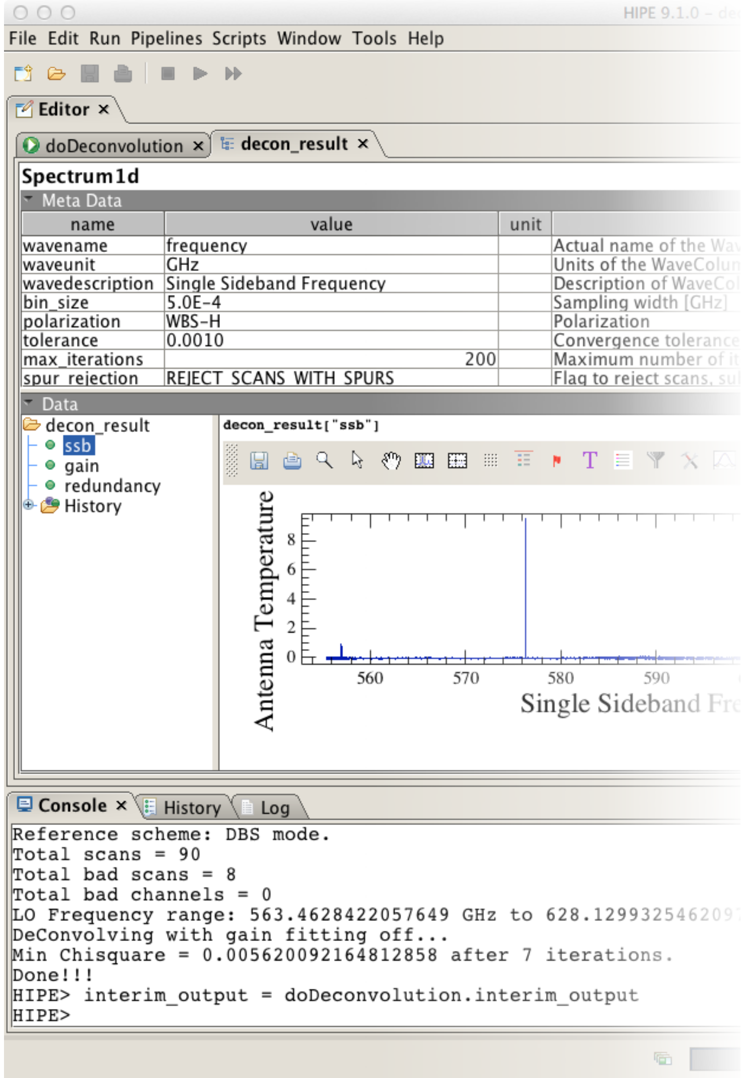
Sideband Deconvolution



name	value	unit	
wavename	frequency		Actual name of the Wa
waveunit	GHz		Units of the WaveColun
wavedescription	Single Sideband Frequency		Description of WaveCol
bin_size	5.0E-4		Sampling width [GHz]
polarization	WBS-H		Polarization
tolerance	0.0010		Convergence tolerance
max_iterations	200		Maximum number of it
spur_rejection	REJECT_SCANS_WITH_SPURS		Flag to reject scans, su

```
Reference scheme: DBS mode.
Total scans = 90
Total bad scans = 8
Total bad channels = 0
LO Frequency range: 563.4628422057649 GHz to 628.129932546209
DeConvolving with gain fitting off...
Min Chisquare = 0.005620092164812858 after 7 iterations.
Done!!!
HIPE> interim_output = doDeconvolution.interim_output
HIPE>
```

Outline

- What is sideband deconvolution and why it is necessary for HIFI data
- General description of the algorithm
- Implementation within HIPE
- Workflow for spectral scans

Heterodyne observations

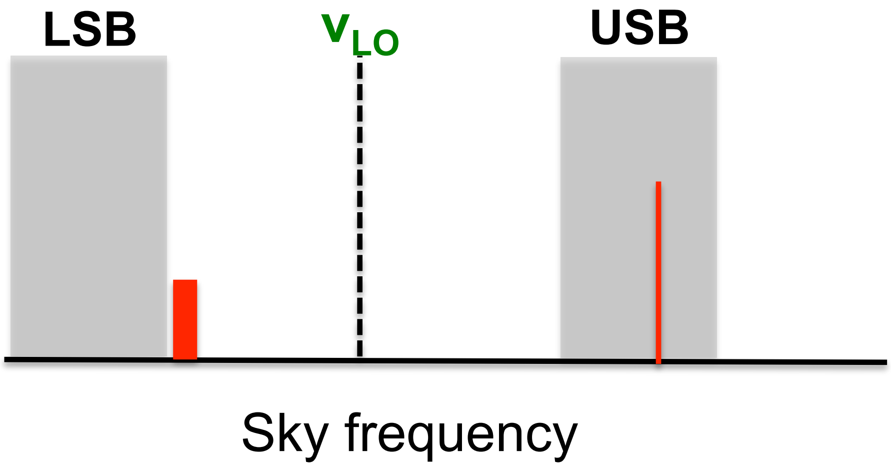
- Detectors are not able to directly measure flux at the frequencies of interest. But by mixing the signal from the sky with a local oscillator, we `downconvert' the frequency.

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

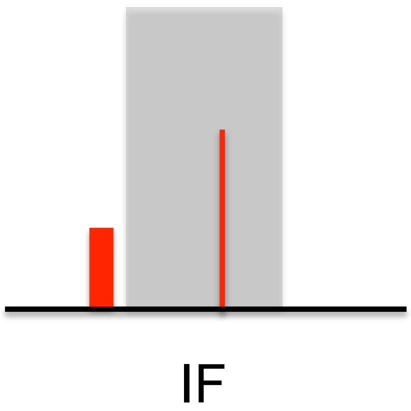
- When ω is the entire, unfiltered sky frequency, you end up being sensitive to TWO bandpasses. $(\cos(v) = \cos(-v))$

Heterodyne observations

What is being measured ->



How it looks when collected->



Heterodyne observations

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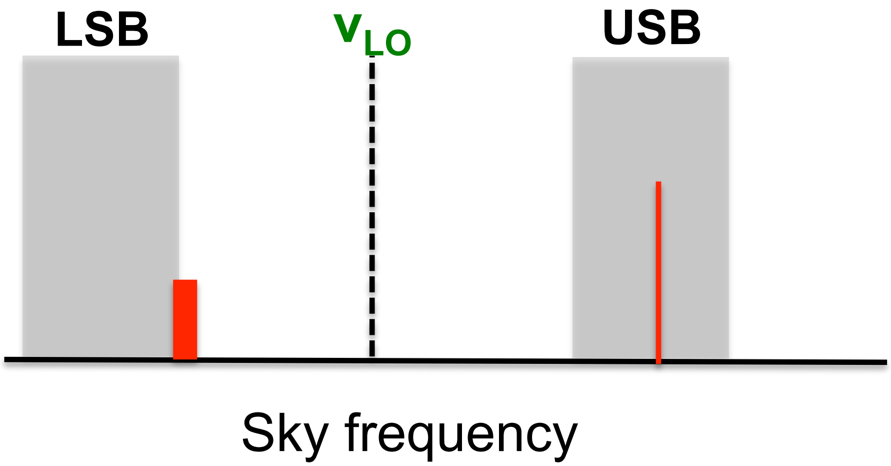

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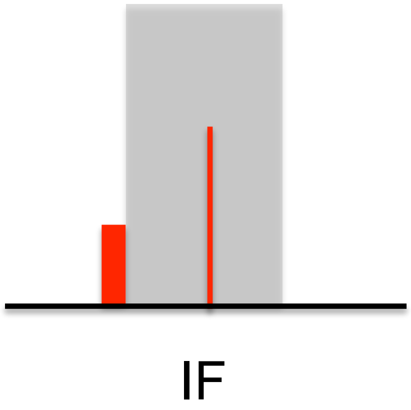
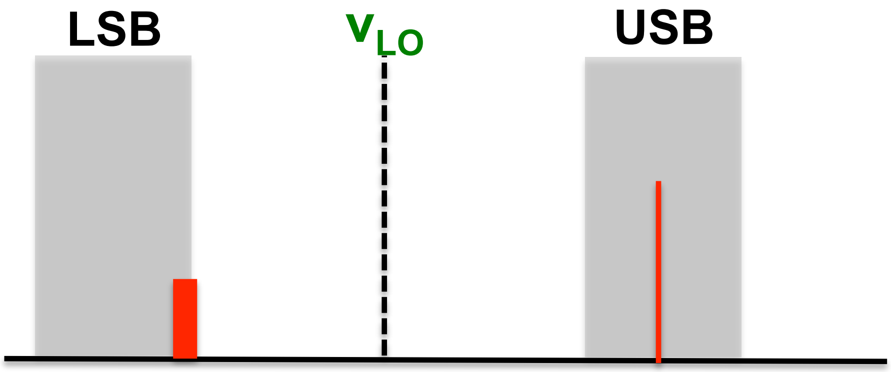


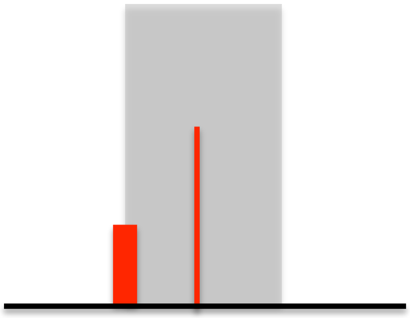
Heterodyne observations

What is being measured ->



Sky frequency

How it looks when collected->



IF

Heterodyne observations

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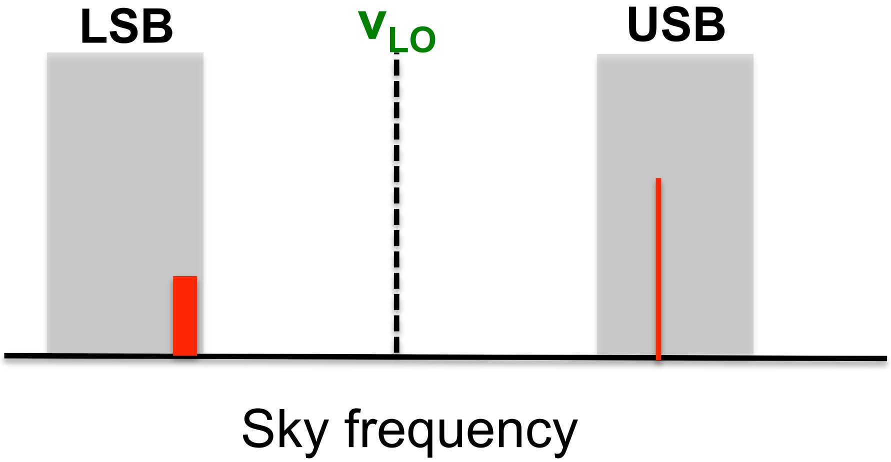

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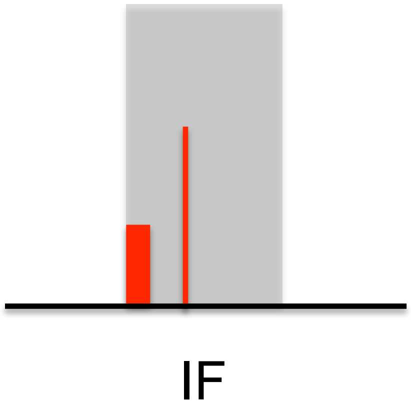

Heterodyne observations

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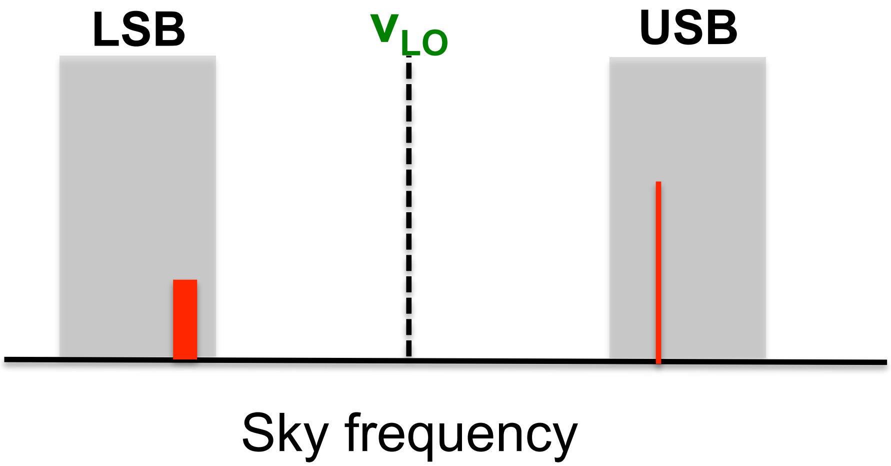

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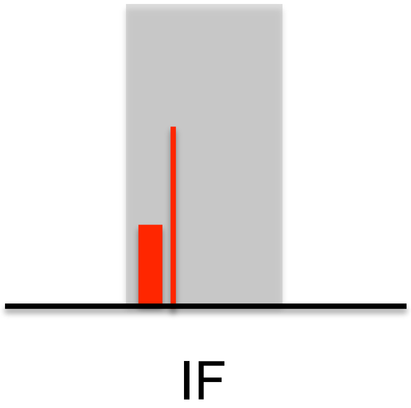

Heterodyne observations

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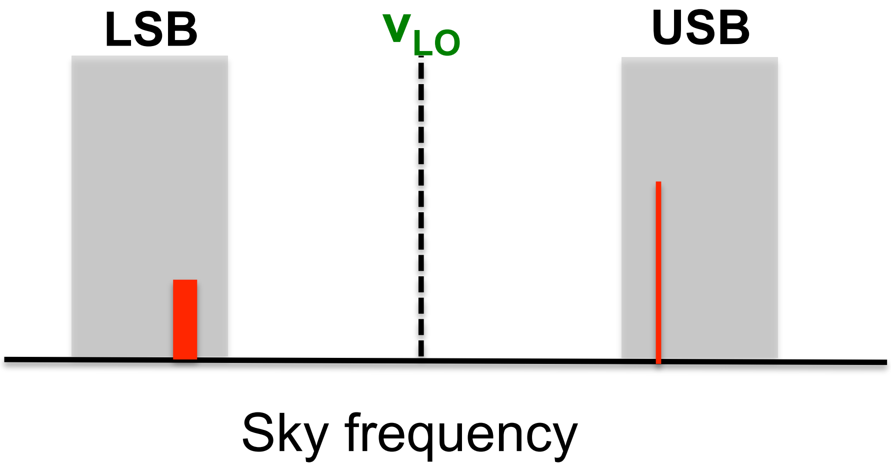

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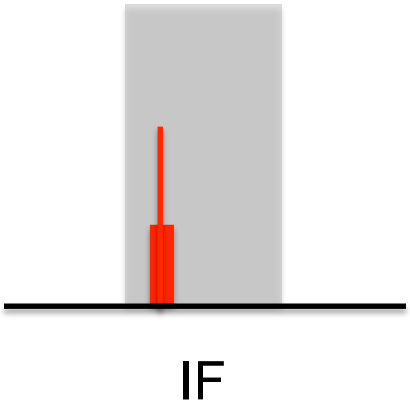

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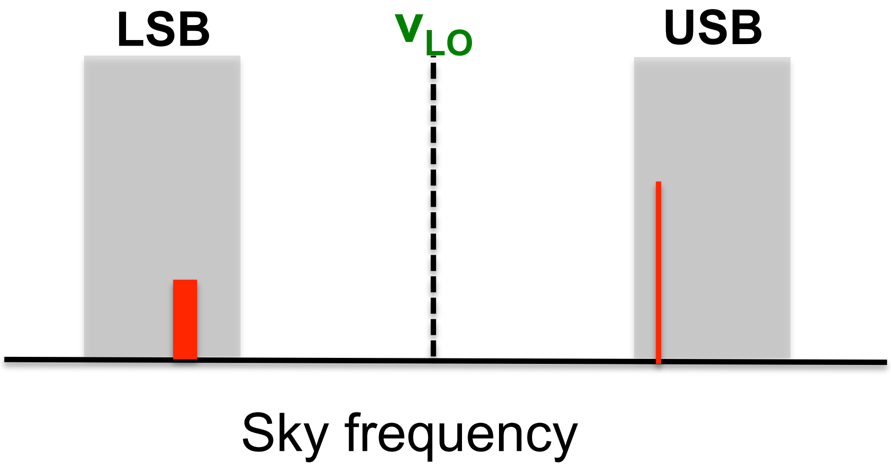

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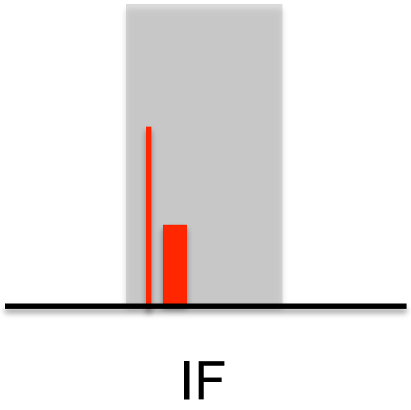

Heterodyne observations

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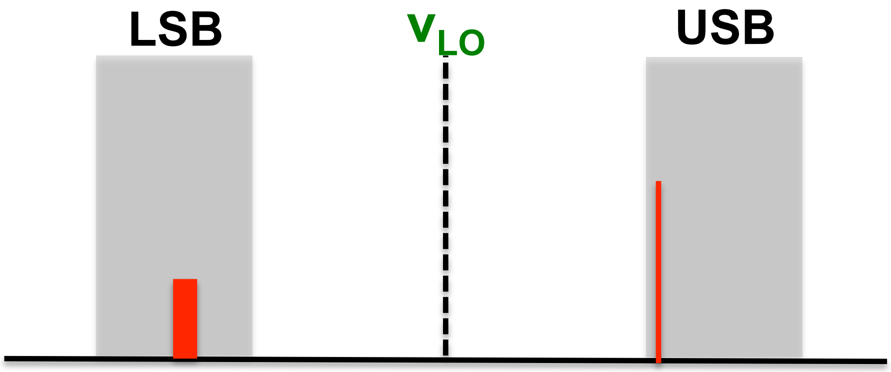
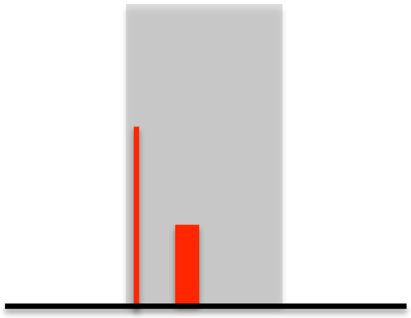


Sky frequency

How it looks when collected->



IF

Heterodyne observations

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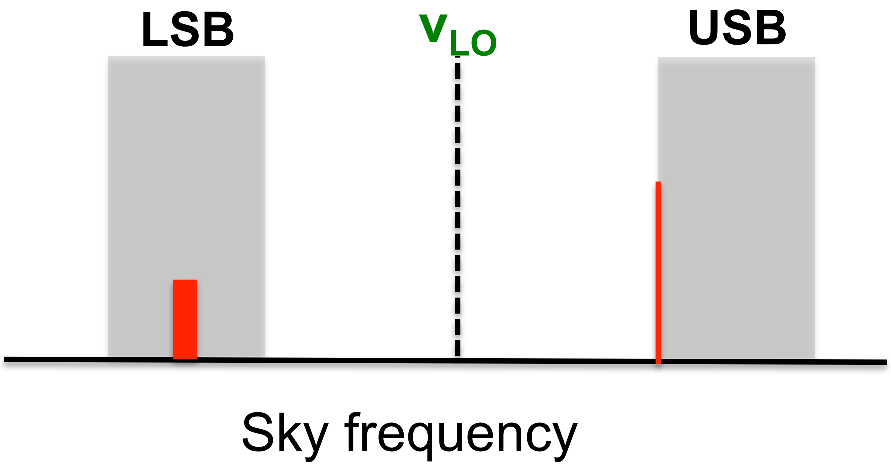

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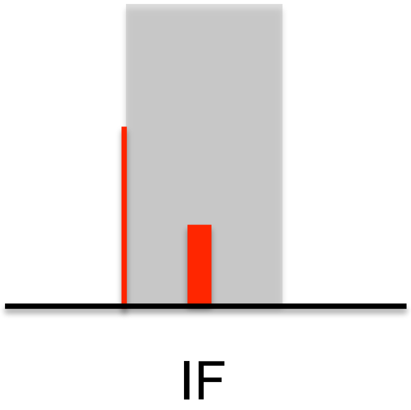

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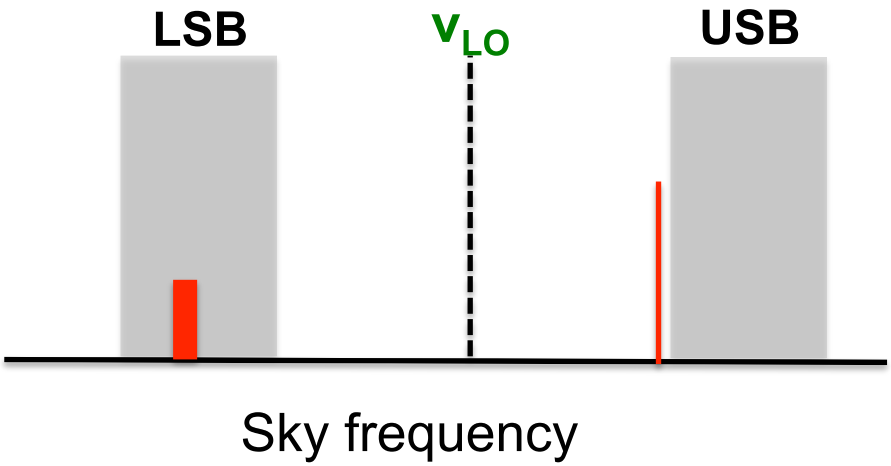

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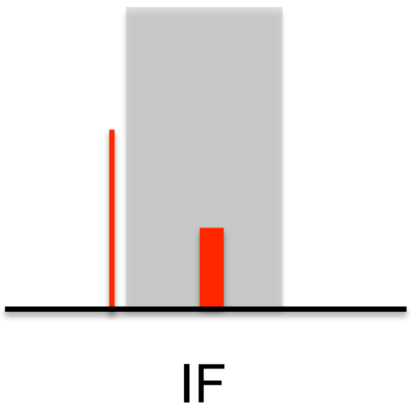

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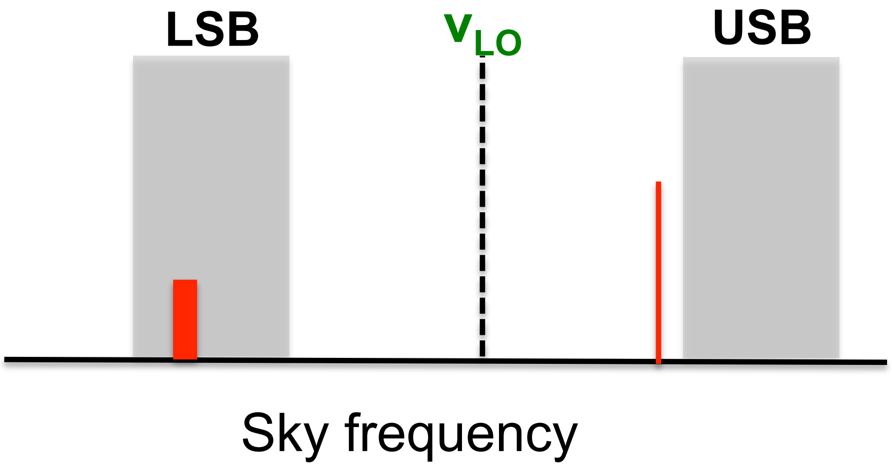

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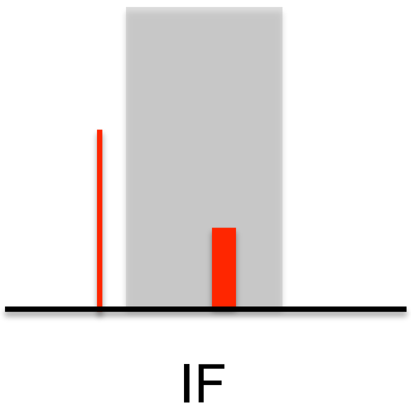

Heterodyne observations

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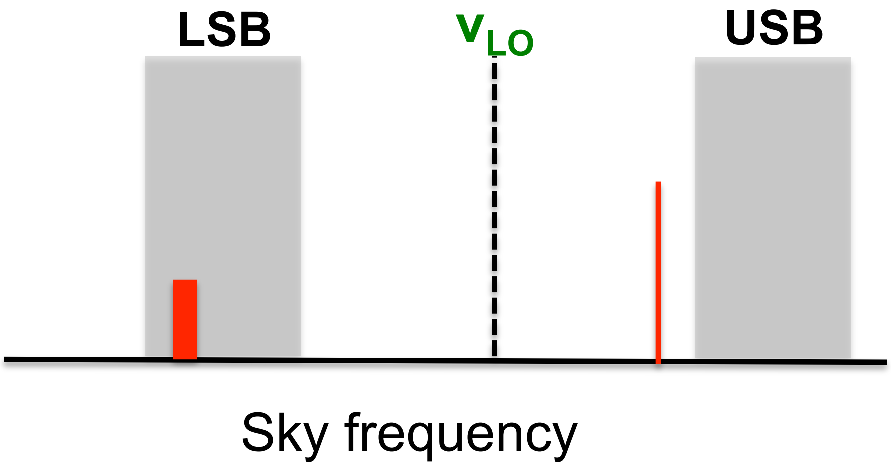

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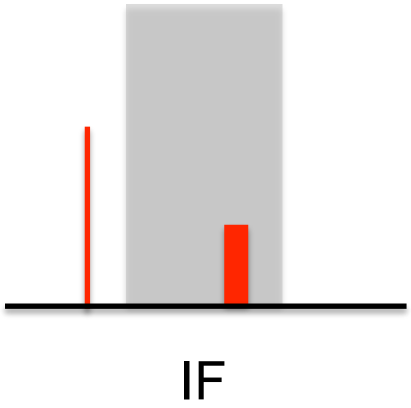
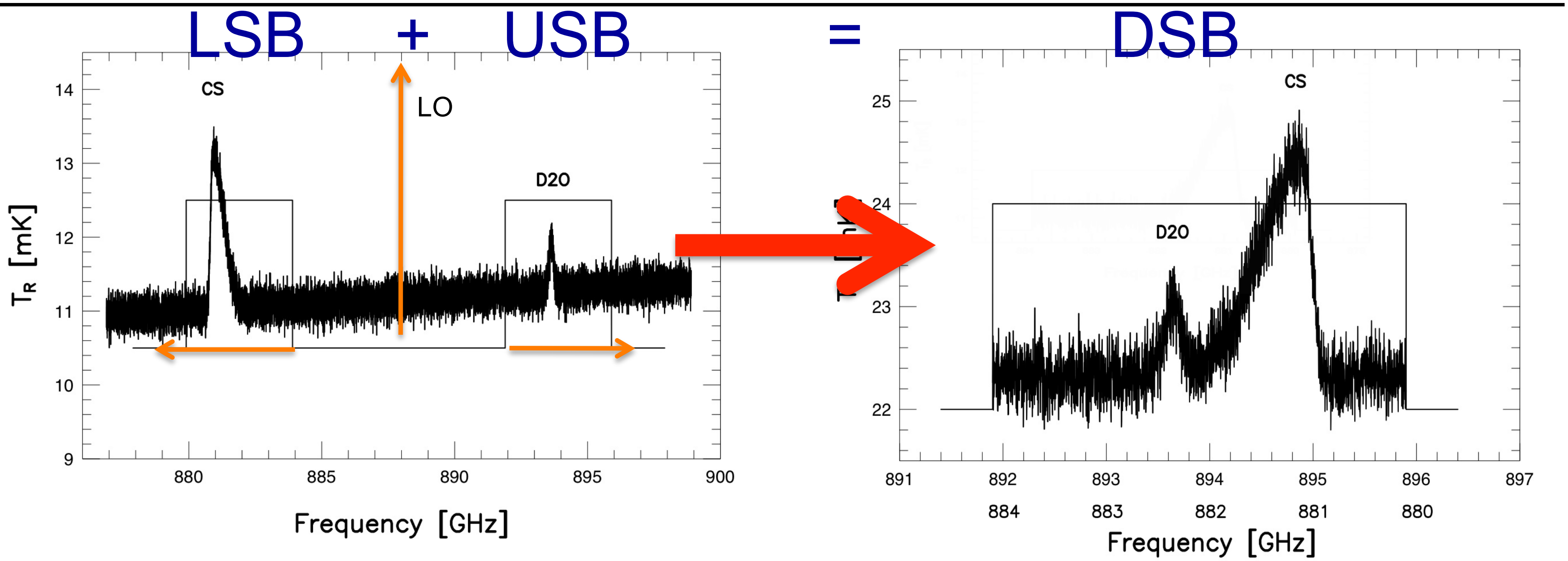


Heterodyne observations



- Lower sideband spectrum is reversed and added
- Two frequency scales result in the DSB result
- The lines may blend but they can be recovered (deconvolved)
- 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)

Sideband Deconvolution

- 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.

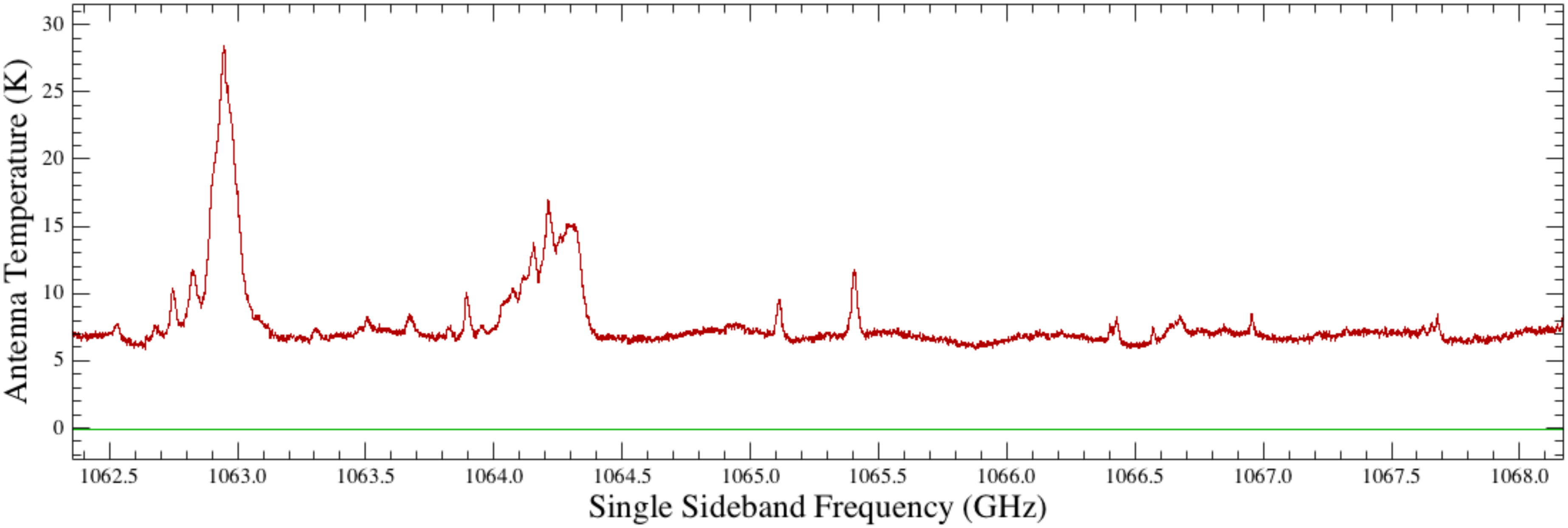
- Has been implemented in CLASS + X-CLASS (Fortran based) but was converted to JAVA for use within HIPE. Upgrades to the algorithm have been almost exclusively within HIPE.

Deconvolution Algorithm

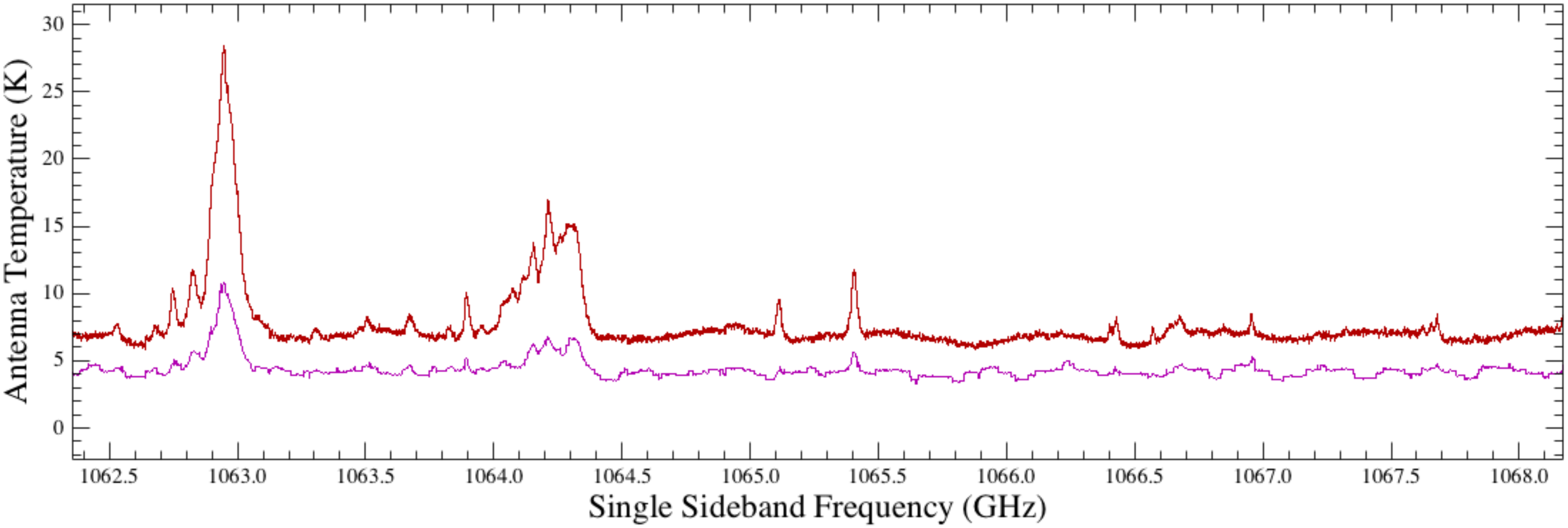
- Start with a guess of the answer – a model with no assumptions for the SSB spectrum – flat
- "Observe it" – using knowledge of the instrument
- compare the observations of the model with the real observations
- compute a chi square and a delta (differential) chi-square
- each model "spectral channel" was in part responsible for some of the chi square change
- follow the slope of the chi square downward (it's partial derivitive 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

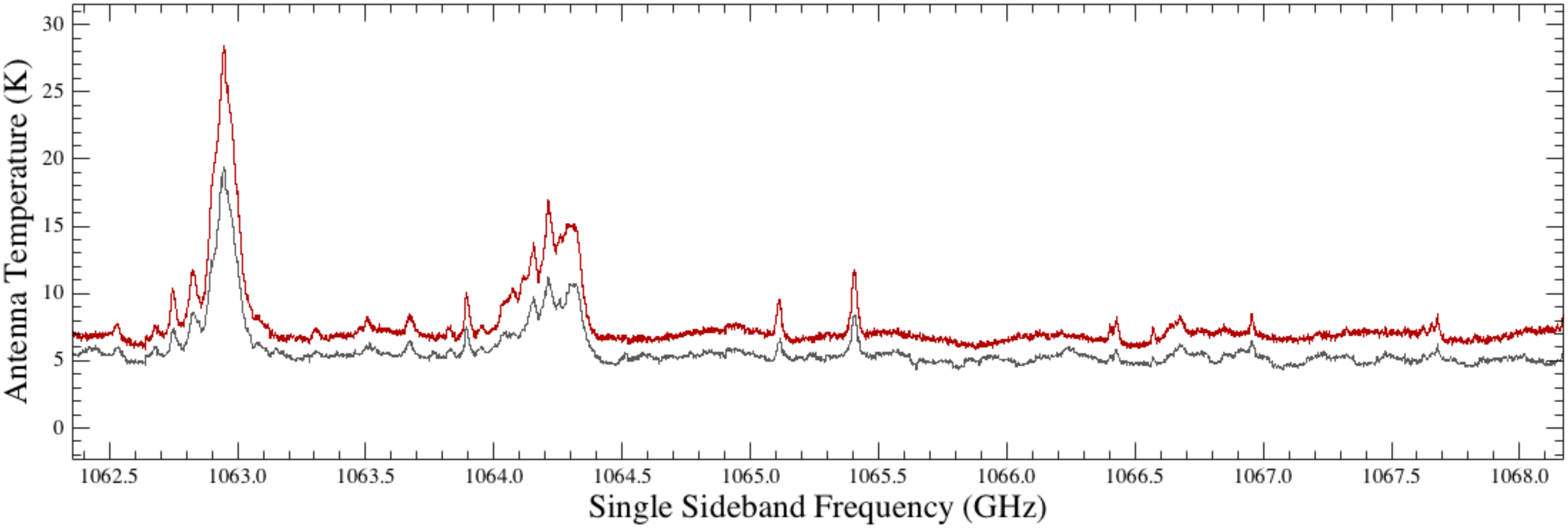
Example: Iteration 0



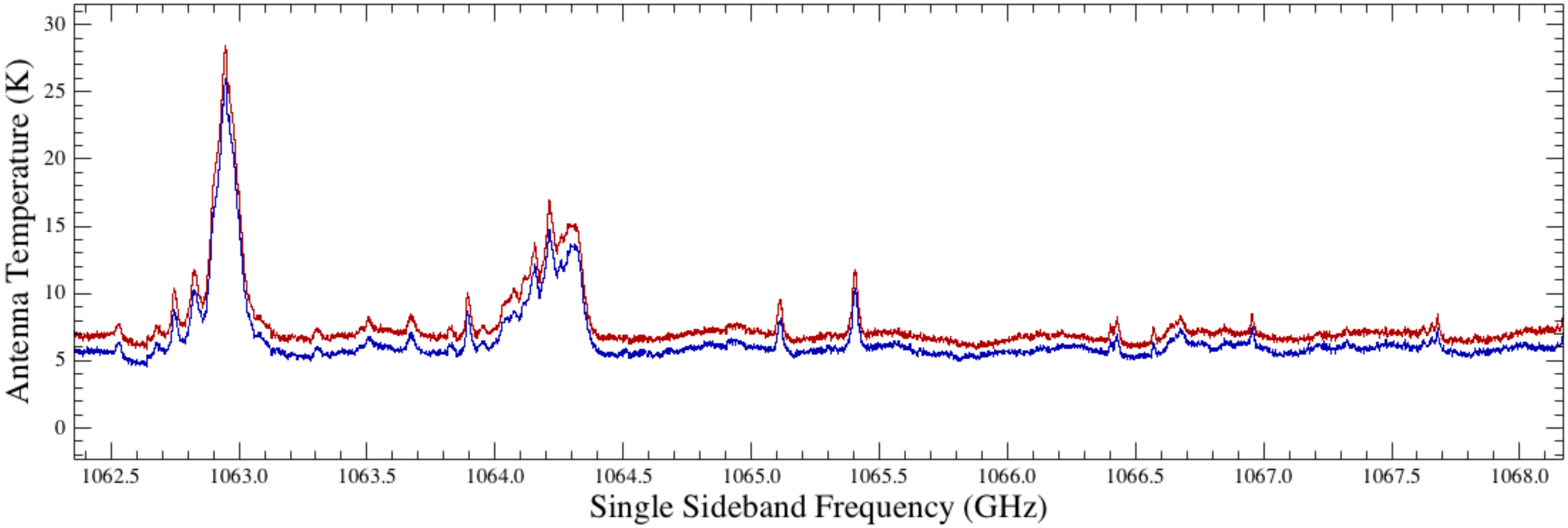
Example: Iteration 1



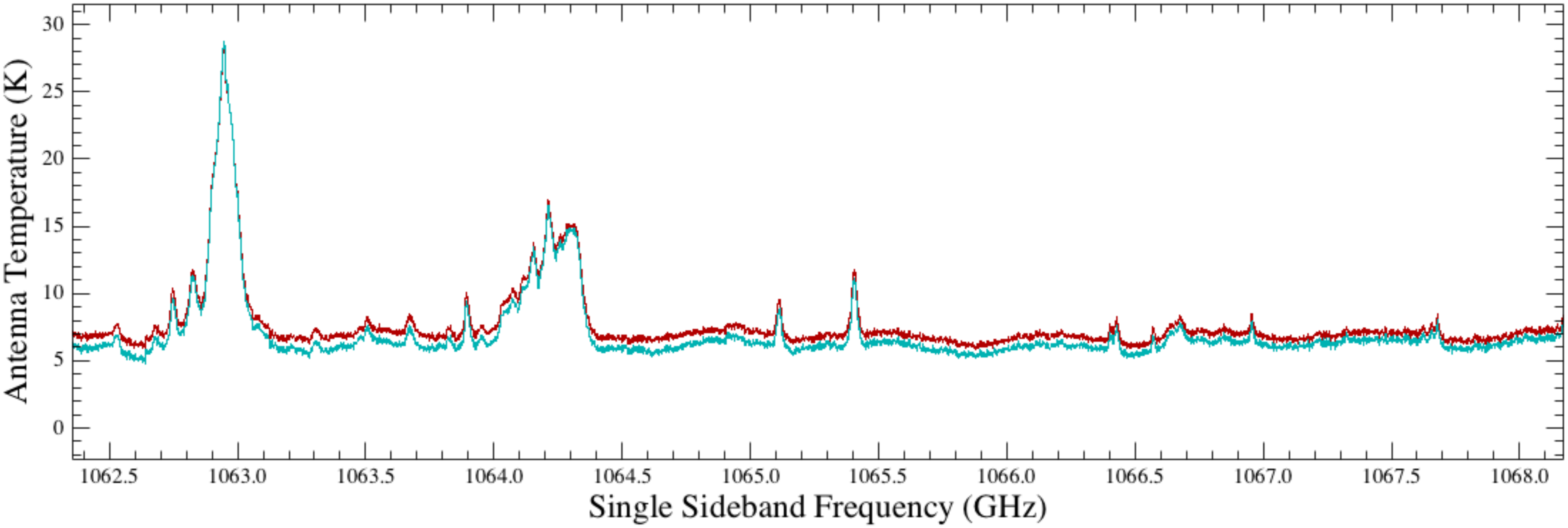
Example: Iteration 2



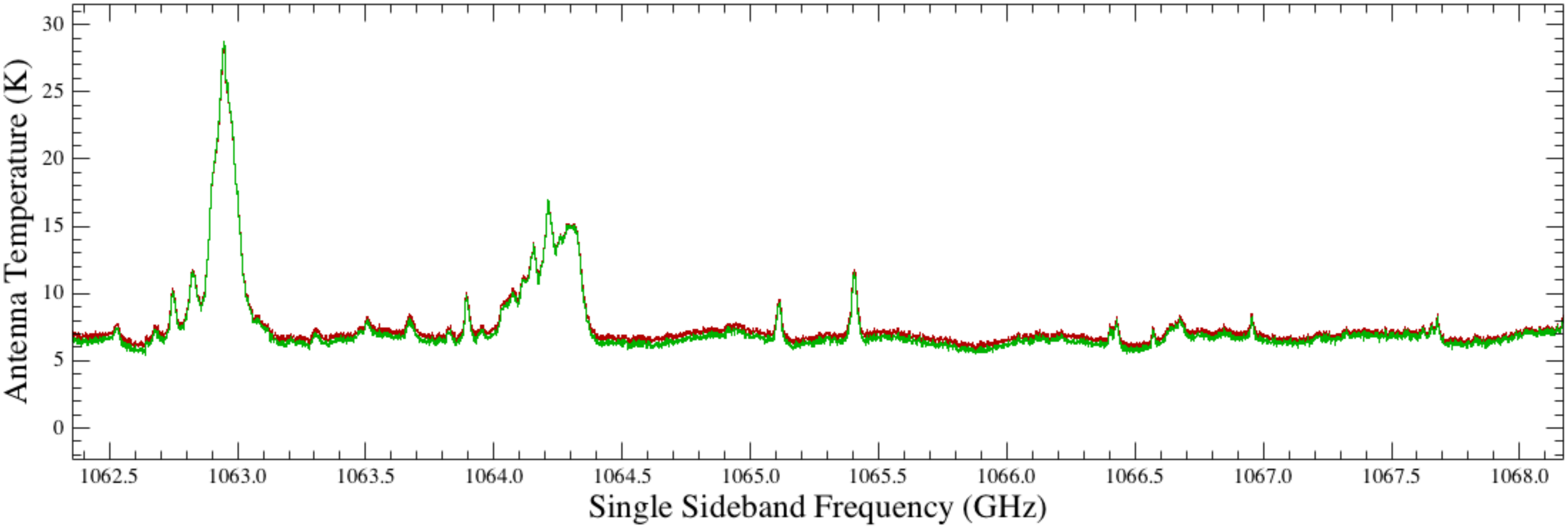
Example: Iteration 3



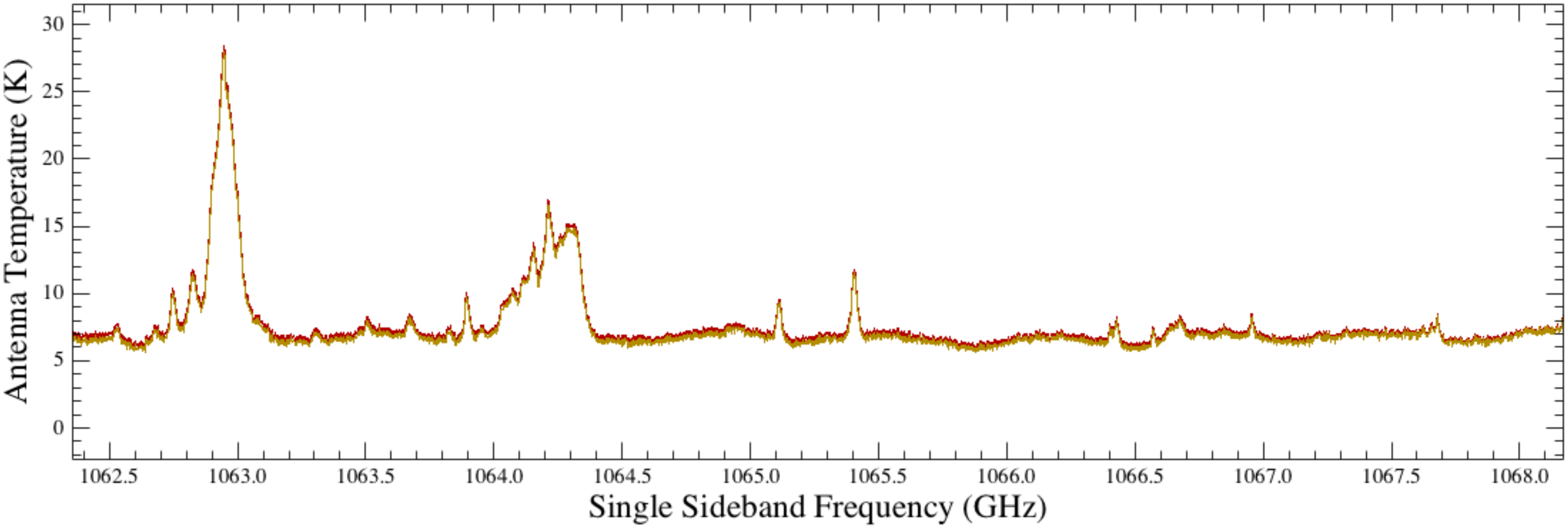
Example: Iteration 4



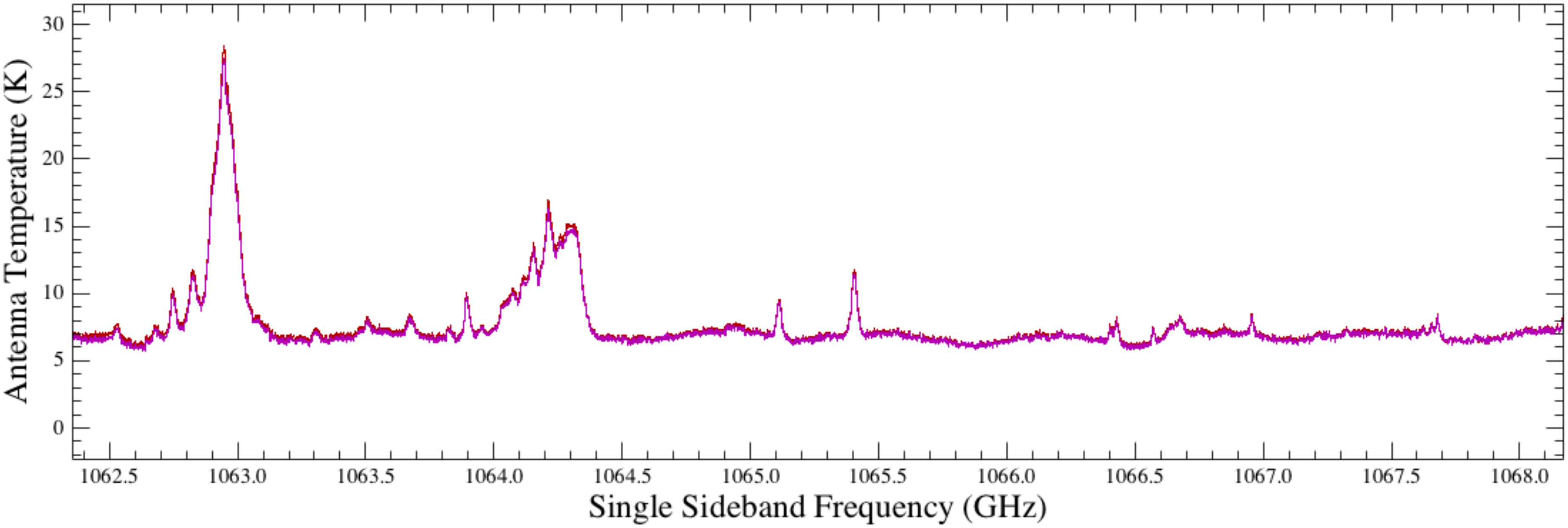
Example: Iteration 5



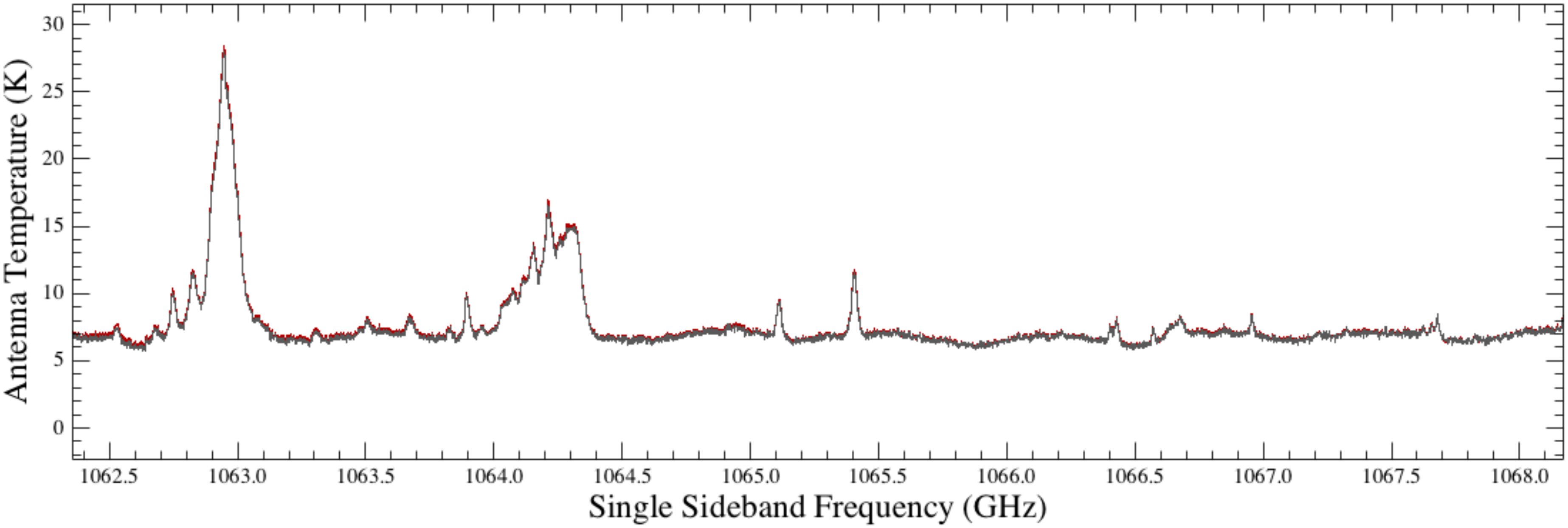
Example: Iteration 6



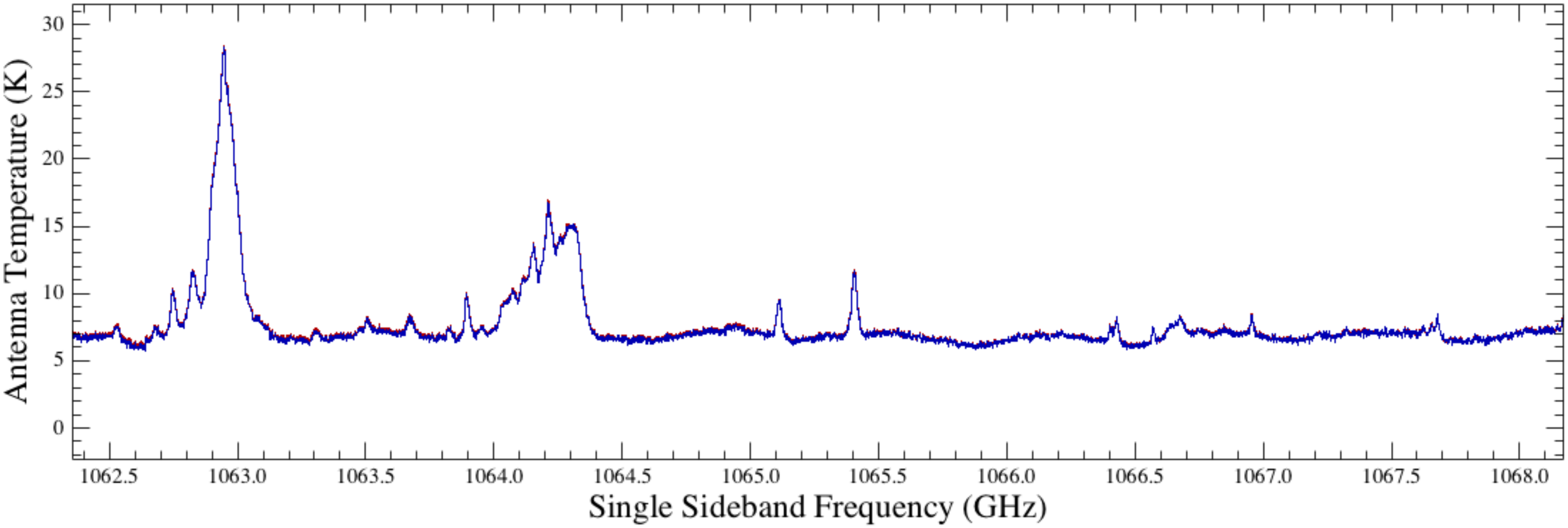
Example: Iteration 7



Example: Iteration 8



Example: Iteration 9



doDeconvolution caveats

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

<u>Most work is done before deconvolution</u>

- Usage of ‘mini-scans’ popular but lack of overlap between LSB and USB is a problem.

doDeconvolution features

- Can deconvolve multiple obsids
- Different levels of flag rejection (IMPORTANT)
- Offers expert level diagnostic plots for scans that behave poorly
- Has a maximum-entropy mode for cases where line density is low.
- Fits for the sideband ratios if desired, or uses values in the calibration tree.

- By default the SPG runs decon, but for interactive analysis it is best to run it standalone.