

“First Lock” for the LIGO Detectors



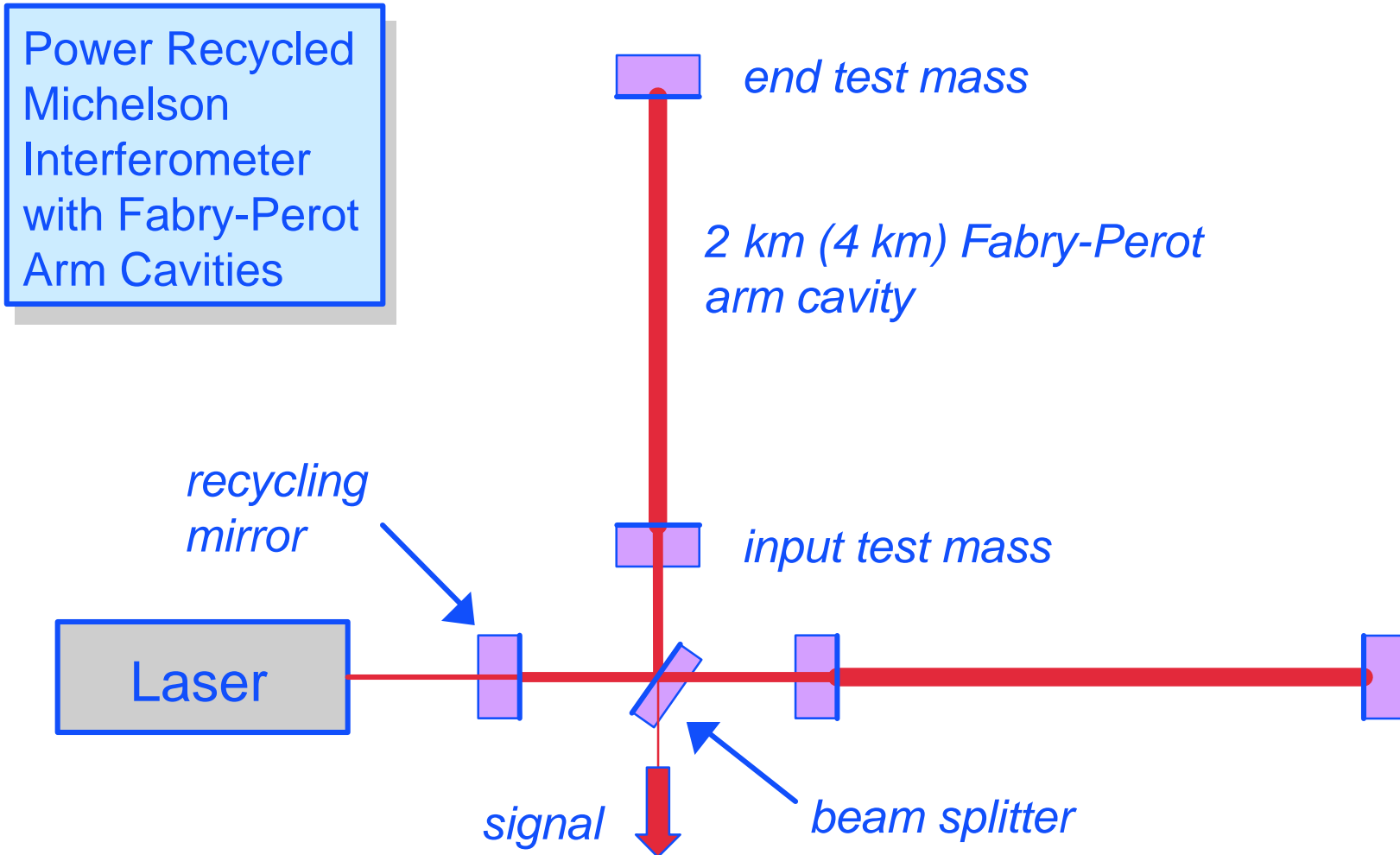
20 October 2000
LIGO Hanford Observatory
Stan Whitcomb



Outline

- The LIGO Detectors
- What is “Locking an Interferometer”?
 - » Why do we need to do it?
 - »and why is it so difficult?
- Evidence for Locking
- The Next Steps

LIGO Interferometer (Detector)



Suspending the Test Masses (Mirrors)



vibration-isolated platform

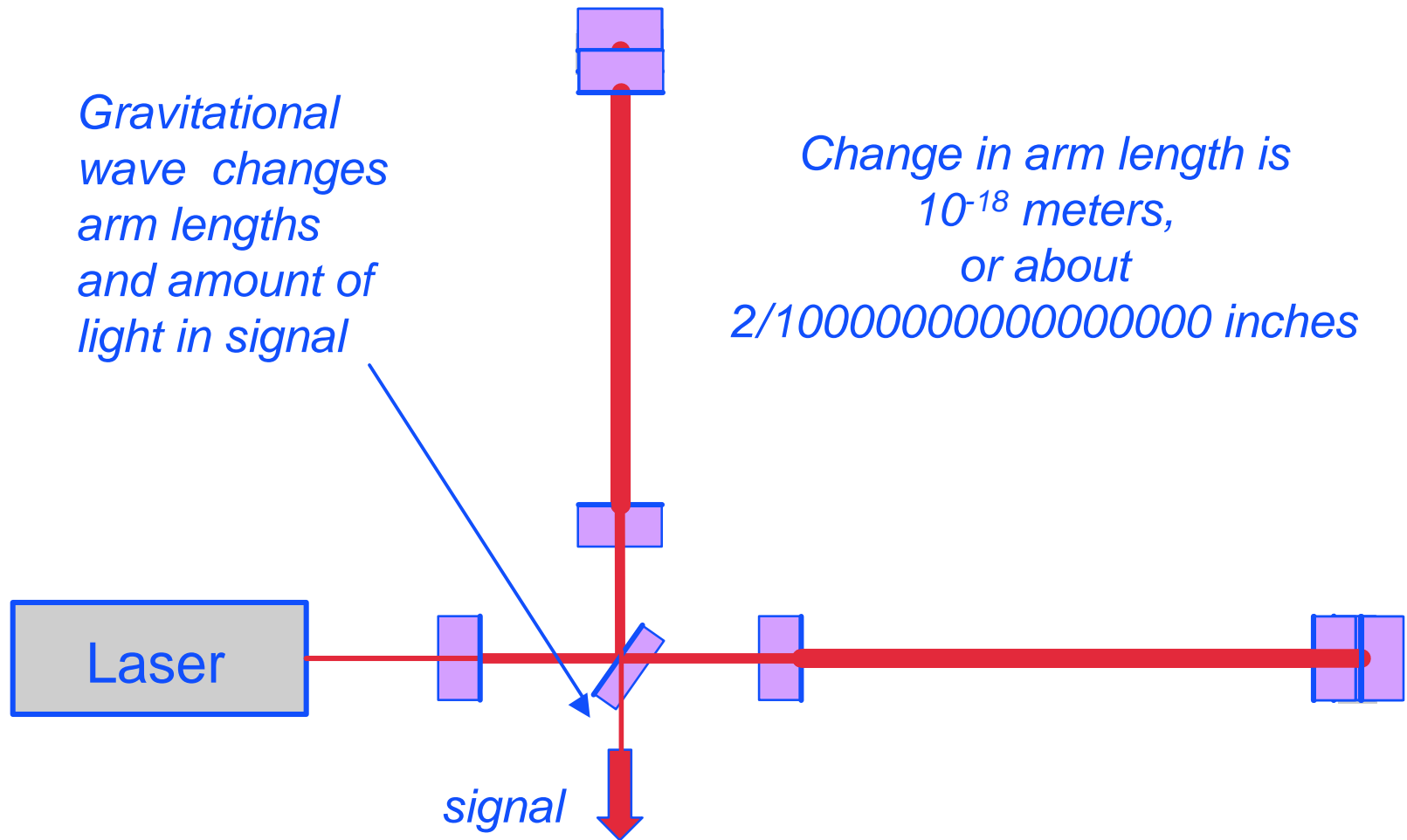


initial alignment

test mass suspended on fine wire



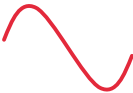
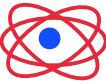

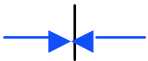


Sensing the Effect of a Gravitational Wave



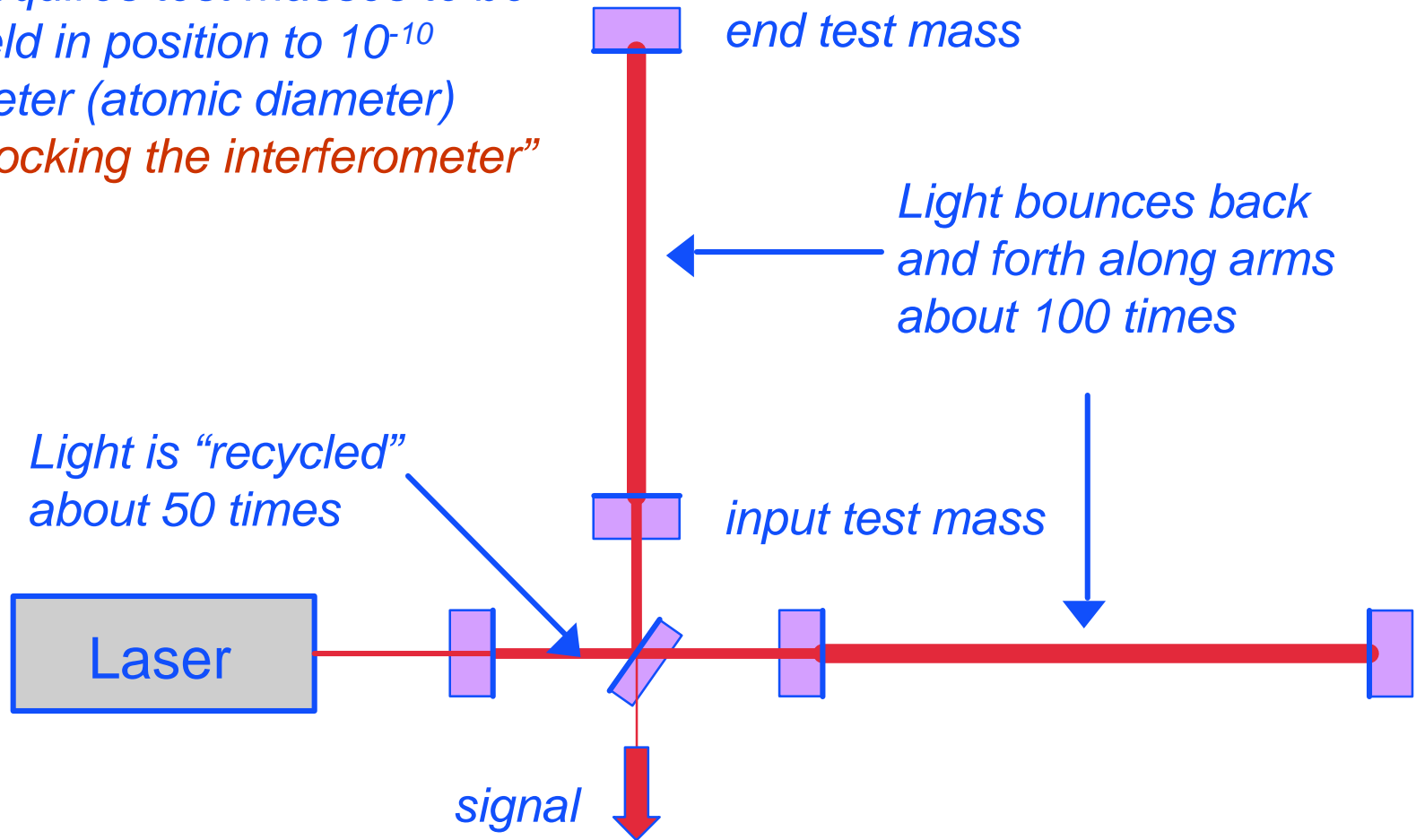


How Small is 10^{-18} Meter

		<i>One meter, about 40 inches</i>
$\div 10,000$		<i>Human hair, about 100 microns</i>
$\div 100$		<i>Wavelength of light, about 1 micron</i>
$\div 10,000$		<i>Atomic diameter, 10^{-10} meter</i>
$\div 100,000$		<i>Nuclear diameter, 10^{-15} meter</i>
$\div 1,000$		<i>LIGO sensitivity, 10^{-18} meter</i>






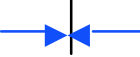
LIGO Interferometers

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

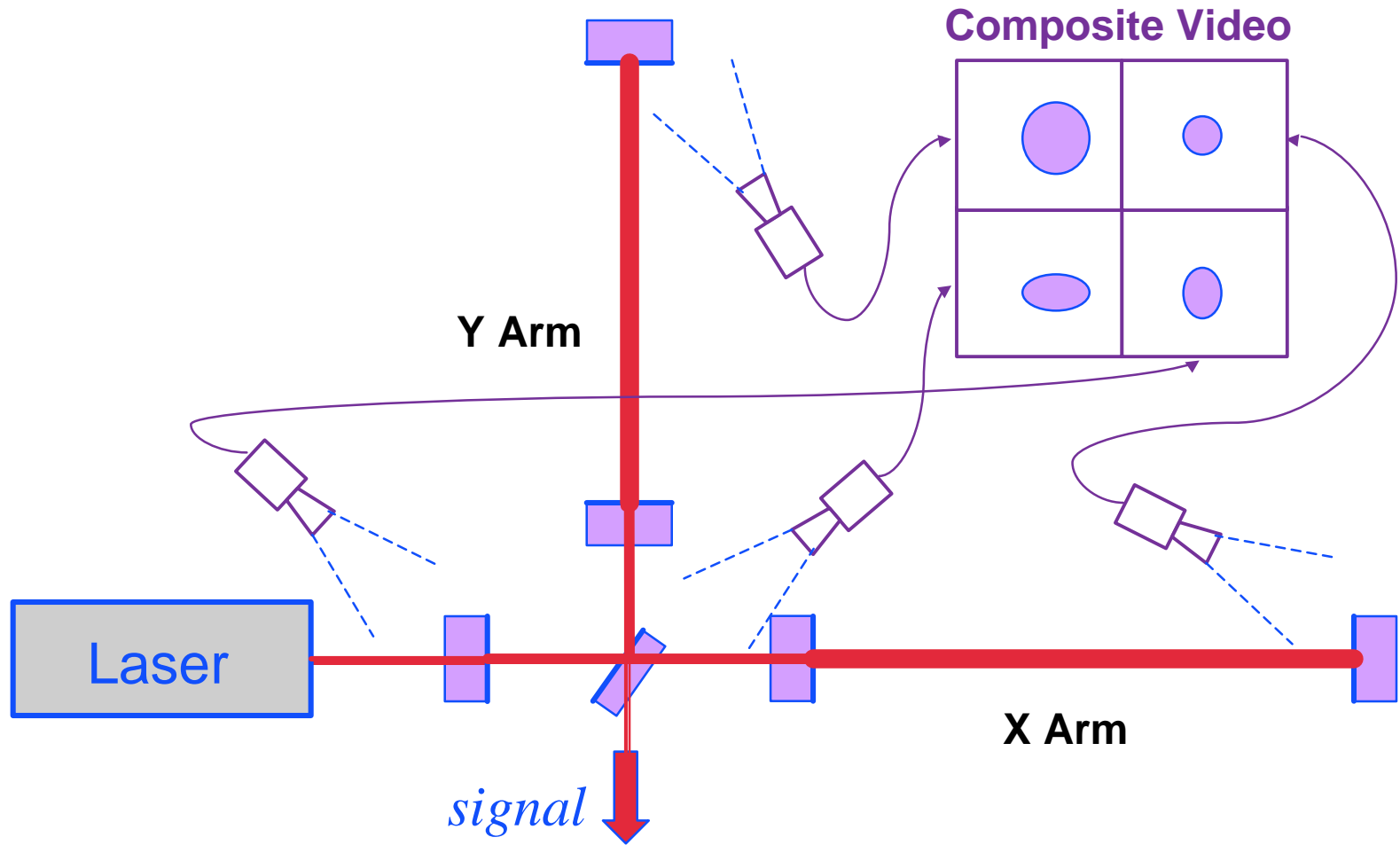




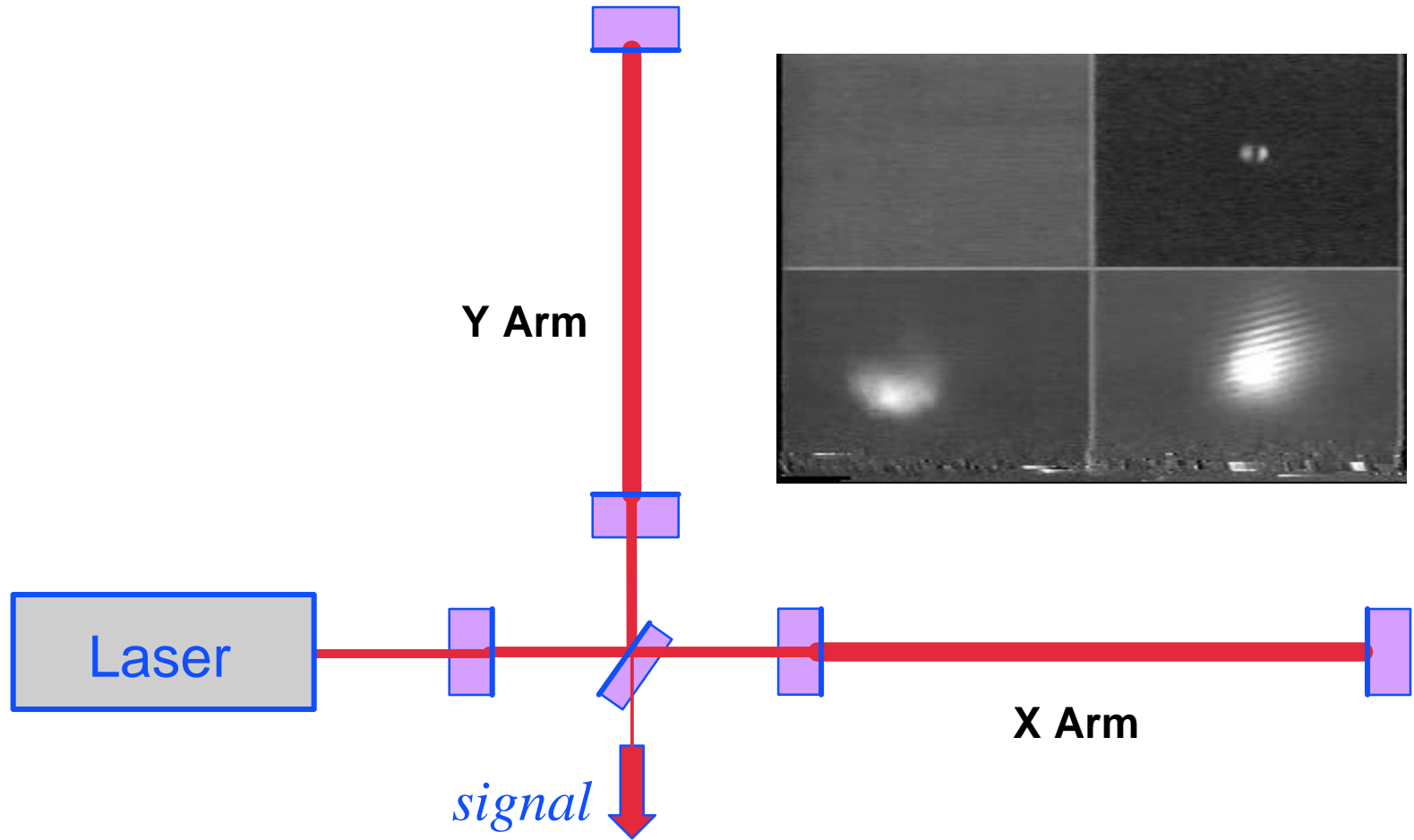
Why is Locking Difficult?

		<i>One meter, about 40 inches</i>
$\div 10,000$		<i>Earth tides, about 100 microns</i>
$\div 100$		<i>Microseismic motion, about 1 micron</i>
$\div 10,000$		<i>Precision required to lock, about 10^{-10} meter</i>
$\div 100,000$		<i>Nuclear diameter, 10^{-15} meter</i>
$\div 1,000$		<i>LIGO sensitivity, 10^{-18} meter</i>

Steps to Locking an Interferometer

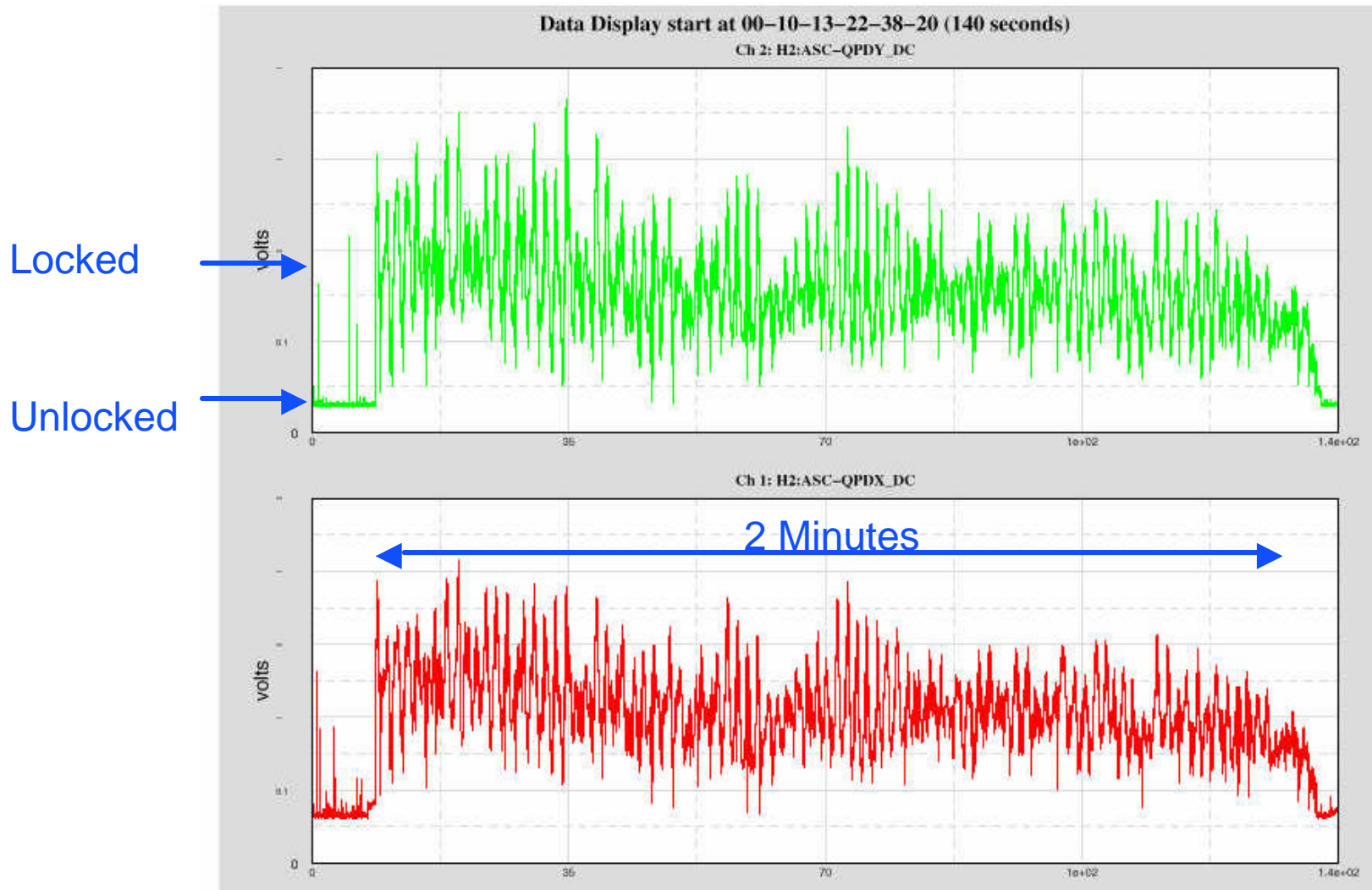


Watching the Interferometer Lock





Lock Duration

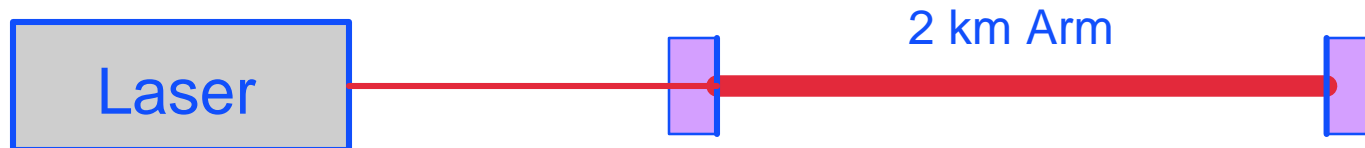




Where Do We Go From Here?

- Extend the time that the interferometer locks
 - » Goal is 40 hours, not seconds or minutes

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



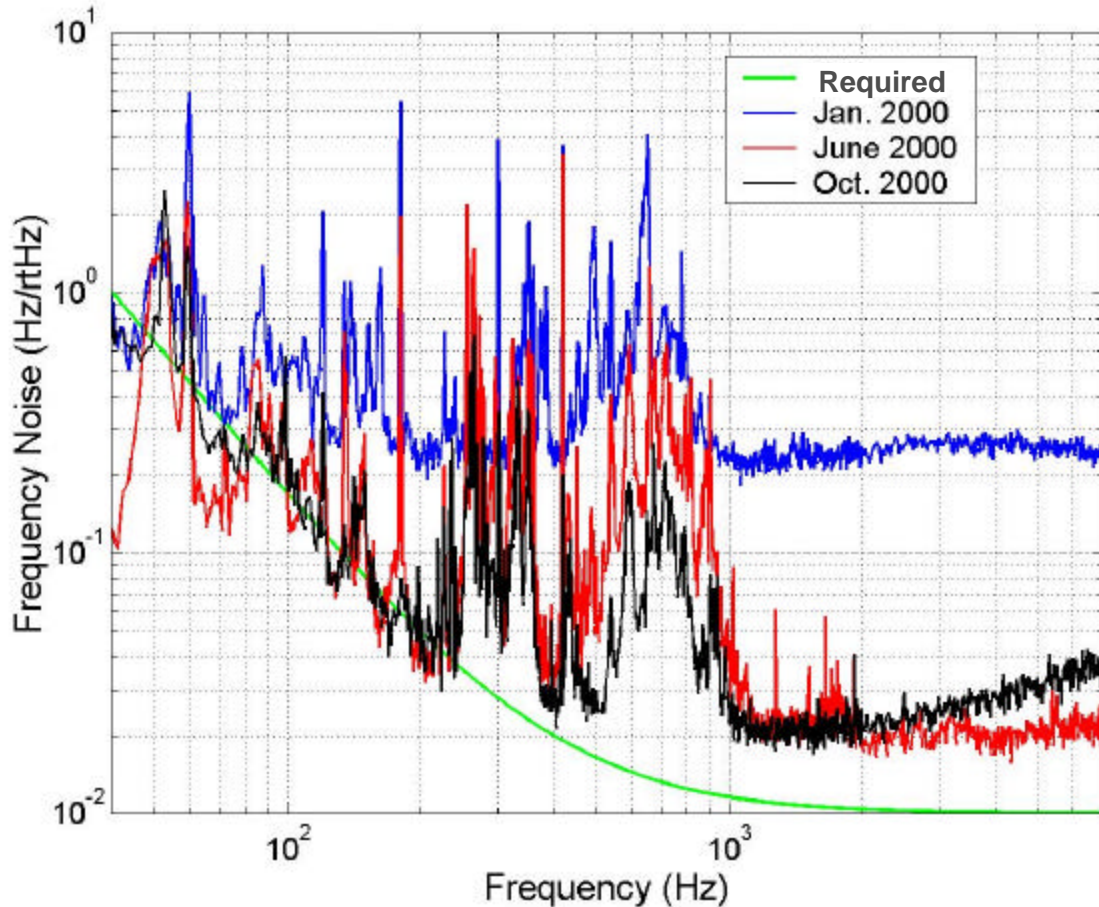
Where Do We Go From Here?

- Extend the time that the interferometer locks
 - » Goal is 40 hours, not seconds or minutes
- Increase the sensitivity (reduce the noise)
 - » Tune each subsystem for optimal performance



Improvements in Laser Performance

- Laser stability an important contributor to LIGO sensitivity
- Steady improvement in laser noise performance
 - » electronics
 - » acoustics
 - » vibrations





Where Do We Go From Here?

- Extend the time that the interferometer locks
 - » Goal is 40 hours, not seconds or minutes
- Increase the sensitivity (reduce the noise)
 - » Tune each subsystem for optimal performance
- Bring two more detectors on-line
 - » Second detector here at Hanford Observatory
 - » Single detector at Livingston Observatory

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

“First Lock”
in the Hanford
Observatory
control room

- Akin to Wright brothers’ first flight
 - » It doesn’t stay up that long
 - » It isn’t very far off the ground
 - » **But it does fly!**

