LIGO Status

Albert Lazzarini

21st Meeting of the LIGO PAC

28, 29 November 2006 at MIT

Outline

- LIGO Laboratory management update
- Status of current science run (S5)
- Beyond S5 -- Enhanced LIGO
- Advanced LIGO
- Public education and outreach
- Planning for operations beyond 2008, during Advanced LIGO construction

Changes in Key Personnel in 2006

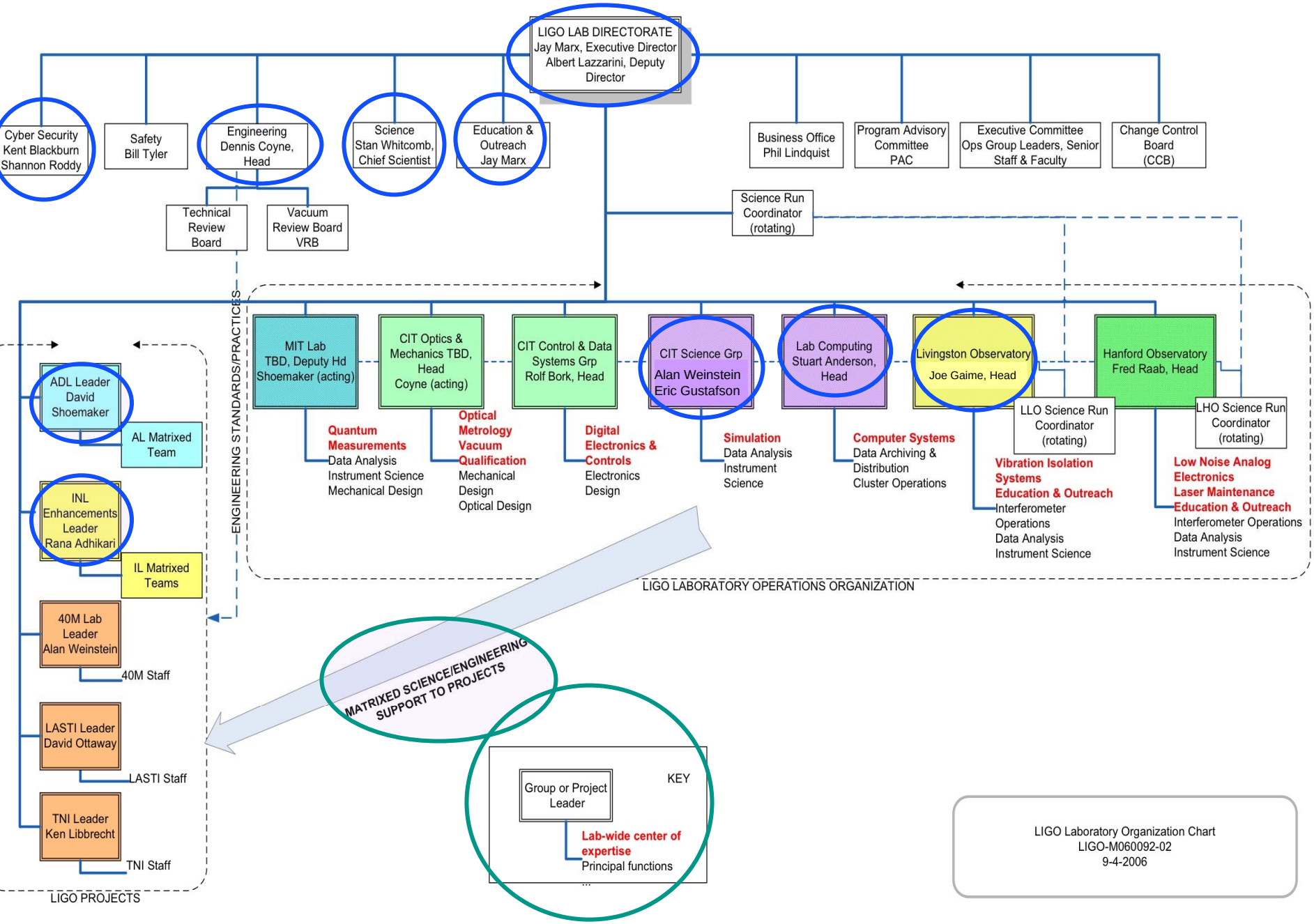
- Before the last PAC meeting ...
  - In March 2006, Jay Marx became the LIGO Executive Director, replacing Barry Barish
- Since the last PAC meeting …
  - Stan Whitcomb has stepped down as Deputy Director to focus on science
    - Chief Scientist of LIGO Lab.
      - Will help define the scientific focus and direction of Laboratory
      - Mentor young scientists
  - Albert Lazzarini succeeds Stan as Deputy Director
    - Formal appointment by Caltech President with concurrence by MIT President and NSF
    - Transition occurred on September 4.
    - Stan will work closely with Albert for next few months to assure a smooth transition

LIGO Laboratory Organizational changes in 2006

- Implemented standard matrix system
  - During Advanced LIGO construction the Lab needs flexibility to staff the project and carry out its other responsibilities
    - Operations groups
      - Explicit recognition of important functional roles in Laboratory organization
    - Projects
      - Cut across group boundaries to assemble teams -- include Advanced LIGO, enhancements and R&D facilities
- Created LIGO Laboratory Chief Scientist role (Stan Whitcomb)
- Coordinated Education and Outreach under Director (Jay Marx)
  - Recognizes Directorate responsibility for education/outreach
- Designated a Laboratory Engineering Head (Dennis Coyne)
    - Assures uniform engineering standards & practices across lab
- Cybersecurity reports to Directorate (Kent Blackburn & Shannon Roddy)

Changes in Group Leadership in 2006

- New Head of LIGO Livingston Observatory
  - Mike Zucker has stepped down as Head of the Livingston Observatory after doing a superb job and enduring a difficult commute for 3 years
  - Caltech has appointed **Joe Giaime** as the new Head
    - Joe is a Caltech employee but will retain tenured faculty appointment at LSU
    - Formerly served as Chief Scientist at LLO under Mike Zucker
- **Stuart Anderson** is new leader of the Laboratory Computing Group
  - Replaces Albert Lazzarini
- CIT Science Group -- largest group of personnel
  - Composed of two sub-groups that will remain closely connected
  - Data Analysis Group
    - **Prof. Alan Weinstein** will lead the subgroup that is heavily involved in astrophysics & data analysis (e.g, most of our postdoctoral scholars & students)
  - Instrument Science Group
    - **Dr. Eric Gustafson** will lead the Instrument Science Group (new senior hire - arrives Jan 2007)


LIGO LAB DIRECTORATE
Jay Marx, Executive Director
Albert Lazzarini, Deputy Director
Cyber Security
Kent Blackburn
Shannon Roddy
Safety
Bill Tyler
Engineering
Dennis Coyne, Head
Science
Stan Whitcomb, Chief Scientist
Education & Outreach
Jay Marx
Business Office
Phil Lindquist
Program Advisory Committee
PAC
Executive Committee
Ops Group Leaders, Senior Staff & Faculty
Change Control Board
(CCB)
Technical Review Board
Vacuum Review Board
VRB
Science Run Coordinator
(rotating)
ENGINEERING STANDARDS/PRACTICES
MIT Lab
TBD, Deputy Hd
Shoemaker (acting)
CIT Optics & Mechanics TBD, Head
Coyne (acting)
CIT Control & Data Systems Grp
Rolf Bork, Head
CIT Science Grp
Alan Weinstein
Eric Gustafson
Lab Computing
Stuart Anderson, Head
Livingston Observatory
Joe Gaime, Head
Hanford Observatory
Fred Raab, Head
Quantum Measurements
Data Analysis
Instrument Science
Mechanical Design
Optical Metrology
Vacuum
Qualification
Mechanical Design
Optical Design
Digital Electronics & Controls
Electronics Design
Simulation
Data Analysis
Instrument Science
Computer Systems
Data Archiving & Distribution
Cluster Operations
LLO Science Run Coordinator
(rotating)
Vibration Isolation Systems
Education & Outreach
Interferometer Operations
Data Analysis
Instrument Science
LHO Science Run Coordinator
(rotating)
Low Noise Analog Electronics
Laser Maintenance
Education & Outreach
Interferometer Operations
Data Analysis
Instrument Science
LIGO LABORATORY OPERATIONS ORGANIZATION
ADL Leader
David Shoemaker
AL Matrixed Team
INL Enhancements Leader
Rana Adhikari
IL Matrixed Teams
40M Lab Leader
Alan Weinstein
40M Staff
LASTI Leader
David Ottaway
LASTI Staff
TNI Leader
Ken Libbrecht
TNI Staff
LIGO PROJECTS
MATRIXED SCIENCE/ENGINEERING SUPPORT TO PROJECTS
Group or Project Leader
KEY
Lab-wide center of expertise
Principal functions
...
LIGO Laboratory Organization Chart
LIGO-M060092-02
9-4-2006

Current status of S5 science run

- Began November 2005
- Goal for this science run--
  - One year's data with coincident operation of both observatories at the our science performance goal --for H1, L1: range over 10 Mpc inspiral range, H2: over 5 Mpc (for 1.4 M_o + 1.4 M_o neutron star pairs)
- Run going very well -- began run at sensitivity goal
  - Sensitivity is now 40% greater than beginning of run
- Reliability and duty factor improving and approaching our target of 85% for each IFO 70% coincidence between sites
- Run now >55% complete
  - Performance past 2 months predicts end of run Sep-Oct 2007
- Details - Talk by Peter Saulson on S5 science

LIGO

Reached SRD (1995) sensitivity requirement
--A major achievement--

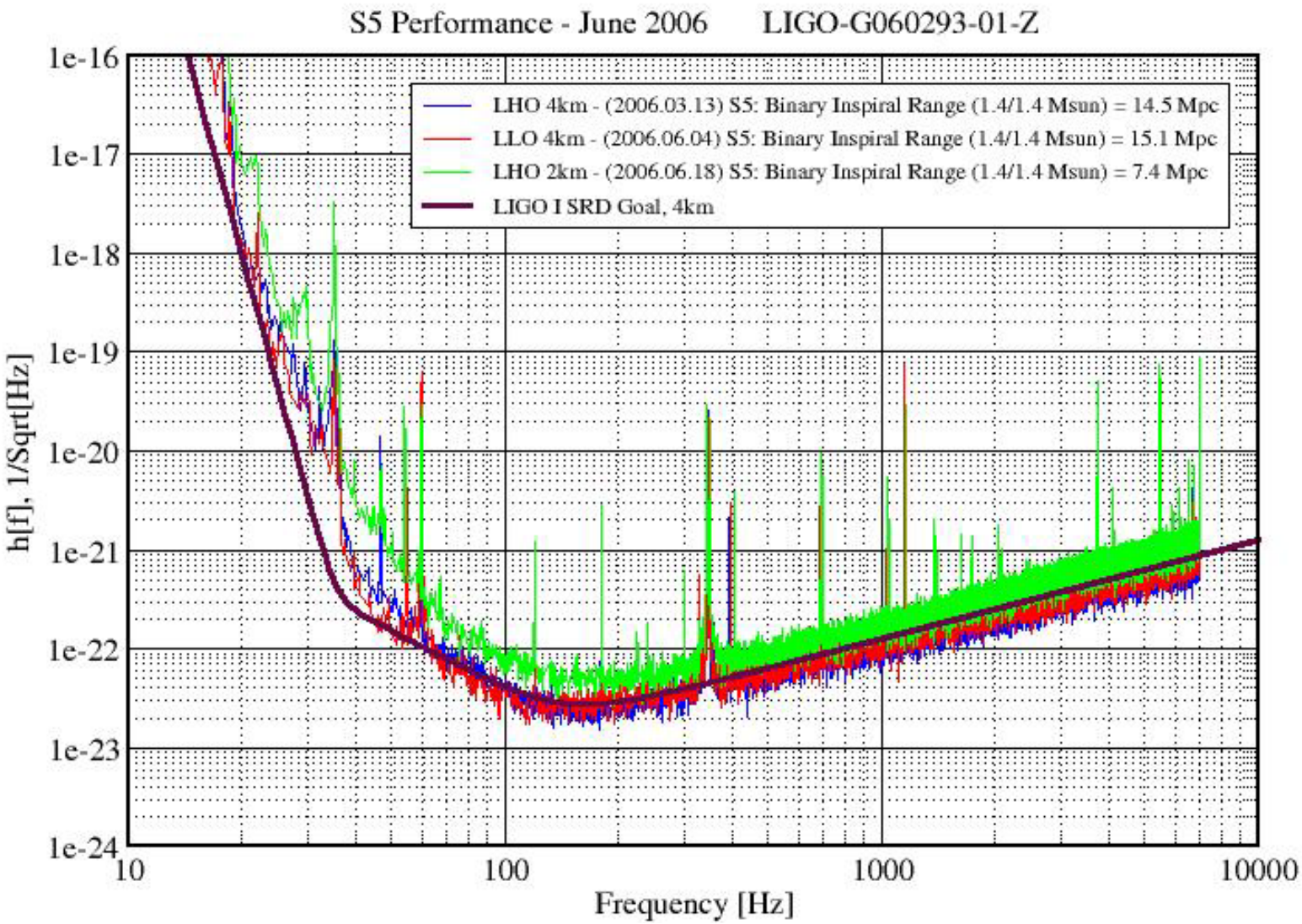
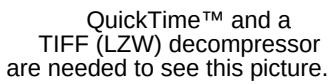


Figure of merit-- 1.4 M_O + 1.4 M_O NS-NS inspiral range, since beginning of S5

QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.

Recent BNS range performance



LLO/LHO coincidence

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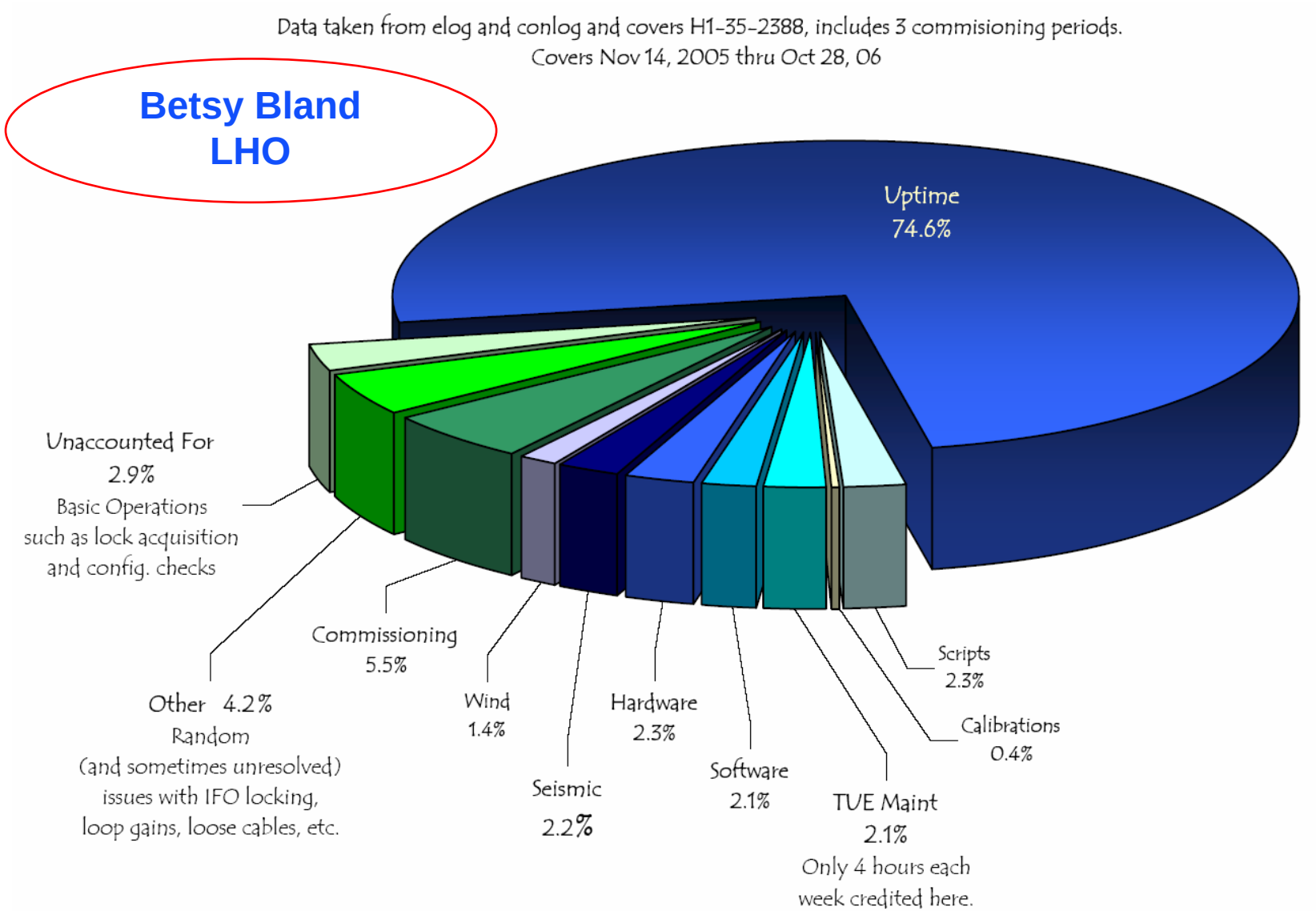
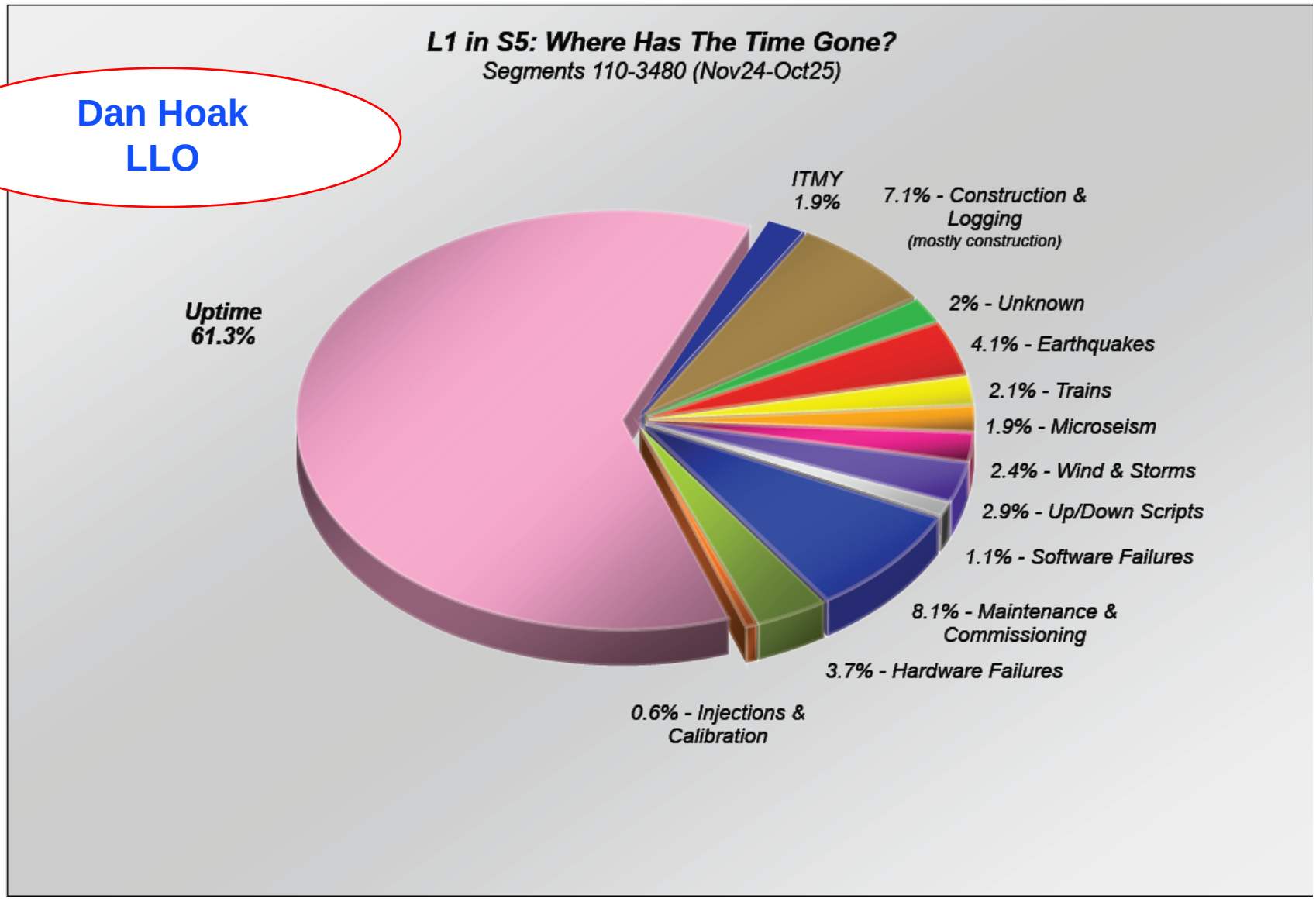
S5 H1 downtime



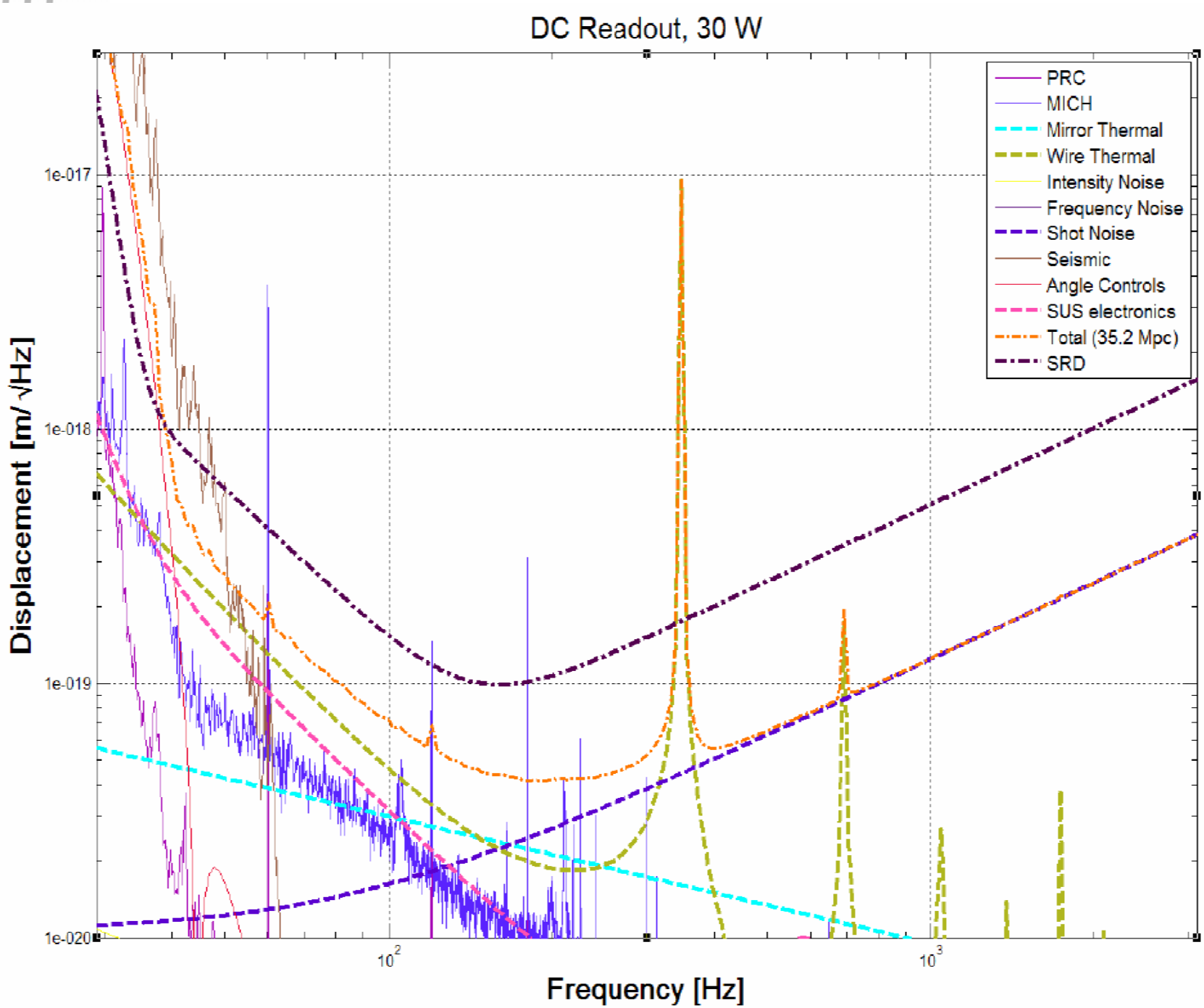
S5 L1 downtime

Dan Hoak
LLO



When will S5 end?

QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.


DC Readout, 30 W
PRC
MICH
Mirror Thermal
Wire Thermal
Intensity Noise
Frequency Noise
Shot Noise
Seismic
Angle Controls
SUS electronics
Total (35.2 Mpc)
SRD
1e-017
1e-018
1e-019
1e-020
Displacement [m/√Hz]
10^2
10^3
Frequency [Hz]

Advanced LIGO- ready for construction start in FY08

- A MREFC project to increase the sensitivity of LIGO by a factor of 10 and thereby increase the number of sources in range by ~1000
  - Build on initial LIGO infrastructure and experience
  - Higher power laser, improved seismic suspension and isolation, signal recycling & improved readout (like enhancements), larger mirrors (to handle increased thermal load), etc.

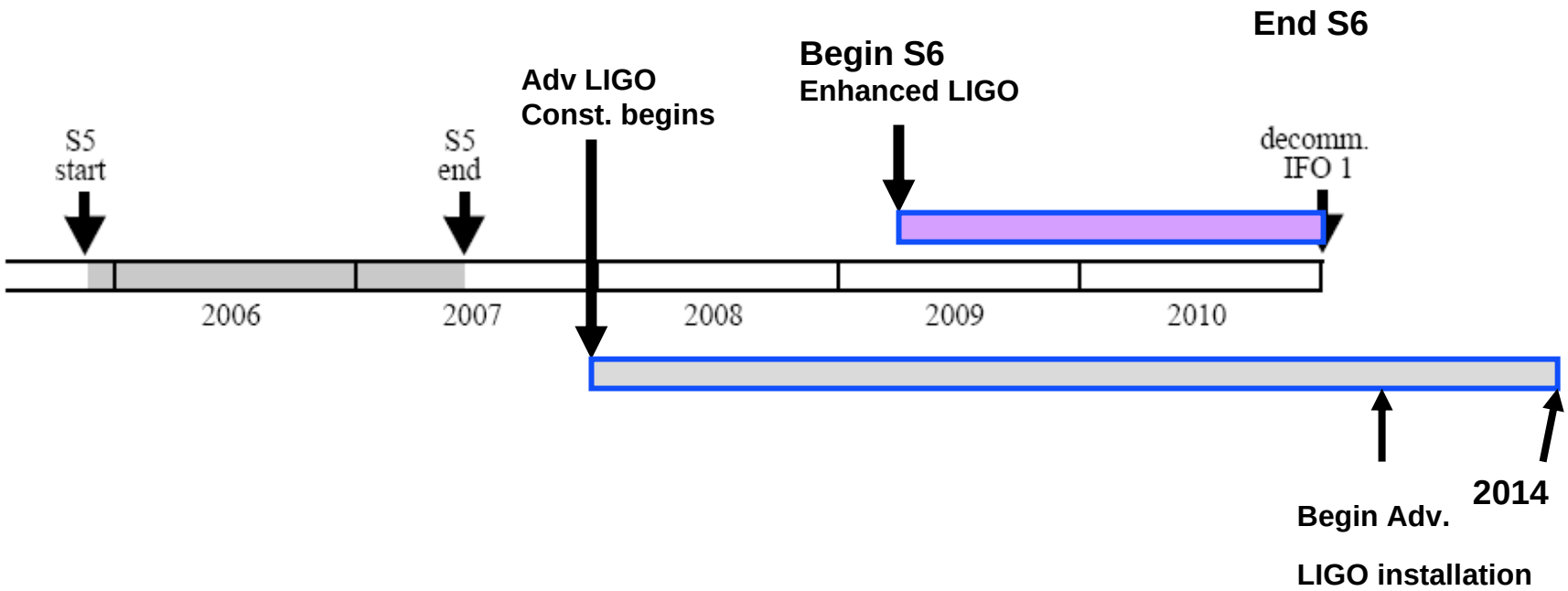
- Successful NSF Baseline Review of Advanced LIGO-
  - May 31-June 2, 2006; ~20 outside experts; chair- Don Hartill
  - “The Panel looked carefully at the Advanced LIGO project and was impressed.”
  - “The Panel recommends that the Advanced LIGO project go forward and agrees that the project can be constructed for (the estimated cost) a total cost of 172.2 M$ (FY 2006 $) on the proposed schedule and is ready for a construction start in FY 08.”

- We expect Advanced LIGO to receive construction start and initial funding in the President’s FY08 Budget Request

Advanced LIGO MREFC

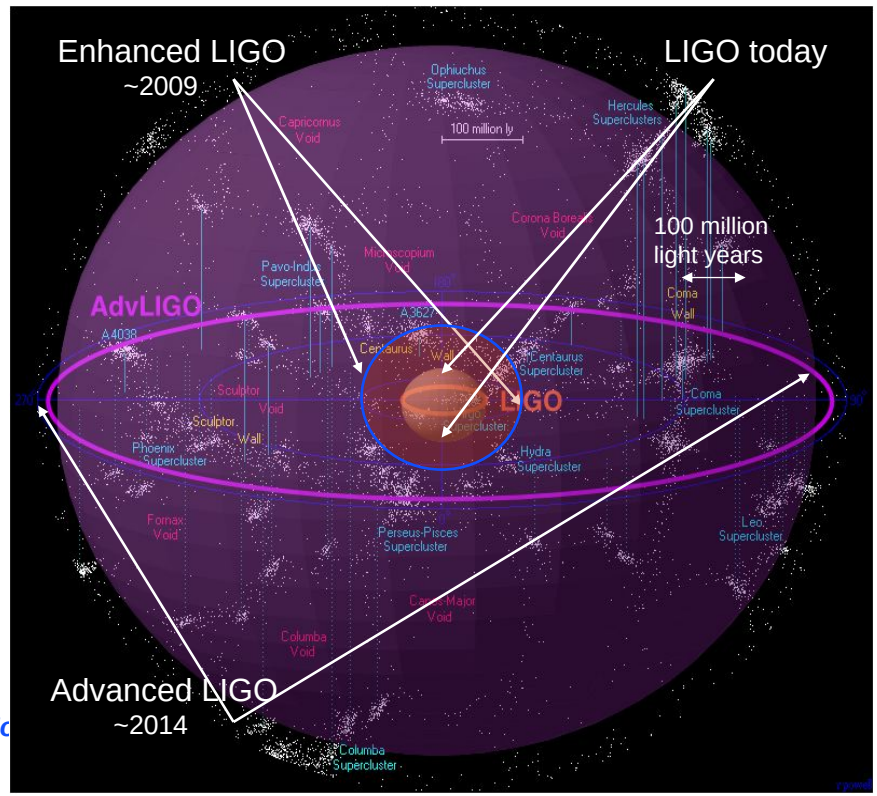
- Schedule-
  - October 2007--August 2014 including 11 months schedule contingency
- Total NSF cost (then-year $)--
  - $205M including ~4.2% inflation and 27% contingency
  - $24M equivalent contributions by UK and Germany: each worth equivalent of ~$6M for development and $6M for fabrication of hardware
    - This hardware is now being tested; delivery ahead of US schedule
- In FY07---
  - Completing needed development and design in preparation for letting contacts in 2008
  - Staffing up from within and outside LIGO Lab and LSC
  - Strengthening our management processes, etc. for the project
- Advanced LIGO Development Program-
  - Subject of 2-day meeting following this PAC (first meeting of the Advanced LIGO Program Advisory Panel)

Simplified timeline for LIGO



The scientific vision for LIGO

- 1st full science run of LIGO at design sensitivity in progress
  - Began November 2005; >55% complete
  - Hundreds of galaxies now in range
  - Discovery possible but not probable during coming year
- Enhancement program
  - In 2009 ~8 times more galaxies in range; discovery probability moderate
- Advanced LIGO project (~$200M)
  - Construction start expected in FY08
  - 1000 times more galaxies in range
  - Expect ~1 signal/day- 1/week in ~2014
  - Will usher in era of gravitational wave astrophysics



Public Education and Outreach- LIGO Livingston

- Science Education Center at Livingston LIGO site
  - Funded through an NSF grant
  - 8000 ft^2 facility just completed;
  - The Center features **fifty** hands-on exhibits that enable students and the public to understand important scientific principles and serve as an important regional resource for teacher training and development.
  - LIGO's partners are Southern University (teacher training program), the San Francisco Exploratorium (developed hands-on exhibits), LA GEAR UP (state educational reform agency under the Louisiana Board of Regents).
  - Inaugurated 13 November 2006
    - Featured a Science Education Symposium and opening ceremonies
    - Guests included representatives of NSF, Caltech, MIT, partners, local educators, political people, media

LIGO Science Education Center
LIGO Livingston Observatory

LIGO Public Education and Outreach (cont.)

- At Hanford Observatory very active education and outreach program
  - Dale Ingram leads Education/Outreach at LIGO Hanford
  - In 2005 --- 3000 visitors to site including 700 students
- Einstein's Messengers - the LIGO DVD
  - Developed by NSF as a classroom tool
  - Supplementary educational materials for classroom being developed for coming school year
  - Winner of a CINE Golden Eagle award
    - awards for excellence in documentary and other informational film and video production; founded 1957.
- Very positive articles about LIGO in major US press
  - Lead article on LIGO in NY Times "Science Times"- May 3.
  - An article appeared in LA Times in early June
  - Article for Discovery magazine (focus on K. Thorne, GWs and LIGO) in early 2007

Education within LIGO

- LIGO's mission includes the education and training of the next generation of GW scientists and contributing to the nation's scientific and technical workforce
- The collaboration seeks to find ways to enhance the quality of the educational experience of its students and postdocs
- Chartered the LIGO Academic Advisory Council to advise the LIGO Executive Director and Directorate on issues related to education of students and postdocs who are participating in LIGO
- Some LIGO Laboratory demographics…
  - 10 Postdocs
  - 10 Graduate students
  - ~ 20/year summer students (SURF and REU)
- More details -- talk by Nergis Mavalvala later today

LIGO planning and tentative budget for operations during FY 2009–2015

- New 5-Year Cooperative Agreement for FY2009-2013 needed between NSF and Caltech
- Plan is to model new agreement after existing Cooperative Agreement
  - LIGO to begin serious work on proposal in early 2007
  - Proposal will be ready to be submitted in August 2007
  - NSF Peer Review in Fall/Winter 2007 (i.e. at Annual Review)
  - Proposal will include proposed funding for FY2009-FY2013
  - Have Cooperative Agreement in place and ready to go by beginning of FY09
- This plan has been discussed between LIGO management and relevant NSF people -- they understand the plan and concur with the model
- Preliminary budget estimates were developed by LIGO and first presented at Advanced LIGO Baseline Review and, after some tweaking, presented again in detail to NSF in July 2006
  - Received strong endorsement that LIGO is planning responsibly and the estimate is consistent with what could fit into anticipated NSF budget

Basis for planning FY2009-2013 funding request (factors in experience base over past 5 years)

- Current LIGO Operations will continue
  - Observatory operations (personnel, travel, infrastructure)
  - Data management and analysis
  - Incremental detector improvements
  - Management and administration
  - Education and outreach
- Advanced LIGO construction begins in FY2008 is funded by MREFC
- R&D will remain an important part of Lab's mission
  - Important experience from initial LIGO:
    - R&D must go on in parallel with Advanced LIGO construction and commissioning to develop techniques for risk reduction, solving problems and future improvements
  - Some R&D aimed to longer term future for good of field and to keep quality instrument scientist engaged
- Additional computing needs in Advanced LIGO era

Conclusions

- Since our last meeting there have been significant changes in the management of LIGO Laboratory
  - A matrix system has been put in place in recognition of the needs of Advanced LIGO
  - Changes in the key personnel who lead the laboratory and in the leaders of a number of laboratory groups
- The new management of LIGO is well established and ready for the challenges ahead
  - Transitions have gone smoothly with no apparent negative impact on LIGO science, operations, R&D, etc.
- Preparing for proposal for next Cooperative Agreement
  - Preliminary funding estimate and vetted with NSF
  - *Will likely be focus of our next PAC Meeting*

Conclusions (cont.)

- LIGO has a clear scientific vision for the next decade and beyond
  - S5 is going very well; > 55% done with excellent sensitivity and improving duty cycle. Discovery possible, not probable; astrophysics results being produced
  - Enhancements to initial LIGO will provide a strong science program into Advance LIGO era; expect S6 start in mid-2009. Moderate possibility for discovery.
  - Advanced LIGO is poised for construction start in FY2008 and will be on-line in 2013/14. Will usher in the era of experimental gravitational wave astrophysics
- Public education & outreach and education within LIGO is very active and of very high quality