CHARA Technical Report

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OPLE Rail Alignment Procedure

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1. INTRODUCTION

The CHARA Array's Optical Path Length Equalizer (OPLE) introduces a continuously variable optical delay into the beam from each CHARA telescope. This is accomplished by means of a cat's eye reflector mounted in a cart which rolls along a set of rails. It is necessary to align these rails with the beam from the telescope so that the return beam will stay in alignment as the OPLE cart moves. This report presents the procedure for aligning the OPLE rails.

2. RAIL ANATOMY

Each rail line is made up of 3 rails, each with a unique function. The rails rest upon thick cross-members called sleepers. The rail feet are clamped on both sides to the sleepers wherever possible to minimise drift of the rail position.

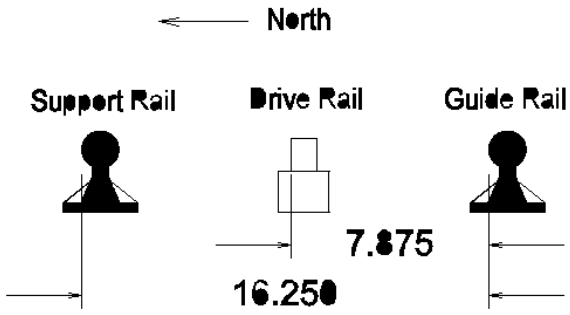

FIGURE 1. OPLE rails as seen from the west end, looking east. North is to the left. Measurements given are from the north edge of each rail.

The southernmost rail is the guide rail. The wheels on the ople cart which contact the guide rail are v-grooved, so the cart's left-right position is determined by the guide rail.

The central rail with the rectangular cross-section is the drive rail. The OPLE cart's drive wheel presses up against the north side of the drive rail.

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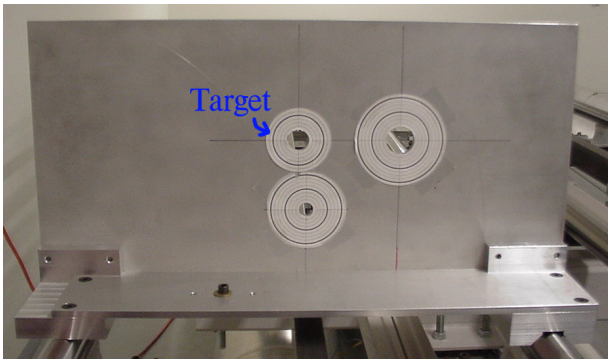

FIGURE 2. OPLE East Mask. Regularly placed just in front of the carts at the far east end of the rails during daily beam alignment. For rail alignment, a paper target is taped over the central aperture.

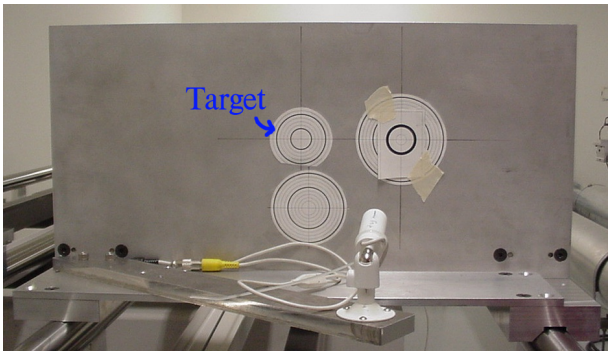

FIGURE 3. OPLE West Mask. Regularly placed at the far west end of the rails, just in front of the periscopes. For rail alignment, the central target (marked in the figure) is used.

The northernmost rail is the suppport rail. The single wheel on the ople cart which contacts the support rail is flat, and the portion of the OPLE motor cart which wraps around the support rail is built with the ability to flex. As a result, the support rail's position is designed to to affect the left-right position of the OPLE cart.

3. ITEMS NEEDED

- Flashlight
- OPLE East Mask
- OPLE West Mask
- OPLE Rail Spacer
- Masking Tape
- 3/8" Hex Wrench
- $\frac{3}{4}$" Socket Wrench
- $\frac{3}{4}$" Wrench

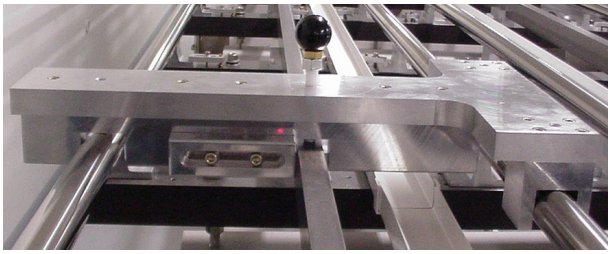

FIGURE 4. OPLE Rail Spacer. Once the guide rail is properly aligned and tightened down, the spacer is used to set the drive and support rails at the appropriate distance from the guide rail.

- Ruler
- Plumb Bob

4. ALIGNING THE RAIL

We have found that the simplest standard for rail alignment is the laser beam used to align the optics in the beam combining lab. The diffraction spot of the laser is viewed on a target which rests on the guide rail, and the guide rail is moved until the spot hits the center of the target. This method is relatively quick, and can position the guide rail with less than a millimeter of error if sufficient care is taken. After the guide rail is aligned, the OPLE Rail Spacer is used to position the drive and support rails with respect to the guide rail.

4.1. Establishing the Feducial Positions Along the Rail

Before using the alignment laser as a reference for the rails, it must be properly aligned itself. This job is usually performed by the Beam Combination Lab Supervisor, as this step requires moving the Beam Reducing Telescopes and Periscopes out of the beam.

Two points define the alignment beam. The first is the alignment beam iris, located on the light source table. The second is the center target on the West OPLE Mask, when it is placed over the sleeper just in front of the OPLE cart, with the cart parked at the far east end of the rails. Once these two points are established, they should not be moved.

When aligning the rails for the very first time, the far east end of the OPLE guide rail needs to be rough aligned. Hang a plumb bob from the center of the north beam of the rail line, either by using an alignment target or an insert in the ople cart aperture. The guide rail is in the correct position when the plumb bob hangs $2\frac{7}{8}$ inches north of the center of the POP pipe.

A theodolite is used to insure that the beam targets on the Beam Switching table and the center target on the East Ople Mask lie within the same plane. If all of the OPLE beams do not lie in this plane, alignment of the science beams when switching baselines will be more difficult. Adjust the height of the sleepers just in front of the ople cart so that all rail lines being aligned lie in the same plane. MAke sure to ask person in charge of the lab which rail line they would like to use to define the plane which the others will be aligned to. The feducial positions are now set. The position of the guide rail at the rear sleeper should not be adjusted from now on.

4.2. Align the Laser Beam to the Feducial Positions

Align the laser beams moving outward from the iris. The order is as follows:

1. Six hole mask on the visible table.

2. Six beam target at the north end of the East line beam switching table.
3. Target in front of the Beam Reducing Telescope secondary.
4. East OPLE Mask center target.

The Beam Reducing Telescopes should be angled slightly such that the alignment beam passes through the central hole of the primary mirror, but misses the secondary. The $\frac{3}{4}$ inch lab beam will pass down the center of the rails. The periscope at the west end of the OPLE rails may need to be temporarily removed to avoid obstruction of the beam.

Adjust the iris if necessary to sharpen the spot at the center of the diffraction pattern. When adjusting the iris, take care to only touch the adjustment handle, as lightly as possible. Bumping the iris can result in movement of the entire alignment beam and a lengthy readjustment of the guide rail to the new beam position. The beam may drift over time, so re-check the beam alignment occasionally. If the beam no longer hits the center target on the West OPLE Mask at the rear sleeper, remember that the guide rail at the rear sleeper has already been locked in the proper position. It is the beam which needs to be adjusted in this case, and not the guide rail.

4.3. Align the Guide Rail to the Laser Beam

Using the laser diffraction pattern, check the guide rail position down the entire length of the rail line. Note any spots out of adjustment. Loosen the guide rail clamps within 2 sleepers of positions in need of adjustment. If many places need adjustment, just loosen all of the guide rail clamps except at the rear sleeper.

Starting at east end, reposition the guide rail at each sleeper so that the target hits the center of the diffraction pattern. You will need a dark enough environment to see the laser spot, but still have enough ambient light to see the lines on the target, as well as the rails and clamps. One solution is to turn on the lights in the far end of the rail line from where you are standing. The other is to tape a flashlight, pointed upward, to the back of the OPLE Mask. If the flashlight is bright enough, there will be enough scattered light off the ceiling for you to see what you are doing.

Left-right adjustment of the guide rail is done by sliding the rail foot back and forth on the sleeper, then clamping it down. Use two clamps on each rail foot wherever possible.

Up-down adjustment is done by changing the elevation of the sleeper. Note that the sleeper is supported by two bolts, one on either side of the concrete pier running down the center of each rail line. The sleeper is held in position on that bolt by two $\frac{3}{4}$ inch nuts, one above and one below. To raise the sleeper, loosen the top nut, then tighten the bottom nut until snug, but do not over-tighten. Likewise, to lower the sleeper, loosen the bottom nut, then tighten the top nut.

Since the sleeper supports two sets of rails, adjusting the height of the sleeper on one side of the pier will affect the alignment of the other set of rails. For this reason, it is best to do this job with two people and align both sets of rails (for example, E1 and E2) simultaneously.

If two rail lines are being aligned at the same time, the East OPLE Mask can be used as a rail alignment target as well. The East OPLE Mask has a hole in its central target, but that is easily fixed. Place the West OPLE Mask on the rear sleeper and make sure the beam is aligned so it hits the center target dead on. Now remove the West OPLE MAsk and place the East OPLE Mask in the same position. Tape a paper target over the hole in the East OPLE Mask such that the target is centered on the laser diffraction spot. Now both OPLE Masks cen be used. Since the east mask has targets on both sides, make sure that you have it placed such that the v-grooved foot is resting on the guide rail.

Align whole length of OPLE rail in one session, to minimise any laser drift problems. When finished, re-check the guide rail position along the entire length of the rails. The guide rail is now aligned, and becomes the standard to which the drive and support rails are aligned.

4.4. Align the Support and Drive Rails to the Guide Rail

Loosen all of the clamps on the feet of the drive and support rails, down the entire length of the OPLE rails.

The OPLE Rail Spacer is used to make sure that the drive and support rails are the proper distance from the guide rail. The jig is T-shaped, where the top of the T rests on the guide rail, the drive and support rails fit into notches in the long part of the T. When you place the OPLE Rail Spacer on the rails, it should slide into place with very little effort. If it does not seem to be sitting level, either the drive or support rail is probably causing it to bind. Pull each both rails toward the guide rail and the jig should fall into place. If either rail does not move easily from side to side, check up to 5 sleepers away for a clamp which may be obstructing the rail's movement.

Once the OPLE Rail Spacer is properly seated, position the drive rail by pushing it away from the guide rail until it rests against the edge of the notch in the jig. Tighten the clamps on the drive rail foot. Do the same for the support rail. Once the rails are clamped down, you should be able to slide the jig along the rails to the next sleeper. The jig will often bind due to the support or drive rail being too far away from the guide rail, so have one person pull both rails slightly toward the guide rail and the other slide the jig to the next position.

Once you have spaced the guide and support rail along the entire length of the rail line, slide the jig back down the entire rail line to find any spots where it binds. Redo the rail spacing at any of those spots.

All rails are now aligned. Put all items back in their proper place.

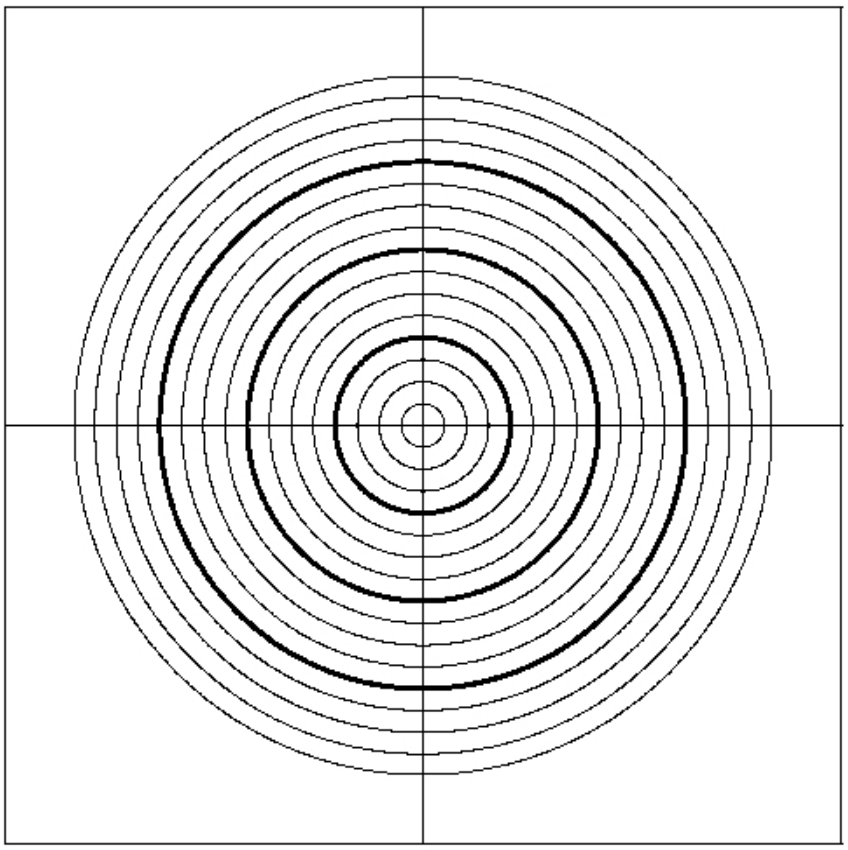

FIGURE 5. A printable target for use on the OPLE East Mask.