



---

# Absolute Calibration of IFO Control Signals

A comparison of two simple DC  
calibration methods of IFO control signals

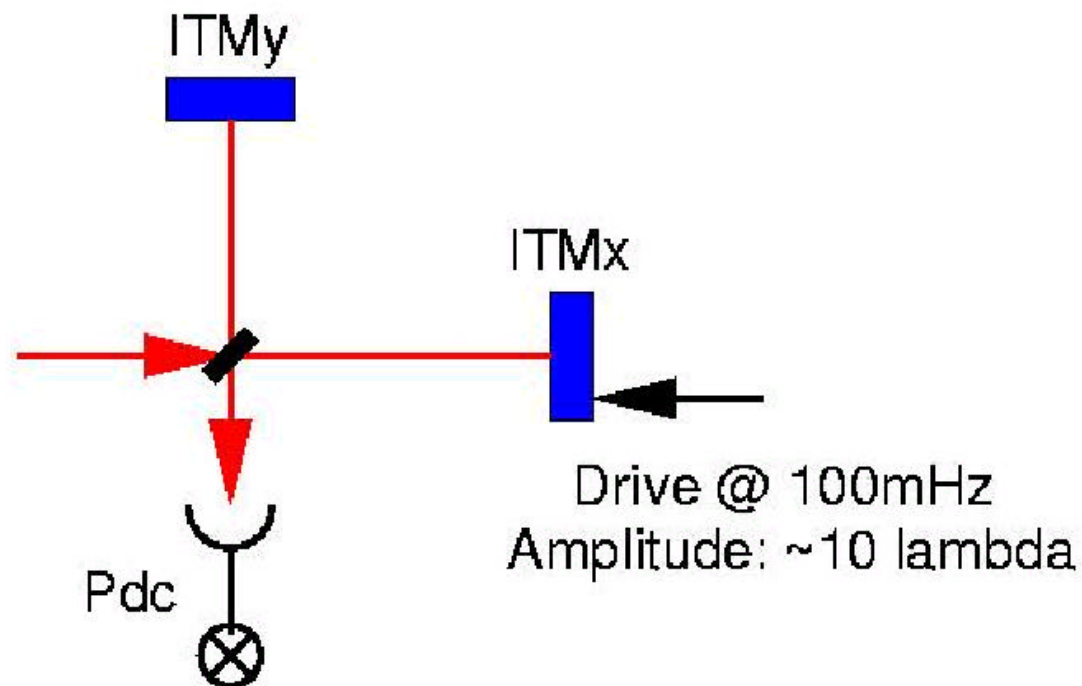
Luca Matone  
LIGO Caltech

Michael Landry  
LIGO Hanford Observatory

Detector Characterization Session

# ITM calibration: fringe counting

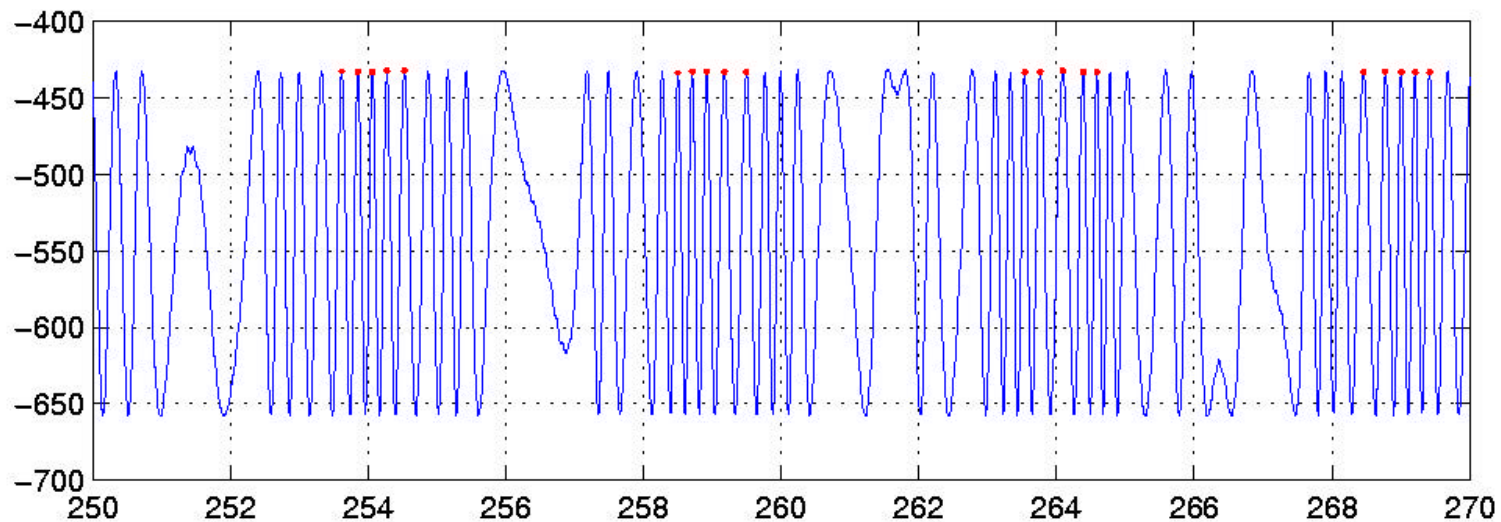
- Basic idea: drive mass with known force and measure displacement
- Drive the ITM with a slow sinusoid (0.1 Hz) and count the number of fringes that are read out at the antisymmetric port.



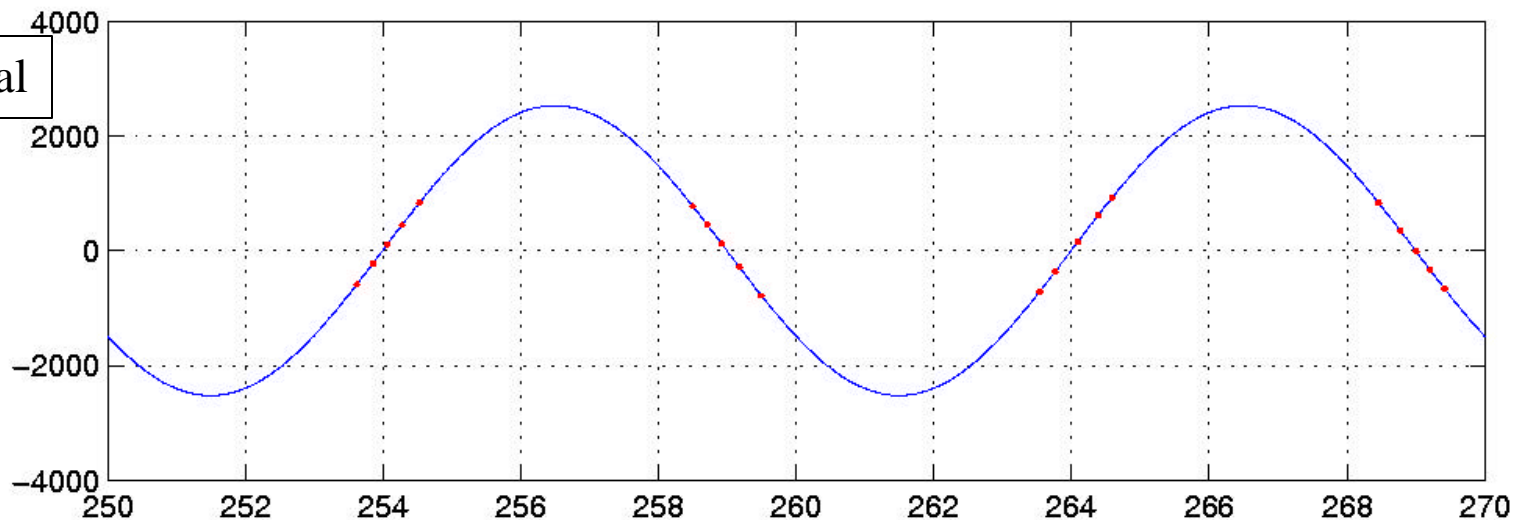


# Swinging data

AS DC

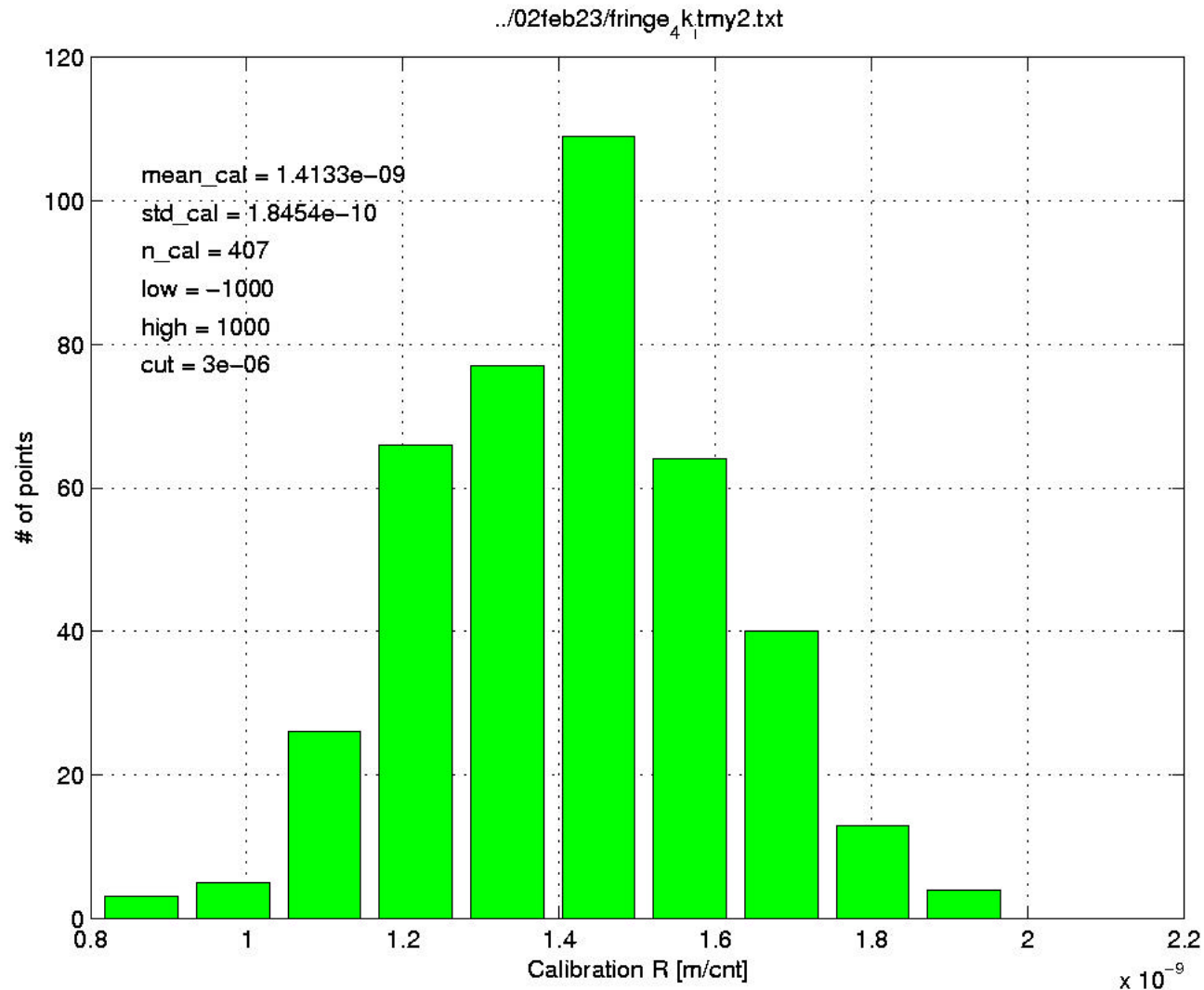


ITM control signal





# Fringe count analysis: 4k ITMY

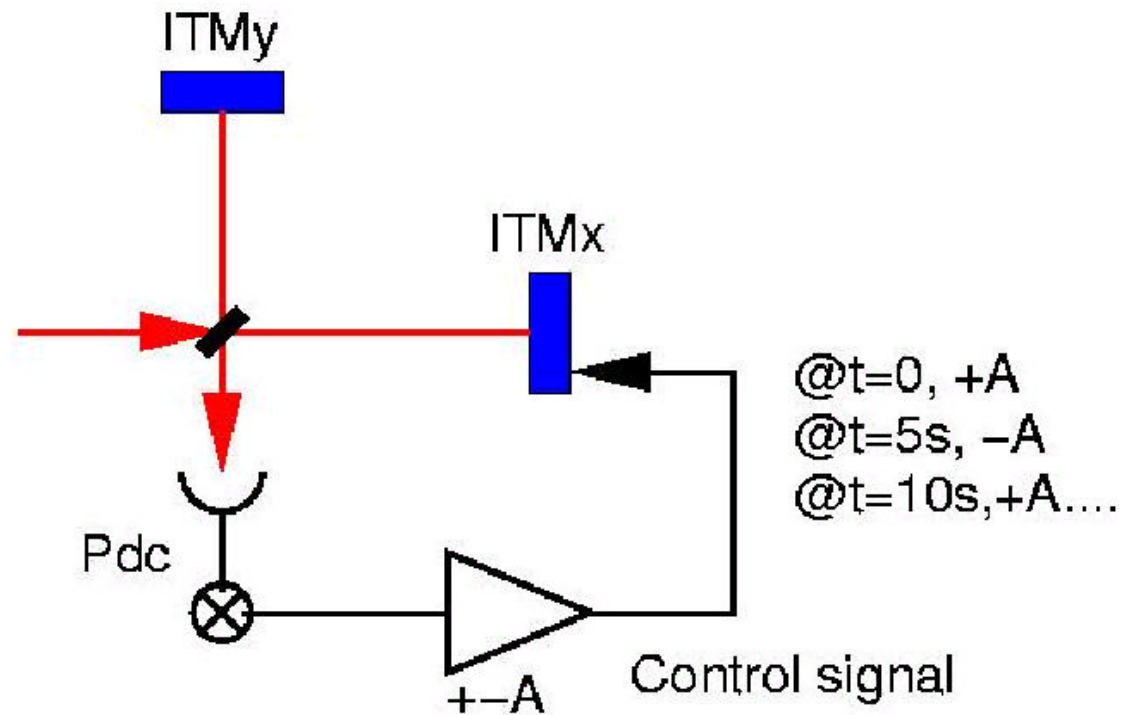


H1:LSC-ITMY  
 $1.413 \times 10^{-9}$  m/count

Sigma  
 $0.185 \times 10^{-9}$

# ITM calibration: fringe toggling

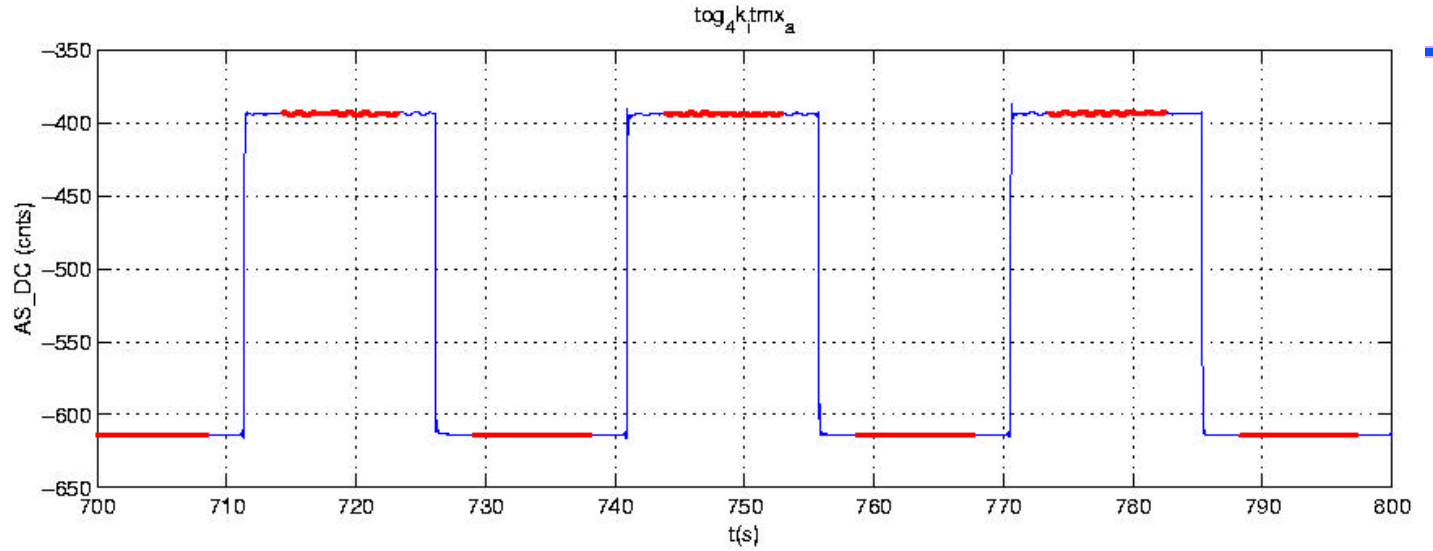
Alternative to swinging: Stan Whitcomb suggested toggling the sign of the Michelson control signal



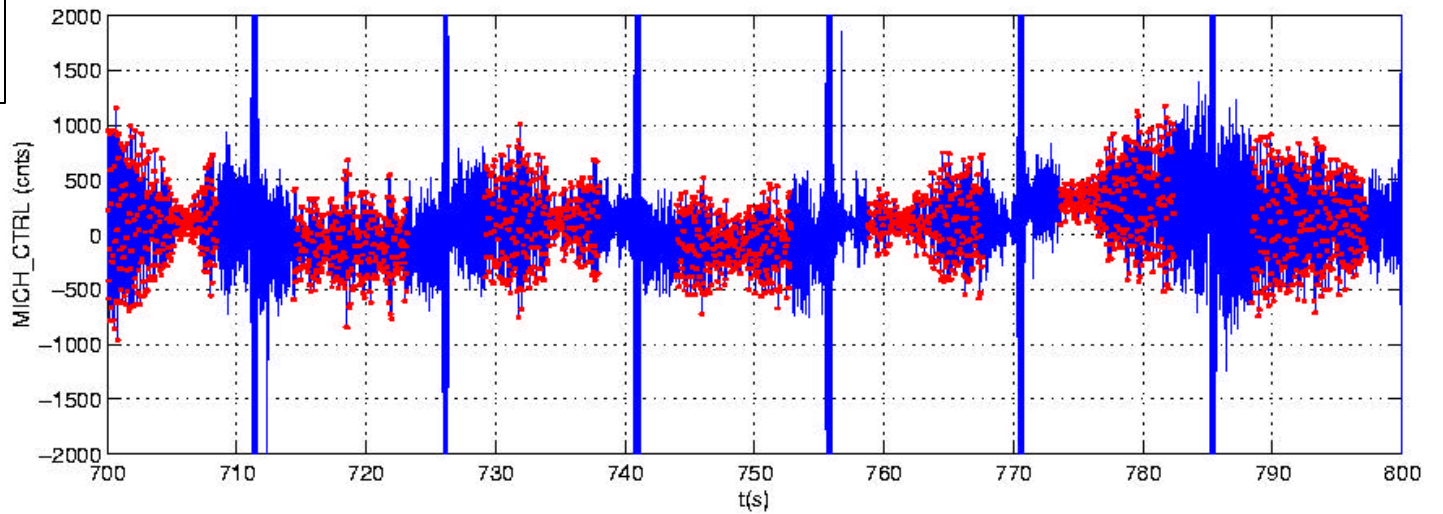


# Toggling data

AS DC



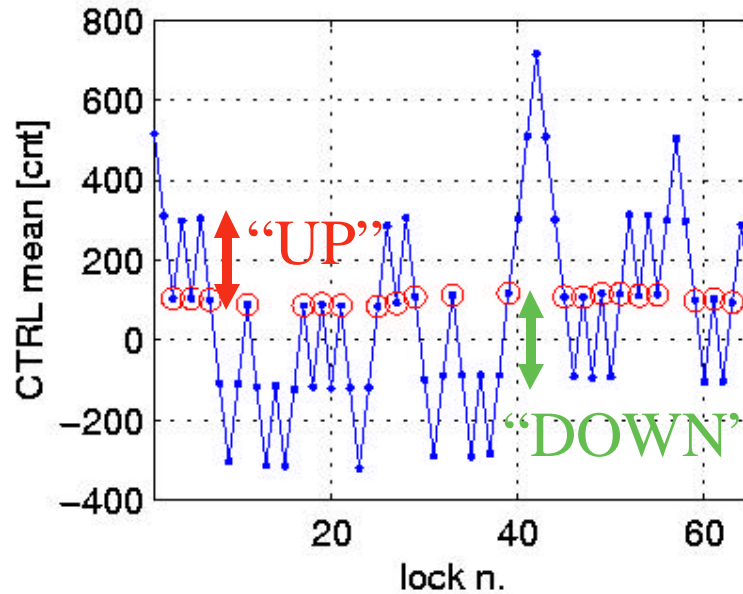
Michelson control signal





# Fringe toggling analysis

Mean of MICH control signal for a given time stretch



Mean (cnt) = 201.6607 ± 5.9289

→ (1.319e-09 ± 3.878e-11) [m/cnt]

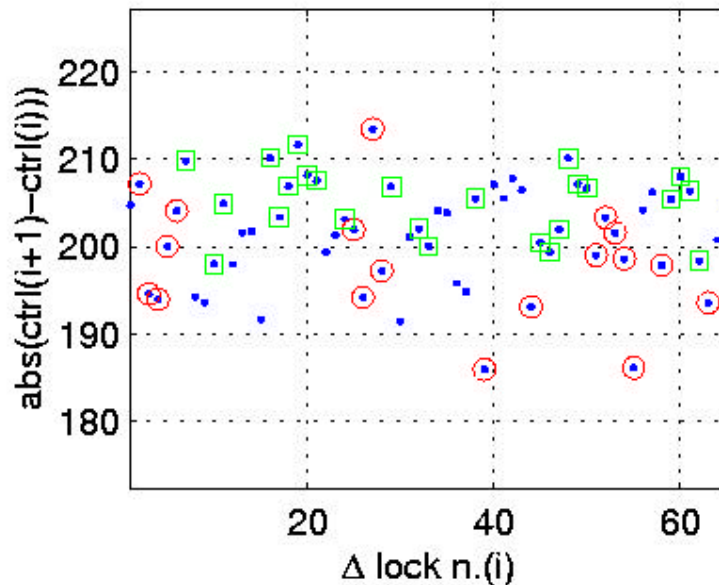
Mean UP(cnt) = 198.1013 ± 6.8505

Mean DOWN(cnt) = 205.0896 ± 3.9418

Mean SUM(cnt) = 403.1908 ± 7.9036

→ (1.3195e-09 ± 2.5865e-11) [m/cnt]

Difference of control signal between two successive locked stretches



H1:LSC-ITMY  
1.32x10<sup>-9</sup> m/count,

Sigma:  
0.03x10<sup>-9</sup>



# Summary

---

- Two precise measurements of ITM control signal that differ by ~10%
- Systematics to account for disagreement
  - » 2% due to pendulum transfer function (0.1Hz drive is not DC measurement)
  - » 6% accounted for by stopband filter: non-unity gain at DC introduced between Michelson control signal and ITM control signal
  - » Remaining 2-3% being hunted down by Luca and Matt Evans (phase lag of the mass with respect to the excitation?)
  - » **E2E played a key role in analysis** – quick modeling of simple Michelson system and creation of simulated data for understanding of systematics – thanks to Hiro Yamamoto for help in this regard

4k ITM, calibrations, systematics accounted for:

|  | FRINGE COUNTING [nm/cnt] | SIGN TOGGLING [nm/cnt] |
|--|--------------------------|------------------------|
|--|--------------------------|------------------------|

|      |                |                |
|------|----------------|----------------|
| ITMX | 1.444 +- 0.009 | 1.406 +- 0.007 |
| ITMY | 1.399 +- 0.020 | 1.360 +- 0.006 |