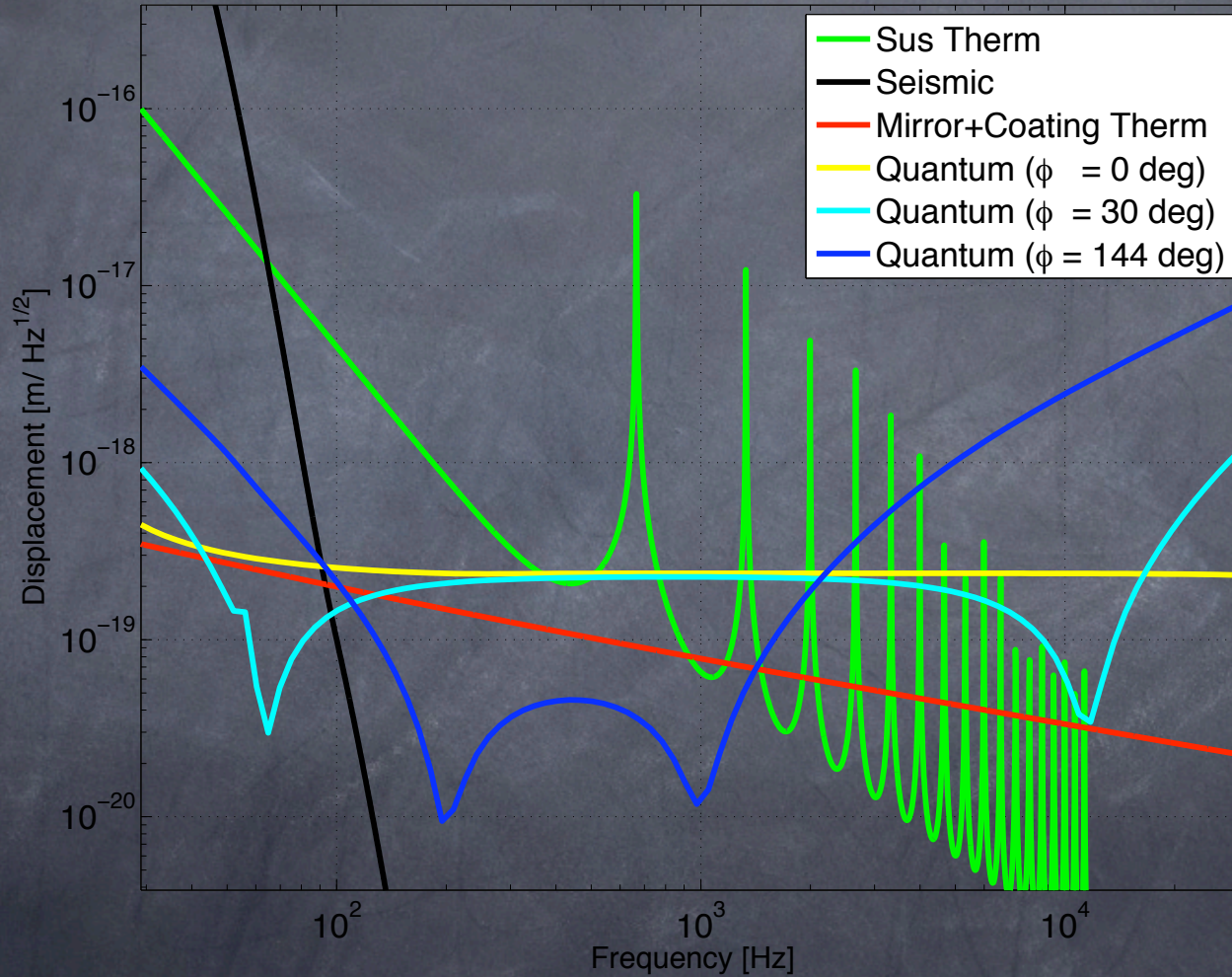


40m TAC Update: Nov 2007

40m Strain Noise w/ light ITMs

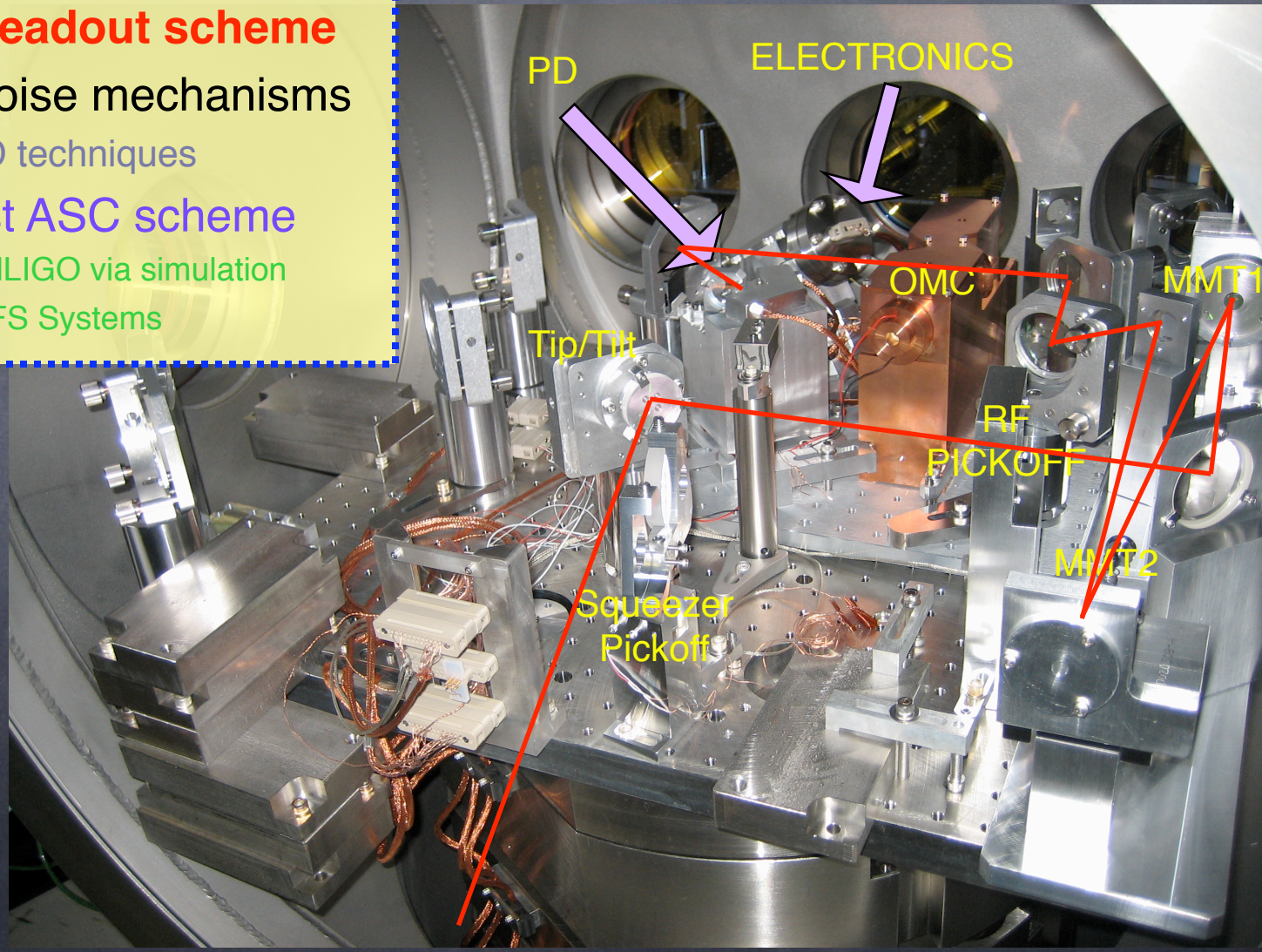


The 40m Mission:

Prototype the Advanced LIGO Length and Alignment Controls

- **Test/Characterize LSC scheme**
- **Develop DC readout scheme**
- Characterize noise mechanisms
 - Test QND techniques
- **Develop/Test ASC scheme**
 - Extrapolate to AdLIGO via simulation
 - ASC/WFS Systems

Prototyping will yield crucial information about how to build and run eLIGO & aLIGO



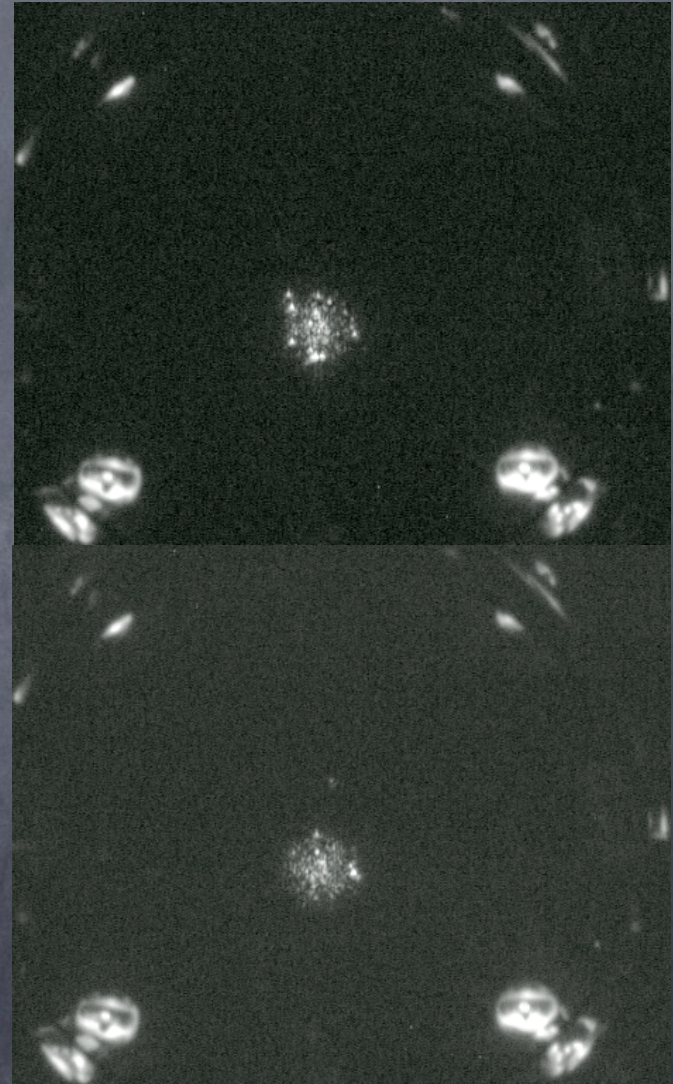
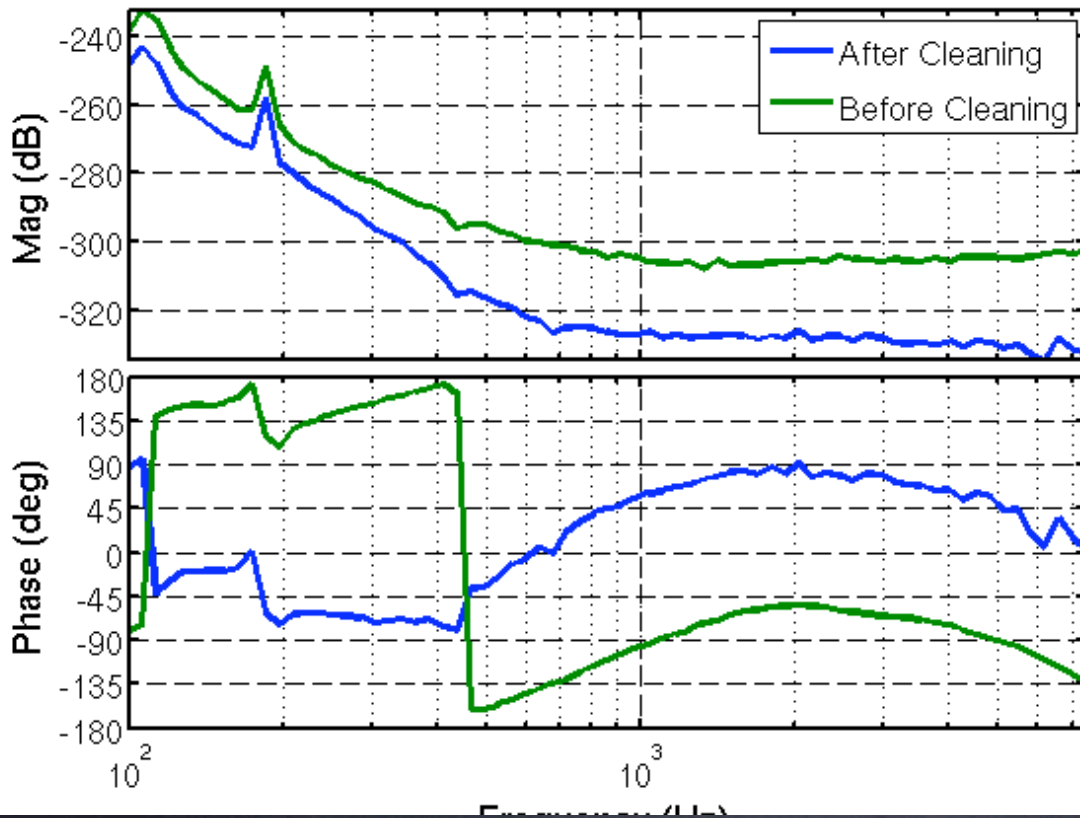
Work since last update (June)

- *ETM Drag Wiping
- *Delay Line Phase Shifters
- *Suspension Tuning Software
- *Wiener + Adaptive Filtering
- *'Optimized' SUS Damping
- *PRFPMI + DC Analysis
- *Matlab DV + Diagnostics
- *RFAM Troubles
- *40m Upgrade Modeling
- *MC Drag Wiping
- *New ELOG

ETM Wiping

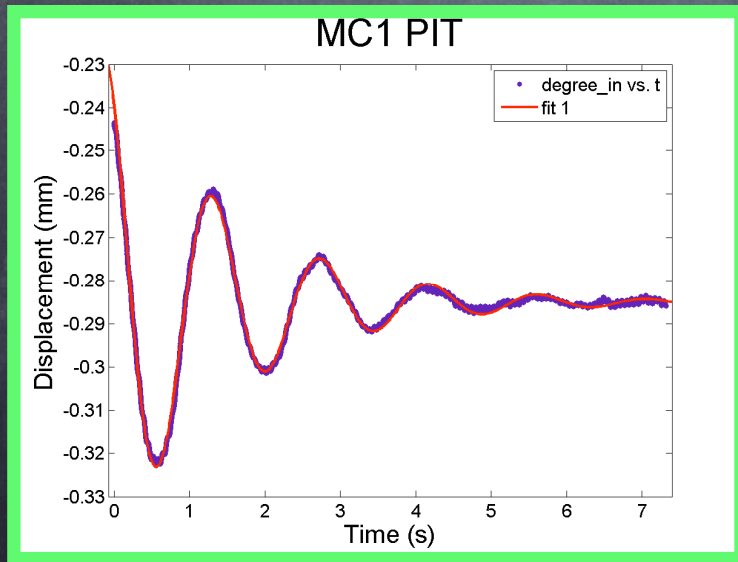
	Before	After	
x arm	216 ppm	152 ppm	(significant improvement)
y arm	176 ppm	173 ppm	(no change)

Effect of optic cleaning on RF Frequency Noise Coupling

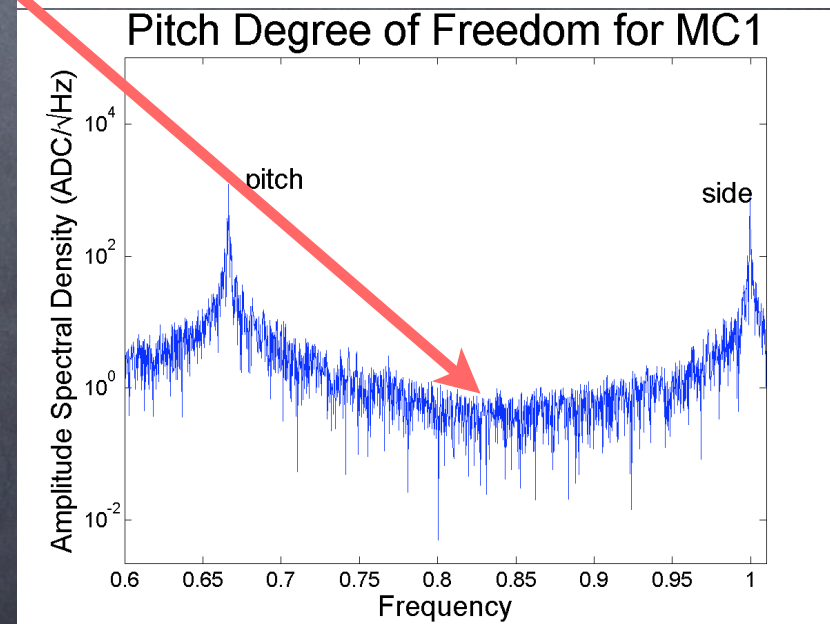
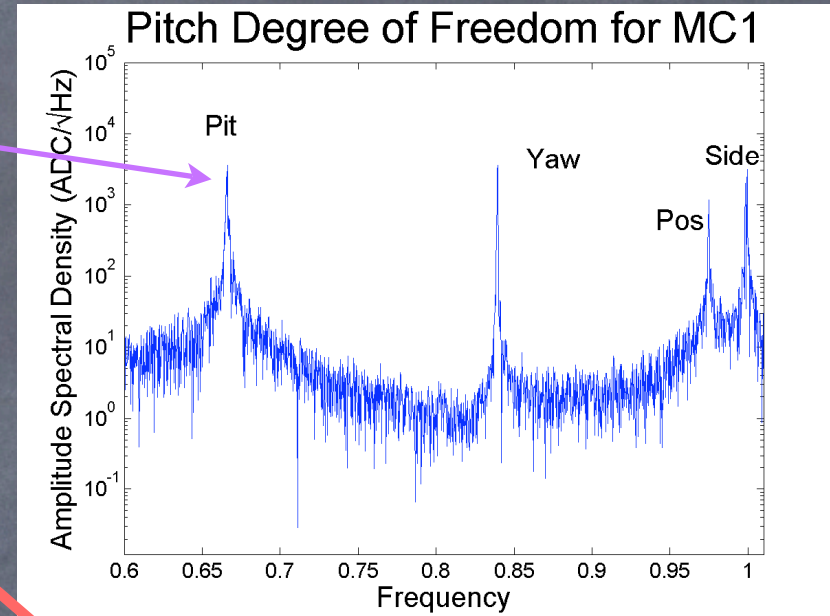


Auto Suspension Tuning

- ★ Free Swinging Spectra Logged
- ★ Auto "Sticking" Diagnostic
- ★ f's and Q's logged
- ★ Q's iteratively set
- ★ 4x4 matrix inversion for damping diagonalization



Sonia Buckley
(SURF from Trinity - Ireland)

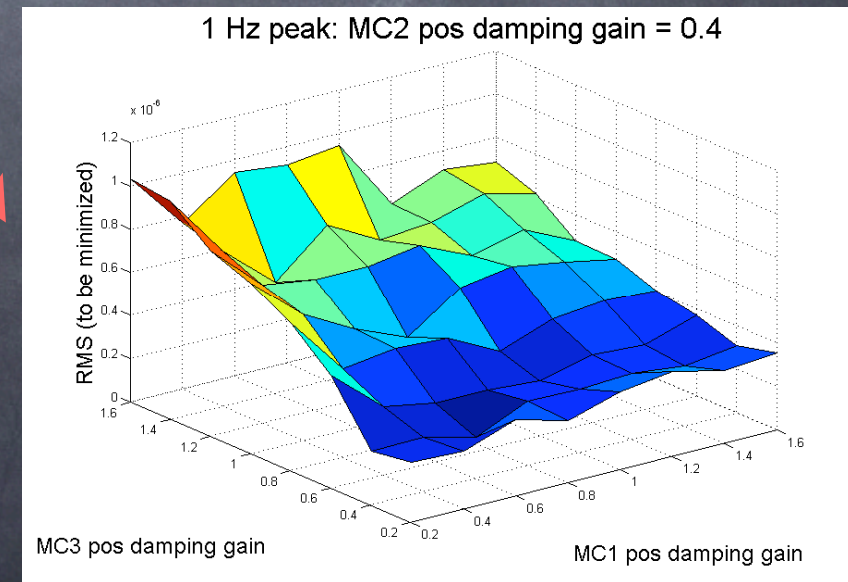
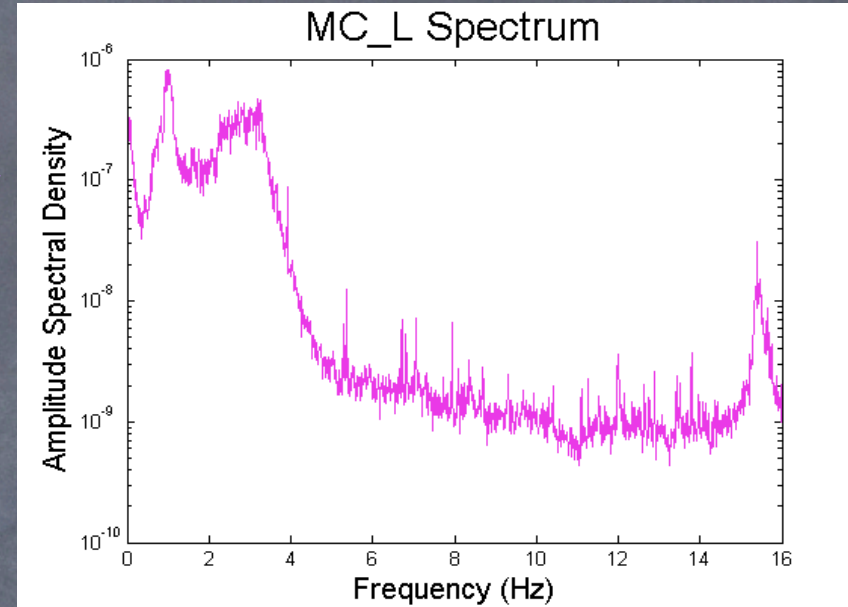


Auto Suspension Tuning

★ Force Spectrum Measured

★ Q Space is mapped out

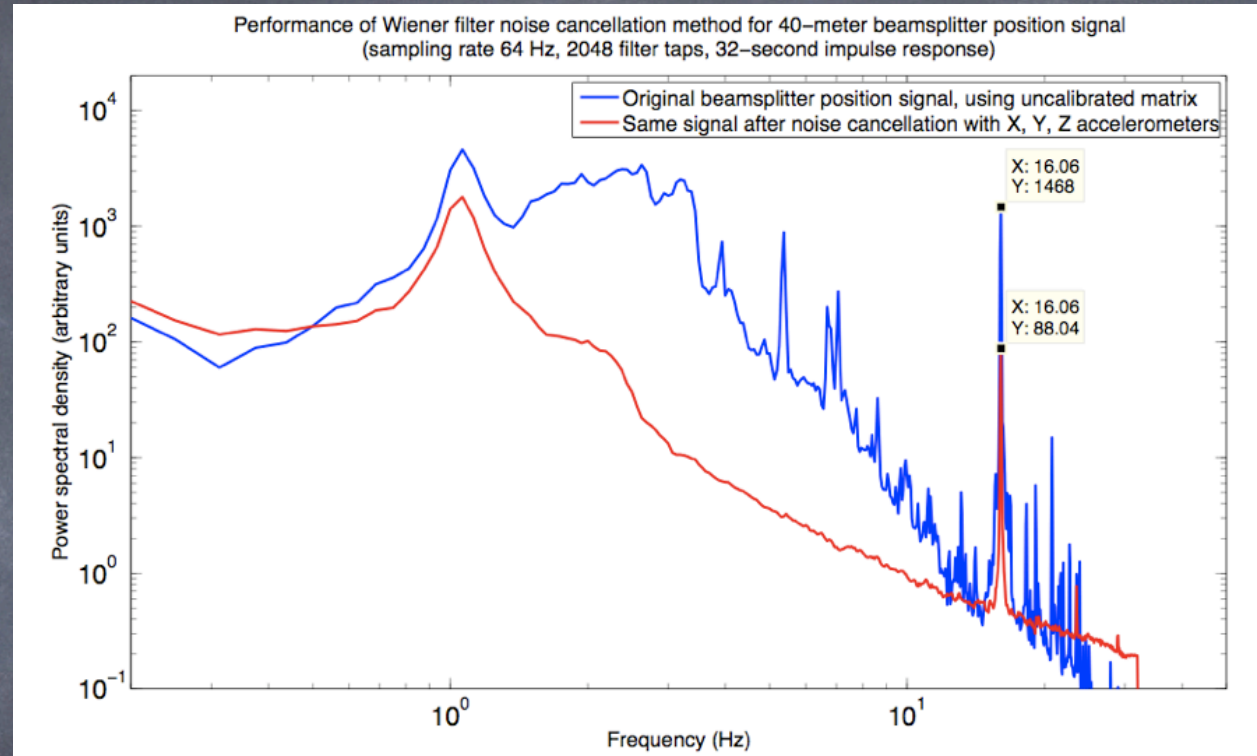
★ Force minimized



Sonia Buckley
(SURF from Trinity - Ireland)

Wiener + Adaptive Filtering

- ★ Optimal FIR FF Filter
- ★ 6 Accelerometers
- ★ Low frequency limit from RAM and ACC

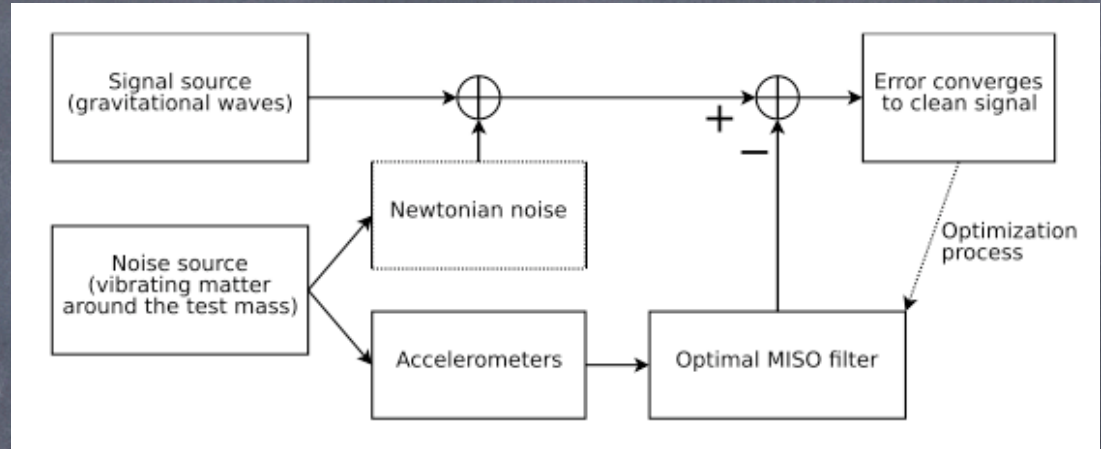


Keenan Pepper
(SURF from FSU)

Adaptive Filtering

(= panacea)

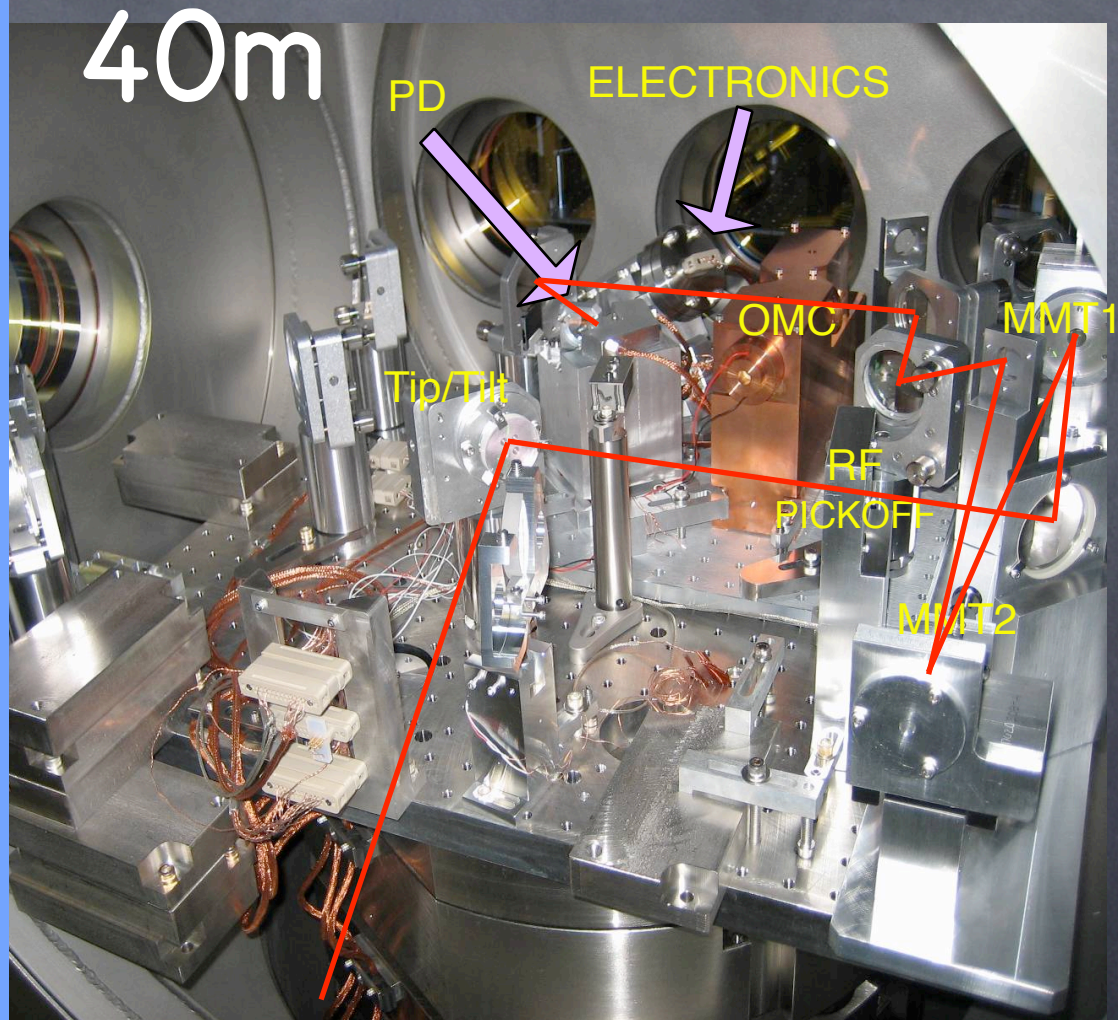
- ★ Converges to Wiener
- ★ Now can do MISO
- ★ No RAM Limit
- ★ Fast than real time
- ★ Handles unknown plant
- ★ Can be used for FF of PEM, ASC, LSC, etc.



Elena Gasparri
(U. of Pisa)

DC Readout @ Caltech

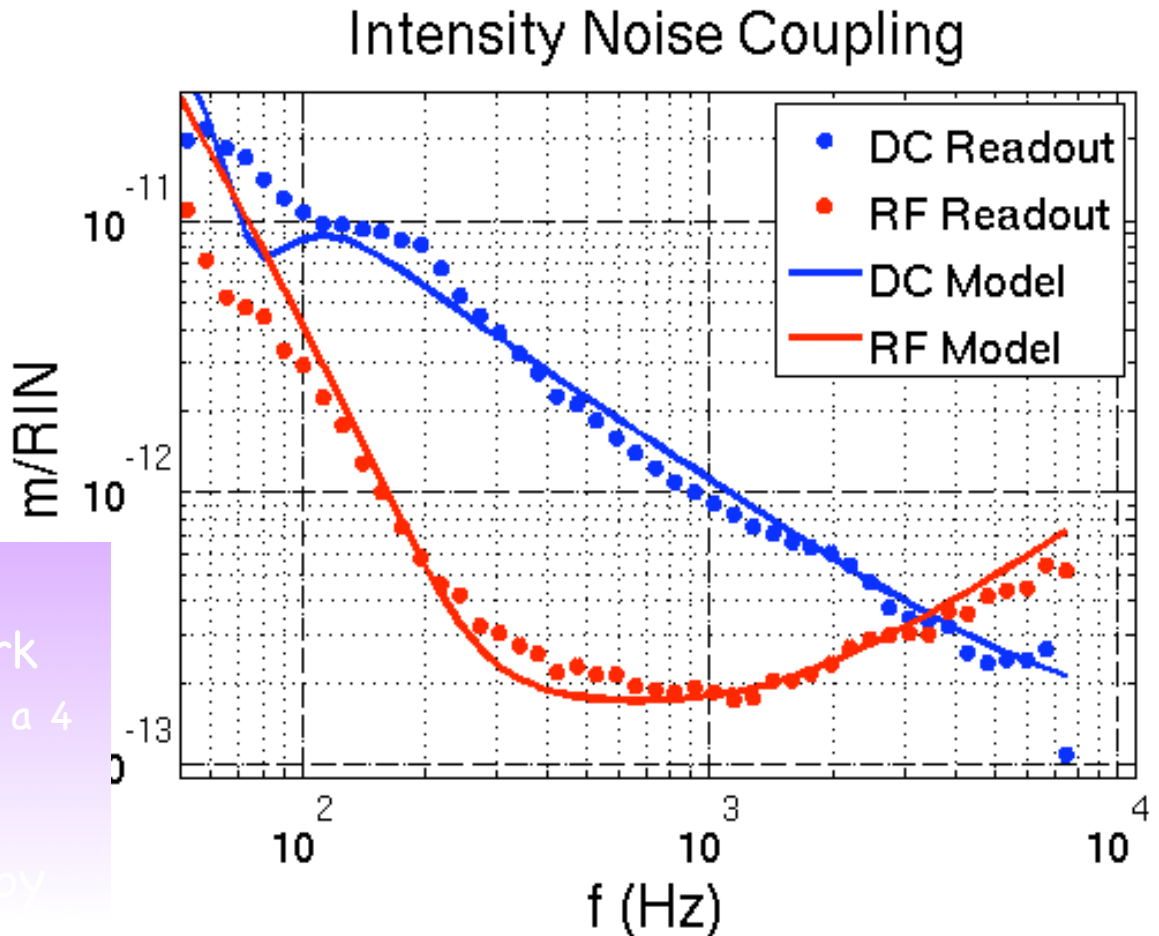
- Monolithic, 4-mirror output mode cleaner
 - finesse: 210
 - 92% transmission
 - 4-mirrors to reduce accidental HOM resonances
- Pair of PZT-driven tip/tilt steering mirrors for input to OMC
- In-vacuum photodetector with electronic preamplifier
- On a seismic isolation stack
 - Not suspended
- Beam picked off before OMC for an RF sensing chain for comparisons & lock acquisition



Laser Intensity Noise

- RF – AS_Q :
 $AS_Q \propto \delta L \cdot RIN + RIN \cdot \delta f_c / f_c$ (rad. pres.)
- DC – AS_DC is first order sensitive to AM:
 $AS_{DC} \propto RIN$

- RF – sidebands transmitted to the dark port unfiltered (only a 4 kHz MC pole)
- DC – carrier filtered by



modeling results from Optickle

Laser Frequency Noise

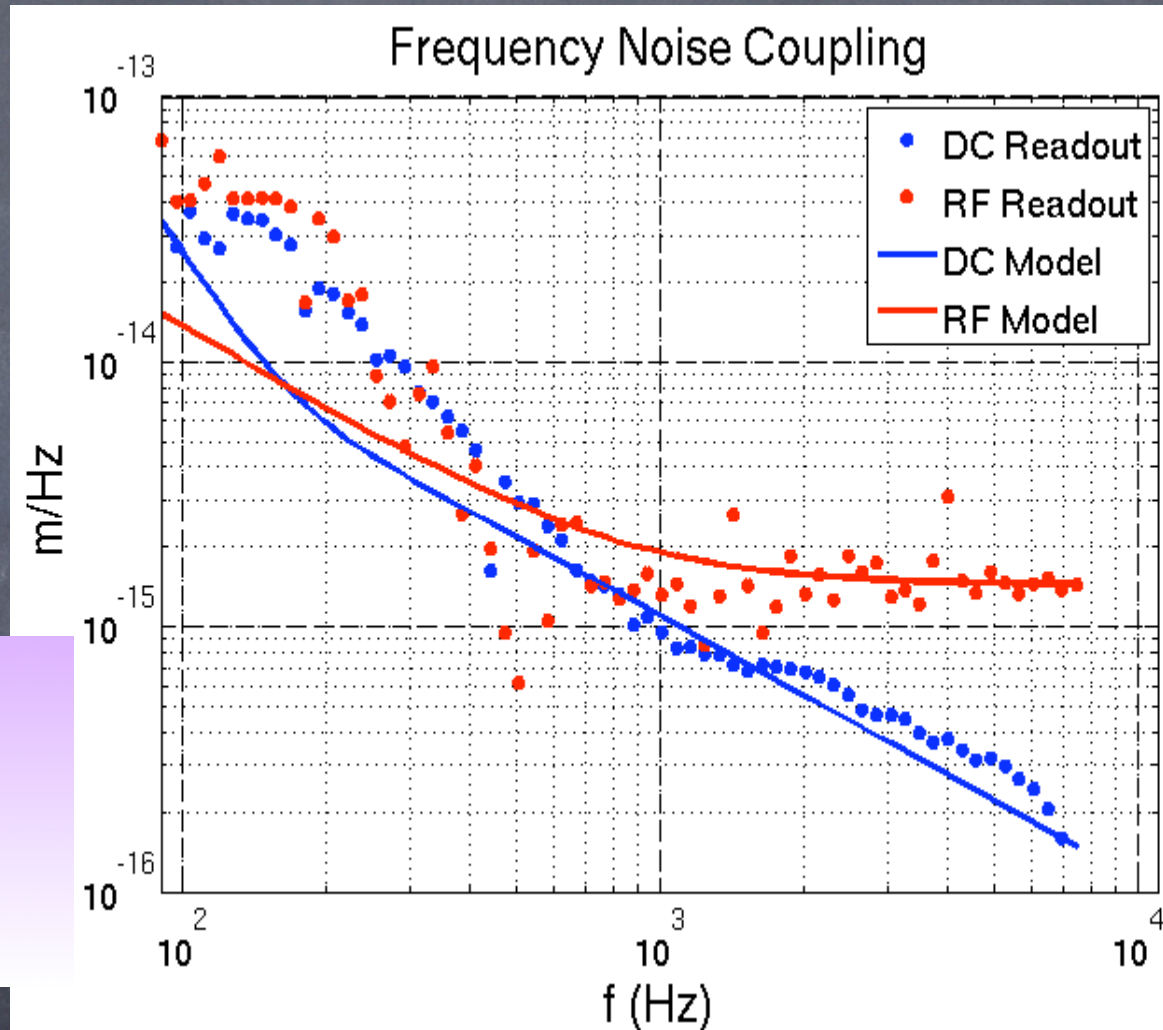
- RF – audio noise sidebands beat with the carrier contrast defect:

$$AS_Q \propto C_D * \delta v$$

- DC – arm cavity pole imbalance couples carrier frequency noise to dark port

$$AS_{DC} \propto \delta f_c / f_c$$

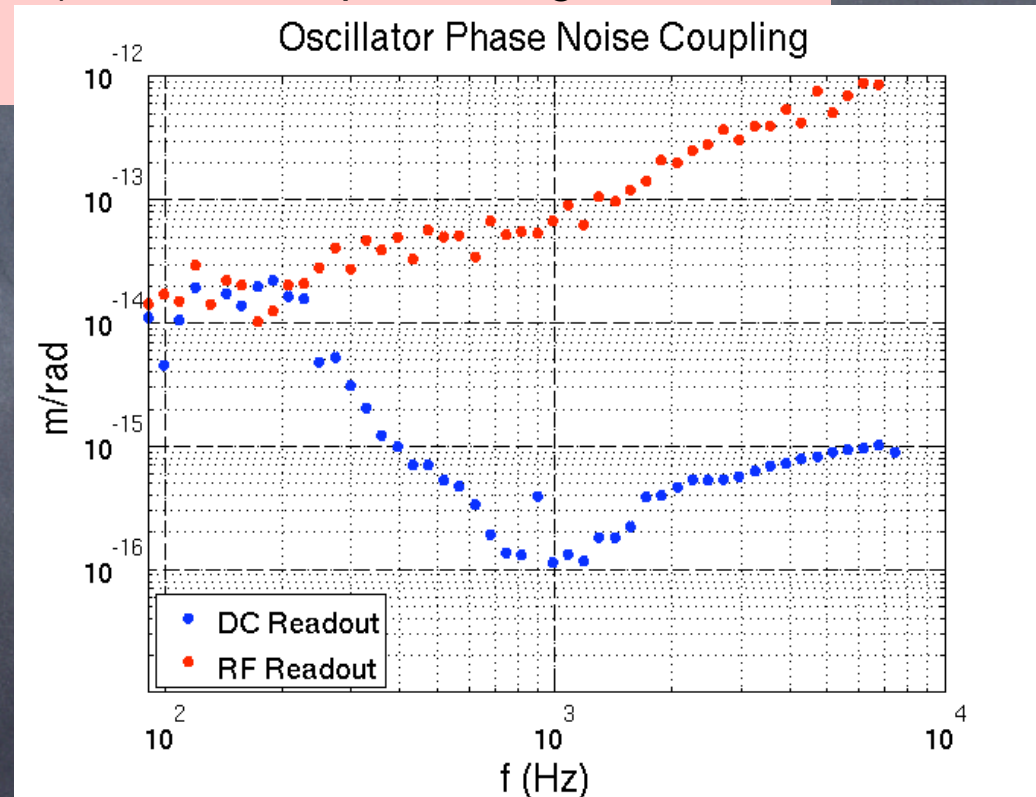
- RF – sidebands transmitted to the dark port unfiltered (only a 4 kHz MC pole)
- DC – carrier filtered by the coupled PR-Arm cavity



Oscillator Phase Noise

- RF – Not completely understood. Something to do with sideband imbalance and higher order modes somewhere.
- DC – Some coupling through finite finesse of OMC and maybe through aux. LSC loops (CARM, MICH, PRC). Closed loop modeling tools under development.

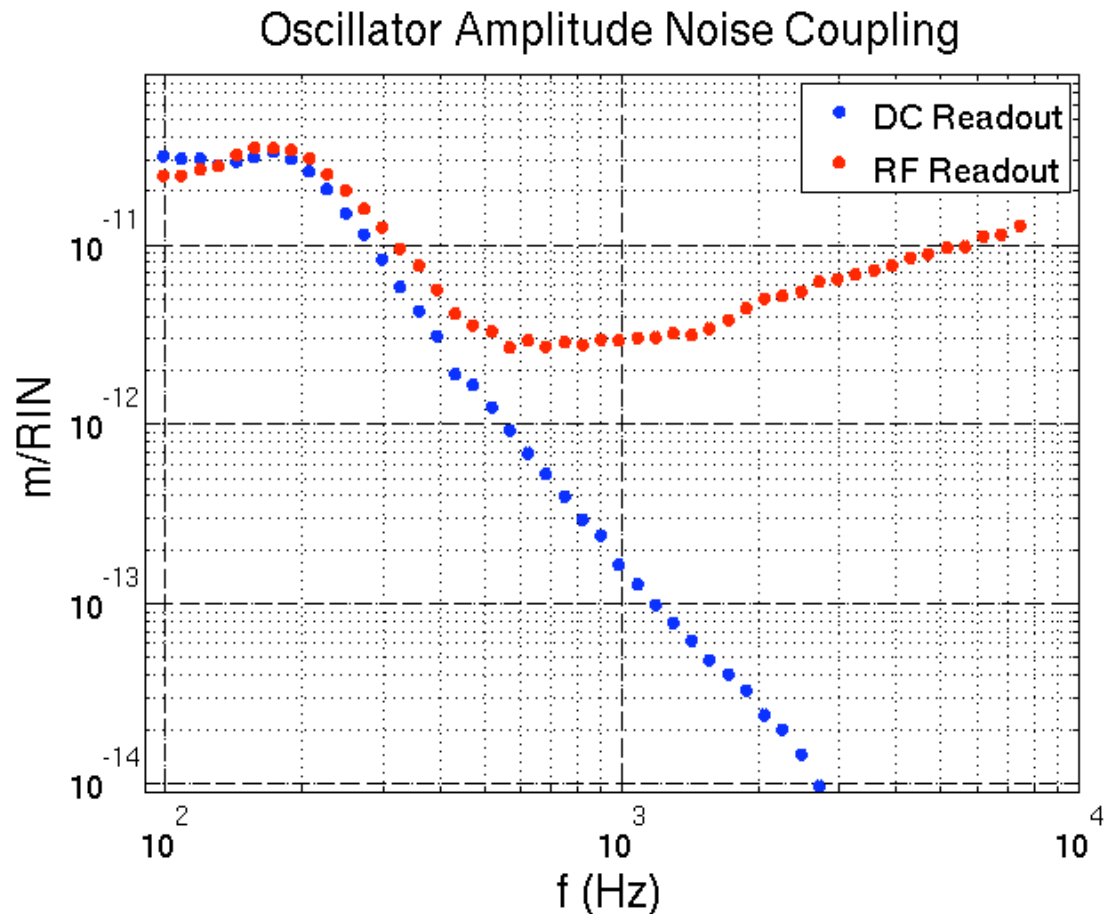
- RF – sidebands transmitted to the dark port unfiltered (only a 4 kHz MC pole)
- DC – sidebands rejected by OMC



Oscillator Amplitude Noise

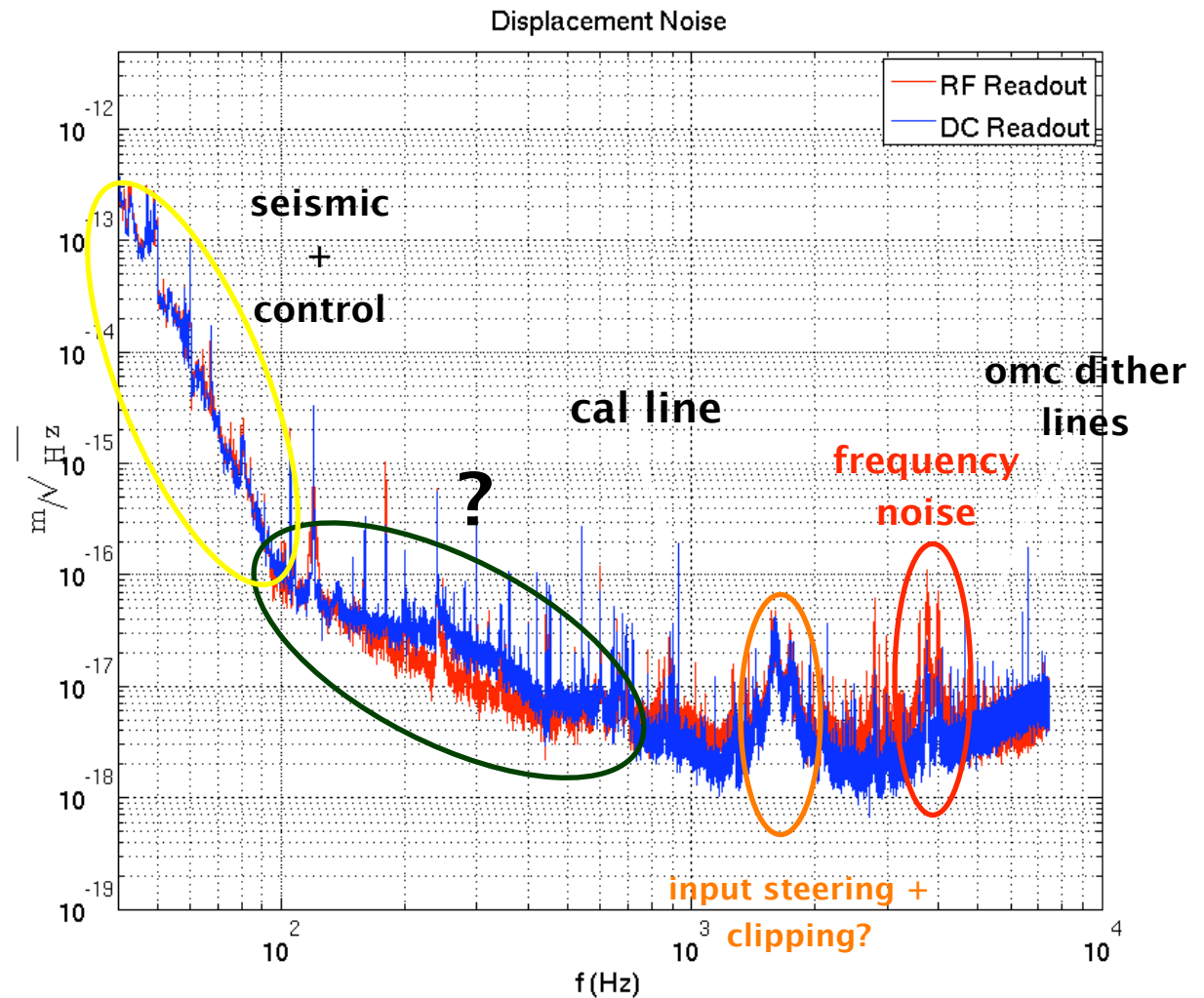
- RF – very similar to laser AM (looks like a gain modulation).
- DC – can show up as intensity noise (oscillator steals power from the carrier)

- RF – sidebands transmitted to the dark port unfiltered (only a 4 kHz MC pole)
- DC – sidebands rejected by OMC



RF vs DC: Displacement

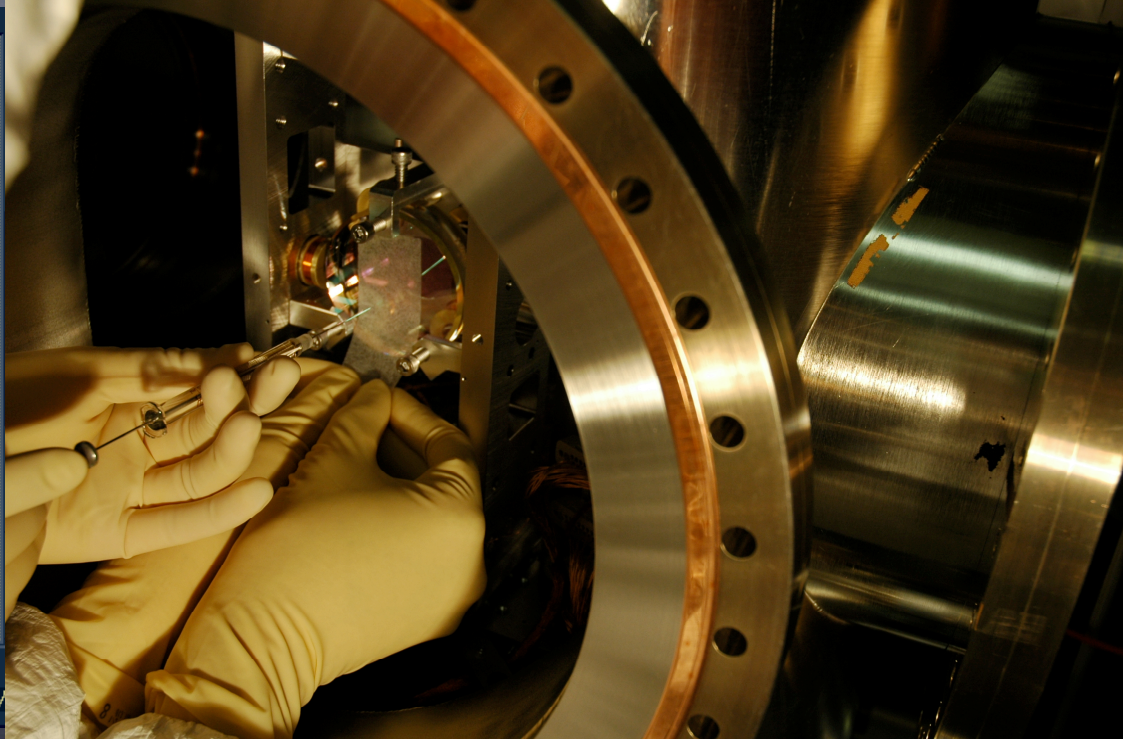
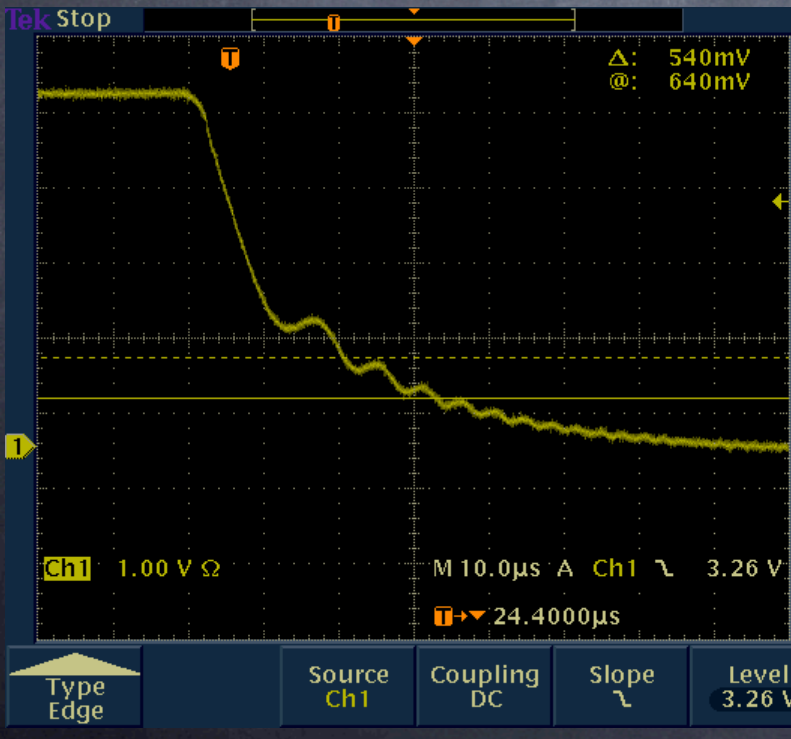
DARM offset
~25pm





MC DRAG WIPING

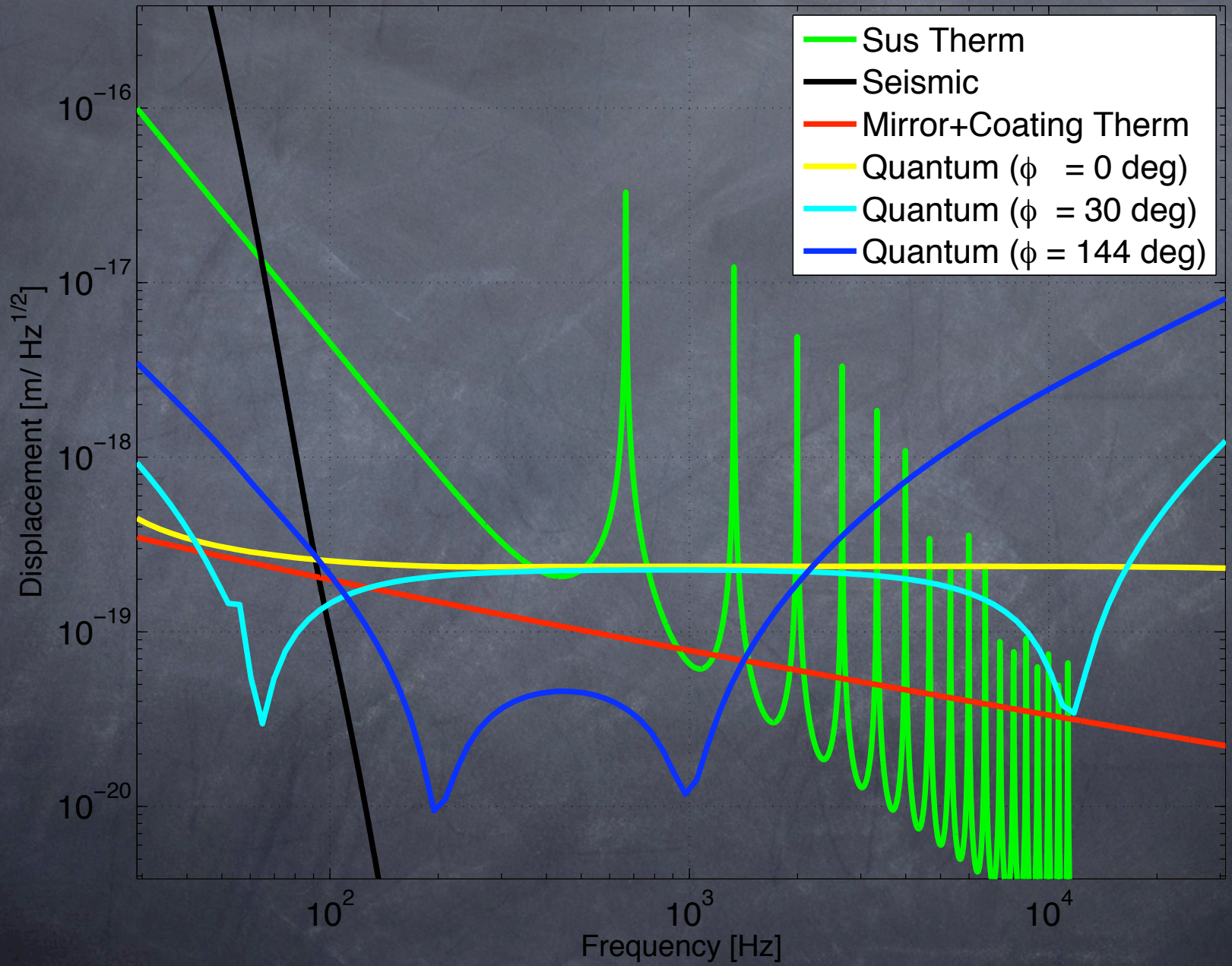
- ★ Start -> 100 ppm per
- ★ No change after wipe
- ★ T ~ 87%
- ★ More Analysis coming



40M UPGRADE

- Revamp LSC Scheme to match AdvLIGO
- Lower arm Finesse by 2x
- Longer RC's
- Lower RF Frequencies
- Small Schnupp Asymmetry
- Light ITMs (0.25 kg) / Keep ETMs (1.3 kg)
- CDS Testbed:
 - RFPDs
 - Demod
 - Timing
 - Front Ends / ADCs/ DACs
 - Adaptive Filtering
- Misc.
-

40m Strain Noise w/ light ITMs



40M UPGRADE - ToDo

- Examine other signals ($7 \cdot f_1$ or $9 \cdot f_1$)
- Fix SUS Thermal
- Add control noise
- Update Kirk's layout
- Better budget
- Get Approval
- Polish, recoat, buy equipment, etc.