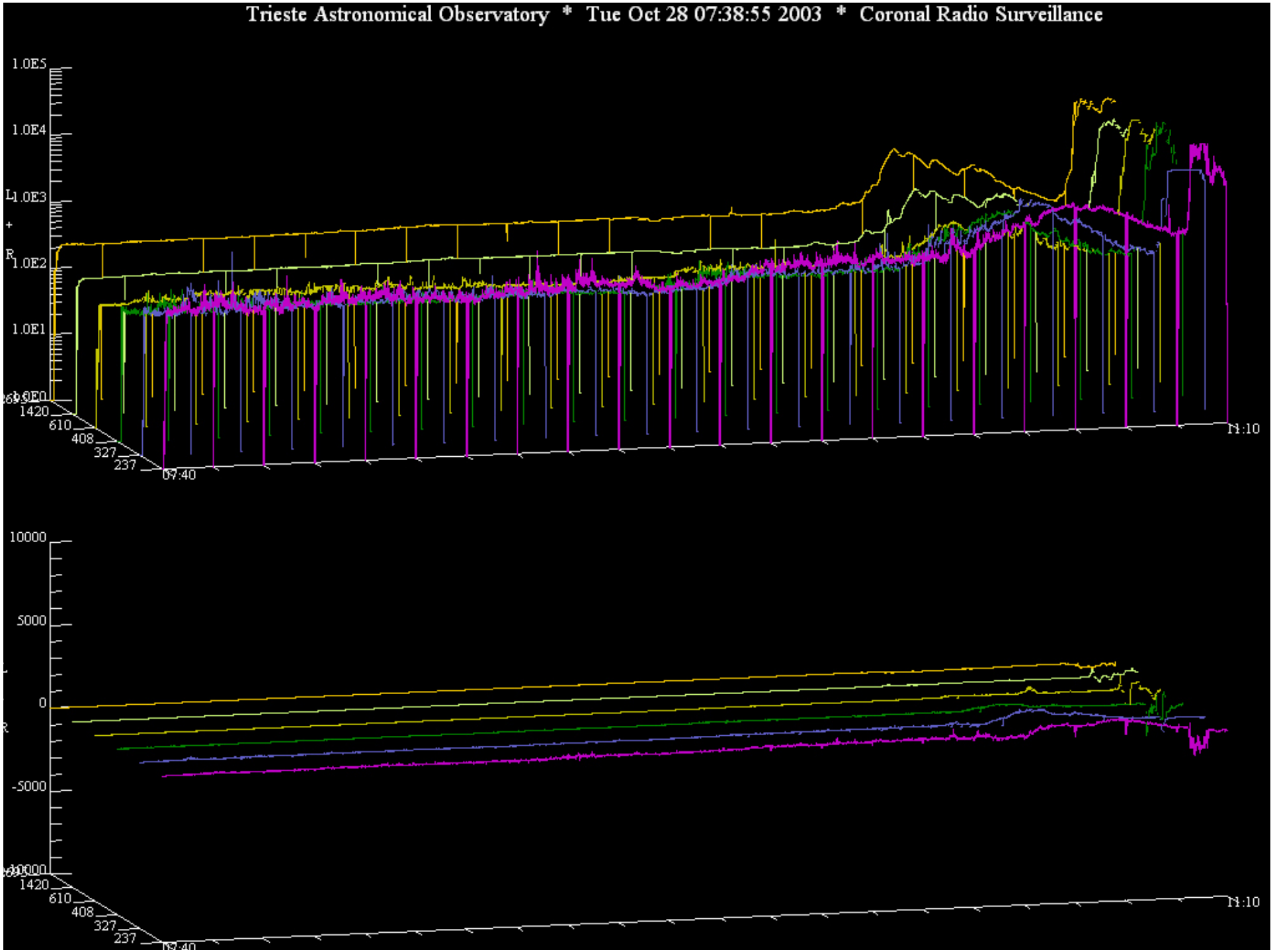
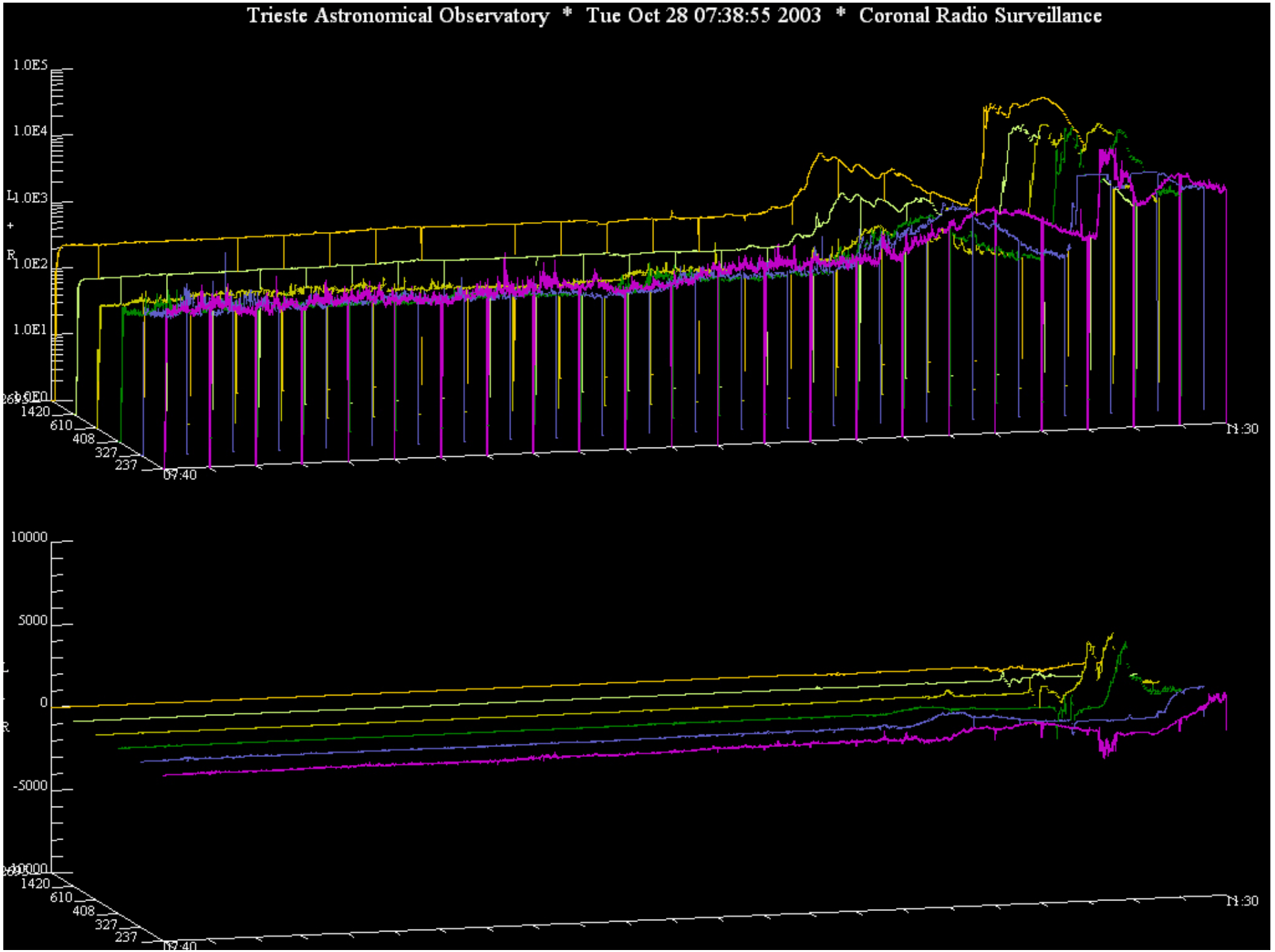
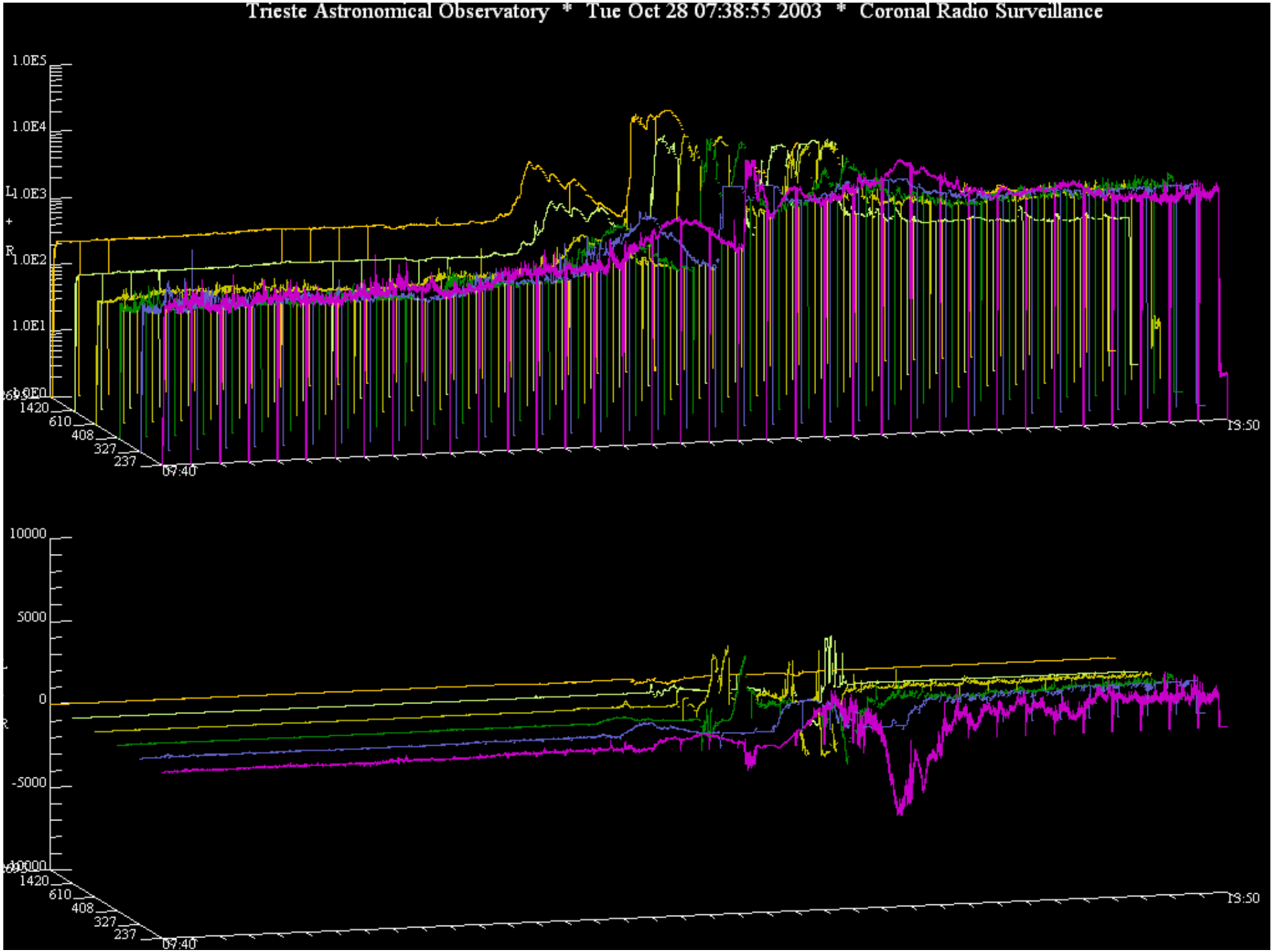
R
0
-1000
-2000
2695
1420
610
408
327
237
09:40
11:00


Trieste Astronomical Observatory * Tue Oct 28 07:38:55 2003 * Coronal Radio Surveillance
10000
1000
L
+
R
100
10
1
2695
1420
610
408
327
237
07:40
11:00
2000
1000
L
-
R
0
-1000
-3000
2695
1420
610
408
327
237
07:40
11:00


Trieste Astronomical Observatory * Tue Oct 28 07:38:55 2003 * Coronal Radio Surveillance
1.0E5
1.0E4
1.0E3
1.0E2
1.0E1
1420
610
408
327
237
07:40
11:10
10000
5000
0
-5000
1420
610
408
327
237
11:10


Trieste Astronomical Observatory * Tue Oct 28 07:38:55 2003 * Coronal Radio Surveillance
1.0E5
1.0E4
1.0E3
1.0E2
1.0E1
1420
610
408
327
237
07:40
11:30
10000
5000
0
-5000
1420
610
408
327
237
07:40
11:30


Trieste Astronomical Observatory * Tue Oct 28 07:38:55 2003 * Coronal Radio Surveillance
1.0E5
1.0E4
1.0E3
1.0E2
1.0E1
1420
610
408
327
237
07:40
13:50
10000
5000
0
-5000
1420
610
408
327
237
07:40
13:50

Trieste Solar Radio System

Near Real-Time Radio Data

- Monitor
- Indices
- Radio Archive
- Web Cam
- Operational Status

Coronal Radio Surveillance

- News
- Project
- Instrumentation
- Sample Data
- Space Weather
- Home

The Trieste Near-Real-Time Solar Radio Indices

Solar radio indices are derived separately for each polarization channel (LH and RH flux density) at each receiving frequency (237, 327, 408, 610 , 1495, 2695 MHz) and for the sum of the two polarization channels (LH + RH [total] flux density), by averaging the related radio flux density over 10-minutes intervals.

The relevant graphs are automatically generated and automatically updated in near-real-time with a time cadence of 10 minutes during the whole daily observing run, which spans from 06:00 UT to 17:00 UT at maximum.

In the graphs black dots indicate observed values and red dots indicate 10-minutes forward-predicted values.

Click on the following links to open independent windows with the relevant graphs for the date:

- Multichannel LCP 1-min-average index graph (PNG)
- Multichannel RCP 1-min-average index graph (PNG)
- Multichannel (LCP+RCP) 1-min-average index graph (PNG)

- Multichannel LCP 1-min-maximum index graph (PNG)
- Multichannel RCP 1-min-maximum index graph (PNG)
- Multichannel (LCP+RCP) 1-min-maximum index graph (PNG)

Click on the following links to open the FITS files:

- 1-min-average index values (FITS)
- 1-min-maximum index values (FITS)
- Full Resolution Data (FITS, last 10 mins)

Solar Radio Indices Graphs and numerical values in ASCII format for the previous days can be retrieved from the relevant Solar Radio Archive.

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SOLRA - *SOLar Radio Archive*

Trieste Solar Radio System

○ any time

◉ selected time interval

Starting date: 2003 November 1 00 00

Ending date: 2003 November 1 23 59

Time intervals are based on the UTC reference system

Data type: ALL

The data type depends on file contents: sampling rate, frequencies and polarization of the observed data, etc.

File format: ALL

The file format depends on how the file is physically stored. There are compressed or uncompressed files, text, binary or graphic files, etc.

File name: (substring search)

Insert a string to search on matching file names, exactly or partially

Search! Reset

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SOLRA - *SOLar Radio Archive*

Trieste Solar Radio System

○ any time

◉ selected time interval

Starting date: 2003 November 1 00 00

Ending date: 2003 November 1 23 59

Time intervals are based on the UTC reference system

Data type: ALL

ALL
Full resolution data (FITS)
1-min-average index values (FITS)
1-min-maximum index values (FITS)
1-min-average index values (BIN)
1-min-maximum index values (BIN)
1-min-average index values (TXT)
1-min-maximum index values (TXT)
Multichannel synoptic graph (PNG)
Multichannel LCP 1-min-average index graph (PNG)
Multichannel RCP 1-min-average index graph (PNG)
Multichannel (LCP+RCP) 1-min-average index graph (PNG)
Multichannel LCP 1-min-maximum index graph (PNG)
Multichannel RCP 1-min-maximum index graph (PNG)
Multichannel (LCP+RCP) 1-min-maximum index graph (PNG)
Uncalibrated raw data files (Custom/BIN)

The data type depends on file , etc.

File format:

The file format depends on ho *s, text, binary or graphic files, etc.*

File name: (substring search)

Insert a string to search on ma

Search! Reset

Trieste Solar Radio System

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SOLRA - *SOLar Radio Archive*

Trieste Solar Radio System

Search result

Click on a header tag to sort data

Sel	FILE	OBS_DATE	END_DATE	Size (bytes)	Repository	Data type
☑	trst_radio_fd_20031101_074000.fts.gz	2003-11-01 07:40:00	2003-11-01 07:50:00	7804898	Fileserver	Full data FITS
☑	trst_radio_fd_20031101_075000.fts.gz	2003-11-01 07:50:00	2003-11-01 08:00:00	7882631	Fileserver	Full data FITS
☑	trst_radio_fd_20031101_080000.fts.gz	2003-11-01 08:00:00	2003-11-01 08:10:00	7815925	Fileserver	Full data FITS
☑	trst_radio_fd_20031101_081000.fts.gz	2003-11-01 08:10:00	2003-11-01 08:20:00	7885957	Fileserver	Full data FITS
☑	trst_radio_fd_20031101_082000.fts.gz	2003-11-01 08:20:00	2003-11-01 08:30:00	7802860	Fileserver	Full data FITS
☑	trst_radio_fd_20031101_083000.fts.gz	2003-11-01 08:30:00	2003-11-01 08:40:00	7742579	Fileserver	Full data FITS
☑	trst_radio_fd_20031101_084000.fts.gz	2003-11-01 08:40:00	2003-11-01 08:50:00	7729124	Fileserver	Full data FITS
☑	trst_radio_fd_20031101_085000.fts.gz	2003-11-01 08:50:00	2003-11-01 09:00:00	7866145	Fileserver	Full data FITS
☑	trst_radio_fd_20031101_090000.fts.gz	2003-11-01 09:00:00	2003-11-01 09:10:00	7588443	Fileserver	Full data FITS
☑	trst_radio_fd_20031101_091000.fts.gz	2003-11-01 09:10:00	2003-11-01 09:20:00	7580816	Fileserver	Full data FITS
☑	trst_radio_fd_20031101_092000.fts.gz	2003-11-01 09:20:00	2003-11-01 09:30:00	7832722	Fileserver	Full data FITS
☑	trst_radio_fd_20031101_093000.fts.gz	2003-11-01 09:30:00	2003-11-01 09:40:00	7881043	Fileserver	Full data FITS

File selected:

- trst_radio_fd_20031101_074000.fts.gz
- trst_radio_fd_20031101_075000.fts.gz
- trst_radio_fd_20031101_080000.fts.gz
- trst_radio_fd_20031101_081000.fts.gz
- trst_radio_fd_20031101_082000.fts.gz
- trst_radio_fd_20031101_083000.fts.gz
- trst_radio_fd_20031101_084000.fts.gz
- trst_radio_fd_20031101_085000.fts.gz
- trst_radio_fd_20031101_090000.fts.gz
- trst_radio_fd_20031101_091000.fts.gz
- trst_radio_fd_20031101_092000.fts.gz
- trst_radio_fd_20031101_093000.fts.gz
- trst_radio_fd_20031101_094000.fts.gz
- trst_radio_fd_20031101_095000.fts.gz
- trst_radio_fd_20031101_100000.fts.gz
- trst_radio_fd_20031101_101000.fts.gz
- trst_radio_fd_20031101_102000.fts.gz
- trst_radio_il_20031101_074000.png
- trst_radio_ir_20031101_074000.png
- trst_radio_is_20031101_074000.png
- trst_radio_mc_20031101_074000.png
- trst_radio_mm_20031101_074000.txt
- trst_radio_ms_20031101_074000.bin
- trst_radio_ms_20031101_074000.fts.gz
- trst_radio_xl_20031101_074000.png
- trst_radio_xm_20031101_074000.txt
- trst_radio_xr_20031101_074000.png
- trst_radio_xs_20031101_074000.bin
- trst_radio_xs_20031101_074000.fts.gz
- trst_radio_xs_20031101_074000.png

30 items

First name:

Last name:

E-Mail:

Institution:

Comments:

Submit your request

Reset

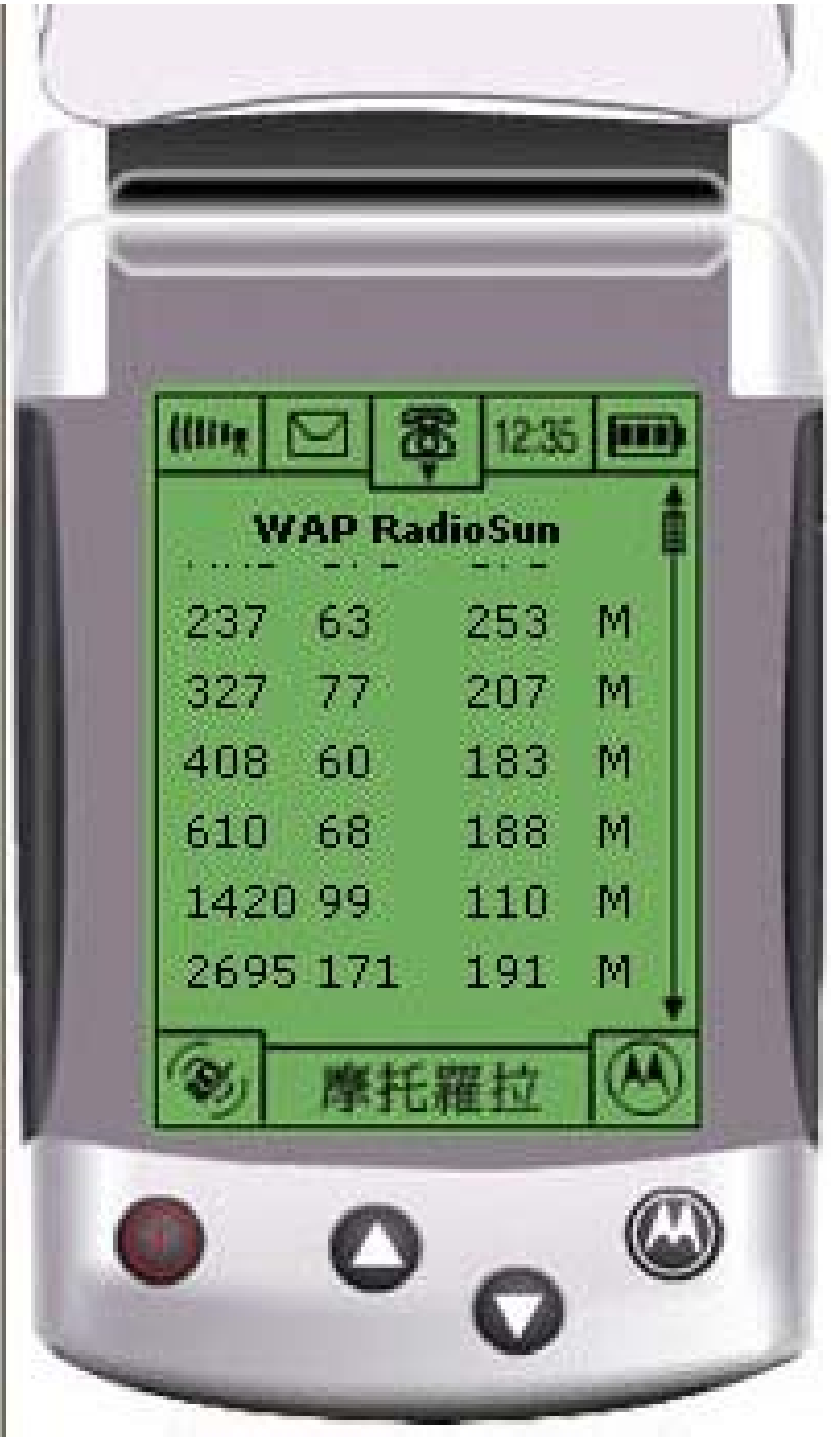

12:35
WAP RadioSun
INAF Trieste
Astronomical
Observatory
Trieste Solar Radio
System
Coronal Radio
Indexes (10 mins
updating)
01 Nov 2003 12:18
摩托羅拉


12:35
WAP RadioSun
freq mean peak SRN
MHz SFU SFU
237 63 253 M
327 77 207 M
408 60 183 M
610 68 188 M
摩托羅拉


12:35
WAP RadioSun
1420 99 110 M
2695 171 191 M
freq mean peak
MHz dBm/Hz dBm/Hz
237 -203 -197
327 -205 -201
摩托羅拉


12:35
WAP RadioSun
408 -208 -204
610 -211 -207
1420 -217 -217
2695 -220 -220
SRN:Solar Radio Noise
Q=Quiet sun
摩托羅拉


12:35
WAP RadioSun
SRN:Solar Radio
Noise
Q=Quiet sun
L=Low
M=Moderate
H=High
SFU:Solar Flux Unit
摩托羅拉


12:35
WAP RadioSun
237 63 253 M
327 77 207 M
408 60 183 M
610 68 188 M
1420 99 110 M
2695 171 191 M
摩托羅拉


12:35
WAP RadioSun
237 -203 -197
327 -205 -201
408 -208 -204
610 -211 -207
1420 -217 -217
2695 -220 -220
摩托羅拉

CONCLUSIONS

- TSRS is now FULLY OPERATIONAL in NRT
- The TSRS archive is now UPDATED in NRT
- Data access is available via HTML and WAP
- TSRS is an EFFECTIVE OBSERVATIONAL TOOL for CORONAL RADIO SURVEILLANCE PURPOSES
- PROJECTS: ESA SWENET, COST Action 724

in Proc. ESA Space Weather Workshop: Developing a European Space Weather Service Network
3-5 November 2003, ESTEC, Noordwijk, The Netherlands