AIPS Memo 127

Interactive flagging in AIPS

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Abstract

The first truly interactive task in AIPS was TVFLG, introduced in the late 1980s. It enabled interactive editing primarily of continuum data. A similar task suited to spectral line data sets appeared in January 1990. This task, SPFLG, has recently undergone some useful changes suggesting that this family of editing tasks should be described in a memo.

1 Introduction

It was this author's dream to write a truly interactive task to edit continuum data from interferometers. AIPS, my seventh system, was the first system on which I worked that became sufficiently mature that I could take the time to develop such a task. The result in the late 1980s was TVFLG, the first truly interactive task in AIPS. It displayed an image of visibility data with baseline on the x axis and time on the y axis. It allowed the data to be calibrated, the baselines to appear in length or numerical order, and to display multiple representations of the visibilities. At this time, the VLA produced primarily continuum data with one, or at most 7, spectral channels, making this a very useful task.

In January 1990, a similar task to edit spectral-line data was released. SPFLG shows images with spectral channel on the x axis and time on the y axis. Modern interferometers such as the Jansky VLA now produce a large number of spectral channels even for continuum observations. This makes SPFLG the more useful interactive editor, allowing examination for interference from terrestrial and celestial (mostly the Sun) sources. While computers are now very much faster than they were in the 1980s, the large volume of JVLA data sets still makes the initial stages of SPFLG time consuming. A task to reduce the start-up time was written in 2013. FTFLG is very similar to SPFLG except that all baselines are summed into a single image (per polarization). The hope is that this task will provide a quick examination of the data to find persistent RFI affecting all antennas. It is less useful for actually editing data.

All three of these tasks begin by reading the visibility data applying user-specified data selection and calibration. The resulting visibilities are written to a "master" grid disk file with times averaged over a user-specified interval. This master grid file is an AIPS cataloged image (type 'MA') which may be retained when the task finishes or discarded. The production of this master file was so expensive in the early days that the tasks have an option to compute and save the master grid and then exit with no interaction (DOCAT=2). Users used to start these tasks in this mode and return the next day to start the interactive portions.

The next sections of this memo will describe the options in some detail but it may be helpful to describe the general structure here. When an image is loaded to the display (XAS TV window), the master grid is read, the visibilities are converted to whatever form has been requested and then are written to a scratch disk file. The TVLOAD subroutine then reads this file and displays it on the TV. Then a menu of options is displayed in 5 columns. This loading operation may involve time averaging, rms computation, data differencing, and more. In the old days, this was expensive enough that the tasks require an explicit LOAD request. The user may select a variety of options changing windows, polarization, display type, display range, and integration times and only then apply the new parameters when finally doing the load operation. Some of the other operations, such as clipping, undoing or redoing flags, and changing the display loading transfer function will reload the display automatically.

One more general concept should be explained here. The basic integration time of the master grid is set by the value of DPARM(6) which should be set to the integration time in the data. In 31DEC24, the verb GETITIME may be useful in determining this value. When the image is loaded to the display, an additional time averaging is applied. The ENTER SMOOTH TIME option lets you set this using the terminal entering an integer in units of the initial DPARM(6). The default smooth time when the task begins is that needed to allow all times to appear in the display. It is displayed at the bottom of the screen with keyword AVG. A smooth time greater than one is required by display types called RMS since that parameter can be computed at load time only if data are time averaged at that point. There is another time interval called the "scan time" in units of DPARM(6). The visibilities are averaged over this time and then compared to the visibility at the central time in a sliding window fashion. The displays that use this are called DIFF. The current value of the scan time is displayed at the bottom of the screen labeled SCAN.

2 Spectral-line editing: SPFLG

2.1 Input parameters

Most of the adverbs in this task are the usual widely-used ones. INNAME *et al.* select the data set to be edited. Numerous adverbs then select the portion of the data set to be processed including SOURCES, CALCODE, TIMERANG, FREQID, BIF, EIF, BCHAN, ECHAN, UVRANGE, SUBARRAY, and most importantly ANTENNAS and BASELINE. All the usual calibration adverbs are applied to the data including DOCALIB, GAINUSE, DOPOL, DOBAND, BPVER, FLAGVER, and SMOOTH.

There are a few adverbs that are used in particular ways by SPFLG. DOCAT specifies that the master grid file should be kept when SPFLG finishes (DOCAT > 0) or should be discarded. If DOCAT$= 2$, SPFLG will exit after creating and filling the master grid file, leaving it to be used at a later time. IN2SEQ specifies the sequence number of the master grid and must be specified to access a pre-existing master grid. If IN2SEQ$= 0$, SPFLG will create a new master grid file. IN2DISK specifies the AIPS disk number to be used for the grid file. OUTFGVER specifies the output flag table version. If it is less than or equal 0, a new flag table will be created and will be populated with the flags in flag table version FLAGVER if it is ≥ 0.

Of the DPARMs, only DPARM(6) is really important. It sets the time interval on the y axis in seconds. This can be used to time average the data while building the master grid, but further time averaging may be done later. It may be best to set this to the integration time of the input data. The AIPS verb GETITIME may be helpful in determining this. DPARM(2) selects what data are included, with 0 including only cross-correlations, 1 including also auto-correlations, and 2 including only auto-correlations. For the VLBA, a value of 2 may be useful, but for the JVLA this is less likely. DPARM(4) controls whether the visibilities after calibration are divided by the source flux with or without spectral index. This may be useful when editing calibration sources. In 31DEC25, DPARM(7) controls the maximum x axis zoom and DPARM(8) limits the maximum y zoom factor. DPARM(1) controls the data type displayed initially, DPARM(3) selects the baseline to be displayed initially, and DPARM(9) and DPARM(10) control the initial range of intensity displayed. All of these can be changed while running the task making it best just to leave them at zero initially.

2.2 The master grid file

The master grid file has AIPS class SPFLGR and is an image (type MA) whose rows are 3 times the number of spectral channels plus 3 in length. The first 3 words contain the source number, the current time (in days), and the time of the next row. Three words are used for each spectral channel to hold the real part, the imaginary part, and the flag number when the data are flagged by SPFLG. If the particular channel was flagged on input, the values are represented by the "magic blank" value used by *AIPS* ('INDE' as a floating point number). The number of rows in the master grid is the number of times represented. To limit the size of the array long gaps in time are represented by no more than 5 blank rows. The third axis in the master grid image is used for Stokes and will be 1, 2, or 4 in length. The fourth axis in this grid is for baseline and includes only those baselines present in the data after application of the task adverbs. Attached to the master grid are two tables. The BL table has three columns labeled ANTENNA1, ANTENNA2, and BASELINE. It is primarily used to acquire the relationship between baseline number and antenna numbers when restarting SPFLG with a pre-existing master grid. The FC ("flag command") table contains 17 columns:

FLAGNUMB	1 I	Number assigned to current logical flag
FLAGOPER	8 C	Type of flagging operation
FLAGTIME	2 R	Time range of flag (days)
FLAGBL	2 I	Baseline number of flag (0 means all)
FLAGCHAN	2 I	Channel range of flag
FLAGIF	2 I	IF range of flag
FLAGSTOK	4 C	Stokes flagged by this command
FLAGSOUR	1 I	Source number of flag (0 means all)
CLIPRANG	2 R	Brightness range of non-flagged pixels
TVTYPE	1 I	Type of visibility displayed
TVCHAN	1 I	Row number on BL table
TVIF	1 I	IF number when clip was done
TVSTOKES	1 I	Stokes value currently displayed
TVWINDOW	4 I	Current image window
TVTIMAVG	1 R	Smoothing time in seconds
TVSCAN	1 R	"Scan" time in seconds
REASON	24 C	Reason for flag

The central column above gives the number of values and the data type (I integer, R real, C character). Some of these parameters translate directly into flag table (FG) entries attached to the input data set. Specifically, these are the time, baseline, channel, IF, Stokes, source, and reason columns. The FLAGNUMB is the flag number used to identify the flag command for listing flags and for marking samples in the master grid flagged by the flag command. FLAGOPER is mostly used when listing the flags. The CLIPRANG and parameters labeled TV are used by the CLIP BY FORM operation to control the "form" of a previous clip now being applied to other parts of the master grid.

2.3 Running SPFLG

After SPFLG builds the master grid, it loads the first baseline's data in the requested form to the TV in grey-scale and draws a five column menu in graphics overlay 2 (usually green in color). The loaded data are smoothed in time from the master grid's integration time enough so that the resulting image fits on the TV display. This initial screen is illustrated in the top of Figure 1 where the data have been smoothed by a factor of 6 to fit on the screen.

When the smoothing parameter is reduced, making the image too large for the display vertically, the menu is changed to refer to the "pieces" of the image. These are overlapping time intervals that will cover the full time range one piece at a time. This is illustrated in the bottom of Figure 1.

At the bottom of the screen is a very important line of text describing the current data display and marking with asterisks any parameters that will change with the next load operation. If your screen is narrow, this text will appear in multiple lines. Parameters 1, 3, 4, 5, 6, 10, 11, and 12 can show asterisks if appropriate. Parameter 2 changes on loads, the others change as soon as they are invoked. For SPFLG this text contains

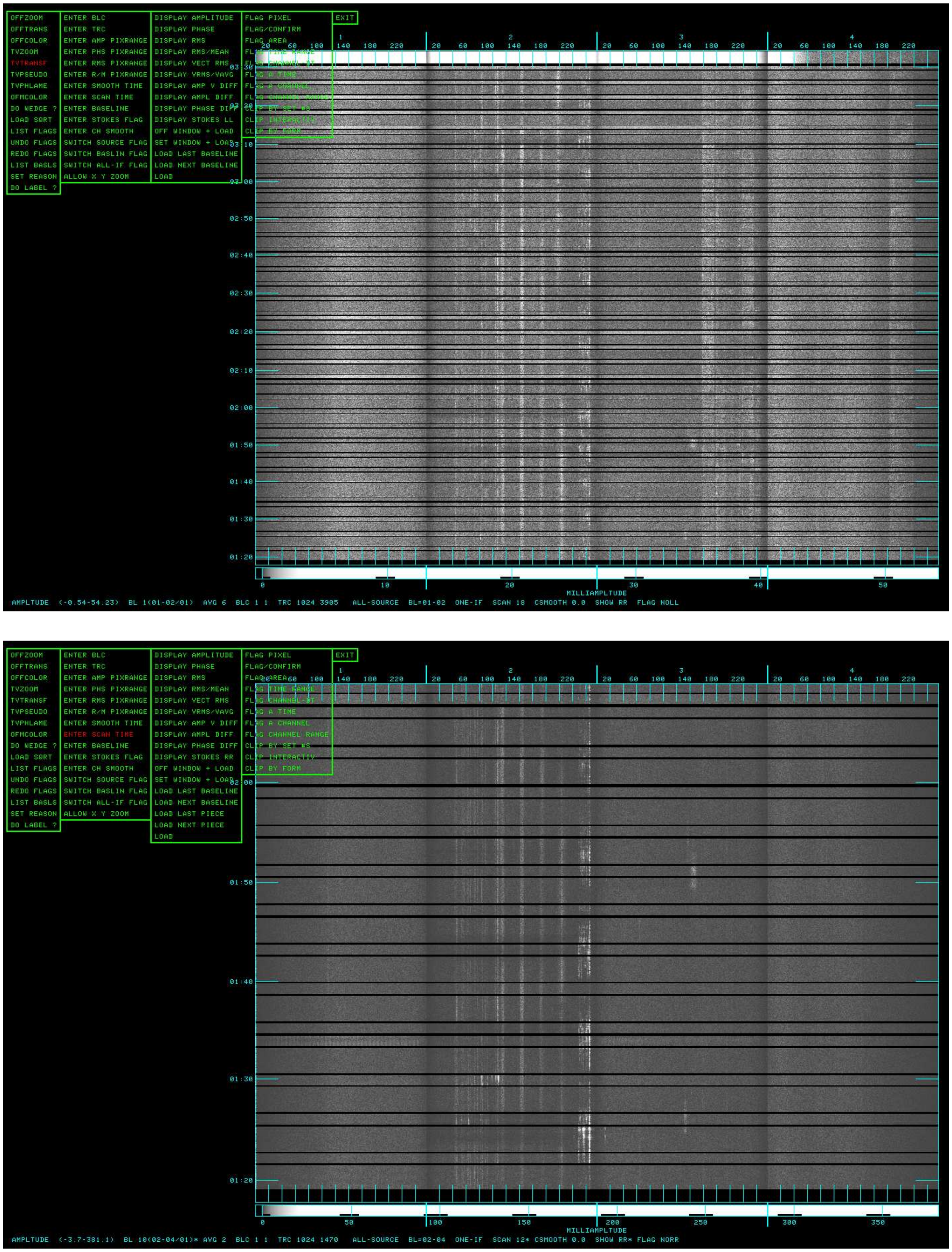


Figure 1: **Top:** Initial display of data after `DO LABEL?`, `DO WEDGE ?`, `LOAD LOG`, and `TVTRANSF` were used to make these data more visible. Note the `SMOOTH 6` in the bottom text line which was required to fit the display on the screen. The master grid was made on a 2 second time interval, matching the data integration time. **Bottom:** Same display after changing the smooth time to two of the master's 2-second intervals. Note in the bottom text line the asterisk next to the baseline, the `SCAN` length, and `SHOW RR` entries. This means that the next `LOAD` will display an image for which these parameters will change.

1.	Data type, *e.g.*, `AMPLITUDE`, `VEC DIFF`, et al.
2.	Intensity range *e.g.*, `(-0.42-77.66)` mJy in this case
3.	Baseline number, antennas, subarray *e.g.*, `BL 4(01-05/01)`
4.	Time averaging in units of `DPARM(6)`, *e.g.*, `AVG 2`
5.	Window bottom left corner *e.g.*, `BLC 1 1`
6.	Window top right corner *e.g.*, `TRC 1024 1470`
7.	Which sources get flagged *e.g.*, `ALL-SOURCE`, `ONE-SOURCE`
8.	Which baselines get flagged *e.g.*, `BL=01-05`, `BL=01-**`, `BL=**-05`, `BL=**-**`
9.	Which IFs get flagged *e.g.*, `ONE-IF`, `IF02-03`, `ALL-IF`
10.	Scan time in units of `DPARM(6)` *e.g.*, `SCAN 12`
11.	Spectral smoothing width in channels *e.g.*, `CSMOOTH 3.0`
12.	Current polarization *e.g.*, `SHOW RR`
13.	Which polarizations get flagged *e.g.*, `FLAG NOLL`

Operations are selected from the menu by moving the cursor to the desired operation, pressing the left mouse button to signal `SPFLG` which will change the color of the menu item from green to red, and then pressing the A, B, or C keys on the keyboard. Pressing the D key will cause helpful information about the operation to appear in the main terminal window.

The left-most column of the menu contains the options

`OFFZOOM`	turn off any zoom magnification
`OFFTRANS`	turn off any black & white enhancement
`OFFCOLOR`	turn off any pseudo-coloring
`TVZOOM`	interactive image zooming as in `AIPS`
`TVTRANSF`	black and white enhancement as in `AIPS`
`TVPSEUDO`	many pseudo-colorings as in `AIPS`
`TVPHLAME`	many flame-like pseudo-colorings as in `AIPS`
`OFMCOLOR`	very many OFM pseudo-colorings as in `AIPS`
`DO WEDGE ?`	switches choice of displaying a step wedge
`LOAD xxxx`	switch TV load transfer function to xxxx= `LOG`, `SQRT`, `LOG2`, and `LIN`
`LIST FLAGS`	list selected range of flag commands
`UNDO FLAGS`	remove flags by number from `FC` table and from the master grid
`REDO FLAGS`	reapply all flags to master grid
`LIST BASLS`	list antenna pairs by baseline "number"
`SET REASON`	enter reason to be attached to flagging commands
`DO LABEL ?`	turns on/off axis labeling
`CHAR MULT`	set the character size multiplier

The first operation turns off any zoom magnification produced by `TVZOOM`, the second operation turns off any black-and-white ehancement produced by `TVTRANSF`, and the third operation turns off any coloring produced by `TVPSEUDO`, `TVPHLAME`, or `OFMCOLOR` operations. The following five operations are interactive and issue instructions on the message terminal. `TVZOOM` allows you to select the center of a pixel-replication zoom, hitting terminal buttons A or B to increment the zoom factor, button C to decrement it, and button D to exit. The zoom is turned off to allow the menu to be accessible, but will be turned back on for the enhancement operations above and for the flagging operations of column 4. `TVTRANSF` adjusts the black-and-white enhancement function with buttons A and B turning on and off a graphics display of the function, button C reversing the sign of the slope, and button D exiting. `TVPSEUDO` offers a rainbow-like coloring on button A, a circular coloring especially good for phase on button B, a set of step functions on button C, and exiting on button D. Repeated hitting of the buttons steps through the color order (A) or the various step functions (C). `TVPHLAME` implements a flame-like coloring with buttons A and B switching the sequence of colors and buttons C and D exiting. `OFMCOLOR` offers 10 different color schemes on each of buttons A, B, and C with button D exiting. The cursor horizontal position adjusts the central point of the color functions.

`DO WEDGE ?` reverses a logical switch controlling whether a step wedge is displayed along with the data. Similarly, `DO LABEL ?` reverses a logical switch controlling whether axis labels appear on the image and step wedge. `CHAR MULT` will appear in the menu only if the task starts with a character multiplier bigger than one or has the default multiplier bigger than one. Unless the display has a very large number of pixels, the large menu of `SPFLG` probably will require you to set the character multiplier to one. `SET REASON` will prompt the user on the terminal to enter a "reason" for the flags to follow. This is not required but can be helpful when reviewing the flag tables produced by `SPFLG`.

When the image is first loaded to the display a linear relationship is used to scale the data minimum to maximum into the display minimum to maximum. `LOAD LOG` will then appear in the menu. To reload the display with a logarithmic relationship, select this option. Then the menu will display `LOAD SQRT` and so forth. The menu will always display the relationship you get if you select it. This option immediately reloads the display when selected. The `LIST BASLS` operation will prompt you for the range of entries in the baseline list to be displayed. The relationship between "baseline" number and antenna numbers is often less than obvious.

The `FC` table is updated every time you create a new flag command so that any interruption (power, software bug, user error) will not cause the work up to that point to be lost. Each flag command is assigned a number which is not necessarily the row number since some commands will require multiple rows in the `FC` table each with the same flag command number. That number is written in the master grid with each voxel flagged by the command. To examine the current contents of the `FC` table select `LIST FLAGS`. If there is more than one, you will be prompted to enter a range of flag command numbers to display. This display only shows the first of each flag number plus a line saying how many `FC` table rows are needed for that flag number. To undo one or more flag commands, select `UNDO FLAGS` which will prompt you for the flag command numbers to be undone, one per prompt with 0 ending the list. Sometimes a later flag command will flag a voxel that was already flagged by an earlier command. Undoing that later command will resurrect the voxel. Select `REDO FLAGS` to undo all remaining flag commands and then redo them in sequence. If you do not do this, voxels will appear unflagged in the master grid but will be flagged when you exit `SPFLG` translating the `FC` table into the flag table attached to the uv data set.

The second column of the menu contains the options

`ENTER BLC`	Type in a `BLC` in pixels on the terminal
`ENTER TRC`	Type in a `TRC` in pixels on the terminal
`ENTER AMP PIXRANGE`	Type in the intensity range to be used for loading amplitude images to the TV
`ENTER PHS PIXRANGE`	Type in the phase range to be used for loading phase images to the TV
`ENTER RMS PIXRANGE`	Type in the intensity range to be used for loading images of the rms to the TV
`ENTER R/M PIXRANGE`	Type in the value range to be used for loading rms/mean images to the TV
`ENTER SMOOTH TIME`	To enter the time smoothing length in units of the master grid y cell size
`ENTER SCAN TIME`	To enter the time averaging length for the "scan average" in units of the master grid y cell size
`ENTER BASELINE`	To enter a desired antenna pair using the terminal or the baseline number and a zero
`ENTER STOKES FLAG`	To type in the 4-character string which will control which correlators (polarizations) are flagged.
`ENTER CH SMOOTH`	To type in the FWHM of a Gaussian smoothing in spectral channels in the data type being loaded.
`SWITCH SOURCE FLAG`	To switch between having all sources flagged by the current flag commands and having only those sources included in this execution of `SPFLG` flagged.
`SWITCH BASLIN FLAG`	To rotate the pointer that selects which baselines are flagged.
`SWITCH ALL-IF FLAG`	To rotate the flag all IFs status from one IF to a range of IFs, to all IFs.
`AUTO X Y ZOOM ?`	To switch between no zooming of the master grid and automatic zooming where possible limited by `DPARM(7)` and `DPARM(8)`

The `ENTER BLC` and `ENTER TRC` operations will prompt you in the terminal for two numbers specifying the bottom left corner and top right corner of the master grid where the x values are in spectral channels.

Selecting these operations will cause an asterisk to appear in the bottom text line. The new corners will be applied on the next load operation. The default "pixrange" for each type of visibility parameter (amplitude, phase, rms, rms/mean) is 0 0, meaning to use the full range of the current (sub)image. To set a fixed value range for each type select the appropriate `ENTER xxx PIXRANGE` option and then type two values into the terminal. If the first of these is less than the second, the specified intensity range will be used henceforth until changed. Enter two zeros to return to self scaling.

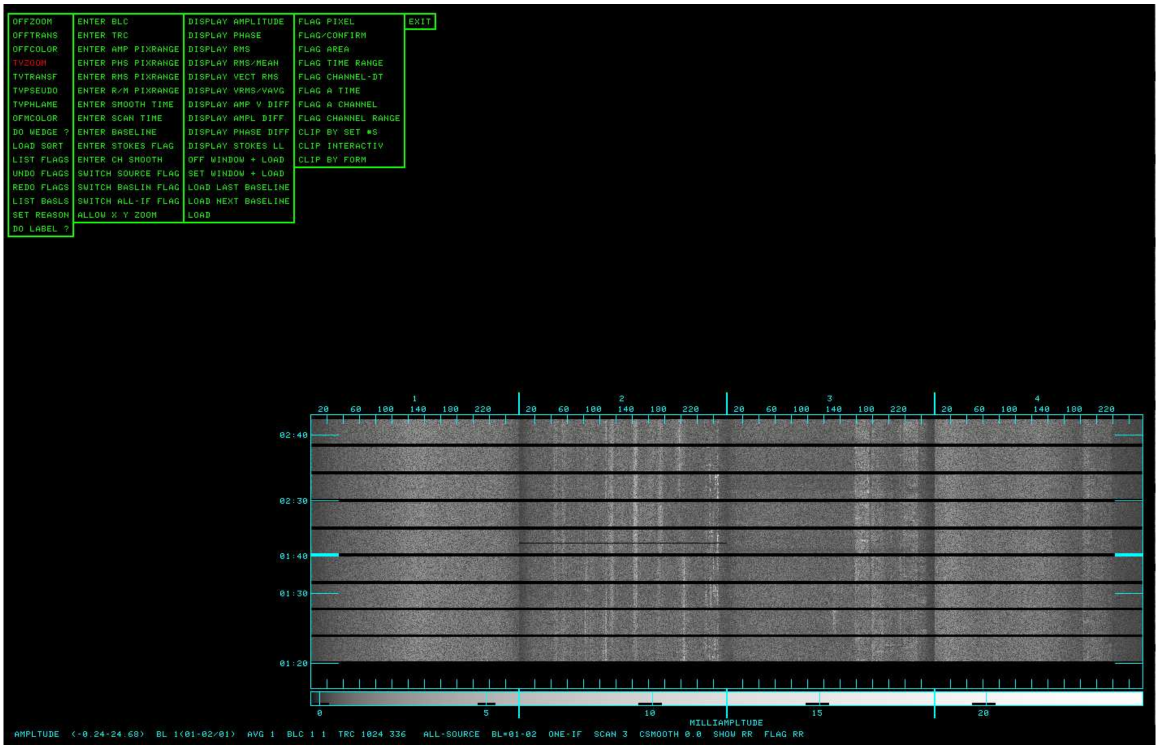
`ENTER SMOOTH TIME` will prompt you to enter on the terminal the number of master grid time intervals to be averaged before the resulting image is loaded to the display. `ENTER SCAN TIME` will prompt you to enter on the terminal the number of master grid intervals surrounding the current data interval to be averaged when differencing the current visibility with this "scan" average. `ENTER BASELINE` will prompt you on the terminal for two numbers, either the two antennas of the baseline you wish to see next or the baseline number itself plus a zero. (`LIST BASLS` will help you with this correspondence.) `ENTER CH SMOOTH` will prompt you for the full width at half maximum in channels of a Gaussian spectral smoothing to be applied to the image as it is being loaded to the display. All four of these options will place an asterisk in the bottom text line indicating that the parameter will change on the next load.

The `ENTER STOKES FLAG` will prompt you to enter a four-character string on the terminal specifying which correlators will be flagged by subsequent flagging operations. By default, this is changed when a new Stokes component is loaded but it is wise to check this since it is possible to display one Stokes component but apply the flags only to other components. The simplest form of this string is a bit mask of zeros and ones, where the first bit applies to I, RR, or VV, the second bit applies to Q, LL, HH, the third bit applies to U, RL, VH, and the fourth bit applies to V, LR, HV. Many other strings will be translated correctly. If the string you enter is not understood, `SPFLG` will complain and in any case the string that will now be applied will be displayed at the end of the string at the bottom of the display.

The next 3 operations control what is flagged by subsequent flagging functions. The `SWITCH SOURCE FLAG` toggles the flag that determines whether subsequent flag commands apply to all sources or just to the source generating the flag. It starts at all sources. `SWITCH BASELINE FLAG` starts at $n - m$ where n and m are the 2 antennas of the baseline currently displayed. If the operation is selected, it then changes to n-*, then m-*, then *-*, and then back to $n - m$, etc., where * means all. The `SWITCH ALL-IF FLAG` has three states, the one-IF state, the range of IFs state (entered from the terminal), and the all-IF state. Flag commands are limited by this so interactive flagging will allow the flagging in the first state to occur in any one IF only. In the second state, the interactive flagging will be confined to the specified IFs. In the third state, interactive flagging will show all IFs. A flag generated on one IF will apply to the listed IFs or all when in the second and third states, but clip operations will only apply to the specific channel and IF being clipped.

The last operation in column two, `AUTO X Y ZOOM ?`, is new in `31DEC25`. It toggles a switch which tells all operations loading an image on the display to have each grid pixel (after any time averaging) correspond to one TV pixel or to blow up the image as much as possible while still fitting on the display. This is illustrated in Figure 2 where the top portion shows the display when the zoom is not allowed and the bottom shows the display when zoom is allowed. Adverbs `DPARM(8)` and `DPARM(9)` limit the maximum magnification factor in x and y, respectively. Like many of the operations, this switch controls what happens for the next image loaded to the display.

The third column of the menu contains the options to choose which aspect of the visibilities is displayed and to load the image to the display. It contains



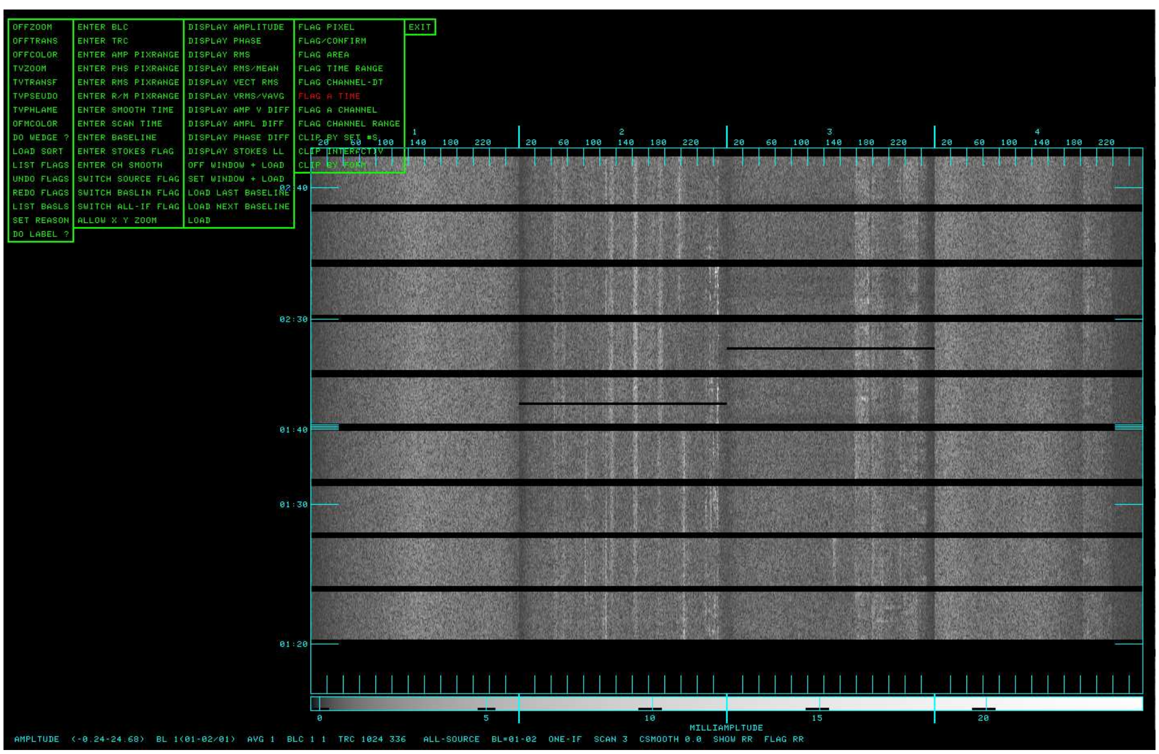


Figure 2: **Top:** Display of data where only one source was selected and the $x-y$ zoom is not allowed. One time has been flagged in IF 2. **Bottom:** Same display after allowing the interplative zoom. The y axis has been zoomed by a factor of 2. For illustrative purpose only, another time in IF 3 has been flagged.

DISPLAY AMPLITUDE	To display amplitudes on the TV
DISPLAY PHASE	To display phases on the TV
DISPLAY RMS	To display scalar amplitude rms on the TV
DISPLAY RMS/MEAN	To display scalar amplitude rms/mean on the TV
DISPLAY VECT RMS	To display vector amplitude rms on the TV
DISPLAY VRMS/VAVG	To display vector amplitude rms/mean on the TV
DISPLAY AMP V DIFF	To display the amplitude of the difference between the data and a running (vector) "scan average"
DISPLAY AMPL DIFF	To display the abs(difference) of the amplitude of the data and a running scalar average of the amplitudes in the "scan"
DISPLAY PHASE DIFF	To display the abs(difference) of the phase of the data and the phase of a running (vector)"scan average"
DISPLAY STOKES xx	To switch to Stokes type xx (where xx can be RR, LL, RL, LR, etc. as chosen by the data plus the STOKES adverb)
OFF WINDOW + LOAD	Reset the window to the full image and reload the TV
SET WINDOW + LOAD	Interactive window setting (like TVWINDOW) followed by reloading the TV
LOAD LAST BASELINE	Reload TV with the current parameters and the previous baseline in sequence
LOAD NEXT BASELINE	Reload TV with the current parameters and the next baseline in sequence
LOAD LAST PIECE	Load the previous overlapping piece of the data
LOAD NEXT PIECE	Load the next overlapping piece of the data
LOAD	Reload TV with the current parameters

The DISPLAY options select the type of visibility data to be displayed by the next load operation. The first two simply select the amplitude and phase of the data from the master grid vector averaged over any smoothing time (default and set by the ENTER SMOOTH TIME operation). The next four options compute rms over the smoothing time and hence require that the smoothing time be greater than one. The first two of these compute the rms from amplitudes and hence are scalar rms and scalar rms weighted by scalar mean amplitude. The second two are rms amplitude evaluated by vector averaging over the smoothing time and rms scaled by the vector averaged amplitude. The DISPLAY AMP V DIFF is a very useful display option that shows the vector amplitude difference between the smoothed sample and the vector average of a "scan" interval surrounding the sample. This display is very sensitive to both short-term differences in phase and amplitude and is the basis of one of the two flagging operations in RFLAG, the popular automatic flagging task. The remaining two display difference operations show in absolute value the difference between the amplitude and the scalar average amplitude in the surrounding "scan" interval and the difference between the phase and the vector average phase in the surrounding interval.

The operation DISPLAY STOKES xx selects the Stokes value of the data to be displayed in the next load operation. This option always appears and shows the next Stokes type from RR,LL, RL, LR, VV, HH, VH, and HV depending on the Stokes values present in the master grid. If there is only one Stokes in the master grid, then this option does nothing.

The remaining operations in this column all load a new image to the display updating all parameters shown with asterisks in the bottom text line(s). OFF WINDOW + LOAD resets the BLC to 1, 1 and the TRC to the size of the master grid. It then reloads the display even if the current smoothing parameter causes the image to be larger in the y direction than the display. SET WINDOW + LOAD lets you use the TV cursor to set the lower left corner and upper right corner of a subimage which is then loaded to the display. This operation is identical to the AIPS verb TVWINDOW except that SPFLG does not let the cursor go outside the available image. The BLC and TRC of this new subimage will be displayed in the text line(s) at the bottom. The LOAD LAST BASELINE loads the previous baseline and the LOAD NEXT BASELINE loads the next baseline from the baseline list. The two antennas in the new baseline are shown in the bottom text line(s). The LOAD LAST PIECE loads the previous vertical subimage and the LOAD NEXT PIECE loads the next (later times) subimage. These operations rotate through the baselines and times and so, for example, if the highest time piece is currently displayed, LOAD NEXT PIECE will load the lowest time subimage. LOAD simply loads the image using any changed parameters but keeping the current baseline and piece number.

The fourth column lets you generate flag commands using

FLAG PIXEL	To flag single pixels
FLAG/CONFIRM	To flag single pixels, but request a yes or no on the terminal before proceeding
FLAG AREA	To flag a rectangular area in Channel-T
FLAG TIME RANGE	To flag all channels for a range of times
FLAG CHANNEL-DT	To flag a channel for a range of times
FLAG TIME	To flag all channels for a specific time
FLAG A CHANNEL	To flag all times for a specific channel
FLAG CHANNEL RANGE	To flag all times for a range of channels
CLIP BY SET #S	To enter from the terminal a clipping range for the current mode and then clip
CLIP INTERACTIV	To enter with the cursor and LUTs a clipping range for the current mode and then clip the data
CLIP BY FORM	To clip selected baselines using the "method" and clipping range of some previous clip operation

The `FLAG` commands let you select data to be flagged with the TV cursor. The source name, time, channel and IF, and data value under the cursor are displayed in the upper left corner. Instructions will appear in the message window. Button D exits from all flagging operations without making an additional flag. Flagging a point, a time, or a channel is done on buttons A, B, or C with C exiting afterwards. The confirm point version will require you to answer y or n in the terminal window for each point selected. Flagging area, time range, channel range, and a channel-time range start with the lower level or corner and button A lets you switch between the levels or corners. Button B after both levels/corners have been set at least once creates a flag and goes on to the next area or range. Button C creates the flag and exits. Note that these flagging operations honor the specified range of IFs. A flag generated in one IF will be applied to all specified IFs. An exception is made when an area or channel range covers more than one IF. In that case, a separate flag is created for each IF and they are not extended to the other IFs.

The `CLIP BY SET #S` operation prompts you for a lower limit and upper limit for the visibility parameter currently displayed. A flag is then generated for each pixel outside this range. The `CLIP INTERACTIVE` operation displays the lower limit and upper limit intensities in the upper left corner and the cursor position is used to change the value. Buttons A and B switch which limit is set and the black and white lookup table is used the make "'clipped" values invisible. Button C exits causing a flag to be generated for each visibility parameter value outside this range. Button D exits without generating any flags. The display is automatically updated.

The `CLIP BY FORM` operation is particularly complex (or perhaps amusing). It prompts you for a previous clip operation flag number which you can get using `LIST FLAGS`. It then applies its display type (amplitude, phase, rms, rms/mean, etc.), averaging interval and clip levels to a range of baselines and Stokes (as entered from the terminal). To terminate the operation, doing nothing, enter a letter instead of one of the requested baseline numbers. To omit a Stokes, reply, if requested for a flag pattern, with a blank line. You may watch the operation being carried out on the TV as it proceeds because it carries out parts of its operation using the TV display.

The fifth column contains only

EXIT	Go resume `AIPS` and enter the flags in the data

When exiting, `SPFLG` will ask if any `FC` table flag commands should be applied to the data. If the answer is yes, the existing `FG` flag table is copied to a new one and the flag commands are translated into `FG` table entries following the pre-existing ones. The master grid is then updated, applying the flag commands in an immutable fashion. If the answer is no, `SPFLG` will ask a second time if the master grid is going to be deleted (`DOCAT`≤ 0) reminding the user that the flag commands will be lost. If the master grid is being retained, the `FC` table is simply kept for later use.

3 Average baselines spectral editing FTFLG

FTFLG first appeared in 2013. It is essentially the same as SPFLG except that the data from all included baselines are accumulated in one plane of the master grid per polarization. This accumulation is done by averaging real parts and imaginary parts separately in each spectral channel and IF, *i.e.*, by vector averaging. The BL table and the FC table are created in a manner identical to that in SPFLG. The menus are also identical except that LIST BASLS is omitted from the first column, ENTER BASLINE and SWITCH BASLIN FLAG are omitted from the second column, and LOAD LAST BASELINE and LOAD NEXT BASELINE are omitted from the third column. Flag table entries from FTFLG apply to all antennas except when the adverbs ANTENNAS and/or BASELINE have one and only one non-zero entry. The bottom line is the sames as for SPFLG except that the current baseline, antenna numbers, and IF (parameter 3) is omitted. Parameter 8 shows which baselines will get flagged and cannot be changed from the menu.

FTFLG was written in the hope that it could create the master grid file more quickly than SPFLG and that it would reveal instrumental issues and RFI that affect all of the data. One really bad antenna can make a voxel in FTFLG appear bad, but flagging all antennas for it is excessive. This is especially true in VLBI where the antennas are not all likely to see the same RFI signals. Thus, it cannot replace SPFLG, but SPFLG is rather demanding when processing a large number of baselines such as are present in the JVLA.

4 Continuum interactive editing: TVFLG

TVFLG was the first task in this family, having been developed in the 1980s. There are enough differences between TVFLG and the other two to require a more detailed exposition here.

4.1 Input parameters

TVFLG is designed to show visibility data on a plane with baseline number on the x axis and time on the y axis. The task has all the usual adverbs to specify which data are included in the master grid and how they are to be calibrated. TVFLG has two significant adverbs not in SPFLG. These are NCHAV to specify pre-averaging of spectral channels within each IF and CHINC to specify the increment in spectral channels between planes written to the master grid.

DPARM is also somewhat different in TVFLG. DPARM(6) is still the most significant time integration parameter and is best set to the integration time in the data or a small integer times that. DPARM(3)> 0 specifies that both baseline $n - m$ and $m - n$ be present along the x axis. This has the advantage that an issue with a particular antenna will be more visible even when the antenna is one of the higher numbered ones. See following Figures which illustrate that point. DPARM(4)> 0 causes the visibilities to be divided by the flux density in the source table before being added to the master grid file. This does help mask the otherwise large differences in amplitude due to source strength. DPARM(5) controls how much each flag command is extended in time when converted to the flag table. DPARM(7) through DPARM(10) control the initial display type and scaling. These matters may easily be changed while running TVFLG and so are best left zero at the start.

4.2 The master grid file

The master grid file has *AIPS* class TVFLGR and is an image (type MA) whose rows are 3 times the number of baselines plus 3 in length. The first 3 words contain the source number, the current time (in days), and the time of the next row. Three words are used for each baseline to hold the real part, the imaginary part, and the flag number when the data are flagged by TVFLG. If the particular correlator was flagged on input, the values are represented by the "magic blank" value used by *AIPS* ('INDE' as a floating point number). The number of rows in the master grid is the number of times represented. To limit the size of the array

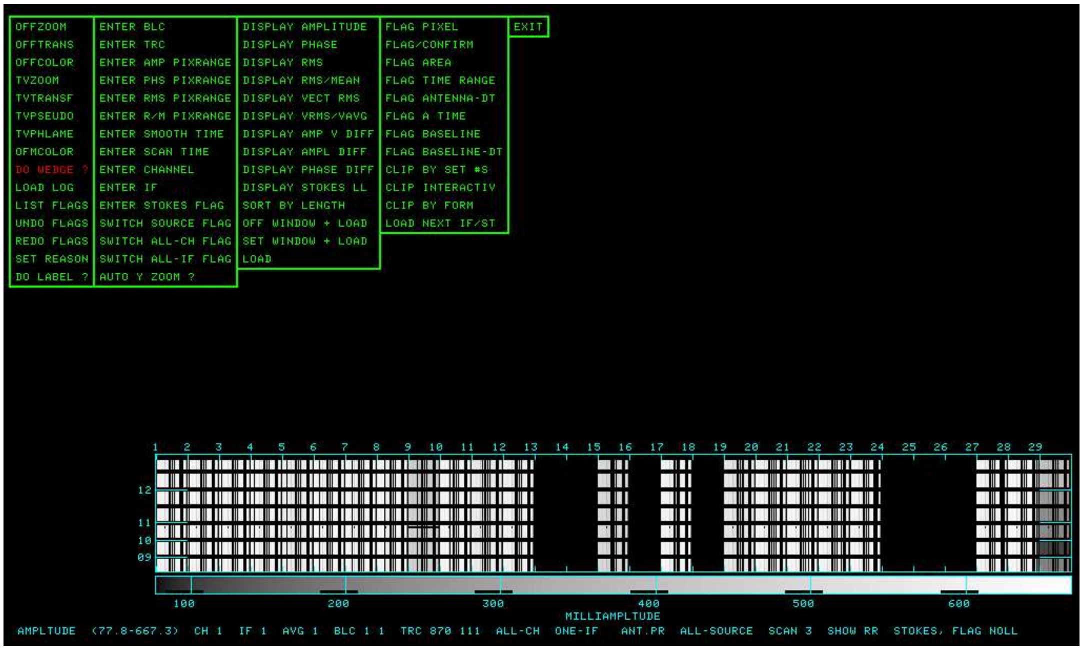


Figure 3: Initial display of data after `DO LABEL?` and `DO WEDGE ?` were used. Each baseline appears twice (`DPARM(3)`$>$ 0) which makes the high and low amplitudes easier to assign to an antenna. This is an old VLA data set which included the Pie Town antenna called VLA antenna 29 and only 111 times including the scan gaps.

long gaps in time are represented by no more than 5 blank rows. The third axis in the master grid is the Stokes included which can be 1, 2, or 4 in number. The fourth axis is frequency (the spectral channels left after `BCHAN`, `ECHAN`, `NCHAV`, and `CHINC`). The fifth axis is the IF or spectral window range set by `BIF` and `EIF`.

Only one table, the `FC` table, is attached to this file. Its contents are the same as those already described for `SPFLG`.

4.3 Running `TVFLG`

After `TVFLG` finishes building the master grid, it loads the requested plane from the grid to the display screen. By default this is the first Stokes value, first spectral channel, and first IF. The loaded data are smoothed in time from the master grid's integration time enough so that the resulting image fits on the TV display. This initial screen is illustrated in Figure 3 where the data have not been smoothed because all of the rows in this modest data set fit easily.

Like `SPFLG`, `TVFLG` displays an important text line at the bottom of the screen. Parameters 1, 3, 4, 5, 6, 7, 10, 12, and 13 can show asterisks if appropriate. Parameter 2 changes on loads, the others change as soon as they are invoked. It contains

1.	Data type, *e.g.*, `AMPLITUDE`, `VEC DIFF`, et al.
2.	Intensity range *e.g.*, `(-0.42-77.66)` mJy in this case
3.	Spectral channel number *e.g.*, `CH 1)`
4.	IF number *e.g.*, `IF 1`
5.	Time averaging in units of `DPARM(6)`, *e.g.*, `AVG 2`
6.	Window bottom left corner *e.g.*, `BLC 1 1`
7.	Window top right corner *e.g.*, `TRC 870 111`
8.	Which spectral channels get flagged *e.g.*, `ALL-CH`, `ONE-CH`

9.	Which IFs get flagged *e.g.*, `ONE-IF`, `IF02-03`, `ALL-IF`
10.	Baseline sort order *e.g.*, `BLNUMB`, `LENGTH`, `ANT.PR` (both $n-m$ and $m-n$)
11.	Which sources get flagged *e.g.*, `ALL-SOURCE`, `ONE-SOURCE`
12.	Scan time in units of `DPARM(6)` *e.g.*, `SCAN 12`
13.	Current polarization *e.g.*, `SHOW RR STOKES`,
14.	Which polarizations get flagged *e.g.*, `FLAG NOLL`

The displayed menu is very similar to that of `SPFLG`. The menu columns will be listed here but the discussion of them will be truncated when it would not be different from that already done for `SPFLG`.

The left-most column of the menu contains the same options as `SPFLG` other than the `LIST BASLS` operation is omitted.

`OFFZOOM`	turn off any zoom magnification
`OFFTRANS`	turn off any black & white enhancement
`OFFCOLOR`	turn off any pseudo-coloring
`TVZOOM`	interactive image zooming as in `AIPS`
`TVTRANSF`	black and white enhancement as in `AIPS`
`TVPSEUDO`	many pseudo-colorings as in `AIPS`
`TVPHLAME`	many flame-like pseudo-colorings as in `AIPS`
`OFMCOLOR`	very many OFM pseudo-colorings as in `AIPS`
`DO WEDGE ?`	switches choice of displaying a step wedge
`LOAD xxxx`	switch TV load transfer function to xxxx= `LOG`, `SQRT`, `LOG2`, and `LIN`
`LIST FLAGS`	list selected range of flag commands
`UNDO FLAGS`	remove flags by number from `FC` table and from the master grid
`REDO FLAGS`	reapply all flags to master grid
`SET REASON`	enter reason to be attached to flagging commands
`DO LABEL ?`	turns on/off axis labeling
`CHAR MULT`	set the character size multiplier

The second column of the menu contains the options

`ENTER BLC`	Type in a `BLC` in pixels on the terminal
`ENTER TRC`	Type in a `TRC` in pixels on the terminal
`ENTER AMP PIXRANGE`	Type in the intensity range to be used for loading amplitude images to the TV
`ENTER PHS PIXRANGE`	Type in the phase range to be used for loading phase images to the TV
`ENTER RMS PIXRANGE`	Type in the intensity range to be used for loading images of the rms to the TV
`ENTER R/M PIXRANGE`	Type in the value range to be used for loading rms/mean images to the TV
`ENTER SMOOTH TIME`	To enter the time smoothing length in units of the master grid y cell size
`ENTER SCAN TIME`	To enter the time averaging length for the "scan average" in units of the master grid y cell size
`ENTER CHANNEL`	To enter the desired spectral channel number using the terminal
`ENTER IF`	To enter the desired spectral window (IF) number using the terminal
`ENTER STOKES FLAG`	To type in the 4-character string which will control which correlators (polarizations) are flagged.
`SWITCH SOURCE FLAG`	To switch between having all sources flagged by the current flag commands and having only those sources included in this execution of `TVFLG` flagged.
`SWITCH ALL-CH FLAG`	To reverse the flag all channel status
`SWITCH ALL-IF FLAG`	To rotate the flag all IFs status from one IF to a range of IFs, to all IFs.
`AUTO Y ZOOM ?`	To switch between no zooming of the master grid and automatic zooming

This column is mostly the same as that used by `SPFLG`. The options to `ENTER BASELINE`, `ENTER CH SMOOTH` and `SWITCH BASLIN FLAG` are not appropriate in `TVFLG`. They are replaced by `ENTER CHANNEL` and `ENTER IF` which let you specify in the terminal window the spectral channel and spectral window (aka IF) to be

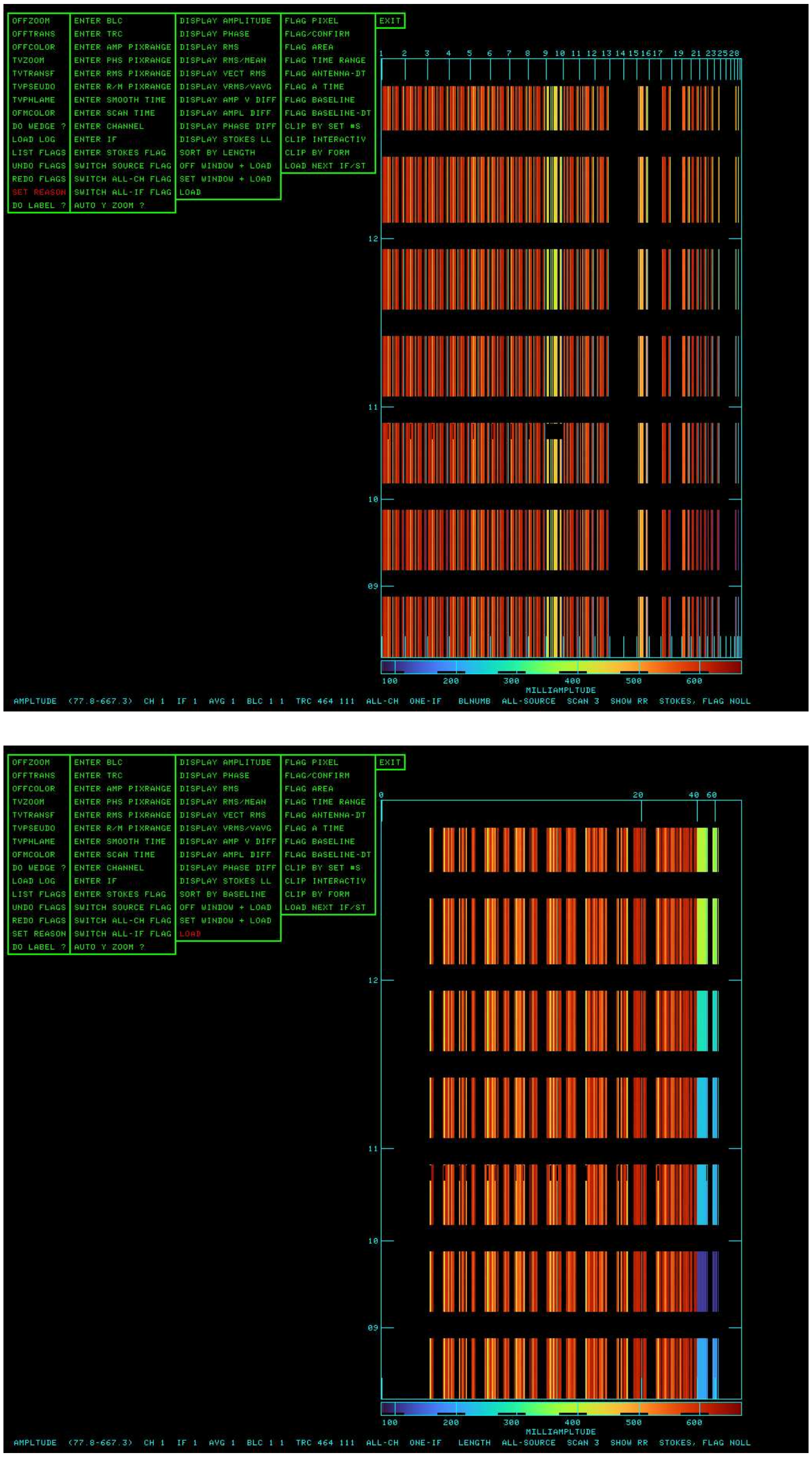


Figure 4: **Top:** Initial display of data after `DO LABEL?`, `DO WEDGE ?`, and `OFMCOLOR` were used to make these data more visible. Each baseline appears only once (`DPARM(3)`$= 0$) which makes the high and low amplitudes more difficult to assign to an antenna. This is an old VLA data set which included the Pie Town antenna called VLA antenna 29. **Bottom:** Same display after selecting `SORT BY LENGTH`. Note that the x axis is highly non-linear with baselines ordered by distance between antennas ignoring projection effects. The lower amplitudes at long baselines are now clear.

displayed next. These are the coordinates in the fourth and fifth axes, respectively, of the master grid. The `SWITCH ALL-CH FLAG` switches between having subsequent flag commands apply to the current spectral channel or to all spectral channels. The auto zoom option is changed to `AUTO Y ZOOM ?` since smoothing in the x axis between baselines is a bad idea.

Figure 4 illustrates the use of the auto zoom option which blows up the compact display of times to something much more manageable. The `OFMCOLOR` option with multiple hits of button B was used to select the "turbo" OFM color scheme which works well here. Note that both of these options are new in `TVFLG` in the `31DEC25` version of AIPS.

The third column of the menu contains the options to choose which aspect of the visibilities is displayed and to load the image to the display. It contains

`DISPLAY AMPLITUDE`	To display amplitudes on the TV
`DISPLAY PHASE`	To display phases on the TV
`DISPLAY RMS`	To display scalar amplitude rms on the TV
`DISPLAY RMS/MEAN`	To display scalar amplitude rms/mean on the TV
`DISPLAY VECT RMS`	To display vector amplitude rms on the TV
`DISPLAY VRMS/VAVG`	To display vector amplitude rms/mean on the TV
`DISPLAY AMP V DIFF`	To display the amplitude of the difference between the data and a running (vector) "scan average"
`DISPLAY AMPL DIFF`	To display the abs(difference) of the amplitude of the data and a running scalar average of the amplitudes in the "scan"
`DISPLAY PHASE DIFF`	To display the abs(difference) of the phase of the data and the phase of a running (vector)"scan average"
`DISPLAY STOKES xx`	To switch to Stokes type xx (where xx can be RR, LL, RL, LR, etc. as chosen by the `STOKES` adverb)
`SORT BY xxxxxxxx`	Reload TV with the x axis data (baseline) ordered by `LENGTH` or by `BASELINE` number
`OFF WINDOW + LOAD`	Reset the window to the full image and reload the TV
`SET WINDOW + LOAD`	Interactive window setting (like `TVWINDOW`) followed by reloading the TV
`LOAD LAST PIECE`	Load the previous overlapping piece of the data
`LOAD NEXT PIECE`	Load the next overlapping piece of the data
`LOAD`	Reload TV with the current parameters

This column does not contain the `LOAD NEXT BASELINE` and `LOAD LAST BASELINE` options of `SPFLG` but does contain either the `SORT BY LENGTH` or the `SORT BY BASELINE` options. The former option appears in the menu when the x is ordered by baseline number, *i.e.*, $1-2, 1-3, 1-4, \ldots\ 1-29, 2-3, 2-4, 2-5, \ldots\ 2-29, 3-4, 3-5, \ldots\ 28-29$ as shown in Figure 4 which was created with `DPARM(3)`$\leq\ 0$. If the length option is selected, the baselines are ordered by the distance between the antennas as listed in the antenna file. This ignores the actual projected baseline lengths which vary with time and do not retain their order as time changes. Note the preponderance of short baselines in the VLA as shown in the bottom half of Figure 4.

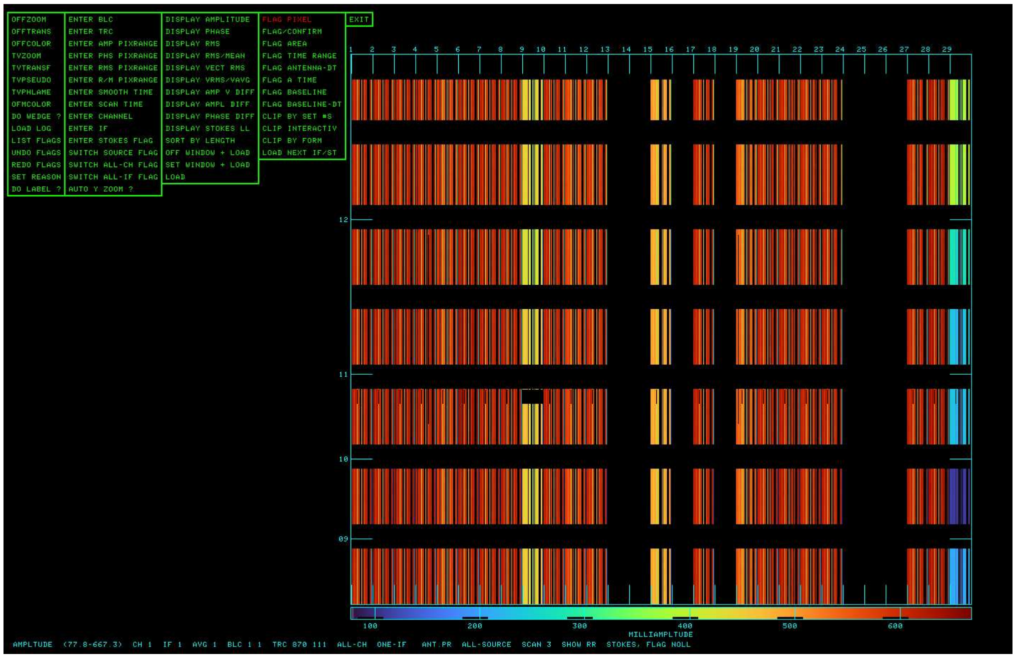


Figure 5: Display of data after DO LABEL?, DO WEDGE ?, OFMCOLOR and AUTO Y ZOOM ? were used to make these data more visible. Each baseline appears twice (DPARM(3)$>$ 0) which makes the high and low amplitudes easier to assign to an antenna.

The fourth column lets you generate flag commands and to change rapidly the spectral channel, IF, or Stokes displayed.

FLAG PIXEL	To flag single pixels
FLAG/CONFIRM	To flag single pixels, but request a yes or no on the terminal before proceeding
FLAG AREA	To flag a rectangular area in Channel-T
FLAG TIME RANGE	To flag all baselines for a range of times
FLAG ANTENNA-DT	To flag all baselines to an antenna for a range of times
FLAG TIME	To flag all baselines for a specific time
FLAG BASELINE	To flag all times for a specific baseline
FLAG BASELINE-DT	To flag a specific baseline for a range of times
CLIP BY SET #S	To enter from the terminal a clipping range for the current mode and then clip
CLIP INTERACTIV	To enter with the cursor and LUTs a clipping range for the current mode and then clip the data
CLIP BY FORM	To clip selected baselines using the "method" and clipping range of some previous clip operation
LOAD NEXT IF/ST	Load TV with next spectral IF or polarization
LOAD NEXT CHAN	Reload the TV with current parameters except the next higher spectral channel
LOAD PREV CHAN	Reload the TV with current parameters except the next lower spectral channel

The 3 flag channel operations of SPFLG are replaced by 3 flag baseline or antenna operations in TVFLG. The FLAG ANTENNA-DT operation starts by requesting an antenna number using the terminal window. Then the vertical cursor position selects the begin and end times of the interval. Use buttons A and B to switch which is being set, button C to exit flagging the data, and button D to exit with no flagging. FLAG BASELINE uses the horizontal cursor position to select the baseline to be flagged. Buttons A and B cause a flag to be generated, button C also generates a flag but then exits, and button D exits without generating any more flags. FLAG BASELINE-DT uses the cursor horizontal position to select a baseline and vertical position to select the begin and end times of the time range. Button A selects which of the 2 limits is being set, button B creates a flag and continues the operation, button C creates a flag and exits, and button D exits creating no more flags. As with all flag operations, instructions will appear on the message terminal.

Three more operations are offered to allow faster movement through the master grid. `LOAD NEXT IF/ST` loads the display with the next IF keeping the current Stokes and spectral channel unchanged. When the IF exceeds `EIF`, it is changed to `BIF` and the Stokes number is increased if possible. `LOAD NEXT CHAN` and `LOAD LAST CHAN` increment or decrement the spectral channel number by one and reload the display. These three options immediately reload the display with the changed channel, IF, or Stokes. Note that the last 2 of these options do not appear in the figures because the data set had only one spectral channel. (`ENTER CHANNEL` does appear in the menu, but with this data set is a no-op.)

Figure 5 illustrates the effect of creating the master grid with `DPARM(3)`> 0. In this case, the baseline order is $1-2, 1-3, 1-4, \ldots\ 1-29, 2-1, 2-3, 2-4, \ldots\ 2-29, 3-1, 3-2, 3-4, \ldots\ 29-29$. The lower amplitudes of antennas 9 and 15 are now obvious as well as the reduction in the visibility amplitudes in the longest baselines (those to the Pie Town antenna 29).

The fifth column contains only

`EXIT`	Go resume `AIPS` and enter the flags in the data