J. Effland 21 Feb 2008
Revised 22 Feb 2008 – changes recommended by Tony Kerr

This reports on the investigation conducted to understand the oscillations observed in Band 6 Cartridge B6-007 installed in the first receiver in the NA FEIC.

Spikes in noise power and noise temperature were observed in Pol 0 at low LO frequencies (Figure 1 and Figure 2) but higher LO frequencies appear normal (Figure 3)

1. Tony Kerr and Matt Morgan checked the configuration and concluded that the problem is likely due to an oscillating preamp when the receiver is tuned to low LO frequencies or when the LO is off and the mixer is biased in a region of high dynamic resistance:
    - Turning off preamp bias for the affected polarization causes the spikes to disappear. In fact, turning off just one of the preamps causes the spikes to disappear.
    - Adjusting preamp bias didn't eliminate the oscillations until the bias voltages were close to zero.
    - I-V curves measured for each mixer chip confirm that the mixer chip-preamp causing the spectral peaks has a normal I-V characteristic when the preamp is off, but when the preamp is on it has a negative resistance (Figure 4). I-V curves for the other mixer chip-preamp are normal with the LO on and off.
    - I-V curves with preamp and LO on at higher frequencies are normal (Figure 5).
    - The problem occurs at lower LO frequencies, but the highest frequency exhibiting oscillations varies between 225 and 229 GHz
2. Despite Tony's and Matt's findings, as an act of desperation, we performed the following additional tests:
    - Replaced bias box C2-015 with C2-022, which is known good because it was just used for PAS testing of a Band 7 cartridge.
    - Replaced WCA-6.007 with WCA-6.009 (along with that WCA's warm IF plate).
3. Tony Kerr also measured the oscillations as a function of the mixer junction voltage with the LO turned off, to present varying impedances into the preamp input. As shown in Table 1, the oscillations occur for high impedances present below the knee of the mixer I-V curve.
4. A final measurement supports Geoff Ediss' theory that the oscillations occur only for physical mixer temperatures below 4K, which is a temperature where the cartridge is never tested. Figure 6 shows a time plot of the 4.5 GHz signal resulting from the oscillations with a chopper running at the input of the receiver. The step at the first left division shows the signal disappearing when mixer heater is turned on to heat the mixer to ~13K. Of course, at that physical temperature, the mixer is no longer superconducting and so is not working, as seen in the 2nd division from the left. As the mixer cools, it starts working and the Y-Factor appears in the 3rd and 4th divisions from the left. Finally, the mixer cools to below 4K and the oscillation commences as shown in the 5th division from the left. All temperatures have a ±0.2K uncertainty because the temperature sensor correction factors have not yet been loaded into the FETMS database.

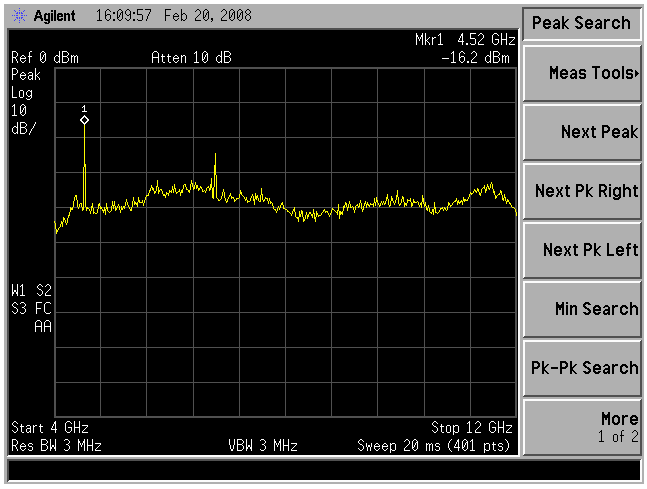


Figure 1: Spectrum Analyzer Plot of Oscillations

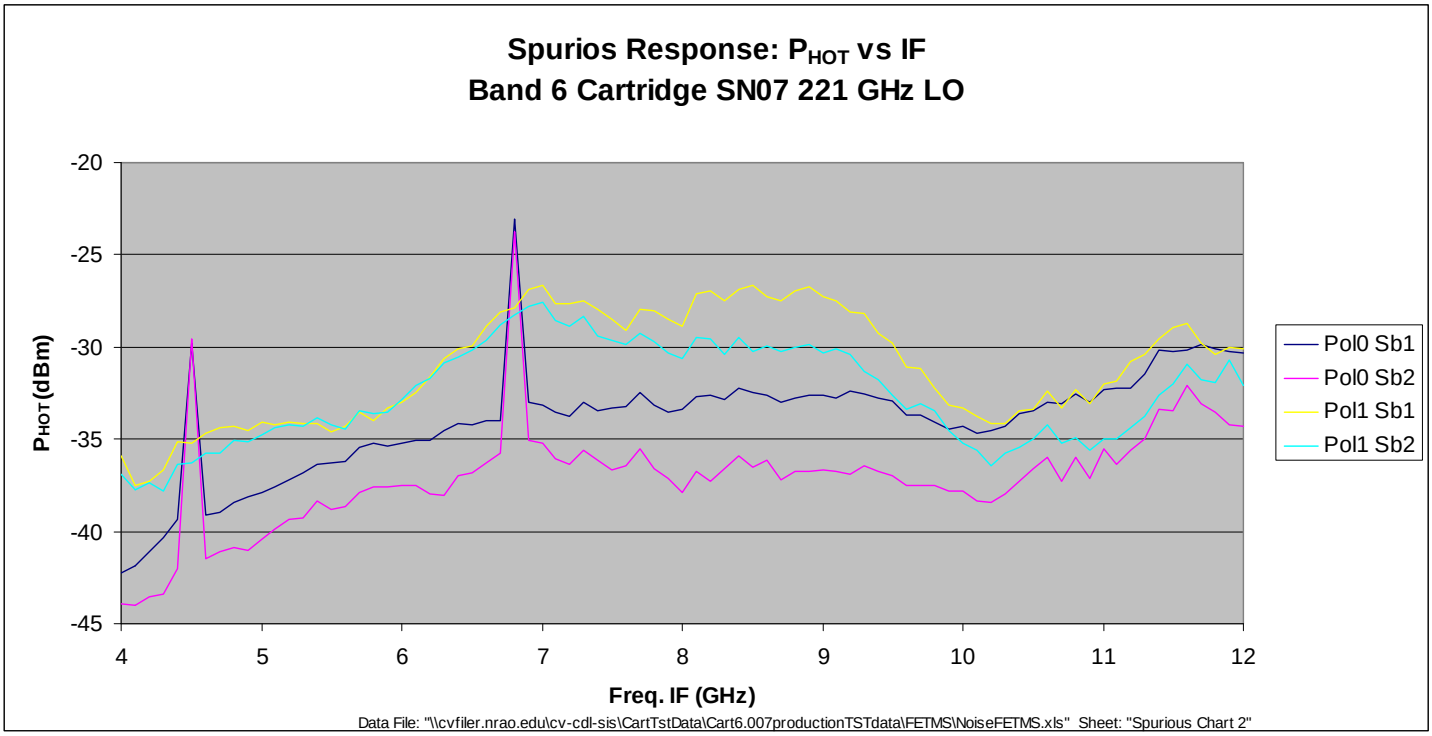


Figure 2: (Source)

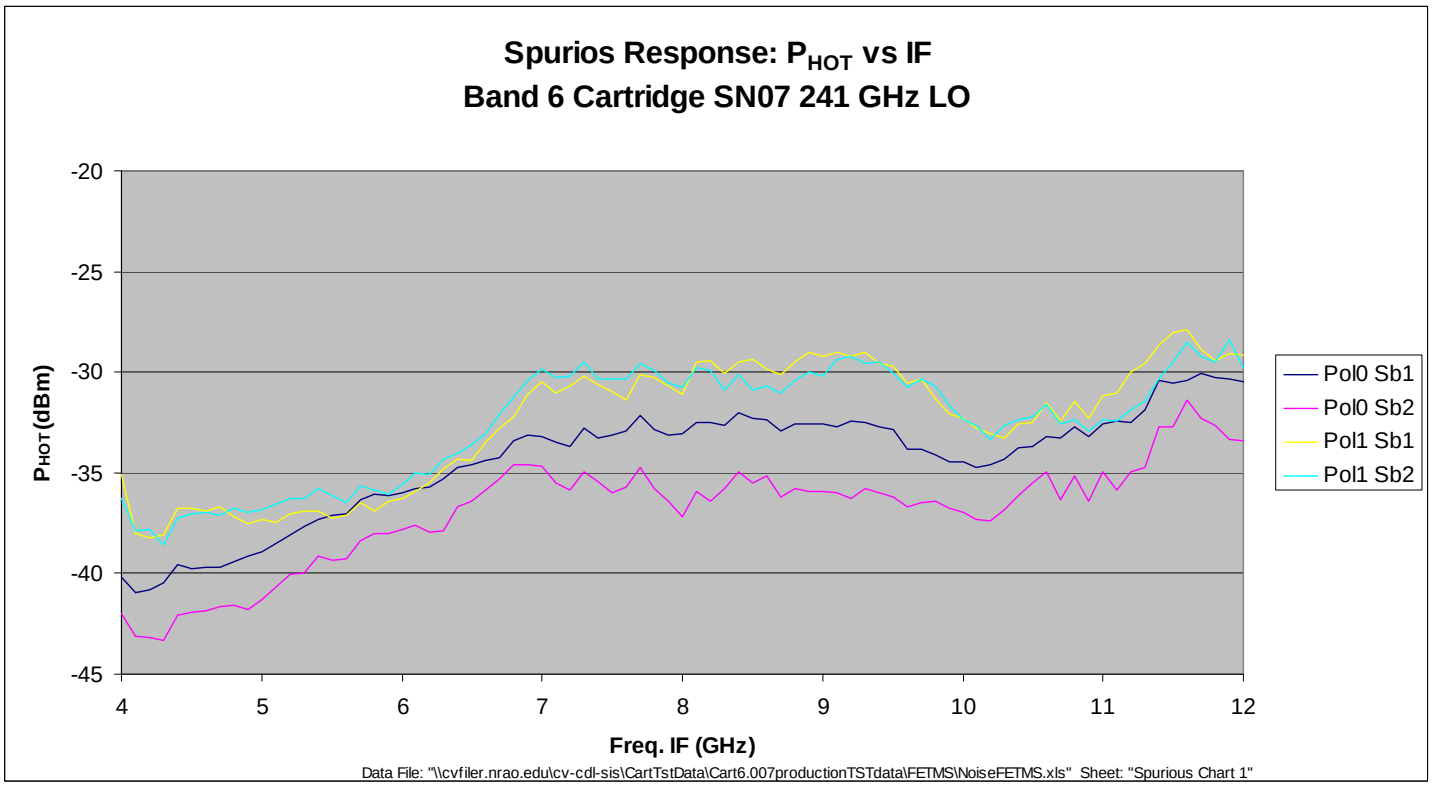


Figure 3:

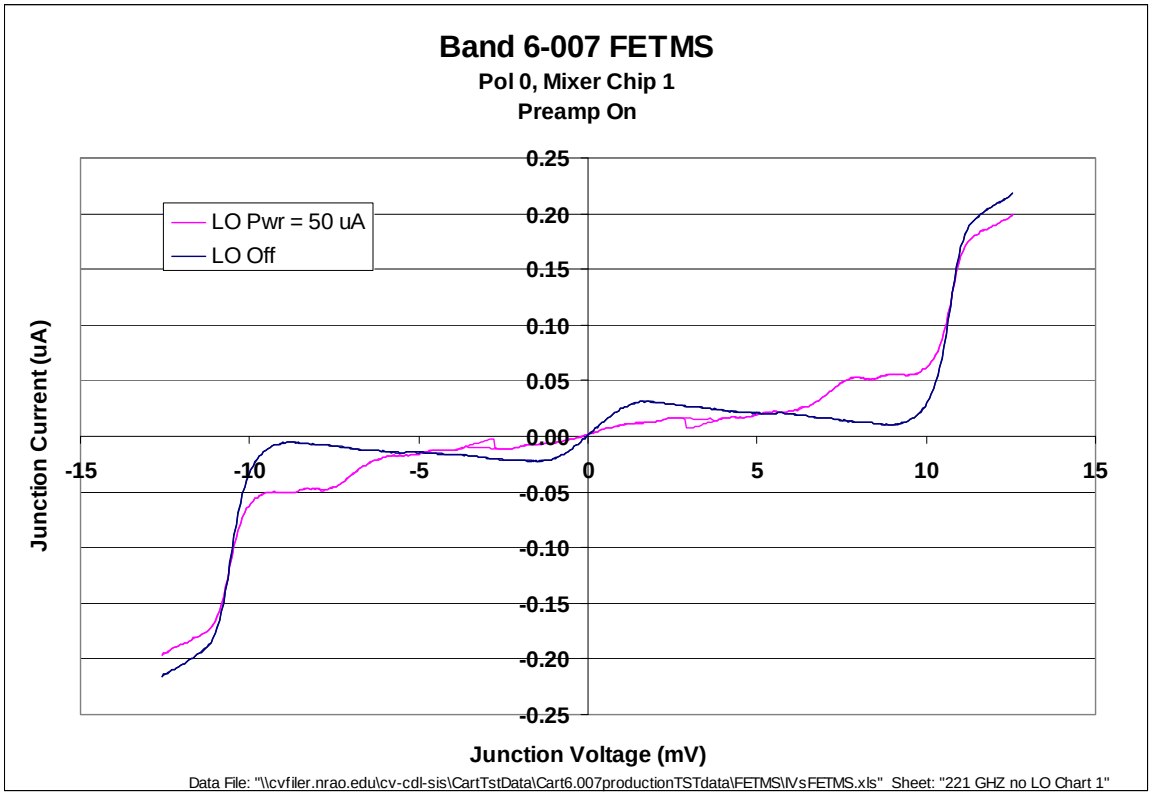


Figure 4: Junction I-V Curves with Preamp On (curves are normal with preamp off) (Source)

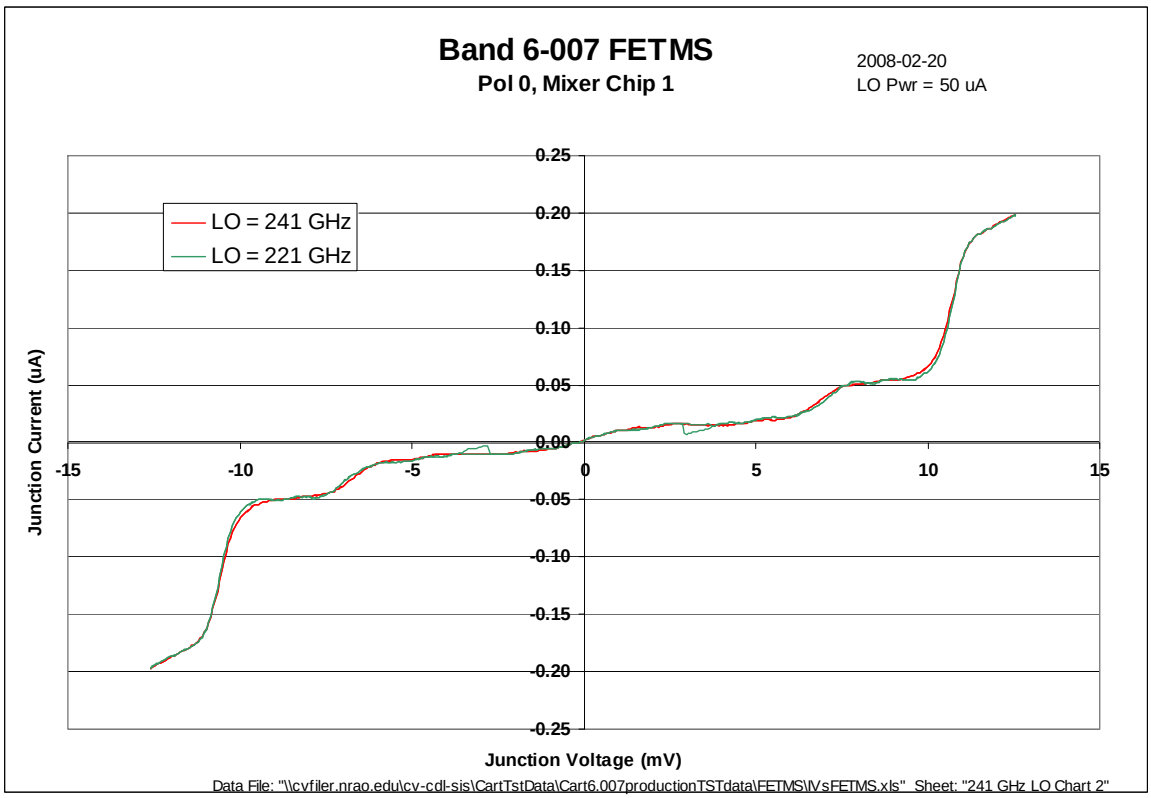


Figure 5:

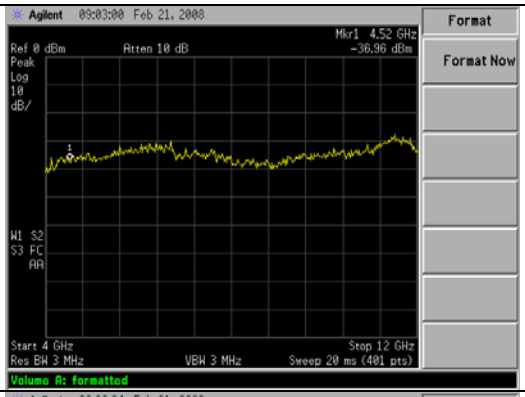
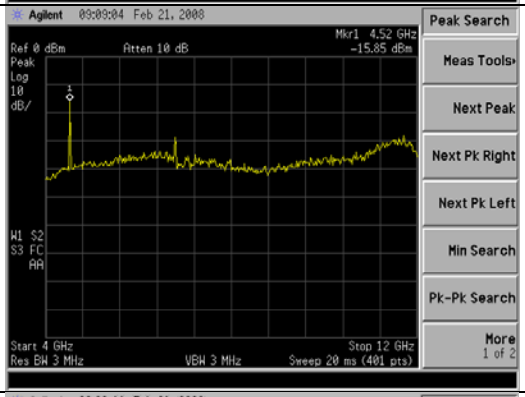
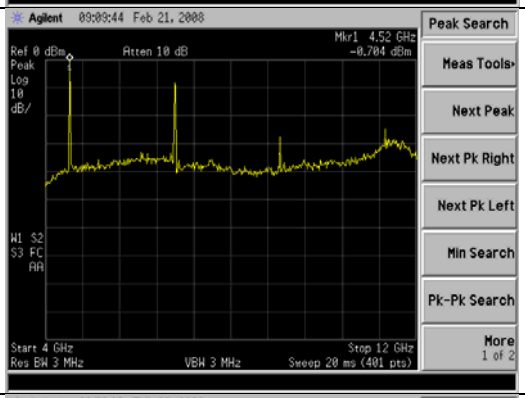
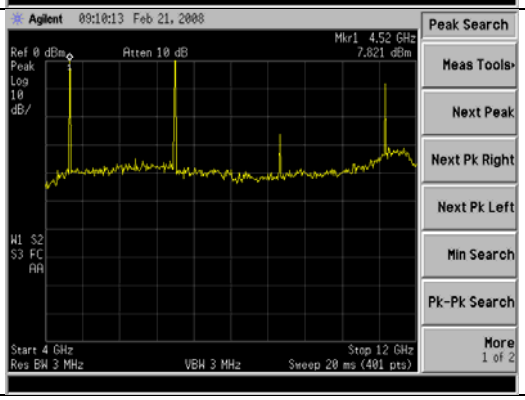
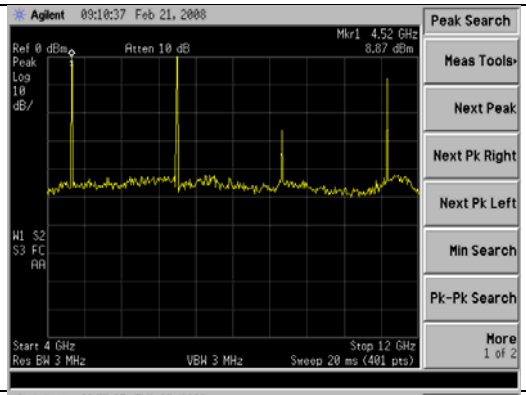
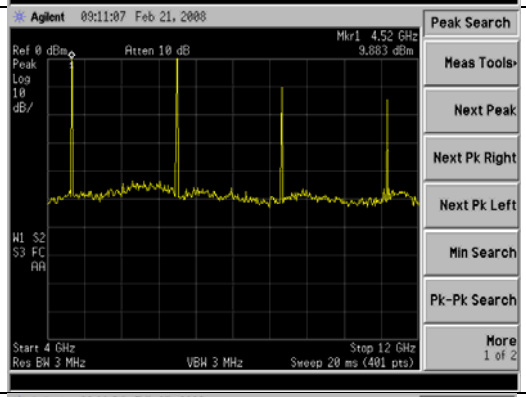
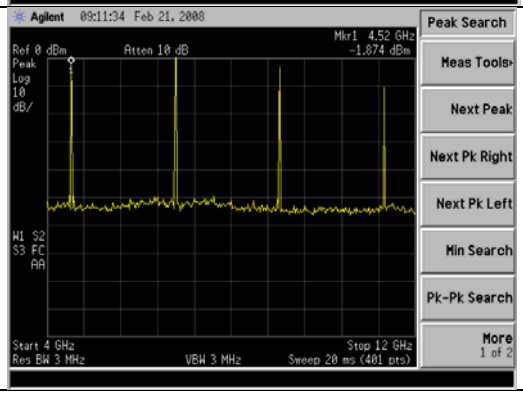
Table 1:Oscillation as a function of Mixer Bias Setting (with LO off)		
Vj (mV)	**Ij (uA)**	**Spectrum**
-15 -10.6 -10.2 -9.6	-262.7 -110.34 -45.91 -14.44	
-8.8	-5.71	
-8.6	-6.33	
-8	-7.71	

Table 1:Oscillation as a function of Mixer Bias Setting (with LO off)		
Vj (mV)	**Ij (uA)**	**Spectrum**
-6	-14.48	
-3	-19.88	
0	1.11	

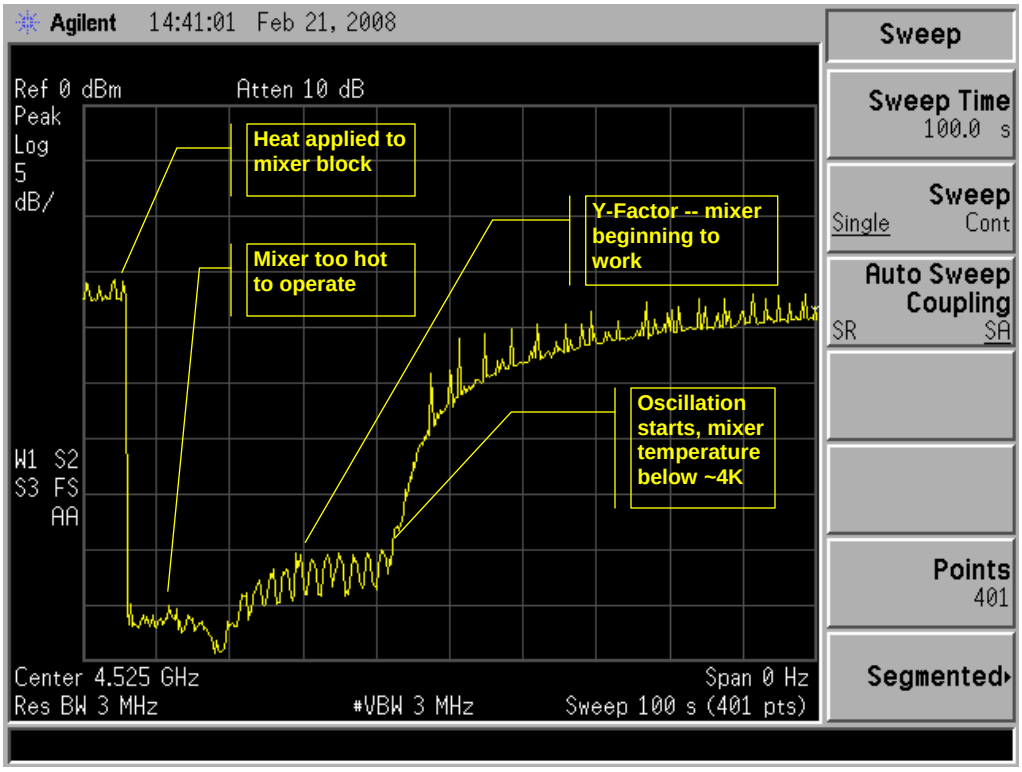


Figure 6: Time Display (100s) Showing Oscillation and Y-Factor