Robert C. Byrd Green Bank Telescope
NRAO Green Bank

Richard M. Prestage

20 August 2013

GBT MEMO 283.1

Astronomical Tests of VEGAS Modes 2 and 3

Abstract

This document describes astronomical testing of the frequency scales for VEGAS Modes 2 and 3.

Contents

Mode	BOF	Bandwidth	Channels	Resolution
2	H16K/HBW	1250 MHz	16384	88 kHz
3	H16K/HBW	850 MHz	16284	61 kHz

Table 1: Basic parameters of the tested modes

1 Introduction

VEGAS, the VErsatile, Green Bank Astronomical Spectrometer is currently undergoing commissioning. VEGAS has 29 modes[1] which provide different combinations of bandwidth and resolution. This note describes astronomical checks on the frequency scales for VEGAS Modes 2 and 3.

2 Observations Details

Observations were performed with Modes 2 and 3. The key parameters of these modes are listed in Table 1.

Observations were performed on the morning of 2013 August 19, from approximately 4:00am to 7:00am ET. Data was taken into project TGBT13B_502_07. Weather was calm, overcast with a light rain. The frequency scales were checked by performing observations of radio recombination lines (RRL) using the X-band (8-10 GHz) receiver. VEGAS was configured using Astrid configuration scripts provided by Amanda Kepley (see Appendix A); this set up for "On-Off" observations with three repeats of 60 seconds in each of the On and Off positions. This was repeated four times for each mode; a summary of the scans is given in Table 2. Observations were made of G061.480+00.090, taken from the Green Bank Telescope Galactic HII Discovery Survey (Bania *et al* 2010). Only Bank A was used for these tests.

3 Data Processing

Data were "filled" using the 2013 August 19 Test version of the SDFITS program; analysis was then performed using the test version of GBTIDL. A short IDL script was written to average the scans together (see Appendix B). The data processing stages were as follows:

- 'getps' to get and calibrate each pair of scans
- average the scans together
- average the polarizations together
- fit and remove a ninth order baseline
- fit a Gaussian to each of the observed RRL

4 Results

The results of the tests are provided in Tables 3 and 4. The columns are as follows: *Transition* the RRL; *Rest Freq.* the rest frequency of that transition; *Sky Freq.* the expected frequency of that line for a velocity of 26.5 km/s; *Obs. Freq.* the observed frequency, and *Error* uncertainty in the position resulting from the "fitgauss" routine.

As can be seen from the table, the observed frequencies agree in all cases with the expected frequencies to within the fitting error; which in all cases is a small fraction of a frequency channel.

[1] see http://www.gb.nrao.edu/vegas/modes

blk:RRLXbandMode2SpecOnOff							
Scan	Object	Proc	SeqN	Of	SkyFreq	GLON	GLAT
9	G061.480+00.090	OnOff	1	2	9.0000	61.4800	0.0900
10	G061.480+00.090	OnOff	2	2	9.0000	61.4800	0.0900
11	G061.480+00.090	OnOff	1	2	9.0000	61.4800	0.0900
12	G061.480+00.090	OnOff	2	2	9.0000	61.4800	0.0900
13	G061.480+00.090	OnOff	1	2	9.0000	61.4800	0.0900
14	G061.480+00.090	OnOff	2	2	9.0000	61.4800	0.0900
15	G061.480+00.090	OnOff	1	2	9.0000	61.4800	0.0900
16	G061.480+00.090	OnOff	2	2	9.0000	61.4800	0.0900
17	G061.480+00.090	OnOff	1	2	9.0000	61.4800	0.0900
18	G061.480+00.090	OnOff	2	2	9.0000	61.4800	0.0900
19	G061.480+00.090	OnOff	1	2	9.0000	61.4800	0.0900
20	G061.480+00.090	OnOff	2	2	9.0000	61.4800	0.0900
blk:RRLXbandMode3SpecOnOff							
Scan	Object	Proc	SeqN	Of	SkyFreq	GLON	GLAT
21	G061.480+00.090	OnOff	1	2	9.0000	61.4800	0.0900
22	G061.480+00.090	OnOff	2	2	9.0000	61.4800	0.0900
23	G061.480+00.090	OnOff	1	2	9.0000	61.4800	0.0900
24	G061.480+00.090	OnOff	2	2	9.0000	61.4800	0.0900
25	G061.480+00.090	OnOff	1	2	9.0000	61.4800	0.0900
26	G061.480+00.090	OnOff	2	2	9.0000	61.4800	0.0900
27	G061.480+00.090	OnOff	1	2	9.0000	61.4800	0.0900
28	G061.480+00.090	OnOff	2	2	9.0000	61.4800	0.0900
29	G061.480+00.090	OnOff	1	2	9.0000	61.4800	0.0900
30	G061.480+00.090	OnOff	2	2	9.0000	61.4800	0.0900
31	G061.480+00.090	OnOff	1	2	9.0000	61.4800	0.0900
32	G061.480+00.090	OnOff	2	2	9.0000	61.4800	0.0900

Table 2: Summary of Scans

Transition	Rest Freq. (GHz)	Sky Freq. (GHz)	Obs. Freq. (GHz)	Error (kHz)
89	9.4878210	9.4869820	9.4869923	4.295
90	9.1733206	9.1725099	9.1725153	3.926
91	8.8725681	8.8717838	8.8717861	8.688
92	8.5848206	8.5840619	8.5840615	7.724
93	8.3093824	8.3086479	8.3086794	16.22

Table 3: Expected and Observed Frequencies for Mode 2

Transition	Rest Freq. (GHz)	Sky Freq. (GHz)	Obs. Freq. (GHz)	Error (kHz)
89	9.4878210	9.4869820	-	-
90	9.1733206	9.1725099	9.1725125	13.84
91	8.8725681	8.8717838	8.8717833	17.23
92	8.5848206	8.5840619	8.5840650	13.95
93	8.3093824	8.3086479	-	-

Table 4: Expected and Observed Frequencies for Mode 3

5 Conclusions

From these tests we conclude that the GBT M & C software, the SDITS filler and the GBTIDL analysis program are handling the VEGAS frequency information correctly.

6 References

Bania, T. M., Anderson, L. D., Balser, D. S. & Rood, R. T., "The Green Bank Telescope Galactic H II Region Discovery Survey", Ap.J. Letters, 2010, V718 pp106-111

A Observing Scripts

A.1 Mode 2 - RRLXbandMode2SpecOnOff

```
scriptdir = '/home/scratch/akepley/vegas_tests/rrl_test/'
Catalog(scriptdir+'hrds_bright.cat')
Catalog(scriptdir+'known_catalog_hrds.cat')

## To overlay RRL transitions in GBTIDL viewer
## GBTIDL> recombh

#source = 'W49A'
#source = 'G049.399-0.489'
#source = 'G048.551-0.001'
source = 'G061.480+00.090'

scanDuration = 60
nscans = 3
myoffset = Offset("J2000",15/60.0,15.0/60.0,cosv=True)
doPoint = False

vegas_config="""
receiver= 'Rcvr8_10'
obstype = 'Spectroscopy'
backend = 'VEGAS'
swmode = 'tp'
noisecal = 'lo'
swtype = 'none'
swper = 0.1
swfreq = 0, 0
vframe = 'lsrk'
vdef = 'Radio'
pol = 'Linear'
dopplertrackfreq=9000.0
beam = 'B1'
bandwidth=1250
deltafreq=0.0
tint=1.0
vegas.vpol = "self"
nchan="high"
```

```
restfreq = 9000.0
vegas.vfreq = [  {"restfreq": 9000.0,  "bank":"A"}]
"""
Configure(vegas_config)

#This setvalue is needed till CRVAL1 is finalized
#Anish Jul 3, 2013
subfreqValues = {
    'sub_frequencyA,1': 750000000,
    'sub_frequencyB,1': 750000000 }

SetValues('VEGAS', subfreqValues)
SetValues('VEGAS', {'state':'prepare'})

# Balance()

Slew(source)

Balance()

if doPoint:
    AutoPeakFocus(source)
    Slew(source)

for i in range(0,nscans):
    OnOff(source, myoffset,scanDuration)
```

A.2 Mode 3 - RRLXbandMode3SpecOnOff

```
scriptdir = '/home/scratch/akepley/vegas_tests/rrl_test/'
Catalog(scriptdir+'hrds_bright.cat')
Catalog(scriptdir+'known_catalog_hrds.cat')

## To overlay RRL transitions in GBTIDL viewer
## GBTIDL> recombh

# source = 'W49A'
# source = 'G049.399-0.489'
# source = 'G048.551-0.001'
source = 'G061.480+00.090'

scanDuration = 60
nscans = 3
myoffset = Offset("J2000",15/60.0,15.0/60.0,cosv=True)
doPoint = False

vegas_config="""
receiver= 'Rcvr8_10'
obstype = 'Spectroscopy'
backend = 'VEGAS'
swmode = 'tp'
noisecal = 'lo'
swtype = 'none'
```

```
swper = 0.1
swfreq = 0, 0
vframe = 'lsrk'
vdef = 'Radio'
pol = 'Linear'
dopplertrackfreq=9000.0
beam = 'B1'
bandwidth=850.0
deltafreq=0.0
tint=1.0
vegas.vpol = "self"
nchan="high"
restfreq = 9000.0
vegas.vfreq = [  {"restfreq": 9000.0,  "bank":"A"}]
"""
Configure(vegas_config)

#This setvalue is needed till CRVAL1 is finalized
#Anish Jul 3, 2013
subfreqValues = {
    'sub_frequencyA,1': 500000000,
    'sub_frequencyB,1': 500000000 }

SetValues('VEGAS', subfreqValues)
SetValues('VEGAS', {'state':'prepare'})

Balance()

Slew(source)

Balance()

if doPoint:
    AutoPeakFocus(source)
    Slew(source)

for i in range(0,nscans):
    OnOff(source, myoffset ,scanDuration)
```

B GBTIDL Analysis Routine

```
pro myav
   sclear,1
   sclear,2
   sclear,3
   for i = 21,32,2 do begin
      getps, i, plnum = 0
      accum, 1
      getps, i, plnum = 1
      accum, 2
  end
  ave, 1
  accum, 3
```

```
  ave, 2
  accum, 3
  ave, 3
  show
  nfit,9
  setregion
  baseline
end
```