Wind QTN Measurements at Solar Wind Reconnection Exhausts

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Recent studies on QTN from WIND/WAVES data

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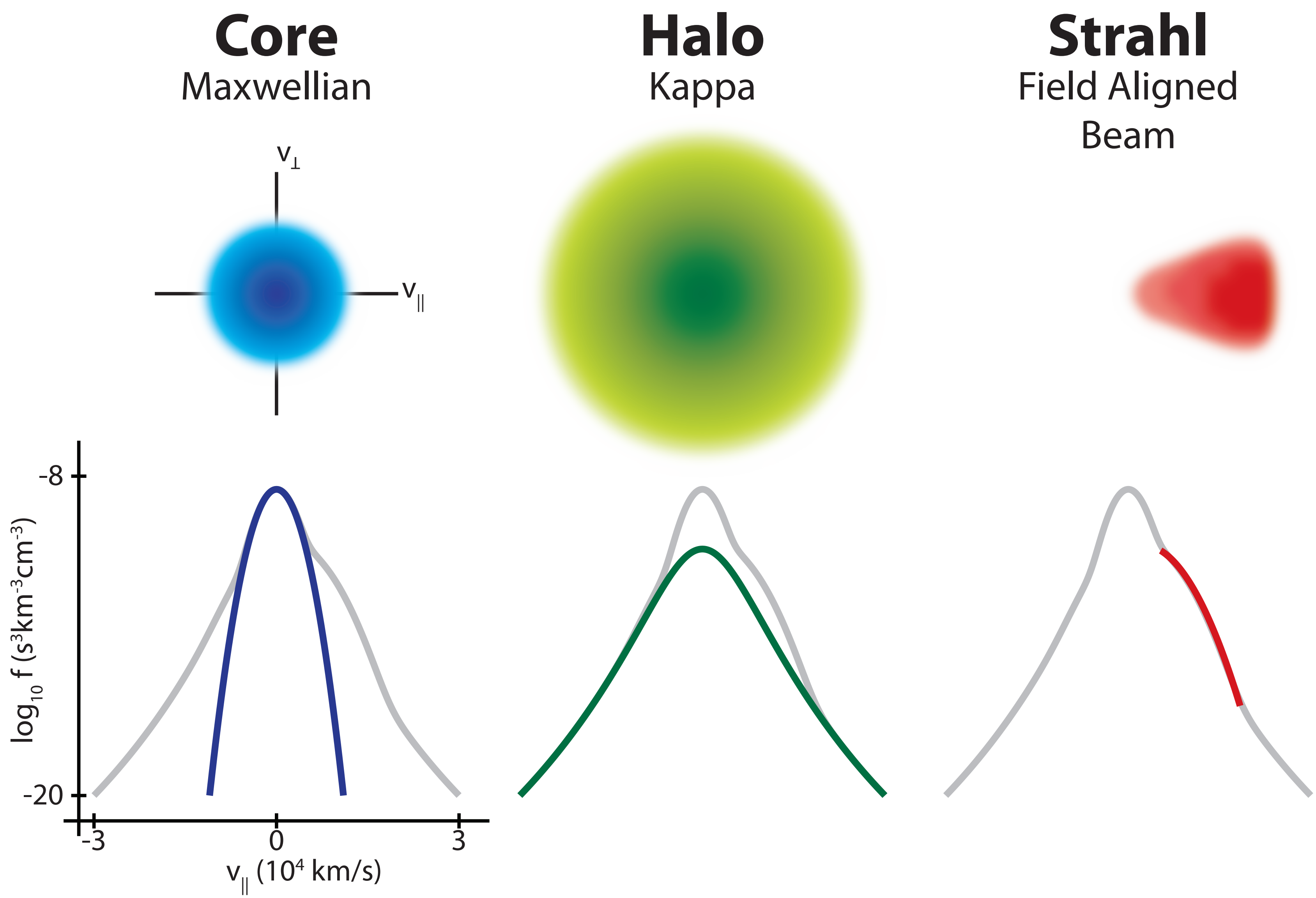
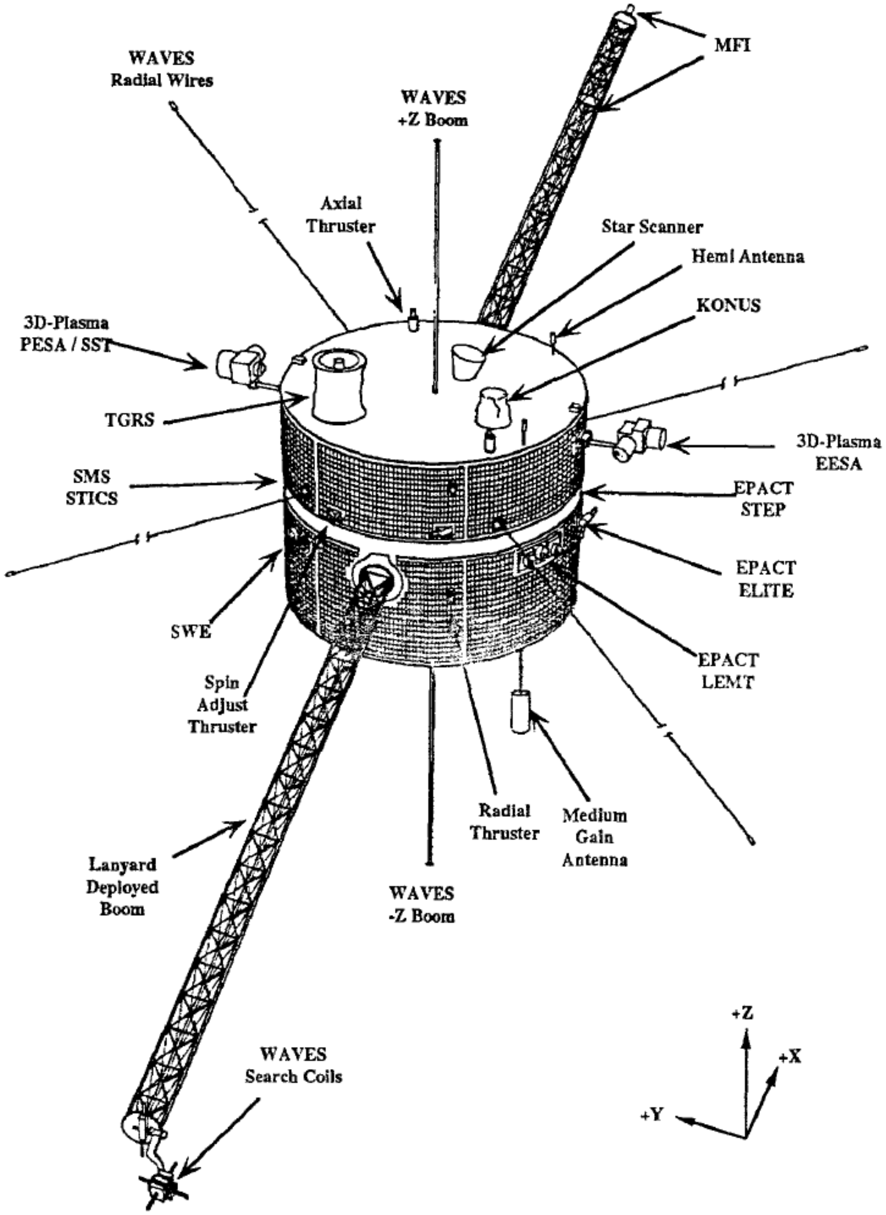
Solar wind electrons

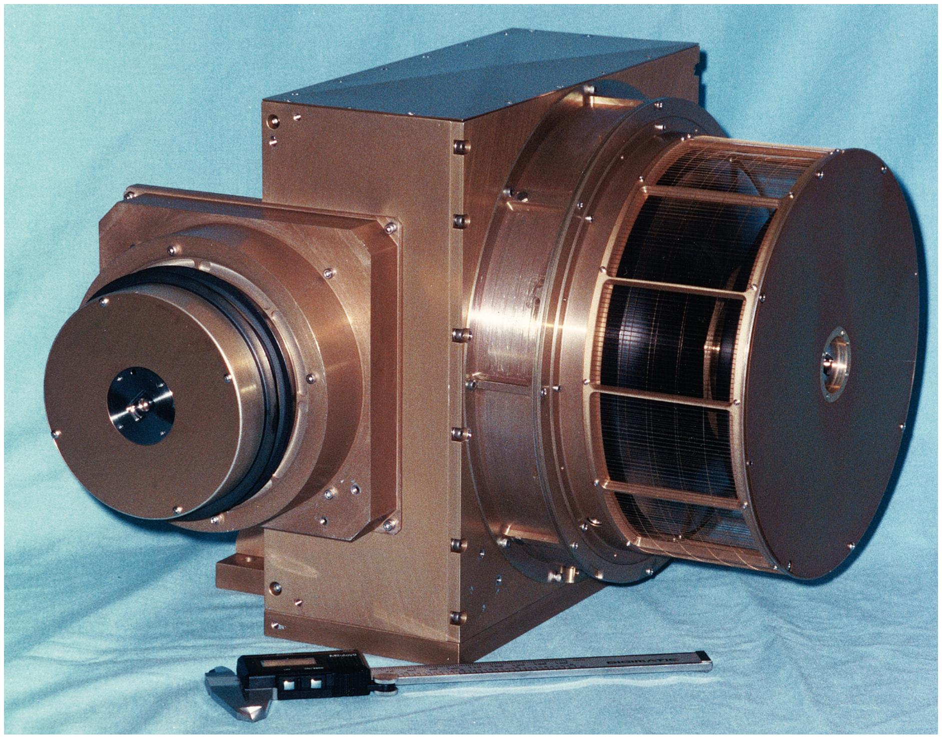


Wind spacecraft



- Launched in 1994 to study the solar wind
- Spinning spacecraft (spin period = 3 seconds)
- After years of various orbits, now parked at L1
- Full suite of plasma and wave measurements

Electron measurements with electrostatic detectors



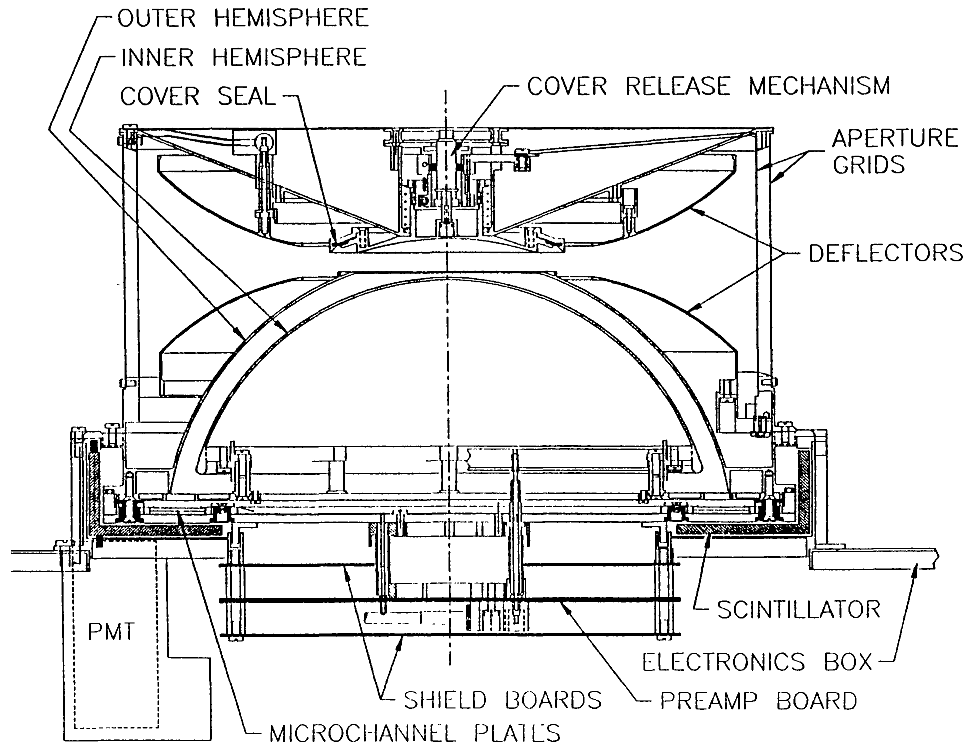
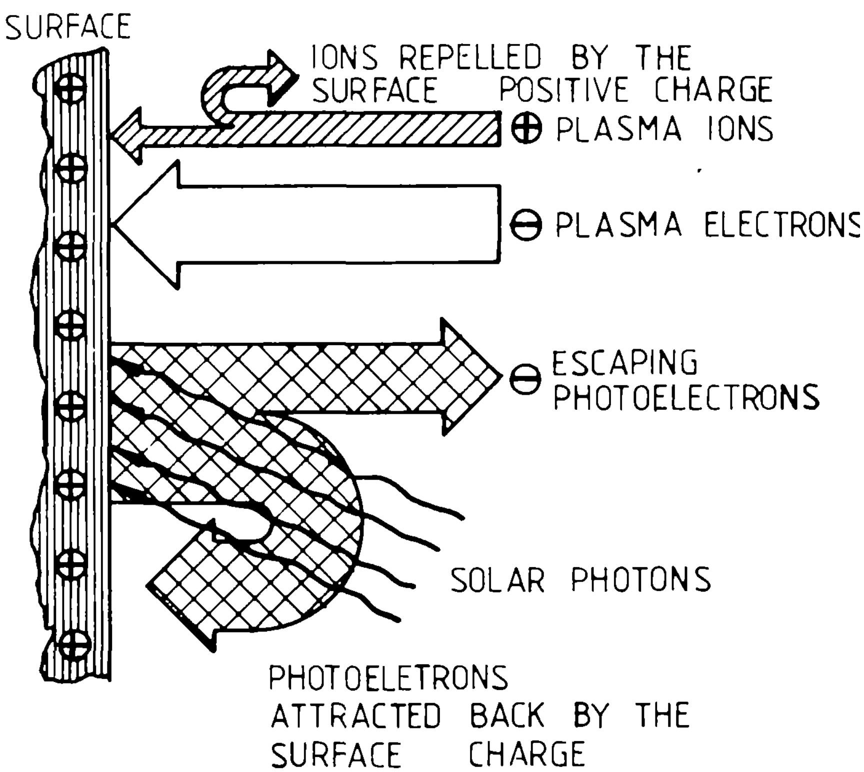


Fig. 7. Cross section of the EESA–H analyzer, showing the electrostatic deflectors.

Lin et al. (1995)

- Wind electrostatic analyzers (EESA-L and EESA-H)

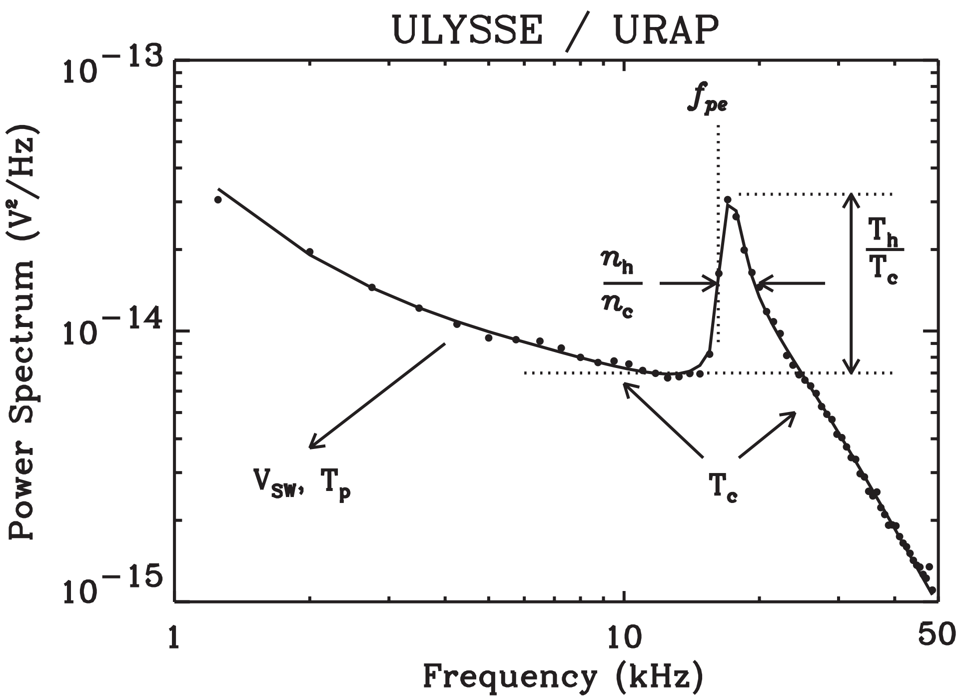
Electron fitting and Spacecraft potential

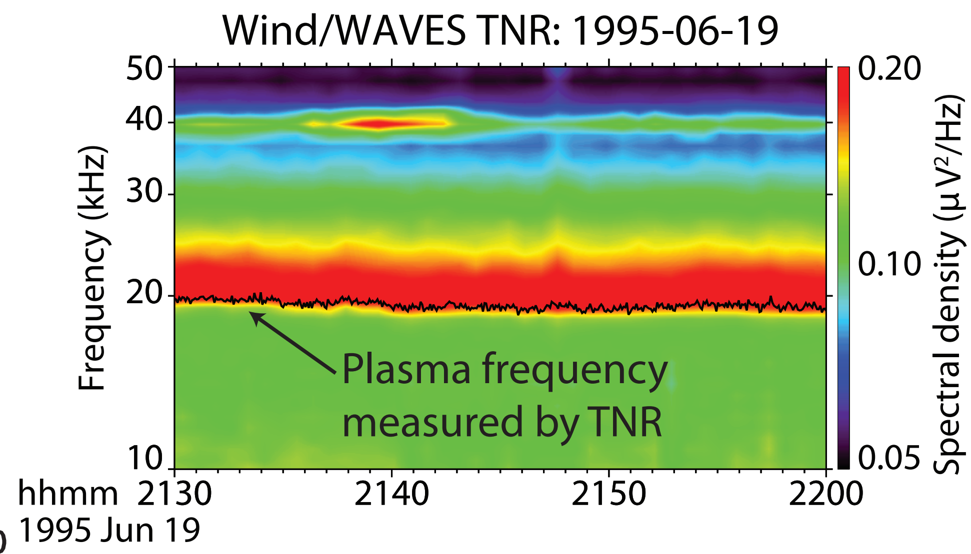


Grard et al. (1983)

- Using the electrostatic electron detectors from the Wind/3DP instrument suite, we have generated a database of quiet time solar wind core/halo/strahl electron measurements.
  - Combined EESA-L and EESA-H to cover broad energy range
  - Fit to Maxwellian core and κ distribution halo, with strahl parameters computed as moments. Measured parameters: density, parallel and perpendicular temperature, drift velocity parallel to magnetic field, heat flux
  - Corrected for spacecraft potential using reference densities measured by Wind/WAVES Thermal Noise Receiver

Electron Measurements with Electric Field Instruments



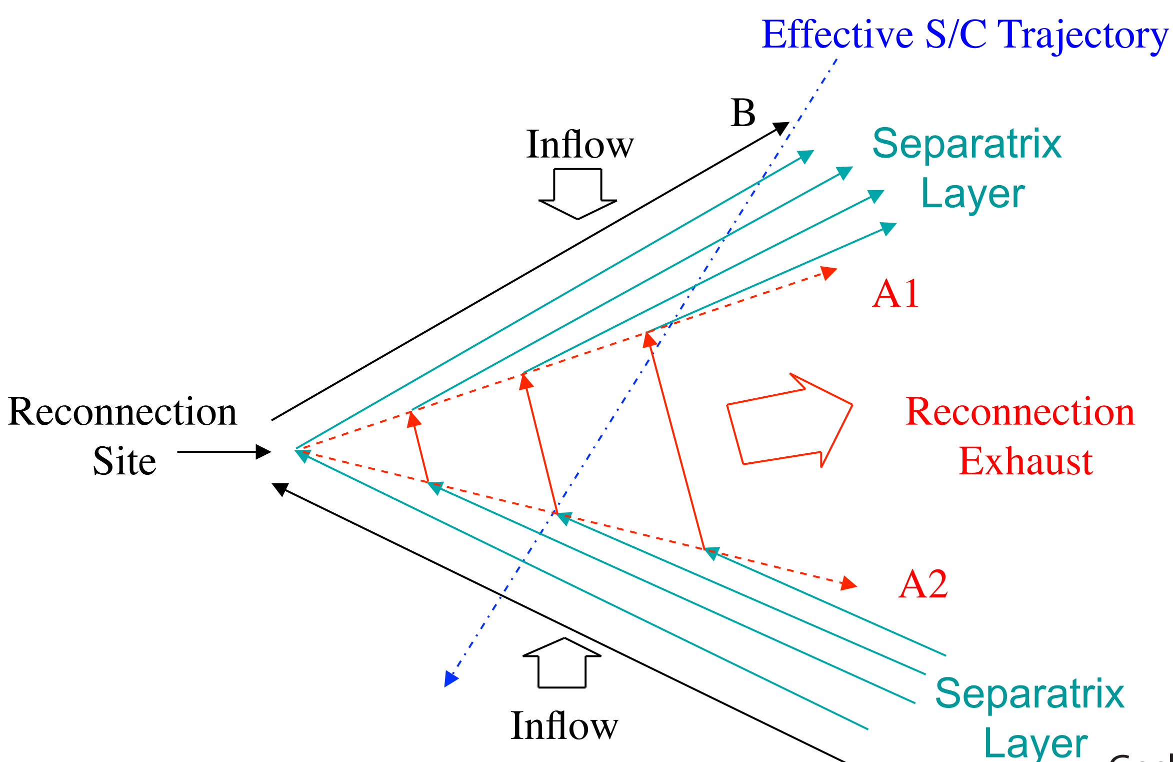


Issautier et al. *2001*

- Plasma peak = electron density
- Thermal noise spectrum also offers measurements of several other in situ parameters

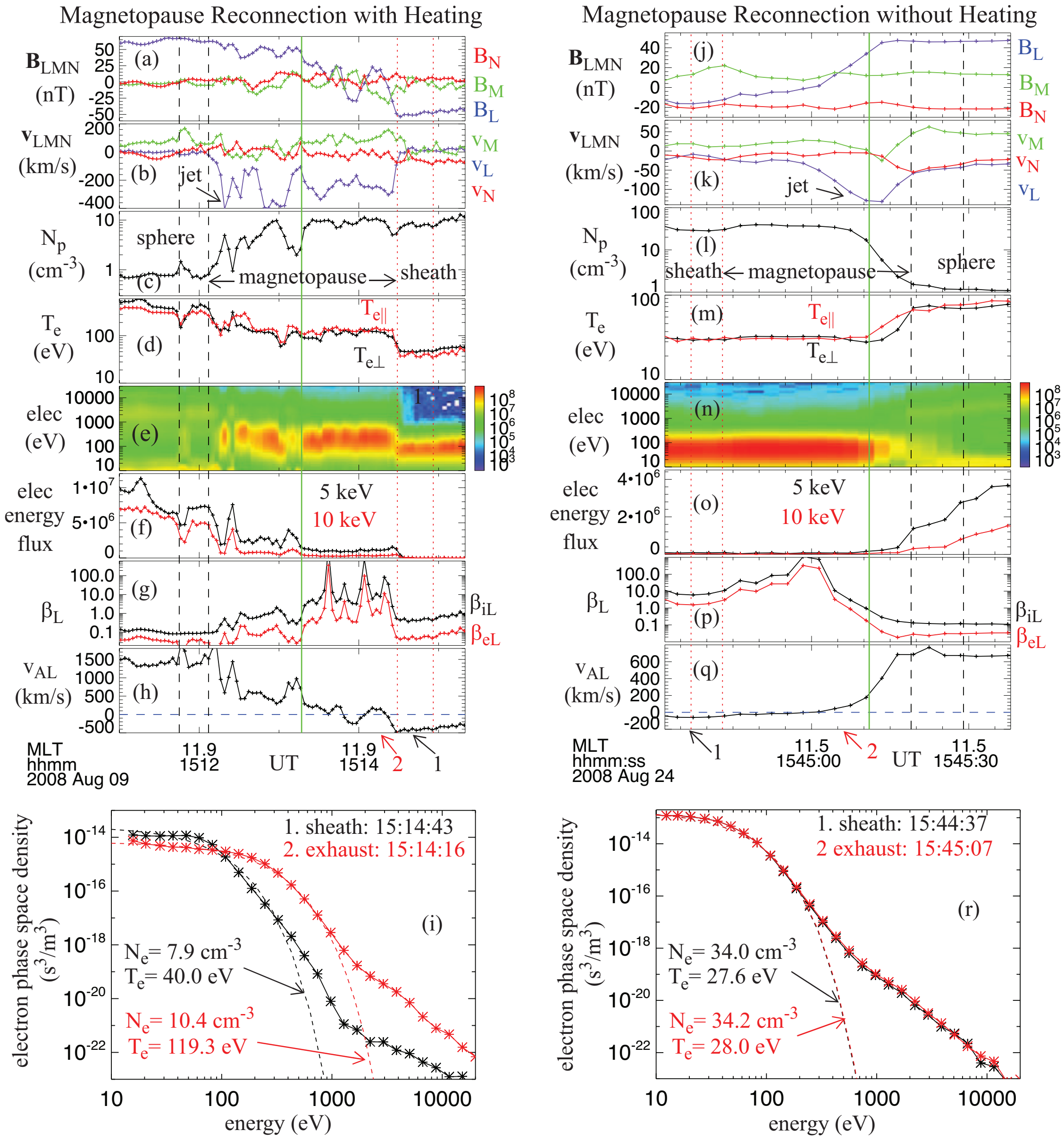
Solar Wind Reconnection: context

- **A recent study of *magnetopause* reconnection (Phan et al., GRL 2013) has established a relation between the inflow Alfvén speed and electron heating.**



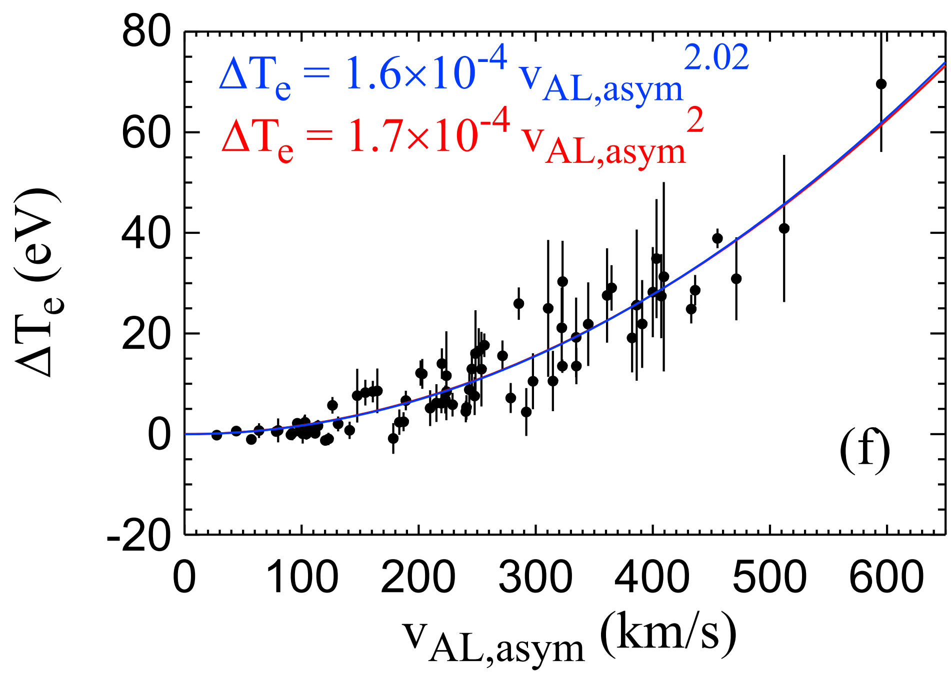
Gosling 2012

Electron heating in reconnection exhausts



- THEMIS observations of electron heating (left) and no electron heating (right) in magnetopause reconnection.
- Phan et al. (2013) surveyed 79 magnetopause reconnection events.

Dependence of heating on Alfvén speed

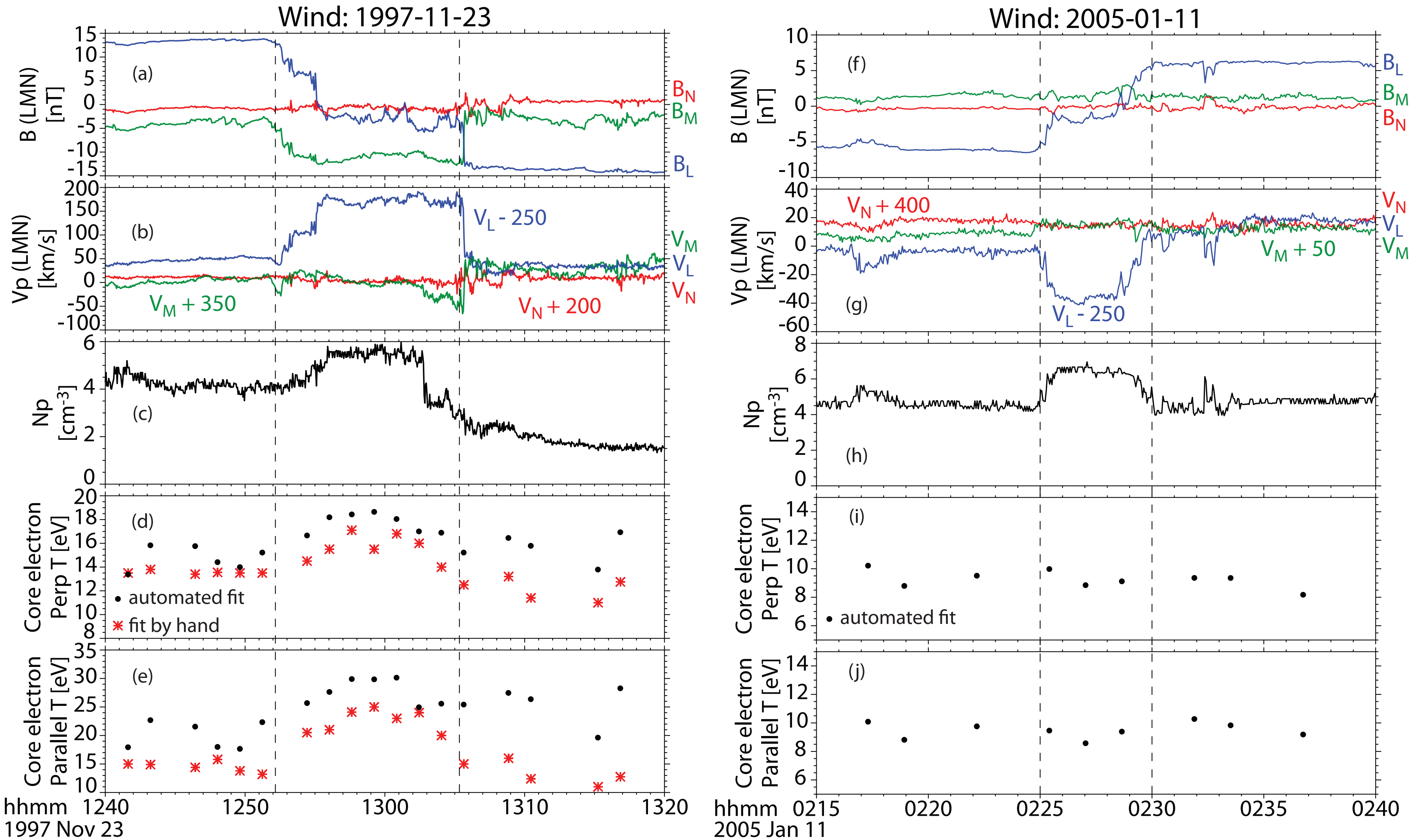


$$\Delta T_e = 0.017\, m_i V_{\mathrm{A,asym}}^2$$

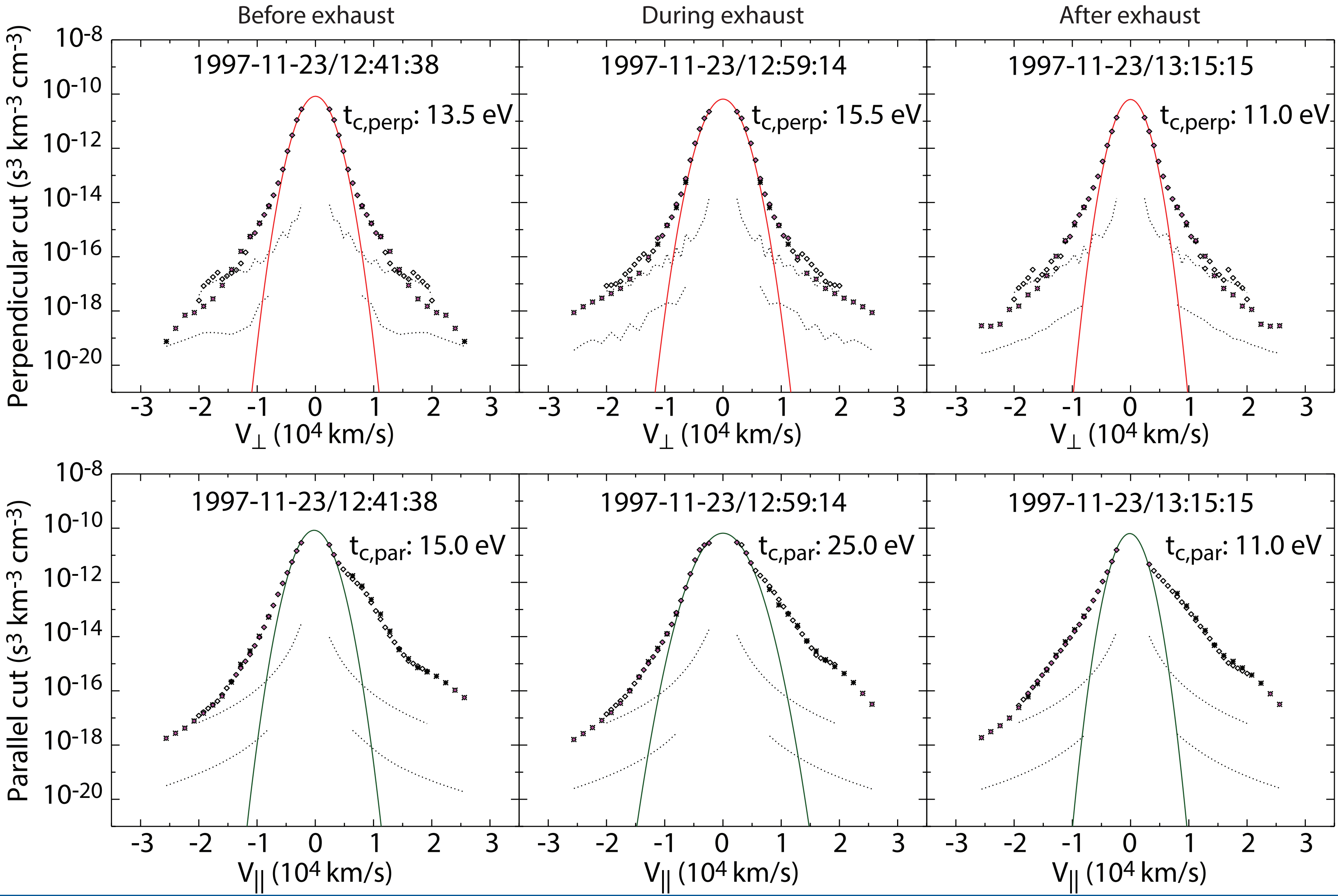
$$V_{\mathrm{A,asym}} = \sqrt{\frac{B_{\mathrm{L1}} B_{\mathrm{L2}} (B_{\mathrm{L1}} + B_{\mathrm{L2}})}{\mu(\rho_1 B_{\mathrm{L2}} + \rho_2 B_{\mathrm{L1}})}}$$

- Result from Phan et al.: Electron heating proportional to the asymmetric Alfvén speed
- Roughly 1.7% of inflow magnetic energy goes into thermal electron heating

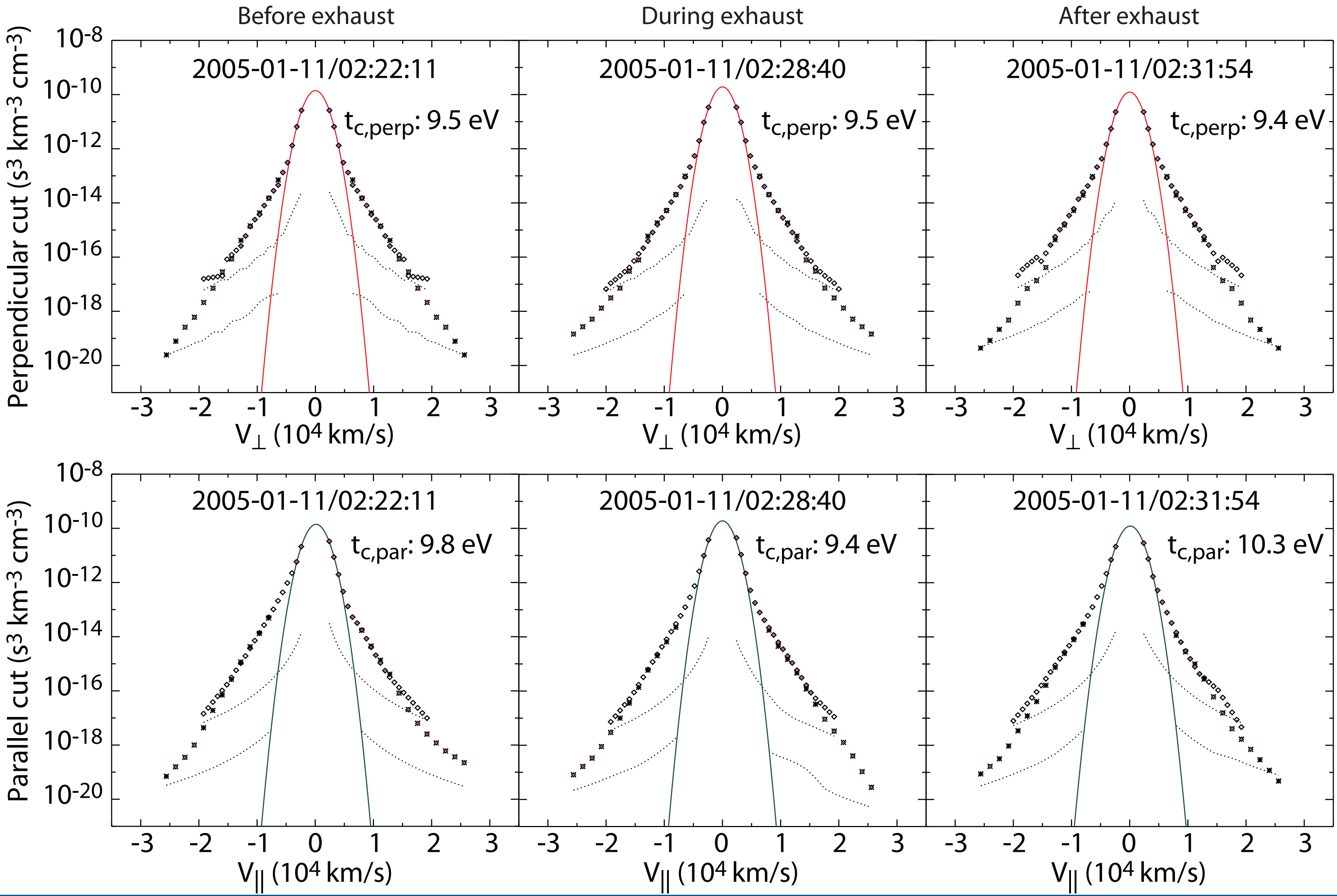
Reconnection in the Solar Wind



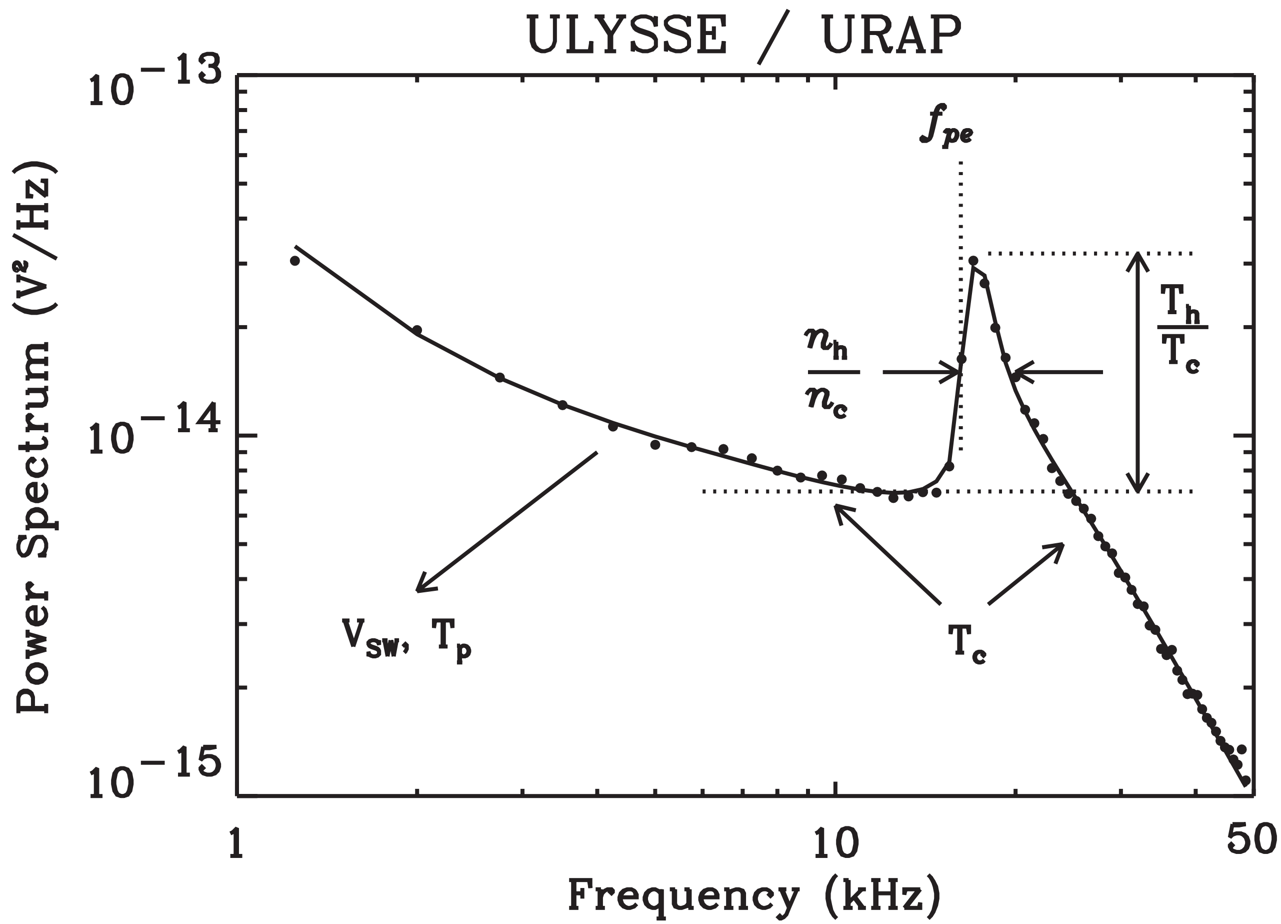
Electron distributions (event with heating)



Electron distributions (event with no heating)



Thermal Noise as a Plasma Diagnostic



Issautier et al. *2001*

- Plasma peak = electron density
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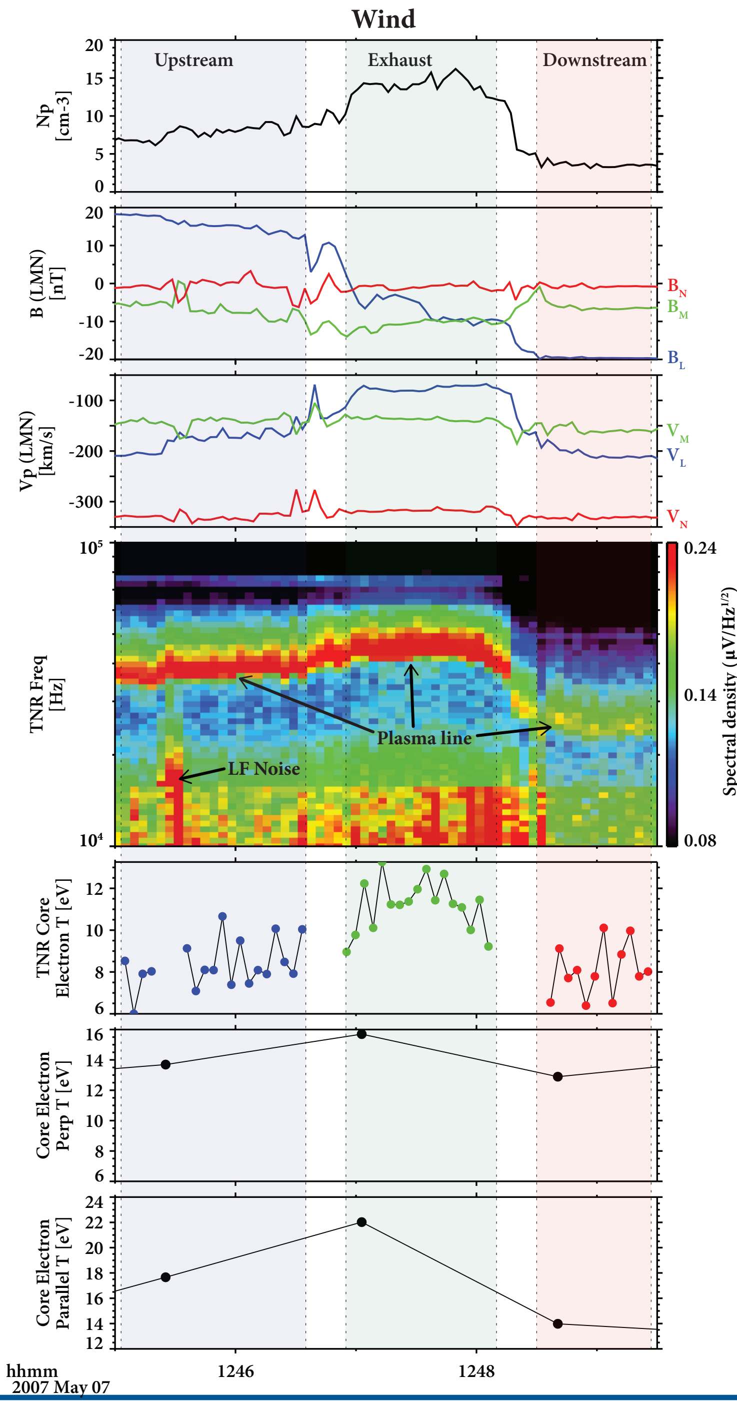
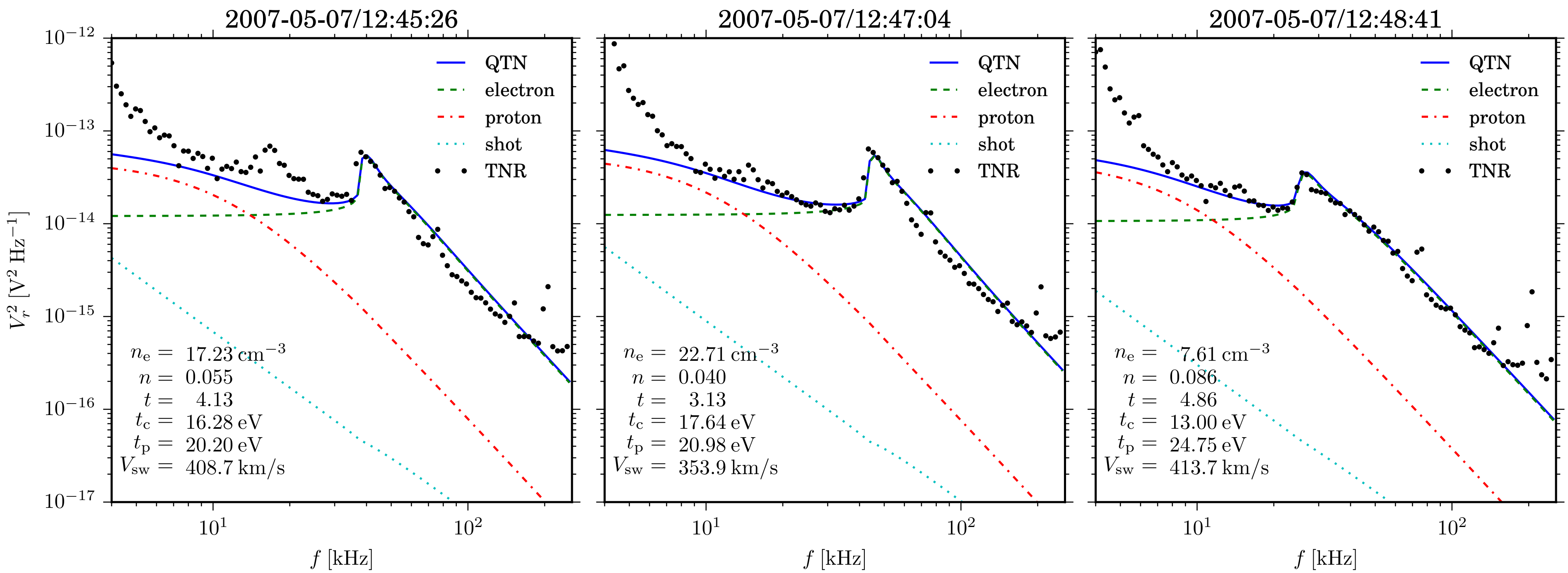
Thermal Noise Measurements in Reconnection Exhausts

- Many solar wind reconnection exhausts are short in duration, so there are not many full eVDF observations (cadence = 45/90 seconds) during the exhaust).
- For these events, we can use ther thermal noise spectrum to find parameters of the eVDF (see right, below).



Comparison of measured and theoretical spectra



- Computed QTN spectrum using thermal and suprathermal parameters from the eVDF fits
- Comparison to measured TNR spectra (not fits!)
- Effective length used is 30 m (after Wind antenna break, how does this affect the spectrum?)

Core temperature from QTN spectra

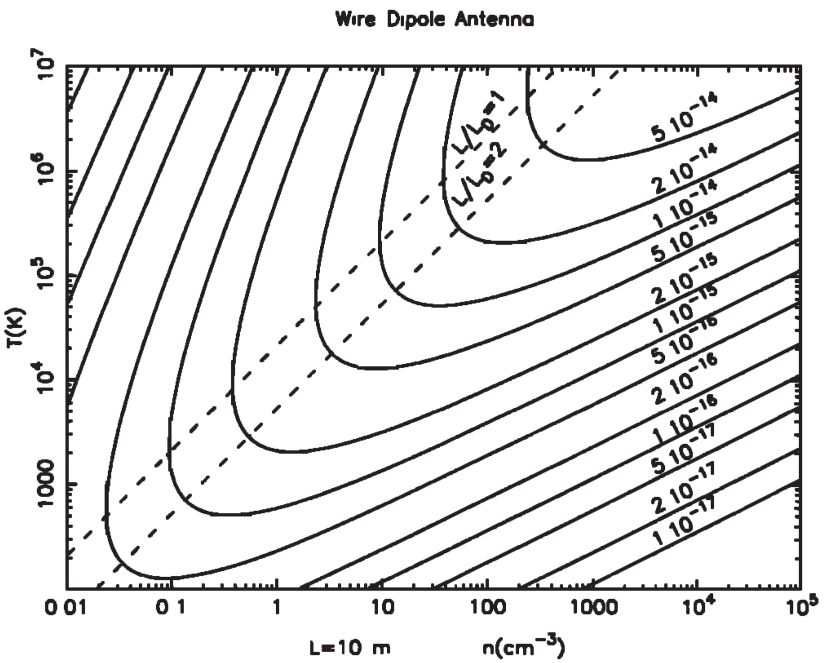
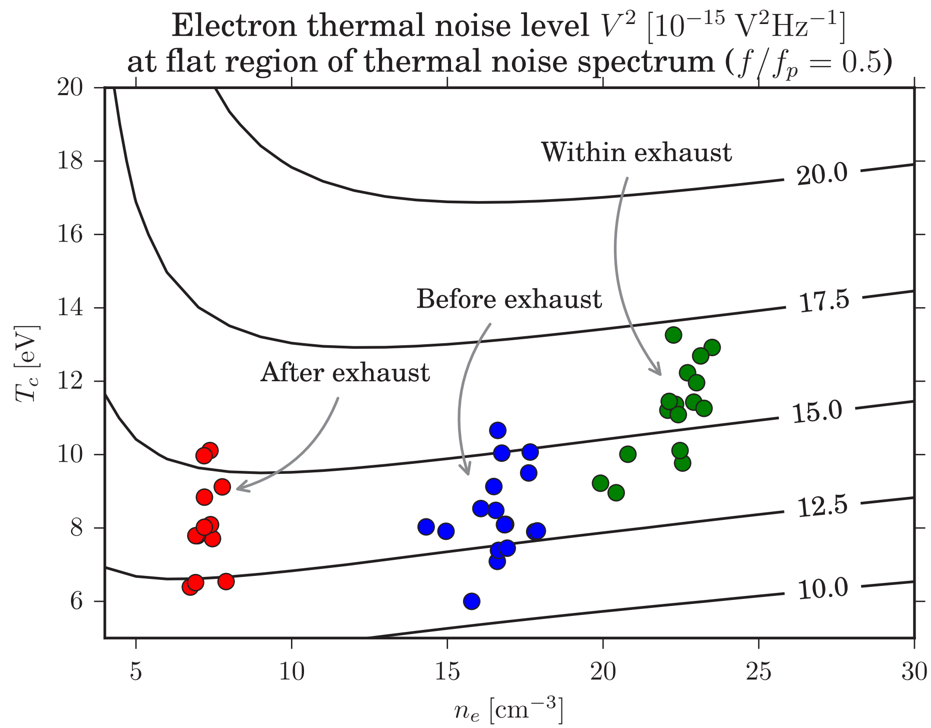


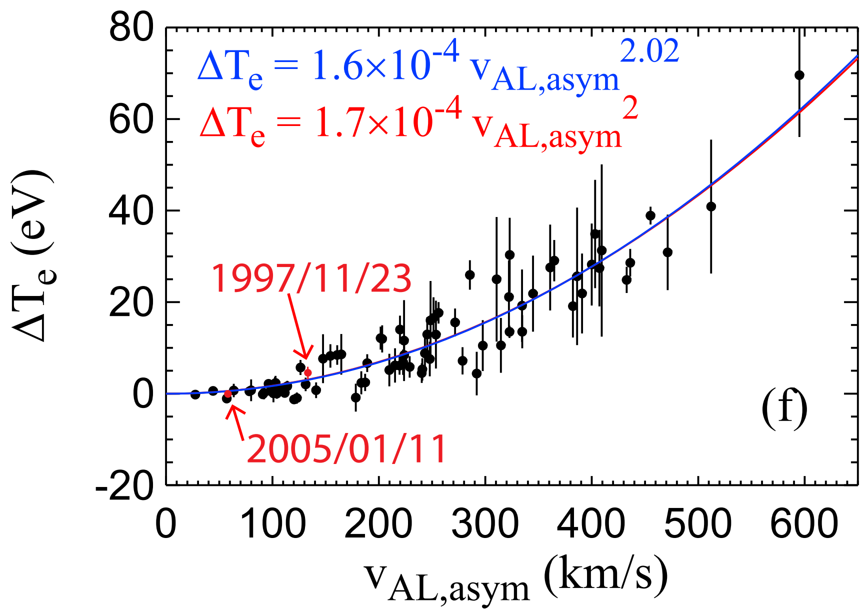
Fig. 4. Thermal noise level (V^2 in V^2Hz^{-1}) for $f/f_p = 0\cdot5$ where the spectrum is nearly flat, as a function of the plasma density and temperature, for a thin wire dipole antenna

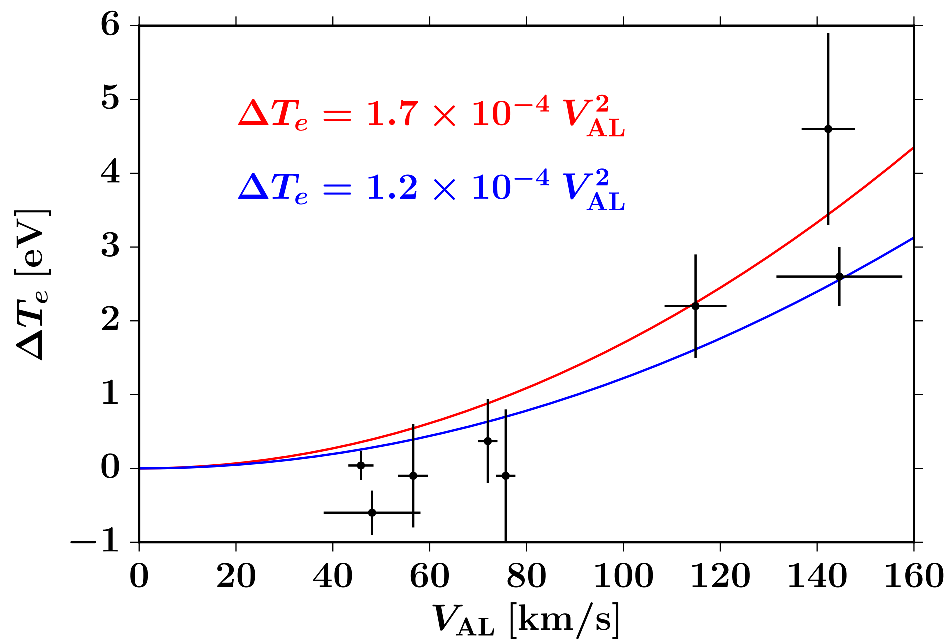


- Using method described in the tool kit paper, generated contour plot of n vs. Tc
- Result shows enhancement of temperature inside the reconnection region, as we saw previously in the longer duration exhausts

Quantitative comparison w/Phan et al.

- **1997 event:**
  - Predicted heating: 3.2 +/- 0.6 eV
  - Observed heating: 4.6 +/- 1.3 eV
- **2005 event:**
  - Predicted heating: 0.6 +/- 0.1 eV
  - Observed heating: -0.1 +/- 0.7 eV





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