LIGO

An example of a ground-based interferometric gravitational wave detector

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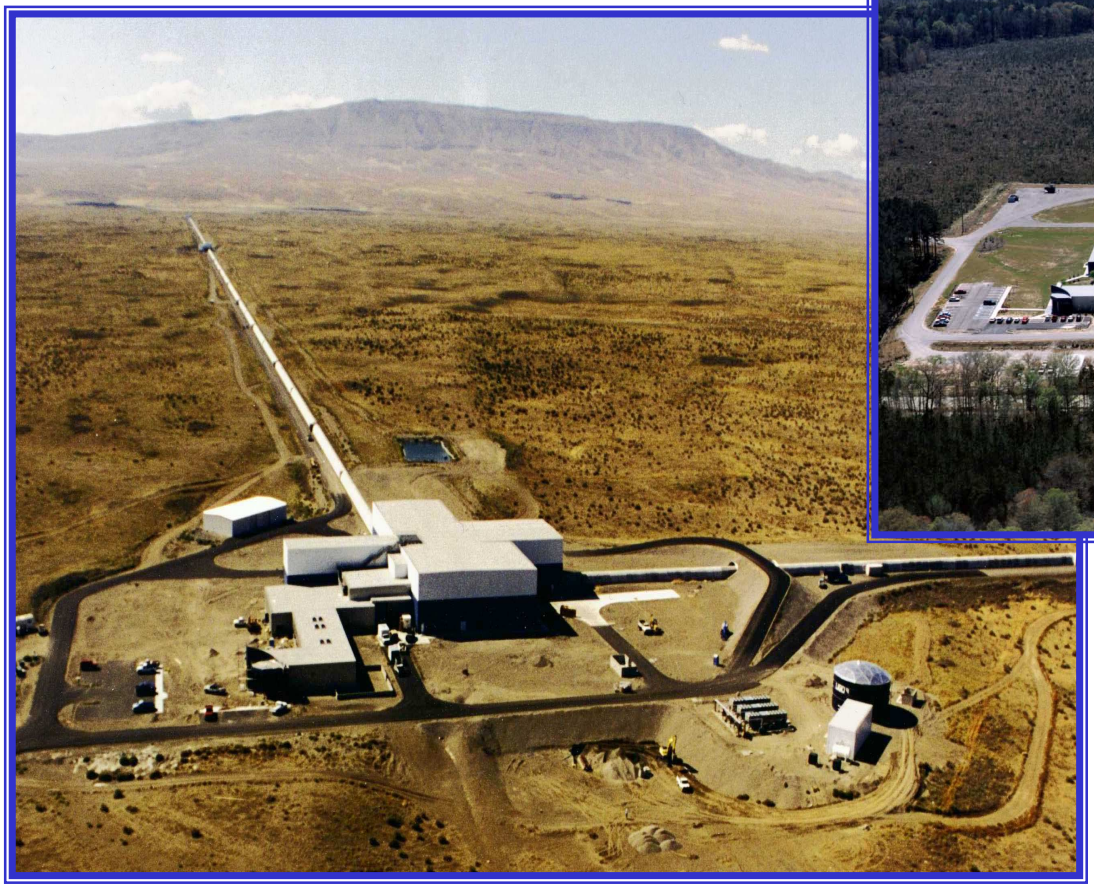
5 June 2000

LIGO Infrastructure: Two sites, separated by 3000 km

Hanford, Washington



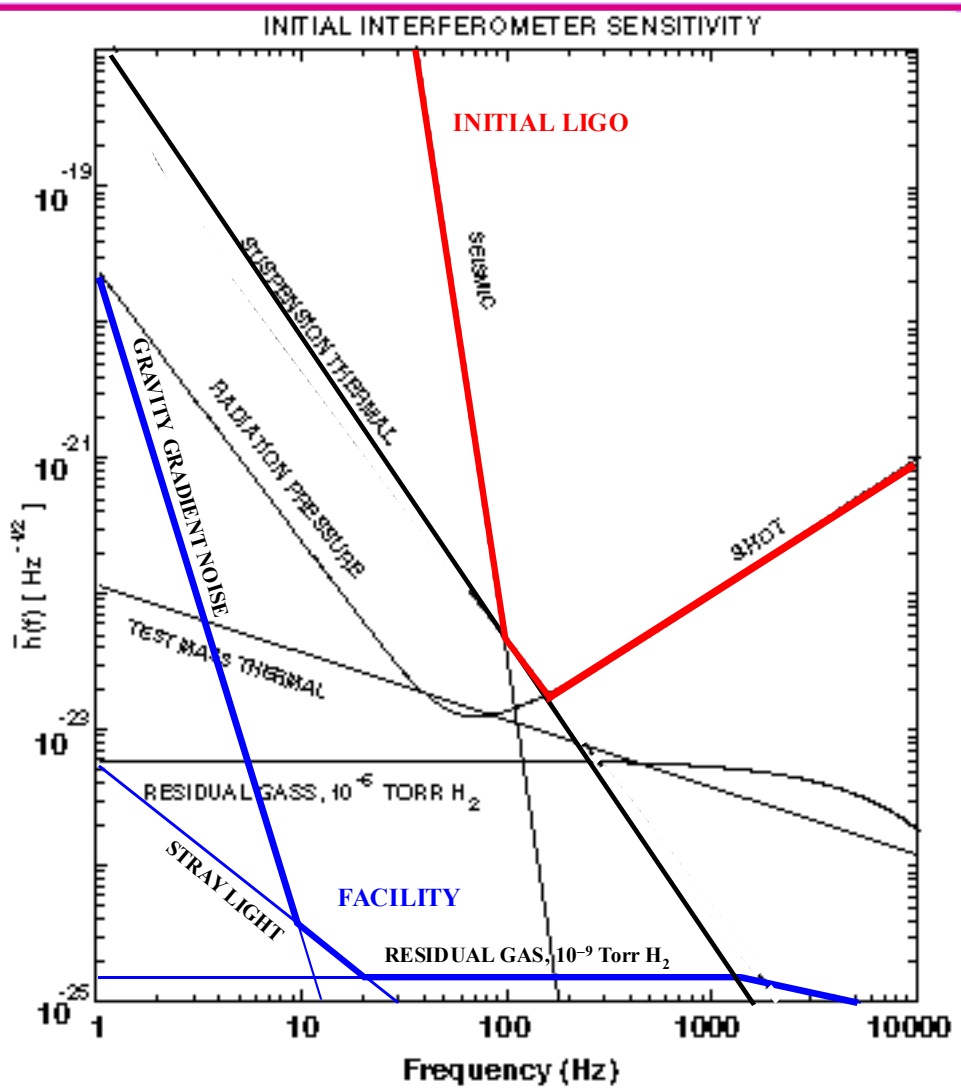
Livingston, Louisiana

Optical Configuration

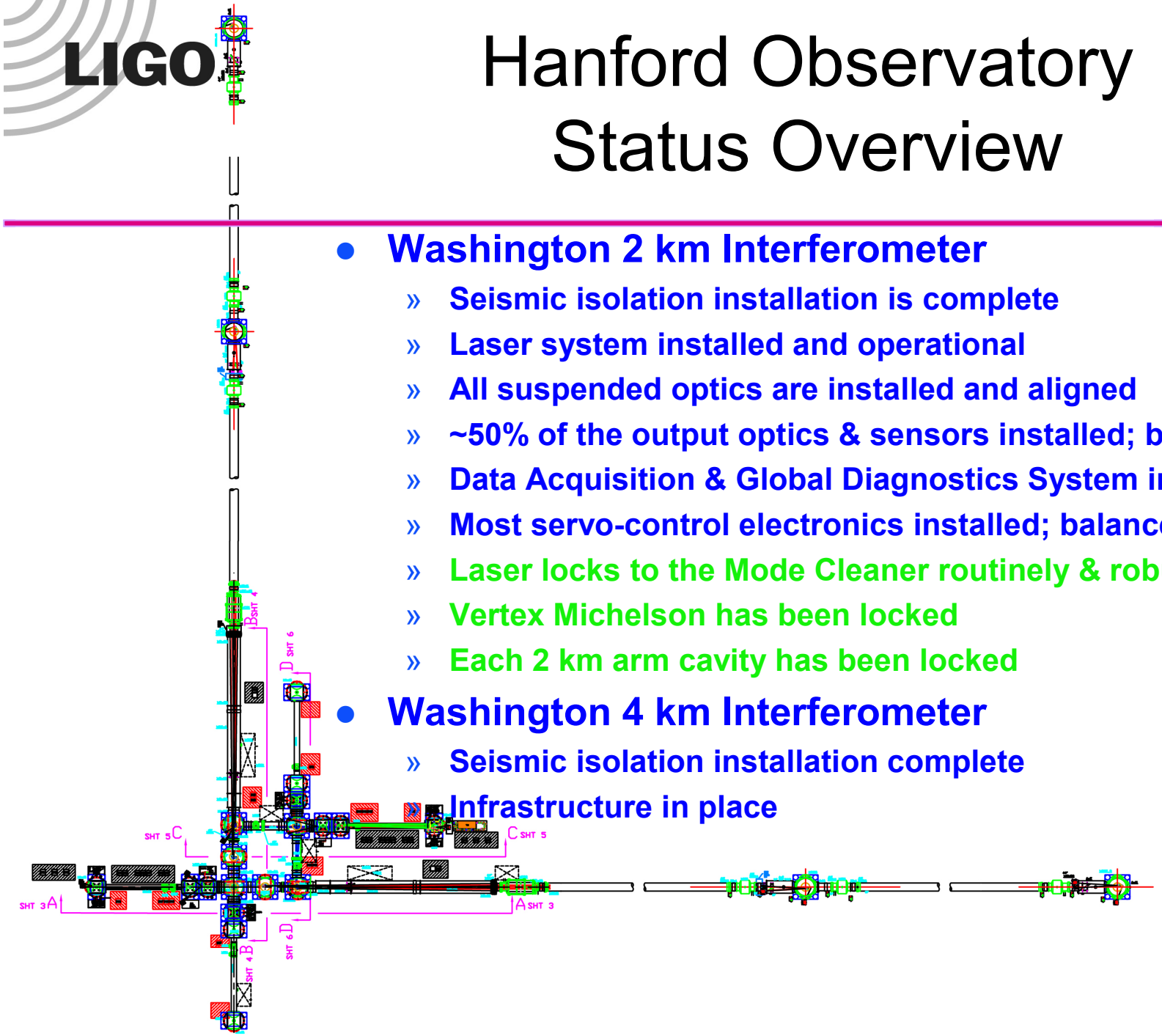
Projected Performance

- Seismic low-frequency limit
- Thermal noise in mid-range
- Photon shot noise at high freq.

- Possible to detect solar-mass neutron-star inspiral events, but not often
- Surprises...



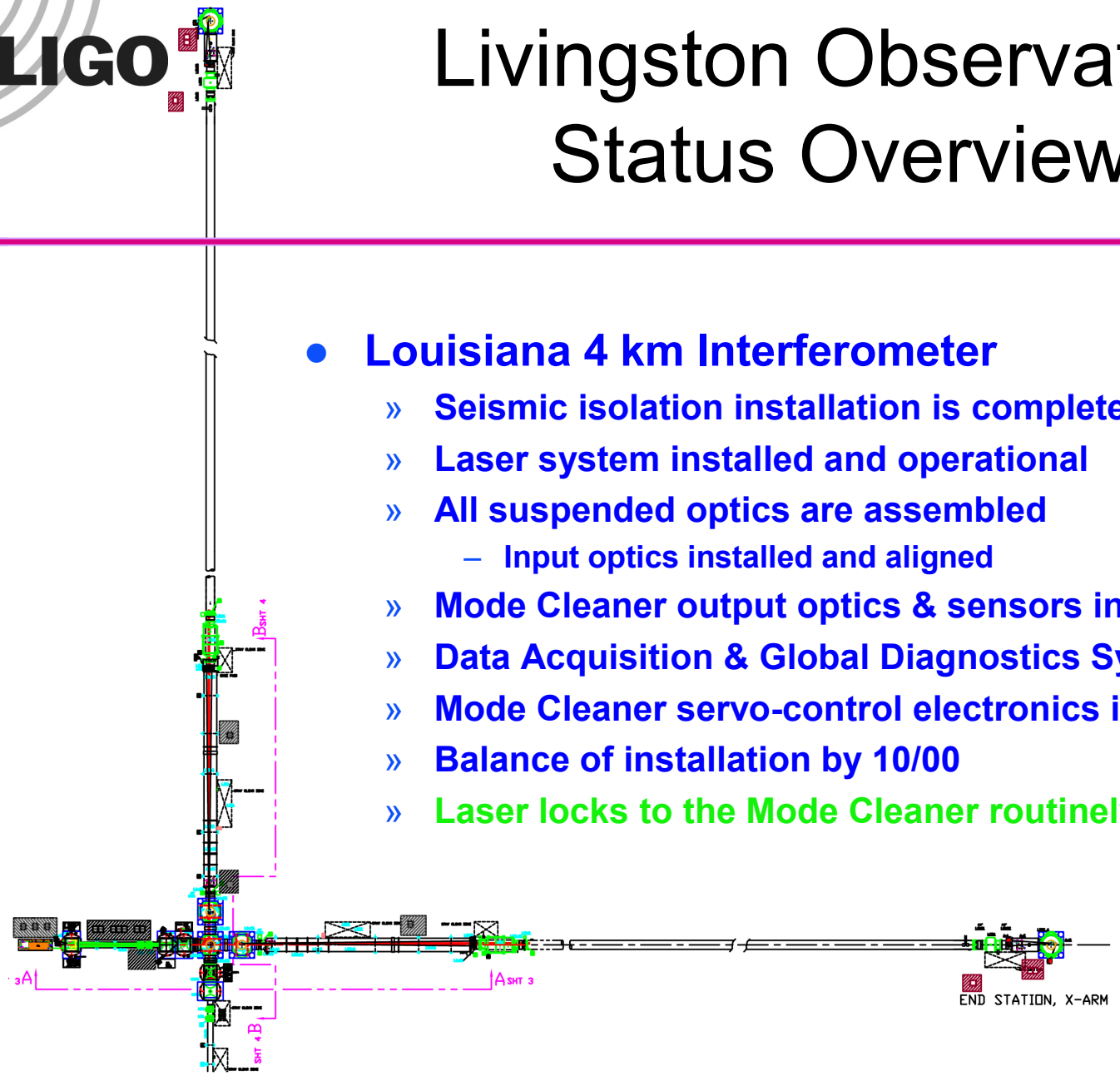
Hanford Observatory Status Overview



- **Washington 2 km Interferometer**
  - » Seismic isolation installation is complete
  - » Laser system installed and operational
  - » All suspended optics are installed and aligned
  - » ~50% of the output optics & sensors installed; balance by 6/00
  - » Data Acquisition & Global Diagnostics System installed
  - » Most servo-control electronics installed; balance by 7/00
  - » Laser locks to the Mode Cleaner routinely & robustly
  - » Vertex Michelson has been locked
  - » Each 2 km arm cavity has been locked
- **Washington 4 km Interferometer**
  - » Seismic isolation installation complete
  - » Infrastructure in place

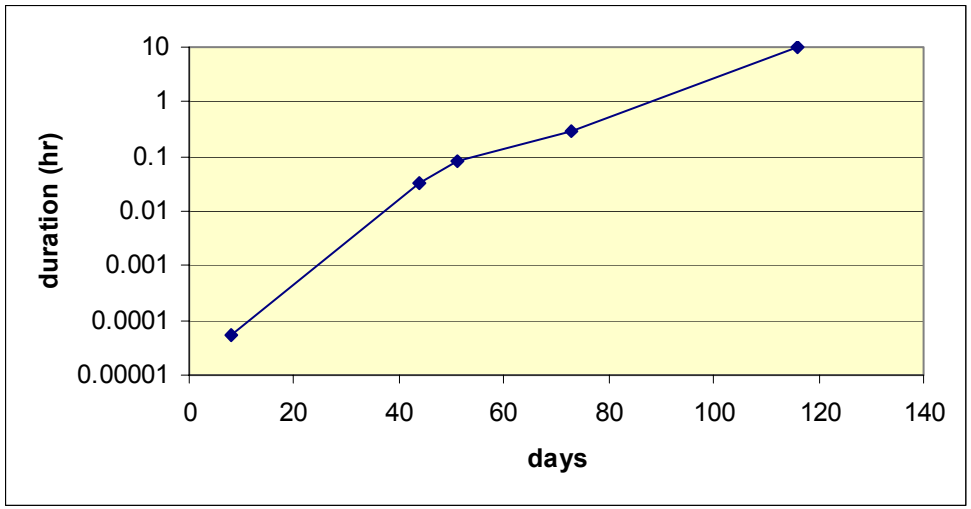
Livingston Observatory Status Overview

- **Louisiana 4 km Interferometer**
  - » **Seismic isolation installation is complete**
  - » **Laser system installed and operational**
  - » **All suspended optics are assembled**
    - – **Input optics installed and aligned**
  - » **Mode Cleaner output optics & sensors installed**
  - » **Data Acquisition & Global Diagnostics System installed**
  - » **Mode Cleaner servo-control electronics installed**
  - » **Balance of installation by 10/00**
  - » **Laser locks to the Mode Cleaner routinely**



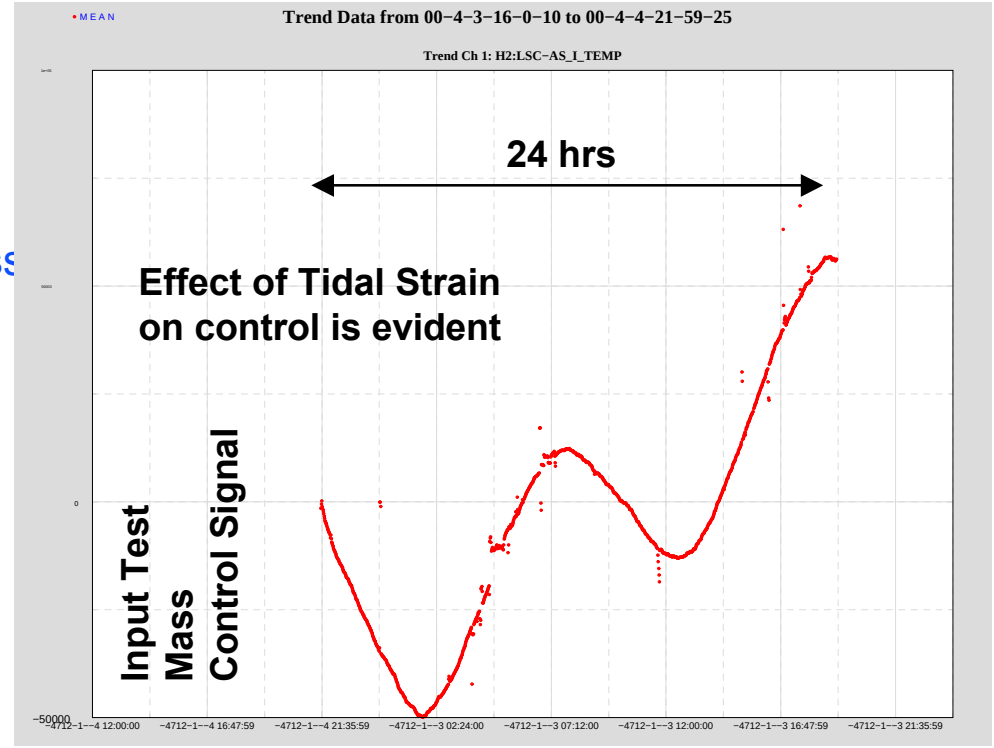
Test Configuration: 2 km Fabry-Perot Cavity

- Includes all interferometer subsystems
  - » many in definitive form; analog servo on cavity length for test configuration
- Ability to lock cavity improves with understanding



2km Fabry-Perot cavity

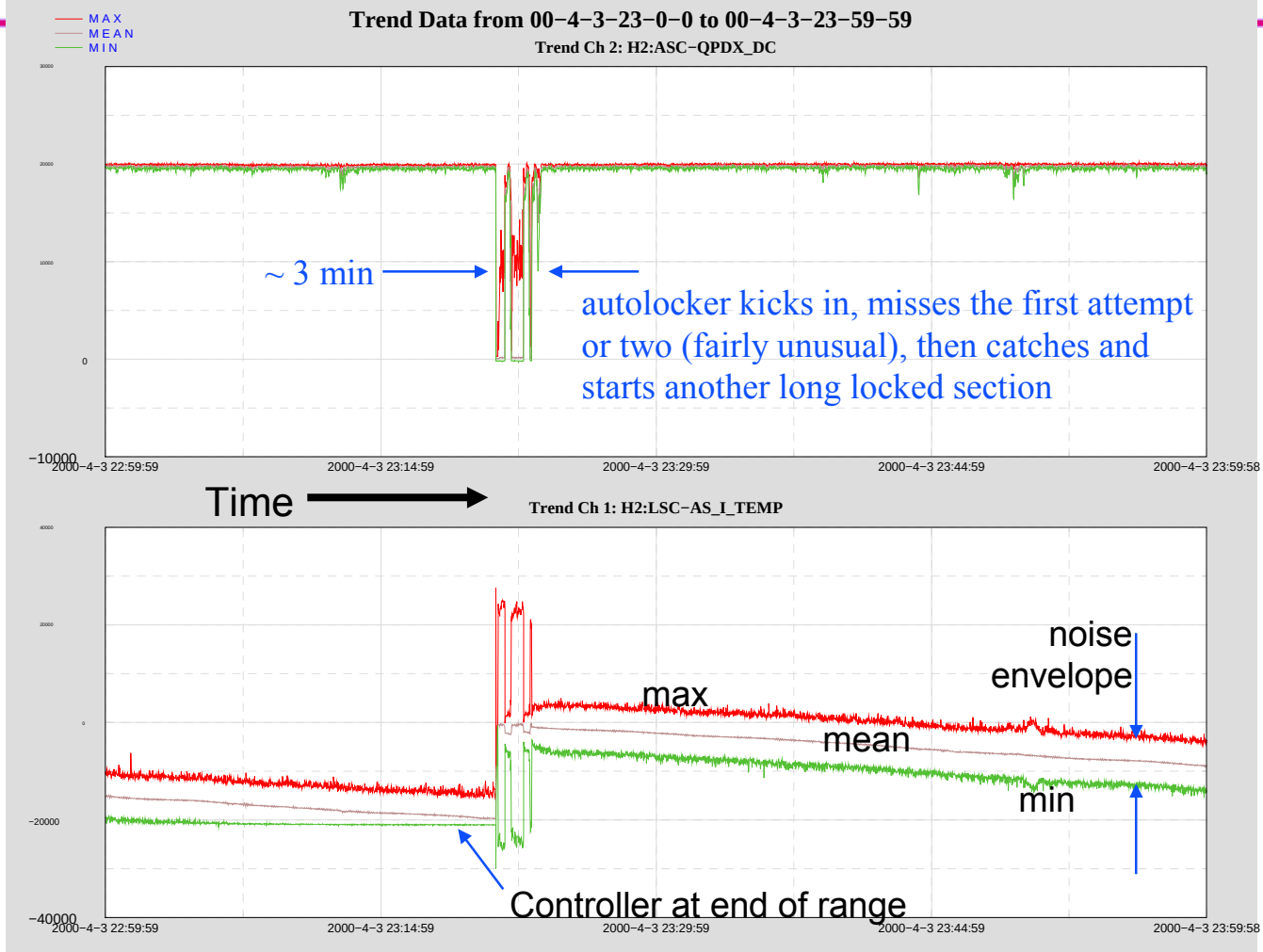
- models of environment
  - » temperature changes on laser frequency
  - » tidal strains changing baselines
  - » seismometer/tilt correlations with microseismic peak
- mirror characterization
  - » losses: 1-2% dip in reflected signal intensity --- ~30 ppm/bounce total loss
  - » scatter appears to be better than requirements
- 24 hour run
  - » long-term characterization
  - » robustness, drifts
  - » see tidal forces (also freq. ref. Temperature drift…)



2km Fabry-Perot cavity: 1 hr stretch with Unlock-Lock Transient

Cavity Transmitted Signal

Input Test Mass Control Signal



Schedule for LIGO I

- Full 2km Hanford configuration locked Fall ‘00
- Full 4km Livingston configuration locked Spring ‘01
- **Start of coincidence measurements!**
- Triple coincidence observations Spring ‘02
  - » networked with other detectors (GEO, VIRGO,…)
- Dedicated to a minimum of one year integrated Science Run

…then...

LIGO II

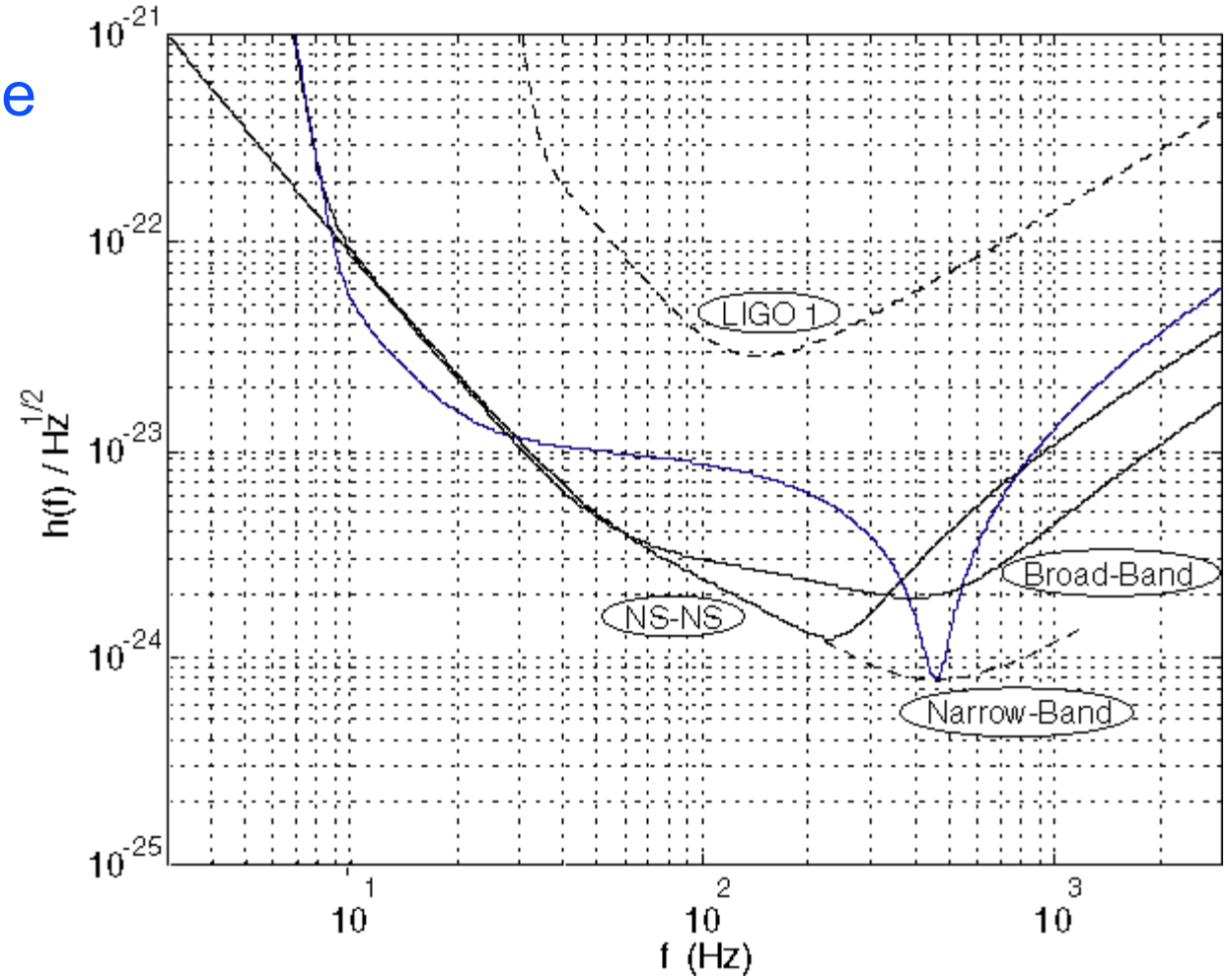
- Next generation interferometer in planning
- Make a significant change in 'Physics Reach'
  - » significantly improved probability of detecting foreseen sources
  - » significantly improved overall sensitivity
- Fully exploit basic configuration
  - » power/signal recycled Fabry-Perot Michelson
  - » transmissive input optics
  - » room-temperature pendulum suspension
- Quantum limited at all useful frequencies
  - » optimize, not maximize, power
  - » Newtonian background, thermal noise lurking below

LIGO II Technologies

- Adopting some improvements, pioneering others:
- Optical configuration
  - » addition of signal recycling - optimization of response)
- Quantum-limited sensing
  - » broad-band improvement due to increase in circulating power - ~150 W
- Thermal noise
  - » pendulum thermal noise improvement through change to fused silica (factor 6 reduction), design of fibers (~factor 5 reduction):
  - » test mass thermal noise: change to sapphire masses
- Seismic noise
  - » improved filtering to ~10 Hz ‘brick wall’ (touching Newtonian background) possibly through high-gain servo-controlled platforms

LIGO II Draft Sensitivity

- Significant increase at all frequencies
- Tunable response
- System trades, Thermal noise still in study



LIGO II Schedule

- LIGO I science run till late 2004
- ready all designs and components for LIGO II in interim
- Install in one interferometer, shakedown, refine
- Have complete new network in 2007-2008
- (one day of LIGO II equivalent to entire LIGO I run!)