A I P S L E T T E R

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A newsletter for users of the NRAO
Astronomical Image Processing System

Written by a cast of *AIPS*

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General developments in *AIPS*

Current and future releases

We now have formal *AIPS* releases on an annual basis. Beginning near the end of 2004, we have made available full binary installation methods for both the frozen and development versions for MacIntosh OS/X (PPC), Solaris, and Linux. A binary release of `31DEC06` is now available for MacIntosh OS/X with the Intel cpu chip. All architectures can do a full installation from the source files. The next release is called `31DEC06` and remains under active development. You may fetch and install a copy of this version at any time using *anonymous* `ftp` for source-only copies and `rsync` for binary copies. This *AIPSLetter* is intended to advise you of developments to date in this new release. Having fetched `31DEC06`, you may update your installation whenever you want by running the so-called "Midnight Job" (MNJ) which uses transaction files to copy and compile the code selectively based on the code changes and compilations we have done. The MNJ will also update sites that have done a binary installation using `rsync`. There is a guide to the install script and an *AIPS* Manager FAQ page on the *AIPS* web site.

The MNJ serves up *AIPS* incrementally using the Unix tool `cvs` running with anonymous ftp. The binary MNJ also uses the tool `rsync` as does the binary installation. Linux sites will almost certainly have `cvs` installed; other sites may have installed it along with other GNU tools. Secondary MNJs will still be possible using `ssh` or `rcp` or NFS as with previous releases. We have found that `cvs` works very well, although it has one quirk. If a site modifies a file locally but in an *AIPS*-standard directory, `cvs` will detect the modification and attempt to reconcile the local version with the NRAO-supplied version. This usually produces a file that will not compile or run as intended.

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Patch Distribution for 31DEC05

Important bug fixes and selected improvements in 31DEC05 can be downloaded via the Web beginning at:

http://www.aoc.nrao.edu/aips/patch.html

Alternatively one can use *anonymous* ftp to the NRAO server ftp.aoc.nrao.edu. Documentation about patches to a release is placed on this site at pub/software/aips/*release-name* and the code is placed in suitable subdirectories below this. As bugs in 31DEC06 are found, they are simply corrected since 31DEC06 remains under development. Corrections and additions are made with a midnight job rather than with manual patches. The patch system has changed because we now have binary installations. We now actually patch the master version of 31DEC05, which means that a MNJ run on 31DEC05 after the patch will fetch the corrected code and/or binaries rather than failing. Also, installations of 31DEC05 after the patch date will contain the corrected code.

The 31DEC05 release had a few important patches most of which were released in April when we changed the patch system. All changes were made on 2006-02-21 and are

1. DBCON did not handle differences in frequency increment between FQ entries properly when changing reference channel to 1
2. DSMEAR subroutine did not handle FQ ID 0 correctly, affecting VLBI data with significant delays
3. SAD had an error in round off for RA and Dec display
4. WIPER did not handle source ID numbers correctly causing elevation et al. to be incorrect on single-source files
5. SETFC had a mathematical error in setting the X coordinate of boxes around NVSS sources
6. INTERPLATE subroutines assigned a LONGINT to an INTEGER causing trouble on AMD-64s

Improvements of interest in 31DEC06

We expect to continue publishing the *AIPSLetter* approximately every six months along with the annual releases. There have been quite a few changes in 31DEC06 in the last six months. Many have been the usual bug fixes, but there have also been a number of new verbs, tasks, and procedures as well as significant improvements in existing tasks. New tasks include ANBPL which plots and prints *uv* data, particularly weights, converted to antenna-based values, UVHIM which constructs images of two-dimensional histograms of *uv* data, and DDBGR which displays the contents of disk files for debugging purposes. New verbs include PLGET which sets a task's adverbs to those used when making a selected plot file, DELBOX which deletes Clean boxes in CLBOX interactively, DFILEBOX which deletes Clean boxes in a BOXFILE interactively, and GETPOPSN which returns the *POPS* number of the AIPS session for use in procedures. New RUN file procedures include STUFFR which merges multiple days worth of *uv* data into a much more compact data set and PEELR which performs a nearly magical self-calibration of image facets containing "interfering" sources. *AIPS* support for MacIntosh OS/X systems using Intel cpu chips has been implemented including binary installations based on the Intel compiler.

31DEC04 through 31DEC06 use a new numbering scheme for magnetic tape logical unit numbers that is incompatible with previous versions. Thus all tape tasks and the server TPMON must be from one of these three releases. Other than this, 31DEC06 is compatible in all major ways with the with the 15OCT98 and later releases. There are significant incompatibilities with older versions.

UV data calibration and handling

Amplitude Calibrator Models for the VLA

It is well known that the main amplitude calibrators for the VLA are resolved at most frequencies and configurations. Where they are not heavily resolved (*e.g.*, L-band D-array), there are confusing sources. The best way to determine the amplitude calibration of the VLA antennas directly is to use detailed models of the source structure of these calibrators. See as an example the first of the color pages at the end of this *AIPSLetter* which shows an image and *uv* plot of 3C48 at X band.

In the `30JUN04` edition of the *AIPSLetter* we announced the availability in *AIPS* of VLA flux calibrator models for the 3 highest frequency bands observed with the VLA. Here we announce the availability of flux calibrator models for all bands from K through L of 3C48 and 3C286, all bands K through C for 3C138, in addition to the models for K, Q and U for 3C147. Additional models for 3C138 and 3C147 at the lower frequencies will become available over the next year. To see what models are available in *AIPS* type `CALDIR`; to load a model use the task `CALRD`. The models shipped with *AIPS* are postage stamps of the central source and all Clean Components. The full model images and components are available for download from `http://www.aoc.nrao.edu/~cchandle/cal/cal.html` (Q, K and U-bands) and `http://www.aoc.nrao.edu/~amiodusz/vlacal.html` (X, C and L-bands)

Now that most VLA primary flux calibrators have models, their use should be the default when calibrating amplitudes on the VLA. See the updated Chapter 4 of the*AIPS CookBook* for details on this. As mentioned above, the VLA primary flux calibrators are resolved at most frequencies and configurations. Even in the configurations and frequencies where they are not resolved there are many confusing sources, so in *all situations* a model will make the flux calibration more accurate. When models are used, there is no need to limit the *uv* range or antennas when running `CALIB`, which in turn will make automated data reduction easier. For example, the *AIPS* pipeline procedure `VLARUN` automatically uses the models if they exist.

ANBPL

`ANBPL` or "antenna-based plot" is a new task to print and plot antenna-based quantities determined from baseline-based visibilities. weights, amplitudes, phases, reals, and imaginaries computed in a couple of ways can be plotted against time, elevation, hour angle, azimuth, and parallactic angle. The plots are similar to ones from `VPLOT` and the printed outputs are in the `LIST` form of `LISTR` more or less with user control of the number of digits. Plots of weight against time have been found to be a very good diagnostic of difficulties in calibration and self-calibration. In fact, a user commented that "it is scary to think how long we have used the VLA without this task."

VLARUN

Lorant Sjouwerman has developed a pipeline to edit, calibrate, and image VLA data. A preliminary version of this pipeline has been available in *AIPS* for several years, but a new, more complete version was released in March. The `RUN` file `VLARUN` compiles a number of procedures including the main user-level procedure also named `VLARUN`. The pipeline begins by doing some automatic flagging using `QUACK` and `FLAGR` in its `TIME` mode. Then it runs `SETJY` to clear the source table and calculate fluxes for standard calibrators or set user-specified fluxes. Then `CALIB` is run for phases using calibrator models where available and the `CL` table updated with `CLCAL`. `CALIB` is then run for amplitudes on phase-calibrated data using models where available, `GETJY` determines the secondary calibrator fluxes, and `CLCAL` again updates the `CL` table. For line data, tables are copied to the spectral-line *uv* file and `BPASS` is run to determine a bandpass function. In the imaging phase, the data are `SPLIT`, imaging parameters are determined with `SETFC` including if needed multi-facet `BOXFILE`s, and then `IMAGR` run to make images of all sources in the data set. If requested, `SCIMG` is used instead of `IMAGR` to do several cycles of imaging with self-calibration.

There seems to be a widespread distrust of pipeline data reductions. Nonetheless, these systems are capable of producing quite good results in favorable cases. In fact, it usually fails only when there are serious problems with the data such as bad atmosphere or ionosphere, absorption lines in the bandpass calibrators, and the like. A number of images produced by `VLARUN` with no hand massaging are reproduced on the second color page at the end of the *AIPSLetter*. At present, `VLARUN` has quite a number of adverbs to allow the user to limit what the procedure attempts to do. It produces a large number of plots which the user may view to determine if the results look reasonable. Future developments in this pipeline will include tools to examine the calibration tables for the user and tools to calibrate and image polarization when appropriate. Pipelines are intended to produce a "standard product" of calibrated data and images for archiving with little or no human intervention. As such, they are not expected to allow truly interactive operations including hand editing of *uv* data, hand setting of Clean boxes, and the like. Nonetheless, it should not be too hard to offer a version with more extensive interactivity that could allow these and other interactions for users processing their own data. When used by the observer, VLARUN may be executed once simply to identify bad data and then re-executed after manual editing. This should yield a nicely calibrated data set to start self-calibration.

VBGLU and VBMRG

The VLBA correlator is in the process of being converted entirely to Mark 5 (disk-based) playback. The number of playback units is still limited and so it may be necessary for multiple passes through the correlator in order to correlate all antennas with all other antennas. Inevitably, many baselines will be repeated between these passes. Users in this situation, should load all of their data to disk with FITLD. The multiple passes must be concatenated, which can be done by FITLD or, after loading into separate files, by DBCON. The old task VBMRG has been resurrected and modernized in 31DEC06 to strip out duplicate correlations from such data sets after they have been sorted into BT order by UVSRT.

The bandwidth of the VLBA correlator is also limited. In order to achieve wider bandwidth, different frequencies may be correlated in separate passes through the correlator. These frequencies may be put into a full bandwidth data set with VBGLU. In 31DEC06, VBGLU was re-written with more efficient algorithms which recover all of the input data even if the input data sets are not identical. Previously, only those times present in the first input data set appeared in the output data sets and there were significant errors when the later data sets had more than a few times not appearing in the first data set.

STUFFR

Deep integrations on chosen fields are currently very popular in astronomy. Radio observations of this type usually involve multiple days on the same pointing position with the same array configuration. After doing an initial round of editing, calibration, and self-calibration on each day individually, it is normal to want to combine all days' data in order to do the final imaging. For efficiency, these enormous data sets need to be compressed in some way. The new RUN file named STUFFR compiles a procedure of the same name to perform this operation. The procedure loops through the input files changing the times to hour angles with TI2HA, sorting into BT order, altering the observation date, and concatenating with DBCON. The final full data set is then time averaged using a baseline-dependent integration time with UBAVG and is finally sorted back into TB order with UVSRT. Like PEELR described below, this procedure only implements things that have been available in *AIPS* for some time. However, it does it efficiently, deleting all temporary files as soon as they are no longer needed, and it does it without the errors that are so easy to make when one attempts a complicated sequence by hand.

Other *uv*-editing matters

UVFLG was changed so that the UFLG operation uses all adverbs including REASON in a very general way, making the REAS option meaningless.

FLAGR was overhauled to perform its operation on up to four polarizations as selected by the user. Apparently, RFI is sometimes much more visible on the cross-hand polarizations.

WIPER was changed to plot axis labels when possible in its display. It was revised to allow simultaneous editing of both parallel-hand polarizations. History-file writing was added and an error causing it to fail to find elevations and the like for single-source files was corrected.

EDITR and EDITA were changed to offer the choice of flagging the current source or all sources. Corrected error that caused it to fail to find the nearest point when the user pointed exactly at it.

TVFLG was revised to offer the options to LOAD NEXT CHAN and LOAD PREV CHAN to speed editing of a multi-channel data set.

SNEDT was changed to allow editing TY tables as calibration tables. A SET VALUES function was added for both table types and a number of problems affecting "crowded" displays in particular were corrected.

Other *uv*-display matters

UVHGM was overhauled to support the full range of calibration adverbs and more `STOKES` values and to offer the option to fit the histograms with Gaussians.

UVHIM is a new task to compute a two-dimensional histogram of a *uv* data set. It write this out as a standard image making all image display functions available. The two axes of the image are chosen from visibility real, imaginary, amplitude, phase, and weight, time, and baseline u, v, w, length, and position angle. For example, an image of visibility real versus imaginary will illustrate the amplitude and phase stability (or lack thereof)

BPLOT was given a `PDIF` option to difference phase with average phase rather than doing vector differences. The option to compute the differences over the full time range in the `BP` file while plotting only a limited time range was added. An additional coloring option was added to have color represent intensity rather than time or antenna. This allows more closely spaced lines. A number of labeling problems were corrected.

LISTR had a bug which caused times to appear different when they actually were not. This caused `GAIN` displays to display each antenna on a separate line rather than in the desired list form.

Other *uv*-related matters

DOCALIB was changed in meaning so that all positive values ≤ 99 cause both the data and the weights to be calibrated. Use `DOCALIB = 100` to avoid calibrating old-style weights that do not depend on system temperature. The change was made because it was too easy to enter `DOCALIB TRUE` and, erroneously, fail to calibrate the weights.

CALIB was changed to report closure errors in excess of `MINAMPER` and `MINPHSER` only when they are "significant." Significance is judged by `CPARM(7)` times the expected error as determined from the weights.

SPLAT was changed to use adverb `CHINC` along with `CHANNEL` when averaging output channels. This allows selecting, for example, every other channel from smoothed spectra. It was also changed to make a multi-source output file when requested even if there is only one source included.

APCAL was changed to use robust methods for fitting the opacity and to test that the answers are reasonable. If they are not, the task reports this and quits. Certain labeling problems were also corrected.

CPASS was changed to convert the parameterized bandpass into a fully-evaluated, normal bandpass by default. Time averaging will then be applied to normal complex values rather than to Chebyshev polynomial parameters.

CLCAL was changed to append calibrator data for a missing source only if those data are outside the pre-existing range for the calibrator source and to tell the user what it is doing. It was also changed to extrapolate calibrations more carefully. Several methods other than `2PT` used the times directly and so did rather extreme extrapolations rather than a the limited extrapolation intended.

FILLM was revised to mark EVLA antennas as such in the `AN` file and to know about the Master Pad which has been used for the first time for observing.

DBCON, `SPLIT`, and `SPLAT` were changed to allow for different frequency increments in different IFs (*e.g.*, opposite signs). The calibration code now also selects the increment of `BIF` for the output header.

VLBI calibration correction for amplitude loss due to significant delays was corrected. It did not function correctly when there was only 1 `FQID` value.

SPLIT was corrected for a bug that caused it to fail for all subsequent sources when a source in the list had no data.

Imaging

IMAGR

In the previous *AIPSLetter* a number of changes to *AIPS* to enable spectral-index imaging were described. To enable testing, tasks IMMOD and UVMOD were changed to include more model components and to include spectral-index, respectively. MCUBE was modified to build "cubes" with an FQID axis including images at an arbitrary set of frequencies. Then the new task SPIXR was written to fit a spectral index image and, optionally, a spectral index curvature image to the transposed cube. In 31DEC06, IMAGR was revised to accept these two images as inputs. When this option is invoked, IMAGR will compute a separate (and temporary) model for each spectral channel adjusting each Clean component to correct the intensity for spectral index and, if requested, primary beam. The component subtraction is then done, one channel at a time, using the corrected model. To reduce the cost of this option, more than one channel may be done with the same model under control of the adverb FQTOL. Since spectral-index images can be uncertain, this option is invoked by setting IMAGRPRM(17) to a radius in pixels over which the images are averaged for each component. The primary-beam correction code was improved to recognize the VLA and ATCA and use the best-fit parameters available for these telescopes.

The spectral-index correction is significant. In a test model over a frequency range suitable to the EVLA, the individual channel images had noises which ranged from 0.83 to 2.08 mJy/beam depending directly on frequency. (Note that, for spectral-index fitting to work, each channel must be forced to have the same Clean beam and that this is then partially responsible for the frequency dependence of the image noise.) When the frequencies were combined in a normal bandwidth synthesis, the noise jumped to 33 mJy/beam with very visible systematic imaging defects. When the new option to correct for spectral index was used, the bandwidth synthesis noise was reduced to 2.2 mJy/beam. When the full spectra index and curvature images were used, the noise dropped to a very gratifying 0.49 mJy/beam. With the same model, but a range of frequencies which is normal for the VLA, the noise figures were 0.9 mJy/beam for the individual channels, 10 mJy/beam for the classical bandwidth synthesis, 0.56 mJy/beam for correction of spectral index, and 0.49 mJy/beam for correction also of the curvature.

A number of other changes were also made to IMAGR. The adverbs ANTENNAS and BASELINE were added to enable selective inclusion or deletion of specific antennas or baselines. The option to delete Clean boxes interactively was added to the TV menu. The maximum patch size for minor-cycle Cleaning was doubled to 2048 and the maximum beam size was raised to 4096 on a side.

PEELR

PEELR is a new RUN file which compiles a procedure of the same name. PEELR is intended to reduce the effects of "interfering" sources in multi-field imaging. Particularly at low frequencies, we find sources well away from the field center that contribute substantial sidelobes and other imaging defects in the areas of greater scientific interest. This is illustrated in the image of Abell 2256 shown on the left in the color sections at the end of this *AIPSLetter*. The source at (α, δ) = (17:01:09.0, 79:32:40) is in the first outer sidelobe of the single-dish beam pattern and still contributes significant sidelobes within the central position of the image. The calibration of this interfering source is not the same as the average calibration at the center of the field due to a variety of effects including pointing, antenna phasing, and ionosphere. PEELR attempts to remove all other sources from the data set, self-calibrate the one field, subtract that field from the self-calibrated data, and then undo the field-specific calibration from the residual data. PEELR can then loop for more fields and, finally, it restores all fields to the adjusted residual data.

PEELR simply combines existing tasks, but achieves considerable efficiency from doing operations over all fields only at the beginning and the end and from avoiding the errors that are so easy to make when one tries to do such a compound operation by hand. The results are quite amazing. Correcting the worst fields often reduces the apparent random noise, but, even when it does not, it clearly removes sidelobes and other small- and large-scale defects from the image. This is illustrated in the color pictures of Abell 2256 in the color pages at the end of this *AIPSLetter*.

Other imaging matters

DELBOX is a new interactive verb that displays NBOXES worth of CLBOX on the TV and lets the user delete selected boxes.

DFILEBOX is a new interactive verb that reads a BOXFILE, displays the selected field's Clean boxes, allows the user to delete excess boxes, and then re-writes the BOXFILE.

SETFC was corrected and a patch issued for an error in setting the coordinates of boxes intended to surround sources from the NVSS or WENSS lists. The $\cos(\delta)$ was divided into the RA difference to compute a pixel offset; a multiplication is what is needed.

Data display

Color contours

PCNTR and KNTR were changed to offer the option of user-controlled color contours. They are implemented through the new adverb RGBLEVS(3,30) which specifies the red, green, and blue colors (0.0 to 1.0) of each of the 30 possible LEVS. If any of RGBLEVS is not zero, these tasks will draw color contours. This option is illustrated in the color plot of Cas-A at the end of the *AIPSLetter*. Note that this option serves the very real purpose of identifying contour levels without intrusive and difficult to read labels. It is not just a way to make excessively gaudy pictures.

Since the choice of values for RGBLEVS is a daunting task, a RUN file named SETRGBL was written. It compiles four procedures RAINLEVS, FLAMLEVS, CIRCLEVS, and STEPLEVS which will color your current LEVS following specified rules. They locate the dividing point in LEVS between positive and negative contours and work outward from there to color the least negative contour the same as the least positive contour and so forth. The first three divide a "rainbow" (TVPSEUDO), "flame" (TVPHLAME), and "circle" (TVPSEUDO button B) color pattern evenly from the least positive to the most positive contour (assuming that there are more positive than negative contours). The last takes an immediate argument from 5 through 10 and assigns that number of colors to the LEVS, repeating the pattern as needed. The plot of Cas-A used STEPLEVS(10) to color the nine positive contour levels with unique colors.

Other display matters

PLGET is a new verb to do a TGET for the adverbs used to make the selected plot file. The verb EXTLIST will show summaries of each plot attached to a *uv* or image file. Select a desired PLVER and the PLGET all of the plot's adverbs.

IMEAN now plots the Gaussian fit to the noise peak when it plots the histogram.

Analysis

MWFLT implements two new OPCODEs which output the MIN and MAX within the moving window. The algorithm was suggested by Rudnick, L. 2002, PASP, 114, 427 as a simple filter to separate smooth and small-scale structures in complicated sources. History writing, defaults, and ill-considered options were also corrected.

BLANK was supplied with a new option, RADI, to blank images outside a user-specified radius in arc seconds.

IM2UV was changed to offer alternative scaling options, to use the Clean beam in the header, and to create axes more acceptable to the *uv* software.

SAD was corrected to remove a bias of 0.0005 seconds of time and 0.005 seconds of arc when displaying celestial coordinates at increased precision.

IMPOS, IMVAL, and MAXFIT were corrected to return adverb COORDINA correctly at negative declinations even when the degree term is zero.

General and programming matters

GETPOPSN is a new verb which returns the current *POPS* number on the stack. It can be used to write procedures that can run in several `AIPS` sessions without interfering with each other.

CookBook was updated for all of the changes made during the last six months. See the *AIPS* web site for details.

DDBGR is a new stand-alone program to do complete binary dumps of user-selected data records in *AIPS* files. It is useful for debugging new ports of the code and disk formats.

MACINT is a new value of `$ARCH` supported in *AIPS*.

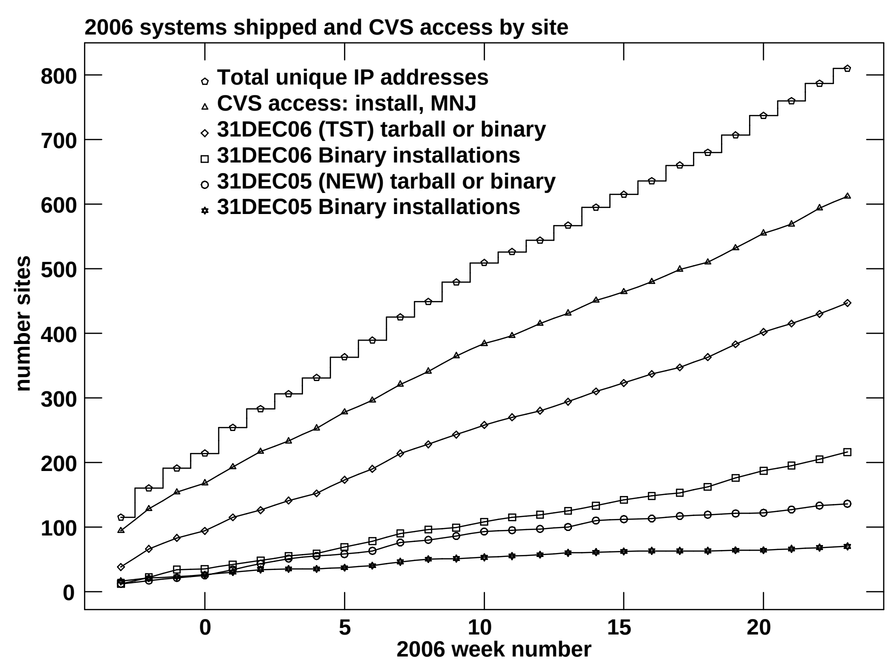
FITLD and all other table-reading tasks will support tables with the columns in any order and report any missing columns.

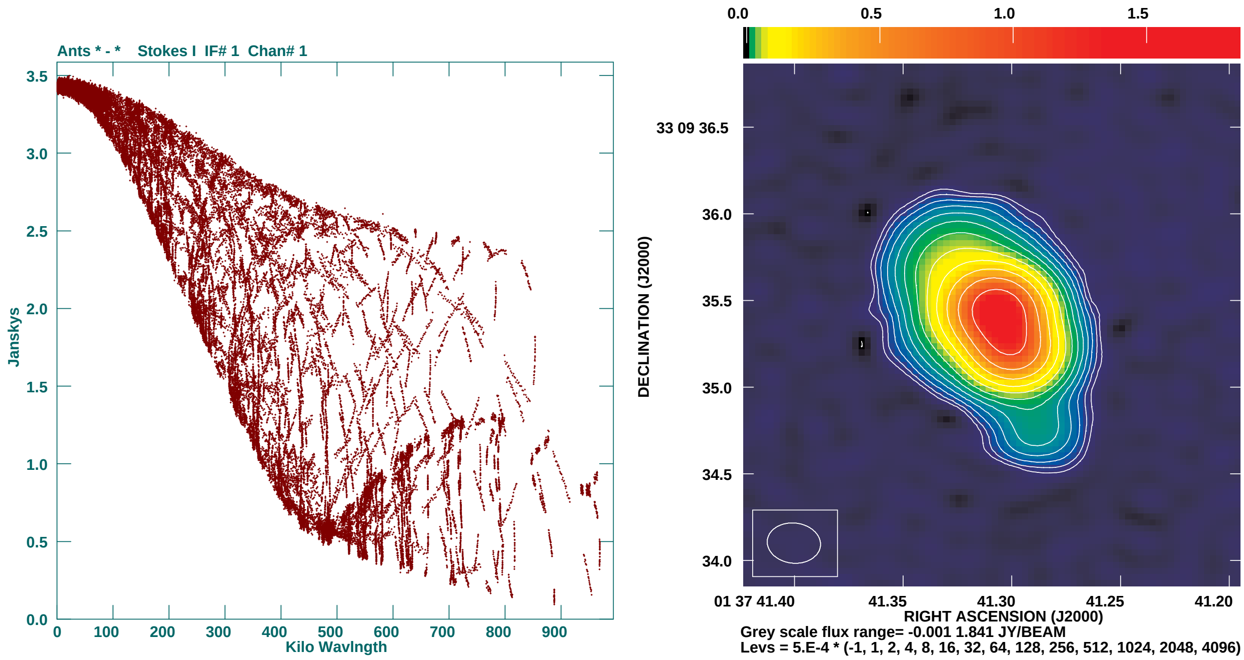
Plotting tasks may now invoke two new operations: `GCOMNT` to place comments in output PostScript files and `GCHDRW` to draw numbers, upper-case letters, and some special symbols as lines anywhere one may plot and in any color the calling task chooses. See Cas-A plot at the end of this *AIPSLetter*.

MNJ is now smart enough to avoid attempting to compile `XAS` for binary installation sites.

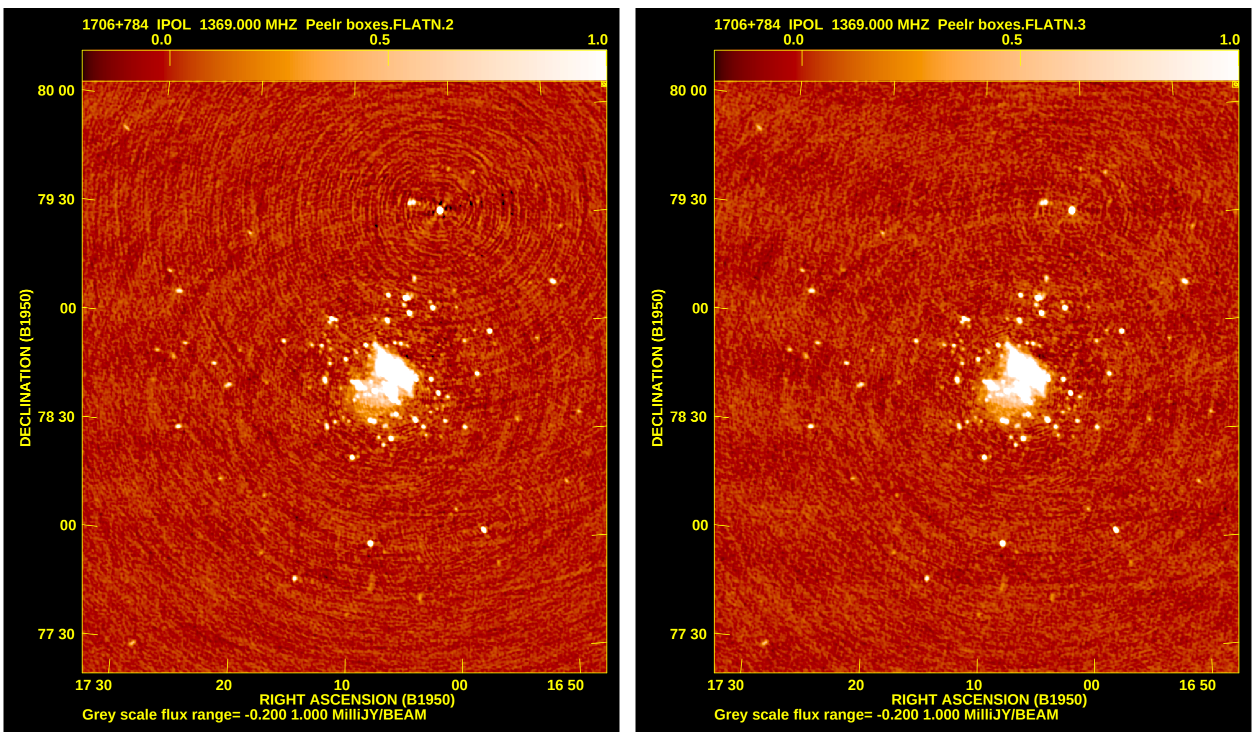
AIPS Distribution

We are now able to log apparent MNJ accesses and downloads of the tar balls. We count these by unique IP address. Since dial-up connections may be assigned different IP addresses at different times, this will be a bit of an over-estimate of actual sites/computers. However, a single IP address is often used to provide *AIPS* to a number of computers, so these numbers are probably an under-estimate of the number of computers running current versions of *AIPS*. In 2006, there have been a total of 612 IP addresses so far that have accessed the NRAO cvs master. Each of these has at least installed `31DEC06` and 186 appear to have run the MNJ on `31DEC06` at least occasionally. During 2006 more than 136 IP addresses have downloaded the frozen form of `31DEC05`, 70 in binary form, while more than 447 IP addresses have downloaded `31DEC06`, 216 in binary form. The attached figure shows the cumulative number of unique sites, cvs access sites, and binary and tar-ball download sites known to us as a function of week — so far — in 2006.

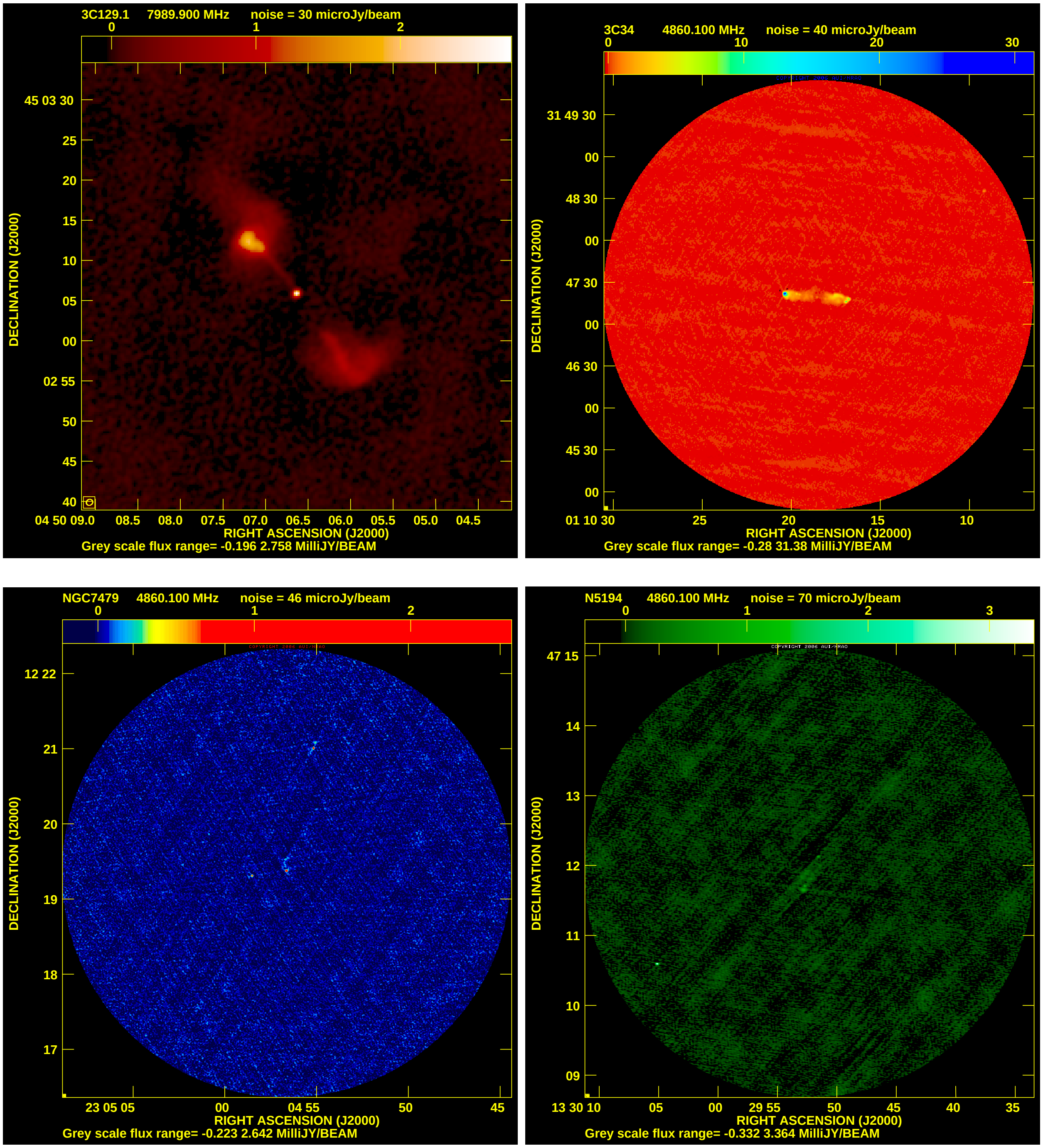




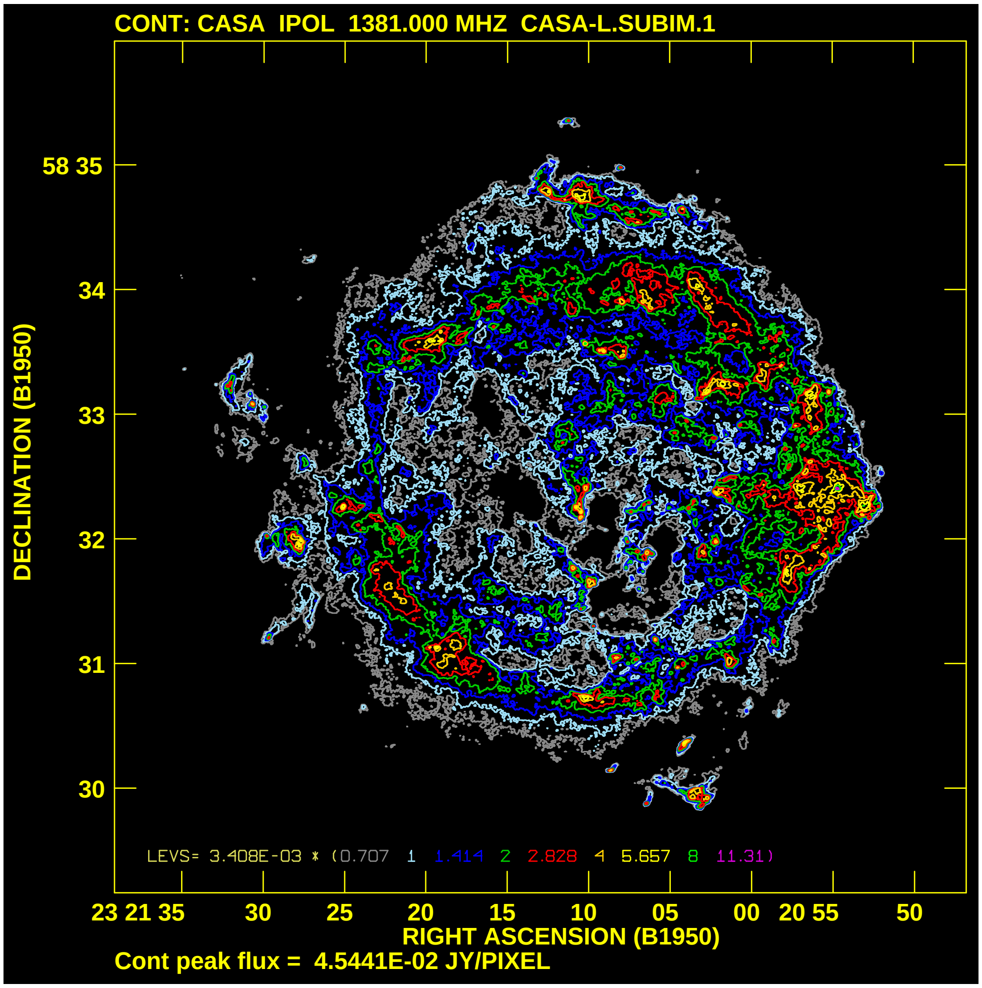
Displays of the visibilities (right) and image (left) for the fundamental calibration source 3C48. Data from all VLA configurations including the VLBA antenna in Pie Town were used. A point source would have visibilities that have a constant amplitude at all baselines and an image matching the beam plotted in the lower-left corner. Data and images processed by Amy Mioduszewski.



IMAGR images made with multiple fields (26) and multiple resolutions (3) of 1706+784 (Abell 2256). The image on the left was constructed from the original self-calibrated data. The image on the right was constructed after one pass of PEELR on the strong "interfering" source seen in the upper right of the image. This source is in the first sidelobe of the single dishes, not in the main beam. Note that the noise is the same in the two images, but that PEELR has removed some substantial systematic artifacts. Data are courtesy of Clarke, T. E., & Ensslin, T. A. 2006, AJ, 131, 2900.



Sample outputs from `VLARUN`, all processed directly with no self-calibration. The source name, coordinates, observing frequency, and rms noise (from `IMEAN`) are shown in the plots. The 3C129.1 image is a detail from the center; the others are the full image as processed for inclusion in the NRAO archive. The full intensity range is shown with a linear transfer followed by pseudo-coloring.

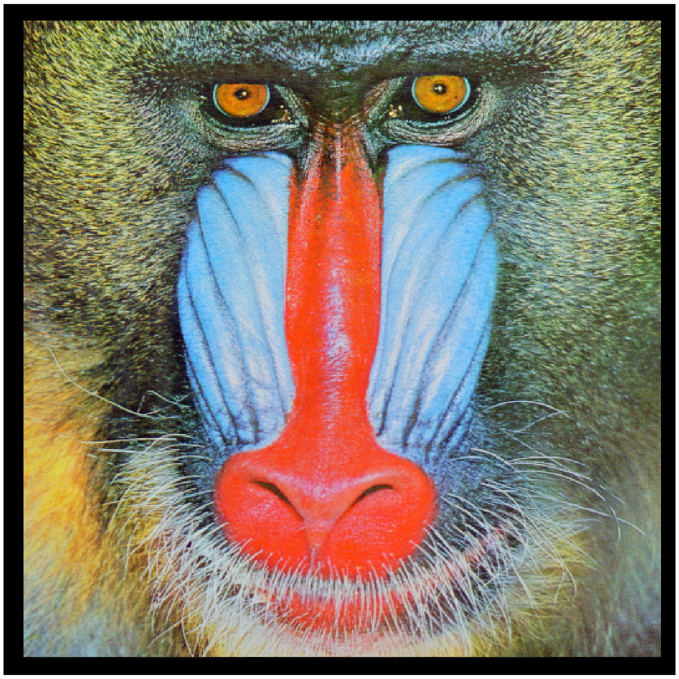



```
KNTR:  Task to generate a plot file for a contour & grey plot
DOCONT        1                     > 0 => do contours
                                    (1 or 2 => which name)
DOGREY       -1                     > 0 => do grey scale
                                    (1 pr 2 => which name)
DOVECT       -1                     > => do polarization vectors
                                    (1 or 2 => which is IPOL)
LTYPE       -13                     Type of labeling: 1 border,
                                    2 no ticks, 3 standard, 4 rel
                                    to center, 5 rel to subim cen
                                    6 pixels, 7-10 as 3-6 with
                                    only tick labels
                                    <0 -> no date/time
                                    special values for RGBLEVS
CLEV        0.003408                Absolute value for levs
                                       (used only if PLEV = 0).
LEVS          0.7071      1         Contour levels (up to 30).
              1.4142      2            2.8284      4
              5.6569      8           11.3137    *rest 0
CON3COL       0                     Color the contours by plane
```

```
RGBLEVS       0.2562     0.2562   Color each value of LEVS
              0.2562     0.3511      0.7297     0.9035
              0          0           1          0
              0.6205     0           1          0
              0          1           0.6205     0
              1          1           0          0
              0.8503     0           0.6594     0
              0.6594    *rest 0

LWPLA:   Sends plot file(s) to a PostScript printer or file
LPEN          3                   Pen width (dots).
RGBGAMMA      2.2        2.2      Gamma correction to apply
              2.2
OFMFILE     *all ' '              Color grey scales....
DOCOLOR       1                   Use PLCOLORS ?
PLCOLORS      1          1        Line, character, background
              0          0.06275  colors - see HELP.
              1          0           1          0.6706
              1          0           1          1
              0          0           0          0
              0          0           0          0
              0          0           0          0
              1          1        *rest 0
```

KNTR plots contours of Cassiopeia A with each contour level separately colored under control of adverb RGBLEVS. The values of RGBLEVS were set by a procedure call STEPLEVS(10) made available by RUN SETRGBL. The image is from the *Images from the Radio Universe* CD, 1992, NRAO with the particular image from Anderson M., Rudnick, L., Leppik, P, Perley, R. & Braun, R. 1991, ApJ, 373, 146.



June 30, 2006

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