Plans for LIGO II

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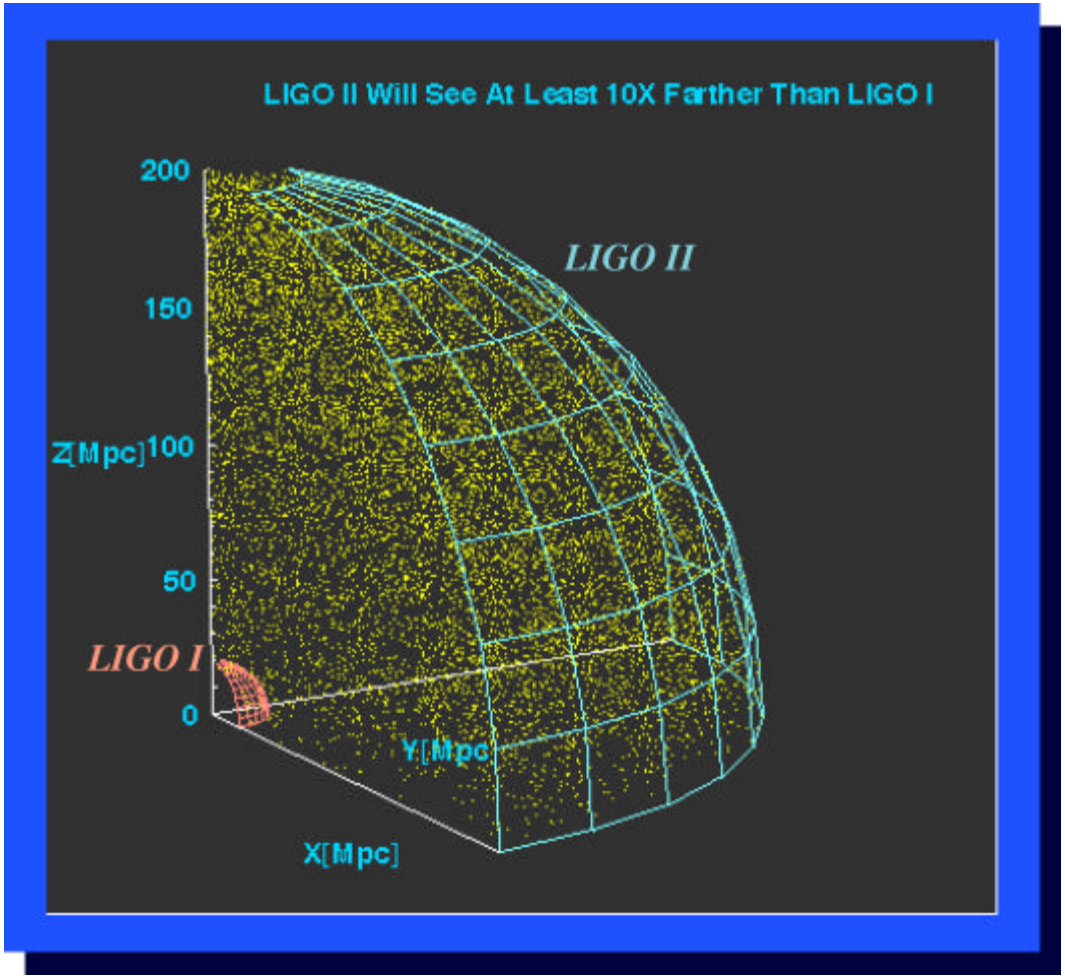
Caltech

LSC Meeting - LLO

March 2000



LIGO II Reach

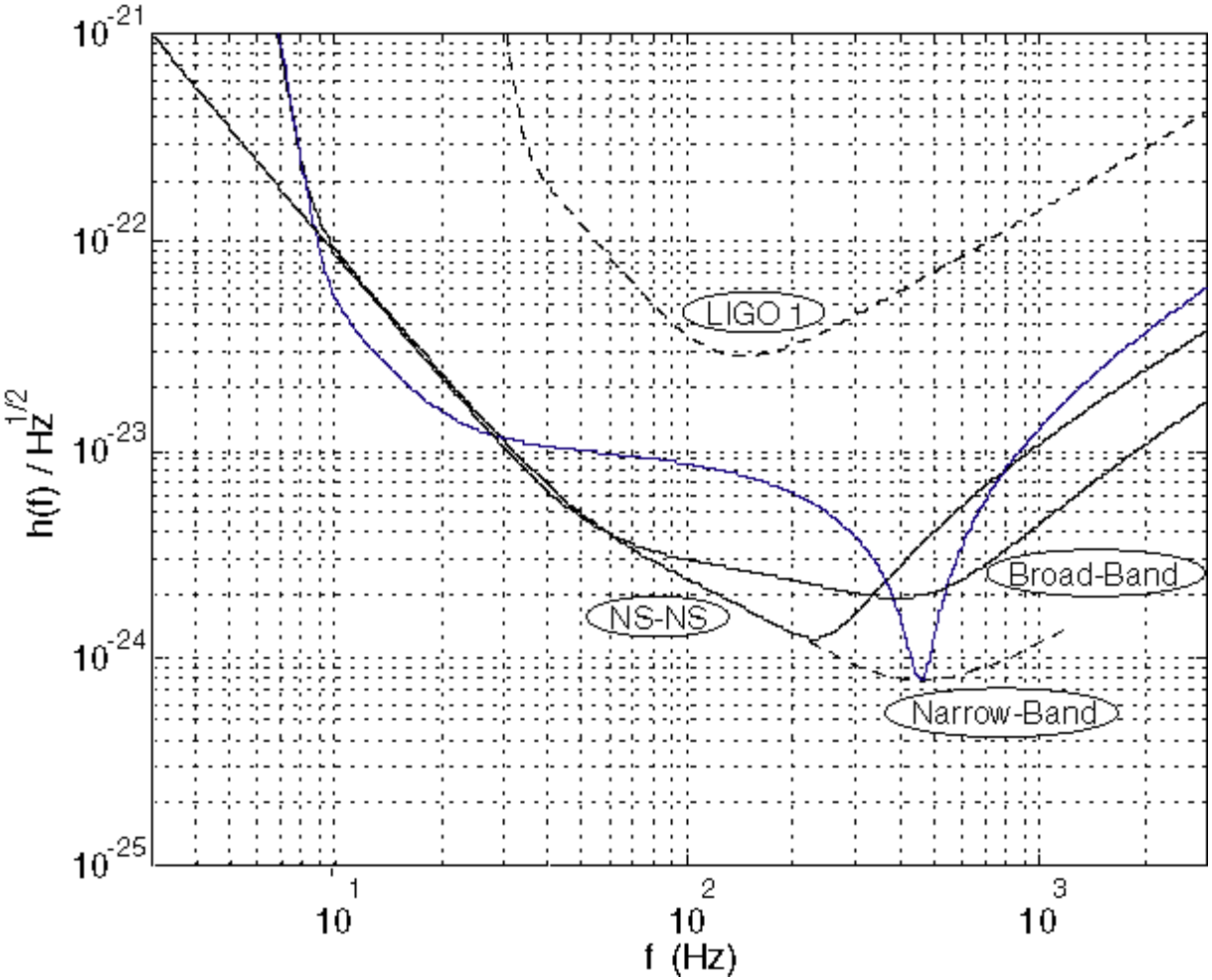
LIGO II Reference Design Parameters / LIGO I Comparison

Subsystem and Parameters	LIGO II Reference Design	LIGO I Implementation
Comparison With LIGO I Top Level Parameters		
Strain Sensitivity [rms, 100 Hz band]	2 x 10^{-23}	*10^{-21}*
Displacement Sensitivity [rms, 100 Hz band]	8 x 10^{-20} m	*4 x 10^{-18} m*
Fabry-Perot Arm Length	4000 m	*4000 m*
Vacuum Level in Beam Tube, (Vacuum Chambers)	< 10^{-6} , (< 10^{-7}) torr	*< 10^{-6} torr*
Laser Wavelength	1064 nm	*1064 nm*
Optical Power at Laser Output	180 W	*10 W*
Optical Power at Interferometer Input	125 W	*5 W*
Power Recycling Factor	80 x	*30 x*
Input Mirror Transmission	3%	*3%*
End Mirror Transmission	15 ppm	*15 ppm*
Arm Cavity Power Loss on Reflection	1%	*3 %*
Light Storage Time in Arms	0.84 ms	*0.84 ms*
Test Masses	Sapphire, 30 kg	*Fused Silica, 11 kg*
Mirror Diameter	28 cm	*25 cm*
Test Mass Pendulum Period	1 sec	*1 sec*
Seismic Isolation System	Active/Passive, 6 stage	*Passive, 4 stage*
Seismic Isolation System Horizontal Attenuation	10^{-8} (10 Hz)	*[3] 10^{-5} (100 Hz)*
Maximum Background Pulse Rate	1 per 10 years, triple interferometer coincidence	*1 per 10 years, triple interferometer coincidence*

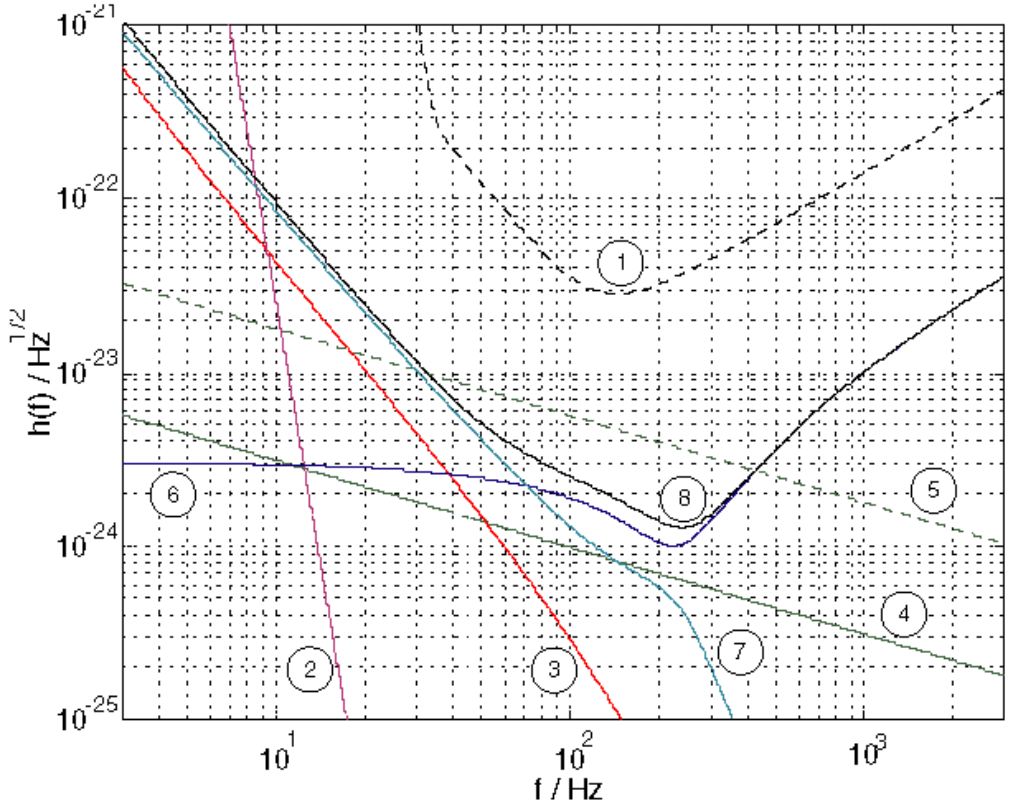
The Real Goals

- Physics - “would be surprising if don’t see many sources” - Thorne yesterday
- Instrumental - quantum limited interferometer across entire sensitive band

LIGO II and LIGO I Sensitivity



Noise Anatomy of LIGO II



1 LIGO I total
2 Filtered seismic noise
3 Suspension thermal noise
4 Internal thermal noise - sapphire
5 Internal thermal noise - fused silica (fallback)
6 Shot noise
7 Radiation pressure noise
8 LIGO II total

The Scenario

YEAR	LIGO I	LIGO II
2000	Installation and commissioning	R&D
2001	Installation and commissioning	R&D
2002	Science run starts	MRE/R&D funds start, R&D, design, long lead items
2003	Science run	R&D, design, fabrication
2004	Science run	Fabrication, on-site assembly
2005	LIGO I interferometers removed	Fabrication, on-site assembly, installation into vacuum system
2006		Installation and commissioning

LIGO Laboratory and LSC Role

- LIGO Laboratory will organize and manage the LIGO II project
- LSC participation in the construction of LIGO II will be governed by Memoranda of Understanding (MOU) and specific, periodic Attachments describing tasks, funding, milestones and personnel, with subcontracts
  - » this model used successfully with Univ. of Florida during LIGO I
  - » this model used with LSC for R&D activities, without subcontracts

  LSC is driving the LIGO II scientific goal and concept
- GEO is proposing a collaborating role and a capital contribution role
- ACIGA role developing (recent)

LSC and Lab Submitted Conceptual Documents

- September White Paper on Advanced Detector R&D
  - » Working Group chairs and spokesperson represented you well
    - – this exercise is a success of the LSC structure and governance
- Conceptual Project Book prepared by Lab staff working with the LSC leadership
  - » Assumed all 3 interferometers replaced in 2005-2006 !
  - » Therefore all of LIGO I is turned off
  - » Assumed maximum possible choices of all options
    - – intended to get cost envelope bracketed
  - » Cost estimate is MRE request $94 million + GEO proposed contribution + contribution from LIGO Lab Operations budget!
    - – Larger cost than expected due to active isolation, number of control loops and data acquisition/analysis complexity

Major Project Options

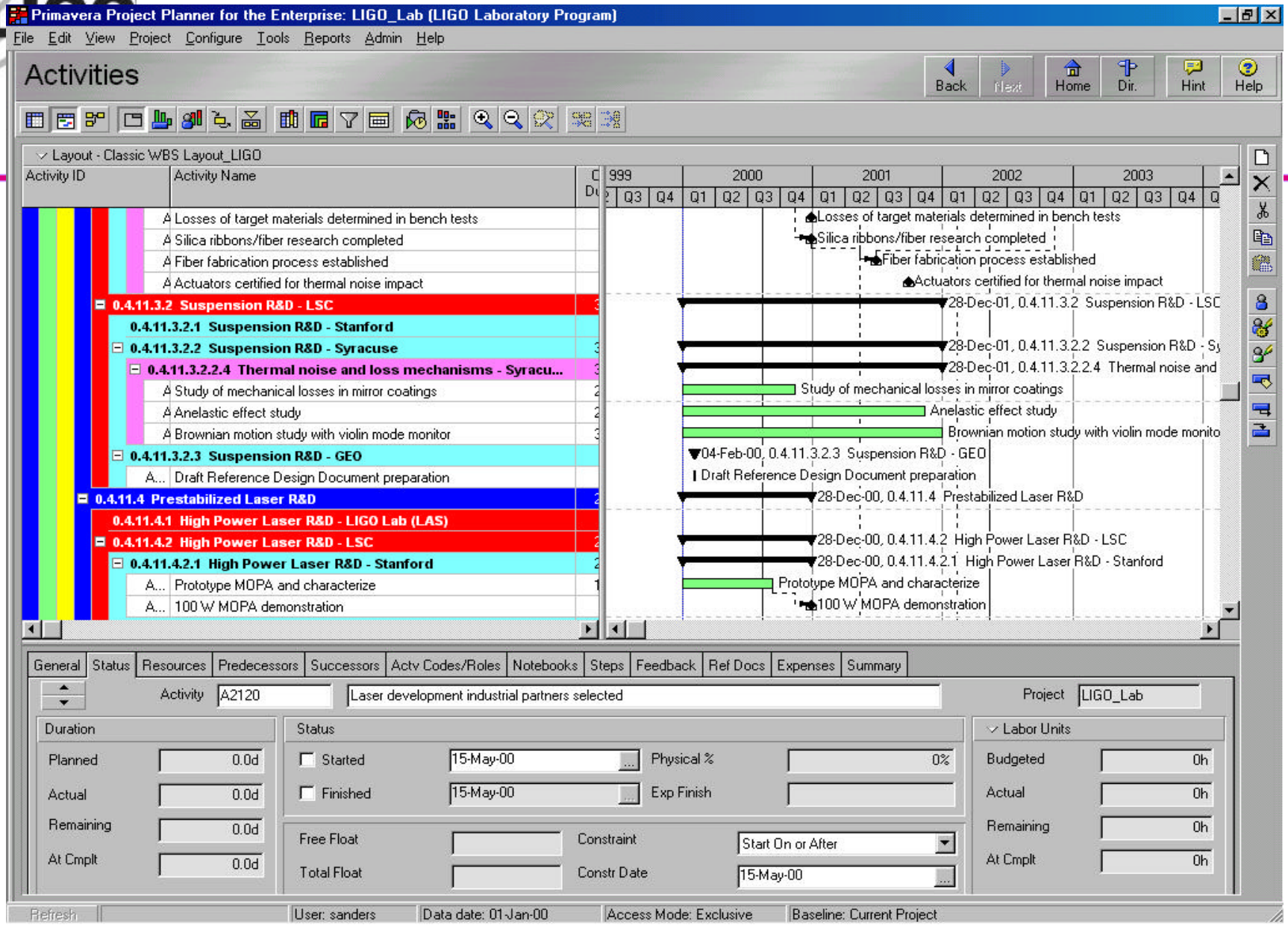
- How many interferometers to upgrade?
  - » Assume all 3 interferometers upgraded
- Convert the Hanford 2 kilometer to a 4 kilometer?
  - » Assume length is increased
- Upgrade done in one phase?
  - » Assume all 3 interferometers upgraded in one parallel installation
  - » **Decision on this may interact with other gravitational wave detectors to insure that observational coverage is considered**
  - » **Phasing of upgrade is a major scientific decision**

My Summary of NSF Review Recommendations

- LIGO Lab should proceed with full construction proposal for LIGO II to be submitted late in 2000
- NSF should establish a framework for evaluating R&D proposals related to LIGO II in order to assure coordination and monitoring
- LIGO Lab should submit an integrated R&D plan for Lab and LSC research in 2000 and 2001
- Construction proposal should identify Preconstruction R&D to begin in 2002
- Meaningful LIGO I data analysis results should be in hand prior to turning LIGO I off

LIGO Lab's Plan

- Integrated R&D Plan for 2000 and 2001 submitted this week
- Full LIGO II Proposal to be submitted near end of 2000, with LSC and GEO participating
- Request R&D $ increment for 2002
- Request construction $ for 2003
- Plan first installation in vacuum system in 2005


Primavera Project Planner for the Enterprise: LIGO_Lab (LIGO Laboratory Program)
File Edit View Project Configure Tools Reports Admin Help
Activities
Back Next Home Dir. Hint Help
Layout - Classic WBS Layout_LIGO
Activity ID
Activity Name
1999 2000 2001 2002 2003
Losses of target materials determined in bench tests
Silica ribbons/fiber research completed
Fiber fabrication process established
Actuators certified for thermal noise impact
0.4.11.3.2 Suspension R&D - LSC
28-Dec-01, 0.4.11.3.2 Suspension R&D - LSC
0.4.11.3.2.1 Suspension R&D - Stanford
0.4.11.3.2.2 Suspension R&D - Syracuse
28-Dec-01, 0.4.11.3.2.2 Suspension R&D - Sy
0.4.11.3.2.2.4 Thermal noise and loss mechanisms - Syracu...
28-Dec-01, 0.4.11.3.2.2.4 Thermal noise and
Study of mechanical losses in mirror coatings
Anelastic effect study
Brownian motion study with violin mode monitor
Brownian motion study with violin mode monito
0.4.11.3.2.3 Suspension R&D - GEO
04-Feb-00, 0.4.11.3.2.3 Suspension R&D - GEO
Draft Reference Design Document preparation
0.4.11.4 Prestabilized Laser R&D
28-Dec-00, 0.4.11.4 Prestabilized Laser R&D
0.4.11.4.1 High Power Laser R&D - LIGO Lab (LAS)
0.4.11.4.2 High Power Laser R&D - LSC
28-Dec-00, 0.4.11.4.2 High Power Laser R&D - LSC
0.4.11.4.2.1 High Power Laser R&D - Stanford
28-Dec-00, 0.4.11.4.2.1 High Power Laser R&D - Stanford
Prototype MOPA and characterize
100 W MOPA demonstration
General Status Resources Predecessors Successors Actv Codes/Roles Notebooks Steps Feedback Ref Docs Expenses Summary
Activity A2120
Laser development industrial partners selected
Project LIGO_Lab
Duration
Planned 0.0d
Actual 0.0d
Remaining 0.0d
At Cmplt 0.0d
Status
Started 15-May-00
Finished 15-May-00
Physical % 0%
Exp Finish
Free Float
Total Float
Constraint Start On or After
Constr Date 15-May-00
Labor Units
Budgeted 0h
Actual 0h
Remaining 0h
At Cmplt 0h
Refresh
User: sanders
Data date: 01-Jan-00
Access Mode: Exclusive
Baseline: Current Project

Management of the R&D

- LIGO Lab is working with LSC Working Group Chairs to define and monitor R&D program
- Fully integrated schedule of Lab and LSC activities is in preparation
- MOU's/Attachments B, C, D updated to agree with this plan
- LSC will host monthly progress telecons with LIGO Lab participating to assess progress and to identify issues

Since September, 1999 White Paper

- R&D White Paper failed to fully consider thermal noise sources
- Braginsky et al and Thorne et al papers on thermoelastic damping change sapphire perspective
  - » goal is to work this result into R&D and into LIGO II design choices
  - » increased emphasis on measuring thermal noise limits with suspended sapphire optics
- Some R&D is being curtailed or accelerated to focus on the LIGO II goals
- R&D program is undergoing greater discussion and coordination
  - » Aspen workshop was intense……!

R&D Questions for This Meeting

- How much risk can we tolerate from limits of our knowledge of the LIGO II thermal noise floor?
  - » How well can we measure thermoelastic noise?
    - – Direct measurement in suspended mass interferometers with fine displacement sensitivity (TNI,…)
    - – Tabletop measures of damping (anelastic tests,…)
  - » Other contributions to thermal noise
    - – Brownian motion noise
    - – Young's modulus response to thermal fluctuations (G. Cagnoli)
    - – Index of refraction response to thermal fluctuations (B. Kells)
    - – others…
- We need the best plan we can define
- This is not a zero risk endeavor

R&D Questions for This Meeting

- Signal tuned configuration research
  - » 10 m Glasgow system
    - – to prove the principle
  - » 40 Meter system
    - – to shakeout an engineering implementation
- How come we measured phase sensitivity for LIGO I and no plan to do this for LIGO II is in our White Paper?
  - » Did not consider path length fluctuations induced by thermal fluctuations driving refractive index
  - » ACIGA role?
- How to integrate opportunities from all the test interferometers in the community?

This Year: Towards Full LIGO II Proposal

- Team forming in LIGO Lab
- Integrated plan being assembled
- Schedule for proposal preparation forming
- Seismic isolation decision MUST be made in April!
- Monthly R&D telecons to start for 3 working groups
- Schedule/cost estimating this summer
- Document complete in October
- LSC full participation is crucial as this is your detector vision
- Lot's of competition pounding the NSF door !
  - » Our field will be held to its own high standards