Adv LIGO Arm Length Stabilisation

Stabilisation of the arm length fluctuations in Adv LIGO for lock acquisition.

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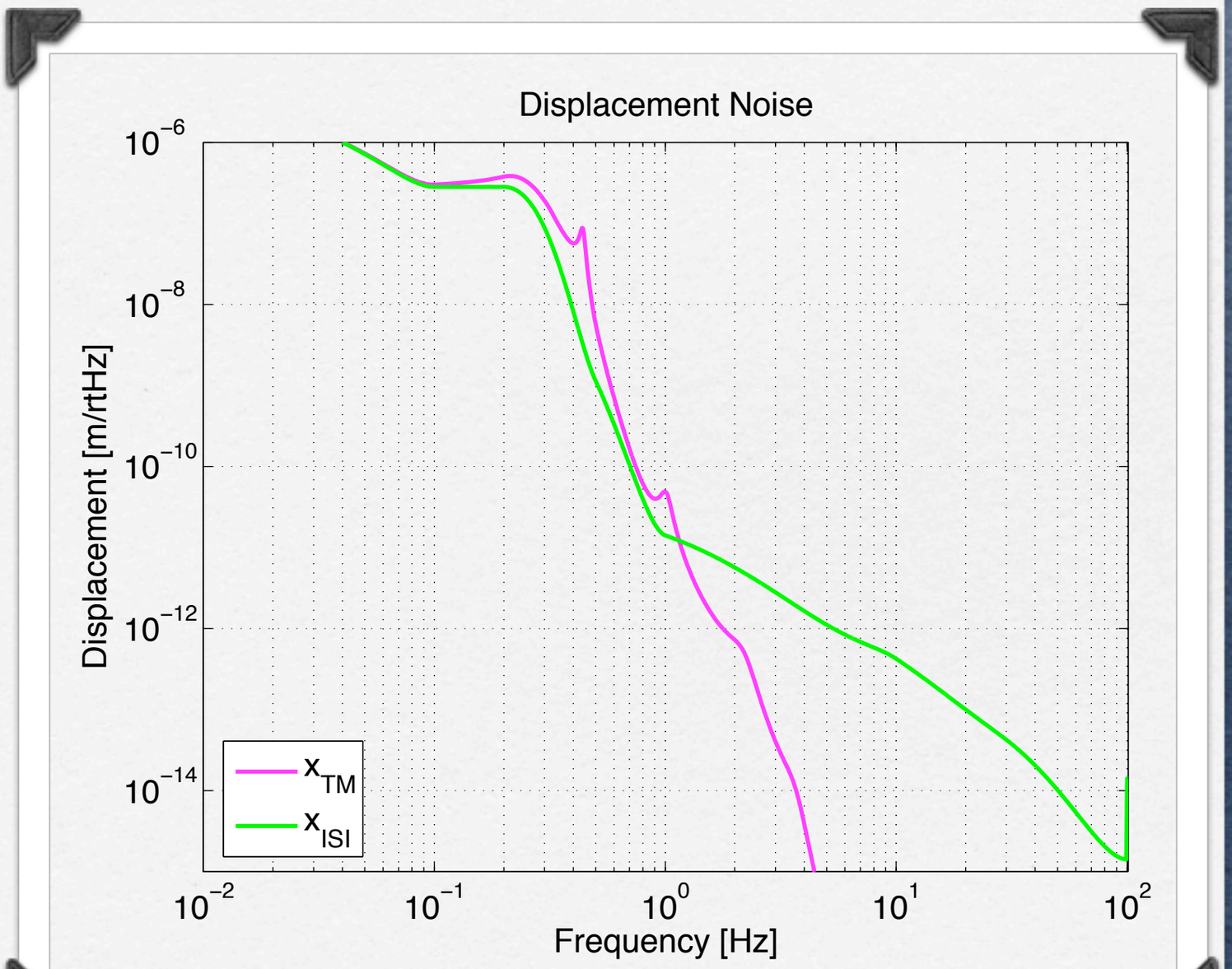
as well as ISC group
(Sam Waldman, Rana Adhikari, Aidan Brooks, etc.)

LIGO-G0900215-v1

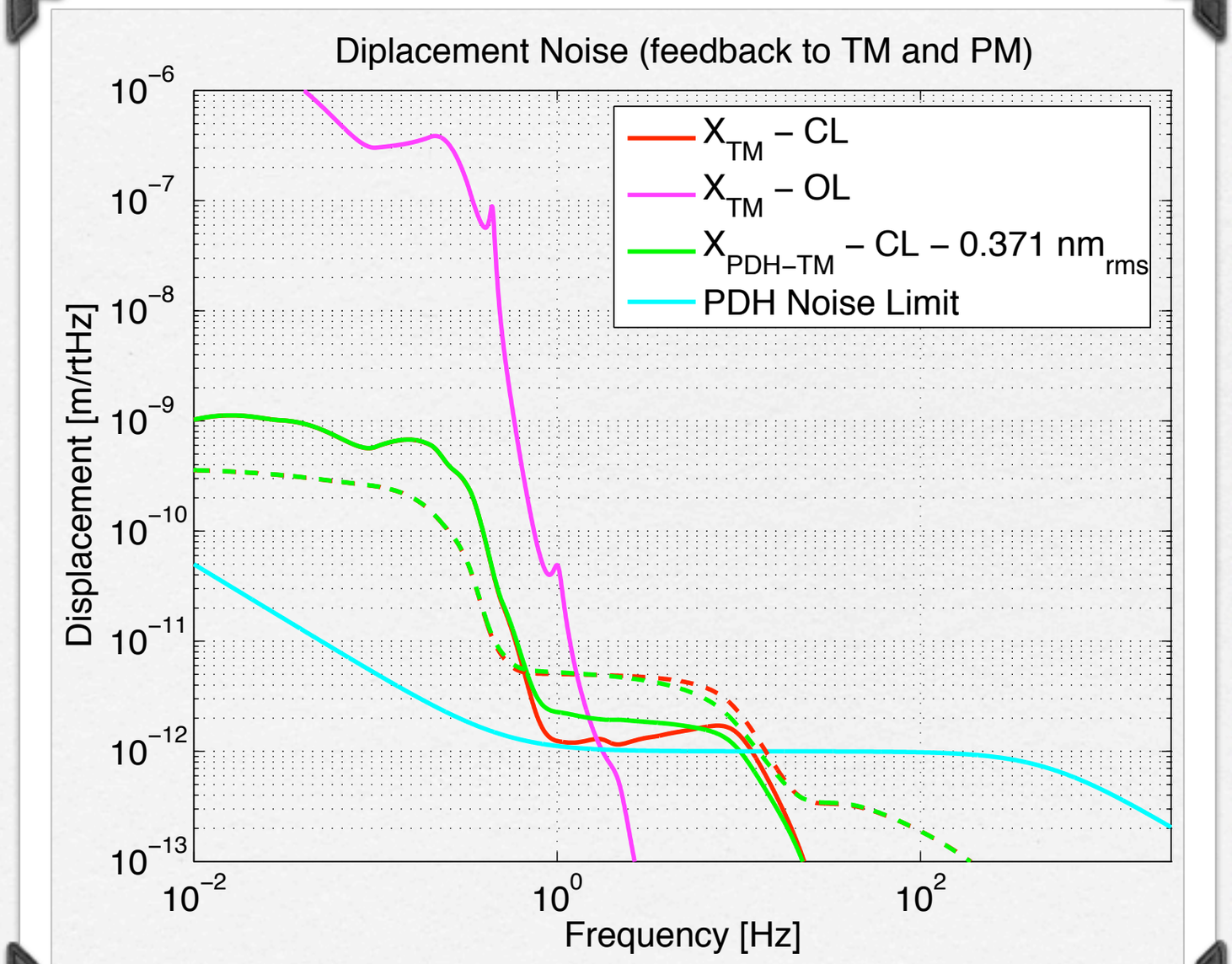
Reason and Aim

- The test mass motion is many arm cavity line widths (~1.3 nm), below 1 Hz.
- Reducing the arm length fluctuations to below 1 nm RMS.
- Results in a deterministic lock acquisition of the full IFO.



Approach - ETM injection

- Inject an auxiliary laser with PDH sidebands into the arm cavity form the end-stations.
  - Lock the laser frequency to the arm length fluctuations.
  - Hand-over the feedback to the quad suspension



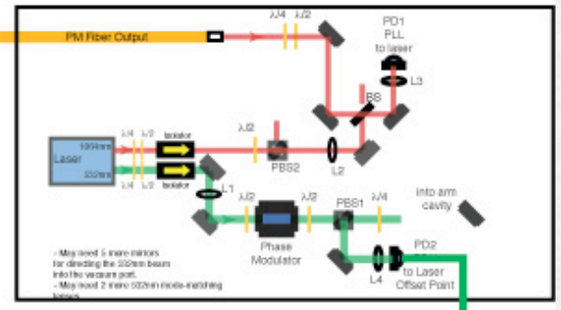
General Layout Overview

PSL
tab-off

(L.O.)

4) Delivery of the PSL phase reference to the End-Station via optical fiber.

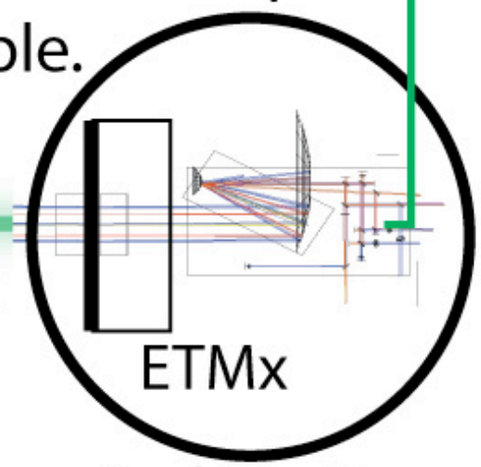
2) Auxiliary Laser table in air.



3) In-Vacuum Telescope Table.

ITMx

1) ITM and ETM additional HR coating for 532nm (ETM R~5%, ITM R > 99%)



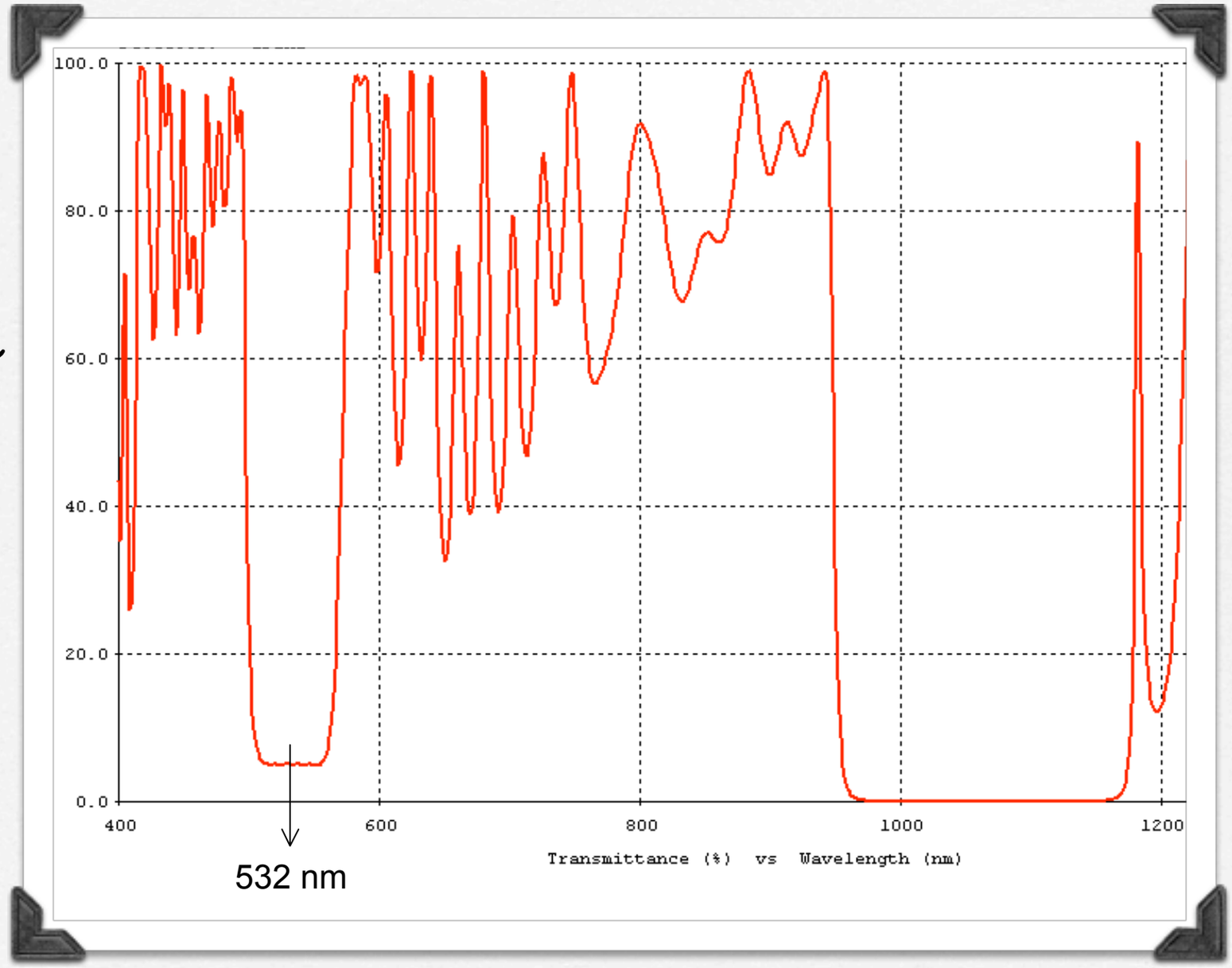
Corner-Station

End-Station

ITM/ETM Coating mods

- LMA model for ETM
  T@1064nm =4.6ppm
  and T@532nm ~5%.

- Thermal noise performance at 1064 nm still good.

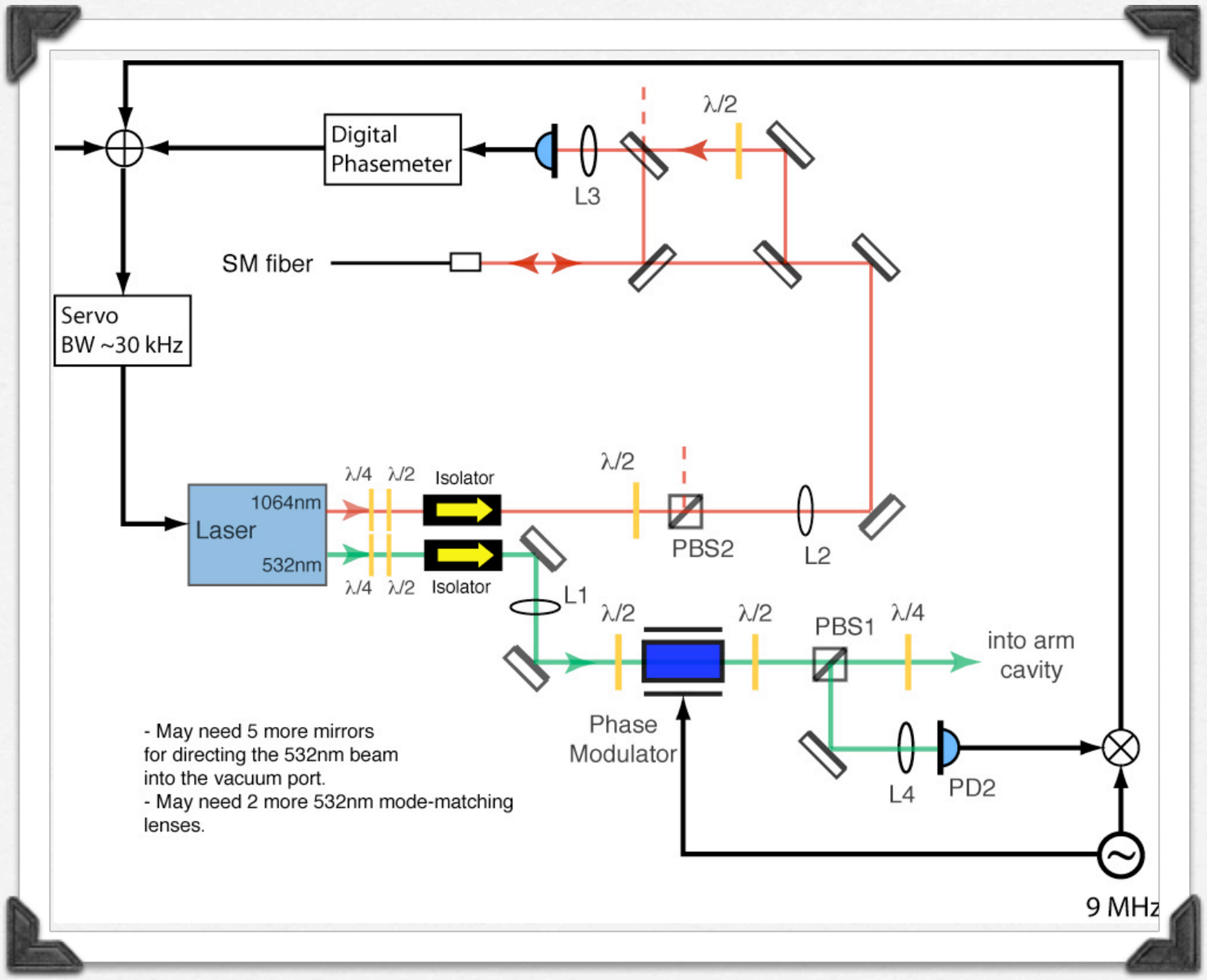


Auxiliary laser

- The auxiliary laser wavelength is 532 nm (second harmonic of 1064 nm).
  - standard Innolight Prometheus laser (single pass 532 nm generation).
  - Not to interfere with the locking of the central cavities (PRC, SRC, MICH).
- The auxiliary laser is phase locked to the pre-stabilised laser (PSL).
  - optical fiber link from the PSL to the end station.
  - Phase noise due to the 4 km long fiber needs to be suppressed below the equivalent 1 nm requirement.

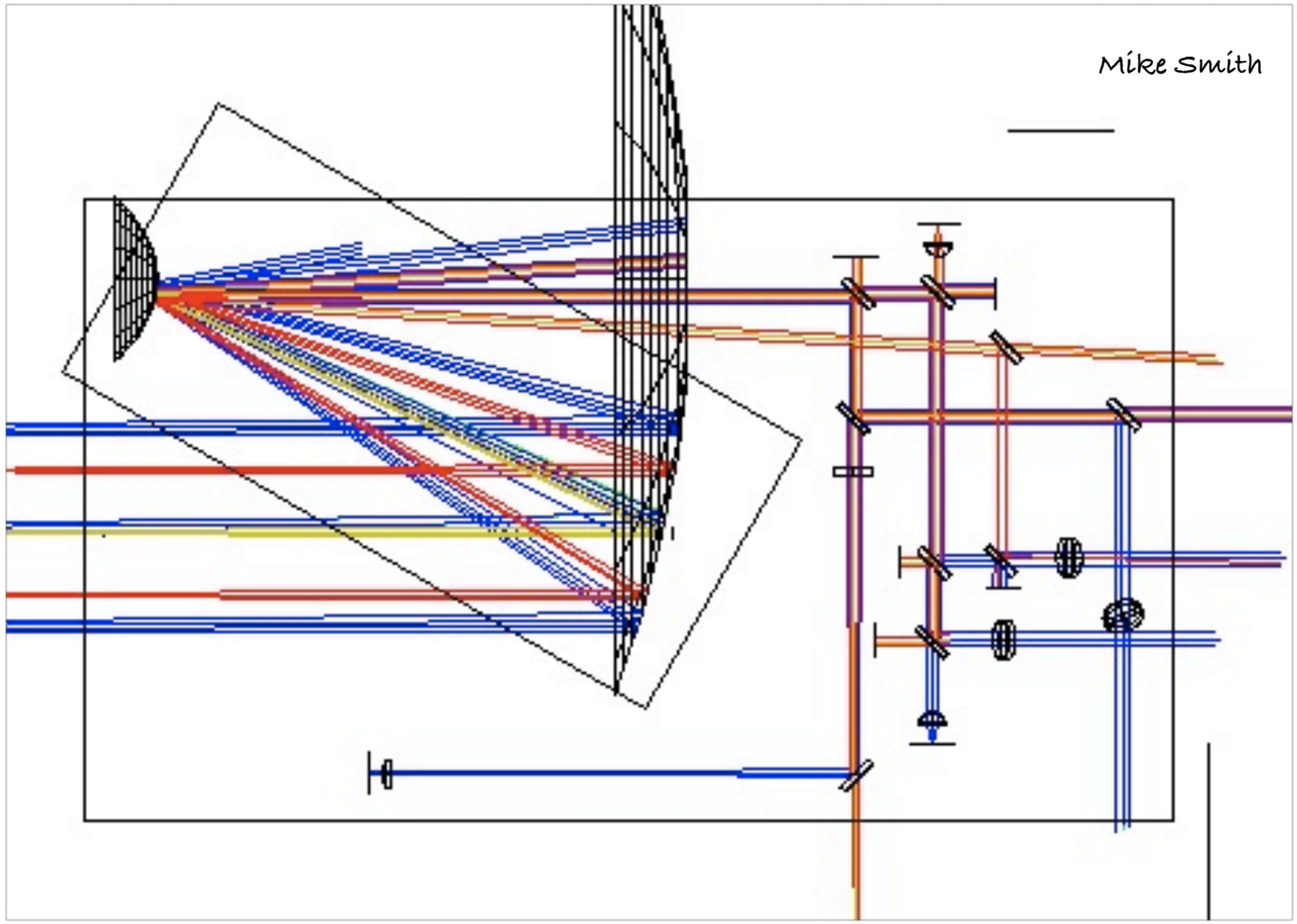
Auxiliary Laser Table

- Table located in air.
- Standard PDH sidebands on the green beam.
- Demodulated error-signal feed back to the laser frequency.



ETM Telescope Design

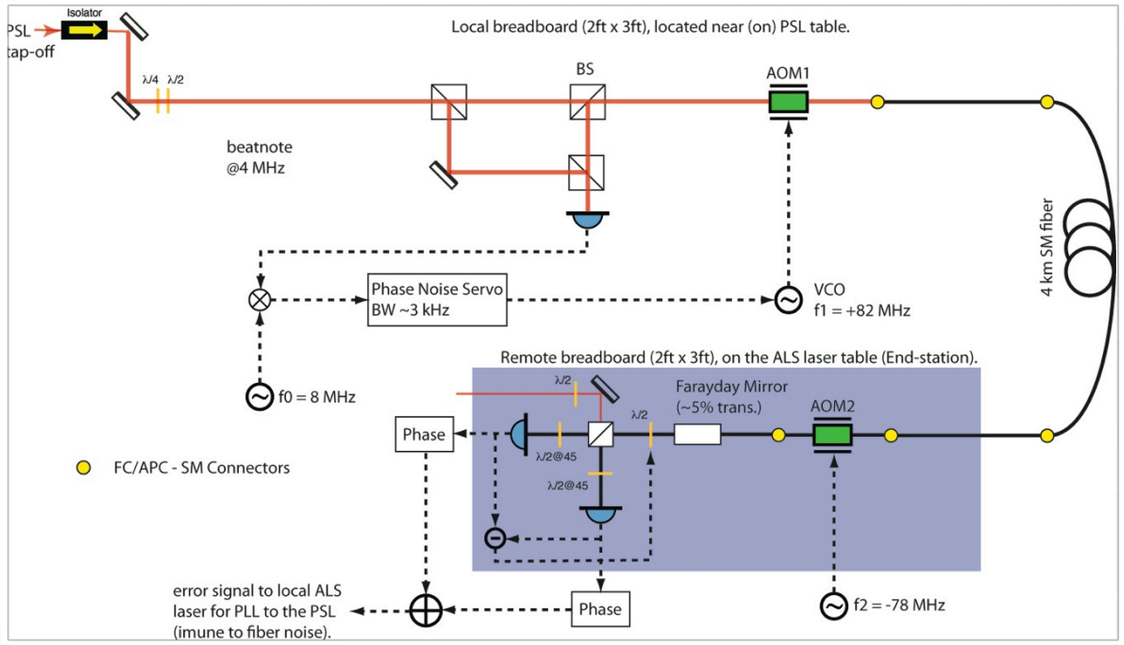
- The telescope needs to guide three beams (1064nm, Hartmann beam, 532nm).
- Holds the 532nm input alignment controls.
- Mike Smith and Sam Waldman ironing this out.



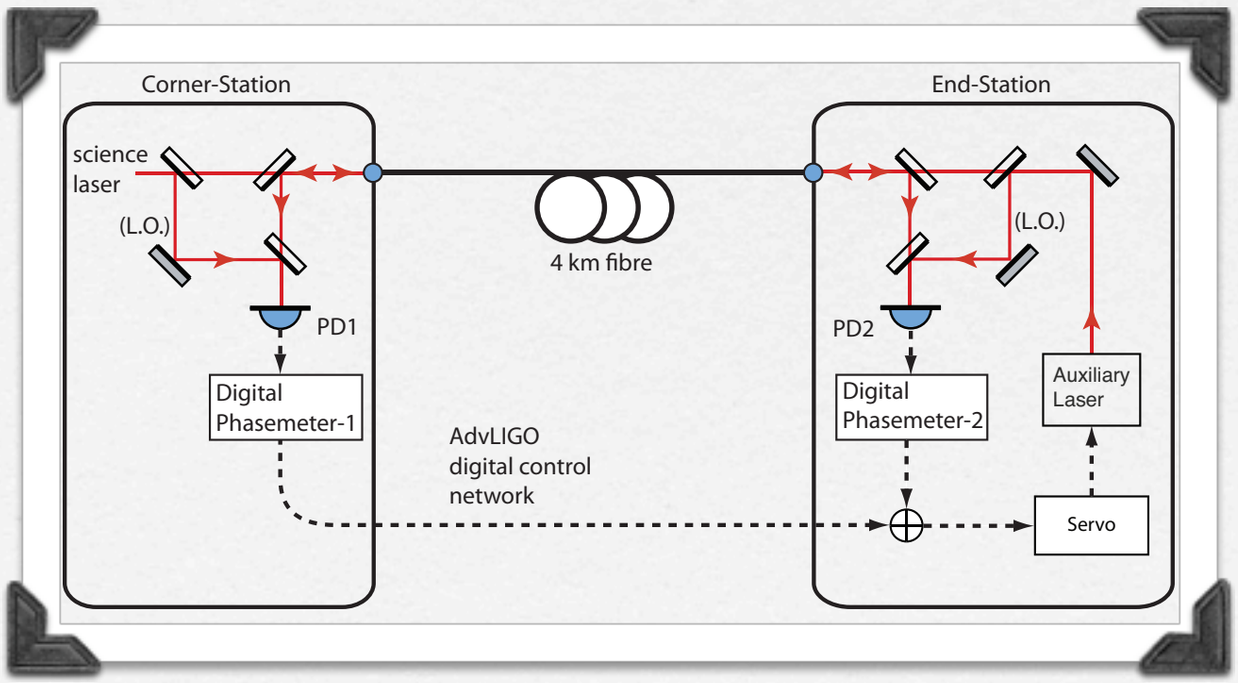
End-Station Phase reference

- Stabilise the relative frequency noise between the main laser and the auxiliary laser.
- Power tab-off from the main laser injected into an optical fiber and sent to both end-stations.
- Auxiliary laser in the end-stations phase-locked to the optical fiber output.
- Noise from the fiber sets the limit of the relative frequency stability - arm cavity displacement noise.

Fiber Noise Cancellation

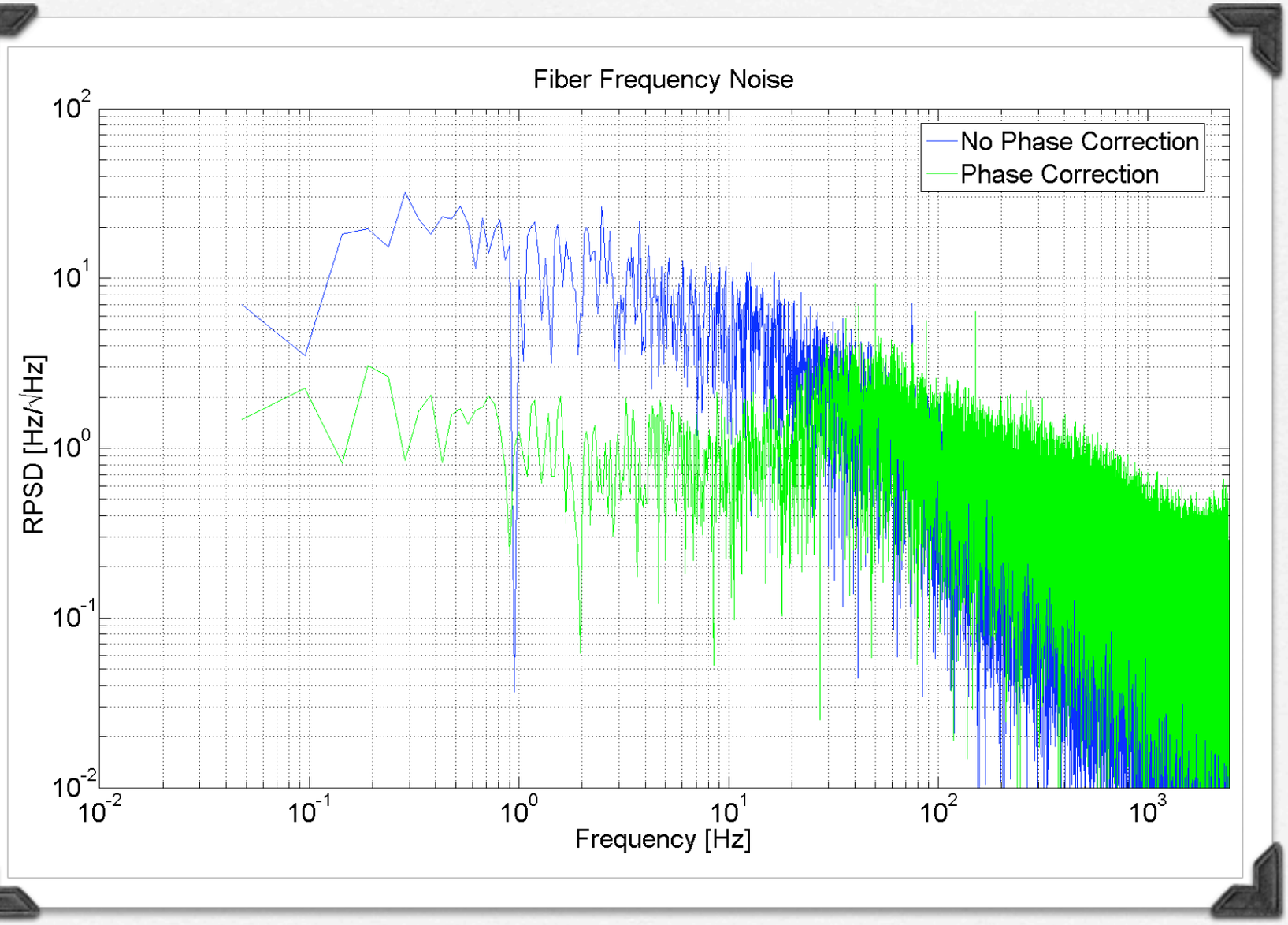


- ANU and 40m-lab/LHO setting up cancellation experiments.
- ongoing...



Initial Cancellation Results

- Need to have another order of magnitude.
- Changing the low-pass filter to 600 Hz



Summary

- Design well underway.
- Phase reference to be ironed out soon.
- ETM Telescope being ironed on.
- Draft Design Requirement document.