Working with excited population structure

- Datasets of class ADF04 contain all the information necessary to evaluate excited populations of an ion. It is called a ‘specific ion file’.
- Code ADAS205 computes the populations at temperatures and densities of your choice.
- The input, data set selection, screen is very similar to that for ADAS201

Populations calculation (contd.)

Distinguish metastable levels X_{ρ}^{+z} indexed by Greek letters

and ordinary levels X_{i}^{+z} indexed by Roman letters

Write the quasi-static equations for the ordinary levels populations in terms of the metastable populations as:

$$\sum_{j=1}^{O} C_{ij} N_j = -\sum_{\sigma=1}^{M} C_{i\sigma} N_\sigma + N_e N_1^+ r_i + N_e N_H q_i^{(CX)} \qquad i = 1, 2, ..$$

$$C_{ij} = -A_{j\to i} - N_e q_{j\to i}^{(e)} - N_p q_{j\to i}^{(p)} \qquad i \neq j$$

$$C_{ii} = \sum_{j<i} A_{i\to j} + N_e \sum_{j\neq i} q_{i\to j}^{(e)} + N_p \sum_{j\neq i} q_{i\to j}^{(p)} + N_e q_i^{(I)}$$

Populations calculation (contd.)

Solution for the ordinary populations is

$$N_j = -\sum_{i=1}^{O} C_{ji}^{-1} \sum_{\sigma=1}^{M} C_{i\sigma} N_\sigma + \sum_{i=1}^{O} C_{ji}^{-1} r_i N_e N_1^+$$

$$+ \sum_{i=1}^{O} C_{ji}^{-1} q_i^{(CX)} N_H N_1^+$$

$$\equiv \sum_{\sigma=1}^{M} \mathscr{T}_{j\sigma}^{(exc)} N_e N_\sigma + \mathscr{T}_{j1}^{(rec)} N_e N_1^+ + \mathscr{T}_{j1}^{(CX)} N_H N_1^+$$

Populations calculation (contd.)

Spectrum line emissivities are

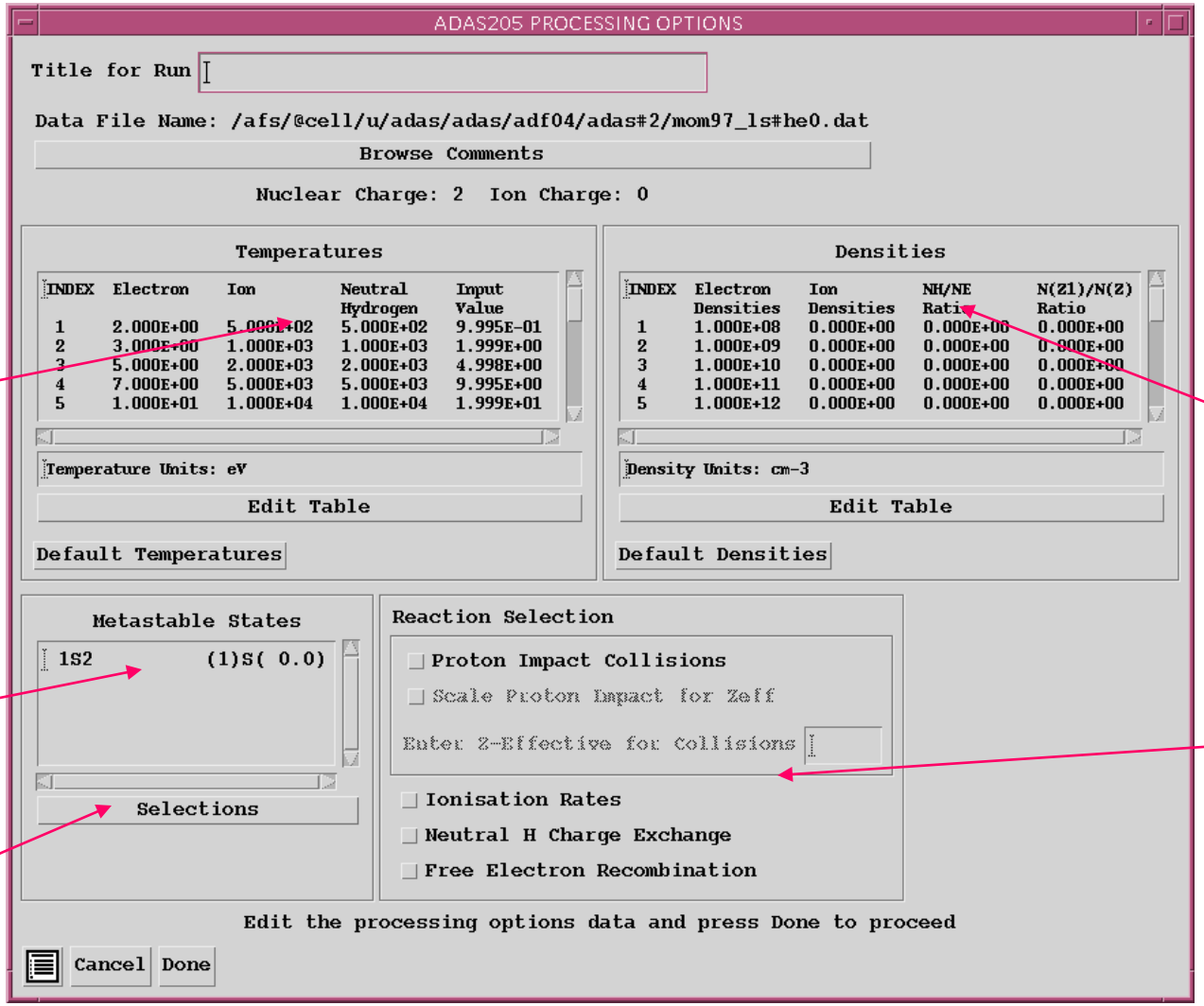
$$\varepsilon_{j\to k} = A_{j\to k}\Big(\sum_{\sigma=1}^{M} \mathscr{F}_{j\sigma}^{(exc)} N_e N_\sigma + \sum_{\upsilon'=1}^{M_{z+1}} \mathscr{F}_{j\upsilon'}^{(rec)} N_e N_{\upsilon'}^{+} + \sum_{\upsilon'=1}^{M_{z+1}} \mathscr{F}_{j\upsilon'}^{(CX)} N_H N_{\upsilon'}^{+} + \sum_{\mu'=1}^{M_{z-1}} \mathscr{F}_{j\mu'}^{(ion)} N_e N_{\mu'}^{-}\Big)$$

Identify excitation and recombination photon emissivity coefficients as

$$\boxed{\mathscr{PEC}_{\sigma,j\to k}^{(exc)} = A_{j\to k}\mathscr{F}_{j\sigma}^{(exc)}}$$

$$\mathscr{PEC}_{\upsilon',j\to k}^{(rec)} = A_{j\to k}\mathscr{F}_{j\upsilon'}^{(rec)}$$

ADAS205 processing



Te grid specification

Ne grid specification

Designated metastables

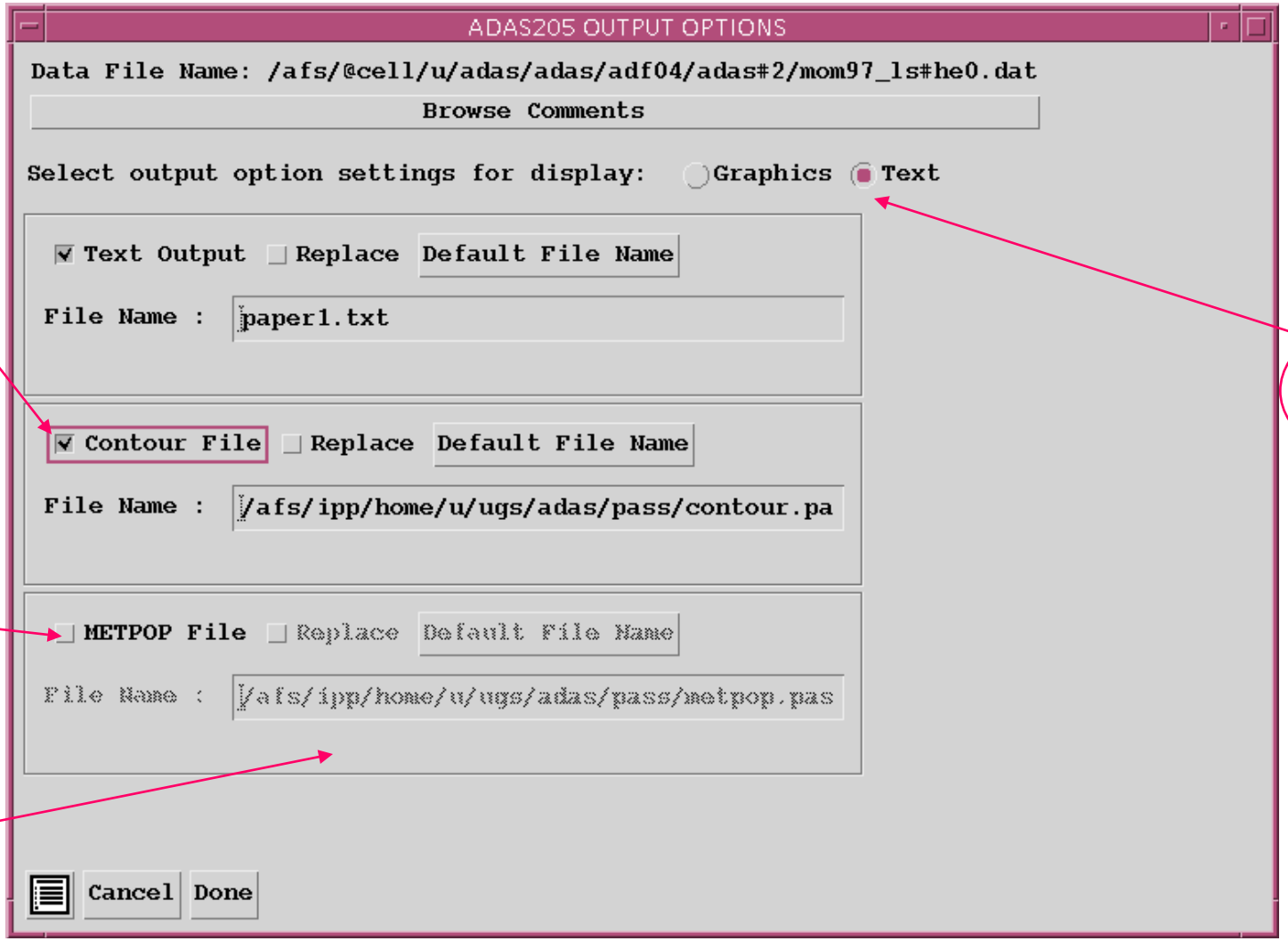
advanced process control

activate to select metastables

Populations and line ratio studies (contd.)

- Output options
  - » Graphical display of the $\mathscr{F}_{j\sigma}^{(exc)}$ as a function of density is allowed.
  - » An output file of the $\mathscr{F}_{j\sigma}^{(exc)}$, called the ‘contour’ pass file, can be generated. This file must be created to allow the next step of looking a line ratios.

ADAS205 output - text



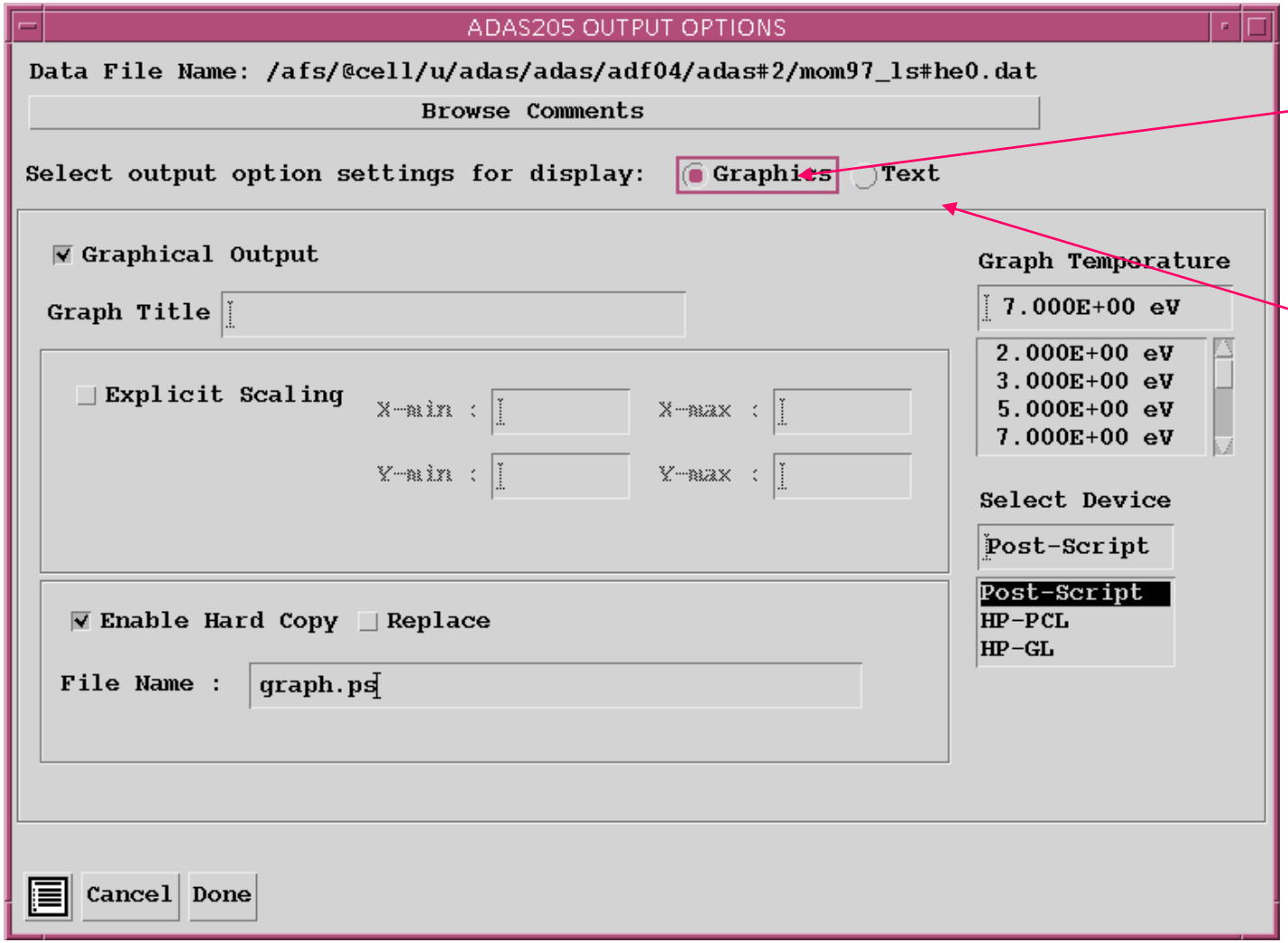
output file required for ratio studies

ADF11 class selected

graph of results

show text output choices

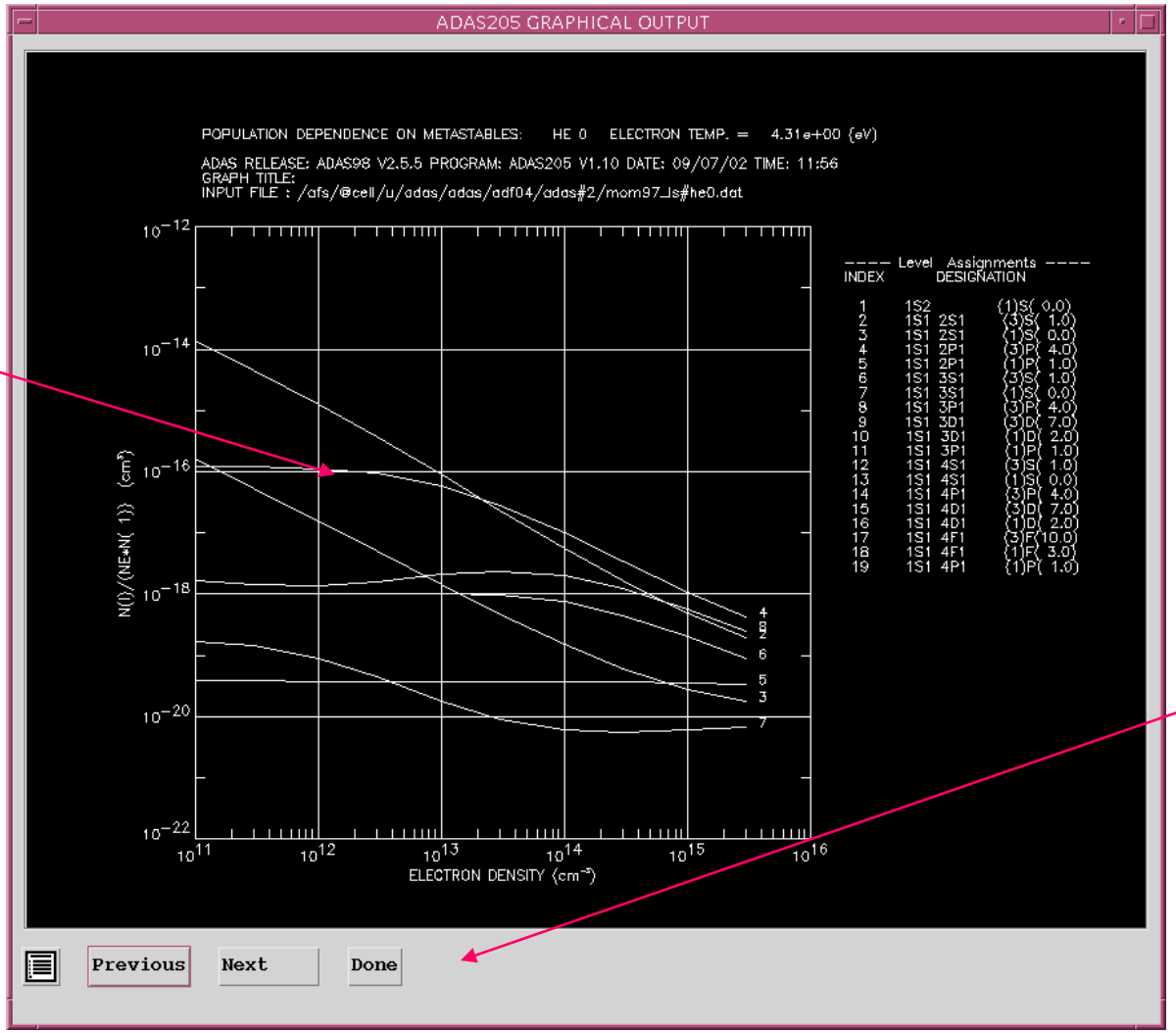
ADAS205 output - graphics



show graphic output choices

graphs may be shown at one Te only

ADAS205 graph



excited population graph

Print button is present if graphic file chosen

Setting up lines

- Code ADAS207 is the diagnostic analysis program which allows study of line ratios.

- It needs the ‘contour’ pass file of populations. It also fetches the specific ion file, of type ADF04, which was used in the population calculation.

Setting up lines (contd.)

The program in deals with two line assemblies which from the numerator and denominator of the line ratio.

The composite emissivity for a line assembly is written as

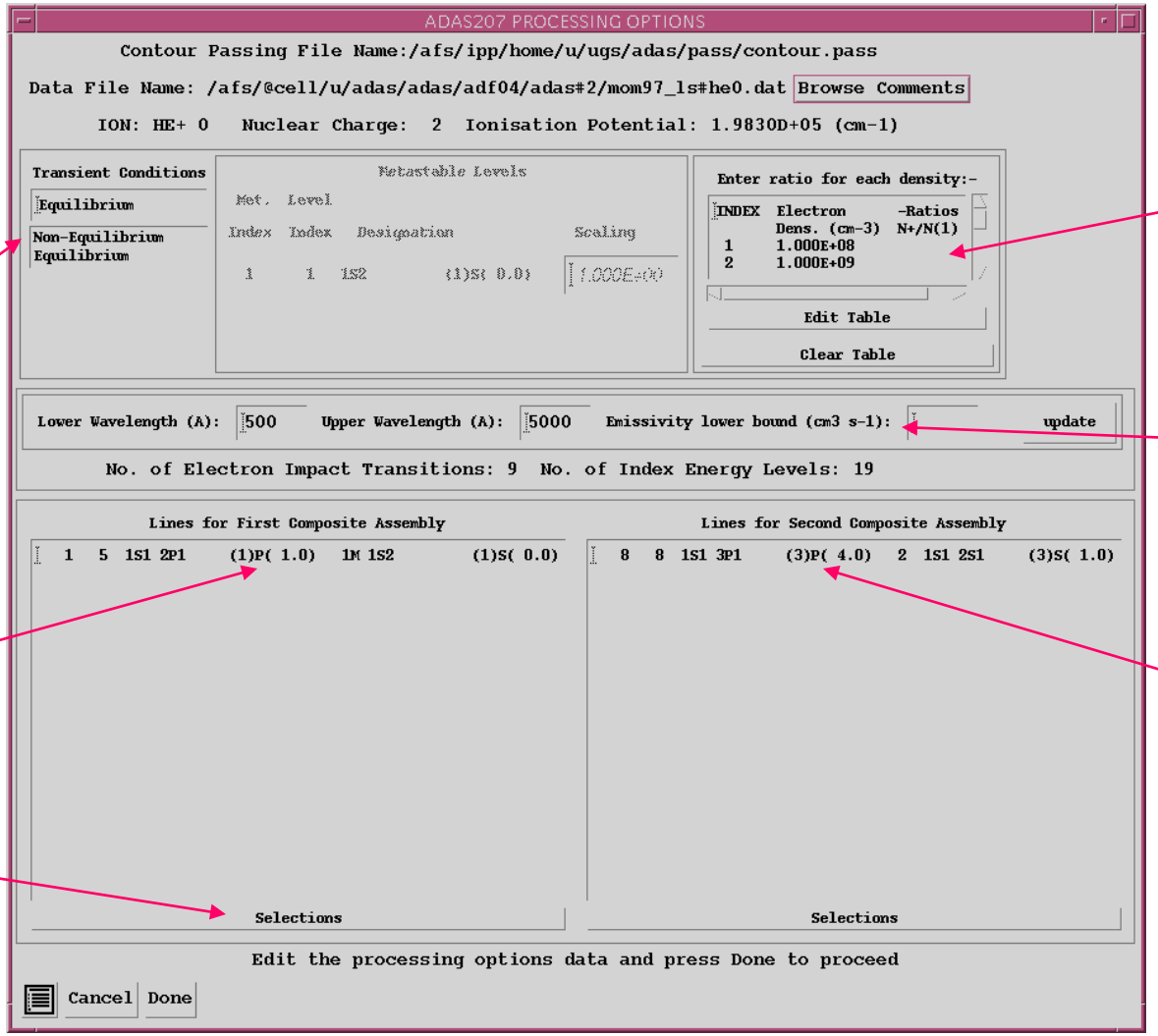
$$\varepsilon_G = \sum_{j\in J_G, i\in I_G} \varepsilon_{j\to i} = \sum_{j\in J_G, i\in I_G} A_{j\to i} N_j$$

$$= \sum_{j\in J_G, i\in I_G} A_{j\to i} \left(\sum_{\sigma=1}^{M} \mathcal{F}_{j\sigma}^{(exc)} N_e N_\sigma + \mathcal{F}_{j1}^{(rec)} N_e N_1^+ + \mathcal{F}_{j1}^{(CX)} N_H N_1^+\right)$$

$$= N_e N_1 \sum_{j\in J_G, i\in I_G} A_{j\to i} \left(\sum_{\sigma=1}^{M} \mathcal{F}_{j\sigma}^{(exc)} \frac{N_\sigma}{N_1} + \mathcal{F}_{j1}^{(rec)} \frac{N_1^+}{N_1} + \mathcal{F}_{j1}^{(CX)} \frac{N_H}{N_e} \frac{N_1^+}{N_1}\right)$$

Diagnostic line ratio modelling deals with $\varepsilon_{G_1} / \varepsilon_{G_2}$

ADAS207 processing



advanced use with metastables

advanced use for recombination

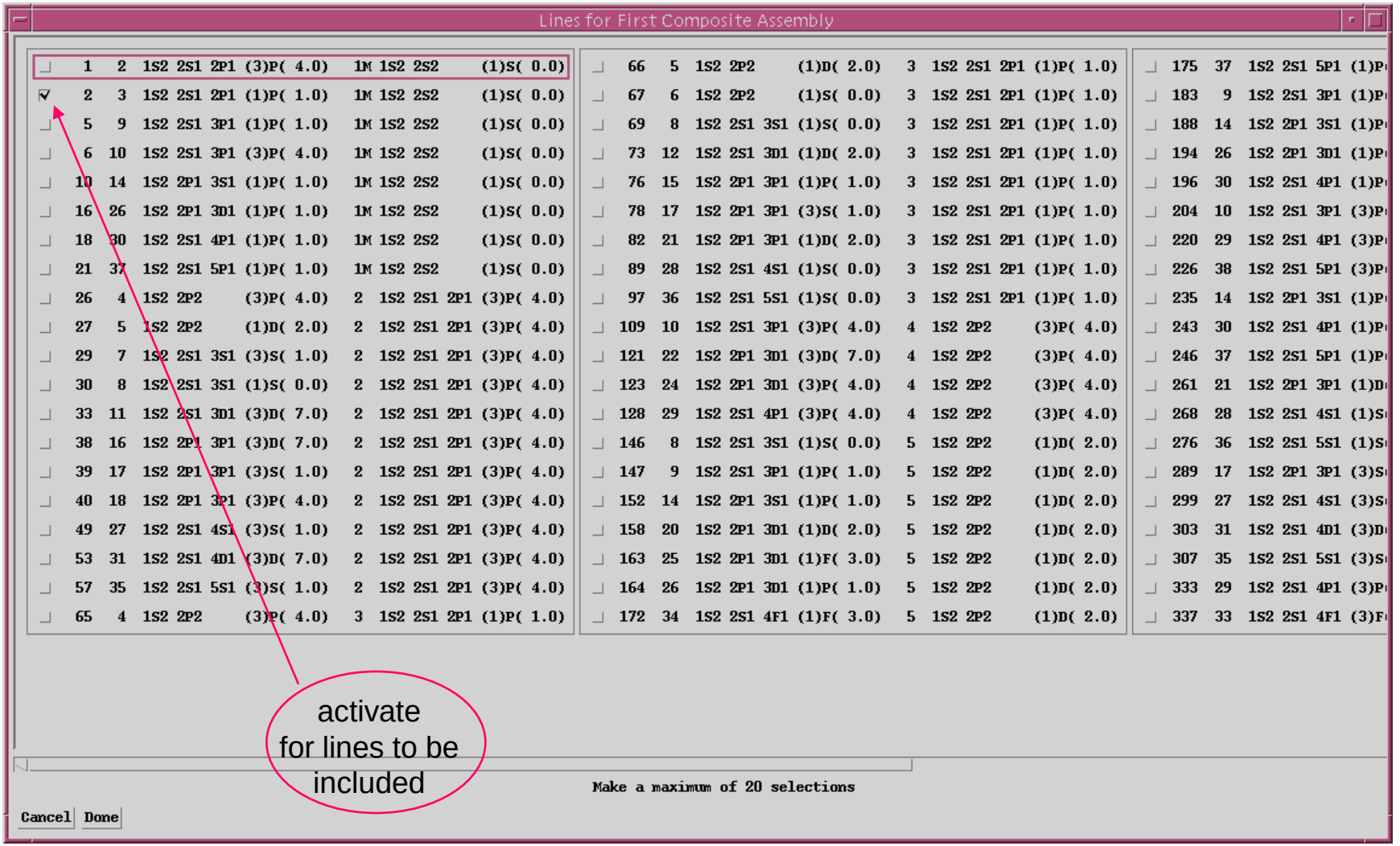
restrict the choice of lines

lines in numerator of ratio

lines in denominator of ratio

show line selection list

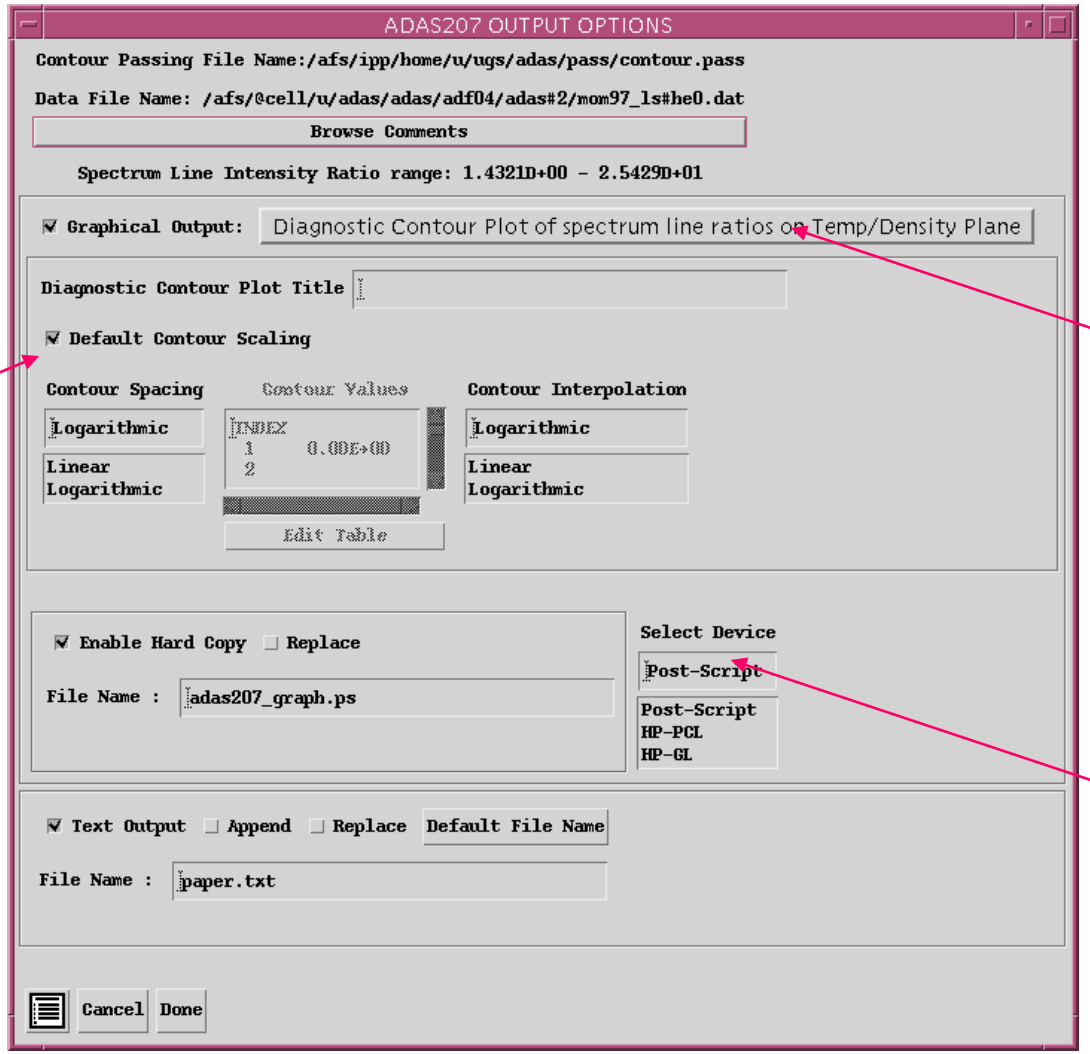
ADAS207 line assembly



Displaying line ratios

- Output options
  - » The type of display of the ratio of line assemblies may be chosen.
  - » The contour form on the Te/Ne plane seems to be the favourite.
  - » Crosses on the graph mark the tabular points at which the populations were explicitly evaluated.
  - » The extensive range of controls on the plot scales and contour lines should be used to refine the diagnostic plot.

ADAS207 output

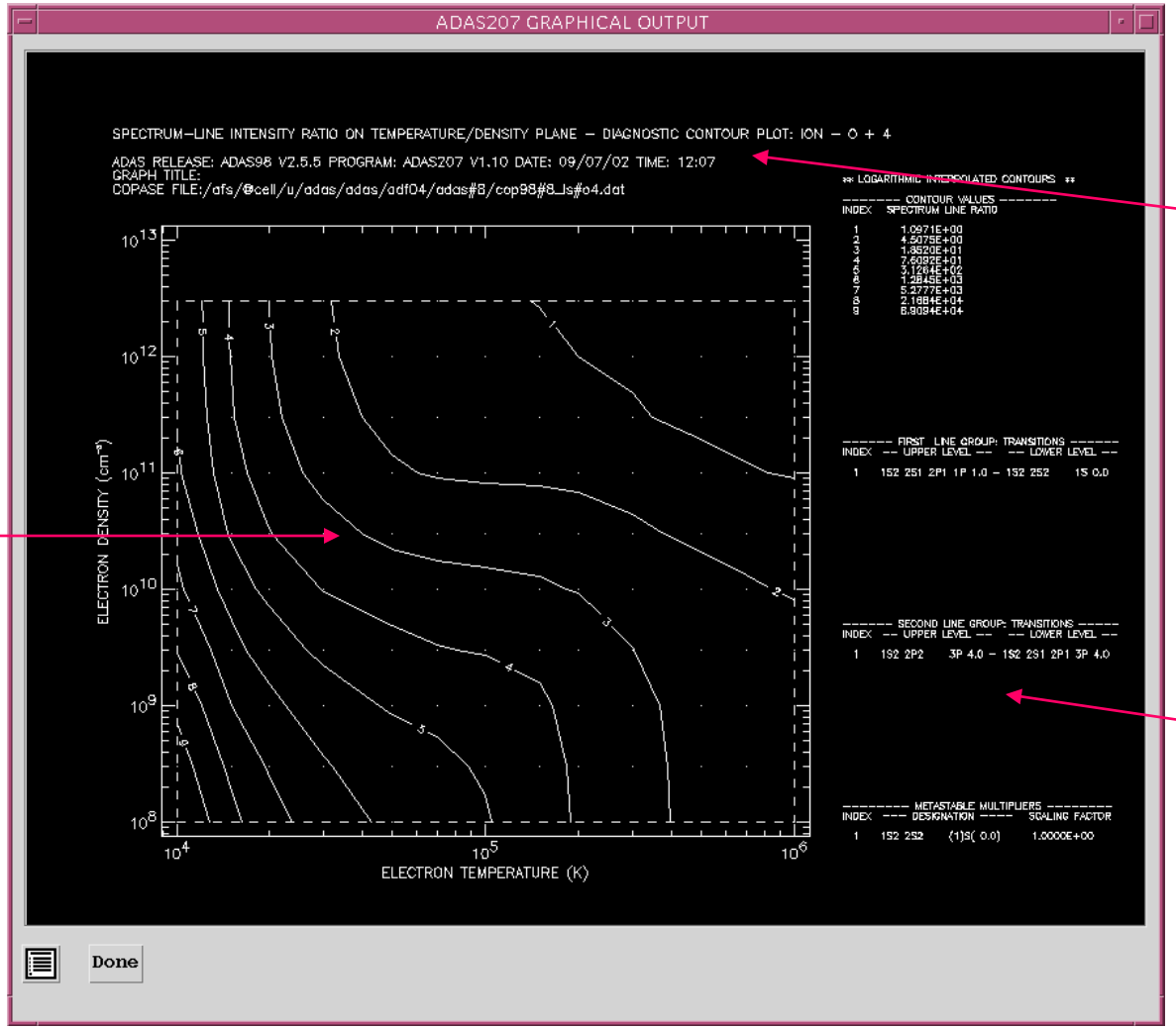


controls on contour plotting

select type of plot

usual graph and text output choices

ADAS207 graph



unique record of case studied

final line ratio contours

details of graph presented