Update from LIGO Laboratory

LIGO-Virgo Collaboration Meeting

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Cascina, Italy

May 22-25, 2007

LIGO Laboratory Update
Outline

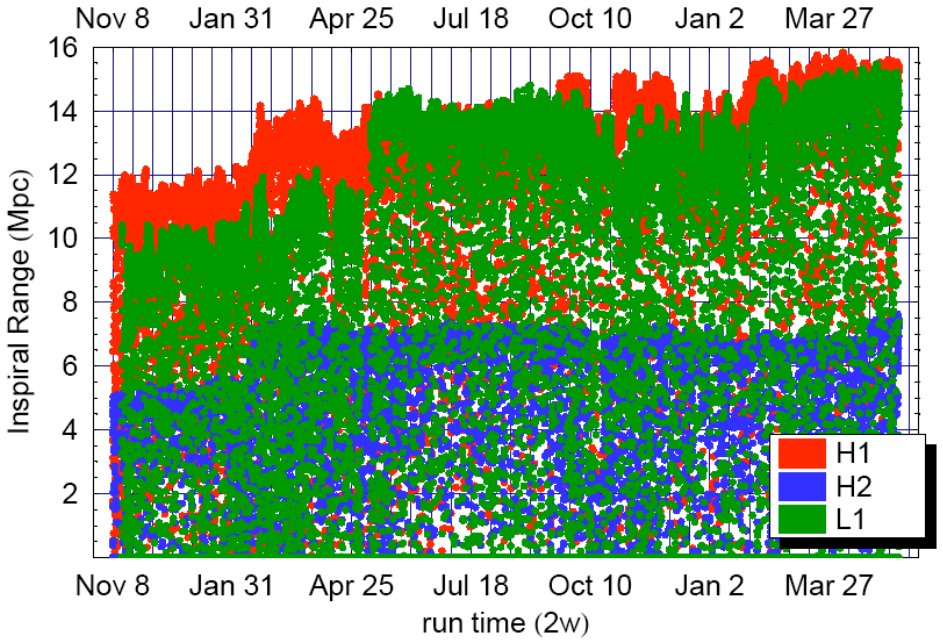
- Progress with the science run
- Enhanced LIGO
- Advanced LIGO
- Outreach

S5 Run Status

- In November 2005 began S5 …
  - Effective range for 1.4 M_o + 1.4 M_o neutron pair coalescence
    - for 4 km IFOs: ~10 Mpc
    - for 2 km IFO: ~ 5 Mpc
- Today ...
  - Ranges are now > 50% greater than at start of run …
    - H1 - up to 16 Mpc peak
    - L1 - up to 15 Mpc peak
    - H2 - almost 8 Mpc peak
  - Duty factors (weekly averaged) exceed 80%

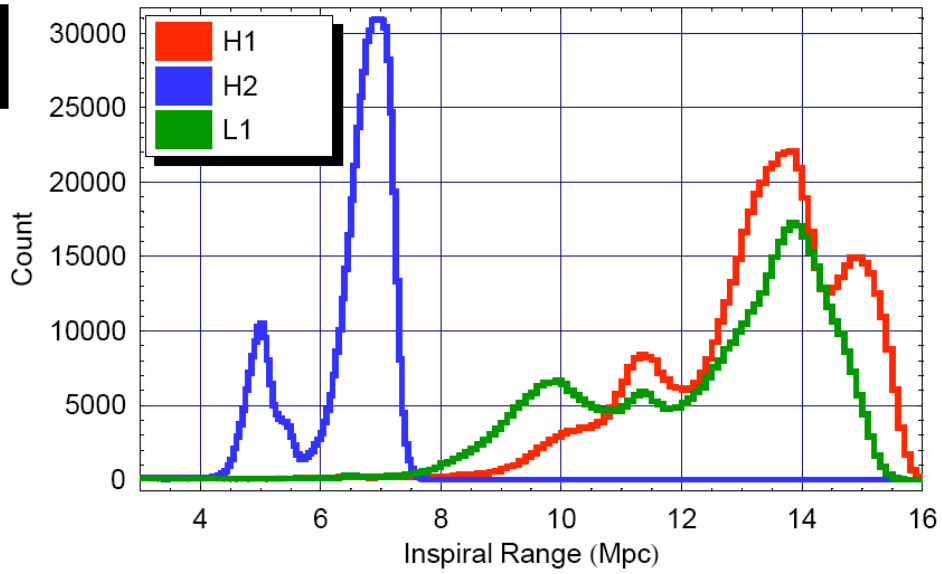
- Virgo is now observing jointly!
  - SR1 -- Effective 18 May

S5: Progress to date
Range trend over run



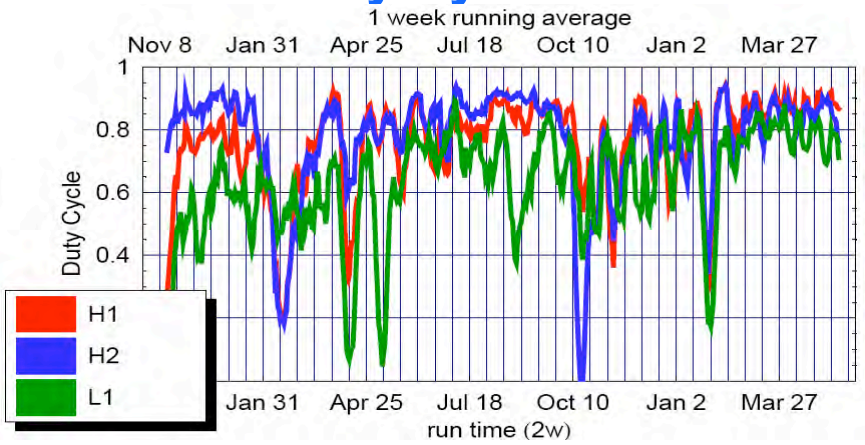
Minute trends in range

Histogrammed minute trends in range

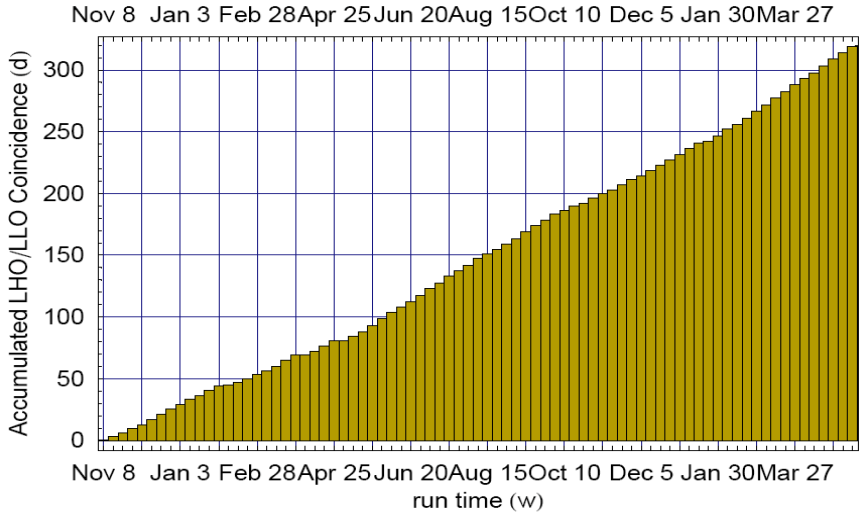


S5: Progress to date
Through 15 May 2007

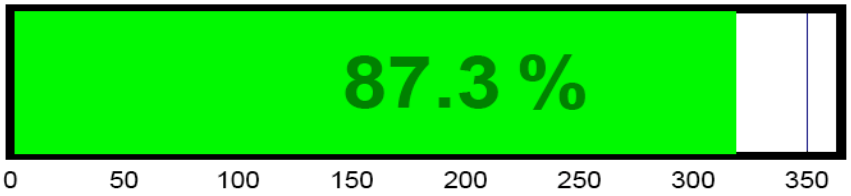
Duty Cycle



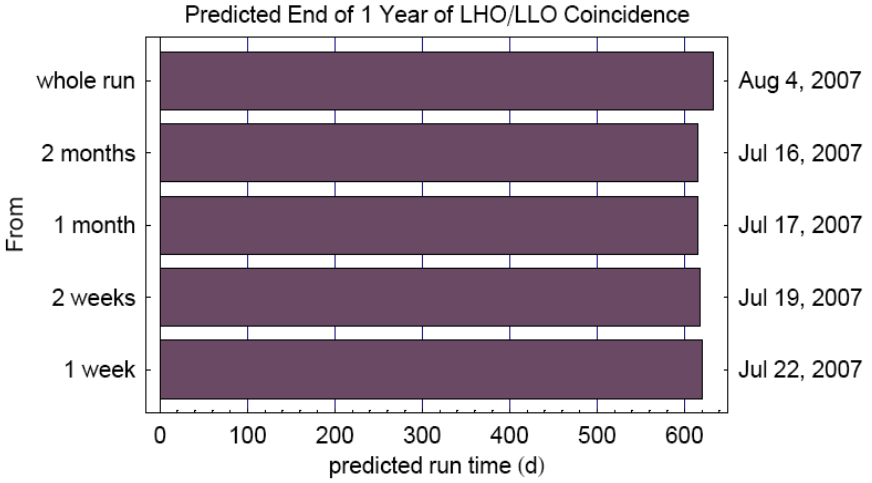
Cumulative Up-time



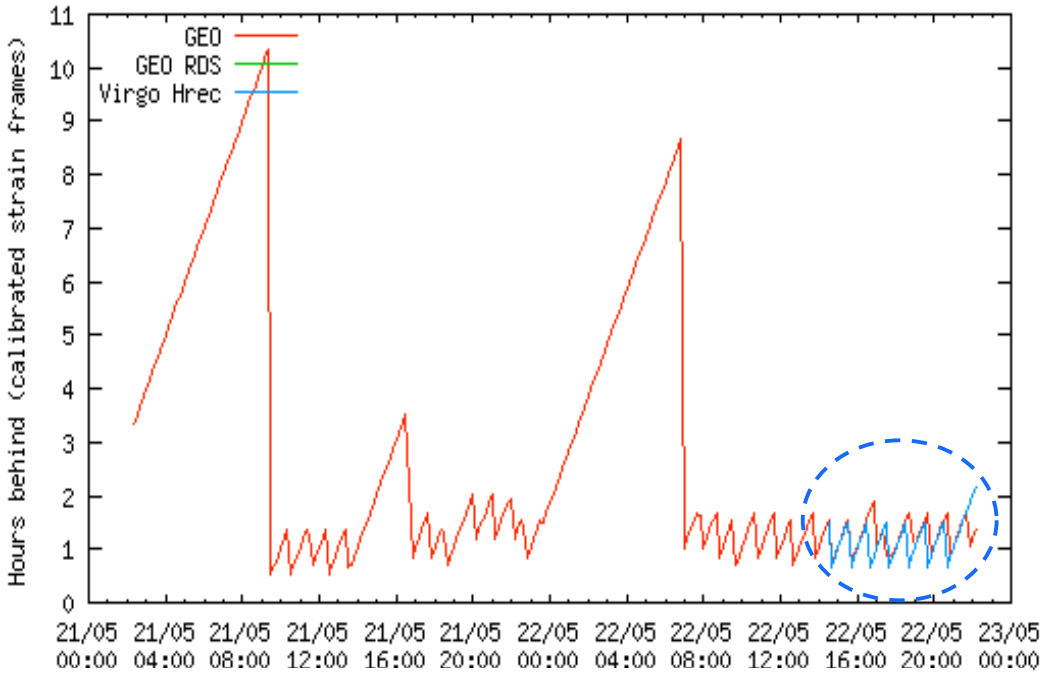
1 Year Coincident Observation



Projected End of S5

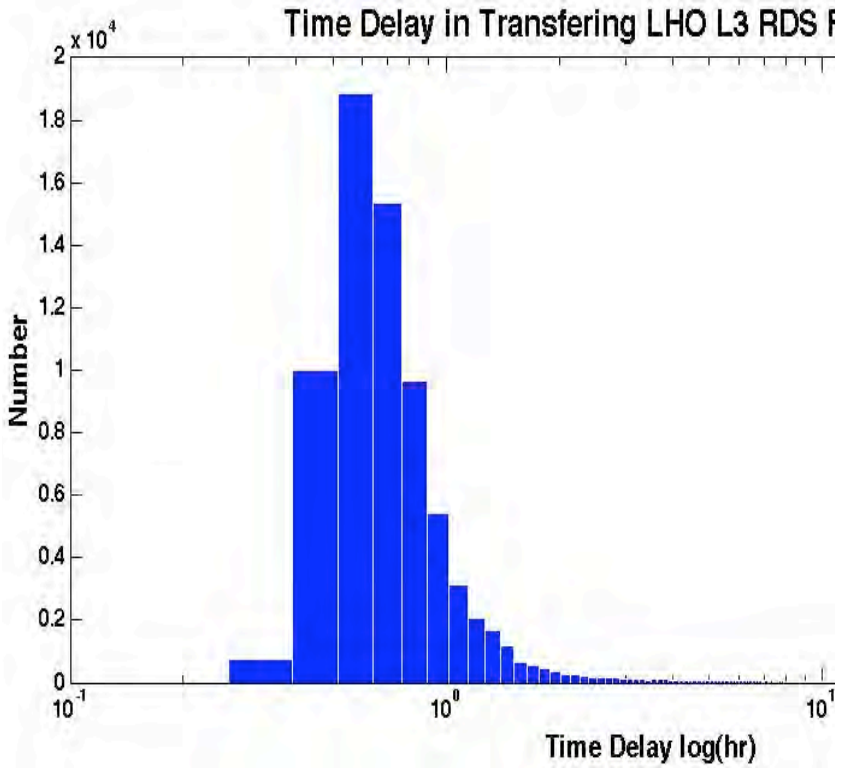


S5: Progress to date
Data and Computing



- As of 21 May -- LIGO-Virgo data *exchange started for h(t).*
  - File replication to all LIGO Data Grid sites
  - Segment Database - for quick data quality lookups and data quality modifications using V1:Hrec_veto_dataQuality

History of LIGO data transmission from sites ->CIT

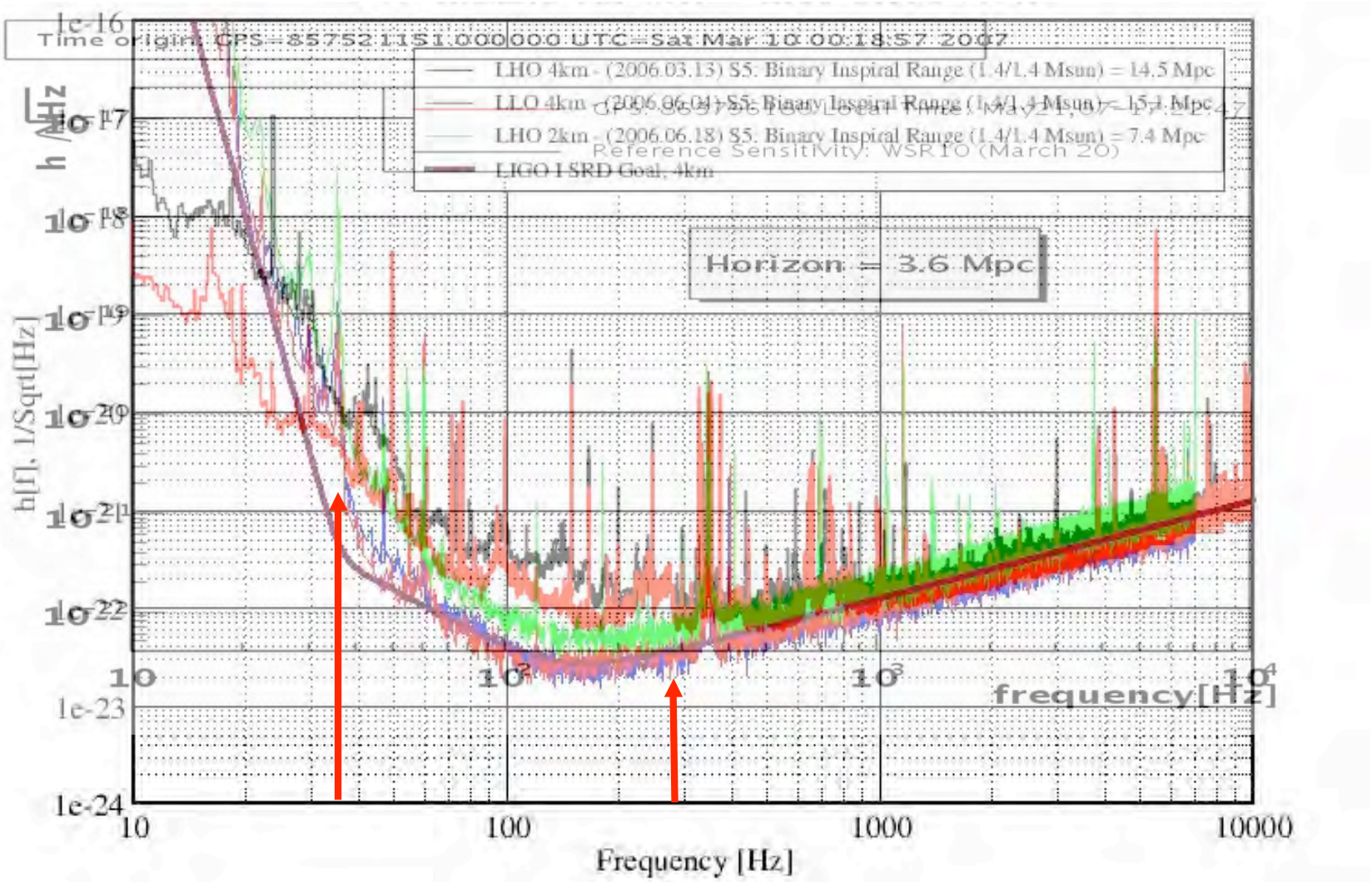


S5 beyond today

Beginning of a new era for the GW community

- 18 May marked the beginning of joint observation with Virgo.
- Culmination of *more than a decade* of communication, planning …
  - First face-to-face with Virgo-LIGO took place at CIT 1996!
  - First discussion of vision for a common data format that would eventually enable common analysis.
- Level of cooperation and coordination is extremely high
  - Judged by frequency & duration of teleconferences …
  - Technical challenges ahead …
    - Addressed by joint committees to coordinate many key activities
      - Run planning,upgrade coordination
      - Data analysis
      - Resource management & sharing

LIGO S5 Sensitivity -- 2006 June



S5 -- Running with Virgo
Joint Run Planning Committee (JRPC)

See talk later in this session

- First meeting of JRPC at LSC-Virgo meeting in Baton Rouge, March 2007.
- Charged with specific short-term items:
  - Coordination for S5 joint running
  - Scenarios for post-S5 to S6 era
- Bi-weekly JRPC teleconferences
  - Most run coordination issues settled
  - Progress has been made on scenarios

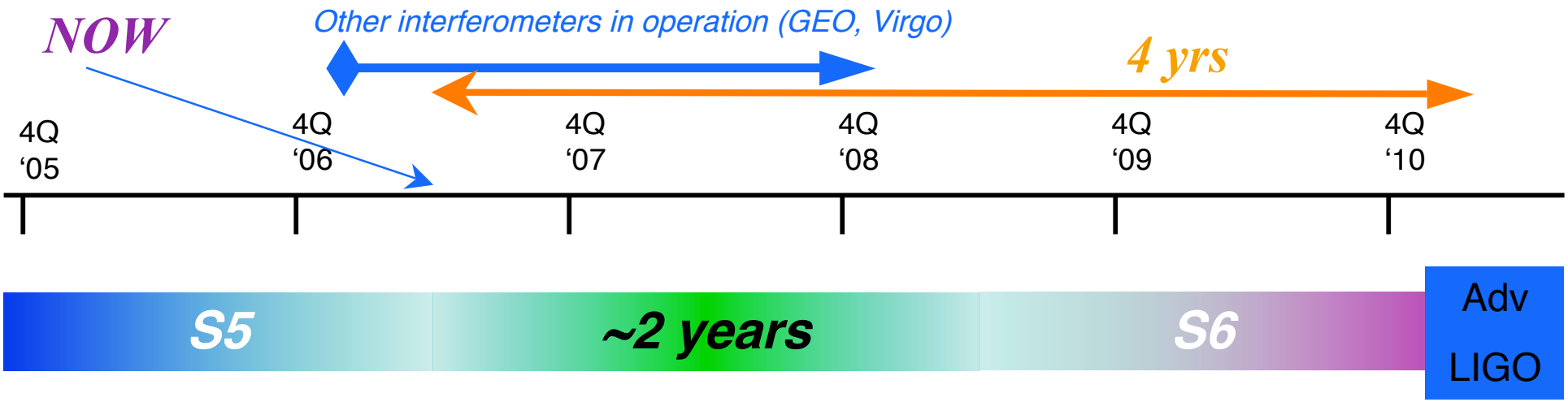
Beyond S5

Enhanced LIGO and S6

See talk later in this session

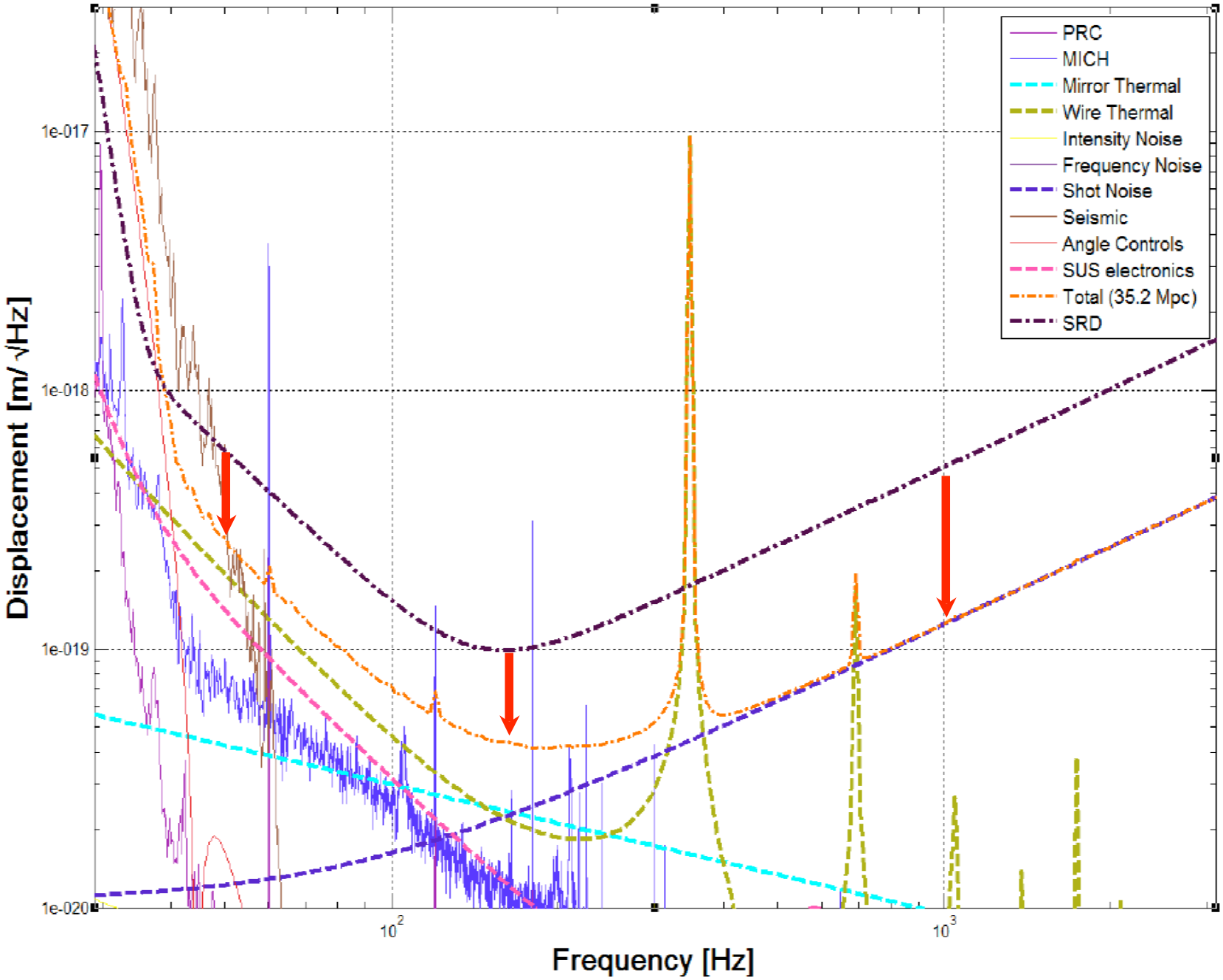
- In 2005/2006 LIGO developed a concept to upgrade of the 4 km interferometers
- Laboratory commitment to upgrade made after August 2006 internal planning review
  - *SYNERGY WITH ADVANCED LIGO: UPGRADE WILL RETIRE RISK FOR A NUMBER OF SUBSYSTEMS*
    - *PSL, input optics, readout, seismic isolation, output mode cleaner, …*
- e-LIGO team in place & working on the upgrade
  - Designs, prototyping, demonstration of proof-of-principle
  - Major hardware procurements
    - Seismic isolation for detection system
    - Lasers
      - Thermal compensation upgrade
      - Main laser (PSL) upgrade to 35W using Advanced LIGO front-end
        - Contributed by GEO
- 8-month status review successfully completed 16 May

e-LIGO - The next three years



- Between now and AdvLIGO, there is some time to learn and improve and detect gravitational waves…
  - ~Few years of hardware improvements + ~1 ½ year of observations.
  - Factor ~2X in noise, factor ~5X-10X in event rate.
  - Better to spend debugging time before AdvLIGO to understand new systems planned for AdvLIGO…
  - *AdvLIGO is a HUGE step in terms of interferometry!*

eLIGO - sensitivity goal

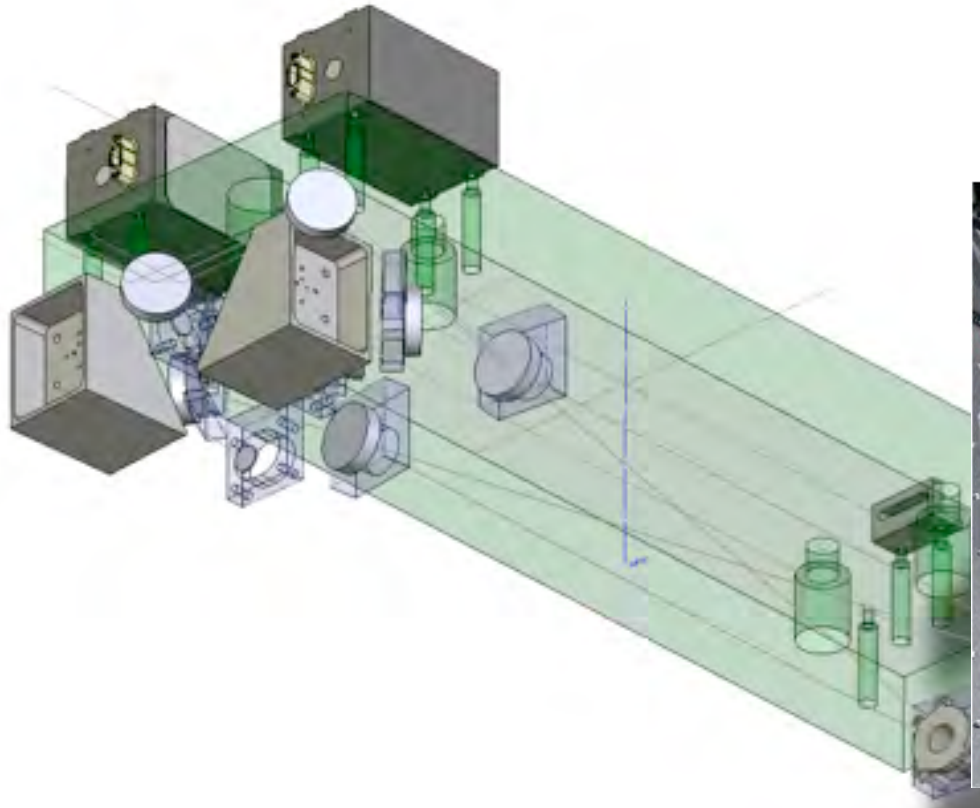


eLIGO Hardware Design & Fabircation

Adv.LIGO stiff active seismic isolation system

High-power Faraday Isolator

ISC: OMC Assembly

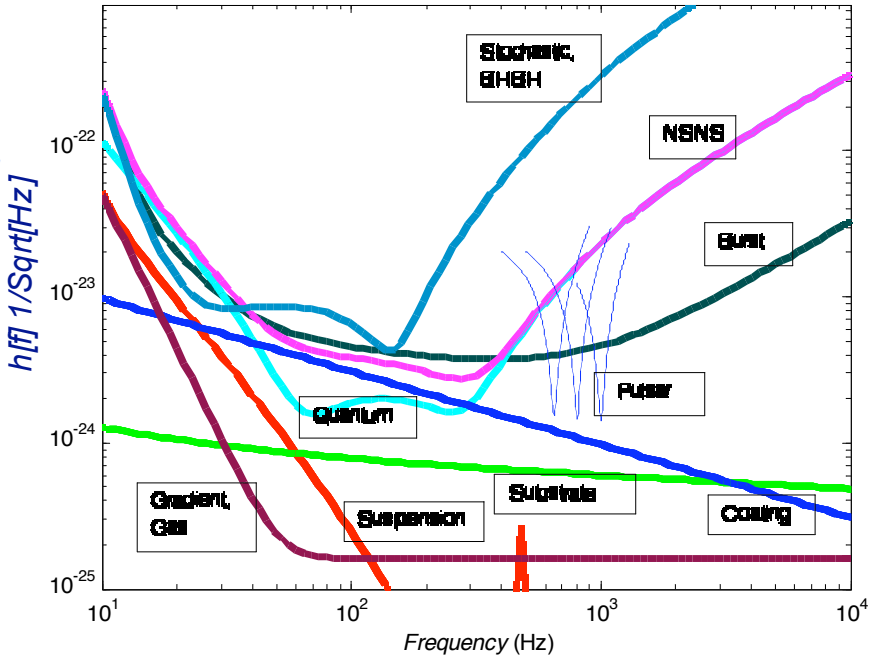


LZH Adv.LIGO laser 35W front end

Advanced LIGO

Advanced LIGO

- Reminder ...
  - Second generation of detectors in LIGO
  - Factor ~10X in amplitude sensitivity
  - Factor ~4X lower frequency 'wall'
- Quantum Limited at most frequencies
  - Recombined Fabry-Perot Michelson
  - ~20X higher input power
  - Signal recycling → tunable
- Gravitational gradient, thermal noise limits
  - 40 kg fused silica masses
  - Fused silica suspension
  - Aggressive seismic isolation

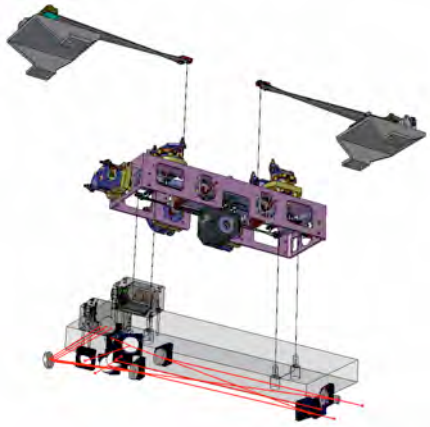


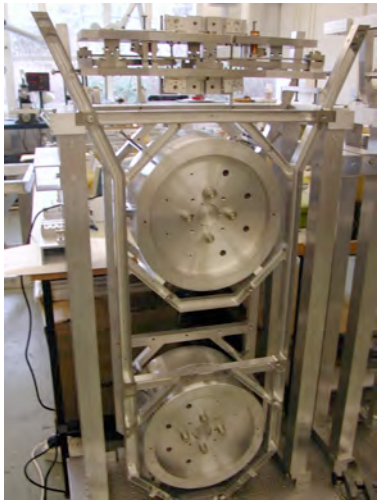
Advanced LIGO Status, Trajectory

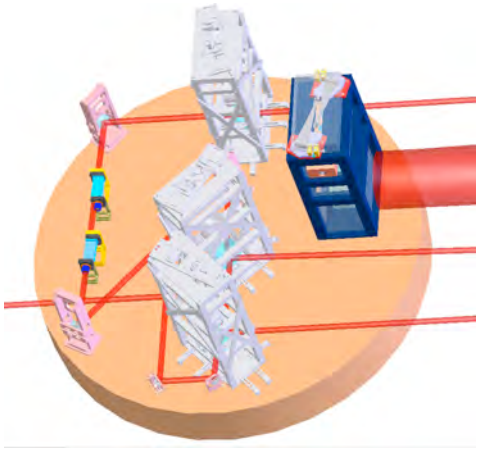
- Team includes many LSC members plus, important capital contributions from UK and Germany
- On track to *start* Adv. LIGO Construction Project in FY08 (1 Oct 2007)
- Final Baseline Review at NSF prior to authorization 5, 6 June 2007
  - Preparatory internal reviews (re)confirmed cost, schedule planning are stable
- The only NSF Major Facility *start* in FY08 in the Office of Management and Budget request
  - Cost and schedule provided by LIGO, accepted by NSF & codified by OMB
- Breach vacuum in 2010 (end of e-LIGO)
- Start commissioning Advanced LIGO in 2013

Progress
Technical advances

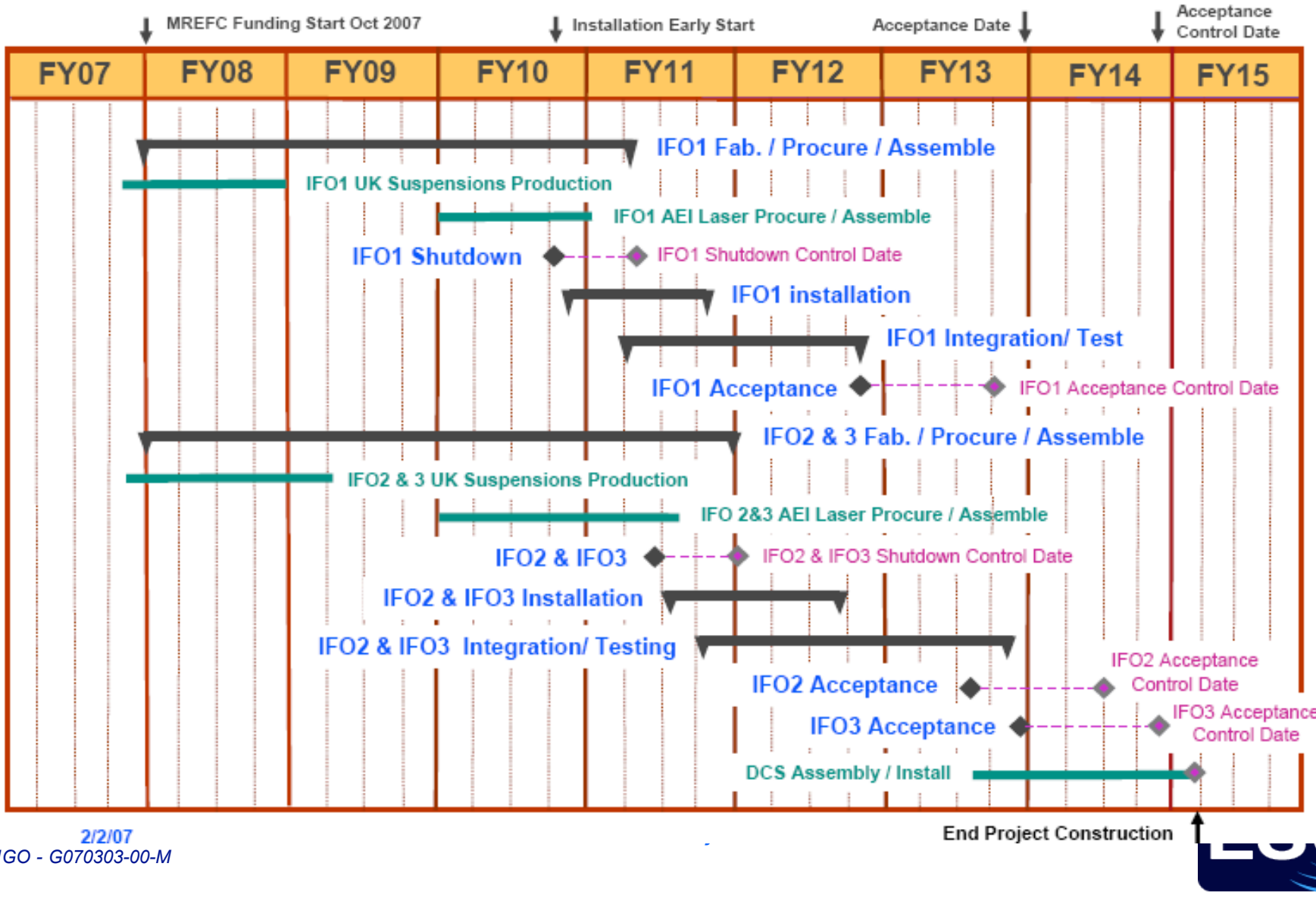
- Full scale prototyping of mechanical systems
- Tests of ‘DC readout’
- Laser production
- Understanding of coating scatter
- Systems design







Schedule


MREFC Funding Start Oct 2007
Installation Early Start
Acceptance Date
Acceptance Control Date
FY07
FY08
FY09
FY10
FY11
FY12
FY13
FY14
FY15
IFO1 Fab. / Procure / Assemble
IFO1 UK Suspensions Production
IFO1 AEI Laser Procure / Assemble
IFO1 Shutdown
IFO1 Shutdown Control Date
IFO1 installation
IFO1 Integration/ Test
IFO1 Acceptance
IFO1 Acceptance Control Date
IFO2 & 3 Fab. / Procure / Assemble
IFO2 & 3 UK Suspensions Production
IFO 2&3 AEI Laser Procure / Assemble
IFO2 & IFO3
IFO2 & IFO3 Shutdown Control Date
IFO2 & IFO3 Installation
IFO2 & IFO3 Integration/ Testing
IFO2 Acceptance
IFO2 Acceptance Control Date
IFO3 Acceptance
IFO3 Acceptance Control Date
DCS Assembly / Install
End Project Construction

Education & Outreach

LHO:

- >2800 total visitors; >1100 students (34% under-represented minorities)
- Summer immersion program for teachers for inquiry-based classroom instruction skills
- e-mentors to 6th local students
- >75% LHO staff participation
- Statewide WA Leradership Assistance Award for Science Education Reform
- Developing an ***E-Lab*** interactive tool for students to build research projects with LIGO PEM data

LLO – Since LIGO Science Education Center opened November 13th, 2006:

- > 2400 student visitors (1 out of state group, 1 group >90 persons)
- > 225 teachers received Prof. Devel. Training at LIGO SEC
- 19 Special Events (star party, SPS Zone 10 mtng, family science night at schools, etc)
- Partners & participants: Southern University, Exploratorium, LA GEAR UP, Tulane University, Southeastern Louisiana University, LA Tech

Outreach

To scientific community

- GWIC Thesis Prize -- replaces LIGO Thesis Prize
  - 8 nominated theses (4 countries, 4 different projects, 5 experimental, 3 theoretical/data analysis)
  - Selection committee of 8 representing different GW projects and expertise
  - Winner announced 22 May 2007
    - Yoichi Aso (University of Tokyo)
    - "Active Vibration Isolation for a Laser Interferometric Gravitational Wave Detector using a Suspension Point Interferometer"
    - Prize to be awarded at Amaldi meeting in Sydney
- American Astronomical Society (AAS) session on GWs
  - **Encouraged to Proposed** a Special Session for the January 2008 meeting in Austin TX
  - 5 talks, 90 minutes,
  - Emphasis: Astronomy results and the evolution of a global network
  - Should hear this summer if proposal is accepted.

Summary

- LIGO is operating in a science mode at design sensitivity
  - 1st long science run is ~87.3% complete
  - Virgo has started SR1 and joined S5 and data are flowing!
- Near term vision: Enhanced LIGO upgrade 2008 - 2010
  - Improve by factor ~ 2X (*w.r.t. S5*) in h[f] in 2009
  - S6 run - last of initial LIGO era
- Longer term -- poised for beginning of Advanced LIGO construction
  - Improve by factor 10X (*w.r.t. S5*) in h[f] ~2014
- LIGO is having a positive, significant impact in both the local (WA, LA) public communities