

# Stones in the Road:

things to watch out for, and some potentially useful tools, as we work toward a better LIGO1 detector

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- ◆ Changes affecting Acquisition and Control Robustness
  - » Sideband mode-matching and thermal compensators
  - » 4k Schnuup asymmetry issues
  - » Non-resonant sidebands as a part of the LSC control system
- ◆ Noise Hunting with SimLIGO
  - » What will lower shot noise reveal?
  - » When do we need to turn off the OSEM damping loops?
  - » How much does noise on POB matter?
  - » Can we get to the SRD noise level?
  - » ASC control schemes: can we use the QPDs to control the TMs?
  - » What is the source of this line?

# Sideband Mode-matching and Thermal Compensators

- ◆ Current best SB recycling gain at H1 is 25
  - » Should be about 37
  - » Unmatched SB provides “stable” reflected SB field (used in REFL\_I to make error signal for CM servo)
- ◆ Increased Thermal Lens
  - » Maximum recycling gain reached at 2.5 W
  - » Thermal compensators may provide better mode-matching
- ◆ ...but is this a good thing?

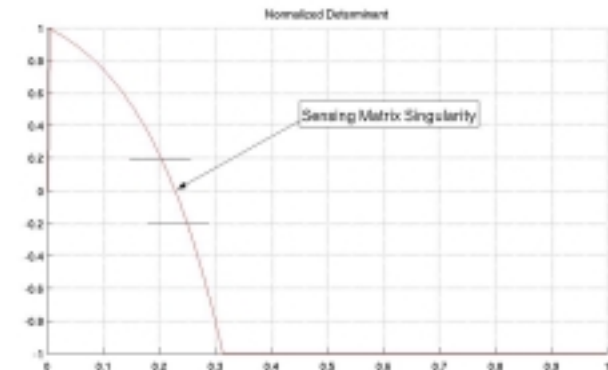
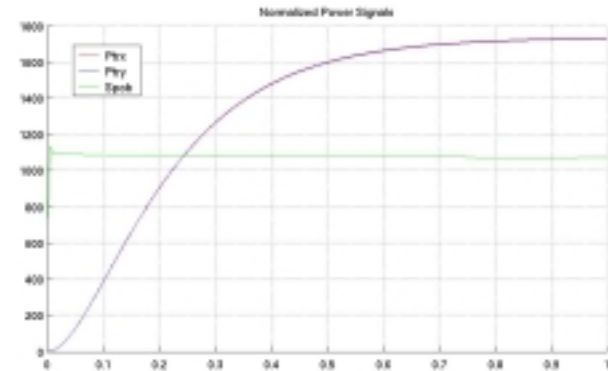
# Sideband Mode-matching continued...

## ◆ Pros...

- » Lower shot noise
- » More stable LSC/ASC sensing matrix
- » Decreased SPOB fluctuation

## ◆ Cons...

- » LSC sensing matrix singularity moves to higher power (usually near PTR-SPOB crossing)
- » Lock acquisition becomes more difficult as singularity crossing happens later (and slower)
- » Lock robustness decreases as REFL\_I gain becomes less stable



# 4k Asymmetry Issues

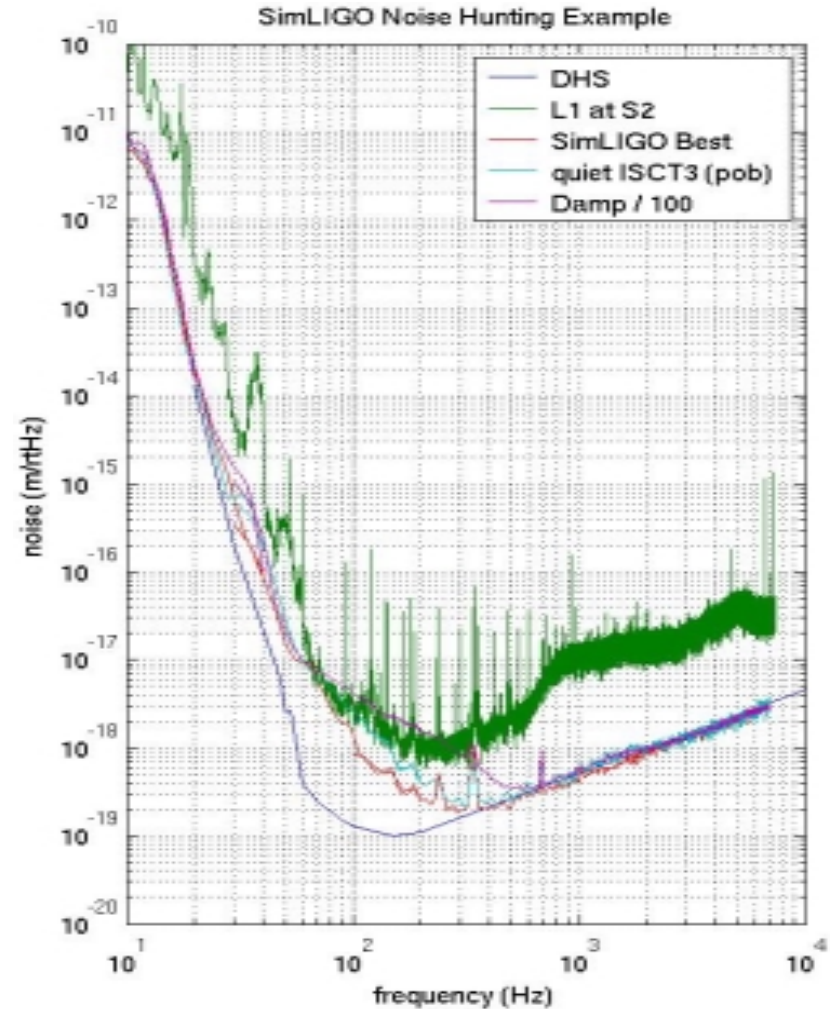
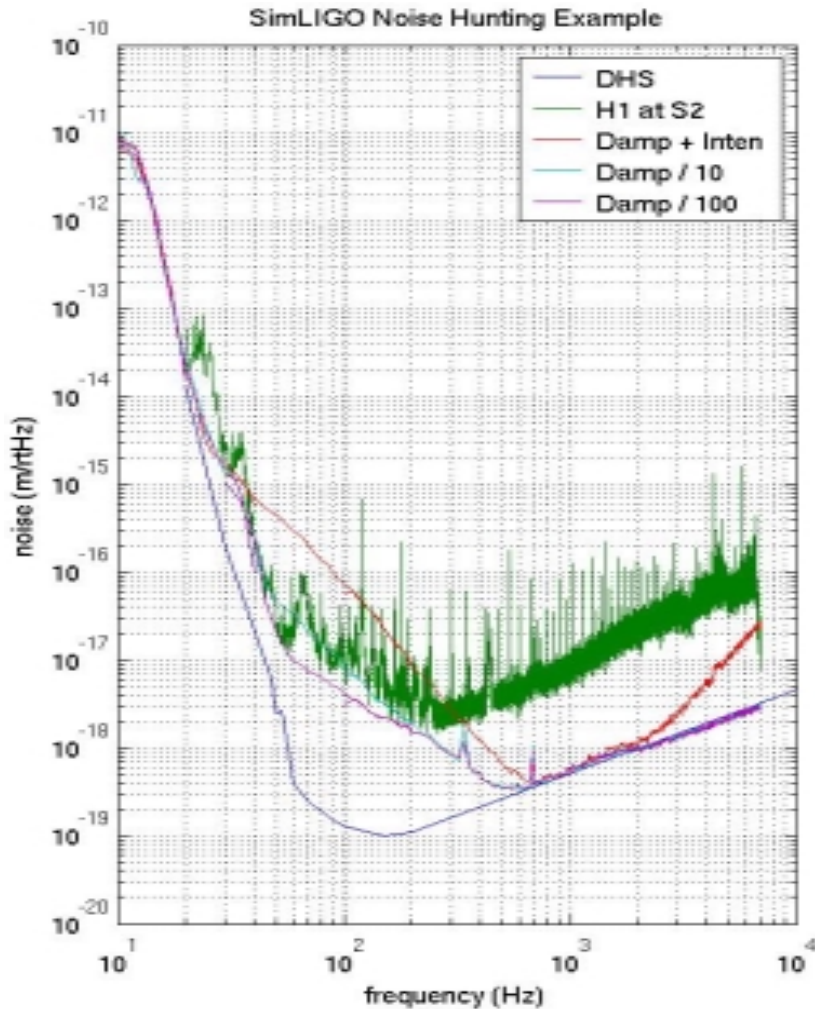
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- ◆ Asymmetry for H2 is 300mm
  - » About 3% power transmission to AS port
  - » Gives 10% SB amplitude reflectivity, as intended
  - » Alignment imperfections effectively increase reflectivity
- ◆ H1 was 323mm, now 379mm
  - » Increased optimal SB amplitude reflectivity to ~10% (was near zero)
  - » Lower reflectivity moves sensing matrix singularity to higher power
- ◆ L1 asymmetry 310mm
  - » About 2.7% power transmission to AS port
  - » Very near critical coupling
  - » Alignment fluctuations may cause large SB reflectivity fluctuations, but not until the SB recycling gain is improved

# Non-resonant SBs as part of LSC control system

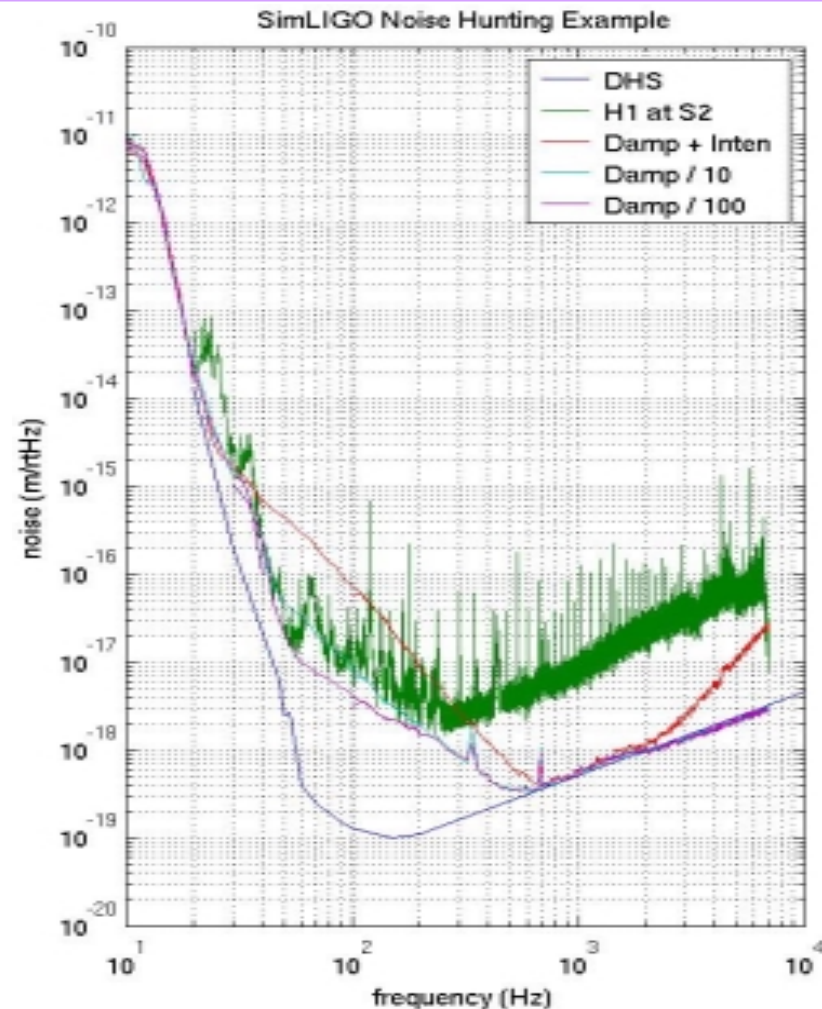
- ◆ ~60 MHz non-resonant sidebands
  - » Included for use in ASC system
  - » Not resonant in any part of the IFO
  - » Added in series modulation with resonant sidebands
  - » Could replace REFL\_I as error signal for CM servo
- ◆ Pros...
  - » Better signal separation, but not perfect (SB on SB contribute)
  - » Moves matrix singularity to much lower power
  - » Eliminates some technical detection problems (REFL\_Q saturation, WFS3 and WFS4 sensitivity to CARM)
- ◆ Cons...
  - » Noisier signal on smaller photo-diode
  - » Not in original design, so not thought out as carefully?

...and now for something a little different...



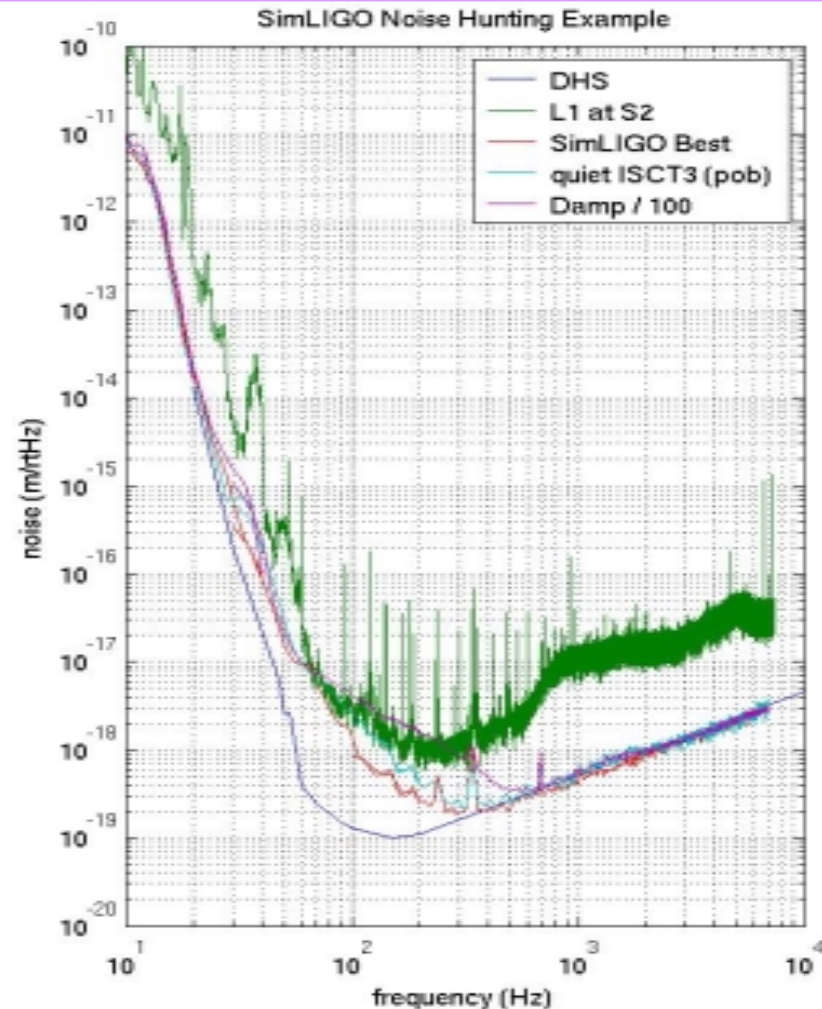
# Noise Hunting with SimLIGO

- ◆ Some things to think about
  - » What will lower shot noise reveal?
    - Intensity noise
    - Frequency noise
    - OSEM damper noise
  - » When do we need to turn off the OSEM damping loops?
    - Design calls for loops to be turned off, but they never are.
    - Critical (red)
    - Down by 10 (cyan)
    - Down by 100 (purple)
    - The loops should be disabled, or should use better filters.



# Noise Hunting with SimLIGO

- » How much does noise on POB matter?
  - Nominal shot noise (purple)
  - No shot noise (yellow)
  - Reduces PRC and MICH noise
- » Can we get to the SRD noise level?
  - Eliminate all other noise sources
  - More realistic estimate given by David Shoemaker et. al.
- ◆ Other uses
  - » ASC control schemes
    - Various control matrices: QPDs?
    - Sidebands on sidebands...who knew?
    - Self-stabilizing alignments?
  - » What is the source of this line?





# Conclusion

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- ◆ Changes affecting Acquisition and Control Robustness
  - » Thermal compensators...a mixed blessing
  - » 4k Schnuup asymmetry...still not enough?
  - » Non-resonant sidebands in LSC...good, but not great...wait until we really know that need them?
- ◆ Ongoing work with SimLIGO
  - » Semi-quantitative estimates of when to expect limiting noises to appear
  - » Qualitative view of possible contributions from some sources
  - » Some help with ASC system, though this is limited by current mode-matching (outside of the range of the SimLIGO modal model)
  - » Possibility for tracking down specific features
- ◆ Thanks to Hiro and Rana