A FWD/REV Problem in Caltech Data

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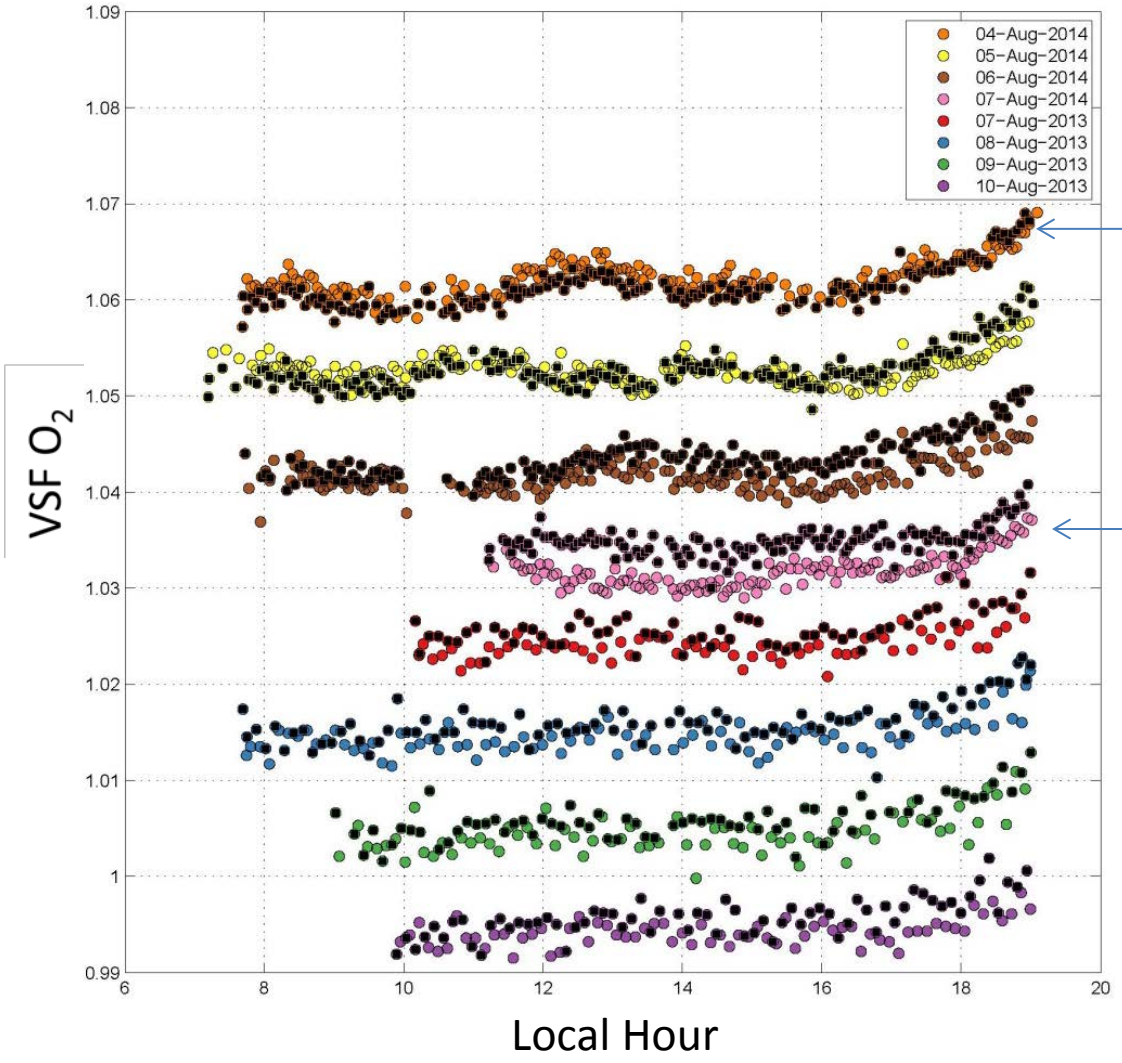
Forward and Reverse Scans Sometimes Differ Systematically



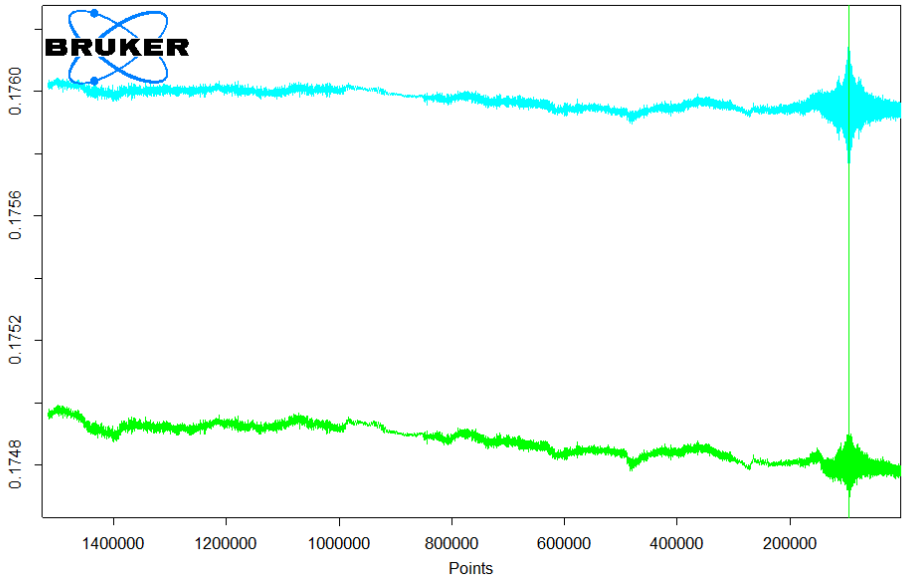
Aug 4, 2014 (small diff)

Aug 7, 2014 (large diff)

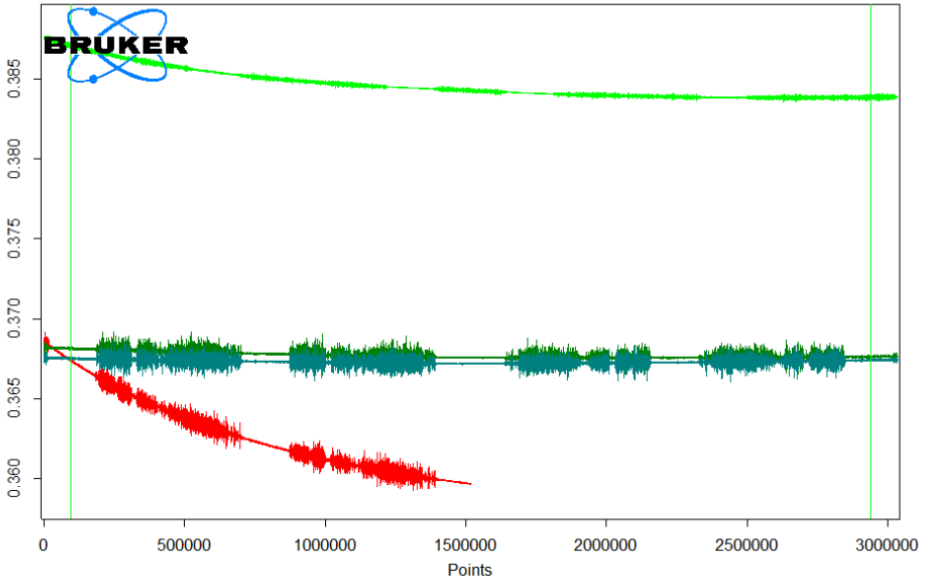
Traces shifted vertically for clarity

Interferograms have periodic noise “bursts”

Solar Scans

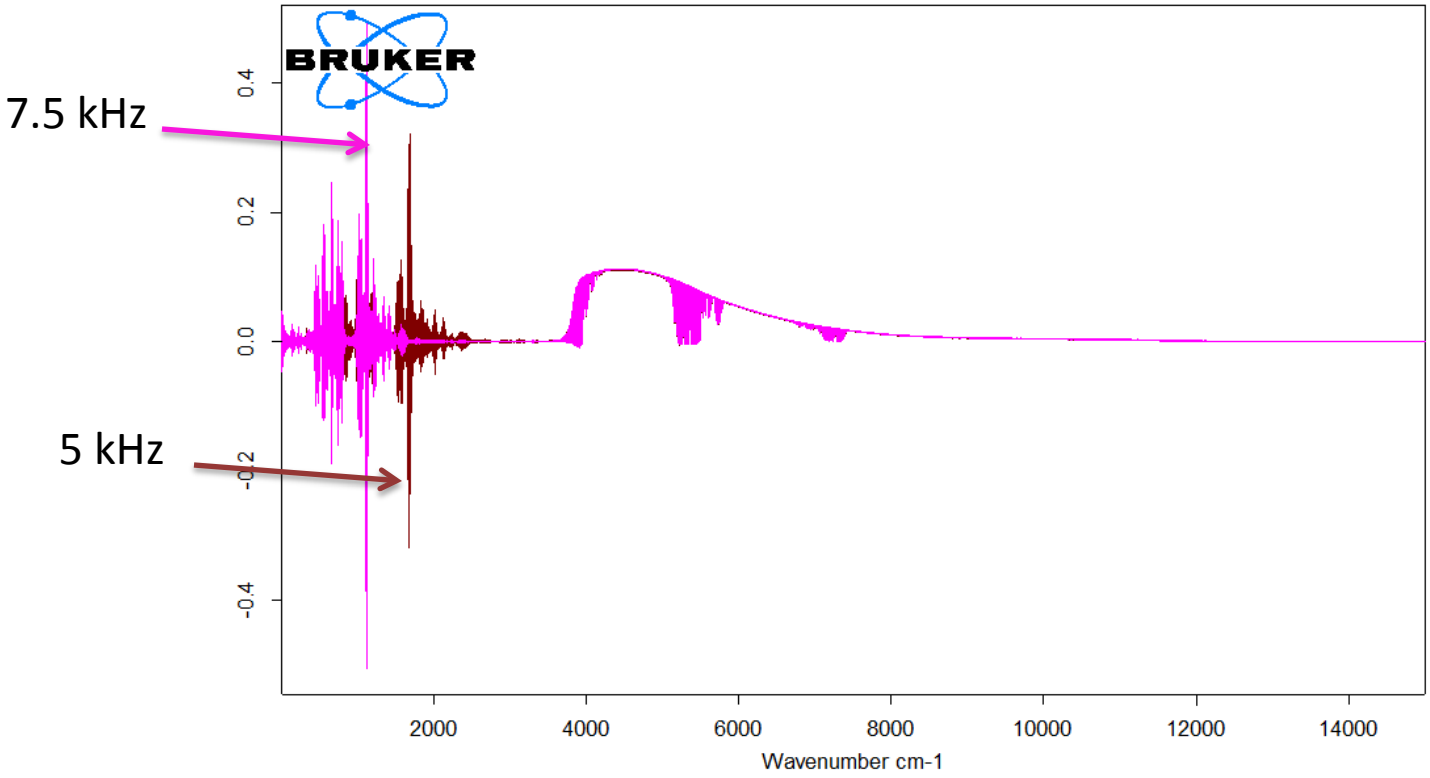


Lamp Scans



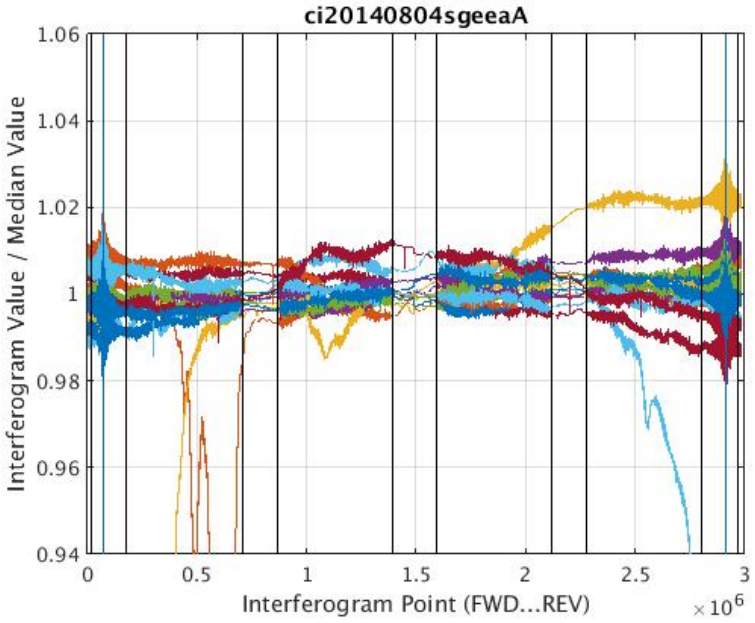
- Remarkably symmetric about MOPD
- Points to scanner motor/encoder assembly as possible culprit
- Can hear periodic “grinding/whining” noise as scanner moves: is perfectly correlated with noise bursts

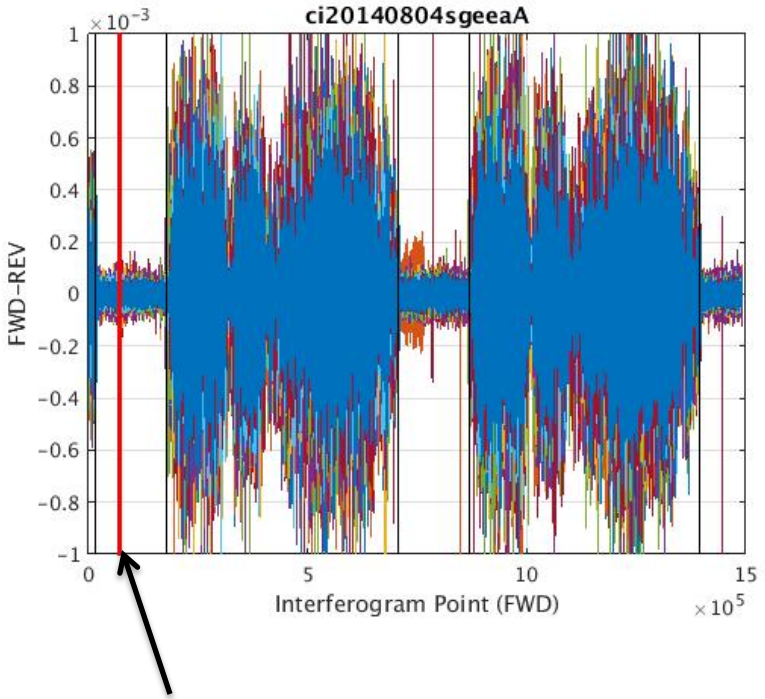
Spectra Show Large Noise Pulses < 2500 cm^{-1}



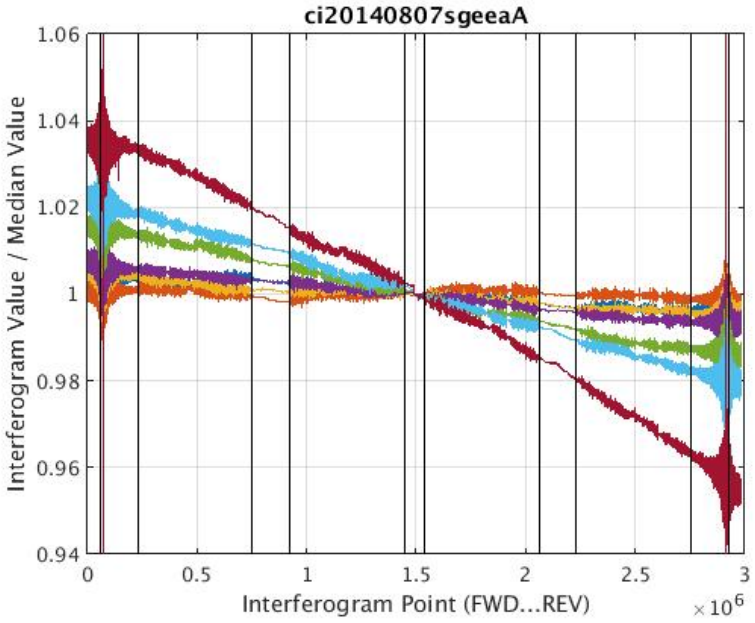
- These noise bursts wouldn't be a problem for our retrievals if they were just noise below 2500 cm^{-1}
- However, we believe that what is causing the noise bursts also mis-sampled the interferograms, which will significantly impact the retrievals!

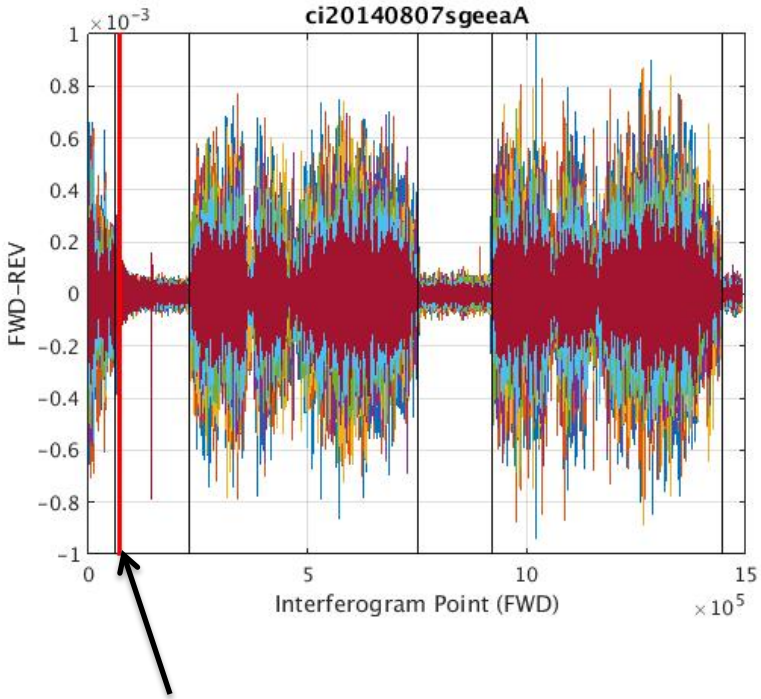
Interferograms on Day with Small FWD/REV Difference



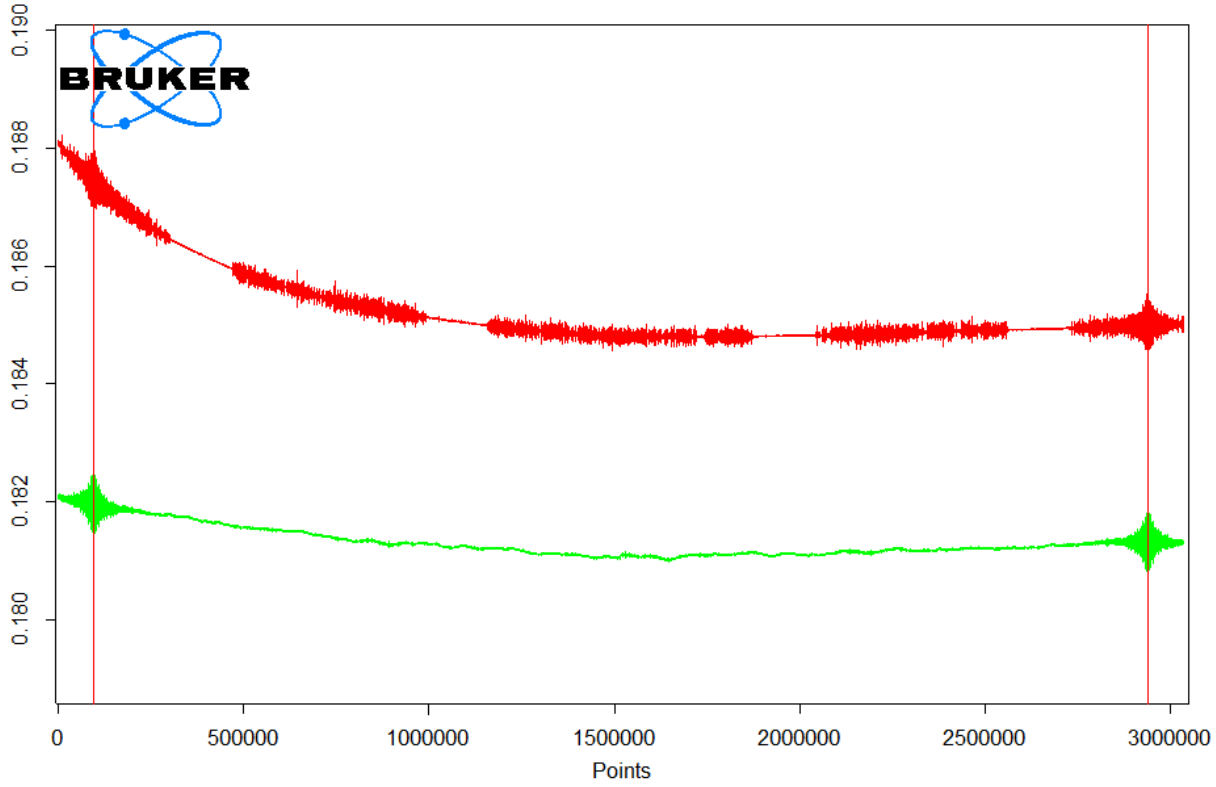


Interferograms on Day with Large FWD/REV Difference





Swapping out Scanner Encoder/Motor Assembly (5 kHz)



Before

After

C:\Users\TCCON\Bruker\ci20150420laaaaa.001	Lab Cell #2	Lab Cell #2	4/20/2015
C:\Users\TCCON\Bruker\ci20150420laaaaa.002	Lab Cell #2	Lab Cell #2	4/20/2015

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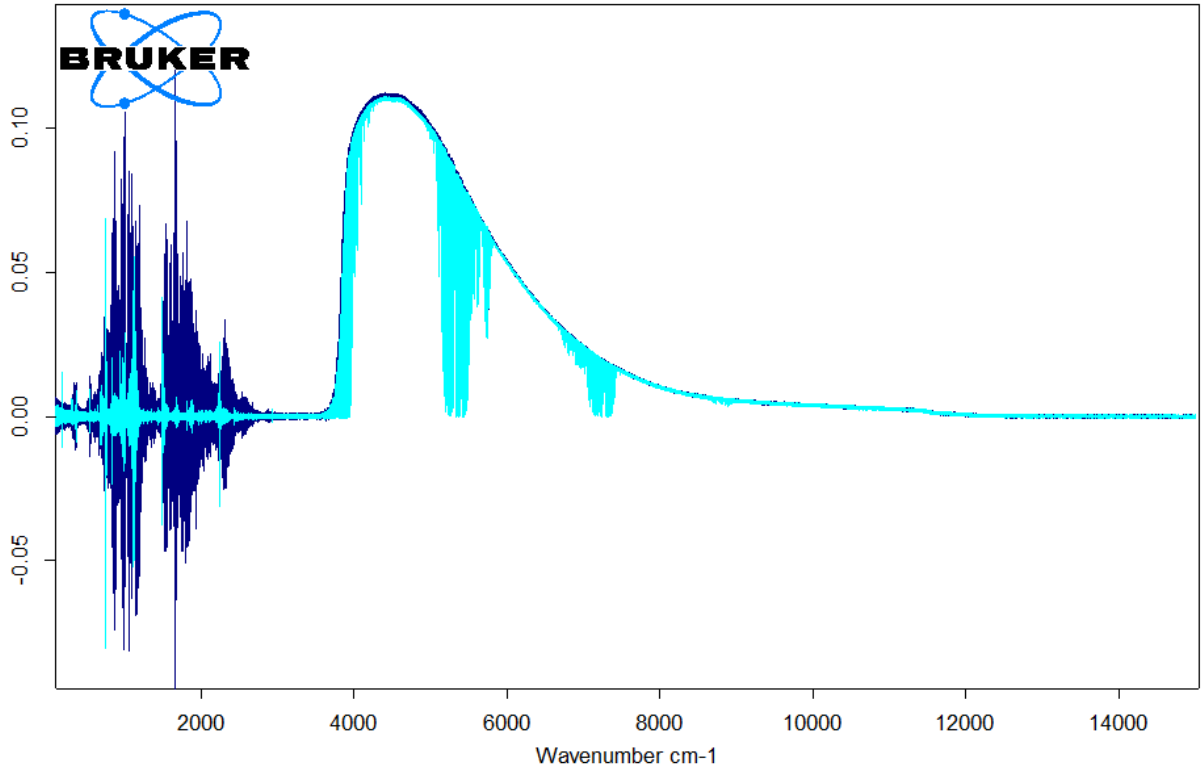
Swapping out Scanner Encoder/Motor Assembly (5 kHz)



Before

After

C:\Users\TCCON\Bruker\ci20150420laaaaa.002	Lab Cell #2	Lab Cell #2	4/20/2015
C:\Users\TCCON\Bruker\ci20150420laaaaa.001	Lab Cell #2	Lab Cell #2	4/20/2015

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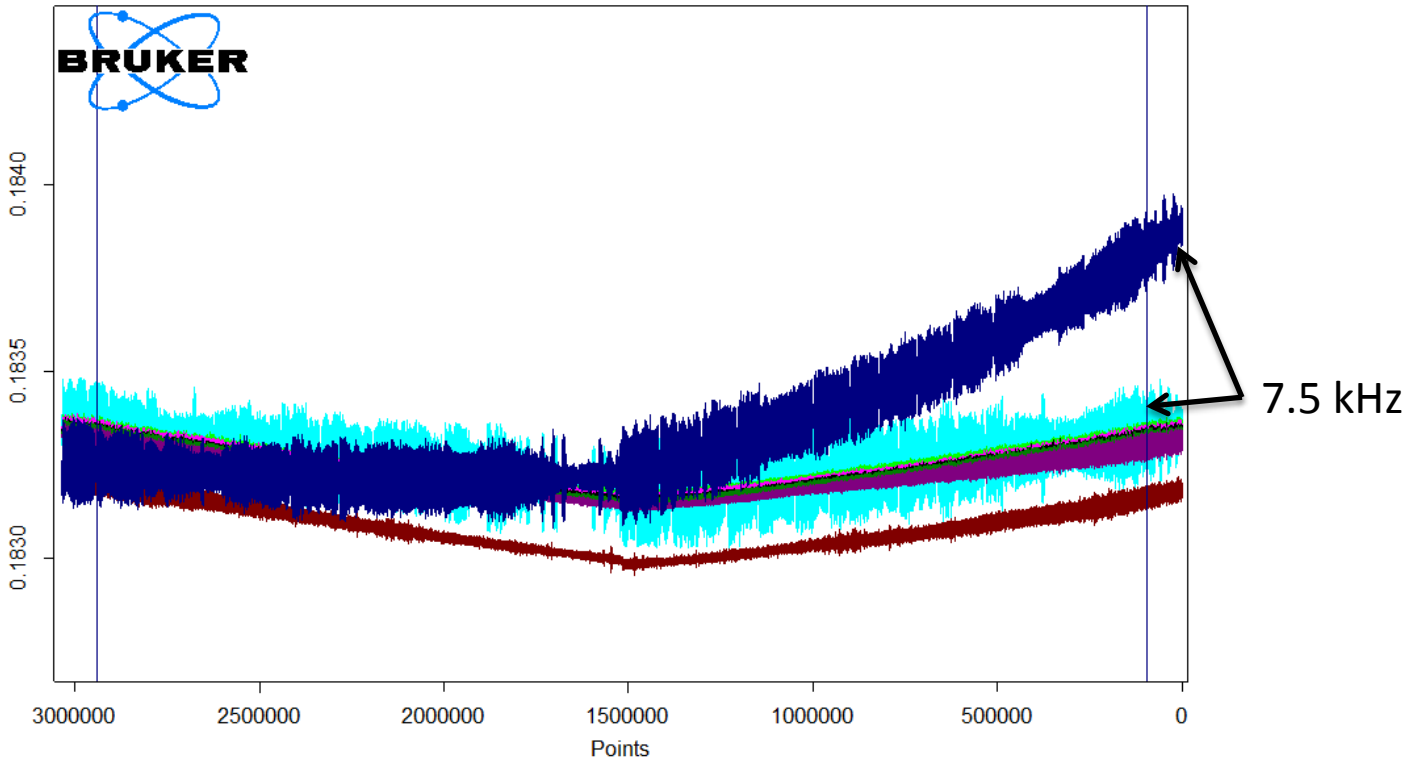
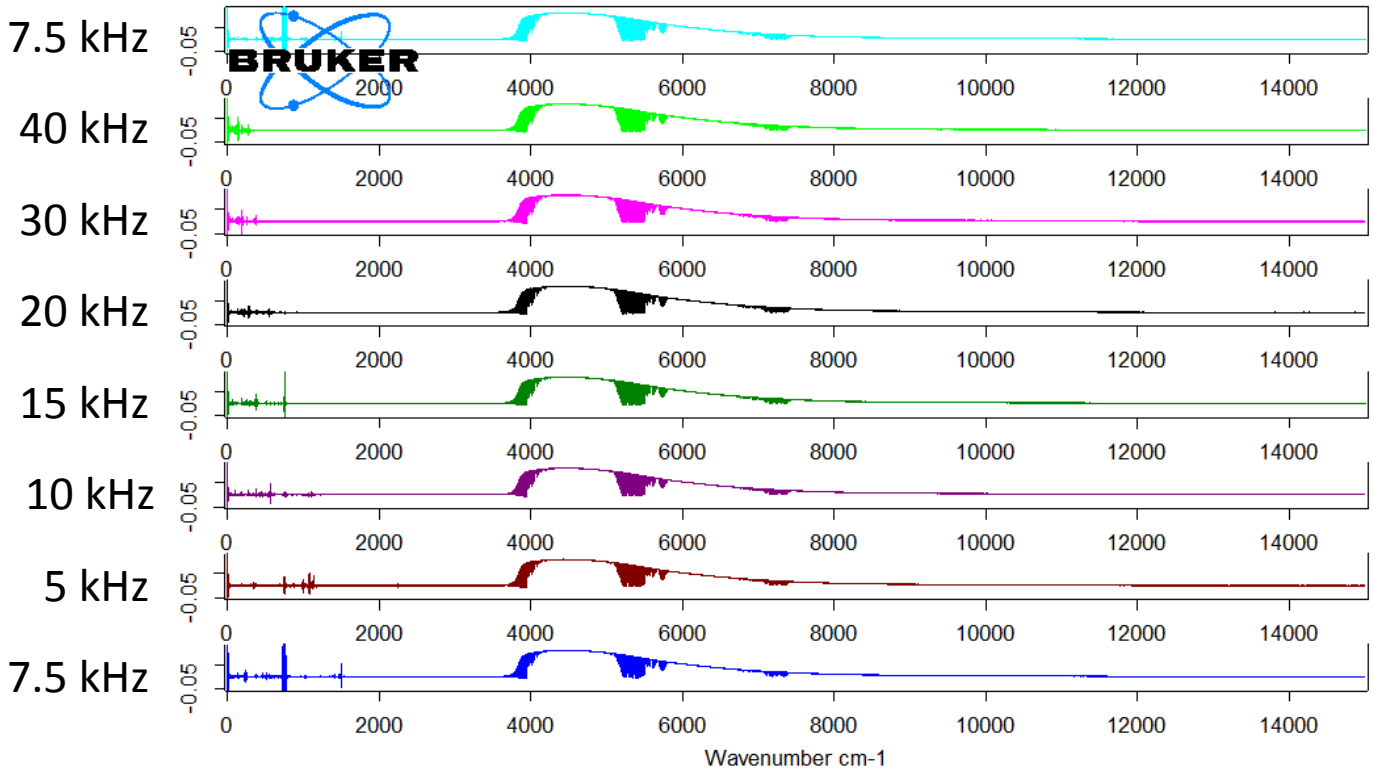
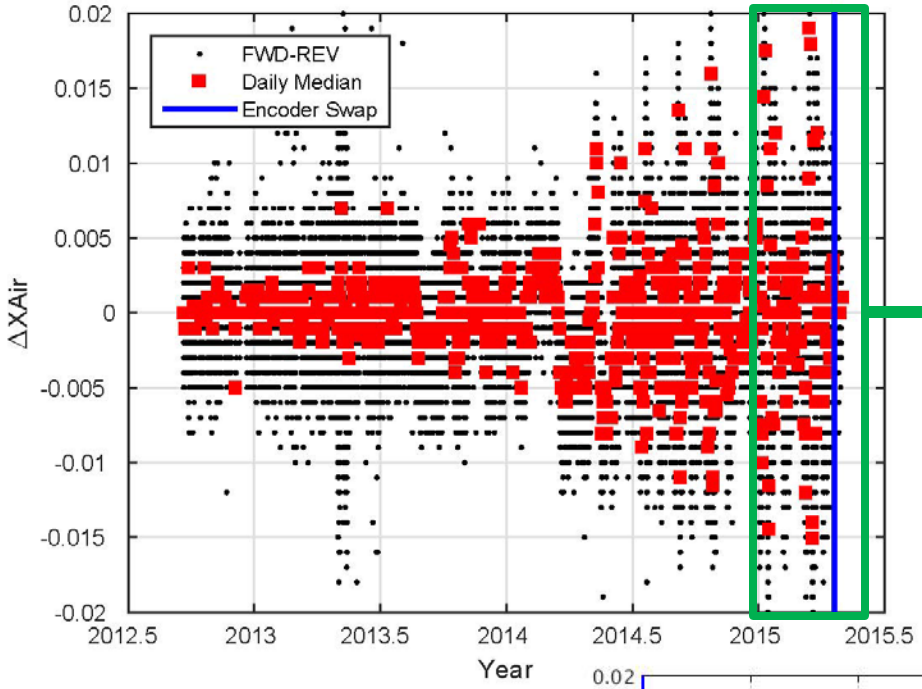
After Replacing Encoder/Motor Assembly (variety of scan speeds)

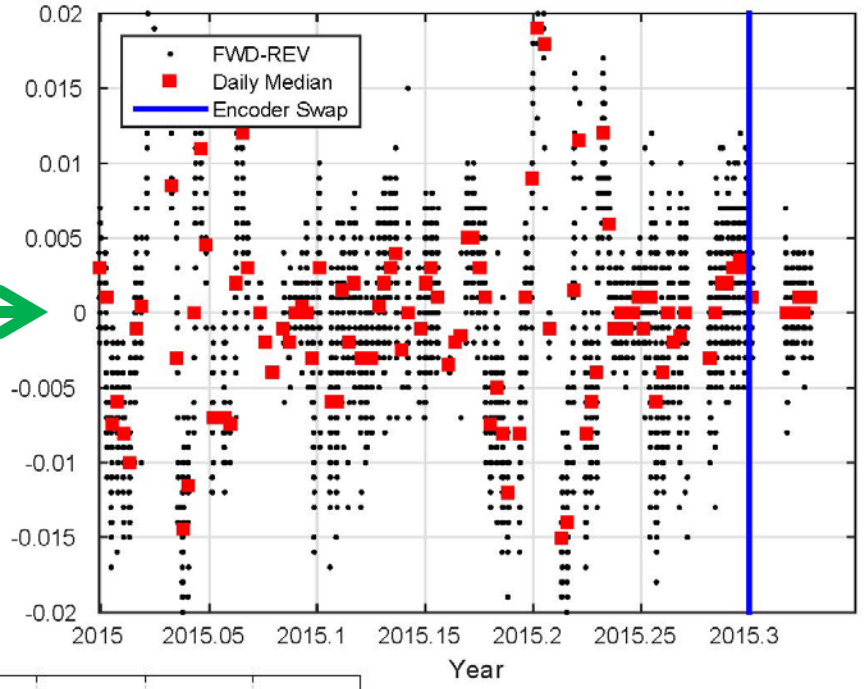


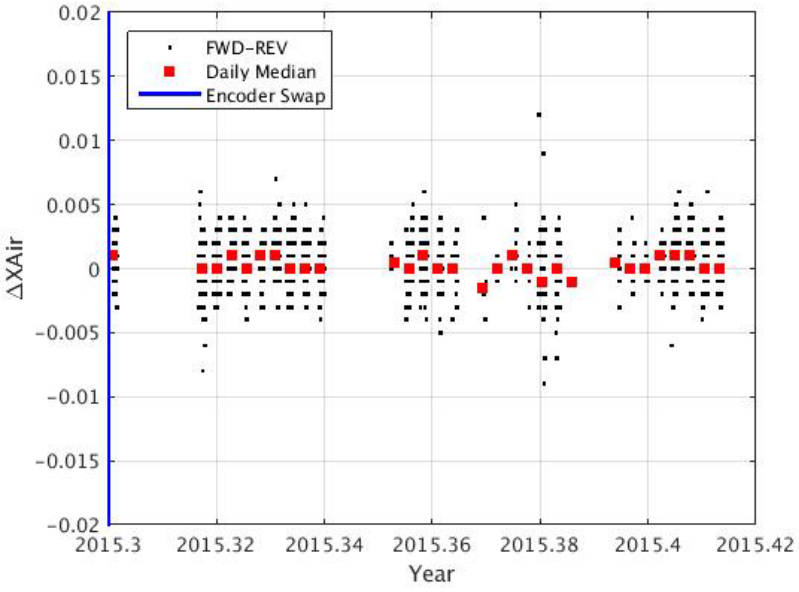
After Replacing Encoder/Motor Assembly (variety of scan speeds)



Xair differences after replacing the encoder/motor assembly

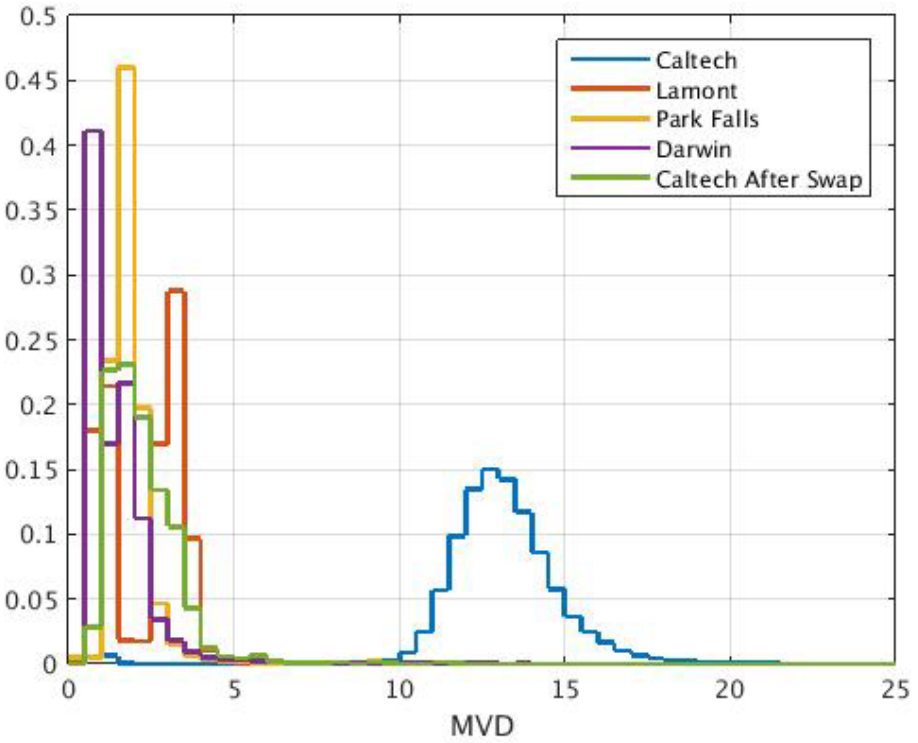




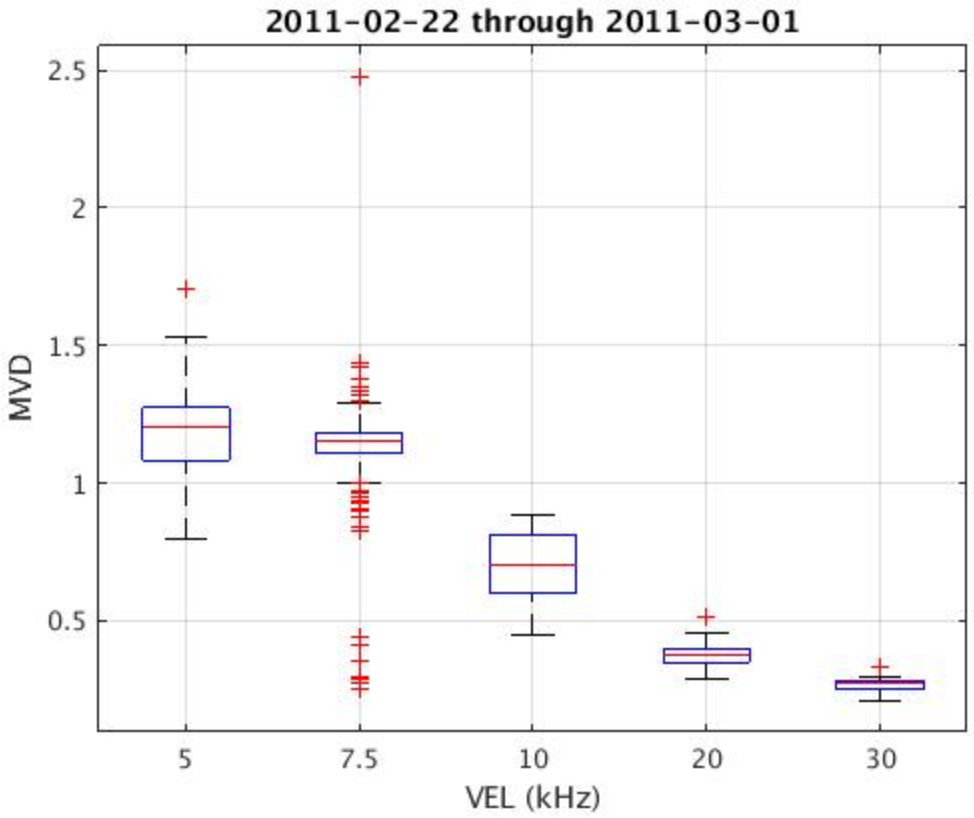


A possible diagnostic: Maximum Velocity Deviation (MVD)

- MVD is a parameter in the interferogram/slice headers, not in the GGG2014 I2S spectrum headers
  - MVD has been added for the next GGG release
- The MVD value is in percentage, and represents the maximum velocity speed deviation over all scans during acquisition.
  - One knock on the instrument will cause a big deviation even when all other scans were smooth and quiet.
  - Damage to the rods may also cause a higher MVD while the scanner passes the damaged area.
  - We should not over estimate the utility of this parameter. However, it provides a hint as to how smoothly the scanner runs.
  - For measurements with solid beam splitters like CaF_2 the MVD is usually <2.
- Values should be small (Gregor says <2, we see typically <5; Caltech was ~12)

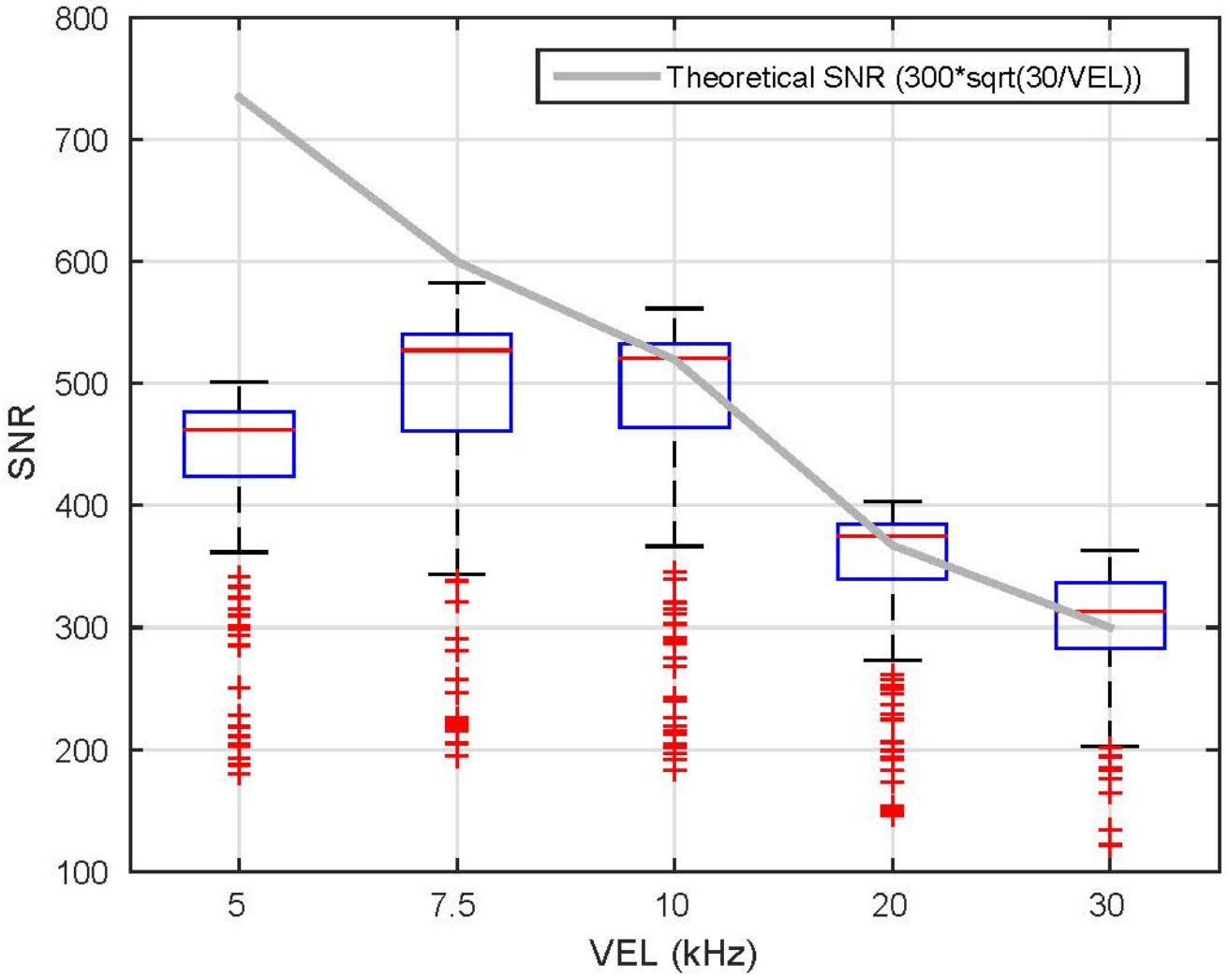


MVD as a function of Scanner Velocity (at Lamont)

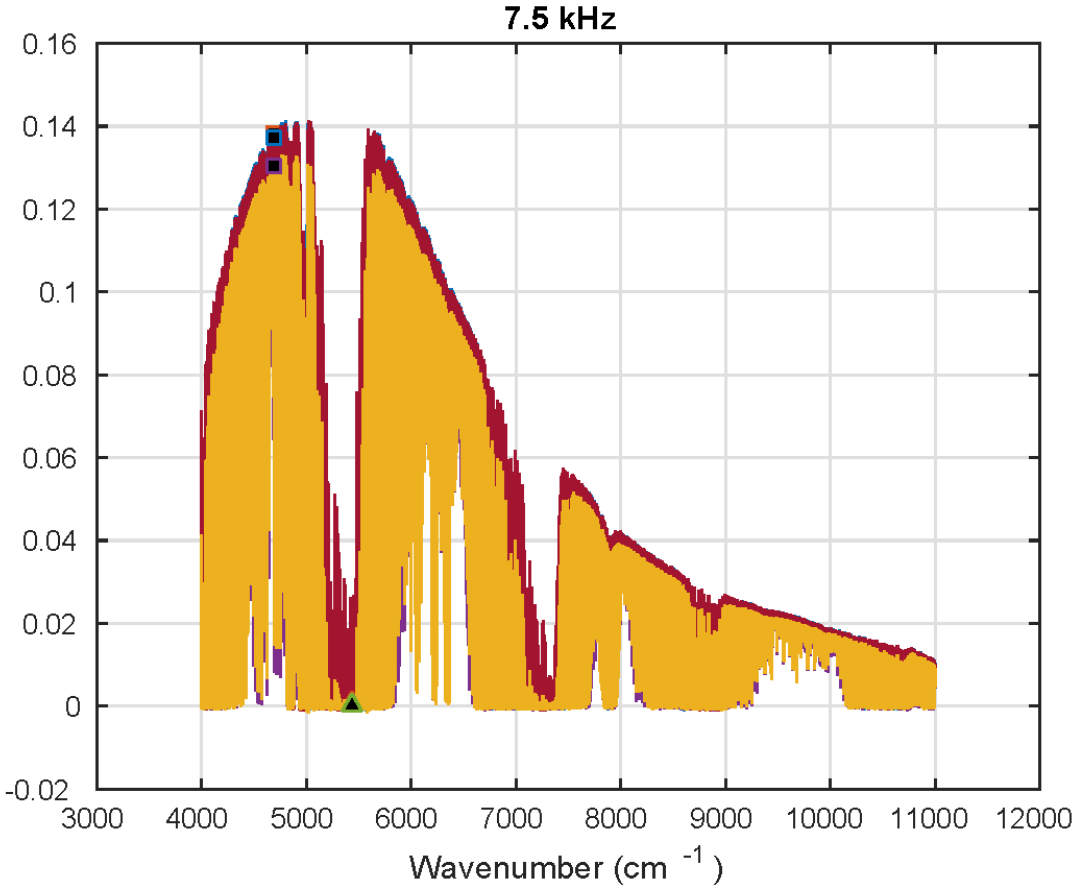


- Many more 7.5 kHz scans than the rest
- Significant difference between 7.5 kHz and 10 kHz in the motor stability
- You'd think SNR would decrease as a function of VEL, but perhaps this is partly mitigated by the MVD decrease?

SNR as a function of Scanner Velocity (at Lamont)

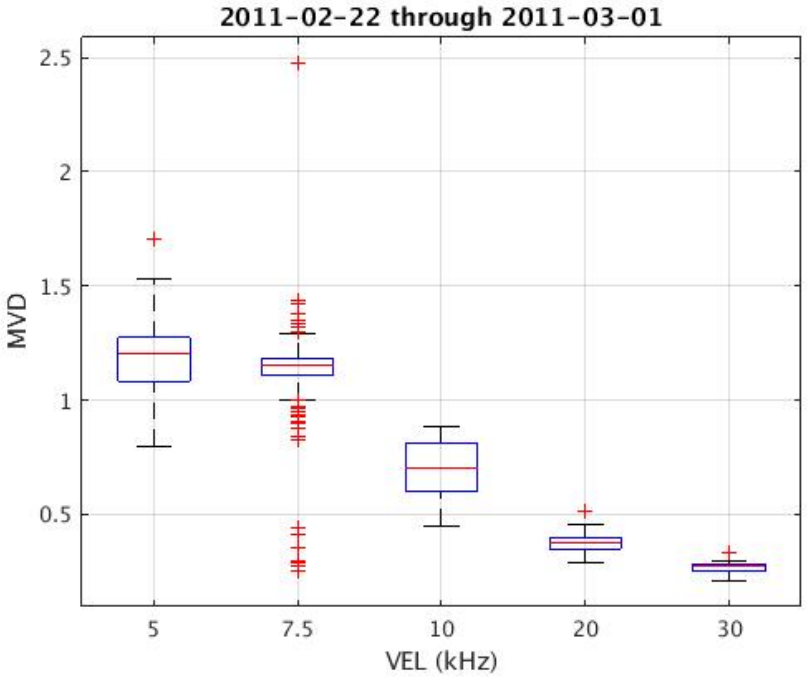


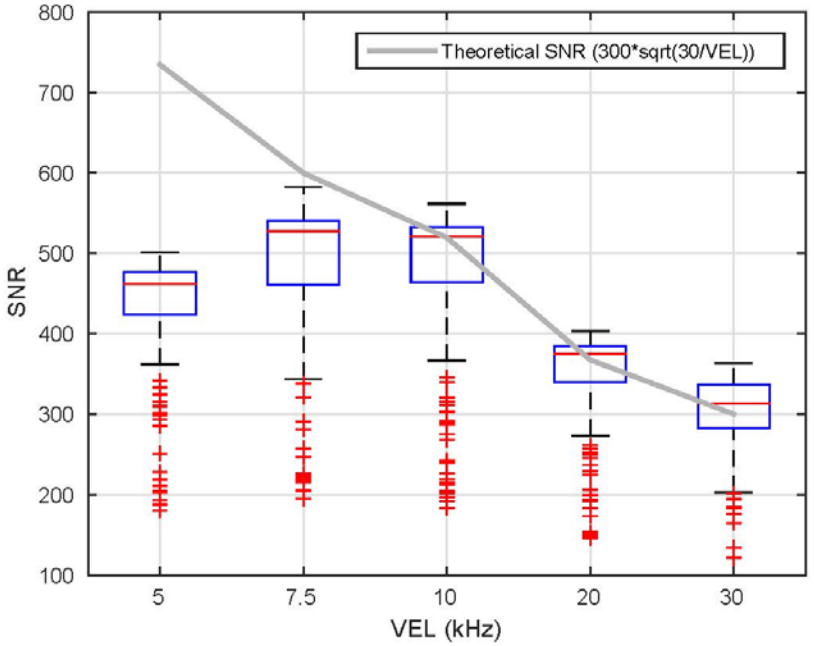
SNR Calculation/Estimation (Lamont)



- Signal taken as median value between [4683 4685]
- Noise taken as standard deviation between [5430 5450]

What Speed Should We Use? (Lamont)

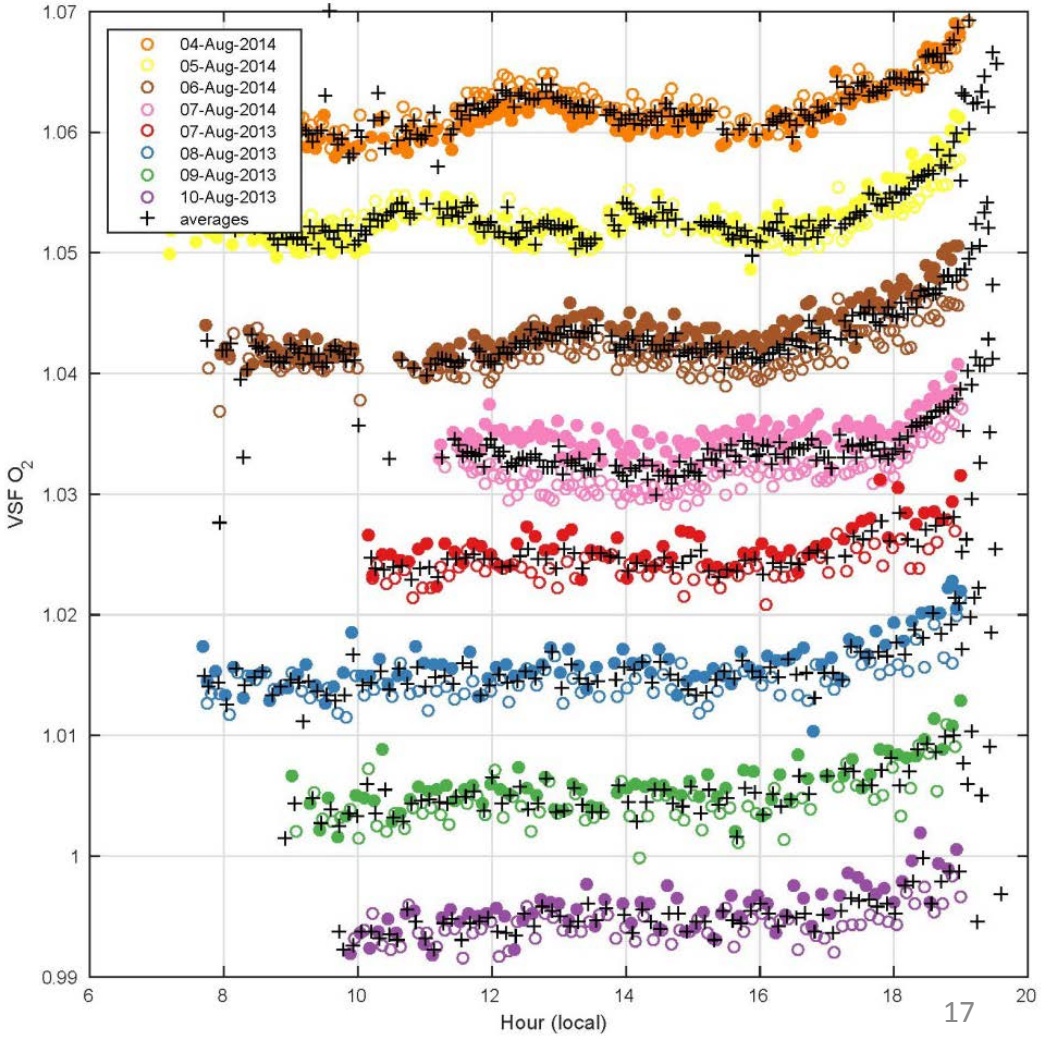




- Looks like 10 kHz is optimal: it has the highest SNR and a reasonably stable MVD

Mitigation Strategy for Historical Caltech Data: Averaging FWD/REV Pairs

- The "+" in the plot to the right have been produced by averaging FWD/REV pairs of spectra, and then running GFIT on the averaged spectra.
- Because the results are so linear (i.e., averaging spectra gives the same result as averaging the VSF), we can average the historical forward/reverse Xgas results.



Lessons Learned and Future Work

- Shows benefit of analysing forward and reverse scans separately: we would never have known about this problem if we immediately averaged spectra!
- Run at 10 kHz.
- Monitor MVD.
- Determine component resonant at 7.5 kHz and tighten/minimize resonance.
  - Gregor Surawicz has seen this resonance signature before in other instruments, so perhaps this is not a likely outcome.