Commissioning at Hanford

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Program Advisory Committee

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LIGO Livingston Observatory

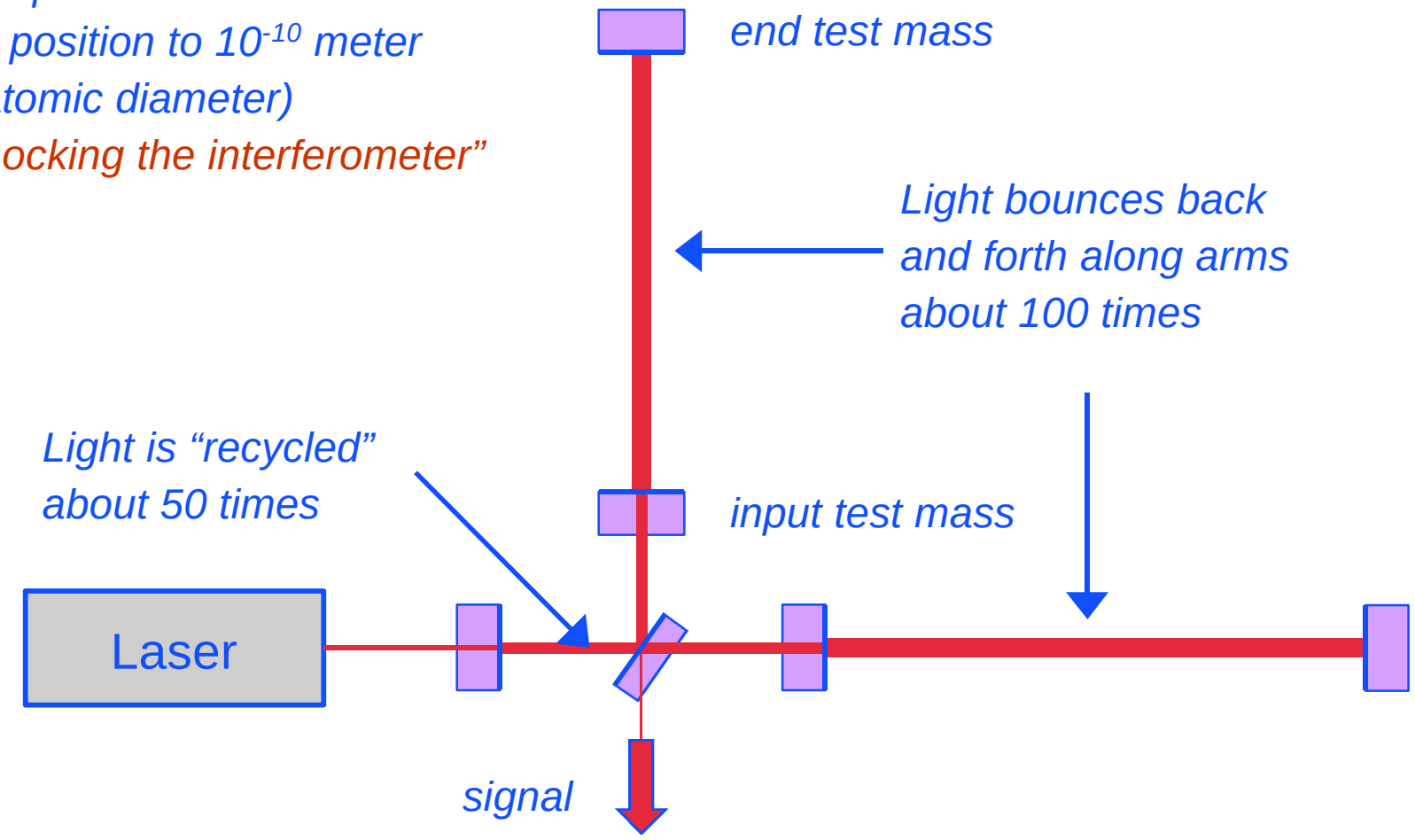
LIGO-G000335-00-D

Installation Summary

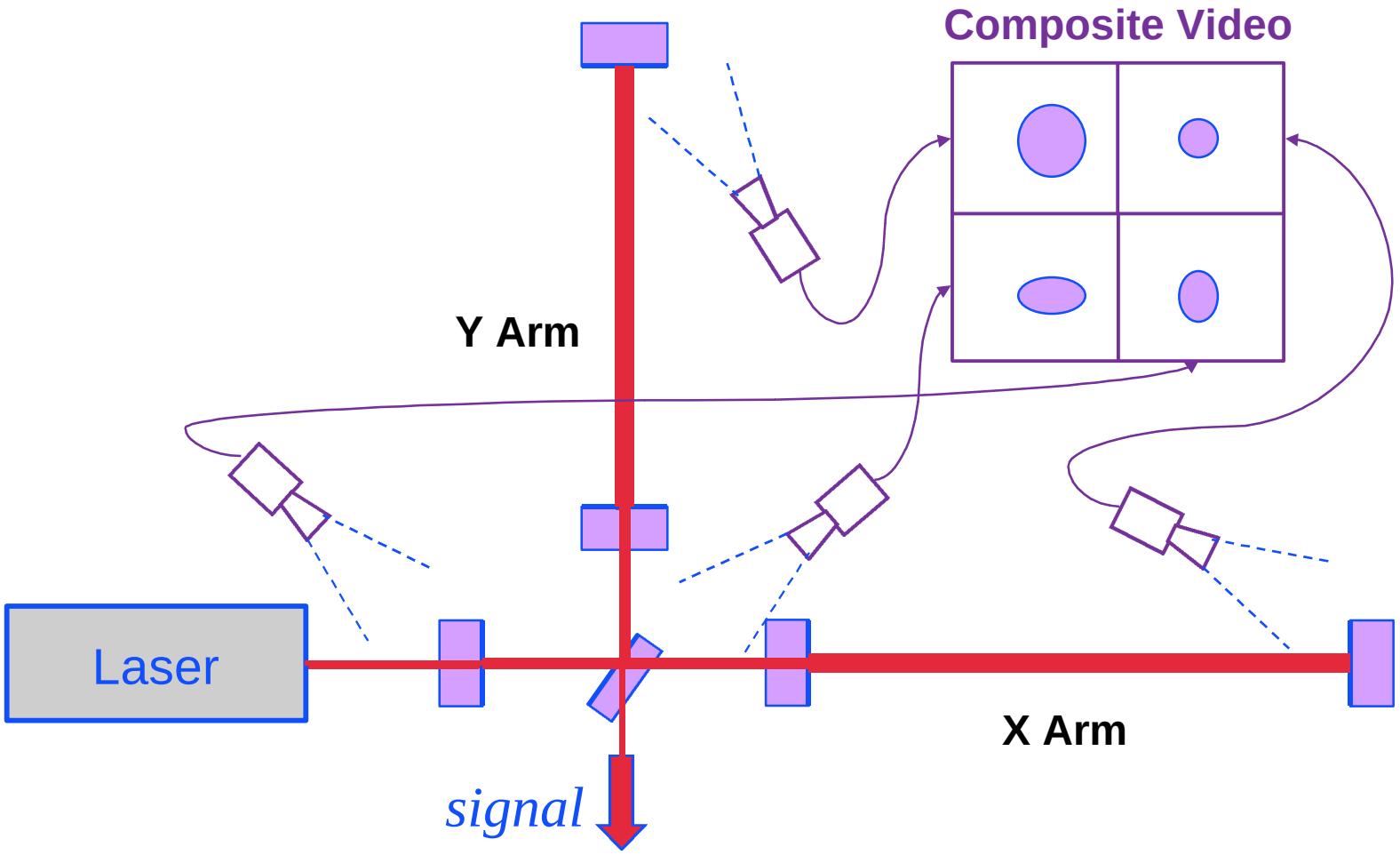
- All in-vacuum installation complete for LHO 2km
- ASC and LSC electronics installed for 2 km interferometer, and under test
- Delayed installation of 4km LHO interferometer pending solution to scattered light problem
  - » Seismic isolation complete
  - » PSL installation underway
  - » In-vacuum optics scheduled for early 2001
- DAQ/Control Network infrastructure complete
  - » Generally reliable, but still a few minor problem areas
  - » Still verifying correct signal hook-ups

First Lock for a LIGO Interferometer

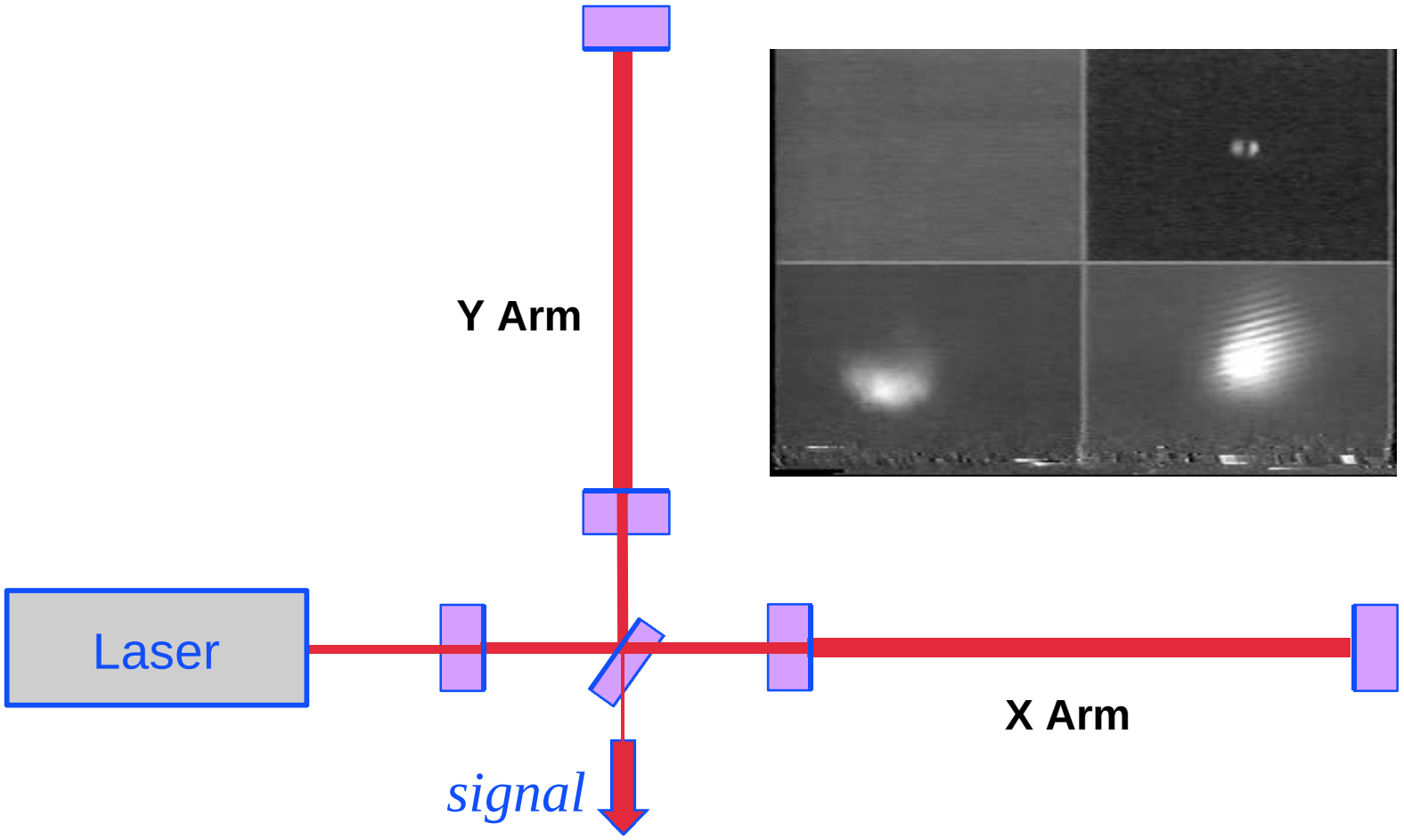
Requires test masses to be held in position to 10^{-10} meter (atomic diameter)
"Locking the interferometer"



Steps to Locking the Interferometer

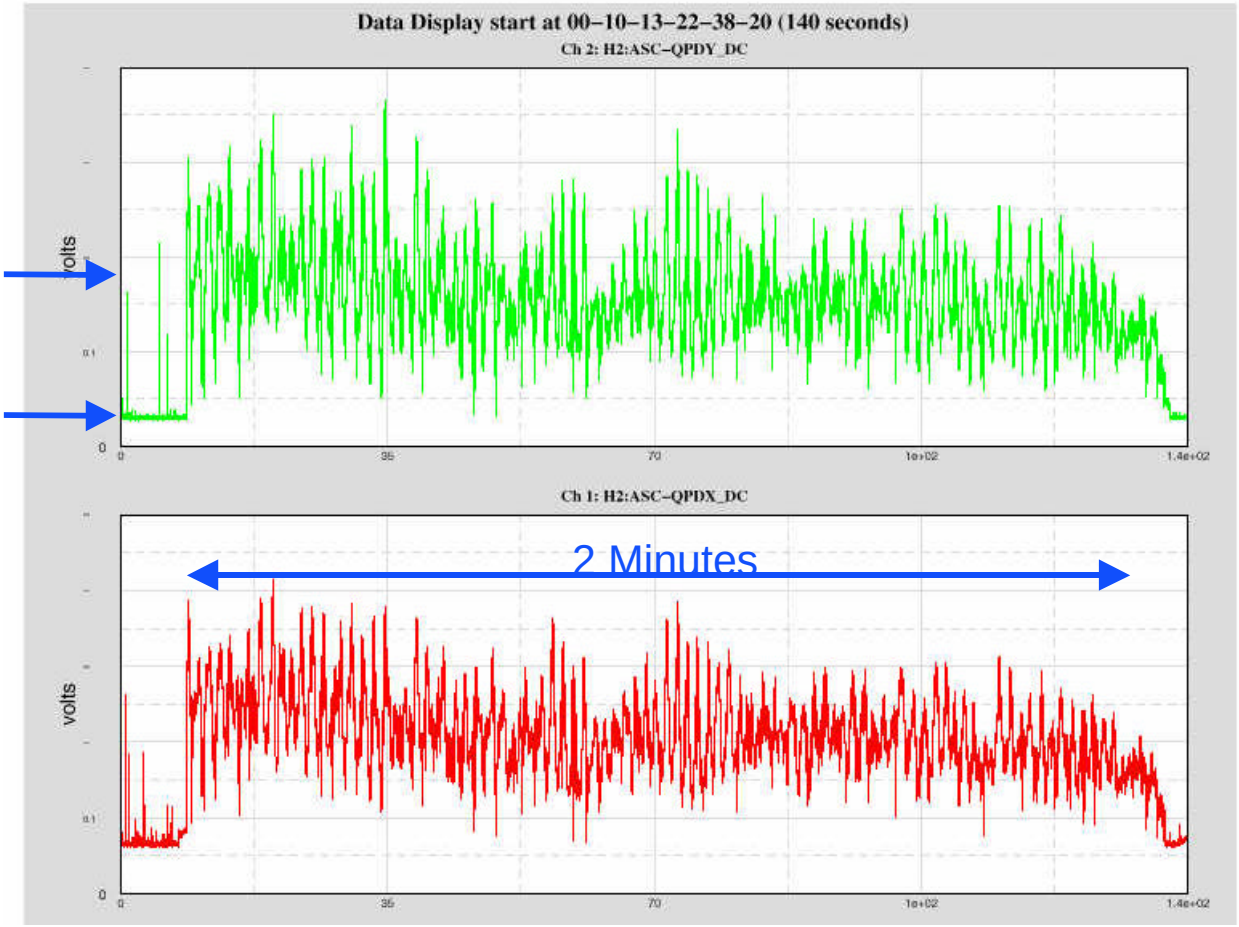


Watching the Interferometer Lock



Full Interferometer Locking

- Still a bit tenuous…….



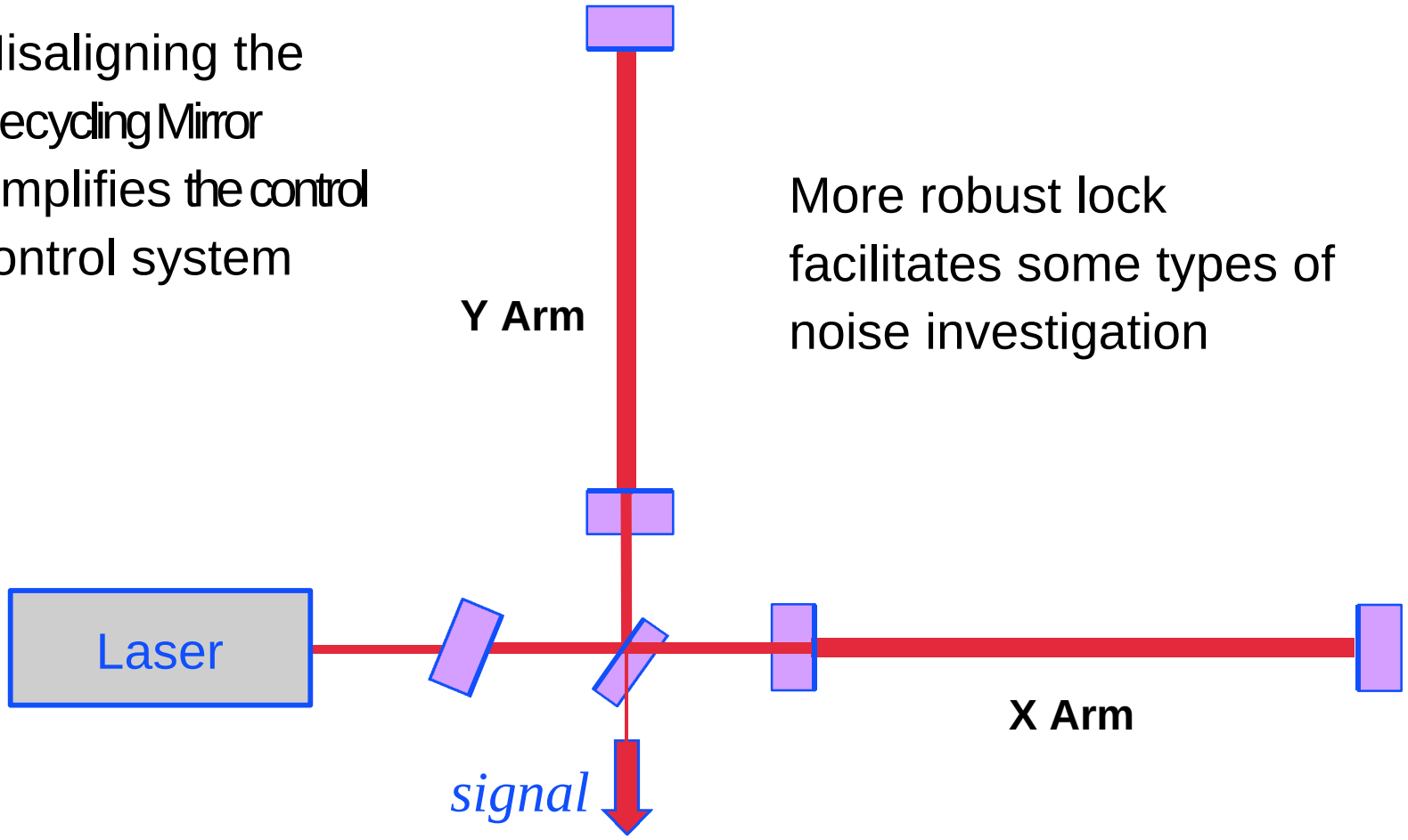
Locked

Unlocked

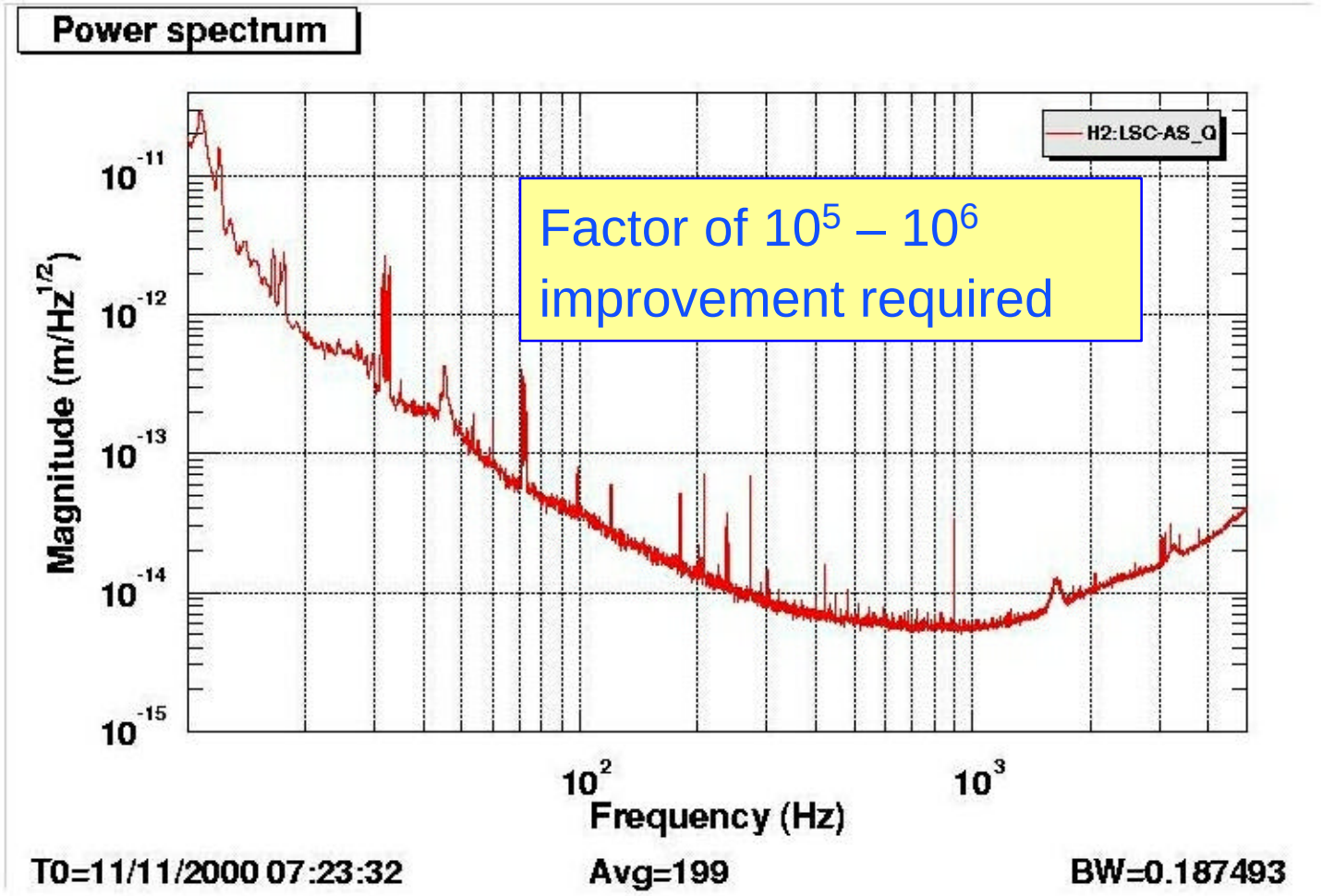
Recombined Michelson with F-P Arms

Misaligning the Recycling Mirror simplifies the control control system

More robust lock facilitates some types of noise investigation



Recombined Interferometer Spectrum

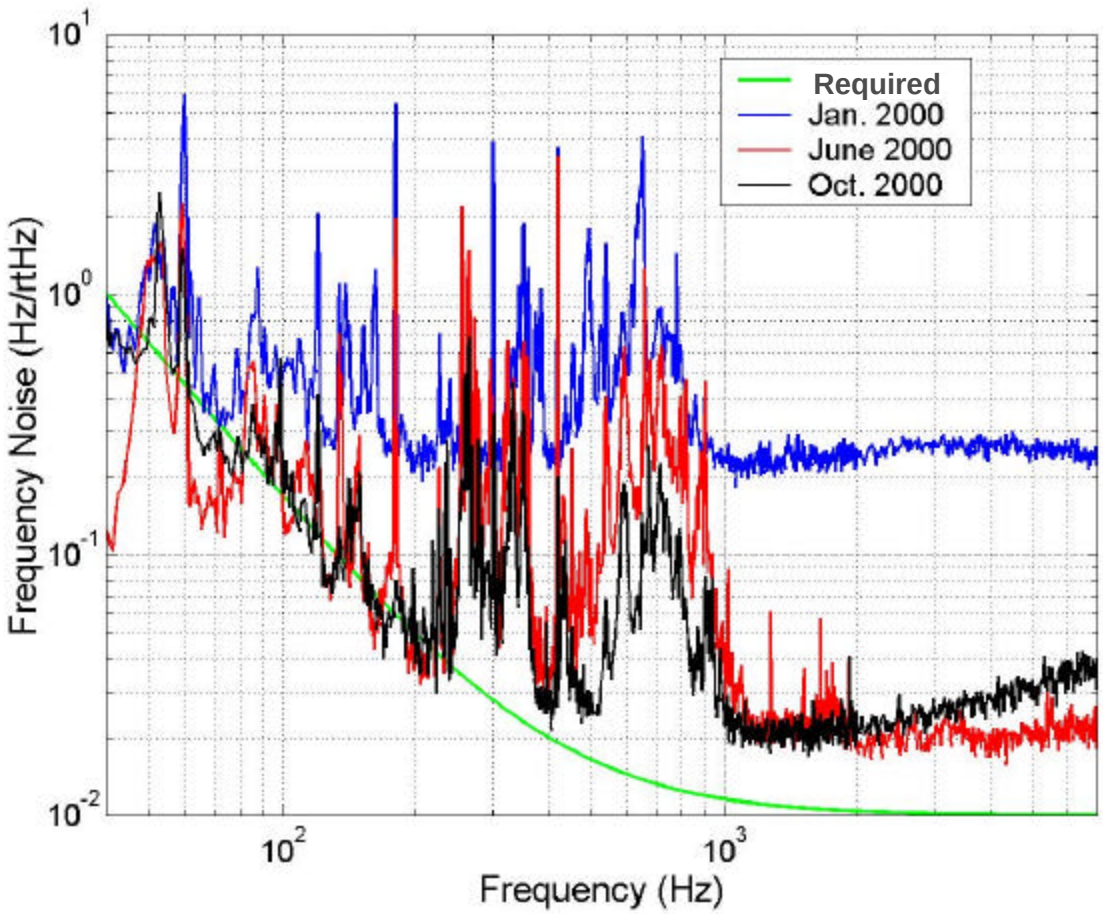


Beginning to Work on Noise

- Identified electronics noise (ADC) as dominant noise at high frequencies (due to low input laser power)
- Laser frequency noise dominates in mid frequency band (stabilization from arm common mode not yet implemented)
- Low frequencies seismic noise?
- Many resonant features to investigate and eliminate

Cont. to Work on Subsystem Performance

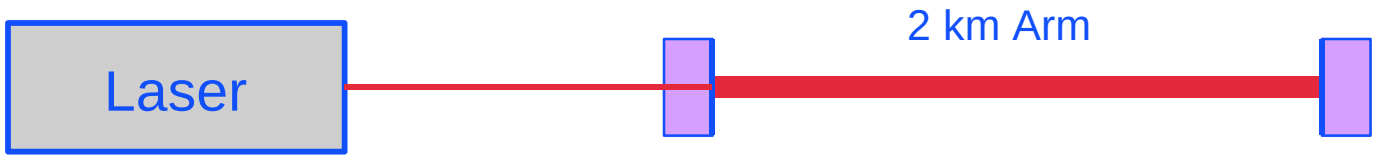
- Example: Prestabilized Laser
- Laser stability an important contributor to LIGO sensitivity
- Steady improvement in laser noise performance
  - » electronics
  - » acoustics
  - » vibrations
  - » elimination of excitation sources



Progress Toward Robust Operation

- Different measure of interferometer performance (in contrast with sensitivity)
  - » Interferometer lock duration goal is 40 hours,
- Prestabilized laser
  - » Two years continuous operation with ~20% loss in power
  - » Locks to reference cavity and premodecleaner for months
- Mode Cleaner
  - » Locks for weeks at a time, reacquires lock in few seconds
- Data Acquisition and Control
  - » Data Acquisition and IOCs (Input Output Controllers) routinely operate for weeks-to-months without problems
  - » Tools in place for tracking machine state: AutoBURT, Conlog

Extending the Lock on a Single Arm



- Start with Y Arm
  - » 12/1/99 Flashes of light
  - » 12/9/99 0.2 seconds lock
  - » 1/14/00 2 seconds lock
  - » 1/19/00 60 seconds lock
  - » 1/21/00 5 minutes lock
- Change to X Arm
  - » 2/12/00 18 minutes lock
  - » 3/4/00 90 minutes lock
  - » 3/26/00 10 hours lock

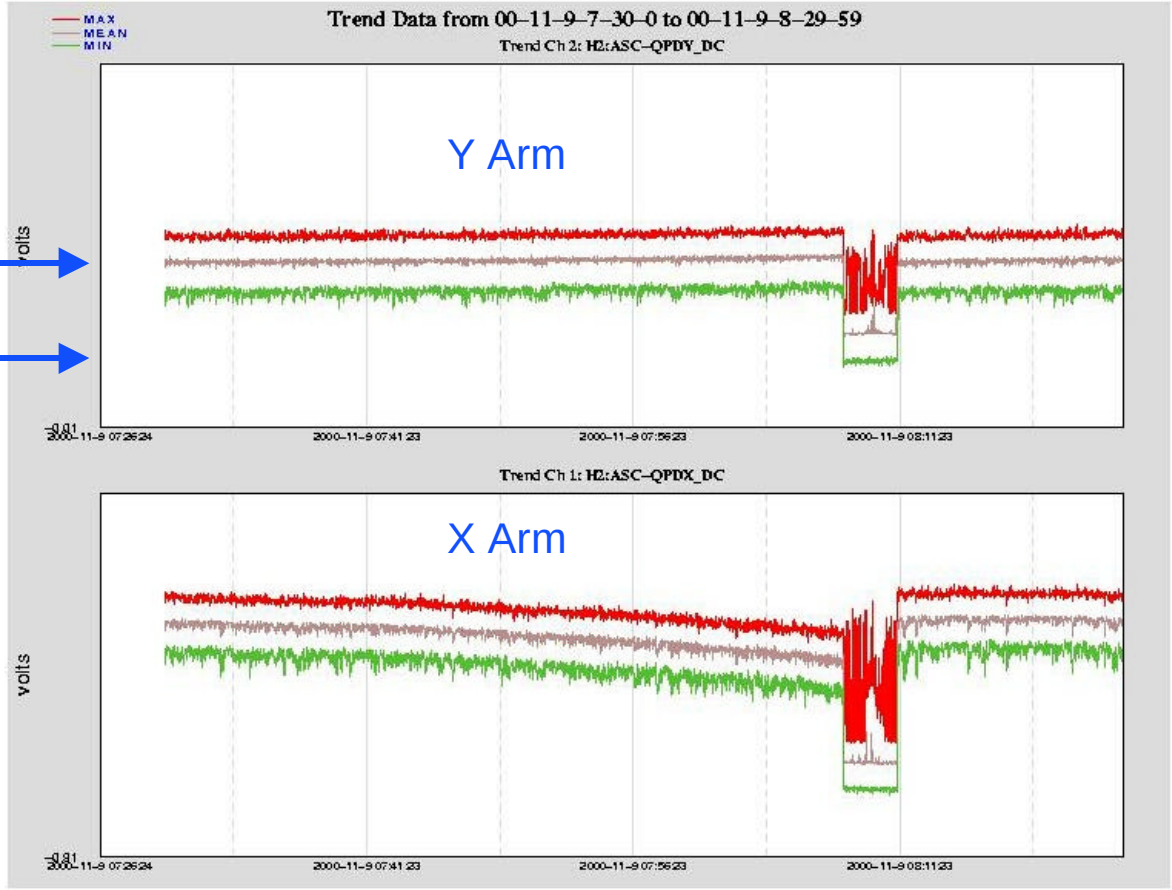
Result of : -automatic alignment system
-tuning electronics
-reduction of noise sources

Recombined Michelson Robustness

Randomly chosen hour from recent engineering run

Locked

Unlocked



Engineering Runs

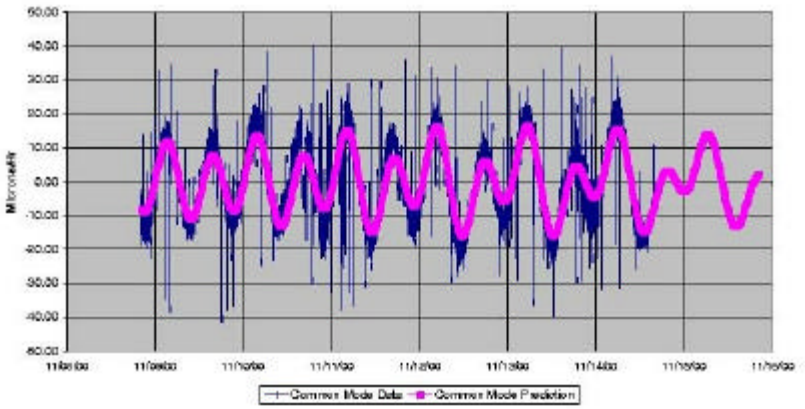
- Engineering Runs are a key part of our commissioning plan
  - » Test interferometer stability, reliability
  - » Well defined dataset for off-site analysis
  - » Develop procedures for later operations
  - » Means to include the broader LSC in detector commissioning
- First Engineering Run (E1) in April 2000
  - » Single arm operation with wavefront sensing alignment
  - » 24 hour duration
  - » Lots of interest and good intentions, but rather limited follow-through on planned analysis

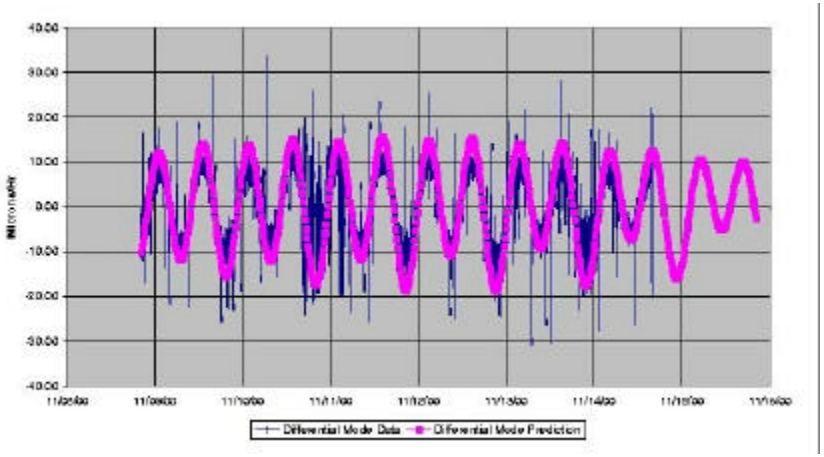
Second Engineering Run (E2)

- November 2000
  - » One week of around the clock operation
  - » Approximately 35 scientists participated on site
- Recombined Michelson with Fabry-Perot arms
  - » Misaligned recycling mirror to make for more robust locking
  - » Typical locked stretches 30 – 90 minutes (longest ~ 3 hours)
  - » >90% duty cycle
- Organized around 14 detector investigations
  - » Earthtides, frequency noise, calibration, noise stationarity, seismic noise, noise bursts, line tracking, …
  - » More analysis during the run than for entire E1
- Major test of DAQ system
  - » Successfully transferred 2 terabytes of data to CACR archive

Earthtide Investigation

- Observed in earlier E1 Run, but predictions had unexplained time shift
- ~200 micons P-to-P
- Main cause of loss of lock for long arms in E2 run
- Input to design of tidal actuator needed for eventual long lock durations
- Common mode (both arms stretch together) and differential mode (arms stretch by different amounts)





Summary

- "Locking the Interferometer" marks a major transition for LIGO
  - » Commissioning a full interferometer, not individual subsystems

- Steady Progress
  - Locking duration
  - Noise performance
  - Operational experience

- Still a long way to go!

"First Lock" in the Hanford Observatory control room