CHIANTI database and programs

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VAMDC Virtual Atomic and Molecular Data Centre

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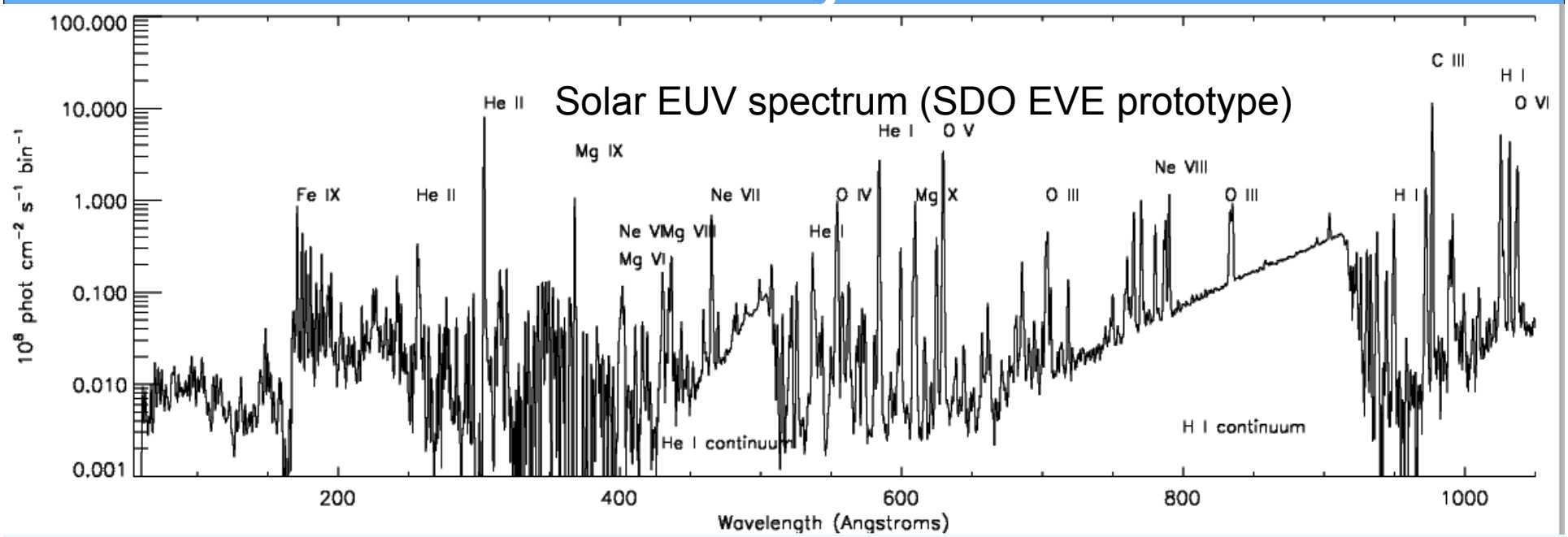
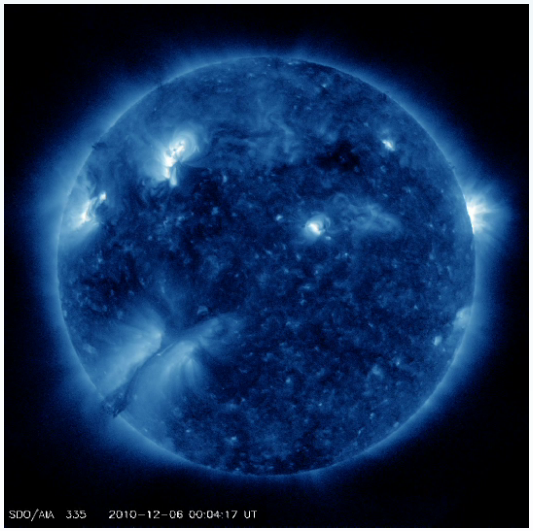
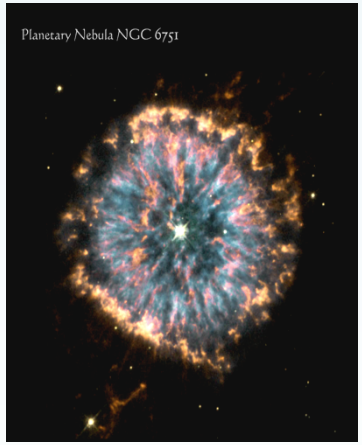
The XUV is dominated by continuum and lines





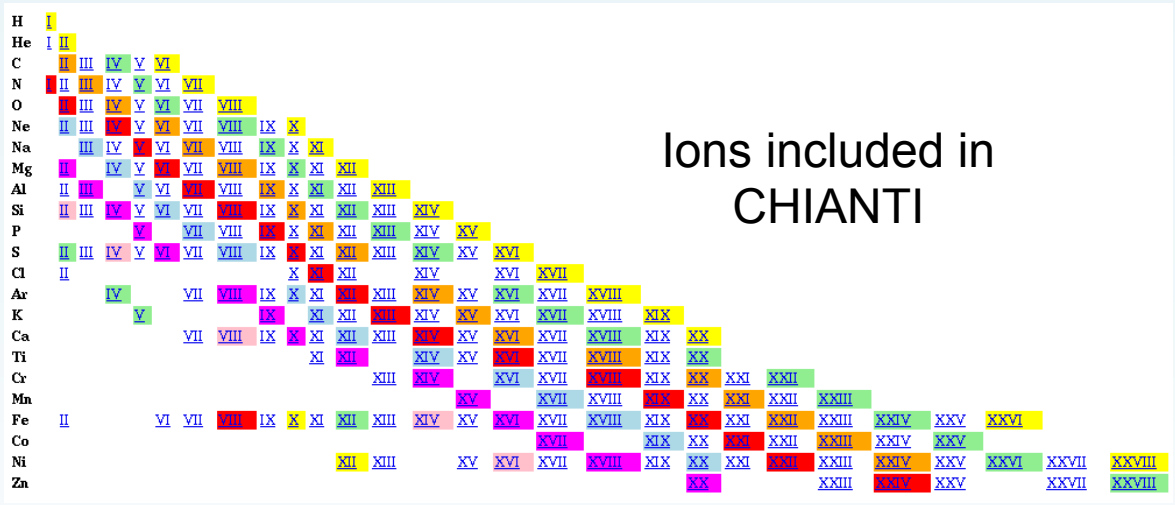


In most astrophysical plasma, lines are optically thin.

CHIANTI atomic package

CHIANTI provides all atomic data and IDL programs to model spectra from collisionally-ionised optically-thin plasmas. Over 3000 citations. Used widely.

Data, programs and user guides: www.chiantidatabase.org
CHIANTI Google user group
Active members: Dere, Young, Landi, Mason



Ions included in CHIANTI

Basic atomic data are included in many other databases and spectral codes. (VAMDC: see http://portal.vamdc.org/, XSTAR, CLOUDY, MOCASSIN, ATOMDB, XSPEC, ISIS, PINTofALE).

The assessment of the atomic data is published in a paper every about two years.

Spectral line intensities

In optically-thin plasmas line intensities are proportional to:

$$I \sim n_j \, A_{ji} = \frac{N_j(X^{+m})}{N(X^{+m})} \, A_{ji} \, \frac{N(X^{+m})}{N(X)} \, \frac{N(X)}{N(H)} \frac{N(H)}{N_e} \, N_e$$

A-value

Level population

(Ne,Te)

Taking into account all populating and de-populating processes

Ion abundances

Calculated in ionization equilibrium.

Elemental abundance

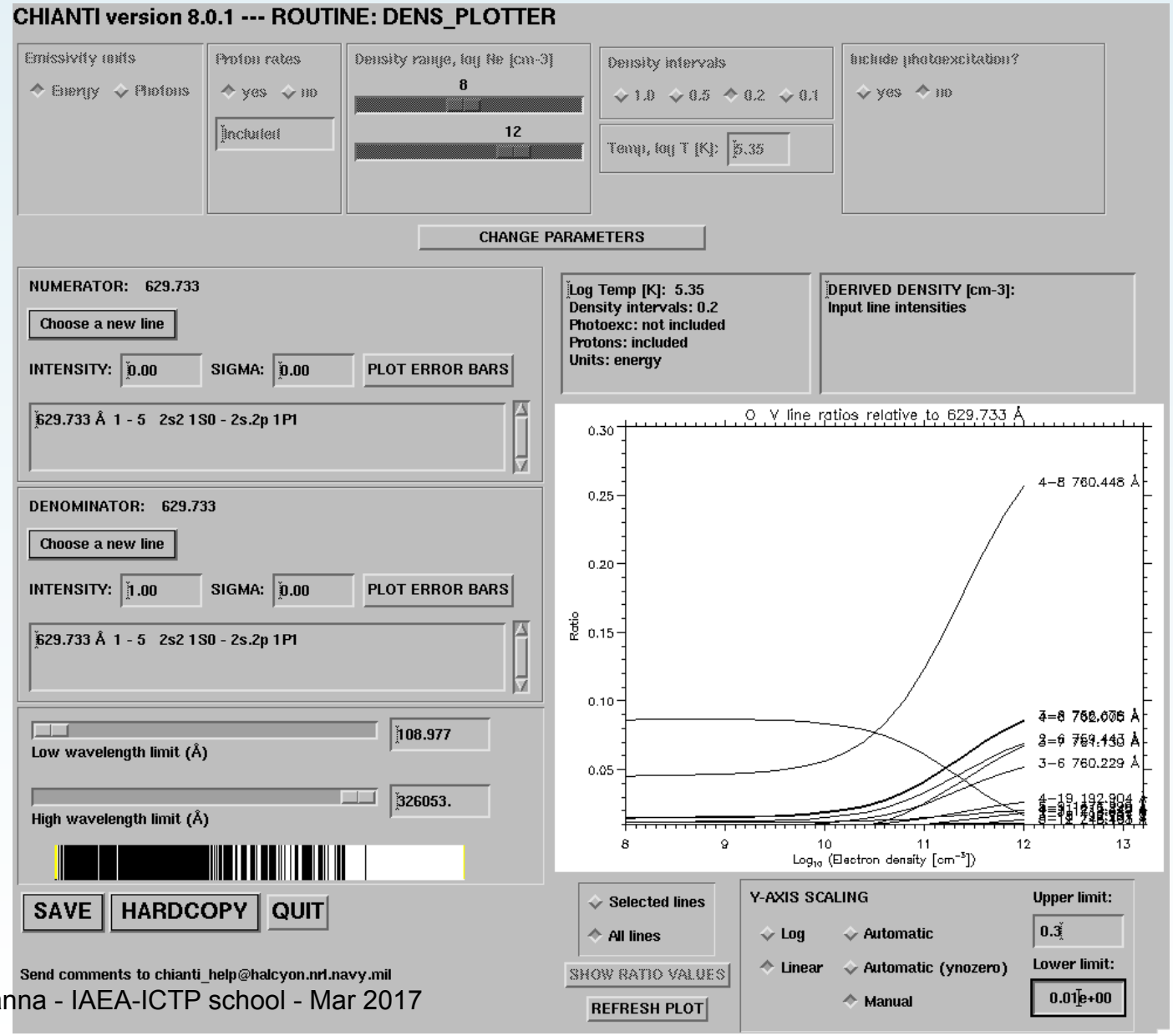
CHIANTI data (ascii)

fe_12.elvlc	Energy levels (theoretical, observed), LSJ for Fe XII (Fe^{11+})
fe_12.wgfa	Transition probabilities, gf values, theoretical, observed wavelengths
fe_12.splups	**Maxwellian-averaged e^- - ion collision strengths. V.8 format: .scups**
fe_12.psplus	Same but for protons.
.diparams .drparams .rrparams	DI, DR, RR total rates

- Experimental wavelengths are taken from NIST but are improved for most important astrophysical ions.
- To tailor for photoionized plasmas the format of the CHIANTI excitation data was changed in version 8 (Del Zanna+2015): actual rates (not fits), and excitations to all levels are included (useful for high-Ne plasma).
- Can include photo-excitation and non-Maxwellian electron distribution.
- Charge-state is calculated in low-density in equilibrium (at present).

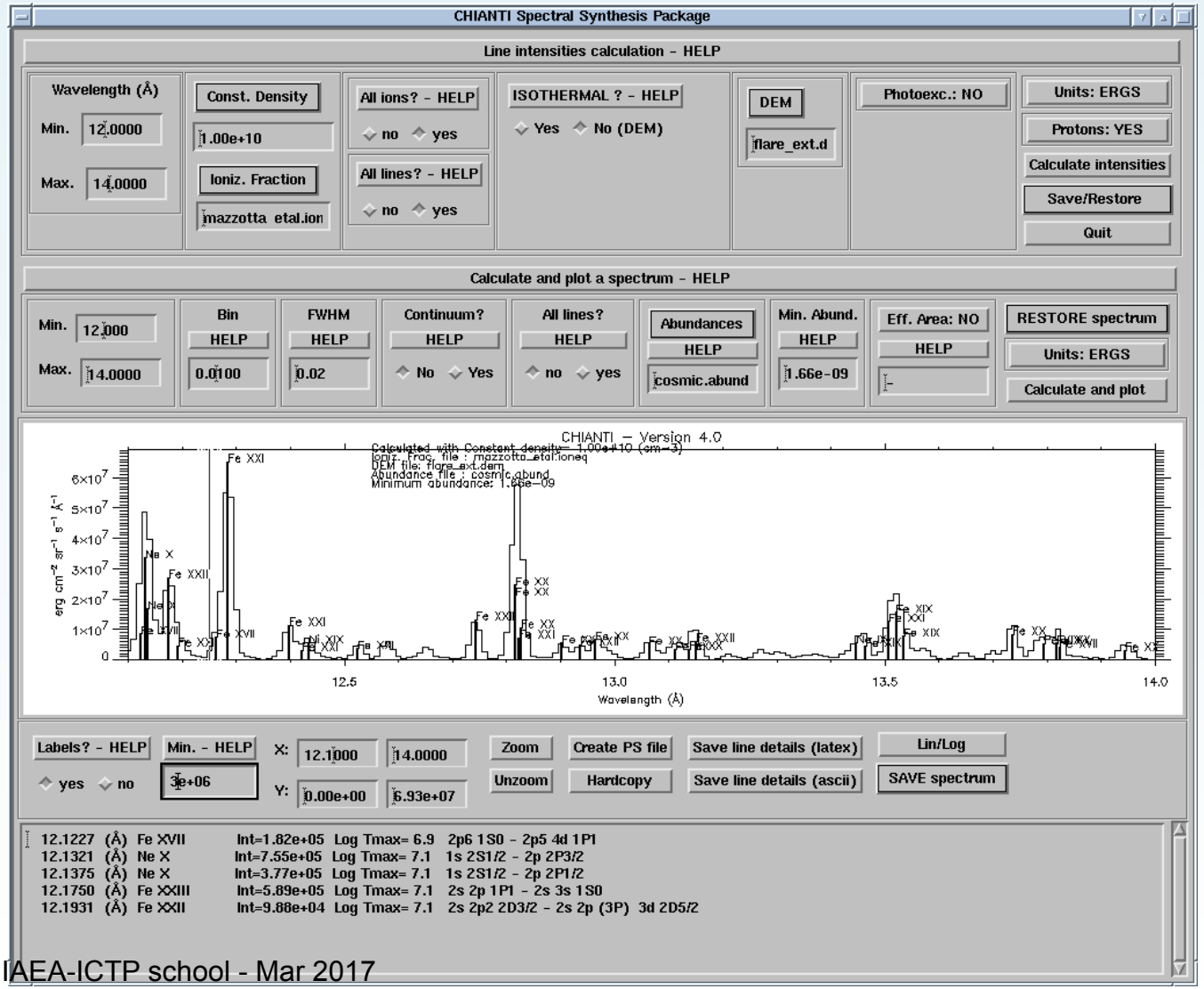
IDL GUI applications

How do I measure densities, temperatures from line ratios?

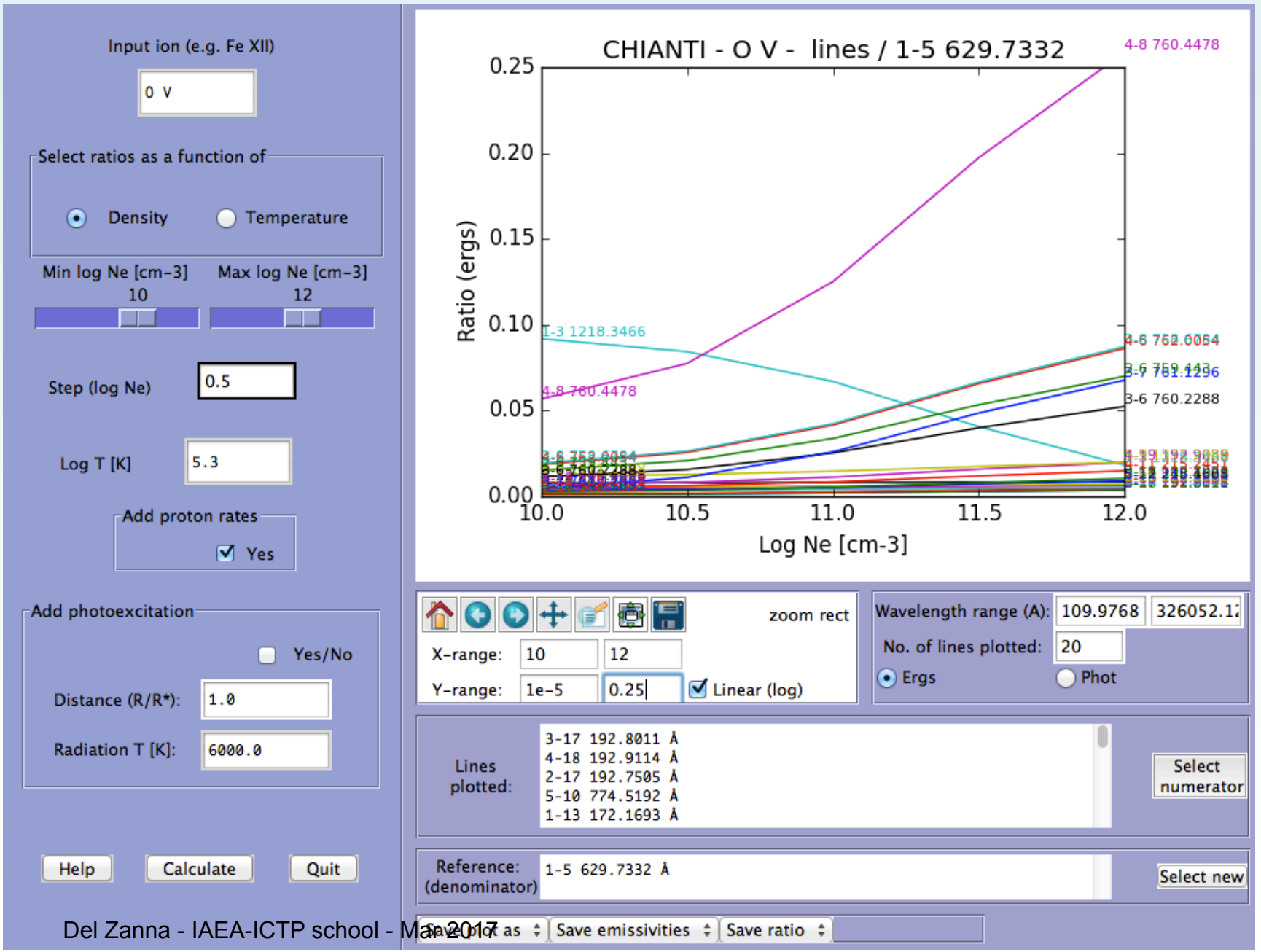


IDL GUI applications

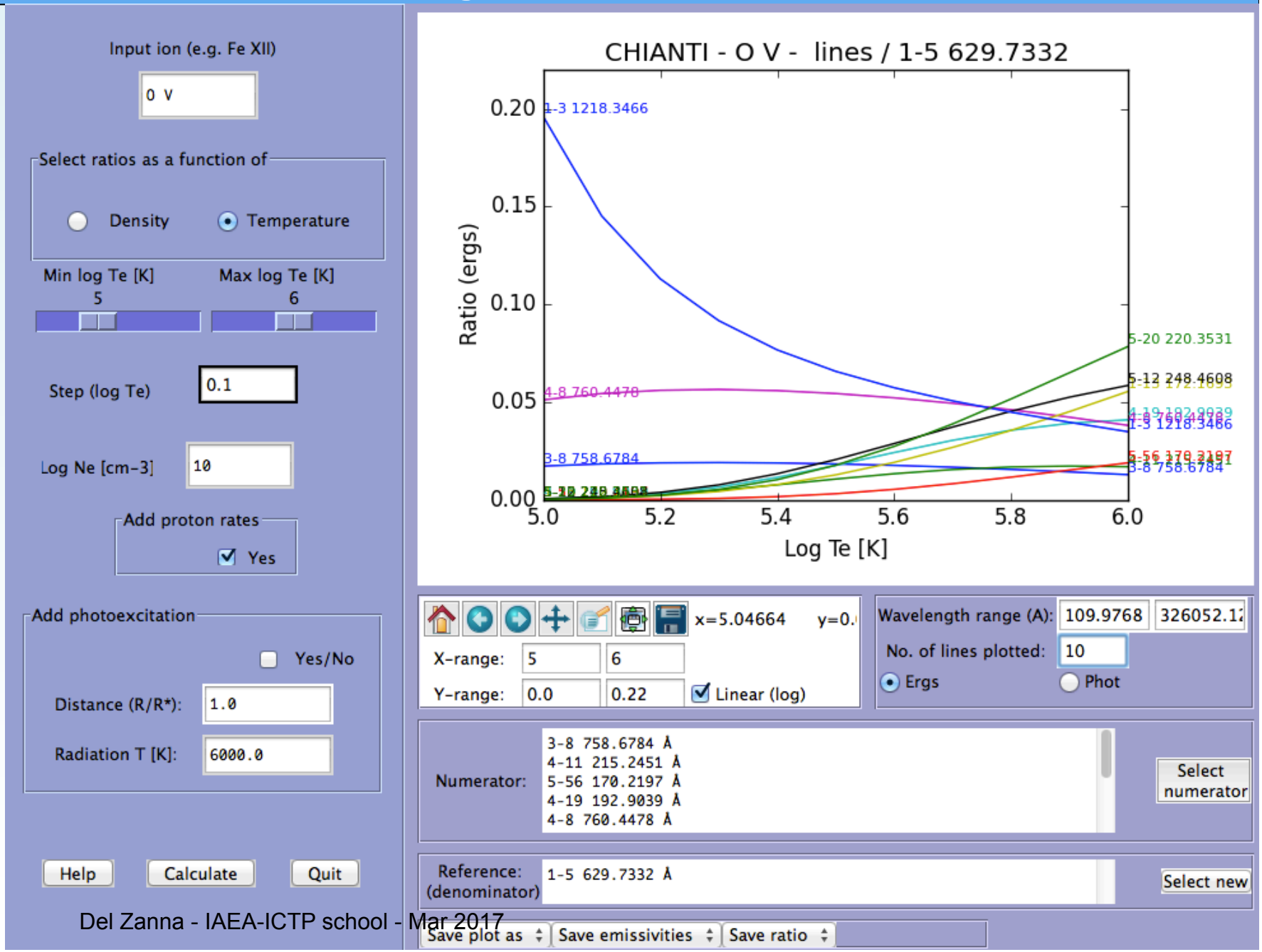
What is the spectrum in a wavelength band for specific densities, temperatures ?



Python GUI (soon available)



Python GUI


Input ion (e.g. Fe XII)
0 V
Select ratios as a function of
Density
Temperature
Min log Te [K]
5
Max log Te [K]
6
Step (log Te)
0.1
Log Ne [cm-3]
10
Add proton rates
Yes
Add photoexcitation
Yes/No
Distance (R/R*):
1.0
Radiation T [K]:
6000.0
Help
Calculate
Quit
CHIANTI - O V - lines / 1-5 629.7332
Ratio (ergs)
Log Te [K]
0.20
0.15
0.10
0.05
0.00
5.0
5.2
5.4
5.6
5.8
6.0
1-3 1218.3466
4-8 760.4478
3-8 758.6784
5-20 220.3531
5-12 248.4608
4-19 192.9039
5-56 170.2197
x=5.04664
X-range:
5
6
Y-range:
0.0
0.22
Linear (log)
Wavelength range (A):
109.9768
326052.1
No. of lines plotted:
10
Ergs
Phot
Numerator:
3-8 758.6784 Å
4-11 215.2451 Å
5-56 170.2197 Å
4-19 192.9039 Å
4-8 760.4478 Å
Select numerator
Reference: (denominator)
1-5 629.7332 Å
Select new
Save plot as
Save emissivities
Save ratio

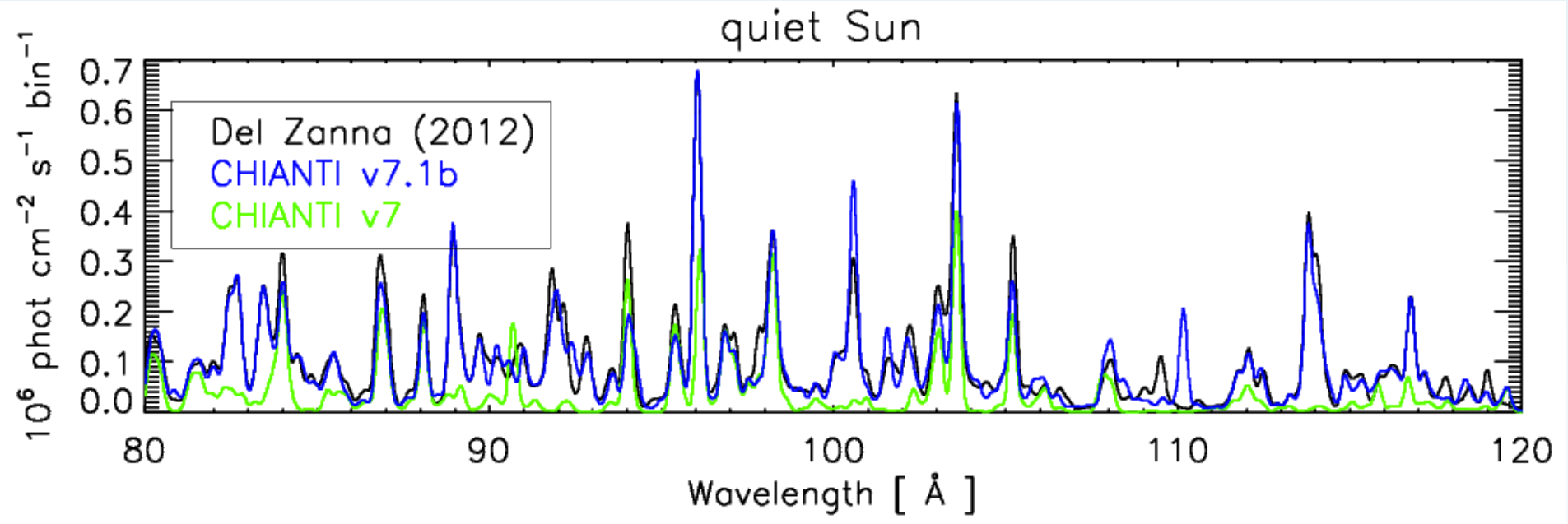
CHIANTI v.8 electron rates

Most of the e-ion collision rates from large-scale R-matrix calculations within the UK APAP network (www.apap-network.org).

We have been the main ion atomic data provider for fusion (e.g. ADAS, see http://open.adas.ac.uk/) and astrophysics.

- Neutrals: S I, N I, C I
- Low charge states: Fe III, S II, S III, Fe VI
- Coronal ions: large-scale calculations up to n=4,5: Fe VIII, IX, X, XI, XII, XIII, Ni XI, Ni XV (Del Zanna et al.)
- He-like (Whiteford et al. 2001)
- Li-like (Liang & Badnell 2011)
- B-like (Liang Badnell & Zhao 2012)
- Ne-like (Liang & Badnell 2010)
- Na-like (Liang, Whiteford & Badnell 2009a,2009b)
- F-like (Witthoeft, Whiteford, Badnell 2007)

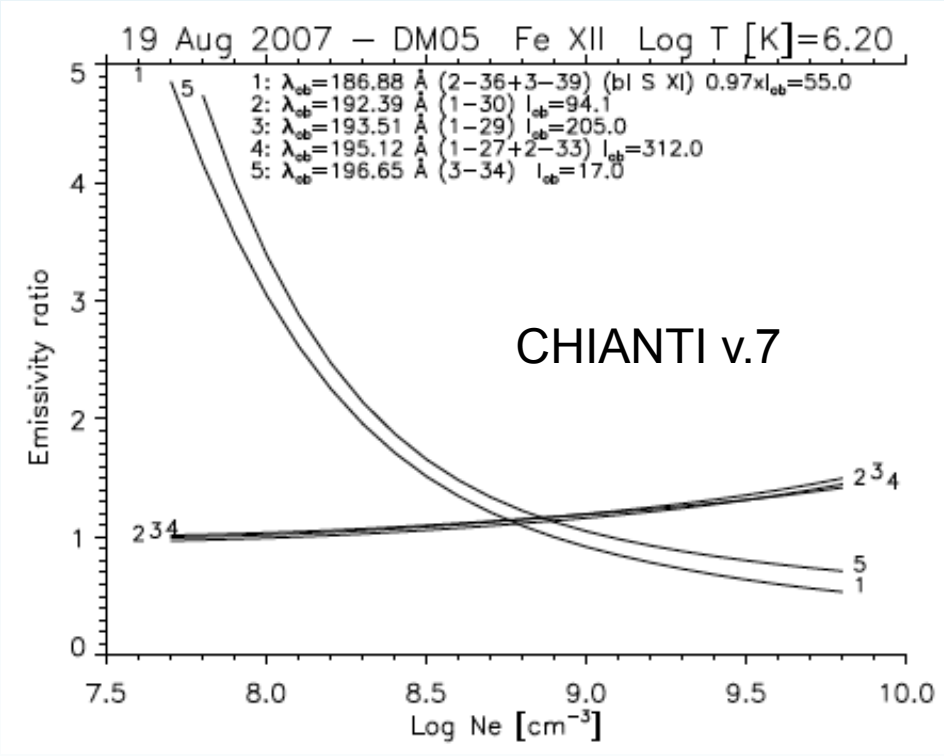
Fe updates have a major effect on Soft X-rays

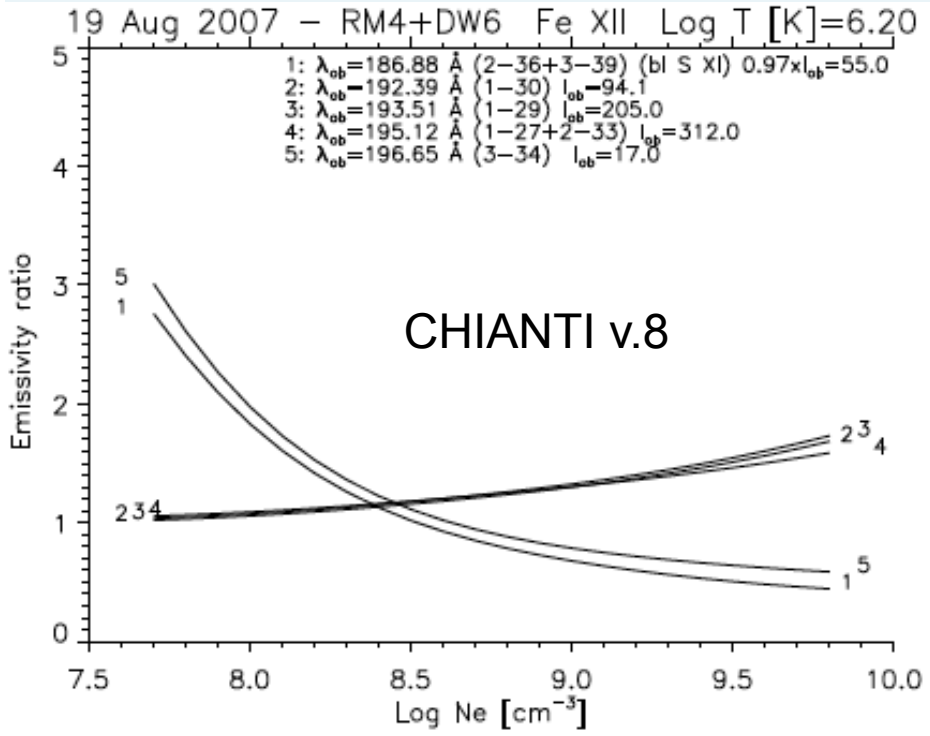


V.7: literature before 2012
V.7.1b: using DW scattering data from FAC
V.8 (Del Zanna): using R-matrix scattering data

Fe XII and Hinode EIS

The new Fe XII ion model reduces densities from EUV lines, resolving long-standing discrepancies.





Del Zanna+(2012)