VLBA AIPS Data Reduction

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AIPS Resources

- AIPS Cookbook contains a huge amount of information
  - can be found on-line at: www.aips.nrao.edu/CookHTML/CookBook.html
  - Chapter 9: Reducing VLBI Data In AIPS is best used as a reference
  - Appendix C: A Step-by-Step Guide to VLBA Data Reduction in AIPS is the best place to start
  - Chapter 3: Basic AIPS Utilities and Chapter 12: AIPS for the More Sophisticated User are also very helpful
  - There are also linked pdf version if you want to download a copy of the whole cookbook available at: ftp://ftp.aoc.nrao.edu/pub/software/aips/TEXT/PUBL/COOKBOOK.PDF

AIPS Help and Explain files

- Help files
  - inside AIPS you can type "help *taskname*" for information on the inputs to the task
- Explain files
  - inside AIPS you can type "explain *taskname*" which will give you everything you get with "help *taskname*" with the addition of more information
  - Explain files are available on-line, and you can click the task/verb name in the on-line and linked pdf Cookbooks.
  - The VLBA tutorial also contains links to the on-line explain files

AIPS Philosophy

Don't touch the data, do it all in tables

- AIPS has its own data structure. Inside AIPS you will have catalog with the data/image and all the associated tables under one name/catalog #
  - on disk these are actually separate files with not very human readable names associated with your AIPS number and catalog number.
- All calibration and flagging is done in tables
  - This means almost (almost) everything you do can be undone by deleting a table
  - Best practice is to always produce a new table

AIPS Tables

- The primary tables we will deal with are:
  - FG flag table
    - list of times, antennas, polarizations etc to flag
  - SN calibration solution table
    - output of most calibration tasks
    - contains incremental calibration steps
  - CL calibration table
    - contains all the calibration
    - you usually apply the latest SN table to the highest numbered CL table
- Other important tables:
  - TY – Tsys
  - GC – Gain curve
  - AN – Antenna
  - NX – Index (list of scans and time and sources)
  - FQ (frequency); HI (history); WX (weather)…

AIPS tasks/inputs/verbs

- "tasks" are the main programs used for calibration
  - each has a set of inputs that control what the task does
  - type "inp *taskname*" to see the inputs.
  - type "go *taskname*" to run the task
    - if you set the task (i.e., type "task '*taskname*') then you can just type "inp" or "go"
  - "verbs" are AIPS commands that you run by just typing their names, some have inputs but usually many fewer than AIPS task. Important verbs include:
    - getn *cat #*– get the name of a catalog # an put it in INNAME, INCLASS, and INSEQ
    - tget *taskname* – get the task and the inputs the last time the task was run (probably the most useful command in AIPS)
    - uc – list uvdata catalog
    - mc – list map (image) catalog

AIPS Procedures

- Most of the data reduction you will see today will use "procedures", which are scripts that put together AIPS tasks and verbs to do part of the calibration
- The set of procedures you will be using are called VLBAUTIL
- To use a procedure you must first load the procedure
  - type "run *procedure*" (e.g., run vlbautil)
  - to run the procedure you type the procedure name

VLBA data reduction

Basic steps (procedure/task)

1. Fix the data
   - sort, create index (NX) table, create first CL table and/or get the polarization or subarray labeling sorted if needed (none of this is needed for this tutorial) (VLBAFIX)
   - correct Earth Orientation Parameters (EOPs) (VLBAEOPS)
     - when the DiFX correlator correlates the data 1-2 weeks after the observation it uses the best EOPs available, but at a later date there are usually better ones. This improves phase referencing and astrometry and should be done on all phase referencing data
   - correct ionopheric delay (VLBATECR)
     - this is important mostly for lower frequencies ($\vartheta < 10GHz$)
     - based on models using gps measurements so not perfect

VLBA data reduction

Basic steps (procedure/task)

2. Amplitude and delay correction, note that the amplitude calibration procedure we will perform is different than in the past due to some changes in the amplitude performance of the rdbe system. You can use this procedure on old data, it will not hurt anything.
   - Correct for digital sampling threshold errors (VLBACCOR)
   - Remove instrumental delays (VLBAMPCL or VLBAPCOR)
     - Seen as phase "jumps" between IFs
   - Calibrate the bandpass shape (VLBABPSS)
   - Perform amplitude calibration (VLBAAMP)
     - Use Tsys and gain curves to finally set amplitudes.

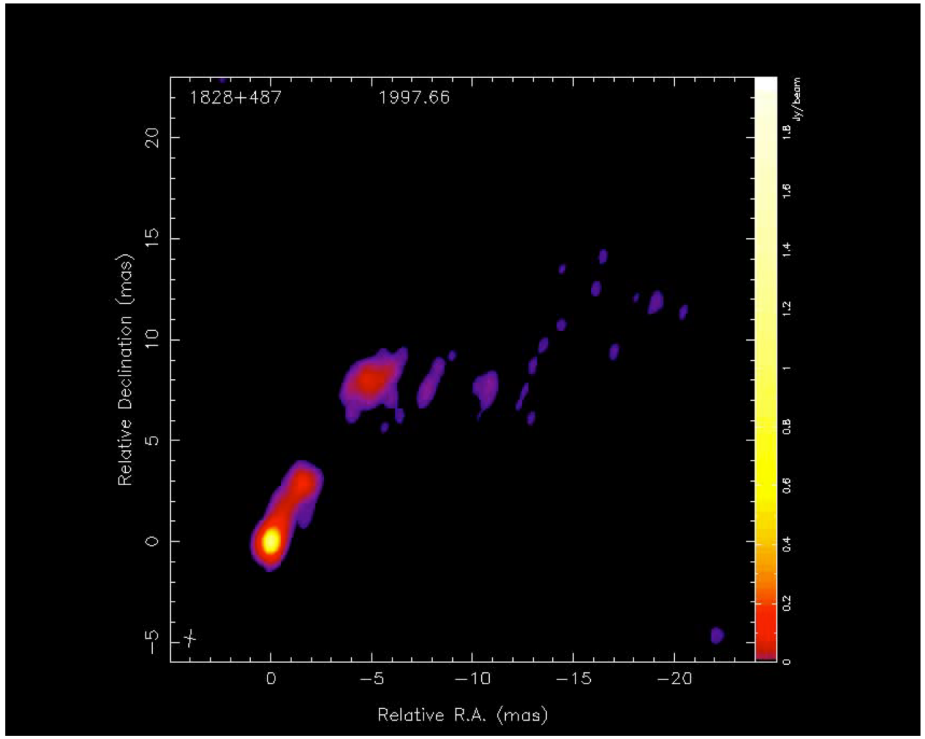
VLBA data reduction

Basic steps (procedure/task)

3. Calibrate time dependent phases, otherwise known as fringe fitting (FRING)
4. Apply all the calibration up to this point and if not spectral line observation average in frequency to reduce size of data.
   - create single source data sets with SPLIT
   - keep multi sources data sets by using SPLAT
5. Create image and "clean" it using IMAGR
6. Self-calibrate the data with CALIB

VLBA Tutorial

- The tutorial is at: https://go.nrao.edu/vlba-tut2
- This tutorial is a simple continuum and includes imaging and self-calibration
- The data includes 3 sources from an observation from the MOJAVE survey.
  - MOJAVE is a large VLBA project to monitor Active Galactic Nuclei at 15GHz and includes polarization. You can find more information on MOJAVE at http://www.physics.purdue.edu/MOJAVE/index.html
  - Includes 2 BL Lac objects and 1 quasar.
  - Original data had 22 targets, but 3 sources are copied out and the sources was averaged slightly in time and frequency so that the dataset is small.



To run aips on machines in Socorro using your visitor account

- Please find your "visitor account name" and "nmpost node" on sheet
- For instructions below: #### = Visitor account number XX= nmpost node number

(For example, my visitor account number is 1202 and assigned nmpost node number is 44)

- Now in a terminal window type:

1) ssh -Y nm-####@ssh.aoc.nrao.edu

2) ssh -Y nmpost0XX

3) vncserver -geometry 1200x1000 -depth 24

create vnc password

vnc will say something like (below is for my numbers):

New 'nmpost044:1 (nm-1202)' desktop is nmpost041:1

make note of number after ":", in above example it is 1; Y=1 for this case

4) exit

5) exit (back to original computer)

6) ssh -t -L 590Y:nmpost0XX:590Y nm-####@ssh.aoc.nrao.edu

use nrao visitor password

7) For Mac, connect to VNC server, server Address: vnc://localhost:590Y

8) Once window opens, click on redhat (lower left hand corner)

search "terminal"

click "Terminal"

VLBA Data Reduction Tutorial

In terminal in vnc window:

1. Set environmental variable:

   ```
   $ export MYAIP=~/data
   ```

2. Then start aips

   ```
   $ aips tv=local:0 pr=18
   ```

   Select printer 18, this is specific to the aips installation at NRAO Socorro, so will be different for different installations

3. aips will ask for your User ID number, use your visitor account number (or anything but 1).

4. Now you are in aips and can start the tutorial

The tutorial is at: https://go.nrao.edu/vlba-tut2

Start with step 5.2 (Loading Data into AIPS).

Other stuff

- If you go wrong somewhere you can continue with the imaging and self-cal by loading the *.SPLIT.1 data which is also in the $MYAIP area. See section 6.16 of the tutorial.
- If you want learn about phase referencing and/or spectral line data reduction see a second VLBA tutorial which can be found at: https://go.nrao.edu/vlba-tut

Also, please fill out the survey which you can find at

go.nrao.edu/nrao-cdsurvey

www.nrao.edu
science.nrao.edu
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