

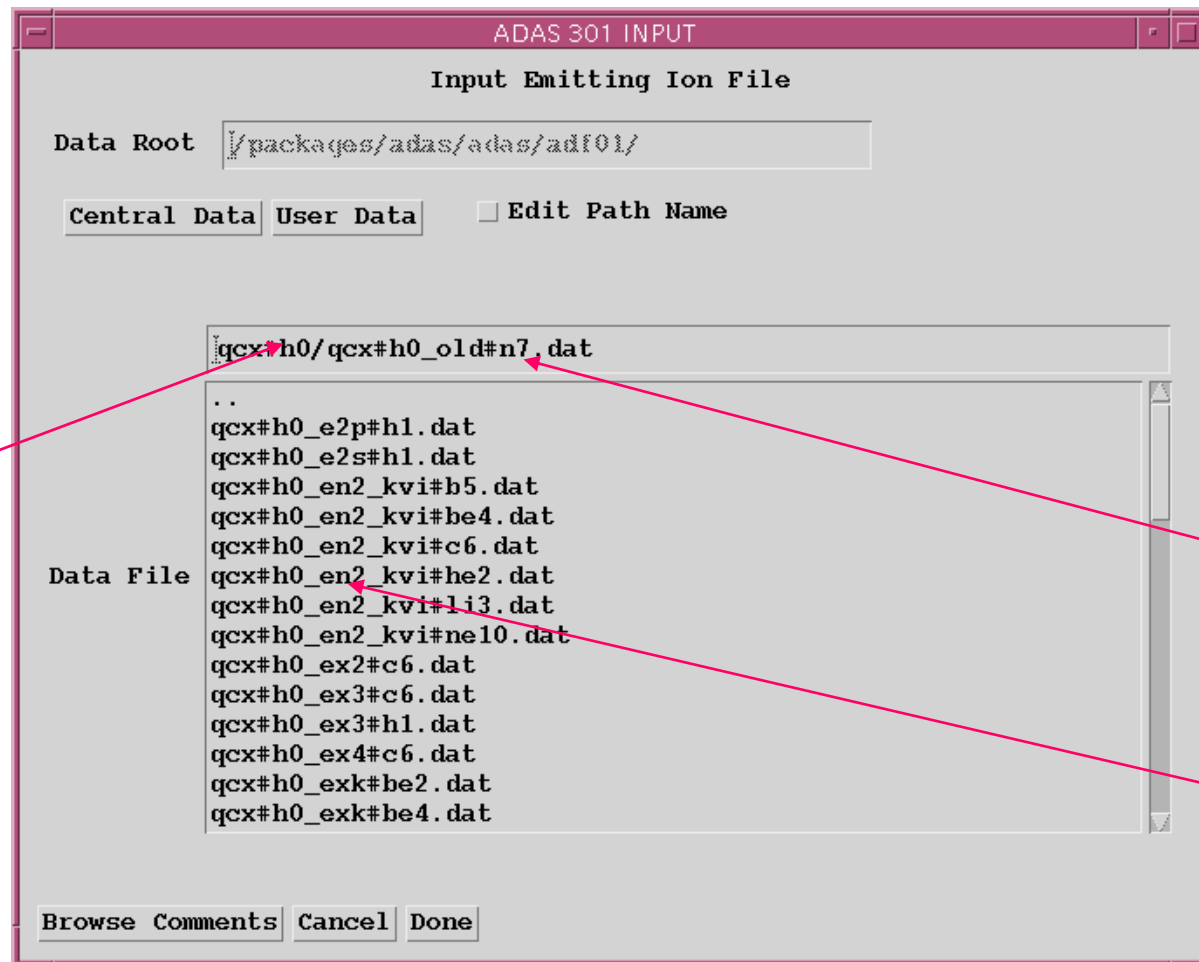
4a. Charge exchange spectroscopy

- Interrogating state selective charge exchange cross-sections using ADAS301.
- Interrogating CXS effective emission coefficients using ADAS303.
- Calculating and examining effective emission coefficients using ADAS308.

Interrogating charge exchange cross-sections

- Datasets of class ADF01 contain state selective charge exchange xsect. (qcx) data as a function of energy.
- These data for bare nucleus light impurity receivers into nl-shells in general.
- The donors may be H, He or Li and can include donation from ground state and excited state. There are separate data sets for each excited donor state.
- Code ADAS301 interrogates ADF01 data sets and displays results at energies of your choice.

ADAS301 input



Hydrogen donor data

N bare nucleus receiver

excited donors

ADAS302 Processing

ADAS301 PROCESSING OPTIONS

Title for Run

Data File Name:

Polynomial Fitting

Fit Polynomial value % :

Select Velocities/Energies for output file

Select quantum numbers for processing

Output Collision Velocities/Energies

INDEX	Output	Input
1	1.000E+03	1.000E+03
2	1.500E+03	1.500E+03
3	2.000E+03	2.000E+03
4	3.000E+03	3.000E+03
5	5.000E+03	5.000E+03

Quantum Numbers

	Range:	Total:
Principal quantum no. N	(4 - 9)	[7] [0]
Orbital quantum no. L	(0 - N-1)	[3] [-1]
Azimuthal quantum no. M	(0 - L)	[0] [-1]

Data is N and L resolved.

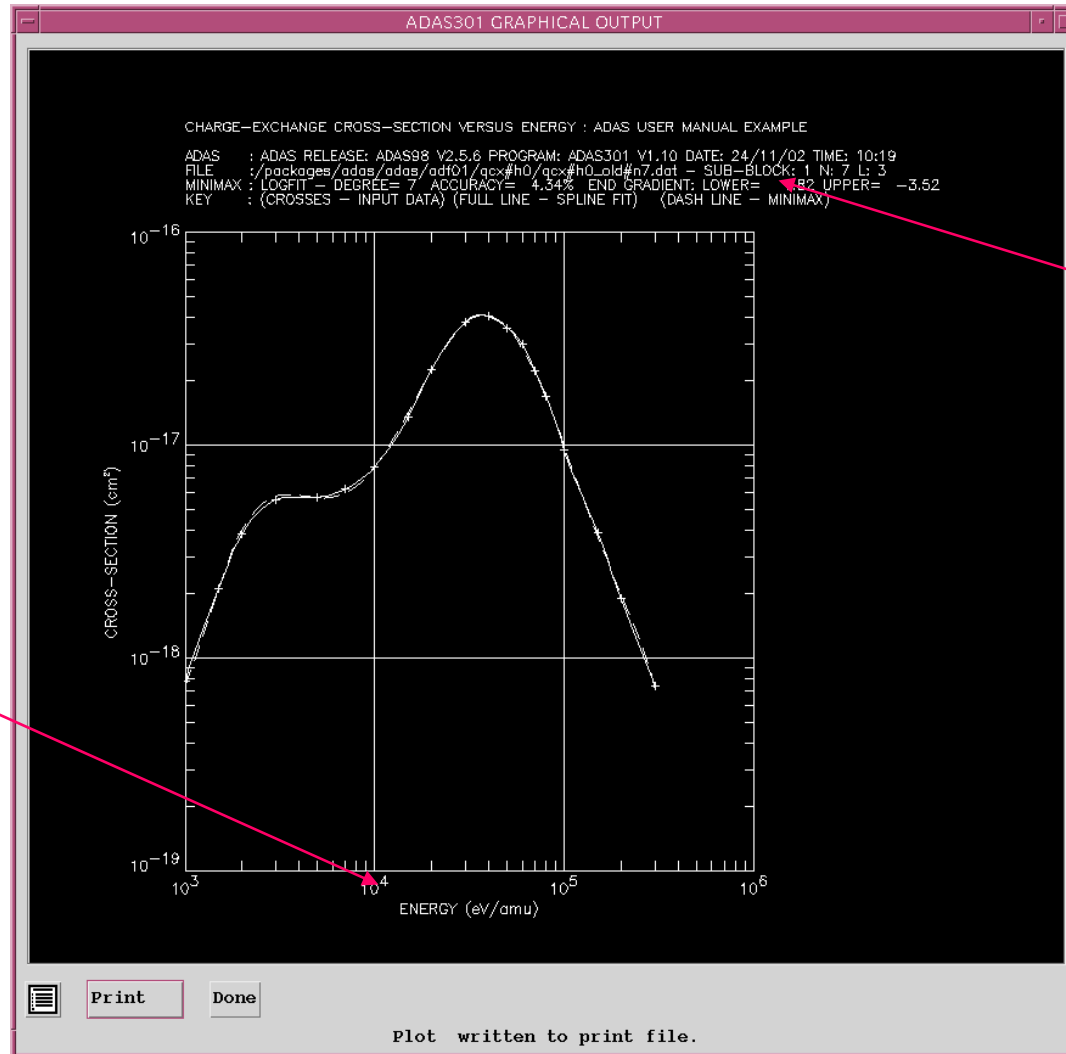
Edit the processing options data and press Done to proceed

Polynomial fit

select partial xsect

Specify energies & units

ADAS301 graph



graph is a function of energy

specification of extracted xsect.

Interrogating CXS effective emission coefficients

- Datasets of class ADF12 contain CXS effective emission (q_{ef}) data as a function of beam and plasma parameters.
- These coefficients include the effect of collisional redistribution of n -substate populations of the receiver ion in the plasma.
- The individual components of the $n \rightarrow n'$ CX transition are not resolvable for bare nucleus receivers so only whole transition arrays are given.
- Code ADAS303 interrogates ADF12 data sets and displays results at beam and plasma conditions of your choice.

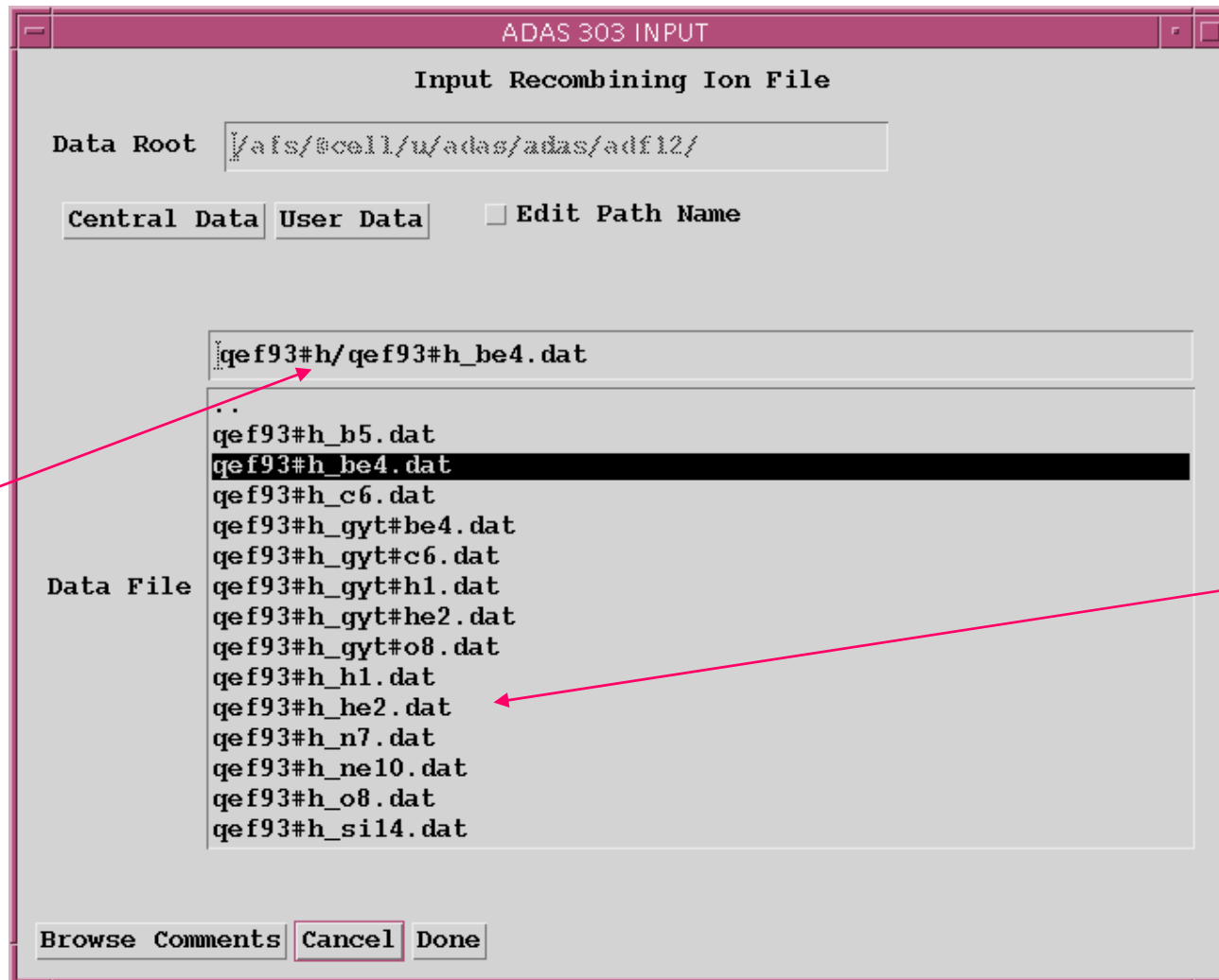
ADF12 charge exchange cross-sections

The diagram illustrates the structure of the ADF12 charge exchange cross-sections table. Red callout boxes identify key components: 'reference rate coefft' points to the first column; 'receiver' points to the second column; 'transition' points to the third column; 'reference parameter values' points to the rightmost columns (ISEL=8, QEFREF, PARMREF, NPARMSC, ENER); '1-D scans from ref.' points to the columns of numerical values; and 'energy scan' points to the QENER column.

reference rate coefft	receiver	transition	reference parameter values				energy scan								
33	SPSCLMS	ON	HE+2	6-4	H(1S)	DONOR	10/7/90	HE2NEW1(4)	LMS	ISEL=8	QEFREF	PARMREF	NPARMSC	ENER	QENER
5.52D-10	4.00D+04	5.00D+03	2.50D+13	2.00D+00	3.00D+00	19	12	17	6	1	7.00D+03	5.00D+04	2.00D+05	0.00D+00	1.62D-11
1.00D+03	1.50D+03	2.00D+03	3.00D+03	5.50D+03	7.00D+03	1.00D+04	1.50D+04	2.00D+04	3.00D+04	4.00D+04	5.00D+04	6.00D+04	7.00D+04	8.00D+04	1.00D+05
1.00D+04	1.50D+04	2.00D+04	3.00D+04	4.00D+04	5.00D+04	6.00D+04	7.00D+04	8.00D+04	1.00D+05	1.50D+05	2.00D+05	3.00D+05	0.00D+00	0.00D+00	0.00D+00
1.67D-13	1.07D-12	2.51D-12	5.02D-12	1.07D-11	1.62D-11	3.20D-11	7.65D-11	1.65D-10	5.06D-10	6.52D-10	5.82D-10	4.65D-10	3.54D-10	2.58D-10	1.40D-10
3.20D-11	7.65D-11	1.65D-10	5.06D-10	6.52D-10	5.82D-10	4.65D-10	3.54D-10	2.58D-10	1.40D-10	3.78D-11	1.25D-11	2.23D-12	0.00D+00	0.00D+00	0.00D+00
4.65D-10	3.54D-10	2.58D-10	1.40D-10	3.78D-11	1.25D-11	2.23D-12	0.00D+00	0.00D+00	0.00D+00	0.00D+00	0.00D+00	1.00D+03	2.00D+03	3.00D+03	5.00D+03
1.00D+03	2.00D+03	3.00D+03	5.00D+03	7.00D+03	1.00D+04	1.30D+04	1.60D+04	1.90D+04	2.20D+04	2.50D+04	3.00D+04	6.53D-10	6.53D-10	6.52D-10	6.52D-10
6.53D-10	6.53D-10	6.52D-10	6.52D-10	6.52D-10	6.52D-10	6.51D-10	6.51D-10	6.51D-10	6.51D-10	6.51D-10	6.51D-10	3.00D+00	0.00D+00	0.00D+00	0.00D+00
6.51D-10	6.51D-10	6.51D-10	6.51D-10	6.51D-10	6.51D-10	3.00D+00	0.00D+00	0.00D+00	0.00D+00	0.00D+00	0.00D+00	0.00D+00	0.00D+00	0.00D+00	0.00D+00
3.00D+00	0.00D+00	0.00D+00	0.00D+00	0.00D+00	0.00D+00	0.00D+00	0.00D+00	0.00D+00	0.00D+00	0.00D+00	0.00D+00	0.00D+00	0.00D+00	0.00D+00	0.00D+00
0.00D+00	0.00D+00	0.00D+00	0.00D+00	0.00D+00	0.00D+00	6.52D-10	0.00D+00	0.00D+00	0.00D+00	0.00D+00	0.00D+00	6.52D-10	0.00D+00	0.00D+00	0.00D+00
6.52D-10	0.00D+00	0.00D+00	0.00D+00	0.00D+00	0.00D+00	0.00D+00	0.00D+00	0.00D+00	0.00D+00	0.00D+00	0.00D+00	0.00D+00	0.00D+00	0.00D+00	0.00D+00
0.00D+00	0.00D+00	0.00D+00	0.00D+00	0.00D+00	0.00D+00	0.00D+00	0.00D+00	0.00D+00	0.00D+00	0.00D+00	0.00D+00	0.00D+00	0.00D+00	0.00D+00	0.00D+00

C EFFECTIVE COEFFICIENT LIST:															
C															
C															
C ISEL TYPE ION INFORMATION															
C ----															
C															
C 8. CX.EMIS. HE+ 1 N = 6 - 4 6559.4 10/7/90 J2460															
C															

ADAS303 input



ADAS303 Processing

ADAS303 PROCESSING OPTIONS

Title for Run []

Data File Name: /afs/@cell/u/adas/adas/adf12/qef93#h/qef93#h_be4.dat

Browse Comments

Polynomial Fitting

Fit Polynomial value % : 5

Select data Block

INDEX N - N'	Transition	Donor	Receiver	QCX File Source	Processing Code	Emission Type
3	5-4	H(1S)	BE+4	OLD#BE4	ADAS309	CX
2	4-3	H(1S)	BE+4	OLD#BE4	ADAS309	CX
3	5-4	H(1S)	BE+4	OLD#BE4	ADAS309	CX
4	6-5	H(1S)	BE+4	OLD#BE4	ADAS309	CX
5	7-6	H(1S)	BE+4	OLD#BE4	ADAS309	CX

Neutral Beam Donor Energy Values

INDEX	Output	Input
1	1.000E+03	1.000E+03
2	1.500E+03	1.500E+03
3	2.000E+03	2.000E+03
4	3.000E+03	3.000E+03

Energy/Velocity Units: eV/amu

Edit Table

Default Energy/Velocitly Values

Select supplementary plasma parameters

	Output Value:	Reference Value:	--- Scan Range --- Minimum Maximum	
Ion Density (cm ⁻³)	2.500E+13	2.500E+13	1.000E+11	1.000E+14
Ion Temperature (eV)	5.000E+03	5.000E+03	1.000E+03	3.000E+04
Z Effective	2.000E+00	2.000E+00	1.000E+00	6.000E+00
B Magnetic (T)	3.000E+00	3.000E+00	3.000E+00	3.000E+00

Cancel Done

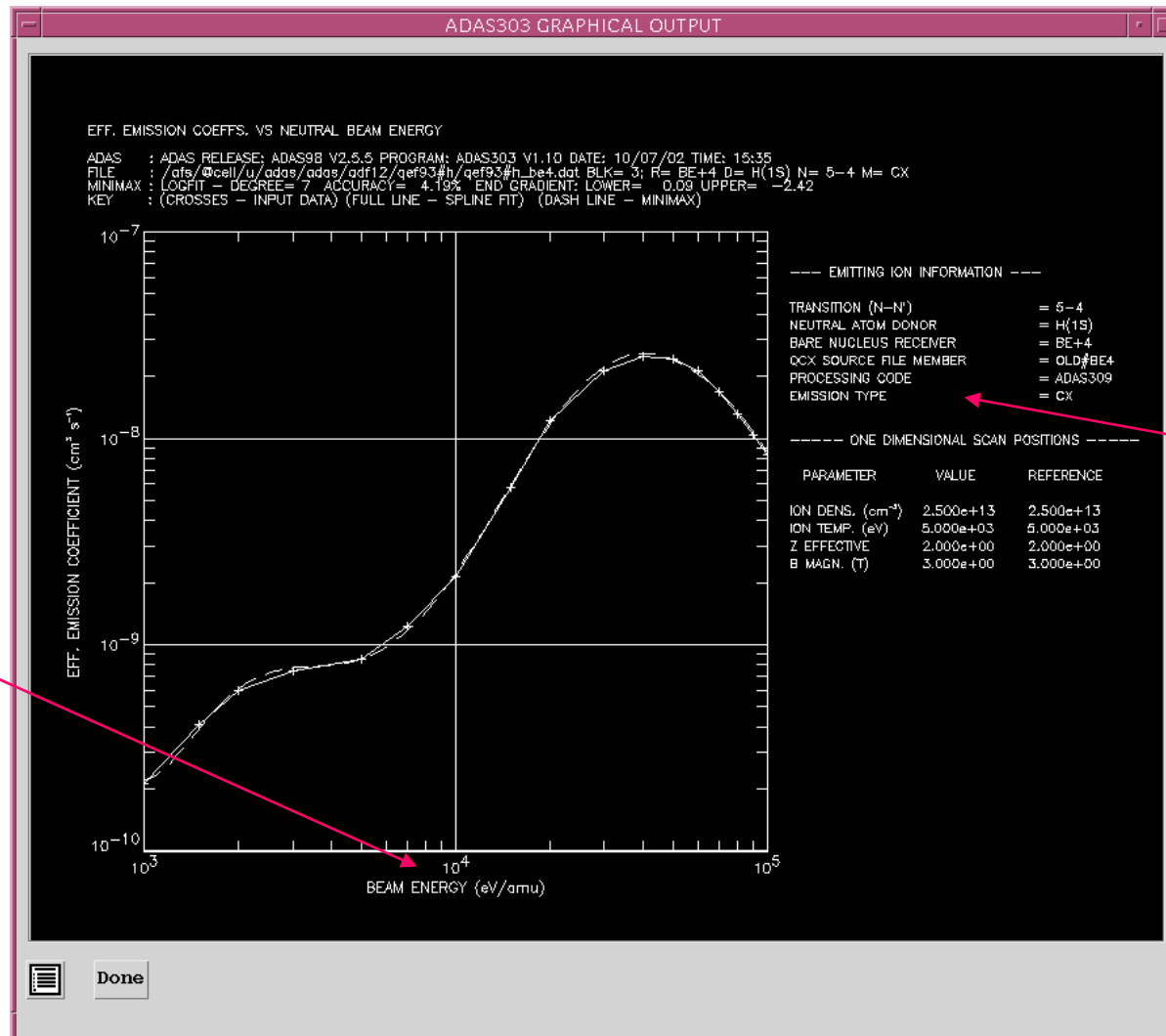
Select transition

Scan range and reference

Specify donor energies

Select plasma conditions

ADAS303 graph



graph is a function of beam energy

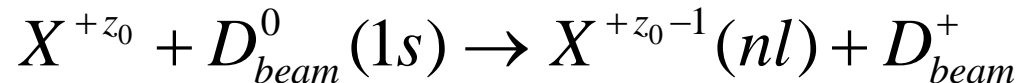
plasma and beam conditions for graph

Calculating CXS effective emission

- Datasets of class ADF01 state selective charge exchange cross-section data for capture by fully ionised ions.
- Code ADAS308 computes effective emission coefficients, predicts CXS line positions and profiles and deduces the beam plasma emission measure.

Calculating CXS effective emission (contd.)

- The driving reactions are



- The effective emission coefficient for n-n' transition is

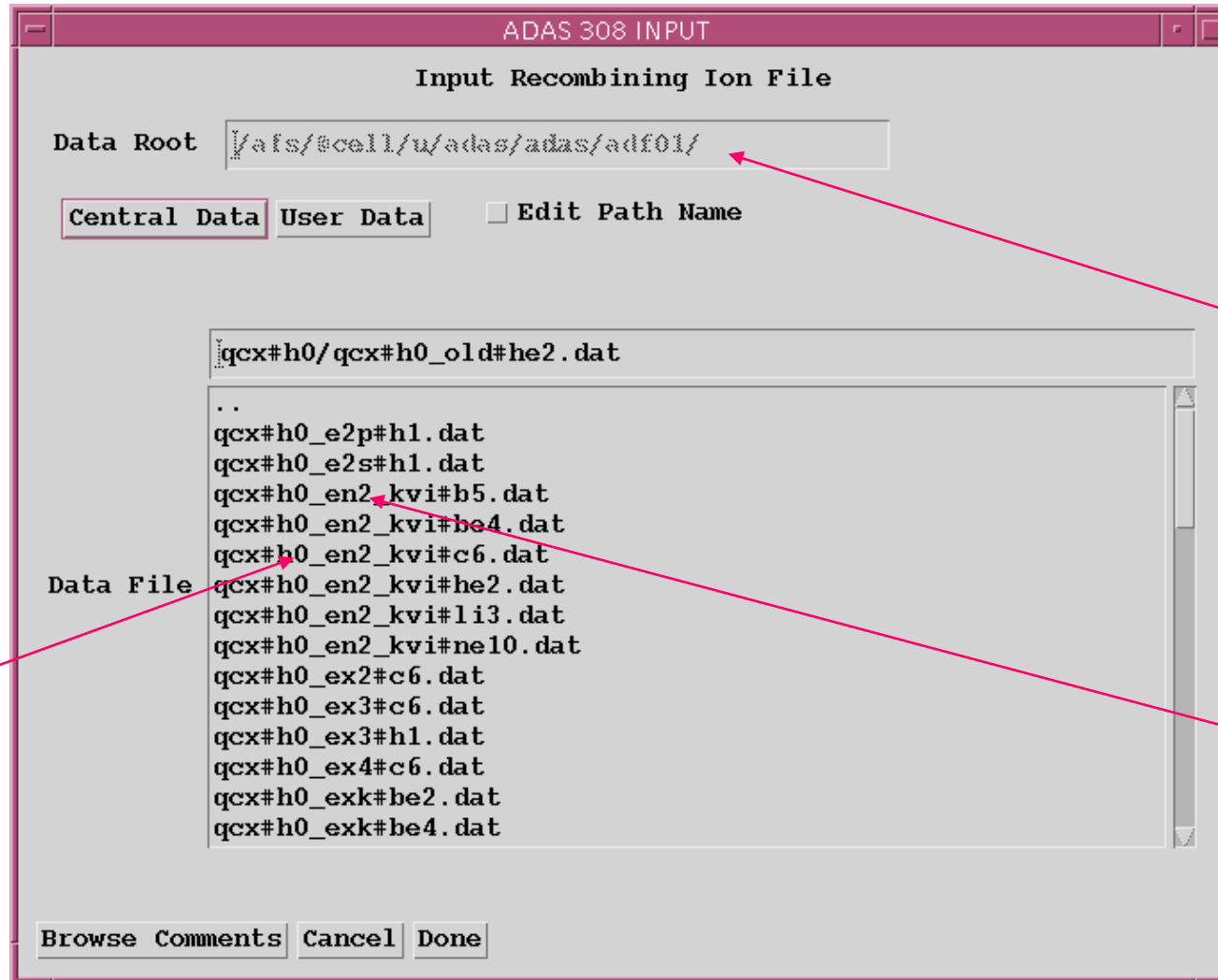
$$q_{n \rightarrow n'}^{(eff)} = \sum_{l, l'} A_{nl \rightarrow n'l'} (N_{nl}^{(z_0-1)} / N_D N^{(z_0)})$$

- Thus a collisional-radiative, resolved-nl population calculation is required to determine the effective emission coefficients.

Calculating CXS effective emission (contd.)

- File selection
 - » The fundamental state selective charge exchange x-sect data is format ADF01. These data are resolved into the nl shells of the receiver.
 - » Note that there are sub-directories for different donors and separate data sets for ground and excited donor states.
- Processing options
 - » *Beam parameter, observed spectrum lines and required emissivity predictions must be entered using Table Editor.*
 - » *Then plasma conditions must be entered.*
 - » *Finally model for emission measure is chosen.*
- Output options
 - » Graphical display of the spectral position, intensity and shape of a designated n-n' transition is given.
 - » Tabulations of predicted intensities of other lines are given together with the estimated emission measure.

ADAS308 Input



hydrogen
beam donor
data

fundamental
state selective
CX x-sects.

excited (n=2)
beam donor
data

Calculating CXS effective emission (contd.)

- ADAS308 is designed to do more than solve for the effective emission coefficients, q_{ef} .
- The program computes the q_{ef} and solves for the emission measure given the line of sight intensity in a charge exchange line as

$$I_{n \rightarrow n'}^{(z_0-1)} \approx q_{n \rightarrow n'}^{(eff)} \int N_D N^{(z_0)} ds$$

- If more than one charge exchange line intensity, with different upper levels, the code can assess the consistency between experimental and theoretical data. ADAS308 casts this onto the consistency of the ADF01 total n-shell capture with observation.
- Most use of ADAS308 has been directed at q_{ef} and its components alone.

ADAS308 processing

ADAS308 PROCESSING OPTIONS

Title for Run

Data File Name: /afs/@cell/u/adas/adas/adf01/qcx#h0/qcx#h0_old#he2.dat

Receiver			- Neutral donor -	
Symbol	charge	ion charge	Symbol	charge
HE	2	2	H	1

Please input following receiver information:-
Atomic mass number of receiver

Input beam and spectrum line information:-
 Beam parameter information
 Observed spectrum lines
 Required emissivity predictions

Input plasma parameter information:-
Ion temp. (eV) : Elec temp. (eV) :
Ion dens. (cm-3) : Elec dens. (cm-3) :
Z effective : B Magn. (T) :

Select charge exchange theory :
Select donor state :
Select emission measure model :
Is rate table printing required?

Required emissivity predictions

INDEX	Upper level N	Lower level N	Key
1	4	3	1
2			
3			
4			

Edit Table

Note: maximum allowed N quantum no. : 20
minimum allowed N quantum no. : 1

Key: 1 = Graphical and tabular output (max. 2)
2 = Tabular output only (max. 5 non-blank entries)
Blank = Summary only

Edit the processing options data and press Done to proceed

information from data set

various data required - appropriate is table displayed

key determines tables and graphs

masses required for ion collisions

model choice - usually input data and CX

ADAS308 output

ADAS308 OUTPUT OPTIONS

Data File Name: /afs/cell/u/adas/adas/adf01/qcx#h0/qcx#h0_old#he2.dat [Browse Comments](#)

Graphical Output

Graph Title:

Explicit Scaling

Plot A: X-min: X-max:
Y-min: Y-max:

Plot B: X-min: X-max:
Y-min: Y-max:

Enable Hard Copy Replace

File Name:


Select Device

Post-Script

Post-Script
HP-PCL
HP-GL

Text Output Replace Default File Name

File Name:

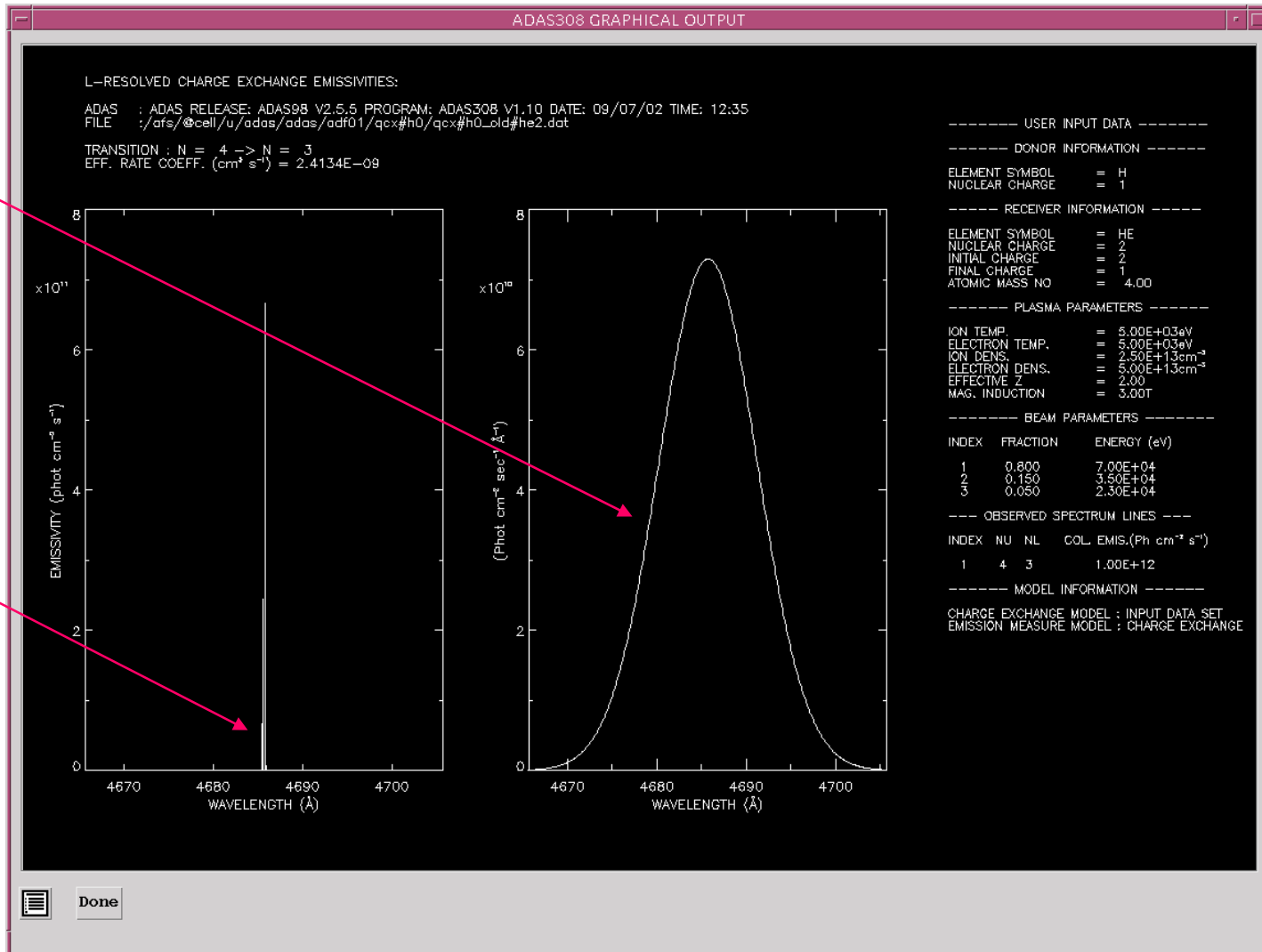


two plots -
stick and
broadened

ADAS308 graph

doppler
broadened
n->n' line

exact
component
wavelengths
and relative
emissivities



Mass production of CX effective emission coeffs.

- ADAS309 is the mass production code for the effective emission coefficients for charge exchange lines.
- The user input is similar to that for ADAS308 but there is no graphical output, nor does it attempt the inversion solution.
- Many transitions can be entered at the one time. An output file of effective emission coefficients is delivered fully formatted to the ADF12 specification.

Extension of the CXS capabilities to heavier species

- Motivated by the need to cope with heavier receiver ions beyond argon, which may be partially ionized.
- There are two new codes ADAS315 and ADAS316. ADAS315 works on a scaleable universal dataset of format ADF49 to produce an ADF01 data set.
- ADAS316 is a bundle-n population model. It requires a driver data set and, for bundle-n in ADAS, these have historically been archived in ADF25. A new sub-directory /a25_p316 has been assigned and a complete redesign of the driver has been carried out.
- Output ADF26 (the bundle-n population solution), ADF12 (charge exchange effective emission coefficients) and ADF40 (feature emissivity coefficients) may be produced.
- For heavy species CXS, because of the very large number of transitions between highly excited states, the ADF40 format becomes more useful than ADF12.