# **PLL with uTCA**



DESY.

Richard Smith ALPS Collaboration Meeting, 09.06.2020





• Modify the length of the PC to match the light circulating in the RC



#### **PLL Test Setup**

- Use ALPS IIa RC to test with green beam from RL and IR beam from HPL
- Frequency control, not length control
- Measure dual resonance using PDH



#### **uTCA Schematic**

- Digital NCO maintains lock with beat note (± ~800 kHz from nominal)
- Control signal from NCO only runs ± 180°
- Implement counter to keep track of how many waves of phase
- Feed NCO control signal and wave accumulator to frequency servo
- Always maintains phase relationship



# **Dual resonance achievable**



- HPL locked to cavity, RL locked to HPL
- Frequency offset adjusted with resolution of ~240 Hz (62.5 MHz clock/2<sup>18</sup>)
- Measured with independently-calibrated PDH signal
- Unity gain frequency of 15 kHz

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# **Dual resonance comparable to analog frequency lock**



- Analog frequency lock measured with a secondary photodector not in control loop
- Analog frequency lock higher unity gain frequency

# Simulating a length lock with a frequency lock



- Reduce gain
- Match transfer function with length control servo
- Significant noise floor encountered with digital demodulation

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# Length lock vs PLL suppression



- Divide control by PDH error signal
- Length lock is in-loop error signal
- PLL does not have resonance compensation filtering

# **Suppressed noise similar to length lock**



- Same measurement procedure as frequency lock comparison
- Length lock uses Moku and analog servo

# **Projecting measurements onto ALPS IIc cavity**



• Apply ALPS IIc cavity pole of ~16 Hz

# **Calculate phase noise**



- Divide by frequency
- Integrate rms to  $1/T_{storage} = 100 \text{ Hz}$
- φrms = 0.2 rad, compared to requirements of 0.1 rad

#### Limitations

- Lock acquisition currently makes length control impossible
  - Beat signal moves quickly beyond range of NCO
  - Cannot turn up gain faster due to word length of input
- Controller servo does not have enough coefficients for length control
  - Controller is 6x6 state space, resonance compensation requires 8x8 plus length control, totaling 10x10



## **Next steps**

- Write up results
- Improve lock acquisition
  - Increase input word length
  - Increase NCO tracking range
- Test with length actuation
  - Add another 6x6 servo
- Implement external timing reference

