The GEO 600 Project
- status report-

Norna Robertson
Benno Willke

for the GEO600 team

LSC meeting, Boulder, August 98

LIGO-G980113-16-M

GEO600 COLLABORATIO

30m Prototy

- Power Rec
- Signal Re
- Auto-Al

Prot

Seism

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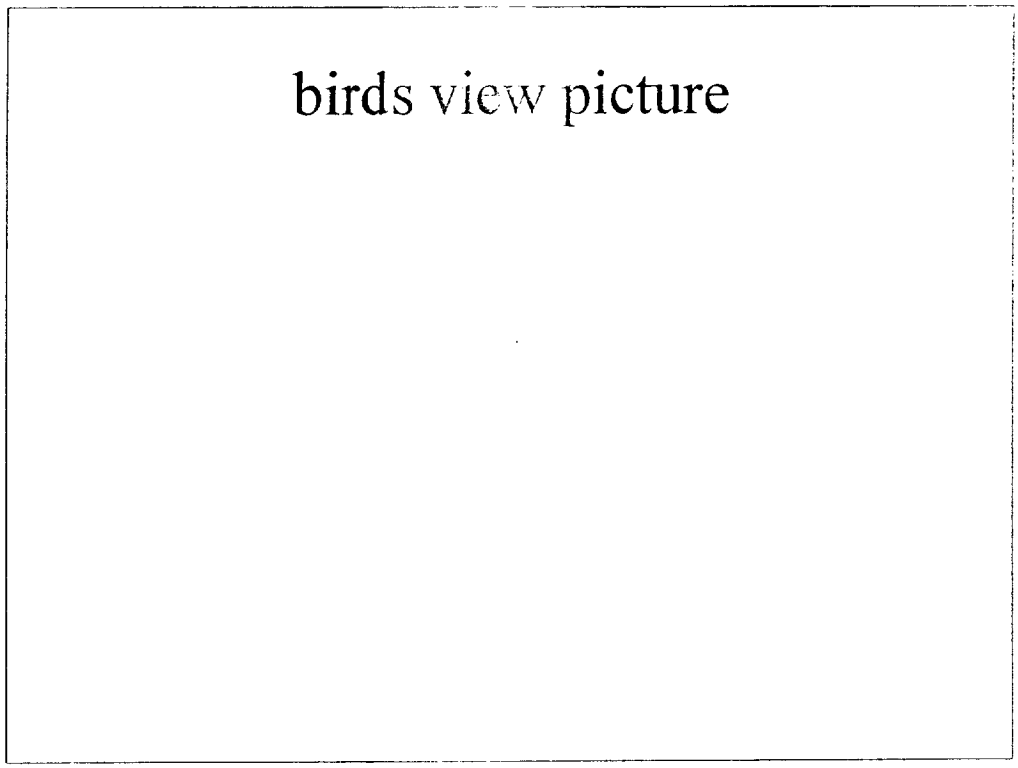
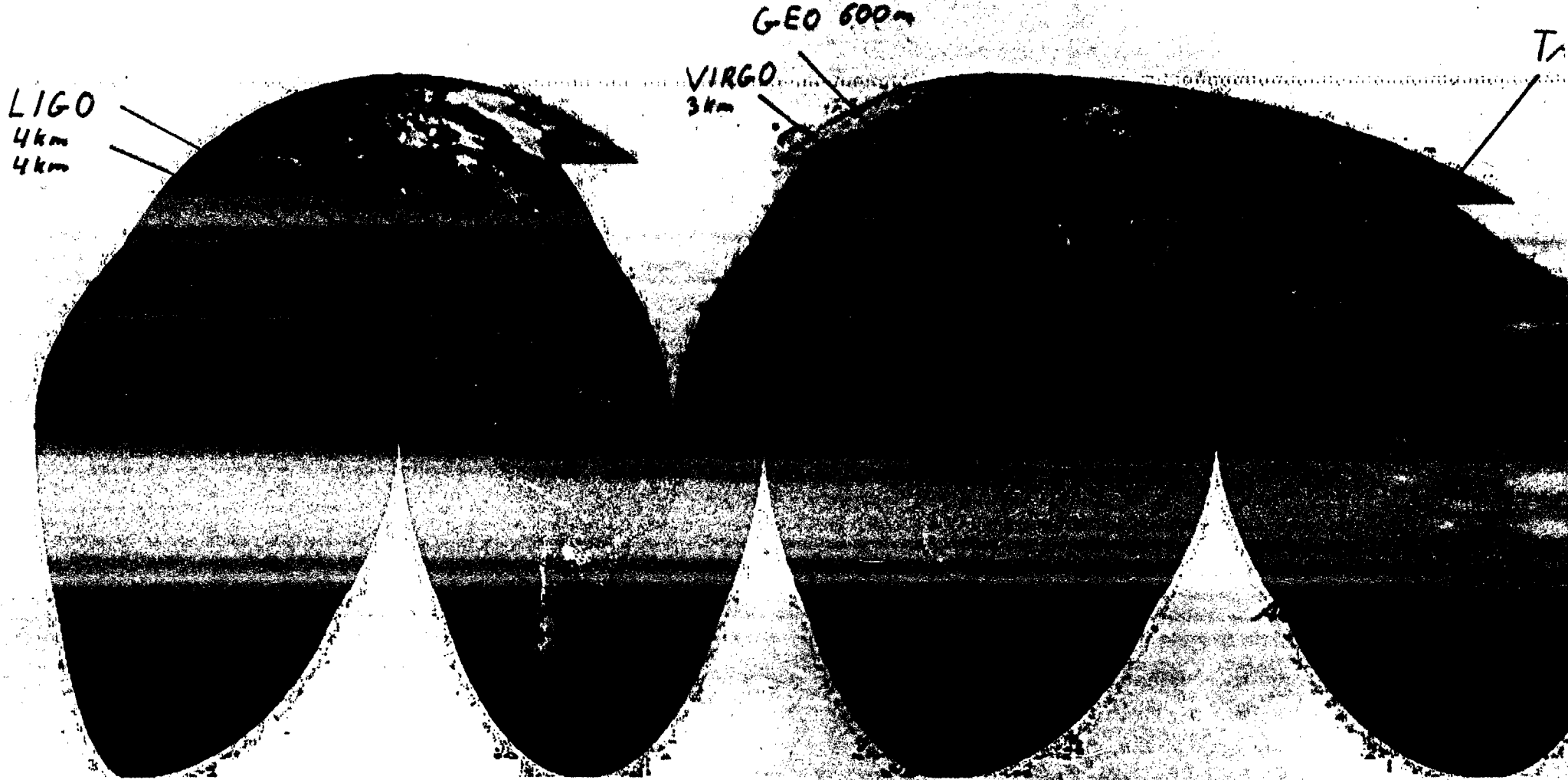
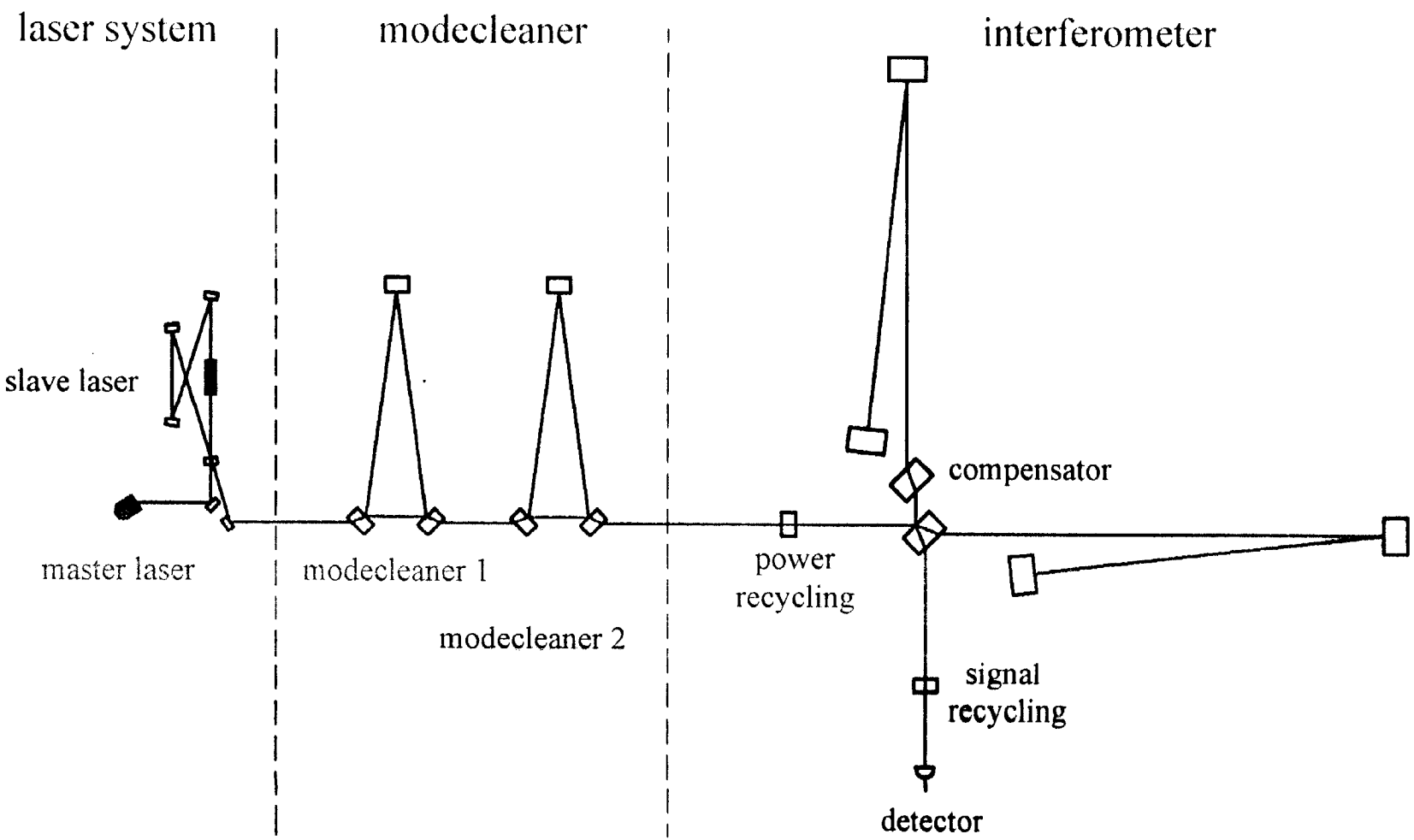

birds view picture

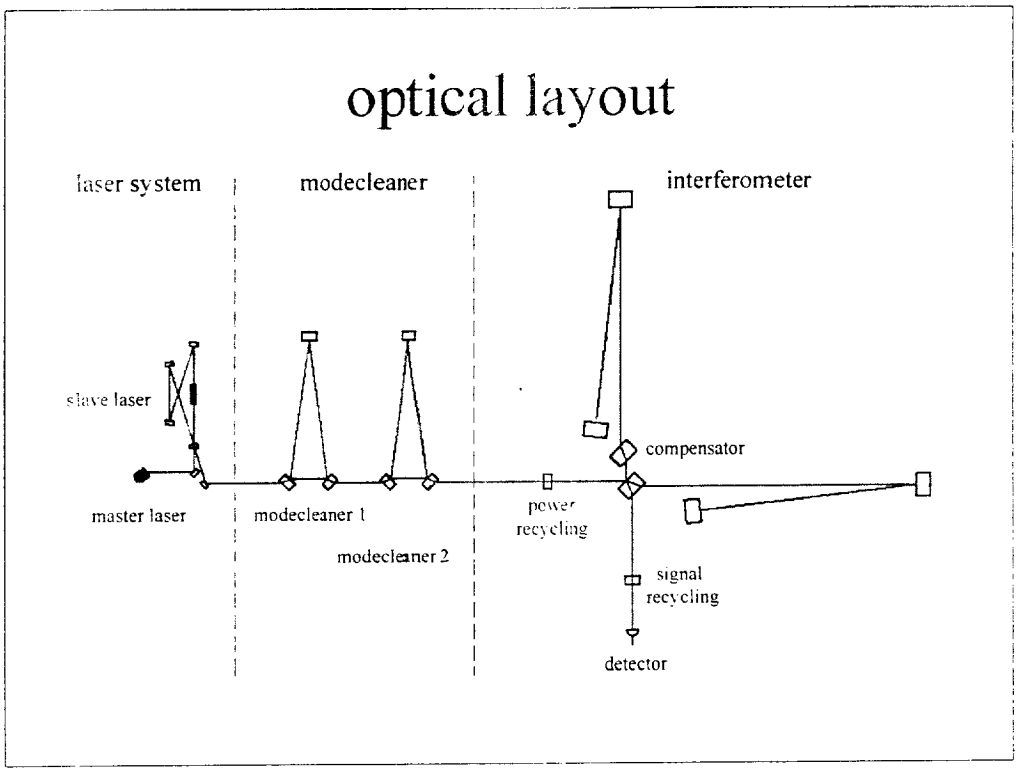

LIGO
4km
4km
VIRGO
3km
GEO 600m
T

current status - site

- buildings finished
- welding of 600m tubes completed
- both tubes leak tested and insulated, one tube baked
- vacuum tanks for modecleaners installed
- fabrication of modecleaner stacks almost finished
- modecleaner mirrors coated
- clean room installed and tested

optical layout





- MC intensity noise filter
- delay line
- no external modulation anymore

THE SENSITIVITY OF GEO600

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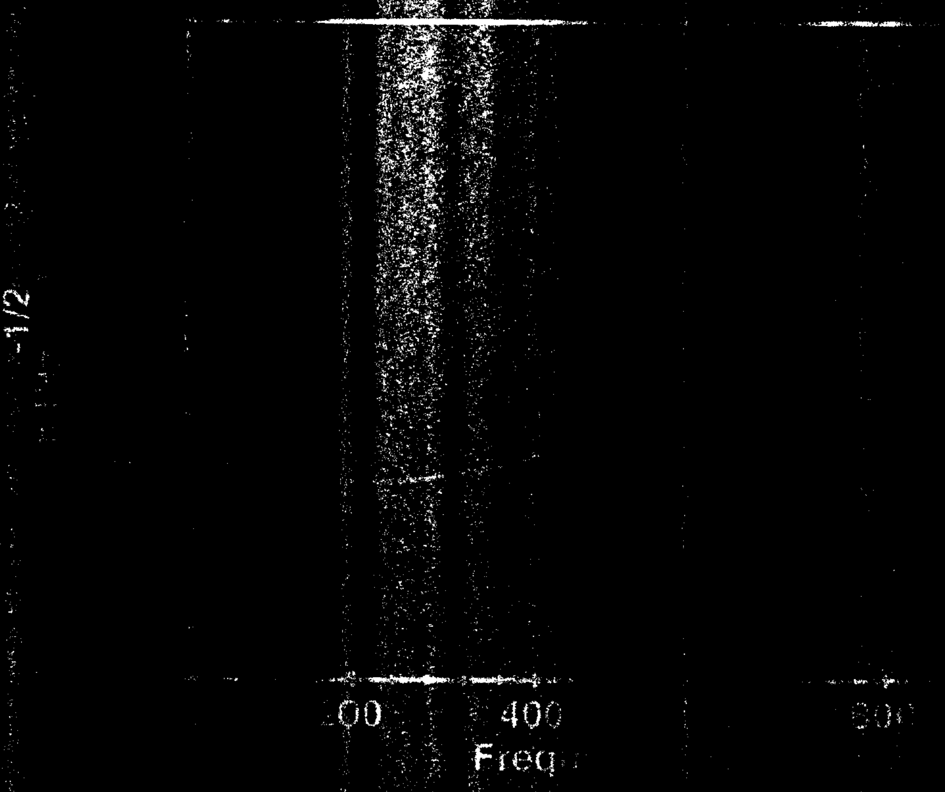

time table

summer 98	:	vacuum system - central cluster
winter 98/99:		installation of the two modecleaners
spring 99	:	1200m long cavity with test optic
summer 99	:	Michelson interferometer with power recycling
winter 99	:	dual recycling
spring 2000	:	final optics

- all experiments with their special auto-alignemen
- not decided when main suspensions, and 10W laser

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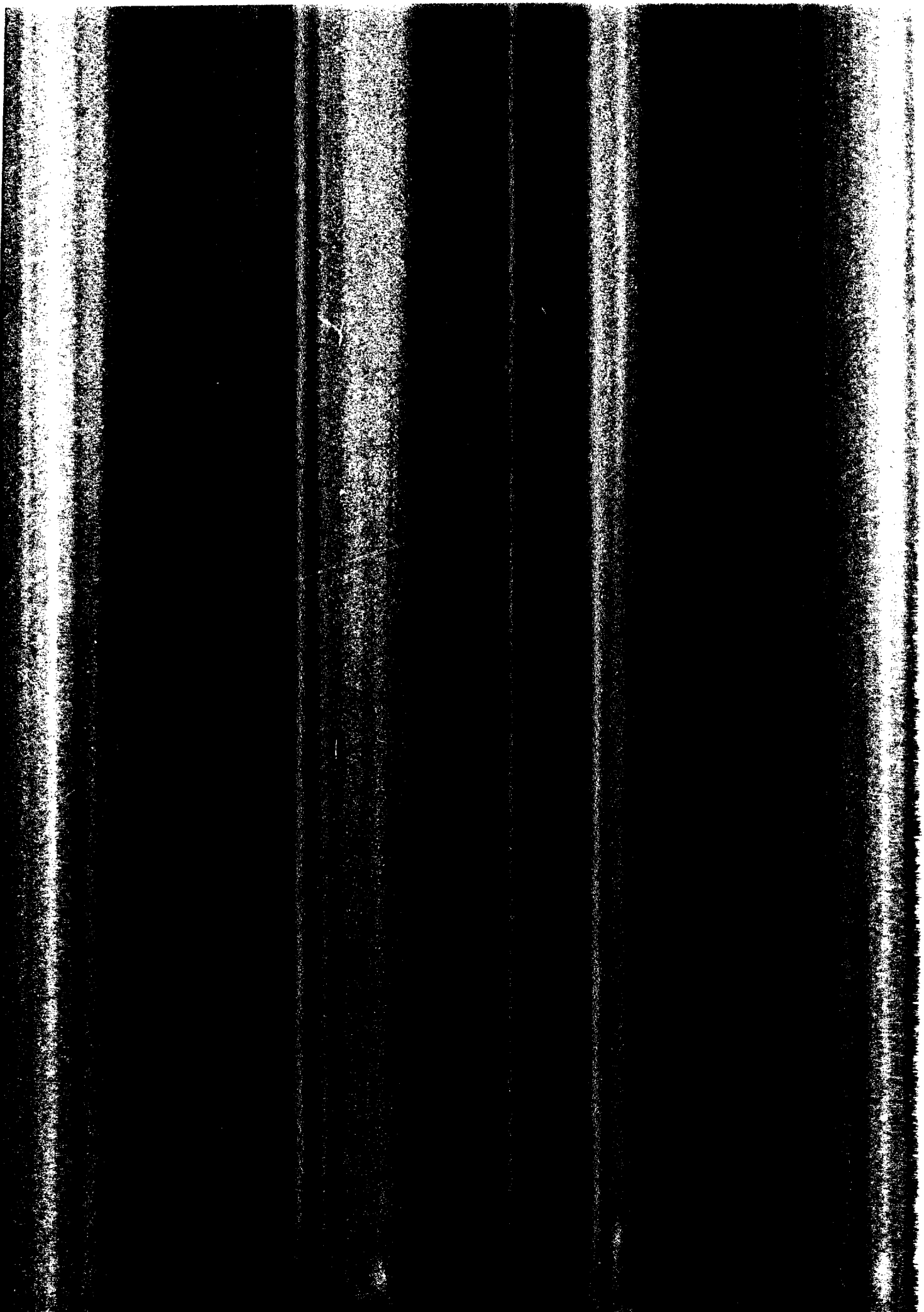
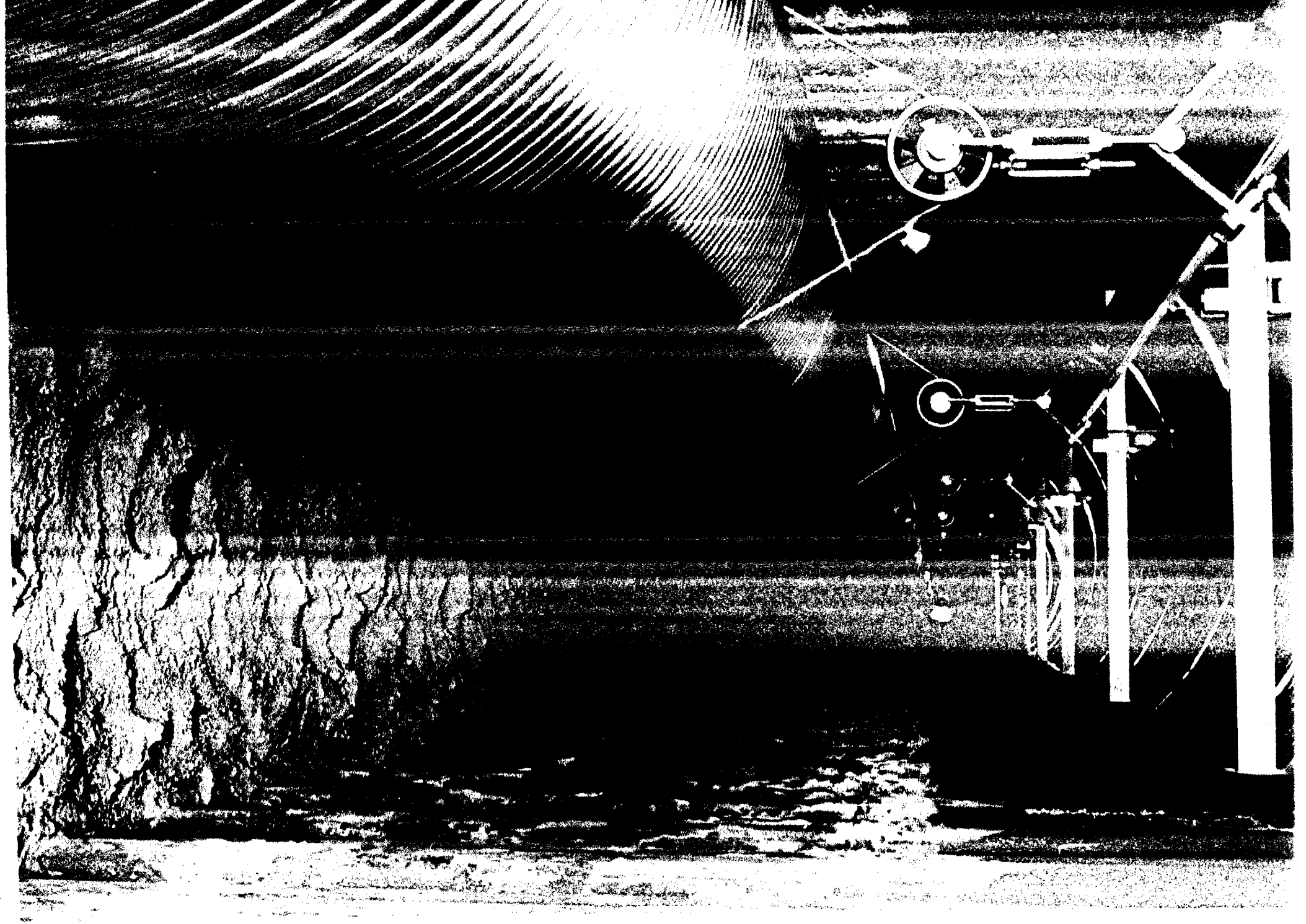


current status / developement

- 10W injection locked Nd:YAG laser system developed at the Laser Zentrum Hannover
- laser stabilization is proceeding as planned
- computerized control system under test at Glasgow 10m prototype
- new dual recycling control scheme demonstrated at the auto-aligned Garching 30m prototype
- developement of the data aquisition system well under way, software package „TIRANA“ ready to use

Norna will talk about main suspension developement



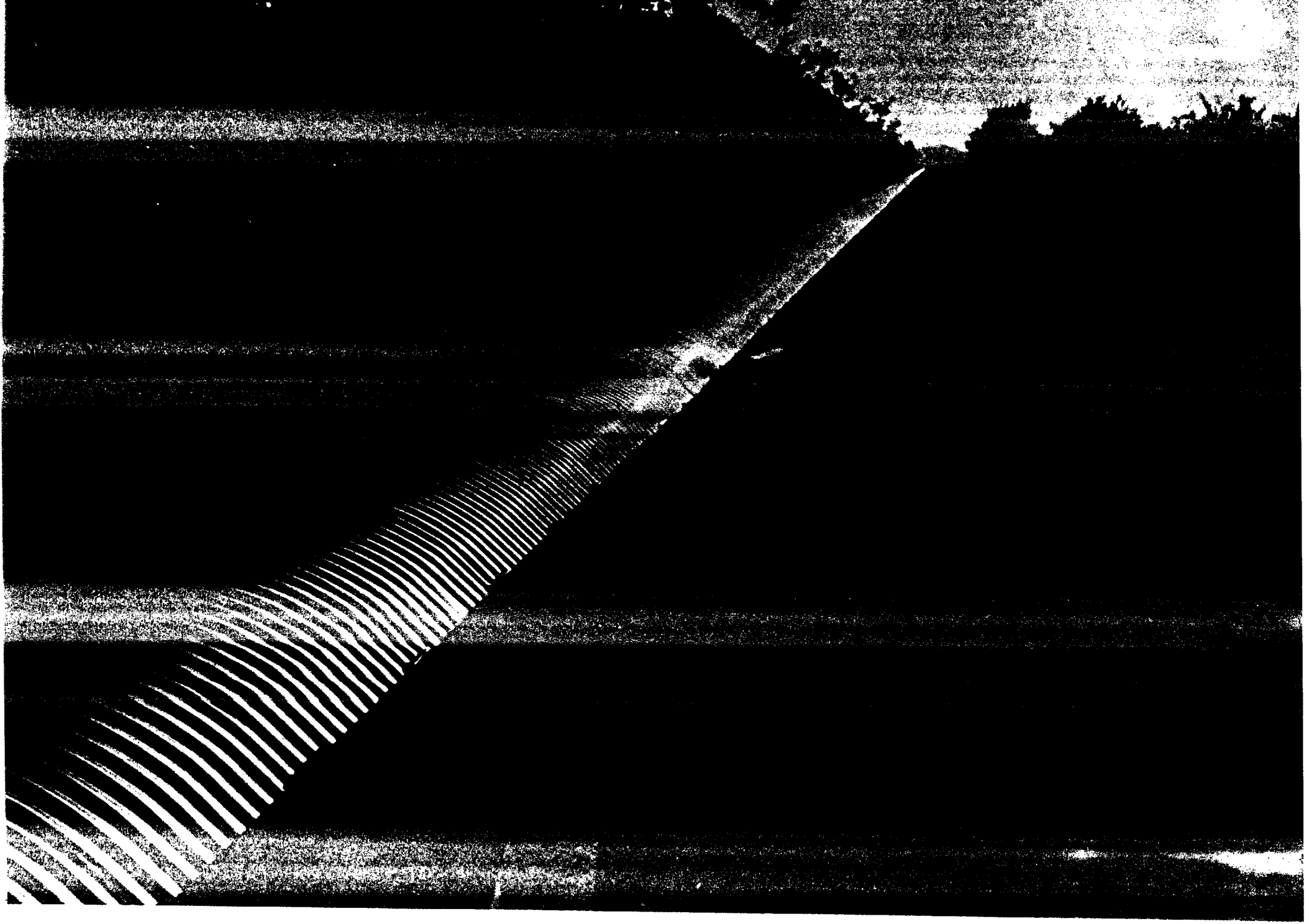
The Vacuum System II

pumps: 4 Scroll pumps (25 m^3/h, 10^{-2} mbar)

4 Turbo-molecular pumps
(magnetic bearings, 1000 l/s for H_2)

pressure:

- east tube: $6*10^{-9}$ mbar / $1.6*10^{-8}$ mbar
- north tube: $4*10^{-7}$ mbar (not baked)
- modecleaner: $9*10^{-9}$ mbar



The Clean Room Concept

Gallery : supplied with filtered air from outside
class 100.000

Inner Area : closed system with HEPA filters and
a small fresh air supply from Gallery
(air flow: 1000 - 6000 m^3/h)
< class 1.000

Clean tent : supplied with filtered air from inner Area
< class 100

The Vacuum System I

Volume: 400 m^3

Surface : 4000 m^2

tubes:

- Insulation: 20cm Rockwool
- air bake: 24h @ 200°C (500A)
- vac. bake: 1w @ 250°C (600A)

tanks:

- air bake: 1d @200 °C
- vac. bake: 1d @ 80 °C

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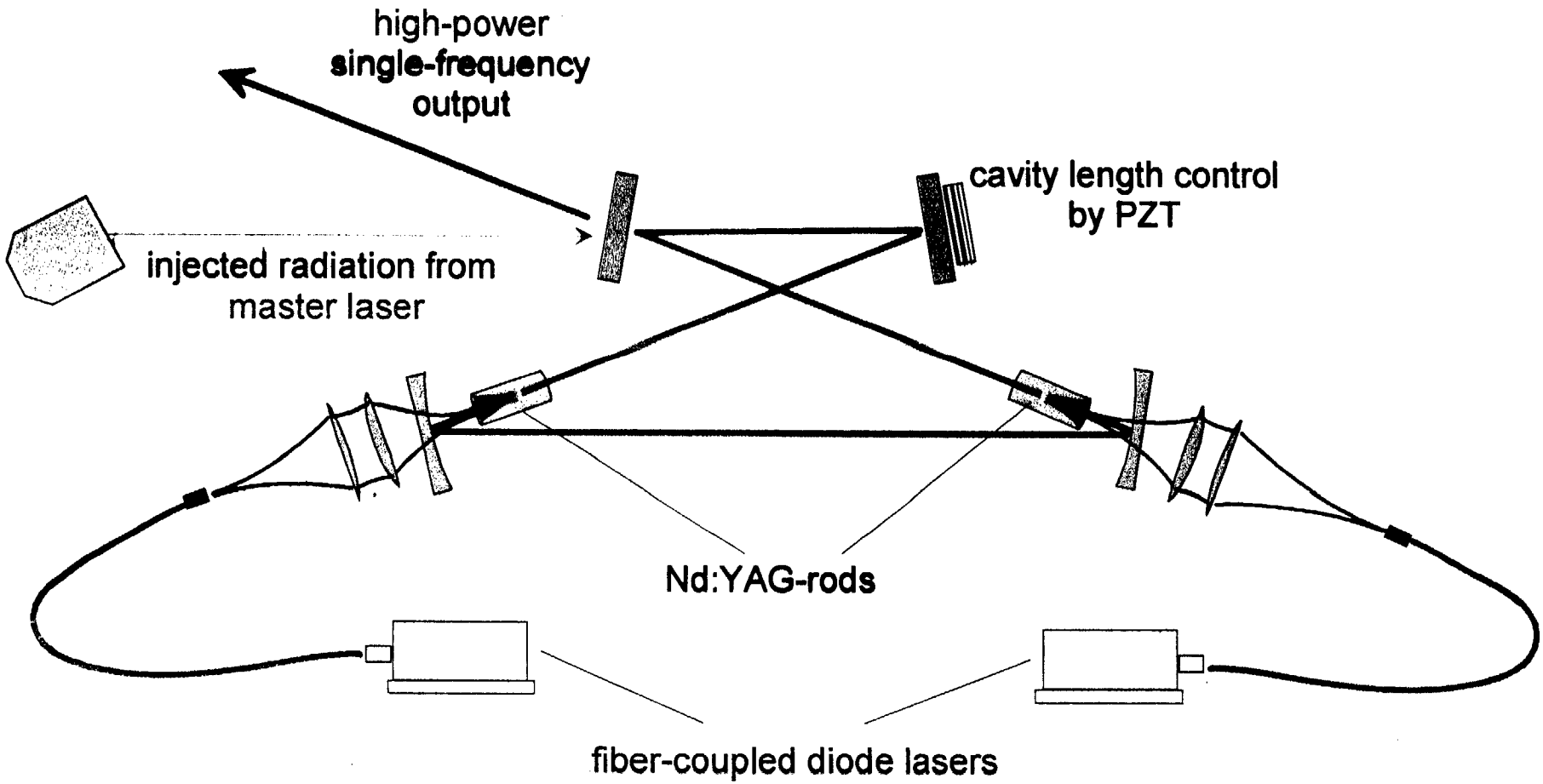
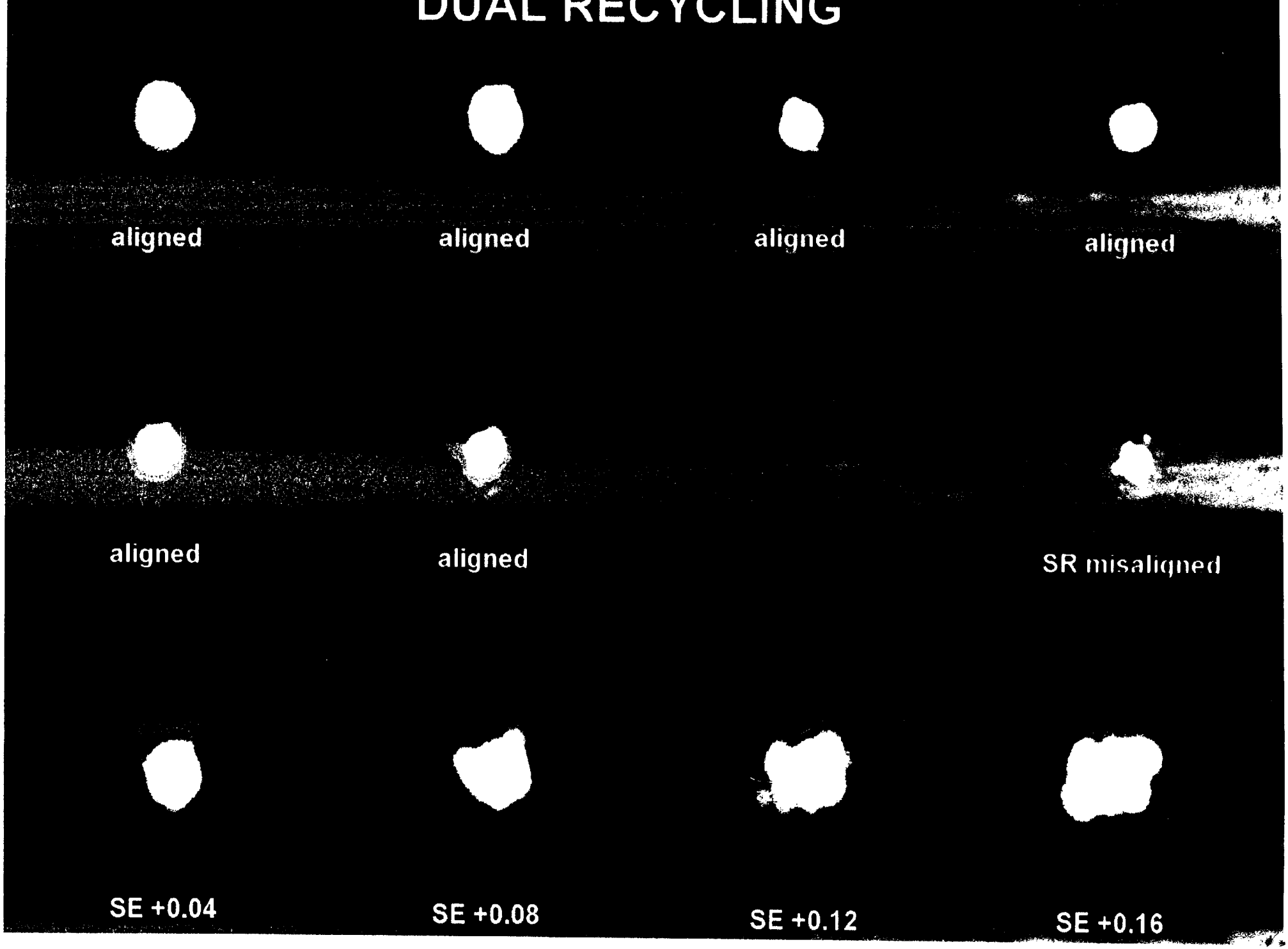
End-pumped slave laser for maximum passive stability



I. Zawischa


DUAL RECYCLING
aligned
aligned
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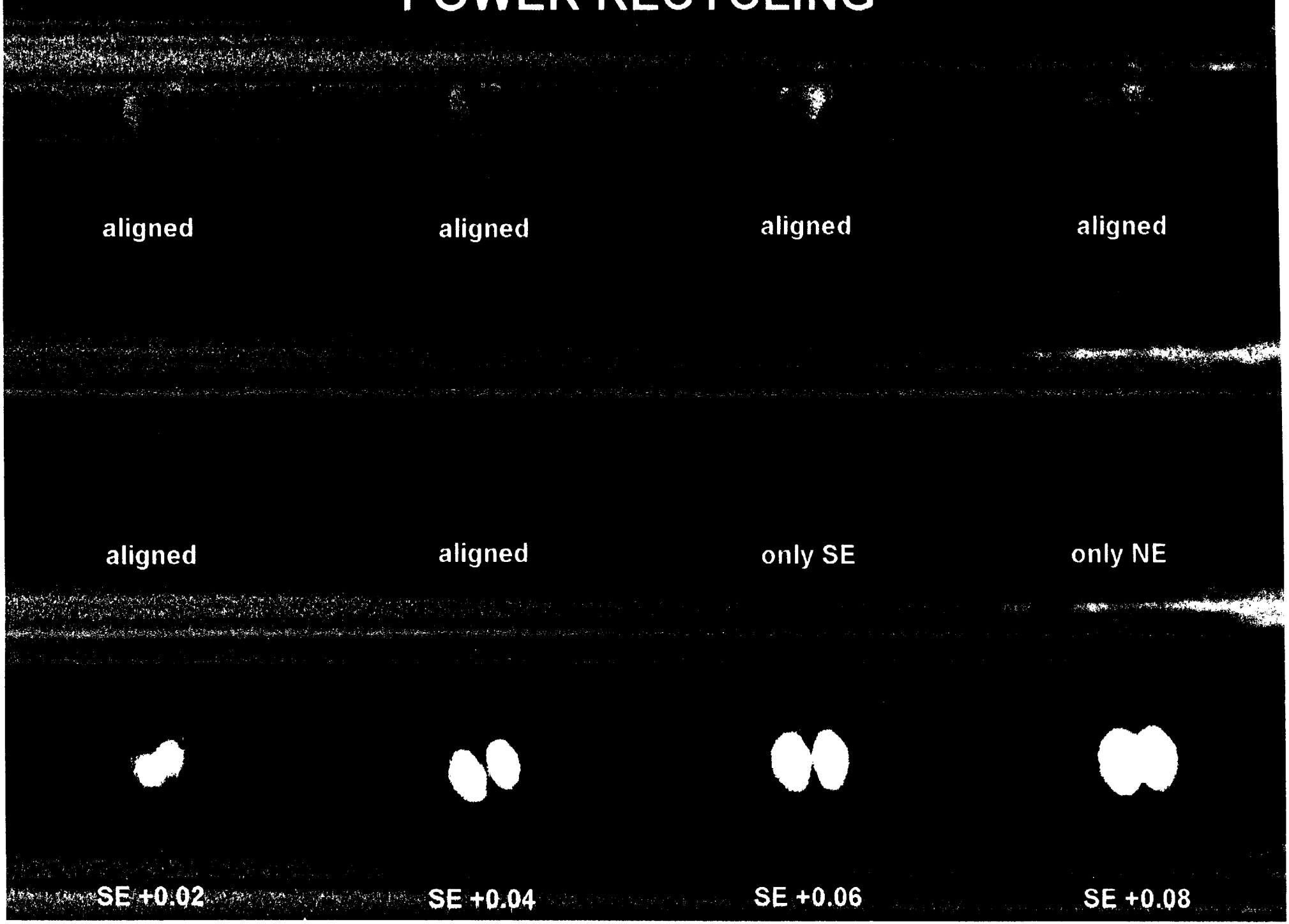
aligned
aligned
aligned
SR misaligned
SE +0.04
SE +0.08
SE +0.12
SE +0.16


aligned
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only SE
only NE
SE +0.02
SE +0.04
SE +0.06
SE +0.08

Update on GEO 600 Activities - University of Glasgow

Norna A Robertson
for GEO 600 team at
University of Glasgow

Research at Glasgow - GEO 600

- Test Mass Suspensions

  Seismic Isolation :
  active pre-isolation stage + stack + triple pendulum + control
  N Robertson, J Hough, M Husman, D Palmer, M Plissi, K Strain, C Torrie

  Thermal Noise Issues :
  fused silica suspensions, bonding etc.
  S Rowan, J Hough, S McIntosh, S Twyford,

- Control - 10 m prototype and GEO 600
  H Ward, M Casey, K Skeldon, K Strain

- Interferometry

  10 m prototype (Glasgow)
  M Casey, D Clubley, G Newton, K Skeldon, K Strain, S Killbourn

  Contribution to 30 m prototype (Garching)
  K Strain, K Skeldon

  LISA (Space)
  P McNamara, J Hough, H Ward,

Aug 1998

Main mirror suspensions:

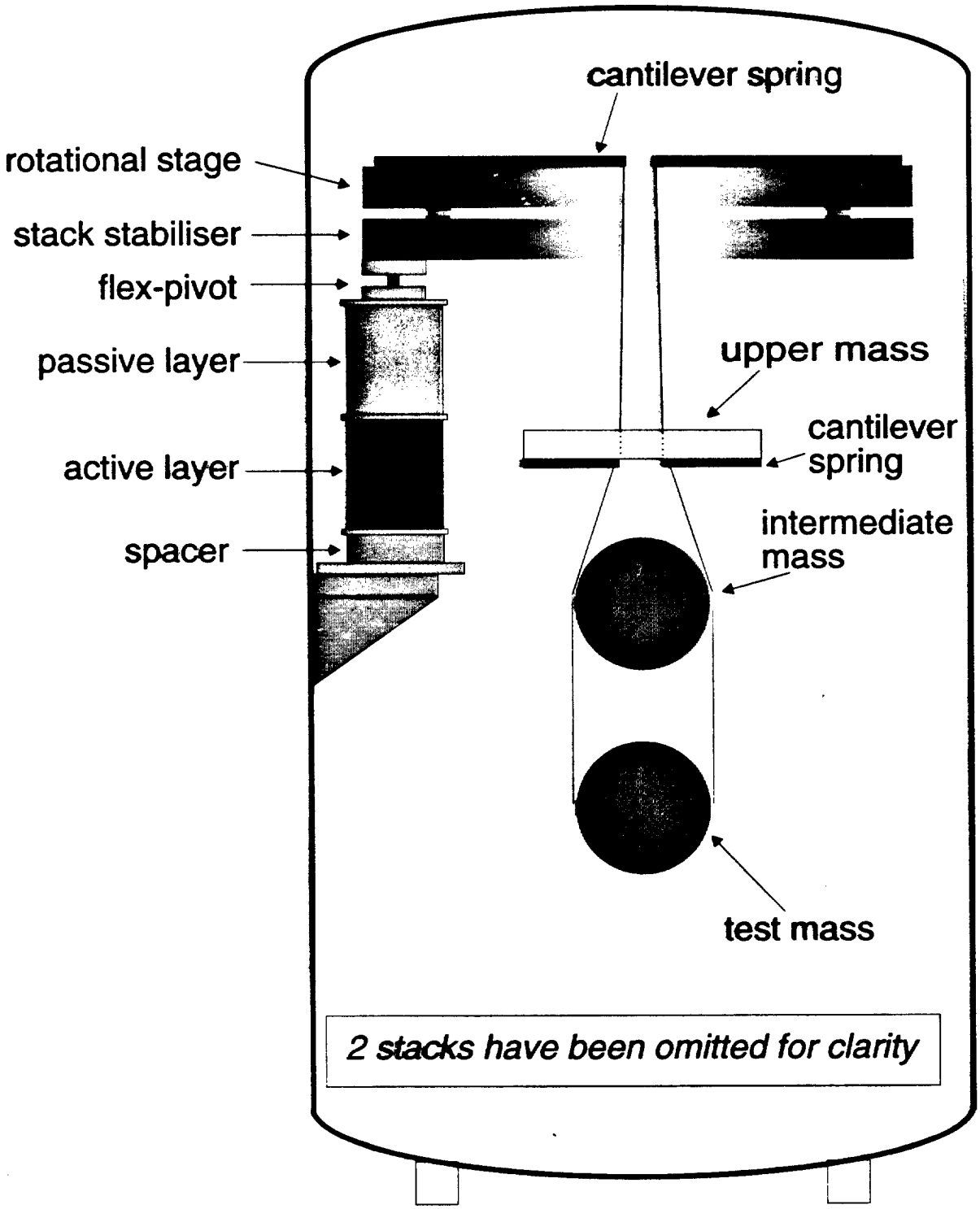
GEO 600 system designed such that it is not limited by seismic noise above 50 Hz

- **Thermal noise level at each test mass of** $(7\times10^{-20}\mathrm{m}/\sqrt{\mathrm{Hz}})$ **at 50 Hz**

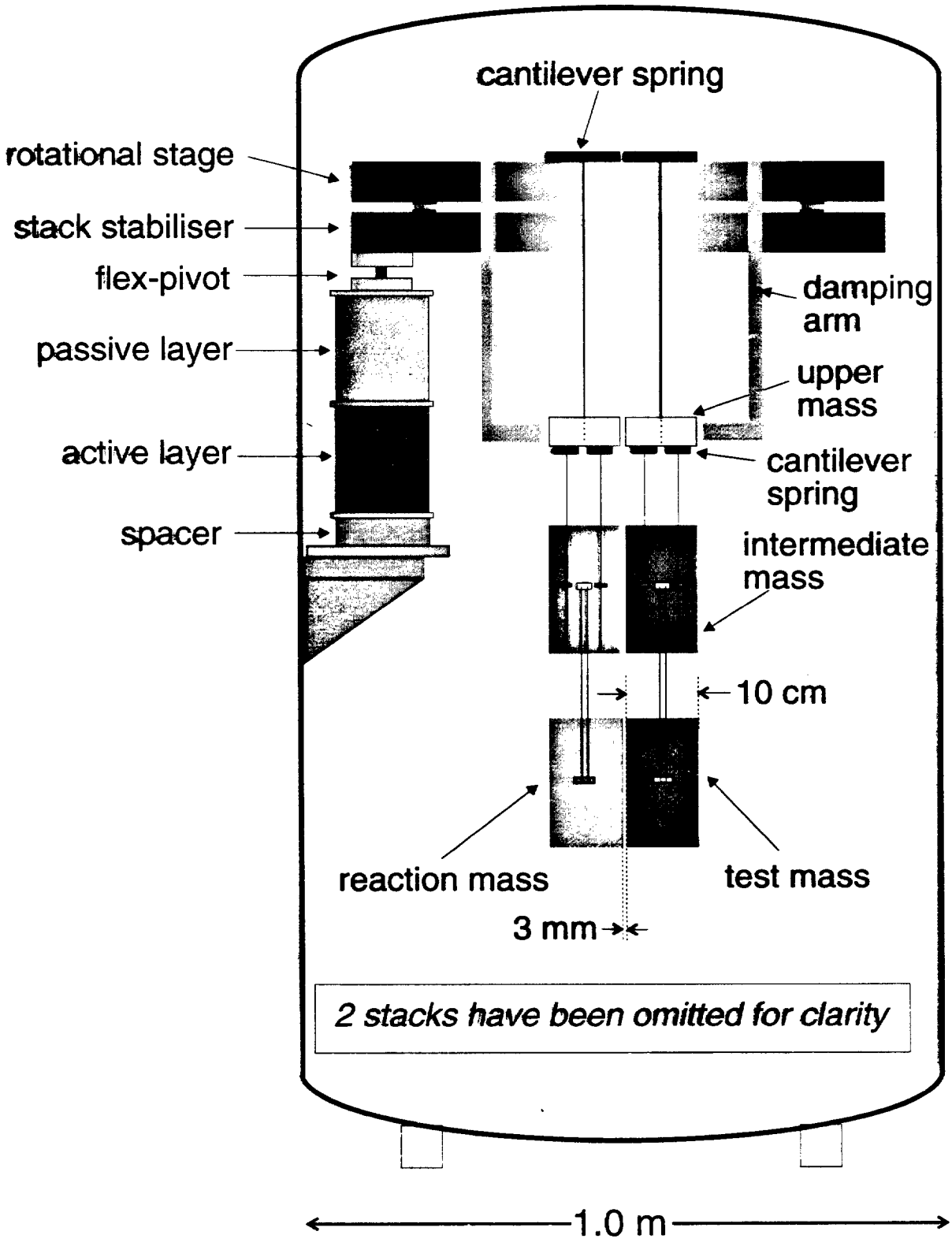
  $\Rightarrow$ **for safety aim to achieve seismic noise level a factor of ~10 less than this**

Elements of suspension design:

- **Active stage plus 1 layer passive stack**
- **Triple pendulum suspension for each optic**
- **2 stages of cantilever springs to improve vertical isolation**
- **Intermediate/test masses made from fused silica with fused silica fibres between them**



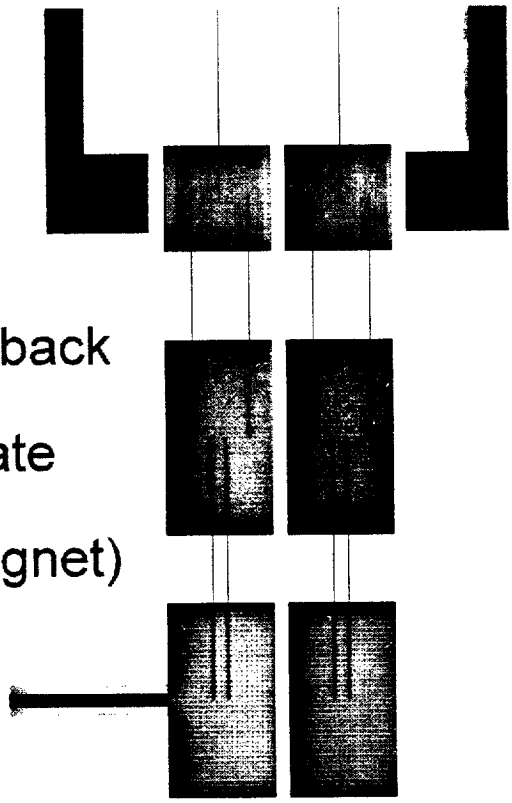
Schematic of test mass suspension (view along optic axis)



Schematic of test mass suspension (view perpendicular to optic axis)

ontrol aspects of GEO 600 triple pendulums

K.A. Strain 08/98
with done with Calum Torrie, Mike Plissi and Matt Husman



local reference

6 dof local control of top stages

0.4 Hz to 5 Hz modes are damped (16)

co-located sensors & actuators

3 dof feedback between intermediate stages (coil & magnet)

main mirror reaction mass

3 dof feedback between bottom stages (electrostatic)

A sophisticated MATLAB dynamical model has been developed to allow design of local control systems and global control actuators

Pendulum modes can be 0.4 to ~ 5 Hz OR >25 Hz.

GEO 600 - specifications thermal noise

- GEO 600 specification ~ 7×10^{-20} m/$\sqrt{\text{Hz}}$ @ 50Hz set by thermal noise from internal modes of test mass; assume:
  - Internal modes $Q \sim 5 \times 10^6$ (set by bulk test mass material)
- Then need:
  - Pendulum modes $Q > 7 \times 10^6$
  - Violin modes $Q > 3.5 \times 10^6$

- Working towards construction of all-fused silica pendulums: 5.6 kg silica masses on fused silica fibres

Measurements show:

- Material Q of suspension fibres:

$Q_{mat} \sim 10^6$

- Pendulum Q of 100g all fused silica (welded) pendulum:

$Q_{pend} \sim 9 \times 10^7$

(for 3 kg mass: $Q_{pend} = 2.4 \times 10^7$: with Univ. Perugia, VIRGO) *

- Violin Q of fused silica fibres:

$Q_{violin} \sim 2 \times 10^7$

All good enough for GEO 600 requirements -

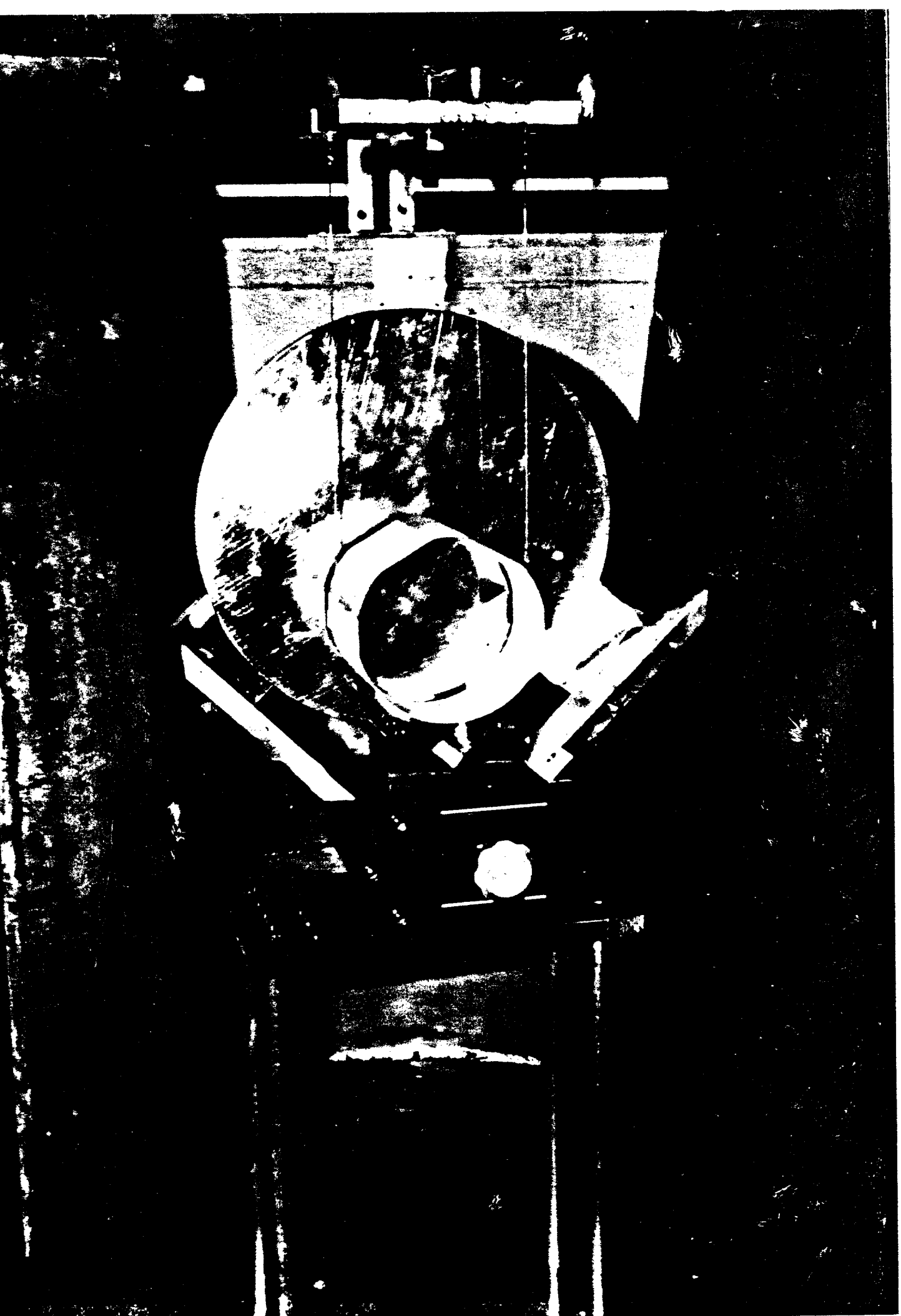
need to continue work on scaling these to larger pendulums

- Work in progress to scale measurements up to heavier pendulums
- Measurements of Q's of pendulum /violin modes underway on 3kg all fused silica pendulum in collaboration with University of Perugia

  (J. Kovalik, S. Rowan, S. McIntosh, J. Hough, L. Gammaitoni)

Q measurements - 3 kg all fused silica pendulum

- Mass formed from synthetic fused silica - Corning 7940
- 2 fused silica pieces jointed to sides of mass using silicate bonding technique
- Fused silica fibres welded to attachments on sides of mass and to fused silica ring at top.
- All fused silica pendulum placed in measurement system in Perugia



Results:

- Pendulum mode Q factor: (48 days)

2.4×10^7 expected ~ 5.2×10^7

(assume fibre $Q_{mat} = 6 \times 10^5$ including effect of thermoelastic damping for d ~ 650μm)

- Violin mode Q factors:

342Hz - 5.7×10^6
629Hz - 1.7×10^6
920Hz - 1.5×10^6

- bifilar torsional pendulum mode Q - preliminary results:

1.9×10^7 (expected = 2.6×10^7)

Glasgow Prototype Computer Automation - Recent Developments

LabVIEW (National Instruments Corporation) used as software development package

Supervisory computer control philosophy adopted

Cavity longitudinal control servos interfaced to computer via digital lines

Automation of 3 cavities achieved June 1998

Remote access (using TCP / IP) to Prototype automation program achieved June 1998

Prototype software directly applicable to GEO 600

Future plans: auto-alignment of cavity mirrors, GEO 600 subsystems software testing

Future Experiments on the Glasgow Prototype Detector

- re-suspension of secondary reaction mass and changes to actuators under way, in order to allow improvements to sensitivity, especially at low frequency

- implementation of infra-red laser and optics to obtain even better sensitivity and test GEO suspension designs

- redesigned prototype can be used as facility to investigate split feedback techniques and other control issues

- option of expanding blocks of the computer control to allow development and demonstration of further aspects of remote operation for GEO600

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Advanced Features of GEO600 - exportable to other detectors

- Recycling of the output back into the system (signal recycling) - enhances narrowband performance
- Triple pendulum suspension system with "monolithic" fused silica final stage - uses new silicate bonding technique for joining suspension fibres to test masses. Technique developed for GPB experiment at Stanford - extended by GEO

Note 1, Linda Turner, 08/20/98 01:01:14 PM
LIGO-G980113-16-M