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Investigating the origins of three acceleration episodes during a weak solar eruption accompanied by type II radio bursts

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SUOMALAINEN TIEDEAKATEMIA
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Energetic Solar Eruptions: Data and Analysis Tools
SOLER

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Outline

1. Introduction
   - Type II solar radio bursts
2. Methods and objective
   - Combining radio observations with a global MHD model of the solar corona
3. Results
   - Radio imaging and source locations of multiple type II bursts
4. Summary and conclusion

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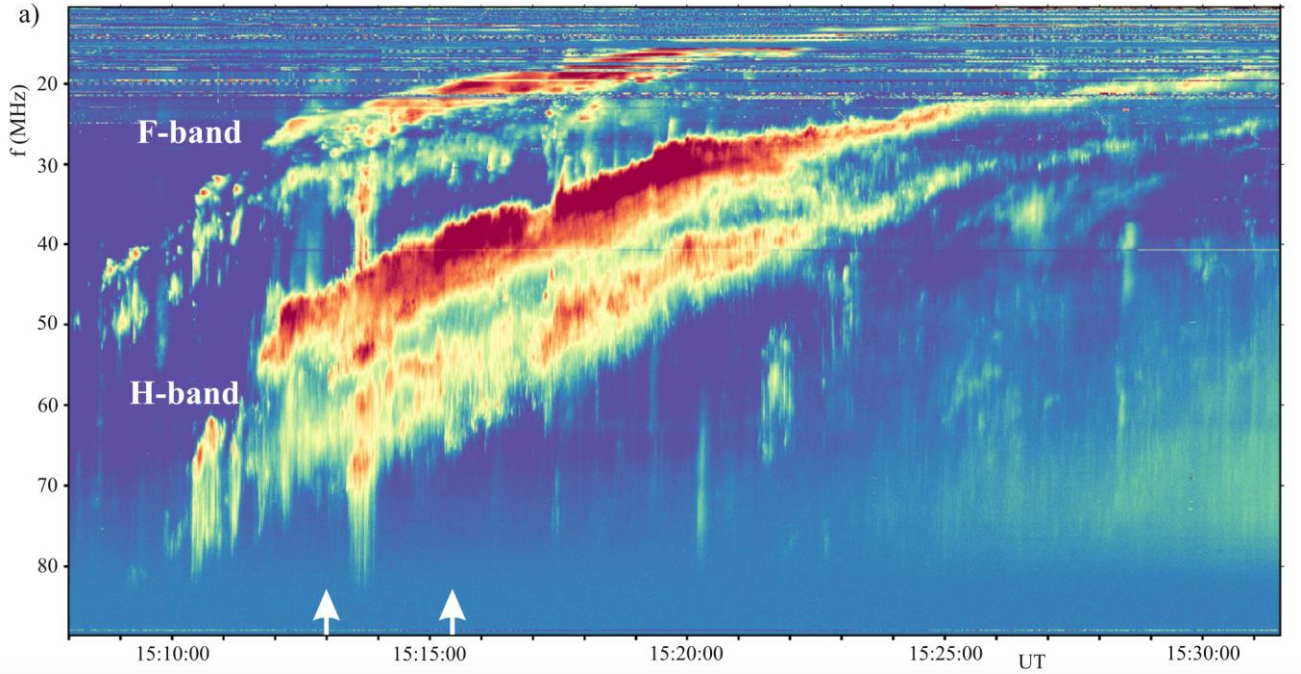
1. Introduction
Type II solar radio bursts

- Lanes of emission drifting slowly toward lower frequencies at f_p and/or $2f_p$
  - Plasma emission: $f_p \propto \sqrt{n_e}$
- Originate from electrons accelerated by shock waves in the solar corona



Magdalenić et al. (2020)

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1. Introduction
Type II solar radio bursts

- Lanes of emission drifting slowly toward lower frequenc
  - Plasma
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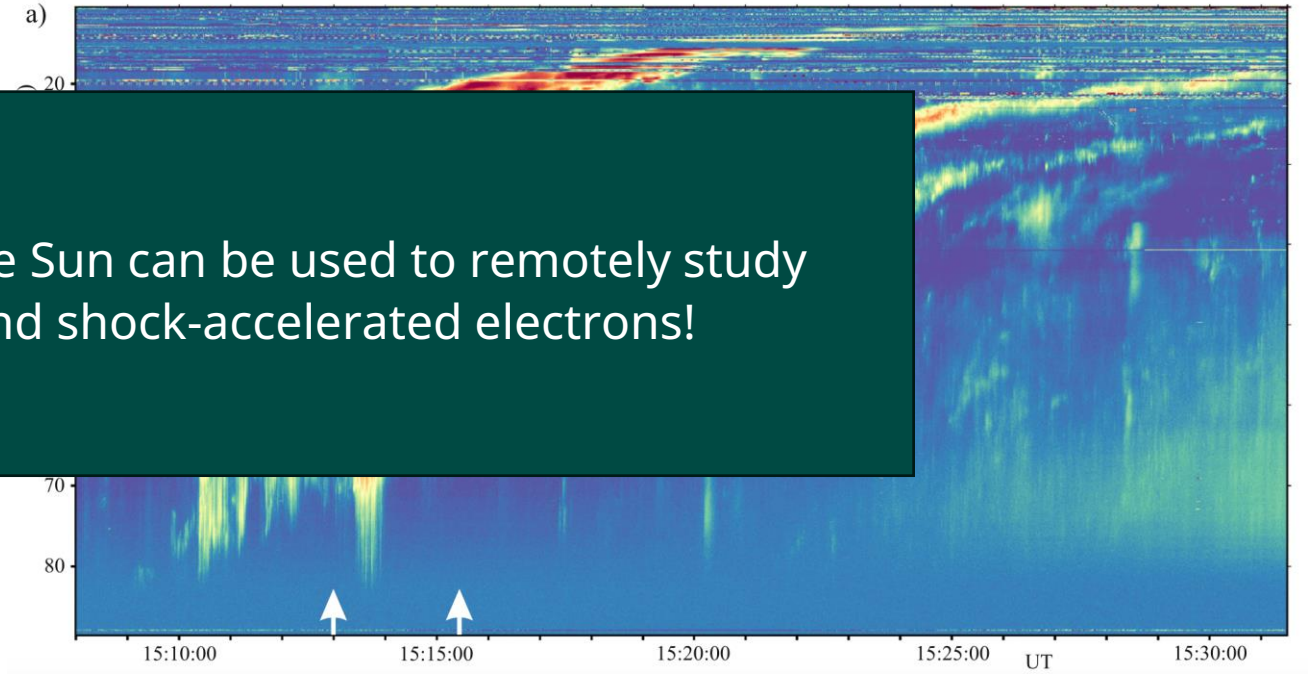
☞ Radio observations of the Sun can be used to remotely study coronal shock waves and shock-accelerated electrons!



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2. Methods and objective

Combining radio observations with a global MHD model of the solar corona

1) Ground-based radio observations:
   - **The Low Frequency Array (LOFAR)**
   - Location of a radio source in the plane-of-sky
2) Global MHD model:
   - **The MAS-Thermodynamic model (Lionello et al., 2009)**
   - Electron densities and magnetic field

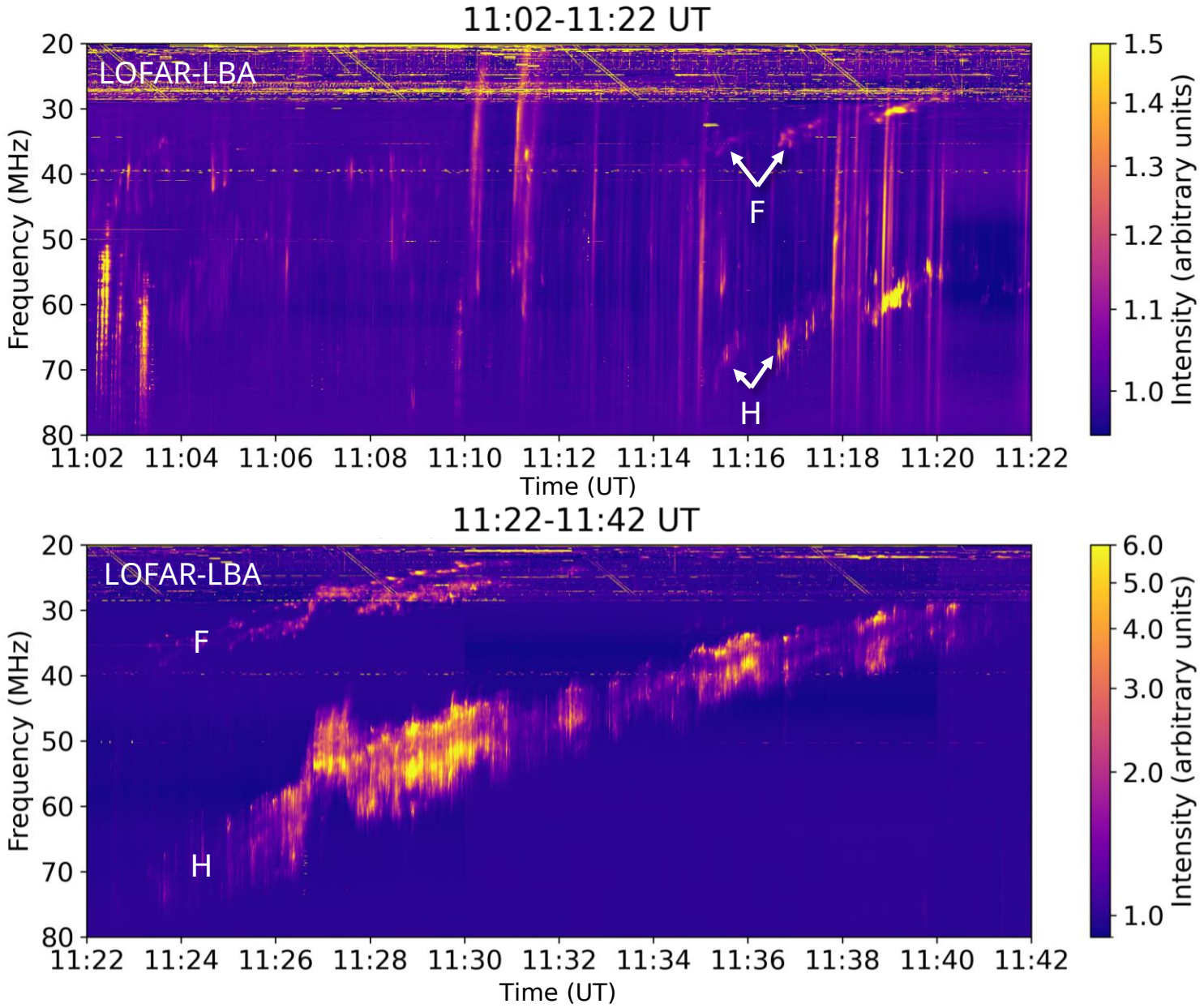
→ The 2D locations of the radio sources are compared to the electron density surface ($f_p \propto \sqrt{n_e}$)

→ Determine the source locations of the radio bursts in 3D and the properties of the emission regions

3. Results

Multiple type II radio bursts on 23 May 2022

- Dynamic spectra of the three type II bursts observed by LOFAR



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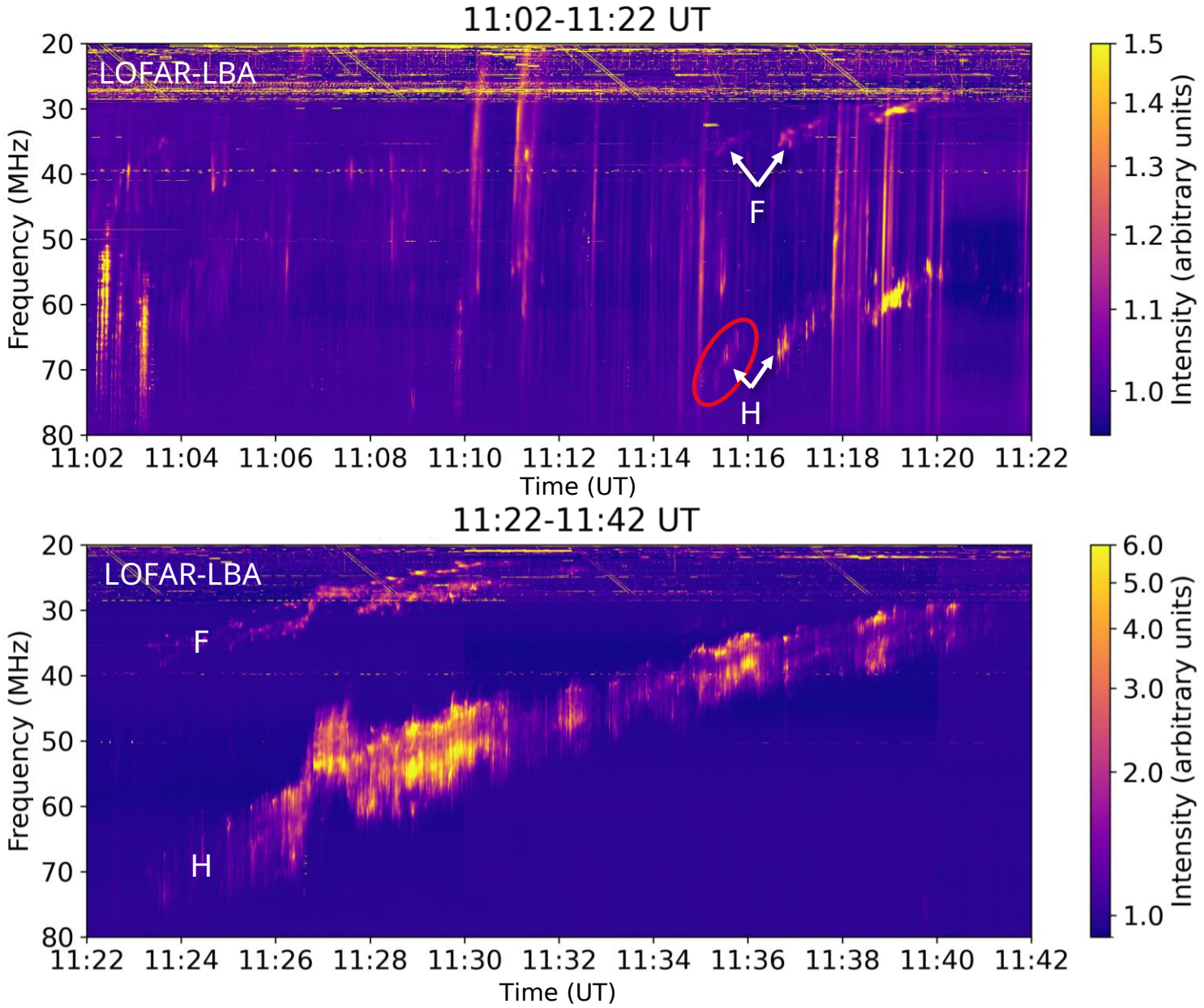

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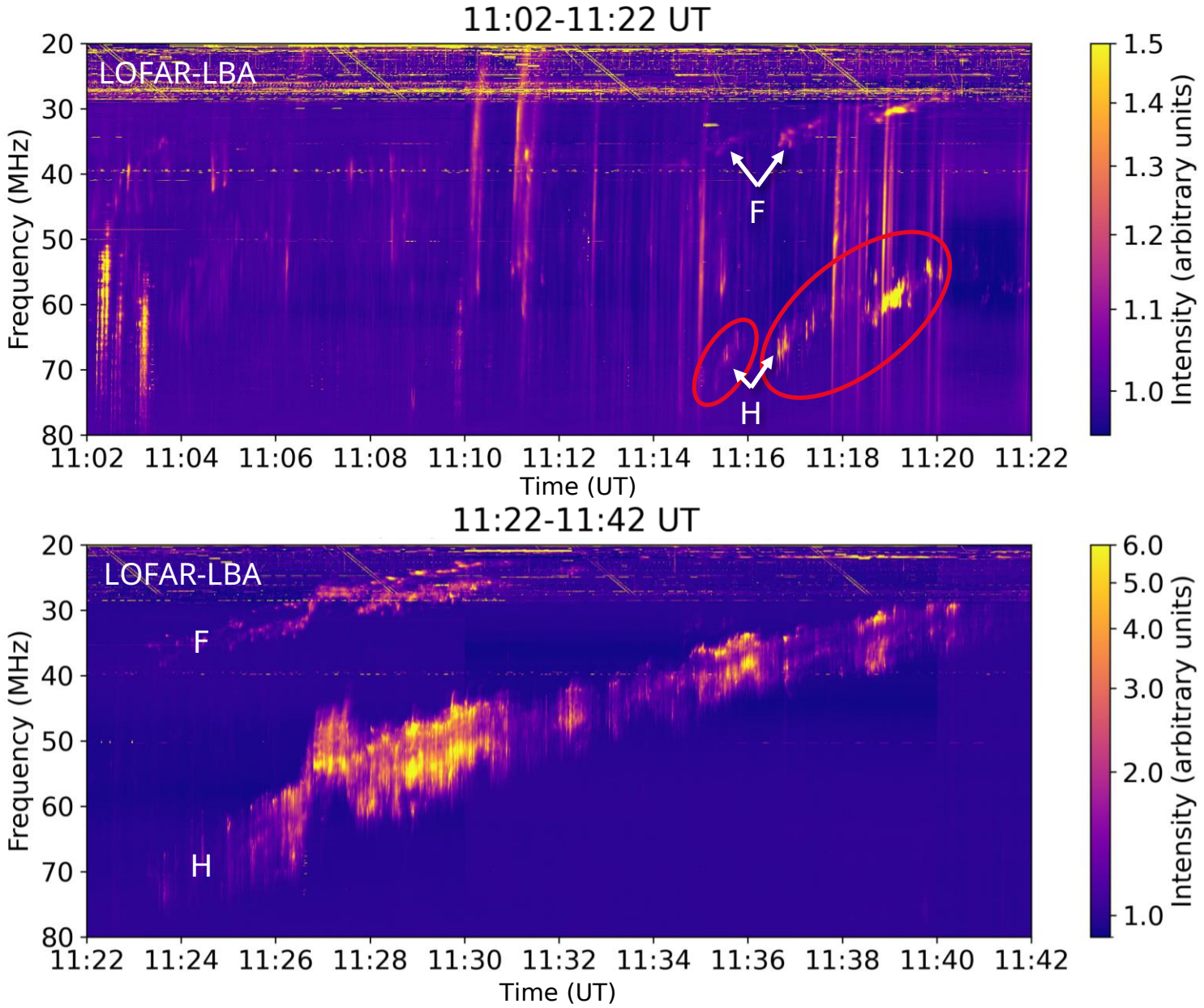

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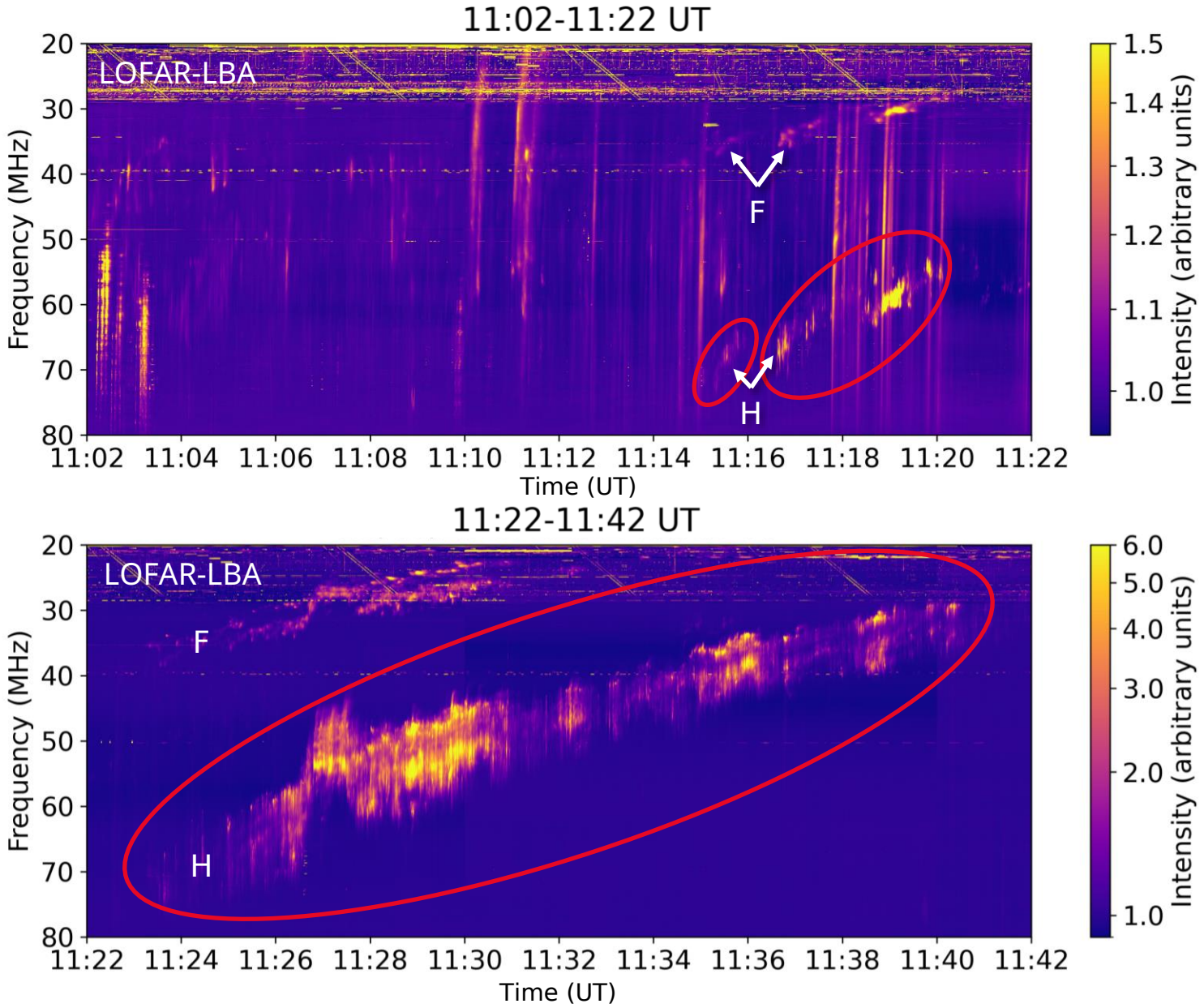

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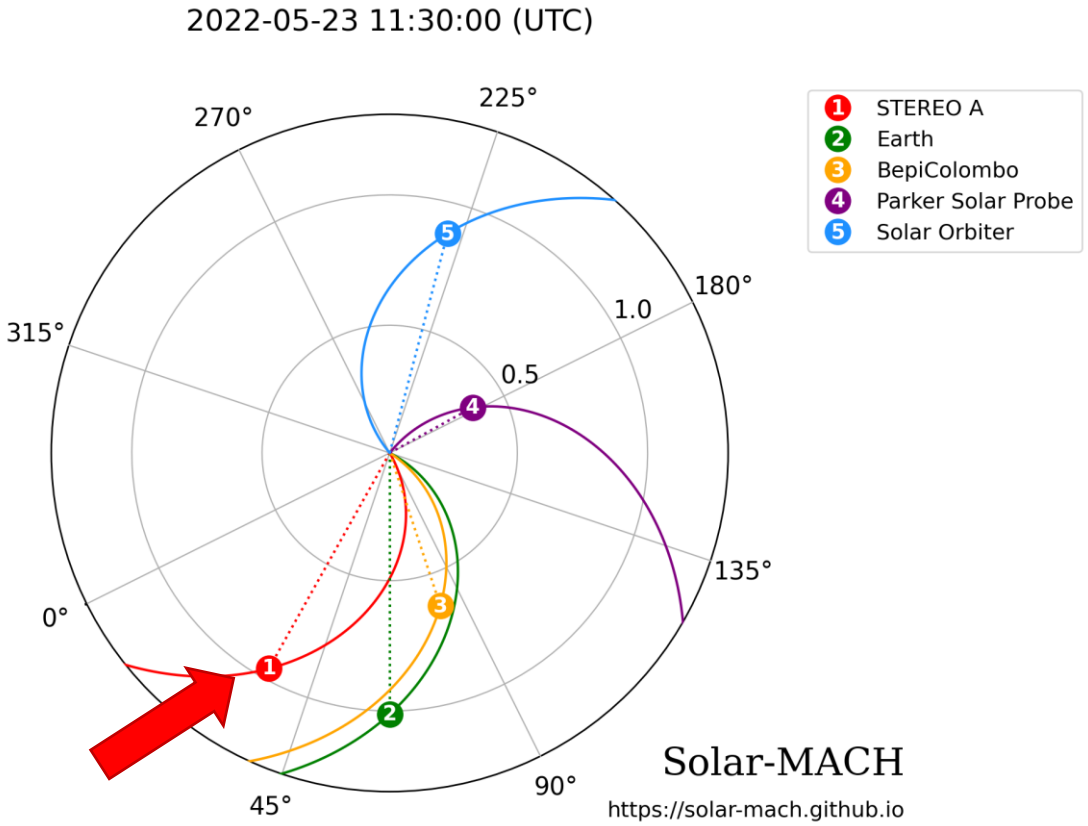
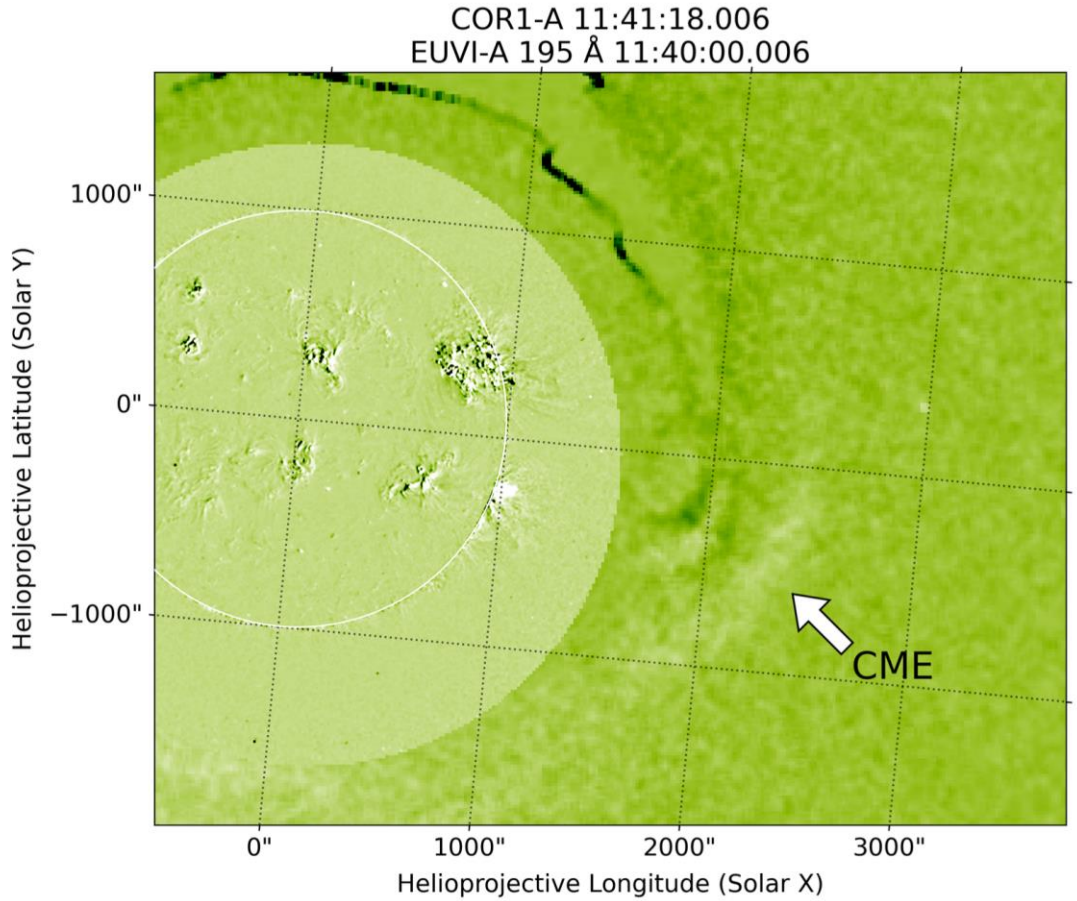
3. Results
The associated CME





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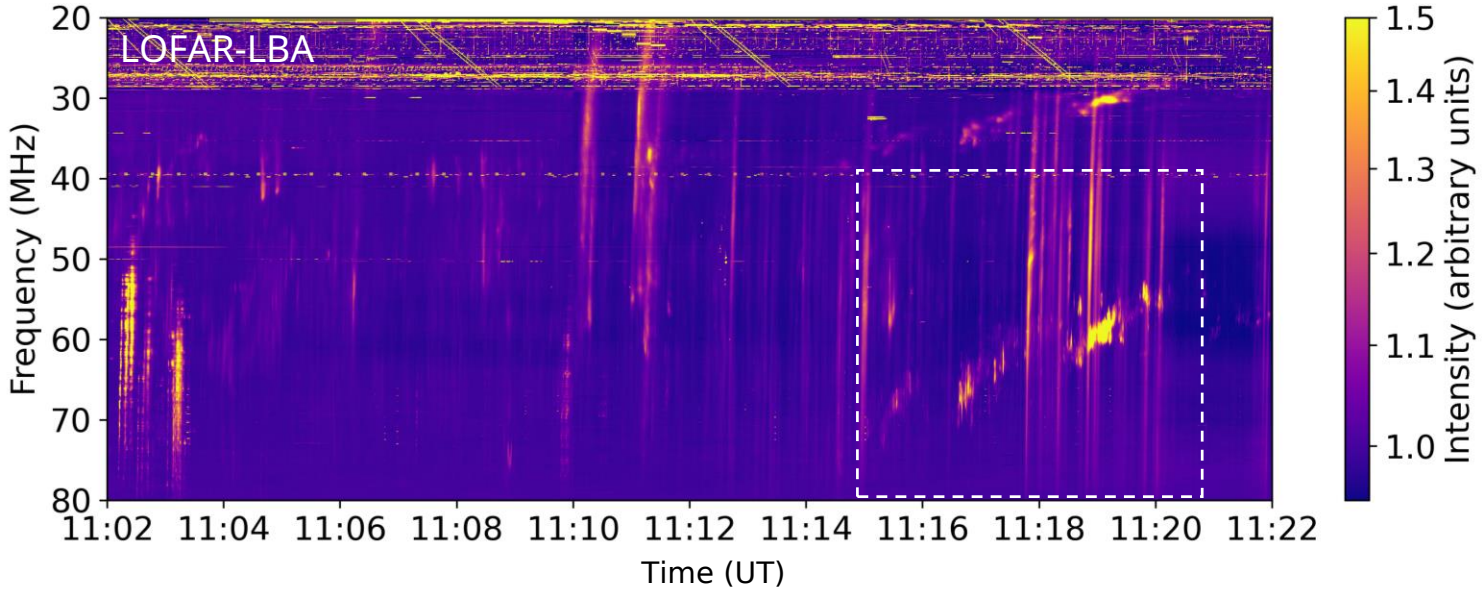
3. Results
Tracking the type II radio bursts

- LOFAR radio imaging over multiple frequencies and time steps
- Centroids obtained by fitting a 2D Gaussian to the radio sources



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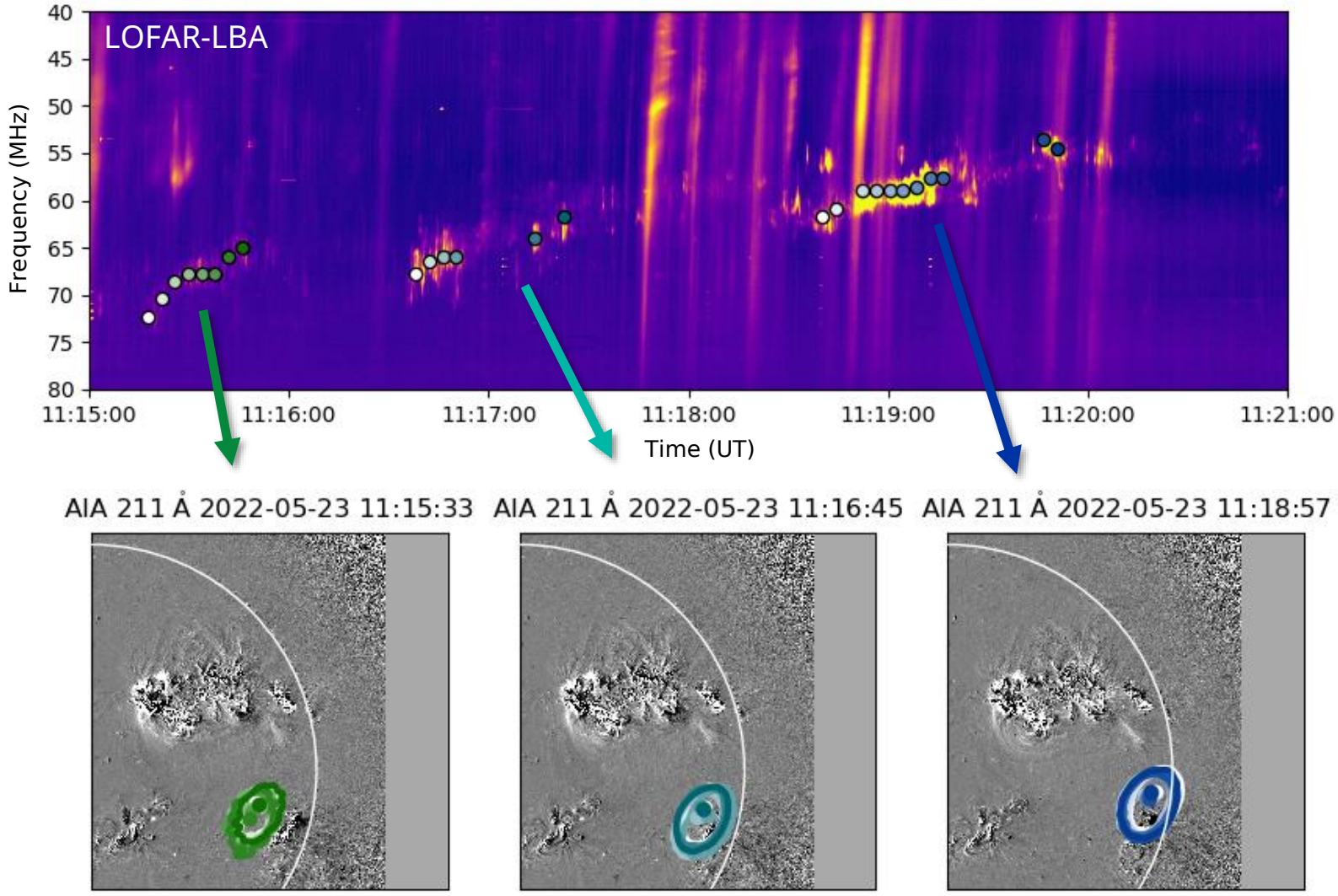

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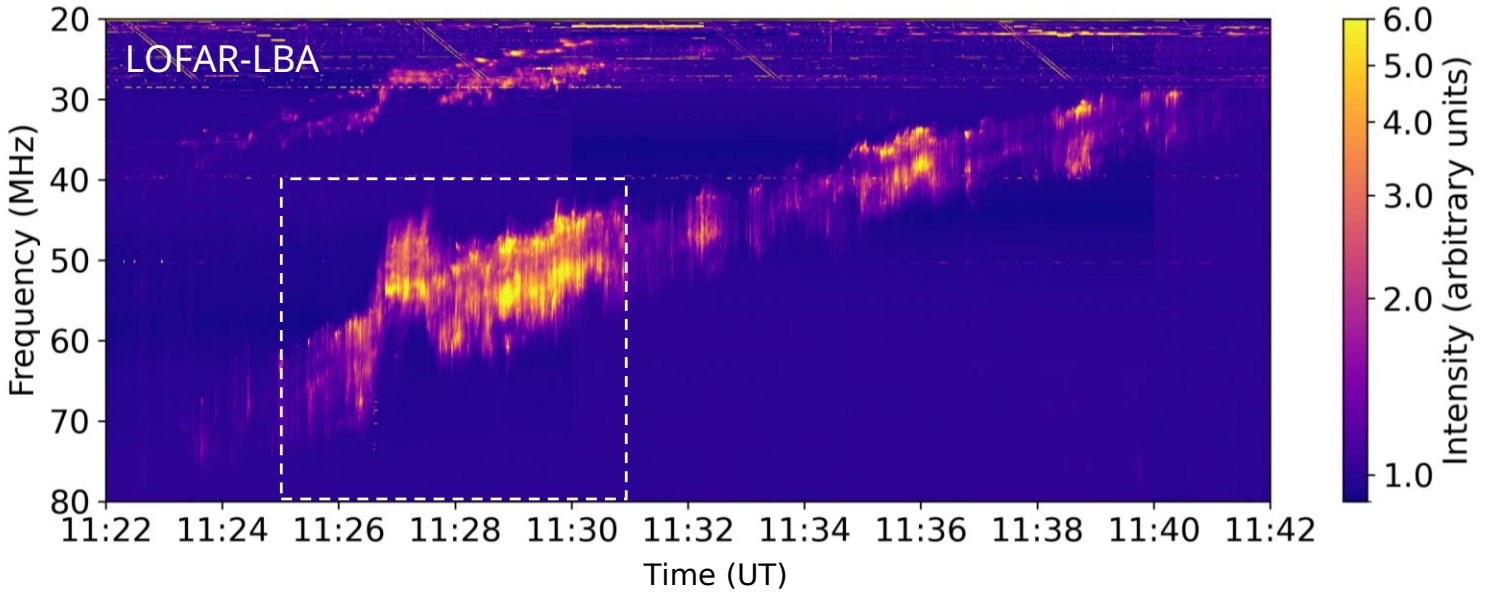

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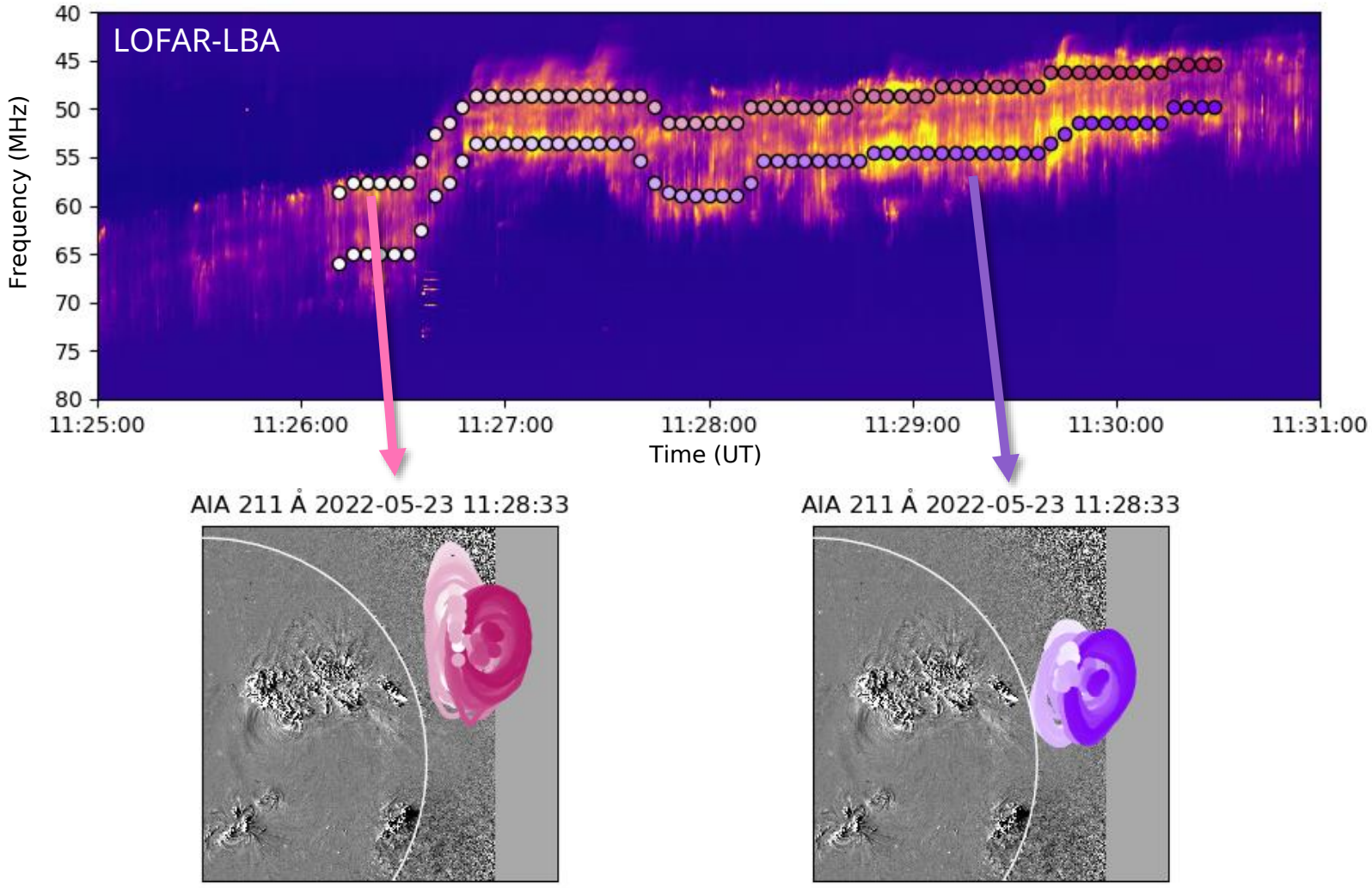

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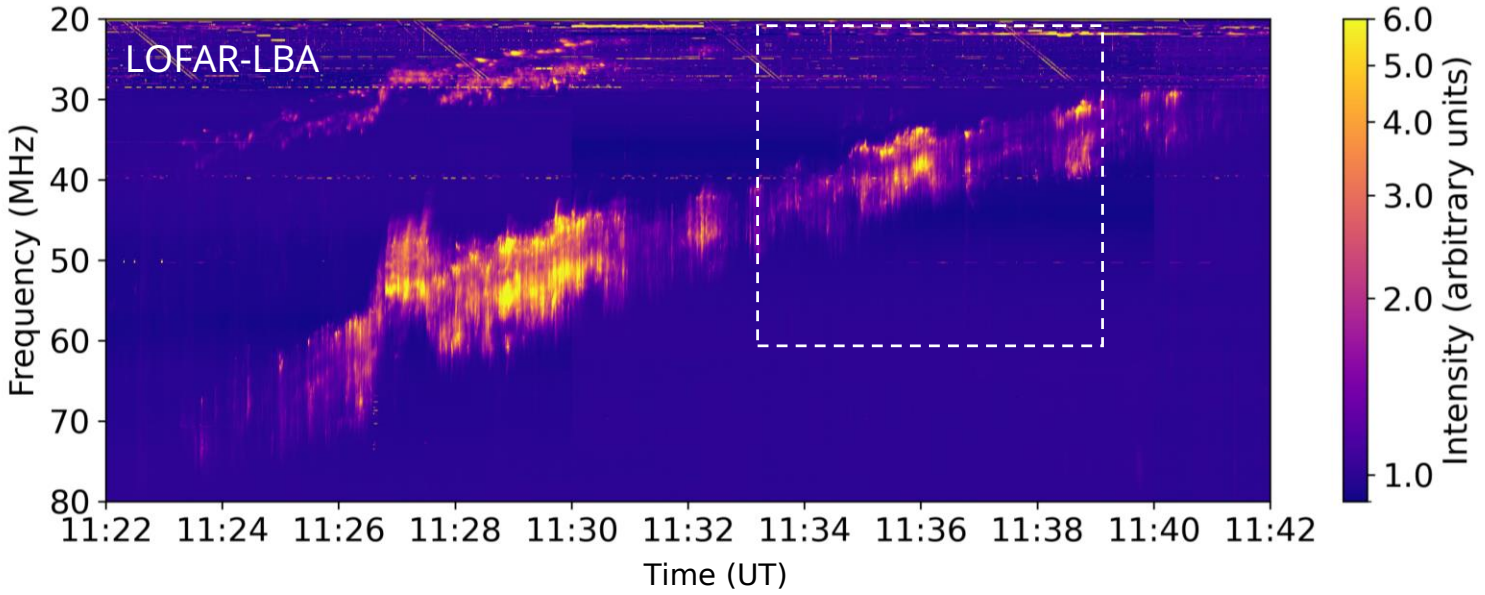

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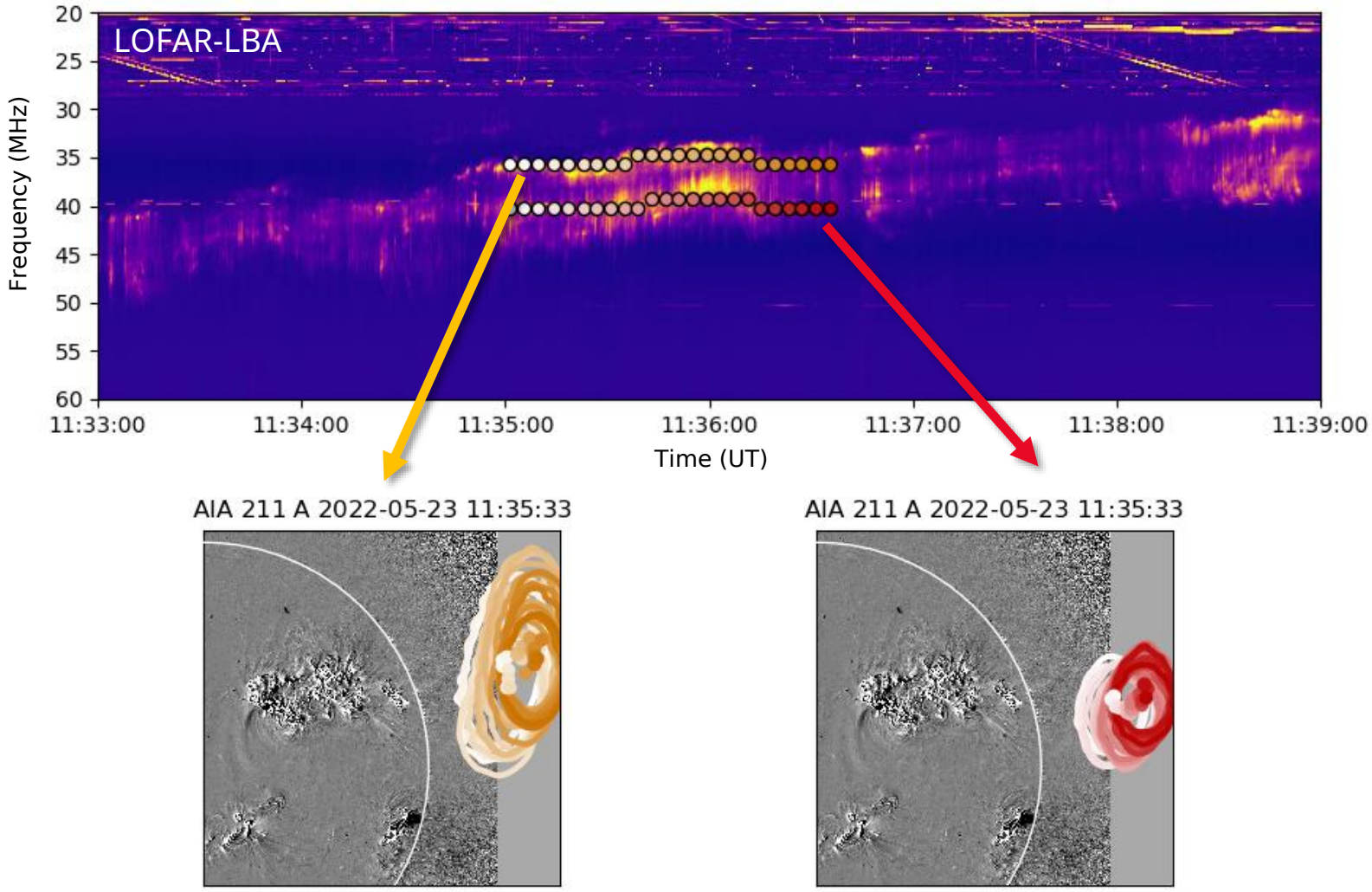

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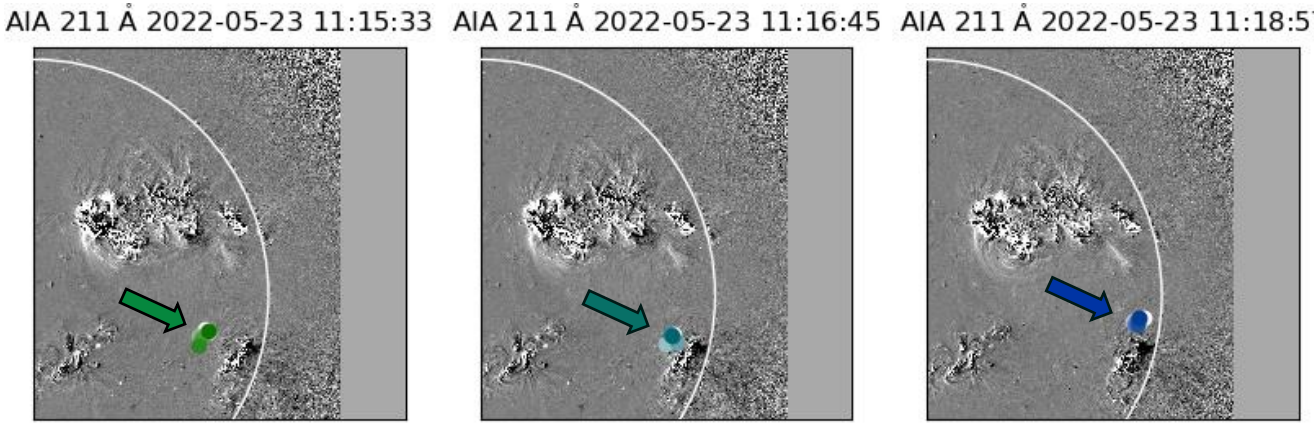
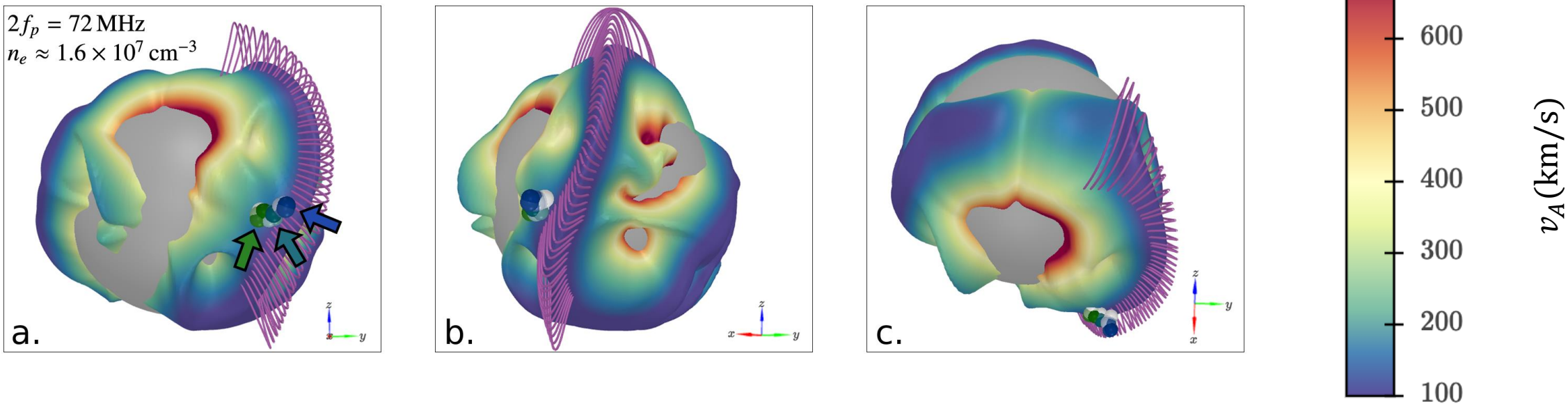
3D source locations of the type II bursts





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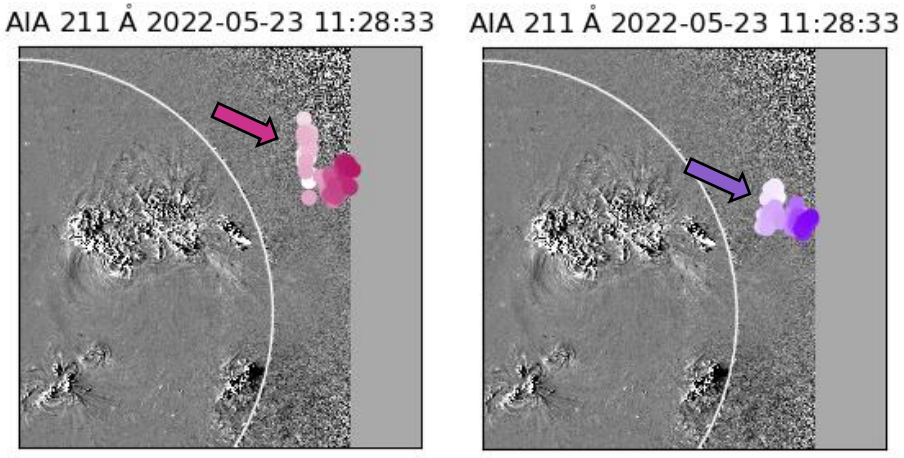

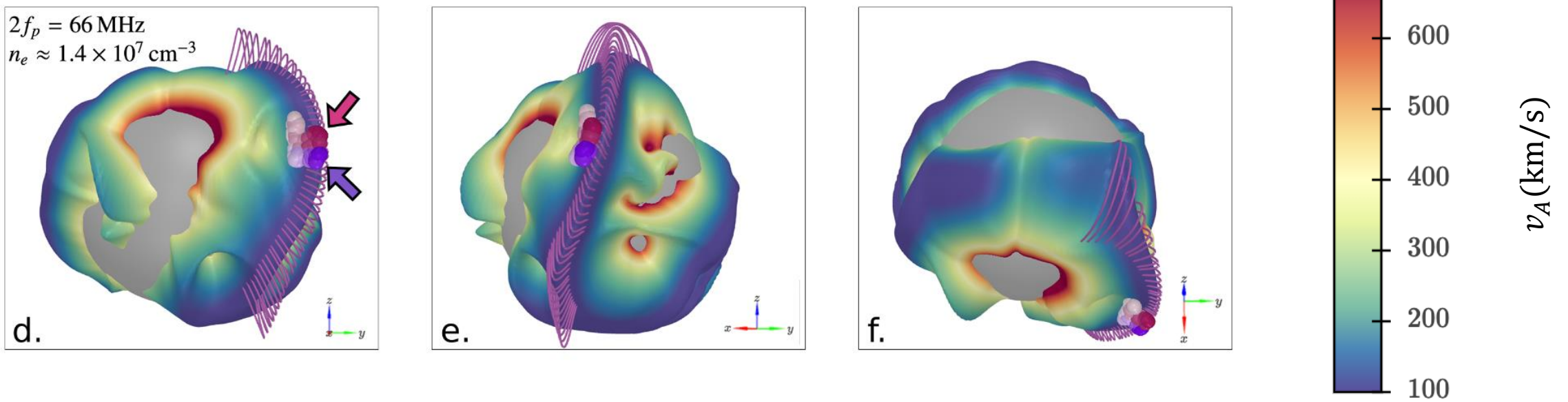

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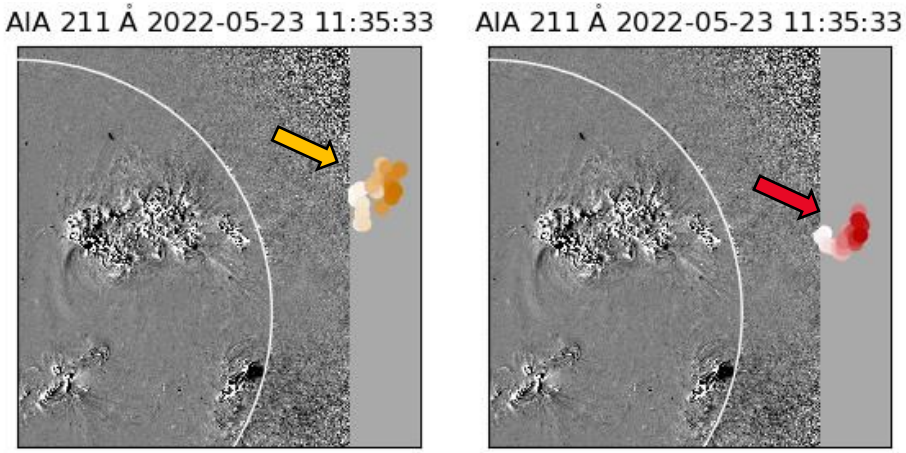

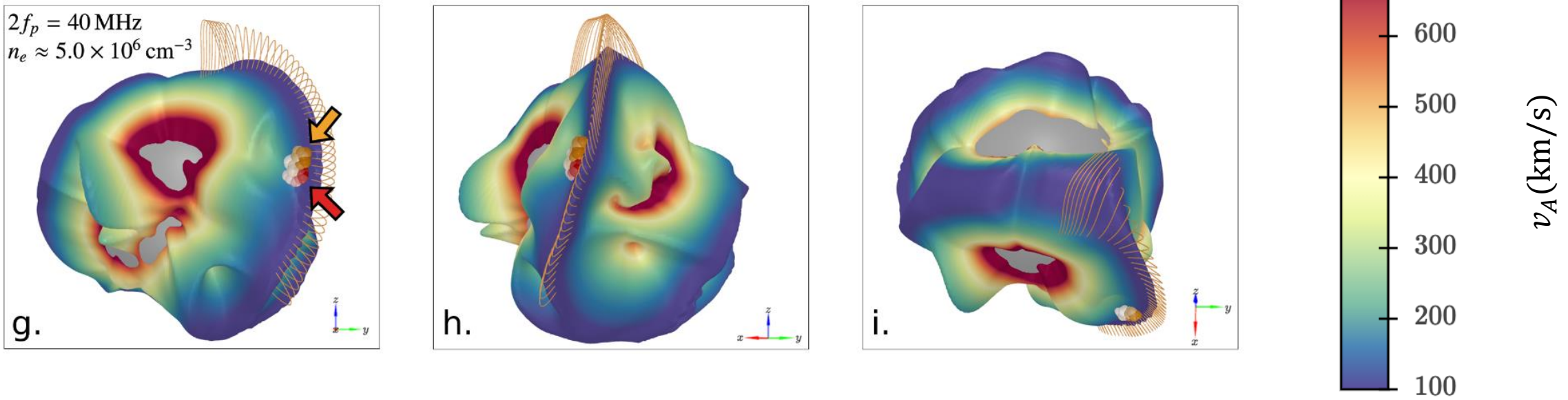

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4. Summary and conclusion

- On 23 May 2022, three type II bursts were observed by LOFAR in the presence of a faint CME
- Using LOFAR spectroscopy and imaging, we find that the three type II bursts are generated in separate and distinct regions
- According to the MAS-Thermodynamic model, the type II bursts originate from a region of high density and low Alfvén speed