ISR Group One Meteor Echoes and Sporadic E

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Outline

- Introduction and Goals
- Background
- Setup and Execution
- Computational Design/Process
- Data/Analysis
- Conclusion

Introduction

Our group was assigned an observation window from 0500 to 0630 (local time). After browsing through the Madrigal archives for observations done during this time slot and time of year, we found that several observations were conducted with the intent to find ***Meteor Echoes.***

Introduction Continued…

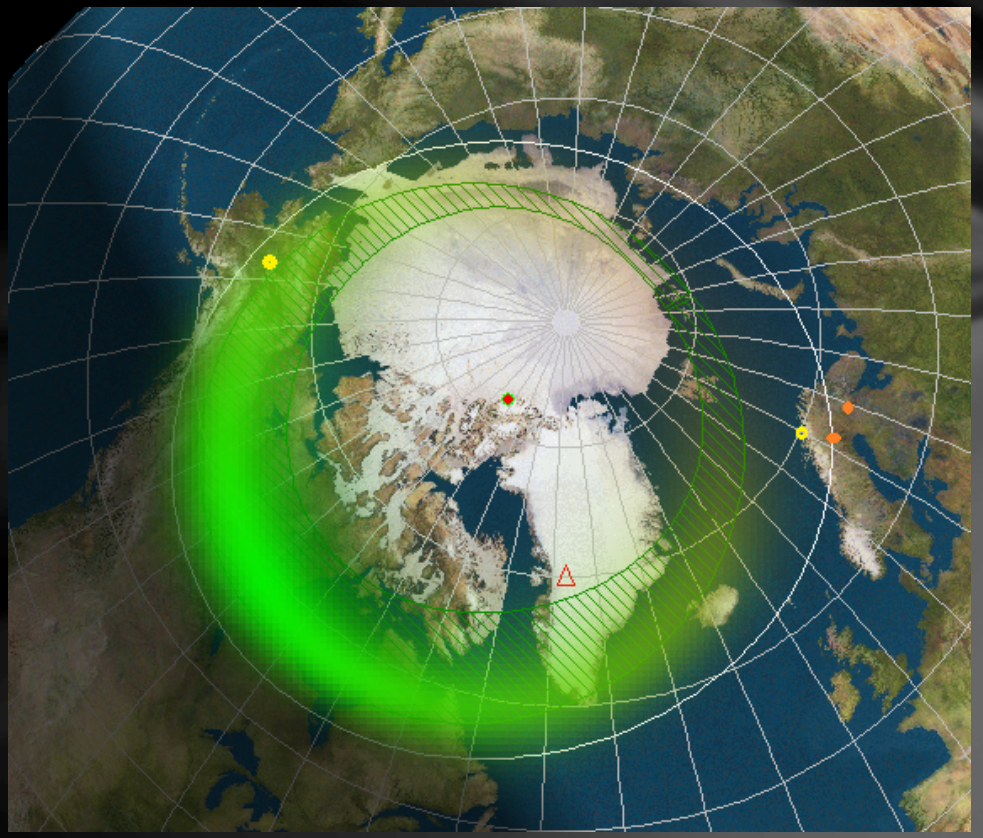
*Our team found that due to the trajectory of Earth's orbit and the increased exposure of our position at that particular time , the probability for detecting meteors increases. *Similar to bugs hitting the car windshield effect.*

Introduction

Auroral Oval at 0700 UT 20 July 2011

Includes positioning for:

- *Sondre*
- *EISCAT*
- *PFISR*



Goals

Our group decided that our primary goal for our observation time was to detect Meteor Echoes. Though, we realized that there was a chance that we might not detect any, so we decided to attempt to observe a Sporadic E as well since their activity peaks during the summer time.

Meteors

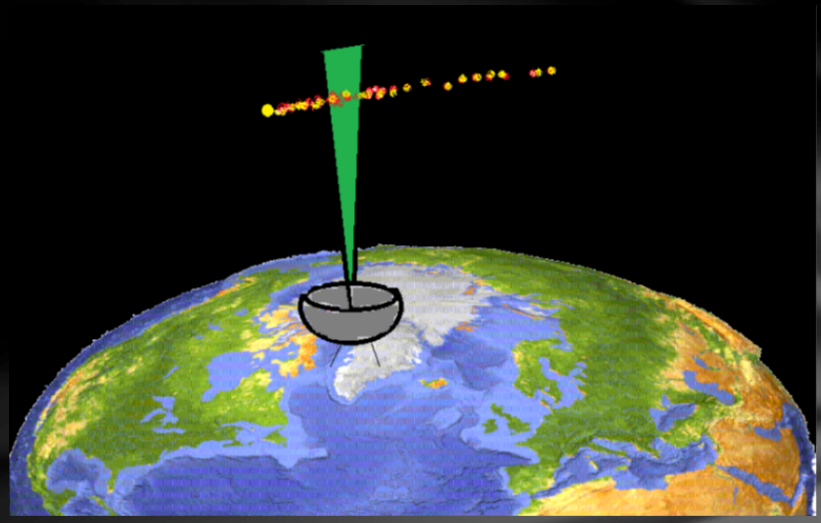
A meteor is the observable path that a meteorite creates as it enters Earth's atmosphere.

Characteristics:

- *Typically occur in Mesosphere (75km -100km)*
- *Millions occur in the atmosphere every day*
- *Most are pebble size*
- *Disintegrate at 50km to 95km*
- *50 percent of meteors enter Earth's atmosphere "west of noon"*

Meteor Echoes

When a UHF signal interacts with a meteor that is crossing perpendicular to the path of the beam, an echo can be analyzed from Fraunhofer diffraction.



Sporadic E

Sporadic E is when cells of ionized atmospheric gas develop in the E region of the atmosphere causing a signal to refract. This occurrence is considered bizarre since Ionized cells that are seen in the sporadic E usually only develop in the F region. Though, it is beneficial to people who are transmitting with VHF radios because it allows their signals to travel farther.

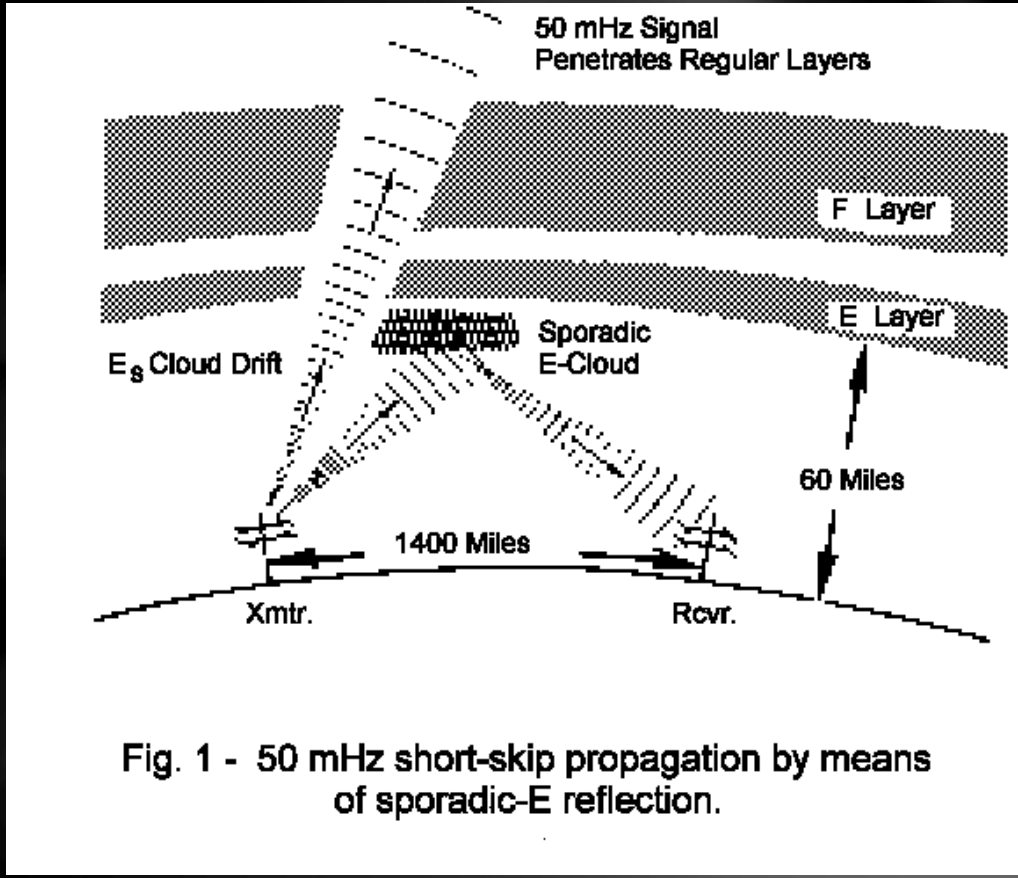


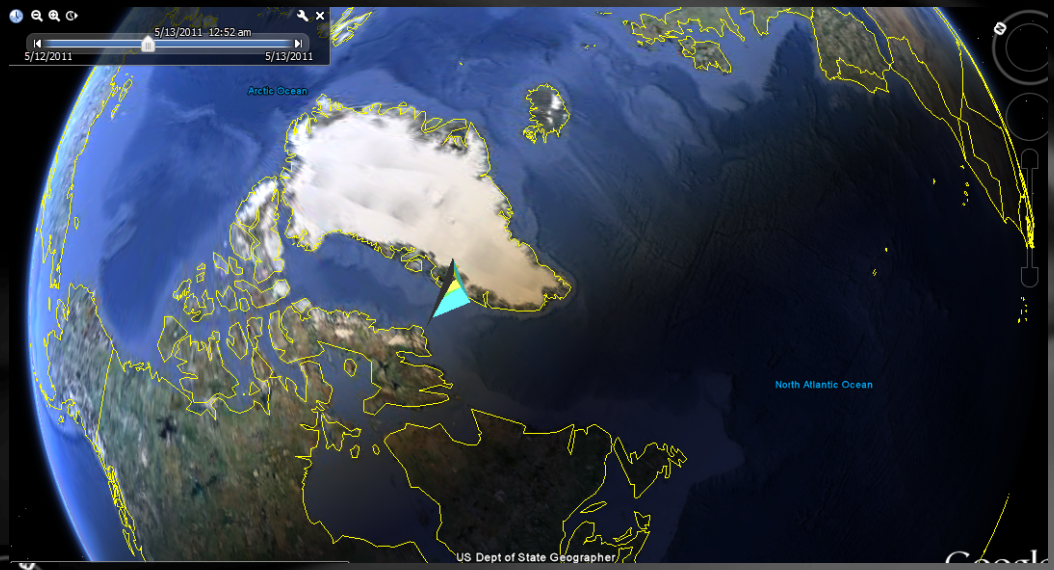
Fig. 1 - 50 mHz short-skip propagation by means of sporadic-E reflection.

Setup and Execution
Sondre

- **Three Propagations**
  - Elevations/Azimuths: 80/141 70/186 70/231
  - Fixed
  - Three minutes each
  - Barker Code, Long Code and Alternating Code
  - Objective to observe both Meteors and Sporadic E

Setup and Execution

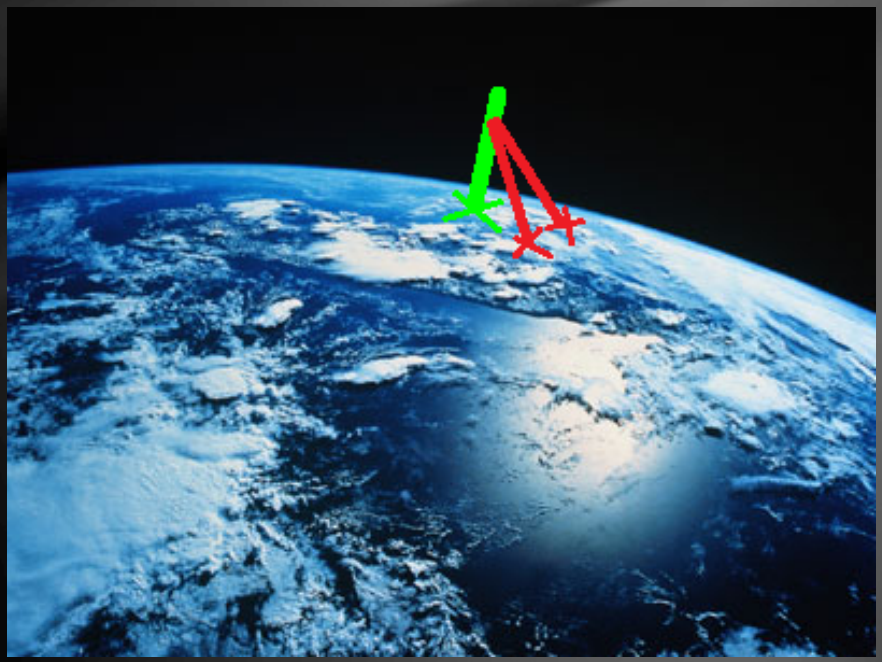
Sondre



Setup and Execution

EISCAT

- **Common Program 6 TX settings w/ CP 1 Propagations**
  - Field Aligned
  - Moderate time resolution, < 1min
  - High range resolution, ~1 km
  - High spectral resolution, 10 Hz
  - D region, 70-100 km



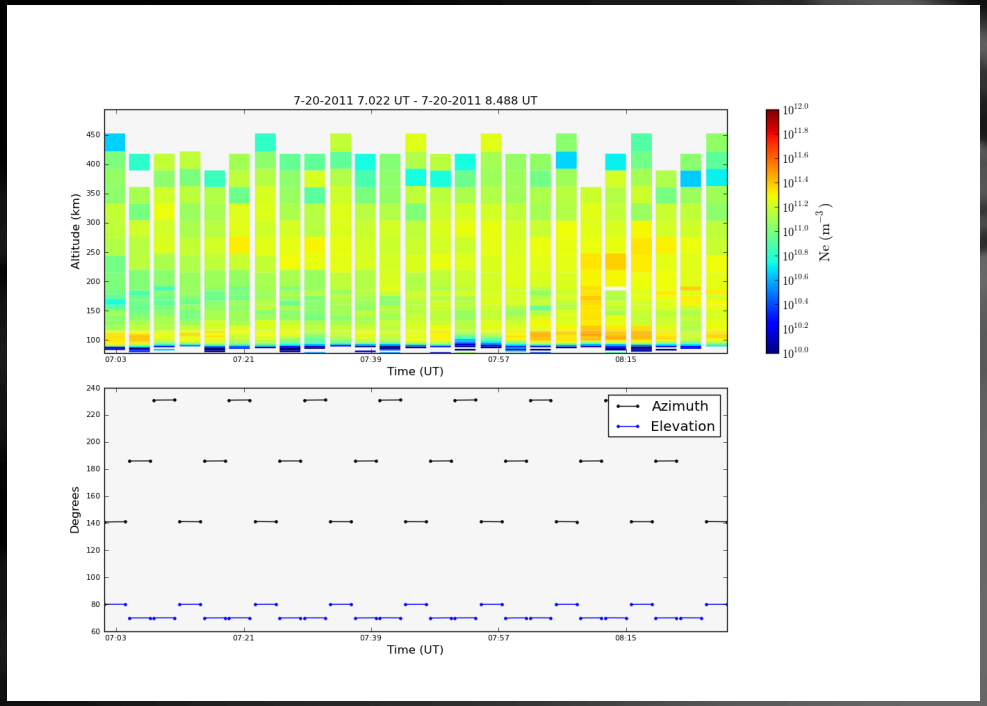
Setup and Execution

PFISR

- Scanning for Sporadic E only

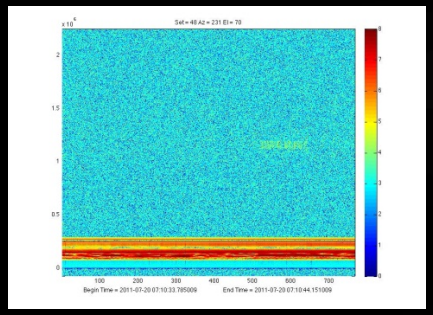
Data: Sondre

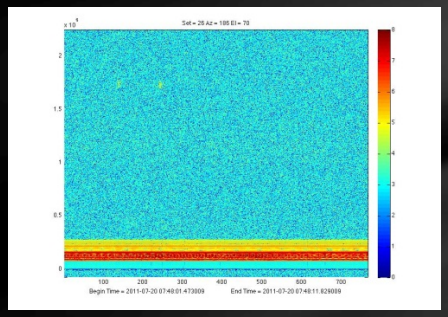
Electron Density during entire observation time

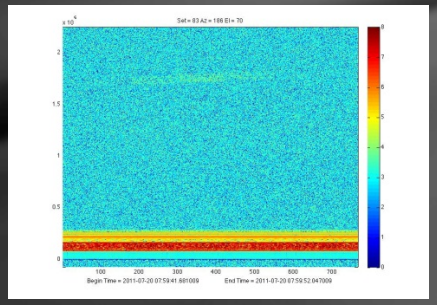


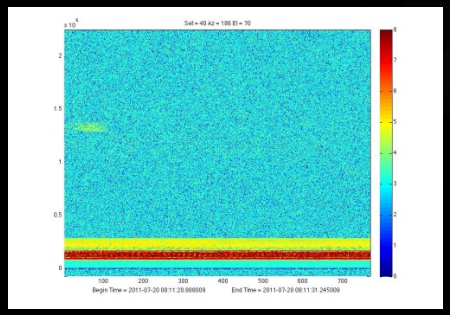
Meteor Method 1

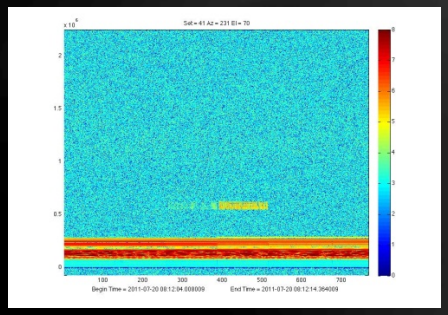
Some Raw data……

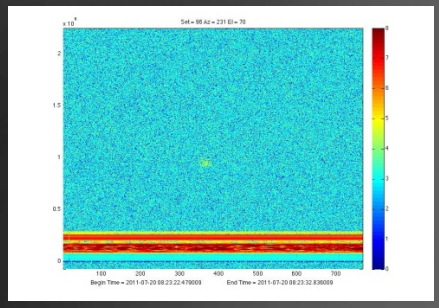










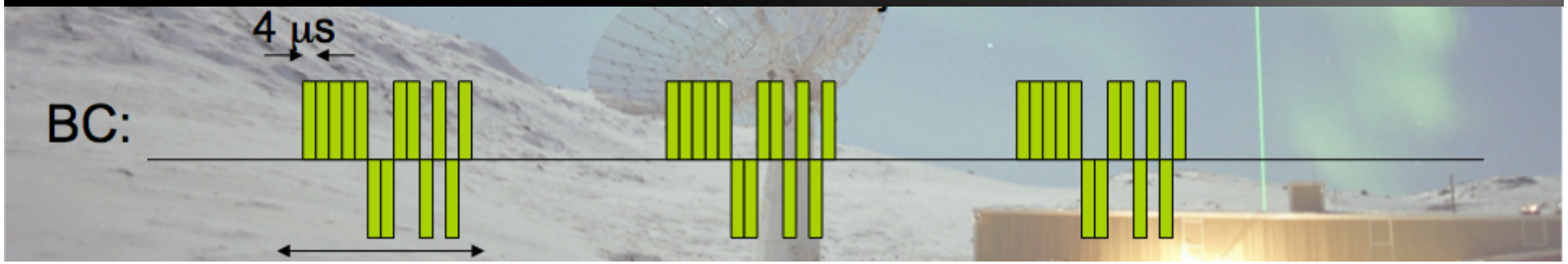


Computing Meteor Doppler Shift

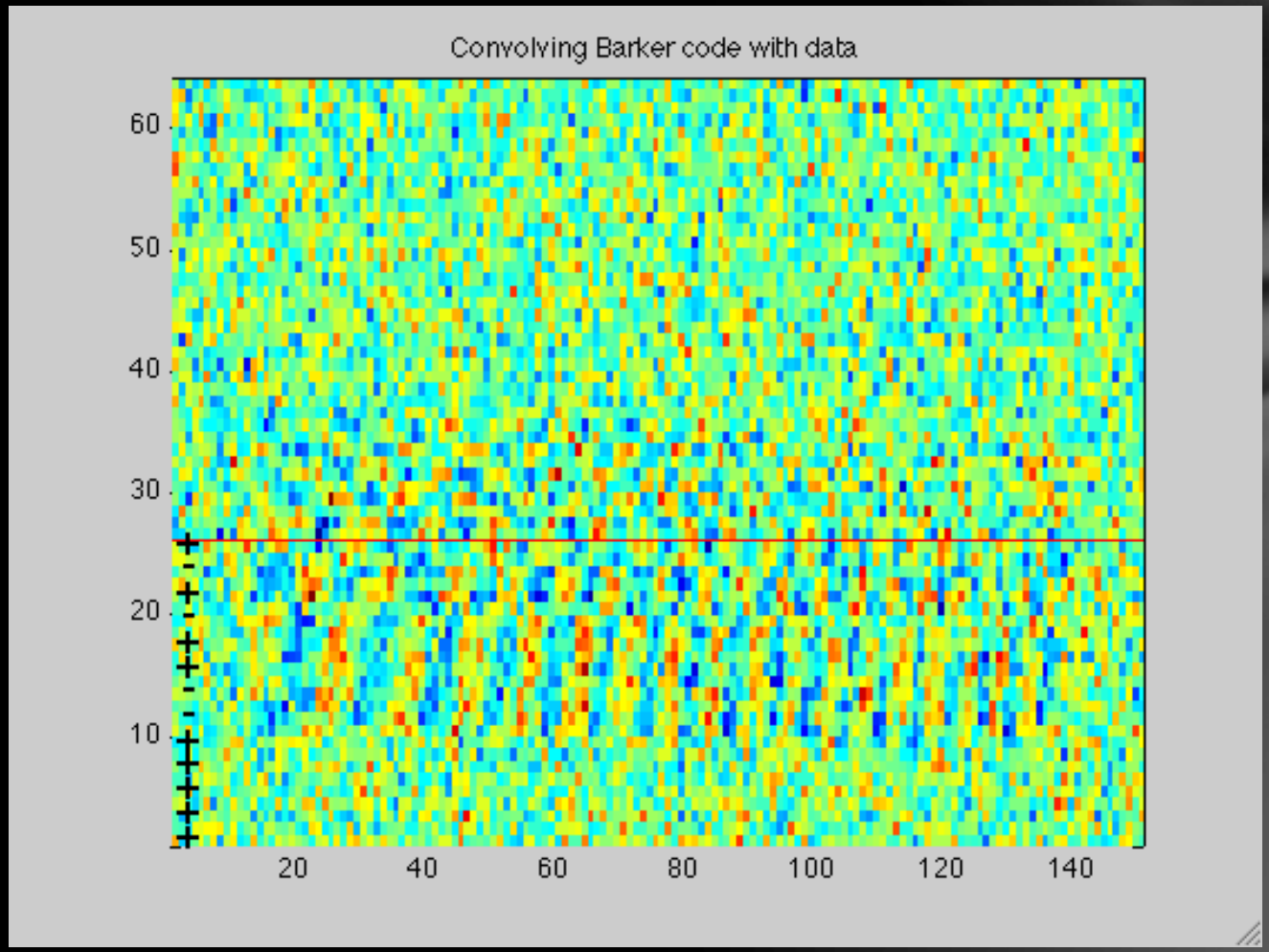
$$Ae^{j\Phi} = I + jQ$$

$$\Phi = a\tan 2(Q, I)$$

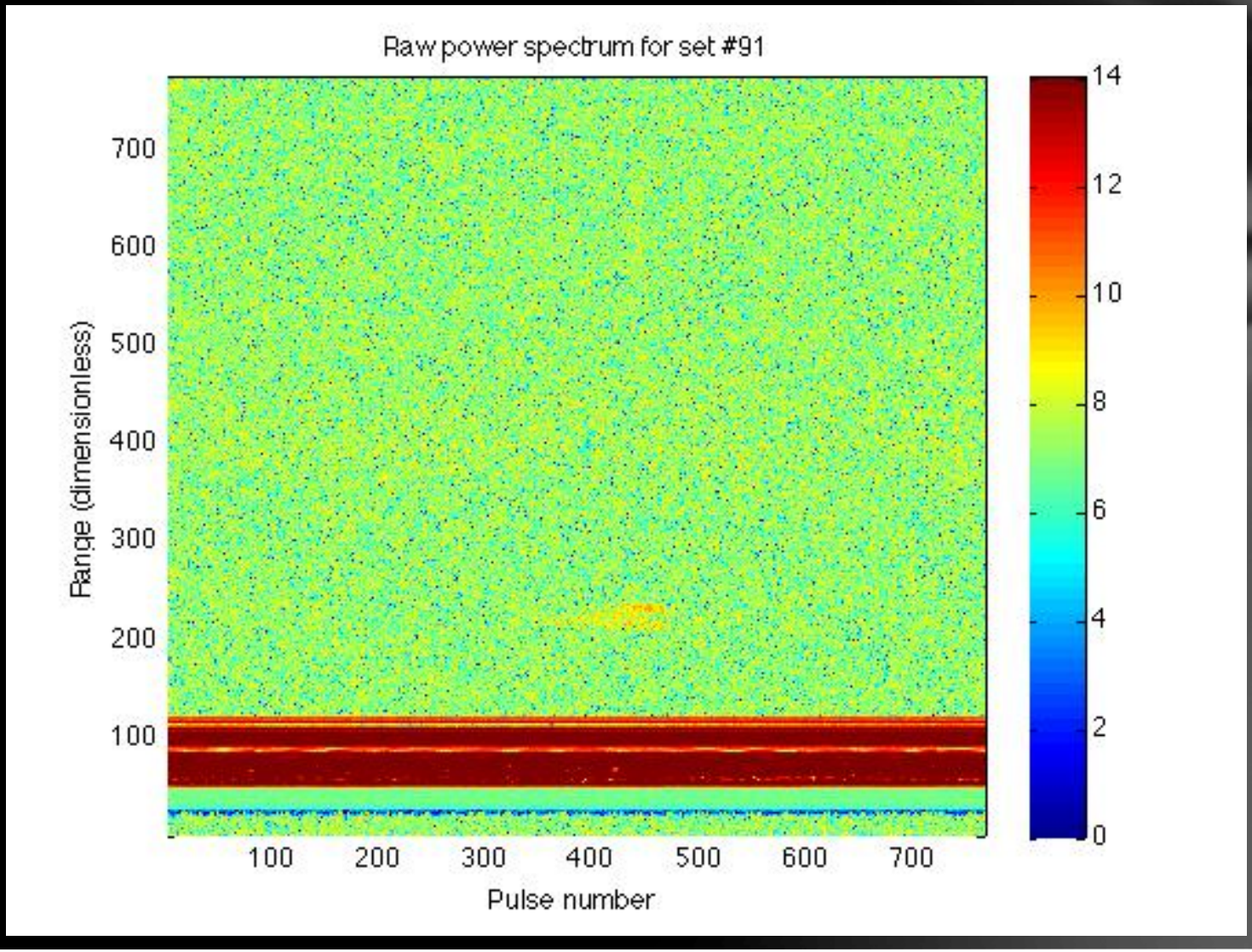
$$FFT(conv(barker .* signal))$$



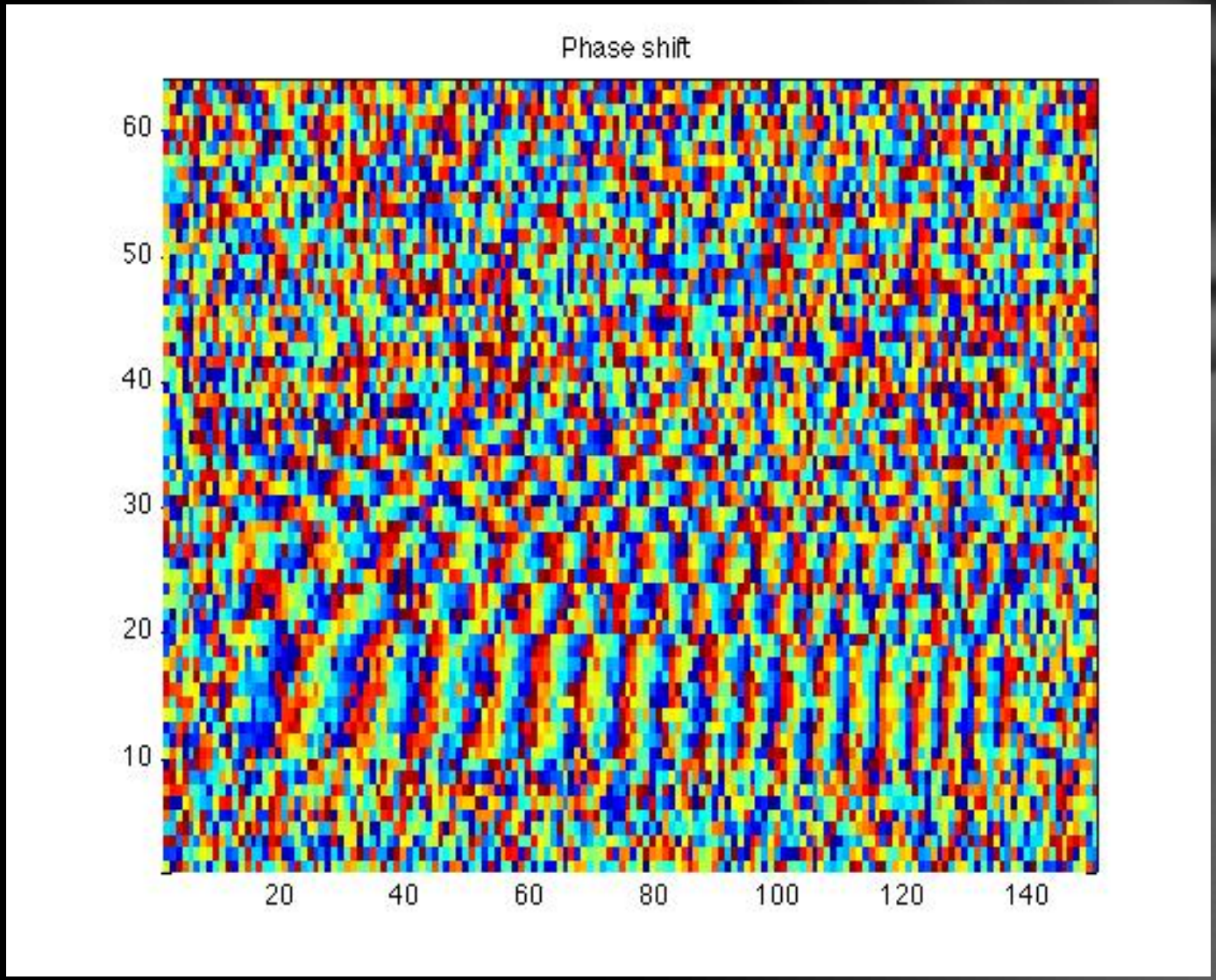
Convolving Barker code with data



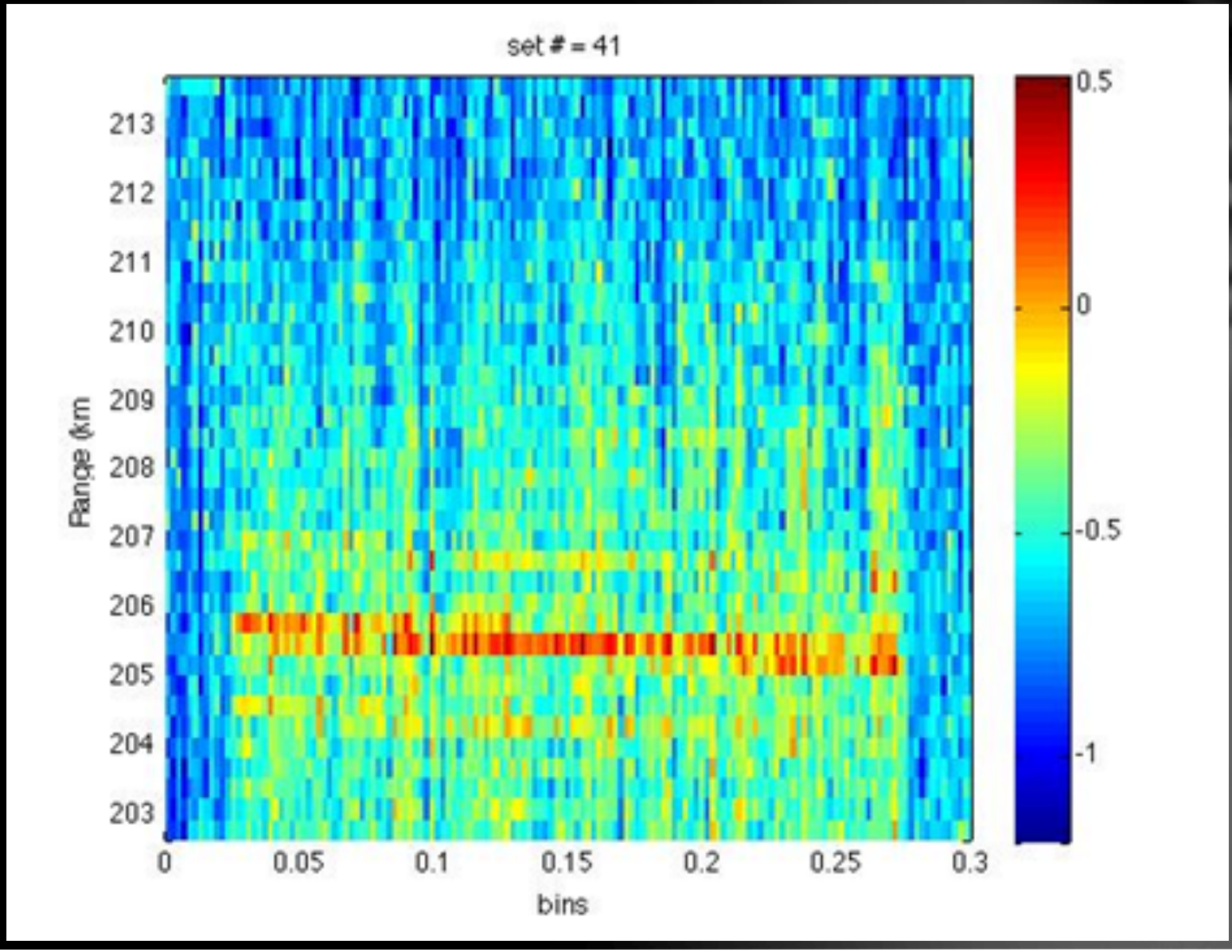
Meteor Power spectrum



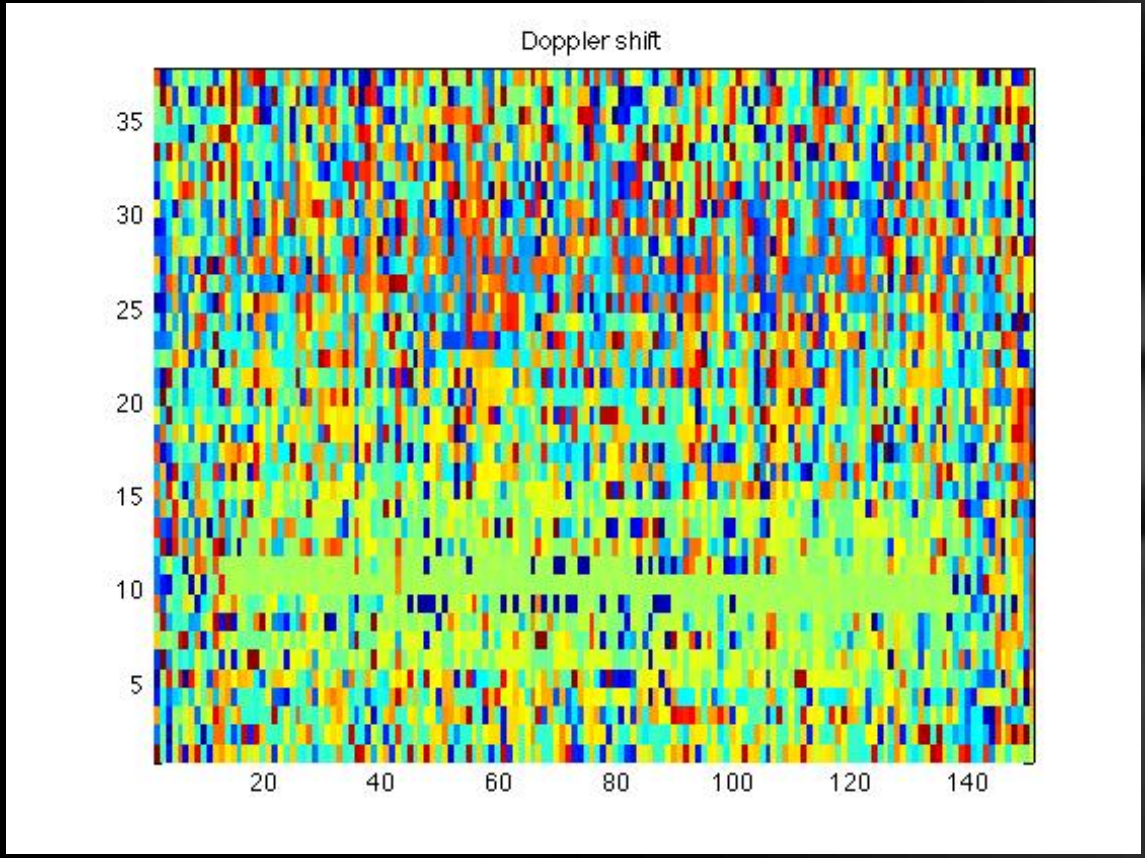
Phase



Sharpened signal

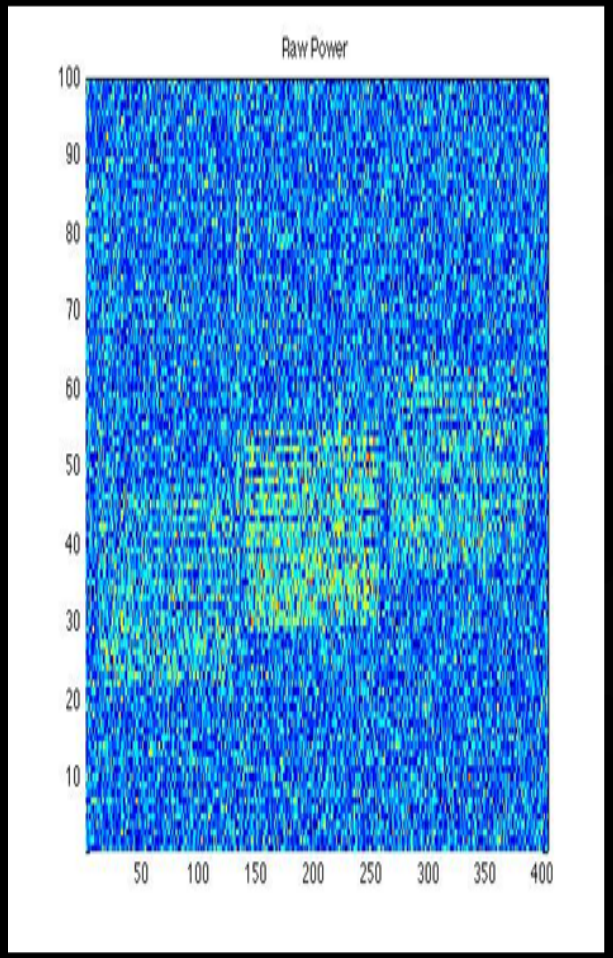


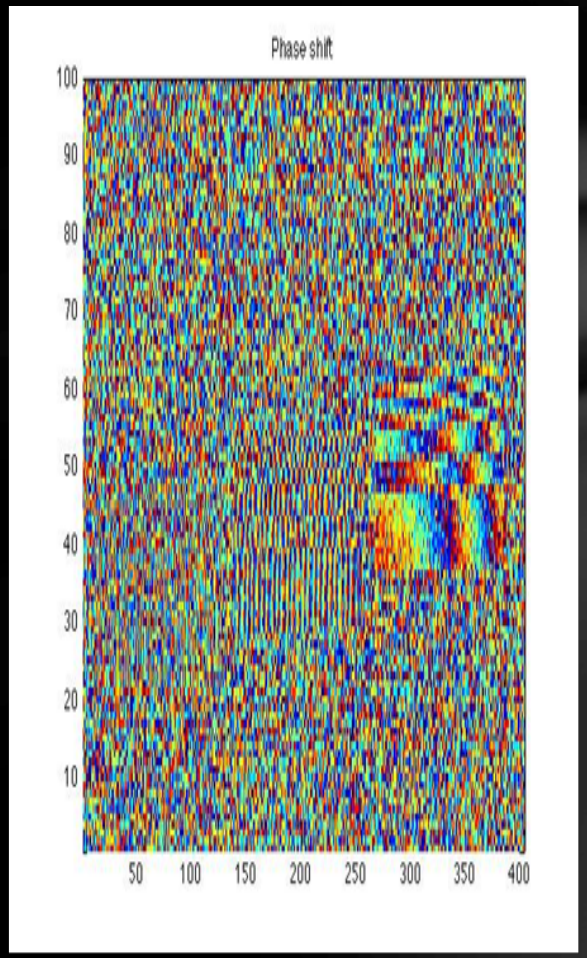
Computing Meteor Velocities

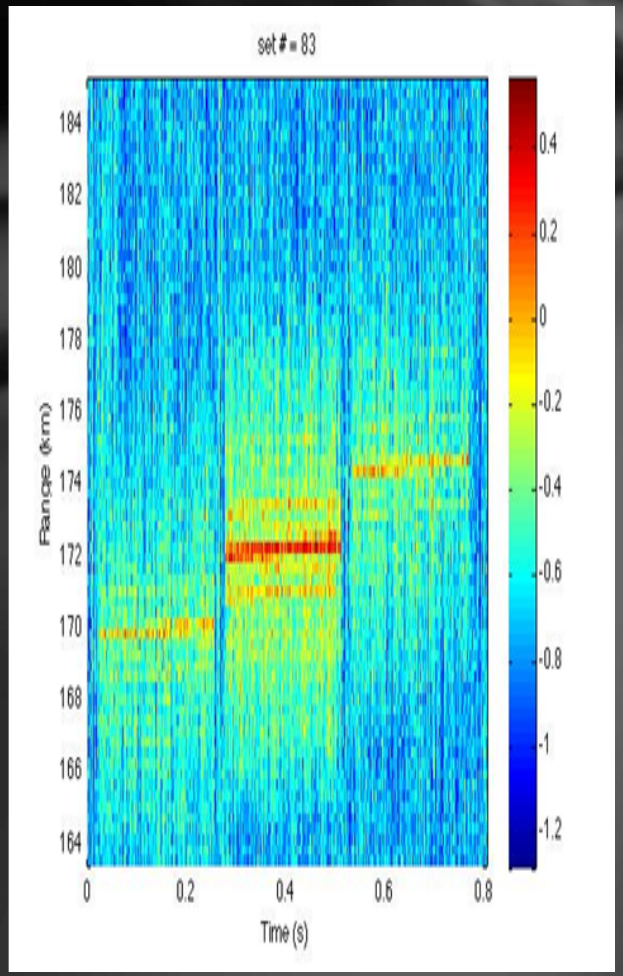


$$v_{meteor} = -\frac{f_D \lambda_{radar}}{2}$$

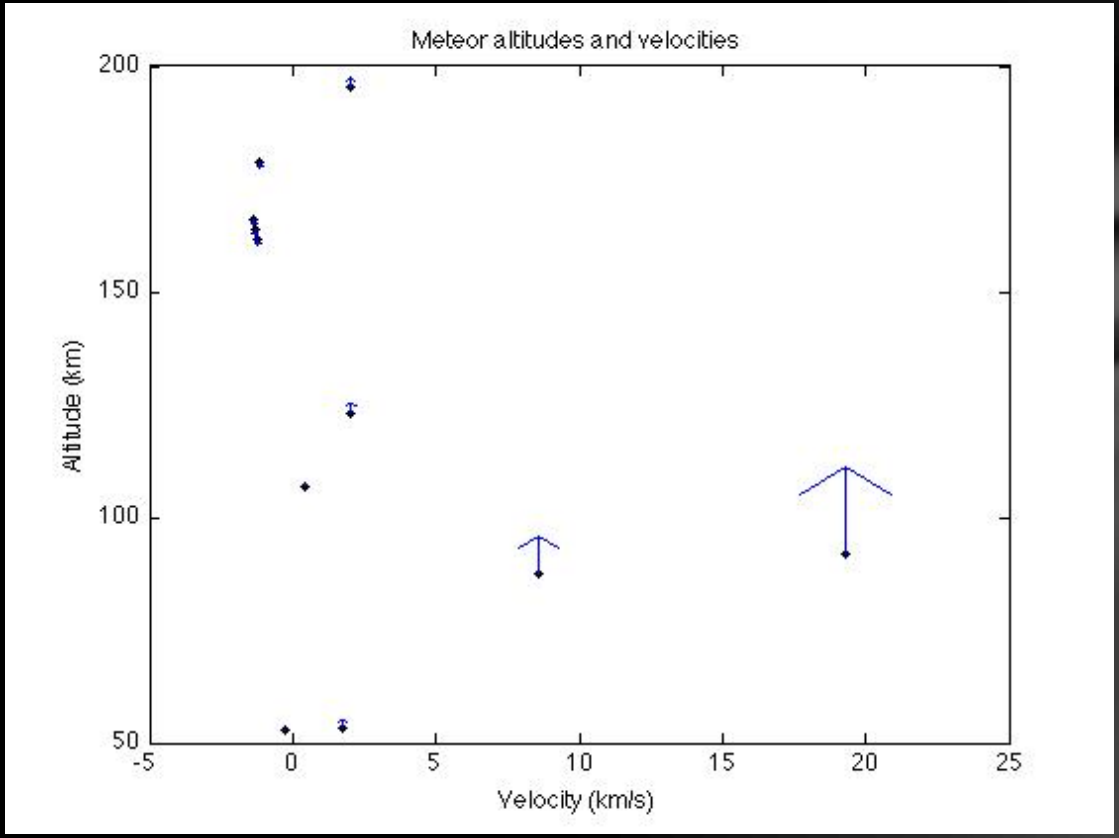
Other Interesting stuff





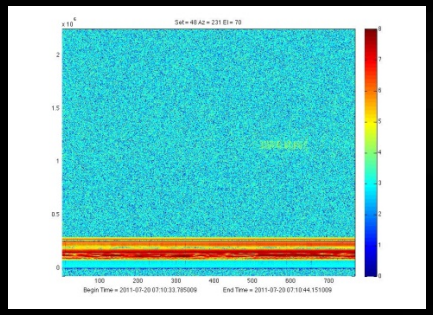


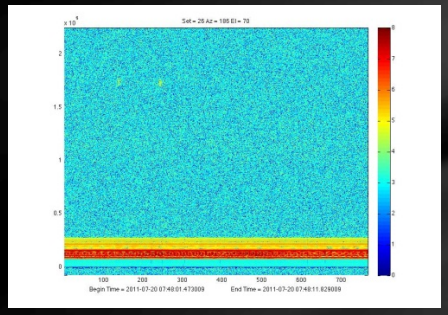
Meteors' Velocity and Acceleration

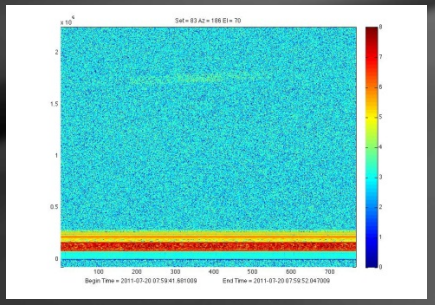


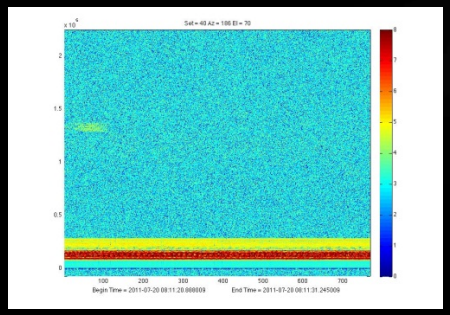
Meteor Method 2
Visually Resolving Meteors

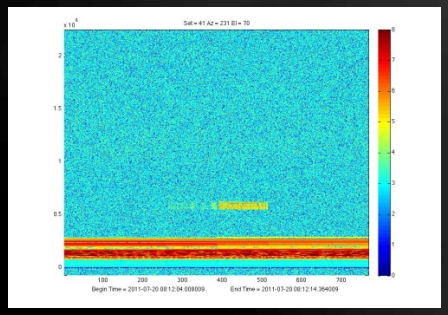
Some Raw data……

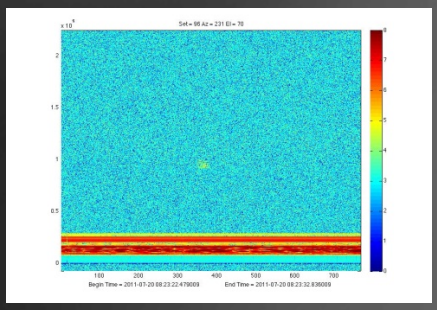




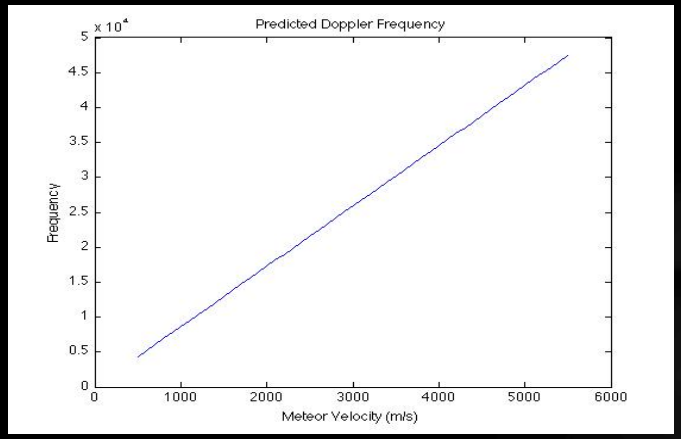


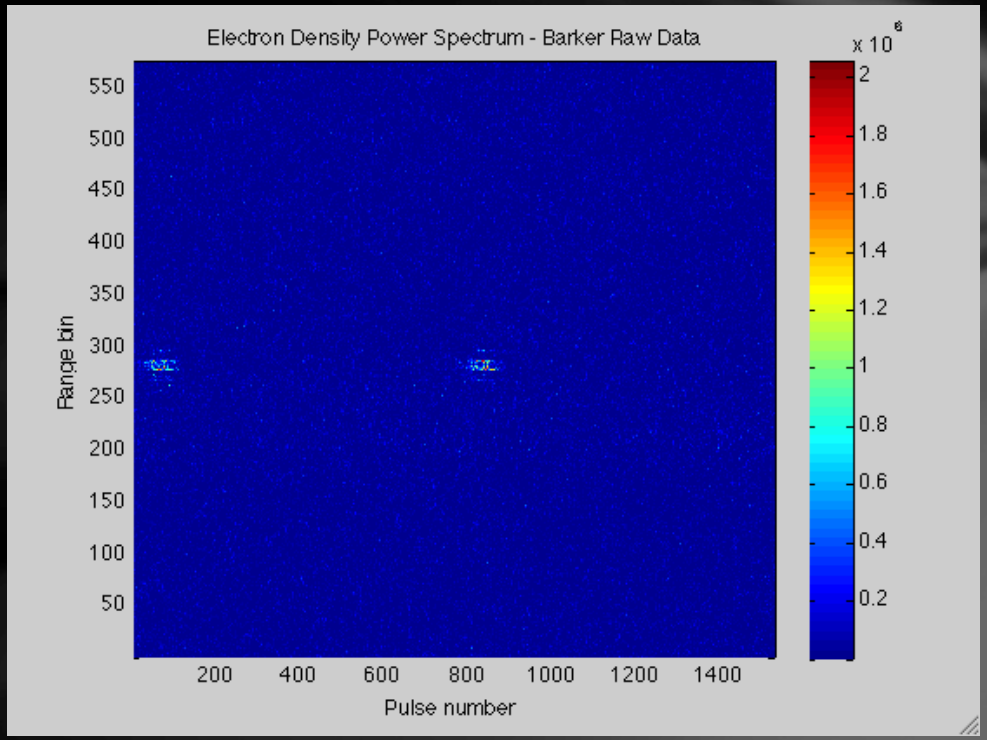






Scanning for Meteor Doppler Shift





Connecting Meteors and Aurora!

AURORAL EFFECTS ON METEORIC
METALS IN THE UPPER ATMOSPHERE

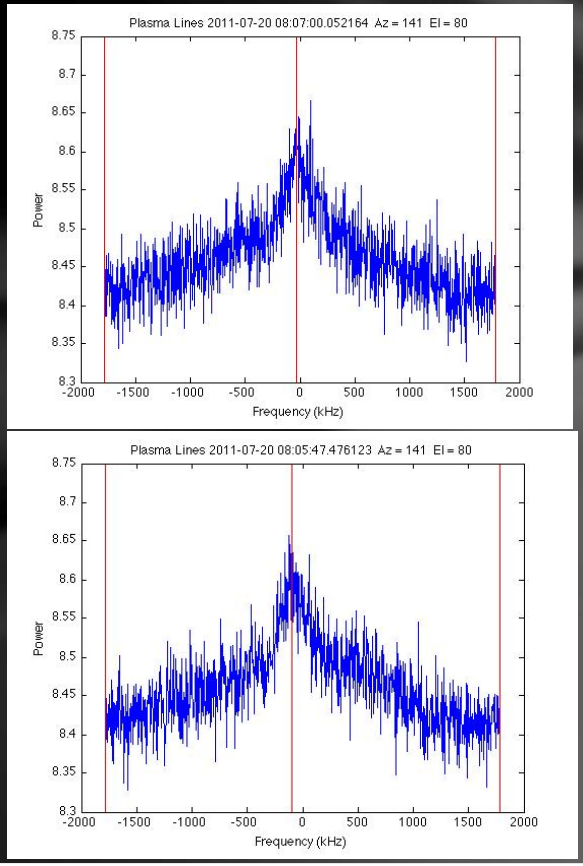
A DISSERTATION
SUBMITTED TO THE DEPARTMENT OF ELECTRICAL ENGINEERING
AND THE COMMITTEE ON GRADUATE STUDIES
OF STANFORD UNIVERSITY
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

By
Craig James Heinselman
June 1999

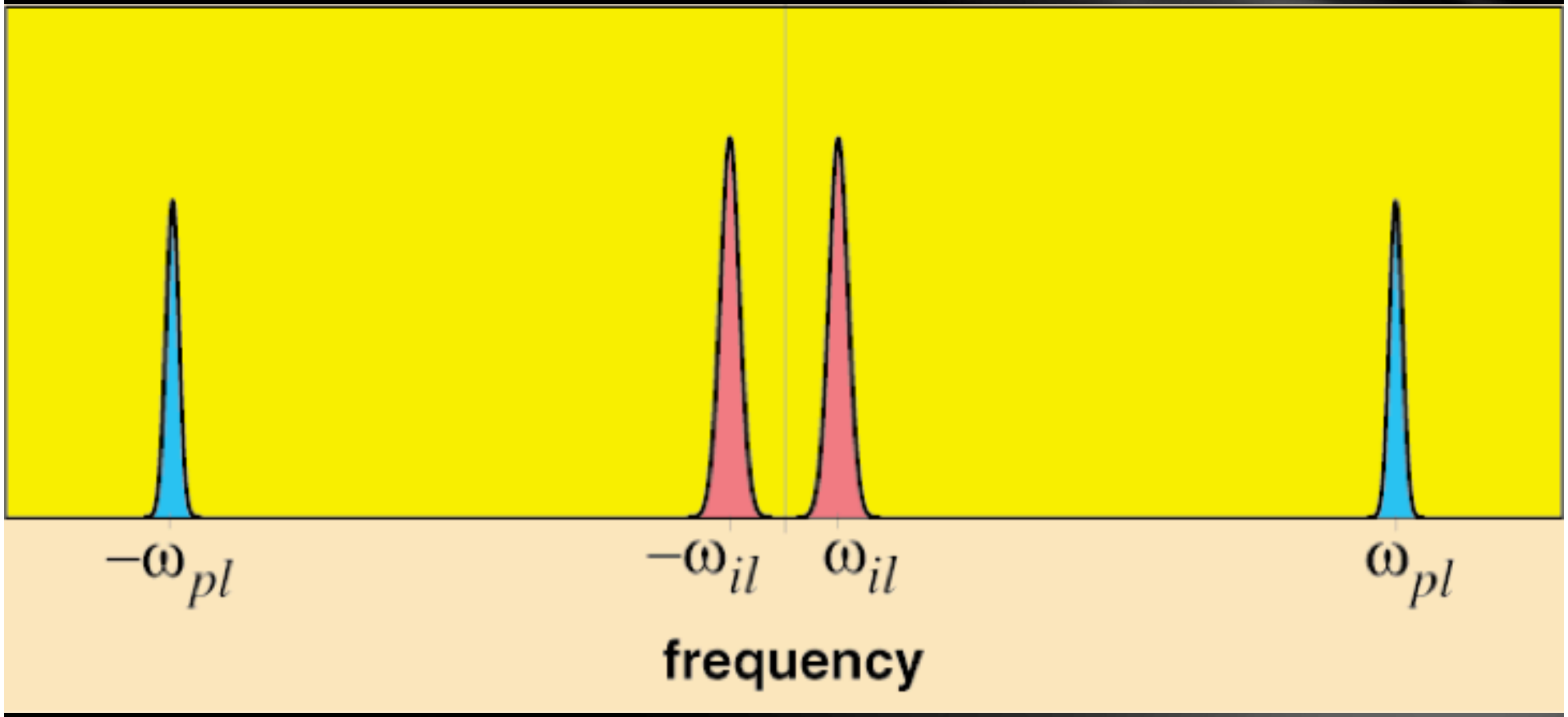
Plasma Lines from Auroral Precipitation

-Observed strong Plasma Lines at a time frame approx. from 0750 to 0810 UT

-Due to Auroral precipitation



Plasma Line Equations and Computational Design



Plasma Line Equations and Computational Design

$$f_r^2 = f_p^2 + \frac{3k^2}{4\pi^2}\frac{k_b T_e}{m_e} + f_c^2 \sin^2\alpha \qquad (1)$$

$$k_\pm = \frac{2\pi}{c}[f_0 + (f_0 \pm f_r)], \qquad (2)$$

$$\delta f = f_{r-} - f_{r+} \approx \frac{f_0}{c}\left(4V_e - \frac{12k_b T_e}{cm_e}\right) \approx 5.733V_e - 0.869T_e \qquad (3)$$

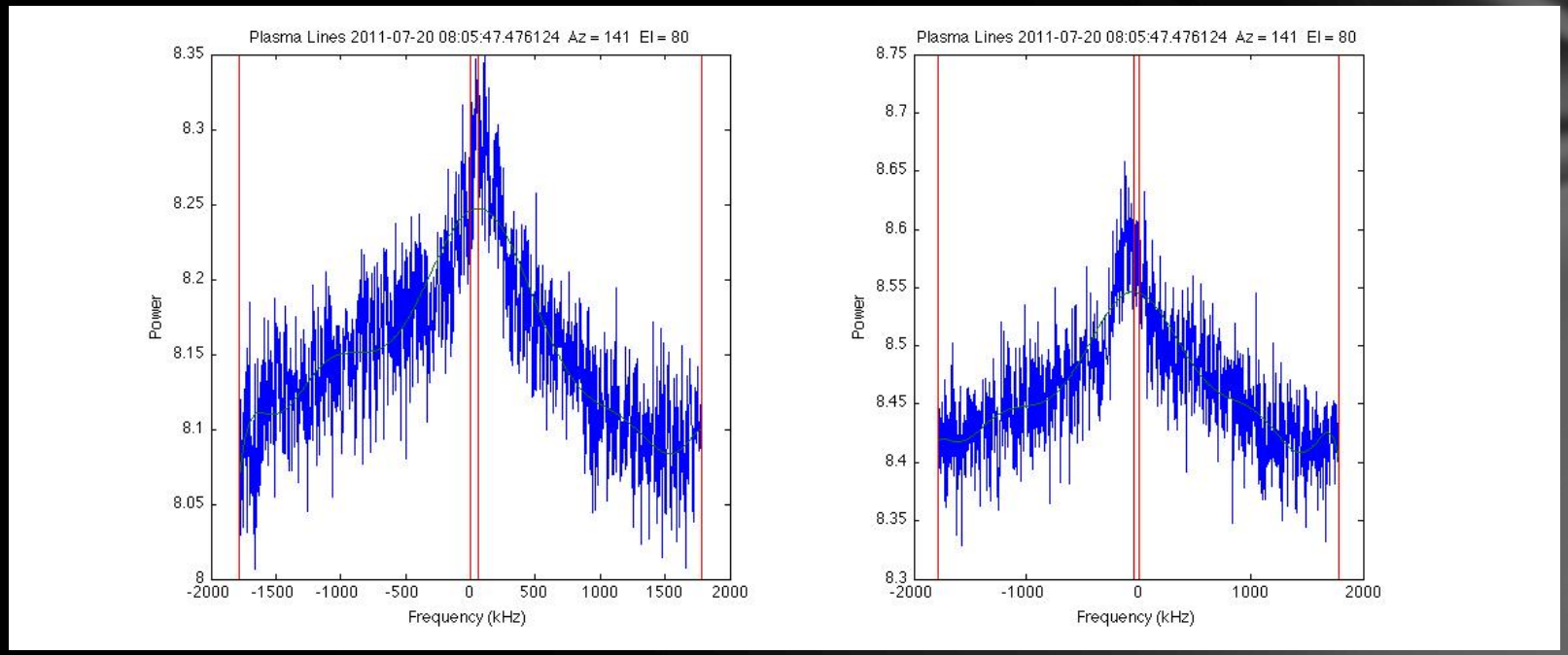
$$0 = |1 + \chi_e| \qquad (4)$$

Plasma Lines

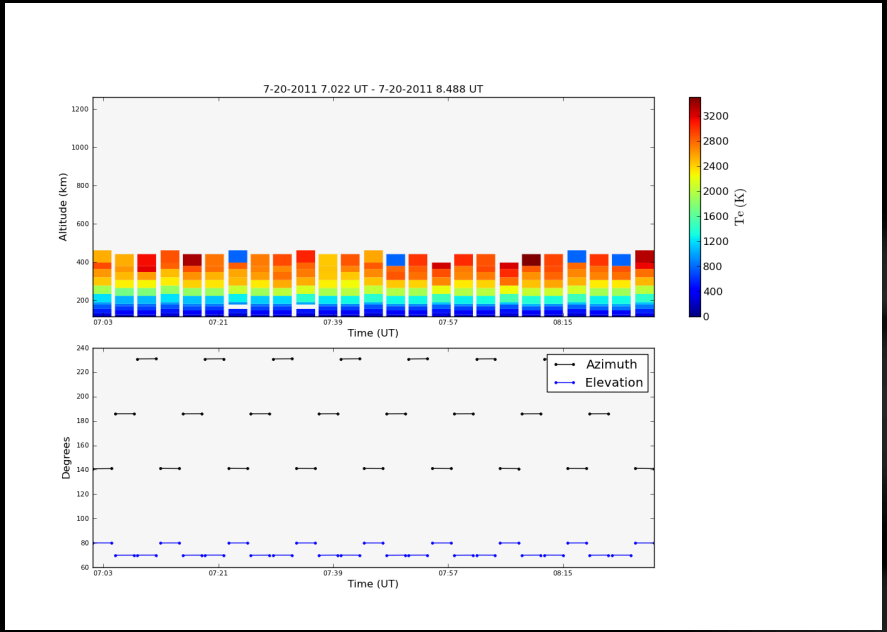
$$\frac{2\pi}{\lambda(\mathrm{TX})} + \frac{2\pi}{\lambda(\mathrm{RX})} = Kbragg$$

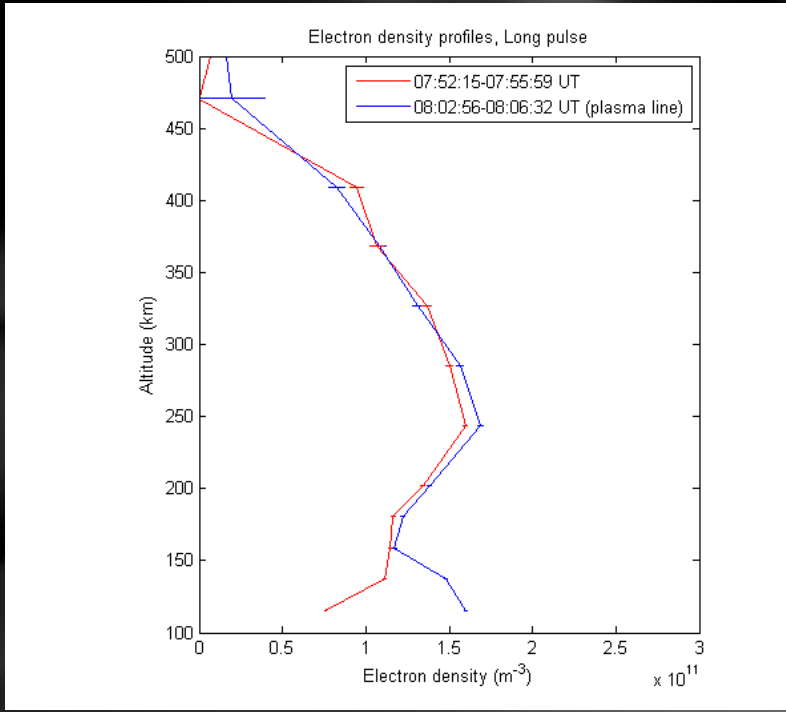
$$\omega(k) = \omega(1 + 3\lambda^2 K^2)$$

Upshifted and Downshifted Plasma Lines from Sondre

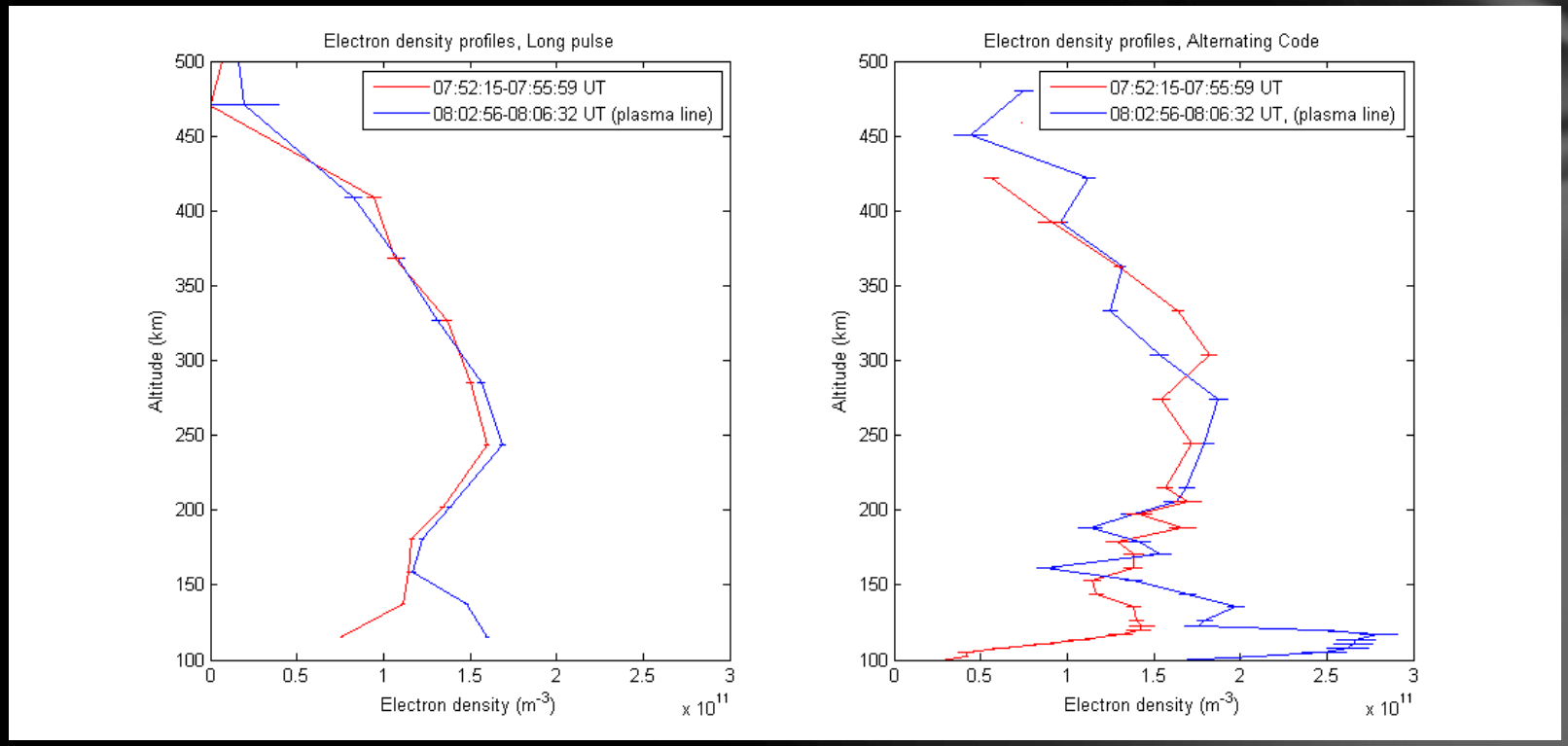


Electron Temperatures and Plasma Density from Plasma Lines





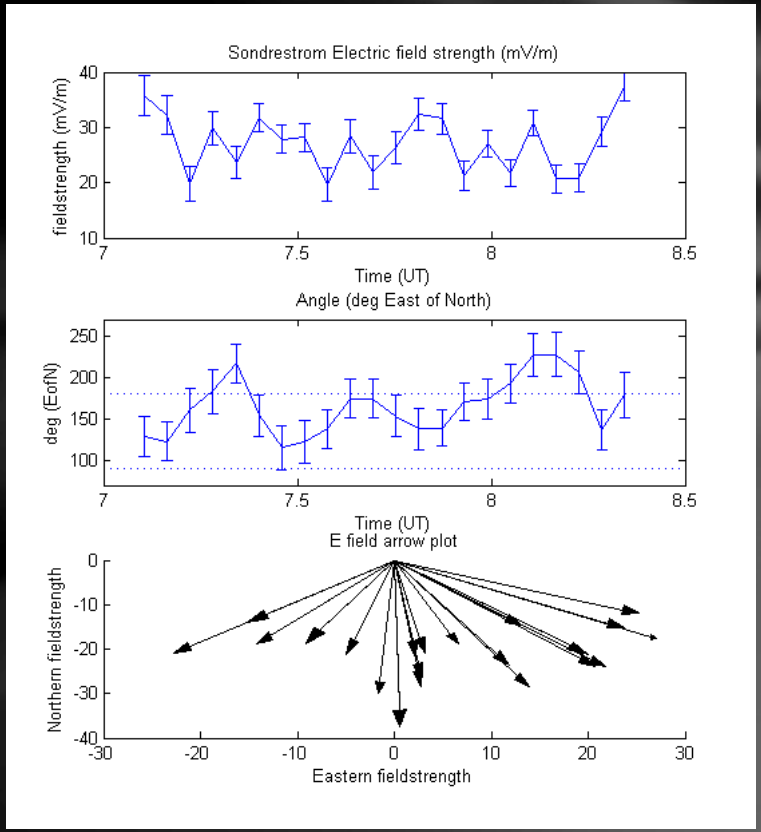
Electron density profiles at Sondre



Deriving Electric Fields at Sondre

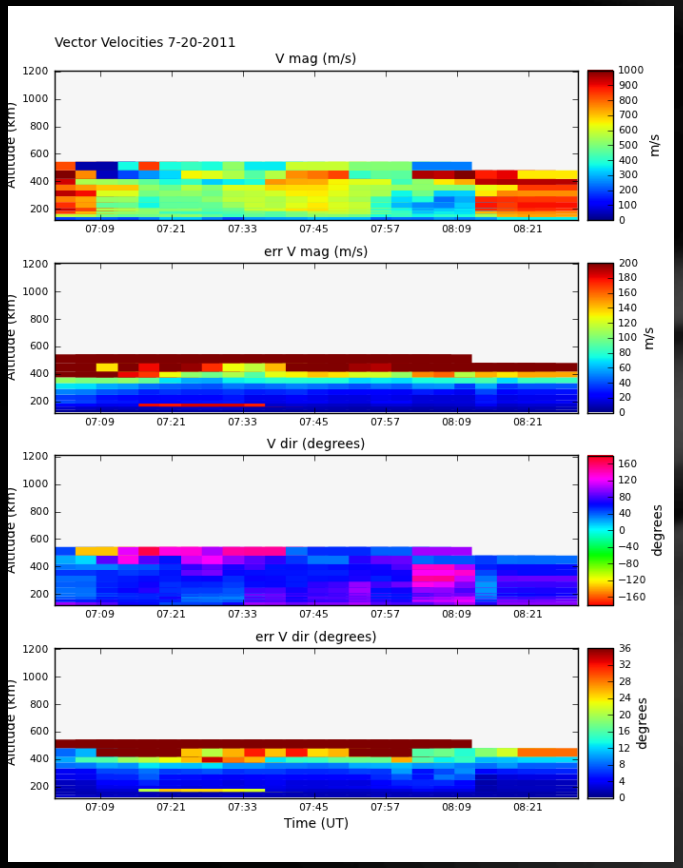
Electric field, Direction, and illustration

Found electric field to have a magnitude of ~30 mV/m, predominately in the southward direction



Vector Velocities from Madrigal

Increased velocities…

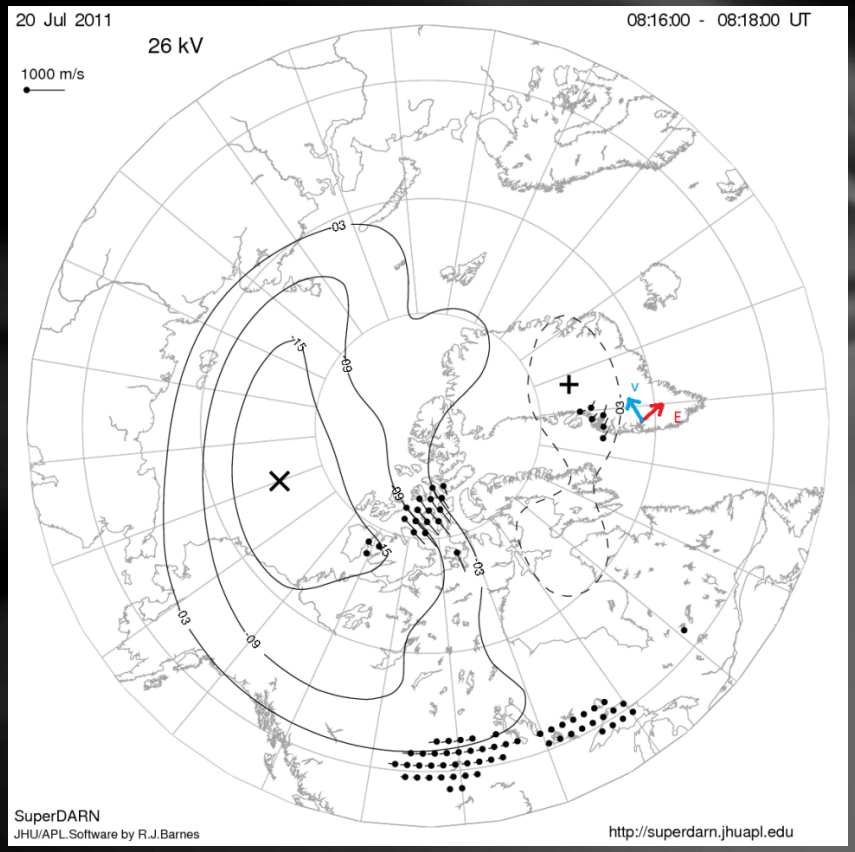


Comparing Electric Fields with SuperDARN

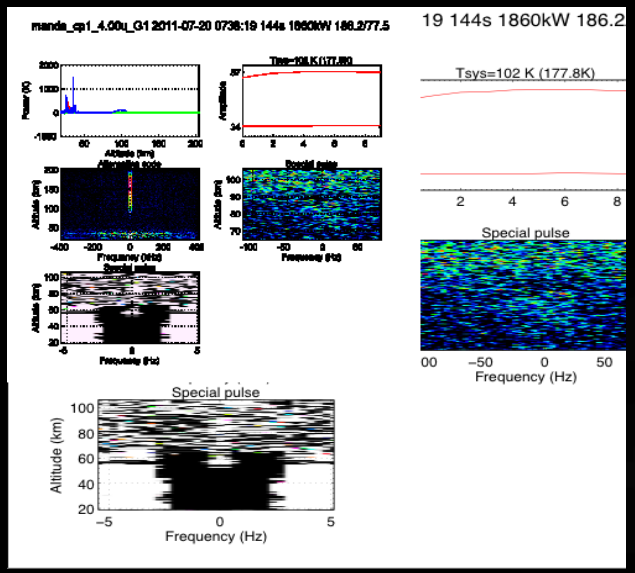
SuperDARN shows convection pattern close to Sondrestrom at 08:16 UT

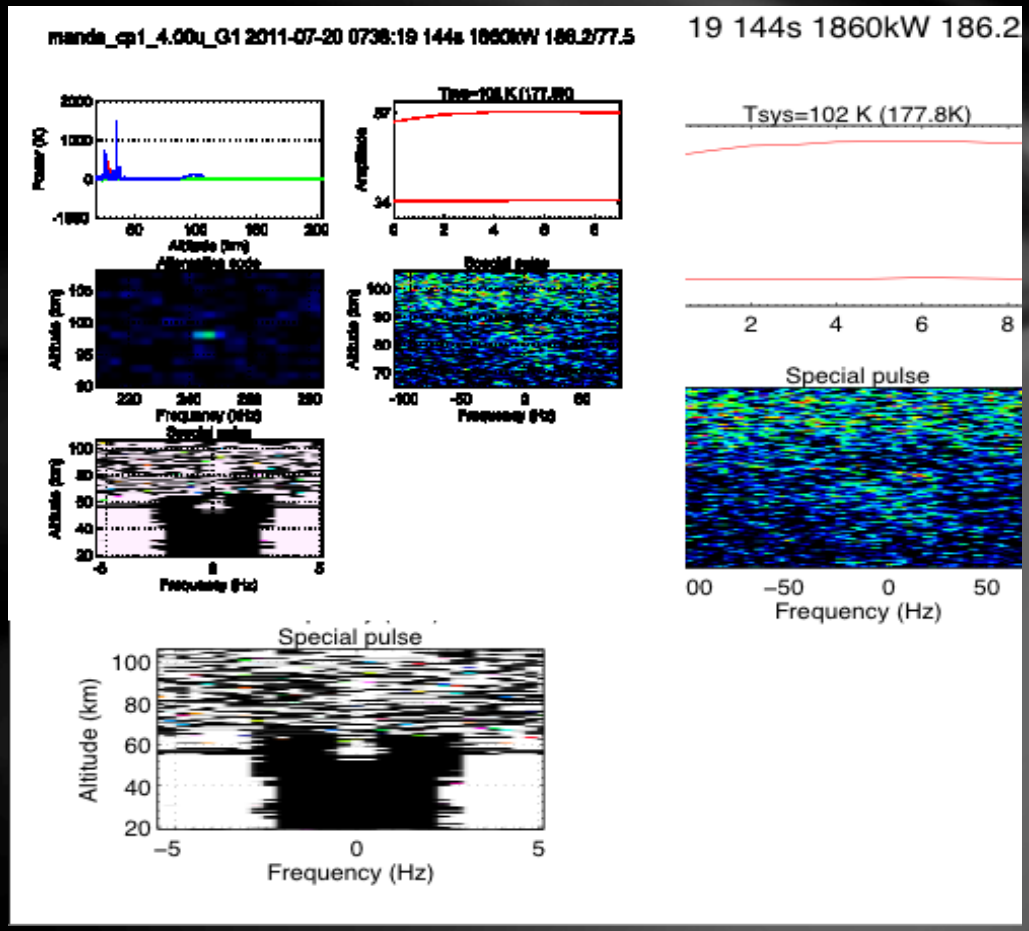
$$\mathbf{u} = \frac{\boldsymbol{E} \times \boldsymbol{B}}{B^2}$$

Sondre measures E of ~30 mV/m at 137 deg EofN, corresponding to v of ~600 m/s in the NE direction.



Meteors tracked by EISCAT



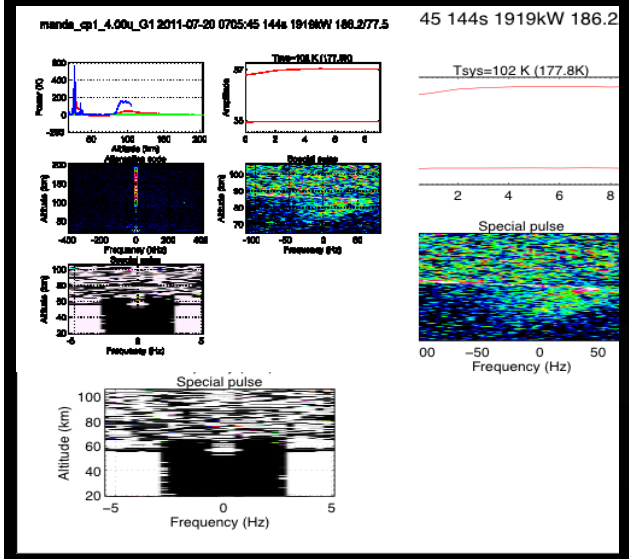


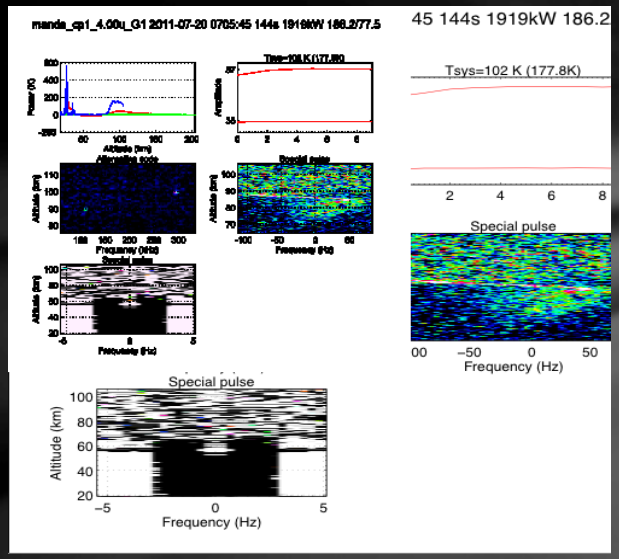
$$v_{meteor} = -\frac{f_D \lambda_{radar}}{2}$$

f_D = 245 kHz
λ_{radar} = 0.32 m

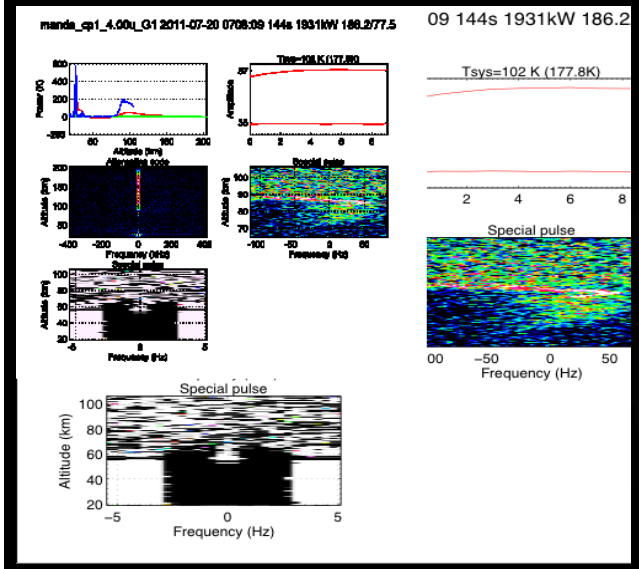
Vmeteor = 40 km/s

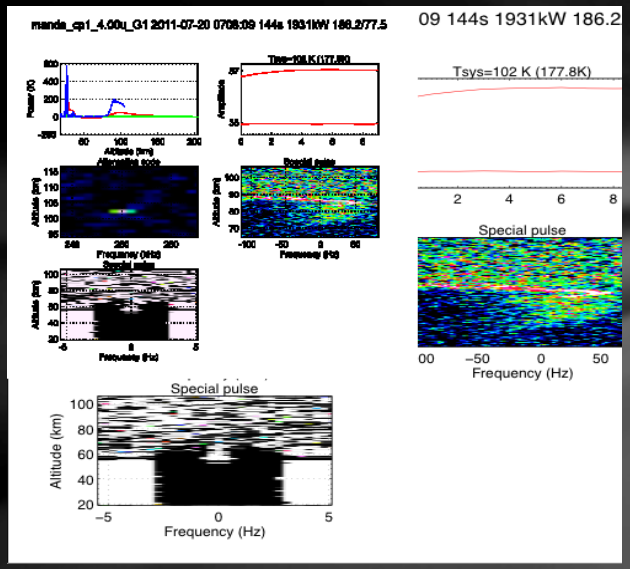
DATA: Meteors tracked by EISCAT



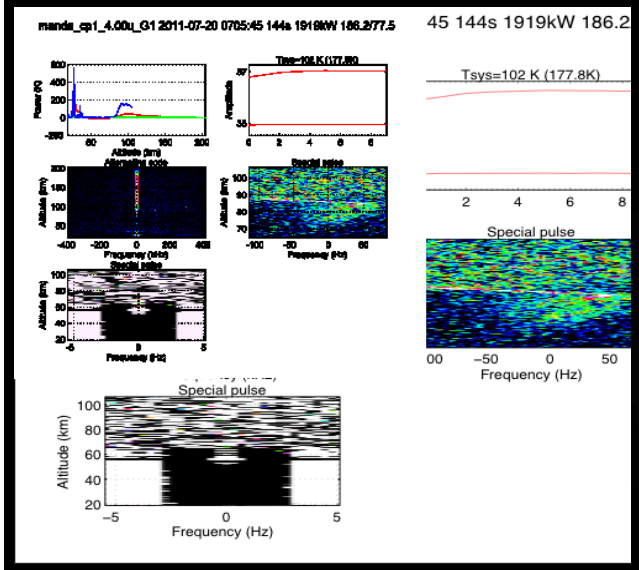


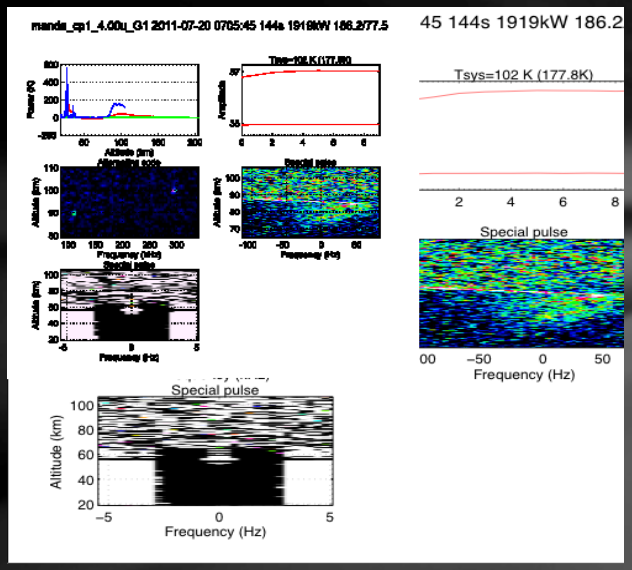
DATA: Meteors tracked by EISCAT





DATA: Meteors tracked by EISCAT

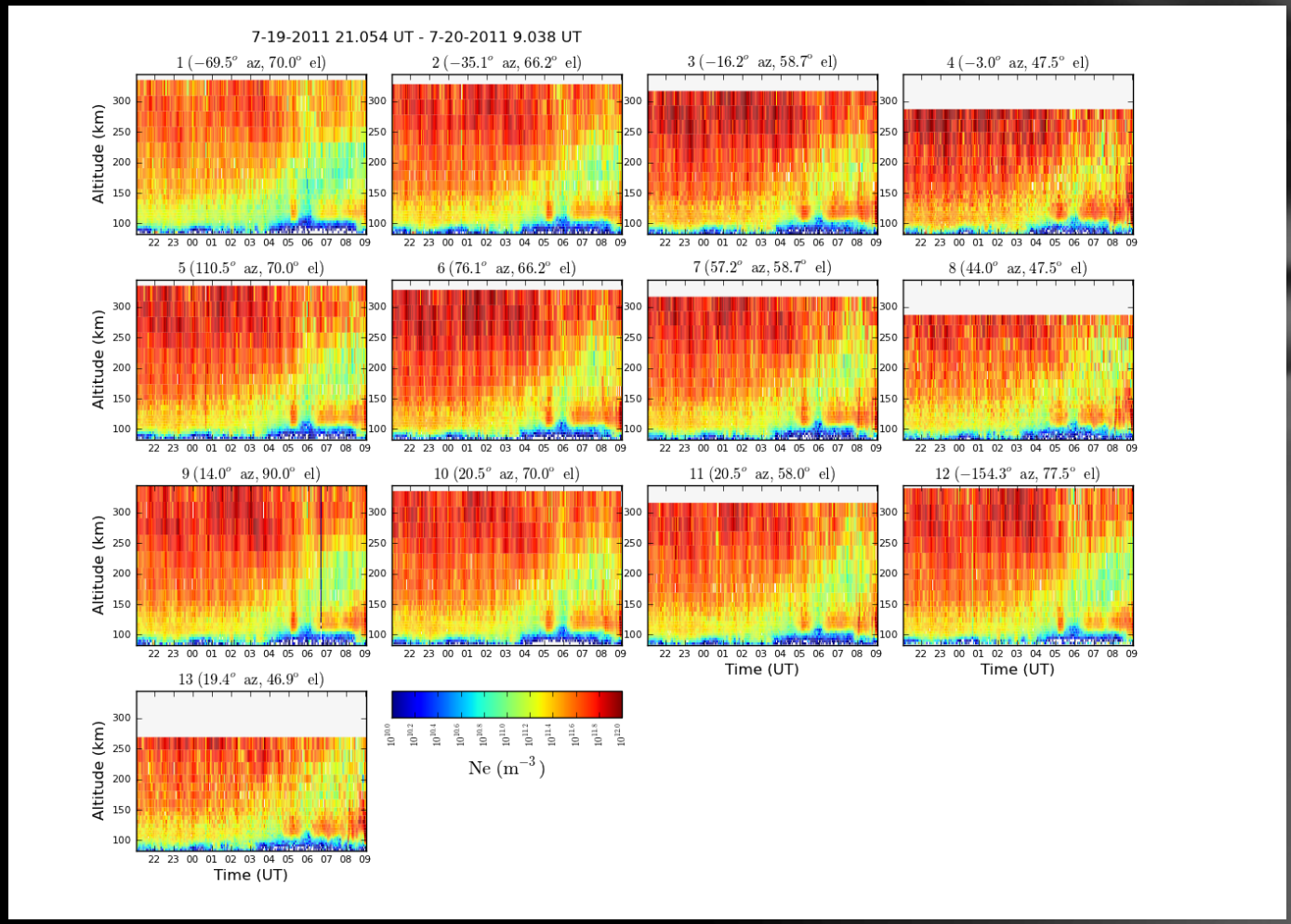




DATA: Meteors tracked by EISCAT

Meteor	Alt (km)	Freq (KHz)	Vel (km/s)
1	90	110	17.7
2	100	295	48
3	103	260	42
4	90	109	17.5
5	100	295	48
Avg	96.6	213.8	34.64

No Sporadic E at PFISR..... ☹



Conclusion

Meteor Echoes

Overall Success

After review of the process, our group has decided that if we were to run this experiment again with the intent of only monitoring meteors, we would only operate from one fixed position for the entire time. During our last experiment time, approximately 9.5 minutes of the 90 were wasted having the dish change positions. That's over 5% of the experiment time.

Sporadic E

Not Detected

References

http://www.agu.org/pubs/crossref/1957/JZ062i001p00079.shtml

http://en.wikipedia.org/wiki/Sporadic_E_propagation

http://isr.sri.com/cgi-bin/madrigal/accessData.cgi

Haggstrom_EISCAT_CP_EXPERIMENT.PDF

Questions? Domande? Des Questions? Frågor? вопросы? питання? vragen? Spørgsmål? Fragen? Kysymyksiä? Pytania? Spurningar? Spørsmål? सवाल?

Must be asked in English (American)….
Answers are not guaranteed.