Solar Physics with the Long Wavelength Array

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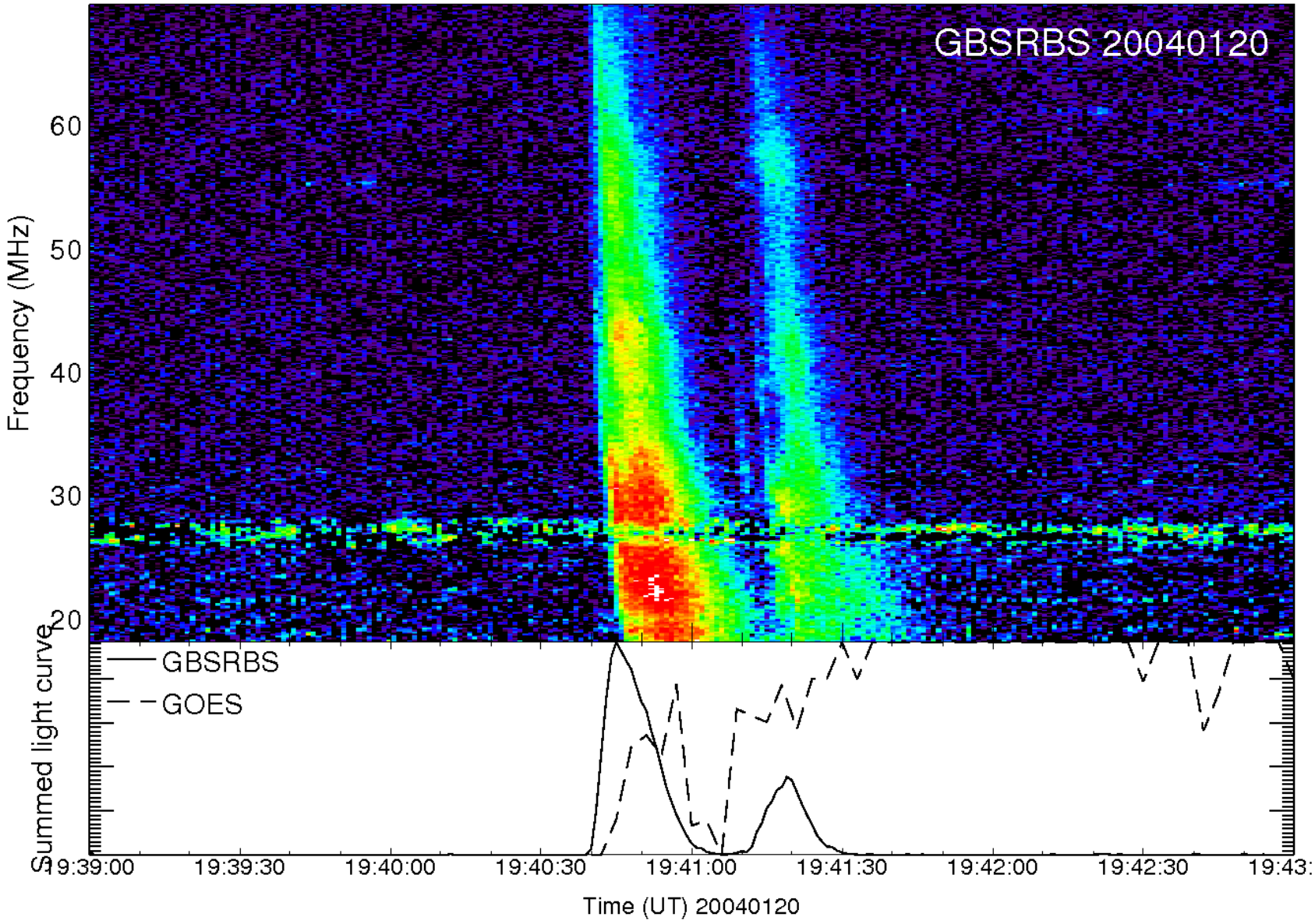
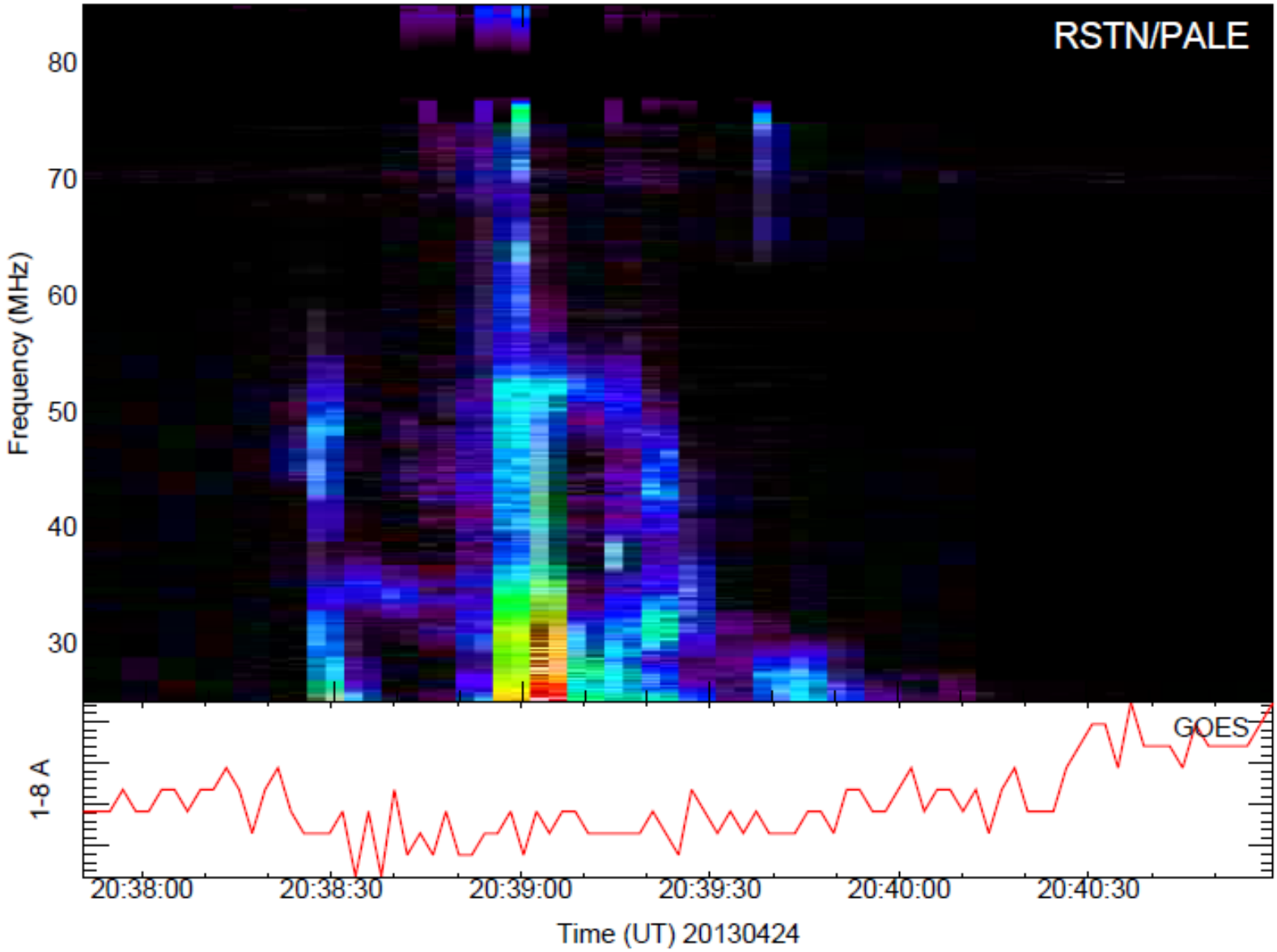
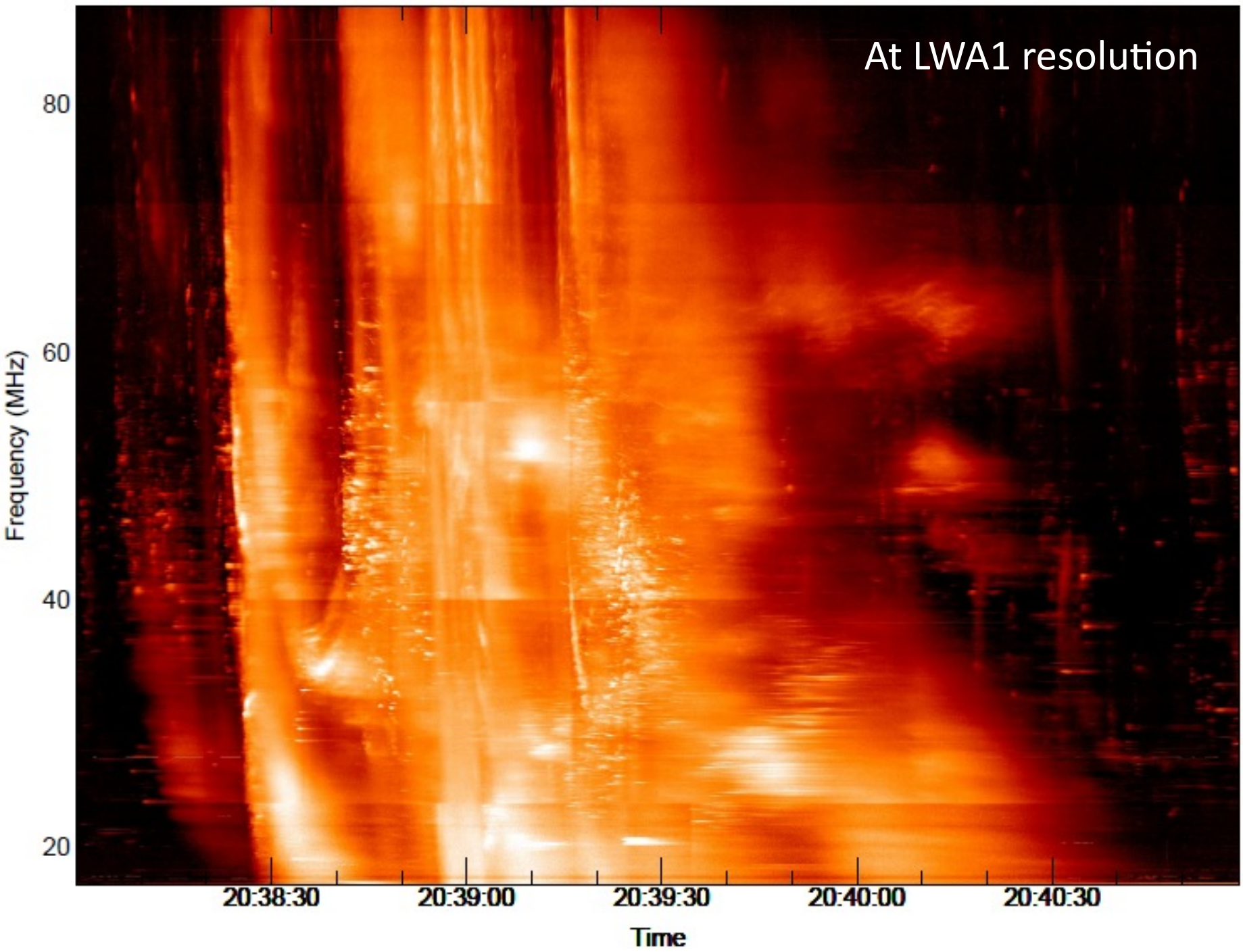
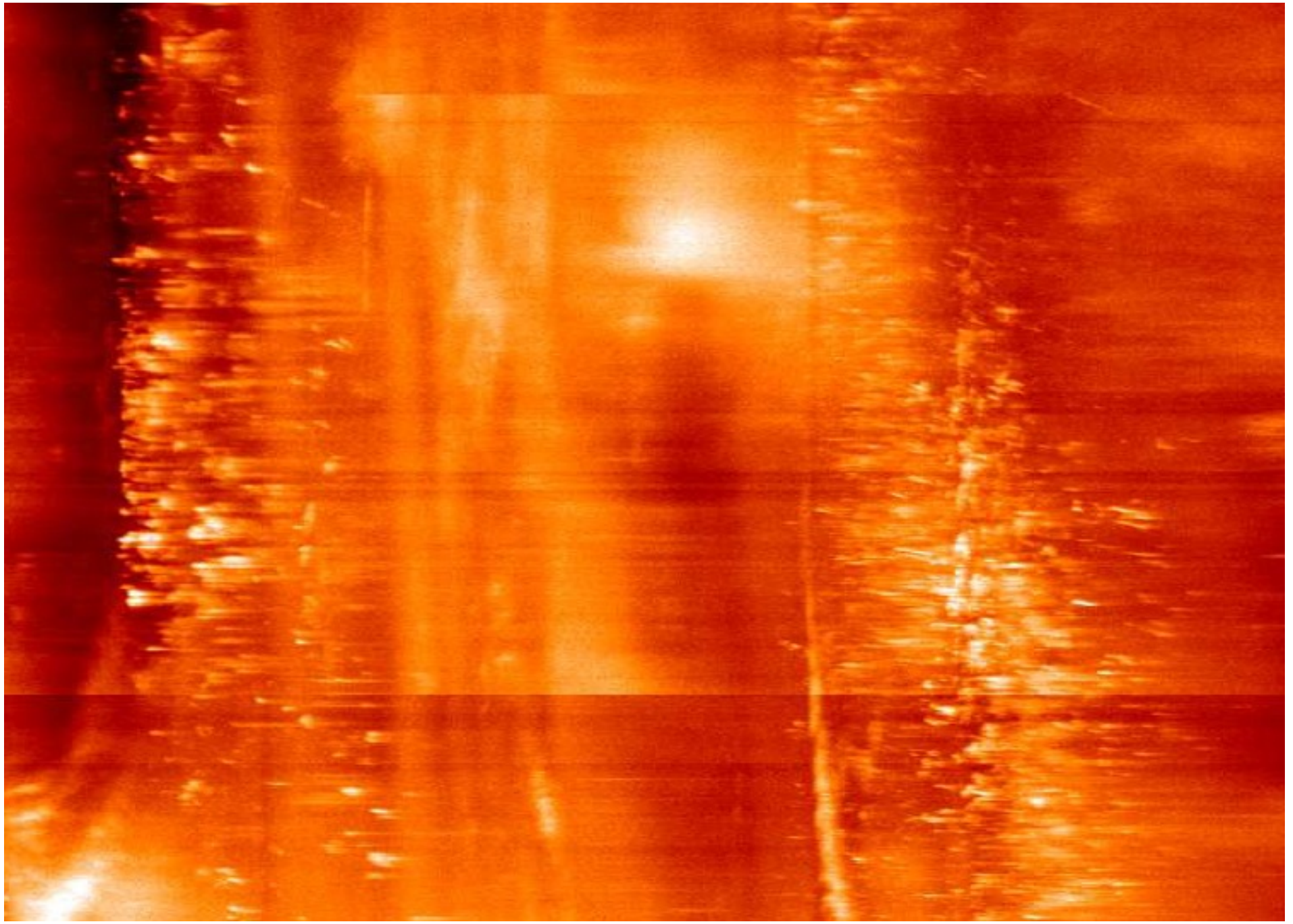
Type III burst: fast-drift electron beam (4 mins)



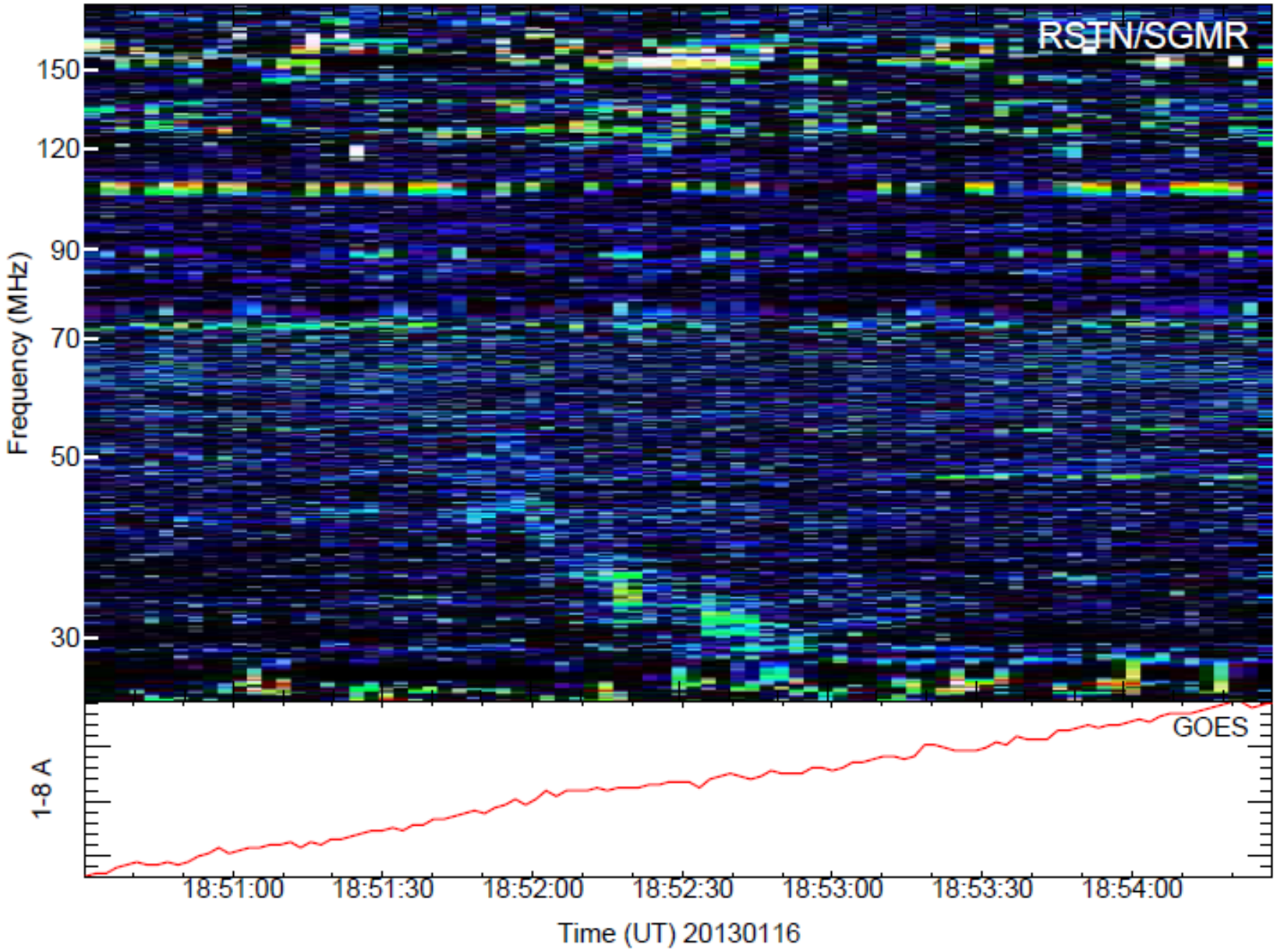
“Type III” burst at RSTN (3 seconds, 0.15 MHz)

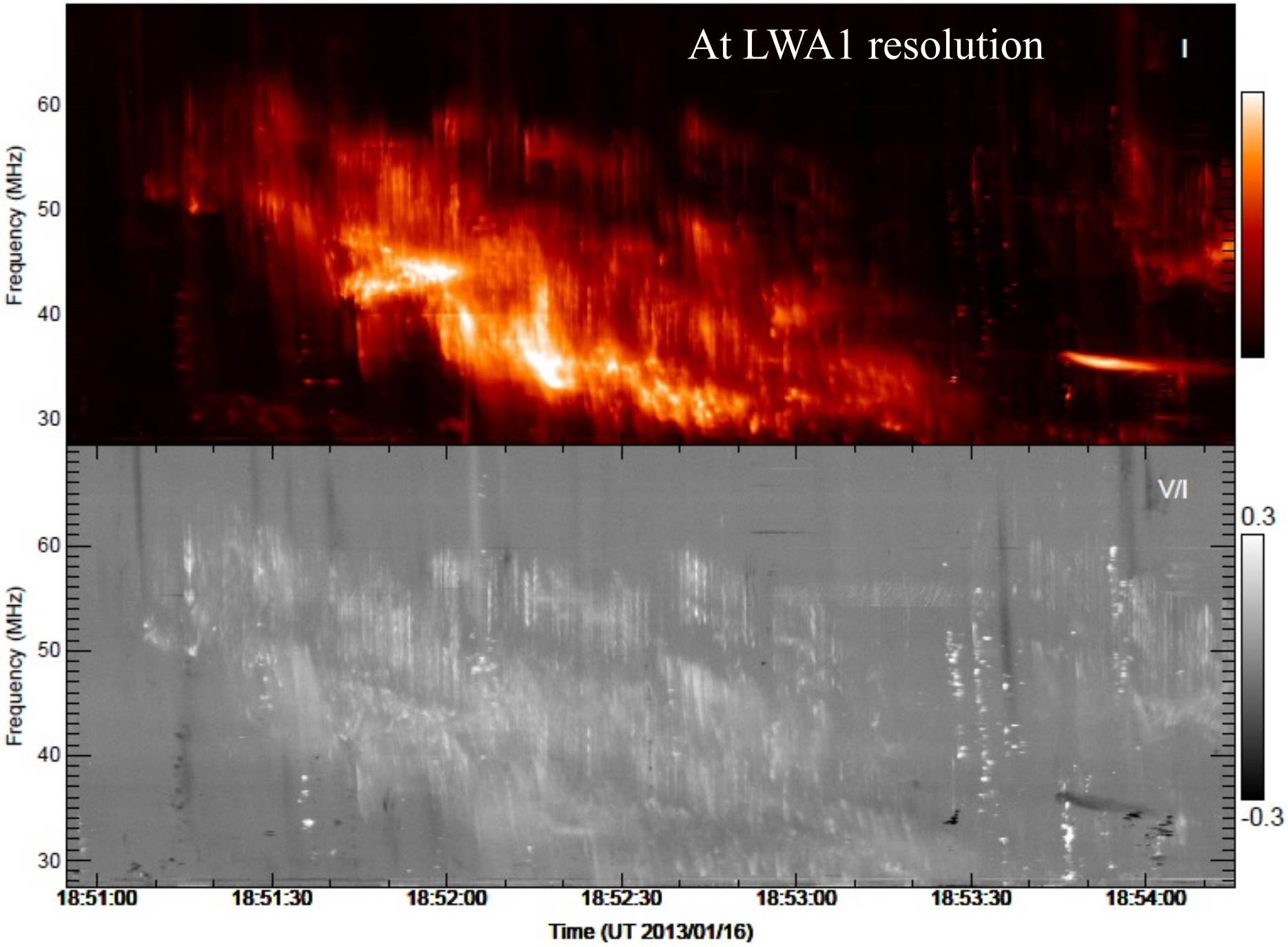



At LWA1 resolution
80
60
40
20
Frequency (MHz)
20:38:30
20:39:00
20:39:30
20:40:00
20:40:30
Time



Burst at RSTN resolution (3 seconds, 0.15 MHz)

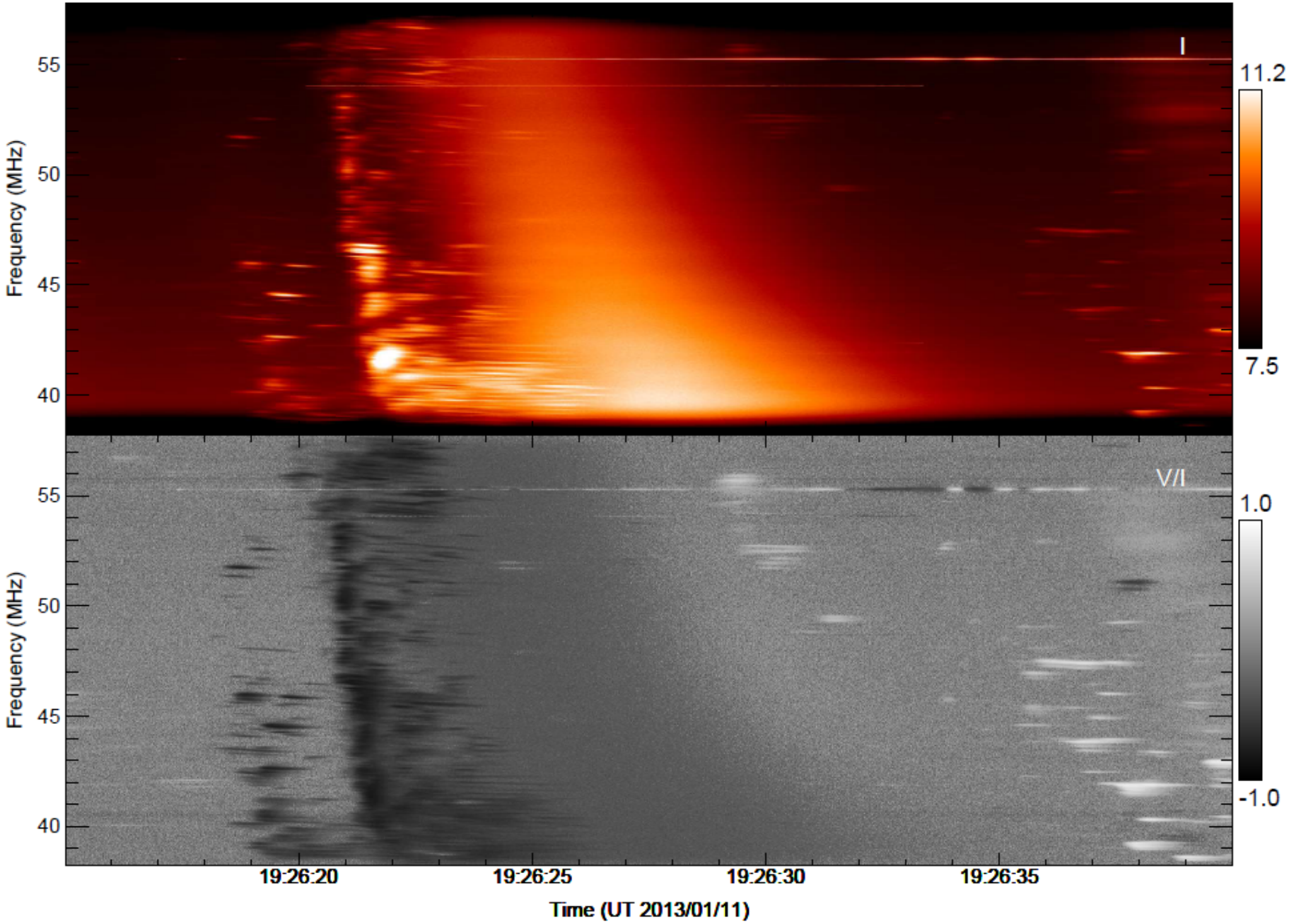


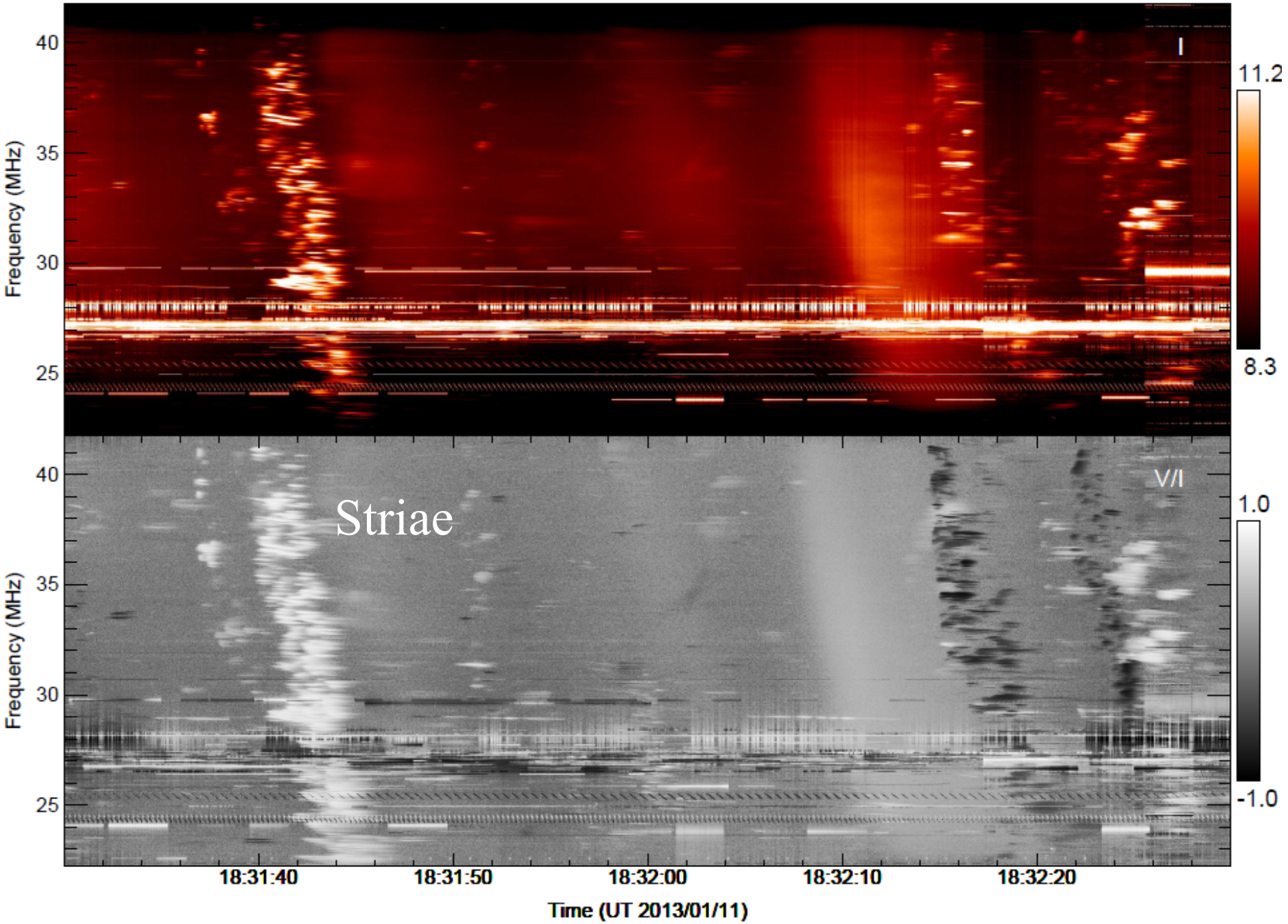

At LWA1 resolution
I
V/I
0.3
-0.3
Frequency (MHz)
60
50
40
30
18:51:00
18:51:30
18:52:00
18:52:30
18:53:00
18:53:30
18:54:00
Time (UT 2013/01/16)

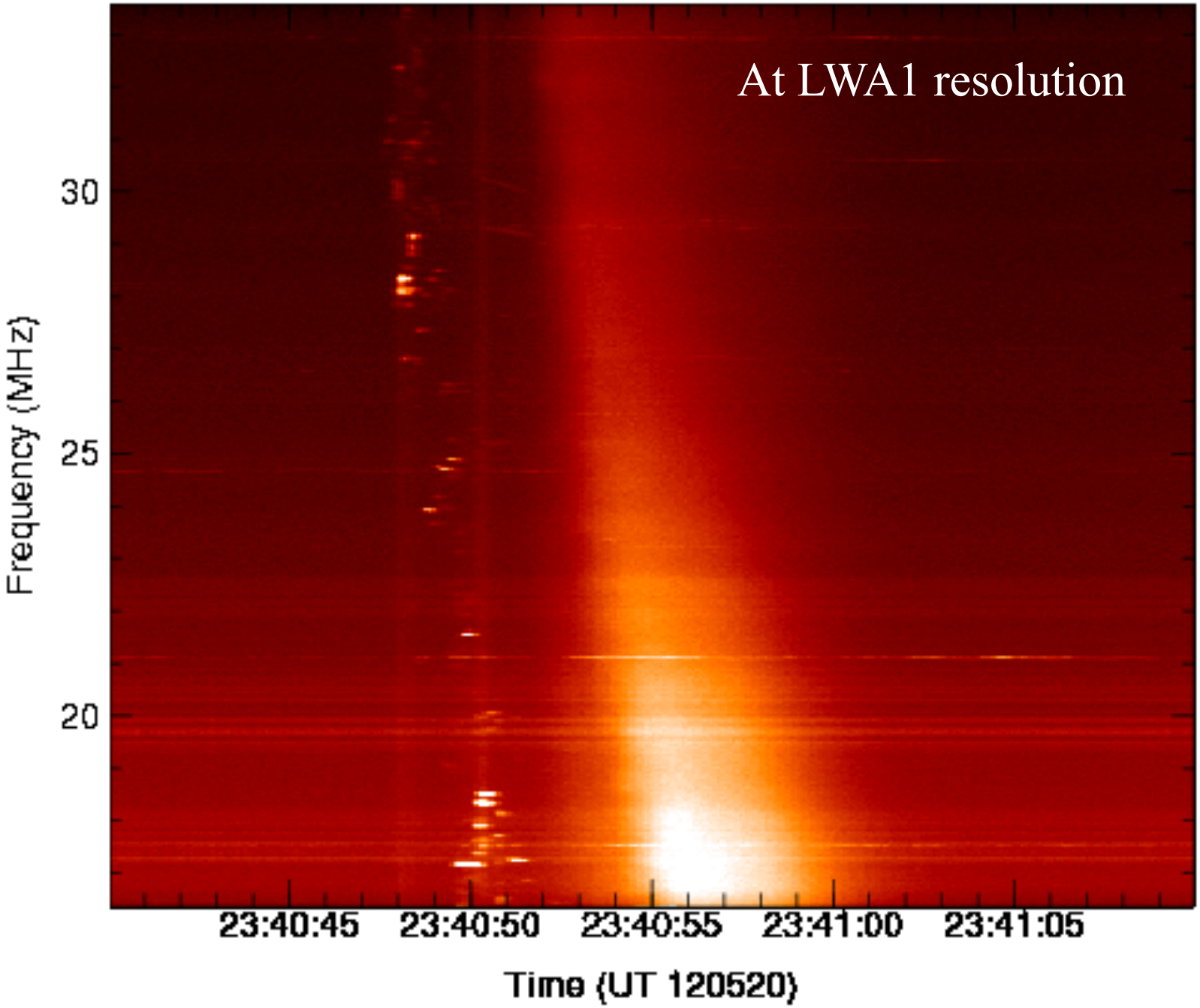
Mechanisms of plasma emission

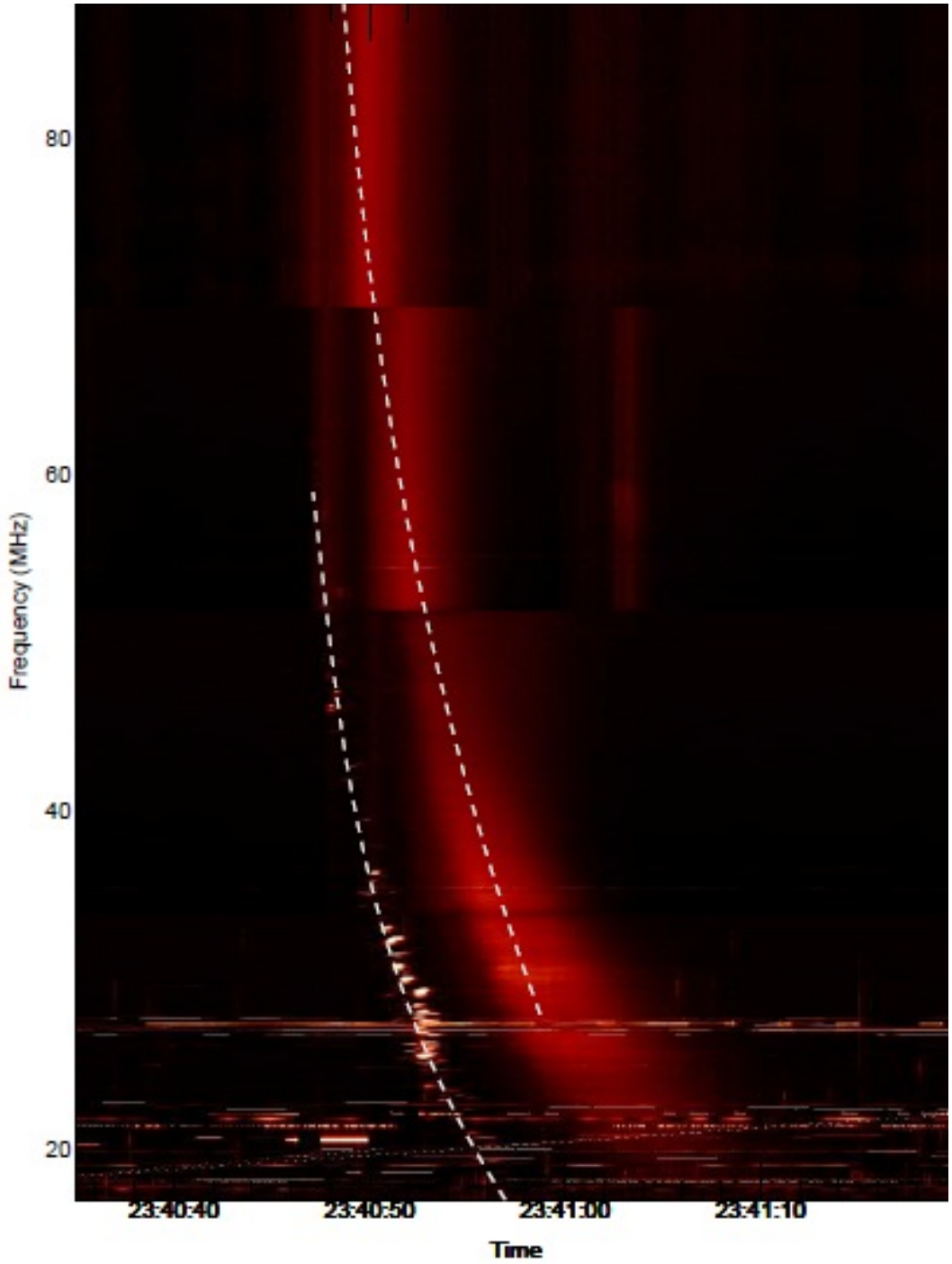
50 years of research on this topic. Two levels to the problem:
(i) beam propagation and interaction of beam and Langmuir waves;
(ii) generation of propagating electromagnetic emission.
Possible mechanisms include:

- Modulational instability: collapse of Langmuir wave packets. Requires very strong electric fields.
- Electrostatic decay: decay of Langmuir waves into low-frequency electrostatic waves and other Langmuir waves (L -> L' + S) or transverse waves (L -> T + S).
- Stochastic growth theory: time-integrated growth of Langmuir waves is a stochastic variable due to interactions between beam, waves and an inhomogeneous plasma that result in marginal stability. Predicts that waves should be bursty and irregular.


I
11.2
7.5
V/I
1.0
-1.0
Frequency (MHz)
55
50
45
40
19:26:20
19:26:25
19:26:30
19:26:35
Time (UT 2013/01/11)


I
11.2
8.3
40
35
30
25
Frequency (MHz)
V/I
1.0
-1.0
Striae
18:31:40
18:31:50
18:32:00
18:32:10
18:32:20
Time (UT 2013/01/11)


At LWA1 resolution
30
25
20
Frequency (MHz)
23:40:45
23:40:50
23:40:55
23:41:00
23:41:05
Time (UT 120520)



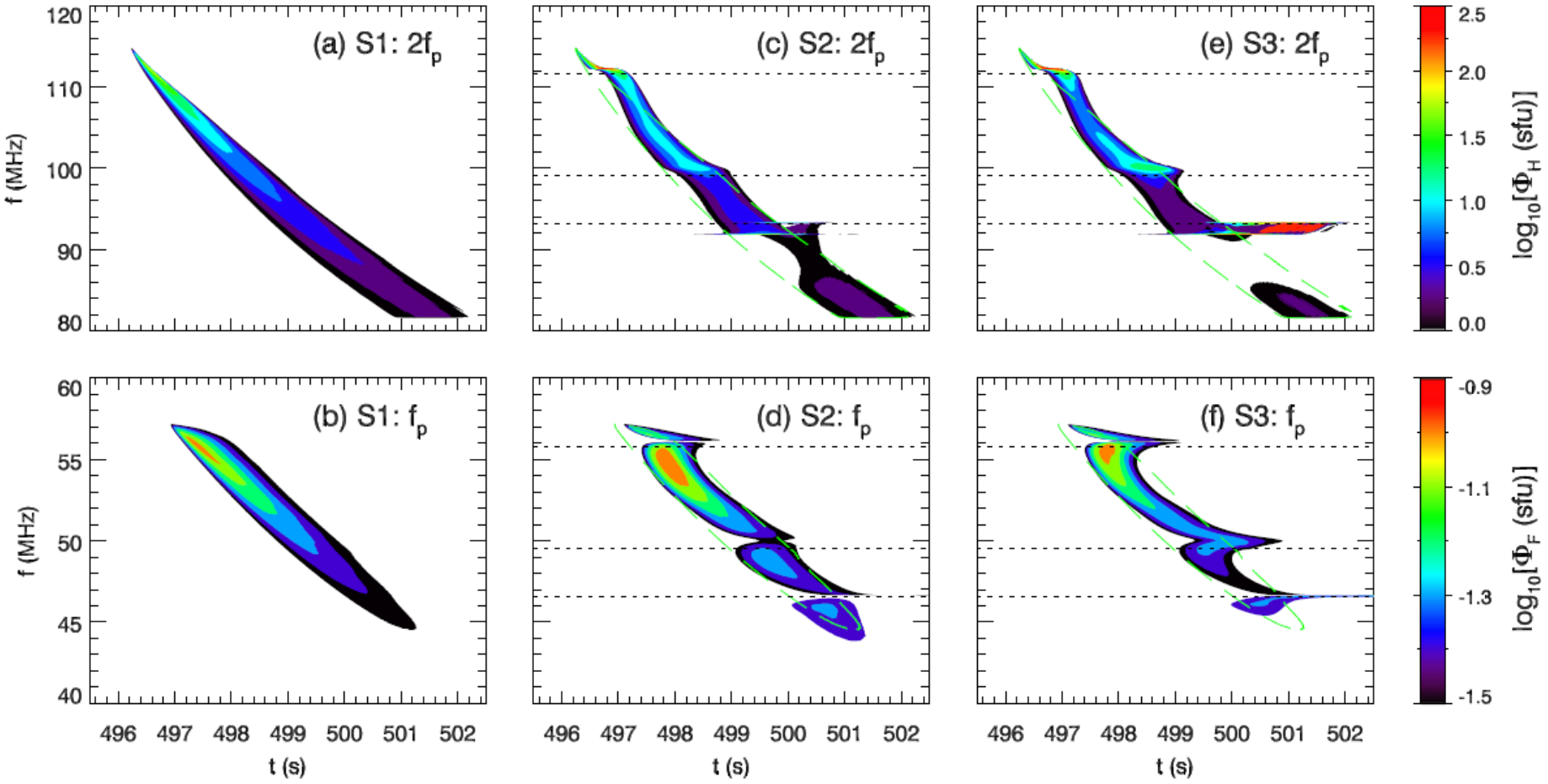
Fundamental-harmonic Type III

At LWA1's resolution, can see structure in the fundamental, known as Type IIIb: instead of smooth rise and fall, have fine frequency structure

Fine structure in Type III bursts

- "Smooth" Type III bursts may be harmonic emission ($f = 2f_p$) while striae are fundamental emission ($f = f_p$): originally suggested because striae are more highly polarized.
- Models say that we can produce striae by local density enhancements (Takakura + Youssef 1975) in which the density gradient is small, source can be large, or
- by electron temperature enhancements, but only in the harmonic (Li et al 2011a), or
- by ion temperature enhancements, which make them more pronounced in the fundamental but emission is still weaker than $2f_p$ (Li et al 2011b).

None of these models explain what we see.

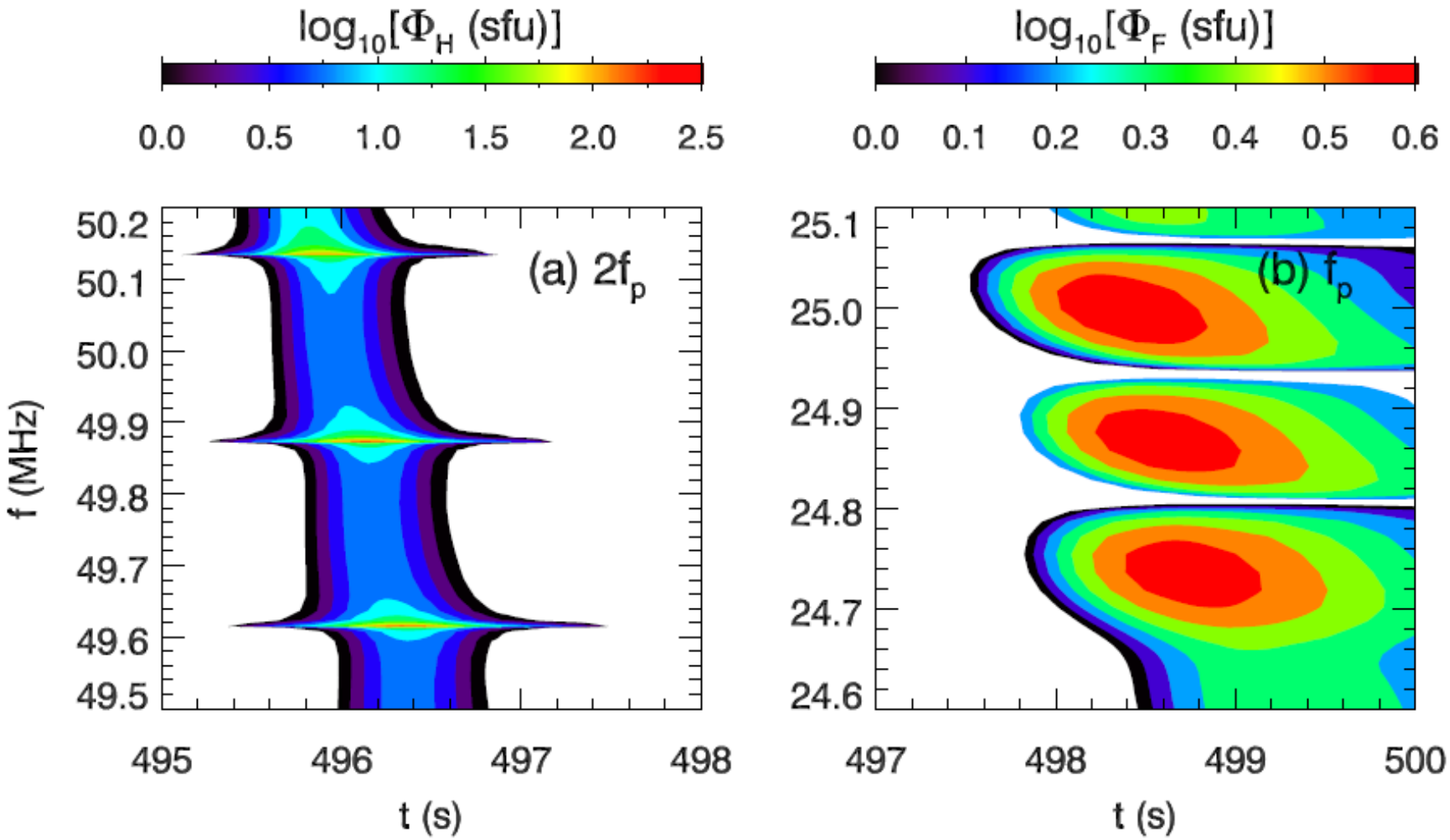


Smooth outward density gradient, fixed temperatures.

3 density fluctuations added to gradient, fixed temperatures.

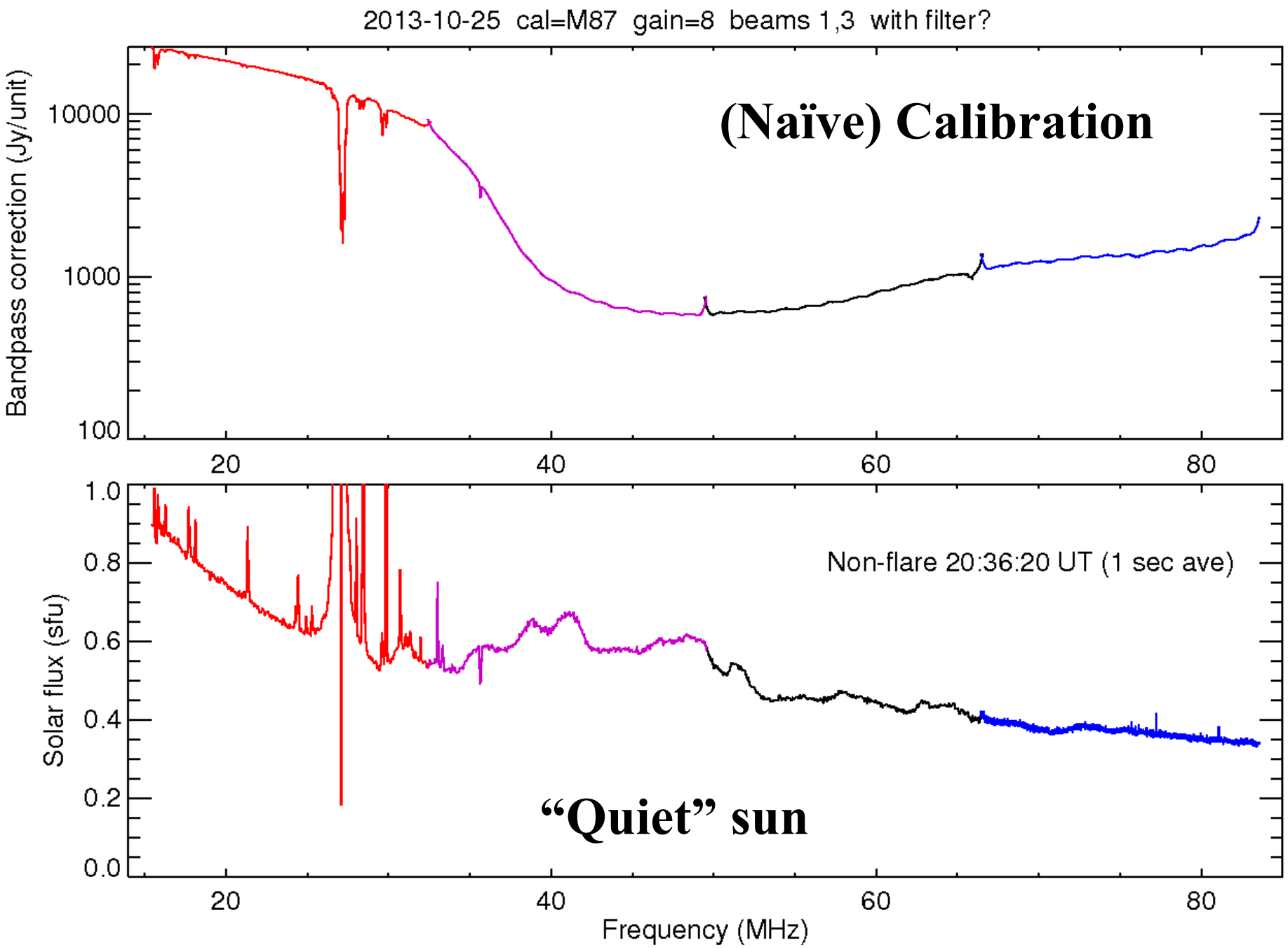
3 density+T_e fluctuations, fixed T_i.

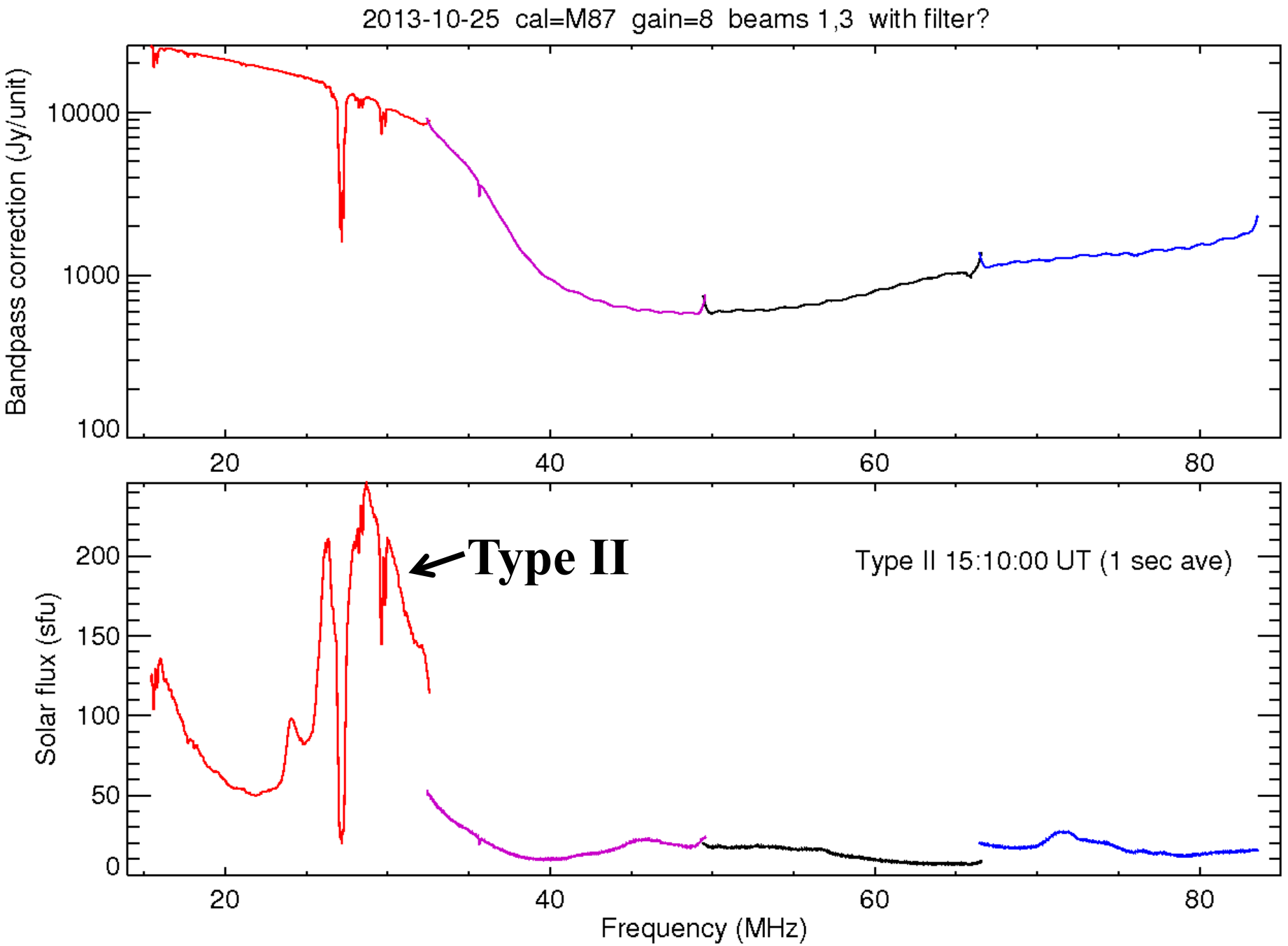
Simulations by Li et al 2012.

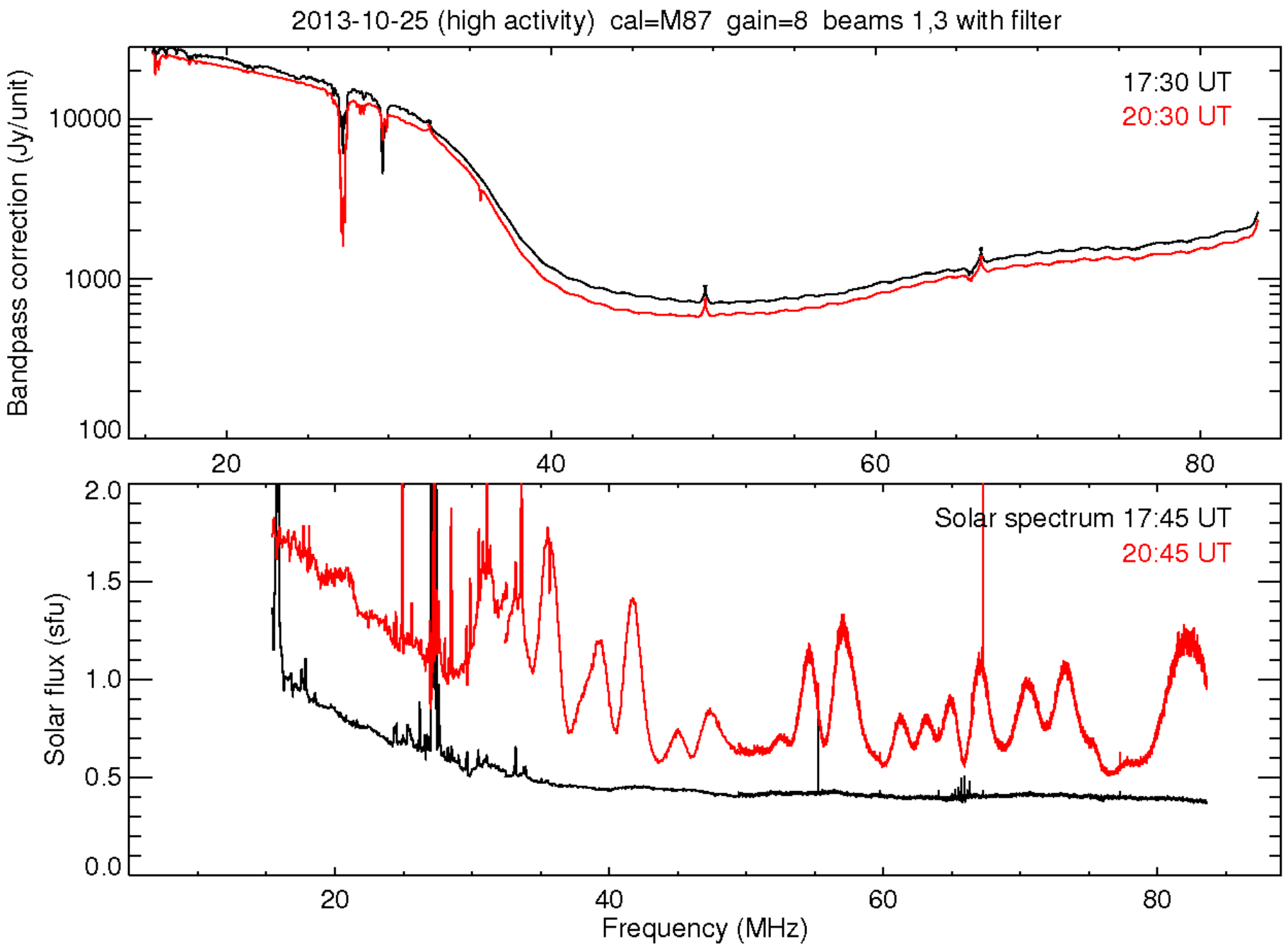


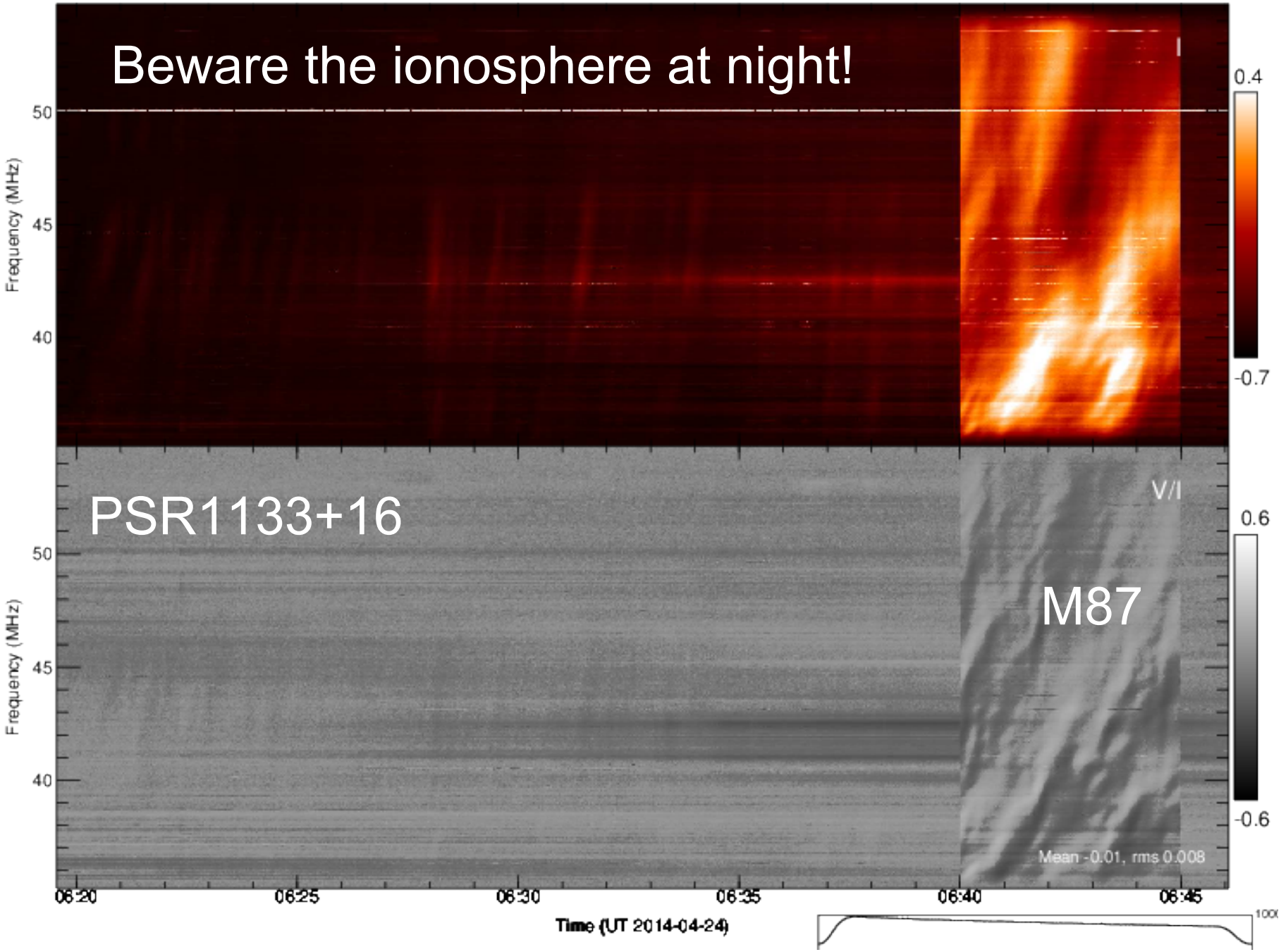
3 closely spaced density fluctuations added to gradient, fixed temperatures.

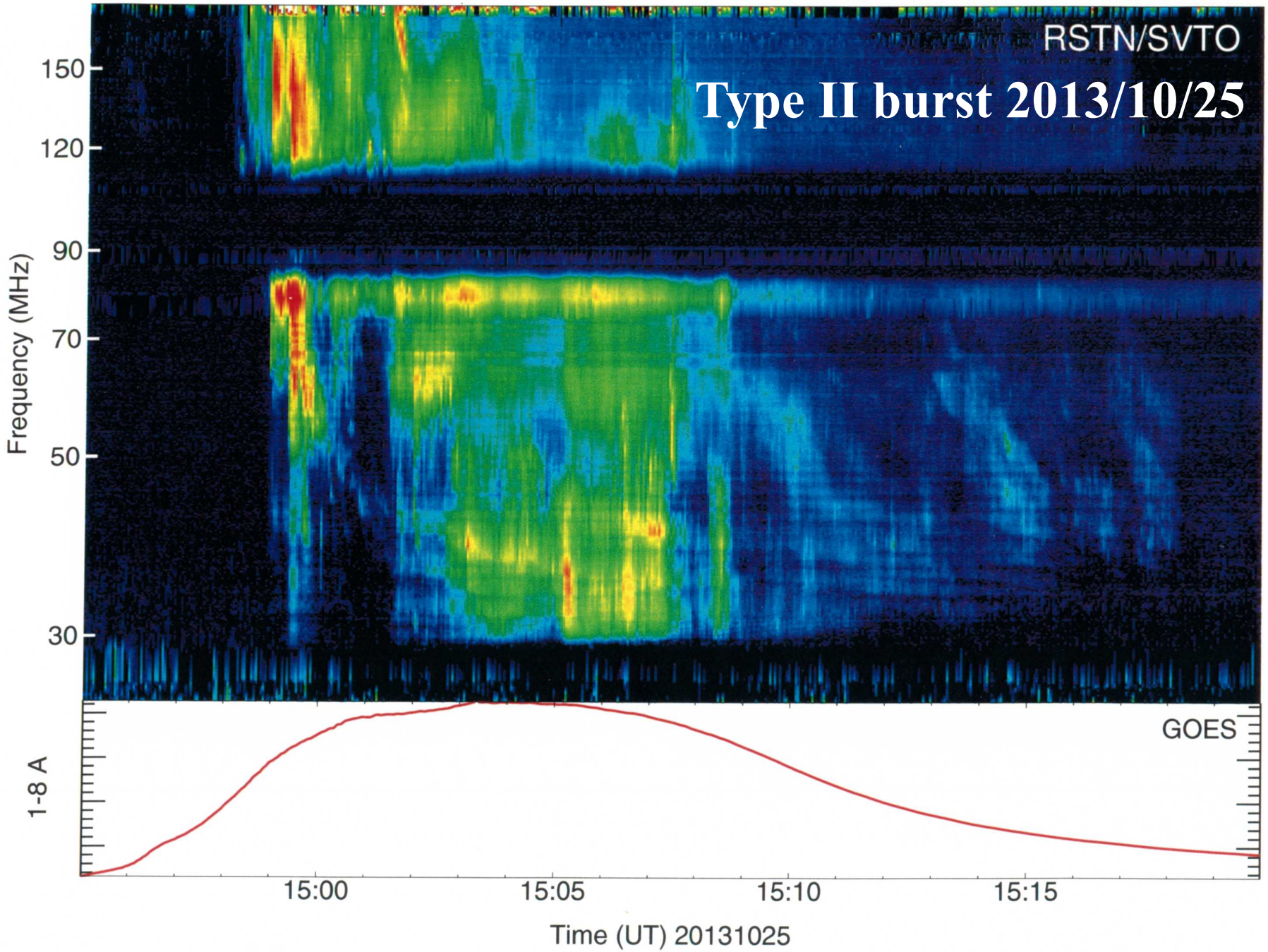
Simulations by Li et al 2012.


2013-10-25 cal=M87 gain=8 beams 1,3 with filter?
Bandpass correction (Jy/unit)
10000
1000
100
(Naïve) Calibration
20
40
60
80
Solar flux (sfu)
1.0
0.8
0.6
0.4
0.2
0.0
Non-flare 20:36:20 UT (1 sec ave)
"Quiet" sun
20
40
60
80
Frequency (MHz)


2013-10-25 cal=M87 gain=8 beams 1,3 with filter?
Bandpass correction (Jy/unit)
10000
1000
100
20
40
60
80
Type II
Type II 15:10:00 UT (1 sec ave)
Solar flux (sfu)
200
150
100
50
0
20
40
60
80
Frequency (MHz)


2013-10-25 (high activity) cal=M87 gain=8 beams 1,3 with filter
Bandpass correction (Jy/unit)
10000
1000
100
17:30 UT
20:30 UT
20
40
60
80
Solar flux (sfu)
2.0
1.5
1.0
0.5
0.0
Solar spectrum 17:45 UT
20:45 UT
20
40
60
80
Frequency (MHz)


Beware the ionosphere at night!
PSR1133+16
M87
V/I
Frequency (MHz)
50
45
40
0.4
-0.7
0.6
-0.6
Mean -0.01, rms 0.008
06:20
06:25
06:30
06:35
06:40
06:45
Time (UT 2014-04-24)
100


RSTN/SVTO
Type II burst 2013/10/25
150
120
90
70
50
30
Frequency (MHz)
GOES
1-8 A
15:00
15:05
15:10
15:15
Time (UT) 20131025

Type II burst on 2013 October 25

Flares and activity on 2013 October 26