Since the telescope reference system constantly moves with respect to the Local Standard of Rest (LSR) an additional Doppler shift of all incoming radiation can be observed. To correct for this effect at Effelsberg the Local oscillator (LO) is tuned to a slightly different frequency instead of the desired rest frequency.

Using the Dopplerformula

$$v_{\mathrm{lsr}} = c\frac{\nu_0^2 - \nu^2}{\nu_0^2 + \nu^2}$$

one can convert the LSR velocity correction to a frequency shift (which needs to be applied to the local oscillator)

$$\Delta\nu_{\mathrm{lsr}} = -\frac{1}{c}\frac{(\nu_0^2 + \nu^2)^2}{4\nu\nu_0^2}\Delta v_{\mathrm{lsr}}$$

As can be seen, the LSR correction frequency shift is dependent of the frequency and rest frequency. Therefore it is impossible to apply the **correct** LO shift for the complete spectrum simultaneously. Fortunately, if the band width is much smaller than the rest frequency effects are small. However, with the advent of modern FPGA-based spectrometers and new receivers it has become possible to work with huge band widths.

This can have serious consequences. Assume we would like to detect very weak and narrow spectral lines, i.e. the total observing time had to be many hours. If now the vLSR correction changes during the session (and usually it will) then the spectral lines far from the center of the band will end up in different spectral channels. Averaging all spectra will now not only broaden the lines but may even lead to non-detection.

For these cases viable solutions will have to be developed. For more information see also Accurate line center frequencies Report - IRAM 30m telescope.

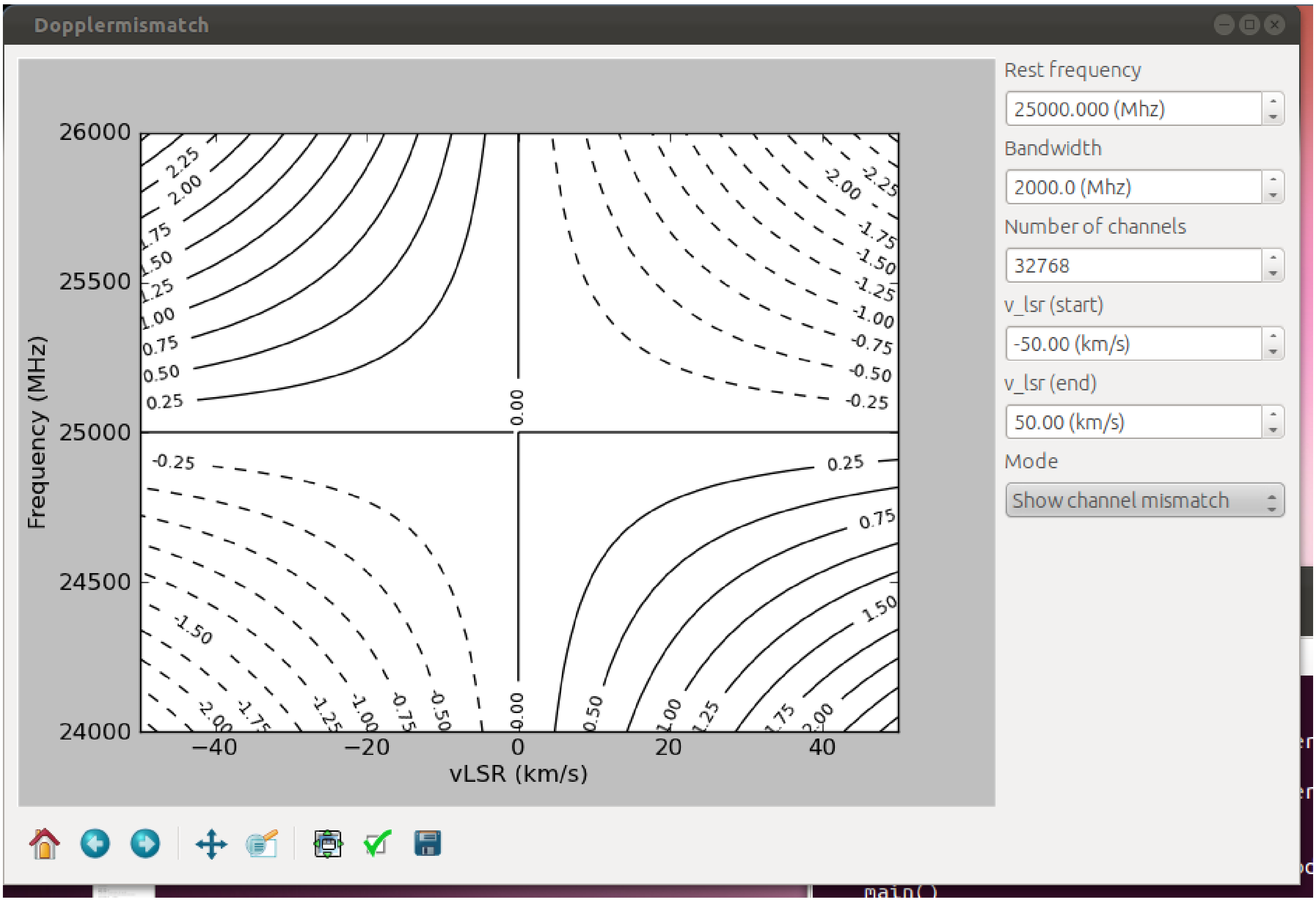
To calculate the size of the effect, we need to compute the difference of the (correct) frequency shift in a certain spectral channel and the shift which is applied practically, i.e., the shift calculated for the center of the band:

$$\Delta\nu_{\mathrm{mismatch}}(\nu) = -\frac{1}{c}\frac{(\nu_0^2 + \nu^2)^2}{4\nu\nu_0^2}\Delta v_{\mathrm{lsr}} - \Delta\nu_{\mathrm{lsr}}(\nu = \nu_0)$$

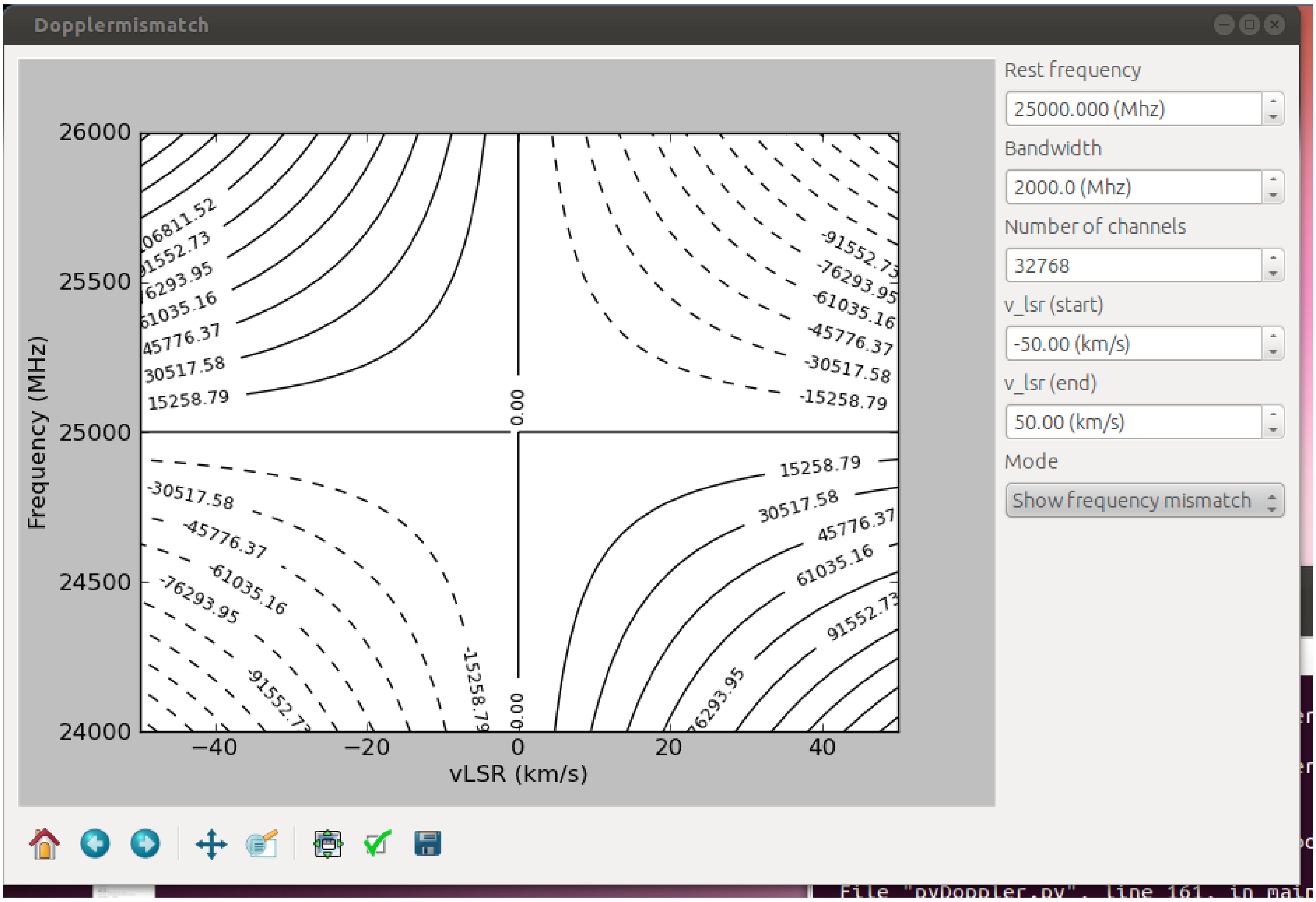
where

$$\Delta\nu_{\mathrm{lsr}}(\nu = \nu_0) = -\frac{\nu}{c}\Delta v_{\mathrm{lsr}}$$

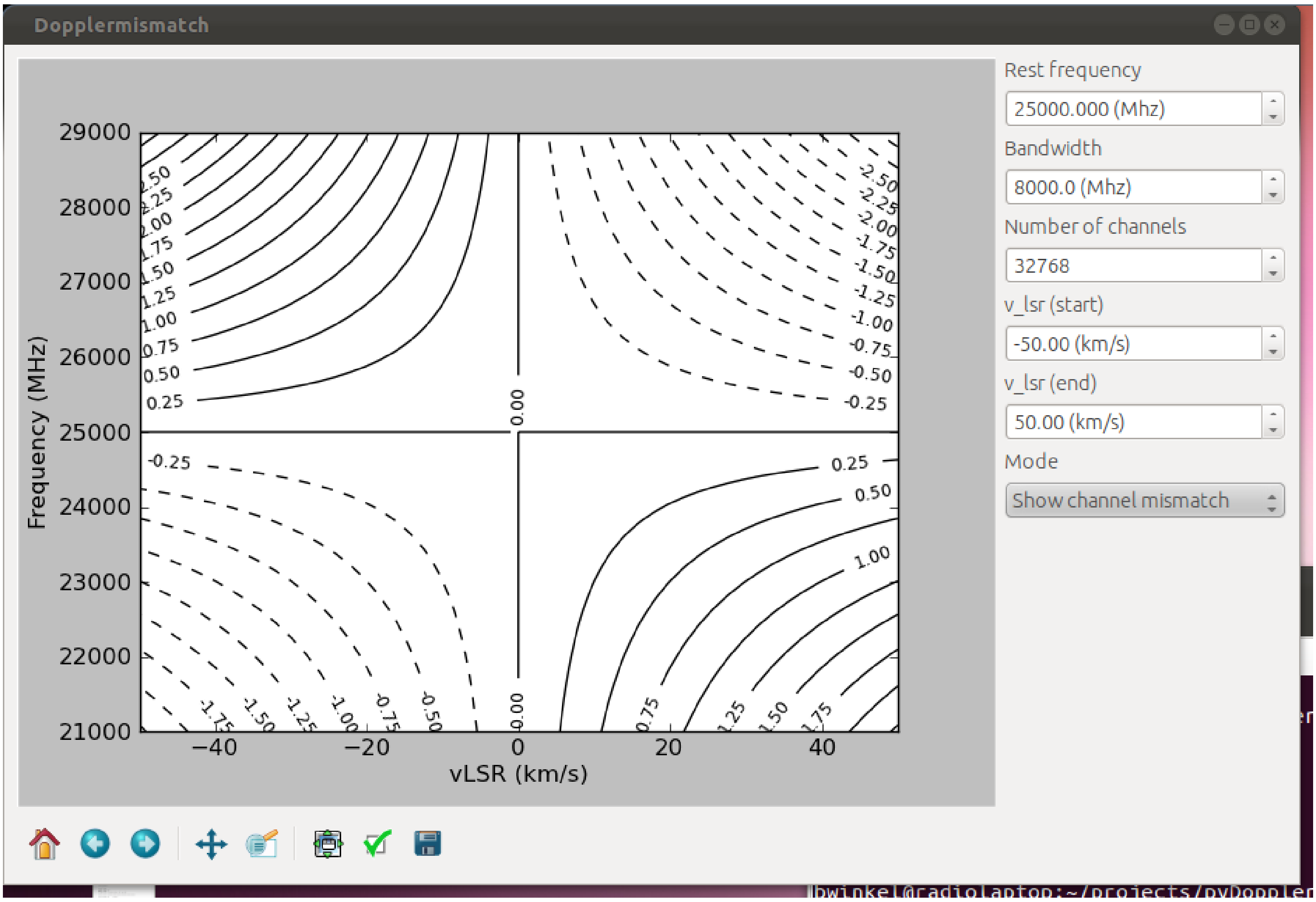
Below one can see some examples.



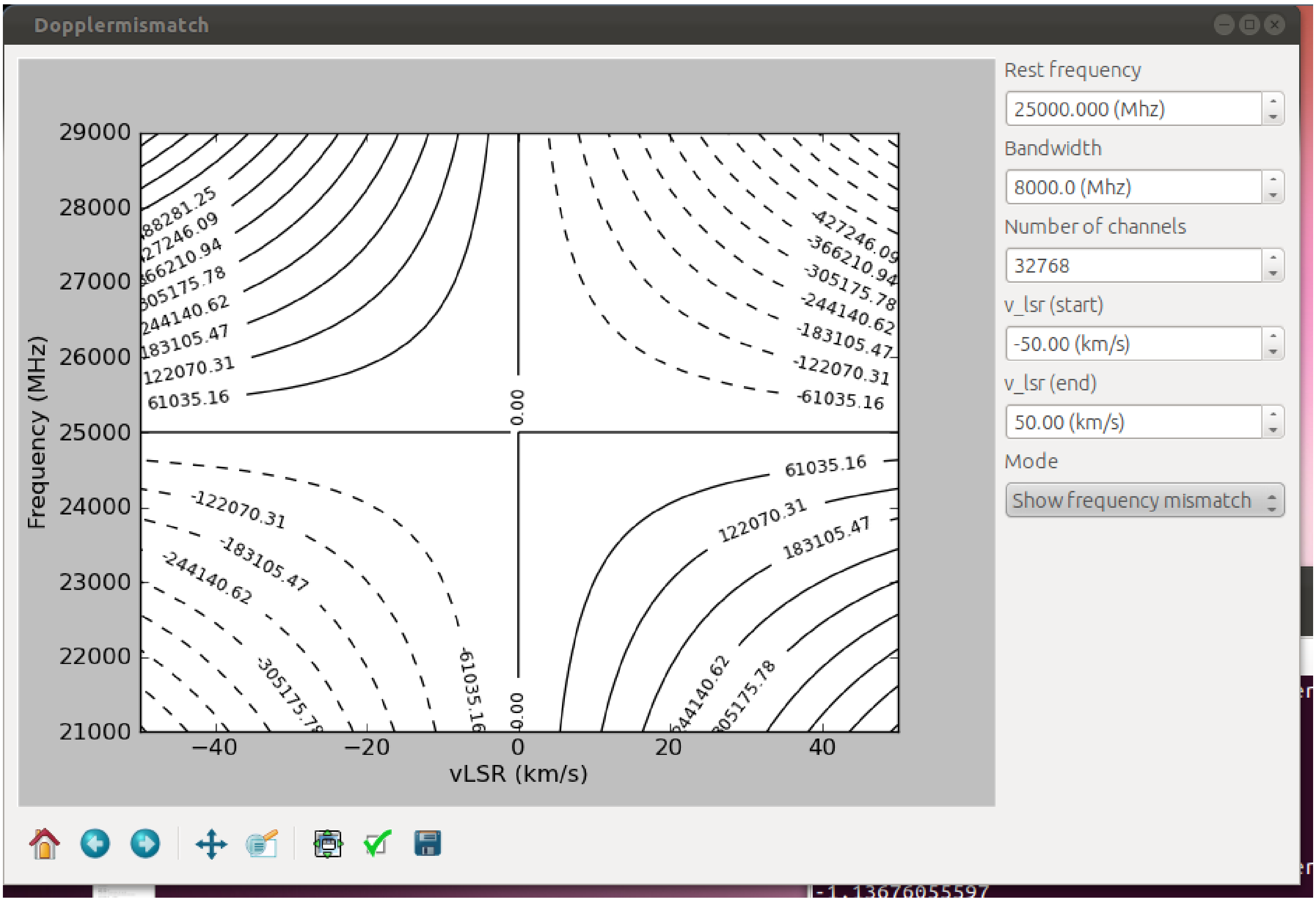
The contours show the mismatch in units of spectral channels.



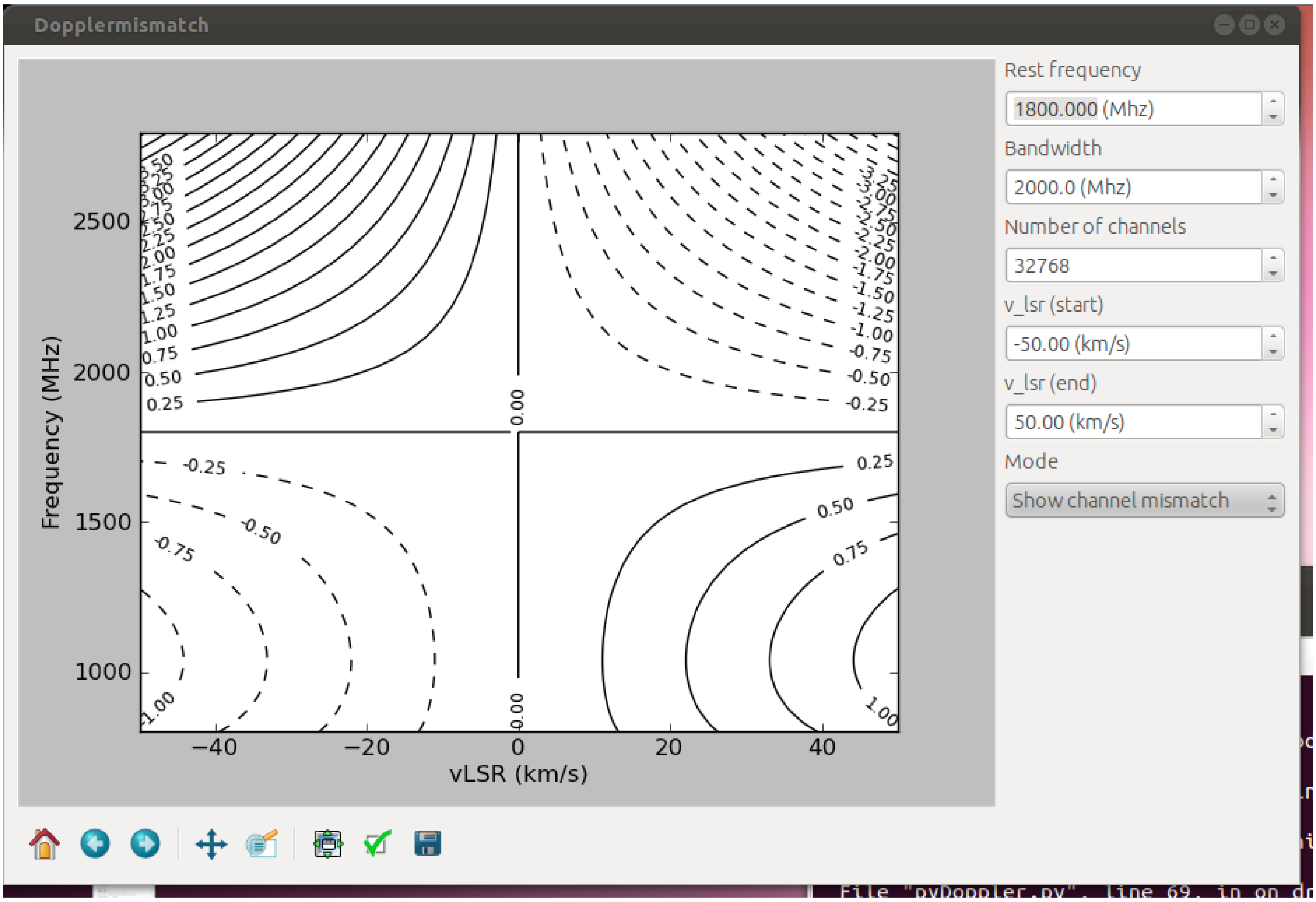
Same plot but showing frequency mismatches.



If one increases the total band width but keeps number of spectral channels the mismatch in units of channels is comparable, but …



… the mismatch in frequency has increased substantially.



If the band width becomes large with respect to the rest frequency, the plot can become quite asymmetric.