OPTION 18 FORM AND MEASURE AVERAGE PROFILE

Here we form an average profile by summing pieces of spectra selected from a given line list. The data must be in linearized form λ or lnλ) on disk in FITS format, i.e. they must have been processed by REDUCE. Those averaged profiles, which are displayed in radial velocity space (see Figure 1), can be measured for radial velocity. Here we define a region by making 2 settings of the X-cursor and fit a parabola to the data between them. By varying the line-list one has the freedom to average helium and hydrogen lines, for example. The program has been used to predict the appearance of a scan that would result from the Fletcher radial-velocity scanner for such a synthetic mask. In this way one can, using the computer, experiment with the effects of different lines without going through the laborious business of making a new mask and installing it in the radial velocity scanner to test the lines.

Once the summed profile is displayed the velocity measurement may be made in a number of ways.

i) Fit a parabola to the minimum

ii) Automatically fit a single Gaussian or Lorentzian function to all, or part, of the data.

iii) Fit a number of Gaussian, Lorentzian or rotational profiles using VLINE as a subroutine (see Appendix A18-1). Under these circumstances average equivalent widths (EW) may also be measured.

STEP 1. The file name for the line-list is defined next. All line-list files used by VLINESUM, REDUCE, VELMEAS or VLINE are compatible

PROMPT: ENTER FILE NAME OF LINE LIST - R to Restart Sequence

Reply. Enter file name. An R will return you to OPERATIONAL OPTIONS Table.

There will be a reference to injecting random noise. This was used to check on the effectiveness of the summing in the presence of extreme noise.

STEP 2. Here one must define the window in RV that the initial summing should take place over. Also, because the velocity may not be zero, one must give a velocity offset to this window. e.g. To display +/-100 km/s either side of a stellar velocity of -66 km/s the entries to the following prompts would be

-66 -100 100

PROMPT: Enter velocity offset for profile averaging

Reply. Enter velocity of the object, if you know it, otherwise enter large limits in the next 2 entries

PROMPT: Enter differential low velocity limit

Reply. Enter lower relative velocity here.

PROMPT: Enter differential upper velocity limit

Reply. Enter the upper relative velocity limit.

STEP 3. The data are summed, displayed and measured here (see Figure 1). The screen image can be manipulated here (expanded, shrunk, moved sideways). Those users familiar with VCROSS will recognize the program since the commands and method of measurement are identical. Measurements may be made directly with the X-cursor using the T command or a parabola fitted to data defined by 2 cursor placements.

PROMPT: Plot:<X>S%WHM; Skip: VCER Measure: T^, function G, std profile P,
R = Restart
Fit function to window: 1 = Gauss, 2 = Lorentz;
End with A for all data; I

Reply.

---Plot---

< Shifts the data 20% (default value) to the left, to longer wavelengths.

> Shifts the data 20% to the right to shorter wavelengths.

X Expands the amount of data displayed by 40% (2 X 20%).

S Shrinks the amount of data displayed by 40%.

% Allows one to alter this % amount. Prompts for a new %.

W Allows the width of the plot to be altered (default value 900). Prompts for a new value.

H Allows the height of the plot to be altered (default value 500). Prompts for a new value.

M Replot graph.

---Measure---

Normal RV measures are made by 2 cursor settings.
To fit a Gaussian or Lorentzian make 2 cursor settings. Enter 1 = G or 2 = L to identify the function. Take all data by entering an A on rightmost setting.

T Encode the X-cursor for a RV measure.

^ Fit a parabola to data below the Y-cursor.

G Fit one or more functions to the data, to measure RV and EW, using VLINE (Appendix 18A-1).

P Form a standard profile and store it (Appendix 18A-2).

---Skip---

V Returns to the beginning of STEP 2 to enable the velocity limits to be altered.

C Returns to STEP to alter line-list.

E Ends process stores a 'P' FITS file and returns to OPERATIONAL OPTIONS Table.

I For information.

R Restarts sequence.

Note that the header from the data file, and the name of the line list file are recorded on the screen so that if you copy the image you will know what was used for the measurement. At the completion of the measuring summaries of the results are written to the line printer.

Figure 1. An Average Profile, and Velocity Measures

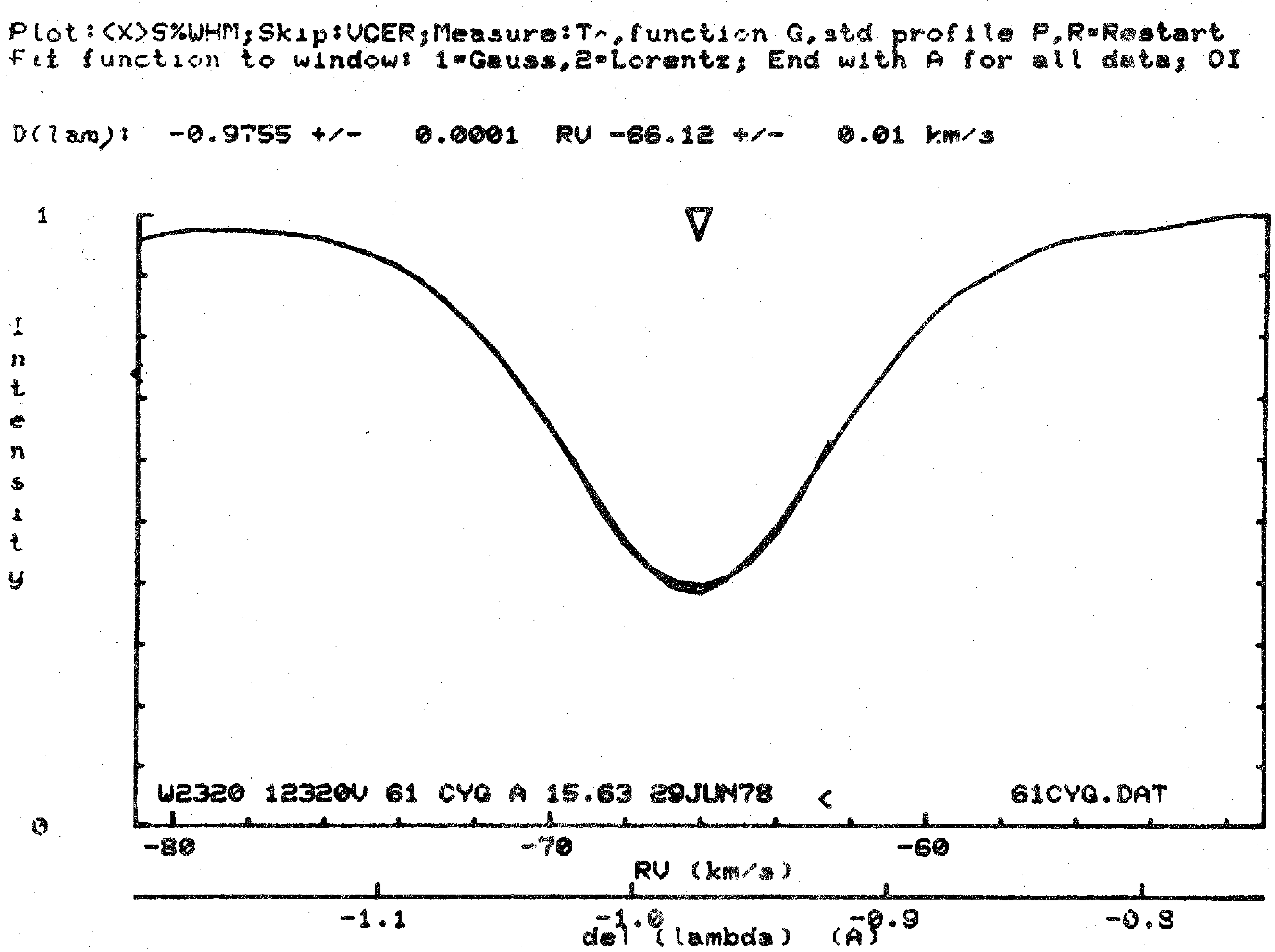
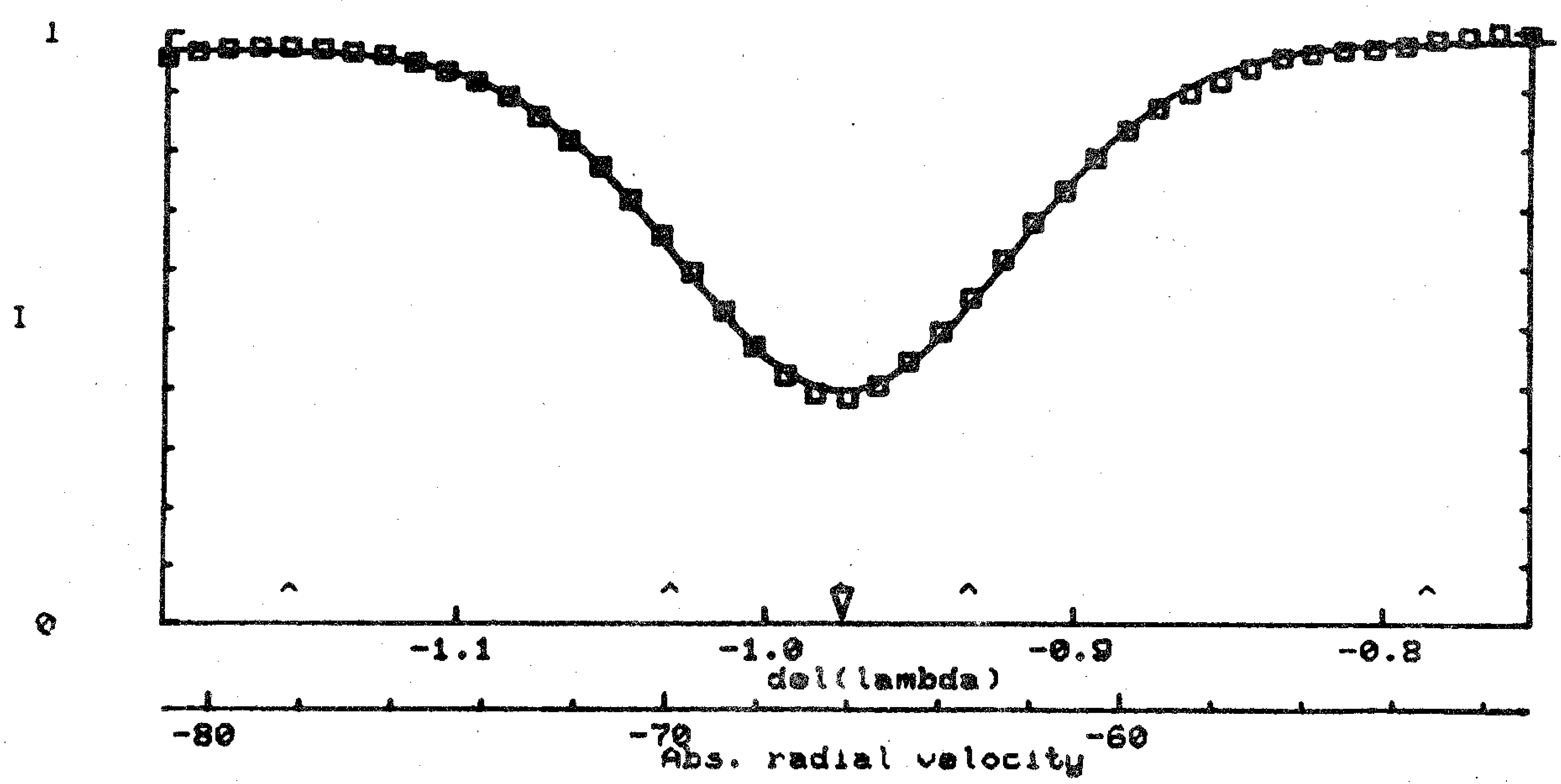


Figure 2. Velocity and E.W. measures of an average profile in VLINE

```
# pts    45 W2320 12320V 61 CYG A 15.63 29JUN78   31-OCT-84
Select? NESB0;                         FIT GLR45--BNAS0;
                                                            Gaus N 38
   D(lam)      err         RV     err        EW     Depth  FWHM k/s
   -0.9751     0.0004   -66.09    0.02      5.51    0.59    8.73     Gaus

Rerun B; Delimit N; 4 new std file; 5 new std file, S to main
V new RV limits; C new line list; R restart sequence
          W2320 12320V 61 CYG A 15.63 29JUN78  31-OCT-84
```



APPENDIX 1.

Fitting multiple functions to data

This subroutine is a slightly modified version of that used in VLINE. It enables the user to select parts of data to be fitted by a function, or combination of functions. The analytical forms available are Gaussian, Lorentzian or rotational, along with non-analytical profile (two max), see Appendix 2. Up to 12 profiles can be fitted to the data with starting values for each profile (depth, mean position, FWHM) being encoded from a series of X and Y cursor placements. A linear continuum is fitted simultaneously with these profiles. Parameters can be fixed to any value or fixed to each other; i.e. the FWHM of all lines may be set to one (unknown) value.

The program steps are as follows:

1. Make initial selection of data, all or part of a screen image.
2. Make a further selection within these data if you choose. You may want to eliminate parts spoiled by gliches for example.
3. Use cursors to establish the starting parameters.
4. Fix parameters to each other, or to a particular value.
5. Display fit and results. Choose a branching option.

STEP 1.

Data selection. Here one has the choice of accepting the whole range of data or taking out part of it. This selection is made by moving the X-cursor to two places and striking the space bar each time. Hitting other keys will direct the program to other steps or to the main program.

PROMPT: Select? NESB@

REPLY: Initiate fixing of parameters by striking @. The program will not encode the cursor and returns to the above PROMPT.

Make 2 cursor placements (using space bar) setting from left to right selecting the part of the data you want to work with.

Enter E on first placement to accept <u>all</u> of the data and skip to STEP 3.

Enter E on last placement to select <u>part</u> of the data and skip to STEP 3.

Enter N on first placement to accept <u>all</u> of the data and to go to the next step.

Enter S to return to main program.

Enter B to restart at this step.

STEP 2.

Selection of discontinuous pieces of data (optional step). Here we select pieces of the data by making pairs of cursor setting (from left to right). The end of this selection is signalled by an E on the last (rightmost) setting.

PROMPT: Delimit profile BSNE

REPLY: Make pairs of settings ending with an E on the final rightmost setting.
Enter B to return to STEP 1.
Enter N to restart this step.
Enter S to skip to main program.

STEP 3.

Establishing starting values. Here we measure the starting values by using the X-cursor, and occasionally the Y-cursor. We can also initiate the fixed parameter mode here if it has not been done at STEP 1. These measures are made by making two continuum settings with the X-cursor (first and last placements in the sequence) and three settings for each profile in order to define the FWHM, mean position and line depth. As an example the complete settings for two profiles are:

left continuum (LC), left FWHM (LH), center (C), right FWHM (RH)
left FWHM (LH), centre(C), right FWHM (RH), right continuum (RC).

Normally the y value is taken to be that y datum nearest the X-cursor but it can be measured by striking the T key. The only Y values that are used are in the continuum and line centre measures. The type of profile to be used in the fit is governed by the key that is struck on either the left FWHM setting or the central setting. The end of the settings (rightmost continuum placement) is signalled by an E key or by a T if the continuum height is being fixed. Ending the data entries in this way removes the necessity for counting the number of placements. A sample sequence for a Gaussian and Lorentzian with a central Gaussian line depth defined by the Y-cursor would be:

space bar (LC), G (LH), T (C), space bar (RH), space bar (LH),
L (C), space bar (RH), space bar (RC)

Some of the keyboard options (S,B,N,@) have already been described and we now discuss them in more detail.

PROMPT: Fit GLR45 BNAS@

REPLY: Initiate fix parameter mode by enter @. Then begin your cursor placements.

Placement 1. Left-hand continuum (can accept nearest y datum by hitting space bar or encode the Y-cursor height by striking the T key).

Placement 2. Set on left-hand side of profile at half-intensity point. Can define the profile type here by entering G=Gaussian, L=Lorentzian, R=rotational, 4=one standard profile, 5=different standard profile.

Placement 3. Set on minimum or maximum profile. Identify profile type if not encoding the Y-cursor with the T key.

Placement 4. Set on right side of profile at half-intensity point.

Placement 5. If more profiles are to be defined repeat STEPS 2-4, otherwise make the final continuum placement now. This placement must be signified by entering an E, or a T if the continuum height is to be defined by a Y-cursor setting. Ending the sequence of entries with the E or T removes the necessity for counting the entries.

The branching options are as before except the A command that will return you to the beginning of this step. (STEP 3)

Enter B to return to STEP 1.
Enter N to return to STEP 2.
Enter A to restart this step.
Enter S to return to main program.

STEP 4.

Fixing parameters. If you have chosen to fix some parameters by entering a @ in STEPS 1 or 3 then the screen will be erased and the current starting values displayed. If the fixed parameter mode has not been initiated this step will be bypassed and you will be at the following STEP (5). Once the current values are displayed you are prompted to enter those values to be fixed, either to each other or to a given value. Enter the index of the parameter to be fixed, followed by the value. If this parameter is to be fixed to another enter a negative index. You will be prompted for the index of this other parameter. The value, in this case, will be determined by the solution. These entries are terminated by the entry of a zero. The screen will clear, the data plotted anew and the fit graphed through the data.

STEP 5.

Display of results. Here the fit is displayed, and the results are written to the screen. One has the choice of redoing the fit, or returning to the main program.

PROMPT: Rerun B; Delimit N; 4 new std file; 5 new std file; S to main.
C new line list; V new velocity limits, R restart sequence

REPLY: Enter B to return to STEP 1.
Enter N to return to STEP 2.
Enter S to return to main program.
Enter 4 or 5 to enable new standard profiles to be defined leaving you still at this step.
C Skips to fetch a new line list in the main program.
V Skips to change velocity limits in the main program.
R Restart sequence.

APPENDIX 2

FORM A STANDARD PROFILE FROM AVERAGED PROFILES.

Not all shapes resulting from and averaging calculation can be fitted by Gaussian or Lorentzian functions. Differences from these shapes may only be small but they may become significant when one is trying to measure a weak secondary velocity component in the wings of the principal profile. In this appendix we describe the creation of such a standard profile. These profiles, which may be rendered symmetric (by folding), are defined in units of the FWHM and therefore look very much the same as the analytic functions identified above.

The program steps are as follows:

1. Measure background level, line positions, strength and FWHM.
2. Manipulate image if more data are needed.
3. Check the derived parameters.
4. Normalize the final profile and store it.

STEP 1

The same image seen in the main program is displayed and one may select a part of this to generate a std profile. Measurements of the line centre must be done now. This measurement is made by fitting a parabola to the peak in just the same way as is done in the main program.

PROMPT: Measure <x>, <d>, <c>; TBJELRDCPF

REPLY: Make two cursor placements with the thumbwheel and the spacebar. Enter T to measure the mean position with the cursor. These measures if made first will leave you at STEP 2.

The following commands will (ultimately) result in the data being replotted, but not until an F has been struck.

Define new window by a left (L) and right (R) cursor placement.

C encodes the Y cursor to define a new background level.

D encodes the Y cursor for a new maximum height.

End these changes with an F. The screen will clear and the data will be replotted leaving you again at STEP 1.

The following commands cause the program to branch.

B return to the beginning of this subroutine, and negate any current measures.

J skips to next step.

P skips to STEP 3 where the std profile is finally formed.

E returns the user to the averaging program.

STEP 2

This is a branching step. Once can begin anew, branch to STEP 1 or move on to define the standard profile.

PROMPT: OPTIONS: BP M=measure anew, E=end

REPLY: B to re-initialize all the measures and return to STEP 1.
M returns to STEP 1 for another series of measures.
P continue to next step
E abort process and return to the averaging program.

STEP 3.

Here you have a final chance to alter the values of the background height, line position and depth prior to the final derivation of the FWHM and the creation of a normalized profile p(x(units of FWHM), intensity). After these questions are answered the displayed profile may be folded, inverted and stored.

The questions invite the user to either adopt the current parameter or alter the value by making a setting with the X and Y cursors and encoding the position by striking the T key. At the end of these questions the following prompt appears.

PROMPT: Fold profile; invert, store I; adopt, store A; E=end

REPLY: If you are happy with the profile as is enter A.
Fold the profile with an F. The resultant profile will be plotted in squares. Store it with an A command. Invert the profile (to an absorption line) and store it with an I.
Skip to main program with an E.
If you elected to store the profile you will be prompted for a file name. I suggest that you append .AVR to this name so that you know later what operation this file resulted from.

STEP 4.

Here one can return to the beginning of the step or to the main program.

PROMPT: What next? B, V, C, E, or R

REPLY: B to reset all the current measures to zero and begin anew at STEP 1.
C select new line list.
V set new RV limits
E returns to the averaging program.
R restart sequence