NH3 Observations with the GBT
K-Band Focal Array (KFPA) Mapping Observations

More detailed information can be found in the GBT Observer's Guide:
http://www.gb.nrao.edu/scienceDocs/GBTog.pdf

```
# Observing script for spectral line observations of NH3 using KFPA mapping
and position switching.

# Reset configuration from prior observation.
ResetConfig()

# Import catalog of flux calibrators and user defined sources.
Catalog(fluxcal)
Catalog('/home/astro-util/projects/quick_guide/catalogs/KFPA_catalog.cat')

# Define configuration parameters
nh3_config='''
receiver          = 'RcvrArray18_26'
beam              = '1,2,3,4,5,6,7'
obstype           = 'Spectroscopy'
backend           = 'VEGAS'
nwin              = 4
restfreq          = 23694.4955, 23722.6336, 23870.1292, 23963.9010, 23687.8974
bandwidth         = 23.44
nchan             = 4096
swmode            = 'tp'
swtype            = 'none'
swper             = 2.0
tint              = 4.0
vlow              = 0
vhigh             = 0
vframe            = 'lsrk'
vdef              = 'Radio'
noisecal          = 'lo'
'''

# Configure telescope.
Configure(nh3_config)

# Slew to your source or calibrator.
Slew('NGC1333')

# Perform position and focus correction on nearby calibrator.
# Leaving the '()' blank will have the system choose your calibrator for you.
AutoPeakFocus()

# Slew to your source.
Slew('NGC1333')

# Reconfigure after calibrator corrections.
Configure(nh3_config)

# Balance the IF system & Backend
Balance()

# RA Long map with reference consisting of 28 rows with a row of separation
of 13.371 arcsec
# For a map size of 7.8x7.8 arcmin²
# Mapping commands are generated via the mapping calculator
RALongMapWithReference('NGC1333'),
      Offset('J2000', 7.8/60., 0.0, cosv=True),
      Offset('J2000', 0.0, 7.8/60., cosv=True),
      Offset('J2000', 0.0, 13.371/3600., cosv=True),
      referenceOffset=Offset("J2000", 1.0, 0.0, cosv=True),
      referenceInterval=3,
      scanDuration=274.7185, start=1, stop=28)
```

Catalogs

To find out more about catalogs: GBT Observer's Guide: Section 6.3

Here is an example of a RA/Dec coordinate system catalog:

```
# Source List for NH3 observing with Equatorial coordinates.

format=spherical
HEAD = NAME COORDMODE RA DEC
NGC1333      J2000  03:29:08.8 +31:15:07
NGC1333_OFF  J2000  03:30:00.0 +31:15:07
```

Note: You can include any number of user defined keywords including velocity. See Observer's guide for more information.

Note: These should be saved as a '.cat' file, in a known location, to be called later.

Configurations

To find out more about configurations: GBT Observer's Guide: Section 6.2

```
# Configuration parameters for spectral line observations of NH3 using position switching.
nh3_config='''
receiver          = 'RcvrArray18_26'      # Selects K-band receiver
beam              = '1,2,3,4,5,6,7'       # number of beams
obstype           = 'Spectroscopy'        # spectral line mode
backend           = 'VEGAS'               # VEGAS as the back-end
restfreq          = 23694.4955, 23722.6336, 23870.1292, 23963.9010 23687.8974
                                          # Specifies frequency of lines NH3(1,1),
                                            NH3(2,2),NH3(3,3), HC5N, HC7N
bandwidth         = 23.44                 # Bandwidth per frequency window
nchan             = 4096                  # Number of channels per spectral window
deltafreq         = 0                     # Offsets in MHz for each spectral window
swmode            = 'tp'                  # Specifies switching mode, total power
swtype            = 'none'                # Specifies position switching, here set as none
swper             = 2.0                   # Specifies length of full switching cycle (seconds)
tint              = 4.0                   # Integration time, integer multiple of swper
vlow              = 0                     # minimum velocity to be observed - default is 0
vhigh             = 0                     # maximum velocity to be observed - default is 0
vframe            = 'lsrk'                # specifies velocity reference frame
vdef              = 'Radio'               # specifies Doppler-shifted velocity frame
noisecal          = 'lo'                  # level of the noise diode, 'lo' for 'fsw'
'''
```

NOTE: Your parameters may differ based on your specific science goals.

Scripts (Scheduling Blocks)

To find out more about scripts: GBT Observer's Guide: Section 6.1

Astrid is used to submit scripts, or Scheduling Blocks, for GBT observations. Astrid is Python based and can incorporate custom user scripts. Here is an example of a basic position switched, KFPA mapping observation of Ammonia.

```
 Observing script for spectral line observations of NH3 using KFPA mapping.

# Reset configuration from prior observation.
ResetConfig()

# Import catalog of flux calibrators and user defined sources.
Catalog(fluxcal)
Catalog('/home/astro-util/projects/quick_guide/catalogs/KFPA_catalog.cat')

# Define configuration parameters
nh3_config='''
receiver          = 'RcvrArray18_26'
beam              = '1,2,3,4,5,6,7'
obstype           = 'Spectroscopy'
backend           = 'VEGAS'
nwin              = 4
restfreq          = 23694.4955, 23722.6336, 23870.1292, 23963.9010, 23687.8974
bandwidth         = 23.44
nchan             = 4096
swmode            = 'tp'
swtype            = 'none'
swper             = 2.0
tint              = 4.0
vlow              = 0
vhigh             = 0
vframe            = 'lsrk'
vdef              = 'Radio'
noisecal          = 'lo'
'''


# Configure telescope.
Configure(nh3_config)

# Slew to your source or calibrator.
Slew('NGC1333')

# Perform position and focus correction on nearby calibrator.
# Leaving the '()' blank will have the system choose your calibrator for you.
AutoPeakFocus()

# Slew to your source.
Slew('NGC1333')

# Reconfigure after calibrator corrections.
Configure(nh3_config)

# Balance the IF system & Backend
Balance()

#RALongMap of the source with reference scans taken every 3 rows.

RALongMapWithReference('NGC1333'),
      Offset('J2000', 7.8/60., 0.0, cosv=True),
      Offset('J2000', 0.0, 7.8/60., cosv=True),
      Offset('J2000', 0.0, 13.371/3600., cosv=True),
      referenceOffset=Offset("J2000", 1.0, 0.0, cosv=True),
      referenceInterval=3,
      scanDuration=274.7185, start=1, stop=28)
```

Data Reduction

To find out more about data reduction: GBTIDL User's Guide

Our current data reduction routines are written in IDL. Users can build custom scripts incorporating generic IDL commands. We will run through some common GBT IDL commands below.

From a Green Bank Observatory data reduction machine (Fourier, Arcturus, Planck, Newton, Euclid), log into GBTIDL by typing "gbtidl" from a terminal.

```
bash$ gbtidl
Starting GBTIDL
------------------------------------------------------------------------
                      Welcome to GBTIDL v2.10.1

    For news, documentation, enhancement requests, bug tracking,
           discussion, and contributions, visit:

                      http://gbtidl.nrao.edu

    For help with a GBTIDL routine from the command line, use
      the procedure 'usage'. For example:

   usage,'show'              ; gives the syntax of the procedure 'show'
   usage,'show',/verbose     ; gives more information on ‘show'

------------------------------------------------------------------------
```

To access the test data presented in this reference guide type ‘offline’ followed by the project name:

```
GBTIDL -> offline, ‘TGBT21B_500_06’
Connecting to file: /home/sdfits/TGBT21B_500_06/TGBT21B_500_06.raw.vegas
GBTIDL -> summary

  Scan  Source   Vel   Proc    Seq   RestF  nIF nInt  nFd    Az    El
-------------------------------------------------------------------
   20    NGC1333  0.0    Track  1   23.688   5   69    7    208.7  82.0
   21    NGC1333  0.0  RALongM  1   23.688   5   69    7    220.9  80.8
   22    NGC1333  0.0  RALongM  2   23.688   5   69    7    225.1  80.2
   23    NGC1333  0.0  RALongM  3   23.688   5   69    7    229.9  79.5
   24    NGC1333  0.0    Track  1   23.688   5   69    7    230.2  79.5
   25    NGC1333  0.0  RALongM  4   23.688   5   69    7    237.0  78.0
   26    NGC1333  0.0  RALongM  5   23.688   5   69    7    240.3  77.1
   27    NGC1333  0.0  RALongM  6   23.688   5   69    7    242.6  76.4
   28    NGC1333  0.0    Track  1   23.688   5   69    7    243.1  76.3
   29    NGC1333  0.0  RALongM  7   23.688   5   69    7    247.6  74.5
   30    NGC1333  0.0  RALongM  8   23.688   5   69    7    249.3  73.7
   31    NGC1333  0.0  RALongM  9   23.688   5   69    7    251.4  72.7
   32    NGC1333  0.0    Track  1   23.688   5   69    7    251.4  72.7
<press spc to continue>
```

GBTIDL allows for you to write your own procedures. Here is a program written to calibrate and write the data to a new file for mapping. Your program may look different based on your observations and science goals.

```
pro reduction

; Read the file in
FileIn='/home/sdfits/TGBT21B_500_06/TGBT21B_500_06.raw.vegas'
If !g.line_filein_name ne FileIn then fill-in,FileIn

file='/home/astro-util/QuickGuides/NH3scans.fits'

; Define on source scans and reference scans
ons=[21,22,23,25,26,27,29,30,31,33,34,35]
offs=[20,20,20,24,24,24,28,28,28,32,32,32]

; Opens and defines the name for the output file
fileout, file

; Turns off the auto-plotter feature (speeds up processing)
freeze

; Calibrate each integration per scan per feed for both polarizations
and average the two polarizations.
for kji=0, 6 do begin

for ijk=0, n_elements(ons)-1 do begin

for inti=0, 68 do begin

; Clears the default global accumulator
sclear

getsigref, ons[ijk], offs[ijk], ifnum=1, plnum=0, fdnum=kji, intnum=inti

accum

getsigref, ons[ijk], offs[ijk], ifnum=1, plnum=1, fdnum=kji, intnum=inti

accum

ave
```

```
; smooth to 12 channels - corresponds to a velocity resolution of
0.07km/s
gsmooth, 12, /decimate

; Set x-axis to channels
chan

; specify the regions free of emission to fit the baseline
nregion, [500, 2300, 3560, 3830]

; specifies the order of the polynomial to be fit
nfit, 3

; subtract the most recent baseline fit
baseline

keep

endfor

endfor

endfor

unfreeze
end
```

To access the program you have written you will compile and then run your program at the command line.

```
GBTIDL -> .compile reduction.pro
GBTIDL -> reduction
```

Note: if your program is not located in your working directory (where you are running GBTIDL from) you will need to provide the full path of the file.

When this is done running you will have the output file `NH3scans.fits` at the specified file path.

The next step is to use the GBTgridder. At the command line we specify optional parameters.

```
$ gbtgridder -channels 2000:3700 -output NGC1333_NH3 -noline -nocont
NH3scans.fits
```

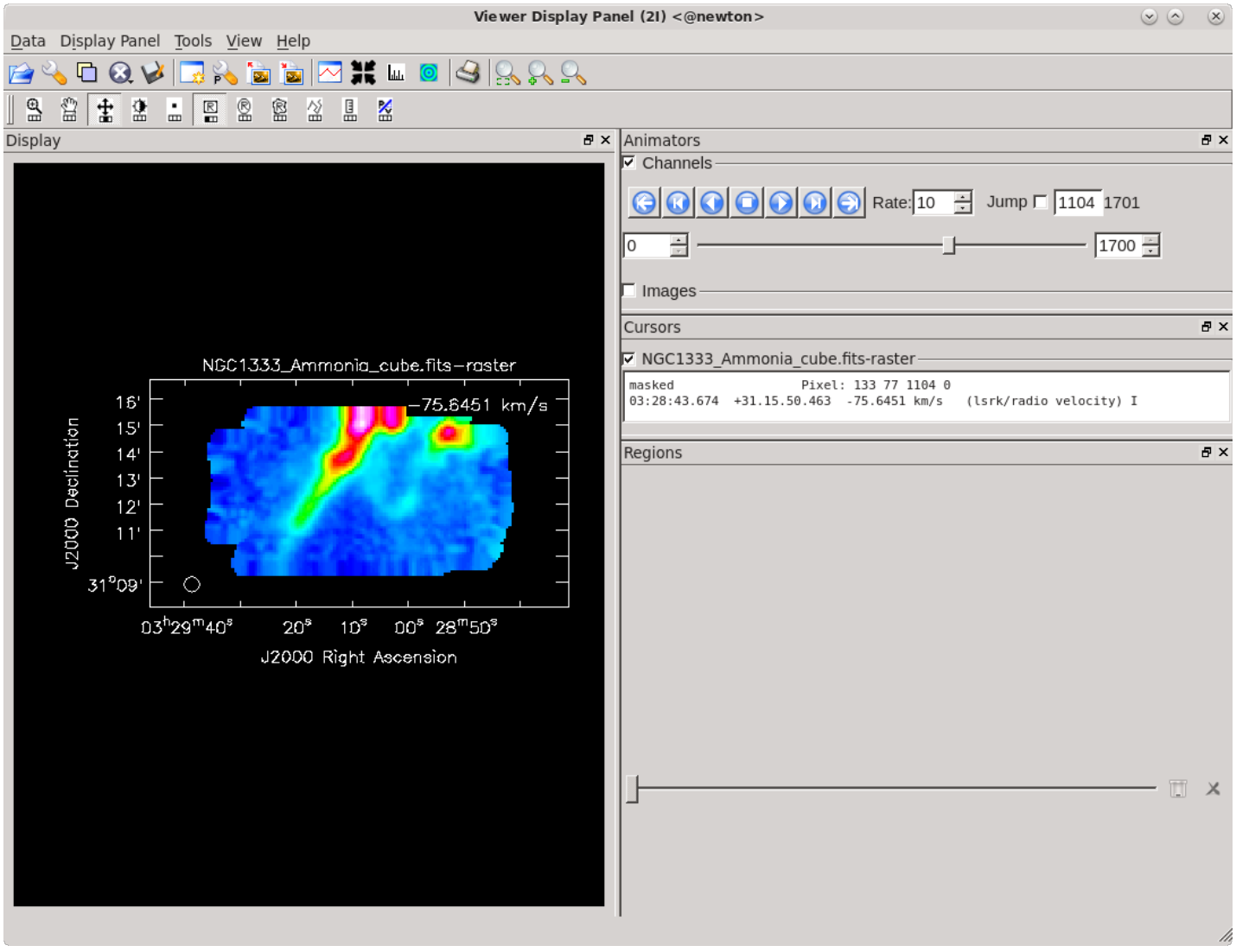
Here channels specifies the channel range we want to grid. The output file name is defined and the data products will follow the conventions below.

`NGC1333_NH3_cube.fits`	A multi-channel data cube
`NGC1333_NH3_cont.fits`	A single-channel “continuum” map
`NGC1333_NH3_line.fits`	A continuum-subtracted data cube

For this example we include the optional parameters `–noline` and `–nocont` which turns off the production of the line cube and the output ‘cont’.

You can use casaviewer or ds9 to examine the data cubes. For this Quick Guide we will use casaviewer.

```
$ casaviewer NGC1333_NH3_cube.fits
```



In order to display a spectral cut through the cube, select “Tools -> Spectral Profile”, then left-click on the crosshair icon and left-click on the map.