The Pipes of Pan Mirrors

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1. INTRODUCTION

The CHARA array offers long baselines, the longest being over 330 m. This requires a system that is capable of compensating differential paths up to 330 m. Collimated beams of D=125 mm in vacuum pipes from the telescopes to the beam combination laboratory. A part of the optical path length equalization (OPLE) system is the Pipes of Pan (POP) system, which makes it possible to add incremental delay to each beam still in vacuum. Only the last portion of the OPLE, the continuous delay portion, is in open air in the laboratory. There are five POP mirrors for each telescope, four of them can be moved remotely in and out of the beam. The distance between the POP mirrors is 18.3 m, making possible to increase the delay in 36.6 m increments. One exception: the distance between POP4 and POP5 (or END mirror) is only 16.7 m.

In the beam train, the star light bouncing off M10 mirror, which is the last mirror in the turning box, will reach a POP mirror, then the lower periscope mirror, M12, which is the last mirror in vacuum. The upper periscope mirror, M13, brings the beam into the beam switching and beam combination plane. The beam travels over the rail in this same plane.
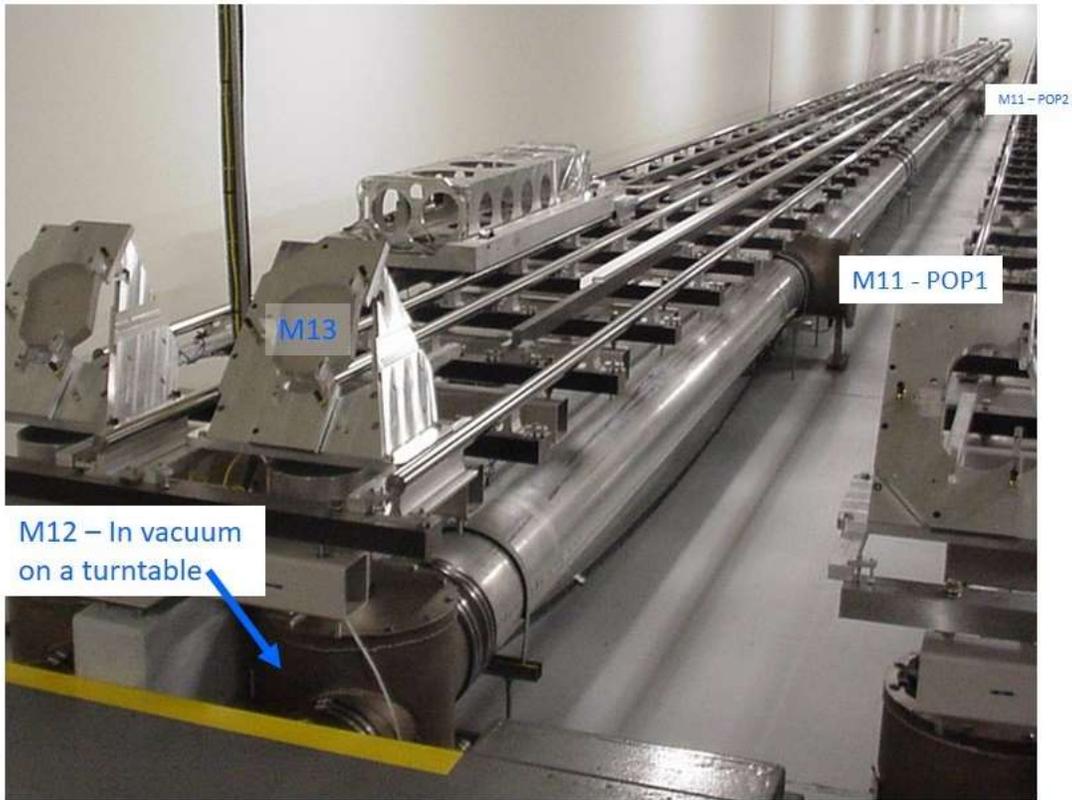
Figure 1. The E1 and E2 delay lines up to POP3, the portion which is in the inner enclosure of the OPLE building. The pipes continue in the storage area where POP4 and POP5 are located.

Since the M11 mirror in the beam train is not a single mirror, but any one of the five so called POP mirrors, ideally they should be positioned in a straight line, so that the optical axis between any of the POP mirrors and M12 falls on the same straight line. See Figure 2.

The POP system was initially aligned to meet the above requirement, but regular checks and adjustments of the alignment are necessary.
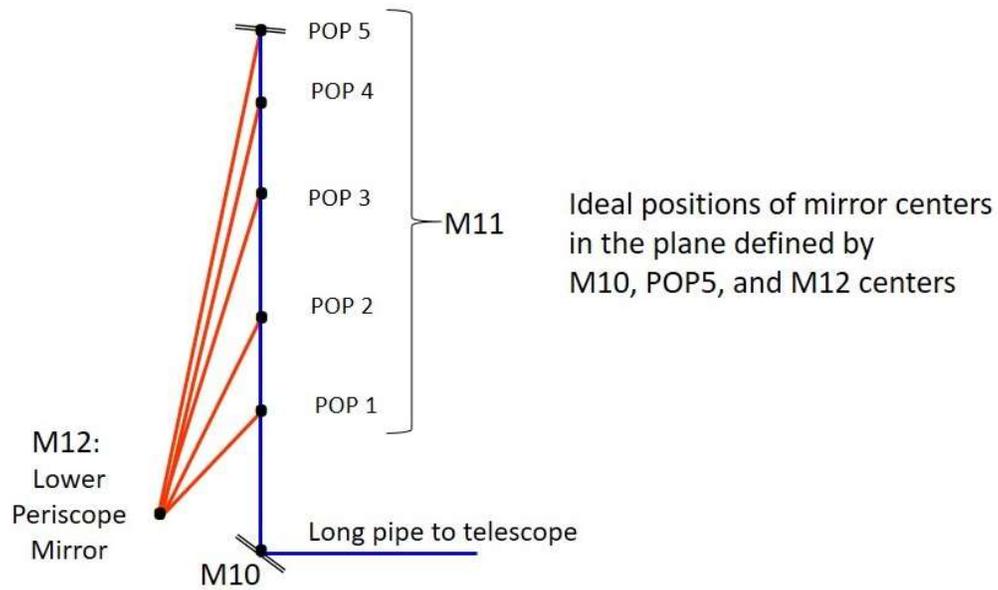
Figure 2. Optical axes of the POP system.

The mechanisms of the movable POP mirrors are quite reliable, but occasionally they need attention.

Figure 3. The mechanism moving the mirrors inside the POP box. The remotely controlled LED at the center of each pop mirror is actually red, but indicated yellow here to stand out more in the picture.

2. PREPARATION FOR POP ALIGNMENT CHECK

Regular checks and adjustments of the lower periscope mirror (M12) up/down tilt and rotation, and POP mirror tilts are necessary to facilitate the night time automated POP change procedure, and to ensure easy M7 servoing during data collection. A check/adjustment every 1 to 2 months has been sufficient.

1. Check the pressure in the vacuum pipe using VACMON GUI, it should be below 2.0 Torr. If it is higher, start pumping.
2. Perform the routine daily alignment check with the green laser using labao, up to the beam sampler dichroic splitter.
3. Put the small corner cube in place on the beam sampling table to send the laser (with ND=5) back to the REFERENCE camera.
4. Set the REFERENCE camera focus around 5.5 – 6 mm. You will see a pupil from the corner cube. Change the Iris diameter using the Iris GUI to get a better sense where the center of the beam is. Move the cross hair to the center of the beam coming from the small corner cube. Save this as the origin for the beam currently used.
5. Remove the small corner cube.
6. Check/adjust the beam using the front rail target with the alignment laser (ND=0)
7. Turn on PICO5 (on top of PERI2 ESP controller) and PICO4 (at the east wall of OPLE). PICO4 controls two tilt axes of POPs 3 and 4, while PICO5 controls the up/down tilt of lower PERIs, and two tilt axes of POPs 1 and 2.
8. PERI1 and PERI2 ESP controllers are to rotate the lower PERI mirrors. These controllers are normally on and they know their current positions. If this is not the case, turn on the controllers and home each axis.

3. ADJUSTING LOWER PERI AND END MIRROR

The target for the lower PERI (M12) mirror is the LED in the center of the END mirror.

The END mirror, or POP5, in each line is different from the other POPs, as it cannot be moved in/out of the beam, so adjustments are almost never necessary, unless the concrete moves underneath. The target for the END mirror tilt adjustment is a remotely controlled target, Figure 4, in the turning box. The target was positioned in front of the M10 mirror to be viewed in the REFERENCE camera for END mirror alignment.
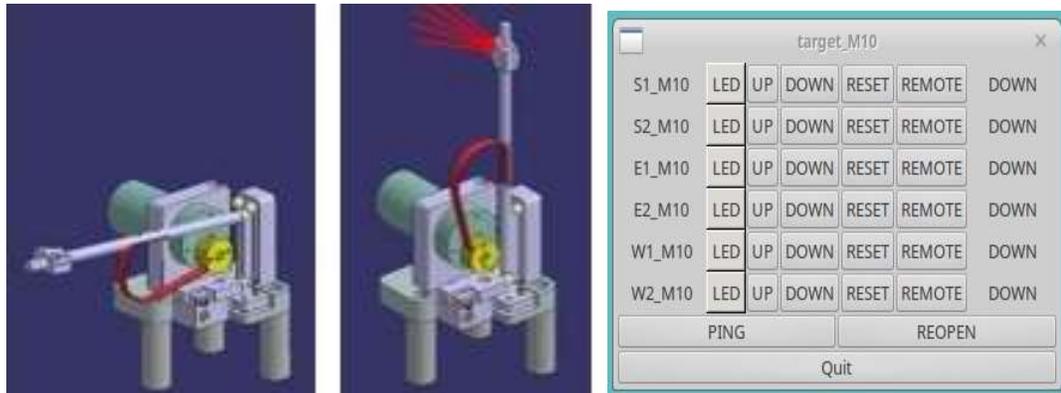
Figure 4. The target in front of the M10 mirror is shown on the left: in DOWN position, in the middle: in UP and LED ON position. The control GUI is shown on the right. The rightmost column displays the status of the targets.

Work at a control computer outside the lab. Let say we are lining up the pops in W1, which is aligned on beam 3.

1. Open the necessary GUIs: telescope, popperigtk, pops, PERI1 (or PERI2 if working with W2, E2, or E1), PICO5, PICO4, espgtk BC2, shutters (xshutgtk), laser filter wheel, targetgtk target_M10, zwogtk REFERENCE.
2. Open M7 cover and look at the alignment laser (ND=0.3) on the screen above M5 in the M10 TV.
3. If not on POP5, switch to POP5 (END mirror) using popperigtk. Once the laser is seen in M10 TV, close the laser shutter.
4. Start the REFERENCE camera, make sure that the cross hair is at the origin that you set it in step 2.4.
5. Open the "pops" GUI and in the pull-down menu select W-END, and turn on the LED. In the pops overview window, both lines representing W1 and W2 POP5 mirrors turn red. Make sure only B3 shutter is open for W1! Open the "Ref" shutter, and check the LED image with respect to the origin.
6. If the LED is high or low, find W1 periscope on PICO5 GUI, and press up or down to move the LED image to the cross hair level. This is the only time, only to the END mirror, when the lower periscope UP/DOWN tilt is adjusted.
7. For horizontal adjustment use the ESP controller PERI1 W1 axis to center the LED. Click on the W1 axis on the GUI to turn it ON → green. The turntable has significant hysteresis. In order to minimize the effect of hysteresis, the PERI position should always be approached in the positive direction, and from at least 0.5 mm away. For the axis used in the PERI GUI write a modified number into the field next to GO button. In the field below write 0.5 and

push the " – " button, this will move the turntable back enough. Then press GO. This way the turntable got a good start and approached the target position moving in the positive direction. (The popperigtk for POP changes is programmed to operate the same way: approaching the target position from at least 0.5 mm away and moving in the positive direction.)

8.   Repeat guessing the best position until GO to the new position lands the spot on the crosshair. Write down the new W1 POP-5 periscope position for the new version of the configuration file, "popperi.conf".

9.   Most of the time there is no need to adjust the END mirror tilts. Normally skip to step 11.

10.   If there is a reason to check/adjust the END mirror tilt, use the M10 target LED, see Figure 4. The image of the M10 target LED in UP position should be moved to the REFERENCE camera crosshair by adjusting the tilts of the END mirror. To be able to adjust the END mirror tilts, you have to hook up the wires to the END mirror PICO5 axis according to the diagram on the W1 END box. When done, turn off M10 LED and move the M10 target down.

11.   Turn off END LED using the pops GUI. Close Ref shutter. Open Laser shutter, laser ND=0.3

12.   Adjust M10 mirror to center the laser beam on the target spot (dark dot created by overlapping centers holes of M7,M6, and M5 mirrors) in the M10 TV. This is the only time M10 is adjusted in the POP system alignment procedure.
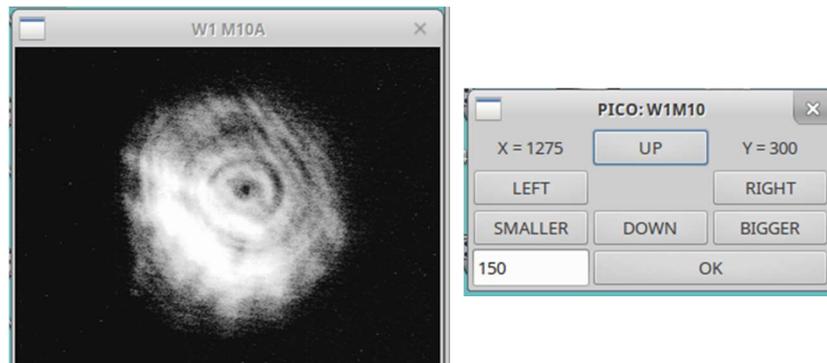
4. ADJUSTING LOWER PERI ROTATION AND POPs 4, 3, 2, 1

1. Switch to POP4 using popperigtk. Once the laser is seen in M10 TV, **DO NOT ADJUST M10!** close the laser shutter. Get rid of the M10 adjustment PICO2 window, which pops up automatically.
2. Start the REFERENCE camera, make sure that the cross hair is at the origin that you set it in step 2.4.
3. In the "pops" GUI pull-down menu select W1-4, and turn on the LED. In the pops overview window, the lines representing W1-4 mirror turns red.
4. For horizontal adjustment use ESP controller PERI1 W1 axis to center the LED. For the axis used in the PERI GUI write a modified number into the field next to GO button. In the field below write 0.5 and push the " – " button, this will move the turntable back enough. Then press GO. This way the turntable got a good start and approached the target position moving in the positive direction.
5. Repeat guessing the best position until GO to the new position lands the spot on the crosshair. Write down the new W1 POP-4 periscope position for the new version of the configuration file, "popperi.conf".
6. Turn off POP-4 LED using the pops GUI. Close Ref shutter. Open Laser shutter, laser ND=0.3
7. Adjust POP-4 mirror using PICO4 (or PICO5) GUI to center the laser beam on the target spot (dark dot created by overlapping centers holes of M7,M6, and M5 mirrors) in the M10 TV.
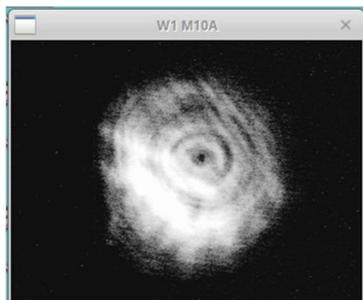
| Use GUI: |
| PICO   W1 POP 4 |

8. Repeat from step 4.1 for the remaining pops.
9. When finally done with POP1, close the telescope dust covers, turn off PERI1 W1 axis on the GUI →axis turns red. Stop the REFERENCE camera.
10. In the lab turn off the power switch on PICO4 and PICO5 controllers.
11. Update the "popperi.conf" file.

5. NOTES

- On S2 POP1 only one of the picomotors work as of now. (On the PICO5 GUI each button tries to move both motors!) Until the motor is fixed, move the picomotor on the POP as little as possible, use the PERI1 rotation to get the laser close to target in M10 TV. Still do not adjust M10 when performing this procedure. M10 will be adjusted anyway when the operator is going to switch to S2 POP1.

- In case a POP mirror does not move, see the Troubleshooting section at the end of the document on the CHARA wiki page: http://chara.gsu.edu/wiki/doku.php?id=chara:night_time_pop_changes