

Spectral Scans and Sideband Deconvolution

HIPE 9.1.0 - dec

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doDeconvolution x decon_result x

Spectrum1d

name	value	unit	
wavename	frequency		Actual name of the Wave
waveunit	GHz		Units of the WaveColumn
wavedescription	Single Sideband Frequency		Description of WaveColumn
bin_size	5.0E-4		Sampling width [GHz]
polarization	WBS-H		Polarization
tolerance	0.0010		Convergence tolerance
max_iterations		200	Maximum number of iterations
spur_rejection	REJECT SCANS WITH SPURS		Flag to reject scans, see

Data

- decon_result
 - ssb
 - gain
 - redundancy
 - History

decon_result["ssb"]

Antenna Temperature

Single Sideband Frequency

Console x History Log

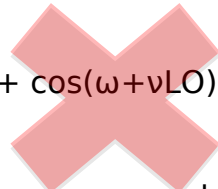
```

Reference scheme: DBS mode.
Total scans = 90
Total bad scans = 8
Total bad channels = 0
LO Frequency range: 563.4628422057649 GHz to 628.1299325462097 GHz
DeConvolving with gain fitting off...
Min Chisquare = 0.005620092164812858 after 7 iterations.
Done!!!
HIPE> interim_output = doDeconvolution.interim_output
HIPE>
    
```

- Data collection in the Spectral Scan mode.
- What is sideband deconvolution and why it is necessary for HIFI data?
- General description of the algorithm
- Implementation within HIPE
- Workflow for spectral scans

- Detectors are not able to directly measure flux at the frequencies of interest. But by mixing the signal from the sky with a local oscillator, we `downconvert' the frequency.

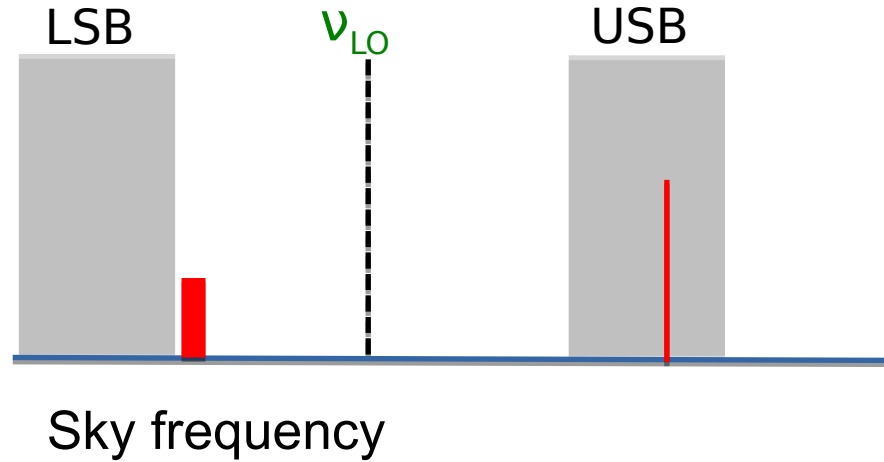
- $\cos(\omega)\cos(\nu_{LO})=0.5[\cos(\omega-\nu_{LO}) + \cos(\omega+\nu_{LO})]$



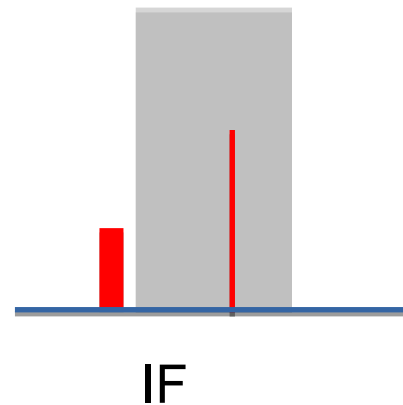
- When ω is the entire, unfiltered sky frequency, you end up being sensitive to TWO bandpasses. ($\cos(\nu) = \cos(-\nu)$)

Related problem: How to observe a frequency range larger than the bandpass of the instrument?

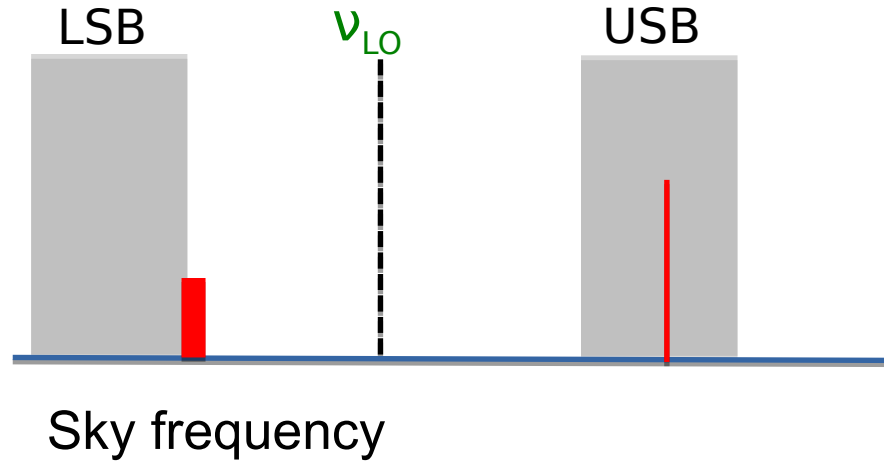
What is being measured ->



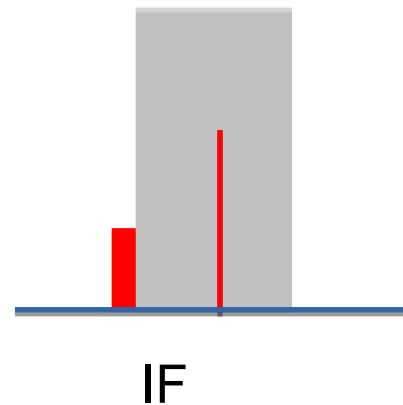
How it looks when collected->



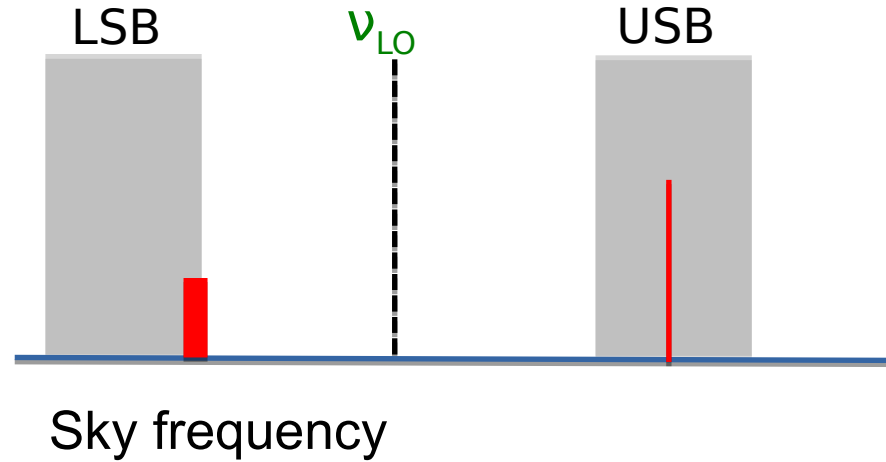
What is being measured ->



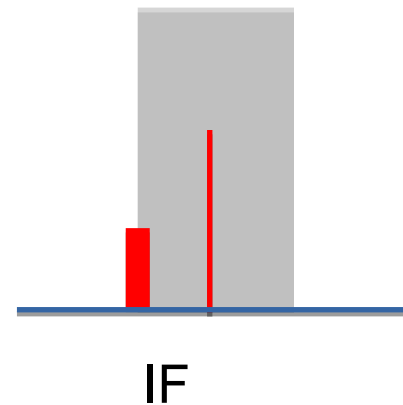
How it looks when collected->



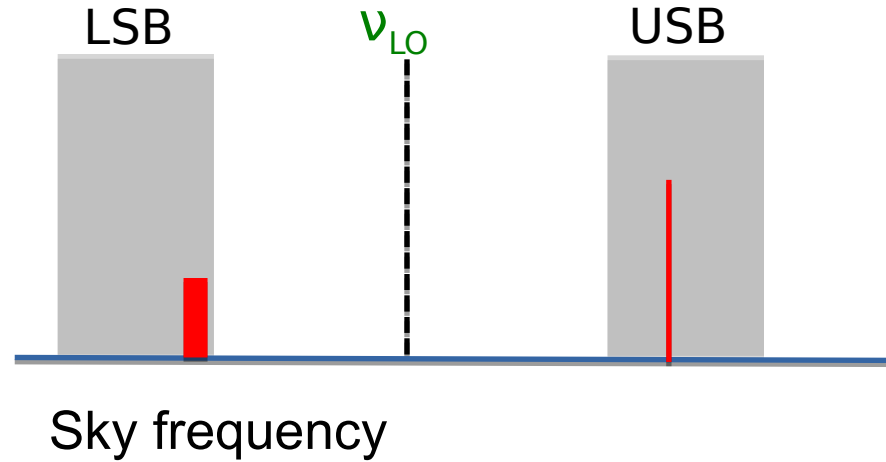
What is being measured ->



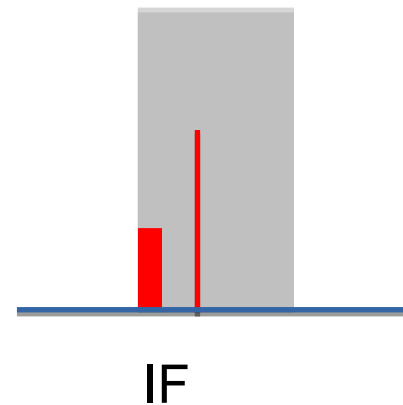
How it looks when collected->



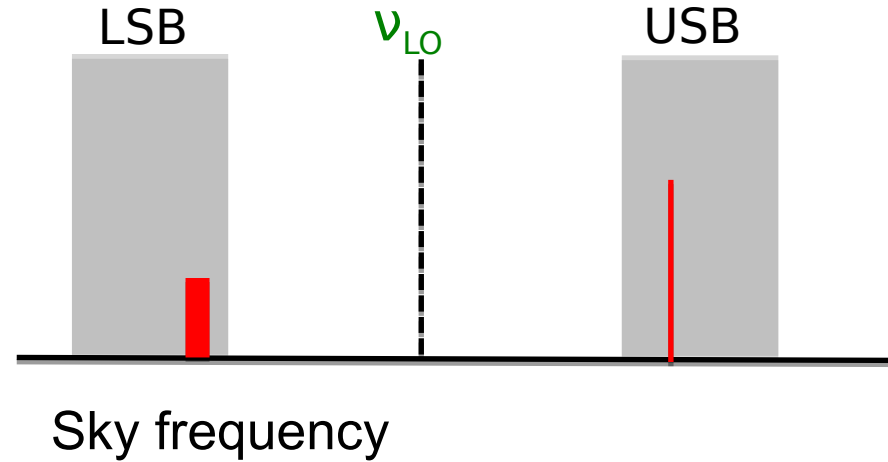
What is being measured ->



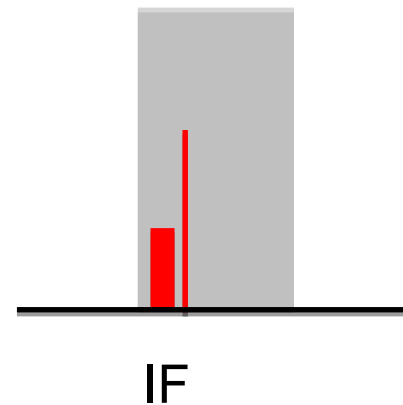
How it looks when collected->



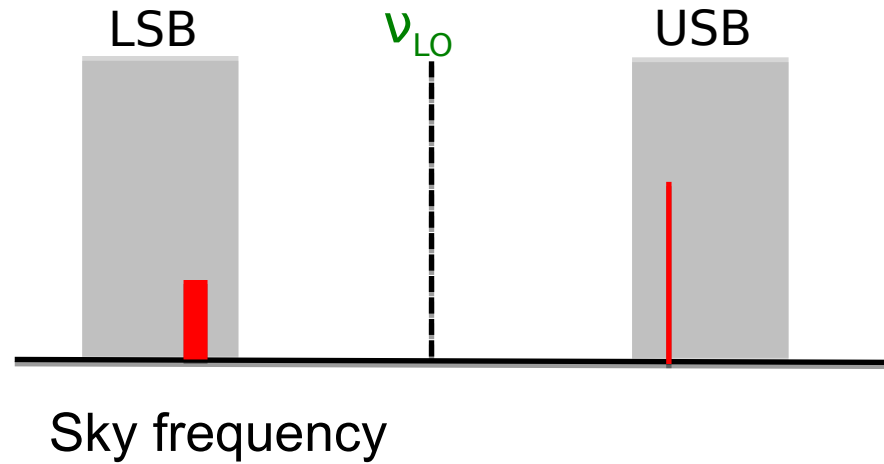
What is being measured ->



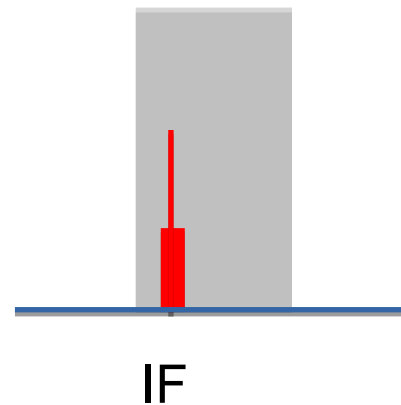
How it looks when collected->



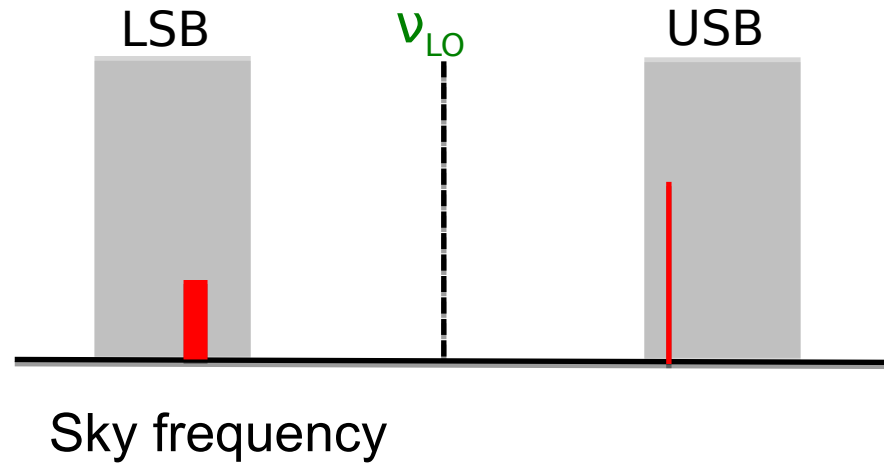
What is being measured ->



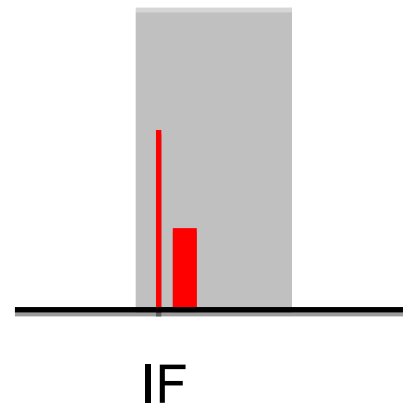
How it looks when collected->



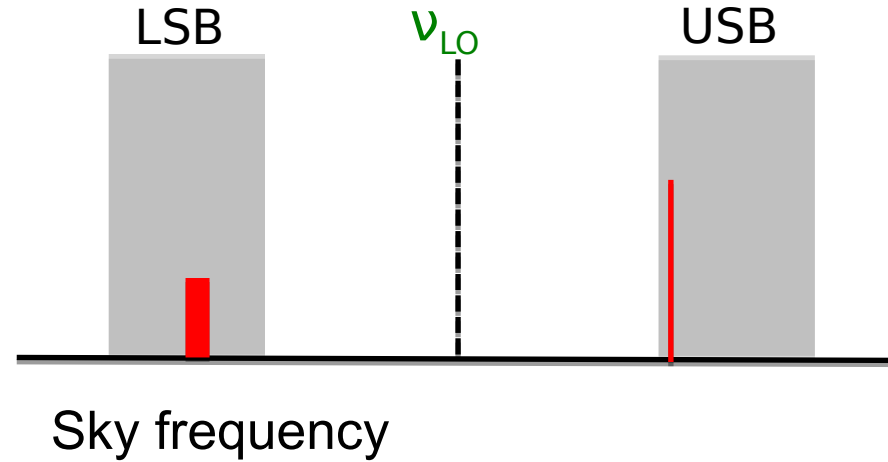
What is being measured ->



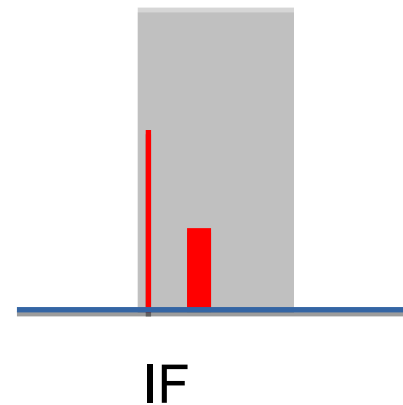
How it looks when collected->



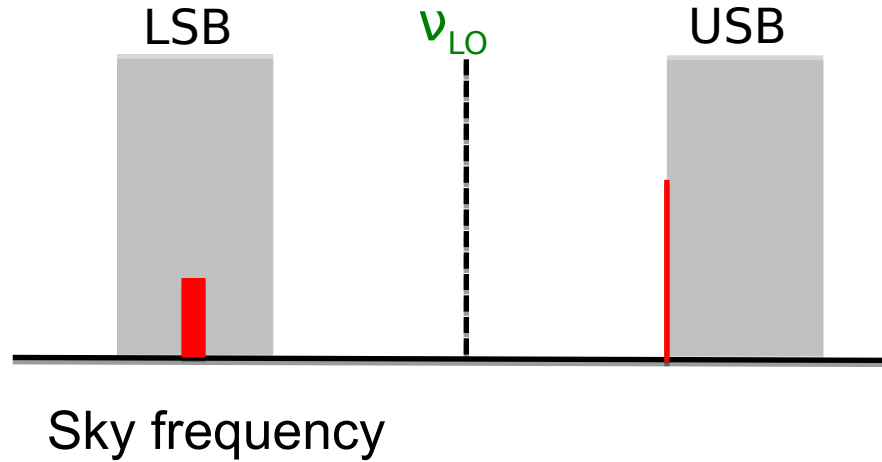
What is being measured ->



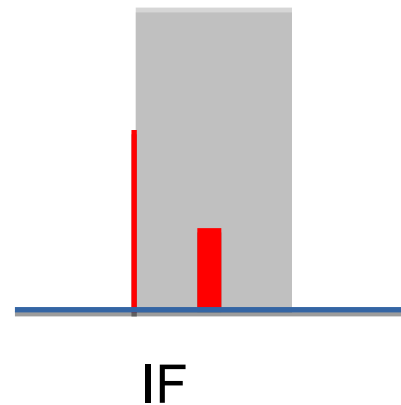
How it looks when collected->



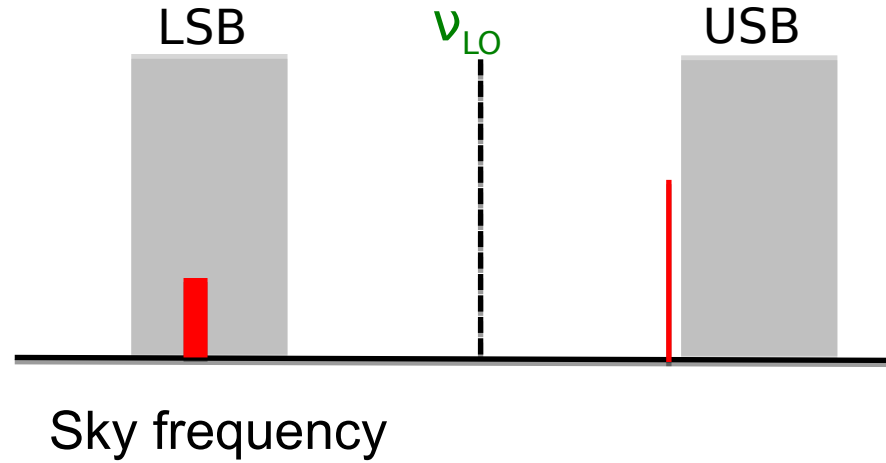
What is being measured ->



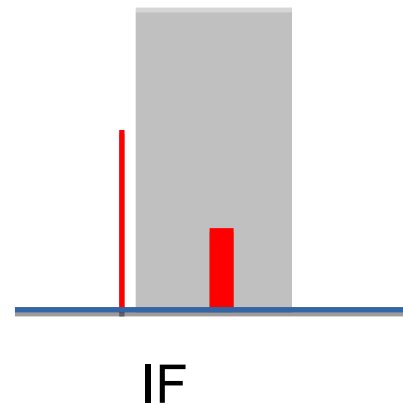
How it looks when collected->



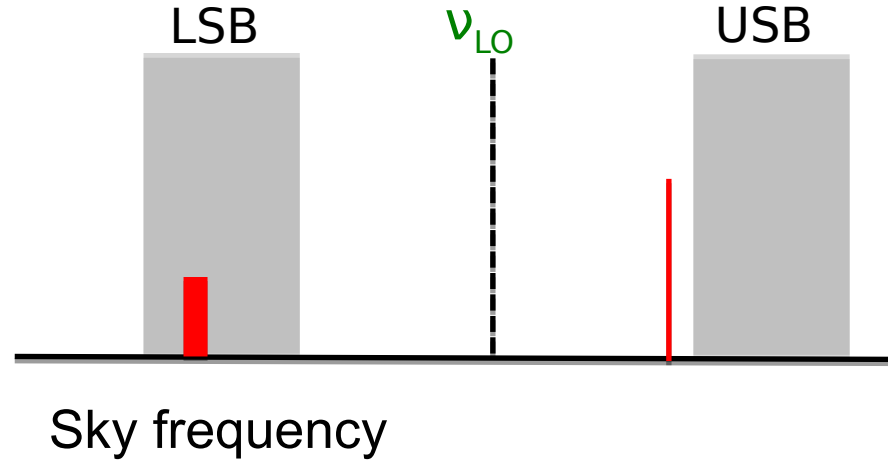
What is being measured ->



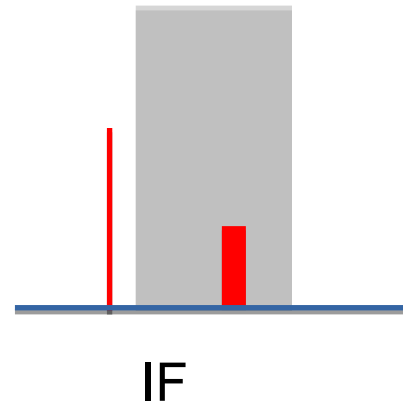
How it looks when collected->



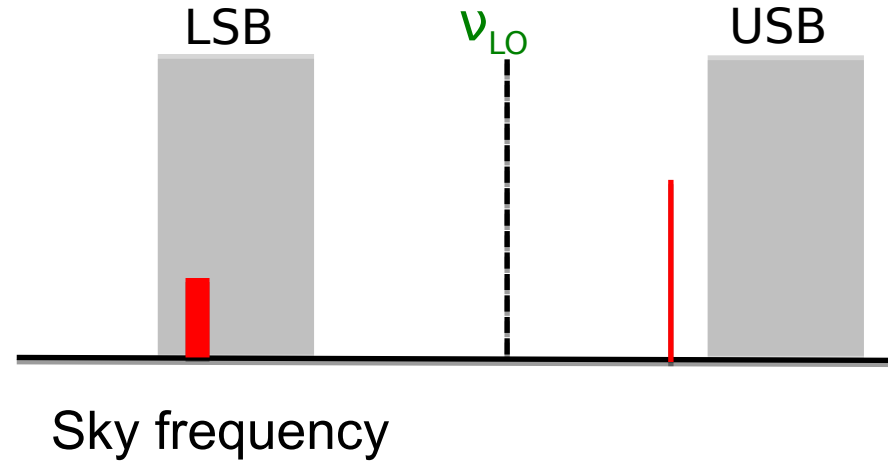
What is being measured ->



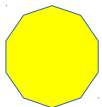
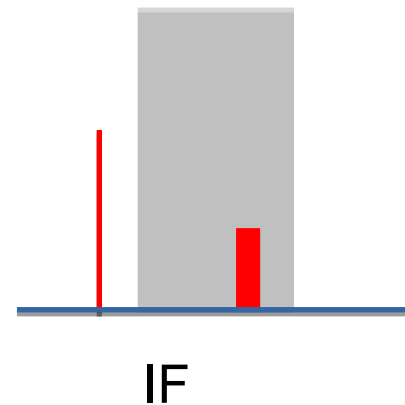
How it looks when collected->

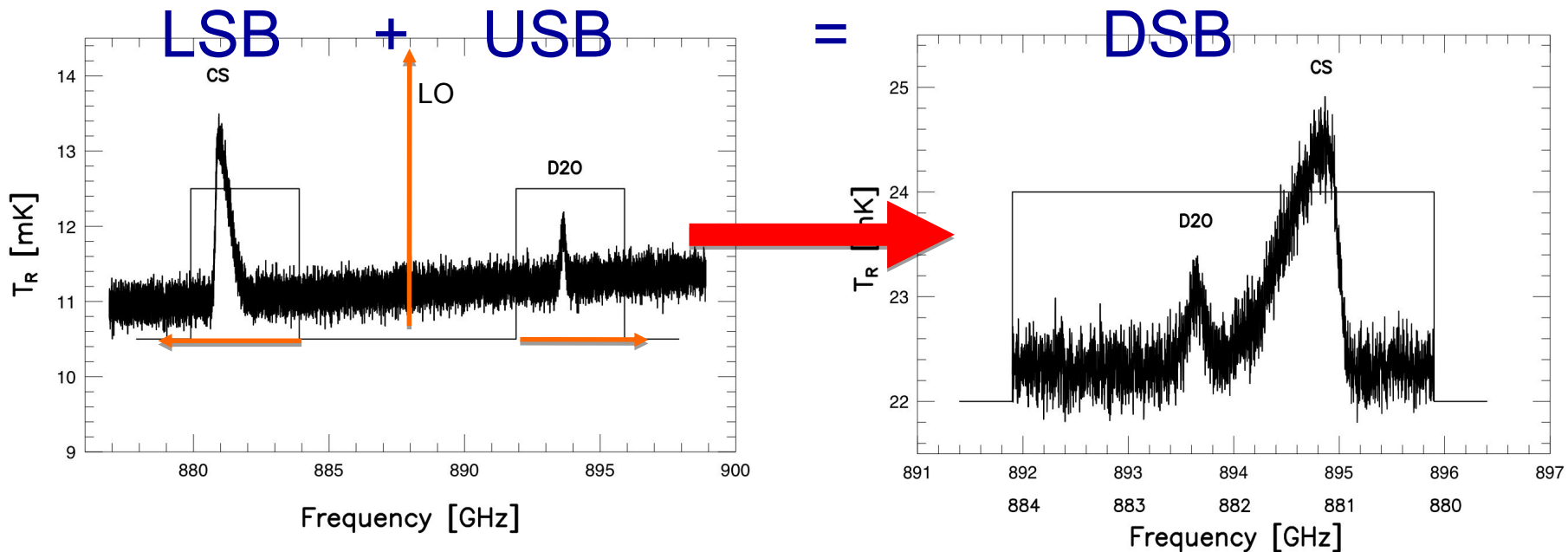


What is being measured ->



How it looks when collected->



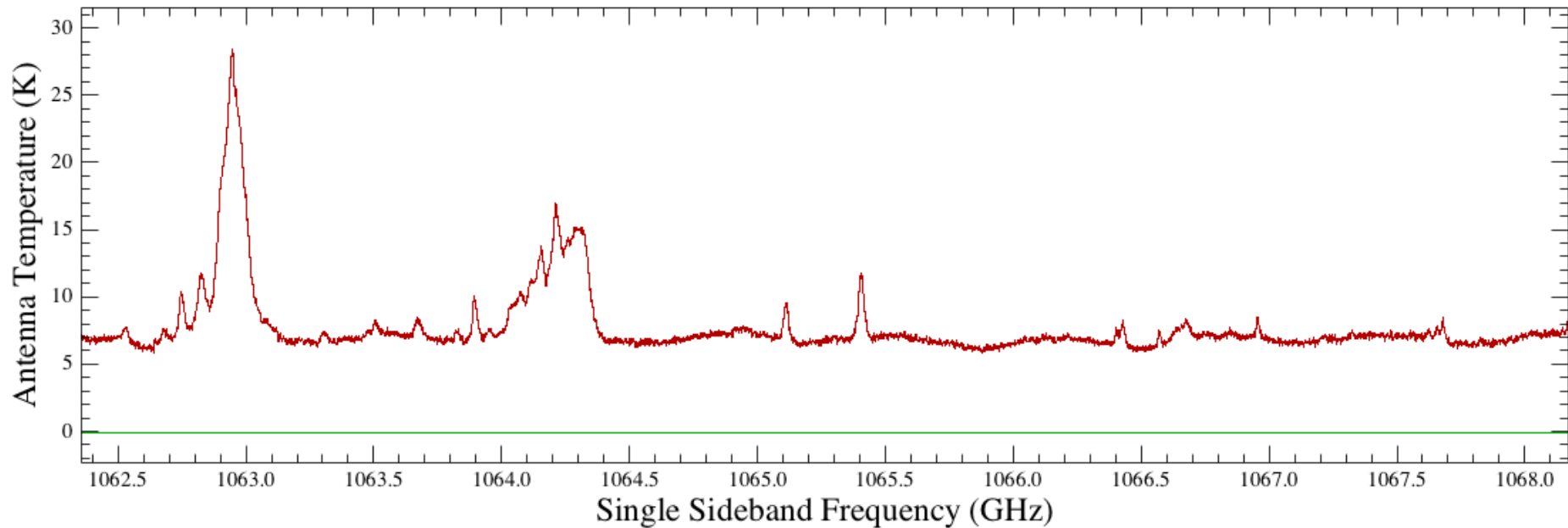


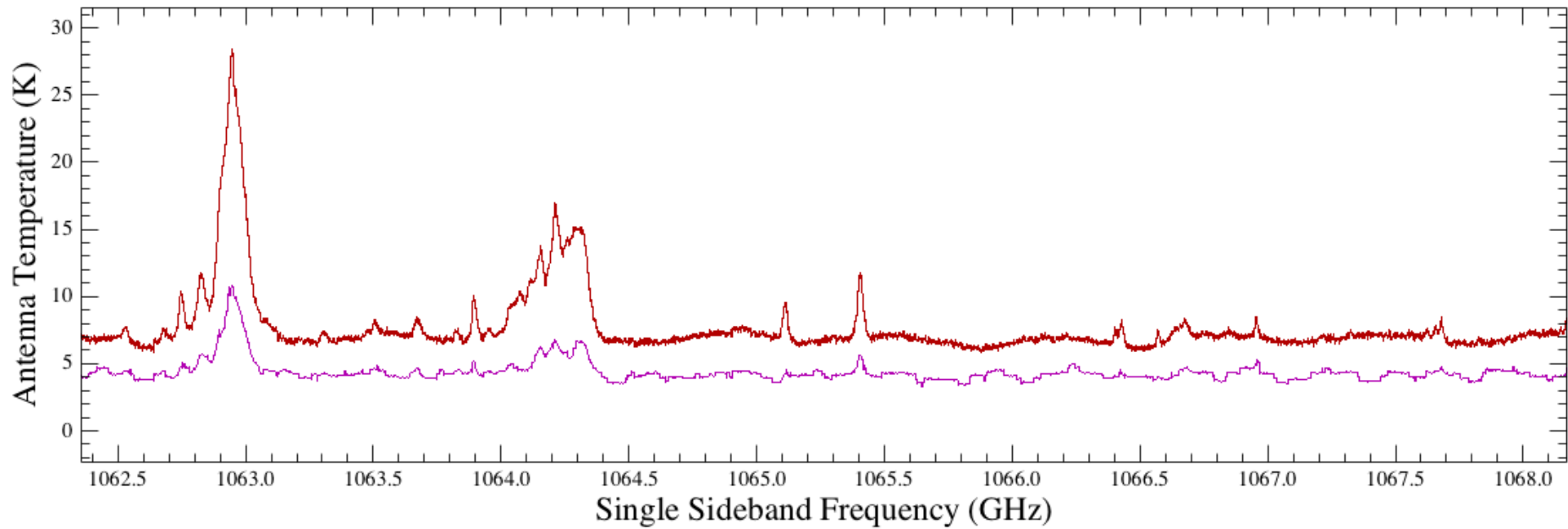
- Lower sideband spectrum is reversed and added
- Two frequency scales result in the DSB result
- The lines may blend but they can be recovered
- The continuum levels add (double) in the DSB
- The continuum slope is flattened but may be recovered (deconvolved)
- The noise adds in quadrature , increasing as $\sqrt{2}$

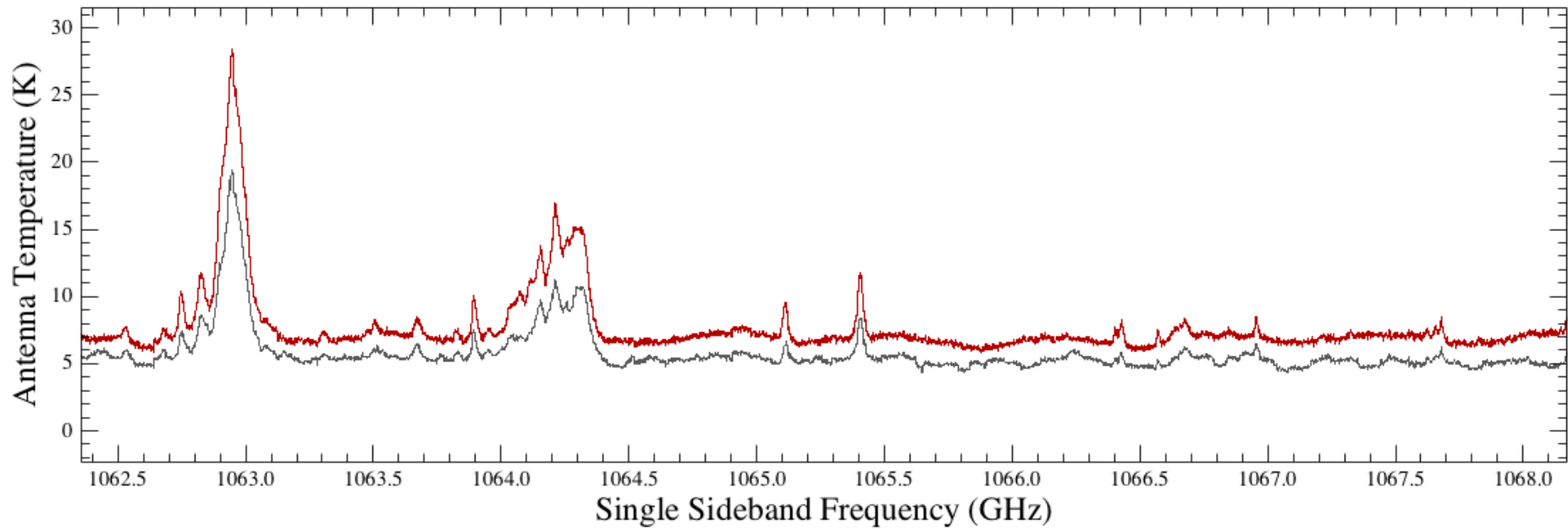
- The problem is the following: Given a collection of double sideband data taken over several LO tunings, how do we recover the original 'sky' spectrum?
- Comito & Schilke (2002) provide an algorithm which has been successfully employed with ground based heterodynes.
- Has been implemented in CLASS + X-CLASS (Fortran based) but was converted to JAVA for use within HIPE. Upgrades to the algorithm have been almost exclusively within HIPE.

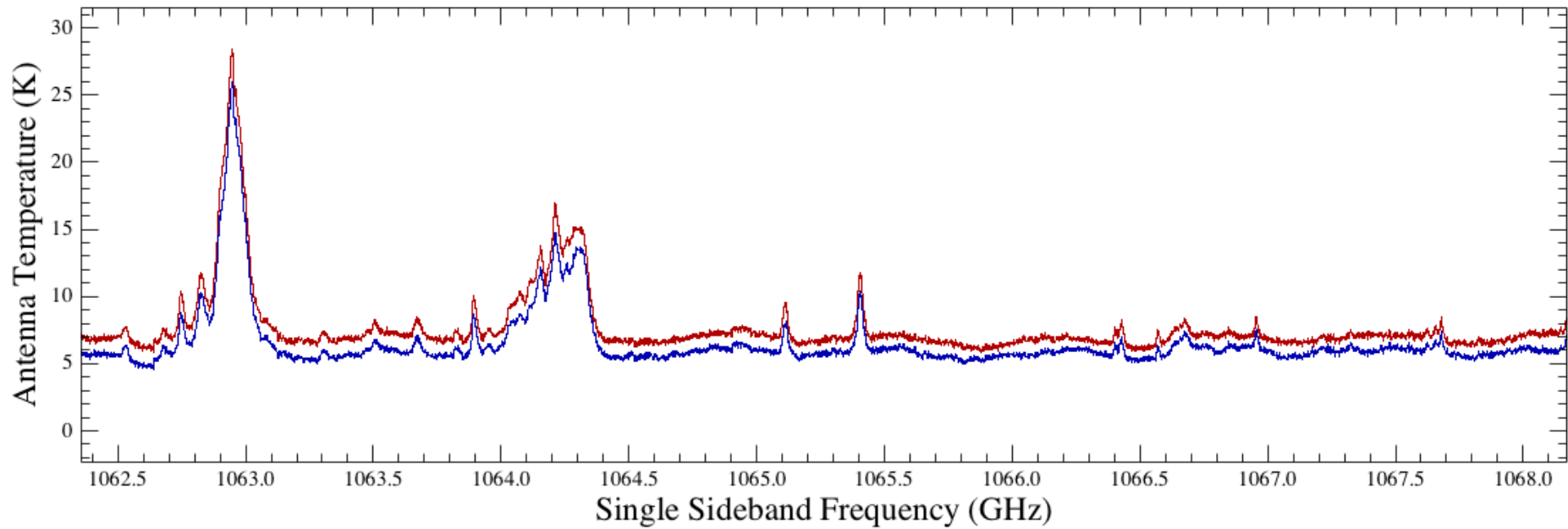
- Start with a guess of the answer – a model with no assumptions for the SSB spectrum – flat
- "Observe it" – using knowledge of the instrument
- compare the observations of the model with the real observations
- compute a chi square and a delta (differential) chi-square
- each model "spectral channel" was in part responsible for some of the chi square change
- follow the slope of the chi square downward (it's partial derivative w.r.t. the channel flux (and optionally the sideband gain))
- new downward steps always move at right angles to previous ones in the *Conjugate Gradient Method*
- Stop, when solution converges asymptotically, as defined by the "tolerance"

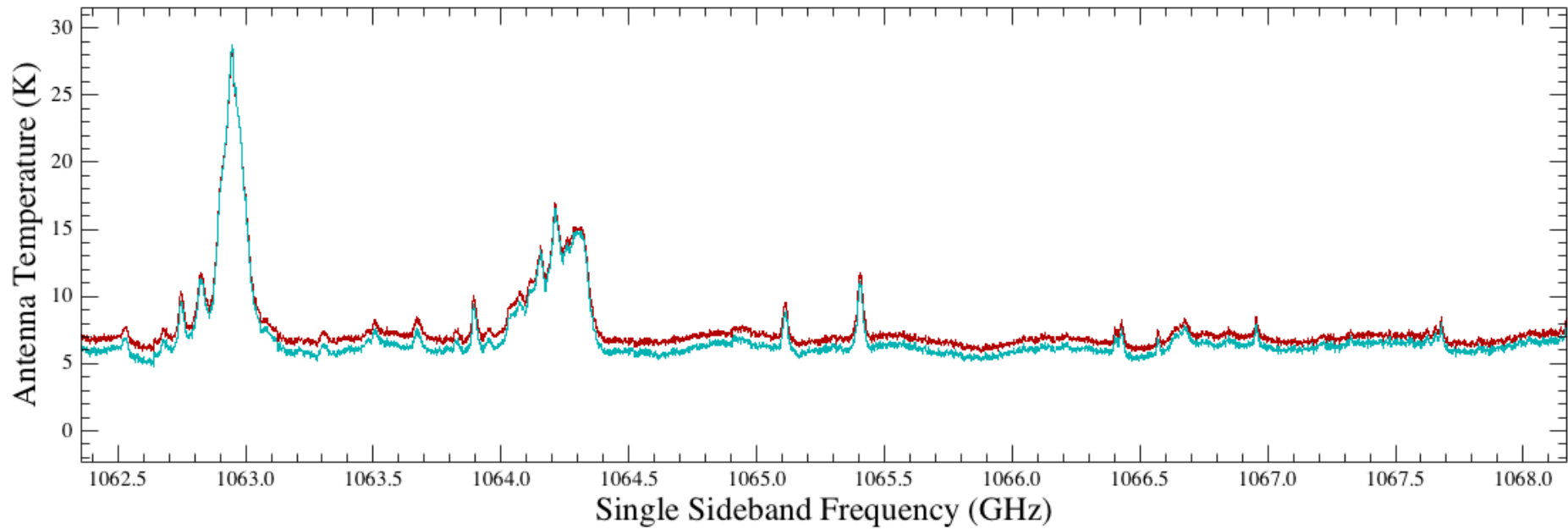
It's iterative

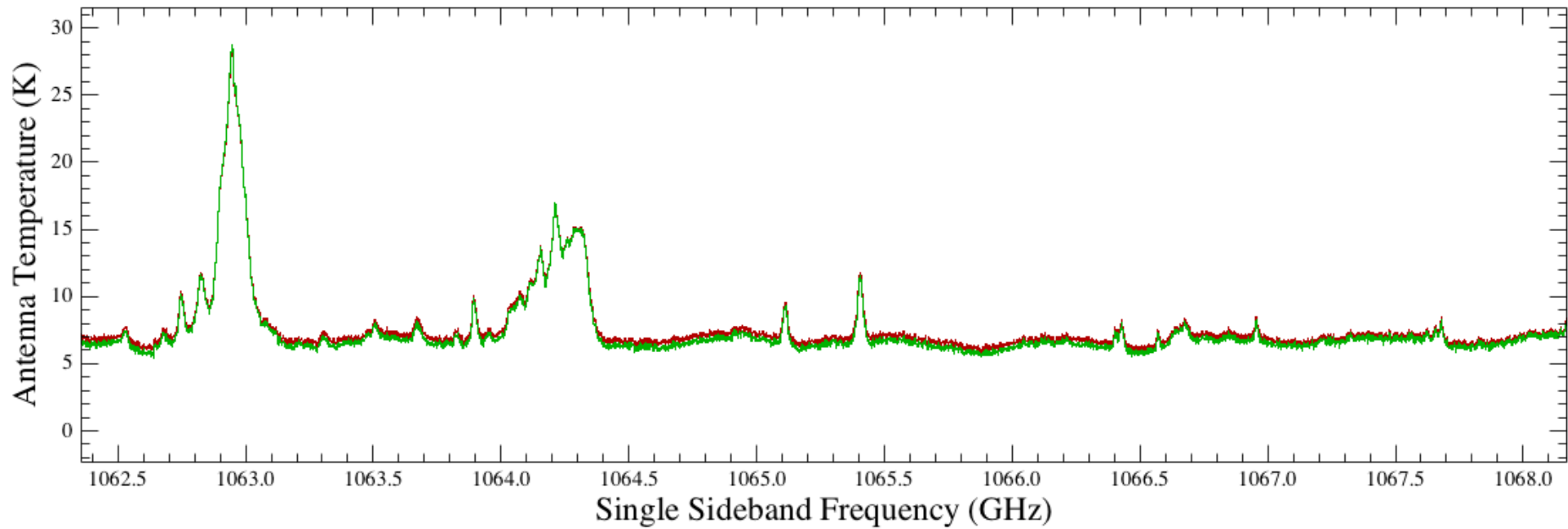


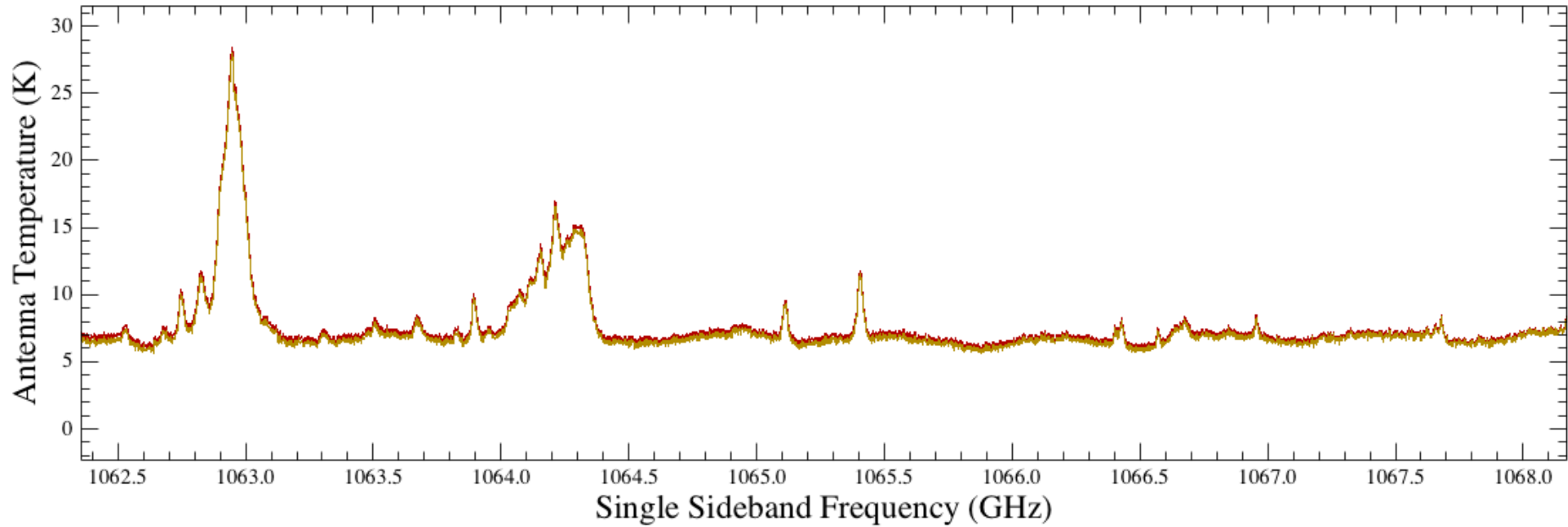


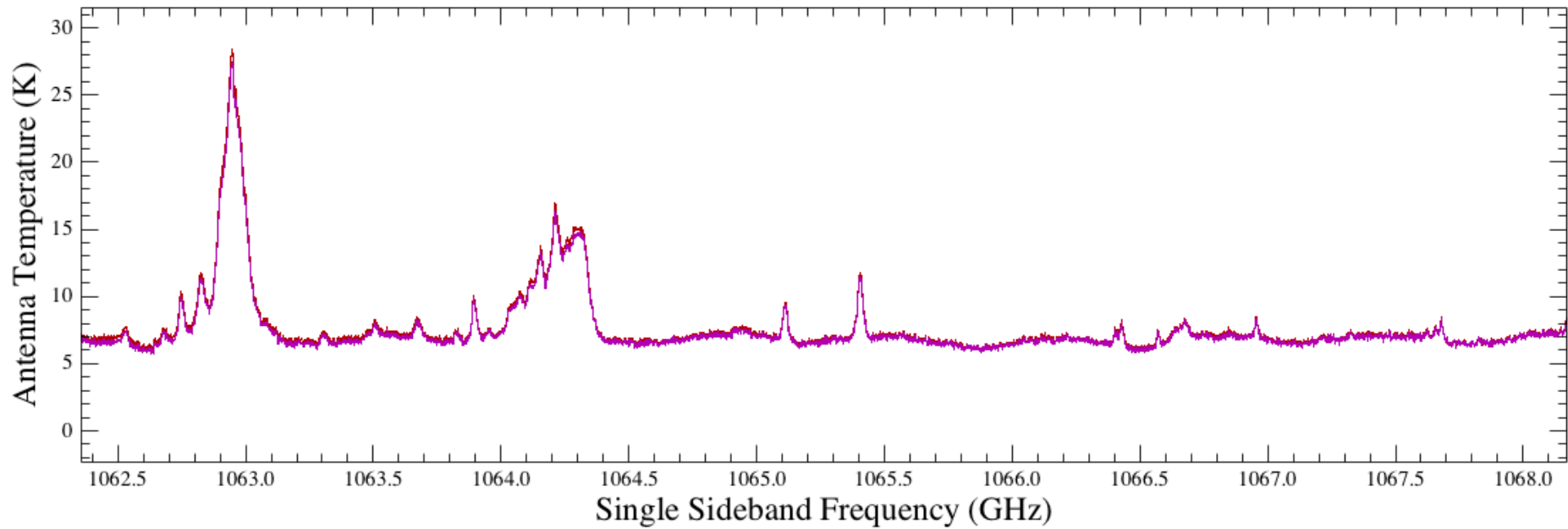


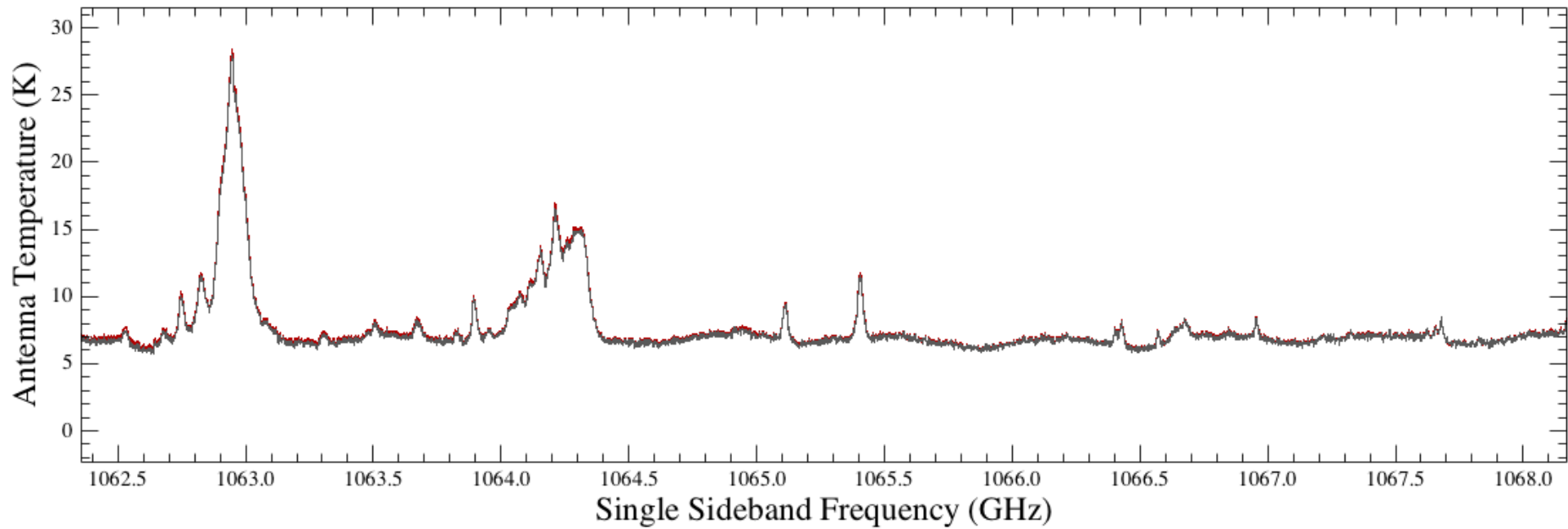


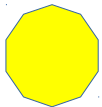
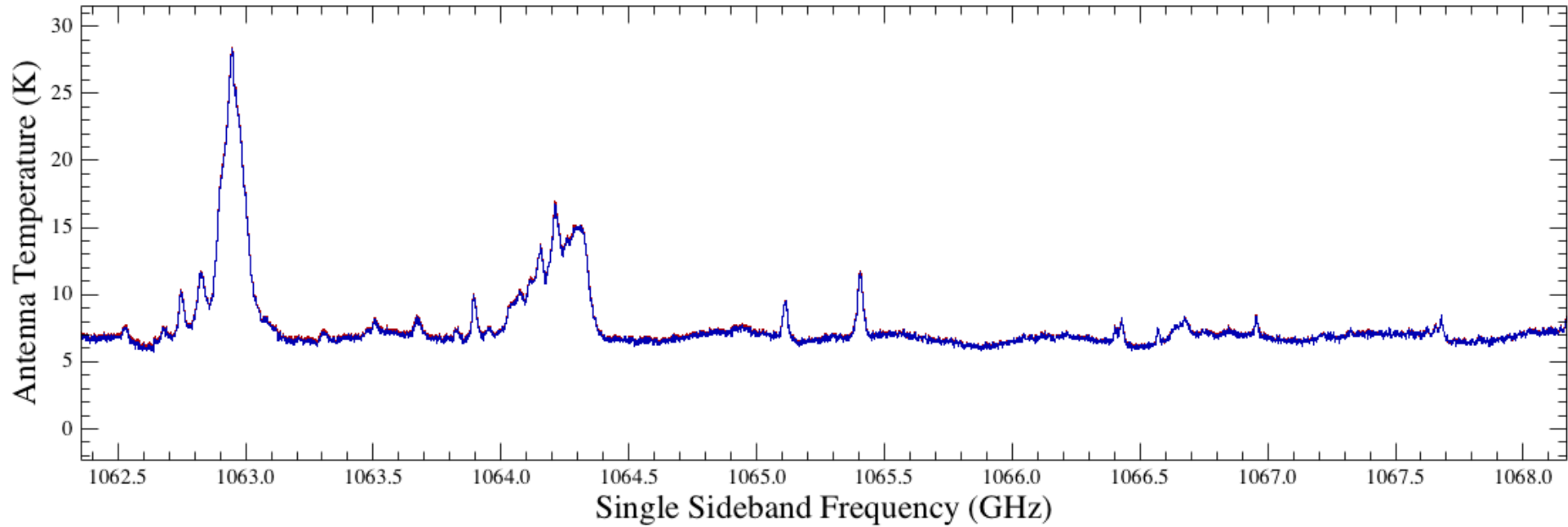












- Iteration requires that the data make sense.
 - Sufficient redundancy (~100% of the time)
 - No spurs
 - Compatible baselines
 - No (or well behaved) standing waves

Most work is done before deconvolution

Inputs

obs*:	<input checked="" type="radio"/> obs	lambda1_channels:	<input type="radio"/> 0.0
obs2_array:	<input type="radio"/> <No variable>	lambda2_gains:	<input type="radio"/> 0.0
spectrometer:	<input type="radio"/> WBS-H	cont_offset:	<input type="radio"/> 0.0
tolerance:	<input type="radio"/> 0.001	diag_mode_on:	<input type="radio"/> <input type="checkbox"/>
max_iterations:	<input type="radio"/> 200	diag_scan_index:	<input type="radio"/> 5
channel_weighting:	<input type="radio"/> <input type="checkbox"/>	diag_dsb_freq:	<input type="radio"/> USB
ignore_bright_line:	<input type="radio"/> <input type="checkbox"/>	plot_dsb:	<input type="radio"/> NO_PLOT
spur_rejection:	<input type="radio"/> REJECT_SCANS_WITH_SPURS		
gain:	<input type="radio"/> GAIN_FIT_OFF_USE_PRESET		
outputNames:	<input type="radio"/> decon_result myDecon interim_output myInterim		

Features not recommended at all (may be deprecated in a later release)

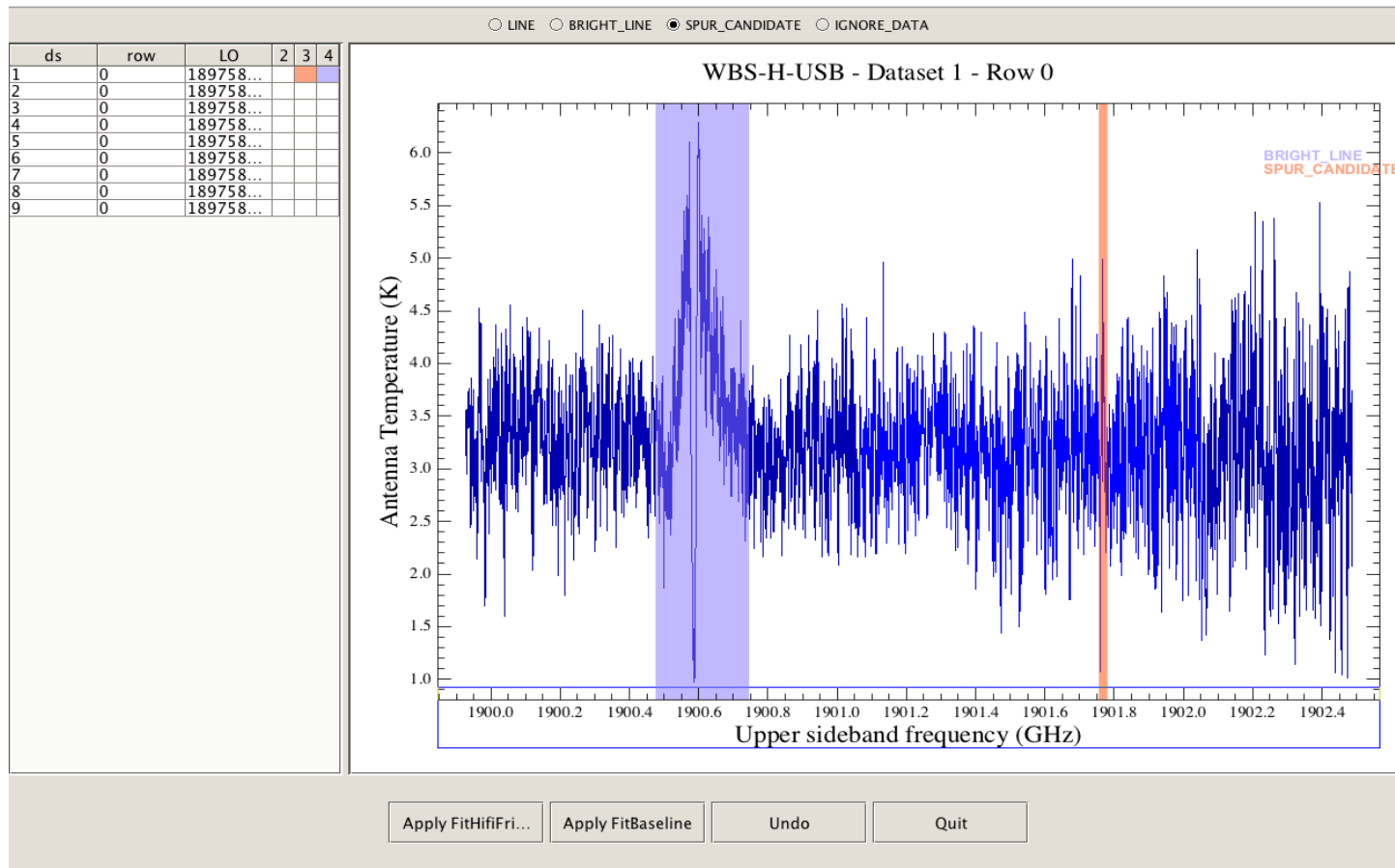
Some features not used very often

The big-three data cleaning tasks

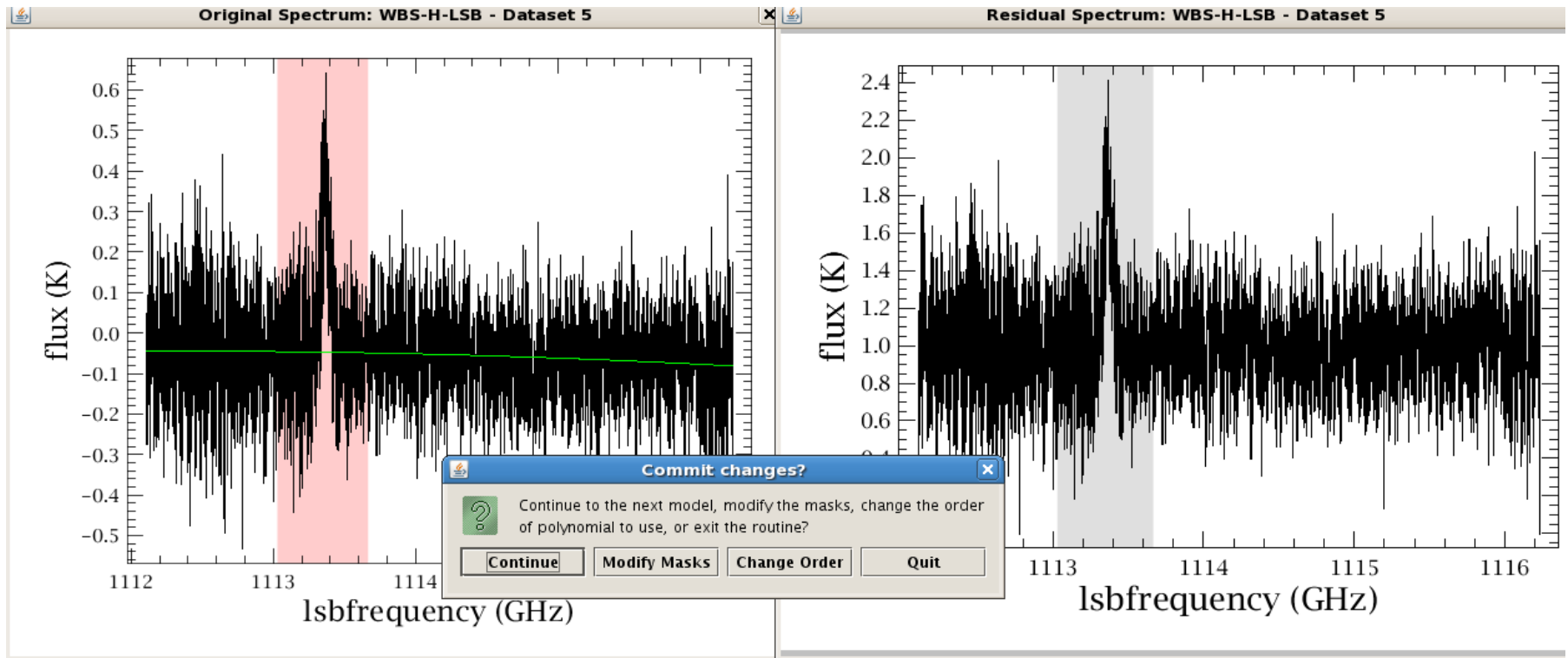
In order of importance

<u>Artifact</u>	<u>Solution</u>
Spurs, etc	FlagTool
Baseline drift	fitBaseline
Standing waves	fitHiFiFringe

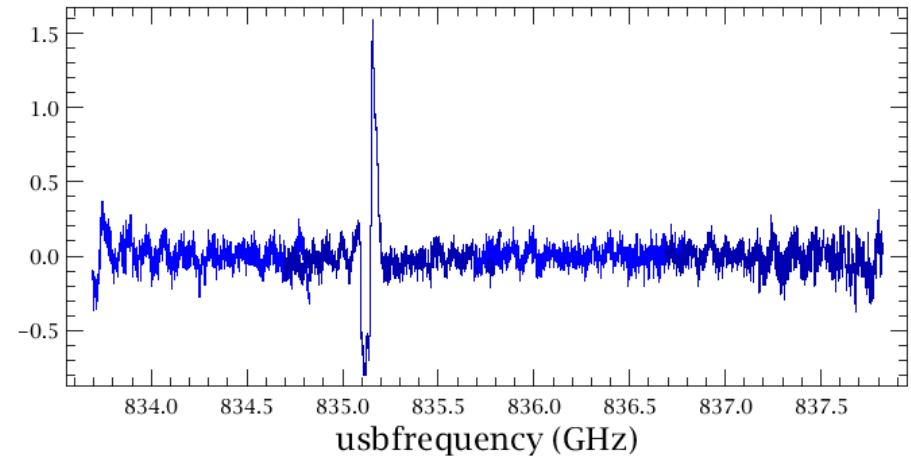
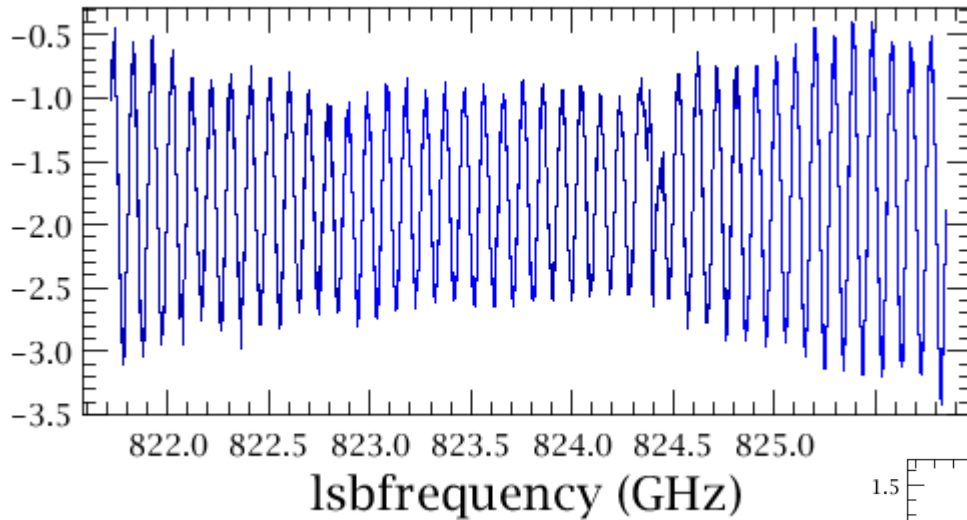
- The workhorse. Can also perform fitBaseline and fitFringe!



- 'intelligent' baseline subtraction

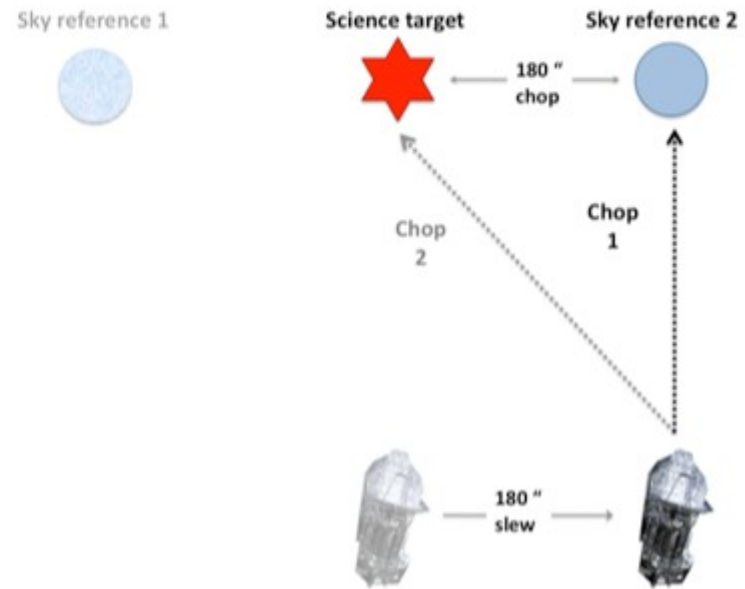
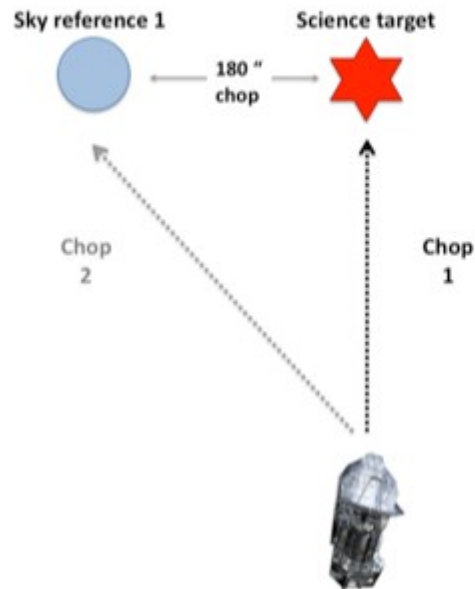


- One approach to standing wave removal

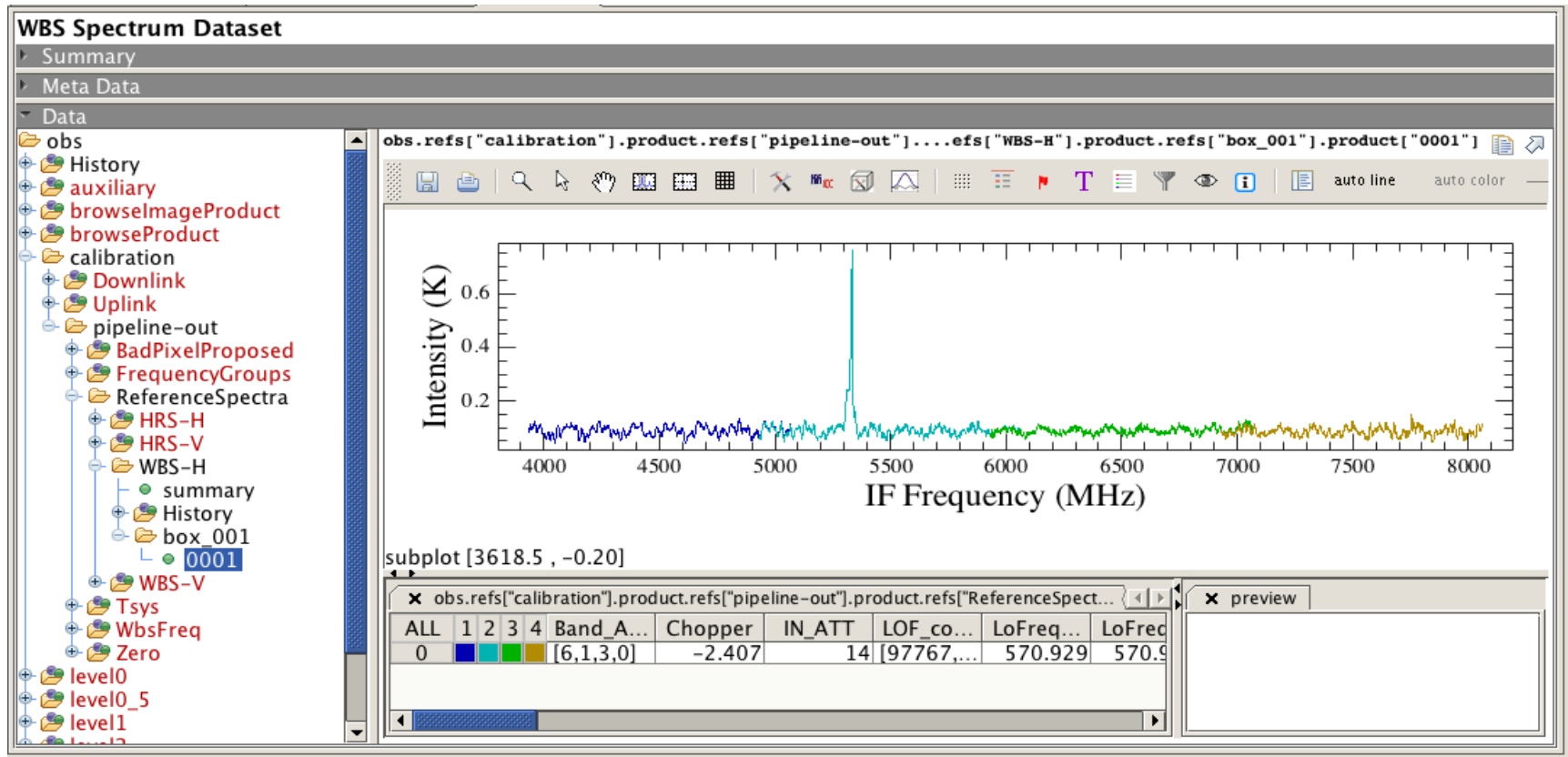


Nod 1

Nod 2



- DBS is the most common spectral scan mode.
- Chopping onto an area with line flux can happen and should be checked



- Legacy value products
 - Phase 1: flagging by ICC and KP experts
 - Phase 2: baseline and fringe removal by experts (tentative)
- HIPE 13 processed data (Spring 2015) should have a good fraction of all Spectral Scans carefully flagged.