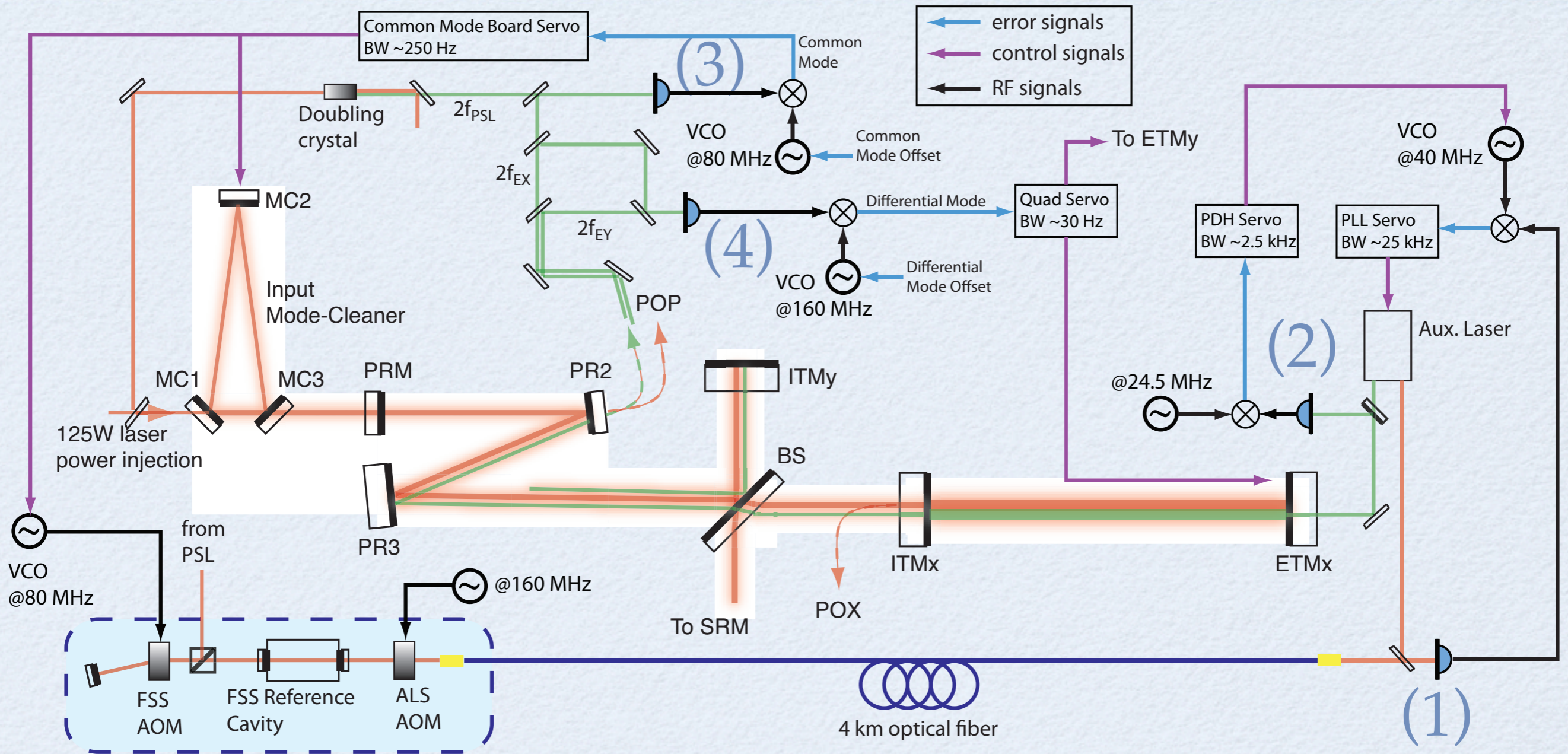


Arm Length Stabilisation VCO Noise requirements

ALS Locking scheme with multiple VCO's
Bram Slagmolen, John Miller & Daniel Sigg
ISC Telecon - LIGO-G1000703

Locking Scheme



(1) Phase lock Aux. laser to the PSL
- feedback to laser Temp and PZT.

(2) Lock the GRN beam to the arm cavity
- feedback to TTFSS VCO.

(3) Lock the 'Common Mode'
- Feedback to CM Board aux input.

(4) lock the 'Differential Mode'
- Feedback to ETMs.

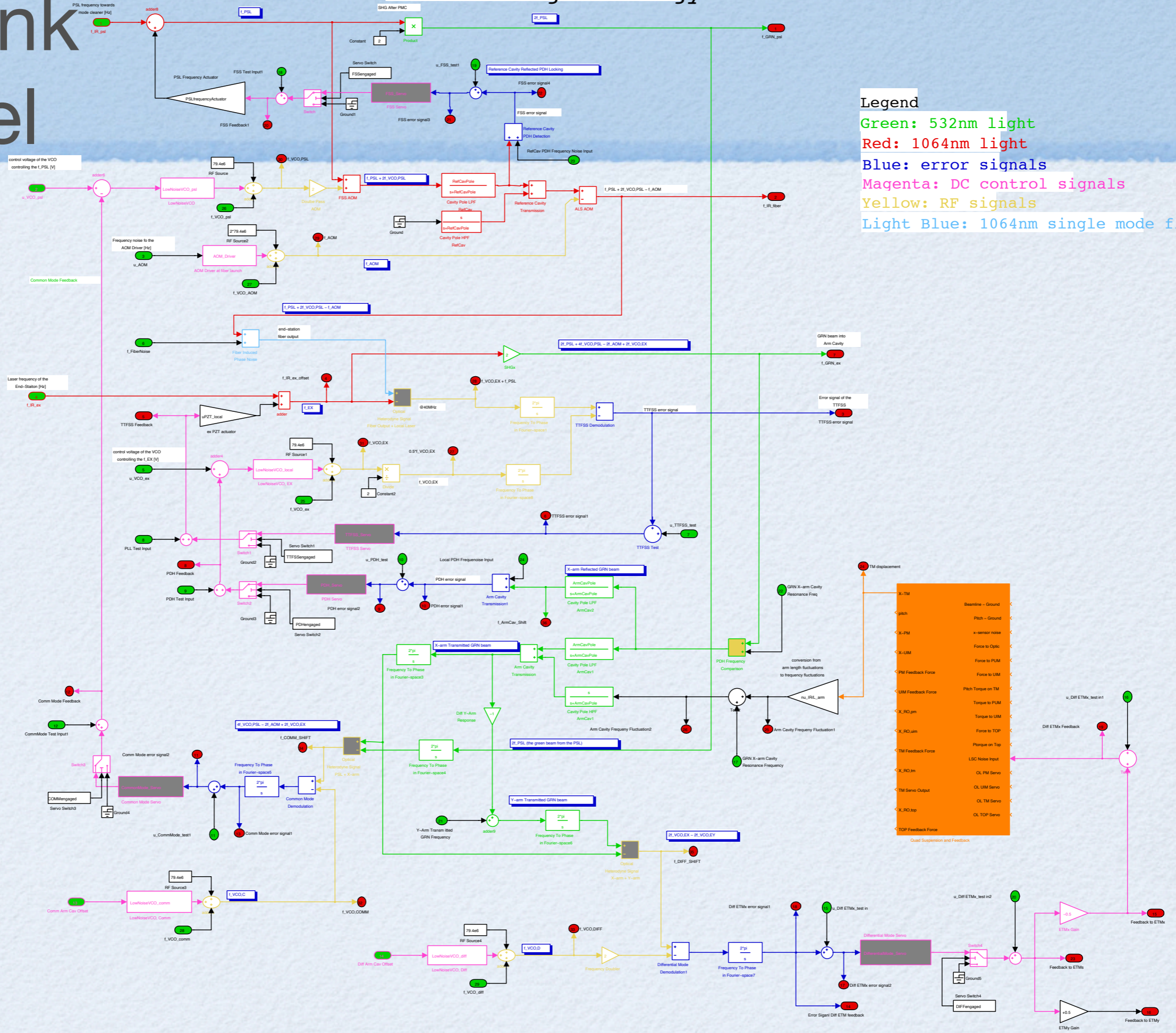
Design Considerations

- VCO noise and dynamic range requirements.
- Locking Bandwidth of the PSL+Aux Laser phase locking loop.
 - Will feedback to the Temp. and PZT provide enough bandwidth,
 - if not, do we need a high bandwidth actuator (e.g. phase modulator) in the 1064nm path (prior SHG).
 - Requires 'external' doubling.

Simulink model

ALS Locking Strategy - 3

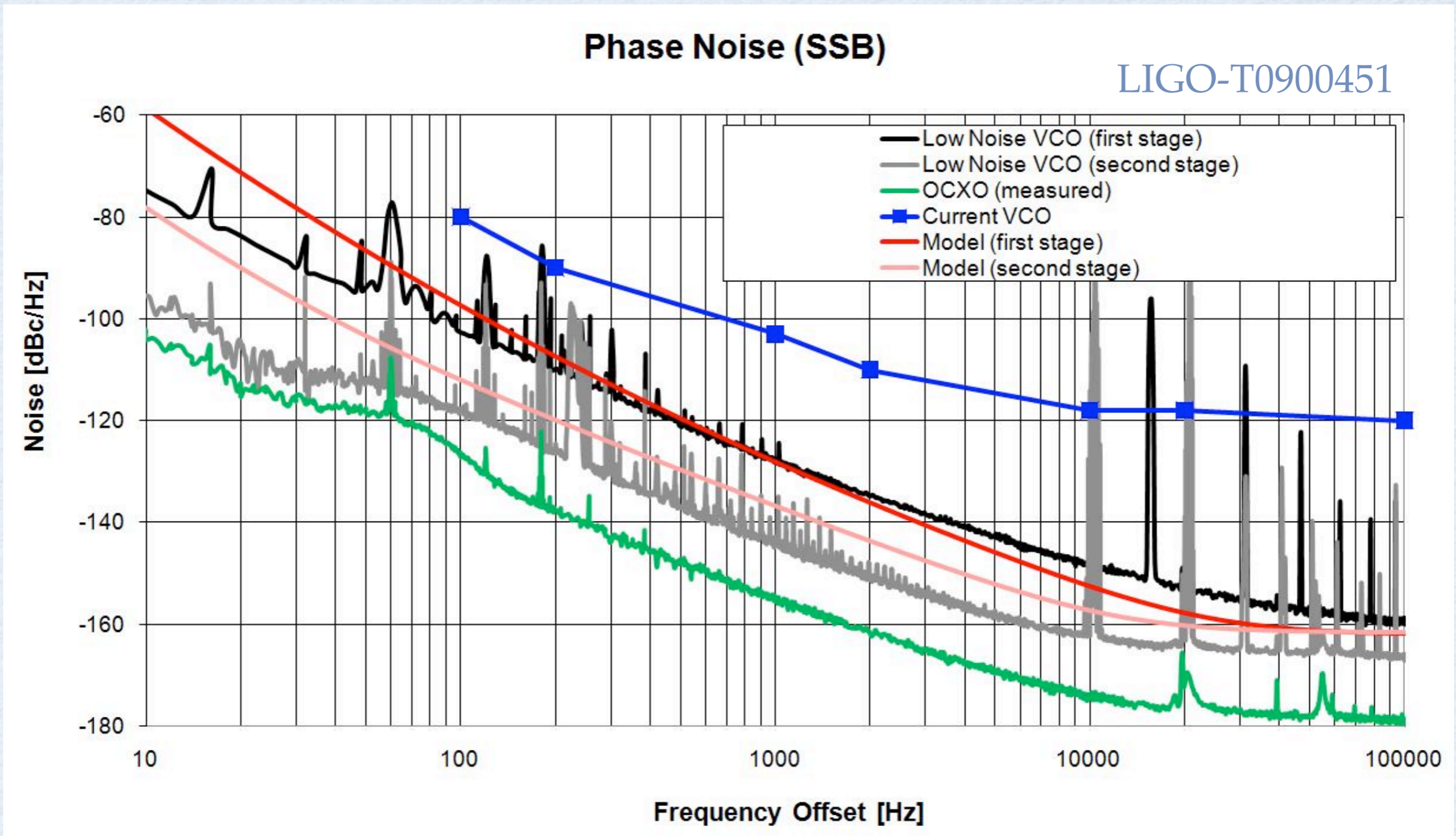
- Legend**
- Green: 532nm light
 - Red: 1064nm light
 - Blue: error signals
 - Magenta: DC control signals
 - Yellow: RF signals
 - Light Blue: 1064nm single mode fiber



Quad Suspension and Feedback

X-TM	Beamline - Ground
pitch	Pitch - Ground
X-PM	x-sensor noise
X-UM	Force to Optic
PM Feedback Force	Force to UIM
UIM Feedback Force	Pitch Torque on TM
X_RO.pn	Torque to PUM
X_RO.um	Force to TOP
TM Feedback Force	Force on Top
X_RO.im	OL PM Servo
TM Servo Output	OL UIM Servo
X_RO.tp	OL TM Servo
TOP Feedback Force	OL TOP Servo

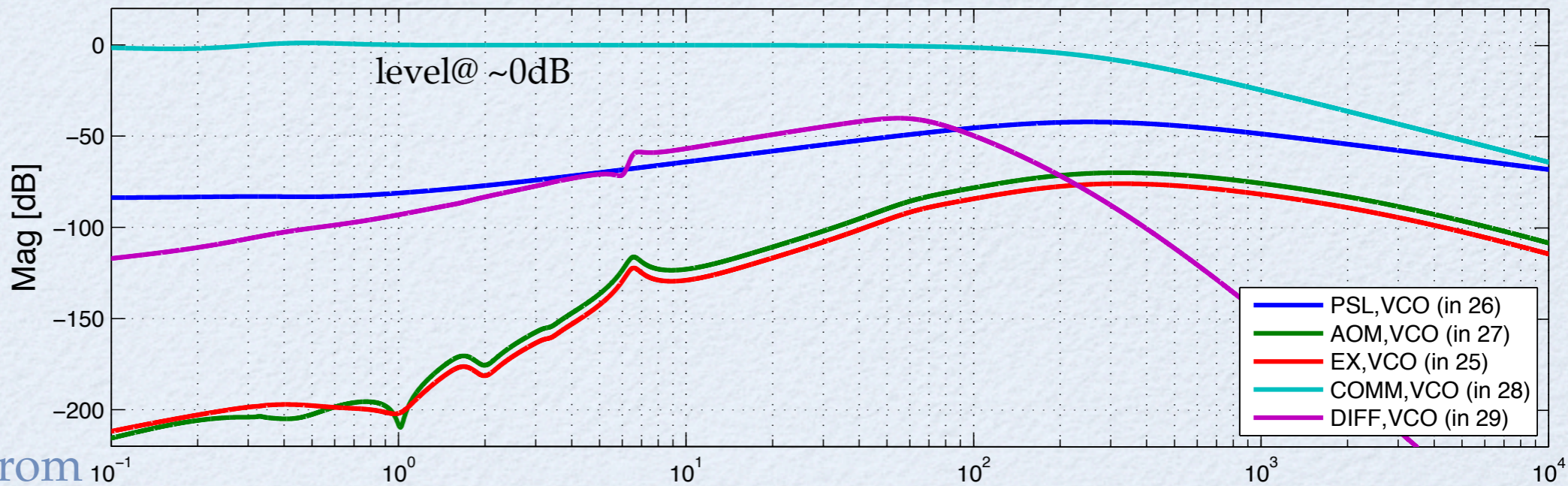
VCO Noise Performance



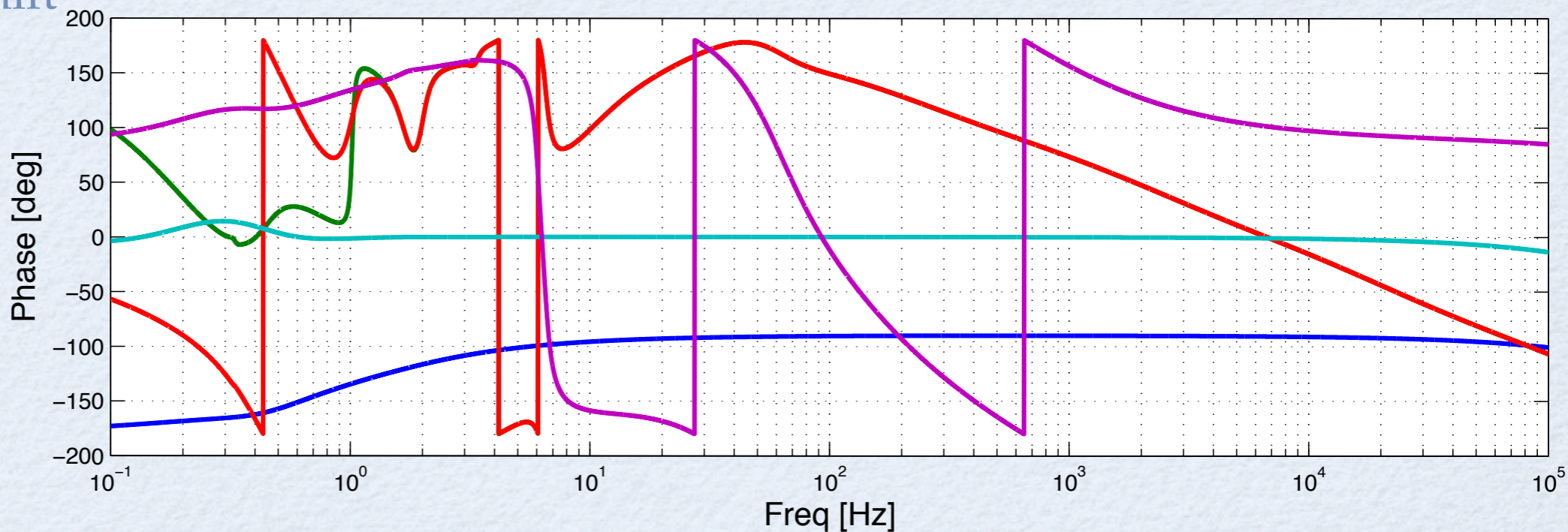
- First Stage VCO equivalent phase noise ~ 1 mHz / rtHz (flat)
- Equivalent displacement @1064nm $\sim 10^{-14}$ m / rtHz.

VCO-Comm Noise TF

VCOs -to- Common Mode Freq. Shift (out 34)
Freq shift between PSL and X-arm Laser

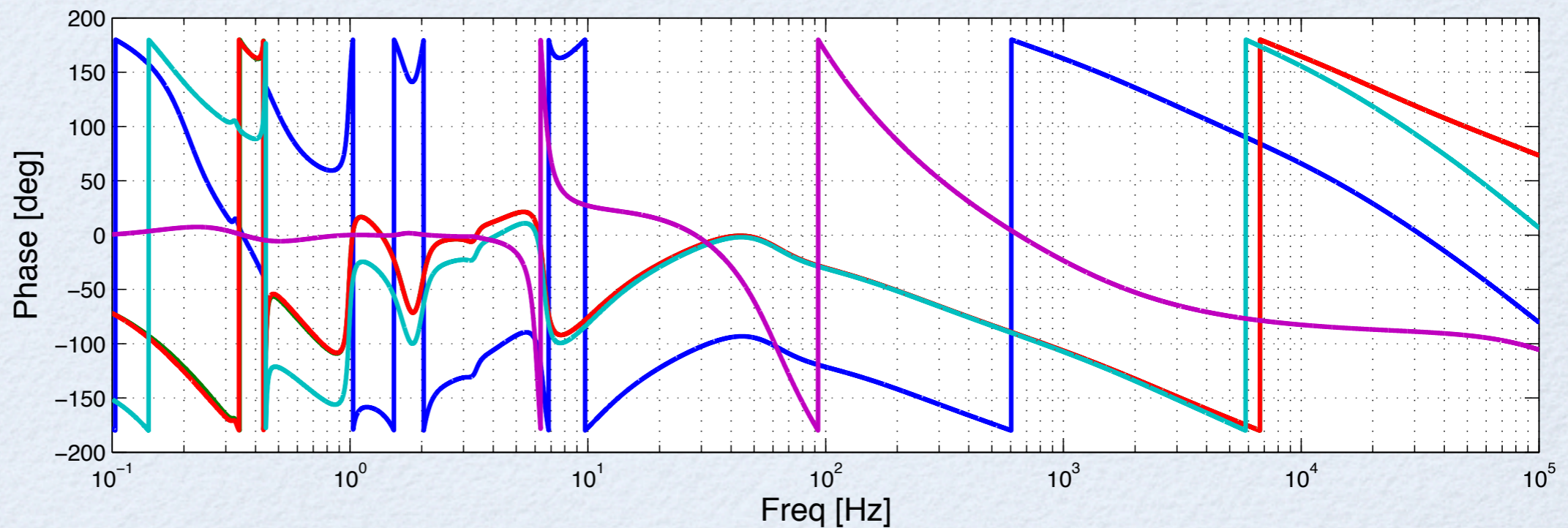
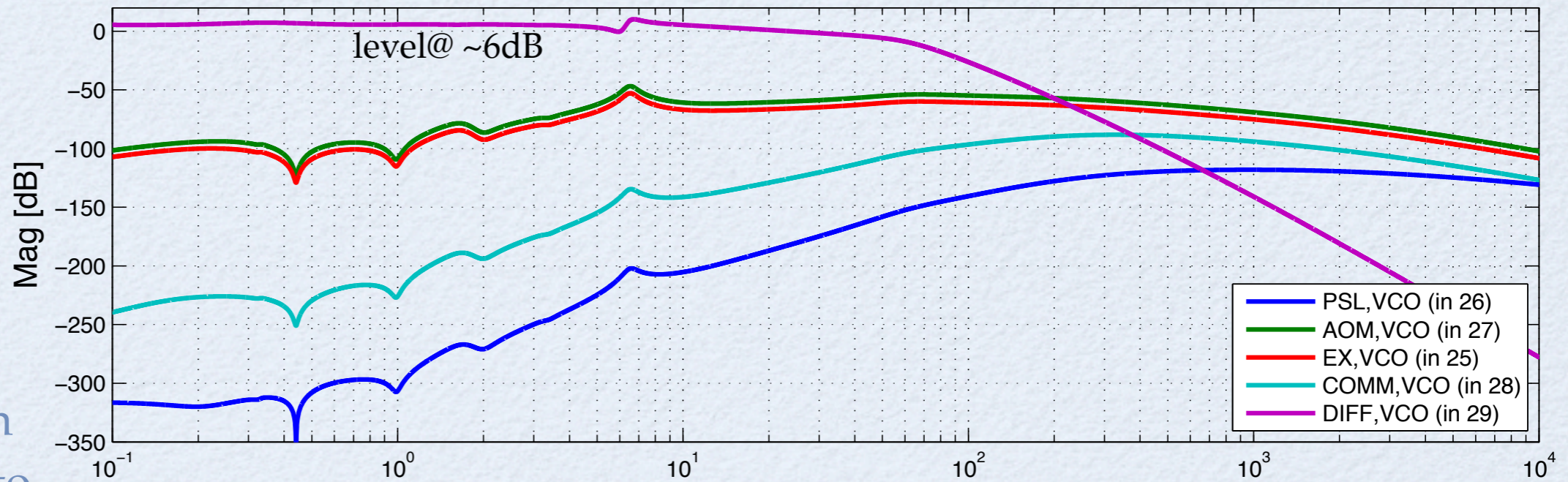


- Transfer function from VCO [Hz] to Comm Mode frequency shift [Hz].



VCO-Diff Noise TF

VCOs –to– Differential Mode Freq. Shift (out 35)
Freq shift between X–arm and Y–arm Lasers



- Transfer function from VCO [Hz] to Diff Mode frequency shift [Hz].

Summary

- Aux. Laser phase locking to PSL (via fiber) by feeding back to the Aux. Laser Temp. and PZT with a BW ~25 kHz (using TTFSS servo).
 - Assuming single mode fiber with no excessive fiber phase noise (<100 Hz/Hz).
- Green PDH locking feedback to TTFSS L.O. VCO with a BW ~2 kHz.
- Vertex Common Mode locking BW ~250 Hz.
 - Feedback to the IFO Common Mode Broad aux input.
- Vertex Differential Mode locking BW ~30 Hz.
 - Feedback to the ETM_{x,y} Quads.
- Single Stage VCO is sufficiently low noise and has enough tuning BW (+/-1MHz).
 - Equivalent displacement @1064nm ~10⁻¹⁴ m/rtHz.