VLBA Scheduling Tutorial

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Basic introduction: Summary

- SCHED is a program for planning and scheduling VLBI observations.
  - Used for VLBA, HSA, Global VLBI, European VLBI Network (EVN), Korean VLBI Network (KVN), etc…
  - Most VLBI networks except geodetic arrays
- SCHED user manual can be found at http://www.aoc.nrao.edu/software/sched/ . Two of the most important sections are:
  - Example schedules
  - List of parameters

Input file/format

- Text file in “keyin format”, I will refer to this as the “.key file” (usually named *expname*.key file, but you can name it whatever you want)
- Keyin format
  - Free format
  - In the form keyword=value
  - Some keywords have no value
  - ! denotes comments, everything after the ! is ignored.
  - Parser collects all input until it encounters a /
    - Usually indicating the end of information about an antenna, frequency setup or scan
  - Don’t worry I’ll show you lots of examples
  - Best thing to do is go to the sched user manual and find the example .key file closest to what you want to do and edit that.

Other input files

- These files come with sched and you shouldn't have to do anything with them.
- Source catalog (e.g., sources.gsfc)
- Station catalog (e.g. stations_RDBE.dat)
- Frequency setup files (e.g. rdbe_pfb_15256_dual.set)
- Frequency catalog (e.g. freq_RDBE.dat)
- Several others that are specialized
- You can also specify your own sources, frequency setup etc. in the .key file.

Output files

- .sum file
  - A file with a summary of the observation
  - The first place to look to make sure sched did what you expected
  - Output is customizable (sumitem parameter)
- sched.runlog
  - File contains everything you see on the screen when you run sched plus some extra messages if there are errors
- .flag file:
  - Contains a flagging information that cover times when data are being recorded but antennas are not on source in a format appropriate to be loaded into AIPS by task UVFLG
  - Can be useful if monitor data doesn't work on the VLBA or you are using one of the numerous telescopes that does not provide on-line flagging
- .vex (VLBI Experiment) file
  - A near universal format for controlling VLBI telescopes.
- Several of other files that you will probably never look at

Example: Cover information

```
! ==========================================================
! ====================  Cover Information  =======================
! ==========================================================
version  = 1
expt     = 'Example: 3C84 6, and 4 cm'
expcode  = BE002
obstype  = VLBA
piname   = 'Craig Walker'
address1 = 'National Radio Astronomy Observatory'
address2 = 'P. O. Box O'
address3 = 'Socorro, New Mexico, 87801'
address4 = ' U.S.A. '
phone    = '575 835 7247 '
obsphone = '575 835 7247 '
email    = 'cwalker@nrao.edu'
fax      = '575 835 7027 '
obsmode  = 'Continuum'
correl   = 'Socorro'
note1    = ' '
```

Adapted from manual_2.key in sched examples

Example: Correlator Information

```
! ============================================================
! ===============  Correlator Information  ===================
! ============================================================

correl    = 'Socorro'
coravg    = 4
corchan   = 16
cornant   = 10
corpol    = 'on'
corwtfn   = 'uniform'
corsrcs   = 'SCHED'
cortape   = FTP
corship1 = 'Craig Walker'
corship2 = 'P. O. Box O'
corship3 = 'Socorro NM 87801'
cornote1 = ' '
```

Example: Source and Station Catalogs

```
! ==========================================================
! ======= Standard Source and Station Catalogs  ============
! ==========================================================

srcfile  = $SCHED/catalogs/sources.gsfc
stafile  = $SCHED/catalogs/stations_RDBE.dat
freqfile = $SCHED/catalogs/freqRDBE.dat
```

Super useful (almost mandatory) to set up a SCHED environmental variable pointing to the sched directories.

- Type in the window you are using sched or even better put in your .bashrc, .tcshrc or .login so the environmental variable get set whenever you log in.
  - For bash: export SCHED=/*pathname*/sched
    - E.g. export SCHED=/home/loki/amy/sched
  - For cshell: setenv SCHED /*pathname/*sched

Example: The Scans

```
! ==========================================================
! ==========================   The Scans   ====================
! ==========================================================
year  = 2017
month = 10
day   = 22
start = 01:30:00

stations = SC, HN, NL, FD, LA, PT, KP, OV, BR, MK, GBT

Source = 3C454.3   Dur   = 5:30   Setup =
$SCHED/setups/rdbe_pfb_6cm_wide_lcp.set    /
Source = 3C454.3   Dwell = 5:30   Setup = $SCHED/setups/rdbe_pfb_8416_dual.set
/

stations = SC, HN, NL, FD, LA, PT, KP, OV, BR, GBT_VLBA

group 4 rep 14  ! About 3 hours in 14 repeats of the next 4 scans.
Source = 3C84      Dur   = 3:00  gap = 2:00  Setup =
$SCHED/setups/rdbe_pfb_8416_dual.set /
Source = 3C84      Dwell = 3:00  gap = 0     Setup =
$SCHED/setups/rdbe_pfb_6cm_wide_lcp.se
Source = 0309+411  Dwell = 2:00  /
Source = 3C84      Dwell = 3:00  /
```

Difference between dwell and duration (dur):

- dwell – duration of scan once antennas are on source
- dur – duration of scan including antenna slew

Common mistake: Values are remembered. So if you set gap=2:00 , your schedule will have 2 minute gaps until you set gap=0

Running sched

- Either type:
  - sched < manual_2.key
  - sched

```
Welcome to program SCHED Version: 11.40 Telease 11.4. March 14, 2015
The manual is at http://www.aoc.nrao.edu/software/sched/index.html
Unix users should set $SCHED to the base area where SCHED in installed
Most run time messages will be in sched.runlog

Some useful commands to give not if running interactively
    SCHedule=<filename>   :Specify input file.
    PLOT                  : Invokes uv, xy, rd, and uptime plotting.
    FREQLIST=lowF, highF  : Make frequency list (MHz). Then exit.
    Exit                  : Leave program
    /                     : End of inputs - run programs (or EXIT)
* plot sched= mauel_2.key /
```

To run sched 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"

Tutorial: Planning observations

- We will be starting a sched example, which can be found in $SCHED/examples
  - Two additional /key files are in the the data directory of your visitor account
- This part of the tutorial will help you plan an observation but will not make telescope control files
- Once you vnc into the Socorro computers and open a terminal type:
  - setup_pgplot
  - setup_vlba
  - cd data
  - cp $SCHED/examples/manual_simp.key .

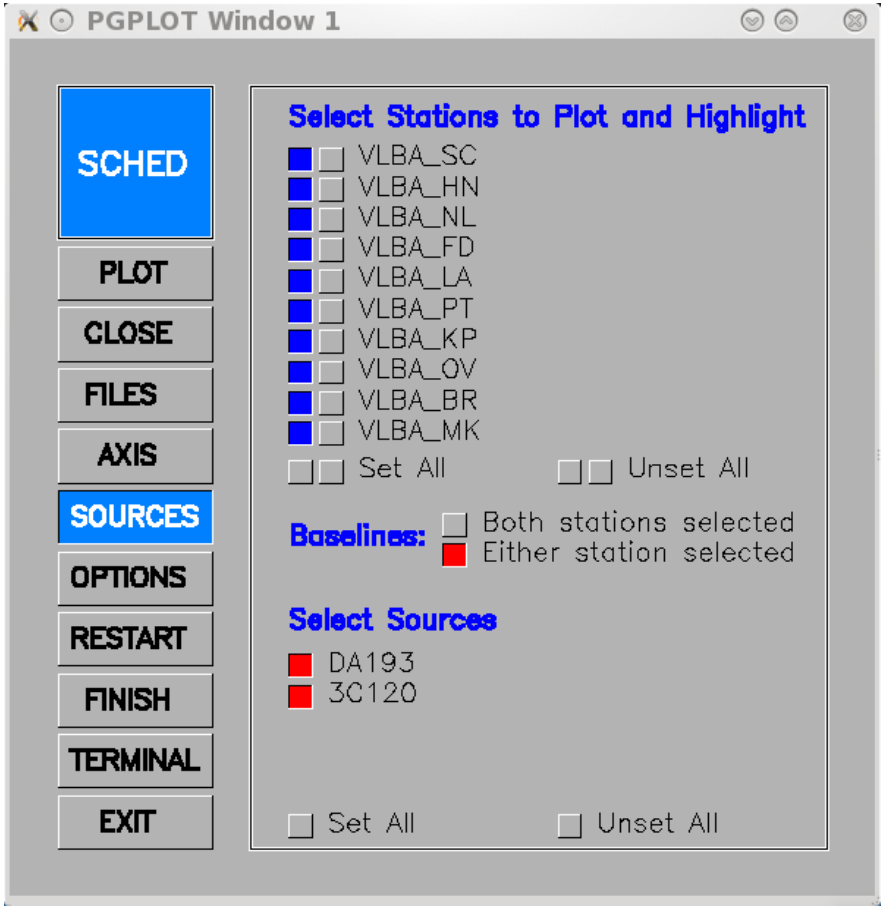
Tutorial: Planning observations

- manual_simp.key:

```
!---------------------------------------------------------------------
!  Example of very simple SCHED file - for making uv etc plots.
!---------------------------------------------------------------------
overwrit                   !  Allow writing over old output files.
expcode  = UVCOV           !  Needed for name of summary file.
obstype  = NONE            !  No tape recording.
nosetup                    !  No setup file.
optmode  = uptime          !  Planning mode.
opdur    = 24:00:00        !  Look at a whole day.
opminant = 4               !  Minimum number of antennas that must be up.
opminel  = 15              !  Don't include scans below this elevation.
year     = 1996  day = 1   !  Year and day.
start    = 00:00:00        !  Start time for plots.
dur      = 10:00           !  Ten minute scans.
stations = SC, HN, NL, FD, LA, PT, KP, OV, BR, MK
source   = DA193 /
source   = 3C120 /
!---------------------------------------------------------------------
! End of example.
!---------------------------------------------------------------------
```

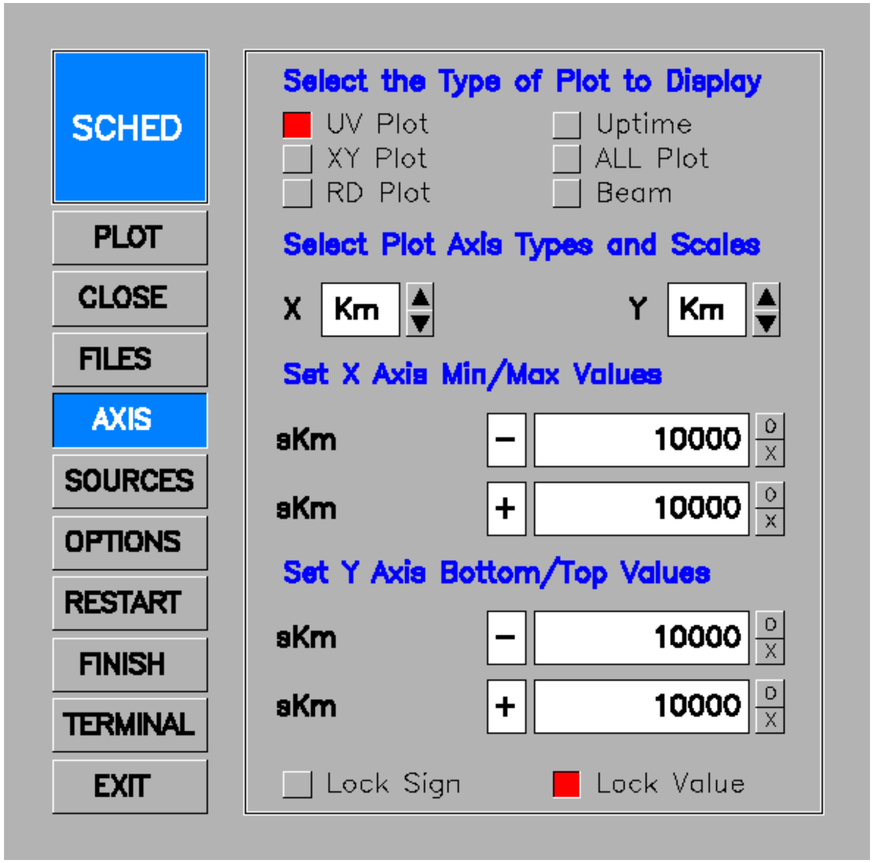
Tutorial: Planning observations

- Now type:
  - ➢ sched
  - * plot sched = manual_simp.key /
- Two pgplot windows should pop up one should be ignored the other will control the plotting:
  - – In this window you can select the sources and antennas.
  - – Click PLOT
    - you will get UV plots for both sources



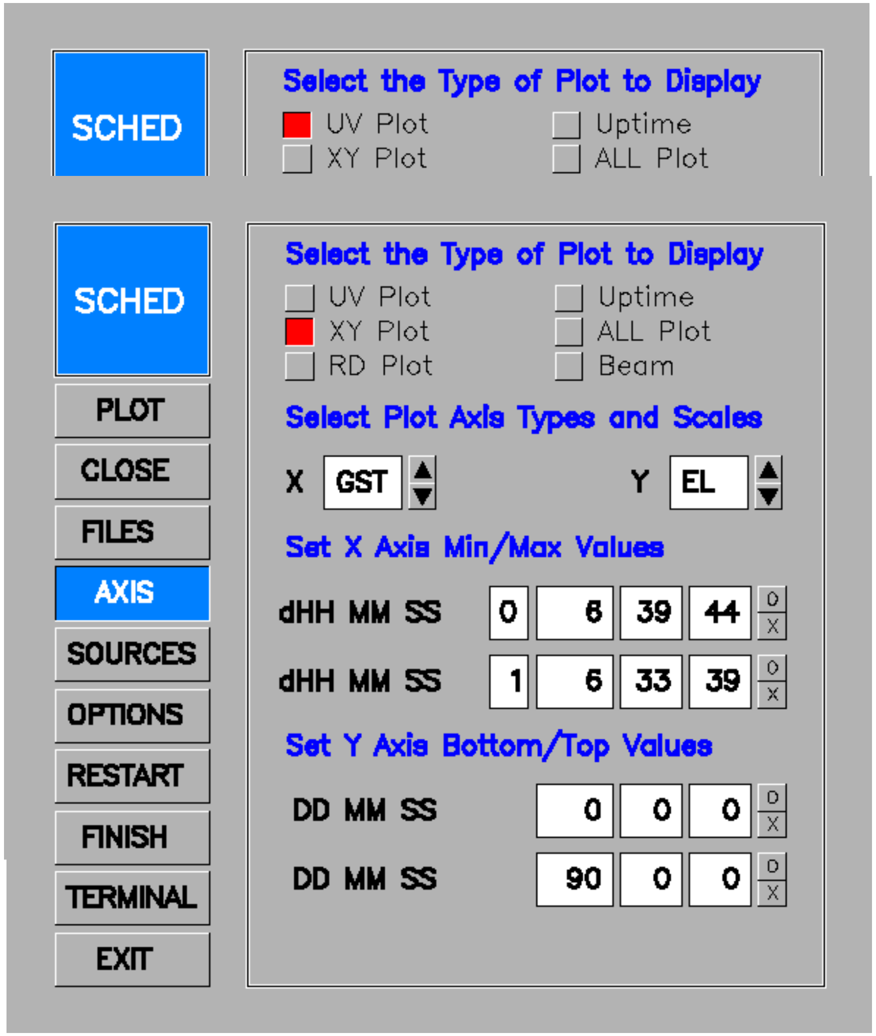
Tutorial: Planning observations

- Click AXIS
  - To change type of plot



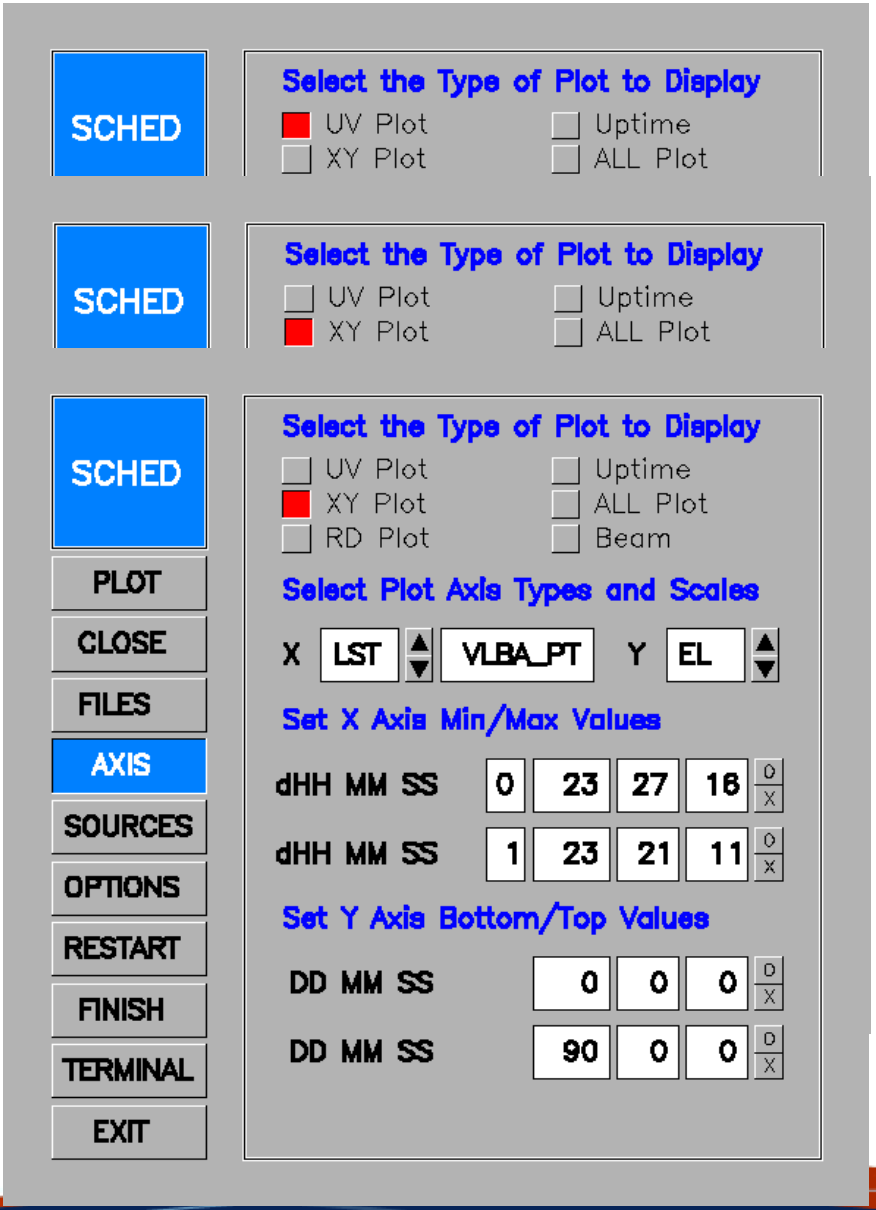
Tutorial: Planning observations

- Click AXIS
  - To change type of plot
- Click XY Plot
  - To plot a variety of things



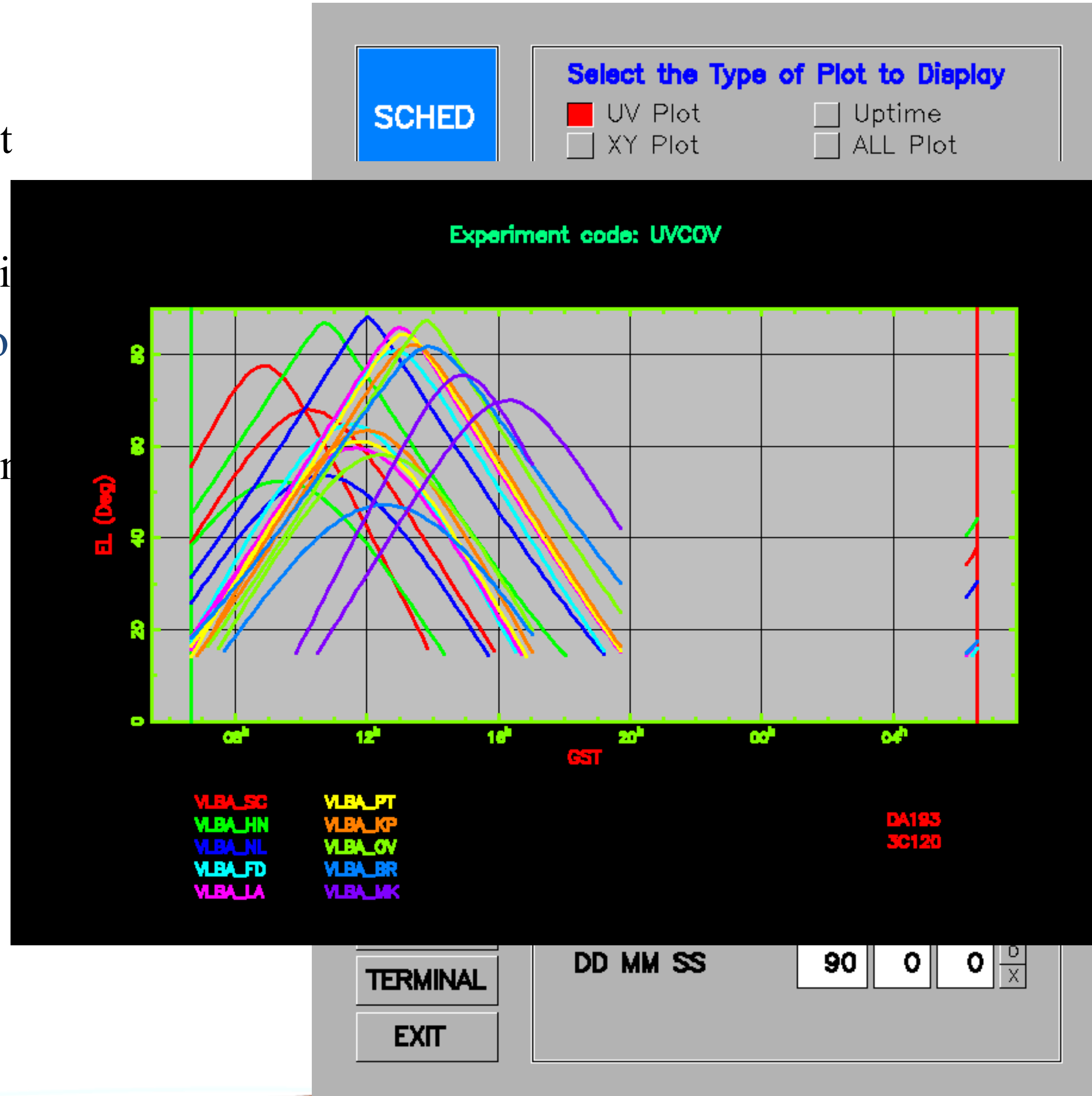
Tutorial: Planning observations

- Click AXIS
  - To change type of plot
- Click XY Plot
  - To plot a variety of things
- Click the arrows next to the X and Y
  - To change what is being plotted
- Click PLOT



Tutorial: Planning observations

- Click AXIS
  - To change type of plot
- Click XY Plot
  - To plot a variety of thi
- Click the arrows next to Y
  - To change what is bei
- Click PLOT
  - You get a plot of elevation vs GST.



Tutorial: Simple Continuum Phase Referencing

Use keyin file phaseref.key

This is a dynamically scheduled observation so “Preferred Dynamic Constraints” at the top of the key file is required.

```
! ==================================================================
!   Preferred Dynamic Constraints.  Alter [defaults] as desired.
! ==================================================================
!  The template for this section is at
!  https://science.lbo.us/facilities/vlba/observing/dynamic-constra
! Equipment constraints:
!    Stations.  Below each station code, the "o" indicates an
!       [optional] station that is to be used if it is available.
!       Change "o" to "r" if the station is required or change
!       "o" to "n" if the station is not to be used.
!           SC  HN  NL  FD  LA  PT  KP  OV  BR  MK
!           r   o   o   o   o   o   o   o   o   r
!       Minimum number of stations [9 (6 for 3mm)]: 8
!    Bands and polarizations.  Below each band code, insert "R"
!       if the righthand polarization is to be used, "L" if the
!       lefthand polarization is to be used, "d" if dual
!       polarizations are to be used, or "o" if the band is in
!       your setups but scheduling should not be constrained by
!       its availability.
!           90cm  50cm  20cm  13cm  6cm  4cm  2cm  1cm  7mm  3mm
!                        d            d
! Weather constraints:
!    [appropriate for bands marked "L", "R", or "d" above
!     and for at least the minimum number of stations]
! Date constraints:
!    Preferred date(s), usually a series start:
!    Excluded dates plus reason [none]:
!    Preferred interval between segments in days [none]:
!    Special conditions (e.g., a series with different
!       spacings in time): nighttime observations
! Start-time constraints:
!    Start-time range in (hhmm - hhmm), in PT_LST [none]:
```

Tutorial: Simple Continuum Phase Referencing

1. **Control information**: telling sched how to run
2. **Source catalog**: this is where you put sources that are not in the provided catalogs or if you want to use a different name or coordinates in that in the standard catalogs
3. **Cover Infromation:** experiment code, you name, address, contact information, plus any notes.

```
! ==============================================================
!       Control Information
! ==============================================================
overwrite              !  Prevents need to clean out old files on restart.
sumitem  = el1, slew   ! Control items in summary file.

! ==============================================================
!       In line source catalog.
! ==============================================================
srccat /
equinox=J2000
source='TTAUSB' ra=04:21:59.4263 dec= 19:32:05.739 /
endcat /

! ==============================================================
!       Cover information  (PI, experiment ...)
! ==============================================================
version  = 1
expt     = 'Example to show simple contimuum phase referencing'
expcode  = 'phaseref'
obstype  = 'VLBA'

piname   = 'Your Name'
address1 = 'Your Address'
address2 = 'Your Town'
address3 = 'Your Country'
email    = 'your@email.edu'
phone    = '+1-555-555-5555 (w)'
obsphone = '+1-555-555-5555 (h)'
obsmode  = '2Gbps continuum'
note1    = 'target                 : TTauSb'
note2    = 'phase reference source : J0423+2108'
note3    = 'phase-ref check source : J0412+1856'
note4    = 'fring finder/bandbass  : J0409+1217'
```

Tutorial: Simple Continuum Phase Referencing

1. **Correlator setup**: gives information on how you want the data correlated, averaging time, spectral channels etc.
2. **Catalog**: the location of the required catalogs.

```
! ==============================================================
!       Correlator section
! ==============================================================
correl   = 'Socorro'
coravg   = 2
corchan  = 64
cornant  = 10
corpol   = 'on'
corwtfn  = 'uniform'
corsrcs  = 'from .sum and catalog'
cortape  = 'ftp'
corship1 = 'my name and address'

! ==============================================================
!       Catalogs.
! ==============================================================
! Standard source catalogs are sources.gsfc and sources.rfc.
! This schedule uses some aliases only in sources.gsfc.
srcfile  = '$SCHED/catalogs/sources.gsfc'
stafile  = '$SCHED/catalogs/stations_RDBE.dat'
freqfile = '$SCHED/catalogs/freq_RDBE.dat'
```

Tutorial: Simple Continuum Phase Referencing

1. **Start day and time**: because this is a dynamically scheduled observation the time is set in PT LST, the year, month, day are just so sched can run, it will be changed once the observation has been picked to run.
2. **Stations**: the stations that are in the observation.

```
! ================================================================
!       The schedule
! ================================================================

!  Time intervals (dur, gap, dwell - but not prescan) are in
!  sidereal units - shorter than UT units by ~1.0027.
!  Start and stop times are in LST for the specified station,
!  which is VLBA_PT for VLBI dynamic scheduling projects.
!  The start day can be specified as the "local sidereal day",
!  which is sort of like MJD, but for sidereal time. The regular
!  UT date can also be used.

lst      = VLBA_PT
! day       = 58000    !  local sidereal day
year     = 2017  month = 4  day = 20
start    = 00:30:00

! This is a phase referencing schedule with a lot of short scans.
! It also switches between 6 and 18 cm.
! For dynamic scheduling, the key calibration scans should be
! toward the middle.  Some time could be lost off either end and
! sources will rise and set at antennas at diffent times.

stations = SC, HN, NL, FD, LA, PT, KP, OV, BR, MK
```

Tutorial: Simple Continuum Phase Referencing

```
! Phase referencing scans on the target source.
! set 1
group = 2 repeat = 10
setup  = $SCHED/setups/rdbe_pfb_6cm_wide_lcp.set
      source = 'J0423+2108'  dwell =  30  record /
      source = 'TTauSb'      dwell = 120  /
      source = 'J0423+2108'  dwell =  30  /
      source = 'J0412+1856'  dwell =  60  / !check source
group = 2 repeat = 7
setup  = $SCHED/setups/rdbe_pfb_1548_dual.set
      source = 'J0423+2108'  dwell =  30  /
      source = 'TTauSb'      dwell = 180  /
      source = 'J0423+2108'  dwell =  30  /
      source = 'J0412+1856'  dwell =  60  / !check source
```

Now the actual scans: So we are nodding fairly rapidly between the target (TTauSb) and the phase ref calibrator (J0423+2108), with occasional looks about every ~30 minutes at the check source.

- "group 2 repeat 10" means take the next two scans and repeat them 10 times.
- Then change frequencies by changing the "setup"
- Remember once you set something in most cases it is remembered which is why we set the setup and leave it until we want to change it.

Tutorial: Simple Continuum Phase Referencing

```
! set 3
group = 2 repeat = 10
setup  = $SCHED/setups/rdbe_pfb_6cm_wide_lcp.set
     source = 'J0423+2108'  dwell =  30  /
     source = 'TTauSb'      dwell = 120  /
     source = 'J0423+2108'  dwell =  30  /
     source = 'J0412+1856'  dwell =  60  / !check source
     source = 'J0409+1217'  dwell = 180  / !fring finder/bandpass
group = 2 repeat = 7
setup  = $SCHED/setups/rdbe_pfb_1548_dual.set
     source = 'J0423+2108'  dwell =  30  /
     source = 'TTauSb'      dwell = 180  /
     source = 'J0423+2108'  dwell =  30  /
     source = 'J0412+1856'  dwell =  60  / !check source
     source = 'J0409+1217'  dwell = 180  / !fring finder/bandpass
```

Now the actual scans: Here along with looking at the target (TTauSb) and the phase ref calibrator (J0423+2108), we have added scans on the fringe finder/bandpass calibrator (J0409+1217).

- We have a couple more scans on the fringe finder/bandpass calibrator in case this one doesn't work
- These scans and the ones one the previous page are repeated until we fill up the time
- Unfortunately scan loops cannot be "nested."

Tutorial: Simple Continuum Phase Referencing

OK lets plot it, type:

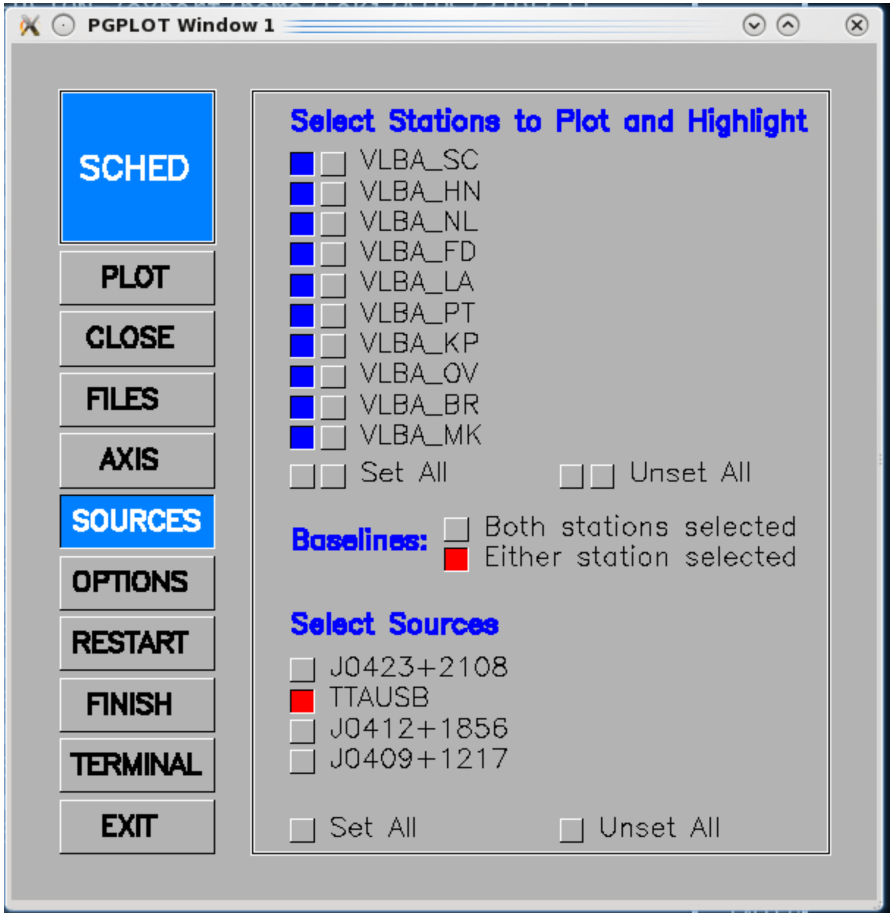
sched

plot sched = phaseref.key /

Then:

Unclick all sources except TTAUSB

Click PLOT



Tutorial: Simple Continuum Phase Referencing

OK lets plot it, type:

sched

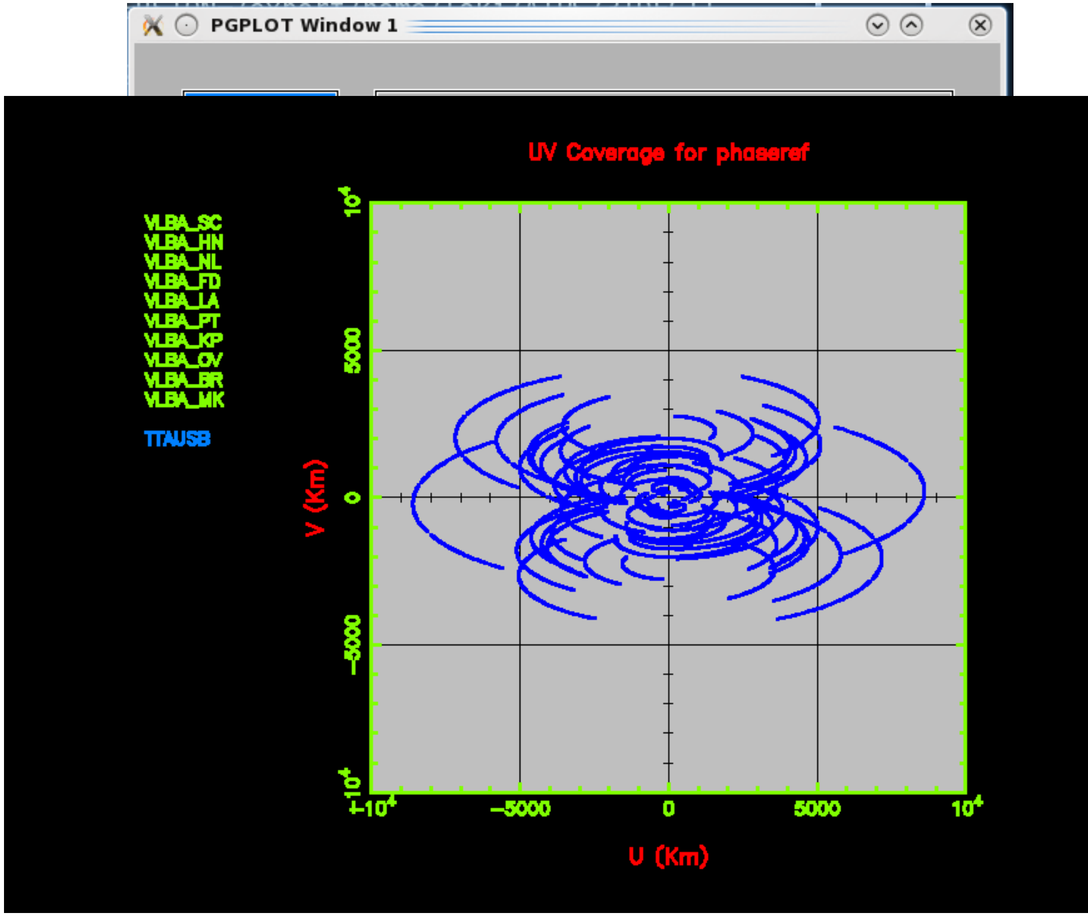
plot sched = phaseref.key /

Then:

Unclick all sources except TTAUSB

Click PLOT

- you will get a uv plot of TTauSb for this observation



Tutorial: Simple Continuum Phase Referencing

OK lets plot it, type:

sched

plot sched = phaseref.key /

Then:

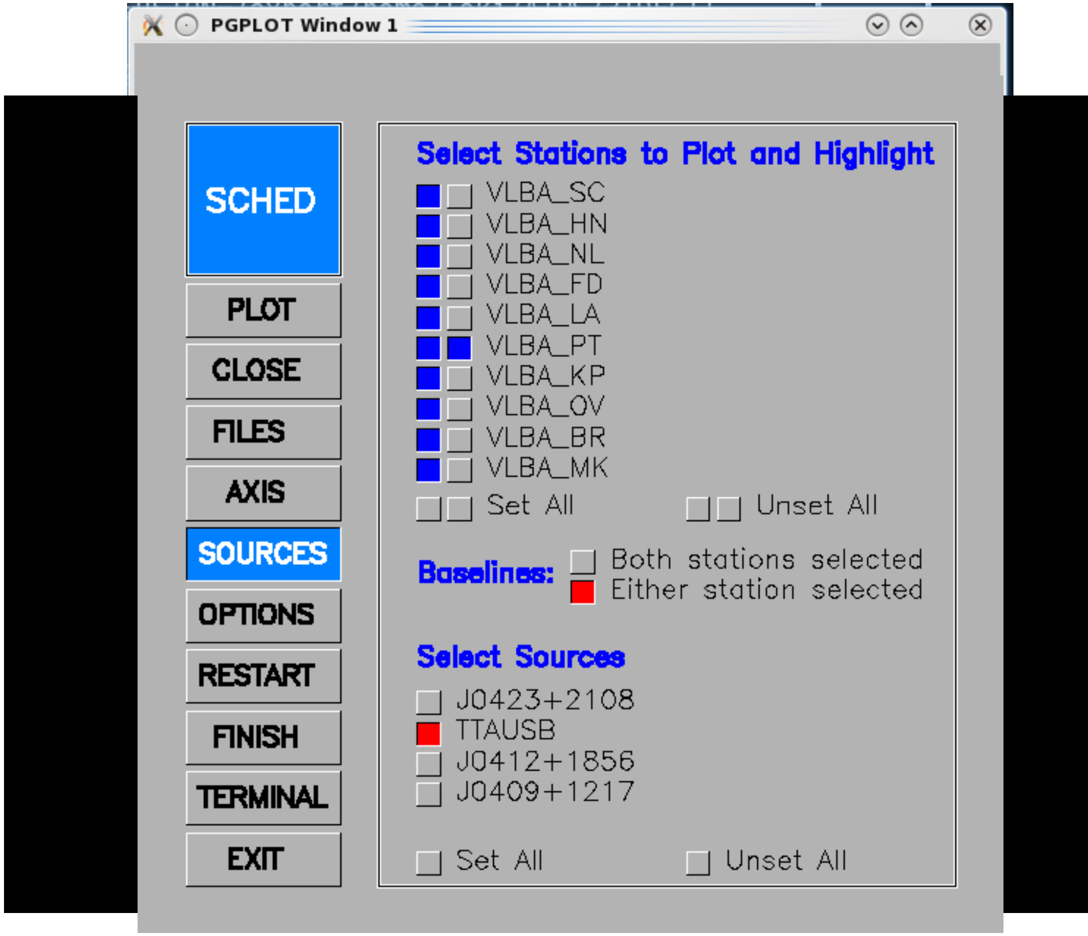
Unclick all sources except TTAUSB

Click PLOT

- you will get a uv plot of TTauSb for this observation

In plot control window click the button in the second column next to VLBA_PT

Click PLOT



Tutorial: Simple Continuum Phase Referencing

OK lets plot it, type:

sched

plot sched = phaseref.key /

Then:

Unclick all sources except TTAUSB

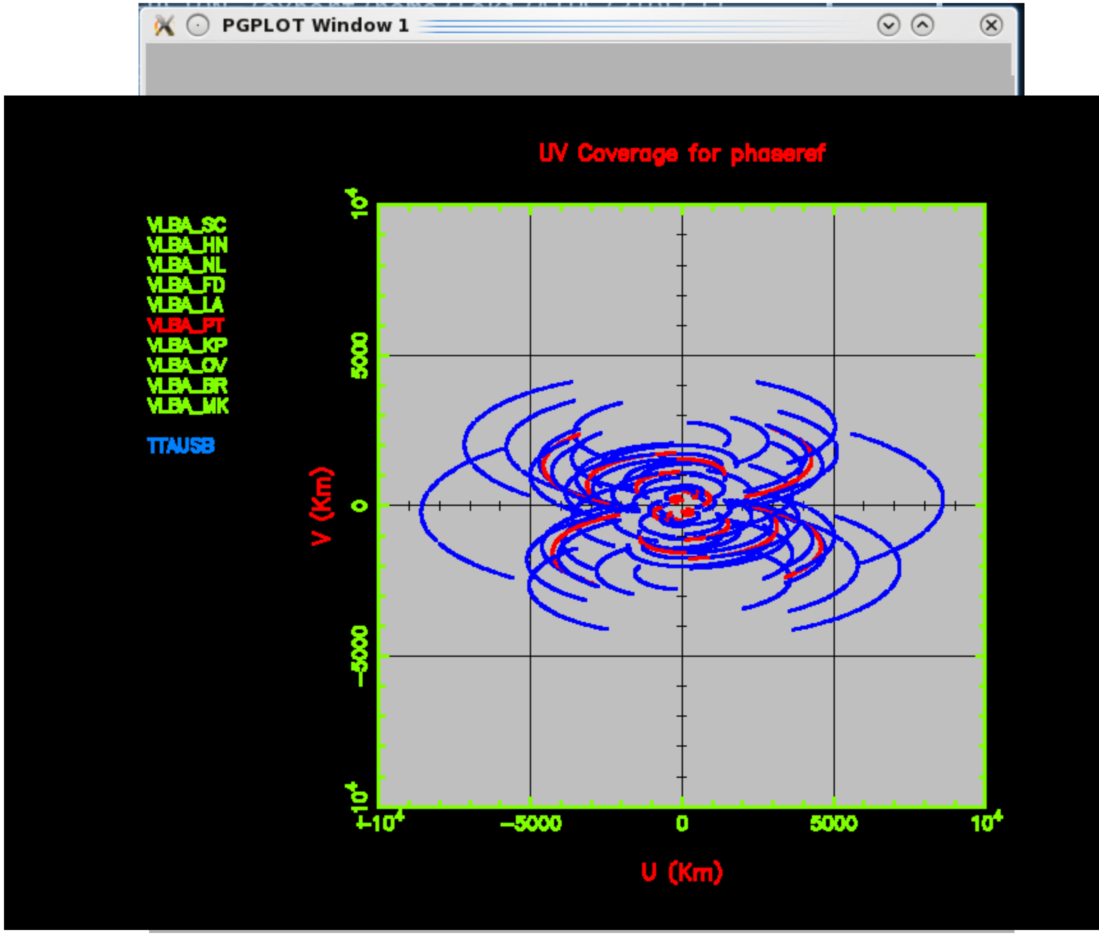
Click PLOT

– you will get a uv plot of TTauSb for this observation

In plot control window click the button in the second column next to VLBA_PT

Click PLOT

– you will get the same plot as before with all the baselines to PT shown in red



Tutorial: Simple Continuum Phase Referencing

OK lets go do other plotting:

Click SOURCES

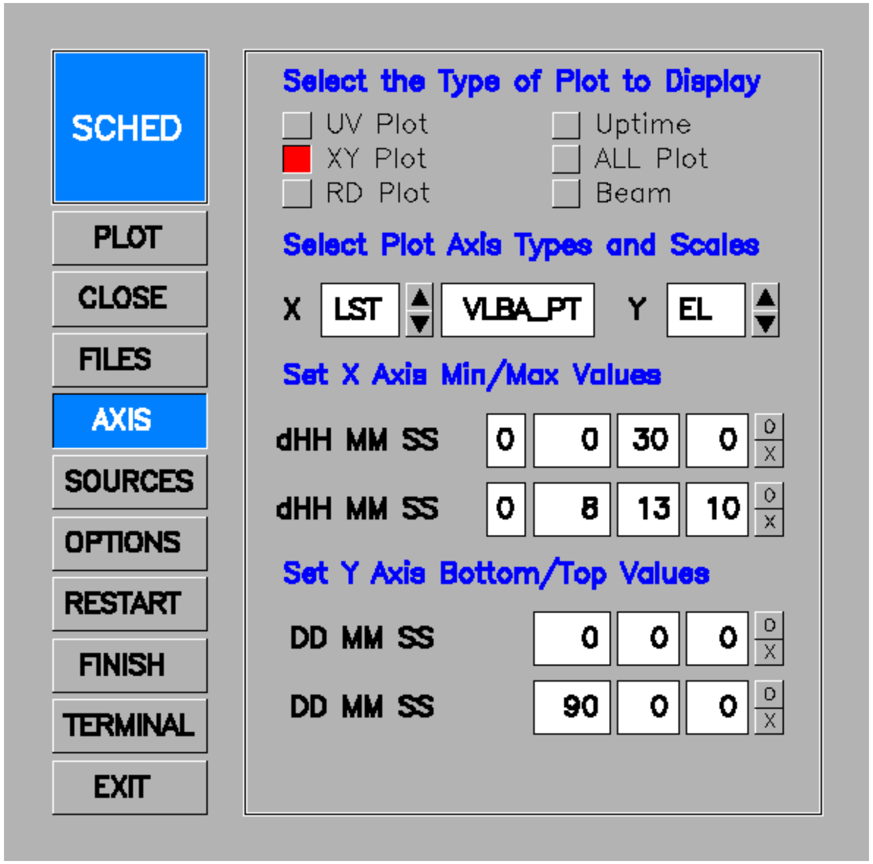
Click Set All under Sources

Click AXIS

Click XY Plot

Change X to LST VLBA_PT

Click PLOT



Tutorial: Simple Continuum Phase Referencing

OK lets go do other plotting:

Click all sources

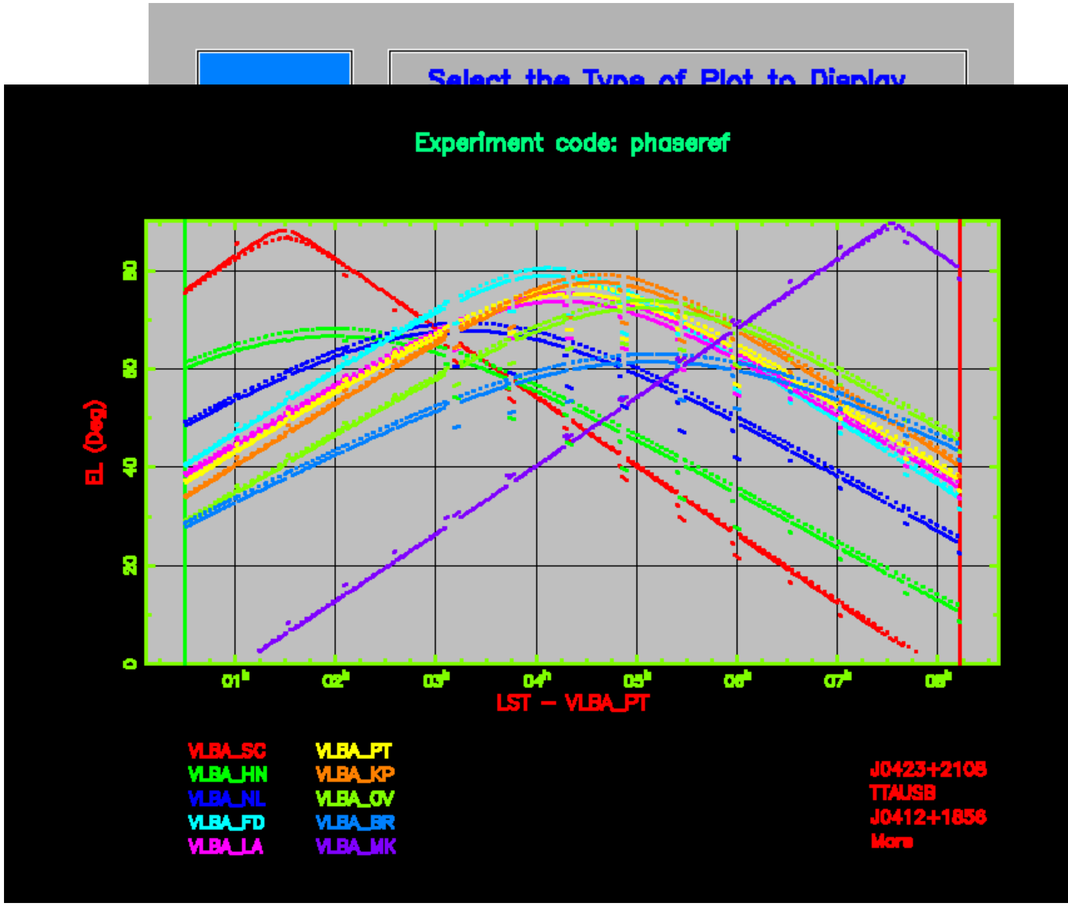
Click AXIS

Click XY Plot

Change X to LST VLBA_PT

Click PLOT

- you will get a elevation vs. PT LST for this observation



Tutorial: Simple Continuum Phase Referencing

OK lets go do other plotting:

Click all sources

Click AXIS

Click XY Plot

Change X to LST VLBA_PT

Click PLOT

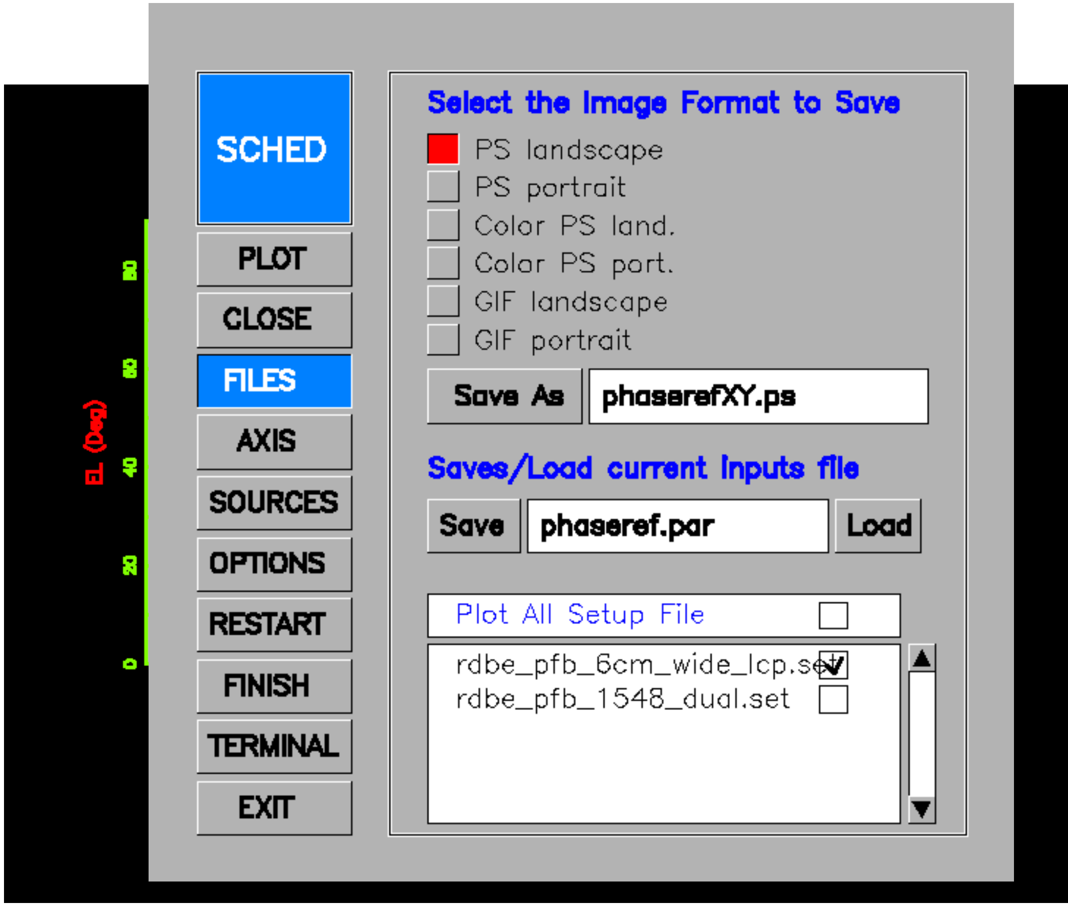
- you will get a elevation vs. PT LST for this observation

Lets just plot one frequency:

Click FILES

Uncheck rdbe_pfb_1548_dual.set

Click PLOT



Tutorial: Simple Continuum Phase Referencing

OK lets go do other plotting:

Click all sources

Click AXIS

Click XY Plot

Change X to LST VLBA_PT

Click PLOT

- you will get a elevation vs. PT LST for this observation

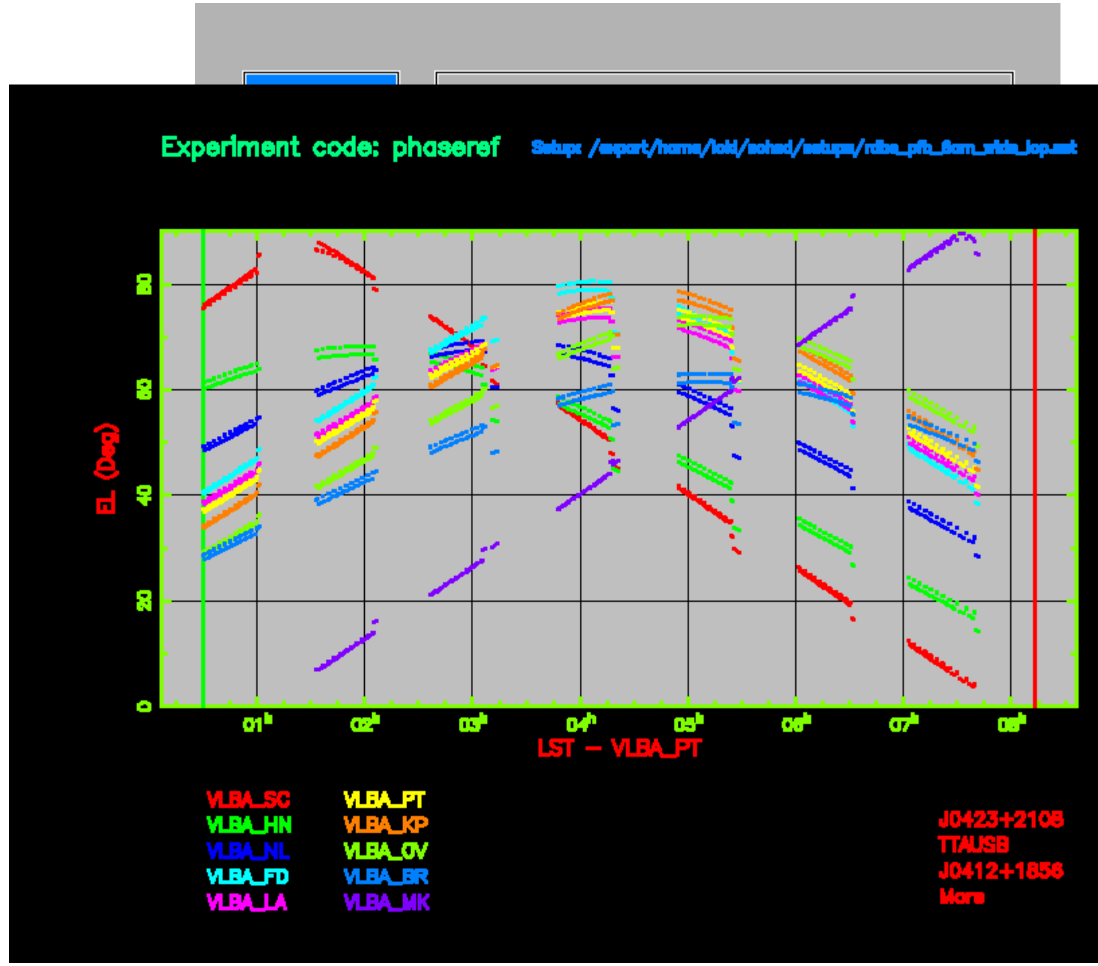
Lets just plot on frequency:

Click FILES

Uncheck rdbe_pfb_1548_dual.set

Click PLOT

- you will get the same plot as before but with only the 6 cm scans



Tutorial: Simple Continuum Phase Referencing

More other plotting:

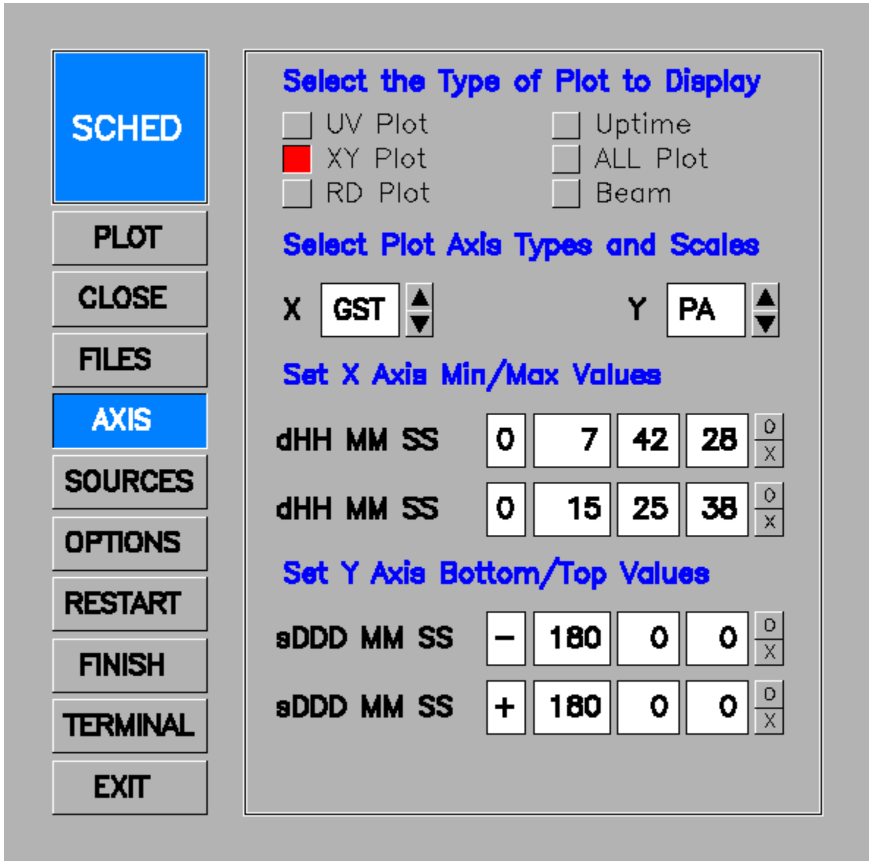
Click AXIS

Click XY Plot

Change X to GST

Change Y to PA (paralactic angle)

Click PLOT



Tutorial: Simple Continuum Phase Referencing

More other plotting:

Click AXIS

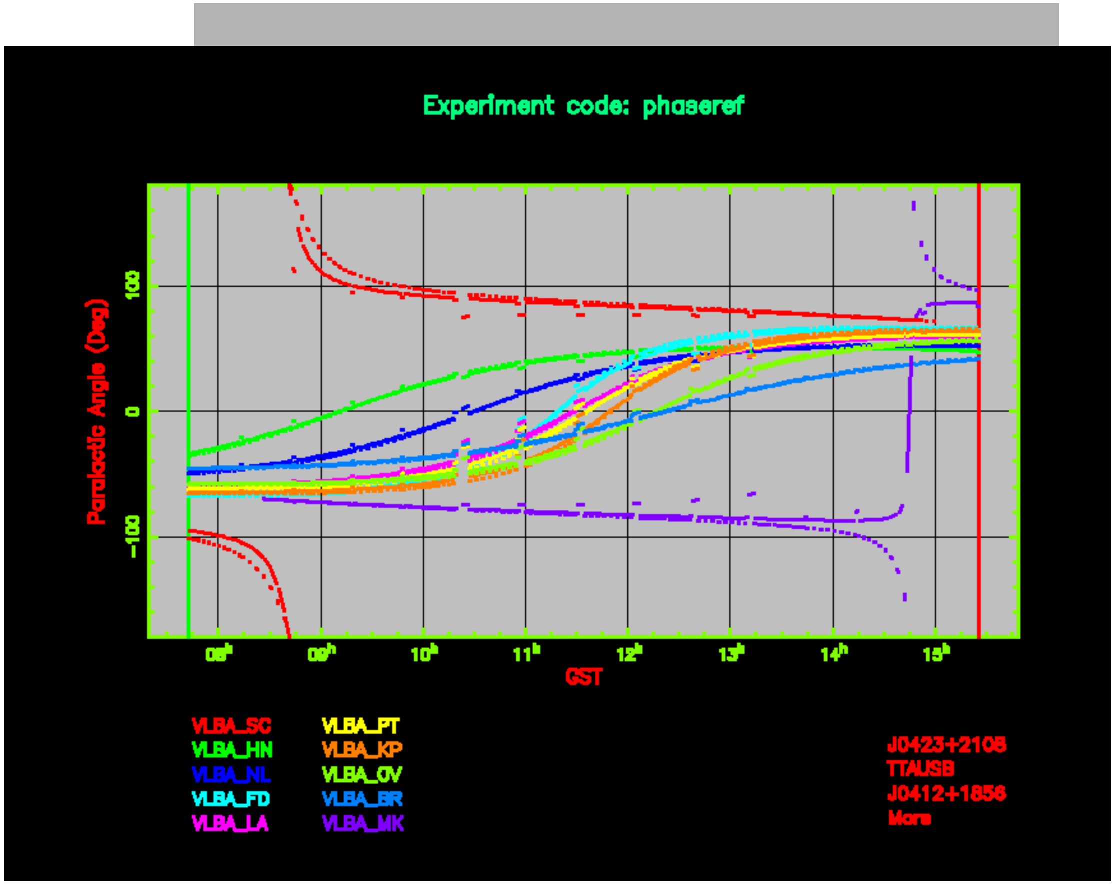
Click XY Plot

Change X to GST

Change Y to PA (paralactic angle)

Click PLOT

- you will get a paralactic angle vs GST plot, useful for polarization observation



Tutorial: Simple Continuum Phase Referencing

More other plotting:

Click AXIS

Click XY Plot

Change X to GST

Change Y to PA (paralactic angle)

Click PLOT

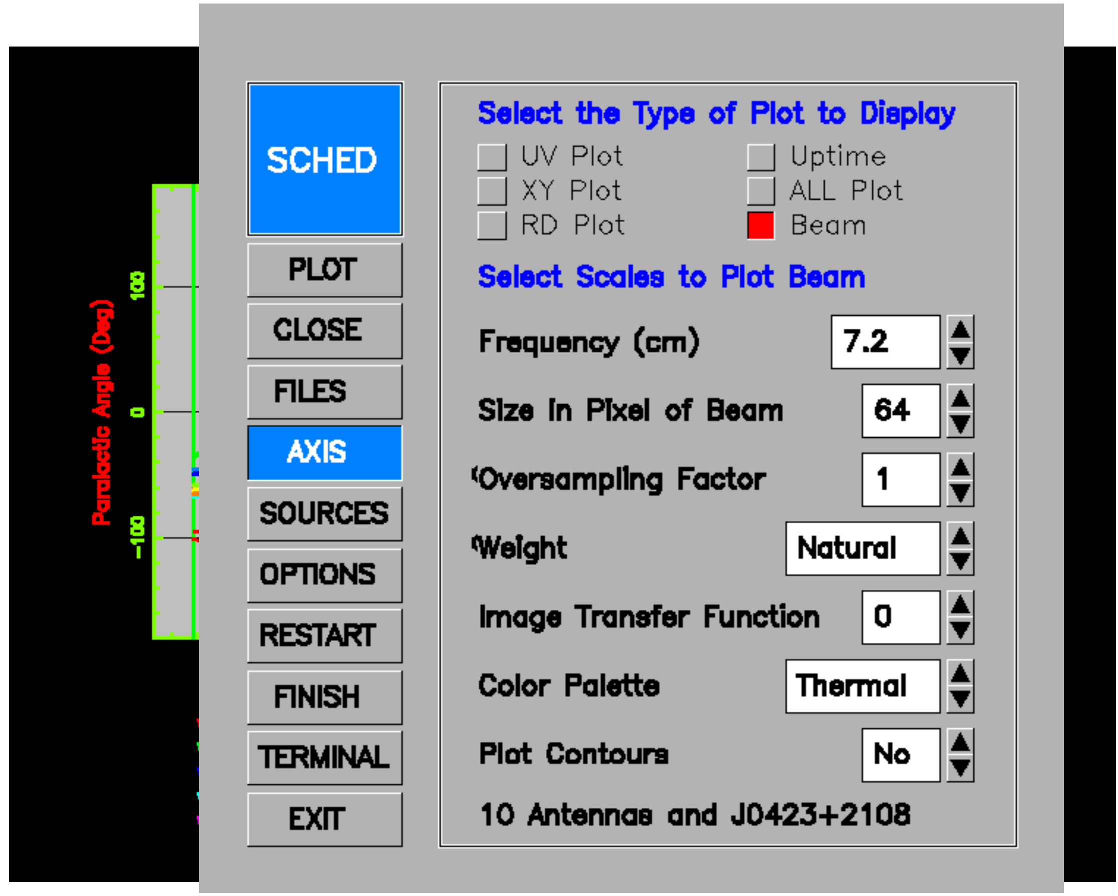
- you will get a paralactic angle vs GST plot, useful for polarization observation

Lets check out another button:

Click Beam

Click Color Palette and pick Thermal (just to make it prettier.)

Click PLOT



Tutorial: Simple Continuum Phase Referencing

More other plotting:

Click AXIS

Click XY Plot

Change X to GST

Change Y to PA (paralactic angle)

Click PLOT

- you will get a paralactic angle vs GST plot, useful for polarization observation

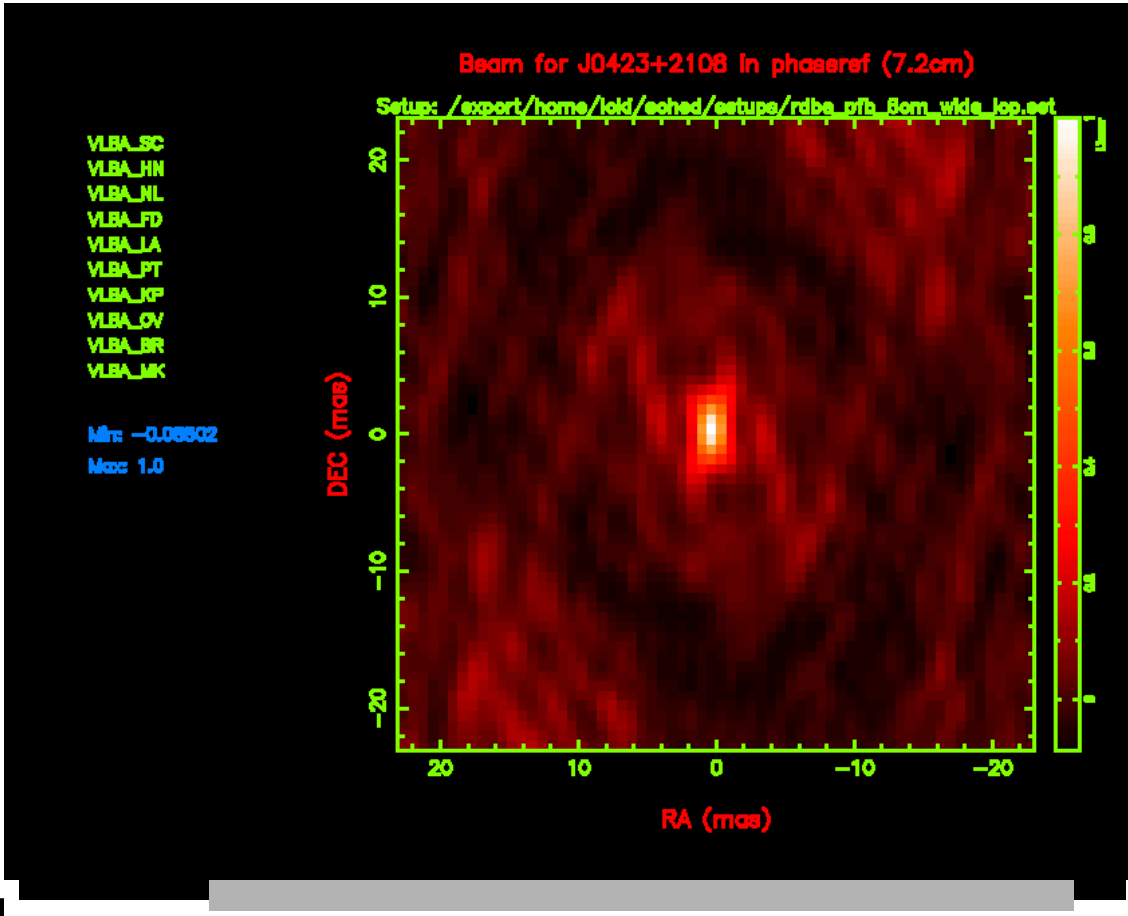
Lets check out another button:

Click Beam

Click Color Palette and pick Thermal (just to make it prettier.)

Click PLOT

- You get a plot of the beam based on the uv coverage for the phase reference source at 7.2cm.



Tutorial: Simple Continuum Phase Referencing

Now let us look at the phaseref.sum file

- The sum file is a text file so look at it with your favorite text viewing app
- The top of the file just has the basic information you put in the .key file
- Plus some useful tidbits like the day number and MJD of your observation date

```
                    SUMMARY FILE FOR PROJECT: phaseref

COVER INFORMATION:

  Experiment: Example to show simple contimuum phase referencing
  Exp. Code:  phaseref
  Start Day 110 is Thu  20 Apr 2017   MJD  57863

  Schedule Version:       1.00
  Processed by SCHED version:  11.40  Release 11.4.  March 14, 2015

  PI:        Your Name

  Address:   Your Address
             Your Town
             Your Country


  Phone:     +1-555-555-5555 (w)
  EMAIL:     your@email.edu
  Fax:
  Phone during observation: +1-555-555-5555 (h)
```

Tutorial: Simple Continuum Phase Referencing

Now let us look at the .sum file

- These are just excerpts of interesting/informative sections of the .sum file
- Here is table of information with the amount of time you have scheduled the maximum correlator output rate etc.
- Useful first thing to check to make sure you have scheduled as much time as you thought.

```
DERIVED INFORMATION FOR CORRELATION:
                                                All scans
  Elapsed time for project (hours):                  7.74
  Total time in scheduled scans (hours):             6.34
  Total time in recording scans (hours):             6.34
  Total baseline hours (recording scans):          338.86
  Projected max correlator output rate (kB/s):      450.6
  Projected correlator output data size (MB):      9993.5
```

Tutorial: Simple Continuum Phase Referencing

Now we get to the meat of the .sum file, the setup files. The top part isn't super useful except to note the Net SB (in this case L(ower) SideBand) and the polarization used (in this case LCP).

```
SETUP FILES:


The following setup groups are the same as group   1 below.
  2:VLBA_HN   3:VLBA_NL   4:VLBA_FD   5:VLBA_LA   6:VLBA_PT   7:VLBA_KP
  8:VLBA_OV   9:VLBA_BR  10:VLBA_MK


======== Setup file: /export/home/loki/sched/setups/rdbe_pfb_6cm_wide_lcp.set
  Matching groups in /export/home/loki/sched/catalogs/freq_RDBE.dat:
    vc_bv

  Setup group:     1          Station: VLBA_SC          Total bit rate:   2048
  Format: MARK5B              Bits per sample: 2        Sample rate: 64.000
  Number of channels: 16     DBE type: RDBE_PFB        Speedup factor:    1.00

  Disk used to record data.

  1st LO=    3600.00    3600.00    3600.00    3600.00    3600.00    3600.00    3600.00    3600.00
             8400.00    8400.00    8400.00    8400.00    8400.00    8400.00    8400.00    8400.00
  Net SB=          L          L          L          L          L          L          L          L
                   U          U          U          U          U          U          U          U
  IF SB =          U          U          U          U          U          U          U          U
                   L          L          L          L          L          L          L          L
  Pol.  =        LCP        LCP        LCP        LCP        LCP        LCP        LCP        LCP
                 LCP        LCP        LCP        LCP        LCP        LCP        LCP        LCP
  BBC   =          1          2          3          4          5          6          7          8
                   9         10         11         12         13         14         15         16
  BBC SB=          L          L          L          L          L          L          L          L
                   L          L          L          L          L          L          L          L
  IF    =         C          C          C          C          C          C          C          C
                  D          D          D          D          D          D          D          D
```

Tutorial: Simple Continuum Phase Referencing

This is one of the most informative section of the setup section, the LO sum tells you what the edges of all the subbands (baseband channels), then knowing the Net sideband and bandwidth you can calculate frequency range being observed:

- in this case Lower SideBand means the subbands' frequency range is

  (LO sum-32MHz) to LO sum=4128 to 4160MHz

```
  VLBA FE=      6cm      6cm      6cm      6cm
  VLBA Synth=   8.4      3.6      8.4

 The following frequency sets based on these setups were used.
    See the crd files for VLBA legacy system setups and pcal detection details.

  Frequency Set:    1  Setup file default.  Used with PCAL = 1MHz
  LO sum=   4160.00  4224.00  4288.00  4352.00  4416.00  4480.00  4544.00  4608.00
            7392.00  7456.00  7520.00  7584.00  7648.00  7712.00  7776.00  7840.00
  BBC fr=    560.00   624.00   688.00   752.00   816.00   880.00   944.00  1008.00
            1008.00   944.00   880.00   816.00   752.00   688.00   624.00   560.00
  Bandwd=     32.00    32.00    32.00    32.00    32.00    32.00    32.00    32.00
              32.00    32.00    32.00    32.00    32.00    32.00    32.00    32.00
```

Tutorial: Simple Continuum Phase Referencing

This is the other most informative section of the setup section, the scan summary. Here it list the elevation and slew time for every scan and every telescope. MK is marked D because the source is down at Mauna Kea

```
^L SCAN SUMMARY for experiment phaserefExample to show simple contimuum phase referencing
    Flags: D=>Down, H=>Below Horizon, R=>Rises, S=>Sets, W=>Slew too long, t=>Tape Chg.
    Top item is:    Start elevation.
    Bottom item is: Slew time in seconds from previous source.
    TYPE top: -=> normal scan, P=>Pointing or Ta;  bottom: -=>recording, N=>not recording.
    Day 110 is Thu  20 Apr 2017   MJD  57863

SCAN  DAY START UT  SOURCE     TYPE  STATIONS    t => tape change
          STOP UT                     Sc     Hn     Nl     Fd     La     Pt     Kp     Ov     Br     Mk

  1  110 17:46:28 J0423+2108    -     75     61     49     41     39     37     34     29     29    ---D
     110 17:46:58 6cm_wide_lcp  -      5      5      5      5      5      5      5      5      5    ---

  2  110 17:47:10 TTAUSB        -     76     60     49     40     38     37     34     29     28    ---D
     110 17:49:10 -             -     12     10     10      9      9      9      9      9     10    ---

  3  110 17:49:22 J0423+2108    -     76     62     50     41     39     38     35     30     29    ---D
     110 17:49:52 -             -     13     10     10      9      9      9      9      9     10    ---

  4  110 17:50:05 TTAUSB        -     77     61     49     41     39     38     35     29     28    ---D
     110 17:52:04 -             -     13     10     10      9      9      9      9      9     10    ---

  5  110 17:52:17 J0423+2108    -     77     62     50     42     40     39     35     30     30    ---D
     110 17:52:47 -             -     13     11     10      9      9      9      9      9     10    ---

  6  110 17:53:00 TTAUSB        -     77     61     50     42     40     38     35     30     29    ---D
     110 17:55:00 -             -     13     10     10      9      9      9      9      9     10    ---

  7  110 17:55:13 J0423+2108    -     77     62     51     43     41     39     36     31     30    ---D
     110 17:55:42 -             -     13     11     10      9      9      9      9      9     10    ---
```

Tutorial: Simple Continuum Phase Referencing

Here lower in the scan summary you can see the source has risen at MK (although it is still pretty low) and that you are observing at different frequency.

33	110	18:38:06	TTAUSB	-	88	65	57	51	49	47	45	39	36	4
	110	18:41:06	fb_1548_dual	-	17	11	10	10	9	9	9	9	10	9
34	110	18:41:20	J0423+2108	-	86	67	59	53	50	49	46	40	38	5
	110	18:41:50	-	-	14	11	10	10	9	9	9	9	10	9
35	110	18:42:02	TTAUSB	-	88	66	58	52	49	48	46	40	37	5
	110	18:45:01	-	-	12	11	10	10	10	10	9	9	10	9
36	110	18:45:13	J0423+2108	-	87	67	59	53	51	49	47	41	39	6
	110	18:45:43	-	-	11	11	10	10	10	10	9	9	10	9
37	110	18:45:55	TTAUSB	-	88	66	58	53	50	49	46	40	38	6
	110	18:48:55	-	-	13	11	10	10	10	10	9	9	10	9
38	110	18:49:13	J0423+2108	-	87	68	60	54	52	50	48	42	39	7
	110	18:49:43	-	-	18	11	10	10	10	10	9	9	10	9
39	110	18:50:31	J0412+1856	-	86	66	60	56	53	52	49	43	39	9
	110	18:51:31	-	-	48	13	13	12	12	11	11	11	11	11
40	110	18:55:10	J0409+1217	-	82	59	55	54	50	49	47	41	36	9
	110	18:56:09	-	-	219	22	19	15	15	15	15	15	17	13
41	110	18:57:25	J0423+2108	-	86	68	61	56	53	52	49	43	41	9
	110	18:57:55	6cm_wide_lcp	-	76	27	20	19	18	18	18	17	17	15

Tutorial: Simple Continuum Phase Referencing

Towards the end of the .sum file there are different and interesting reports like this one that reports the sun distance from the sources on the date of observation, as you can see there are a little close to the sun for 1.6 GHz.

```
EFFECT OF SOLAR CORONA

  The solar corona can cause unstable phases for sources too close to the Sun.
  SCHED provides warnings at individual scans for distances less than 10 degrees.
  The distance from the Sun to each source in this schedule is:
    Source          Sun distance (deg)
   TTAUSB               36.3
   J0409+1217           32.9
   J0412+1856           34.0
   J0423+2108           36.7

  Barry Clark estimates from predictions by Ketan Desai of IPM scattering sizes
  that the Sun will cause amplitude reductions on the  longest VLBA baselines
  at a solar distance of 60deg F^(-0.6) where F is in GHz.
  For common VLBI bands, this is:
       327 MHz         117. deg
       610 MHz          81. deg
       1.6 GHz          45. deg
       2.3 GHz          36. deg
       5.0 GHz          23. deg
```

Tutorial: Complicated Spectral Line

Use keyin file specddc.key

This example is an observation at 6cm and 7mm and includes:

- Zoom mode correlation
- Manual setup of frequencies
- Doppler setting of frequencies
- Just the important differences will be shown

```
! ============================================================
! ==============  Correlator Information  ==================
! ============================================================
 correl    = 'Socorro'
 coravg    = 2
 corchan   = 256
 cornant   = 12
 corpol    = 'on'
 corsrcs   = 'standard'
 corship1  = 'Craig Walker'
 corship2  = 'P.O. Box 0'
 corship3  = 'Socorro, NM 87801'
 cortape   = 'FTP'
 corwtfn   = 'Uniform'
 cornote1  = 'Please do two passes, one with 256 channels'
 cornote2  = 'and all the IFs and second pass just the scans'
 cornote3  = 'using dopper setting with 1024 channels from'
 cornote4  = '43100-43150 and 43310-43370 MHz.'
```

In the Correlator Information we use the cornote1-cornote4 to give information about the zoom mode correlation. Zoom mode allows you to correlate a only the part of the spectrum you are interested in with a much higher spectral resolution. It is this simple to set up, but does require an additional correlator pass.

Tutorial: Complicated Spectral Line

Manuel frequency setup for 6cm.

- DDC mode
- Using 2x128 dual pol subbands (or baseband channels)
- The firstlo and bbsyn set the freqs.
- firstlo for the current backend is very coarse (every 200M Hz) and there are limitations in where you can place the subbands.
- This setup will give you 2 subbands: one 4868-4996 MHz and one from 4996-5124 MHz

```
setini = hsaddc.6cm /
  nchan    = 4
  bbfilt   = 128.0
  bits     = 2
  netside  = U
  pol      = dual

  dbe      = 'rdbe_ddc'
  firstlo  = 4100.0
  sideband = U
  bbsyn    = 768.0, 768.0, 896.0, 896.0
  station  = vlba, eb_rdbe
    /
endset /
```

Tutorial: Complicated Spectral Line

Manuel frequency setup for 7mm.

- Similar setup for 7mm
- the firstlo are different but the bbsyn are the same (this will **not** always be the case).
- because this setup will be used for the spectral line observations the pulse cals (pcal) are turned off
- This setup will give frequencies: 43168-43296 MHz and 43296-43424 MHz ***BUT*** the schedule uses Doppler setting, so those will change.

```
!  Now do a very similar set at 7mm.

setini = hsaddc.7mm /
  nchan    = 4
  bbfilt   = 128.0
  bits     = 2
  netside  = U
  pol      = dual
  dbe      = 'rdbe_ddc'
  firstlo  = 42400.0
  sideband = U
  bbsyn    = 768.0, 768.0, 896.0, 896.0
  station  = vlba, gbt_vlba, gbt_cold
  pcal=off
    /
endset /
```

Tutorial: Complicated Spectral Line

Spectral line information

- In the source catalog (srccat) add the velocity of the source
- In the lineinit section put the rest frequency of the spectral line(s) you are interested in.

```
! ===========================================================
! ============== Spectral line information =================
! ===========================================================

srccat /
! Entry taken from sources.pointing.
  source='P-SPer'  CALCODE = 'L'
  RA=02:22:51.713  DEC=58:35:11.5   equinox=j2000  vel=-40., -40.
  remarks='Baudry' /
endcat /

lineinit /
!    The first two channels have the true rest frequency.  The second
!    two are offset by 50 MHz to serve as off-source data.
  lineset ='SiO431'  restfreq=43122.03,  43122.03, 43172.03, 43172.03   /
endlines /
```

Tutorial: Complicated Spectral Line

The scans: this schedule has three sections

- Some ordinary 6cm and 7mm scans (with no Dopper).

```
!                   ---------  7mm  --------

  setup = hsaddc.7mm

  stations = VLBA_MK,VLBA_BR,VLBA_OV,VLBA_KP,VLBA_FD,
             VLBA_PT,VLBA_LA,VLBA_NL,VLBA_HN,VLBA_SC
  group 2 repeat 5
  source = 'J0217+7349'  dwell = 300  /
  source = 'J0243+7120'  dwell = 300  /
  source = 'J0217+7349'  dwell = 300  /
```

Tutorial: Complicated Spectral Line

The scans: this schedule has three sections

- Some ordinary 6cm and 7mm scans (with no Dopper).
- Then the 7mm Doppler section where you must set the linename set in lineinit, use the Doppler keyword and set the "dopsrc"
  - This will shift the frequencies to the correct Doppler shift taking into account the motion of the earth and the velocity of the source

```
!            ------- 7mm SiO observation ---------

!  Just to add even more excitement to an already complex demonstration,
!  here we show a spectral line observation.  The target is
!  SiO in P-SPer, whose information is in the source catalog entry
!  above.  We will use the same 7mm setup used for the continuum sources,
!  but will request a zoom mode during correlation on P-SPer and Doppler
!  based frequency from the schedule.  We will observe a nearby calibrator.

!  Do the actual scans.  Doppler for both sources

 stations = VLBA_MK,VLBA_BR,VLBA_OV,VLBA_KP,VLBA_FD,
            VLBA_PT,VLBA_LA,VLBA_NL,VLBA_HN,VLBA_SC

  setup = hsaddc.7mm  doppler linename='SiO431' dopsrc = 'P-SPer'
  source = 'J0303+4716'  dwell = 120 /
  source = 'P-SPer'      dwell = 300 /
  source = 'J0303+4716'  dwell = 120 /
```

Tutorial: Complicated Spectral Line

sched-nrao < specddc.key

The .sum file

- We're just going to look at the frequencies for the 7mm setup
- Below is the top section, which lists the bit rate, 1st LO, Net Sideband, Polarization etc.

```
======== Setup file: hsaddc.7mm
  Matching groups in /export/home/loki/sched/catalogs/freq_RDBE.dat:
    v7mm_c8

  Setup group:    10          Station: VLBA_MK           Total bit rate:   2048
  Format: VDIF                Bits per sample: 2         Sample rate:256.000
  Number of channels:   4     DBE type: RDBE_DDC         Speedup factor:    1.00

  Disk used to record data.

  1st LO=  42400.00  42400.00  42400.00  42400.00
  Net SB=         U         U         U         U
  IF SB =         U         U         U         U
  Pol.  =       RCP       LCP       RCP       LCP
  BBC   =         1         2         3         4
  BBC SB=         U         U         U         U
  IF    =         A         C         A         C

  VLBA FE=     7mm      omit      7mm      omit
  VLBA Synth=   3.9      7.6      11.6
```

Tutorial: Complicated Spectral Line

The specddc.sum file

- Below is the bottom section, which has the frequencies that you are observing.
- The top frequencies are the frequencies for the first set of 7mm scans when there was no Doppler set.
- The second set of frequencies are for when Doppler was set, not that they are at slightly different frequencies.

```
 Frequency Set:  10  Setup file default.  Used with PCAL = off
 LO sum=   43168.00  43168.00  43296.00  43296.00
 BBC fr=     768.00    768.00    896.00    896.00
 Bandwd=     128.00    128.00    128.00    128.00
 VLBA legacy crd files using  4 channels based on RDBE channels:   1  2  3  4
 CRD fr=     824.00    824.00    952.00    952.00
 CRD bw=      16.00     16.00     16.00     16.00
  Matching frequency sets:  10  11  12  13  14  15  16  17  18  19

Frequency Set:  20  Based on FREQ, BW, and/or DOPPLER in schedule.  Used with PCAL = off
 LO sum=   43063.125  43063.125  43113.125  43113.125
 BBC fr=     663.125    663.125    713.125    713.125
 Bandwd=     128.00    128.00    128.00    128.00
 VLBA legacy crd files using  4 channels based on RDBE channels:   1  2  3  4
 CRD fr=     719.13    719.13    769.13    769.13
 CRD bw=      16.00     16.00     16.00     16.00
  Matching frequency sets:  20  21  22  23  24  25  26  27  28  29
```

Lastly,

- If you have problems please send a helpdesk ticket (https://help.nrao.edu)
- Submit your schedule by e-mailing your .key file to vlbiobs@lbo.us
  - Most schedules are dynamically scheduled so submit your schedule before the start of the semester you were granted time for the best chance to get observed
  - For fixed date (HSA, EVN, Global VLBI….) submit your schedule ***2 weeks before the observation***

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