GALFACTS MEMO: # 10
ALFA RFI Saturation Problem

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1 Overview

Observations made with ALFA can be partially or completely lost due to strong RFI saturating a component in the receiver chain. While the RFI is likely transmitted on a narrow band, when strong it can effect all channels acquired by the spectrometer backend. Even worse, the saturation caused by the strong RFI can take many seconds or ten's of seconds to recover and return to normal behaviour. This can affect all beams and all polarisations which makes the loss of data an extremely serious problem.

Using the 100MHz filter after the ALFA receiver greatly reduces the impact of this RFI and is therefore common observing practice when observing with ALFA. However, with the arrival of the new 300MHz pDev spectrometer, this method will not be possible without losing the 2/3 of the spectrum that the new spectrometer is intended to measure.

A determination of where the saturation is occuring should be made, and the problem solved. This should be done in the timeline of the comissioning of the pDev so that its use can be maximized upon its arrival.

2 Example Measurement

Figure 1 is from A2174 which was observed comensually with Galfacts and the WAPPS backend which the primary observer was using Galspec in November 2006. This data was taken without the 100MHz filter, which was added for subsequent observations as a result of this analysis. The plot shows beam0 PolA, but is not atypical for the other beams and polarisation. This is a band average from WAPPS: all the channels have similar behaviour and the average was used to improve the S:N to more clearly show features in the plot.

There are several striking features to this plot. First of all, every 12s there is a spike that is clearly attributible to a radar sweep. The amplitude of these pulses is not at all high, typically only 10% of Tsys, where other types of RFI can easily exceed 1000% of Tsys or more. The reason the spike is not high is because this RFI is outside of the band that the WAPPS is actually measuring. However, clearly there is strong energy entering the front end which is causing some device in the signal chain to behave badly.

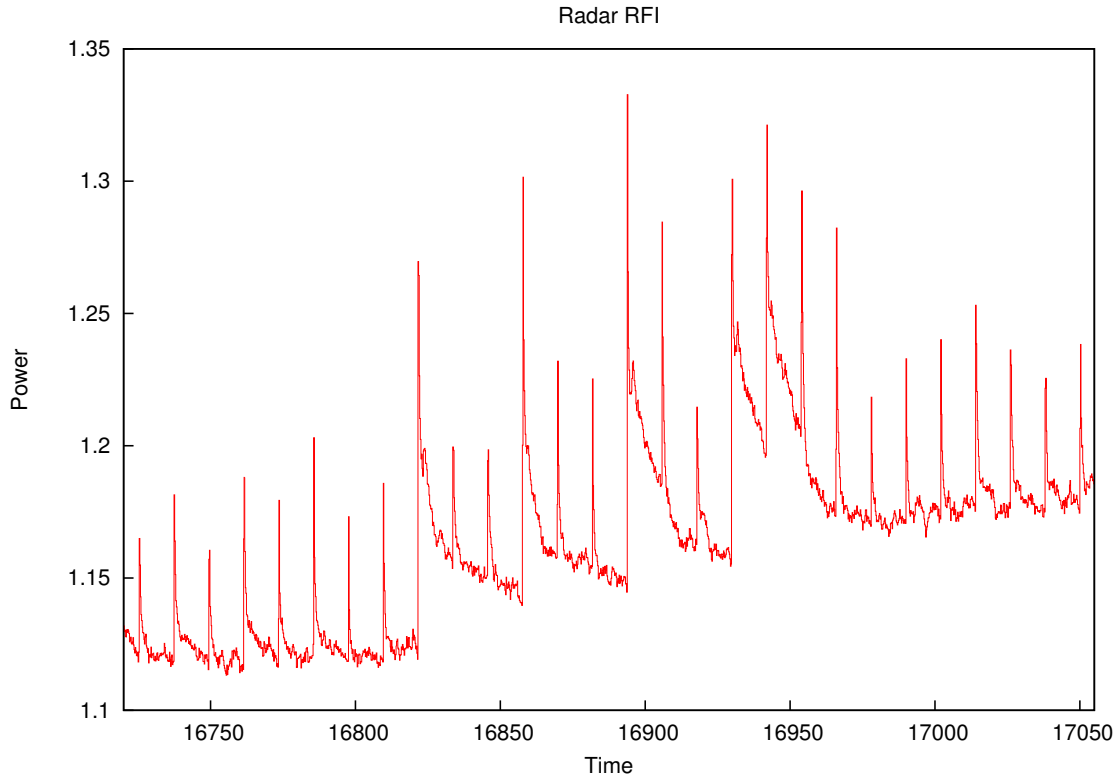

Figure 1: Band average plot for 135 seconds showing the effect of Radar RFI in the continuum.

After each spike, there is a ramp down phase before the signal returns to the baseline. This is the really problematic nature of this RFI in that it causes the receiver to go non-linear and take some time for the recovery to occurr. In these ramp down phases, the displacement above the baseline can be only 1% or less, but is still easily identifiable as an artifical response.

Also, the duration of the recovery time varies widely from less than a second to longer than 12 seconds, in some cases up to a minute! There are cases where the receiver is still recovering when another Radar pulse further boosts the offset from the baseline.

3 Continuum vs. Spectral Line

Spectral line observations are not as effected by this saturation behaviour as continuum observations. Data from Galspec can use a "on minus off" procedure to subtract out much of the recovery time behaviour as it is similar in all channels. However, this also subtracts out the continuum, which is obviously not a useful technique for continuum measurements. The new pDev spectrometer observations will be greatly impacted with significant lost data as a result of the saturating component and the associated recovery time.

There is no doubt that the new pDev spectrometer will be a great addition to the available instruments at AO. However, at this time there will be two choices when observing with Alfa and pDev: to use the 100MHz

filter and and have a situation hardly better than with WAPPS or to observe the 300MHz spectrum and have to re-observe on days where the RFI swamps the majority of your data.

4 Proposed Action

Components that are experiencing the saturation should be identified with certainty. It is clear that the problem is not within ALFA itself, but is somewhere down the signal chain or else the 100MHz filter would not have mitigated the problem. There is the suspicion that the amplifiers on the Alfa fiber encoders (located in the spectrometer room along with the Alfa monitor) are to blame, but an accurate assessment should be made.

After the site of the saturation is identified, options should be considered in solving the problem. Ideally the part that is saturating should be repaired or replaced with more robust amplifers. If that is impractical, a method of protecting the saturating device should be determined. These options may include a signal limiter to attenuate very high amplitude signals, a notch filter around the problematic frequencies or perhaps to use the radar blanker similar to LBW but to use a bank of RF switches to turn off the signal for the short duration of the radar sweep.