CHARA TECHNICAL REPORT

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OPLE Rail Alignment Procedure

JUDIT STURMANN

ABSTRACT:

Rail alignment checks should be done at least yearly, and re-alignment may be necessary. This report describes an updated procedure to follow, including a new approach to rail clamping.

1. INTRODUCTION

The CHARA Array's Optical Path Length Equalizer (OPLE) consists of two parts. The Pipes of Pan (POP) system can add incremental delay, and on top of that, a continuously variable optical delay is made possible by OPLE carts moving on rails. The usable length of each delay line is approximately 45 m, the distance between the home sensor and the back limit switch on the OPLE rails.

The first technical report on OPLE rail alignment TR. No. 92 describes how the rails were aligned early on. At this stage of development, the procedure as described in TR 92 is no longer viable. Furthermore, the clamping scheme described there proved counterproductive.

The temperature of the OPLE and beam combination (BC) area is kept within a few degrees, but the foundation of the building is subject to gradual earth movements. Over the years, the concrete slabs under the whole OPLE and BC area moved considerably relative to one another, mostly up and down. Therefore, even though a deeper foundation supports the rails, the rail alignment has to be checked regularly.

2. WHEN TO ALIGN

Before checking the rail alignment of any delay line, the light pipe has to be pumped down, and the usual alignment check has to be done with the CHARA alignment laser up to M10 alignment. It does not matter which one of the six beams is used for this test of a delay line.

The delay line has to be turned on, and the OPLE server needs to be running. The alignment should be done when the cart is at the back limit switch. Adjust the Iris until you see a well-defined center of the alignment beam, as seen in Figure 1.

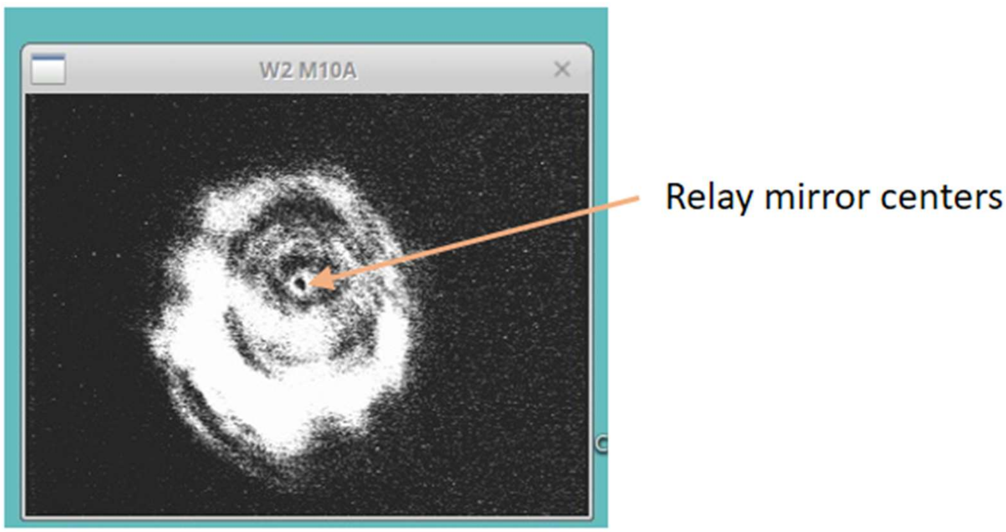


Figure 1. The CHARA alignment laser (ND=0.3) in M10 TV

In Figure 1, the dark dot is the center of M7 (It is actually the overlapping shadow of the centers of all other relay mirrors in the telescope up to M5). When the laser diffraction pattern has a bright center, it is easy to notice any change in the beam's position.

Send the cart forward. Nothing else but the cart should be moving, and no one should be moving around and standing next to the laser beam in the BC and OPLE lab. Watch how much the beam moves as a result of the cart moving on the rail from the back switch up to the to home sensor. Adjust the Iris in case the diffraction pattern turns dark in the middle. If the laser beam moves more than 3 times further than the diameter of the center dot, it is time to adjust rail alignment.

See an alternative rail alignment check: Steps 4.4.11 and 4.4.12. This check is done by a person inside the lab, and does not involve the path to the telescope, so the light pipe does not need to be pumped down. If the alignment laser spot at the back of the front rail target stays within a 1/8” circle at the target center as the cart moves up to the home sensor, the rail alignment is good enough.

Ideally, the laser beam should not move while the cart moves from the back switch up to the home sensor. However, the laser beam will move when the cart goes closer to the periscope than the home sensor, making the first few meters of the rail unusable. See a detailed study of the problem and attempt to reduce the effect in TR 94, “Periscope mounts and the DL front position” by Bob Thompson in 2007.

3. RAIL AND CART ANATOMY

The rails rest upon thick cross members, called sleepers. Each delay line cart makes use of 3 rails, each with a unique function. Two delay line carts share sleepers, so each sleeper supports 6 rails. The sleepers can be vertically positioned relative to steel crossbeams, which are fastened to concrete pillar blocks. The rail feet are clamped to the sleepers. Not all rail feet are clamped down; it turned out that clamping all feet was unnecessary. It did not make rail alignment more stable; it would also make subsequent rail alignments a lot more time-consuming.

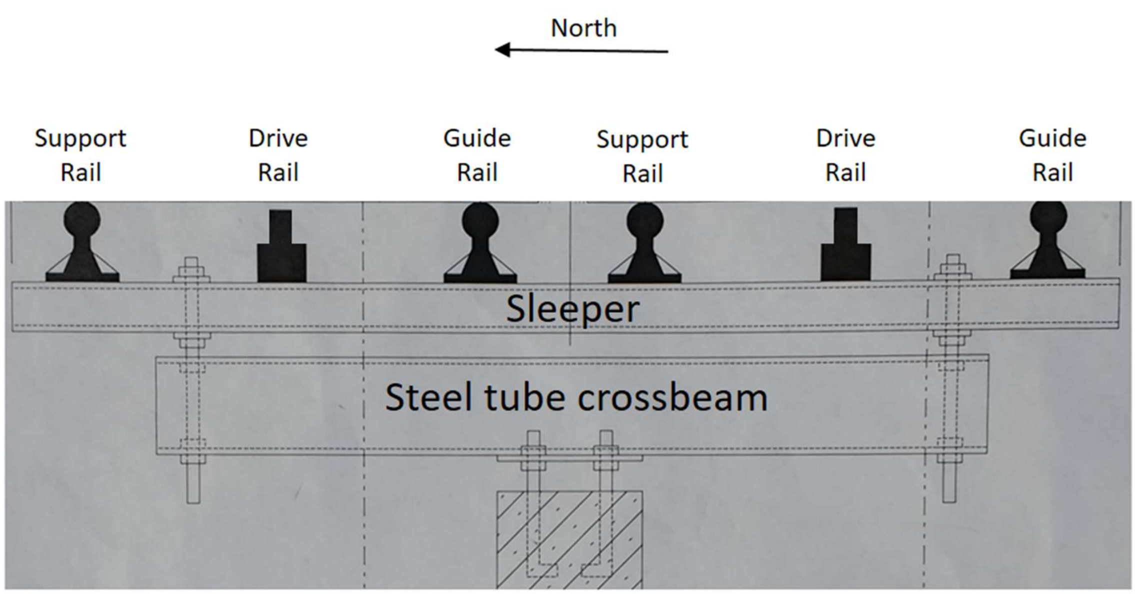


Figure 2. OPLE rails as seen from the beam sampling area looking east toward the end of the delay lines.

Each OPLE cart consists of three portions: the main portion is carrying the optics, there is also a motor cart, and a pulley cart.

For each OPLE cart, the southernmost rail is the guide rail for the optics carrying portion. Two wheels on the main cart are riding on the guide rail, and those two wheels 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 motor cart's drive wheel presses up against the north side of the drive rail. These drive rails are rolled steel bars, and their shape is far from ideal. There are setscrews to adjust the preload of the gripping mechanism on the south side of the drive rail. There is a narrow range where the preload is strong enough for the drive wheel to follow the rail and yet loose enough for compliance with rail imperfections.

One flat wheel of the main cart rides on the northernmost rail, called the support rail. The support rail should be level with the guide rail, and the distance between the guide rail and support rail is determined by the width of the motor cart and pulley cart. The portion of the motor cart that wraps around the support rail is built to flex, allowing more tolerance for rail spacing. The same is true for the pulley cart. By design, the support rail is not affecting the main cart's lateral position.

Since the height of the sleepers might be adjusted, and a sleeper supports two sets of rails, it is better to start the alignment with the set on the south side of the sleepers (S1, W1, or E2), where the guide rail is at the edge of the sleepers. See Figure 2. When the set of rails on the north side of the sleepers is going to be adjusted, the south side guide rail is close to the pivot point, so its height will not be affected that much.

4. ALIGNING THE RAIL

The main alignment laser beam is the most straightforward reference for rail alignment. The diffraction spot of the laser is viewed on the rail target, which rests on the guide and support rails, and its lateral position is determined by the guide rail. The guide rail is adjusted until the laser spot is centered on the target at any point on the rail. The guide rail can be positioned with better than a millimeter precision; however, the accuracy of this adjustment depends on the level of air turbulence along the laser beam. It is better if only one person is in the lab for the entire time of the guide rail alignment, and the laser beam is observed on the target at each point long enough until it looks calm. After the guide rail is aligned, the rail spacer (Figure 6) is used to position the drive and support rails.

4.1. Establishing fiducial points

Select one of the six beam positions to put the line to be aligned.

1. Proceed with the usual alignment steps up to LAB DICH alignment using the labao GUI.
2. Place the front rail target on the rail over the home sensor, V-groove on the guide rail (Figure 3).
3. Adjust by hand the tilts of the DM mount to center the laser on the front side of the front rail target.

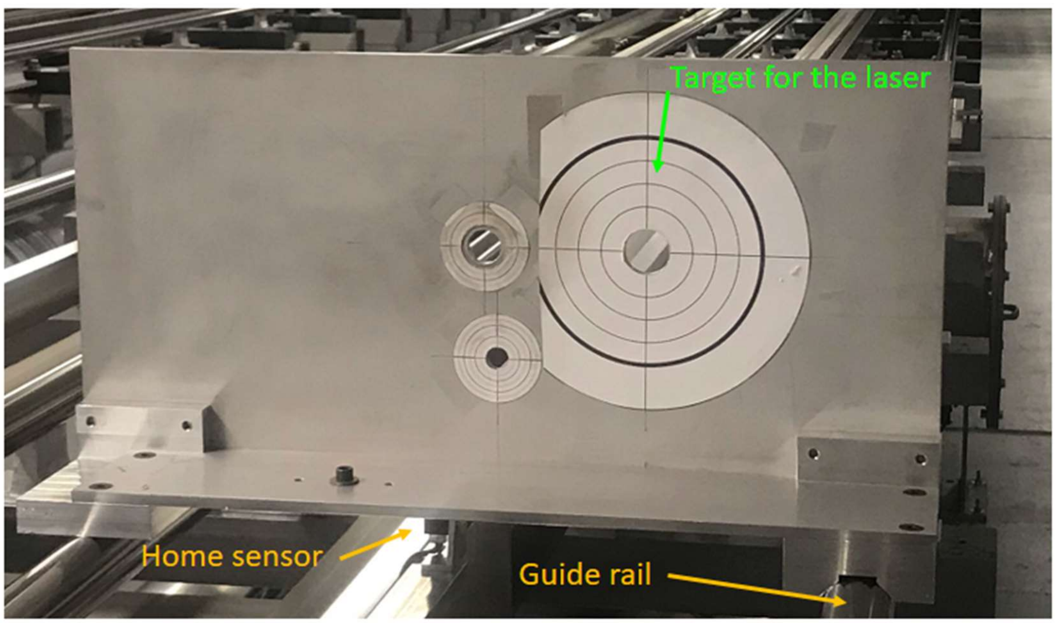


Figure 3. The front side of the front rail target.

4. The OPLE cart has to be on the back switch. Place the back rail target just in front of the cart. The back rail target has to be placed just like the front rail target, V-groove on the guide rail. The back rail target is similar to the front one, except there are no apertures cut in this target (Figure 4).

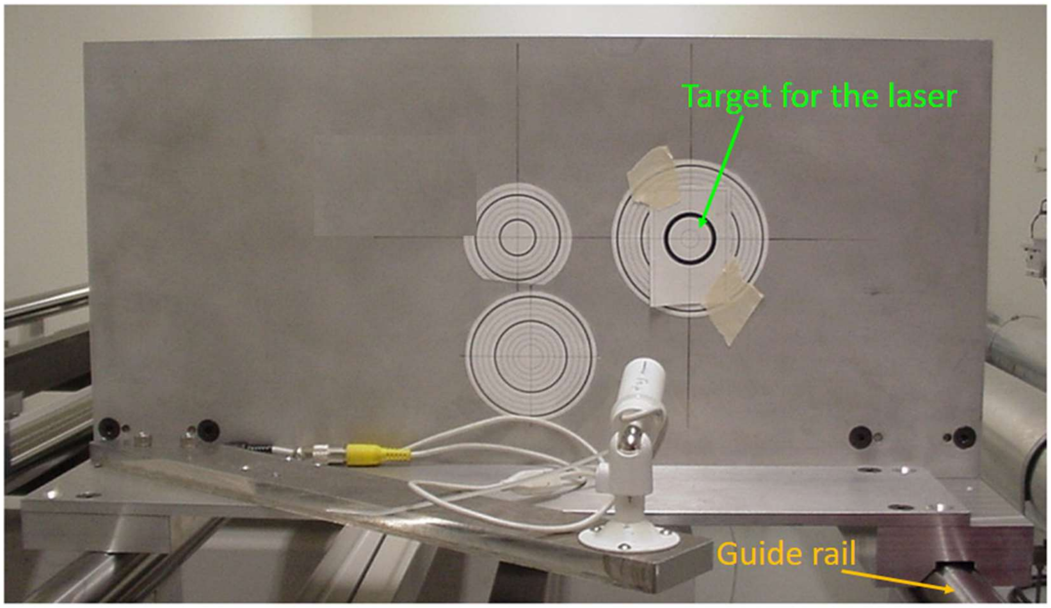
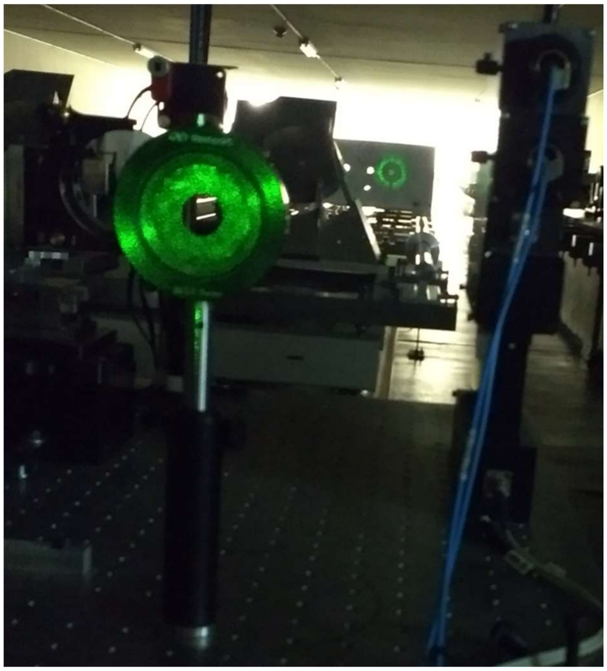


Figure 4. The back rail target.

5. Adjust the beam reducing telescope (BRT) primary mirror using the brtgtk GUI to center the laser on the back rail target.
6. Align an additional iris precisely on the laser beam to better control the diffraction pattern at any point on the rail. The iris in a magnetic post holder can be placed on the beam sampling table near the metrology black box, as shown in Figure 5. Adjust the opening of the auxiliary iris and ensure that the opening is centered on the beam axis by watching its shadow on the front rail target. Adjust the post holder's position until the shadow of the iris is concentric with the front rail target.
7. Clamp down the post holder for added security so that this iris will not move as the opening will be adjusted later for a convenient diffraction pattern.



This auxiliary iris will make a better-defined diffraction pattern to help make a more precise guide rail adjustment.

Figure 5. The placement of the additional iris for guide rail alignment.

4.2. Alignment of the guide rail

In order not to build up tension in the rails, all rail clamps from the home sensor backward for all 3 rails have to be released before starting. Do not release the clamps at the home sensor and forward toward the periscopes. The rails currently are not clamped down to each sleeper, but generally to every 3rd or 4th, and at most places only on one side, alternating sides if possible. Under the assumption that we will make small adjustments, we can ignore the effect of the other 3 clamped-down rails on the same sleepers for the other line.

We are going to rely on the stability of the alignment laser for the duration of the re-alignment procedure. The extra iris should remain in place until finished so that one could verify the alignment laser every couple of hours at two points: a) the E table target and b) on the front rail target placed over the home sensor.

1. Starting from the first clamps behind the home sensor and proceeding toward the back of the rail, loosen the ¼ -20 screws holding down the guide, drive, and support rail clamps up to the cart.

2. Push the cart forward (drive motor not on), release the clamps on the back sleepers, then carefully push the cart back. Ensure that the cart is not catching on the limit switch holders and position the rails horizontally if necessary to avoid damage. Turn the steel cable pulley to take up the loose steel cable.
3. Place the back rail target (Figure 4) over the home sensor, open the laser shutter, laser ND=0, and create comfortable ambient lighting to be able to see well the target and the laser at the same time. Adjust the auxiliary iris to have an easy-to-use diffraction pattern.
4. Ideally, the laser should be right on target at this point of the rail; if not, repeat steps 4.1.1 through 4.1.3. except use the back rail target (Figure 4) this time.
5. Start sliding the target backward, stopping over each sleeper. Evaluate the position of the diffraction pattern on the target.
    a. If the laser spot is too high on the target, raise the sleeper relative to the crossbeam (Figure 2). You need to loosen the top nut with a ¾” fork wrench. Raise the bottom nut, also ¾“, until the target reaches the level of the laser spot. Tighten the top nut, but not too much; there are spring washers under the top nut, leave some room for the spring to work.
    b. If the laser spot is too low on the target, lower the sleeper by lowering the bottom nut. Try to slide a piece of paper under the rail foot to determine whether it is still touching the sleeper. The target might be held up by the rail, which is no longer supported by the sleeper you are working on, but the next sleeper. In that case, lower the next sleeper and then return to the one you started working on. The laser should be on target, and the rail foot touching the sleeper; when that is the case, tighten the top nut as described above.
6. Gently tap the guide rail to make horizontal adjustment until the target is centered on the diffraction pattern.
7. Repeat steps 5 and 6 until you reach the last sleeper in front of the cart.
8. Go back to step 4 to check the alignment laser.
9. Make a second pass: start sliding the target backward. This time the height should be good; make perhaps slight adjustments. Check that each guide rail foot touches the sleeper. Tighten down the loose clamps on the guide rail feet as you proceeding backward all the way to the last sleeper before the cart.

4.3. Alignment of the drive and support rails

Once the guide rail is aligned and tightened down, use the rail spacer jig to set the drive and support rails at the appropriate distance from the guide rail.

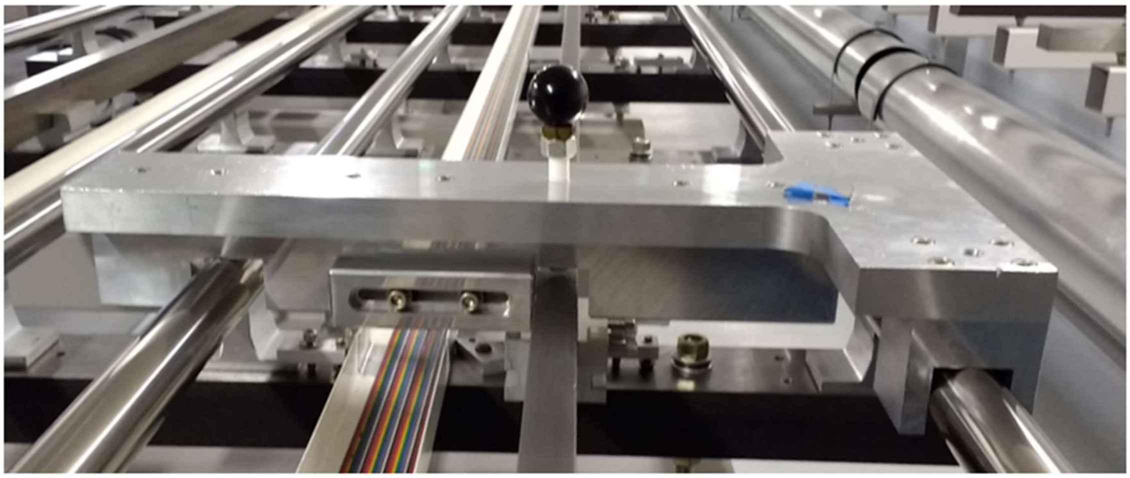


Figure 6. The rail spacer.

The rail spacer is T shaped (Figure 6). The top of the T fits snugly over the guide rail. Always put that side down first and let it rest on the guide rail.

At the bottom, there is an adjustable opening where the drive rail should be and another opening for the support rail. The top of the jig is horizontal when properly supported by the guide and support rails. Pull the drive or support rail in case they prevent seating the jig correctly. There is a big teflon screw in the jig. The teflon screw will be above the guide rail when the jig is seated on the rails.

The teflon screw is there to set an upper limit for the drive rail height. The cart dimensions determine this upper limit.

The adjustable part of the drive rail opening was set based on the motor cart dimensions, such that when the drive rail is at a proper distance from the guide rail, there is about 1 mm between the adjustable edge and the north side of the drive rail. This adjustable piece was set once, and it is unlikely that its position needs to be changed.

1. Close the laser shutter to protect your eyes. Turn on the fluorescent lights in the OPLE area.

2. Take care not to damage the home sensor with the rail spacer! Place the rail spacer over the rail just behind the home sensor looking from the front of the rail.
3. Ensure that the rail spacer is seated correctly on the guide and support rails, and start sliding it towards the end of the rail. Move it down for about five sleepers and slide the drive rail and support rails on the sleeper to maintain about 1 mm distance from the north sides of the openings. There is some tolerance on the 1 mm distance, as the gripping mechanism of the drive motor and the block supporting the motor and pulley carts do have some compliance.
4. Fasten the clamps of the drive and support rails.
5. It is not likely that there will be problems with the height of the drive rail. If a new problem develops, it will likely require a unique solution.
6. Move the spacer jig back over the freshly clamped section to double-check. The spacer has to slide effortlessly, and the ~ 1mm distances should be kept, as described in step 3.
7. Repeat steps 3 to 6 until you reach the last sleeper in front of the cart.

4.4. Finishing steps

The finishing steps include fastening the rail clamps on the last few sleepers, which are under the parked cart at the back, and a final check.

1. Turn on the delay line electronics and start the OPLE server.
2. Open up fully the auxiliary iris on the BS table.
3. Check the alignment laser: repeat steps 4.1.1 through 4.1.5.
4. Optional: If you wish, you could check the consistency of the alignment by closing down the auxiliary iris and check the shadow of the iris. It should be concentric with the front rail target. If not perfectly concentric, that indicates the margin of error in the consistency of the alignment beam. If the shadow is off-center by more than 1 mm, something went wrong, investigate. Otherwise, remove the auxiliary iris from the beam.
5. Run ‘opletab’ on the tablet. Remove the back target, and send the cart forward until no parts of the cart are over the last few sleepers where the rails are not yet clamped down.
6. Check the cart alignment by looking at the laser beam at the back of the front rail target (Figure 7). Adjust the micrometers at the backside of the cart primary by hand to center the laser on the target. To avoid changing the cart’s focus, use only the micrometer on the top, and use the one on the north side of the two at the

bottom. At this point, it is convenient to have a second person to look at the target. In any case, be aware of the turbulence caused by people around the alignment beam and observe the laser beam on the target long enough until it looks calm.

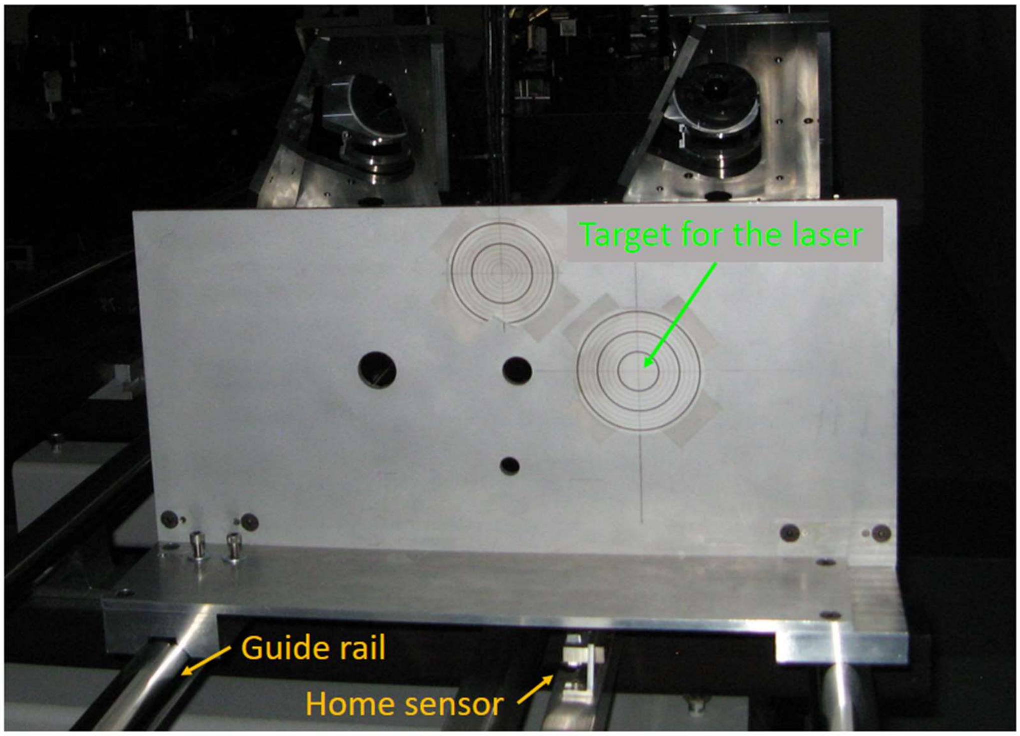


Figure 7. The back of the front rail target.

7. Run ‘opletab’ on the tablet, and move the cart all the way back while standing next to the cart and making sure it is not hitting the back switch holder. (It should go close to it.) Stop the cart and adjust the rail positions if necessary. When the cart reached the back switch, check the laser spot at the back of the front rail target.
8. Evaluate the position of the laser spot on the target. It is possible to make small adjustments by adjusting the rail under the cart. Remember, there is little room for horizontal adjustments because of the limit switch holders.
    a. If the laser spot is too high or low on the target, adjust the sleeper under the cart primary relative to the crossbeam (Figure 2). Follow a similar procedure as described in steps 4.2.5 a and b. Make sure also that all those sleepers in the back touch the guide rail feet.
    b. If the laser spot is off horizontally, it is possible to tap the guide rail gently under the cart to center the laser spot in case the laser spot moved horizontally.

9. Move the cart forward using the 'opletab' GUI on the tablet to clear the back sleepers. Fasten all rail clamps on the back sleepers. Check that the cart can freely move back and stopped by the back limit switch.
10. Once the cart sits all the way back, repeat step 6 to make corrections if any compromise had to be made when fastening the rail clamps to the back sleepers.
11. Finally, walk up to the front rail target and move it on the rail toward the periscope so that the cart may move up to the home sensor. (The laser spot on the target should not move when you push the target forward, in case it does, remember that the laser spot should stay close to the point wherever it is right now.)
12. Evaluate the rail alignment by watching the spot on the back of the rail target (Figure 7.) as the cart moves forward up to the home sensor. Try to stay away from the rail and the target as much as possible not to cause much turbulence. Usually the alignment procedure described here cannot be done much better than a residual wander of 2-3 mm (<1/8 ") around the target point.