



Integrating High Resolution Solar Physics

Development of Integral Field Units based on image slicers for solar spectropolarimetry

Silvia Regalado Olivares

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- Optical design and analysis

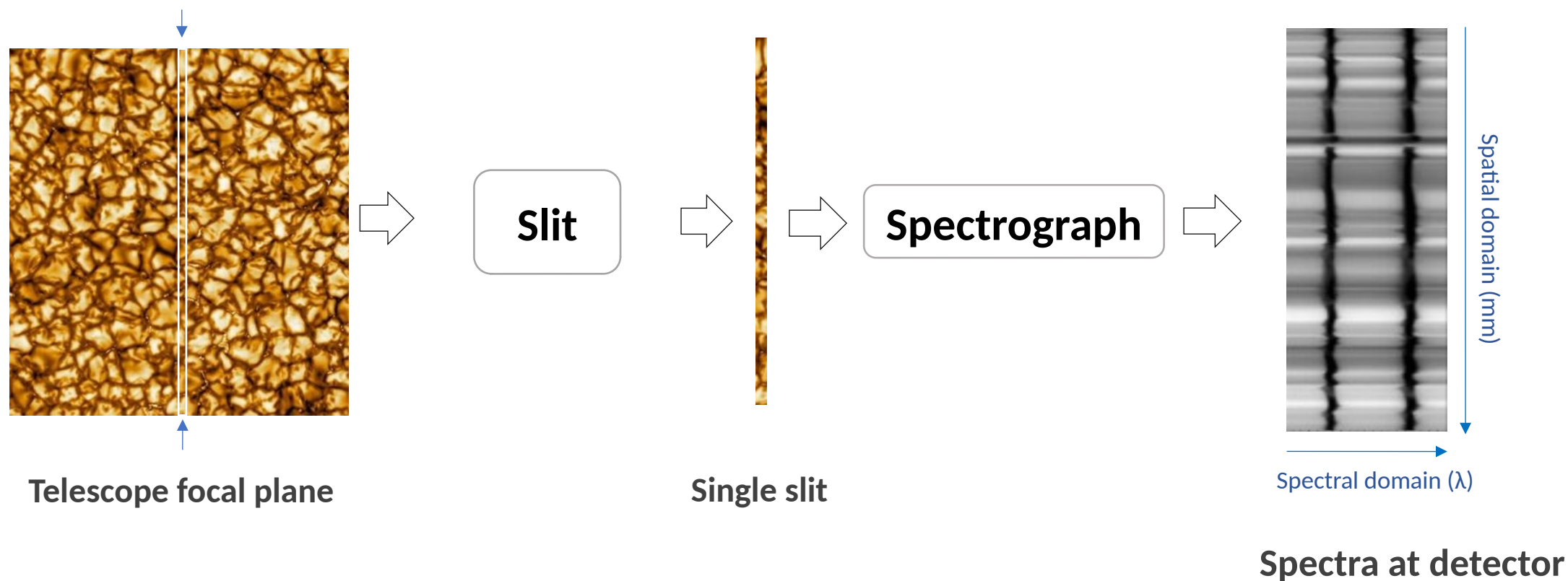
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1. Introduction - Actual status

- **Single slit vs Integral Field Unit (IFU)**

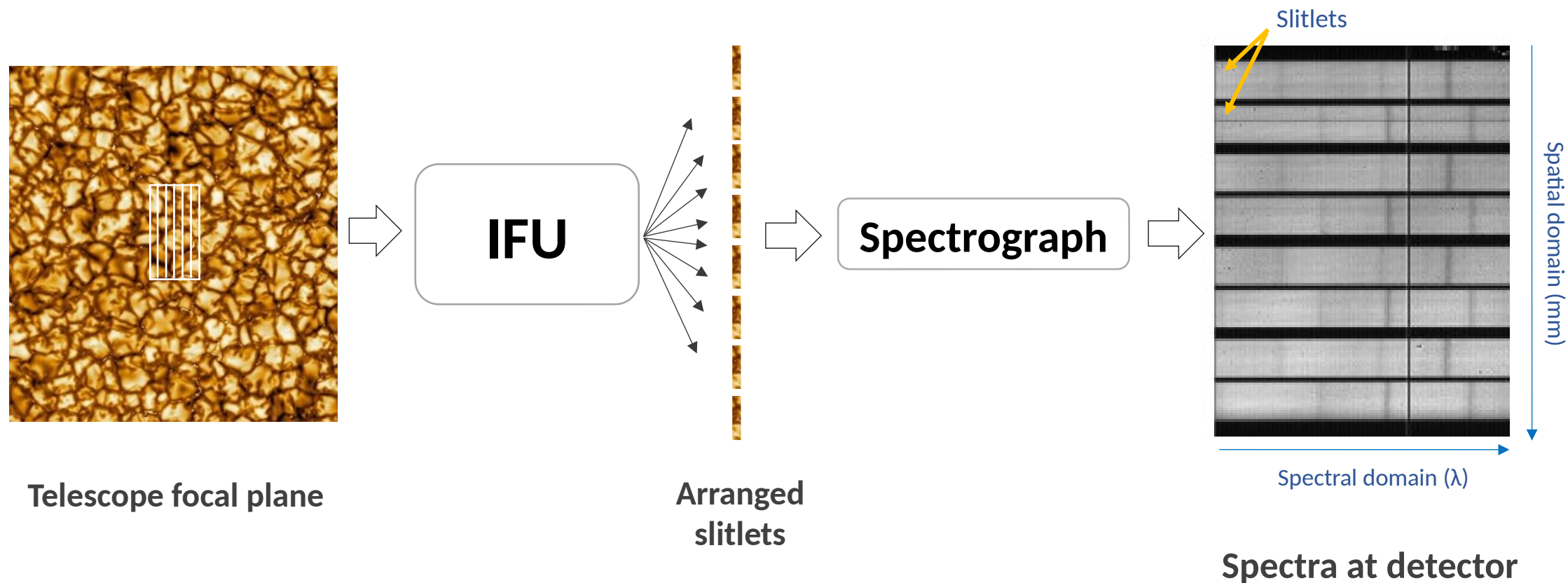
1. Introduction - Actual status

- **Single slit vs Integral Field Unit (IFU)**



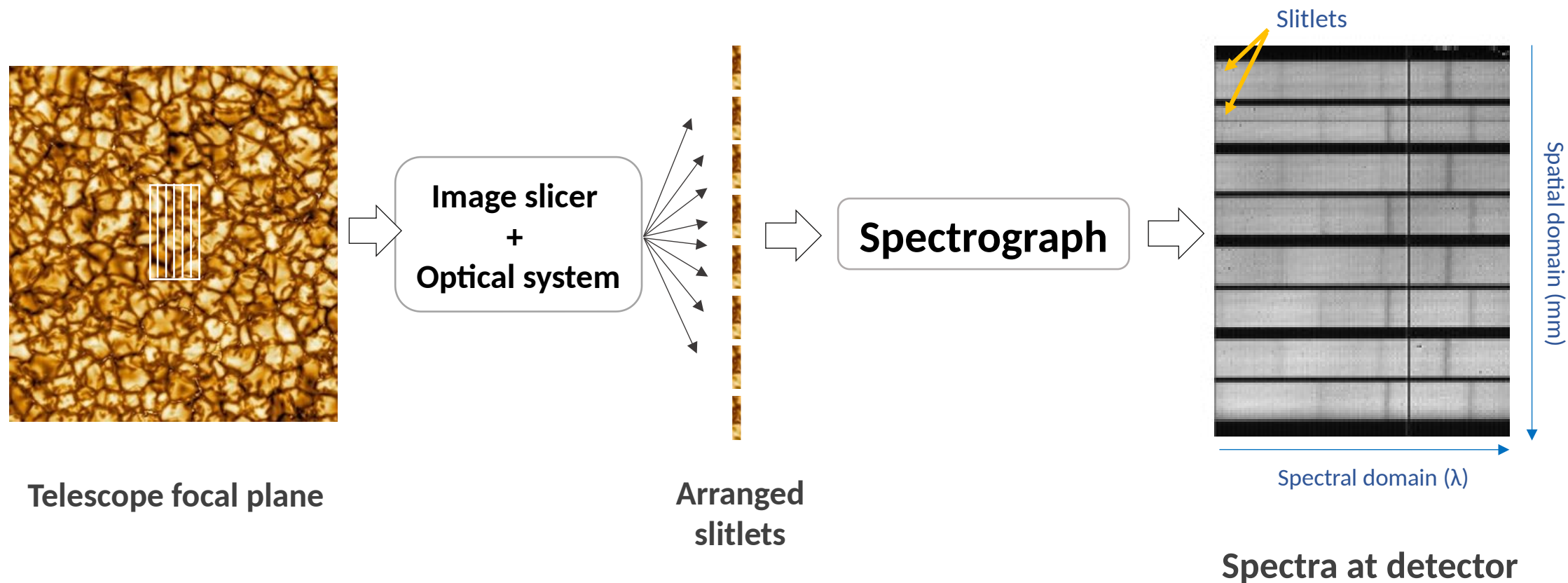
1. Introduction - Actual status

- **Single slit vs Integral Field Unit (IFU)**



1. Introduction - Actual status

- **Single slit vs Integral Field Unit (IFU)**



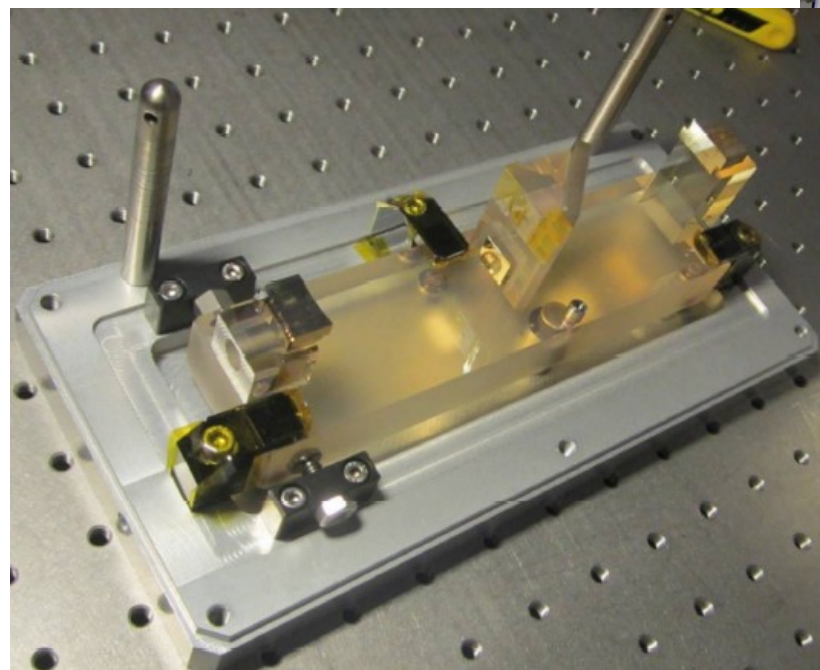
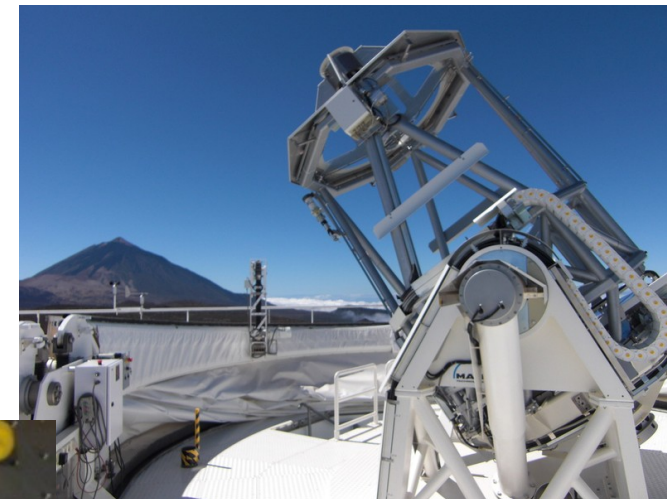
1. Introduction - Actual status

- **100 μm Image slicer**

- Optical design by IAC (*Calcines et al., 2014*)
- Manufactured by WS
- Installed at GRIS



GREGOR Telescope

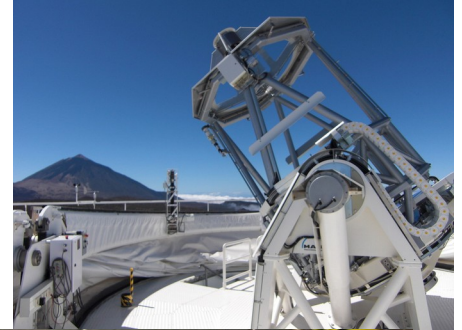


IFU AIV (*Dominguez-Tagle et al., 2018*)

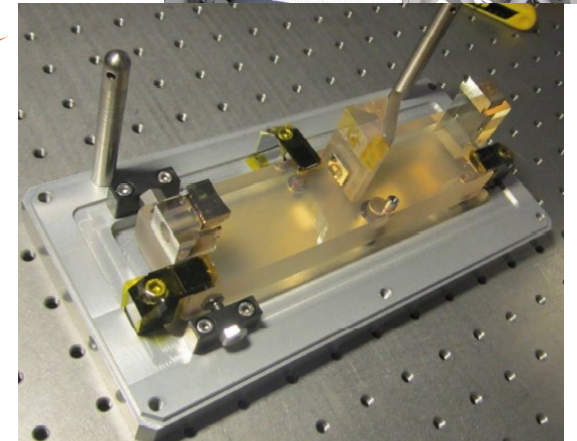
1. Introduction - Actual status

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GREGOR Telescope



Winlight



IFU AIV (Dominguez-Tagle et al., 2018)

1. Introduction - Actual status

• 100 μm Image slicer

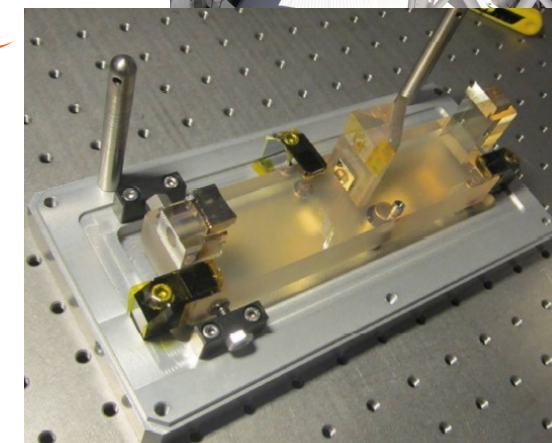
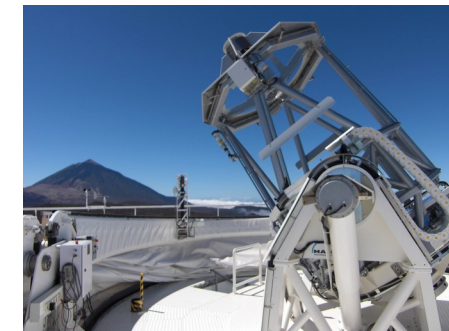
- Optical design by IAC
- Manufactured by WS
- Installed at GRIS

Slicer width	100 μm (0.38")
N° slitlets	8
N° Out slits	1
Material	Glass

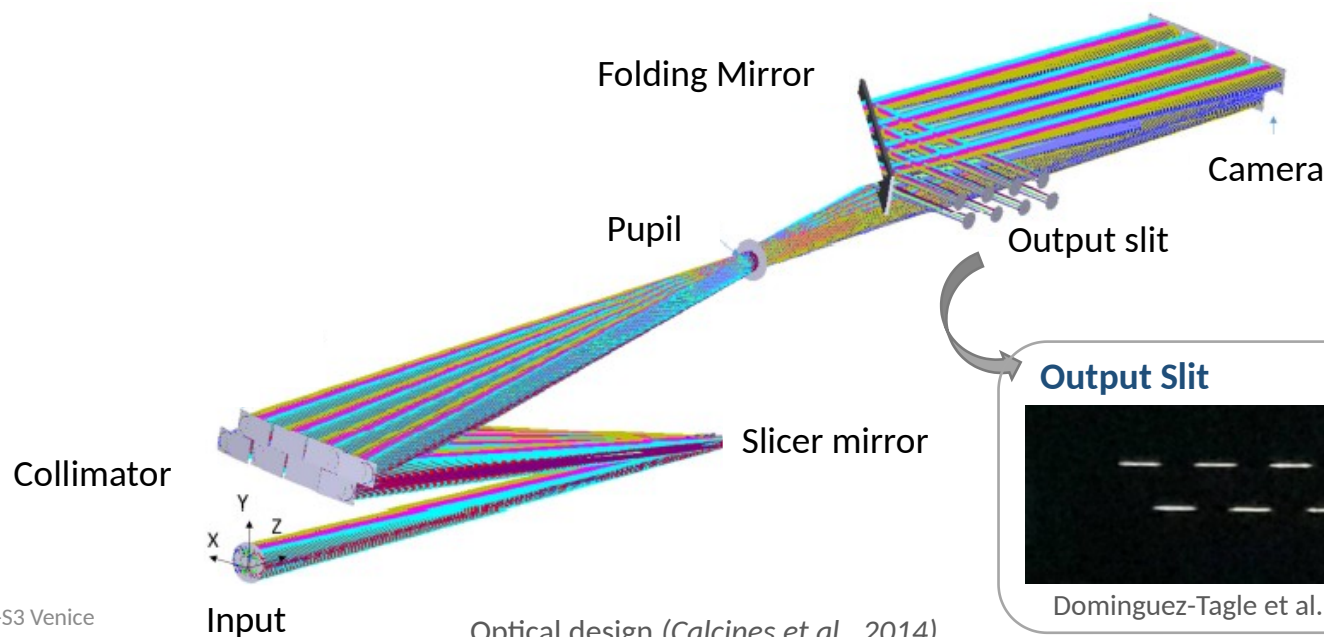
FoV \square 6" x 3"



GREGOR Telescope



IFU AIV (Dominguez-Tagle et al., 2018)



Output Slit



Dominguez-Tagle et al., submitted

1. Introduction - Actual status

• 100 μm Image slicer

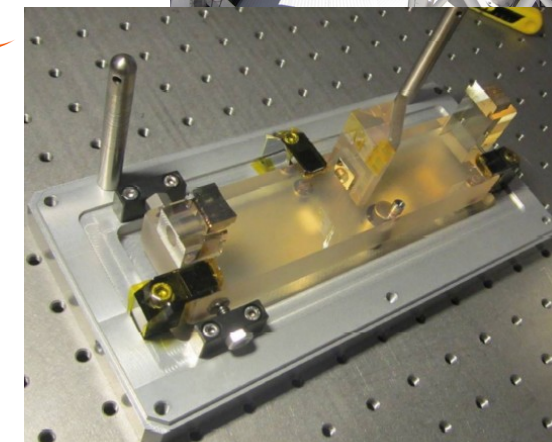
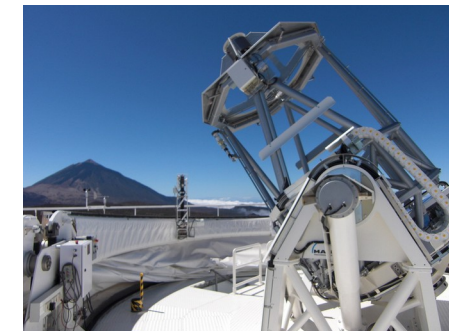
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FoV \square 6'' x 3''



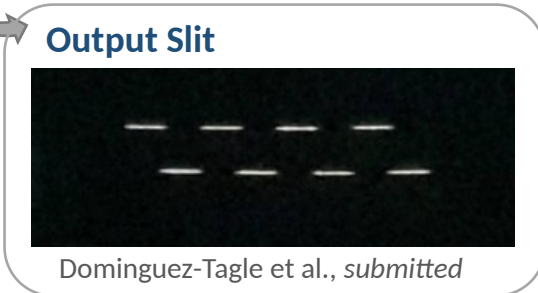
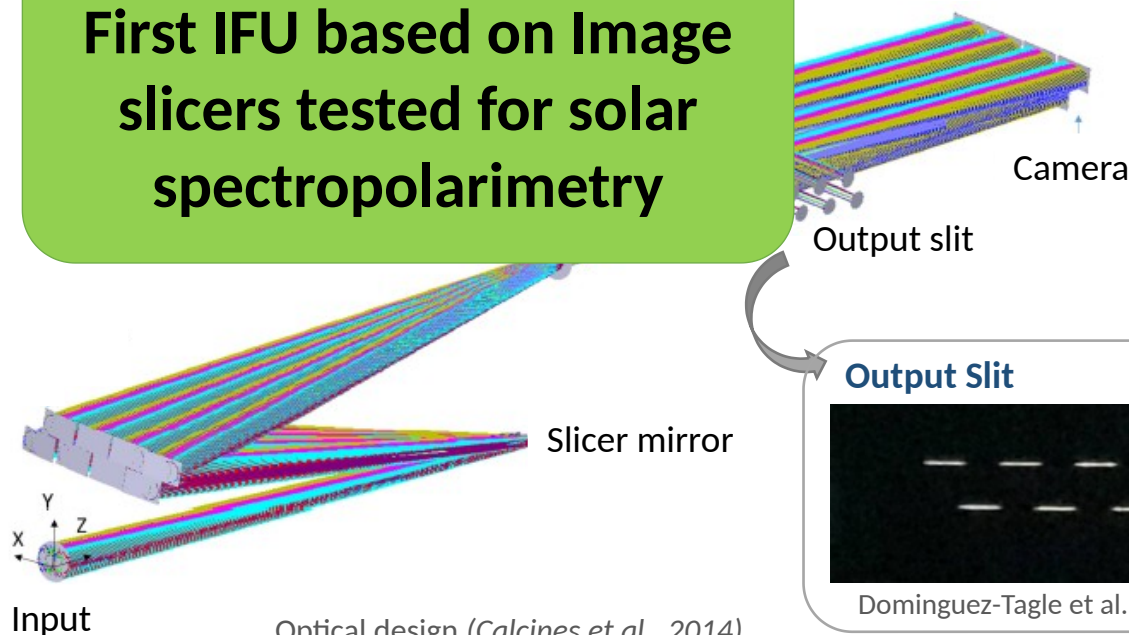
GREGOR Telescope



IFU AIV (Dominguez-Tagle et al., 2018)



First IFU based on Image slicers tested for solar spectropolarimetry



1. Introduction - Actual status

- Objectives

1. Introduction - Actual status

- **Objectives**

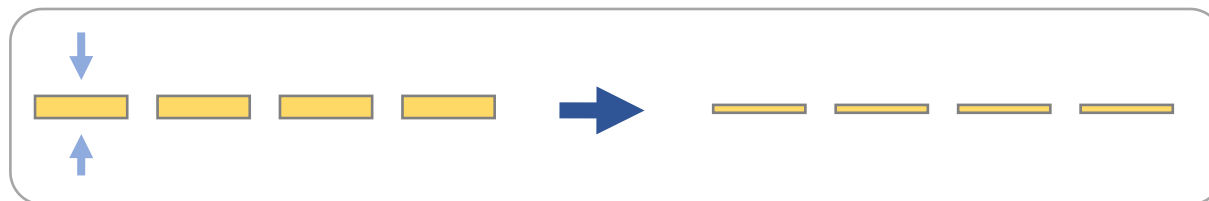
- ✓ MORE SPATIAL RESOLUTION

1. Introduction - Actual status

- Objectives

- ✓ MORE SPATIAL RESOLUTION

Slicer width

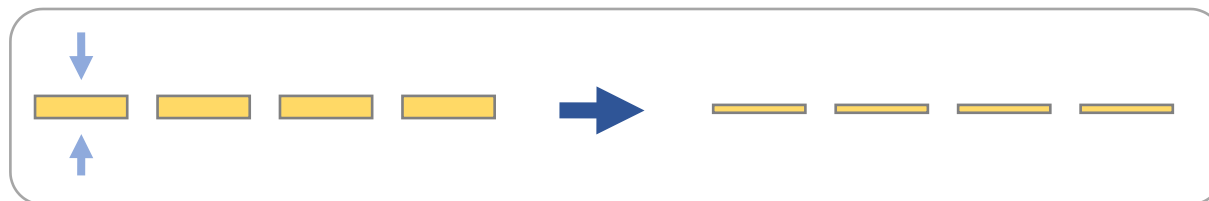


1. Introduction - Actual status

- Objectives

- ✓ MORE SPATIAL RESOLUTION

Slicer width



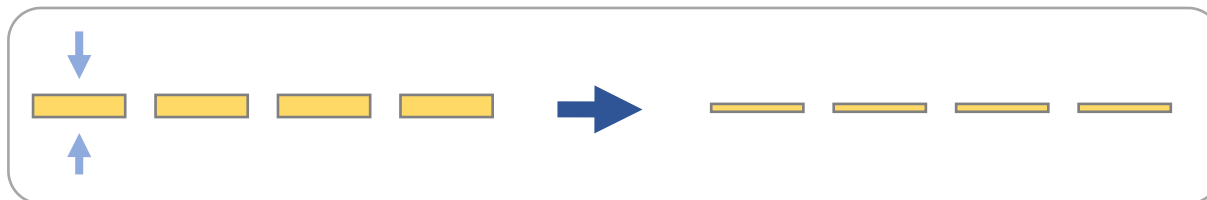
- ✓ MORE FoV

1. Introduction - Actual status

• Objectives

- ✓ MORE SPATIAL RESOLUTION

Slicer width



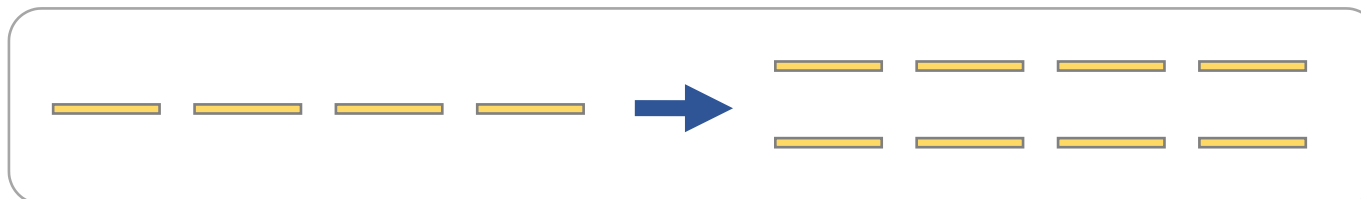
- ✓ MORE FoV

N° slitlets



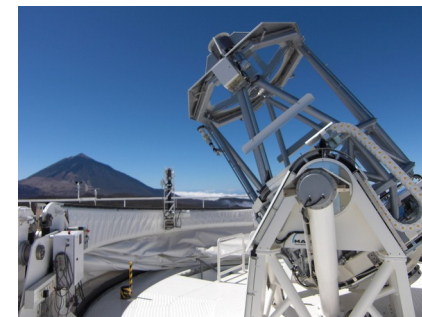
- ✓ N° OUTPUT SLITS

N° out slits



1. Introduction - Actual status

- **70 μm Image slicer**
 - Optical design
 - Manufactured by WS

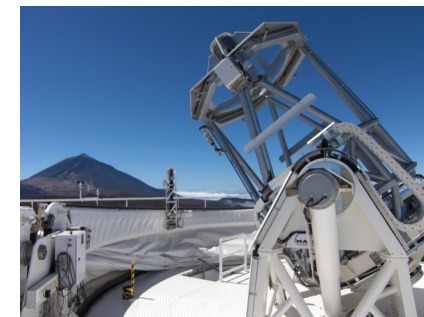


GREGOR Telescope

1. Introduction - Actual status

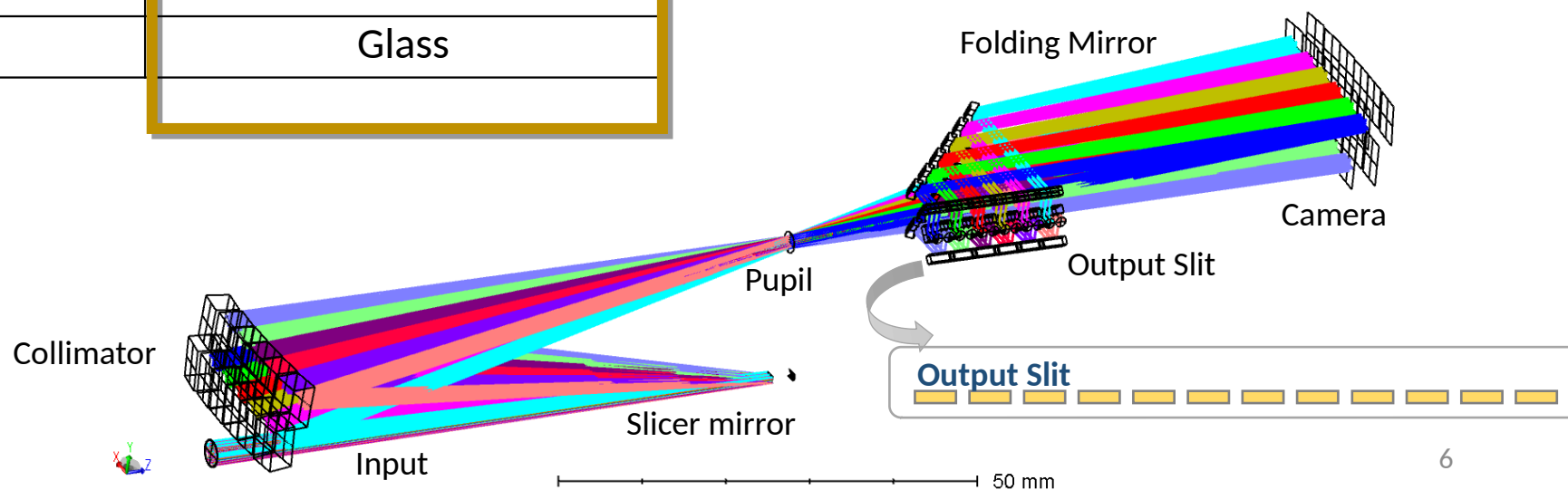
- **70 μm Image slicer**

- Optical design
- Manufactured by WS



GREGOR Telescope

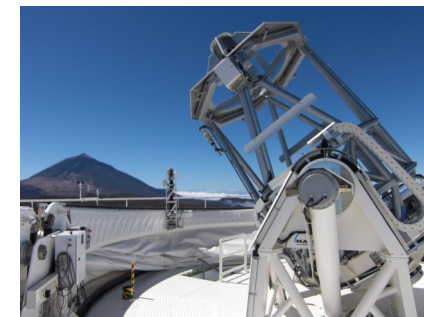
	100 μm Image slicer	70 μm Image slicer
Slicer width	100 μm	70 μm
N° slitlets	8	12
N° Out slits	1	1
Material	Glass	Glass



1. Introduction - Actual status

- **70 μm Image slicer**

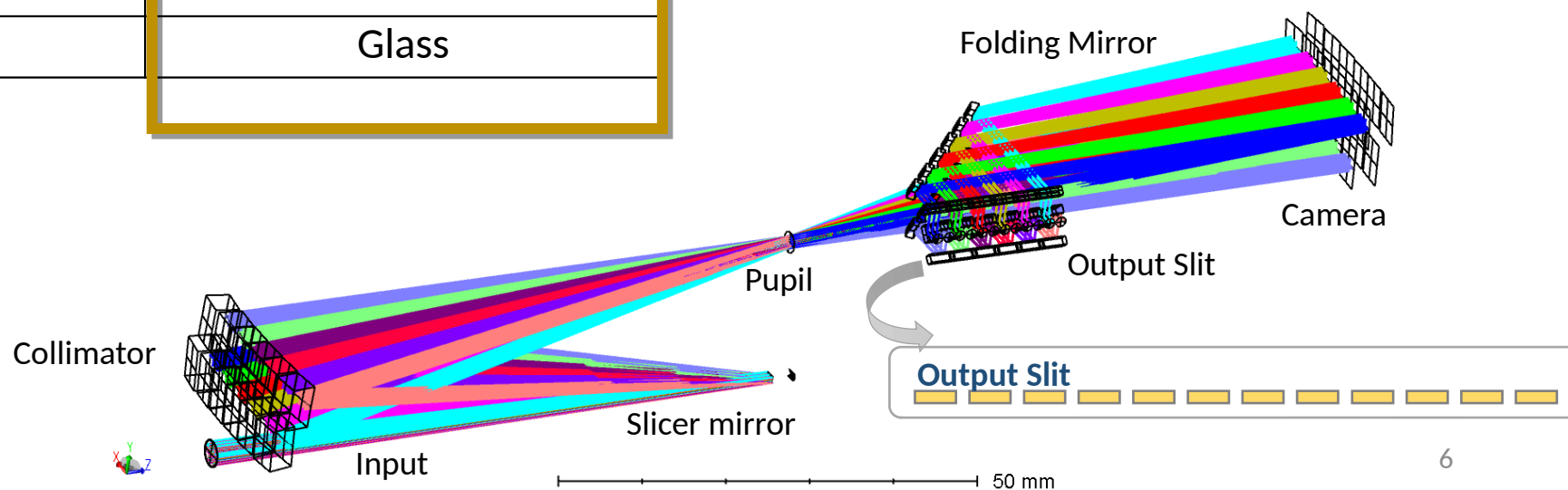
- Optical design
- Manufactured by WS



GREGOR Telescope

	100 μm Image slicer	70 μm Image slicer
Slicer width	100 μm	70 μm
N° slitlets	8	12
N° Out slits	1	1
Material	Glass	Glass

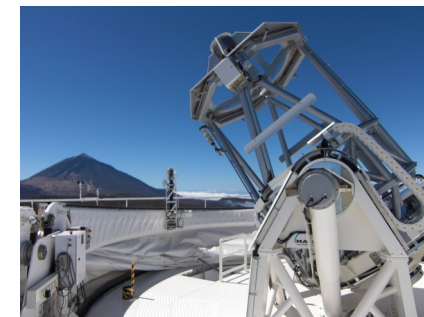
← Thinner
← More slitlets



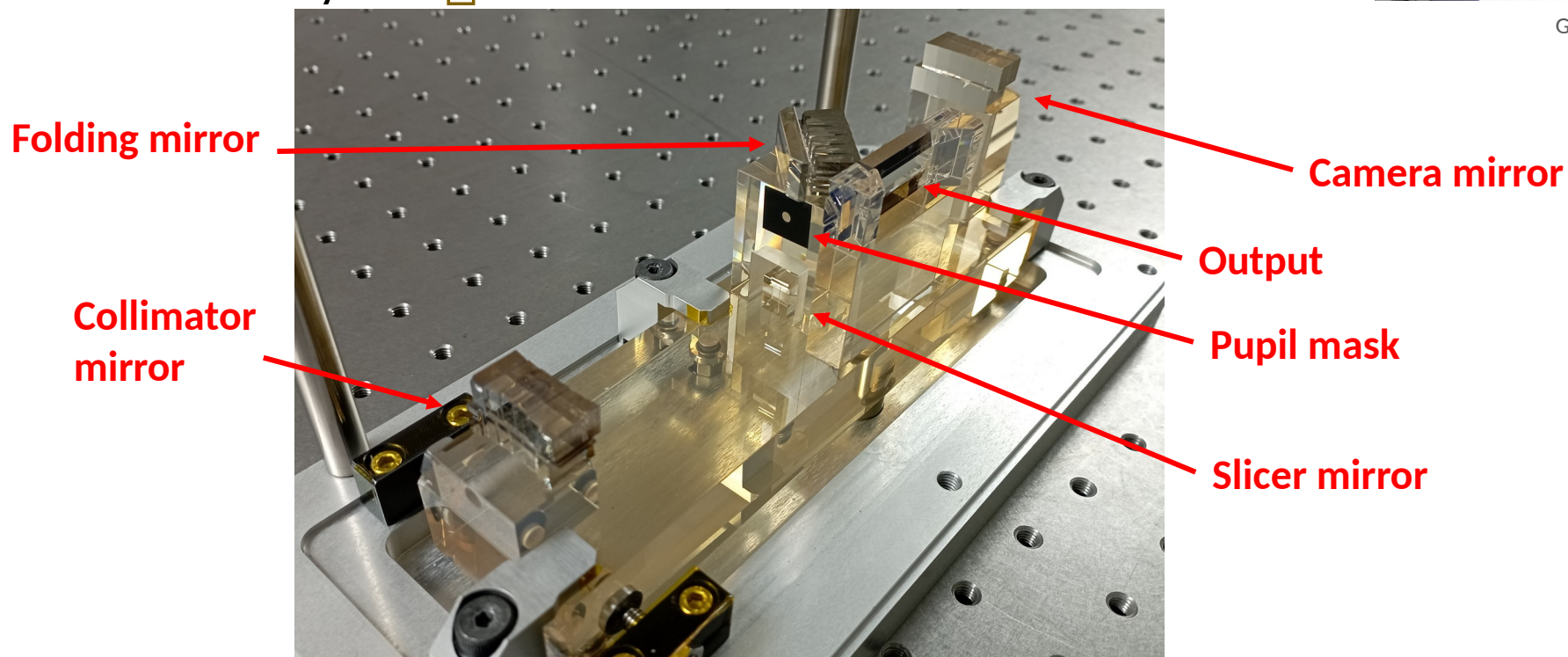
1. Introduction - Actual status

- **70 μm Image slicer**

- Optical design
- Manufactured by WS **Delivered in June 2023**



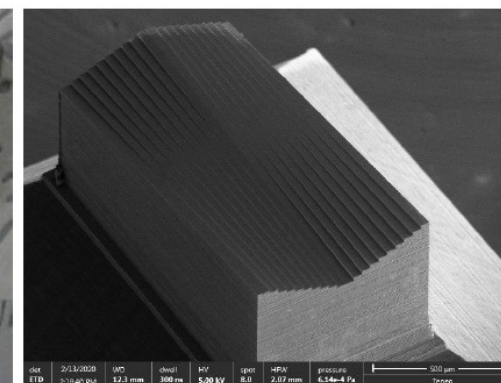
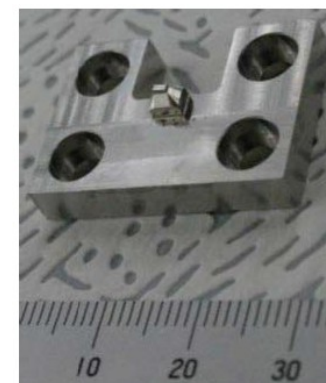
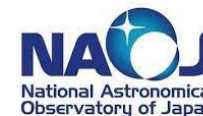
GREGOR Telescope



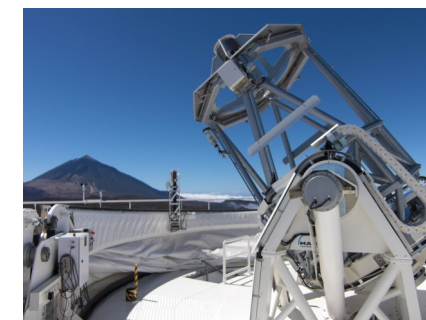
1. Introduction - Actual status

- **35 μm Image slicer**

- Slicer mirror manufactured
- IFU additional optics at design status



35 μm width image slicer (SOLARNET_D6.3)

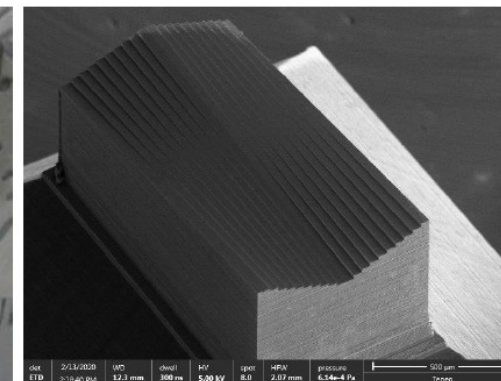
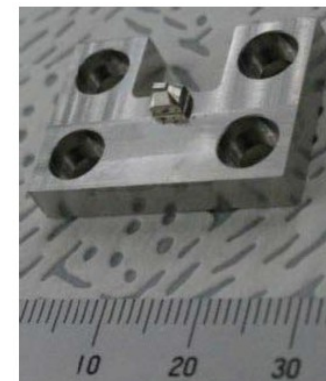
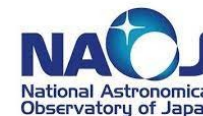


GREGOR Telescope

1. Introduction - Actual status

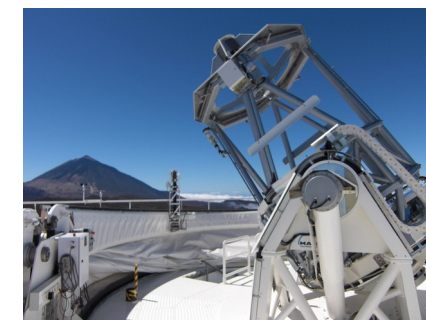
- **35 μm Image slicer**

- Slicer mirror manufactured
- IFU additional optics at design status



35 μm width image slicer (SOLARNET_D6.3)

	100 μm Image slicer	70 μm Image slicer	35 μm Image slicer
Slicer width	100 μm	70 μm	35 μm
N° slitlets	8	12	8
N° Out slits	1	1	2
Material	Glass	Glass	Metallic

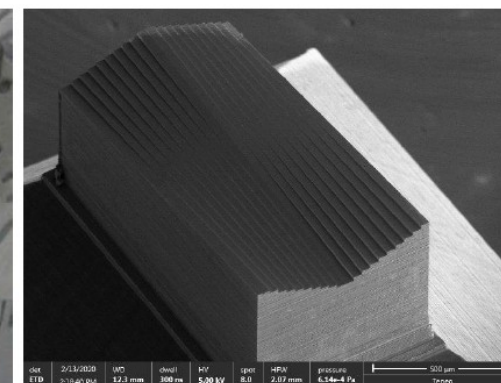
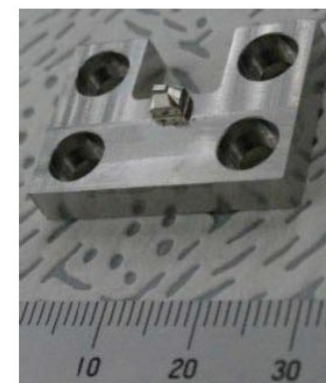


GREGOR Telescope

1. Introduction - Actual status

- **35 μm Image slicer**

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35 μm width image slicer (SOLARNET_D6.3)

	100 μm Image slicer	70 μm Image slicer	35 μm Image slicer
Slicer width	100 μm	70 μm	35 μm
N° slitlets	8	12	8
N° Out slits	1	1	2
Material	Glass	Glass	Metallic

← Thinner - close to EST diffraction limit

← Multi - slit

← Different material



OR Telescope

35 μm Image slicer design

35 μm Image slicer design

- Start requirements and constraints

General

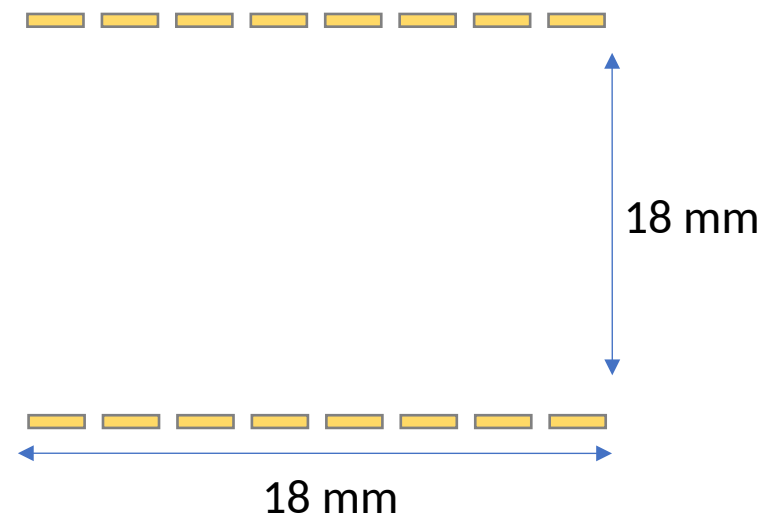
F #	40.58
Wavelength	1.565 μm , 1.080 μm
Illumination	Telecentric
Magnification	1:1
Detector	1020 x 1024 px 18 $\mu\text{m}/\text{px}$

Slicer Mirror

Slices n°	16
Slices width	35 μm
Slices length	1.176 mm

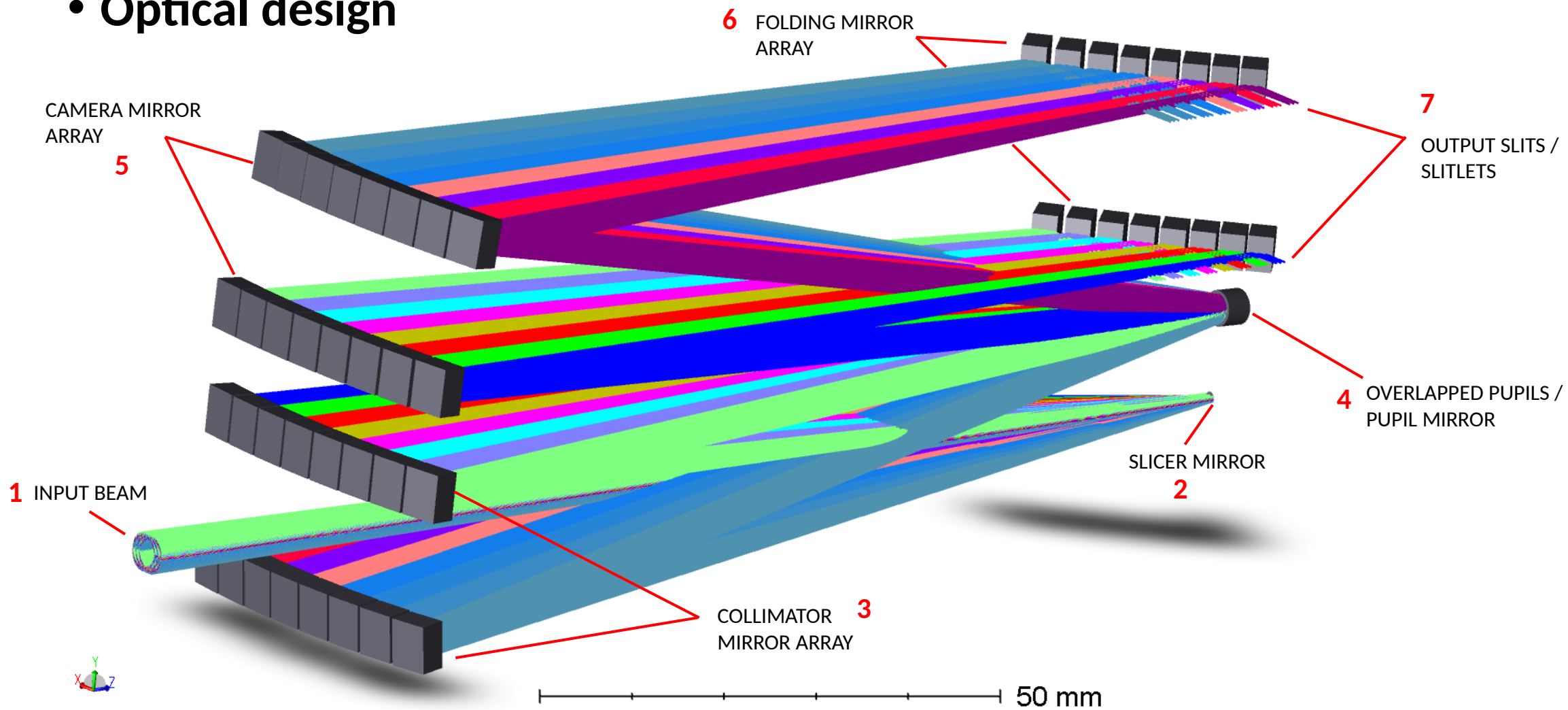
IFU Output

2 Continuous Slits:



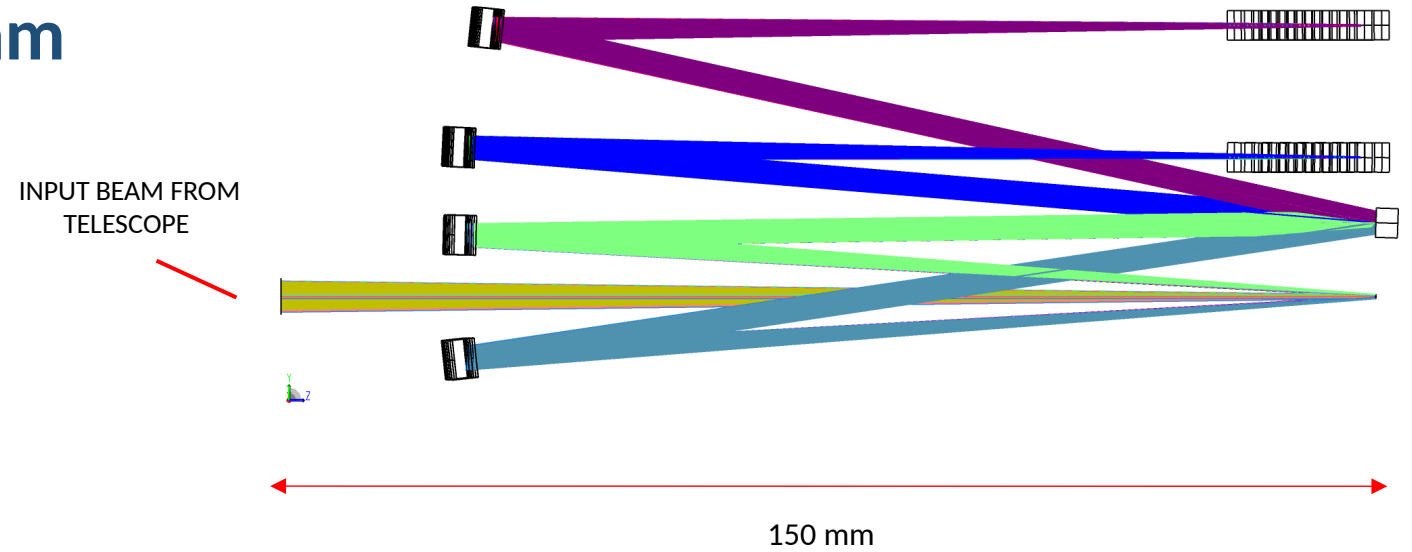
35 μm image slicer design

• Optical design



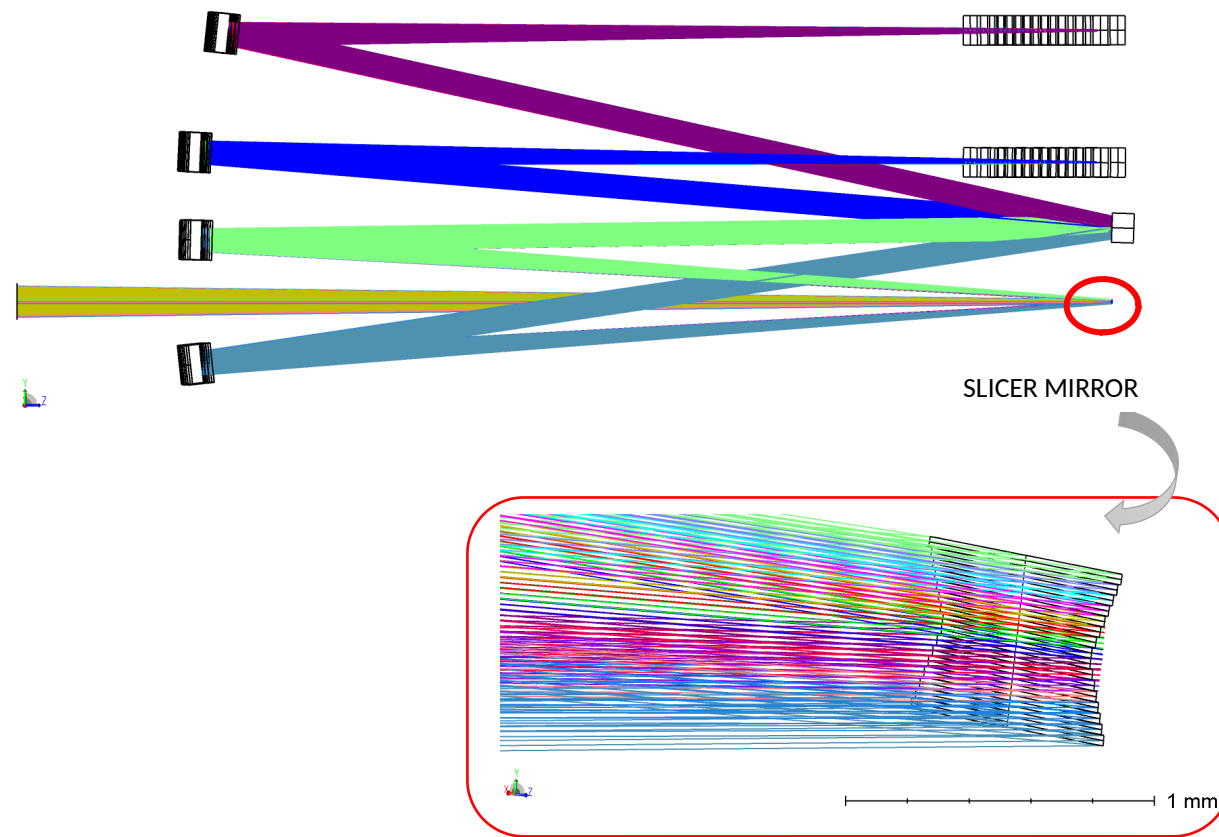
35 μm image slicer design

- **Optical design - Input beam**



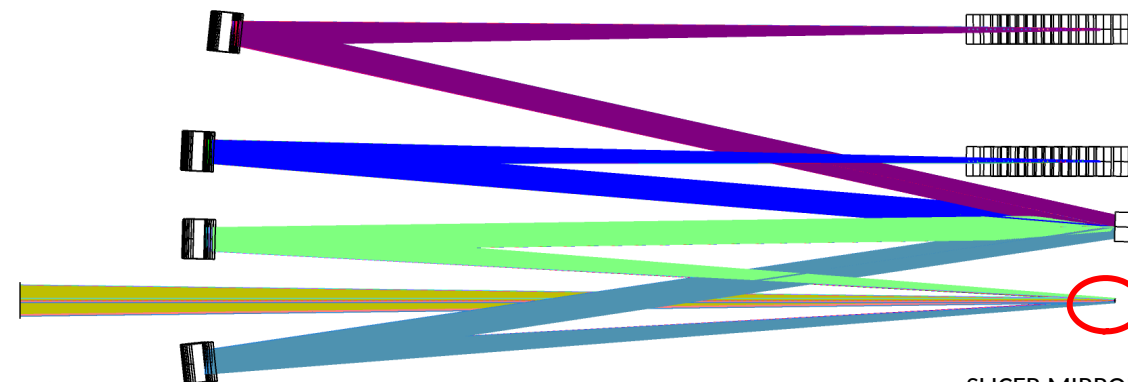
35 μm image slicer design

- Optical design – Slicer mirror



35 μm image slicer design

• Optical design – Slicer mirror



Slicer mirror # 8
Slicer mirror # 7
Slicer mirror # 6
Slicer mirror # 5
Slicer mirror # 4
Slicer mirror # 3
Slicer mirror # 2
Slicer mirror # 1
Slicer mirror # 9
Slicer mirror # 10
Slicer mirror # 11
Slicer mirror # 12
Slicer mirror # 13
Slicer mirror # 14
Slicer mirror # 15
Slicer mirror # 16

Y axis origin

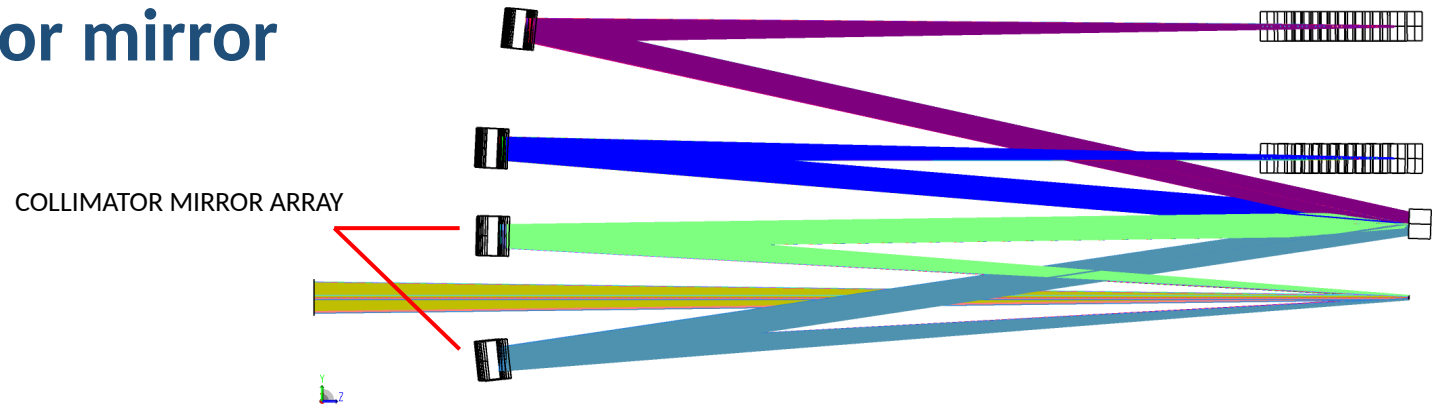
0.5 mm

N° of slices	2 x 8
Slicer Size	1.176 mm x 0.035 mm
Curvature	Flat
FoV	2.13'' x 4.47 ''



35 μm image slicer design

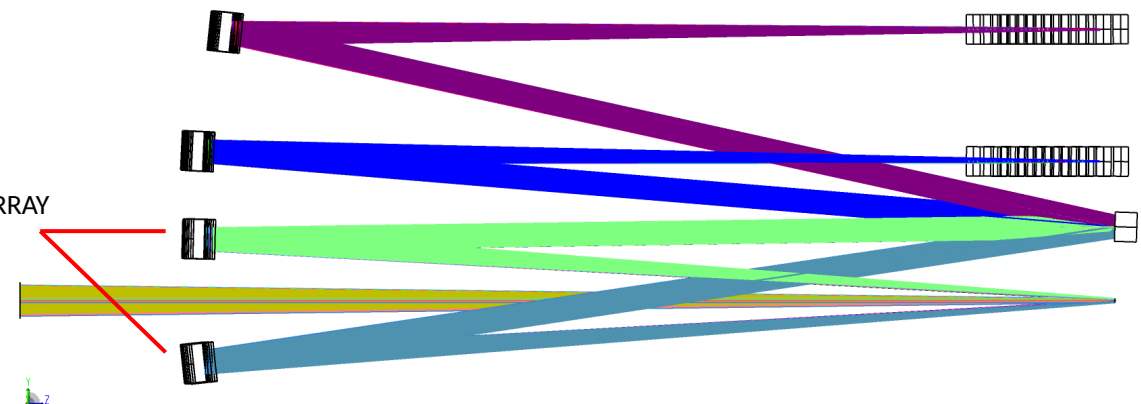
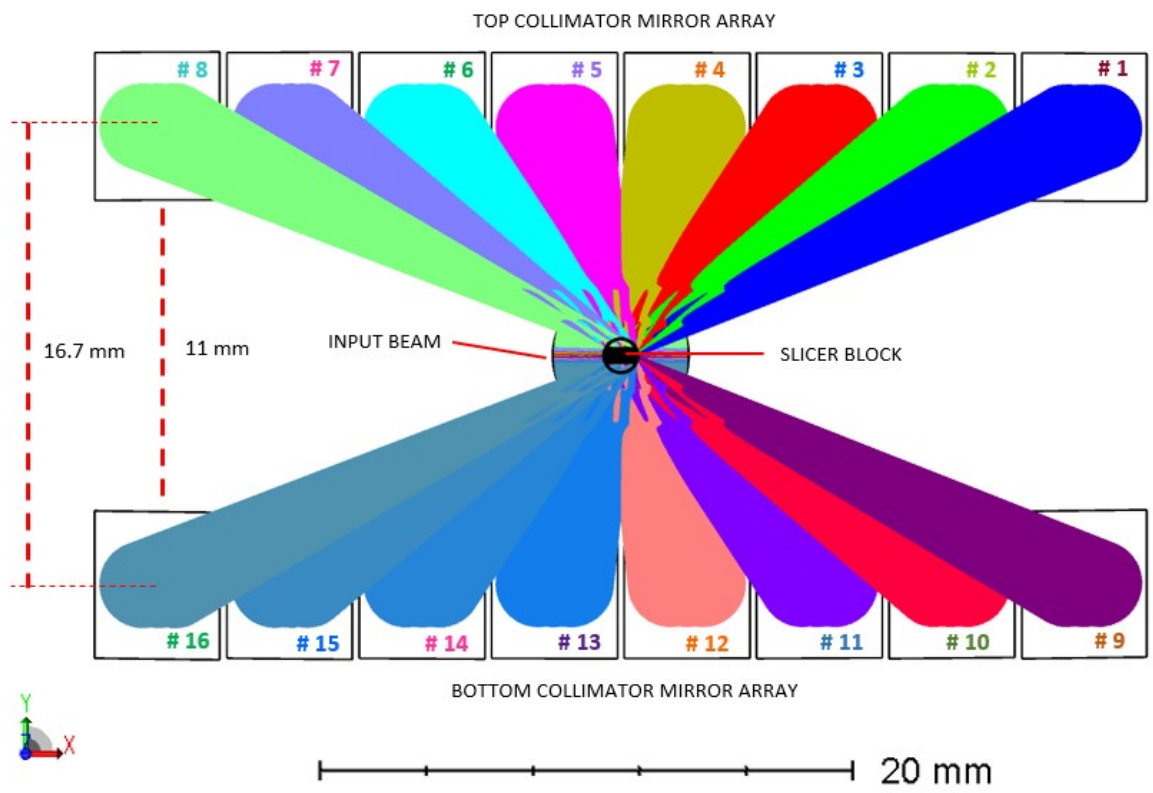
- **Optical design – Collimator mirror**



35 μm image slicer design

• Optical design – Collimator mirror

COLLIMATOR MIRROR ARRAY

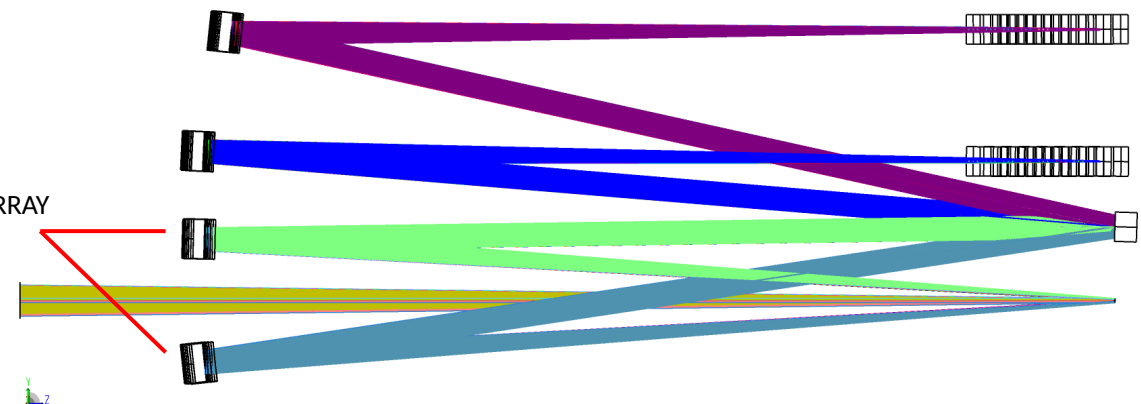
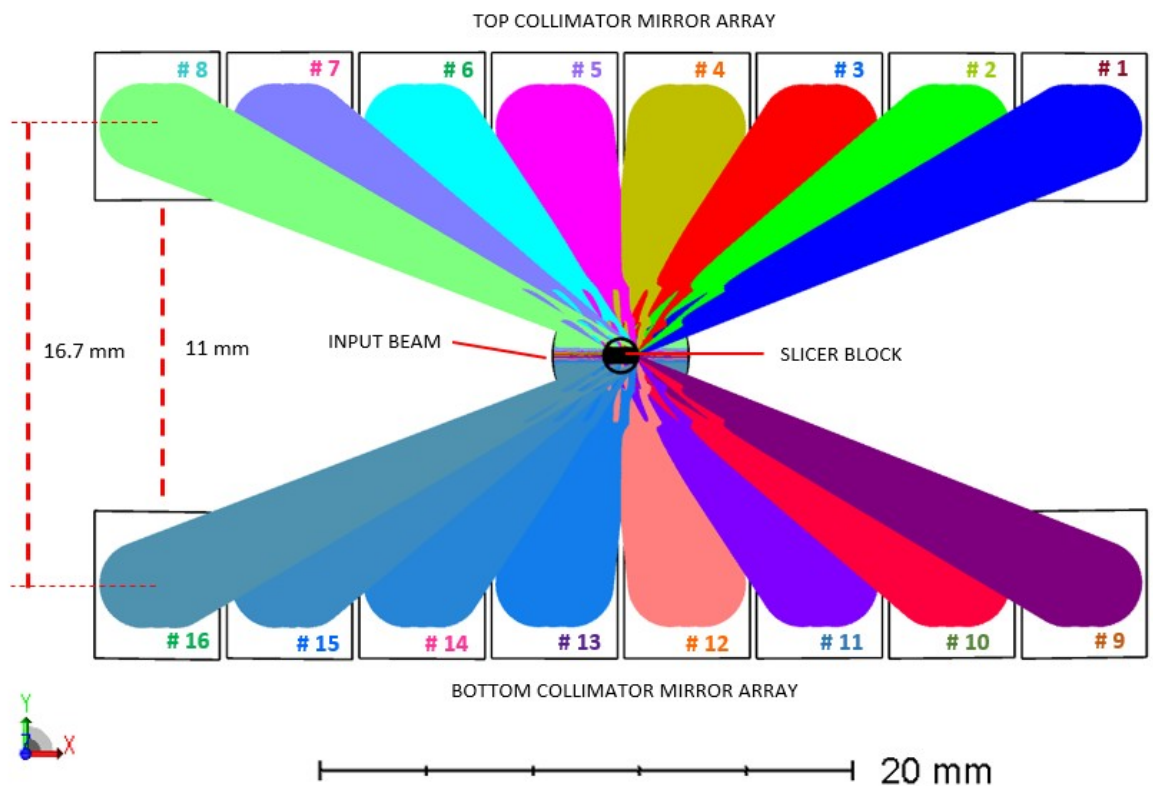


N° of mirrors	2 x 8
Mirror Size	4.6 mm x 5.4 mm
Focal length	125 mm

35 μm image slicer design

• Optical design – Collimator mirror

COLLIMATOR MIRROR ARRAY

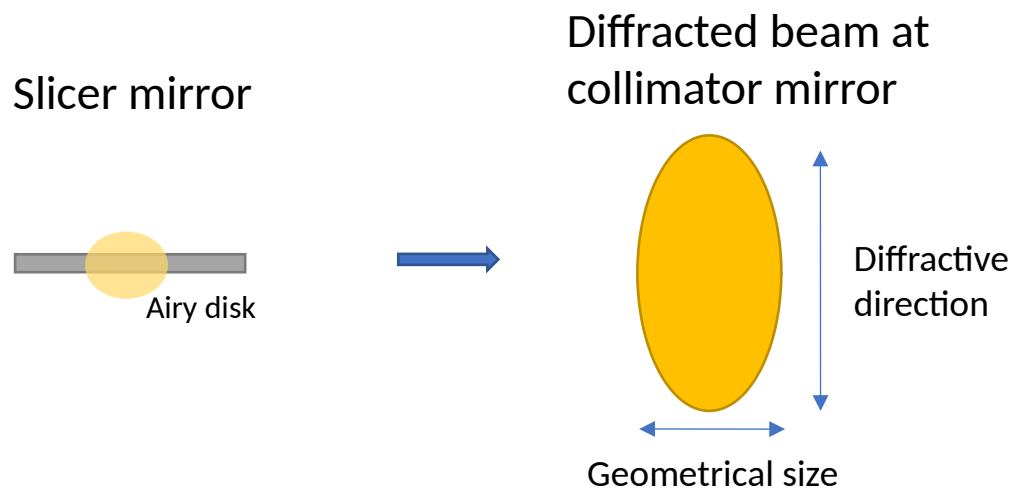


N° of mirrors	2 x 8
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**Oversized
Diffraction effects**

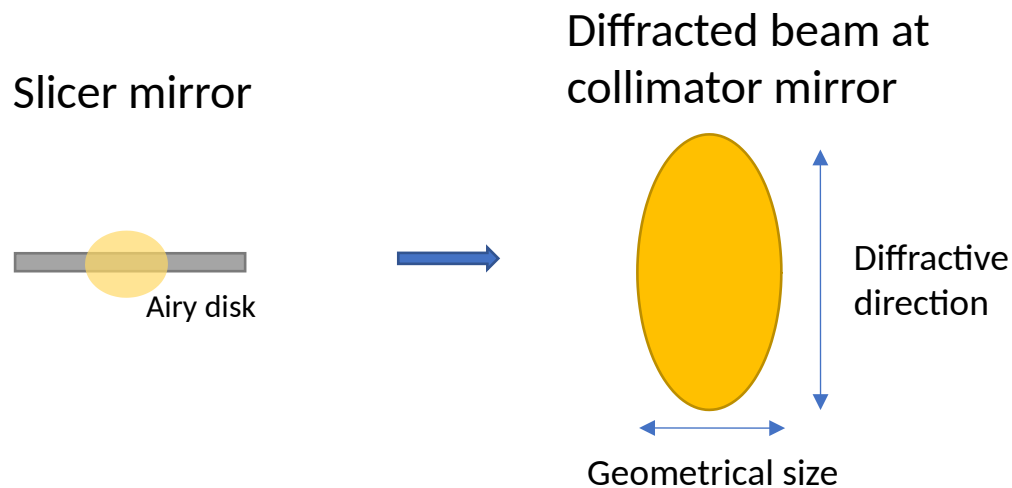
35 μm image slicer design

➤ Diffraction effects on the optical design

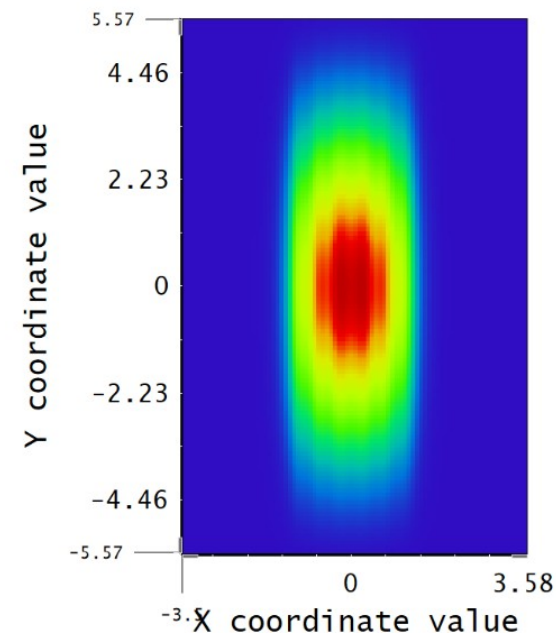


35 μm image slicer design

➤ Diffraction effects on the optical design



POP simulation at collimator mirror

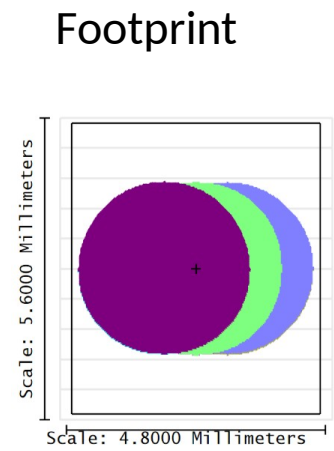
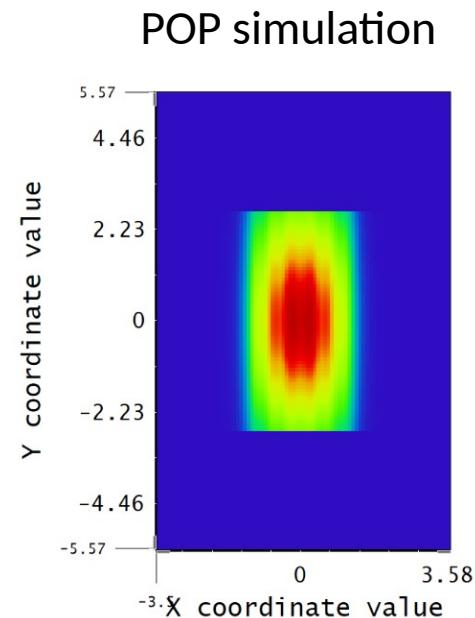
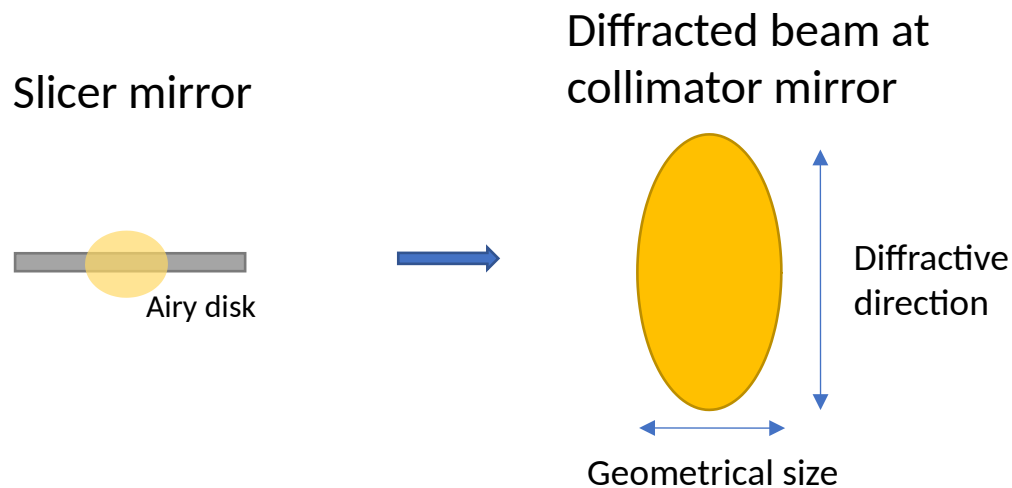


Beam size at collimator mirror	
Geometrical	3.1 mm
Diffracted ($\lambda = 1.565 \mu\text{m}$)	11.9 mm
Diffracted ($\lambda = 1.080 \mu\text{m}$)	8.0 mm

Geometrical and main diffractive lobe beam for F# 40.58

35 μm image slicer design

➤ Diffraction effects on the optical design



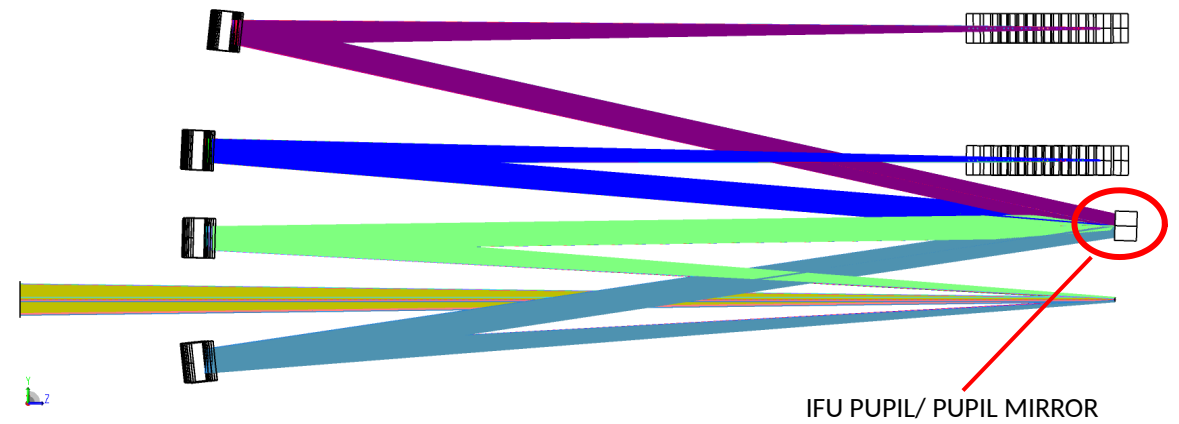
**Collimator mirror's size
4.6 mm x 5.4 mm**

Beam size at collimator mirror	
Geometrical	3.1 mm
Diffracted ($\lambda = 1.565 \mu\text{m}$)	11.9 mm
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Geometrical and main diffractive lobe beam for F# 40.58

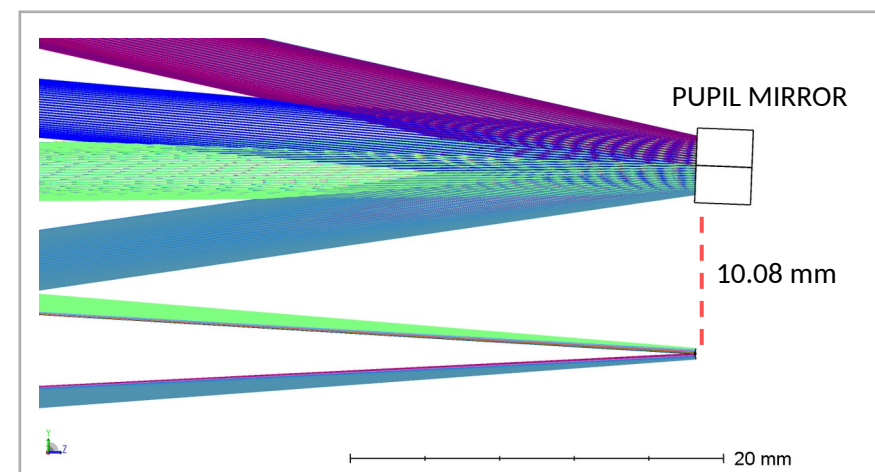
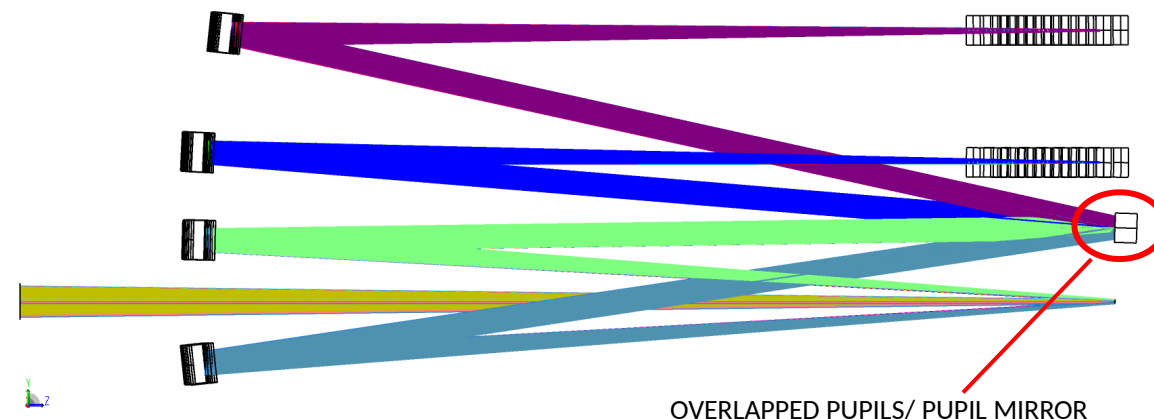
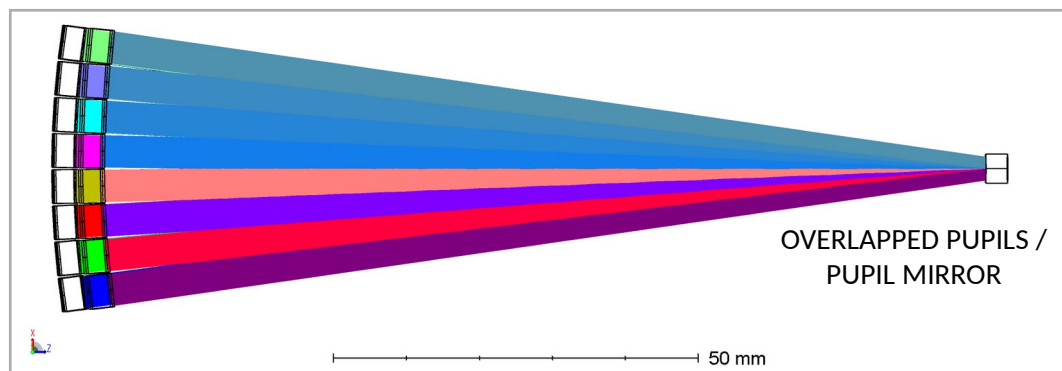
35 μm image slicer design

- Optical design – IFU Pupil



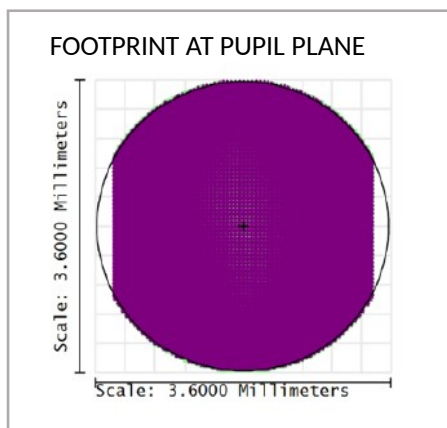
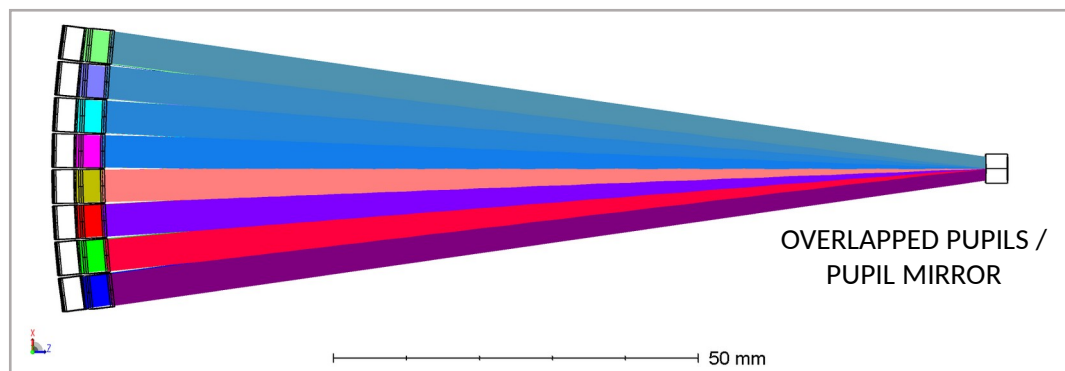
35 μm image slicer design

- Optical design - IFU Pupil

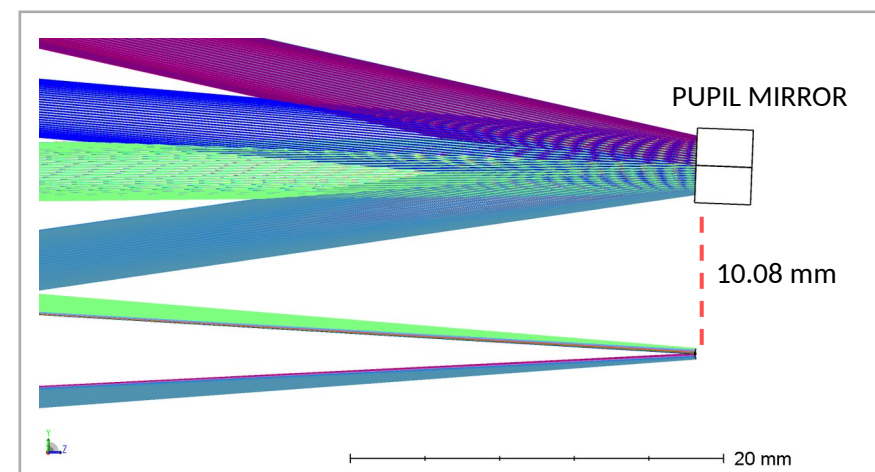
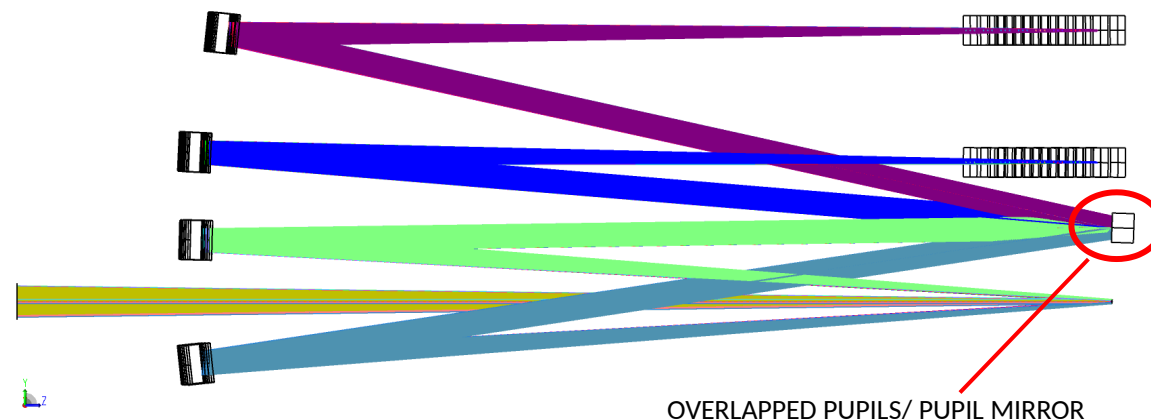


35 μm image slicer design

• Optical design – IFU Pupil

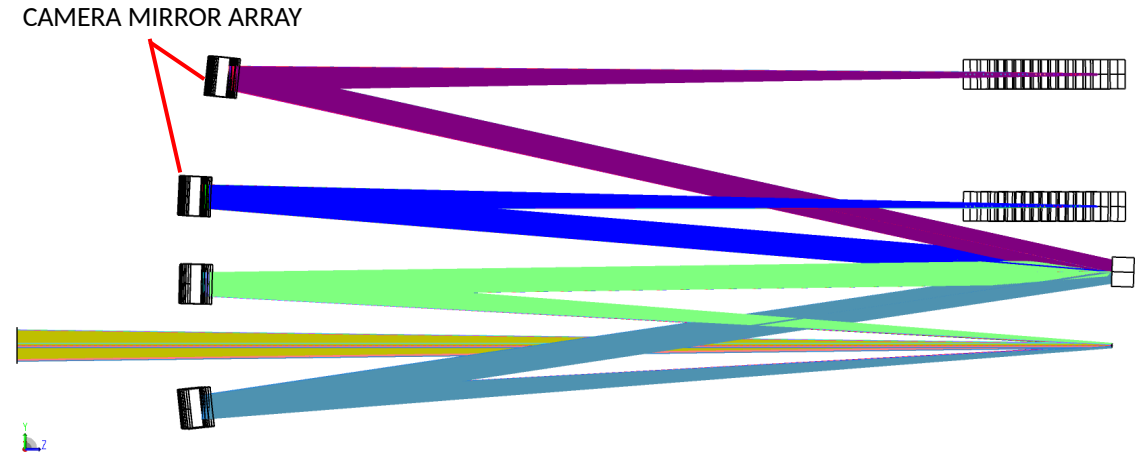


N° of pupil mask	1
Diameter	3.56 mm



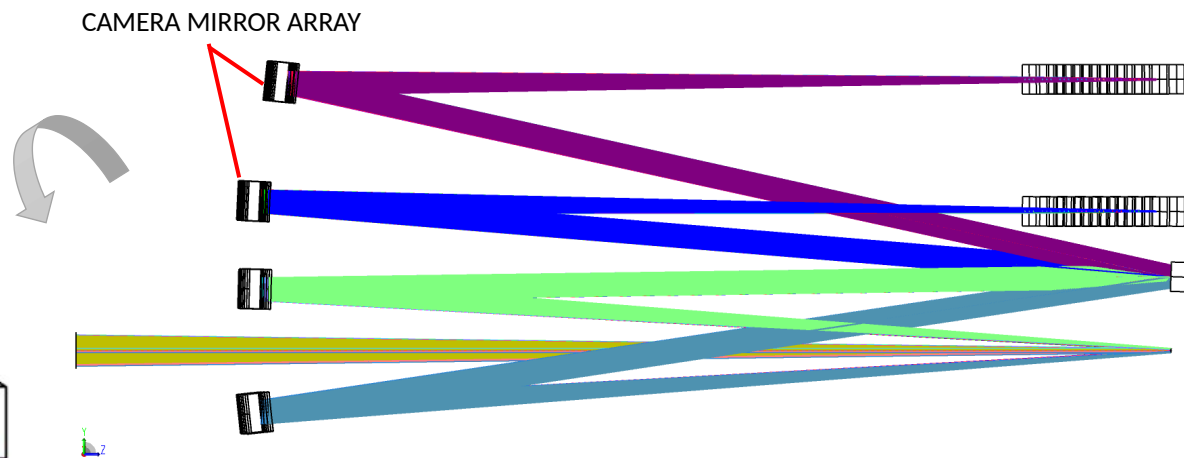
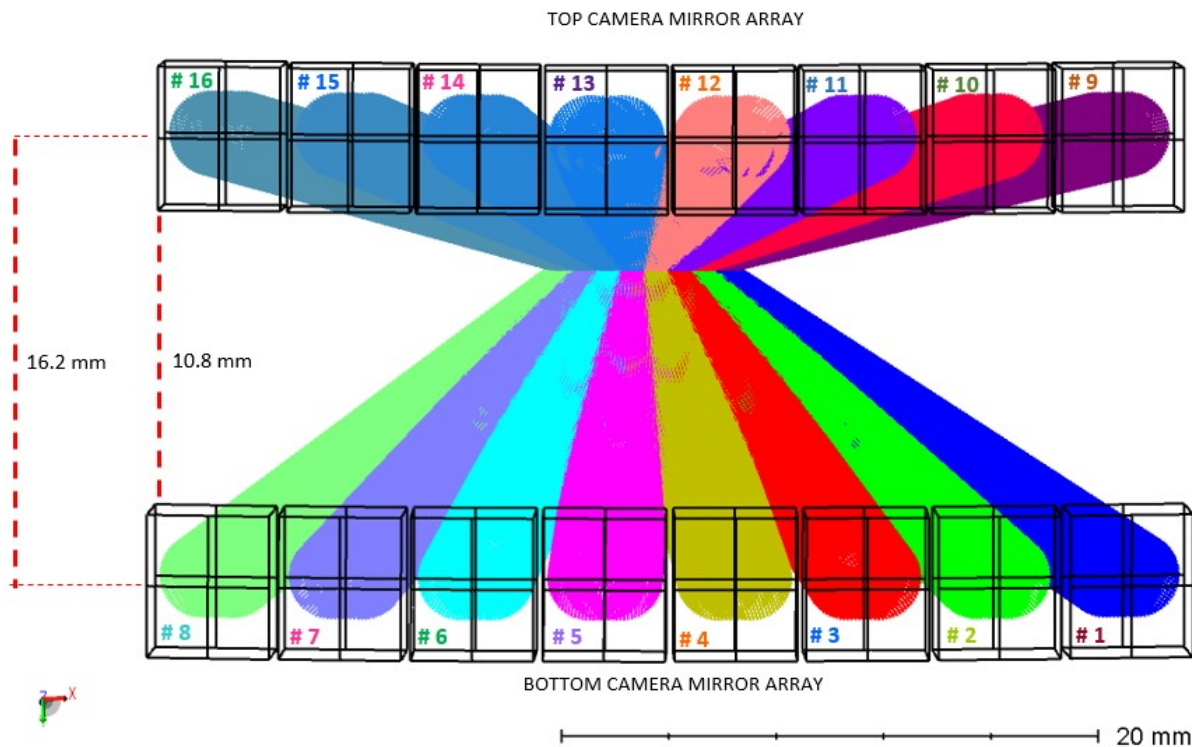
35 μm image slicer design

- Optical design – Camera mirror



35 μm image slicer design

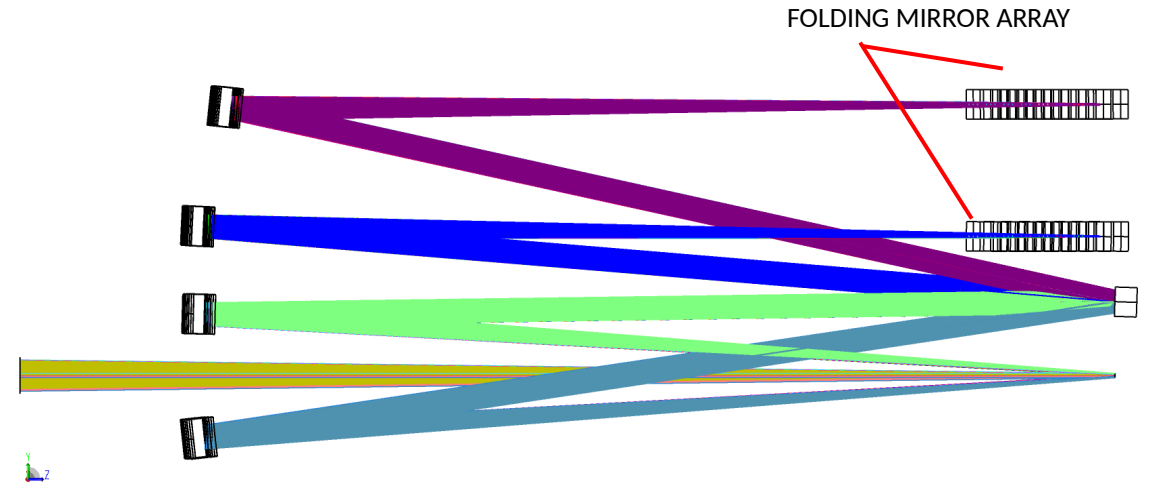
- Optical design – Camera mirror



N° of mirrors	2 x 8
Mirror Size	4.6 mm x 5.4 mm
Focal length	125 mm

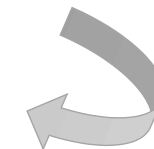
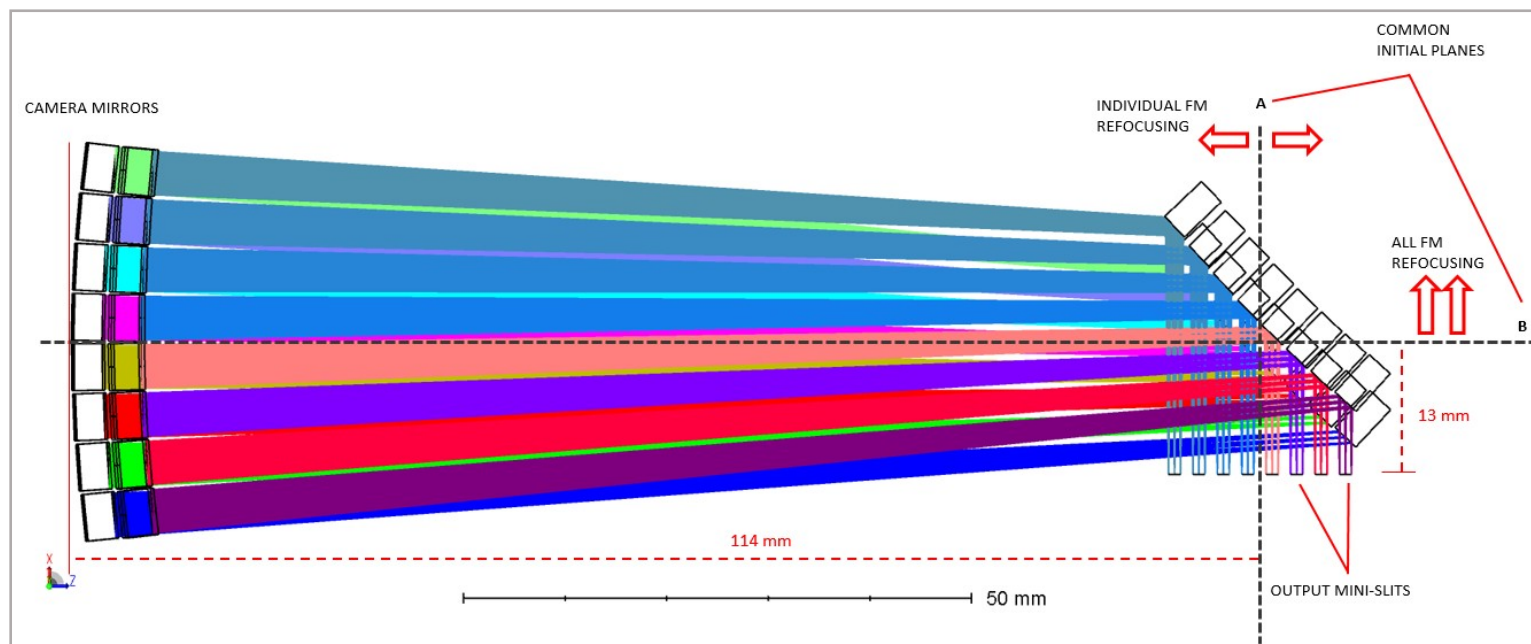
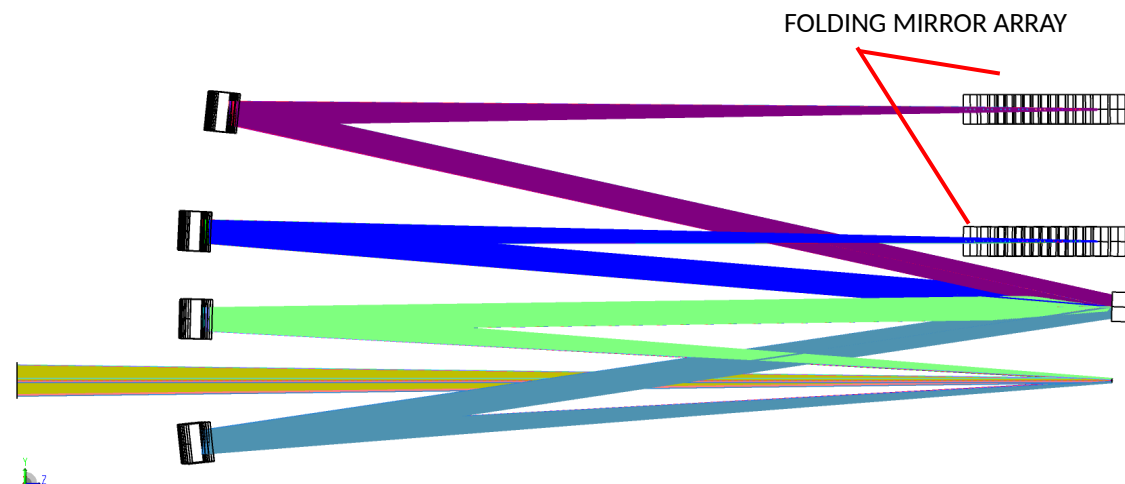
35 μm image slicer design

- Optical design – Folding mirror



35 μm image slicer design

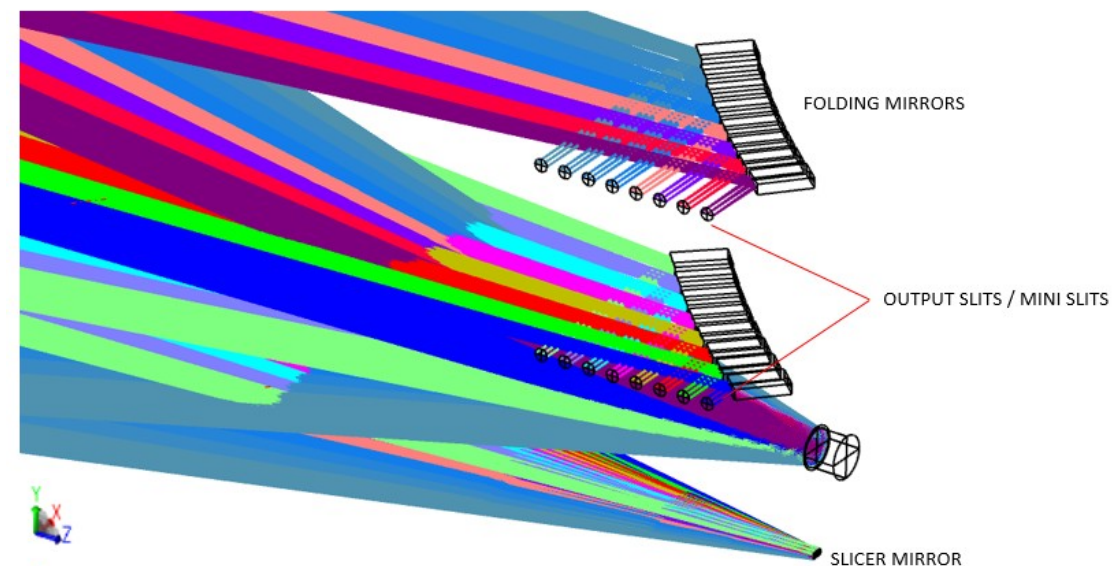
- Optical design – Folding mirror



Mirror shape	Rectangular
Mirror size (width x height)	2.8 x 4 mm
Mirror curvature	Flat

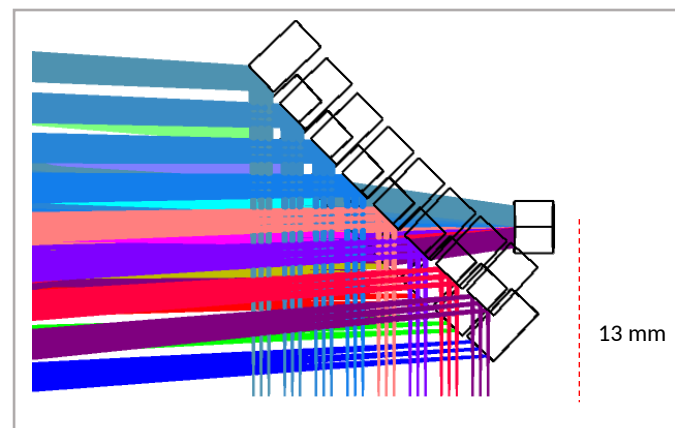
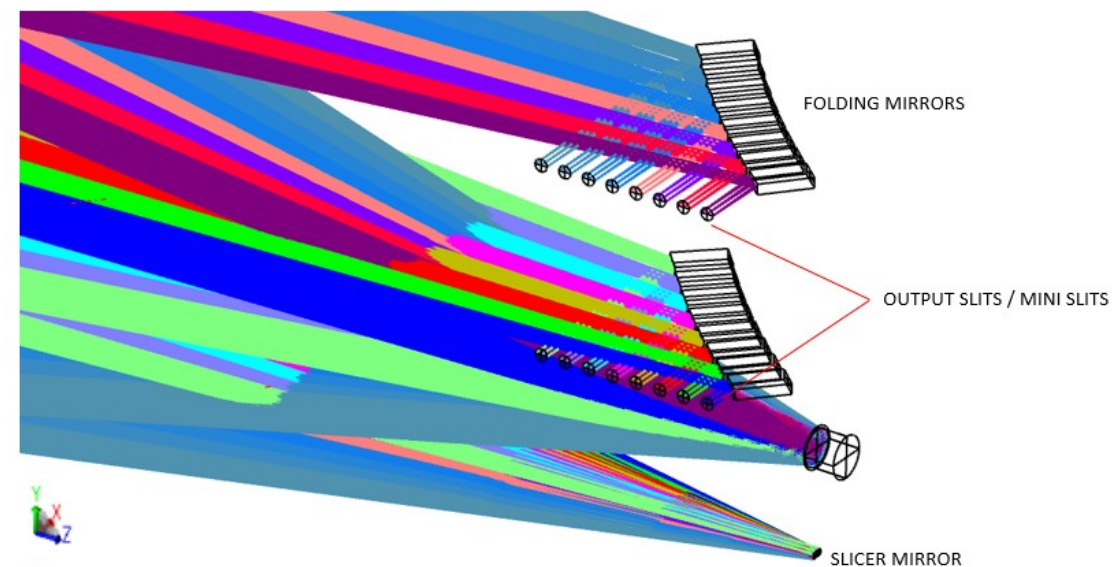
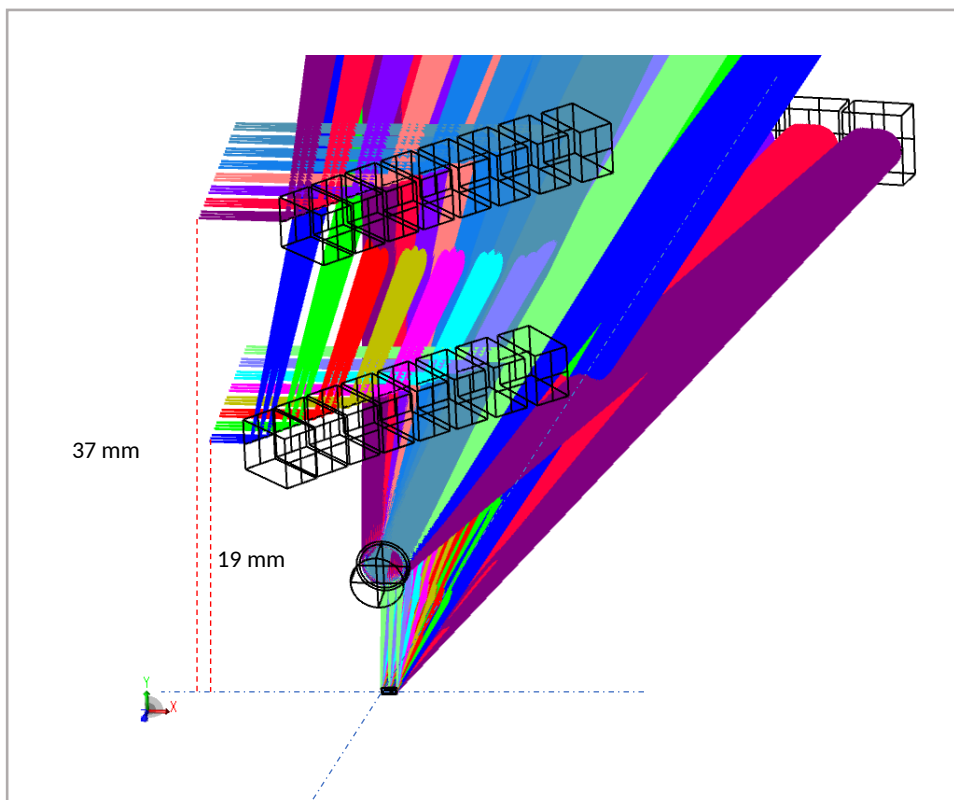
35 μm image slicer design

- Optical design – Output slits



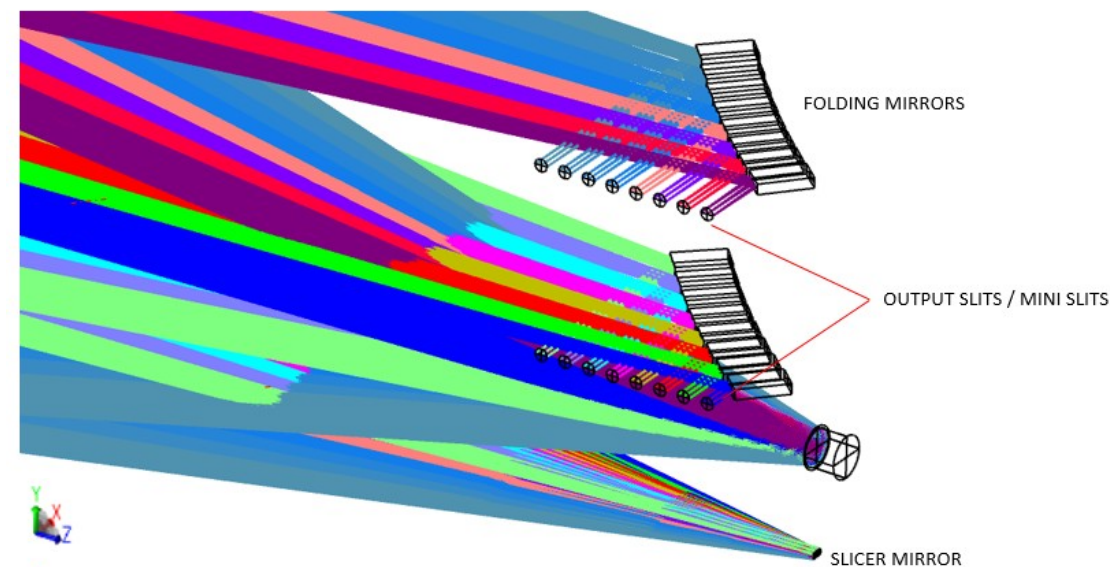
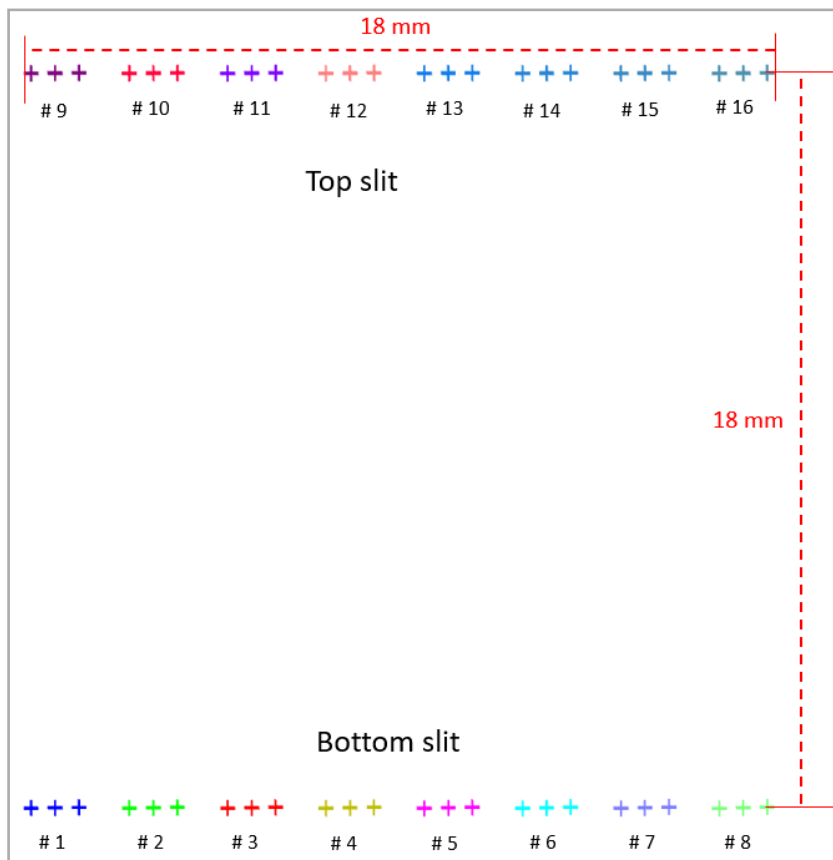
35 μm image slicer design

- Optical design – Output slits



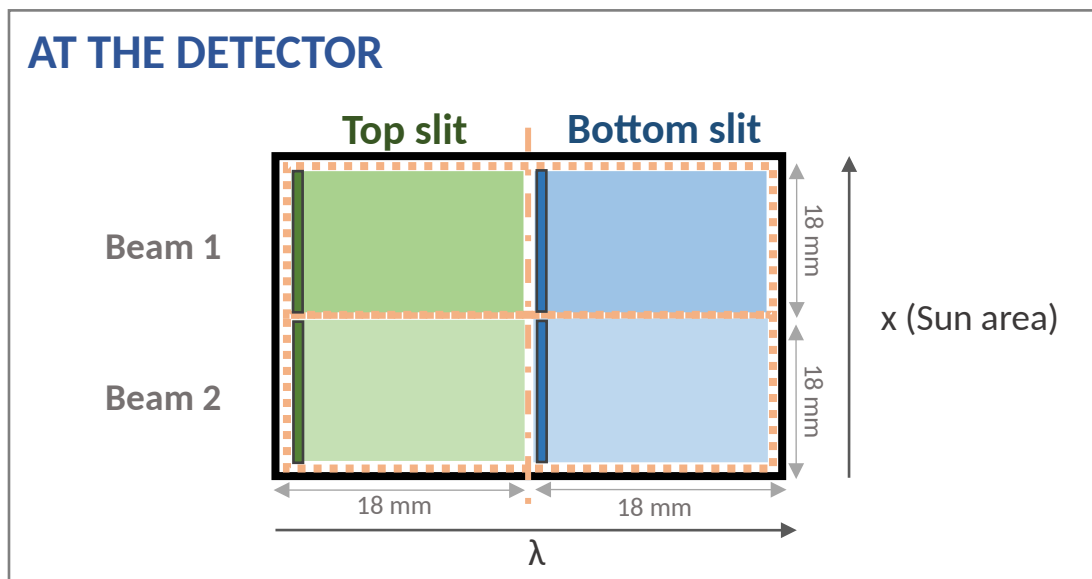
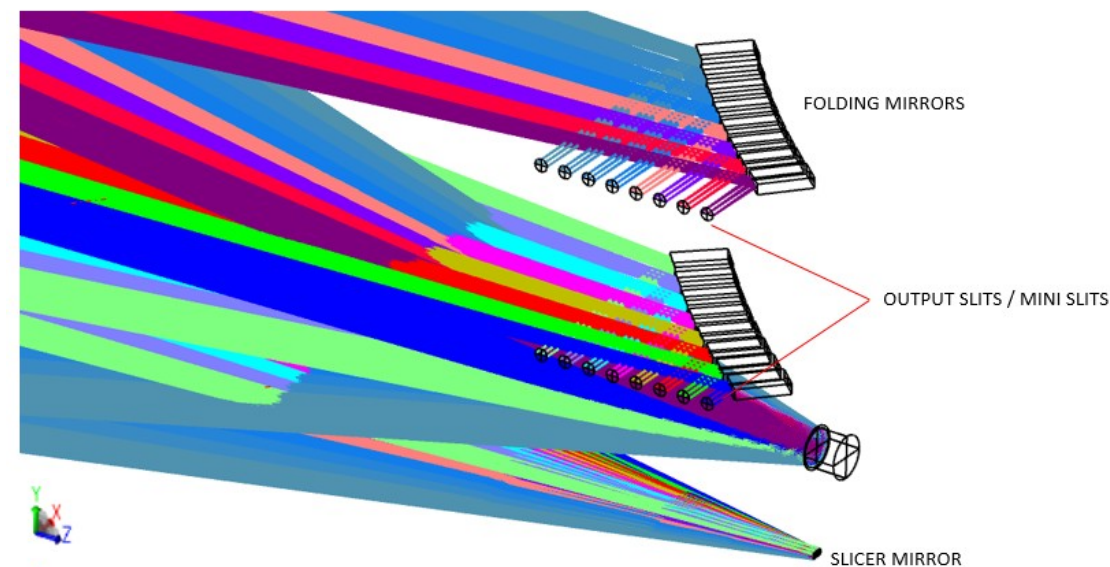
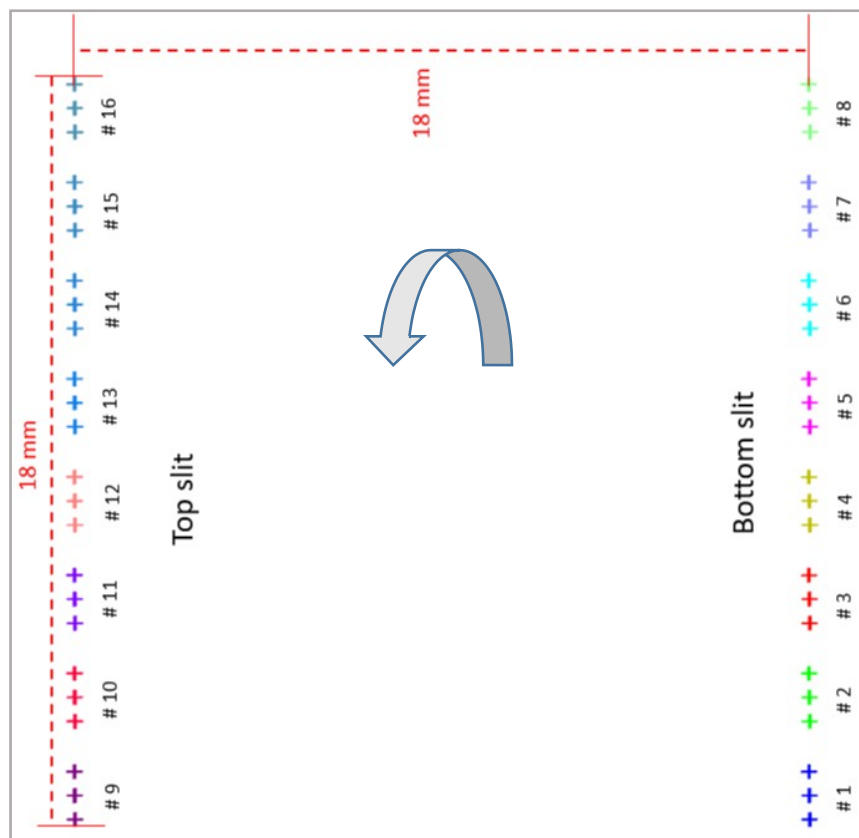
35 μm image slicer design

- Optical design – Output slits



35 μm image slicer design

- Optical design - Output slits

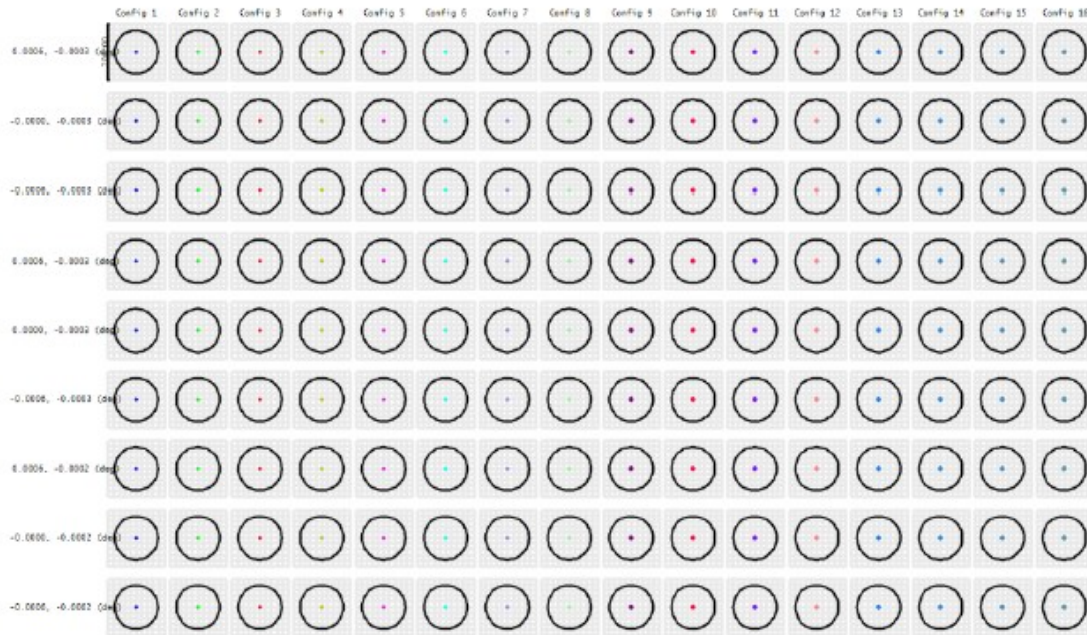


35 μm image slicer design

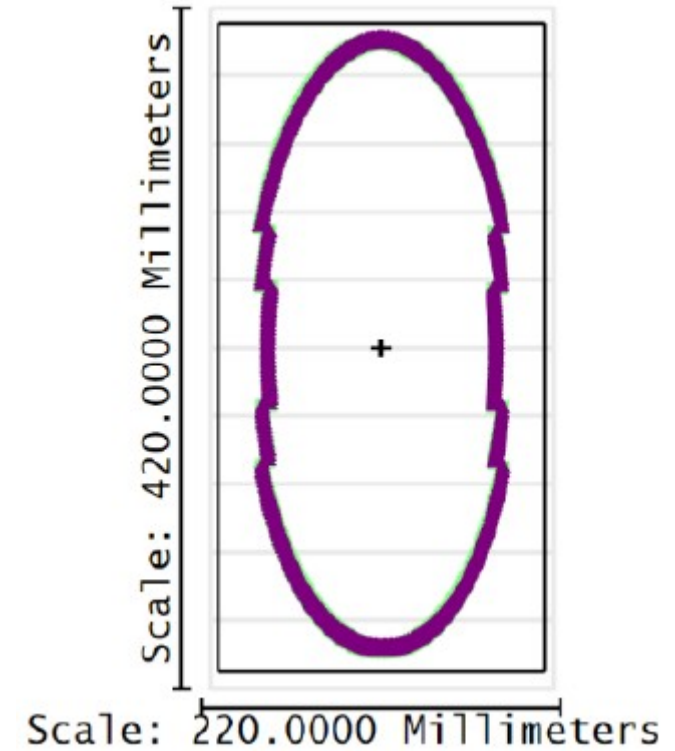
- Optical design – Analysis

All pupils overlapping at diffraction grating

Spot diagram at image plane for 1.56 μm



Configuration n°



Conclusions

Conclusions



The **capabilities** of **image slicers** for solar spectropolarimetry have been **demonstrated** (Dominguez-Tagle et al., *submitted*)



The new designs that we are evaluating **improve** the **spatial resolution** and **FoV**

Future steps



Study how to handle with **multiple slits** at detector stage



Evaluate the operating conditions with a **metallic image slicer** in terms of:

- Thermal requirements
- Image quality





Thank you

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