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# LIGO

# Status Report

**Barry Barish**

*PAC Meeting - Hanford*  
*29-Nov-01*

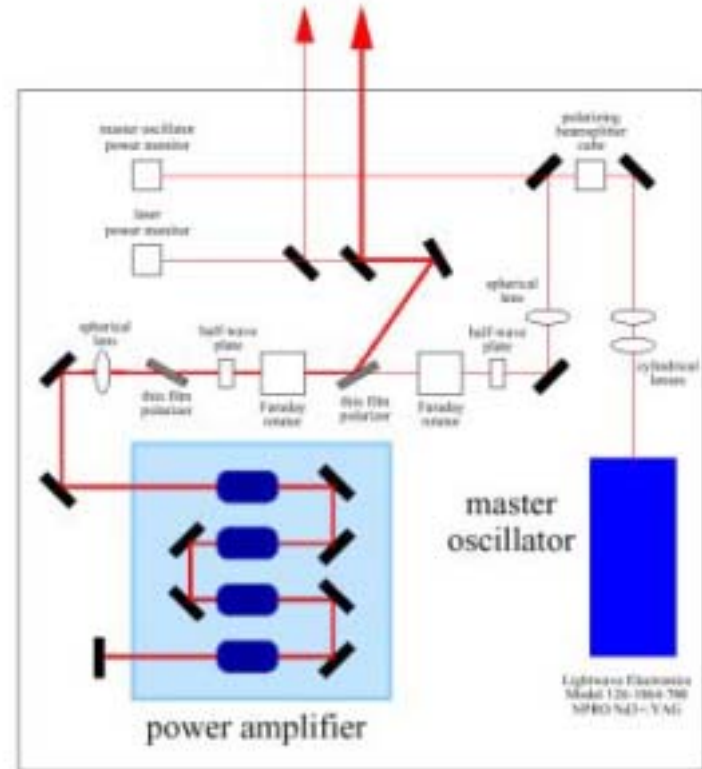
# LIGO Plans

## *schedule*

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- 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**

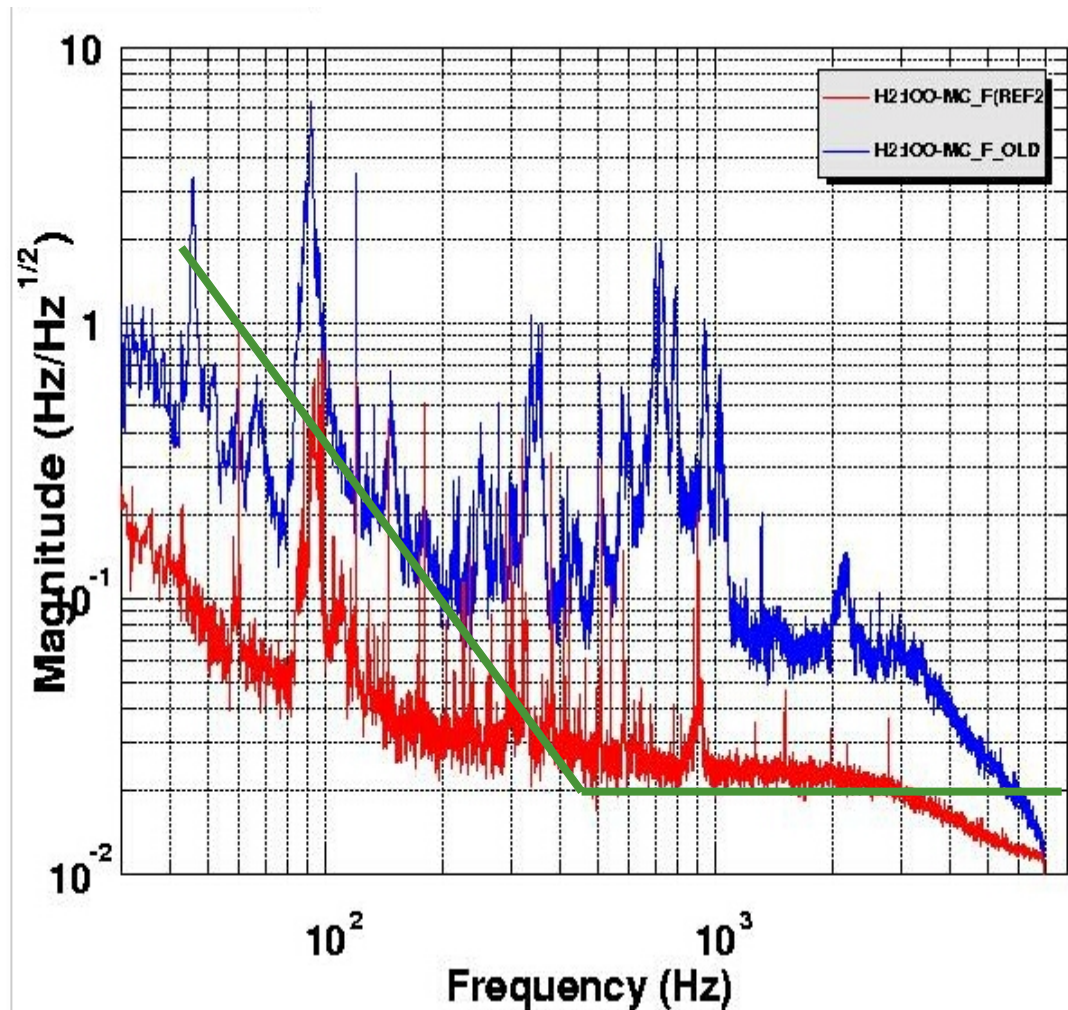
- Nd:YAG
- 1.064 mm
- Output power > 8W in TEM00 mode



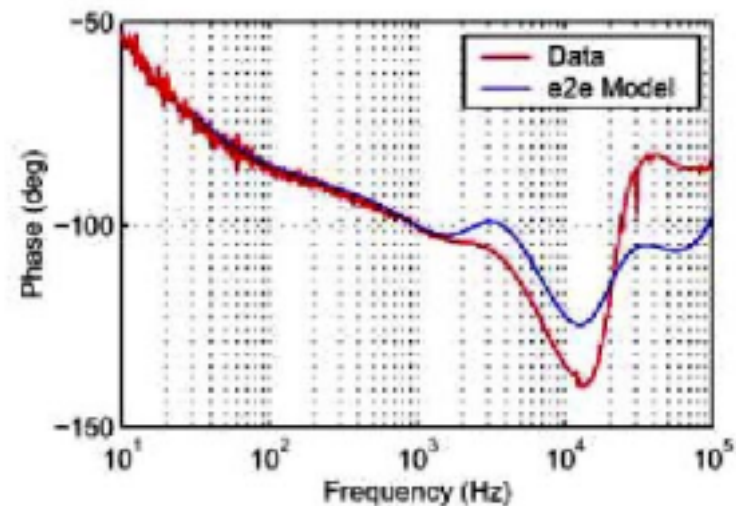
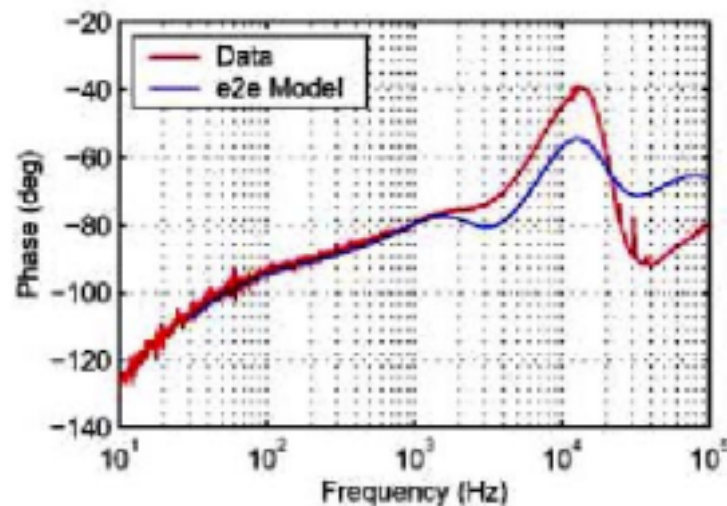
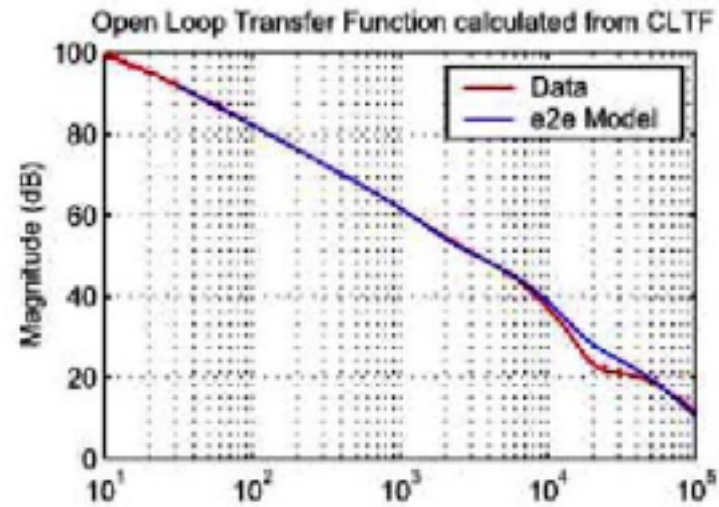
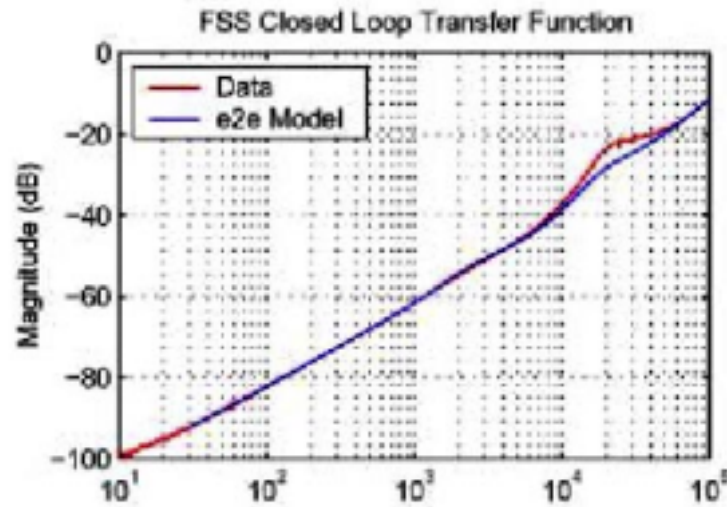
# Prestabilized Laser

## *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

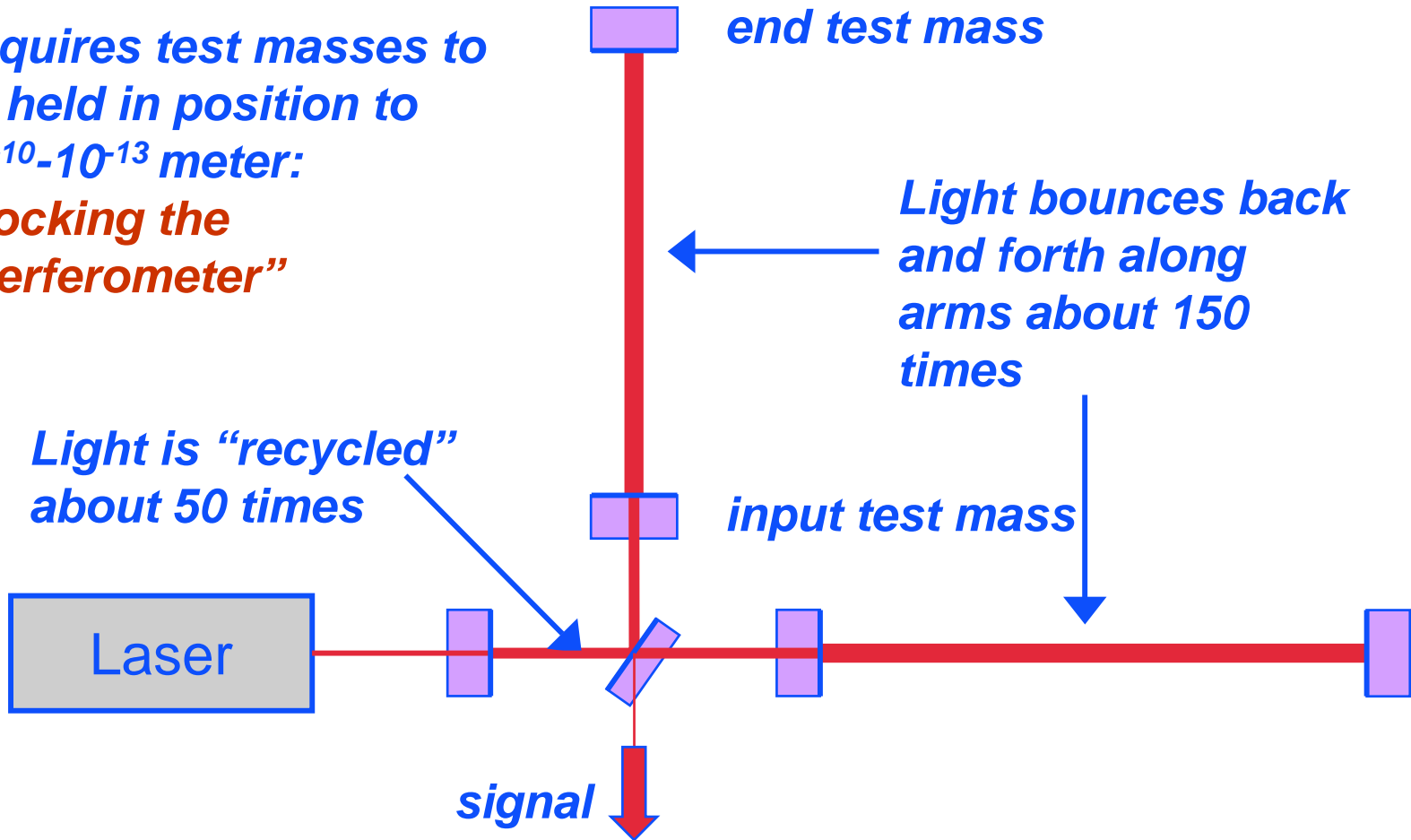


## *laboratory data vs e2e simulation*



# Interferometer *locking*

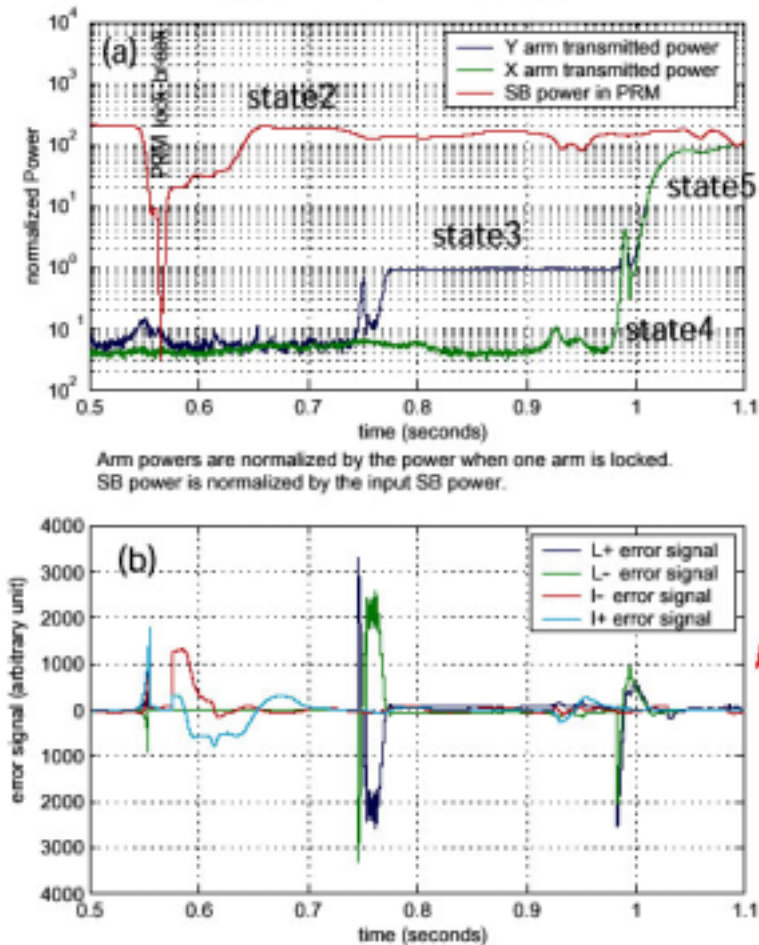
Requires test masses to be held in position to  $10^{-10}$ - $10^{-13}$  meter:  
**“Locking the interferometer”**



# Lock Acquisition

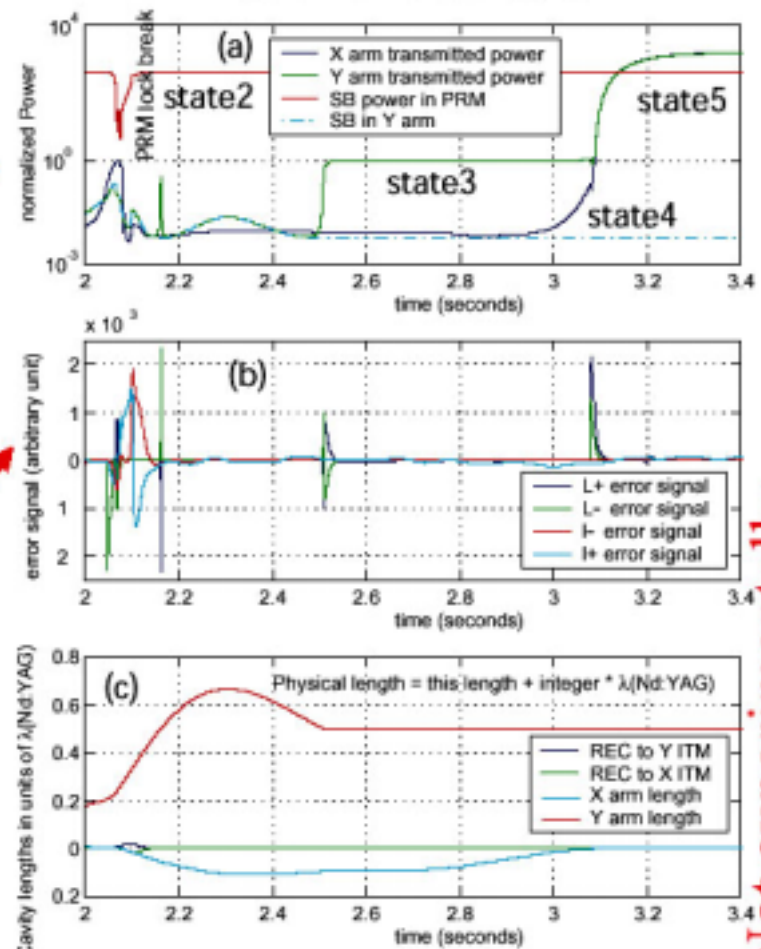
*data compared with e2e simulation*

Figure 1. LHO 2k IFO data



observable

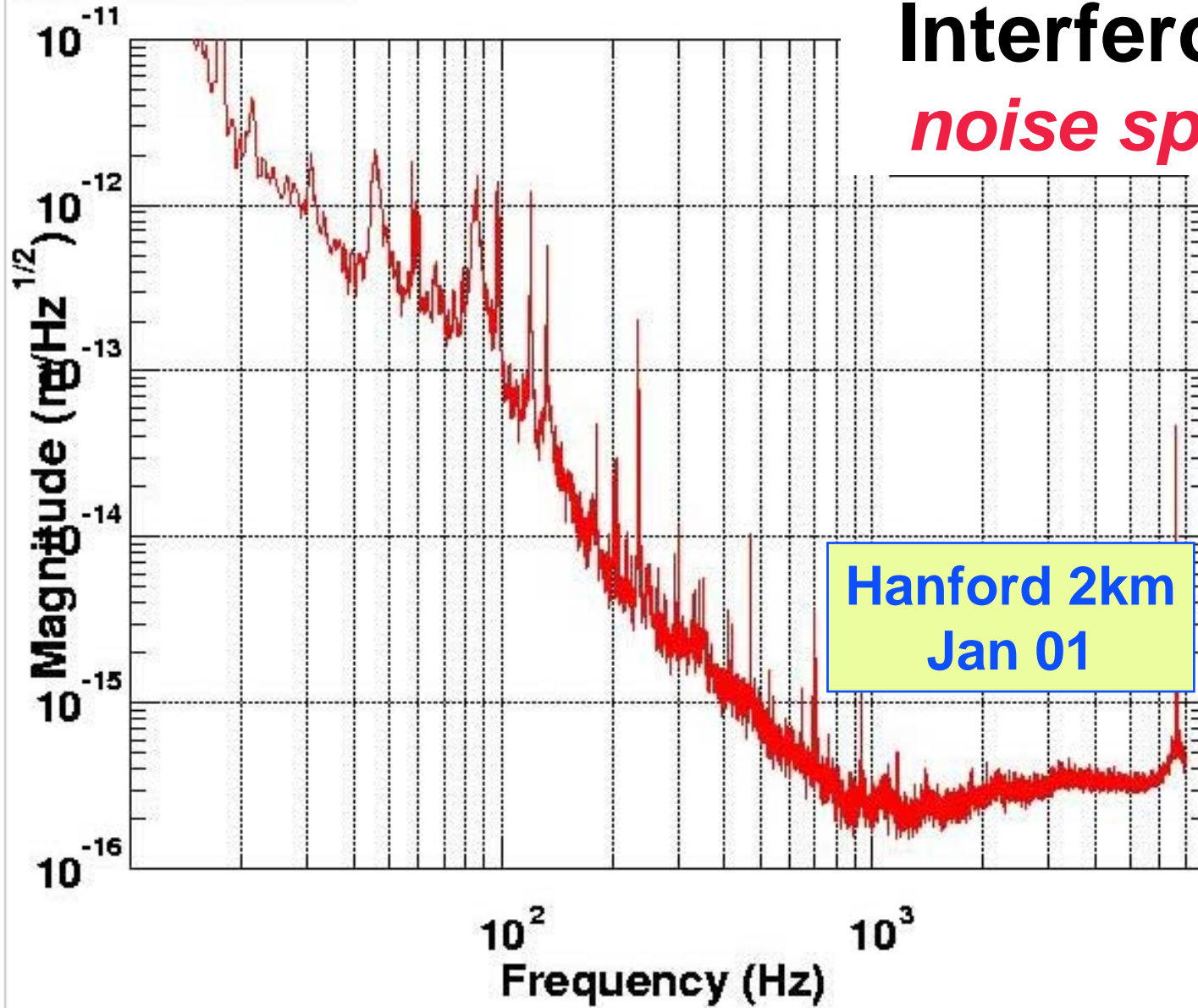
Figure 2. Simulated signal



Not experimentally observable

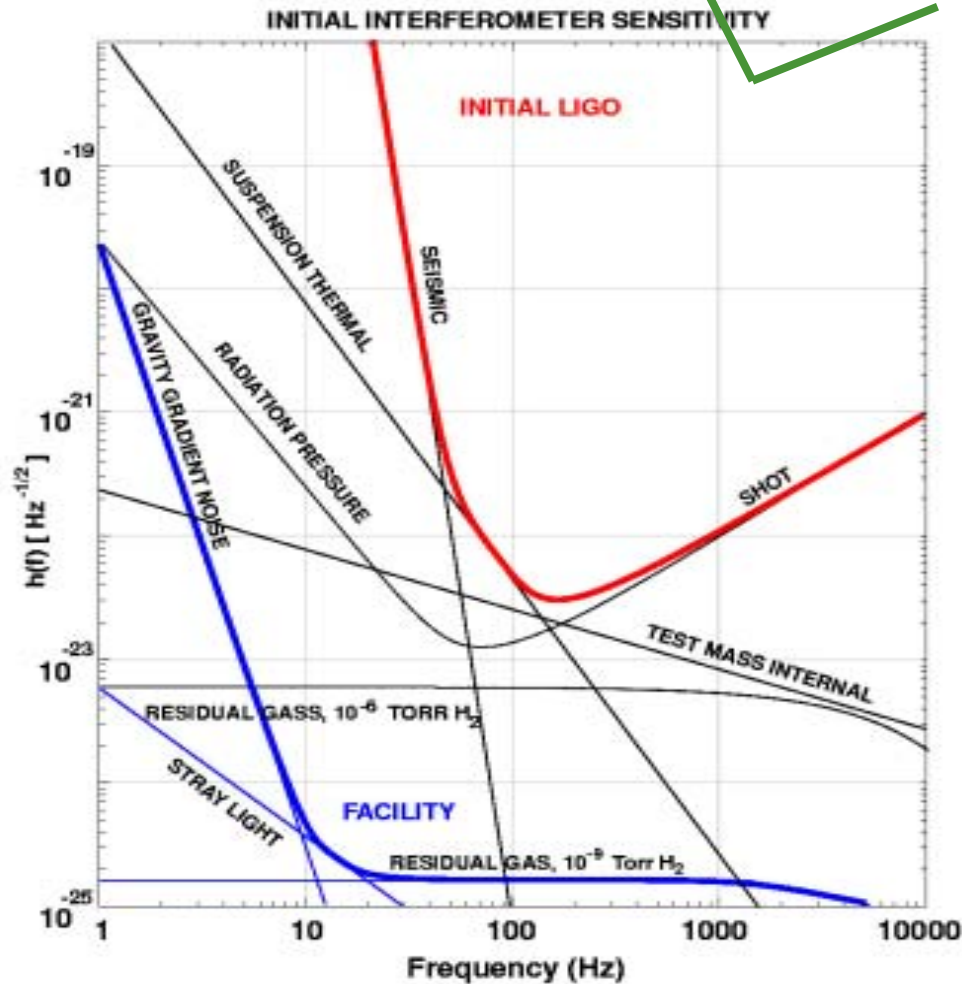
Power spectrum

Interferometer  
*noise spectrum*






## Sensitivity Goal



- Strain sensitivity  $< 3 \times 10^{-23} \text{ 1/Hz}^{1/2}$  at 200 Hz

*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 plan**
  - » **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.**
  - » **Use the engineering run data to exercise the complete analysis pipeline**
  - » **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**

### ■ **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

- **“E7” run (December 28 - 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 E7 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**



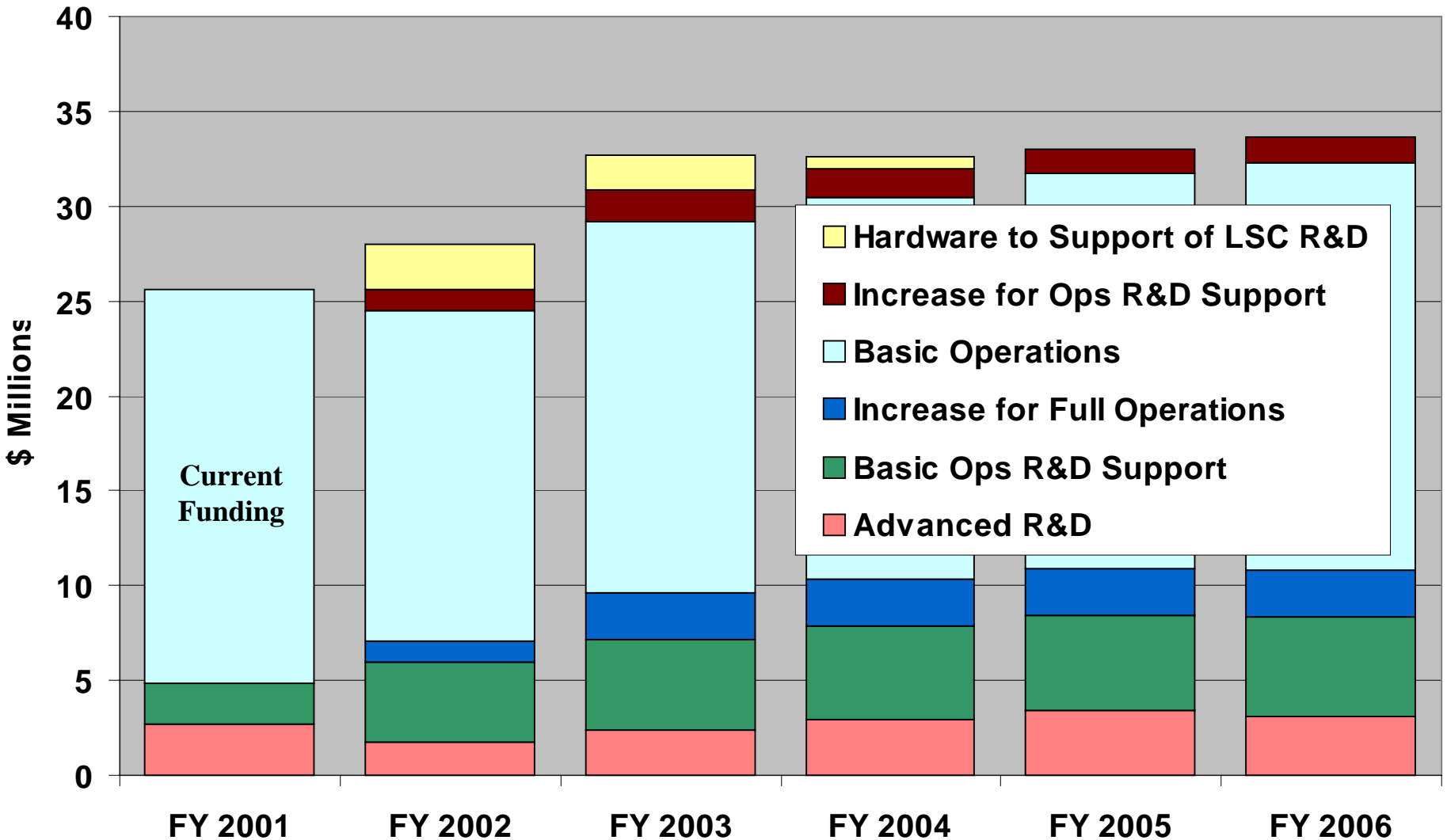
# LIGO Laboratory Budgets

## *operations renewal*

	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
<b>Total Budgets</b>	<b>25.62</b>	<b>28.00</b>	<b>32.71</b>	<b>32.63</b>	<b>33.03</b>	<b>33.63</b>	<b>160.00</b>

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.

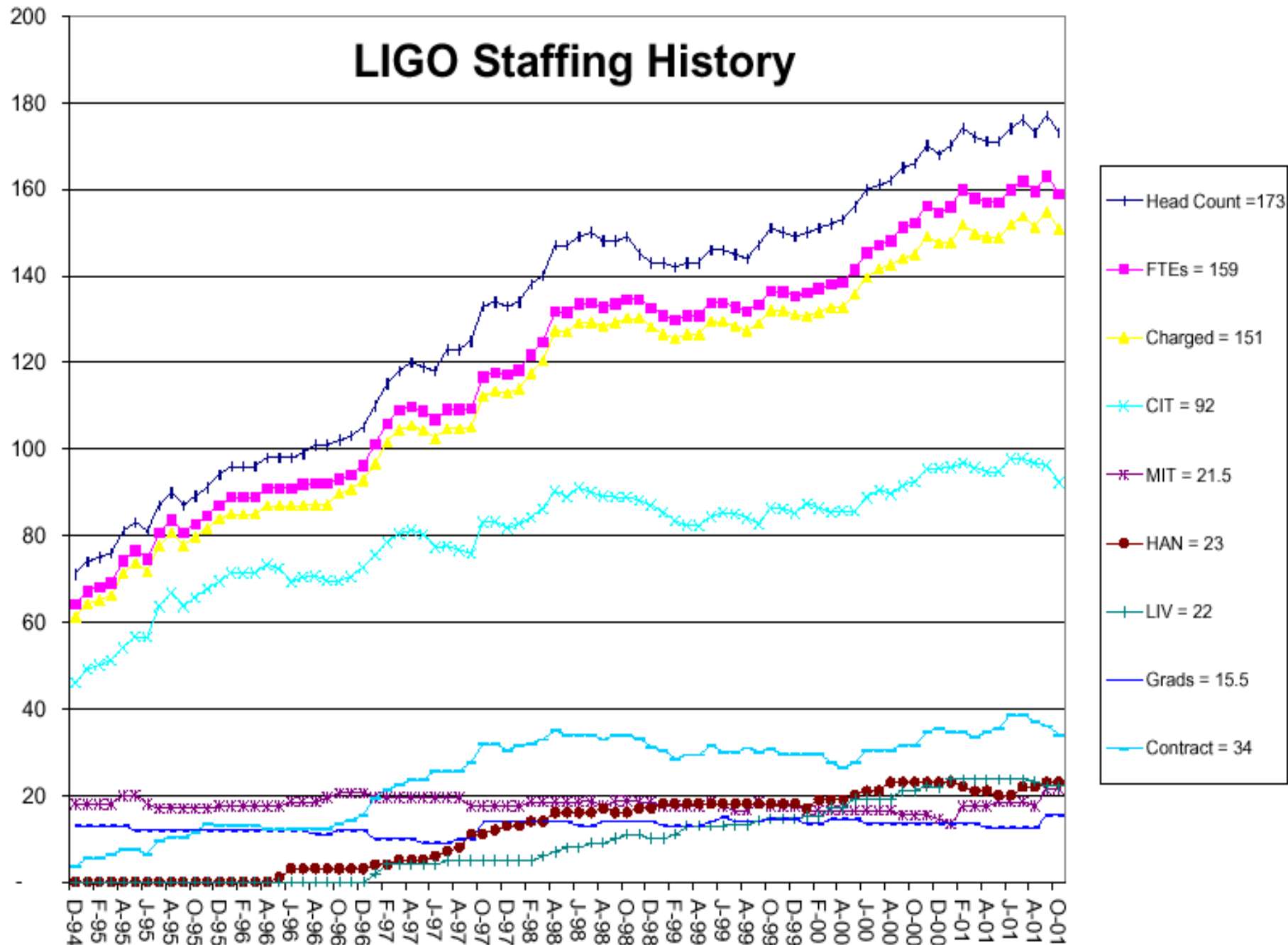
# LIGO Budgets



FY 2001 funding normalized to 12 months shown for comparison



# LIGO Staffing History



# Status and Plans

- **Commissioning in progress**
  - » Emphasis on making three fully operational interferometers
  - » E7 run begins at end of December
  - » Improvements (seismic mitigation at LLO, ...)
  - » Sensitivity studies to become the focus next year
- **LIGO I Program**
  - » Series of Mock Data Challenges for LDAS
  - » Preparations of Upper Limit Groups
  - » S1 run about May 02
- **Funding**
  - » LIGO Operations funding FY02+ (\$160M for 5 years )
  - » Penn State awarded PFC (S Finn)
  - » iVDGL funded – LIGO tier 2 centers at UWM and Penn State

## *focus of the program*

- **Obtain Reliable Interferometer Operations**
  - » Robust Locking
  - » Multiple Interferometers
- **Achieve Good Sensitivity**
  - » Improvements; limiting noise; path to design goals?
- **Demonstrate Science Capability**
  - » Upper Limit Run - Physics Results (S1 run)
- **Develop Advance LIGO**
  - » Advanced R&D program
  - » Design, Costs, and International Collaboration
  - » When to propose MRE funding?