Outline

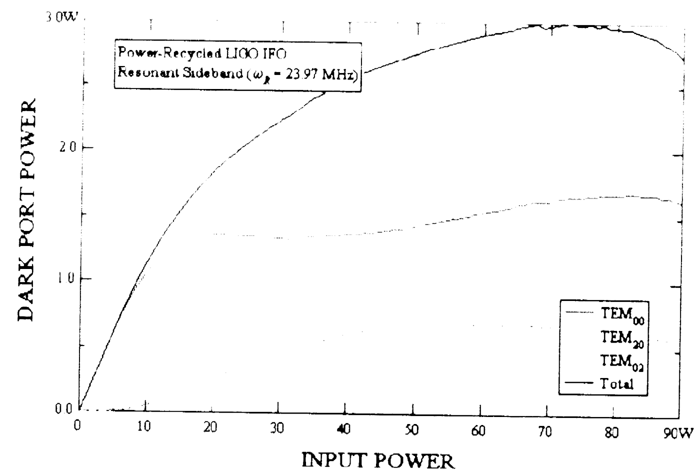
- Thermal Engineering and Modeling
- Advanced Core Optic Materials
- Modulators and Isolators
- Laser Development
- Working Group Agenda

LIGO-G990022-07-M

Thermal Engineering and Modeling

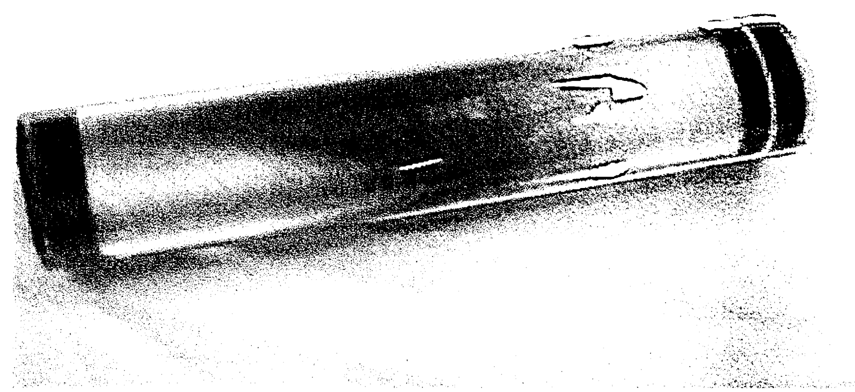
• Thermal Modeling Code

Object-oriented architecture in MATLAB
Flexible modulation and resonance schemes
Autolock routines for LIGO I/II/III, GEO
Astigmatic beamsplitter thermal lens
Hello-Vinet mirror thermal lens
Mirror misalignment operators
Demodulation detector class
SIMULINK interface



Advanced Core Optic Material

- Material Absorption
  - Off the shelf YAG 100 ppm/cm
  - Sapphire ~50 ppm/cm
- Q of YAG $2x10^7$

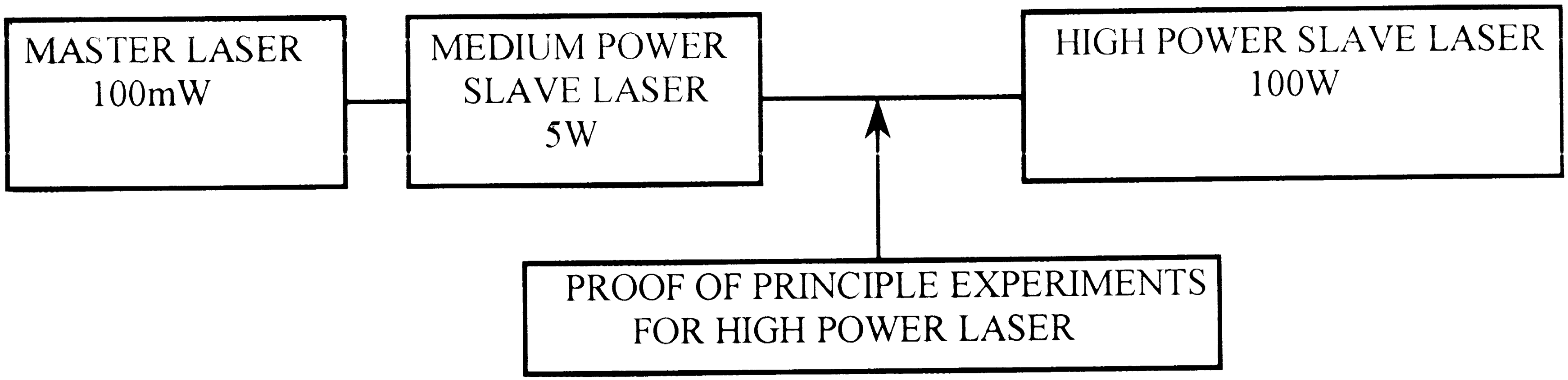


Modulators and Optical Isolators

- Wave front sensor and direct absorption measurements of phase modulators now agree
- Modulators and Isolators

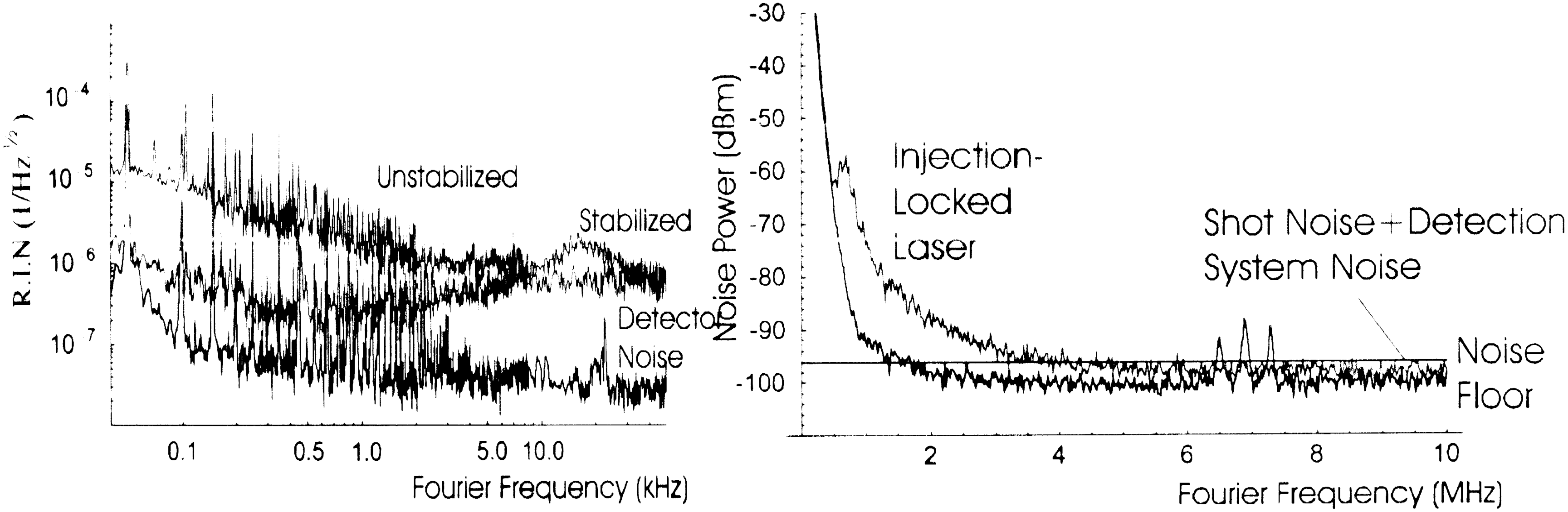
High Power Laser Development for Advanced Long-Baseline Interferometers

- Strategy: USE A CHAIN OF INJECTION-LOCKED LASERS



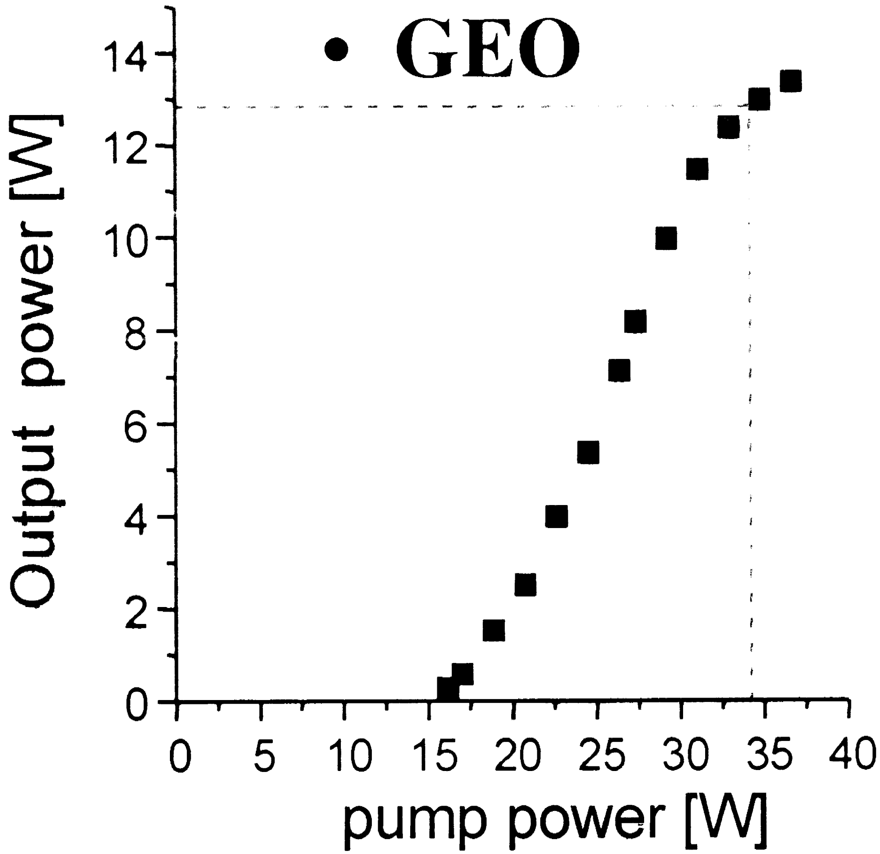
- AN ADELAIDE-ACIGA/STANFORD/LIGO COLLABORATION
- HIGH POWER LASER USES A 'STABLE/UNSTABLE' LASER RESONATOR TO PRODUCE A LASER THAT IS EFFICIENT, INTRINSICALLY STABLE AND SCALABLE TO >100W

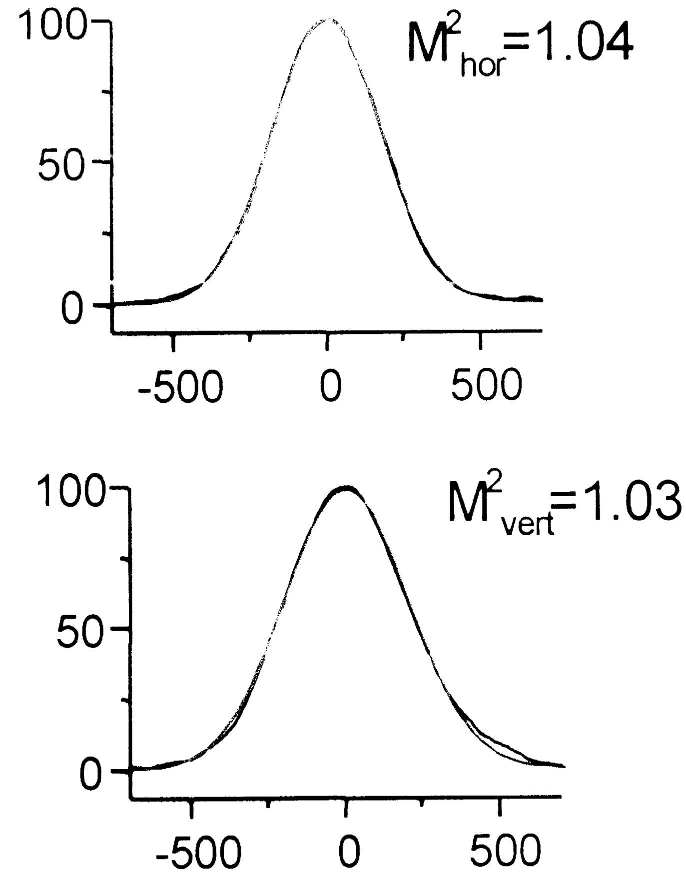
Intensity Noise of 5 W Injection-Locked CPFS Laser



* Low frequency feedback to the laser diode drive current ensures the intensity noise of the laser meets LIGO 1 requirements
* The laser is shot noise limited for 6 mA of photo-current above 5 MHz Fourier frequency

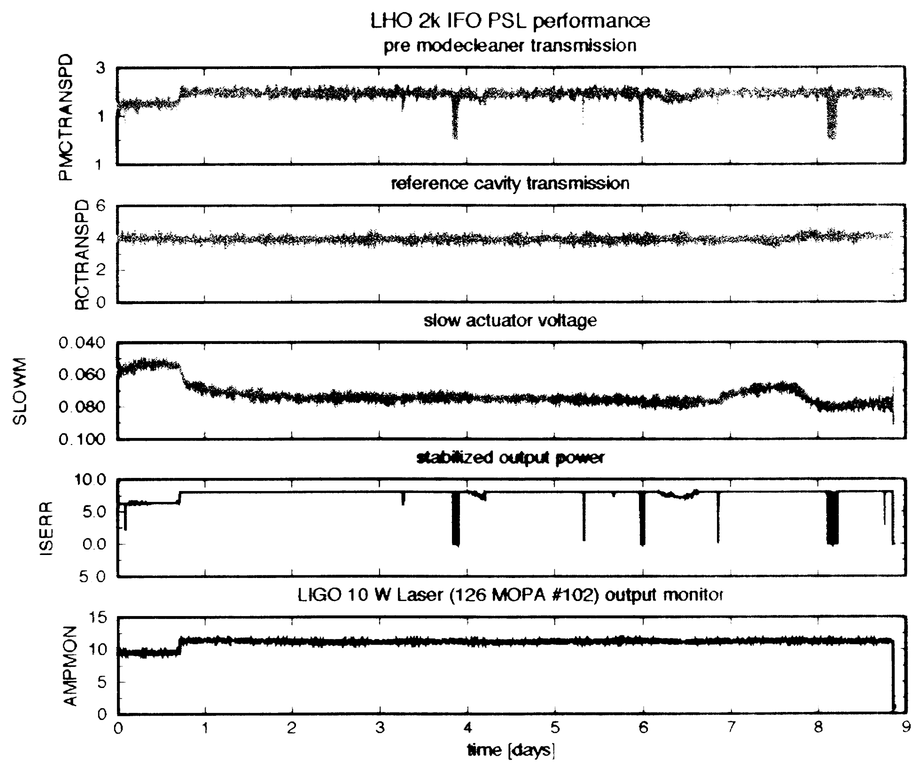
Laser Development





99% Linear Polarization

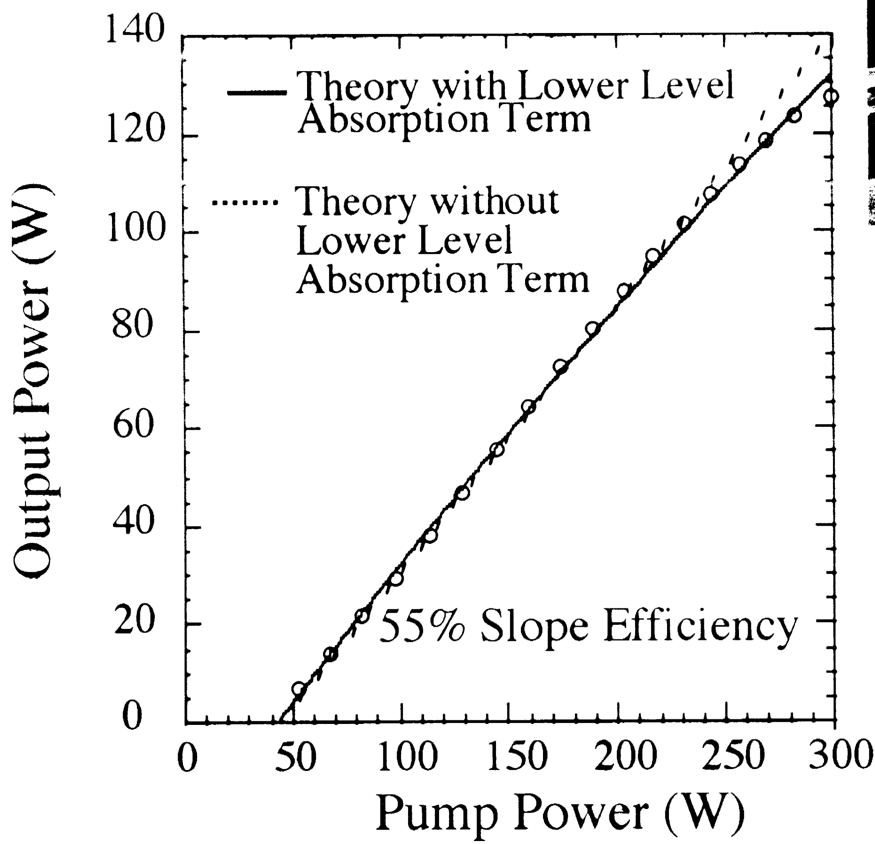
LHO 2k IFO PSL

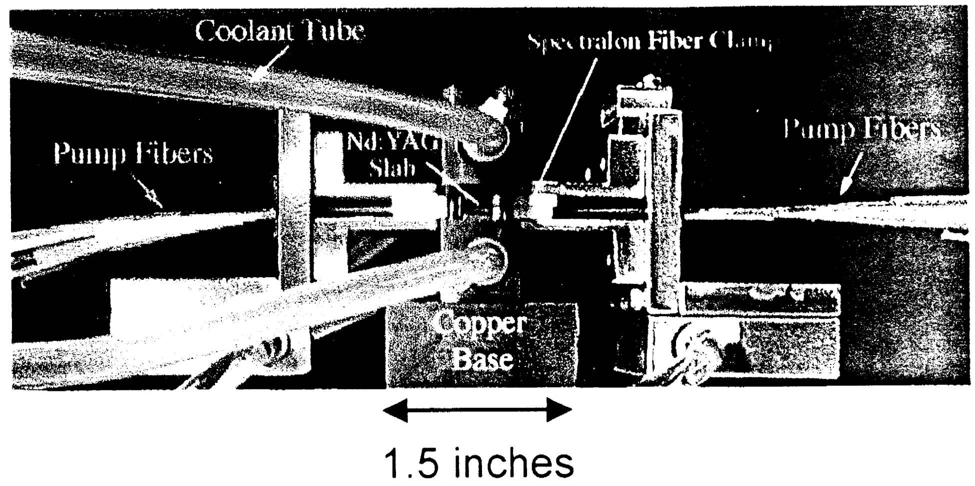


- PSL remained in lock for a period of 30 days
- Automatic lock acquisition demonstrated

Laser Development

- Stanford





- **Nd:YAG Slab**
  - 1% Doped Nd:YAG
  - 1.5 x 4.5 x 38.9 mm w/ Brewster end faces
  - SiO_2 Coating for low loss TIR
  - **1.5 % single-pass loss**

LIGO Scientific Collaboration
Lasers and Optics Working Group

www.stanford.edu/group/ligo

History

Research

Members

Meetings

Publications

White Papers

Materials

History // Research // Members // Meetings // Publications // White Paper // Materials

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Last Update: 2/25/98
sbretz@stanford.edu

Some potential core optic materials and their properties

Below we list several materials which could be used for advanced core optic materials and their mechanical and optical properties.

Mechanical Properties

Material	Best Bulk Resonator Q	Density (cm/cm^3)	Youngs modulus (Gpa)	Poisson ratio
Silica	2x10^7(Ref.1)	2.202	72.6	0.16
Sapphire	2x10^8(Ref.2)	3.987	400	0.23
YAG	2x10^7(Ref.3)	4.55	283	0.25
Spinel	NA	3.577	275	0.28

All unreferenced numbers are from the "Electro-Optics Handbook," Ronald Waynant and Marwood Ediger Editors,McGraw-Hill, Inc., 1994, pages 11.13-11.23.

Ref.1

Ref.2 "Systems with small dissipation," V.B. Braginsky, V.P Mitrofanov, and V.I. Panov, The University of Chicago Press, 1985, Page 30.

Ref.3 Sheila Rowan private communication, Ginzton Laboratory, Stanford University, Stanford, California, 94305-4085, (650)723-1178, srowan@loki.stanford.edu

Optical Properties

Material	Crystal Class	Absorption @ 1064 nm	dn/dT (10^-6)	Refractive index
Silica	NA	1 ppm/cm (Ref.1)	11	1.4506
Sapphire	Hexagonal	? (Ref.2)	? (Ref.4)	1.7555(o) 1.7478(e)
YAG	Cubic	100 ppm/cm (Ref.3)	7.6(Ref.5)	1.815
Spinel	Cubic		250	1.701

All unreferenced numbers are from the "Electro-Optics Handbook," Ronald Waynant and Marwood Ediger Editors,McGraw-Hill, Inc., 1994, pages 11.13-11.23.

Ref.1 Virgo reference

Ref.2

Ref.3 Martin Fejer, private communication, Ginzton Laboratory, Stanford University, Stanford,

Lasers and Optics Working Group Agenda

Friday

Advanced Core Optic material (9:00 - 11:00) - Jordan Camp
White Paper review (11:20 - 12:00) - Eric Gustafson
Lasers (1:00 - 2:20) - Benno Willke
Modulators, isolators and photodiodes (2:40 - 4:00) - David Reitze

Saturday

Thermal engineering and modeling (9:00 - 11:30) - Hiro Yamamoto
Planning for the next LSC meeting (11:30 - 12:00) - Eric Gustafson

Agenda Lasers and Optics Working Group Meeting						
March 4-6, 1999 Gainsville Florida						
Friday 5 March 1999	Speaker	Start	Stop	Q&A	ET	
A. Advanced Core Optic Materials	**Jordan Camp**					
1. Review of LIGO I Specs and Testing	Jordan Camp	9:00 AM	9:20 AM	0:05	0:20	
2. How Crystals are Grown - I	Roger Route	9:25 AM	10:05 AM	0:05	0:40	
3. Absorption measurements in crystals	Alex Alexandrovski	10:10 AM	10:30 AM	0:05	0:20	
4. Status of Q measurements in advanced materials	Sheila Rowan	10:35 AM	10:55 AM	0:05	0:20	1:40
Break		11:00 AM	11:20 AM		0:20	
B. White Paper Review and Recommendations		11:20 AM	12:00 PM		0:40	
Lunch		12:00 PM	1:00 PM			
C. Lasers for Gravitational Wave Interferometry	**Benno Willke**					
1. Status of the GEO laser system	Benno Willke	1:00 PM	1:20 PM	0:03	0:20	
2. Status of the TAMA laser system	Shinsuke Taniguchi	1:23 PM	1:28 PM	0:00	0:05	
3. Transverse pumped slab lasers	Bill Tulloch	1:28 PM	1:48 PM	0:03	0:20	
4. The future of diode pumped lasers	Robert Byer	1:51 PM	2:11 PM	0:03	0:20	
5. The prospects for shorter wavelength sources	Marty Fejer	2:14 PM	2:34 PM	0:03	0:20	1:20
Break		2:37 PM	2:57 PM		0:20	
D. Modulators, isolators and photodetectors	**David Reitze**					
1. Measurements of LiNbO3 phase modulators	David Reitze	2:57 PM	3:17 PM	0:03	0:20	
2. Measurements of optical isolators	Efim Khazanov	3:20 PM	3:40 PM	0:03	0:20	
3. Adaptive core optic control	Peter Fritschel	3:43 PM	4:03 PM	0:03	0:20	1:00
Saturday 6 March 1999	Speaker	Start	Stop	Q&A	ET	
E. Thermal engineering and modeling	**Hiroaki Yamamoto**					
1. Thermal modeling using Matlab	Ray Beausoleil	9:00 AM	9:25 AM	0:05	0:25	
2. Thermal effects and the LIGO end to end model	Hiroaki Yamamoto	9:30 AM	9:55 AM	0:05	0:25	
3. Wavefront sensing	Justin Mansell	10:00 AM	10:25 AM	0:05	0:25	
4. Status of contamination measurements	Jordan Camp	10:30 AM	10:55 AM	0:05	0:25	
5. Preview of the modeling workshop	Guido Mueller	11:00 AM	11:25 AM	0:05	0:25	2:05
F. Planning for the next LSC Meeting		11:30 AM	12:00 PM		0:30	