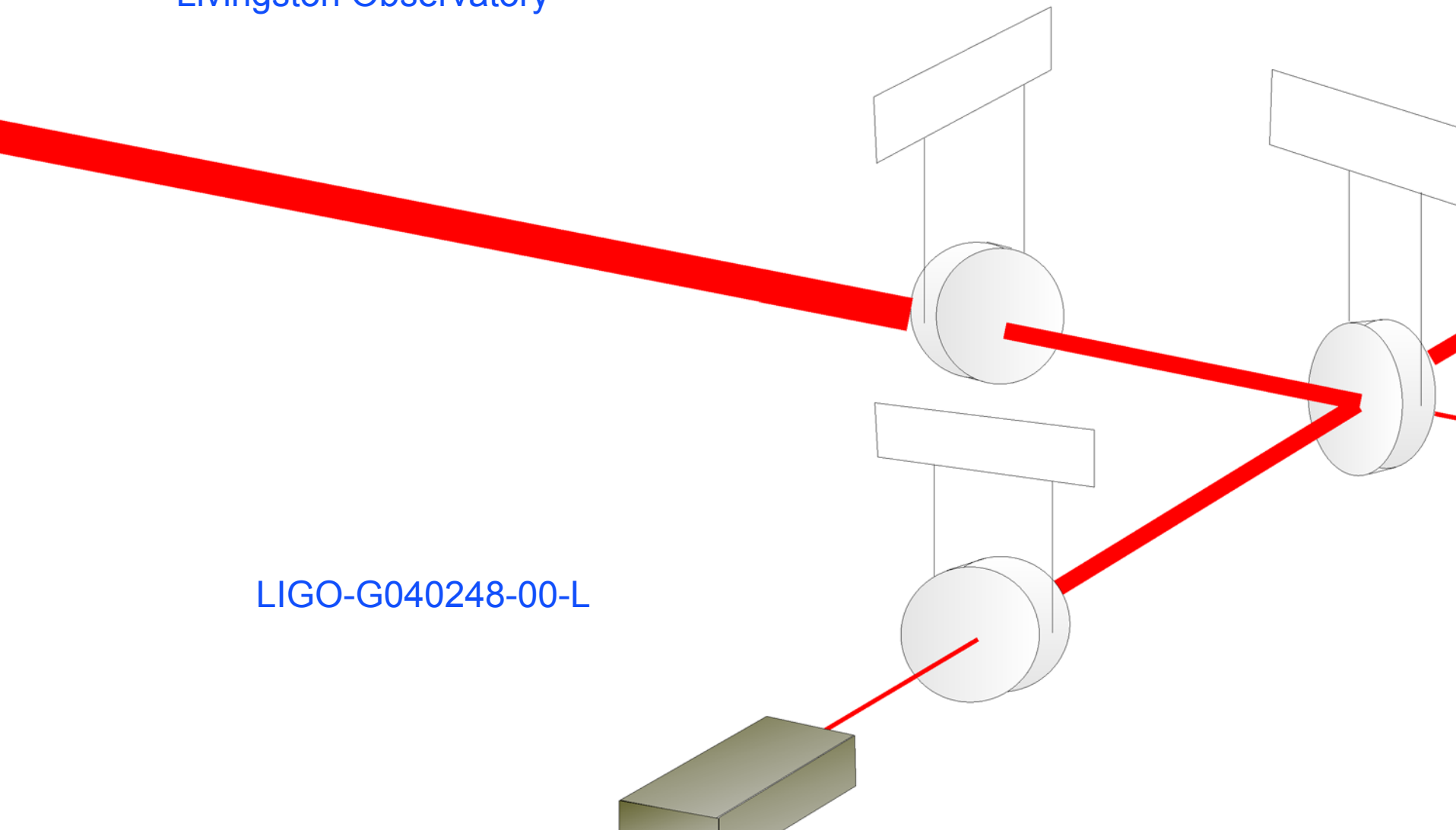
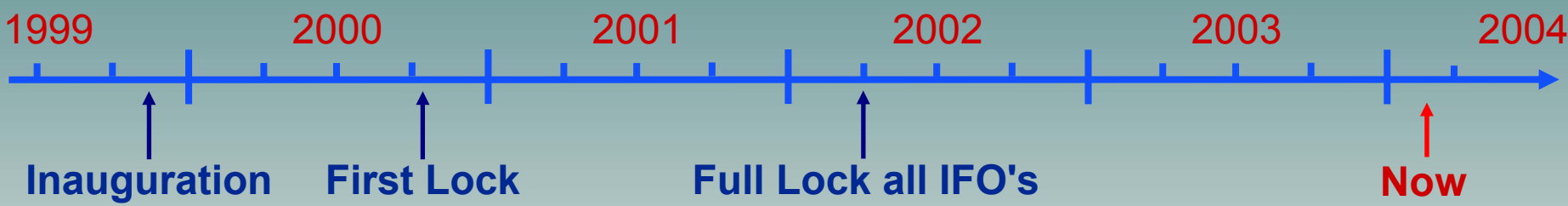
Status of LIGO

Andri M. Gretarsson
Livingston Observatory

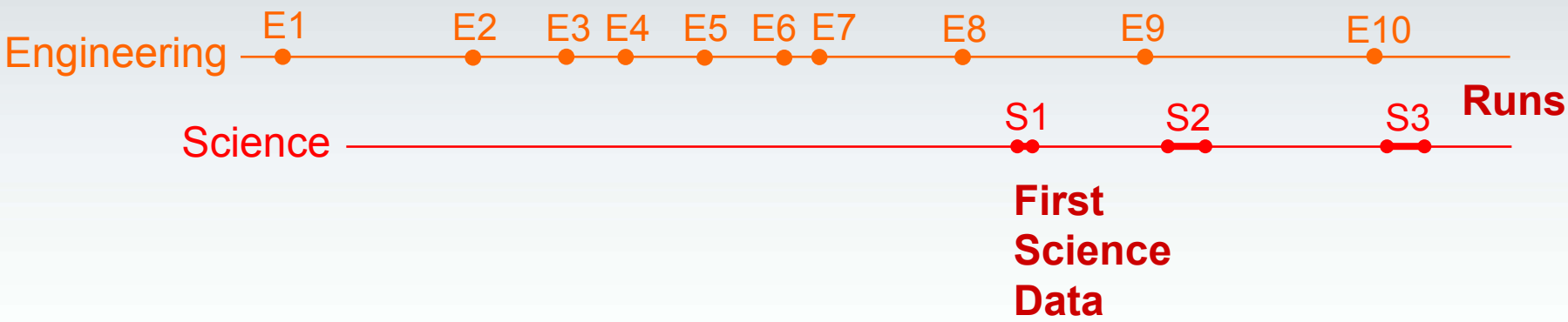


LIGO-G040248-00-L

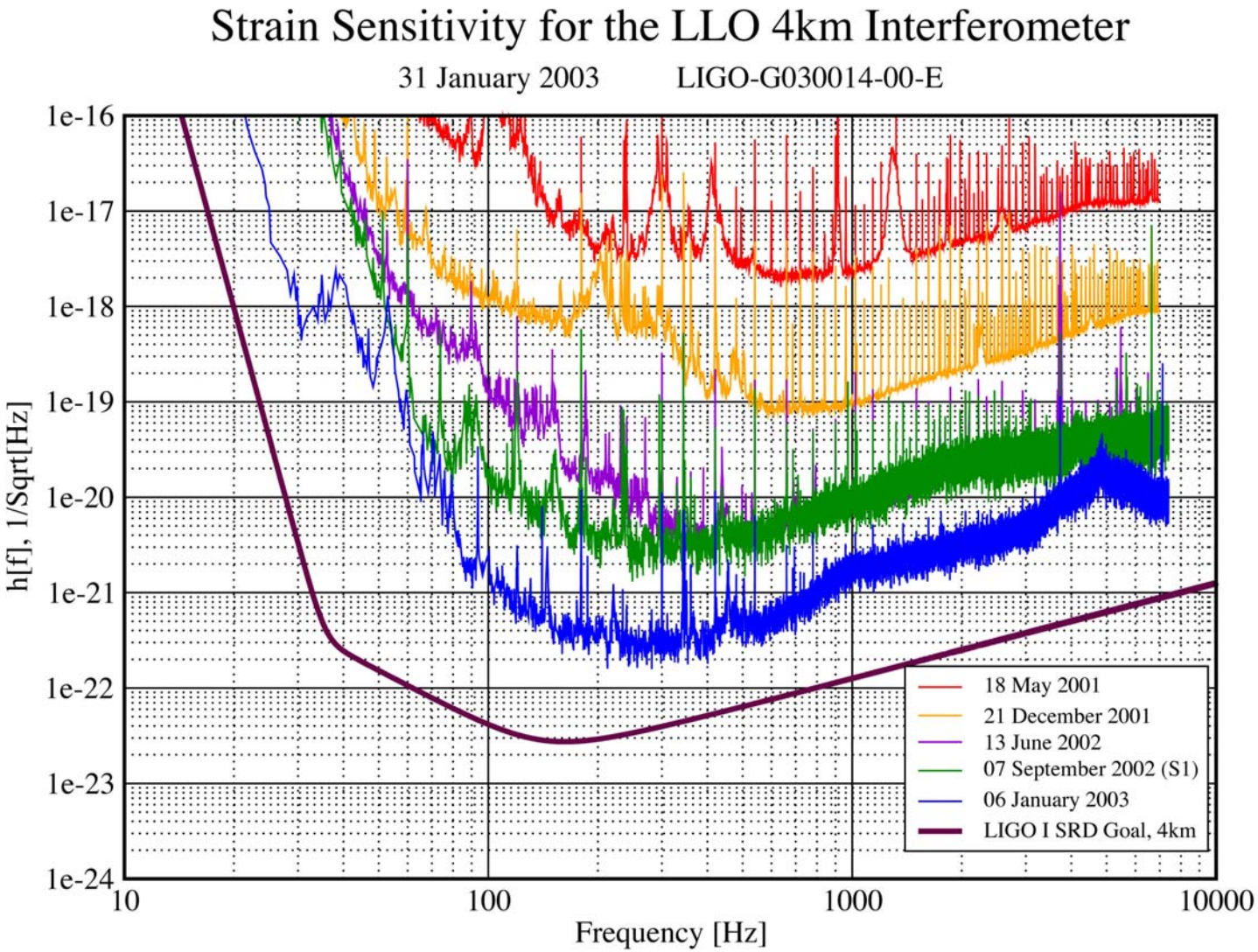
Timeline


1999
2000
2001
2002
2003
2004
Inauguration
First Lock
Full Lock all IFO's
Now

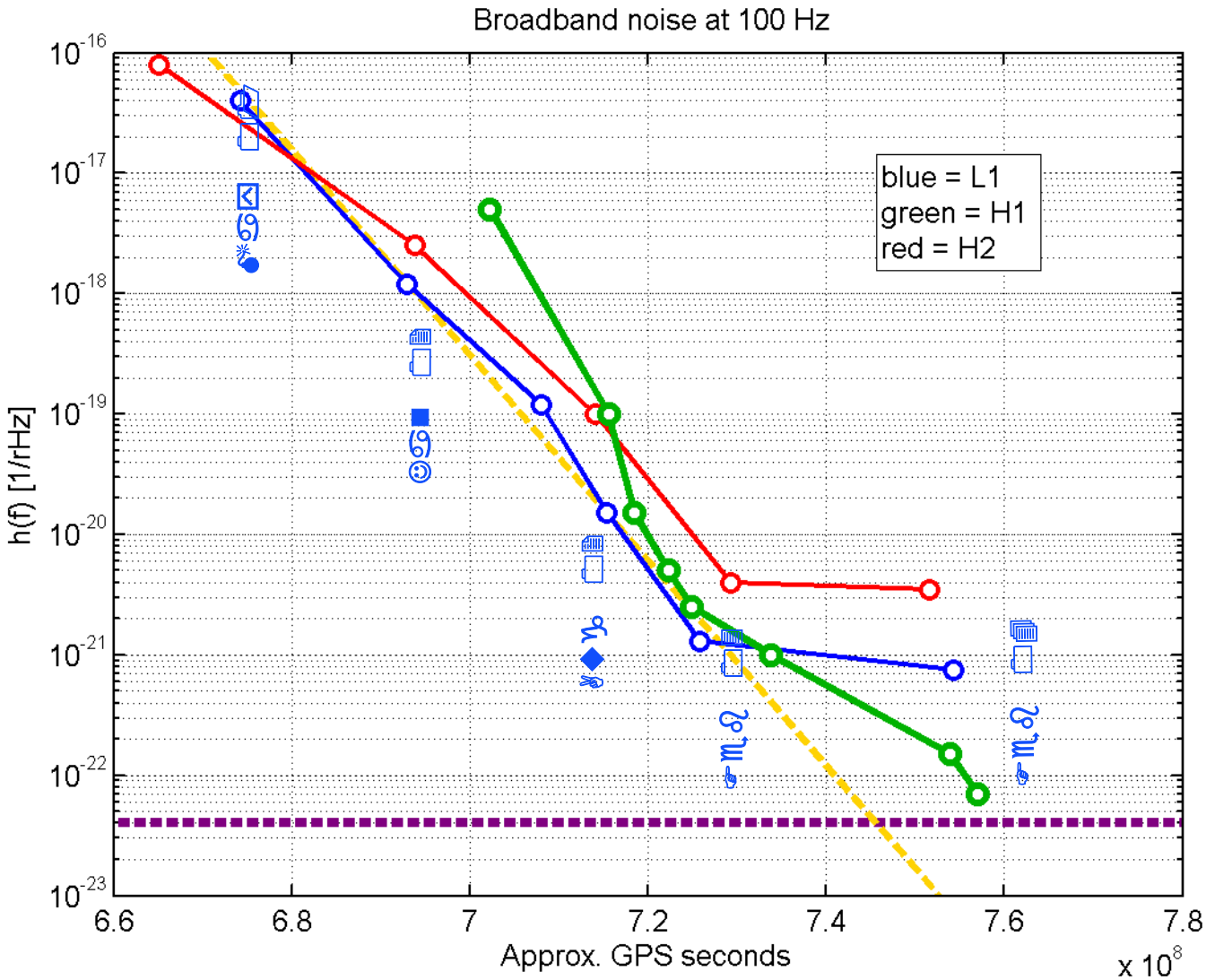

strain noise density @ 200 Hz [Hz$^{-1/2}$]
10^{-17}
10^{-18}
10^{-19}
10^{-20}
10^{-21}
10^{-22}


Engineering
E1
E2
E3
E4
E5
E6
E7
E8
E9
E10
Science
S1
S2
S3
Runs
First
Science
Data

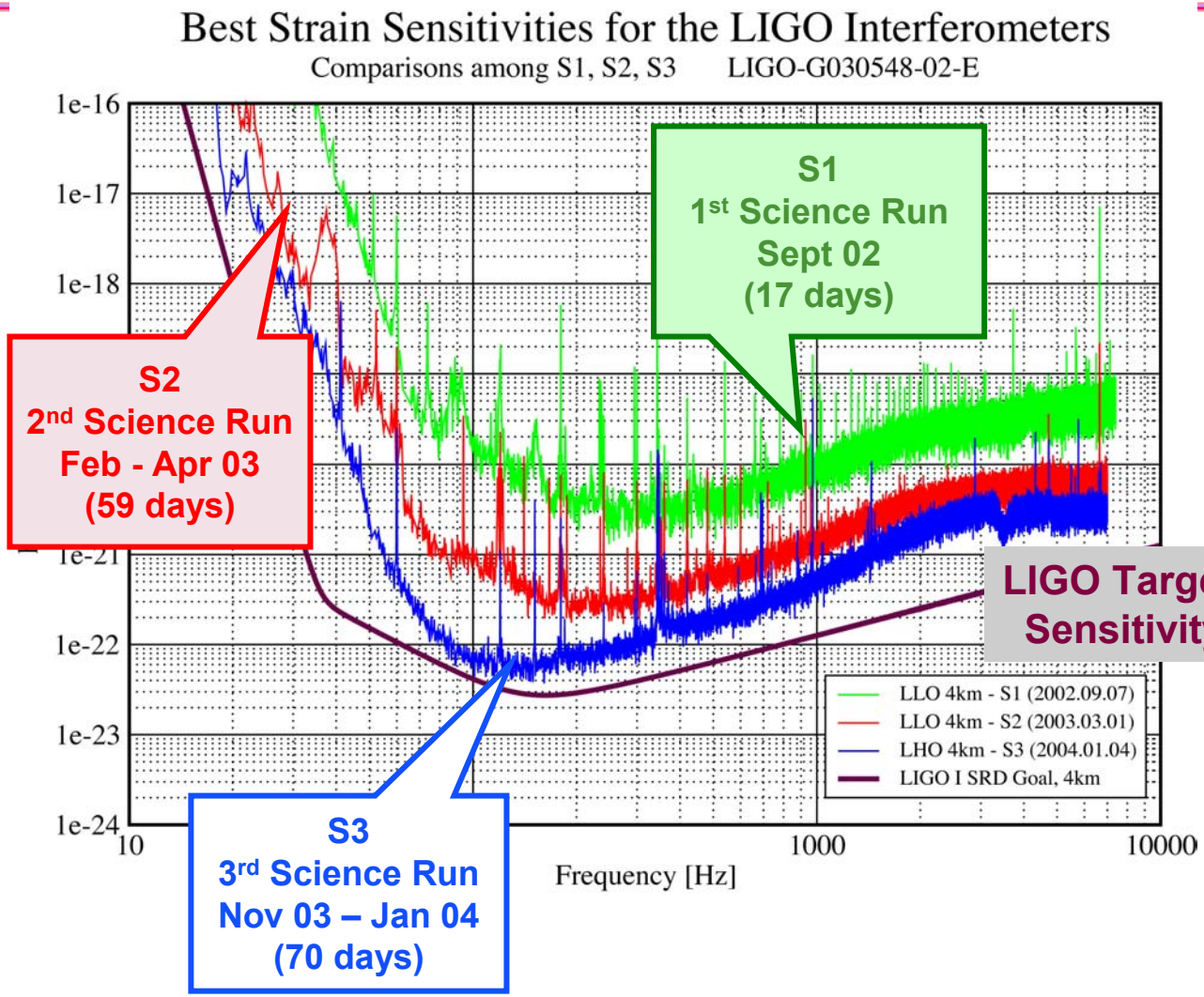
Commissioning Progress



Commissioning Progress (2)



S3...best yet

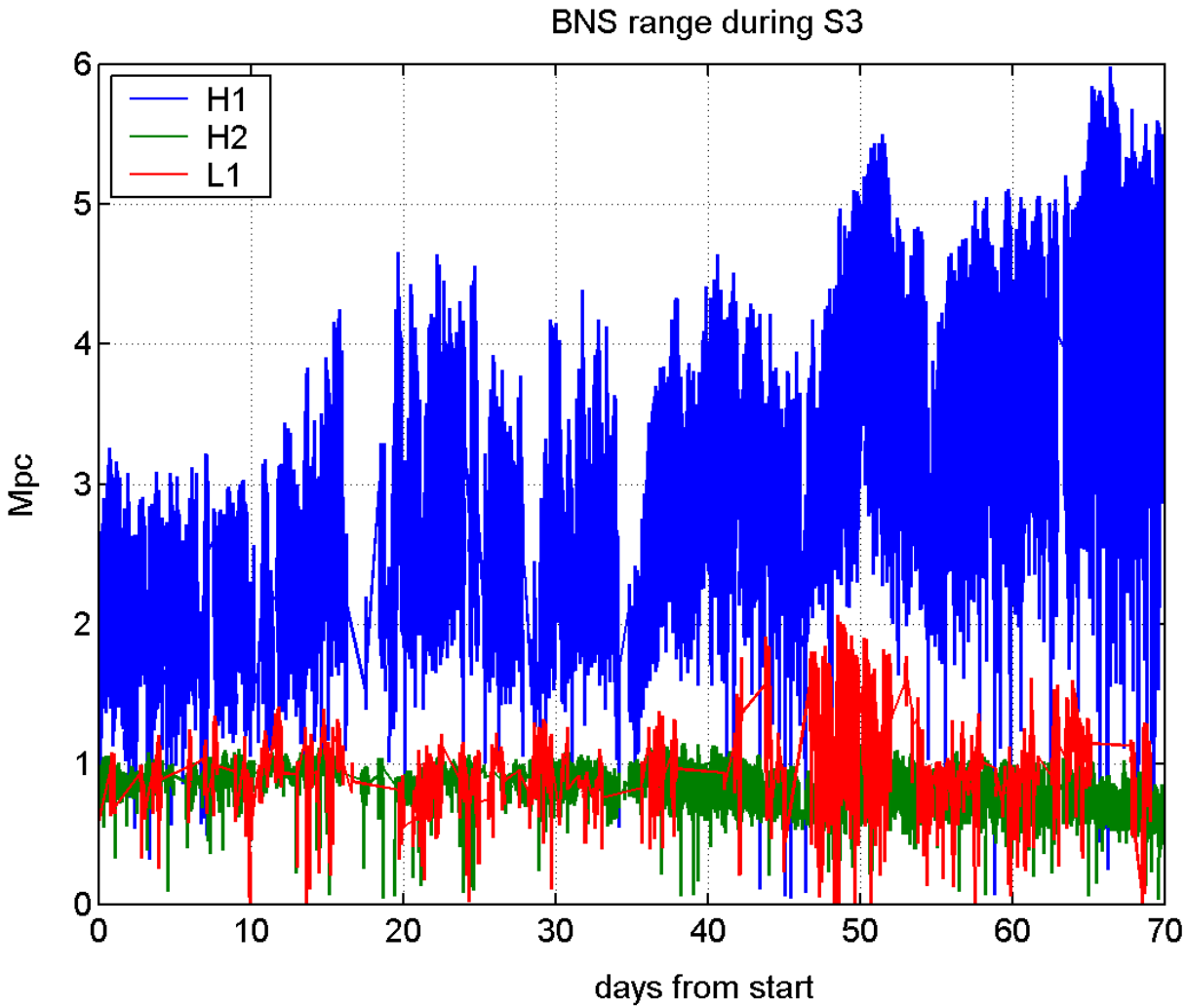


S3 Duty Cycle	
Hanford 4km	69%
Hanford 2km	63%
Livingston 4 km	22%*

* Limited by high ground noise

BNS inspiral range

(8 sigma, average direction)



S1 results are "out"

Papers by the LIGO Science Collaboration (~370 authors, 40 institutions):

- "***Detector Description*** *and Performance for the First Coincident Observations between LIGO and GEO",* Nucl.Instrum.Meth. A517 (2004) 154-179 , **gr-qc/0308043**

- "*Setting upper limits on the strength of* ***periodic gravitational waves*** *using the first science data from the GEO600 and LIGO detectors*" **gr-qc/0308050**, accepted for publication in PRD

- "*Analysis of LIGO data for gravitational waves from* ***binary neutron stars***", **gr-qc/0308069,** being reviewed by PRD

- "*First upper limits from LIGO on* ***gravitational wave bursts*** ", **gr-qc/0312056,** accepted for publication in PRD

- "*Analysis of First LIGO Science Data for* ***Stochastic Gravitational Waves***", **gr-qc/0312088,** submitted for publication in PRD

S2 analysis in progress, S3 data awaits...! See Stan Whitcomb's talk.

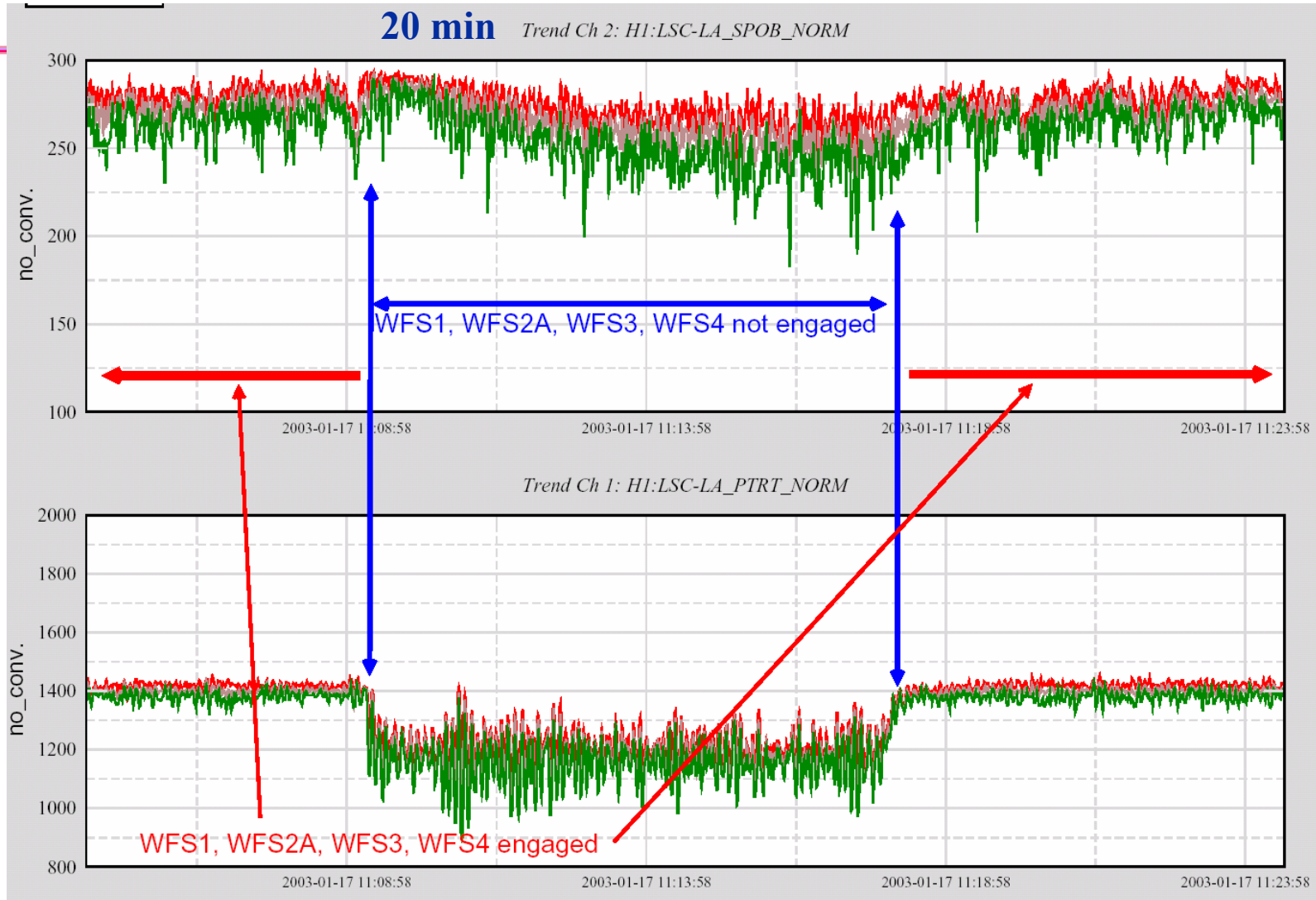
Sensitivity improvements in the past year (or so)

- More wavefront sensors on-line (esp. H1)
- Reduced acoustic coupling
- Power increase
- Adaptive LSC gains
- On H1, found DC alignment sweet-spot (using QPD offset)
- Linear power supplies
- ...many many smaller things leading to significant broadband noise reduction (esp. H1)

WFS system (mostly) running

wavefront sensor	degree of freedom	light sampled	Like LSC sensor
WFS 1	ETMd	AS	AS_Q
WFS 2A	ITMc	POY	POB_I
WFS 2B	ITMd	POY	POB_Q
WFS 3	MMT	REFL	REFL_I
WFS 4	ETMc	REFL	REFL_I

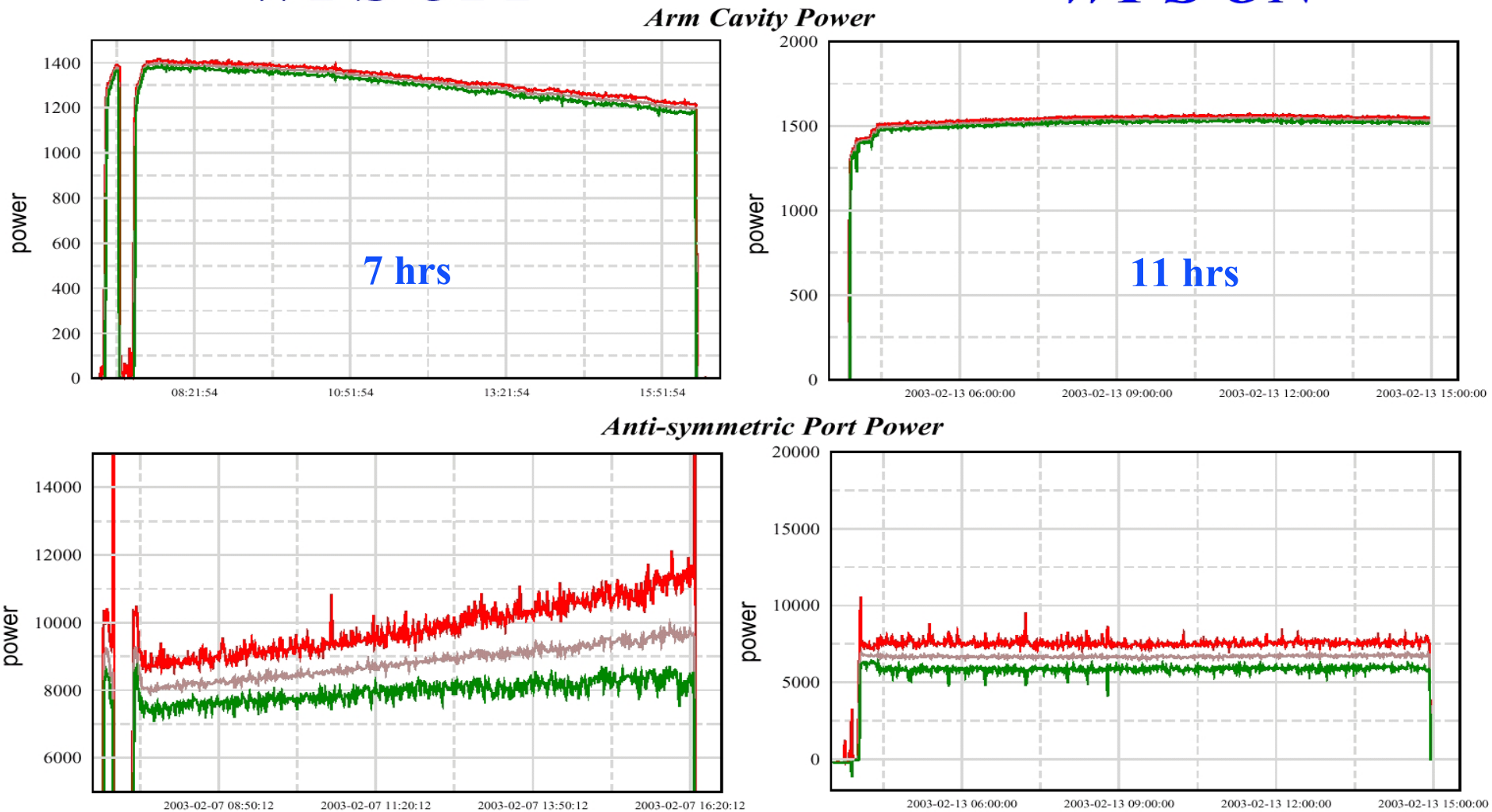
Effect of wavefront sensors



Effect of wavefront sensors (2)

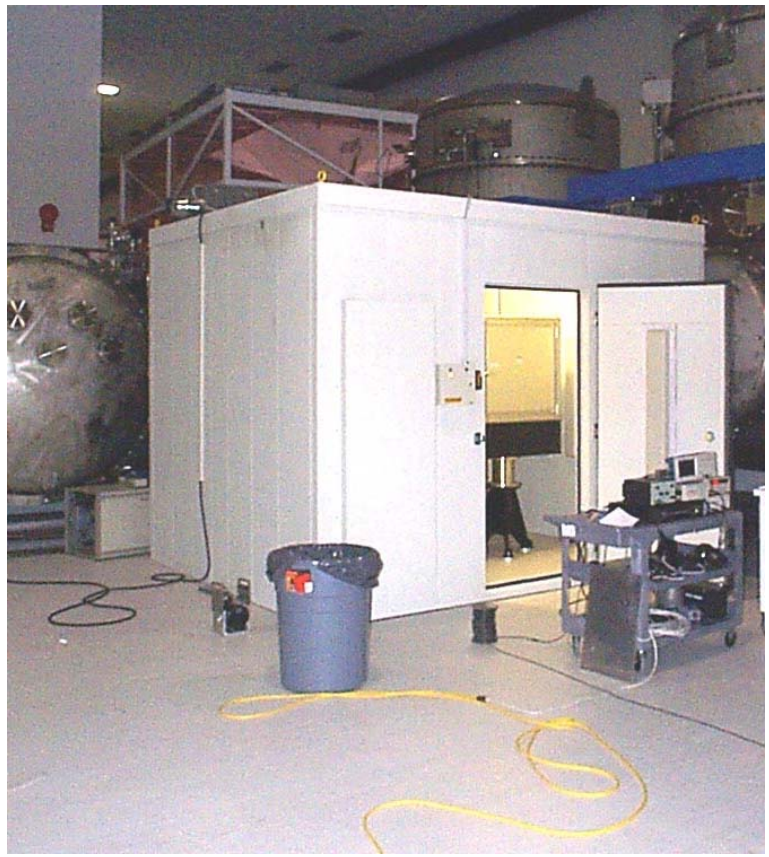
WFS OFF

WFS ON

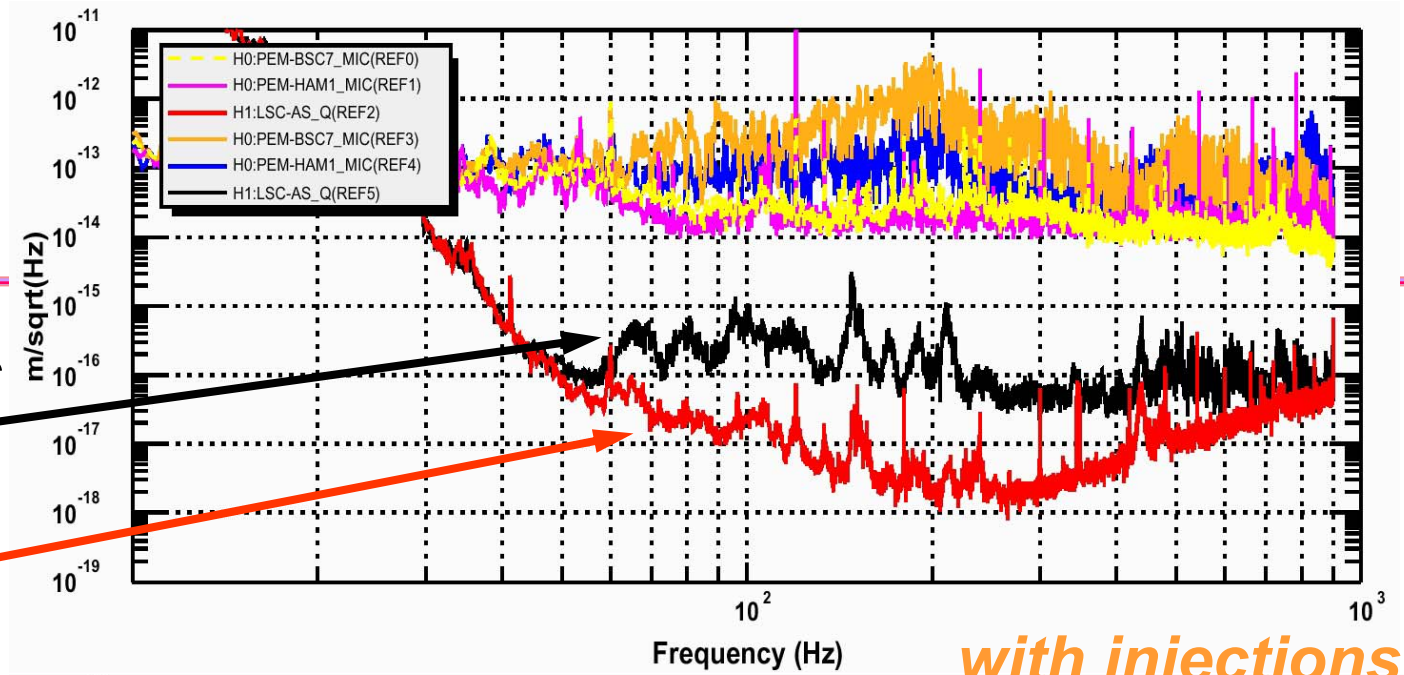


Acoustic Mitigation

- Primary sources:
  - ***Building HVAC***
  - ***Electronics cooling fans***
- Removed microphonic optics (clipping)
  - ***opened to 2" clear aperture at critical locations***
  - ***EO shutters removed at ISCT4 and ISCT1***
  - ***stiffened & damped beam delivery periscopes***
- Installed acoustic enclosures on dark ports
- Results:
  - ***>10x from reducing clipping ~10x from acoustic enclosure***
  - ***No acoustic peaks left in S3 spectra and reduced broadband in H1 in the decade around ~100 Hz***
  - ***H1 - H2 correlations substantially reduced***



LIGO

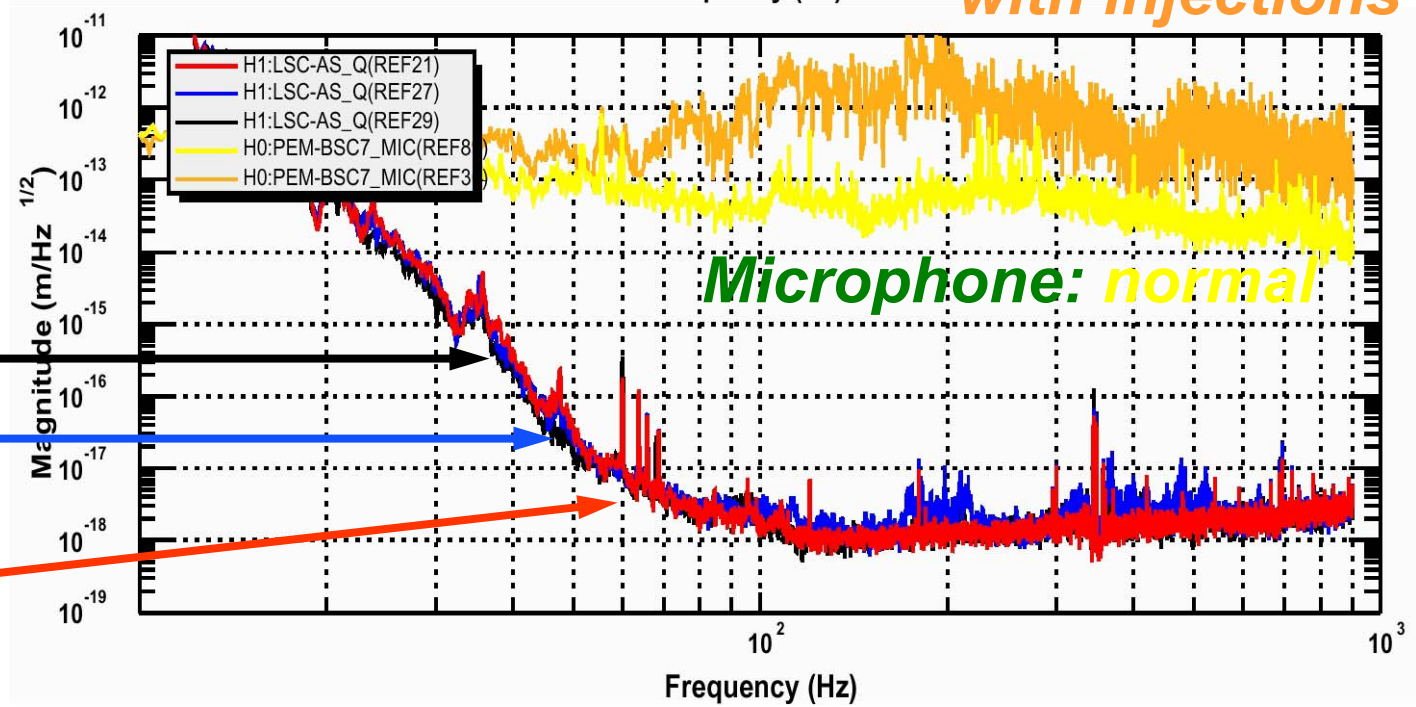


with acoustic injections at ISCT4

S2

Displacement Spectra

with injections



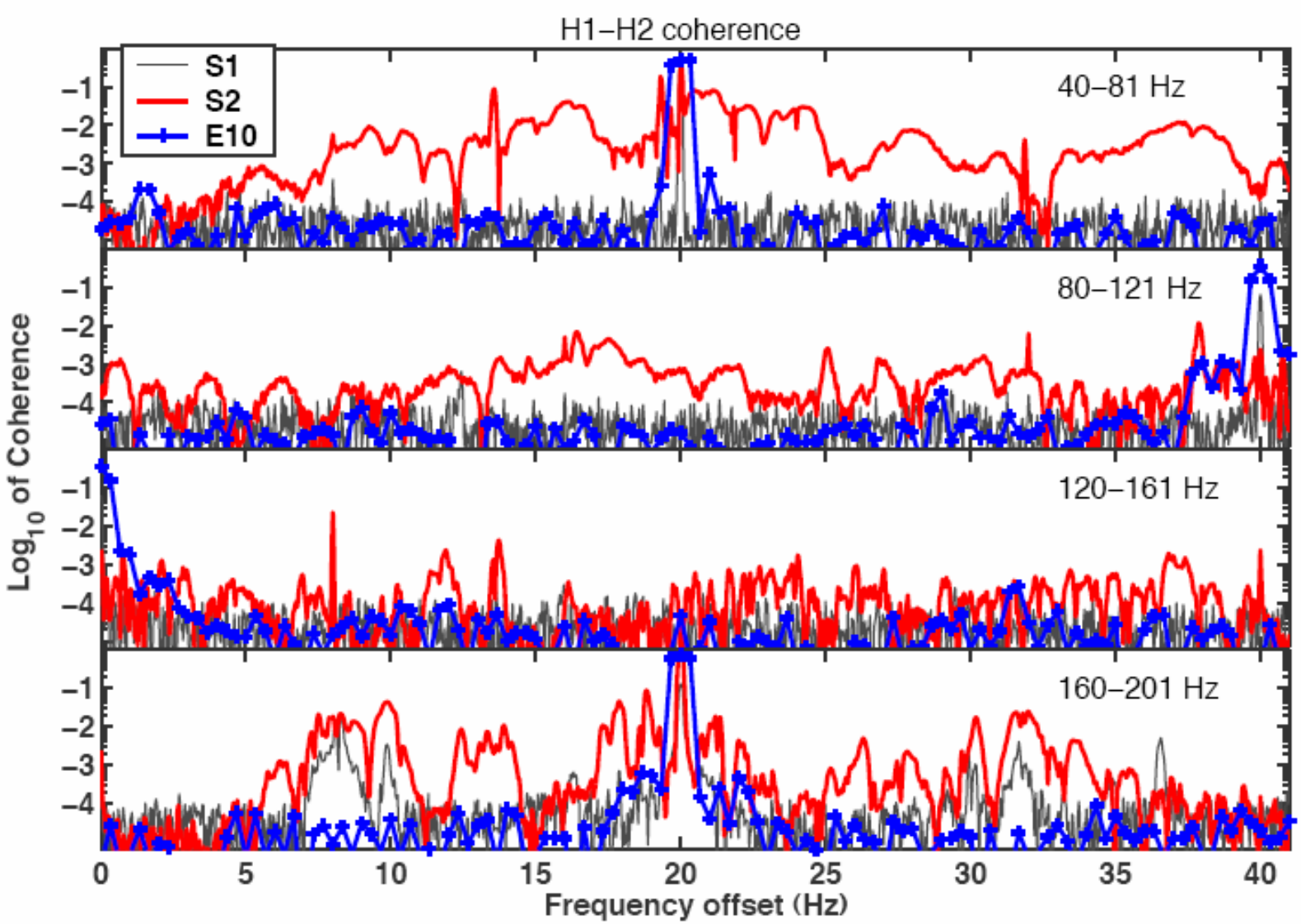
with acoustic injections at ISCT4 and

ISCT1

S3

Microphone: normal

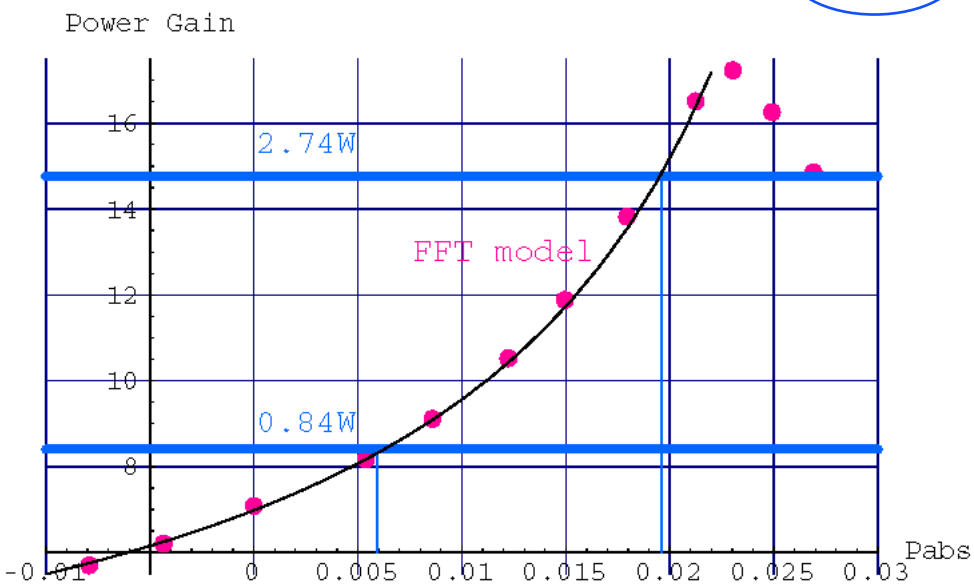
H1-H2 Correlations Reduced

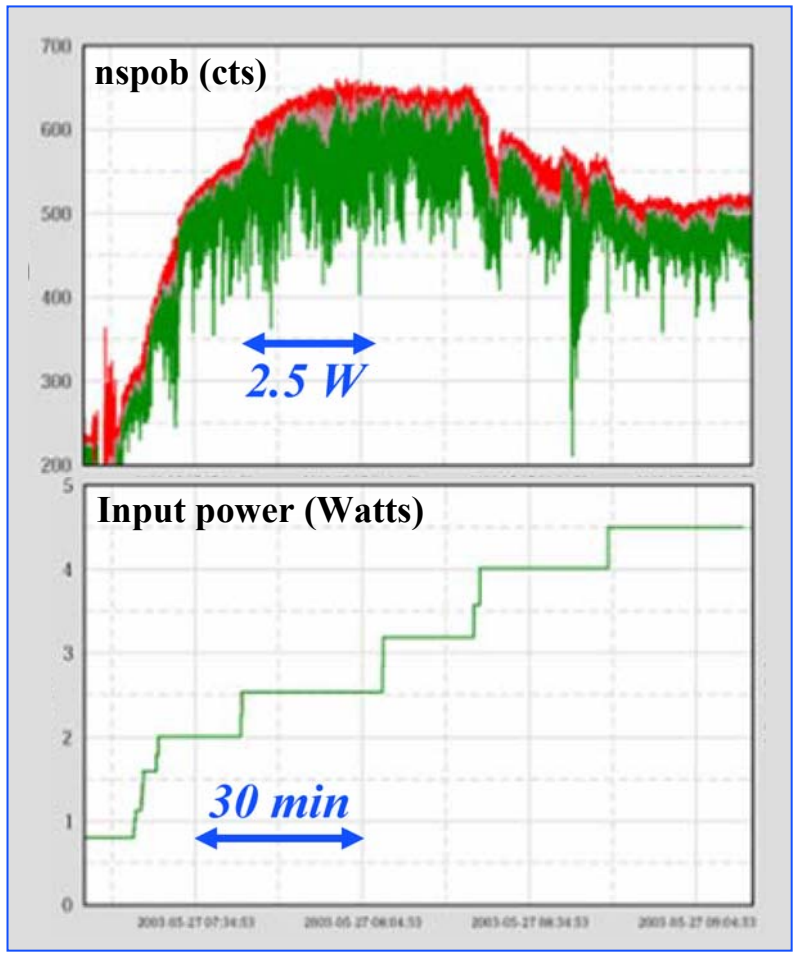


Power increase

- LHO: 0.8 ❄ 2.0 W
- LLO: 1.6 ❄ 4.2 W

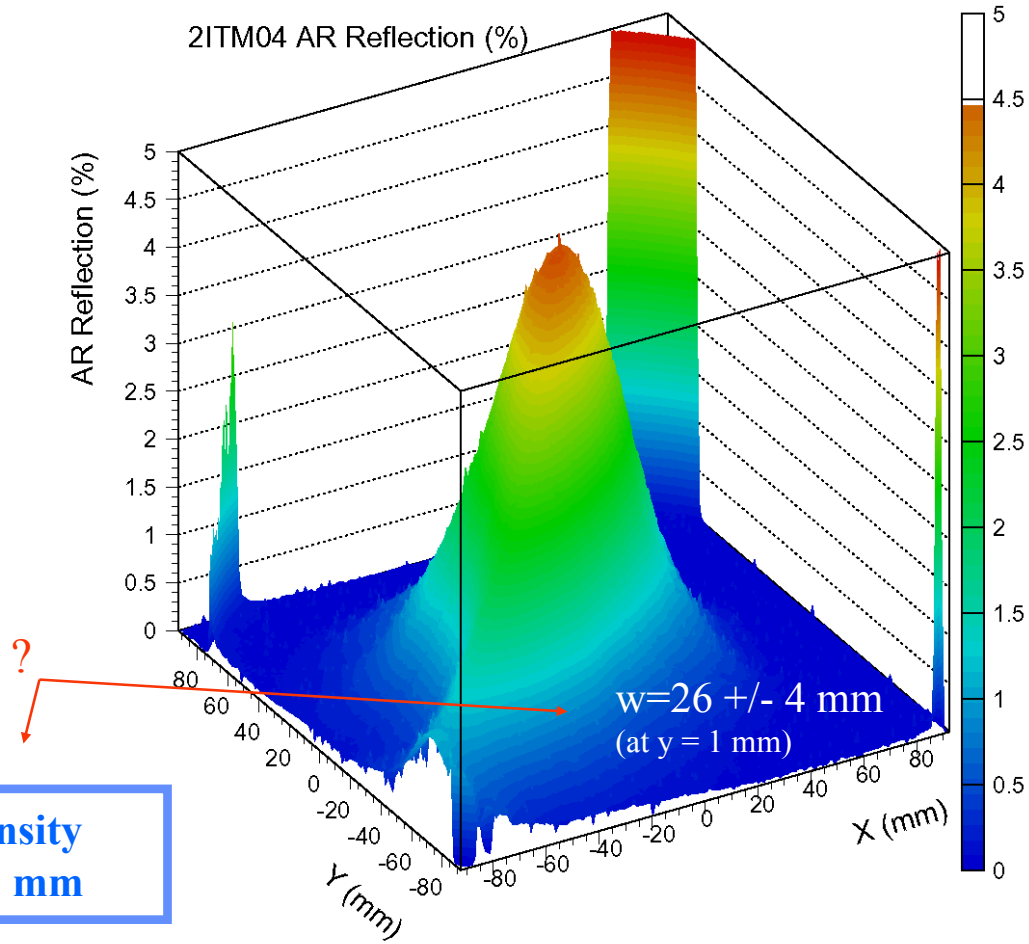
LHO





Vacuum incursions

- LHO 2k ITMX replaced in April 2003 due to damaged AR coating
- LHO 2k MMT1 reinstalled June 2003 after suspension wire failure
- LLO ITMY moved by 2 cm in July 2003 to optimize recycling cavity length

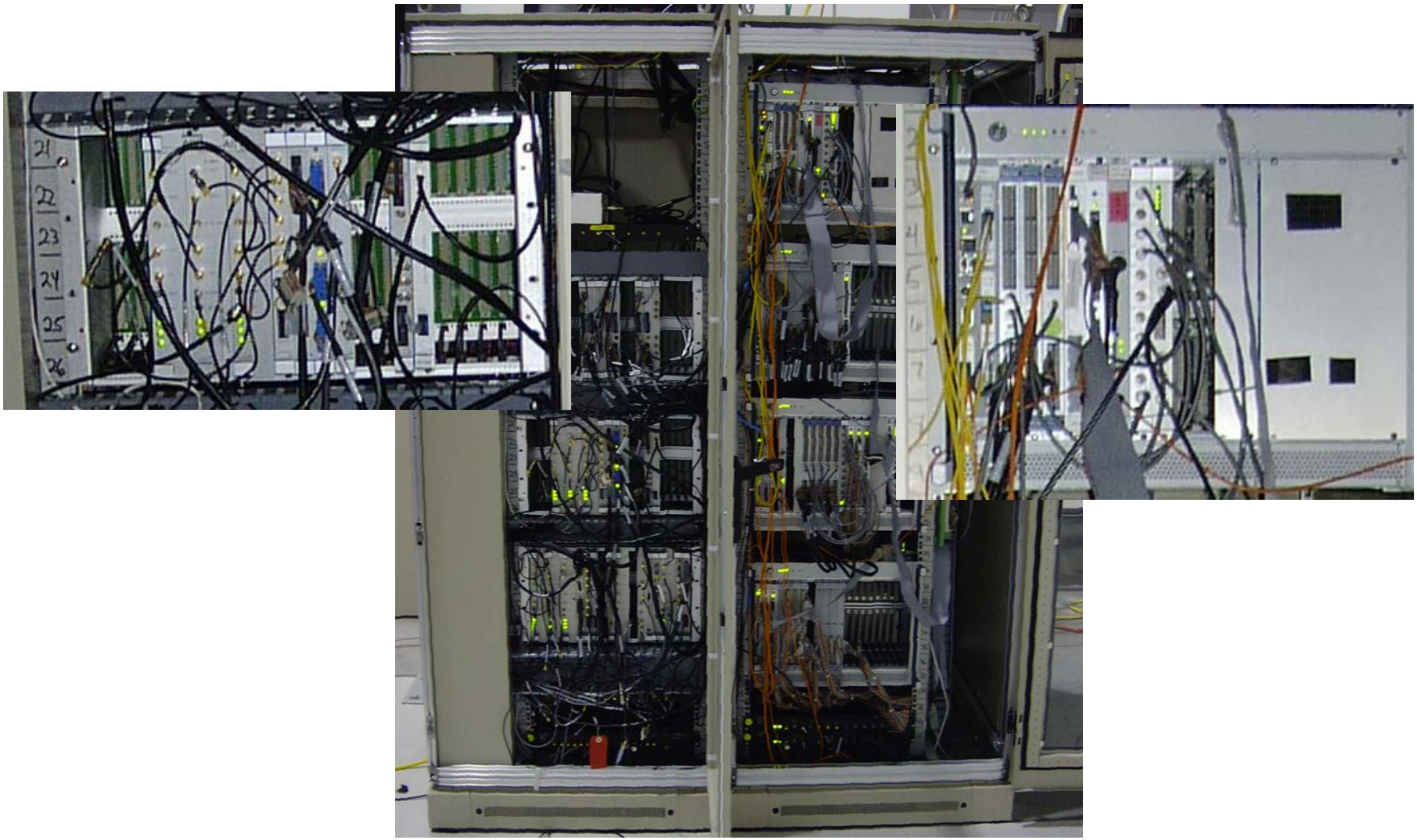


Beam intensity width = 23 mm

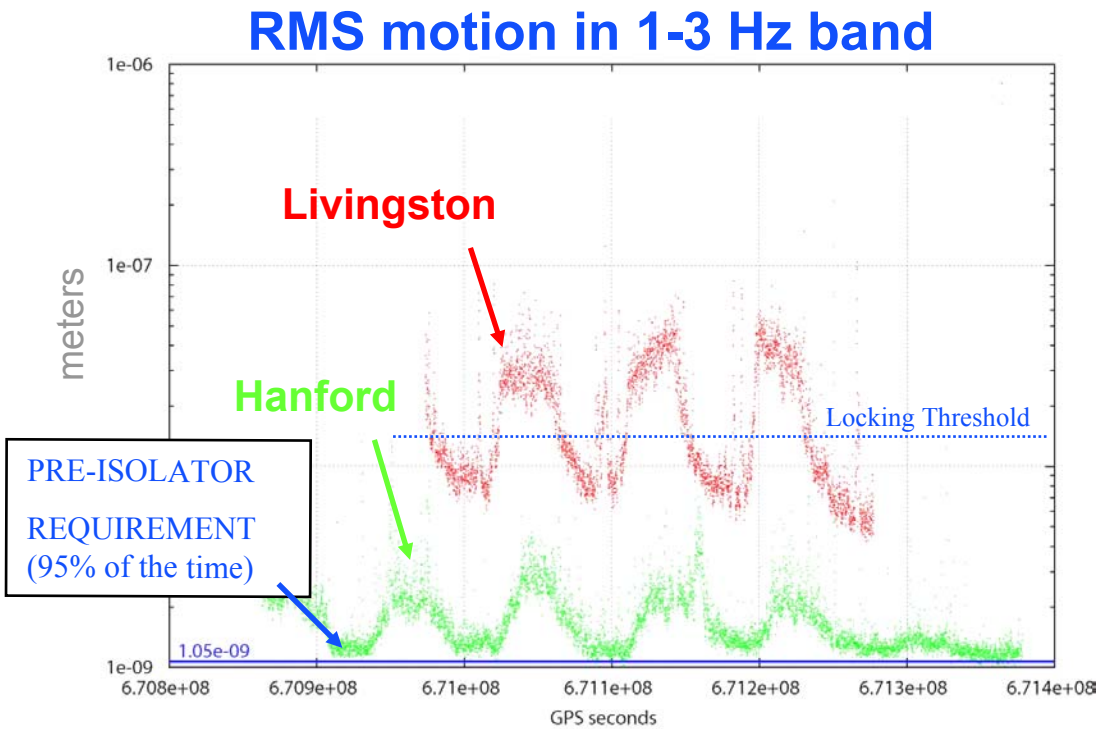
The coming year

- Improvements to current systems
  - » HEPI
  - » More power
  - » Increase WFS bandwidth and turn off optical levers
  - » Electronics EMI/RFI and acoustic mitigation
    - – move racks
    - – separate analog/digital parts,
    - – new RFI-proof racks
- New systems/configurations
  - » Output modecleaner
  - » Thermal compensation system
  - » Photon Calibrator
  - » Cesium clock timing

Rack relocation and analog-digital separation

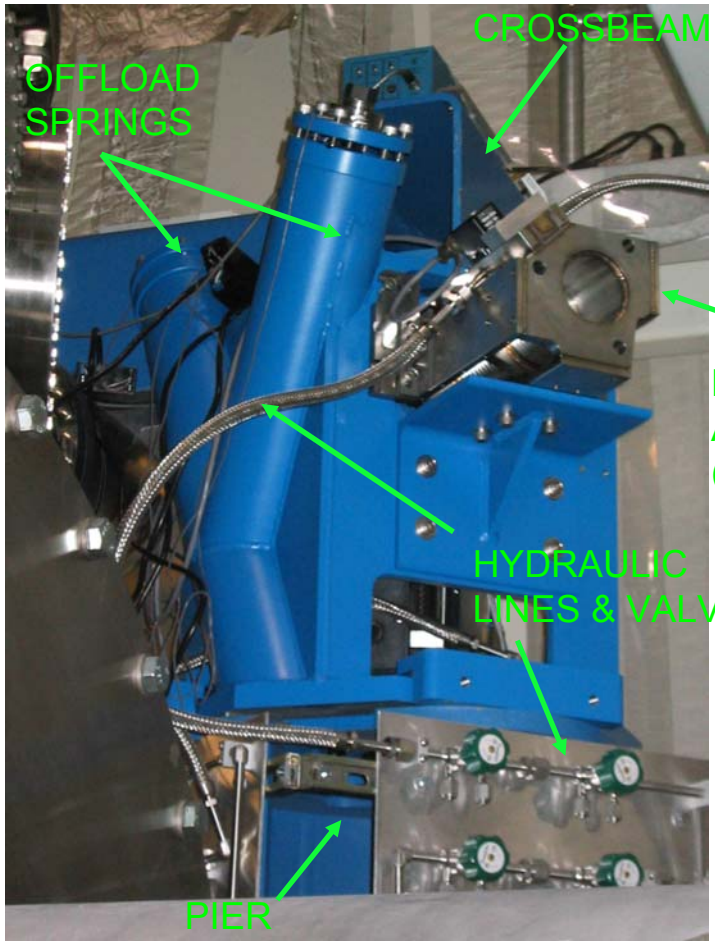


LLO seismic noise amelioration badly needed



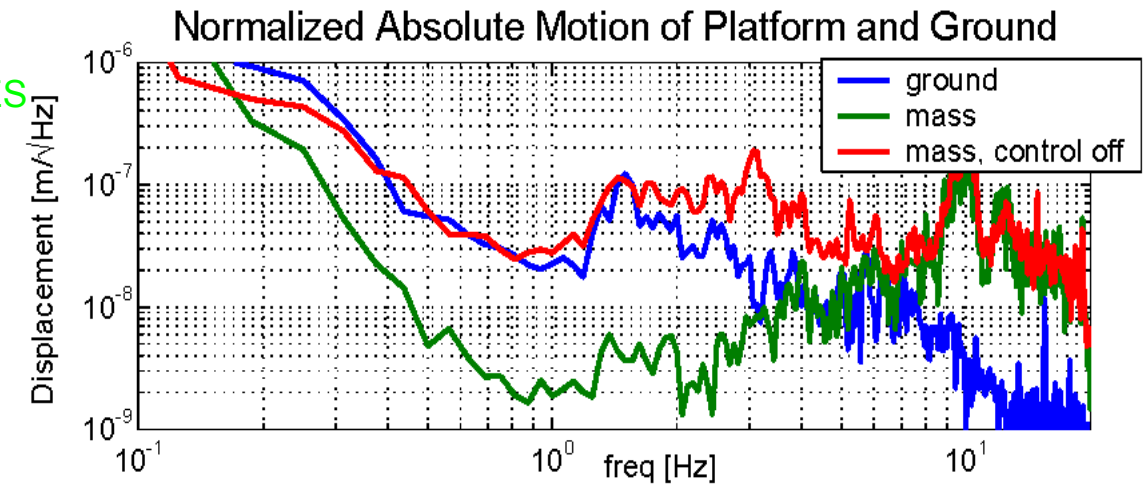
- Anthropogenic
  - »Mostly logging and trains
  - »Science data only available at night
  - »Even night-level alignment fluctuations cause significant non-stationarity
- Microseism due to ocean waves
  - »Locking difficult/impossible for several days at a time
  - »worse in winter (high-microseism activity several times/month)

HEPI



MIT test

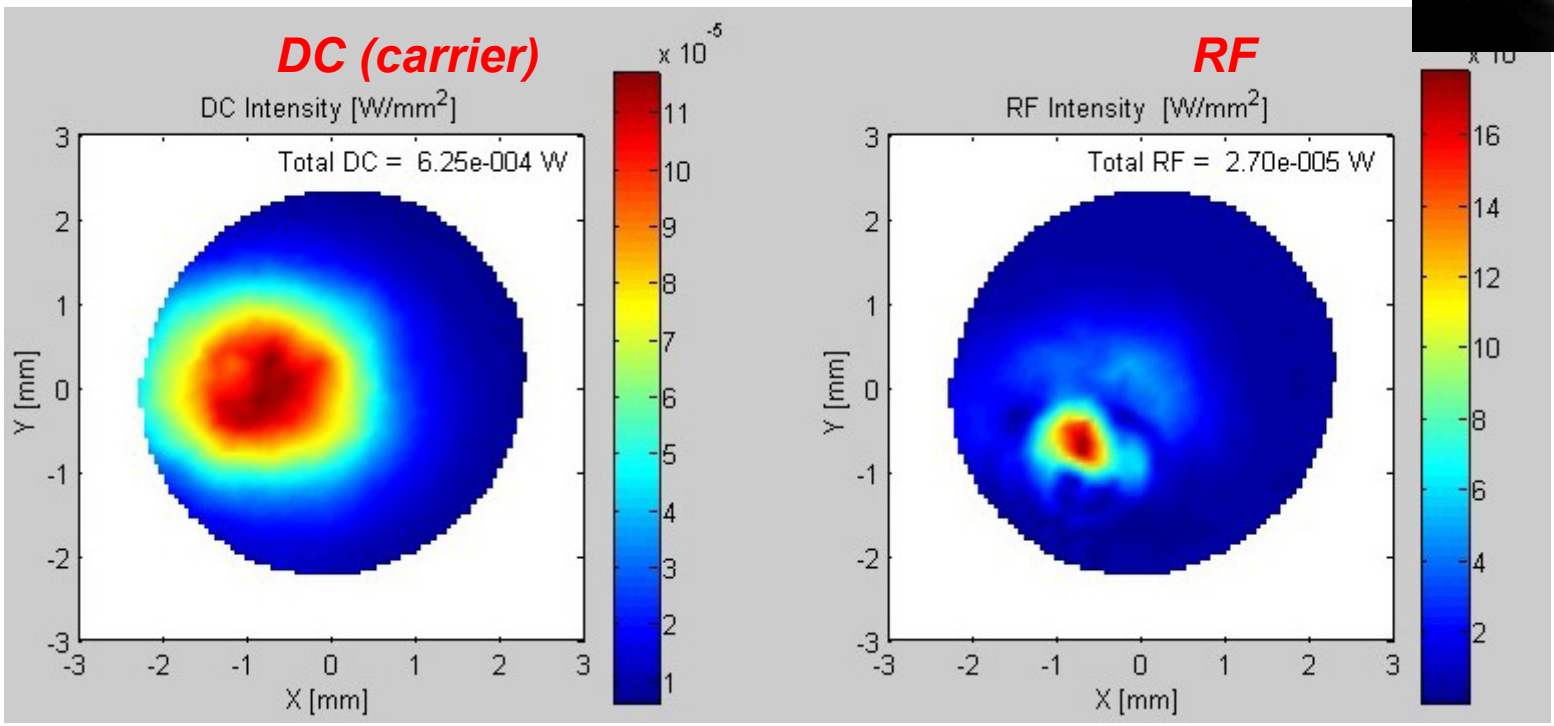
- ~6 months install period for hydraulic external pre-isolators
- Prototype tested at Stanford and MIT
- Fabrication nearly complete, installation just beginning



TCS is needed for proper thermal lensing

- Original "point design" depends on specific, balanced **thermal lensing**
- Sidebands aren't properly matched into the recycing cavity without the thermal lens
- RF sideband efficiency found to be very low
  - » H1 efficiency: ~6% (anti-symmetric port relative to input)

Bad mode overlap



Initial thermal compensation system

- Modify the test mass radii of curvature by adding/subtracting appropriate thermal lens
- correct absorption mismatches between test masses and (possibly) absorbtion inhomogeneities