# LSST Structural Design

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Special LSST design considerations

- Unique optics and mass distribution
- Center of mass of the optics alone is near the vertex of the primary
- The center of mass of optics plus cells is near the rear of the primary
- Therefore the elevation axis structure is the primary mirror cell
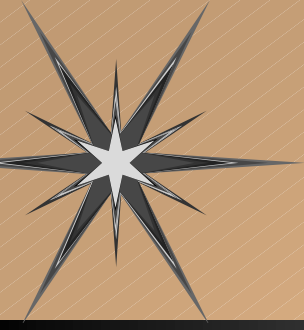
Rationale for high stiffness

- Telescopes benefit from better structural stiffness and thus servo performance in many ways.
  - Tracking is better.
  - Wind rejection is better.
  - Pointing corrections are smaller.
  - Optics moving with gravity is reduced.
- High stiffness is worth the trouble.
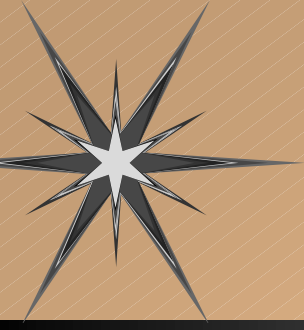
Servo Performance Criteria

- Experience has shown an alt-az telescope with a 1 Hz servo bandwidth will track at about 0.15 arc-seconds rms.
- A good tracking servo performance goal is 2 Hz.
- Wind has significant power even up to 3 Hz.
- We need an Error Budget to do it right.
- We need servo analysis to do it right.
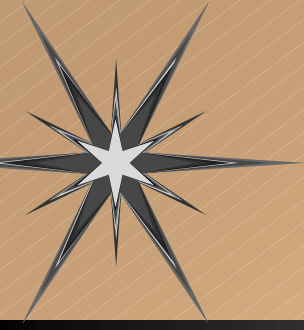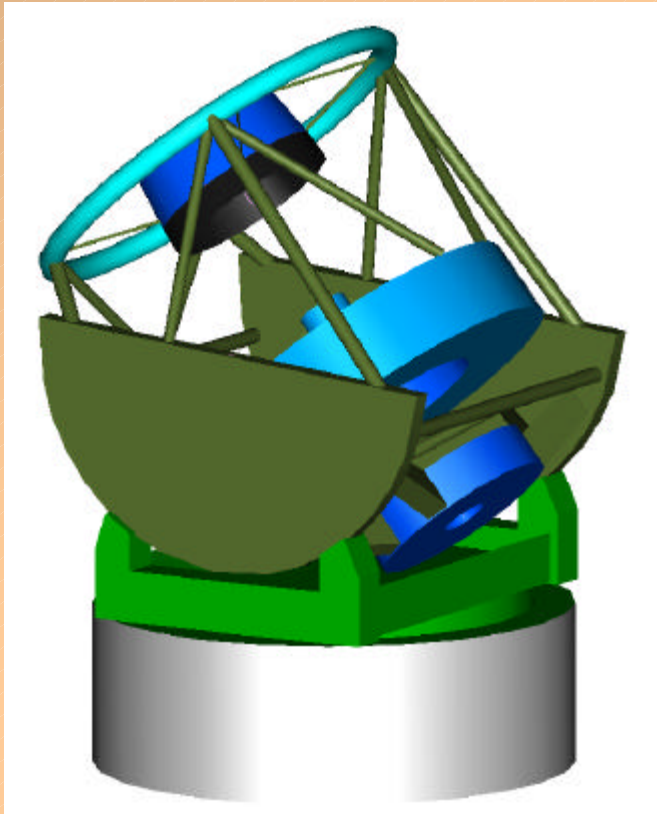
Derived Structure Performance Criteria

- Since the servo needs to be about 2 to 3 Hz. The structure needs a locked rotor resonant frequency of 4 times that or about 8 to 12 Hz.

- With the right design this is very realistic.

- Our preliminary design has a lowest frequency of 7.1 Hz which can easily be improved.

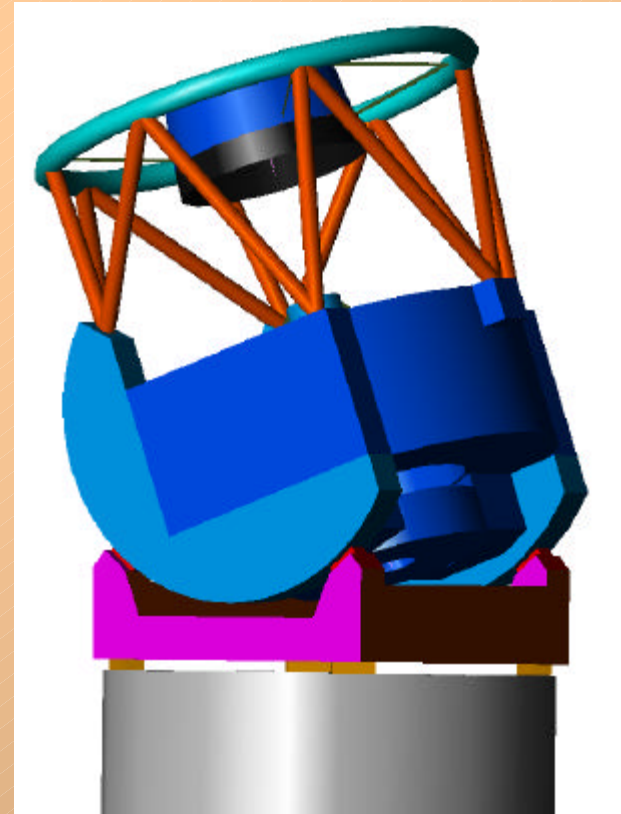- We need to continue this effort.
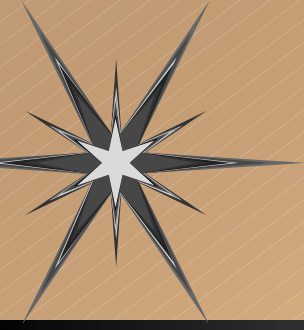
Initial Evolution of Design
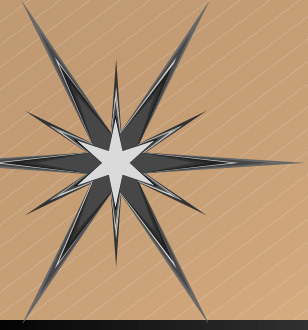
ä   Concept   First Design

Why C-Rings

- The compliance of the mechanics depends on the square of their radius

- The bearings and drives of telescopes are usually made small to decrease their cost. Thus their compliance contribution is usually about 4 times the structure.

- Simply increasing the bearing surface and ring gear from 2m to 9m makes the same components 20 times stiffer which should double the frequency performance.
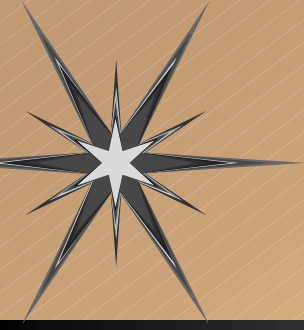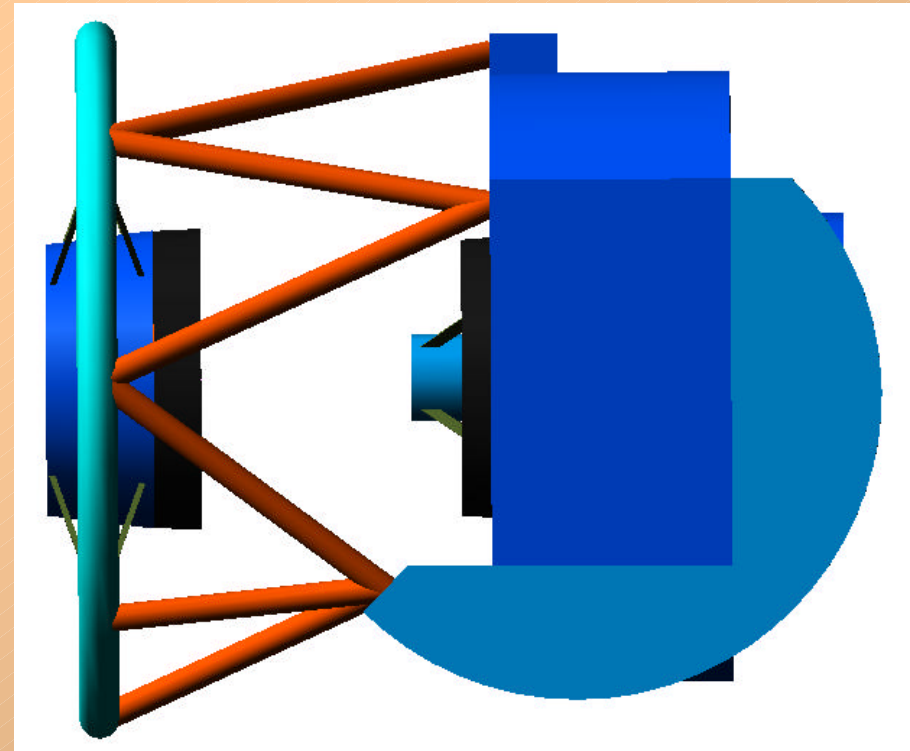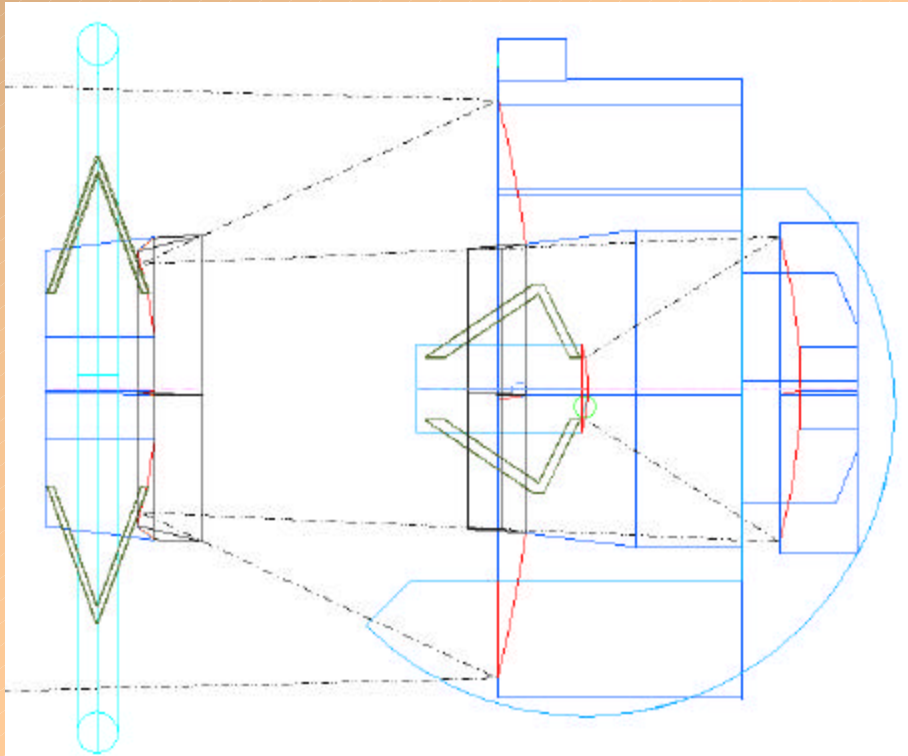
Telescope Design Features

ä Center to center distance of C-rings is 8m, glass diameter is 8.4.

ä Primary mirror cell made an integral part of the structure.

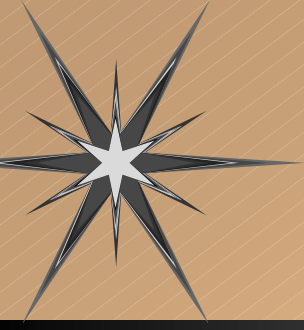ä Top ring is largest diameter element.
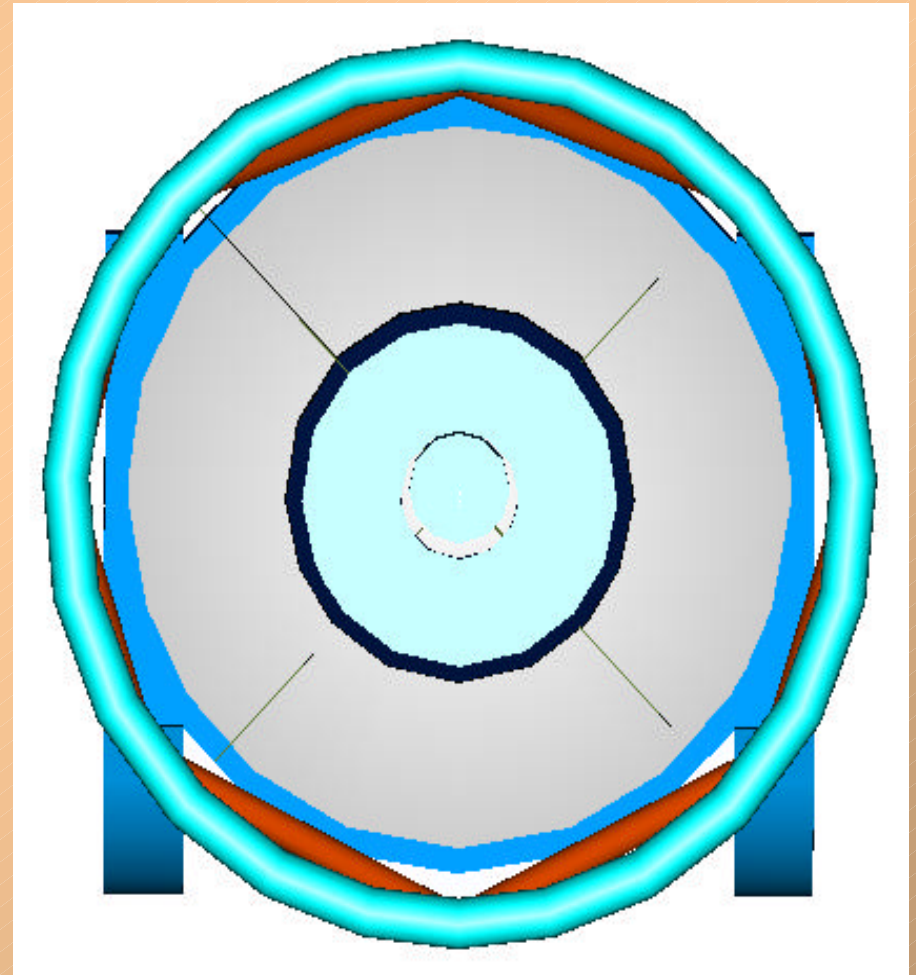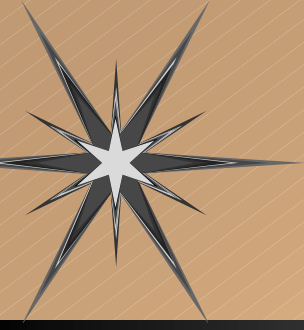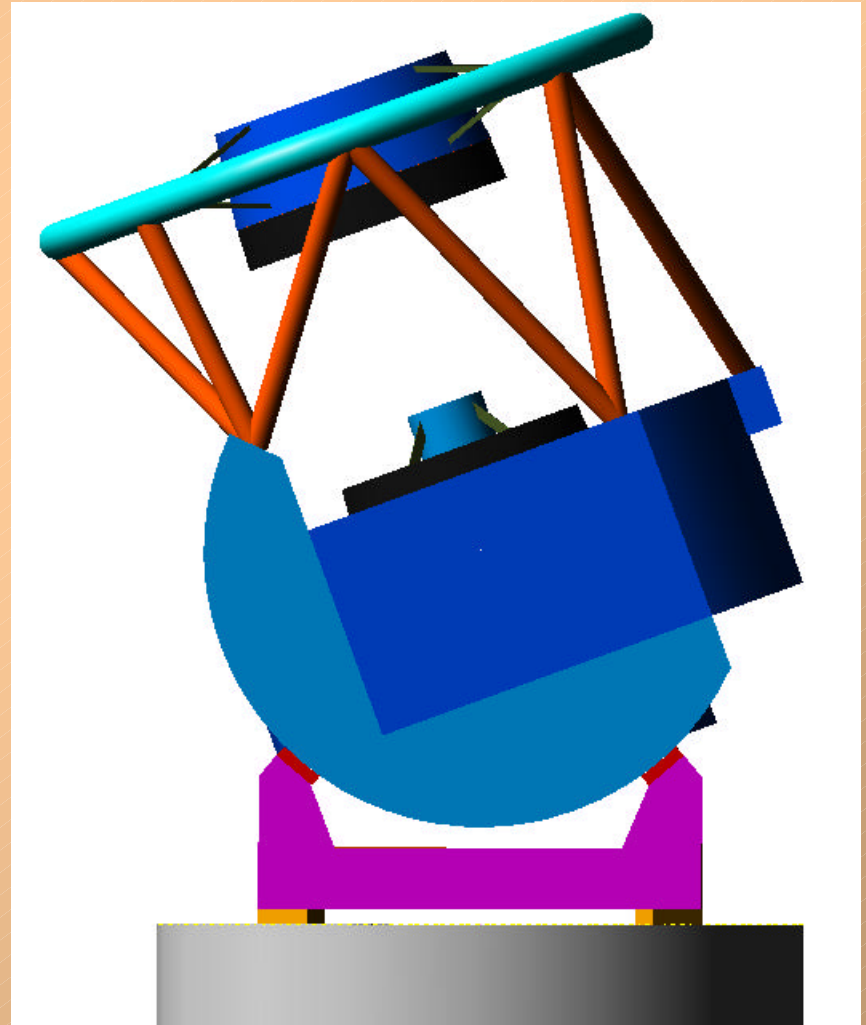
Telescope Design Features

äSwing radius of 9.2m

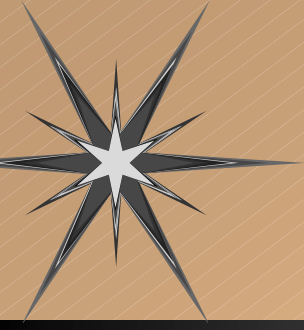äOptical axis and telescope axis are not coincident to achieve balance.

Telescope Design Features

- ä Compact azimuth platform with the elevation bearings directly above azimuth bearings.
- ä Top of pier bearing surface 10.5 meters diameter.
- ä Lateral bearings on edges of C-rings.
- ä Center mechanical bearing or lateral bearing on side of azimuth bearing.
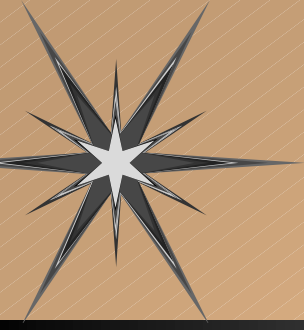
LBT Design features

- ä Compact azimuth platform with the elevation bearings directly above azimuth bearings.
- ä Top of pier bearing surface 14 meters diameter.
- ä Lateral bearings on edges of C-rings.
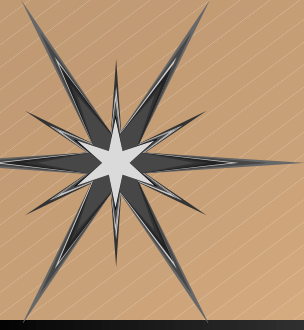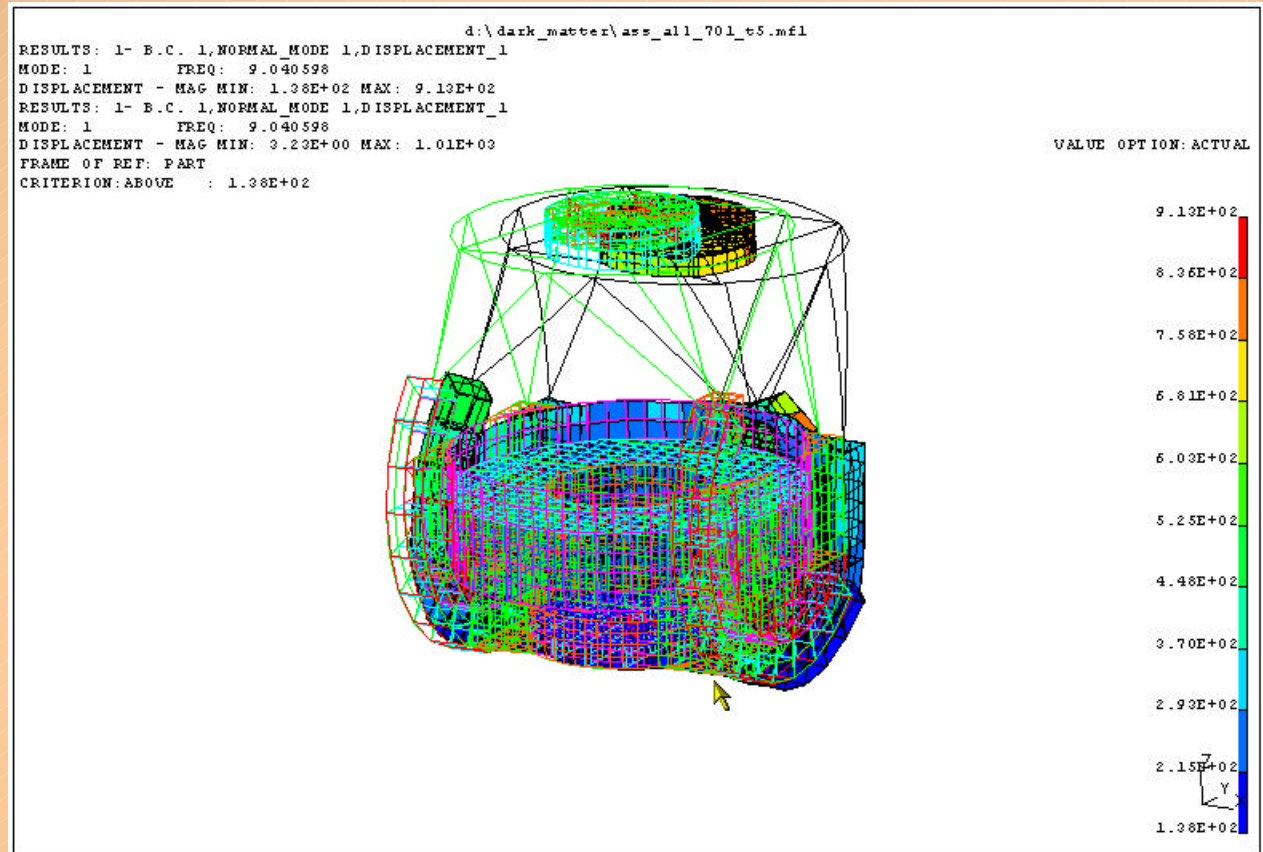- ä Center mechanical bearing

FEA Telescope Model

ä The FEA model has 25,800 degrees of freedom.

ä Total mass 232 tons.

ä Total elevation mass 163 tons.

ä Optics mass 23 tons
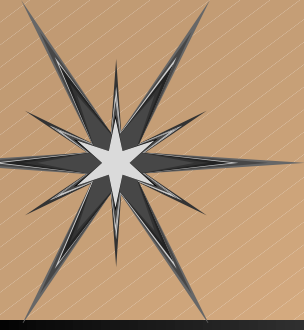
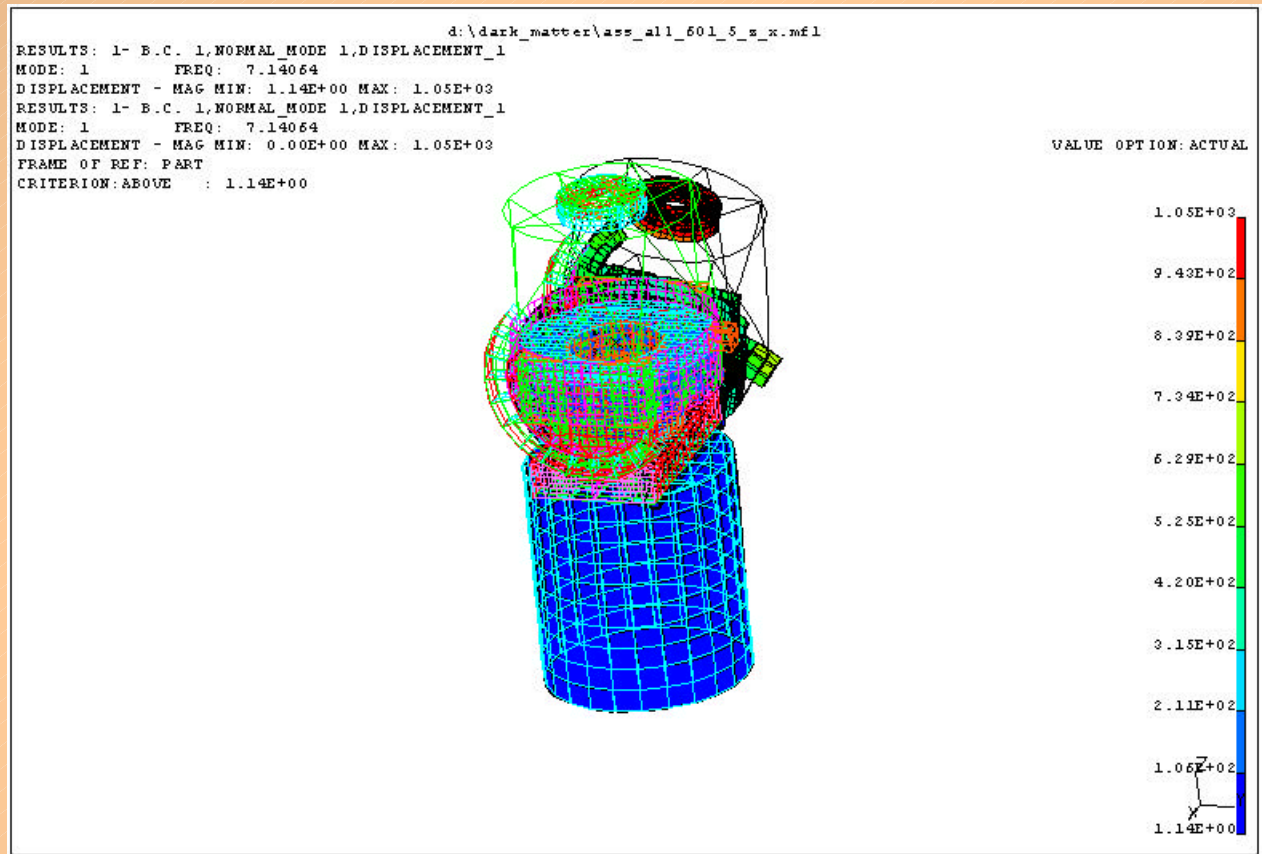ä Secondary assembly mass x tons.
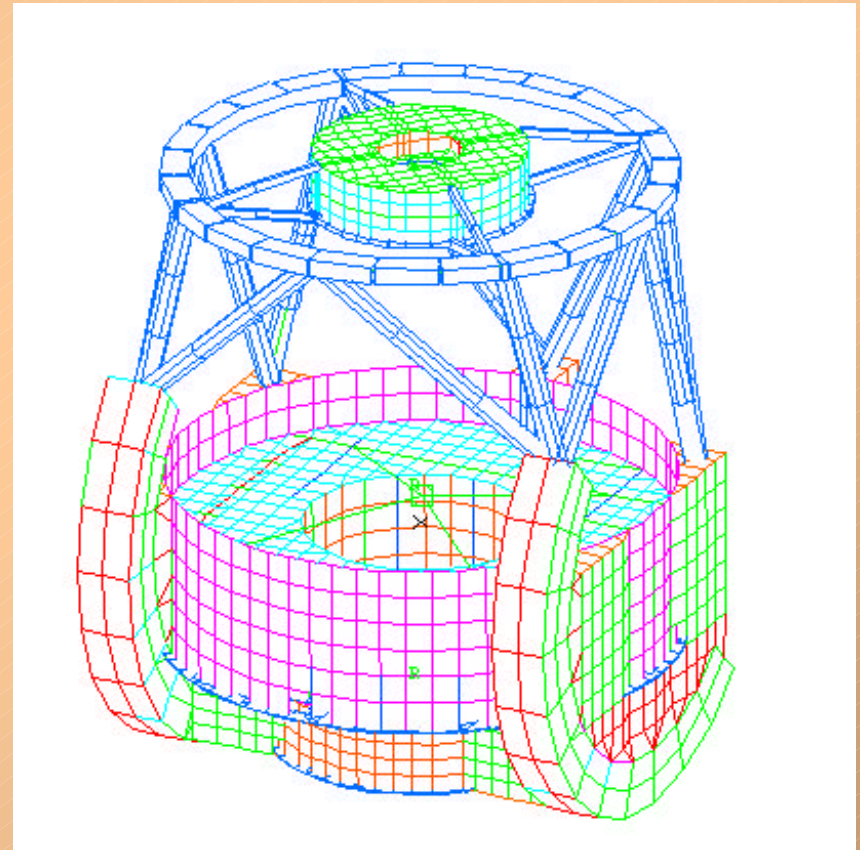
Elevation Structure FEA

ä First resonant frequency 9Hz – Elevation rocking mode.

ä Can easily be improved by eliminating design error of front truss attachment
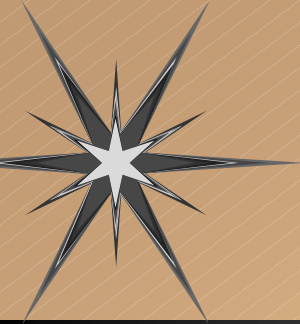
First Telescope Resonance

ä The First resonant frequency of the entire telescope is at 7.1 Hz.

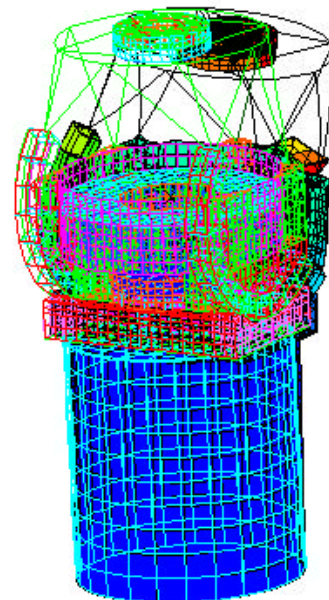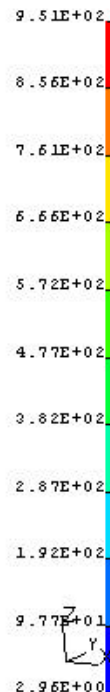ä Elevation mode caused by a local deflection.

d:\dark_matter\ass_all_601_5_s_x.mfl
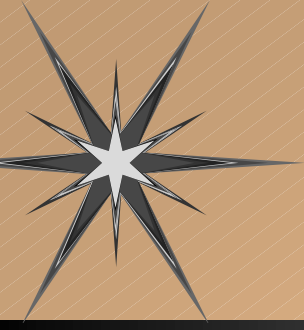
RESULTS: 1- B.C. 1,NORMAL_MODE 1,DISPLACEMENT_1
MODE: 1   FREQ: 7.14064
DISPLACEMENT - MAG MIN: 1.14E+00 MAX: 1.05E+03
RESULTS: 1- B.C. 1,NORMAL_MODE 1,DISPLACEMENT_1
MODE: 1   FREQ: 7.14064
DISPLACEMENT - MAG MIN: 0.00E+00 MAX: 1.05E+03
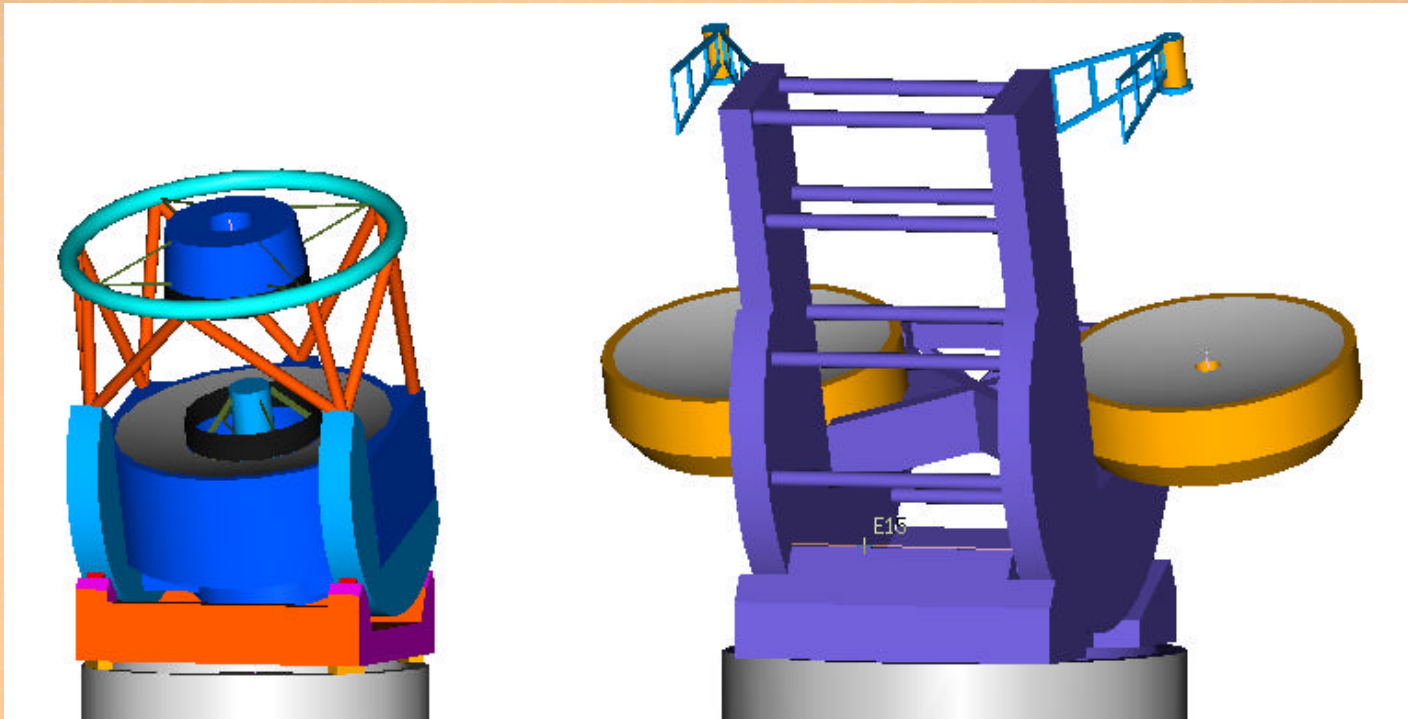FRAME OF REF: PART
CRITERION:ABOVE   : 1.14E+00

VALUE OPTION: ACTUAL

1.05E+03
9.43E+02
8.39E+02
7.34E+02
6.29E+02
5.25E+02
4.20E+02
3.15E+02
2.11E+02
1.06E+02
1.14E+00

Second Telescope Resonance

ä Second mode 8.7Hz.
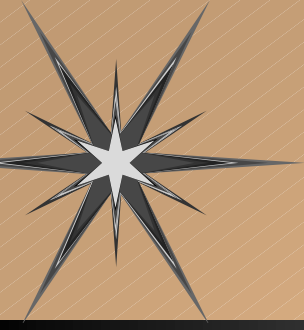
LSST to LBT Comparison

- ä Comparison of   LSST   and   LBT
- ä Moving Mass   290   700   Metric tons
- ä Crings   9 meters   14 meters
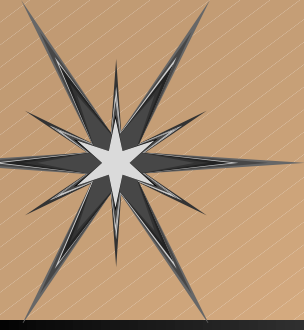- ä Pier Diameter   10.5 meters   14 meters

We can build LSST

- ä LBT assembled in Milan.
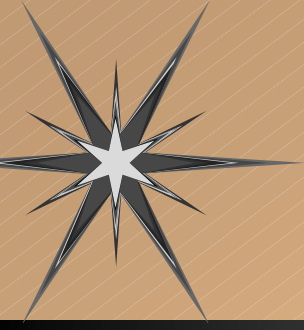- ä LSST is about half this size, we can easily build it.

LBT Acceptance Tests

ä LBT preliminary performance data with two of four motors on each axis.

  ä Elevation resonant frequency 7hz

  ä Azimuth resonant frequency 3hz and 10hz, The 3hz appears to be the electrical cabinet

Mass and cost estimate

- ä Least Resonant Frequencies should exceed 10 Hz.

- ä LBT grew from 560 tons to 700 tons from design to construction so LSST should finish around 290 tons (290/700=.41).

- ä Telescope Structure and Mechanics Cost 45% of LBT (21M) $9.5 million .

- ä Telescope Structure and Mechanics Cost 170% of Magellan (6.1M) $10.4 million .
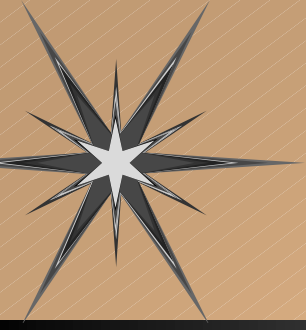
Tall Tent Poles

ä Credibility----How can I convince you we can build an 8.4m telescope structure which has only 270 tons of moving mass, a 10hz resonant frequency and cost $10 million.

ä We need detailed engineering studies.

ä Start design to show critical systems.

ä What does it take for YOU to believe it.