



SAS group R&D results

Riccardo DeSalvo

8th October 2002

1. TAMA-SAS
2. Active Internal Damping
3. Passive Pre-Isolation
4. Glassy metal developments
5. Nursery

- Akiteru Takamori's PhD thesis

Univ. of Tokyo

M. Ando
Y. Iida
K. Nanjo
Y. Nishi
K. Numata
K. Otsuka
K. Somiya
A. Takamori
K. Tsubono
T. Yoda

Caltech

R. DeSalvo
Sz. Márka
V. Sannibale
H. Yamamoto
C. Wang
H. Tariq

Universita' di Pisa

A. Bertolini
G. Cella

NAOJ

M. Fukushima
S. Kawamura
R. Takahashi

INSA de Lyon

F. Jacquier
N. Viboud

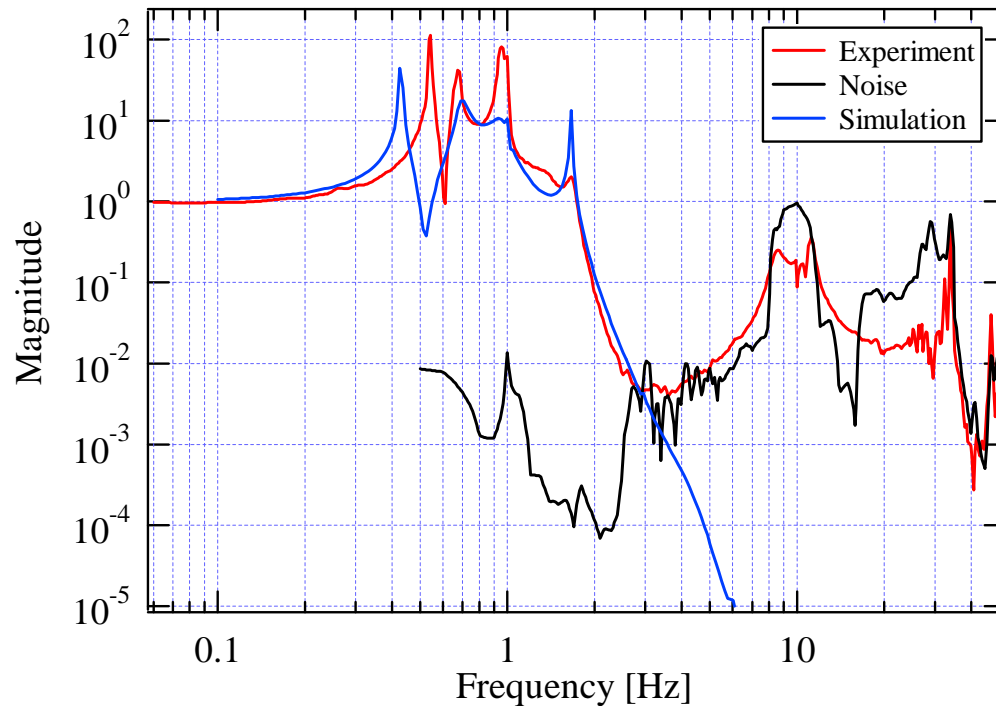
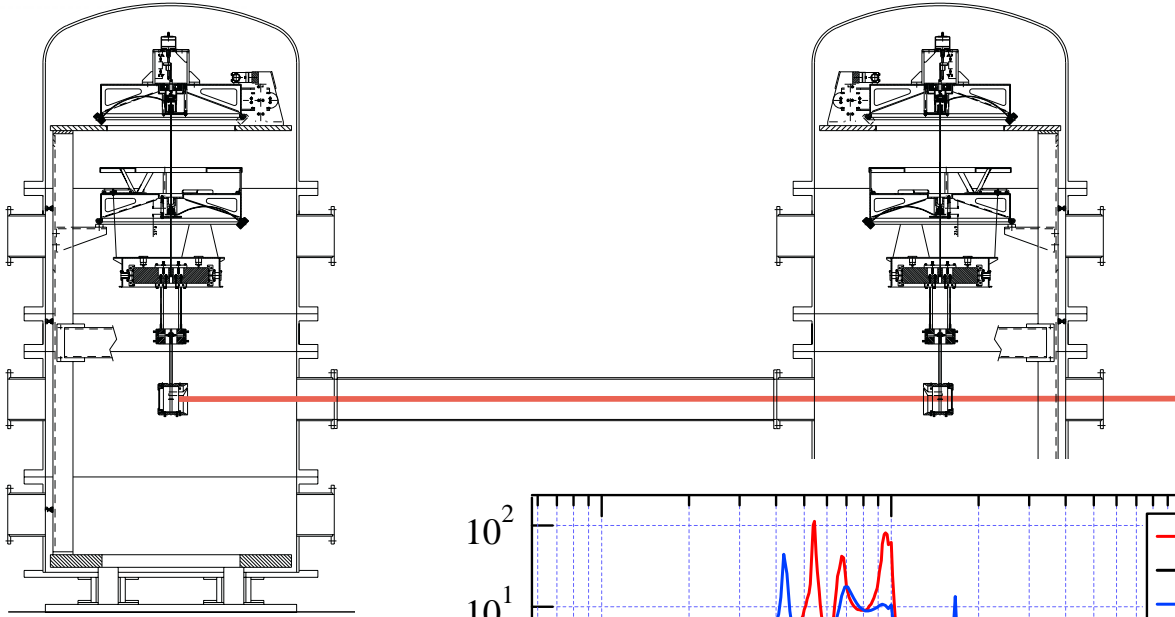
Other Institution

G. Losurdo (Virgo)
and others

1 TAMA-SAS results

- **Completed assembly** of TAMA-SAS suspended **3 m test F.P. interferometer**,
- **Characterizing performance** (A.T. thesis subject).
- **Validating design and performance** for production of the **main towers for TAMA 300** (production in 2003) **other users** (production in 2002/2003) :
 - 3 towers for Naples,
 - 1 tower for Florence

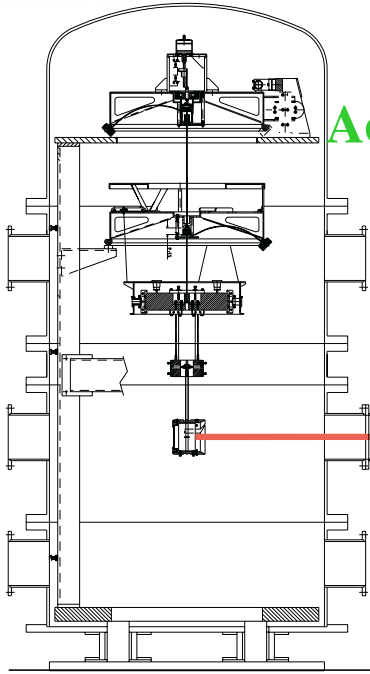
TAMA SAS 3 m F.P. experiment



SAS noise
Reduction:

One tower
Measuring
A Michelson
to ground

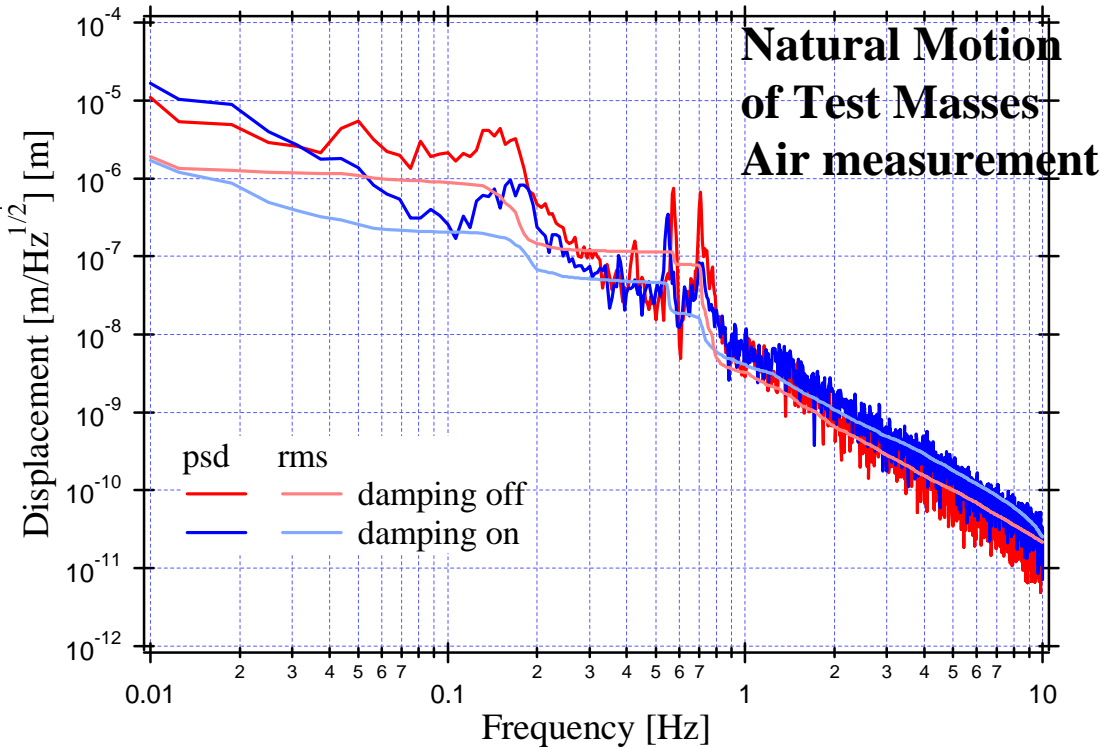
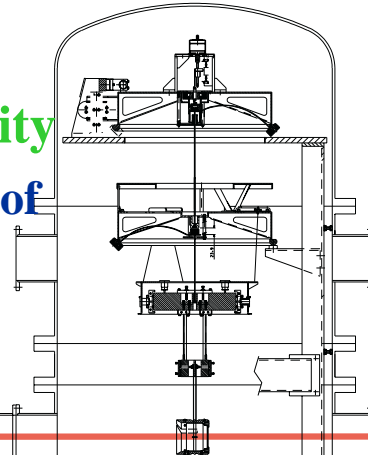
TAMA SAS 3 m F.P. experiment



Acquired Lock of Cavity

- Test Mass Motion of
0.2 nm r.m.s.

4 nm/rtHz @ 1 Hz



1 TAMA-SAS

future developments/commitments

- Provide technical support for :
 1. production of **TAMA-300 SAS** towers (2003-2004)
 2. SAS tower development optimized for **LCGT** and second generation **Cryo-Virgo** (long term)
 3. production of a **TAMA-SAS** tower for University of Florence **accelerometer development facility**(2003)
 4. production of **3 TAMA-SAS** towers for University of Naples **test interferometer** (2003)
- No construction costs, marginal drafting costs (\$5000)



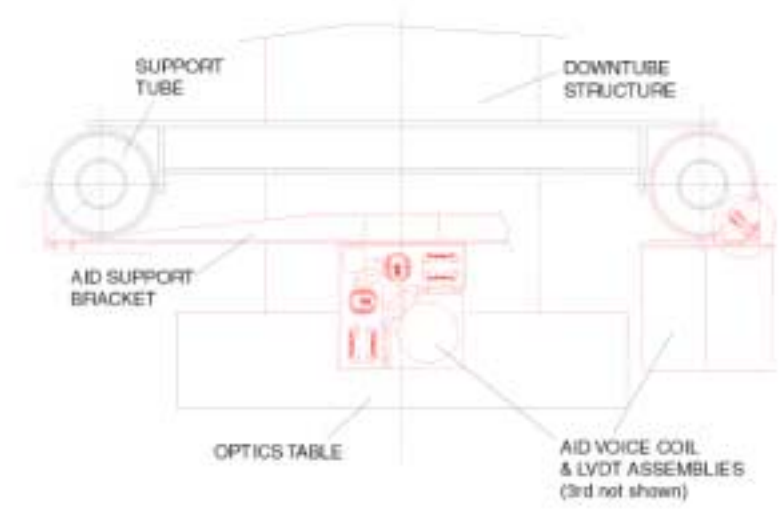
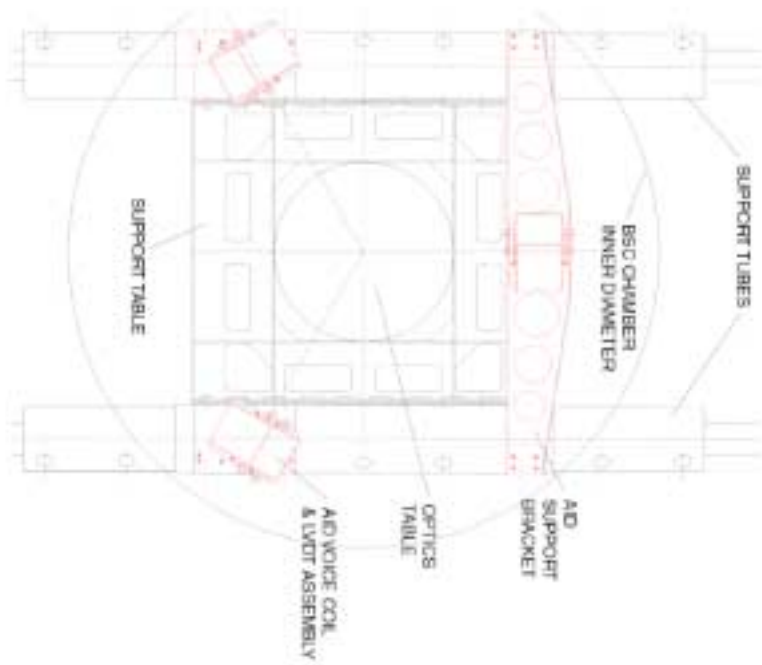
1 TAMA-SAS

possible future developments

- Small **incremental improvements of SAS** passive attenuation chain concept
- Study of **use of glassy metal GAS springs for mirror suspensions**
- Timescale
 - Low priority operation
- Costs
 - Marginal drafting and hardware costs

2 Active Internal Damping

- Developed in vacuum damping scheme to limit the excitation of the present LIGO stacks,
 - LIGO- T020038-01-R
- Made **complete construction design** and started **construction of parts for installation in LASTI**
 - LIGO -D020212-00-R

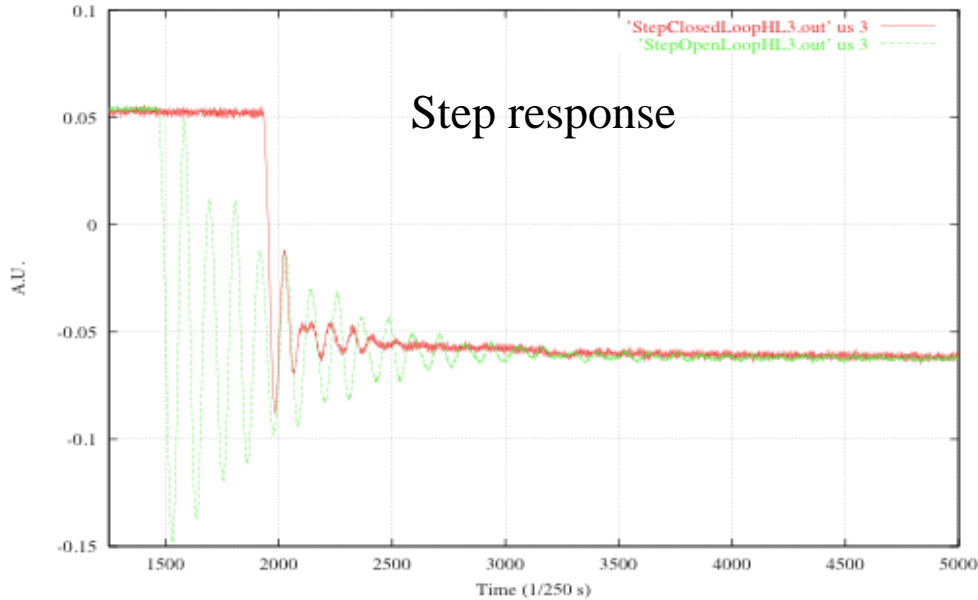


2 Active Internal Damping

- Developed in vacuum damping scheme to limit the excitation of the present LIGO stacks,
 - LIGO- T020038-01-R
- Made complete construction design and started construction of parts for installation in LASTI
 - LIGO -D020212-00-R
- **Built functional 1-to-1 prototype** with spare LIGO springs, an optical table and cannibalized SAS sensors and actuators
 - LIGO- G020169-00
- **Tested successfully the 6 degree of freedom damping scheme**
 - LIGO- G020212-00



- Damping OFF



QuickTime™ and a
Photo - JPEG decompressor
are needed to see this picture.

- Damping ON

QuickTime™ and a
Photo - JPEG decompressor
are needed to see this picture.



2 Active Internal Damping

- Aborted production
- Mothballed in April 2002
 - deemed superfluous because of active pre-isolator expected performance (HEPI/MEPI).

3 Passive Pre-Isolation

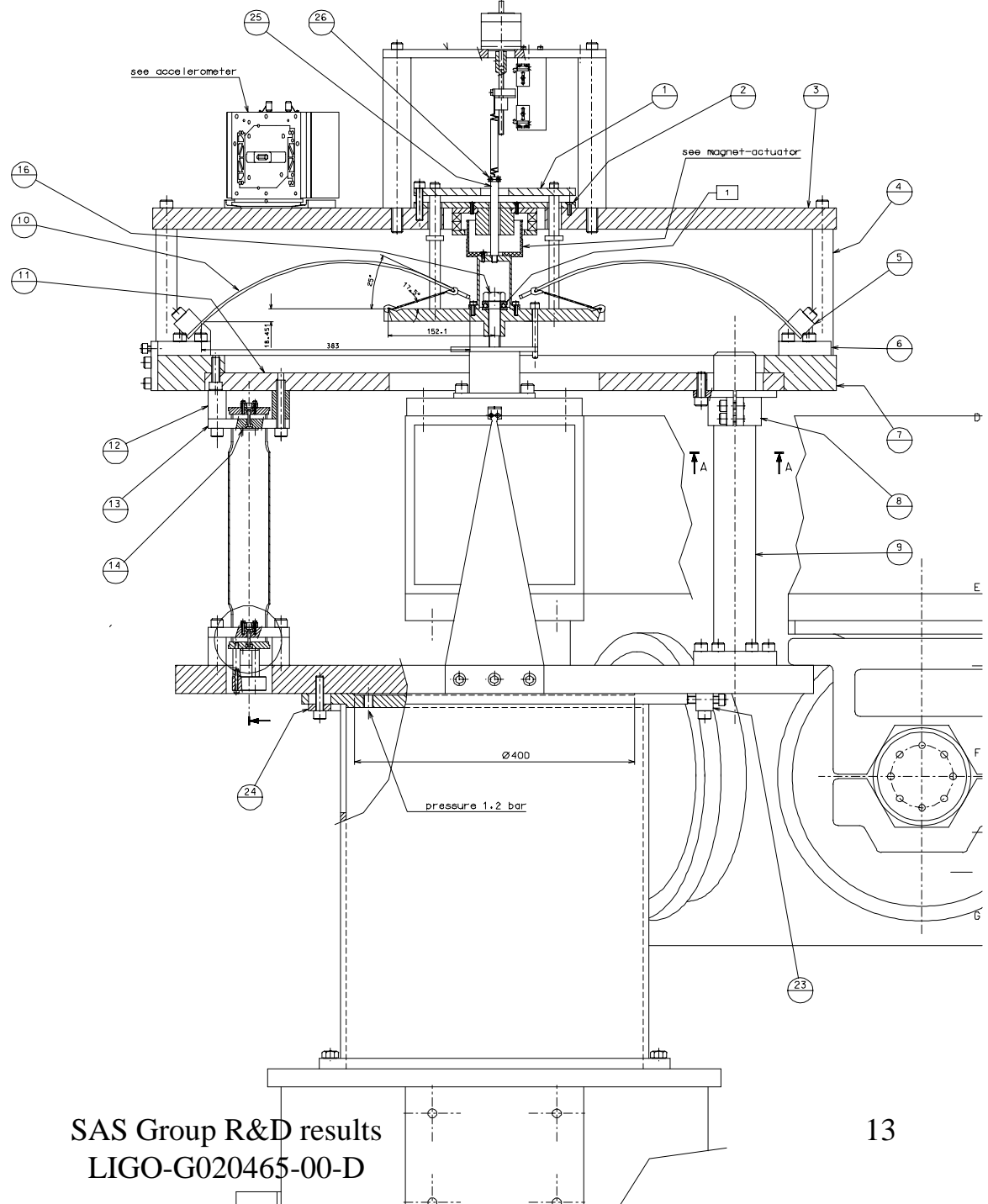
- Developed **passive pre-isolator alternative** to HEPI/MEPI.
 - Negative stiffness springs, derived from SAS would mount on each pier and both support the LIGO platform weights and neutralize the bellow springness.
 - Performance: **>40dB estimated above 1 Hz**,
 - upgradable to **>60dB and lower frequency** with low power (mW) active operation **LIGO- T020039-01-R**
- **Full size, partial prototypes** of the horizontal and vertical negative stiffness springs **built** with SAS spare parts,
- **Successfully tested performance and validated concept**
 - **LIGO- T020055-00-R**
 - **LIGO- T020052-00-R**

Mechanical
design

LIGO- D200001-00-R

LIGO
Passive External
Pre-isolator

mounted on
a pier

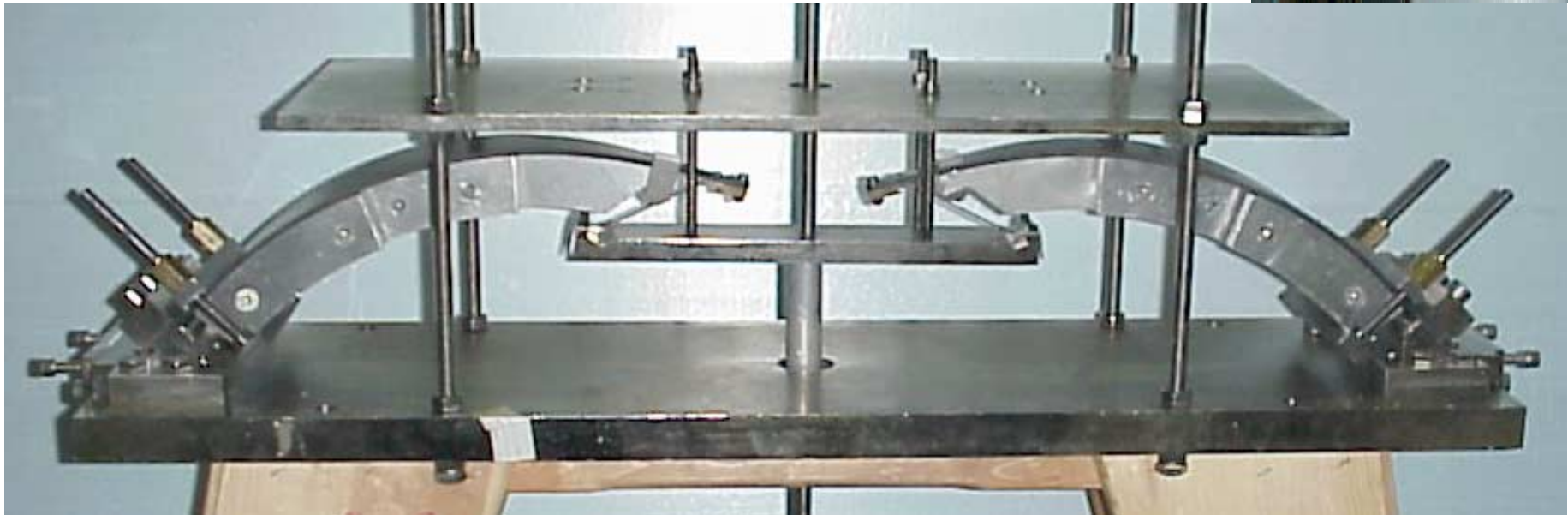


LIGO

3

Passive Pre-Isolation

- Made complete construction design of Passive Pre-Isolator,
- Built partial prototype according to production design
- ready for production **LIGO- D200001-00-R**



3 Passive Pre-Isolation

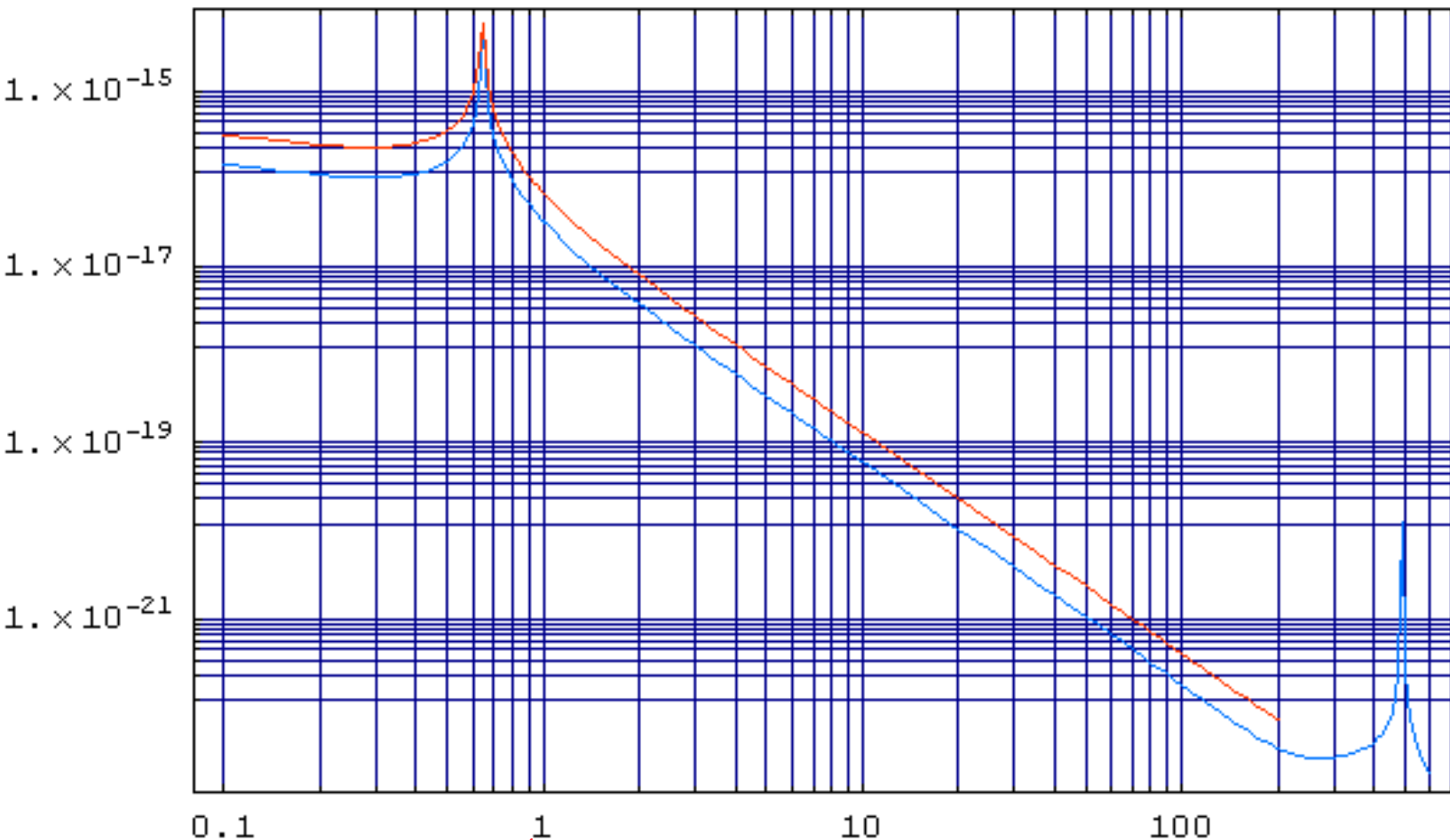
- Made complete construction design of Passive Pre-Isolator, ready for production
 - LIGO- D200001-00-R
- Built partial prototype according to production design
- Costed the system at **50,000\$/BSC or HAM**
 - plus 40,000\$ for active upgrade
- Estimated production time **~ 2 months**
- **Mothballed in May 2002** counting on success of baseline active system.

4 Glassy Metal advanced suspension development program

- Developing a **low loss mirror suspension** scheme, capable of delivering **advanced performance at room temperature**
- The aim is to find a **viable alternative to the fused silica fiber suspensions** (more reliable and better performance) **for Adv. LIGO**
- The idea is to take advantage of the **superior useable strength** ($\sim 5\text{GPa}$) of glassy metal to manufacture **very small section (a few micron thick) flex joints suspensions**
- The **high fracture toughness** of glassy metal insure **very high reliability** while requiring minimal safety factors
- **Simulations** using glassy metal properties **indicate performance exceeding the fused silica fiber's**



Glassy Metal simulated performance



Glassy metal $Q=10^4$, Fused SiO_2 dumb bell shaped fiber $Q=8.4 \cdot 10^8$,
 $10 \cdot 3000 = 30,000 \mu\text{m}^2$, $357 \mu\text{m}$ diameter, $100,000 \mu\text{m}^2$,
60 Kg mirror, 40 Kg mirror

October 8th 2002

SAS Group R&D results
LIGO-C010465-00.D

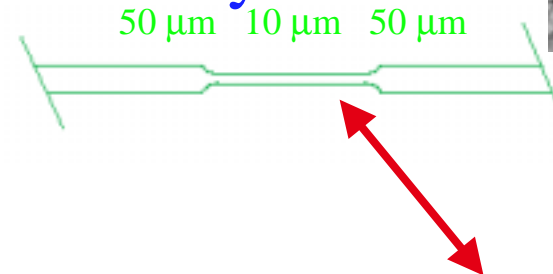
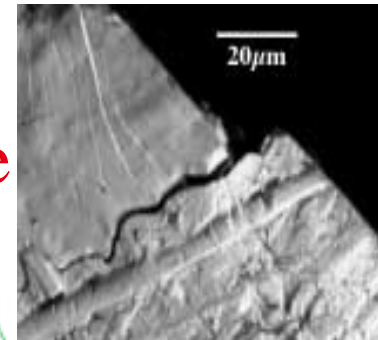
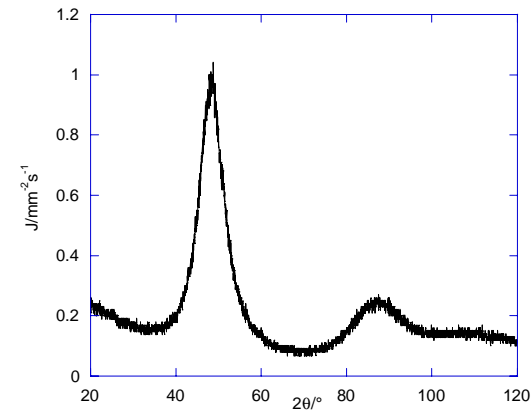
Glassy metal team

•Hareem Tariq's PhD thesis

- | | |
|-----------------------|---|
| •Valerie Cervantes | Data Analysis (TP) / H.S. Student Mayfield (Pas.) |
| •Allyson Feeney | Hardness / H.S. Student Westridge (Pas.) |
| •Maddalena Mantovani | Hardness & Elasticity / Undergraduate Pisa |
| •Stefano Tirelli | Stress & Strain / Undergraduate Pisa |
| •Brian Emmerson | X-Ray Diffraction / Undergraduate Cambridge |
| •Michael Hall | Thermal Properties / Undergraduate Drexel |
| •Rosalia Stellacci | Creep Analysis / Undergraduate Pisa |
| •Xavier De Lepine | FEA of Flex Joint / Undergraduate INSA Lyon |
| •Eric Kort | Sample Uniformity / Undergraduate Pomona C. |
| •Stoyan Nikolov | FEA of Flex Joint / Undergraduate INSA Lyon |
| •Charles Bordier | material properties / Undergraduate INSA Lyon |
| •Barbara Simoni | Phase Transition / Undergraduate Pisa |
| •ChenYang Wang | Stress & Strain / Graduate Student Caltech/Stanford |
| •Jan Schroers | Post Doctoral Scholar Caltech |
| •Alessandro Bertolini | Assistant Professor (University of Pisa) Pisa |
| •Bill Johnson | Professor (Materials Science) Caltech |
| •Riccardo DeSalvo | Sr. Scientist Caltech |
| •Hareem Tariq | Coordinator / Graduate Student Caltech |

4 Glassy Metal advanced suspension development program

- Main focus of the SAS group efforts
- Established a GM production line
- Testing the material properties
- Developing a suspension construction scheme
- Developing a suspension test facility



QuickTime™ and a JPEG decompressor are needed to see this picture.

4 Glassy Metal advanced suspension development program

- Timescale / Costs / Efforts:
- Aim is to validate simulations, that exceed Fused Silica fiber performances, within 2003
- many small expenses (~\$100,000) not detaileable
- Will absorb bulk of SAS team attention and efforts
 - Unless need to resume mothballed projects
- Mainly run by students of various degrees.

5 Nursery

- Trying to draw talented students to
Gravitational Wave Interferometers
(poaching in HEP and other fields all over the
world)
- 2 Grad students
- ~10 undergrad students
- 2 High School students

5 Nursery effect

- **Akiteru**, finishing **Tokyo Univ. PhD thesis**
on TAMA-SAS, moving to Hanford
– (will continue support TAMA-SAS installation)
- **Hareem**, starting **Caltech PhD thesis**
on low thermal noise mirror suspensions
- **Chenyang**, **Caltech**, moving to Stanford
- **Eric**, **Pomona College**, will return for 6 month stage and
make graduation work with us
- **Mike**, **Drexel**, will make graduation work with us,
will apply for graduate school in Caltech,
possibly on Gravitational Waves

5 Nursery effect

- **Barbara, Lia, Maddalena, Stefano**, University of Pisa, third year thesis on Glassy Metals, some will return for fifth year thesis (Master thesis), some to finish measurements
- **Brian**, Cambridge, will apply for graduate school in Caltech, possibly on Gravitational Waves
- The four Pisa students funded through **INFN/NSF international student exchange program**.
- Three **US exchange students** worked in Virgo (Fidecaro).
- Forthcoming **grad student from Pisa** to somewhere in LIGO
 - Student selection committee in November