LIGO II: LIGO Laboratory View and Role

Gary Sanders

LSC Meeting

July 20, 1999

Stanford University

I asked at Gainesville LSC meeting...

LIGO II Scope ?

- When are we ready to document a strawman LIGO II configuration, with well-defined options?
- LIGO Laboratory is ready to support the LSC in laying out a schedule and cost baseline
- NSF is already engaged in long term planning for construction of upgrades
- This meeting might consider this as we work towards revisions in White Paper

LIGO's Ages

- Albrecht's View from the Amaldi Conference
  - » infancy - early ideas
  - » youth - R&D and proposals
  - » adolescence - LIGO I construction
  - » maturity - make it work, confront data stream
- Sanders asks:
  - » LIGO II construction - A second adolescence?
- Where are we now as we develop concept?
  - » Second childhood? The ferver of youth?
  - » Can we do this?
  - » Have we lost our senses?

LIGO Funding By Year and Program

MRE

Fiscal Year	Construction	R&D	Operations	Advanced R&D	Total
Through 1994	35.9	11.2			47.1
1995	85	4			89
1996	70	2.4			72.4
1997	55	1.6	0.3	0.8	57.7
1998	26	0.9	7.3	1.6	35.8
1999	0.2		20.9	2.5	22.5
2000			21.1	2.6	23.7
2001			19.1 (10 months)	2.7	22.9
Total	272.1	20	68.7	10.2	371.1

LIGO Laboratory Engineering and Infrastructure

- LIGO Laboratory Advanced R&D is supported by Operations funded engineers, administrative support, and infrastructure
  - » campus interferometers (40 Meter, LASTI)
  - » engineering mostly supplied from Lab staff engineers
- LIGO II construction may support additional contract engineering

LIGO Laboratory Planning Assumptions

- LIGO II Advanced R&D is an LSC-wide activity with LIGO Lab participating
  - » LSC takes a leading role in identifying future program and detector capabilities (LIGO II design “strawman” is an example)
- LIGO II construction proposal to be submitted in time for 2002 start
  - » “Construction” funding through Major Research Equipment (MRE) line item account of NSF appropriation
- LIGO Lab to manage LIGO II construction just as we have managed LIGO I construction
  - » but participation in construction proposal/activities is open to LSC institutions

LIGO Laboratory Planning Assumptions (cont'd…)

- LIGO Lab will work together with the LSC to produce properly planned and costed LIGO II construction proposals
  - » Sept. 1999 submittals for R&D and "conceptual" LIGO II construction documents will be planned through LIGO Lab process
  - » LIGO Lab will create a LIGO II Work Breakdown Structure and this will guide cost estimate and schedule planning
  - » LIGO Lab will assess feasibility of proposed design and work to define a realistic implementation
    - – **LIGO Lab must be able to take responsibility for what is to be built**

Early Issues In Achieving LIGO II Readiness by 2004

- Long lead-time procurements
  - » Can we initiate procurement of optics blanks before FY2002? Are there alternate funding sources to allow a start?
- Will R&D support be sufficient to develop technology in time? Will we focus it well?
- How will we manage the significant conflict between LIGO I and II staff (LIGO Lab and LSC)
- What is the model for LSC to be engaged?
  - » principally R&D?
  - » more subsystems at other institutions, outside of lab?

OK

BUT LIGO Lab Plan for LIGO I Run

- LIGO I science run is planned for 2002-2004
  - » but
    - – Will LIGO II be ready for installation at end of run?
    - – Is terminating the LIGO I run after this period the correct action?
    - – Will there be great improvements to develop that justify continuing?
      - Technical noise reduction
      - Detector availability improvements
      - Perfection of understanding that comes with running an instrument and which may be a prerequisite to operating an advanced instrument
  - » Plan is correct if everything goes well and LIGO II is ready for a start

BUT Advanced R&D Program Assumption

- LIGO Advanced R&D program is planned to demonstrate initial LIGO II technologies by 2002
  - » R&D carried out by LIGO Lab and LSC
- But advanced R&D proposals envisioned “initial” LIGO II technologies as:
  - » modest improvements to seismic isolation
  - » multiple pendulum suspensions
  - » 40 - 100 W lasers
  - » fused silica optics in the 11 - 18 kg range + thermal compensation
- But LSC strawman of 9 July calls for
  - » 30 kg fused silica or replacement by 30 kg sapphire
  - » 10 Hz isolation systems with major fabrication and replacements and new technology

BUT Staging of LIGO II Upgrade

- LIGO II construction funding profile would extend from 2002 through 2006
  - » 2002 start facilitates long lead-time purchases
    - – optics blanks
    - – major mechanical structure orders
    - – “first-articles”
    - – extra design contractors
  - » but
    - – can we choose silica or crystal material by 2002?
    - – can we demonstrate the chosen seismic system?

BUT Staging of LIGO II Upgrade

- Upgrade assumed until this week to be implemented in two stages in 2004 and in 2006
  - » availability of the technologies suggests staged implementation
    - – crystalline core optics and signal tuned configuration likely available after 2004
- But
  - » staged implementation impacts observation
    - – missed triple coincidence observation time at pre-upgrade sensitivity should be small compared to delayed observation time at improved sensitivity (lessons learned in accelerator lab scheduling)
  - » staged implementation may be dictated by funding profile
  - » we may not be ready in 2004 for major seismic refit

Elements of a Complete LIGO II Effort

- Are vacuum equipment modifications required?
  - » no additional pumps for beam tube appear necessary
  - » output mode cleaner ? Signal recycling does it?
  - » BSC dome height increase ?
    - – Very expensive (money, cleaning, disruption, rigging) for all chambers
    - – Impacts planned use of Lab testbed at MIT
    - – performance advantage seems marginal
  - » Any changes may be very expensive...
- support for infrastructure (DAQ, control, data analysis) in parallel with LIGO I efforts
  - » this will be a challenge

Even Broader Options

- Hanford 2k IFO --> 4k ?
  - » No case made for this
- and/or second 4k IFO at Livingston ?
  - » not for astrophysical interest initially
  - » maybe vital for observing strategy
- Are all three interferometers to be upgraded in same configuration?
  - » High vs. not so high laser power
  - » Different test masses
  - » no case made for this

By Subsystem

- Facility Modifications
  - » vacuum tank changes due to seismic system?
  - » LIGO facilities built for advanced LIGO interferometers
  - » No other major changes known at this time
- Seismic Isolation
  - » 10 Hz goal seems to be consensus
  - » active vs. passive vs. mixed approach
    - – How long before decision must be made?
      - Need more modeling and testing now
      - But need to decide before committing to full scale prototype
      - Tall option blocks further preparation of MIT testbed, stretching schedule

By Subsystem

- Suspensions
  - » promise of great suspension thermal noise reduction
  - » many development issues, many groups working, effort needs to be coordinated and rationalized
- Prestabilized Laser
  - » laser design choice
    - – amplifier vs. injection locked technique
  - » industrialization of chosen laser

By Subsystem

- Input Optics
- Core Optics
  - » crystal vs. silica optics
  - » What is the right sapphire development program?
    - – Industrial involvement
    - – manage Chinese institute development?
    - – Suggest topical workshop to collect advice on how to proceed
  - » “pathfinder” process for polishing and coating
  - » cost

By Subsystem

- Support Optics
- Interferometer Controls
  - » signal recycling strategy
  - » LIGO II requirements may drive detailed revision of controls
- Data Acquisition/Diagnostics
- Support Equipment
- R&D
  - » What is not included in the current Advanced R&D program?
- Data Analysis
  - » appears to be driven by mass range for NS-NS inspiral searches

By Subsystem

- Installation
  - » included in this construction proposal scope
  - » includes removal of existing detector systems
- Project Management

Conclusions

- LIGO Lab and LSC can carry out a coherent program based on a mix of sure and likely technologies
- LIGO II would be a significant step forward in sensitivity
  - » LIGO II could not guarantee observations or disprove GR
  - » Could we implement a quantum noise limited detector?
- LIGO II is clearly the right thing to do given the large investment in LIGO and the new “bang for the buck”
- LIGO Laboratory will take the central responsibility to implement this program of the LIGO Scientific Collaboration

This Meeting

- Need agreement on a reference design
- Some design choices might be appropriate for this meeting
- Some clearly defined options should be carried
  - » Clear milestones for final design choices must be identified
- Detailed matrix of LIGO II R&D responsibilities, program completeness, balance, resource requirements needed from this meeting