STUDENT INVOLVEMENT WITH INCOHERENT SCATTER RADAR SCIENCE

Elizabeth Kendall
SRI International

CEDAR Workshop
June 19, 2006

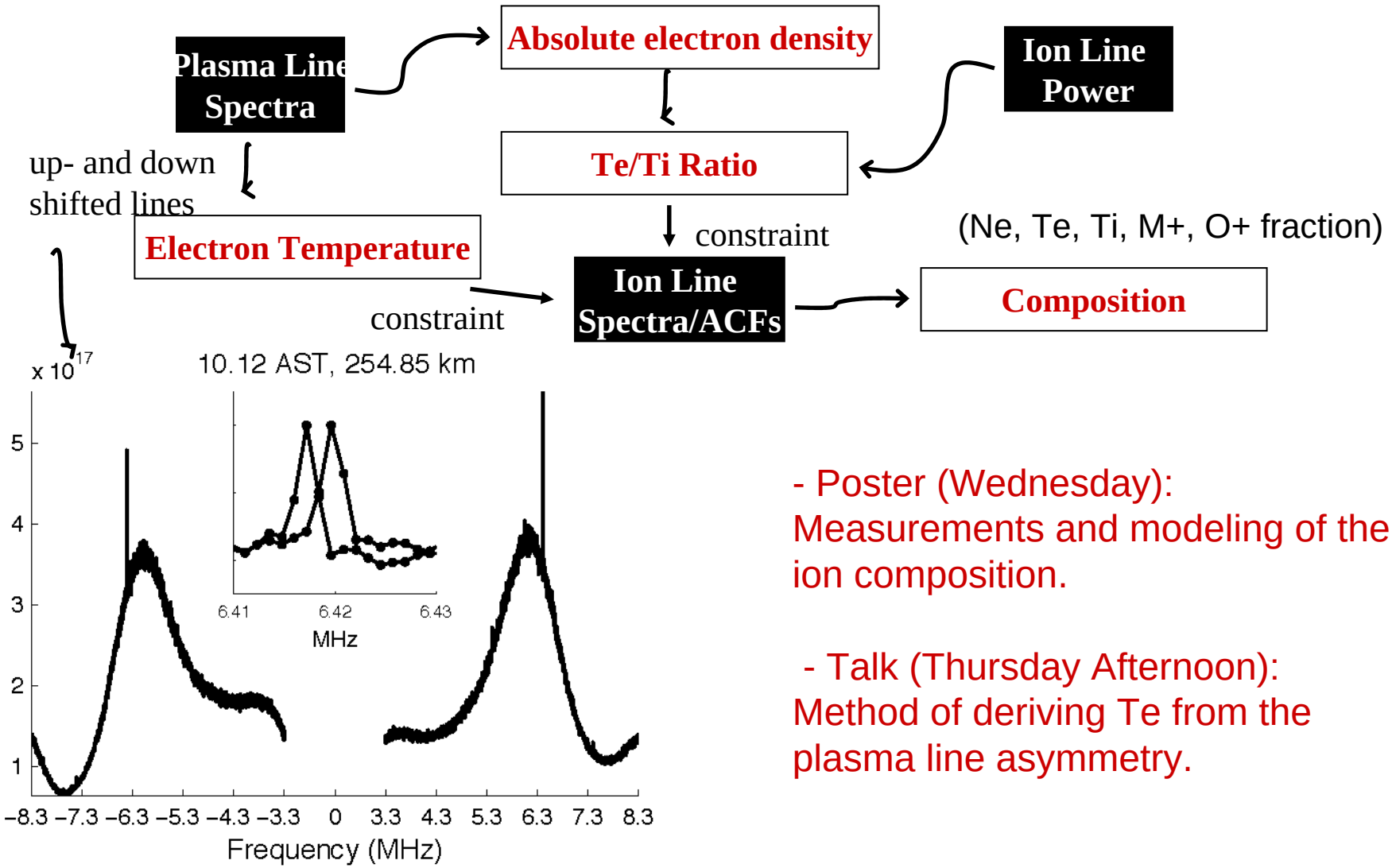
Poster Presentations

Mike Nicolls	*Cornell University*
Stan Briczinski	*Penn State University*
Elizabeth Bass	*Boston University*
Lloyd Rochester	*University of Colorado*
Jia Yue	*Colorado State University*
Tanya Phillips	*University of Texas*
Amal Chandran	*University of Colorado*
Ilgin Seker	*Penn State University*
Asti Bhatt	*Cornell University*
Marcos Diaz	*Boston University*
Fabiano Rodrigues	*Cornell University*
Dorey Livneh	*Penn State University*
Amanda Johnson	*Boston University*
Takuo Tsuda	*Nagoya University*
Freddy Galindo	*Universidad Nacional de Ingenieria*
Esayas Shume	*Cornell University*
Romina Nikoukar	*University of Illinois*
Xiaoni Wang	*University of Central Florida*
Marco Milla	*University of Illinois*
Paloma Farias Guiterrez	*Arecibo Observatory*
Johannes Wiig	*Arecibo Observatory*

Measuring and modeling the ion composition, density, and temperature in the F1 region over Arecibo

M. Nicolls, N. Aponte,
M. Sulzer, S. Gonzalez

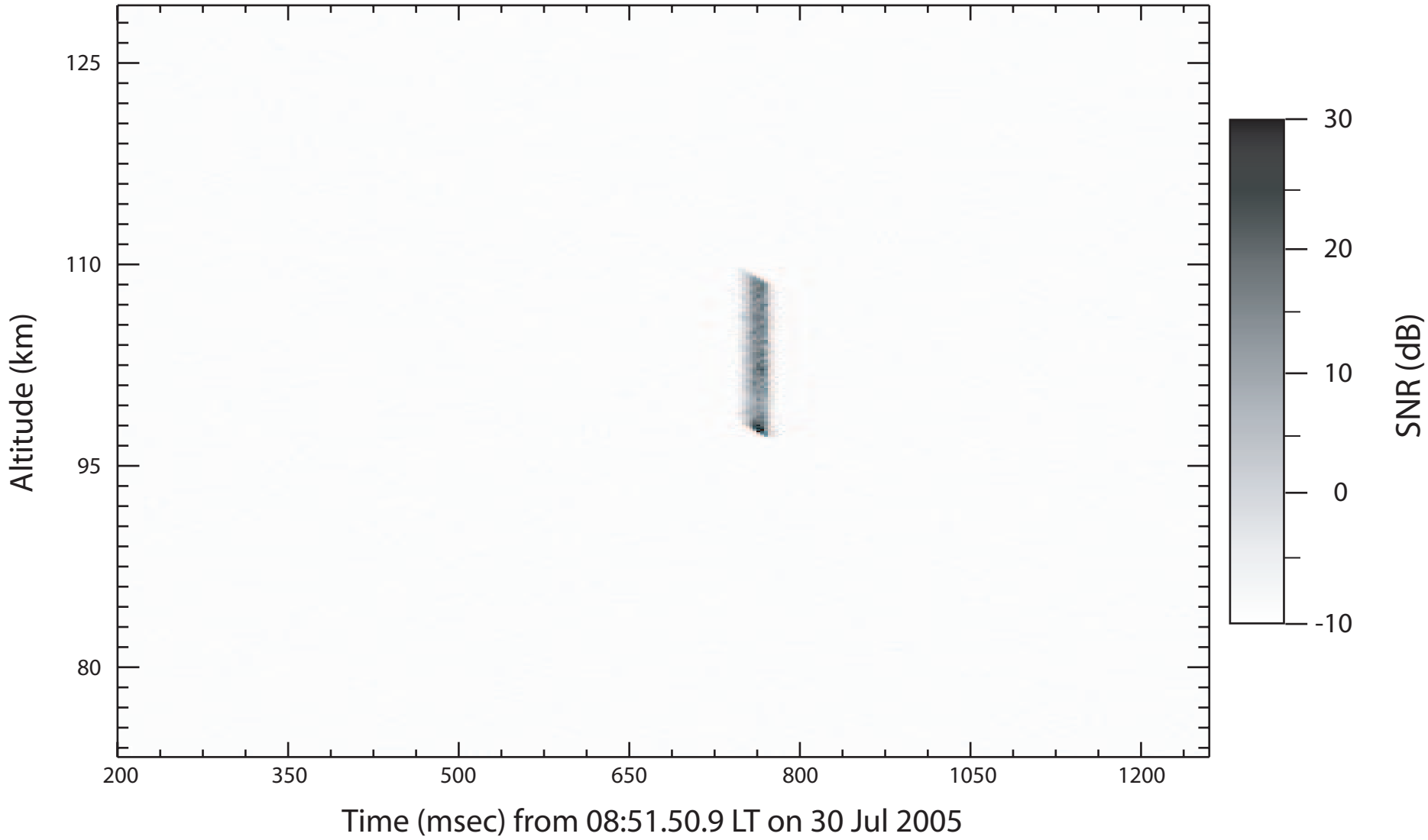
There exists an temperature-mass ambiguity in incoherent scatter theory that makes fitting for composition and temperature simultaneously impossible in the F1 region.



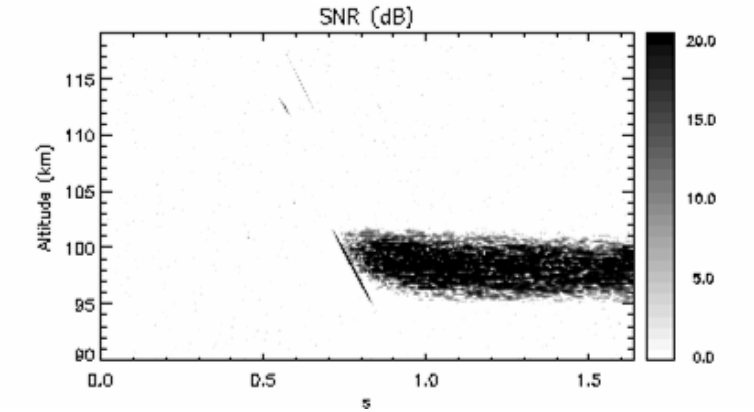
- Poster (Wednesday): Measurements and modeling of the ion composition.

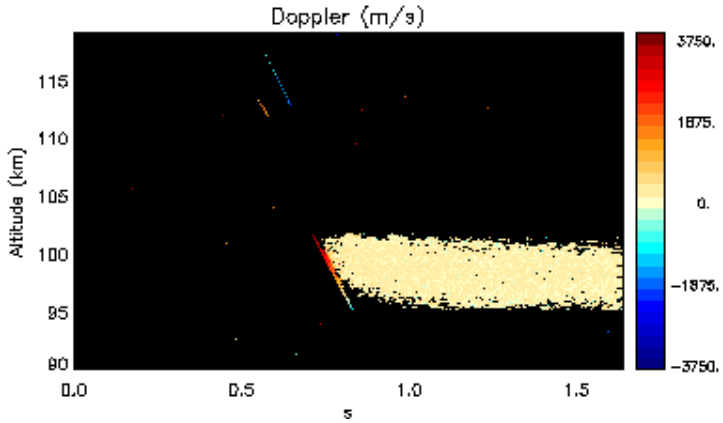
- Talk (Thursday Afternoon): Method of deriving Te from the plasma line asymmetry.

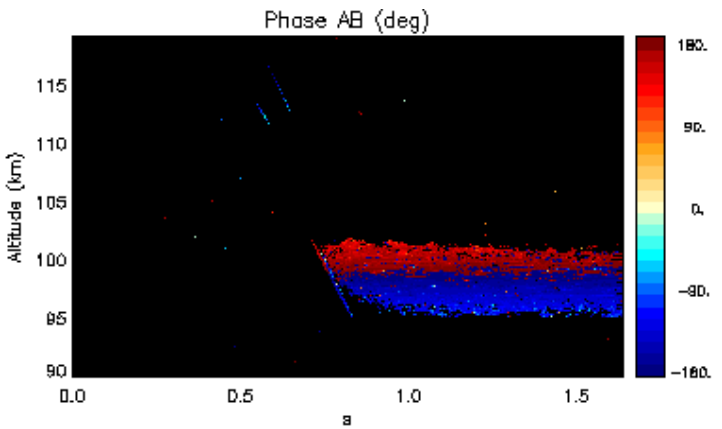
Stan Brinczinski, *Penn State University*



Elizabeth Bass, Boston University







Jicamarca Radio Observatory as three coherent radars

- Observes meteor head echoes and non-specular trails
- Separate phase and amplitude signals
- Interferometry and Doppler measurements
- Can calculate meteor mass

OVERVIEW:

A proposed digital receiver setup for the COBRA meteor radar is shown in Figure 1 below. The system consists of an antenna setup, analog pre-amplifier consisting of analog gain and filtering stages, the proposed digital receiver system, a host computer equipped with USB, the Linux operating system and a mass storage device such as a disk drive. Inside the digital receiver is an Analog Devices AD6654 digital receiver chip, a low cost Altera Cyclone FPGA, and a Cypress FX2 High Speed USB chip. Current software for the receiver is designed for the Linux operating system.

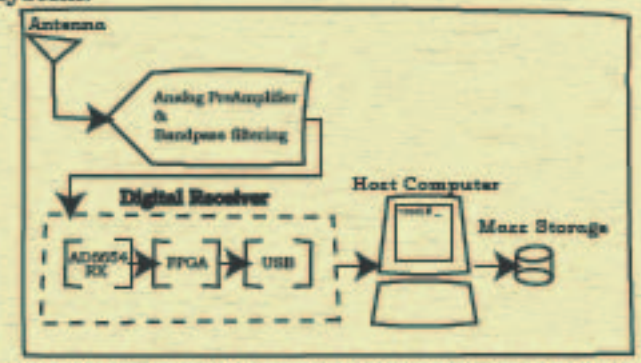


FIGURE 1. DIGITAL RECEIVING SYSTEM

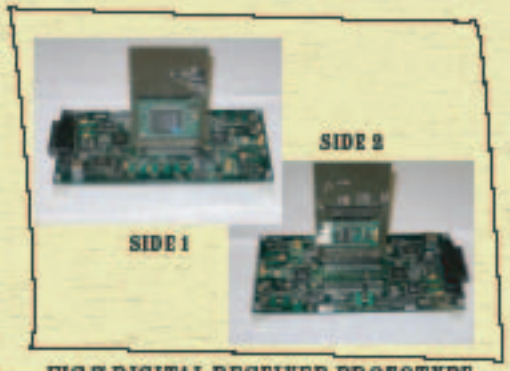


FIG 7 DIGITAL RECEIVER PROTOTYPE

The digital receiver consists of 3 main components working together to provide a digital signal through USB efficiently and reliably, see Figure 2. The AD6654 receiver chip filters and adjusts the sampling rate then hands off the digitized data to the Cyclone FPGA. The FPGA provides data buffering, and glue logic necessary for the AD6654 and USB integrated circuit. The USB circuit provides all the necessary logic to transfer data reliably to the host computer.

Poster Title: An all-solid-state transportable narrowband sodium lidar for mesopause region temperature and horizontal wind measurements

Authors: J. Yue, P. Acott, J. Vance, C. She, CSU; Q. Wu, NCAR; B. Williams, CORA; R. Collins, UAF

•All-solid-state sodium lidar is able to measure both mesopause region neutral horizontal wind and temperature directly on a 24-hour continuous basis. Complement to AMISR capability (see Table).

•The lidar combines mature technologies utilized by CSU sodium lidar (Doppler free spectroscopy, Acoustic-Optic Modulator and Faraday filter) with innovative SFG solid-state seed laser and solid-state Na temperature lidar deployed in Syowa Station, Antarctica.

•Transportable, robust, semi-automatic, remote monitored operation.

•Cooperating between CSU, NCAR, CoRA and UAF. Designed and proposed to be assembled and tested at Fort Collins and Boulder, field tested at Fairbanks, AK, deployed at Resolute Bay, Canada.

All-solid state Na lidar vs AMISR at 80-110 km

	All-solid-state lidar		**AMISR**
Neutral wind measurement capability	Direct measurement Summer Noon error 17 m/s Winter Noon error 5.6 m/s	Direct measurement Summer Night error 1.7 m/s Winter Night error 1.1 m/s	Indirect measurement, assuming ions and neutrals are in equilibrium
Neutral temperature measurement capability	Direct measurement Summer Noon error 11 K Winter Noon error 2.6 K	Direct measurement Summer Night error 1.1 K Winter Night error 0.6 K	Indirect measurement, assuming (1) ions and neutrals are in equilibrium, and (2) known ion-neutral collision frequency
Time resolution	1 hour		10 mins
Altitude resolution	2 km		150 m below 100 km 1.2 km above 100 km

Data and Model Comparison of the Neutral Temperature & Composition

T.R. Phillips[1], G.D. Earle[1], S.-R. Zhang[2] and J.M. Holt[2]

Method

Energy Equation

$$a(T_e - T_i) = b(T_i - T_n) \quad (1)$$

$$a = 7.6\times10^{20} N_i N_e T_e^{-3.2} \ \mathrm{Wm^{-3}}$$

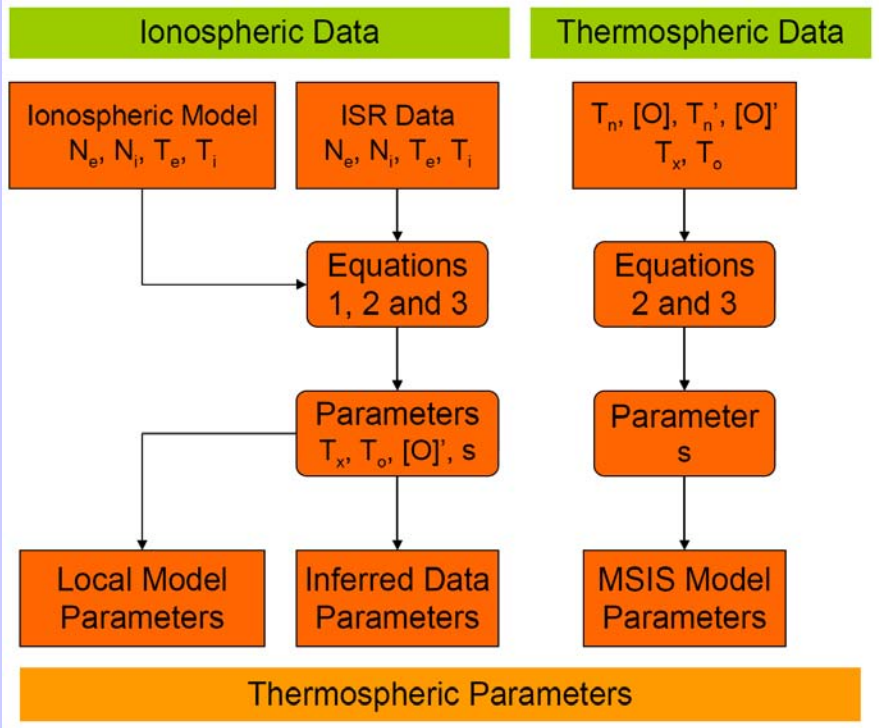
$$b = 3.36\times10^{-28} F N_i [O] (T_i + T_n)^{1/2} \ \mathrm{Wm^{-3}}$$

Oxygen Density

$$[O] = [O]'(T'_n/T_n) \exp\left(-\int \frac{mg}{kT_n} dz\right) \quad (2)$$

Neutral Temperature

$$T_n = T_x - (T_x - T_o) \exp[-s(Z - Z_o)] \quad (3)$$



Equation 1 – heat transfers from electrons to ionized oxygen, then from ionized oxygen to neutral oxygen with only collisional heat transfer considered.

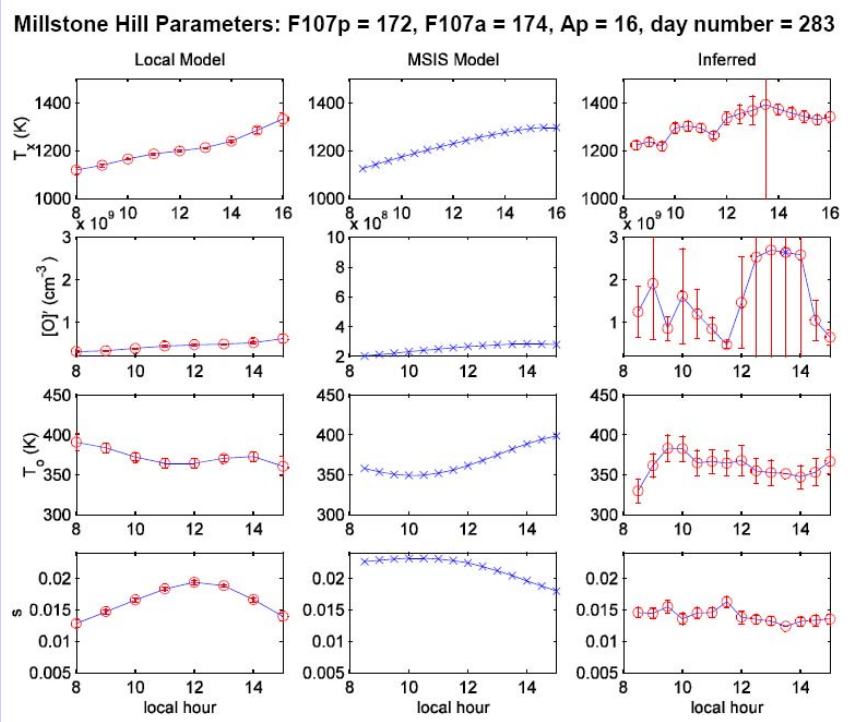
Equation 2 – assumes that oxygen is in diffusive equilibrium at all altitudes.

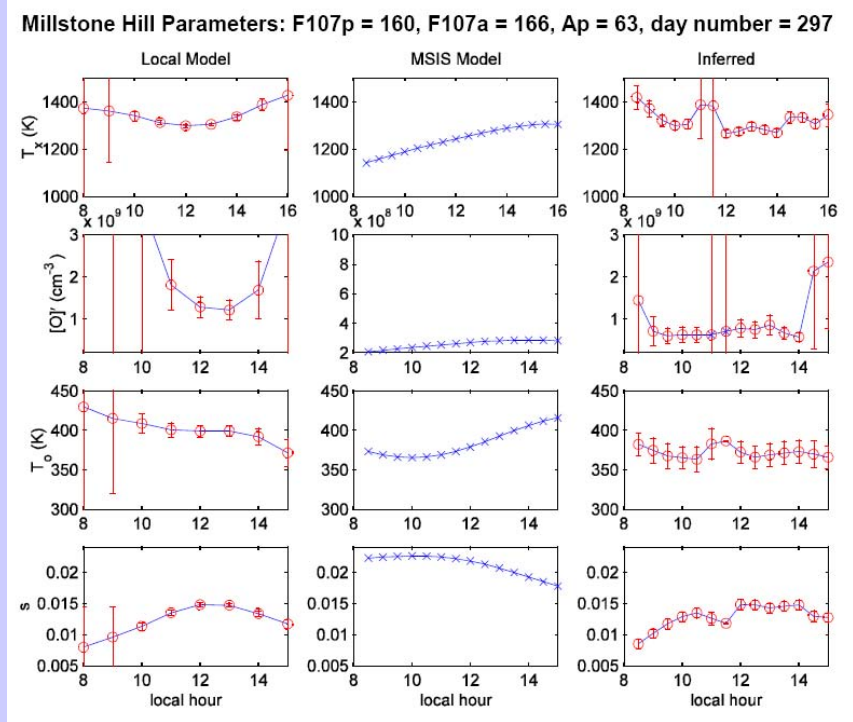
Equation 3 – Bates function (Bates, 1959).

Data and Model Comparison of the Neutral Temperature & Composition

T.R. Phillips[1], G.D. Earle[1], S.-R. Zhang[2] and J.M. Holt[2]

Results



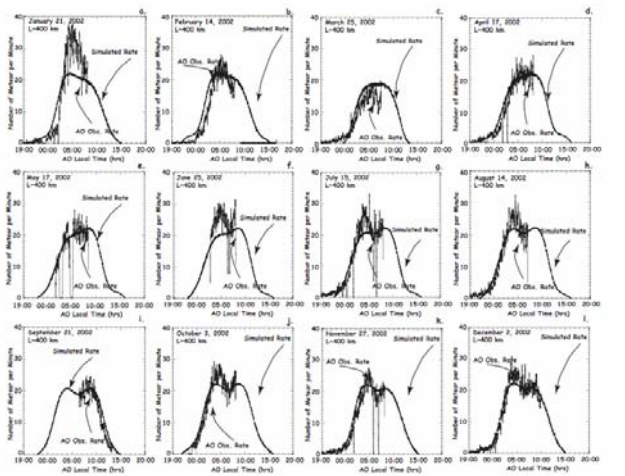


One of the Conclusions:

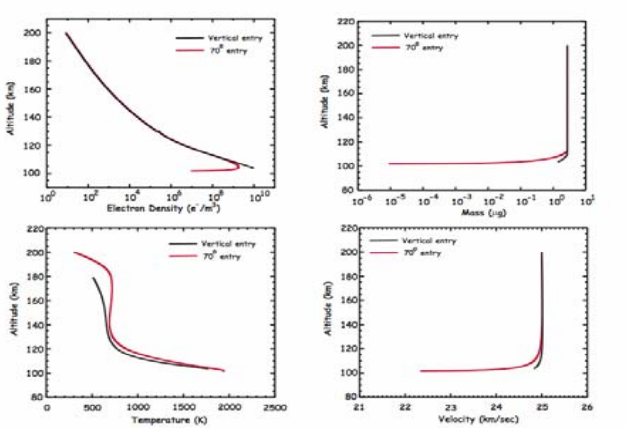
Assumption of Diffusive Equilibrium in Equation 2 may require some extra terms to account for days of high solar activity.

Modeling the Meteoric mass deposition in the Upper Atmosphere

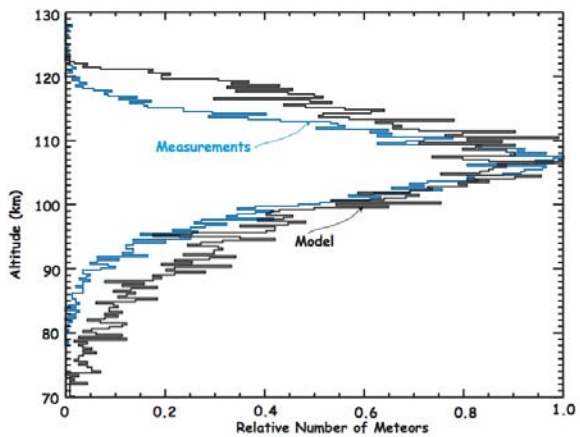
Amal Chandran (UCB), Diego Janches (NWRA), Scott Palo (UCB)



Comparison between the Meteor Input model (Janches et al, 2006) with empirical atmospheric effects and the observed meteor diurnal rate with the 430 MHz radar at the Arecibo Observatory for every season during 2002.



A four panel figure showing the electron volume density in the meteor head-echo, meteoroid mass ablation, increase in meteor temperature and deceleration during meteor entry.



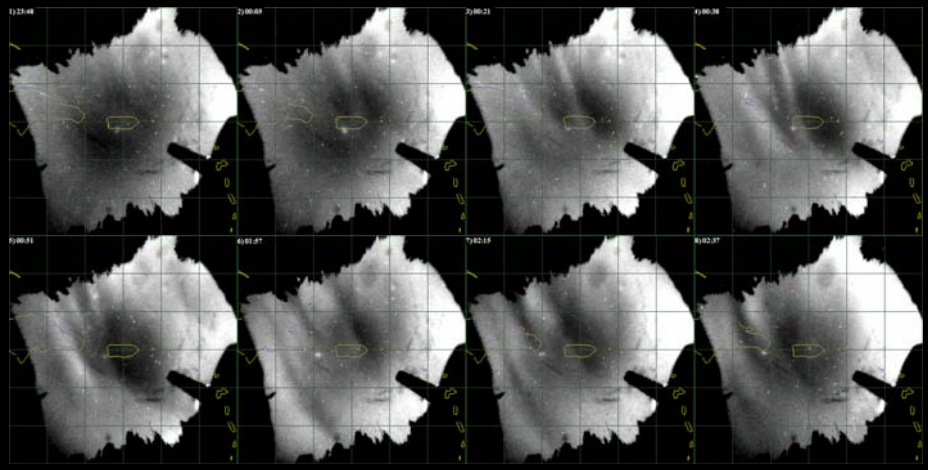
Comparison between the modeled and observed meteor head echo initial altitude distribution. The modeled initial altitude is chosen as the altitude where the electron volume density reaches 10^{-10} e/m3.

Categorization of the Events Observed by the Penn State Allsky Imager at Arecibo Observatory

Ilgin Seker, John D. Mathews (Penn State University)

630nm (F-region)

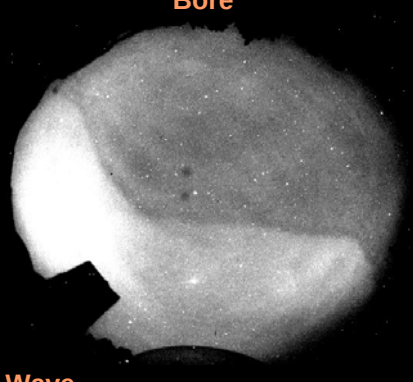
Bands



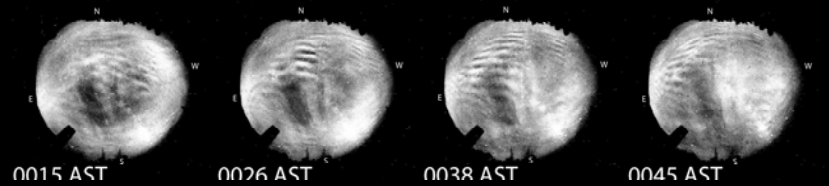
557.7nm (Mesosphere)

Regular and Turbulent Waves

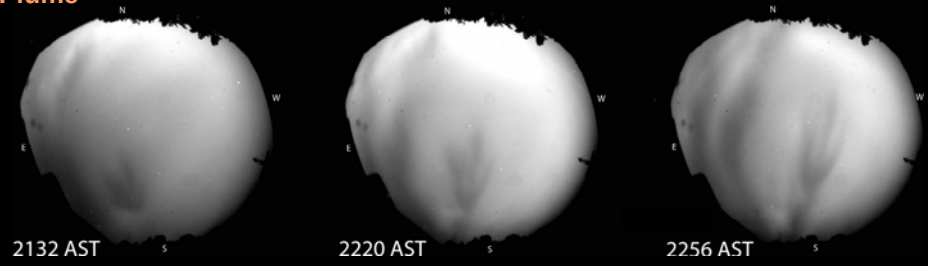
Bore



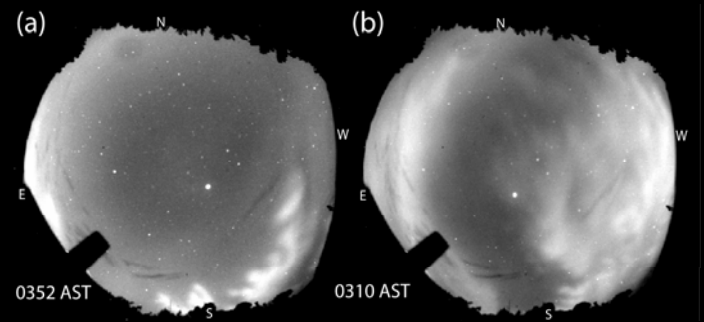
Ripple Wave



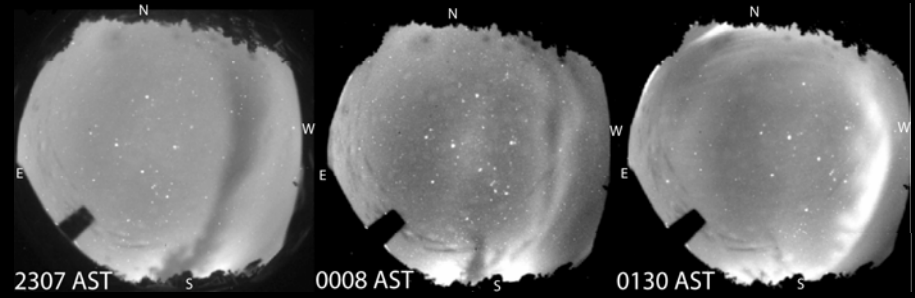
Plume



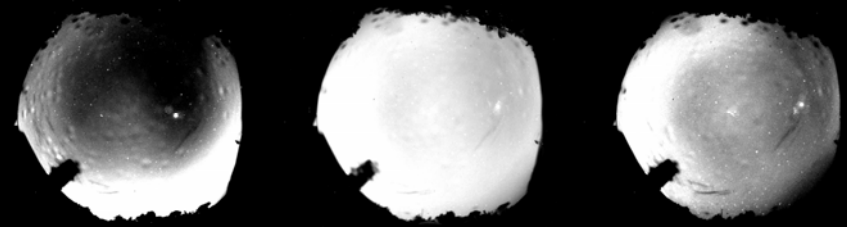
Enhancement



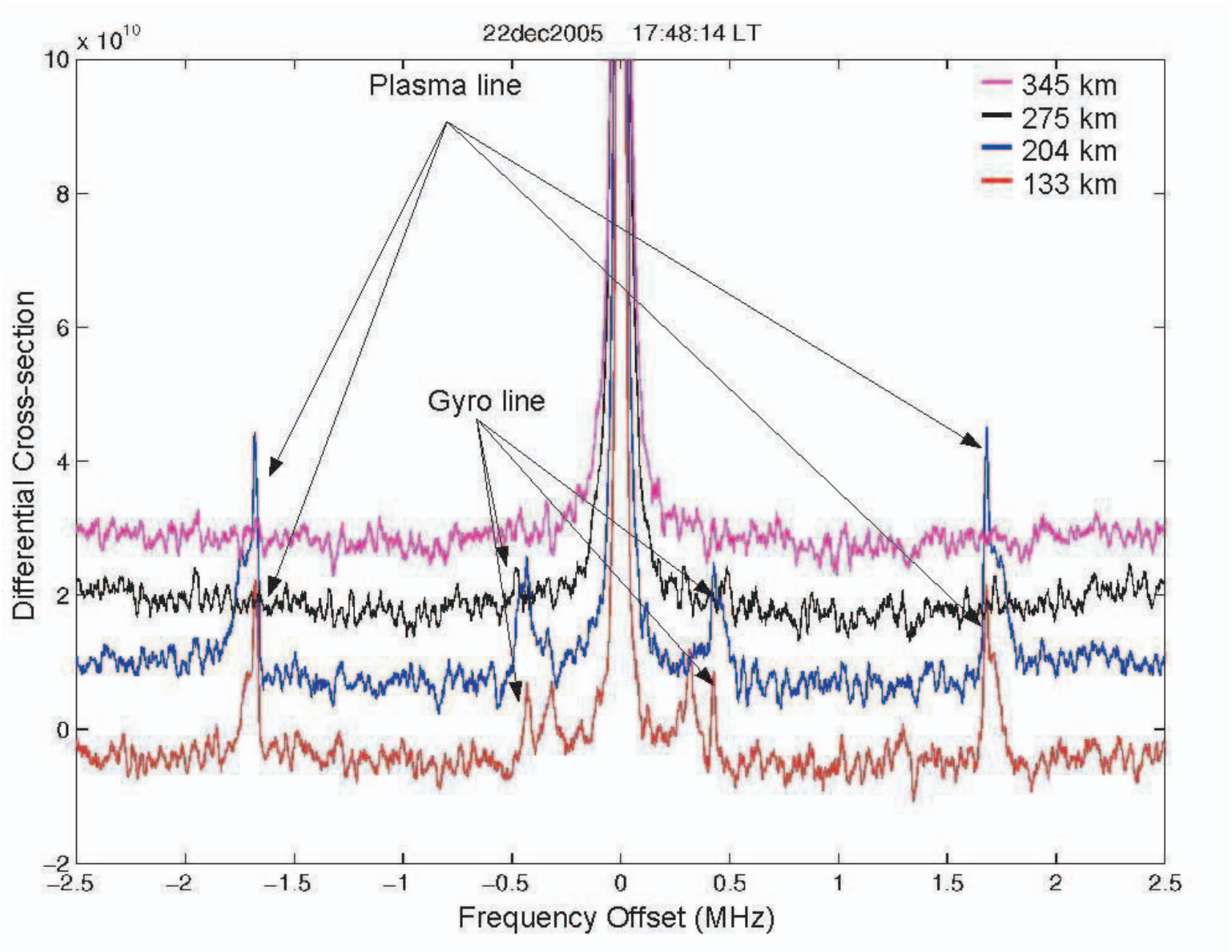
Inversion



MTM-BW

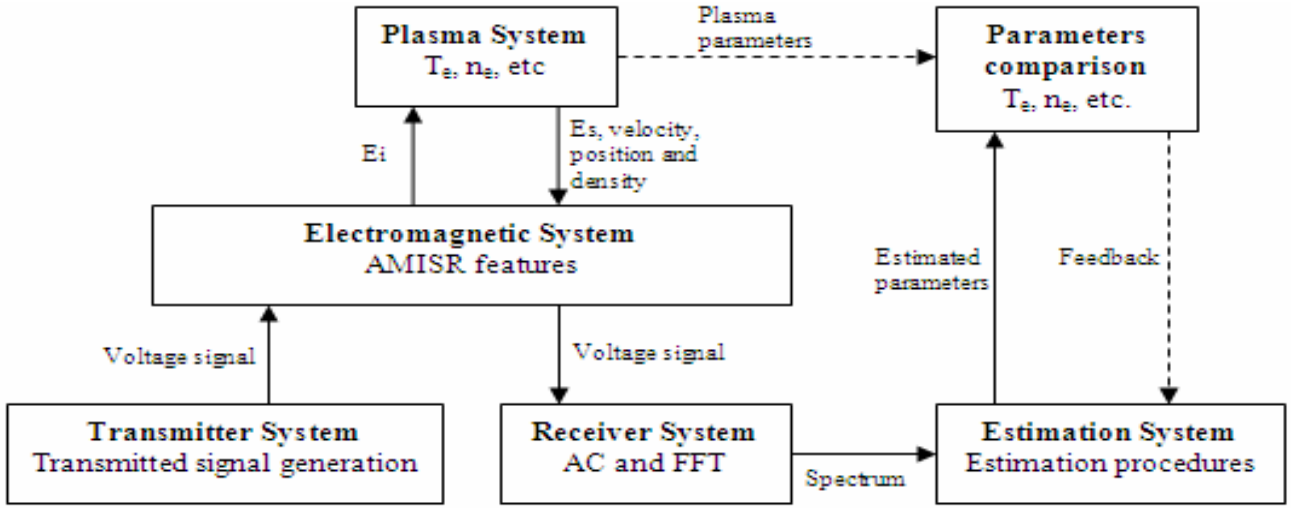


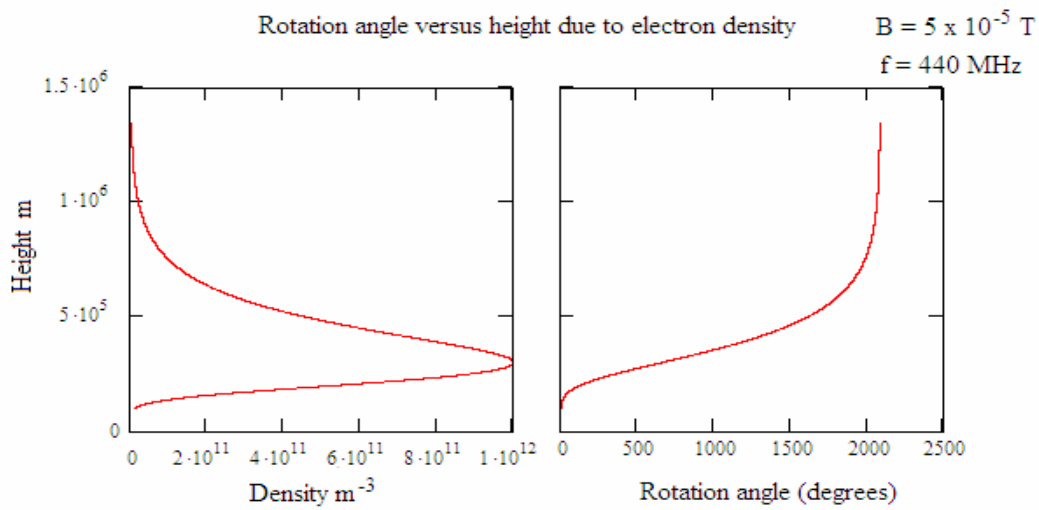
Asti Bhatt, *Cornell University*



Simulation of UHF waves in the auroral ionosphere

Marcos Diaz. ECE, Boston University





Optimal (aka Full-Profile) Analysis of Jicamarca ISR Data

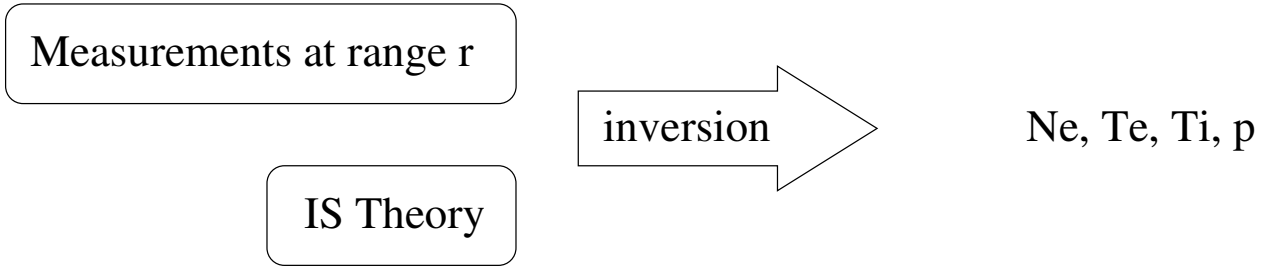
Fabiano S. Rodrigues[1], **David L. Hysell**[1] and **Jorge L. Chau**[2]

[1]Cornell University, Ithaca - NY, USA

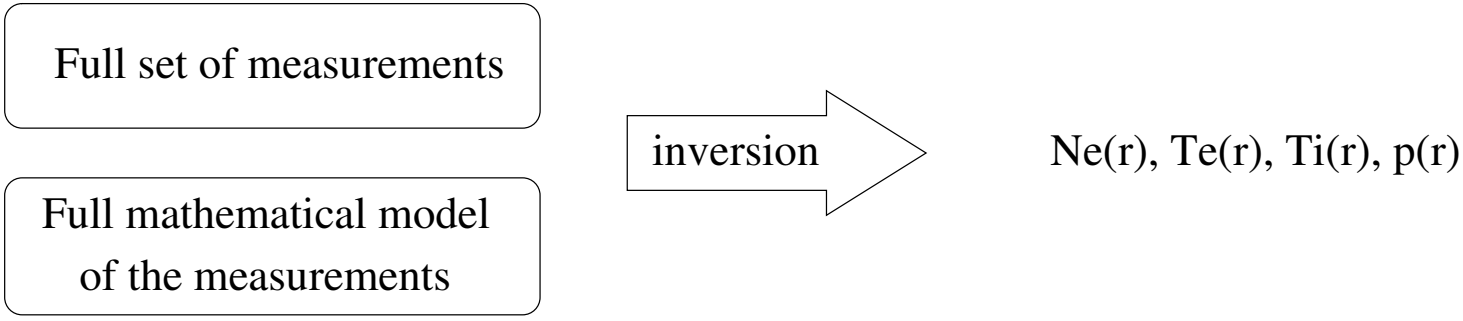
[2]Jicamarca Radio Observatory, Peru

Full-Profile Analysis

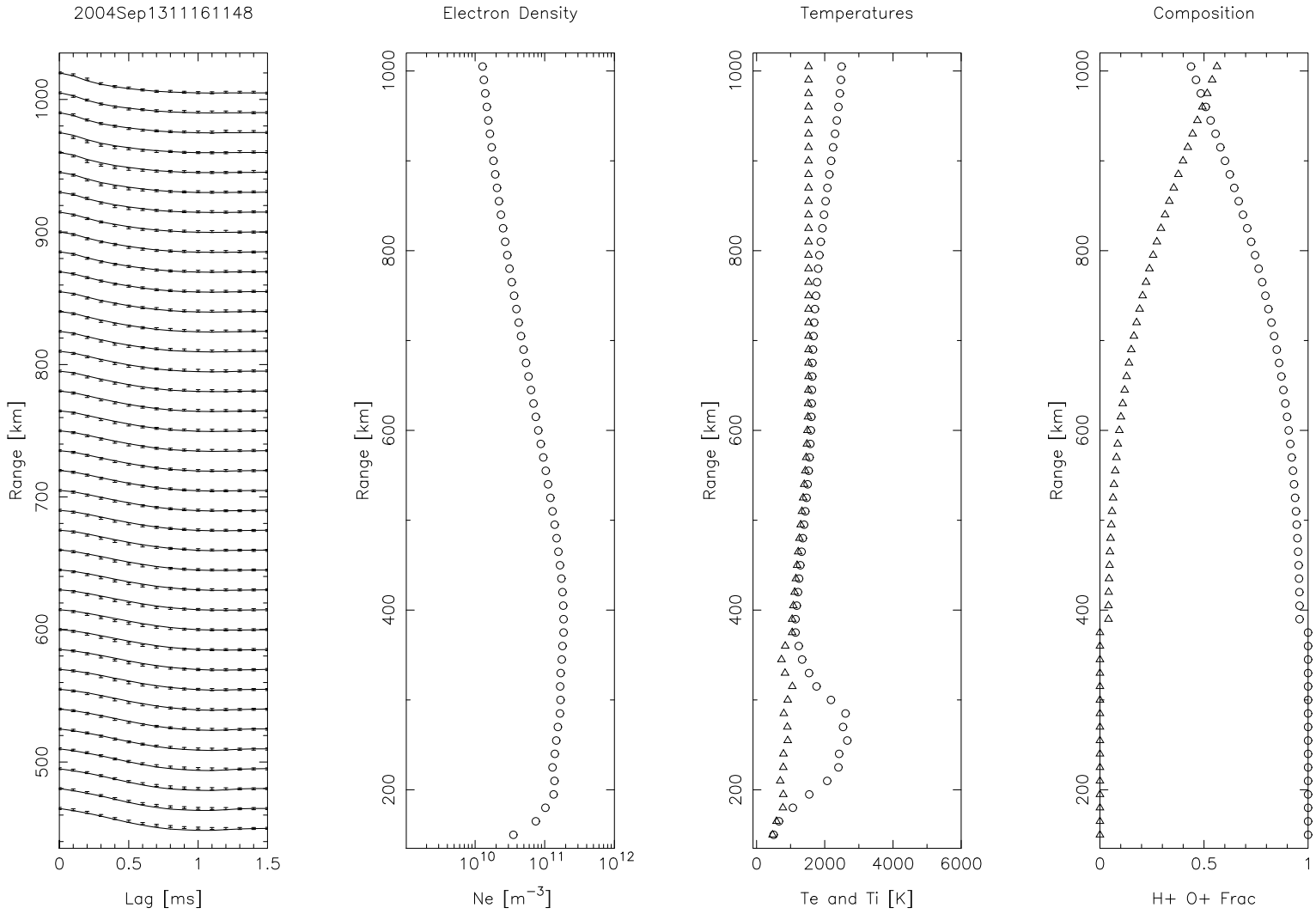
Gated Analysis



Full–Profile Analysis

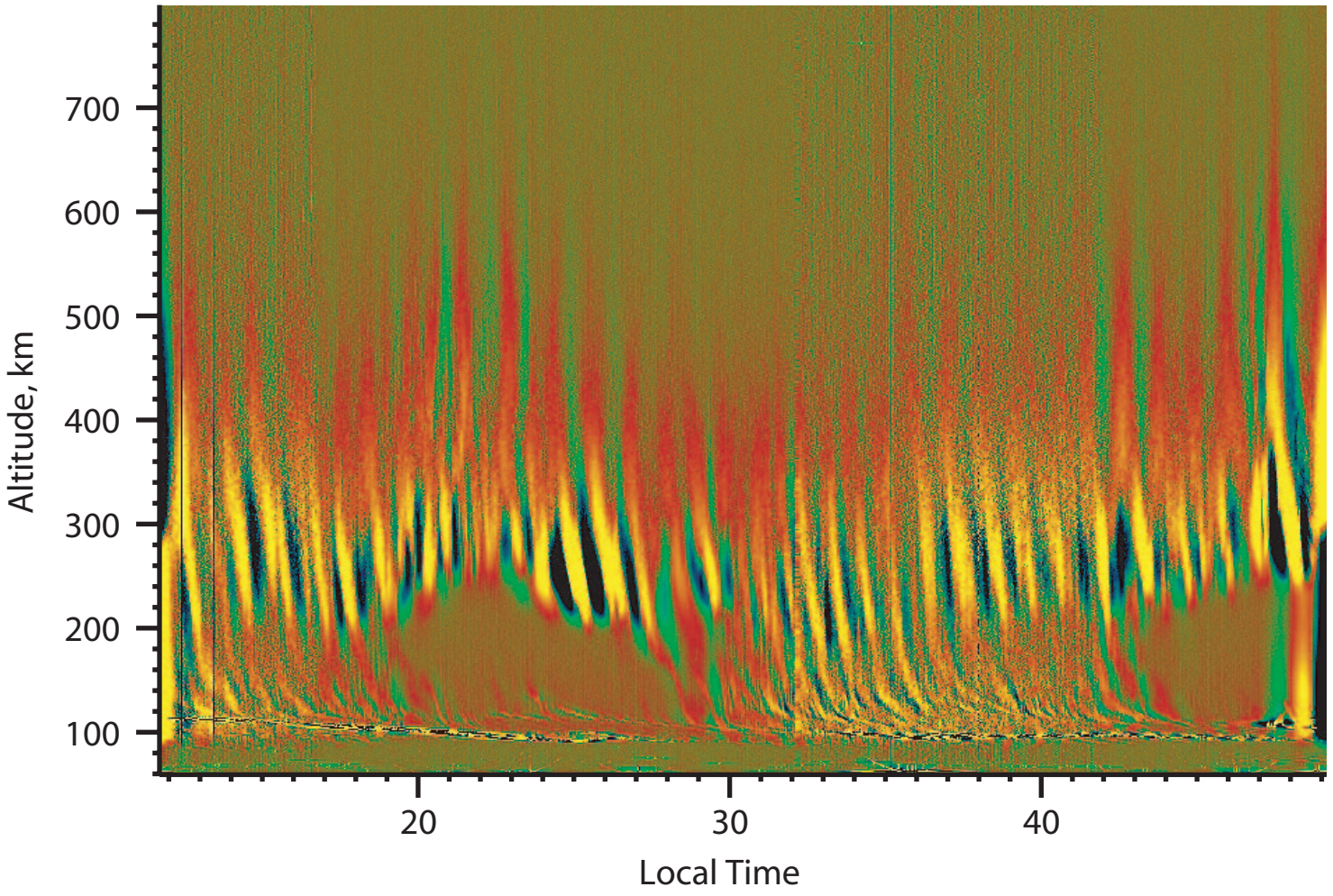


Example

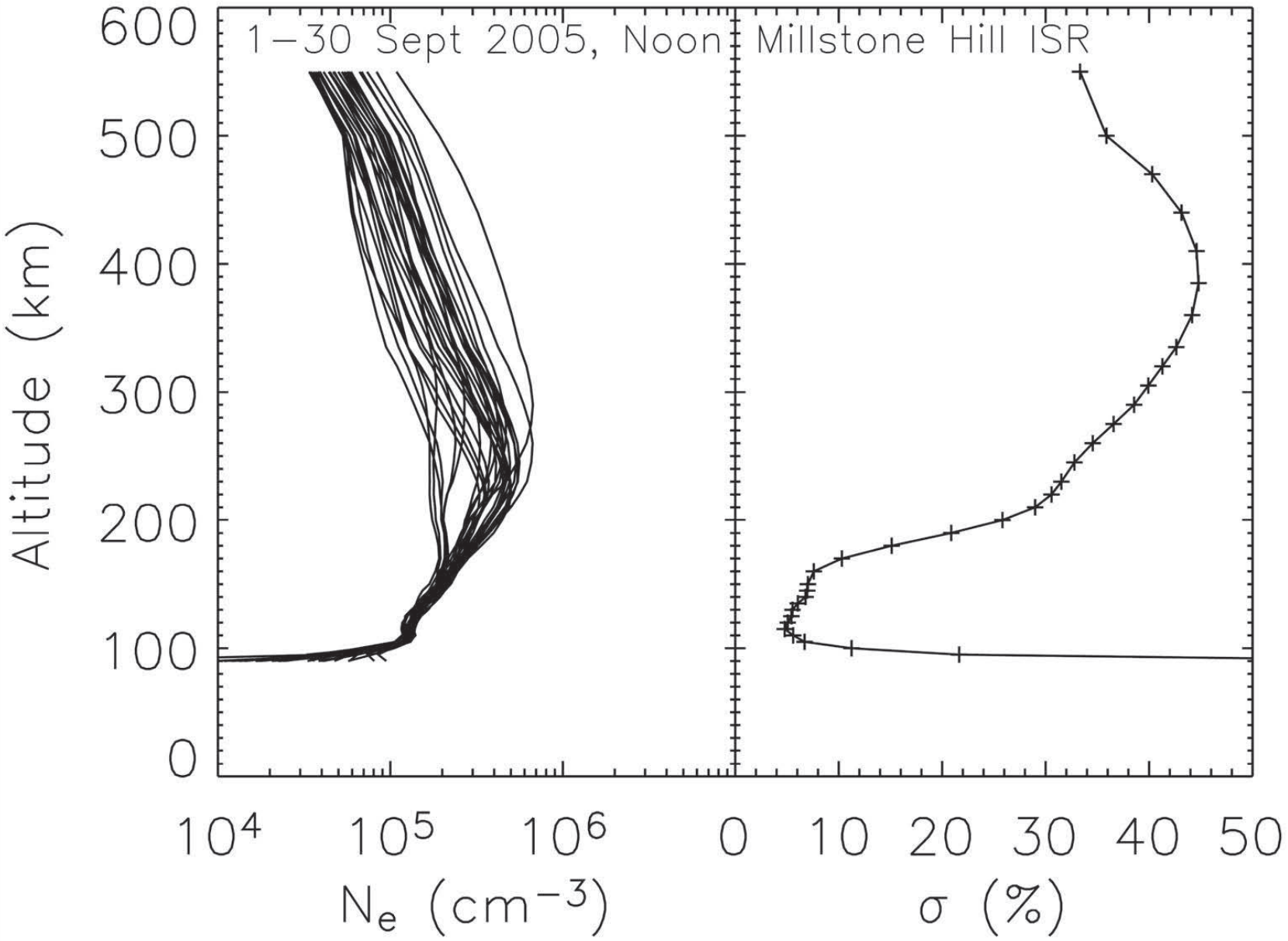

2004Sep1311161148
Range [km]
Lag [ms]
Electron Density
Ne [m^{-3}]
Temperatures
Te and Ti [K]
Composition
H+ O+ Frac

Dorey Livneh, *Penn State University*

Processed Image for June 5 -6, 2005



Amanda Johnson, *Boston University*



Study of an ion-drag contribution to the lower thermospheric wind in the summer polar cap using the ESR data

Takuo, TSUDA, STEL, Nagoya Univ.

Poster Session #2 (Thursday): [MLTT-02]

Objective:

To examine whether or not the ion-drag is effective against the lower thermospheric wind dynamics.

Evaluation of following parameters

EISCAT data

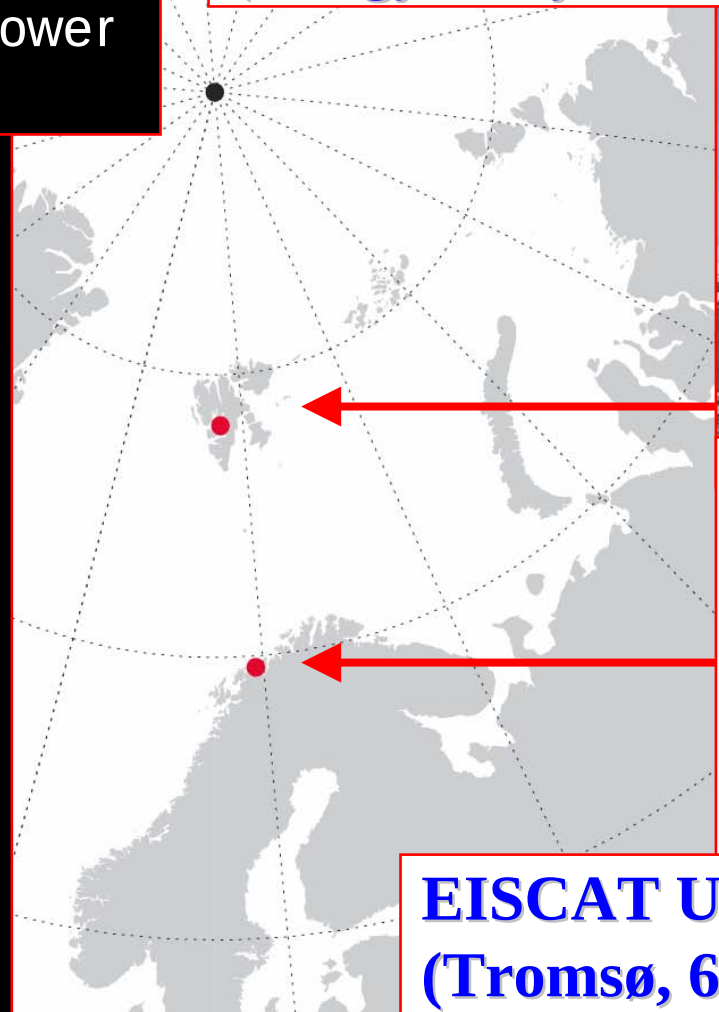
Observed data:

- Electron density
- Ion velocity
- etc.

Estimated value:

- Electric field
- Neutral wind velocity
- **Ion-drag force**
- etc.

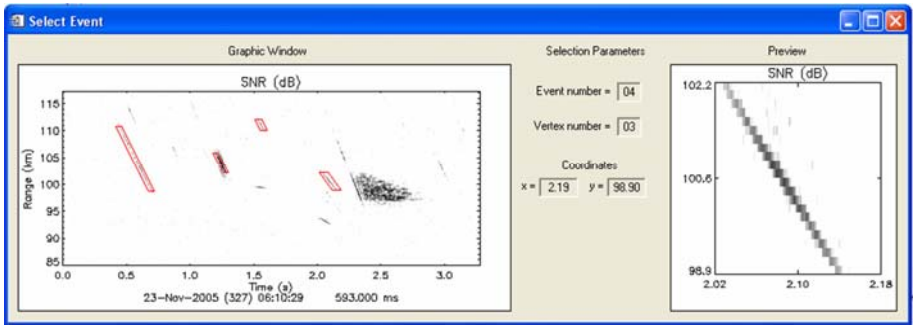
EISCAT Svalbard Radar (ESR)
(Longyearbyen, 78.2º N, 16.0º E)



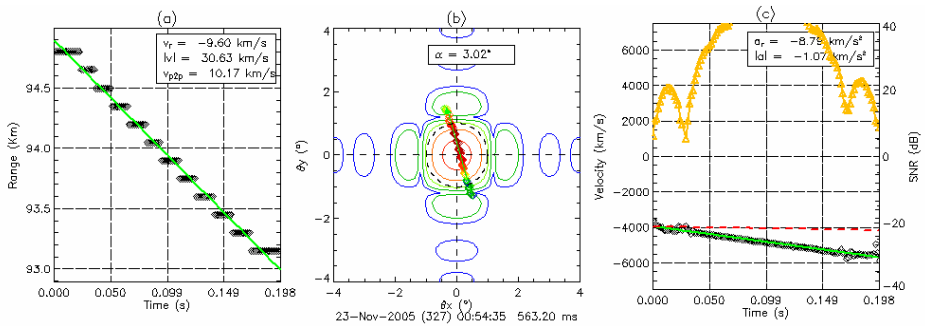
EISCAT UHF radar
(Tromsø, 69.6º N, 19.2º E)

Processing algorithms for meteor-head characterization over Jicamarca

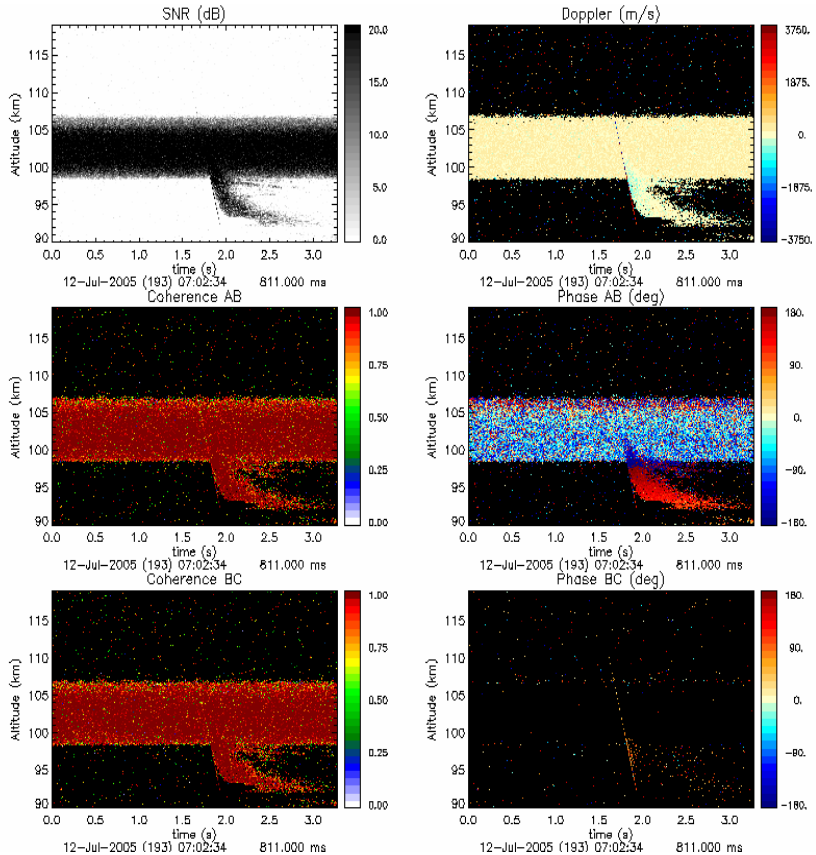
Interface



Meteor parameters



Removing EEJ and non-specular echoes



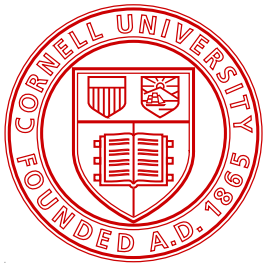
Freddy Galindo, Universidad Nacional de Ingenieria

Utilizing the Equatorial Electrojet for Diagnostics

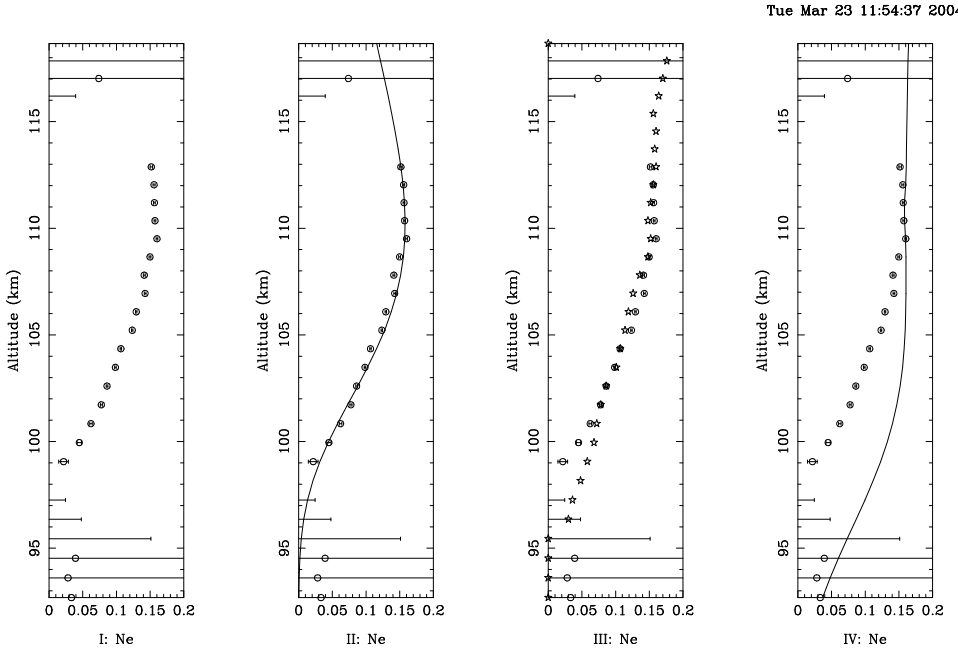
E. B. Shume[1], D. L. Hysell[1], and J. L. Chau[2]

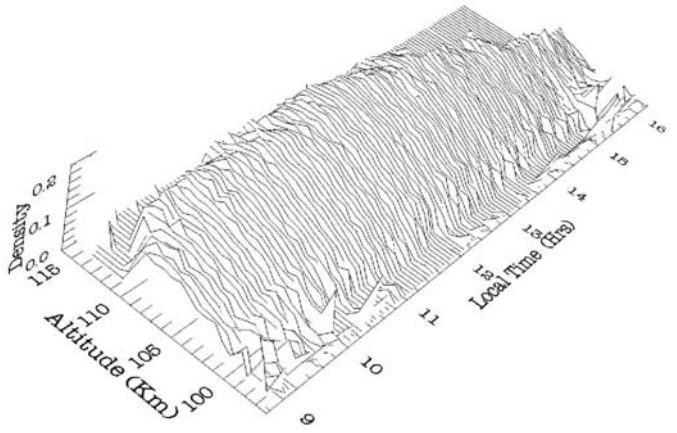
[1]Cornell University, [2] Jicamarca Radio Observatory

CEDAR 2006, Santa Fe, NM
June 19, 2006



E REGION ELECTRON DENSITIES



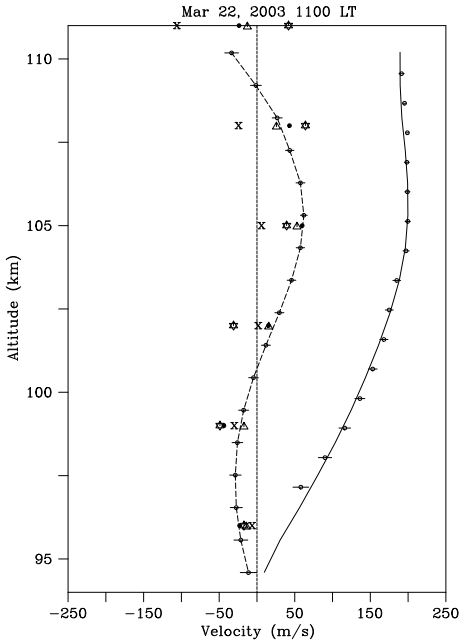


E region wind profiles

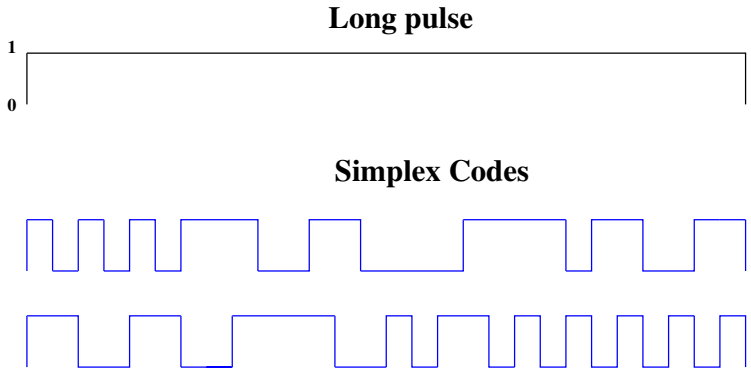
➠ Linear Doppler velocity,

$$\frac{\omega(p)}{k} \simeq \frac{\cos(\beta)}{B(1+\Psi')}\left[\left(\frac{1}{h_\varphi}\frac{\partial\Phi}{\partial\varphi} - E_\circ\right)\right] - \frac{\sin(\beta)}{B(1+\Psi')}\left[\frac{1}{h_p}\frac{\partial\Phi}{\partial p} + \Psi' Bu(p)\right]$$

$$\Psi' = (\nu_e + \nu_e^*)\frac{1}{\Omega_e}\left(\sum_j f_j \frac{\Omega_j}{\nu_j}\right)^{-1}, \quad \nu_e^* = \frac{\Psi_\circ}{1+\Psi_\circ}\frac{\Omega_e^2}{2\nu_e}\left\langle\left|\frac{\delta n}{n}\right|^2\right\rangle$$

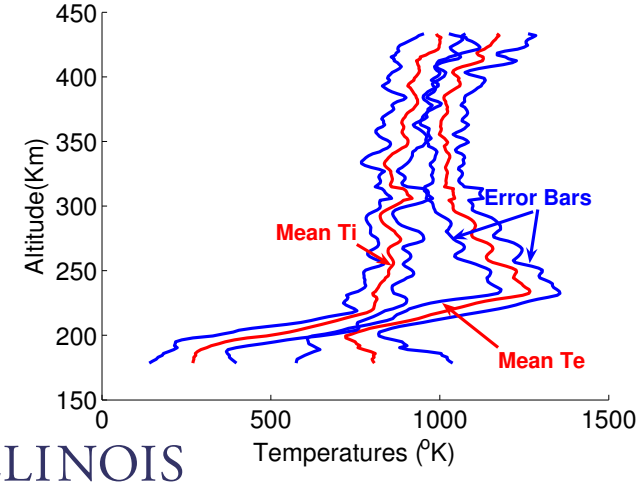


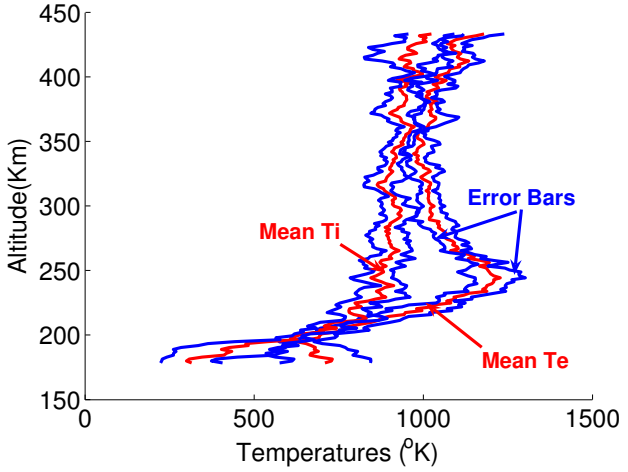
A New Coding Technique for F-Region Incoherent Scatter Measurements



- Goal : Achieve more accurate and efficient estimation of ionospheric parameters
- Implementation of the new technique at Arecibo has confirmed the reduced levels of uncertainty of parameters

Temperature Estimation Results from Arecibo Data





Compare the Short-term Variations (≤ 27 days) of solar irradiances with foF2

Xiaoni Wang, University of Central Florida

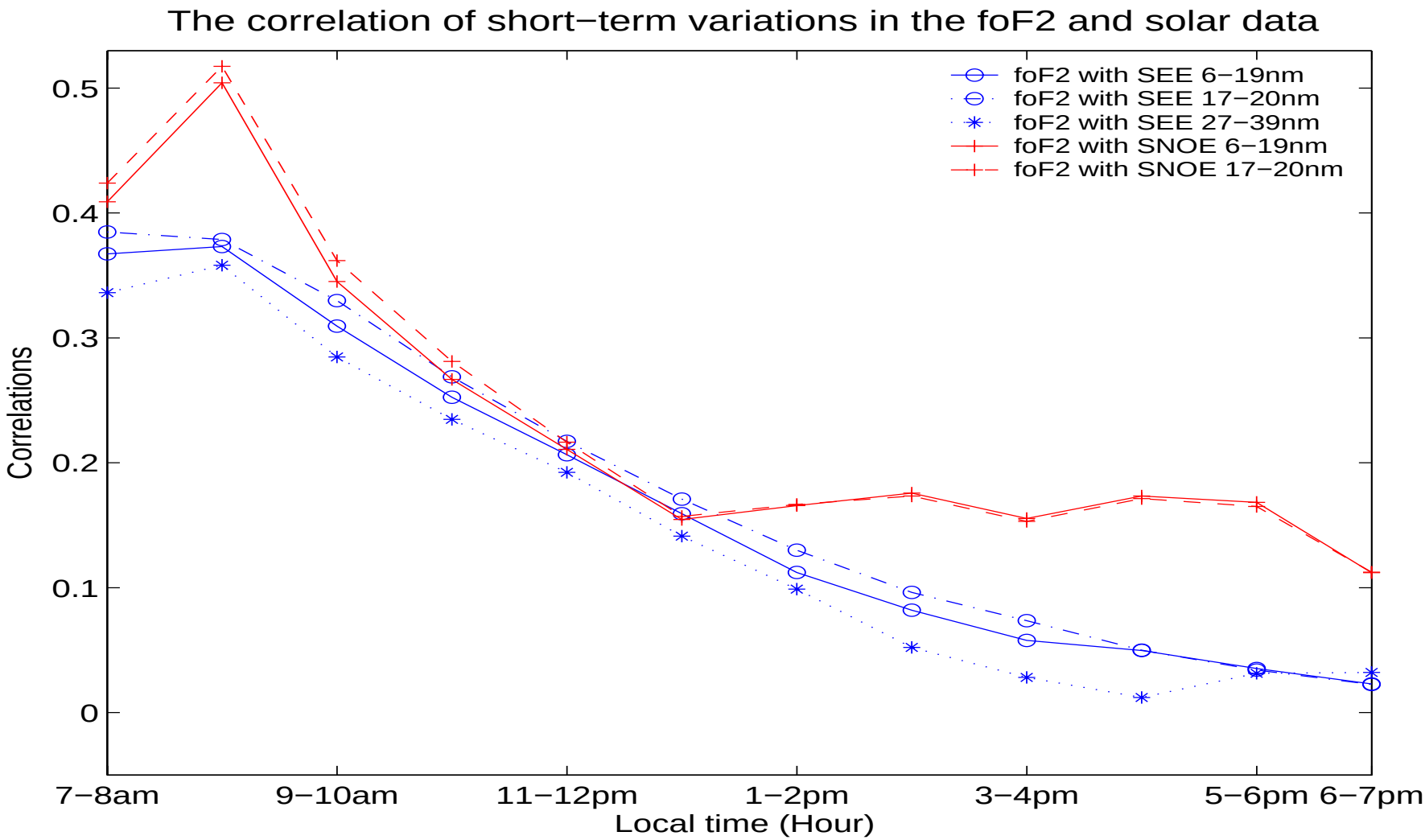


Figure 2. Correlation of short-term (≤ 27 days) variations of solar irradiance (daily average) and foF2 (hourly)

Agenda for 2006 CEDAR Workshop
June 19 - 23, 2006
Eldorado Hotel
Santa Fe, New Mexico

Monday, 19 June 2006

	CEDAR Student Workshop (Non-students Welcome) **Theme - Introduction to Incoherent Scatter Theory, Techniques, and Coordinated Science** **Student Workshop will be held in Zia**	**Co-Chairs:** **Michael Nicolls (Cornell)** **Carlos Martinis (BU)** **CEDAR student reps**
07:45 and 08:30	Bus departs from Fort Marcy Suites to Eldorado	
08:00 – 08:45	Breakfast, Registration, Sign Travel Vouchers	In concourse
08:45 – 09:00	Student welcome	Jan Sojka (CSSC chair) and Rich Behnke (NSF)
09:00-09:10	Agenda information; organizational details; activity information	Mike Nicolls and Carlos Martinis (CSSC student reps)
09:10-09:40	Incoherent scatter radar related science: Past, present, and future	Bob Robinson (NSF)
09:40-10:40	Keynote: Radar remote sensing of the ionosphere	John Sahr (U WA)
10:40-11:00	--- Break ---	
11:00-12:10	An interactive introduction to incoherent scatter	Josh Semeter (BU) and Phil Erickson (MIT)
12:10-12:40	Lunch provided for everyone	
12:40-13:00	Student Introduction to AMISR	John Kelly (SRI)
13:00-13:30	IS coordinated science at high latitudes	Jeff Thayer (U CO)
13:30-14:00	ISR coordinated science at equatorial latitudes	Jorge Chau (Jicamarca)
14:00-14:20	--- Break ---	
14:20-14:50	IS coordinated science at low latitudes	Nestor Aponte (Arecibo)
14:50-15:20	IS coordinated science at mid latitudes	Anthea Coster (MIT)
15:20-16:00	Student involvement with ISR science, intro to student posters, and IS-related activities at CEDAR	Elizabeth Gerken-Kendall (SRI)
16:00	Adjourn	
16:10	Bus departs Eldorado for Ft. Marcy	
16:00-19:00	Free time for student recreation (soccer, volleyball, etc.) 4:30 – 5:30: Gym reserved for volleyball (one net) 4:30 – 6:30: Lap swimming available at $1.85 pp. Outdoor baseball field available for soccer and frisbee.	Ft. Marcy Recreation Center -and- Ft. Marcy Park baseball field – first come, first serve
19:15	Bus departs from Fort Marcy Suites to Eldorado	
19:30-21:00	Reception for Students and Non-Students	Anasazi and Zia
21:00	Bus from Eldorado to Fort Marcy Suites (via grocery store)	

Tuesday, 20 June 2006
All sessions will be held in Anasazi unless otherwise noted.

07:15 and 07:45	Bus departs from Fort Marcy Suites to Eldorado	
08:00-08:10	Opening Addresses	Jan Sojka (CSSC) Rich Behnke (NSF) Art Richmond (NCAR)
08:10-08:20	Report on Student Workshop	Michael Nicolls (Cornell)
08:20-08:30	Introduction of Students by Institution	Carlos Martinis (BU)

08:30-09:15	CEDAR Prize Lecture: Incoherent Scatter Radar perpendicular to B	Erhan Kudeki (U IL)
09:15-09:25	NSF Aeronomy Update	Bob Kerr (NSF)
09:25-10:00	--- Break (Posters go up in Pavilion) ---	
10:00-11:30	Plenary Workshop (continued on Fri): Frontiers in CEDAR Science: A workshop to develop campaigns that advance the frontiers in CEDAR Science	R. Collins, E. Donovan
11:30-13:00	Lunch on own (CSSC lunch at O'Keefe Cafe)	
	--- OR ---	
10:00-13:00	Cooking School (sign up with Santa Fe Destinations)	extra fee
	--- OR ---	
11:35	Bus departs for shopping at Tin-nee-Ann Trading Company	
12:45	Bus departs Tin-nee-Ann Trading Company for Eldorado	
13:00-15:00	▪ Equatorial Ionosphere and Scintillation Workshop **(Anasazi South)** ▪ Ground-Based Coordination with the AIM Satellite Mission **(Anasazi North)** ▪ Sensitivity Study in Global Thermosphere/Ionosphere Simulations and Comparison with Observations **(Sunset)** ▪ Continuing on Towards an Integrated Data Environment with the Virtual Observatories **(Zia)**	▪ O. de La Beaujardiere, D. Anderson, C. Lin, D. Hysell, M. Kelley, J. Chau ▪ M. Taylor, J. Russell, S. Bailey ▪ Y. Zhang, W. Wang ▪ M. Weiss, J. Holt, P. Fox, D. Morrison, S. Nylund
15:00-16:00	--- Break ---	
16:00-18:00	▪ New Research Opportunities with the AMISR and Co-Located Instruments at Poker Flat Alaska **(Anasazi South)** ▪ Inosophere-Thermosphere Research Using Measurements in Space – What's Needed? What's Possible? What's Realistic? **(Sunset)** ▪ Ionospheric Effects of Lighting **(Zia)**	▪ J. Kelly, B. Watkins ▪ J. Grebowsky, R. Pfaff ▪ N. Liu, M. Stanley, M. Taylor
18:10	Bus departs Eldorado for Ft. Marcy	
19:30-21:30	▪ Midlatitude Nighttime Ionospheric Structures: Theory, Modeling and Physical Explanations **(Zia)**	▪ J. Makela, J. Mathews, J. Meriwether
20:45	Bus departs Ft. Marcy for Salsa Party	
21:00-midnight	Salsa Party **(Sunset)**	
22:30	Bus departs Eldorado for Ft. Marcy (last bus)	

Wednesday, 21 June 2006

All sessions will be held in Anasazi unless otherwise noted.

07:15 and 07:45	Bus departs from Fort Marcy Suites to Eldorado	
08:00-09:00	Tutorial #1: Comparative Planetary Aeronomy	Michael Mendillo (BU)
09:00-09:20	The CEDAR Database and Virtual Observatory Effort	Peter Fox (NCAR)
09:20-09:35	Post-Doc #1: Comparative Aeronomy at Earth and Mars	Paul Withers (BU)
09:35-10:05	--- Break ---	
10:05-10:20	Post-Doc #2: Estimating Thermospheric Density and Temperature from Combined Optical and Radar Measurements	Lara Waldrop (U IL)
10:20-10:35	Post-Doc #3: Monthly Climatology of Mean Values and Tides in Mesopause Region Temperature and Winds	Tao (Titus) Yuan (CSU)
10:35-10:50	Post-Doc #4: Unlocking the Meteor Toolbox for Aeronomy and Planetary Science	Lars Dyrud (CRS)
10:50-11:10	The Low-latitude Ionospheric Sensor Network (LISN) Distributed Observatory: Deployment Phase	C. Valladares (BC)

11:10-11:20	Post-Doc #5: Investigating Mesospheric Gravity Wave Propagation and Momentum Flux at Low Latitudes	Mitsumu Ejiri (USU)
11:20-11:30	Post-Doc #6: Multi-Instrument AMISR-Jicamarca Observation of Equatorial Electrojet Irregularities	Josef Drexler (Cornell)
11:30-13:00	--- Lunch on own ---	
13:00-15:00 or 16:00	▪ Structure and Irregularities in the Mid-Latitude Ionosphere and Thermosphere **(Anasazi to 16:00)** ▪ Data Assimilation in Space Sciences **(Sunset)** ▪ Applications of the Consortium of Resonance and Rayleigh Lidars to CEDAR Science **(Zia)**	▪ M. Ruohoniemi, R. Pfaff, G. Earle ▪ M. Codrescu ▪ J. Thayer, X. Chu, D. Fritts, J. She, G. Swenson
15:00-16:00	--- Networking Break ---	
16:00-19:00	Poster Session #1 (Ionosphere/Thermosphere, Long-Term Variations, Solar-Terrestrial Interactions, Polar Aeronomy, Irregularities)	Pavilion with Break
	--- OR ---	
15:30-19:30	Bus trip to Tsankawi Ancient Cavedwellers tour (sign up with Santa Fe Destinations)	extra fee
19:30	Bus depart Eldorado for Ft. Marcy	
19:30-21:30	▪ Jicamarca Amigos **(Zia)**	▪ D. Hysell, J. Chau

Thursday, 22 June 2006

All sessions will be held in Anasazi unless otherwise noted.

07:00 and 07:45	Bus departs from Fort Marcy Suites to Eldorado	
07:15-08:00	Student Breakfast (from hallway) with NSF	alcove in Eldorado Court
08:00-09:00	Tutorial #2: UV Remote Sensing	Larry Paxton (APL/JHU)
09:00-09:05	Announcement of new CSSC members	NSF
09:05-09:30	--- Break ---	
09:30-11:30	▪ Opportunities of Research in Aeronomy in Latin America **(Anasazi)** ▪ Thermospheric Density and Composition **(Sunset)** ▪ MLT Structure and Dynamics in Tropical/sub-tropical Regions **(Zia)**	▪ D. Janches, C. Martinis ▪ A. Richmond ▪ X. Chu, J. Friedman, G. Swenson
11:30-01:00	-- Lunch on own (CSSC lunch at O'Keefe Cafe) --	
	--- OR ---	
11:30-13:00	▪ World Day Planning (alcove in Eldorado Court) – buy own lunch	▪ W. Swartz
13:00-16:00	▪ Meteors and the Upper Atmosphere **(Anasazi South)** ▪ Incoherent Scatter Radar Long-Duration Experiments and CEDAR **(Anasazi North)** ▪ Plasma Structures and Turbulence (PSAT) **(Sunset)** ▪ Recent Progress in Fabry-Perot Applications to CEDAR Science **(Zia)**	▪ L. Dyrud, D. Janches ▪ S. Zhang, L. Goncharenko ▪ E. Mishin, A. Streltsov ▪ J. Meriwether, R. Niciejewski
16:00-19:00	Poster Session #2 (MLT, Coupling, Sprites, Meteors, Planetary Atmospheres)	Pavilion with Break
	--- OR ---	
15:30-19:30	Bus trip to Easy Hike to Tent Rocks (sign up with Santa Fe Destinations)	extra fee
19:30	Bus depart Eldorado for Ft. Marcy	
19:30-21:30	• Radar Meteor Studies: Where Next? **(Zia)**	• J. Mathews, S. Close, L. Dyrud

Friday, 23 June 2006

All sessions will be held in Anasazi unless otherwise noted.

07:15 and 07:45	Bus departs from Fort Marcy Suites to Eldorado	
08:00-09:00	Tutorial #3: Ionosphere: Past, Present and Future Problems	Robert Schunk (USU)
09:00-09:10	Announcement of Poster Prize Winners	Rick Doe (CSSC)
09:10-09:30	--- Break --- (Winning posters go in hallway)	
09:30-11:30	• Penetration Electric Fields and Ionospheric Storms **(Anasazi South)** • Climatology / Long-Term Trends **(Zia)** • TIMED/CEDAR Collaborative Atmospheric Dynamics **(Anasazi North)**	• C.-S. Huang, S. Sazykin • J. Sojka • E. Talaat, J.-H. Yee, S. Palo, I. Azeem
11:30-13:00	--- Lunch on own ---	
	--- OR ---	
11:45-12:45	• Plenary Workshop (continued from Tue) with pizza lunch: Frontiers in CEDAR Science: A workshop to develop campaigns that advance the frontier in CEDAR science **(Anasazi South)**	• R. Collins, E. Donovan
13:00-15:00	• Optical Calibration Techniques and Issues **(Anasazi South)** • Global Electrodynamics and Storm Effects at Mid and Low Latitudes **(Anasazi North)**	• S. Nossal • T. Fuller-Rowell
14:00-15:30	Chile Amor! Cooking Class (sign up with Santa Fe Destinations)	02:00-03:30
15:00	--- ADJOURN ---	03:00
	--- OR ---	
15:30-19:30	Bus trip to Pecos National Monument (sign up with Santa Fe Destinations)	
19:30	Bus departs Eldorado for Ft. Marcy	

Saturday, 24 June 2006

08:30	Bus pick-up at Ft. Marcy for trip to Colorado	
08:45	Bus pick-up at Eldorado for trip to Colorado	
08:30-13:00	Float/Rafting Trip along Rio Grande River (sign up with Santa Fe Destinations)	extra fee
12:30-15:30	Backstage Opera and Shidoni Foundary and Sculpture Garden Tour (sign up with Santa Fe Destinations)	extra fee