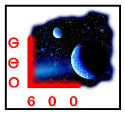
SUSPENSION DESIGN FOR ADVANCED LIGO: Update on GEO Activities

Norna A Robertson
University of Glasgow
for the GEO 600 suspension team

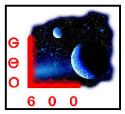
LSC Meeting, Louisiana, 16 March 2001
Sus/Isol Working Group Session



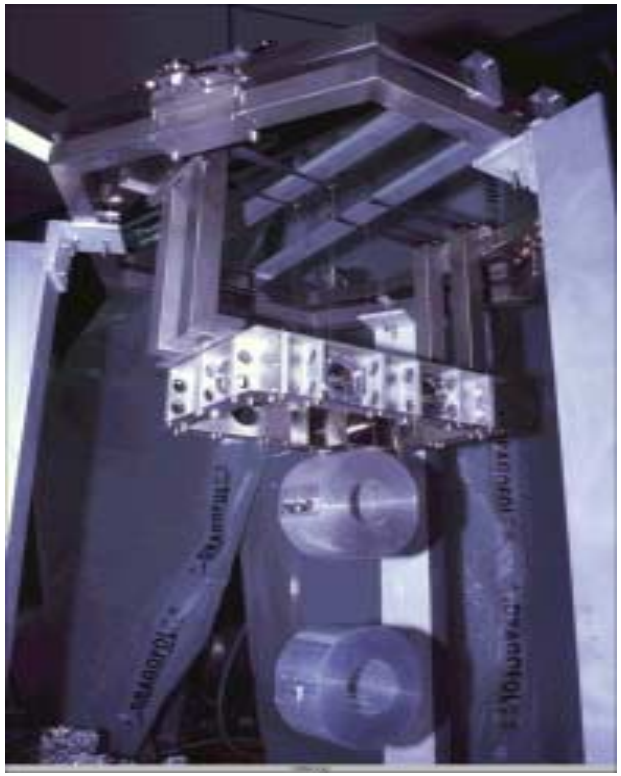
LIGO-G010125-00-Z

Conceptual Design for Advanced LIGO

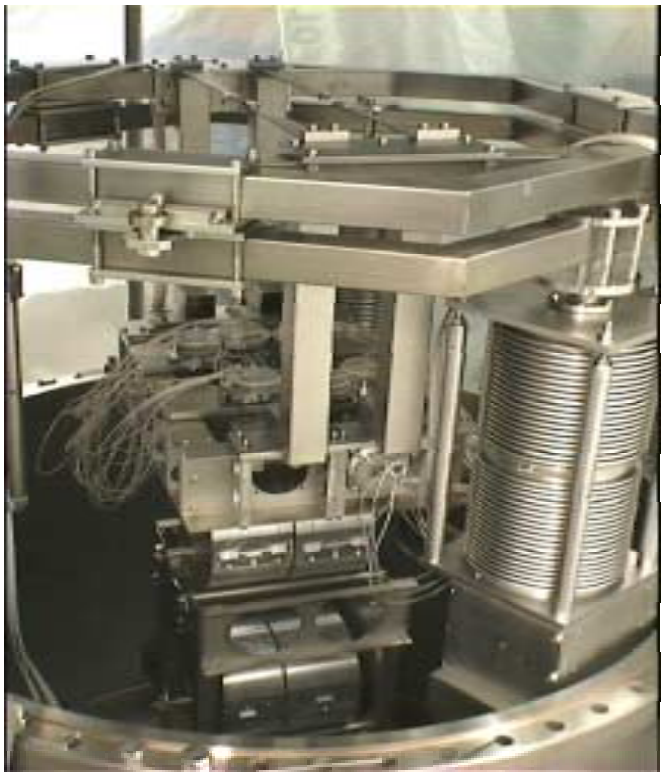
- Suspension design based on modified GEO 600 triple pendulum
- Key points in GEO design
  - Fused silica fibres in final stage suspension for low pendulum thermal noise
  - Preservation of high Q of test mass through silicate bonding of suspension fibres – essentially construction of *monolithic fused silica pendulum*
  - Local control (continuous) for damping of all low frequency pendulum modes by 6 co-located sensors and actuators on topmost mass in triple pendulum
  - 2 stages of enhanced vertical isolation
  - Global control at intermediate and lower mass (electrostatic at lower) using adjacent "identical" reaction triple pendulum



GEO Suspension System

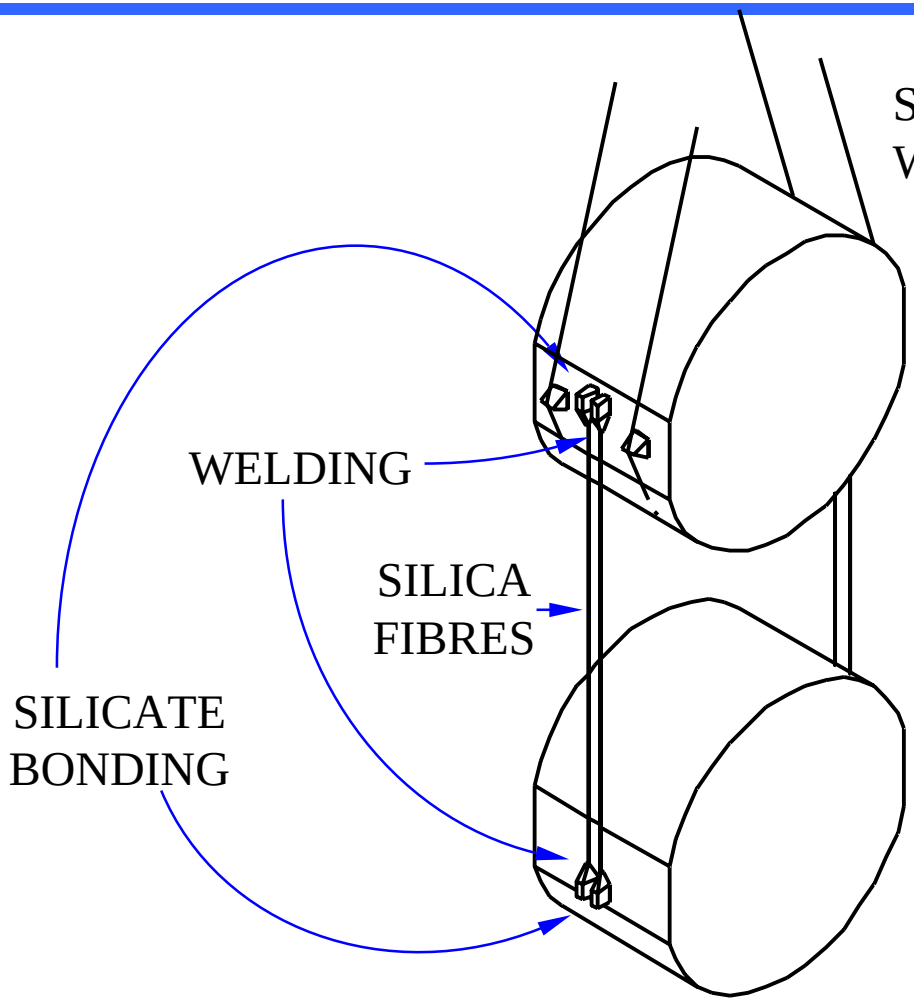


Initial assembly of triple pendulum



Triple pendulum + reaction pendulum in situ

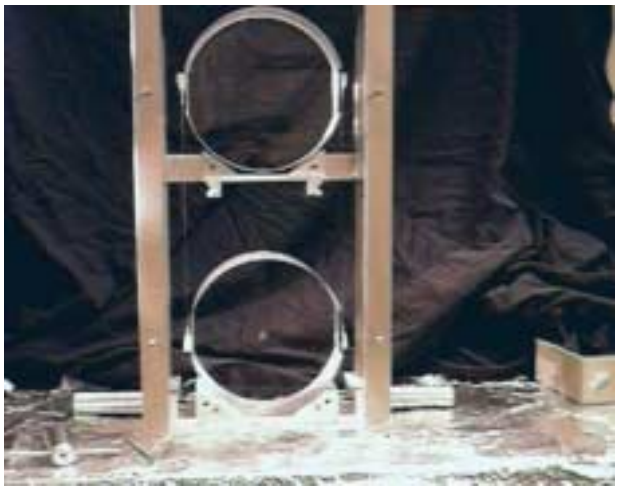
Monolithic Suspension - Detail



Suspension
Thermal Noise
(pendulum and violin modes)

Internal Thermal Noise

GEO 600 Monolithic Suspension Test



Baseline Design for Adv. LIGO
Main Mirror Suspensions

Modifications required to existing GEO design

- More stringent requirement on internal thermal noise performance:-

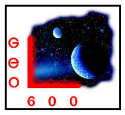
  sapphire rather than silica for mirror for potentially improved internal thermal noise performance

- More stringent requirement on pendulum thermal noise:-

  use of *ribbons* rather than fibres to increase dilution factor

- More stringent requirements on reduction of local control noise (i.e. for damping):-

  change to *quadruple* suspension, with damping at topmost mass, and three stages of enhanced vertical isolation



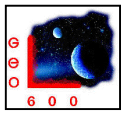
Baseline Design for Adv. LIGO suspensions

contd

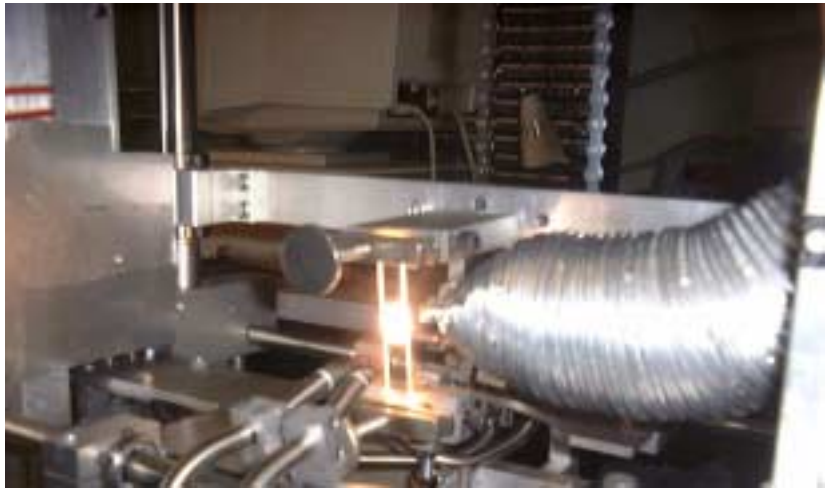
- Fused silica ribbons suspending sapphire mirror – lowest mass in quadruple pendulum
- Quadruple pendulum incorporating 3 stages of enhanced vertical isolation using blades
- local control sensors/actuators or eddy current damping on top mass
- overall length ~ 2 m
- all locally controlled freqs. in 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

Current and Future Work - Thermal Noise Issues

- Redesign and testing of larger fused silica ears for silicate bonding, prior to first assembly of full GEO mirror suspension
  - mirrors being coated in March at REO
  - silicate bonding scheduled for April
  - first suspension in GEO thereafter
- Ribbon fibre pulling machine now in operation - ribbon testing to follow
- Continuing coating loss tests and analysis (see Sheila Rowan's talk)



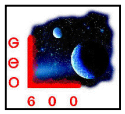
Ribbon Pulling Machine



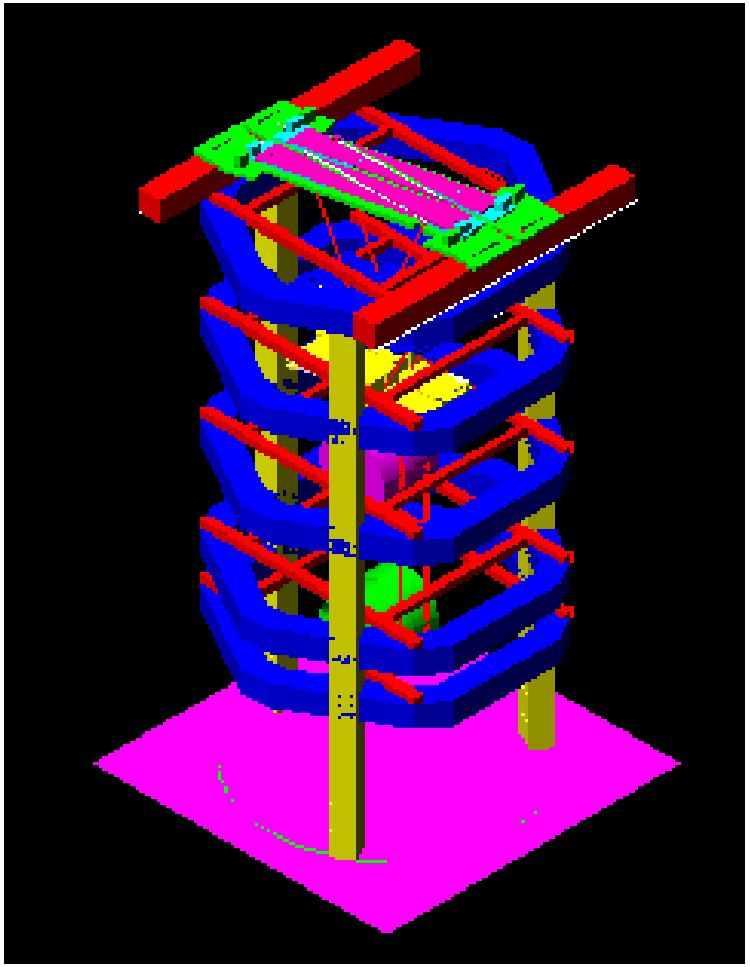
Current and Future Work - Mechanical Design Issues

- Initial tests of quadruple pendulum
  - in Glasgow: design of all-metal pendulum essentially complete and parts currently being procured
  - at MIT (summer 2001): quadruple pendulum to be transferred from Glasgow

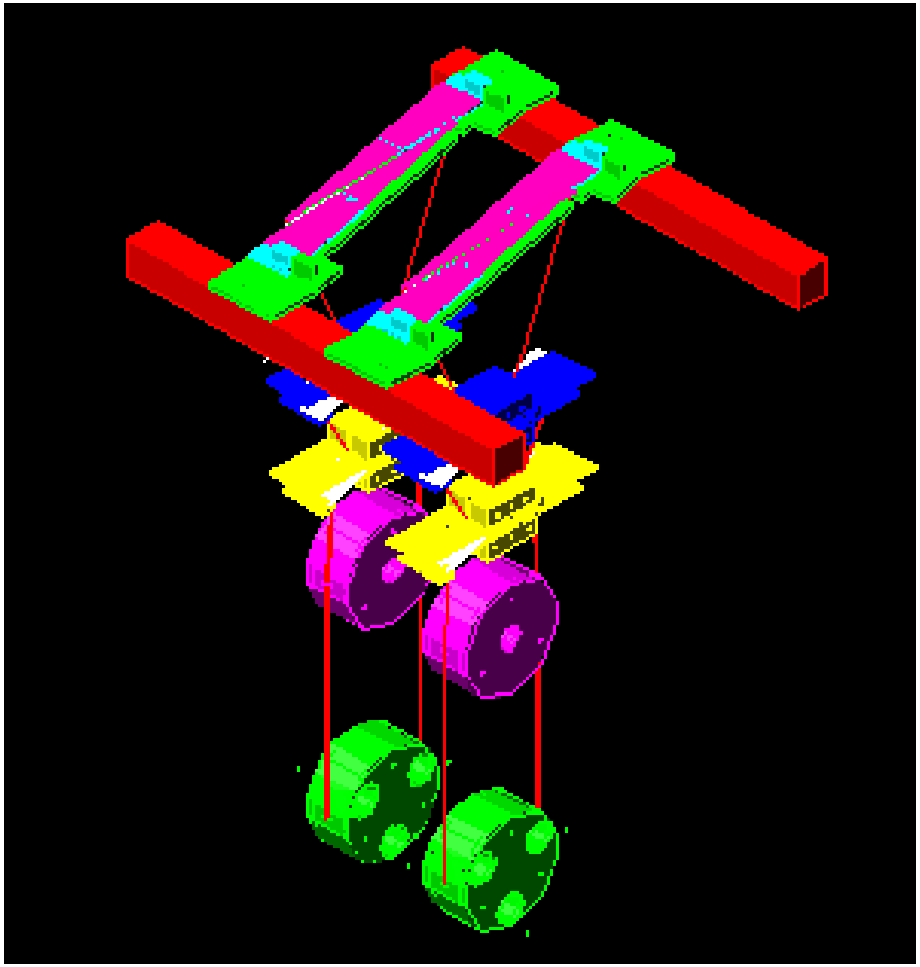
  tests : mode frequencies, damping, transfer functions, feedback issues, engineering design, assembly and fit issues
- Other design issues
  - heavy glass samples being procured (loaded with PbO or Bi_2O_3 , densities from 3.8 to 7.2 g/cc) - possible material for penultimate “heavy” mass
  - tests of bonding to follow



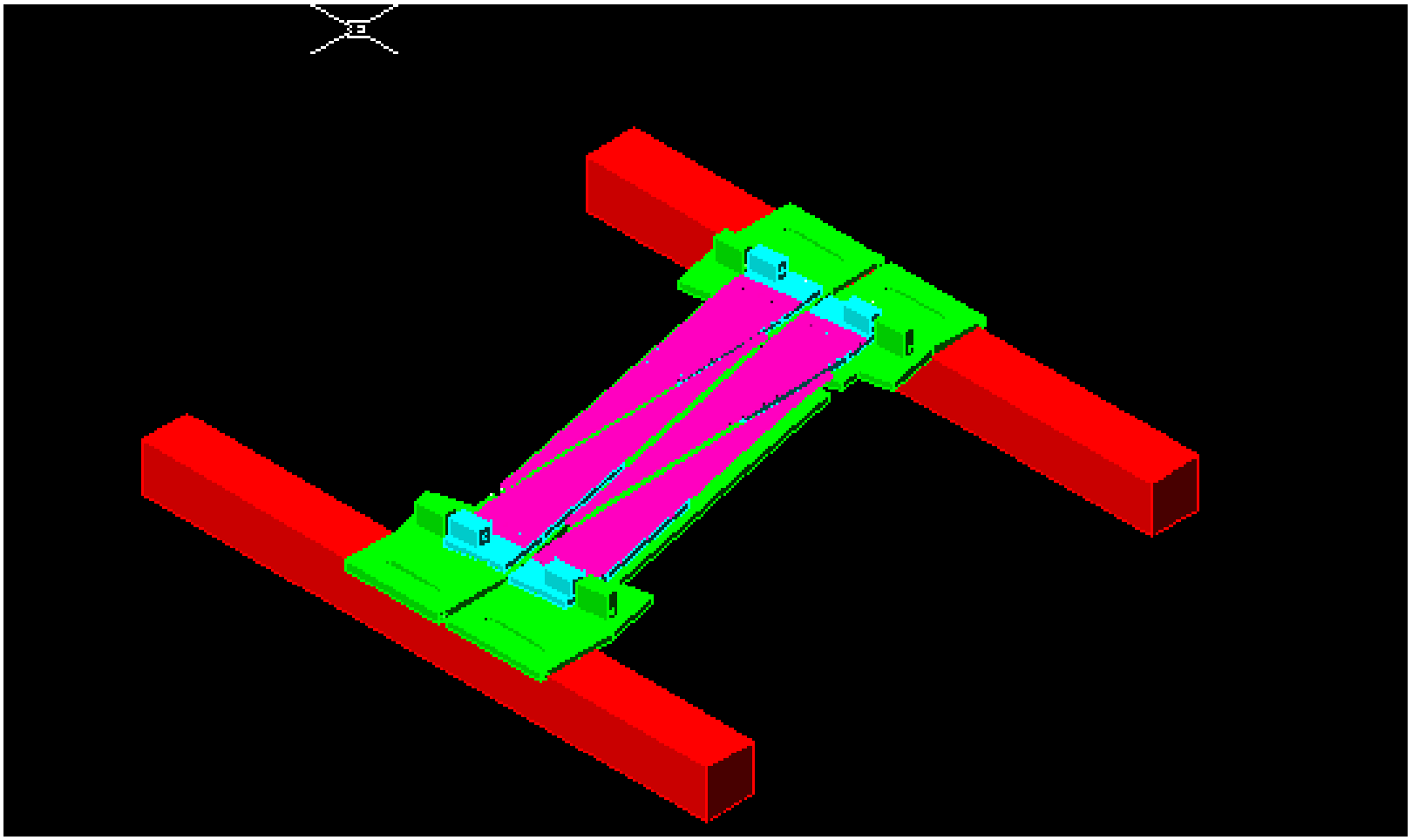
Mechanical Design of Quadruple Suspension – Autocad Diagrams



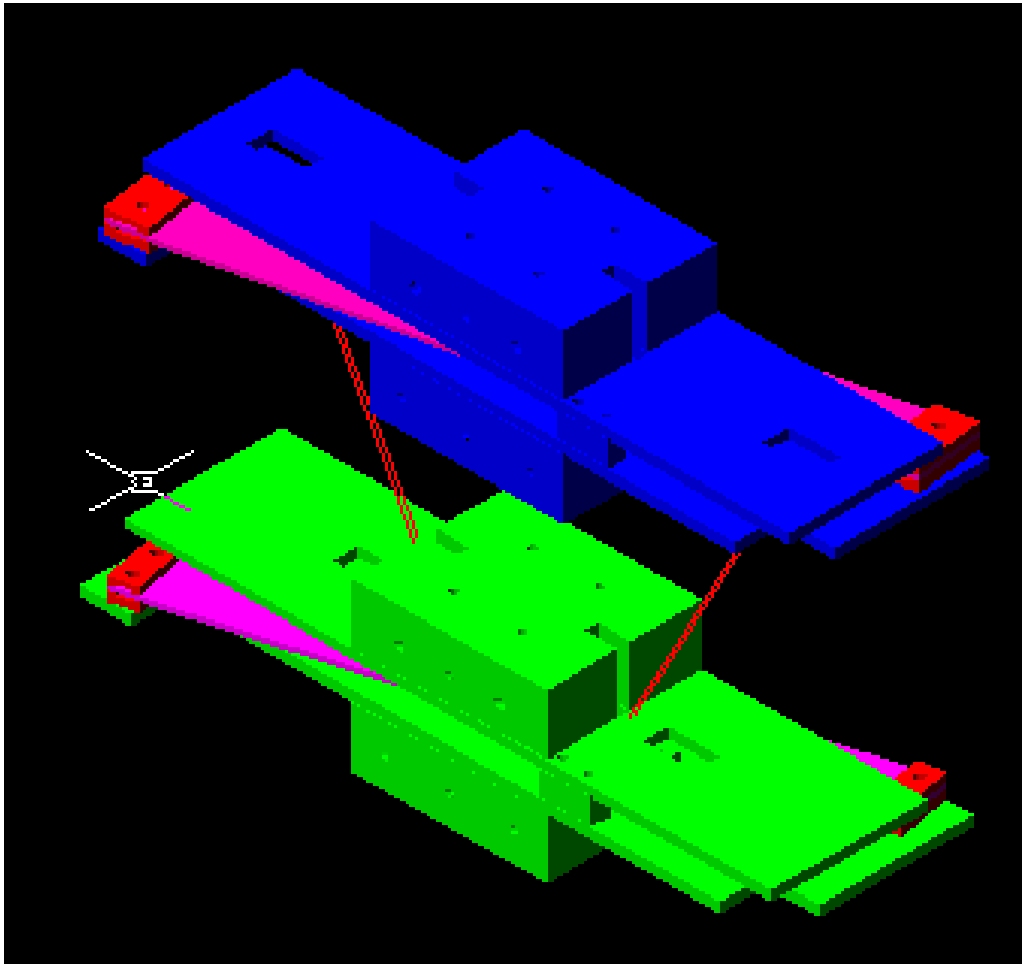
Autocad Diagrams contd.



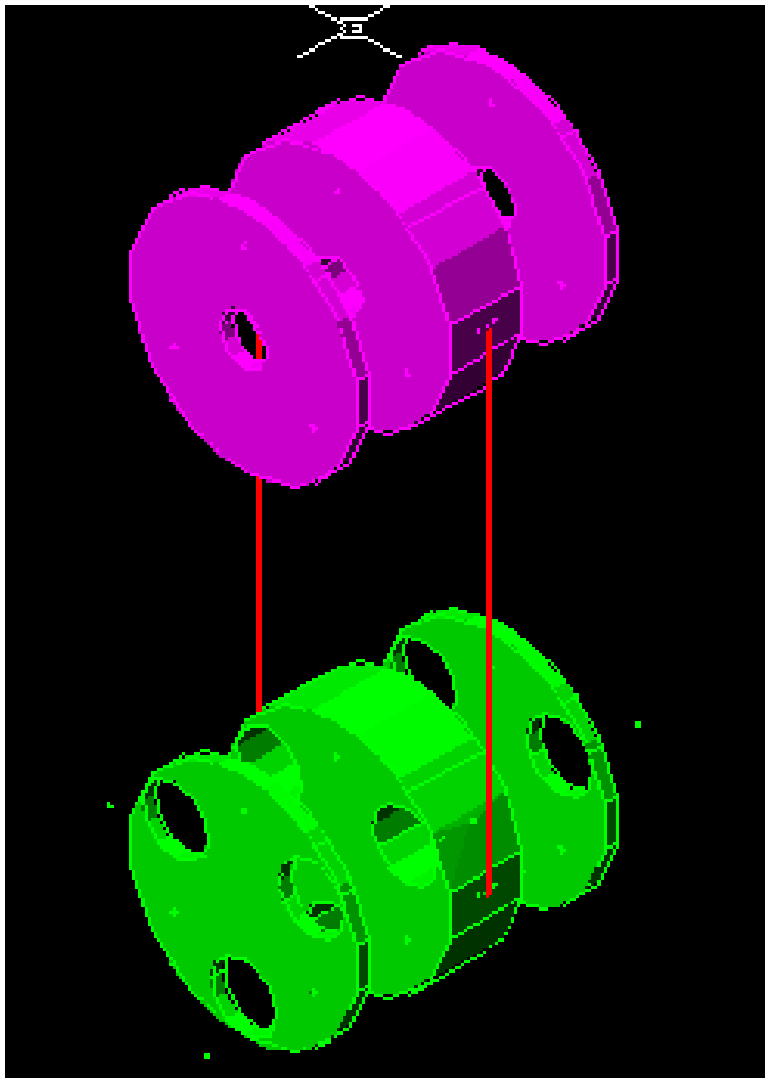
Autocad diagrams contd.



Autocad Diagrams contd.



Autocad Diagrams contd.



Autocad Diagrams contd.