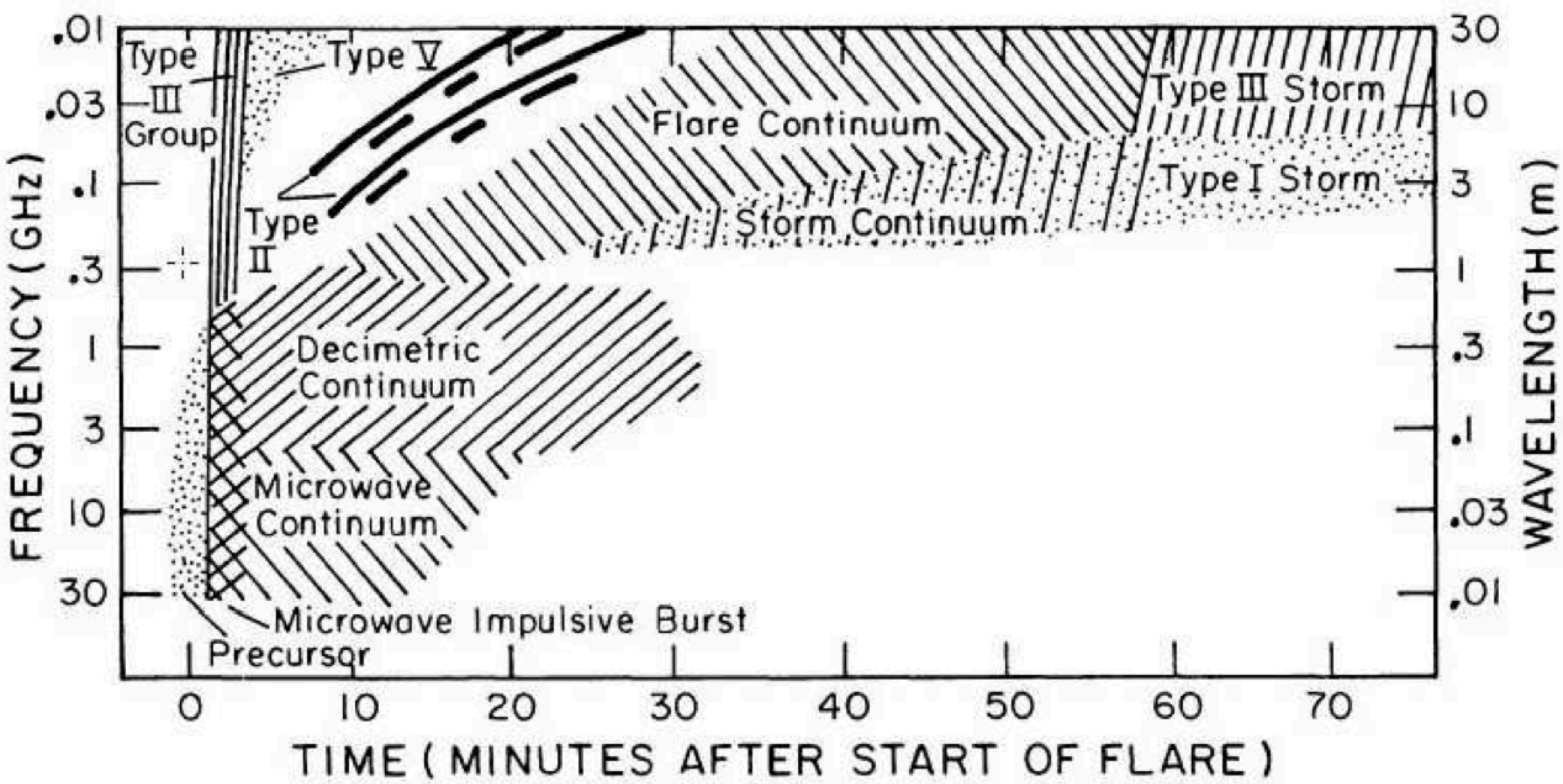
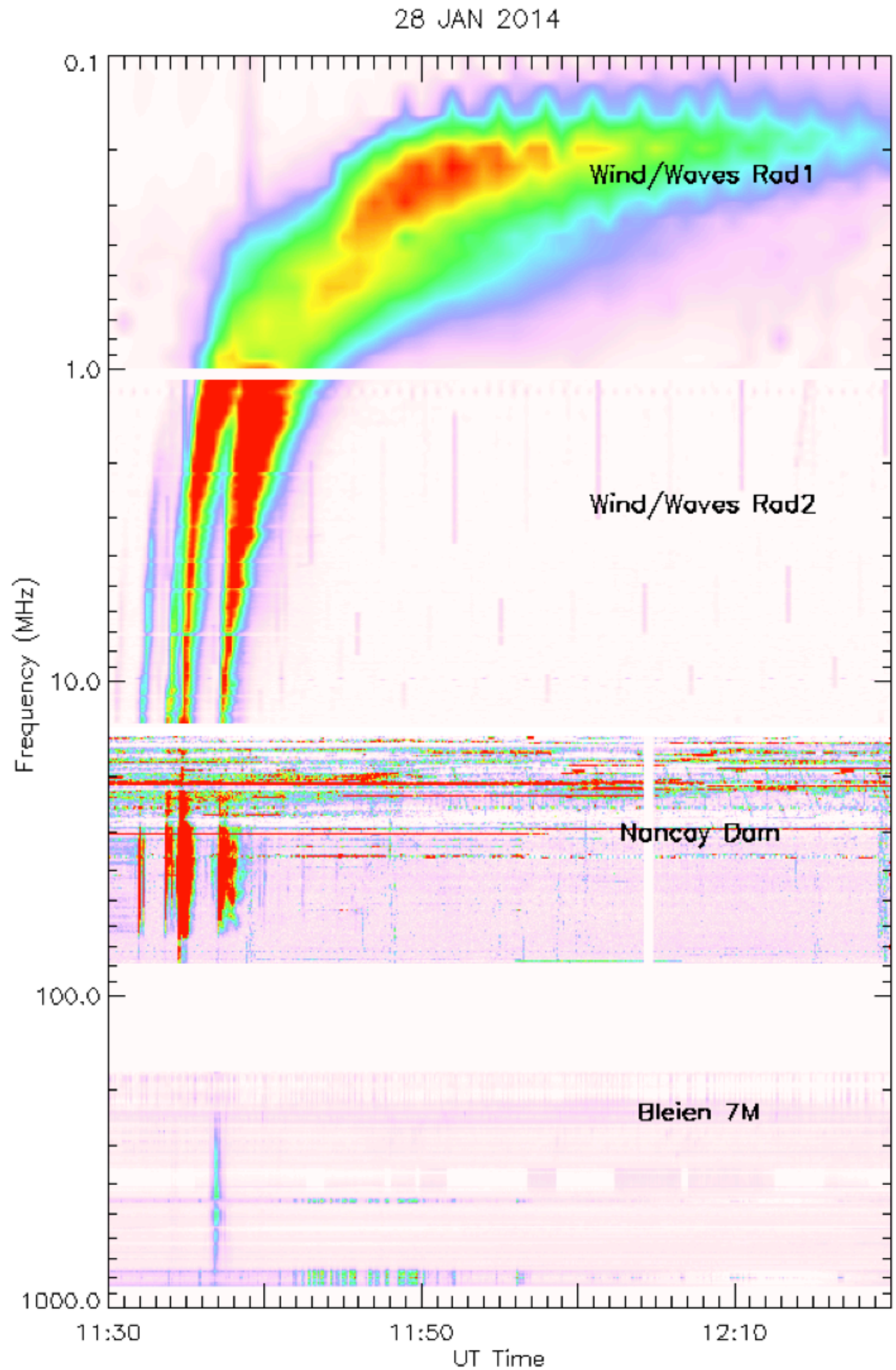
Solar Radio Burst

- A solar radio burst is a structure in frequency space that changes with time. Type I, II, III, IV, V + subtypes.



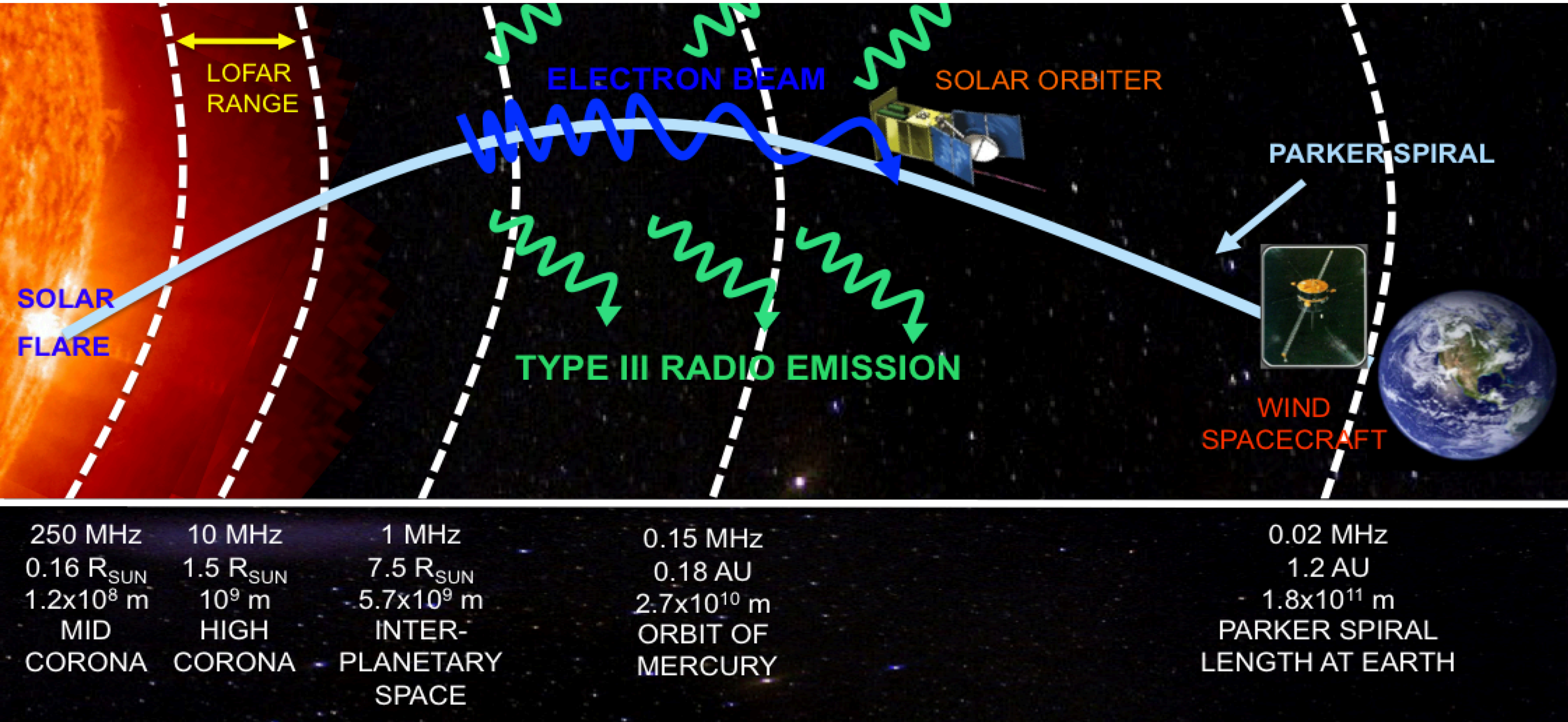
- Type III burst is created by an electron beam through plasma emission.

- The radio emission tracks the electron beam as it travels through the decreasing plasma density of the solar corona and solar wind.

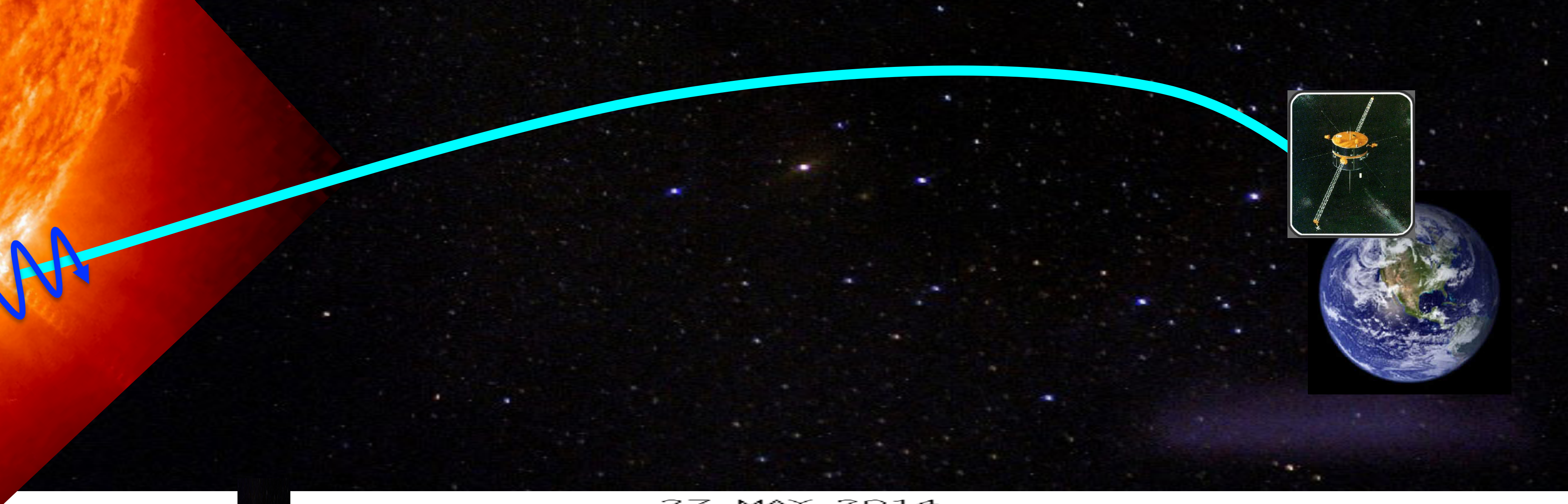


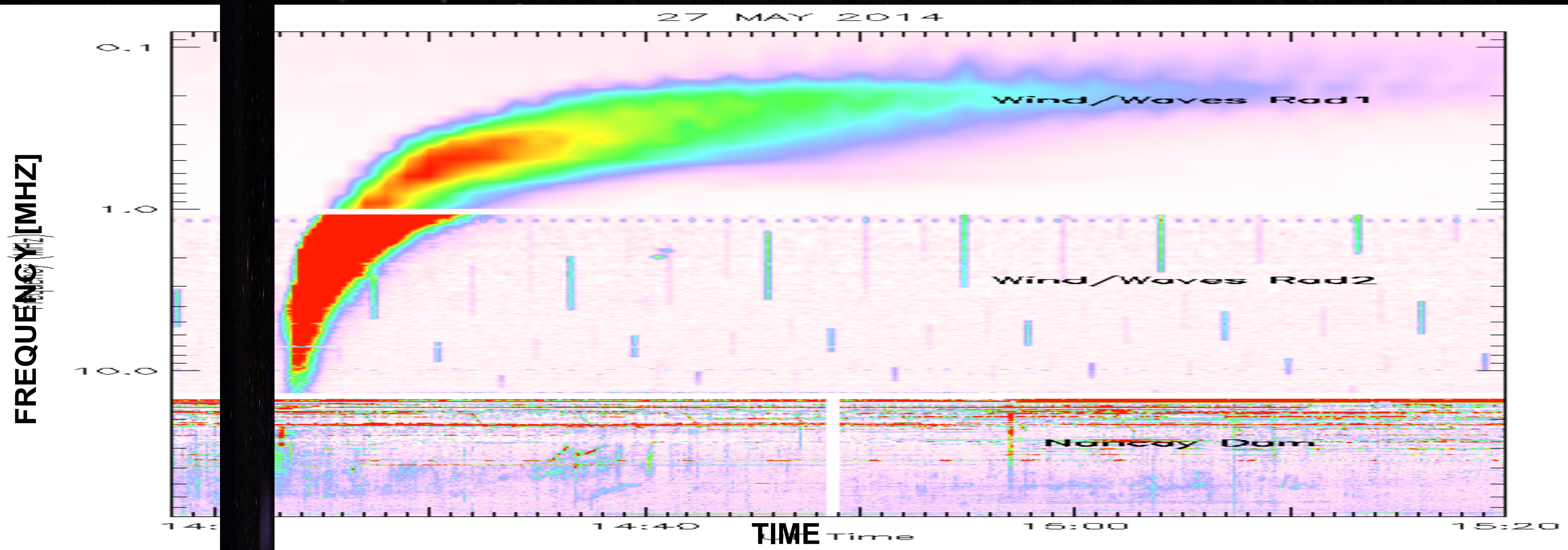
Type III Radio Bursts

Type III radio bursts are created by electrons and can be observed in space and/or at Earth (e.g. see Reid & Ratcliffe 2014 RAA).



Type III burst frequency (related to background electron density) decreases as a function of distance from the Sun.

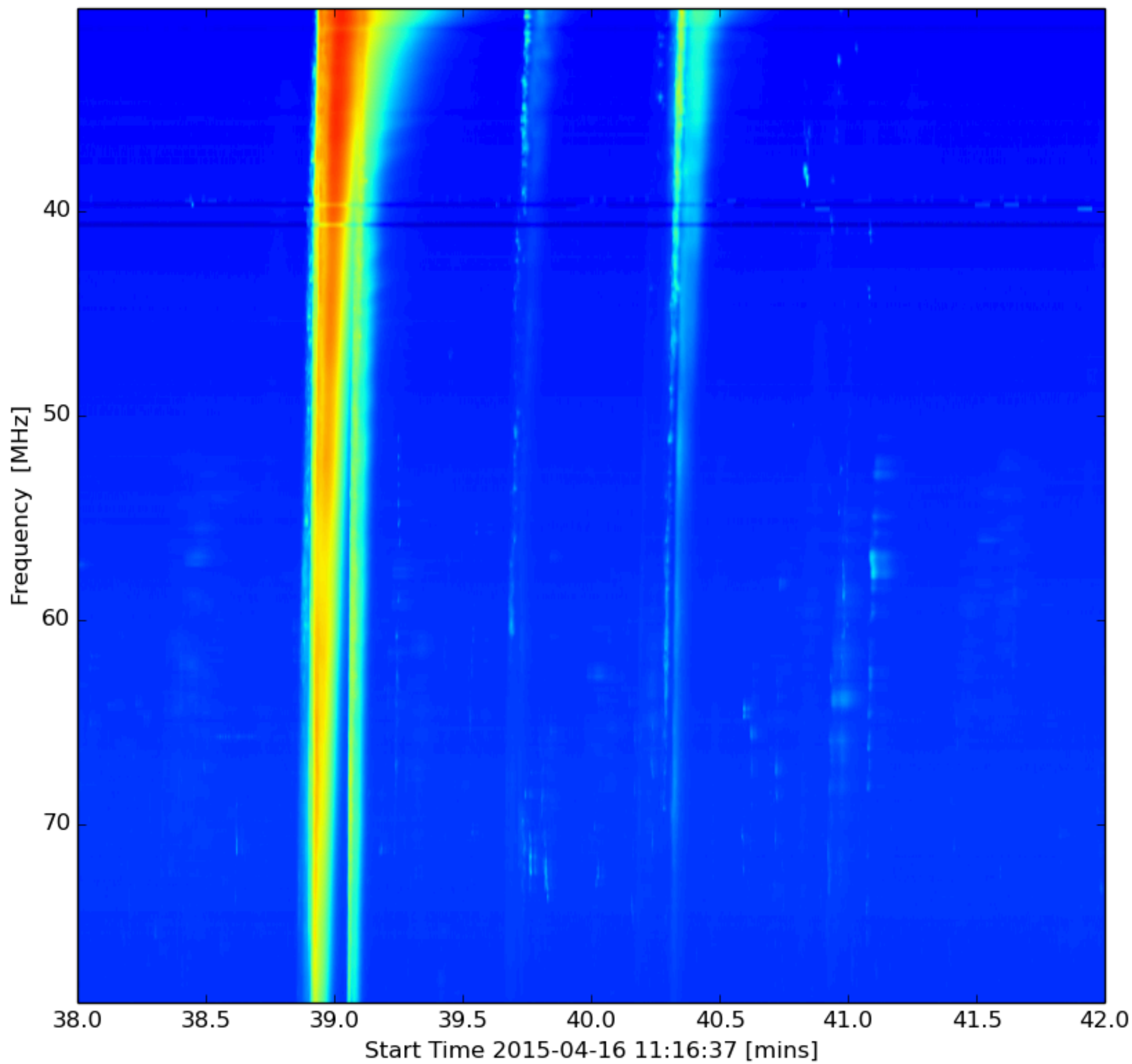




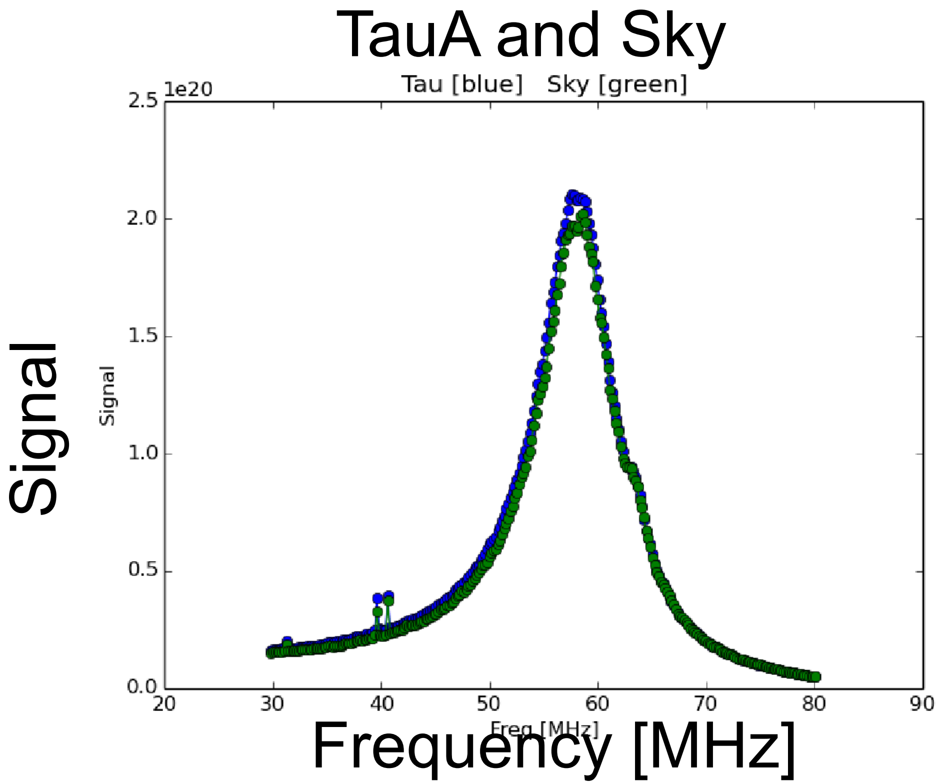
Research Goals

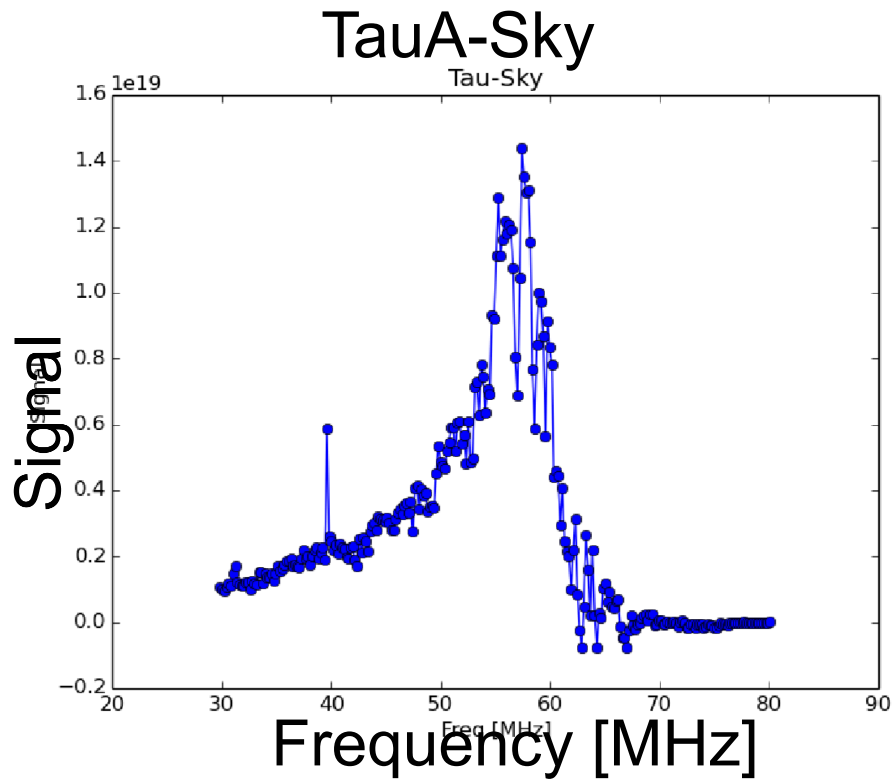
- Obtain estimates of type III centroid positions as a function of frequency and time.
- Find the type III source sizes to see how the source expands as a function of time over a close frequency range.
- Measure the calibrated flux of type III radio bursts to be able to compare with other type III properties.

Radio Spectra



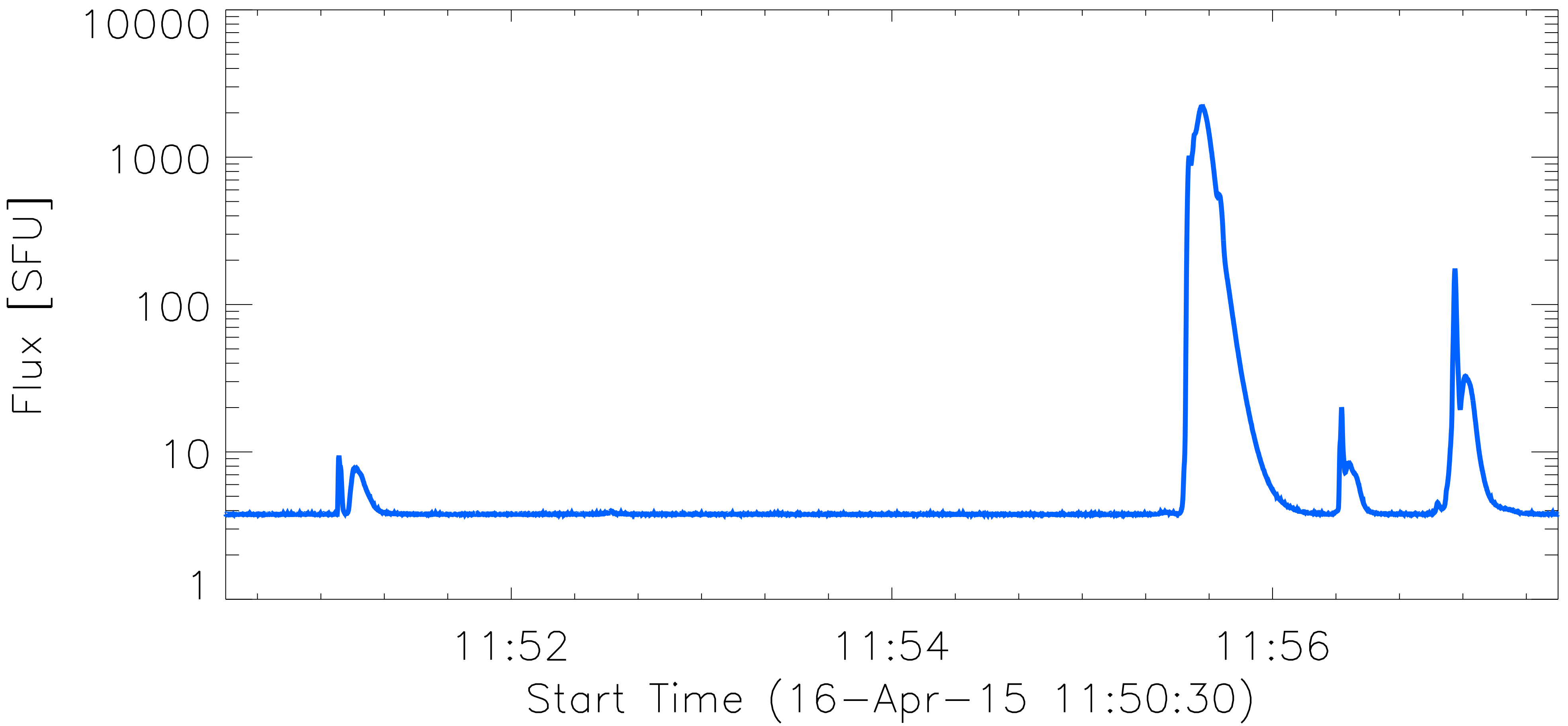
Calibration





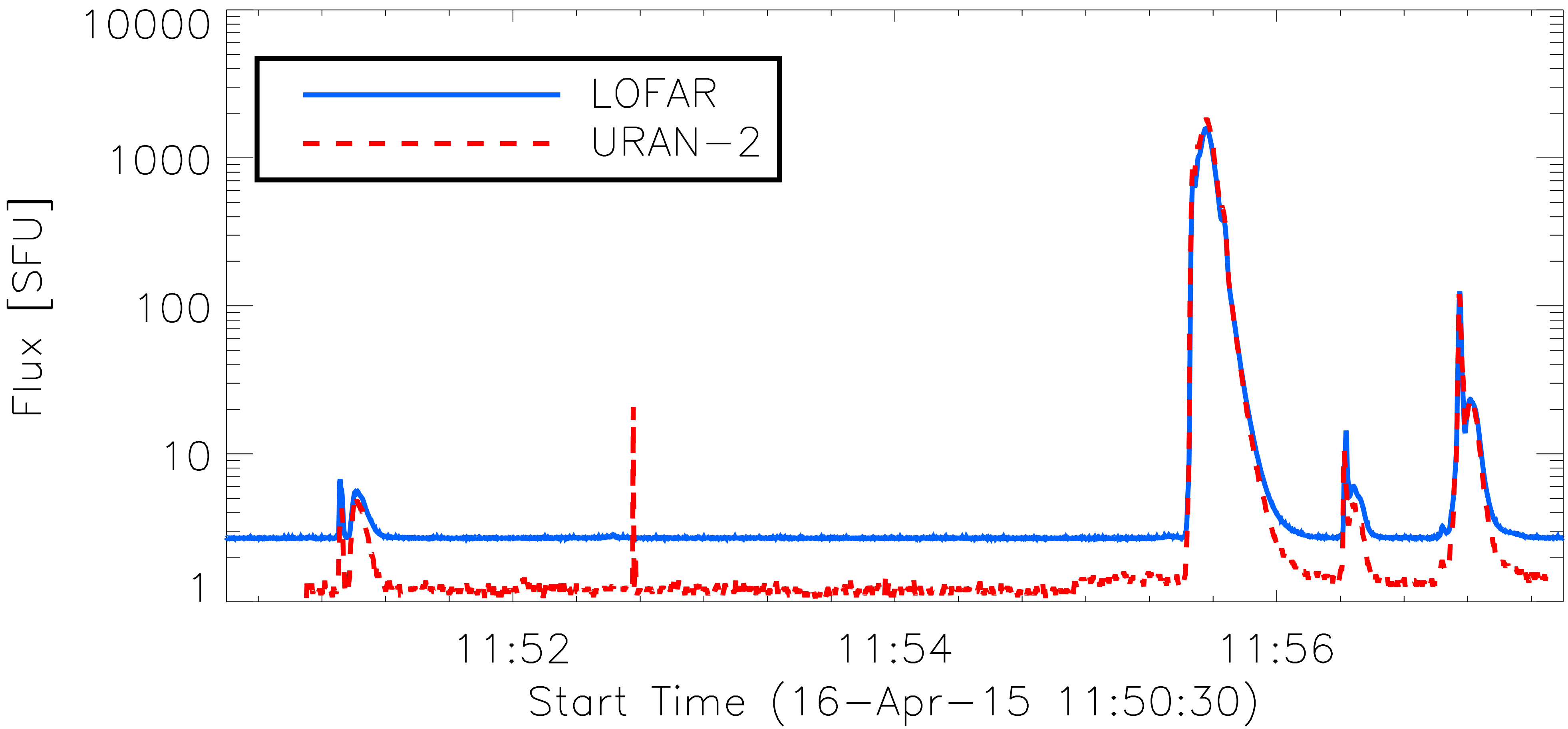
- Used 10 mins of TauA observation subtracted from the sky to obtain a calibration of our results.
- Acceptable till 60 MHz but not good at higher freq.
- Low signal? Far off-pointing from the Sun?

Calibration using TauA

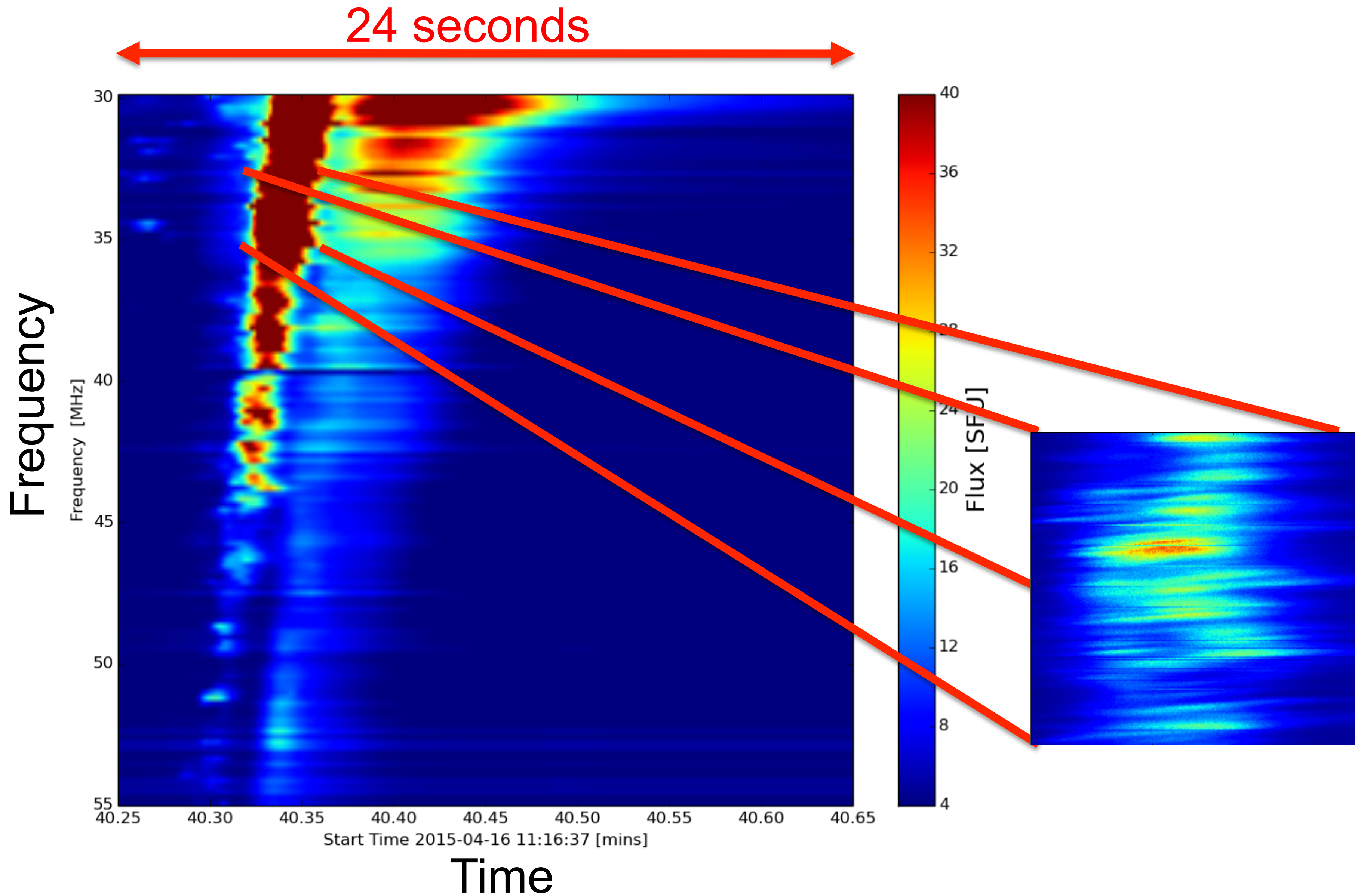


Calibration with URAN-2

We can cross-calibrate LOFAR with URAN-2, a large low-frequency array in Ukraine.

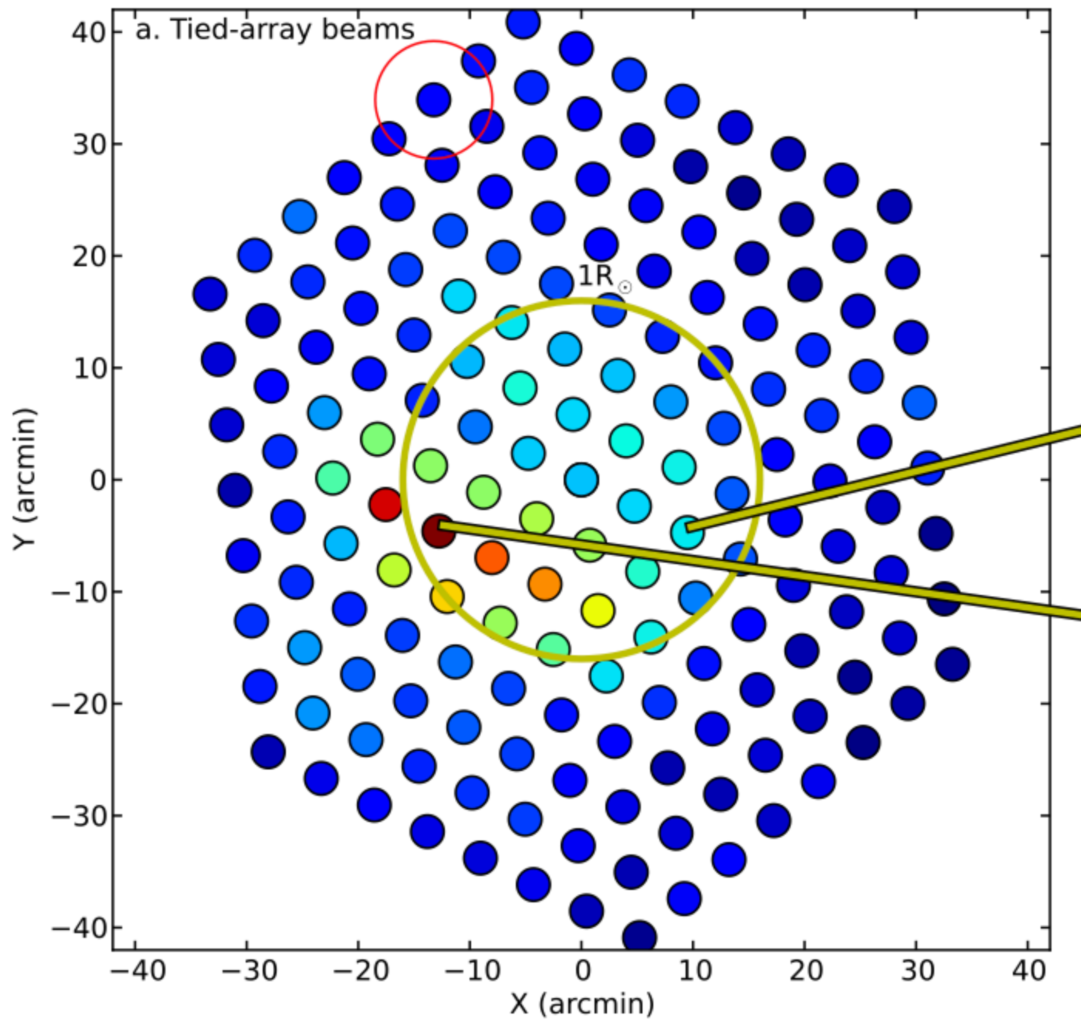


Type III Fine Structure

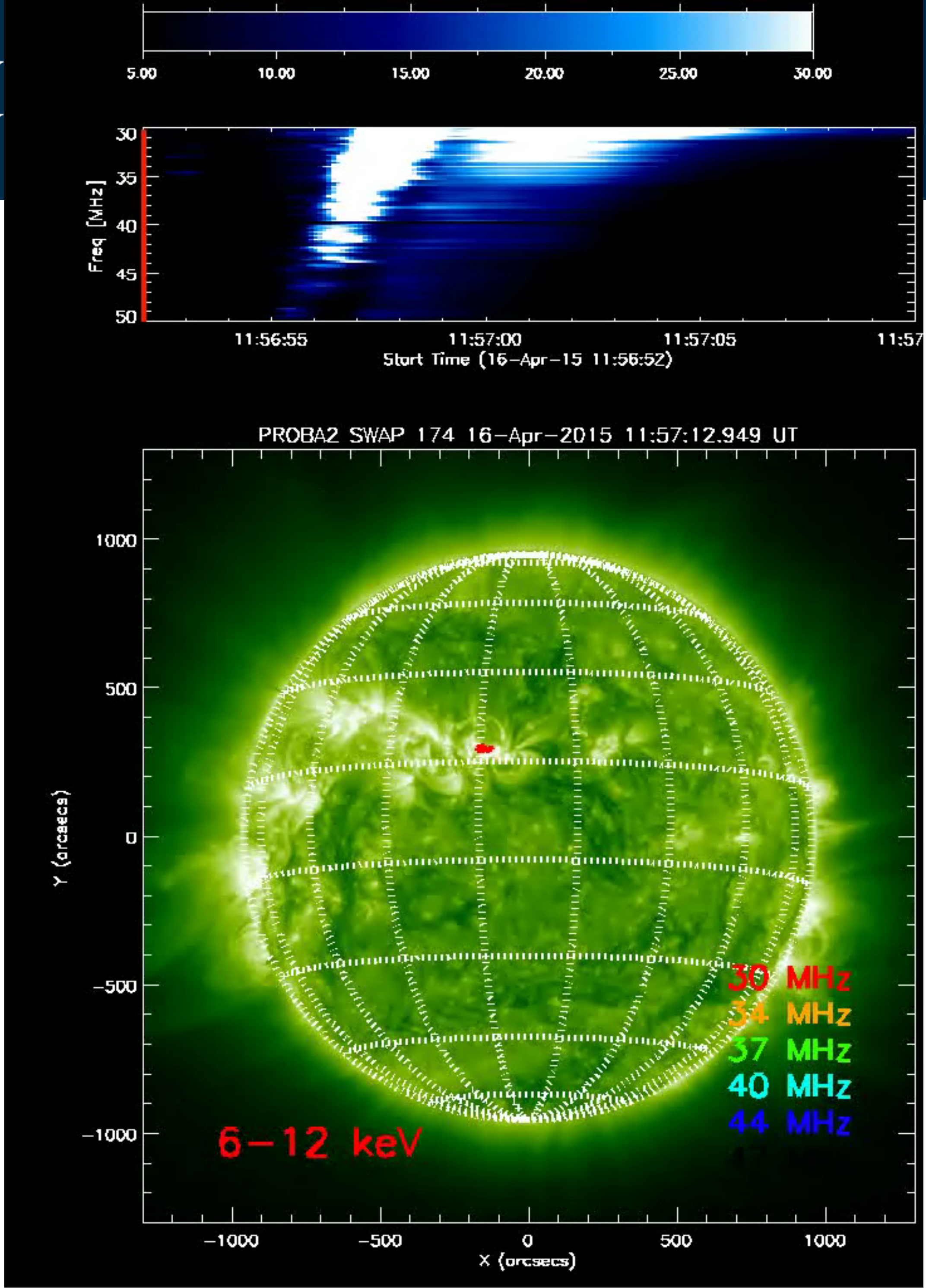


Tied-Array Imaging

- Use the tied-array beam mode, used for Morosan et al 2014 to image the Sun.
- The field of view uses 7 tied-array rings with an overlap in points using the FWHM of the LOFAR beam size.
- Allows high frequency resolution (10s kHz) and time resolution (0.01s per image). This is highly desirable for solar radio bursts to capture the fine detail.



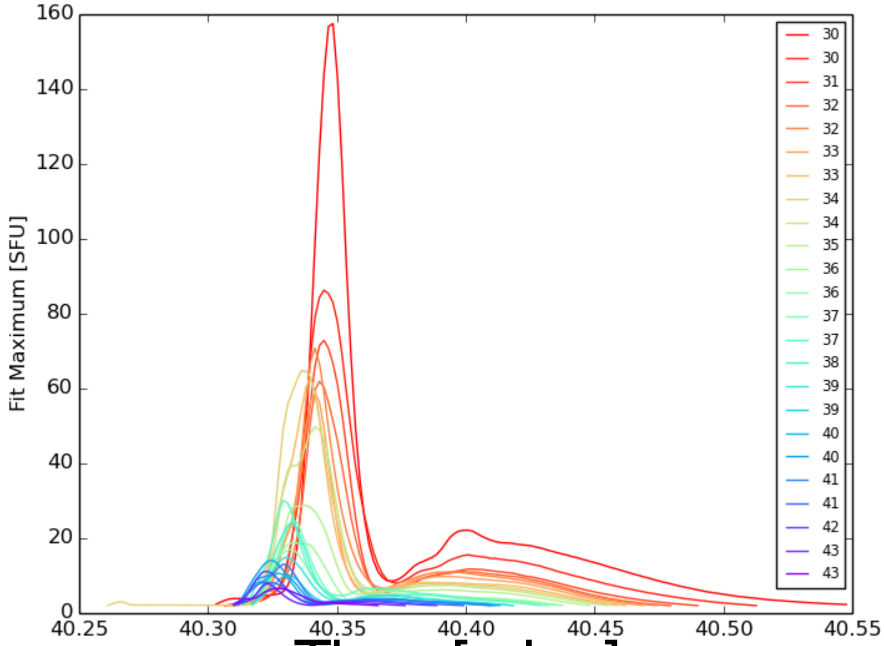
Morosan et al 2014



5.00
10.00
15.00
20.00
25.00
30.00
Freq [MHz]
11:56:55
11:57:00
11:57:05
Start Time (16-Apr-15 11:56:52)
PROBA2 SWAP 174 16-Apr-2015 11:57:12.949 UT
Y (arcsecs)
X (arcsecs)
30 MHz
34 MHz
37 MHz
40 MHz
44 MHz
6-12 keV

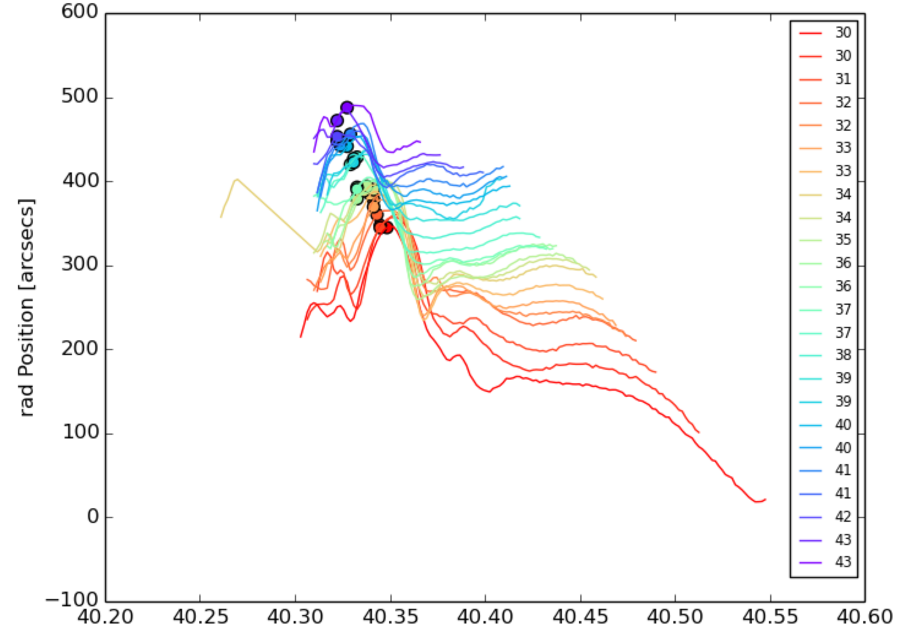
Source Fitting

Fit Maximum



Time [mins]

Fit Radial Positions

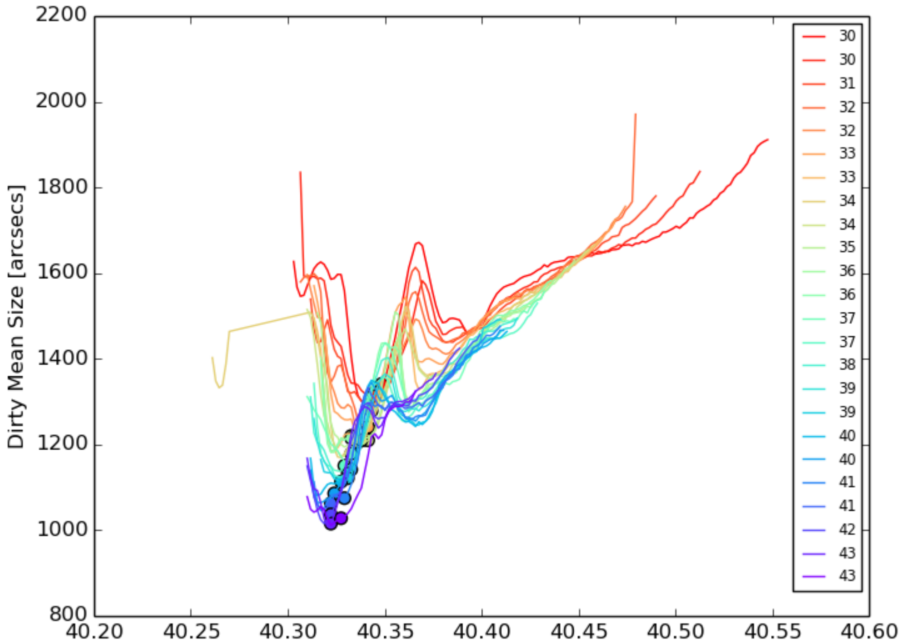


Time [mins]

We fit the sources to obtain estimates of their radial positions as a function of frequency and time.

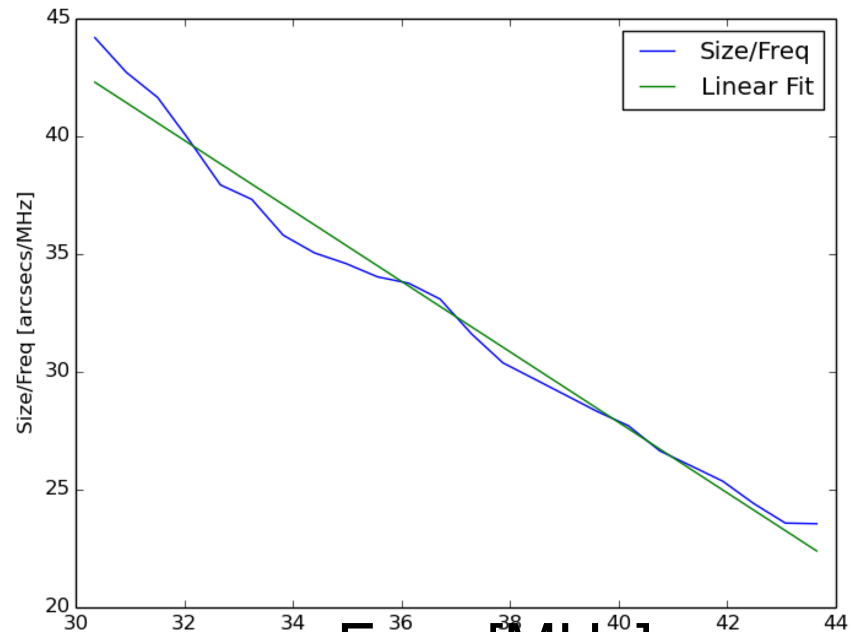
Source Size

Source Sizes



Time [mins]

Sizes/Freq



Freq [MHz]

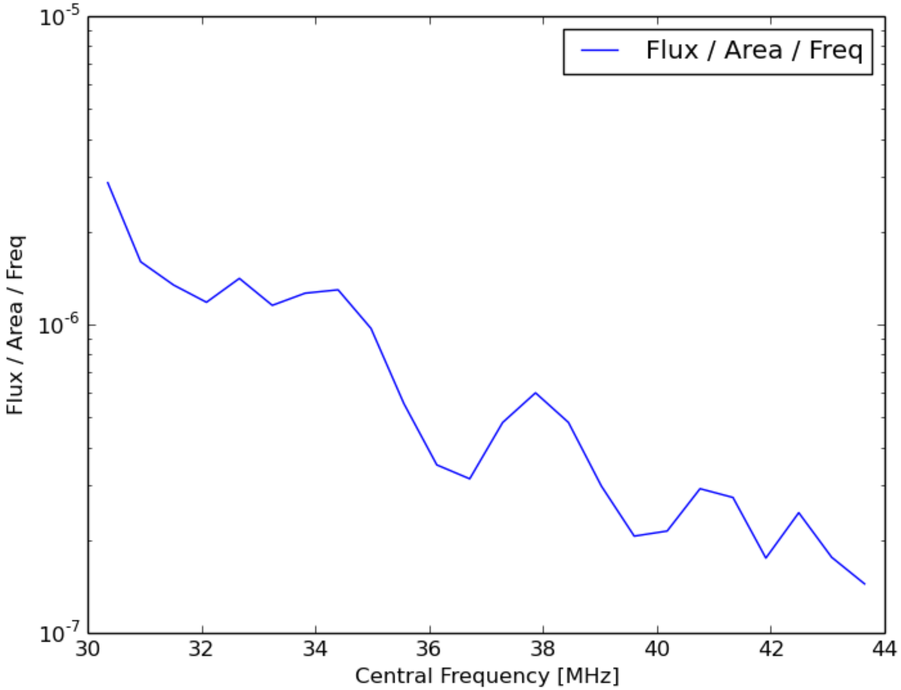
Change in source size as a function of time. We find similar linear increase in source size with decreasing frequency (Suzuki et al 1985)

University of Glasgow

Source Positions and Sizes

- We notice a shift in the position during the radio sources.
- Assuming a fundamental/harmonic pair, such a shift has been observed before (Dulk & Suzuki 1980).
- We also observe the first frequency structure (F?) varies during the course of the emission whilst the second
- Sizes are within previously found sizes - 20 arcmins.
- Sizes are not expected to be too affected by scattering on account of small centre/limb source sizes variations.
- There appears to be an increase in source size between the two frequency structures.

Intensity and Size

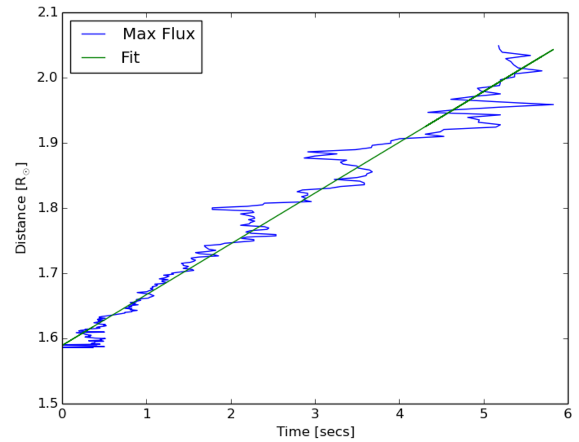


- Source size increase (expansion) decreases the radio emission (e.g. Reid & Kontar 2015).
- Lower frequency plasma finds the electron beam easier to produce radio emission (e.g. Dulk 2000)
- We still find an increase in flux as the source size increases.

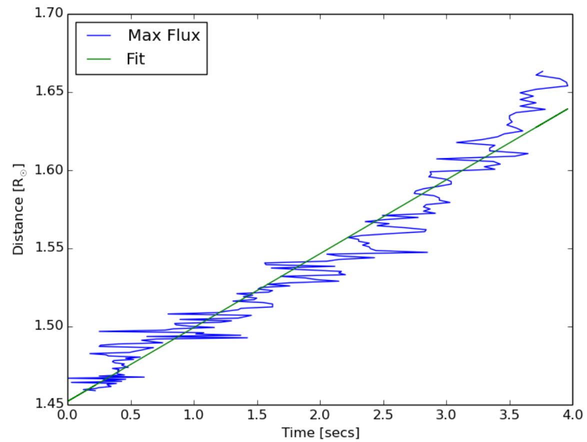
Drift Rates, Electron Velocity

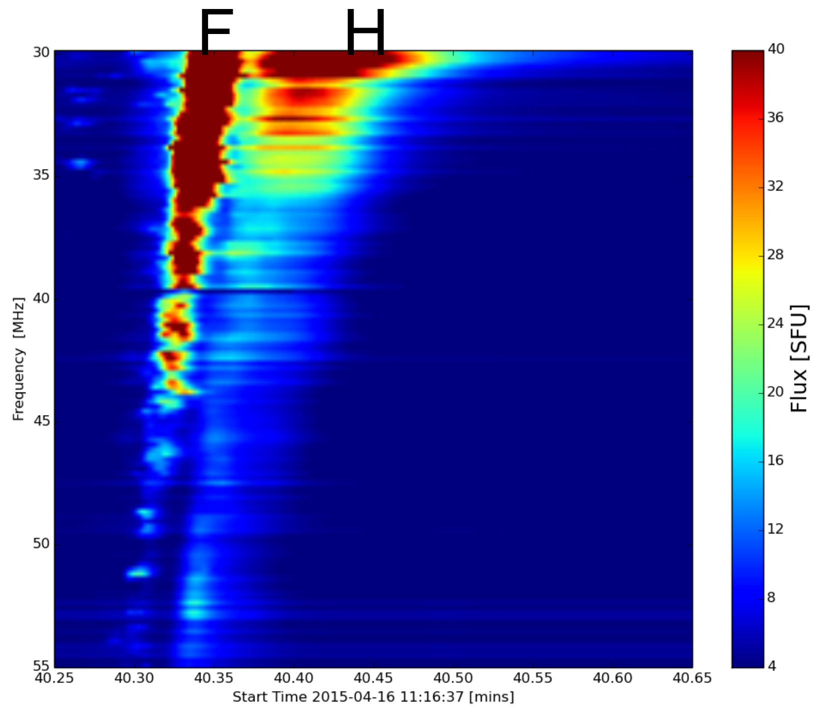
Crude estimates of their velocity reveal discrepancies.

H



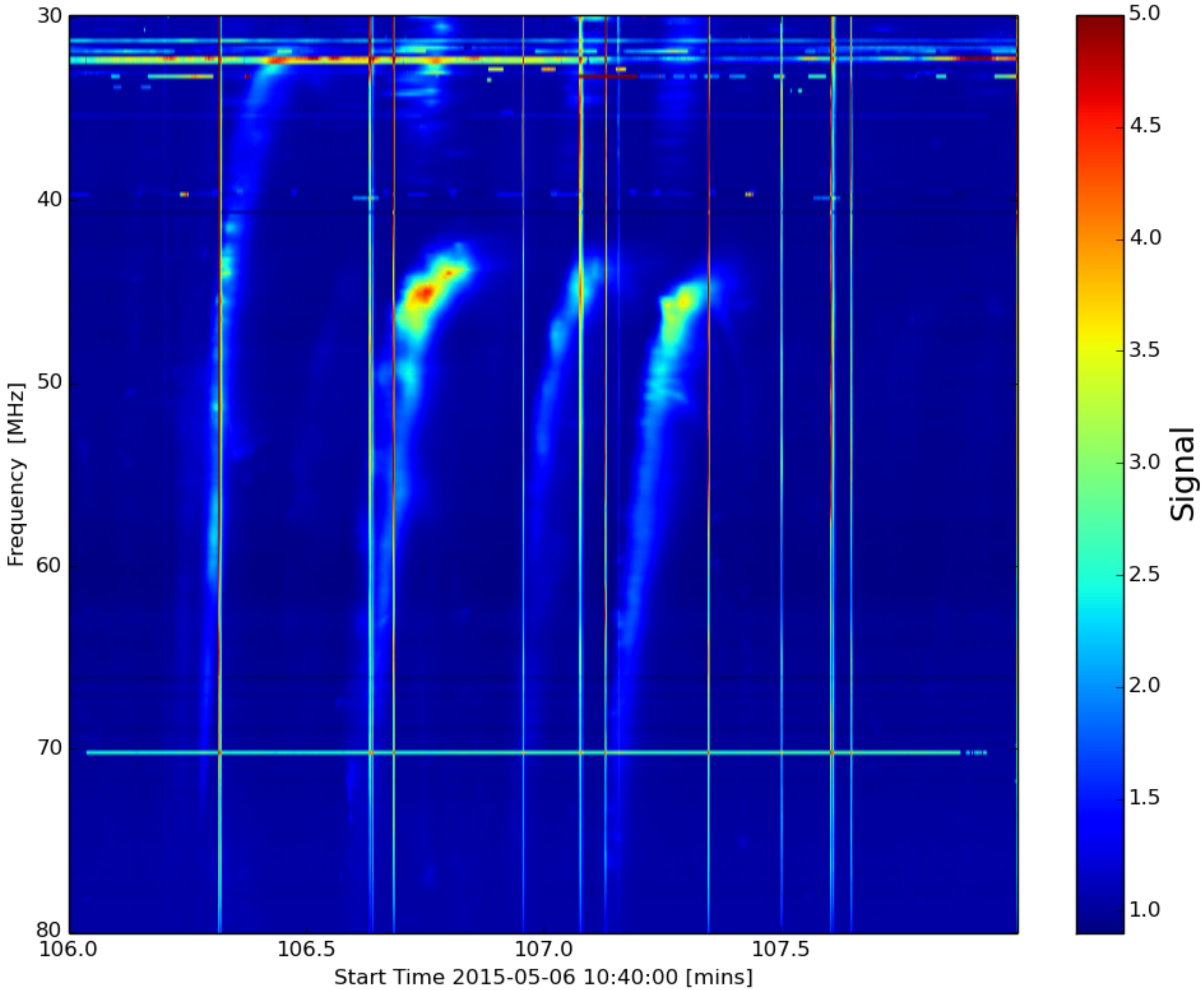
F



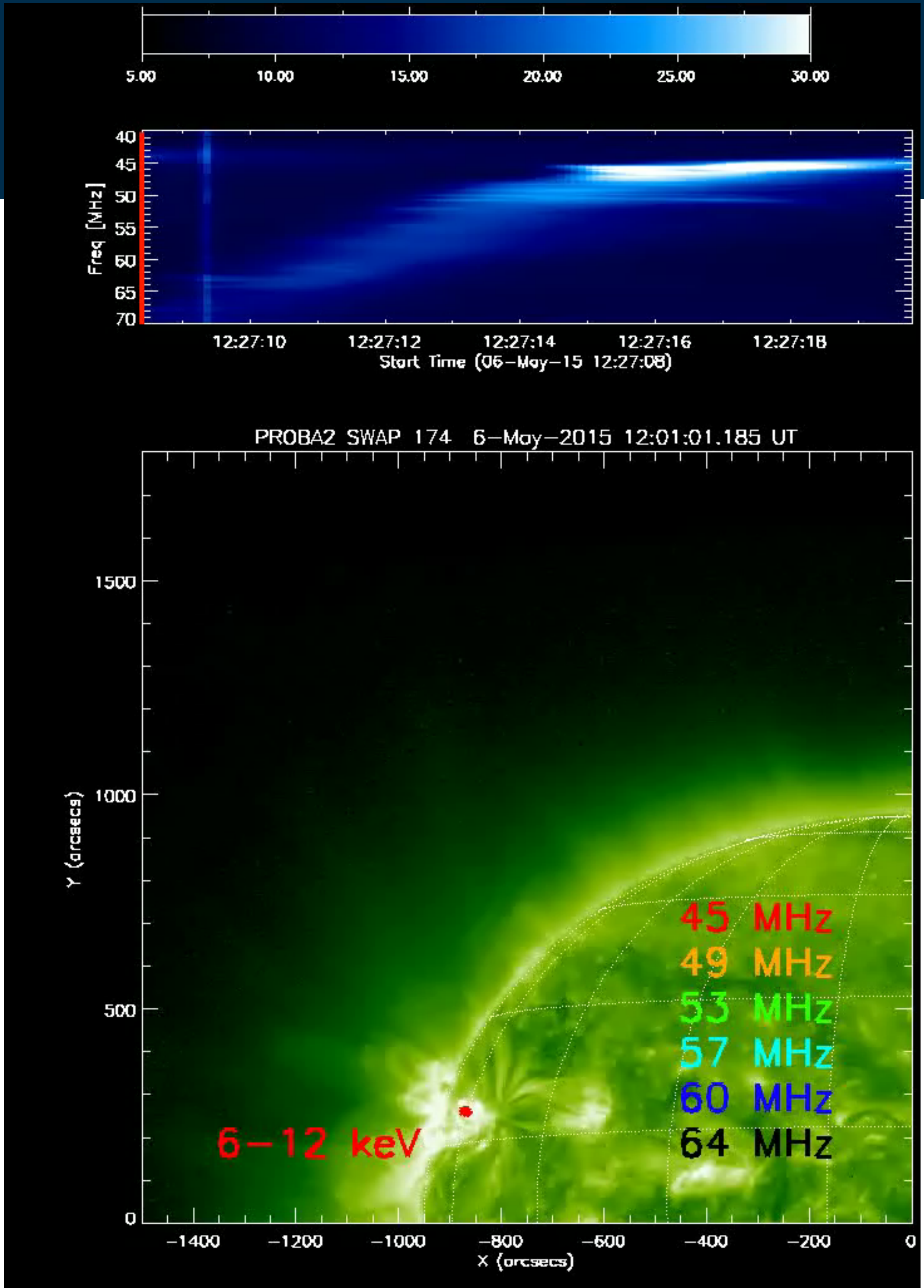


F: v=0.11c   H: v=0.18c

J-bursts



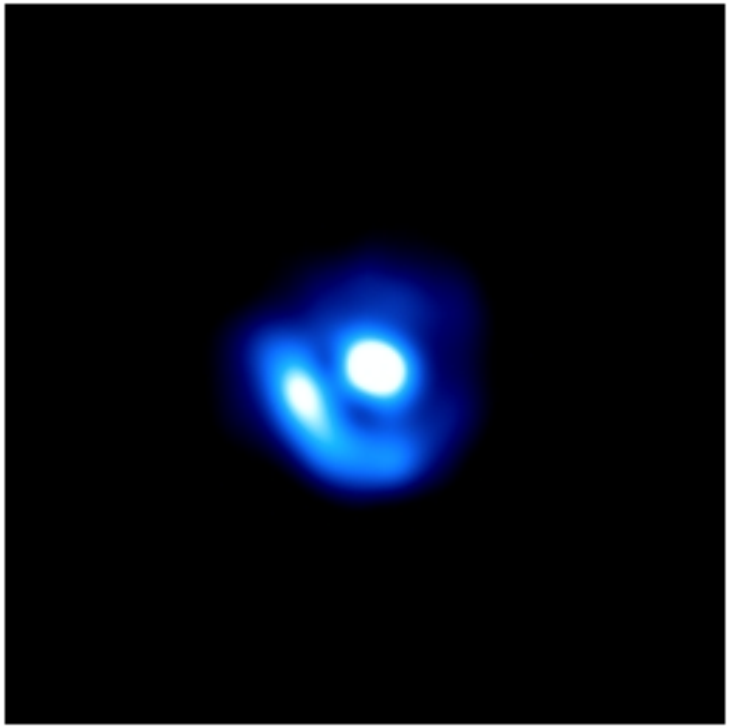
30
40
50
60
70
80
Frequency [MHz]
106.0
106.5
107.0
107.5
Start Time 2015-05-06 10:40:00 [mins]
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
Signal

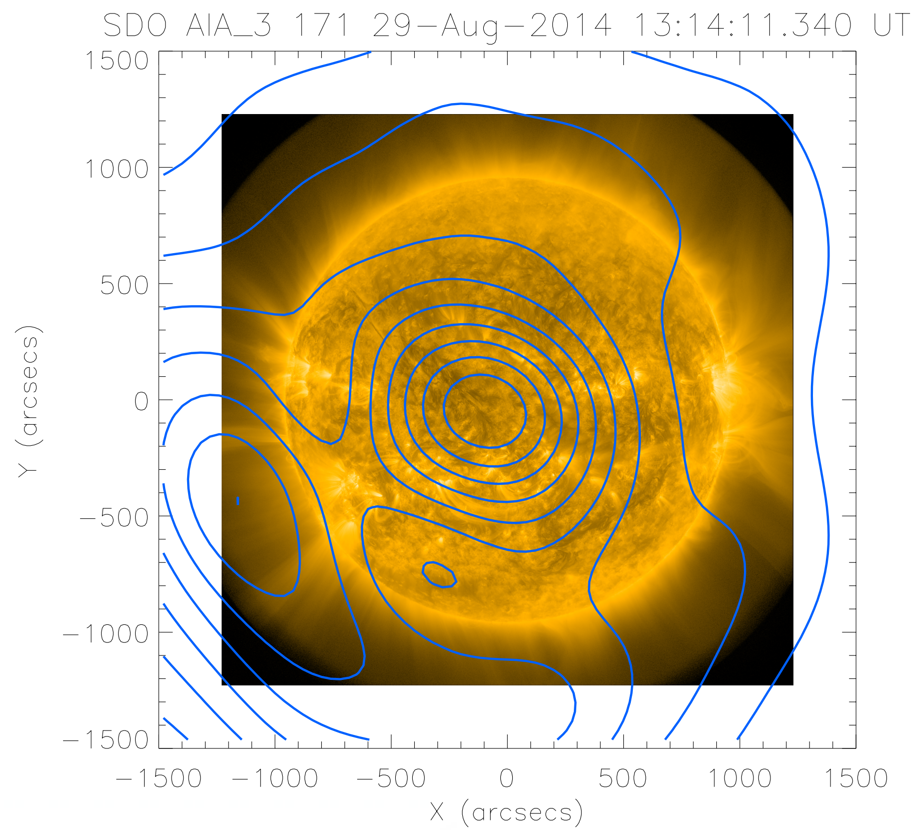

5.00
10.00
15.00
20.00
25.00
30.00
Freq [MHz]
40
45
50
55
60
65
70
12:27:10
12:27:12
12:27:14
12:27:16
12:27:18
Start Time (06-May-15 12:27:08)
PROBA2 SWAP 174 6-May-2015 12:01:01.185 UT
Y (arcsecs)
1500
1000
500
0
-1400
-1200
-1000
-800
-600
-400
-200
0
X (arcsecs)
45 MHz
49 MHz
53 MHz
57 MHz
60 MHz
64 MHz
6-12 keV

J-burst Sizes and Position

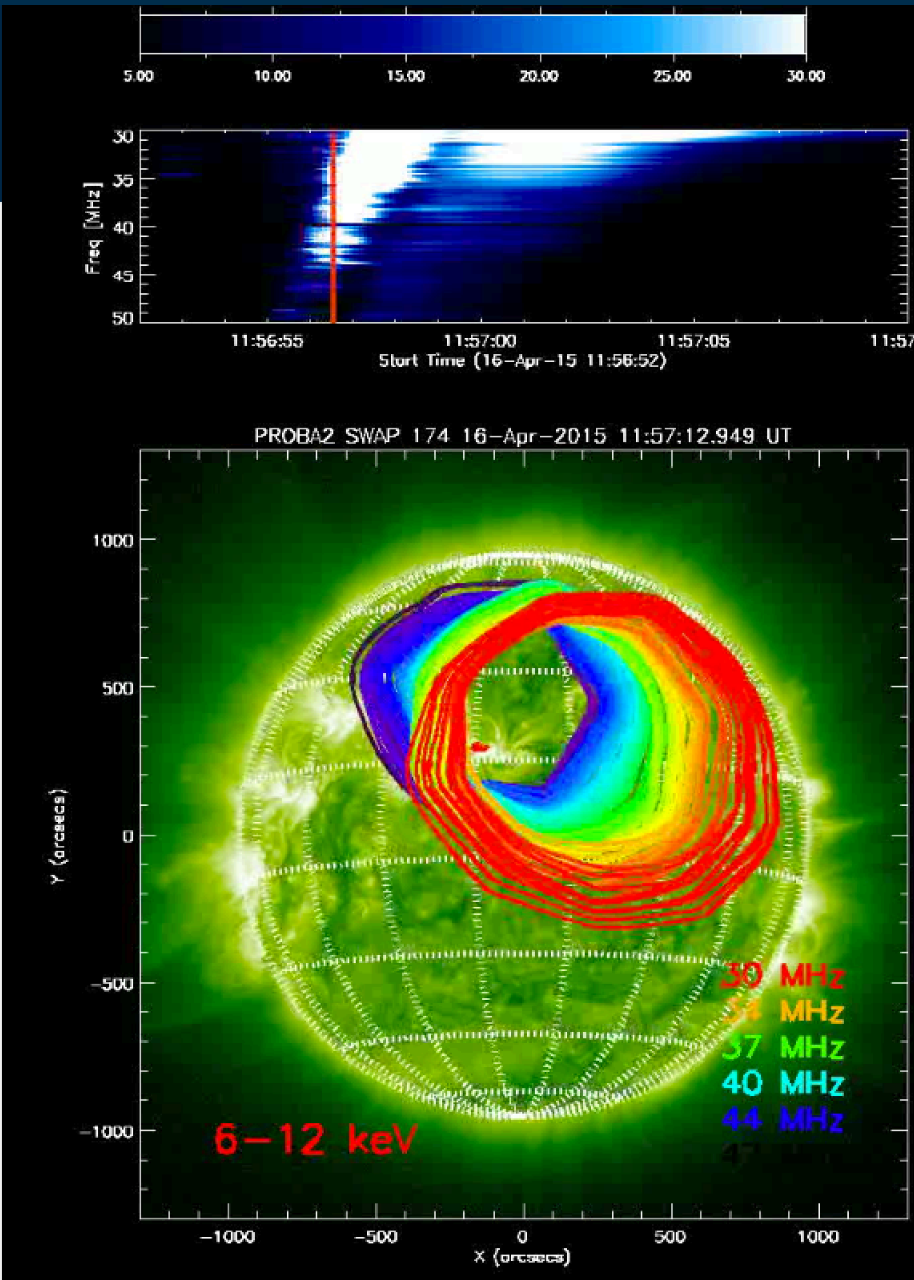
- Position is slightly above the solar active region. A magnetic field extrapolation reveals large loops north of the active region.
- Size of the source is much larger than the other type III bursts observed, closer to 30 arcmins.

Quiet Sun @ 50 MHz



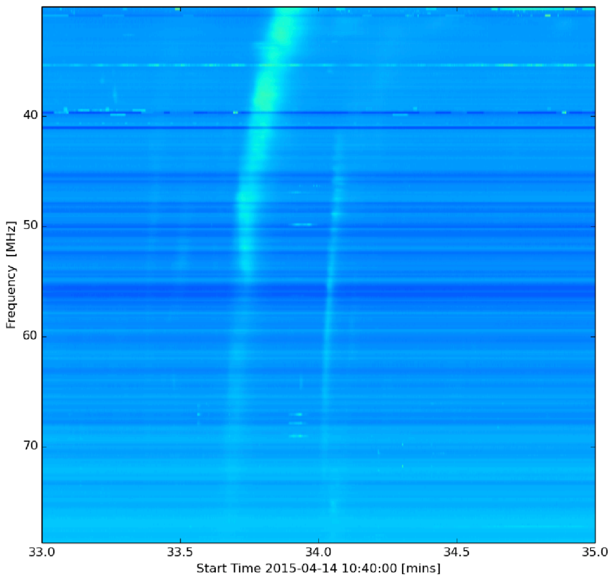


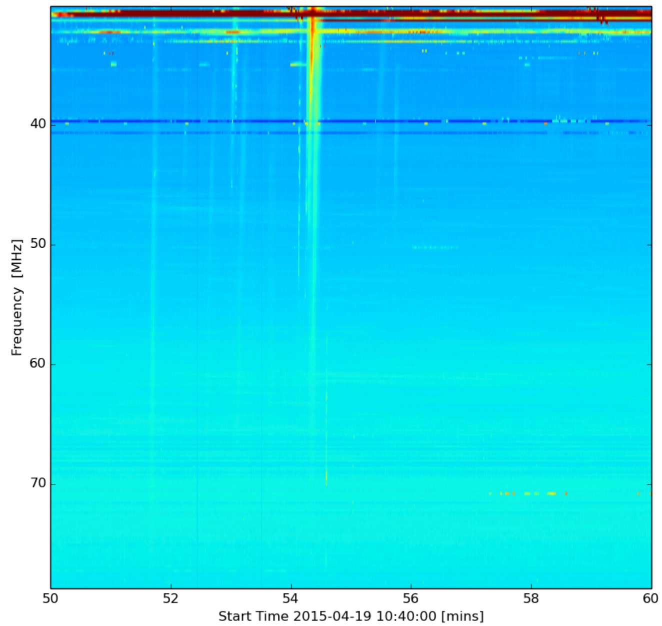
Summary

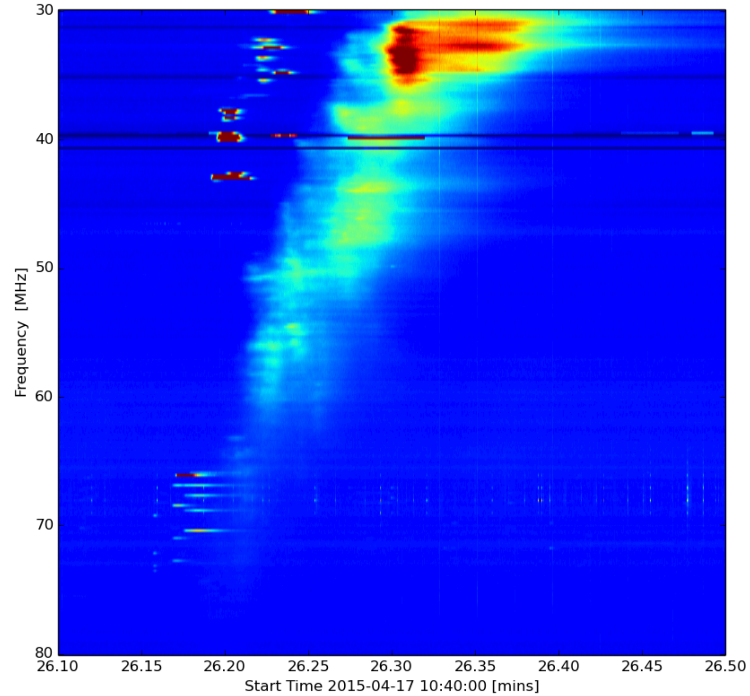


- We found source motions during the radio burst and between the two frequency structures.
- Size and increase in source size remains similar to observed previously over larger frequency range.
- We have preliminary calibration method but more work is required to check robustness.
- Desirable to correct for the beam size for careful analysis.

Radio Spectra







Apparent Velocities