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.
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.
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

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

- Center to center distance of C-rings is 8m, glass diameter is 8.4.
- Primary mirror cell made an integral part of the structure.
- Top ring is largest diameter element.
Telescope Design Features

- Swing radius of 9.2m
- Optical axis and telescope axis are not coincident to achieve balance.
Telescope Design Features

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

- Compact azimuth platform with the elevation bearings directly above azimuth bearings.
- Top of pier bearing surface 14 meters diameter.
- Lateral bearings on edges of C-rings.
- Center mechanical bearing
The FEA model has 25,800 degrees of freedom.

- Total mass 232 tons.
- Total elevation mass 163 tons.
- Optics mass 23 tons
- Secondary assembly mass x tons.
Elevation Structure FEA

- First resonant frequency 9Hz – Elevation rocking mode.
- Can easily be improved by eliminating design error of front truss attachment
The First resonant frequency of the entire telescope is at 7.1 Hz.

Elevation mode caused by a local deflection.
Second mode 8.7Hz.
LSST to LBT Comparison

- Comparison of LSST and LBT
- Moving Mass: 290 vs. 700 Metric tons
- Crings: 9 meters vs. 14 meters
- Pier Diameter: 10.5 meters vs. 14 meters
We can build LSST

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

- LBT preliminary performance data with two of four motors on each axis.
  - Elevation resonant frequency 7hz
  - Azimuth resonant frequency 3hz and 10hz. The 3hz appears to be the electrical cabinet
Mass and cost estimate

- Least Resonant Frequencies should exceed 10 Hz.
- LBT grew from 560 tons to 700 tons from design to construction so LSST should finish around 290 tons ($290/700 = .41$).
- Telescope Structure and Mechanics Cost 45% of LBT ($21M$) $9.5$ million.
- Telescope Structure and Mechanics Cost 170% of Magellan ($6.1M$) $10.4$ million.
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.

- We need detailed engineering studies.
- Start design to show critical systems.
- What does it take for YOU to believe it.