ISR SUMMER SCHOOL

Group 6

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PROLOGUE: A QUESTION POSED

Is there always a unique set of plasma parameters for each measured ACF or power spectrum?

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Is there always a unique set of plasma parameters for each measured ACF or power spectrum?

No

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The Doppler shift Δf expected for an ion moving at the mean speed of the ions is given by

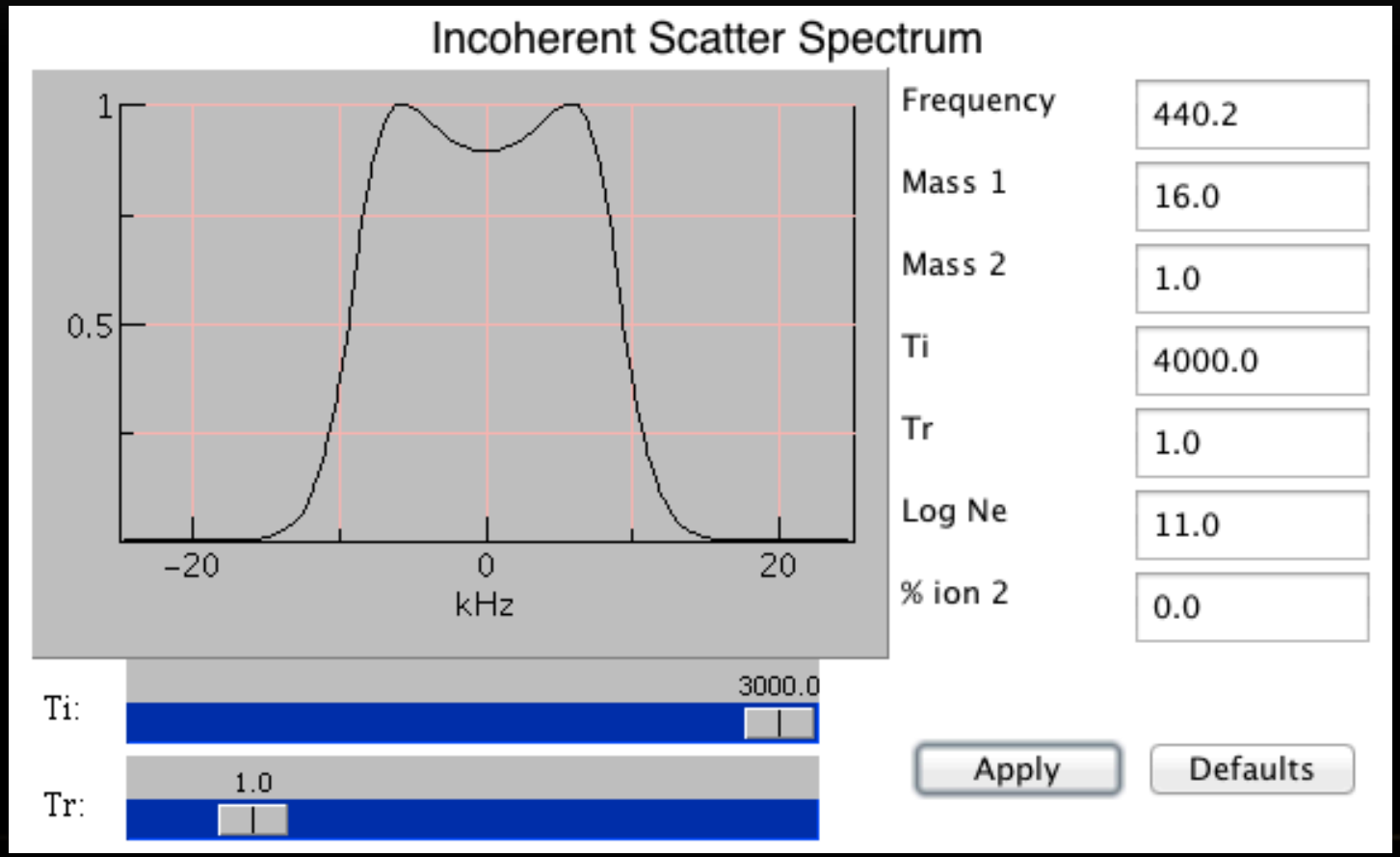
$$\Delta f = \frac{1}{\lambda}\sqrt{\frac{8KT_i}{m_i}}\ \mathrm{Hz}$$

Therefore the ion acoustic frequencies of the spectrum are shifted by a Δf amount from the probing frequency.

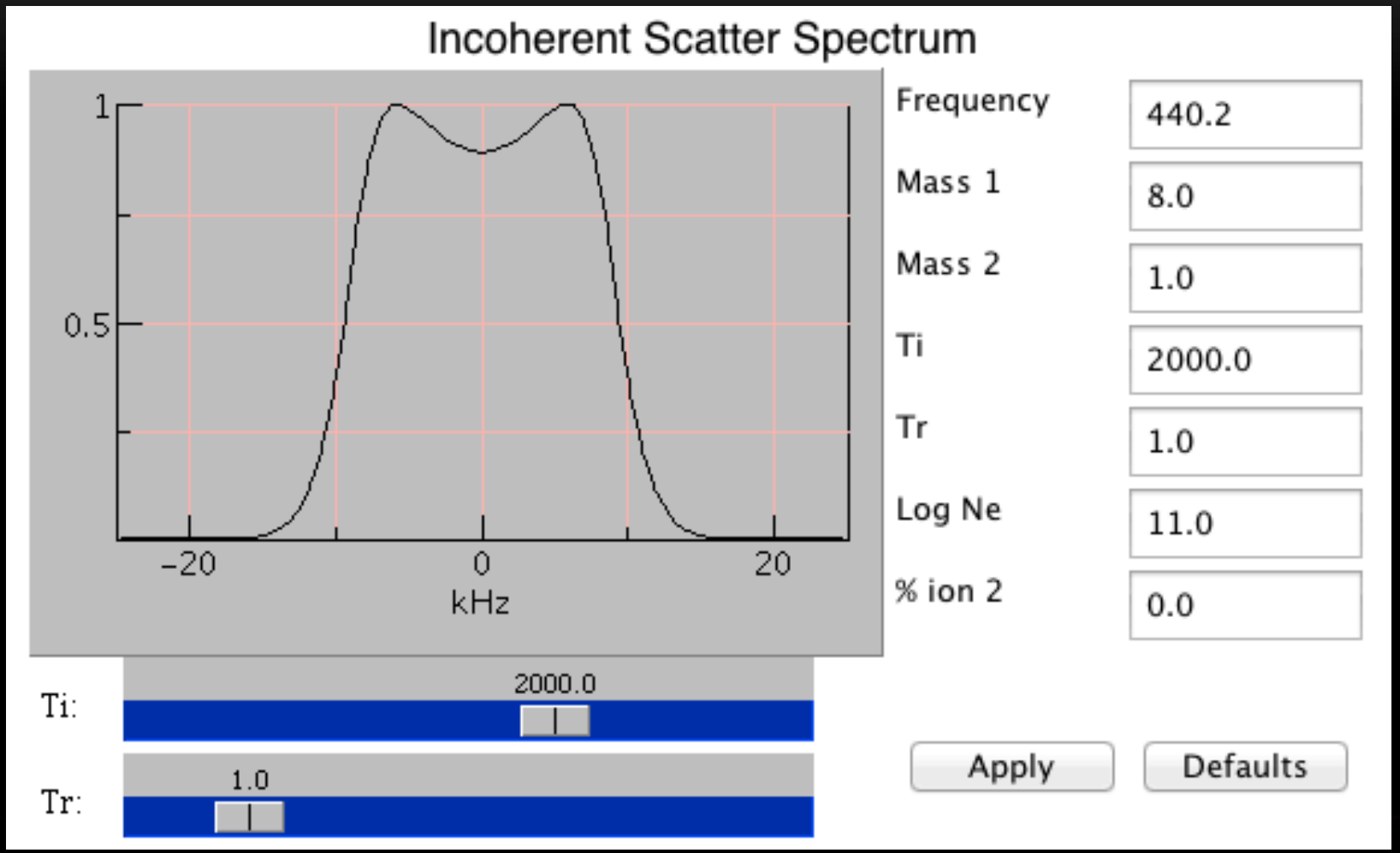
$$\Delta f \propto \frac{1}{\lambda}\sqrt{\frac{T_i}{m_i}}$$

i.e. for different sets of *Ti*, *mi* where the above ratio is constant will give the same spectrum.

SET 1


Incoherent Scatter Spectrum
1
0.5
-20
0
20
kHz
Frequency
440.2
Mass 1
16.0
Mass 2
1.0
Ti
4000.0
Tr
1.0
Log Ne
11.0
% ion 2
0.0
Ti:
3000.0
Tr:
1.0
Apply
Defaults

SET 2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−20
0
20
kHz
Frequency
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Mass 1
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Mass 2
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Ti
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Tr
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Log Ne
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% ion 2
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Ti:
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Tr:
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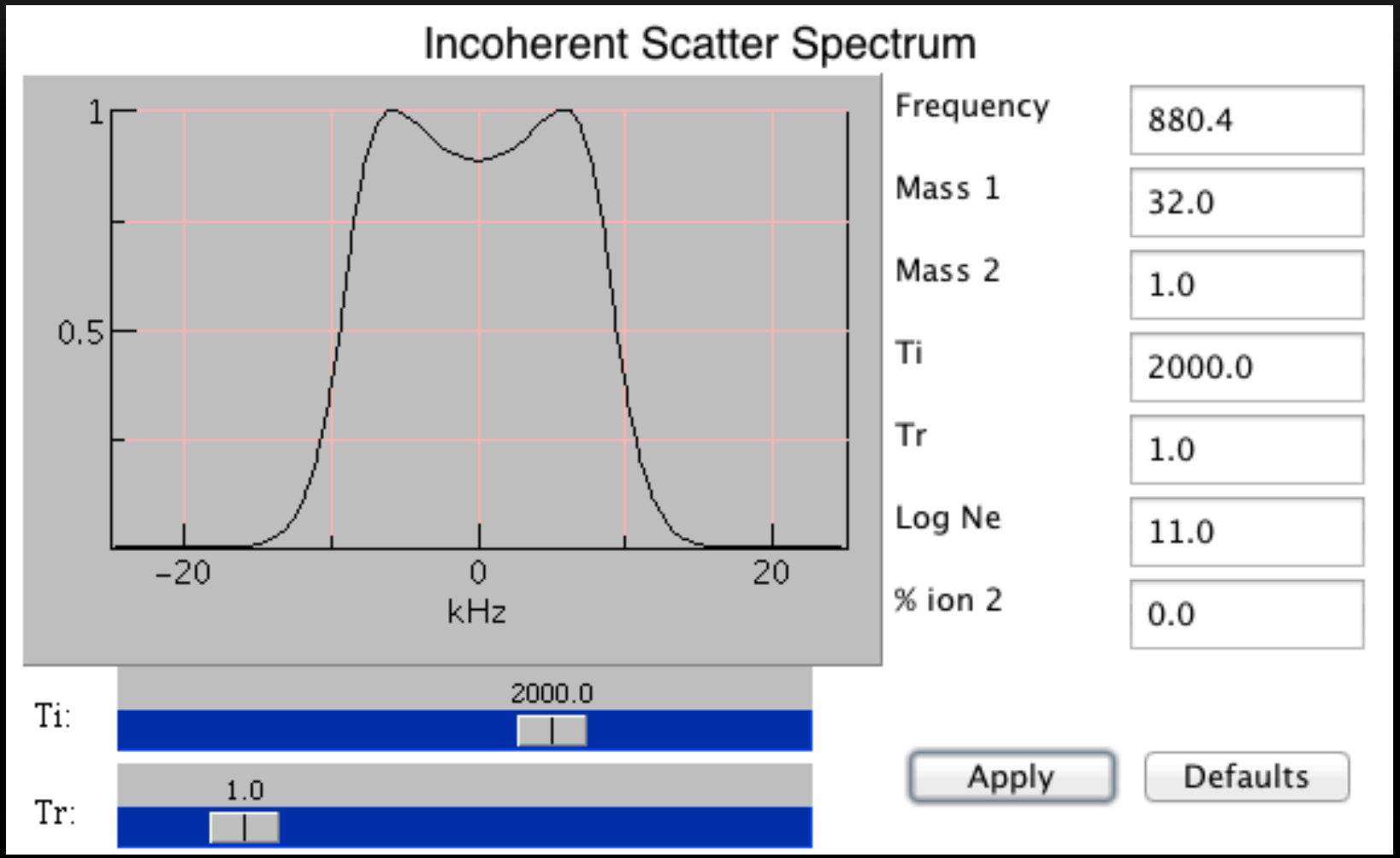
Apply
Defaults

SET 3


Incoherent Scatter Spectrum
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-20
0
20
kHz
Frequency
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Mass 1
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Mass 2
1.0
Ti
2000.0
Tr
1.0
Log Ne
11.0
% ion 2
0.0
Ti:
2000.0
Tr:
1.0
Apply
Defaults

PROLOGUE: A QUESTION POSED

- Since the spectrum is the Fourier transform of the auto correlation function we can have the same ACF for different ion mass-ion temperature pairs

SCIENCE

We do what we must,

because we can.

EXPERIMENT OVERVIEW

- Collect ionospheric data at locations that differ greatly to compare longitudinal and latitudinal variations
- Determine possible physics explanations of phenomenae that are observed
- Verify data against:
  - IRI model predicted data
  - Previous experimental data at/near our locations

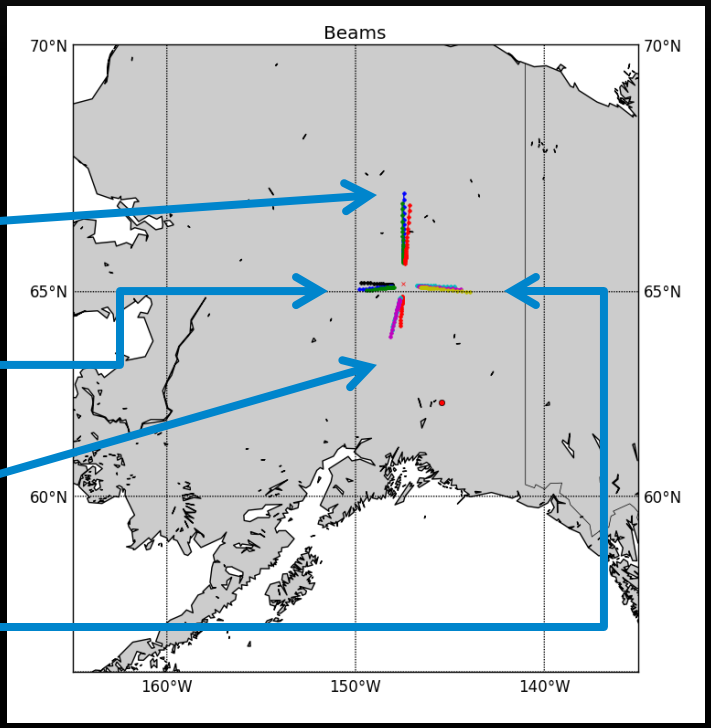
EXPERIMENT DESIGN

- To ensure diversity of target areas, beam paths that are strongly separated in the cardinal directions were chosen
- To assure homogeneity/accuracy of data, multiple points were selected at each location: two collinear and one offset
- Coding schemes were selected per:
  - Alternating code, for good spatial resolution in the E-region
  - Long pulse, for good statistical accuracy in the F-region

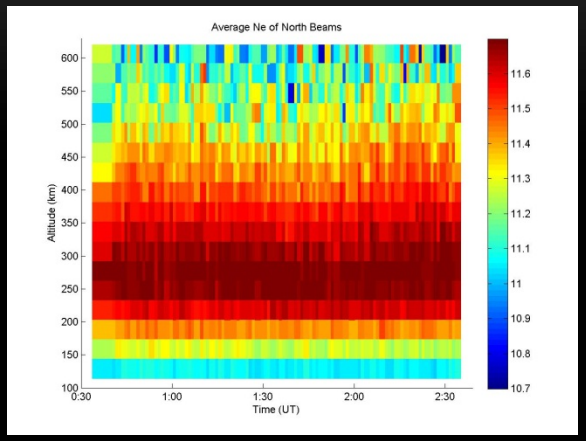
EXPERIMENT DESIGN

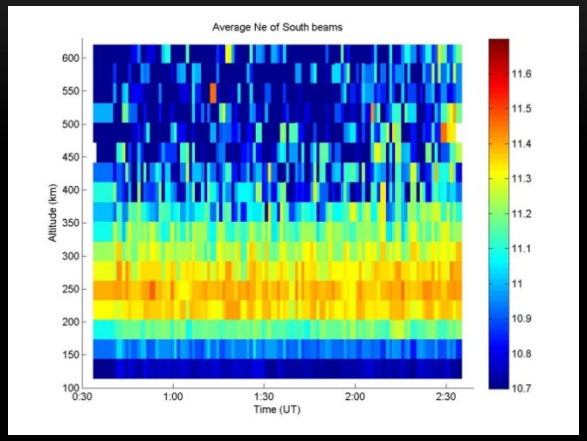
Execution Time: 0030 – 0230 UT

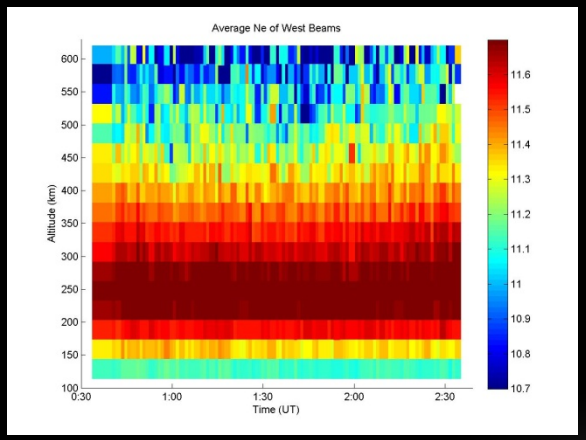
Region	Beam #	Azimuth	Elevation
North	64337	-0.72	54.74
North	64274	0.34	51.81
North	64340	4.38	55.44
West	65396	-95.59	73.95
West	65393	-93.21	71.02
West	65336	-84.03	71.74
South	65525	-175.13	72.69
South	65528	-165	70
South	65531	-165	67
East	65183	88.92	68.10
East	65186	91.49	65.27
East	65189	93.62	62.41

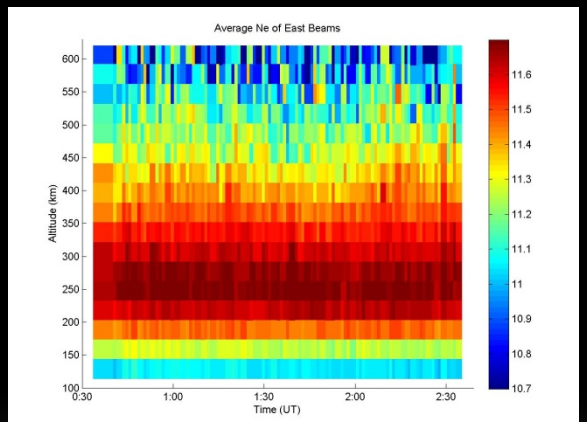


AVERAGE ELECTRON DENSITY IN DIFFERENT DIRECTIONS









$Ne_{north} > Ne_{south}$

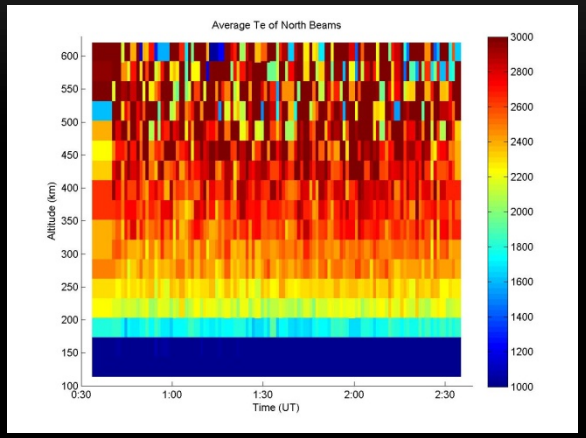
- ~~Solar zenith angle (55° vs. 53 °)~~
- The main ionospheric trough

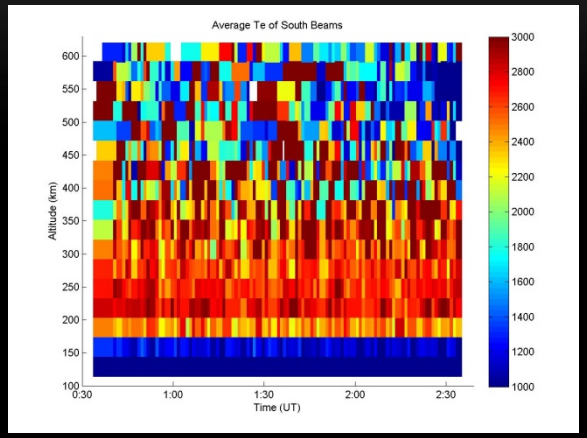
  An ionospheric trough is a region of decreased F layer plasma density.

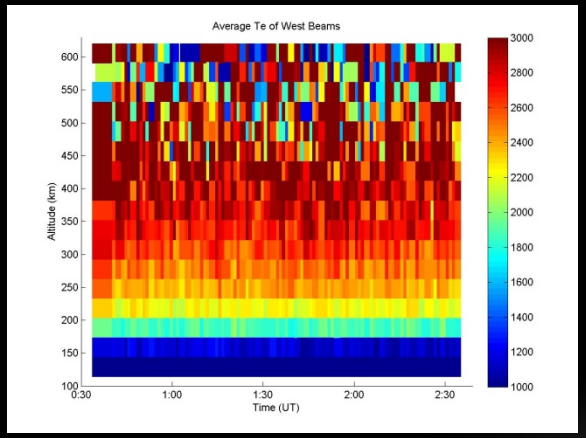
$Ne_{west} > Ne_{east}$

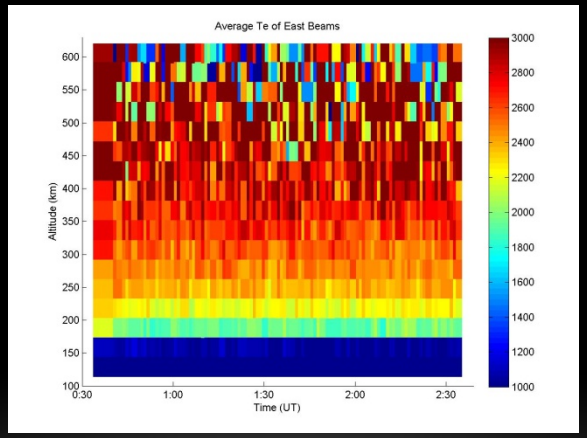
- LT: 14:00 —16:00PM
- Solar radiation

AVERAGE ELECTRON TEMPERATURE IN DIFFERENT DIRECTIONS









$Te_{south} > Te_{north}$ (below 350km)

- The main ionospheric trough is also characterized by high electron temperatures because of reduced cooling (proportional to electron density) and increased soft precipitation.

$Te_{north} > Te_{south}$ (above 350km)

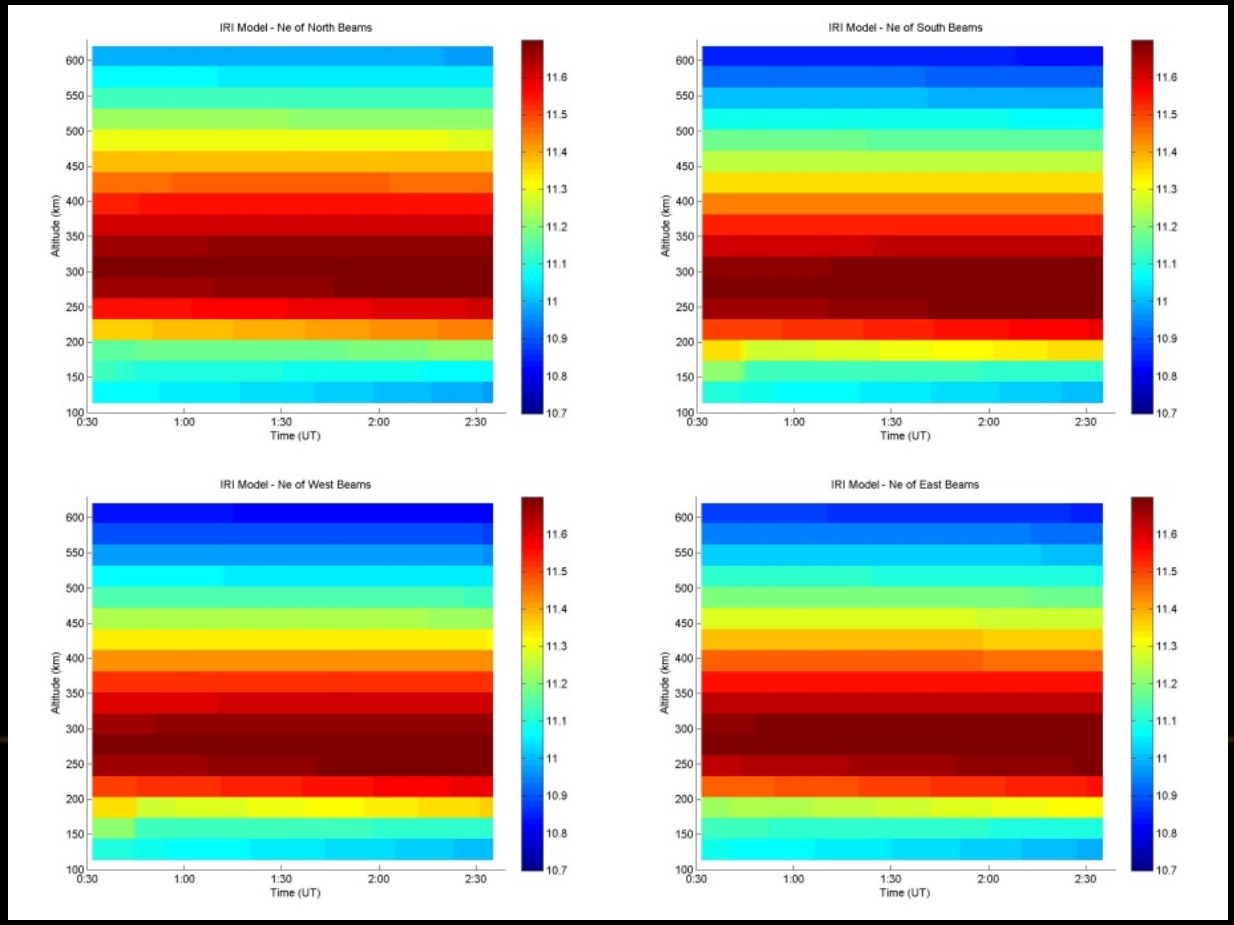
- Heat sources in higher latitude

  Magnetosphere-Ionosphere Coupling, solar wind, high energy particle precipitation...

- Larger errors in higher altitude, or lower SNR of south beams.

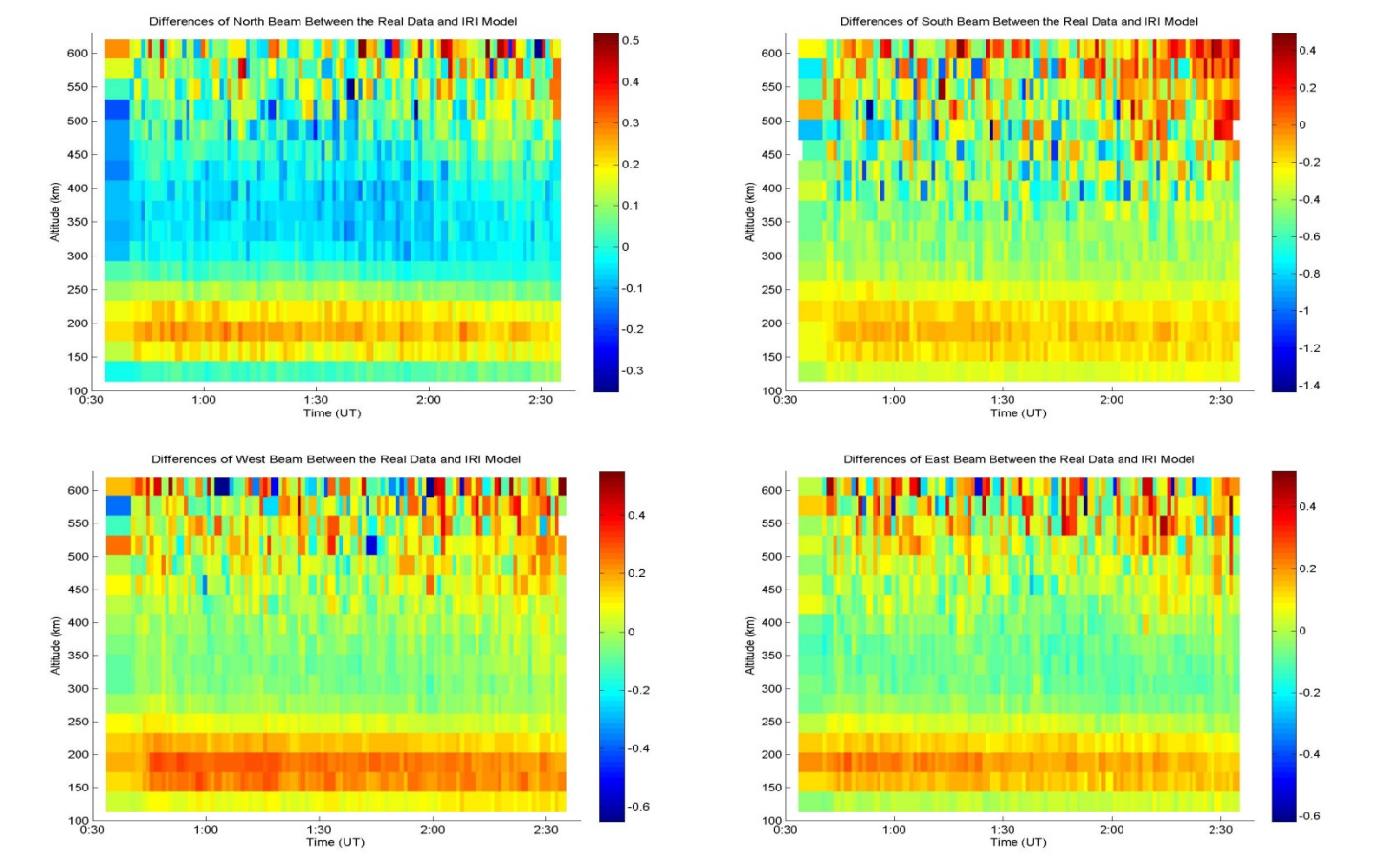
RESULTS VS IRI EMPIRICAL MODEL

Our results were compared against predictions derived from the IRI2012 model. As is visible, there is a relatively good agreement except for the southern area.



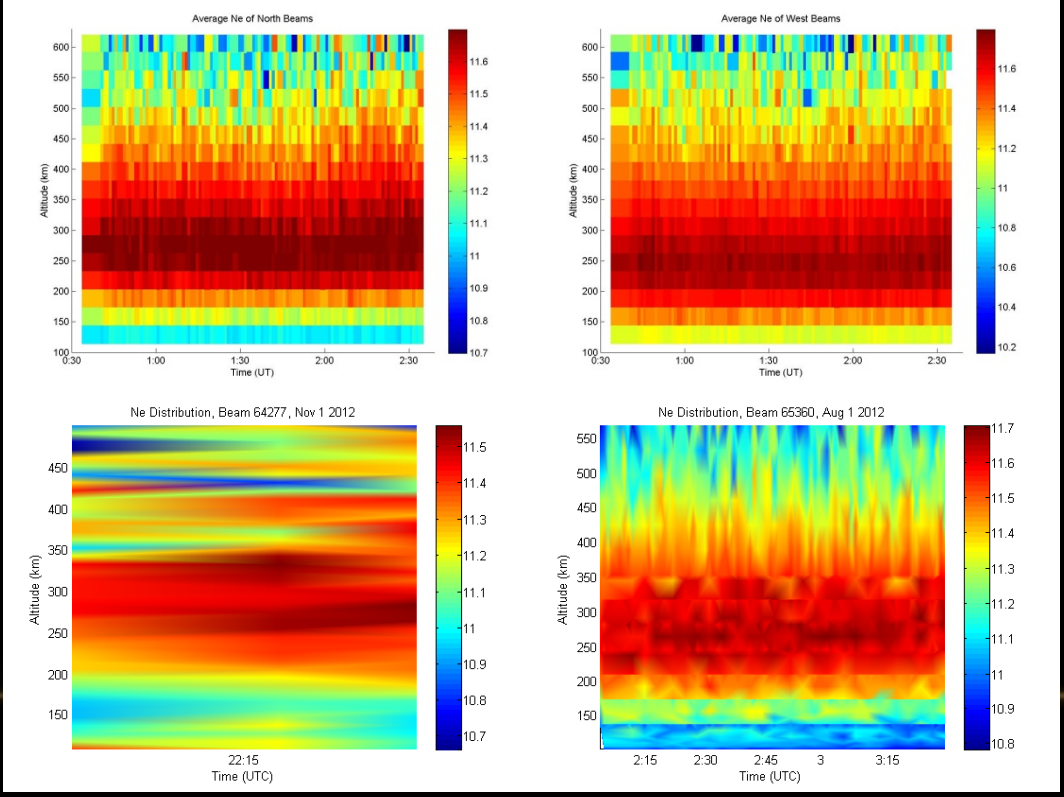
RESULTS VS IRI EMPIRICAL MODEL

The following residues illustrate the difference between the IRI model and the results.



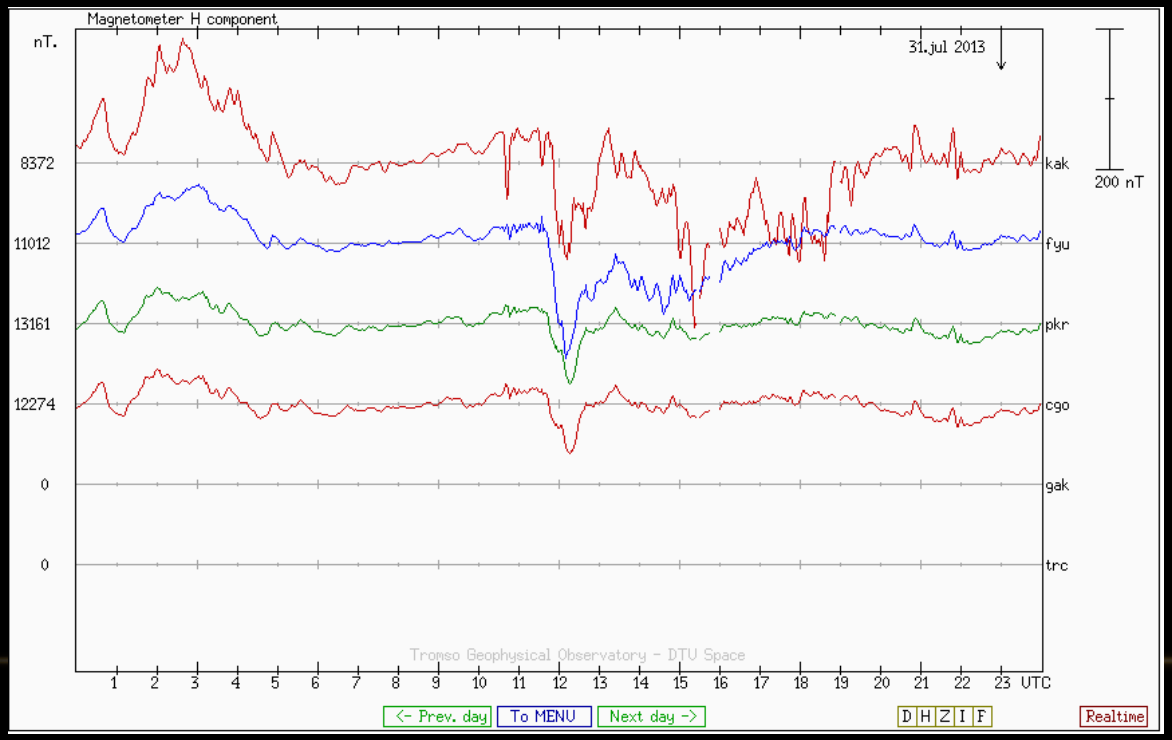
RESULTS VS PAST DATA

Previous results for beams in similar areas were pulled from Madrigal. Unfortunately, only relevant results for the north and west were available (matched for location, time, and parameters), but match well.

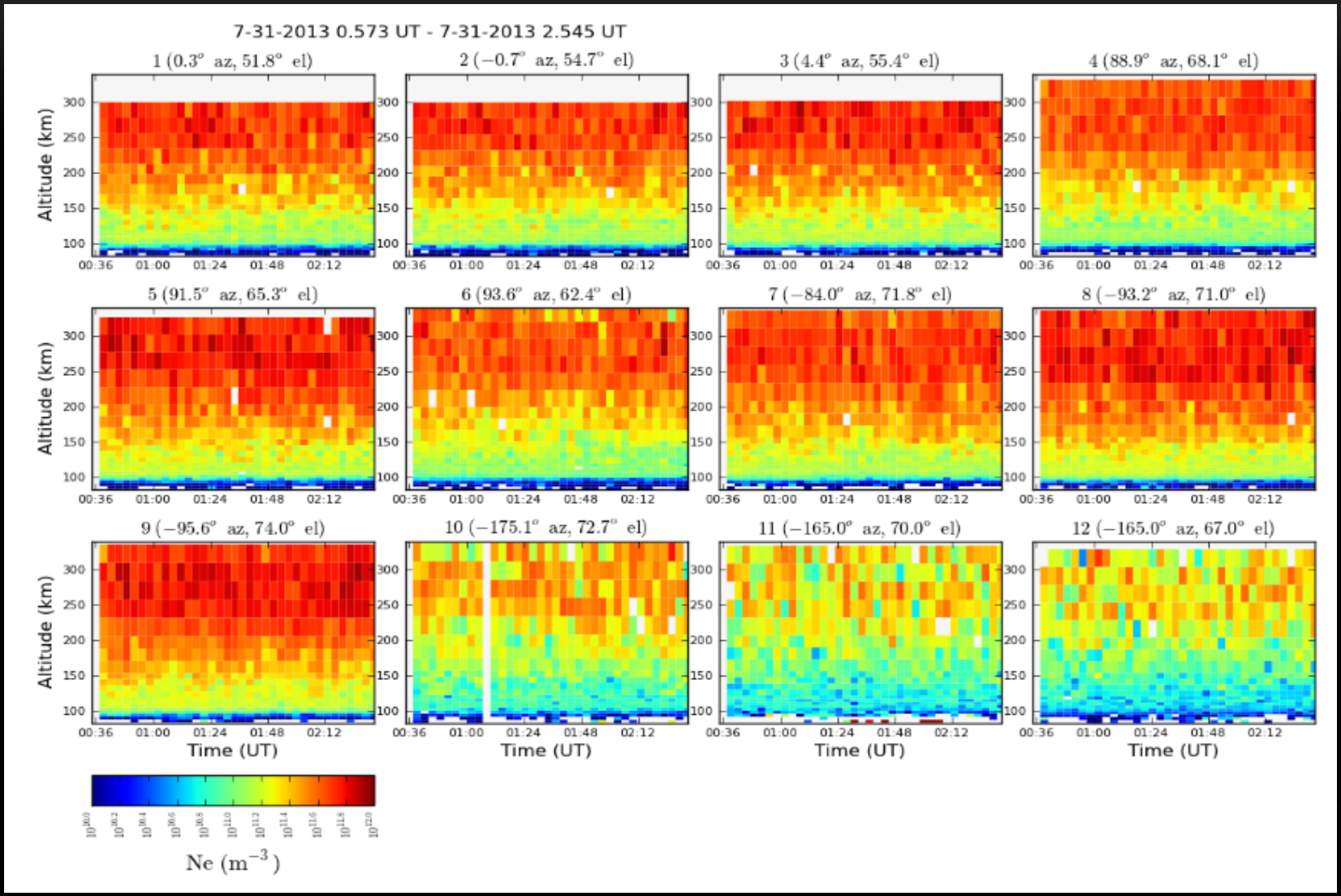


REGIONAL MAGNETOMETER DATA

- Magnetometer H component displayed in Kaktrista, Ft Yukon and Poker Flat.
- Higher magnetic field values in northern regions according to data plot.
- Possible particle precipitation due such phenomena.
- Higher values in electron density may exist in the northern region due to this behaviour.

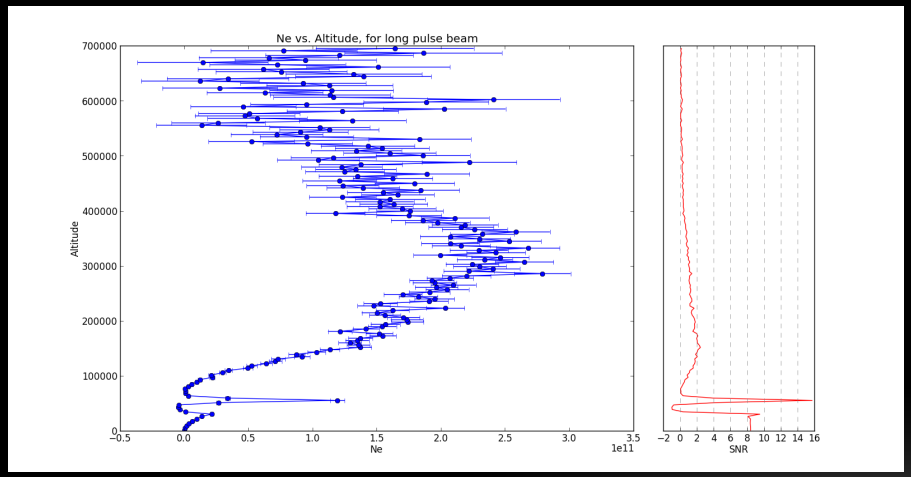


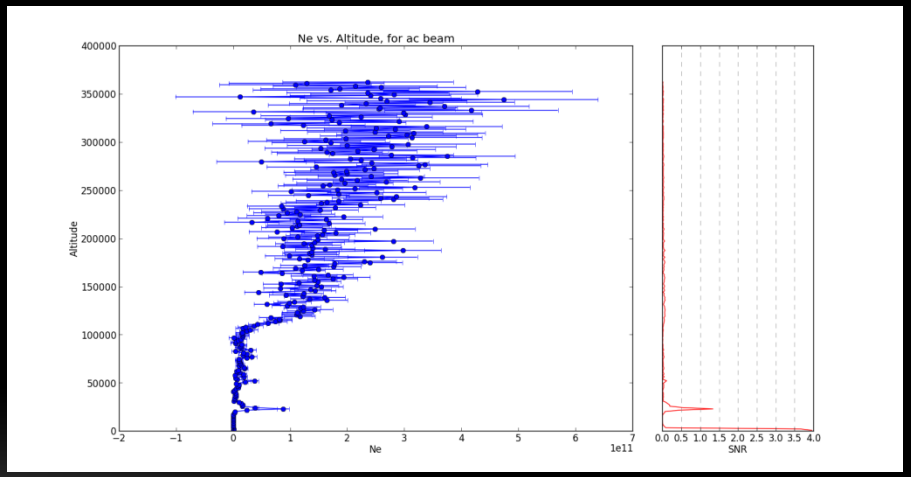
LONG PULSE NE DISTRIBUTION RESULTS



NE DERIVED FROM POWER

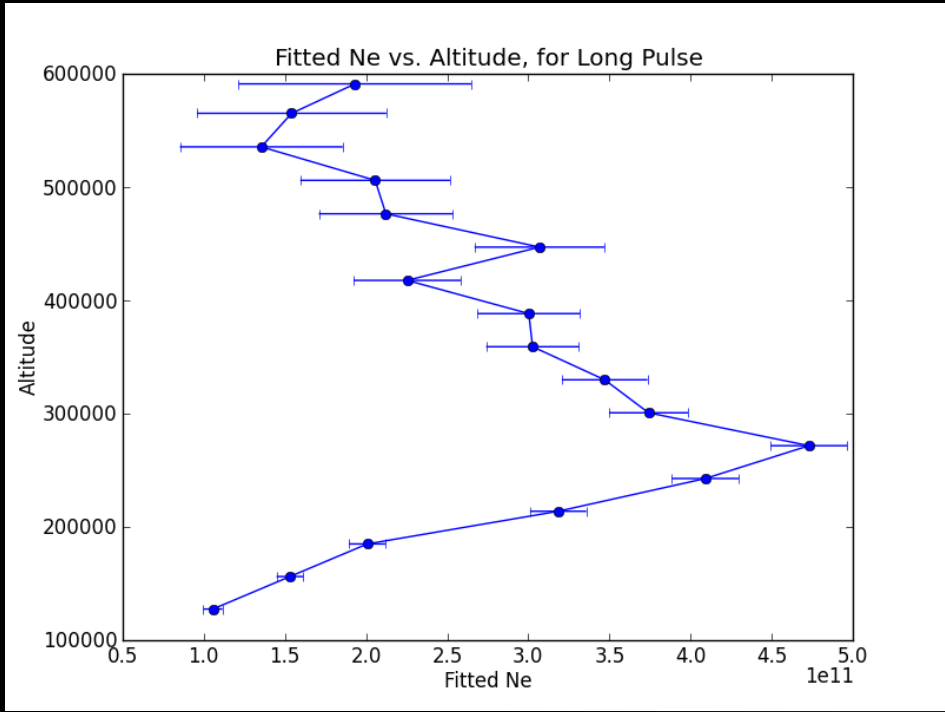
- The following show NE distributions derived from power measurements
- Uncertainties are indicated by the error bars as shown

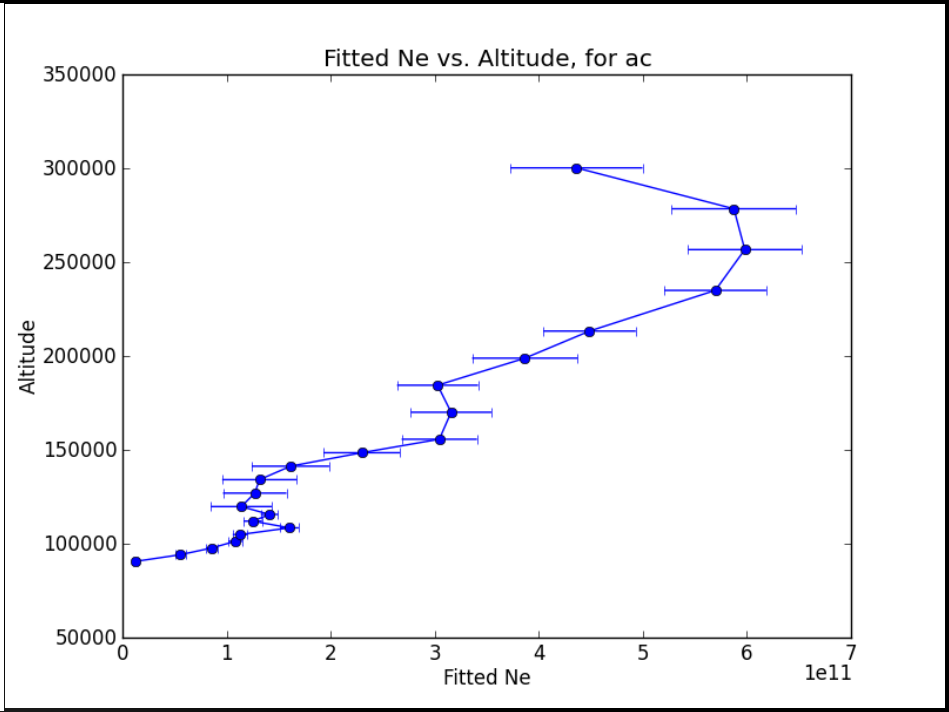




FITTED NE WITH ERROR

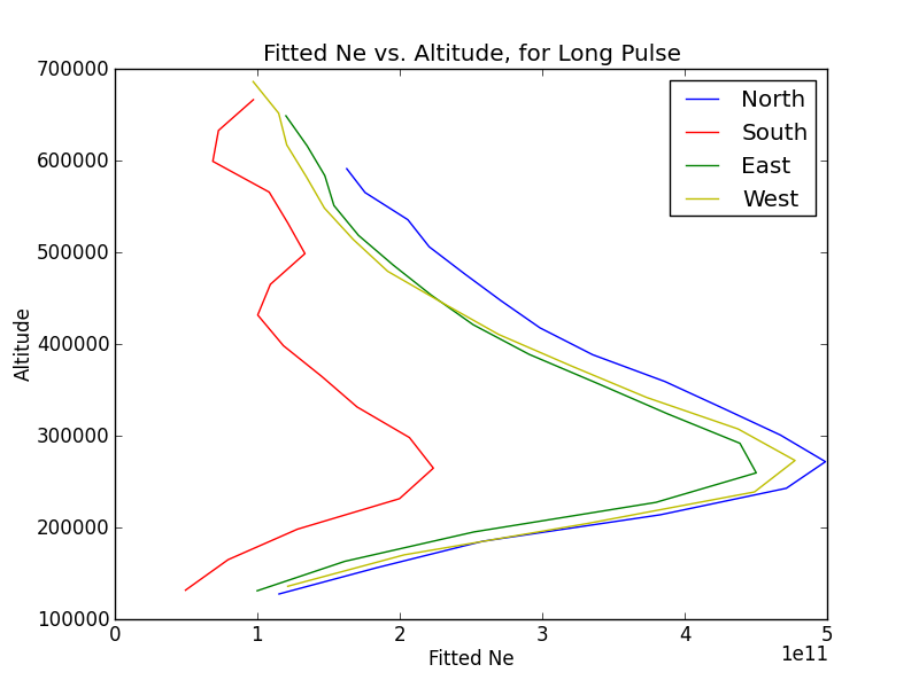
- The fitted results with error bars are presented below

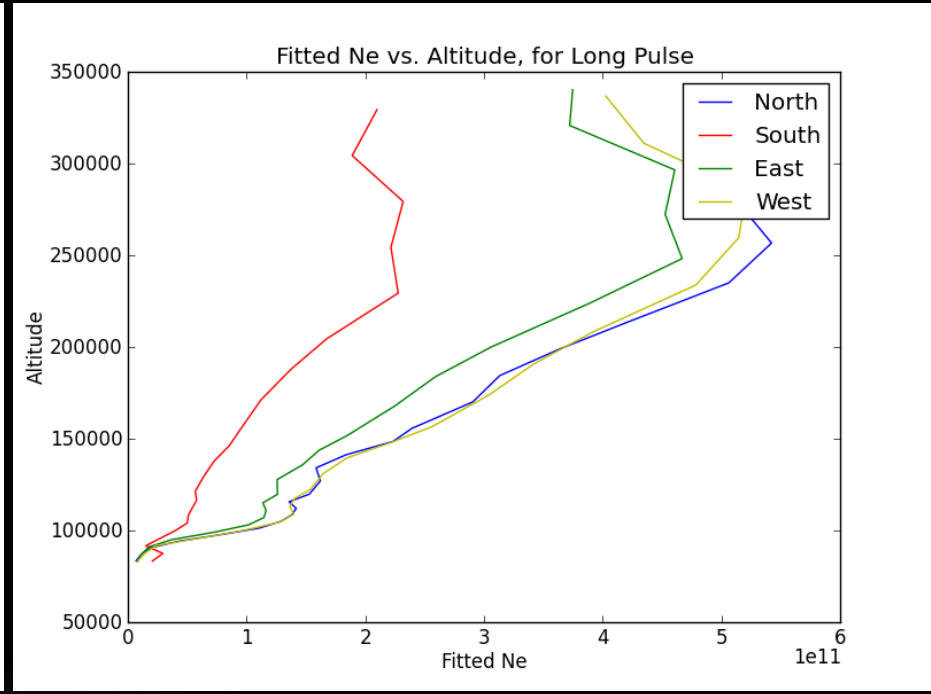




FITTED NE BY AREA

- The discrepancy in the southern region is very apparent





SUMMARY AND CONCLUSION

- The experiment indeed seems to indicate some latitudinal variation: the electron density in the south is lower than that in north. This may be due to the main ionospheric trough.
- The electron temperature also shows such a trend since high electron temperature is observed in the south.
- Results for the other regions match very closely with both the empirical model as well as available previous data from within the last year. However, the IRI model does not describe all ionospheric features, but may be useful in certain applications (GPS).
- Natural physical phenomena must be considered in critical analysis of the data – sun location, sidelobe interference, possible physical phenomena (troughs) or other error
- Alternatively, northern regions could be substantially more suitable for ISR measurements because of plasma characteristics at higher latitudes.