



Interferometer Measurement Procedure

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1 Purpose

This is a brief summary of the procedure used to measure the LIGO one optics. The procedure assumes a basic familiarity with the equipment. It is expected that this procedure will be updated to provide more detail about the different types of measurements made in the metrology laboratory as well as the procedures for stabilizing the environment during measurement.

1.1 Set up

1.1.1 Define the optical axis

1. Mount the aluminum dummy optic
2. Put a reference flat on the dummy
3. Put a crosshair on the reference flat, being careful not to tighten too much, as the flat will de-bond from the mounting cell.
4. Put the instrument in max zoom (~6x) using the interferometer switch
5. Increase the intensity until you can see the crosshairs on the monitor, the ND filter on the back of the interferometer will have to be moved out of the beam.
6. Verify that the crosshairs are at the center of rotation of the dummy mass by rotating the dummy 0 and 180 to verify that the center of the crosshairs stays in the same place on the monitor, mark the monitor with a dry-erase marker as a placeholder for the central spot. If the crosshairs do not remain in the same spot, move the adjustment screws on the crosshair until the center is halfway between the 2 center positions. Iterate until the 0 and 180 degree center positions are the same.

1.1.2 Position the mount

Move the optic test stage until the center of the crosshairs is at 184,243. Verify by taking a dataset in the min zoom mode. To find the crosshair location, choose "custom display" then "scrollcont" right click on the plot to choose the zoom area and right click again to display in base units. For this measurement it is easiest to find the center pixel if the crosshairs are lined up with the video lines. Alignment does effect the result, so fringes should be nulled for this verification.

This should be checked before taking data on a new optic. The Y position should not need to be adjusted, if it does (ie it had been moved, or a different size optic is being measured) Adjust the height (Y translation) first before adjusting the lateral position. Changing the height will change the lateral position, but the converse is not true.

1.1.3 Mount the optic

1. Remove the bail, lower the camera and open the spring roller.
2. Using cleanroom gloves, carefully mount the optic with Surface 1 (arrow points toward S1) toward the interferometer. The optic is sitting squarely in the mount when the three mounting contact lines can be clearly seen.
3. Return the bail, camera and spring roller to their normal positions.



Interferometer Measurement Procedure

1.1.4 Null the reference flat

Use flat C for measuring coated optics. Flat F is a back up for flat C, but is not as flat and is not as well characterized. Place the retro-reflector in front of the reference flat. Null the reference flat by adjusting the screws on the front of the interferometer. Null the fringes from the retro-reflector image. This alignment will change with temperature. *The aluminum enclosure should be placed around the test for roughly an hour and then the null of the reference flat checked and corrected if necessary.*

1.1.5 Set the rotation of the optic

1. Line up the arrow head fiducial with the camera using the rotation feature of the position control box.
2. Zero the readout.
3. Rotate the optic +126.796 degrees clockwise as viewed from the interferometer. This places the reference mark at top dead center of the measurement map.
4. Zero the readout. This is the 0 degree position for measurement

1.1.6 Cover the optic

Place the “crown” of paper and bubble wrap onto the reference flat. Cover the bail and the top and back of the optic mount with bubble wrap. This is to prevent turbulent drafts from destroying the fidelity of the measurements.

1.1.7 Seal the enclosure

Again, seal against drafts. The purpose of the enclosure is to provide the minimum thermal gradient over the full area of the measurement and to isolate the experiment as much as possible from transient temperature changes.

1.1.8 Align the optic (turn off motor driver after alignment)

Use the interferometer switch to change to Alignment mode. Bring the spots toward the center. Switch back to Test mode. Null the fringes. Having the encoders on adds heat (and drafts) to the measurement system. The driver box should be on for as short a time as possible.

1.1.9 Set the intensity

Click the sun icon at the top of the screen, this brings up the intensity screen. Increase the intensity so that the camera just begins to saturate, this happens when you see red on the display. Lower the intensity by small amounts until the red just disappears from the display.

For HR optics the Neutral density filter will have to be IN the beam, this is controlled from the top panel at the back of the interferometer. For uncoated surfaces the ND filter will have to be OUT of the beam.

1.2 Taking a measurement

1.2.1 Check that the environment is stable

1. The Present Value and Set Point should be the same on the Temperature controller, and there should be at least one bar showing on the heater control. If not, see the Thermal Control section later in this document.
2. The Temperature inside the box should be 20C +/- 0.1 C
3. The Tilt (Z1&Z2) should be changing by less than .002 waves in an 8 average Difference measurement
4. The initial alignment should be better than .02 waves in Z1 and Z2 (no average is ok to check this)



Interferometer Measurement Procedure

1.2.2 Set up for a Run

In *Measurement Options* (single white sheet icon with red tab);

Only *PSI options* and *Automation* (3 tabs) need to be checked and changed, everything else will stay the same while using the *Vision.ini* configuration

Be sure to exit using the OK button. **Closing the window in any other way will not apply your changes.**

PSI options should look like this:

Automation

Under *Measurement options* click the *Automation* tab.

The first tab under *Automation* is the *Options* tab. This box should look like this:



Interferometer Measurement Procedure

Measurement Options

Options | Prompts | PSI Options | Acquisition | Automation

Options | Data Titles | Saving Data | Error Handling

Automation On Measurement Cycles: 60

Auto Close Data Window Sequence Number: 1

Reset Sequence Number at Start of Run Time Between Measurements

Update Master Database at End of Run 0 Sec

Use Stage Movement

Move to Next Location After Valid Measurement

Use Robot

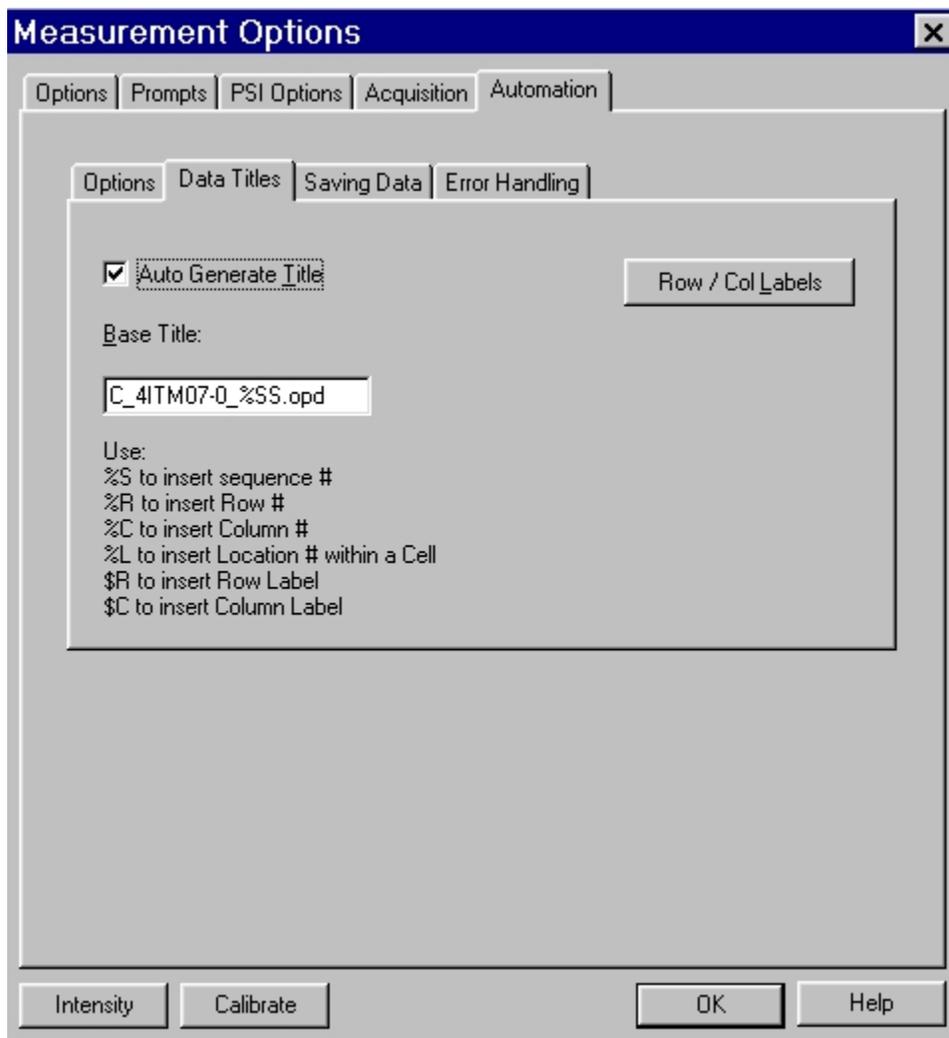
Intensity Calibrate OK Help

Automation on
Measurement cycles 60
Sequence number 1 to start, 61 for next dataset.... Take ~120 good datasets in all



Interferometer Measurement Procedure

1.2.2.1 Data titles for Automation



1.2.2.2 Filename convention:

Reference flat_(optic sn)-RotationPosition_DataSetNumber.opd

The measurements we take

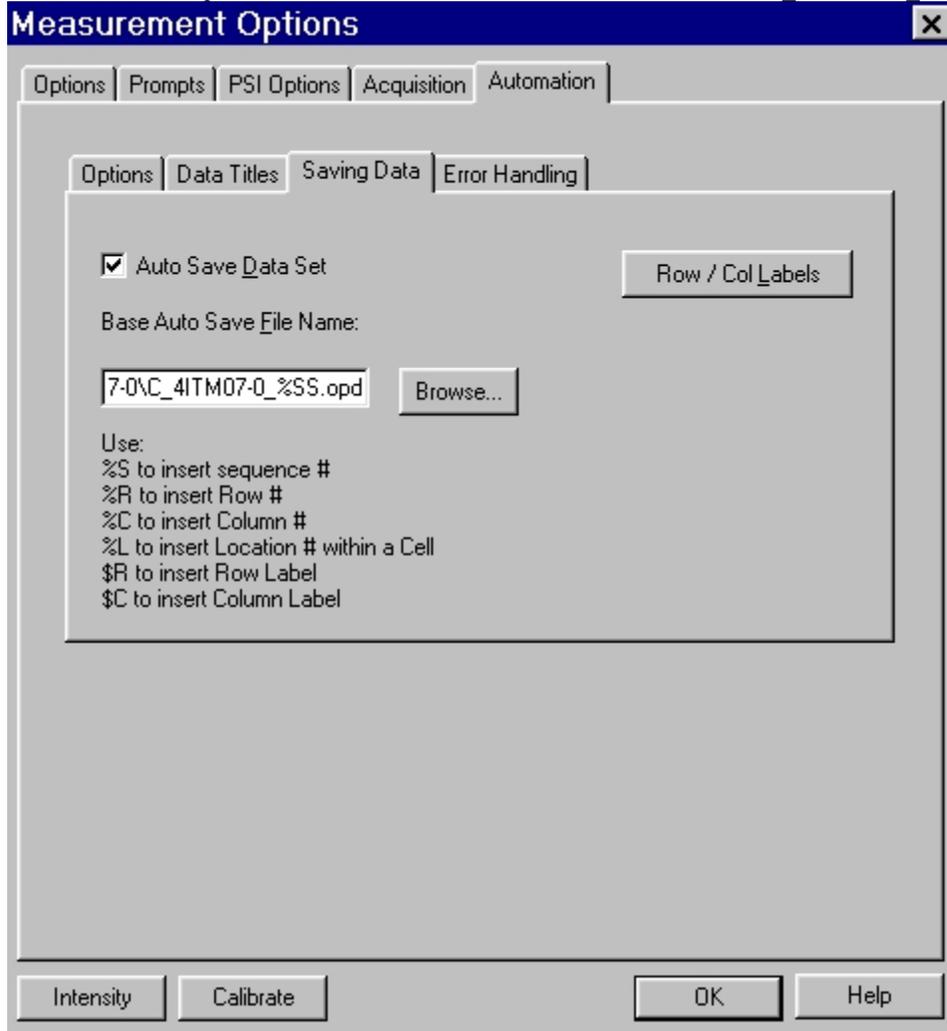
1. C_4ITM07-0_%SS.opd 0 degree rotation, arrow at top.
2. C_4ITM07-45_%SS.opd 45 degree
3. C_4ITM07-90_%SS.opd 90 degree
4. C_4ITM07-180_%SS.opd 180 degree
5. C_4ITM07-6X_%SS.opd 6X magnification (max zoom) (to 360 degree rotation, reset intensity, move out ND filter)
6. C_4ITM07-OA_%SS.opd Off Axis, 1700 counts in X (at 360 degree rotation, reset intensity, move in ND filter)



Interferometer Measurement Procedure

Saving Data for Automation

1. Create a folder with the SN of the optic on drive D: (or wherever you have space)
2. Create a subfolder with the SN of the optic and the orientation
3. For example the file to save would be D:\4ITM07\4ITM07-0\C 4ITM07-0 %SS.opd

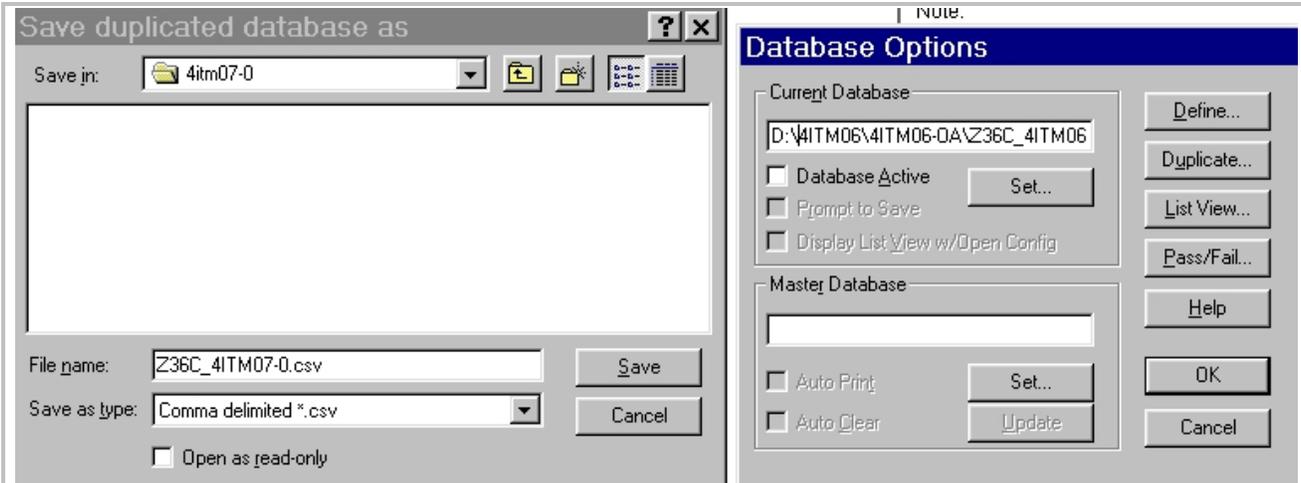


1.2.3 Set up the Data Base

It is easiest to Duplicate an existing Data base.

Choose Duplicate from the Data Base Options as shown below

Interferometer Measurement Procedure



First select the Data base to duplicate, then select the place and name to save the new data base. Data bases should be saved into the same folder as the data. Data bases have a Z36_ prefix indicating that these are the zernike coefficients for these data sets. You should choose to view the Data base as Data are taken, this keeps you aware of what's going on. From the data table itself choose View, graph, Z1... Z2 & Z3.

1.3 The final Checklist

1. Temperature PV = SV
2. Temperature inside the box = 20C +/- .1
3. Difference measurement gives < .002 waves of tilt on each axis
4. Alignment is good to < .02 waves of tilt on each axis

PSI OPTIONS

1. Averaging 8
2. Automation ON, correct # datasets, **correct start number**
3. Data Titles ON
4. Saving Data ON
5. Data Base is ACTIVE, saving to correct location

1.3.1 Common mistakes

1. Starting to save Data at 1 and over writing previous data
2. Forgetting to null the reference flat with the retro reflector
3. Forgetting to check the position of the optical axis with the Dummy mass
4. Forgetting to set the rotation angle of the mirror after it is mounted
5. Forgetting to set the intensity
6. Taking data with the outside monitor ON, destroys the camera signal

1.4 The Lab Book

For each data set record:

1. Date

	LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY	T000129 -00- D
	SPECIFICATION	Drawing No Rev. Group
		Sheet 8 of 8

Interferometer Measurement Procedure

2. Measurement title ie. C_4ITM07-0
3. Time the data set started
4. Temperature at the time the set started
5. Inside the box
6. PV
7. SV
8. Number of bars showing on the control panel
9. Paste into the log book graphs of Z1, Z2 and Z3 for the duration of the data set

10. Thermal Control

A stable environment is crucial so that measurements can be averaged. The environment can and should be stable enough so that the alignment tilt does not change by more than ~80 nm in a run of 60 data sets. This is the definition of a “good” run.

2 Beamsplitter Measurement at 45° angle of incidence

2.1 Initial alignment

1. Level the Interferometer
2. Mount A and B flats
3. Install crosshairs on A and B flats (Assume A is on interferometer and B is on WYKO mount)
4. Use WYKO mount ONLY for all alignment
5. Position Beamsplitter at 1st measurement rotation (0°)
6. Rotate crosshair on B to be sure it is centered on the flat
7. Rough in B crosshair using A crosshair as a guide
8. Remove A crosshair
9. Bring B crosshair onto center pixel (284,243 as of this writing)
10. Install crosshair onto Beamsplitter
11. Rough in the Beamsplitter crosshair using B crosshair as a guide
12. Remove B Crosshair
13. Bring Beamsplitter crosshair onto center pixel (284,243)
14. Remove Beamsplitter crosshair
15. Final align with WYKO mount
16. Install shrouds
17. Wait for stability
18. Now Align using motor drivers

2.2 For each 45° incidence Beamsplitter rotation position

1. Rotate Beamsplitter to next position
2. Install crosshair on B flat
3. Use WYKO mount ONLY for all alignment during this repositioning
4. Align fringes
5. Position crosshair using WYKO mount translations (in zoom, the spot on the monitor can be used as a reference)
6. Rotate crosshair on B to be sure it is centered on the flat (zoom in helps here as well as increasing the intensity)
7. Bring B crosshair onto center pixel (284,243)