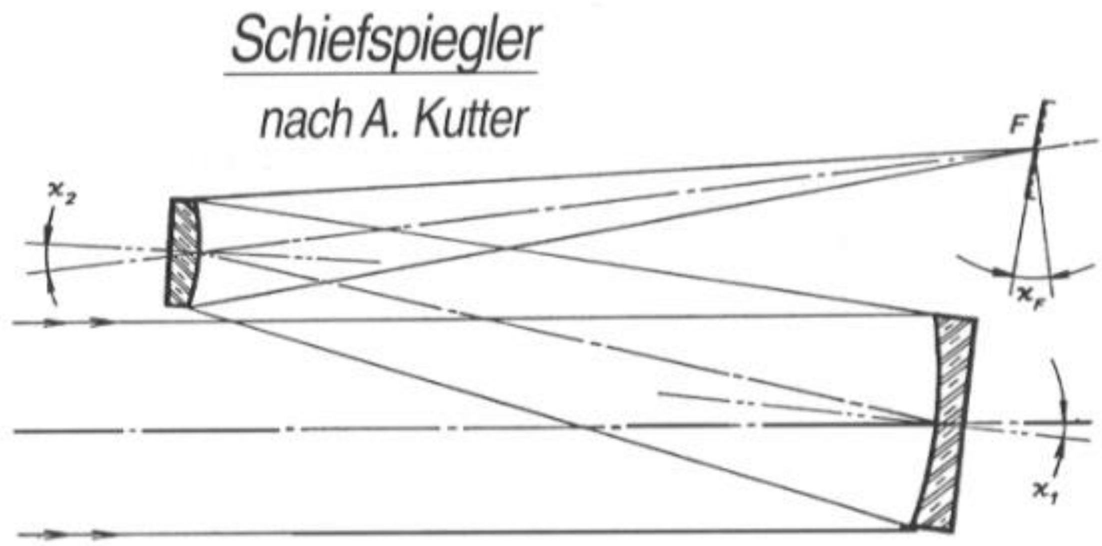
Application of Schiefspiegler Heritage Anton Kutter‘s basic ideas

Outline

1. A brief discussion of Anton Kutter’s early Schiefspiegler and benefits of Schiefspiegler designs in general
2. Selection of modern Schiefspiegler
3. A Schiefspiegler Laser beam expander telescope for spaced based communication.

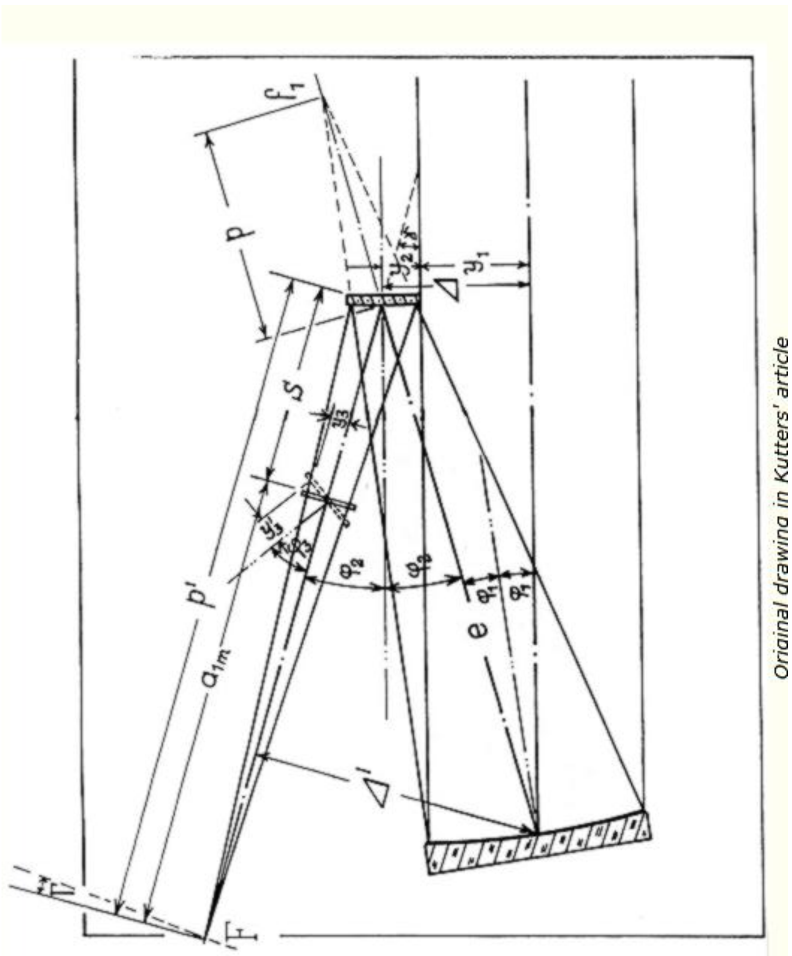
The“Kutter” Schiefspiegler

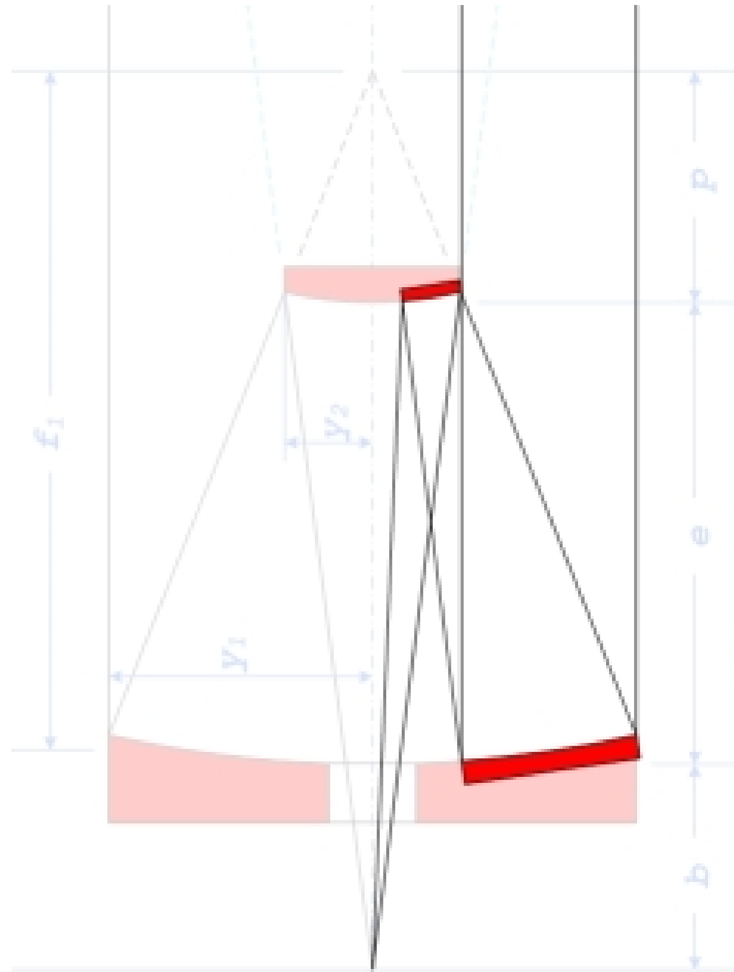
Anton Kutter’s request: A mirror telescope for high image definition



- Free of chromatic aberrations
- No obstruction
- Only spherical mirrors (i.e. easiest to manufacture and test)

Schiefspiegler seen as a cut-out of rotational symmetric optical design



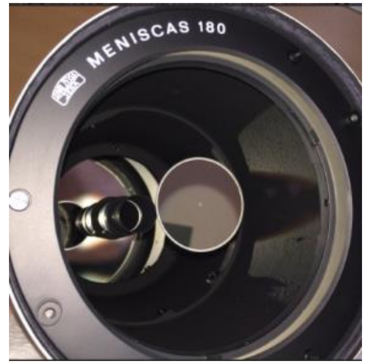


Diffraction limited images

Object

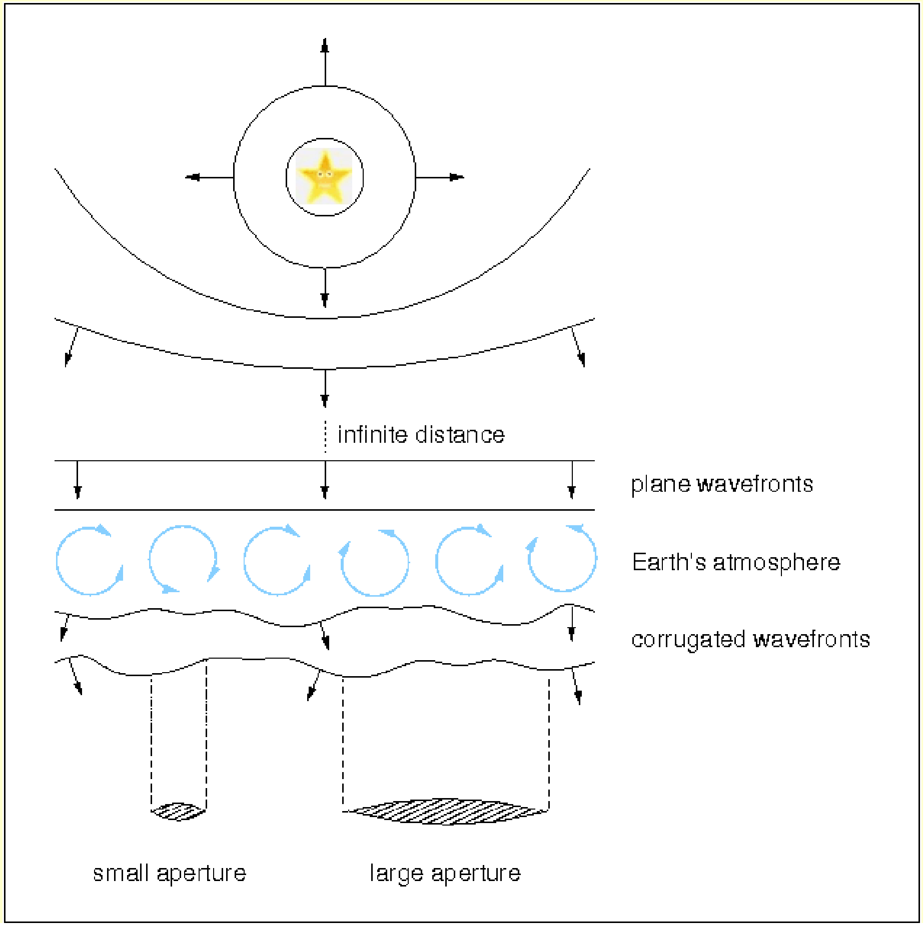
Rule of thump:
effective Diameter = free aperture diameter minus obstruction diameter

Zeiss Meniscas D= 180
Obstruction d = 60 mm



Kutter with
D=110 mm

On Earth 110 mm best compromise between seeing and diffraction blur



- Smaller telescope are less prone to seeing conditions.
- Unbeatable advantage of Schiefspiegler design with respect to obstructed systems.

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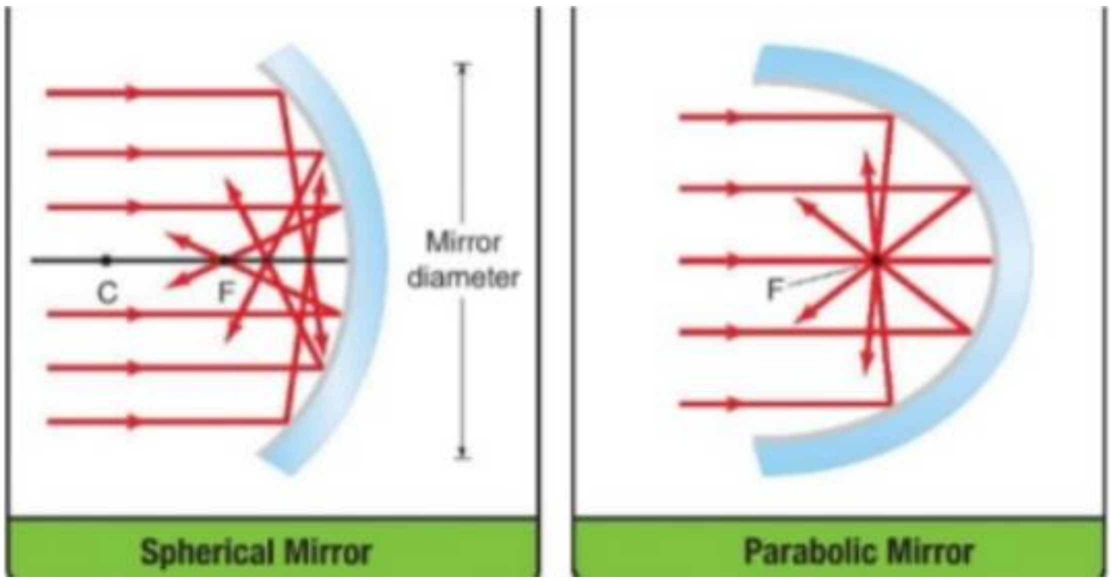
Schiefspiegler possible drawbacks

- Additional image blur due to geometrical aberrations, for instant use of spherical mirrors.



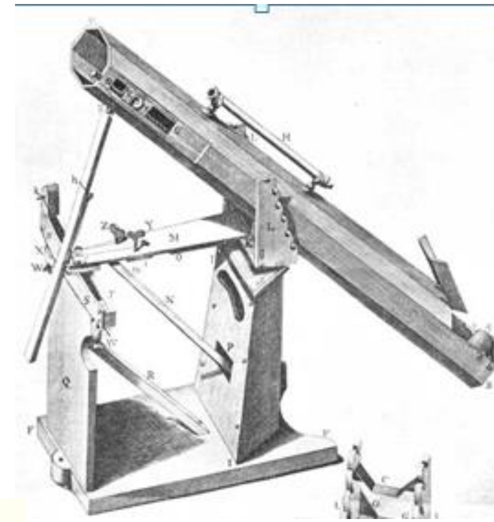
- Objective: Suppress geometrical aberrations < 0.25 wave for visual systems, best close to zero for professional systems.

Methods to correct geometrical aberrations

#1 High F-number F#

(F# ratio between focal length and aperture)

Means large systems and image brightness goes down with F-number²

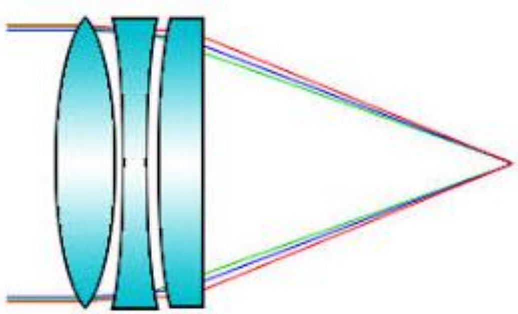


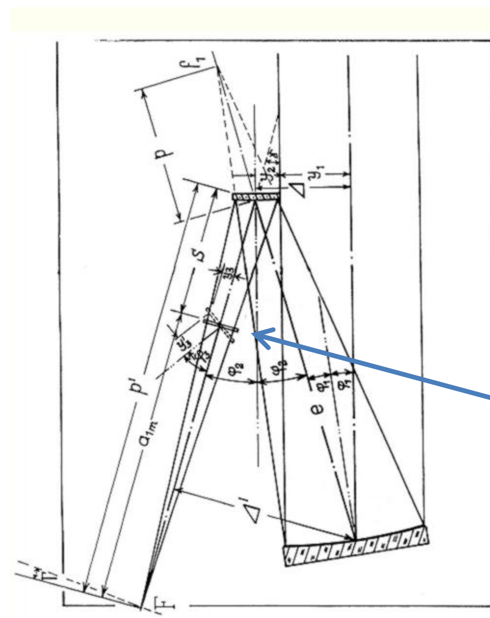
#2 aspheric

Hadley telescope 1721

#3 more elements

Example Apochromat





Original drawing in Kutters' article

#4 correctors

Anton Kutter's wedged shaped lens

COSTAR: Glasses for Hubble

Benefits of Schiefspiegler designs

The combination of an unobstructed aperture together with an all reflective (mirror) design includes:

- Least possible diffraction blur .
- Absence of chromatic aberrations.
- Maximum possible light throughput.
- Absence of all mechanical structures within field of view leading to reduced stray light, no first order scattering.
- No thermal radiation emitting structures within field of view, important for infrared telescopes.
- Absence of secondary support spider, no diffraction spikes
- Relative light weightiness of mirror systems compared to refractive lens systems

1# Multi-Schiefspiegler

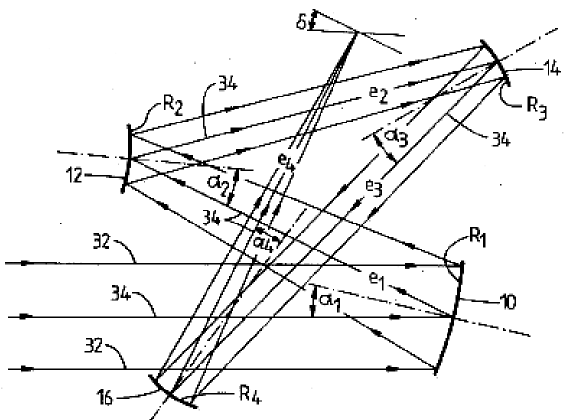
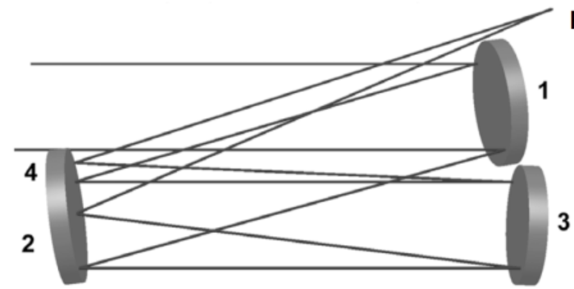


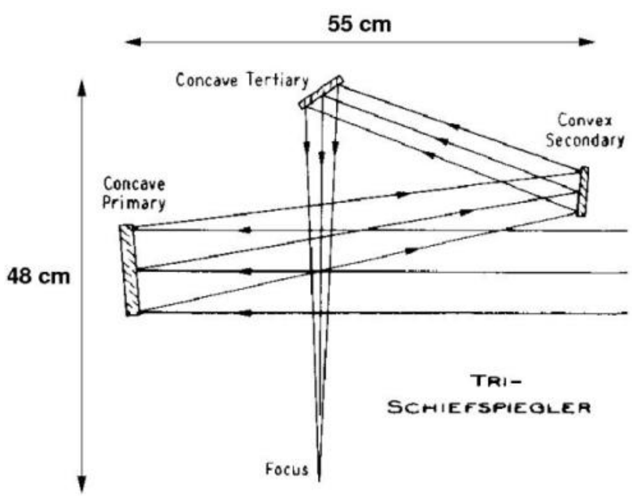
Fig. 3

Brunn Tetra-Schiefspiegler

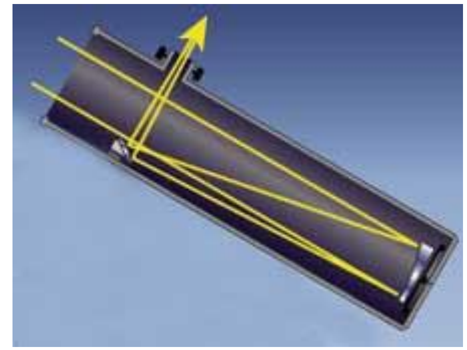
Optical path of the Multi-Schiefspiegler



"Wolterscope"



2 Newton Schiefspiegler with parabolic mirror



Orion “CLANT”

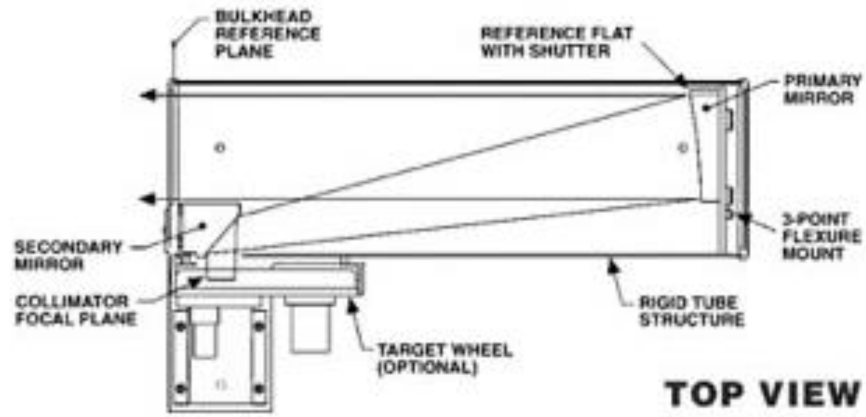
(Clear Aperture Newton)

91 mm aperture / 1240 mm focal length (f/13.6)

Same image definition as a good apochromatic refractor with same aperture

#3 Schiefspiegler Collimators for optical system alignment and testing

Schiefspiegler Newton design

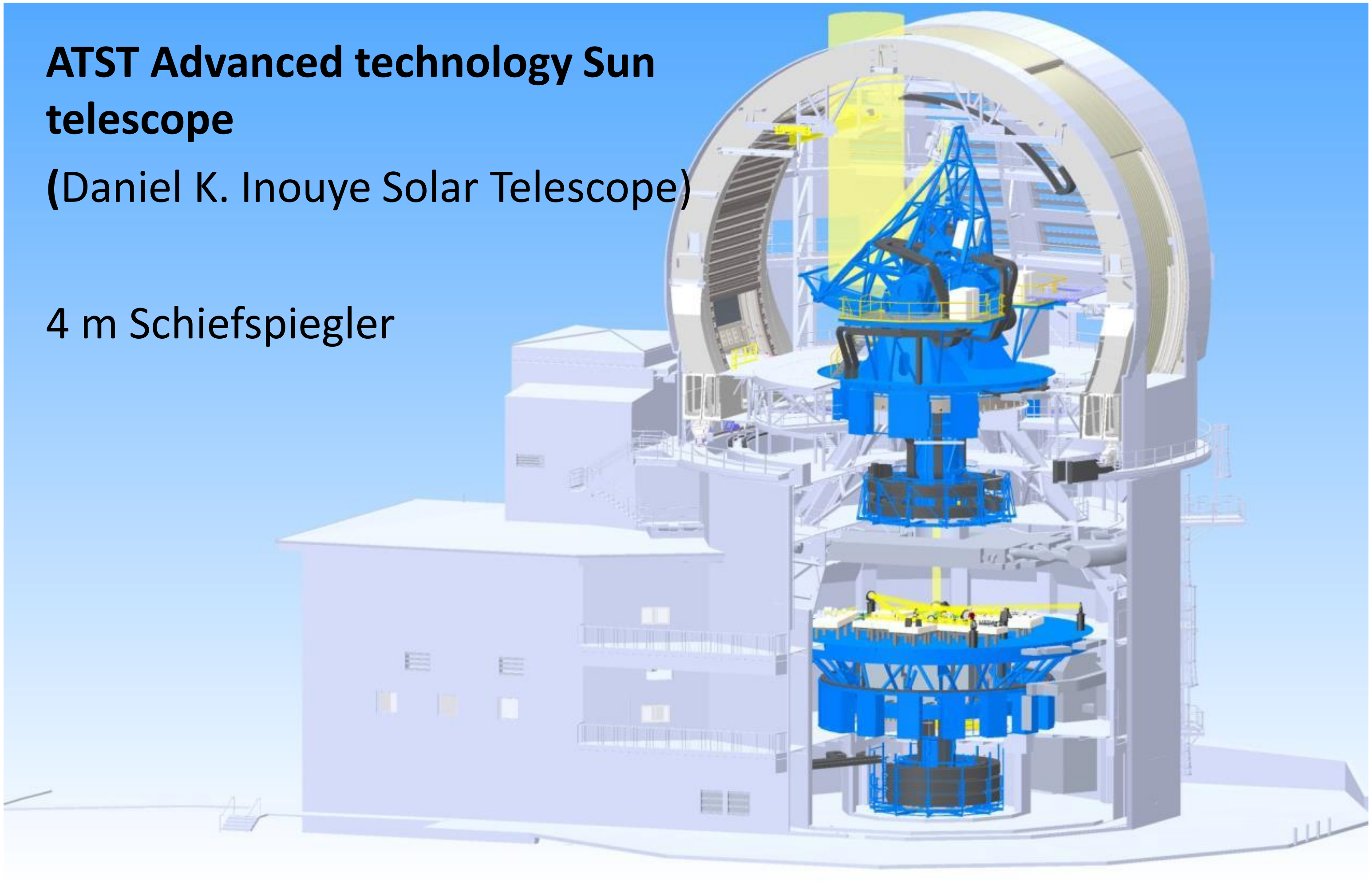


All reflective
Perform for wavelength from UV to Infrared

For testing of:

- Optical resolution (MTF)
- Line of sight

#4 Example sun telescope

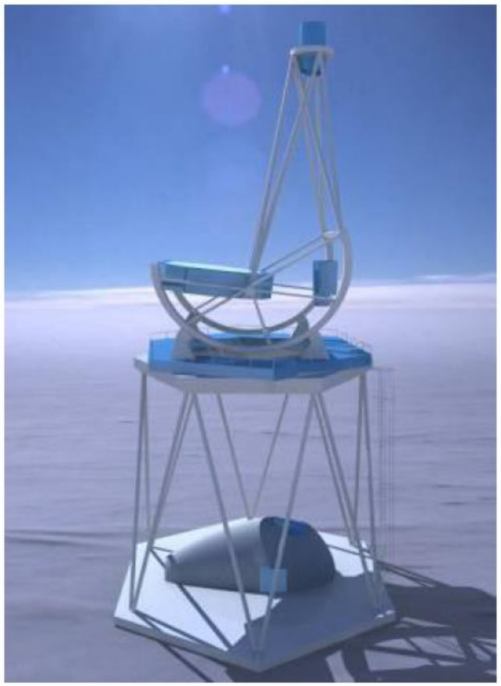


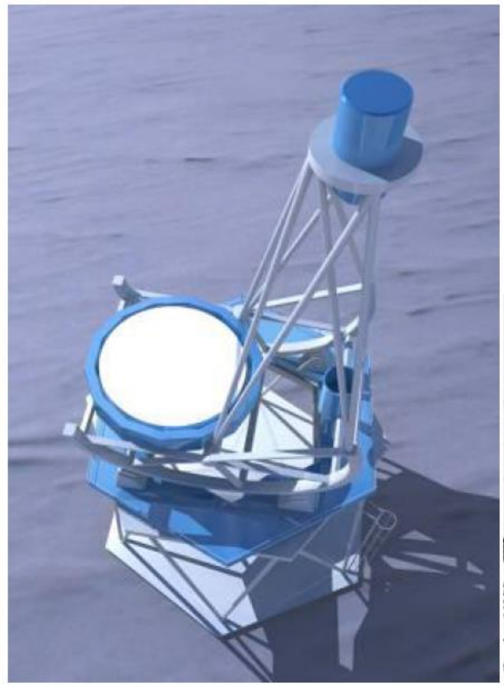
ATST Advanced technology Sun telescope

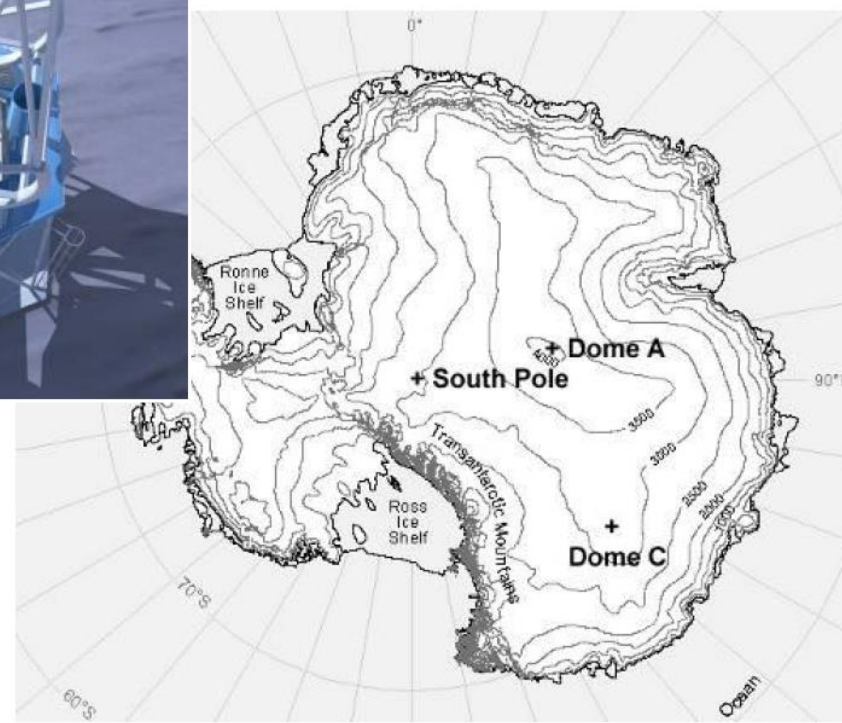
(Daniel K. Inouye Solar Telescope)

4 m Schiefspiegler

#5 Example for an infrared telescope





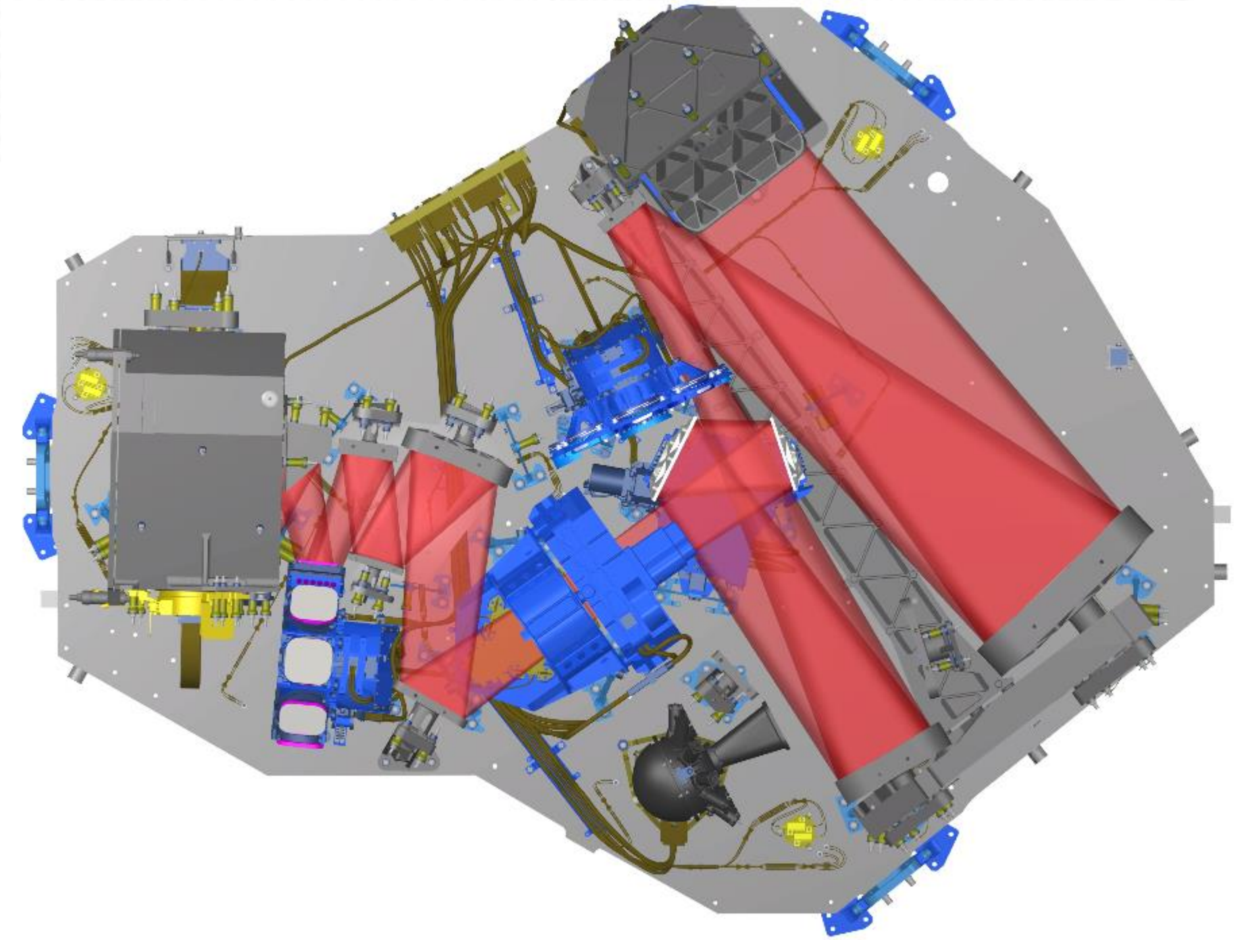


LAPCAT– Large Antarctic Plateau Clear-Aperture Telescope

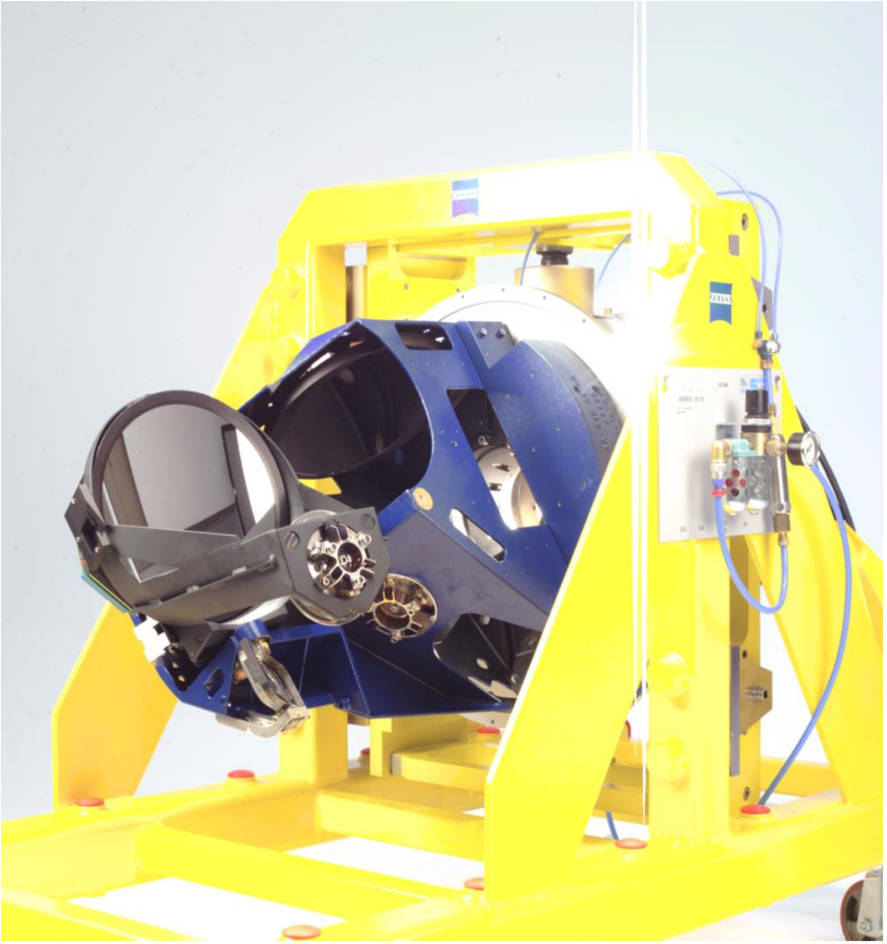
study for a 8.4m-Telescope in Antarctica

Dome C: world wide best Seeing

#6: Near infrared Schiefspiegler spectrograph for James Webb Space telescope

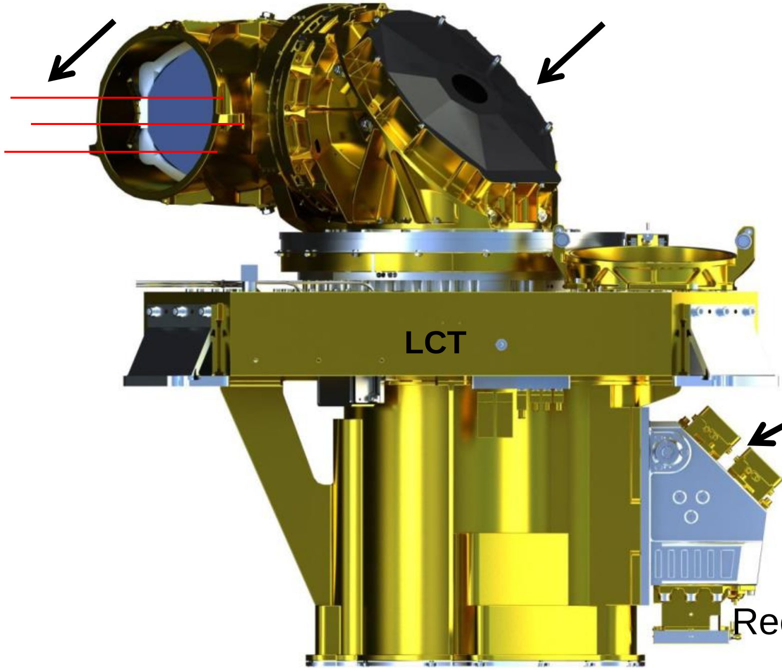


LOROP: Schiefspiegler Demonstrator for military reconnaissance pods



TLU project: Schiefspiegler telescope unit for space based LCT

Range : 40000 km; λ 1064 nm; 1-10 W; Data rate > several Gbps



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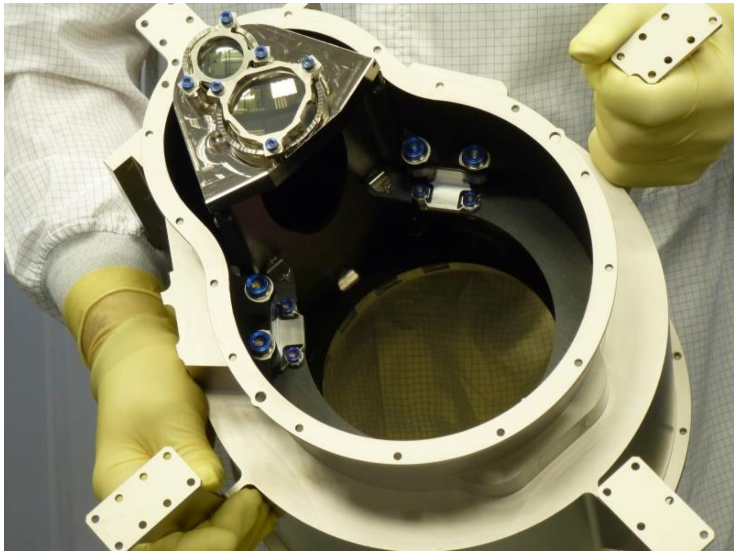
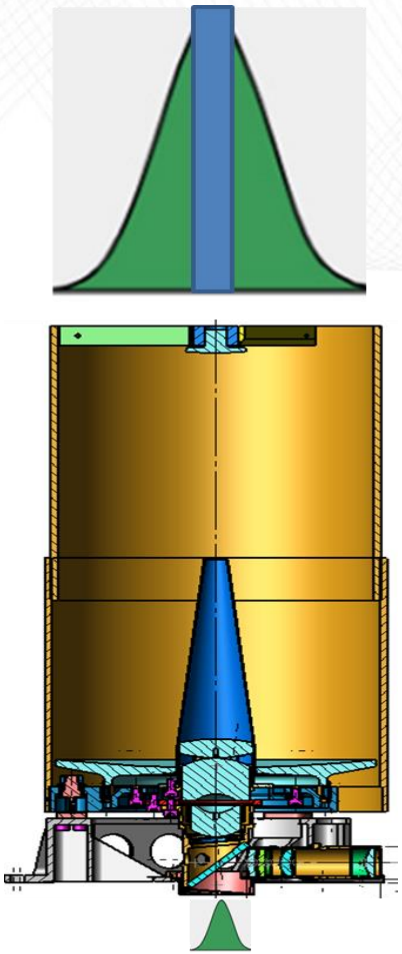
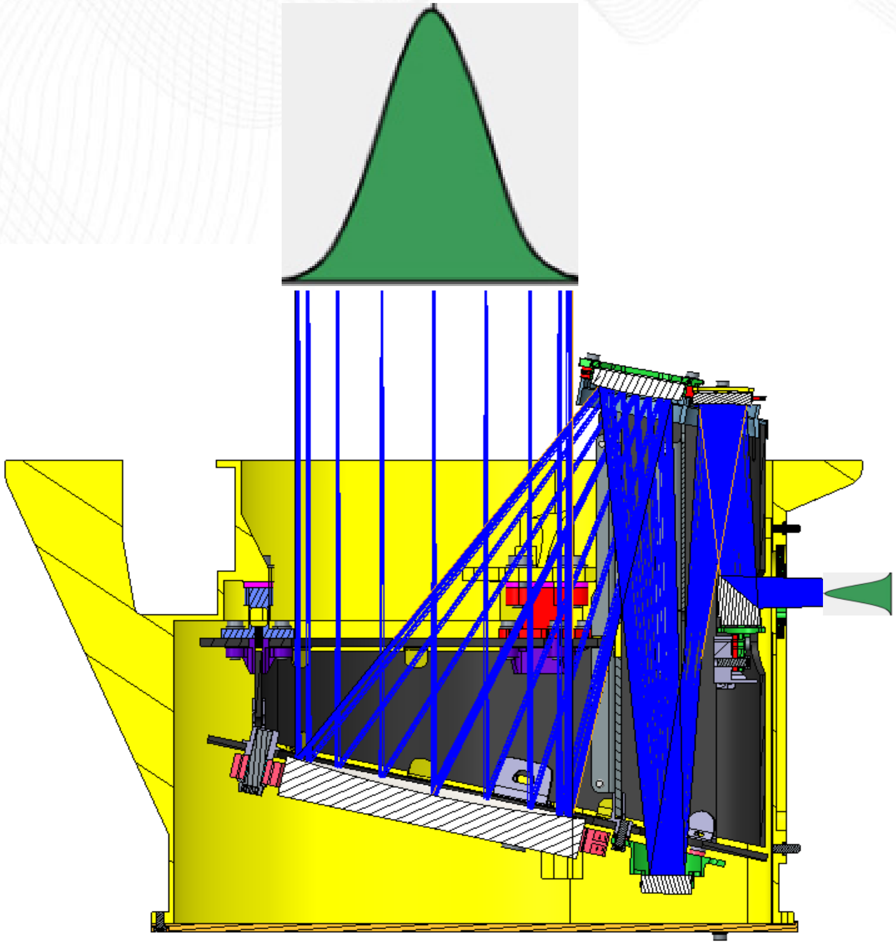


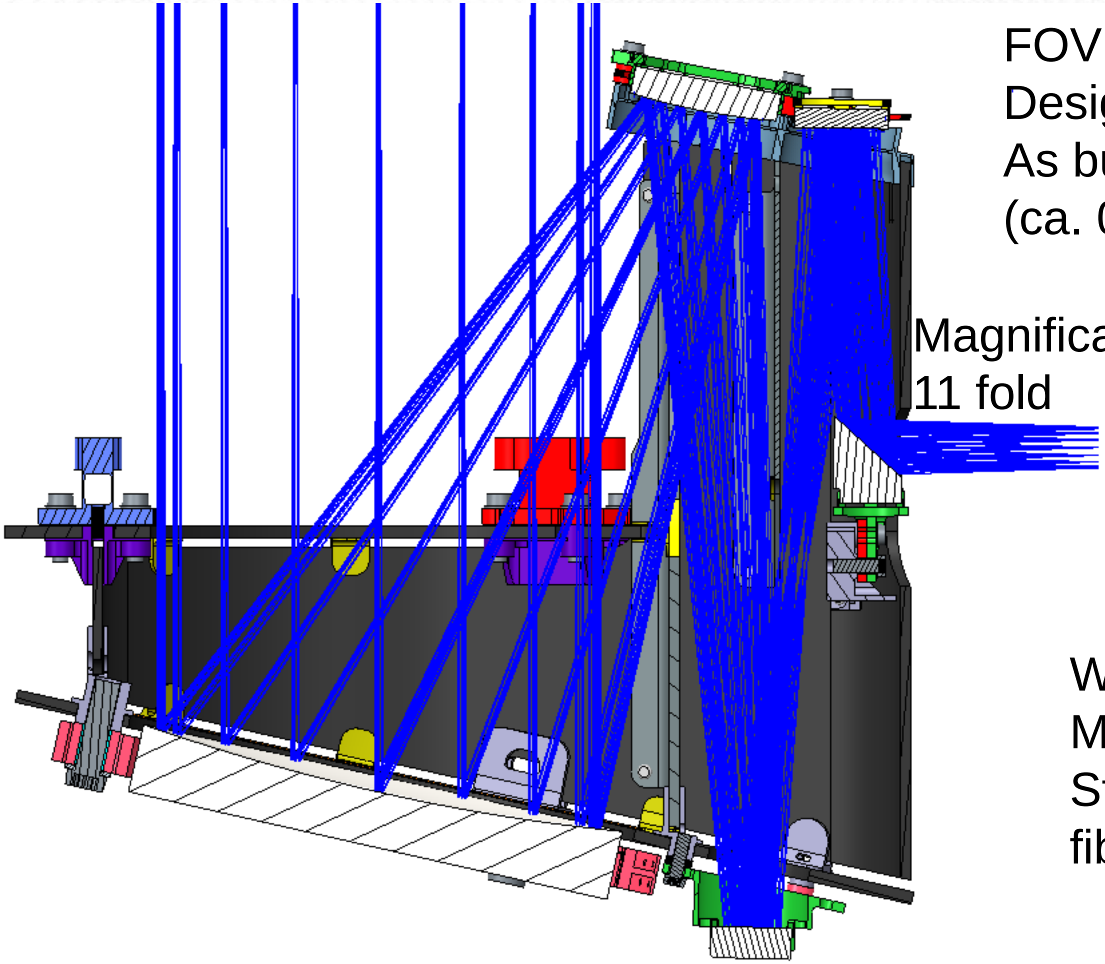
TLU project: Evolution from on axis design to Schiefspiegler design





TLU project: Optical Design

Effective output aperture 135 mm

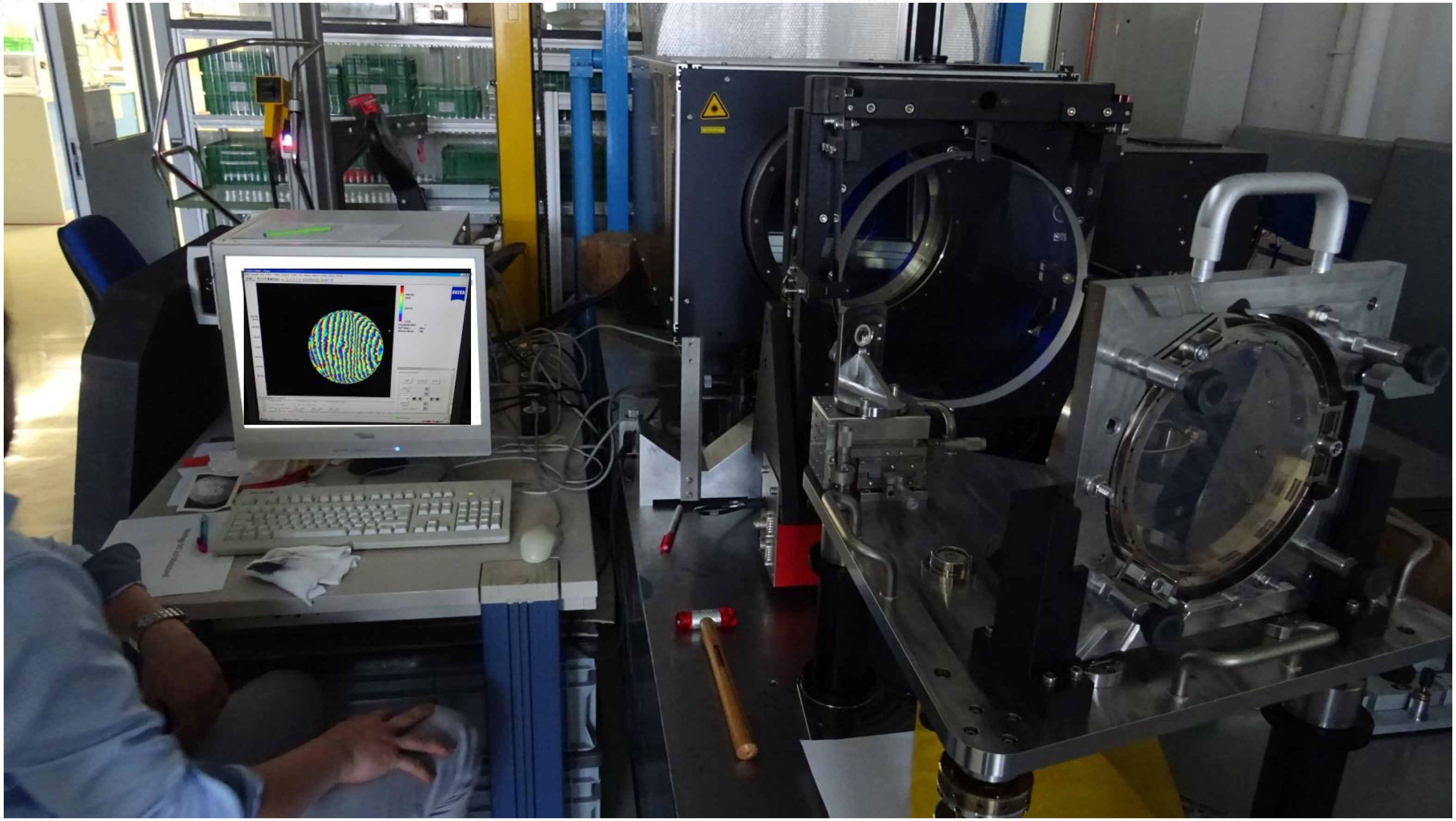


FOV +- 0,2 °
Design error < 3 nm RMS
As built WFE < 25 nm RMS
(ca. 0,1 wave)

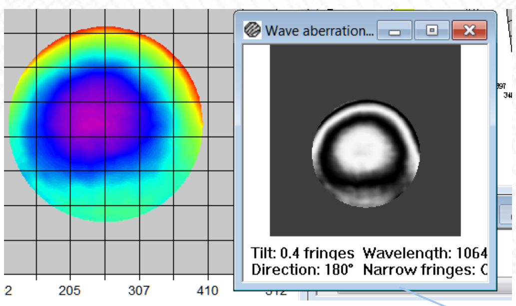
Magnification
11 fold

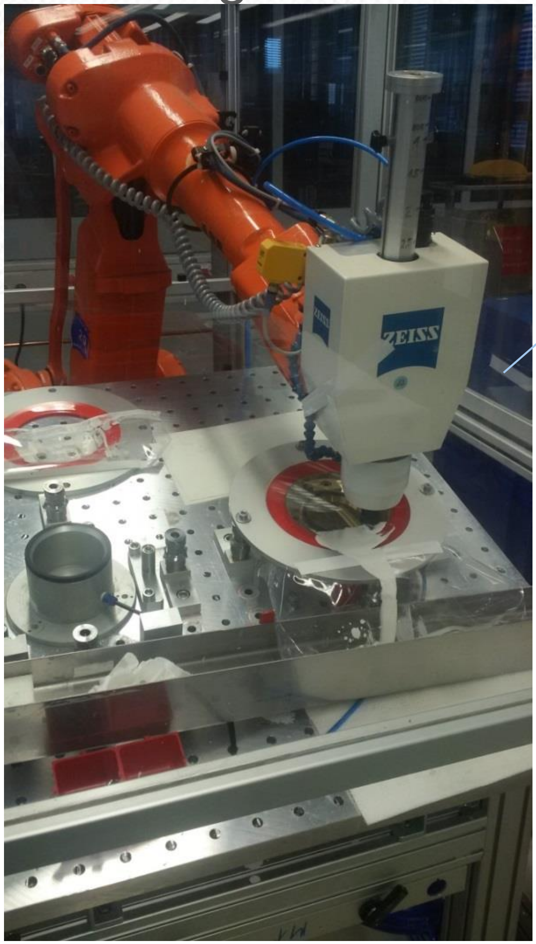
Weight: 3,6 kg
Mirror material: Zerodur
Structure material: carbon fibre and Invar

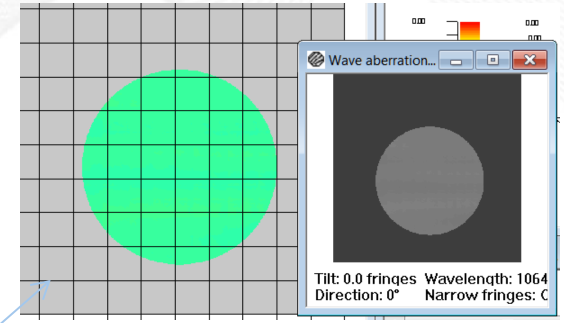
TLU project: Manufacturing of primary mirror
Interferometer testing



TLU project : Schiefspiegler off axis primary mirror manufacturing with Computer Controlled Polishing



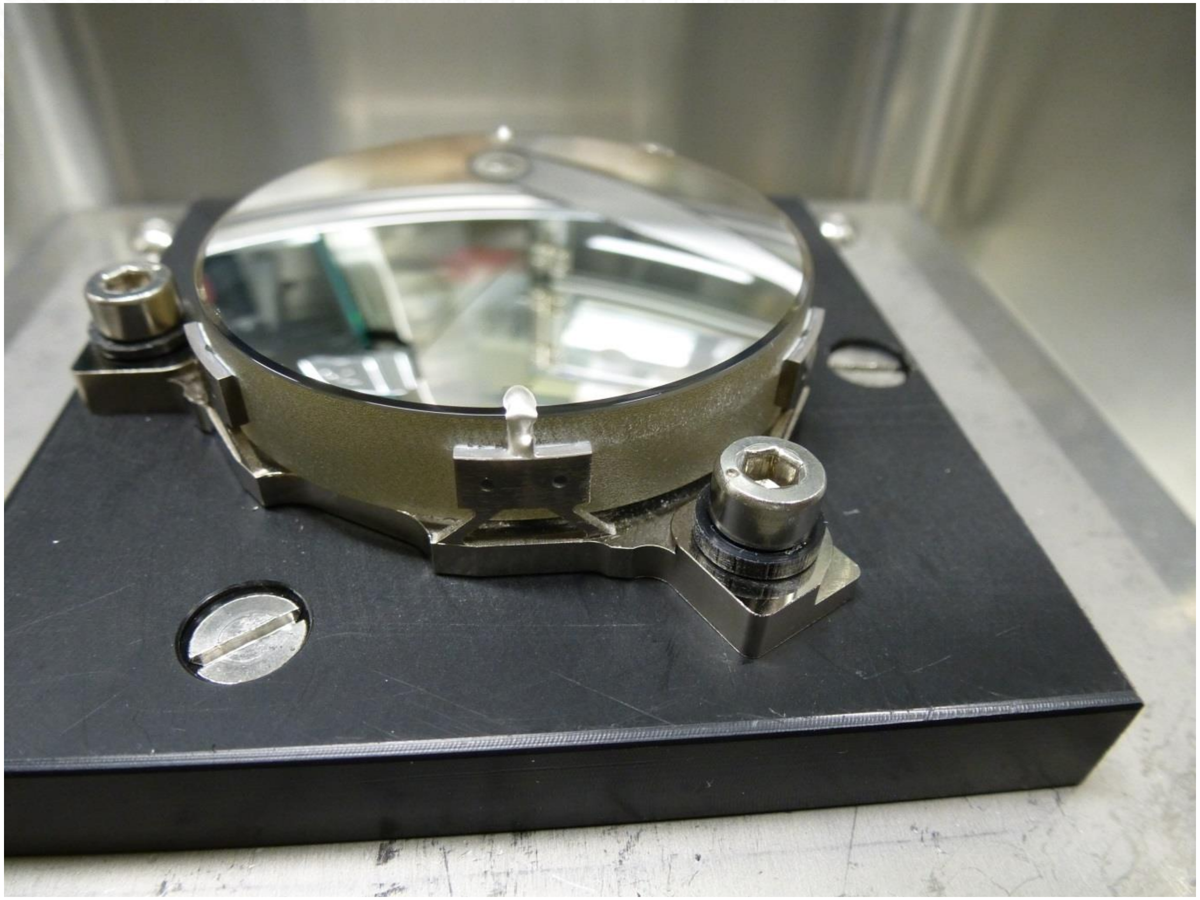




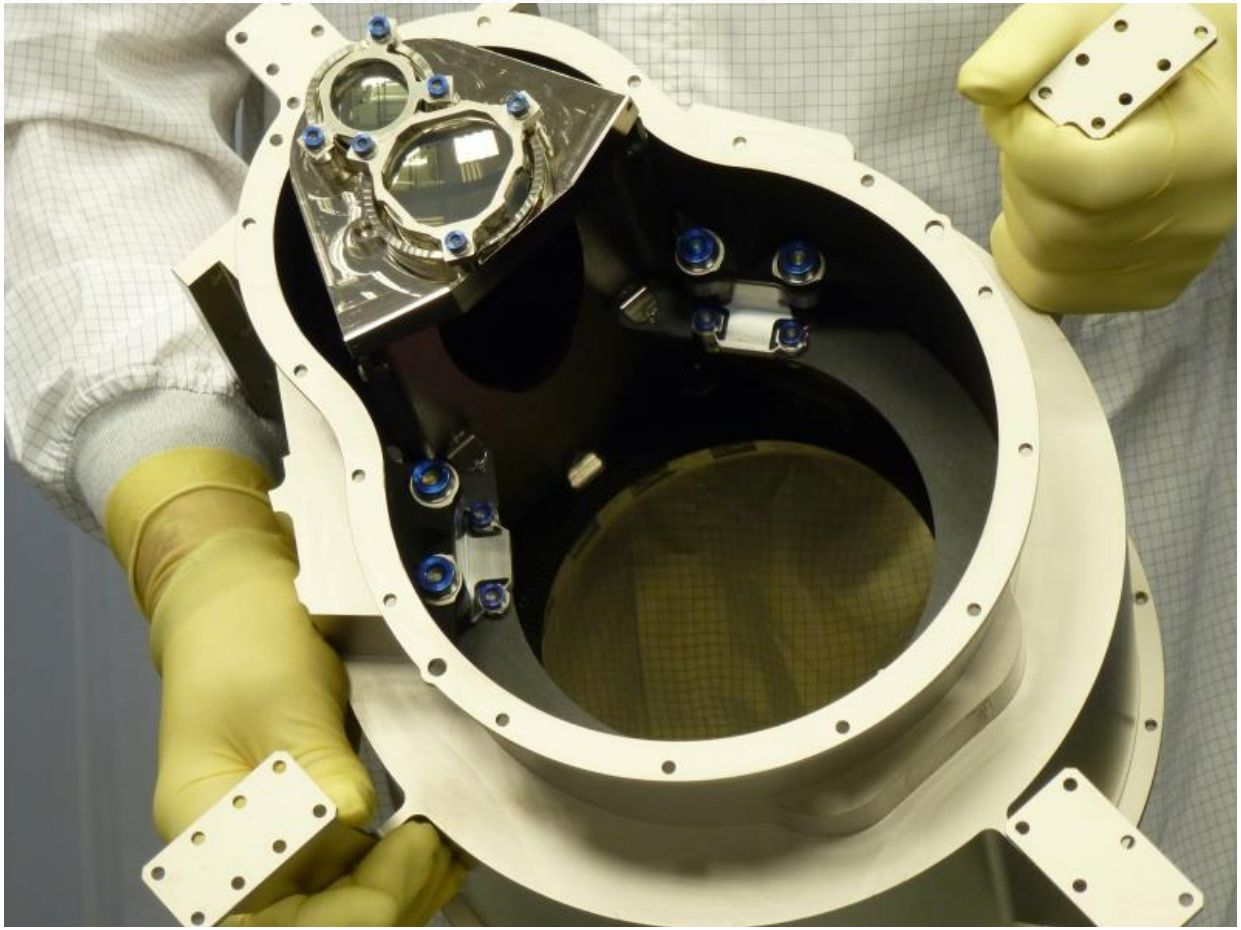
WFE < 10 nm RMS

Ion Beam Figuring:
Atomic Level Figure Control

TLU project: Off axis secondary mirror coating (Ag)



TLU project: Schiefspiegler telescope integrated and aligned, ready for performance and load testing.

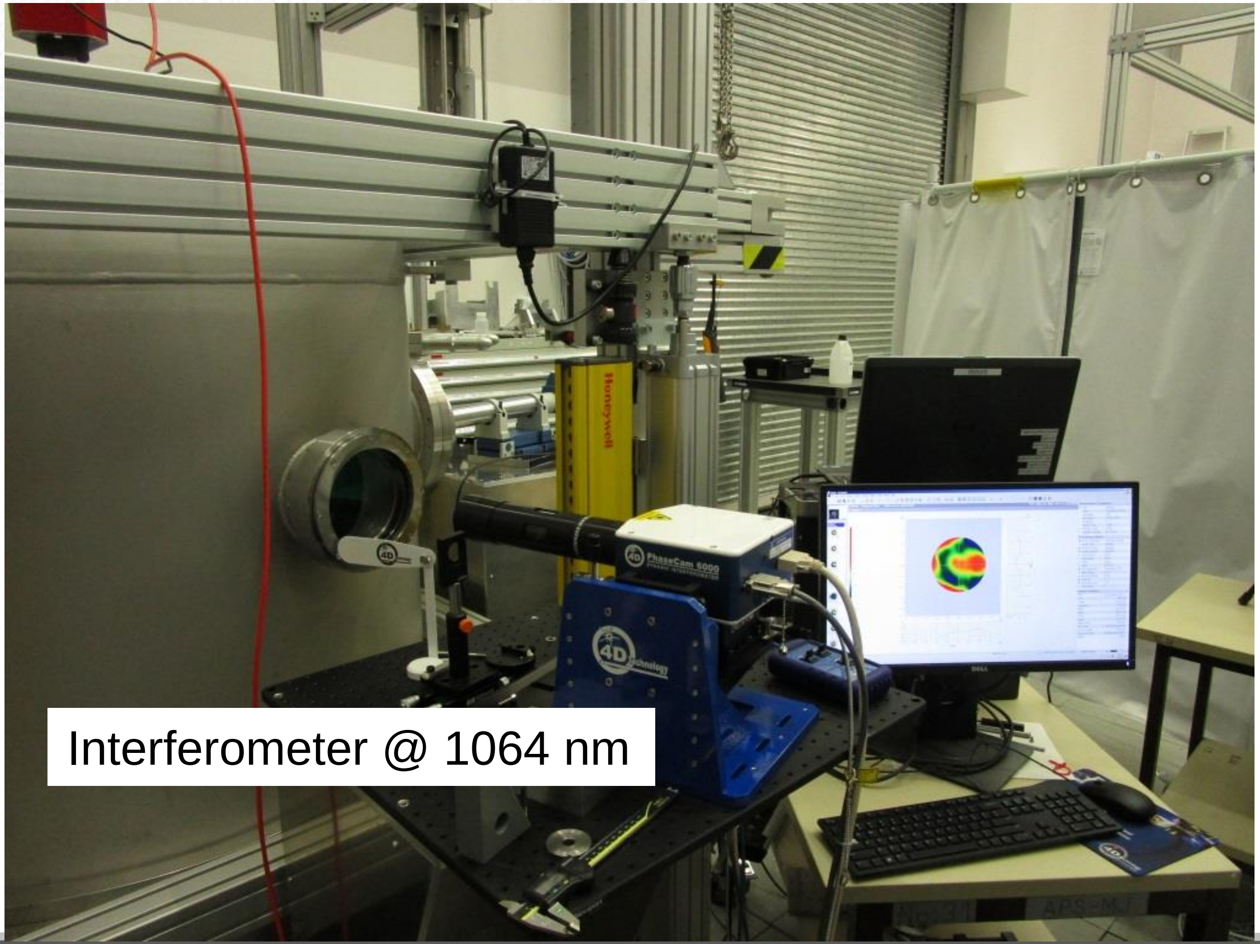


TLU project: Optical performance tests of Schiefpiegler telescope in thermal vacuum chamber

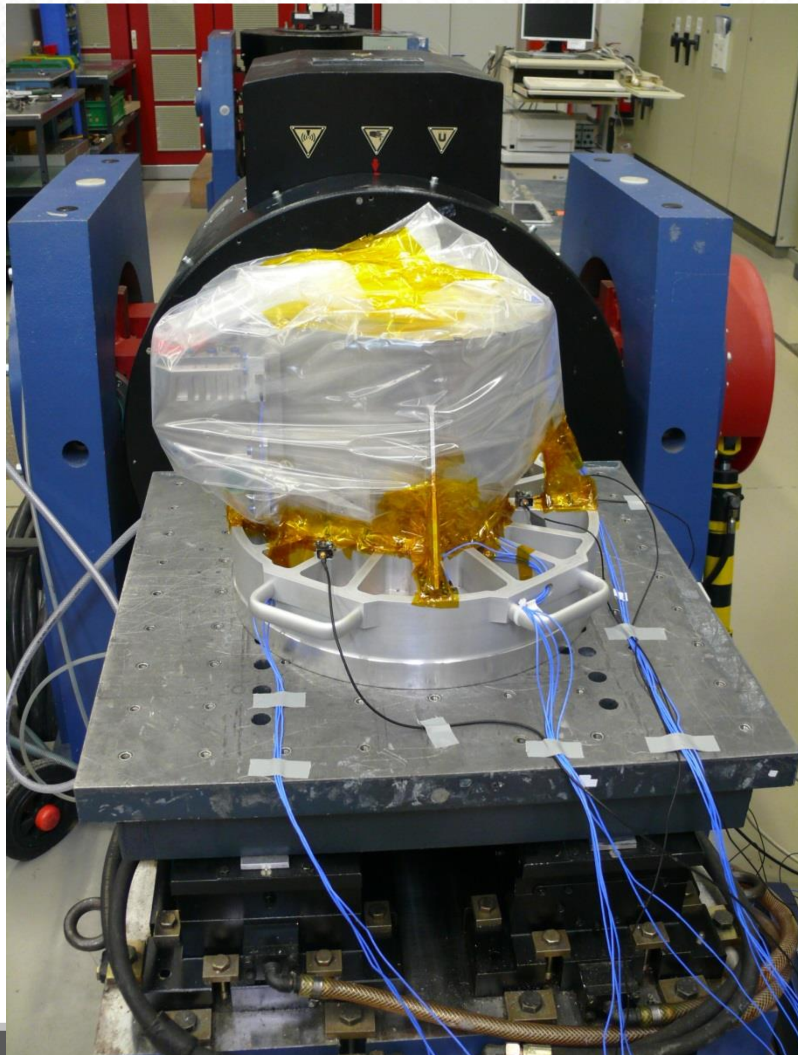
Operational: 10°C-65°

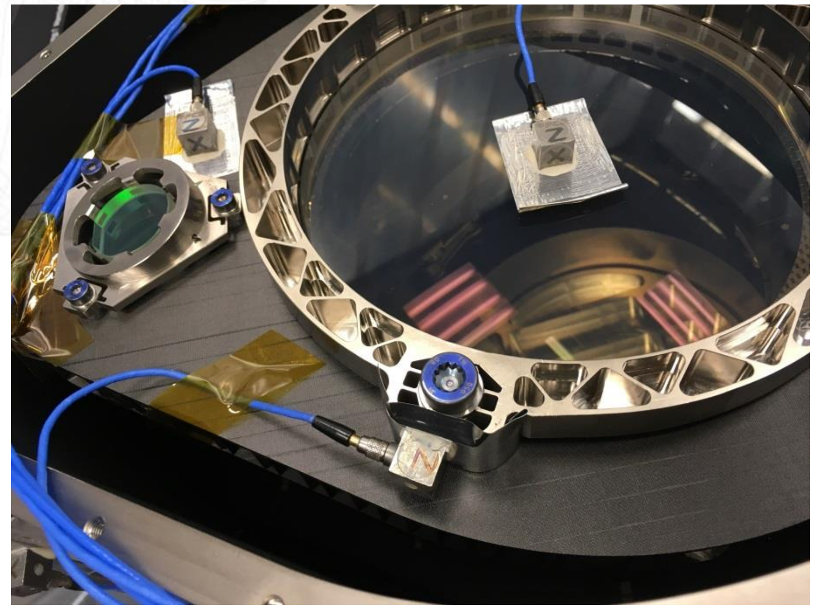
Non Op.: -40°C-70°

Vacuum : < 10E-5 mbar



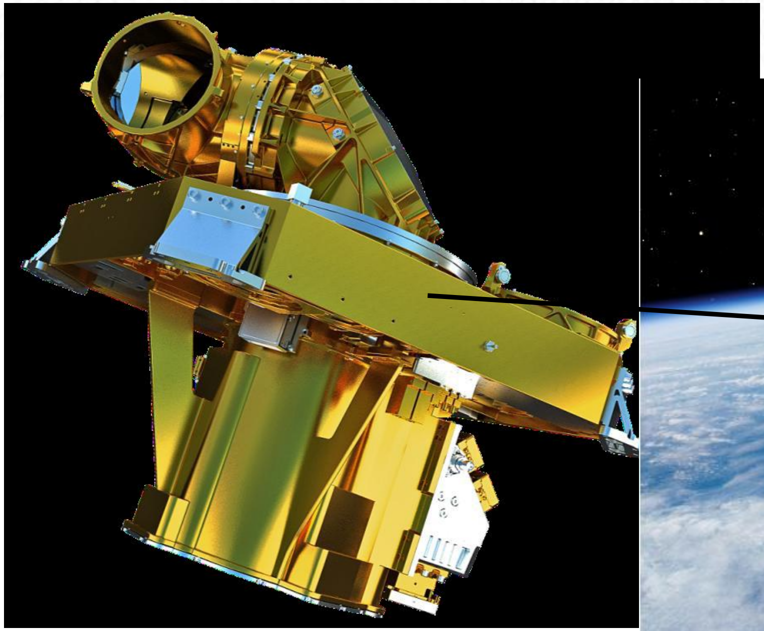
TLU: Shock and vibration tests, withstanding the rocket launch!





Test levels : 18 g rms random

TLU: After integration into LCT and satellite and after launch



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Final Summary

Schiefspiegler designs has their specific benefits and they are still in production for professional applications!

Thank you for your attention!