appendix 7

Radius of sphere before starting aspherisation

Document of E-value measurement

subject: **M1 Kottamia**

date: 16.11.95

angle: $\Theta = 6^0\ 11'\ 17''$

base: D = 1921,1 mm

sag with respect to base D: $sag = D^2/(8R^*) = 25{,}23$ mm
mit $R^* = 18285$ mm

distance between theodolit and centre of curvature of sphere:
x= 493,6 mm

distance between theodolit and height of mirror edge
$A = D/2 * 1/\tan(\Theta/2) = 17770{,}35$ mm

from this follows the radius of curvature:

$R = A + sag + x$

$R = 17770{,}35\ mm + 25{,}23\ mm + 493{,}6\ mm$

$R = 18289{,}2\ mm$

tolerance: ±2 mm

appendix 11

Influence of E-value tolerances

Math-F 71/95-12-19
by
Dr.Henneberg

Phase evaluation

For phase evaluation we applied our DIRECT 100 (interferometer) software. The DIRECT 100 evaluates the phase map in video real time (25 times per second). For each phase calculation only one frame (interferogram) has to be taken. In combination with the very short exposure time DIRECT100 is very insensitive to vibration. On the other hand it allows to average a large number of interferograms with a rate of 25 per second in order to reduce effects of air turbulences as well as residual mathematical errors without any artificial smoothing of the wavefront. Applying the test we got very long light pathes, so single frame evaluation (with the short exposure time) and real time averaging was very helpful to obtain the results with the required accuracy.

Test procedure

In order to separate the mirror inherent residual errors from non-rotationally symmetric errors of the test setup (including test tower), the mirror was measured in 6 different rotational positions relative to the interferometrical setup. The phase maps have been rotated back to the original position of the mirror and have been averaged. This gives us the information about the mirror inherent error.

5. Testing the E-value

To fabricate the KOTTAMIA primary two points have been of highest importance. The null corrector has to produce the predicted aspherical wavefront and the correct distance between the vertex of the null corrector and the KOTTAMIA primary has to be guaranteed within a range relatively small compared to the absolute distance (E-value).

We have a fixed reference point at our vibration isolated table in the test tower where the interferometrical setup was located. Using this reference point for situating a theodolit we

K O T T A M I A .

2 m Telescope

Influence of the "E"-value-tolerance on the position of the telescope focus.

1. The manufacturing procedures for the telescope mirrors are controlled by "Null-lenses".

The test set-up then demands certain design values for the distance between the "Null-lens" and the vertex of the mirrors under test.
This design values are called "E-values".

Deviations from the design values are called "E-value-tolerances".

"E-value-tolerances" ΔE in the test set-up lead to deviations from the design values of the manufactured mirrors even if the polishing procedure ends up with straight lines in the interferograms.

Especially the curvature of the mirrors will differ from the design values.

2. If the mirrors manufactured with "E-value-tolerances" are inserted into the telescope certain parameters of the telescope will deviate from the design values, of course.

3. We have to distinguish between the three following alternitives:

3a. the mirrors manufactured with "E-value tolerances" are installed in the telescope with the design value for the mirror separation e.
Then the following changes with respect to the design values in the telescope will occur:

Prüfschein
Test Certificate
Certificat de Contrôle

ZEISS

(1)

Carl Zeiss
D-73446 Oberkochen

Prof. Hanafy Deebes
National Research Institute of
Astronomy and Geophysics
El Marsad Street
Helwan
CAIRO/Egypt

Qualitätssicherung
Quality Assurance
Assurance de Qualité

No.: C 2001/97/Nau

1,88 m Primary Mirror M 1, Kottamia

Contract-No.: CZ/J/Kott - contract AG 13-95702

The mirror was tested according to the conditions of customer's order and to Carl Zeiss specifications.

The mirror has passed all technical tests and meets all requirements as spelled out in the test plan.

Quality assurance and quality tests/inspections comply with EN ISO 9001. The quality system of Carl Zeiss is certified by the TÜV-Zertifizierungsgemeinschaft e. V., Certificate Registration No. 09100 3071.

The mirror was released for delivery.

Carl Zeiss Qualitätssicherung

Datum/Date:

28.04.1997

measured the angle between two opposite points at the mirrors shape with an accuracy of better than 1arcsec.
Additionally we measured the distance between these two points with an accuracy of better than 0.2 mm and calculated the height over vertex using the parabolic equation.
If we know all these values we determined the E-value with an accuracy of better than 2mm.

6. Optical parameter calculation

Based upon the measured E-Value and on the measured wavefront we determined the optical parameters of the KOTTAMIA primary.
Multiplying the measured wavefront by a factor of 0.5 we obtained the surface error.

In appendix **1** the results concerning **the surface error** of the KOTTAMIA primary after the last fabrication step are attached.

The **encircled energy** concentration of the KOTTAMIA primary was calculated based upon the measured wavefront. A lateral resolution of 34 points over the diameter was applied for this calculation. The detailed result is shown in appendix **2**.

The **focal length** of the primary was calculated using the measured E-value and using the mathematical model of the test setup. It is more described in appendix **3**.
If the correct design and assembly of the **null corrector** is indispensable for a correct mirror fabrication, the complete verification of the null corrector is documented in appendix **4**.
Although it is not of interest for the final state of the KOTTAMIA primary, the surface topography, the encircled energy concentration and the radius of curvature of the sphere - before starting of aspherisation - was documented in appendix **5**,**6**,**7**.

$$\Delta g(mm) = 7.0 * \Delta E1(mm) - 3.59 * \Delta E2(mm)$$

$$\Delta W(lambda) = -0.014 * \Delta E1(mm) + 0.0076 * \Delta E2(mm)$$

with the meaning of the symbols:

$\Delta g(mm)$: deviation from the design-focus position in mm;

$\Delta W(lambda)$: spherical aberration in units of 632.8 nm;

$\Delta E1$, $\Delta E2$: "E-value tolerances" for mirrors M1 and M2.

3b. the mirrors manufactured with "E-value tolerances" are installed in the telescope such that the design value g for the focus position is reached. Then the following changes with respect to the design values in the telescope will occur:

$$\Delta e(mm) = 0.467 * \Delta E1(mm) - 0.248 * \Delta E2(mm)$$

$$\Delta W(lambda) = -0.0039 * \Delta E1(mm) + 0.0024 * \Delta E2(mm)$$

with the meaning:

$\Delta e(mm)$: deviation from the design value e for the mirror separation in the telescope.

$\Delta W(lambda)$: defined as above;

$\Delta E1$, $\Delta E2$: defined as above.

3c. the mirrors manufactured with "E-value tolerances" are installed in the telescope such that the image in the focus is free from spherical aberration. Then the following changes with respect to the design values in the telescope will occur:

7. Project-team at ZEISS in Oberkochen

from left to right:
Erdmann, Schillke, Knohl, Schwarz, Dr. Börret

$$\Delta e(mm) = 0.657 * \Delta E1(mm) - 0.366 * \Delta E2(mm)$$

$$\Delta g(mm) = -2.77 * \Delta E1(mm) + 1.83 * \Delta E2(mm)$$

with the meaning of the symbols:

$\Delta g(mm)$: deviation from the design-focus position in mm;
$\Delta e(mm)$: deviation from the design value of the mirror separation in the telescpoe;
$\Delta E1$, $\Delta E2$: "E-value tolerances" for mirrors M1 and M2.

4. Examples:
==========

Let us assume that the mirrors are manufactured with toleances:

$\Delta E1 = 10.$ mm and $\Delta E2 = 5.$ mm

Then we have the following possible alternatives in the telescope:

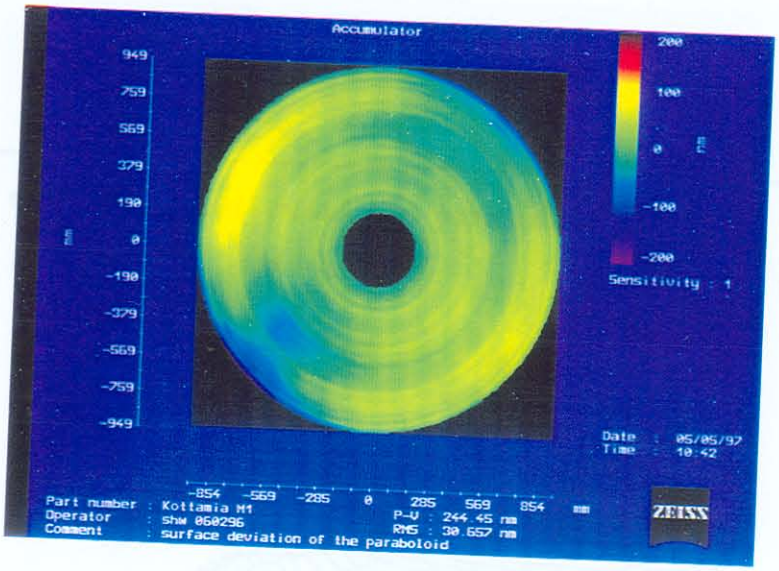
4a. mirror separation with design value e = 6993.8 mm;
consequence:
$\Delta g = 52.$ mm; $\Delta W = 0.1$ lambda (632.8 nm)

4b. mirror separation e = 6994.23 mm ($\Delta e = 3.43$ mm);
consequence:
$\Delta g = 0.$ mm $\Delta W = 0.03$ lambda (632.8 nm)

4c. mirror separation e = 6998.54 mm ($\Delta e = 4.74$ mm);
consequence:
$\Delta g = -18.6$ mm; $\Delta W = 0.$

appendix 1/1

surface topography of the KOTTAMIA primary



Zernike - coefficients
after removing of constant, tilt, focus and coma

Aberration	X-coefficient [nm]	Y-coefficient [nm]
constant	---	
tilt	---	---
focus	---	
astigmatism	13	-56
coma	---	---
spherical aberr. h^4	- 7	
triangular coma	- 7	14
astigmatism h^4	- 2	3
coma h^5	12	- 1
spherical aberr. h^6	-20	
4-wave error	24	- 7

P-V : 244 nm; RMS : 30.7nm surface

5. If, in addition, we assume tolerances of:

$\Delta E1 = 10.\ mm$ and $\Delta E2 = -5.\ mm$

one would get a focus position according to the design value if one chooses a mirror separation of:

$e = 6999.7\ mm$ ($\Delta e = 5.91\ mm$)

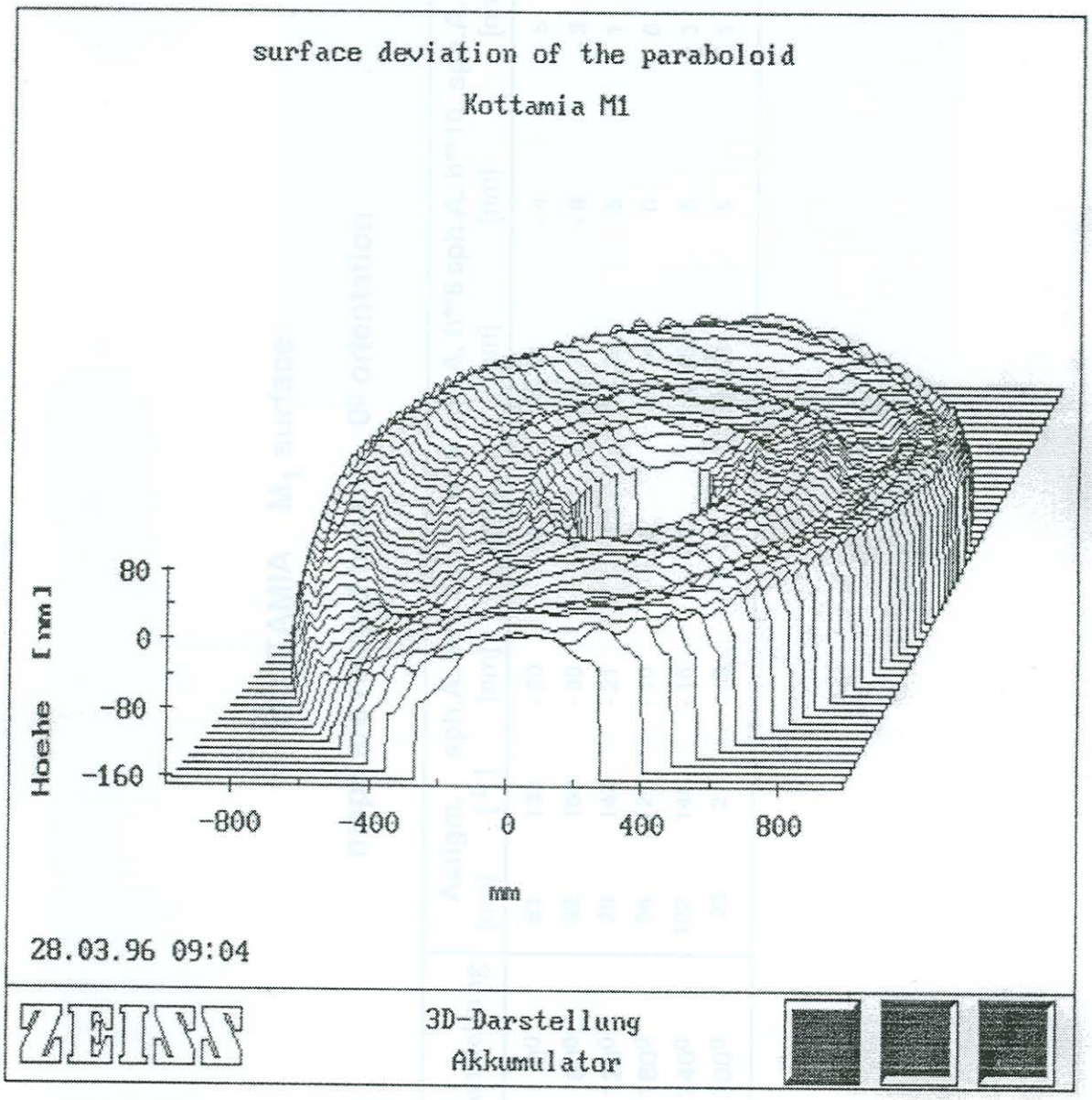
with a spherical aberration of:

$\Delta W = 0.05$ lambda (632.8 nm).

That means in this case:
the specified focus position behind the mirror M1 could be maintained if the mirror separation will be increased by 5.9 mm.
The introduced spherical aberration can be neglected completely.

appendix 1/2

surface topography of the KOTTAMIA primary



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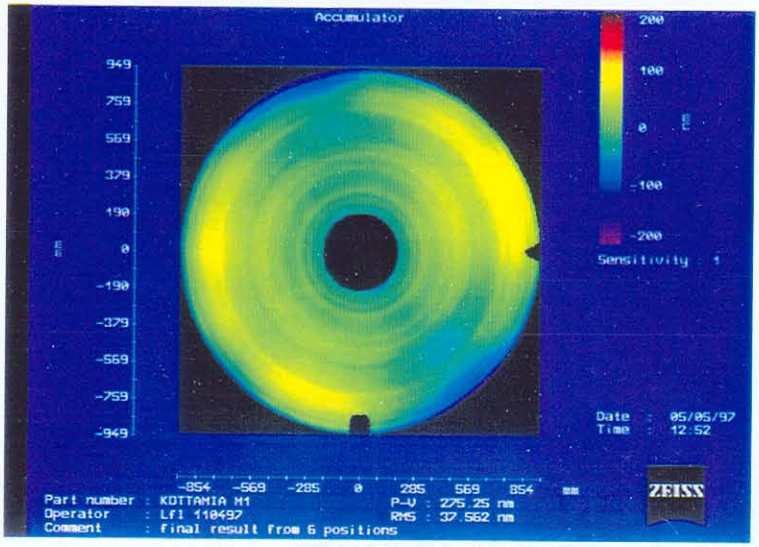
surface topography of the KOTTAMIA primary in modified cell at PA = 0º



Zernike - coefficients after removing of constant, tilt, focus and coma

Aberration	X-coefficient [nm]	Y-coefficient [nm]
constant	---	
tilt	---	---
focus	---	
astigmatism	34	51
coma	---	---
spherical aberr. h^4	- 35	
triangular coma	3	39
astigmatism h^4	- 4	- 3
coma h^5	12	0
spherical aberr. h^6	-26	
4-wave error	21	- 13

P-V : 275 nm: RMS : 37.6nm surface

appendix 1/3

Table with Zernike-coefficients for 6 rotated positions

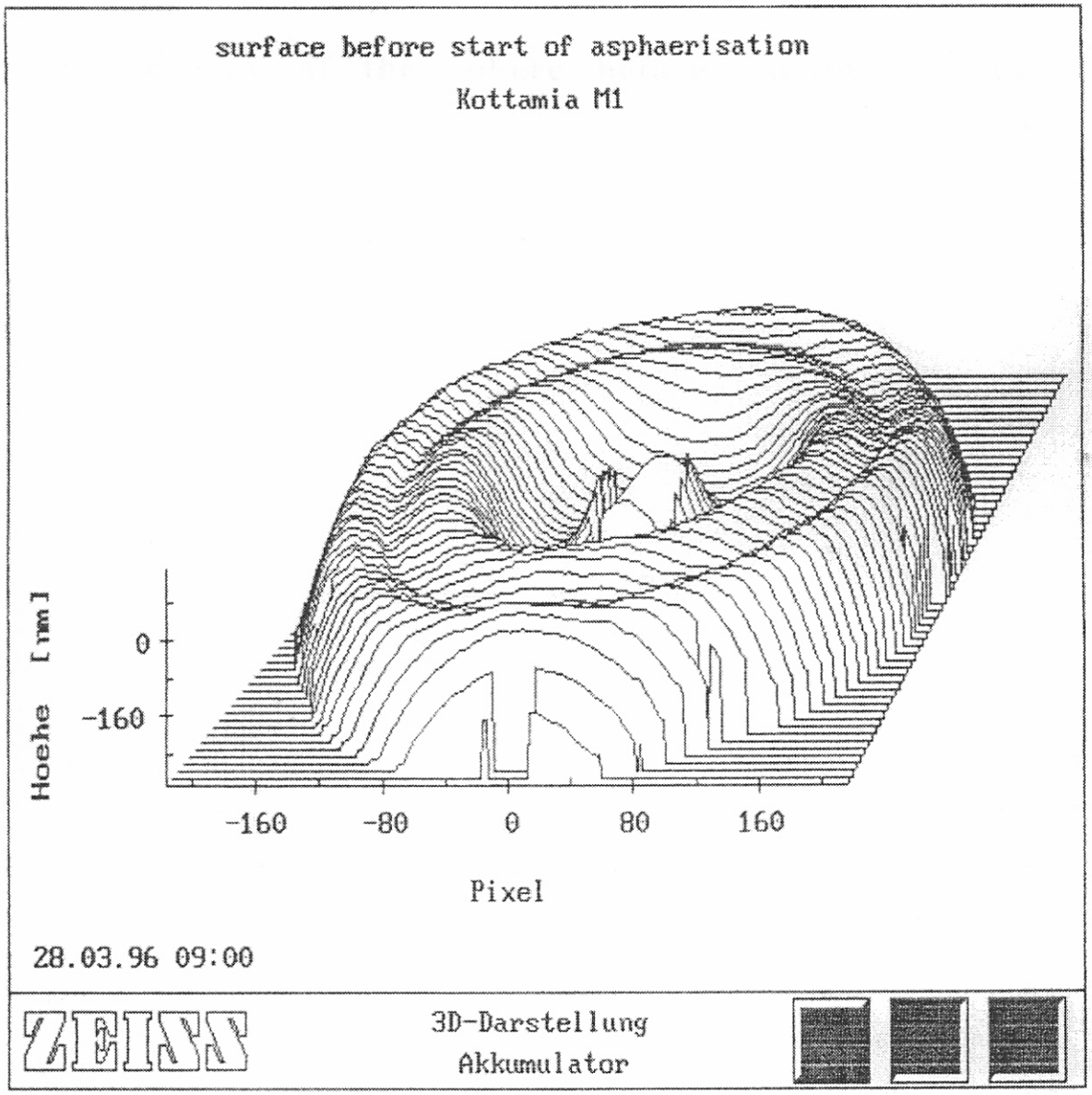
KOTTAMIA M_1 surface

maps are rotated back to 0^0 orientation

Drehstellung	Astigm. [nm]	Astigm. [^{0}]	sph.A. h**4 [nm]	sph.A. h**6 [nm]	sph.A. h**8 [nm]	sph.A. h**10 [nm]	sph.A. h**12 [nm]
0^0	61	130	- 20	- 8	- 41	- 4	- 5
60^0	92	150	- 30	- 3	- 37	- 8	- 3
120^0	29	142	- 21	- 6	- 38	5	1
180^0	94	127	- 10	- 15	- 34	0	6
240^0	102	148	- 18	- 6	- 43	8	3
300^0	22	21	- 3	- 14	- 38	5	1

appendix 5/2

surface topography with respect to the best sphere before starting of aspherisation



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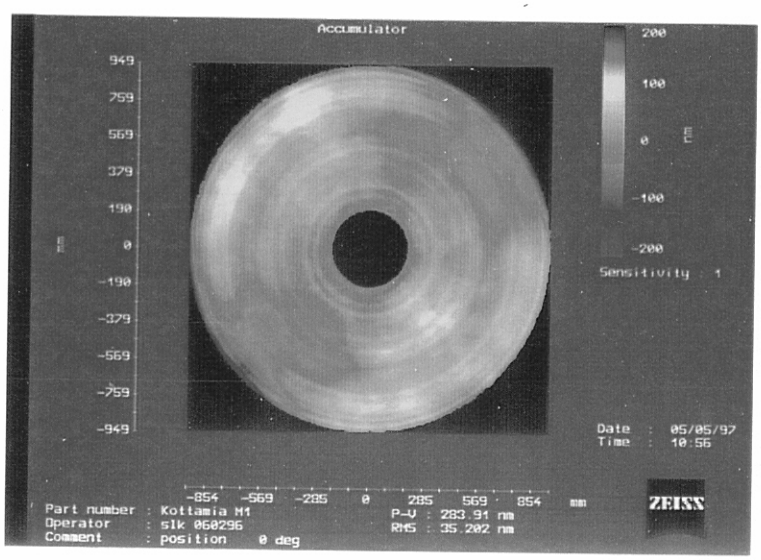
0º contour plot + Zernike coefficients



Zernike - coefficients
after removing of constant, tilt, focus and coma

Aberration	Modulus [nm]	Angle [degrees]
constant	---	
tilt	---	---
focus	---	
astigmatism	61	130
coma	---	---
sph. aberr. h^4	- 20	
sph. aberr. h^6	- 8	
sph. aberr. h^8	- 41	
sph. aberr. h^{10}	4	
sph. aberr. h^{12}	5	

P-V : 283.9 nm; RMS : 35.2nm surface

appendix 2-1/3

Table with Zernike-coefficients for 6 rotated positions

M1 in modified cell at PA = 0^0

KOTTAMIA M_1 surface
in its modified cell at PA = 0^0
maps are rotated back to 0^0 orientation

Drehstellung	Astigm. [nm]	Astigm. [^{0}]	sph.A. h**4 [nm]	sph.A. h**6 [nm]	sph.A. h**8 [nm]	sph.A. h**10 [nm]	sph.A. h**12 [nm]
0^0	52	42	- 44	- 19	- 39	3	7
60^0	53	13	- 45	-16	- 38	5	7
120^0	88	29	- 47	-17	- 35	4	10
180^0	51	43	- 46	- 17	- 38	3	7
240^0	58	11	- 47	-18	- 39	3	7
300^0	90	29	-46	- 17	- 39	4	6

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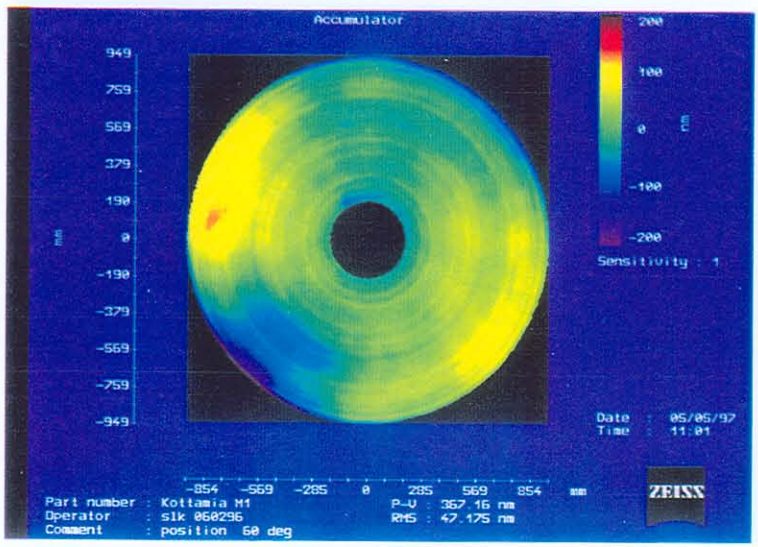
60º contour plot + Zernike coefficients



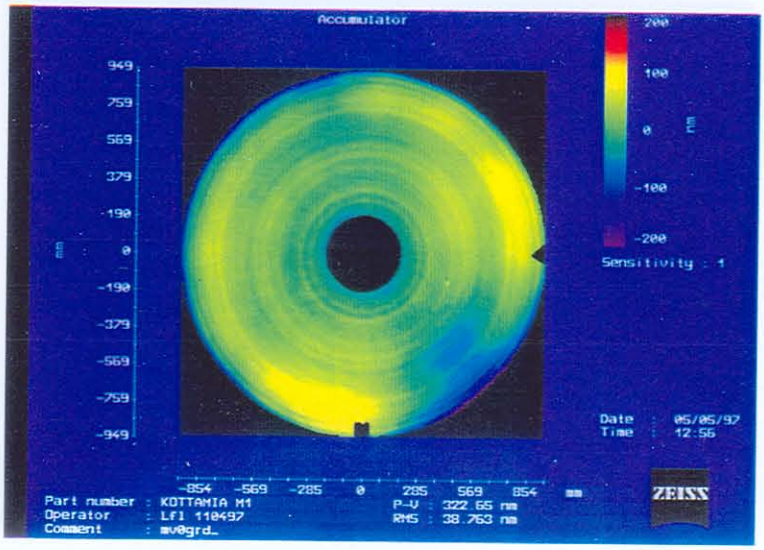
Zernike - coefficients
after removing of constant, tilt, focus and coma

Aberration	Modulus [nm]	Angle [degrees]
constant	---	
tilt	---	---
focus	---	
astigmatism	92	151
coma	---	---
sph. aberr. h^4	- 30	
sph. aberr. h^6	- 3	
sph. aberr. h^8	- 37	
sph. aberr. h^{10}	8	
sph. aberr. h^{12}	3	

P-V : 367.2 nm; RMS : 47.2nm surface

appendix 2-1/4

0° contour plot + Zernike coefficients
PA = 0°



Zernike - coefficients
after removing of constant, tilt, focus and coma

Aberration	Modulus [nm]	Angle [degrees]
constant	---	
tilt	---	---
focus	---	
astigmatism	52	42
coma	---	---
sph. aberr. h^4	- 44	
sph. aberr. h^6	- 19	
sph. aberr. h^8	- 39	
sph. aberr. h^{10}	3	
sph. aberr. h^{12}	7	

P-V : 323 nm; RMS : 38.8nm surface

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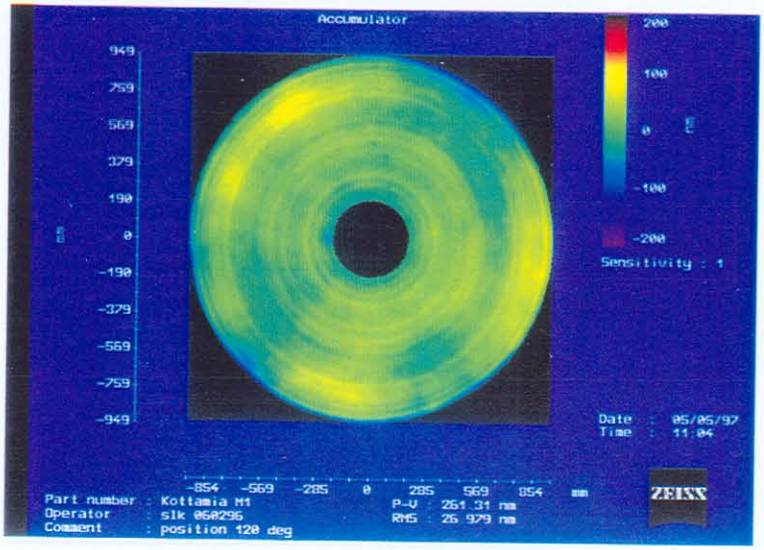
120º contour plot + Zernike coefficients



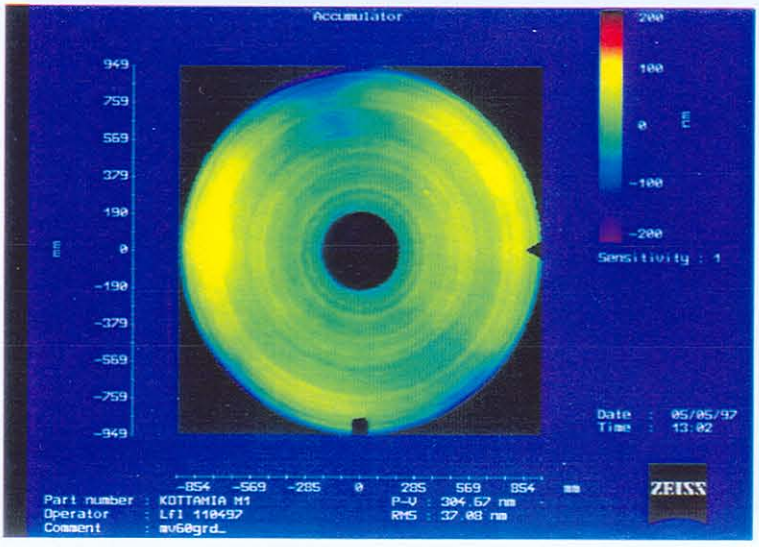
Zernike - coefficients
after removing of constant, tilt, focus and coma

Aberration	Modulus [nm]	Angle [degrees]
constant	---	
tilt	---	---
focus	---	
astigmatism	29	142
coma	---	---
sph. aberr. h^4	- 21	
sph. aberr. h^6	- 6	
sph. aberr. h^8	- 38	
sph. aberr. h^{10}	5	
sph. aberr. h^{12}	1	

P-V : 261.3 nm; RMS : 27.0nm surface

appendix 2-1/5 40

60° contour plot + Zernike coefficients
PA = 0°



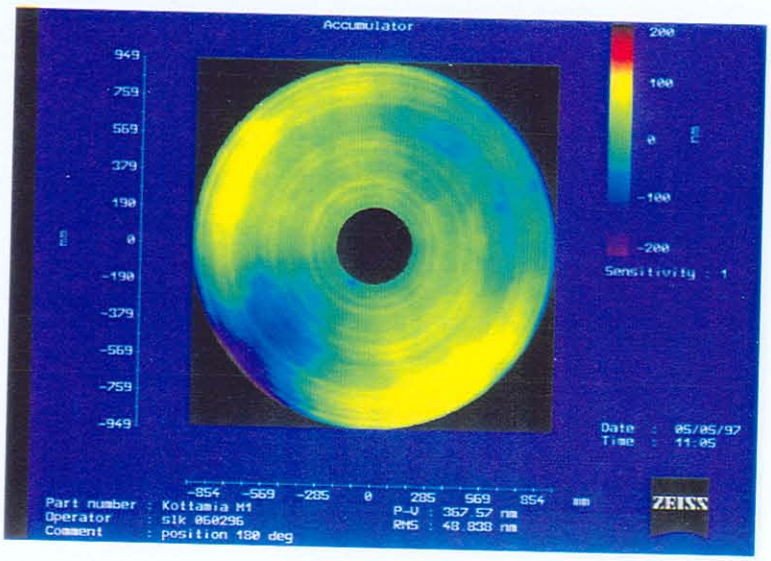
Zernike - coefficients
after removing of constant, tilt, focus and coma

Aberration	Modulus [nm]	Angle [degrees]
constant	---	
tilt	---	---
focus	---	
astigmatism	53	13
coma	---	---
sph. aberr. h^4	- 45	
sph. aberr. h^6	- 16	
sph. aberr. h^8	- 38	
sph. aberr. h^{10}	5	
sph. aberr. h^{12}	7	

P-V : 305 nm; RMS : 37.1nm surface

appendix 1/7 18

180º contour plot + Zernike coefficients



Zernike - coefficients
after removing of constant, tilt, focus and coma

Aberration	Modulus [nm]	Angle [degrees]
constant	---	
tilt	---	---
focus	---	
astigmatism	94	127
coma	---	---
sph. aberr. h^4	- 10	
sph. aberr. h^6	- 15	
sph. aberr. h^8	- 34	
sph. aberr. h^{10}	0	
sph. aberr. h^{12}	4	

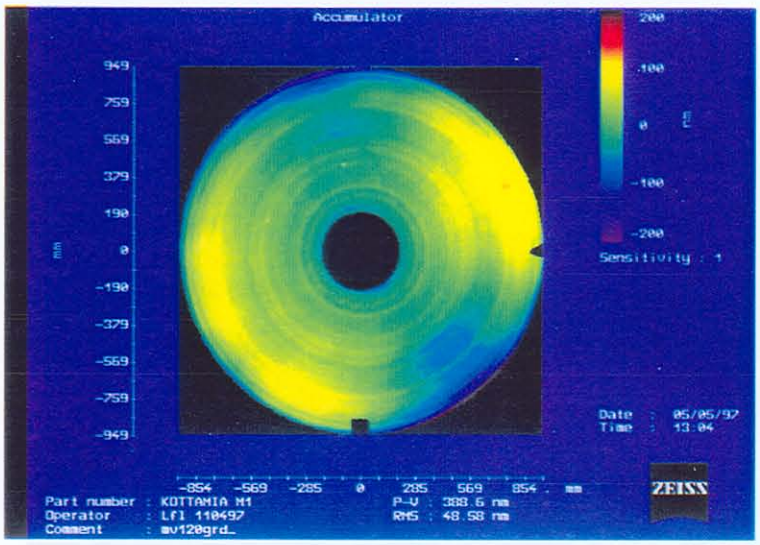
P-V : 367.6 nm; RMS : 48.8nm surface

appendix 8

Blank certificate
Schott
OT -0795473

appendix 2-1/6 41

120⁰ contour plot + Zernike coefficients
PA = 0°



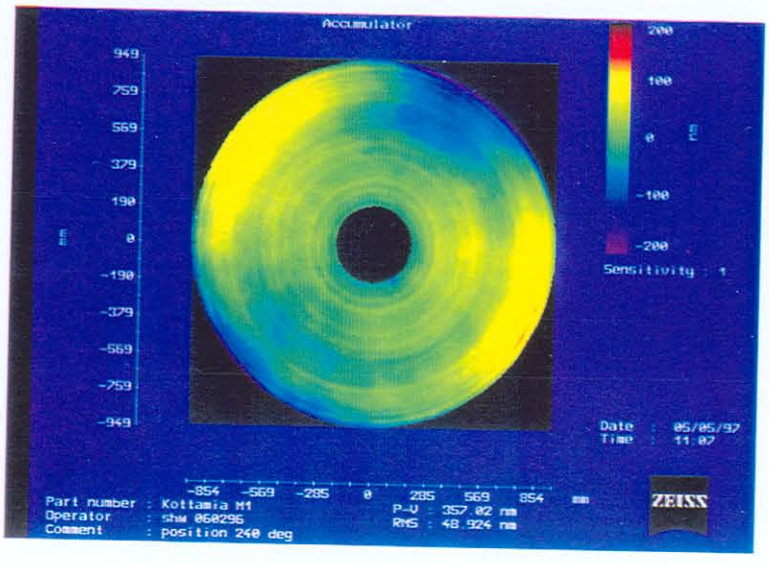
Zernike - coefficients
after removing of constant, tilt, focus and coma

Aberration	Modulus [nm]	Angle [degrees]
constant	---	
tilt	---	---
focus	---	
astigmatism	88	29
coma	---	---
sph. aberr. h^4	- 47	
sph. aberr. h^6	- 17	
sph. aberr. h^8	- 35	
sph. aberr. h^{10}	4	
sph. aberr. h^{12}	10	

P-V : 389 nm; RMS : 48.6nm surface

appendix 1/8 19

240º contour plot + Zernike coefficients



Zernike - coefficients
after removing of constant, tilt, focus and coma

Aberration	Modulus [nm]	Angle [degrees]
constant	---	
tilt	---	---
focus	---	
astigmatism	102	148
coma	---	---
sph. aberr. h^4	- 18	
sph. aberr. h^6	- 6	
sph. aberr. h^8	- 43	
sph. aberr. h^{10}	9	
sph. aberr. h^{12}	3	

P-V : 357.0 nm; RMS : 48.9nm surface

NRIAG
Helwan/Cairo

ZEISS

Test Certificate

1,88m Primary Mirror M_1

Kottamia

rev. 2

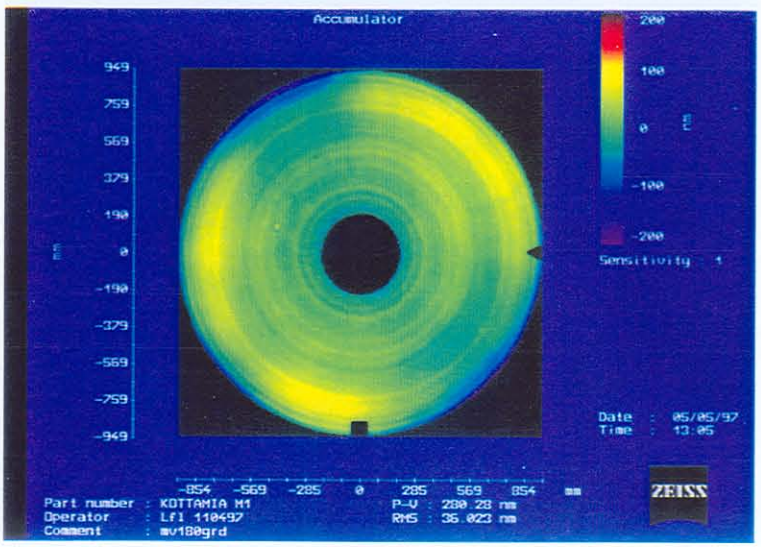
CZJ/Kott Contract AG 13 95702

Oberkochen

28th April 1997

appendix 2-1/7 42

180⁰ contour plot + Zernike coefficients
PA = 0°



Zernike - coefficients
after removing of constant, tilt, focus and coma

Aberration	Modulus [nm]	Angle [degrees]
constant	---	
tilt	---	---
focus	---	
astigmatism	51	43
coma	---	---
sph. aberr. h^4	- 46	
sph. aberr. h^6	- 17	
sph. aberr. h^8	- 38	
sph. aberr. h^{10}	3	
sph. aberr. h^{12}	7	

P-V : 280 nm; RMS : 36.0nm surface

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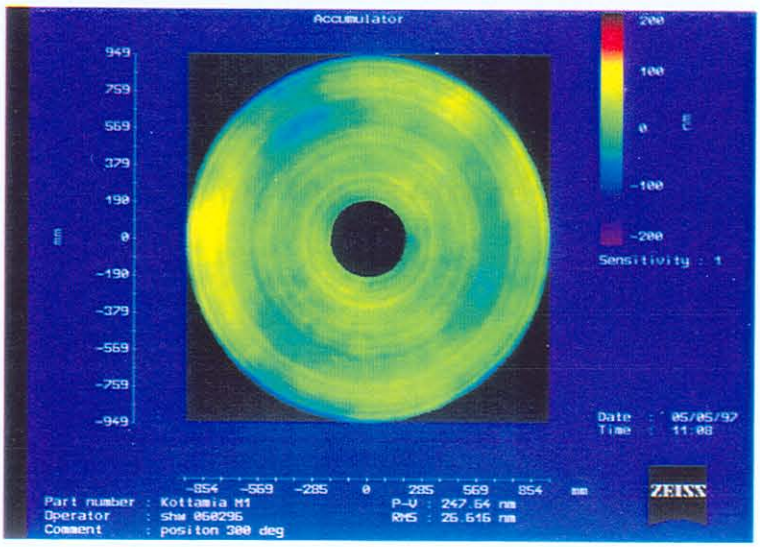
300º contour plot + Zernike coefficients



Zernike - coefficients
after removing of constant, tilt, focus and coma

Aberration	Modulus [nm]	Angle [degrees]
constant	---	
tilt	---	---
focus	---	
astigmatism	22	21
coma	---	---
sph. aberr. h^4	- 3	
sph. aberr. h^6	- 14	
sph. aberr. h^8	- 38	
sph. aberr. h^{10}	5	
sph. aberr. h^{12}	1	

P-V : 247.6 nm; RMS : 26.6nm surface

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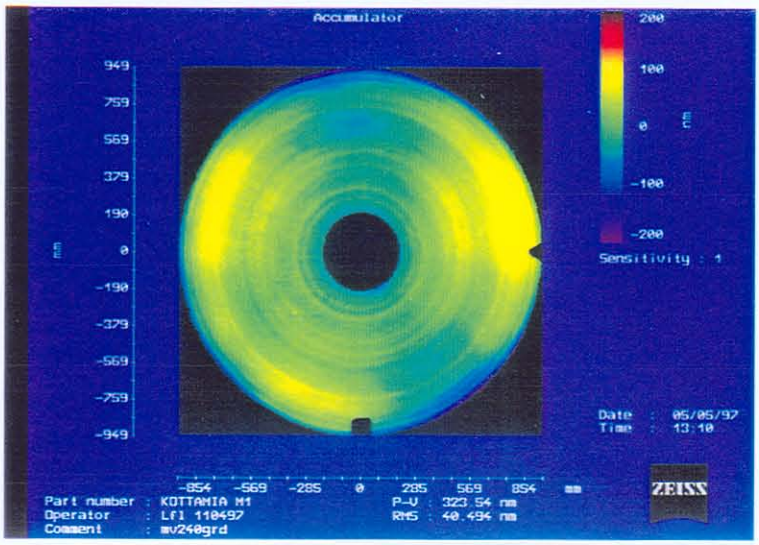
240⁰ contour plot + Zernike coefficients
PA = 0°



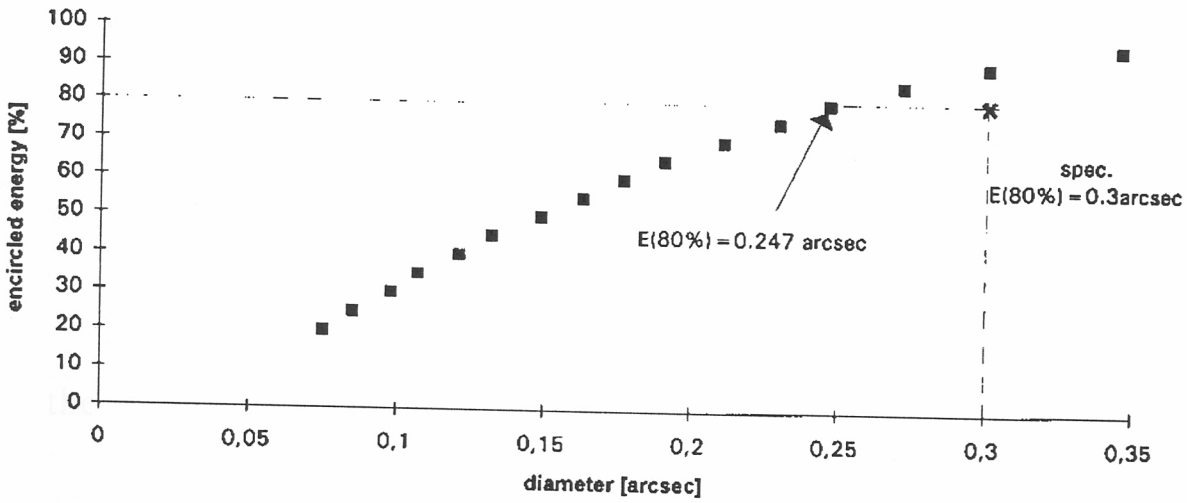
Zernike - coefficients
after removing of constant, tilt, focus and coma

Aberration	Modulus [nm]	Angle [degrees]
constant	---	
tilt	---	---
focus	---	
astigmatism	56	11
coma	---	---
sph. aberr. h^4	- 47	
sph. aberr. h^6	- 18	
sph. aberr. h^8	- 39	
sph. aberr. h^{10}	3	
sph. aberr. h^{12}	7	

P-V : 324 nm; RMS : 40.5nm surface

appendix 2

Encircled energy of the Kottamia Primary



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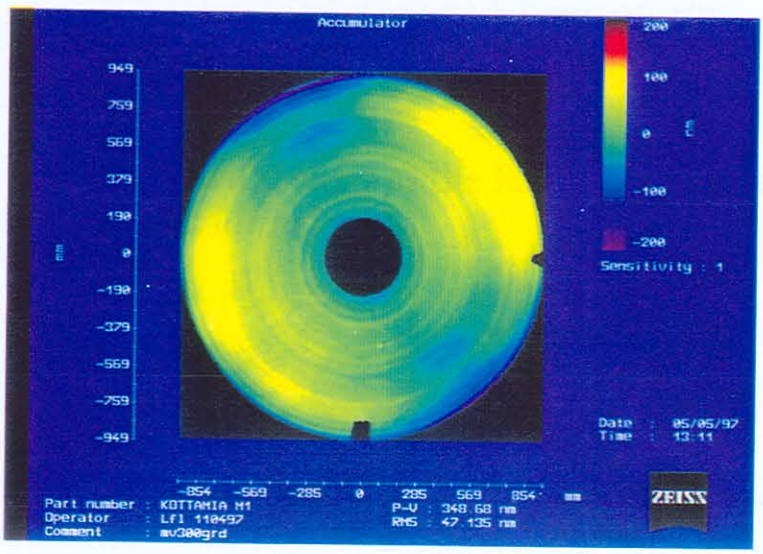
300⁰ contour plot + Zernike coefficients
PA = 0°



Zernike - coefficients
after removing of constant, tilt, focus and coma

Aberration	Modulus [nm]	Angle [degrees]
constant	---	
tilt	---	---
focus	---	
astigmatism	90	29
coma	---	---
sph. aberr. h^4	- 46	
sph. aberr. h^6	- 17	
sph. aberr. h^8	- 39	
sph. aberr. h^{10}	4	
sph. aberr. h^{12}	6	

P-V : 349 nm; RMS : 47.1nm surface

appendix 3

Focal length of the Kottamia Primary

Protocol E-value measurement

object: Kottamia M1
date: 5.2.96 (final state)

distance theodolit to K-system
x = 856,05 mm

distance theodolit to base D:
$A = D/2 * 1/ \tan(\Theta/2)$

with angle $\Theta = 6^0\,12'\,43''$

and base across mirror: D = 1920,85 mm

A = 17 699,57 mm

sag at apex with respect to base D:
$sag = D^2 / 8R^*$ with $R^* = 18\,300$ mm
sag = 25,20 mm

E-value results from this:
E = x + A + sag
E = 18 580,8 mm ± 2 mm

the required E-value is:
E_{spec} = 18 592 mm

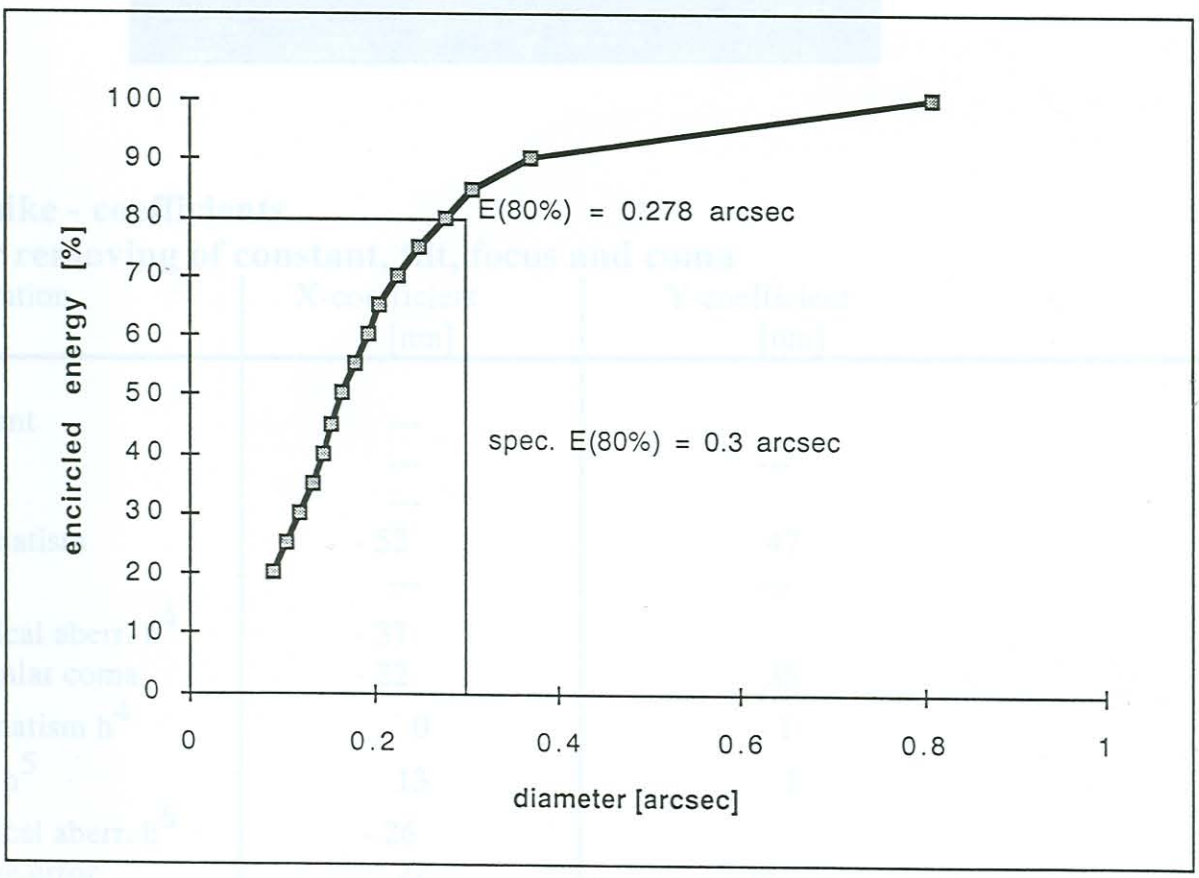
E-value deviation: ΔE = 18 580,8 mm - 18 592 mm =
ΔE = -11,2 mm ± 2 mm

from this results the focal length: $f = f_{spec} + \Delta E/2$

f = 9138 mm ± 1 mm

appendix 2-02

Encircled energy of the Kottamia Primary in modified cell at PA = 0°



appendix 4/1

Verification of the null corrector design and assembly

in order to guarant correct design and assembly of the null corrector the following steps have been performed:

1. Measurement of the refractive index of the glass what has been choosen for lens material
--> for measurement protocoll see page 4/2

2. Design of the null corrector (a two lens system)

3. Fabrication of the lenses

4. Measurement of the lens thickness
--> for measurement protocoll see page 4/3

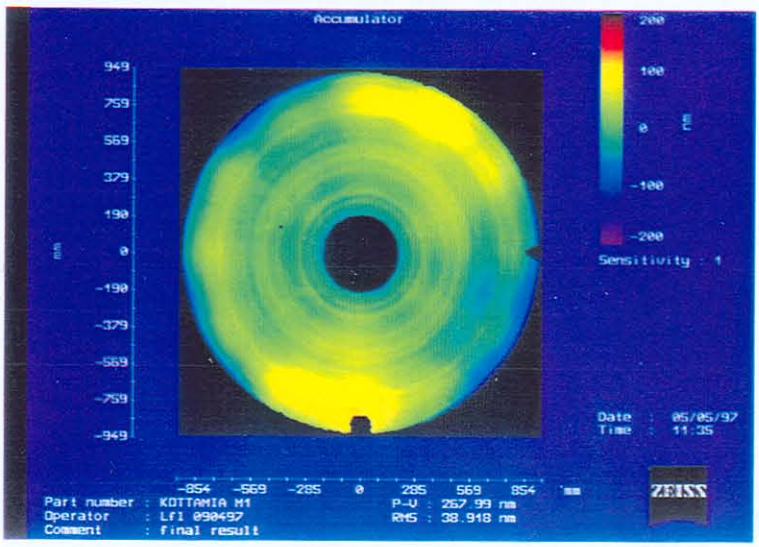
5. Redesign of the null corrector taking into account the thickness of the fabricated lenses. Redesign means, that the distance between the two lenses of the null corrector changes slightly in order to produce the required parabolic wave.

6. Final assembly of the null corrector

7. Testing of the correct distance between the two lenses inside the null corrector
--> for measurement protocoll see page 4/4

appendix 3-1/1

surface topography of the KOTTAMIA primary in modified cell at PA = 15°



Zernike - coefficients after removing of constant, tilt, focus and coma

Aberration	X-coefficient [nm]	Y-coefficient [nm]
constant	---	
tilt	---	---
focus	---	
astigmatism	- 52	47
coma	---	---
spherical aberr. h^4	- 37	
triangular coma	- 22	35
astigmatism h^4	0	- 1
coma h^5	13	1
spherical aberr. h^6	- 26	
4-wave error	22	- 18

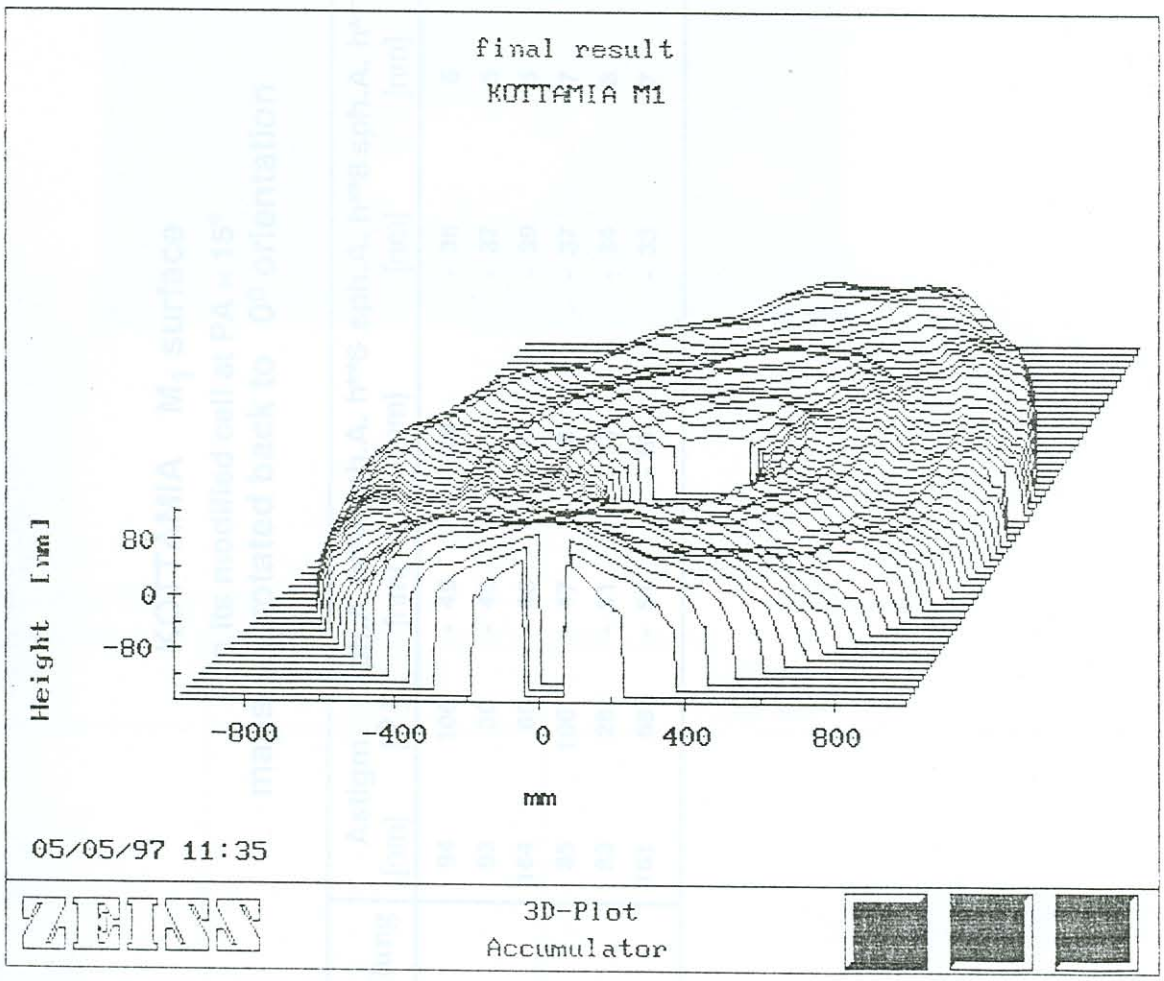
P-V : 268 nm; RMS : 38.9nm surface

appendix 4/2

Null-lens design

appendix 3-1/2

surface topography of the KOTTAMIA primary in modified cell at PA = 15°



ZEISS

2 m -Spiegelsystem KOTTAMIA;
K-System fuer S1

DATEN: f(1-4) = 363.2; s'(4) = 304.0.
f(1-2) = 939.0 f(3-4) = 494.4
Eingang von Unendlich

OBERKOCHEN: RECHNUNG VOM 27.10.95

ABT. -APS-T

ZEICHNUNG: 563618

KO-APS-K02

1000

KØ HERAUSGEGEBEN AM 15.05.95

MATH -F/Hbg

RADIUS			58.294	53.860	1224.4	211.35	18288.									
SKIZZE D TEIL NR.	10.00	6.03	183.3	5.99	18592	Ø 0.00										
			1	2	3	4	5									
2H			38.Ø	39.3	3Ø.4	3Ø.3	1995.3									
FREIER Ø			38.Ø	39.4	3Ø.6	3Ø.4	1995.Ø									

Ø																
GLASART SCHMELZE				BK7 120428k27811		BK7 120428K27811										
(632.8 nm) STUFE				1.51560		1.51560										
Vd STUFE				64.26		64.26										

Nur angegebene Schmelze f. BK7 120428III K27811 verwenden.
Linsendicken wurden vermessen.
Pruefling ist Rotationsparaboloid.

Angegebene Radien sind IST-Radien.

Datenblatt gilt als K1

TOLERANZEN: KOMBINATIONSFREIE FERTIGUNG

D				±Ø.Ø5	±Ø.1Ø	±Ø.Ø5										
KITT																
Ø) KUEHLUNG																
1) BLASEN				5xØ.63		5xØ.63										
2) SCHLIEREN																

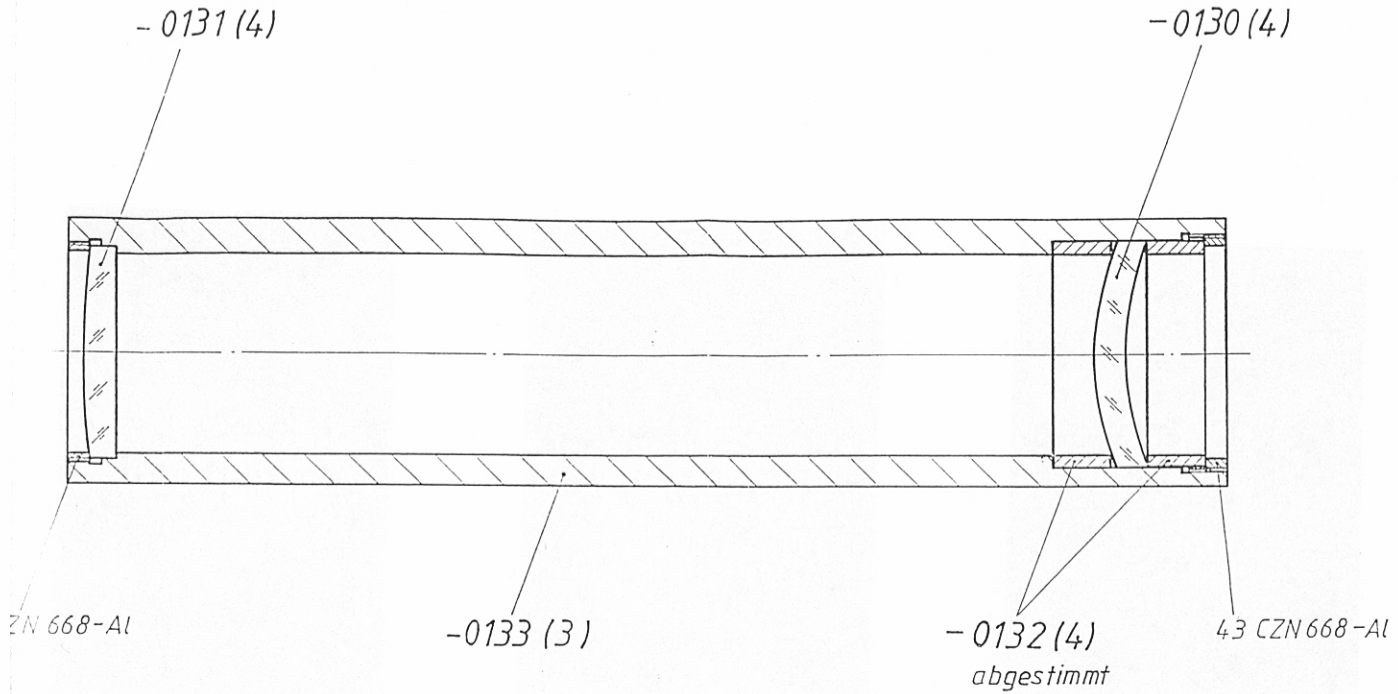
3) PASSE			Ø.1(Ø.1)	Ø.1(Ø.1)	Ø.1(Ø.1)	Ø.1(Ø.1)										
4) ZENTR.			Ø.2'	Ø.2'	Ø.2'	Ø.2'										
5) UNSAUB.	Ø		5xØ.63	5xØ.63	5xØ.63	5xØ.63										

appendix 3-1/3

Table with Zernike-coefficients for 6 rotated positions

KOTTAMIA M_1 surface
in its modified cell at PA = 15°
maps are rotated back to 0^0 orientation

Drehstellung	Astigm. [nm]	Astigm. [°]	sph.A. h**4 [nm]	sph.A. h**6 [nm]	sph.A. h**8 [nm]	sph.A. h**10 [nm]	sph.A. h**12 [nm]
0^0	94	106	- 49	- 19	- 36	5	9
60^0	93	30	- 45	- 23	- 37	5	7
120^0	164	69	- 46	- 21	- 39	5	7
180^0	85	106	- 47	- 18	- 37	7	10
240^0	83	28	- 51	- 17	- 34	8	10
300^0	161	68	- 51	- 16	- 33	7	10



19. 05. 95

Kö

Geprüft auf Gerätesicherheit
Sicherheitsstufe: S

DIN 6784

Klassifizierungsschlüssel

Oberflächenbehandlung

zul. Abw. mittel DIN 7168

Oberfläche Reihe 2 DIN 3141

Maßstab 1:1

	Datum	Name
1995		
Bearb	18. 5.	Ren
Gepr	19. 5.	
Scha		
Norm		

K - System

Carl Zeiss

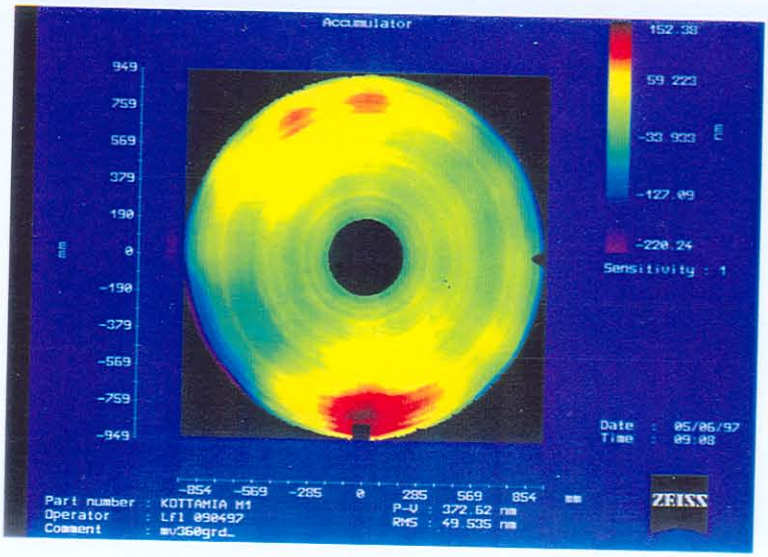
56 36 18 - 8013 (3)

Bl. von

Zust | Änderung | Datum | Name | GS

Ers. für | Ers. durch

appendix 3-1/4
0° contour plot + Zernike coefficients
PA = 15°



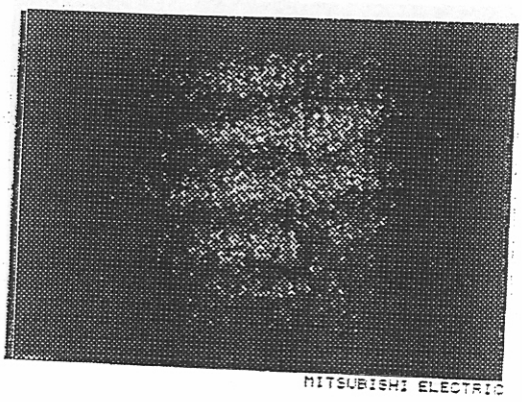
Zernike - coefficients
after removing of constant, tilt, focus and coma

Aberration	Modulus [nm]	Angle [degrees]
constant	---	
tilt	---	---
focus	---	
astigmatism	94	106
coma	---	---
sph. aberr. h^4	- 49	
sph. aberr. h^6	- 19	
sph. aberr. h^8	- 36	
sph. aberr. h^{10}	5	
sph. aberr. h^{12}	9	

P-V : 373 nm; RMS : 49.5nm surface

appendix 4/3

Lens protocoll/1

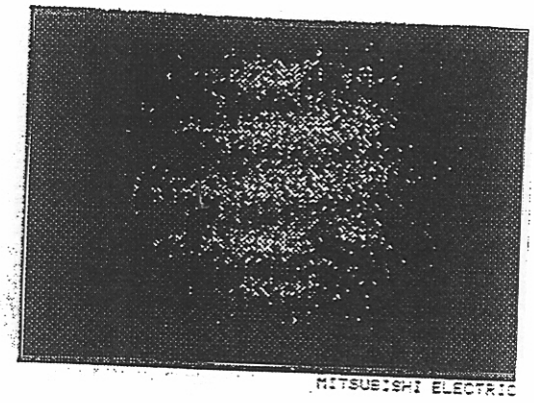


lens No. 1 (selected)

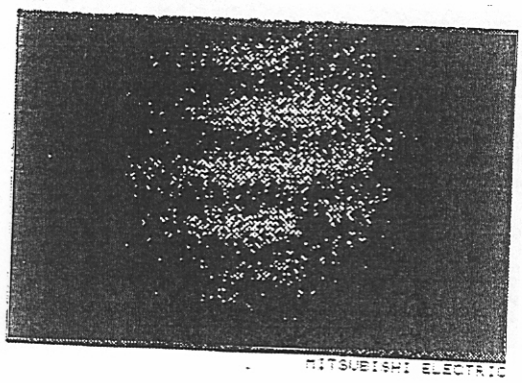
Kottamia
K-lens

No. 1 563618-131 d = 5,989
r = ∩ 211,35 (0,2) E
after coating

r = ∪ 1223,2
→ (no matching test possible)



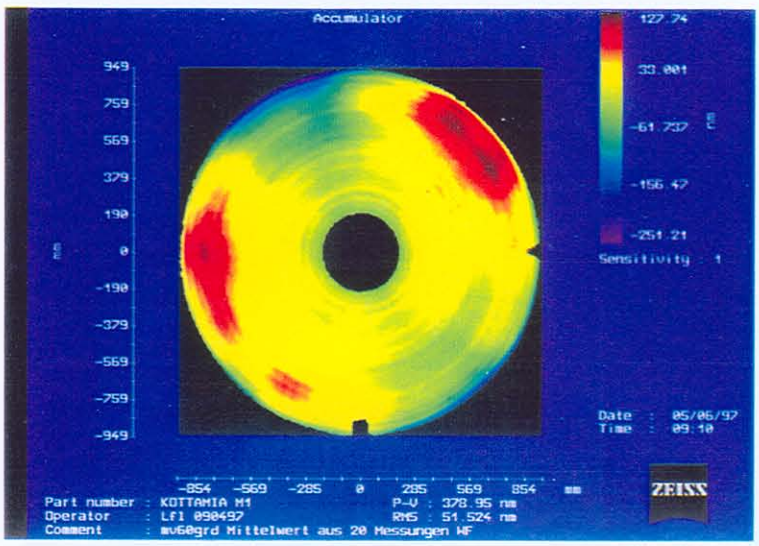
No. 2 563618-131 d = 5,931
(5,936)
r = ∩ 211,35 (0,2) E



No. 3 563618-131 d = 5,964
r = ∩ 211,35 (0,2) E

appendix 3-1/5 50

60° contour plot + Zernike coefficients
PA = 15°



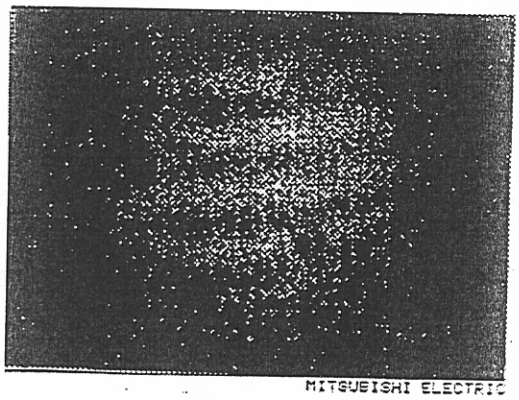
Zernike - coefficients
after removing of constant, tilt, focus and coma

Aberration	Modulus [nm]	Angle [degrees]
constant	---	
tilt	---	---
focus	---	
astigmatism	93	30
coma	---	---
sph. aberr. h^4	- 45	
sph. aberr. h^6	- 23	
sph. aberr. h^8	- 37	
sph. aberr. h^{10}	5	
sph. aberr. h^{12}	7	

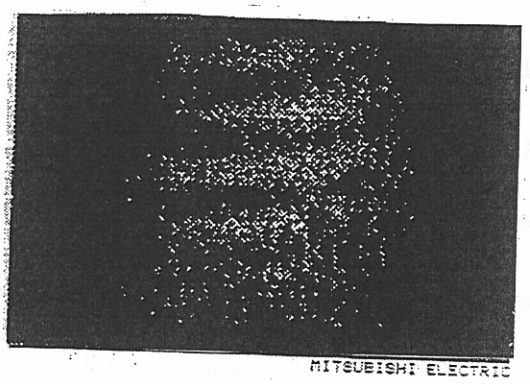
P-V : 379 nm; RMS : 51.5nm surface

appendix 4/3

Lens protocoll/2



No. 1 563618-130 d = 6,019
r = ∩ 53,858 (0,3) H

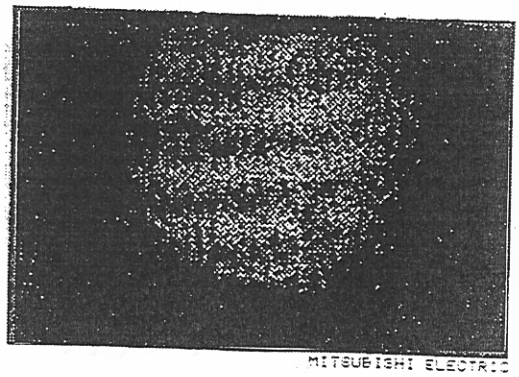


lens No 3 (selected)

Kottamia
K-lens

No. 3 563618-130 d = 6,030
r = ∩ 53,858 (0,2) H

after coating



No. 2 563618-130 d = 6,021
r = ∩ 53,858 (0,2) H

SCHOTT

Schott Glaswerke Postfach 2480 D-55014 Mainz

SCHOTT GLASWERKE
Hattenbergstraße 10
D-55014 Mainz
West Germany

Telefon (06131) 661
Telex 4 187 9220 sm d
Telegramm
Glaswerk Mainz

Geschäftsbereich
Optik

Certificate / Zertifikat

nach / according to DIN 50049 - 2.3

Nr. / No.:	Datum / Date:	Bl. / von / Page / from:
OT - 0795473	19.07.95	1/3

Lieferanzeige Nr. / to Delivery Note No.: vom/of: Zeichen des Herstellwerkes / Mark of the Manufacturer Zeichen des Sachverständigen / Inspector`s Stamp:

Besteller / Purchaser: Carl Zeiss

Bestellung Nr. / Order No.:

Datum / Date:

Unsere Auftrags-Nr. / Our Order-No.: Astro 89982

Unsere Abteilung / Our Department: OGQ/Quality assurance

Hausruf / Tel. Int.: 3563

Erzeugnisform / Product: Glass ceramic mirror blank

Lieferbedingungen / Terms of Delivery:

Werkstoff / Lieferzustand / Quality / Condition of Delivery: ZERODUR

Lieferbedingungen und / oder amtliche Vorschriften
Terms of Delivery and / or Official Regulations:

Pos. / tem.:	Anzahl und Einheit / Quantity and Materials:	Erzeugnisform und Abmessungen / Typ / Product and Dimensions / Typ:	Werkstoff / Lieferzustand / Quality / Conditions of Delivery:
1	1 pc.	Mirror blank with center hole Diameter: 1930 ± 2 mm Diameter of center hole: 188 + 1/-0 mm Thickness at the outer edge: 230 + 0.5/-0 mm	Zerodur Melt-No.: 890 094 Annealing-No.: K 28986 K 31230

Es wird bestätigt, daß die Lieferung den Vereinbarungen bei der Bestellung entspricht. /
We hereby certify, that the material discribed above has been tested and complies with the terms of the order.

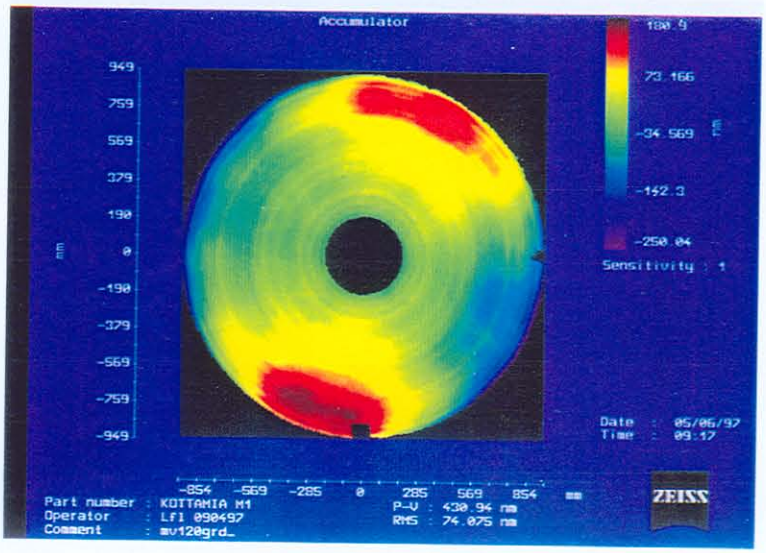
SCHOTT GLASWERKE
Geschäftsbereich Optik
Qualitätssicherung

Quality assurance

SCHOTT
GRUPPE

appendix 3-1/6

120⁰ contour plot + Zernike coefficients
PA = 15°



Zernike - coefficients
after removing of constant, tilt, focus and coma

Aberration	Modulus [nm]	Angle [degrees]
constant	---	
tilt	---	---
focus	---	
astigmatism	164	69
coma	---	---
sph. aberr. h^4	- 46	
sph. aberr. h^6	- 21	
sph. aberr. h^8	- 39	
sph. aberr. h^{10}	5	
sph. aberr. h^{12}	7	

P-V : 431 nm; RMS : 74.0nm surface

appendix 4/4

Measured apex distance

MESSPROTOKOLL ZEISS UMESS

2m Spiegelsyst. K-System fuer S1 MANUELLE MESSUNG

ZEICHNUNGS NR	AUFTRAGS NR	LIEFERANT/KUNDE	ARBEITSGANG
563618-8013	D KOTTAMIA	R APS-KO 2	messen

PRUEFER	DATUM	TEIL-NR
U.HOLZ	10.11.95	1

ADR	IRKF	AUFGABE	BEZ	ISY	IST-MASS	NENN-MASS	O.TOL	U.TOL	ABW	UEB
1		KREIS A		Y	-102.6336					
				Z	-197.9633					
				D	49.9495					
	4P	S/MIN/MAX			0.0015		(4) -0.0008		(1) 0.0008	
2		KREIS A		Y	-102.8075					
				Z	-197.9663					
				D	49.9362					
	4P	S/MIN/MAX			0.0038		(4) -0.0020		(1) 0.0019	
3		DREHEN RAUM		W	0.0501					
4		NULL-P		Y	-102.9311					
				Z	-197.9684					
5		PUNKT		X	133.3125					
6		NULL-P		X	133.3125					
7		PUNKT		X	195.2979					
------ DISTANZMASS VON SCHNITTPUNKT ZU										
8	7*	PUNKT		X	195.2979					

Soll : 195,32

VERWENDBAR ( ) NACHARBEIT ( ) AUSSCHUSS ( )
ABTEILUNG : UNTERSCHRIFT :

K - System i.O.
13.11.95 dgb

English Translation of internal document:

2m mirror system, K system for M1

operator: U.Holz date: 10.11.95

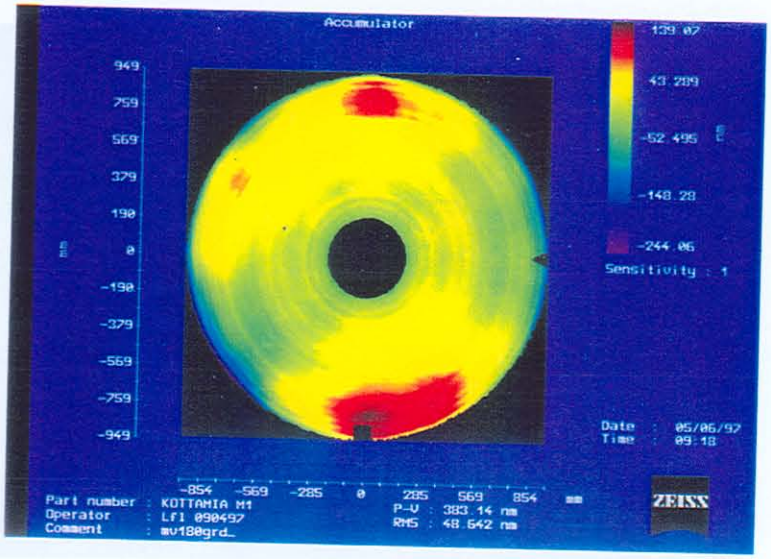
nominal value: 195.32
result:
distance from apex to apex: 195.2979 (passed)
approved: Dr. Henneberg

Contents

Appendix

appendix 3-1/7

180° contour plot + Zernike coefficients
PA = 15°



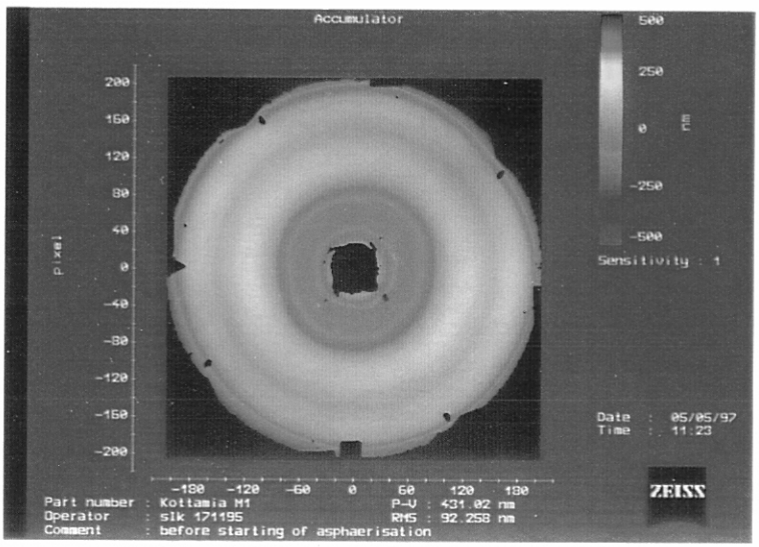
Zernike - coefficients
after removing of constant, tilt, focus and coma

Aberration	Modulus [nm]	Angle [degrees]
constant	---	
tilt	---	---
focus	---	
astigmatism	85	106
coma	---	---
sph. aberr. h^4	- 47	
sph. aberr. h^6	- 18	
sph. aberr. h^8	- 37	
sph. aberr. h^{10}	7	
sph. aberr. h^{12}	10	

P-V : 383 nm; RMS : 48.6nm surface

appendix 5/1 28

surface topography with respect to the best sphere before starting of aspherisation



Zernike - coefficients after removing of constant, tilt, focus

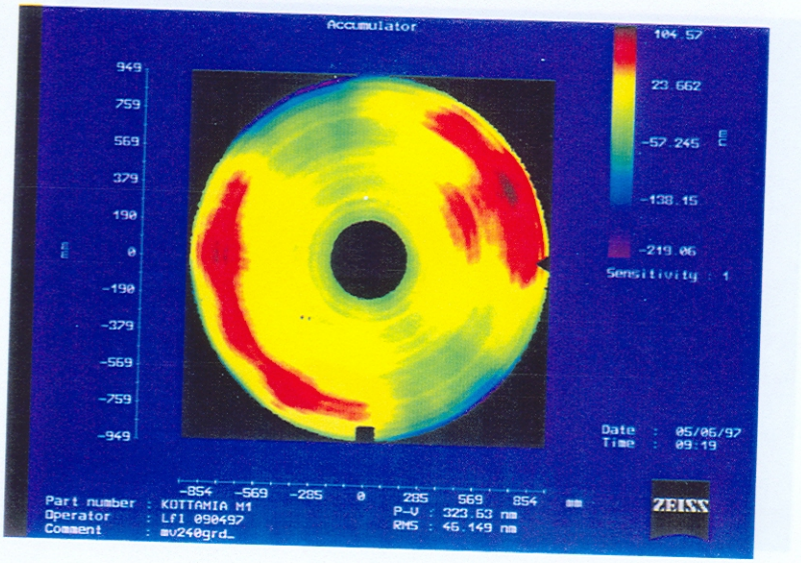
Aberration	X-coefficient [nm]	Y-coefficient [nm]
constant	---	
tilt	---	---
focus	---	
astigmatism	27	-49
coma	7	14
spherical aberr. h^4	-187	
triangular coma	- 0	- 5
astigmatism h^4	- 13	3
coma h^5	0	2
spherical aberr. h^6	- 12	
4-wave error	26	-17

P-V : 431 nm; RMS : 92.3 nm surface

appendix 3-1/8

53

240° contour plot + Zernike coefficients
PA = 15°



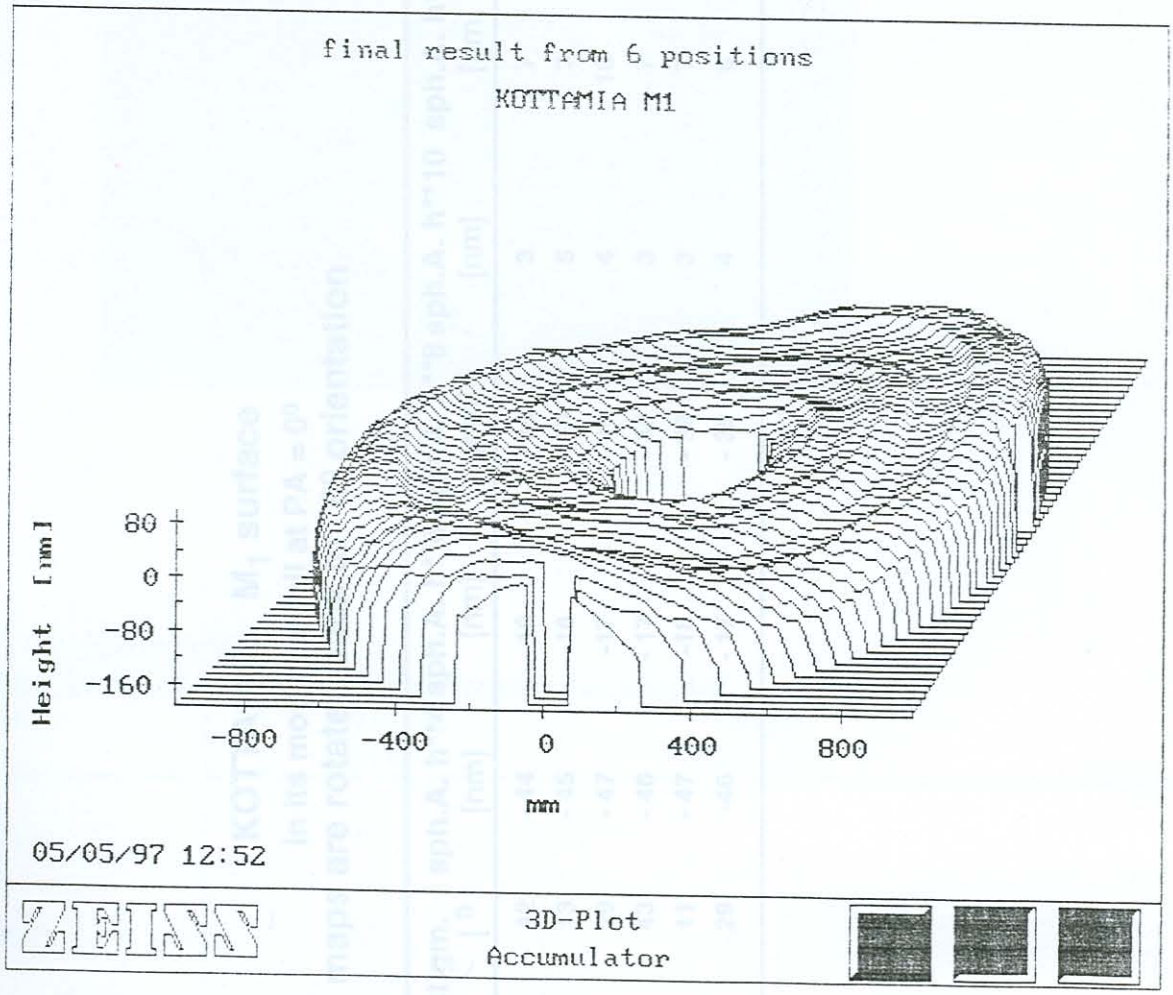
Zernike - coefficients
after removing of constant, tilt, focus and coma

Aberration	Modulus [nm]	Angle [degrees]
constant	---	
tilt	---	
focus	---	---
astigmatism	83	28
coma	---	---
sph. aberr. h^4	- 51	
sph. aberr. h^6	- 17	
sph. aberr. h^8	- 34	
sph. aberr. h^{10}	8	
sph. aberr. h^{12}	10	

P-V : 324 nm; RMS : 46.1nm surface

appendix 2-1/2

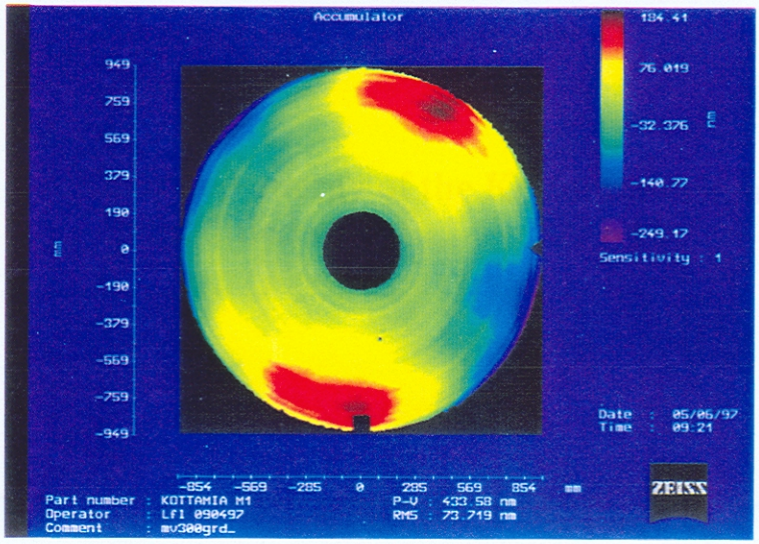
surface topography of the KOTTAMIA primary in modified cell at PA = 0°



appendix 3-1/9

54

300⁰ contour plot + Zernike coefficients
PA = 15°



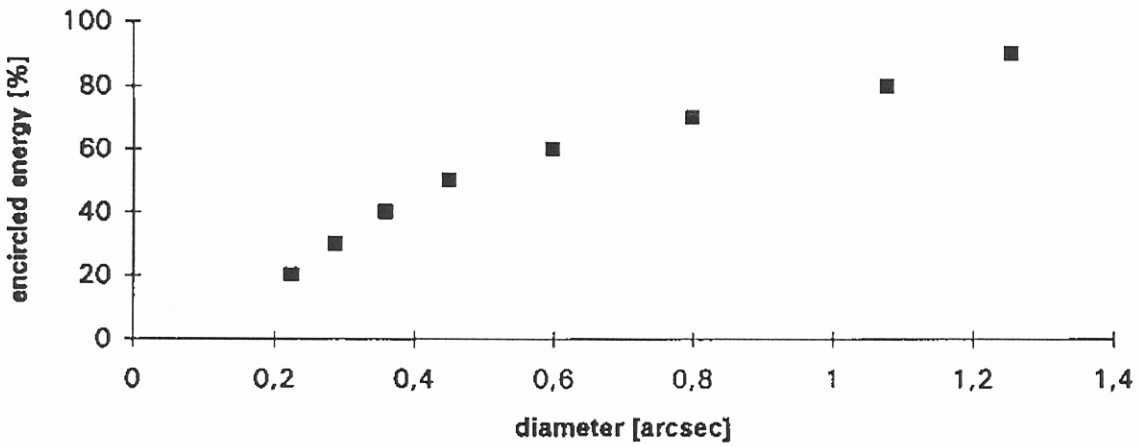
Zernike - coefficients
after removing of constant, tilt, focus and coma

Aberration	Modulus [nm]	Angle [degrees]
constant	---	
tilt	---	---
focus	---	
astigmatism	161	68
coma	---	---
sph. aberr. h^4	- 51	
sph. aberr. h^6	- 16	
sph. aberr. h^8	- 33	
sph. aberr. h^{10}	7	
sph. aberr. h^{12}	10	

P-V : 349 nm; RMS : 47.1nm surface

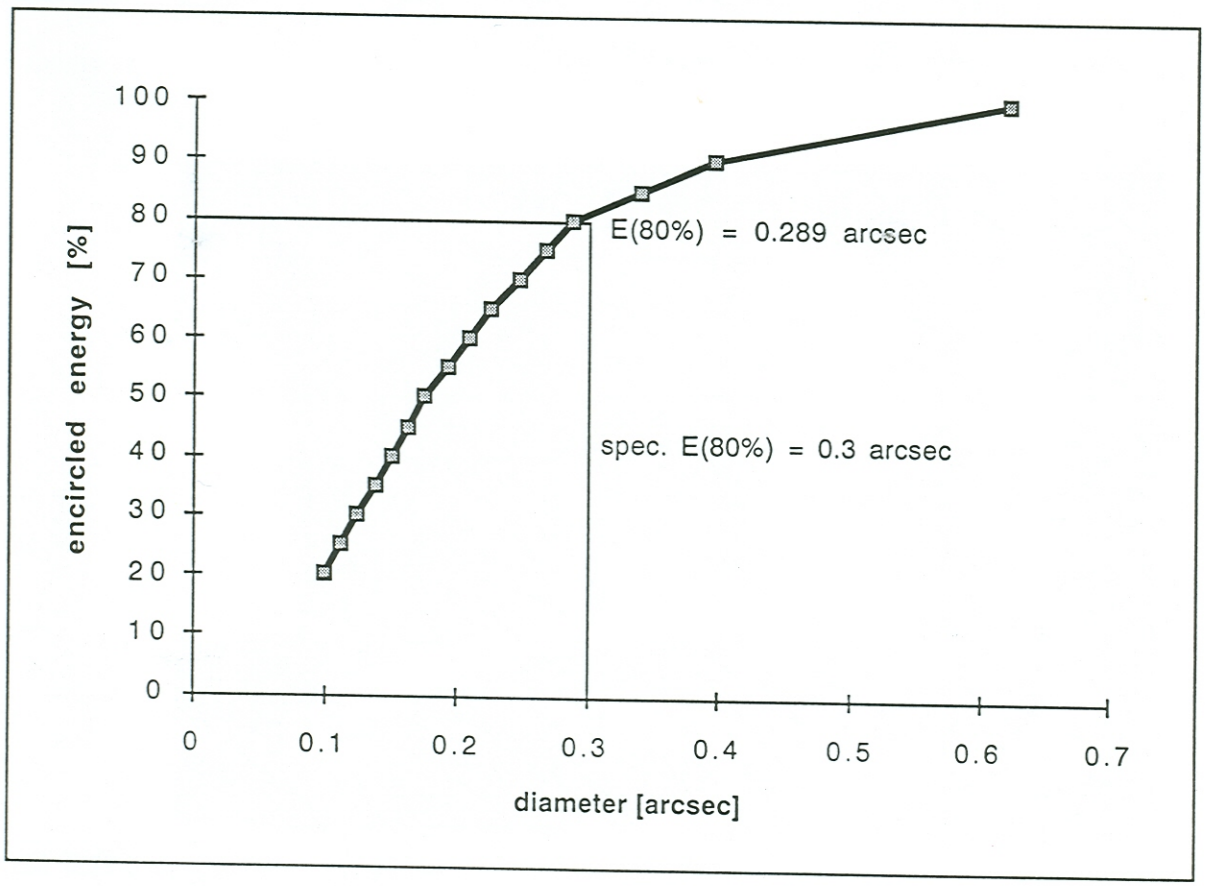
appendix 6

Encircled energy of the sphere before starting asphersation



appendix 3-02

Encircled energy of the Kottamia Primary in modified cell at PA = 15°

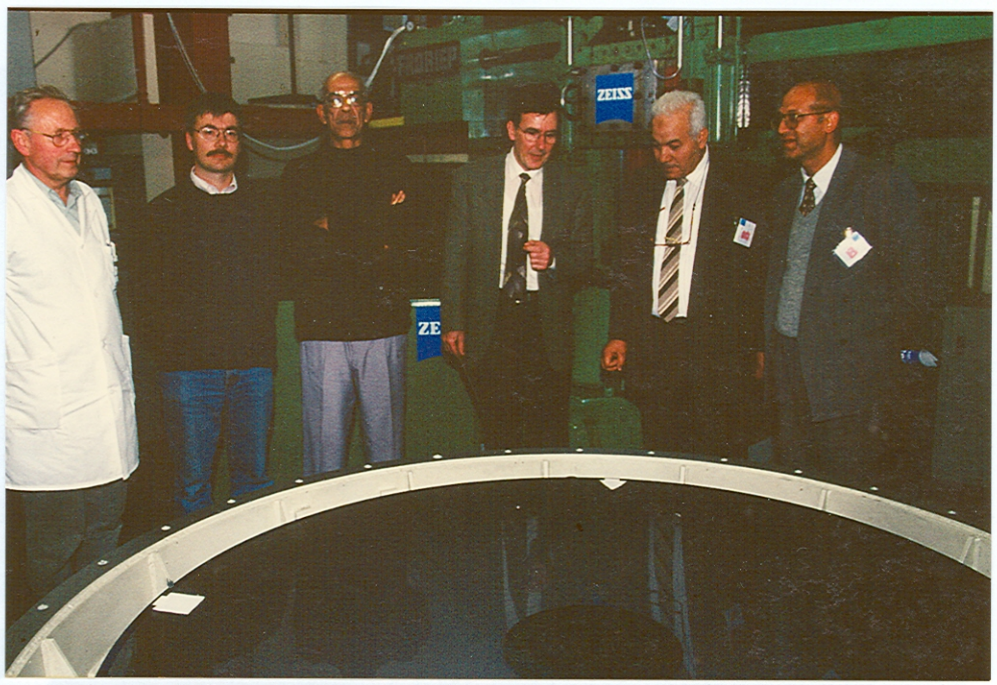


appendix 4

Minutes of Meeting
10.04.1997 to 12.04.1997
in Oberkochen

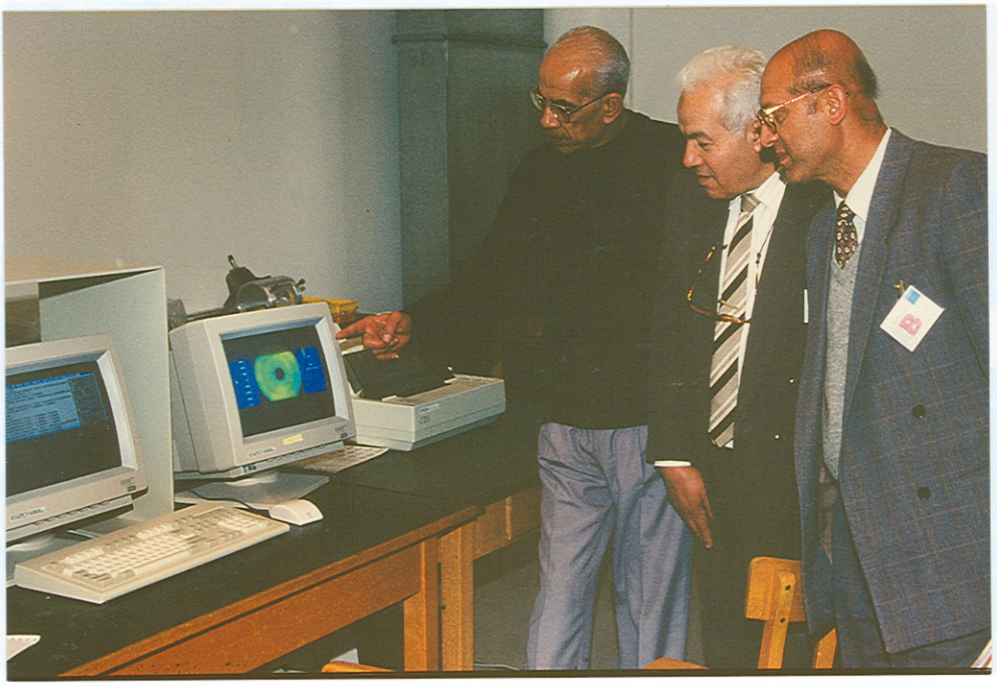
The Jewel Kottamia Mirror M1 being inspected in its modified cell

from left to right: *Löffler, Knohl, Prof.Hassan Sobhy, Köhler, Prof.Hanafi Deebes, Dr.Anas Osman*



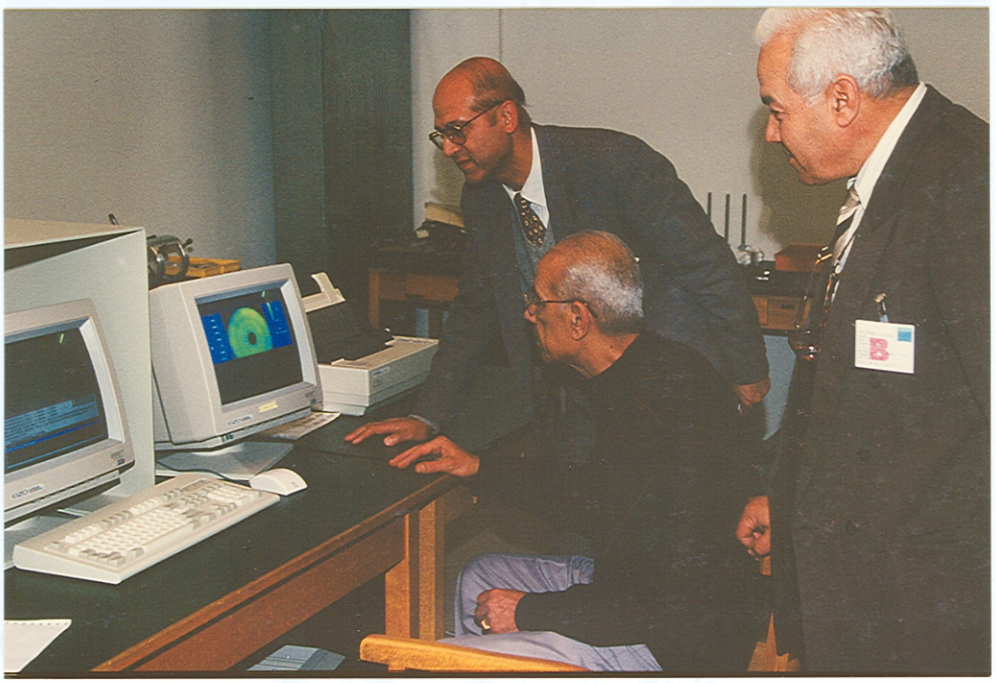
from left to right: *Löffler, Schillke, Prof.Hassan Sobhy, Köhler, Prof.Hanafi Deebes, Dr.Anas Osman*

The final optical quality of the Jewel Kottamia Primary in its modified cell being interferometrically tested with DIRECT 100
The fine results are discussed:



from left to right:

Prof. Hassan Sobhy, Prof. Hanafi Deebes, Dr. Anas Osman



The provisional acceptance of the Kottamia Primary in its modified cell is being discussed ....

and the wording is worked out.

from left to right:

Prof. Hassan Sobhy, Prof. Hanafi Deebes, Dr. Anas Osman

from left to right:

Prof. Piero Rafanelli, Köhler

Signature of the minutes of meeting.

from left to right:

Dr. Anas Osman, Prof. Piero Rafanelli, Prof. Hanafi Deebes, Köhler

SCHOTT

nach / according to DIN 50049 - 2.3

Nr. / No.: OT- 0795473 Datum / Date 19.07.95 Bl. / von / Page / from 2/3

		limit value	actual value
1.	**Geometrical dimensions [mm]**		
1.1.1	Diameter	1930 ± 2	1931
	Diameter of center hole	188 +1/-0	188.2
	Diameter of concave surface profile	1910 ± 2	1909.7
	Thickness at the outer edge	230 + 0.5/-0	230.3
1.1.2	Flatness (plano side)	≤ 0.1	0.01
1.1.3	Concave radius	18300	18300
	Profile of concave surface	≤ 2.5	0.53
1.1.4	Chamfers at outer edge	7 ± 1 45°	7.5 45°
	Chamfers at center hole (concave side)	8 ± 1 45°	8 45°
	Chamfers at center hole (plano side)	5 ± 1 135°	4.1 135°
2.	**Internal quality**		
2.1	Inclusions in the uncritical volume		
	Projected area of all inclusions in mm^2 per volume of 100 cm^3	≤ 2	< 2
	Maximum diameter of individual inclusions in mm	≤ 5	3.5

SCHOTT
GRUPPE

ZEISS

Carl Zeiss Jena GmbH

Geschäftsfeld Astronomische Geräte

Besprechungsprotokoll

Minutes of Meeting

CZJ/ AS-PA-GF /V/Khr/96

Subject/Thema: Kottamia 74" optics/ Progress Meeting 3+4 (M1 +cell tests)
Location/Ort: CZO/TO
Date/Datum: 10.4.97/11.4.97/12.4.97
Distribution/Verteiler: participants +

Participant	Organ.	Participant	Organ.	Participant	Organ.
Prof. Hanafy Deebes	NRIAG	E.-D. Knohl	CZO/WT	Loffler	CZO/TO
Prof. Hassan Sobhy	NRIAG	W.Heilemann	CZJ/AS	Dr. Derst	CZO/TO
Prof.Anas Osman	NRIAG	P.Kohler	CZJ/AS	Schillke	CZO/TO
Prof. Rafanelli	AI Padua				

Agreements, Statements

The meeting was called to discuss the results of the M1 tests and to attend the tests of the M1 in the modified cell. A new version of the test plan had be distributed prior to the meeting to NRIAG and a copy has been sent to Prof. Rafanelli, consultant of NRIAG. For the tests the independant consultant was engaged by NRIAG. The report of the M1 test had been discussed with Prof. Rafanelli/Padua/Italy prior to the meeting and his remarks have been added to the text, to be approved. The test plan has been accepted with the warnings and modifications reported in section 2.

The following agenda was agreed upon:
1. Discussion of the test Certificate of the M1
2. Discussion of the test plan of M1 in the cell
3. Contractual matters
4. Schedule
5. Test and discussion of the results of the M1 plus cell test

Action:

Signatures/ Unterschriften: Hanafy Deb. P. Rafanelli A M Osman

date: P. Kohler E. Knohl

Agreements, Statements

1. Test certificate

The certificate of M1 on the polishing desk proves that its basic quality is in fact better than required by the contract. The diameter of the encircled energy E80% is 0.247arcsec. For the certificate some actions were agreed upon.

2. Test Plan of the M1 in the cell

The test plan was discussed. It was agreed to carry out 2 test campaigns of the M1+cell : one putting the mirror in the right position on the pads (namely putting the pads of the cell exactly in the same position as during polishing, position angle PA=0°), another trying to create the least favourable position, i.e. putting the external pads exactly between subsequent right positions. This means the mirror was rotated in the cell clockwise of 15° (PA=15°.

It was suggested by Zeiss and agreed by the consultant and NRIAG representatives that this kind of test would have been more profitable than rotating the mirror of 90 ±30°.

It has also been agreed to use for the interferometric test a grid of size 34x34 instead of the size 20x20 reported in the contract. This higher resolution has the effect to produce

Action:

1. CZO/WT is to issue a formal Quality assurance certificate in English. Two originals for NRIAG, 1 for CZJ/AS.

2. Annexed internal documents in German will be translated into English

3. The included pictures for the K lenses on pages 23/24 will be provided as original photographs

4. The computer contour plots for the 6 measured azimuths will be provided in better quality and with the English terms for the Zernike coefficients (dictionary).

1/2 3D-plot
1/3 table with Zernike coefficients for 6 rotated positions
1/4 0 degr. contour-plot + Zernike coefficients
1/5 60 degr. contour-plot + Zernike coefficients
1/6 120 degr. contour-plot + Zernike coefficients
1/7 180 degr. contour-plot + Zernike coefficients
1/8 240 degr. contour-plot + Zernike coefficients
1/9 300 degr. contour-plot + Zernike coefficients

-02- Encircled energy of the KOTTAMIA primary **on machine support**

-03- Focal length of the KOTTAMIA primary

-04- Verification of the null corrector design and assembly
4/1 Verification procedure
4/2 Null-lens design
4/3 Lens protocol
4/4 Measured apex distance

-05- Topography of the sphere before starting of aspherisation
5/1 Contour-plot + Zernike coefficients
5/2 3D-plot

-06- Encircled energy of the sphere before starting of aspherisation

-07- Radius of the sphere before starting of aspherisation

-08- Blank certificate from Schott OT-0795473

-09- Measured weight of KOTTAMIA M_1

-10- Cleanliness of optical surface

-11- Influence of E-value tolerances

larger values of the diameter of the encircled energy E(80) than in the case 20x20 required by the contract.
This effect is clearly shown in figure 1, where the measured values of the encircled energy are plotted as a function of the grid size. The size of E(80) decreases lineary reducing the number of elements of the grid.
This means that is has been decided to perform a more careful and conservative analysis of the quality of the images than required in the contract.

Agreements, Statements

3. Contractual Matters

NRIAG asks to extend the Zeiss Bank guarantees according to the new schedule.

NRIAG stresses that no contract change will be possible which involves changes in the payment milestone definition.
I.e. the splitting of the acceptance milestone in Installation/Adjustment and tests on the sky is not accepted.

An English written report with original figures and tables on the test of M1 in the cell has to be provided by Zeiss before the next progress meeting to be held on May 13 in Jena.

4. Schedule

NRIAG stresses that any further extension of final accceptance after end of June is not acceptable. CZJ explains that the seeing expected in summer time and to little time after delivery of the M2 will make it virtually impossible to achieve the best results. However, every effort will be made, in order to have the telescope in a preliminary working condition by end of June. The final acceptance test will be carried out next September in the presence of the consultant. Details on the Test program and on the definition of goals shall be discussed during PM5 with NRIAG representatives and Prof. Rafanelli who will quite likely do some preliminary observations on the sky after 30 June 97.

The updated schedule was discussed and annexed. Progress Meeting 5(coating M1 plus cell acceptance) is now scheduled for 13/5/97. In addition a discuussion about test plan and the test procedure for M2 will be included. Prof. Rafanelli will attend This meeting.

The test of M2 and the detailed discussion of the mathematical combination with M1 have also to be collected with original figures and tables in an English written report. Details on this report will be discussed during the progress meeting of May 13.

Action:

5. CZJ is to extend the letter of guarantee in the amount of 10% of the contractual value until 30 Sep 97. Instructions to be given to MISR Bank Egypt, copy to NRIAG.

6.CZJ is to extend the performance bond until delivery (June 97). Instructions to be given to MISR Bank Egypt, cpopy to NRIAG.

7. Conditions and limitations on the use of the Telescope prior to final acceptance will be given in a separate document to be agreed upon between Zeiss, NRIAG and the consultant.

Agreements, Statements

5. Test of the Performance of the M1 in the cell

The first test campaign was performed, as mentioned above, locating the pads of the cell exactly in the same position as the pads were located during polishing. 24000 short exposure frames were recorded with the interferometer and reduced using the routines developed by Zeiss. The diameter of the encircled energy E(80) calculated in this way was 0.278 arcsec (34x 34 grid size).(fig.2)

The mirror was then rotated in the cell by 15° from the previous position clockwise and the measurements were performed in the same way recording 12000 short exposure frames. The calculated diameter of the encircled energy E(80) was 0.289 arcsec (grid size 34x34). (fig. 3)

It must be pointed out that both values are within the limits required by the contract for grid size 20x20.

Subsequently the position of the mirror and the cell were marked with black ink in the right position.

NRIAG representatives and their consultant were present at major parts of the test.

The results of the tests confirm that the final encircled energy of the optical train with the cell (M1+cell+M2) E(80) ≤ 0.35 arcsec will be reached quite easily.

Action:

8. The markings on the mirror are to be replaced by a permanent red marking.

Influence of different measuring grids

lateral resolution [Pixel /diameter]	diameter for encircled energy of 80% [arcsec] at fabrication support	[arcsec] at mirror cell
66	0,324	0,383
53	0,295	0,342
42	0,273	0,311
34	0,247	0,278
20 (extrapolated)	*0,22*	*0,24*

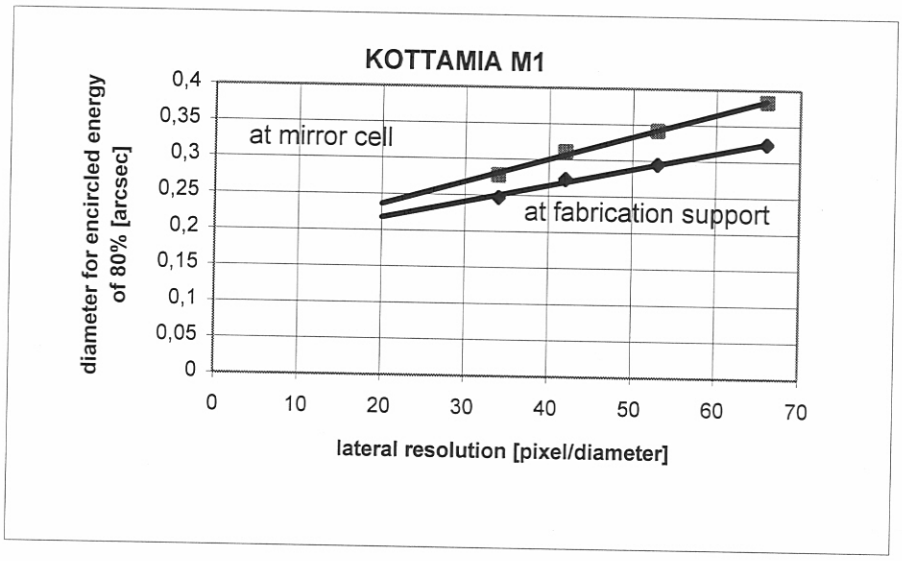
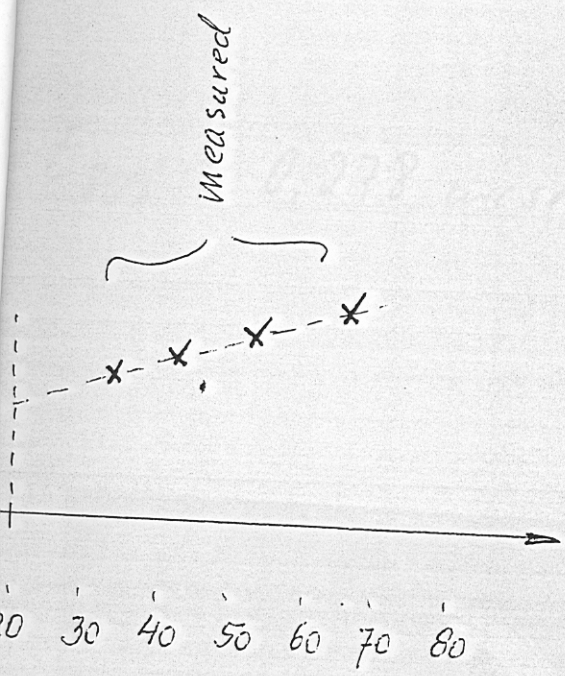


Fig. 1

P-TM / Slk
11.06.1997



30 40 50 60 70 80

lateral resolution [Pixel/diameter]

Fig. 1

Kottamia - M1 in the cell

11.4.97 after alignment in cell

34 x 34 matrix

$E_{80\%} = 0{,}278$ arcsec

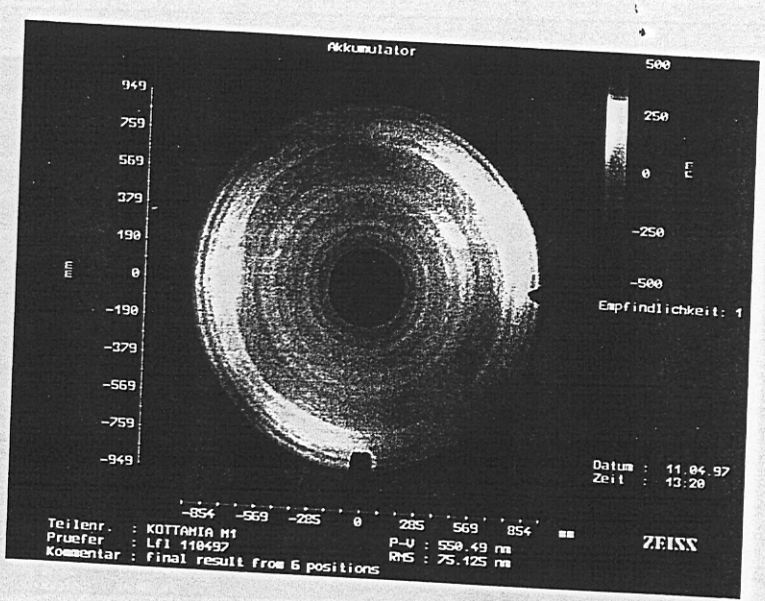


Fig. 2

Kottamia – M1 in the cell

10.4.97 / demo 34 x 34 matrix

$E_{80\%} = 0{,}289$ arcsec

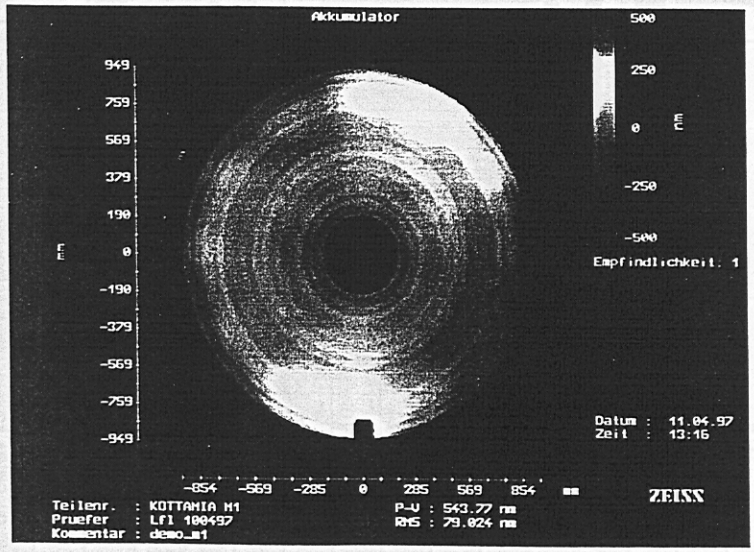


Fig. 3

		limit value	actual value
	Average number of inclusions per 100 cm^3	≤ 5	< 5
2.2	Inclusions in the critical volume		
	Maximum diameter of individual inclusions in mm	≤ 2	< 1
	Average number of inclusions per 100 cm^3	≤ 4	< 4
2.3	Bulk stress	compressive ≤ 10 nm/cm	- 1.5 nm/cm
3.	**Surface quality**		
	Concave surface	D76	D76
	plano side	D107	D76
	edge surfaces	D64	D64
4.	**Material properties**		
4.1.1	Mean coefficient of linear thermal expansion [10^{-06} K^{-1}]	0 ± 0.10	0.06
4.1.2	Homogeneity of the coefficient of thermal expansion [10^{-06} K^{-1}]	≤ 0.02	0.01

2-01- Topography of the KOTTAMIA primary
in modified cell at PA = 0^0

- 2-1/1 Contour-plot + Zernike coefficients
- 2-1/2 3D-plot
- 2-1/3 table with Zernike coefficients for 6 rotated positions
- 2-1/4 0 degr. contour-plot + Zernike coefficients
- 2-1/5 60 degr. contour-plot + Zernike coefficients
- 2-1/6 120 degr. contour-plot + Zernike coefficients
- 2-1/7 180 degr. contour-plot + Zernike coefficients
- 2-1/8 240 degr. contour-plot + Zernike coefficients
- 2-1/9 300 degr. contour-plot + Zernike coefficients

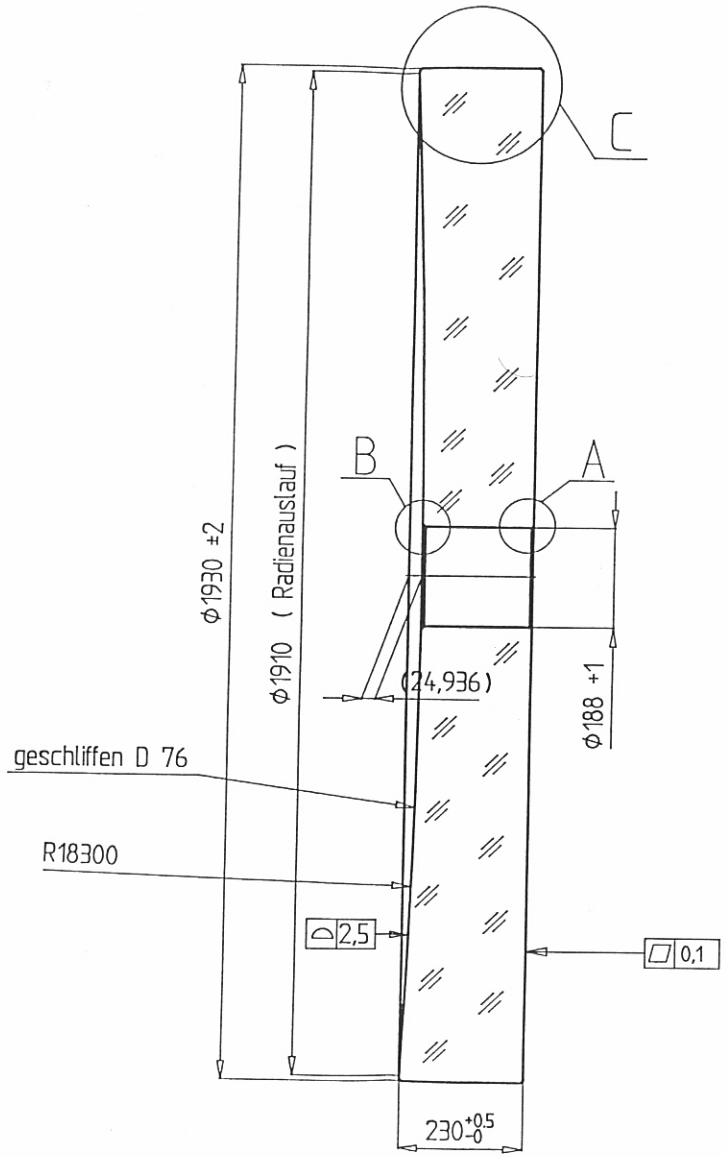
2-02- Encircled energy of the KOTTAMIA primary
in modified cell at PA = 0^0

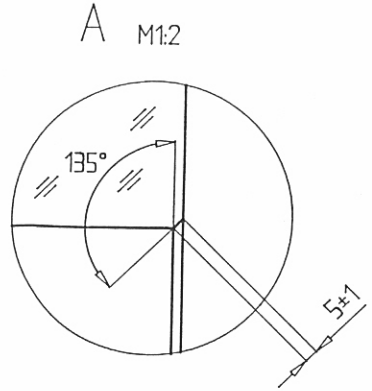
3-01- Topography of the KOTTAMIA primary
in modified cell at PA = 15^0

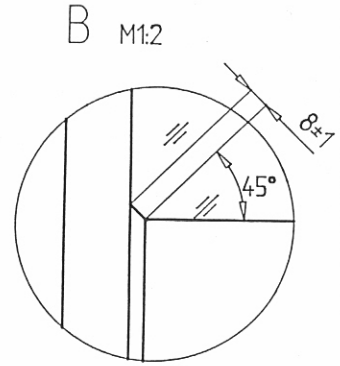
- 3-1/1 Contour-plot + Zernike coefficients
- 3-1/2 3D-plot
- 3-1/3 table with Zernike coefficients for 6 rotated positions
- 3-1/4 0 degr. contour-plot + Zernike coefficients
- 3-1/5 60 degr. contour-plot + Zernike coefficients
- 3-1/6 120 degr. contour-plot + Zernike coefficients
- 3-1/7 180 degr. contour-plot + Zernike coefficients
- 3-1/8 240 degr. contour-plot + Zernike coefficients
- 3-1/9 300 degr. contour-plot + Zernike coefficients

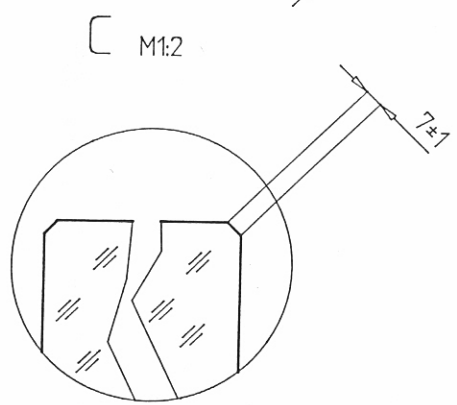
3-02- Encircled energy of the KOTTAMIA primary
in modified cell at PA = 15^0

4 Minutes of Meeting 10.4.97 to 12.4.97 in Oberkochen









hierzu Spez. TSD 0135.28 Rev. C

Zust.	Änderung	Datum	Name	GS	m Datum				

Geprüft auf Gerätesicherheit: Sicherheitsstufe: S

Oberflächenbehandlung

+0,5 +0,1 / +0,2 +0,5 DIN 6784

zul. Abw. mittel DIN 7168

Oberfläche DIN ISO 1302

Klassifizierungsschlüssel

Maßstab 1:10

Zerodur

	Datum	Name
Bearb.	21.7.	Heilem
Gepr.		
Scha.		
Norm		

Konstr.-Gr. ASTRO

CARL ZEISS JENA

Primary mirror

161499:004.07 (3)

Bl. von

Ers für | Ers durch

CZJ 55003

Introduction and summary of results.

Three test campaigns have been performed with the **1,88 m Primary Mirror Kottamia.**

First was the M_1 supported on the machine table with the position angle PA = 0^0. The mirror was measured in 6 different rotational positions relative to the interferometrical setup. The phase maps have been rotated back to the original position of the mirror and have been averaged. Thisway all interferometric and testtower influences could be eliminated. About 6x2000 frames have been taken. For a grid size of 34x34 the diameter of the encircled energy turned out to be :

$E_{80\%}$ within 0,247 arc.sec. dia.

Second the mirror M_1 was put into its modified cell in the angular position PA = 0^0 and 6x4000 frames were taken and averaged. For a grid size of 34x34 the diameter of the encircled energy turned out to be :

$E_{80\%}$ within 0,278 arc.sec. dia.

This optimum position is marked in the cell.
Third the mirror M_1 was rotated in its modified cell to the angular position PA = 15^0 to create the least favourable position and again 6x2000 frames were taken and averaged. For a grid size of 34x34 the diameter of the encircled energy turned out to be :

$E_{80\%}$ within 0,289 arc.sec. dia.

It must be pointed out that all results are well within the limits required by the contract.

The Minutes of Meeting from 10.4.97 to 12.4.97 which had been approved and signed by all participants of this test campaign should be a reference to this document. (App. 4)

1. Requirements and results

The requirement concerning the Kottamia primary was defined as follows:

The encircled energy concentration of the wavefront has to be less than 0.35 arcsec for an amount of 80%
with grid size 20x20:

$$E_{80\%} < 0.35 \text{ arcsec dia}$$

During final testing of the Kottamia primary the following results have been obtained:

encircled energy concentration :

$$E_{80\%} = \mathbf{0.247 \text{ arcsec dia}}$$

with grid size 34x34
mirror supported on machine table

focal length : **f = 9138.4 mm +/- 1mm**

2. Blank acceptance at Schott

The acceptance of the 1,88m Primary blank took place at the 24th of July 1995 in Mainz at the Schott plant.The pictures show the happy customers and the people from Schott and ZEISS.
The high ZERODUR quality is listed in the Schott documents which are included in the blank certificate OT -0795473 from Schott .
(added in Appendix -8-)

appendix 9

Measured weight of Kottamia 1,88m Primary M1

Blank acceptance at Schott in Mainz July 24th 1996

from left to right:

Köhler, Heilemann, Dr. Anas Osman, Prof. Hassan Sobhy, Prof. Hanafi Deebes, Knapp, Ibrahim Ghafar, Knohl

from left to right:

Köhler, Heilemann, Dr. Anas Osman, Prof. Hassan Sobhy, Prof. Hanafi Deebes, Knapp, Ibrahim Ghafar

2Øm Primary Kottamia

Wiegen des 2.0m Kottamia-Spiegels

Ort: Astro-Halle Bau 1/a
Datum: 20.3.1996 10 15 Uhr
anwesend: Heiko Bäuerle, Willi Bäuerle, Erdmann, Knh

Messgerät: Kranwaage TIGRIP
ZEISS Nr. 2700902
DK.Nr. 3884
ID.Nr. 26438 LMB Nr. 91010791
TYP TKS Bj.: 01.04.1991
Tragfähigkeit 2,5 to

Hersteller: Schmidt,Kranz & Co. GmbH
3425 Walkenried
Tel. 05525/201-0

Prüfgenauigkeit: +0,2%

Messvorgang:		digitale Anzeige
1.)	Waage + Schekel nullen	000 kg
2.)	Aushebevorrichtung	101 kg
3.)	Spiegel + Aushebevorrichtung	1701 kg
4.)	Aushebevorrichtung	101 kg
5.)	Waage + Schekel	000 kg

Spiegelgewicht: **1600 kg - 5kg**

Bestätigung der Messung
Oberkochen, den 22.3.1996

Dipl.Ing. E.-D. Knohl
CARL ZEISS
Abt. Weltraumtechnik

In front of the ZERODUR-blank

from left to right:

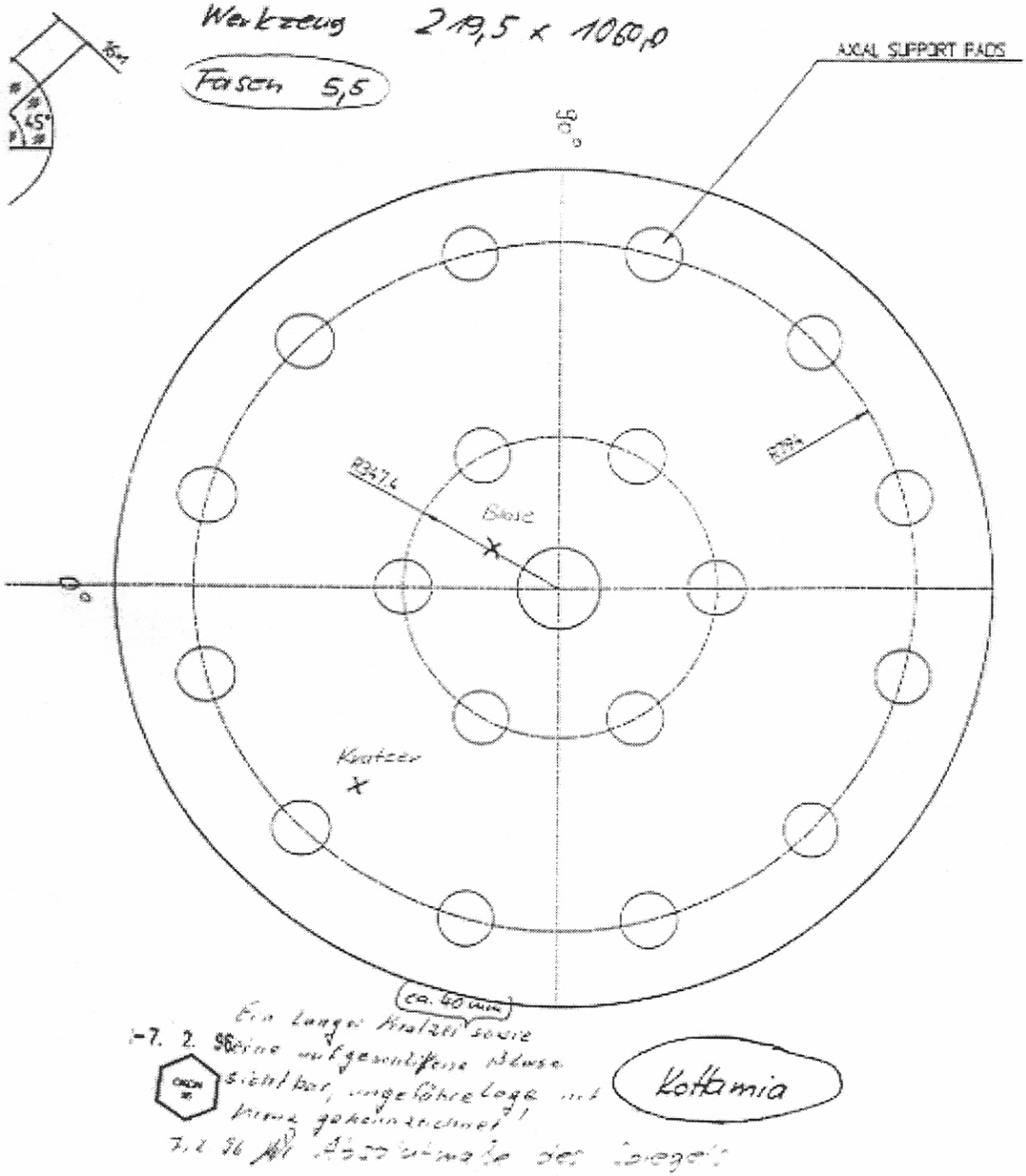
Dr. Anas Osman, Prof.Hanafi Deebes, Knapp, Prof.Hassan Sobhy, Knohl

from left to right:

Ibrahim Ghafar, Dr.Anas Osman, Prof.Hanafi Deebes, Knapp, Prof.Hassan Sobhy, Köhler

appendix 10

Cleanliness of optical surface



3. Test philosophy

In order to control the polishing process and in order to verify the optical quality of the KOTTAMIA primary we applied interferometry. As the result we obtained the wavefront error due to the mirror shape.
The calculation of the encircled energy has been based on the measured wavefront. If we have a very high accuracy during interferometry, the calculation of the encircled energy is very precise too.
In order to evaluate the focal length we measured the E-value. (The E-value is the distance between the vertex of the primary and the vertex of the null corrector lens).

4. Interferometrical testing

Optical setup

For interferometrical testing of the KOTTAMIA primary a vibration isolated optical table was situated close to the center of curvature at a height of about 15m above the mirror. At the table the complete interferometrical setup of Twyman-Green type was erected and adjusted. As the light source a HeNe-type laser was applied. The measuring wavelength was 633 nm. The used CCD-camera was connected to the host computer, where phase evaluation was performed.

For alignment of the interferometrical setup with respect to the mirror the optical table and one folding mirror was adjustable.

Null Corrector

Because the primary under test is the autocollimation mirror and the shape of the primary is of aspherical (parabolic) type, a Null corrector (designed for the Kottamia primary) producing the parabolic wavefront was used for interferometrical testing.