

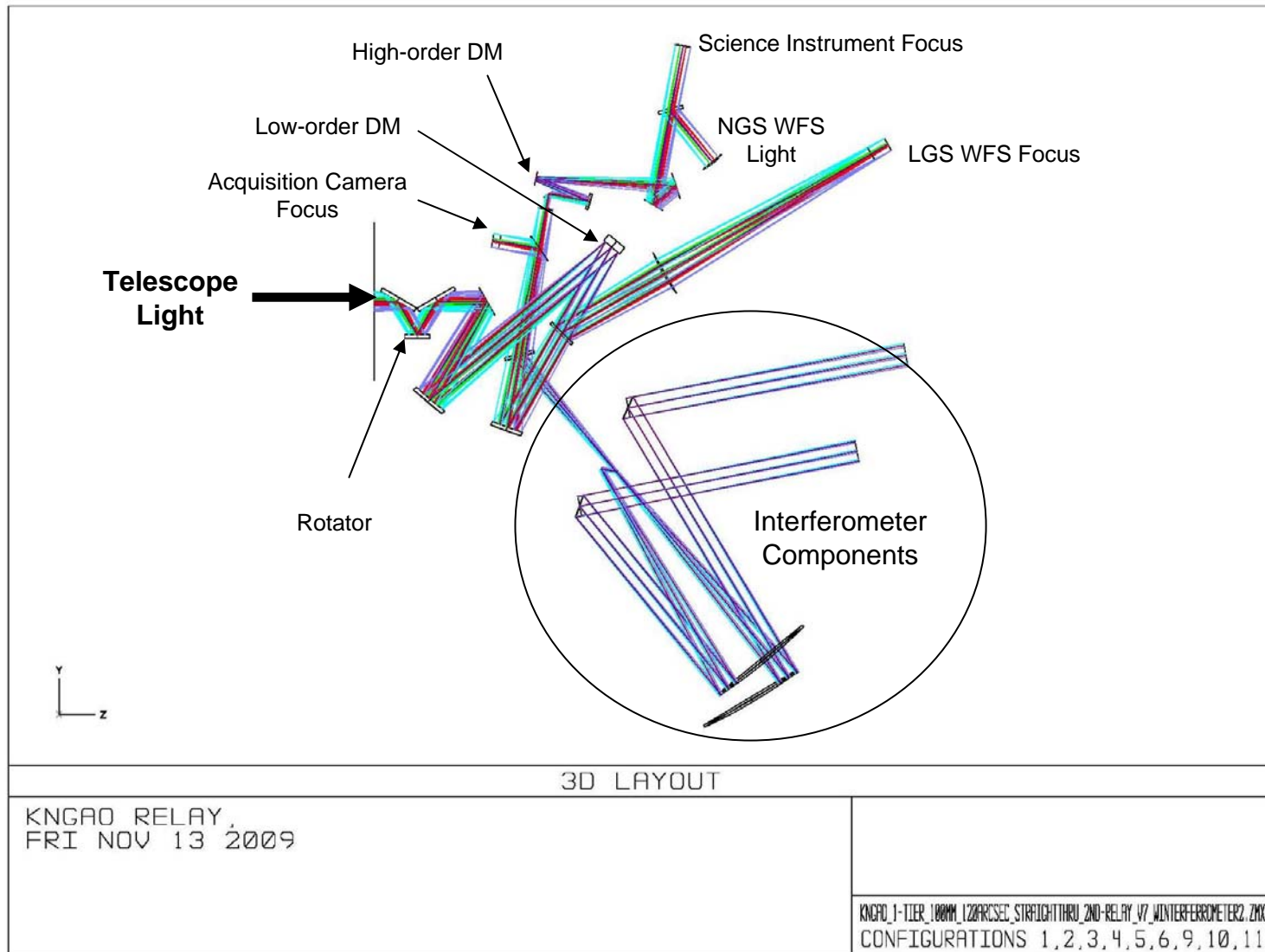
# Keck Next Generation Adaptive Optics

Instrument Bench  
Preliminary Mechanical Design

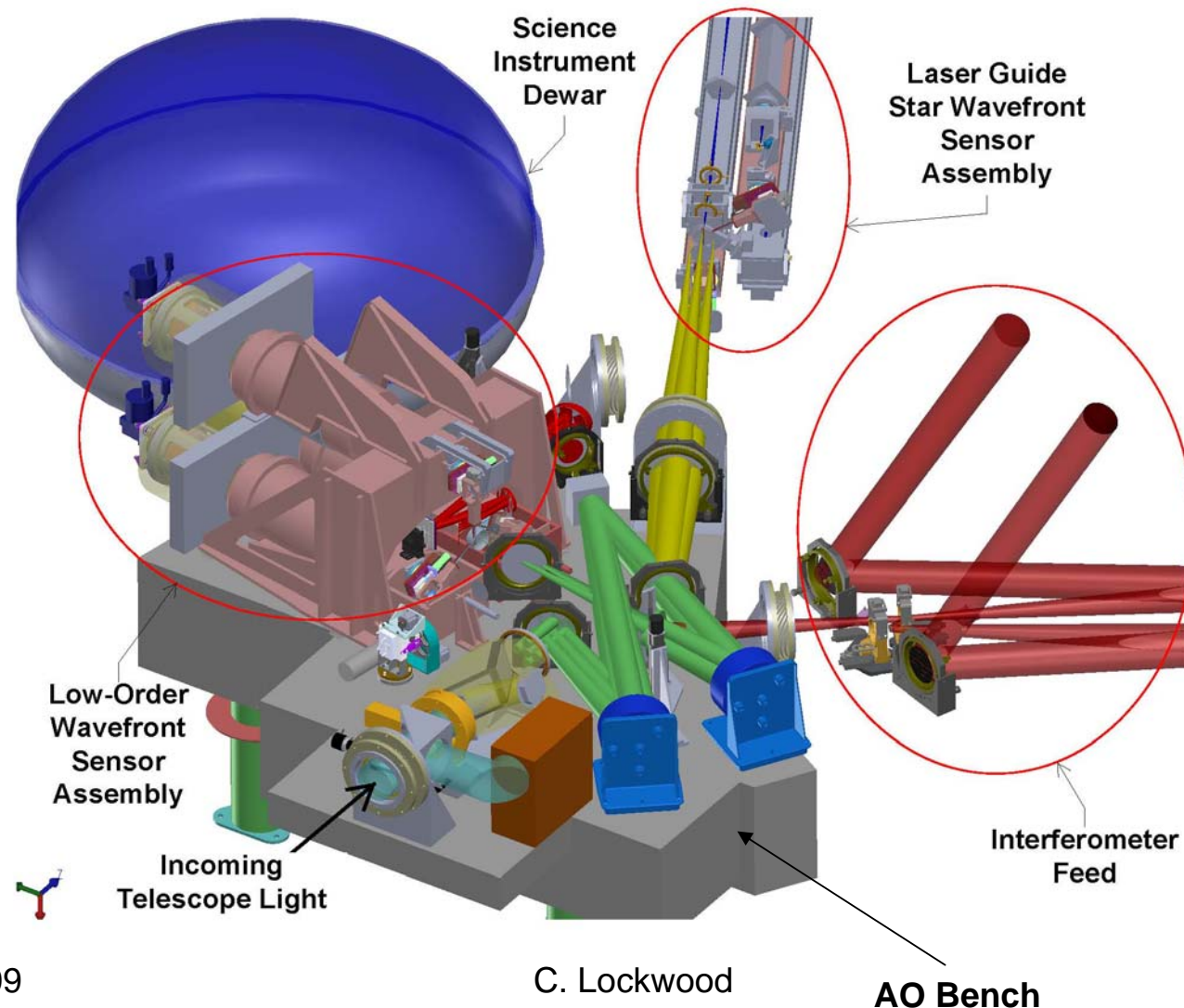
# Scope and Goals (AO relay only)

- Iterate optical and mechanical designs to a compatible layout.
- Generate design detail at levels adequate to show feasible mountings without interference or vignetting.
- Verify adjustment resolution can satisfy alignment tolerance requirements of optical design.
- Evaluate thermal stability from maintenance (dome) temperatures, to instrument operating conditions.
- Evaluate stability of instrument interface to telescope.
- Assess vibration stability considering internal and external sources.
- Identify challenges for subsequent phase.

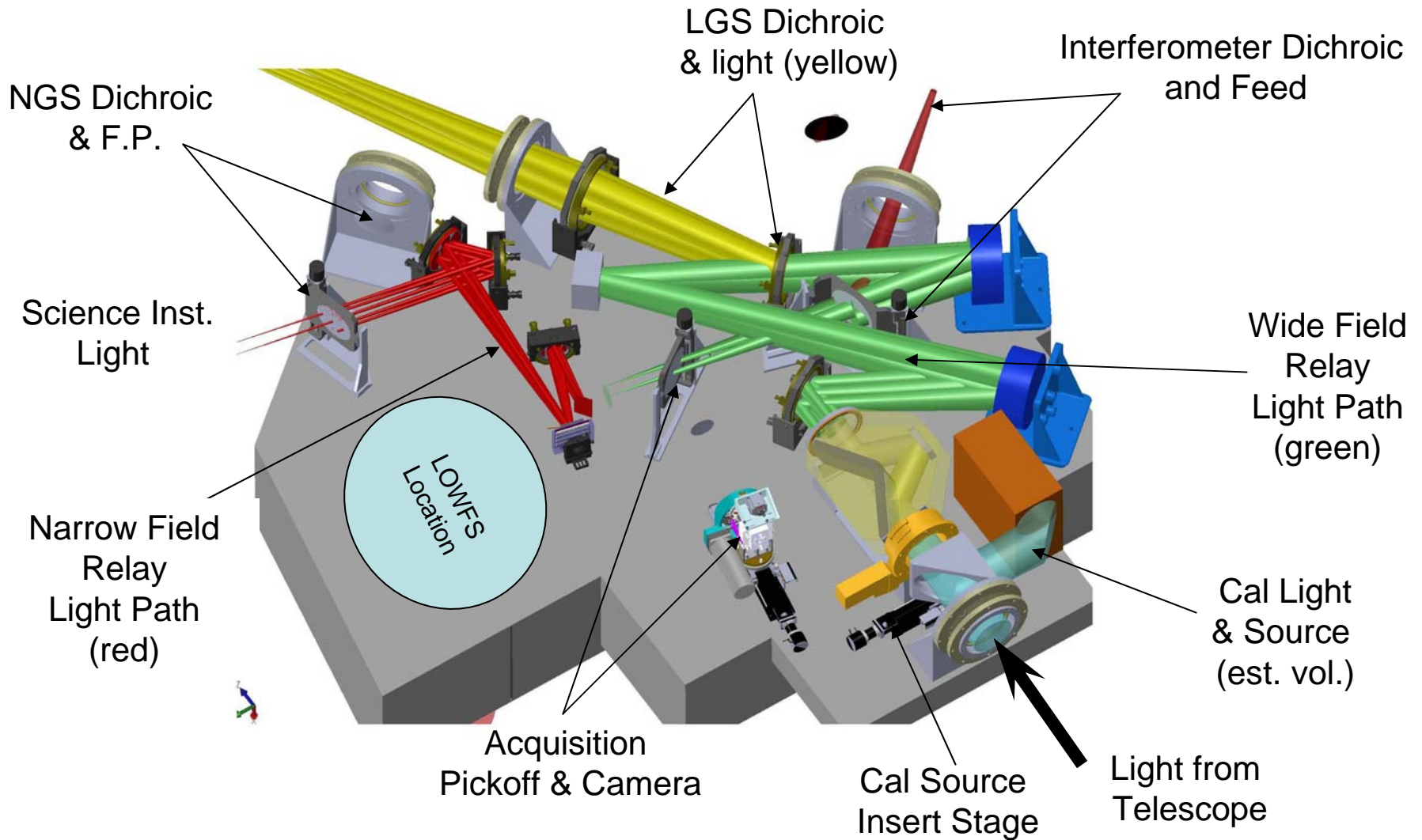
# Zemax Design Layout



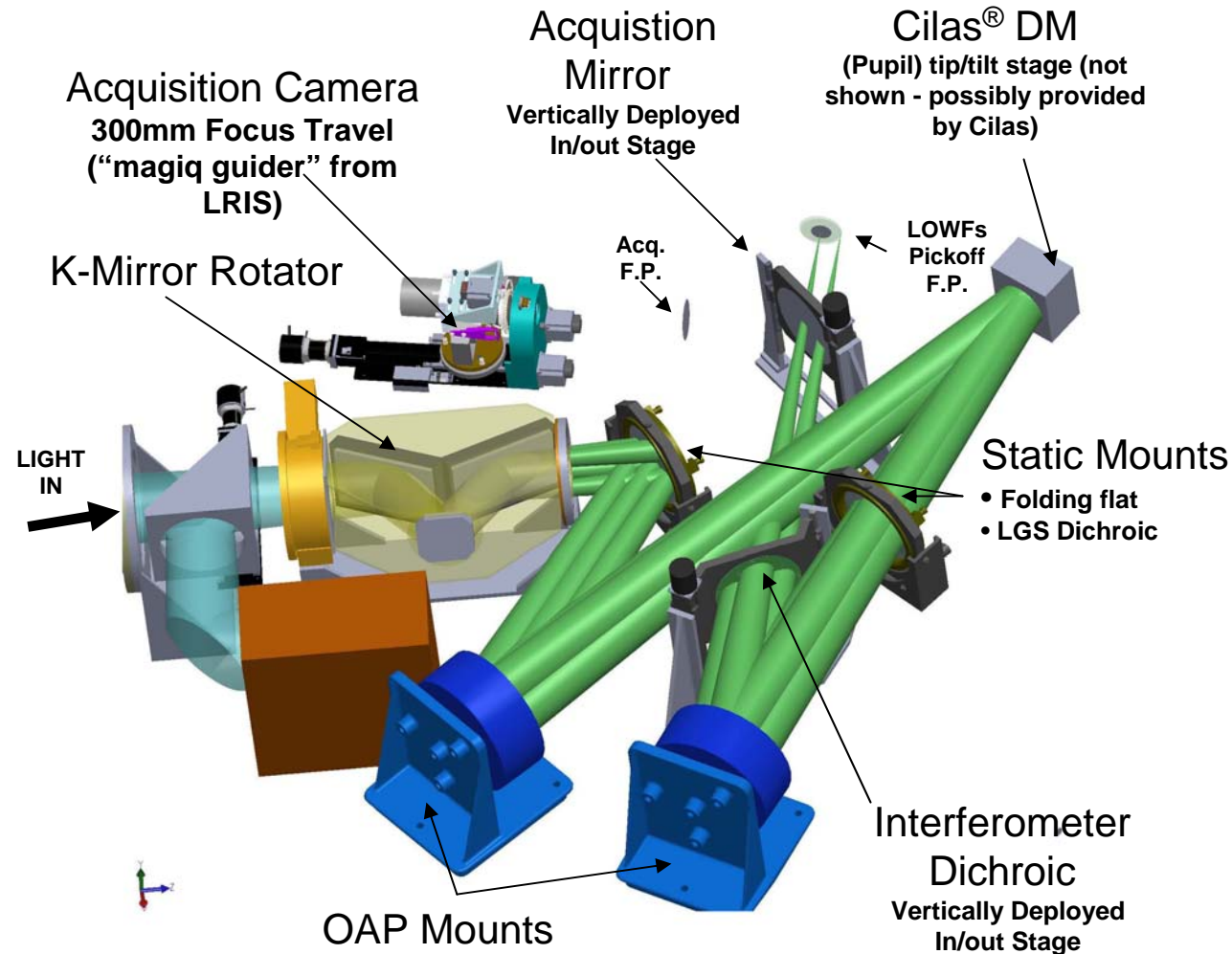
# Bench & Related Assemblies



# Bench Layout



# Wide Field Relay



- Tip/tilt stage-mounted Deformable mirror (mfg's design pending)
- 2 Static mounts (choice – TBD). Shown are Optosigma gimbal mounts w/out (desired) lockable adjustments.
- Acquisition camera shown is "magiq guider" design from LRIS.
- Interferometer dichroic and acquisition camera require custom in/out stages to avoid vignetting.
- Parabola mounts shown are mfg'd by SORL. Packaging limitations may require other choice other choice to fit in final enclosure walls.



# K-Mirror Rotator

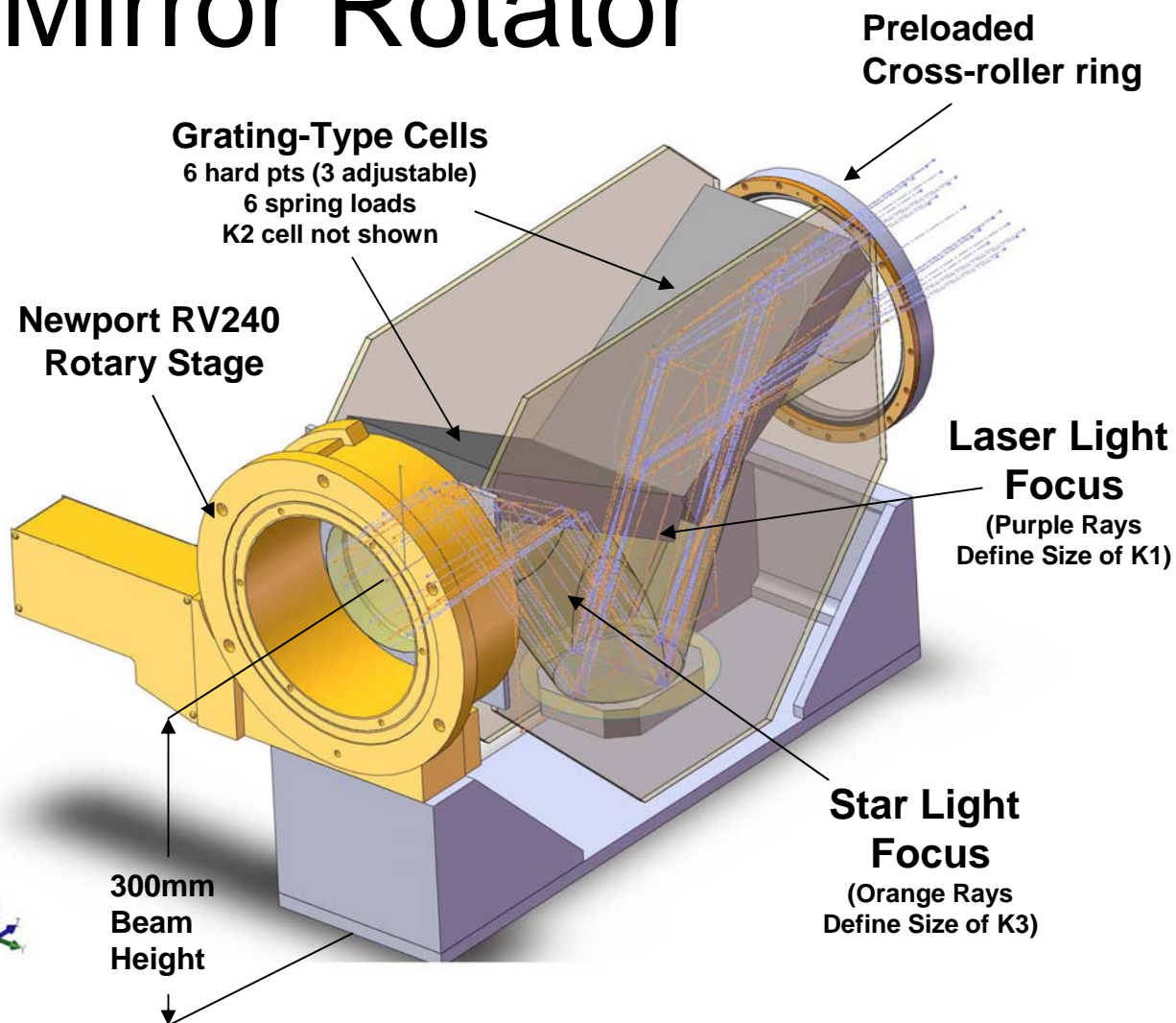
## Newport RV240 Rotational Stage

### Mfg Specifications

|                                   |                                 |
|-----------------------------------|---------------------------------|
| Aperture diameter (mm)            | 240                             |
| Travel Range (°)                  | 360                             |
| Resolution (°)                    | 0.001                           |
| Minimum Incremental Motion (°)    | 0.001                           |
| Uni-directional Repeatability (°) | 0.001 typical, 0.002 guaranteed |
| Reversal Value (Hysteresis) (°)   | 0.001 typical, 0.001 guaranteed |
| Absolute Accuracy (°)             | 0.007 typical, 0.010 guaranteed |
| Maximum Speed (°/s)               | 80                              |
| Wobble (μrad)                     | 8 typical, 16 guaranteed        |
| Eccentricity (μm)                 | 1.4 typical, 4 guaranteed       |

### Not Specified

Minimum Operating Temperature  
Pressure/Altitude limits



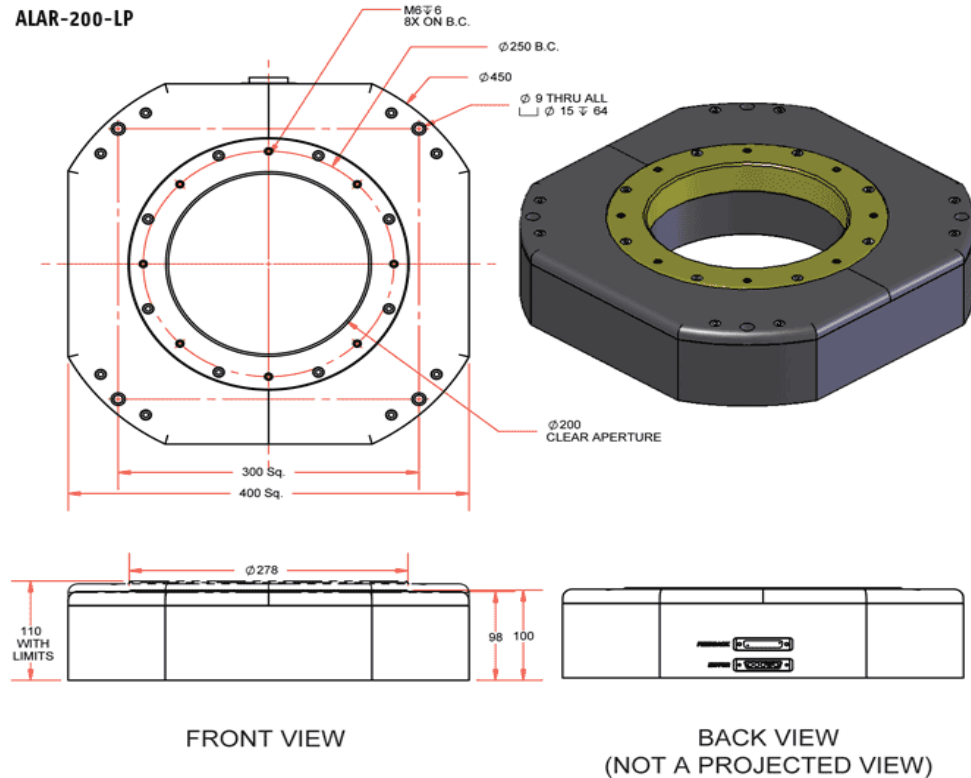
# K-Mirror Rotator (cont'd)

- Performance TBD (FR1890 thru 1896).
- Previous Alignment (KAON093)
  - ~1.8 mm on the bench.
  - $\sim \pm 10$  arcsec tip/tilt internal/external  $\Rightarrow$  5 micron over 100mm.
- New sub-apertures of 1/3 size  $\Rightarrow$  2 micron req'd.
- Tracking Speed: Up to 1.8deg/sec
- Tracking Accuracy:  $\pm 5\%$  sub-aperture, 64 across,  $\sim 5$  arcmin/(2x rotator motion)  $\sim 2.5$  arcmin during an exposure...
- Slew rate TBD



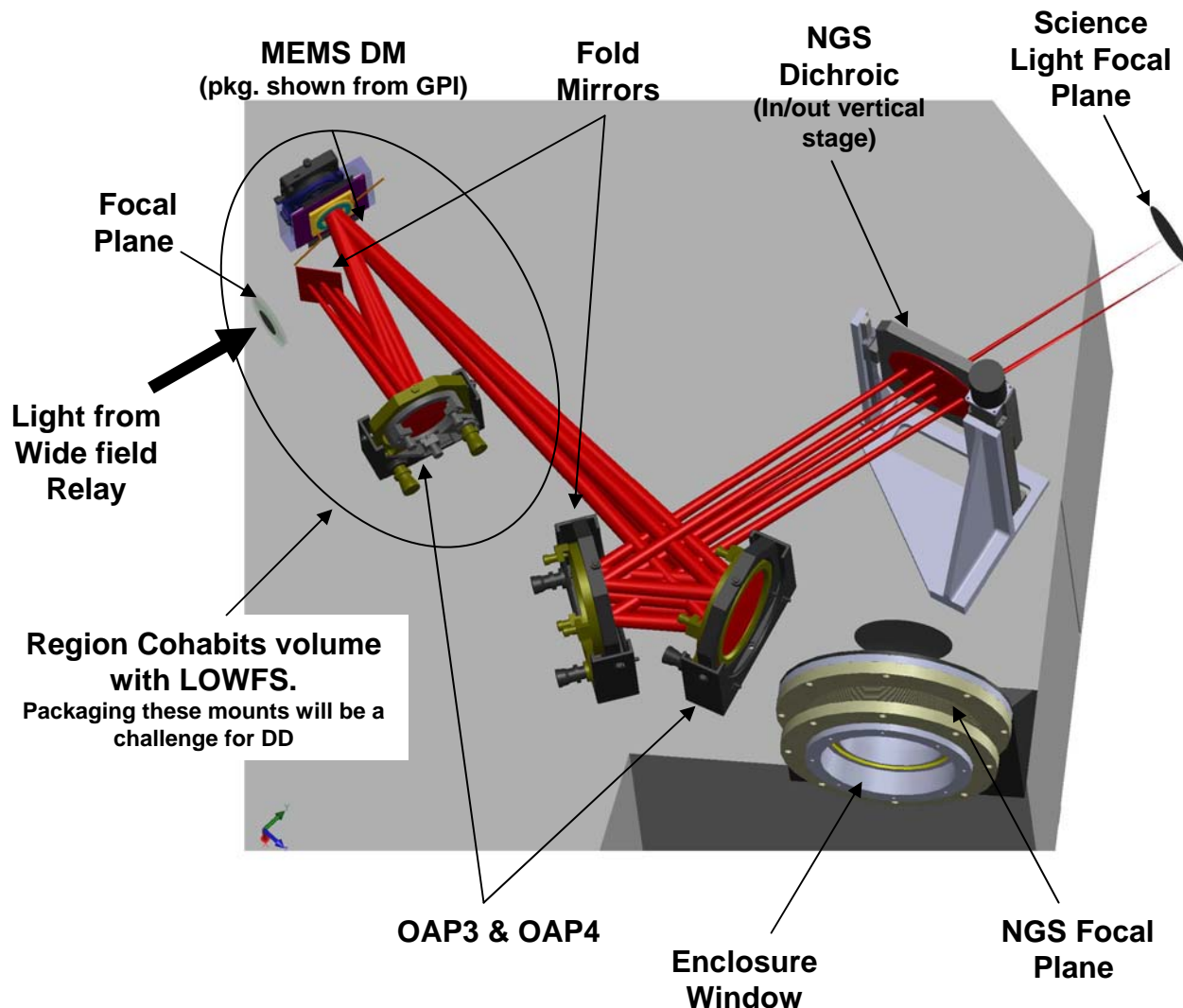
# K-Mirror Rotator (cont'd)

- Alternative Rotary Stage being considered
- Aerotech Direct Drive
- Meets resolution, accuracy, speed, and travel requirements (of the current system).
- No gearing backlash
- DC servo



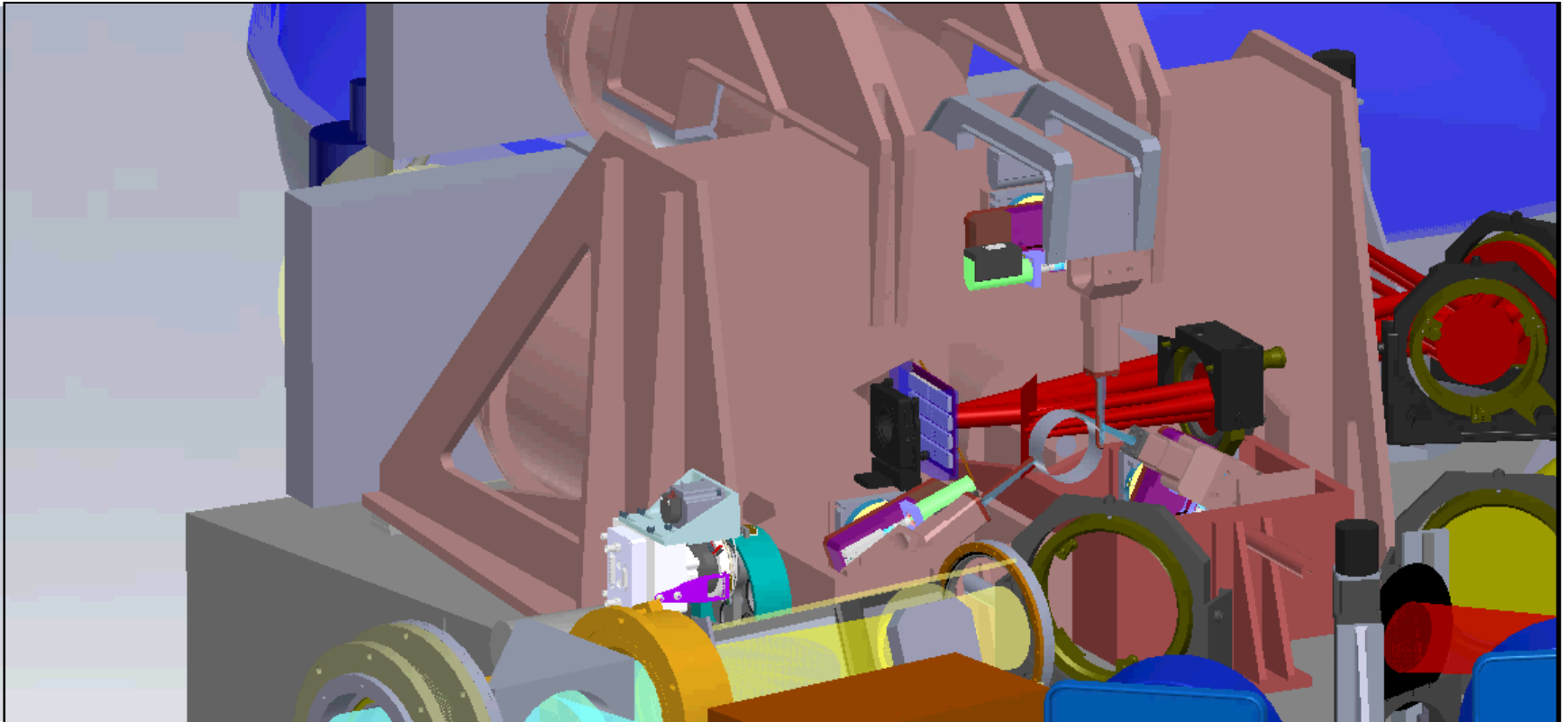
# Narrow Field Relay

- MEMs Deformable mirror shown on 5-DOF Newport mirror mount. Slow tip/tilt stage-mount will be pursued in DD.
- MEMs & OAP3 mount must be suspended inside LOWFS structure (see next slide).
- Static mounts choice TBD. Shown are Optosigma gimbal mounts w/out lockable adjustments (desired).
- In/out stage req'd NGS WFS dichroic.
- Parabola mounts are TBD. Packaging is tight for this relay.



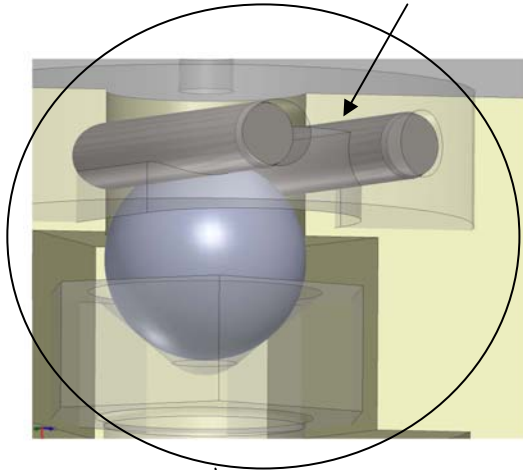
# Packaging Issue for Narrow Field Relay

(right click, “play movie”)

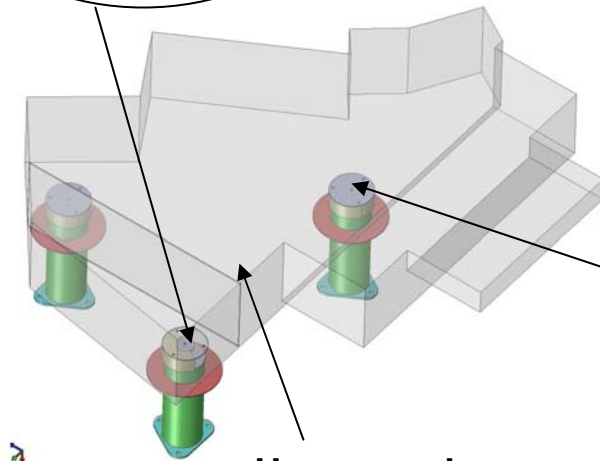


# Bench Structure

Groove element of Cone-groove-flat Kinematic mount



Pedestals Mounts  
w/kinematic  
interface to Table  
(locations from current  
installation)



Honeycomb  
Optical Table

- **Complex Table shape required for clrnc of external structures and minimization of thermal enclosure vol. (not shown).**
- **Size and Mat'l: Thickness nominally 500mm. Weight, stiffness, thermal expansion, payload, and dynamic forces req'd for full specification.**
- **Location for pedestals based on current configuration – may change in Detailed Design with better mass estimates.**
- **Current kinematics are cone-groove-flat type. Will evaluate 3-radial-groove type as well as matching upper and lower structures for rolling vs. sliding DOFs, in Detailed design.**

# Alignment

- General positioning req'd not difficult to achieve with commercial mounts - from optical design tolerance analysis:
  - Decenter < ~100 micrometers
  - Tilt < ~14 arcsec
  - Separation < ~200 micrometers
- K-mirror Rotator alignment specs not yet set (FR-1892). From KAON093 most difficult is internal/external tip/tilt, +/-10arcsec required for pupil alignment to +/-5% of a sub-aperture. **3x better req'd for 63 actuator DM – or ~ 2micron over 100mm.**
- Narrow field DM will require more stringent alignment. If we use the 5% of a sub-aperture criteria, decenter will be approximately +/-20 micrometers.
- OAP alignment procedure and adjustment requirements to be established in DD.

# Vibration Stability

- On-instrument sources – required to operate during observations:
  - K-mirror rotator
  - Tip/tilt stage for (woofer) deformable mirror
  - Slow tip/tilt mount for MEMs deformable mirror
  - LOWFS (CCRs and pickoff motors)
- Telescope coupling.
- No stability specification set (FR-1879) - optical design tolerances set upper limit.
- Mass and CG of all subsystems are required to continue with modal analysis of bench mount, table & components.

# Thermal Stability

- ~20deg C difference between maintenance/alignment conditions, and operating conditions.
- In-plane displacements of ~ 0.25mm expected for SS (across a meter at  $dT=20$ ) – detailed image quality impact & consideration of options (low cte table material, metering elements) req'd for DD.
- Vertical displacements expected on same scale. Impact and options (optical mount compensators, low cte/compensator table mounts) req'd in DD.



# Motorized Mechanisms

| Component           | Mode          | Type                                  | Accuracy                      | Cooling** ? |
|---------------------|---------------|---------------------------------------|-------------------------------|-------------|
| Cal source          | in/out config | stepper                               | ~2mm                          | unlikely    |
| K-mirror Rotator    | tracking      | servo                                 | unspecified (FR-1894)         | likely      |
| Tip/Tilt Stage      | Continuous    | Electro-static (nominally from Cilas) | 100 mas                       | unknown     |
| Cilas DM            | Continuous    | Deformable mirror                     | -                             | no          |
| IF Dichroic         | in/out config | stepper                               | moves normal to beam. ~few mm | Unlikely    |
| Acq. Camera Mirror  | in/out config | stepper                               | moves normal to beam. ~few mm | Unlikely    |
| LOWFS *             |               |                                       |                               |             |
| Slow Tip/Tilt Stage | Continuous    | unknown                               | high                          | likely      |
| NGS Dichroic        | in/out config | stepper                               | moves normal to beam. ~few mm | unlikely    |
| Narrow Field ADC    | Continuous    | servo                                 | TBD                           | TBD         |

\* The LOWFS are addressed in a separate report and mentioned here only for ref.

\*\* Device/motor selection and power dissipation slated for Detailed Design