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Langmuir Waves Associated with Magnetic Holes

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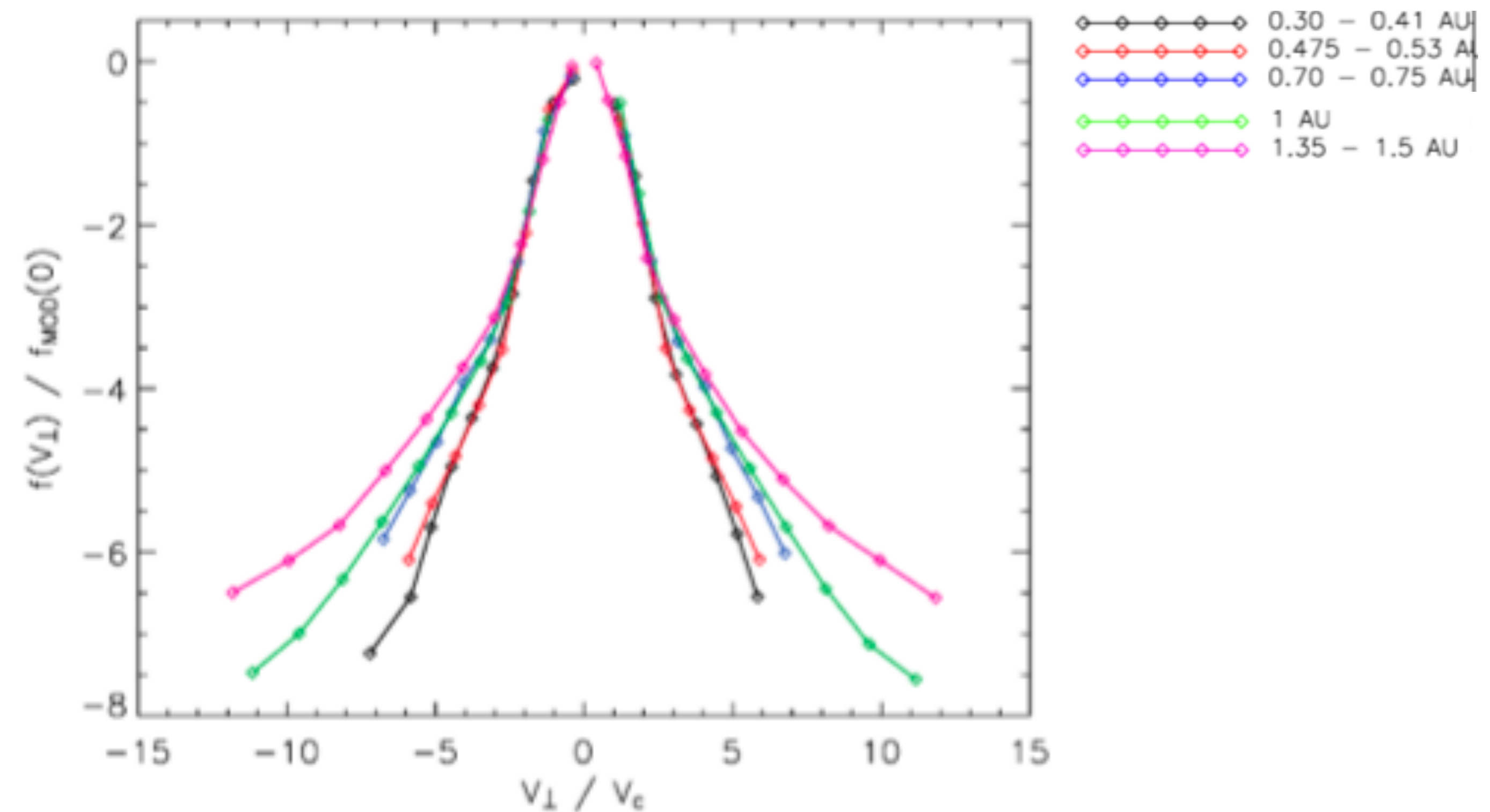


Introduction

- The solar wind is a continuous magnetized plasma outflow arising from the solar corona.
- Given the low level of collisionality, the scattering of the solar wind electrons must involve the wave-particle interactions or large-scale inhomogeneities of the interplanetary field.
- We will understand the evolution of the solar wind by studying the plasma waves.

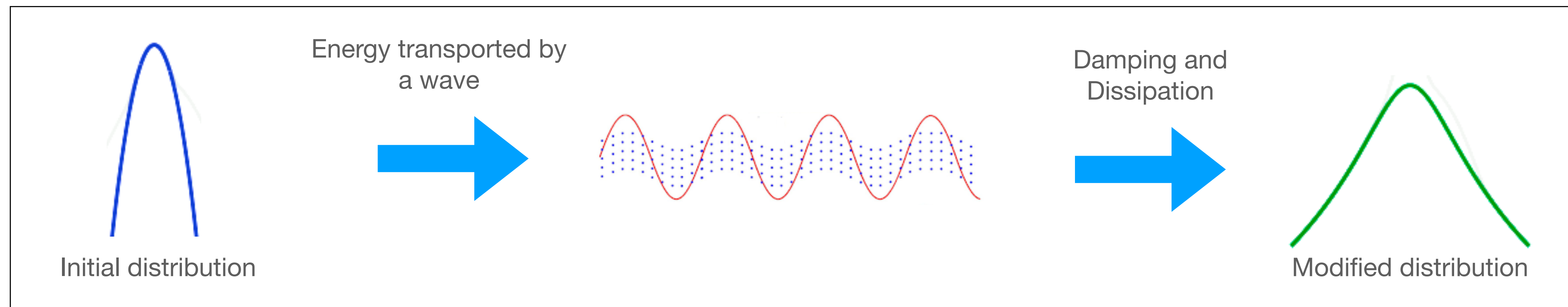
Electron distribution in the solar wind

The electron distribution function in the solar wind has been observed to change with radial distance.



Maskimovic et. al, 2005

Wave-Particle interaction

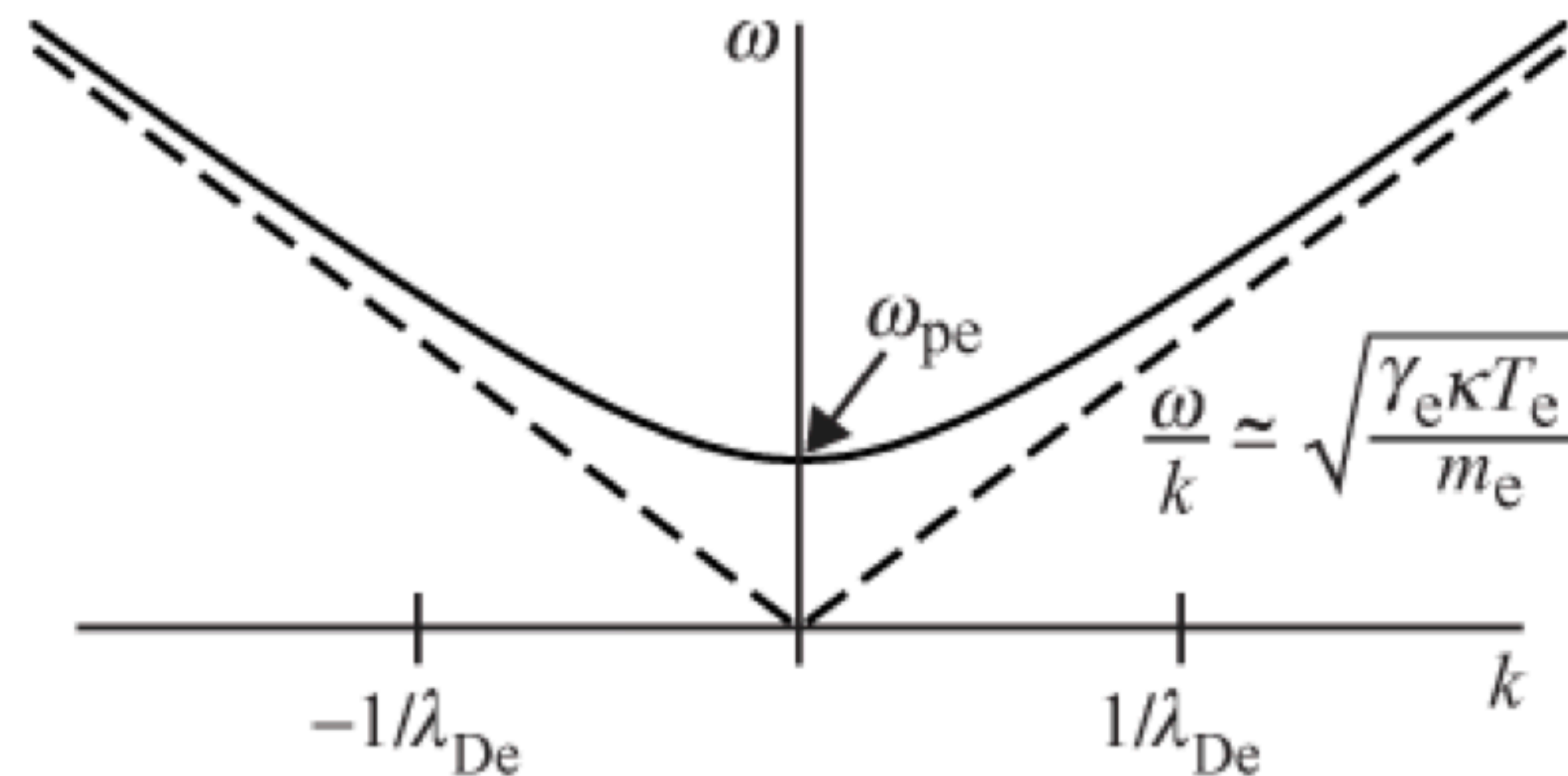


Which waves and what role they play in shaping the distribution function in the solar wind is still unknown.

Langmuir waves

- Electrostatic longitudinal waves, strongly affected by electron pressure which produces a shift in the electron plasma frequency ω_{pe} .

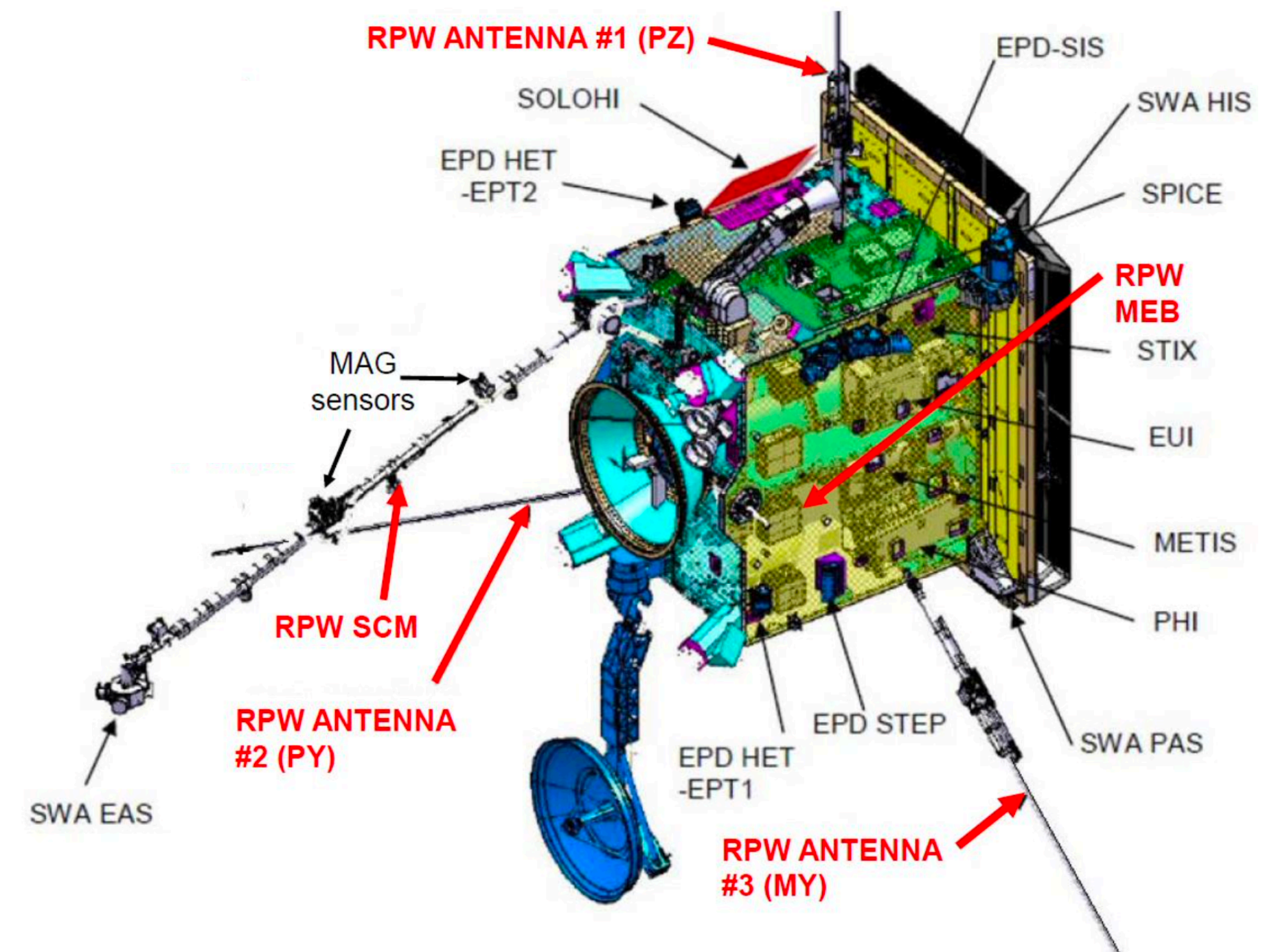
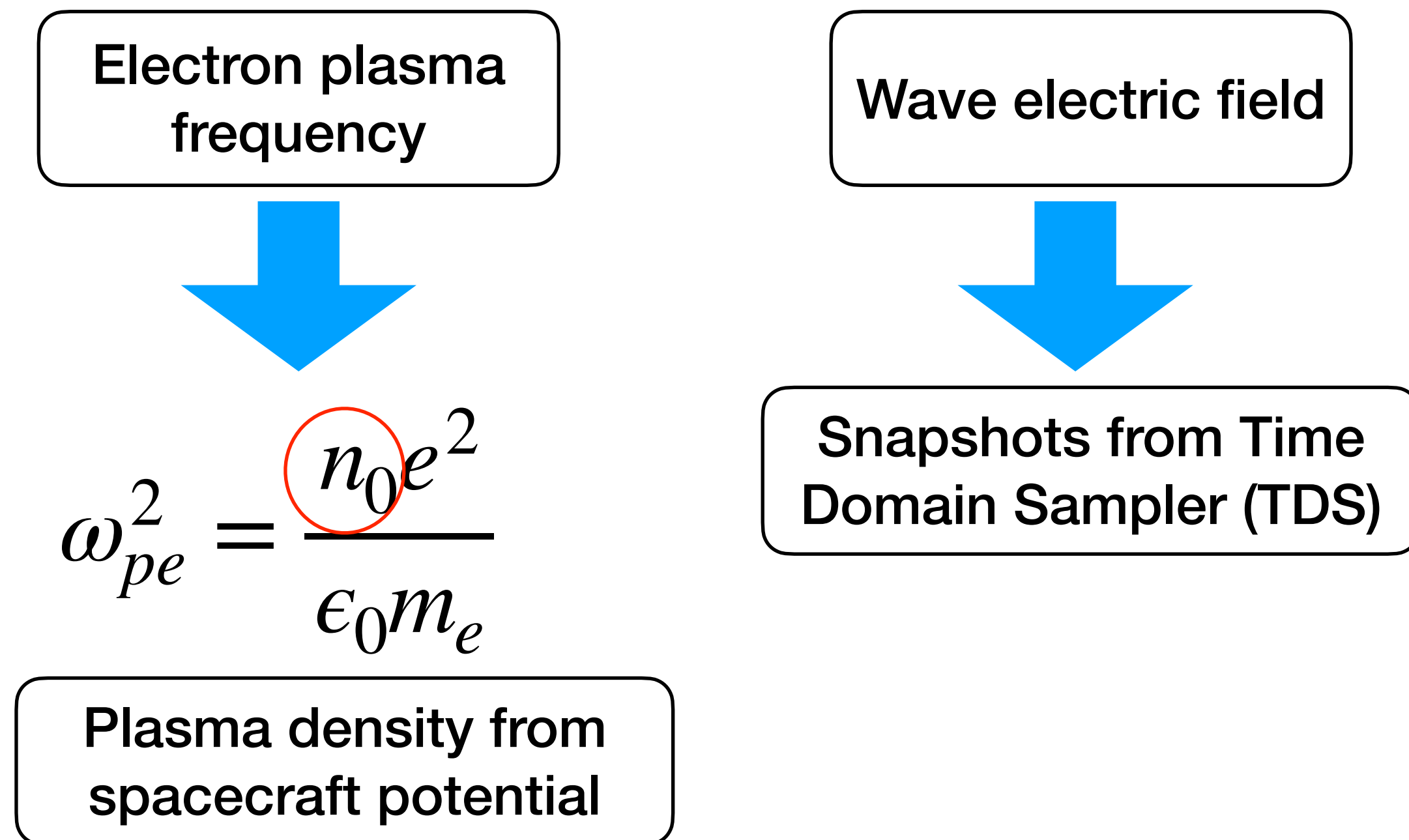
$$\omega^2 = \omega_{pe}^2 + 3\left(\frac{\kappa T_e}{m_e}\right)k^2$$



Gurnett, 2017

LW identification with Solar Orbiter's RPW

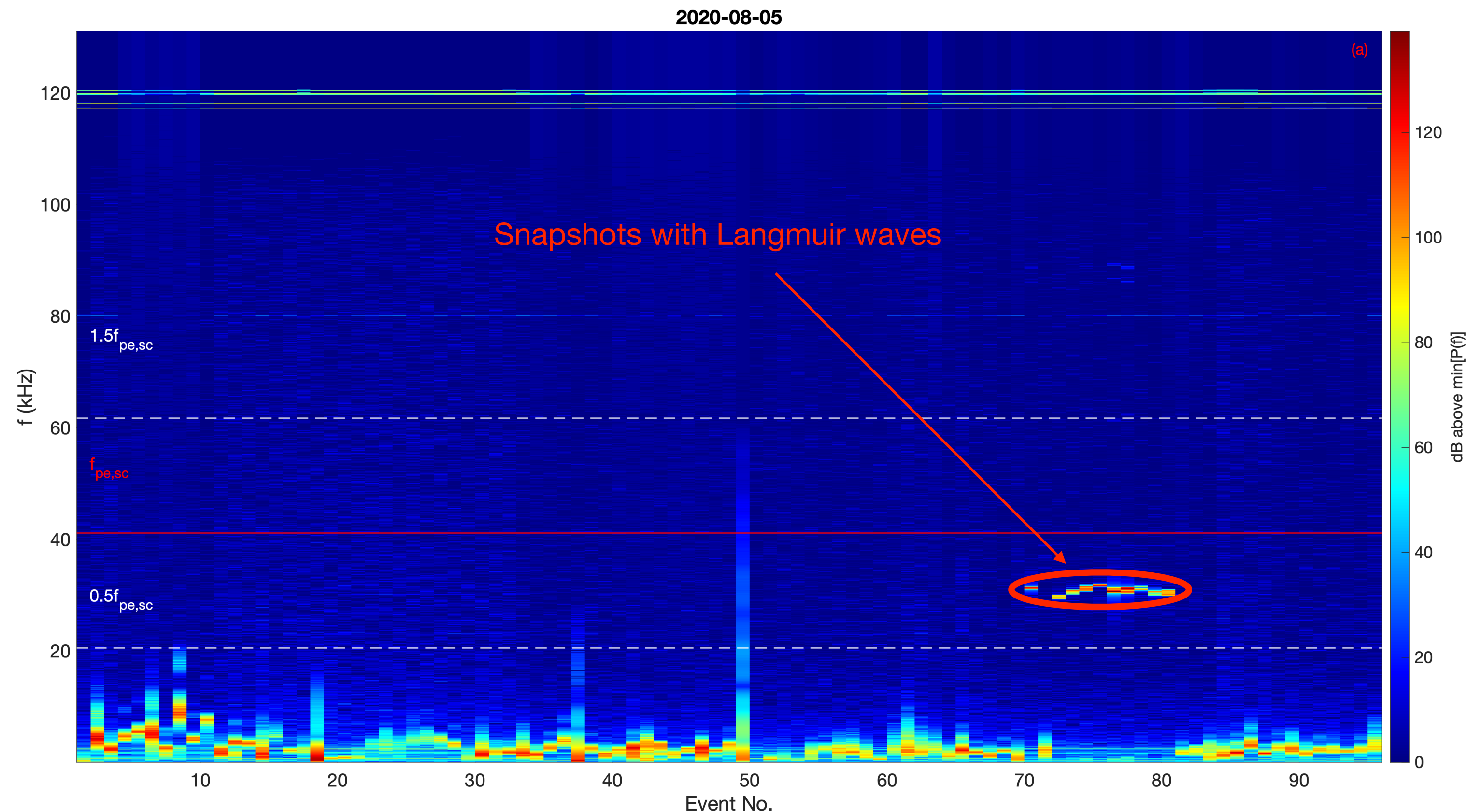
- Looking for electric field oscillations near the electron plasma frequency, Langmuir waves can be detected.



Maskimovic et al., 2021

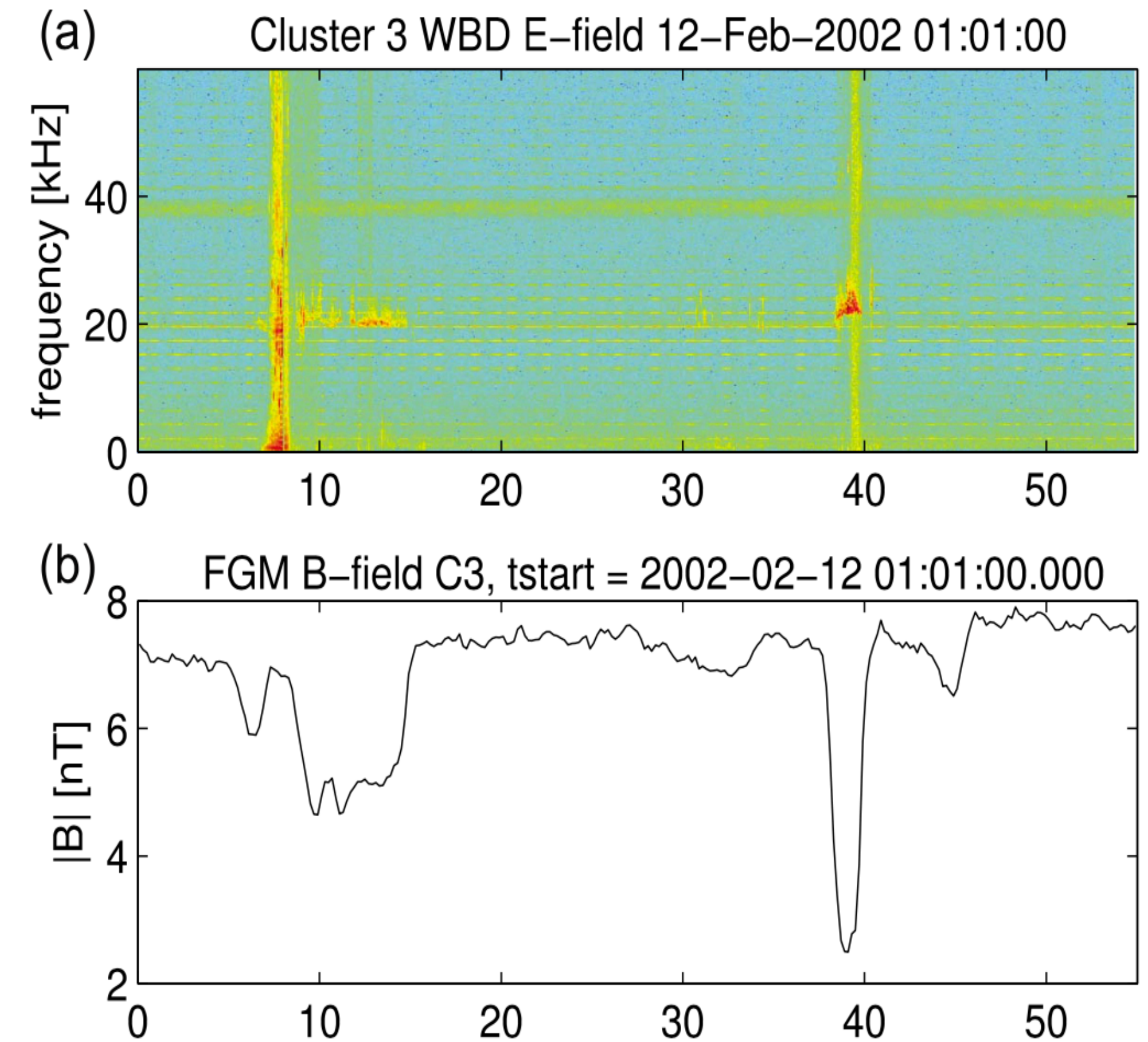
Langmuir Waves (LW)-TDS Snapshots

- Wave Electric field PSD peak is between 0.5 and $1.5 f_{pe,sc}$ obtained from the S/C potential and two orders of magnitude above the background power.



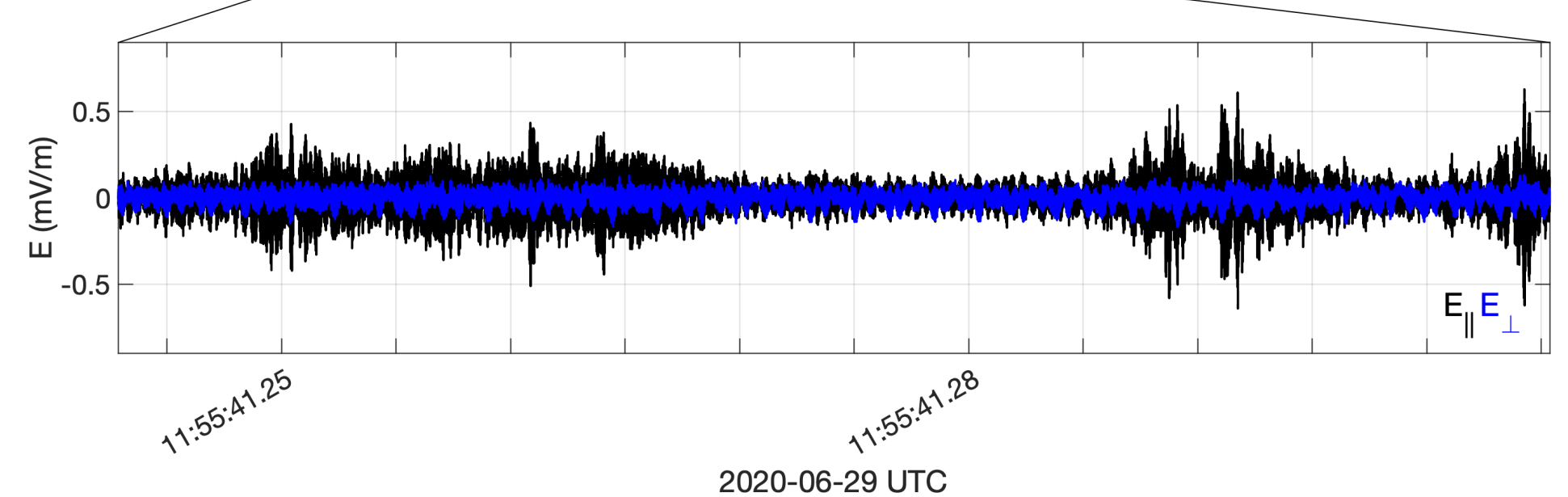
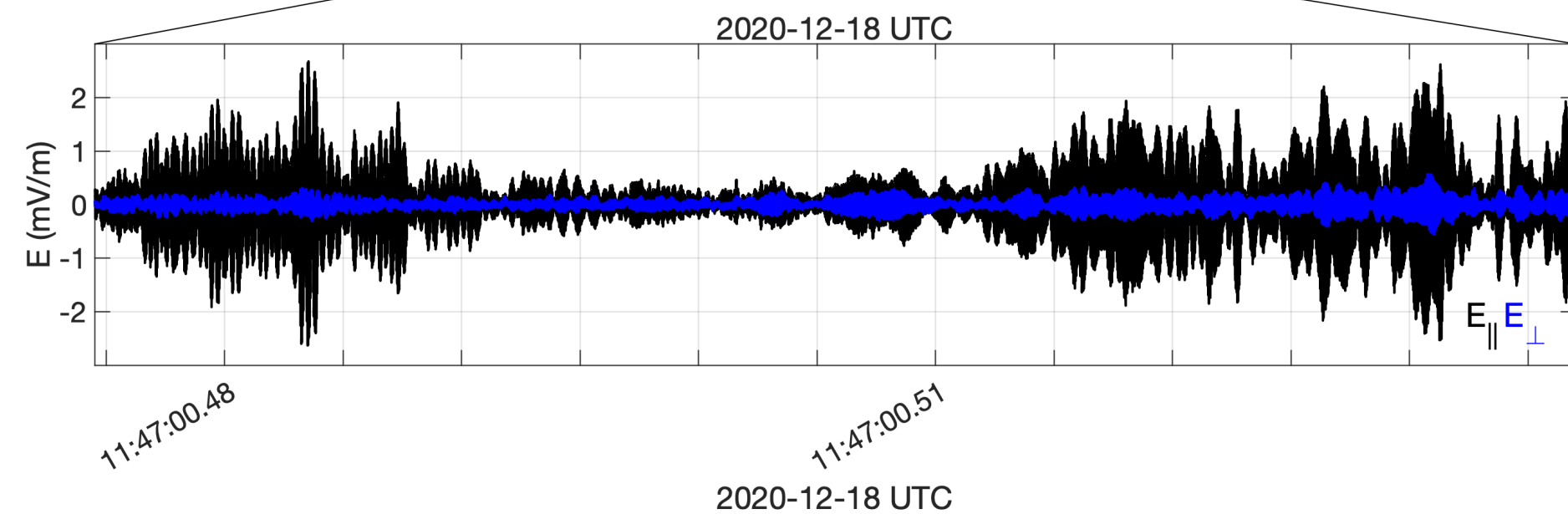
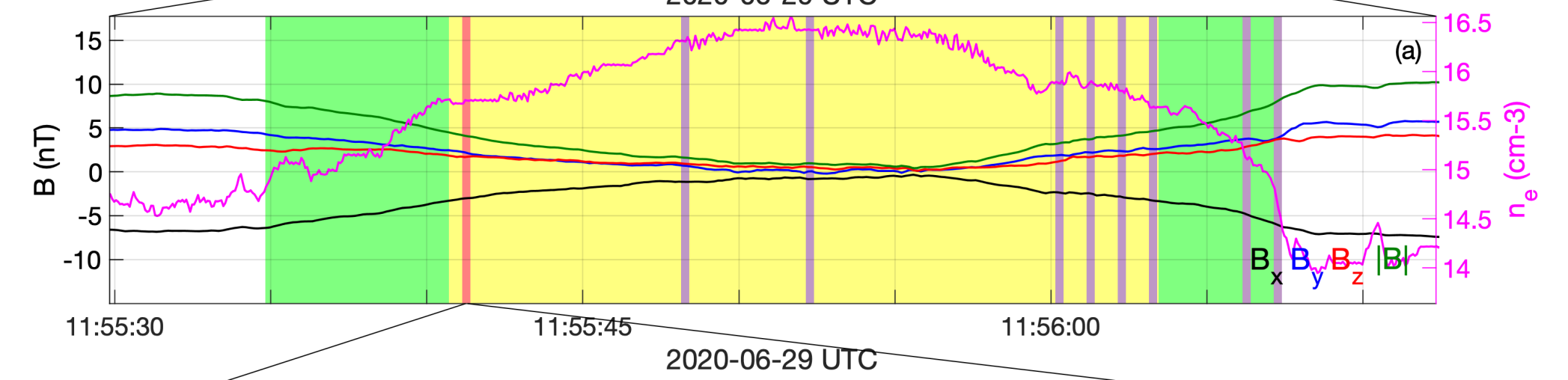
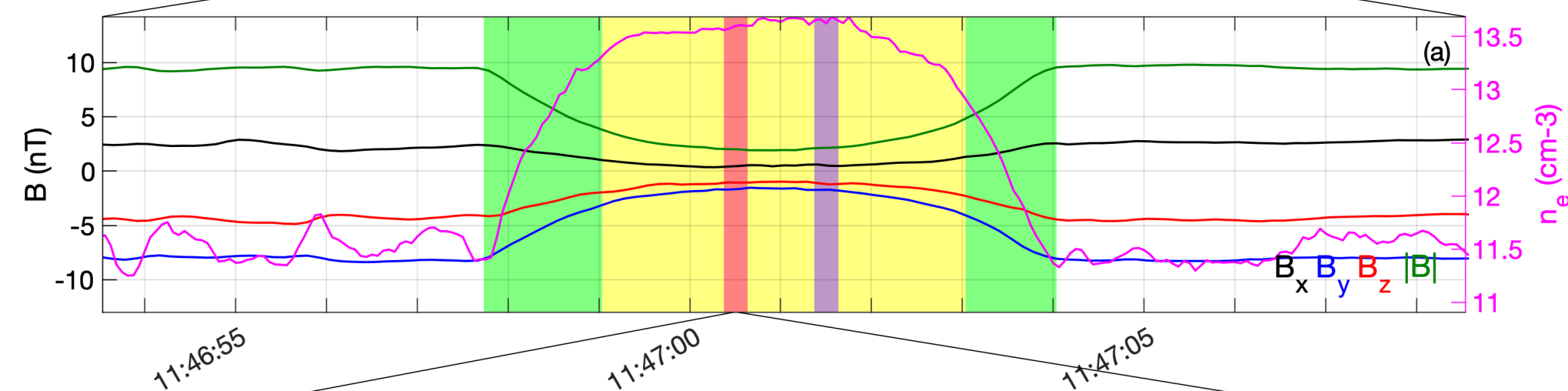
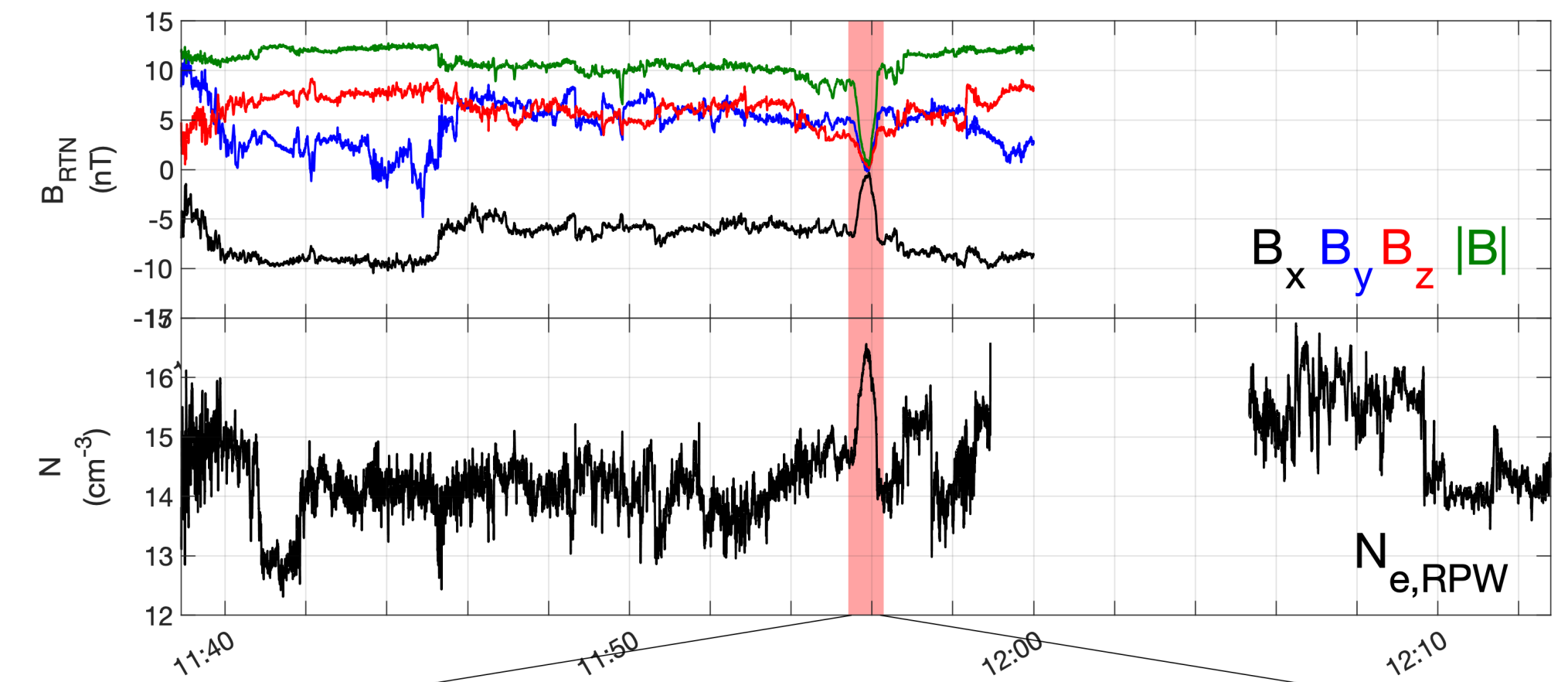
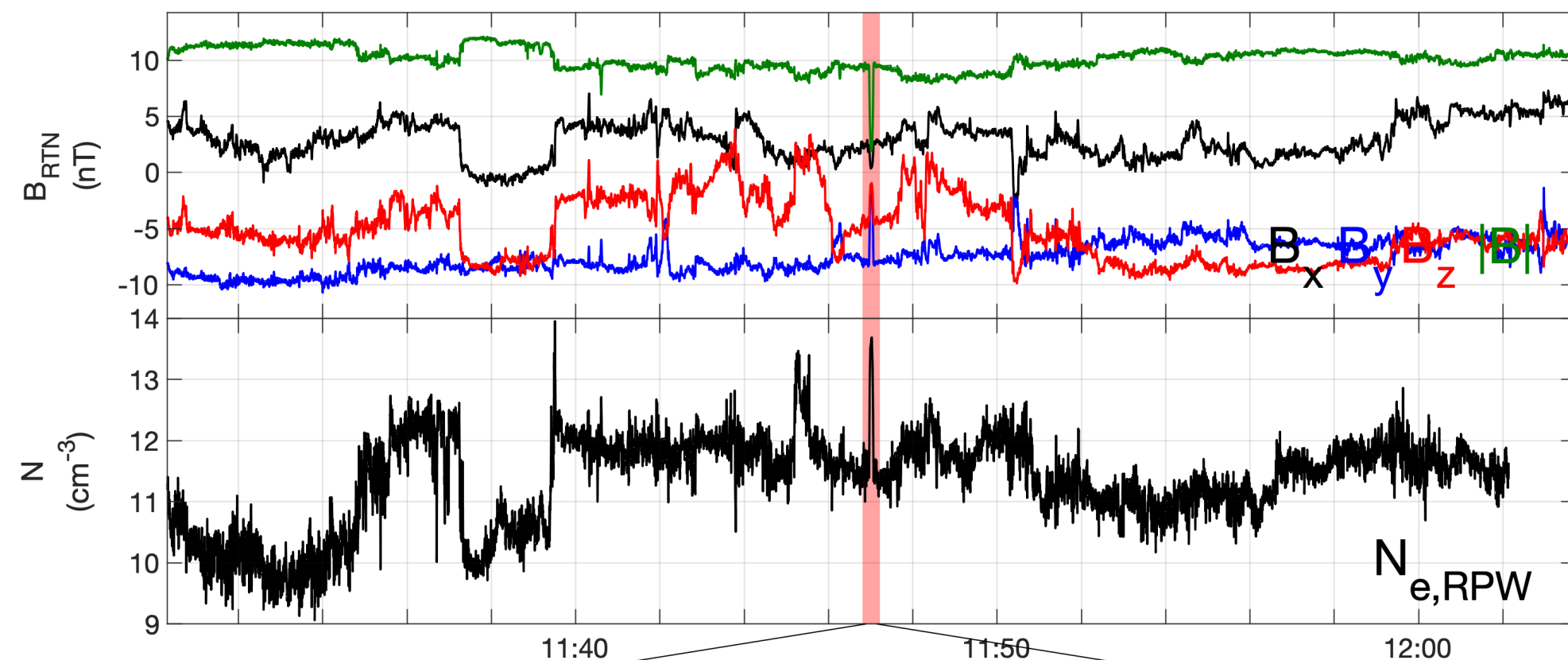
Magnetic Holes

- Magnetic holes (MH) are structures with significant depletion in magnetic field strength.
- MHs are common structures found in the solar wind and in many other interplanetary environments.
- Langmuir Waves are often associated with MHs.



[Briand et al., 2010]

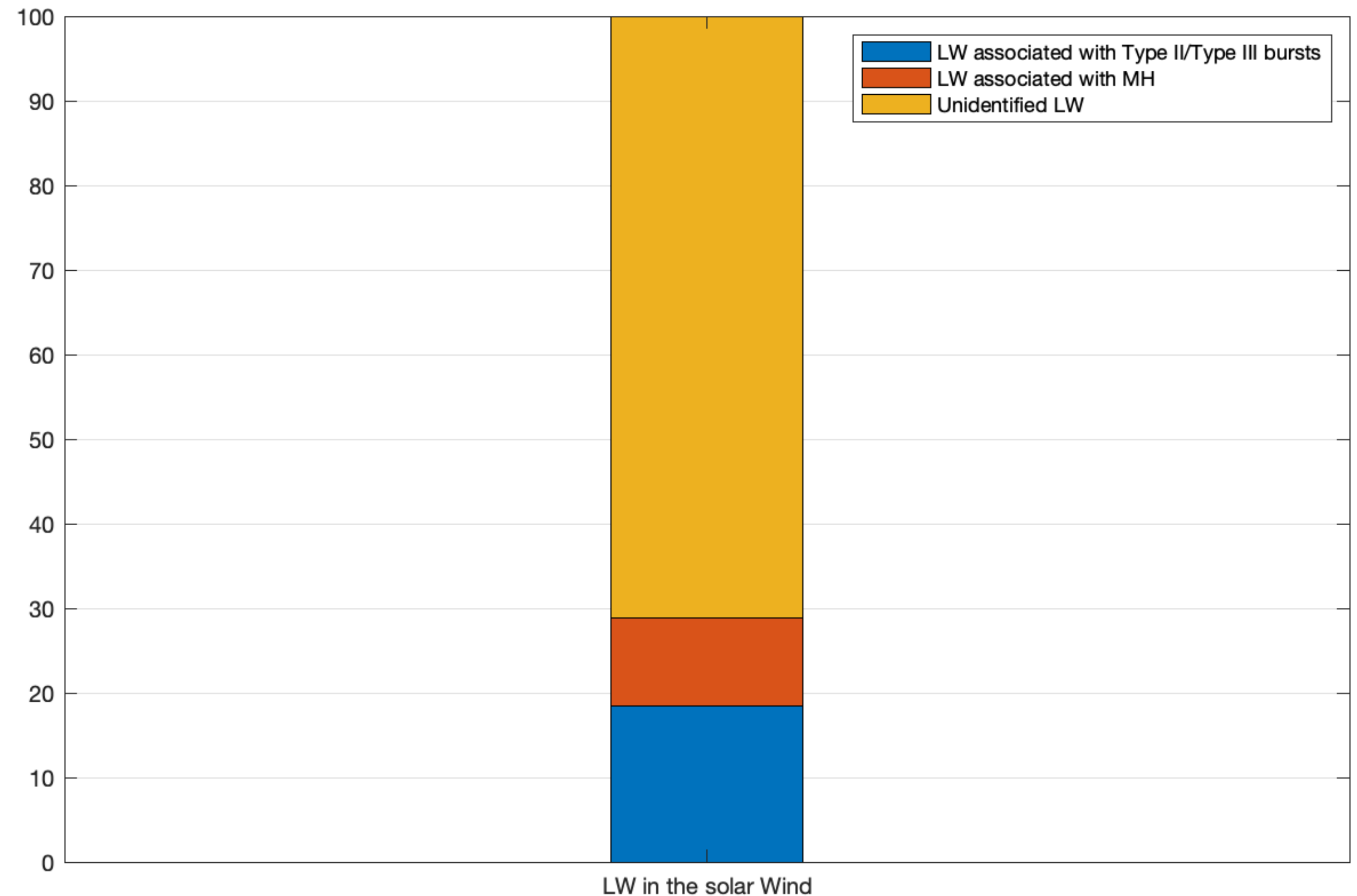
Langmuir waves in Magnetic holes (MH)



Statistics of LW in the solar wind

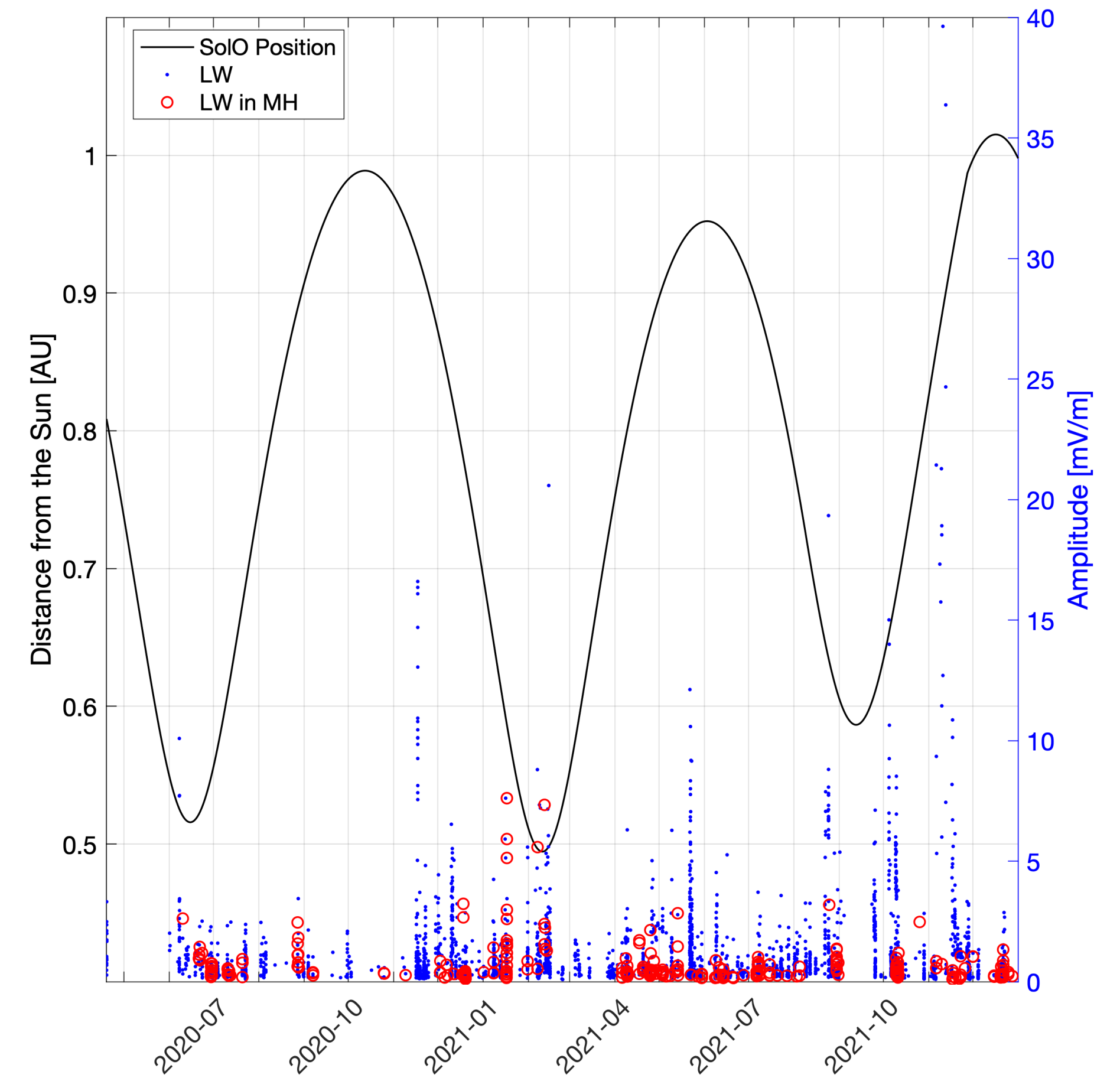
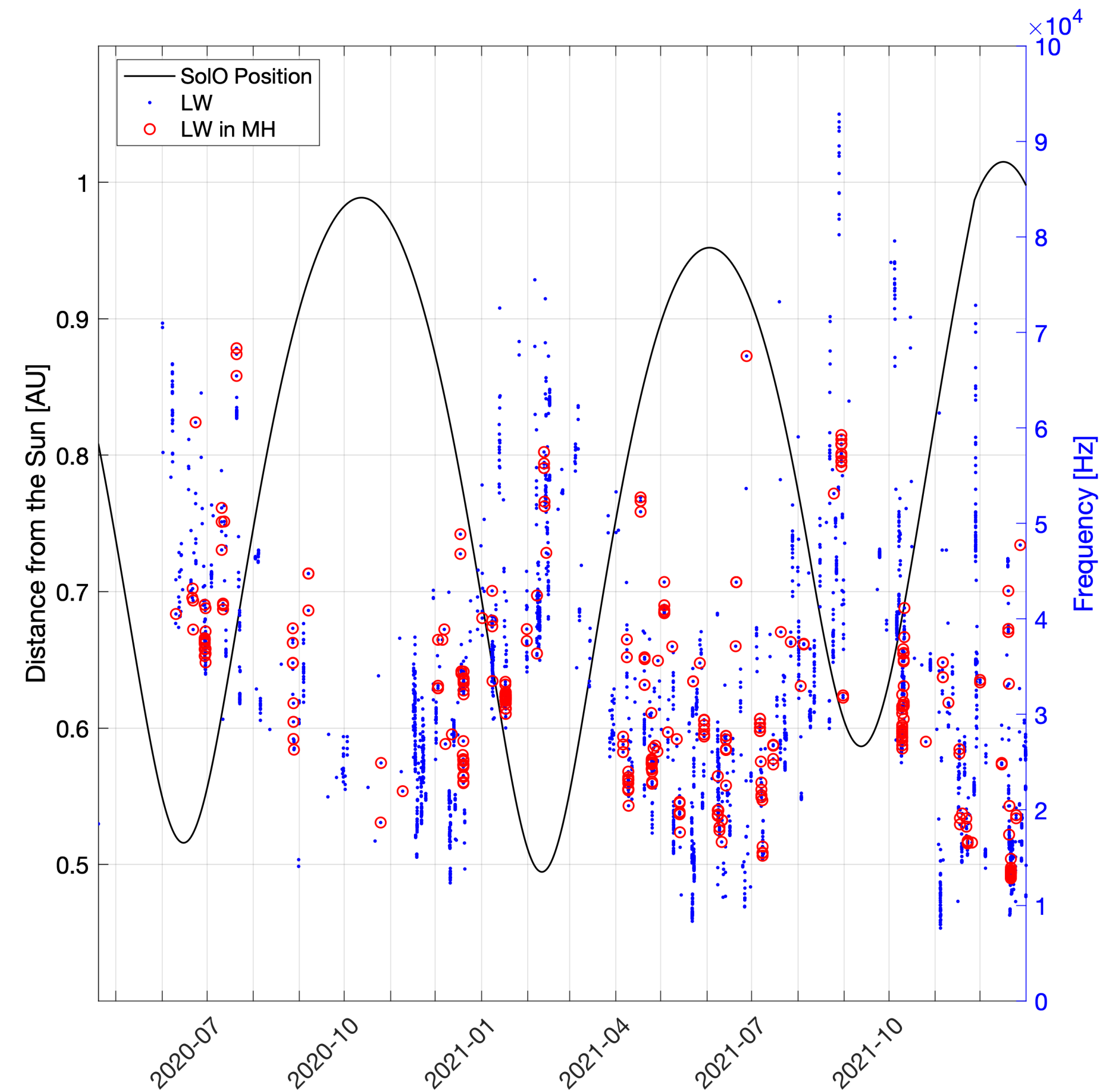
Data from 2020-2021

- Total = 3103 LW
- LW in MH = 320 (10.3%)
- Type II/III ~ 574 (18.5%)

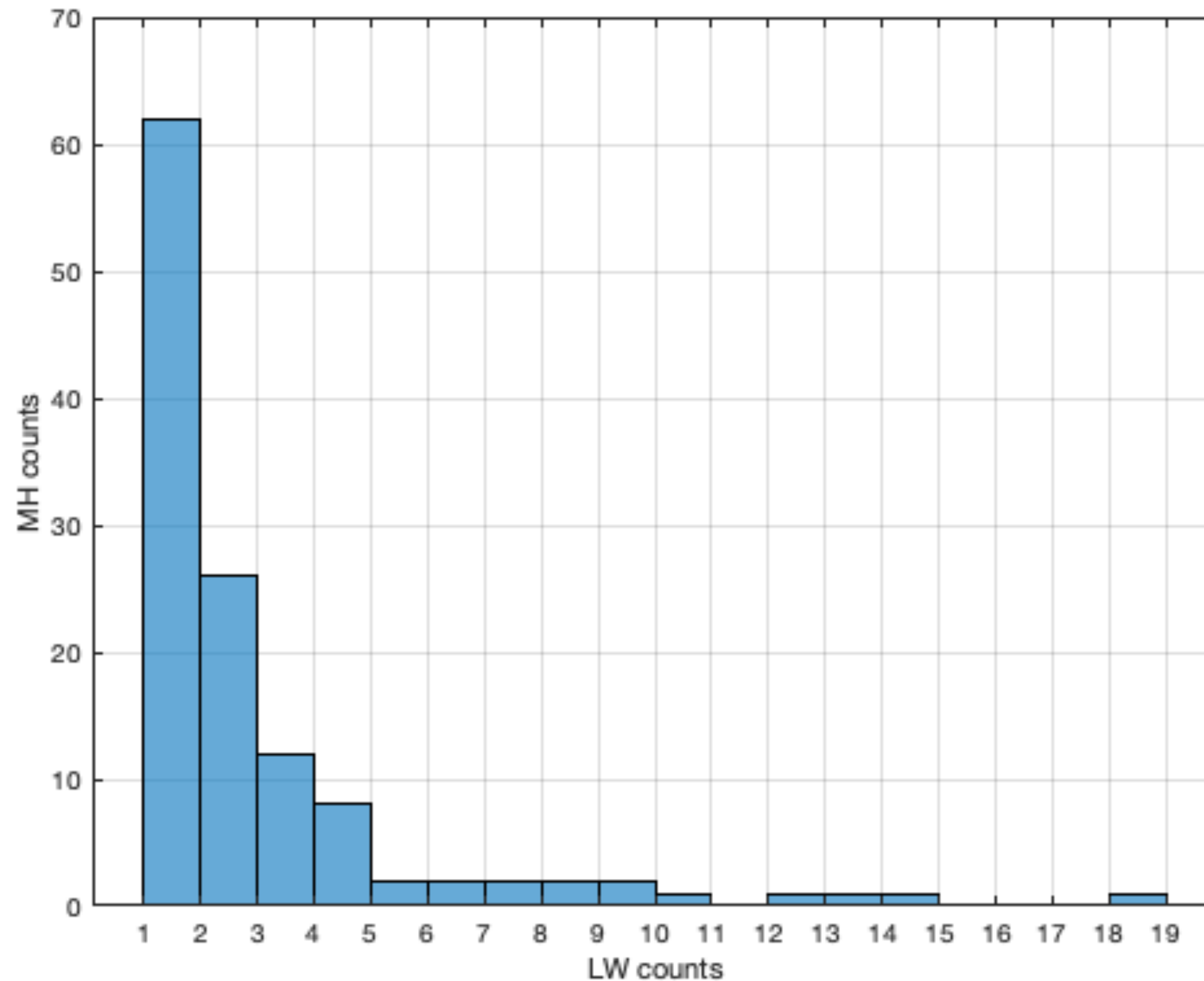


Langmuir waves along SolO trajectory

Data from 2020-2021



Magnetic Holes Overview



- 1643 holes during 2020-2021.
- 123 holes (7.4%) contain at least one LW.
- From which, 61 holes (49.5%) contain more than one LW.

Conclusions

- A total of 3103 LW found, with 10.3% inside MH. Similar amount as waves associated with Type II/III radio bursts.
- 123 (7.4%) magnetic holes found containing at least one LW. Given the amount of time Solar Orbiter is inside magnetic holes, the number of LW associated with MH is not negligible.
- Most of the waves inside MH have a peak amplitude of <1 mV/m. In comparison, typical LW associated with Type II/III bursts can exceed 10 mV/m.
- LW inside MH found consistently throughout Solar Orbiter's trajectory.