Test Report

Off-Axis Parabolas

Prepared for

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Introduction

This report will supply the results of the transmitted wavefront error (TWE) and wedge angle tests performed by Absolute Metrology Services on the off-axis parabola (OAP) samples supplied by the CHARA Array of Georgia State University.

Interferometer Used:

The 4" 633nm Zygo Mark IV, coupled with a 4" – 12" beam expander (shown in later photos) was used to measure these pieces.

Measurement of Samples: Test Setup Diagram

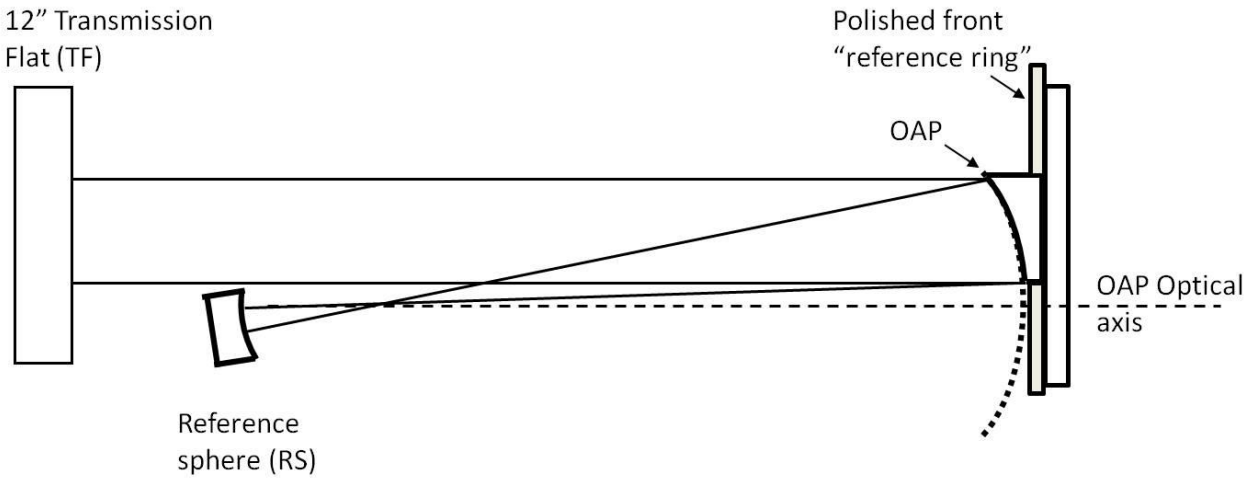


Figure 1. Diagram of test setup used. A 12" Transmission flat was used to generate the reference beam, a reflection off of the front surface of the TF back into the interferometer. The test beam was made from the beam exiting the interferometer, reflecting off of the OAP to the reference sphere, and returning to the TF along the same path. To ease the alignment of the OAP, a parallel polished 'reference ring' was made and screwed to the front of the OAP backplate. This was aligned to the reference surface (which is aligned to the optical axis of the interferometer).

Measurement of Samples: Test Setup Photos

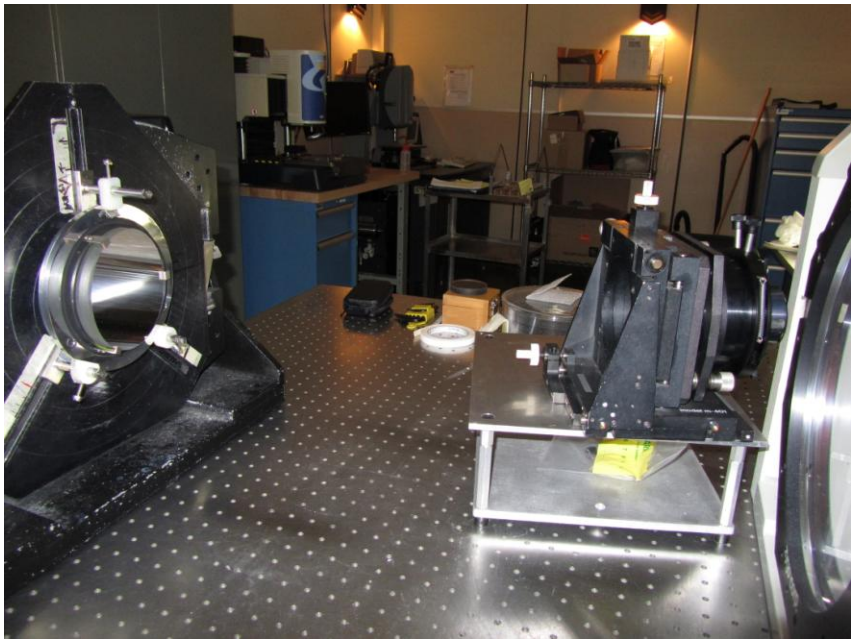


Figure 2. Photos of setup used. Photo at left, taken from parabola position, shows 12" TF with returning RS mounted just behind parabola focus. Lower photo shows parabola mounted with ½" wide polished ring mounted to it. Parabola was adjusted with ring perpendicular to outgoing beam before fine-tuning was performed to minimize aberrations.

Testing/Analysis Notes:

- Both a 125mm and 'no mask' conditions were used for analysis.
- 'Minimum aberration' condition was determined during measurement by minimizing PV, saving an adjustment in a particular direction, then repeating that adjustment again to confirm continual rising of PV and/or aberrations before repeating this procedure in each of the four tilt adjustment directions. This was done with a subaperture created on-site which may be slightly different than the 125mm mask used for final analysis.
- Data was acquired over an 'orange' area such as the one shown in Figure 3. It is comprised of the fringe pattern plus a small area surrounding it. Areas marked with black circles show the positions of very small dings in the 12" transmission flat surface. The marks produce data 'blips' from 10-20nm in height and did not adversely affect the Zernike values.
- Also to be noted is the large diffraction effect (concentric circles, defocused edge) caused by the long distance required between the test part and the RS; this may cause quick data bends just outside of the 125mm mask area. The slightly light/dark pixel rows of this particular camera caused a 5-10nm PV ripple in this direction only.
- The name of the original data set (usually called "NMinA.dat" or similar) was loaded and analyzed for the screen shots.
    - After analysis, the 125mm masked data for each part, with best fit sphere removed, was saved as "N_125mm.dat".
    - After analysis, the full data set for each part, with best fit sphere removed, was saved as N_full.dat".
    - "N_125mm.dat" and "N_full.dat" were then re-loaded to produce the Zernike table, which is provided separately in Excel format.

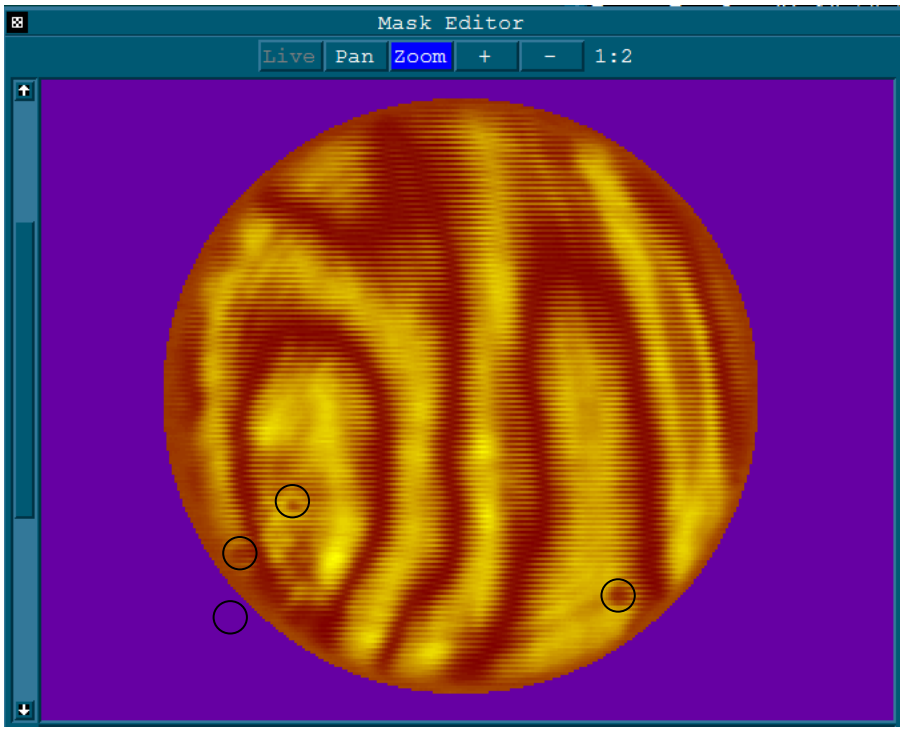


Figure 3. Area of data acquired for one particular part, showing locations of very small pits present on the 12" TF, enlarged due to the defocusing effect of the very long cavity. One circle is not in the measured area of this particular piece, but is in the measured area of others.

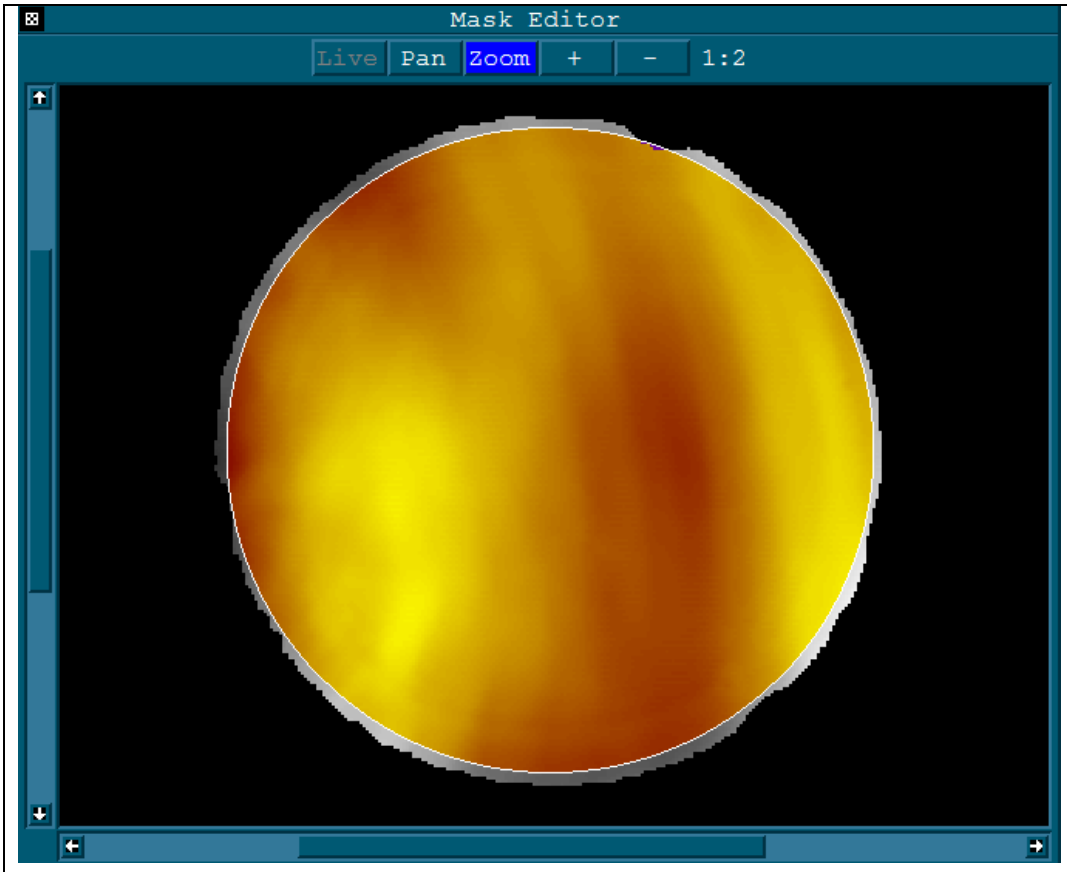


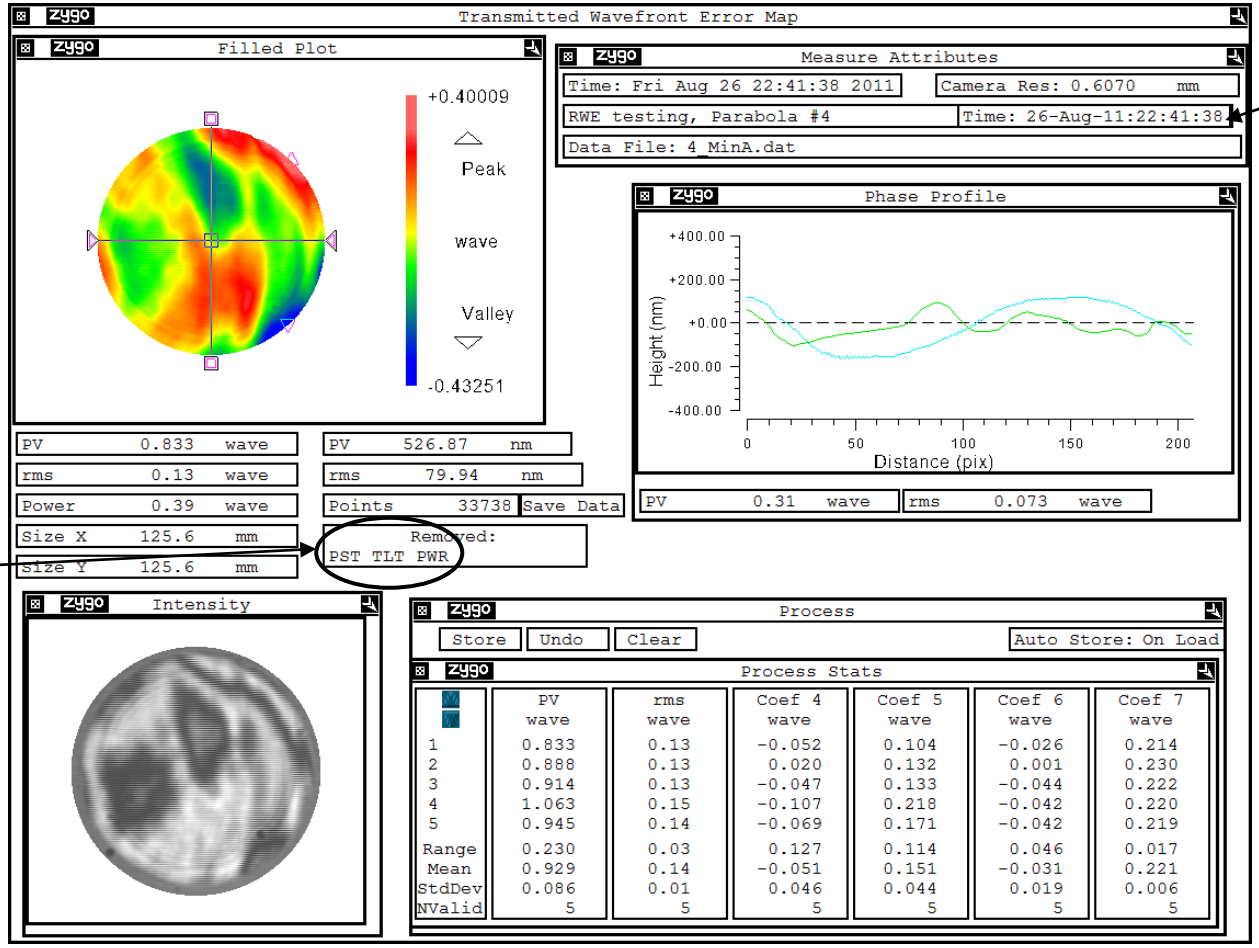
Figure 4. Resulting valid data area with 125mm mask applied.

Figure 5. Example of Data View (SAMPLE ONLY).

Filled Plot: This shows the shape of the wavefront after it has traveled through your test part. High (red) areas indicate higher areas of the test part.

"Removed" attributes: This shows what has been removed from your data before presenting the plots. In this case, it is Piston (PST) only.

Intensity Map: The actual view of the fringes as taken by the camera. This is one of the thirteen 'phase shift' frames taken.

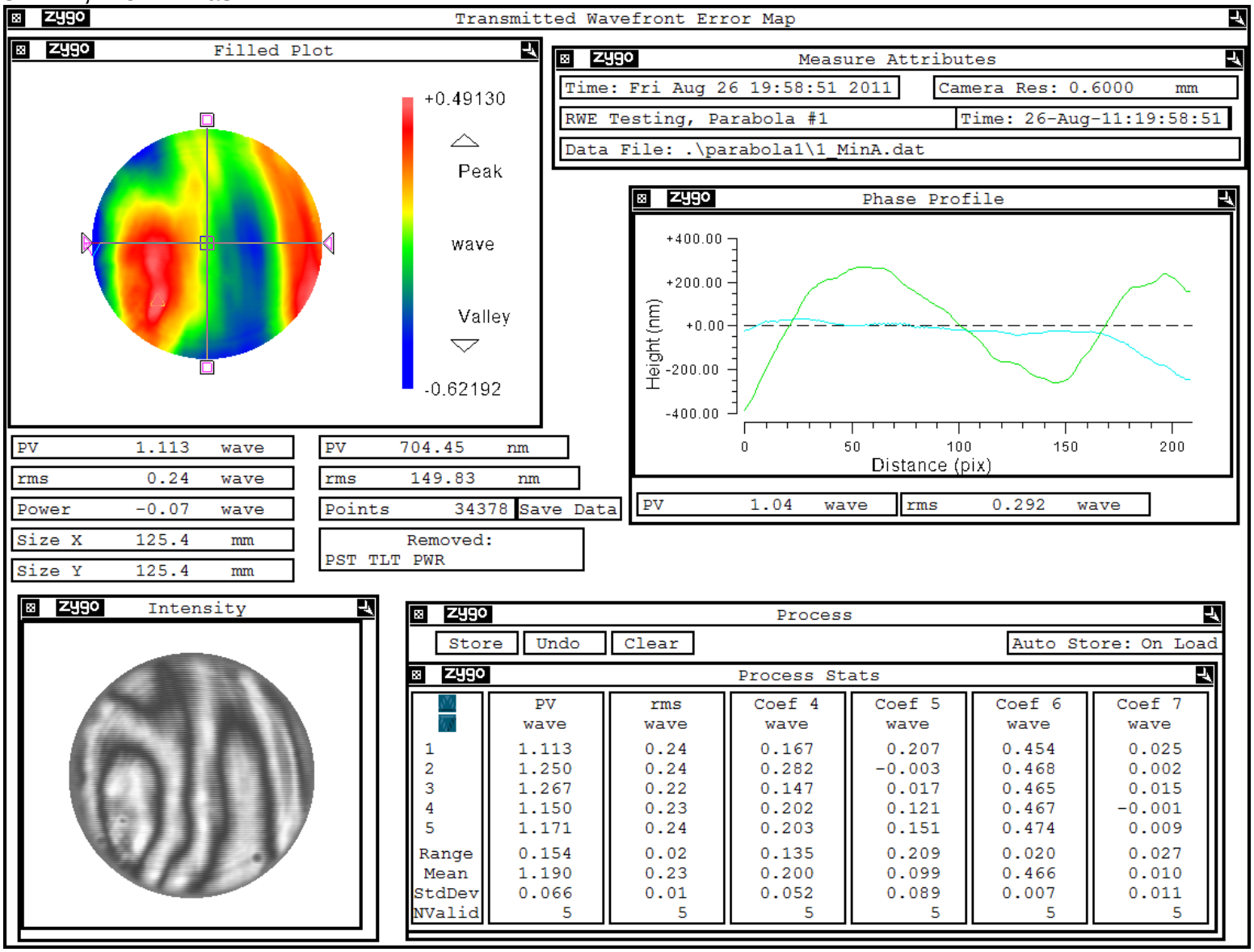


General information about the original data file being analyzed and testing conditions can be found here. 1_TWE.dat with PST removed is saved as "1_TWE_pstrem.dat" in your final data sets.

Surface profiles, aligned on the X and Y axes are shown here. The green line marks the 'triangle-end' profile from the Filled Plot.

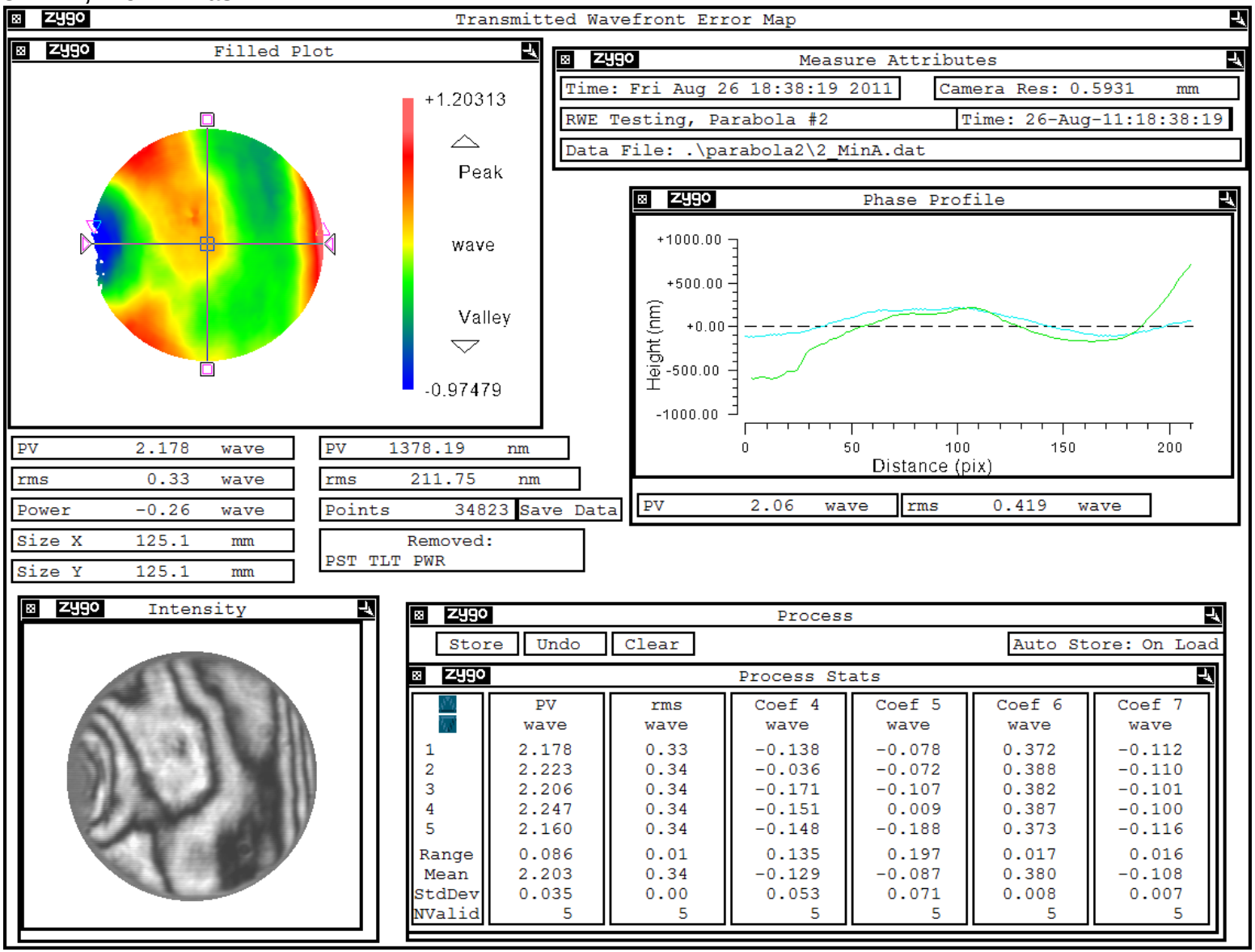
Specific parameters that AMS tracked during alignment are found here for the 125mm analysis. Position 1 is the best tip/tilt location, while positions 2-5 are adjustments in each of the four directions.

OAP #1, 125mm mask



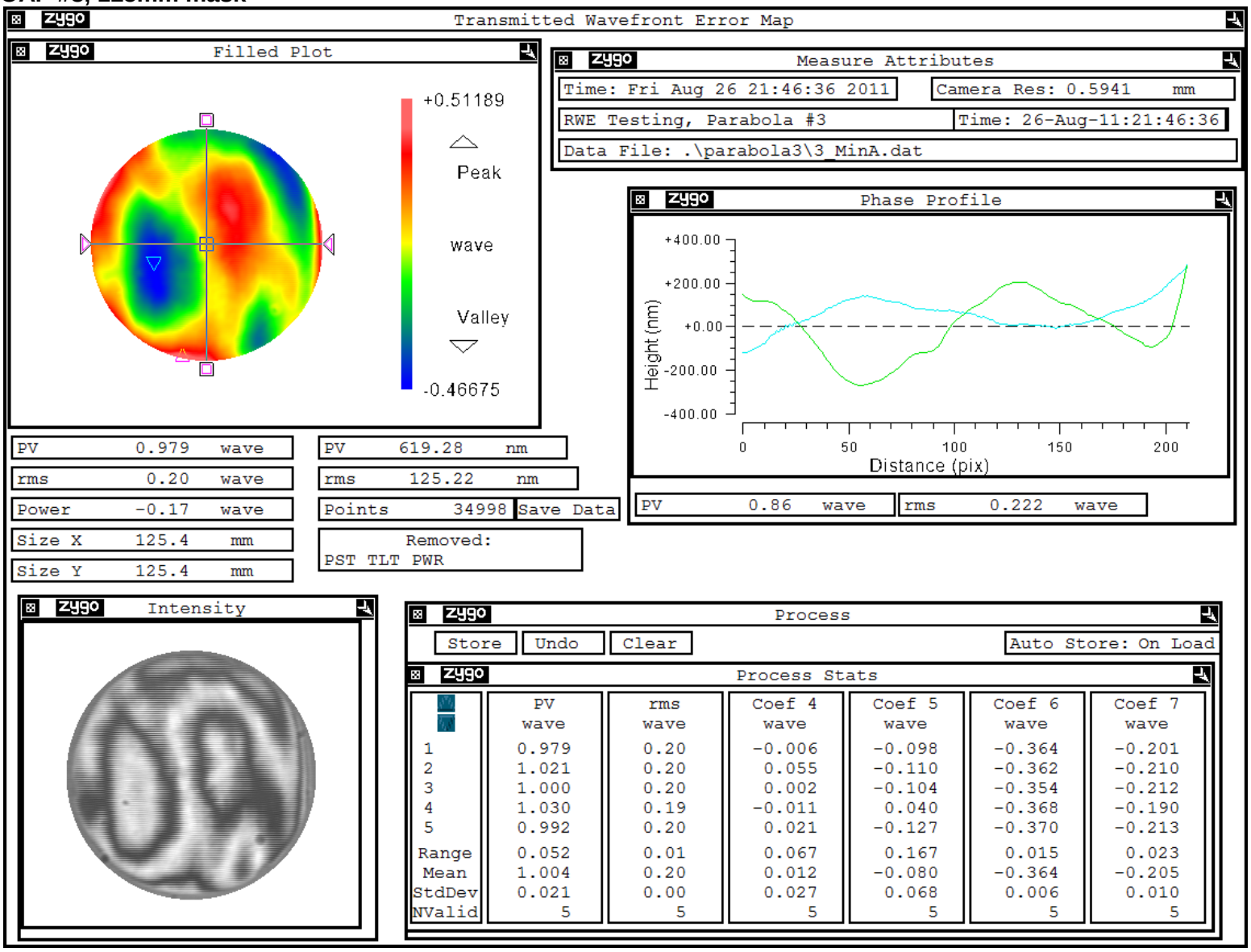
	PV wave	rms wave	Coef 4 wave	Coef 5 wave	Coef 6 wave	Coef 7 wave
1	1.113	0.24	0.167	0.207	0.454	0.025
2	1.250	0.24	0.282	-0.003	0.468	0.002
3	1.267	0.22	0.147	0.017	0.465	0.015
4	1.150	0.23	0.202	0.121	0.467	-0.001
5	1.171	0.24	0.203	0.151	0.474	0.009
Range	0.154	0.02	0.135	0.209	0.020	0.027
Mean	1.190	0.23	0.200	0.099	0.466	0.010
StdDev	0.066	0.01	0.052	0.089	0.007	0.011
NValid	5	5	5	5	5	5

OAP #2, 125mm mask



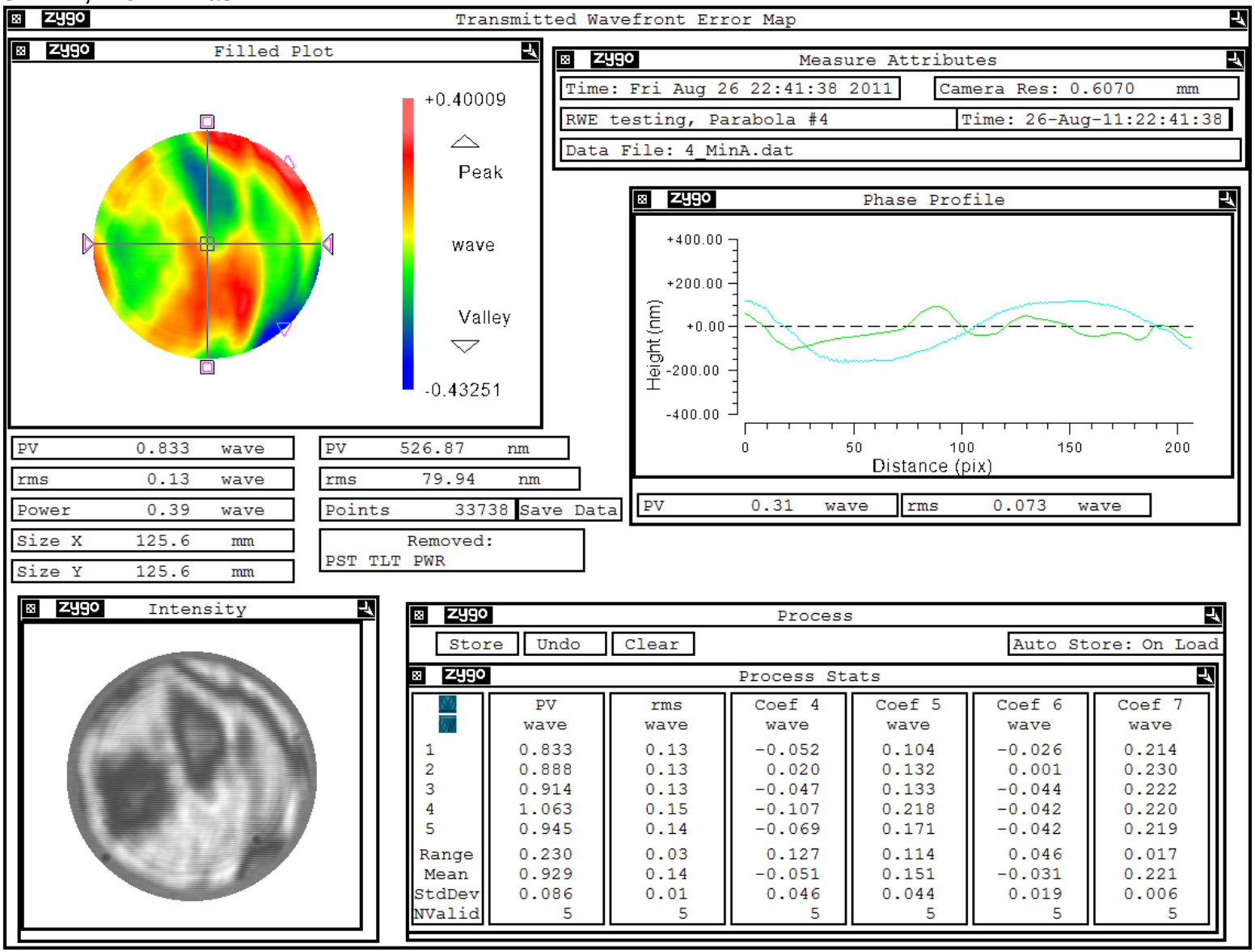
	PV wave	rms wave	Coef 4 wave	Coef 5 wave	Coef 6 wave	Coef 7 wave
1	2.178	0.33	−0.138	−0.078	0.372	−0.112
2	2.223	0.34	−0.036	−0.072	0.388	−0.110
3	2.206	0.34	−0.171	−0.107	0.382	−0.101
4	2.247	0.34	−0.151	0.009	0.387	−0.100
5	2.160	0.34	−0.148	−0.188	0.373	−0.116
Range	0.086	0.01	0.135	0.197	0.017	0.016
Mean	2.203	0.34	−0.129	−0.087	0.380	−0.108
StdDev	0.035	0.00	0.053	0.071	0.008	0.007
NValid	5	5	5	5	5	5

OAP #3, 125mm mask



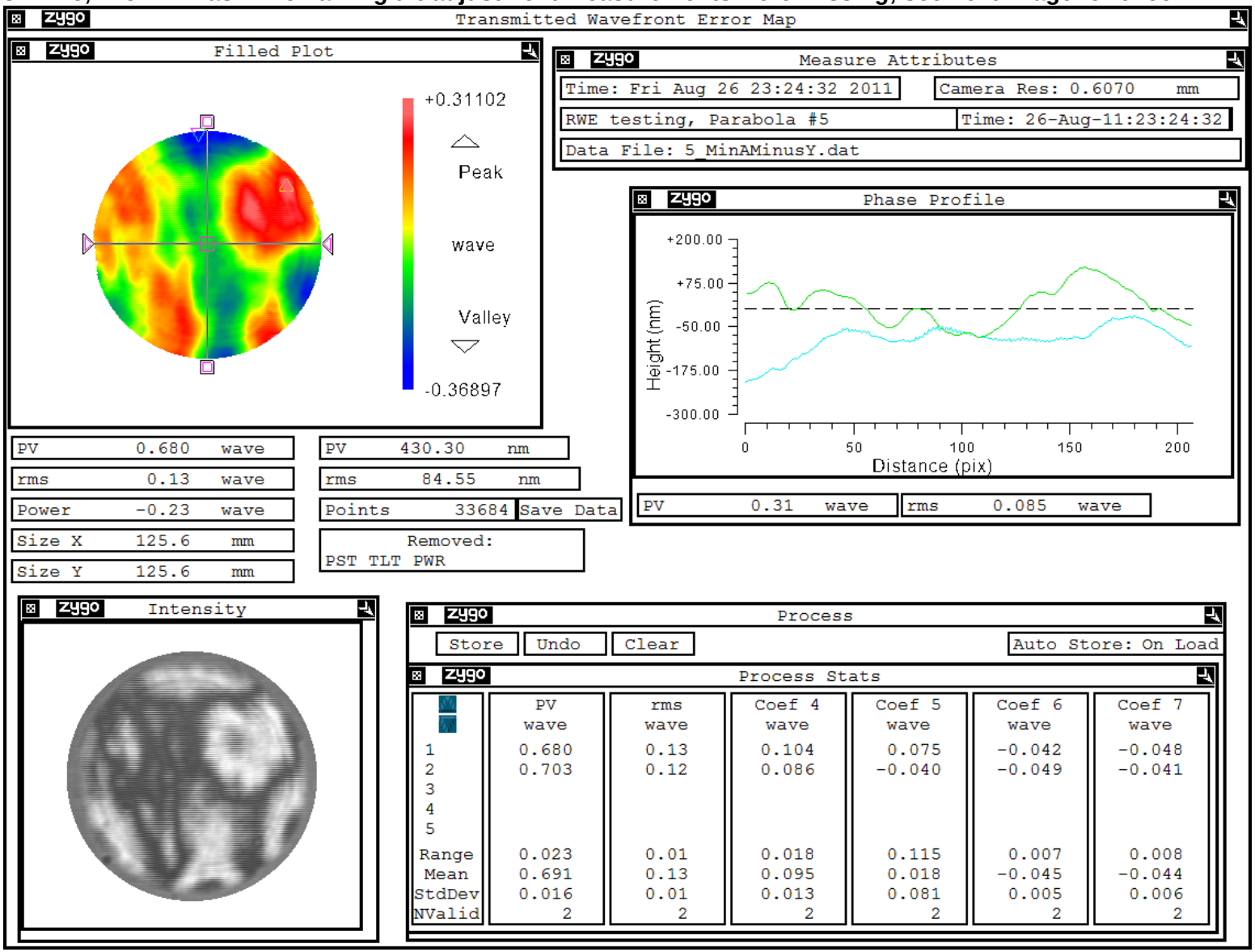
	PV wave	rms wave	Coef 4 wave	Coef 5 wave	Coef 6 wave	Coef 7 wave
1	0.979	0.20	-0.006	-0.098	-0.364	-0.201
2	1.021	0.20	0.055	-0.110	-0.362	-0.210
3	1.000	0.20	0.002	-0.104	-0.354	-0.212
4	1.030	0.19	-0.011	0.040	-0.368	-0.190
5	0.992	0.20	0.021	-0.127	-0.370	-0.213
Range	0.052	0.01	0.067	0.167	0.015	0.023
Mean	1.004	0.20	0.012	-0.080	-0.364	-0.205
StdDev	0.021	0.00	0.027	0.068	0.006	0.010
NValid	5	5	5	5	5	5

OAP #4, 125mm mask



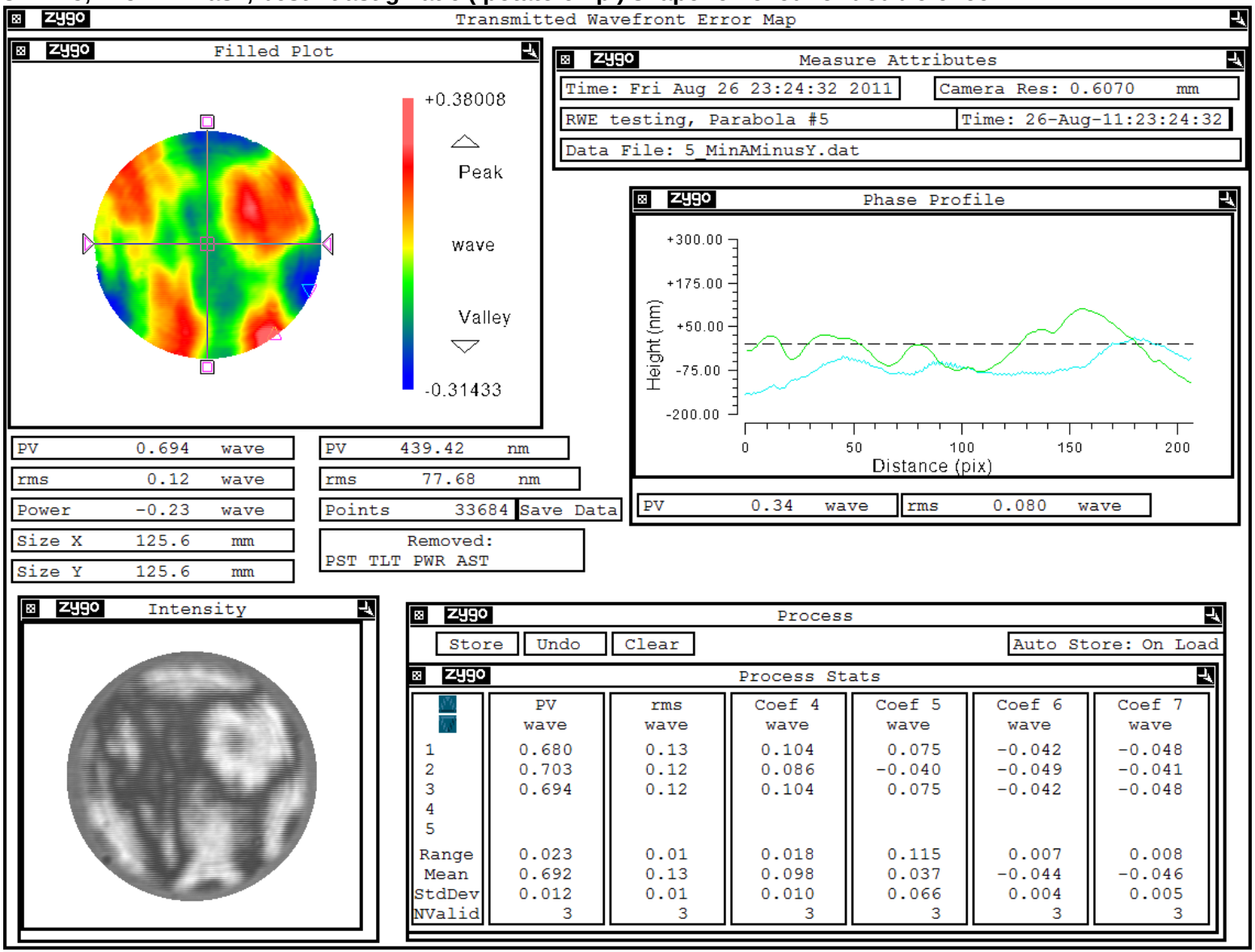
	PV wave	rms wave	Coef 4 wave	Coef 5 wave	Coef 6 wave	Coef 7 wave
1	0.833	0.13	-0.052	0.104	-0.026	0.214
2	0.888	0.13	0.020	0.132	0.001	0.230
3	0.914	0.13	-0.047	0.133	-0.044	0.222
4	1.063	0.15	-0.107	0.218	-0.042	0.220
5	0.945	0.14	-0.069	0.171	-0.042	0.219
Range	0.230	0.03	0.127	0.114	0.046	0.017
Mean	0.929	0.14	-0.051	0.151	-0.031	0.221
StdDev	0.086	0.01	0.046	0.044	0.019	0.006
NValid	5	5	5	5	5	5

OAP #5, 125mm mask. Remaining tilt-adjustment measurements were missing; see next image for check.



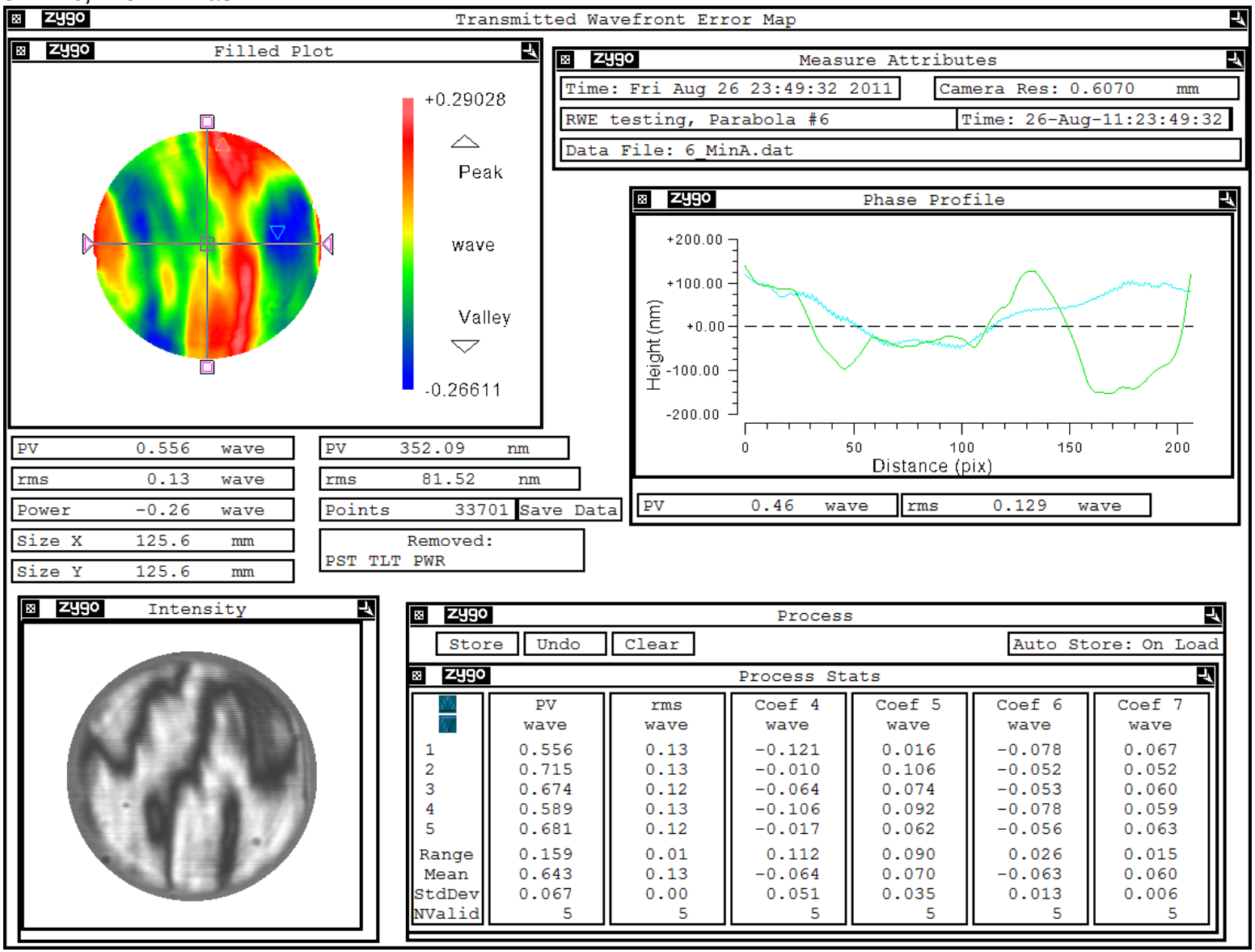
	PV wave	rms wave	Coef 4 wave	Coef 5 wave	Coef 6 wave	Coef 7 wave
1	0.680	0.13	0.104	0.075	-0.042	-0.048
2	0.703	0.12	0.086	-0.040	-0.049	-0.041
3						
4						
5						
Range	0.023	0.01	0.018	0.115	0.007	0.008
Mean	0.691	0.13	0.095	0.018	-0.045	-0.044
StdDev	0.016	0.01	0.013	0.081	0.005	0.006
NValid	2	2	2	2	2	2

OAP #5, 125mm mask, best fit astigmatic ('potato chip') shape removed for double-check.



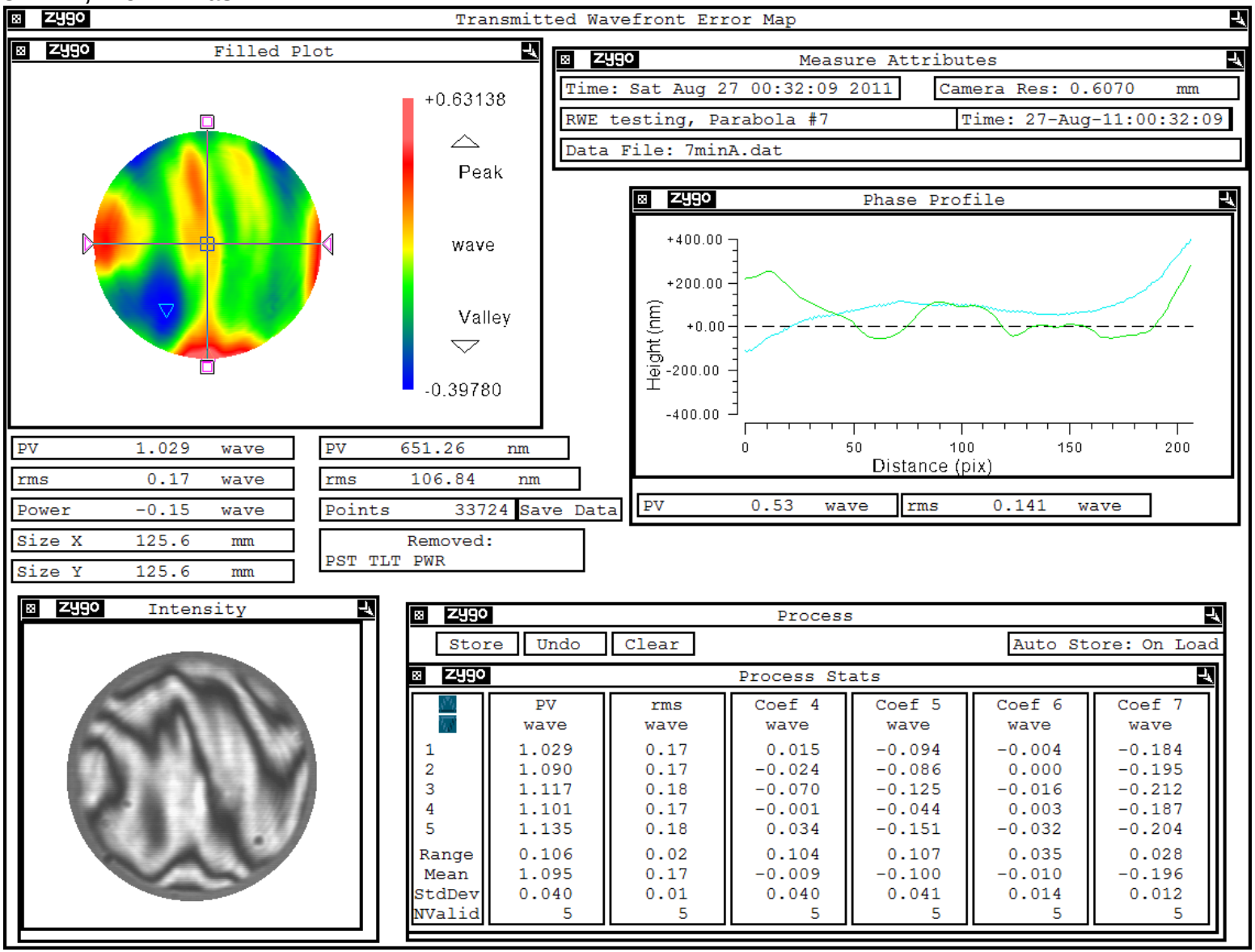
	PV wave	rms wave	Coef 4 wave	Coef 5 wave	Coef 6 wave	Coef 7 wave
1	0.680	0.13	0.104	0.075	-0.042	-0.048
2	0.703	0.12	0.086	-0.040	-0.049	-0.041
3	0.694	0.12	0.104	0.075	-0.042	-0.048
4						
5						
Range	0.023	0.01	0.018	0.115	0.007	0.008
Mean	0.692	0.13	0.098	0.037	-0.044	-0.046
StdDev	0.012	0.01	0.010	0.066	0.004	0.005
NValid	3	3	3	3	3	3

OAP #6, 125mm mask



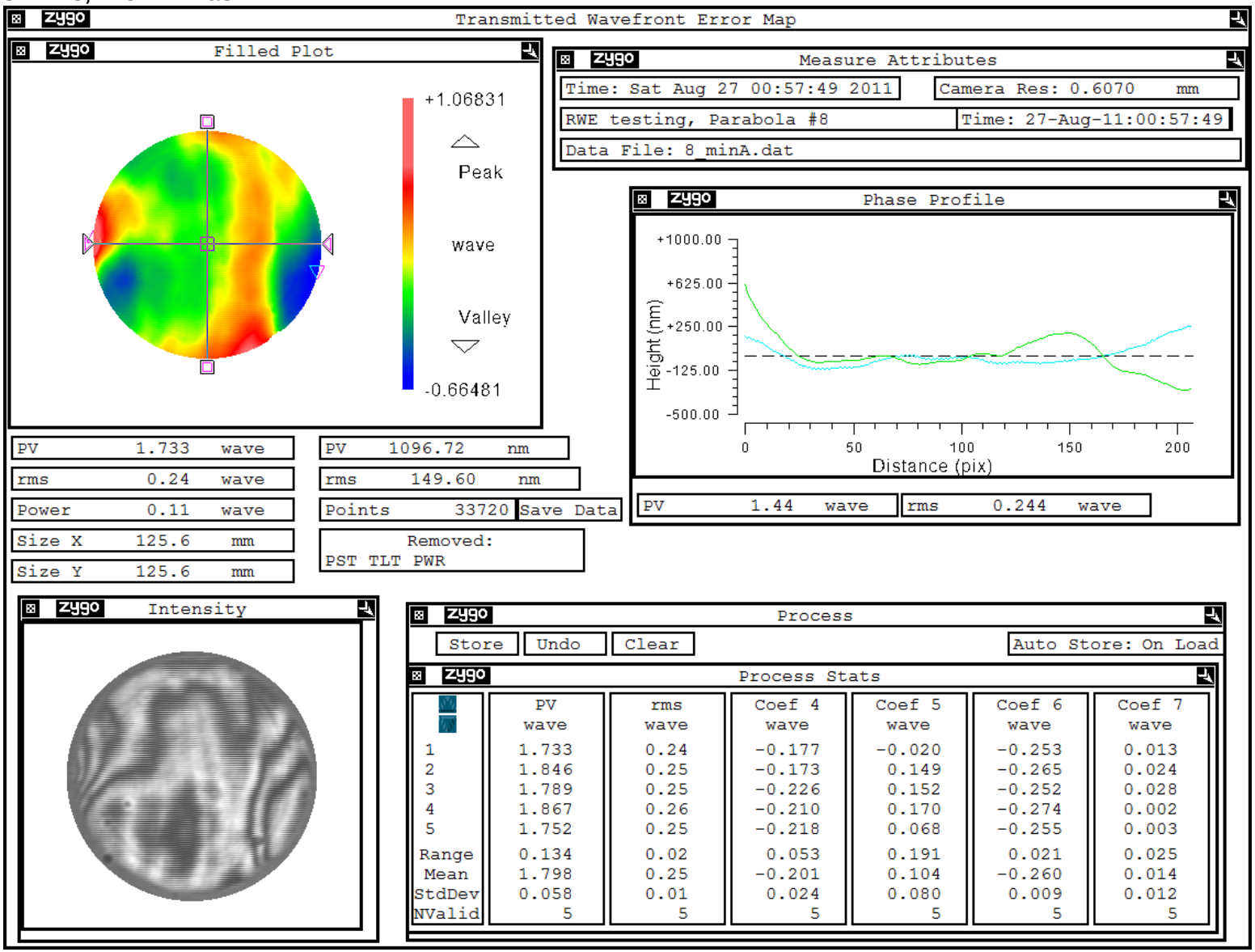
	PV wave	rms wave	Coef 4 wave	Coef 5 wave	Coef 6 wave	Coef 7 wave
1	0.556	0.13	-0.121	0.016	-0.078	0.067
2	0.715	0.13	-0.010	0.106	-0.052	0.052
3	0.674	0.12	-0.064	0.074	-0.053	0.060
4	0.589	0.13	-0.106	0.092	-0.078	0.059
5	0.681	0.12	-0.017	0.062	-0.056	0.063
Range	0.159	0.01	0.112	0.090	0.026	0.015
Mean	0.643	0.13	-0.064	0.070	-0.063	0.060
StdDev	0.067	0.00	0.051	0.035	0.013	0.006
NValid	5	5	5	5	5	5

OAP #7, 125mm mask



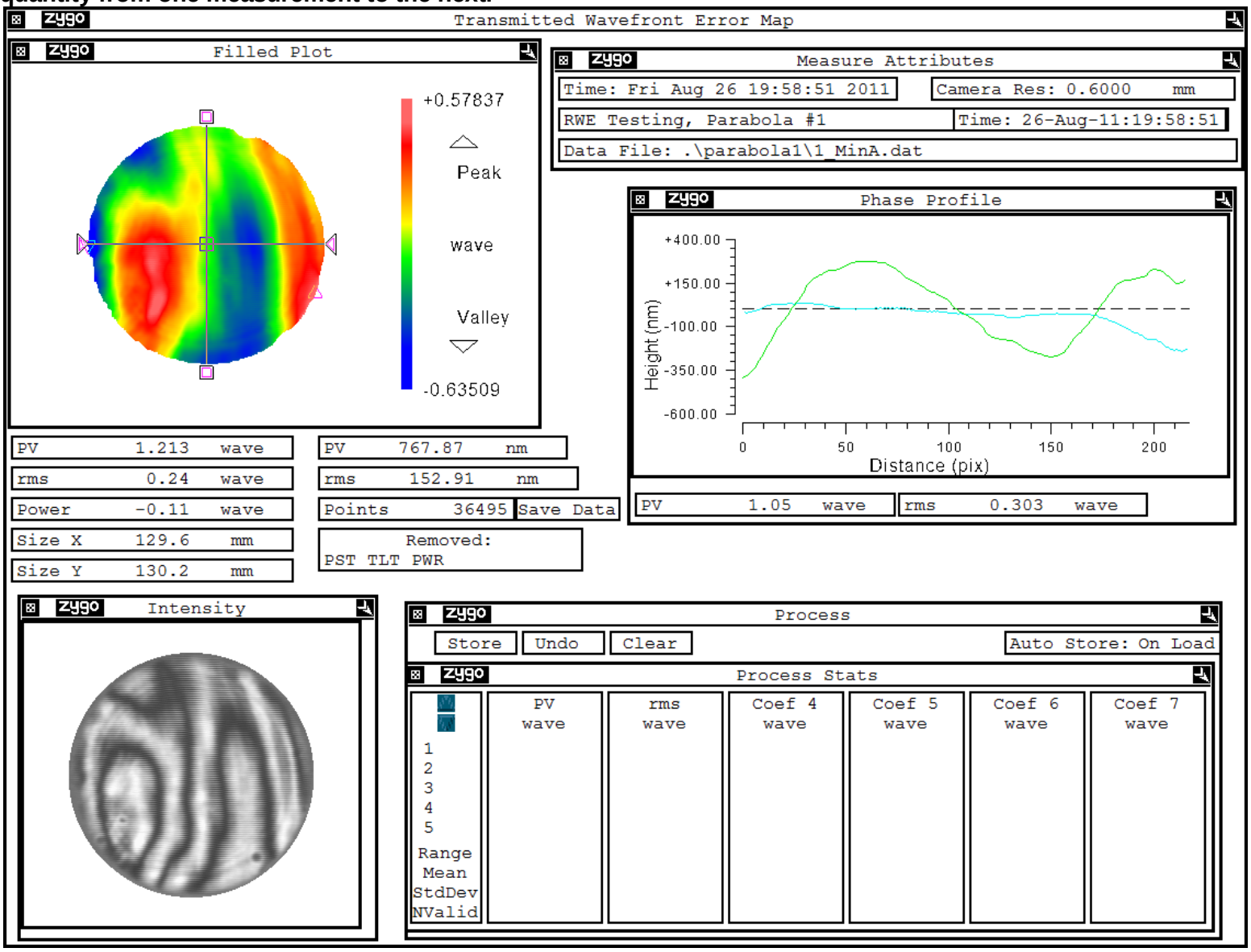
	PV wave	rms wave	Coef 4 wave	Coef 5 wave	Coef 6 wave	Coef 7 wave
1	1.029	0.17	0.015	-0.094	-0.004	-0.184
2	1.090	0.17	-0.024	-0.086	0.000	-0.195
3	1.117	0.18	-0.070	-0.125	-0.016	-0.212
4	1.101	0.17	-0.001	-0.044	0.003	-0.187
5	1.135	0.18	0.034	-0.151	-0.032	-0.204
Range	0.106	0.02	0.104	0.107	0.035	0.028
Mean	1.095	0.17	-0.009	-0.100	-0.010	-0.196
StdDev	0.040	0.01	0.040	0.041	0.014	0.012
NValid	5	5	5	5	5	5

OAP #8, 125mm mask

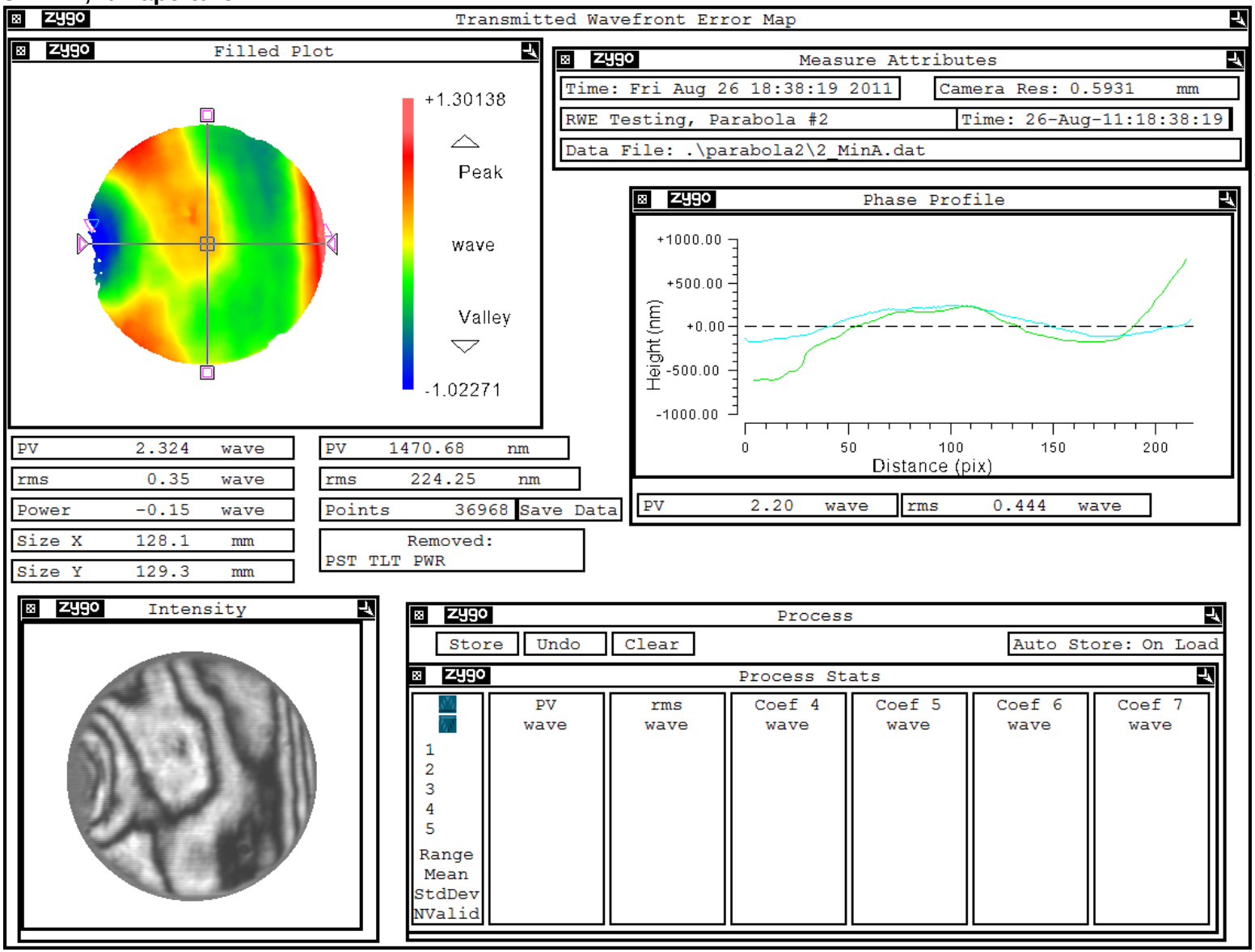


	PV wave	rms wave	Coef 4 wave	Coef 5 wave	Coef 6 wave	Coef 7 wave
1	1.733	0.24	-0.177	-0.020	-0.253	0.013
2	1.846	0.25	-0.173	0.149	-0.265	0.024
3	1.789	0.25	-0.226	0.152	-0.252	0.028
4	1.867	0.26	-0.210	0.170	-0.274	0.002
5	1.752	0.25	-0.218	0.068	-0.255	0.003
Range	0.134	0.02	0.053	0.191	0.021	0.025
Mean	1.798	0.25	-0.201	0.104	-0.260	0.014
StdDev	0.058	0.01	0.024	0.080	0.009	0.012
NValid	5	5	5	5	5	5

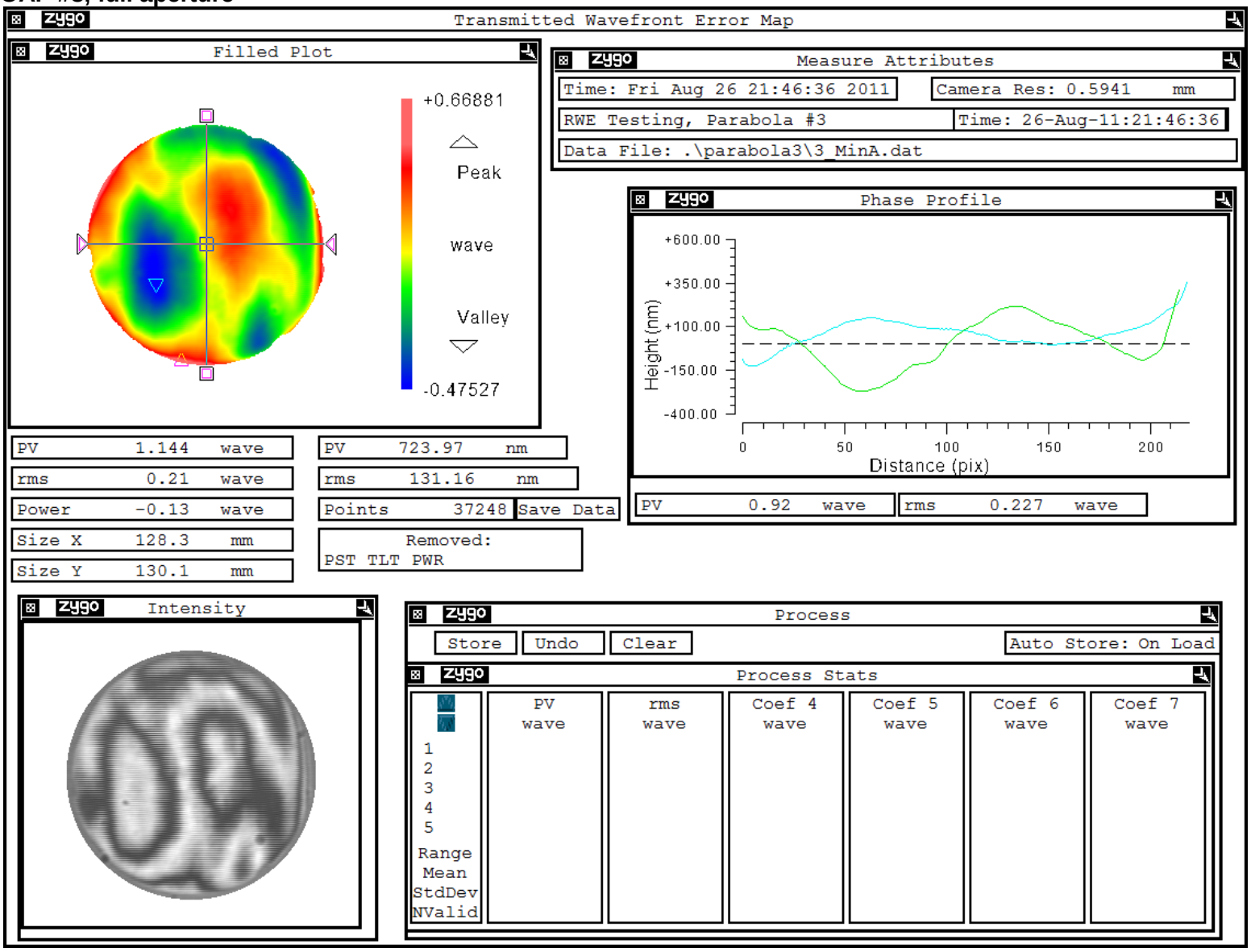
OAP #1, full aperture. Note: full aperture comparisons of tilt adjustments were not performed due to varying edge data quantity from one measurement to the next.



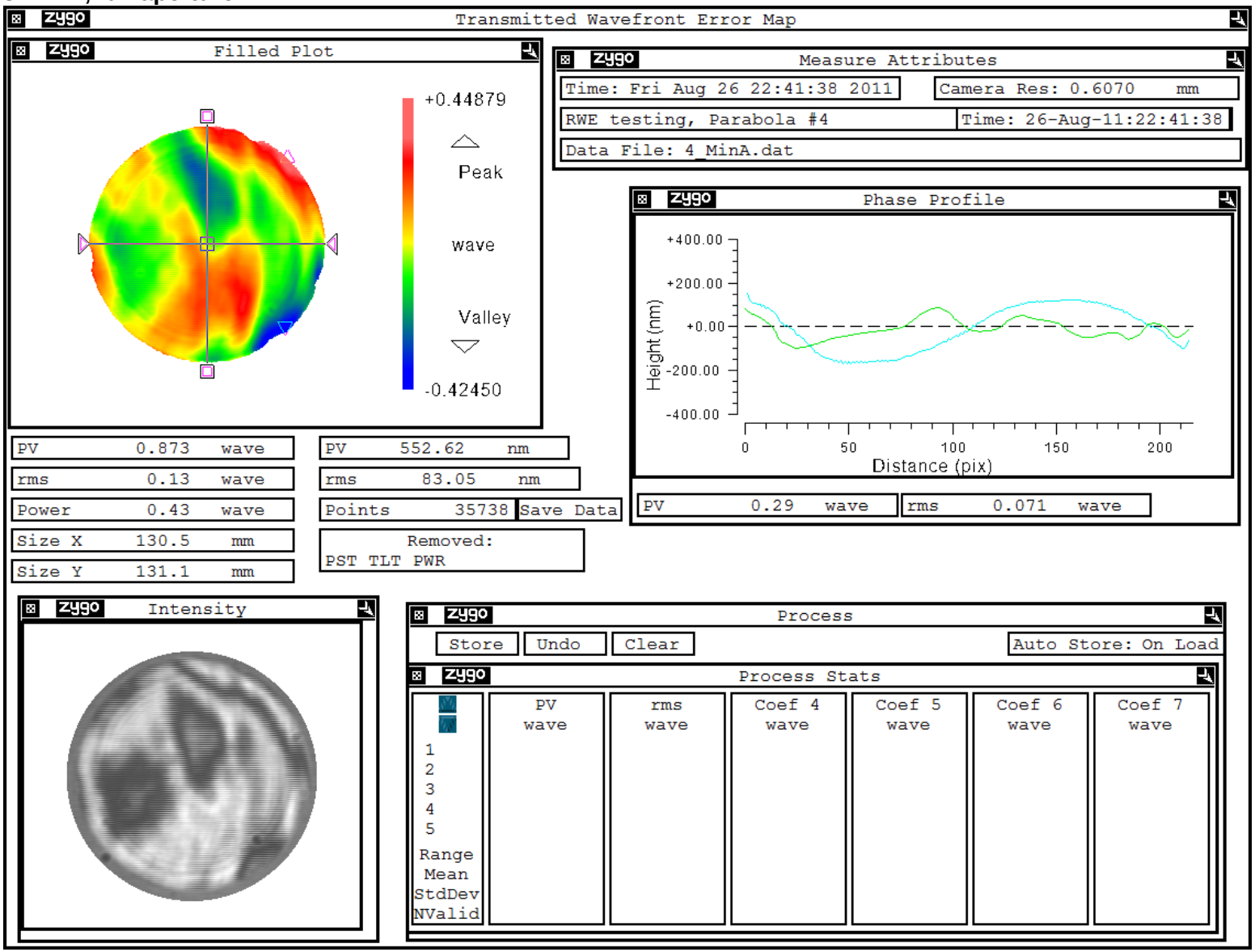
OAP #2, full aperture



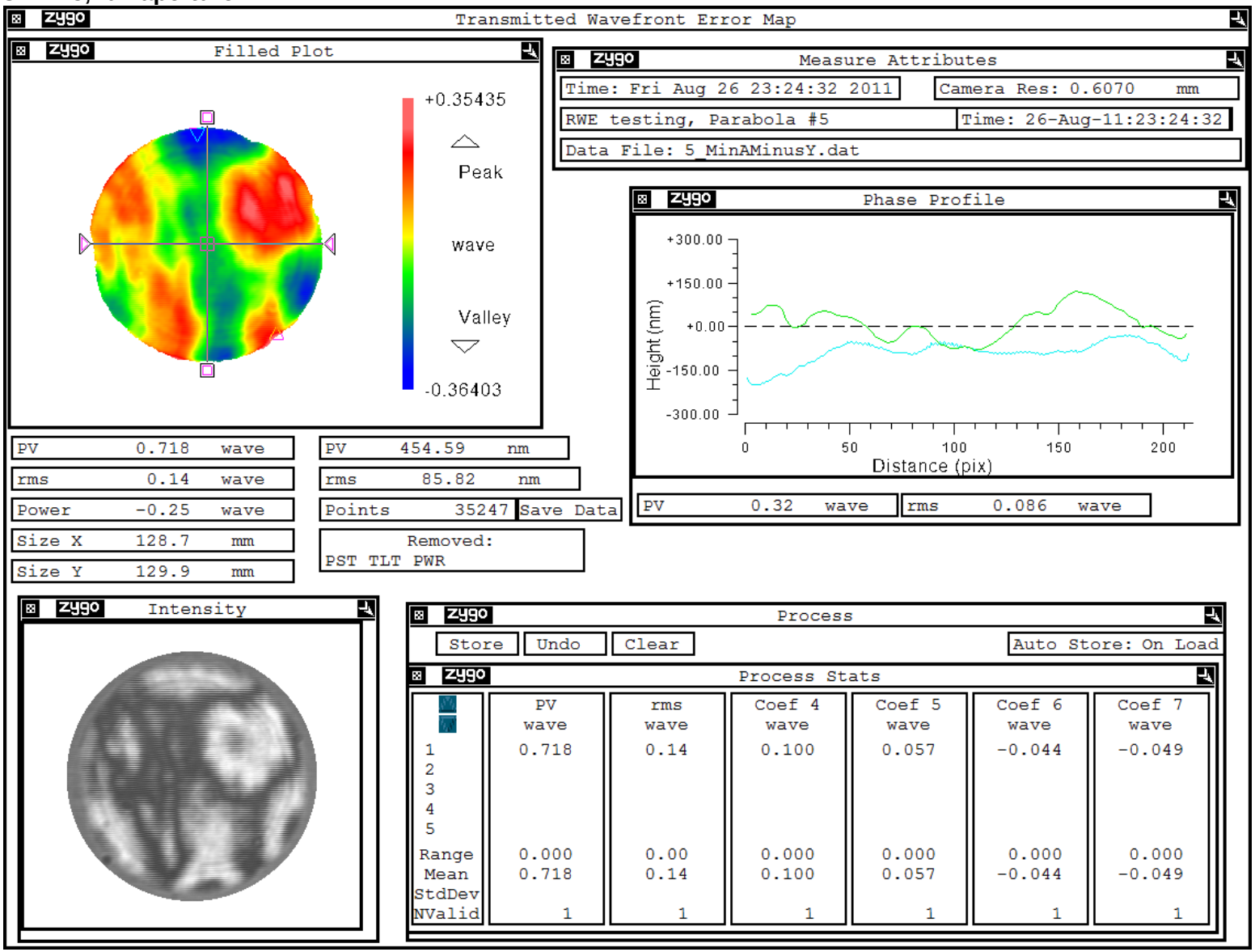
OAP #3, full aperture



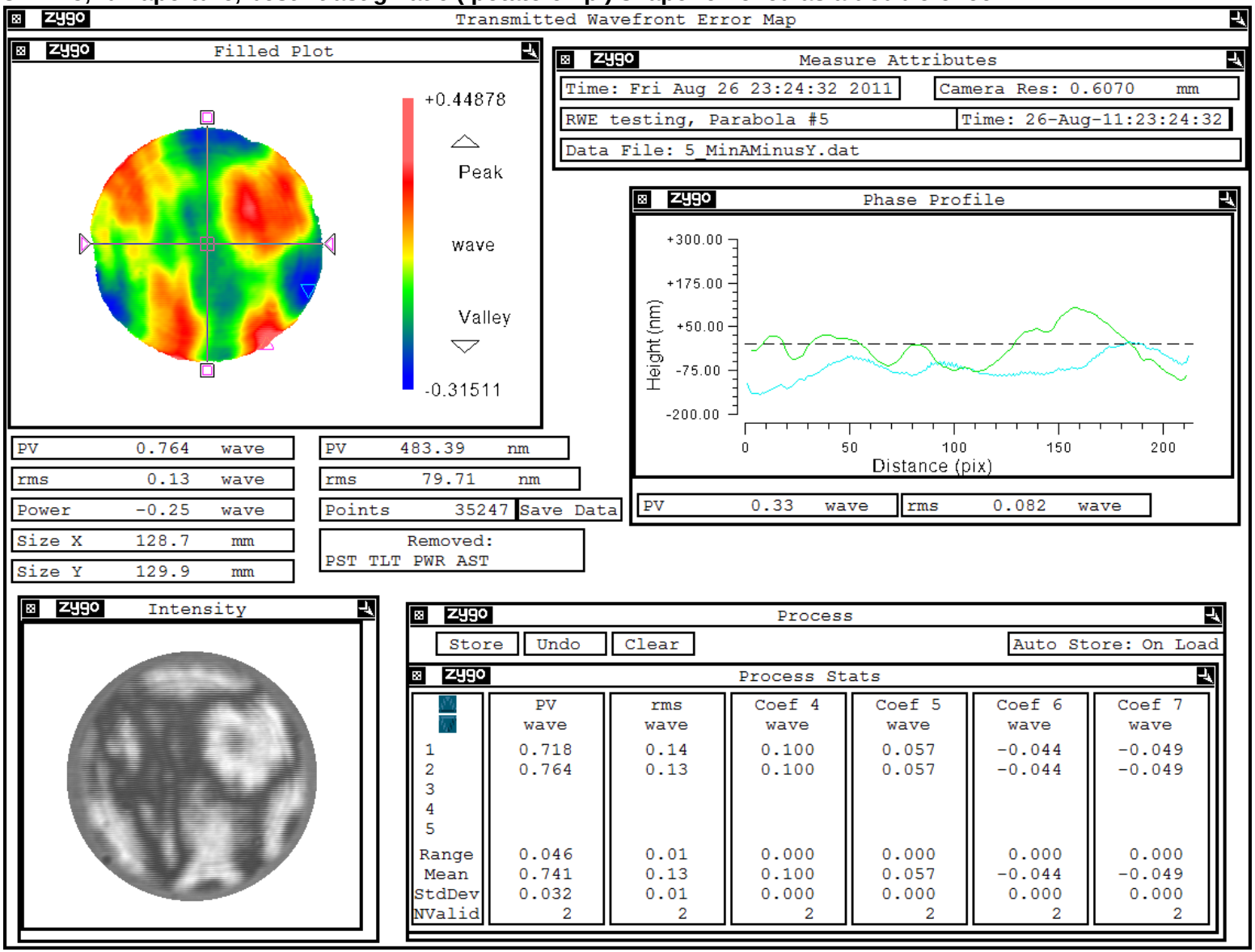
OAP #4, full aperture



OAP #5, full aperture

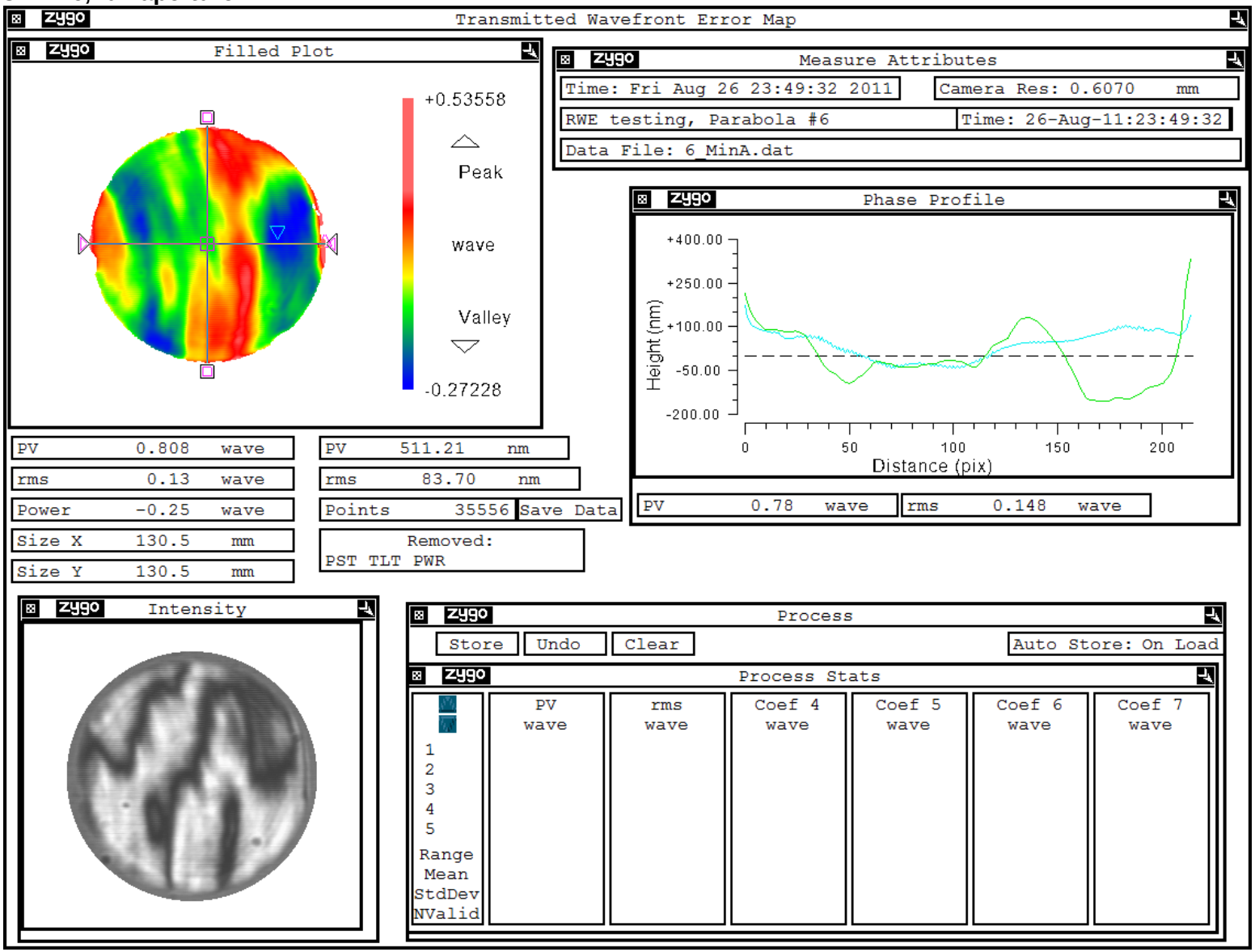


OAP #5, full aperture, best fit astigmatic ('potato chip') shape removed as a double-check.

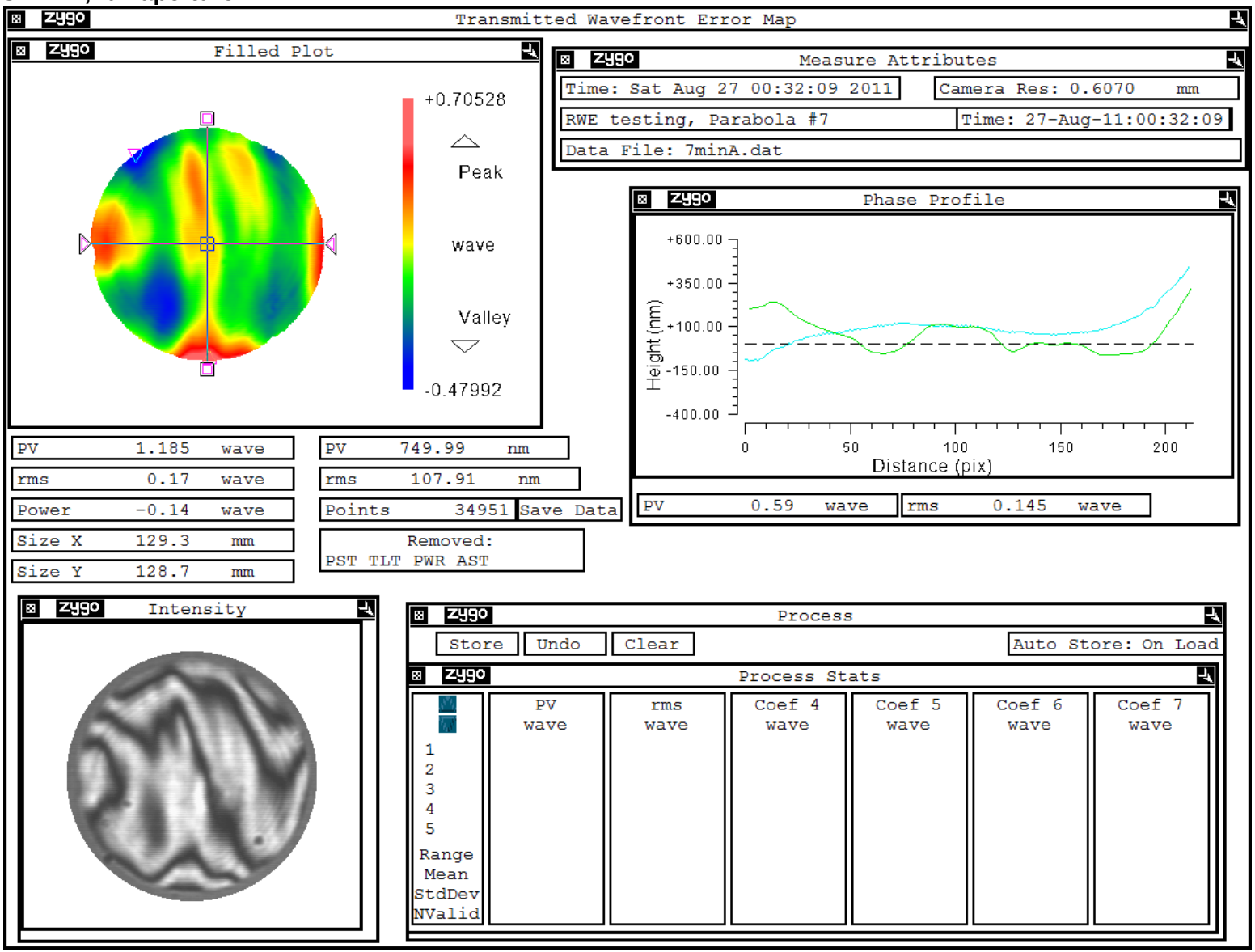


	PV wave	rms wave	Coef 4 wave	Coef 5 wave	Coef 6 wave	Coef 7 wave
1	0.718	0.14	0.100	0.057	-0.044	-0.049
2	0.764	0.13	0.100	0.057	-0.044	-0.049
3						
4						
5						
Range	0.046	0.01	0.000	0.000	0.000	0.000
Mean	0.741	0.13	0.100	0.057	-0.044	-0.049
StdDev	0.032	0.01	0.000	0.000	0.000	0.000
NValid	2	2	2	2	2	2

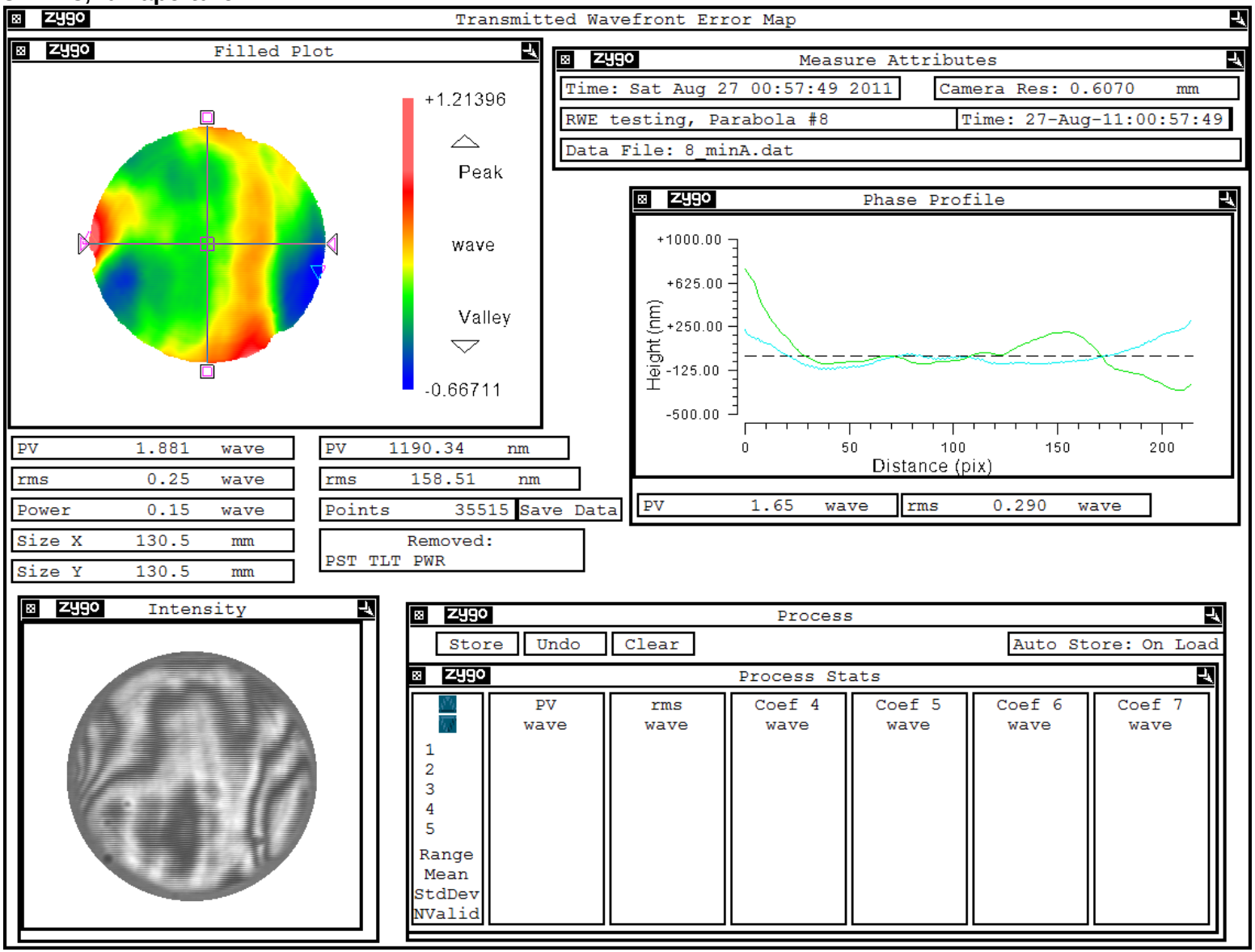
OAP #6, full aperture



OAP #7, full aperture



OAP #8, full aperture



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Company Profile: Absolute Metrology Services

Absolute Metrology Services was established in 2005 by Maria D. Robinson (Chief Metrologist). Maria has a B.S. in Applied Physics from the California Institute of Technology (1993) and a M.S. in Optical Sciences from the University of Arizona (1995). Maria shifted her career from optical design to interferometry in 1998, working for Zygo Corporation in customer education, applications engineering, and later moving into research and development projects where only the most precise metrology would be used.

AMS was originally created as a means to meet the demand for quality interferometry training while continuing to satisfy the need for high level R&D project testing. We have taught proper metrology methods to over one thousand students: at Zygo Corporation, the University of Rochester, ASPE, and optics manufacturers around the world. High-level metrology experience includes absolute testing and calibration of optics to nanometer levels. Maria states, "We enjoy the customer training just as much as the high-level metrology projects, and AMS given us the flexibility to do both. It has been very rewarding."

When the economic downturn in the fall of 2008 diminished the need for nanometer-level testing, AMS expanded its offerings to include general optical testing. Maria states, “We thought that we could provide basic metrology services at a more affordable price than the larger optical testing services, and that this would be well received.”

Our Mission Statement:

AMS strives to deliver quality training and testing at an exceptional value to our customers.

AMS has the advantage of nanometer-level training and testing experience without the large-company prices. We are able to do this because we are in constant contact with optics manufacturers who own interferometers and have used AMS’ training and testing services, and we do not hire separate salespeople, secretaries, or accountants for day-to-day business.

We are enjoying our sixth year as we continue to assist customers with their metrology challenges. Thank you for your business!