# BS Example

A beam switch (BS) spectrum with SEQUOIA is obtained by switching between two pixels in the array. Thus, we always have one of the two beams on the source and there is no time lost for observation of a reference. This results in a square root of two improvement in noise.

The BS approach is most appropriate for point sources where the small offset between pixels is sufficient to get a good "OFF" measurement.

Usually, we track pixel 10 and switch the telescope to pixel 8 for the reference observation. This allows us to read data from only one of the roach boards to do the reduction of the spectrum.

## Necessary Imports

In [1]:

```
# Python Imports
import numpy as np
import matplotlib.pyplot as pl

# Line Data Reduction Imports
from spec import *
from ifproc import *
from spec_viewer import *

from line_reduction import *
```

## Setup parameters for the reduction

In [2]:

```
# set all parameters to control the reduction and plot

data_path = './example_data/'
obsnum = 83057
pixel_number = 10

# calibration options
use_calibration = True
tsys = 100.

# designate pixels for the BS reduction
list_of_pixels = [8,10]
bank = 0

# baseline options
baseline_order = 0
plot_limits = [20,60,-10,300]
baseline_regions = [[-100,20],[60,200]]
line_integral_regions = [[25,55]]
```

## Read and reduce the spectrum

The `read-obsnum_bs` function follows the procedure of `read_obsnum_ps` used to produce PS spectra with the exception that the role of Main and Reference are reversed for the first pixel in the pixel list.

In [3]:

```
I, S = read_obsnum_bs(obsnum, list_of_pixels, bank, use_calibrat
ion, tsys=tsys, path=data_path)
```

```
found roach2_83057_0_1_W-Hya_2019-04-26_045336.nc
append roach2_83057_0_1_W-Hya_2019-04-26_045336.nc
found ifproc_2019-04-26_083057_00_0001.nc
before read npix = 16
from pixels npix = 16
from xlen npix = 16
TRACKING Sequoia PIXEL  8
./example_data/ifproc/ifproc_2019-04-26_083057_00_00
01.nc does not have map parameters
83057 is a Bs observation
read_roach ./example_data/spectrometer/roach2/roach2
_83057_0_1_W-Hya_2019-04-26_045336.nc
r:2 inp:0 pix:8 to:-0.030000
r:2 inp:2 pix:10 to:-0.030000
found roach2_83053_0_1_W-Hya_2019-04-26_045111.nc
append roach2_83053_0_1_W-Hya_2019-04-26_045111.nc
found ifproc_2019-04-26_083053_00_0001.nc
before read npix = 16
from pixels npix = 16
from xlen npix = 16
TRACKING Sequoia PIXEL  10
./example_data/ifproc/ifproc_2019-04-26_083053_00_00
01.nc does not have map parameters
./example_data/ifproc/ifproc_2019-04-26_083053_00_00
01.nc does not have bs parameters
83053 is a Cal observation
read_roach ./example_data/spectrometer/roach2/roach2
_83053_0_1_W-Hya_2019-04-26_045111.nc
r:2 inp:0 pix:8 to:-0.030000
r:2 inp:2 pix:10 to:-0.030000
```

```
/Users/schloerb/anaconda/envs/py37env/lib/python3.7/
site-packages/numpy/core/fromnumeric.py:734: UserWar
ning: Warning: 'partition' will ignore the 'mask' of
the MaskedArray.
  a.partition(kth, axis=axis, kind=kind, order=order
)
/Users/schloerb/Desktop/LMT/DataReduction/NewDataRed
uction/pipeline/spec.py:187: RuntimeWarning: invalid
value encountered in true_divide
  ps_list[i,:] = (self.reference_spectra[i,:]-self.m
ain_spectra[i,:])/self.main_spectra[i,:]
/Users/schloerb/Desktop/LMT/DataReduction/NewDataRed
uction/pipeline/spec.py:184: RuntimeWarning: invalid
value encountered in true_divide
  ps_list[i,:] = (self.main_spectra[i,:]-self.refere
nce_spectra[i,:])/self.reference_spectra[i,:]
```

## Create LineData objects for analysis

The following code block creates individual `LineData` objects for the spectra on the Main position (pixel 10) and the Reference position (pixel 8). The individual spectra are plotted.

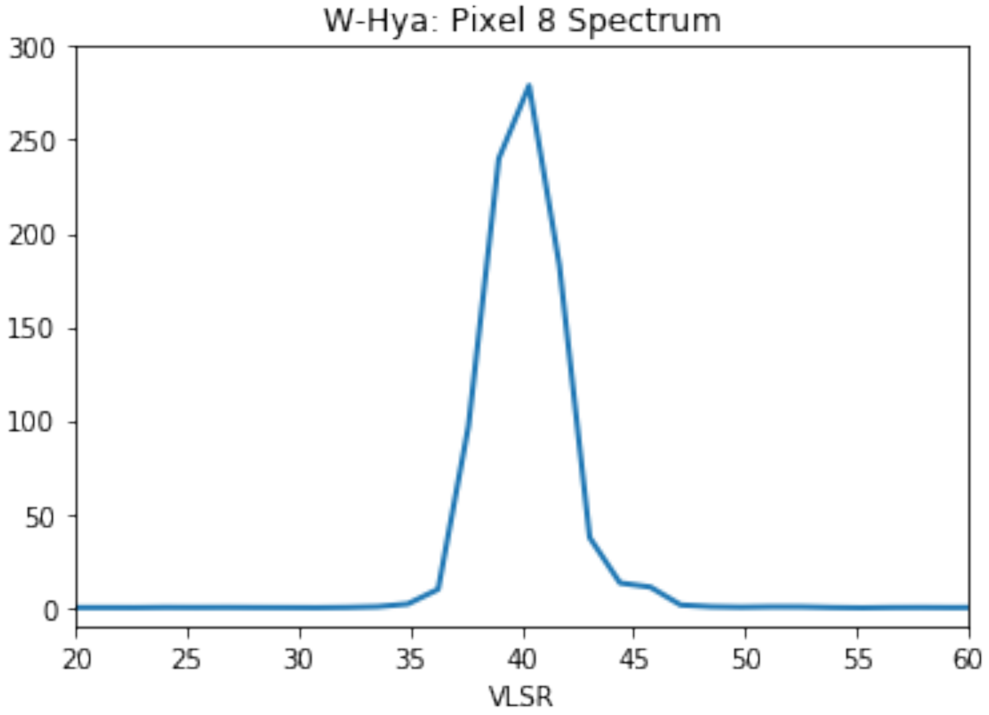
In [4]:

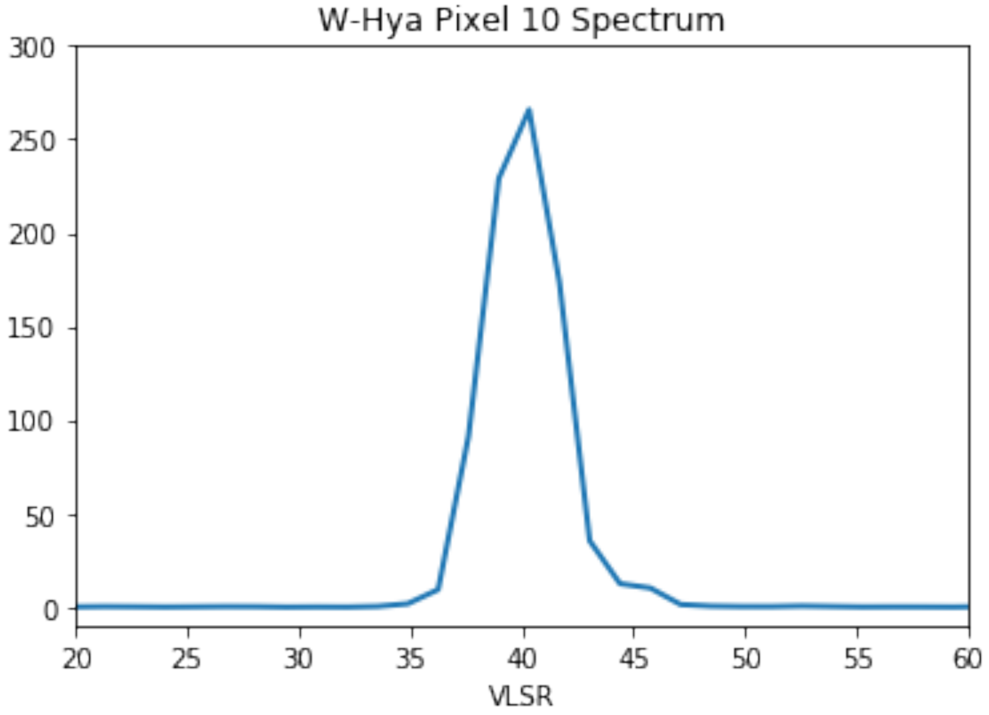
```
LD_0 = LineData(I,bank,S.nchan,S.bandwidth,S.roach[0].ps_spectru
m)
LD_1 = LineData(I,bank,S.nchan,S.bandwidth,S.roach[1].ps_spectru
m)

# select "V Source" option since this is a comet spectrum
LD_0.x_vlsr()
LD_1.x_vlsr()

# make a plot of the two spectra
pl.figure()
pl.plot(LD_0.xarray,LD_0.yarray)
pl.axis(plot_limits)
pl.xlabel(LD_0.xname)
pl.title('%s: Pixel %d Spectrum'%(I.source,list_of_pixels[0]));

pl.figure()
pl.plot(LD_1.xarray,LD_1.yarray)
pl.axis(plot_limits)
pl.xlabel(LD_1.xname)
pl.title('%s Pixel %d Spectrum'%(I.source,list_of_pixels[1]));
```





## Forming the BS Spectrum

We can also combine the individual spectra from the reduction to derive the BS result. We create a single `LineData` object with the result.

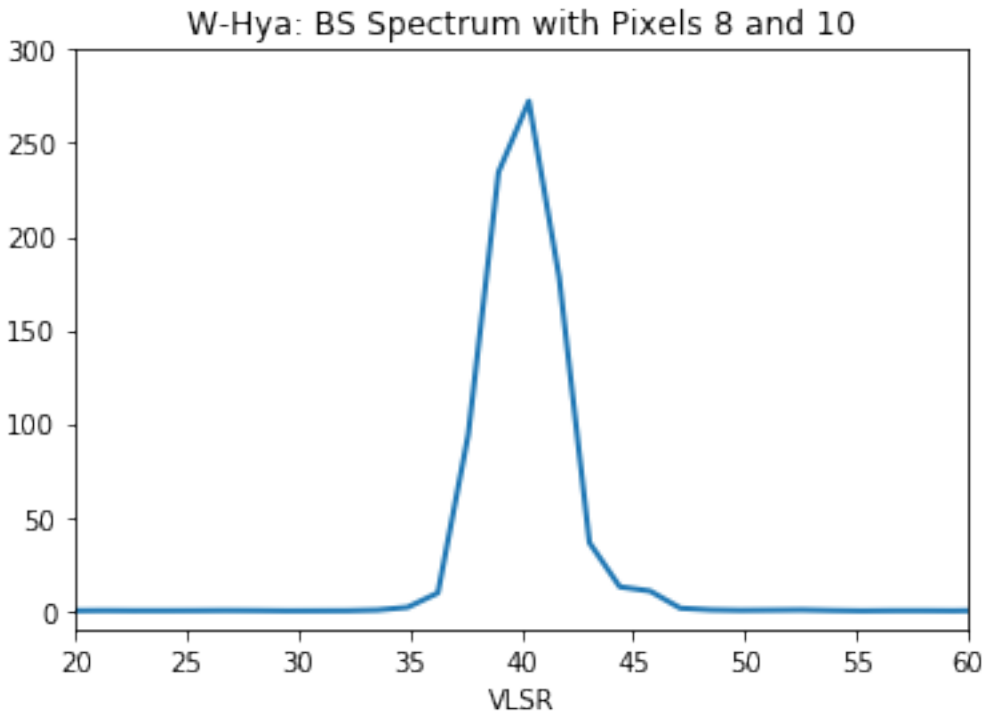
In [5]:

```
# create a LineData object with the BS spectrum
BS_LineData = LineData(I,bank,S.nchan,S.bandwidth,(S.roach[0].ps_spectrum + S.roach[1].ps_spectrum)/2.)

# plot the combined result
pl.plot(BS_LineData.xarray,BS_LineData.yarray)
pl.axis(plot_limits)
pl.xlabel(BS_LineData.xname)
pl.title('%s: BS Spectrum with Pixels %d and %d'%(I.source,list_of_pixels[0],list_of_pixels[1]))
```

Out[5]:

```
Text(0.5, 1.0, 'W-Hya: BS Spectrum with Pixels 8 and 10')
```



In [6]:

```
# create Line obeject to use spectral line methods
BS_Line = BS_LineData.line()

# fit baseline
blist, nb = BS_Line.xlist(baseline_regions)
BS_Line.baseline(blist,nb,baseline_order)

# compute "line" parameters
llist, nl = BS_Line.xlist(line_integral_regions)
BS_Line.line_stats(llist,nl)

# print the results
print('Results for %s %d'%(I.source,I.obsnum))
print('YMAX = %f  YINT = %f  XMEAN = %f  XMAX = %s'%(BS_Line.ymax,BS_Line.yint,BS_Line.xmean,BS_Line.xmax))
print('RMS = %f'%(BS_Line.rms))
```

```
Results for W-Hya 83057
YMAX = 272.341210  YINT = 1157.713345  XMEAN = 39.24
3295  XMAX = [40.32107053]
RMS = 0.058172
```