

Thermal energy distribution of electrons in the mid-latitude ionosphere

Group 1

*Racheal Athieno, M Hasan Chowdhury, Ian Cohen,
Mohsen Ghezlbash, Joshua Smith*

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Outline

- **Review**
- **Experiment Theory**
- **Results**
- **Analysis**
- **Conclusions**
- **Craig Captioned**

ISR Review

- Free e^- in ionized medium scatter radio waves
- ISR: radar pulses scatter off electrons in ionospheric plasma creating an incoherent scatter return
- ISRs can:
 - ✓ measure $N_e(z,t)$ and $T_e(z,t)$ out to several R_E
 - ✓ measure auroral ionization
 - ✓ detect transient streams of charged particles coming from space

Review of Auroral

- Accelerated particles with energies of 1-10s keV (e^-) and 10-100 keV (p^+)
- Particles can penetrate as far as 100 km altitude, colliding with multiple atmospheric molecules along the way
- These molecules eventually relax back to the ground state by emitting photons
 - green emission from oxygen
 - red/blue emission from nitrogen

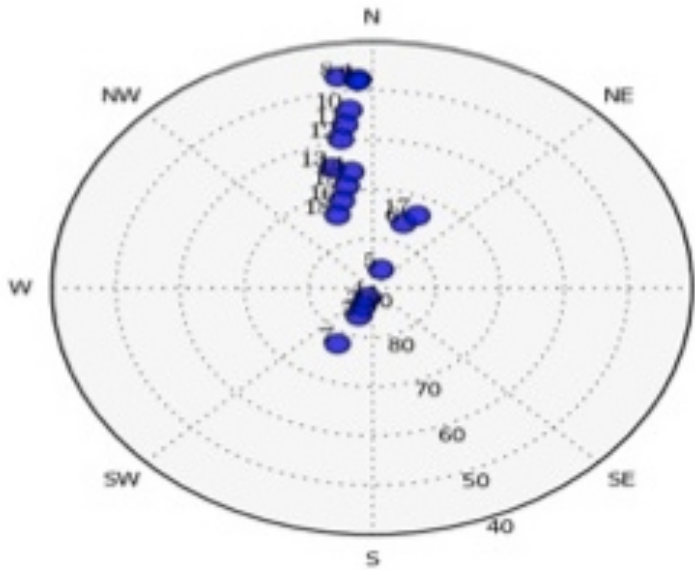


(Credit: ESA/G. Marklund)

Experiment Objectives

- Collect electron data (T_e , N_e) at 24 locations along four different mid-latitude magnetic field lines near PFISR
- Calculate the thermal and kinetic energy profiles of the incident auroral electrons across these field lines
- Analyze and interpret these energy distribution profiles

Geometry



$L=6.46$

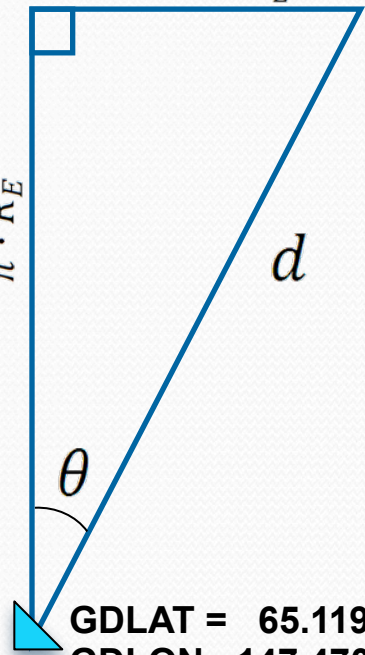
$L=6.26$

$L=5.88$

PFISR

$$\theta_y = \frac{180 \cdot d \cdot \sin \theta}{\pi \cdot R_E}$$

$$\theta_x = \frac{180 \cdot d \cdot \cos \theta}{\pi \cdot R_E}$$



GDLAT = 65.119° N
GDLON = 147.470° W

***Geometry does not allow support from other radars/instruments**

x

$d=50 \text{ km}$

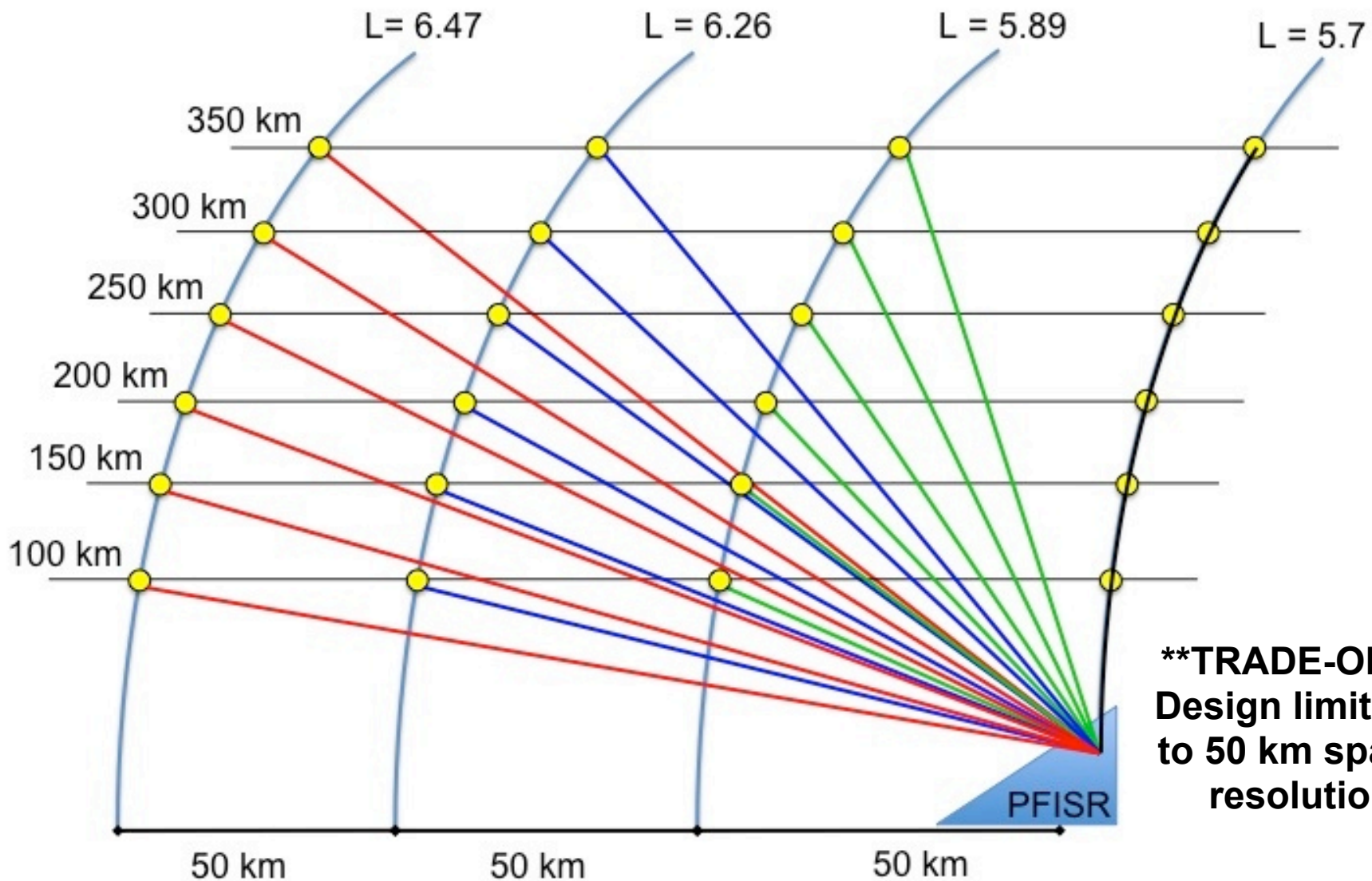
$d=100 \text{ km}$

$d=150 \text{ km}$

y
(To GD-NP)

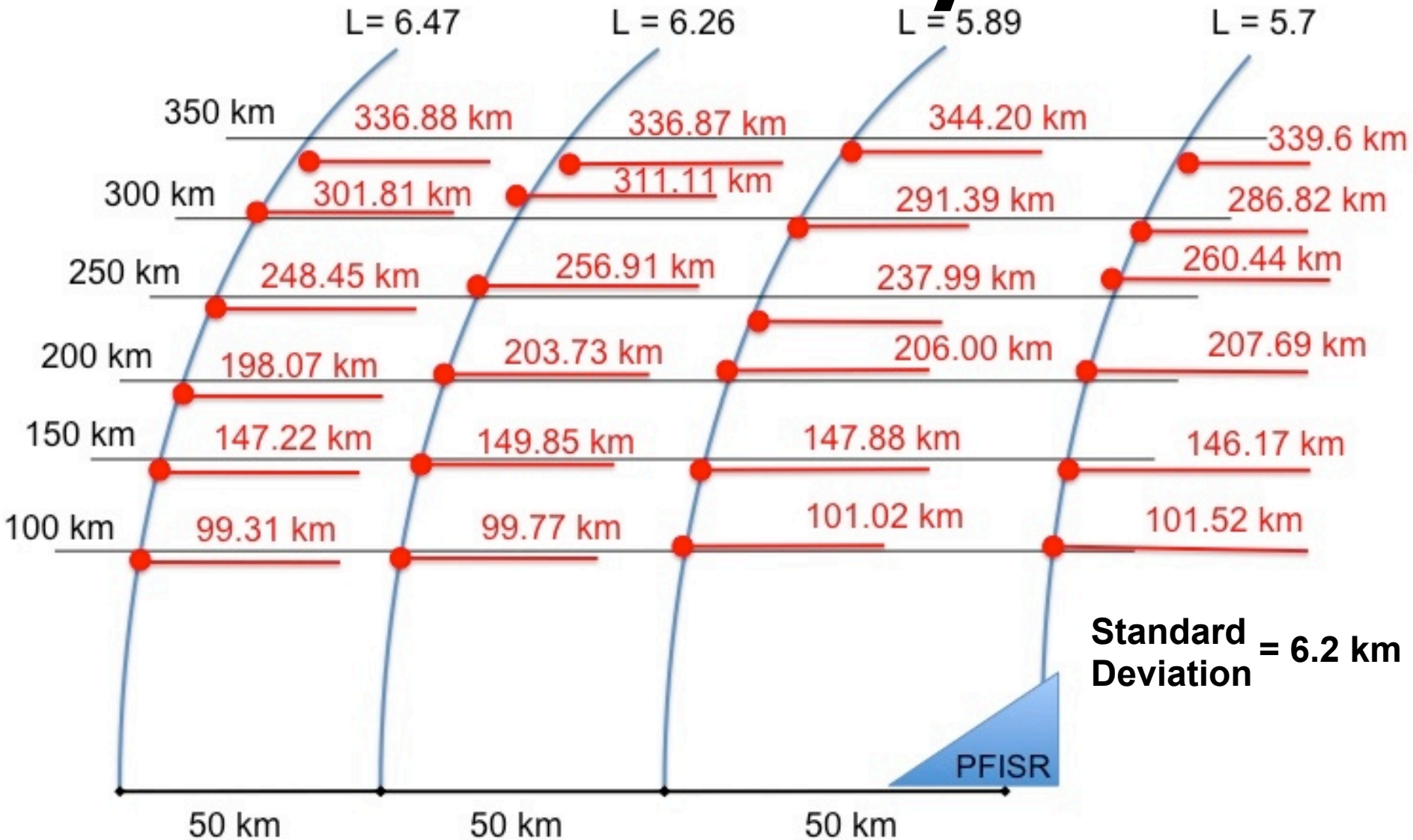
$\theta=20^\circ$

(To GM-NP)



****TRADE-OFF****
Design limits us
to 50 km spatial
resolution

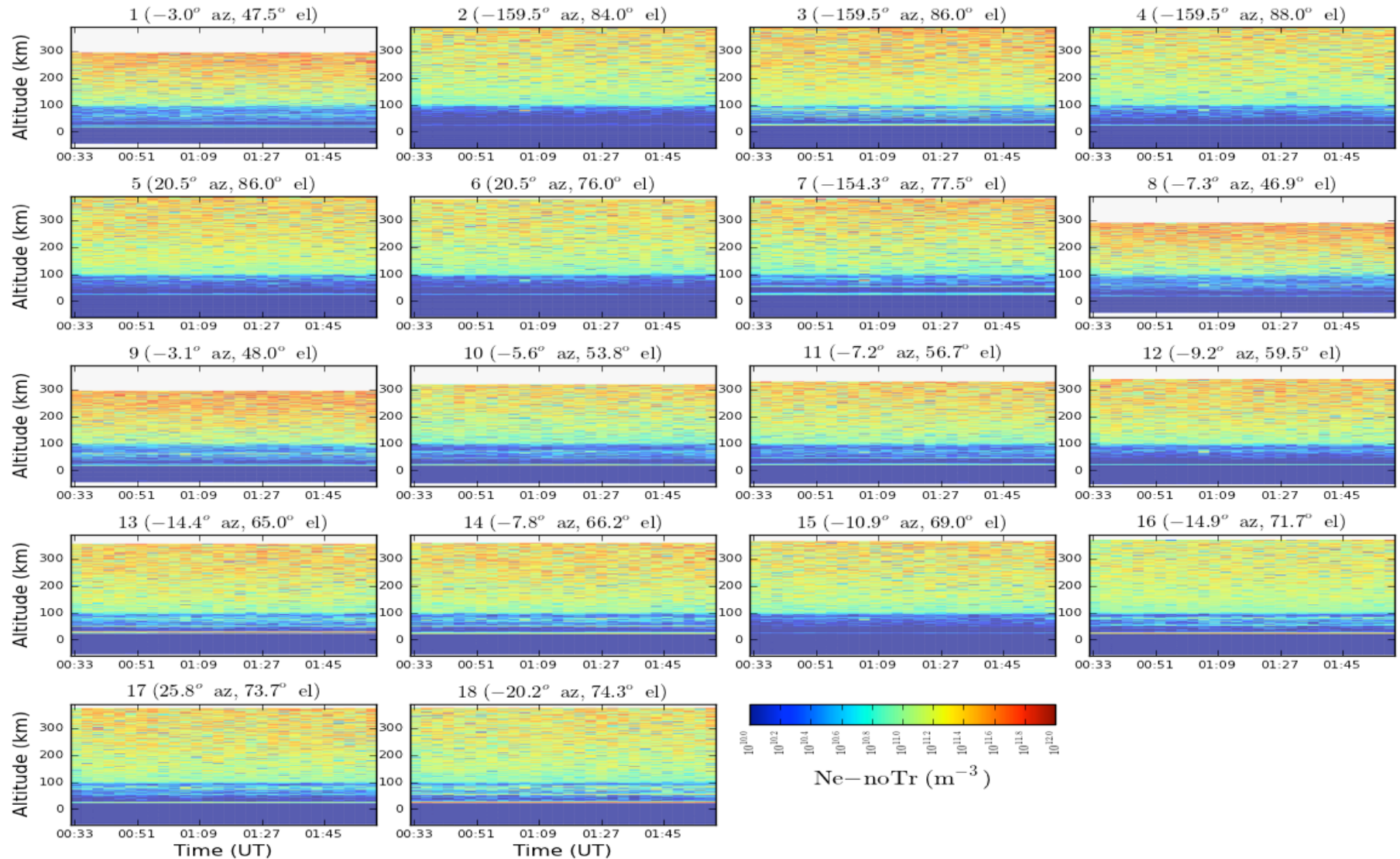
What We Actually Got...



...AND NO AURORAL PRECIPITATION

Electron Density profile

8-1-2012 0.530 UT - 8-1-2012 2.001 UT



NEVER FEAR!

WE LOOKED AT THE DATA ANYWAY! (EH?)

Twice actually...



Mandatory Canadian
content

Energy Calculation

- Can't look at auroral precipitation energy, so we will only look at thermal energy
- Thermal Energy Per Volume of electrons:

$$U_e = \frac{1}{2} f N_e k T_e$$

k = Boltzmann constant = 8.617×10^{-5} eV/K

N_e = electron density

T_e = electron temperature

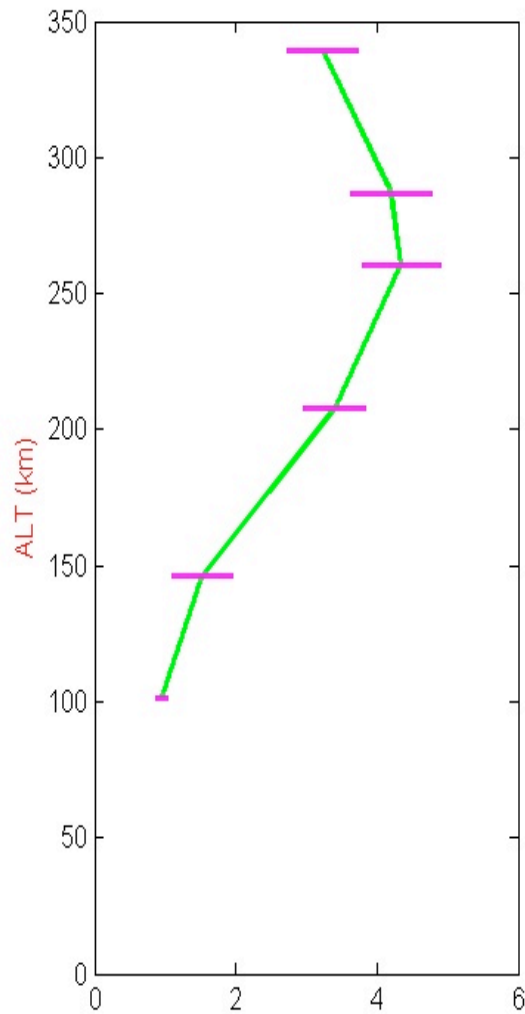
f = degrees of freedom = 3



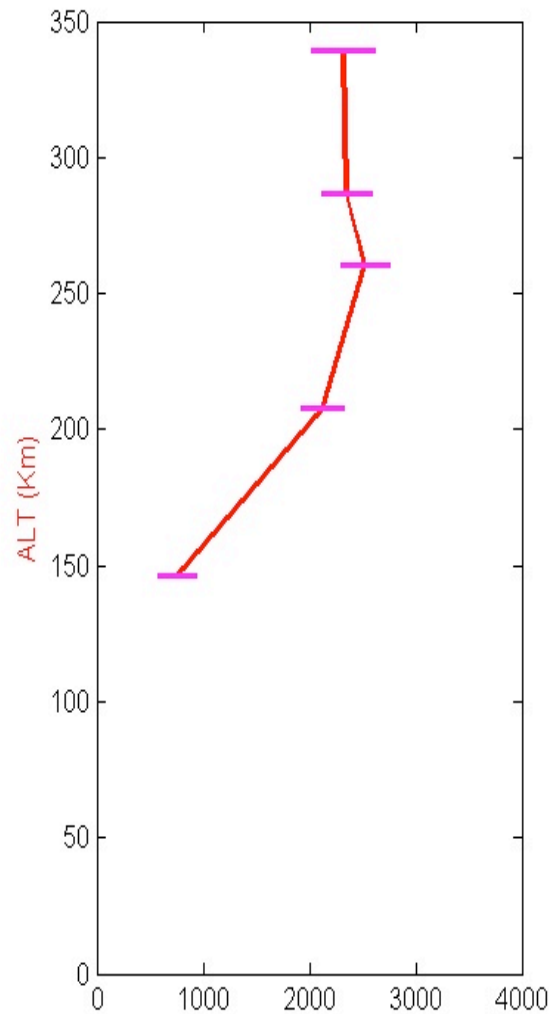
DATA ANALYSIS #1: MATLAB

Field Line 0: 0 KM (L=5.7)

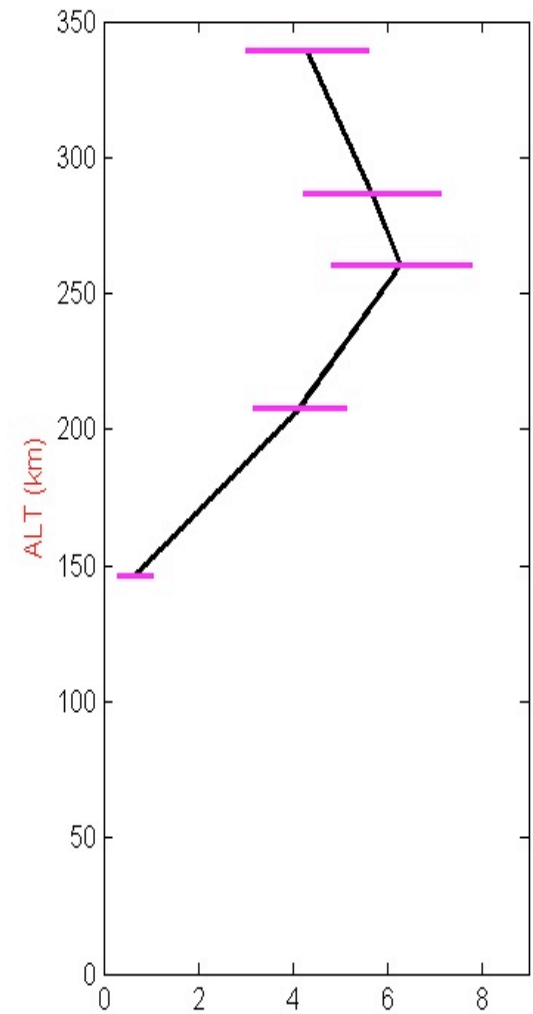
fieldLine0



N_e ($\times 10^{11}$ #/m³)



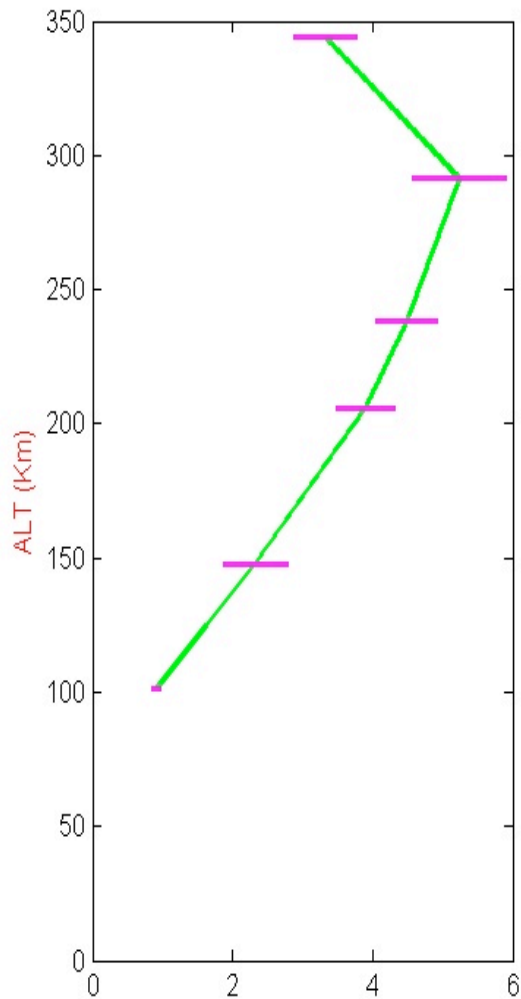
T_e (K)



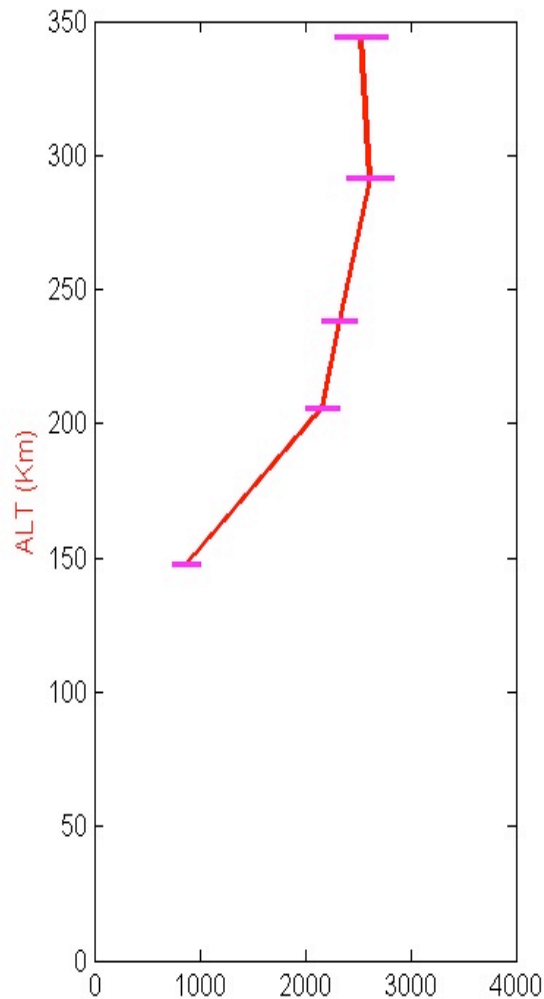
U_e ($\times 10^{10}$ eV/m³)

Field Line 1: 50 KM (L=5.89)

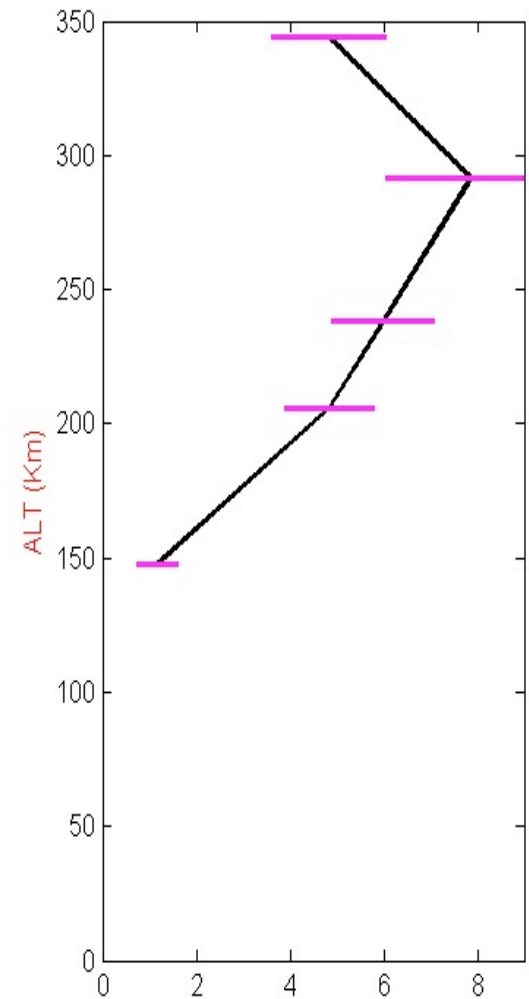
fieldLine1



N_e ($\times 10^{11}$ #/m³)



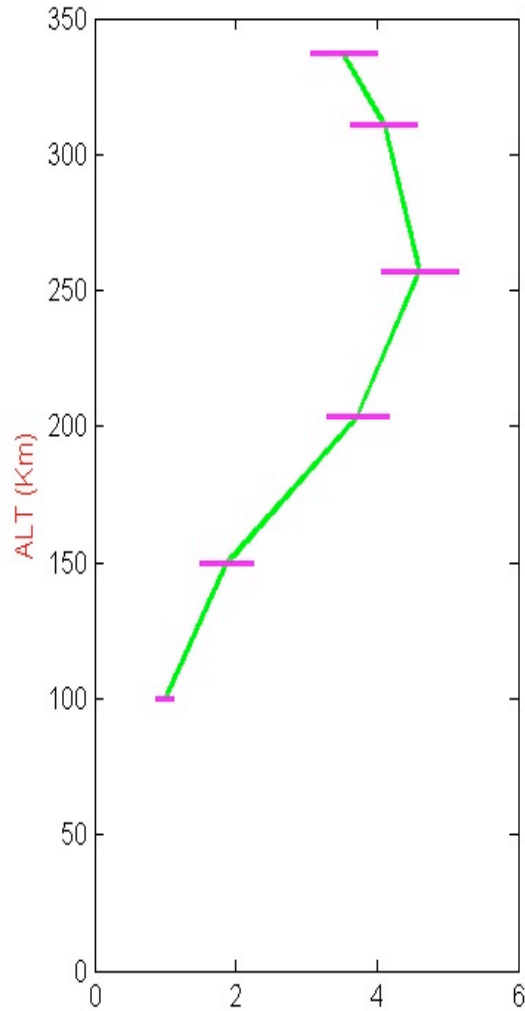
T_e (K)



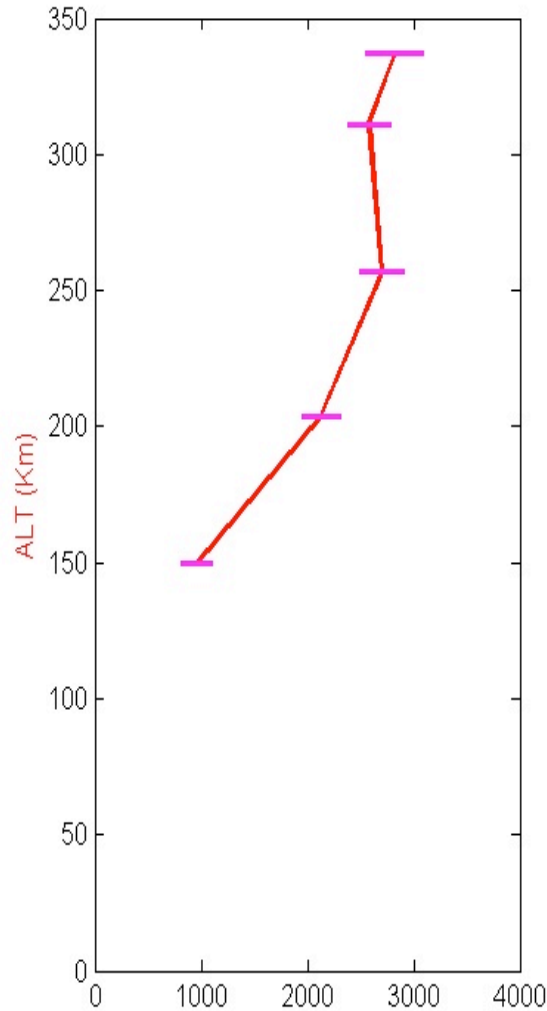
U_e ($\times 10^{10}$ eV/m³)

Field Line 2: 100 KM (L=6.26)

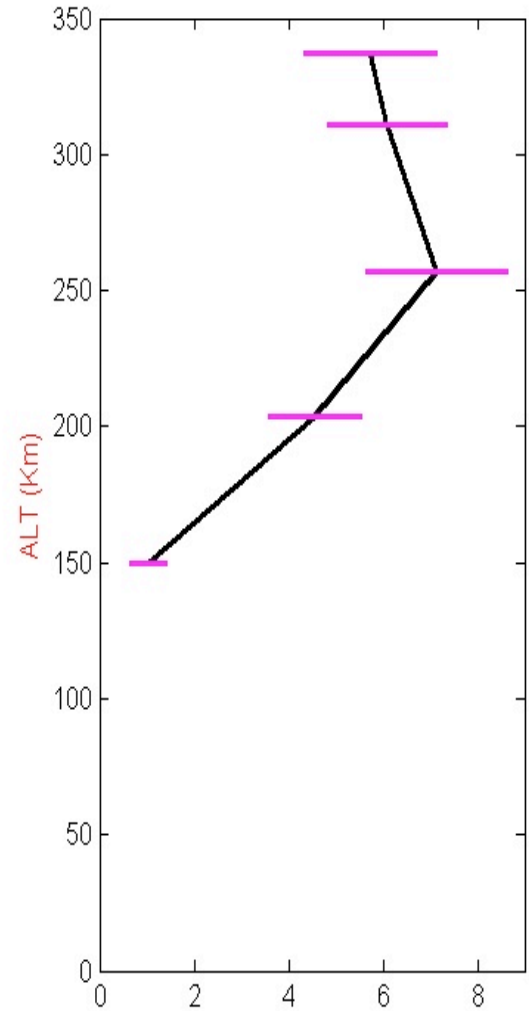
fieldLine2



N_e ($\times 10^{11}$ #/m³)



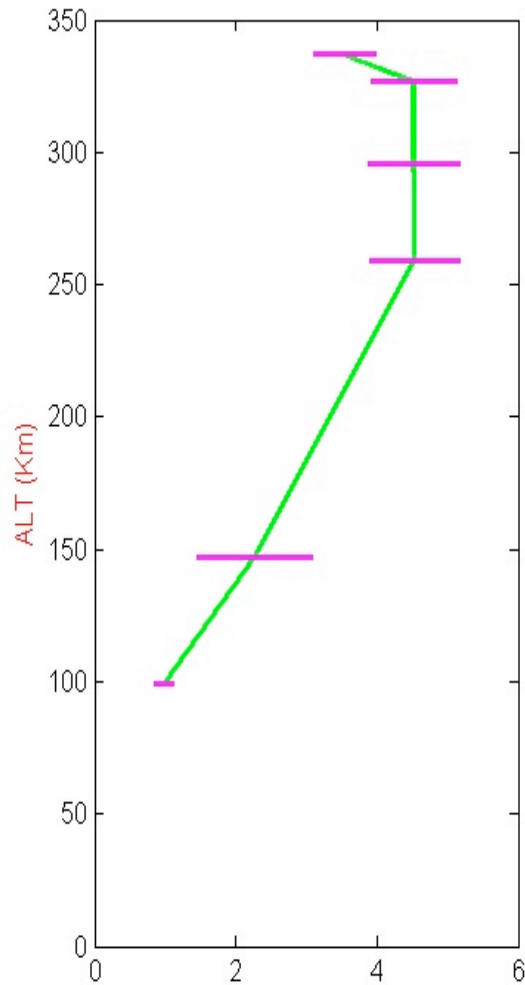
T_e (K)



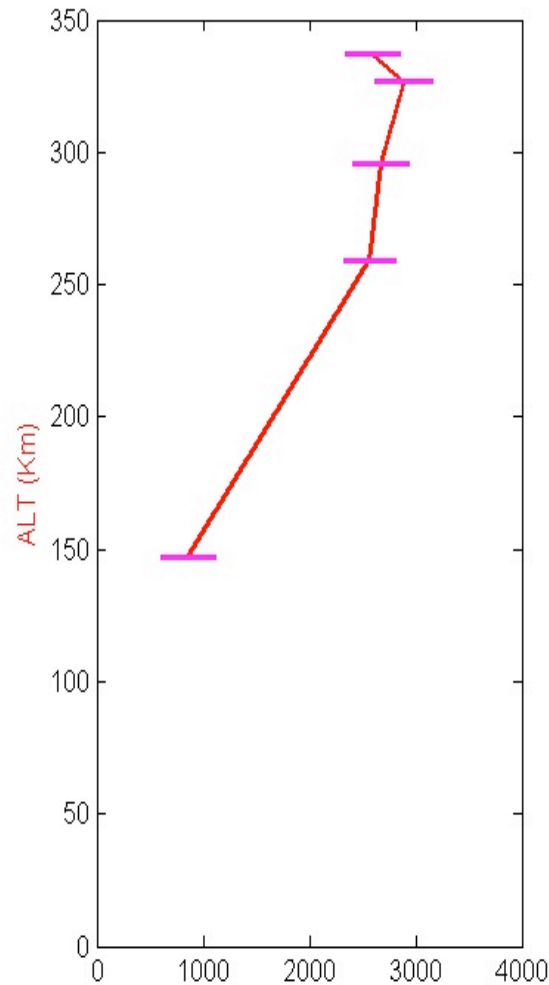
U_e ($\times 10^{10}$ eV/m³)

Field Line 3: 150 KM (L=6.47)

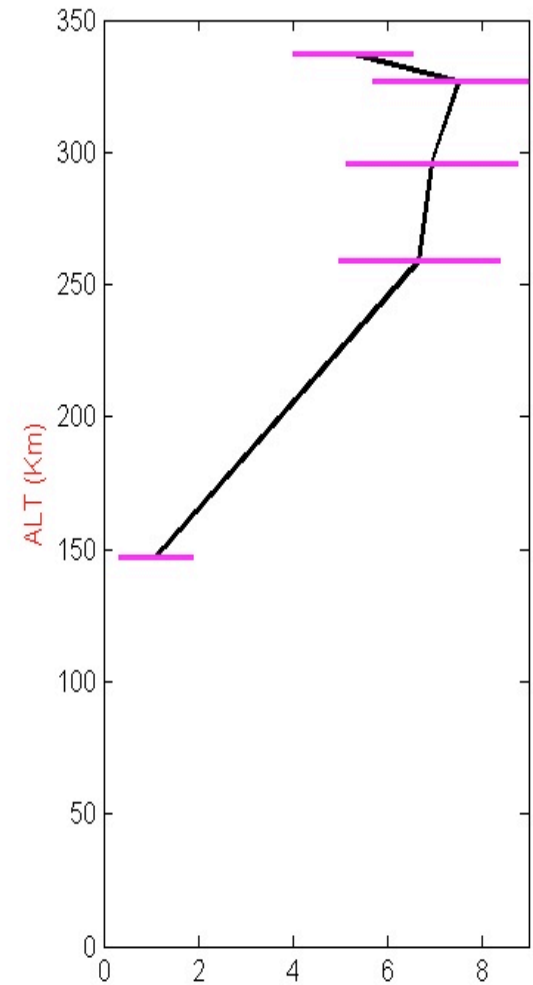
fieldLine3



N_e ($\times 10^{11}$ #/m³)



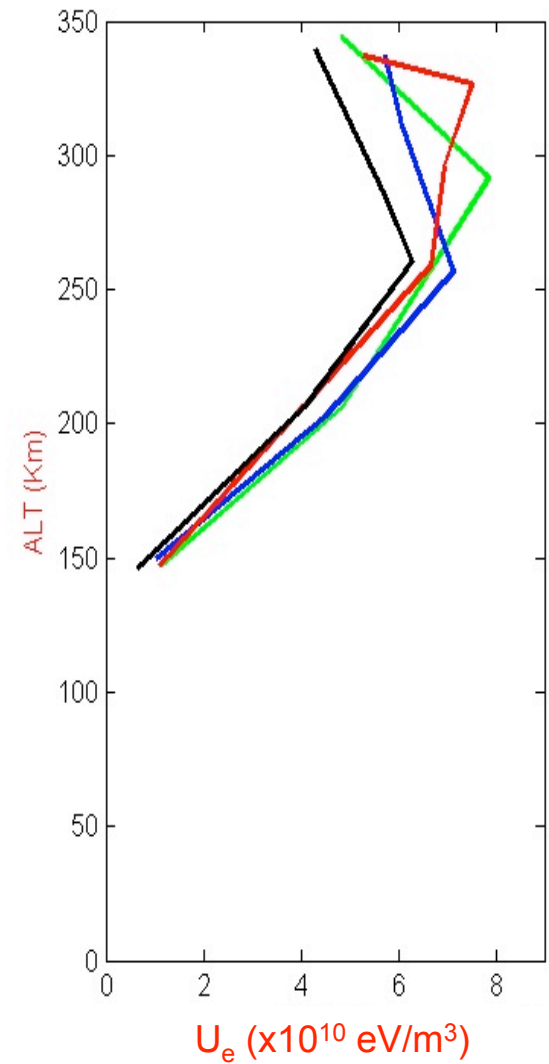
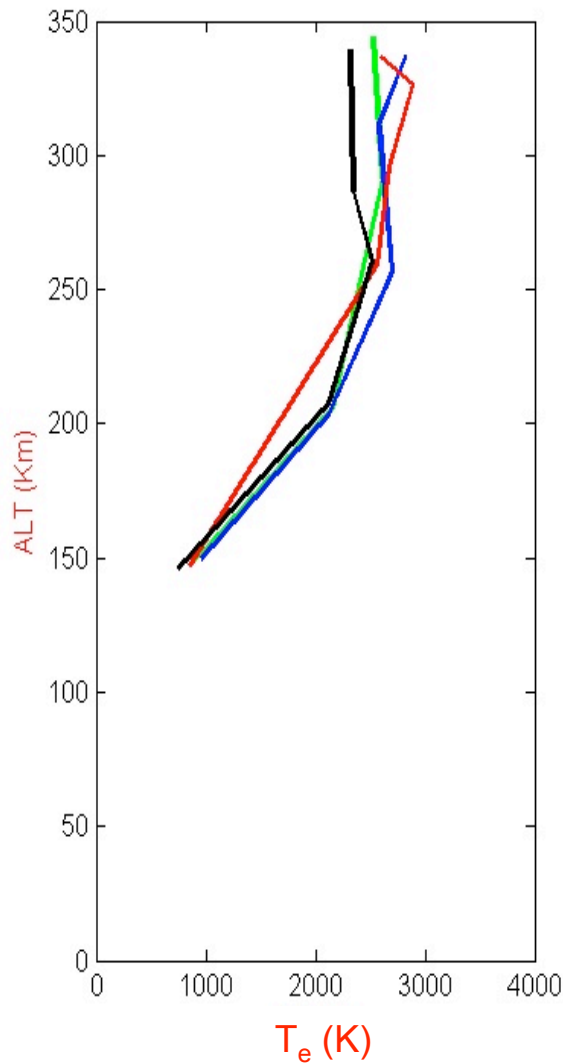
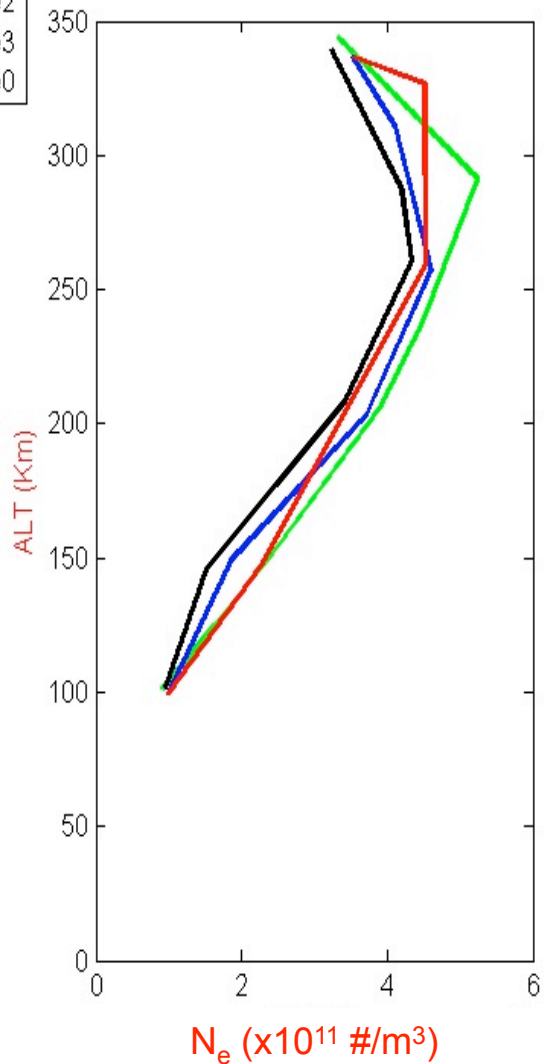
T_e (K)




U_e ($\times 10^{10}$ eV/m³)

All Data: Four Field Lines

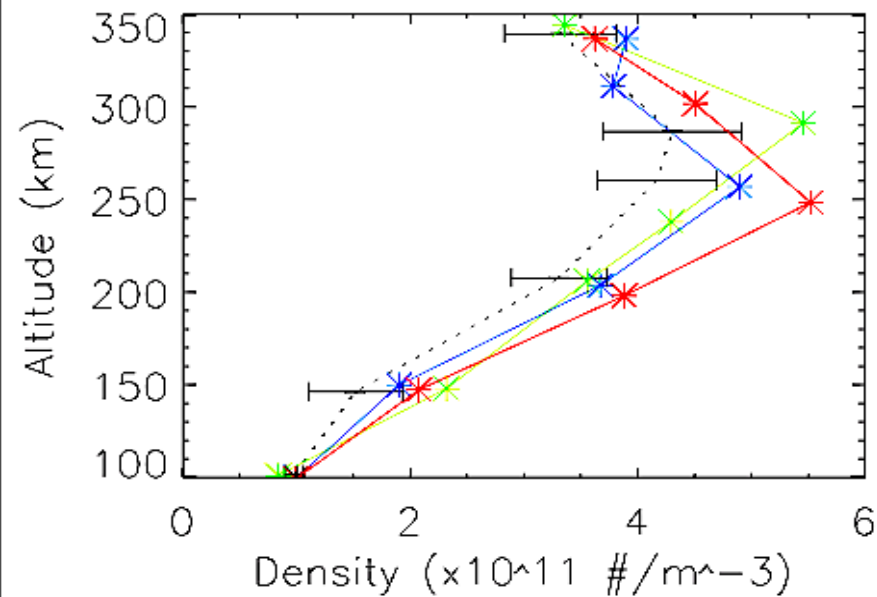
fieldLine1
fieldLine2
fieldLine3
fieldLine0



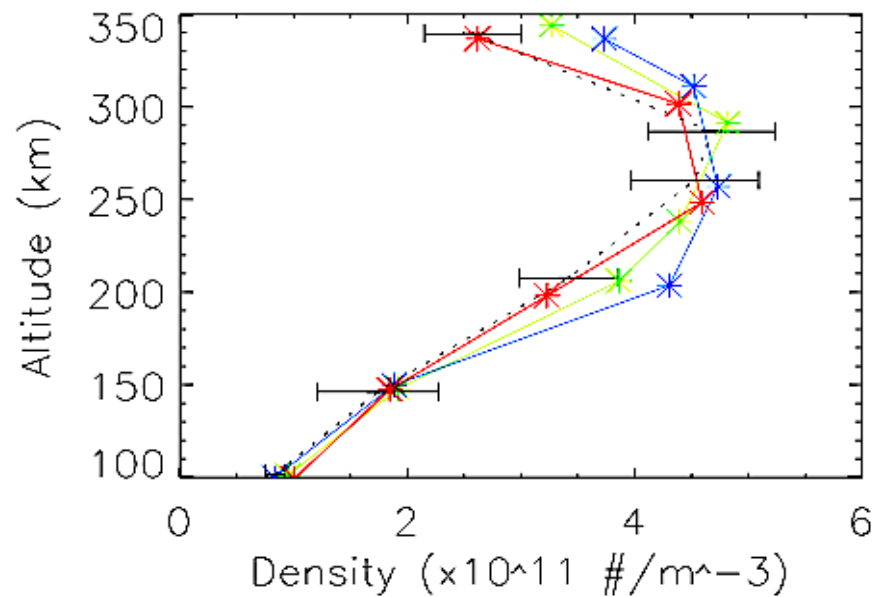


DATA ANALYSIS #2: IDL

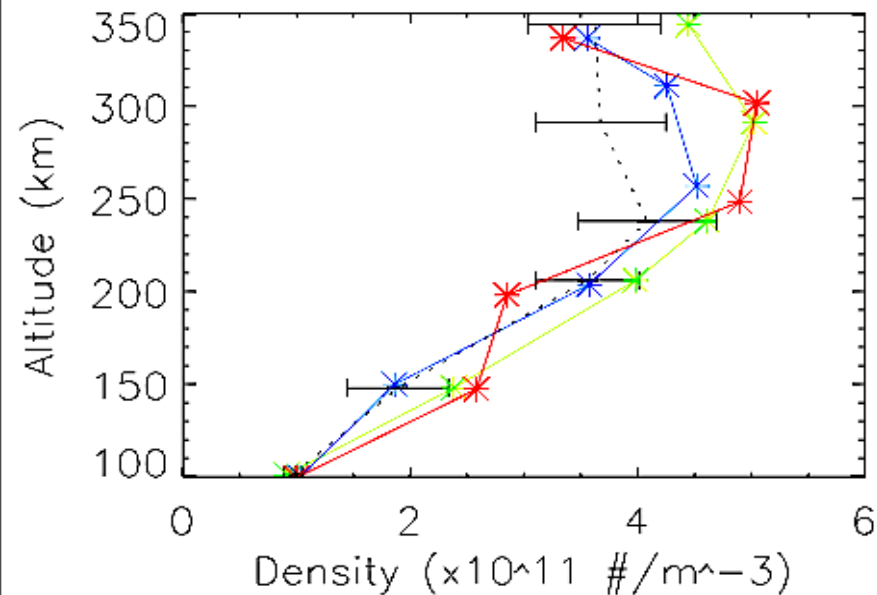
00:33–00:52 UT



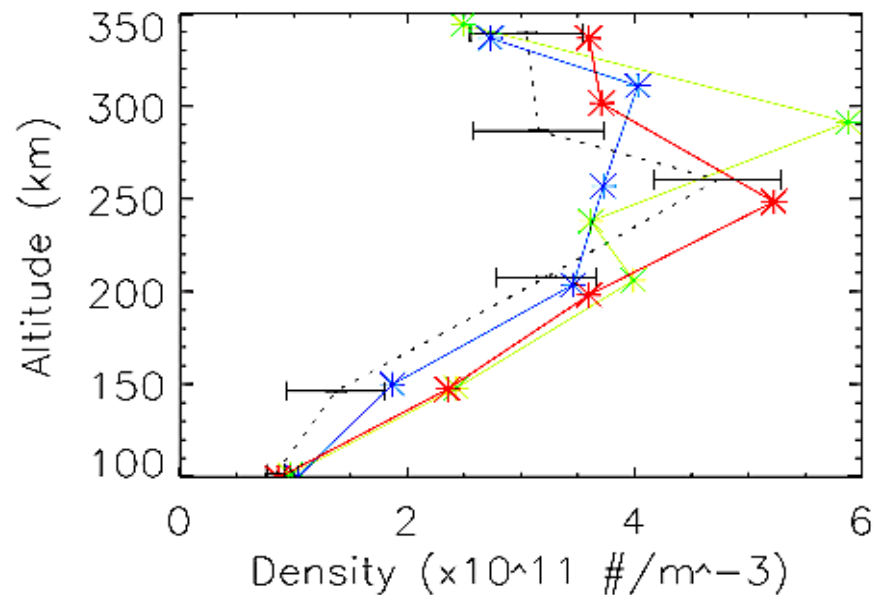
00:53–01:14 UT



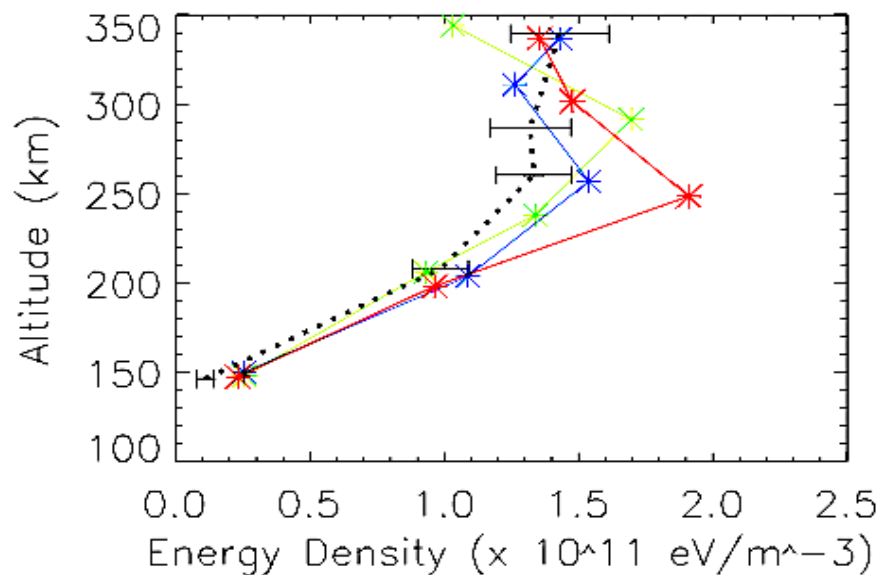
01:14–01:39 UT



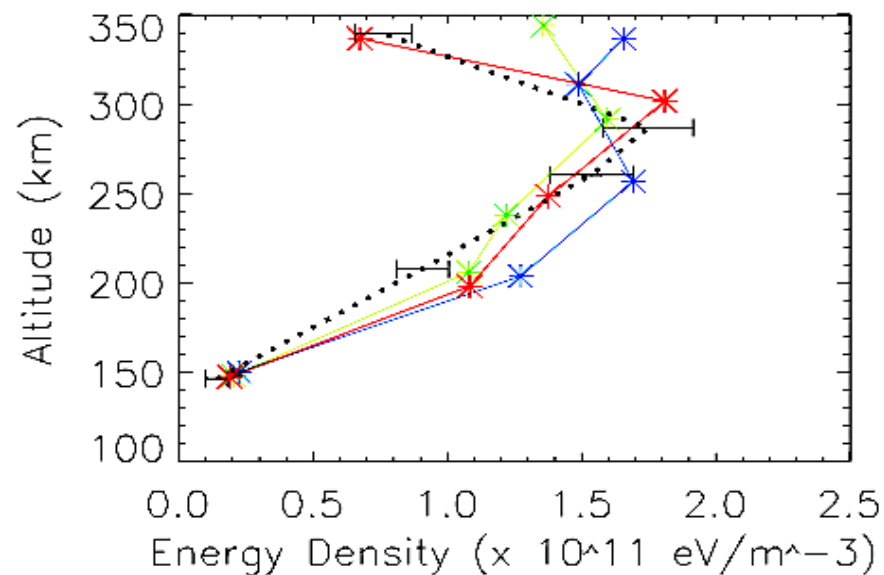
01:39–01:58 UT



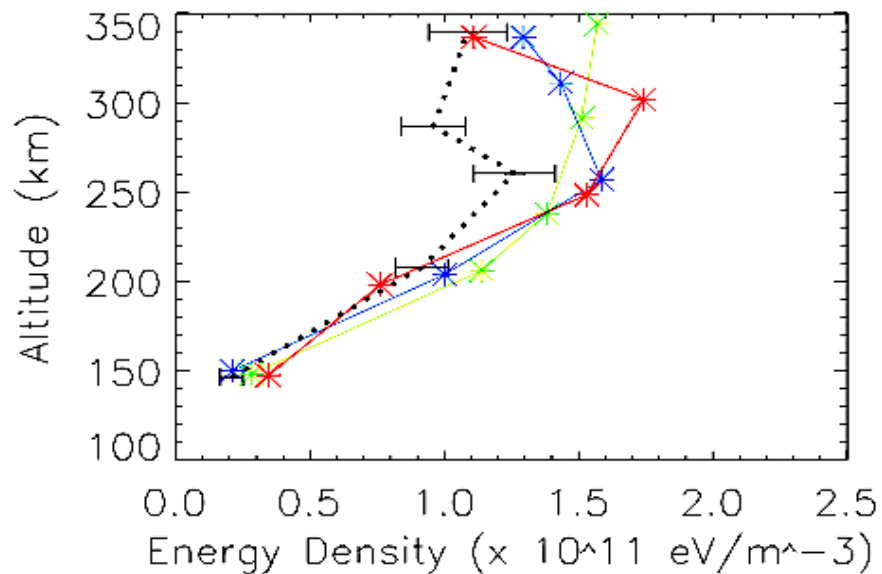
00:33–00:52 UT



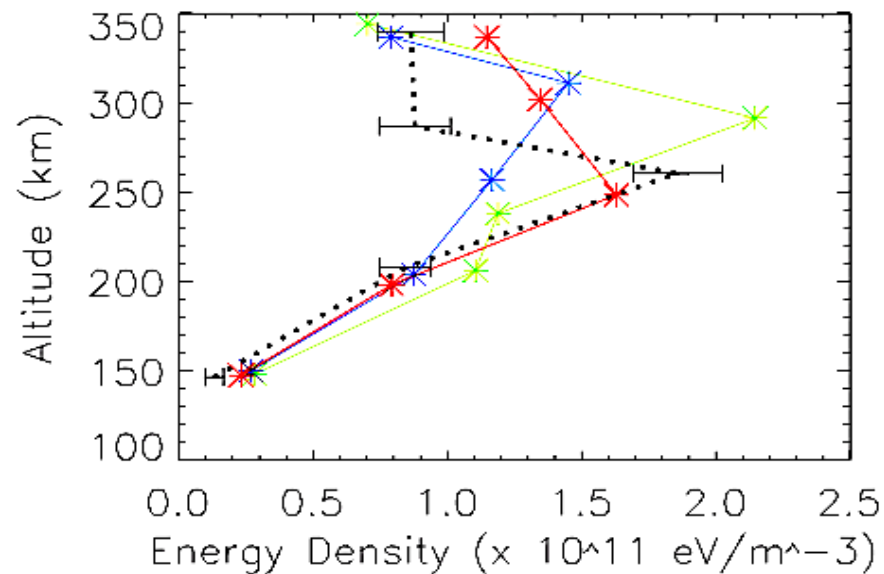
00:53–01:14 UT



01:14–01:39 UT



01:39–01:58 UT



Conclusions

- No auroral precipitation and slight standard deviation from theoretical observation points
- 2 independent data analyses:
 - Both able to resolve F-region peak at ~250-300km
 - Suspicious lack of evidence of E-region (most likely due to poor resolution)
- High energy densities (~ 10 's GeV/m^{-3})
 - Possibly real if ionosphere has been absorbing solar radiation all day
- Confident in strength of our theoretical design
- Successfully used basic kinetics to calculate thermal energy



**IT'S A
TOQUE!!**



**STAR
WARS**



ACKNOWLEDGMENTS

- Craig Heinselman
- Josh Semeter and Phil Erickson
- All the other ~~organizers~~ “grown-ups”
- Group 5 for allowing us to use their data (even though we didn't)