7.9 AO Wavefront Correctors: high order and tip tilt

In order to increase optical transmission and simplify the optical design, the function of correcting the tip tilt (pointing) and higher order optical aberrations will be combined in a single optical device. The proposed implementation would be to mount the deformable mirror onto a tip tilt stage. Although nothing forbids using a deformable mirror with extreme stroke, at the present time the gimbal mounted deformable mirror appears to be the most appropriate solution. The NGAO Cascade architecture has a large (100mm) relatively low actuator density deformable mirror used to feed wide field instruments and AO subsystems, followed by a high actuator density mirror of a smaller size (25.6 mm) used to feed narrow field high Strehl AO instruments.

Each channel of the NGS LOWFS (tracking plus focus and astigmatism correction) will have internal MOAO optical correction elements for the purpose of sharpening the tip tilt stars. Similar correctors will be included in each channel of the deployable integral field spectrograph (also know as d-NIRI). The requirements for these correction elements are detailed in this section of the FRD and not the instruments requirements section.

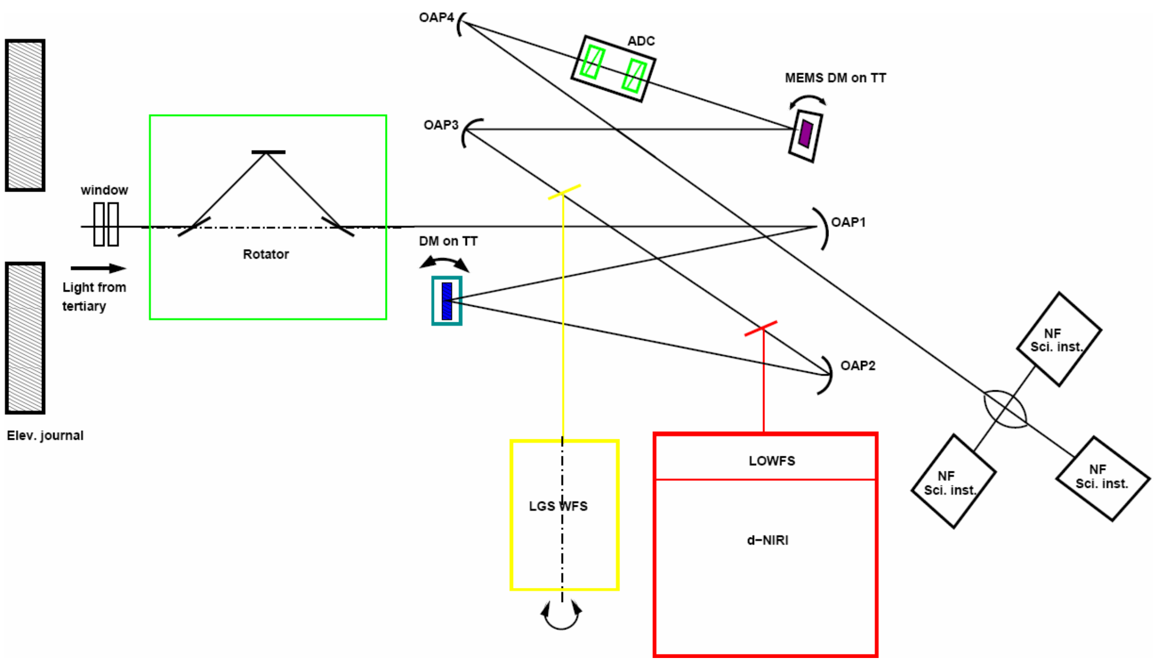

Figure 1: A schematic representation of the NGAO Cascaded Relay

As part of the NGAO system design process, a preliminary architecture selection was made during the months of July and August 2007. The result of this process was a two staged AO system known as the "Cascaded Relay". A sketch of the optical relay is included in Figure 1. More details of the Cascaded Relay can be found in KAON 499.

7.9.1 Architectural Assumptions & Overall Requirements

Actuators across telescope pupil:

a) *The first stage corrector will have 20 actuators across the relayed pupil of the Keck telescope for the corrections of higher order aberrations.*
b) *The second stage of the cascaded relay (the high Strehl stage) correctors will have 64 actuators across the Keck telescope pupil.*
c) *The LOWFS correctors will have 32 actuators across the Keck telescope pupil.*
d) *The d-NIRIR corrector will have 64 actuators across the Keck telescope pupil.*

For the purposes of this requirement, the pupil of the Keck telescope is 10.949 meters in diameter. This represents a circle that contains (circumscribes) all 36 hexagonal segments.

The requirements are derived from the NGAO wavefront error budget version 1.26

Method of AO correction:
AO correction for both tip tilt and higher order aberrations will be provided by a single optical surface. Mostly likely this will be a deformable mirror mounted on a steering gimbal.

7.9.2 Optical Requirements

Pupil diameter:
The pupil diameter for the first stage corrector in the Cascaded Relay will be consistent will a pupil diameter of 100 mm corresponding to 10.949 m at the telescope primary mirror.
The pupil diameter for second stage correctors, the LOWFS correctors and the d-NIRI correctors will be 25.6 mm corresponding to 10.949 m at the telescope primary mirror.

Optical quality:
The optical quality for the AO correctors is TBD

Stroke to flatten:
The optical quality of the mirror should be high enough that only TBD % of the total mechanical motion of the mirror surface is needed to produce an optical surface that meets the optical quality specification above (see previous specification).

Correction residual during closed loop operation:
The correction residual during closed loop operation will be TBD nm of optical aberration.

Surface roughness:
The optical quality for the AO correctors is TBD.

Reflectivity:
The reflectivity of the AO correctors should be as high as possible for wavelength between 0.5-14 microns.

7.9.3 Mechanical Requirements

Actuator Pitch:
The actuator pitch for deformable mirrors in the two main relays will be commensurate with the required number of actuators across the pupil and the size of the pupil image determined from the design of the optical relay for the first and second stage correctors. The actuator pitch for deformable mirrors in the LOWFS relay will be commensurate with the required number of actuators across the pupil and the size of the pupil image determined from the design of the first stage of the optical relay and the internal pupil relay of each LOWFS channel. The actuator pitch for deformable mirrors in the d-NIRI relay will be commensurate with the required number of actuators across the pupil and the size of the pupil image determined from the design of the first stage of the optical relay and the internal pupil relay of each d-NIRI channel.

Actuator Geometry:
The actuators will be arranged in a square geometry. A sufficient number of actuators will be provided such that at least one ring of "guard band" actuators will be outside the clear aperture of an effective 11m circular telescope pupil.

Actuator Stroke:
The actuator stroke for correction of aberrations excluding tilt should be 4 microns mechanical motion of the mirror surface corresponding to an optical correction of 8 microns in the reflected beam. The corrector stroke for tilt is TBD arc seconds (sky reference)

Fitting Error:
The fitting error for a tilt removed Kolmogorov wavefront characterized by a r_0 *of 18 cm will be TBD nm for the first stage corrector, TBD nm for the secondary stage corrector, TBD nm for the LOWFS internal corrector and TBD nm for the d-NIRI internal correctors*

Inter actuator mechanical coupling:
The inter-actuator coupling will be TBD %.

Lowest mechanical frequency:
Lowest mechanical frequency of the higher order corrector will be TBD Hz. The lowest mechanical frequency of the tip tilt stage will be TBD Hz.

Phase lag:
Requirement is TBD, this includes both the tip tilt correcting stage and the higher order deformable mirror actuators.

Actuator hysterisis:
Requirement is TBD, this includes both the tip tilt correcting stage and the higher order deformable mirror actuators

Thermal dissipation into AO enclosure:

Requirement is TBD

Operating environment:
The correctors will be able to operate at standard temperature and humid environments as other instruments at Keck observatory. In order to meet its emissivity requirements the AO correctors must be able to meet spec at -20 C in a cooled AO enclosure.

Vibrations

The tip tilt stages must not introduce extra vibration in the AO Bench and its optics, as well as other AO subsystems or instruments. Requirement value is TBD.

7.9.4 Electronic/Electrical Requirements

Power supply:
A power supply will be provided to drive all AO corrector actuators

Input signal and # channel:
These requirements are TBD

Cut-off frequency:
The cut-off frequency for driving all AO correctors is TBD

Phase-shift:
The phase shift for driving all AO correctors is TBD

7.9.5 Safety Requirements

These requirements are TBD

7.9.6 Software Requirements

Control software requirements for all AO correctors are covered under the section Real-time control. All AO correctors will interface to the AO RTR directly.

7.9.7 Interface Requirements

Real Time Control system:

AO correctors must be interfaced to the Real Time control systems. The exact requirements are TBD

AO enclosure

The AO correctors must be compatible with the mechanical design constraints of the AO bench. The electrical interface (cabling) must be routed to avoid interference with the optical, mechanical and electrical functioning of the other AO systems and instruments.

7.9.8 Reliability Requirements

Probability of actuator failure:

The rate of actuator failure shall be low enough that one actuator would fail per 10 years of typical astronomical observations and daytime testing.

7.9.9 Spares Requirements

TBD pending results of failure analysis of system.

7.9.10 Service and Maintenance Requirement

TBD pending results of failure analysis of system.

7.9.11 Documentation

Standard documentation provided including:
Mechanical drawings
Electrical schematics
Optical specification