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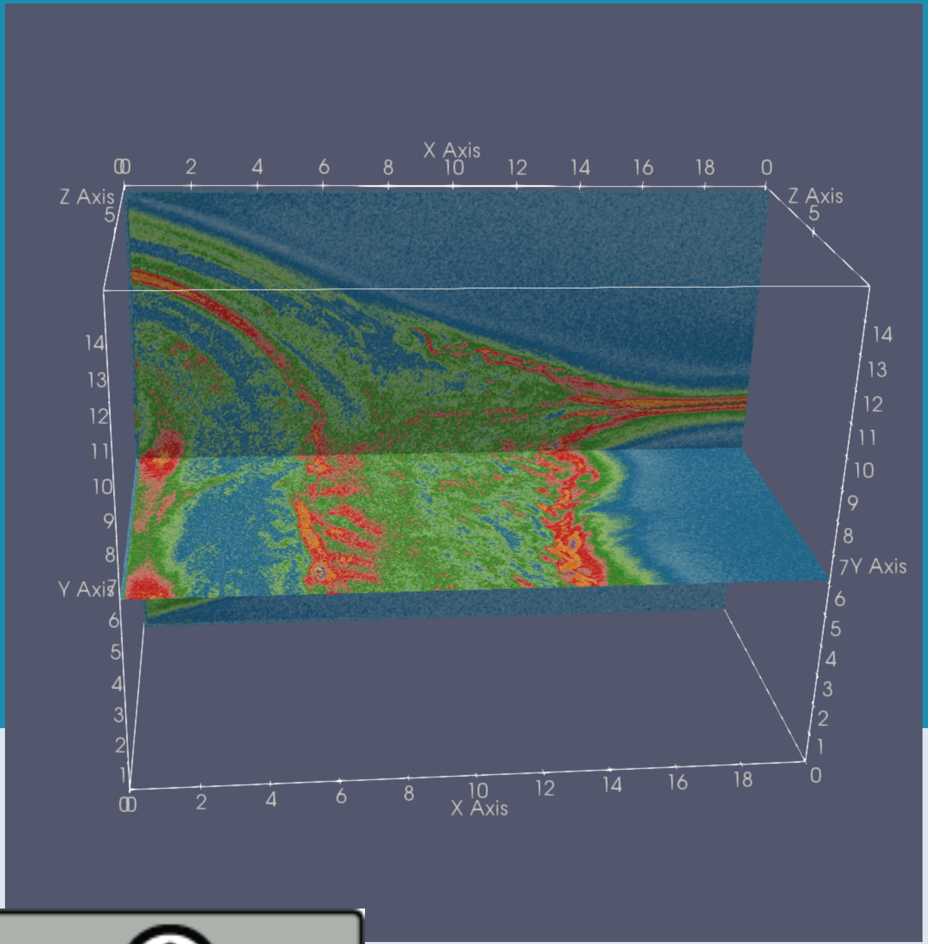
Analysis of Local Regimes of Turbulence generated by 3D Magnetic Reconnection



L. Sanna, G. Lapenta, S. Eriksson,
D.L. Newman, M.V. Goldman, F. Pucci,

Wassily Kandinsky, Division-Unity, 1934

Results form iPic3D Simulations

More info in Lapenta et al.(2020). ApJ., 888(2), 104.

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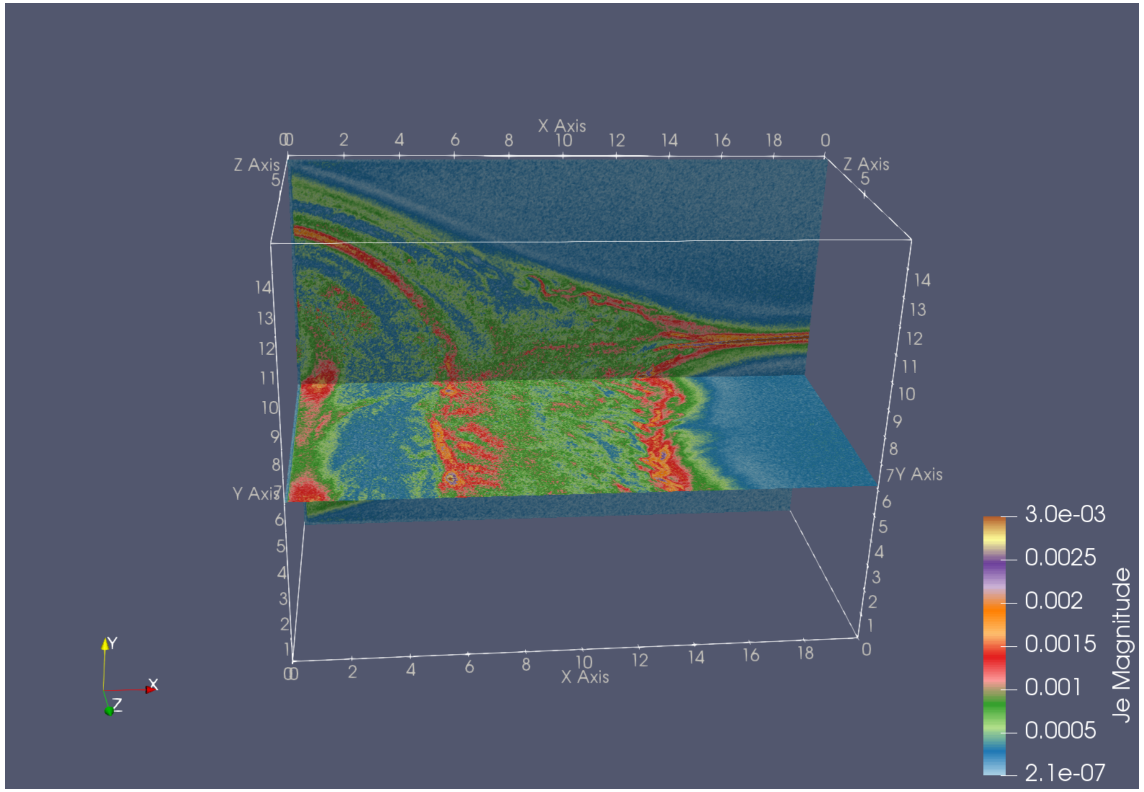
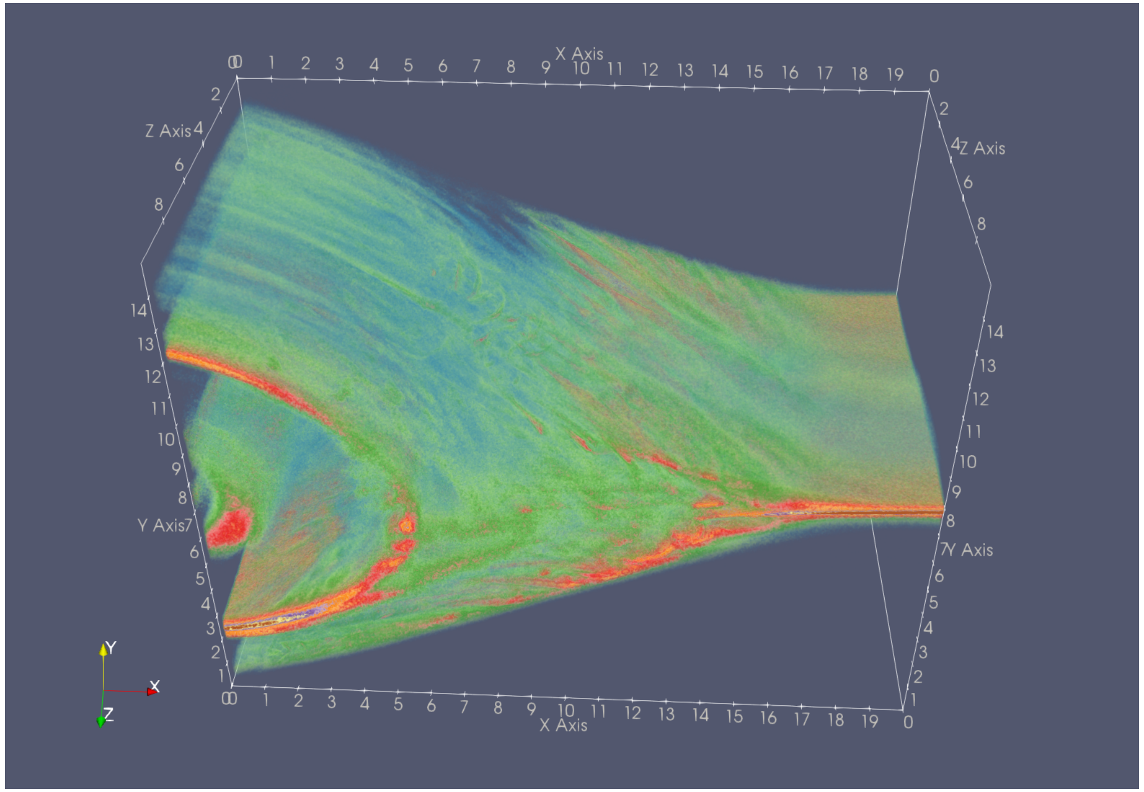
How 3D reconnection really is

Mi/me=256
B_g=1/10
Grid:1200x450x300
Resolution $\Delta x = d_e/2$
Resolution $\omega_{ce}\,\Delta t = 1/30$

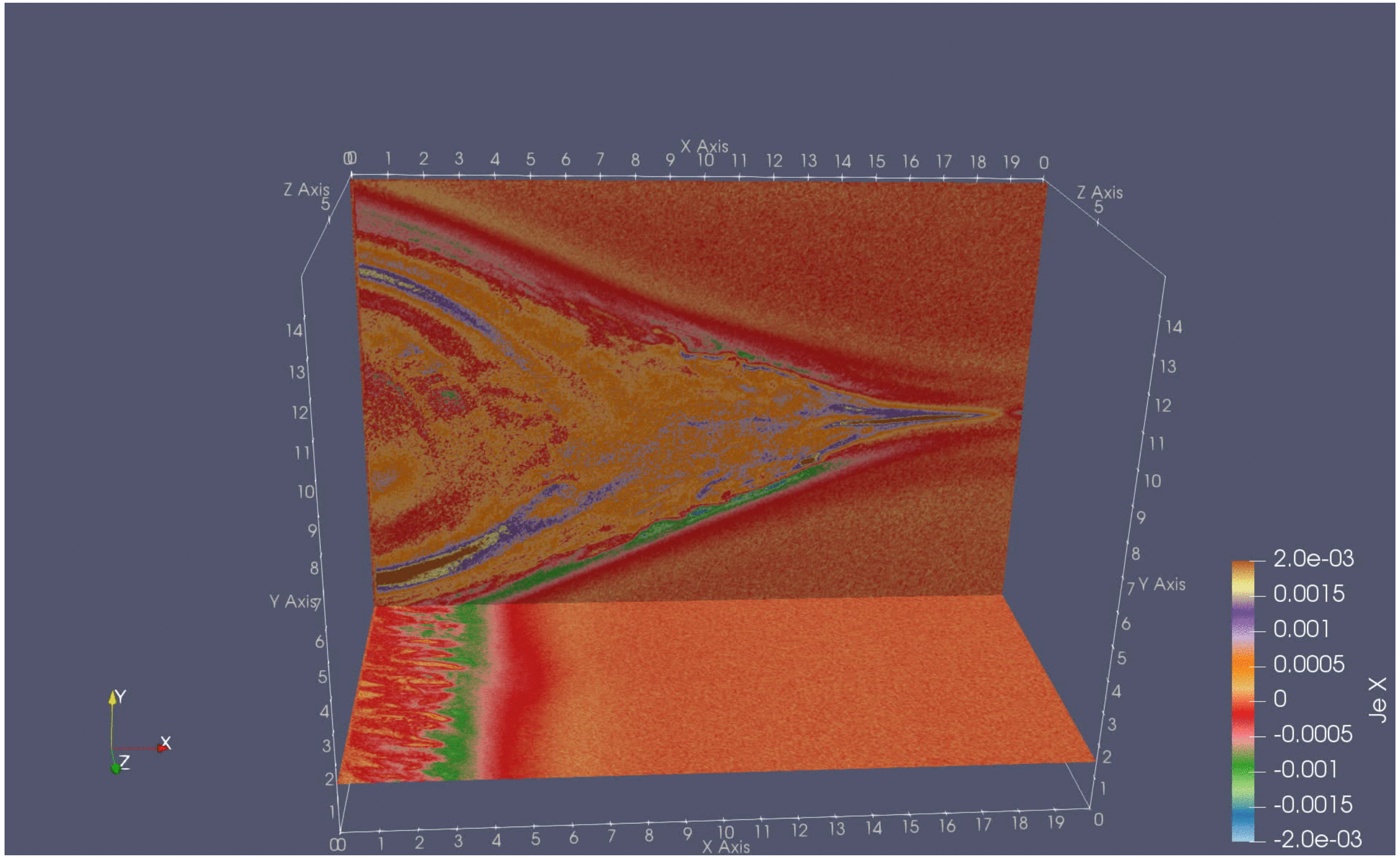


Electron Current Density – Magnitude - Cuts

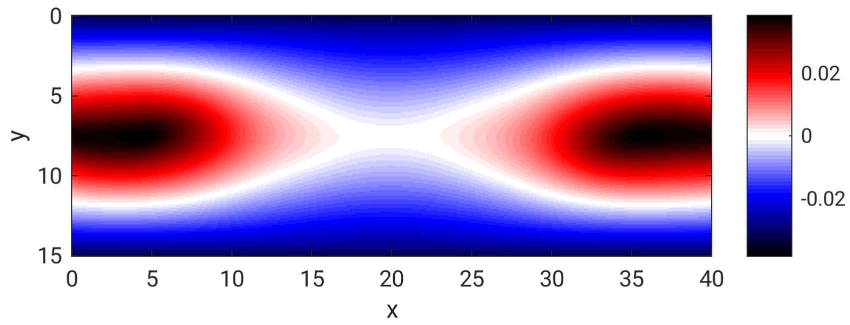


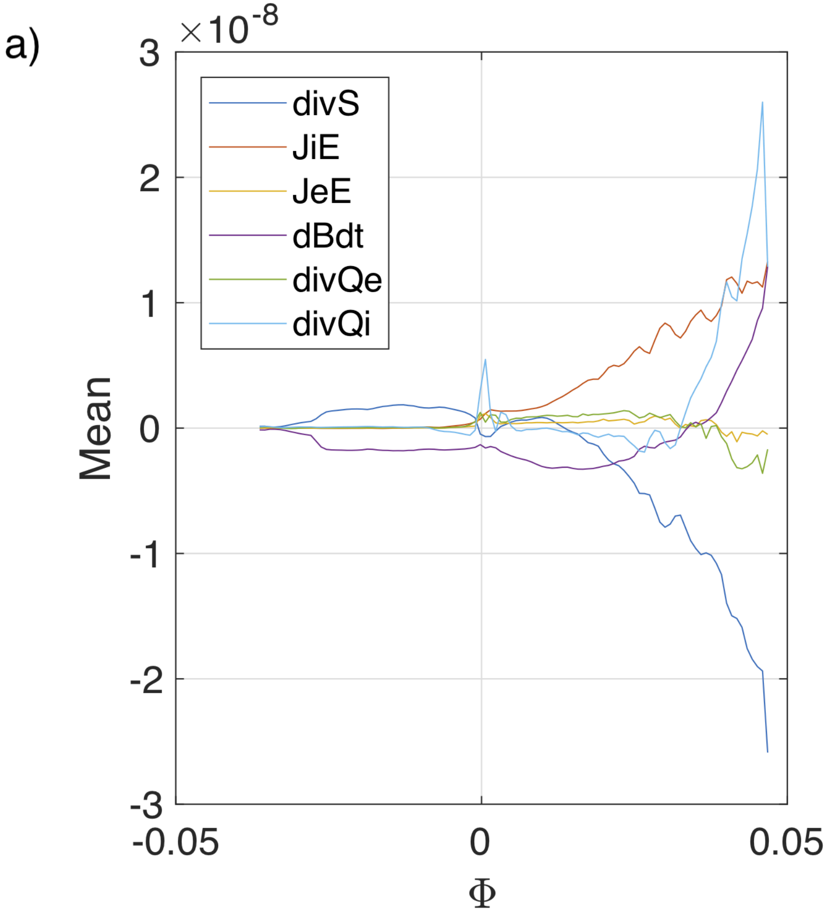
Electron Current Density – Magnitude –Volume rendering

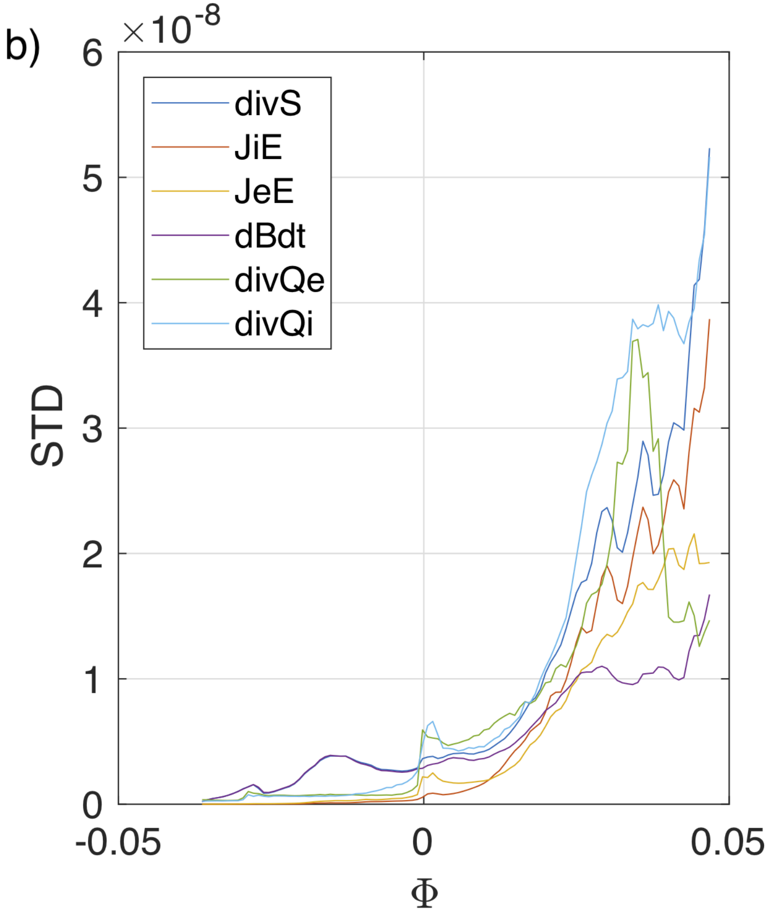
Horizontal (along x, Earth-Sun) Electron current



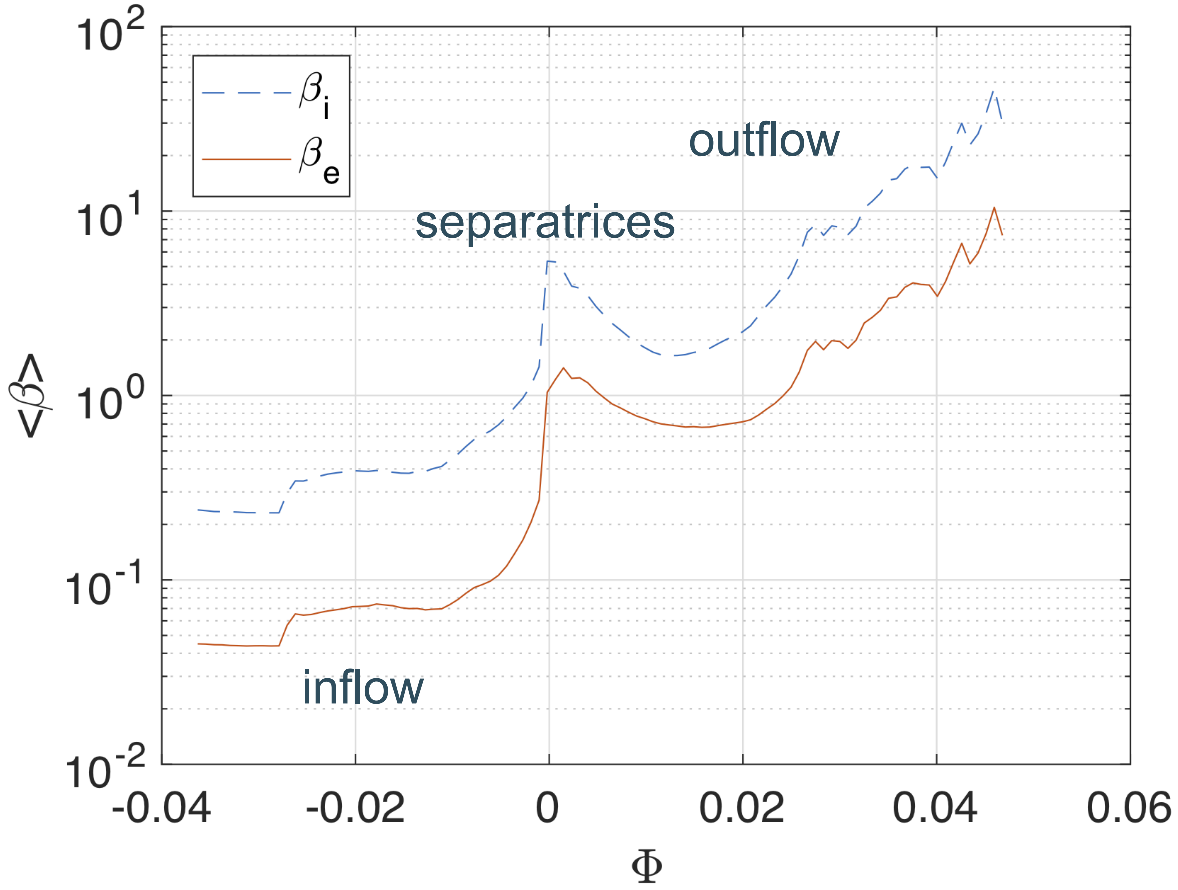
Energy exchanges

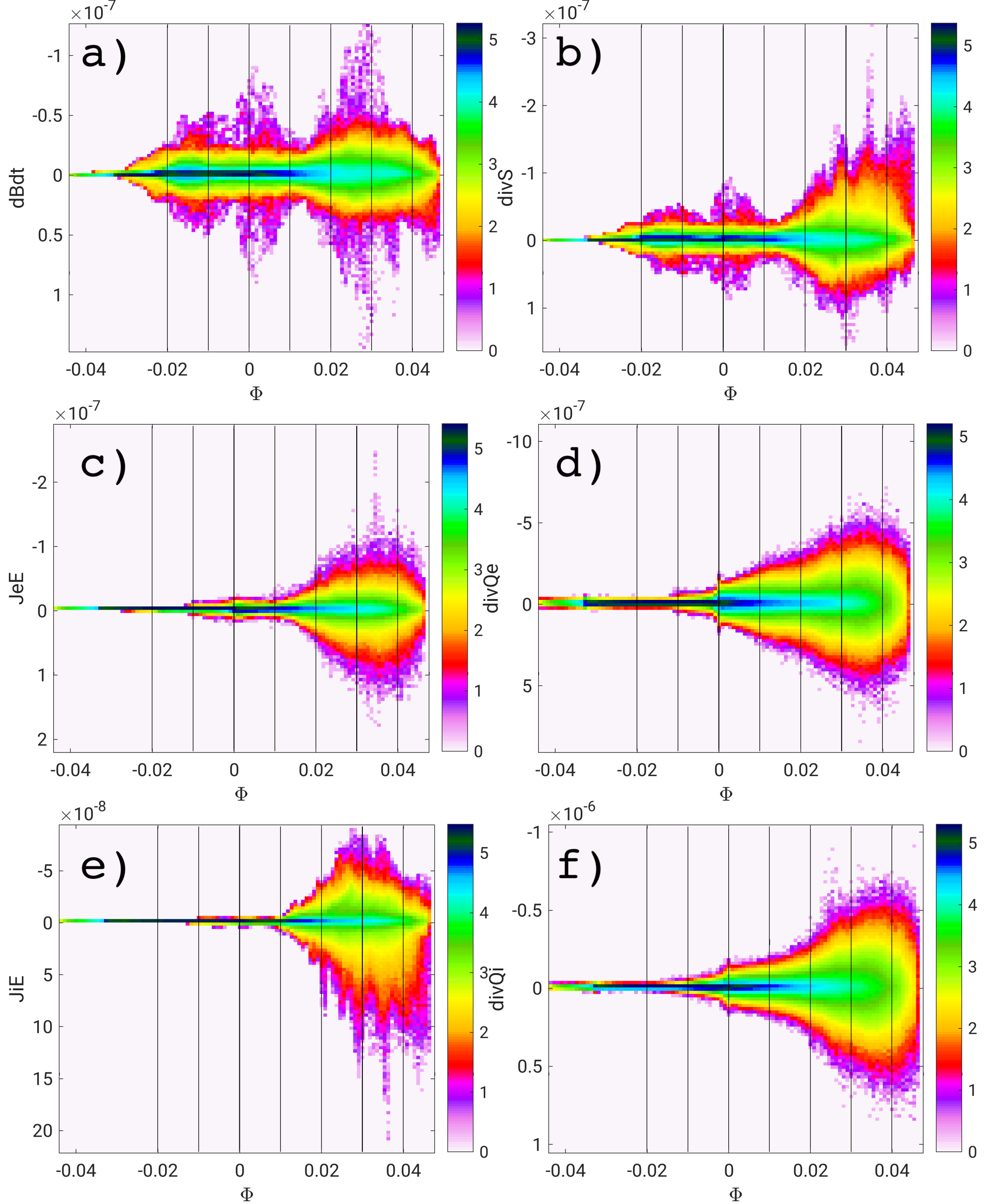






Different regimes of turbulence





More info in Lapenta et al.(2020). ApJ., 888(2), 104.

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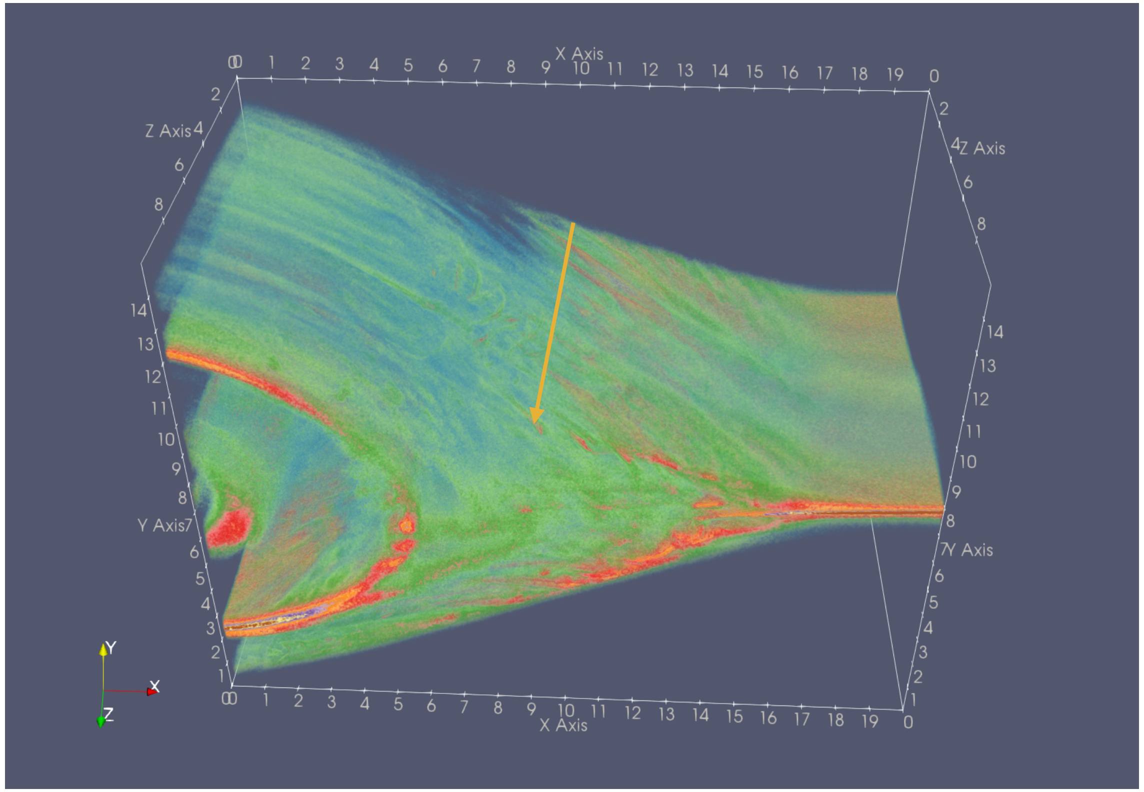
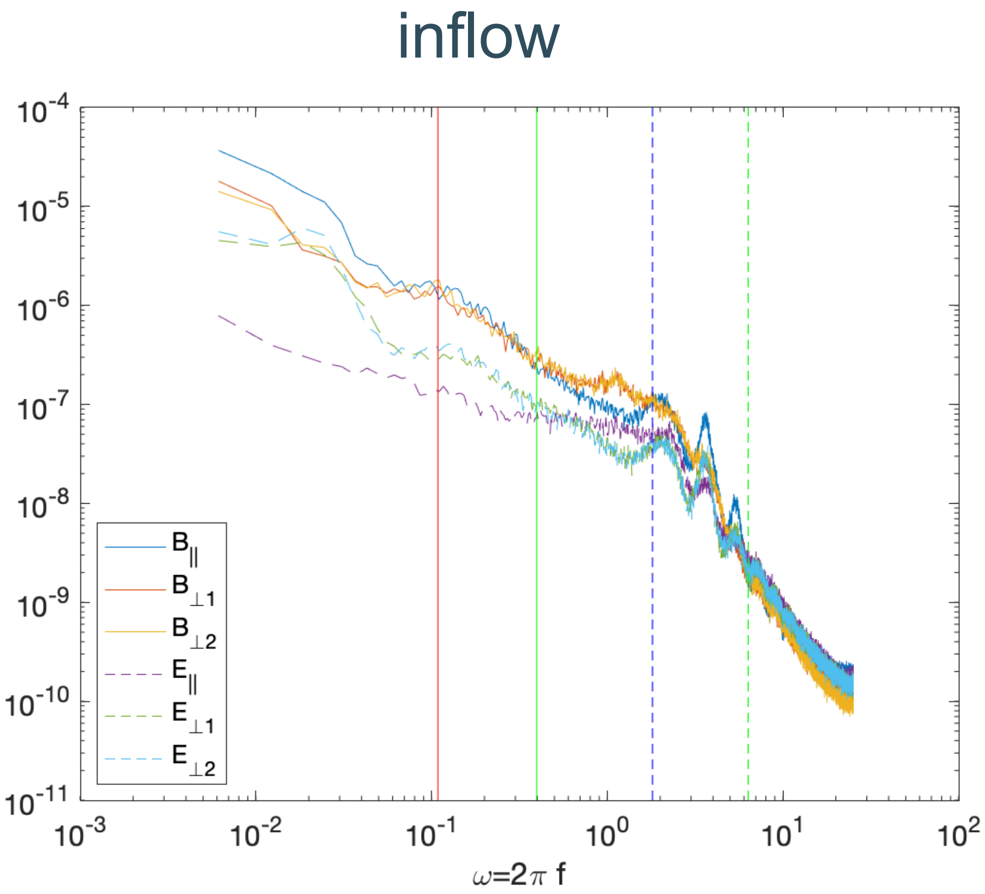
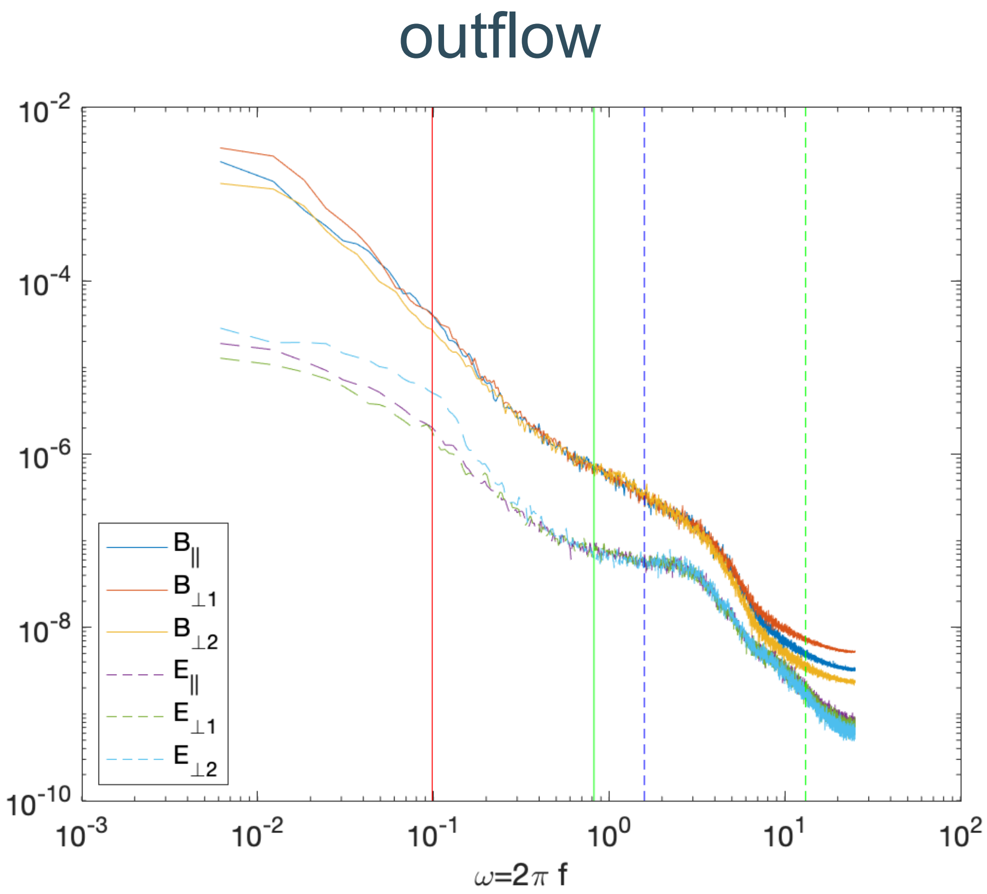
Virtual probes



- We set arrays of 3x3x3 probes per computational processors.
- This forms 27 virtual spacecrafts at a given (x,y) location, uniformly spread along z
- From this signal recorded every time step we can make spectrograms and other analysis of fluctuations in time

Spectrum of waves – virtual probes





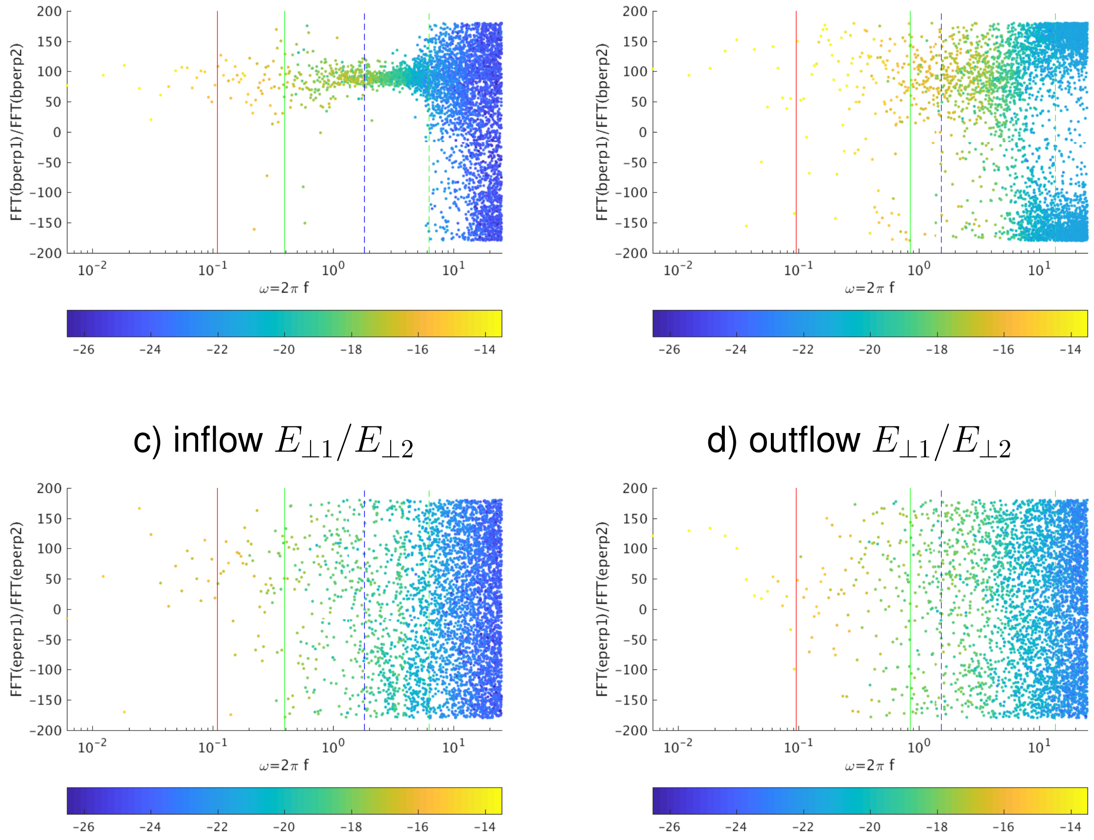
Polarization of the wave

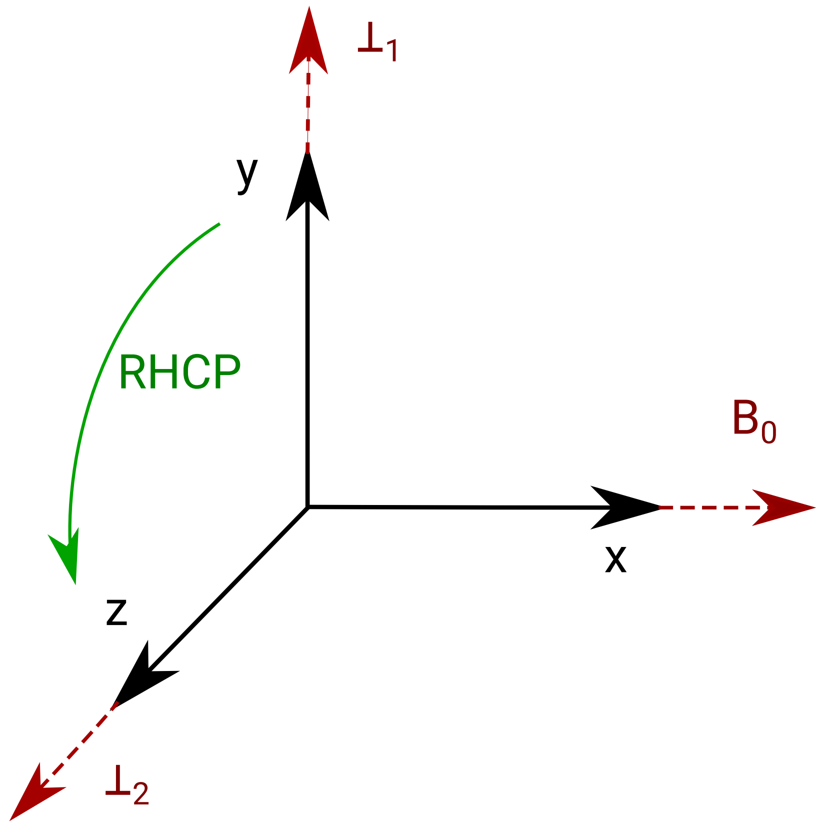
a) inflow $B_{\perp1}/B_{\perp2}$

b) outflow $B_{\perp1}/B_{\perp2}$

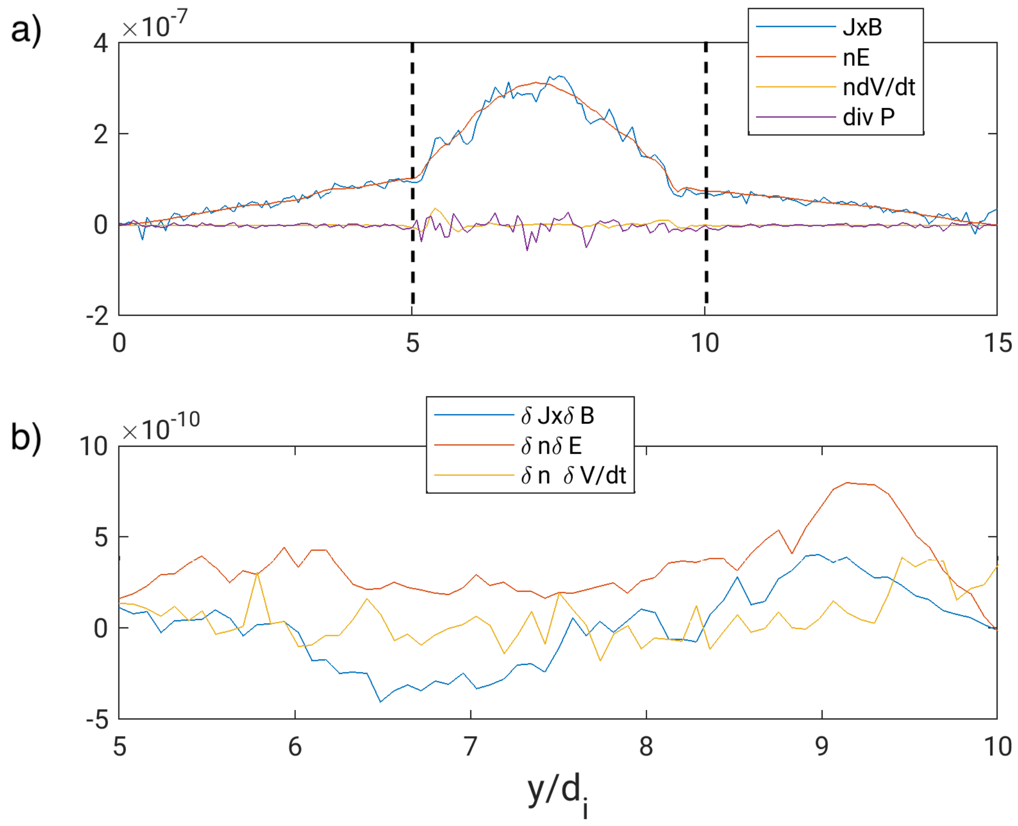
c) inflow $E_{\perp1}/E_{\perp2}$

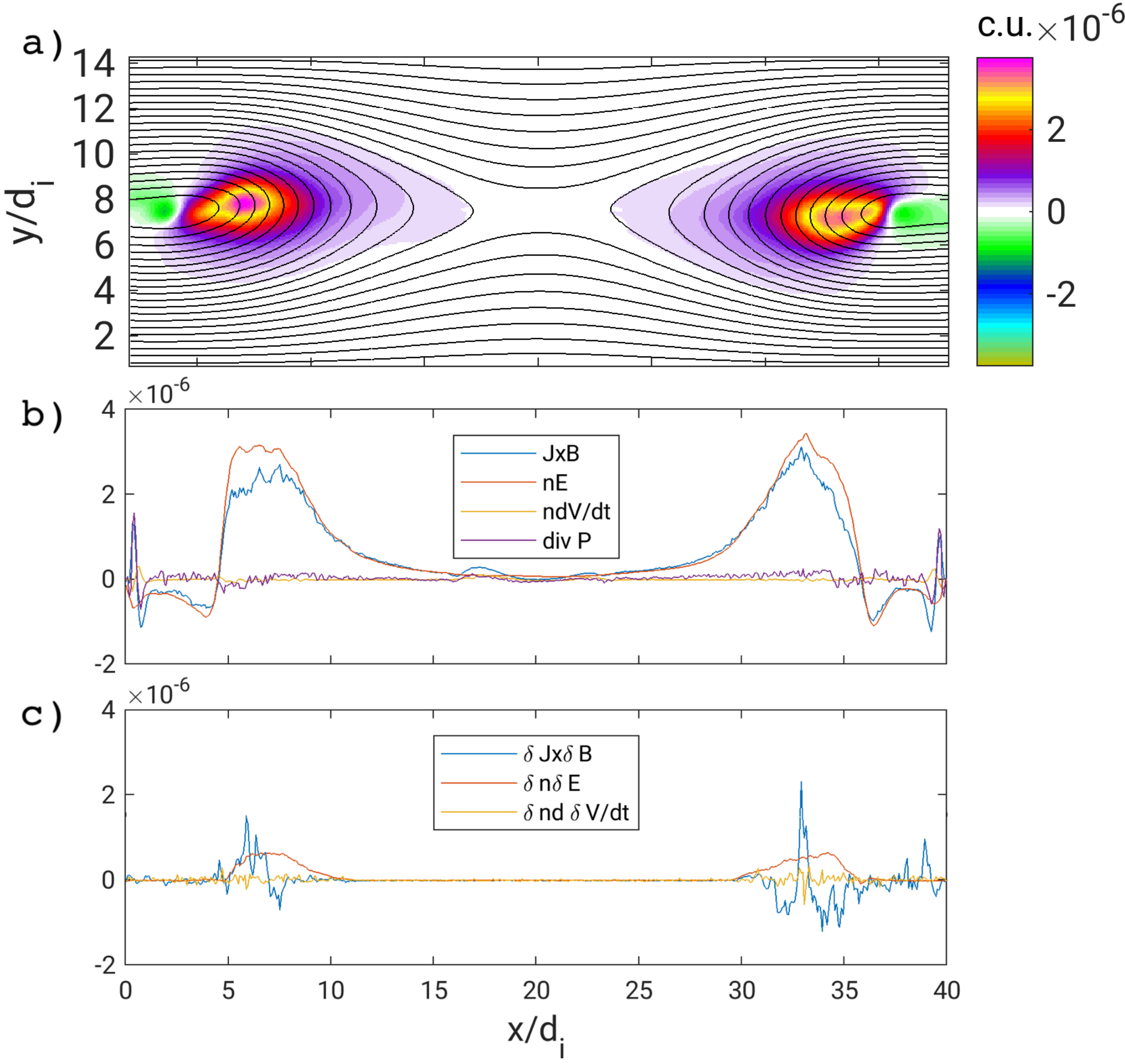
d) outflow $E_{\perp1}/E_{\perp2}$

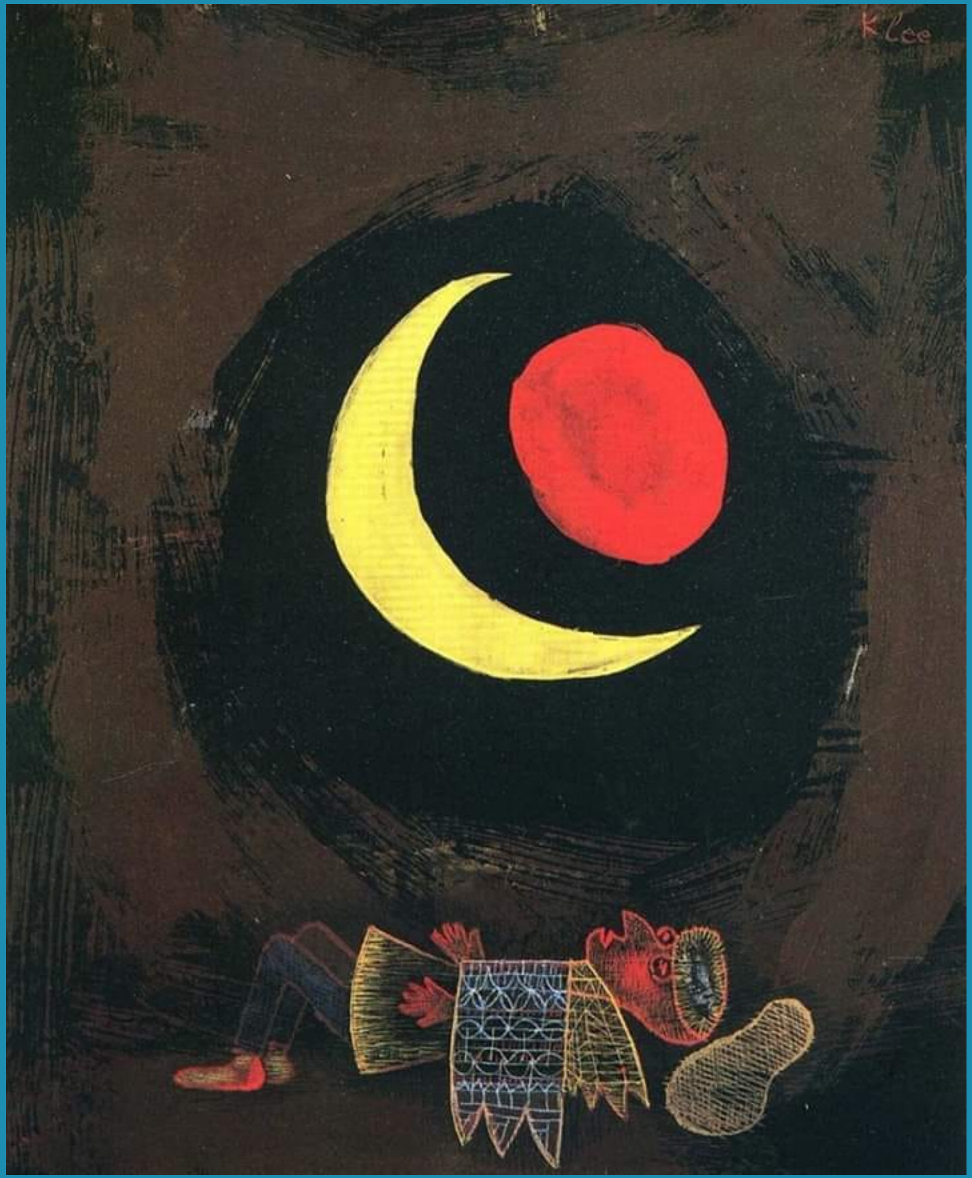




Impact on momentum transfer





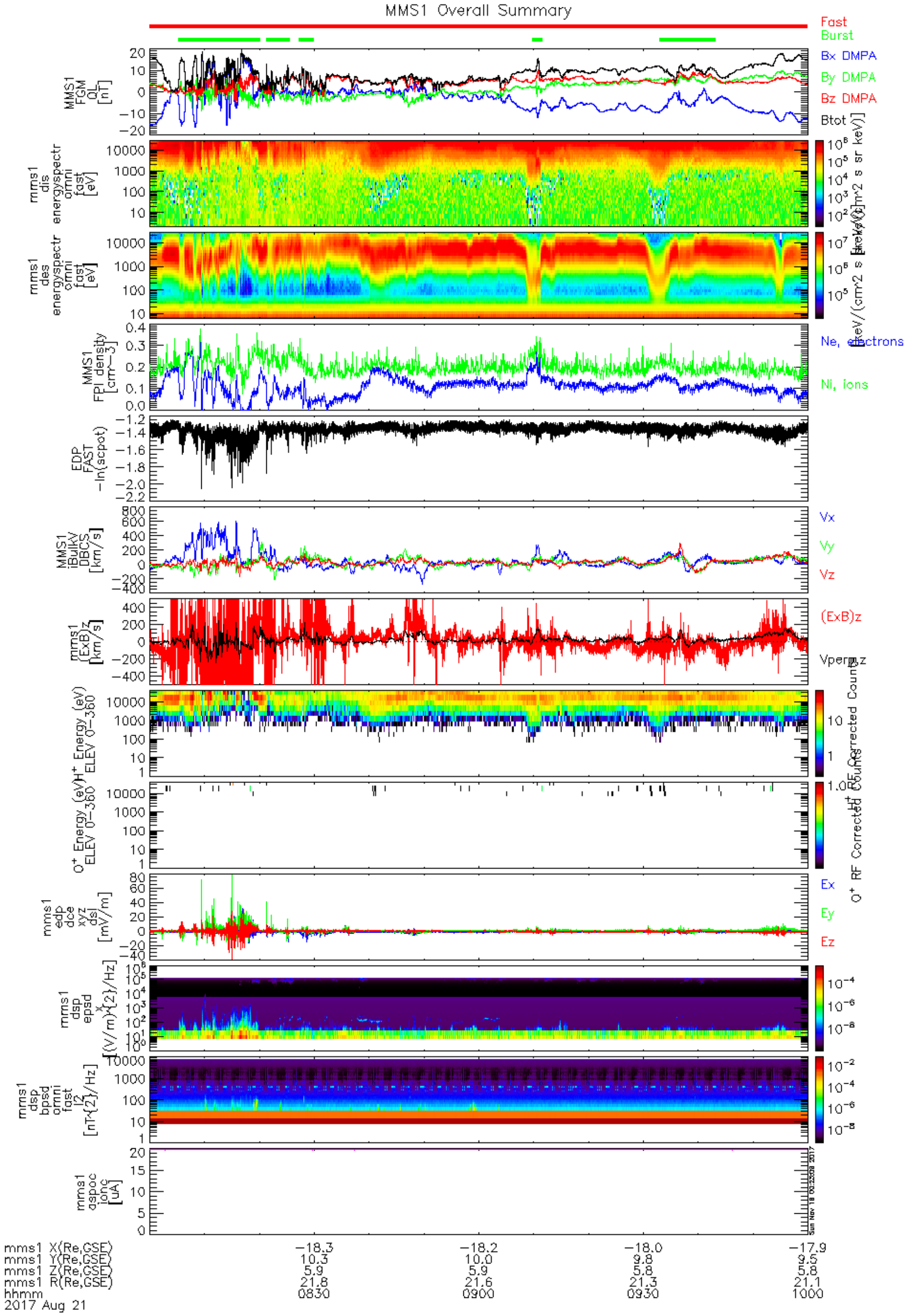


Strong Dream (1929) — Paul Klee

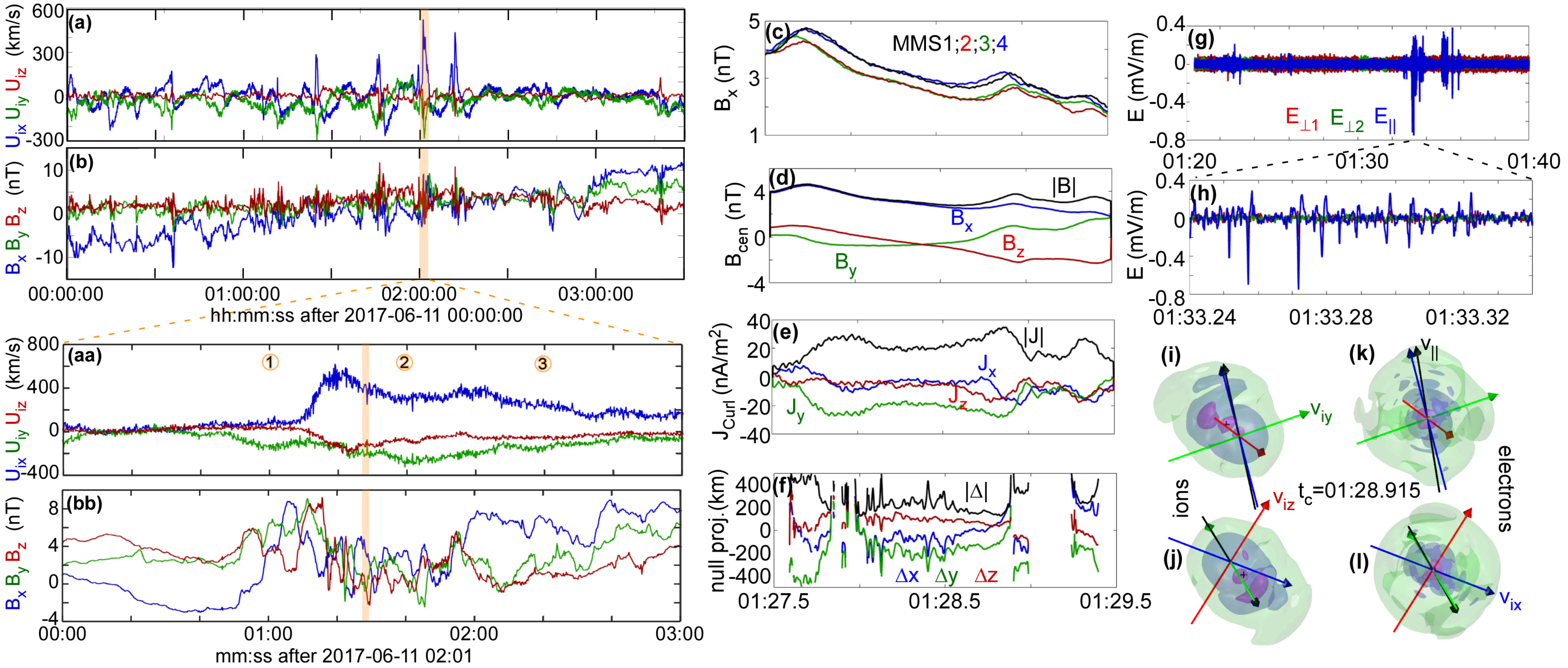
Observations form MMS

Look from MMS

- We (Stefan Eriksson) identified about 200 crossings in the tail that display turbulent reconnection outflows.
- Here is one example we analysed in more details:



Looking for null points within the turbulence



Conclusions

- Reconnection generates turbulence
  - **Fluctuations** are present all around
  - **Different regimes of fluctuations** in inflow, separatrices and outflow
  - **Fully developed turbulence** in the outflow
  - Waves of **different nature** in the inflow and outflow
  - Turbulence produces **secondary reconnecting layers**
- The impact of these processes is enhanced turbulent **energy exchanges**
- **Momentum** exchange is enhanced in the outflow primarily (anomalous transport)
- **MMS data** shows many turbulent outflows and within them null points can be detected