Type III solar radio event observations on 22 August 2017 with LOFAR telescope

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Abstract

We hereby present the interferometric LOFAR observations of the solar radio event on 22 August 2017, during which the type III radio bursts have been detected. Solar radio image and dynamic spectra were recorded in the 20 – 80 MHz frequency band. Additionally to LOFAR observations, the data recorded by instruments onboard the Solar Dynamics Observatory (SDO) in the UV spectral range, GOES and RHESSI in X-ray spectral range complement observations in the radio field. Our study shows that the interferometric LOFAR observations, in combination with observations at other wavelengths can give better understanding of the environment in which the type III radio events occur.

Instruments

LOFAR LC8_013 “Interferometric Observations of the Active Regions in Radio Domain Before and After the Total Solar Eclipse on 21 August 2017”

Radio: LOFAR

Imaging data:

- 35 LOFAR stations (23 core and 12 remote stations)
- freq. band: 20 – 80 MHz
- max. baseline: about 60 km
- spatial resolution: about 10 arcsec (for 80 MHz)
- calibrator: Taurus A

Spectral data:

- frequency resolutions: 0.0154 MHz
- temporal resolutions: 0.0104 s

X-ray: RHESSI and GOES satellites

EUV: SDO satellite

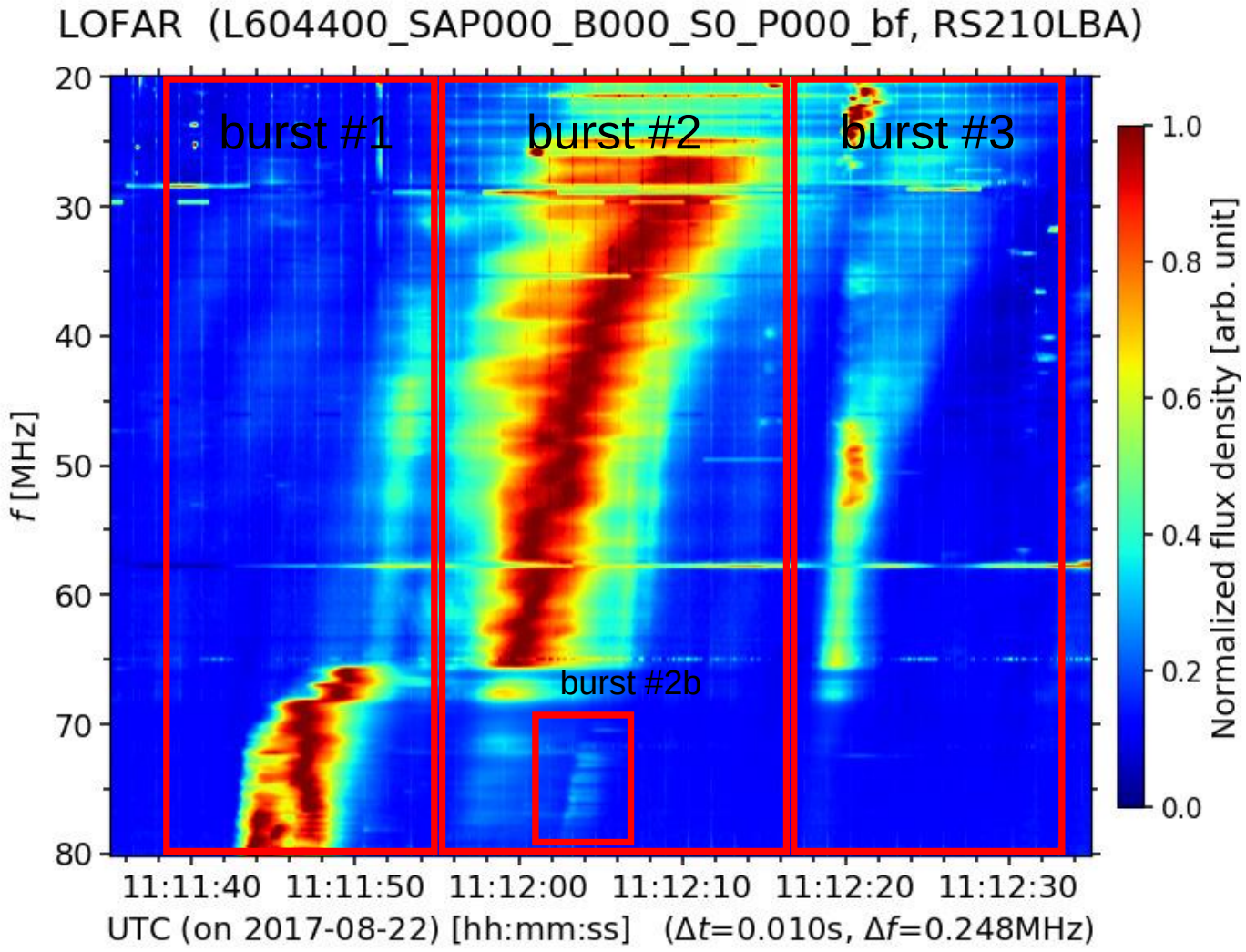
Observations

Type III solar radio bursts
22 August 2017
09:00:00 – 13:59:59 UT

C1.0 flare (NOAA 12671)
22 August 2017
11:09 – 11:16 UT

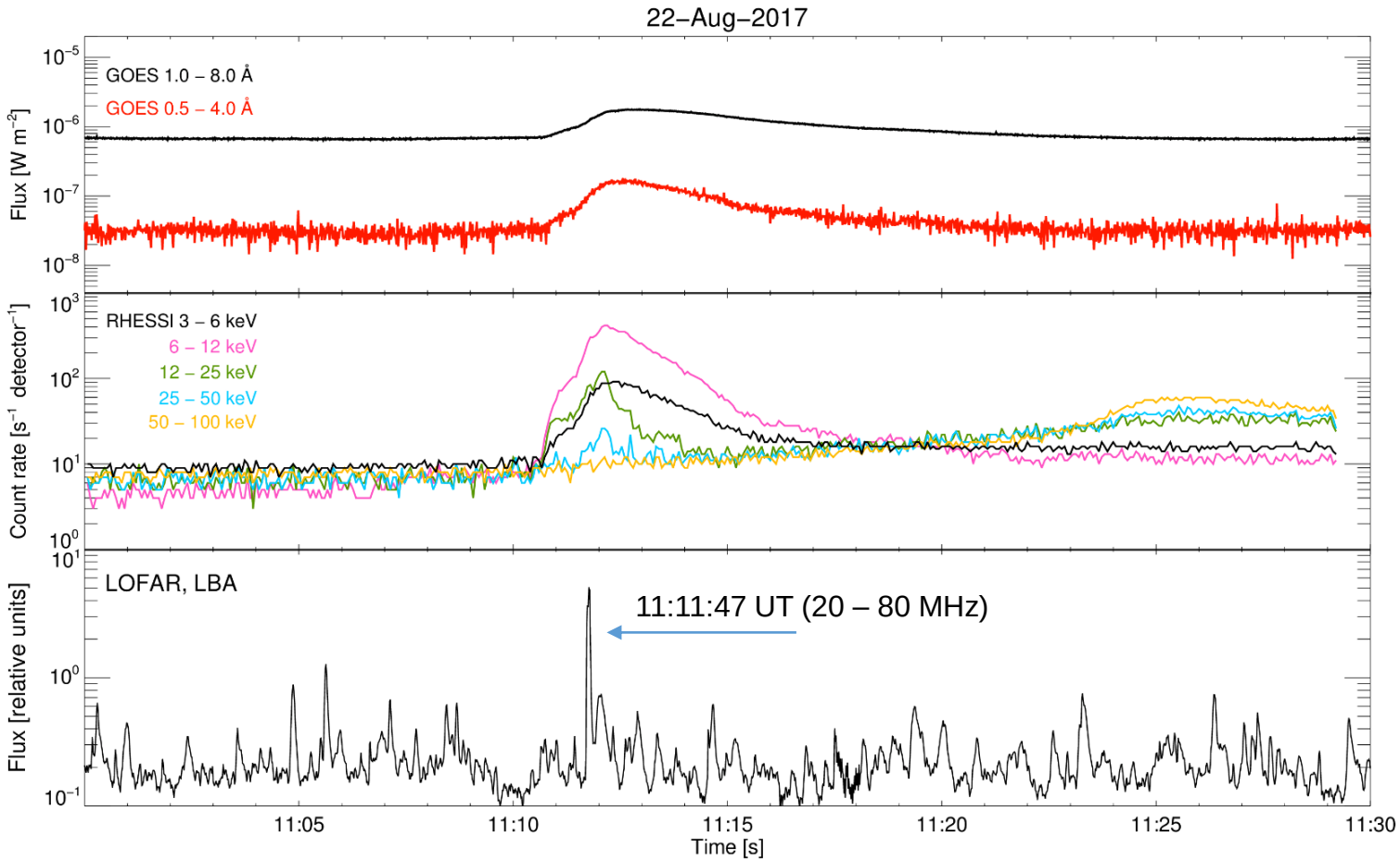
Study of the type III radio bursts that occur around the maximum (11:11:46 UT) in radio range.

We distinguished three type III solar radio bursts: hereafter burst #1, burst #2 and burst #3.



Observations

C1.0 solar flare
(NOAA 12671, 5.73° N, 25.84° W)



Results

Burst #1
11:11:46 UT
65 – 80 MHz

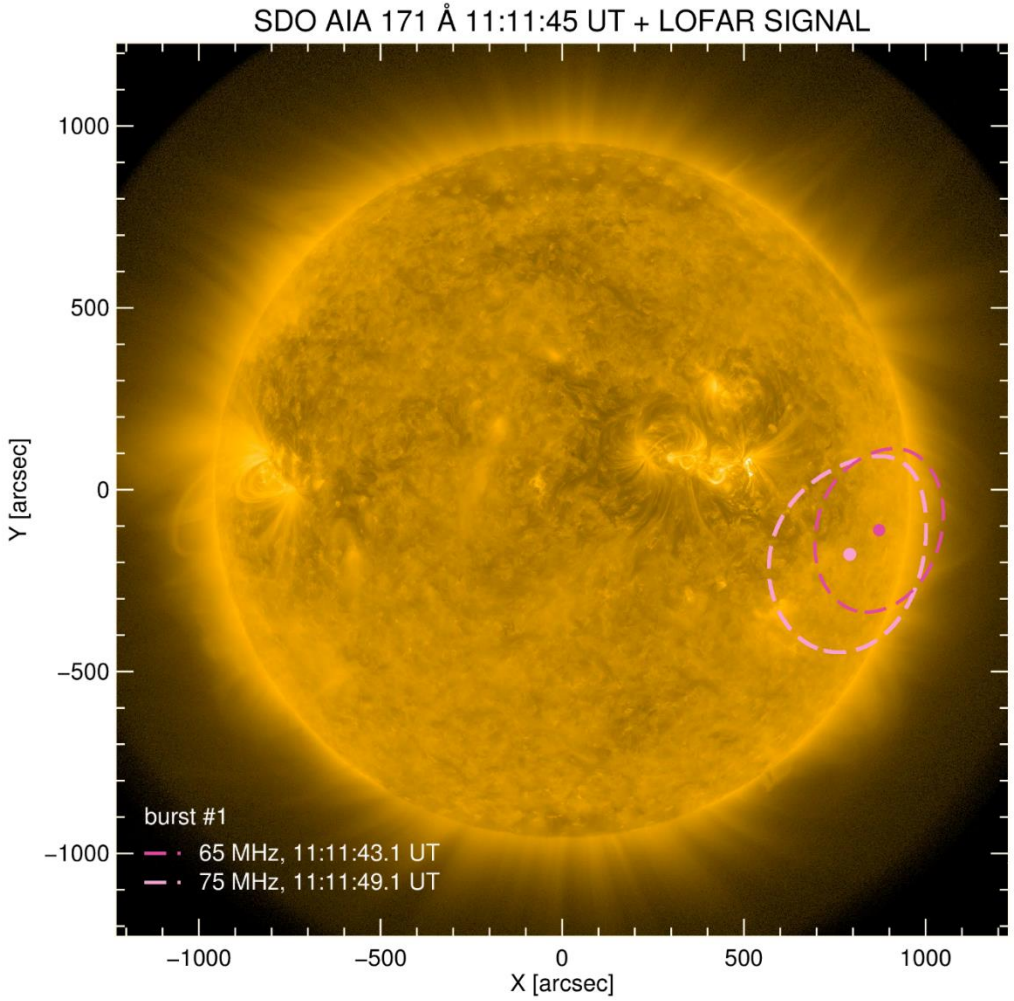
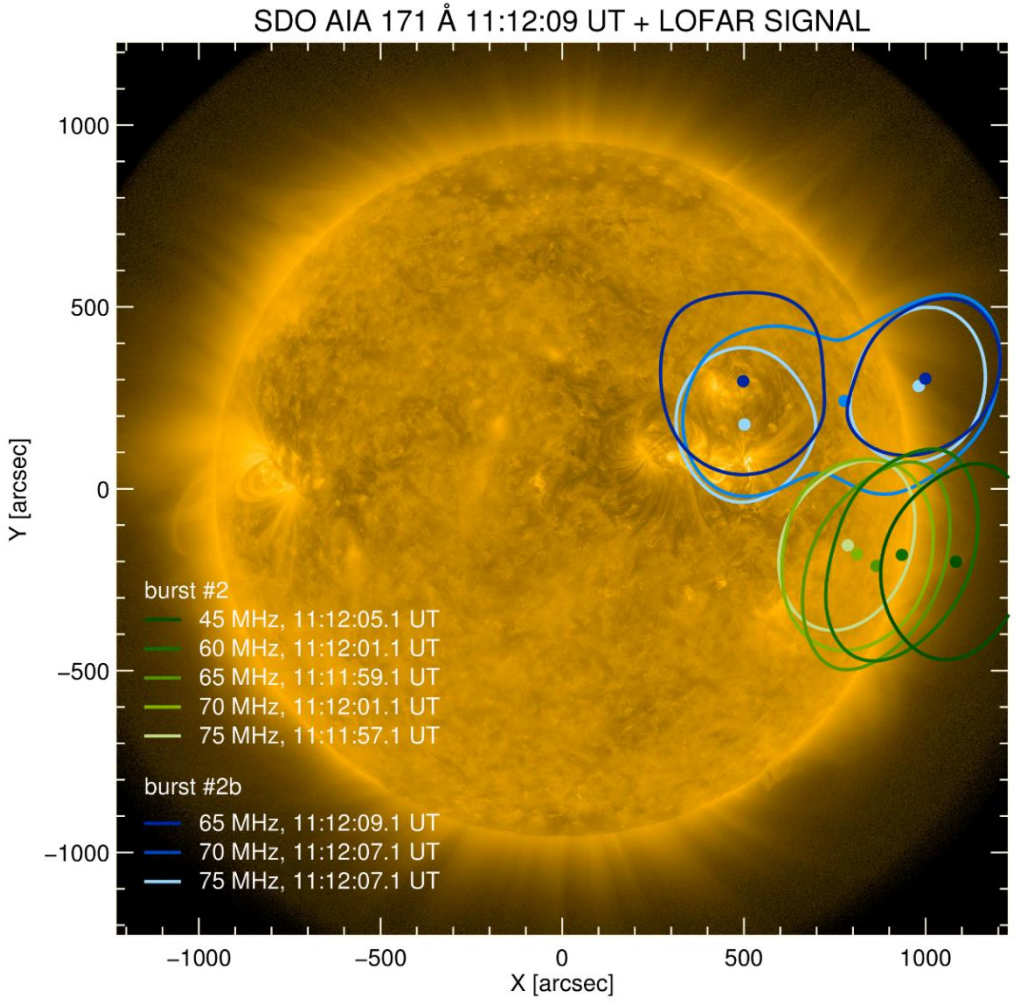


Image of the Sun received in the AIA 171 Å channel by SDO satellite with superimposed contours showing type III burst #1 at a range of frequencies.

Results

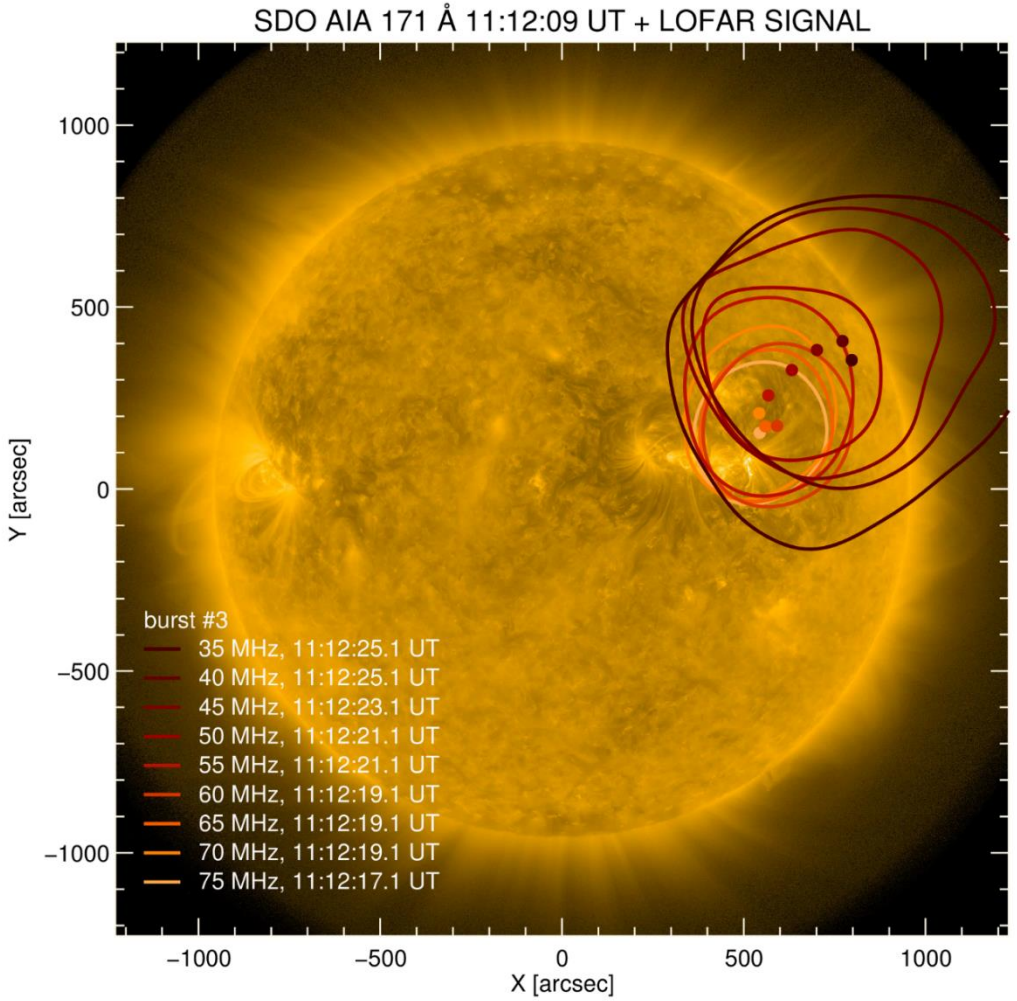
Burst #2
11:12:03 UT
fundamental (F): 29 – 77 MHz
harmonic (H): 73 – 79 MHz

Frequency ratio: about 1.7



Results

Burst #3
11:12:20 UT
28 – 74 MHz



Conclusions

In the total radio flux we observed a single strong peak, a rapid and short-lived increase by a factor of about 30 (but no precursor activity), accompanied by a flare of C1.0 solar flare class.

Comparison shows that the maximum peak in the radio range occurs earlier than in the X-ray range. It is hard to explain why there is a delay of about 1 min. One of possible explanations is a missing increasing phase in the solar flare.

The burst #1 was observed in 65 – 80 MHz frequency band, which suggests that it only occurred in the lower regions of the solar corona. The burst #2 was observed in the 29 – 77 MHz band and burst #3 occurred in the 28 – 74 MHz band.

The positions of bursts are different, what indicates they all these bursts come from different sources.

In EUV images from SDO (i.e. from AIA 171 A channel) one can see the solar flare in AR 12671, and mass flow. There were more events visible in the active region, but mostly plasma flows in the loops.

Conclusions

The velocity of the electrons beams responsible for the bursts' generation (according to the Newkirk electron density model) for the burst #2 is 0.06c and for burst #3 0.09c. The velocities of bursts #2 and #3 are generally similar to each other and stick to the lower boundary of the standard type III radio bursts velocities of 0.1c – 0.6c.

The size of the radio emission area depends on the height at which we measure them and they are here at 1.3 $R_{\odot}$: $9.5 \cdot 10^{10}$ km^2 (for the burst #1), $7.1 \cdot 10^{10}$ km^2 (for the burst #2) and $5.9 \cdot 10^{10}$ km^2 (for the burst #3). This shows that for a fixed height (1.3 $R_{\odot}$) the size of the emission area is different. This may confirm that these bursts were generated in various areas.

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