



LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

*LIGO Laboratory / LIGO Scientific Collaboration*

LIGO-E1300431-v1

*LIGO*

5/14/2013

Surface figure measurement of ETM09

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## 1 Introduction

The purpose of this note is to memorialize the results of figure measurement of ETM09.

## 2 Method

This is the average of eight measurements taken every 45 degrees, the optic under test is rotated. See T1100370-v2 for more detail.

### 2.1 Uncertainty

The final uncertainty in the measurement of ETM07 is estimated to be of order 0.6nm rms over 300mm and 0.19nm rms over 160mm. This uncertainty is the combination of environmental and Reference File errors. See Section 4.1 of T1100370-v2.

## 3 Results

The ETM is measured every 45 degrees in 8 orientations. The final map is the average of all 8 datasets rotated to one orientation (arrow up.) The Reference file is subtracted from each data set before averaging. A key to the coefficients listed on data images is found in figure 1; for instance coef 4 corresponds to term# 4 in the list of Zernike polynomials.

### *Zernike Polynomials Table*

In this table,  $\phi$  = polar coordinate angle, and  $\rho$  = radius (normalized to 1 at the edge of the aperture). The numbers in columns m and n are the indices for Zernike polynomials

<i>n</i>	<i>m</i>	<i>Term #</i>	<i>Polynomial</i>	<i>Meaning</i>
0	0	0	1	Piston or Bias
1	+1	1	$\rho \cos \phi$	Tilt X
	-1	2	$\rho \sin \phi$	Tilt Y
	0	3	$2\rho^2-1$	Power
2	+2	4	$\rho^2 \cos 2 \phi$	Astigmatism X
	-2	5	$\rho^2 \sin 2 \phi$	Astigmatism Y
	+1	6	$(3\rho^2-2)\rho \cos \phi$	Coma X
	-1	7	$(3\rho^2-2)\rho \sin \phi$	Coma Y
	0	8	$6\rho^4-6\rho^2+1$	Primary Spherical
3	+3	9	$\rho^3 \cos 3 \phi$	Trefoil X
	-3	10	$\rho^3 \sin 3 \phi$	Trefoil Y
	+2	11	$(4\rho^2-3)\rho^2 \cos 2 \phi$	Secondary Astigmatism X
	-2	12	$(4\rho^2-3)\rho^2 \sin 2 \phi$	Secondary Astigmatism Y
	+1	13	$(10\rho^4-12\rho^2+3)\rho \cos \phi$	Secondary Coma X
	-1	14	$(10\rho^4-12\rho^2+3)\rho \sin \phi$	Secondary Coma Y
	0	15	$20\rho^6-30\rho^4+12\rho^2-1$	Secondary Spherical

### 3.1 Radius of curvature : 2242.4

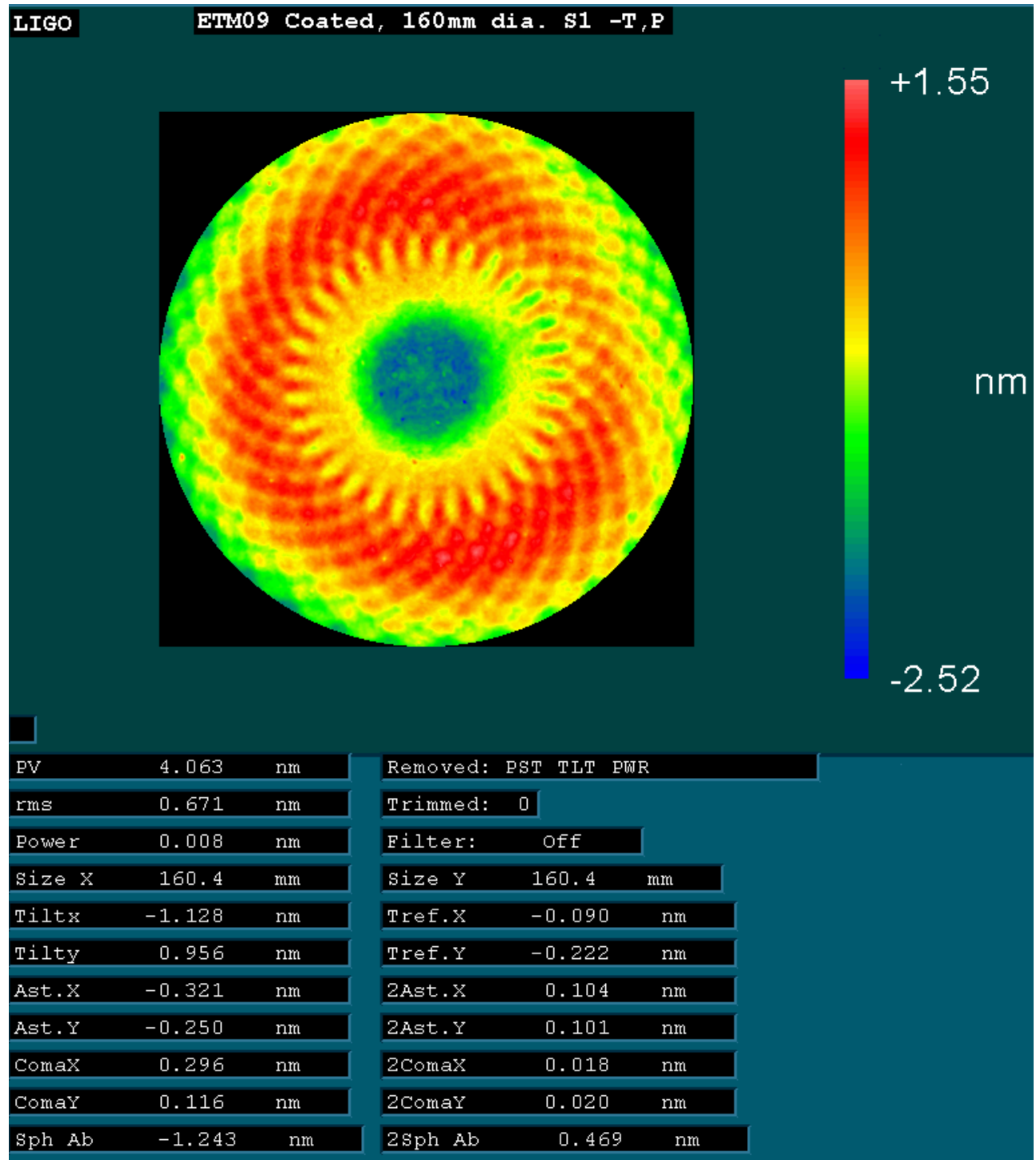
The radius of curvature was measured against the known radius of the reference sphere (-2100m) and calculated as the sum of saggital heights of the part as measured, plus cavity distance, plus reference saggita. The ROC data were taken over a period of 72 hours. The saggita had a standard deviation of 0.19nm, over 160 mm diameter. This corresponds to an uncertainty due to environment of 0.29 meters in radius.

### 3.2 High Frequency data

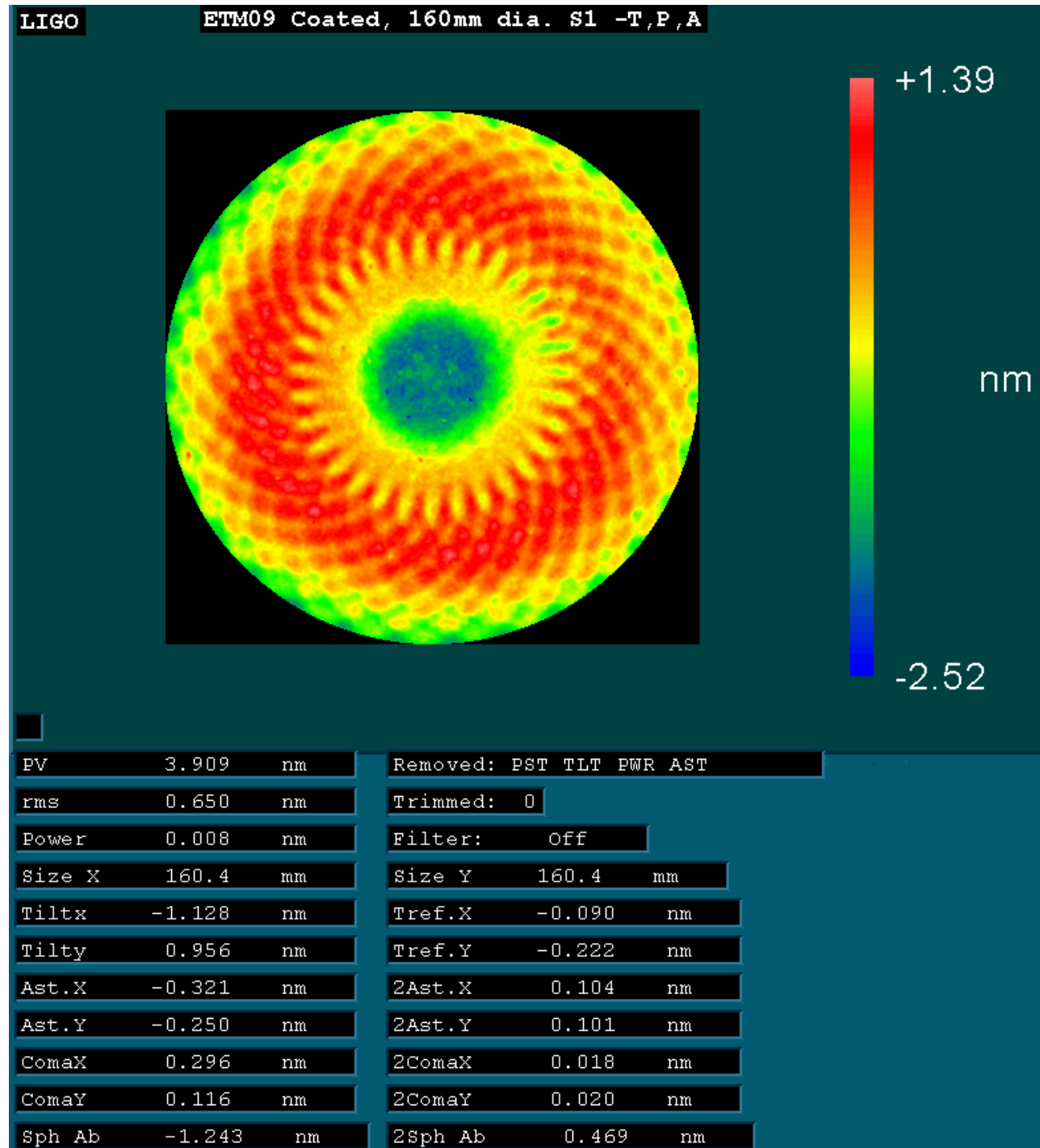
Data have been taken at 0.023 and 0.047mm/pixel, these data are self referencing (averaged to get a local, current image of the reference. The reference is temperature dependent at High Spatial frequency. These data are best viewed as a PSD. A sampling of raw files will be uploaded to the DCC. The raw files have central rings which come from the internal reflections of the interferometer, these rings should be avoided when analyzing the high spatial frequency data.

### 3.3 Low Frequency Data

Side One 160 mm diameter, power subtracted



Side One 160 mm diameter, power and astigmatism subtracted



Amplitude of the spiral at R=43mm

