Open Questions in Plasmaspheric Composition, Wave Propagation, and Plasmapause Detection

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Things we know

Plasmasphere is a dense torus of cold plasma with a temperature of ~ 1eV (Lemaire,1998)

The Plasmapause marks the boundary of the plasmasphere, appears as a kink in the plasma density profile (Carpenter, 1966)

Plasma waves propagate through and are distorted by the plasmasphere (i.e. chorus waves -> Plasmaspheric Hiss, Bortnik et al., 2008)

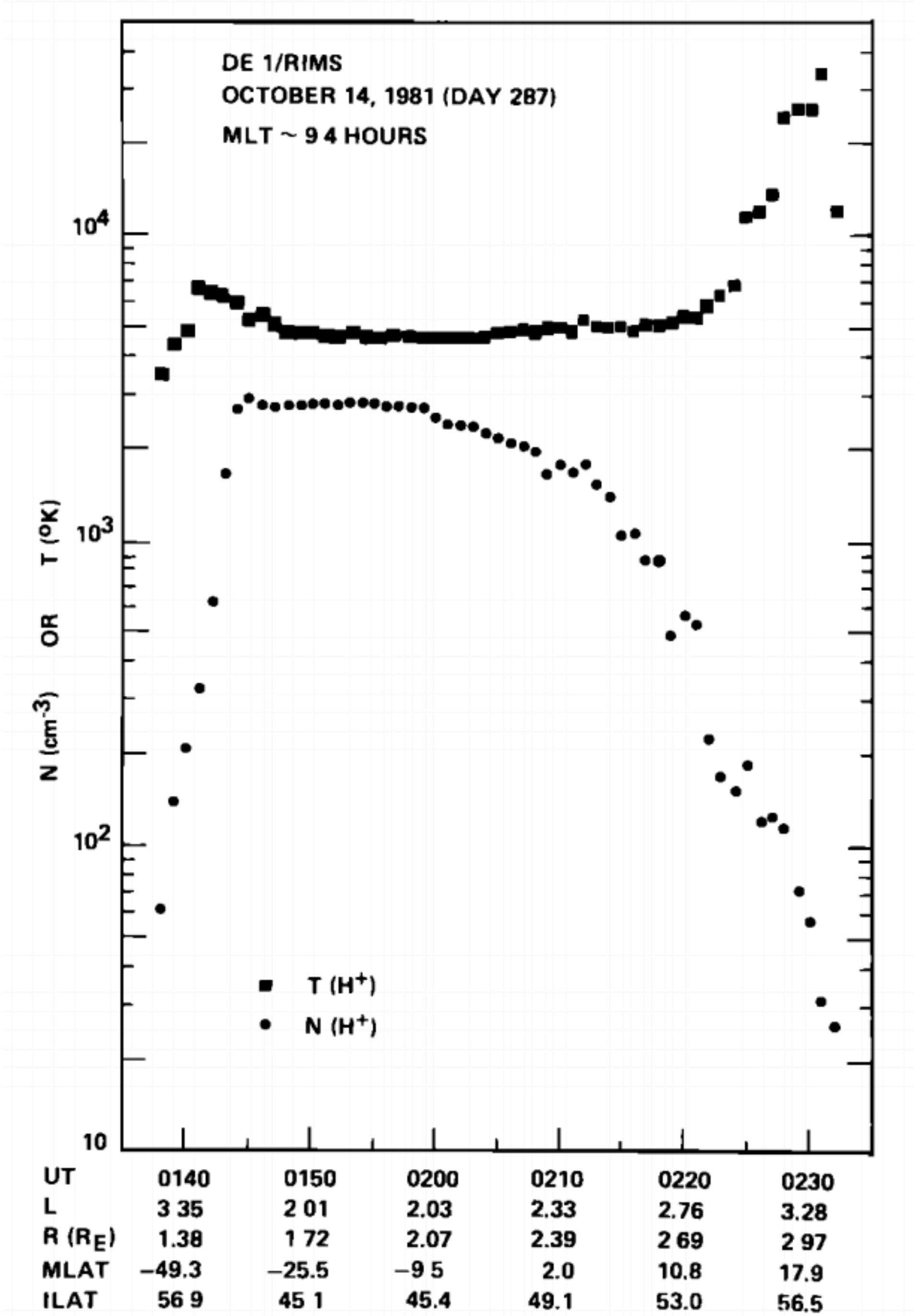
Things we wish we knew

What does the temperature profile of these ions look like? Is there diurnal variation?

What is the best method for determining the plasmapause?

Do waves interact with the core plasmasphere?

When is the plasmasphere ion population a controlling factor in the magnetospheric system?



From Comfort 1985, DE-1 RiMS data

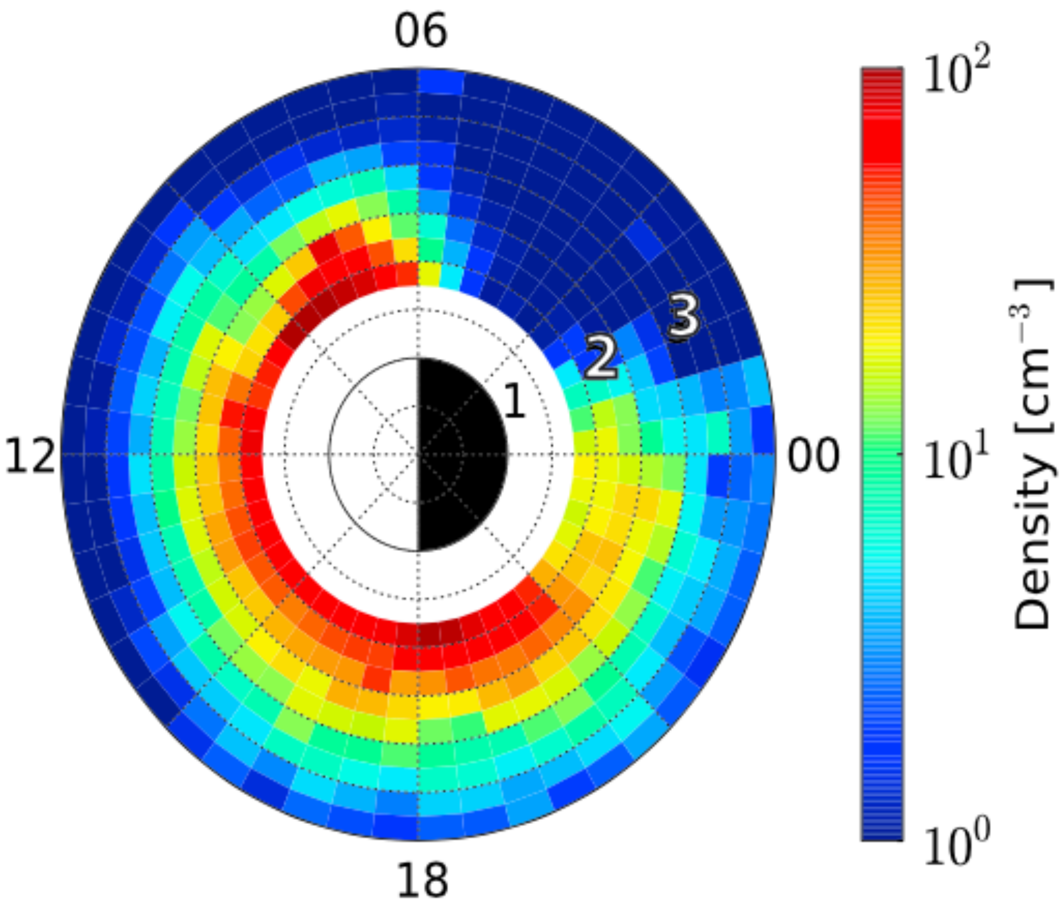
Observational results show quick passes which fail to capture the full distribution

How much does 10 eV contribute to the core plasmasphere temperature vs 0.5 eV?

Possible Resolution: We need a spacecraft mission with excellent s/c charging control that can measure low energy ion fluxes in the plasmasphere

From this, we can calculate ion composition and temperature distribution profiles throughout the inner plasmasphere instead of Gaussian fits and guesses

Why?



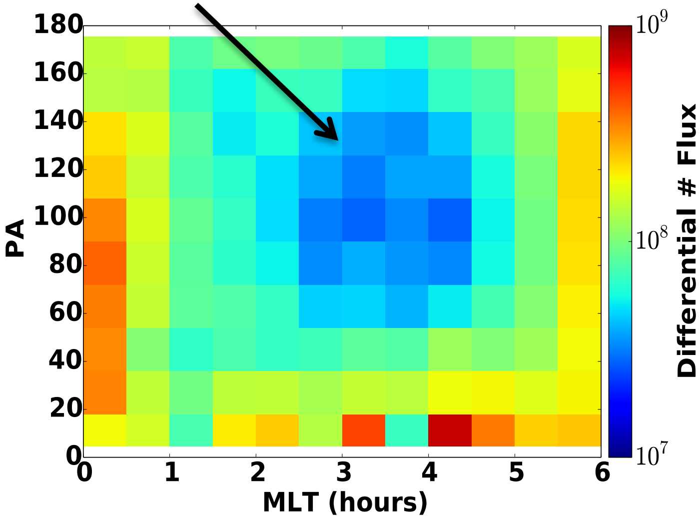
Sarno-Smith et al., 2015

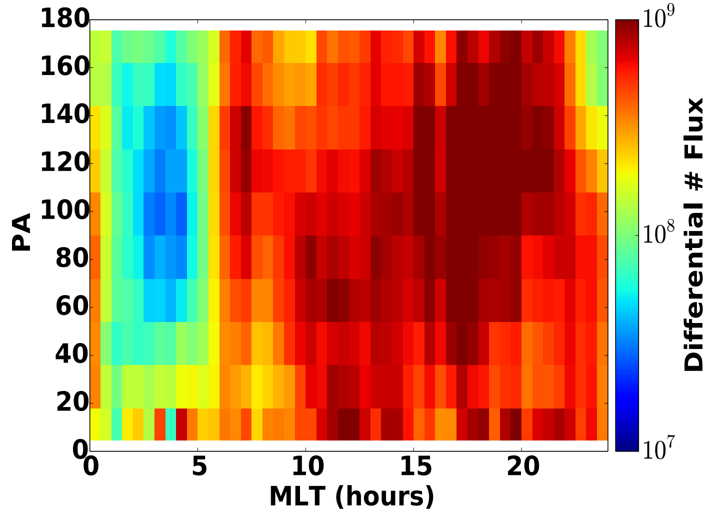
Van Allen Probes HOPE showed us that 1-10 eV ion partial density shows diurnal variation with large drop out in post-midnight sector

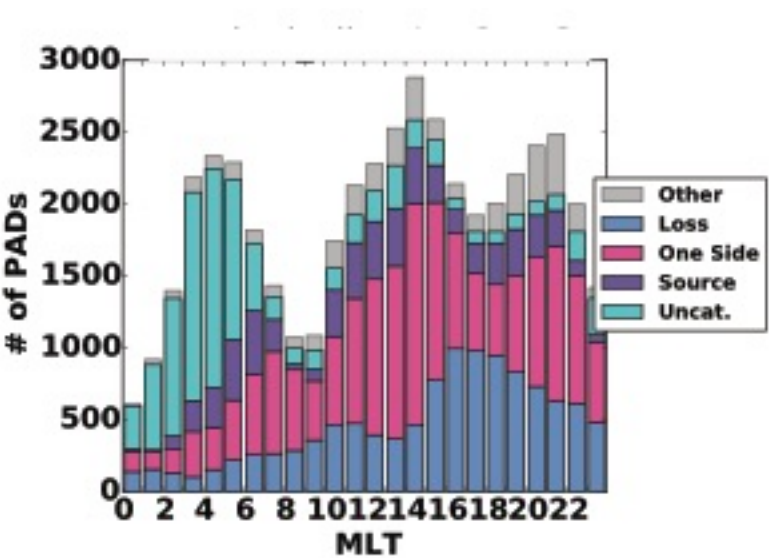
But what about the energies below that?

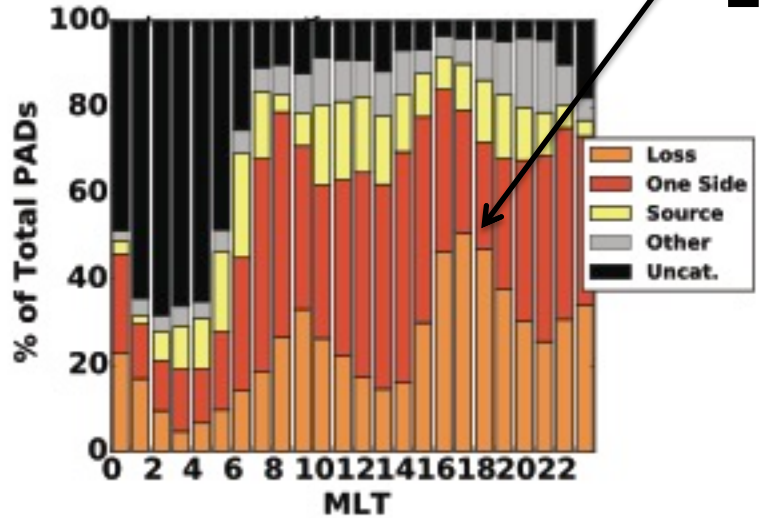
Looking at the Pitch Angles

Trapped Population Gone









Enhanced Dusk Sector Loss Cone

Plasma Wave - Core Plasma Interaction

Low-energy He^+ and H^+ distributions and proton cyclotron waves in the afternoon equatorial magnetosphere

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Although discussing 10 eV to 50 eV in this paper in the outer plasmasphere (L > 4), what makes us think that these waves can't resonate with core plasma?

$$\omega = \frac{\Omega_i}{n} \qquad (n = 2, 3, 4, , , ,)$$

Ω_i = cyclotron frequency

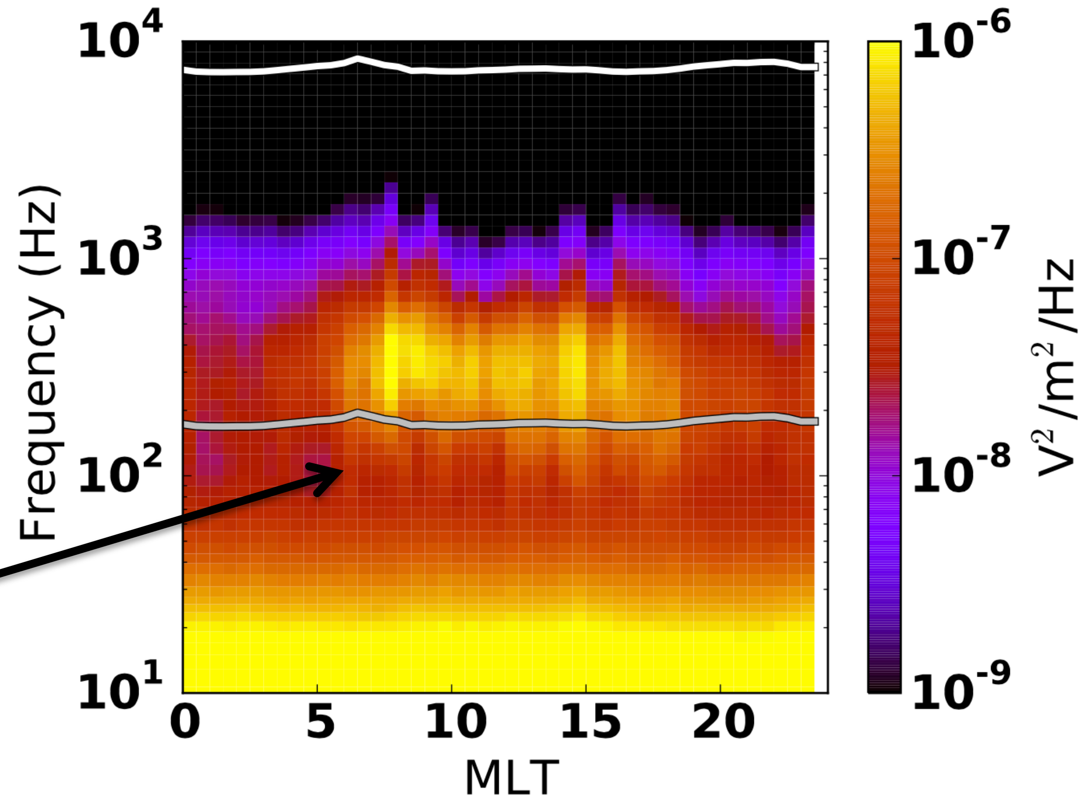
ω = wave frequency

n = harmonics

So at L = 2, B is approximately 2000 nT

so q B/m ~ 200 Hz

We see a peak in magnetosonic waves at L=2 on the dayside from RBSP



Based on heating rates…

$$\frac{dW}{dt} = \frac{1}{2}\frac{q^2}{m}\psi$$

W = Perpendicular Energy
q= charge
m = mass
ψ = wave amplitude

From Singh et al., 1987

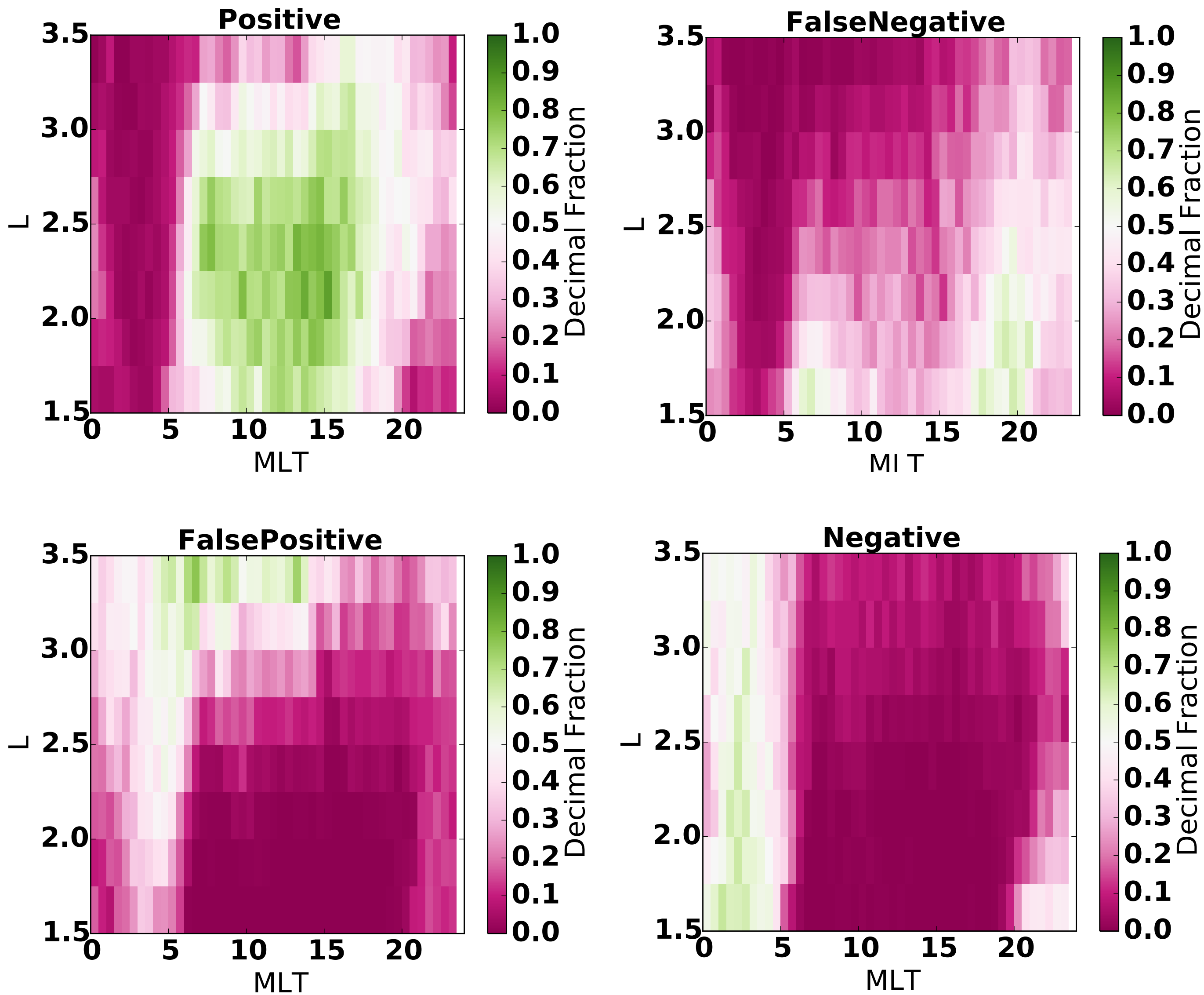
We expect a dayside heating rate for an ‘average’ intense magnetosonic wave (1e-11) to be 0.75 eV/1000 seconds

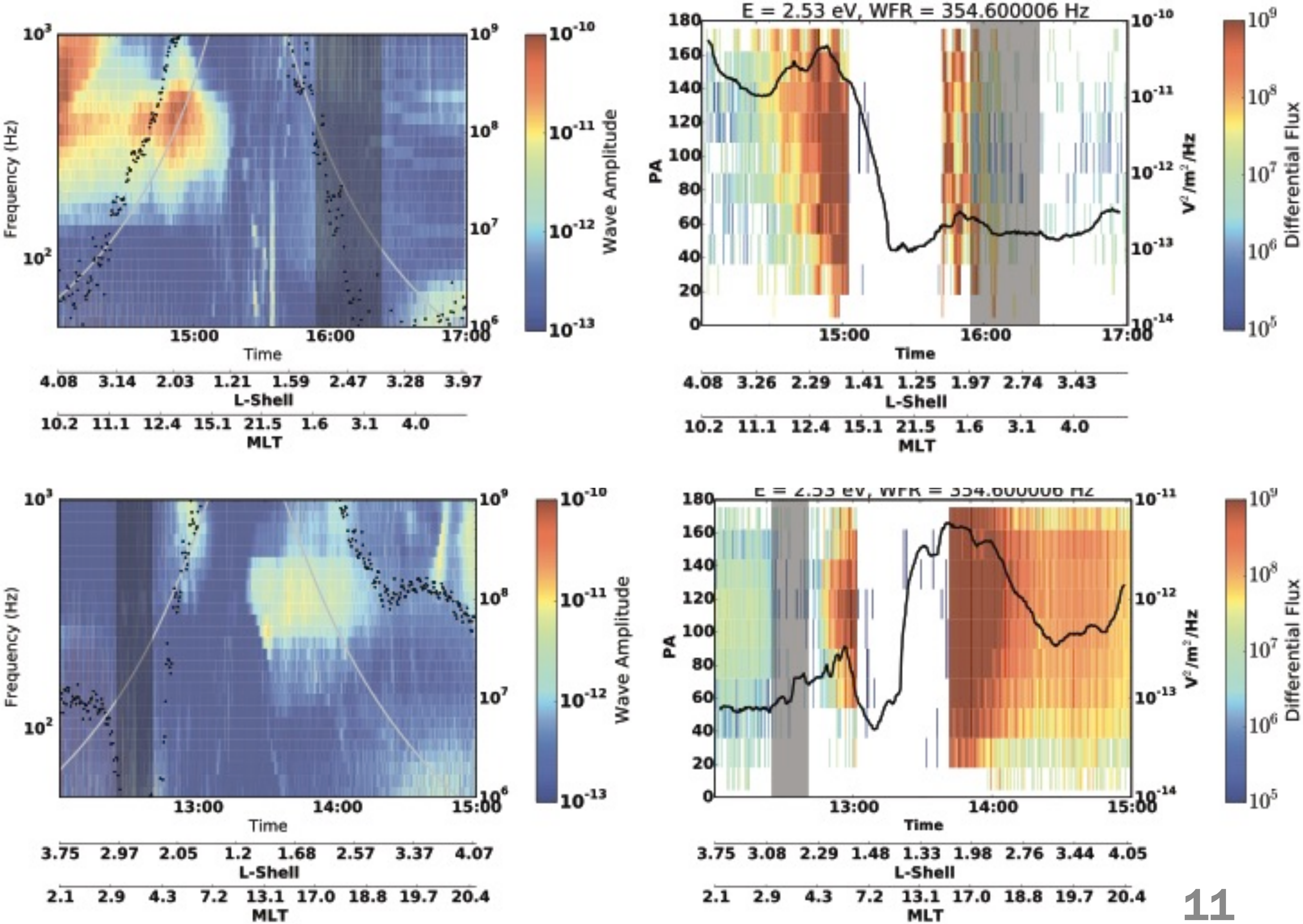
→ This will heat the core plasmasphere and generate a dayside suprathermal ion population

High Wave | **Low Wave**

High Particle

Low Particle




E = 2.53 eV, WFR = 354.600006 Hz
Frequency (Hz)
Time
L-Shell
MLT
Wave Amplitude
PA
V²/m²/Hz
Differential Flux
15:00
16:00
17:00
13:00
14:00
4.08 3.14 2.03 1.21 1.59 2.47 3.28 3.97
4.08 3.26 2.29 1.41 1.25 1.97 2.74 3.43
10.2 11.1 12.4 15.1 21.5 1.6 3.1 4.0
3.75 2.97 2.05 1.2 1.68 2.57 3.37 4.07
3.75 3.08 2.29 1.48 1.33 1.98 2.76 3.44 4.05
2.1 2.9 4.3 7.2 13.1 17.0 18.8 19.7 20.4

What's still unresolved here?

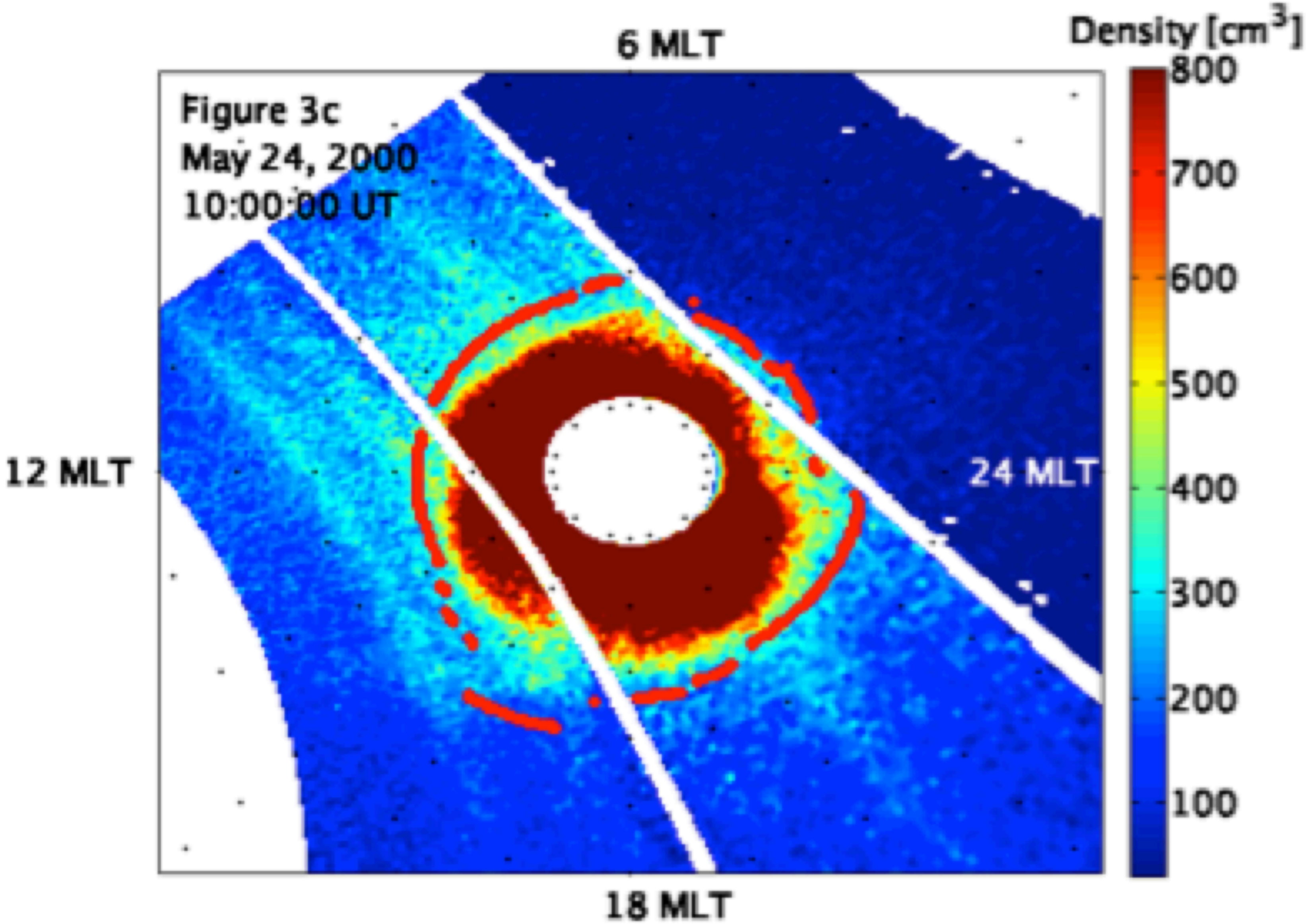
Exploring wave-particle interactions with core plasma, both ions and electrons

Looking at the implications of suprathermal heating of core plasma for wave propagation, etc.

Determining scattering rates of these particle populations across the night-side when the wave activity is lower

Current Methods for Determining Plasmapause

1. Last Equipotential Boundary between corotating and convecting plasma [Parks 1991]
2. Specific density value [Chappell, 1970,1974]
3. Specific density drop [Moldwin, 2002]
4. Visually defined gradient in EUV intensity [Goldstein, 2002, 2003]
5. Using Kp to define a radial extent of plasmasphere [Carpenter and Anderson, 1992]
6. Equatorial density maps as a function of Kp [Larsen, 2007]
7. Radial distance with sharpest density drop as a function of MLT [Katus, 2015]



Katus et al., 2015 automated plasmapause method

Open Questions in Plasmapause Detection

Storm-time convection makes plasmapause detection difficult – which is the best method to use during storm time?

Would using multiple satellites/models for a total comparison reveal strengths/weaknesses of each approach?

What is the best approach for detecting the plasmapause in missions like Van Allen Probes?

Summary

How to make the best possible thermal plasma measurements?

How do plasma waves interact with low energy particles?

How to best describe where the plasmapause is?