



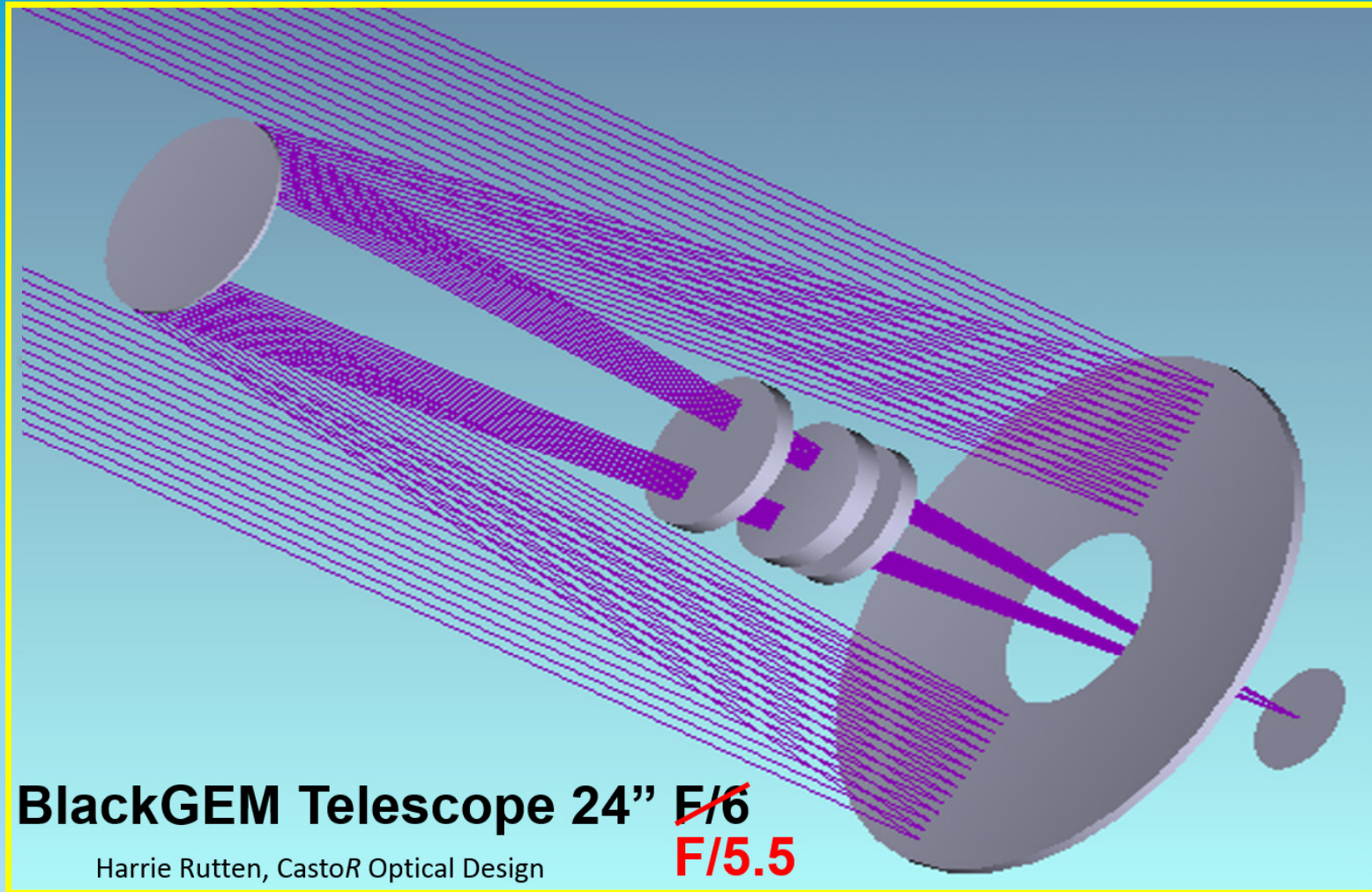
De BlackGEM telescoop

Opticadag 9 maart 2019 – TNO Delft

Harrie Rutten



BlackGEM Telescope 24" F/6 → F/5.5

Opticadag
9 maart 2019
TNO – Delft

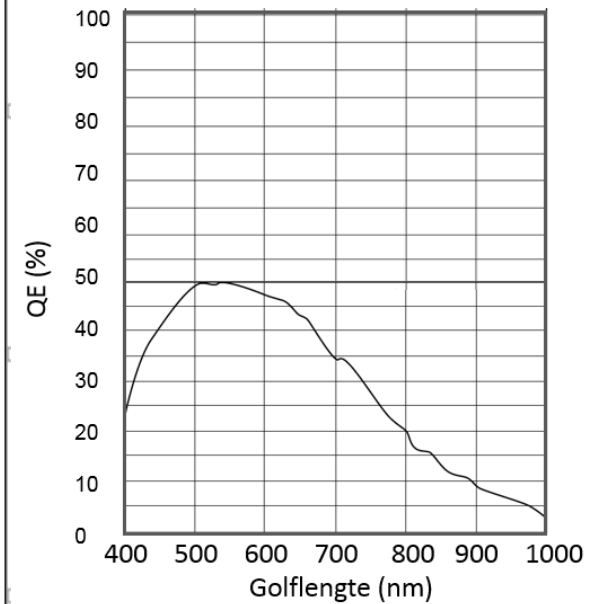
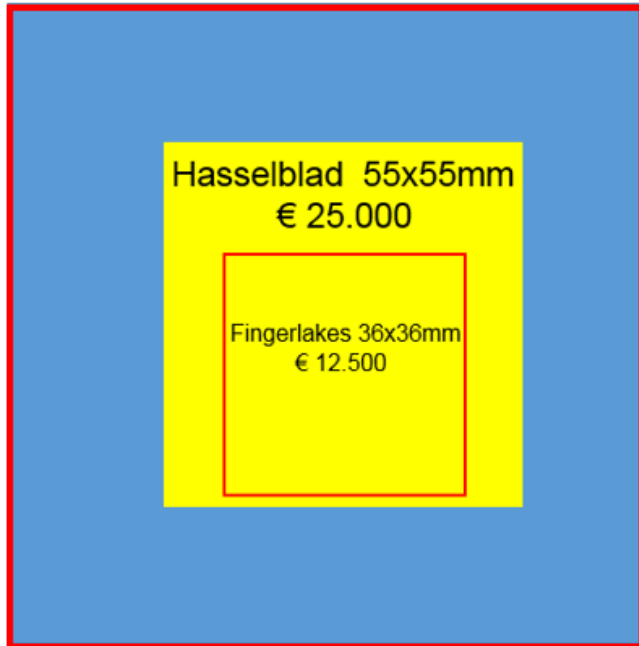


BlackGEM Telescope 24" F/6 → F/5.5

Gewijzigde Basiseisen (het ontwerp was helemaal klaar):

- Apertuur: min. 600 mm
- Pixel schaal ~ 16 $\mu\text{m}.\text{arcsec}^{-1}$ \Rightarrow F ~3300 mm was 17 $\mu\text{m}.\text{arcsec}^{-1}$, resp.3600 mm
- Vlak veld 95 x 95 mm (10k x 10k à 9.5 μm px) was 90x90 mm, 10 μm
- Spectrale bandbreedte 350 – 990 nm was 400-900, wens 350-990 nm
- Gebruik van Sloan filters set (u, g , r, i en z)
- ADC was geen ADC
- TIPP TILT M2 was geen TT
- 10 nm H α - filter
- m = 23 in 5 minuten
- [athermaal]
- [parfocaal]
- [obstructie A-36%  , L-60% ]

BlackGEM Telescope 24" F/6 → F/5.5



SURFACE IMA: BEELDVLAK

FULL FIELD SPOT DIAGRAM

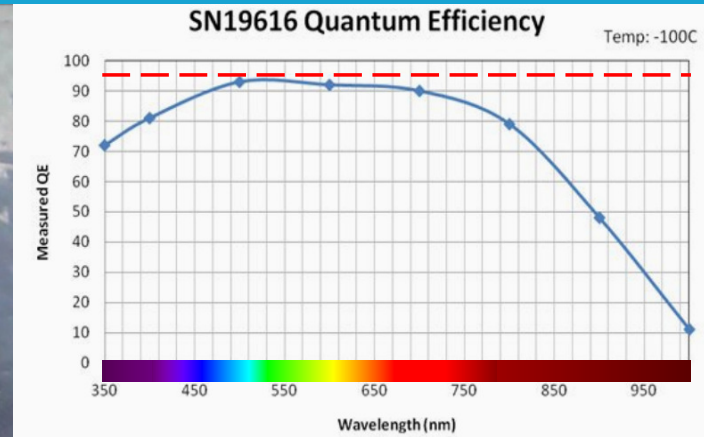
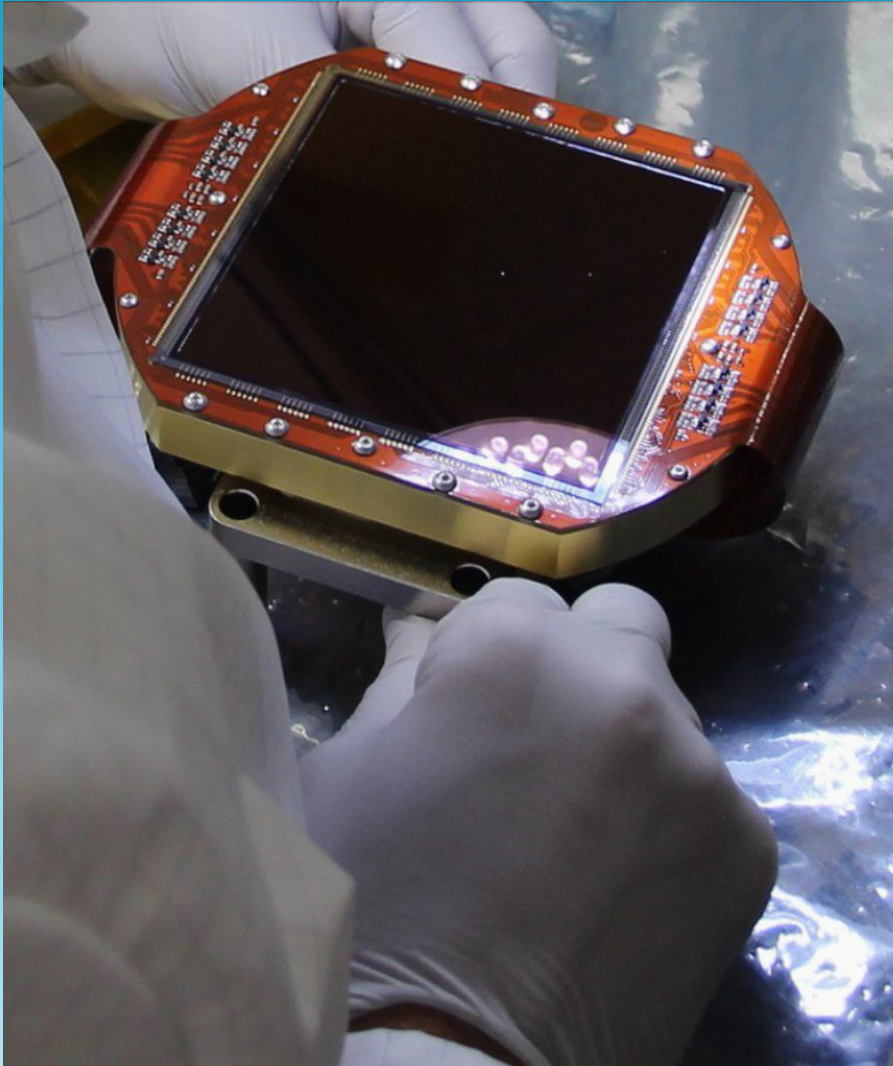
BLACK GEM TELESCOPE 24" F/6
24-12-2012

C A S T O R OPTICAL DESIGN
HARRIE G.J. RUTTEN
ARJEN - THE NETHERLANDS
CUSTOM ASTRONOMICAL OPTICS

De chip 95 x 95 mm, dure vergelijking
QE ~ 50%

BlackGEM Telescope 24" F/6 → F/5.5

Opticadag
9 maart 2019
TNO – Delft



BlackGEM Telescope 24" F/6 → F/5.5

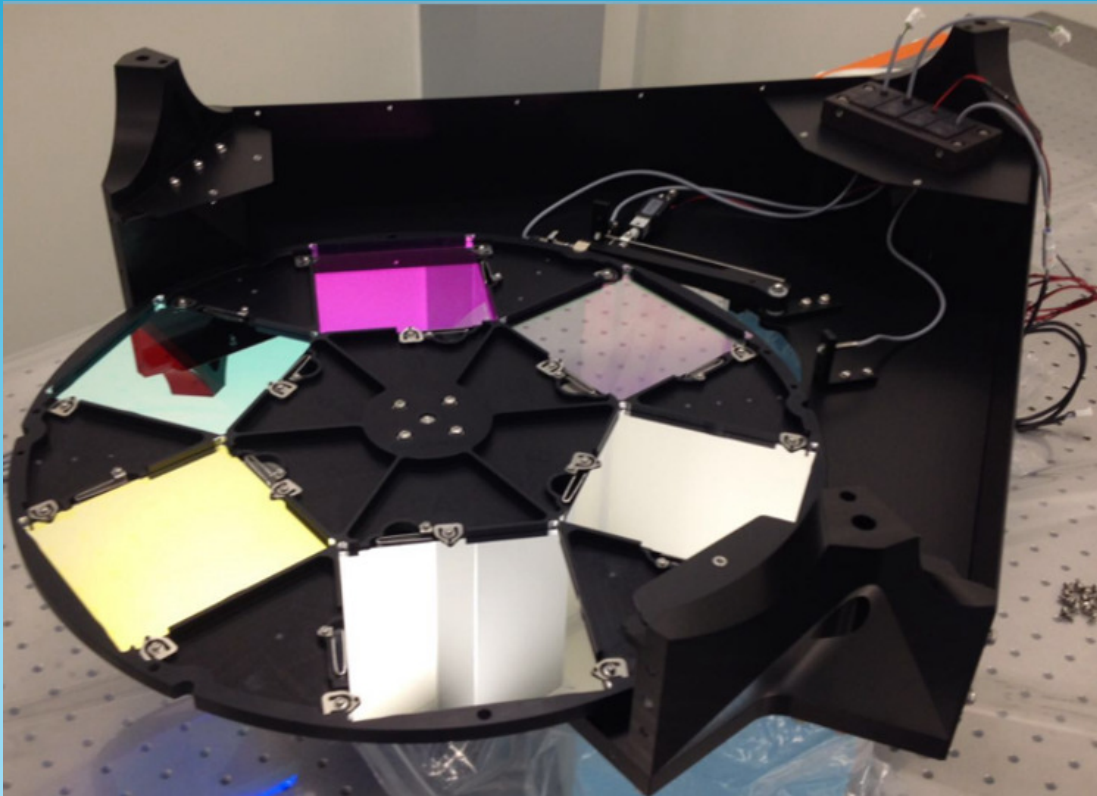
Opticadag
9 maart 2019
TNO – Delft

Wat nog meer?

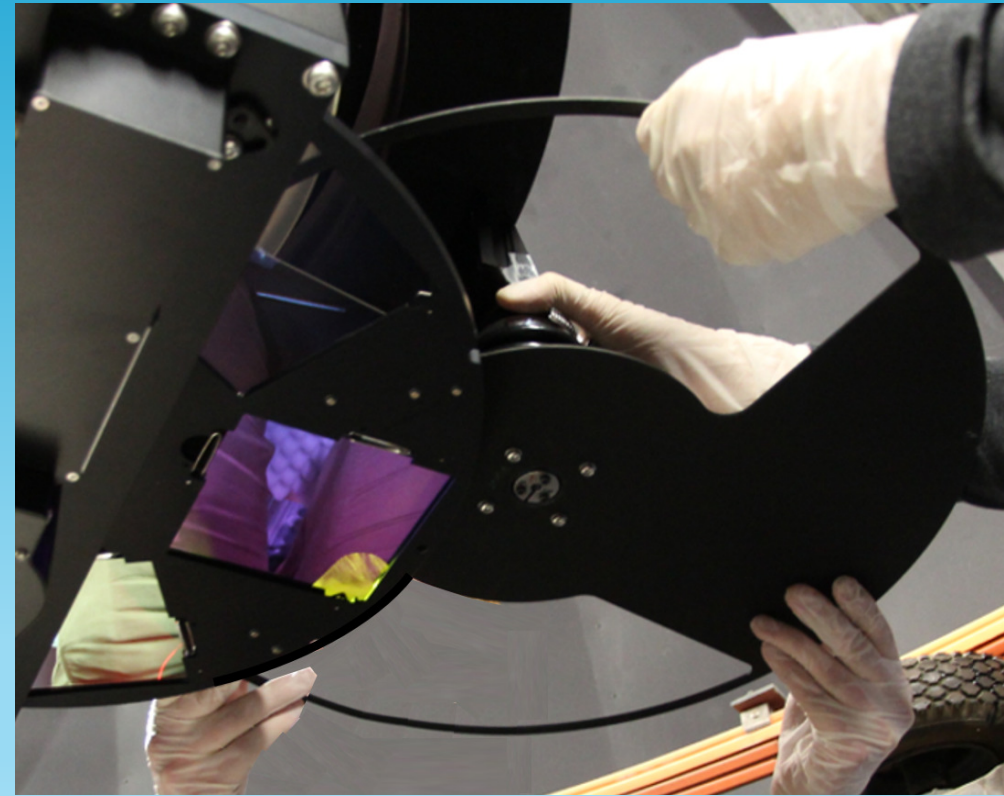
Hoogvacuumaggregaat

Chipkoeling op -100°C

En natuurlijk ook:

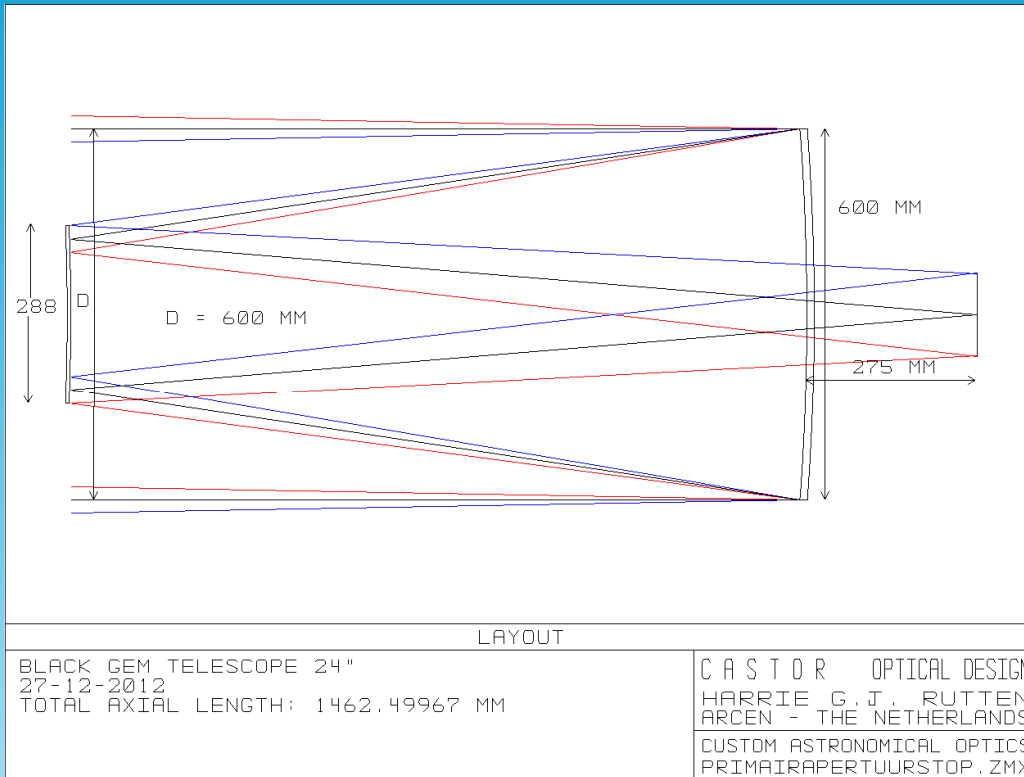


Filterwiel, 6 Astrodon Filters \square 135 mm, Egaliteit \sim 1%



Sluiter, elk pixel zelfde belichtingstijd

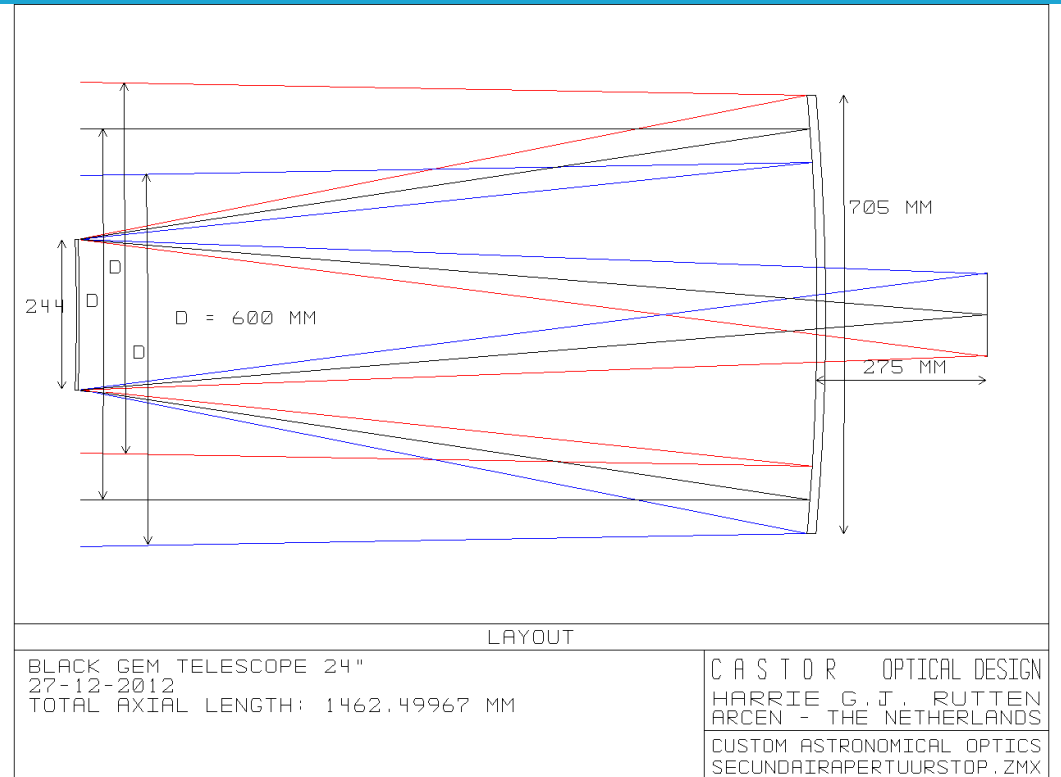
BlackGEM Telescope 24" F/6 → F/5.5



Apertuur bij primaire spiegel

L – 48% (A – 23%)

netto obstructie



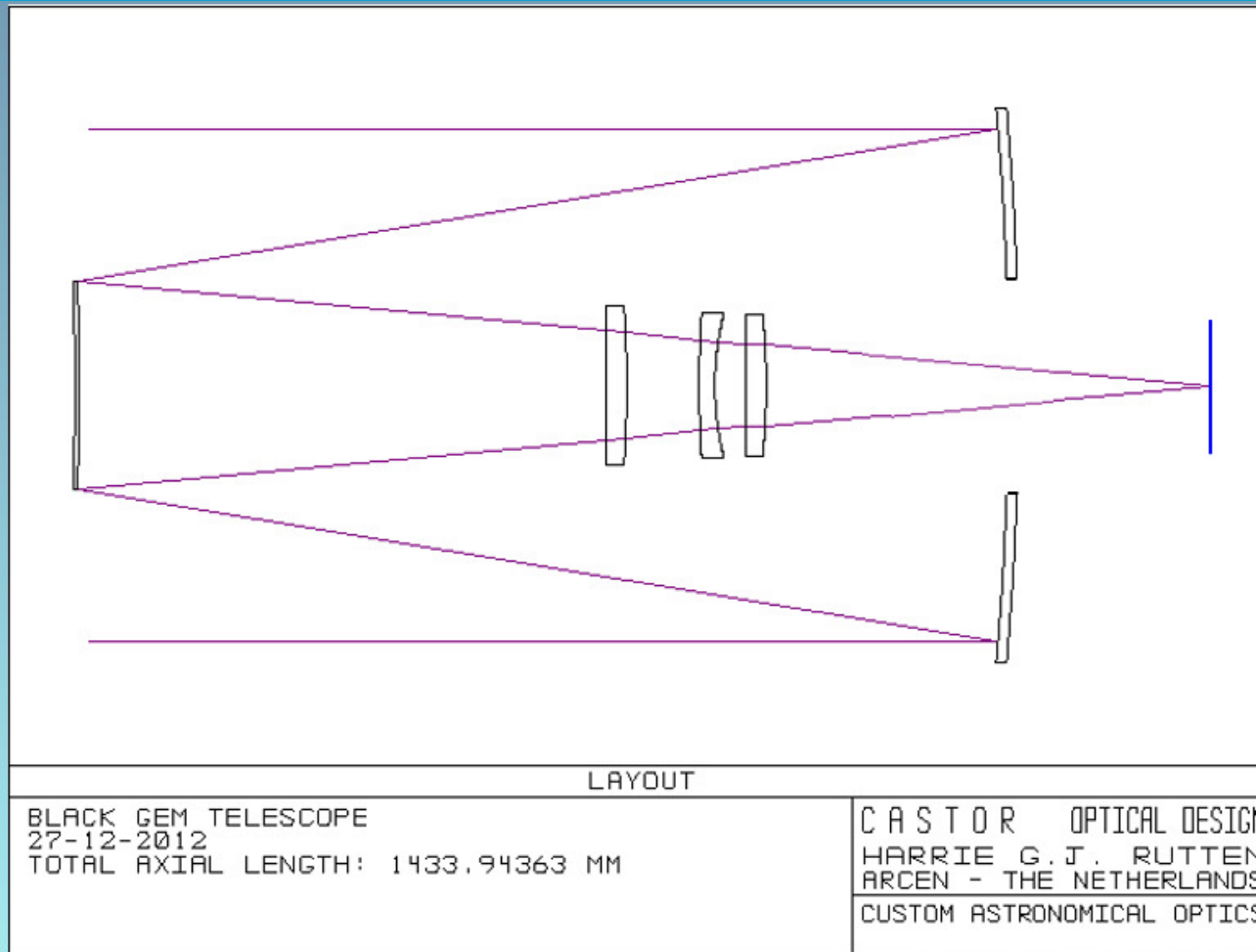
Apertuur bij secundaire spiegel

L – 40,5% (A – 16,5%)

Invloed van de positie van de apertuurstop op de obstructie

BlackGEM Telescope 24" F/6 → F/5.5

Opticadag
9 maart 2019
TNO – Delft

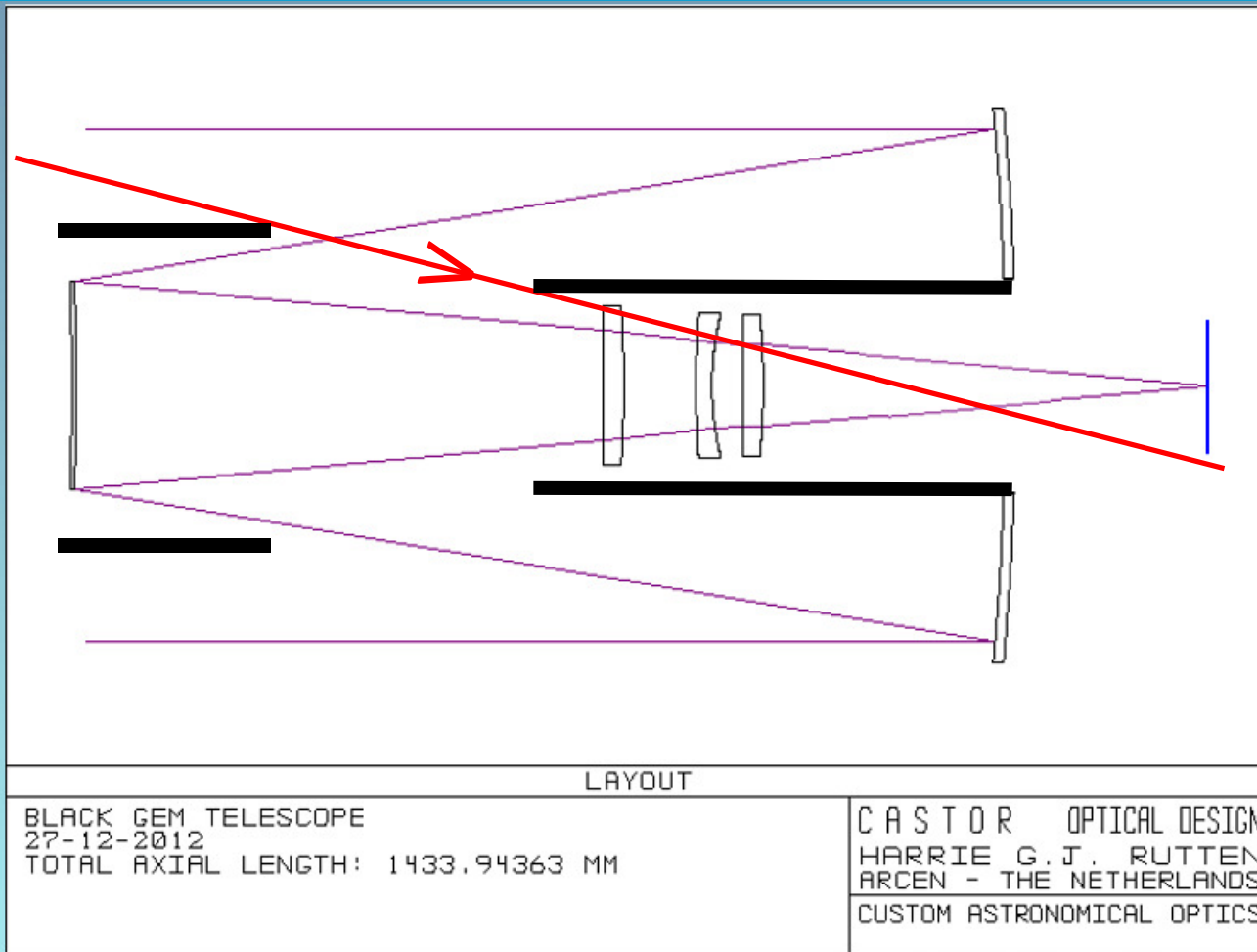


Het uiteindelijke ontwerp

3 lens – zelfde glassoorten, zelfs zelfde smelt

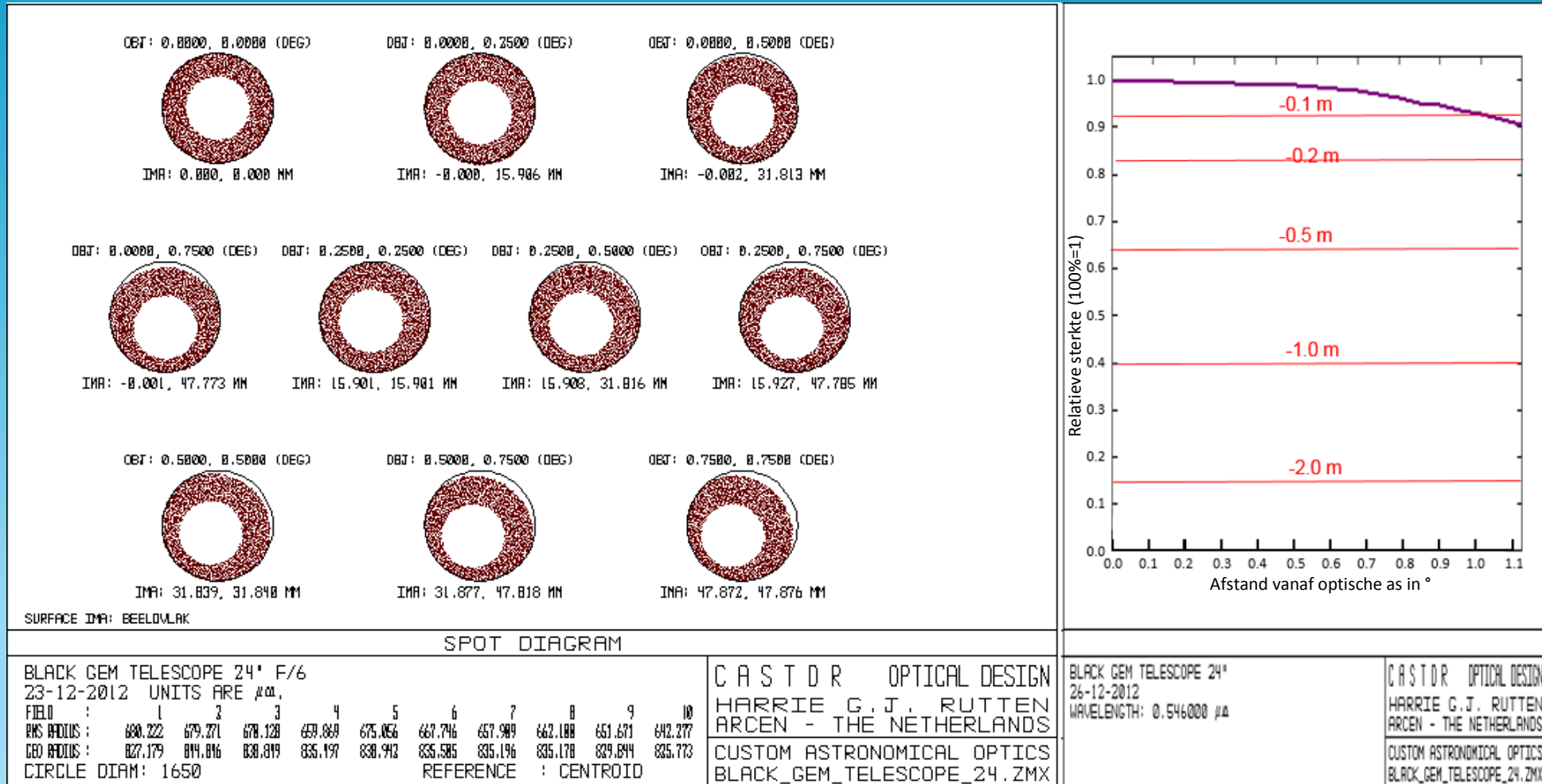
BlackGEM Telescope 24" F/6 → F/5.5

Opticadag
9 maart 2019
TNO – Delft



Het baffle systeem
met corrector

BlackGEM Telescope 24" F/6 → F/5.5



Illuminantie veld

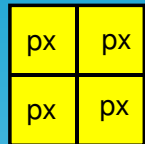
BlackGEM Telescope 24" F/6 → F/5.5

Opticadag
9 maart 2019
TNO – Delft

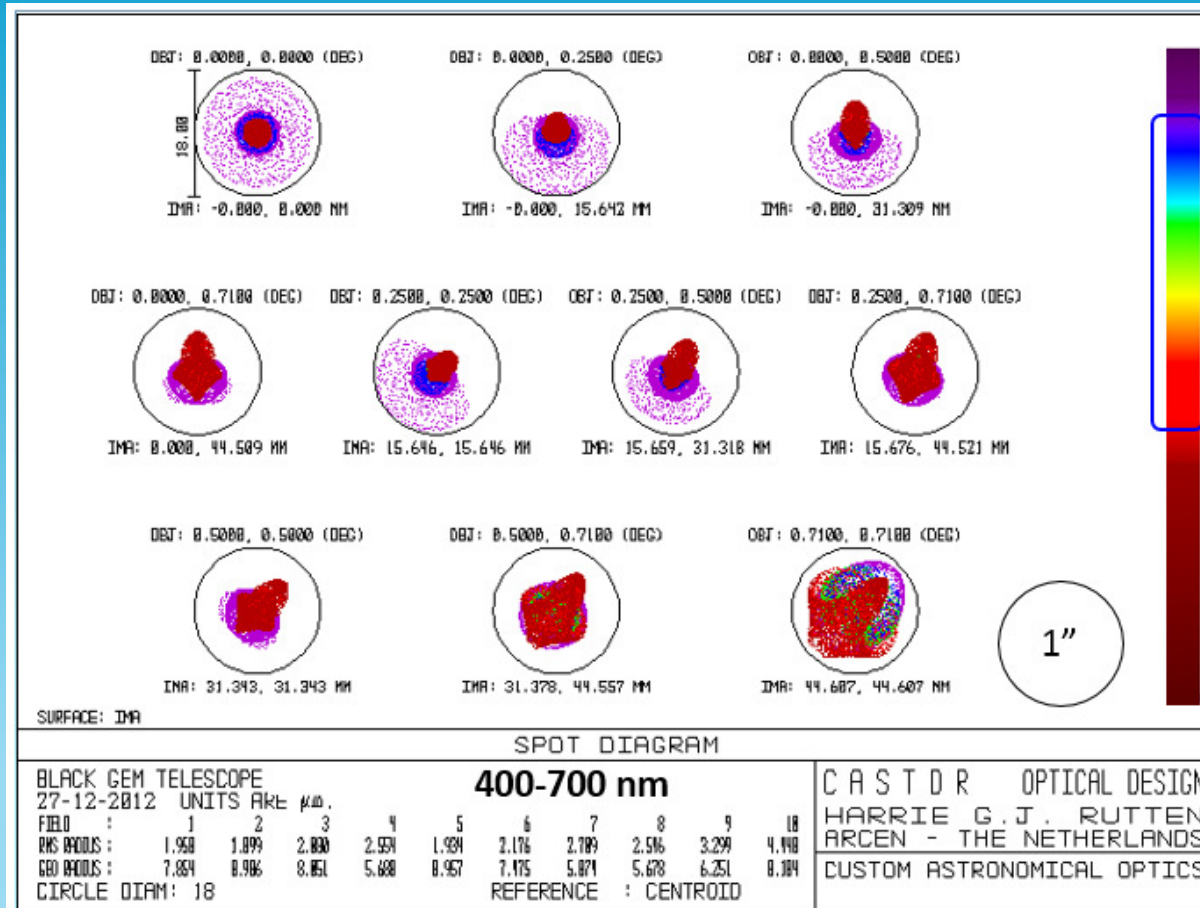


Het gezichtsveld voor de 60 cm F/5,5

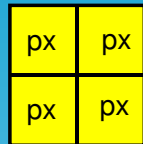
BlackGEM Telescope 24" F/6 → F/5.5



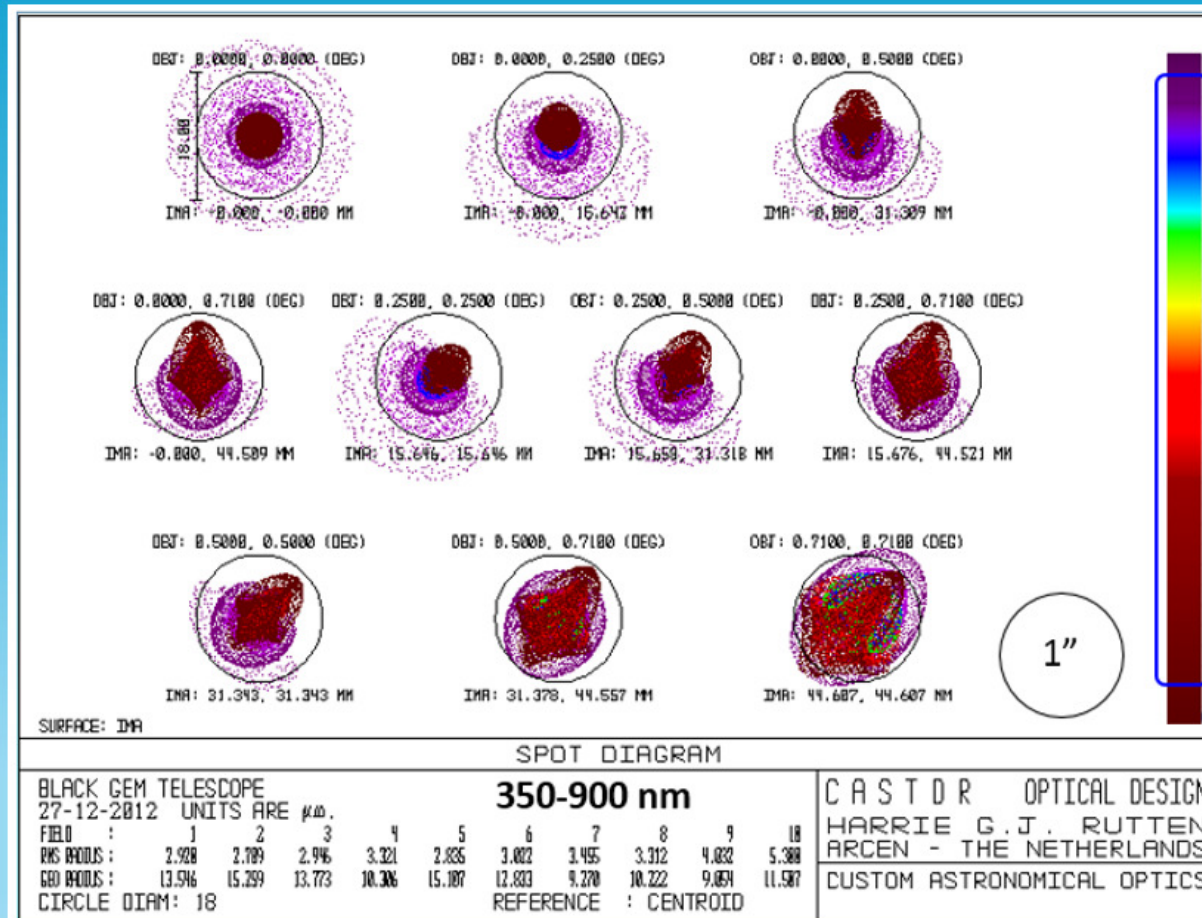
Pixel \square
9,5 μ m



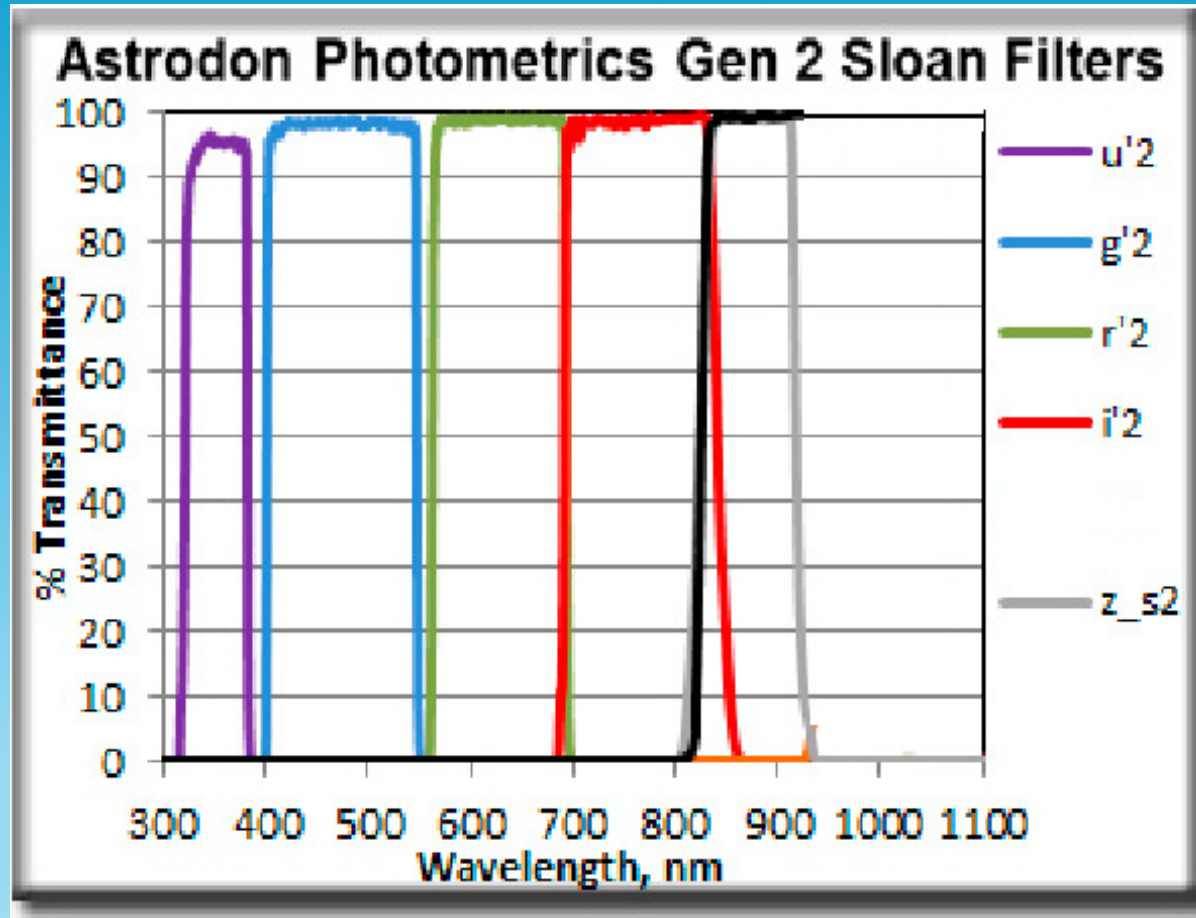
BlackGEM Telescope 24" F/6 → F/5.5



Pixel \square
9,5 μ m



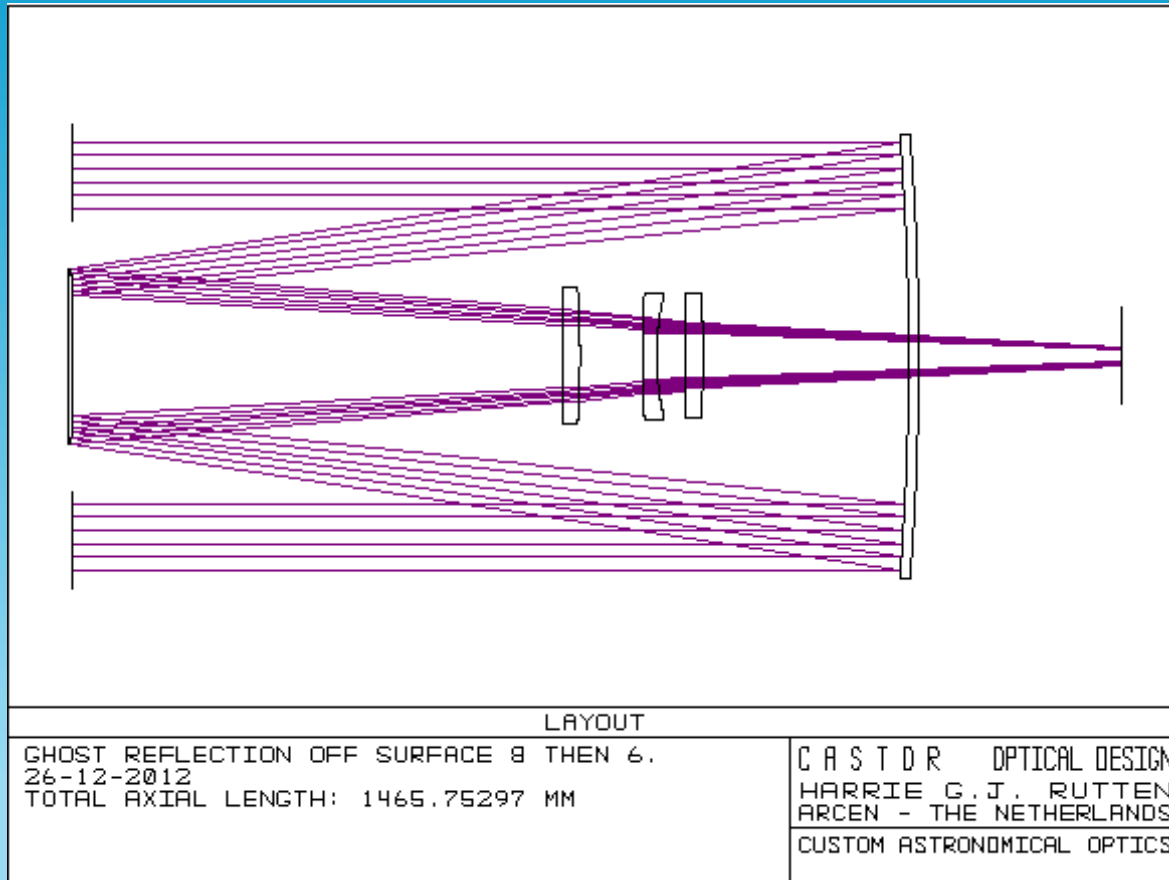
BlackGEM Telescope 24" F/6 → F/5.5



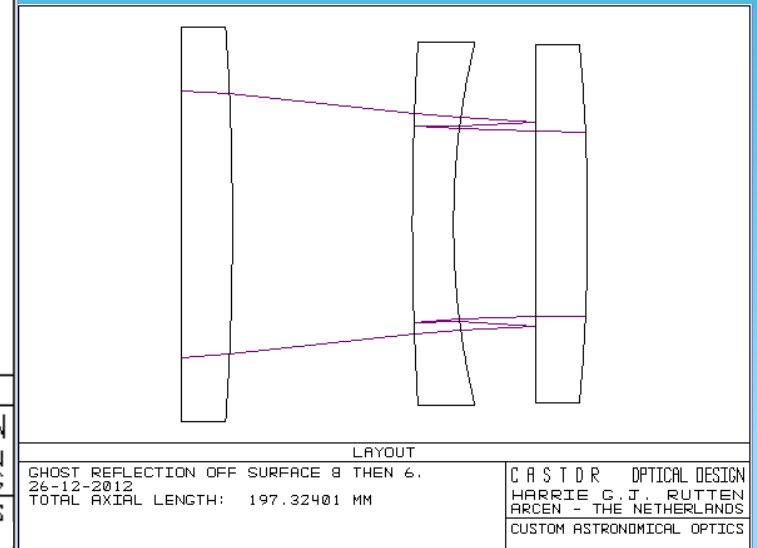
Sloan filters bij de berekeningen
incl. silica, excl. AR-coatings

BlackGEM Telescope 24" F/6 → F/5.5

Opticadag
9 maart 2019
TNO – Delft



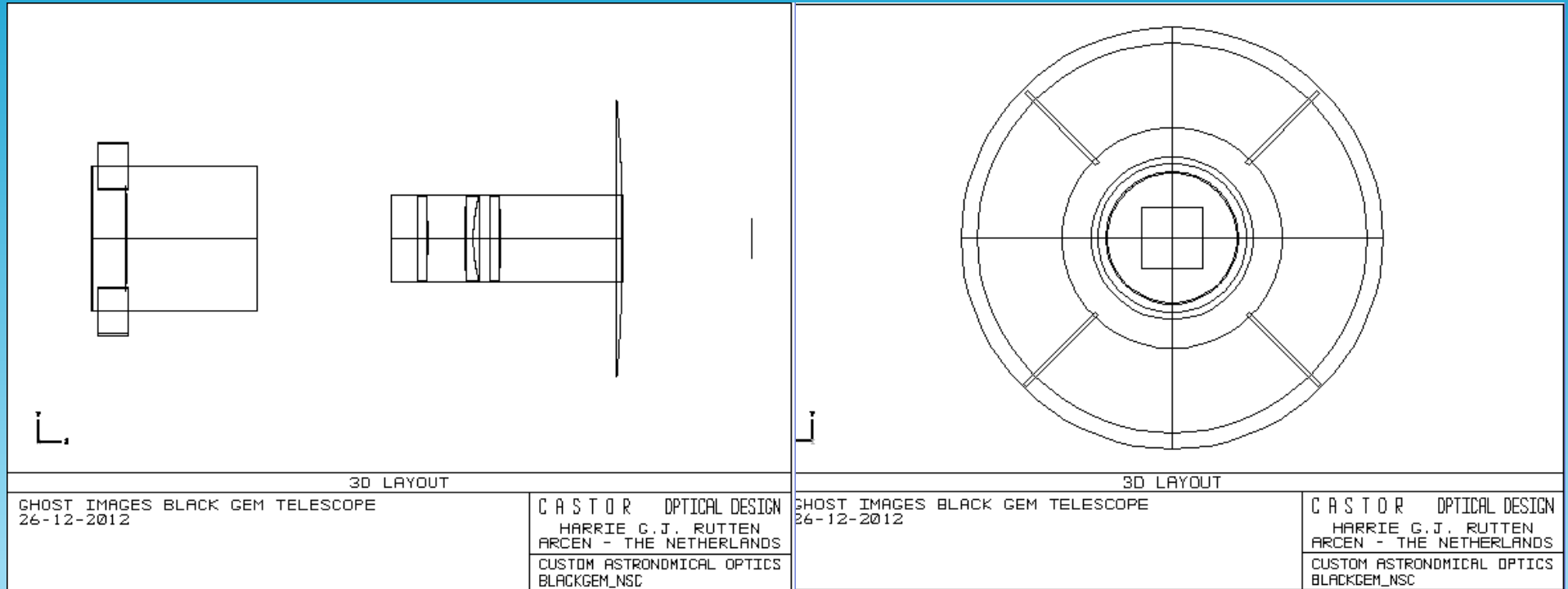
Spookbeelden



Worst Case Ghosting

BlackGEM Telescope 24" F/6 → F/5.5

Opticadag
9 maart 2019
TNO – Delft

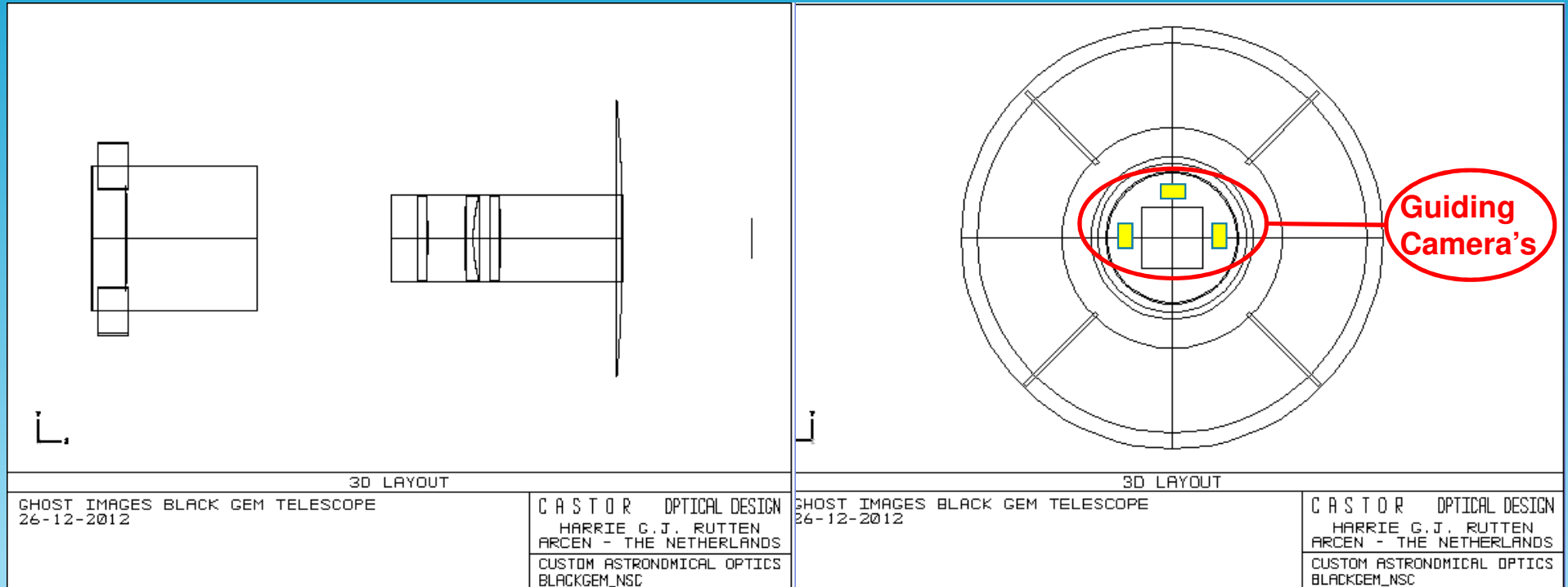


Gebruikte geometrie brekening irradiantie van de CCD

- ongecoate refractieve optiek
- volledig absorberende mechanica

BlackGEM Telescope 24" F/6 → F/5.5

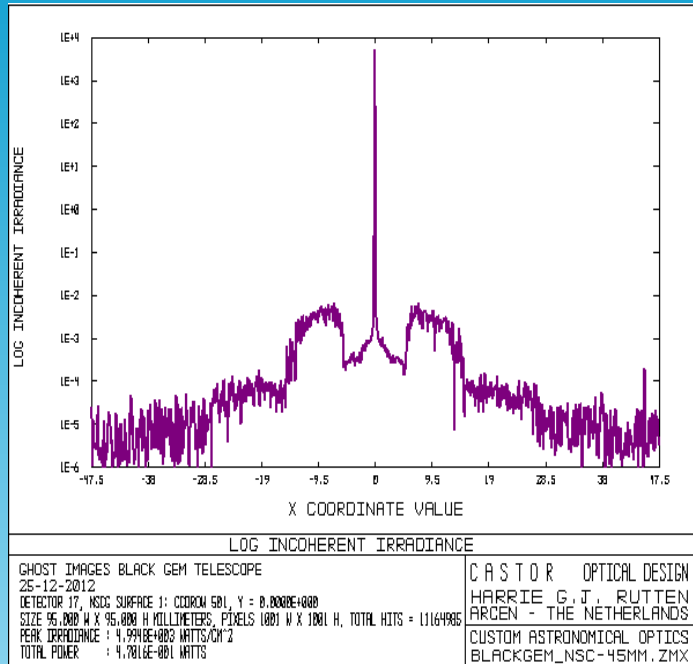
Opticadag
9 maart 2019
TNO – Delft



Gebuikte geometrie brekening irradiantie van de CCD

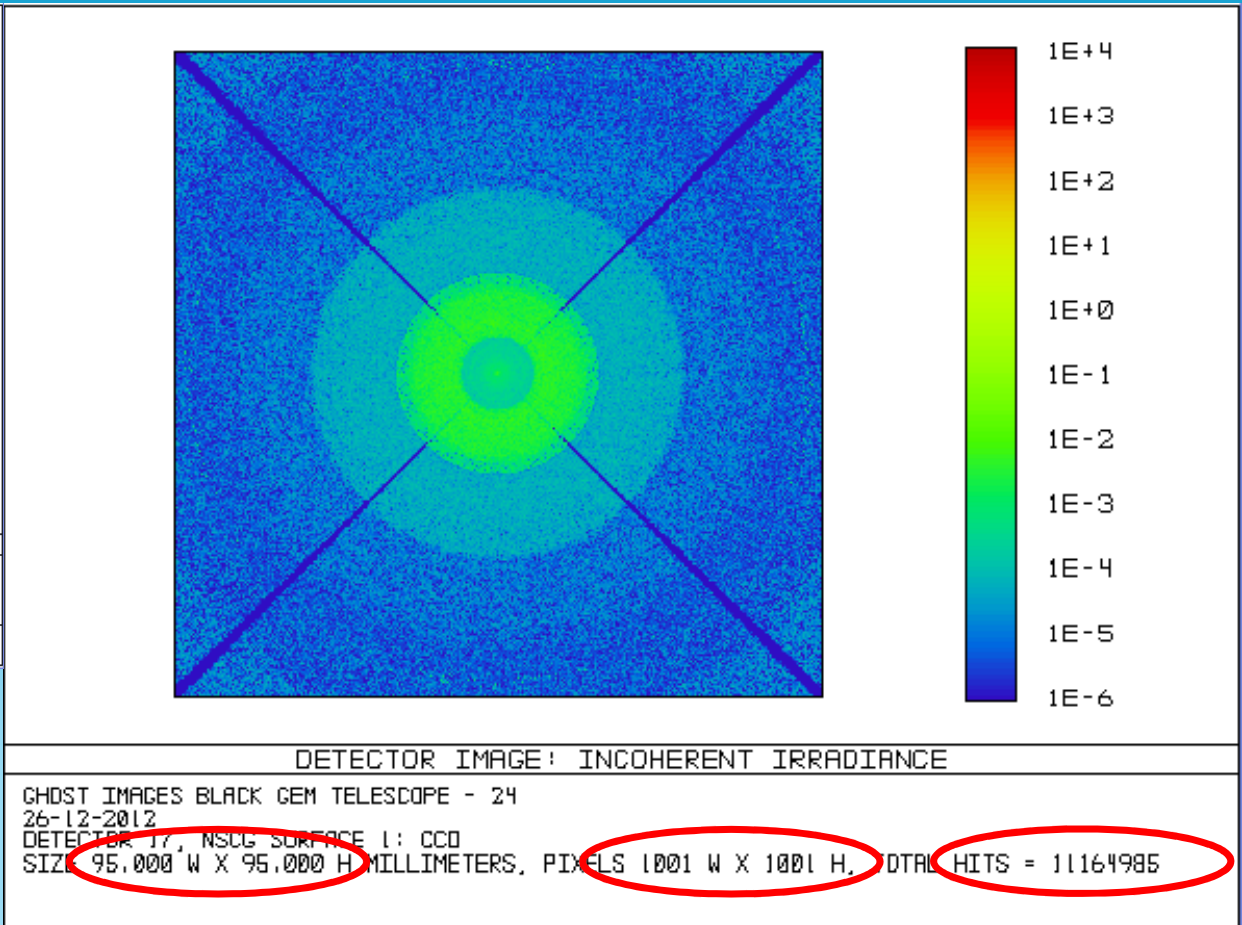
- ongecoate refractieve optiek
- volledig absorberende mechanica

BlackGEM Telescope 24" F/6 → F/5.5

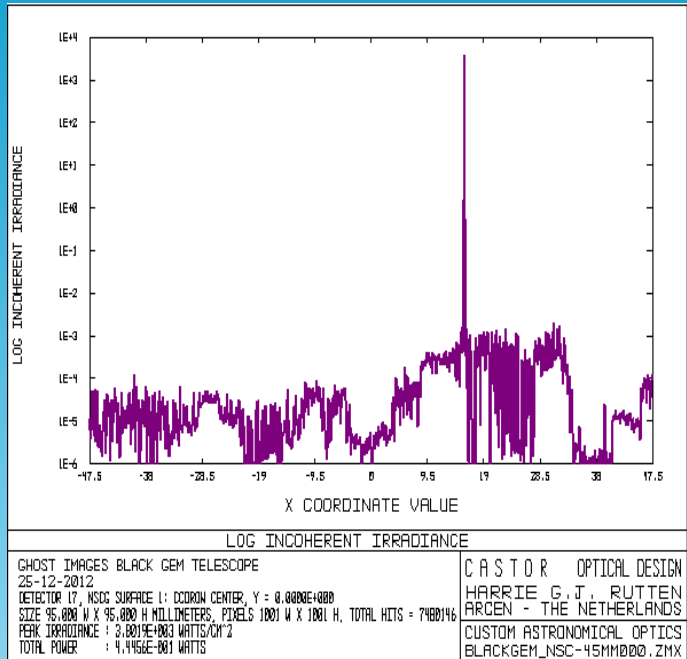


Axiaal spookbeeld

(let op log. schaal)

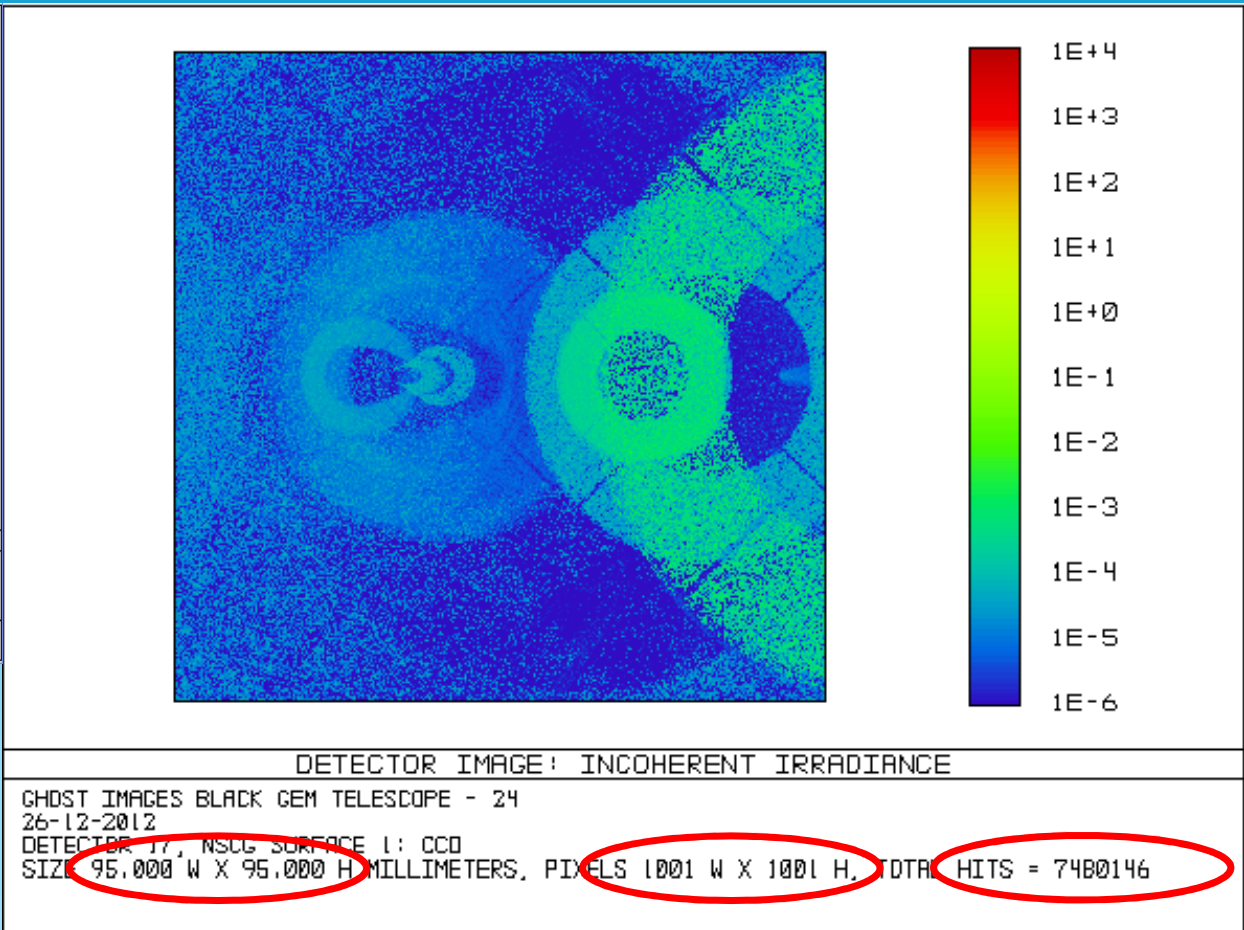


BlackGEM Telescope 24" F/6 → F/5.5



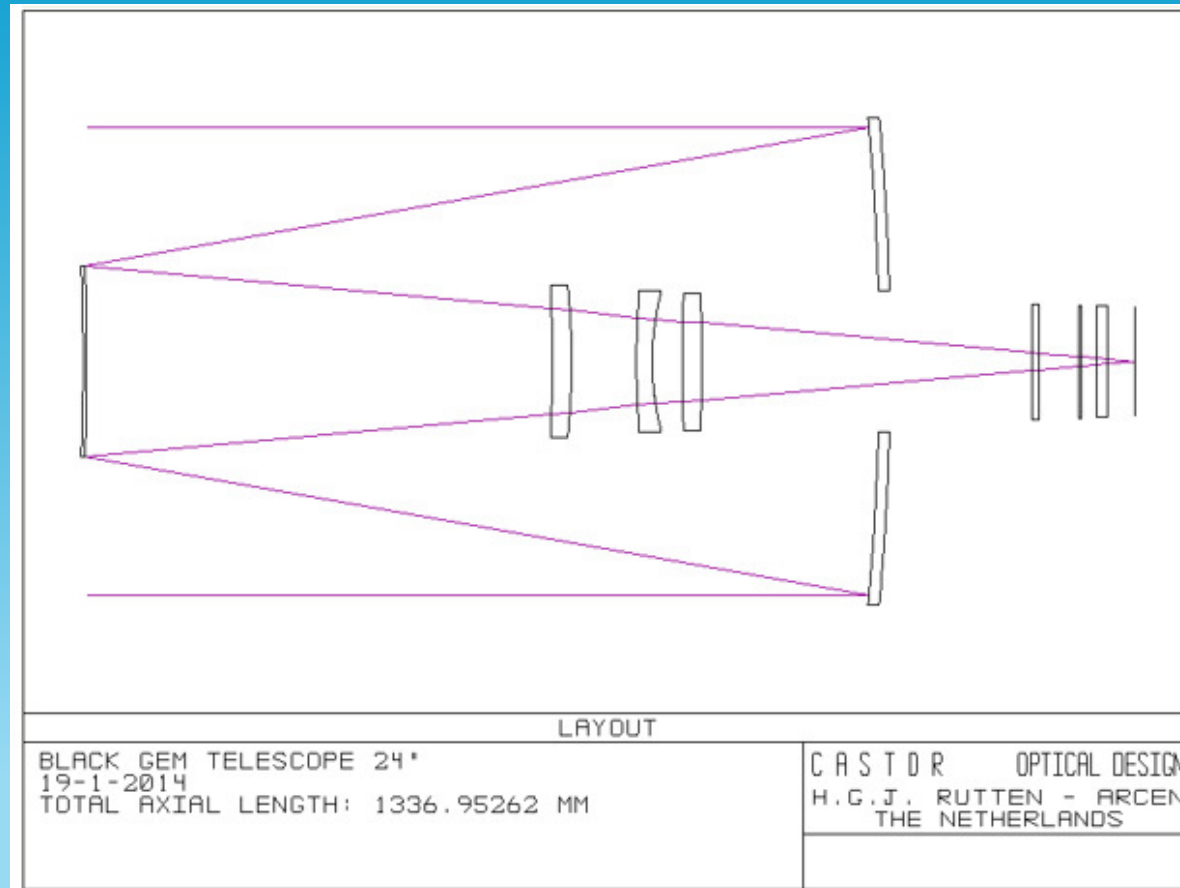
0,25° spookbeeld

(let op log. schaal)



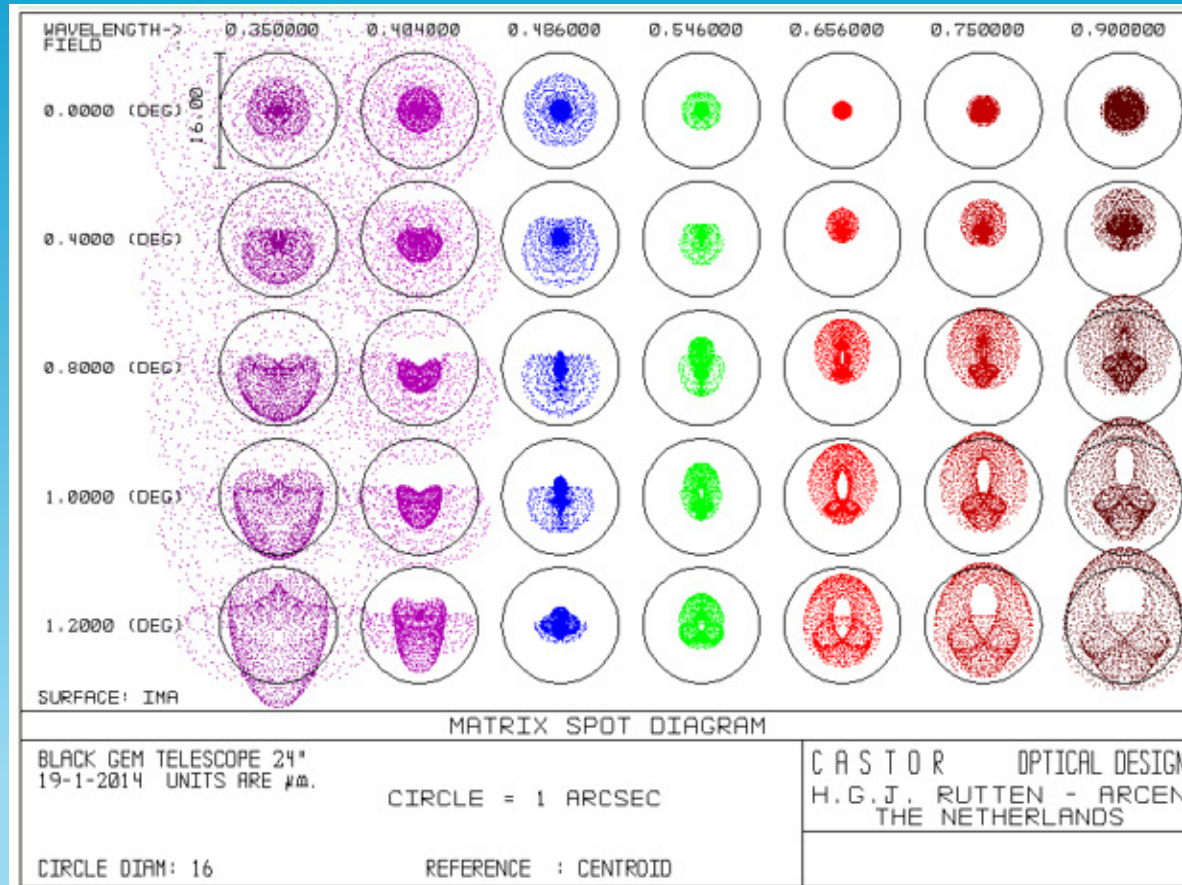
BlackGEM Telescope 24" F/6 → F/5.5

Opticadag
9 maart 2019
TNO – Delft



Nieuwe uitdaging: F/6 moet F/5,5 worden

BlackGEM Telescope 24" F/6 → F/5.5



Homofocale spot diagrammen

1 bgsec

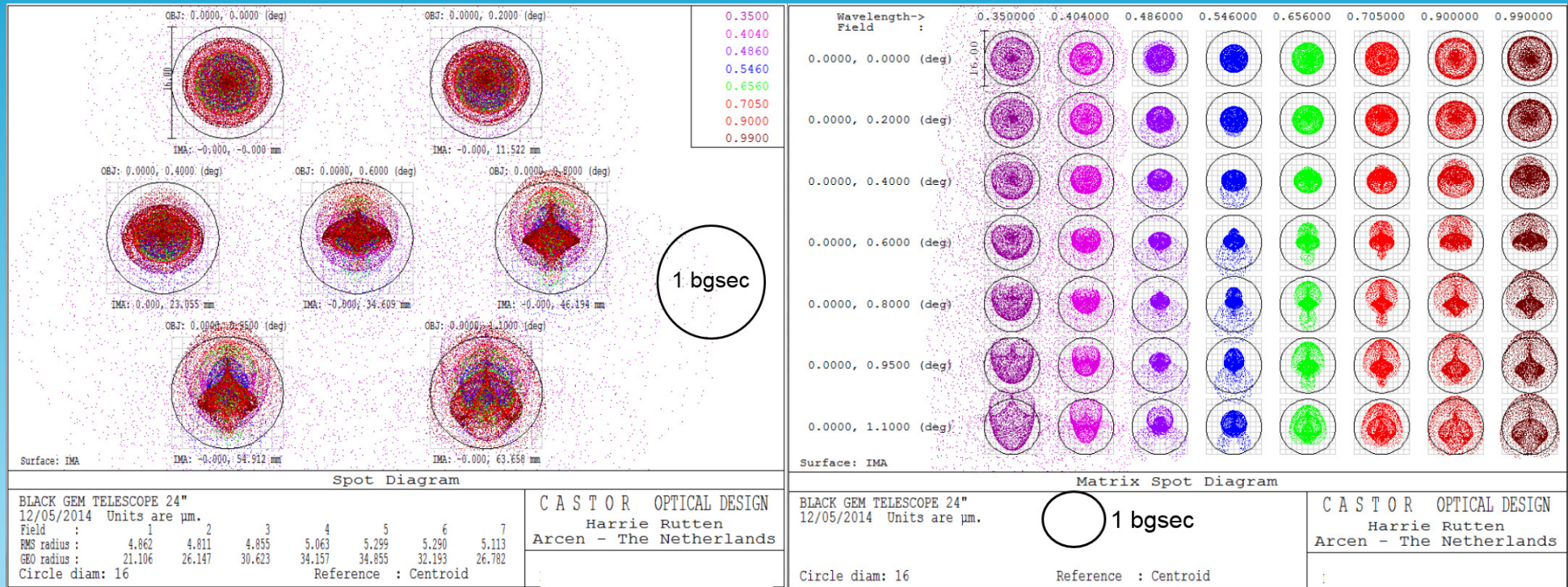
BlackGEM Telescope 24" F/6 → F/5.5

Opticadag
9 maart 2019
TNO – Delft

ADC

Atmospheric
Dispersion
Corrector

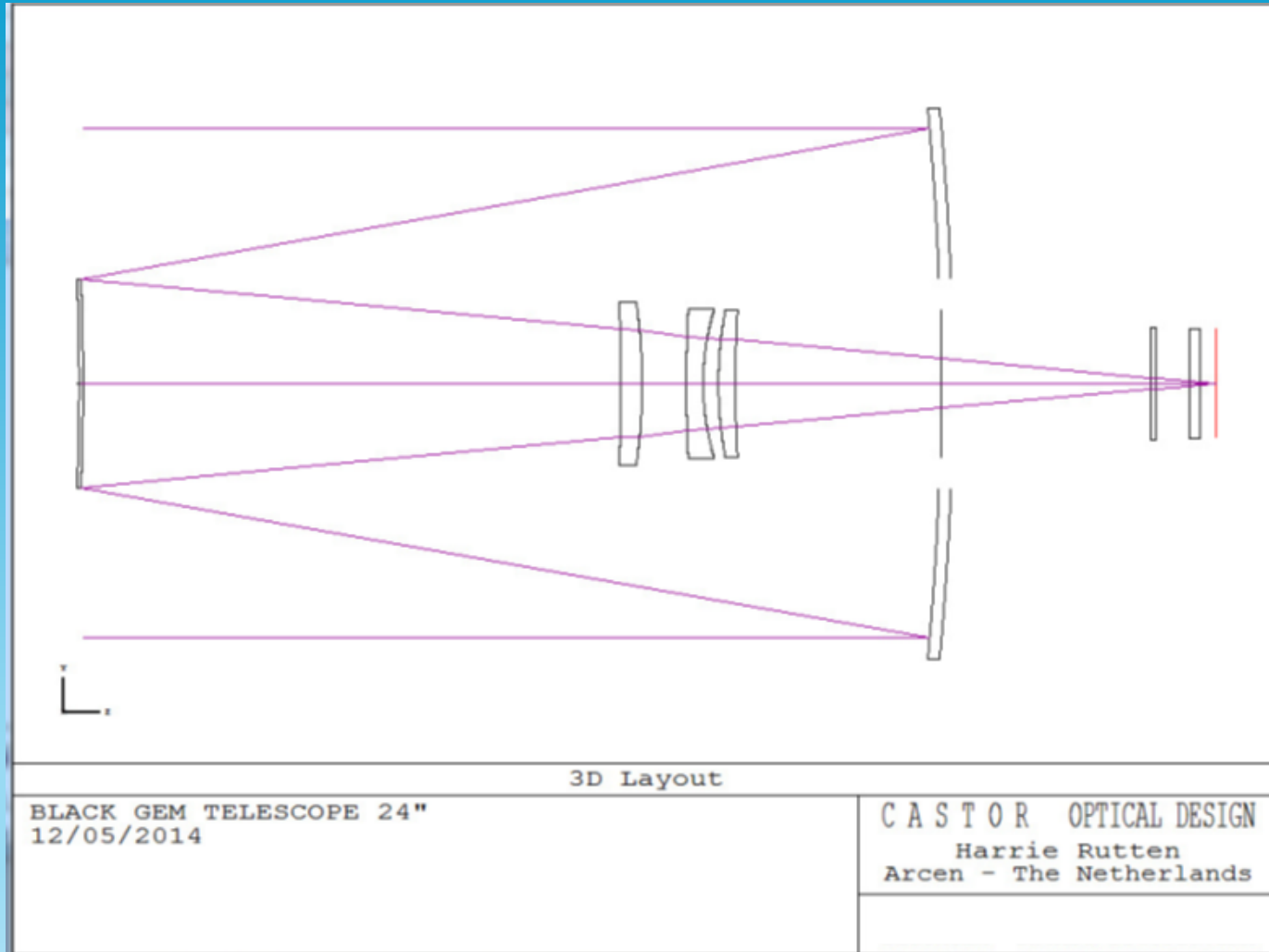
BlackGEM Telescope 24" F/6 → F/5.5



Even ter herinnering het afbeeldingskwaliteit bij een polychromatische best focus positie van de chip

BlackGEM Telescope 24" F/6 → F/5.5

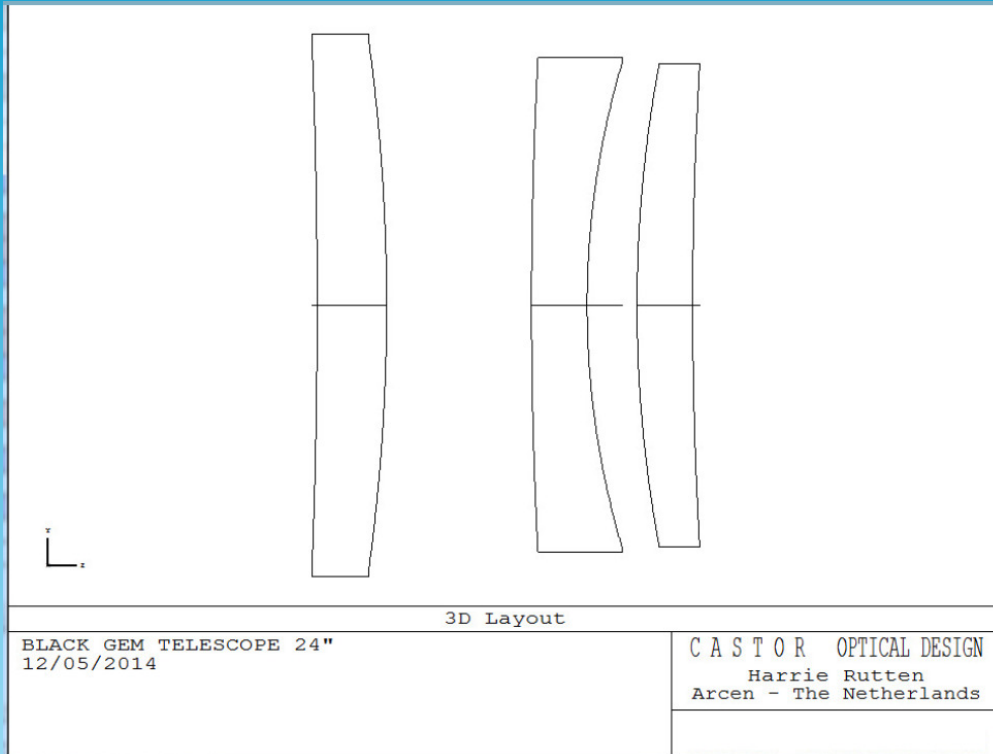
Opticadag
9 maart 2019
TNO – Delft



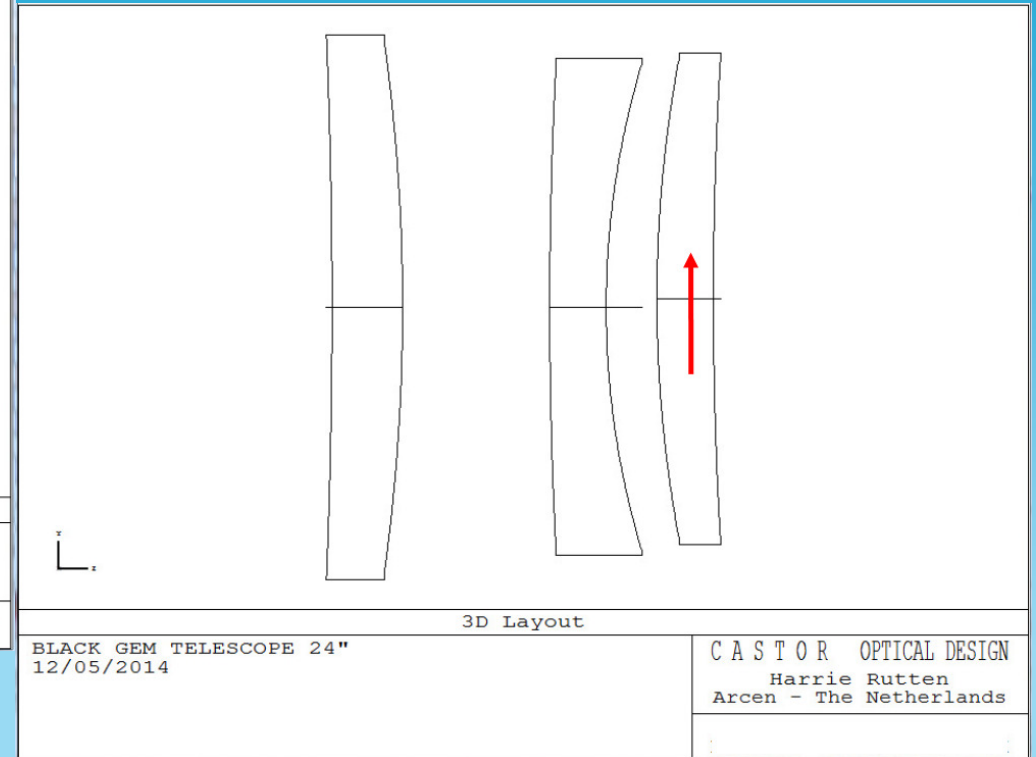
Even ter herinnering de lay out van het complete system

BlackGEM Telescope 24" F/6 → F/5.5

Opticadag
9 maart 2019
TNO – Delft

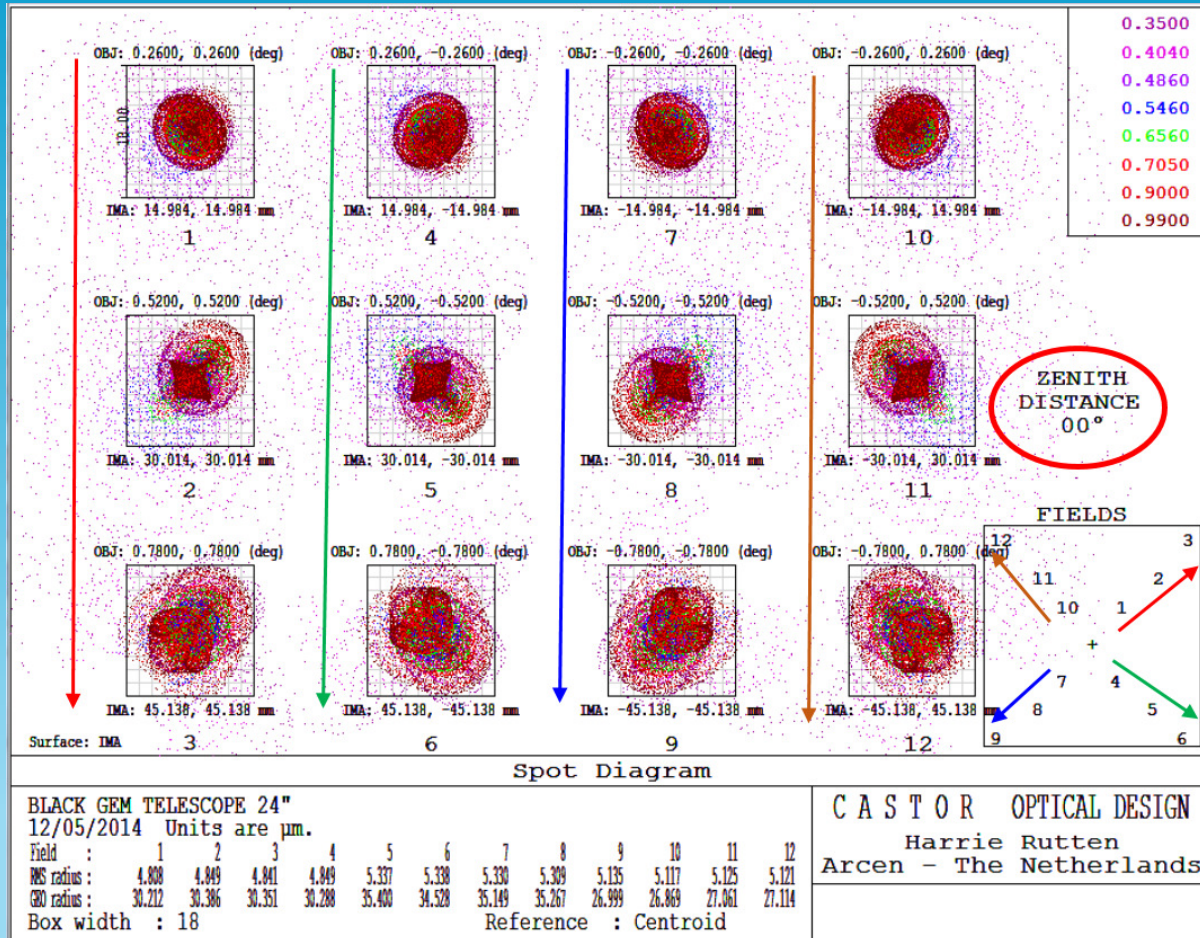


Even ter herinnering de corrector



De corrector nu tevens als ADC

BlackGEM Telescope 24" F/6 → F/5.5

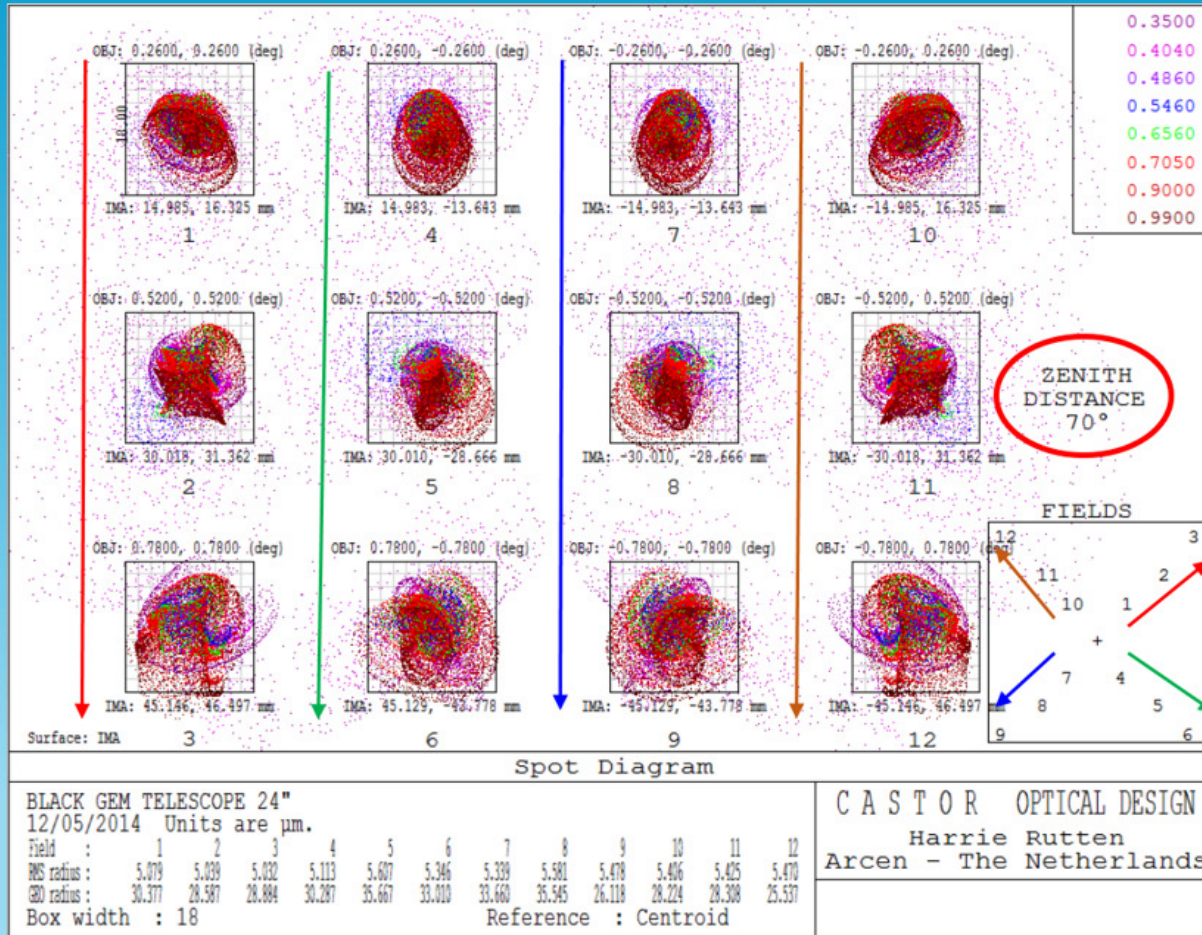


1 bgsec

Polychromatische afbeelding 350 – 990 nm in het zenit ADC in neutral ("0") positie



BlackGEM Telescope 24" F/6 → F/5.5



Polychromatische afbeelding 350 – 990 nm 70° afstand van het zenit (20° altitude)
ADC in correctieve positive = lens 3 ca. 3 mm excentrisch(!)



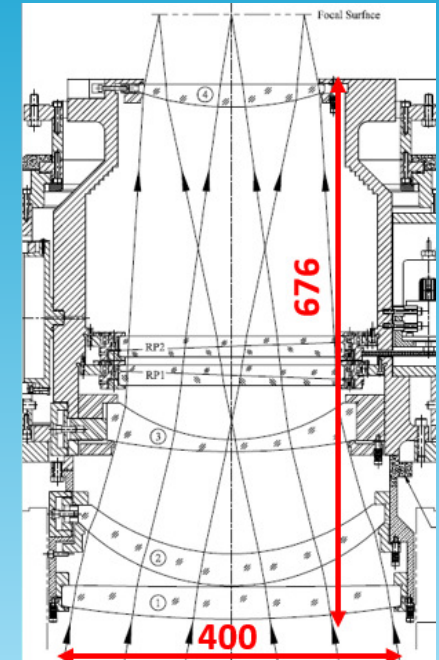
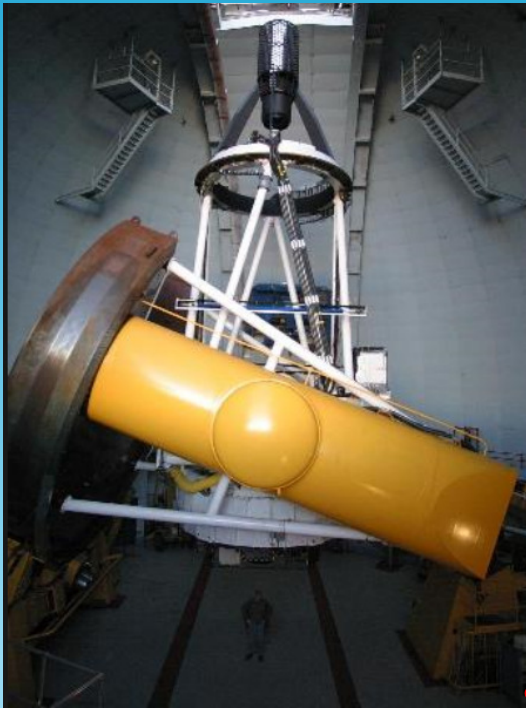
BlackGEM Telescope 24" F/6 → F/5.5

Opticadag
9 maart 2019
TNO – Delft

Ghosting

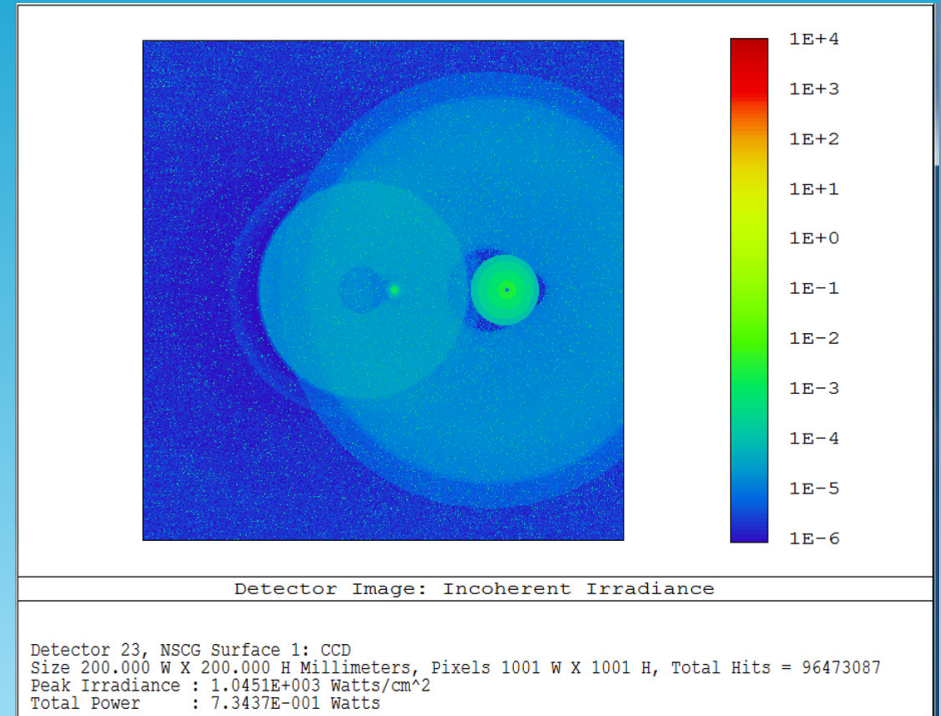
BlackGEM Telescope 24" F/6 → F/5.5

Opticadag
9 maart 2019
TNO – Delft



BlackGEM Telescope 24" F/6 → F/5.5

Opticadag
9 maart 2019
TNO – Delft



Controle van de strooilichtberekeningen

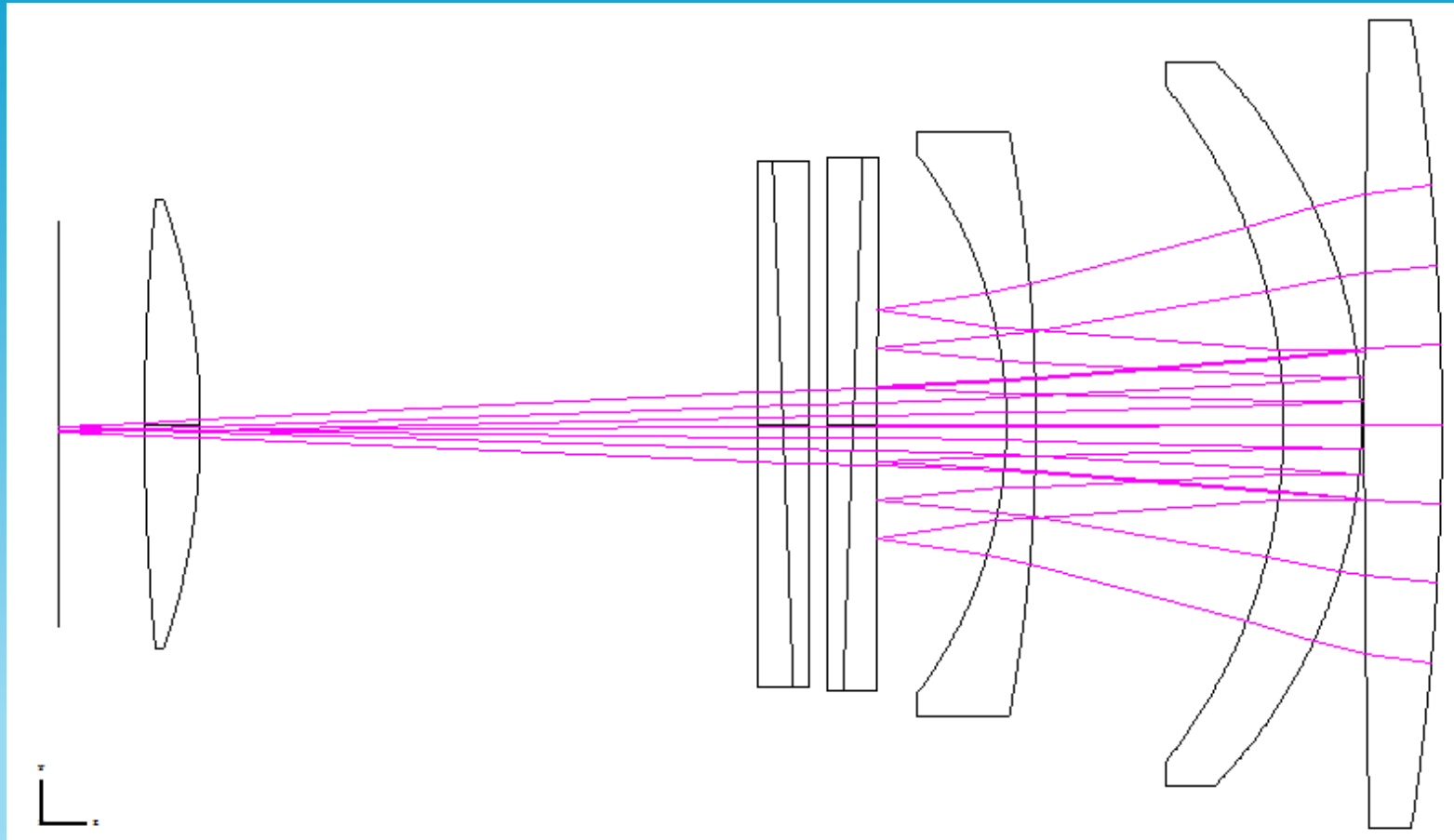
De foto

De berekening met originele gegevens

Nu de juiste schaal in de foto gezet

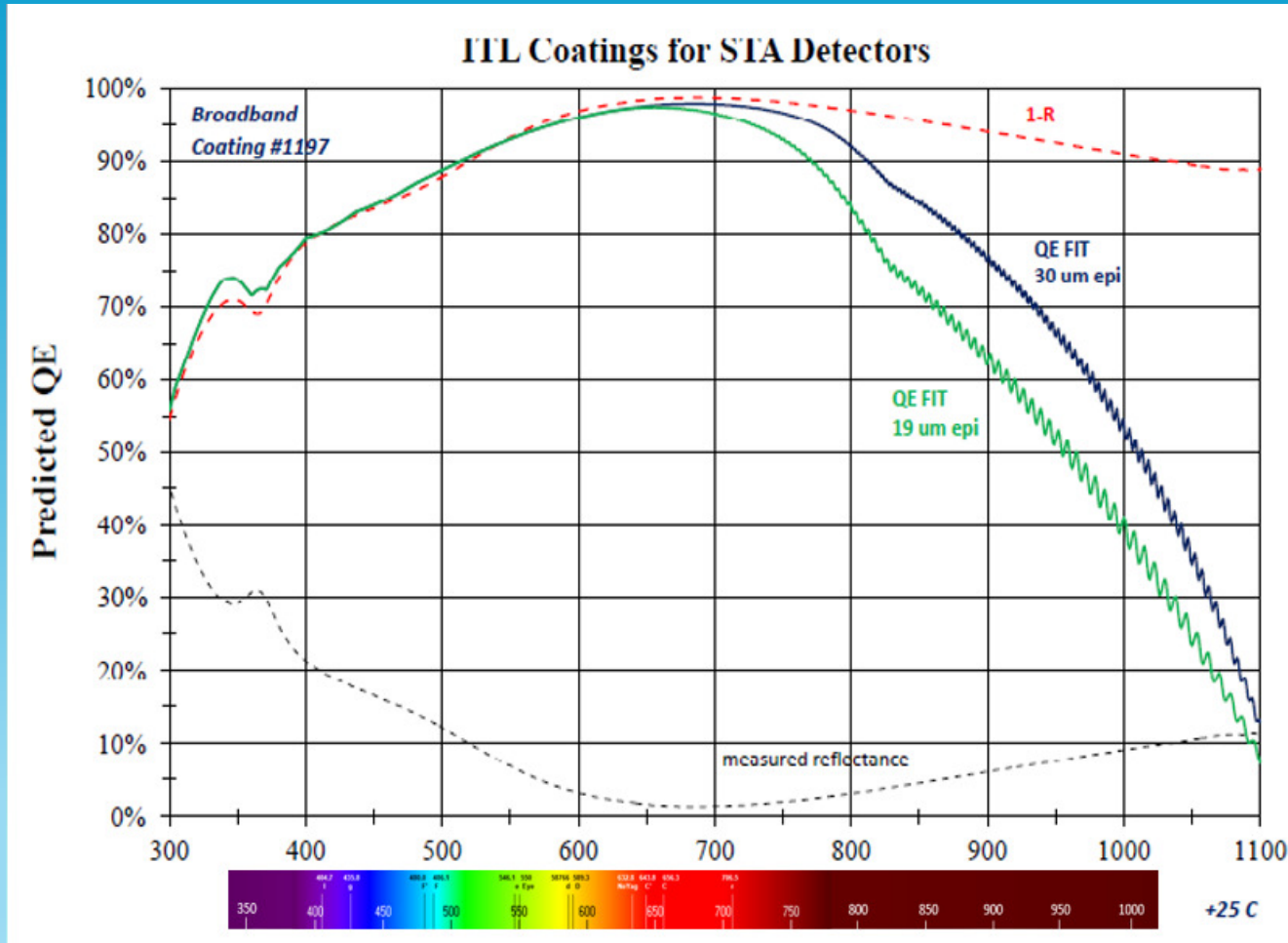
BlackGEM Telescope 24" F/6 → F/5.5

Opticadag
9 maart 2019
TNO – Delft



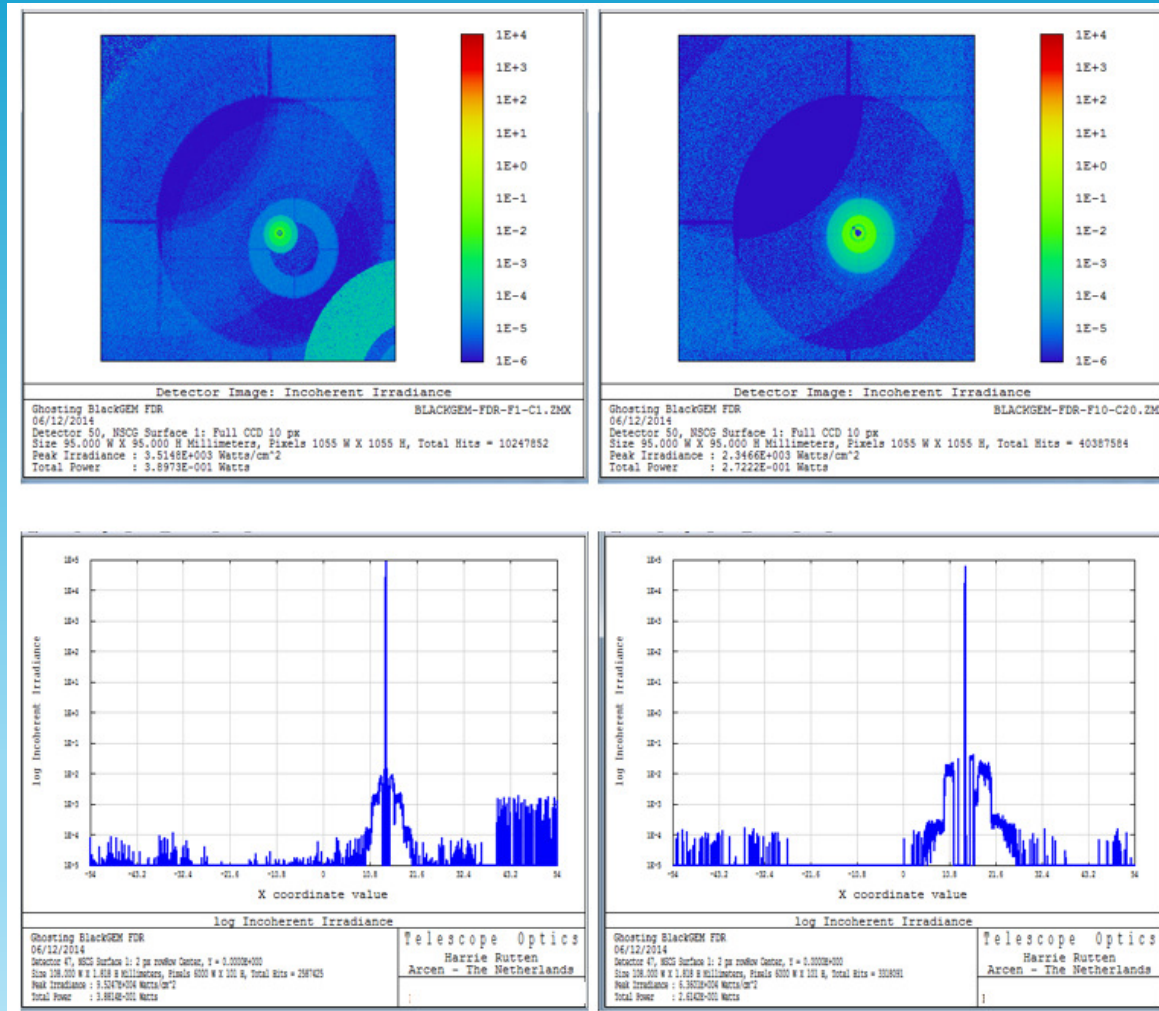
**Complexe en zeer kostbare ADC
Met nare gevolgen voor ghosting**

BlackGEM Telescope 24" F/6 → F/5.5



Reflectieve eigenschappen van het CCD-array

BlackGEM Telescope 24" F/6 → F/5.5

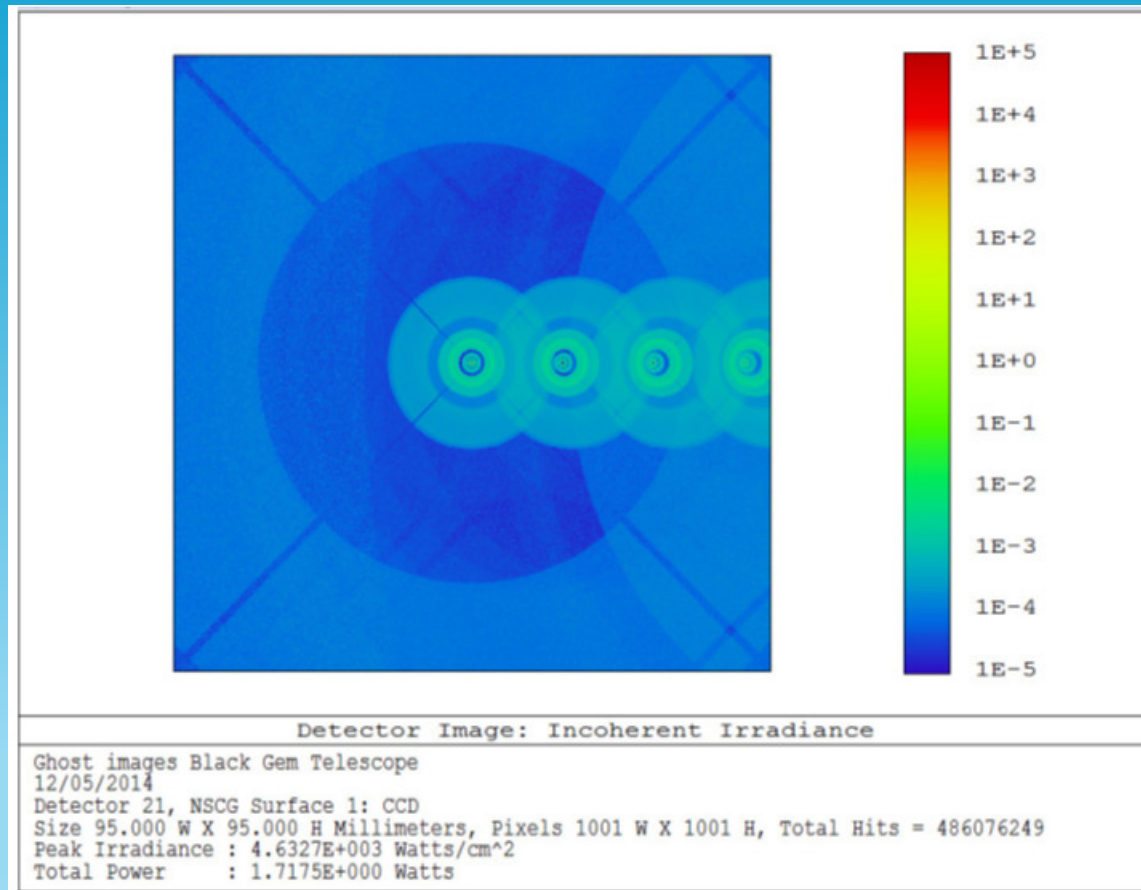


Het hele CCD
Andere reflectie
Waarden coatings

Grafiek diagonaal

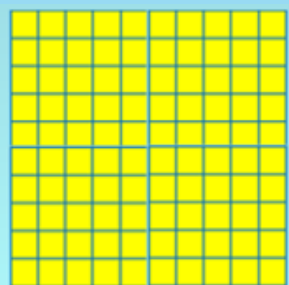
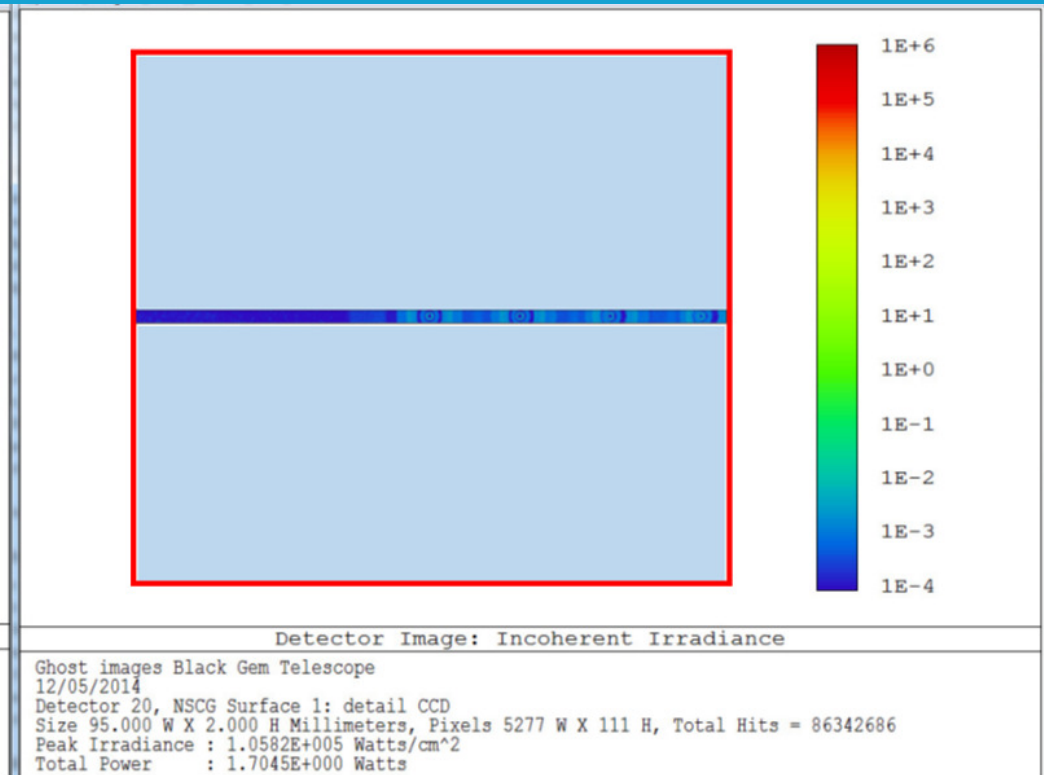
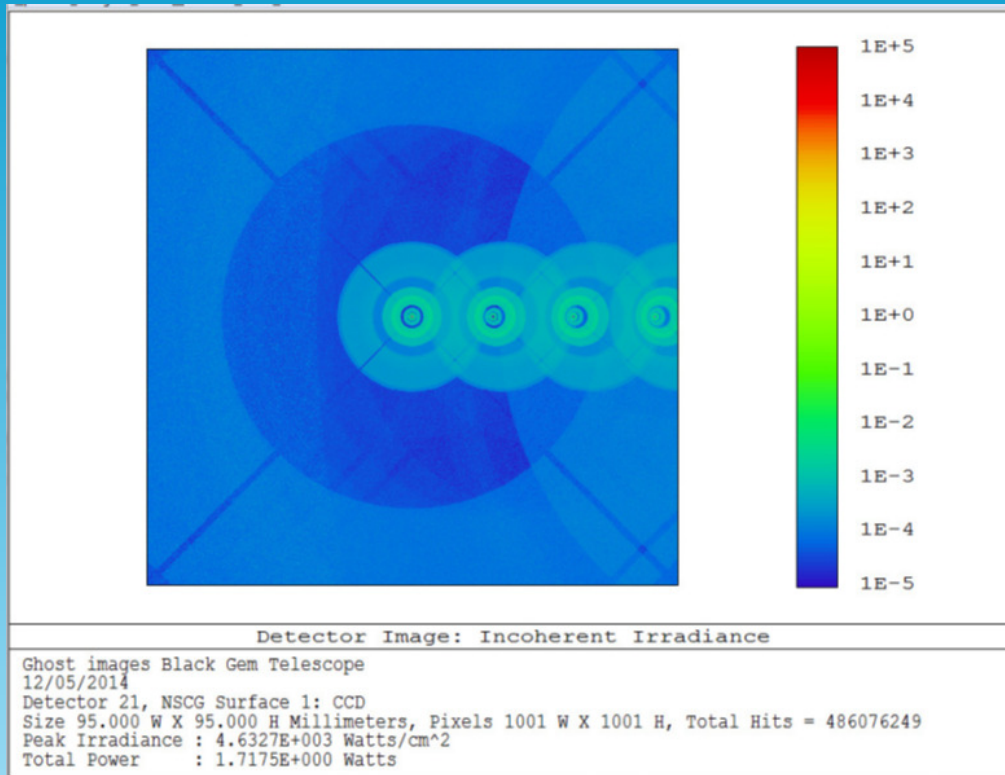
LET OP:
Rekenpixels zijn 95 x 95 μm

BlackGEM Telescope 24" F/6 → F/5.5



Ghosting in de
BlackGEM voor
hele CCD

BlackGEM Telescope 24" F/6 → F/5.5



10

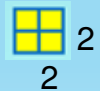
10

**Ghosting in de
BlackGEM voor hele
CCD**
Rekenpixels 95 μm

t.i. ruim 486 miljoen hits = gem. 486 p.px

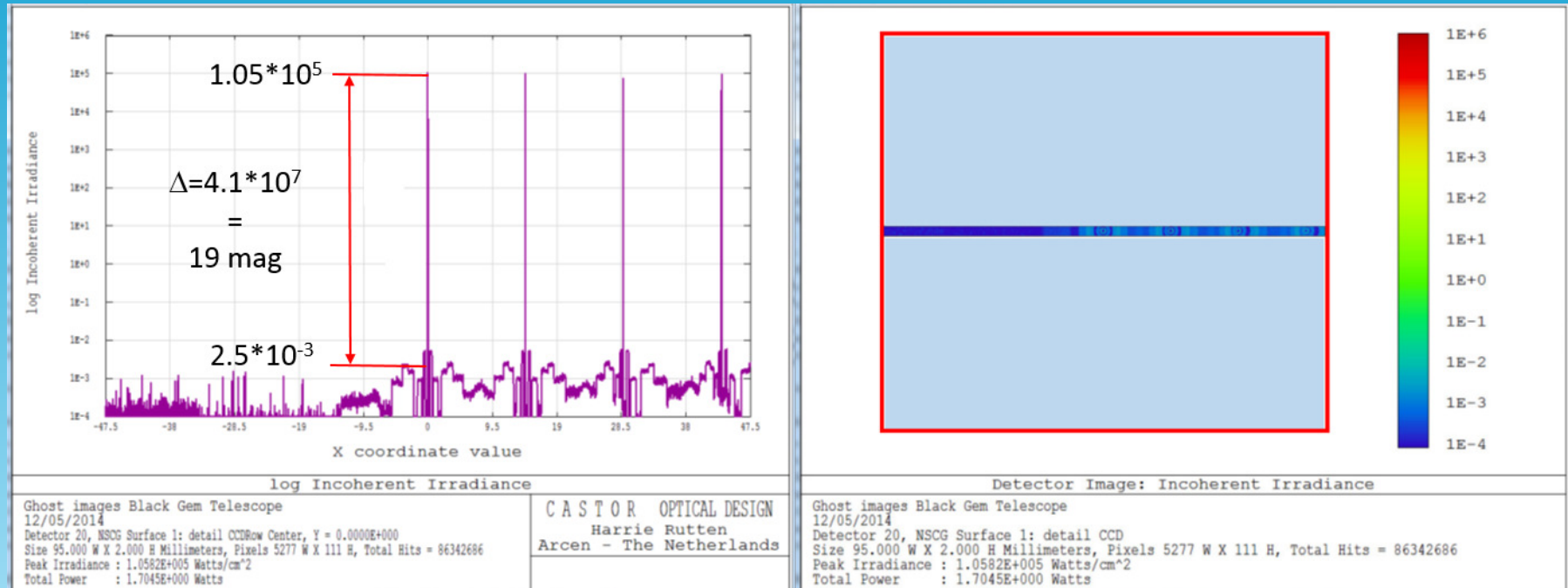
**Ghosting in de BlackGEM
voor hele CCD echter
strook met hoge Resolutie**
Rekenpixels 19 μm
(bin 2x2)

t.i. ruim 86 miljoen hits = gem. 147 p.px



2
2

BlackGEM Telescope 24" F/6 → F/5.5



Ghosting in BlackGEM voor het hele CCD gemodelleerd maar een strook gerekend met pixels van 19 x 19 μm (bin 2x2)

Nu Δ : 19 magnituden

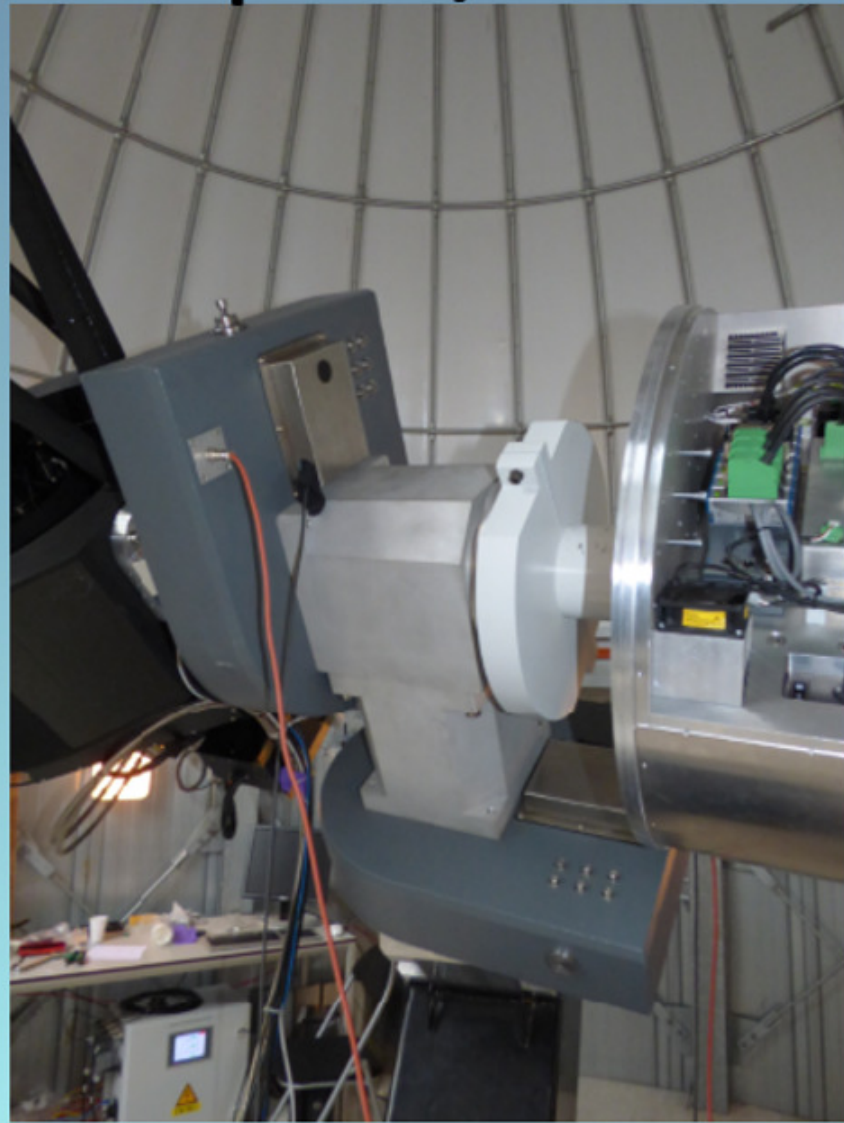
BlackGEM Telescope 24" F/6 → F/5.5

Opticadag
9 maart 2019
TNO – Delft

**Tot slot
Een
paar plaatjes**

BlackGEM Telescope 24" F/6 → F/5.5

Opticadag
9 maart 2019
TNO – Delft



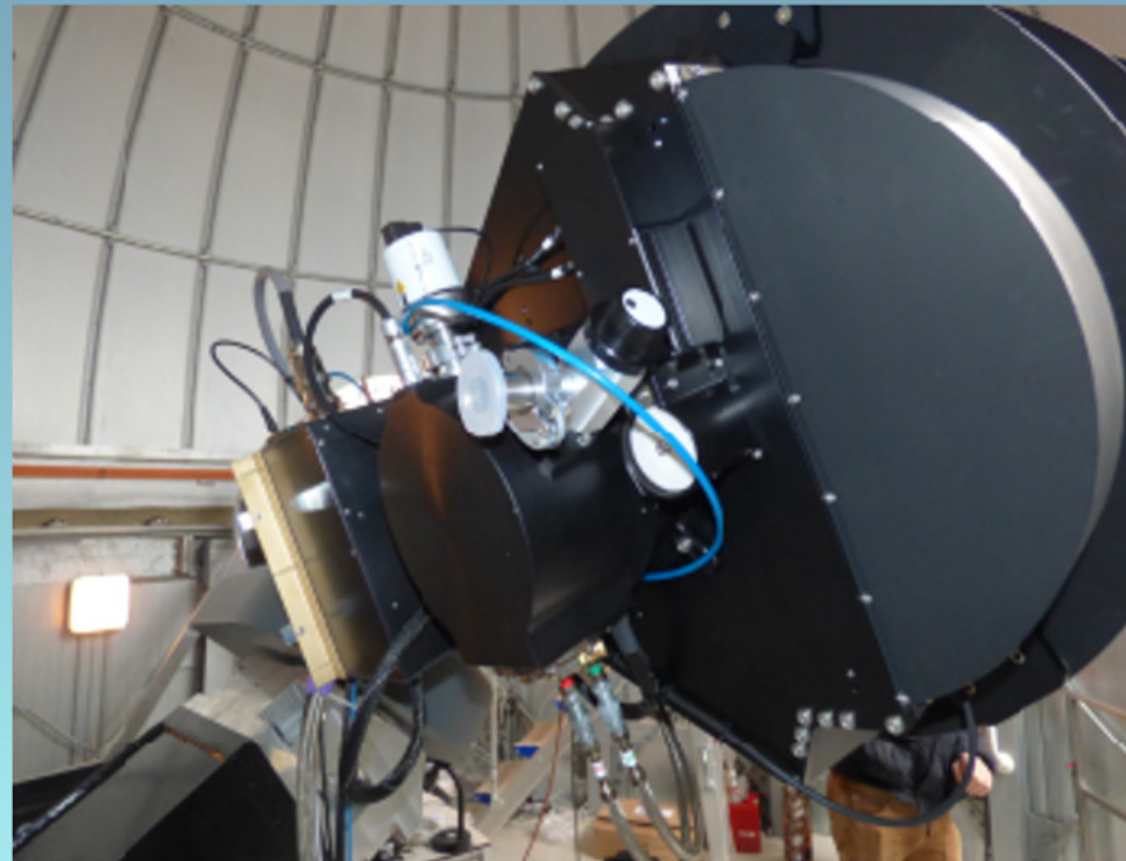
BlackGEM Telescope 24" F/6 → F/5.5

Opticadag
9 maart 2019
TNO – Delft



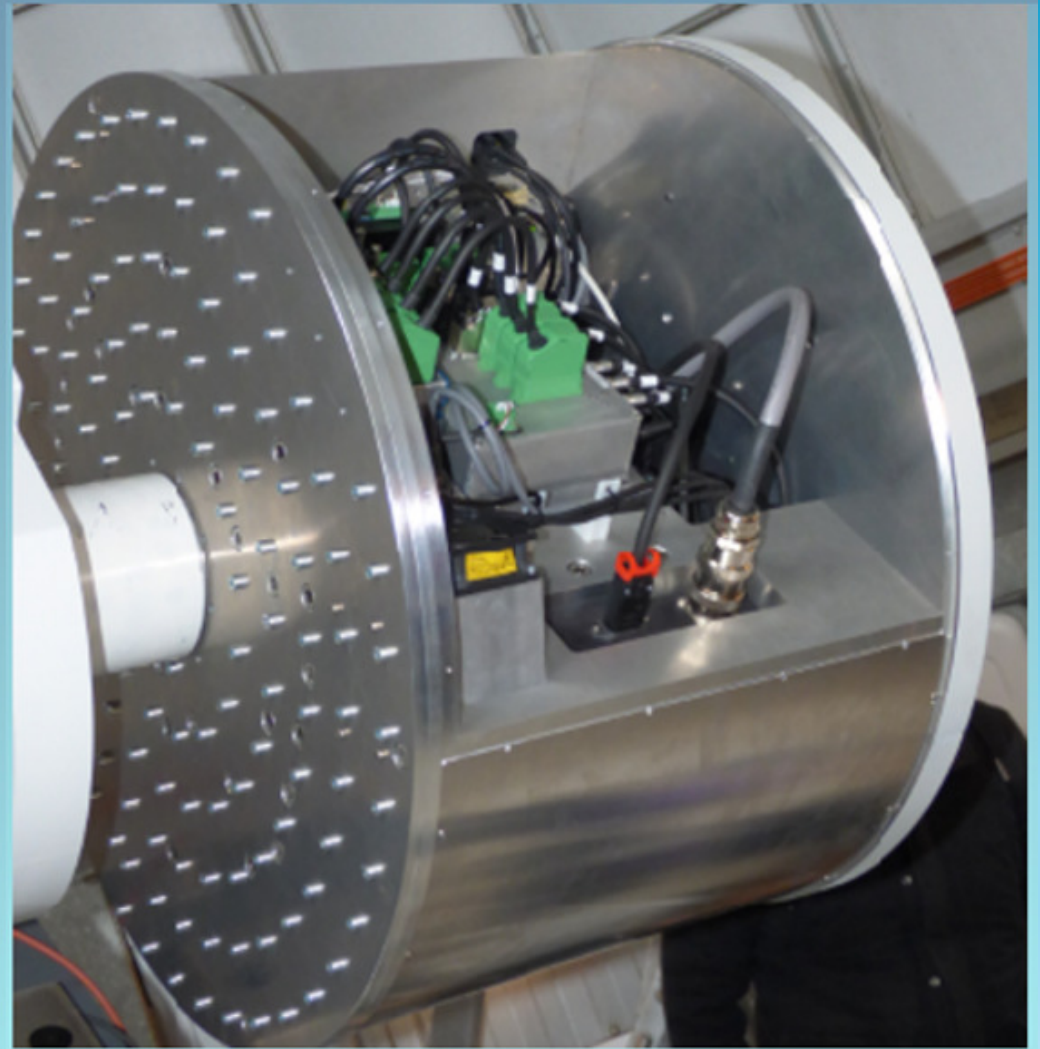
BlackGEM Telescope 24" F/6 → F/5.5

Opticadag
9 maart 2019
TNO – Delft



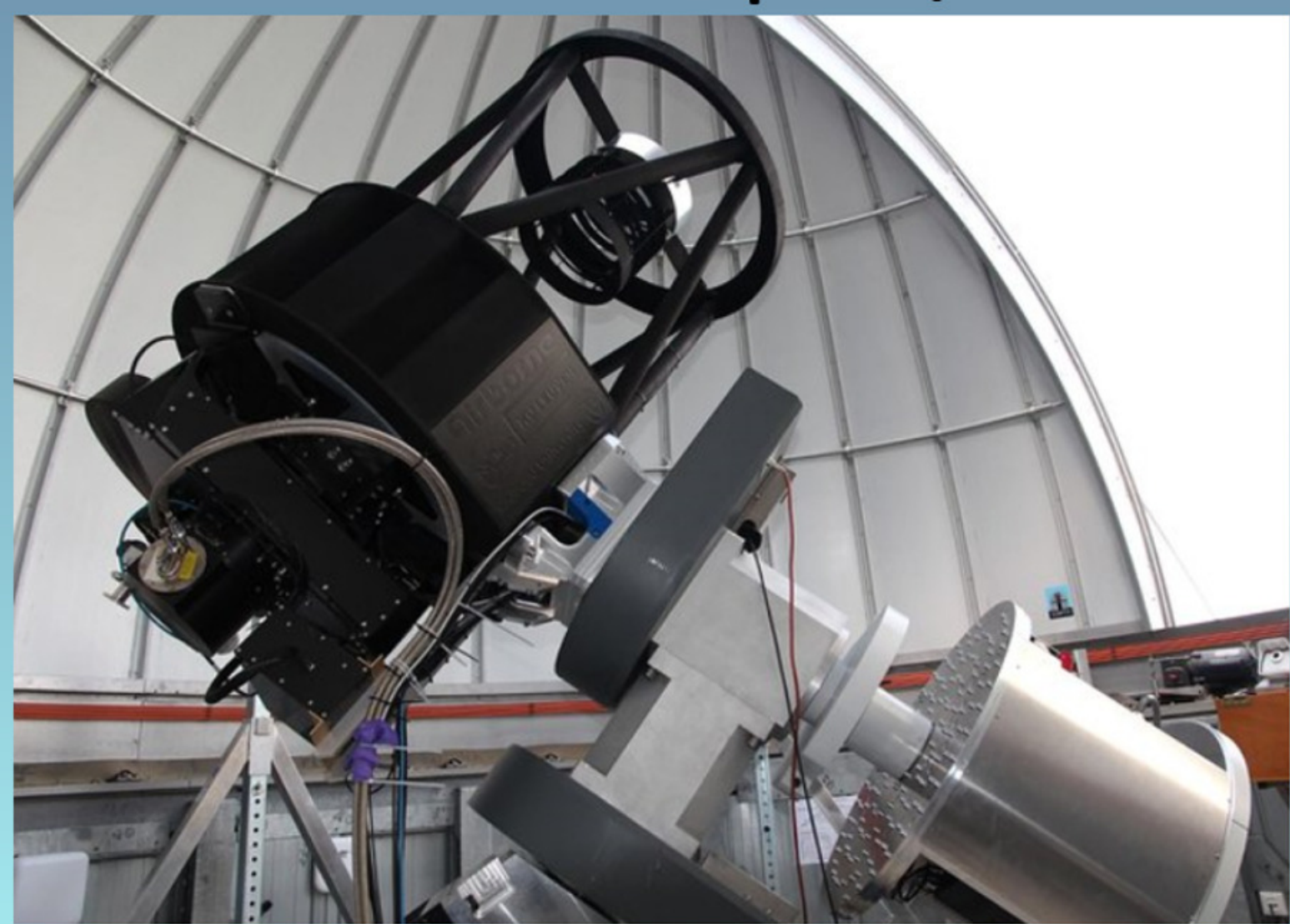
BlackGEM Telescope 24" F/6 → F/5.5

Opticadag
9 maart 2019
TNO – Delft



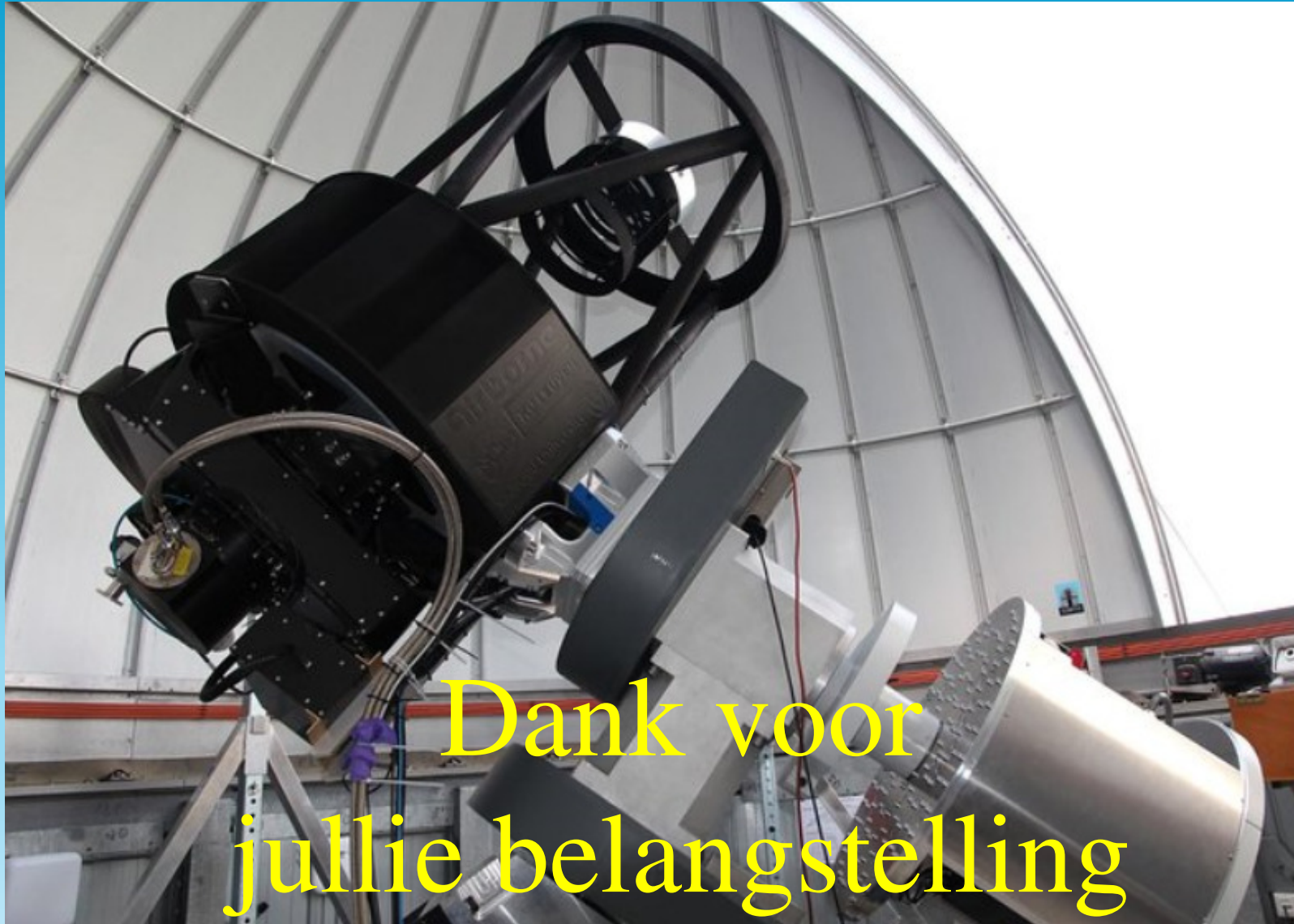
BlackGEM Telescope 24" F/6 → F/5.5

Opticadag
9 maart 2019
TNO – Delft



BlackGEM Telescope 24" F/6 → F/5.5

Opticadag
9 maart 2019
TNO – Delft



Dank voor
jullie belangstelling

BlackGEM Telescope 24" F/6 → F/5.5

Opticadag
9 maart 2019
TNO – Delft

