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VEGAS Mode 1 commissioning report

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Abstract

A summary of the results of the VEGAS Mode 1 commissioning observation is given in this report. The analysis of the data shows that the GBT M&C system, SDFITS filler and GBTIDL analysis routines are processing VEGAS Mode 1 data correctly.

1 Introduction

Versatile GBT Astronomical Spectrometer (VEGAS) is currently being commissioned. VEGAS has 29 Modes¹ of operation. This report summarizes the results of commissioning observation with Mode 1 of VEGAS.

2 Observation Details

The observations were done with VEGAS using Mode 1 on 21 June 2013 (Project ID : TGBT13A_502_01). Mode 1 has a bandwidth of 1250 MHz, 1024 spectral channels and *advertised* spectral resolution of 1.46 MHz. For the commission observations the ADC sampling frequency was set to 2880.0 MHz, which provided a spectral resolution of 1.406 MHz. L-band (1.4 GHz) receiver of the GBT was used for commissioning observations. A set of position switched, frequency switched and mapping observations were performed. Position and frequency switched observations were done toward the HII region DR21. A $2^\circ \times 3^\circ$ region centered at RA(2000) 19:54:00, DEC(2000) +32:53:00 was imaged in Mode 1. A well known supernova remnant, CTB80, is present within the observed region. We also observed the calibrator 3C 286, however, the data was later found to be bad due to a configuration error. Therefore we include here position switched scans taken on the calibrator 3C 123 in Mode 1 as part of the project TGBT13B_502_07 observed by Richard Prestage.

During the analysis of the commissioning data, the sig/ref and cal on/off states generated by VEGAS were found to be inverted with respect to the convention used in GBTIDL (see Section 3). These ‘inversions’ were corrected in the switching signal generation part of the VEGAS manager software. Test data without moving the antenna but with a internal tone signal injected to the L-band receiver was taken on 9 July 2013 (Project ID : TGBT13A_504_20) after the software correction. This data set is used to test the analysis of the frequency switching observations and the results are included here.

3 Data Analysis

SDFITS files were generated using a test version (Version 1.19) of the program sdfits. The data were analyzed using the test version (Version 2.9) of the GBTIDL, which has been upgraded to analyze VEGAS data. During the analysis of 21 June 2013 data set, we found that the sig/ref and cal on/off states generated by VEGAS were inverted with respect to the convention used in GBTIDL. Therefore the analysis was mostly done using a modified version of the procedure getsigref.pro. The modification is essentially the software reversal of the state convention in getsigref.pro. The mapping data was analyzed using this modified program and converted to UVFITS using idlToSdfits (written by Dr. Glen Langston). The UVFITS file was loaded to AIPS package and the task SDGRID was used to make the image of CTB80 region.

The position switched data on 3C 123 from the project TGBT13B_502_07 was analyzed using the gbtidl task *getps* and the frequency switched data from the project TGBT13A_504_20 was analyzed using the task *getfs*.

4 Result

- **Observation toward 3C 123 :** *getps* provided a spectrum in antenna temperature toward the source 3C 123. The flux density of 3C 123 at 1.465 GHz is 47.8 Jy (Perley & Butler 2013). The antenna temperature measured at this frequency is about 100 K, which gives a telescope gain of 2.1 K/Jy. The measured off-source system temperature is 18.7 K. The uncertainty in these measurements are mostly due to the value used for the calibrated noise and is expected to be about 10 %.

¹see www.gb.nrao.edu/vegas/modes

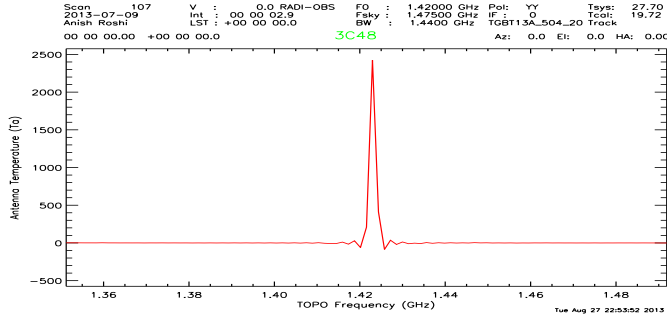


Figure 1: Frequency switched spectrum obtained with an injected tone at 1422.96875 MHz

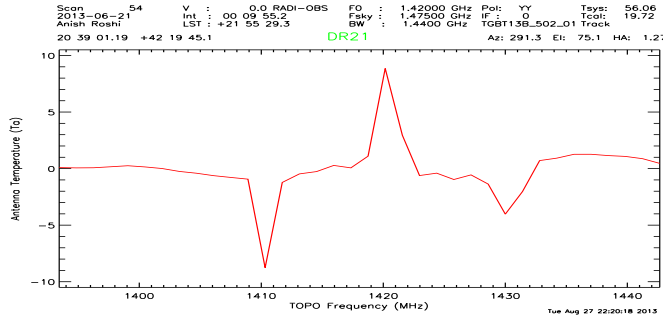


Figure 2: HI emission spectrum toward the source DR21. The absorption features seen at either side of HI emission at 10 MHz away are expected artifacts resulting from the analysis of frequency switched data in GBTIDL.

- **Test tone data :** A tone of frequency 1422.96875 MHz was injected at the front-end of L-Band receiver using LO1B synthesizer. A spectrum obtained with *getfs* is shown in Fig. 1. No artifact is seen near ± 10 MHz (the frequency by which local oscillator (LO) was switched) from the tone, indicating that the LO blanking is correctly applied by VEGAS. Moreover, the tone appears at the expected frequency in the GBTIDL spectrum validating the frequency calibration.
- **HI observations :** The HI spectrum obtained toward RA(2000): 20:39:01, DEC(2000): +21:55:29 is shown in Fig. 2. This spectrum is obtained by switching the LO frequency by 10 MHz. The velocity resolution (308 km s^{-1}) of Mode 1 is not good enough to measure the HI profile. The peak HI emission temperature toward the observed position in LAB survey (Kalberla et al., 2005) is about 60 K and its width is $\sim 40 \text{ km s}^{-1}$. The measured HI antenna temperature is consistent with LAB data, if we take into account of the ‘smearing’ of HI line due to the coarse spectral resolution of Mode 1.
- **Mapping observations :** A continuum map of CTB80 field made from the commissioning data is shown in Fig. 3. The data is analyzed as described in Section 3. The image is made from one spectral channel centered at 1.47 GHz. The amplitude scale is converted to Jy using the telescope gain of 2 K/Jy. The features seen in the map corresponds well with those in the CGPS images of the same region (Taylor et al. 2003).

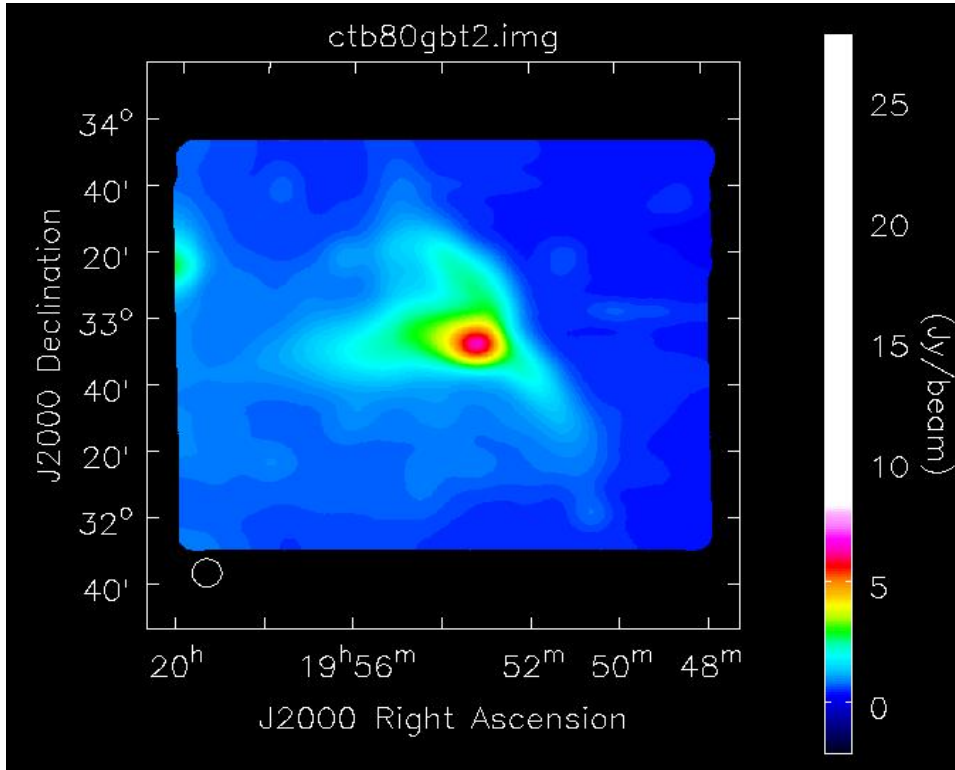


Figure 3: Image of CTB80 Supernova remnant made with the GBT. The color scale represents flux density variation across the field in Jy. The image is made at the frequency 1.47 GHz with data from one spectral channel (bandwidth 1.406 MHz).

5 Conclusion

Our commission observations show that the GBT M&C system, SDFITS filler and GBTIDL analysis routines are processing VEGAS mode 1 data correctly. The frequency information in GBTIDL, LO blanking, Sig/Ref and Cal on/off switching are properly handled by the hardware and software. The VEGAS manager drops about 20 to 30 % data at the end of each scan, which was identified as due to an issue in the interaction of the HPC (high-performance computing) software and VEGAS manager software. This issue will be resolved in a future VEGAS manager/HPC software upgrade. This drop in data will not be a limitation for most of the observations, but should be fixed in the long term.

6 Reference

- Kalberla, P. M., et al. 2005, A&A, 440, 775
 Perley, R. A., Butler, B. J., 2013, ApJS, 204, 19
 Taylor, A. R., et al. 2003, AJ, 125, 3145.

A Observing Scripts

A.1 Lmodelspecfresw

```

vegas_config=""
receiver= 'Rcvr1_2'
obstype = 'Spectroscopy'
backend = 'VEGAS'
swmode = 'sp'
noisecal = 'hi'
swtype = 'fsw'
swper = 1.0
swfreq = 0, 10
vframe = 'topo'
vdef = 'Radio'
pol = 'Linear'
dopplertrackfreq=1420.0
beam = 'B1'
bandwidth=1250
deltafreq=0
tint=2.0
vegas.vpol = "self"
restfreq = 1420.0
nchan="low"
vegas.vfreq = [ {"restfreq": 1420.0, "bank":"A"}]
"""

Configure(vegas_config)

#This setvalue is needed till CRVAL1 is finalized
#The sampling freq used is 1440 x 2 MHz.
#Anish
subfreqValues = {
    'sub_frequencyA,1': 720000000,
    'sub_frequencyB,1': 720000000 }
SetValues('VEGAS', subfreqValues)
SetValues('VEGAS', {'state':'prepare'})

Break()

Catalog(fluxcal)
calname = "3c48"
calname = "DR21"
Slew(calname, beamName='1')
Balance()

Track(calname, None, 10*60)

```

A.2 Lmodelspeconoff

```

vegas_config=""
receiver= 'Rcvr1_2'
obstype = 'Spectroscopy'
backend = 'VEGAS'
swmode = 'tp'
noisecal = 'lo'
swtype = 'none'
swper = 1.0
swfreq = 0, 0
vframe = 'topo'
vdef = 'Radio'
pol = 'Linear'
dopplertrackfreq=1420.0
beam = 'B1'
bandwidth=1250
deltafreq=0
tint=2.0
vegas.vpol = "self"
restfreq = 1420.0, 1420.0
nchan="low"
vegas.vfreq = [ {"restfreq": 1420.0, "bank":"A"}]
""

```

```
Configure(vegas_config)
```

```

#This setvalue is needed till CRVAL1 is finalized
#The sampling freq used is 1440 x 2 MHz.
#Anish
subfreqValues = {
    'sub_frequencyA,1': 720000000,
    'sub_frequencyB,1': 720000000 }
SetValues('VEGAS', subfreqValues)
SetValues('VEGAS', {'state':'prepare'})

```

```
Break()
```

```

Catalog(fluxcal)
calname= "3C227"
Slew(calname, beamName='1')
Balance()

```

```

for i in range(2):
    OnOff(calname, Offset("J2000", 1.0, 1.0, cosv=True), 60, "1")

```

A.3 Lmodelspecmap

```

vegas_config=""
receiver= 'Rcvr1_2'
obstype = 'Spectroscopy'
backend = 'VEGAS'
swmode = 'tp'

```

```

noisecal = 'lo'
swtype = 'none'
swper = 1.0
swfreq = 0, 0
vframe = 'topo'
vdef = 'Radio'
pol = 'Linear'
dopplertrackfreq=1420.0
beam = 'B1'
bandwidth=1250
deltafreq=0
tint=1.0
vegas.vpol = "self"
restfreq = 1420.0, 1420.0
nchan="low"
vegas.vfreq = [ {"restfreq": 1420.0, "bank":"A"},
                 {"restfreq": 1420.0, "bank":"B"}]
"""

```

```

Configure(vegas_config)

```

```

#This setvalue is needed till CRVAL1 is finalized
#The sampling freq used is 1440 x 2 MHz.
#Anish
subfreqValues = {
    'sub_frequencyA,1': 720000000,
    'sub_frequencyB,1': 720000000 }
SetValues('VEGAS', subfreqValues)
SetValues('VEGAS', {'state':'prepare'})

```

```

Catalog(fluxcal)
Catalog("/users/aroshi/GBTobs/GBT12A-355/cbt80cent.cat")
Slew("ctb80fcen", beamName='1')
Balance()
Break()

```

```

RALongMapWithReference("ctb80fcen",
    Offset("J2000", 3.0, 0.0, cosv=True),
    Offset("J2000", 0.0, 2.0, cosv=True),
    Offset("J2000", 0.0, 0.058, cosv=True),
    Offset("J2000", -6.5, 4.0, cosv=True),
    4,
    77)

```