Characterization of Fluctuations in Solar Type III Radio Spectra Observed by PSP and SolO

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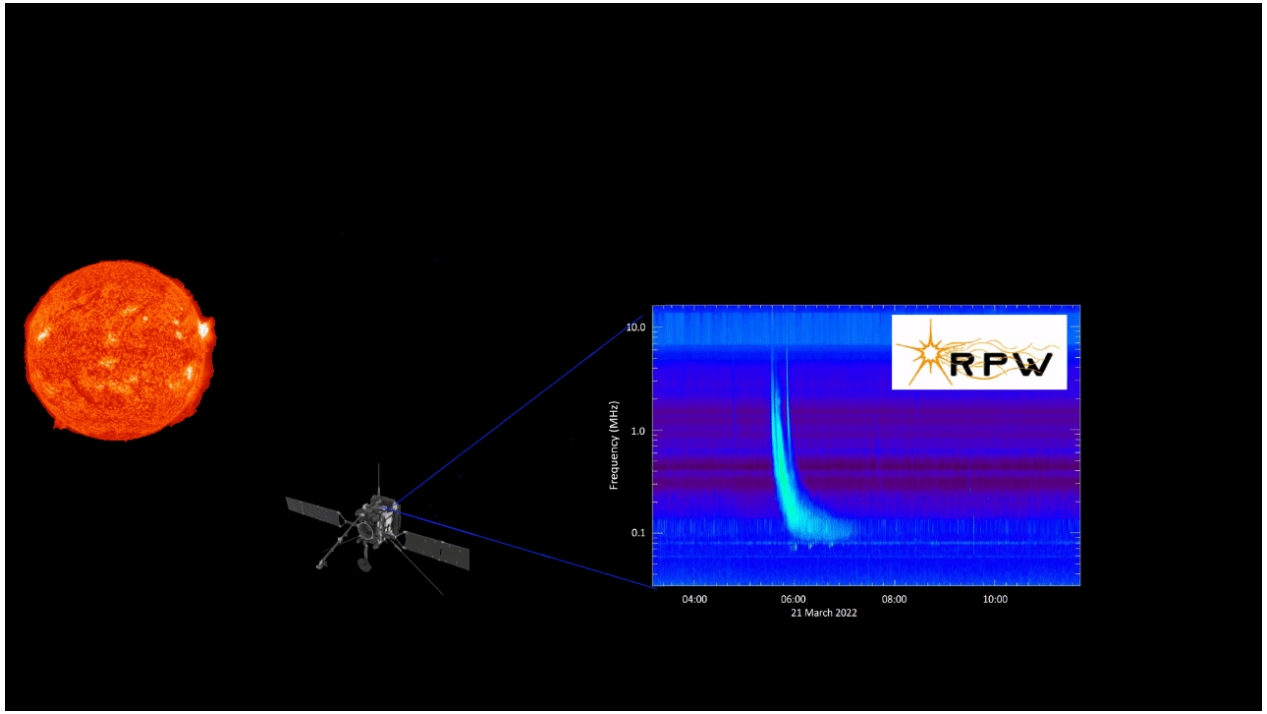
Solar Type III Burst



Credit : https://www.esa.int/Science_Exploration/Space_Science/Solar_Orbiter/Catch_solar_bursts_in_new_citizen_science_project

- Produced by electron beams accelerated at solar flare reconnection sites
- Electron beams drive Langmuir waves, which are converted into radio waves near the plasma frequency through nonlinear processes

$$\omega_p \propto \sqrt{n_e}$$

- Characterized by a rapid drift in time towards lower frequencies

- Provides a powerful remote sensing diagnostic tool for electron acceleration and transport, and the conditions of the background plasma they travel through

Data Processing and Analysis

Collecting Data

Background Subtraction

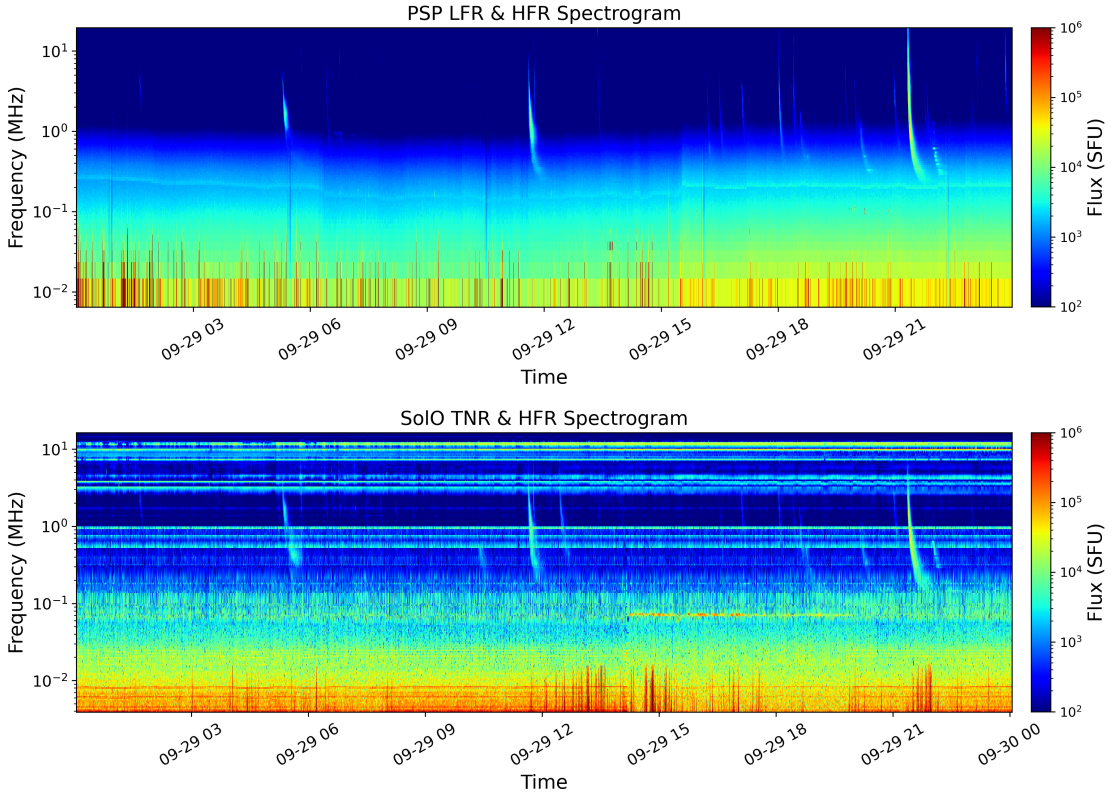
Type III Burst Detection

Maximum flux fitting

PSP : FIELDS L3

SolO : RPW L3

September – December 2023



SFU
(Solar Flux Unit)
is normalized to the distance at 1 AU

Data Processing and Analysis

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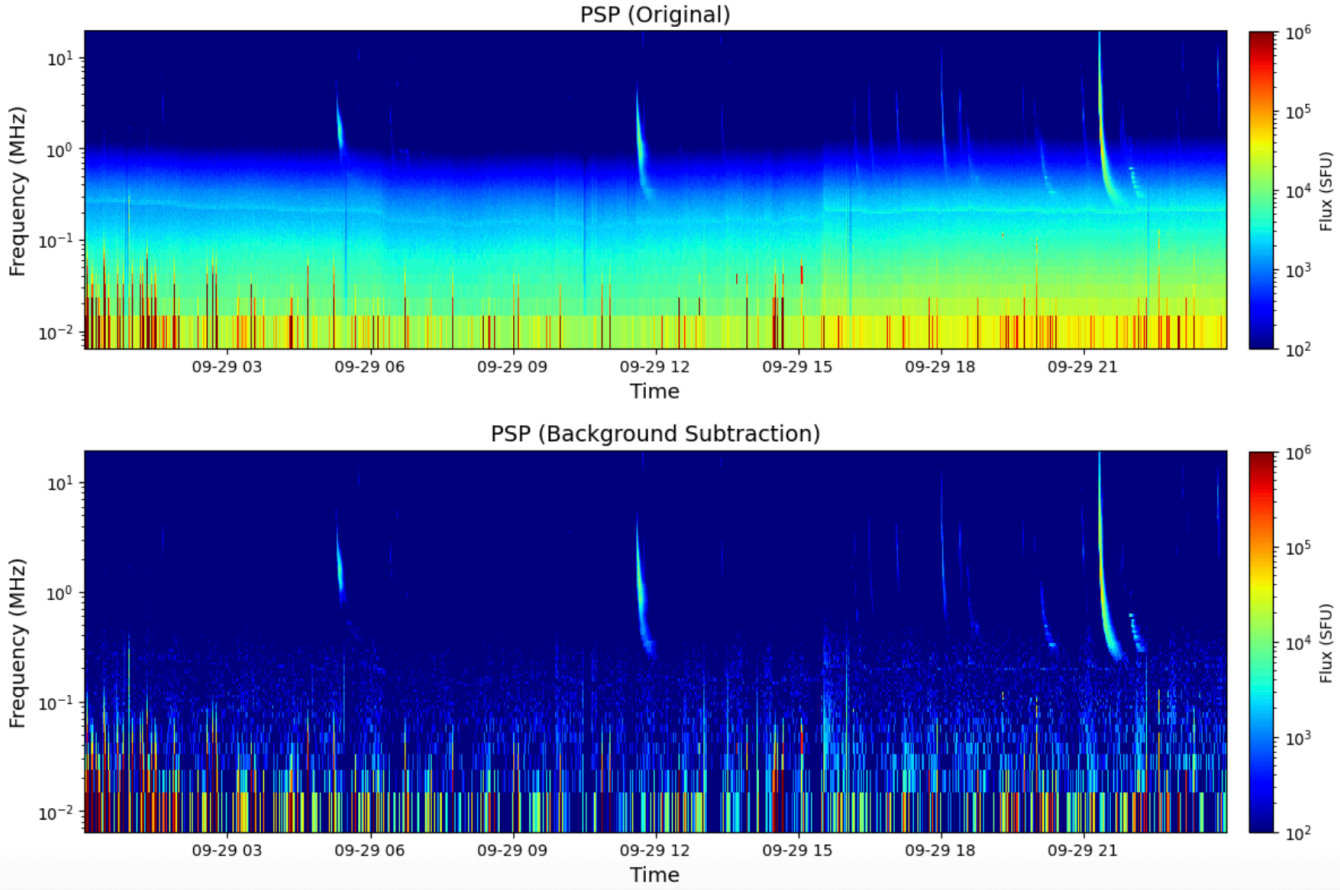
Maximum flux fitting

- The background signal was obtained by computing the average spectrum during the longest burst-free periods of each day.



QTN also removed

Data Processing and Analysis

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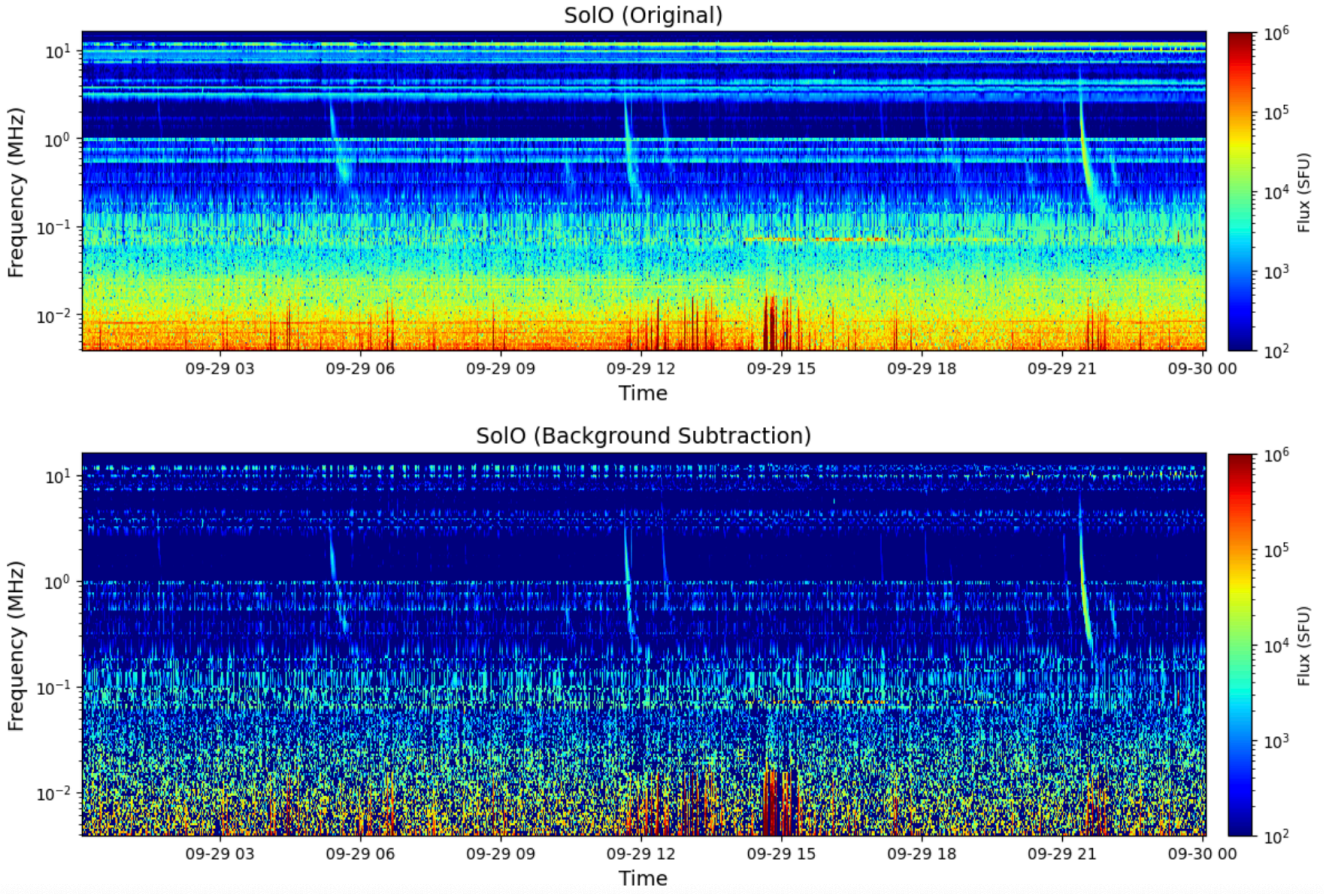


Data Processing and Analysis

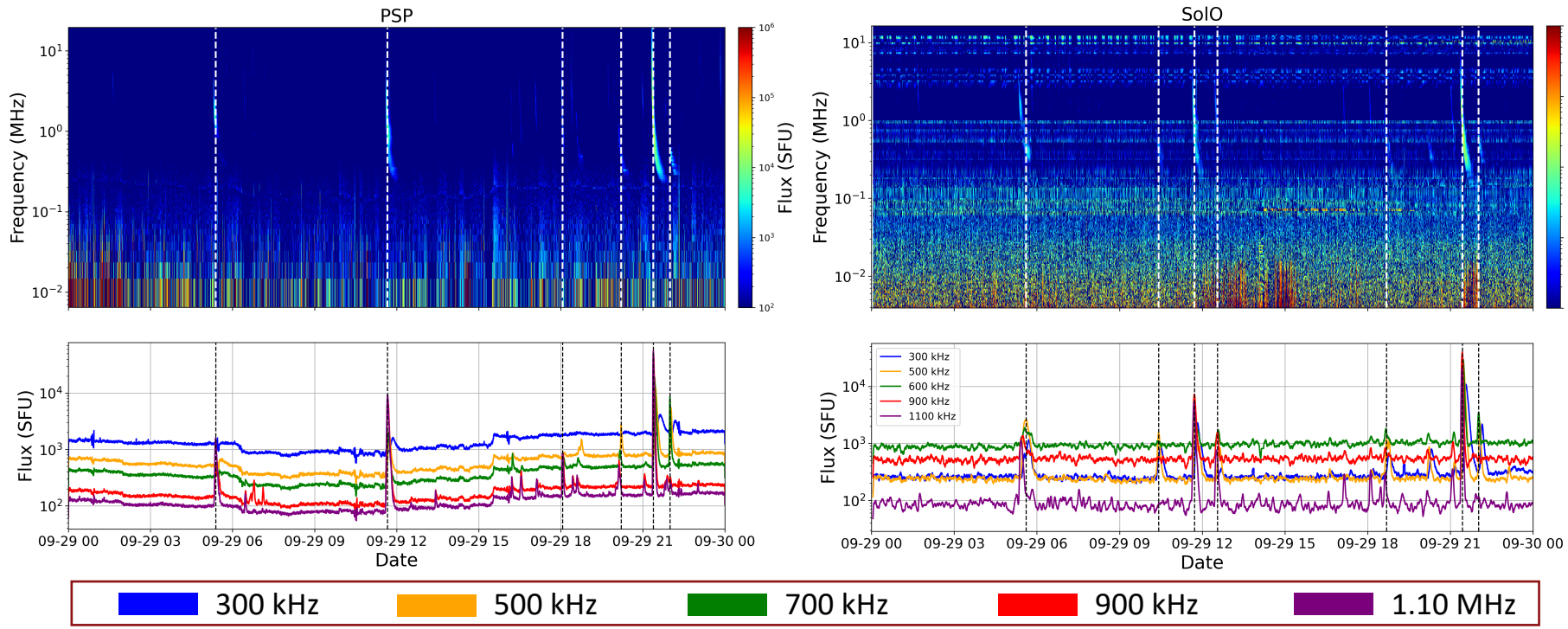
Sample from 29/09/2023

Collecting Data

Background Subtraction

Type III Burst Detection

Maximum flux fitting



- Detecting enhancements in radio flux across 5 selected frequencies for each spacecraft.
- A candidate Type III event is marked when the flux exceeds 3 x local MED in at least 3 of the selected frequencies.

Data Processing and Analysis

Sample from 29/09/2023

Collecting Data

Background Subtraction

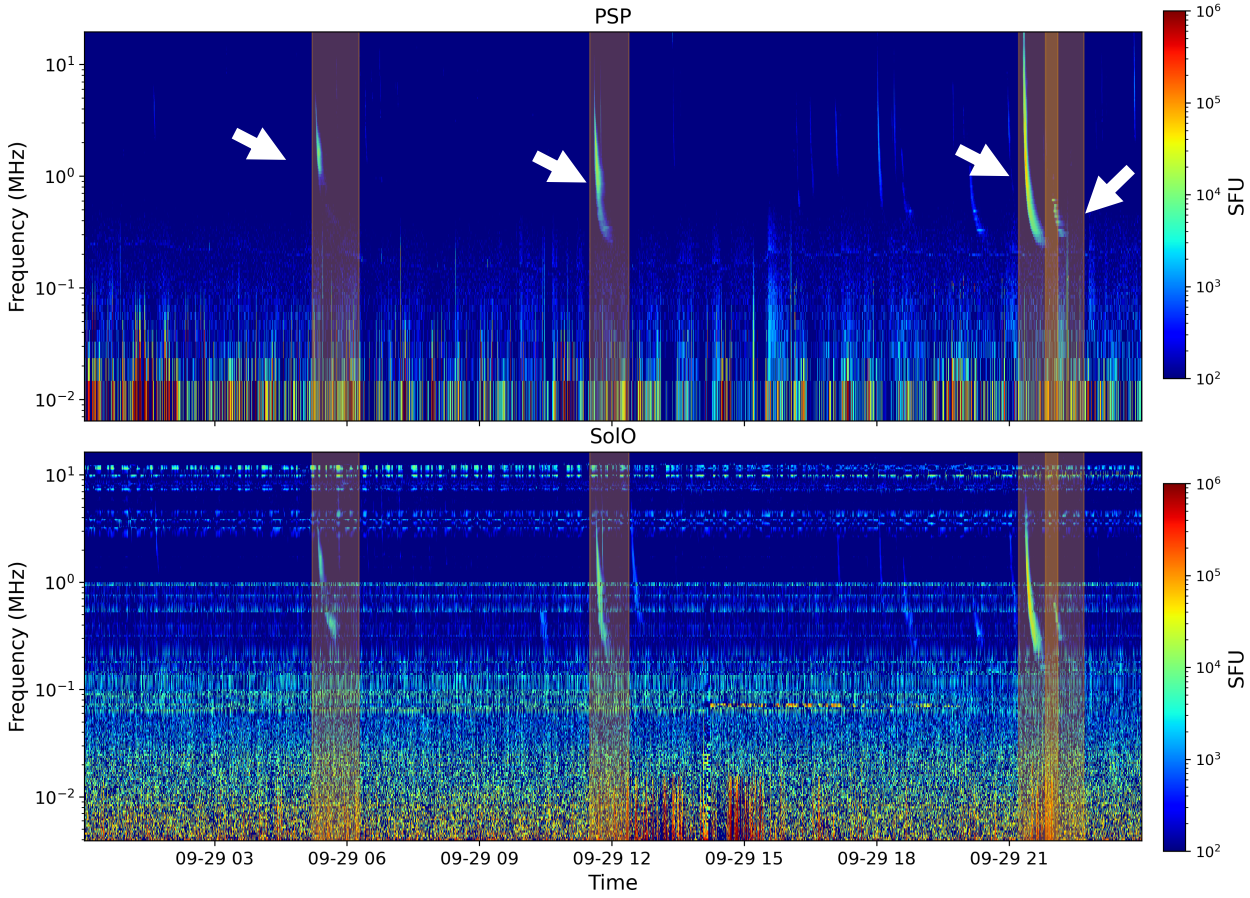
Type III Burst Detection

Maximum flux fitting

- Select events that were simultaneously observed by both SolO and PSP
  - Time difference less than 10 mins

PSP

SolO



Data Processing and Analysis

Collecting Data

Background Subtraction

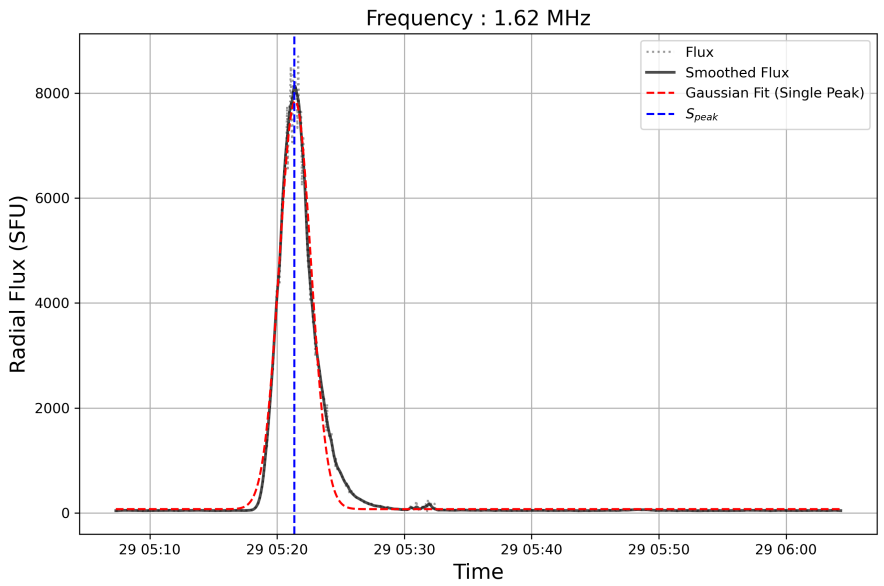
Type III Burst Detection

Maximum flux fitting

- The maximum flux of Type III radio bursts for each frequency obtained by fitting a Gaussian function to the time profile of the burst (Chen et al. 2021).

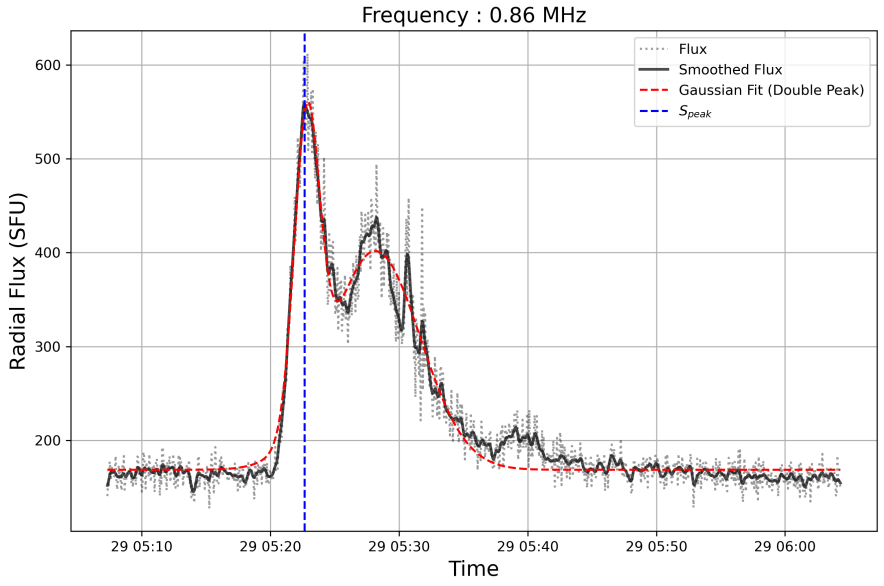
Single Peak

$$F(t) = a_0 + a_1 e^{-b_t (t-t_0)^2}$$

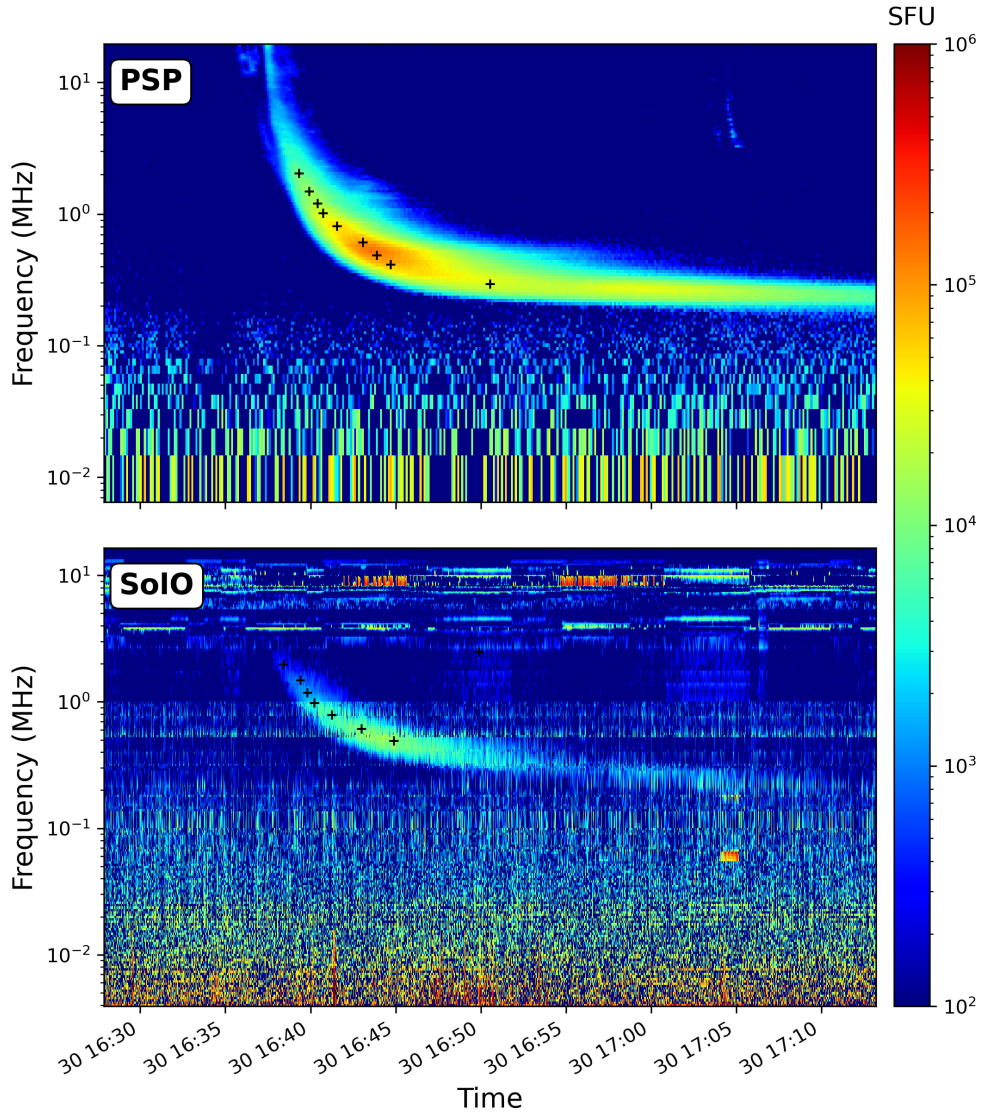


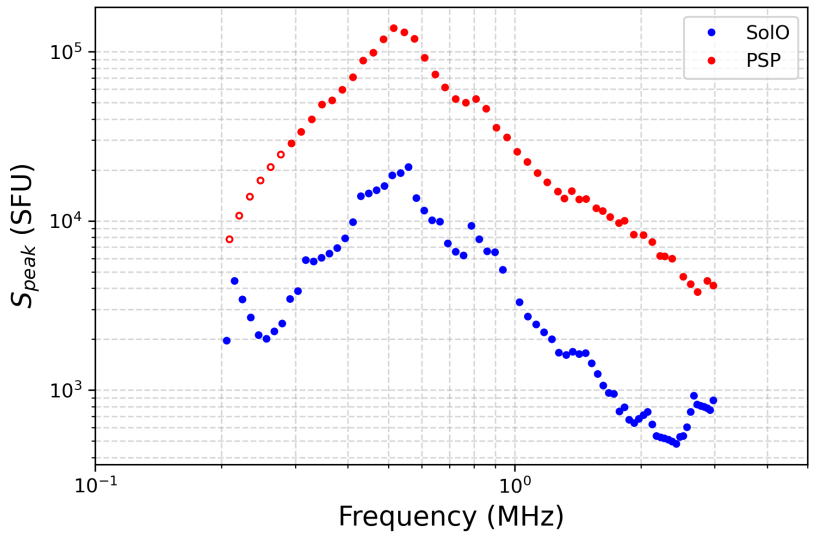
Double Peak

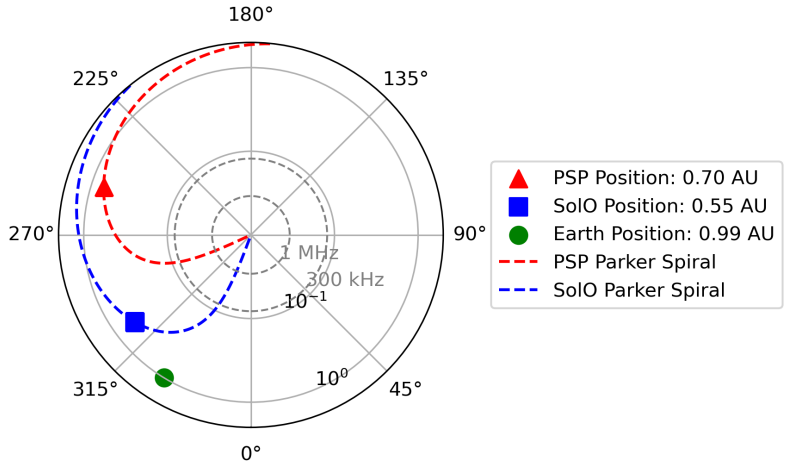
$$F(t) = a_0 + a_1 e^{-b_t (t-t_0)^2} + a_2 e^{-b_{t2} (t-t_{02})^2}$$



Preliminary Results







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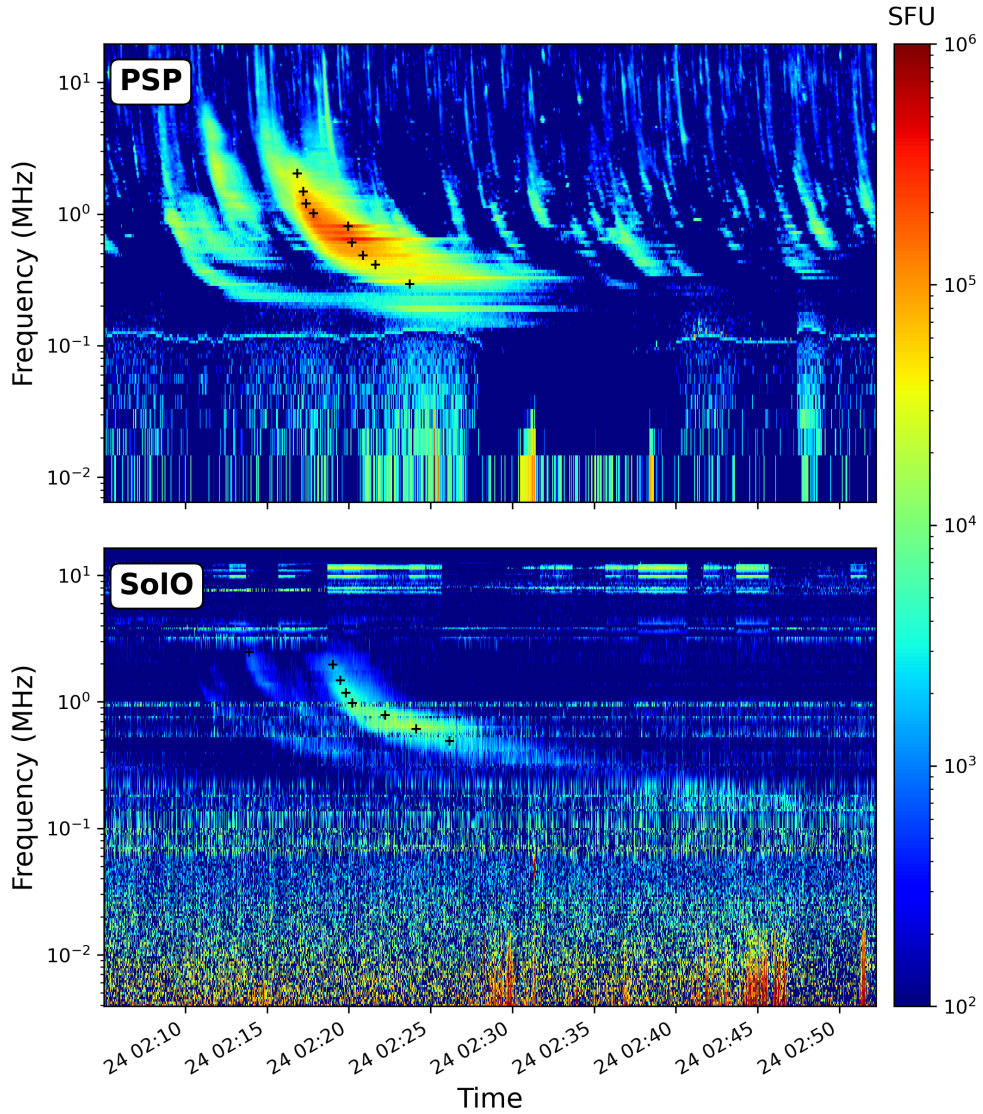
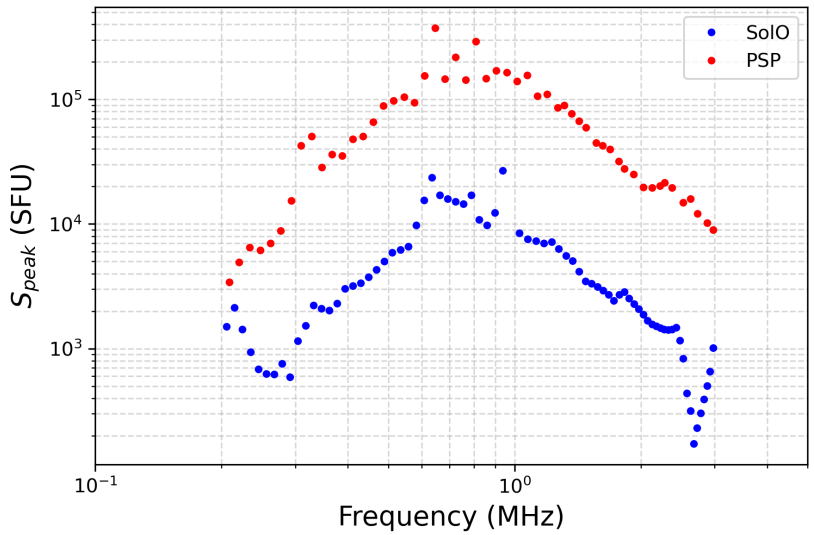
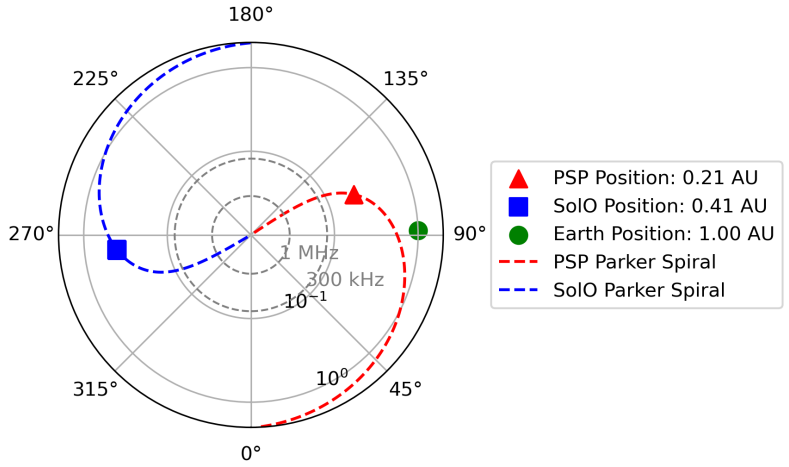
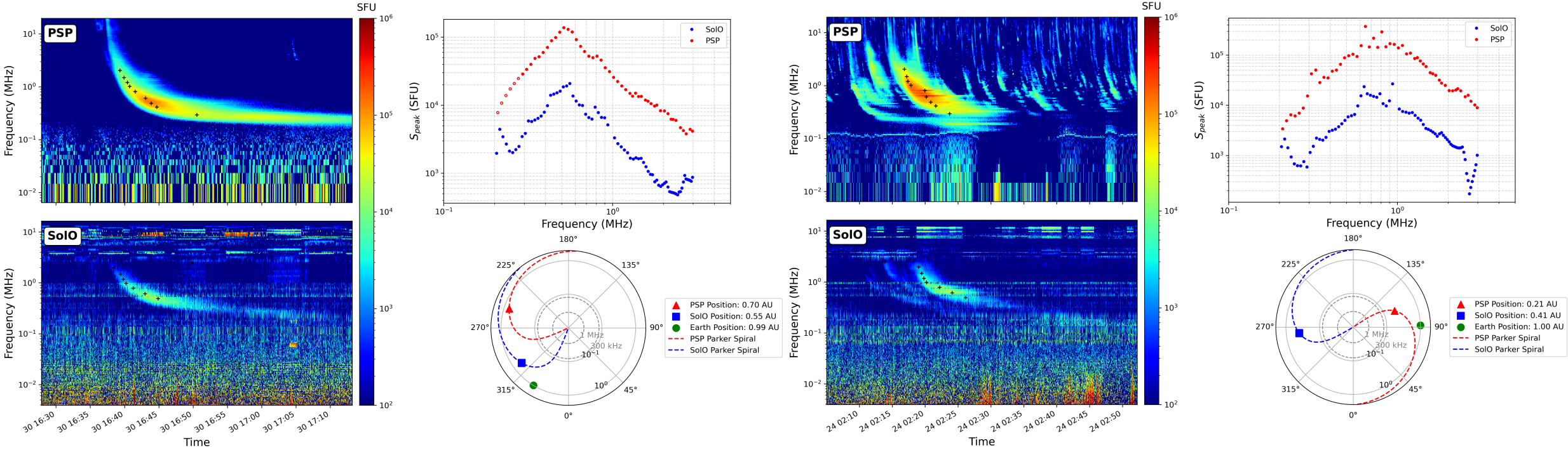




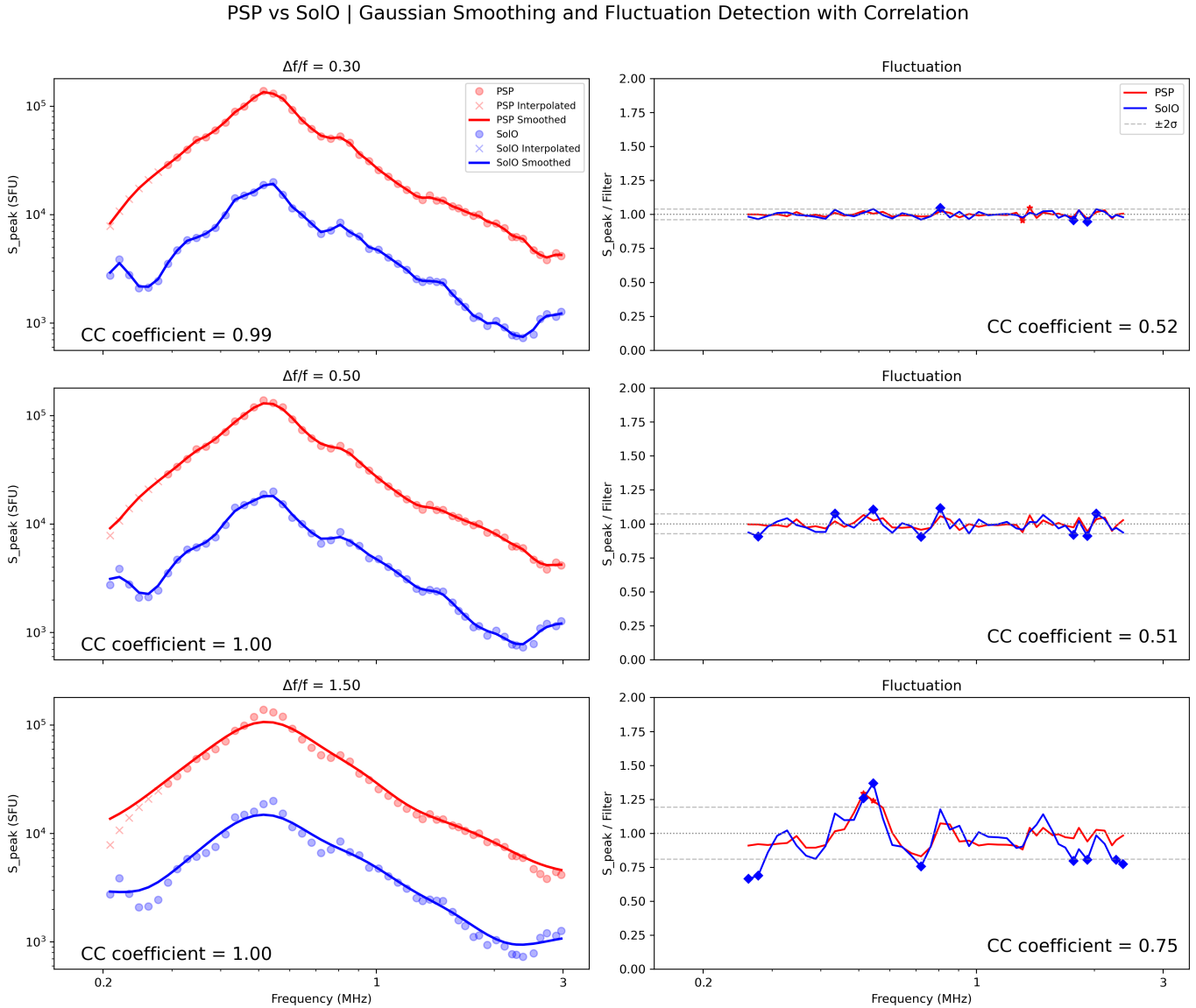


Preliminary Results



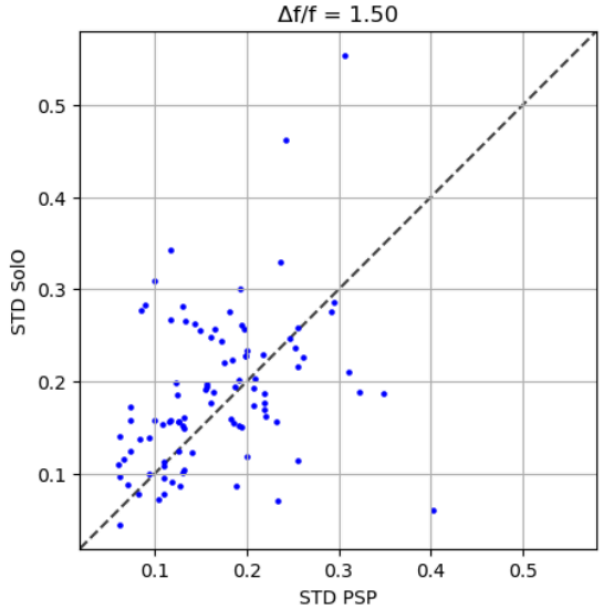
The fluctuations of the maximum type III radio flux appear **‘similar’** when observed by both spacecrafts, in despite of their different radial distances and heliolongitudes, suggesting that local effects are responsible for these fluctuations.

Fluctuation in Type III Spectra

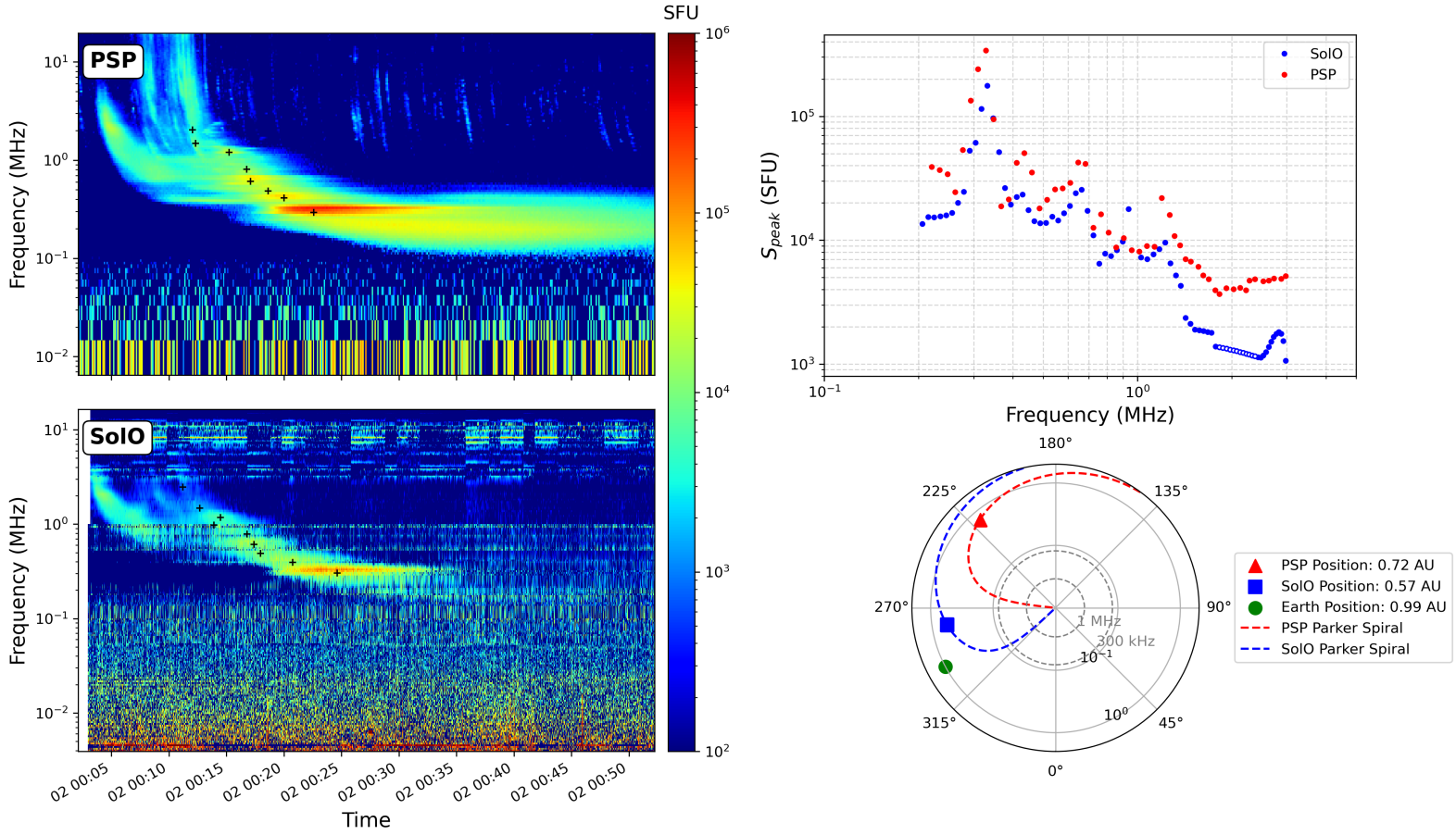


- Interpolate SolO to match PSP's frequency
- Gaussian weight smoothing
  - Different window size of $\Delta f / f$
- σ is used as a measured of the fluctuations at each scale and for each events. For a Type III with very small fluctuation, at $\Delta f / f$ = 1.5, $\sigma_{ref} = 0.096$

Computed STD from
$S_{peak}/S_{smoothed}$
96 events

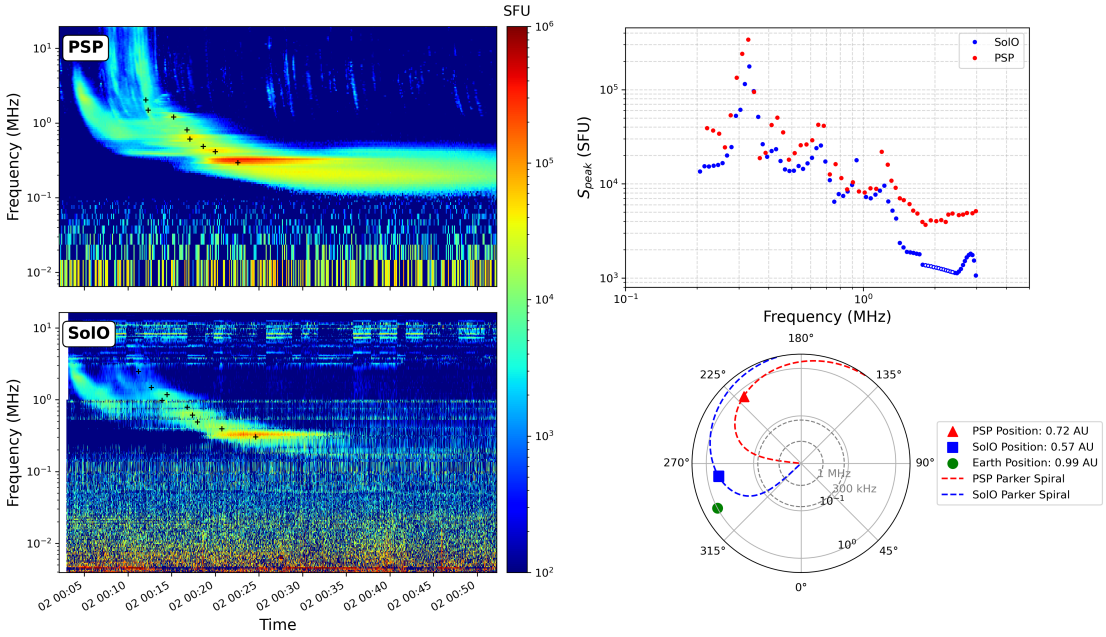


Fine Structure : Striae

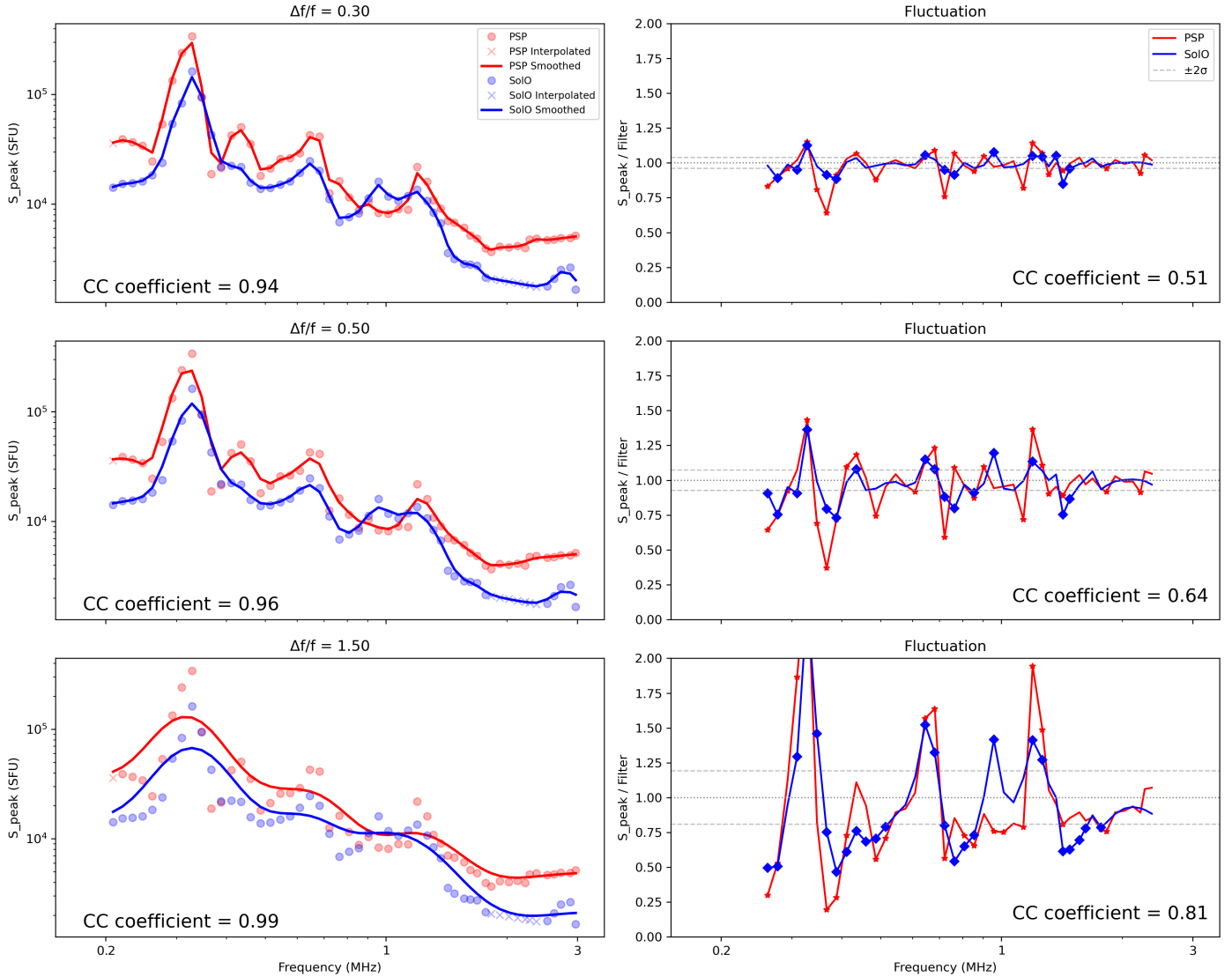


A narrowband, fragmented features forming chains of quasi-periodic striae in dynamic spectra, which are indicative of sub-second evolution in the electron distribution. Striae are often associated with CMEs (Chen et al. 2021; Clarkson et al. 2023).

Fine Structure : Striae



PSP vs SolO | Gaussian Smoothing and Fluctuation Detection with Correlation



- Larger fluctuations compared to typical type III burst

Identify and create catalog of Striae

Preliminary Conclusion

- Despite differences in spacecraft positions, the fluctuations in the maximum flux of Type III bursts appear similar, suggesting that local mechanisms are responsible.

Future Work

- Improve the processing technique for Type III burst detection and fitting.
- Improve the statistical analysis.
  - Extend the dataset by including additional months and years.
  - Incorporate data from additional spacecraft, such as STEREO and Wind.
- Investigate striae in greater detail.

References

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