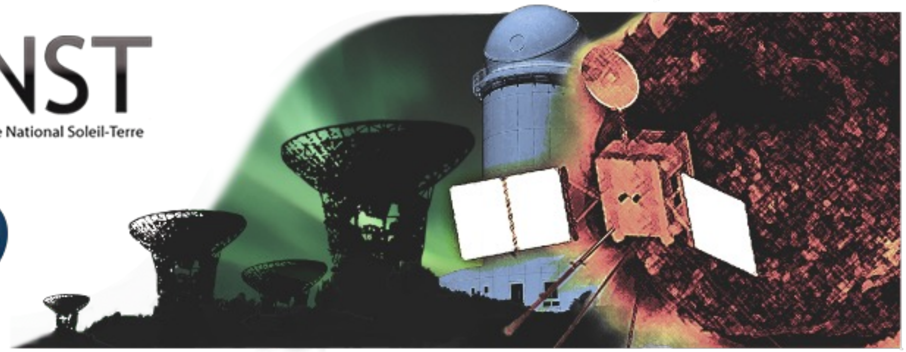
POSTER #37

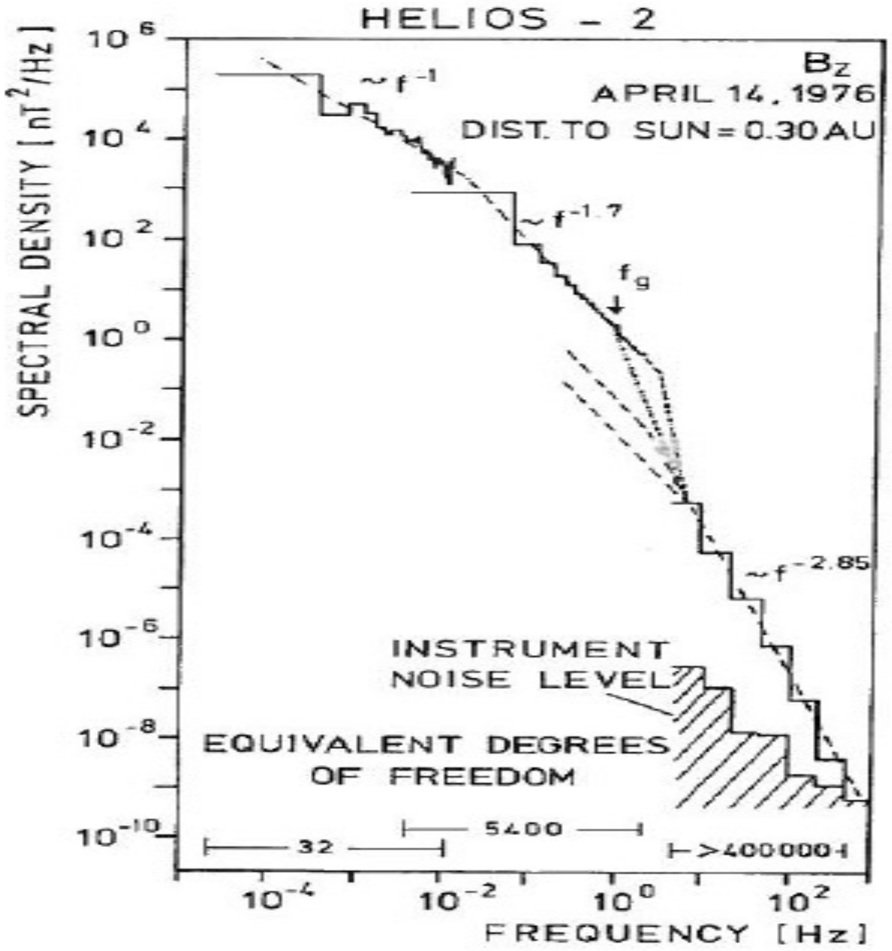
Colloque scientifique PNST
16-20/05/2022 Marseille, France



Dissipation range of solar wind turbulence

Olga Alexandrova, Vamsee Jagarlamudi,
Jessica Martin (Master student, Observatoire de Paris),
P. Hellinger, M. Maksimovic, C. Lacombe, A. Mangeney

Turbulent spectrum as measured by Helios mission DLR/NASA 1974-1984

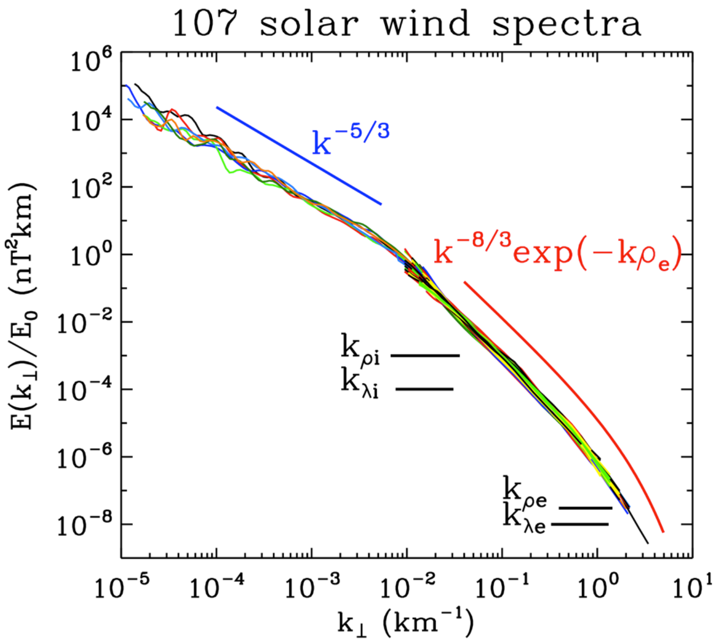


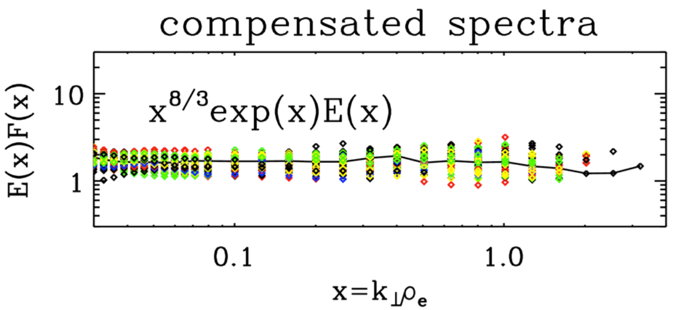
- R= 0.3 AU from the Sun
- Magnetic field measurements with MAG and SCM =>
- **Inertial range and kinetic ranges are covered**
- Spectral break around the gap at ion scales (2-4.7 Hz)
- For f > 4.7 Hz (sub-ion scales) and up to 400 Hz,

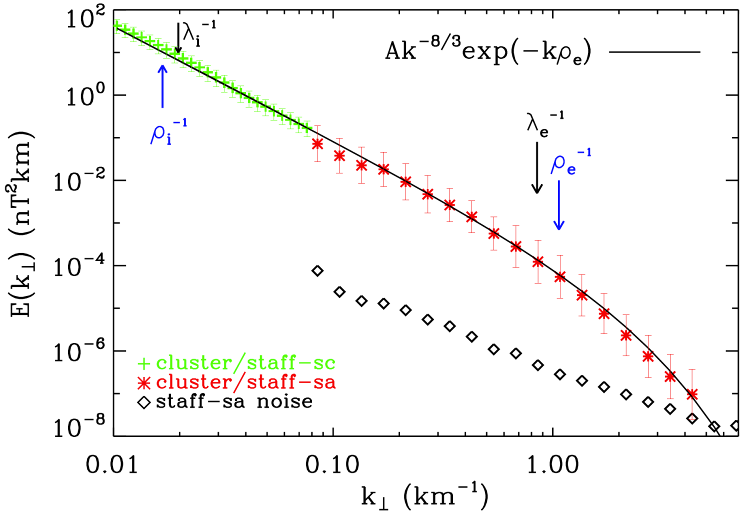
spectral index of -2.85 is observed at 0.3 AU (mean spectrum).

[Denskat et al., 1983]

Turbulent spectrum at 1 AU as measured by Cluster FGM+STAFF





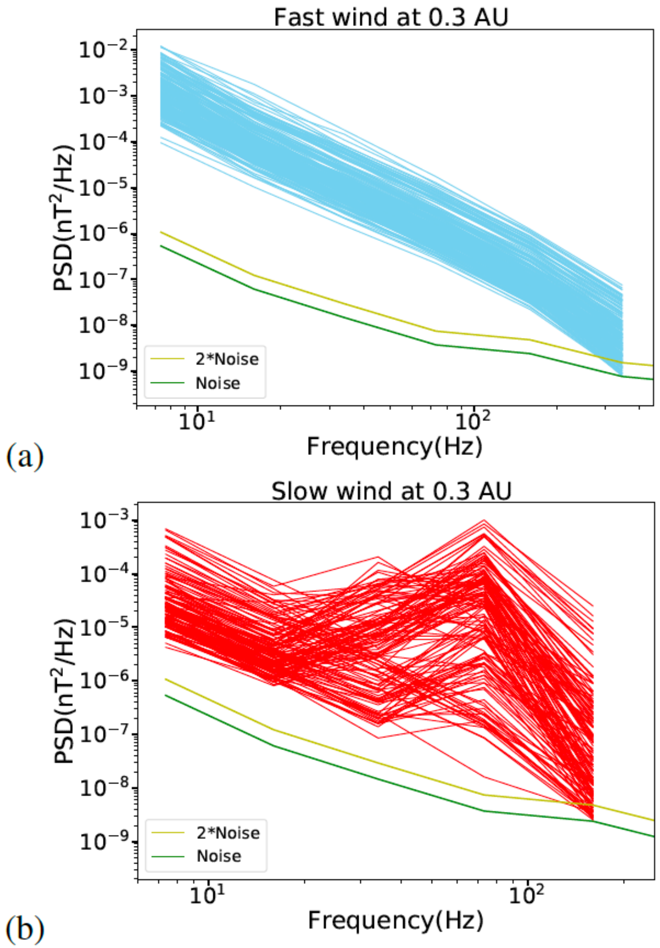


$$E(k) = Ak^{-8/3}\exp\left(-k\ell_d\right)$$

$$\ell_d \simeq \rho_e = \sqrt{2k_BT_em_e}/eB$$

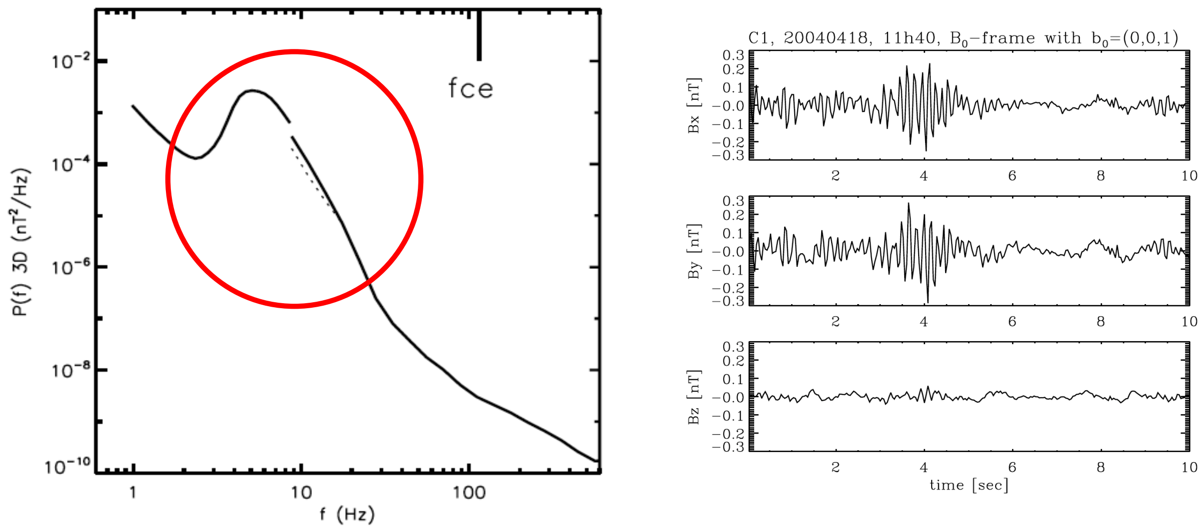
- "Fluid-like" roll-off at electron scales => no more spectral self-similarity, **dissipation range of e/mag turbulence.**
- We find the same spectrum for different solar wind conditions.
- **Electron Larmor radius** seems to play a role of the **dissipation scale** in collisionless solar wind [Alexandrova et al., 2009 PRL, 2012 APJ].

Back to Helios/SCM at 0.3 AU (individual spectra)



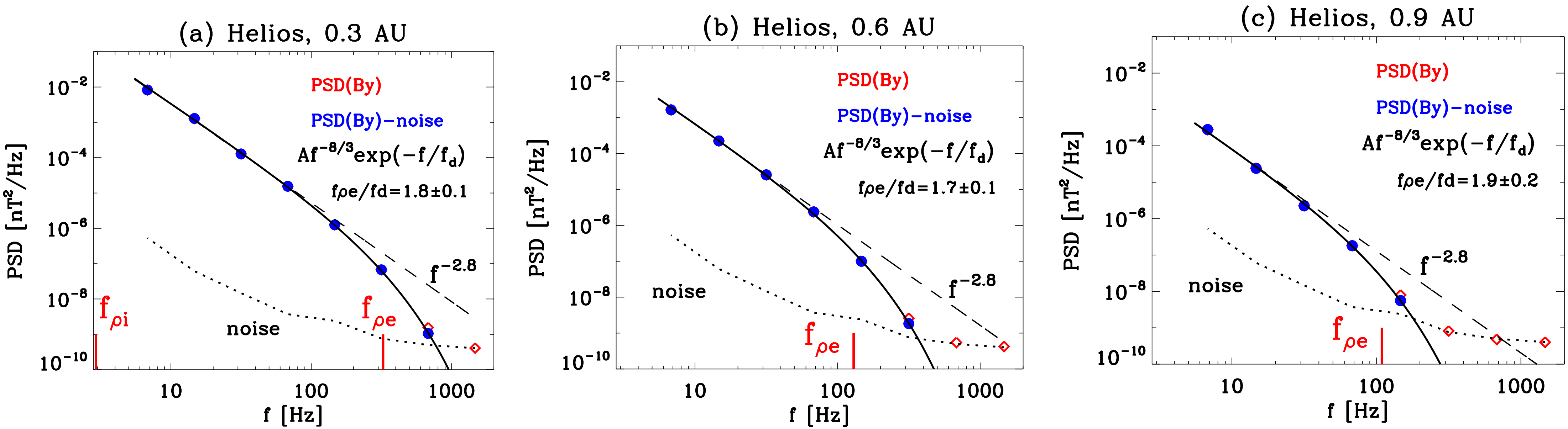
[Jagarlamudi et al. 2020, APJ]

From Cluster measurements [**Lacombe et al. 2014**, Kajdic et al. 2016, Roberts et al. 2017] we know that **'Bump' or 'Break' at a fraction of f_{ce} means parallel whistler waves:**



Helios/SCM spectra with whistlers signatures are studied in [Jagarlamudi et al., 2020].
Here we will focus on spectra without whistlers.

Helios measurements at 0.3, 0.6 and 0.9 AU

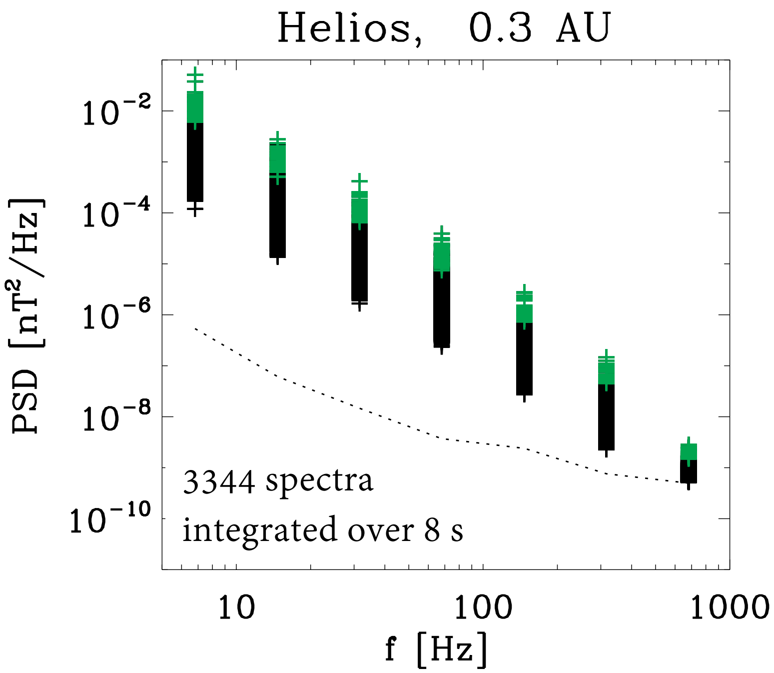


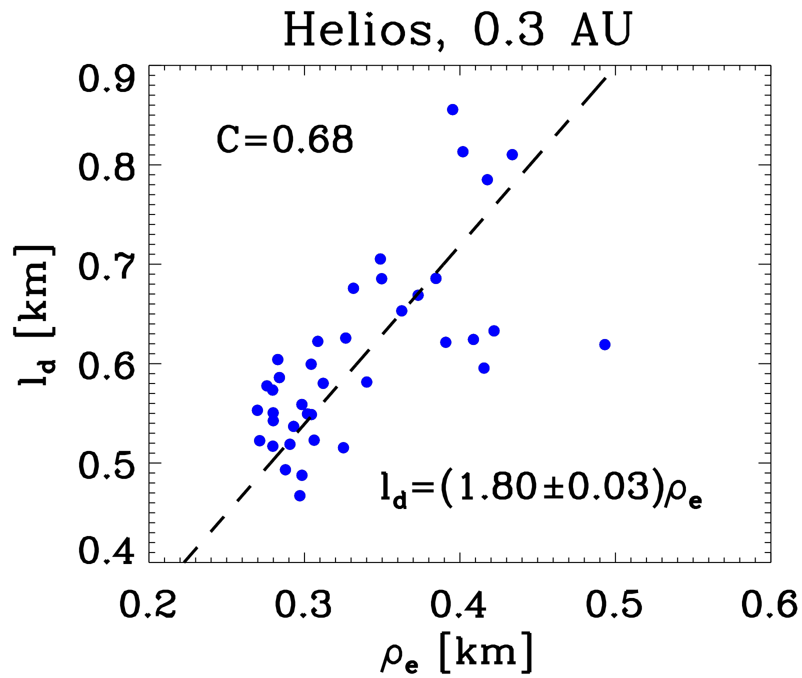
$$P_{\mathrm{model}}(f) = Af^{-8/3}\exp\left(-f/f_d\right)$$

- At 3 radial distances the model function fits well the data.
- As turbulence level goes down with radial distance, the number of resolved frequencies (3 times over the noise) decreases.
- Better to stay at 0.3 AU to have maximal number of resolved frequencies (7).

Helios measurements at 0.3 AU

[Alexandrova, Jagarlamudi et al. 2021 PRE]





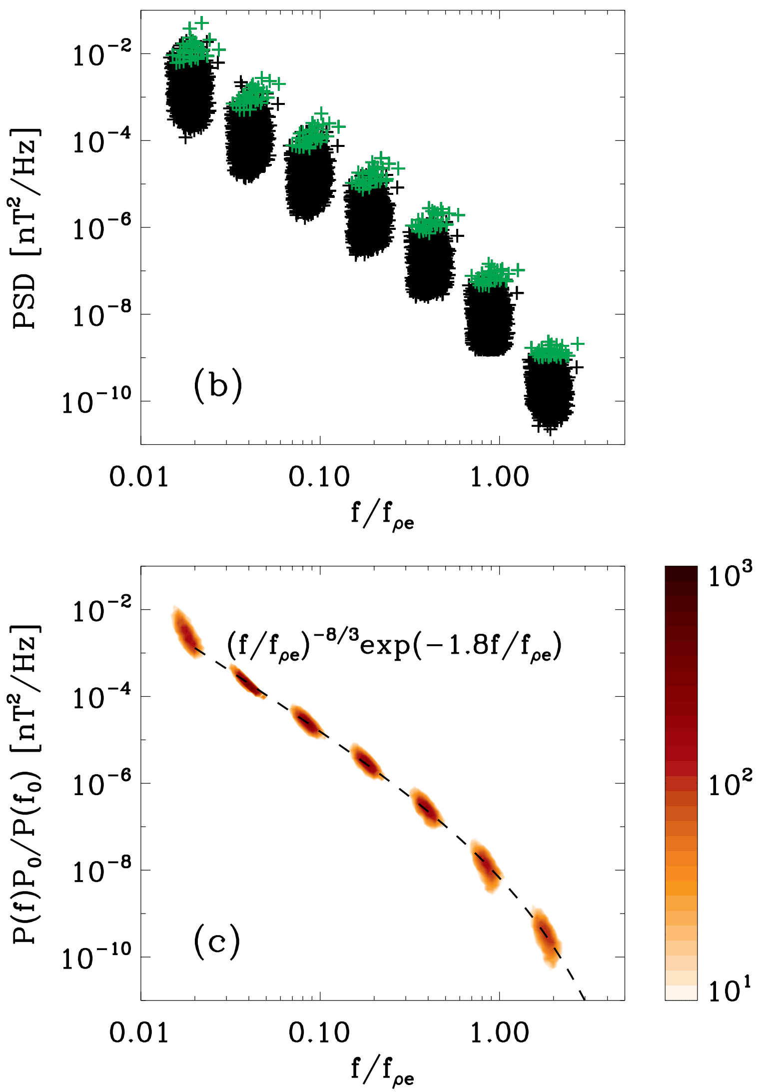
$$E(k) = Ak^{-8/3} \exp\left(-k\ell_d\right)$$
$$\ell_d \simeq \rho_e = \sqrt{2k_B T_e m_e}/eB$$

Electron Larmor radius seems to play a role of the **dissipation scale**, as at 1 AU [Alexandrova et al. 2009, 2012].

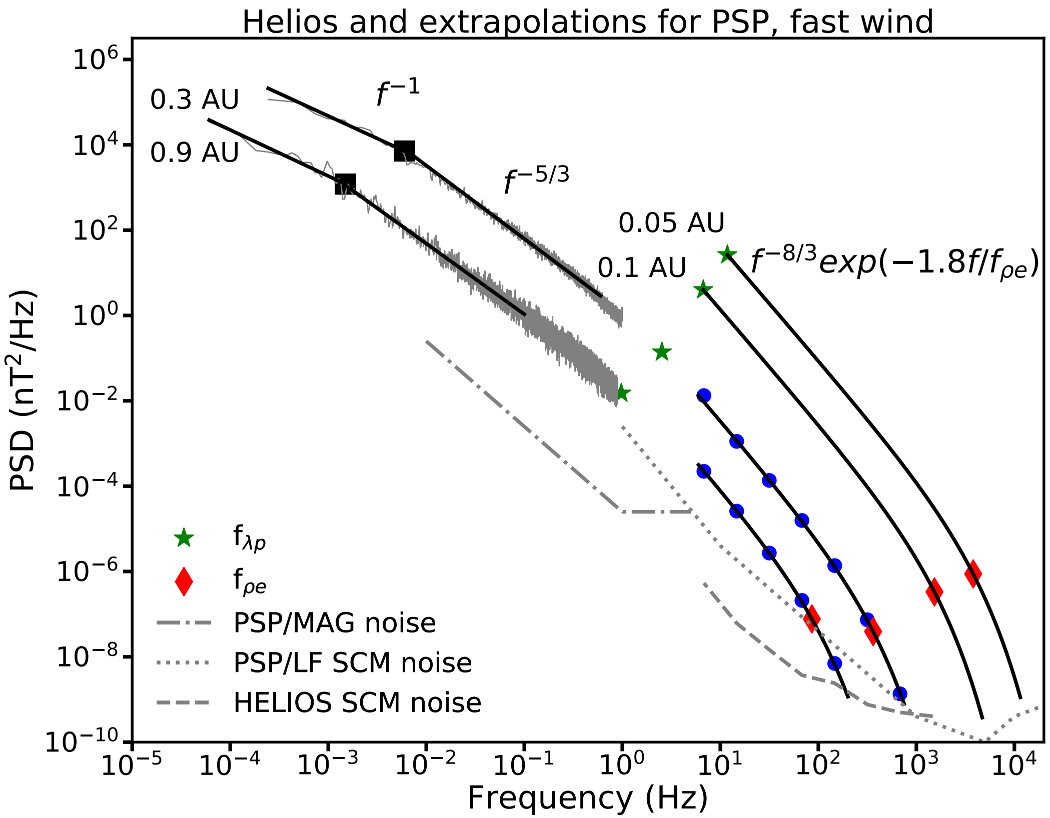
Helios measurements at 0.3 AU

$$P_{\mathrm{model}}(f) = A f^{-8/3} \exp\left(-1.8 f / f_{\rho e}\right)$$

- Taking-off dependence on A by collapsing 3344 spectra in amplitude (in 1 point), all spectra can be described by the model function (without free parameters).
- No particular fitting is done !
- The same function describes kinetic spectrum at 1 AU, just the coefficient 1.8 differs…(why ?)
- Toward the universality of kinetic spectrum in the Heliosphere…
- PSP/SCM data ?
- SOLO/RPW/SCM data ?



Helios turbulent spectrum (fast wind) and extrapolations for PSP



[Alexandrova, Jagarlamudi, Hellinger, Maksimovic et al. 2021 PRE]

Assumptions for extrapolations:

- The turbulence level goes together with the mean field: $\delta B/B_0 \sim$ const
- $f^{-1} - f^{-5/3}$ break goes as $R^{-1.52}$ [Bruno & Carbone, 2013]
- The density matches both the 0.3 to 1 AU Helios density observations and the coronal density observations obtained remotely by Sittler and Guhathakurta [1999];
- The conservation of the mass flux

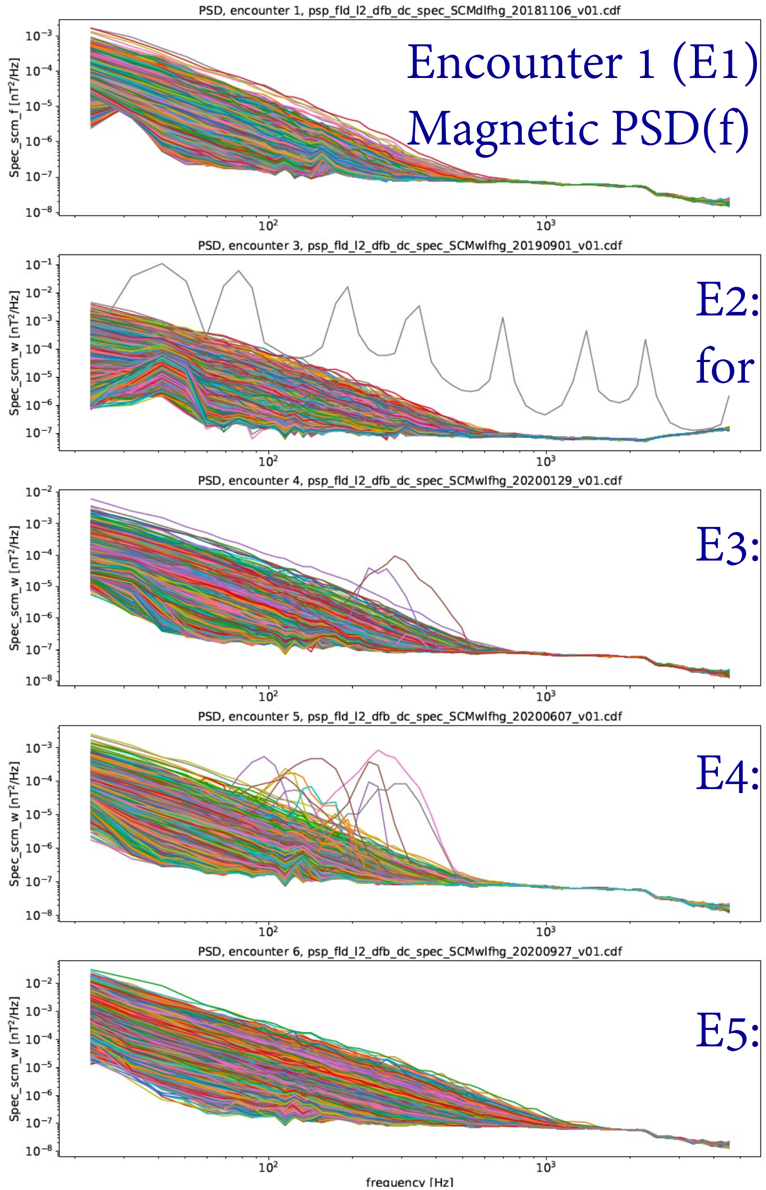
$$n_e(R)V(R)R^2 = \text{const.}$$

PSP/FIELDS/SCM spectral products (sub-ion scales)

[Jessica Martin, M1, 2021]

SCM noise ?

Encounter 1 (E1)
Magnetic PSD(f)



E1: Background turbulence

E2: Turbulence and signal for on-board calibration

E3: Turbulence and Whistlers

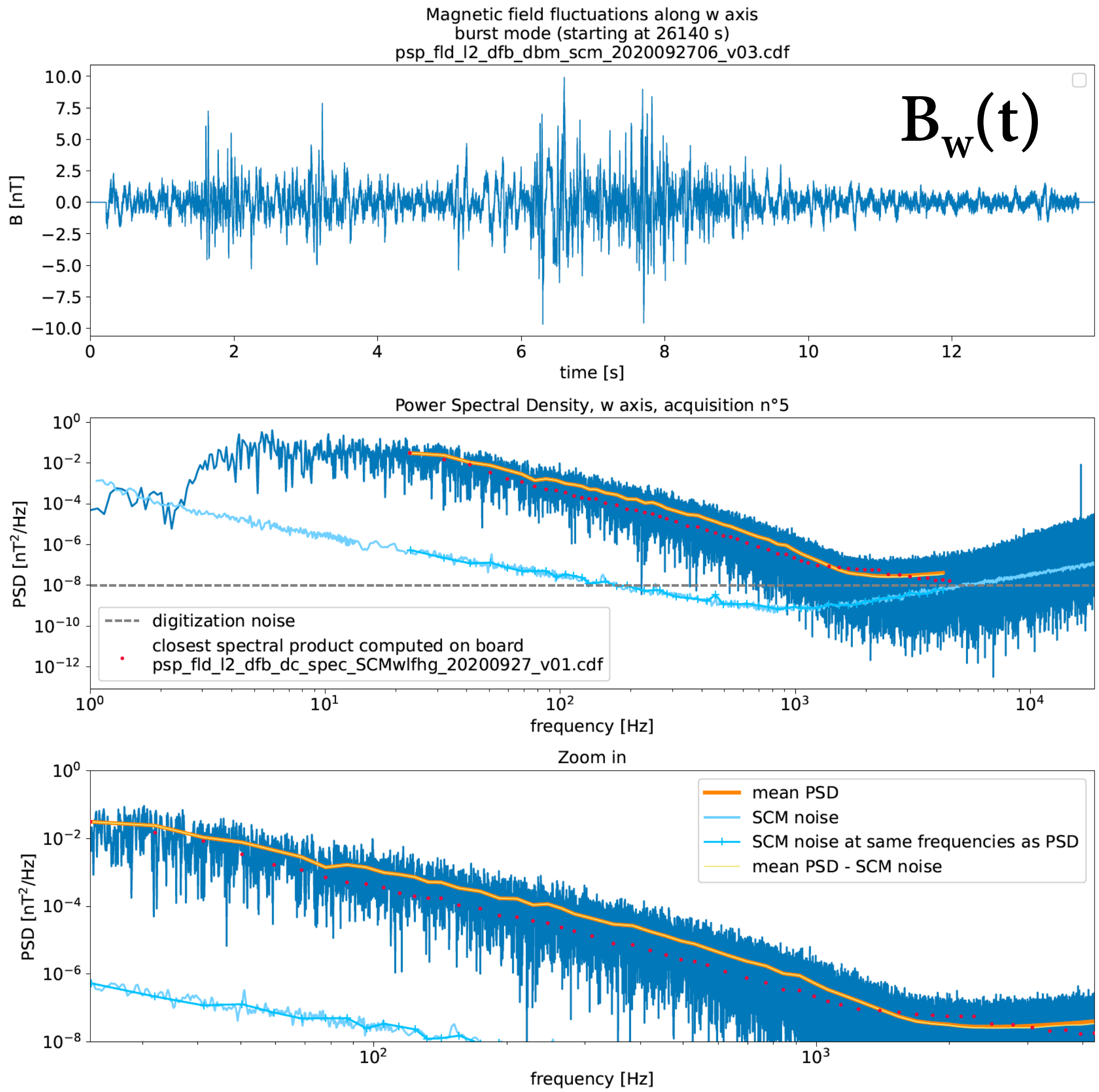
E4: Turbulence and Whistlers

E5: Background turbulence

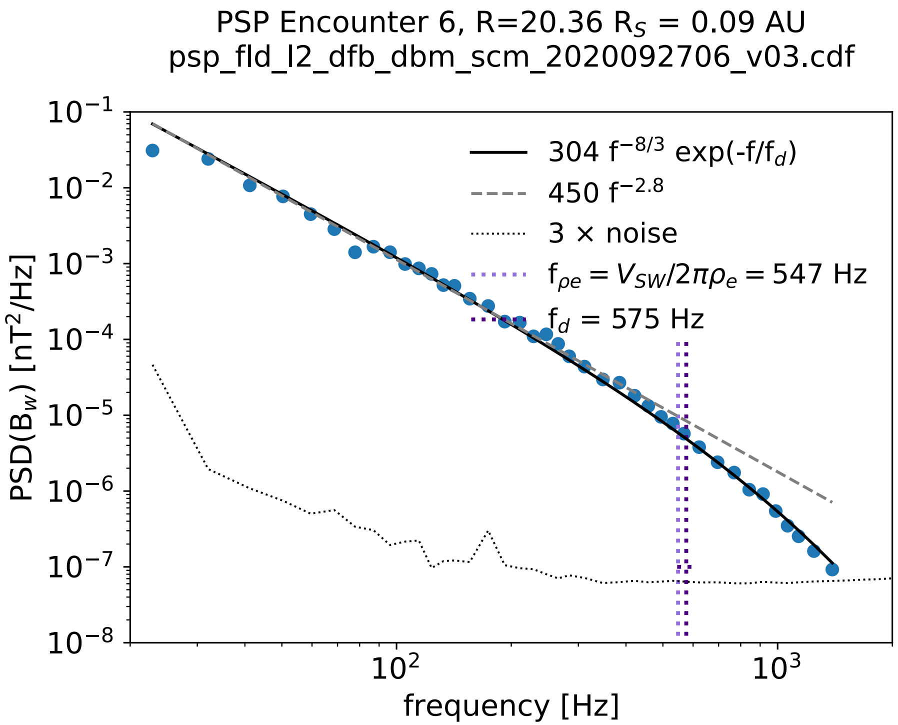
PSP/FIELDS/SCM spectra vs burst mode waveforms

Problems with spectral products ?...

=> we use burst mode waveforms to get kinetic spectrum



Parker Solar Probe: observations at 0.09 UA



[Master-1 diploma thesis of Jessica Martin, June 2021]

$$E(f) = A_0 f^{-8/3} \exp\left(-f/f_d\right)$$
$$E(k) = A k^{-8/3} \exp\left(-k\ell_d\right)$$
$$k = 2\pi f/V_{SW}$$
$$\ell_d/\rho_e = f_{\rho_e}/f_d = 0.84$$

Observations of Cluster & Helios :

$$E(k) = A k^{-8/3} \exp\left(-k\ell_d\right)$$
$$\ell_d = 1.4\rho_e,\ \text{R=1 UA (Cluster)}$$
$$\ell_d = 1.8\rho_e,\ \text{R=0.3 UA (Helios)}$$

Conclusions on PSP/SCM analysis :

- Preliminary results
- But we see the same form of spectrum => generality !
- The e/m cascade **ends** onto the electrons. Theoretical model ?

Bonus: determination of the in-flight PSP/SCM noise

Spectra computed from burst mode data, E6

Code: Noise_and_spectra.ipynb, Saved in: Plot_estimated_noise

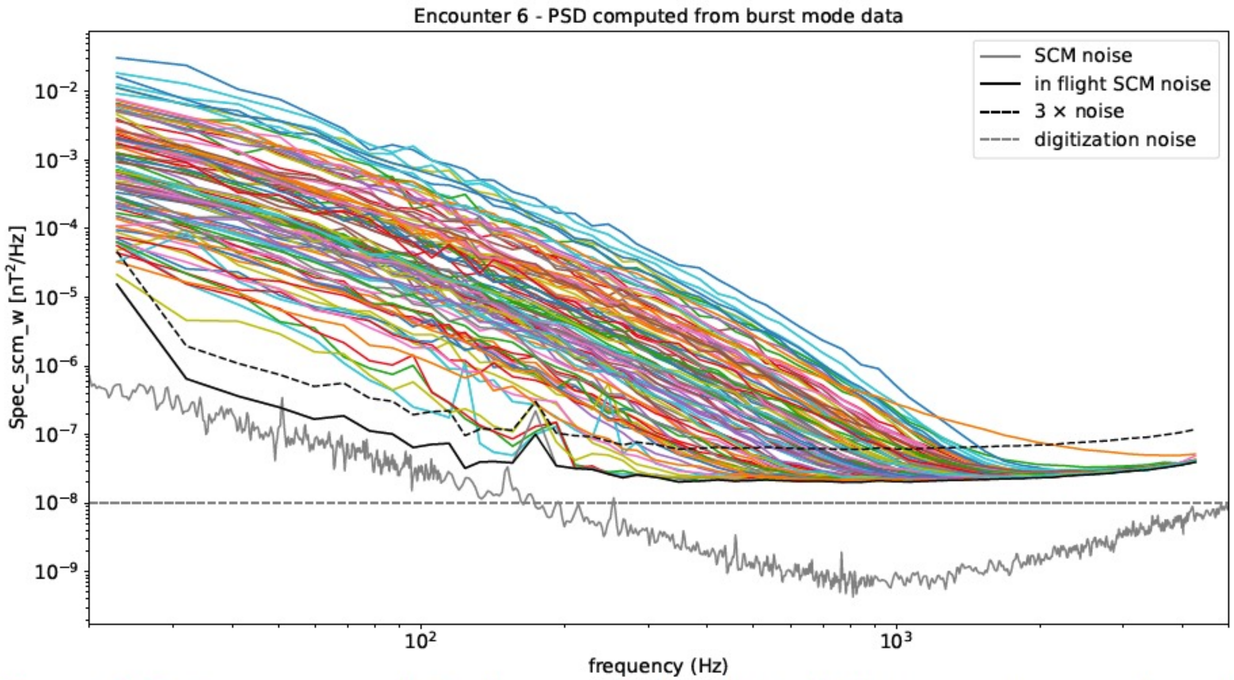


Figure A.20: Spectra computed from burst mode data during E6 (101 spectra), averaged around 54 frequencies

PSP/FIELDS/SCM in-flight noise: Minimal PSD value at each frequency (see black solid line).