Keck Adaptive Optics Note 555

Keck Next Generation Adaptive Optics
AO System to Instrument Interface Definitions

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1. Introduction

This note summarizes the optical and mechanical aspects of the NGAO low order and high order AO relays that will affect the design of the NGAO instrumentation[1]. This note is not intended to be a rigorous interface control document, but instead seeks to summarize in a brief way the key aspects of the interface presented by the AO system for the benefit of developing instrument concepts and identifying potential issues with the assumptions made by the AO system design.

2. Low Order AO Relay

The low order AO relay provides an AO corrected focal plane for the AO tip-tilt sensors and the deployable near-IR integral field spectrograph (d-IFS). The optical characteristics of the low order AO relay output are summarized in Table 1.

Table 1: NGAO low order AO relay output optical characteristics

Parameter	*Min.*	*Typ.*	*Max.*	*Units*	*Notes*
FOV(diameter)	150	-	-	"	1
Focal ratio	-	*f*/15	-	N/A	
Plate scale	-	1.3751	-	"/mm	
Focal plane radius of curvature	-	-1406.924	-	mm	2
Wavelength range	0.97	-	2.40	μm	3
Transmission	80	-	-	%	4
Pupil telecentricity	100	-	-	%	5

Notes:
1. Unvignetted field of view. The central 120" is fully accessible to the d-IFS and the tip-tilt sensors; the outer 30" is reserved for the tip-tilt sensors.
2. Positive radius of curvature describes an AO relay output focal plane where a given point in the AO relay output focal plane not located on the optical axis is displaced in the +z direction away from the AO relay focal plane. This value is correct for the NGAO Zemax model "KNGAO_2-tier_folded-2nd-relay_v4_wtelescope.ZMX".
3. This definition is consistent with KAON-530.
4. From the output of the telescope (Nasmyth focus) to the output of the low order AO relay.
5. At all field points over the unvignetted FOV.

The mechanical characteristics of the low order AO relay focal position are summarized in Table 2 and Figure 1.

[1] The existing OSIRIS instrument and one of the Keck-Keck Interferometer DSMs also require access to a NGAO focal station. These requirements are not included in this document.

Table 2: NGAO low order AO relay focal position mechanical characteristics

Parameter	*Min.*	*Typ.*	*Max.*	*Units*	*Notes*
Focal plane optical center					1
X axis location	-	-11.818	-	mm	
Y axis location	-	25.959	-	mm	
Z axis location	-	52.297	-	mm	
Orientation of optical axis					2
α (angle in the X plane)	-	0º	-	-	
β (angle in the Y plane)	-	129.93º	-	-	
Available envelope					3
X	1200	-	1800	mm	4
Y	800	-	825	mm	
Z	1800	-	2500	mm	

Notes:
1. X = 0 and Y = 0 correspond to the center of the telescope optical axis. Z = 0 is the telescope Nasmyth focal plane. This is located 272.5 mm in Z from the Nasmyth platform side of the telescope elevation bearing. This corresponds to surface 6 in the NGAO Zemax model "KNGAO_2-tier_folded-2nd-relay_v4_wtelescope.ZMX".
2. The orientation of the optical axis is defined as the angle between the optical axis for the given focal plane and a line parallel to the telescope optical axis passing through the center of the focal plane. Positive angles are defined as the amount of clockwise rotation in each plane required to place the parallel line on the optical axis of the given focal plane.
3. Shared by the OSM, tip-tilt sensors and d-IFS.
4. Overall dimensions, including a projecting "snout" as shown in Figure 1.

3. High Order AO Relay

The high order AO relay provides an AO corrected focal plane for the near-IR and visible imagers, and the NGS mode wavefront sensor. The optical characteristics of the high order AO relay output are summarized in Table 3.

Table 3: NGAO high order AO relay output optical characteristics

Parameter	*Min.*	*Typ.*	*Max.*	*Units*	*Notes*
FOV(diameter)	30	-	-	"	1
Focal ratio	-	*f*/46.5	-	N/A	
Plate scale	-	0.4436	-	"/mm	
Focal plane radius of curvature	-	-277.53	-	mm	2
Wavelength range	0.680	-	2.40	μm	3,4
Transmission	75	-	-	%	5
Pupil telecentricity	100	-	-	%	6

Notes:
1. Unvignetted field of view.
2. Positive radius of curvature describes an AO relay output focal plane where a given point in the AO relay output focal plane not located on the optical axis is displaced in the +z direction away from the AO relay focal plane. This value is correct for the NGAO Zemax model "KNGAO_2-tier_folded-2nd-relay_v4_wtelescope.ZMX".
3. Goal range of 0.620 μm to 2.40 μm.
4. This definition is consistent with KAON-530.
5. From the output of the telescope (Nasmyth focus) to the output of the high order AO relay.
6. At all field points over the unvignetted FOV.

The mechanical characteristics of the high order AO relay focal position are summarized in Table 4. Sharing of the high order relay output amongst the two imagers and the NGS wavefront sensor

is accomplished by a beam selection system. The imagers and the NGS wavefront sensor mount on the lower optical table of the AO system. Kinematic mounting as required for each instrument is included in the envelope dimensions given in Table 4, but any translation stage that may be required to provide for focusing the near-IR or visible imager by physically translating the instrument along the optical axis is not included in the envelope dimensions.

Table 4: NGAO high order AO relay focal position mechanical characteristics

Parameter	*Min.*	*Typ.*	*Max.*	*Units*	*Notes*
Visible imager					1
Focal plane optical center					
X axis location	-	-11.818	-	mm	
Y axis location	-	-76.028	-	mm	
Z axis location	-	31.019	-	mm	
Orientation of optical axis					2
α (angle in the X plane)	-	0º	-	º, ', "	
β (angle in the Y plane)	-	70.79º	-	º, ', "	
Near-IR imager					1
Focal plane optical center					
X axis location	-	-11.818	-	mm	
Y axis location	-	-35.711	-	mm	
Z axis location	-	58.432	-	mm	
Orientation of optical axis					2
α (angle in the X plane)	-	0º	-	º, ', "	
β (angle in the Y plane)	-	40.79º	-	º, ', "	
NGS wavefront sensor					1
Focal plane optical center					
X axis location	-	-11.818	-	mm	
Y axis location	-	-55.341	-	mm	
Z axis location	-	15.449	-	mm	
Orientation of optical axis					2
α (angle in the X plane)	-	0º	-	º, ', "	
β (angle in the Y plane)	-	60.79º	-	º, ', "	
Beam height above lower optical table	-	250	-	mm	
Available envelope: imagers					
X	500	-	600	mm	3
Y	500	-	600	mm	
Z	625	-	800	mm	
Available envelope: NGS wavefront sensor					4
X	TBS	-	TBS	mm	
Y	TBS	-	TBS	mm	
Z	TBS	-	TBS	mm	

Notes:

1. X = 0 and Y = 0 correspond to the center of the telescope optical axis. Z = 0 is the telescope Nasmyth focal plane. This is located 272.5 mm in Z from the Nasmyth platform side of the telescope elevation bearing. This corresponds to surface 6 in the NGAO Zemax model "KNGAO_2-tier_folded-2nd-relay_v4_wtelescope.ZMX".
2. The orientation of the optical axis is defined as the angle between the optical axis for the given focal plane and a line parallel to the telescope optical axis passing through the center of the focal plane. Positive angles are defined as the amount of clockwise rotation in each plane required to place the parallel line on the optical axis of the given focal plane.
3. Overall dimensions as shown in Figure 2.
4. Overall dimensions as shown in Figure TBD.

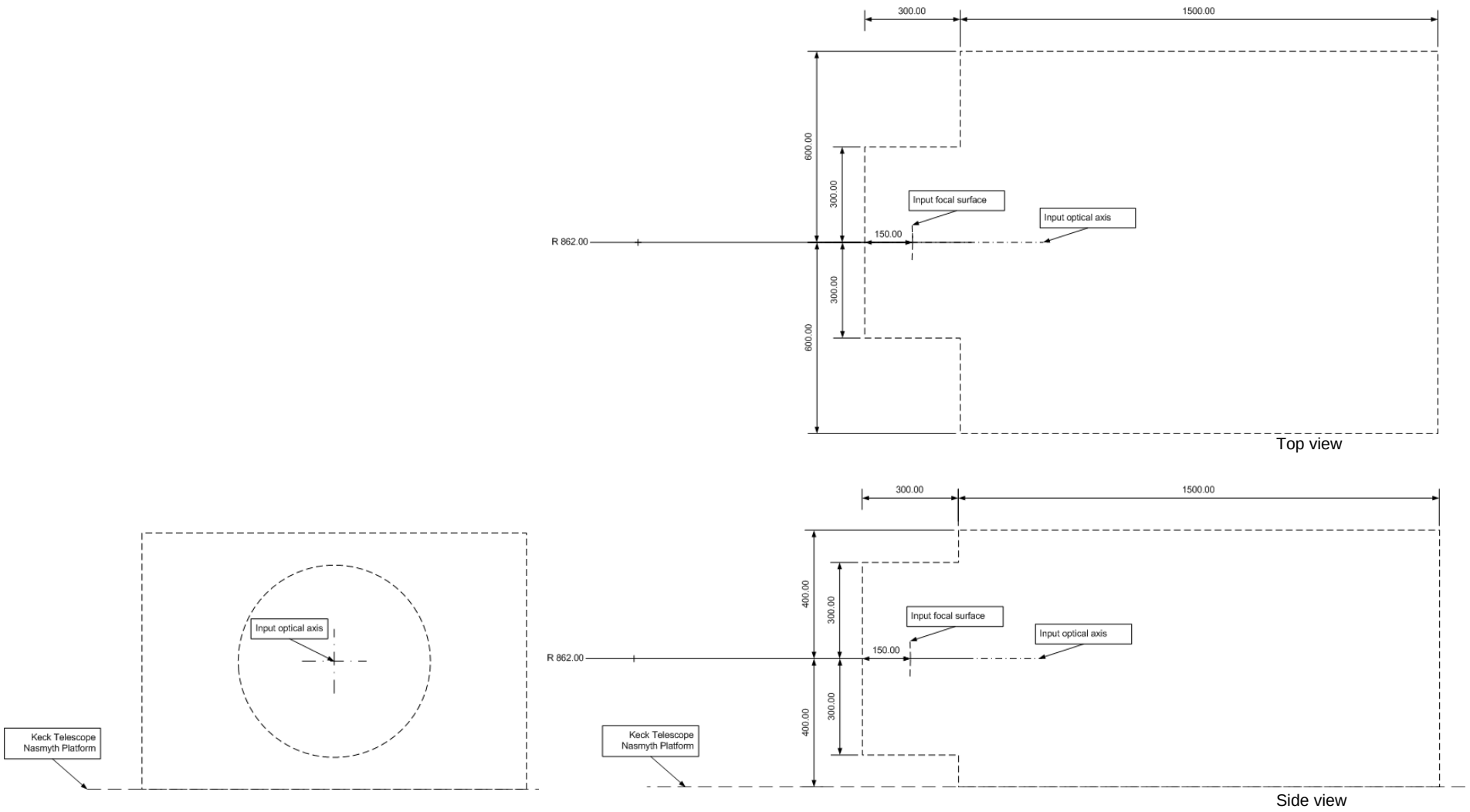

Figure 1: Mechanical envelope available at the low order AO relay output
(All dimensions in mm, do not scale drawing)

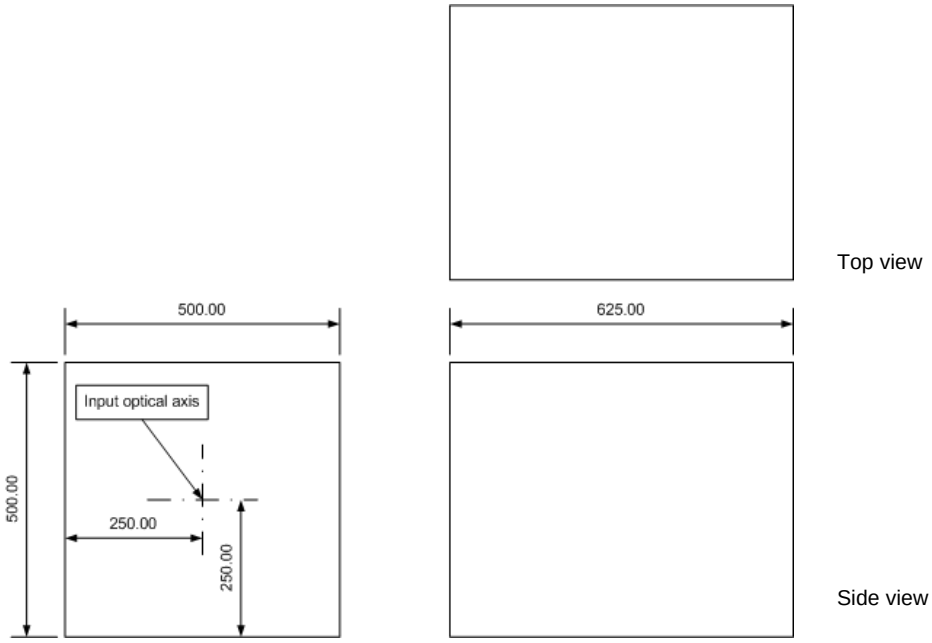

Figure 2: Mechanical envelope for the narrow field imagers
(All dimensions in mm, do not scale drawing)

4. References

Adkins, Sean, "Next Generation Adaptive Optics System Passband Definitions", Keck Adaptive Optics Note 554, W. M. Keck Observatory, December 12, 2007.