Analysis of powerful flare events at the maximum of solar cycle 24 in a wide range of microwaves

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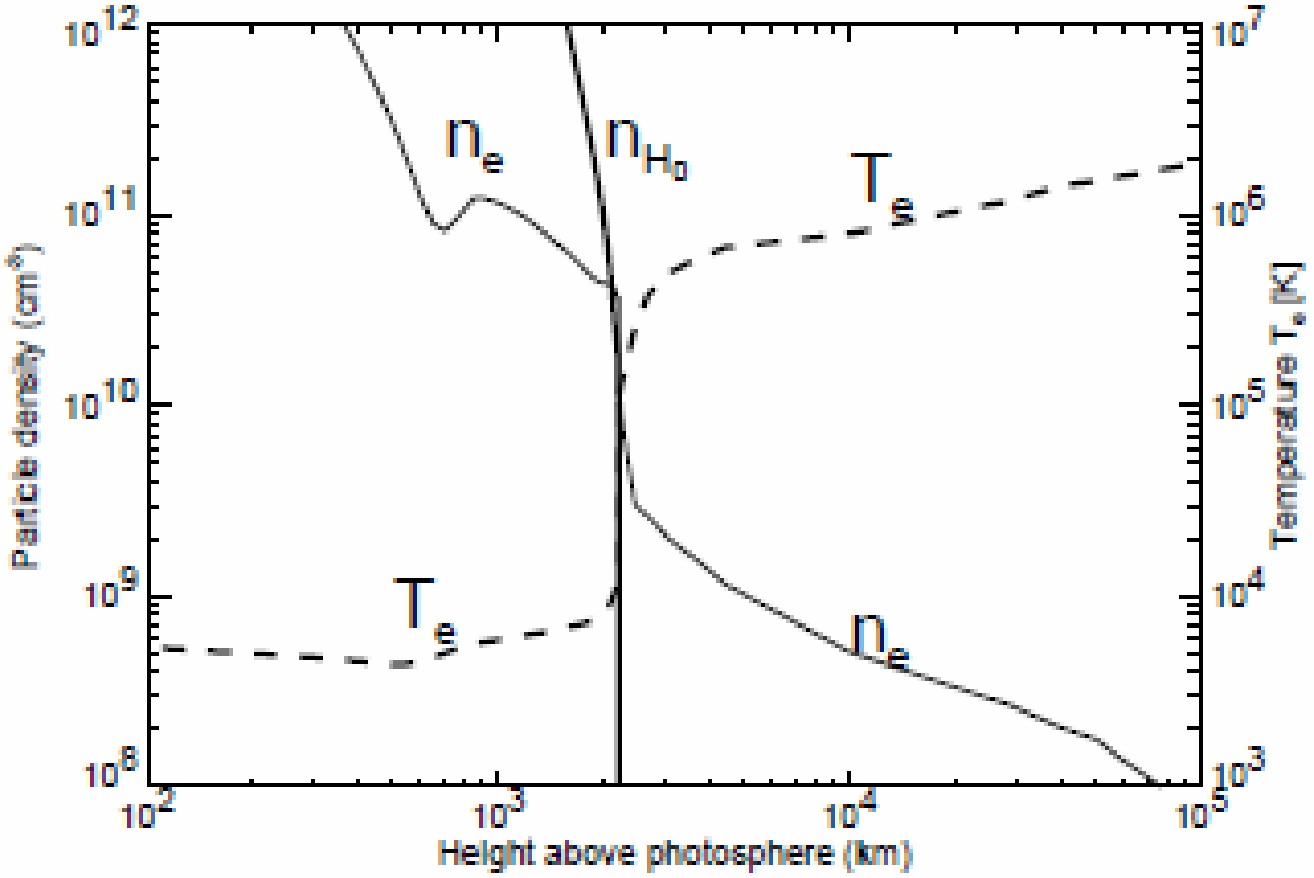
Radio astronomical methods are important tools for the study of the solar atmosphere because they provide the data about the parameters of active plasma over a wide range of heights that are difficult to probe using other methods.

The radio emission of the chromosphere can be observed at mm-wave frequencies, whereas the transition region between the chromosphere and the corona and the lower corona radiate efficiently at centimeter- and decimeter-wave frequencies.



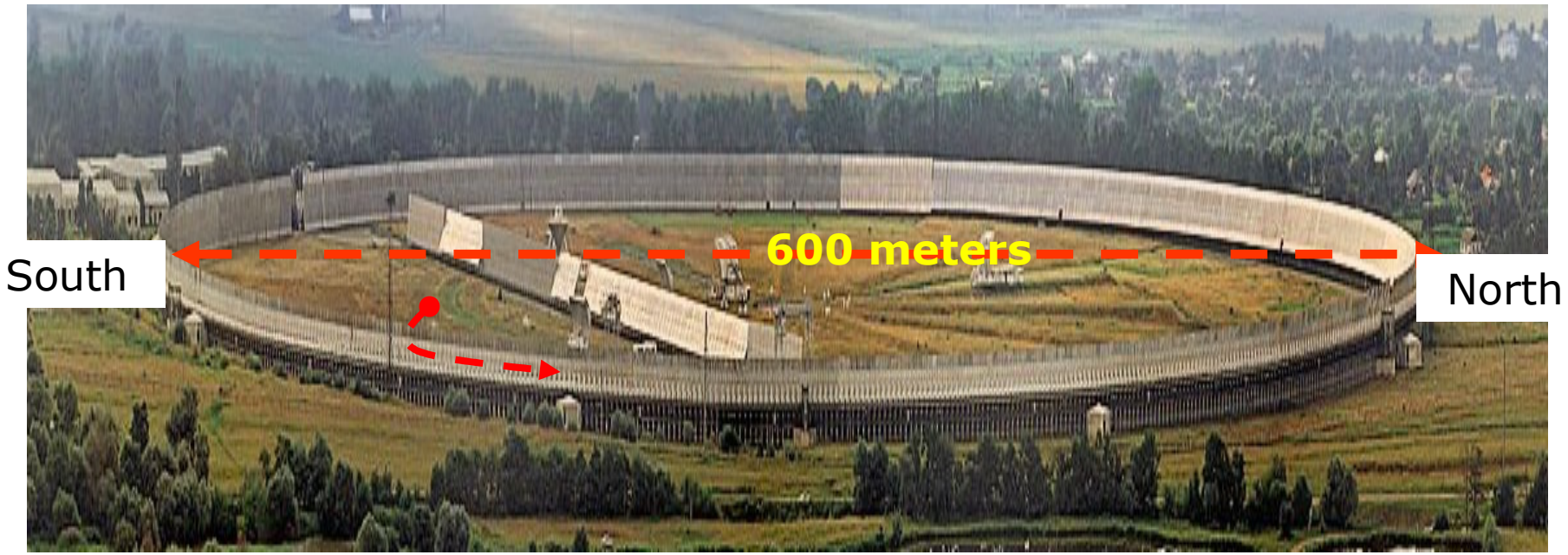
. Electron density and temperature model of the chromosphere (Fontenla et al. 1990; Model FAL-C) and lower corona (Gabriel, 1976).

Abrupt change in the physical conditions (plasma temperature and density), development of special magnetic configurations, current sheets, etc. at the heights of the transition layer and low corona should result in appreciable changes of the polarized signal depending both on the observing frequency and activity state.

Abrupt changes in the structure of polarized emission depending on the observing frequency were recorded in flare productive active regions with RATAN-600.

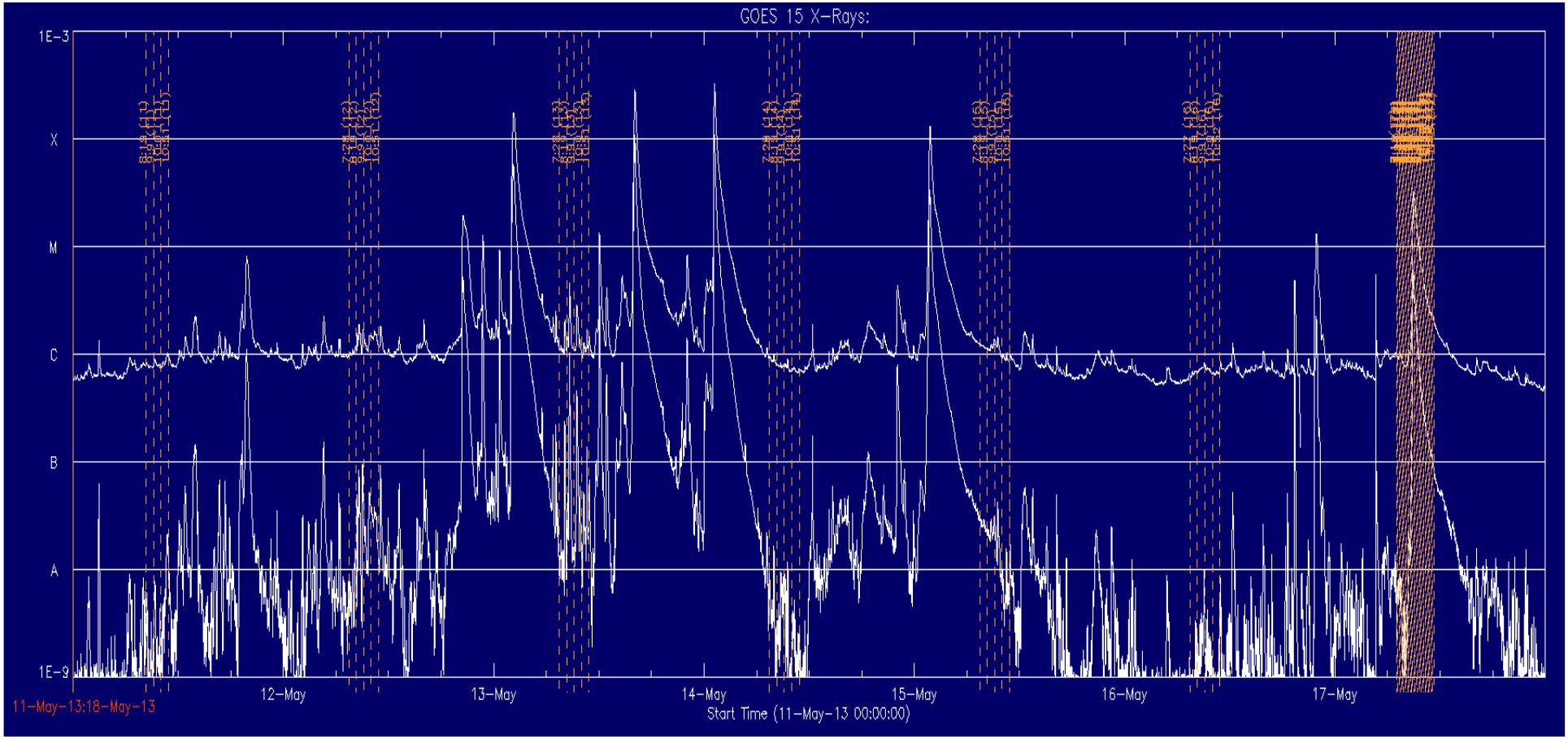
RATAN-600 parameters for solar research

	range	resolution
Spectral	1-18 GHz	1%
Spatial		~15 arcsec x 17 arcmin at 18GHz
Temporal	7-11 UT	4 min cadence
Other parameters:		
Circular polarization accuracy of measurement		1-10%
Flux sensitivity		0.1 s.f.u.

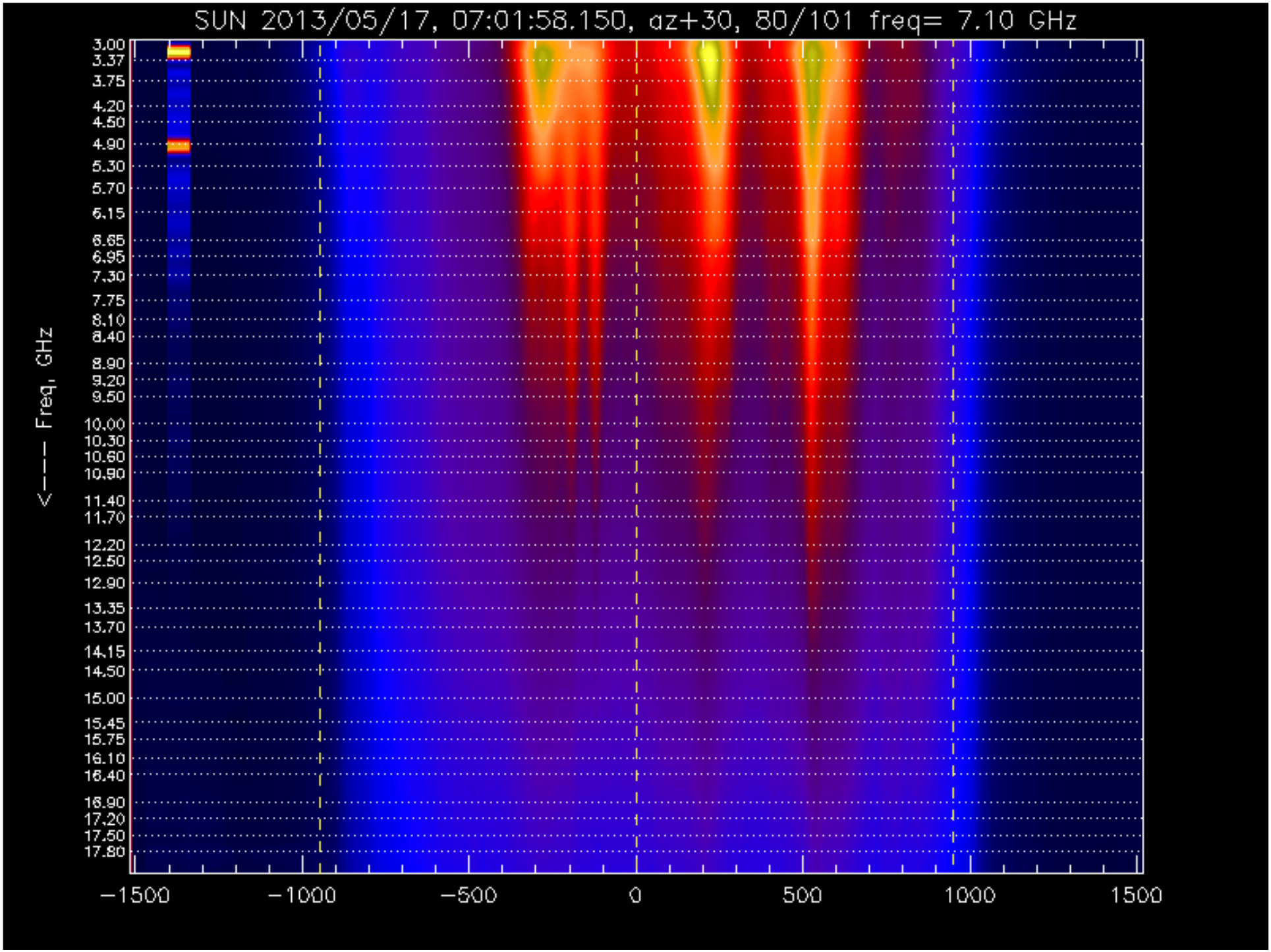


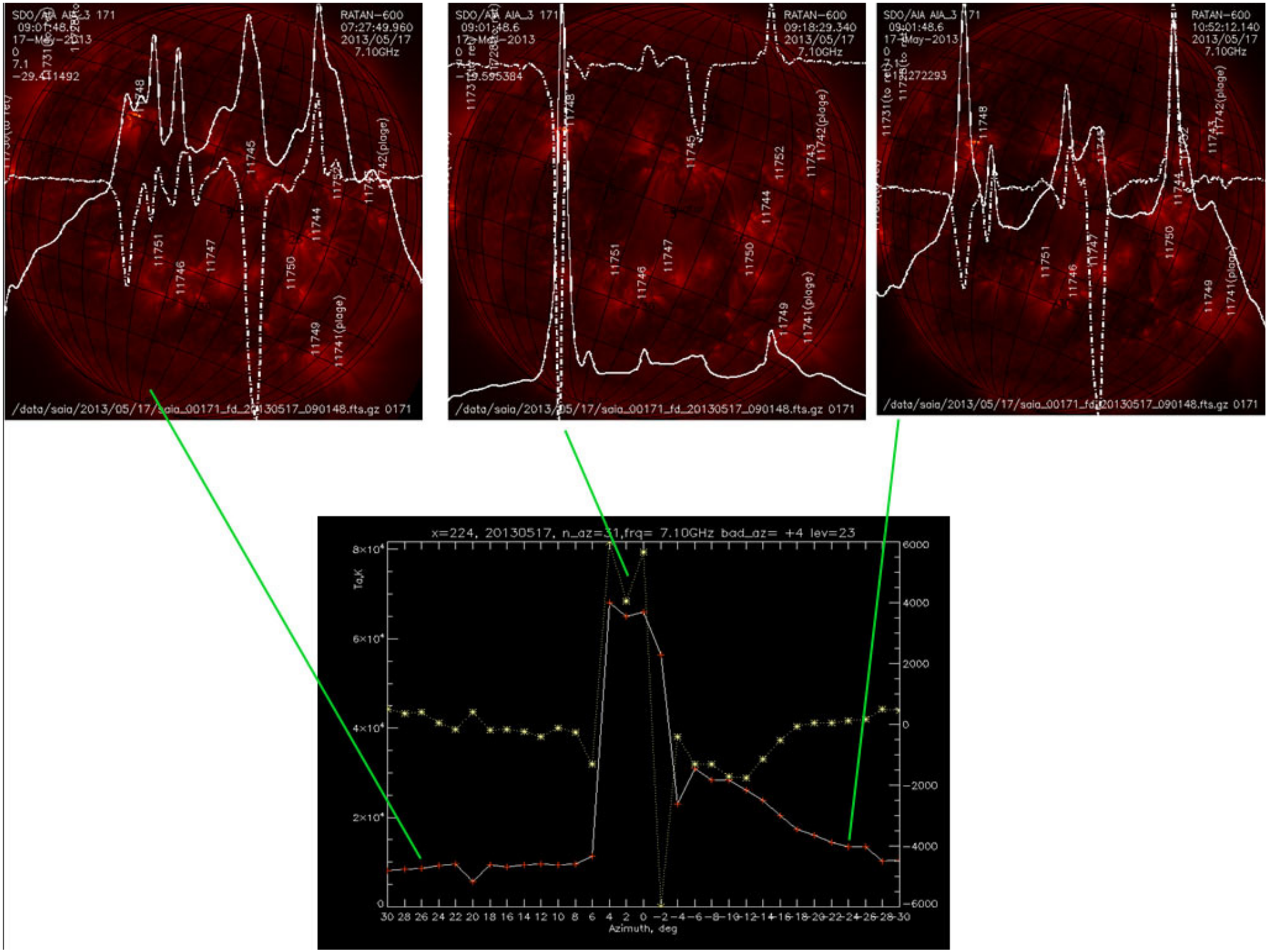
The study of preburst plasma contributes to understanding the processes that lead to a flare, and also facilitates the development of the criteria for forecasting the flare activity.

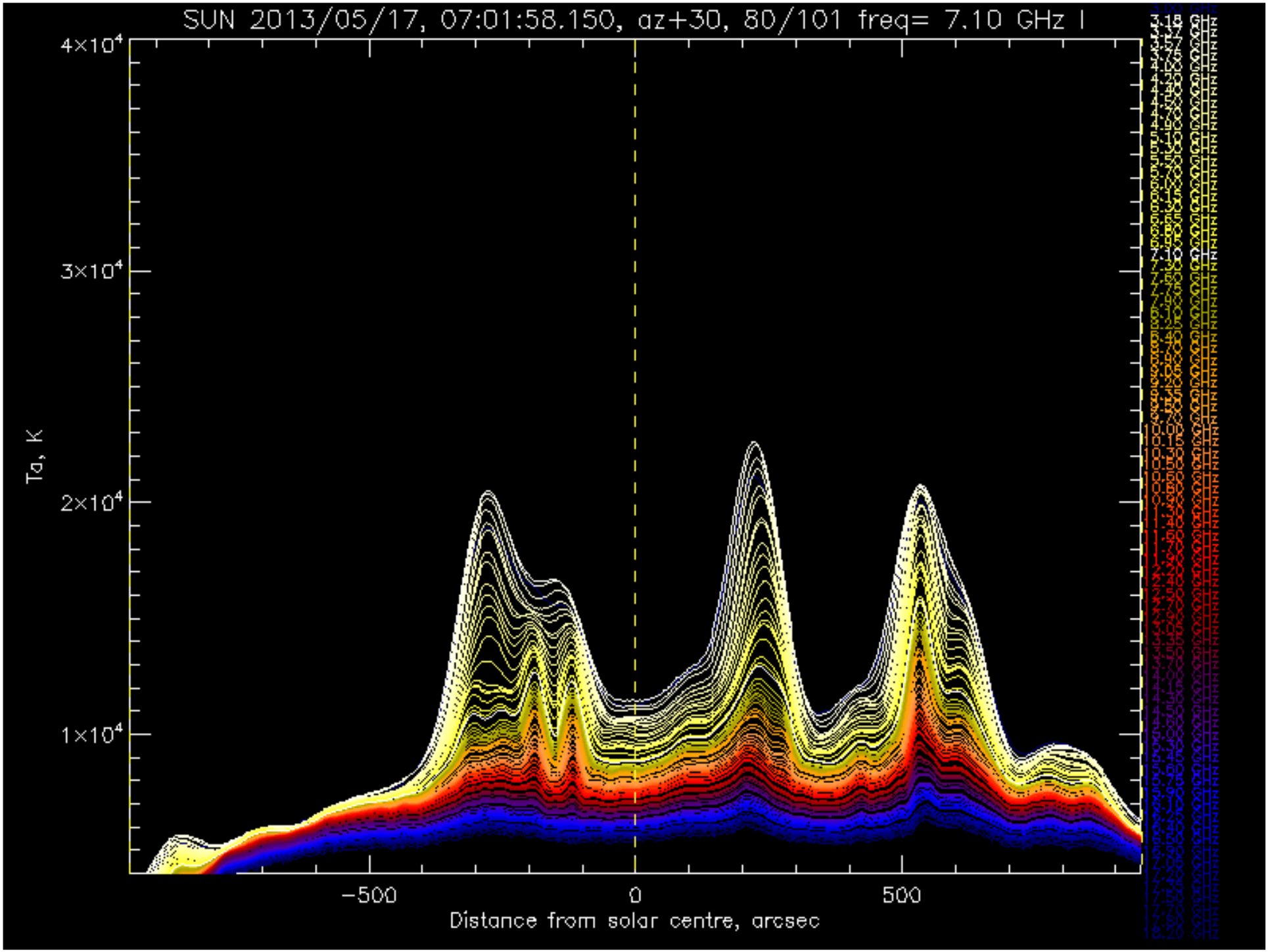
The study of the post-flare plasma provides an insight into the processes of loop heating and the development of new preburst conditions in active regions.

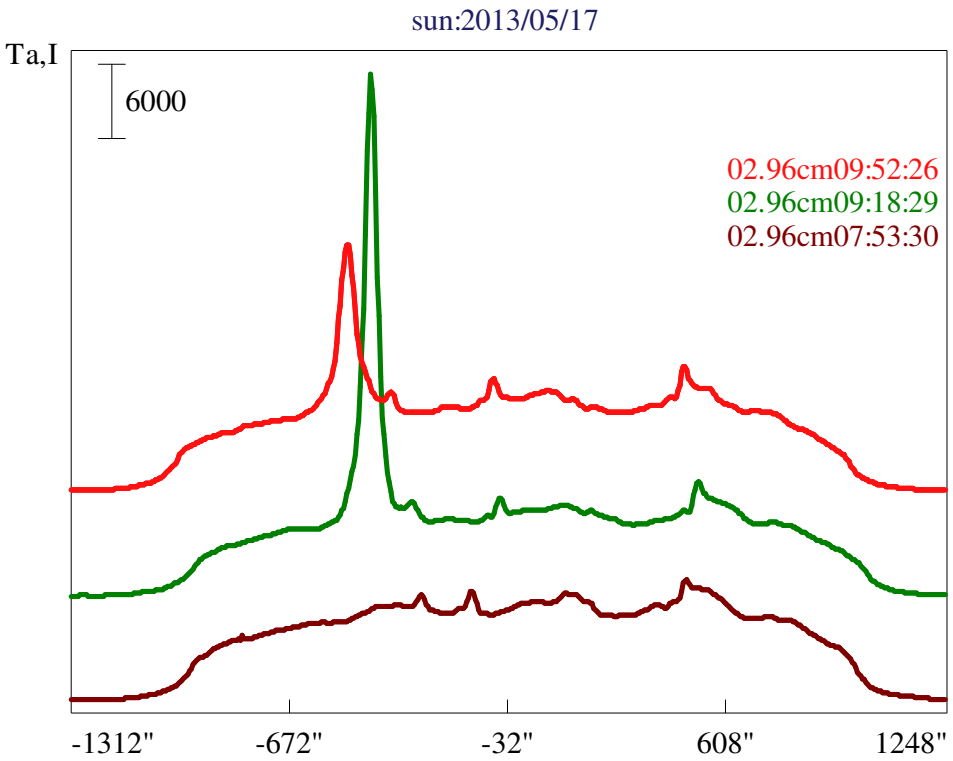


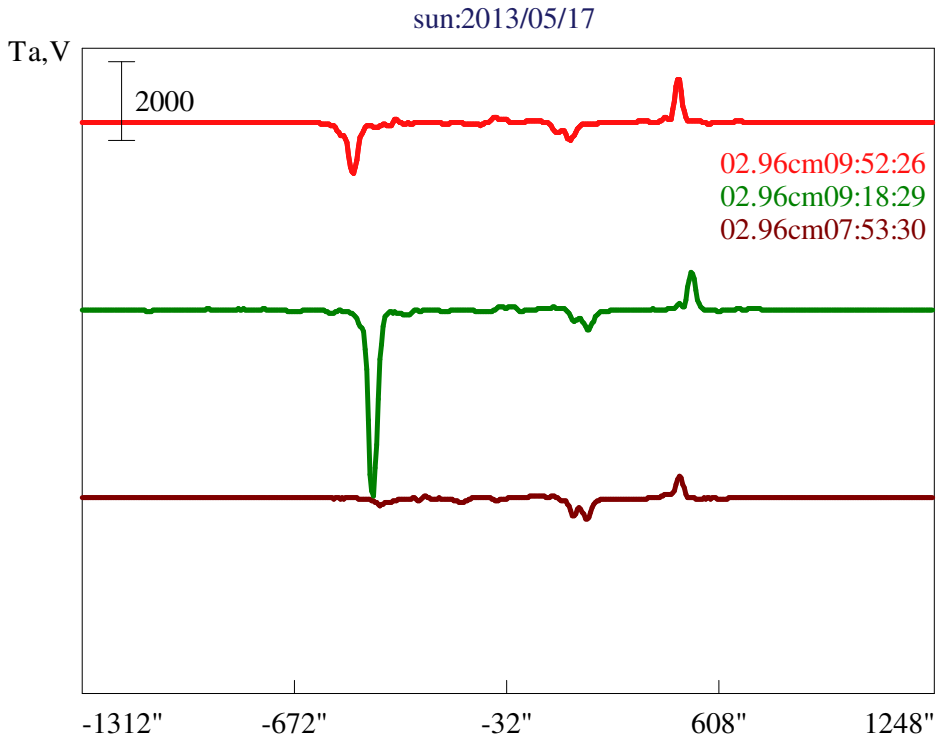
May, 17, 2013 AR 11748 M3.2

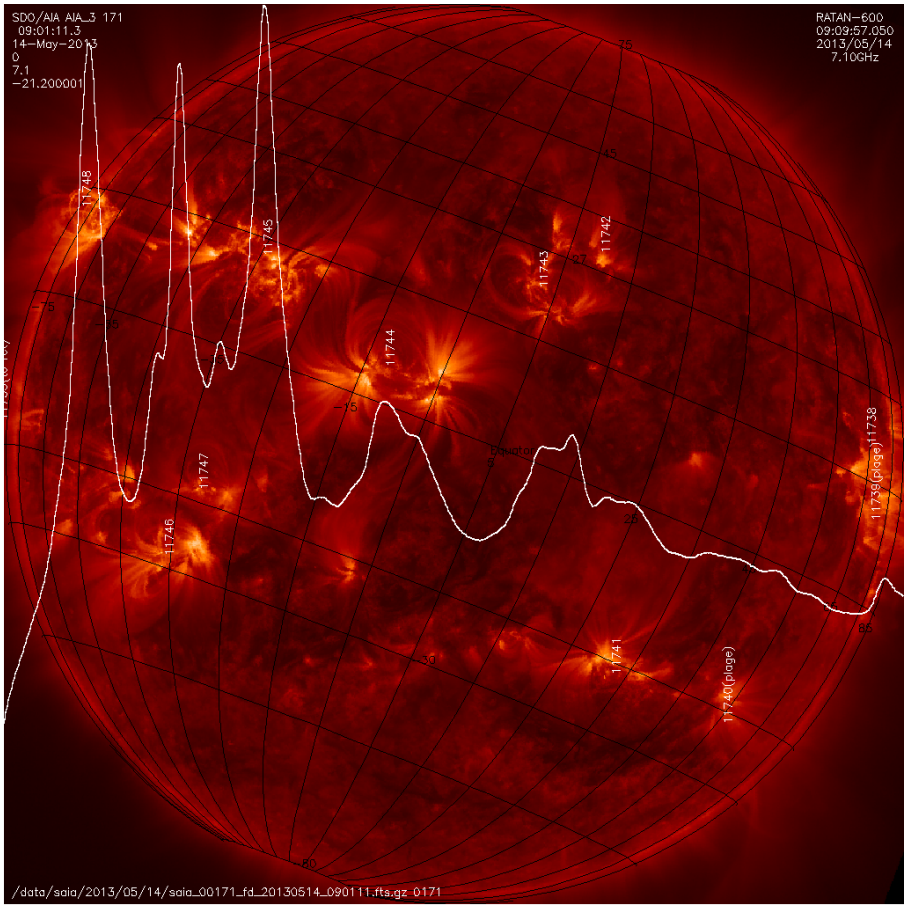

SUN 2013/05/17, 07:01:58.150, az+30, 80/101 freq= 7.10 GHz
<--- Freq, GHz
3.00
3.37
3.75
4.20
4.50
4.90
5.30
5.70
6.15
6.65
6.95
7.30
7.75
8.10
8.40
8.90
9.20
9.50
10.00
10.30
10.60
10.90
11.40
11.70
12.20
12.50
12.90
13.35
13.70
14.15
14.50
15.00
15.45
15.75
16.10
16.40
16.90
17.20
17.50
17.80
−1500
−1000
−500
0
500
1000
1500


SDO/AIA AIA_3 171
09:01:48.6
17-May-2013
RATAN-600
07:27:49.960
2013/05/17
7.10GHz
09:18:29.340
10:52:12.140
11748
11745
11752
11744
11743
11742(plage)
11751
11746
11747
11750
11749
11741(plage)
/data/saia/2013/05/17/saia_00171_fd_20130517_090148.fts.gz 0171
x=224, 20130517, n_az=31,frq= 7.10GHz bad_az= +4 lev=23
Ta,K
8×10⁴
6×10⁴
4×10⁴
2×10⁴
0
6000
4000
2000
0
-2000
-4000
-6000
30 28 26 24 22 20 18 16 14 12 10 8 6 4 2 0 -2 -4 -6 -8 -10 -12 -14 -16 -18 -20 -22 -24 -26 -28 -30
Azimuth, deg


SUN 2013/05/17, 07:01:58.150, az+30, 80/101 freq= 7.10 GHz I
4×10^4
3×10^4
2×10^4
1×10^4
Ta, K
−500
0
500
Distance from solar centre, arcsec


sun:2013/05/17
Ta,I
6000
02.96cm09:52:26
02.96cm09:18:29
02.96cm07:53:30
-1312"
-672"
-32"
608"
1248"


sun:2013/05/17
Ta,V
2000
02.96cm09:52:26
02.96cm09:18:29
02.96cm07:53:30
-1312"
-672"
-32"
608"
1248"


SDO/AIA AIA_3 171
09:01:11.3
14-May-2013
0
7.1
-21.200001
RATAN-600
09:09:57.050
2013/05/14
7.10GHz
11748
11745
11742
11743
11744
11747
11746
11741
11740(plage)
11739(plage)11738
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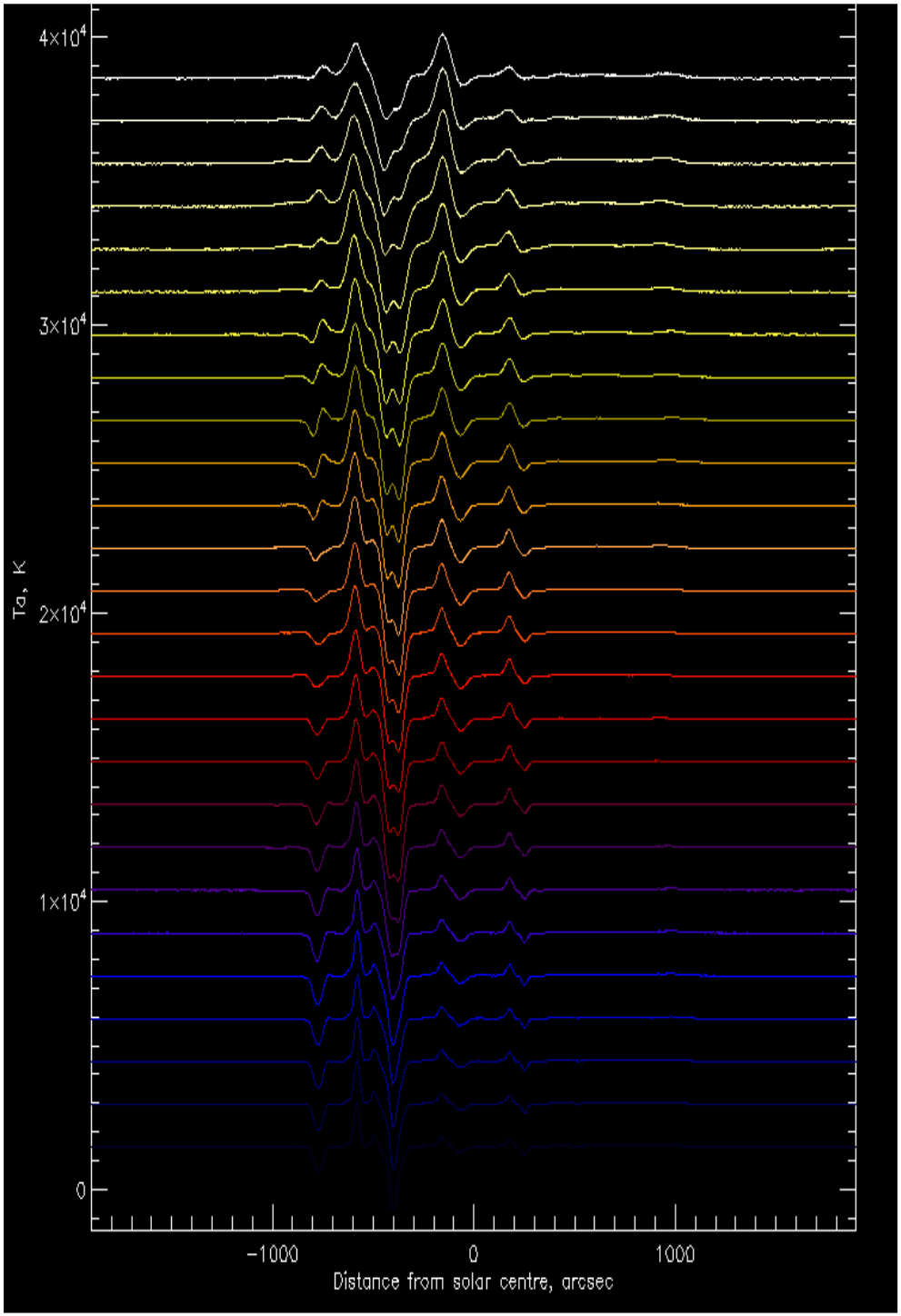
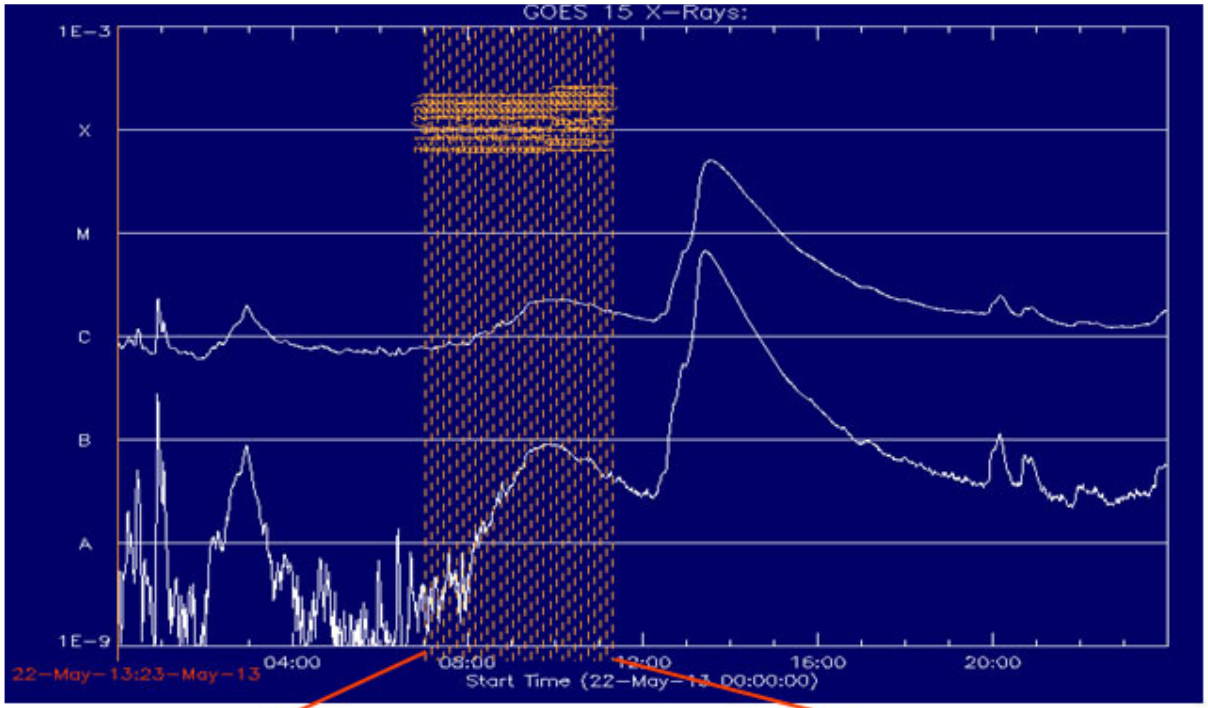
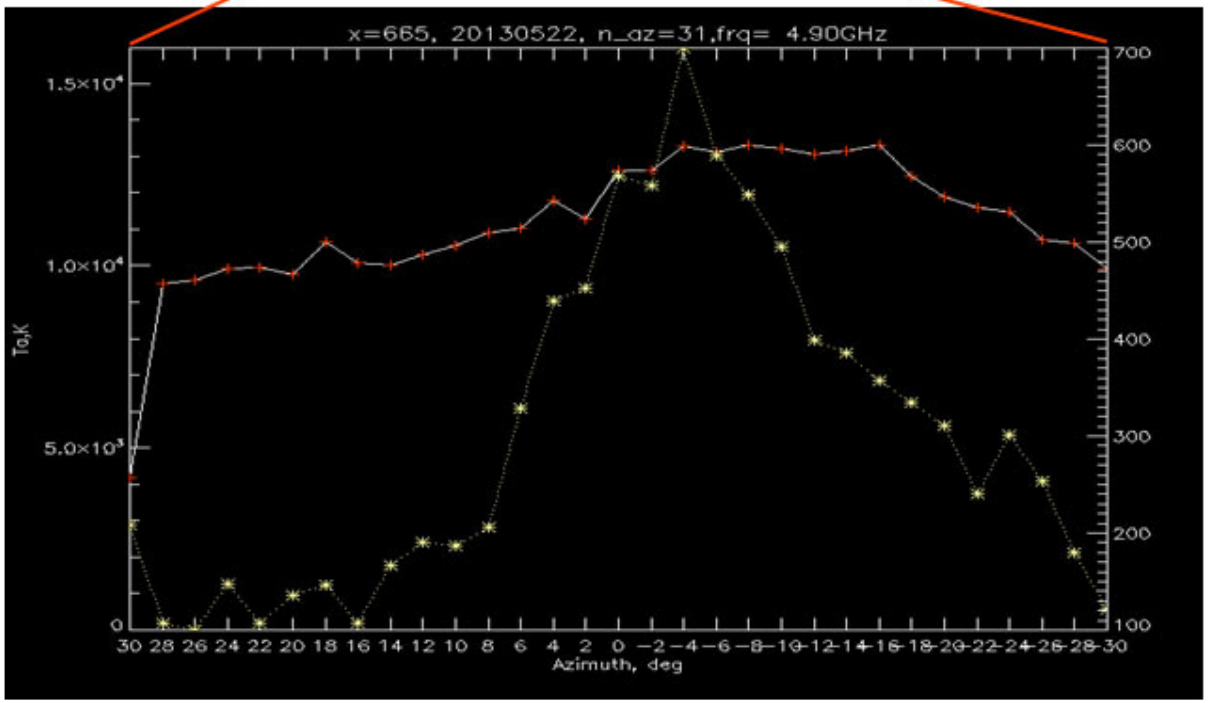
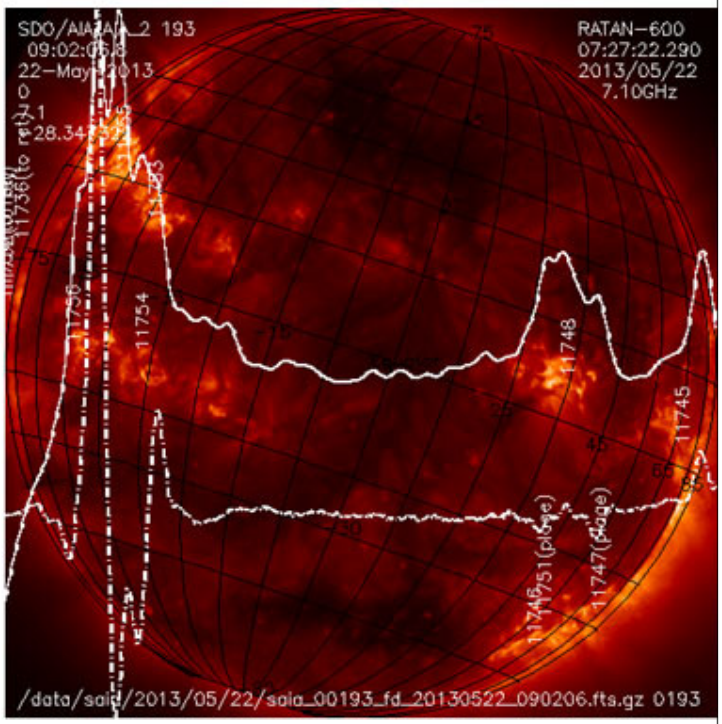

4x10^4
3x10^4
2x10^4
1x10^4
0
Ta, K
-1000
0
1000
Distance from solar centre, arcsec

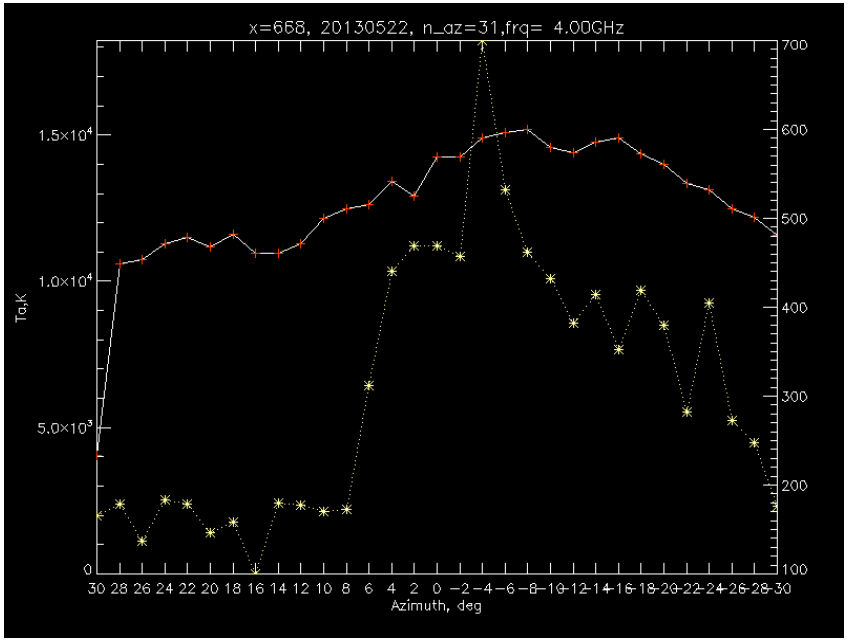






May, 22, 2013 AR 11745

M5.0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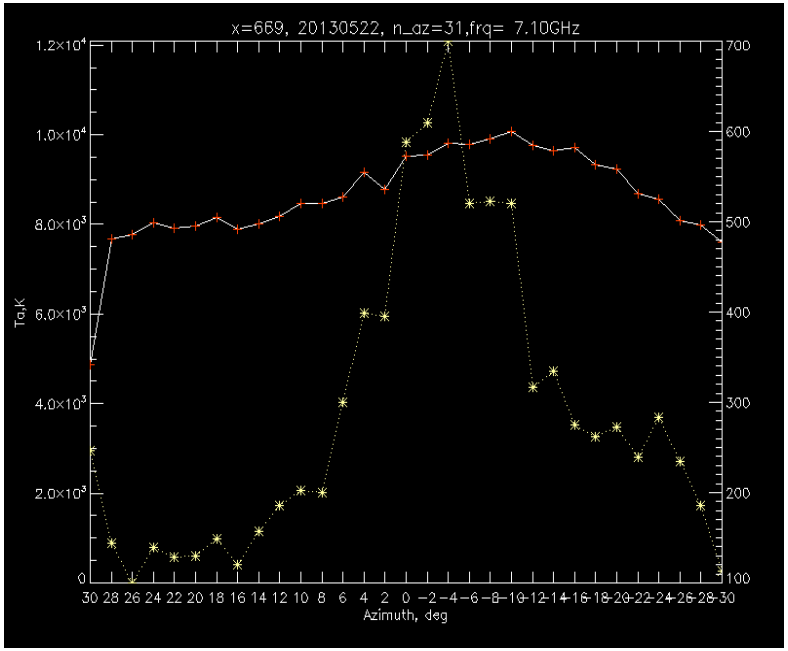
Ta,K
Azimuth, deg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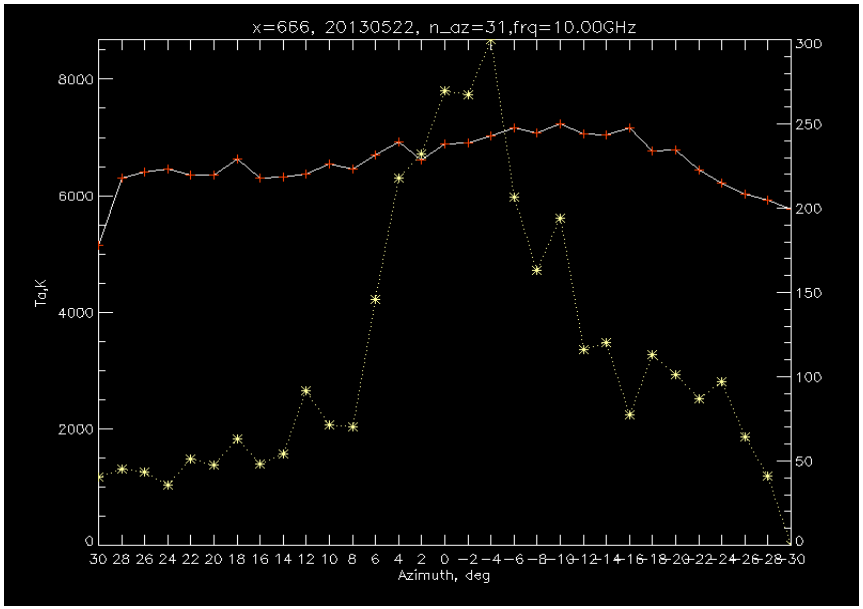
Ta,K
Azimuth, deg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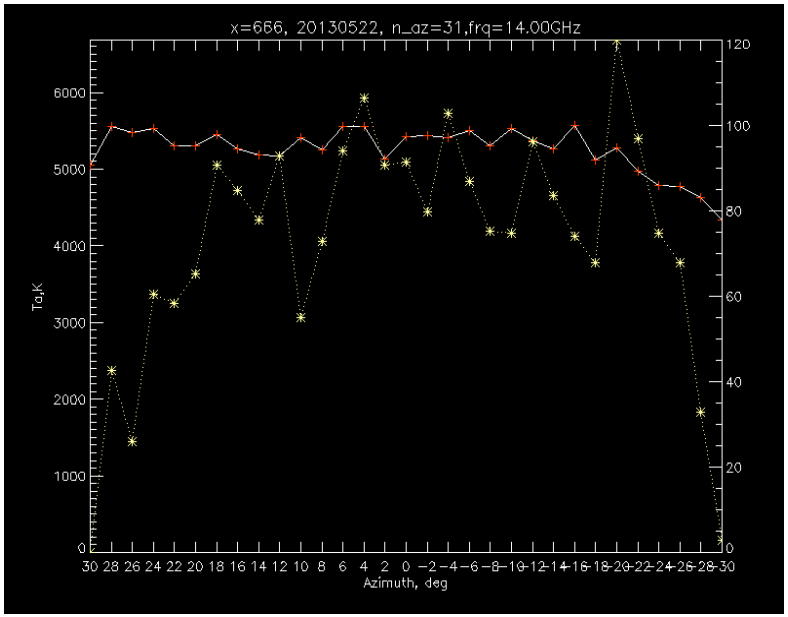
Ta,K
Azimuth, deg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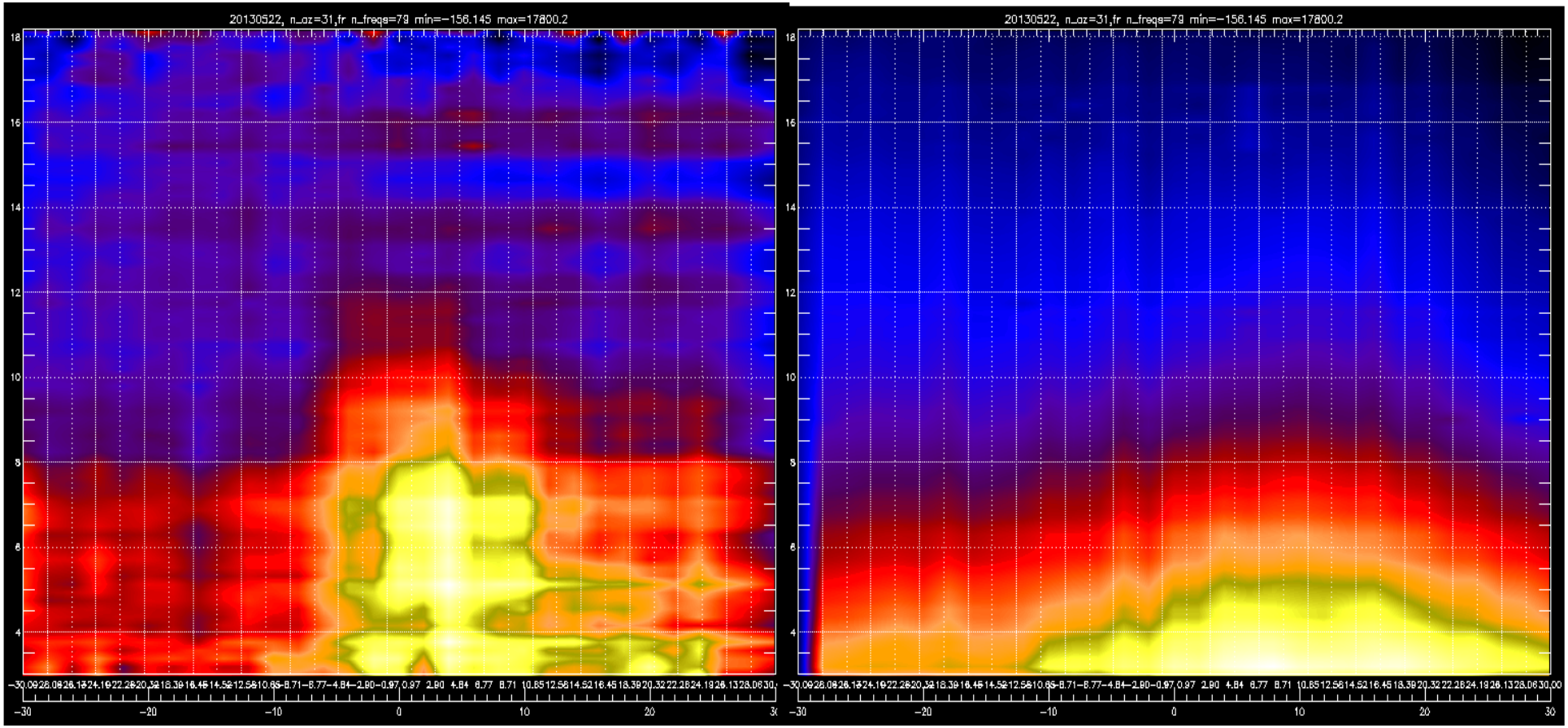
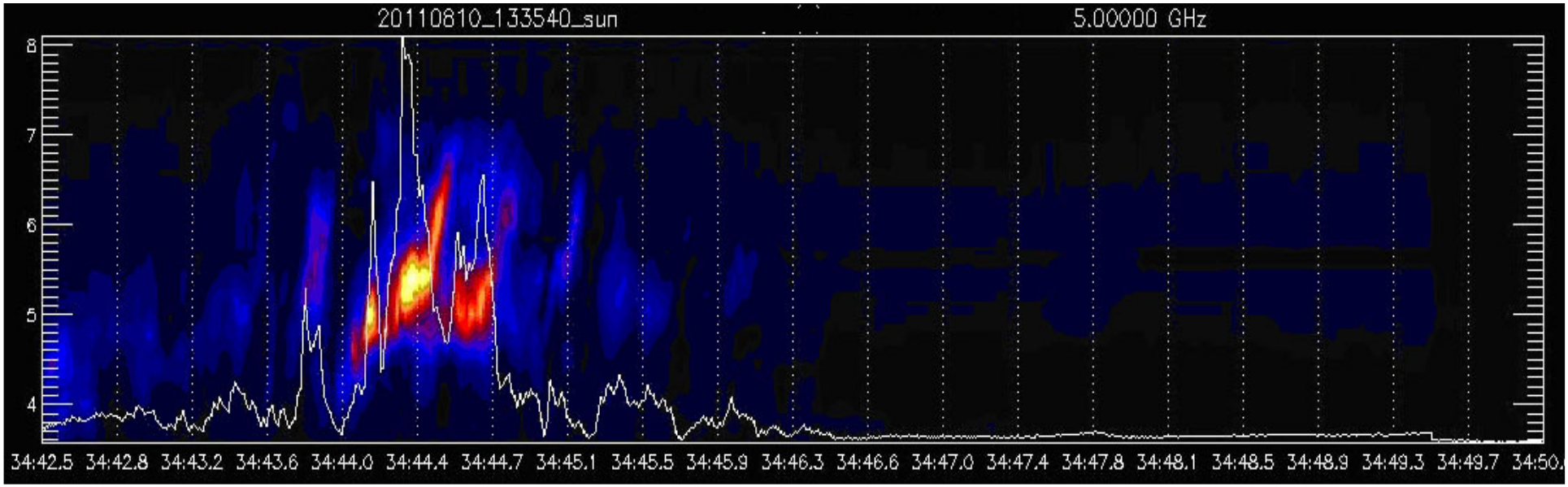
Ta,K
Azimuth, deg


20130522, n_az=31,fr n_freqs=79 min=-156.145 max=17800.2
20130522, n_az=31,fr n_freqs=79 min=-156.145 max=17800.2

- *On the possible mechanisms of energy release in the C-class flare*
- *L.K. KASHAPOVA , S.K.TOKHCHUKOVA, G.V.RUDENKO, V.M.BOGOD AND A.A.MURATOV*

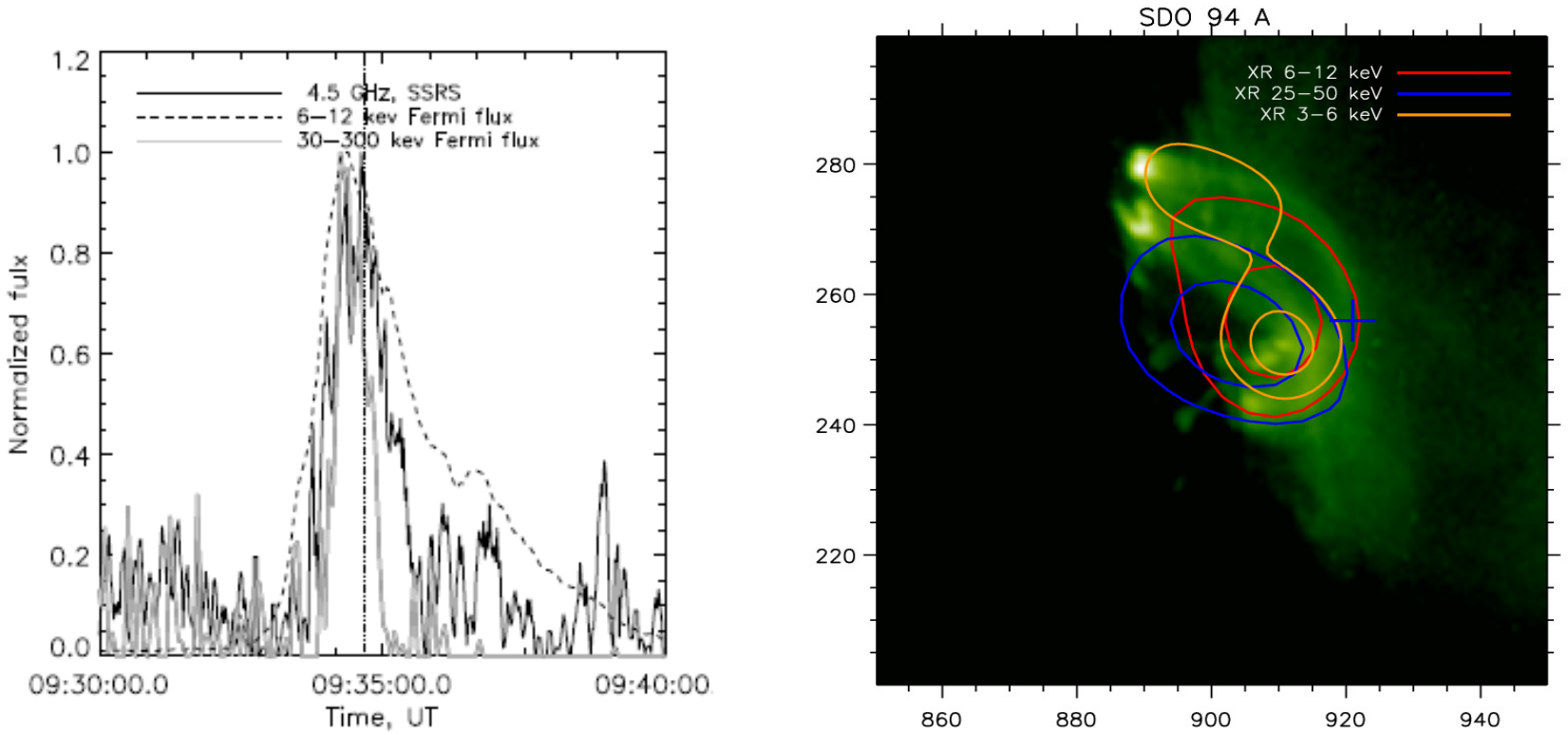
Cent. Eur. Astrophys. Bull. **37** (2012)

- The study the C2.4 flare occurred at 9:35 UT, 2011 August 10 in AR 11263 near the western limb.
- It was observed by RATAN-600 and the Siberian Solar Radio Spectropolarimeter (4-8 GHz) in microwaves and by RHESSI and FERMI in the hard X-rays (HXR).
- For the first time the subsecond impulses were registered by 14 ms temporal resolution with RATAN-600 in 3.5 - 8 GHz.



•A peculiarity of this event was the detection of HXR flux with energies above 25 keV that is not typical for such weak flares. The good correlation between the HXR and MW time profiles indicates the generation of both HXR and MW emission by common population of electrons.

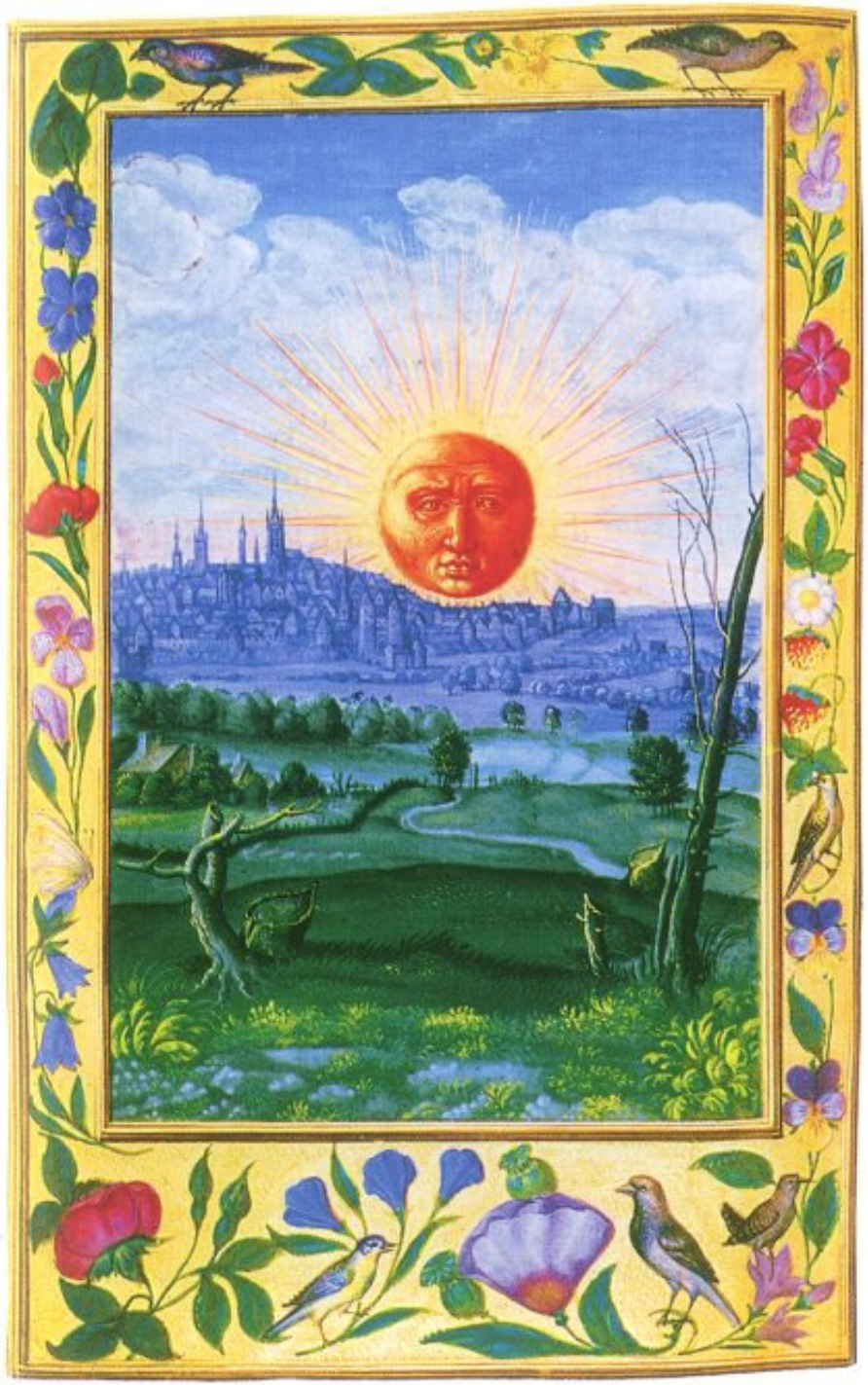
• Results of fitting the HXR spectra revealed that the flare emission of energies above 25 keV could be generated both by high-temperature source (T> 30 MK).



Left: Evolution of MW flux and HXR fluxes during the flare. Right: Position of the HXR and MW sources during the flare. The image is 94Å EUV image by AIA/SDO

Summary

- We have analyzed several powerful solar events that took place at the maximum of cycle 24 based on regular observations with RATAN-600 radio telescope.
- The spectral-polarization observations over a wide wavelength range from DM waves to mm-wave reveal numerous intensity and polarization effects reflecting the characteristics of active regions at the pre-flare, flare and post-flare stages.
- The frequency range covers the gyroresonance emission from all the active regions, corresponding to the magnetic field strengths found in the corona (up to 2500 G), and other emission mechanisms, being able to indicate the preflare state and monitor the solar flare activity.
- The RATAN-600 archive of daily solar observations is open for investigations.
- Regular observations are important for tracking both the gradual and abrupt changes in the spectra of polarization, and especially to detect the the onset of powerful flares.



Salomon Trismosinus
“Splendor Solis”
around 1535