Prototype Quadruple Pendulum Update – Part 1

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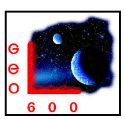
for the GEO 600 suspension team

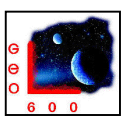
LSC Meeting, Hanford, 14 August 2001
Sus/Isol Working Group Session

LIGO-G010291-00-Z



Baseline Design for Adv. LIGO suspensions

- Fused silica ribbons suspending 40 kg sapphire mirror – lowest mass in quadruple pendulum
- Quadruple pendulum incorporating 3 stages of enhanced vertical isolation using blades
- local control sensors/actuators or eddy current damping on top mass
- overall length ~ 2 m
- all locally controlled freqs. in range ~0.4 - 5.5 Hz
- global control above 0.01 Hz, split between 3 controllers on 3 lowest stages, acting against quad. reaction pendulum



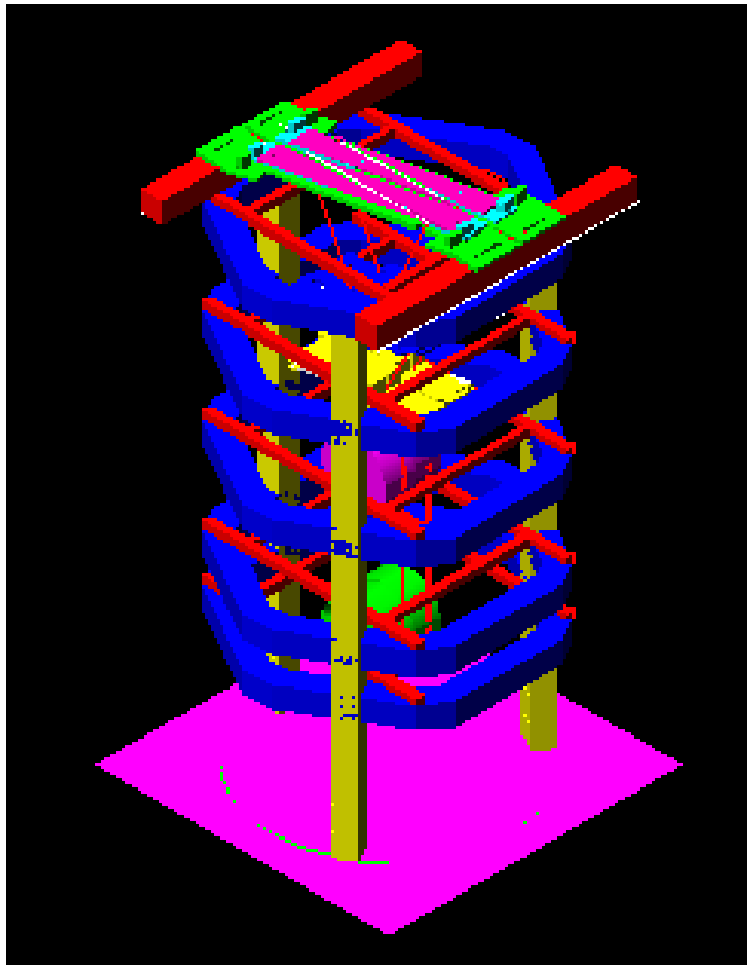
Mechanical Design – first steps

- Design of prototype all-metal quadruple pendulum and reaction pendulum and Bosch support frame carried out in Glasgow (Torrie et al): masses (top to bottom) 15, 15, 16, 30 kg.

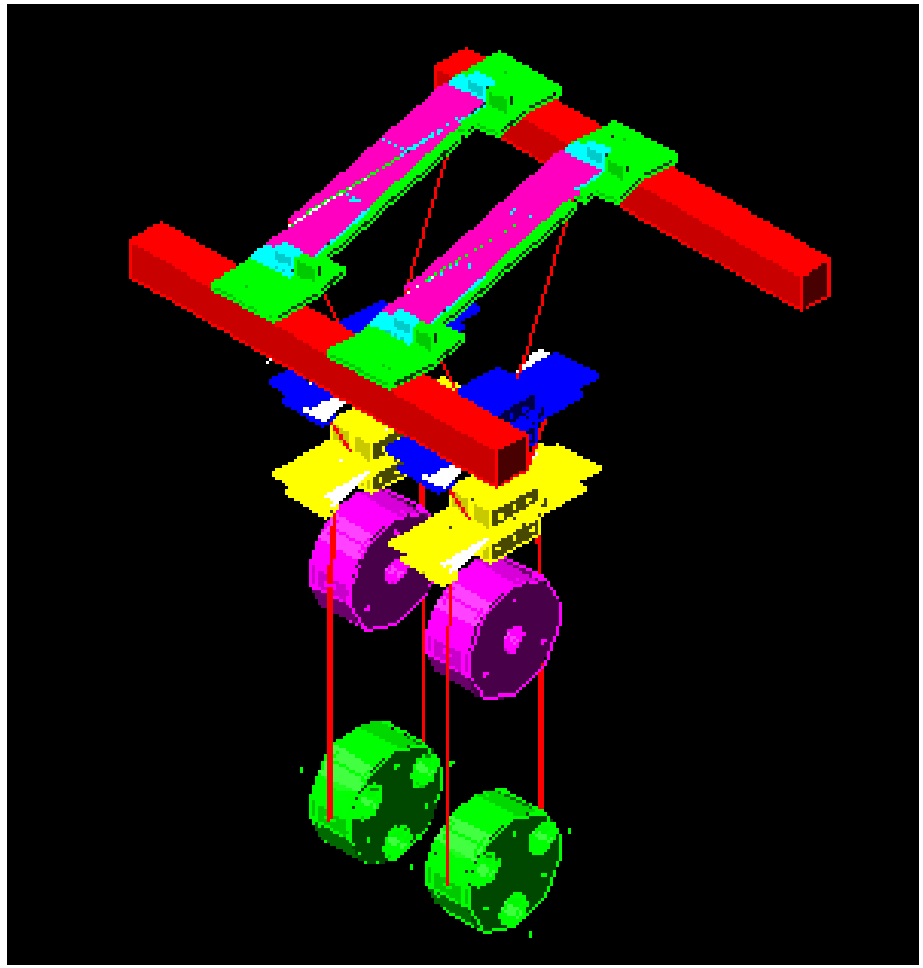
  Penultimate mass aluminium with central hole and lowest mass aluminium with steel insets, to mimic silica and sapphire respectively (with same dimensions). Upper masses designed to incorporate blades.

- Autocad diagrams produced, and parts procured. Some preassembly carried out in Glasgow, excluding blades (due to late delivery). Parts sent to MIT late June
- Calum Torrie and Norna Robertson spent ~1 month at MIT June/July

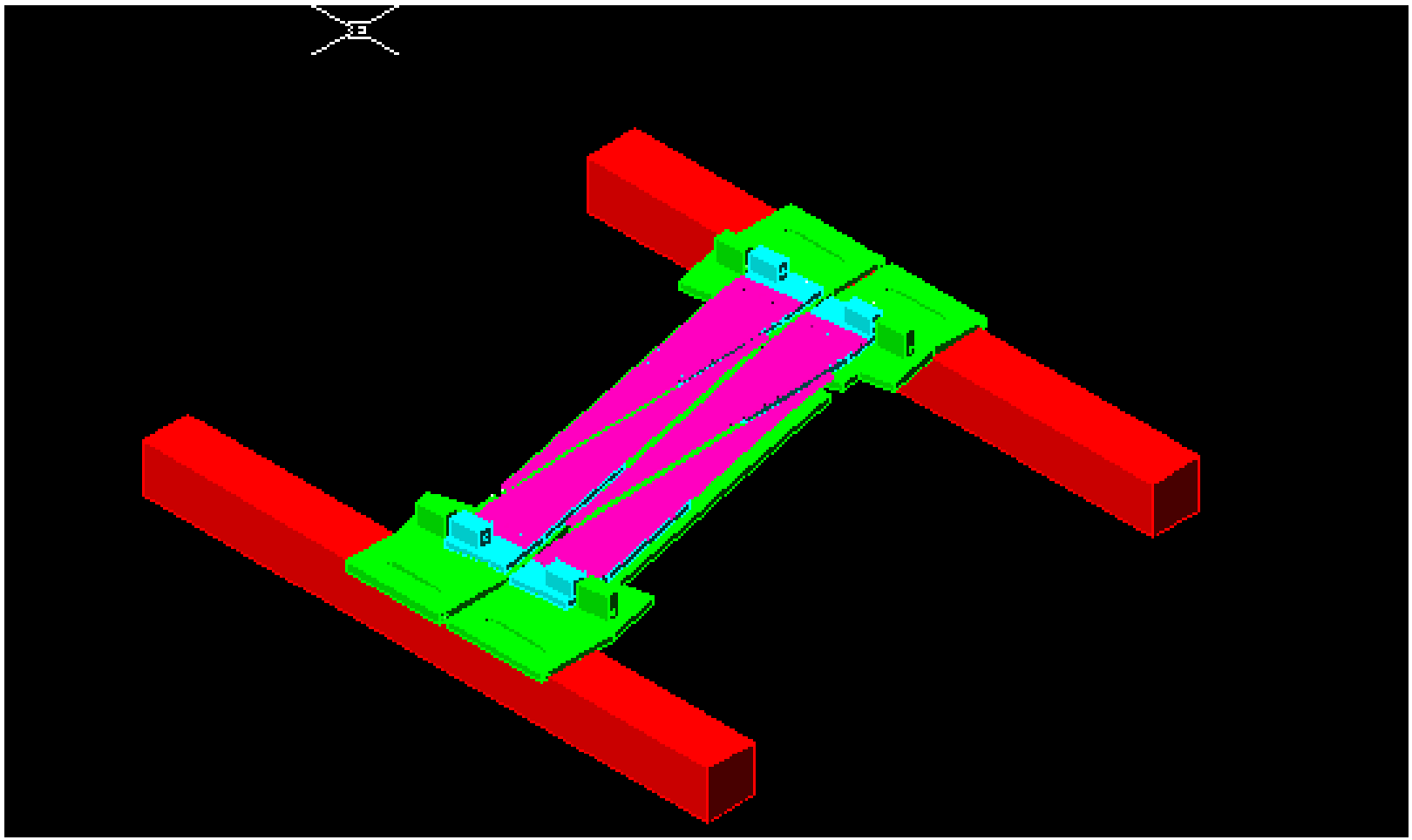
Mechanical Design of Quadruple Suspension – Autocad Diagrams



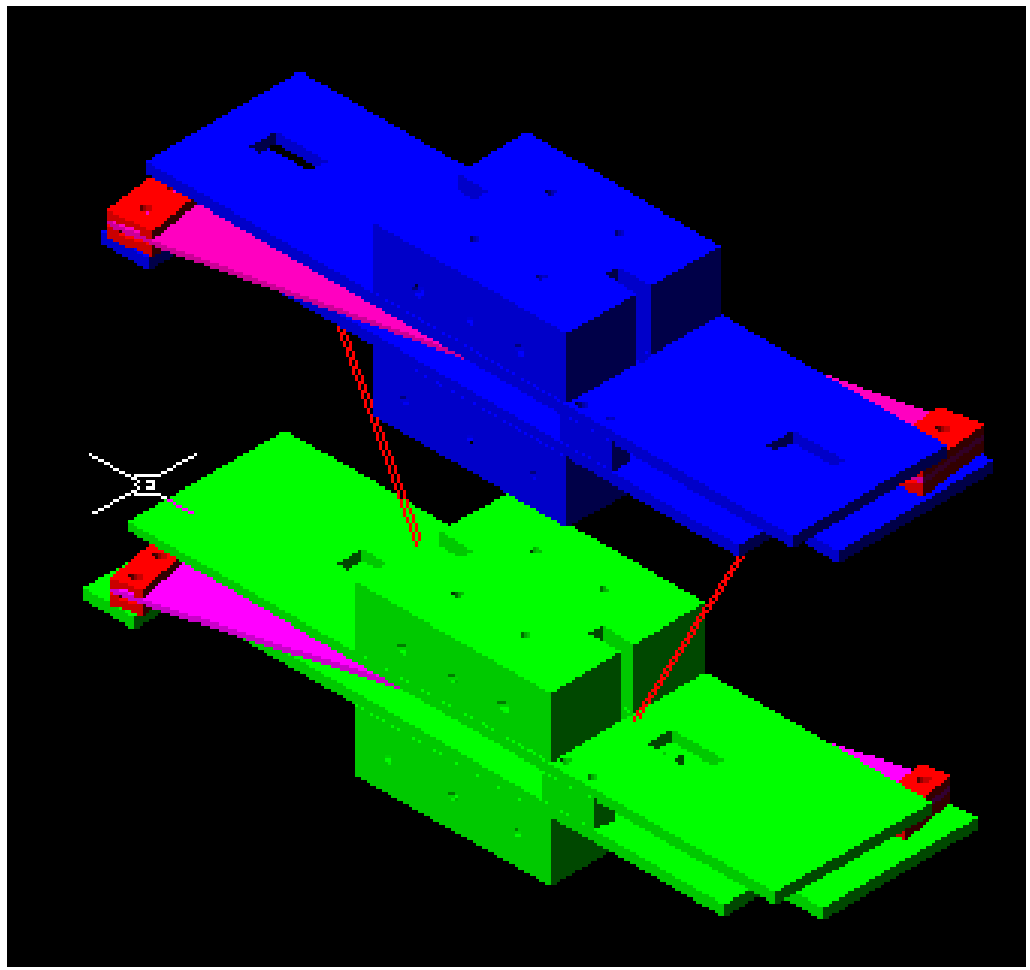
Autocad Diagrams contd.



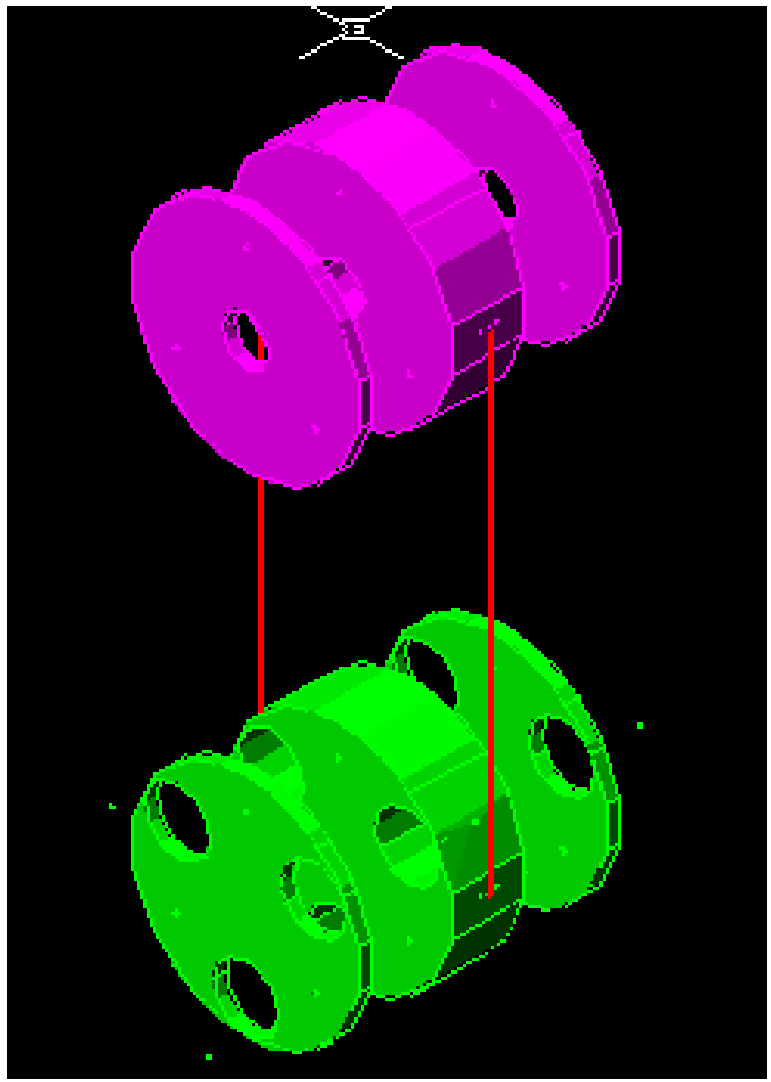
Autocad diagrams contd.



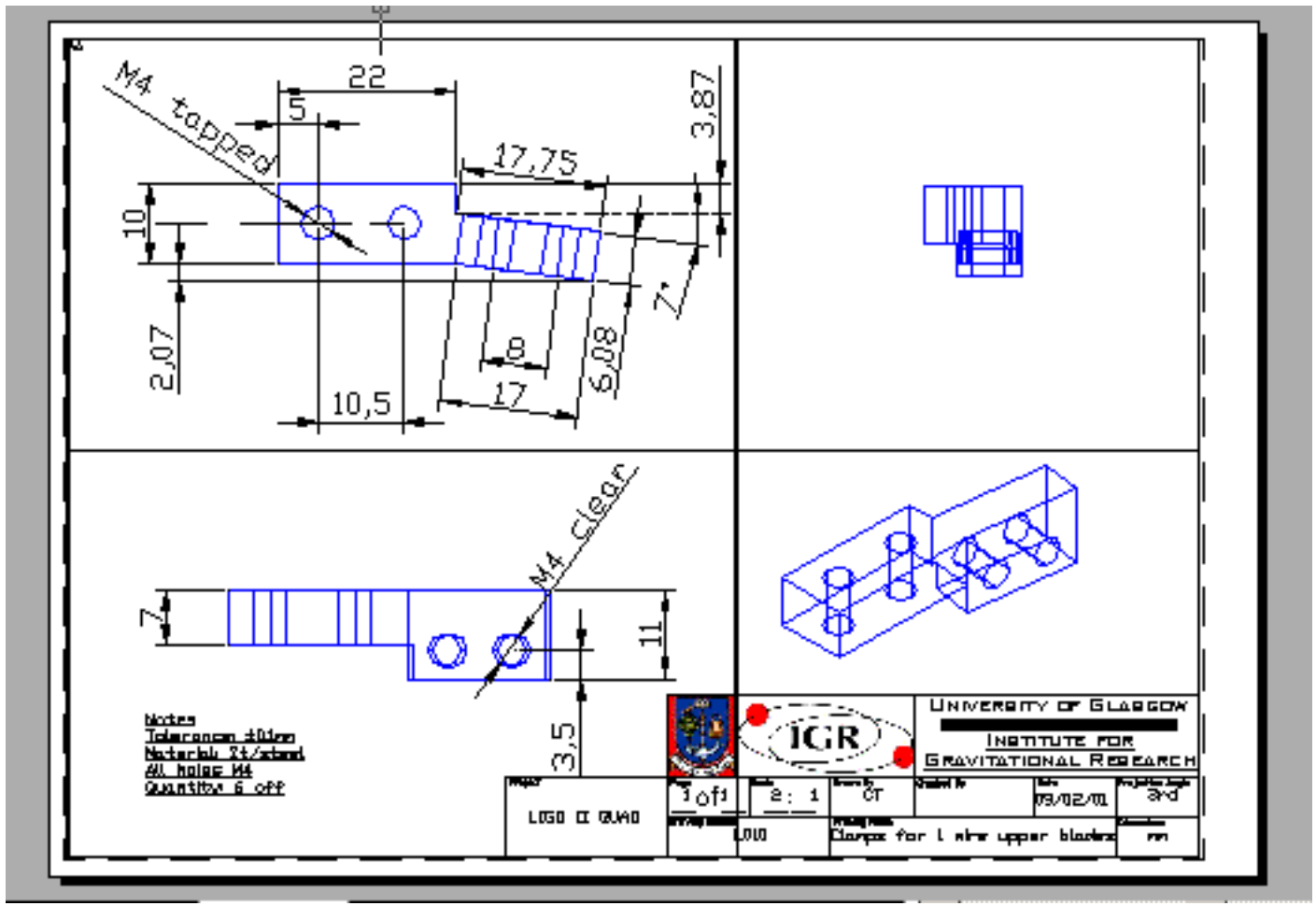
Autocad Diagrams contd.



Autocad Diagrams contd.

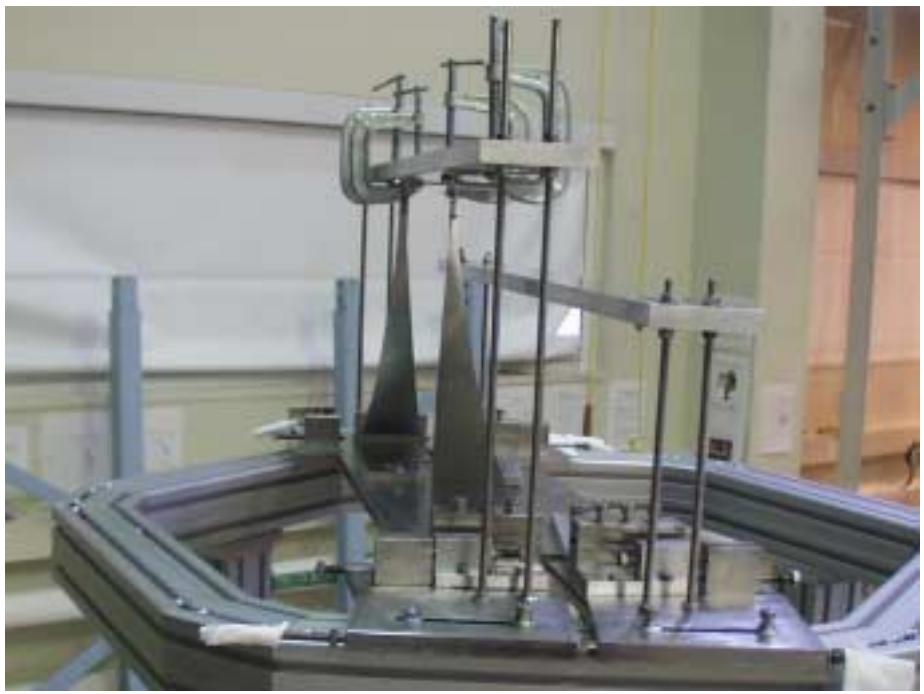


Autocad Diagrams contd.



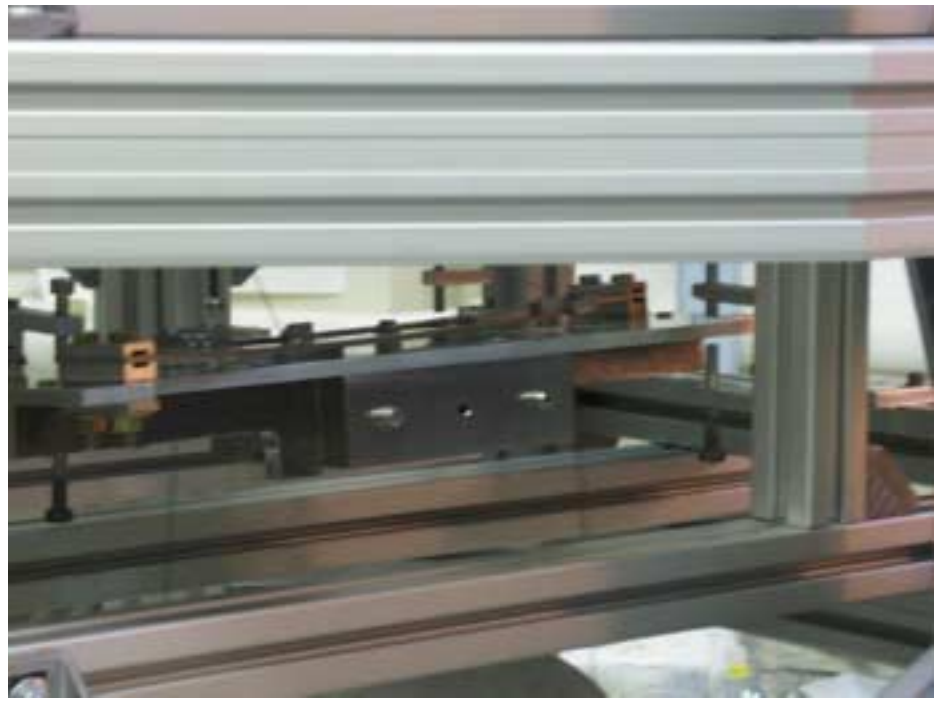
Bosch Frame

Top Blades



Top and Second Mass

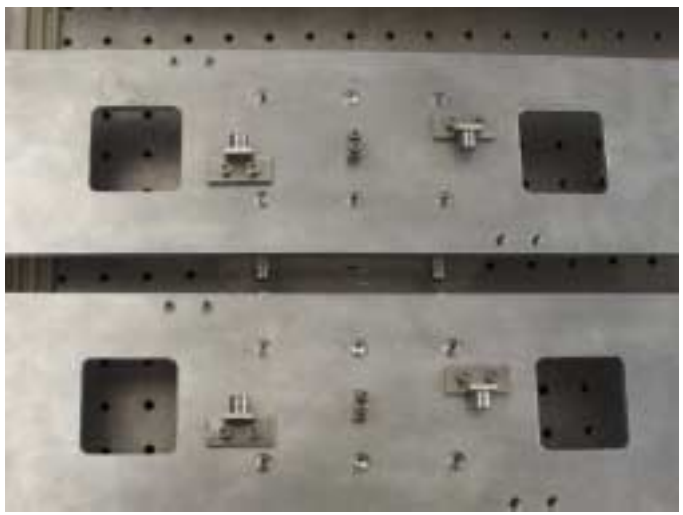
Top mass before its blades were loaded



Second mass after its blades were loaded

Methods of Wire Attachments

steel clamp for blade

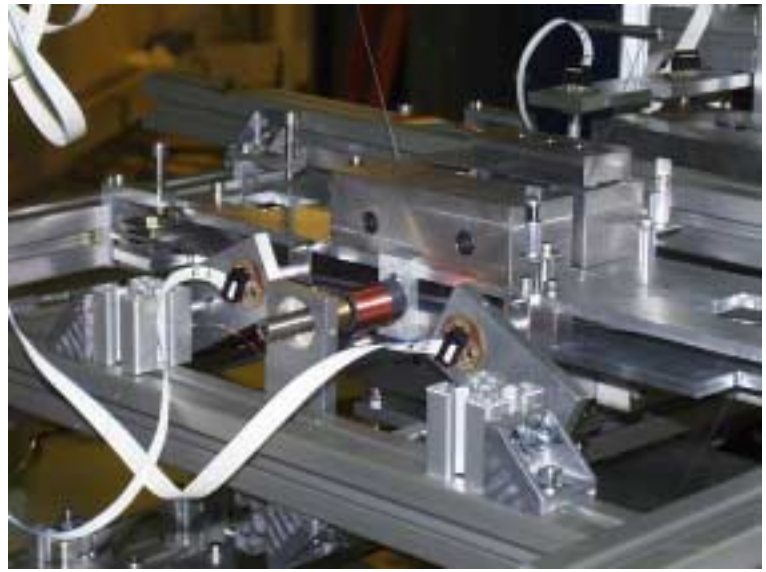


barrels with grooves-
part of second mass

penultimate mass

Penultimate and Final Masses

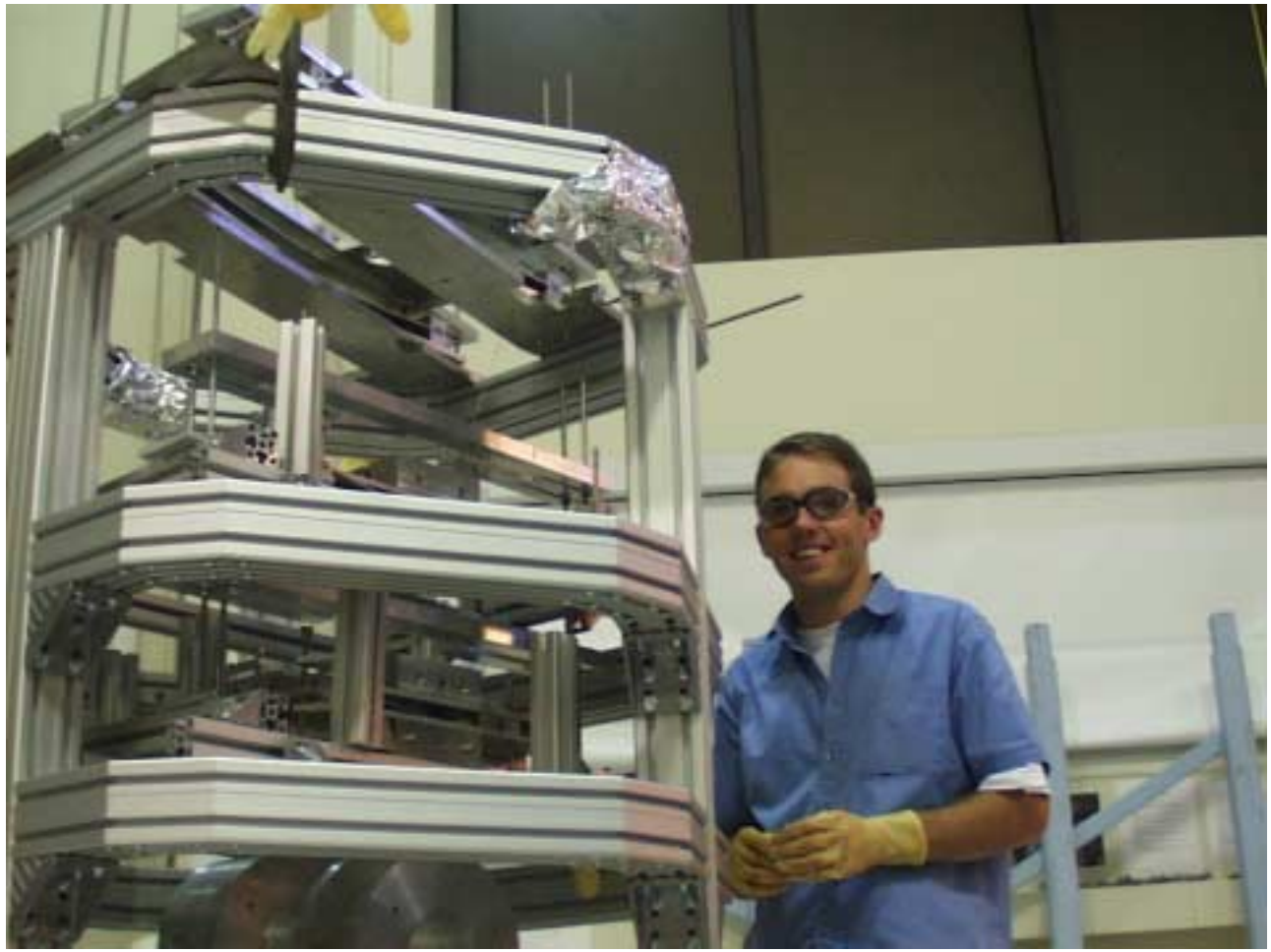
Top Mass with Local Controls



General Views

Assembly on Vacuum Platform

The Happy Parent



Lessons Learned So Far

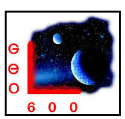
- Design of upper masses incorporating blades requires modifying to strengthen
- Method of putting grooves in clamps, and of tightening clamps, requires care
- Method of adjusting tilt in masses with blades: top mass adjustment worked well, extend to next mass
- Experience in assembling masses, preparing wire lengths with jigs, installing blades, adjusting, disassembling etc. important
- Bosch frame structure works well for prototyping
- Handling these sizes of masses non trivial – moving to larger masses will involve specialist lifting and handling equipment

Thanks

Many people contributed to the assembly of the quads at various times:

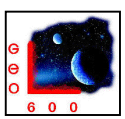
Dan Mason, Ken Mason, Richard Mittleman, Michael Perreur-Lloyd, Janeen Romie, Virginio Sannibale, Phil Willems .....

and invaluable technical assistance from Myron MacInnis and Fred Miller



Future Work

- mode frequencies
- active damping - impulse responses
- transfer functions
- eddy current damping
- global control feedback
- design, engineering issues for next prototype



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