



LIGO

Status Report

Barry Barish

LSC Meeting - Hanford
14 Aug 01

LIGO Plans

schedule

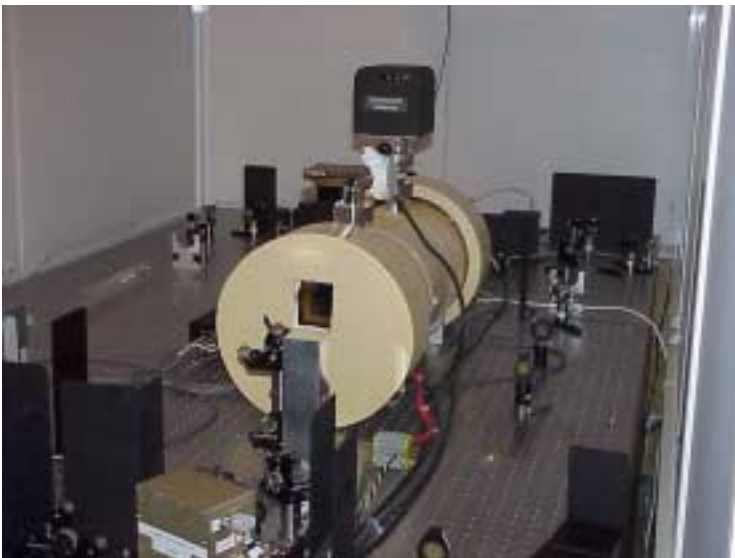
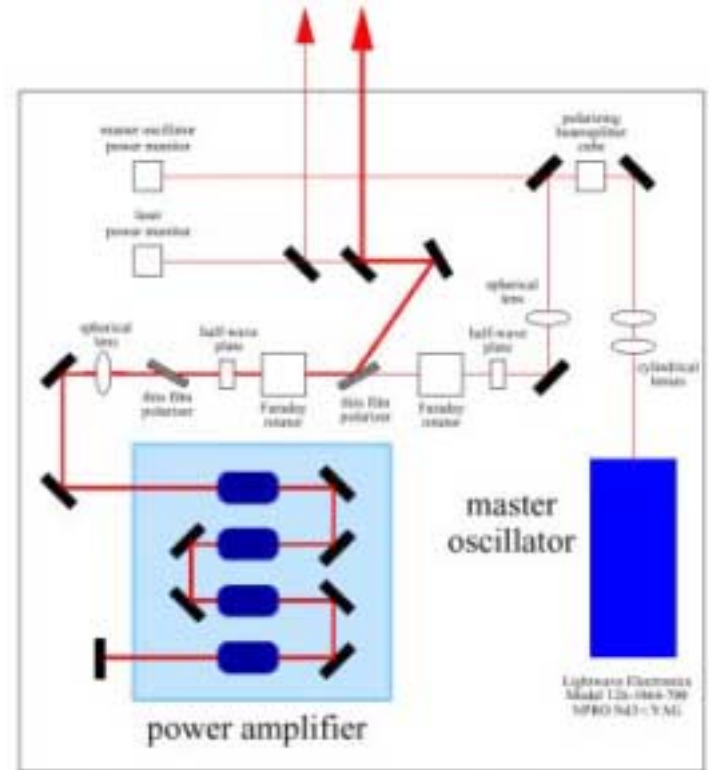
- 1996 Construction Underway (mostly civil)
- 1997 Facility Construction (vacuum system)
- 1998 Interferometer Construction (complete facilities)
- 1999 Construction Complete (interferometers in vacuum)
- 2000 Detector Installation (commissioning subsystems)
-  2001 Commission Interferometers (first coincidences)
- 2002 Sensitivity studies (initiate LIGO I Science Run)
- 2003+ LIGO I data run (one year integrated data at $h \sim 10^{-21}$)

- 2006+ Begin 'advanced' LIGO installation

LIGO

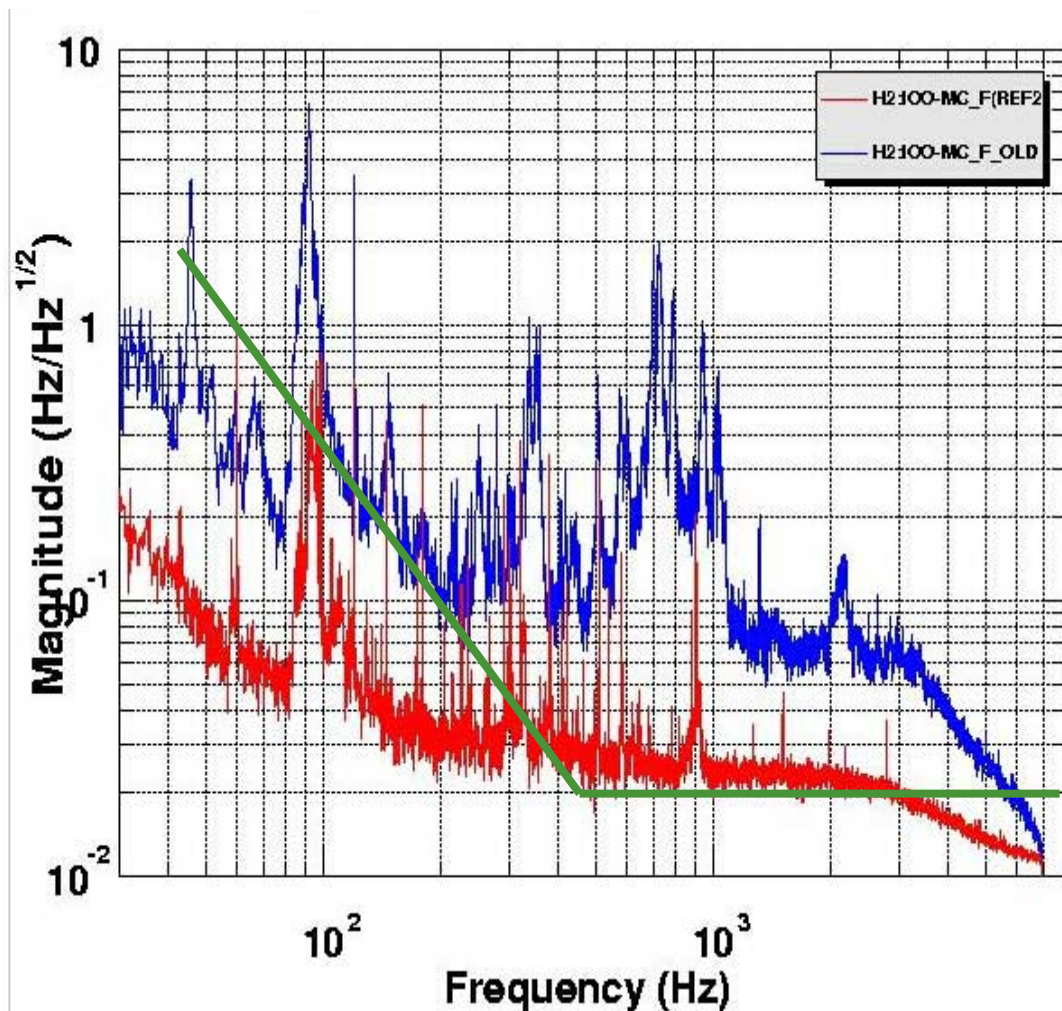
LIGO *laser*

- Nd:YAG
- 1.064 nm
- Output power > 8W in TEM₀₀ mode

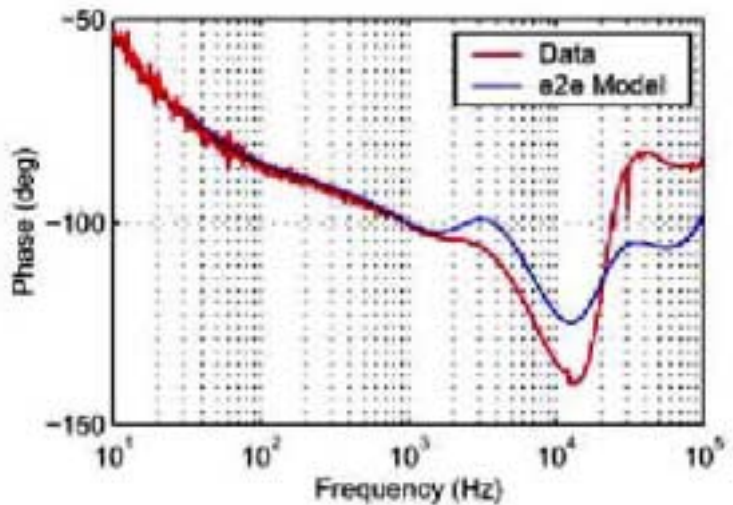
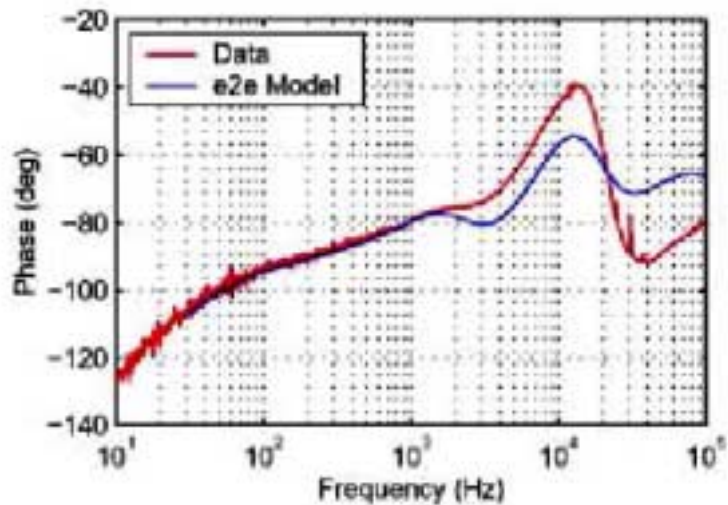
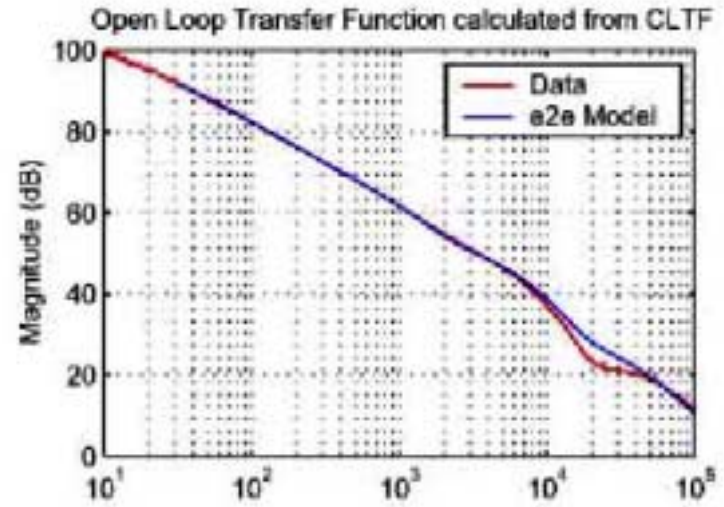
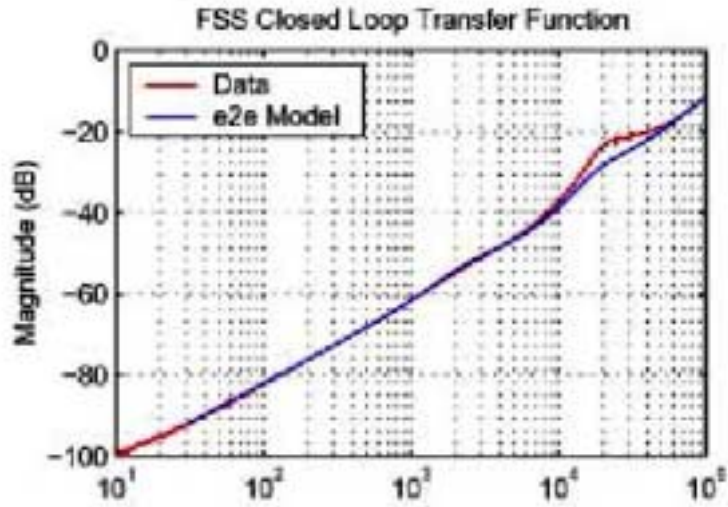


frequency noise

- Simplification of beam path external to vacuum system eliminates peaks due to vibrations
- Broadband noise better than spec in 40-200 Hz region

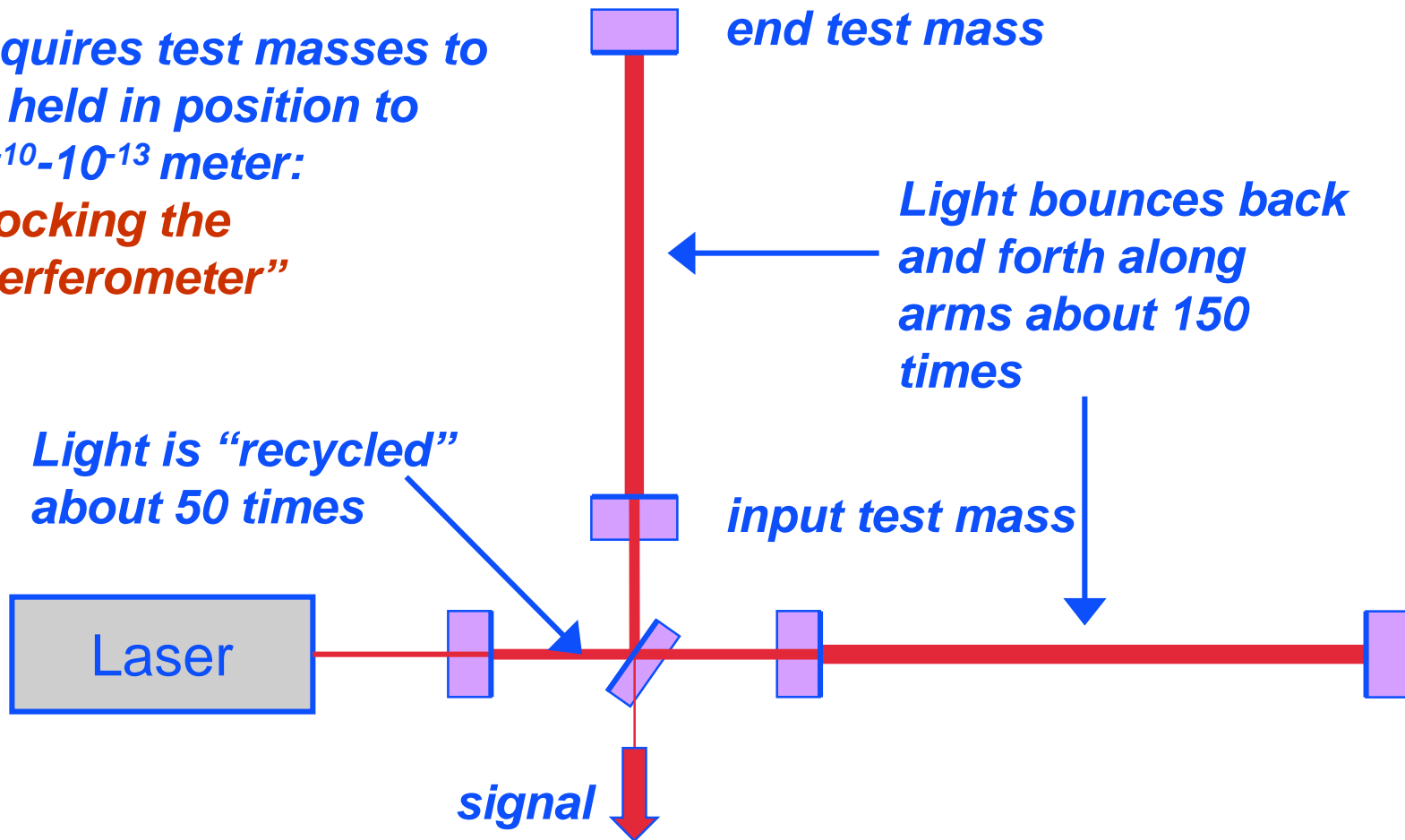


laboratory data vs e2e simulation



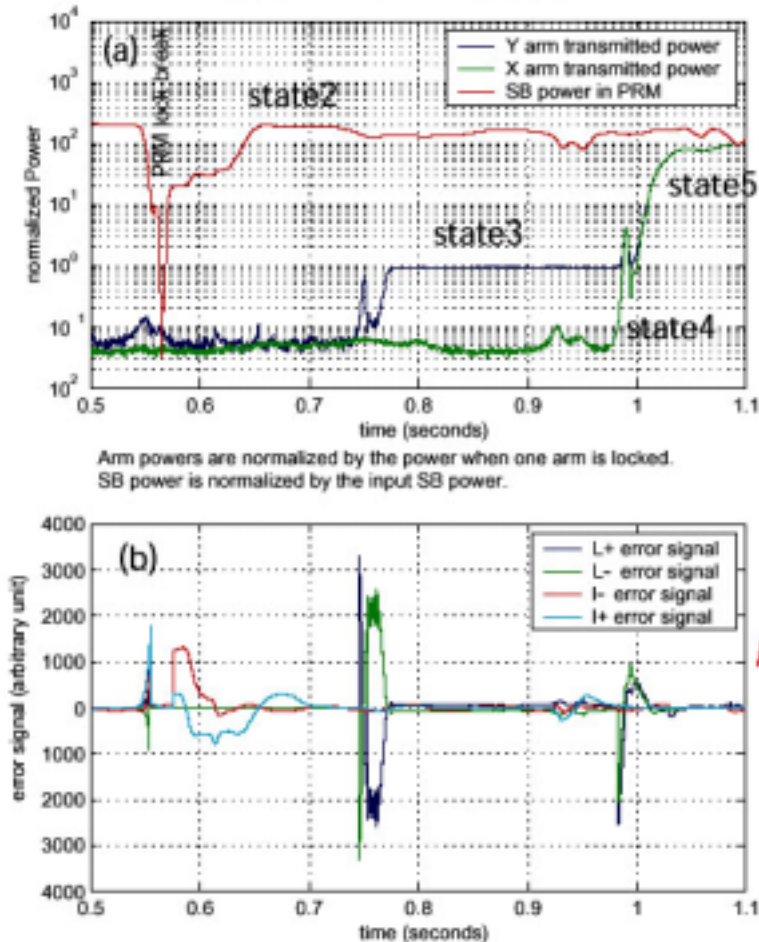
Interferometer *locking*

Requires test masses to be held in position to 10^{-10} - 10^{-13} meter:
“Locking the interferometer”



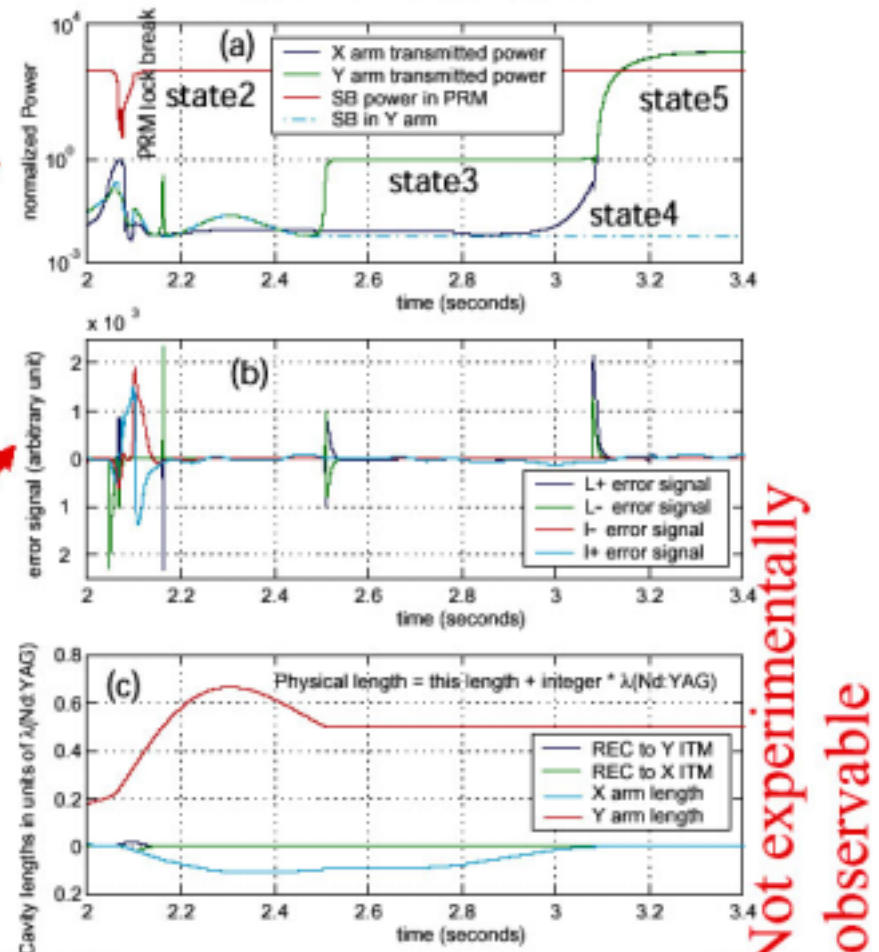
data compared with e2e simulation

Figure 1. LHO 2k IFO data



observable

Figure 2. Simulated signal



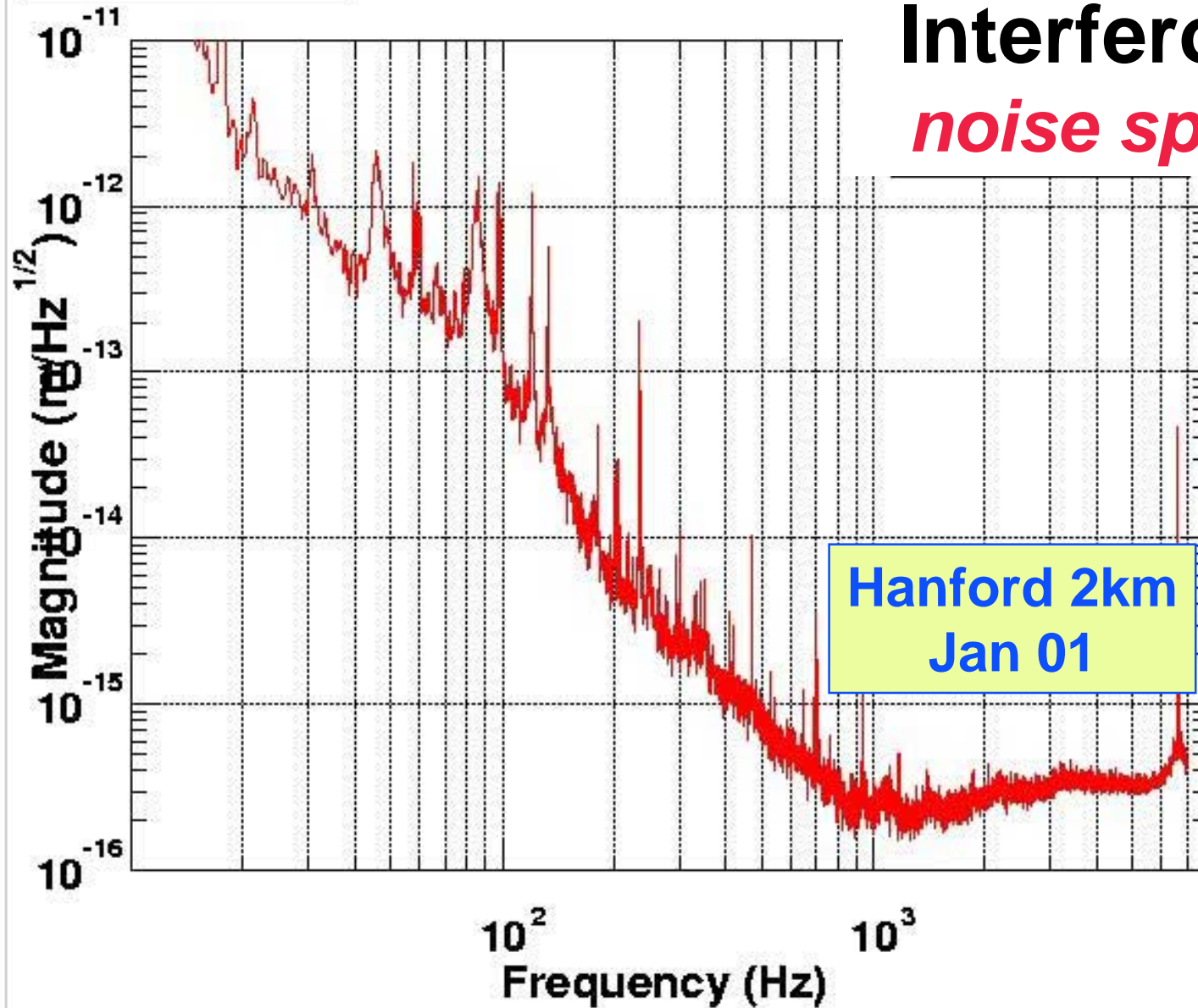
Not experimentally observable

Detector Status

- **All in-vacuum installation complete**
 - » Continuing installation and commissioning of control systems
- **LHO 2 km interferometer**
 - » Locked in recycled configuration for ~1 hour times
 - » Sensitivity $\sim 10^{-18}$ rms
 - » Working to improve both
- **LLO 4 km interferometer**
 - » Locked as Michelson with F-P Arms
 - » Problem with seismic noise at low frequencies
- **LHO 4 km interferometer**
 - » Commissioning just beginning

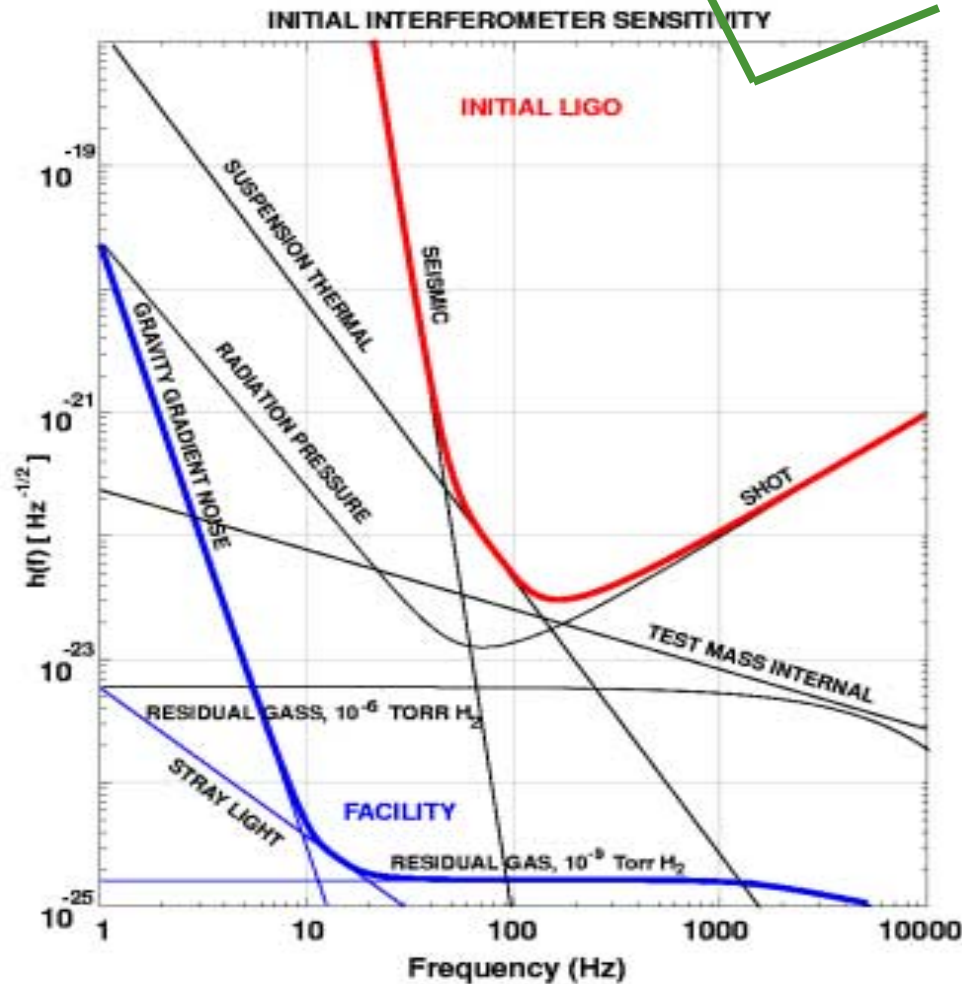
Power spectrum

Interferometer
noise spectrum



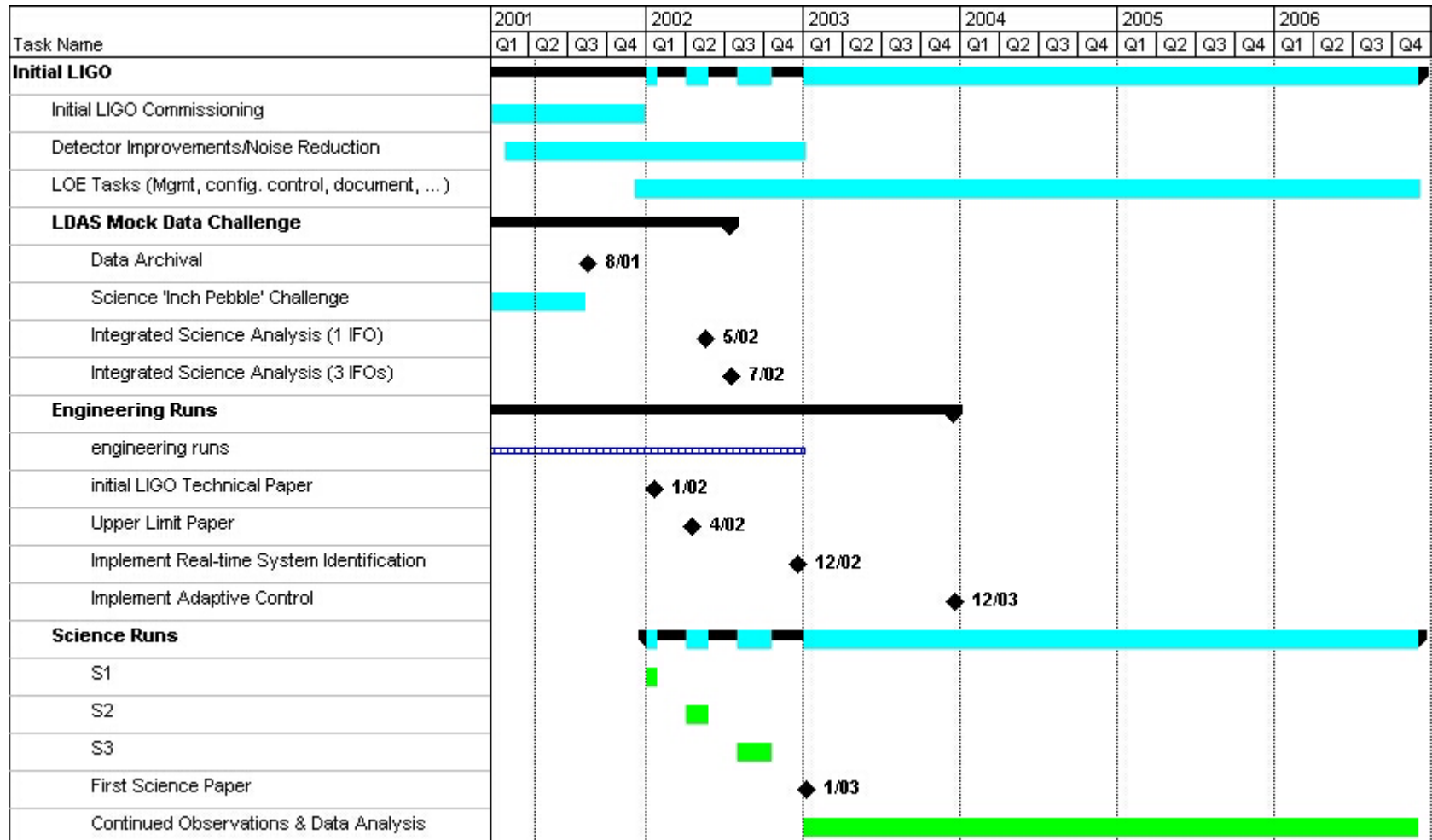
Hanford 2km
Jan 01

Initial LIGO Sensitivity Goal




- Strain sensitivity $< 3 \times 10^{-23} \text{ 1/Hz}^{1/2}$ at 200 Hz
- Sensing Noise
 - » Photon Shot Noise
 - » Residual Gas
- Displacement Noise
 - » Seismic motion
 - » Thermal Noise
 - » Radiation Pressure

Initial Detector Milestones



steps prior to science run

- **commissioning interferometer**
 - » **robust locking**
 - » **three interferometers**
 - » **sensitivity**
 - » **duty cycle**

- **interleave engineering runs (LIGO Science Collaboration)**
 - » **implement and test acquisition and analysis tools**
 - » **characterization and diagnostics studies**
 - » **reduced data sets**
 - » **merging data streams**
 - » **upper limits** 

■ Overall goals

- » Bring interferometers, and data acquisition and analysis capability rapidly to the ability to collect and analyze coincidence data to address the scientific goals of LIGO.
- » Initiate scientific running in 2002 interleaved with progressive noise and availability studies
- » Advance both the interferometer commissioning and the commissioning of our analysis capability in a mutually balanced manner
- » Milestone, for the use of engineering run data to exercise the complete analysis pipeline

■ Definitions:

- » Engineering runs (Ex): data taking runs that are primarily motivated by the Laboratory detector improvement program
- » Science runs (Sx): intended to produce a data product for the LSC with scientific goals and resulting in publications

- **“E6” run before the end of 2001 (December for two full weeks)**
 - » At least one interferometer at each observatory with at least one interferometer in full recycled configuration
 - » Goal of significant locked coincidence data, but sensitivity not guaranteed
 - » Laboratory responsibility, with participation open to LSC members in the LIGO I working groups. Data available to upper limits groups
 - » Analysis goal: sensitivity curves (February), full analysis (April)
 - » if not successful, repeat the E6 run in January 2002
- **S1 run - May 2002.**
 - » Prime purpose to carry out the first scientific searches
 - » Joint responsibility of the Laboratory and the LSC
 - » Sensitivity goal is a two site coincidence with 3 interferometers running and the achieved scientific reach ($R = \text{Volume} \times \text{time}$) 10x better than E6
- **S2 run**
 - » At least 10x improvement in scientific reach beyond S1, following completion of S1 analysis
- **Interleaving of E and S runs with improved scientific reach until design sensitivity and reliability are obtained**

The LIGO logo consists of the word "LIGO" in a bold, black, sans-serif font. To the left of the text is a stylized graphic of several concentric, overlapping circles or rings, suggesting a gravitational well or a signal waveform.

LIGO - GEO

data exchange

Thu, 02 Aug 2001

Dear Barry and Rai,

I regret that I won't be able to attend the LSC meeting this month. This is the only period available for a family holiday, and the family has seen little of me lately. The AEI is well represented, however, by Maria Alessandra and her team.

I have not seen an agenda for the meeting but I hope that someone will give the general meeting details of the data-sharing MOU. **In some of the upper limit groups there seems to be some confusion still about the use of GEO data taken simultaneously with E6, so I think we should encourage all the upper limit groups to integrate GEO data into their thinking and planning for the analysis. I think a clear presentation of the MOU would help.** Maria Alessandra is well briefed by me to represent my point of view on this, and of course Jim Hough will be there if anyone needs a statement from one of our PIs.

Hope you have a good meeting.

Best regards

Bernard

LIGO - GEO

data exchange

LIGO-M010188-00-M/GEO-E2001-01

**Memorandum of Understanding
Between the
German/British Collaboration for the Detection of Gravitational Waves (GEO)
And the
Laser Interferometer Gravitational Wave Observatory (LIGO) Project
June 15, 2001**

The purpose of this Memorandum of Understanding is to establish and define the cooperation between the German/British Collaboration for the Detection of Gravitational Waves (GEO) and the Laser Interferometer Gravitational Wave Observatory (LIGO) Project **in respect of the operation of their detectors, the sharing of data, the joint analysis of data, and the dissemination of results of that analysis.** Both parties to this agreement share the joint goals of observing gravitational radiation and of using gravitational radiation as an astrophysical probe. This agreement is intended to assist in the realization of these joint goals. The two parties already have a Memorandum of Agreement dated August 15, 1997 (LIGO -M970077-00-M). The present MOU strengthens the cooperation established by the previous one and does not replace it.

LIGO - GEO

data exchange

Addendum A to the
Memorandum of Understanding (LIGO M010188-00-M/ GEO-E2001-01)
Between the
GEO 600 Gravitational Wave Collaboration
and the
Laser Interferometer Gravitational Wave Observatory (LIGO) Laboratory
15 June 2001

This Attachment to the Memorandum of Understanding LIGO M010188-00-M/ GEO-E2001-01 describes the operation of the LIGO-GEO data exchange agreement. It applies to data acquired by either Project from the effective date of the agreement. The agreement shall remain in force until one or the other party withdraws from it or a revised agreement is adopted.

LIGO - GEO

data exchange

1. All provisions of this attachment are reciprocal. Any provision for the treatment of GEO data by LIGO applies equally to the treatment of LIGO data by GEO. Responsibility for operation of the exchange lies with the LIGO Director on the one hand and the GEO Principal Investigator for Data Analysis on the other. In general, both projects agree that they will endeavor to distribute, analyze, and ensure the security of data received from the other project in the same way as their own.

LIGO - GEO

data exchange

2. The word “data” refers to any experimental data recorded from any detector and its associated monitoring systems. The term “reduced data set” refers to a data product that includes a calibrated data stream suitable for analysis for gravitational wave signals. The exact format of the reduced data set will be agreed upon from time to time by LIGO and GEO

LIGO - GEO

data exchange

3. Members of LIGO Laboratory and of the LIGO Science Collaboration (LSC) named in Attachment 1 have the right to access the full GEO data set, and members of GEO and GEO Associate Scientists named in Attachment 2 will have the right to access the full LIGO data set. The projects will maintain a joint public list of scientists who access either data set, listing the data accessed and the purpose of the investigation. Investigators should normally analyze data of comparable sensitivity from all detectors of the two projects that were recording data during the period covered by their investigation, in order to arrive at a result with maximum confidence. Scientists will submit 6-monthly reports on the progress of their work to their Project. LIGO and GEO will each make 6-monthly reports to the other on the use of the other project's data. Any publication of results from this data will be subject to the provisions of paragraph 6 below.

LIGO - GEO

data exchange

4. LIGO and GEO agree to exchange reduced data sets on a continual basis. Each project will make the reduced data set from the other project available to its own scientists and collaborators from its own data archive. LIGO and GEO will ensure maximum reasonable compatibility between data formats in order to facilitate analysis. Through the LIGO Scientific Collaboration(LSC) LIGO and GEO will encourage maximum cooperation between members of each Project on data analysis.

5. LIGO and GEO will cooperate to the best of their abilities on scheduling observations, with the aim to ensure that at any time at least two independent detectors are operating with good sensitivity in full-bandwidth mode. Planned periods of data recording will be discussed and coordinated by representatives appointed by the Director of LIGO and the Principal Investigators of GEO.

LIGO - GEO

data exchange

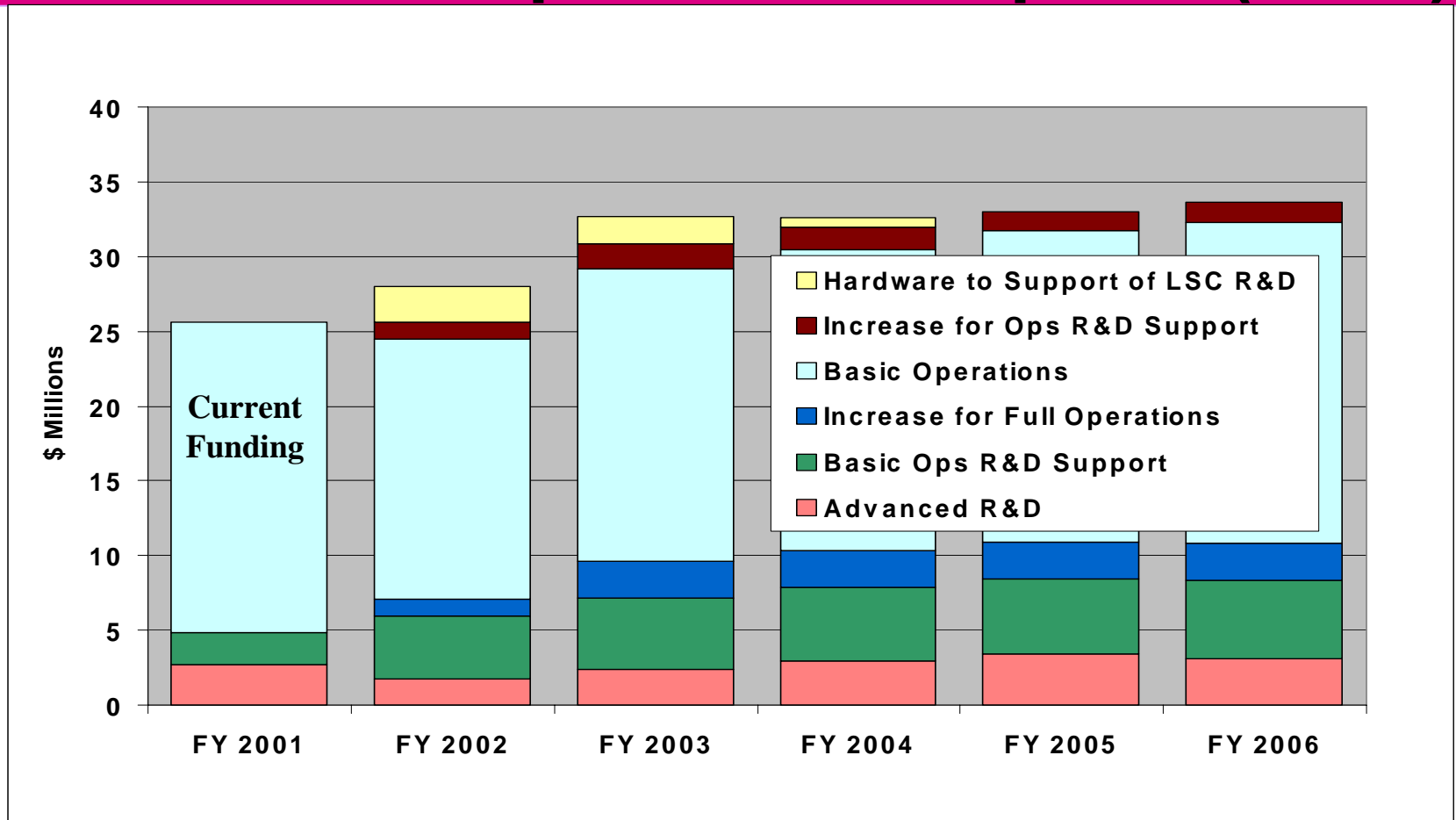
6. Any form of dissemination of the results of the analysis of the data covered by this agreement to persons outside the projects may be made only with the permission of both the Director of LIGO and the GEO Principal Investigator for Data Analysis. Scientific publications describing such results will be jointly authored by individuals identified by each Project. Any press releases based on the analysis of data under this agreement will be issued jointly and simultaneously by LIGO and GEO.

Future Operations Proposal Budget

	FY 2001 (\$M)	FY 2002 (\$M)	FY 2003 (\$M)	FY 2004 (\$M)	FY 2005 (\$M)	FY 2006 (\$M)	Total 2002-6 (\$M)
Currently funded Operations	22.92	21.63	24.32	25.05	25.87	26.65	123.52
Increase for Full Operations		2.24	4.13	3.91	3.77	3.85	17.90
Advanced R&D	2.70	1.73	2.39	2.98	3.39	3.13	13.62
R&D Equipment for LSC Research		2.4	1.86	0.70			4.96
Total Budgets	25.62	28.00	32.71	32.63	33.03	33.63	160.00

FY 2001 currently funded Operations (\$19.1M for ten months) is normalized to 12 months and provided for comparison only and is not included in totals.

Future Operations Proposal (cont.)



FY 2001 funding normalized to 12 months shown for comparison

Summary and News

- **Commissioning in progress**
 - » Emphasis on making three robust fully operational interferometers
 - » E6 run in December
 - » Sensitivity studies and improvements
 - » S1 run in May
- **LIGO I Program**
 - » Series of MDCs for LDAS underway
 - » Preparations of Upper Limit Groups
- **Awards**
 - » LIGO Operations funding FY02+ (5 years) approved by NSF (\$160M)
 - » Penn State awarded PFC (S Finn)
 - » iVDGL funded – LIGO tier 2 centers at UWM and Penn State
- **Advanced LIGO – preparations and plans (Sanders)**