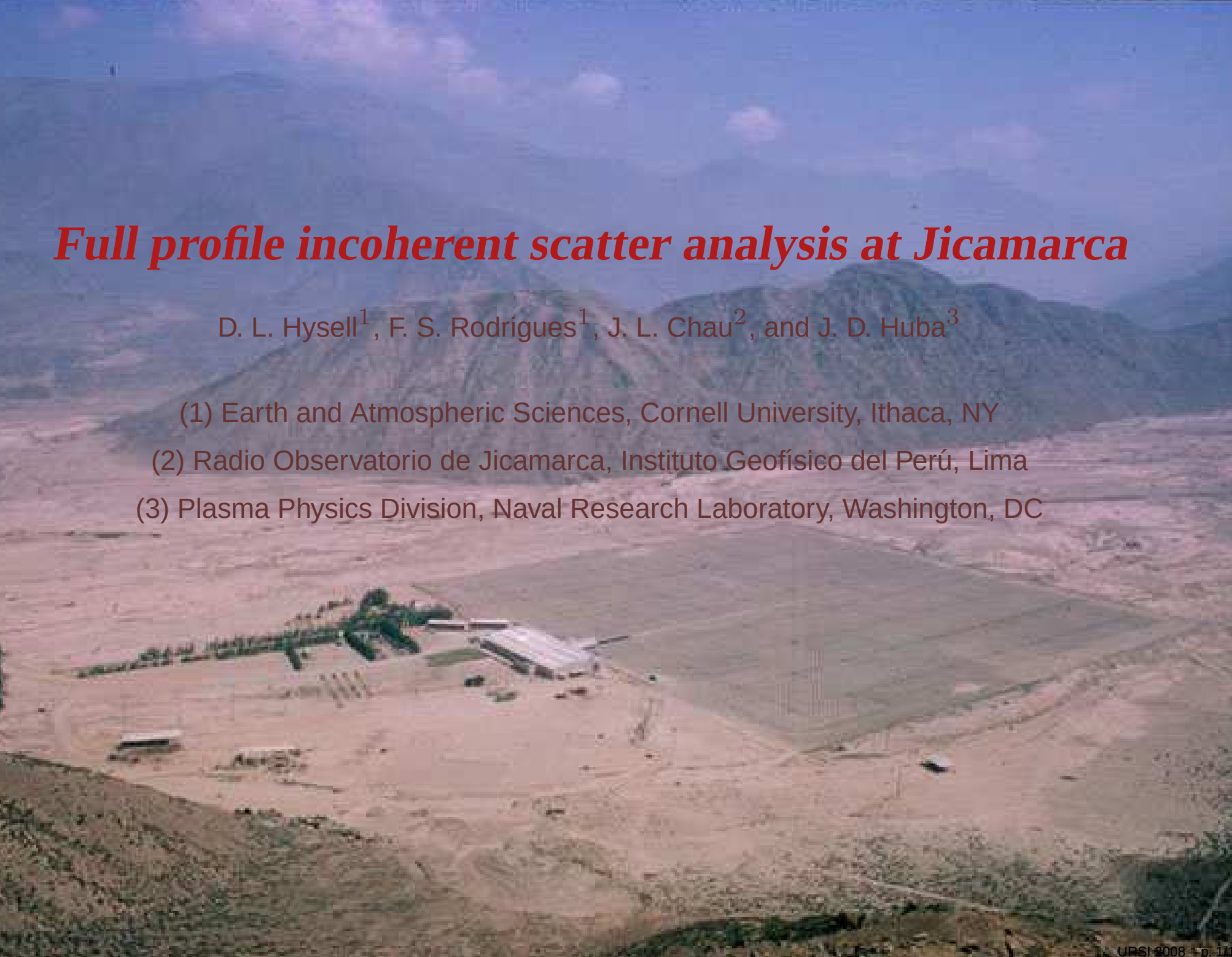


Full profile incoherent scatter analysis at Jicamarca

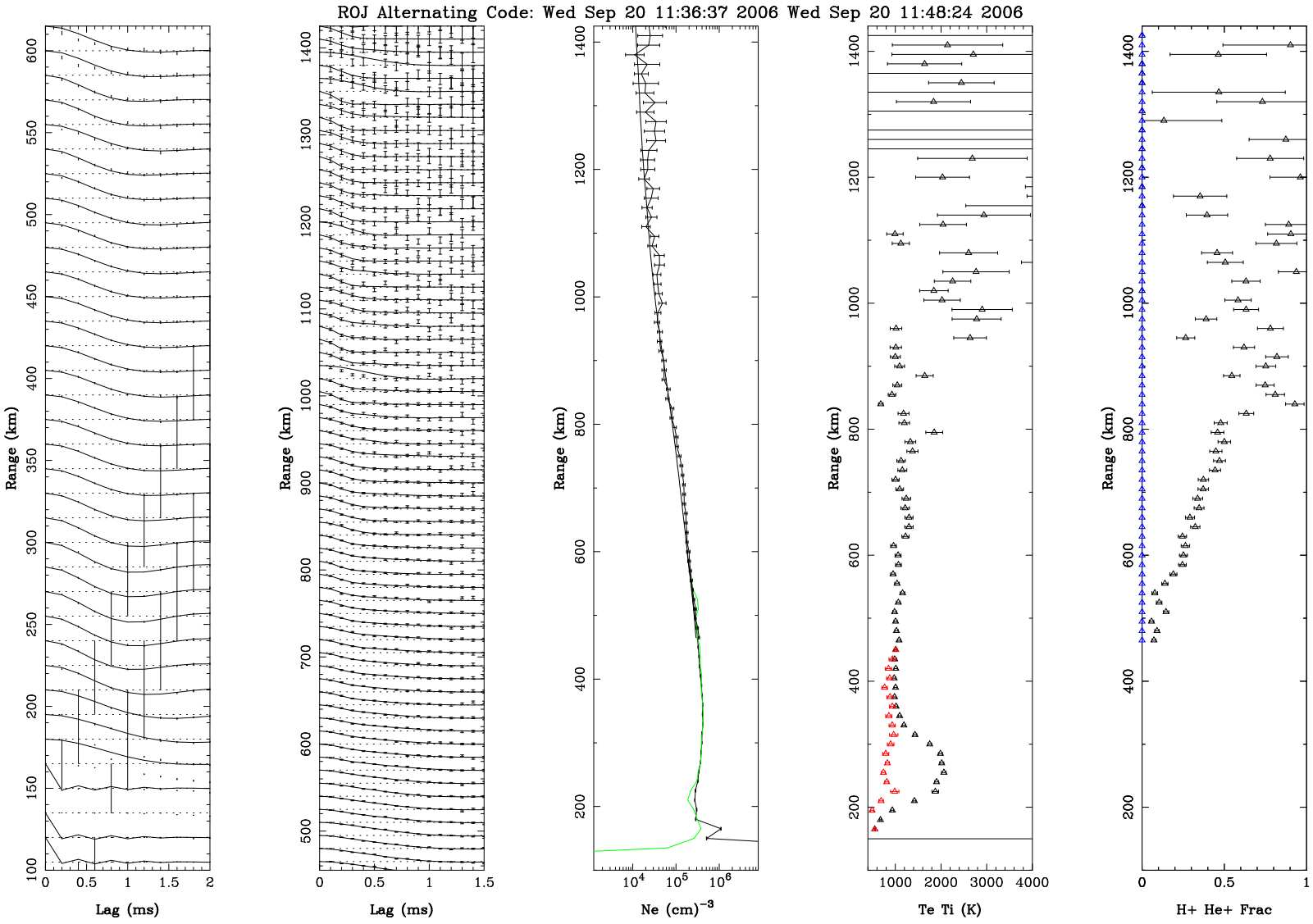
D. L. Hysell[1], F. S. Rodrigues[1], J. L. Chau[2], and J. D. Huba[3]

(1) Earth and Atmospheric Sciences, Cornell University, Ithaca, NY

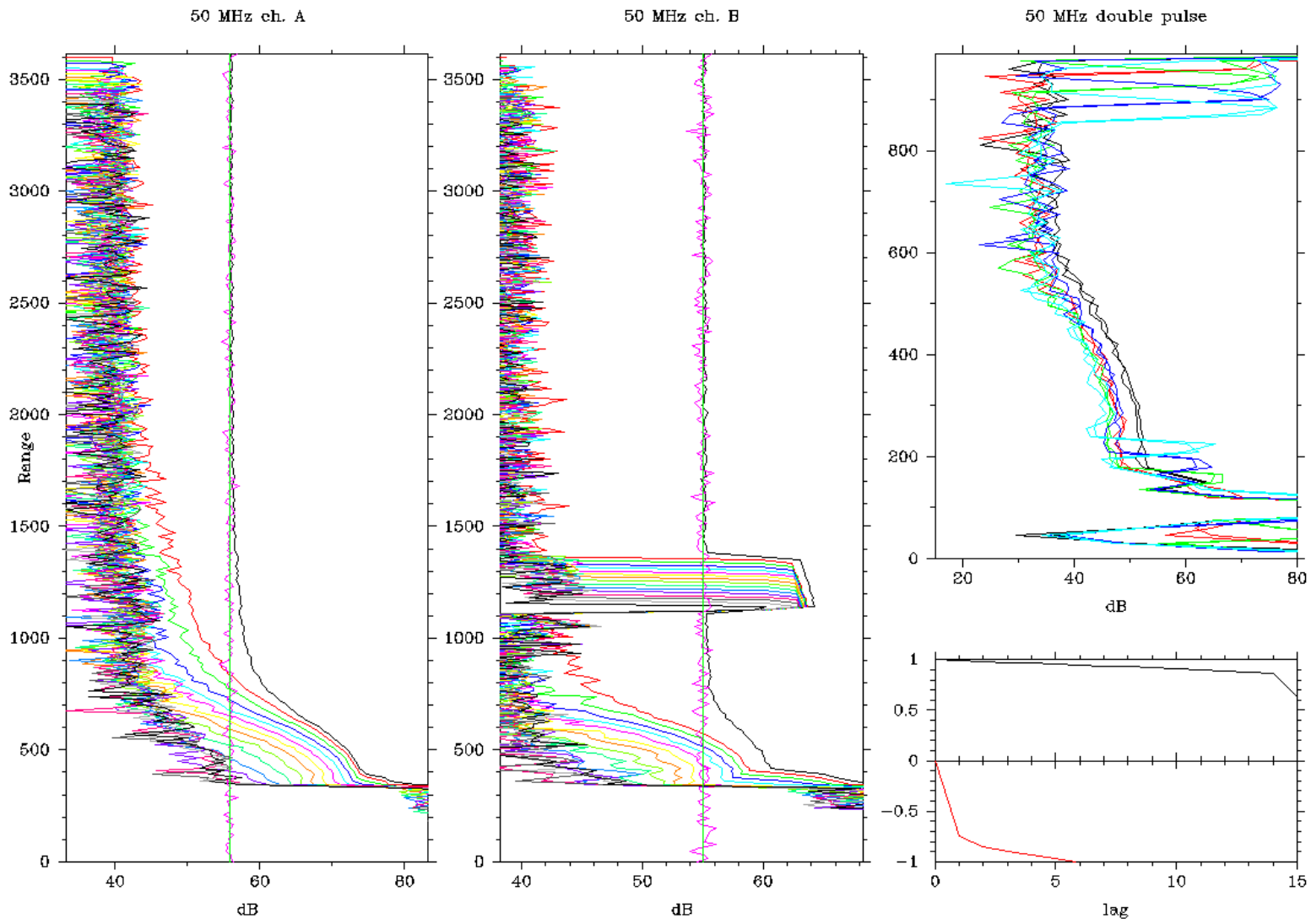
(2) Radio Observatorio de Jicamarca, Instituto Geofísico del Perú, Lima

(3) Plasma Physics Division, Naval Research Laboratory, Washington, DC

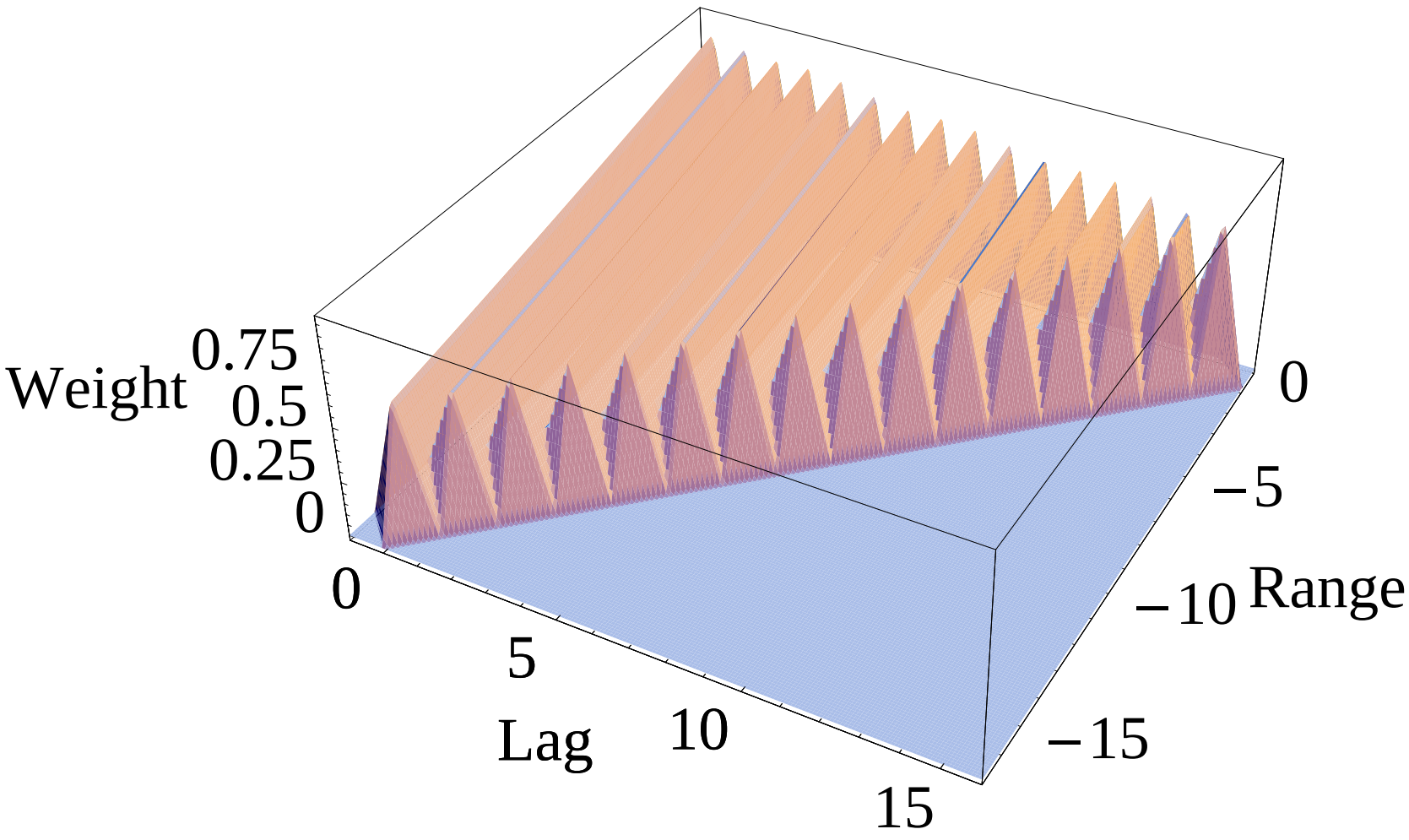
coded pulse data



long-pulse data



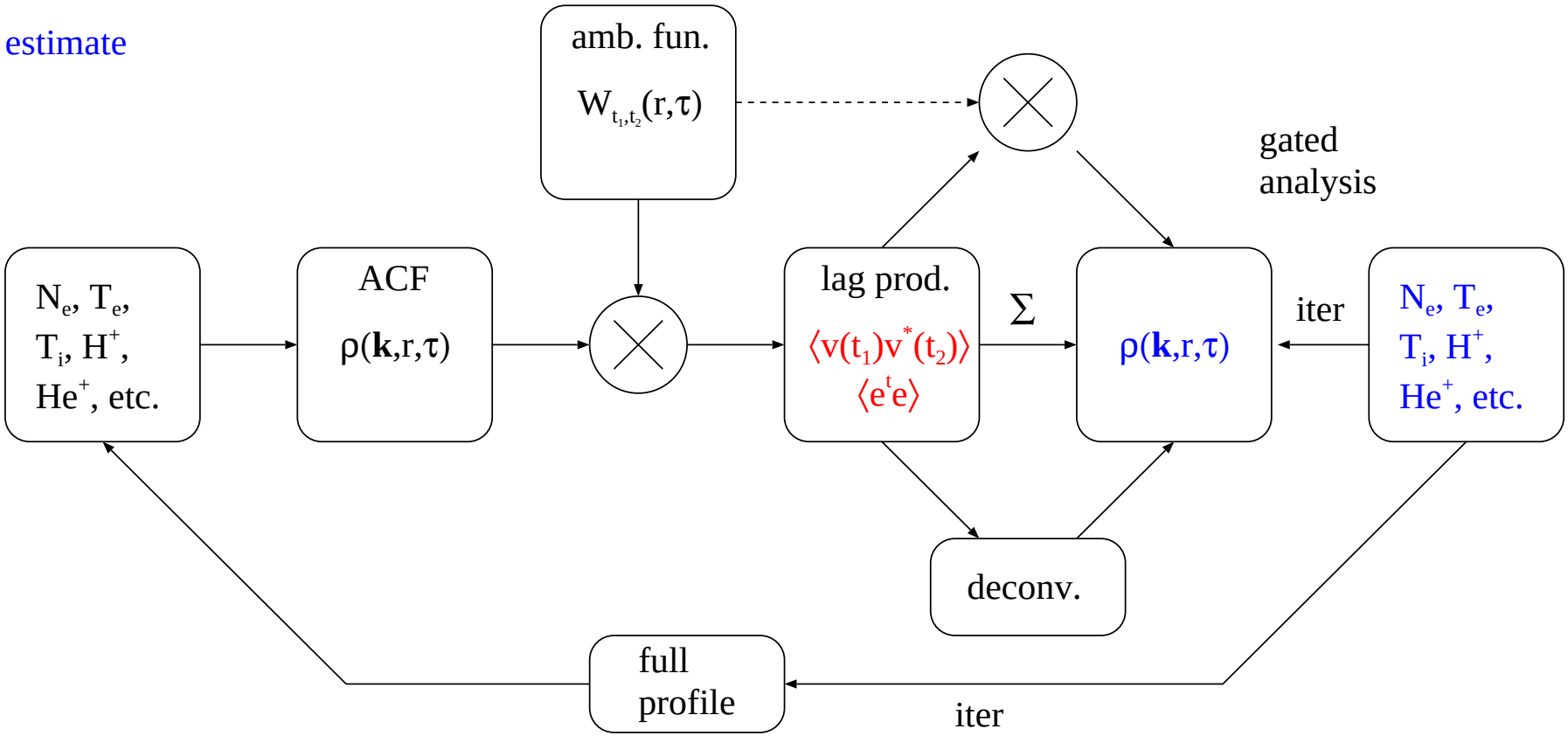
ambiguity functions



full profile analysis

data

estimate



inverse methodology

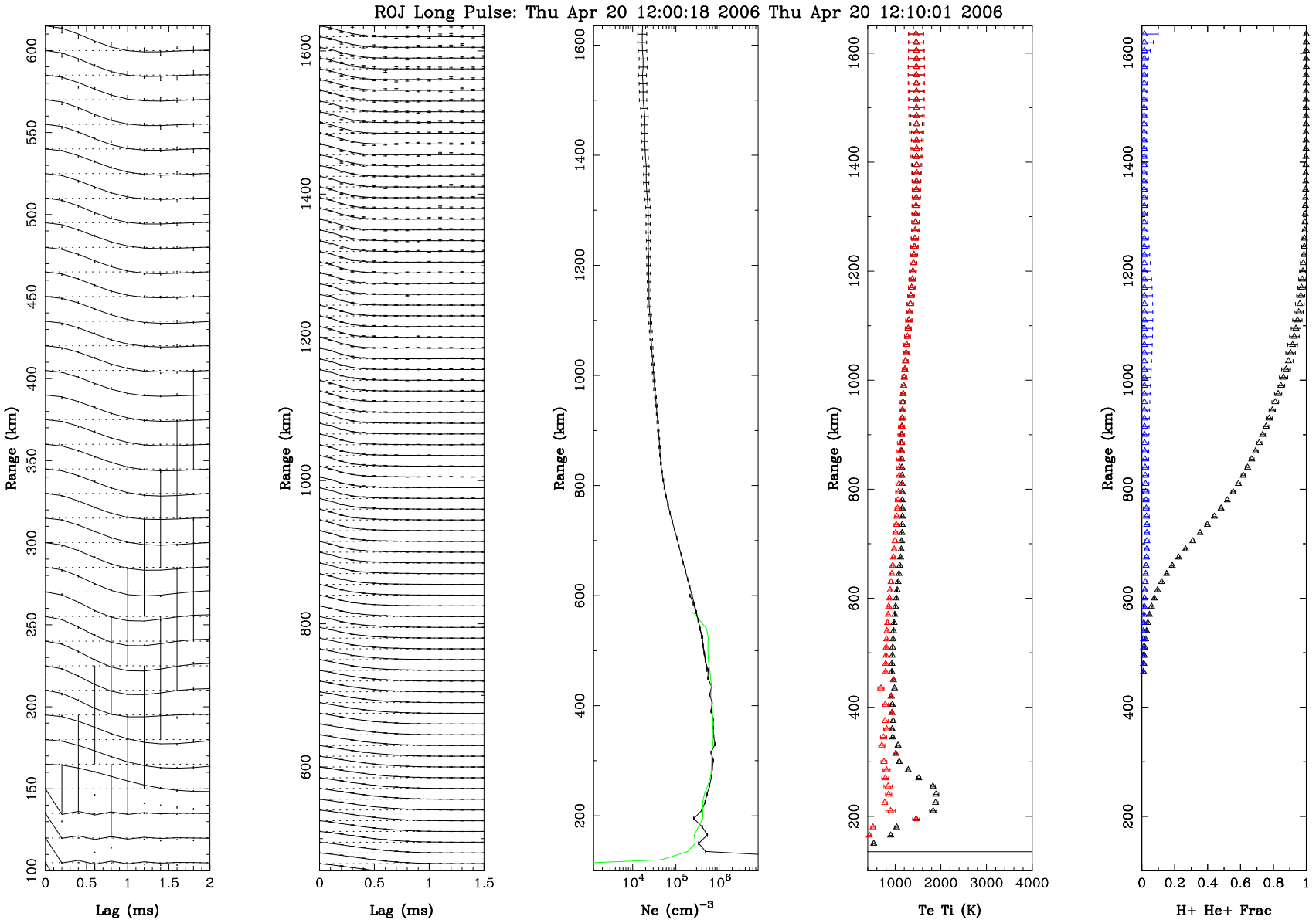
- Problem is to find density, temperature, and composition of ionosphere consistent with lag-product measurements (1600) within confidince limits (determining bandwidth, pulse width, integration time). Must begin with sufficiently accurate lag products, error estimates.
- Strategy is to solve the forward problem, iterate using nonlinear damped/augmented least squares methodology (regularization).
- Discretization: parameterize temperature, composition curves by finite number of points (20) and fill in using cubic B-spline interpolation.
- Problem is mixed determined (no exact solution, many statistically indistinguishable solutions) and poorly conditioned (solutions to noisy data problem typically very oscillatory).
- Regularize by introducing prior information to cost function.

cost function

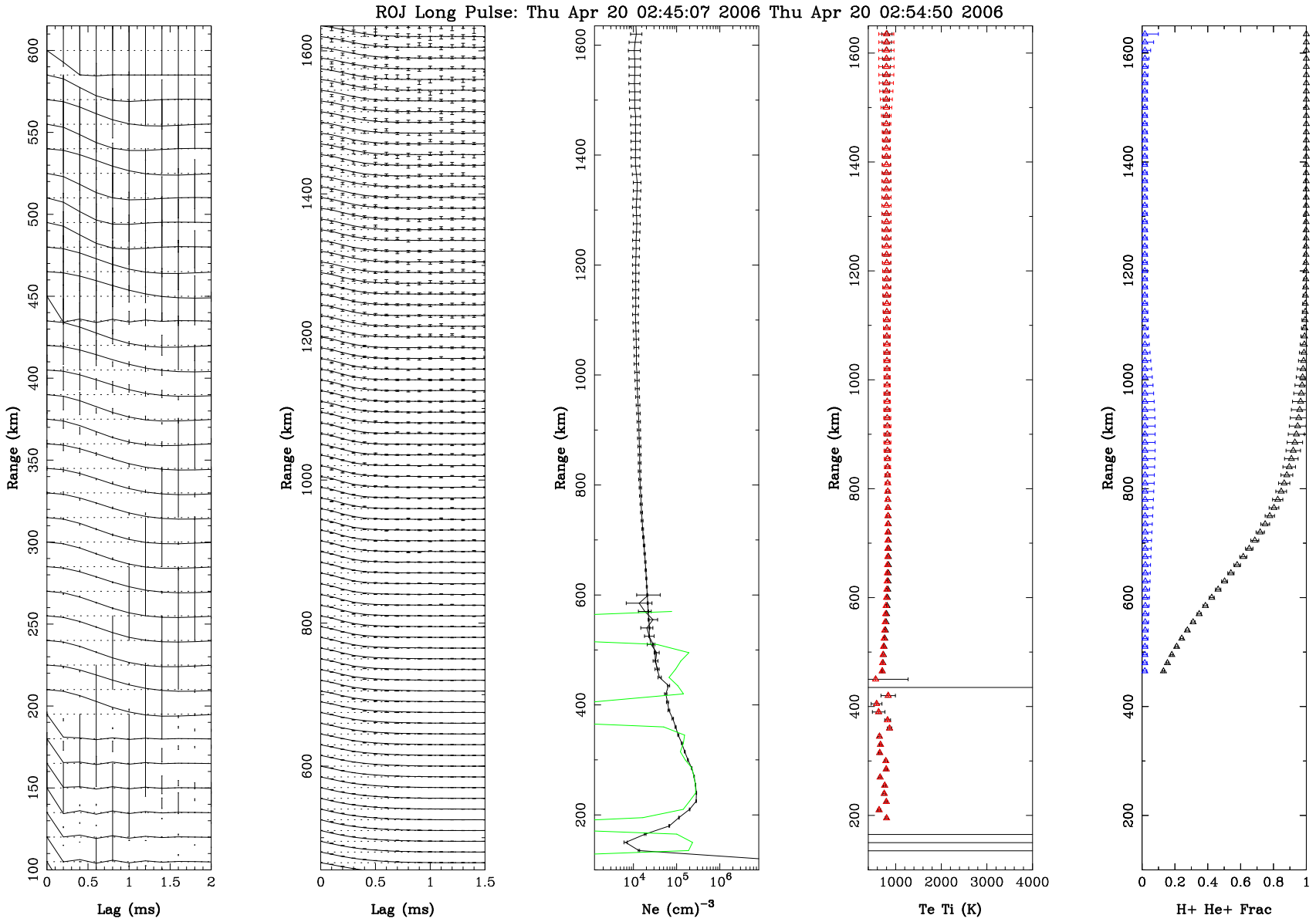
Minimize penalty composed of the following elements

- prediction error norm $e^t C_d^{-1} e$
- $||T_e''||_2^2 \, ||T_i''||_2^2$ temperature roughness
- $T_i/T_e \leq 1$ temperature ratio
- $||H^{+''}||_2^2$ hydrogen ion roughness
- composition fractions [0,1]

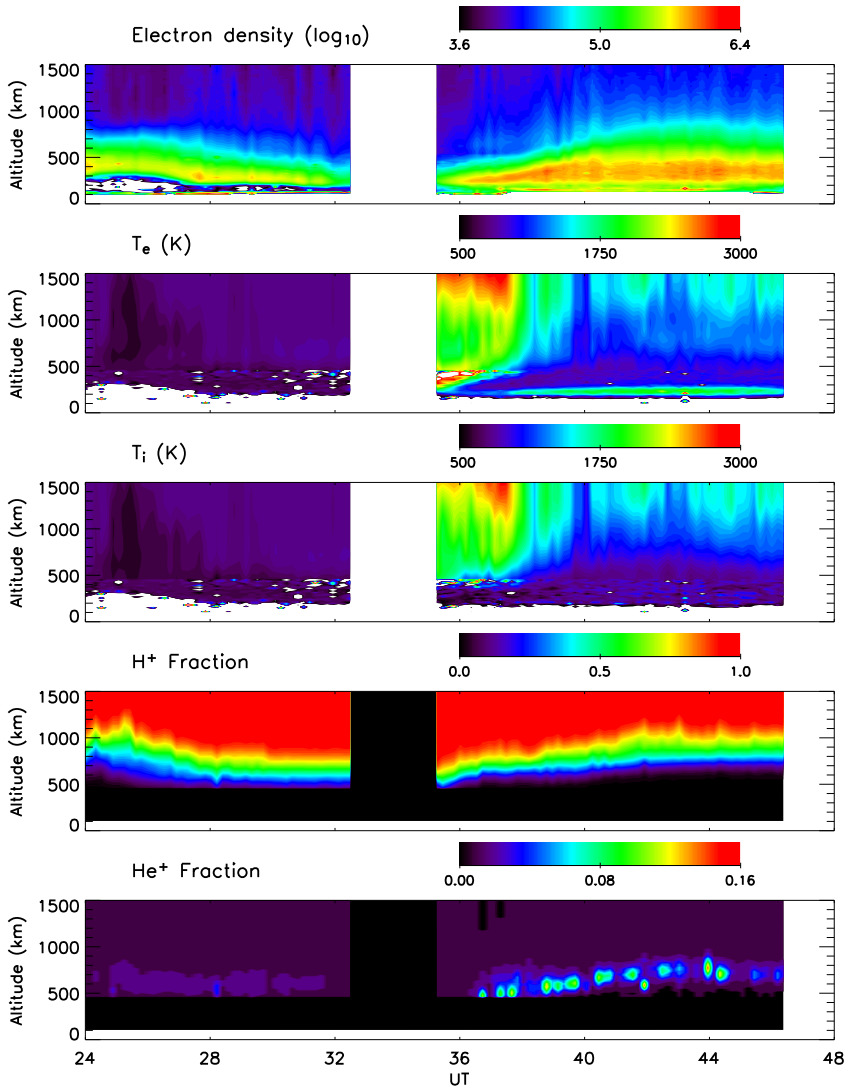
12 LT


ROJ Long Pulse: Thu Apr 20 12:00:18 2006 Thu Apr 20 12:10:01 2006
Range (km)
Lag (ms)
Ne (cm)$^{-3}$
Te Ti (K)
H+ He+ Frac

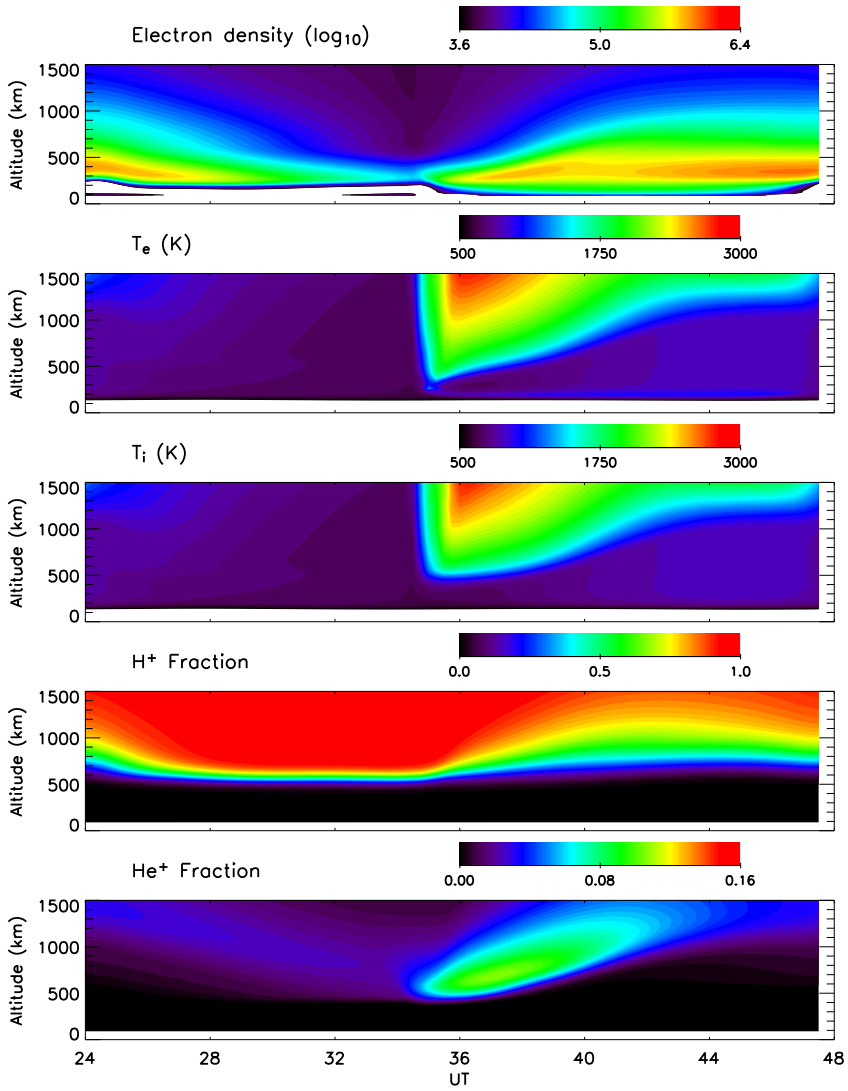
3 LT


ROJ Long Pulse: Thu Apr 20 02:45:07 2006 Thu Apr 20 02:54:50 2006
Range (km)
Lag (ms)
Ne (cm)$^{-3}$
Te Ti (K)
H+ He+ Frac

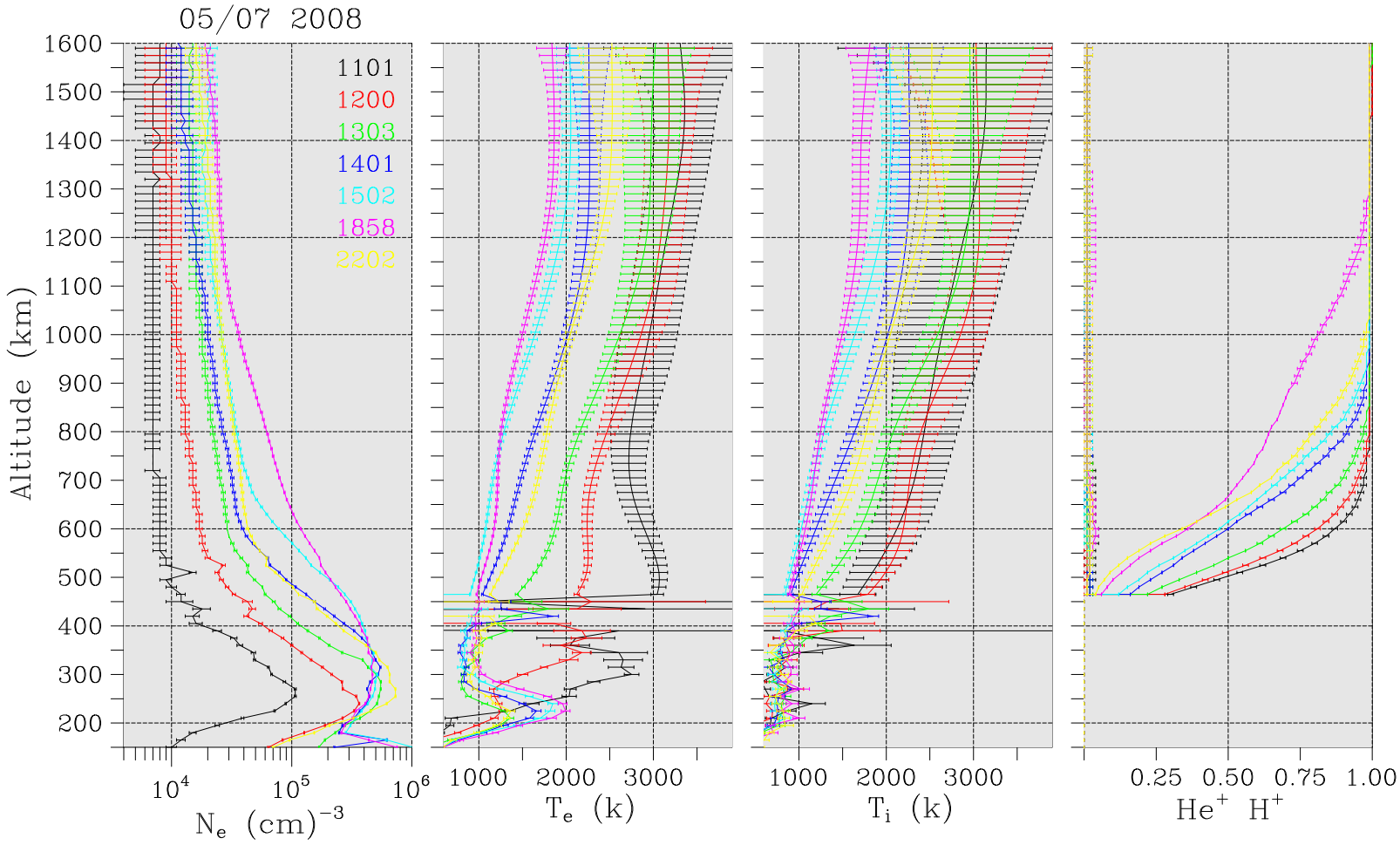
24 hours


Electron density (log10)
3.6
5.0
6.4
Te (K)
500
1750
3000
Ti (K)
500
1750
3000
H+ Fraction
0.0
0.5
1.0
He+ Fraction
0.00
0.08
0.16
Altitude (km)
1500
1000
500
0
24
28
32
36
40
44
48
UT

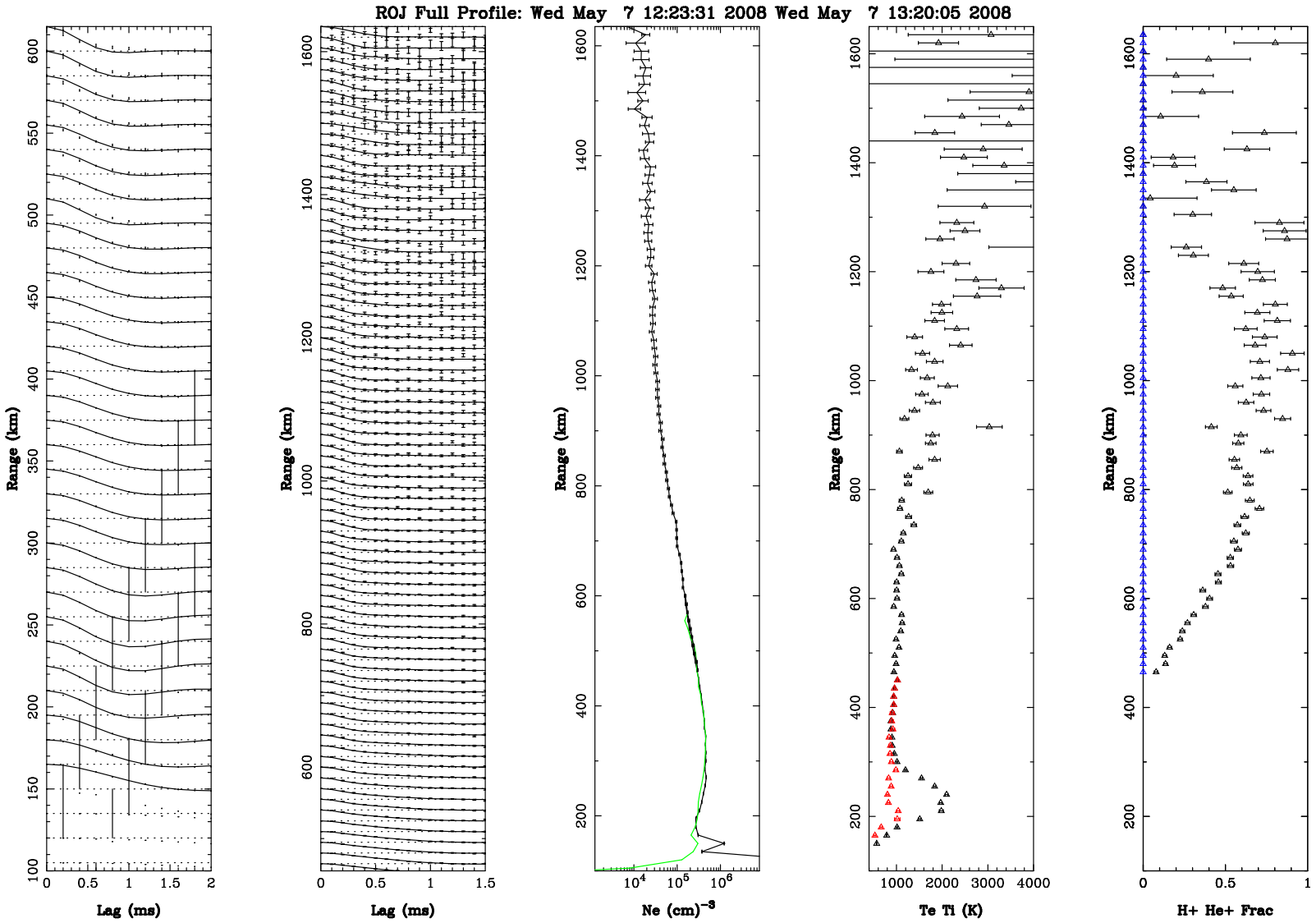
SAMI2 comparison



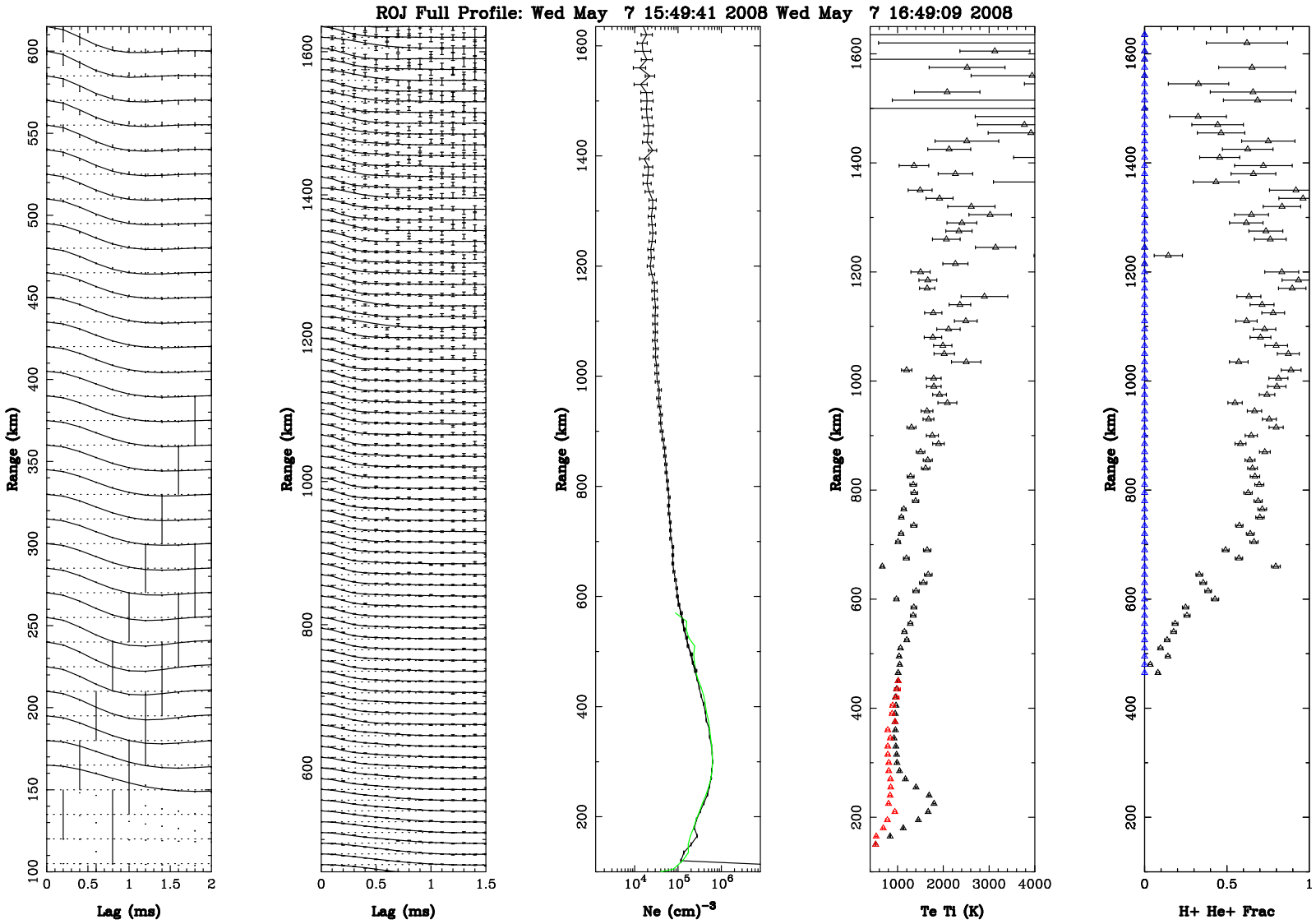
May ’08


05/07 2008
1101
1200
1303
1401
1502
1858
2202
Altitude (km)
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
10^4
10^5
10^6
N_e $(cm)^{-3}$
1000
2000
3000
T_e (k)
1000
2000
3000
T_i (k)
0.25
0.50
0.75
1.00
He^+ H^+

alternating code



alternating code



summary

- Full-profile analysis will permit the first comprehensive, time-resolved measurements of plasma density, temperature, and compisition profiles with drifts at Jicamarca.
- Validation — compare other modes?
- More meaningful comparisons with *in situ* (RPA) and radio propagation (TEC, occultation) measurements from space now possible.
- Thermal balance, ion composition, and photoelectron transport studies getting underway.
- Substantial improvement in noise estimation, debris removal and transmit pulse characterization should facilitate new analyses, including conventional drift measurements.