An Introduction to DC Readout

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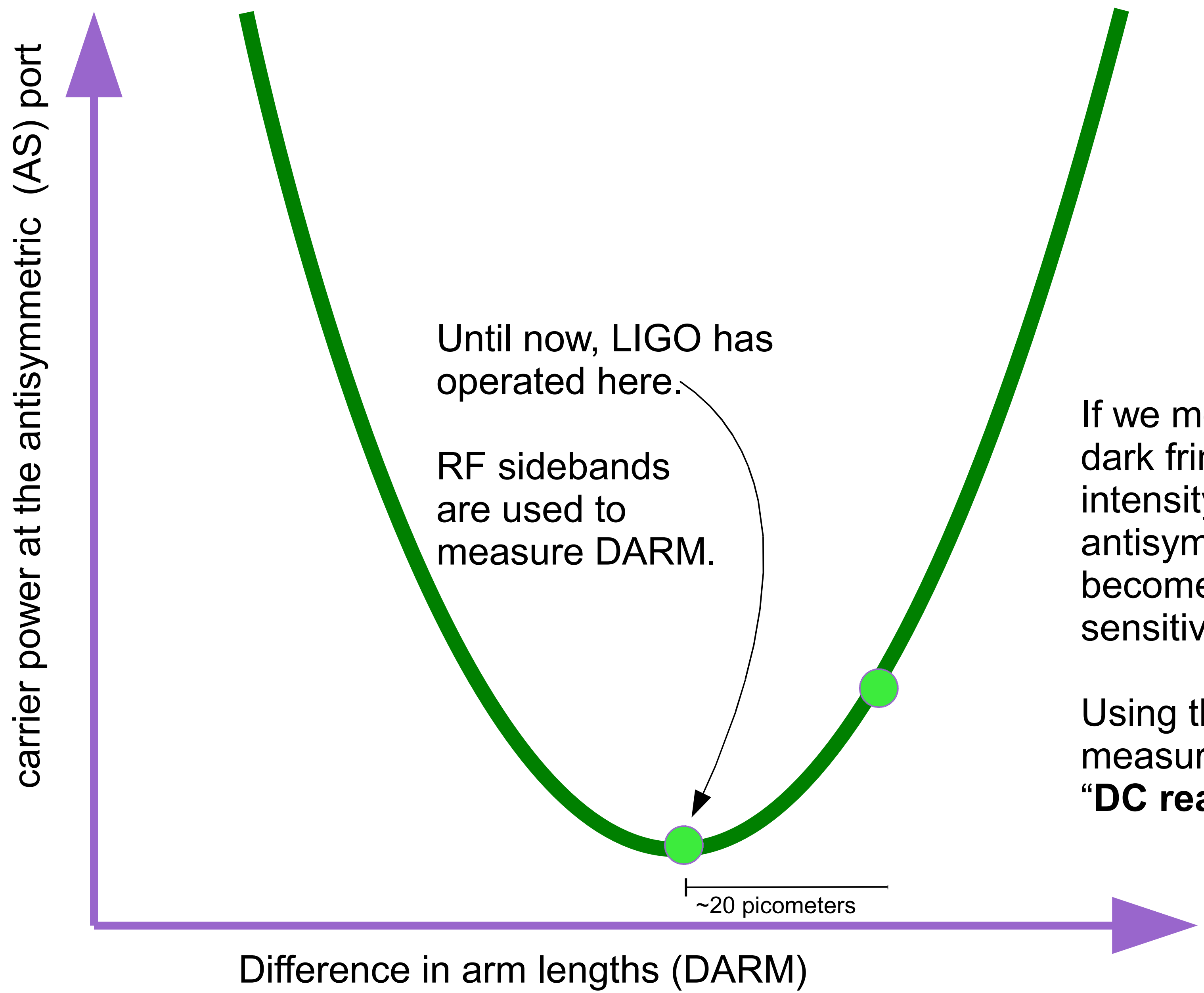
but first...

HAPPY BIRTHDAY BRIAN!

DC Readout: What is it?

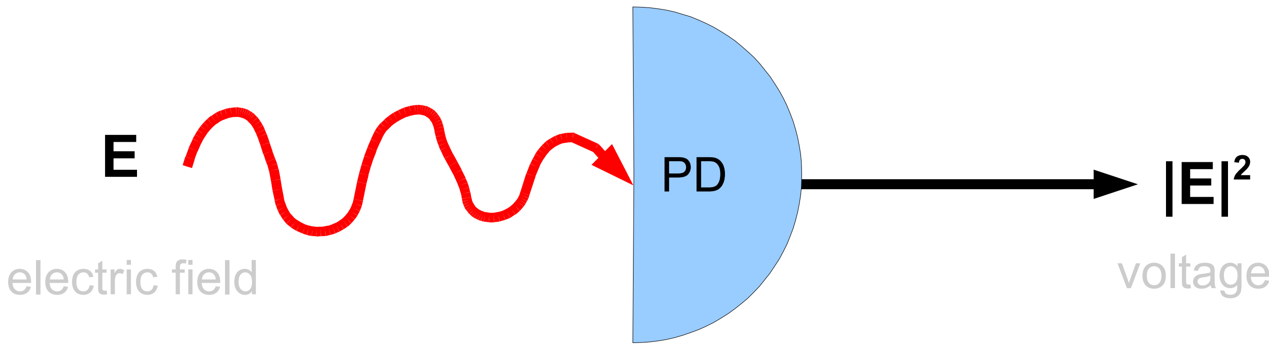
Here's a doodle of the 'dark fringe':



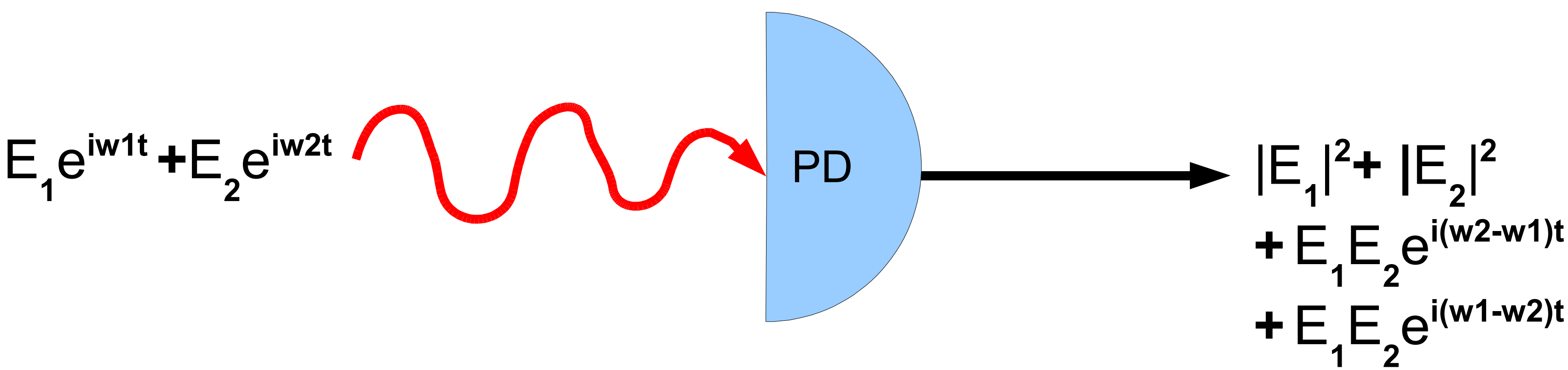
If we move off of the dark fringe, the light intensity at the antisymmetric port becomes linearly sensitive to DARM.

Using this as our measure of DARM is "**DC readout**".

brief aside: remember, **photodiodes measure power**



this means that they see **beat notes**:

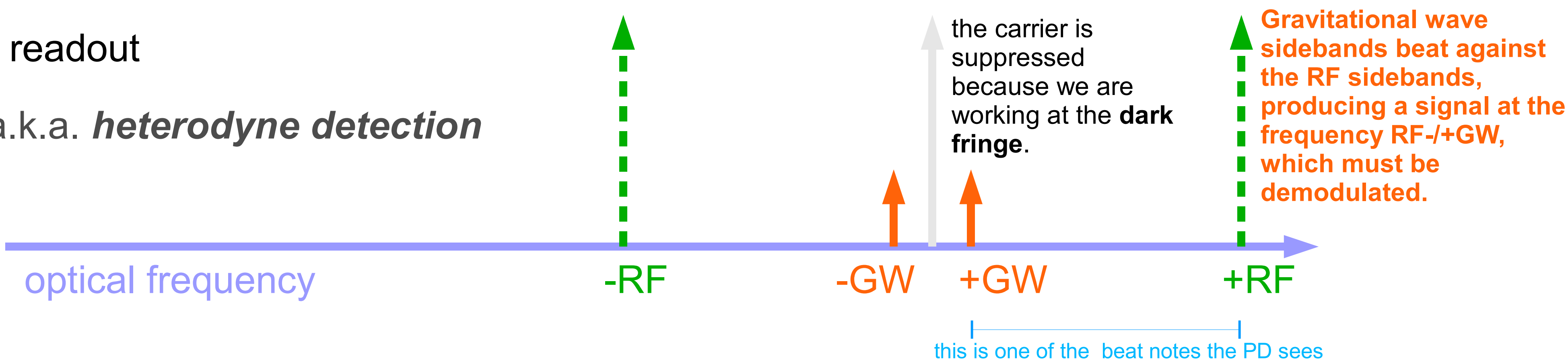


If the electric field is given by “sin (w1t) + sin(w2t)” then we will see signals from the PD at frequencies (w1+w2) and (w1-w2)

The frequency-domain picture: light at the antisymmetric port

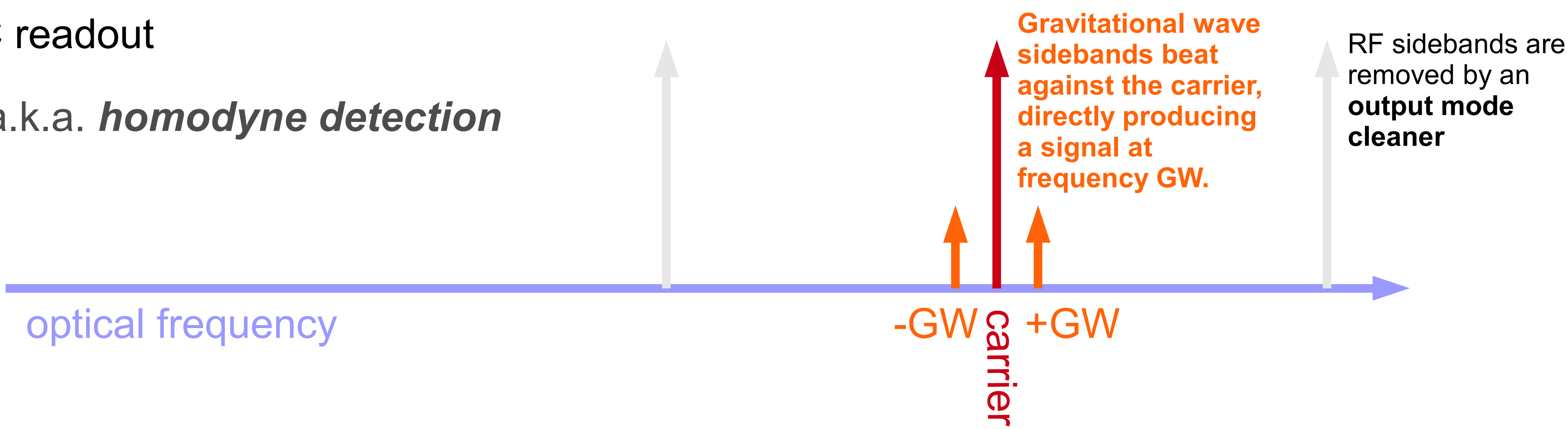
RF readout

a.k.a. ***heterodyne detection***



DC readout

a.k.a. ***homodyne detection***



It's called DC readout because we don't have to demodulate the signal on the PD. It's also kind of a pun because “**d**irect **c**onversion” is another name for homodyne detection.

DC readout: why?

The carrier is cleaner than the RF sidebands

The carrier is filtered by both the power recycling cavity and the arms. This **coupled-cavity pole** is at only a few Hertz!

The RF sidebands originate with some kind of radio frequency oscillator which is not perfect. **Oscillator amplitude noise** and **oscillator phase noise** pollute the RF readout signal.

Other noise couplings are also better.

In-vacuum readout.

Simpler electronics.

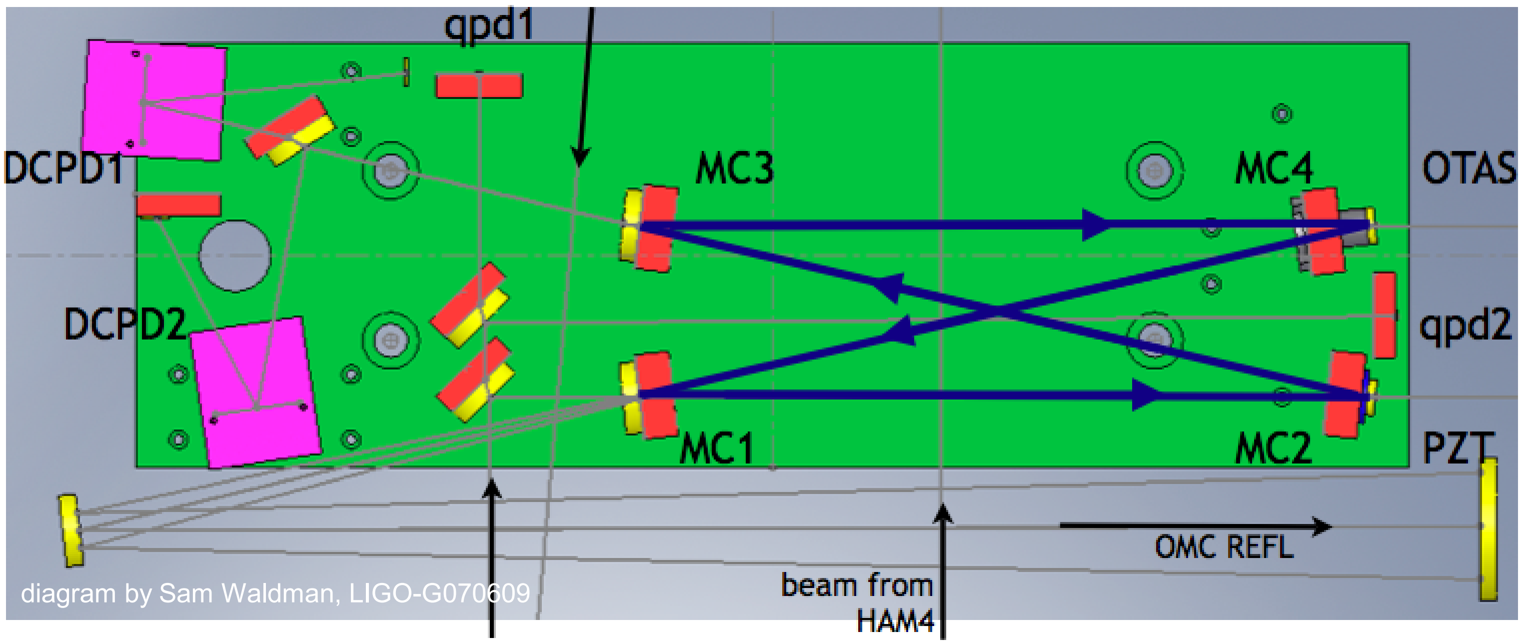
Can handle more power with fewer photodiodes

OMC removes junk light and guarantees perfect overlap of GW sidebands with local oscillator (carrier)

It's required by Advanced LIGO (?).

The Output Mode Cleaner

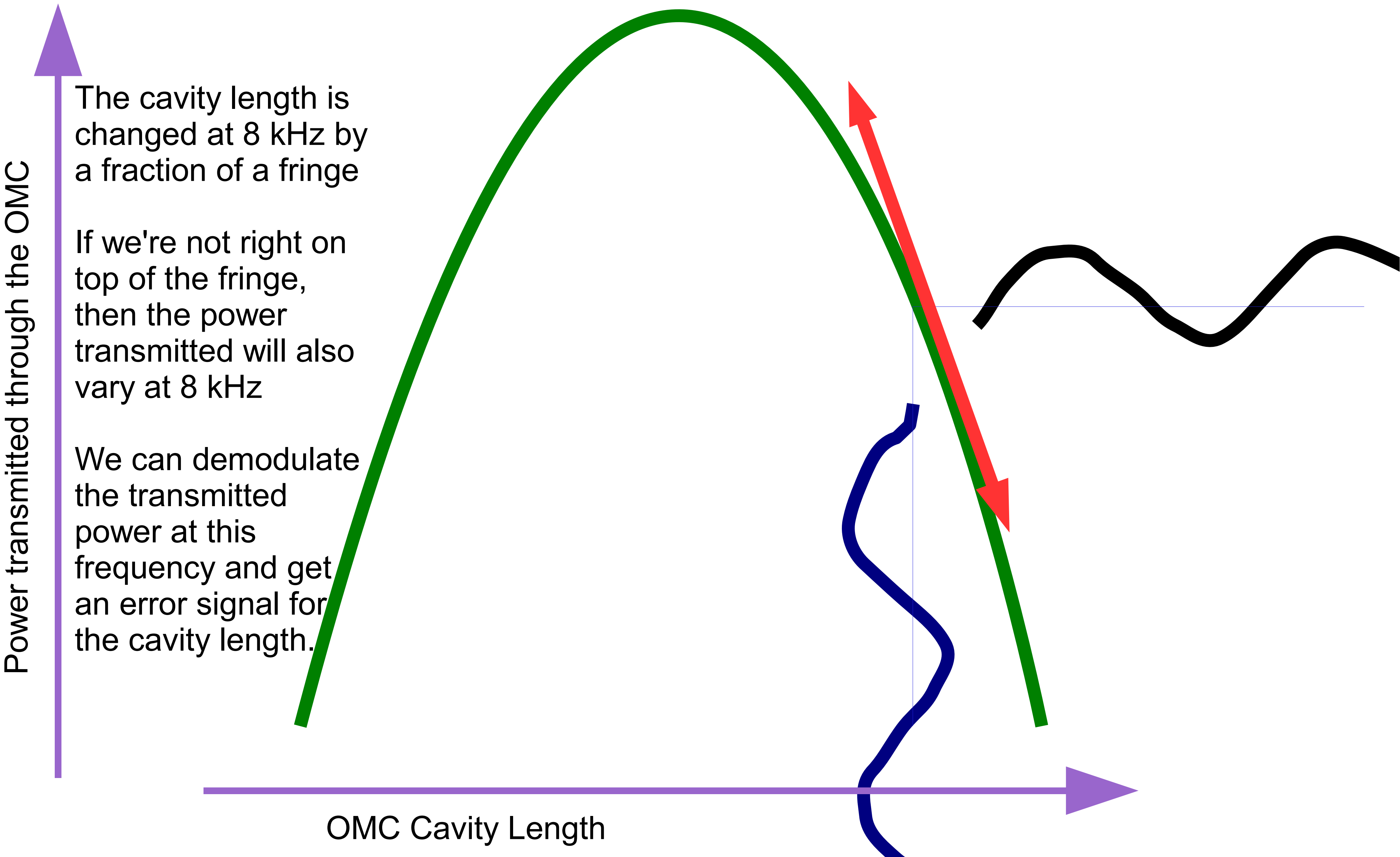
An **output mode cleaner** is used to remove the RF sidebands and higher order modes ("junk light").



- four mirror cavity (Finesse = 377, f_fsr = 286 MHz, f_c = 379 kHz)
- suspended, in-vacuum
- monolithic, ultra-low-(thermal)-expansion glass
- on-board readout photodiodes and quadrant photodiodes
- length dither locked

How the OMC is locked

The OMC itself is **dither locked**.



The cavity length is changed at 8 kHz by a fraction of a fringe

If we're not right on top of the fringe, then the power transmitted will also vary at 8 kHz

We can demodulate the transmitted power at this frequency and get an error signal for the cavity length.

The OMC suspension

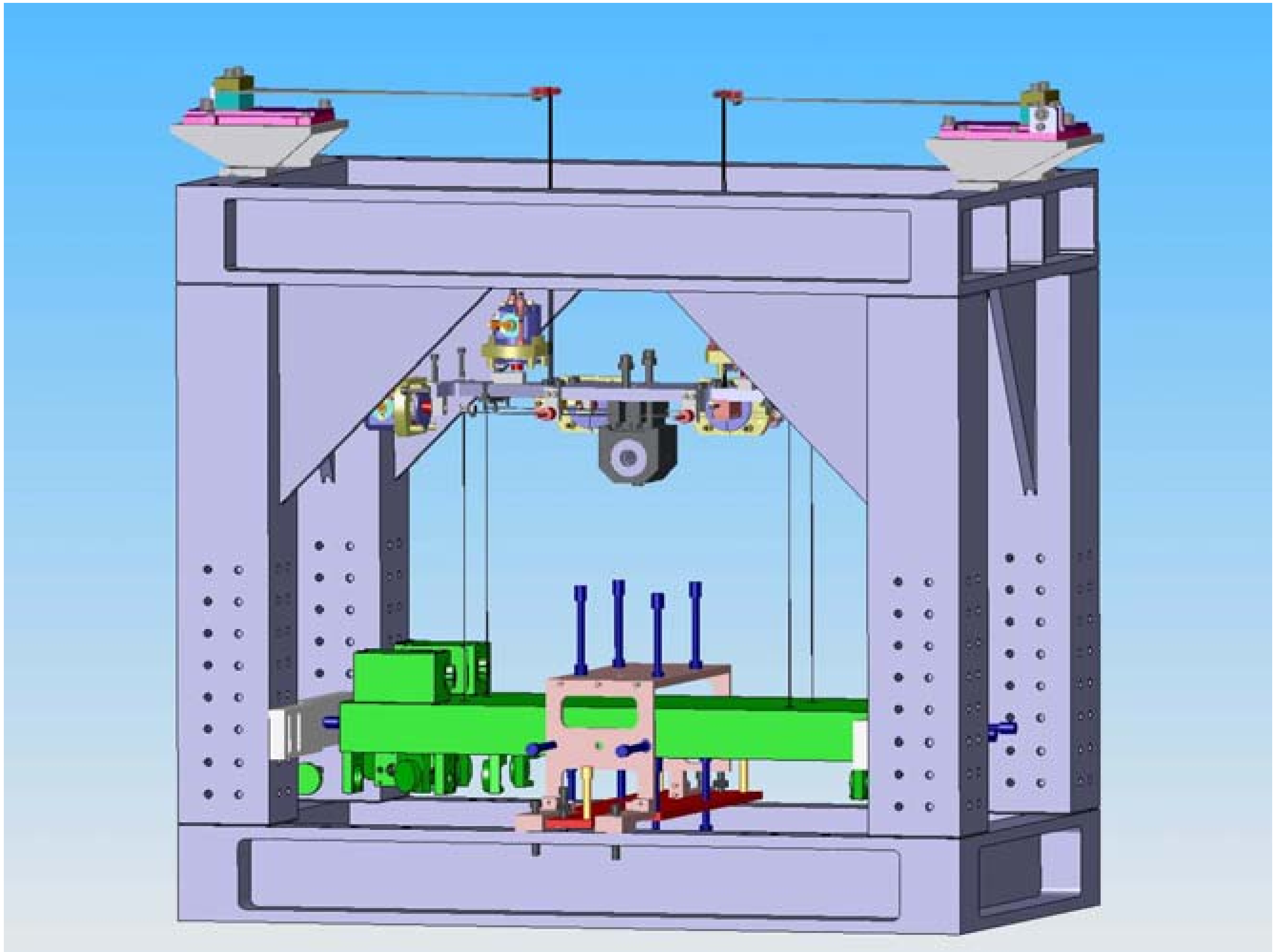


diagram from Norna Robertson's OMC SUS talk, G070062-00-R

HAM ISI table in HAM6

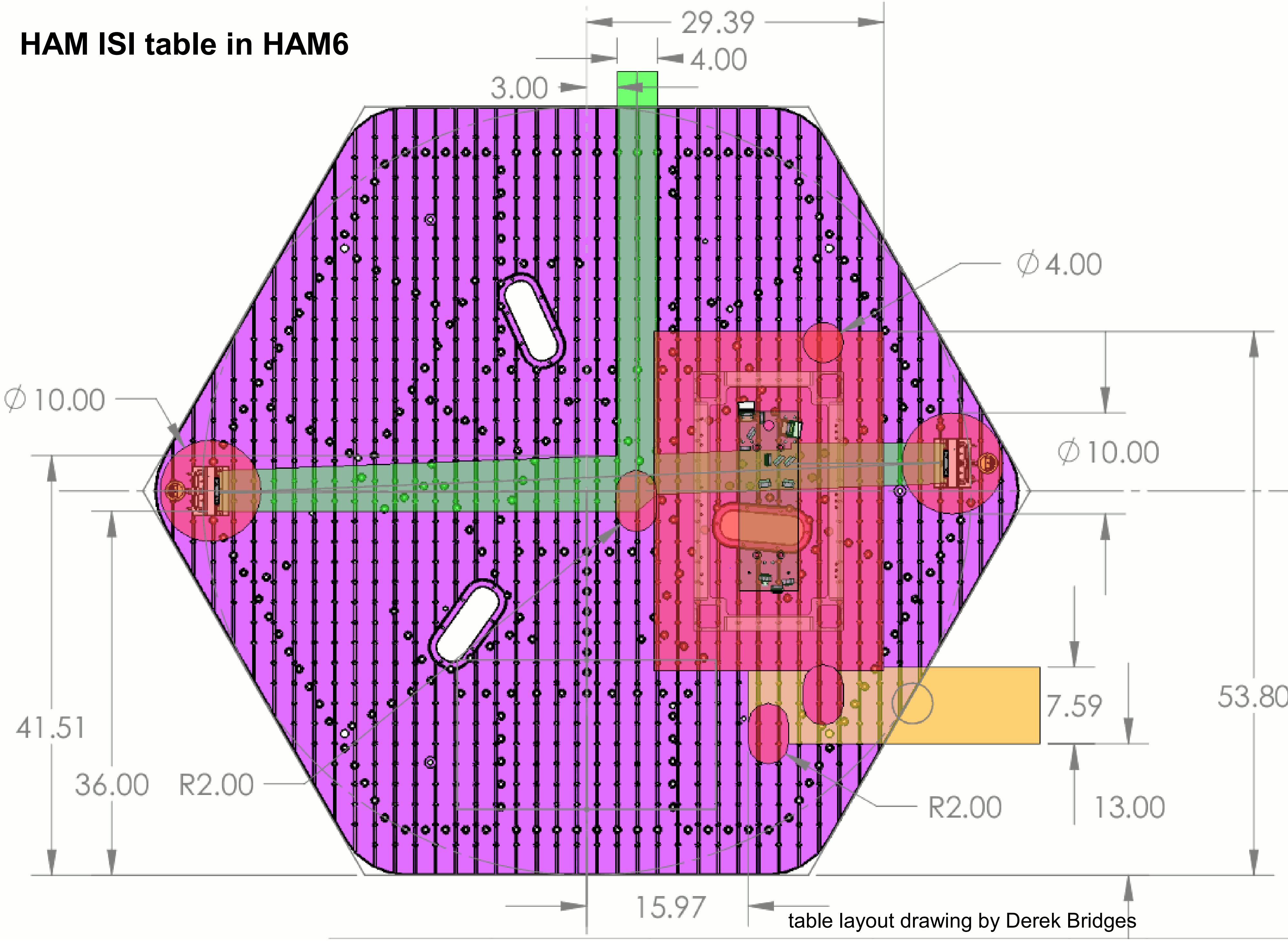


table layout drawing by Derek Bridges

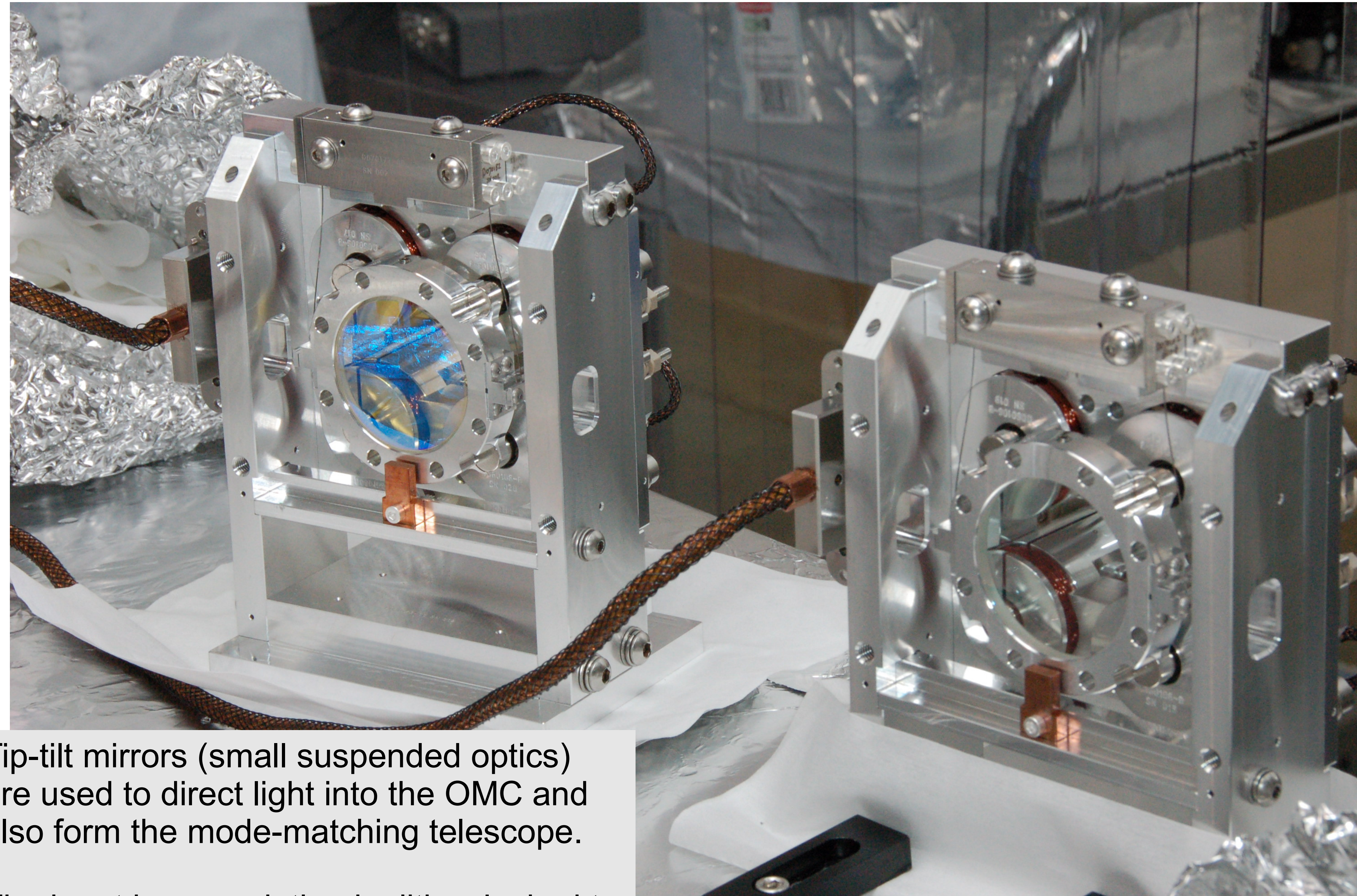
Angular (input beam pointing) controls

The OMC converts jitter of position and angle of its input beam into intensity variations at its output.

During a DC lock, these intensity variations will be interpreted as DARM variations. The spectrum will be polluted.

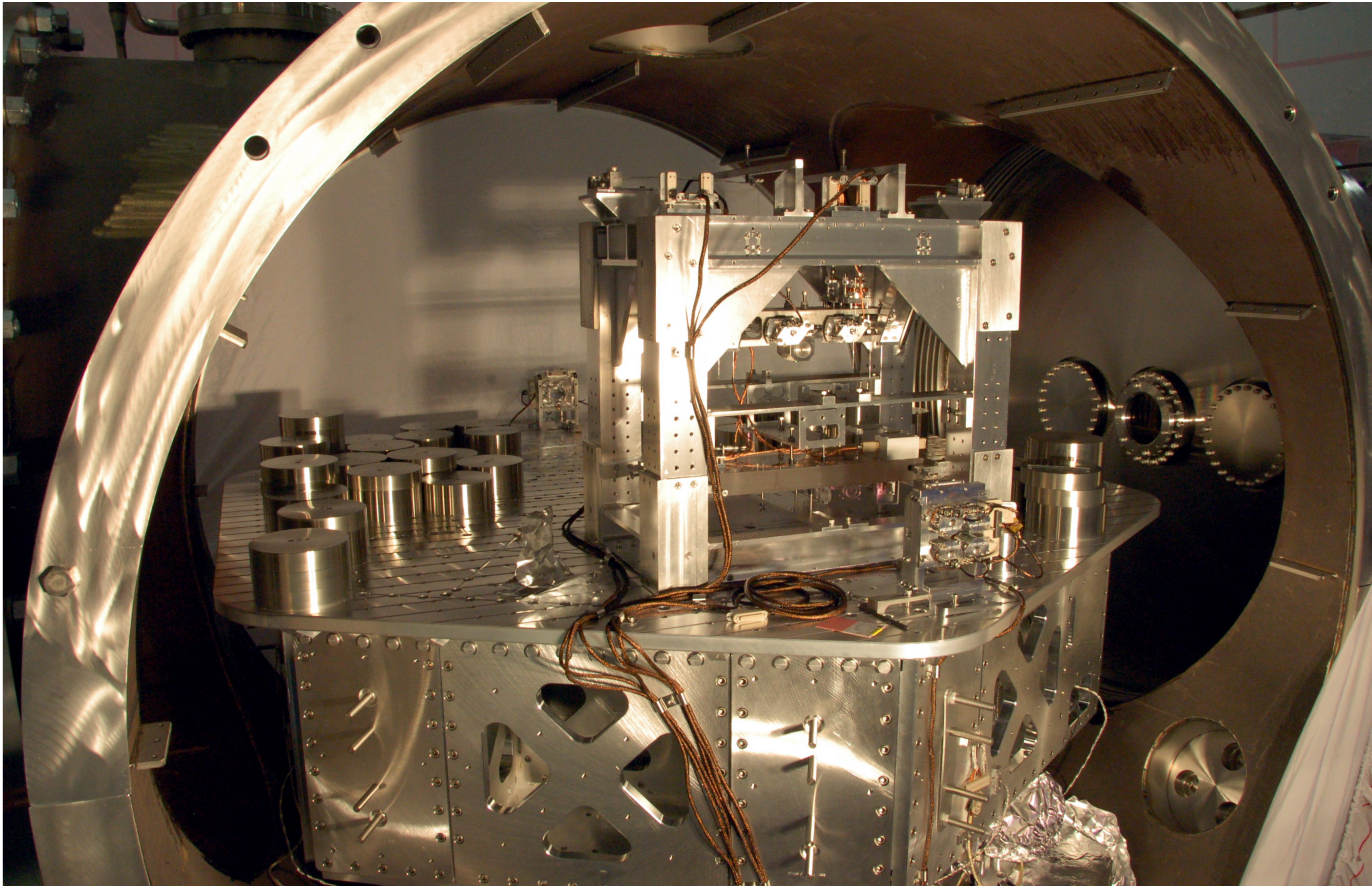
Therefore angular controls are needed to keep the beam aligned to the OMC cavity.

the “tiptilts”

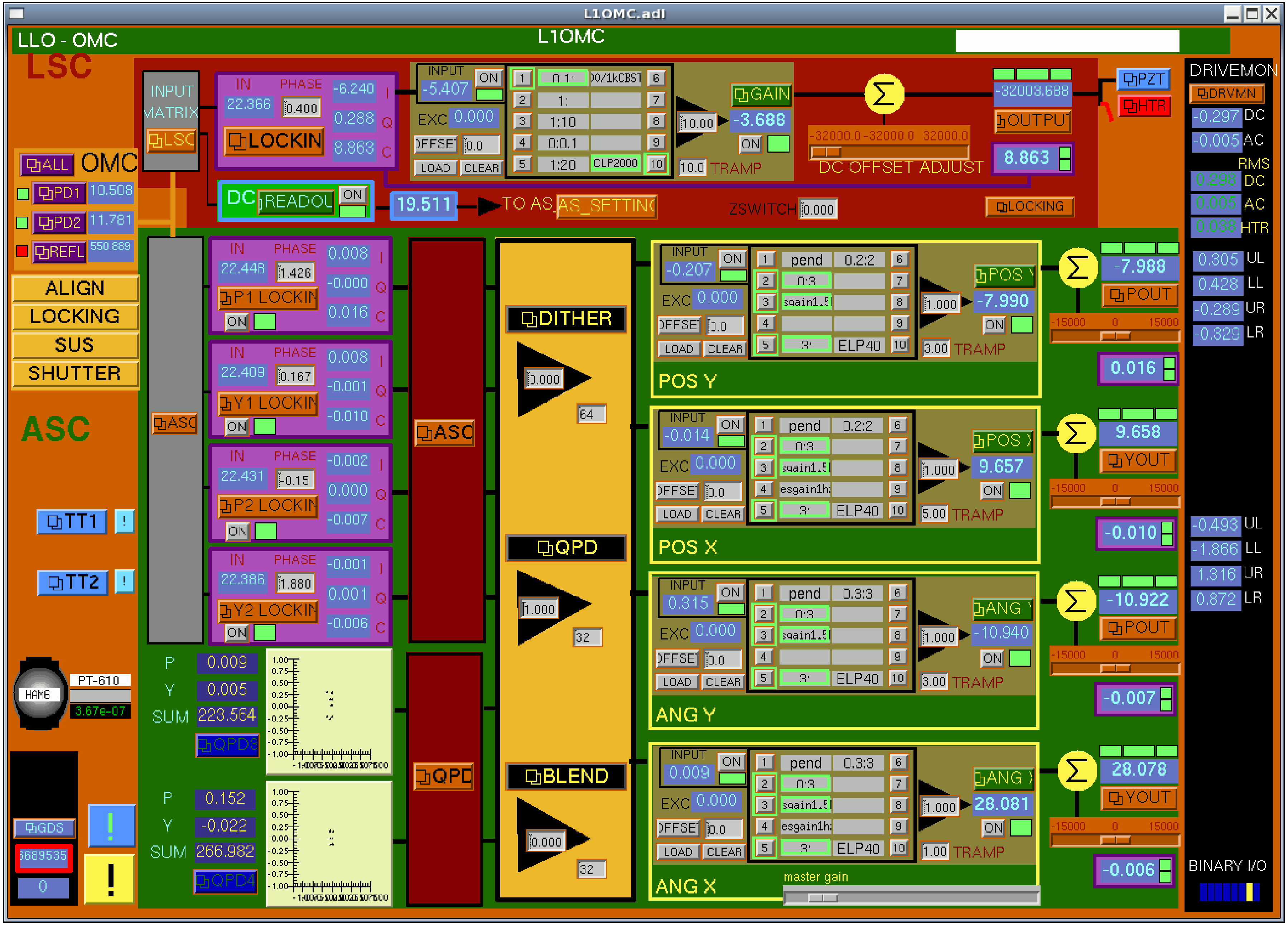


Tip-tilt mirrors (small suspended optics) are used to direct light into the OMC and also form the mode-matching telescope.

The input beam pointing is dither-locked to the cavity the installed OMC



The OMC's MEDM screen



Imported directly from 40m (including color scheme!)

How we transition to DC locking

1. Lock the interferometer in the usual way, using RF, on ASPD5 (the high dynamic range, high noise locking PD)

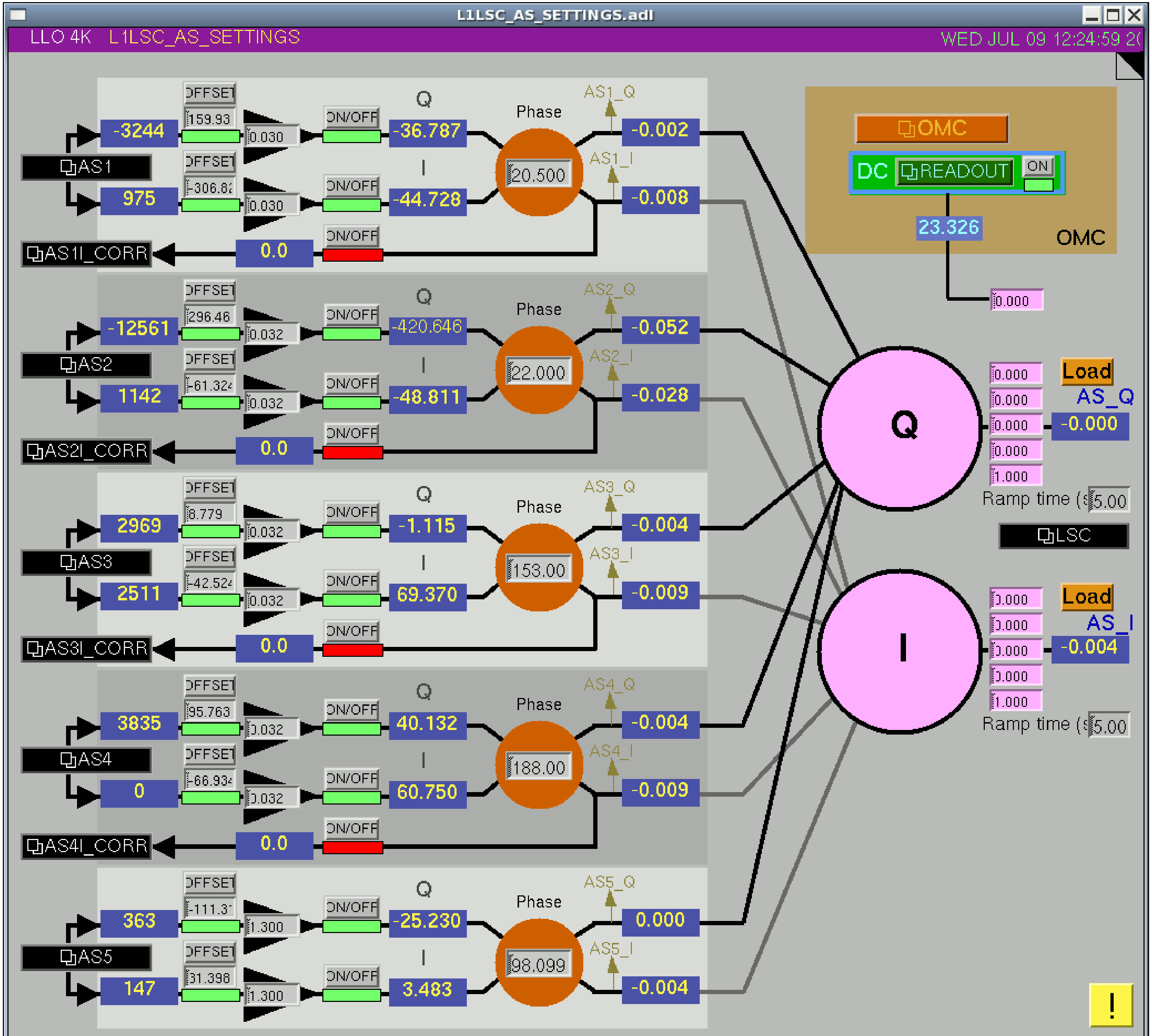
2. Put in a DARM offset

3. Lock the Output Mode Cleaner to the carrier

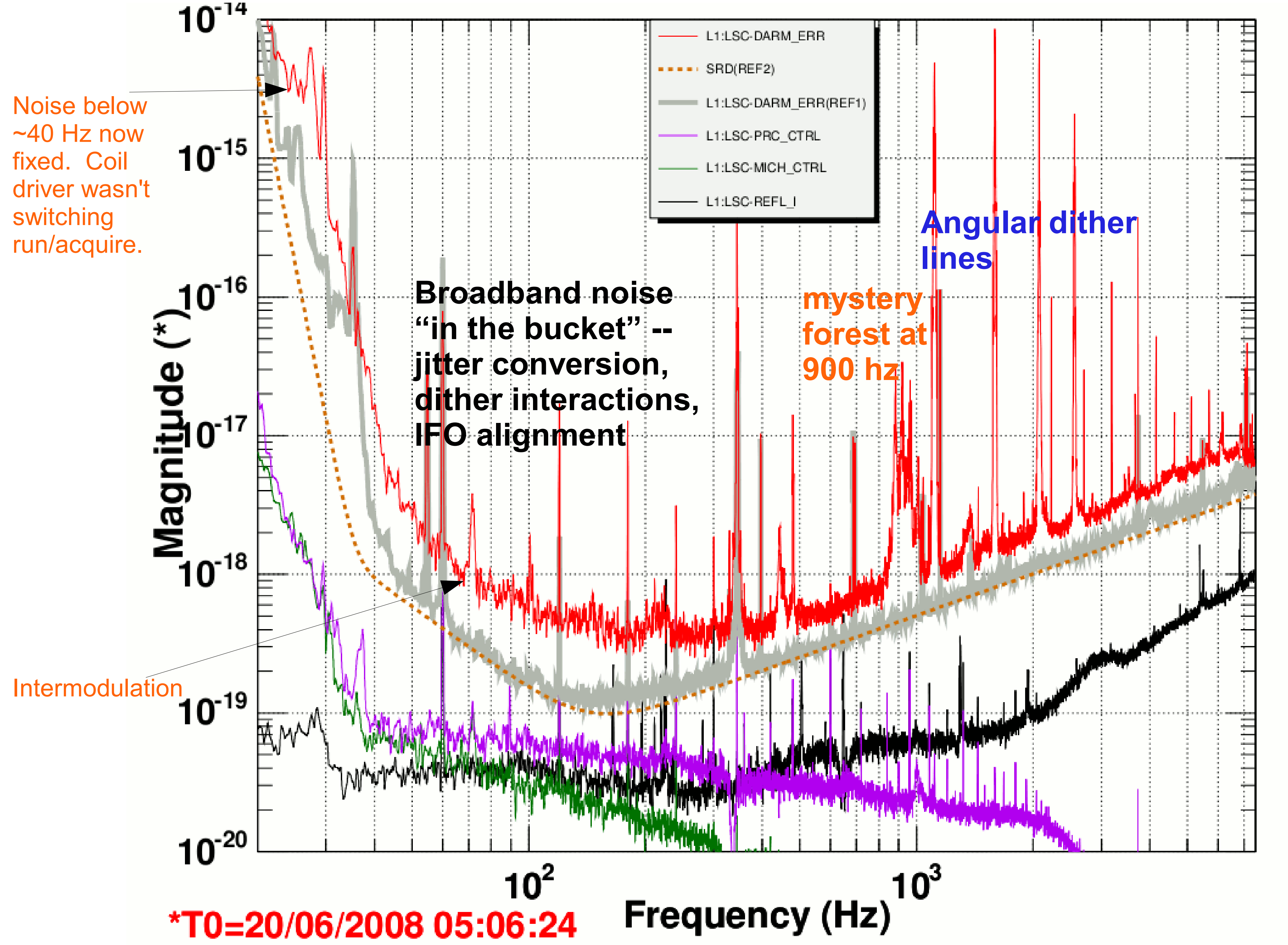
4. Adjust the OMC_READOUT gain and offset to match AS_Q

5. Change the AS matrix so that DARM_ERR comes from OMC_READOUT instead of AS_Q

The new AS PD MEDM screen



sort-of recent noise



where we are now

We can DC lock the interferometer via the OMC and get a noise spectrum approaching S5's.

But it remains to be seen whether the scheme of dithering locking both cavity length and input beam pointing will be sufficient.