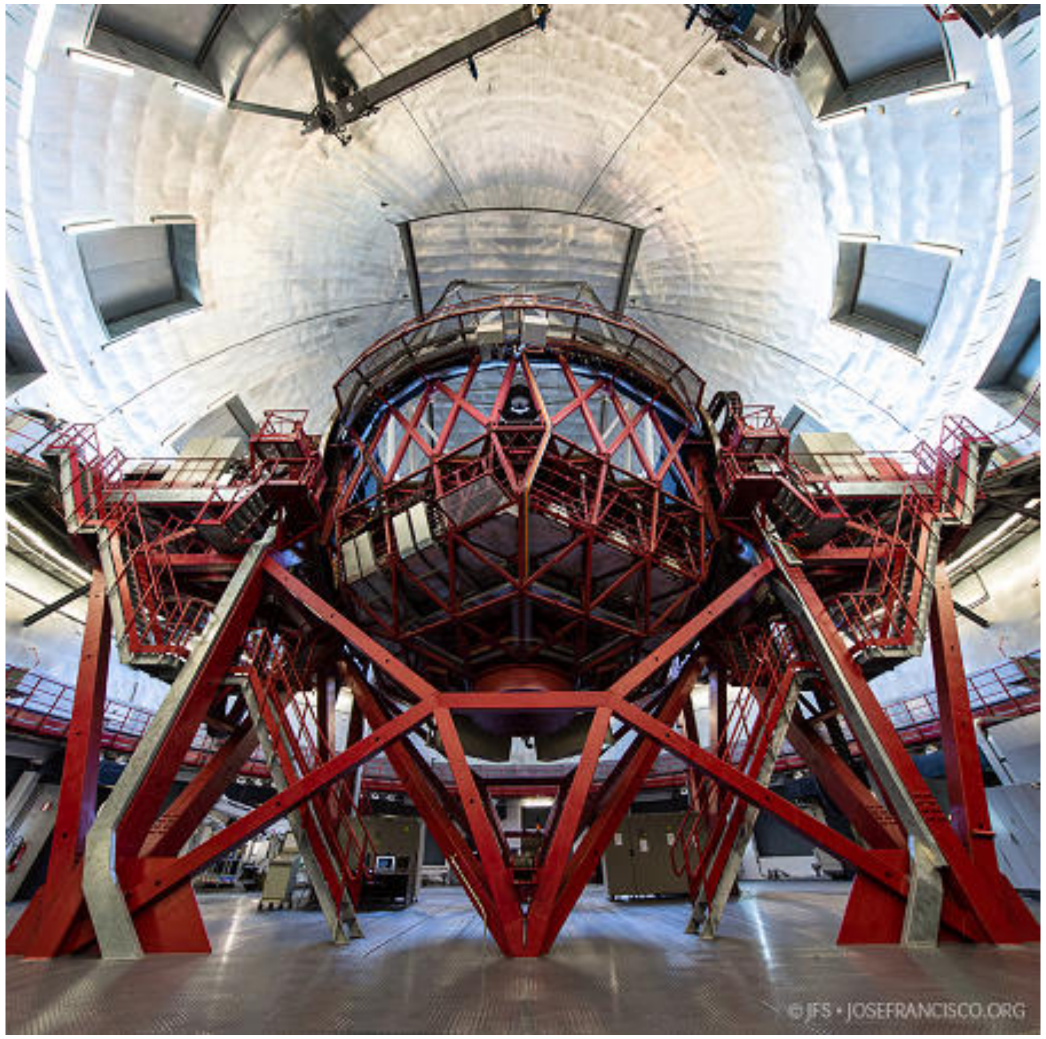
MAAT

The MAAT Instrument

A new Integral Field Spectroscopy mode for OSIRIS at GTC



Proposal submitted to the GTC Director and Steering Committee

MAAT P.I. Francisco Prada

The MAAT Proposal

The MAAT Proposal has been developed through a fruitful collaboration of a group of scientists and engineers in Spain, Australia, Denmark, and Sweden:

Francisco Prada (P. I.), IAA-CSIC, Spain
Robert Content, AAO, Australia
Enrique Pérez, IAA-CSIC, Spain
Luca Izzo, DARK, Denmark
Ariel Goobar, Stockholm University, Sweden

We also acknowledge the contribution from Ernesto Sánchez Blanco (OpticsDevelopment) and Winlight Systems.

The work presented in the MAAT proposal would have not been possible without the technical support and help of the GTC staff Manuela Abril (Optical Scientist and Contact person for MAAT), Kilian Henríquez Hernández (Mechanical Engineer), Andreas Gerarts (Mechanical Engineer), Luis A. Rodríguez García (Head of Engineering), Antonio Cabrera (Head of Astronomy), and Romano Corradi (Director).

GTC has provided a detailed 3D space envelope study for MAAT and all the relevant documentation on the optics and mechanics of OSIRIS. We are grateful to Manuela Abril for their very efficient and instantaneous feedback over the last four months after our many requests and questions. Furthermore, their effort included 3D printed relevant pieces to test the envelope of MAAT inside OSIRIS. Proper credit to their work has been recognised, see figure captions.

The MAAT basic parameters

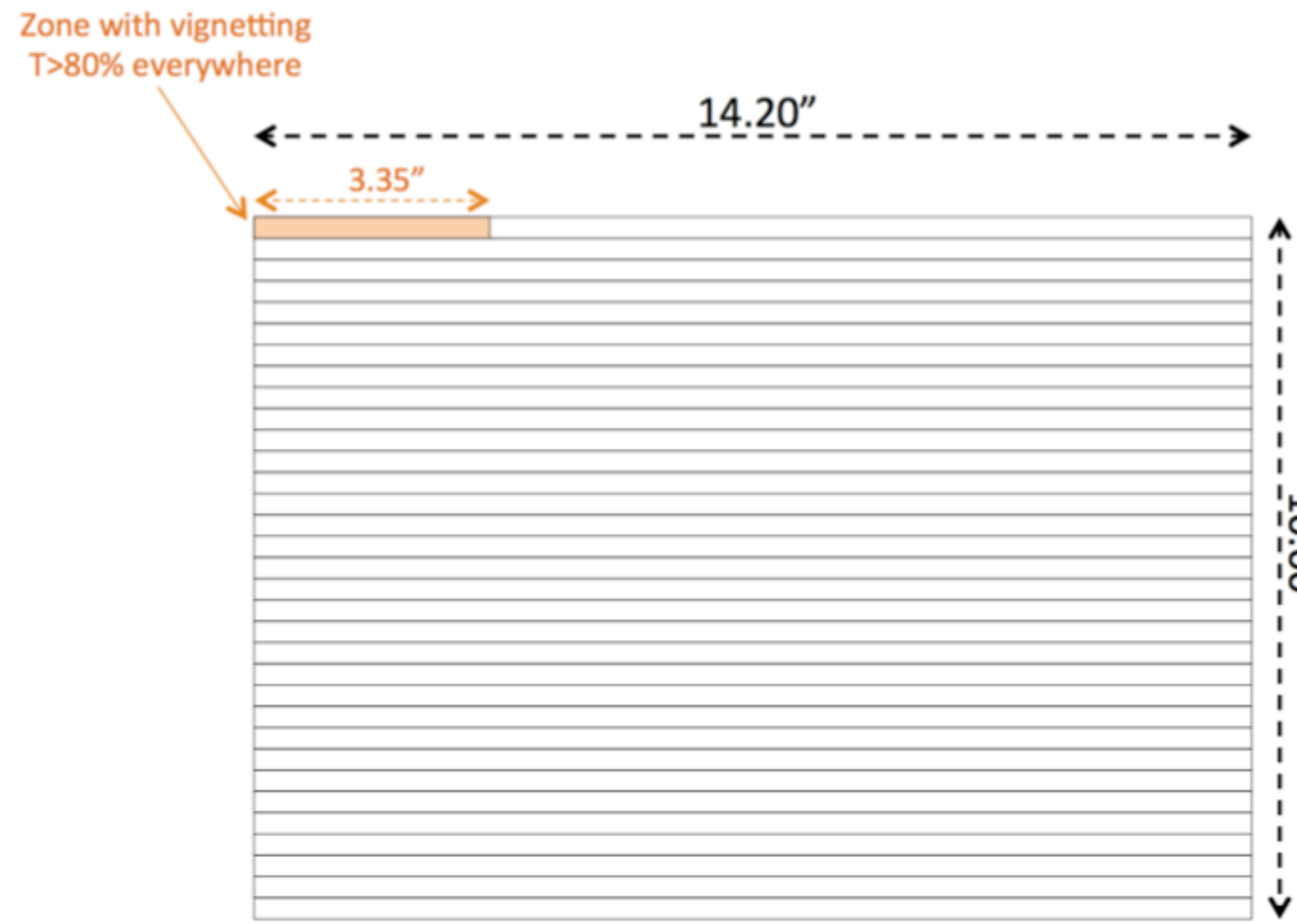
Parameter	Value
Spectrograph	OSIRIS at GTC-Cass
Module	Integral Field Unit
Field of View[1]	$14.20'' \times 10.00''$
Field aspect ratio	1.42
Slice width	$0.303''$
Spatial sampling[2]	$0.303'' \times 0.127''$
Wavelength range	360 to 1000 nm
Spectral resolution[3]	600 to 4100
Detector[4]	$4k \times 4k$ (15 μm pixel)
CCD plate scale	$0.127''$ per pixel

[1] IFU surface on the sky is 142 arcsec^2, and 141 arcsec^2 without vignetting).

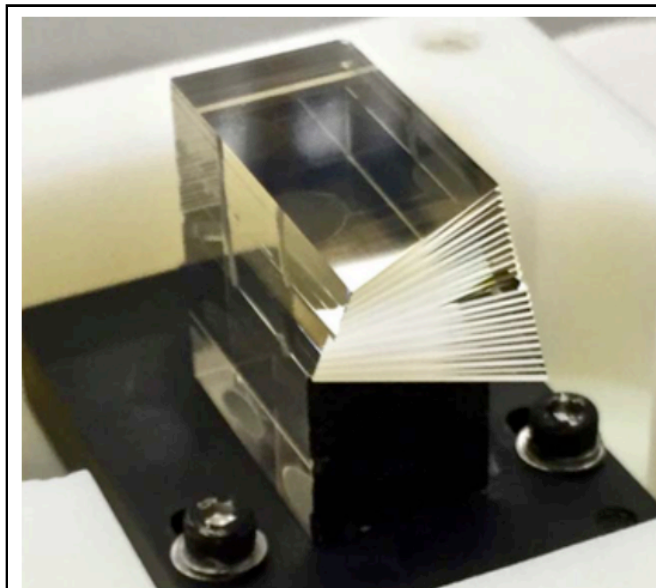
[2] With 1×2 CCD binning$0.303'' \times 0.254''$.

[3] Enhanced 1.6 times resolving power w.r.t. to that of a $0.6''$ long-slit. All OSIRIS grisms and VPHs can be used.

[4] The new OSIRIS detector is a Teledyne-e2v CCD231-84 deep-depleted standard silicon, astro multi-2.



Sky footprint of the MAAT mirror-slicer IFU



A close-up view of the KCWI slicer built at Winligth. The MAAT slicing mirror stack will be very similar but with 33 slicers each 0.8 mm thick (0.303” on the sky).

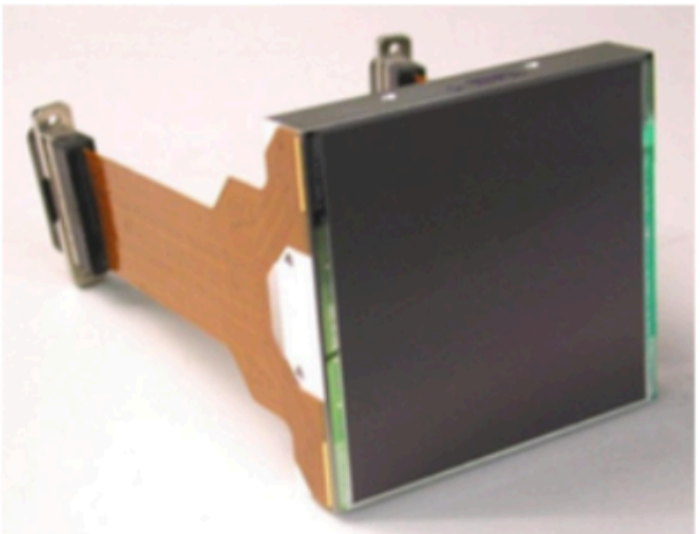
MAAT will enhance the resolution power of OSIRIS by 1.6 times with respect to its 0.6'' wide long-slit. All the eleven OSIRIS Grisms and VPHs will be available to provide broad spectral coverage with low / moderate resolution (R=600 up to 4100) in the 3600 - 10000 AA spectral range.

ID	λ_c (Å)	$\Delta\lambda$ (Å)	D (Å/pix)	R (LS[1])	Peak Efficiency	Type
R300B	4405	3600-7200	2.60	575 (360)	70%	Grism
R300R	6635	4800-10000	4.02	560 (348)	70%	Grism
R500B	4745	3600-7200	1.87	860 (537)	68%	Grism
R500R	7165	4800-10000	2.58	940 (587)	67%	Grism
R1000B	5455	3630-7500	1.13	1630 (1018)	65%	Grism
R1000R	7430	5100-10000	1.40	1795 (1122)	65%	Grism
R2000B	4755	3950-5700	0.46	3465 (2165)	87%	VPH
R2500U	3975	3440-4610	0.33	4090 (2555)	70%	VPH
R2500V	5185	4500-6000	0.44	4025 (2515)	80%	VPH
R2500R	6560	5575-7685	1.56	3960 (2475)	80%	VPH
R2500I	8650	7330-10000	1.73	4005 (2503)	80%	VPH

[1] Resolving power for the OSIRIS 0.6″ long-slit (LS) mode.

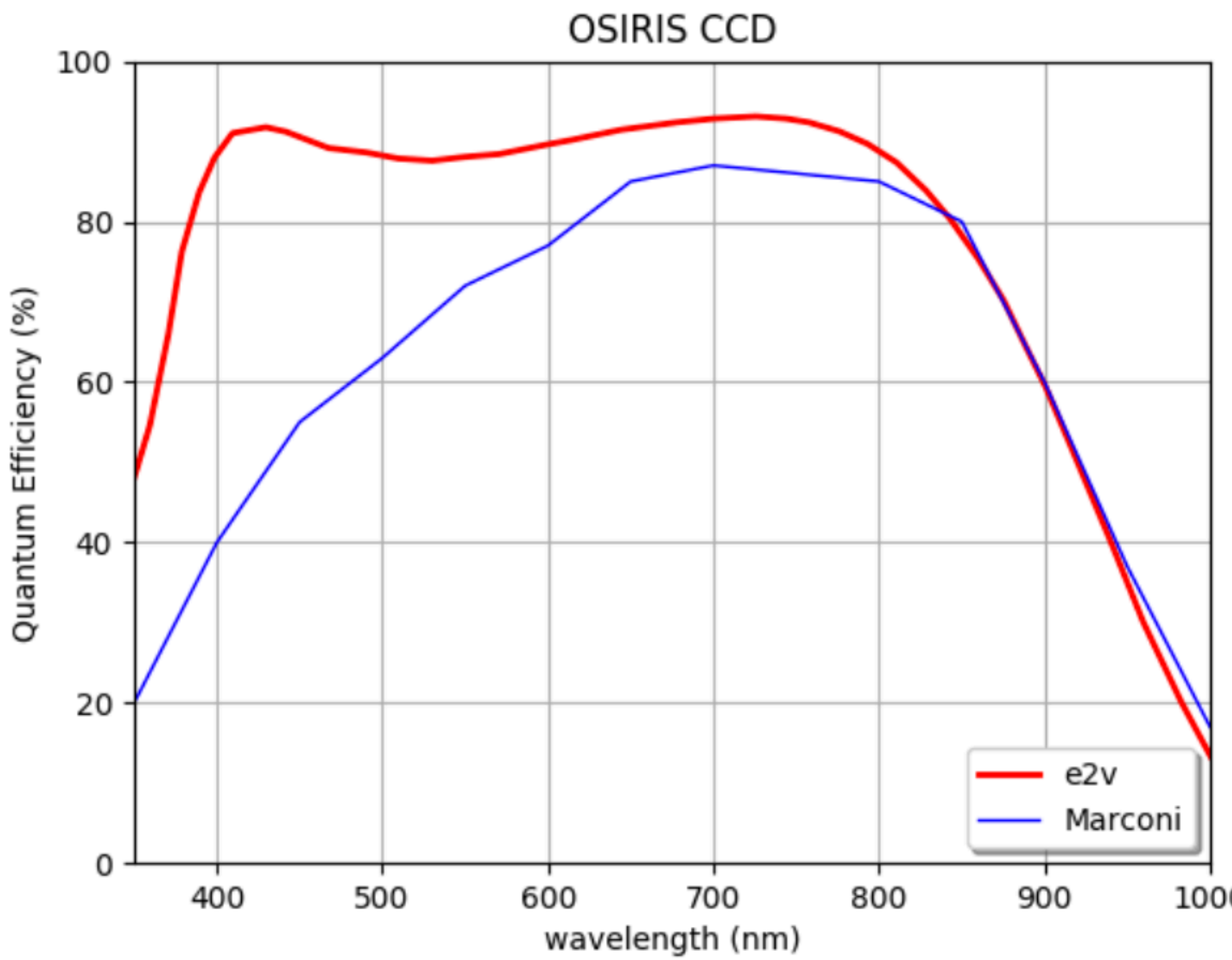
Resolutions and spectral ranges with OSIRIS+MAAT
for all available Grisms and VPHs

MAAT will benefit from the new OSIRIS detector upgrade:
Teledyne-e2v CCD231-84 deep-depleted standard silicon (astro multi-2)



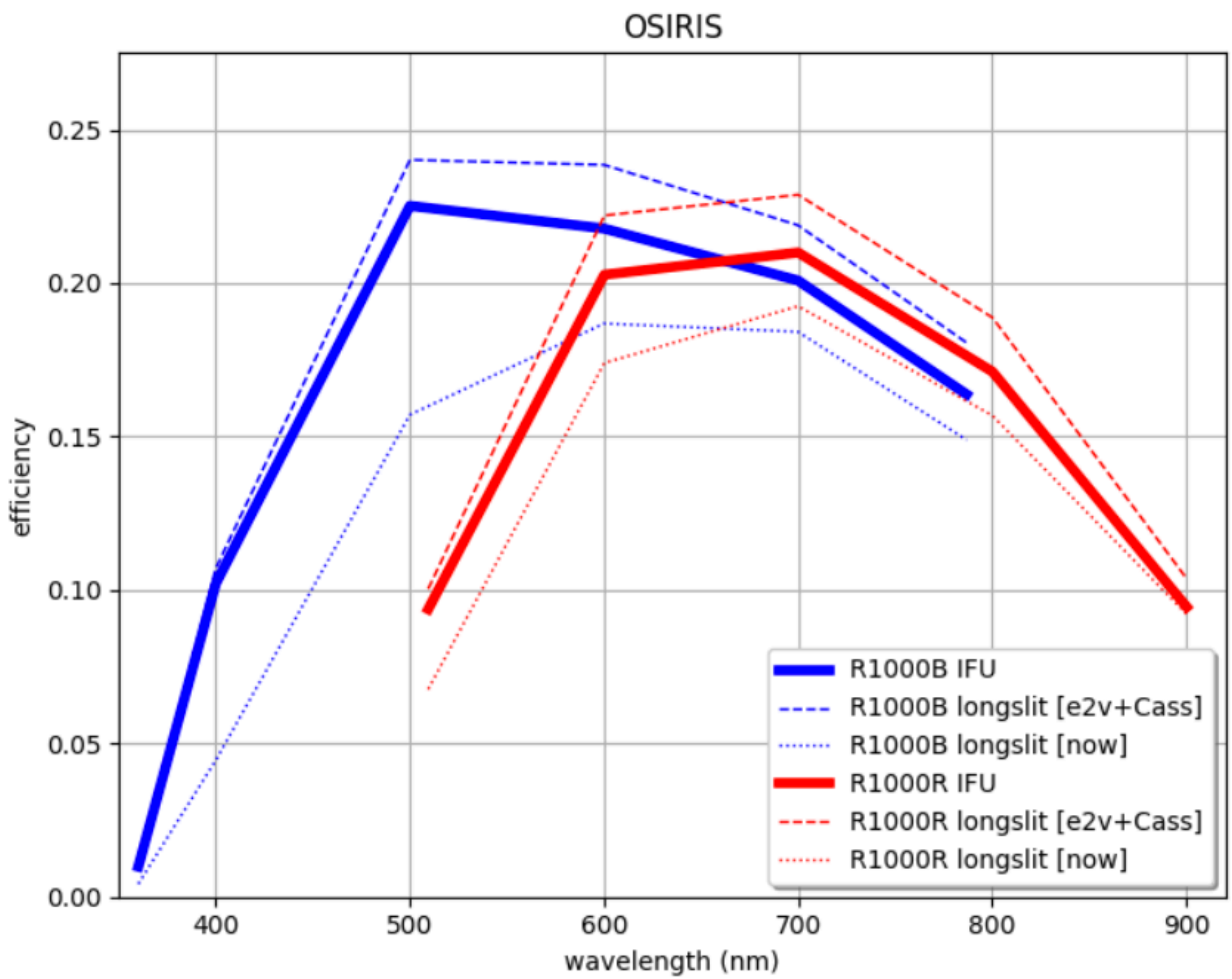
SUMMARY PERFORMANCE (Typical)

Number of pixels	4096(H) x 4112(V)
Pixel size	15 µm square
Image area	61.4 mm x 61.7 mm
Outputs	4
Amplifier sensitivity	7 µV/e⁻
Readout noise (rms)	5 e⁻ at 1 MHz 2 e⁻ at 50 kHz
Maximum pixel data rate	3 MHz
Charge storage (pixel full well)	350,000 e⁻
Flatness (both packages)	15 µm (peak to valley)
Package size	63.0 x 69.0 mm
Package format	SiC & 2 flex connectors
Focal plane height, above base	15.0 mm
Height tolerance	±10 µm
Connectors	Two 37-way micro-D



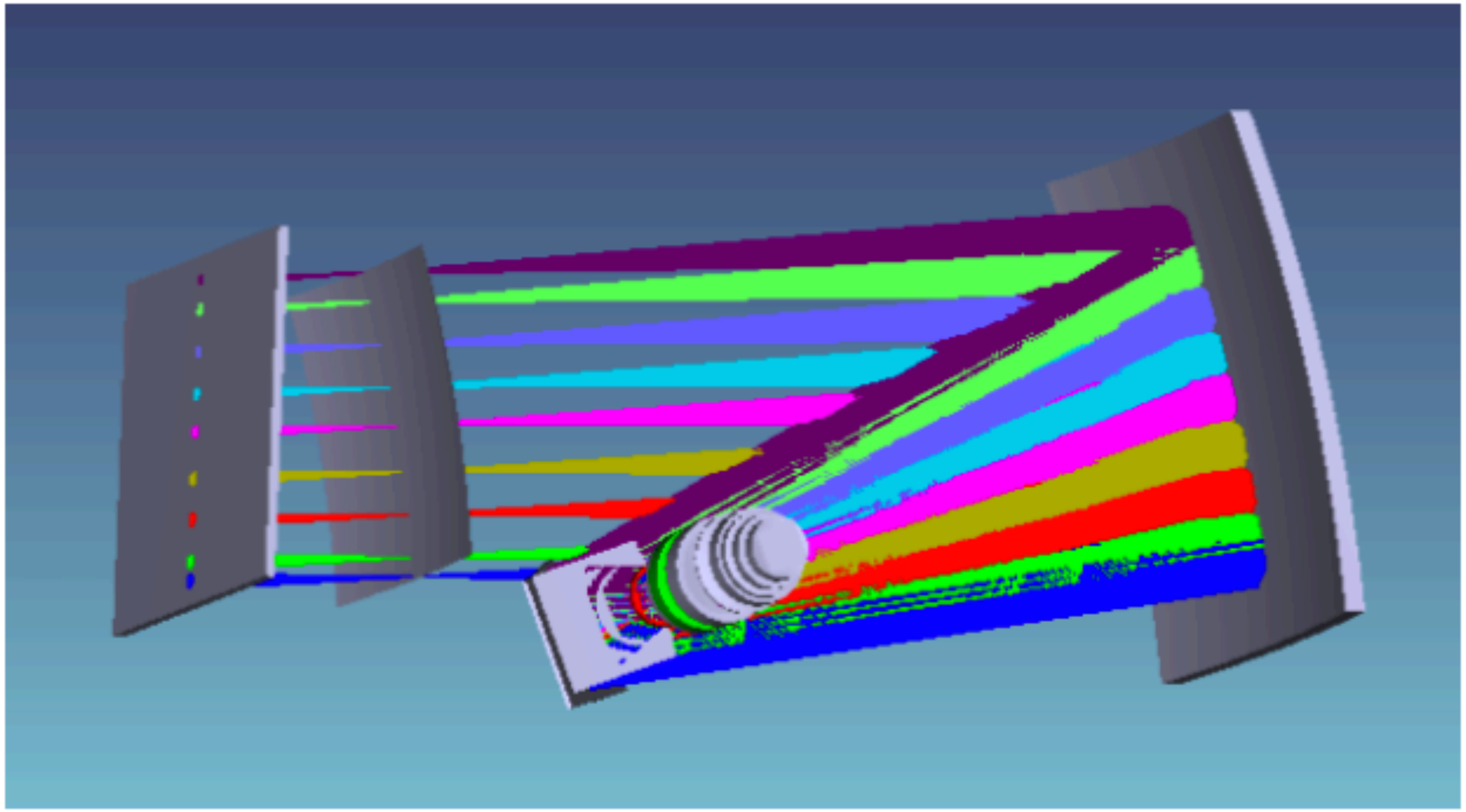
Left: Characteristics of the new OSIRIS e2v CCD231-84 detector. Right: Spectral response of the new OSIRIS e2v CCD231-84 (red) compared to the current Marconi CCD44-82 (black) (Credit: GTC).

OSIRIS+MAAT Efficiency



Total throughput (atmosphere, telescope, and instrument) of the OSIRIS long-slit and IFU mode as currently mounted on the Nasmyth focus and as it will be on the Cassegrain, which will result in a significant gain in efficiency derived from the new e2v detector and the absence of M3. The curves are shown for the broadband R1000B and R1000R Grisms.

MAAT Instrument Overview



OSIRIS optical layout in spectroscopy mode

MAAT Optical Study
by Robert Content

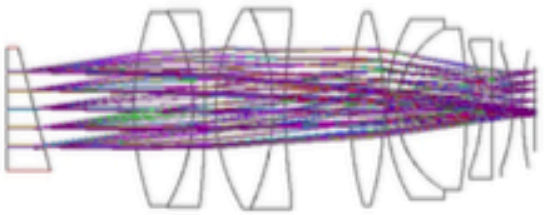
MAAT Envelope
by GTC

MAAT Manufacturing
by Winlight System

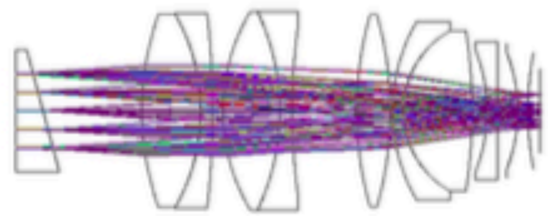
MAAT Pipeline
by Rubén GB

Zemax ray-tracing models of the OSIRIS suite of Grisms (left) and VPHs (right)

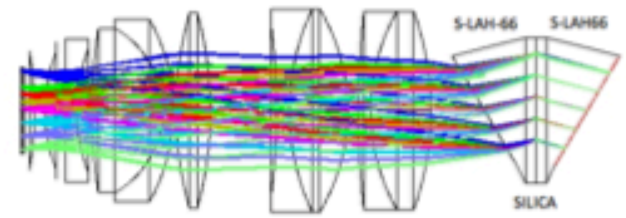
R300B $\lambda_c = 442$ nm



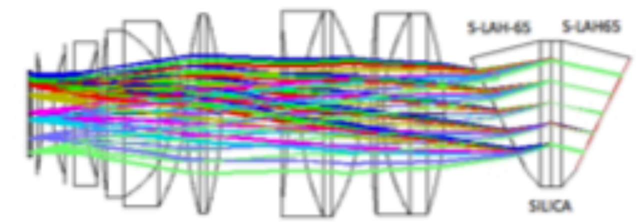
R300R $\lambda_c = 665$ nm



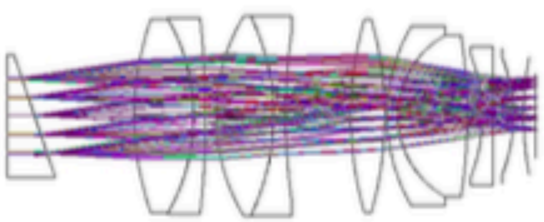
R2500U $\lambda_c = 398$ nm



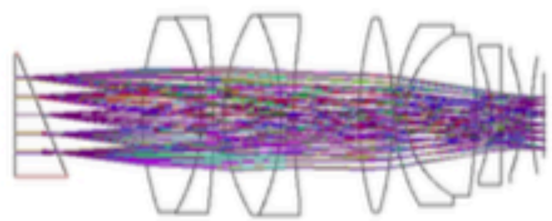
R2000B $\lambda_c = 475$ nm



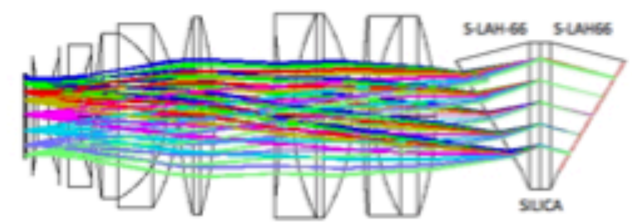
R500B $\lambda_c = 473$ nm



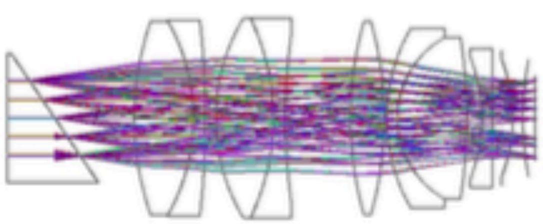
R500R $\lambda_c = 717$ nm



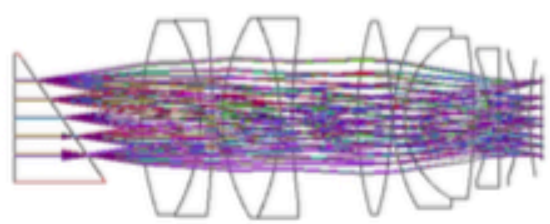
R2500V $\lambda_c = 518$ nm



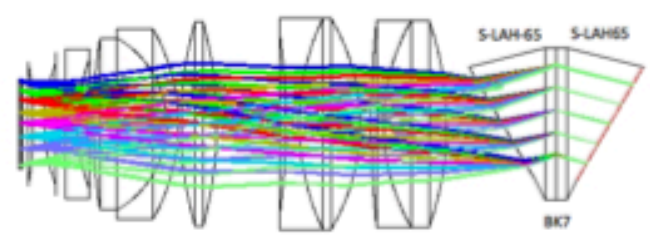
R1000B $\lambda_c = 545$ nm



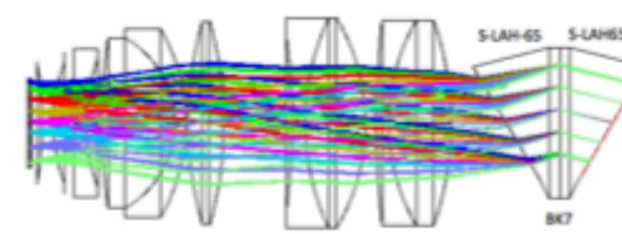
R1000R $\lambda_c = 744$ nm



R2500R $\lambda_c = 656$ nm

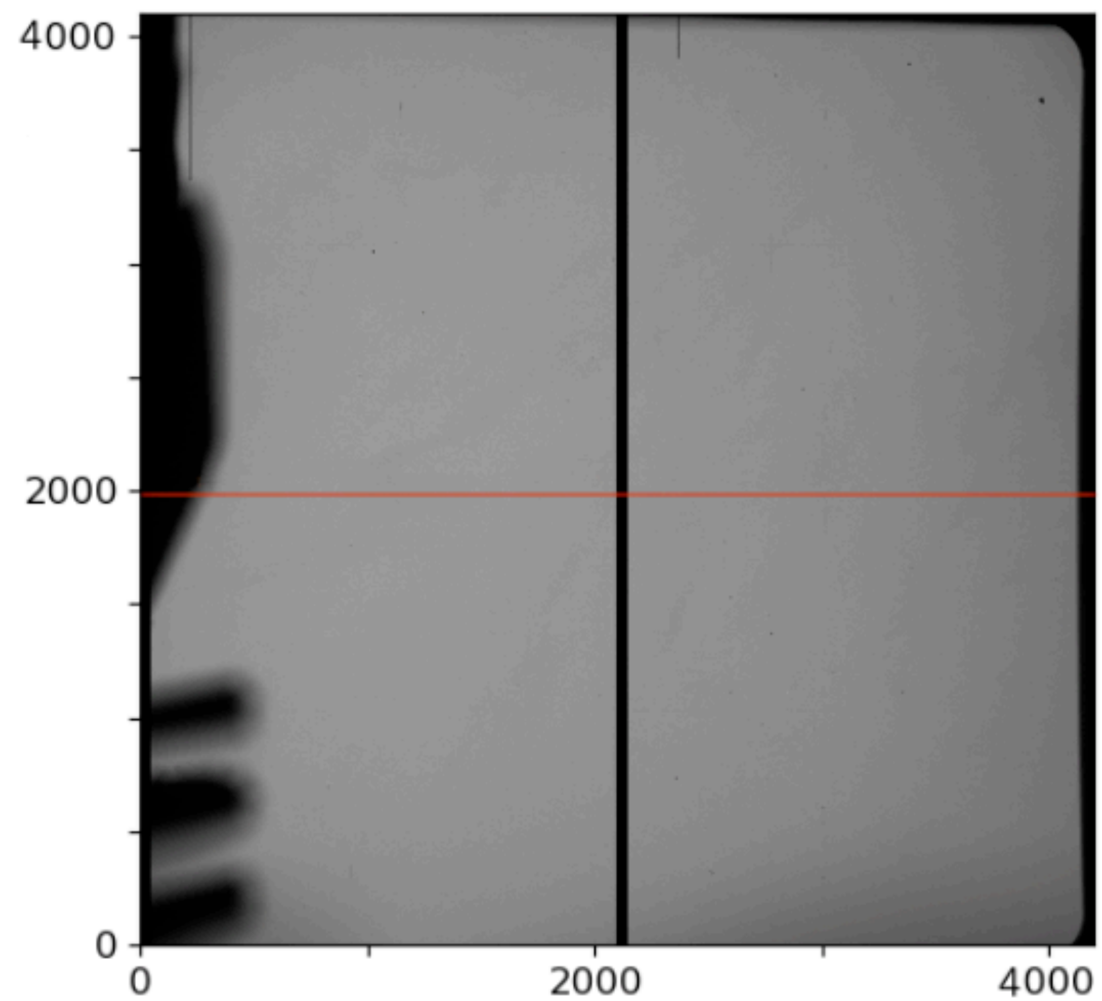


R2500I $\lambda_c = 865$ nm



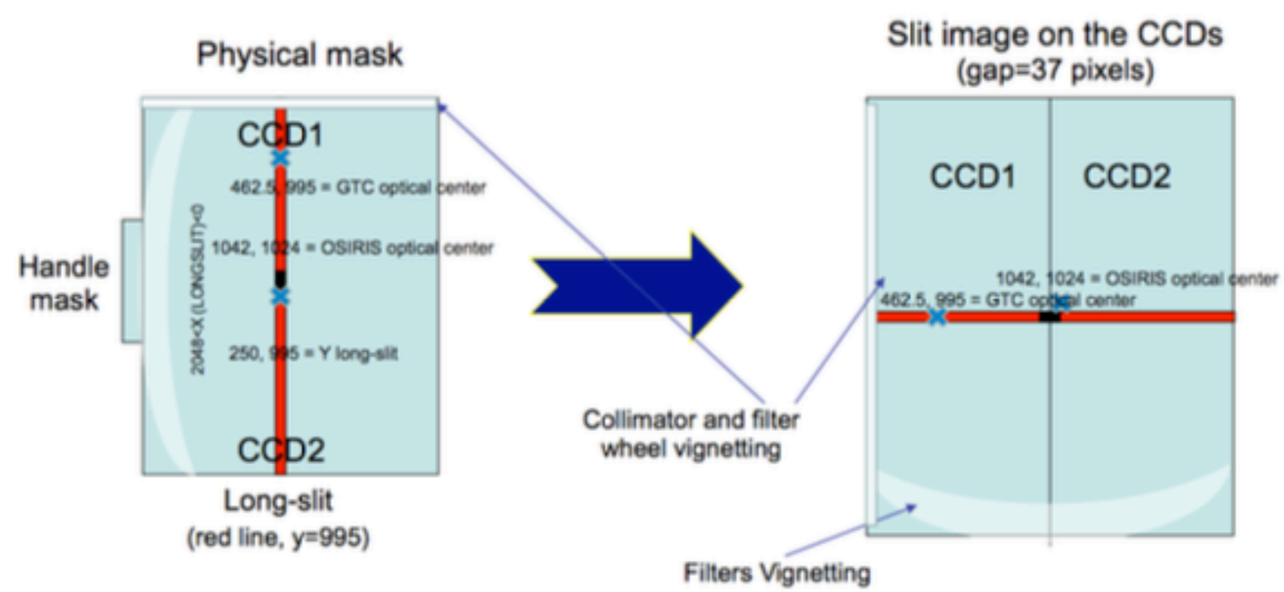
Implemented in Zemax by Ernesto Sanchez Blanco

Vignetting pattern as seen in an OSIRIS image. The red line marks the correct position of the OSIRIS long-slit, which we adopted for the IFU pseudo-slit.

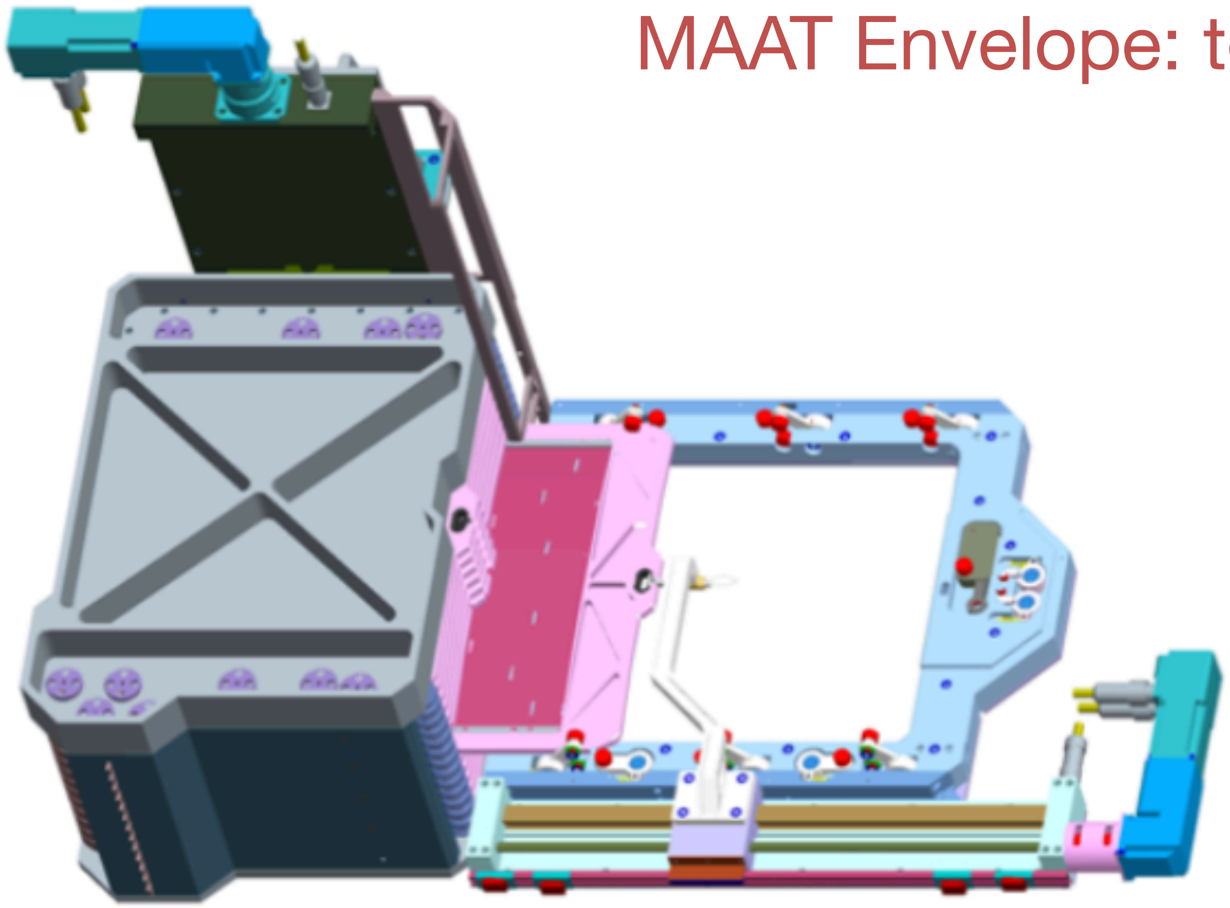


See Robert's talk

Physical long-slit mask correspondence with the OSIRIS CCD (Credit: GTC)



MAAT Envelope: technical specifications



Parameter	Value
Spectrograph focal plane radius[1]	1814 mm
Focal plane sag along slit[2]	11.07 mm
Slit length[3]	400.2 mm
Angle slit vs. OSIRIS optical axis[4]	4.16 deg
Space envelope	X: 405 mm
	Y: 441 mm
	Z: 112 mm
Weight[5]	10 Kg

[1] Edges toward the telescope.

[2] Edge to slit centre.

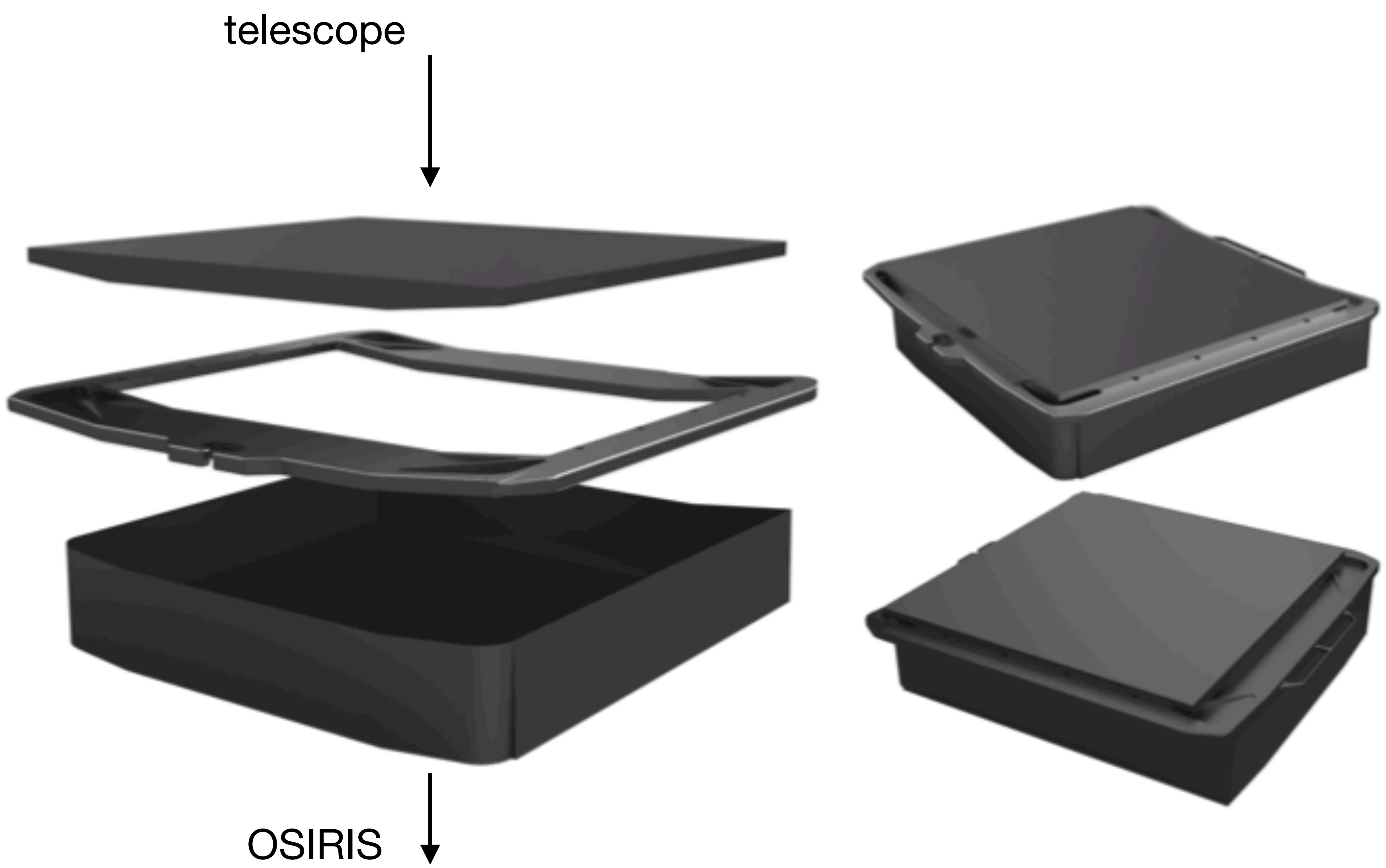
[3] Ignoring curved focal plane.

[4] As in the OSIRIS Zemax.

[5] Maximum weight load of the entire MAAT box (to be confirmed, see text).

Top: Model view of the OSIRIS Slit Subsystem without baffle, consisting of a Jukebox (on the left in gray), with a capacity of 13 masks and a Charger, on the right in blue, which inserts the mask (in pink) selected by the control on the plane focal length of the telescope (Credit: GTC). The MAAT box will be inserted in the Jukebox and occupies the equivalent to 6 masks (see text). Bottom: Picture of the OSIRIS Cartridge and focal plane assembly as built. We highlight in color different metal pieces: yellow for the masks edge protection, green and red baffle for mechanical support and as baffle (see text for more details). To all effects, the MAAT box will be inserted in the focal plane of OSIRIS when required as if it were another long-slit mask (Credit: GTC).

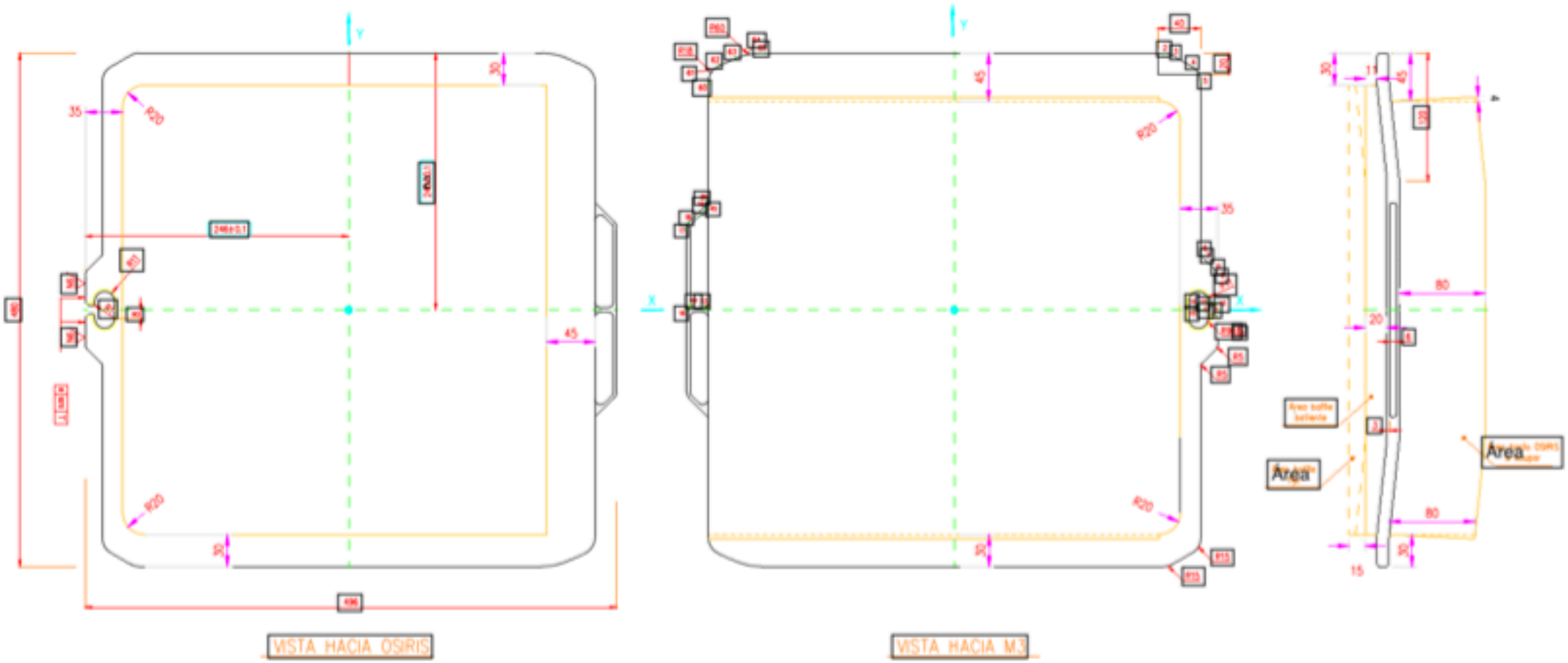
The MAAT box



A realistic overview of the MAAT module based on the exhaustive space mechanical and interfaces study done by the GTC staff. The mask-frame (middle component in the left panel) is identical as that of any OSIRIS mask. Top and bottom directions points to M2 and OSIRIS respectively. The box has one entrance hole (not shown) for the IFU pick-off mirror on its surface pointing to M2. The surface pointing in the direction of OSIRIS will have the slit aperture.

There are no moving parts, neither cables, electronics inside the MAAT box. To all effect, it is just another OSIRIS mask, which it can be removed from the Cartridge if needed.

MAAT Envelope dimensions



2D drawing of the MAAT space envelope with dimensions (Credit: GTC).

MAAT Envelope tests (**on-going**)

Top: 3D printed dummies built for the in situ testing of the MAAT envelope on OSIRIS (Credit: GTC). Bottom: In situ testing of the dummy of the MAAT module on OSIRIS: a) MAAT envelope dummy placed in the Loader mask, b) Baffle to redesign in order to accommodate the subsystem mask frame plus MAAT envelope, c) Width of the MAAT envelope, d) Free space between the rollers and the lower part of the MAAT envelope (orientation rotB = 80 deg), and e) Free space between the upper part of the MAAT envelope and the masks edge protection (orientation rotB = 80 deg). All these pictures have been taken with orientation of rotB = 80 deg (Credit: GTC).

MAAT Optical Study

by Robert Content

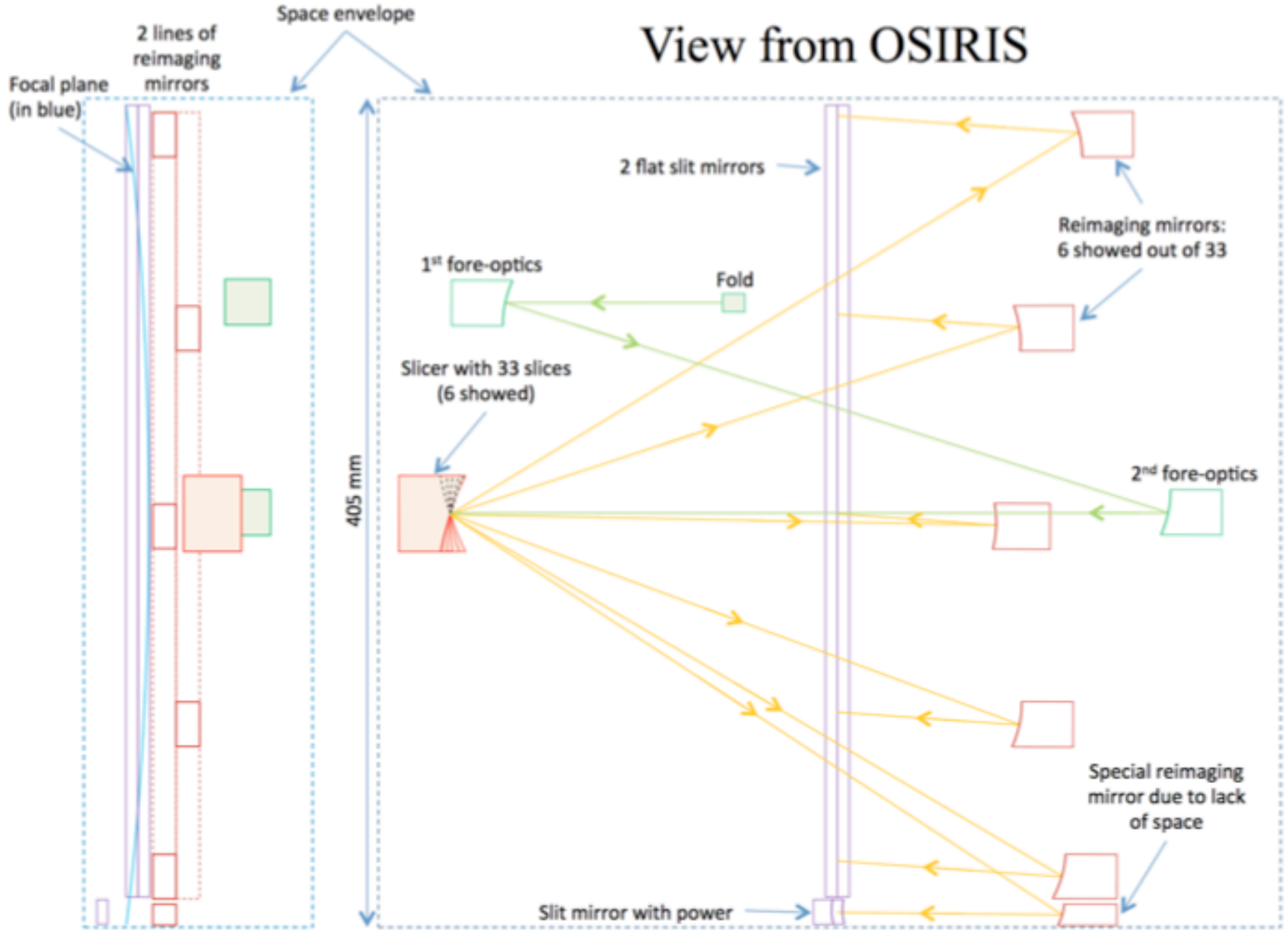
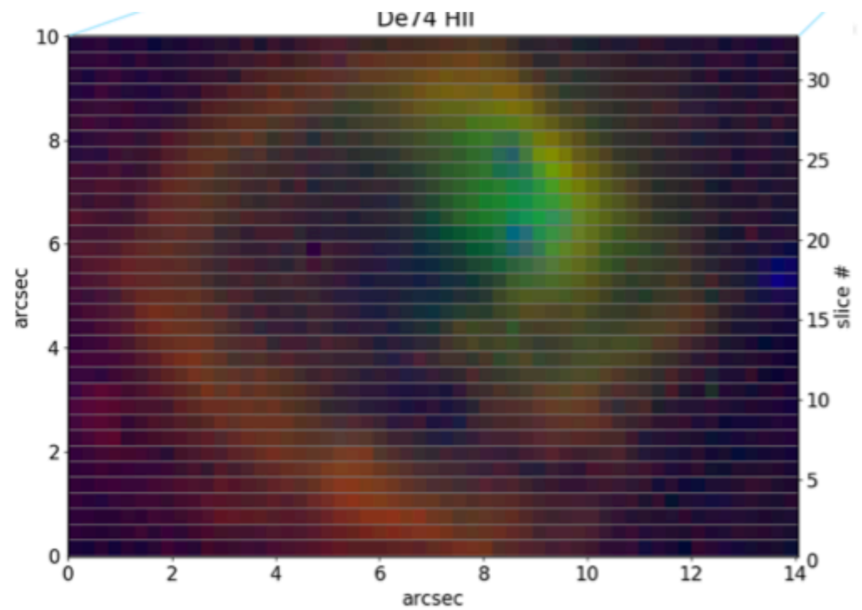
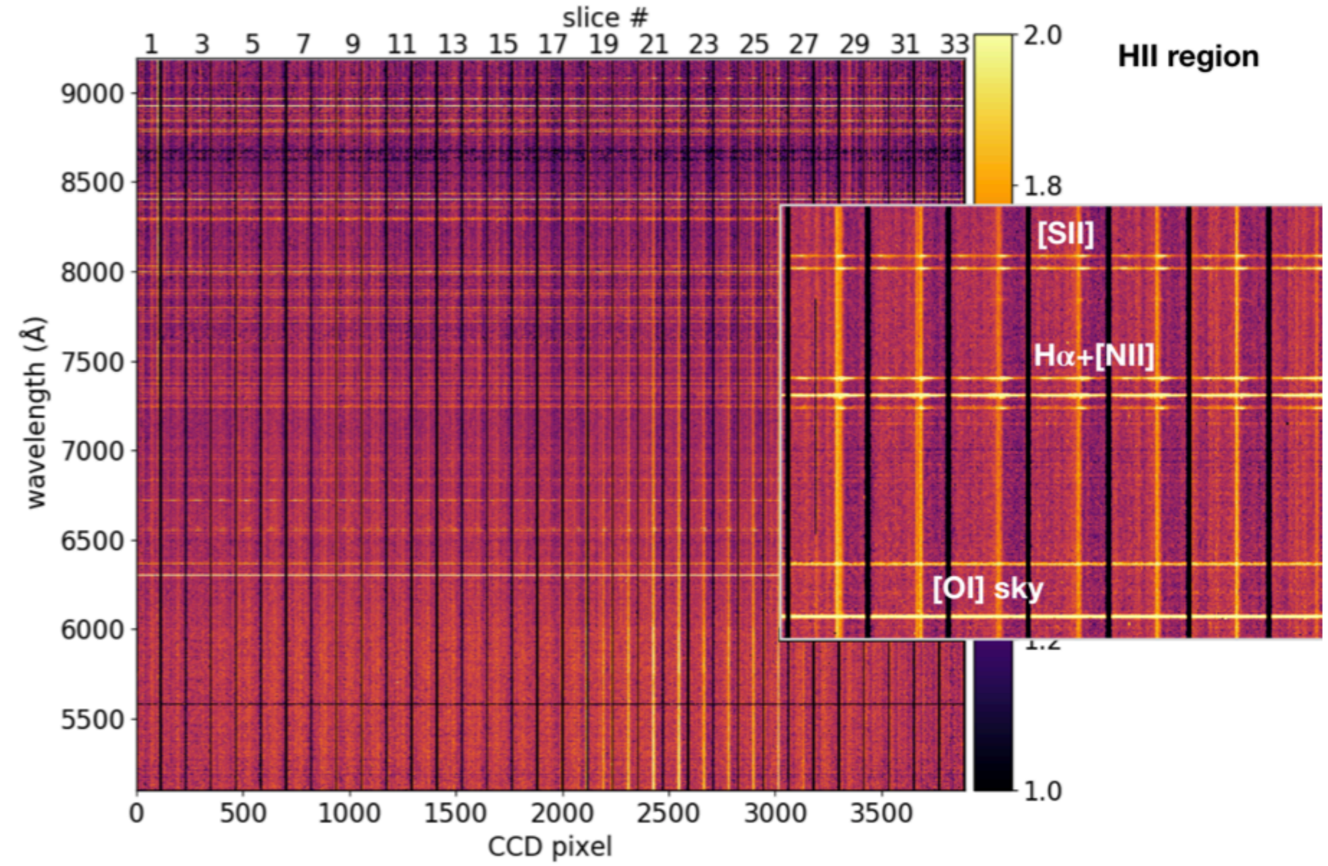


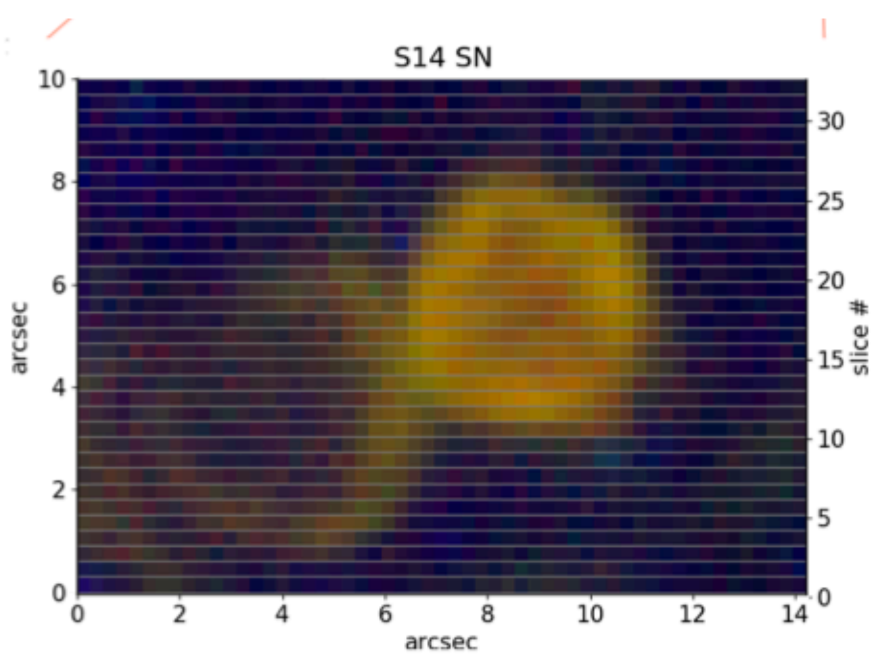
Figure 21. Optics lay-out of the proposed IFU concept (only 6 out of 33 slices are shown).

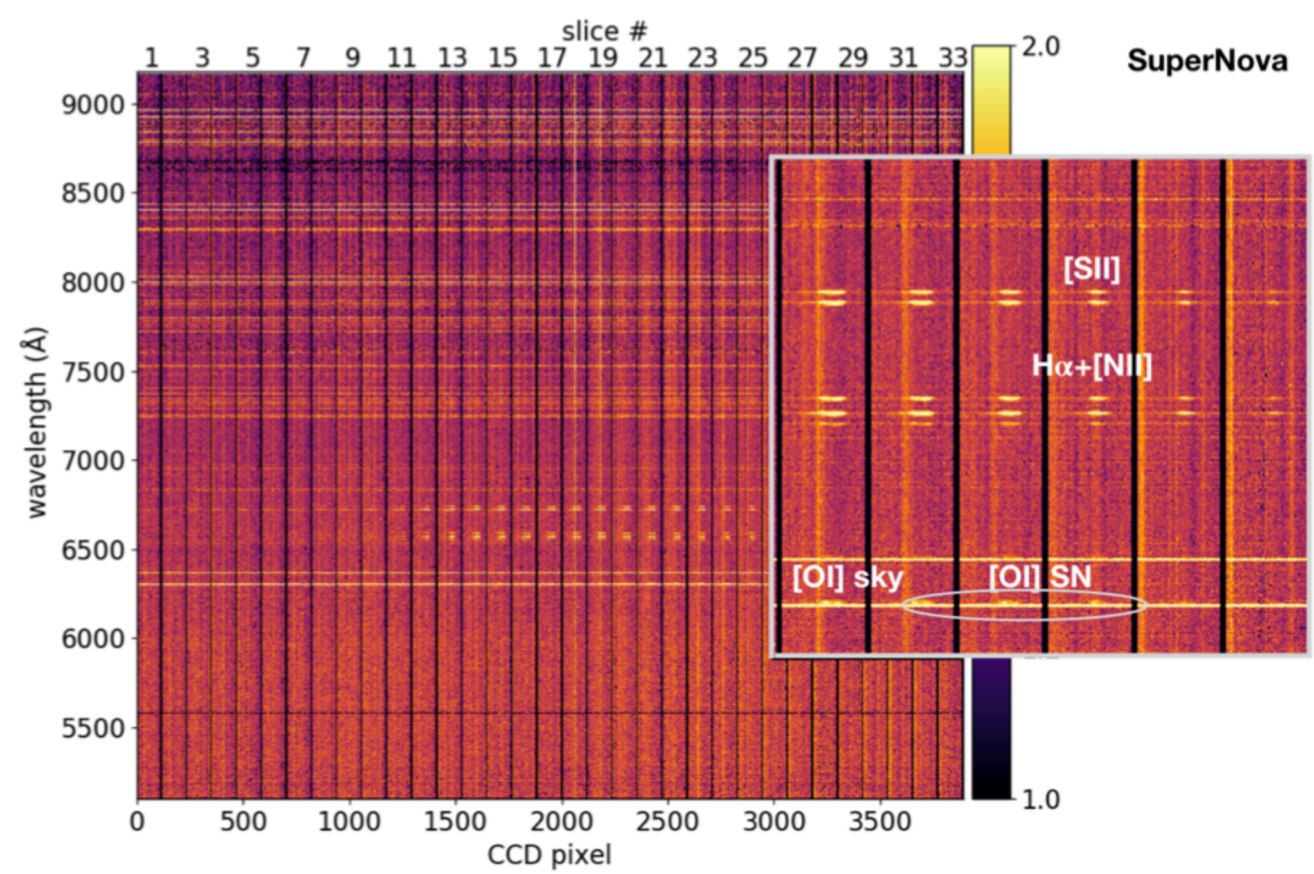
See also Yves's talk for manufacturing details

MAAT simulated CCD frames of the giant HII region De74 (top) and the SN remnant S14 (bottom) in the galaxy NGC300









See RGB's talk

MAAT

MAAT *refers to the ancient Egyptian concepts of truth, balance, order, harmony, law, morality, justice, and cosmic order.*

Thanks!