

A+ ISC Design Requirement and Conceptual Design Review

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August 15th, 2019

Background

- DRD was put together several months ago - at that time we were targeting FDS + BHD, but we studied the case without BHD as well; also, at that time the horizon for FDS was O5, not O4 as recently decided
- The DRD was not reviewed at that time - in the last few months some decisions had to be made; they have been discussed during A+ meetings but not yet incorporated in the DRD
- An updated version of the DRD will be uploaded after this review

Back scatter noise requirement and need of 1064 sensing (a.k.a. RLF)

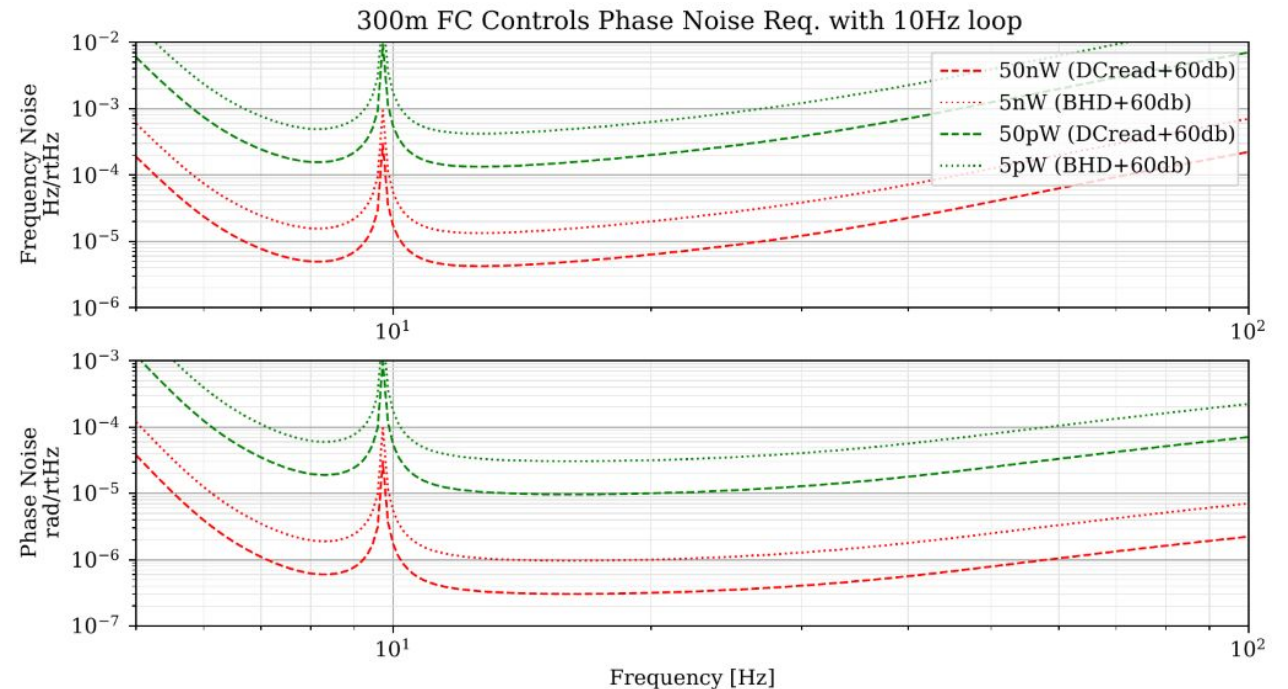
$1e-4$ Hz/rtHz @ 10Hz (equiv $1e-5$ rad/rtHz). this is dependent on a reasonable loop shape that sufficiently suppresses ISI+HSTS length noise.

cannot be achieved on 532 beam from air without additional control (just like the OPO pump stabilization from CLF-loop)

Need freq-stabilized beam: IFO AS beam is phase stable, LO loop stabilizes CLF field to IFO beam via SQZ laser.

Piggyback CLF-field stabilization for cavity sensing with Resonant Locking Field (RLF)

Must check all sensing noises in SQZ loops to see if this will be sufficient..



Req's based on reference control loops in T1800447

How many Faradays do we need?

- We asked Florida to make two low-loss Faraday for the squeezing path (both SF1 and SF2)
- This is the conservative choice in case of FDS without BHD, to meet the noise requirements down to 10 Hz

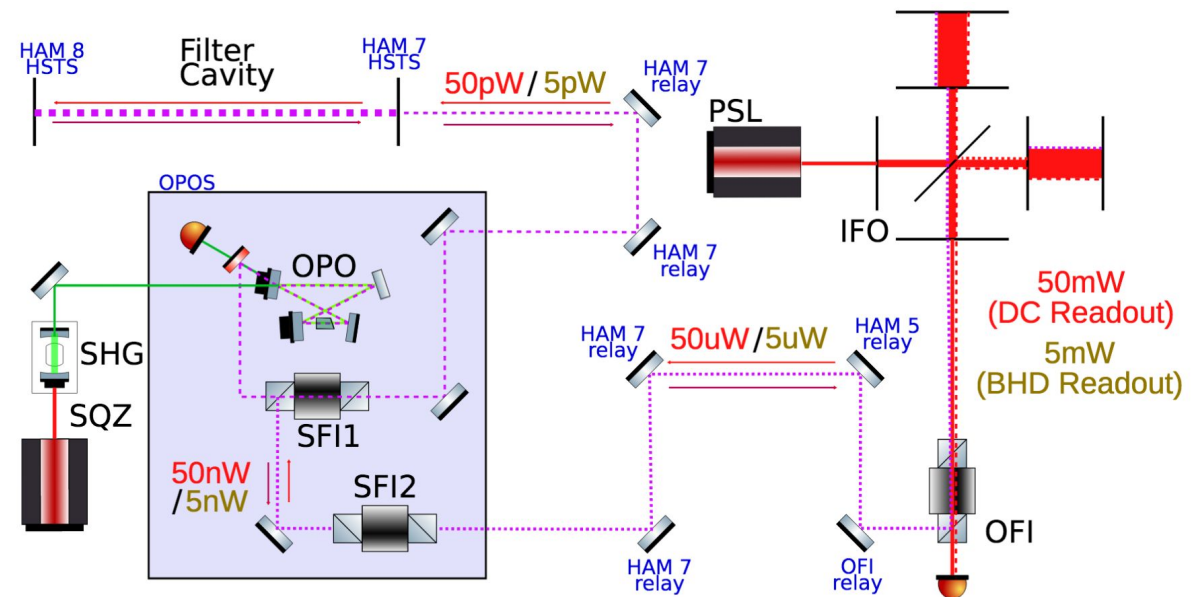
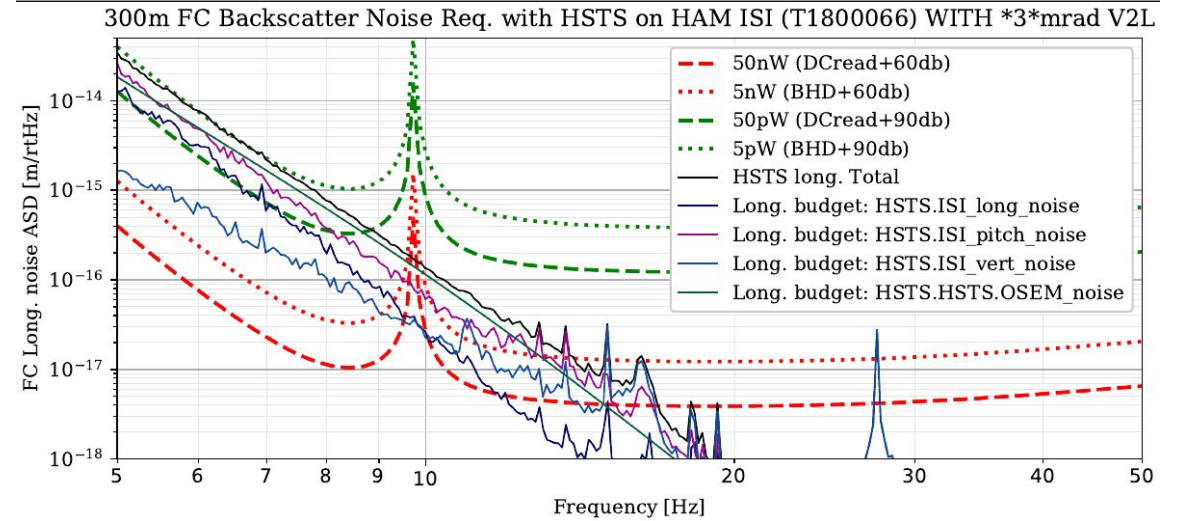
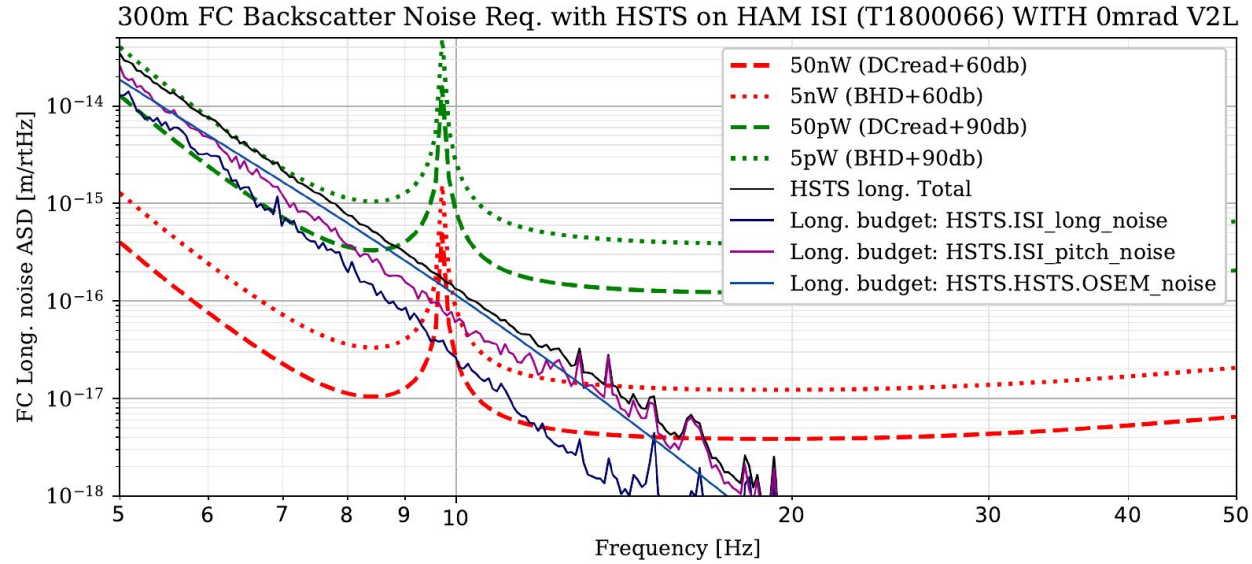


Figure 2: Simplified drawing showing the back scattered light path from the IFO to the FC. Power levels quoted here are for the Balanced Homodyne and DC readout configurations. The calculations in the following sections consider the option of having either one Faraday in the squeezed path (SF1) or two (both SF1 and SF2).

Corrected Figs. 4&5 of T1800447



What about the relay optics?

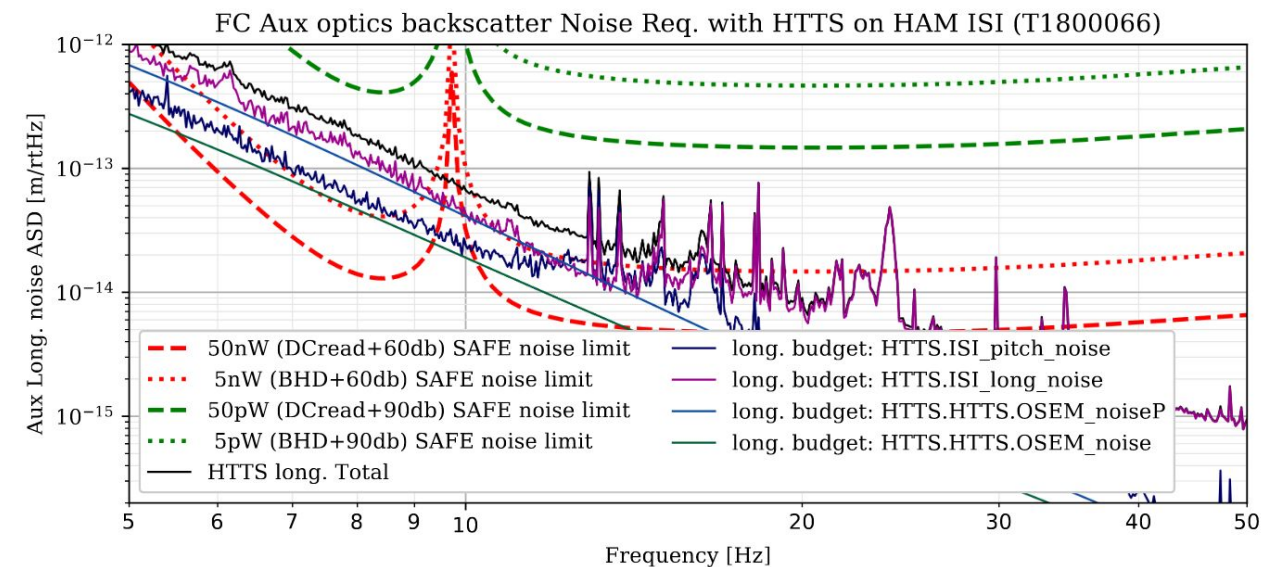


Figure 7: Length noise of an HTTS (single stage, tip-tilt) suspension on standard aLIGO HAM ISIs (T1800066), compared to length noise requirement imposed by back scattered light noise.

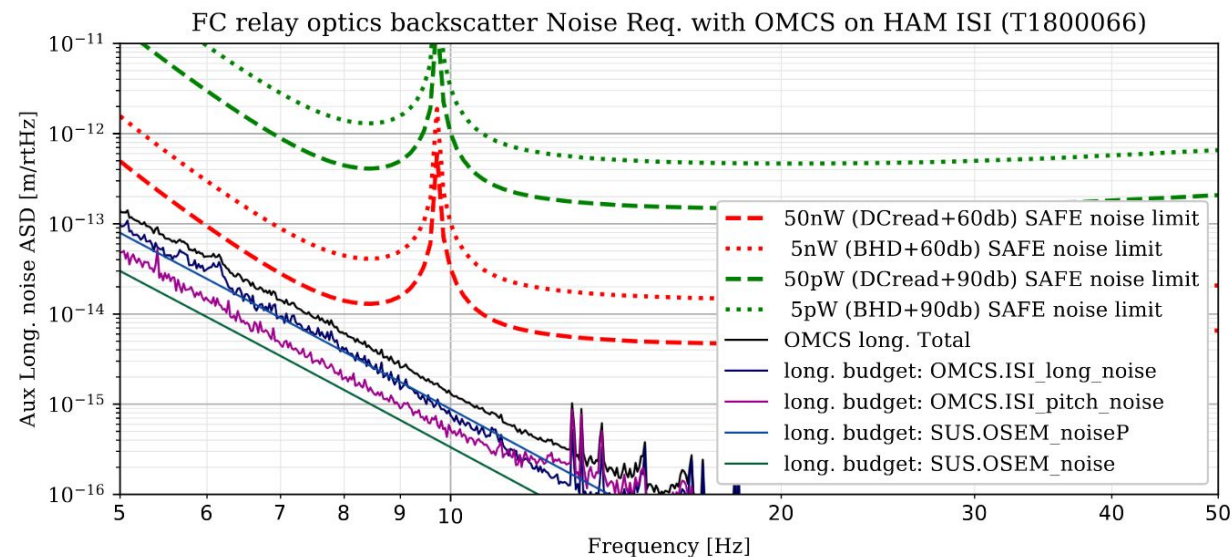
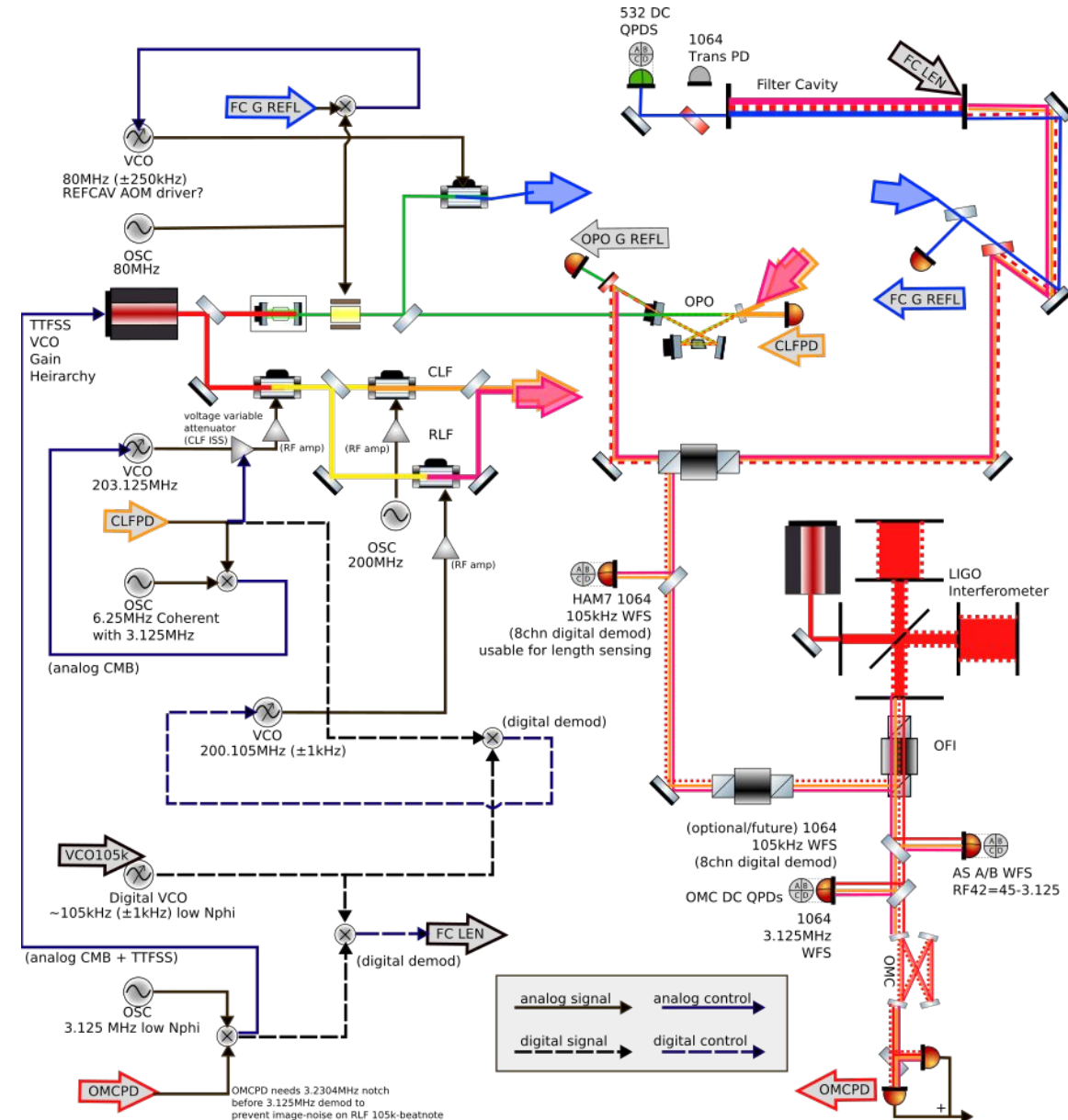


Figure 8: Length noise of an OMCS type suspension (double stage) on standard aLIGO HAM ISIs (T1800066), compared to length noise requirement imposed by back scattered light noise. A dedicated double stage suspension for a single 2" optic is under design (E1800272), so here we use the transfer functions of the OMCS as example.

With both SF1 and SF2 Faradays tip-tilt suspensions are ok, but given that double stage suspensions are being designed for AWC, the goal is to have double suspensions for all of the relay optics (with tip-tilt as backup solution in case of time/person power constraints) update or future design docs will check multiplicity, but 3 Faradays should be OK.

Filter cavity locking scheme

1. 532 for lock acq. and rough alignment
2. 1064 stabilized by CLF/LO-loops
3. WFS from CLF-RLF beatnote (modeling shows this is quite "clean" PDH-like)
4. Length sensing either from CLF-RLF beatnote, or RLF-LO(fringe) beatnote.
 - a. existing loops will need 105kHz notches!
 - b. cavity detuning operating point set from demod angles and/or RLF frequency (TBD)
5. The 105kHz beatnotes to be done by digital demod
 - a. analog is fine, but 105kHz will req. new elec.
6. Still a WIP
 - a. multiple ways to derive error signals, but fundamental risks to it are similar in most schemes
 - b. testing in LASTI on 16m FC
 - c. (recently) modeling error signals, sensing matrix



FC Control Implementation notes

- Optics layouts in **D1900281 (to be updated after review)**
- Requires moving many HAM6 SQZ elements to HAM7
- does NOT require significant optics changes to ISCT6
 - adding new FC532 field
 - table available for testing when moving racks and in-vac components
- requires re-orienting SQZT6

Need for high power CLF

Using the IFO fringe light (LO) for a phase reference imposes phase-noise sensitivity requirements.

Just a reference power:

250uW CLF +250uW RLF on OPO M2,
with 4% transmission to (locked) OPO
and 1% through OMC

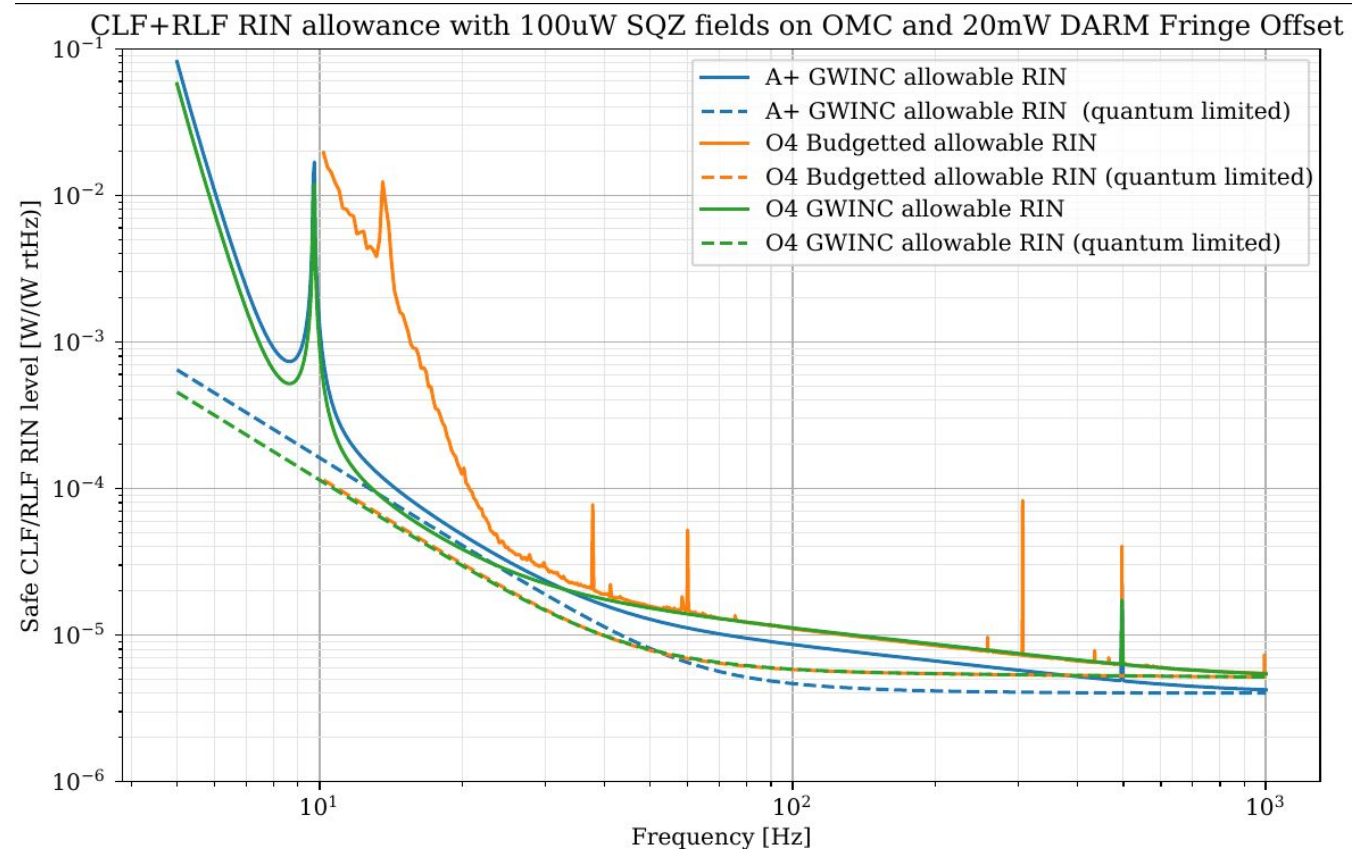
- ~20uW on OMC
- ~200nW on OMCPDs

This gives

~1e-5 rad/rtHz sensitivity in each field
(shot-noise limited)

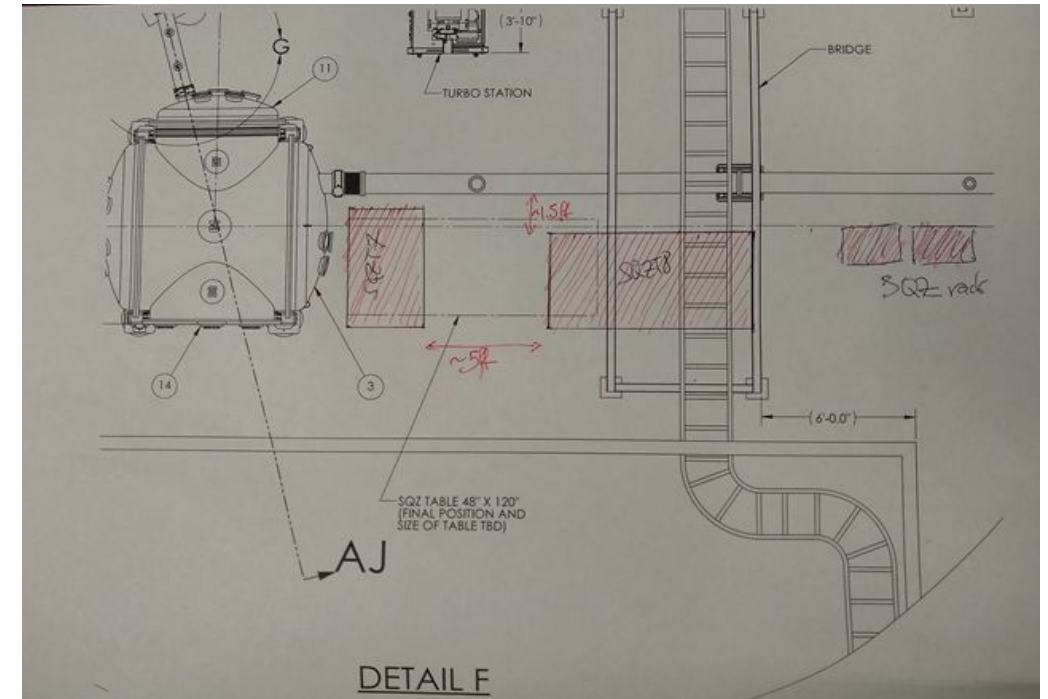
Need to test turning up the CLF to meet this.
ALL locking schemes will require CLF to have
sufficient power level*.

Will need more Faraday isolation if this power
level is not achievable.



Tables location

- We have been thinking at table locations that do not require moving them every time either HAM6 or HAM7 are opened
 - this is mostly because this has been somewhat painful at both sites leading into O3;
 - Avoids new HAM5,6,7 cleanroom
 - Further decouples HAM7 in-chamber work from IFO commissioning
 - LLO doesn't have any ISC components on ISCT6 anymore; if LHO wants to have some components at the AS port it seems easier to have a small table just for that
 - BHD design not considered here
- (design not mature enough; not for O4 anyway)
- Ultimately, we are ok with this committee having the final word



Filter Cavity Optics Status

- Design considerations: <https://dcc.ligo.org/LIGO-T1900279>
- Purchase is a multi-step process: material, ROC/polishing, coating
- GariLynn has already placed the order for material
- She is investigating with vendors the option of having the input coupler ROC = 1m to simplify the mode-matching telescope, shrinking beams on relays.