

# Two cosmology experiments with the VST in 2020s

Adriano Agnello

5th June 2017



## Cosology and surveys in the 2020s:

- Euclid: NIR imaging, slitless spectroscopy
- LSST: *ugriz* multi-epoch imaging (every  $\approx$ three nights)

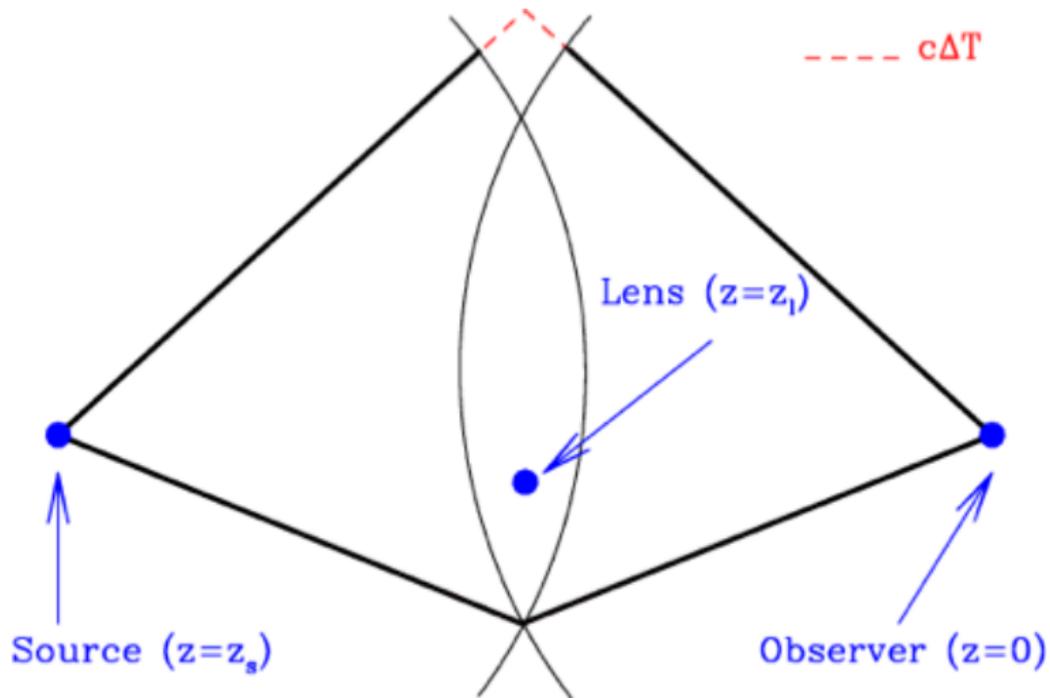
How can we do better?

Higher cadence, optical spectroscopy without preselection<sup>1</sup>.

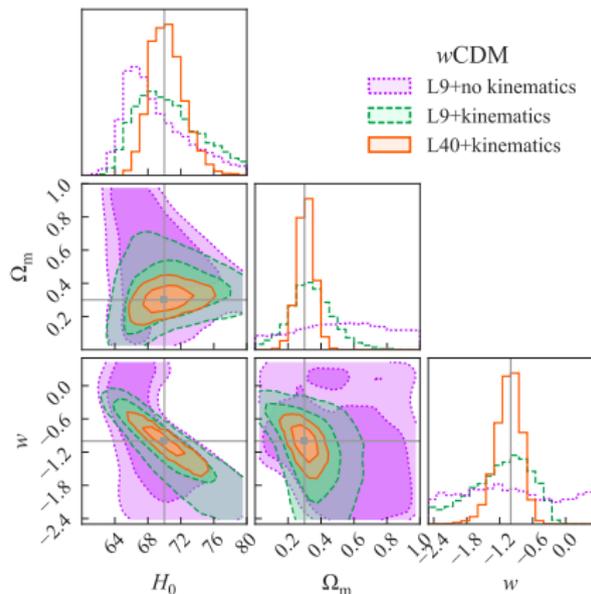
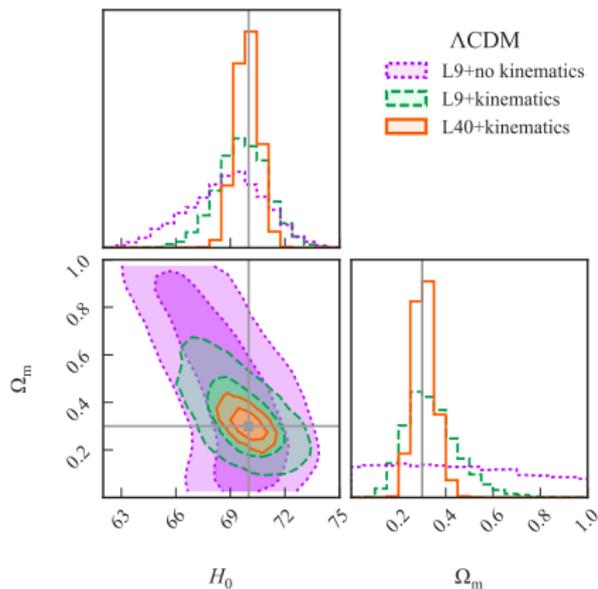
---

<sup>1</sup>Contrast with fibre surveys, e.g. SDSS-V and 4MOST.

# Time-delay cosmography

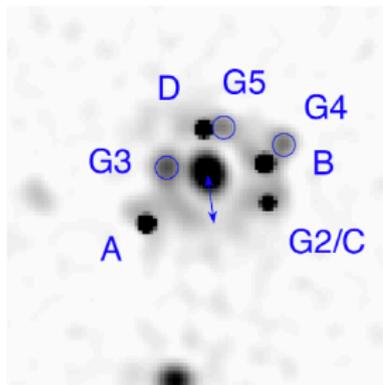
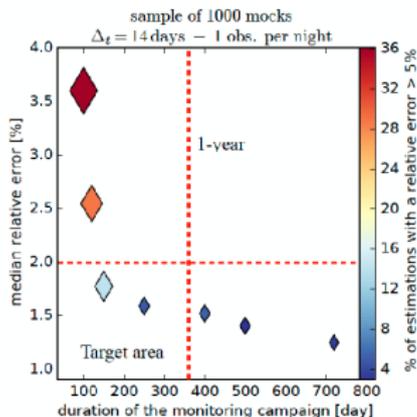


# Some forecasts

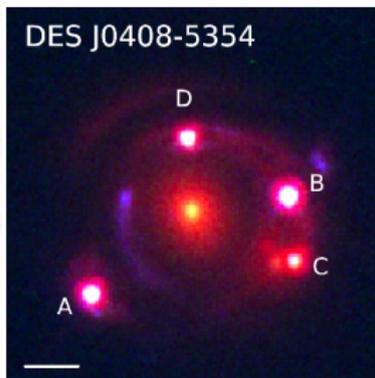


(forecasts from Shajib, AA & Treu 2017)

# High-cadence needs



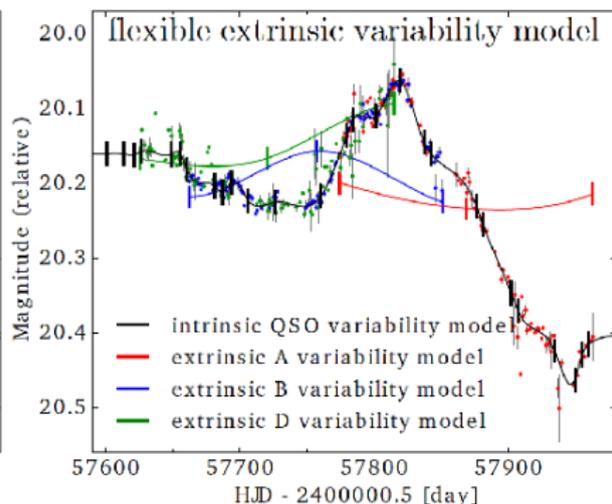
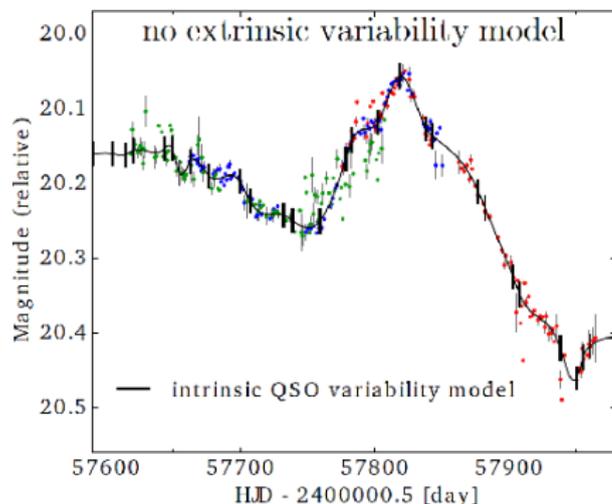
From Agnello et al. 2018, MNRAS 472, 4038



HST image from Shajib et al. 2018, in prep

Nightly cadence, long duration (sim's courtesy of V. Bonvin); good image-quality for lightcurve extraction ( $\approx 0.8'' - 1''$  FWHM,  $\approx 0.2''/\text{px}$ )

## Current 2p2 campaigns (eCOSMOGRAIL)



$$\Delta t(AB) = -112.1 \pm 2.1 \text{ days (1.8\%)}$$

# 2p2 Operations

## COSMOLOGICAL MONITORING OF GRAVITATIONAL LENSES COSMOGRAIL

★ Publications People Telescopes Released data Software Euler instructions Zni2 instructions

Where:    

### Observing at the 2.2m telescope

#### Dear observer

Welcome at the 2.2m MPG telescope! This page is made to help you with the observation of gravitational lenses for the COSMOGRAIL project which is led by the [Laboratory of Astrophysics](#) of the [École Polytechnique Fédérale de Lausanne \(EPFL\)](#).

During your observing run, you will observe gravitational lenses every night, typically for one hour and a half in summer time and two hours and a half in winter.

#### About the project

Finding Charts

Planning

Night reports

Troubleshooting

#### IN A NUTSHELL

→ Take dome and sky flats in the BSAR/162 filter every night

→ Lock at the planning to know which targets you have to observe - and observe them all!

## High-cadence monitoring at the MPIA 2.2m telescope



#### GROND:

- griz and JHK
- 5.5 and 10 arcmin FoV
- 0.16 and 0.3 arcsec pixels
- dichroics



#### FEROS:

- high-res spectra

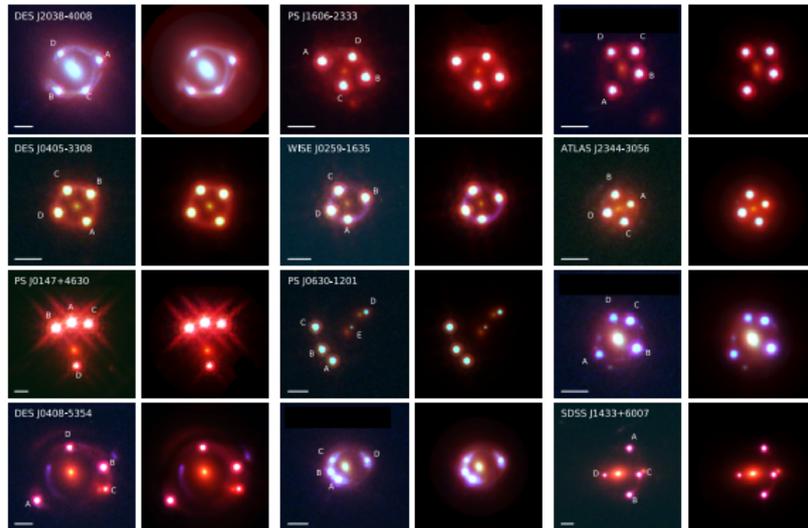


#### WFI:

- optical filters
- 0.2 arcsec pixels
- 36 arcmin FoV
- Excellent optical quality

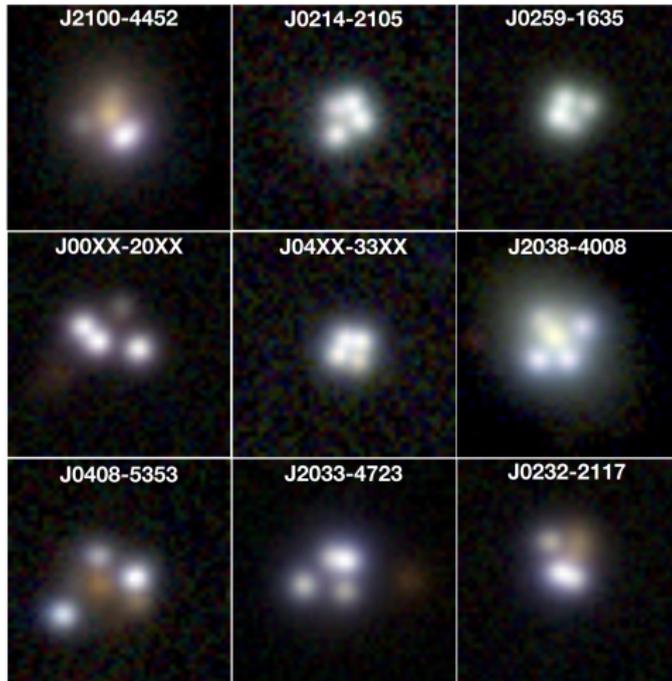
Share the  
autoguider

# Some lenses



(compilation from Shajib, et al. 2018, in prep.; HST-C25 data)

# More lenses



(AA & Spiniello 2018)

# Build your own?



The SPECULOOS telescopes at Paranal

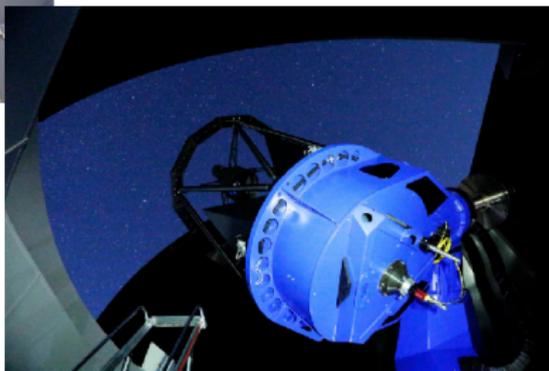
**8 robotic 1m telescopes:**

**4 at Paranal**

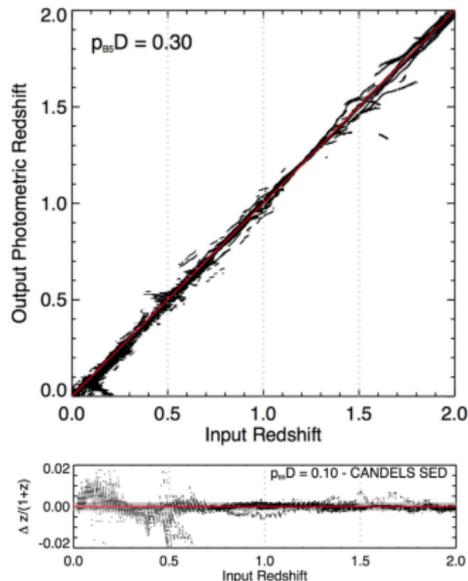
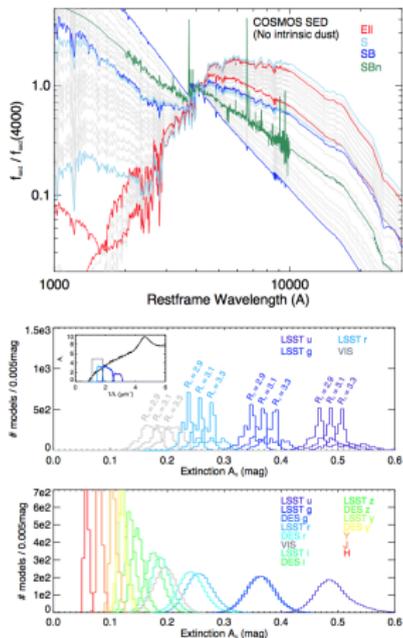
**4 in La Palma**

**1 Meuro Each**

**Operating cost 50'000 euro/year**



# LSST-Euclid synergy



(Galamez, et al. 2017)

Can we get calibration spec-phot in regions with different E(B-V)?

# Slitless, wide-field spectroscopy

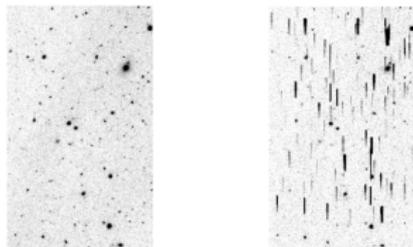
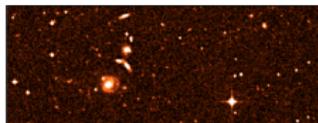
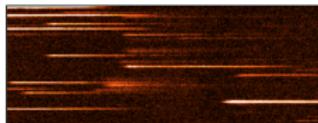


Figure 6: Direct image (left) and simulated gray image (right) in the blue, for a 1 hour exposure in the wavelength range from 3700 to 6300 Å, with a seeing of 0.5" and a dispersion of 40 Å/pix. The faintest spectra correspond to  $B = 25$ .

Small section from the Digitized Sky Survey:



In this image there are several starlike objects in the magnitude range  $B = 12-20$ , and  
The same sky area in the corresponding spectral image:



- Low-medium resolution on wide field.
- Various surveys in the past (until HE survey  $\approx 1999$ ), mostly on photographic plates. Strong cutoffs given by sky (in the blue) and photographic emulsion (in the red).
- KPNO International Spectroscopic Survey (KISS; Salzer et al. 2000), an objective-prism on a 1m Schmidt telescope with CCD detectors.
- Simulations made also for Megacam on the CFHT (1997), with a tilted grens.

# Why slitless? Why not fibre?

Table 1: Summary of properties of the WFI grisms.

Grism	Blaze wavelength nm	Wavelength Range		Dispersion		IQ Resolution	
		nominal nm	measured nm	nominal nm/pix	measured nm/pix	pix	nm
B50	400	400-650	380-740	0.807	0.701	4.5	3.1
R50	600	650-850	420-900	0.811	0.691	6.3	4.4

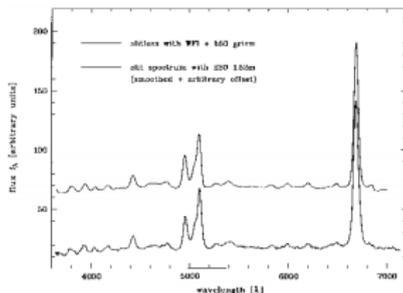


Figure 10: Spectra of the Seyfert 1 galaxy Mrk 1239. Lower spectrum in black: WFI slitless plus B50; upper spectrum in red: slit spectrum taken with ESO 1.52-m telescope.

(A grism on the 2p2, P68; Wisotzki, Selman, & Gilliotte, The Messenger 2001)

## Fibre spectroscopy:

- object preselection: what do we miss?
- fibre magnitudes to object magnitudes?
- really needed for faint objects?

## Slitless:

- *all* objects within prescribed depth;
- emission-line object detection, rare object classes (EMP stars);
- shapes and magnitudes from zeroth order and spatial profile
- a "super-MUSE" with enough p.a.s

# Why slitless? Why not fibre?

Table 1: Summary of properties of the WFI grisms.

Grism	Blaze wavelength nm	Wavelength Range		Dispersion		IQ Resolution	
		nominal nm	measured nm	nominal nm/pix	measured nm/pix	pix	nm
B50	400	400-650	380-740	0.807	0.701	4.5	3.1
R50	600	650-850	420-900	0.811	0.691	6.3	4.4

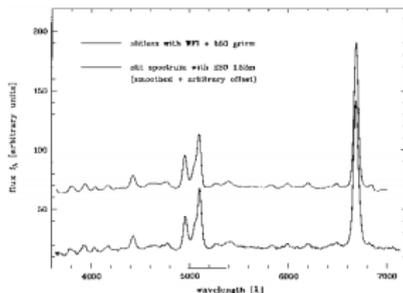


Figure 10: Spectra of the Seyfert 1 galaxy Mrk 1239. Lower spectrum in black: WFI slitless plus B50; upper spectrum in red: slit spectrum taken with ESO 1.52-m telescope.

(A grism on the 2p2, P68; Wisotzki, Selman, & Gilliotte, The Messenger 2001)

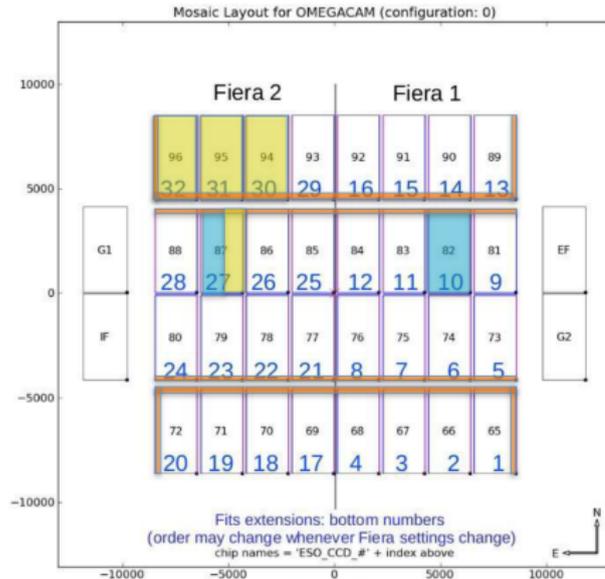
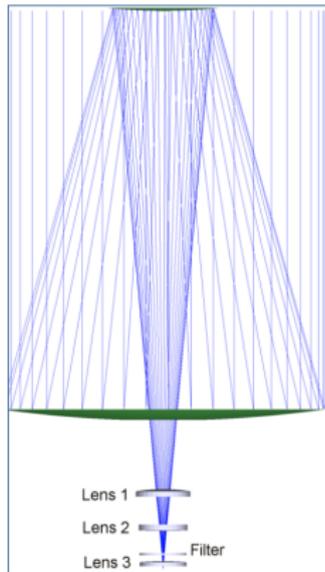
## Fibre spectroscopy:

- object preselection: what do we miss?
- fibre magnitudes to object magnitudes?
- really needed for faint objects?

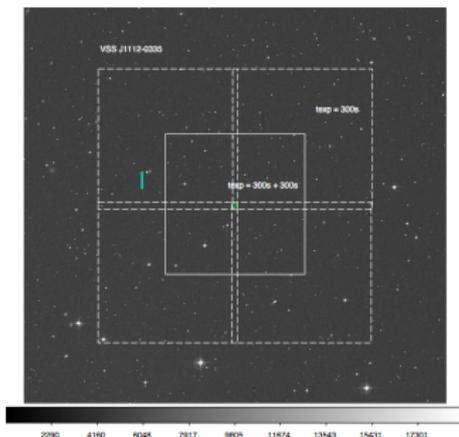
## Slitless:

- *all* objects within prescribed depth;
- emission-line object detection, rare object classes (EMP stars);
- shapes and magnitudes from zeroth order and spatial profile
- a "super-MUSE" with enough p.a.'s

# On the VST



# Estimates



(An older plan for slitless spectroscopy with VIMOS, LR-blue)

Two p.a.'s,  $t_{\text{exp}}=600\text{s}$  each, down to  $i \approx 21$ , quasars out to  $z_s \approx 3$ .  
 $\approx 36\text{deg}^2$  in  $\approx 6\text{h}$ . Still  $0.2''/\text{px}$ ;  
WFI P68 experiment suggests good image quality overall.  
Compare with array of  $N=27$ ,  $f=4$ ,  $D=25\text{cm}$  Newtonians:  $\approx 3''/\text{px}$ ,  
 $\approx 36\text{deg}^2$  in  $\approx 12\text{h}$ ; just hardware cost  $\gtrsim 300\text{kEUR}$ .

**NB:** Omegacam+VST is  $\approx 8$  times faster than VIMOS+VLT!

Blue mode:  $3600 \lesssim \lambda \lesssim 7600$  ( $O_3$ +filter); red mode:  $7000 \lesssim \lambda \lesssim 9000$ .

## Summing up:

### Two cosmology experiments:

- High-cadence monitoring of time-delay lenses, one in three colours every night, or three every night, one hour each.
- Wide-field slitless spectroscopy ( $\approx 40/\text{px}$ ), calibrate LSST-Euclid photo-z's, rare object searches and characterization.

### Operations:

- The instrument remains OmegaCam, with greys in place of ADC  $\Rightarrow$  BOB-compatible;
- OmegaCam acquisition, img. analysis, autoguiding being automated right now (J. Smoker, progress report);
- TIO SciOps 2.0: when needed for VLTI/Coudé, one TIO is left to operate VST+VISTA;
- Export 2p2 operation model? Train observers on VST, rely on ESO for eng.side of troubleshooting.

## Summing up:

### Two cosmology experiments:

- High-cadence monitoring of time-delay lenses, one in three colours every night, or three every night, one hour each.
- Wide-field slitless spectroscopy ( $\approx 40/\text{px}$ ), calibrate LSST-Euclid photo-z's, rare object searches and characterization.

### Operations:

- The instrument remains OmegaCam, with greys in place of ADC  $\Rightarrow$  BOB-compatible;
- OmegaCam acquisition, img. analysis, autoguiding being automated right now (J. Smoker, progress report);
- TIO SciOps 2.0: when needed for VLTI/Coudé, one TIO is left to operate VST+VISTA;
- Export 2p2 operation model? Train observers on VST, rely on ESO for eng.side of troubleshooting.