Naomi WFS alignment procedure (provisional) wht-naomi-47

A step by step procedure is given for the full optical alignment of the WFS. Notes describing each stage follow a diagram of the general set-up. The various components used in the procedure are represented by symbols in the diagrams and are listed below.

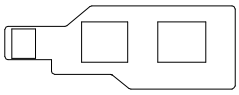
Alignment equipment

Numbers for the symbols used for each piece of test equipment are given after the description of the item in the list.

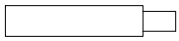
1. Micro-alignment telescope with axis height set to *******mm above the optic bench.
2. Target for mounting on the CCD stage. (Target number ****.)
3. Two bench mounted targets.
4. Height gauge.
5. gimbal mounted flat mirror.
6. Mounted penta prism.
7. Laser source giving f/8 or faster converging beam. Note that a low power of around 1mW is advisable.
8. 5?m clock gauge and mount.

Symbols

1. WFS base.

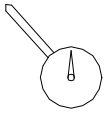


2. Micro-alignment telescope.

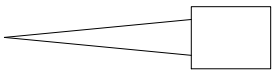


2. Target or reticule.

3. Engineers dial gauge.

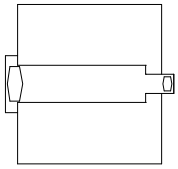


4. Laser source

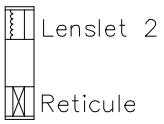


5. Penta prism.

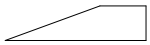
6. Camera.



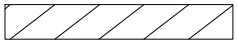
7. Lenslet wheel.



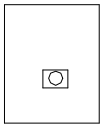
8. Height gauge.



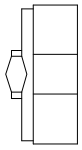
9. gimbal mounted mirror.



10. Pick-off unit and mirrors.

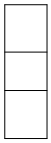


11. Filter unit with collimator doublet and filter wheel installed. In the rest of the document the filter



wheel/collimator assembly will be referred to as the collimator.

12. Filter unit without collimator and filter wheel.



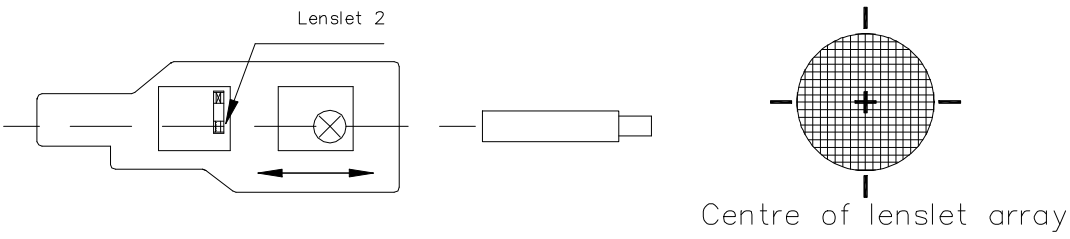
Alignment procedure

The steps in the procedure for the alignment of the WFS are illustrated below.

1. Before commencing with the alignment of the WFS use either a height gauge or precision spirit level to set the base parallel to the optical bench.

2. Mount the lenslet wheel on the fore-optics carriage and drive the reference lenslet (lenslet 2) into position. This lies at ***** degrees from datum and establishes the axis height of the system above the carriages.

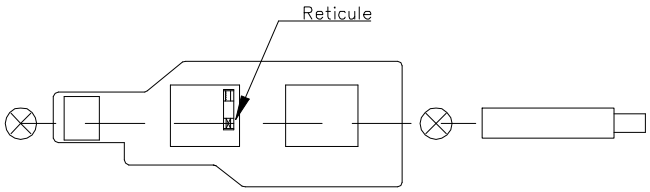
3. Mount a reticule on the CCD carriage at approximately the same height as lenslet (within 1mm). This is viewed through the alignment telescope which is brought into alignment with the axis of



the WFS (as defined by the rails) by viewing the target as the stage is driven between its end stops and adjusting the telescope appropriately. Measure the centre of the reference lenslet array and record the value. **Tip**: it was found that by placing a dark, straight edged object behind the lenslet array partially obstructing the line of sight, the rows and columns of lenslets easily seen. By

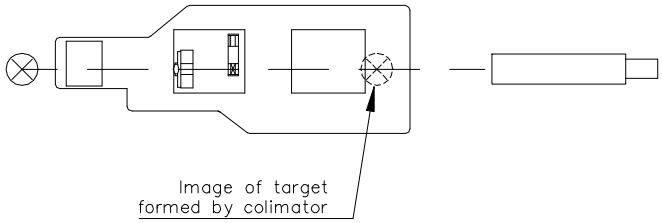
suitably positioning a vertical and a horizontal edge formed, say, by a pair of blocks, the centre line becomes clear.

4. Remove the reticule from the CCD stage. Drive the reticule in the lenslet wheel onto axis. Position targets at either and of the WFS, mounted on the bench and inline with the axis. These targets are a



precautionary measure used to check if the WFS or telescope have been moved. It must be possible to repeatably remove and replace the target nearest the telescope. Record the positions of all targets as read on the telescope scales.

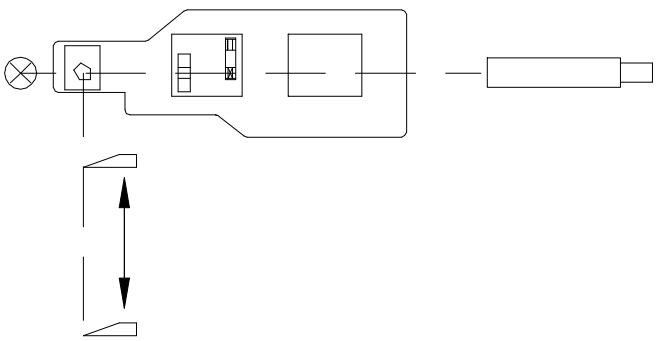
5. Mount the Filter wheel unit and collimator on the fore-optics carriage. The filter wheel should be positioned so that there is a clear aperture in line with the collimator. Remove the bench mounted



target closest to the telescope. Adjust the position of the filter unit so that the image of the far target is on axis. In the initial set-up this required that the unit be shimmed up by 40?m.

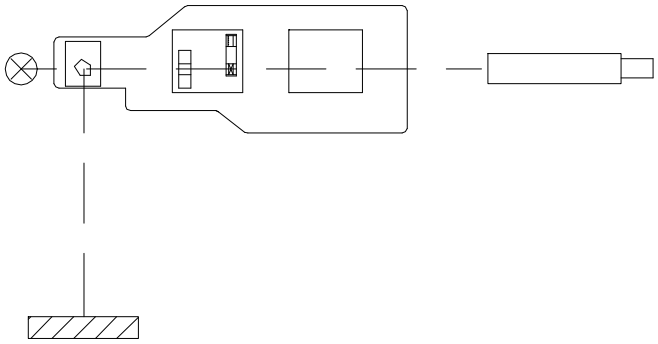
6. Remove the collimator and filter wheel (as a single unit) from the filter unit. It is designed to be removed and replaced repeatably without the subsequent need for realignment of the optics.

7. Place the penta prism on the pick-off carriage, or on the rails before the carriage. Viewing the height gauge as seen through the prism at two positions along the folded axis allows for the

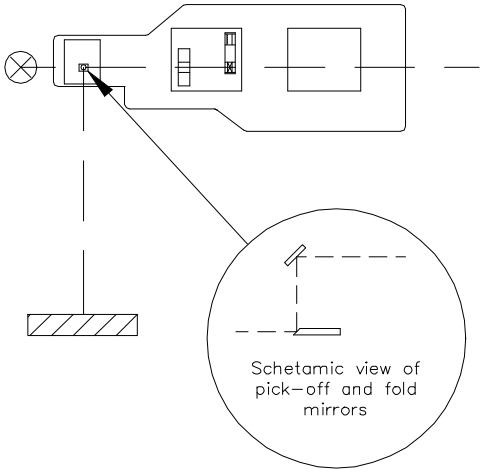


adjustment of the prism's angle of rotation about the axis of the WFS to fold the axis out parallel to the optical bench.

8. Square the flat mirror onto the folded axis using the telescope in autocollimation mode.

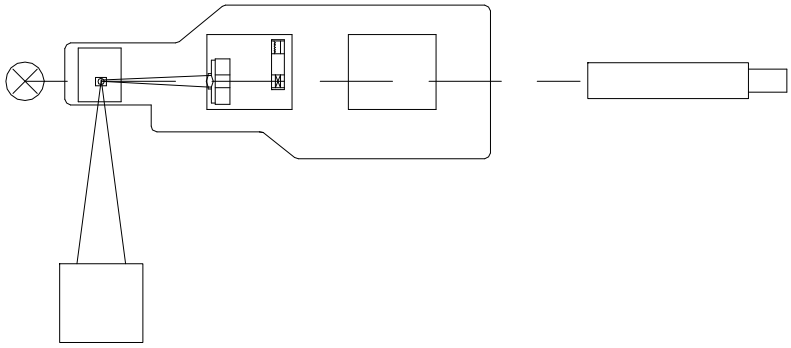


9. ***Re-write after repeating the alignment…….***
Mount the pick-off and fold mirrors on the pick-off carriage. The procedure for the alignment of



the two mirrors involves driving the mirrors along their rails. The approximate alignment of the fold mirror is obtained by viewing the pick-off mirror as it is driven along its rails. Viewing the return from the flat through the telescope in autocollimation allows the two mirrors to be accurately aligned. This is not a straightforward procedure and some experimenting on the part of the operators is required. Note that the adjustments for tip and tilt of each of the two mirrors are cross coupled and the only way to make progress is to make a trial adjustment of each screw in turn and observe the result.

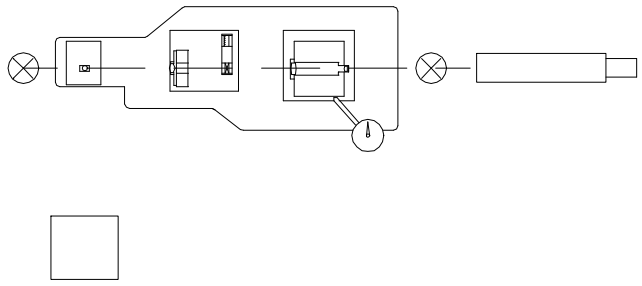
10. Replace the collimator doublet. Arrange for the focus of the laser unit to fall on, or within a couple of millimetres of the pick-off mirror and over fill the collimator. The position of the fore-optics



stage should be adjusted so that pick-off is at the focus of the collimator doublet. Adjust the laser so that the focused spot is on axis. Focus the telescope on the doublet and check that the illumination is uniform.

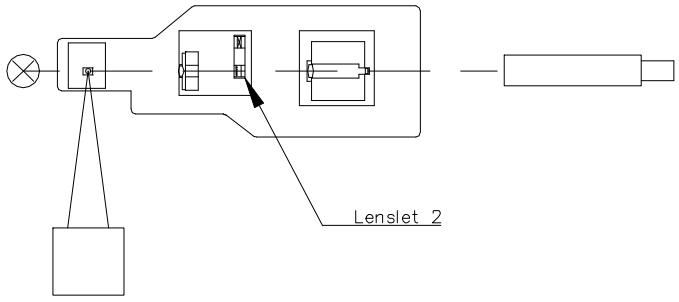
11. Turn off the laser and roughly position the camera unit on the CCD stage.

12. Provisionally align the camera to the axis by viewing the image of the lenslet wheel reticule through the camera relay and checking that the camera body is aligned to the mechanical axis of



the rails by clocking the body as it is driven too and fro' along the rails. Remove the collimator and view the pick-off. The pick-off and the reticule in the lenslet wheel should both appear to be centred as viewed through the telescope.

13. Accurate alignment of the camera. Switch on the interferometer and drive lenslet 2 on axis. Adjust the alignment of the camera body so that the spot pattern formed by the lenslet is correctly



positioned and the illumination is symmetrically distributed about the centre of the field.

14. Iterate between stages 12 and 13 until the illumination is correct and the reticule appears on axis. The camera body is then aligned.

15. Replace the collimator.

16. Fit the two ADC prism units. Note that the alignment of these two items is non-critical as regards lateral displacement, and so long as the two units are square to the carriage base they can be considered aligned.

Alignment of the camera heads

The final stage in the alignment of the WFS is to fit and bring into alignment the two cameras. During steps 1 and 2 the alignment telescope cam be used to check the system.

1. Send a datum command to the Epics system to bring the WFS to the nominally correct alignment. The following should be checked before proceeding: (a) that the reference lenslet has been driven

to the correct position to be on axis, and (b) that the prisms ADC1 and ADC2 are at positions 0? and 165? respectively so that zero dispersion is attained. If they are not, use the device level epics screens to drive then into position.

2. Set up an on-axis point source, either the laser source or a white light source, with the focus approximately 3mm beyond the pick-off mirror. The beam should be f/8 or faster and so sufficient to fill the WFS optics without careful pointing. At this stage you have the choice of moving the illumination system or the pick-off; the latter is usually easier and the WFS mechanisms should track the motion of the pick-off, so maintaining nominal focus.

3. Fit the camera heads to the camera body and connect the cooling and gas supply. Keep an eye on the camera heads as the coolant supply is turned on lest there be any leaks.

4. Set the camera system to read out images from the heads using the display and analysis tool "NaomiWFSAlign" that reads out from the C40 system and contains the software masks tailored to the WFS internal alignment rather than for the Naomi system alignment. It is most convenient if the display can be arranged on a monitor positioned beside the operator who is aligning the heads so that the display is clearly visible and the spot pattern statistics can be read as adjustments are being made in the dark.

5. Deploy the beamsplitter so that light is detected by both heads.

Chose "edges/on" from the display options of NaomiWFSAlign. This displays a fixed grid on the WFS display marking the corners of the pixel boxes into which the array of spots has to fall.

6. Drive the camera stage to view the pupil at the lenslet. This can be achieved by issuing the Epics command 'Pupil' as the camera command string.

7. View the display from the master camera on NaomiWFSAlign. Ensure that the pupil (i.e. the lenslet) is fully illuminated.

8. Deploy the doublet in the and send the camera to focus. With a low level of background light in the lab it will be possible to see the pick-off mirror on the CCD at the same time as the spot of the on-axis point source. Use this to check that the spot is on axis; that is, the spot appears to be on the centre of the mirror, *not* the CCD.

9. Deploy the reference lenslet and send the camera back to view the pupil. The grid formed by the lenslets should be clearly visible. If it is not sufficiently clear, back off the camera by up to 10mm which will have the effect of broadening the dark lines that form the grid.

10. Attach the alignment micrometers to the master camera head. Align the CCD to the grid of the lenslet in both axis and rotation. When this has been achieved to the limit of the resolution of the CCD (in the operators judgement, there are no software aids for this stage) lock the CCD in position as described in 11 below.

11. Proceed to lock the CCD head by tightening the three M4 cap screws that hold the CCD mounting block in the head, and the two M3 and one M5 cap screws that lock the rotation. As these screws are tightened there is a tendency for the CCD to be displaced, so the process is a gradual one of tightening and putting in a slightly over compensating displacement and further tightening until the CCD position is locked. It takes about half an hour to successfully lock the CCD in alignment. Once the CCD block is fully locked remove the micrometers and loosen the spring plungers, then tape over all holes in the head with metal tape for RF screening.

12. Fit the pupil stop into the reference lenslet.

13. Send the camera to the focused position. At this position the spots should appear sharp and centred very much on each of the squares defined by the 'edge' display. If they are not quite centred that is because the angle of illumination of the system is not ideal. Switch on the 'centroids' of NaomiWFSAlign. Chose the option 'Tools/Alignment'. That will give a readout of the average spot positions, average spot separations, RMS spot positions and the rotations.

14. The average separation should be 8.00. If it is less than 8.00 the fore-optics stage is too far from the pick-off stage, so move the fore-optics and camera forward until the separation is correct. Likewise, if the separation is too great, then move the fore-optics and camera away from the pick-off.

15. If necessary make fine adjustments to the position of the pick-off to get the average spot positions to 0,0. The rotation should be correct to about 0.02 pixels. If not, then the alignment at step 10 was not done correctly and should be repeated. Once the spots are centred, proceed.

Alignment of the slave head.

The slave head is aligned to the spot pattern that has been established with the master head, so read out the slave CCD output to NaomiWFSAlign for the next stage in the alignment.

16. Fit the alignment micrometers to the slave CCD head.

17. Using the micrometers drive the CCDs until the whole array of spots falls roughly in the centre of the display. At this stage it is best to have the edge display turned on to define the boxes into which the spots must fall and the centroids turned off.

Note: In the early stages of the slave head alignment the spot separation and position should be judged by eye as the readings given by the centroiding algorithm will be inaccurate until the spots fall within their assigned boxes on the CCD.

18. Once the spots are roughly centred turn the centroids on and call up the alignment tools.

19. Take out any rotation. The illustration below shows the use of a screwdriver to adjust the rotation of the CCD block (slave head shown).

20. Adjust the CCD in x and y until the alignment tools indicate that the alignment is correct. Note that the average spot separation should not require any adjustment. If the spot separation is not 8.00 the fore-optics, or the light source, must have been moved.

Once aligned the average spot positions should be within ?0.02 pixels in both x and y. The average spot separation should be 8.00 ?0.02 pixels and the rotation something like ?0.02 pixels for both co-ordinates and both camera heads.

21. Lock the slave head CCD in position as before.

22. Make a final check on both heads using the NaomiWFSAlign that the spot centres agree to within 0.1 pixels total average spot separation (i.e. the root sum squared x and y positions should be 0.1 or better).

23. Finally, put the cover panels and rubber RF gasket over the back of each head, tape over all the openings for adjustment screws, micrometers etc. with metal tape.

The internal alignment of the WFS is now complete.