EGU22-2945

Using Wavelet Analysis to Scale Plasma Fluctuations in the MHD Range of Solar Wind Turbulence Seen by Parker Solar Probe

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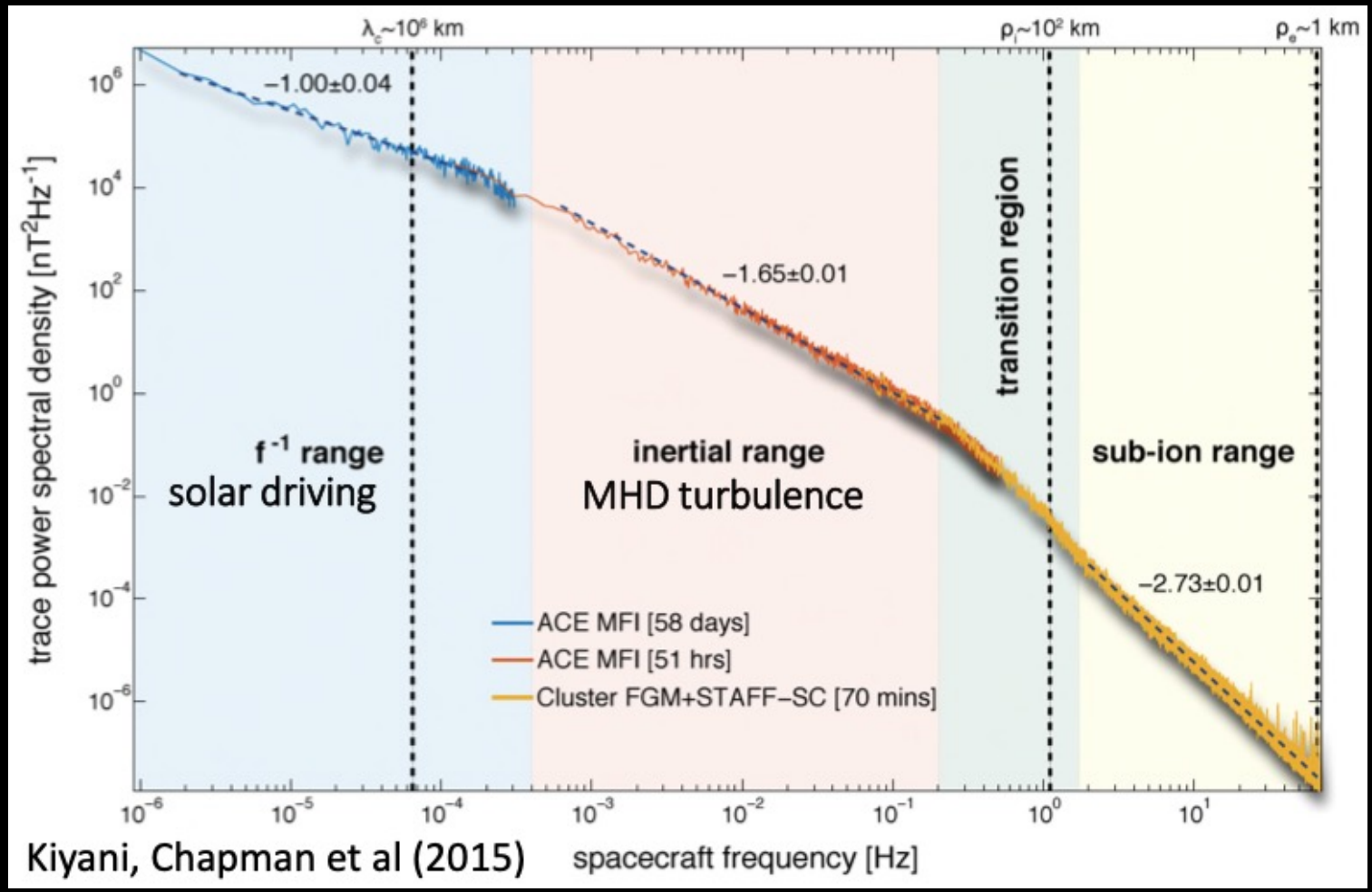
Turbulence spectrum at 1AU

inertial range of MHD turbulence



Combined fourier spectrum

Why the Value of the Exponent is Important

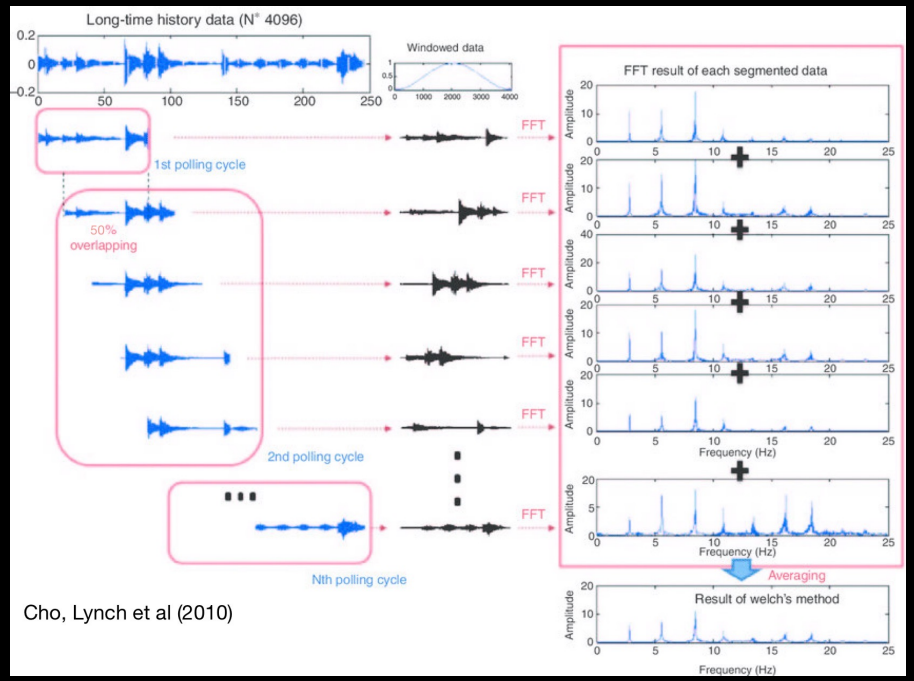
- Solar wind exhibits inertial range scaling in power spectra of the magnetic field
- The exponent indicates underlying physics
- Different theories of turbulence predict different power spectral exponents for the MHD inertial range

Eg: Kolmogorov (-5/3),Iroshnikov-Kraichnan(-3/2)

Power Spectra Estimation

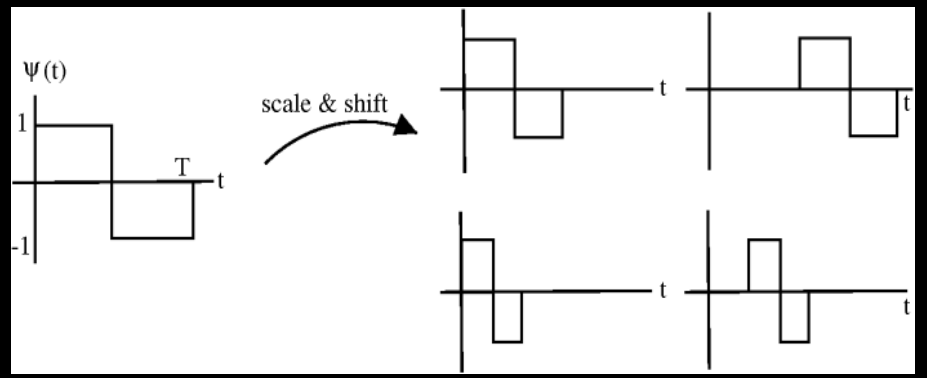
- FFT and Welch method — average subsamples — uniform Δf on linear scale
- Wavelet — one sample = full range — uniform Δf on log scale

Welch method: uniformly subsample on linear scale and then average power spectrum

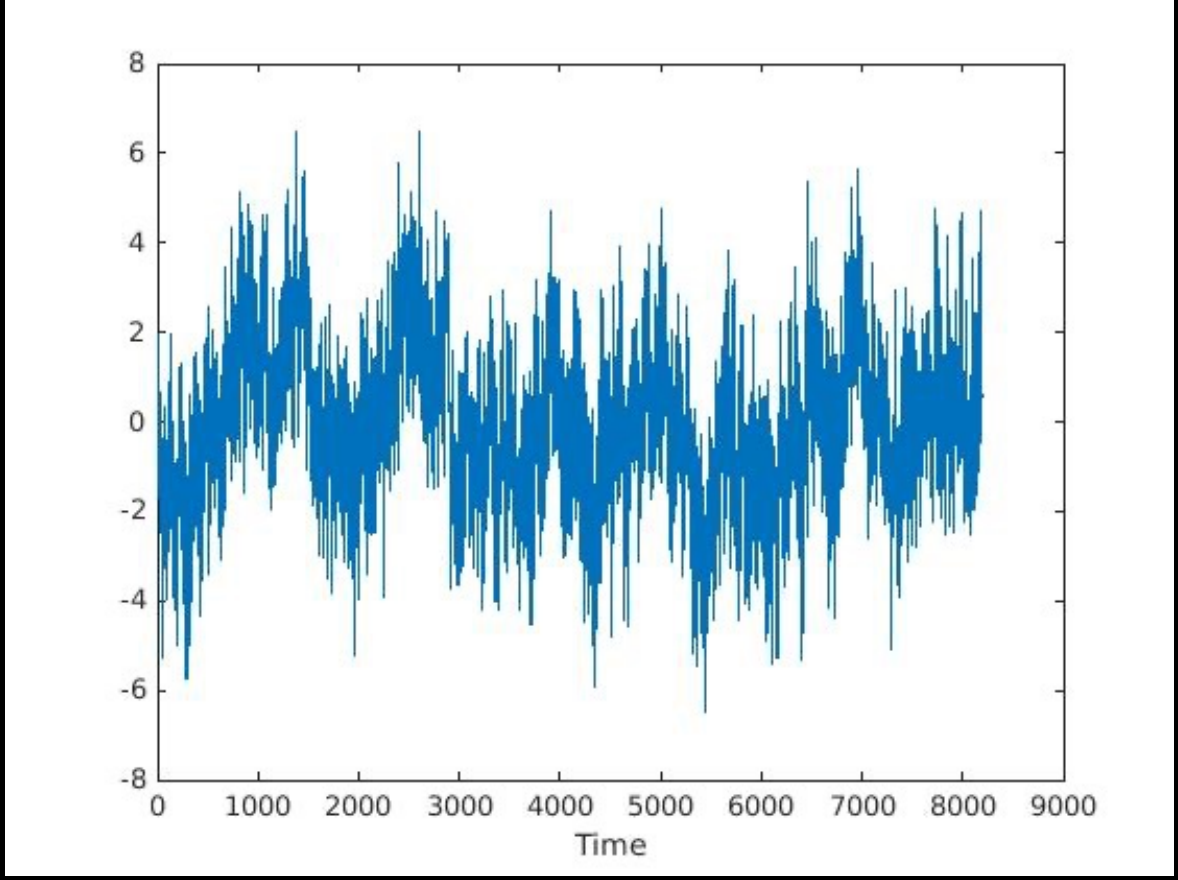


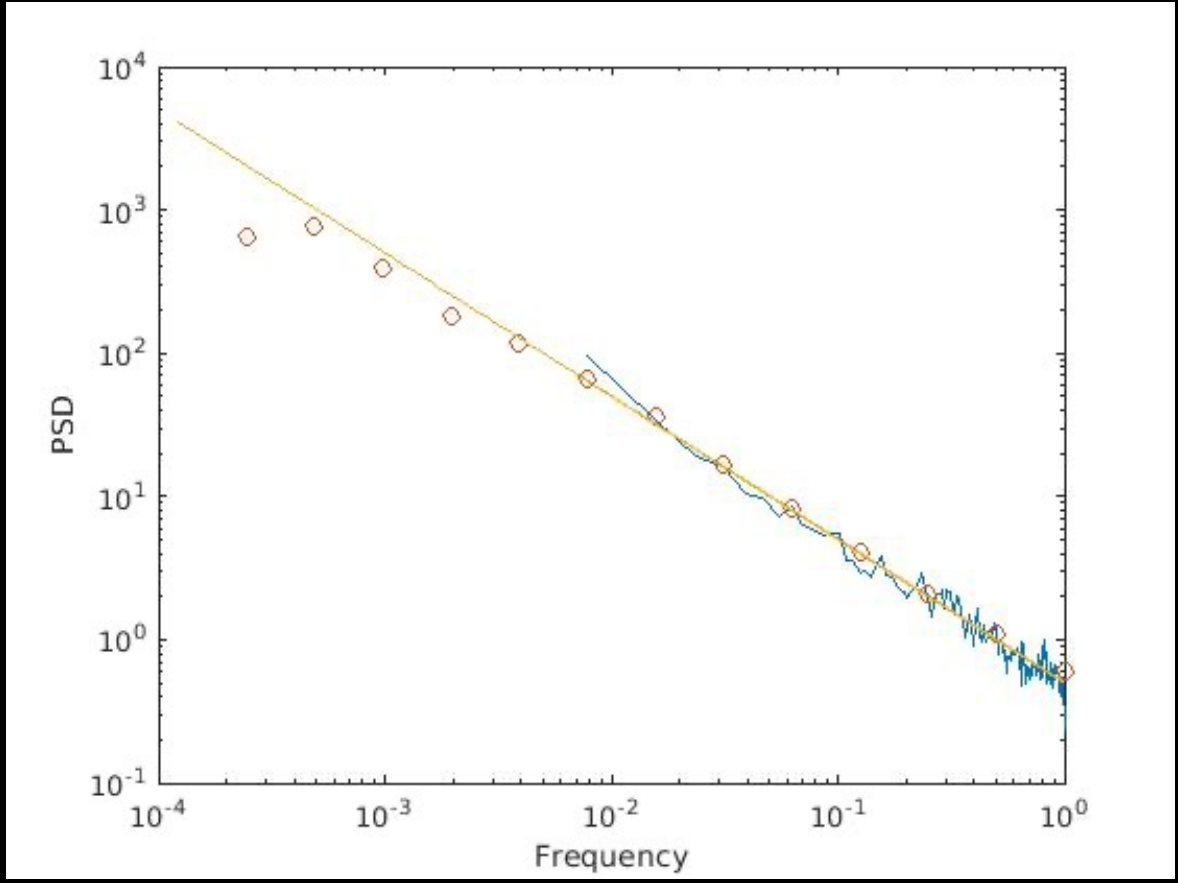
Cho, Lynch et al (2010)

We use Haar wavelet: The Haar wavelet transform can be considered to pair up input values, storing the difference and passing the sum recursively, pairing up the sums to prove the next scale.



Colored Noise Model Test of Haar Wavelet Spectrum

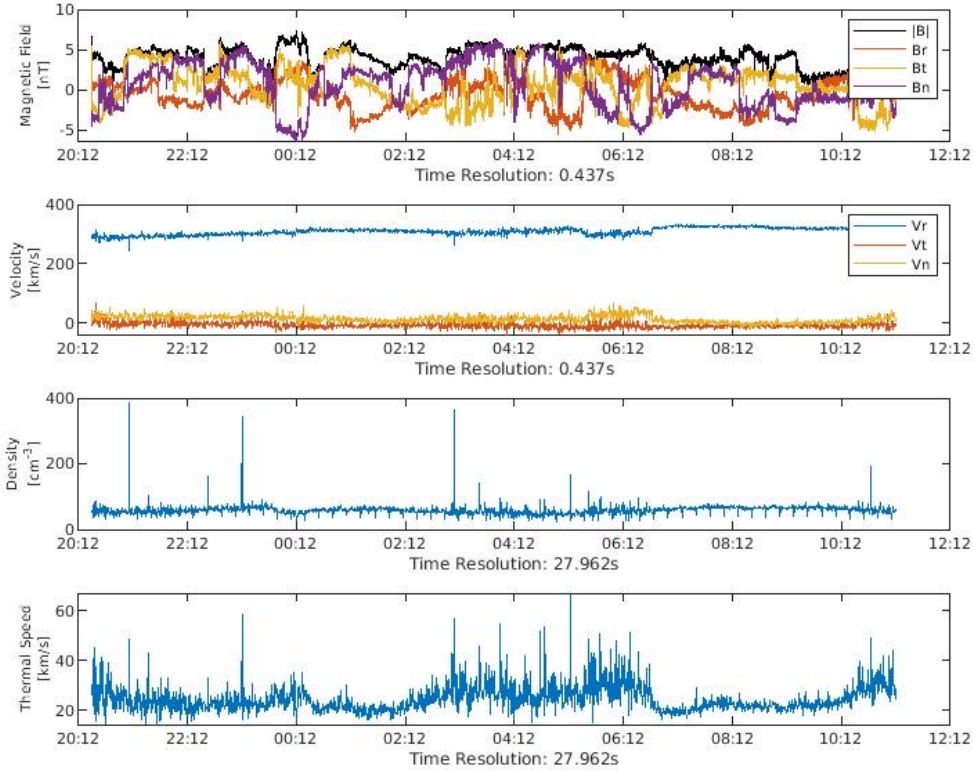


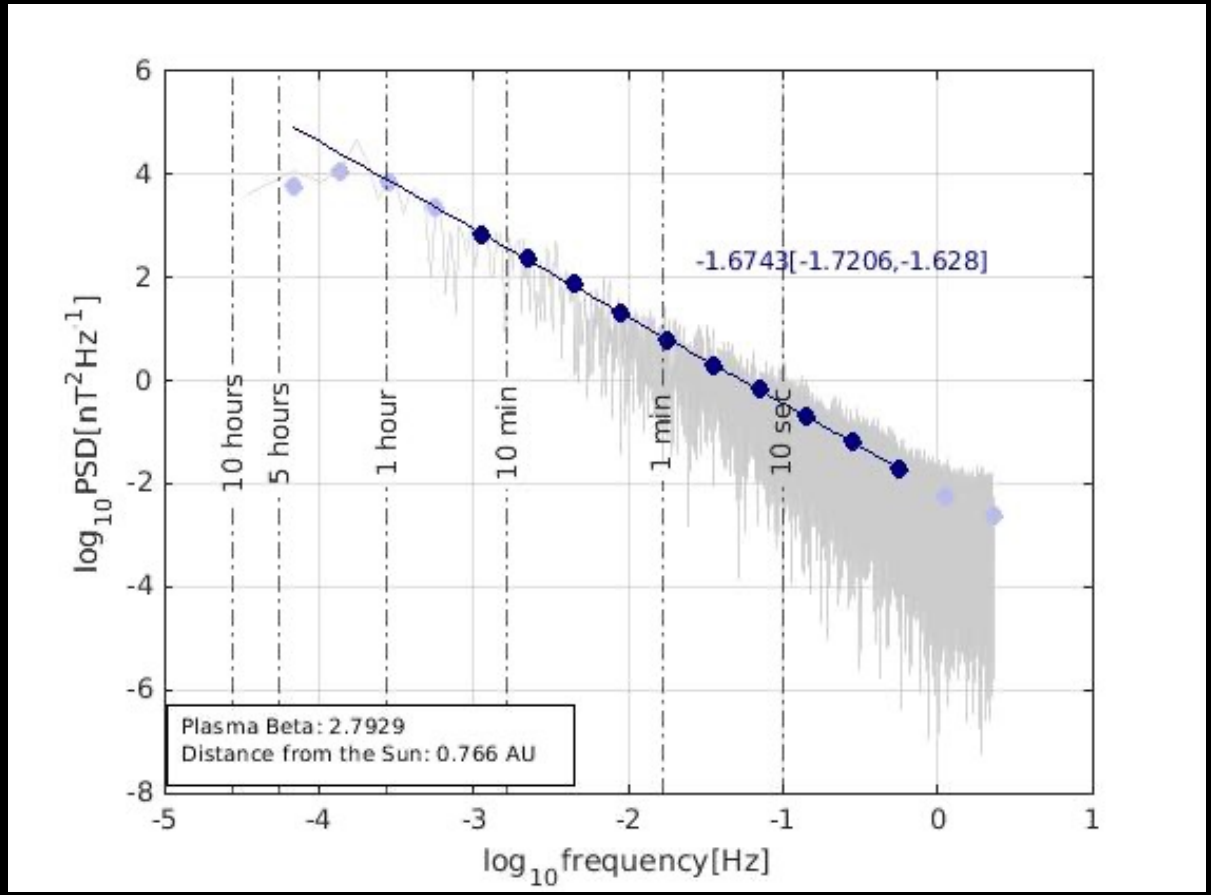


Matlab colored noise generator

Specify spectral exponent
Compare Welch averaged subsampled FFT and full-range Haar wavelet spectrum
Check correct spectral exponent

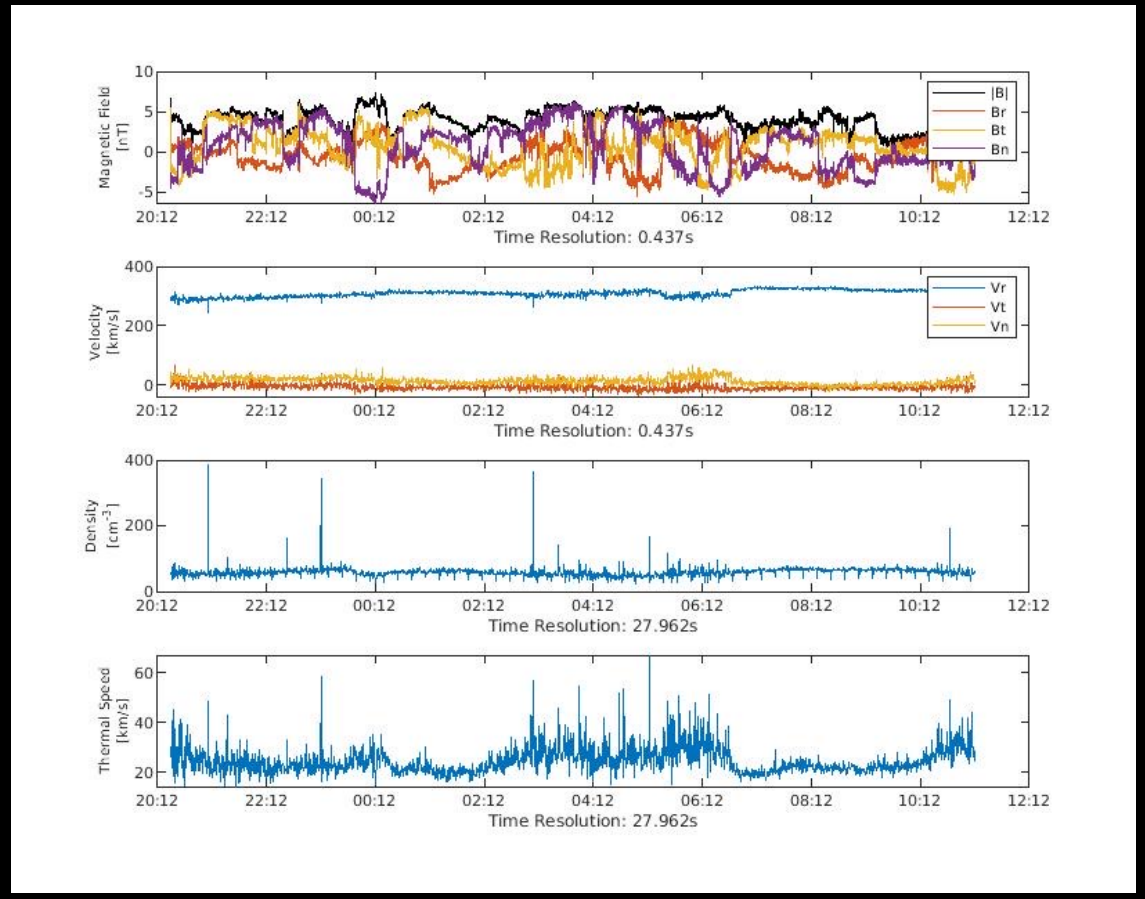
PSP 15-hour Interval at 0.766 AU -Kolmogorov Scaling

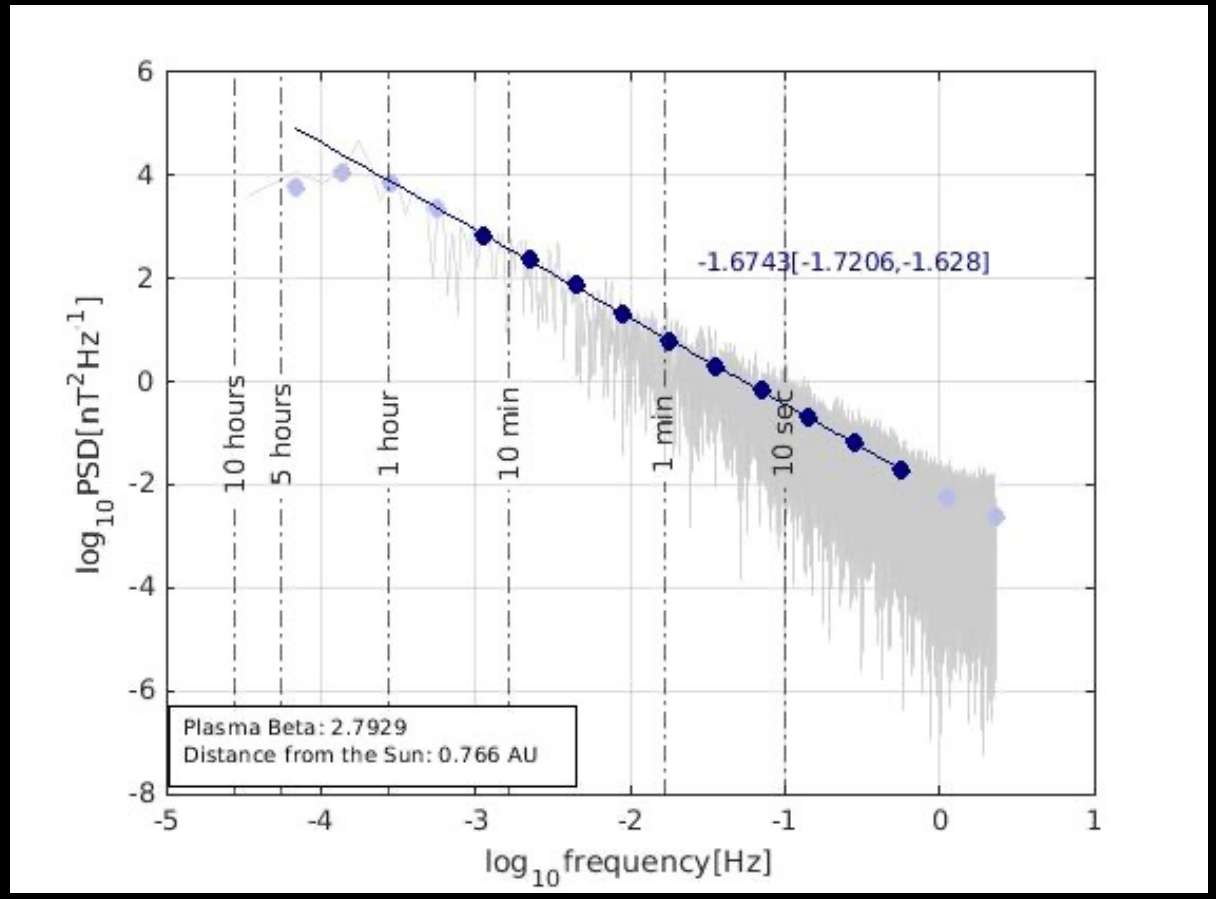




Overplotted Br spectrum
Gray- FFT (full interval)
Blue- Haar wavelet (full interval)

PSP 15-hour Interval at 0.766 AU -Kolmogorov Scaling





・95% confidence bounds:
Distinguish Kolmogorov(-5/3) and Iroshnikov-Kraichnan(-3/2)

・Straight line fit in log-log space

Overplotted Br spectrum
Gray- FFT (full interval)
Blue- Haar wavelet (full interval)

Summary

- Study MHD inertial range of turbulence
- PSP – different intervals at different distances from the Sun
- Haar wavelet provides accurate estimate of the spectral exponent over the full spectral range
- Kolmogorov: the example shown excludes Iroshnikov-Kraichnan