LIGO-G040540-01-E

Status of LIGO

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Gravitational Wave Data Analysis Workshop
December 15, 2004
Annecy, France

Thanks to Rana Adhikari and David Shoemaker

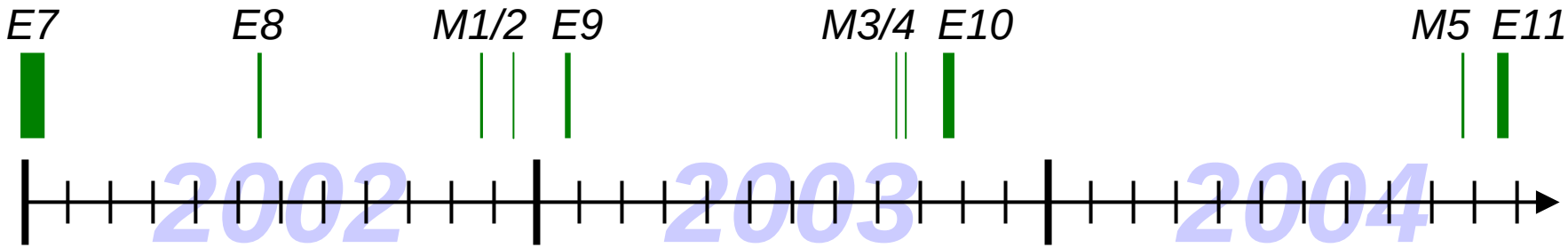
The LIGO Observatories

Adapted from “The Blue Marble: Land Surface, Ocean Color and Sea Ice” at visibleearth.nasa.gov

NASA Goddard Space Flight Center Image by Reto Stöckli (land surface, shallow water, clouds). Enhancements by Robert Simmon (ocean color, compositing, 3D globes, animation). Data and technical support: MODIS Land Group; MODIS Science Data Support Team; MODIS Atmosphere Group; MODIS Ocean Group Additional data: USGS EROS Data Center (topography); USGS Terrestrial Remote Sensing Flagstaff Field Center (Antarctica); Defense Meteorological Satellite Program (city lights).

LIGO Data Runs

"Engineering" runs



"Science" runs

	S1	S2	S3
	23 Aug – 9 Sep 2002	14 Feb – 14 Apr 2003	31 Oct 2003 – 9 Jan 2004
Duty factors:			
H1	59 %	74 %	69 %
H2	73 %	58 %	63 %
L1	43 %	37 %	22 %

Science Run S1

The LIGO Scientific Collaboration published four data analysis papers using data from the S1 run

"Setting upper limits on the strength of periodic gravitational waves using the first science data from the GEO600 and LIGO detectors"
Phys. Rev. D **69**, 082004 (2004)

"First upper limits from LIGO on gravitational wave bursts"
Phys. Rev. D **69**, 102001 (2004)

"Analysis of LIGO data for gravitational waves from binary neutron stars"
Phys. Rev. D **69**, 122001 (2004)

"Analysis of first LIGO science data for stochastic gravitational waves"
Phys. Rev. D **69**, 122004 (2004)

Also:

"Detector Description and Performance for the First Coincidence Observations between LIGO and GEO"
Nuclear Instruments and Methods A **517**, 154 (2004)

Science Run S2

~5–10 times lower noise than S1

~4 times more data collected

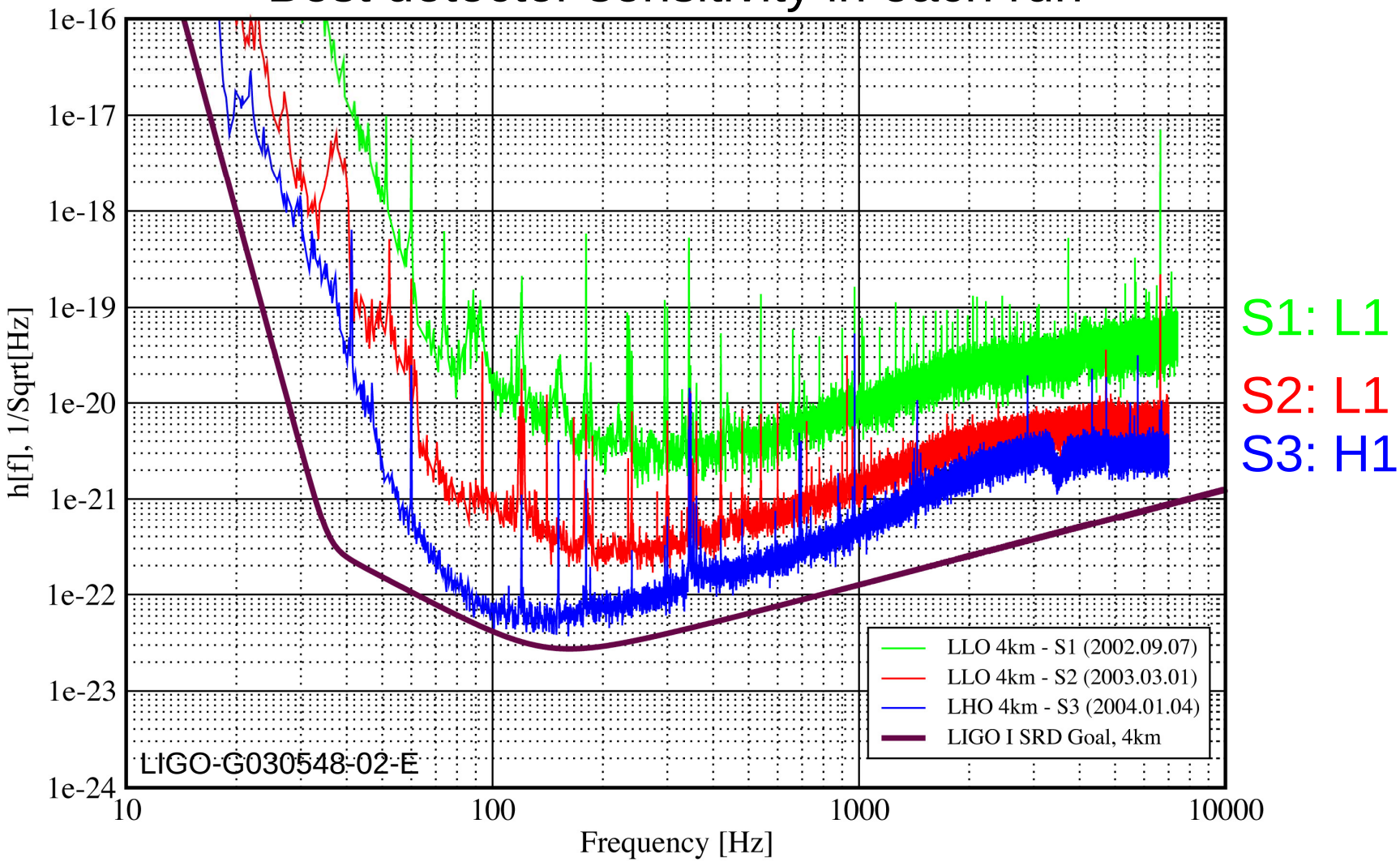
Many searches underway, several at a mature stage

See talks by:

Whelan	[Stochastic]
Creighton, Takahashi/Fairhurst, Messaritaki	[Binary inspiral]
Krishnan, Messenger, Pitkin, Itoh	[Periodic]
Zweizig, Sutton, Chatterji	[Bursts]

From S1 to S2 to S3

Best detector sensitivity in each run



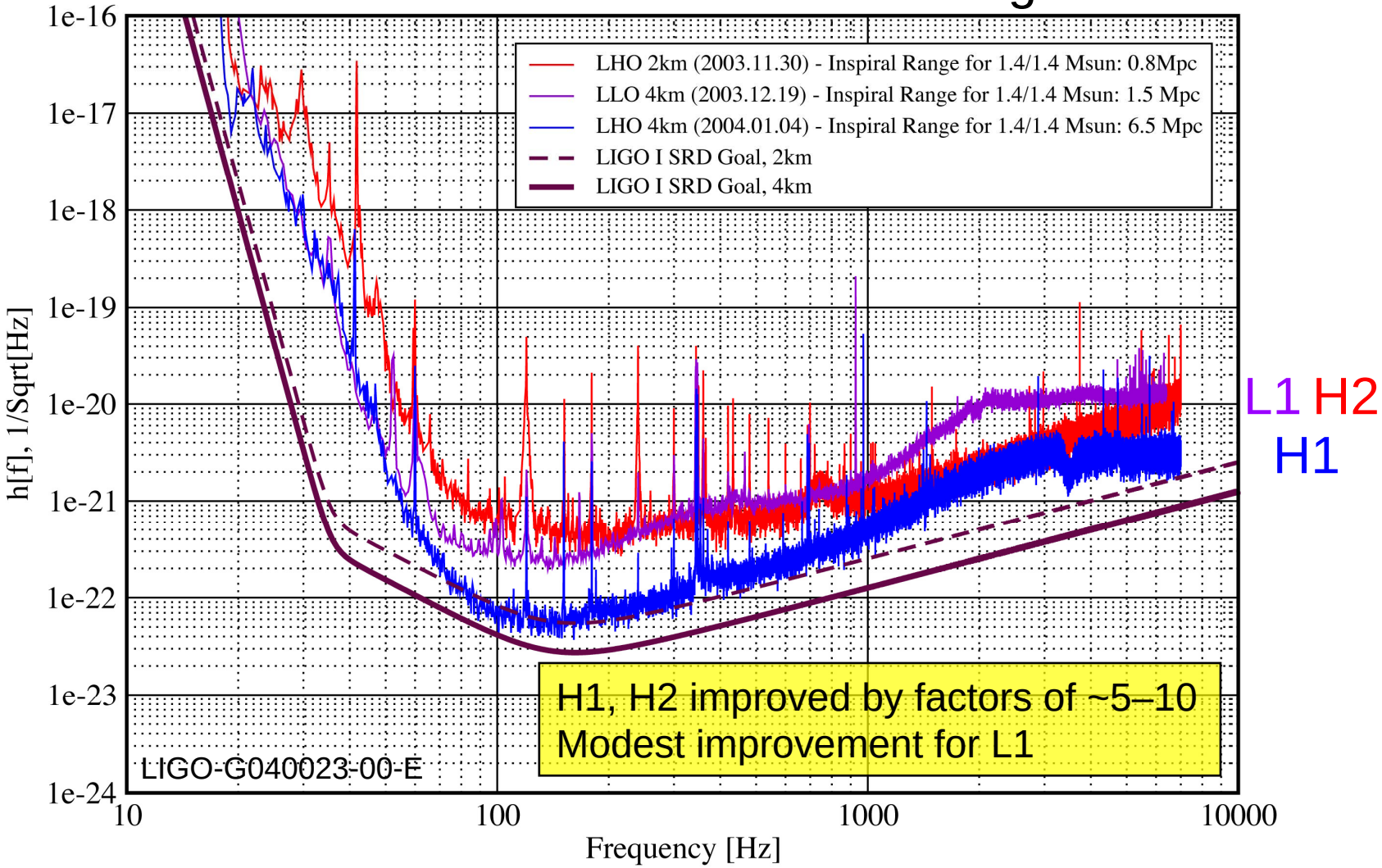
S1: L1

S2: L1

S3: H1

S3 Best Sensitivities

Lowest noise for each detector during S3 run



Status of S3 Data Analysis

Several searches underway

See talks by:

Bose	[Stochastic]
Jones	[Binary inspiral]
Siemens, Pitkin	[Periodic]
Yakushin, Klimenko	[Bursts]

… plus new search methods under development

What's Been Happening Since S3?

(Besides data analysis)

Livingston

Installation of seismic pre-isolation system

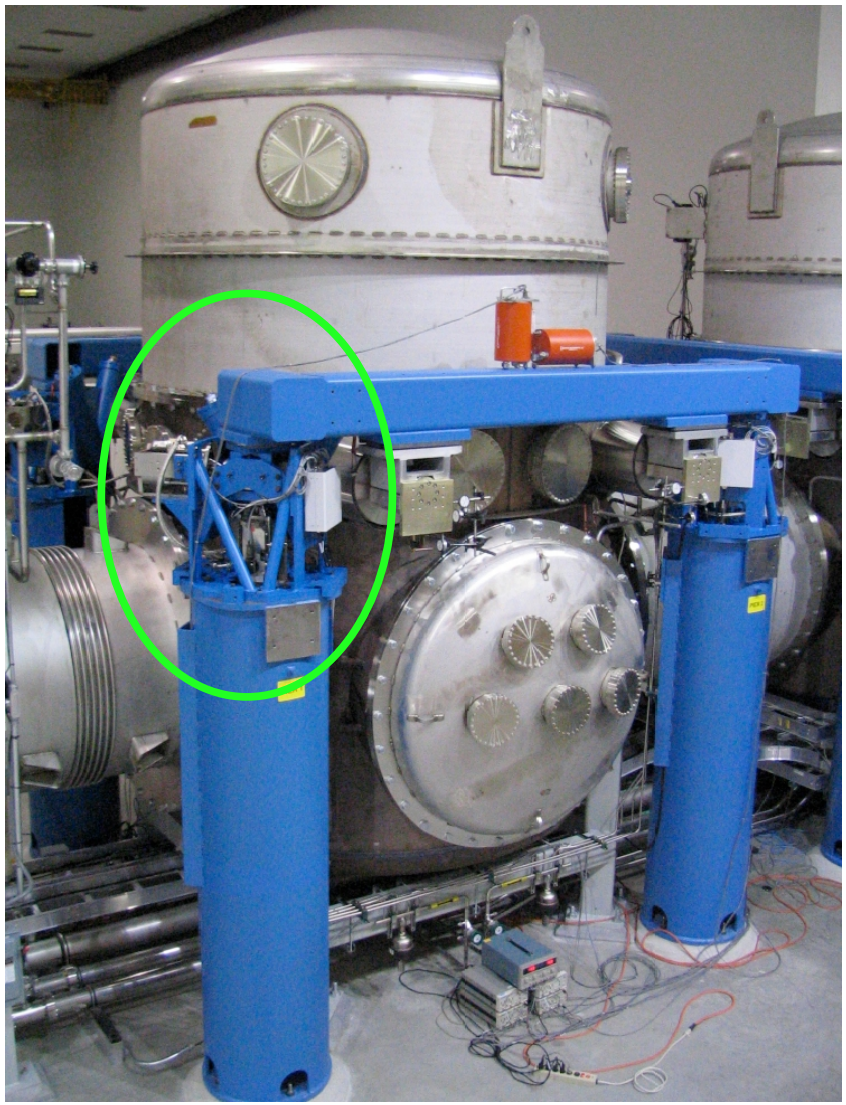
Hanford

High-power operations

Active thermal compensation

Reduction of several noise sources

Active Seismic Isolation at LLO



Hydraulic external pre-isolator (HEPI)

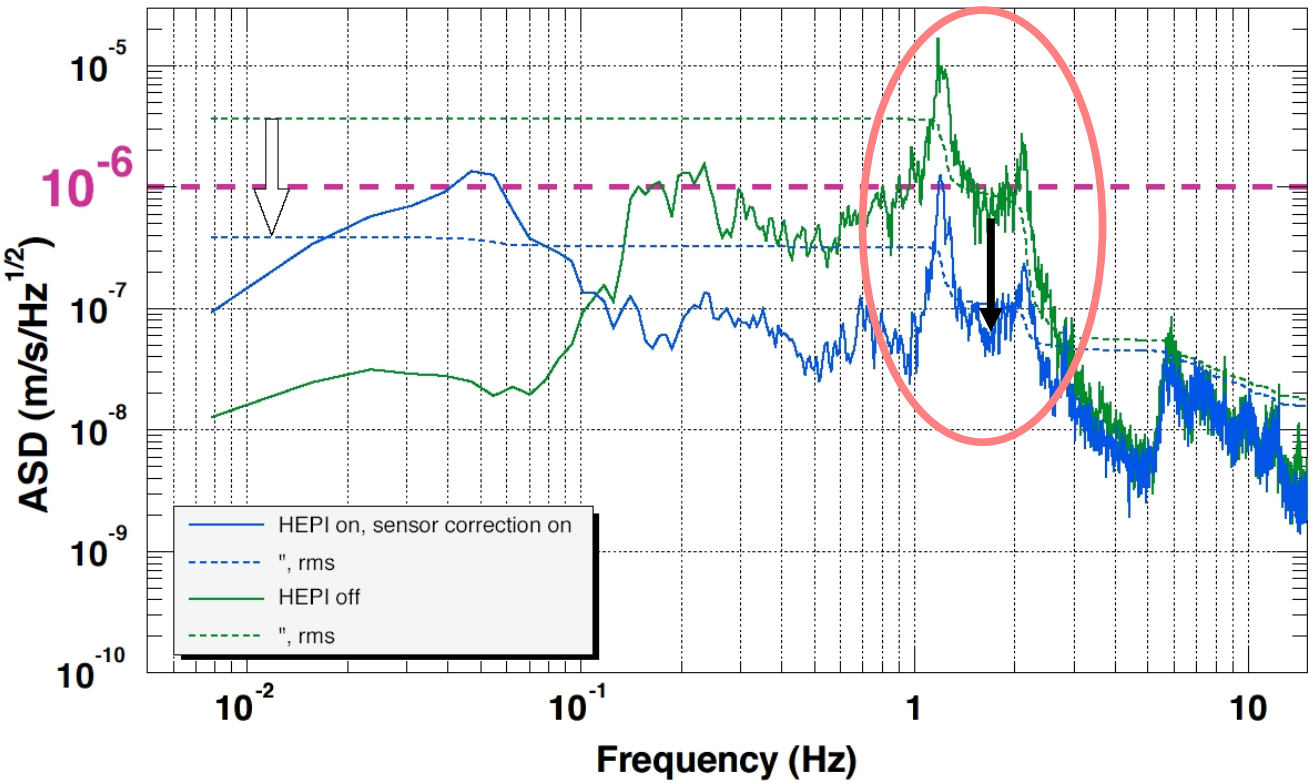
Signals from sensors on ground and cross-beam are blended and fed into hydraulic actuators

Status:

- Installed on all 4 piers at each of 9 vacuum chambers
- Partly operational

Active Seismic Isolation at LLO

Achieves factor of 10 reduction in the crucial frequency band and in overall rms motion



Can lock (and do commissioning work!) during daytime
Able to stay locked even when train passes nearby

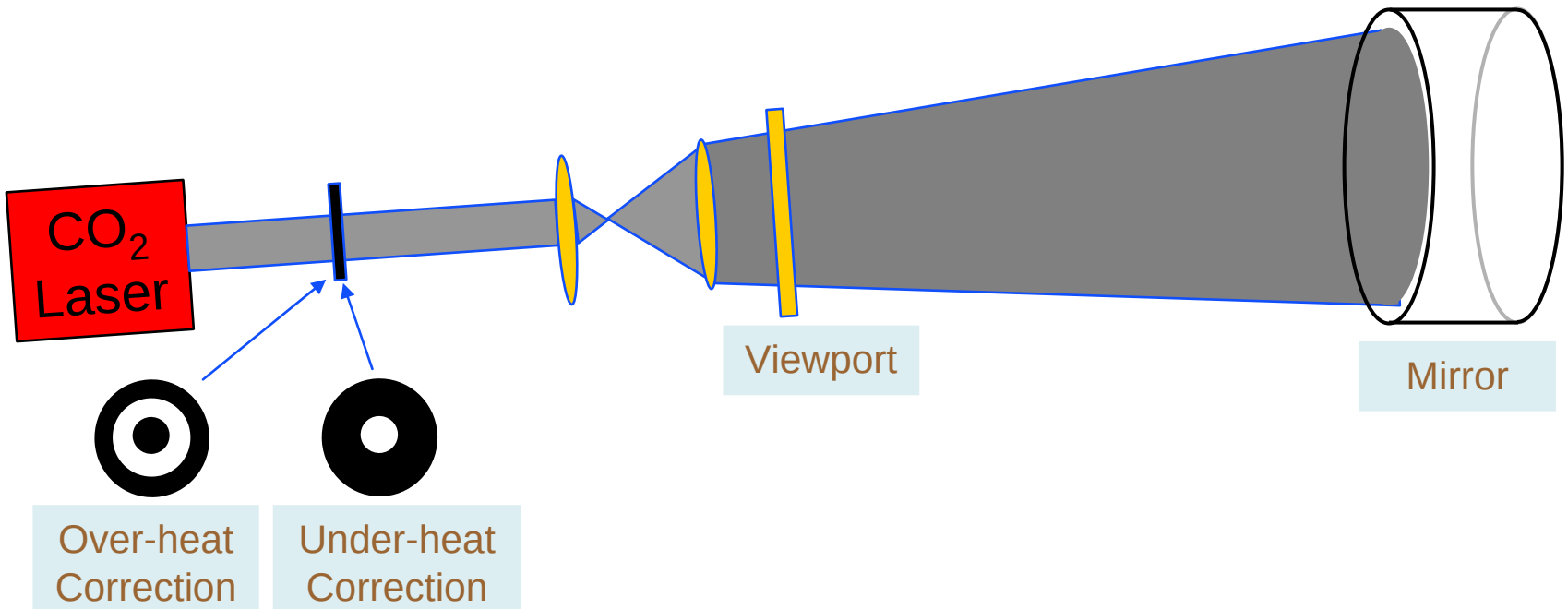
High-Power Operations at Hanford

Tuned up H1 laser to deliver 10 W

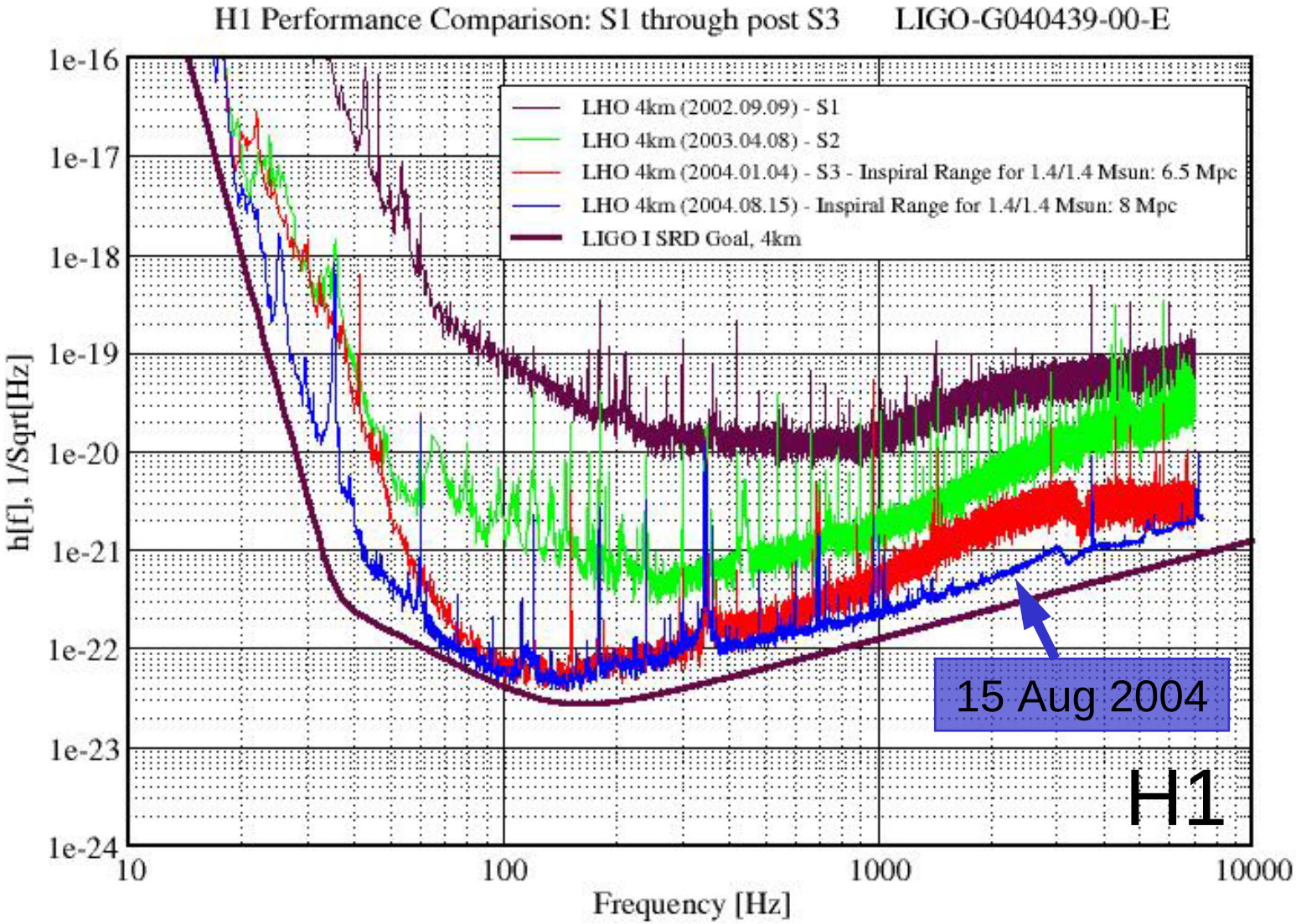
Use multiple photodetectors to handle increased light

Compensate for radiation pressure in control software

Correct thermal lensing by heating mirrors



Pushing the Sensitivity Envelope



Operations Plan for 2005

Finish re-commissioning L1

Reach a stopping point in incremental improvements to H1

Duplicate some H1 improvements on L1 and H2

Engineering run E12

Science run S4

Scheduled to start on February 23 and run for 4 weeks

Performance goals: modest improvements over current best sensitivities; high duty factor for L1

Several months of commissioning

Duplicate rest of H1 improvements on L1 and H2; improve duty factors

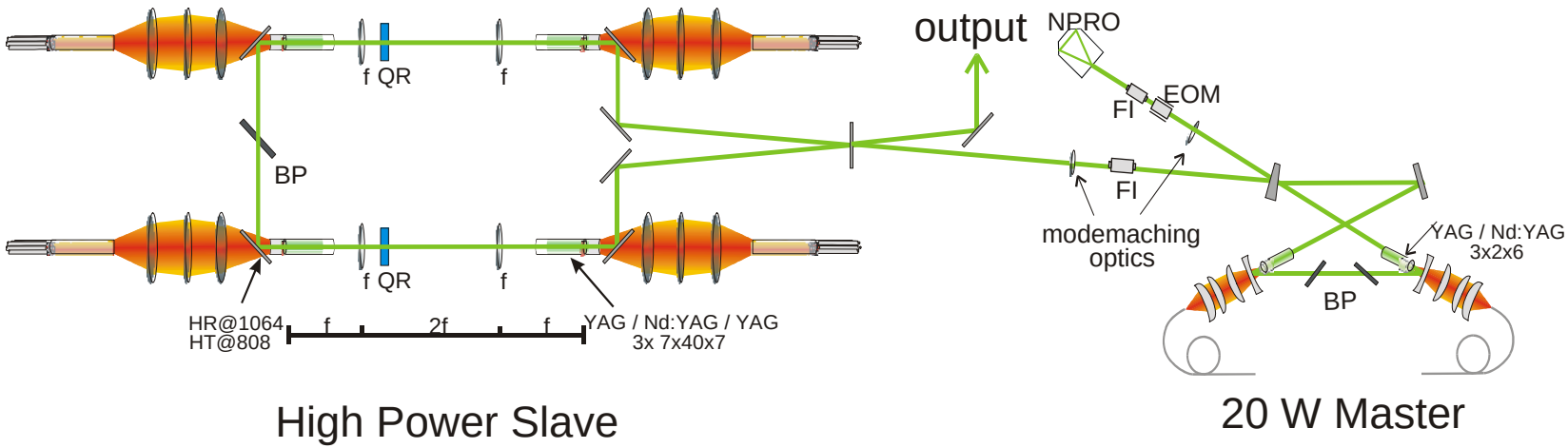
Science run S5

Plan to start in the latter half of 2005

Plan to run for extended period at design sensitivity for all 3 interferometers

Progress on Advanced LIGO Technical Issues

Successful demonstration of 200 W laser



High-power testing of optical components for interferometer input

Progress on Advanced LIGO Technical Issues

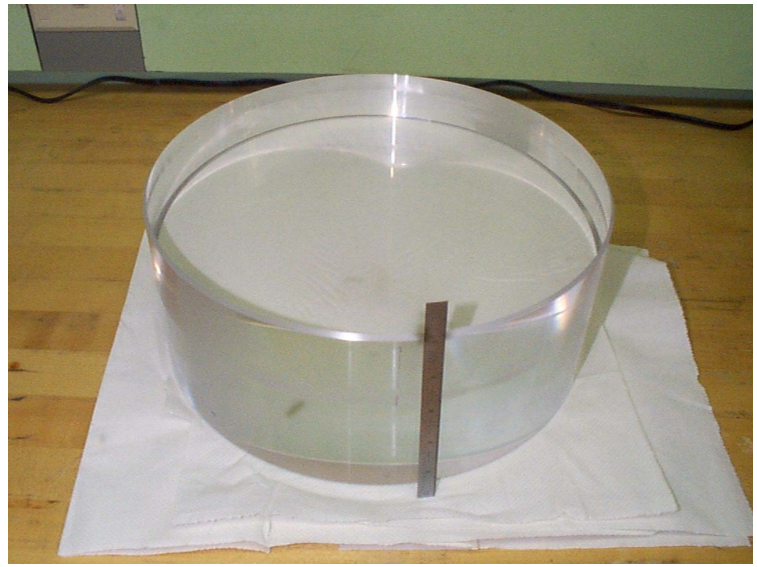
Improved understanding of mirror material properties

Full-size silica and sapphire substrates have been fabricated

Measurements of bulk absorption in large sapphire pieces

Direct measurement of thermoelastic noise

Mirror coatings: measurements of optical and mechanical losses



Choice between sapphire and silica will be made in a few months

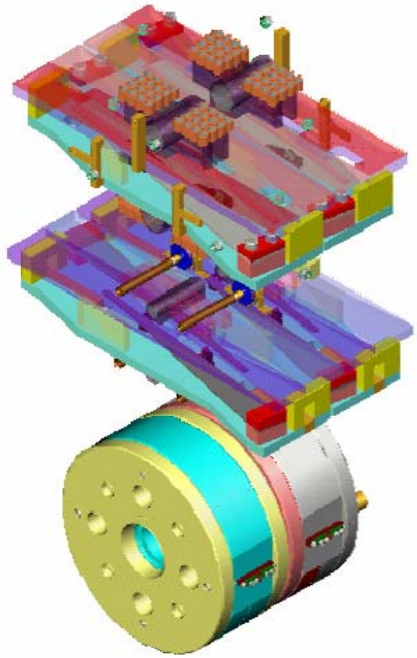
Design and modeling of active thermal compensation

For silica and sapphire options

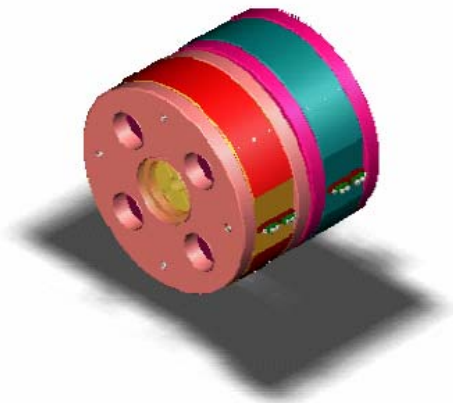
Progress on Advanced LIGO Technical Issues

Successful implemention of seismic pre-isolation at LLO

Detailed design and testing of mirror suspensions



Caltech 40-meter prototype exploring controls for dual recycling



Status of Advanced LIGO

National Science Board approved Advanced LIGO proposal

> "The Board concurred that planning for Advanced LIGO is sufficiently advanced and the intellectual value of the project sufficiently well demonstrated to justify consideration by the Acting Director and the National Science Board for funding in FY 2007 or a future NSF budget request." – 14 October 2004

Scientific approval, not a specific commitment for funding

Funding could begin as early as 2007

Projected schedule:

2007	Begin procuring materials, fabricating sub-assemblies
2010	Decommission current interferometer at Livingston
	Begin installing new interferometer at Livingston
	Hanford interferometers will follow at 6-9 month intervals
2013	Begin coincident observations with good sensitivity

Summary

- ***Lots of activity over the past year***
  - S1 data analysis papers published
  - Many more searches underway using S2 and S3 data
  - Commissioning: making big and small improvements
- ***Design sensitivity is within reach***
  - Still a lot of work needed to get all three interferometers to that point
- ***Advanced LIGO approval is a welcome confirmation of our long-term goals***
  - Current interferometers will run for a number of years before being decommissioned
- ***We can look forward to a vigorous LIGO program for many years to come***