Path to an ALPS II Upgrade

Plans on improving the performance of the optical system in summer/fall 2021

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Characterizing performance

Duty Cycle vs. Sensitivity

Improving Duty Cycle

- Actuators (or lack thereof) likely limiting duty cycle
  - Proposal: Floating tables
- Very low duty cycle could limit sensitivity if measurement time is limited

Improving Sensitivity

- Increasing power circulating in PC
  - What needs to change for this?
- Increasing power build up in the RC
  - Plans to procure lower loss mirrors
- Other ideas (Guido)

Actuator limited by pointing noise

Improving Duty Cycle

- New long range actuator design could increase dynamic range
  - Same wave washer ‘sandwich’ concept as previous actuator, but with short range and long range piezo
    - Long range Piezo 100um with 1000V commercial HV
    - Short range Piezo 2.5um with 400V AEI HV
- Newport stage is the suspected cause of the pointing coupling
- Not expected to be limited by long term pointing of tables
- Even with long range actuator PZT actuator pointing coupling is still expected to be a problem

Other Actuator Options

Floating tables at the end stations as long range actuators

- Would potentially provide long range angular and longitudinal actuators
  - No active actuation of pointing with current system
- Likely improved performance in length lock PLL
  - Newport stage not needed, mount could be rigidly fixed to table
    - Increases the frequency of resonances (BW increases)
    - Isolation at critical frequencies (10-100Hz) of end stations
      - No isolation at central table, but potential for feed forward from a single sensor on COB
    - Likely to reduce pointing coupling of length actuator

Other Actuator Options

Drawbacks on floating tables

- From correspondence with BILZ
  - Step size 10um
  - Company doesn't recommend using them for active horizontal positioning as it will short the isolation
    - Does that matter for such small actuation range?
  - Cost ~100k euro total for two tables
- Noise perfomance at resonances?
- Stability during commissioning?

Operating PC at higher power

What needs to change

- COB QPDs gain (damage threshold?)
- Straylight?
- Other components that may have longer lead times?

Cavity Scattering loss

Challenges to achieving high power buildup

Scattering losses due to surface roughness of substrates

- Deviations from a perfect sphere scatters light into higher order modes
- Integrated over the area of the beam
  - Larger beams ➜ more scattering losses

- To achieve 40,000 power build requires losses < 25 ppm
  - ALPS IIc substrates: 40-65 ppm losses with 6 - 9 mm beam radius
  - aLIGO test masses: 40-65 ppm losses with 50 - 60 mm beam radius

Cavity Scattering loss

For RC mirror T_i = 100 ppm, T_o = 5 ppm (with 40-60 ppm losses)

- Power build up in the range of 13,800 - 19,000

For RC mirror T_i = 120 ppm, T_o = 5 ppm (with 40-60 ppm losses)

- Power build up in the range of 13,300 - 17,600

For RC mirror T_i = 45 ppm, T_o = 5 ppm (with 40 ppm losses)

- Power build up of 22,200

For RC mirror T_i = 25 ppm, T_o = 5 ppm (with 20 ppm losses)

- Power build up of 40,000

Cavity Scattering loss

How do we acquire substrates with improved scattering losses???

- Coastline claimed they would not have bid had they fully understood the specifications
- All others have also no-bid: Coherent, Gooch and Housego, REO, and ATF
- Need LIGO Test mass quality substrates in terms of surface quality
  - LMA???