Using Finesse to Model Mode-Mismatch in aLIGO

The Setup

- Start with aLIGO standard .kat file
  - Includes all main optics
  - Added tunable squeezing (10db) + a filter cavity
  - Added ideal mode-matching optics between SRC and OFI

The Big Questions

- We’ve seen SR3 and SRM RoC changes affect the mode-matching of the IFO:
  - How do those changes affect the h(t) w/ and w/o squeezing?
  - If we vary the mode of the SRC, but keep the Arms and OMC mode-matched, how does that effect h(t)?
    - If the negative effect of changing the SRC mode is small, it could allow us to use SRM as a mode-matching actuator.

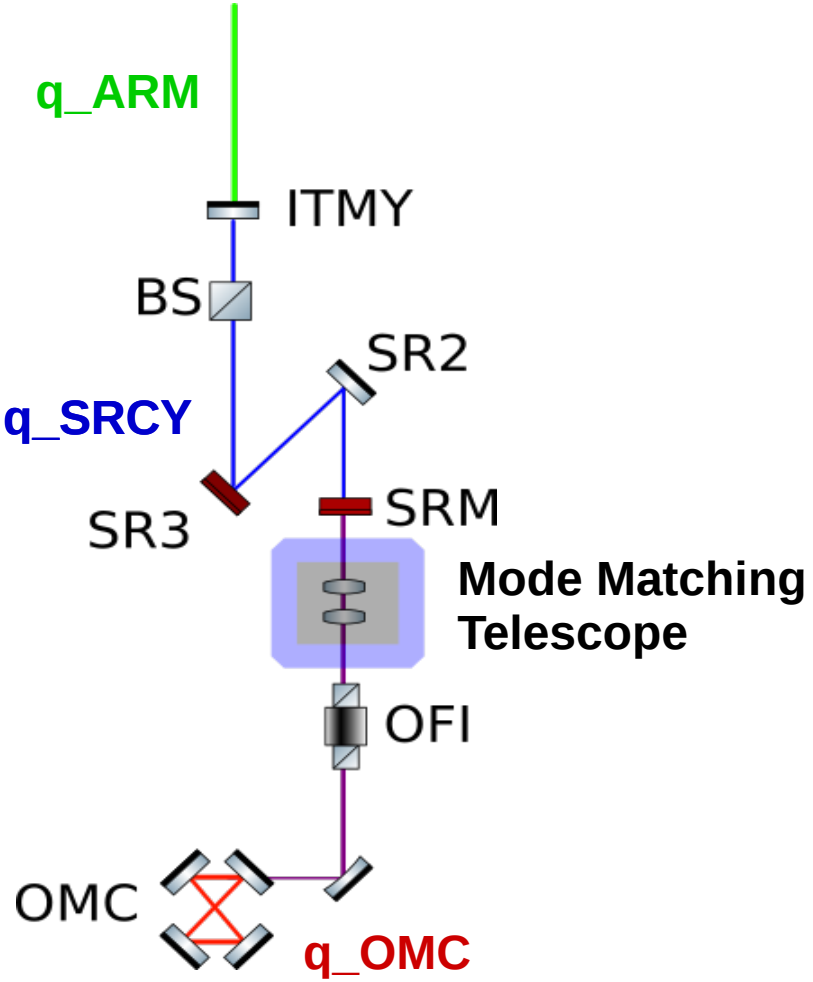
The Modified Cavities

1. Vary the SRM **OR** SR3 RoC

2. Use the Mode Matching Telescope to keep the ARM and OMC overlap at 100% while changing the SRM Roc.

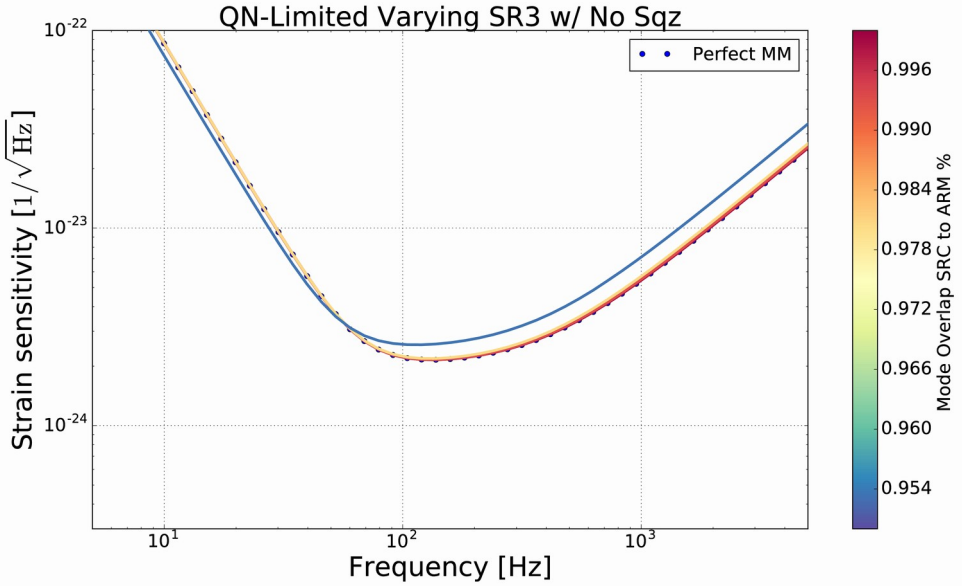
3. Find the ARM, SRC, and OMC modes at the BS to measure the overlaps between any two modes.

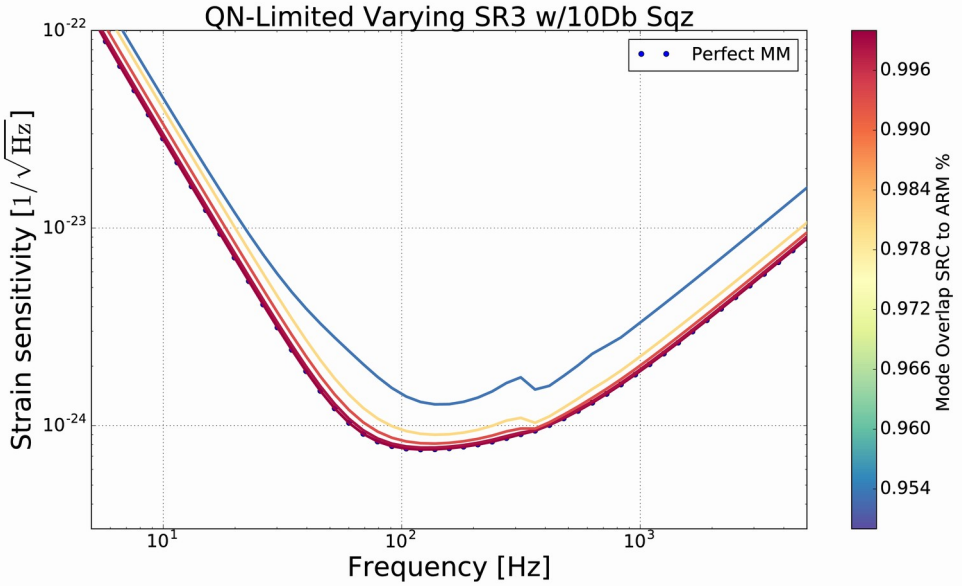
4. Output the QM-limited h(t) to see how badly an SRC mismatch hurts us.



Sensitivity Outputs

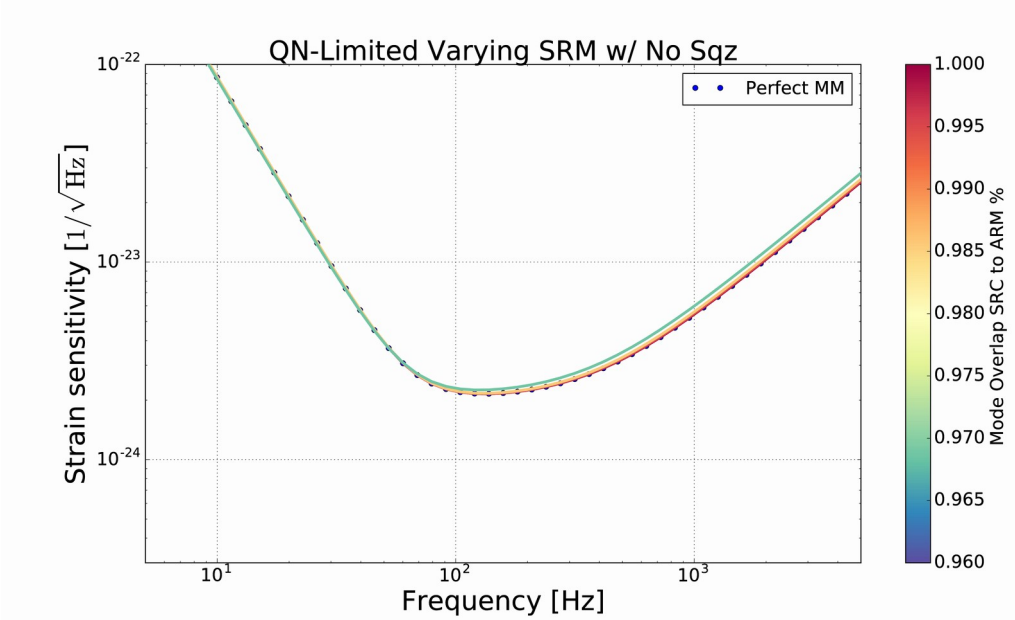
- Changing SR3 curvature by up to 2cm
  - It's clear to see that that mode-mismatching SR3 hurts us, especially in the Squeezed IFO

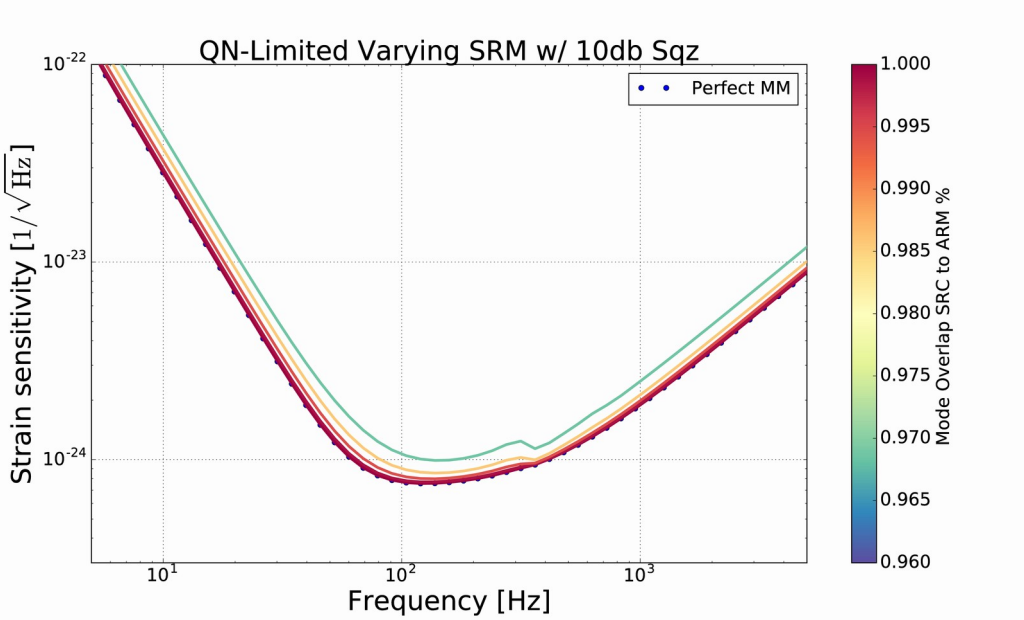


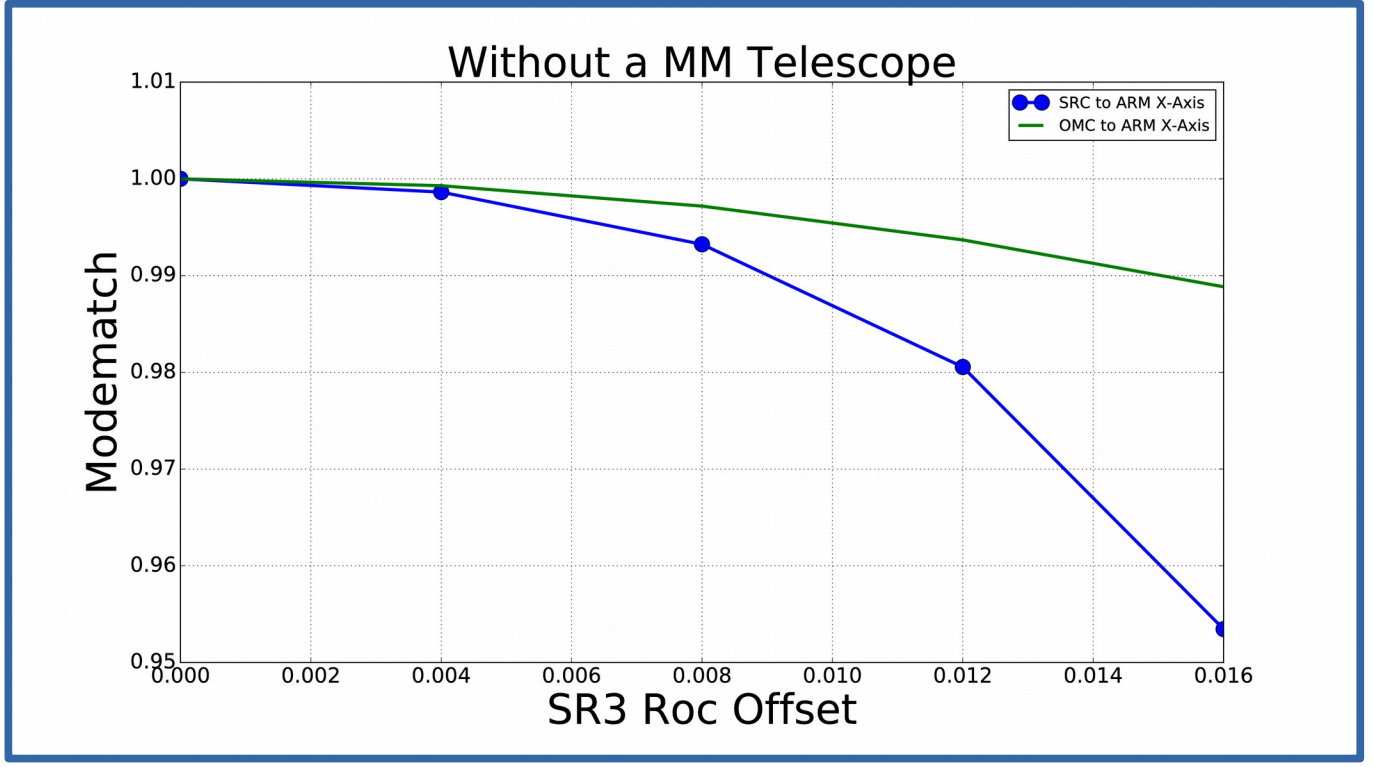


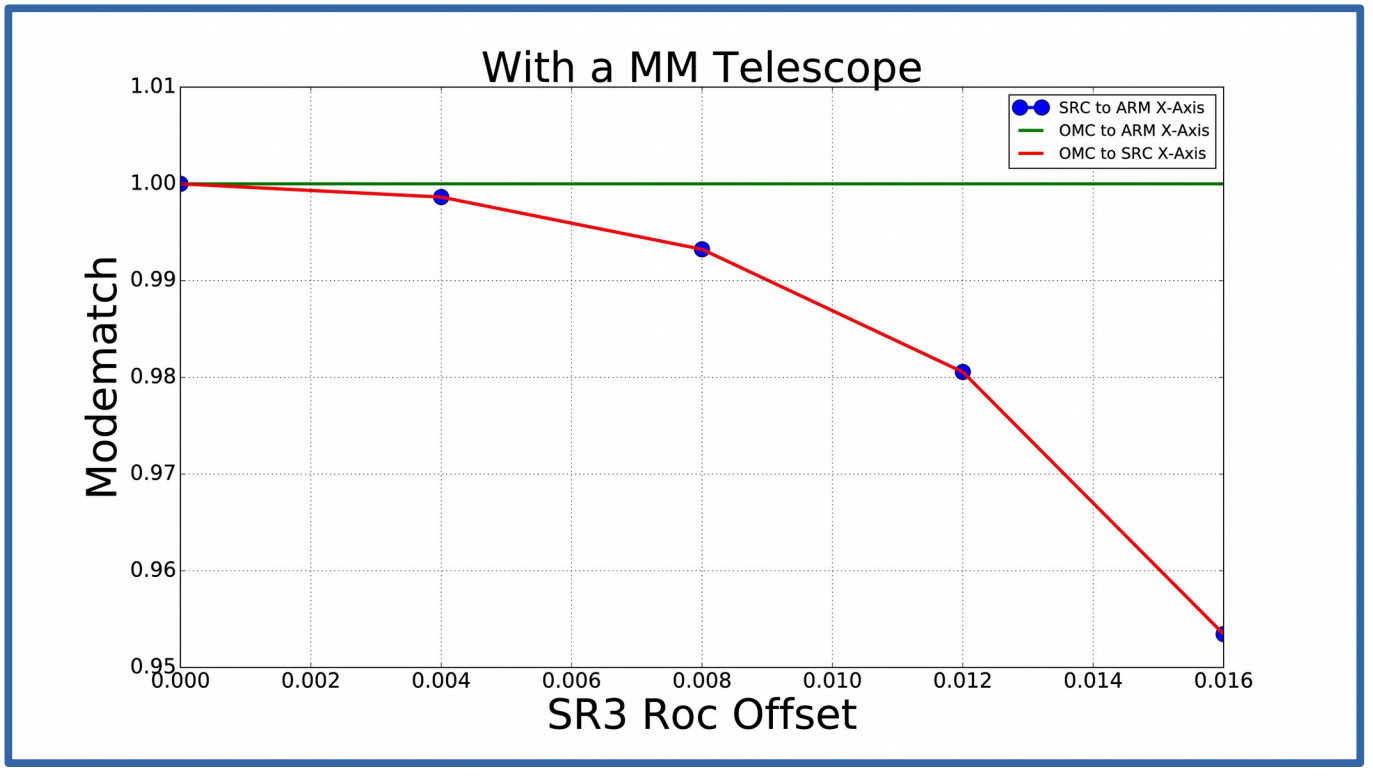
Sensitivity Outputs

- Changing SRM curvature by up to 50cm (this is huge!)
  - Not terrible for either squeezed or non-squeezed.



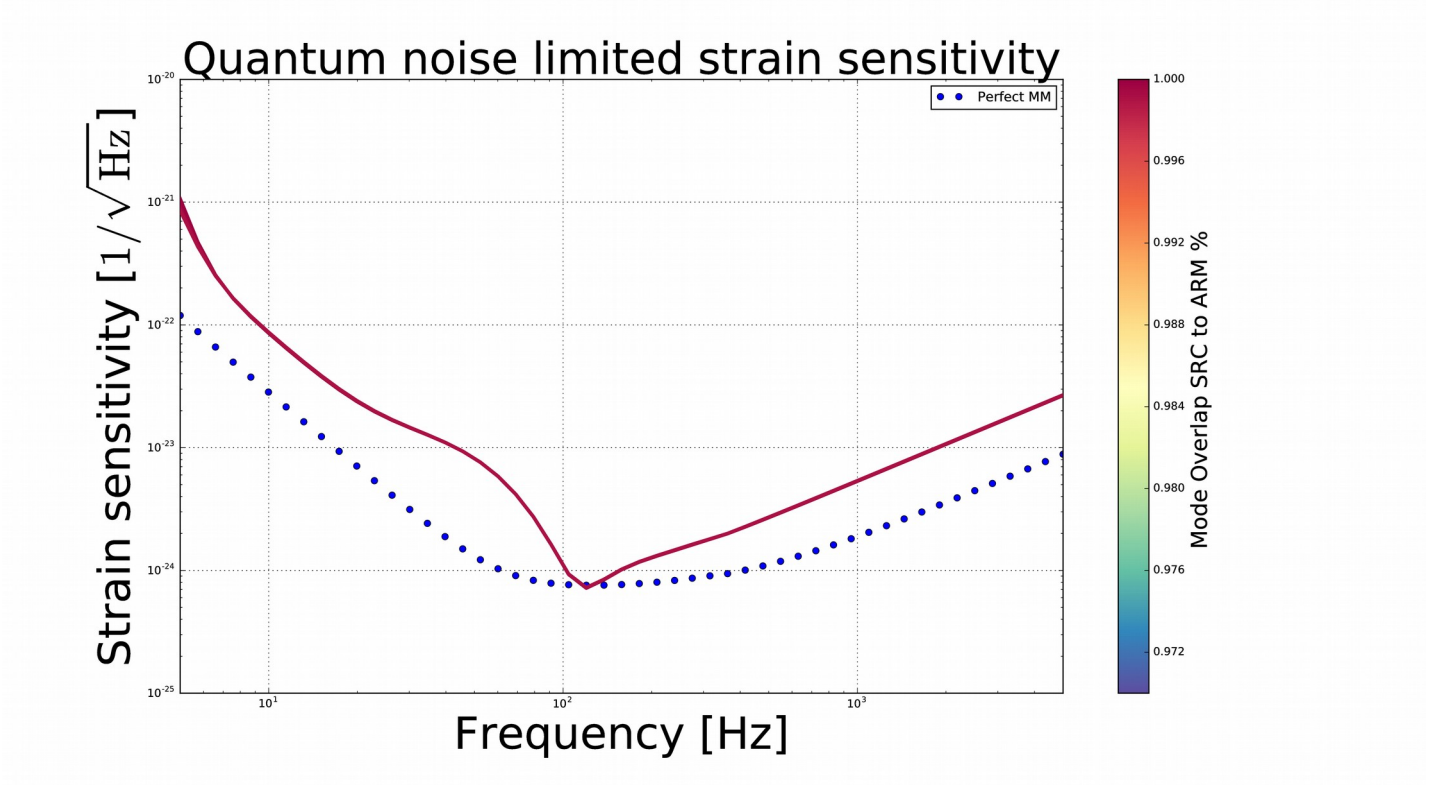



Without a MM Telescope
SRC to ARM X-Axis
OMC to ARM X-Axis
Modematch
SR3 Roc Offset
1.01
1.00
0.99
0.98
0.97
0.96
0.95
0.000
0.002
0.004
0.006
0.008
0.010
0.012
0.014
0.016


With a MM Telescope
SRC to ARM X-Axis
OMC to ARM X-Axis
OMC to SRC X-Axis
Modematch
SR3 Roc Offset
1.01
1.00
0.99
0.98
0.97
0.96
0.95
0.000
0.002
0.004
0.006
0.008
0.010
0.012
0.014
0.016

Checking Ourselves

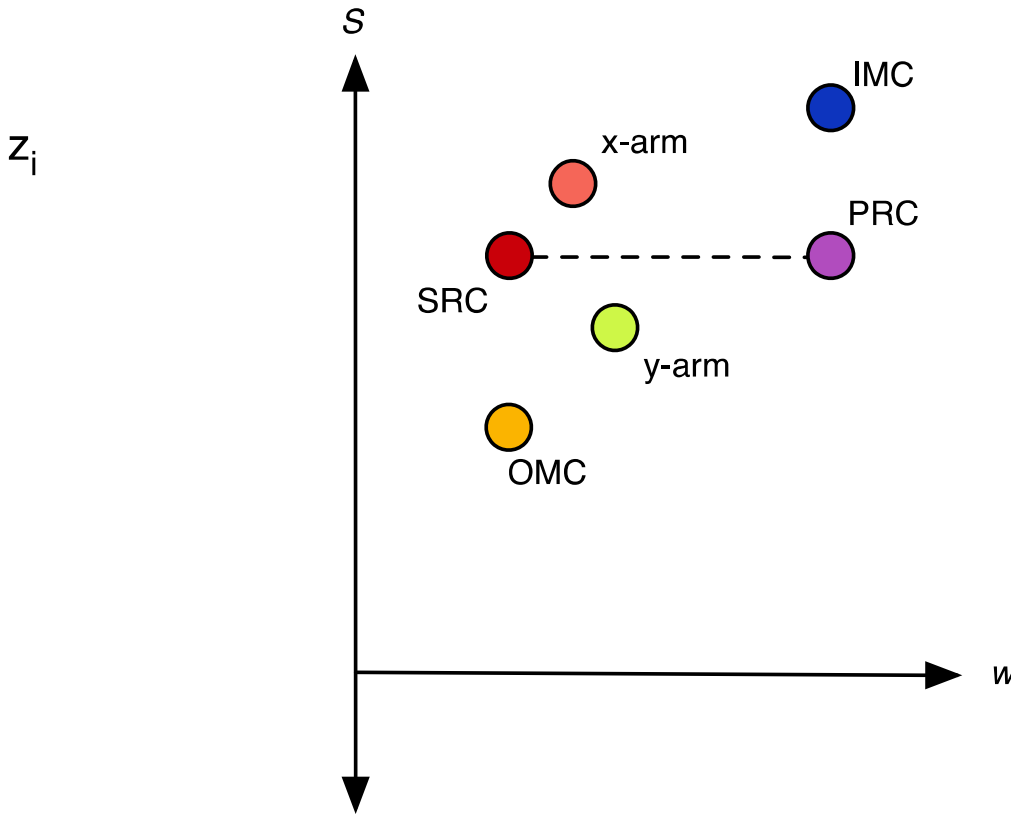
- Setting the SRM Trans to 1:
  - We should see no effects when varying the curvature as long as we include sufficient higher order modes.



WS Space

Next Steps

- Look to see how mode-mismatch affects other cavities and the guoy phase relation between actuators:



Extra Slides: Finesse+Pykat

- Advantages
  - A full aLIGO Fourier domain analyses
  - Output a QM-limited sensitivity
  - You can add optics as needed for design purposes
- Disadvantages
  - Complexity (multiple cavities & a lot of code)
  - Need careful consideration of higher order modes
    - The larger the mismatches, the more coupling to HOMs, the more computationally expensive it is to run this analysis.