LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

LIGO Laboratory / LIGO Scientific Collaboration

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Surface figure measurement of ITM06

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1   Introduction

The purpose of this note is to memorialize the results of figure measurement of ITM06.

2   Method

The surface one measurement 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 ITM06 is estimated to be of order 0.51 nm rms over 300mm and 0.21 nm rms over 160 mm. This uncertainty is the combination of environmental and Reference File errors. See Section 4.1 of T1100370-v2.

3   Results

The ITM 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, ϕ = polar coordinate angle, and ρ = radius (normalized to 1 at the edge of the aperture). The numbers in columns m and n are the indices for Zernike polynomials

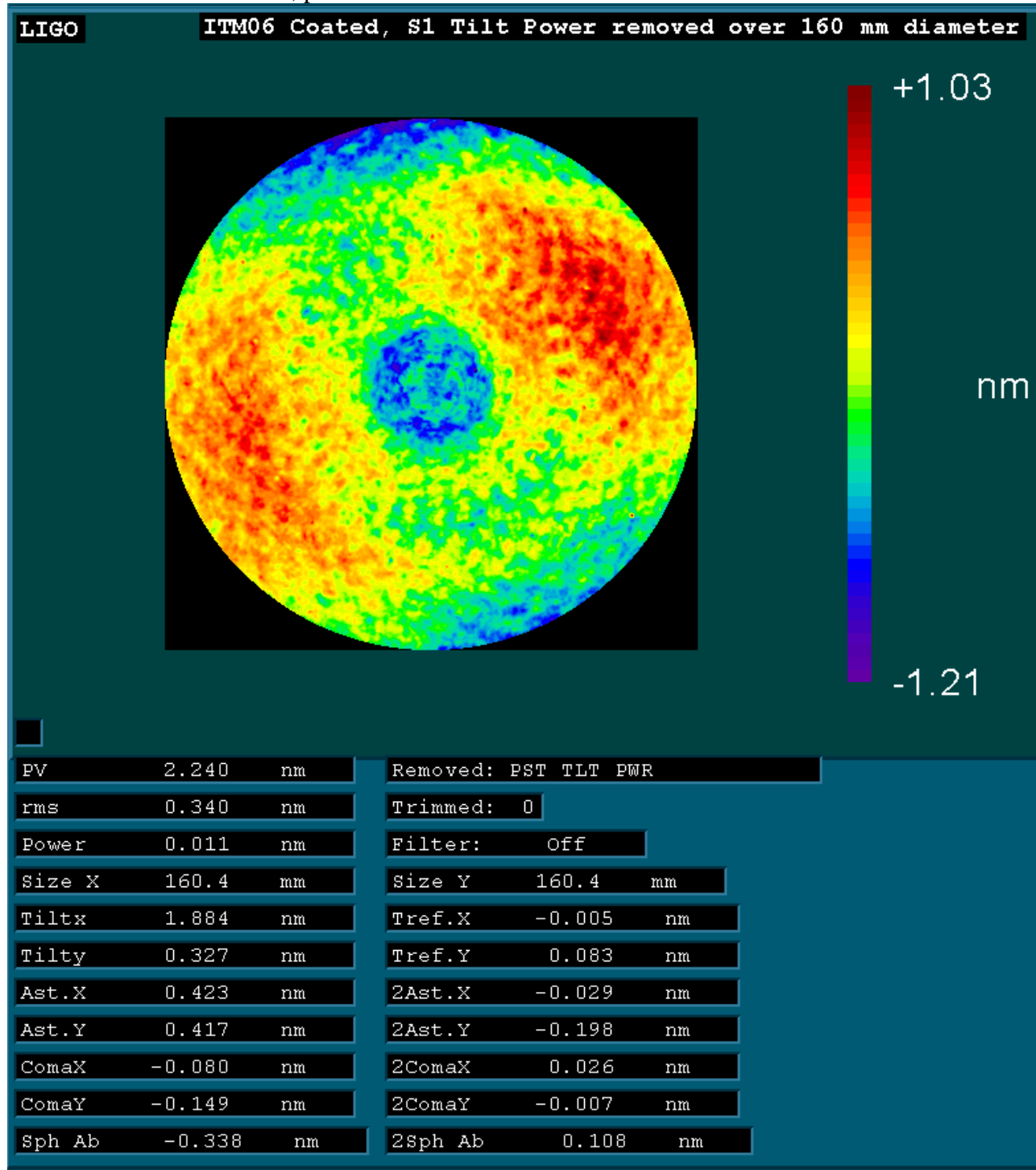| n	m	Term #	Polynomial	Meaning
0	0	0	1	Piston or Bias
1	+1	1	$\rho \cos \phi$	Tilt X
	-1	2	$\rho \sin \phi$	Tilt Y
	0	3	$2\rho^2-1$	Power
2	+2	4	$\rho^2 \cos 2\phi$	Astigmatism X
	-2	5	$\rho^2 \sin 2\phi$	Astigmatism Y
	+1	6	$(3\rho^2-2)\rho \cos \phi$	Coma X
	-1	7	$(3\rho^2-2)\rho \sin \phi$	Coma Y
	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 : 1934.3 meters

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 saggita had a standard deviation of 0.20 nm when measured over 160 mm diameter. This corresponds to an uncertainty due to environment of 0.23 meters in radius.

3.2 High Frequency data

Data have been taken at 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

PV	2.240	nm	Removed:	PST TLT PWR	
rms	0.340	nm	Trimmed:	0	
Power	0.011	nm	Filter:	Off	
Size X	160.4	mm	Size Y	160.4	mm
Tiltx	1.884	nm	Tref.X	-0.005	nm
Tilty	0.327	nm	Tref.Y	0.083	nm
Ast.X	0.423	nm	2Ast.X	-0.029	nm
Ast.Y	0.417	nm	2Ast.Y	-0.198	nm
ComaX	-0.080	nm	2ComaX	0.026	nm
ComaY	-0.149	nm	2ComaY	-0.007	nm
Sph Ab	-0.338	nm	2Sph Ab	0.108	nm

The image title reads: ITM06 Coated, S1 Tilt Power removed over 160 mm diameter. Scale: +1.03 nm to -1.21 nm.

Side One 160 mm diameter, power and astigmatism subtracted

PV	2.143	nm		Removed: PST TLT PWR AST		
rms	0.238	nm		Trimmed:	0	
Power	0.011	nm		Filter:	Off	
Size X	160.4	mm		Size Y	160.4	mm
Tiltx	1.884	nm		Tref.X	-0.005	nm
Tilty	0.327	nm		Tref.Y	0.083	nm
Ast.X	0.423	nm		2Ast.X	-0.029	nm
Ast.Y	0.417	nm		2Ast.Y	-0.198	nm
ComaX	-0.080	nm		2ComaX	0.026	nm
ComaY	-0.149	nm		2ComaY	-0.007	nm
Sph Ab	-0.338	nm		2Sph Ab	0.108	nm
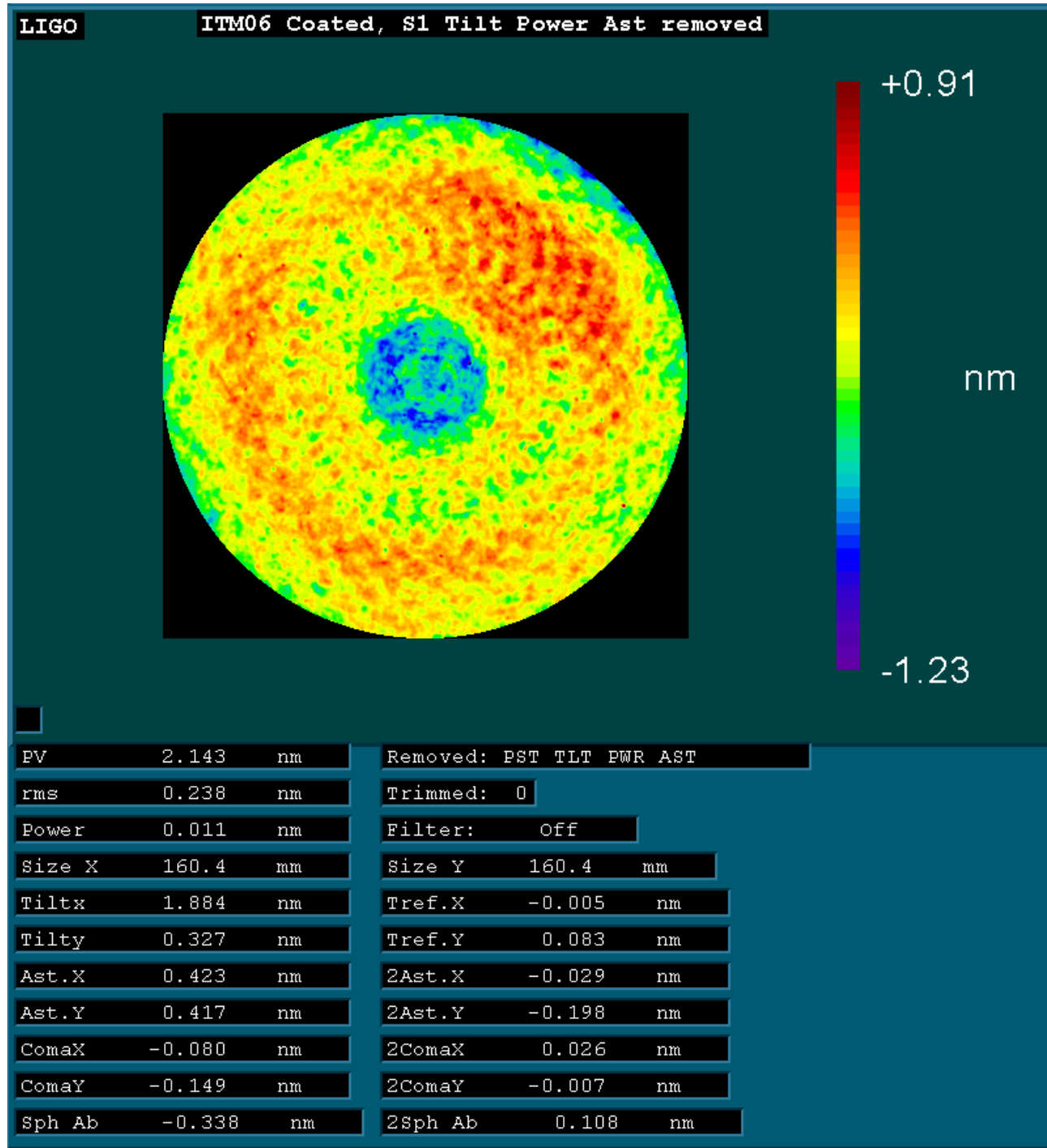
Amplitude of the spiral at R=40 mm, approximately 0.5 nm.
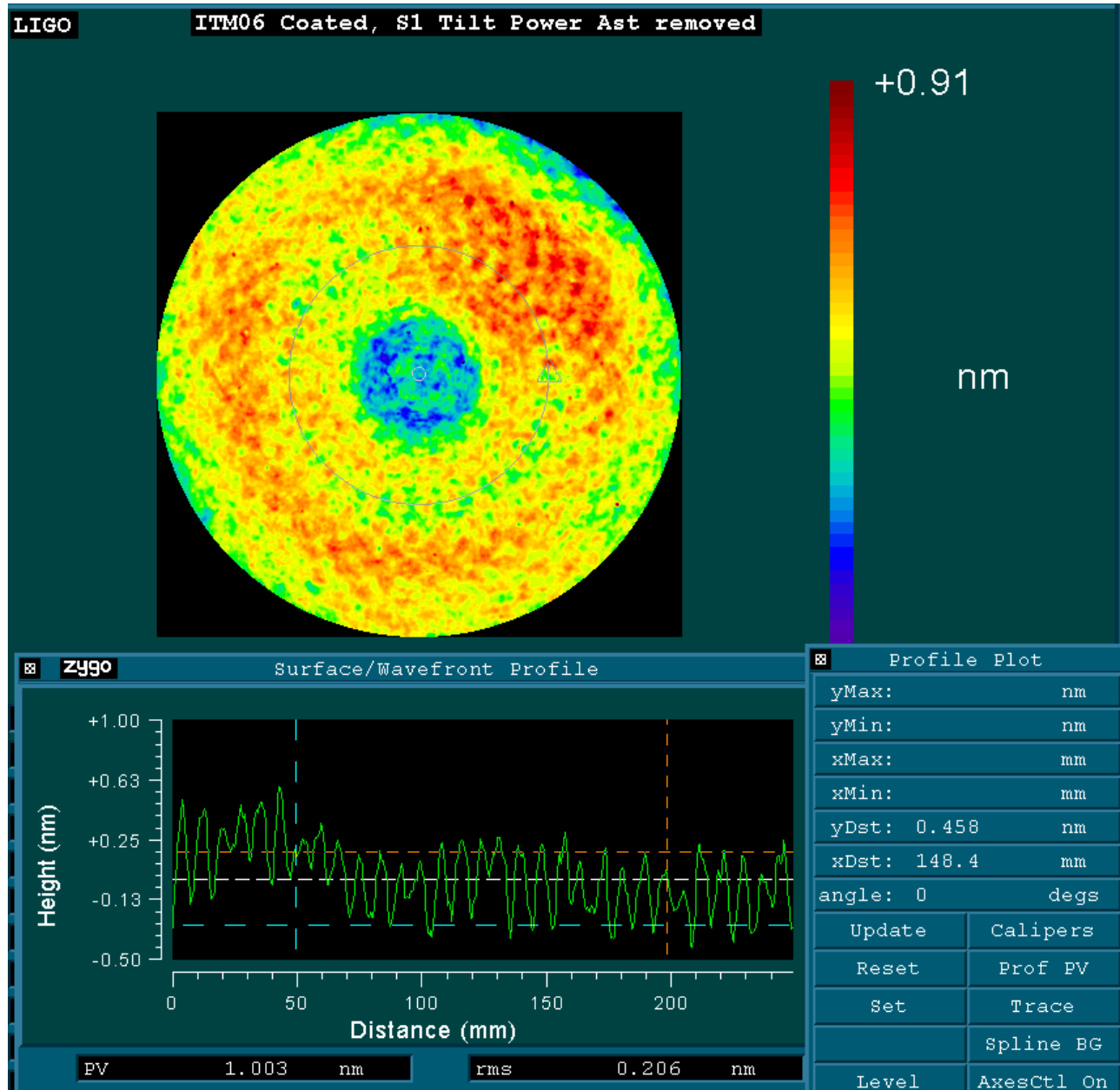
3.3.1 Transmitted wavefront,

Over 160 mm diameter the power is measured with respect to a 2100 m curve and is calculated to be -1333 meters, with an environmental uncertainty of 1.3 meters.

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+4.45

nm

-6.76

PV	11.206	nm	Removed:	PST TLT PWR		
rms	1.928	nm	Trimmed:	0		
Power	-4005.206	nm	Filter:	Off		
Size X	160.4	mm	Size Y	160.4	mm	
Tiltx	-115.139	nm	Tref.X	3.060	nm	
Tilty	9.338	nm	Tref.Y	-0.159	nm	
Ast.X	1.278	nm	2Ast.X	0.006	nm	
Ast.Y	0.025	nm	2Ast.Y	-0.065	nm	
ComaX	-0.597	nm	2ComaX	-0.241	nm	
ComaY	0.825	nm	2ComaY	-0.503	nm	
Sph Ab	-2.700	nm	2Sph Ab	1.111	nm	