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CONTROLS PROTOTYPE ETM SUSPENSION

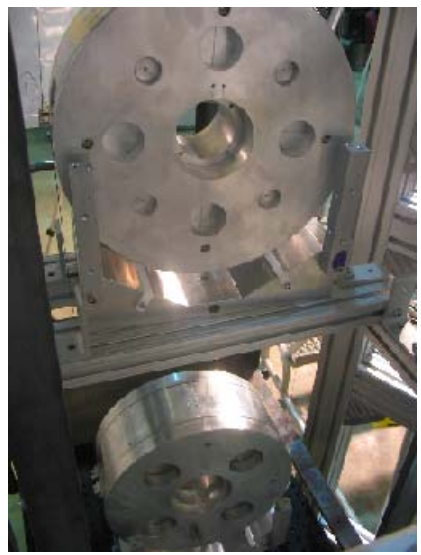
Sub-assembly, procedure/tooling development and associated testing, leading to the build of the suspension prototypes

Calum I. Torrie

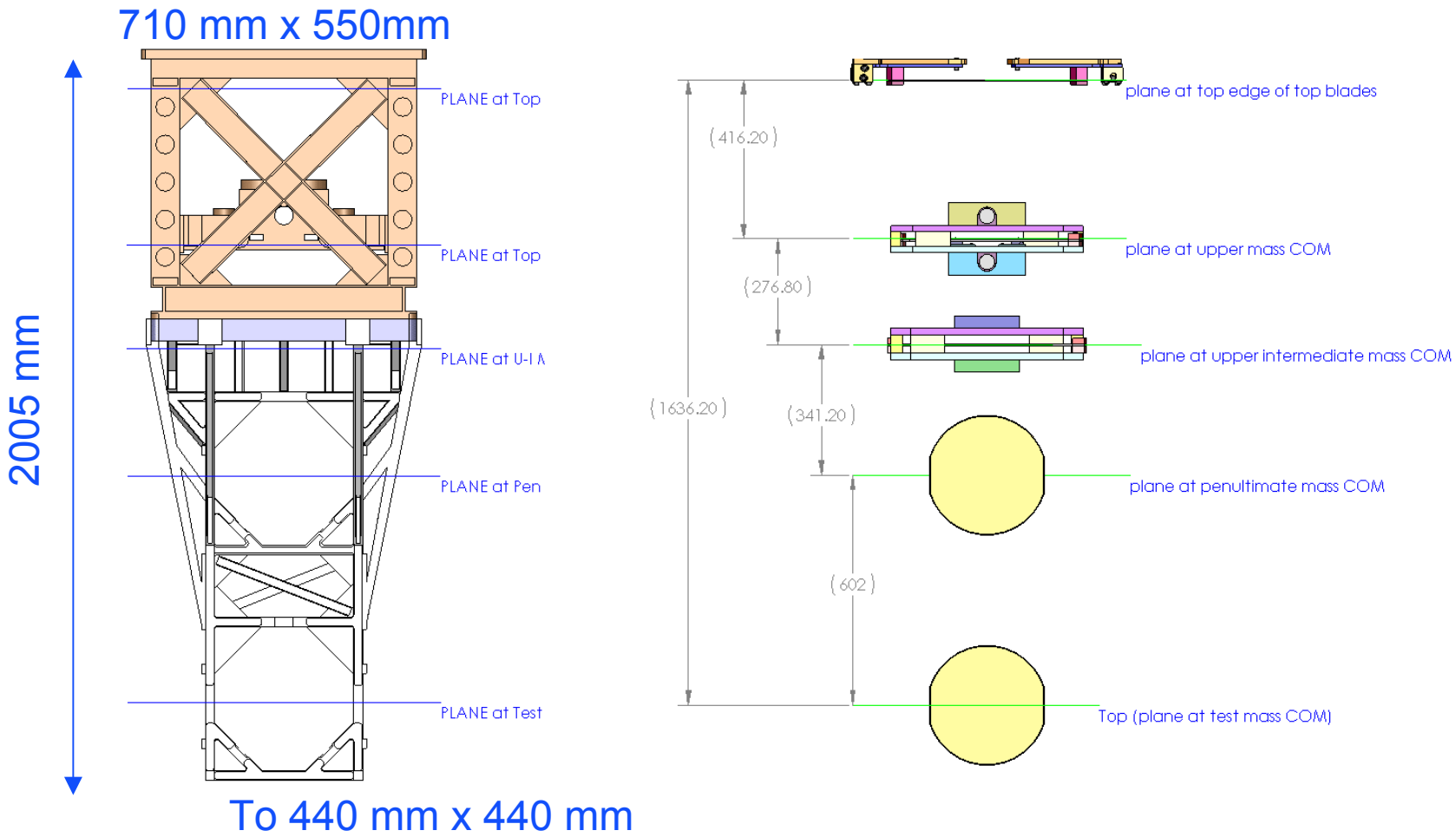
for the advanced LIGO SUS team

G050175-00

LSC, March 22nd 2005



Layout of the Controls prototype, reference LIGO-T010103



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Cf. 418 kg from LIGO-T030137

Controls Prototype Mass Budget

- UPPER
  - » TOP MASS, 22 kg x 2 (S) = 44 kg
  - » Tablecloth etc … (NS) 15 kg + 25 % C = 19 kg
  - » Top Stage (NS) 24 kg + 25 % C = 30 kg
  - » Ring (NS) 5 kg + 100 % C = 10 kg
  - » UPPER STRUCTURE 37 kg + 25 % C = 46 kg
- LOWER
  - » UI MASS, 22 kg x 2 (S) = 44 kg
  - » PEN MASSES, 40 jg x 2 (S) = 80 kg
  - » TEST MASSES, 40 kg * 2 (S) = 80 kg
  - » CLAMPING etc, 23 + 25 % C (NS) = 29 kg removable ?
  - » Ring (NS) 5 kg + 100% C = 10 kg
  - » Lower Structure (NS) 23 kg + 25% C = 29 kg

TOTAL = 422 kg

OVERALL NON-SUSPENDED inc. STRUCTURE ~ 140 kg *

18th March

8kg

30kg

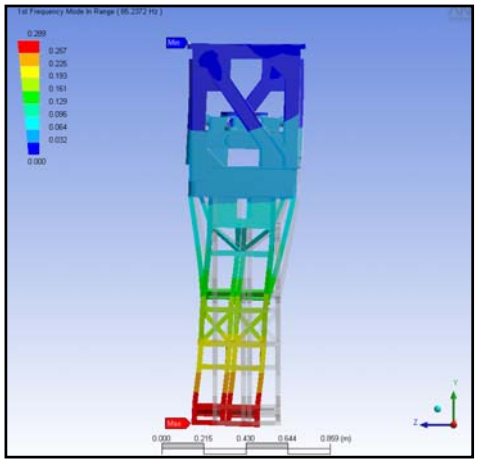
42kg

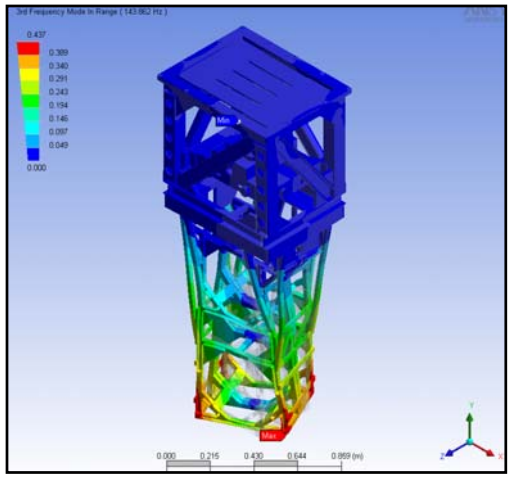
6kg

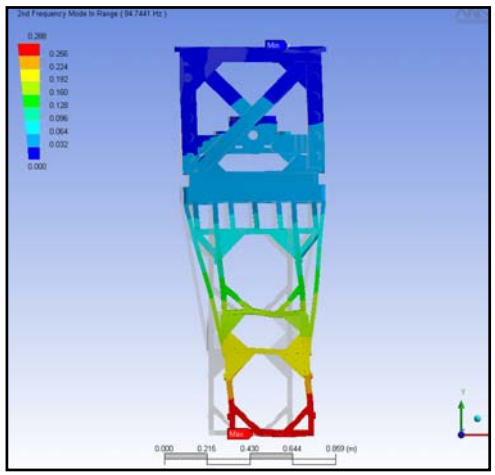
50kg

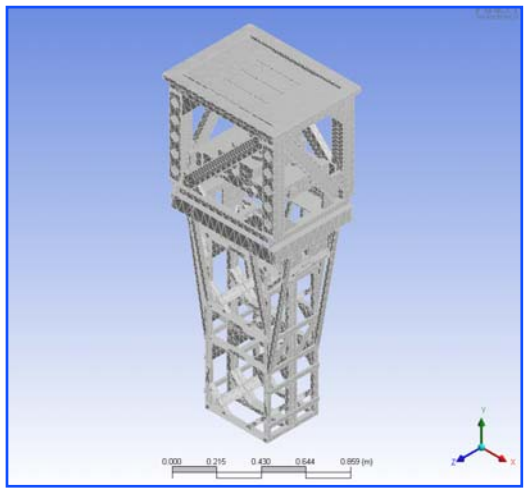
136 kg

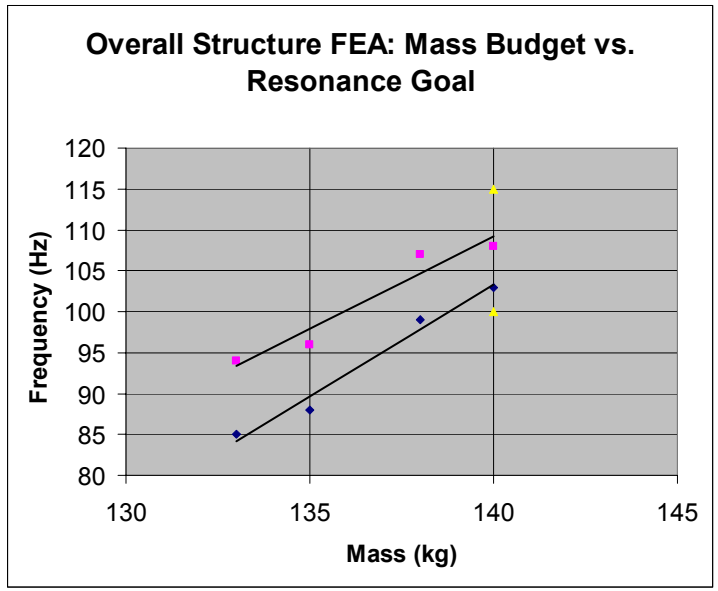
Overall Structure Modeling, reference LIGO-T040214 and T040198



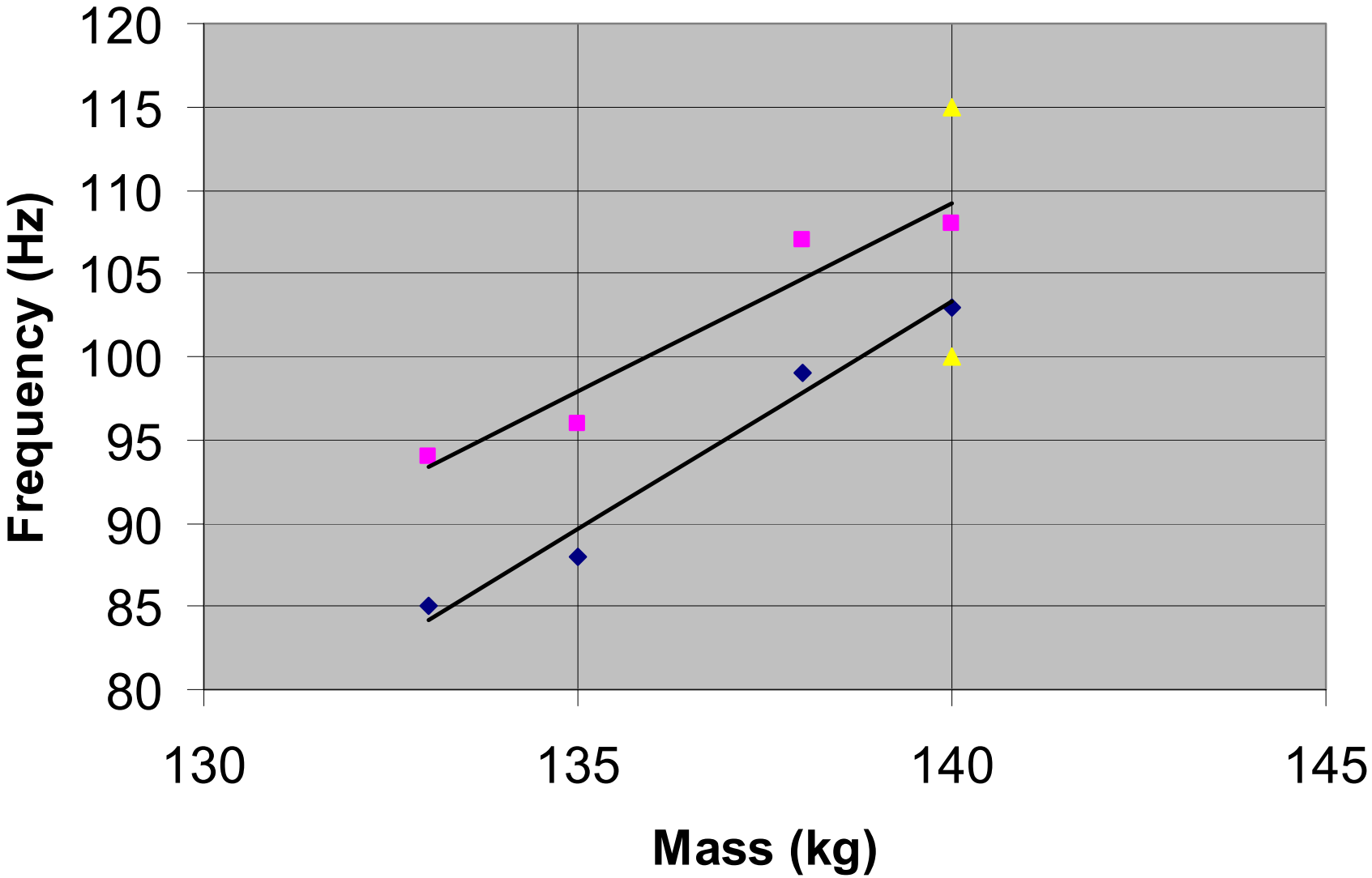








Overall Structure FEA: Mass Budget vs. Resonance Goal



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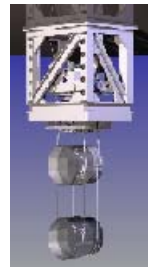
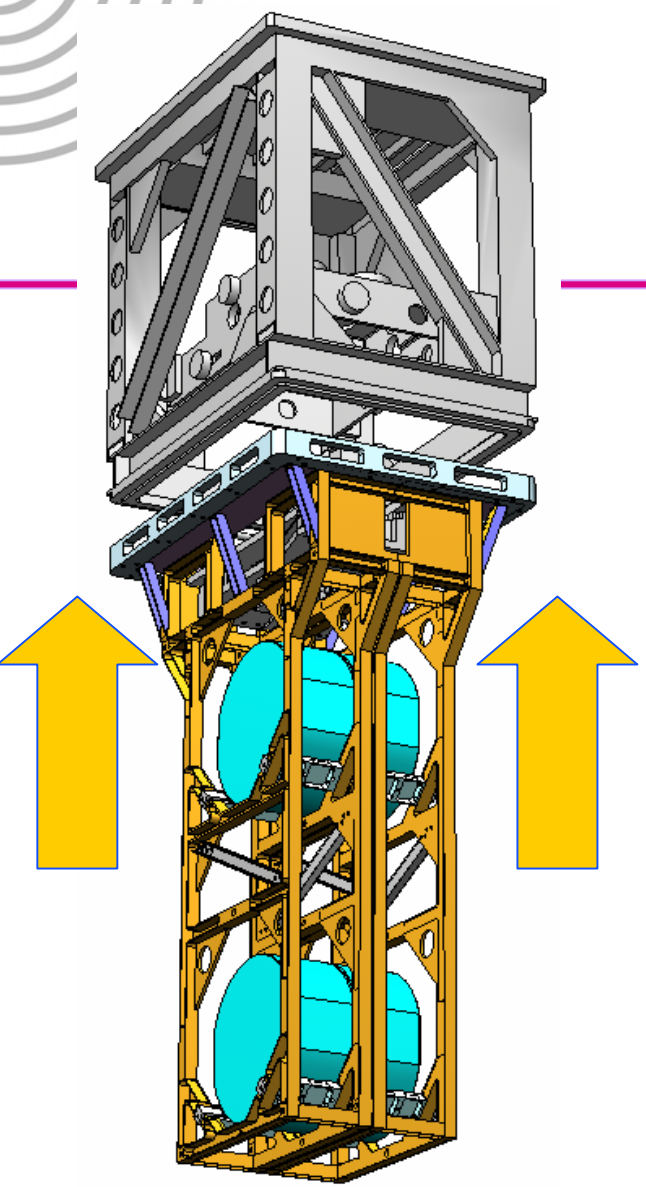
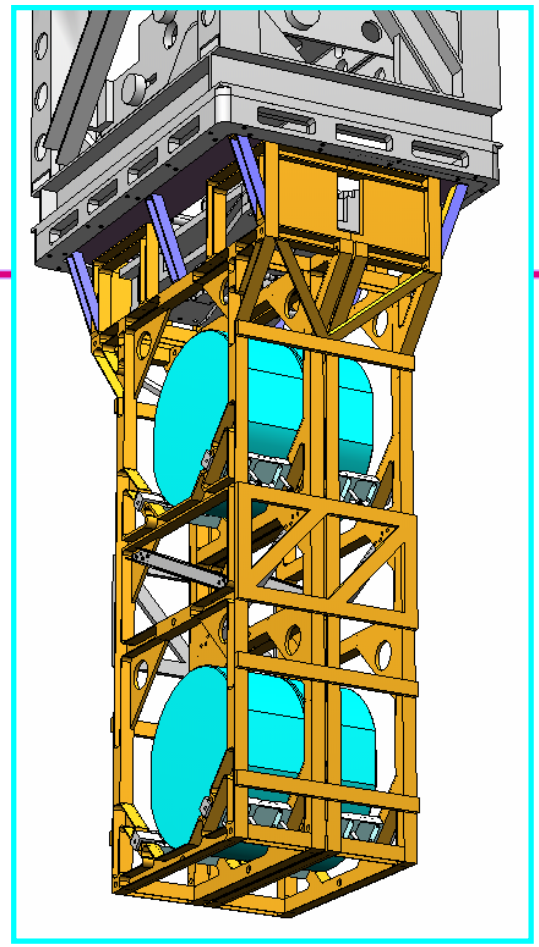
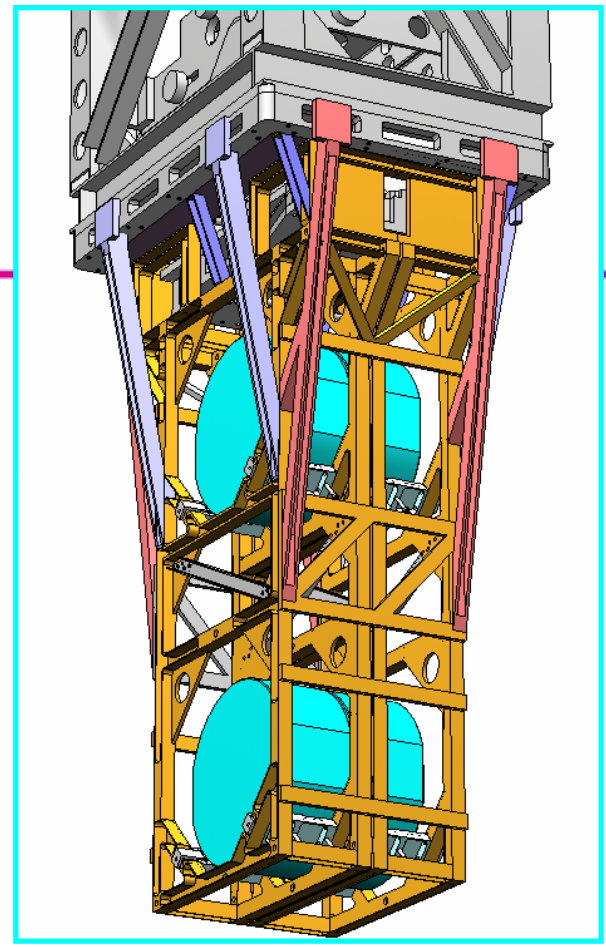
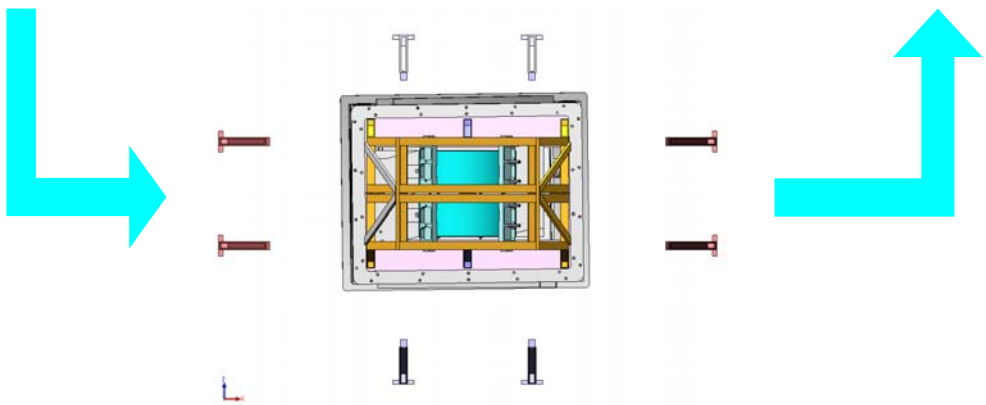
“3 & 1” assembly Technique, reference LIGO–T050034











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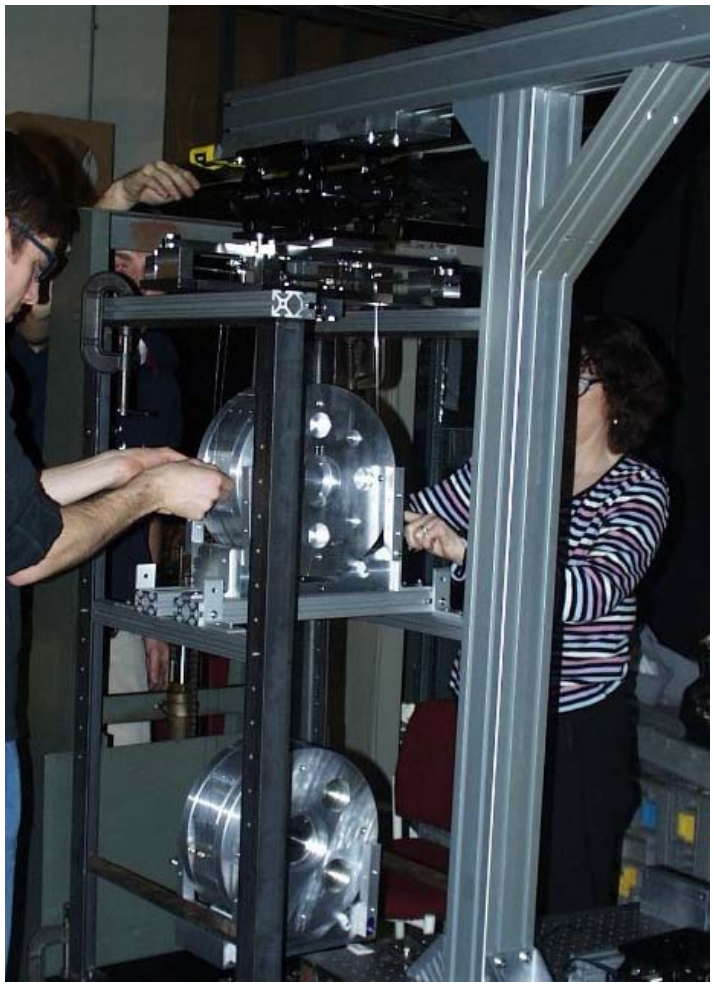
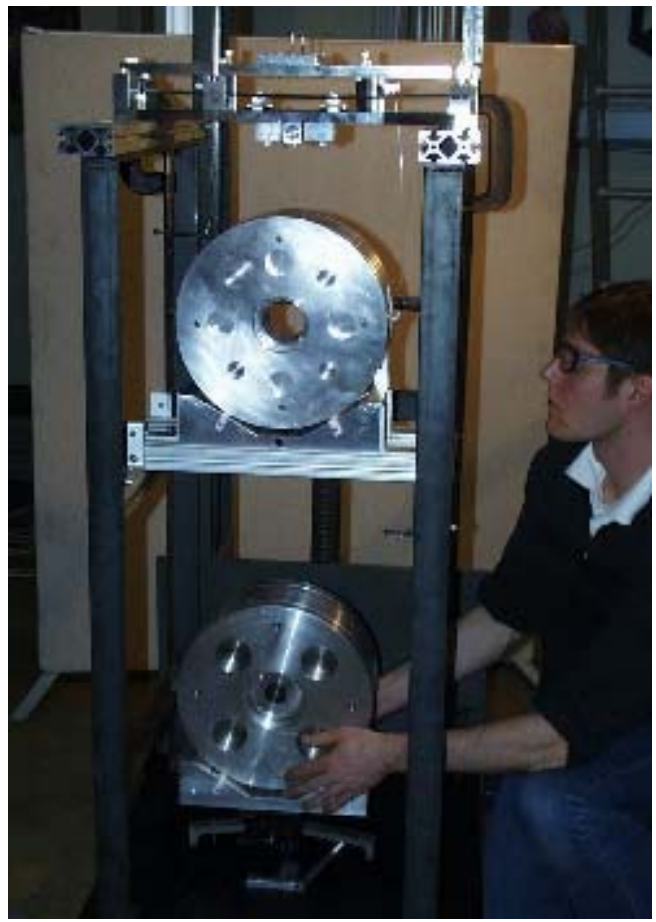
“3 + 1” Assembly Technique





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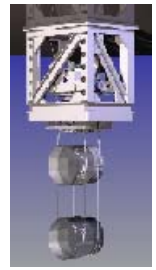
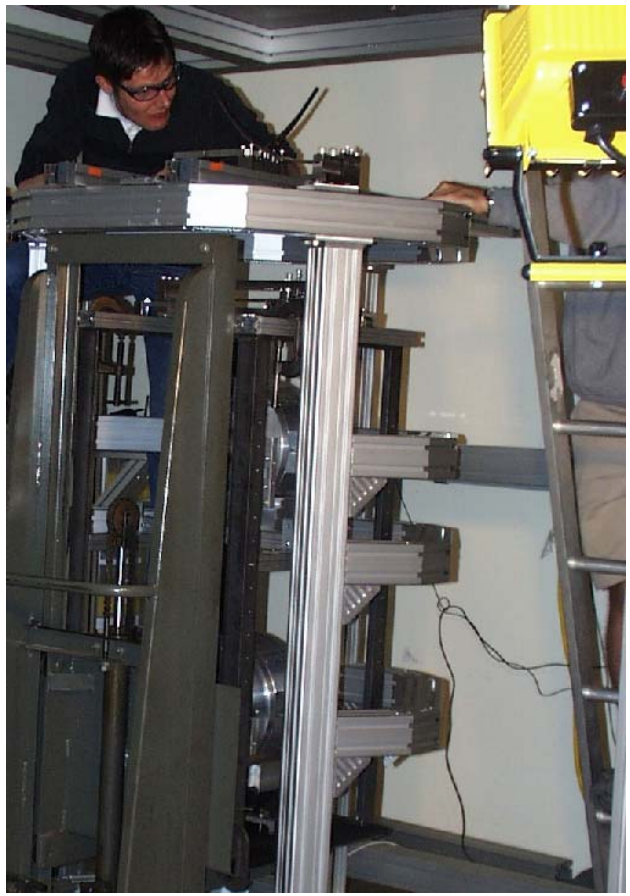
“3 & 1” assembly Technique



- 28 mm range confirmed!
  - » extended by pushing down the blades



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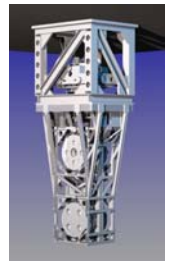
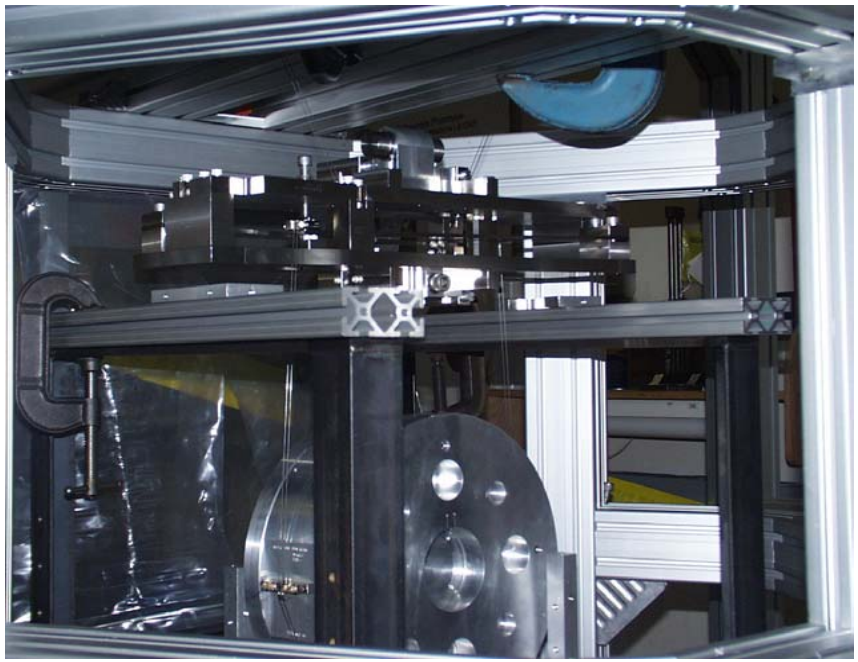
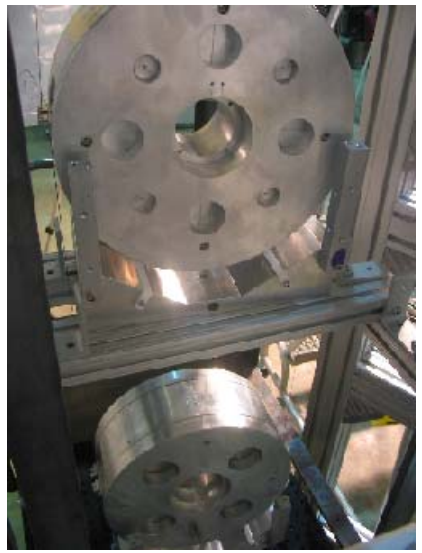
The Quad as a Triple







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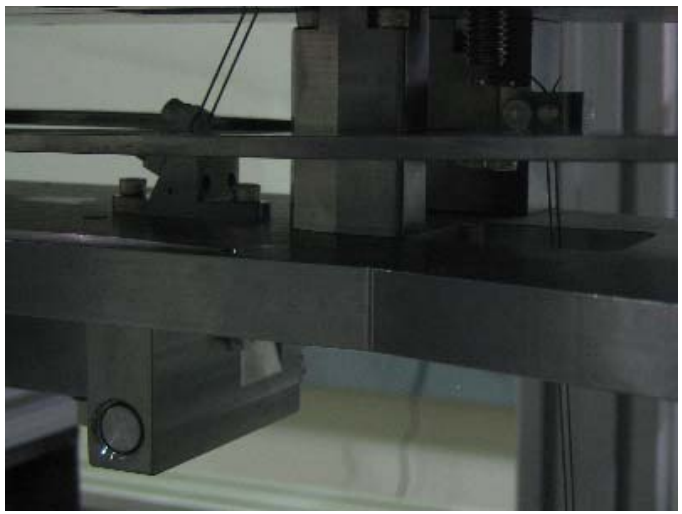

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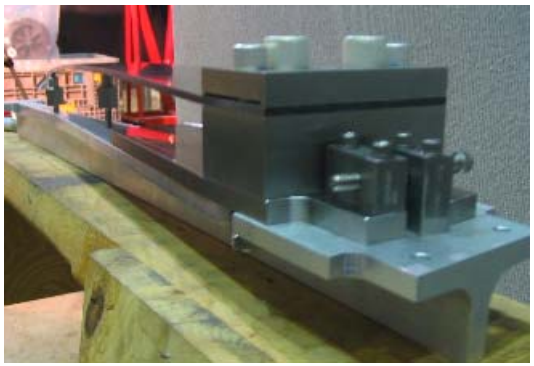
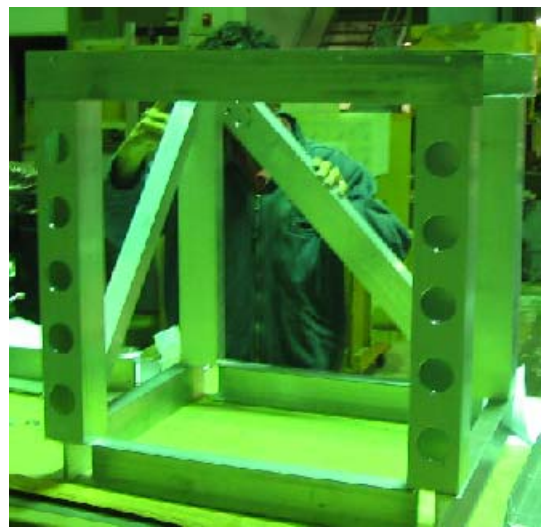
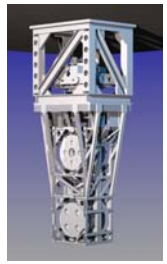
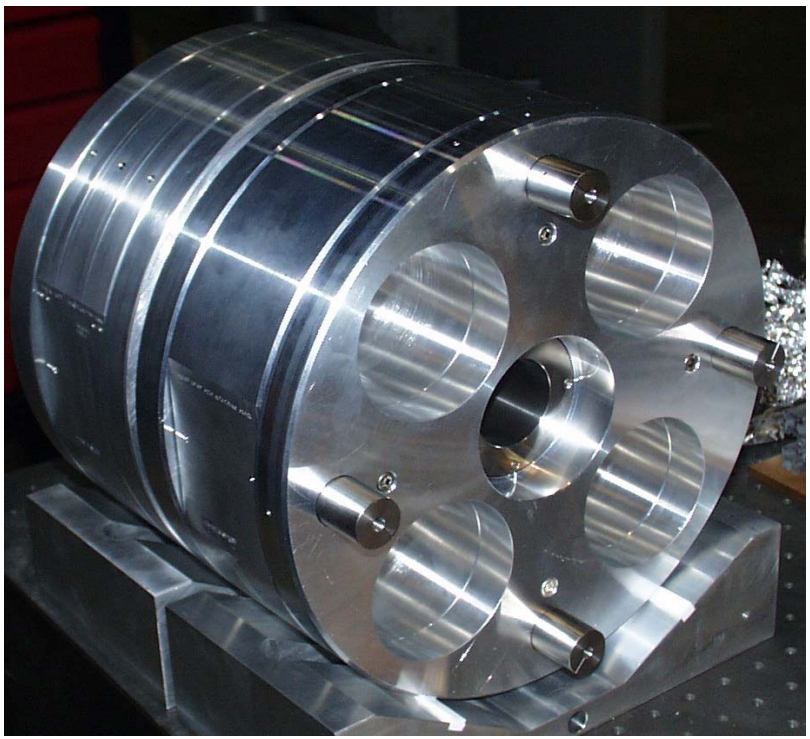
Building to a Quad

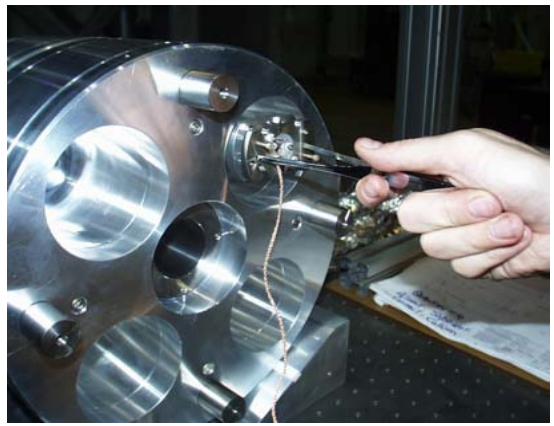


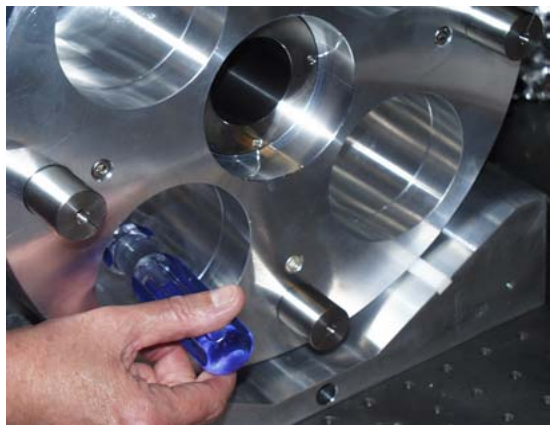


Assembly of the lower masses (Penultimate Masses)









reference PDS, LIGO-T040013

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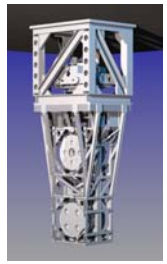
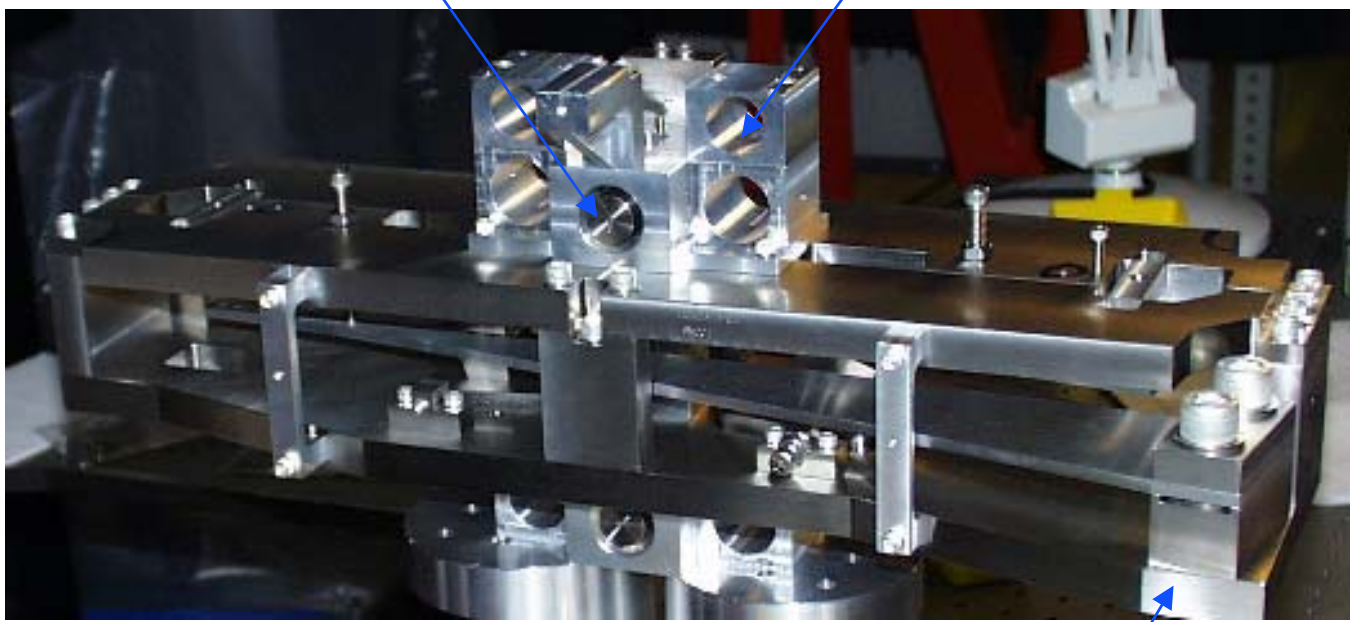
Assembly of the Top Masses





- reference assembly and PDS, LIGO-D040350

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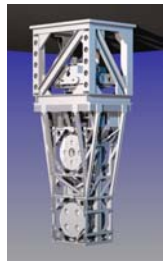
Spring Steel Wire



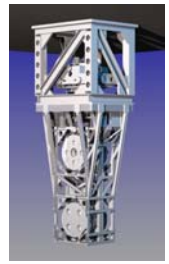
- Spring Steel Wire
  - California fine wire Company & Knight Precision
  - B.S. ~ 2 e 9 Pa
  - Storage (rust) and handling (“kinks”) important
  - Working at 1/3 B.S. (all wires tested in clamps)
  - Heat

» Top stage 2 wires ø 1.1mm
  - Switch to double nail ended wires for C-Ptype

» Upper intermediate stage 4 wires ø .7 mm
  - Okay! Consider double nail ended wires for C-Ptype

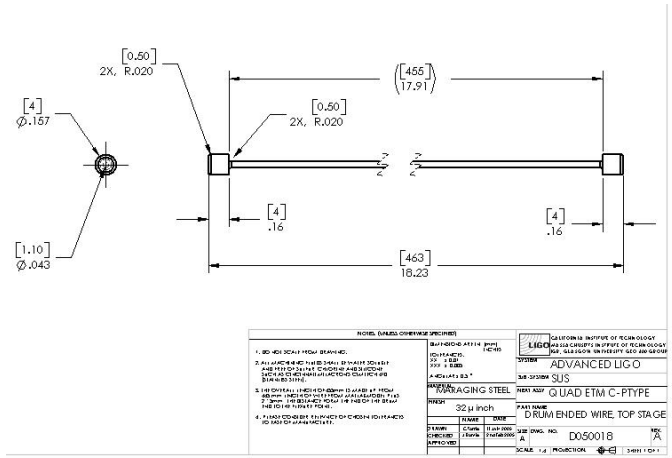
» Penultimate Stage 4 wires ø .6 mm
  - Okay! Consider double nail ended wires for N-Ptype

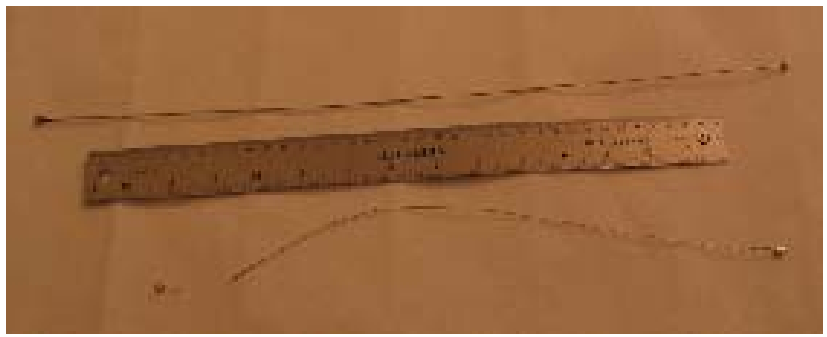
Double Nail Ended Wires



Measurements

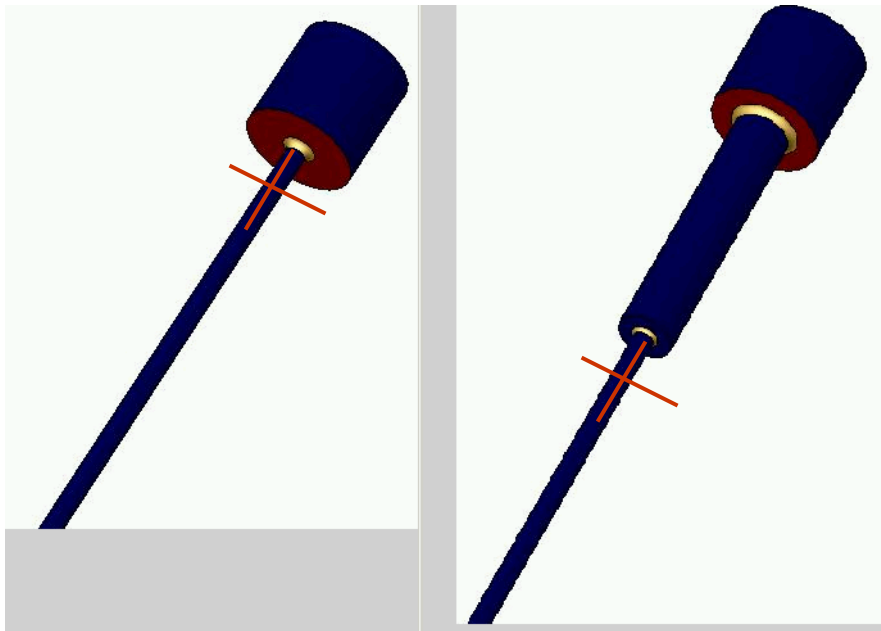
- Breaking Stress
  - » Theoretical Breaking Stress B.S. = 1.6e9 Pa (ref VIRGO)
  - » Measured B.S. = 1.4e9 Pa
    - – Measured data point
  - » c.f. Spring Steel 2.0e9 Pa
  - » Recommendations
    - – thicker wires,
    - – safety factor 2.75 instead of 3
    - – and work on B.S.
- Hardness – difficult!
- Reference LIGO-T050049





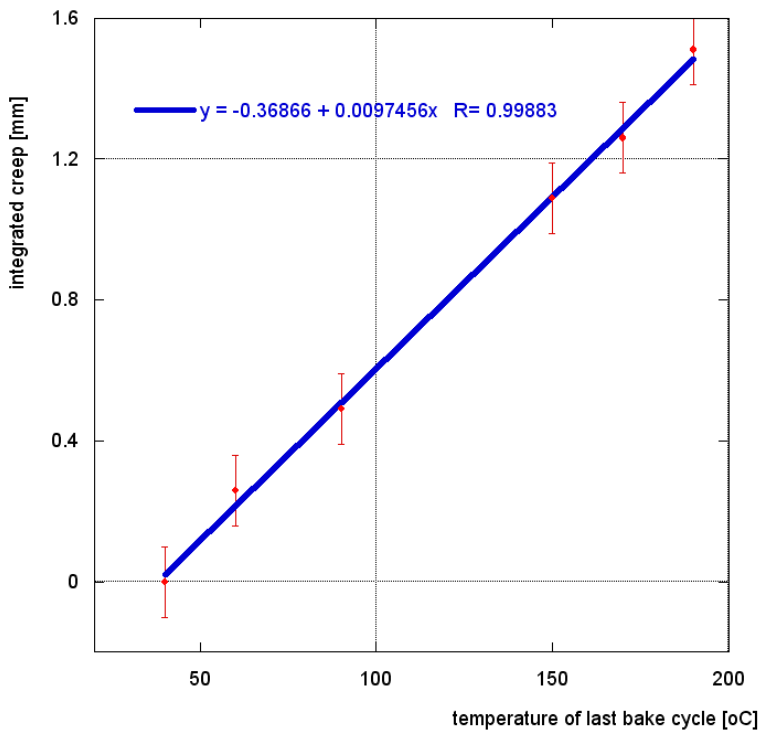
Modified Double Drum Ended wire for Upper Intermediate Stage

- Real Estate issue between the wire clamps & the blades
- Incorporate double drum ended wire
  - » Heads Ø 4mm, Length = 4mm
  - » Extra Drum Ø 2mm, Length 10mm
  - » Wires Ø .7mm, length ~ 300m
- FEA in process
- reference LIGO-T050049



Pre Processing and procurement of the blades

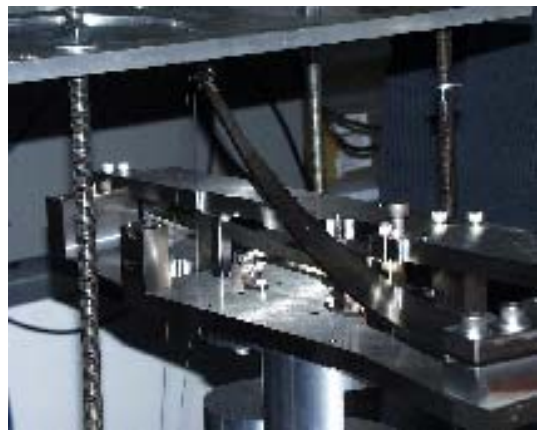
- Creep in maraging steel cantilever blades
  - » Short term creep and hardness
    - – 4 hour heat treatment extended to 100 hours
  - » Long term creep
    - – recommend baking out all stresses Maraging blades at a temperature comprised between 100 and 200oC for a week,
      ref LIGO – T050047 by Nicky Virdone et al
- Careful storage of material
- Blades manufactured
  - » Caltech Machine Shop and
  - » VP (less strict requirements)

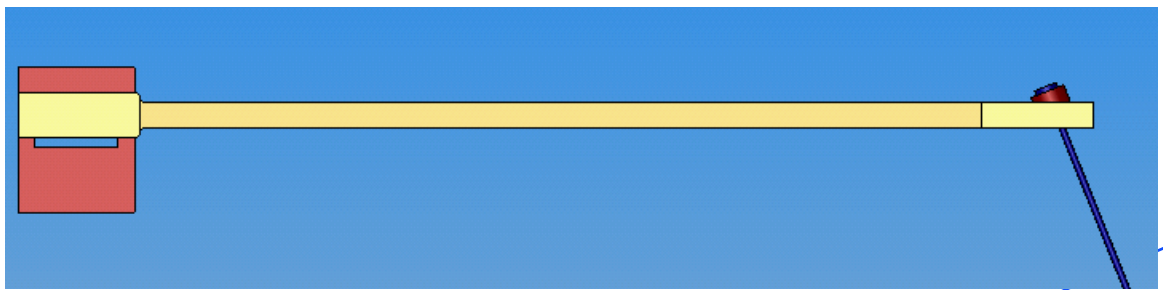


ref LIGO REPORT, T050047 by Nicky Virdone et al

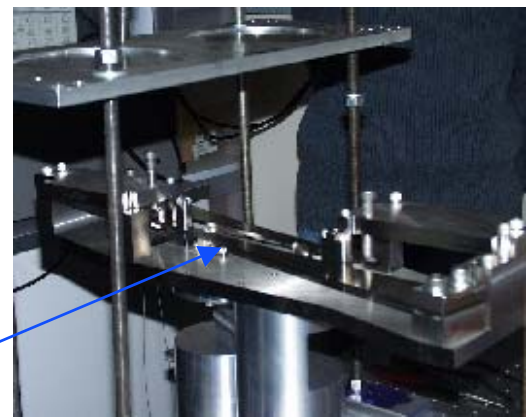
Post Processing and selection of blades

- Hardness (in Rockwell C)
  - » Sample
    - – Before hardness ~ 32
    - – After precipitation ~ 55
  - » Actual CES C Ptype Blades
    - – After precipitation ~ 55
- Data characterization
  - » 1 per set failed inspection
  - » All passed a within 1mm criteria of going back to their original shape after loading
  - » Sets selected for C Ptype with matched “stiffness” and skimmed clamps
  - » Blade frequencies
  - » Reference **LIGO–T040229**





D040296-005 with .86 degree clamp



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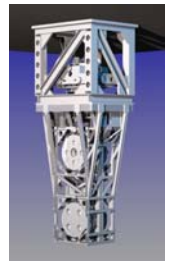
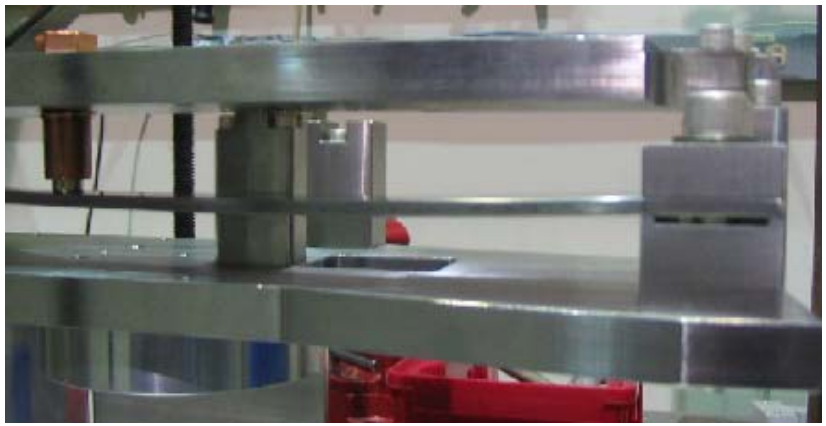
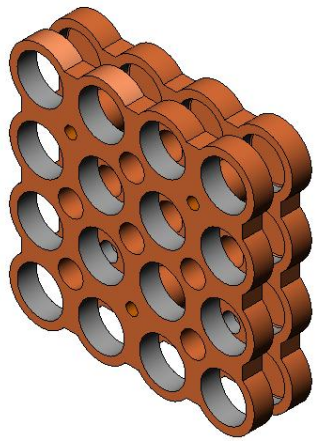
EDDY CURRENT DAMPING



- Bottom blades
  - » Resonance ~ 112 Hz
    (2nd March)
  - » With 2.5 magnets on the blade and copper on the mass
    - – Q ~ 25 (in air)
  - » Reference LIGO-T050050

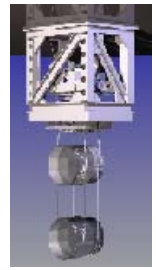


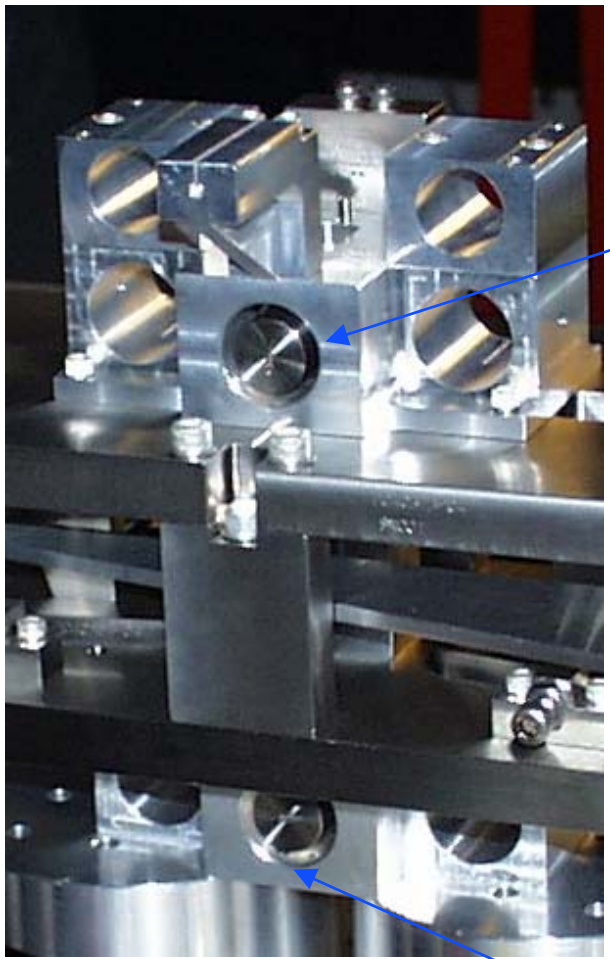
- Suspension ECD
  - » 1 4x4 array 27 kg/s
  - » Looking at Lightweight copper design and in situa adjustment

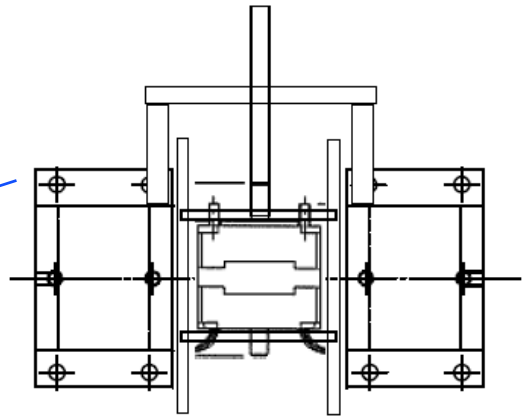


Review of Scientific Instruments -- November 2004 -- Volume 75, Issue 11, pp. 4516-4522
M. Plissi, C. Torrie, M. Barton, N. A. Robertson A. Grant, C. A. Cantley, and K. A. Strain P. A. Willems and J. H. Romie K. D. Skeldon M. M. Perreur-Lloyd, R. A. Jones, and J. Hough An investigation of eddy-current damping of multi-stage pendulum suspensions for use in interferometric gravitational wave detectors

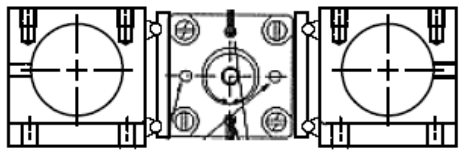
Noise Prototype

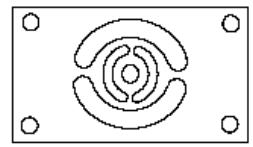






MOTOR AML B14.1 WITH THREADED M5 SHATF (IT EXISTS)
GLIDING ON 4 BARS.
THE THREADED SHAFT SCREWS IN A DRILLED AND TAPPED PEEK PLATE





- Vacuum motor by A.M.L.
- reference LIGO-T050051

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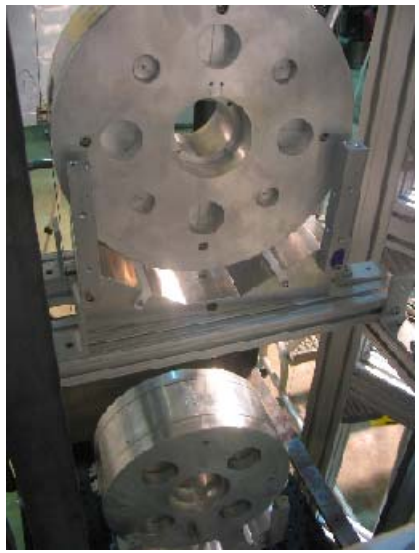
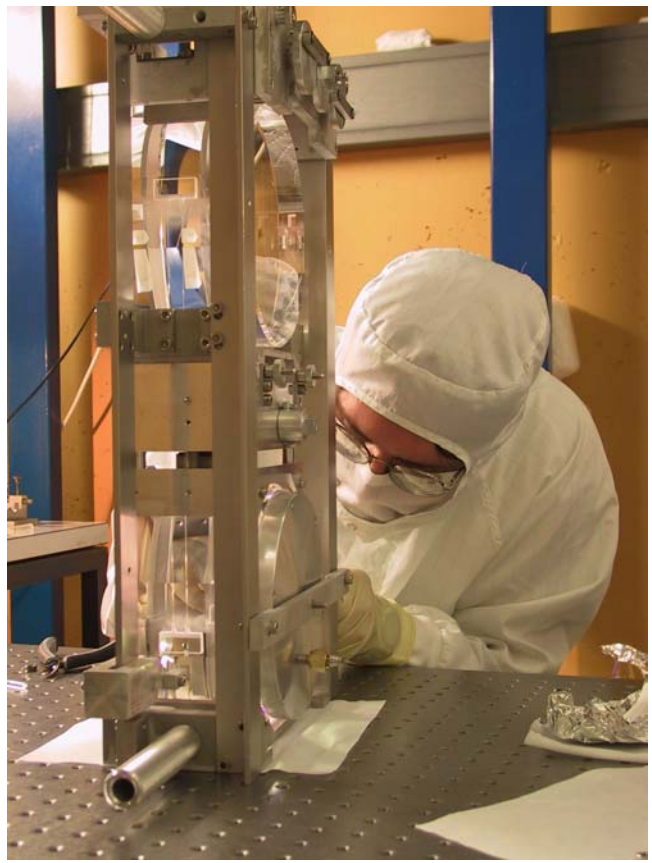
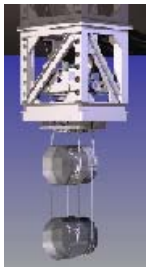
Noise Prototype

- Penultimate to Upper intermediate mass
  - » interface between glass and metal
  - » Fibres / ribbons inside metal wires
- Use of double nail ended wires
  - » Loop or
  - » Interface with ear?

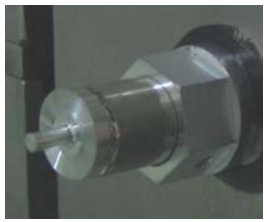




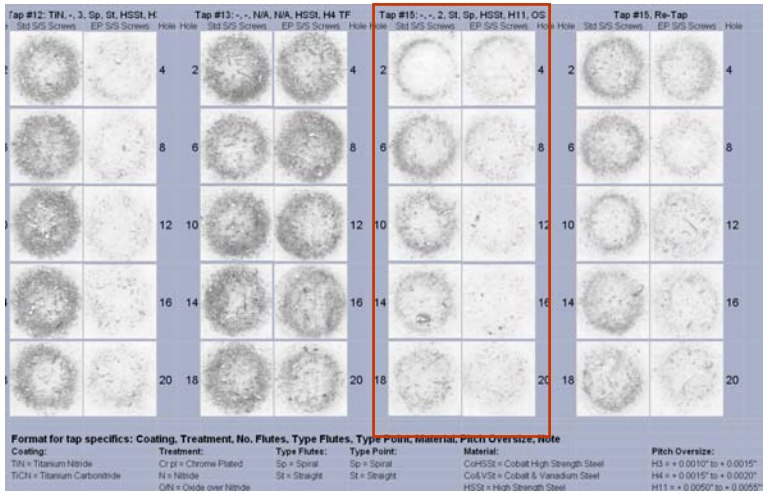
Working above glass and in clean conditions

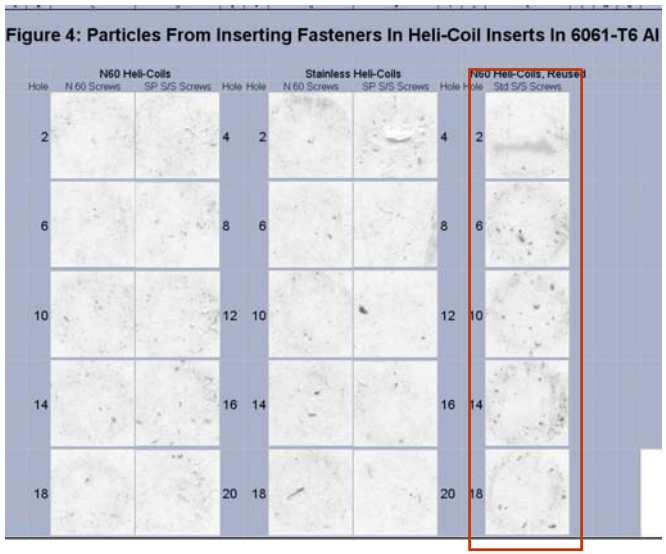


- Modified magnet assemblies



- Captive screws & “Safety net”
- Modified Allan wrenches & Wrist bands for tools
- Reducing galling and dust, reference LIGO-T040111
  - » .005 oversize taps in steel with silver plated screws
  - » Nitronic 60 inserts in Aluminium for parts that are expected to be disassembled
  - » Relax requirement on cutting fluid?





SURF PROJECT: - Test Machine for double nail ended wires *

* On loan at Caltech from VIRGO Summer 2005

VISITORS + STAFF AT CALTECH