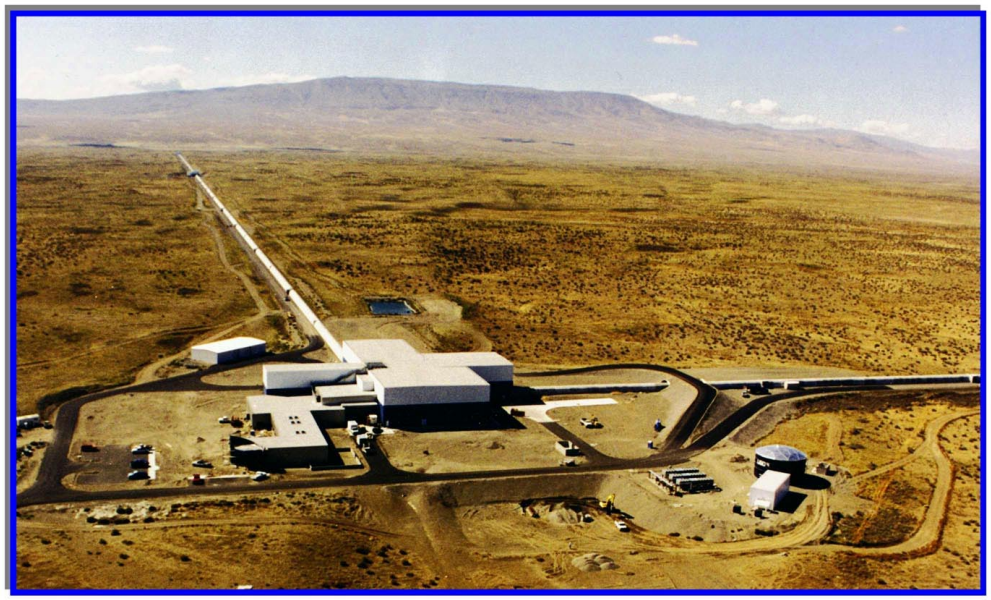
Commissioning of the LIGO Detectors

4th EDOARDO AMALDI CONFERENCE

July 10, 2001

Daniel Sigg, LIGO Hanford Observatory

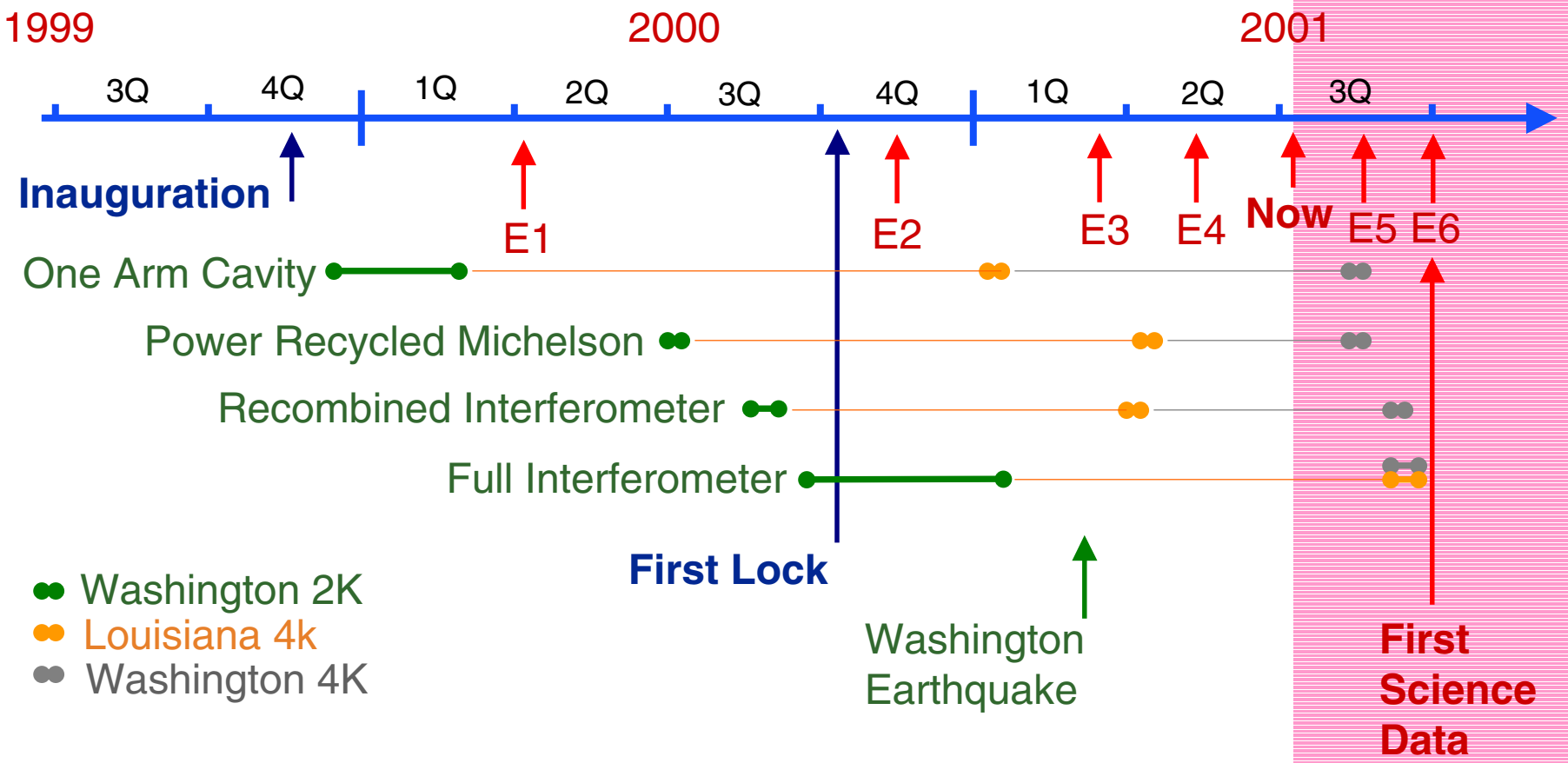
LIGO-G010244-00-D



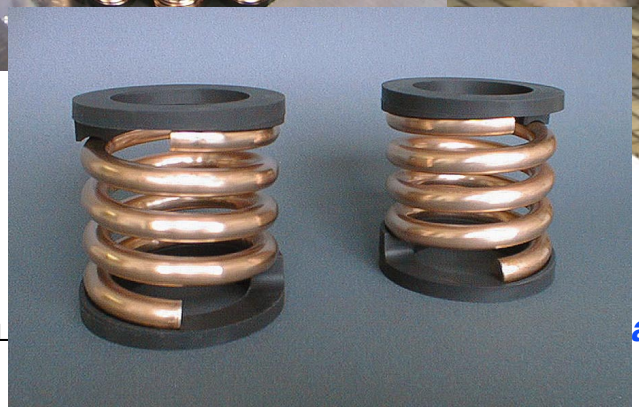
LIGO Hanford Observatory

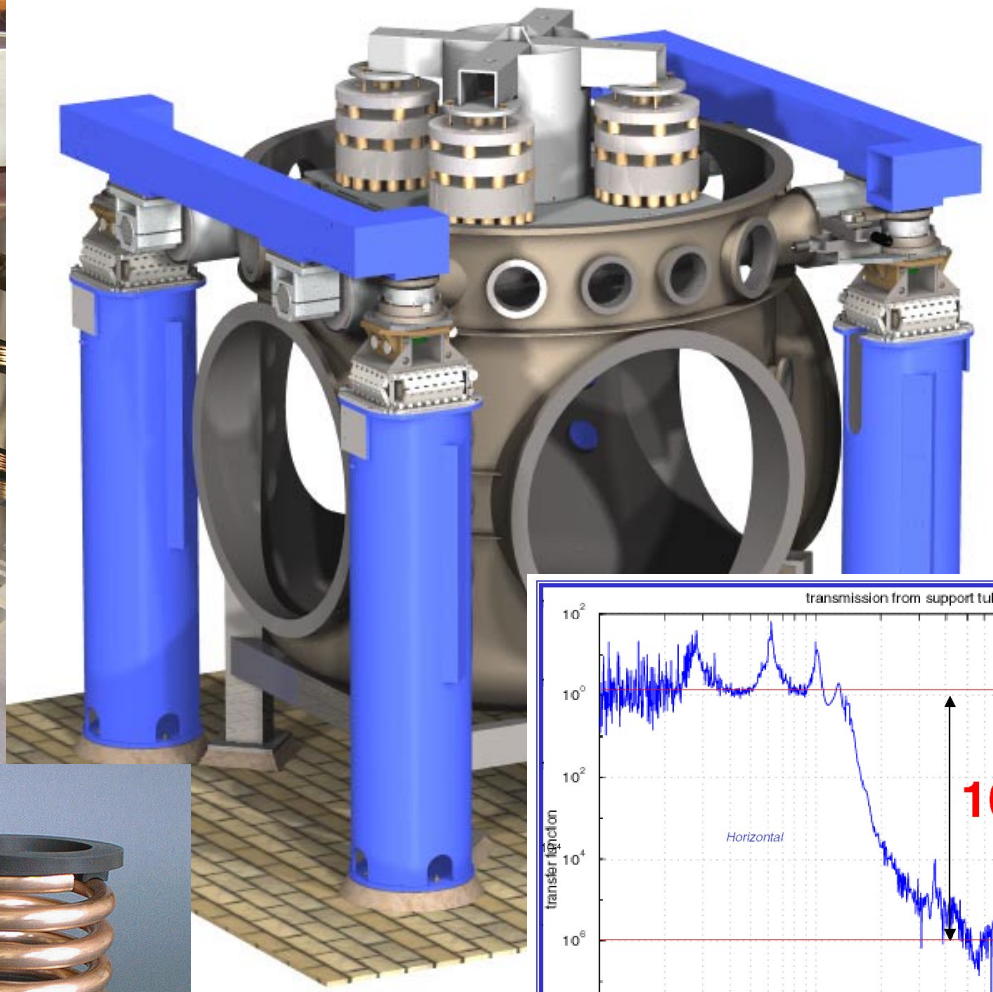
LIGO Livingston Observatory

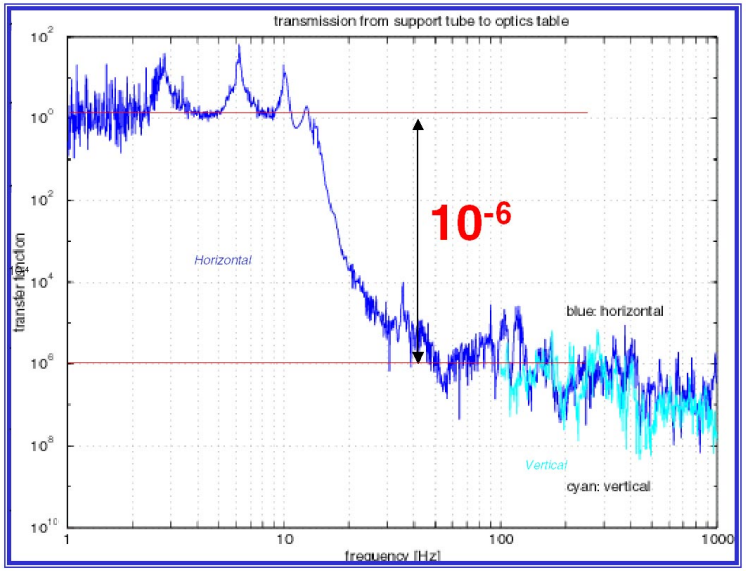
Time Line


1999
2000
2001
3Q
4Q
1Q
2Q
3Q
4Q
1Q
2Q
3Q
Inauguration
E1
E2
E3
E4
Now
E5
E6
One Arm Cavity
Power Recycled Michelson
Recombined Interferometer
Full Interferometer
First Lock
Washington
Earthquake
First
Science
Data
Washington 2K
Louisiana 4k
Washington 4K

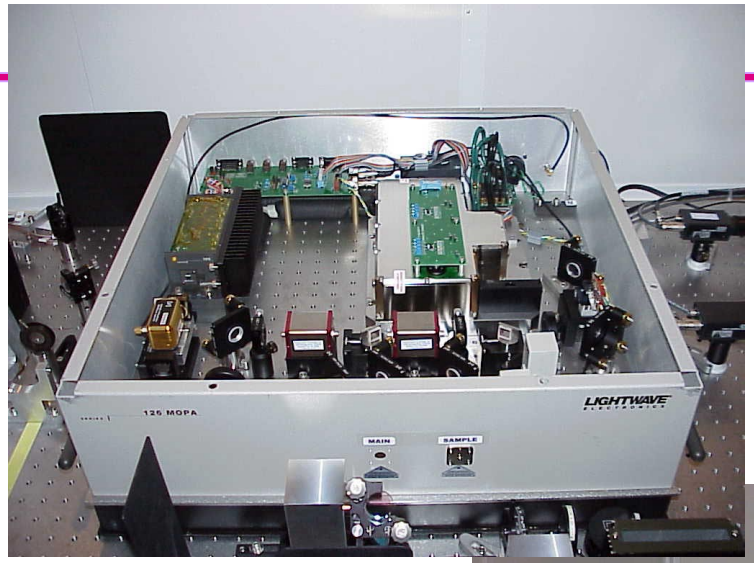
Seismic System Performance

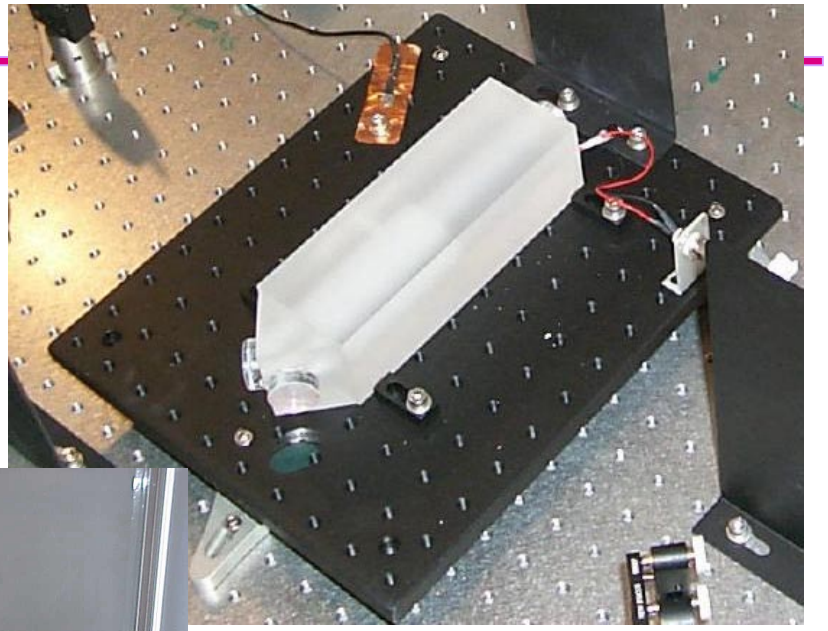


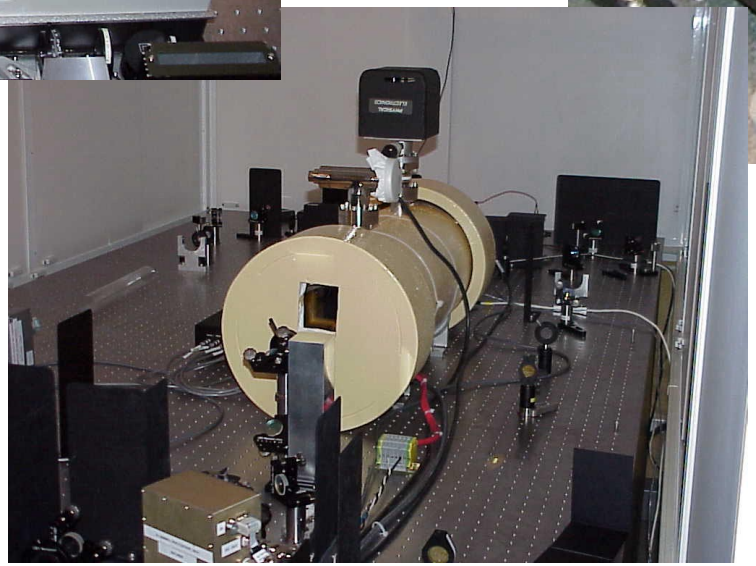




The Laser







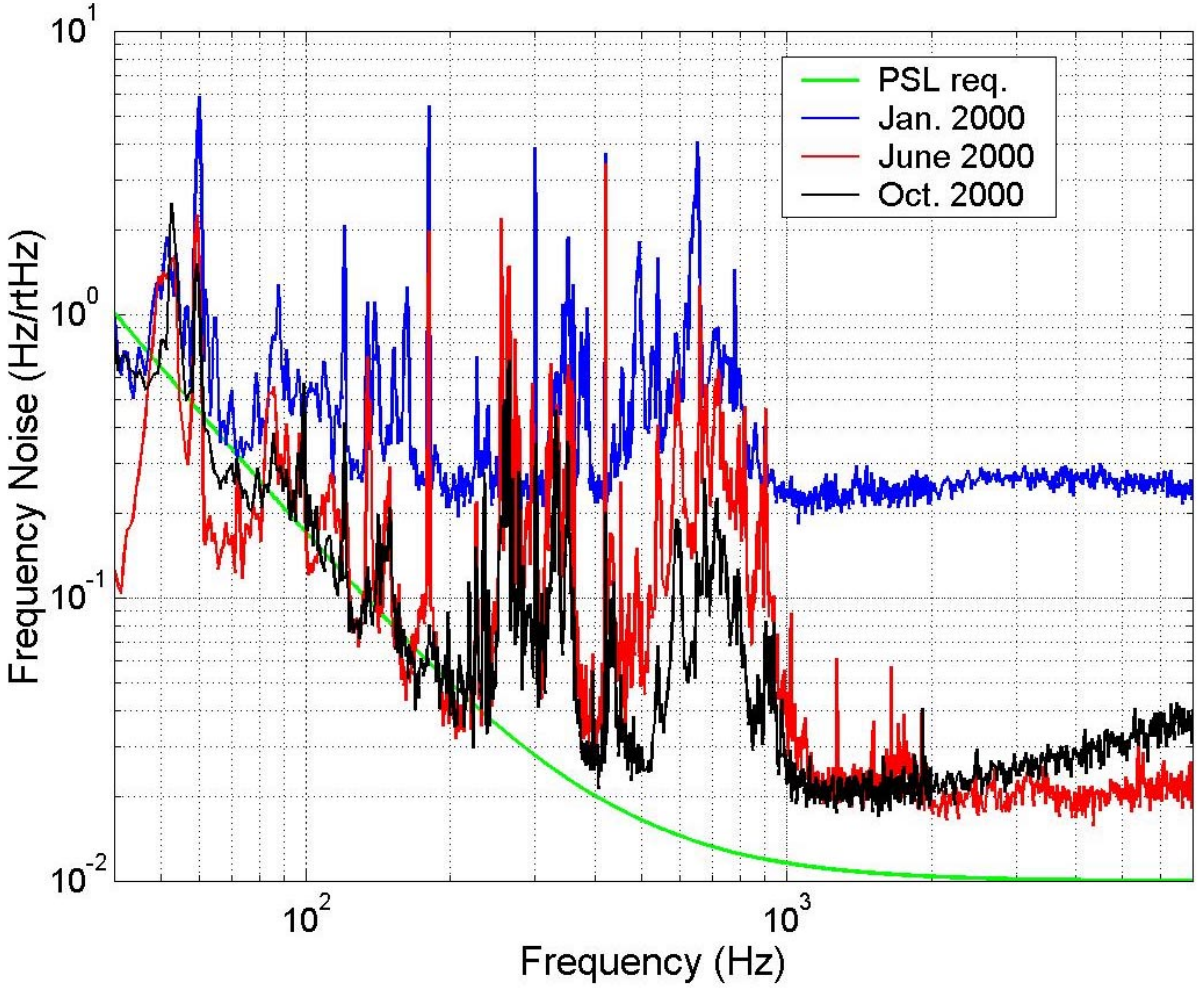
>20,000 hours continuous operation

Frequency lock typically holds for months

Frequency Noise

Improvement in noise performance

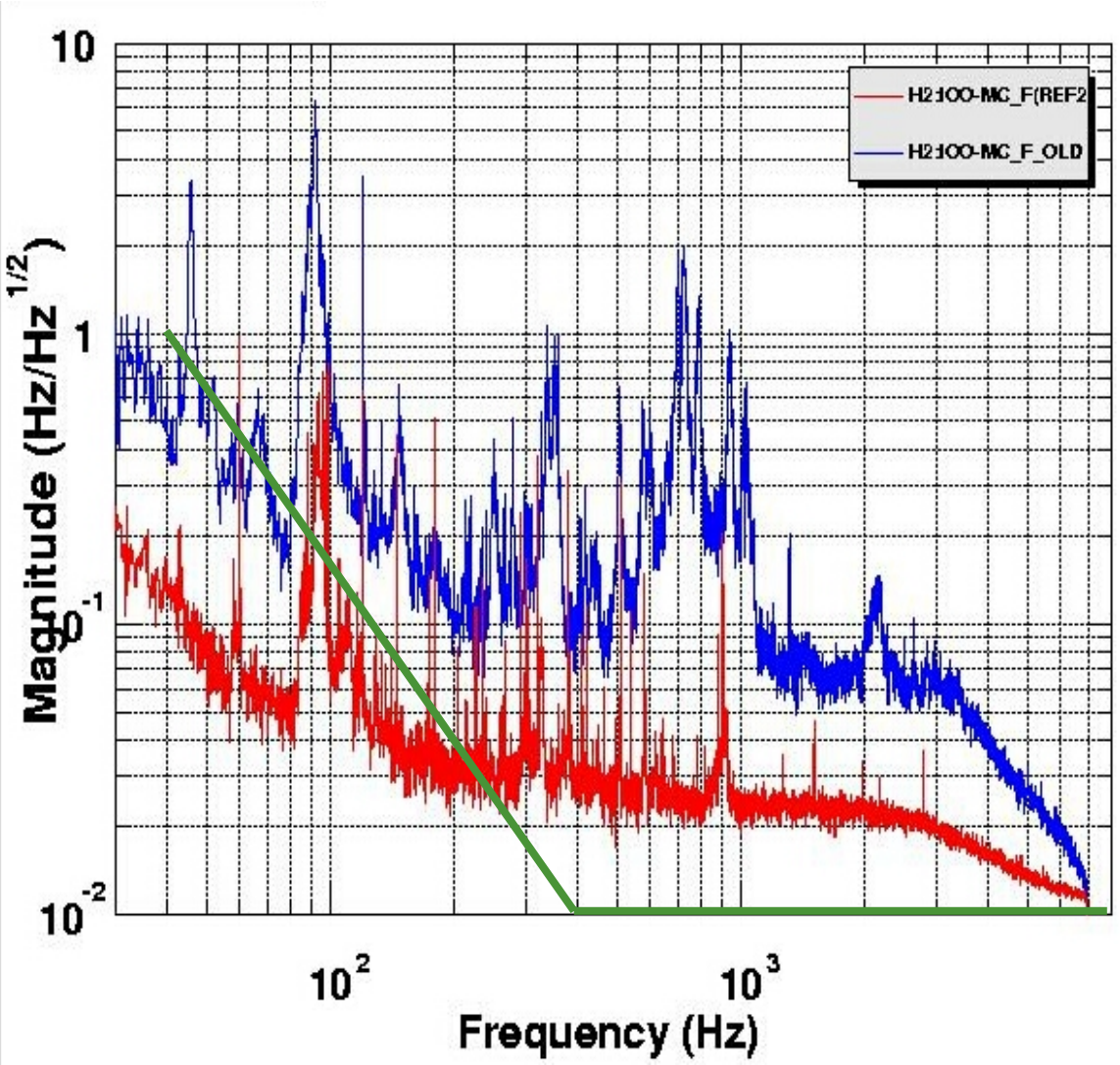
- Electronics
- Acoustics
- Vibrations



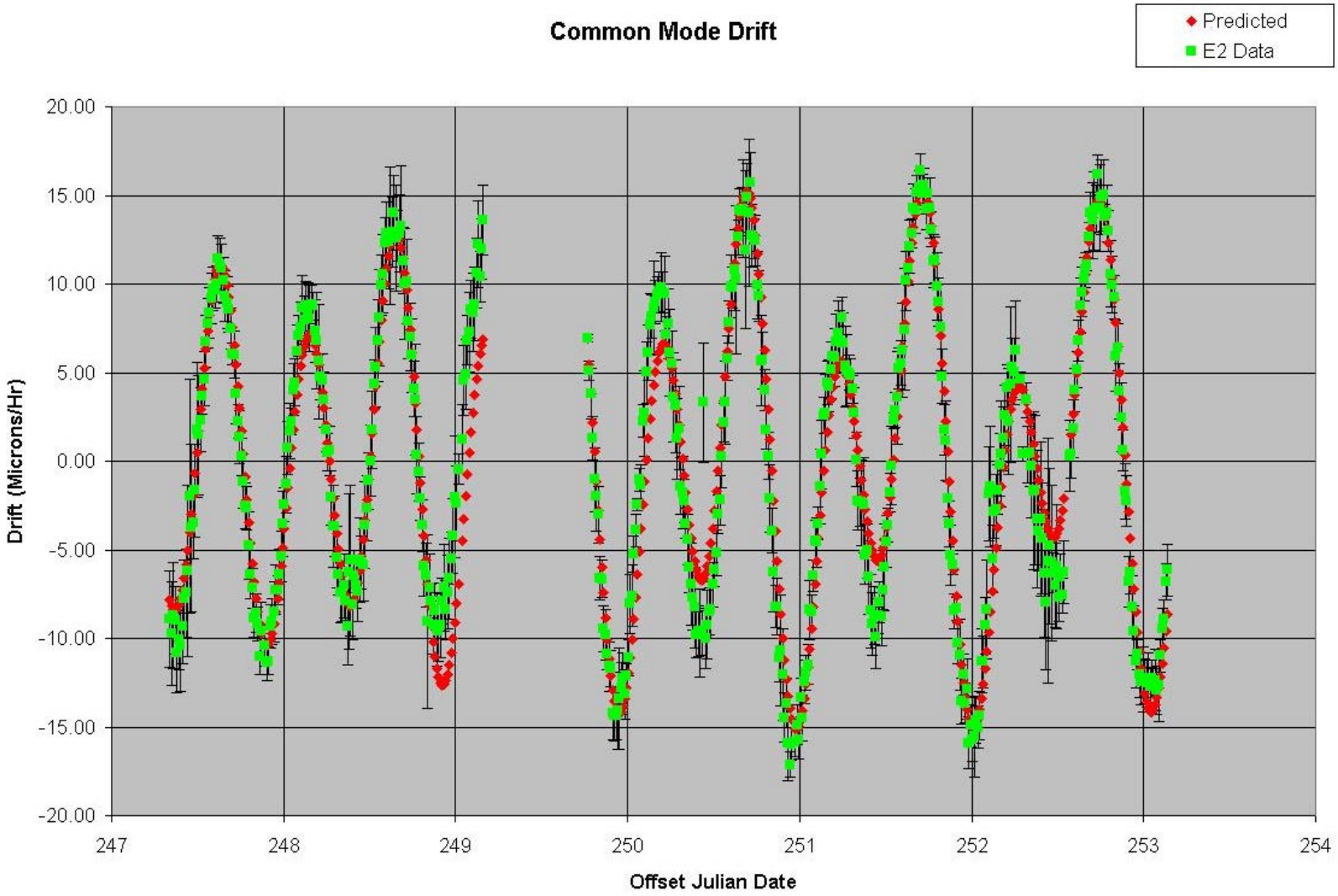
Frequency Noise (2)

Simplification of beam path external to vacuum system eliminates peaks due to vibrations

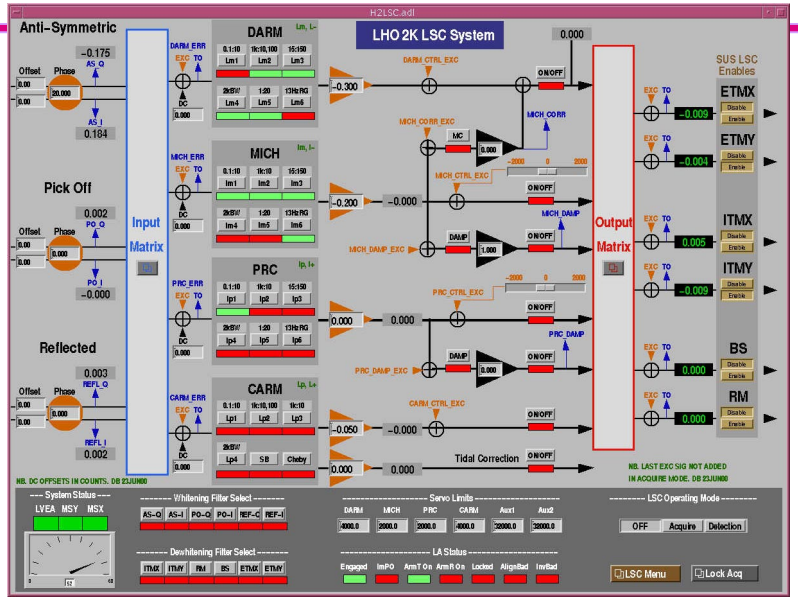
Broadband noise better than spec in 40-200 Hz region



Tidal Effects

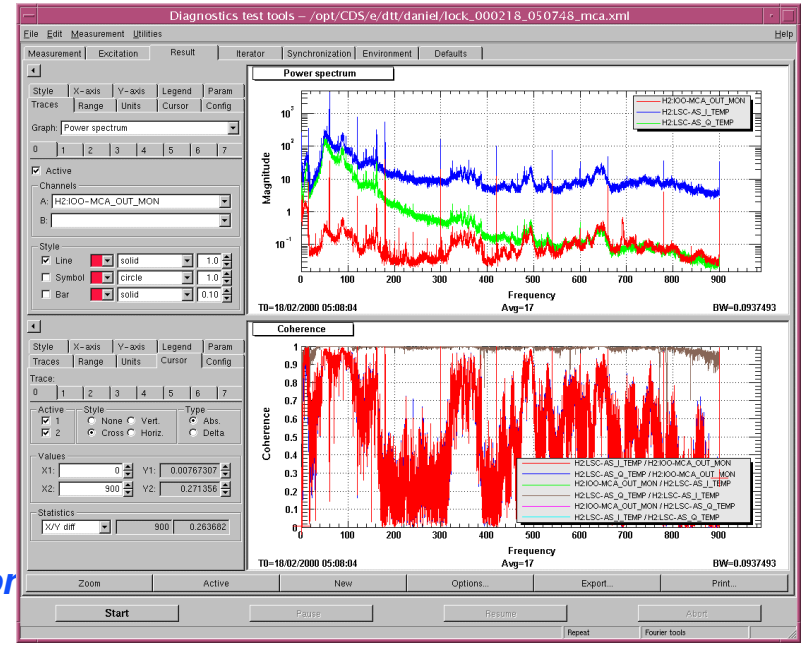


Data Acquisition, Controls and Diagnostics System

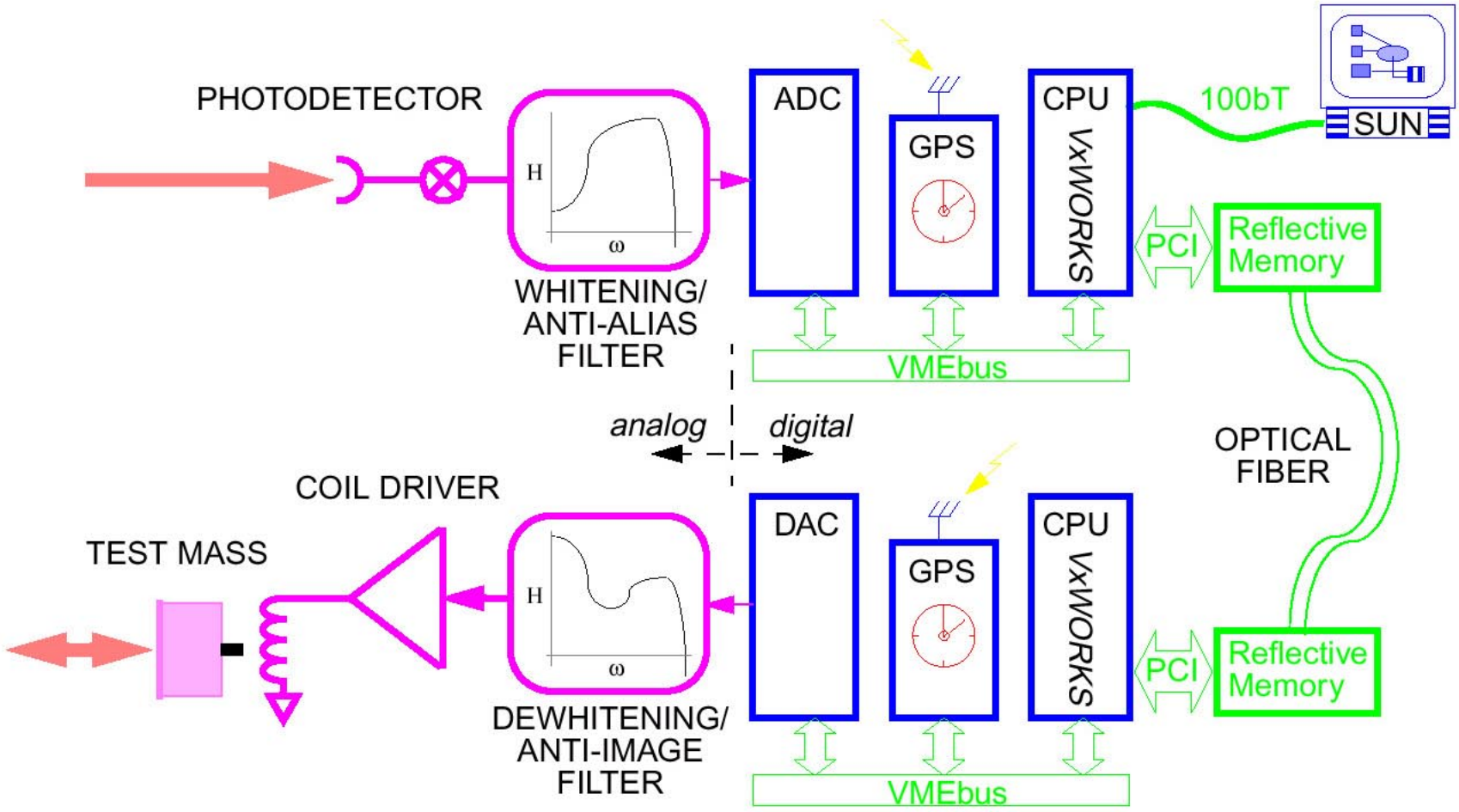


- ~50 real-time processors
- ~20 workstations per site
- ~5000 process variables (switches, sliders, readings, etc) per interferometer
- Fiber optic links between buildings
- Multiplexed video

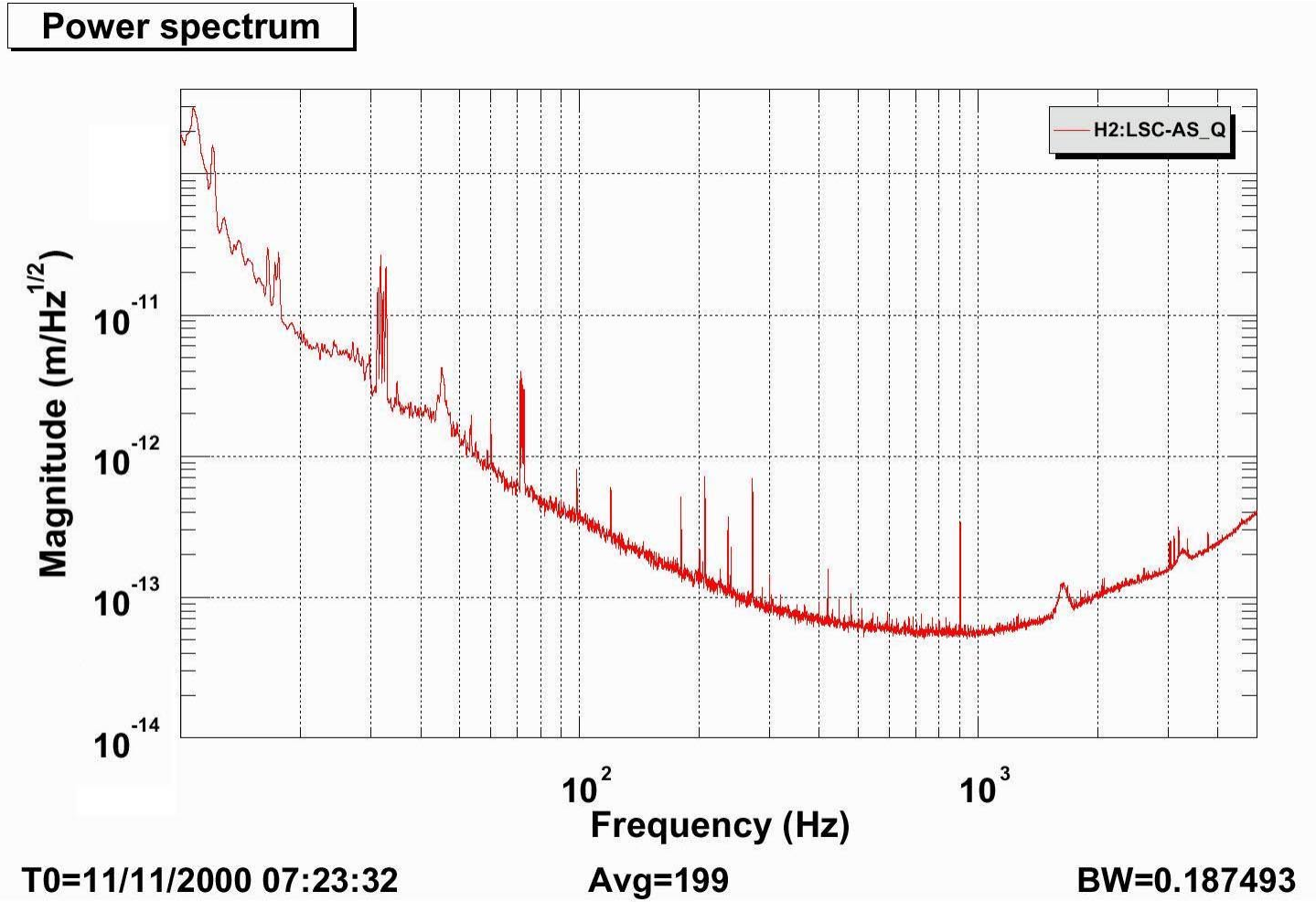
- Data acquisition rate of 3 MB/s per interferometer, 24h disk storage
- Data Viewer
- Interactive Tools
- Monitor Tools



The Digital Control System

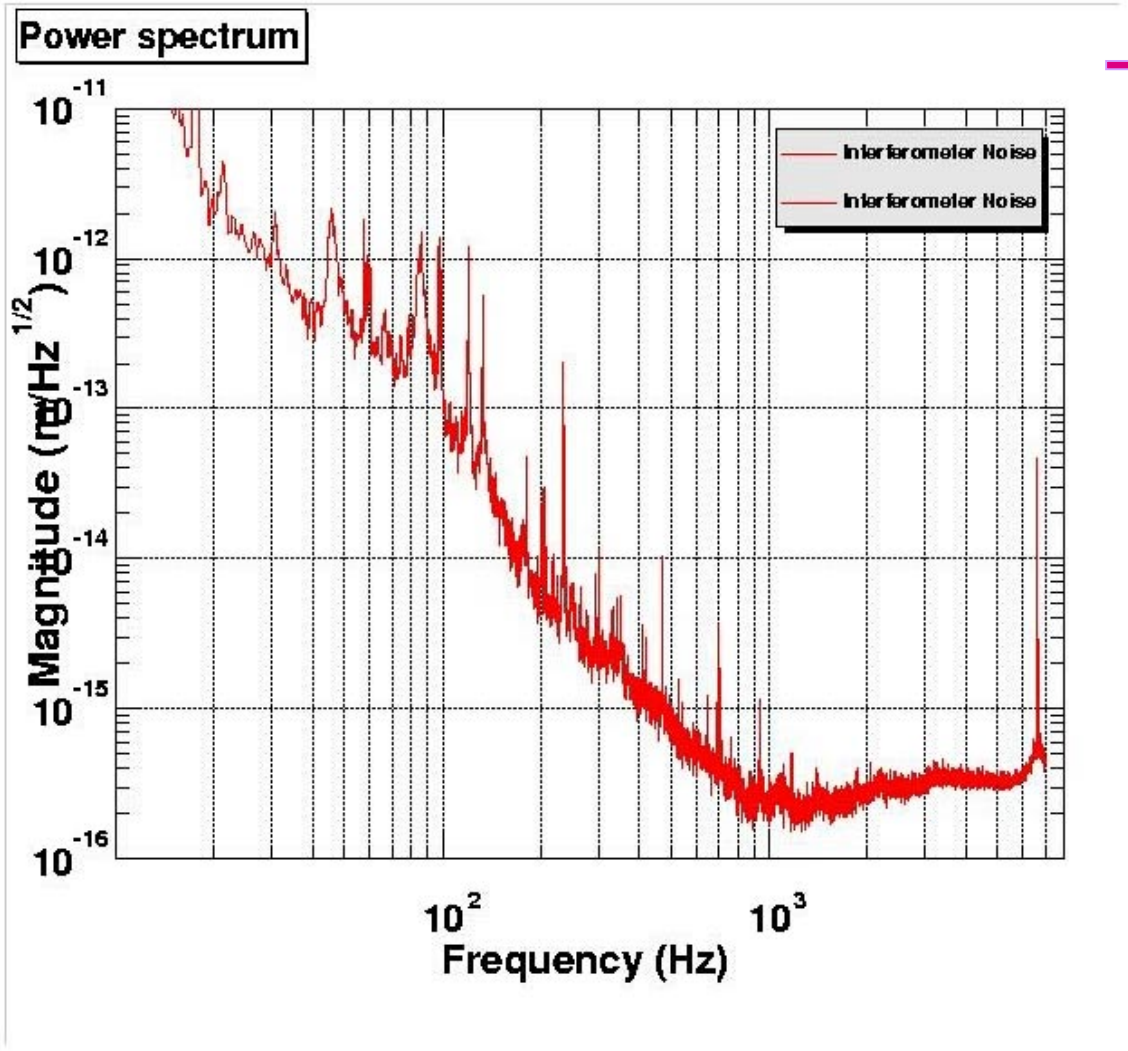


Noise Spectrum: 2K Recombined



E2 Run

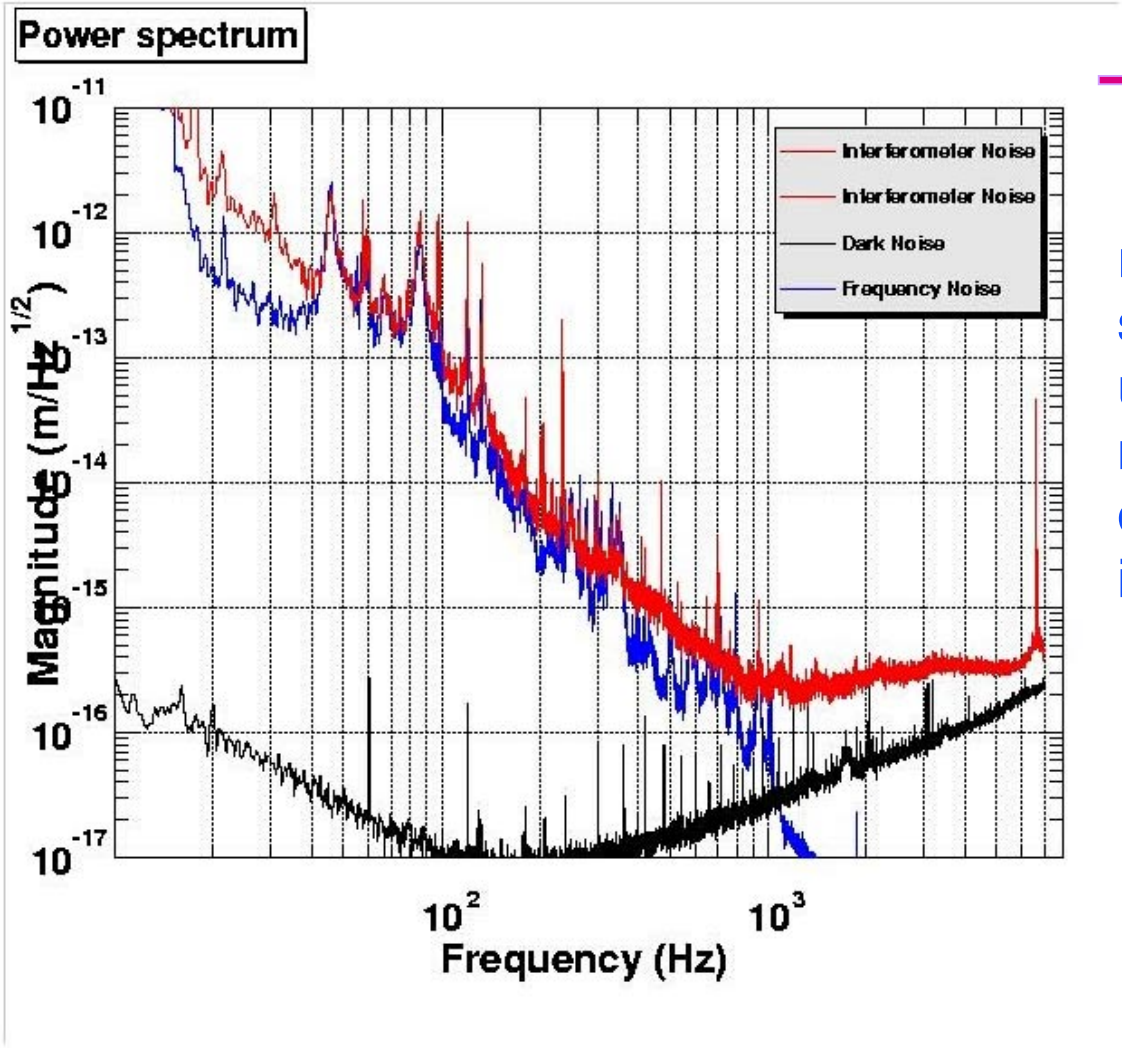
Noise Spectrum: 2K Recycled



Factor of 200 improvement (over E2 spectrum)

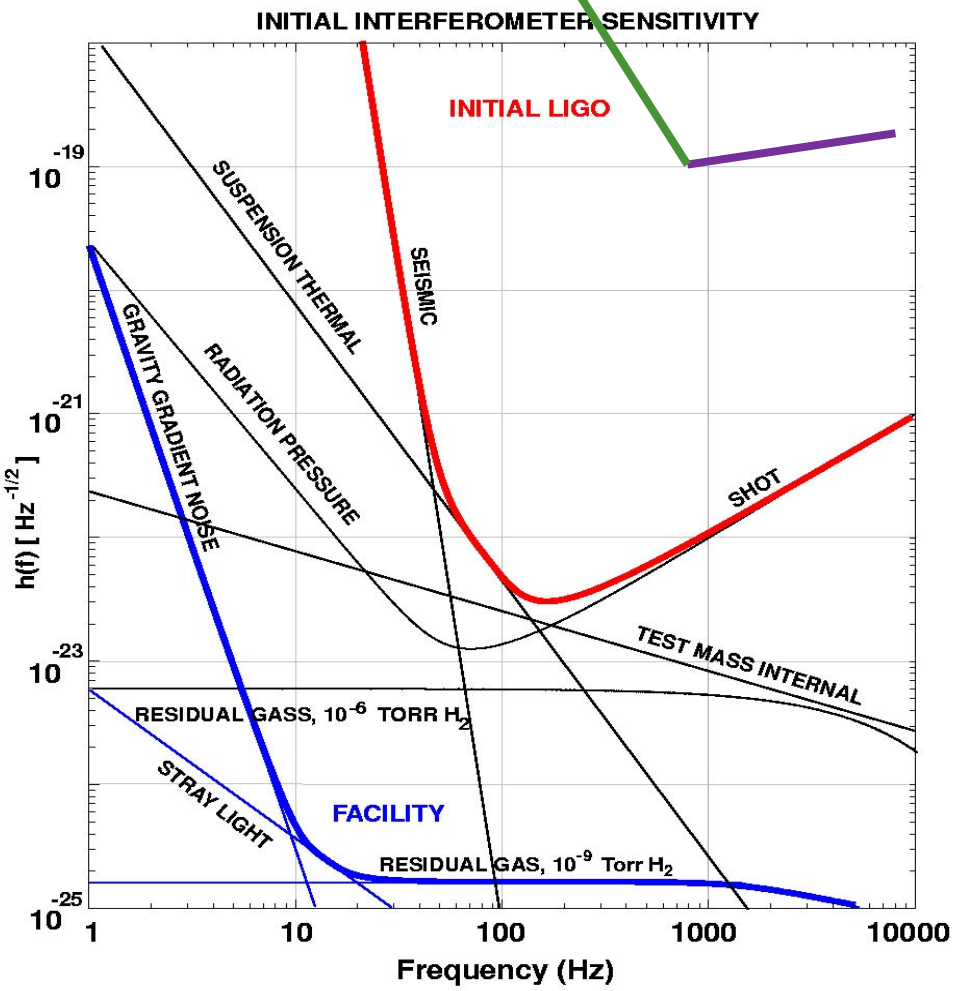
- Recycling
- Reduction of electronics noise
- Partial implementation of alignment control

Known Contributors to Noise



Identification and reduction of noise sources underway using well-established noise-hunting techniques developed on prototype interferometers

Initial LIGO Sensitivity

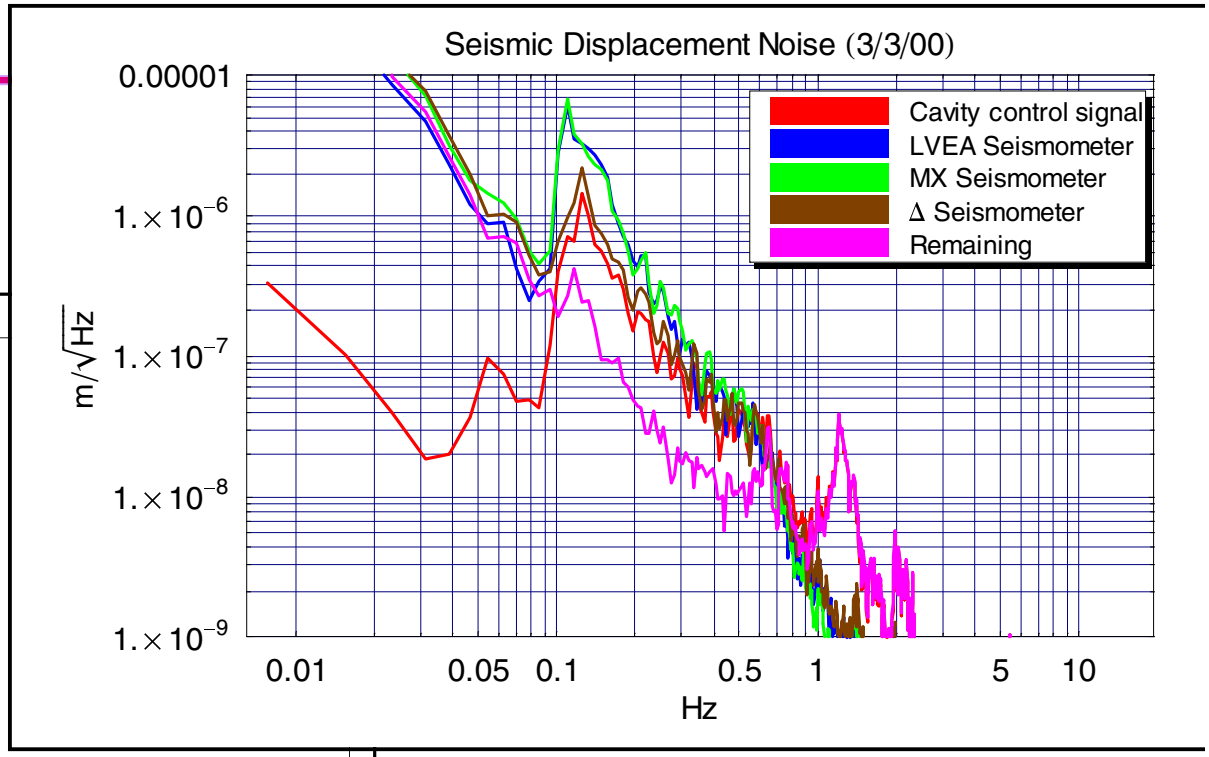


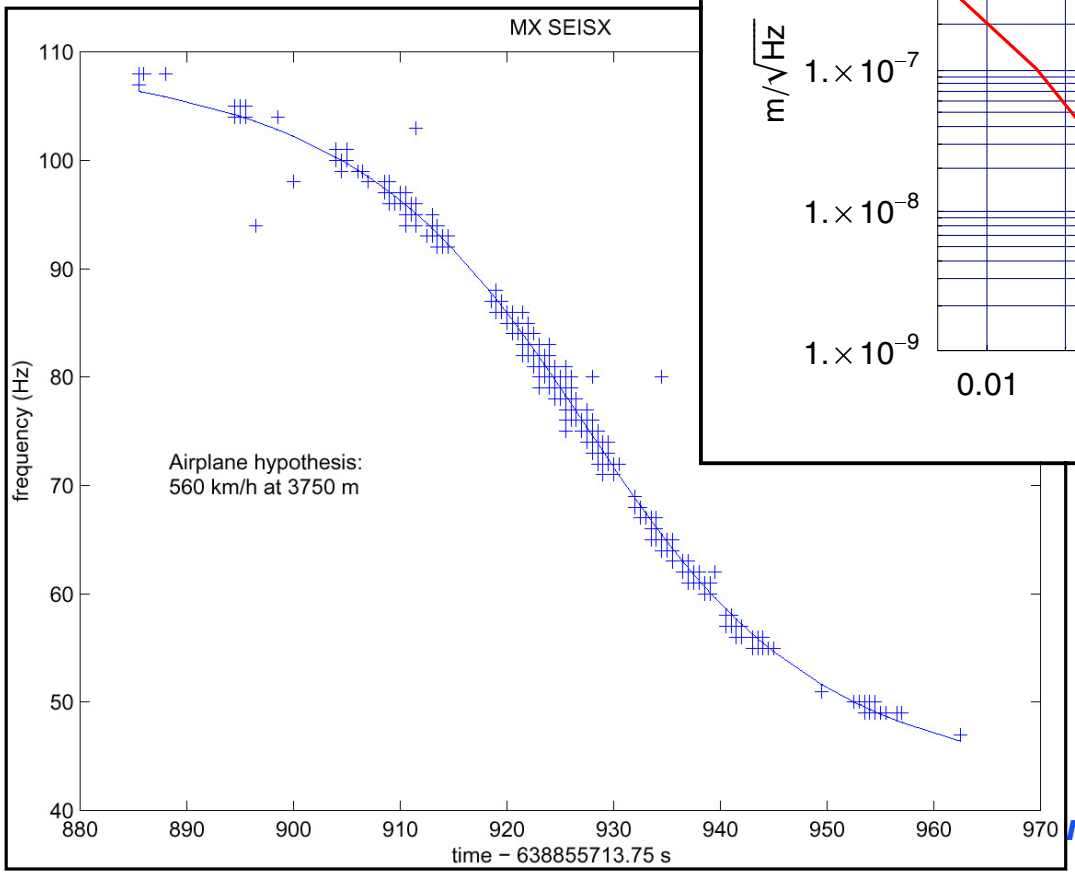
- Frequency noise
  - Improve PSL Table layout (done)
  - Tailor MC loop (done)
  - Implement common-mode feedback from arms
- Electronics noise
  - Scales as P^{-1}
  - Increase power from 12 mW to 6 W
  - Increase recycling factor from 15 to 30-50 (Wavefront-sensing alignment servos)

New Suspension Sensors / High Power Operations

- Developed in parallel with low power commissioning activities
  - Develop a robust solution without pressure of critical path
- Use different LED/photodiode combination with interference filter to discriminate against scattered laser light
- Implementation scheduled to minimize impact on commissioning
  - LHO 4 km installation scheduled to make use of new sensors from beginning
  - LHO 2 km retrofit made in combination with earthquake repairs
  - LLO 4 km retrofit in progress
- **LHO 2 km mode cleaner successfully tested to full power last month!**

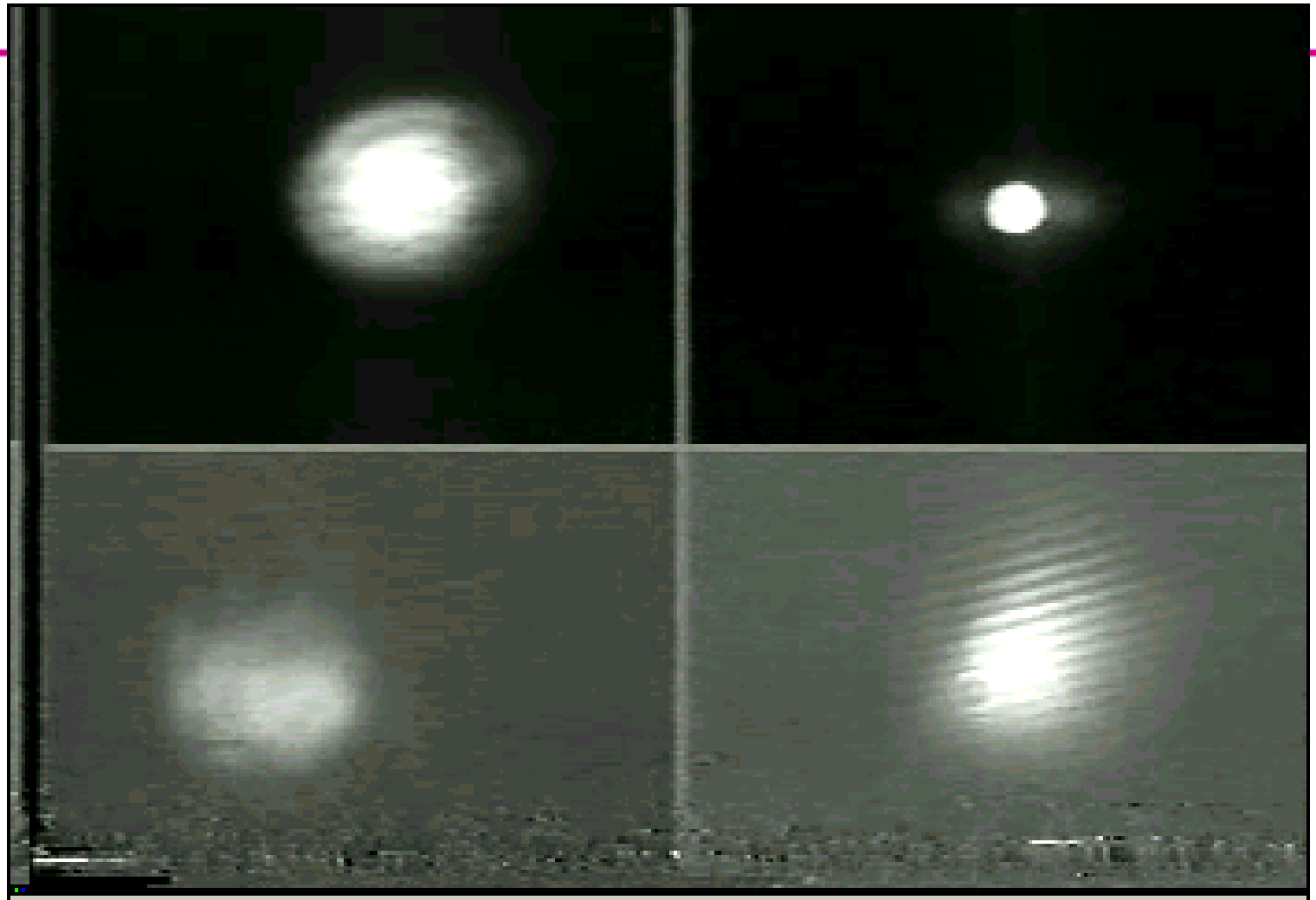
Engineering Run Results





Poster by John Zweizig

Locking



XY_arm_locking.mpg