Test of a 600 mm mirror F3 at radius curvature center point	ALCOR SYSTEM
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The mirror to be tested is a 600 mm F3 parabolic mirror (k=-1). It was figured in 2007 by a company that is not to be disclosed in this report. The thickness is 57 mm, and is made of SUPRAX glass. It not coated.

Figure 1.

The company that did figure this mirror, checked it with a knife edge test (caustic test), and claimed to be a λ/19 PTV error mirror.

The mirror support must be very well designed to avoid any astigmatism due to glass elastic flexure by gravity. This was a something important to solve. It is held by 90° side supports.

The focal length is 1804 mm, and the place to perform the curvature radius test is located at twice this distance, i.e 3608mm. The longitudinal abberation due to the parabolic shape is 25 mm

The shack hartmann used is an ALCOR-SYSTEM 100x100 device, that has been put at 3.6 m from the mirror, with a 10µ led lit pinhole. A 50 mm collimator focal length has been installed. This is a center of curvature test, with an enormeous spherical abberation (12.55 waves @550 nm that is 6902 nm Z8 zernike).

Many optical stages are used under the shack hartmann, because the mirror has no degree of freedom motion. A Z stage axis was missing for this test.

Figure 2.

Results

Two analysis have been achieved:

1. Full diameter Ø 594 mm (actual measured diameter), up to chamfer.
2. Slightly stopped down to Ø 583 mm.

Full diameter Ø 594 mm

This is equivalent to Ø 1110 pixels at Shack Hartmann sensor focal plane. The shack Hartmann spot elongation amplified (tilt, defocus, coma removed) shows an issue at the edges of the mirror. This edge is folded, that is a current defect during mirror figuring.

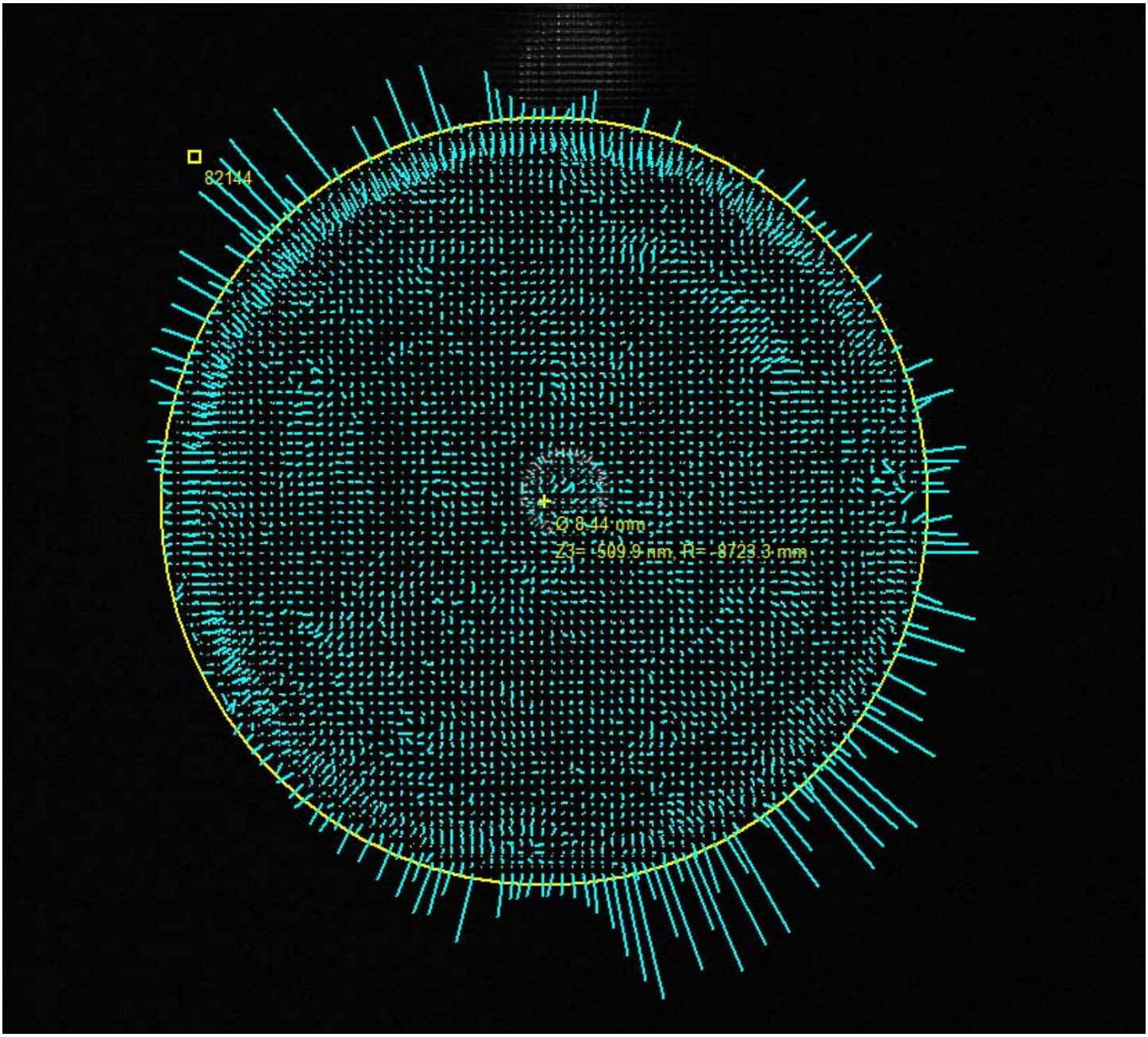

Figure 3.

The global RMS error, including astigmatism is 140 nm (λ/4 rms). **This is far from λ/18 PTV measured with knife test.**

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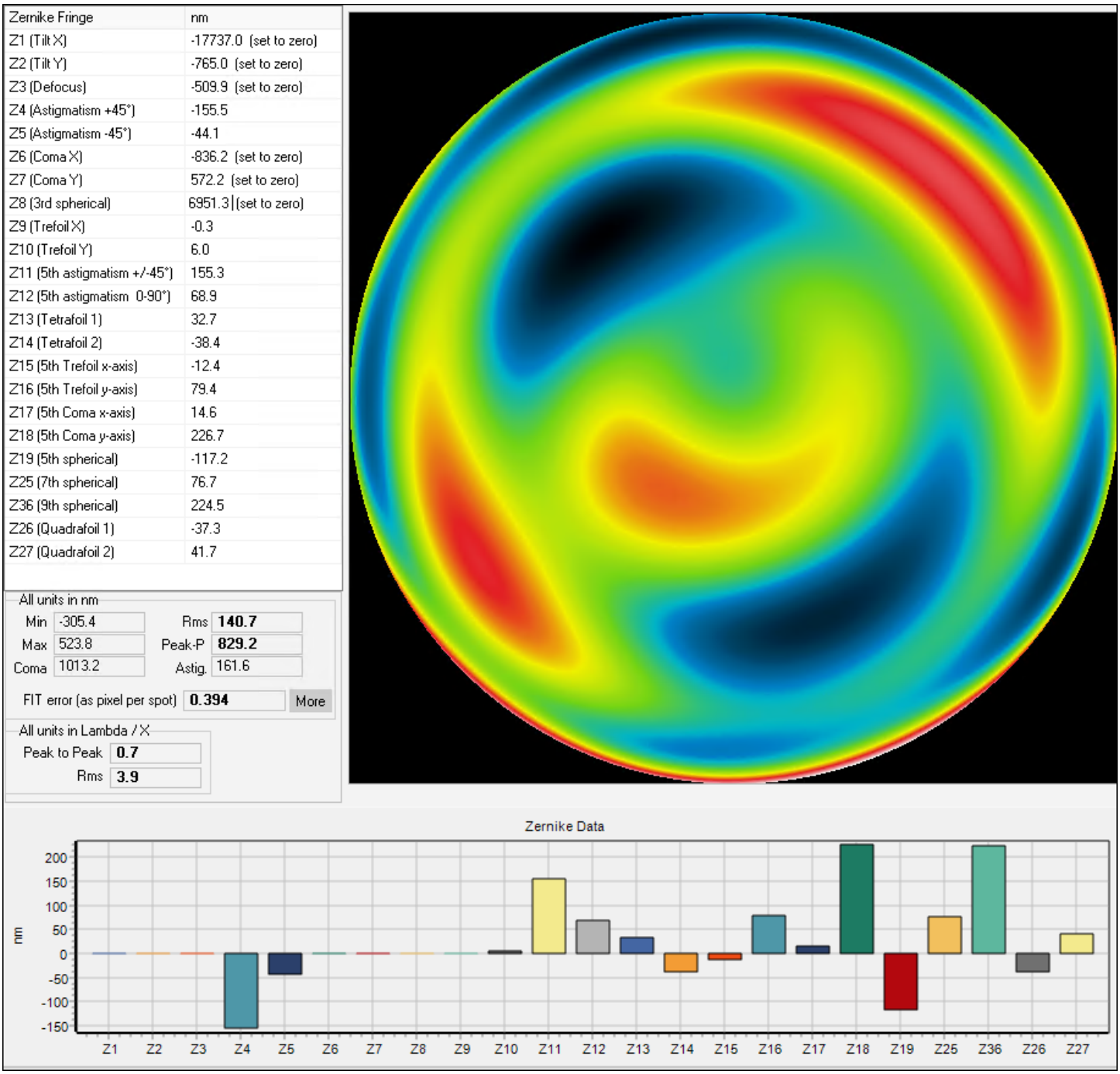

Figure 4.

Spherical aberration has been canceled out, and computed to be 6902 nm theoretically, it has been measured at 6951 nm by the Shack Hartmann, so the difference is only 50 nm that is quite good. Parabolic figuring was achieved properly and spherical aberration error is negligible for this mirror.

PSF reconstruction shows that Strehl ratio is only 8 % that is not an outstanding performance.

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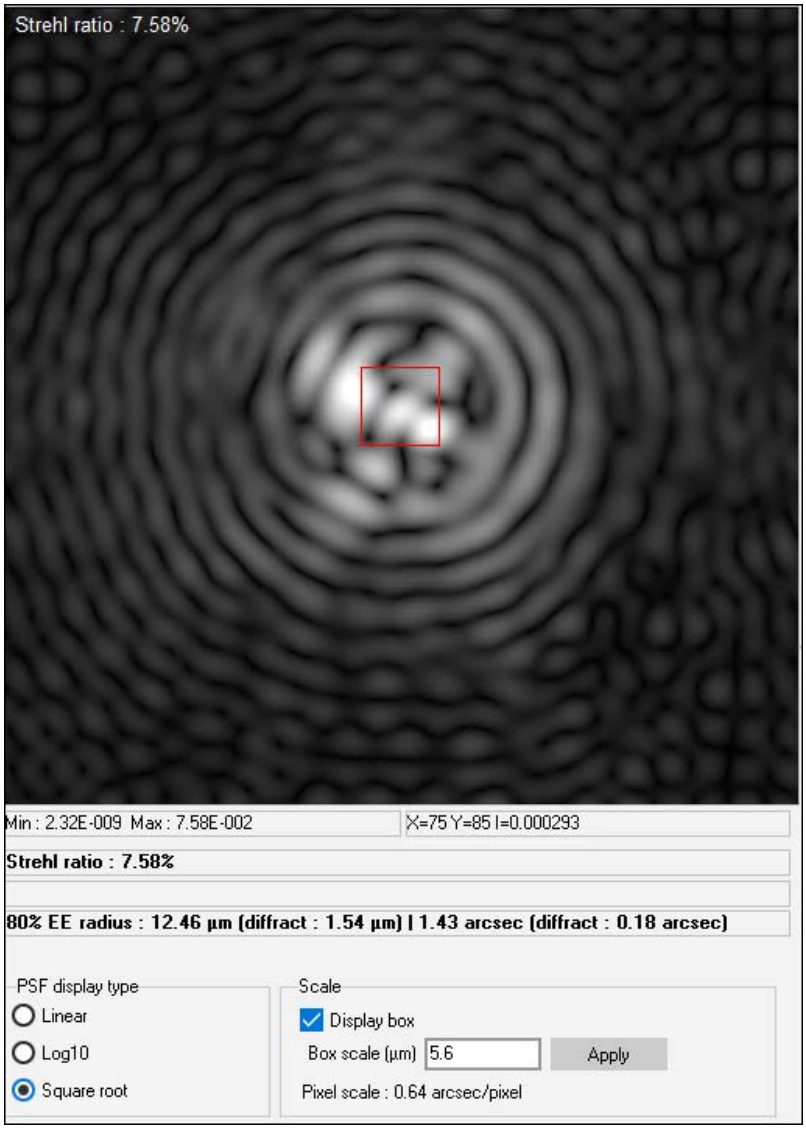

Figure 5.

Assuming that astigmatism can be due to vertical mirror holding method (it does not rotate with the mirror), it can be removed.

Performance is 124 nm rms. So astigmatism did not play a big role.

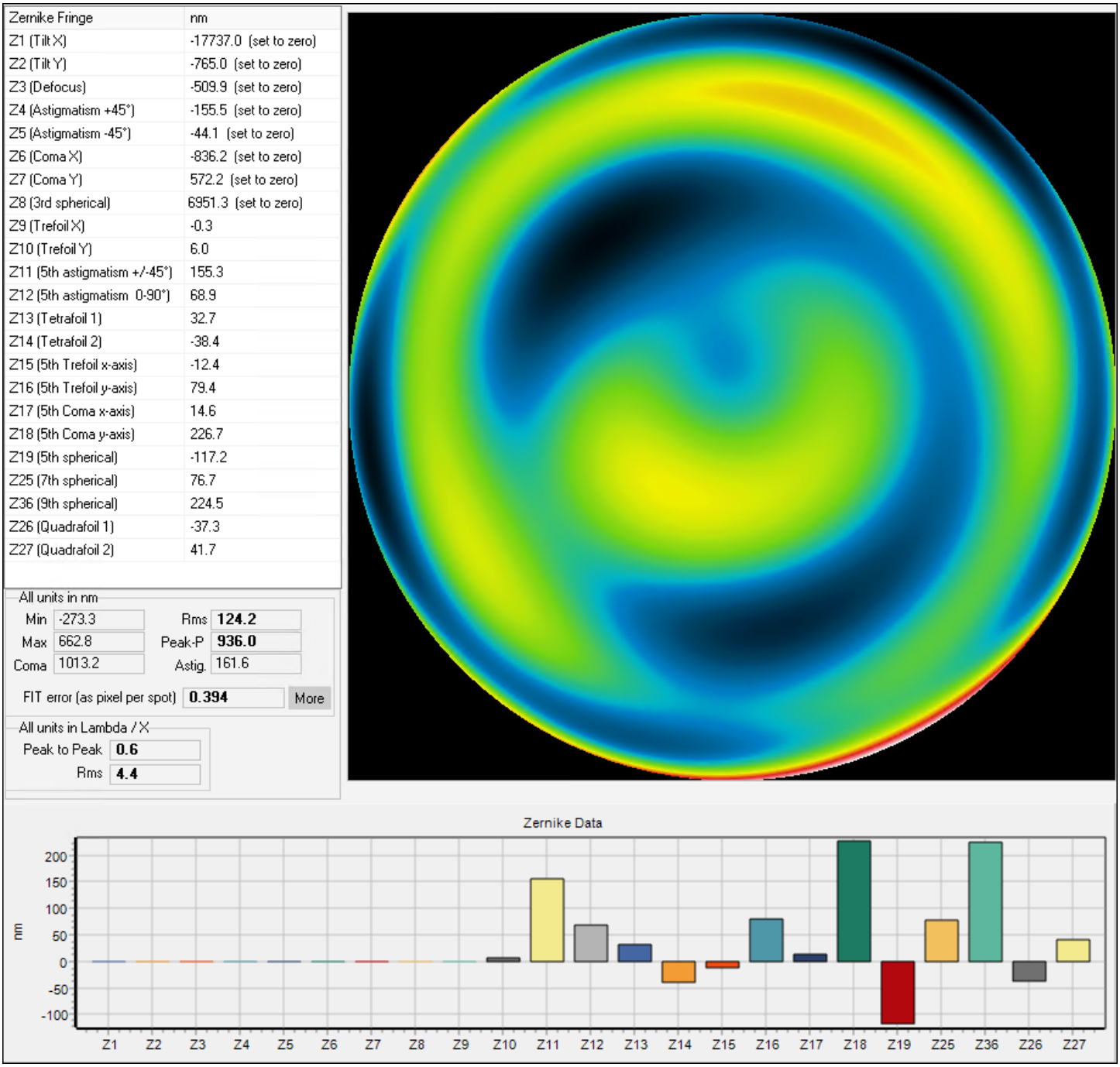

Figure 6.

If Zonal reconstruction is performed, figuring defects can be seen in a better way and more accurately. It requires a shack Hartmann with 60x60 spots at least.

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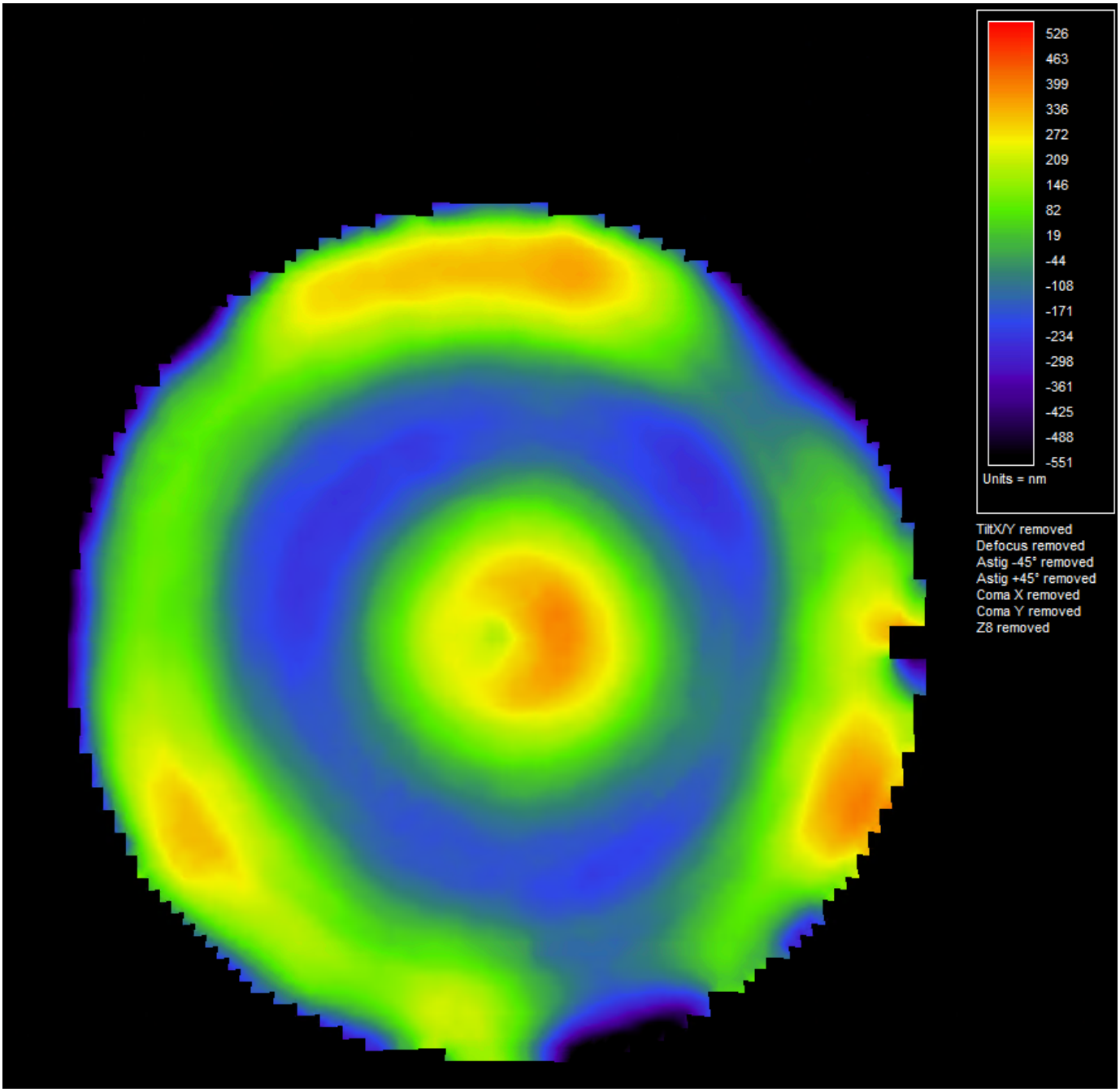

Figure 7.

Mirror stopped down to Ø 583 mm

At the Shack Hartmann level, this is very easy to carry out mirror diameter decrease. The analysis diameter has been reduced from Ø 1110 pixel down to Ø 1090 pixels

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This can be achieved on the physical mirror by a 5.5 mm thickness outer ring. Analysis shows that spot elongation error is reduced by far on the mirror edge.

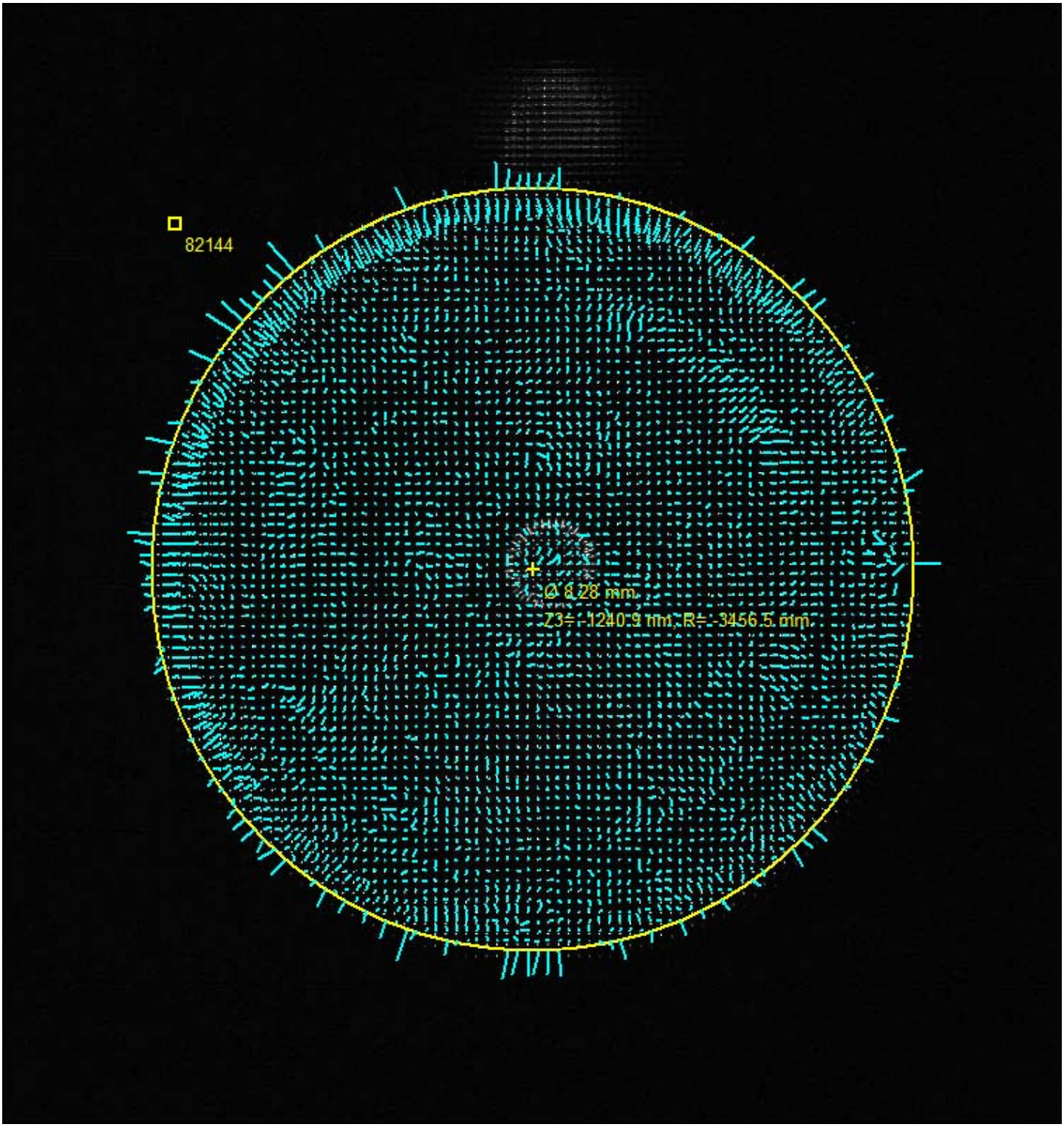

Figure 8.

The Modal Zernike analysis computes a 93 nm rms error (compared to 140 nm rms without the stop).

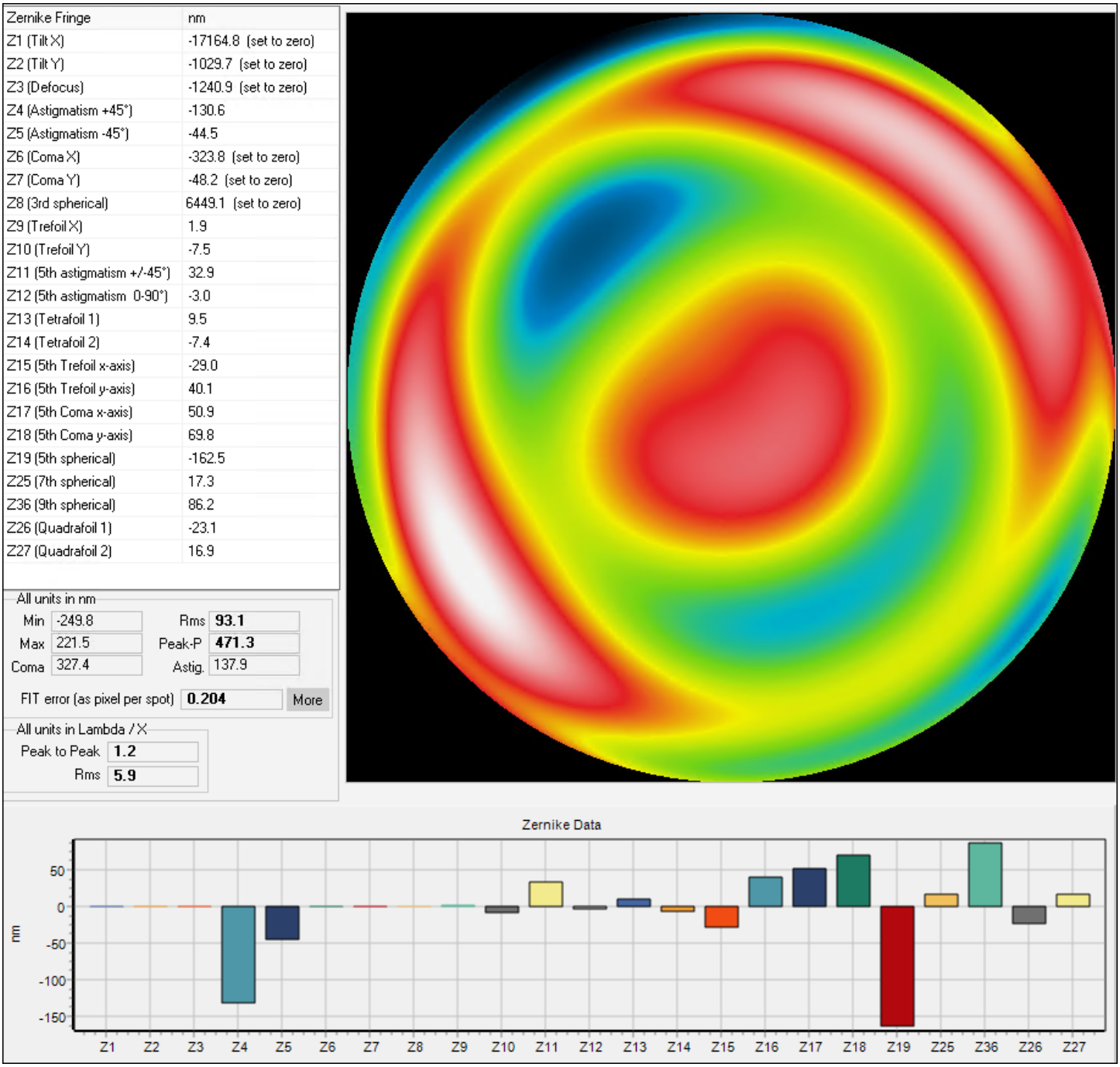

Figure 9.

Strehl ratio increases from 7.7 to 30.5%

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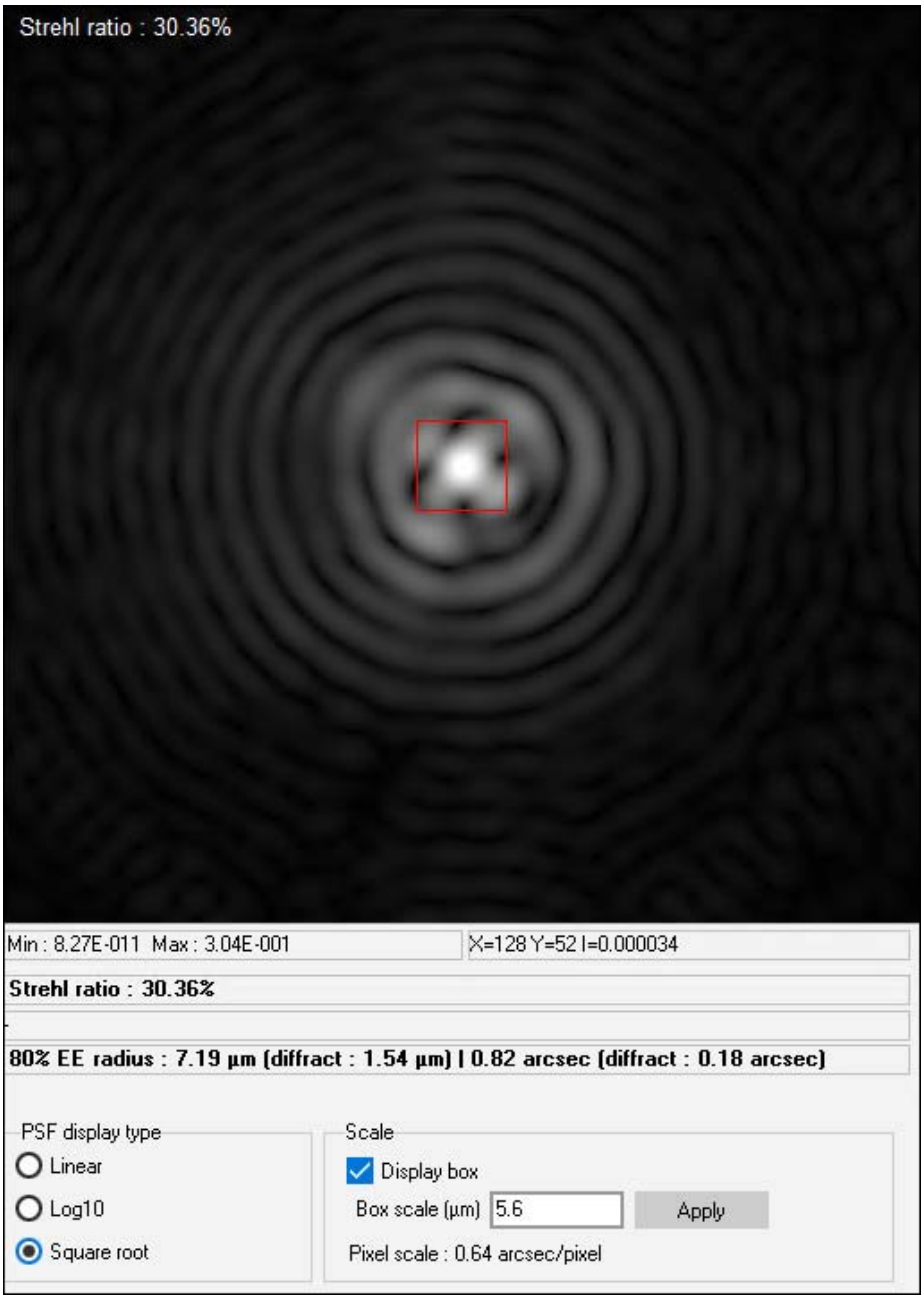

Figure 10.

Assuming an error of astigmatism due to the support (it turned out that astigmatism does not follow rotation when the mirror is rotated by 90°), the overall error is 74 nm rms ($\lambda/7.4$), that starts to be a good mirror.

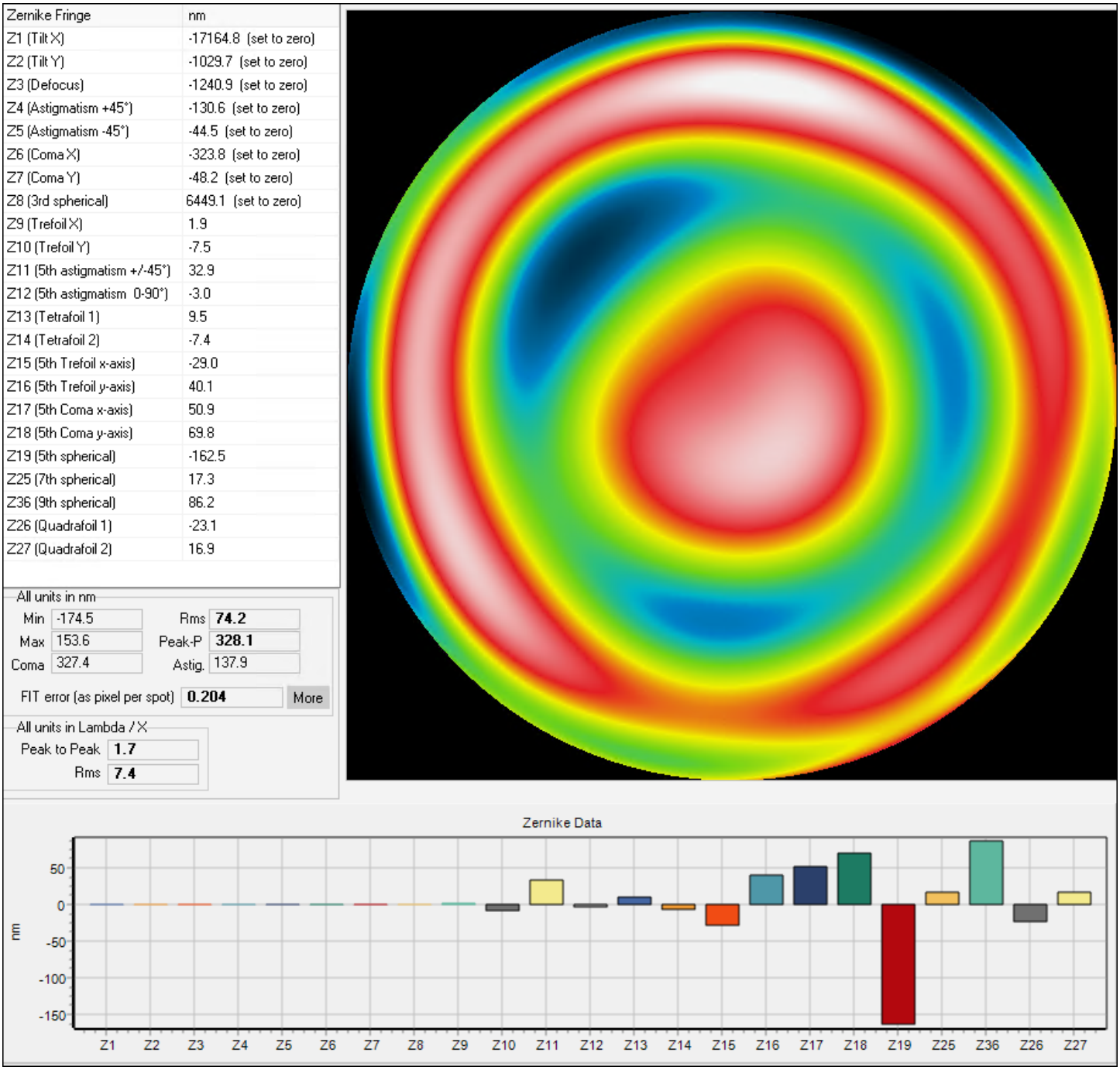

Figure 11.

Strehl ratio jumps to 47%, being an acceptable performance.

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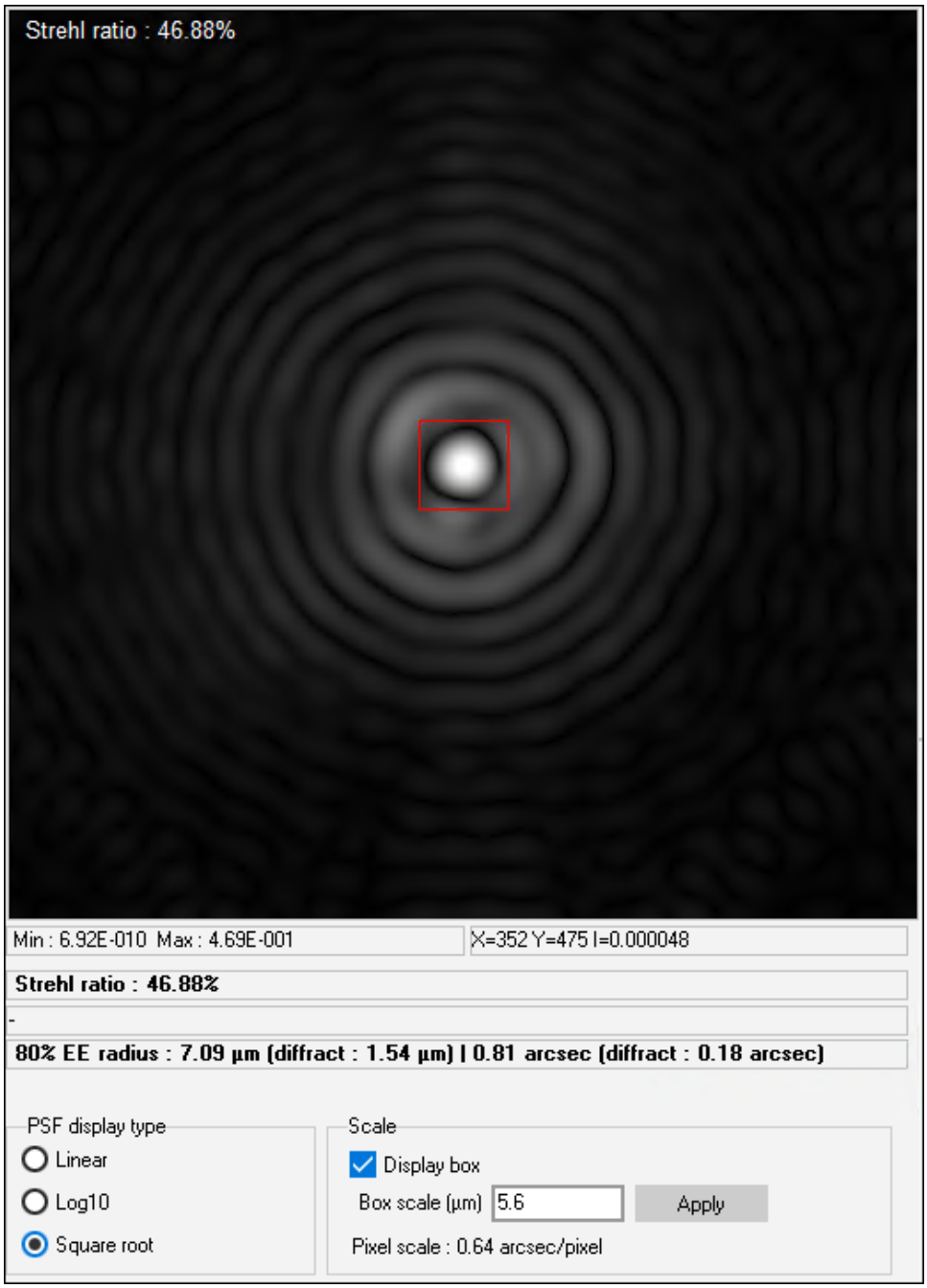

Figure 12.

Again, Zonal reconstruction shows better local defects. It shows a central bump that will be hidden by secondary mirror, or a camera located directly at the primary focus, and another error ring at the edge of the mirror.

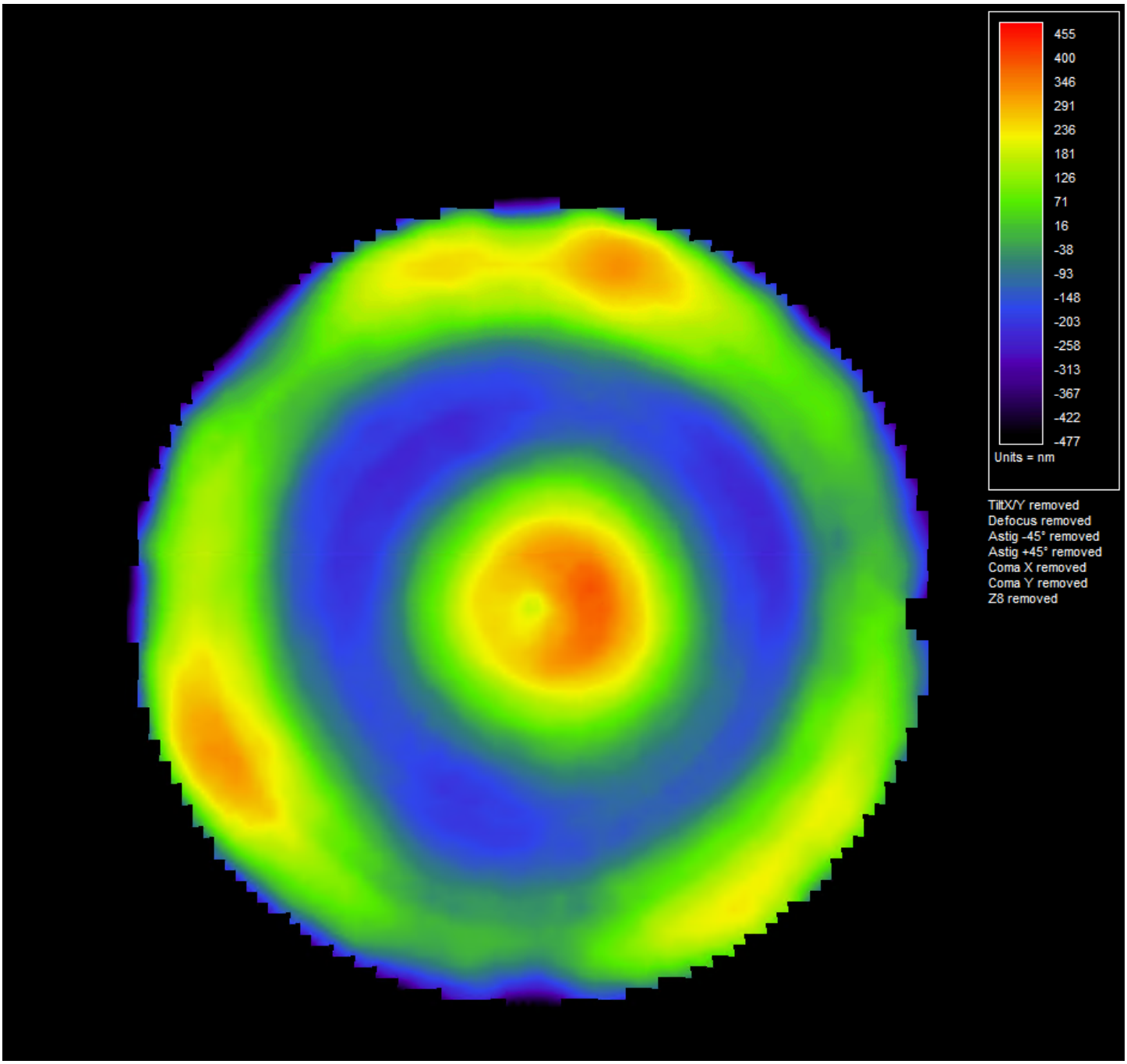

Figure 13.

If only high frequencies defaults are considered (all Zernike are removed up to Z35), the Shack Hartmann can reveal many rings from the figuring process. The RMS error of these rings is around 30 nm.

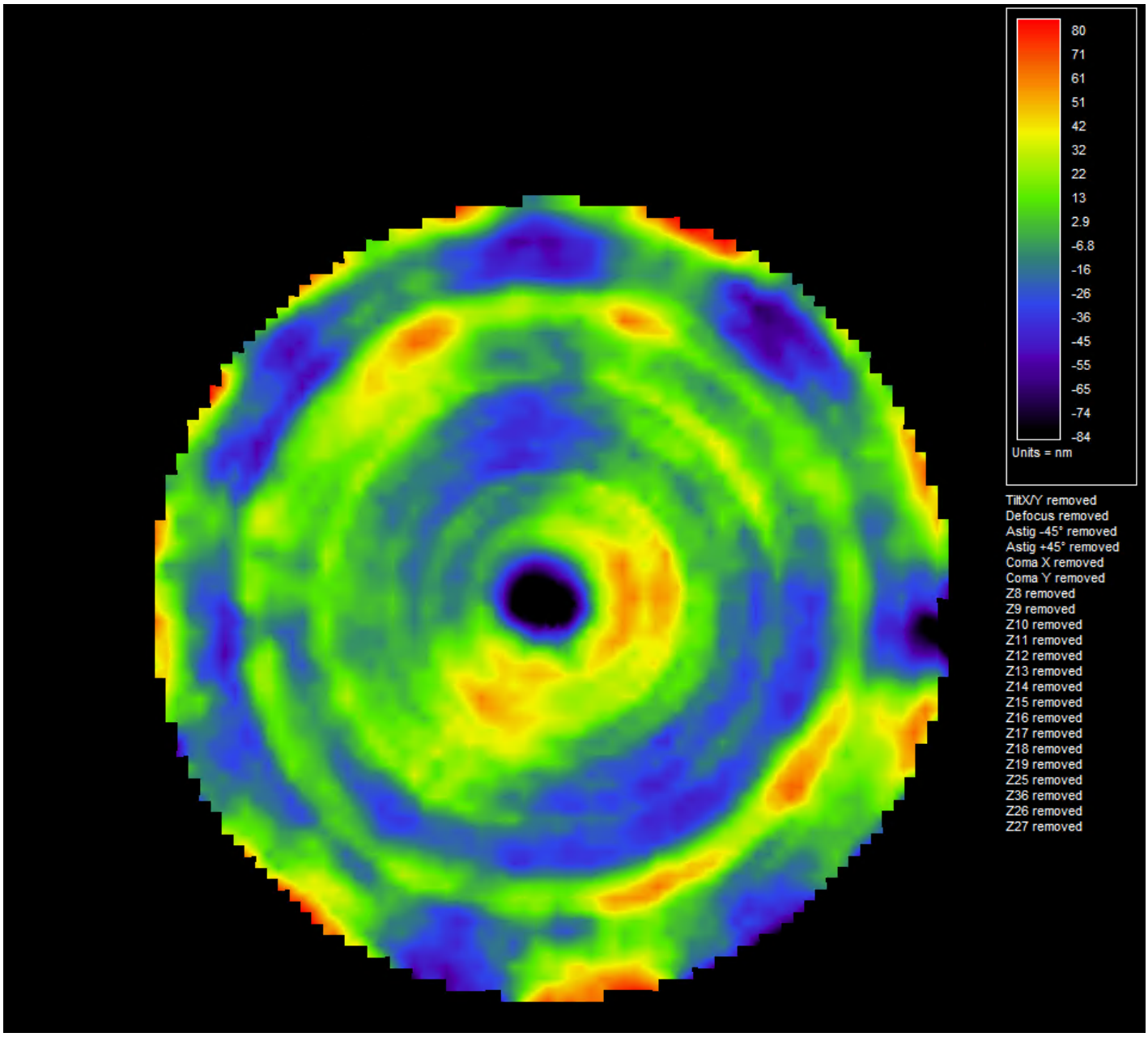

Figure 14.

Is was also noticed with a knife test with an artificial star located at 4 km, but this test does not give any quantitative data of the defects.

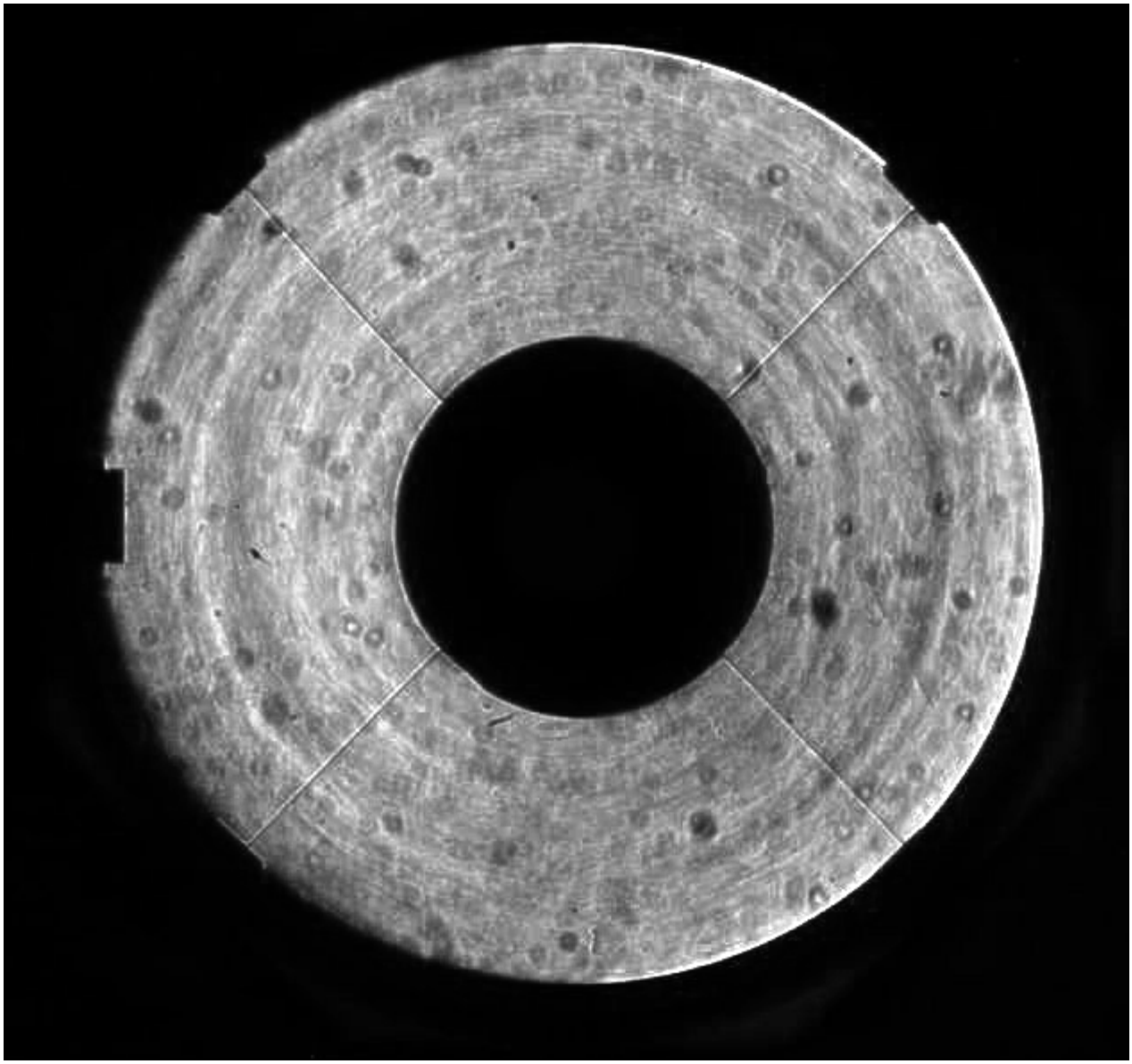

Figure 15.

Conclusions

This reports prove that direct test at curvature radius center of a mirror can be performed with ALCOR SYSTEM Shack Hartmann, and that a very costly flat mirror can be avoided, despite 12.55 λ of spherical aberration (Z8, or Z9 of Zemax software). The λ/19 PTV announced by the company that figured the mirror is not realist, this is because of lack of measurement points (classical issue with the knife test).

The mirror test is not so good at full aperture, but when stopped down a bit its performance increases dramatically.

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