All The (Toy) Problems

Vinay Kashyap (SAO/CXC-Cal/ICHASC)
(also Warren and Weber)

Plasma densities from line ratios

- The ratio of intensities from certain lines is a diagnostic of the plasma density
- Line Intensity arises due to transitions from an upper quantum level to a lower, releasing a photon with a specific wavelength
- Upper level is populated by collisions between particles — if decay to lower level by radiative and collisional deexcitation is slower, the line intensity will be density dependent

Plasma densities from line ratios

- examples:
  - He-like (2 electrons left) O VII and Ne IX in high-resolution X-ray gratings spectra of stars

Model of r,i,f lines in He-like systems

Gabriel & Jordan,_1969,_MNRAS,_145,_241

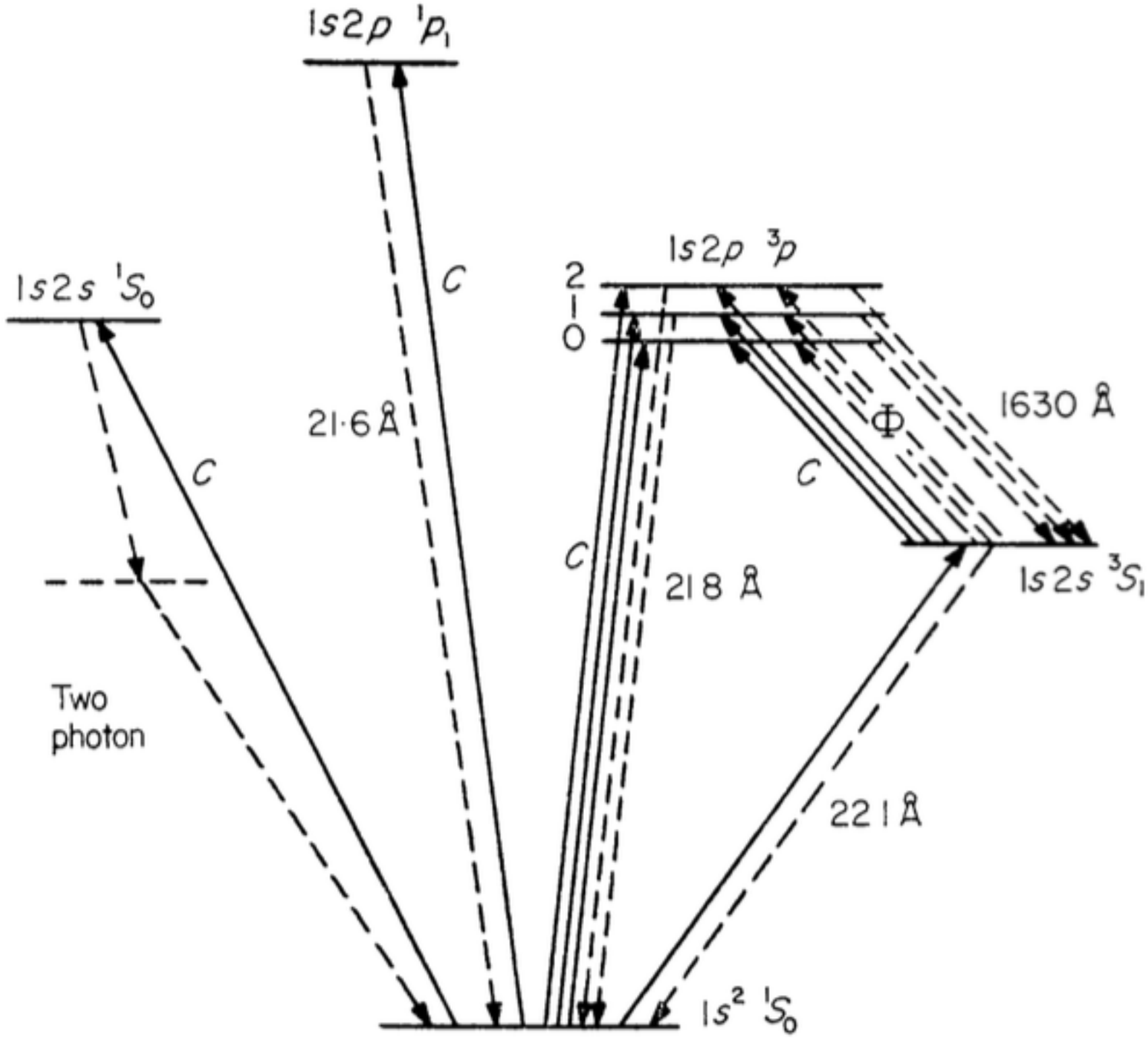
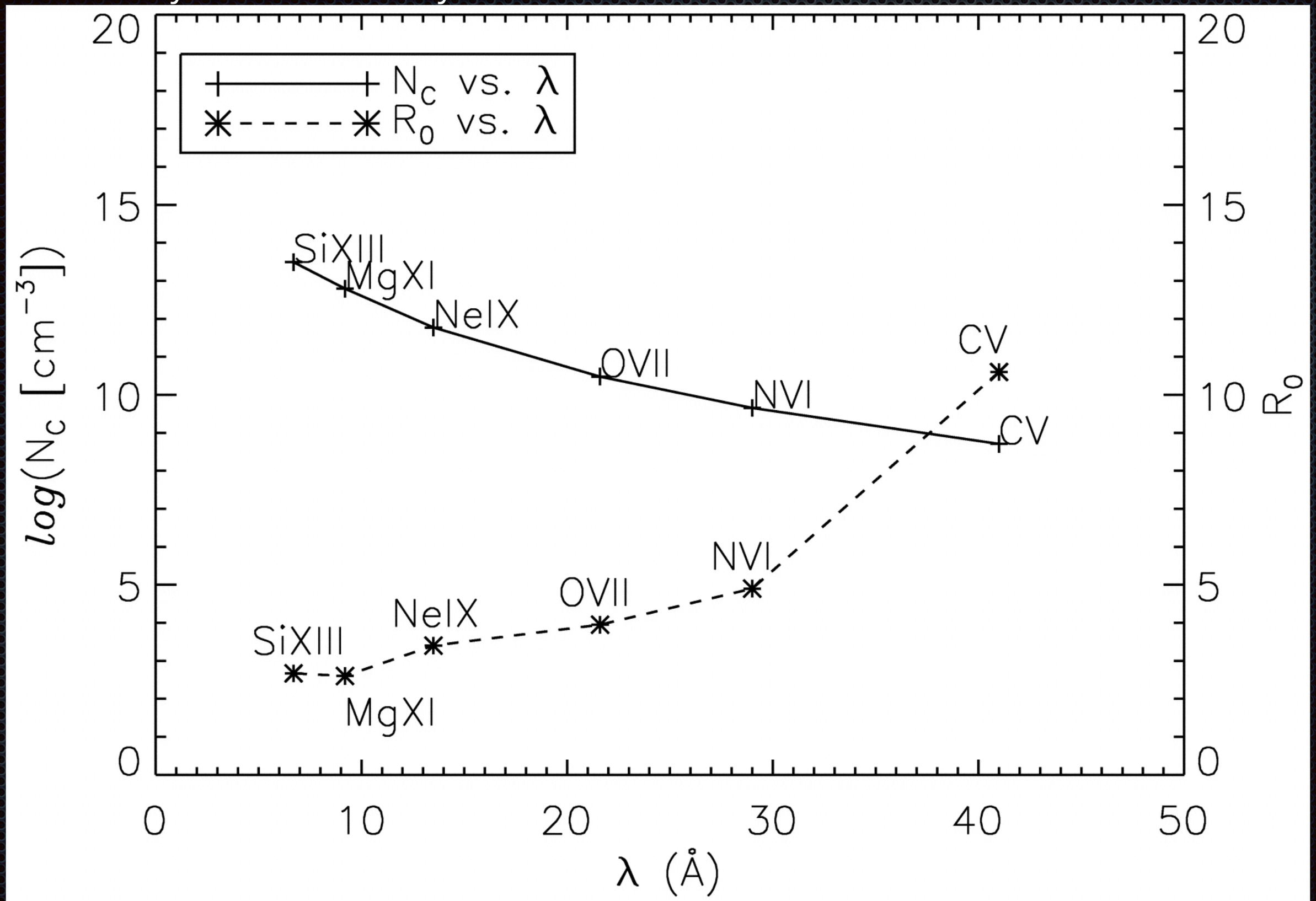


FIG. 1. *The He-like ion, showing those terms and processes involved in the present analysis. The wavelengths indicated apply to the case of oxygen VII.*

sensitivity of different systems

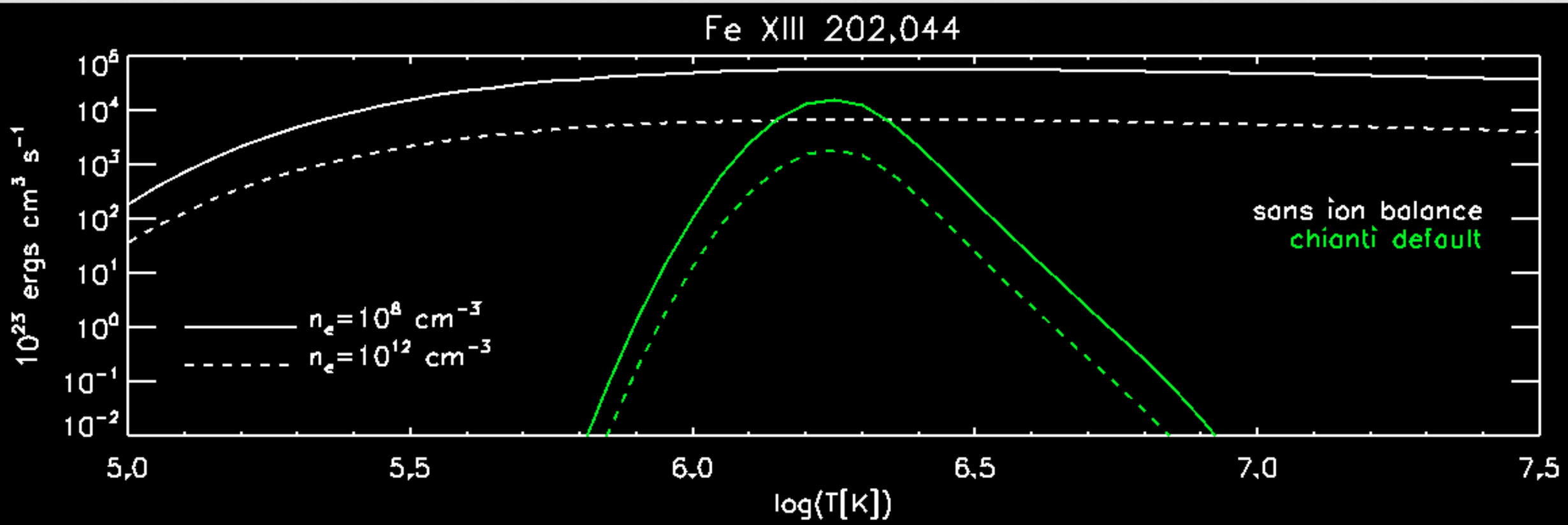
Ness et al. 2003, ApJ, 598, 1277

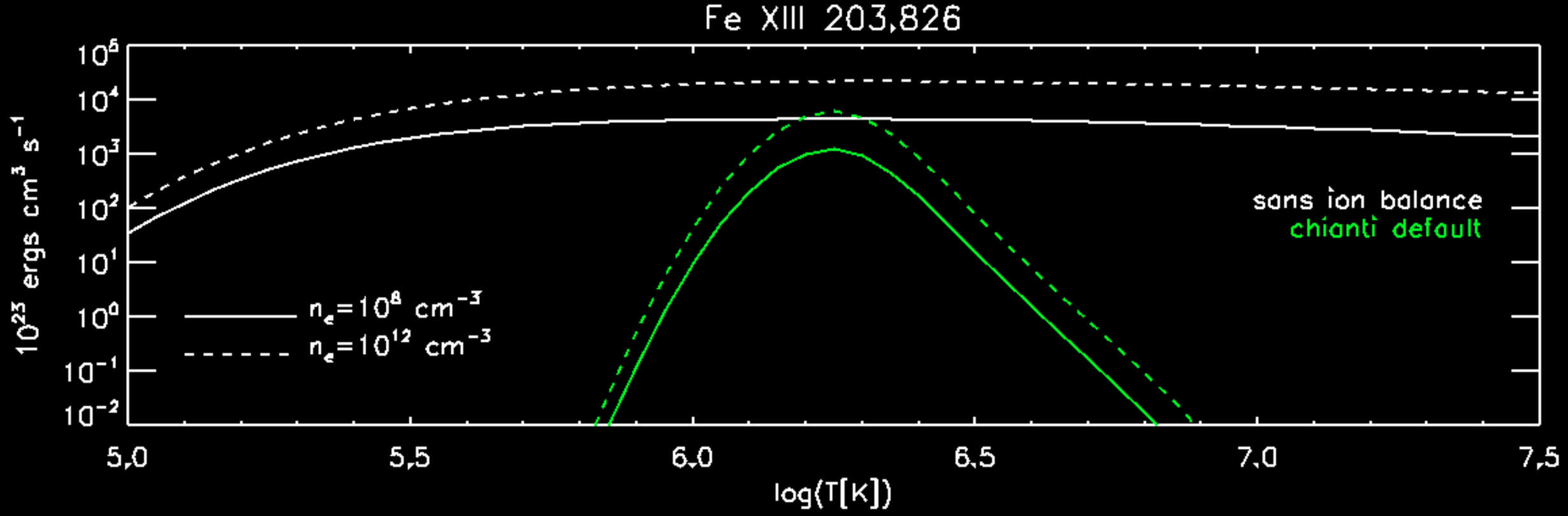


Plasma densities from line ratios

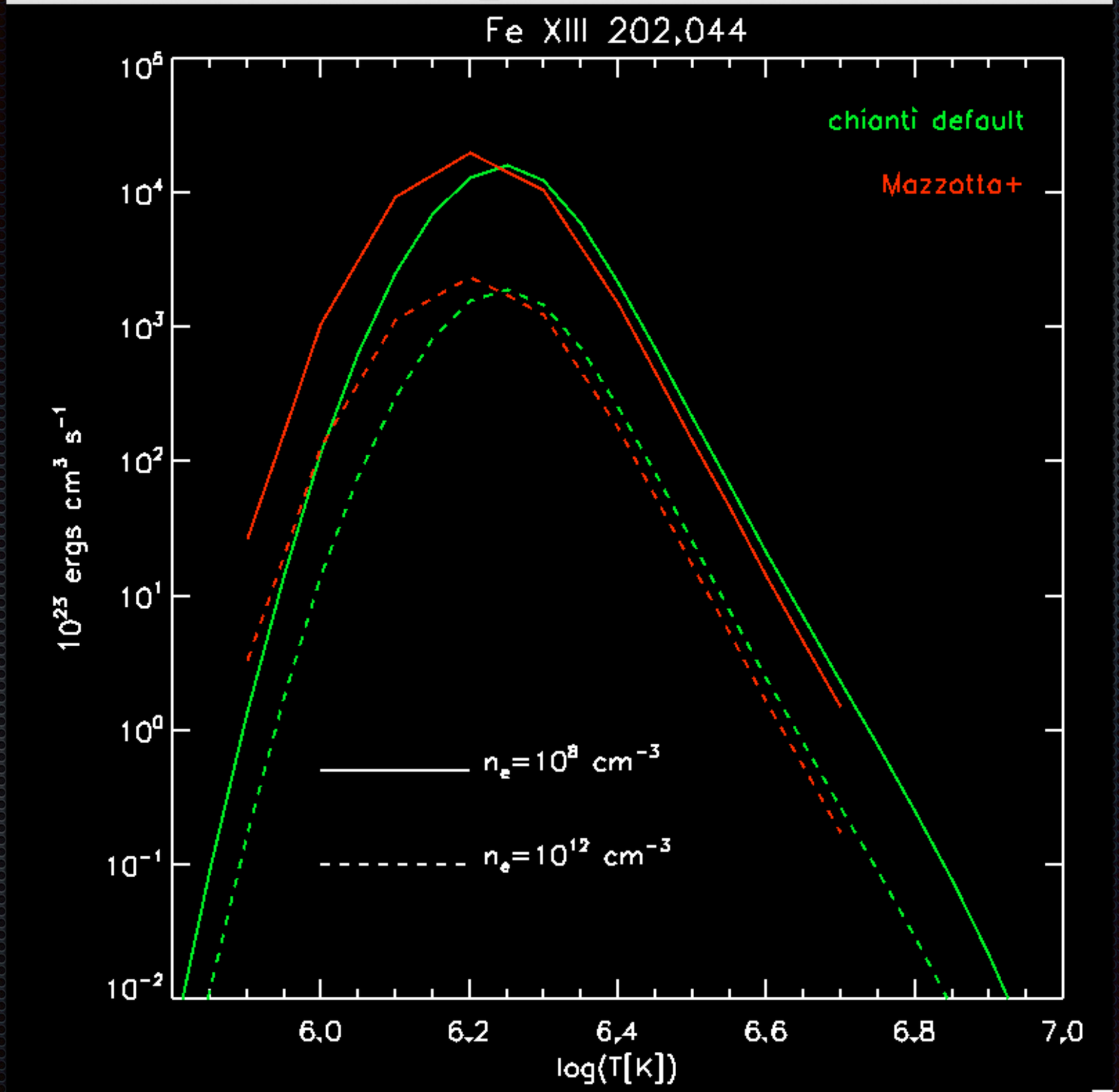
- examples:
  - He-like (2 electrons left) O VII and Ne IX in high-resolution X-ray gratings spectra of stars
  - Fe XIII λ203.826 and λ202.044 in Hinode/EIS spectra of the Sun

Fe XIII 202.044+203.826

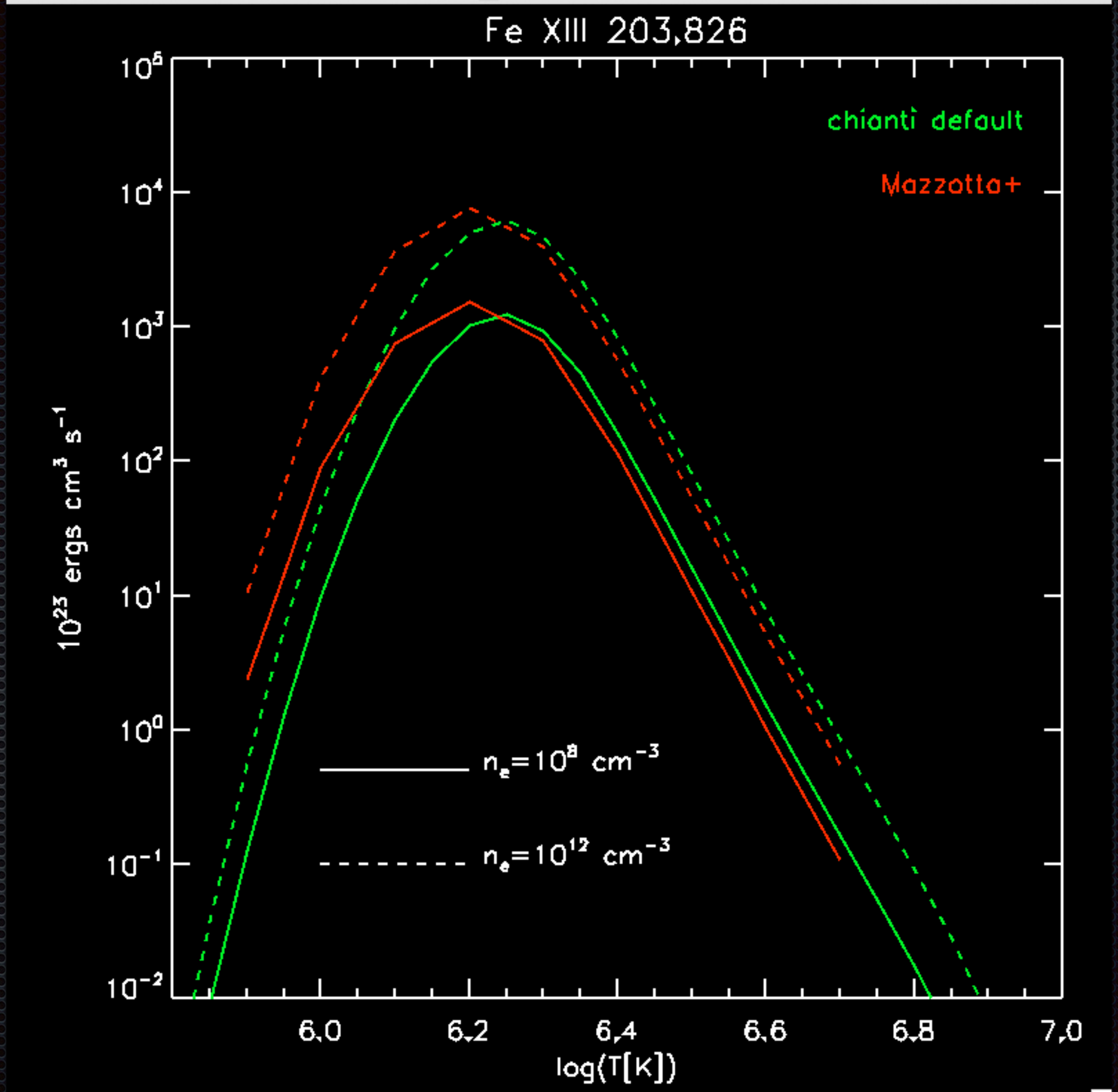


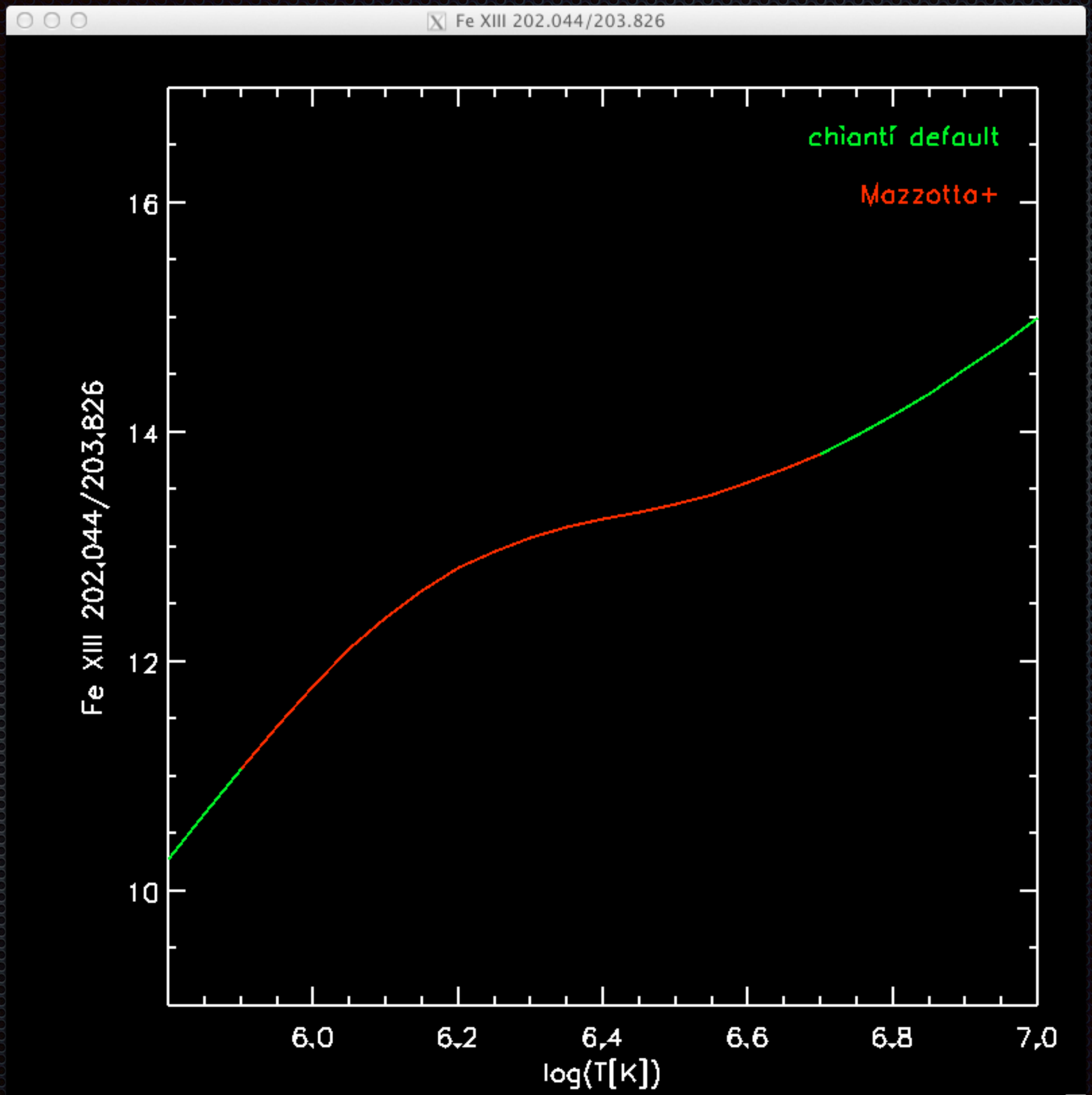


Fe XIII 202.044



Fe XIII 203.826



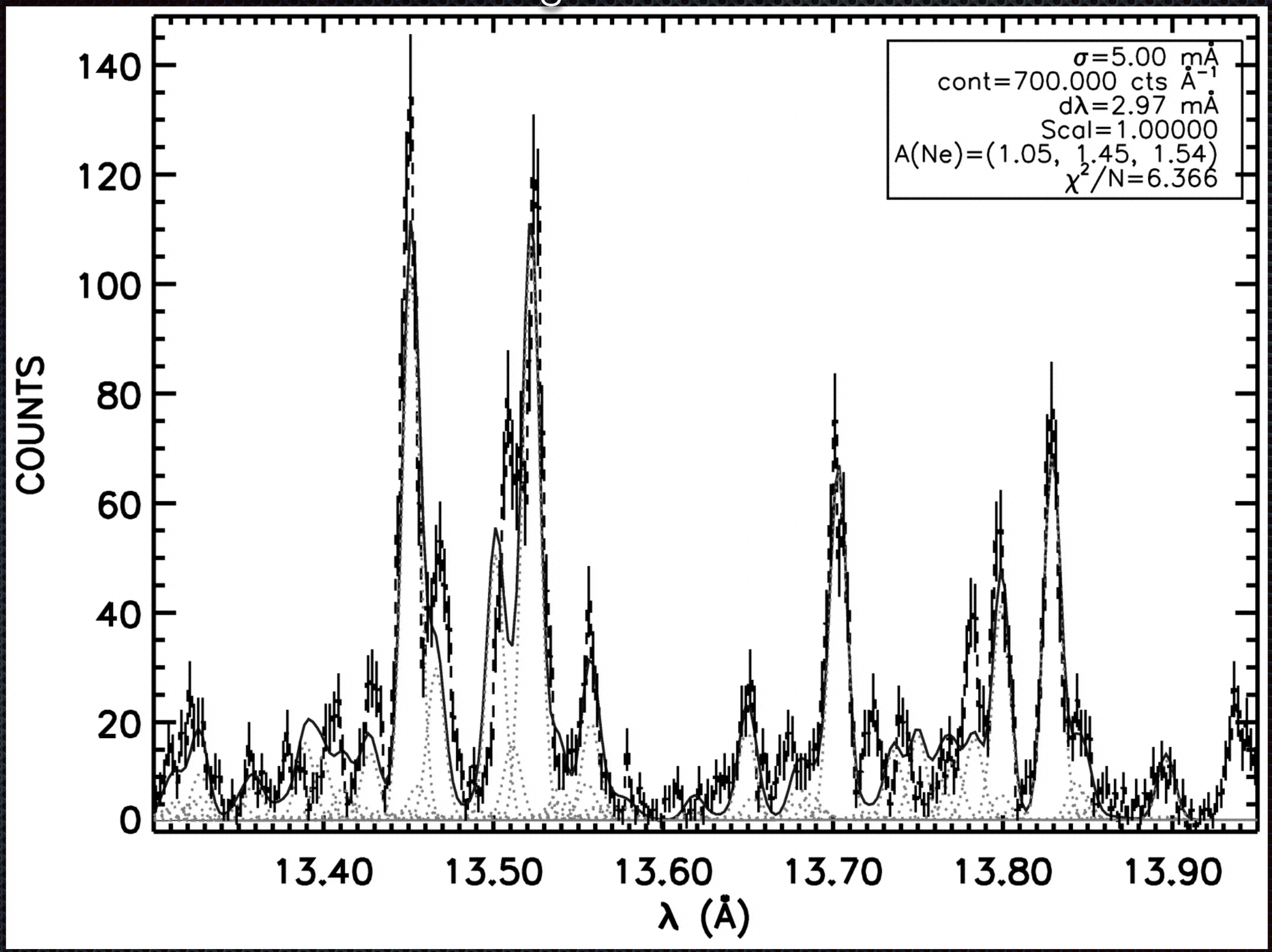

Fe XIII 202.044/203.826
chianti default
Mazzotta+
Fe XIII 202,044/203,826
16
14
12
10
6.0
6.2
6.4
6.6
6.8
7.0
log(T[K])

Peeling the onion: intensity measurement

- accounting for background
- accounting for continuum
- shape of the line spread function
- effective area calibration
- contamination from nearby lines
- line profile fitting

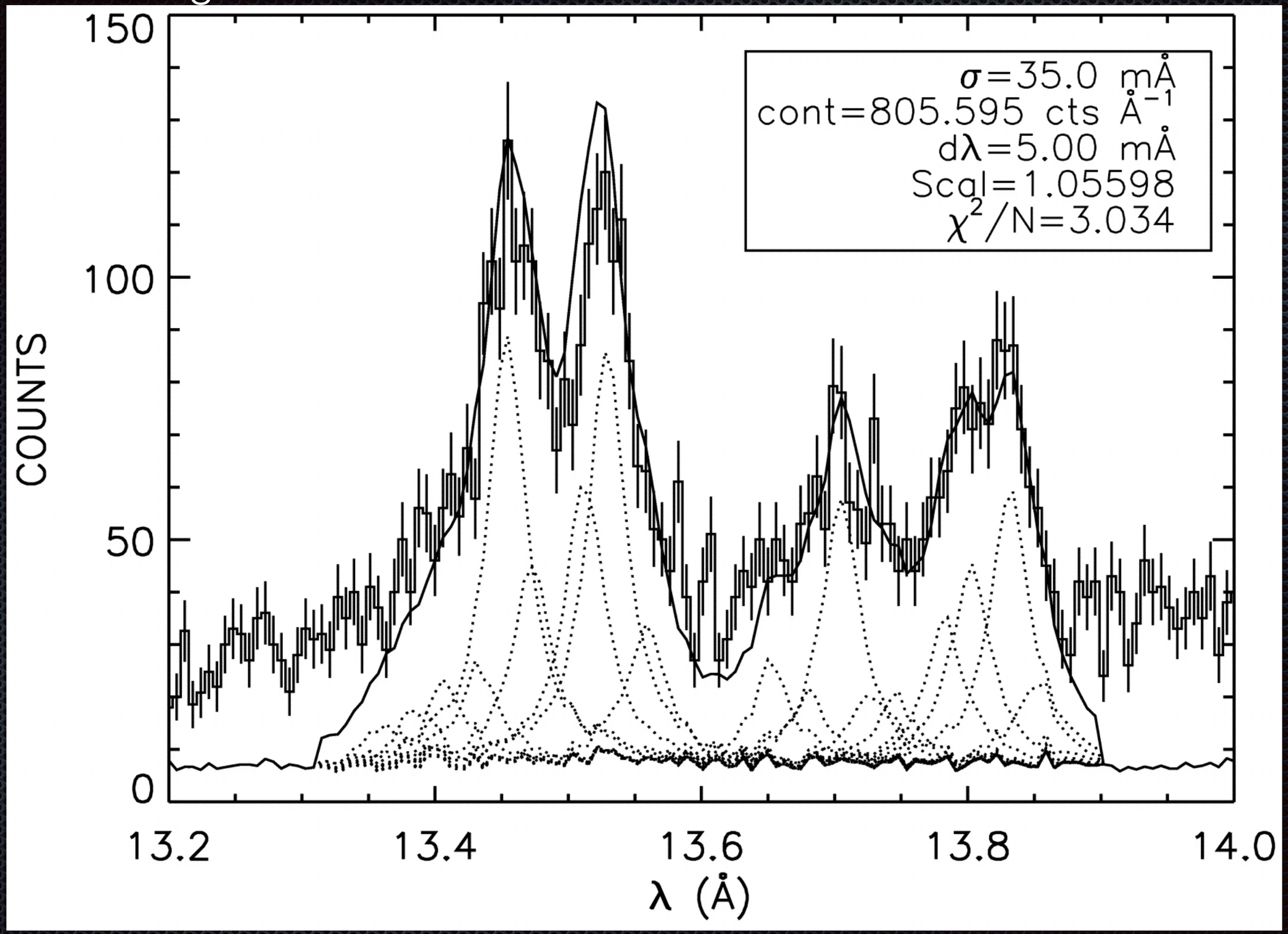
multi line model of Ne IX region in HEG

Ness et al. 2003, ApJ, 598, 1277



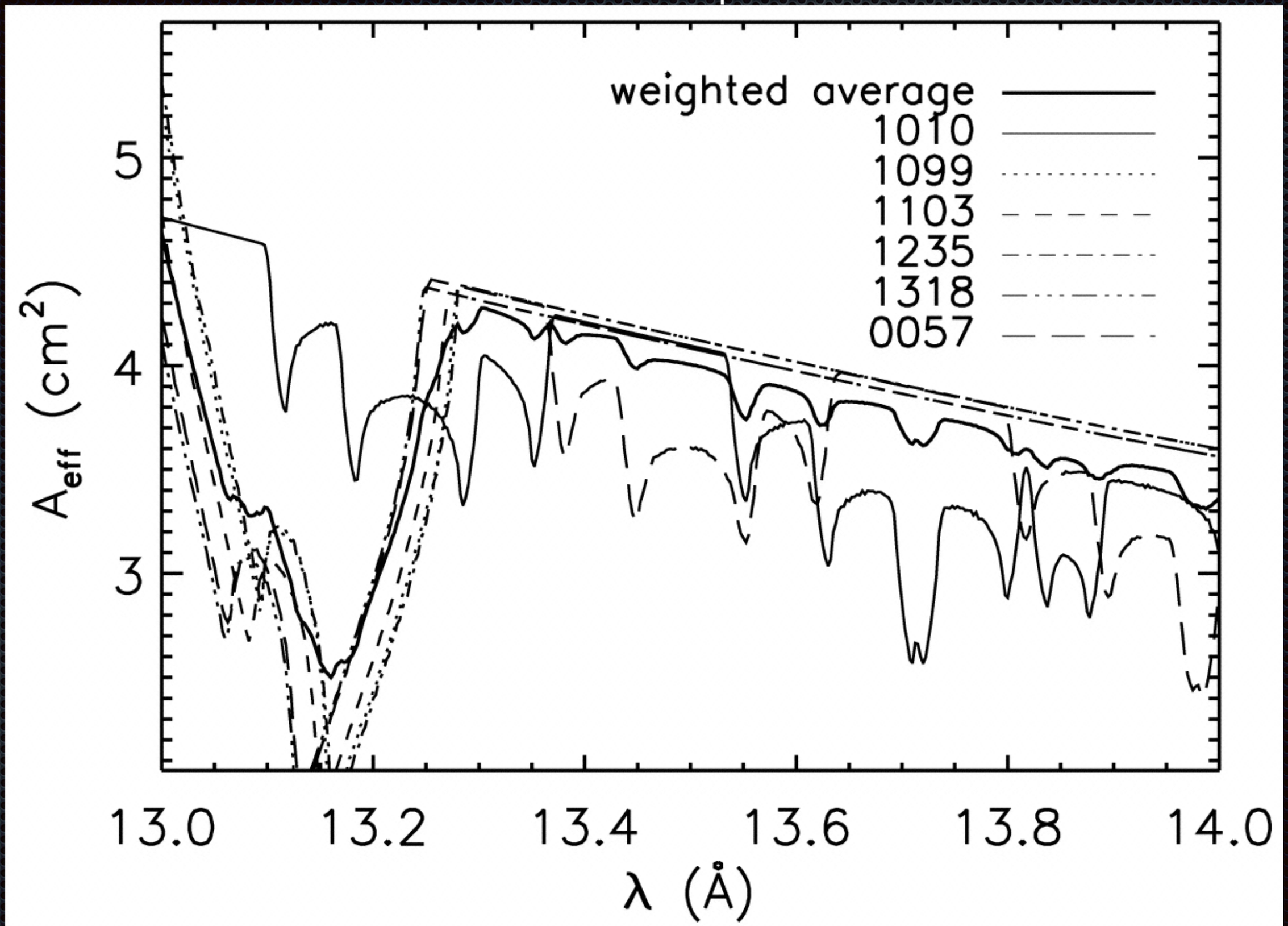
translating HEG model to RGS

Ness et al. 2003, ApJ, 598, 1277



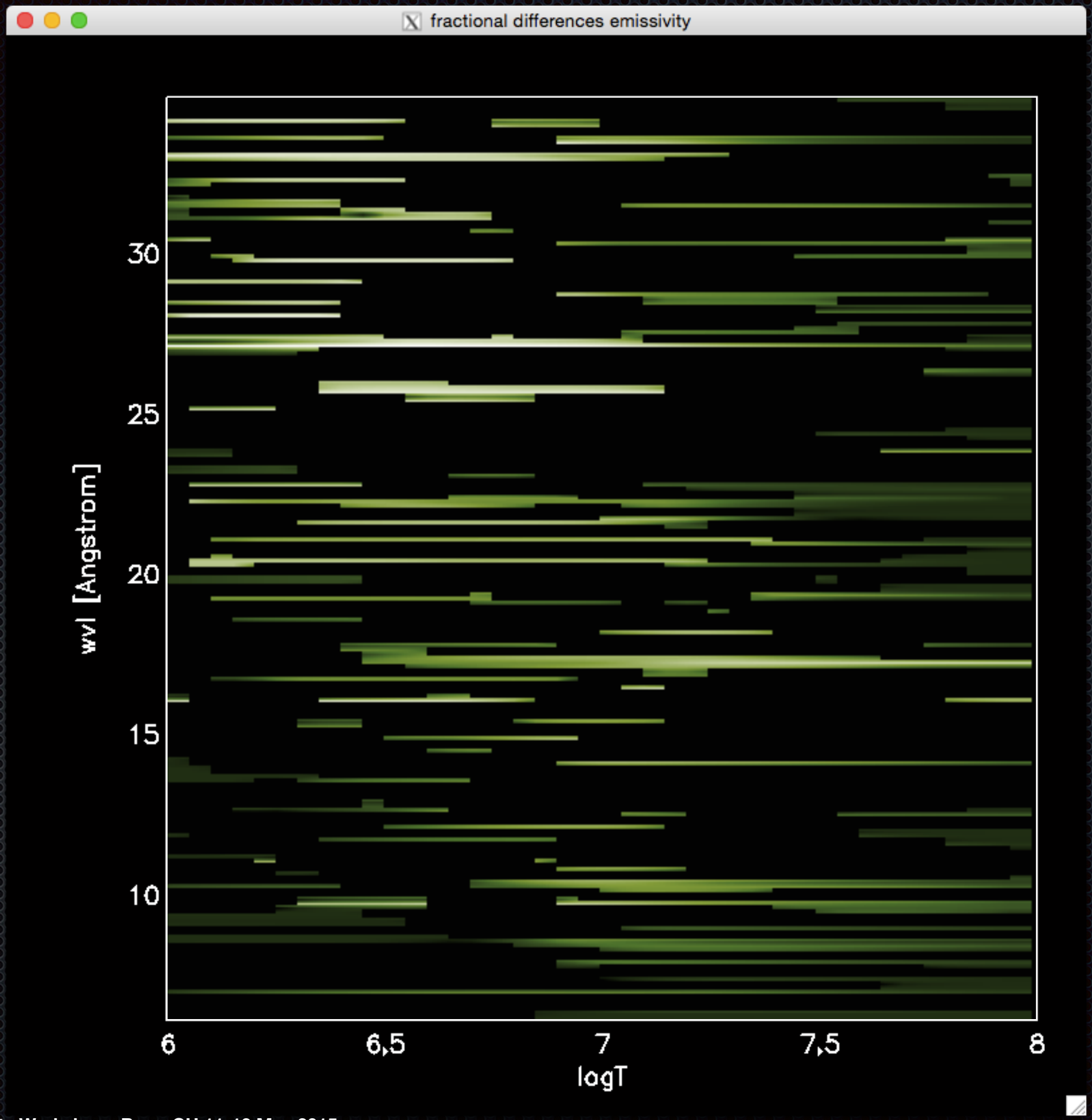
HEG effective area under Ne IX complex

Ness et al. 2003, ApJ, 598, 1277



Peeling the onion: identification

- line location and matching to database
  - affected by both calibration and database completeness
- chicken and egg problem: must know temperature to know emission species to know temperature


fractional differences emissivity
30
25
20
15
10
wvl [Angstrom]
6
6,5
7
7,5
8
logT

Peeling the onion: equilibrium assumptions

- not an issue for line ratio problem
  - abundance anomalies
  - ion balance could be varying with time, or even in stationarity, could have a different profile along line of sight than equilibrium
    - *can it affect level populations? is that ignorable?*
  - integration time averages over dynamical processes
- density fluctuations along line of sight
- observed intensity is weighted by amount of plasma at different densities and temperatures

Peeling the onion: Maths is hard

- high-frequency instability in DEM(T) solutions
- large dynamic ranges
- Data are only approximately Poisson distributed

dynamic range in EM can be substantial

Ness et al. 2003, ApJ, 598, 1277

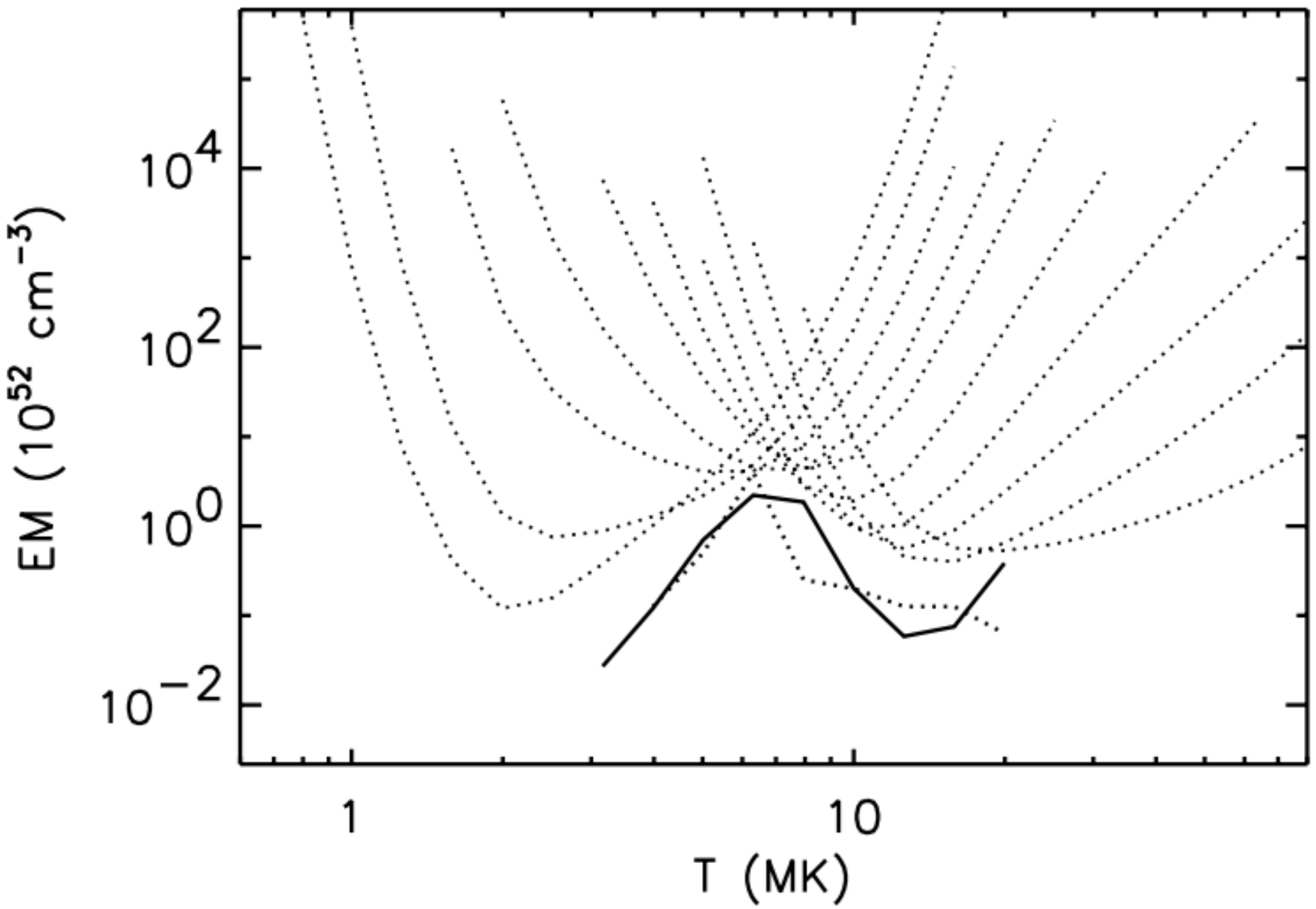
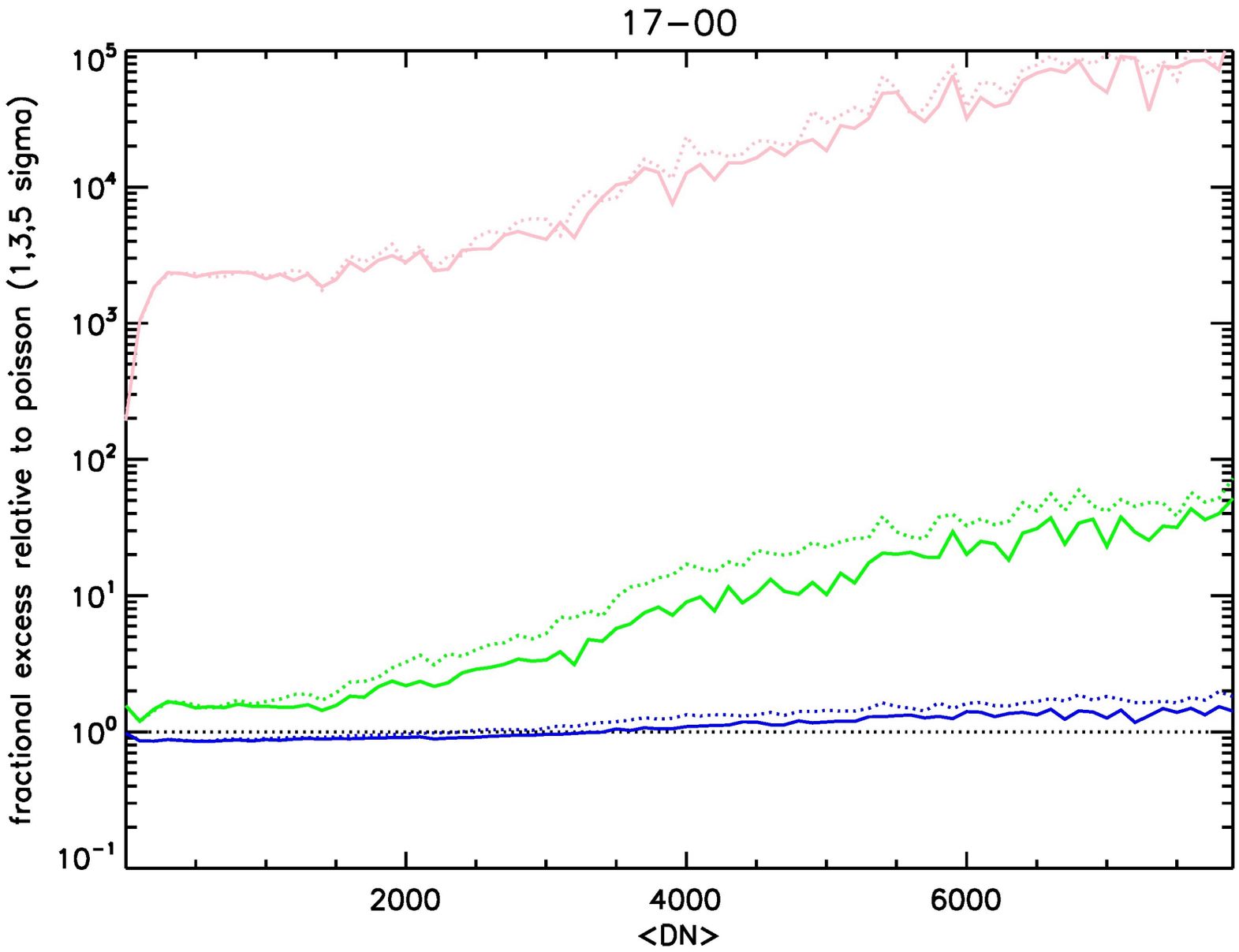
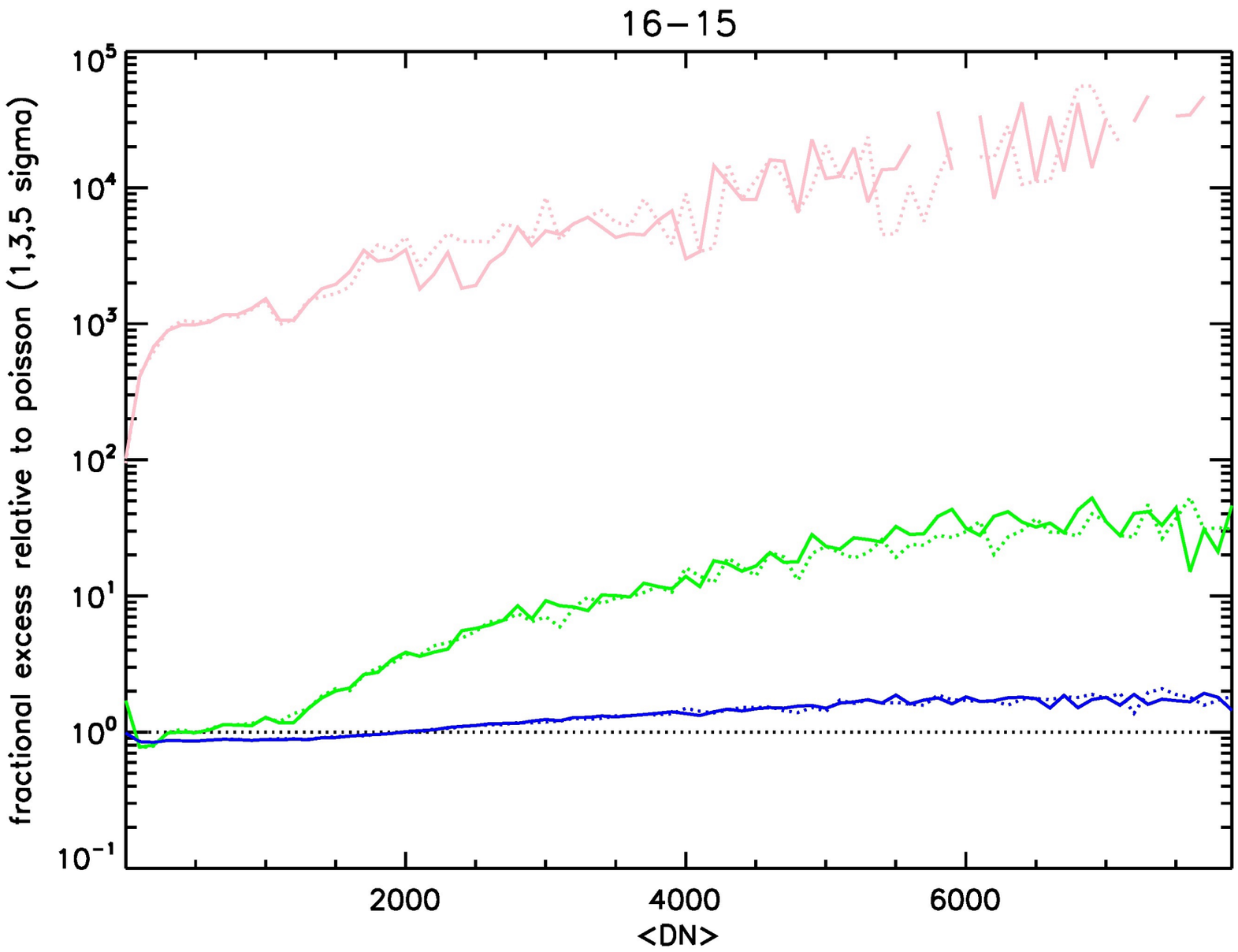


FIG. 7.—Best-fit emission measure distribution derived from iron lines in ionization stages Fe XV to Fe XXIV (*solid line*). The result from Brickhouse et al. (2000) is also shown (*lower dotted line*). Individual line emission measure curves (*upper dotted lines*) are shown for the lines in Table 6.

fluctuations are over dispersed compared to Poisson



fluctuations are over dispersed compared to Poisson



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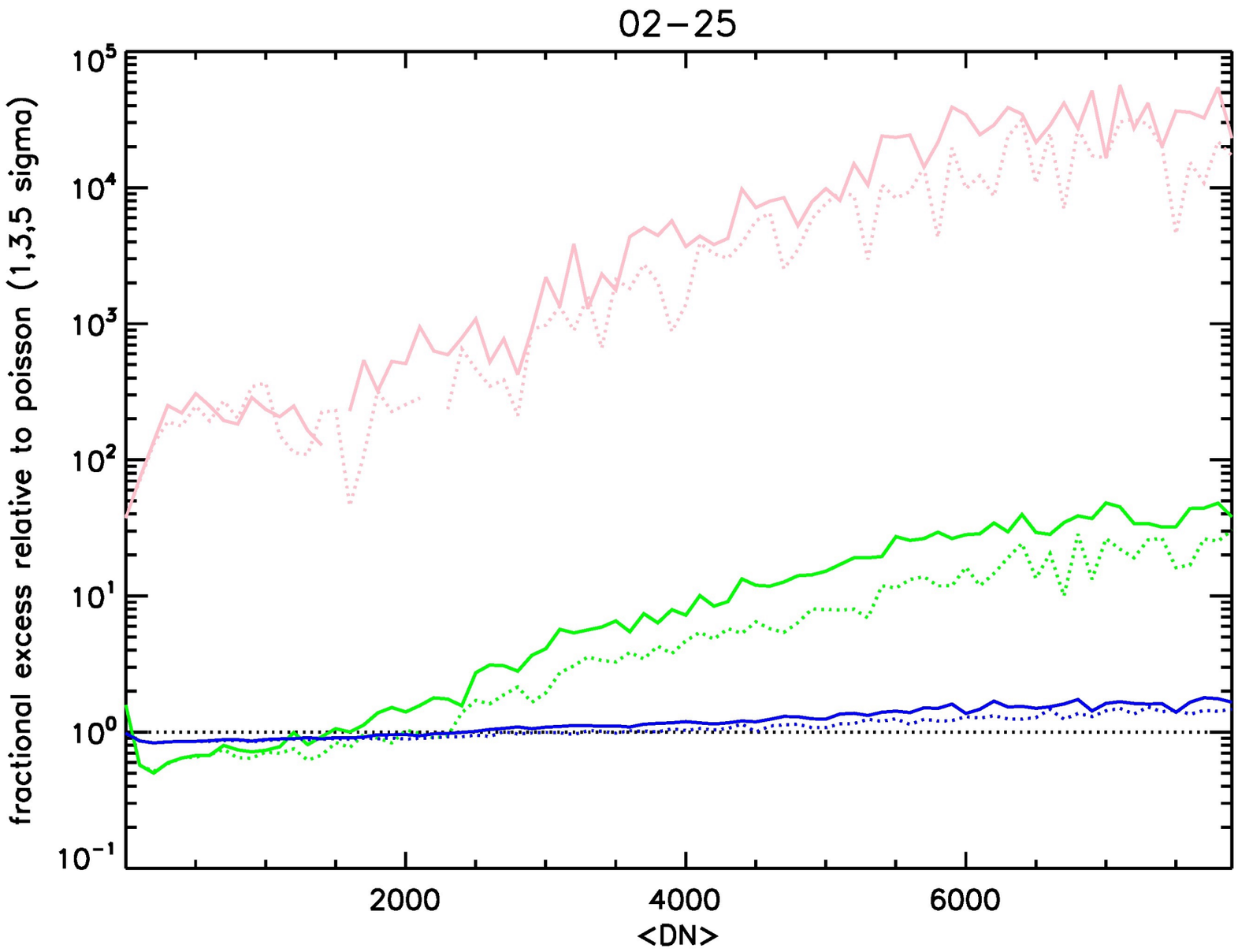
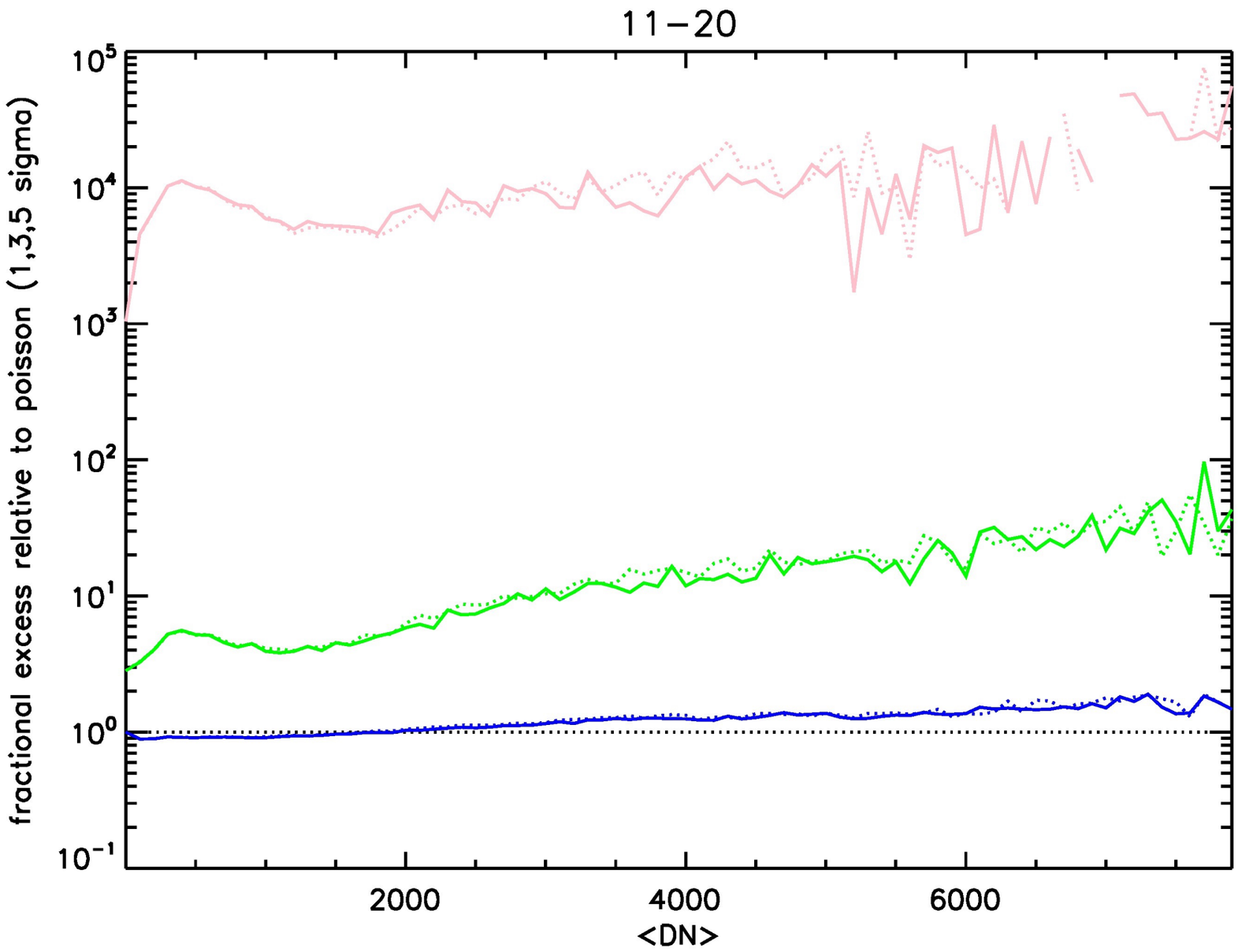


fluctuations are over dispersed compared to Poisson



Peeling the onion: Uncertainties from Atomic Databases

- line location
- transition coefficients
- level populations
- ion balances
- weak lines and missing lines and pseudo-continuum