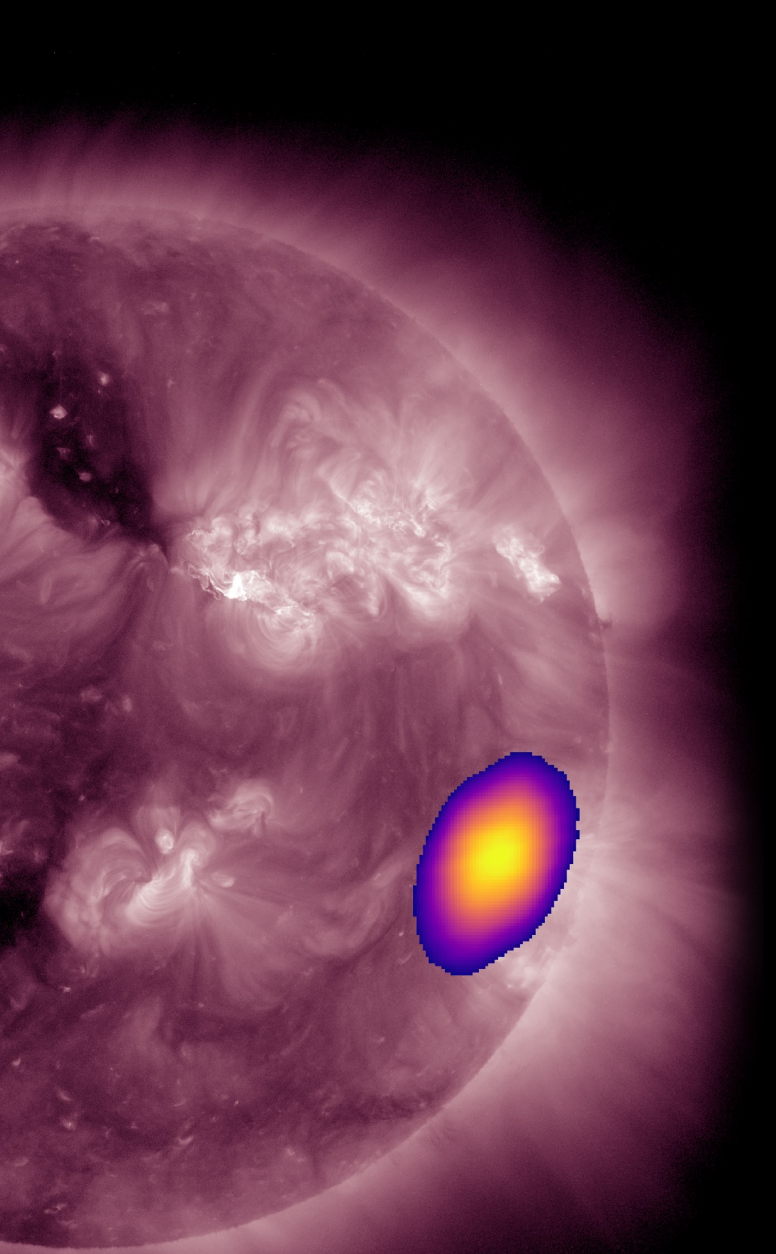

UNIVERSITY OF TURKU

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

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Energetic Solar Eruptions: Data and Analysis Tools
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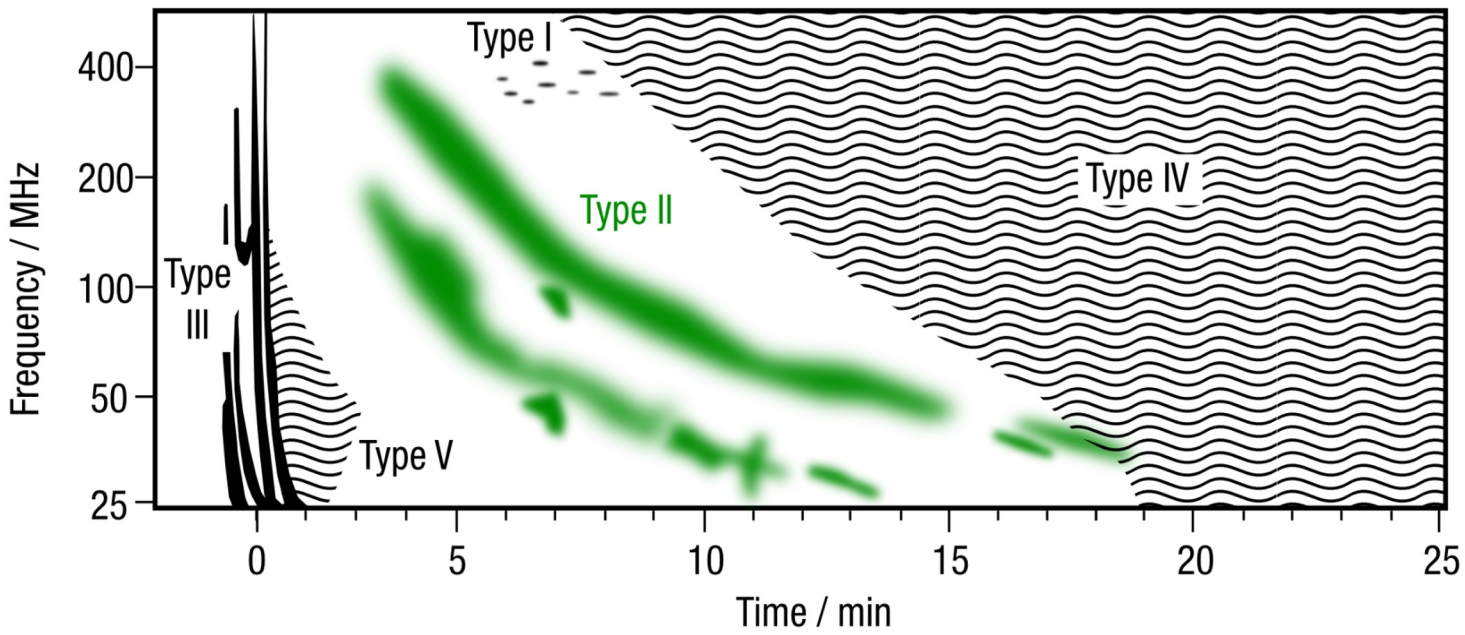
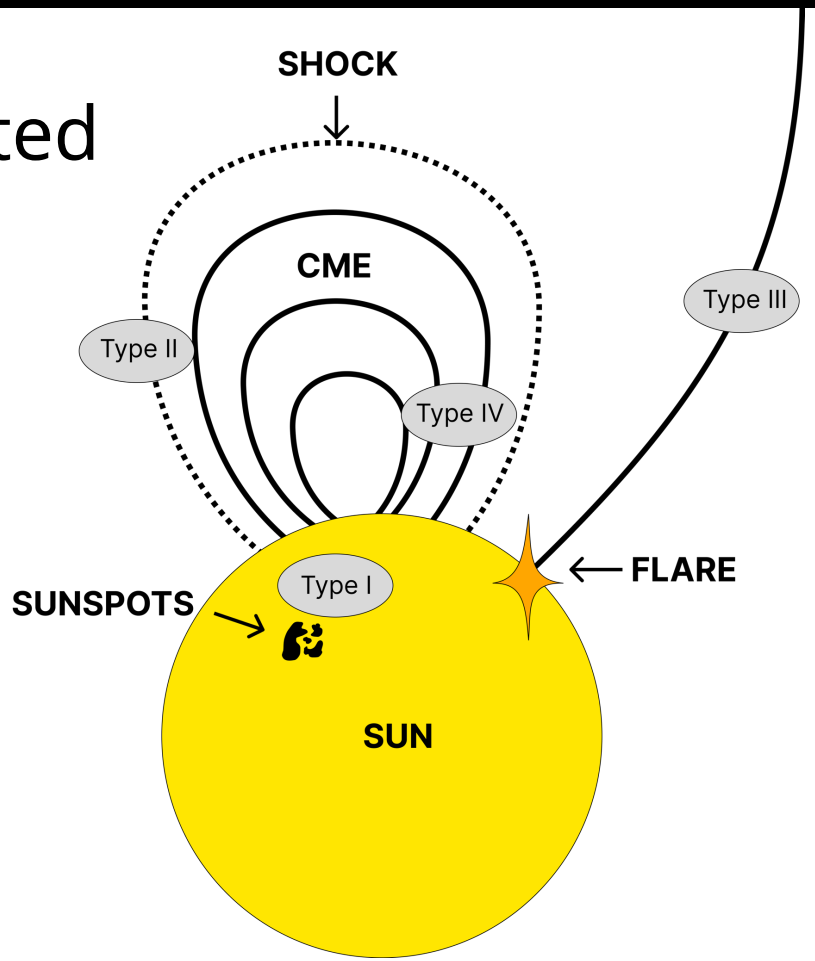
# Solar radio bursts

- Classified into types I-V which are associated with different forms of solar activity:

Ganse et al., *Sol. Phys.*, 2012





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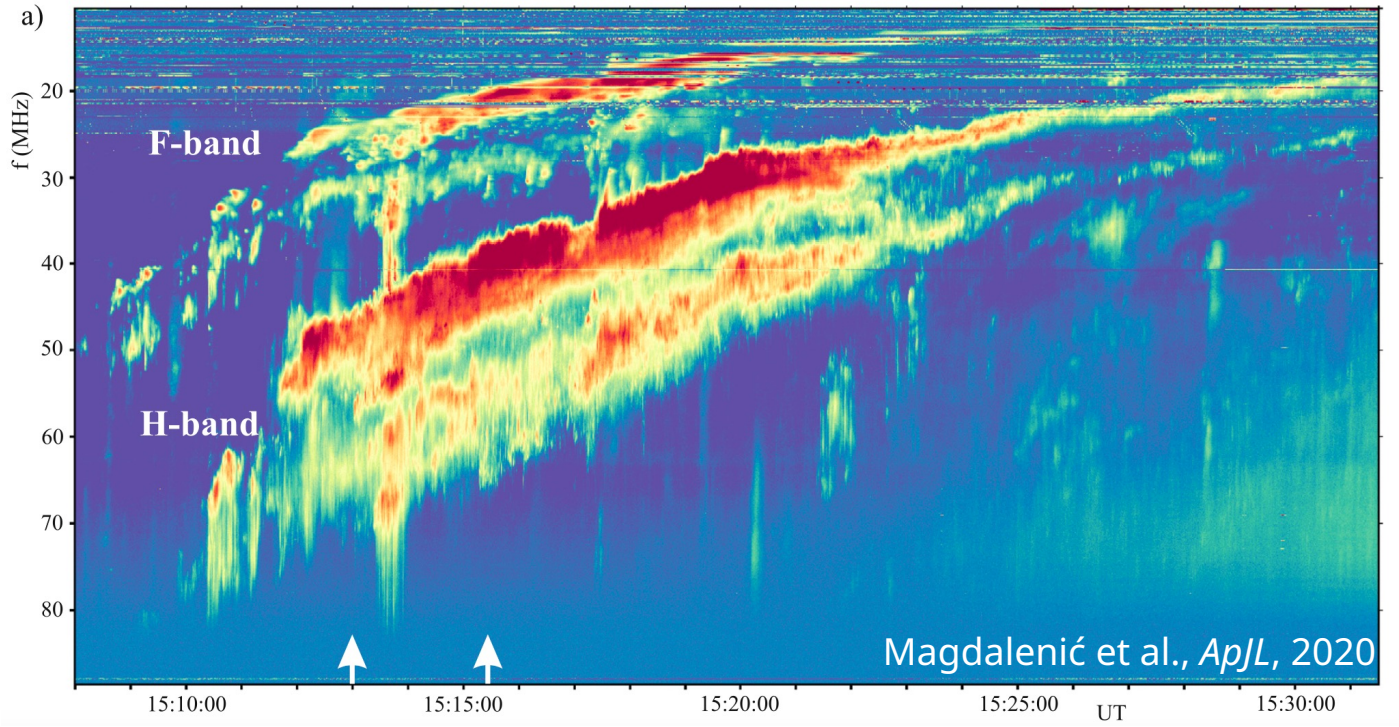
# Type II solar radio bursts

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





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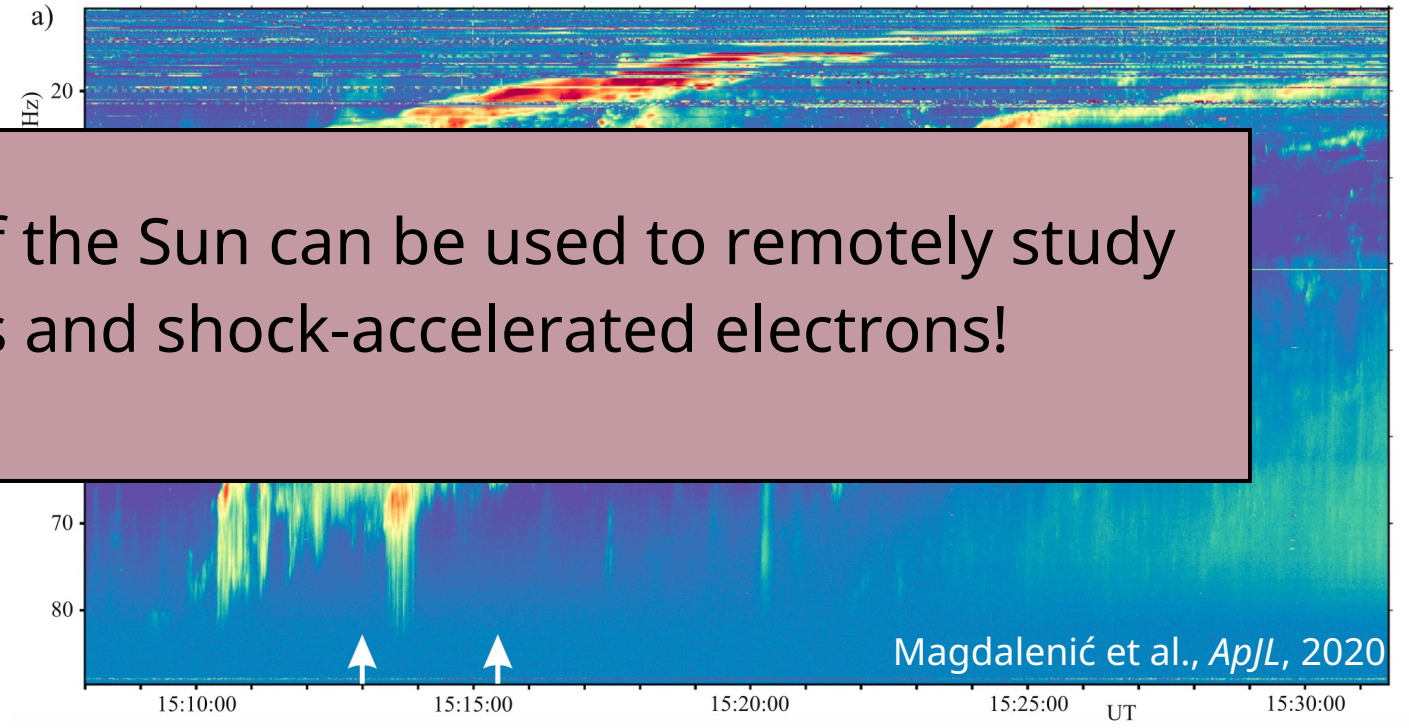
☞ Radio observations of the Sun can be used to remotely study coronal shock waves and shock-accelerated electrons!





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# Methods and objective

**LOFAR dynamic spectra and imaging:**

- Plane-of-sky source location for the type II bursts

→

**Global magnetohydrodynamic (MHD) model:**

- Thermodynamic mode of the Magnetohydrodynamic Algorithm outside a Sphere (MAS) model (Lionello et al. 2009) developed by Predictive Science Inc.
- Global values of electron density and magnetic field strength

→

**Radio source locations in 3D and properties of the emitting regions:**

- The 2D positions of the type II sources can be compared to the modelled density iso-surfaces ($f_p \propto \sqrt{n_e}$)


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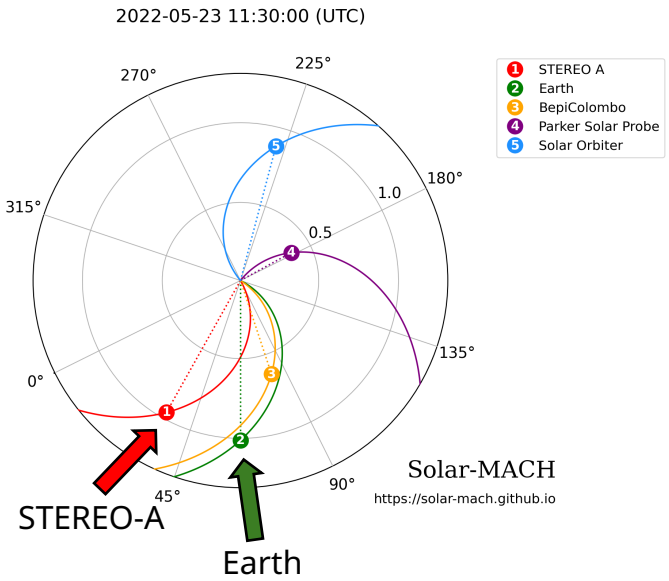
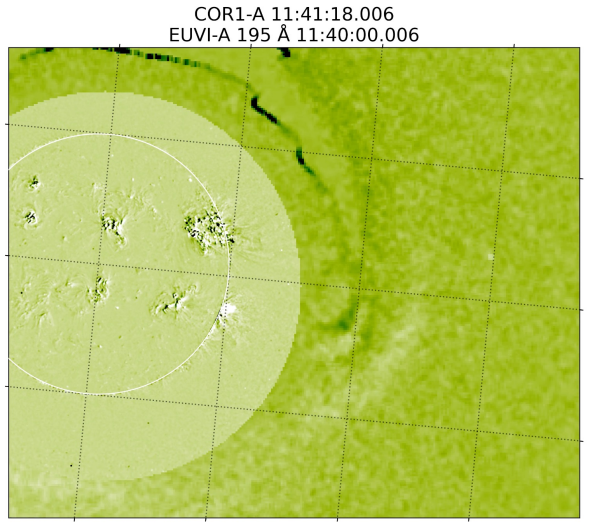
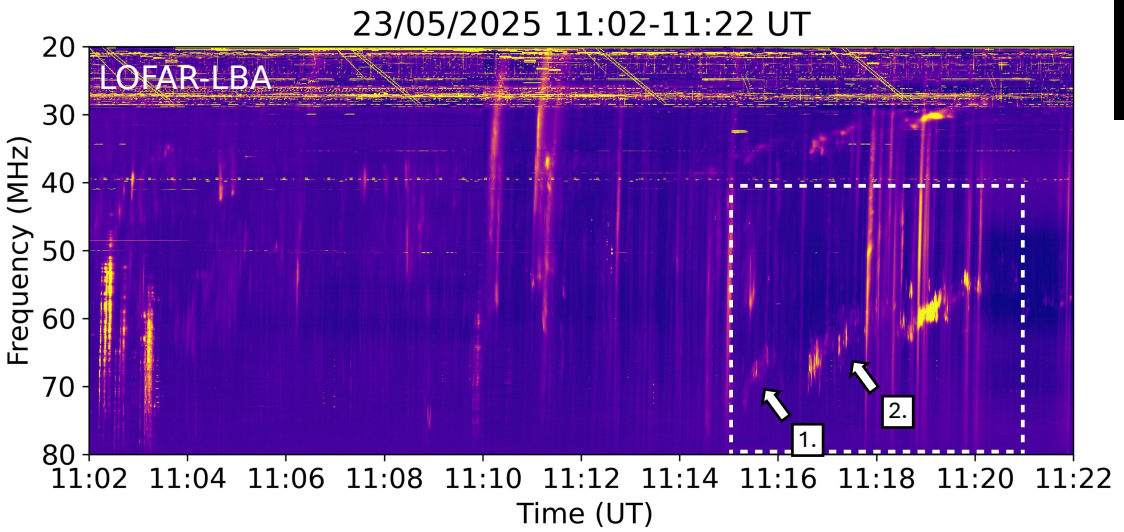
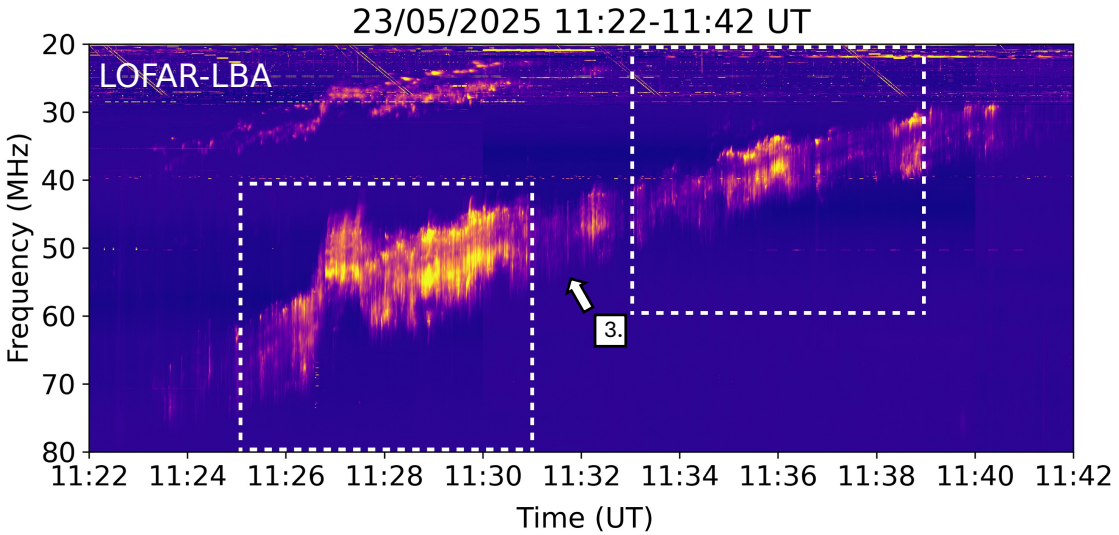
# Multiple type II radio bursts on 23 May 2022





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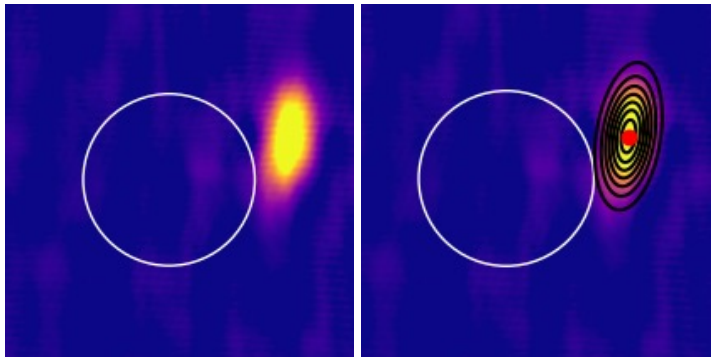
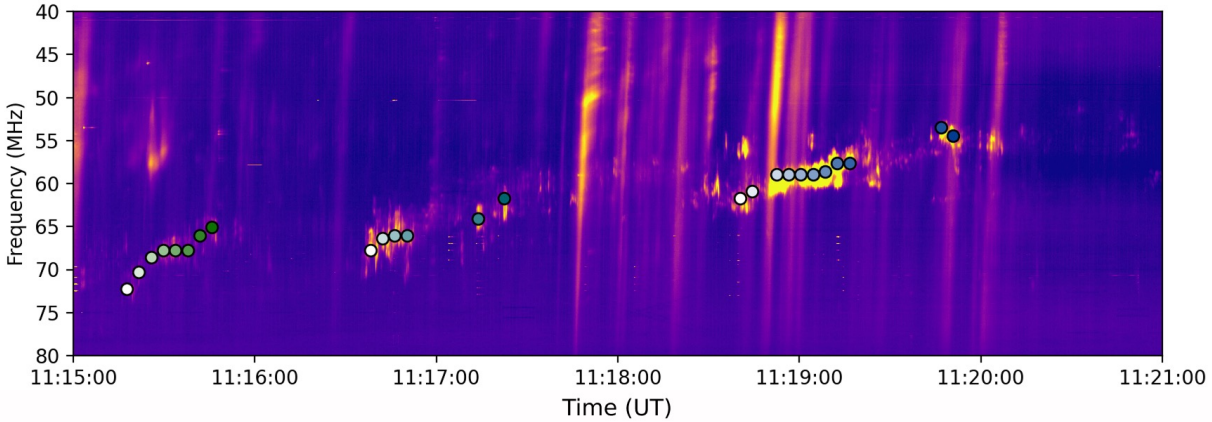
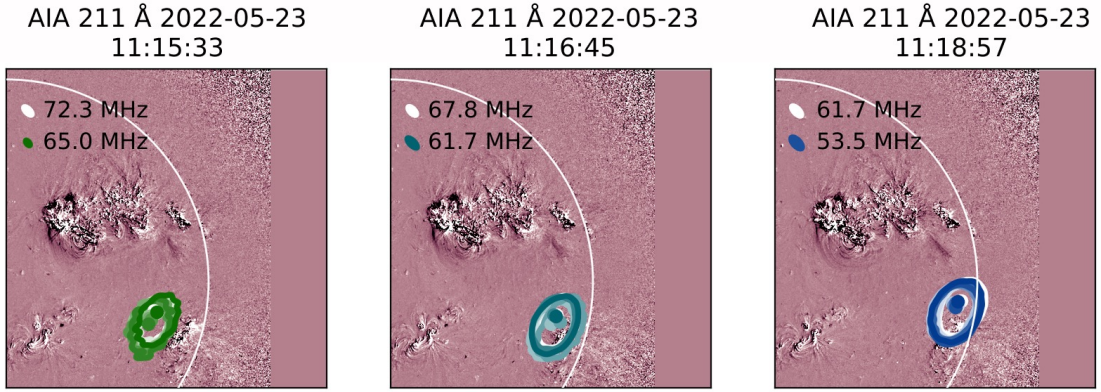
# Tracking the type II bursts

**1st and 2nd type II burst:**

- Imaging extracted according to the tracking in the spectrum
- Centroids of the radio sources obtained via a 2D Gaussian fit:







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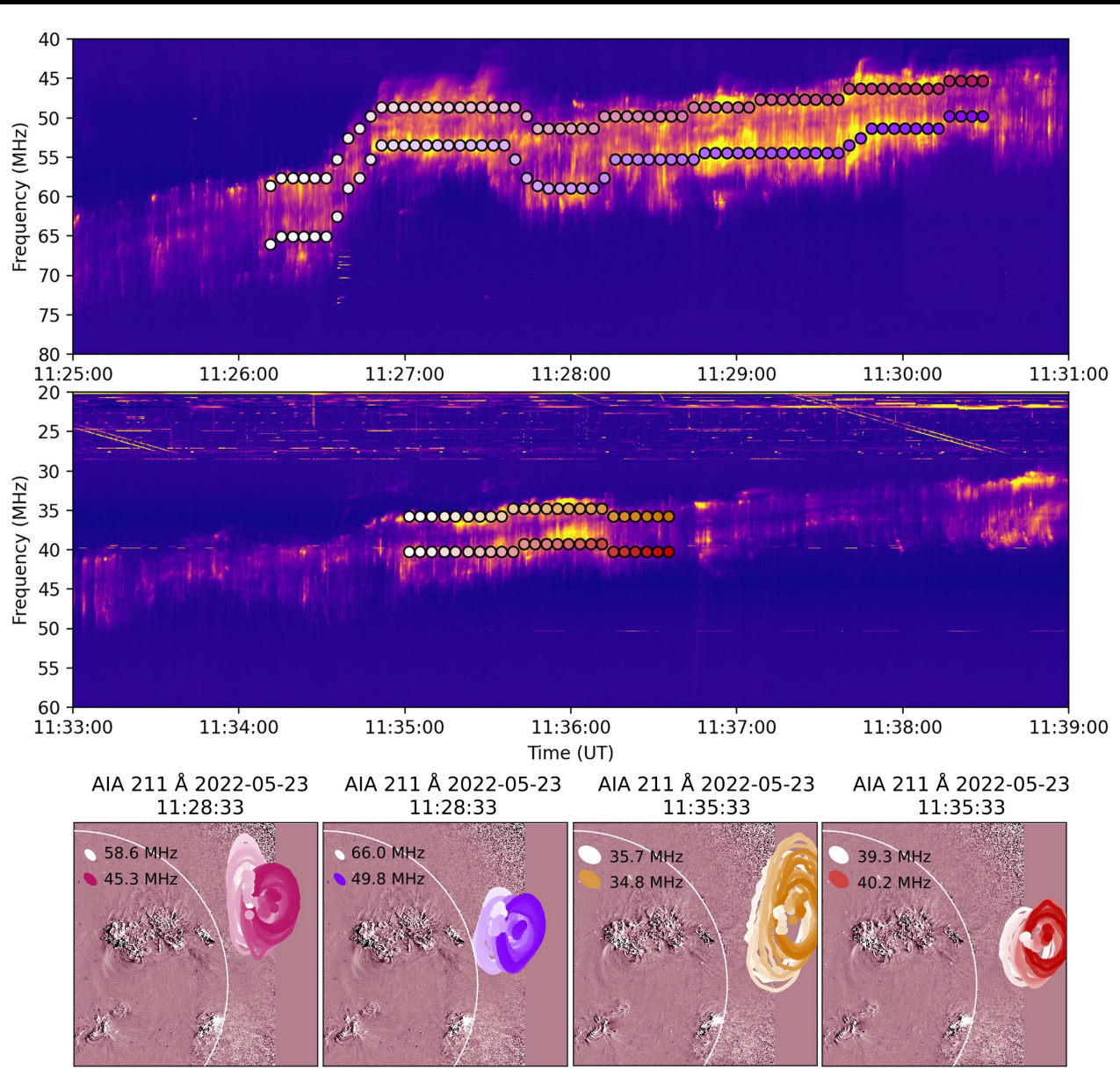
# Tracking the type II bursts

**3rd type II burst:**

- An earlier and a later part of the burst was tracked
- Due to band-splitting, both the higher and lower frequency components are tracked
- Imaging extracted accordingly





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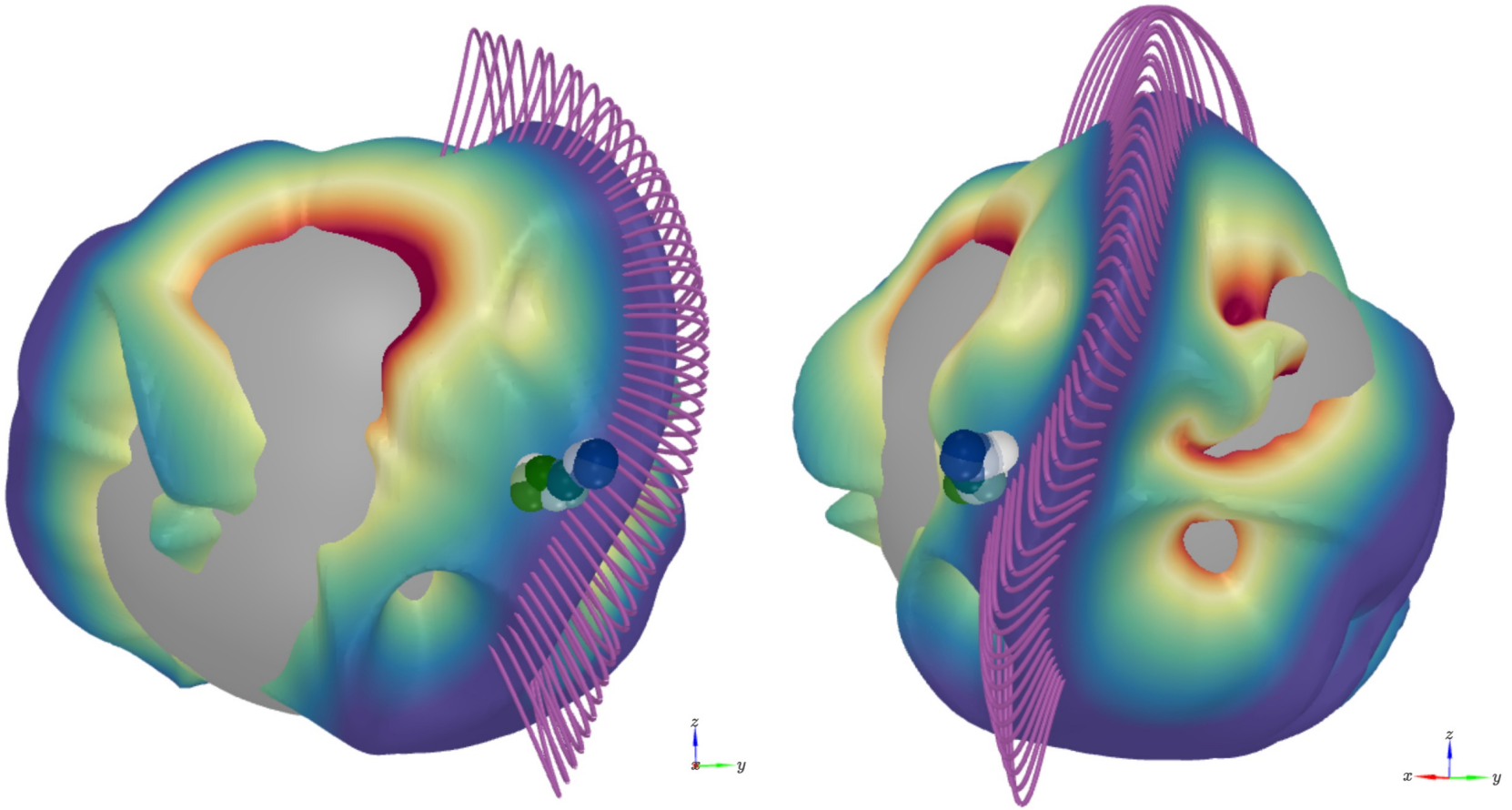
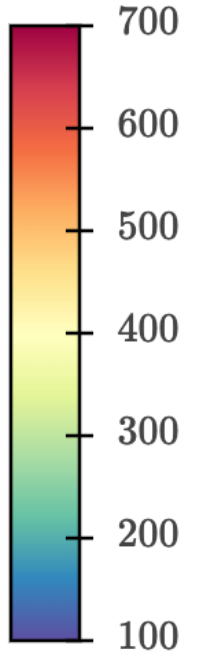
# Source locations of the type II bursts in 3D: 1st and 2nd burst






$$\left(v_A = \frac{B}{\sqrt{\mu_0 \rho}}\right)$$

$2f_p = 72$ MHz, $n_e \approx 1.6\times10^7 \mathrm{cm}^{-3}$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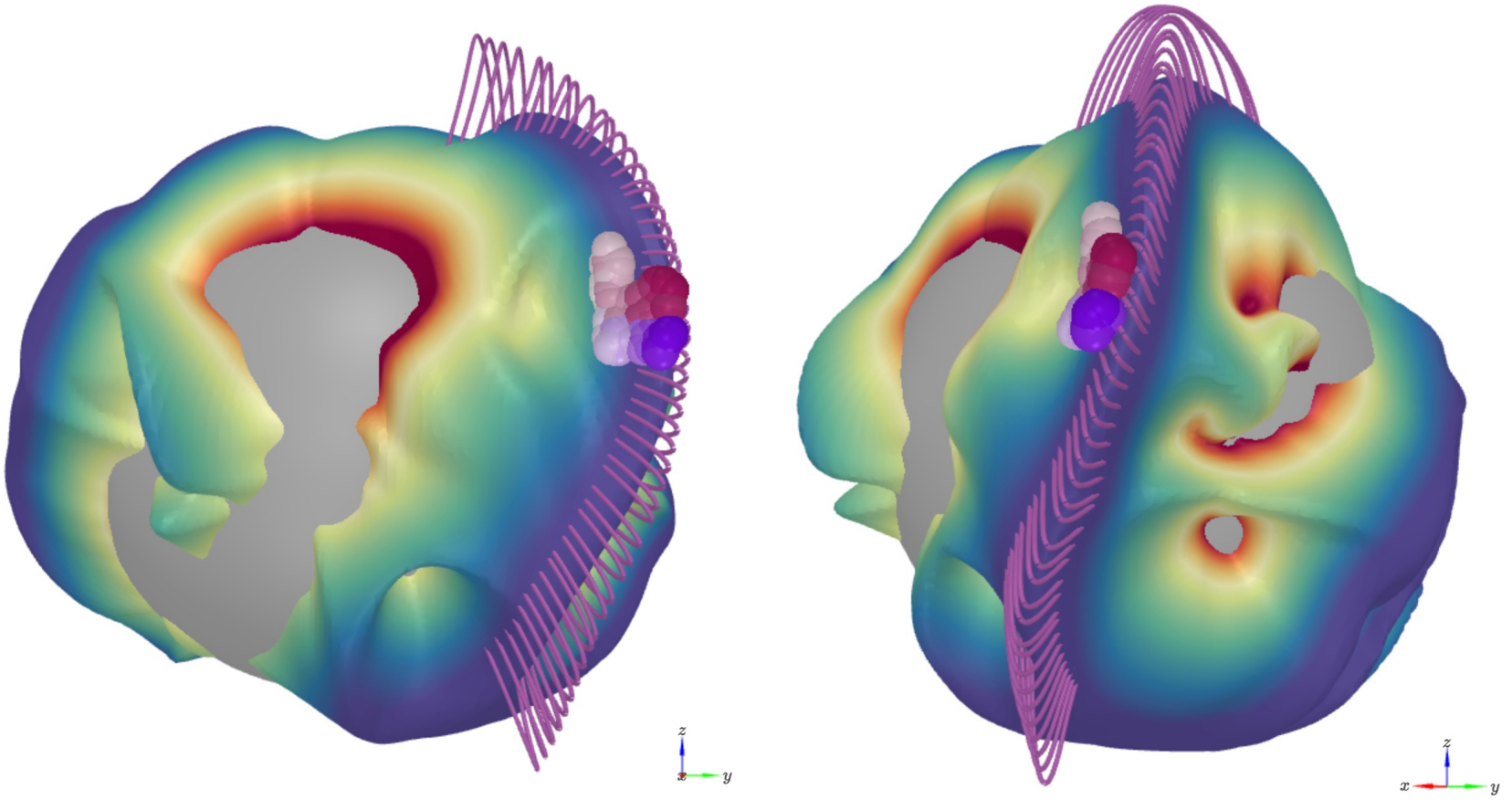
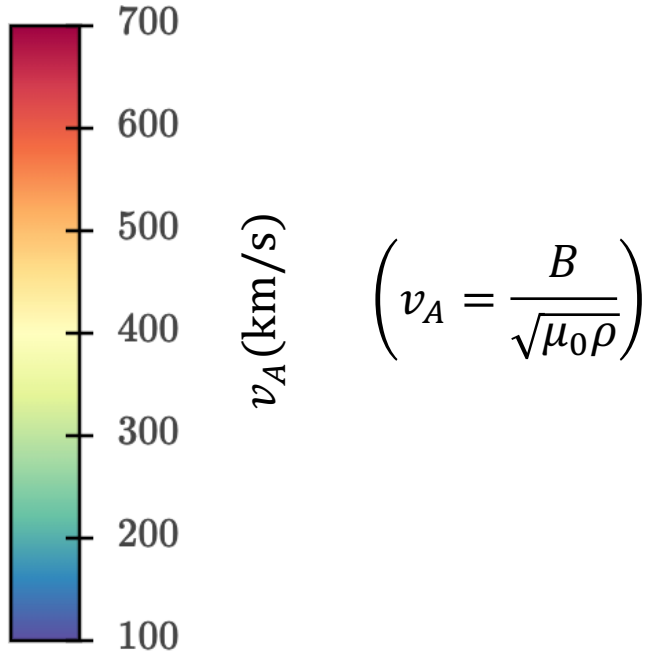
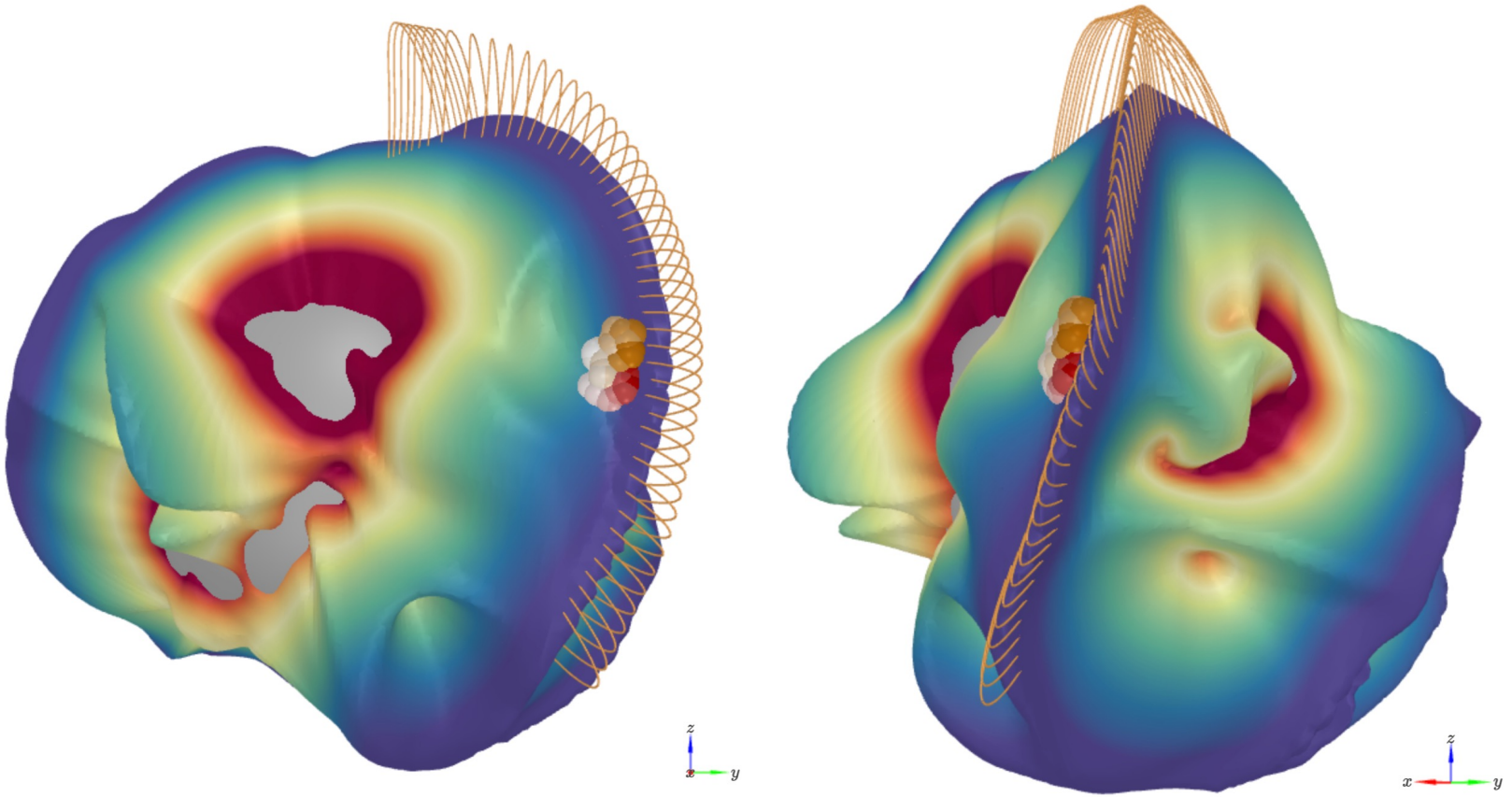
# Source locations of the type II bursts in 3D: 3rd burst (earlier part)

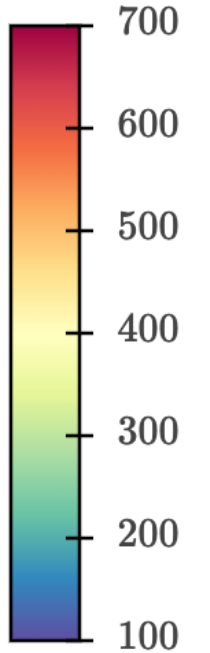





$2f_p = 66$ MHz, $n_e \approx 1.4\times10^7 \mathrm{cm}^{-3}$

# Source locations of the type II bursts in 3D: 3rd burst (later part)






$$\left(v_A = \frac{B}{\sqrt{\mu_0 \rho}}\right)$$

$$2f_p = 40 \text{ MHz}, n_e \approx 5.0\times10^6 \text{cm}^{-3}$$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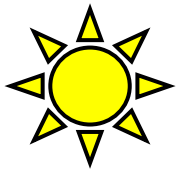
# Summary and conclusion

- Using LOFAR spectroscopy and imaging, we find that the three type II bursts are generated in separate and distinct regions
- Despite their distinct locations, all type II bursts originate from a high density and low Alfvén speed streamer
- In these regions, the CME was likely able to drive a shock and accelerating electrons at multiple sites and times
- CME-streamer interactions can create favourable conditions for type II burst generation!

Thank you! 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