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# Update from LIGO Laboratory

## LIGO-Virgo Collaboration Meeting

Albert Lazzarini

Hannover, Germany

October 22-25, 2007



LIGO - G070649-00-M





# LIGO Laboratory Update Outline

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- End of S5
- Interim S5 - eLIGO activities
- Enhanced LIGO status
- Advanced LIGO status
- Continuation of LIGO Operations 2009 - 2013
- Outreach

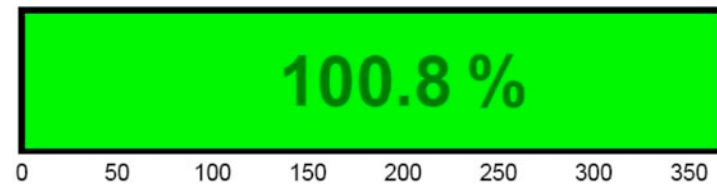


# LIGO S5 Run Has Been Successfully Completed!

- In November 2005 we began S5 ...

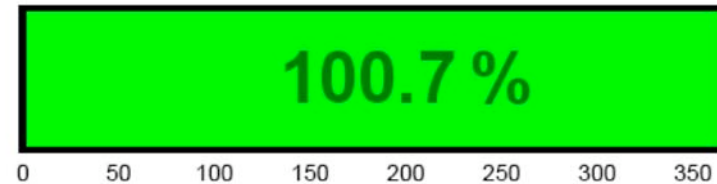
## *Since Jay's July report:*

- On 24 July -- LLO - LHO site-site coincidence exceeded 1 year of observation in science mode



Source: D. Sigg  
LIGO weekly  
report, 24 July  
2007

- On 21 September -- L1+H1+H2 3X coincidence exceeded 1 year of observation in science mode

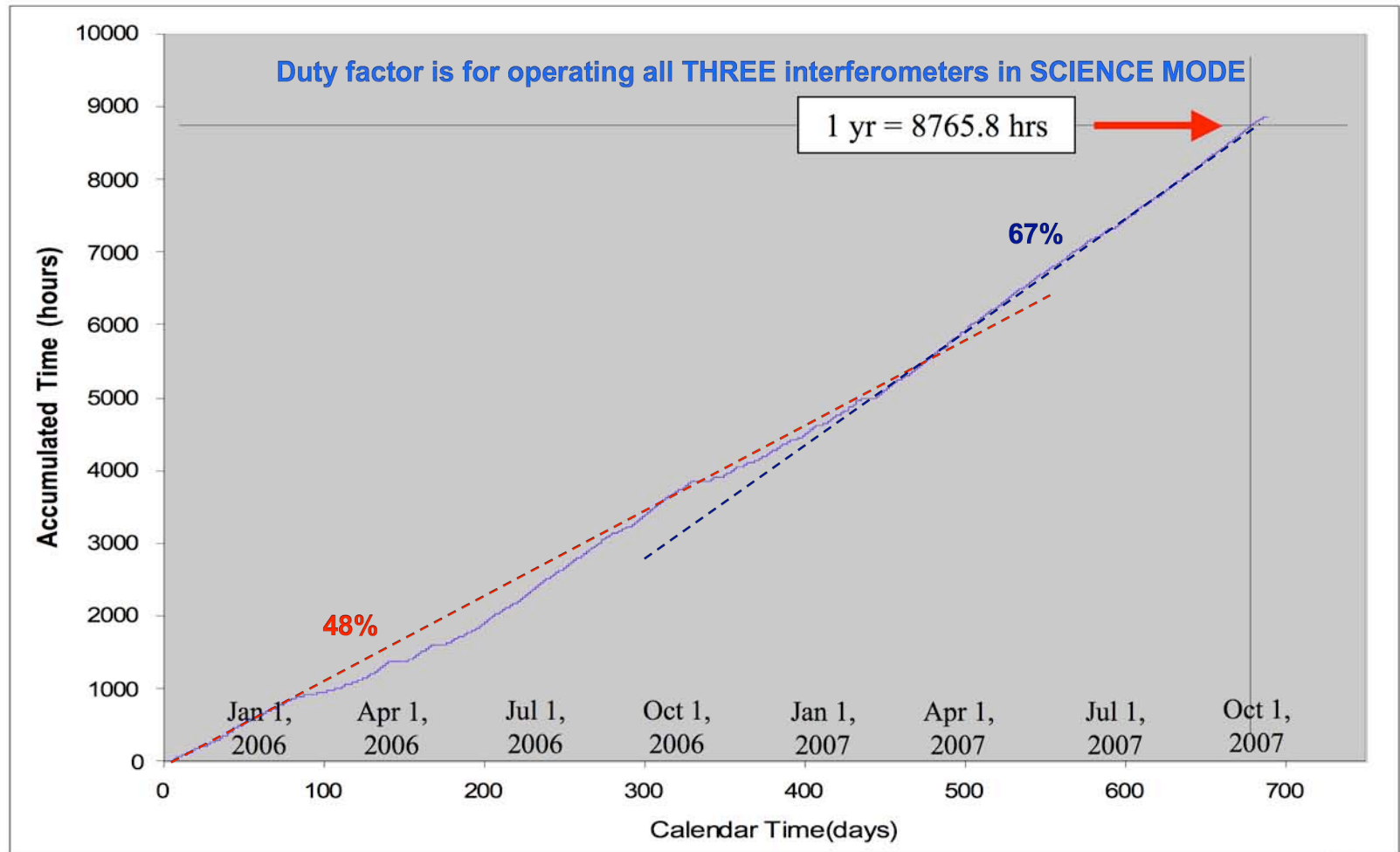


Source: D. Sigg  
LIGO weekly  
report, 03  
October 2007

- S5 and SR1 officially ended UTC 00:00 1 October



# Triple-coincidence Science Mode Observation Time Accumulation vs. Calendar Time





# Post - S5 & Pre-eLIGO Planned Activities

## Fred Raab appointed "czar" & coordinator

S5 Post-Data Schedule	Oct.1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
2007-Sep-23	M	T	W	Th	F	Sa	Su	M	T	W	Th	F	Sa	Su	M	T	W	Th	F	Sa	Su	M	T	W	Th	F	Sa	Su	M	T
<b>Standard Calibrations</b>																														
L1 Start 14:00																														
H1 Start 12:00																														
H2 Start 12:00																														
<b>Other Calibration Techniques</b>																														
LLO Start 14:00																														
LHO Start 12:00																														
Fine Actuator Sweep LLO HEPI																														
Fine Actuator Sweep LHO PEPI																														
P-Cal: Sign & Timing LLO																														
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VCO Cal LLO																														
VCO Cal LHO																														
<b>Cavity Pole</b>																														
LLO																														
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<b>Photon Calib</b>																														
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<b>Electronics Measurements</b>																														
LLO																														
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<b>HF Calib</b>																														
LLO																														
LHO																														
<b>PEM Injections</b>																														
Standard Suite + 2nd Level LLO																														
Standard Suite LHO																														
Power Supply Monitoring LLO																														
2nd Level tests LHO																														
H1-H2 Coupling																														
Line Finding, Violins ~330Hz																														
Dust & Wandering Peaks																														
Ultrasonic PEM (?)																														
<b>Upconversion</b>																														
<b>Astrophysical Injections</b>																														
<b>Large Optic Images</b>																														
<b>Test Mass Absorption Measurements</b>																														
<b>CDS DAQ &amp; Controls Documentation</b>																														
Software - ongoing																														
Photograph Tables																														
Photograph Racks																														
Photograph Cards, etc. (as available)																														
Voltages, RF levels, Timing System																														

Work performed as areas become available at LLO & LHO





# The Post S5 Era

- S5 close-out activities will occupy October
  - Calibrations
  - Signal injections & environmental injections
  - Optics characterizations
- Enhancements to initial LIGO (4 km interferometers) will start at end of October (Enhanced LIGO, eLIGO)
  - Installation phase until Jan2008
  - Commissioned by Jan 2009, observe 2009-2010
- H2 (2 km interferometer) Astrowatch program in conjunction with GEO600
  - Minor improvements to H2 planned during the Enhanced LIGO installation phase
  - Provide best-effort coverage during 2008 - 2009 inter-run period between S5 and S6
  - ***Plan: 1 afternoon and 1 owl shift coverage, led by LSC students***
  - ***Partial support will be provided by the Laboratory for those students committed to 6 month or longer service***



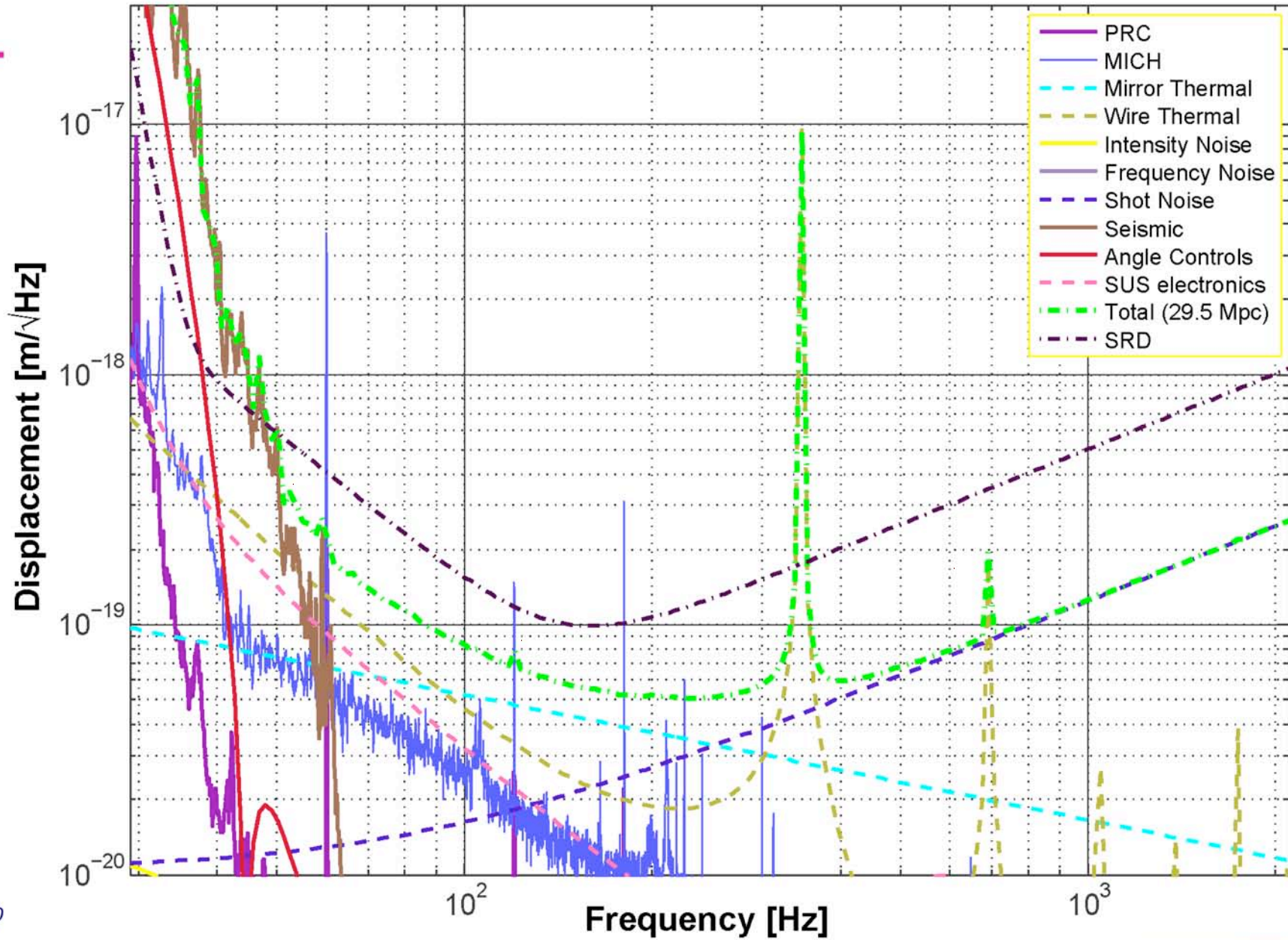
# The *next* Science Run: Enhanced LIGO and S6

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- In 2005/2006 LIGO developed a concept to upgrade of the 4 km interferometers
- Laboratory commitment to upgrade made after August 2006 internal planning review
- Schedule status in September 2007 showed that project is on track
- e-LIGO team has been cutting metal & building
  - Output mode cleaner (OMC) & suspension;
  - Seismic isolation for detection system being fit-checked at vendor, ready for cleaning & delivery to LLO;
  - Lasers
    - Thermal compensation upgrade in progress
    - Main laser (PSL) upgrade to 35W using Advanced LIGO front-end
      - Contributed by GEO
      - First unit for testing received at Caltech in September



Limiting noise sources for an enhanced detector are understood







# Enhanced LIGO -- Advanced LIGO R&D Prototype Components for Early Deployment in 2008

- **35 W Laser**
  - 3.5x increase in power
  - The “front-end” of the AdL laser
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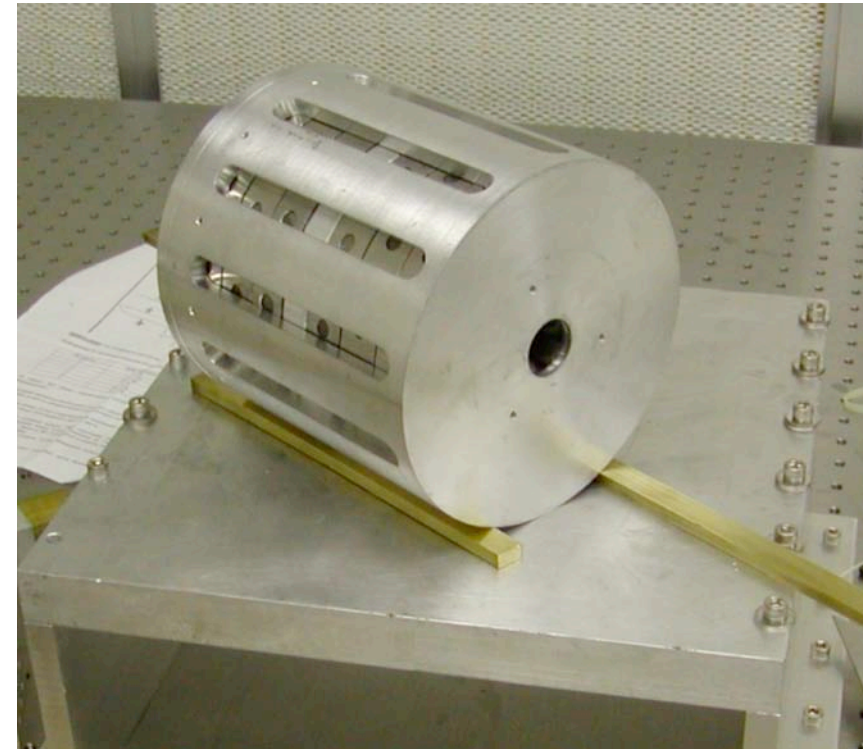
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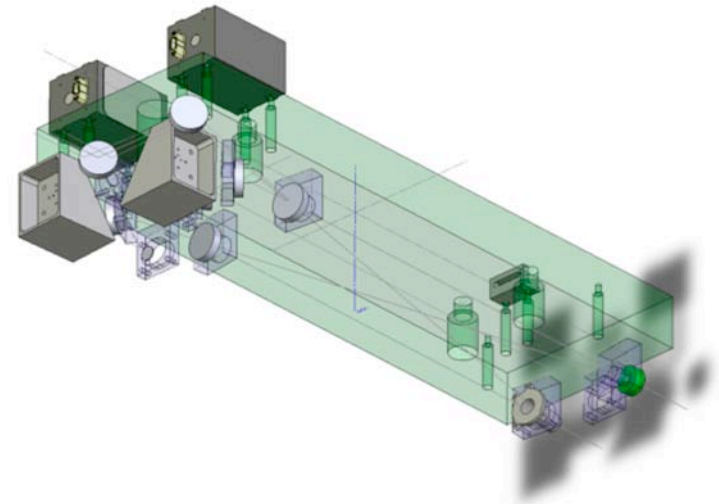
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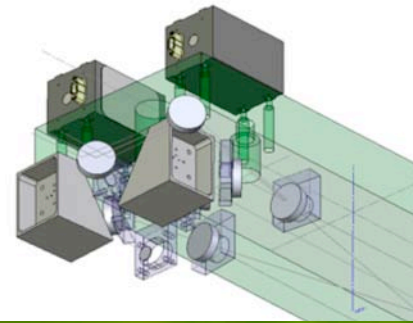
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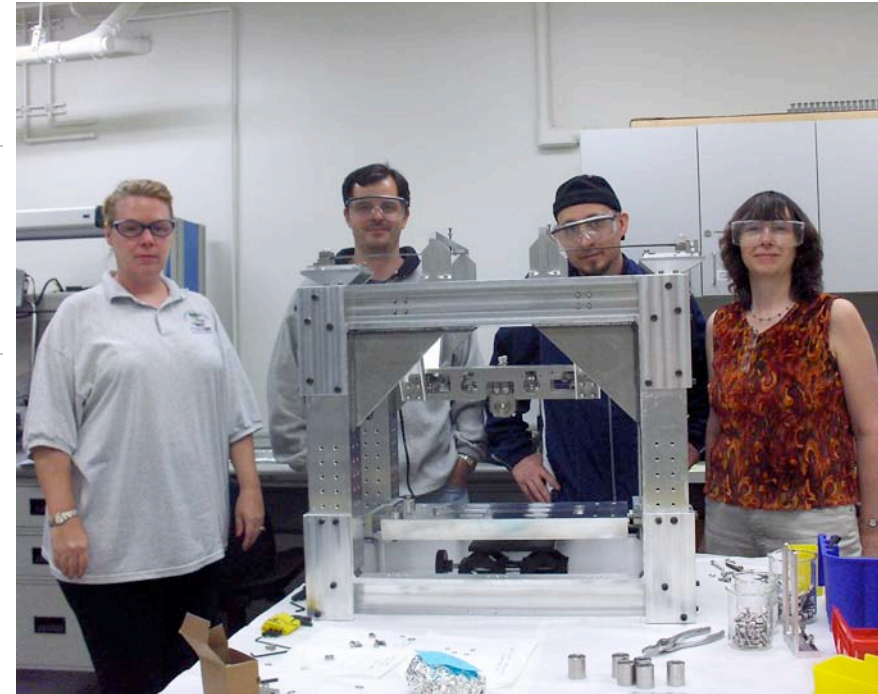
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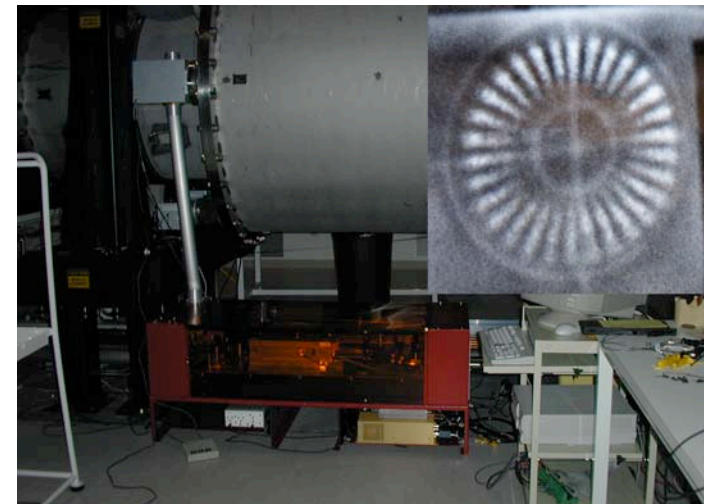
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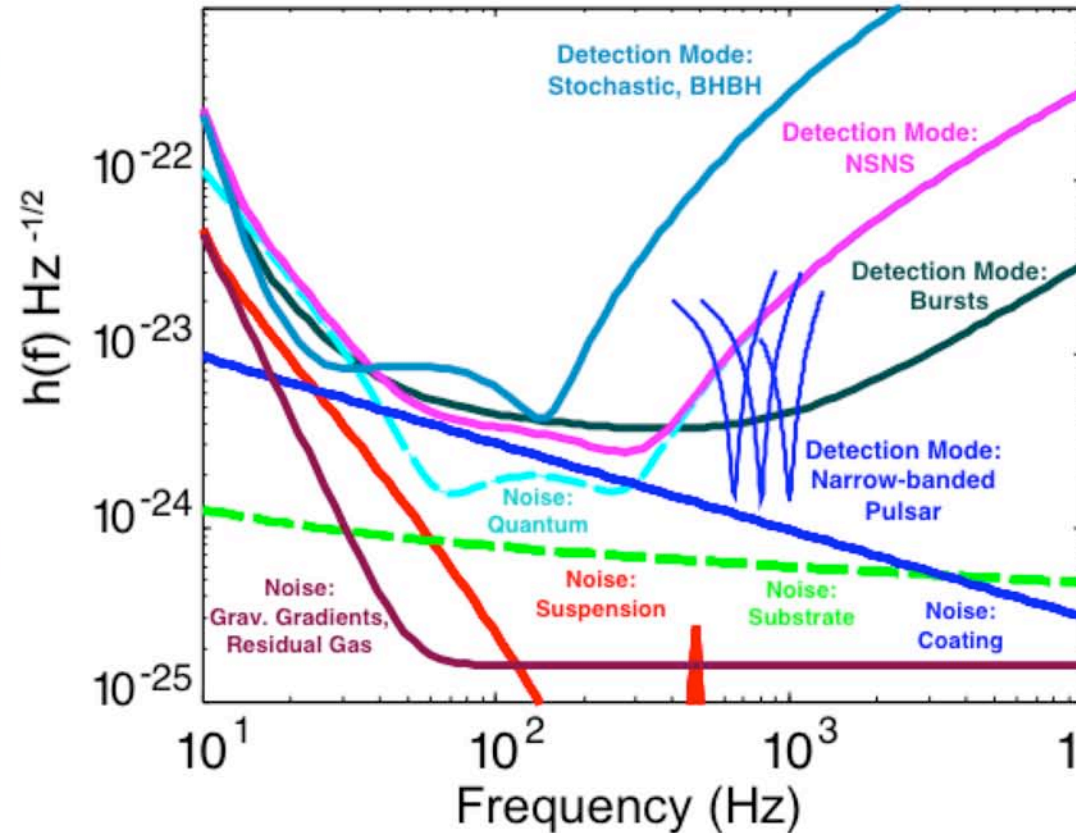
***UPGRADES  
ARE COMMON  
TO THE  
ADVANCED  
LIGO PROJECT***





# Advanced LIGO

- MREFC project for \$209M ...
  - Second generation of detectors in LIGO
  - Factor ~10X in amplitude sensitivity (over S5 Initial LIGO)
  - Factor ~4X lower frequency 'wall'
- Mostly quantum limited at highest power & midrange frequencies
  - Recombined Fabry-Perot Michelson
  - ~20X higher input power
  - Signal recycling → tunable
- For lower power & lowest frequencies, limited by gravitational gradient, thermal noise limits
  - 40 kg fused silica masses
  - Fused silica suspension
  - Aggressive seismic isolation





# Progress

## Technical advances

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- Full scale prototyping of mechanical systems
- Tests of 'DC readout'
- Laser production
- Understanding of coating scatter
- Systems design



# Status of Advanced LIGO

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- **Baseline Review in June 2006**
  - Review committee gave us high grades, agreed that we're ready to start construction
  
- **Follow-on update to Baseline Review in June 2007**
  - Review responses to recommendations from 2006 review
  - Committee confident that Advanced LIGO was prepared to move into construction phase
  
- **Follow-on to follow-on to Baseline Review in November 2007**
  - "Mini-status-review" appended to NSF LIGO Laboratory Annual Review
  - Required readiness review prior to release of funding by NSF...
  
- **Construction start awaits the conclusion of the budget process for FY08 in Washington....**
  - If funding starts as expected ...
    - Breach vacuum in 2010 (termination of the S6 eLIGO observational run)
    - Start commissioning 1st interferometer for Advanced LIGO in 2013



# Continuing operations of LIGO Laboratory: 2009 - 2013

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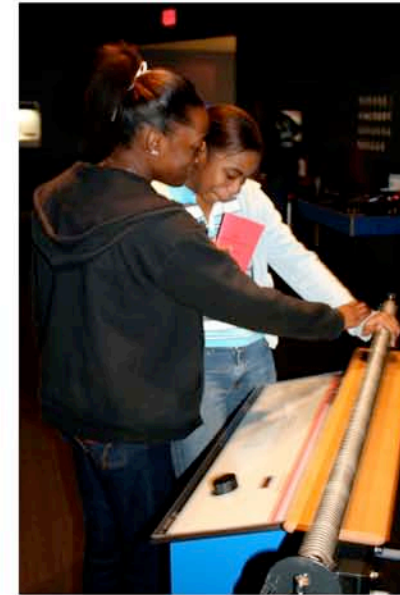
- New Cooperative Agreement with NSF
- 5-year period FY2009-FY2013 is concurrent with construction of Advanced LIGO
- Proposed scope:
  - Operation of interferometers for S6 with enhanced LIGO
  - Data analysis and science from S5 and S6
  - Expanded education and outreach
  - Preparing to operate Advanced LIGO, accepting first subsystems & interferometer(s) for tuning (2012-2013)
  - Targeted R&D to reduce risks for Advanced LIGO, for improvements to Advanced LIGO and for future capabilities
- NSF Annual Review will focus on proposed work & scope
  - ~\$160M (Advanced LIGO has separate construction funding)
  - 6 - 8 November at Caltech

# Education & Outreach





Major outreach strategies include field trips, on-site public events, off-site activities and teacher professional development programs



Outreach activities engage the ethnically diverse populations that surround the Observatories







# The LLO SEC illustrates the power of outreach partnerships



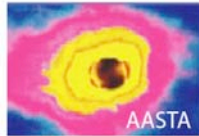
**Docents in Training from Southern University**



**LA GEAR UP provides access to low performing schools**



# LIGO Hanford programs rely on partnerships to fuel growth







**LHO outreach received state (LASER) and local (SE WA Community Award) recognition in 2007**

- **Goal: A science education center for Hanford**
  - Build on the successful SEC model at Livingston
- **Timing: Take advantage of the planned LHO shutdown for Advanced LIGO installation (~2011-2012)**

LIGO Laboratory at Caltech





# Summary of important news

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- S5 was successfully completed
  - Data analysis is in full swing
- Enhanced LIGO is around the corner!
  - Metal being cut, looks in good shape and on track for 2009 startup
- Advanced LIGO ready to start construction in FY2008
- Outreach program continues to grow and have an impact on the local communities surrounding the observatories
  - SEC for LHO being strategized
- NSF Review of laboratory proposal for continued operations 2009-2013 (during Advanced LIGO construction) scheduled in two weeks at Caltech