CHARA TECHNICAL REPORT

No. 104 May 3, 2021

Alignment Maintenance Task List for Daytime

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ABSTRACT:

This report lists tasks that have to be completed daytime in order to maintain the optical alignment of the CHARA Array. For each task there is a suggested frequency based on experiences over the years. The terminology used here assumes familiarity with the CHARA Array and the terminology used by the CHARA team.

1. INTRODUCTION

The alignment procedures have evolved over the years. The procedures and the frequency of necessary adjustments changed as a result of learning the stability of subsystems, and improving stability whenever it was possible. With the additions of new subsystems to the CHARA Array, especially the adaptive optics systems, the alignment became more complex, and at the same time most of the routine daily alignment procedures became more automated. Some of the alignment maintenance procedures are described elsewhere in more details.

The automated procedures require wave front sensing systems, and the alignment of those systems require monitoring by experts. The lab wave front sensors were stable enough for several years now, also years-old default flats work quite well. Labao reconstructors shuld be checked about yearly. The telescope wave front sensors also went for years without major adjustments, but new reconstructors are being done more frequently. Design documents for both the lab and telescope wave front sensors exist. Instructions for their alignment and calibration is to be summarized in another document.

Any installation and re-alignment procedures after mirror coatings, as well as the alignment procedures used during observations are outside of the scope of this document.

2. ALIGNMENT SOURCES

There are several alignment sources in use to align the CHARA beam train and instruments, but all sources have to be aligned to the defining CHARA alignment laser.

2.1. The CHARA alignment laser

The CHARA optical axis is defined by a green (>200mW, 532 nm) laser in the beam combination laboratory. The laser beam after going through a spatial filter is expanded to a D>19 mm collimated beam, which is then split up by the ‘VIS-beams’ combiner and eventually defines 6 axes, for 6 telescopes. The beam diameter in the lab is 19 mm, this is the result of geometrical optics calculations taking into account the reduction of the 1 m Mersenne telescope and the laboratory beam reducing system. The alignment laser beam diameter can be controlled by an iris under computer control using the Iris GUI, where the BEAM setting is the default D_{lab}=19 mm. The alignment laser beam can go out to each telescope primary, although a small retro reflector in front of the telescope secondary is the farthest point it is used.

The alignment laser can be turned around with mirrors at several places in the direction of star light, and by doing so it is also used to align beam combiners and reference cameras operating both in the visible and infrared. The laser is powerful enough to overcome the optical density of the VIS/IR beam splitter, so it can be seen and used also in the IR side.

2.2. The white light source

The collimated beam of the white light source is combined with the alignment laser before the combined alignment beams are split up by ‘VIS-beams’ and directed into the 6 axes. The white light source is there to align and co-phase both VIS and IR beam combiners. Description of the source entitled “New CHARA WL Source” can be found next to the Oriel box on the top of the source table.

2.3. The metrology alignment laser

The alignment of the metrology system for the delay lines also requires expert maintenance. The metrology system has its own alignment laser, it happens to be green as well, because the metrology optics was designed to be achromatic for green and the metrology wavelength, which is 1319 nm.

2.4. The AO beacon

At each telescope on the adaptive optics board there is a source, which can provide blue or red collimated beams, D=127 mm, for the alignment of the adaptive optics systems.

2.5. The Six Telescope Simulator

The Six Telescope Simulator (STS) was installed on the Metrology table. It was co-aligned and co-phased with the CHARA alignment laser. It is mostly used to maintain the MIRCx alignment. The alignment is of it is maintained by the MIRC team.

3. TASKS USING THE ALIGNMENT LASER

3.1. From the alignment laser source to M10

The following list of maintenance tasks is organized roughly by the order the CHARA alignment laser is reaching a subsystem, rather than by suggested frequency.

	System or optics	**Target**	**Adjustment / Frequency** and references to procedures
1	Spatial filter and collimator (including folds to spatial filter), and also folds to the mirror on the VIS-beams translation stage	In the end CHECK targets and the established beam paths by the VIS-beams fiducials*	Only in case of accident or need of replacement.
2	VIS-beams translation stage mirror tilts	CHECK target at the North edge of VIS table	Usually good for years. Tilt adjustment using Pico 3 controller “CHECK” connection.
3	VIS-beams combiner all possible beam pairs (laser injected to 2 adjacent beams at a time)	* IR table 6-beams target on the visible beams	Manual adjustments of tilts, once a year check is sufficient.

4	VIS-beams combiner all possible beam pairs (laser injected to 2 adjacent beams at a time)	* E1 beam sampling table 6 beams target	Remote pico-motor tilt adjustments using Pico 3 controller. At least once a day before every observing night, or before a daytime test/task starts.
5	IR/VIS splitter on the beam sampler	labao wfs	Automated tilt adjustments using labao GUI “LAB DICH” button. Every time the scope aligned to another beam, or daily check before observing, or a daytime test/task starts.
6	Lab DM tilt stage	Front side of front rail target	Weekly check. This tilt stage seems to be weak. Manual tilt adjustments.
7	BRT secondary	No simple fiducial, see alignment procedure.	In case of disaster or accident. Very stable good for years.
8	BRT primary tilts	Back rail target	Weekly check, or at configuration change. Remote adjustment using brtgtk GUI.
9	Delay line cart primary tilt (cart at back)	Back side of front rail target	In case of accident, or couple of times a year.
10	Periscope top mirror tilt	Center of lower periscope mirror	Adjust only in case the lower mirror tilt adjustment runs out of range, OK for decades.
11	Periscope lower mirror up/down tilt	REFERENCE camera origin, set by beam from the small corner cube on BS table.	In 1-2 months. Adjust only when pop5 is in use! Turn on END LED using POPs GUI, watch on REF camera. Remote adjustment using Pico 5 controller.
12	Periscope lower mirror rotation to each pop	REFERENCE camera origin, set by beam from the small corner cube on BS table.	In 1-2 months. Turn on the LED in the pop using POPs GUI, watch on REF camera. Remote adjustment using PERI 1 or PERI 2 controllers. Write down PERI positions for each pop, edit “popperi.conf”.
13	The tilt of pop5 or END mirror	M10 target moved in place by “targetgtk target_M10” GUI	As stable as the END-box. Adjustment rarely necessary, maximum 1-2 times a year using Pico 4 “ANY POP 5”. First, the **control wire has to be manually moved to the END mirror to be adjusted.** See connector diagram pasted at each END mirror.

14	The tilt of pop mirrors 4,3,2, and 1.	Mirror centers viewed in M10 camera	Same time when #12 is done. When pop5 LED was centered in REFcam, adjust M10 to center the laser beam on the black dot. For pops 4,3,2, and 1 do not touch M10, when their LED is centered on REFcam, move the pop using Pico 4 or Pico 5 controller to center the laser.
15	M7 tilts	Center of field rotation	A) M7 is actively controlled during most observations using the blue beacon. B) Daytime Coude alignment should be done after task #12 and 13 were completed. See: Coude … for this, the alignment laser or the beacon could also be used.
16	M10 tilts	Mirror centers viewed in M10 camera	Before observing or a daytime test/task starts.
17	Rail alignment	The rail targets	As needed and indicated by too much beam motion while only the cart is moving, could be OK for more than a year. See: TR…

3.2. Turning back from the small retro reflector at the BRT

For each telescope there is a 1” corner cube on a kinematic base, which allows for the alignment of those systems, which receive light only from the direction of the starlight, such as the REFERENCE camera, beam combiners, lab tiptilt detector. After the alignment was checked up to the IR/VIS beam splitter, #5 in the previous table, the small retro reflector may be put in place to a point before the laser beam gets expanded by the DM+BRT system.

	System or optics	Target	Adjustment / Frequency and references to procedures
1	Small retro reflector	The incoming beam	Only in case of accident or need for replacement.
2	IR mirror on the beam sampler	6-beams target placed to the IR beam combiner to be used	Remote adjustment of IR mirror tilts using Pico 2 controller. Each time when changing configuration.

3	Fold mirrors (on Zaber mounts) to Lab TipTilt	The designated 4 pixels in the CCD for each beam.	Computer controlled adjustments of fold mirror tilts using Zaber_2 GUI. In case PAVO splitters are taken in/out of the beams, otherwise check in 1-2 weeks. See procedure …
4	REFERENCE camera	The injection optics should be on axis with the alignment laser.	The camera and related optics do not need to be adjusted unless an accident. NOTE: The origins of different beams vary by a few pixels. Use shutters, make sure you are looking at one beam only when determining the origin for that beam.
5	PAVO	See PAVO User Guide	Before a run starts, weekly in case of longer runs.
6	CLIMB 1 and 2	See ………..	Before a run starts, or if accident
7	JouFLU, currently not in use		
8	MIRCx		Done remotely by users using STS

3.3. From M10 to M2

No relay mirrors between M10 and M2 are adjusted unless they were removed for recoating, with the exception of M7 (see 3.1. #14) and M4.

Each telescope has a fixed glass M4 and a deformable M4. The mounts of these two mirrors fit on a common kinematic base, installed on the telescope, so they are easily interchangeable. Tilt adjustments may have to be done manually, when DM and fixed mirrors are swapped. See ………..procedure.

The CHARA alignment laser is used to position and tilt relay mirrors after recoating. The positions of the mirrors are usually well preserved, so when the freshly coated mirrors are reinstalled, the alignment mainly amounts to get the tilts right. However in case of M6, the position and also the rotation/tilt of the mirror is lost when the mirror is removed. See ……….. procedure.

4. THE USE OF THE WHITE LIGHT SOURCE

The collimated WL beam comes from a fiber tip at the focal point of an off-axis parabolic mirror. This portion is very stable.

There is a fold mirror to direct the WL to meet the alignment laser beam, this fold mirror is motorized and could be adjusted each time before the WL beam is used.

Since the WL source is there to align beam combiners, WL beams are always used coming back from retro reflectors, maximum two at a time. Small retros for adjusting beam paths, and big retros on designated kinematic bases for co-phasing. See procedure elsewhere for co-phasing.

The WL fold mirror adjustment can be done on any beam, when the small retro is in place after a proper laser alignment was done. The WL fold mirror can be adjusted via a hand paddle after the knob on the controller above the lab alignment scope was turned to WL. The WL fold mirror has to be tilted until the laser spot and the WL spot overlap in the lab alignment scope. ND=5 at least in the laser! When done, turn the controller knob to a neutral spot, it has a tendency to keep sending random signals to the mirror axes!

The white light source is used to align IR beam combiners and to co-phase all beam combiners. The 'VIS-beams' beam combiner has been the phase reference for the CHARA Array. The recently commissioned STS could be also used to align beam combiners, and could be used as phase reference. At the installation of the STS in 2019, it was co-aligned with the CHARA beam path and co-phased with 'VIS-beams'. So far there is no indication that STS co-alignment and co-phasing needs adjustment.

5. METROLOGY ALIGNMENT LASER

The IR metrology laser is injected into polarizers and fibers on the metrology breadboard. There is an original metrology alignment laser, which was used for aligning these injections on the metrology breadboard. That original green alignment laser is no longer working, or very weak. Fortunately, there were no accidents in the last several years that would have necessitated realigning the metrology breadboard.

A single IR metrology reference signal is used for all six delay lines in the control system. That reference signal is injected into a fiber via a coupler between the metrology laser fiber and the fiber going out to the control system. No adjustment to that can be done or needed.

For the ‘unknown’ signals from the carts, the metrology laser is injected into distribution boxes for the S and P polarization channels. (Mislabeled before the distribution boxes, do not change.) There are fibers connecting the distribution boxes to the ‘black boxes’ at each of the delay lines. The new green Throlabs metrology alignment laser has fiber output. The alignment beam can be injected into any of the metrology fibers going to the ‘black boxes’ at a simple coupling point. This way the green fiber laser can be used to align the ‘black boxes’ and other relay optics for the metrology laser beam.

	System or optics	**Target**	**Adjustment / Frequency** and references to procedures
1	Anything on the metrology breadboard	Seek procedure	Only in case of accident or need of replacement.
2	Black boxes	Seek procedure	Only in case of accident.
2	Met 0	Front rail target front side	In case of accident or need of replacement. Manual tilt adjustment as a part of a procedure…..
3	Met 1	Back rail target (or back side of front rail target)	Remote pico-motor tilt adjustments using Pico 2 controller engineering GUI, as a part of a procedure…. **Daytime** check in 1-2 months, or as needed.
4	Met 2 (the mirror that returns the beam to the cart for second pass)	A) Outgoing beam from ‘black box’ OR B) optimizing IR signal during the night	A) Remote pico-motor tilt adjustments using Pico 2 controller engineering GUI, as a part of a procedure. Daytime check in 1-2 months. B) as needed maybe at night.

6. THE AO BEACON

The mounting of the Adaptive Optics Board (AOB) to the side of the telescope was designed to minimize the anticipated flexure. Most of the optical elements are equipped with motors enabling remote adjustments. As the flexure of the AOB cannot be reduced to a required tolerance dictated by the AO system, some adjustments are servoed during observations. The following list shows daytime tasks to be done before observations. The tasks should be completed strictly in this order after the alignment with the CHARA alignment laser was done up to M10 alignment. Iterations of steps 1,2,3, and 4 maybe necessary.

	System or optics	**Target**	**Adjustment / Frequency** and references to procedures
1	Beacon fold mirror, in GUIs also called Beacon, or B-Flat	The TWFS through the hole in the Acq.fold mirror Watch x,y terms in twfs GUI.	Depending on temperature gradient, few minutes to few hours. Remote adjustment buttons reachable on several GUIs
2	AOB splitter tilt, in GUIs also called Scope Dich	The lab wfs Watch x,y terms in labao GUI	Before observing or daytime test starts, or as needed. Remote adjustment buttons reachable on several GUIs
3	Beacon Focus	The lab wfs Watch F term in labao GUI	Before observing or daytime test starts, or as needed. Remote adjustment buttons reachable on several GUIs
4	twfs Focus	The twfs. BUT only if Beacon Focus was checked within a few minutes and proven stable. Watch F term in twfs GUI	Before observing or daytime test starts, or as needed. Remote adjustment buttons reachable on several GUIs
5	AOB splitter change	Progress should be monitored in Acq. TV. After the switch is completed, steps 1 through 4 should also be completed.	As needed. Automated procedure activated by a push of a button available on several GUIs. Best to use the HUT engineering GUI.