New Modulation Scheme for Advanced LIGO

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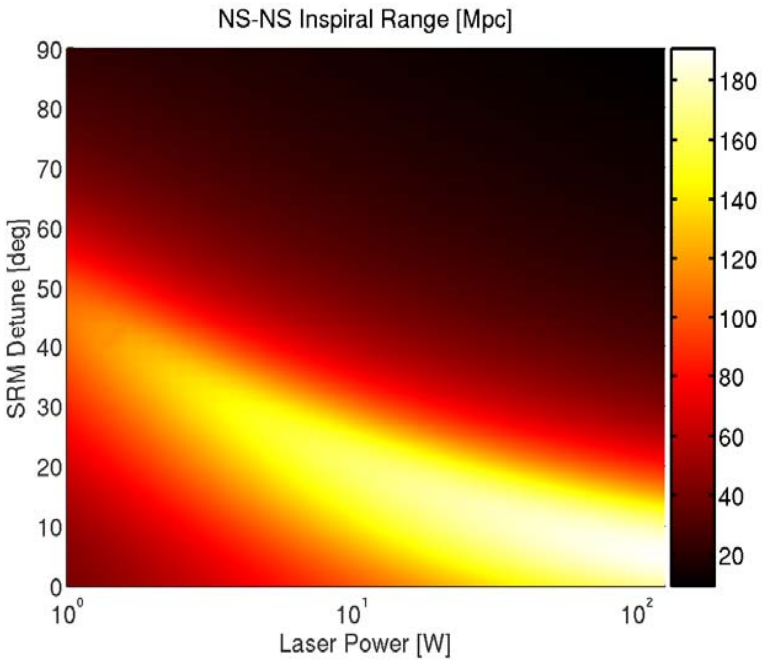
LIGO-G070191-00-Z

Motivation for a different scheme

- Frequencies of nominal scheme: 9 & 180 MHz
  - High-frequency SB transmits 100% thru Michelson to probe the SRM
  - Low-frequency SB meant to probe the power-recycled MI
  - 180 MHz is too high for detectors; could be reduced down to 108 MHz … still kind of high
  - **Want to get below 100 MHz**
- Signal recycling cavity tuning
  - Gives a high-sensitivity signal for the SRC, but only for a ~1 deg range around a chosen SRC phase
  - **Want continuous tuning capability** from a couple of degrees to about 15 degrees (one-way phase shift)

Design since ~1999

Length Sensing & Control Layout

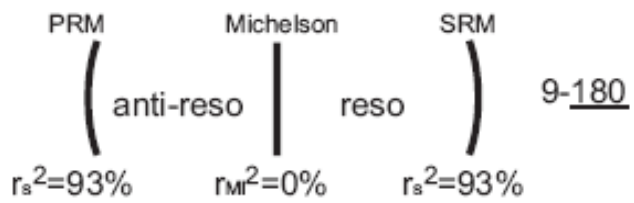


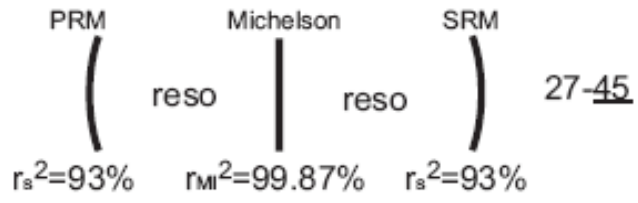
- HF SB goes to the dark port
- LF SB stays in the PRC

New scheme

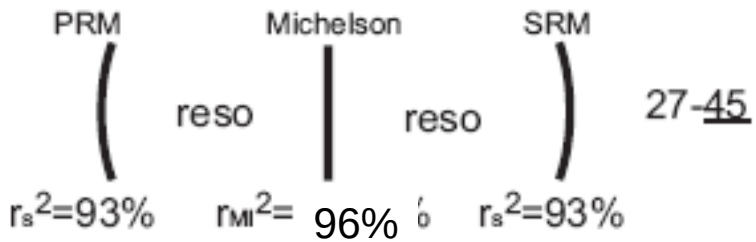
- Start with Kentaro's idea to reduce the upper modulation frequency:

Both give critical coupling of one of the f2 SB's





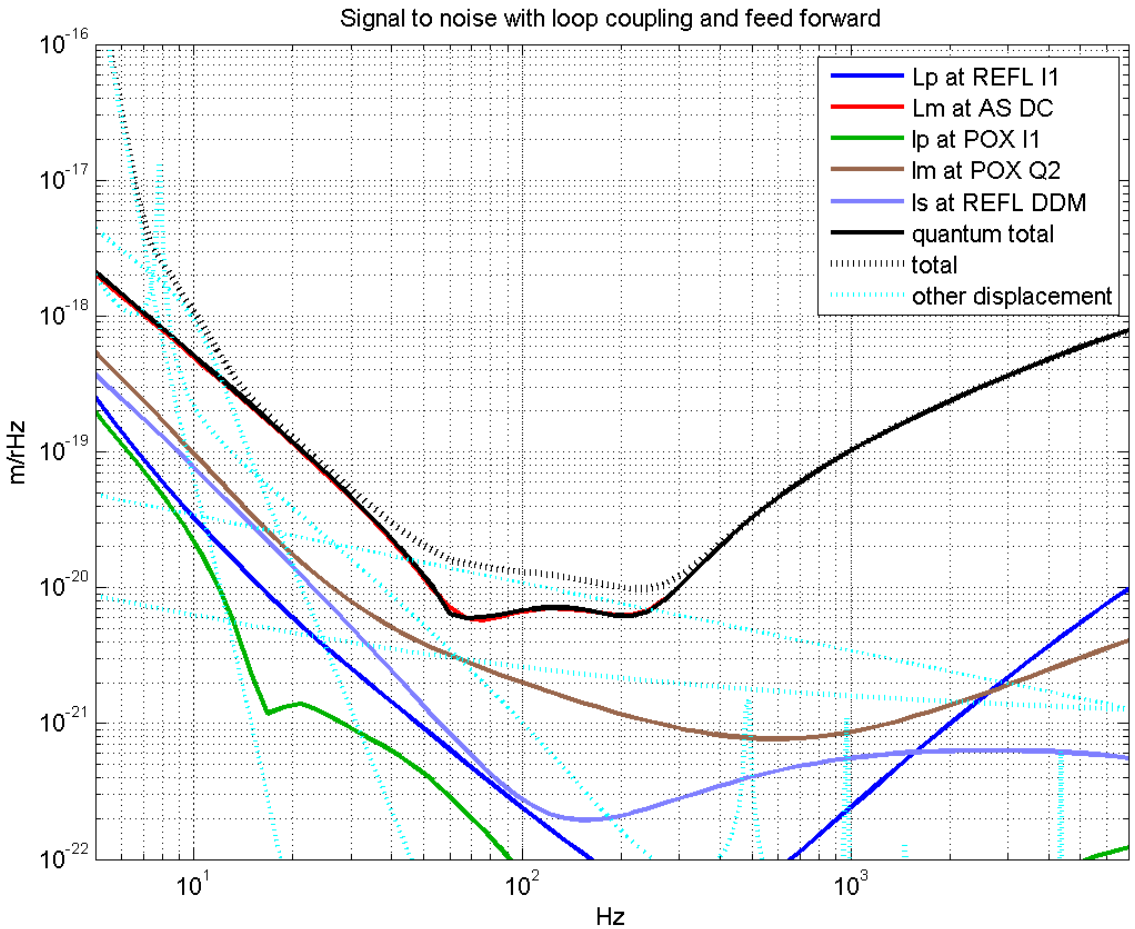
- Increase the range of the SRC discriminant by adjusting asymmetry to lower the finesse for f2 (not critically coupled):



Sensing noise

- We decrease the optical gain by lowering the finesse for the SRC probe

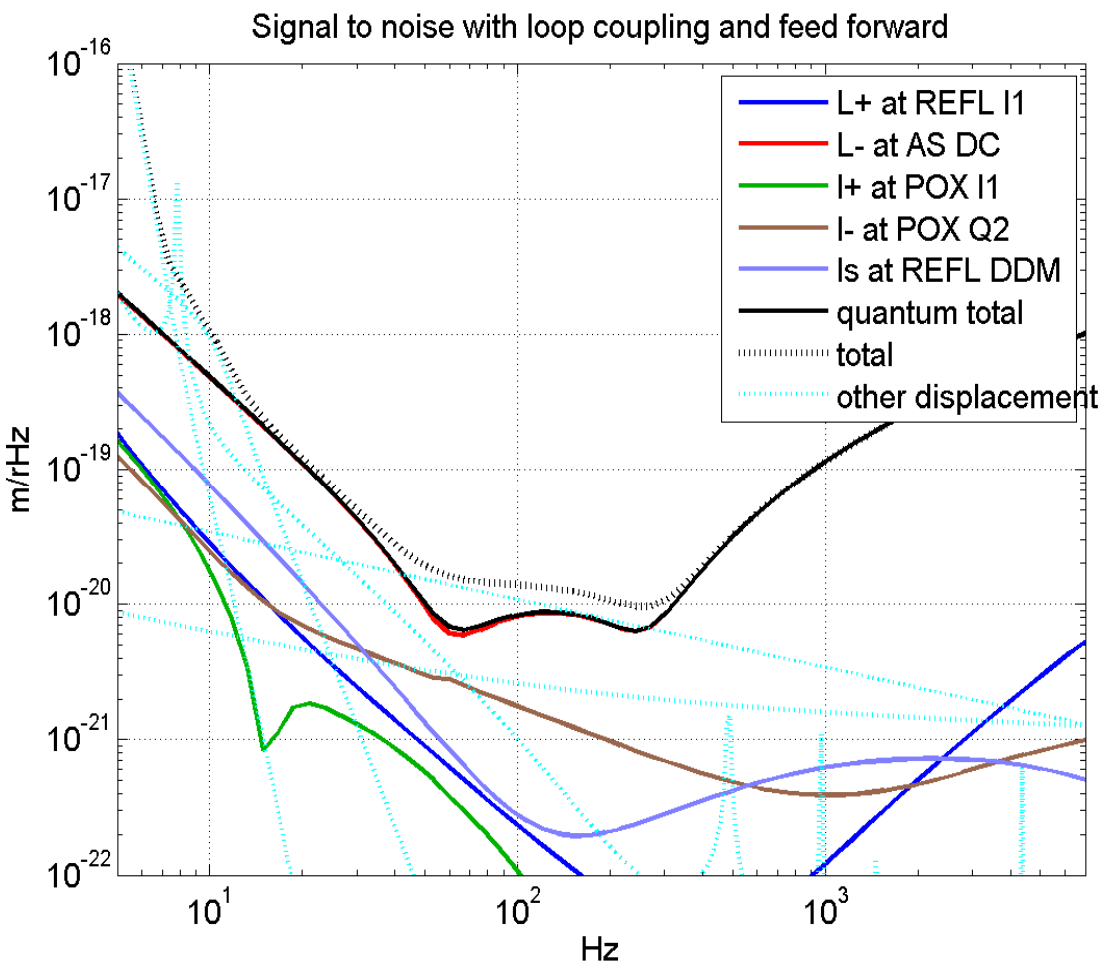
Whether it's good enough is checked by calculating how the sensing noise in auxiliary DOF feeds into the GW channel



Sensing noise (T_ITM = 0.015)

- 3x lower arm finesse. ~2x higher BS power.

preliminary look



Options

- **Which ports & signals** to use for lp, lm & ls
  - Depends on allowed power levels, high power PDs
- **Offsets**: May need to lock where the error signal doesn't cross zero.
- **How high** to go with f2: 45 vs 63 MHz
- Single sideband for f2
- Lowering f1 using a longer, 4-mirror IMC

System implications

- Recycling cavity lengths
  - PRC length = 8m, 16m, … (53.7 m)
  - SRC length = 8m + n*3.3m (52.1 m)
- Modulation
  - Lower upper frequency, but should allow for **high-modulation index** (**0.8**) for low-power operation: gamma=0.8 (per MZ arm).
- Recycling cavity pick-off
  - Dump POX and POY in-vac on stacks. We only get ‘POB’ (whatever). Also dump Stable RC leaks.

Summary

- Let's settle on 9/45 MHz today! Its flexible and gives some kind of ASC matrix (see next)
- Also works with low finesse arm design.
- 40m plan also includes a 9/45 plan; makes the electronics more likely the same.
- Let's plan the road to rework the 40m and test this out----