BATMAN @ Gemini:
A Visiting DMD-based spectro-imager

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+ BATMAN French-Italian team

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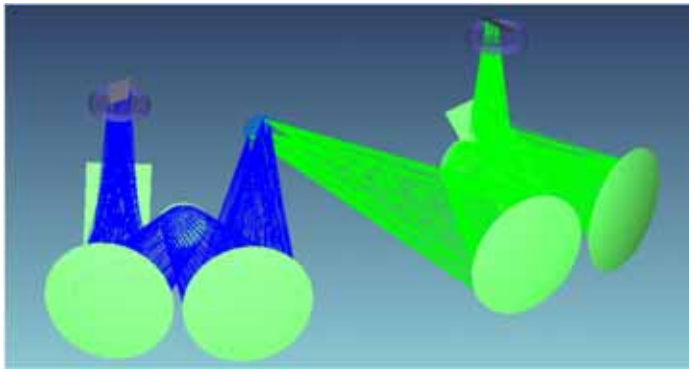
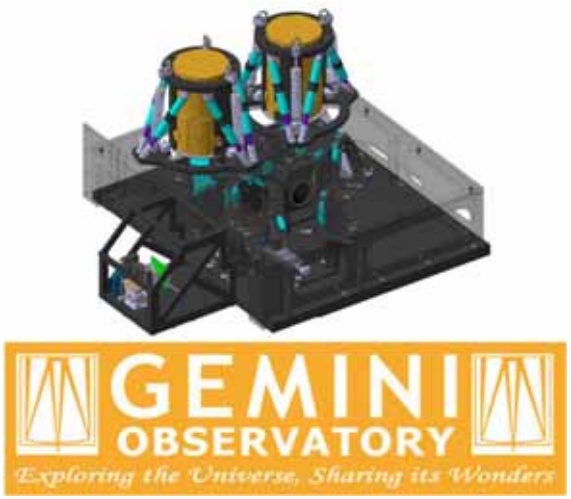
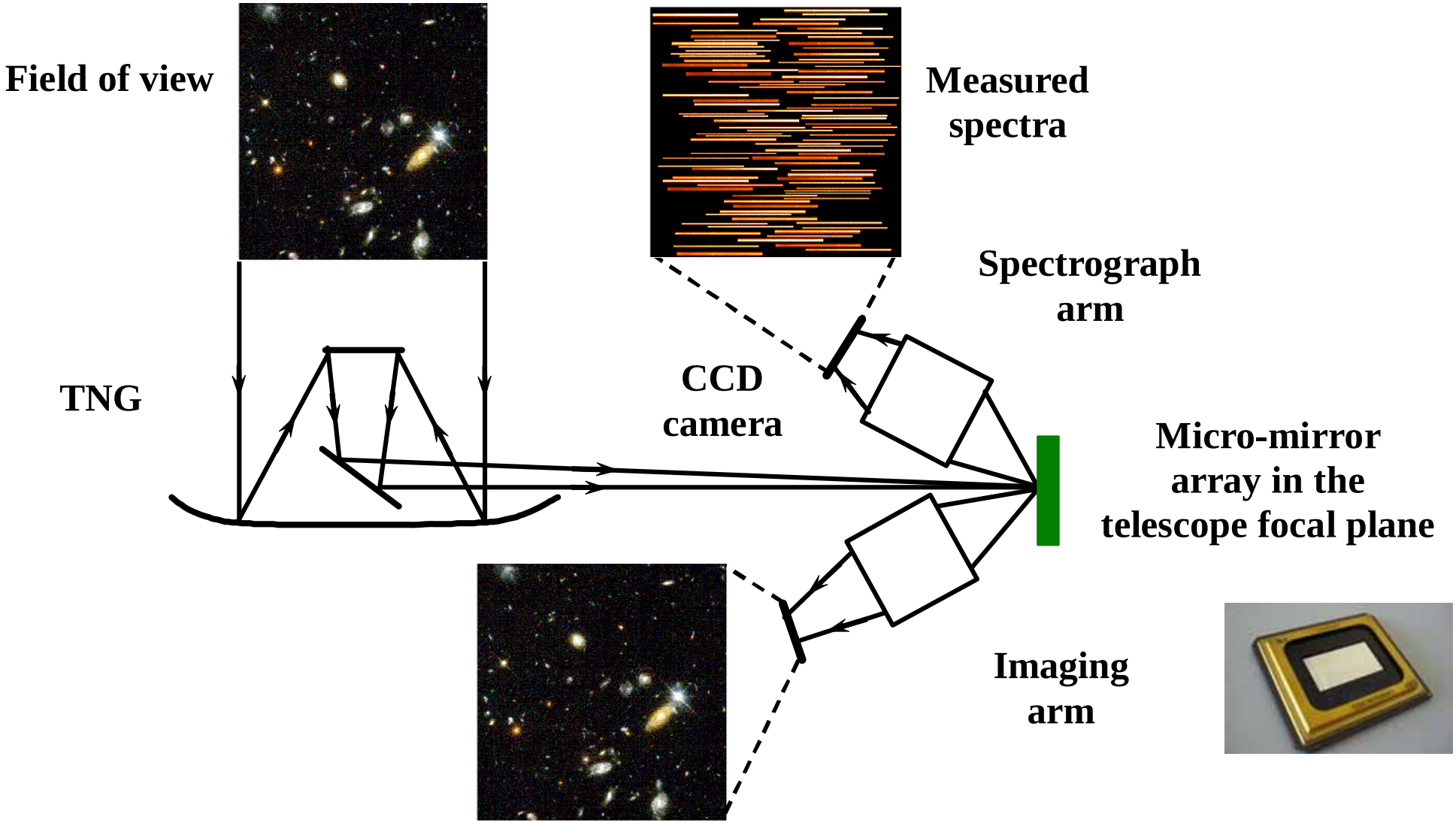
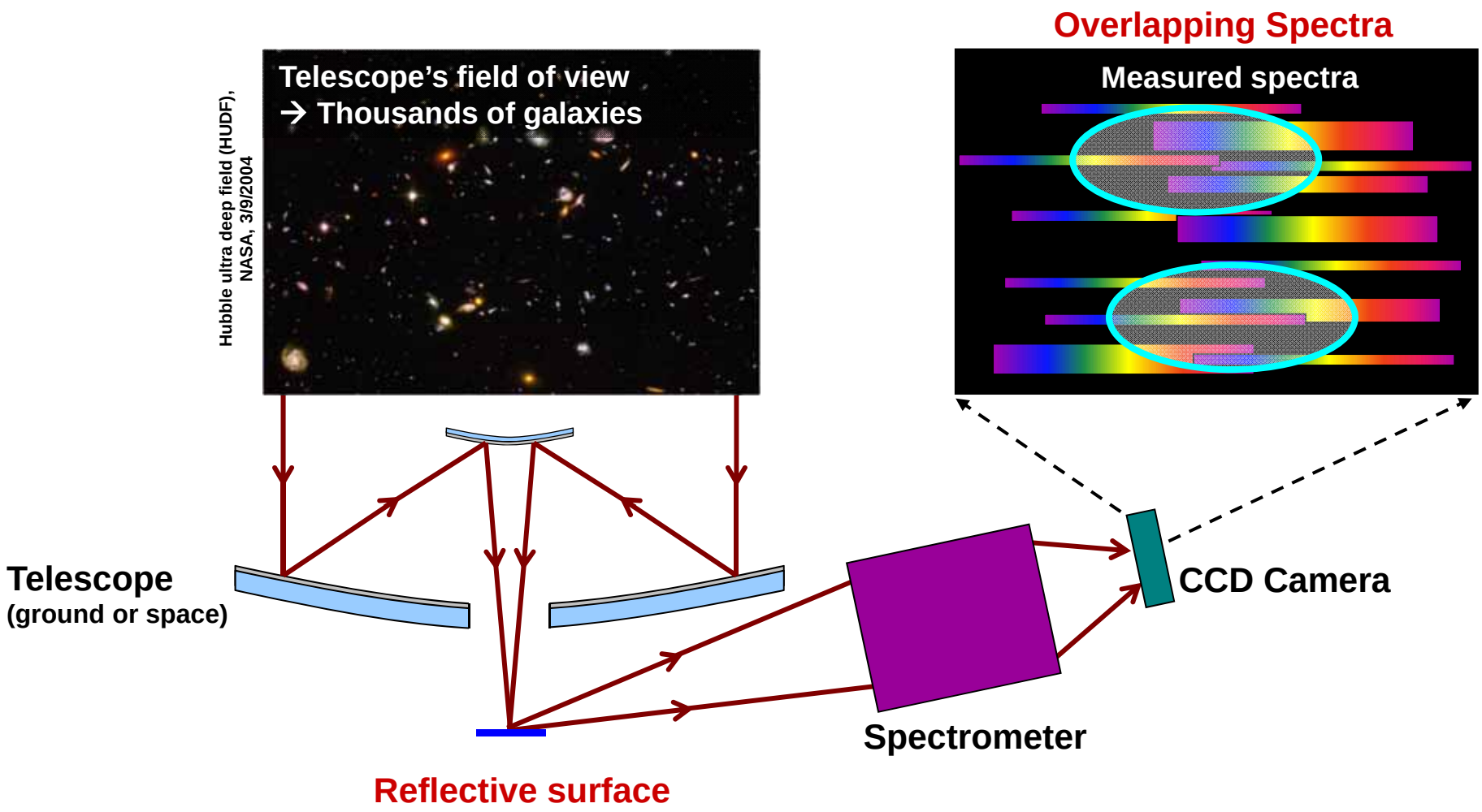




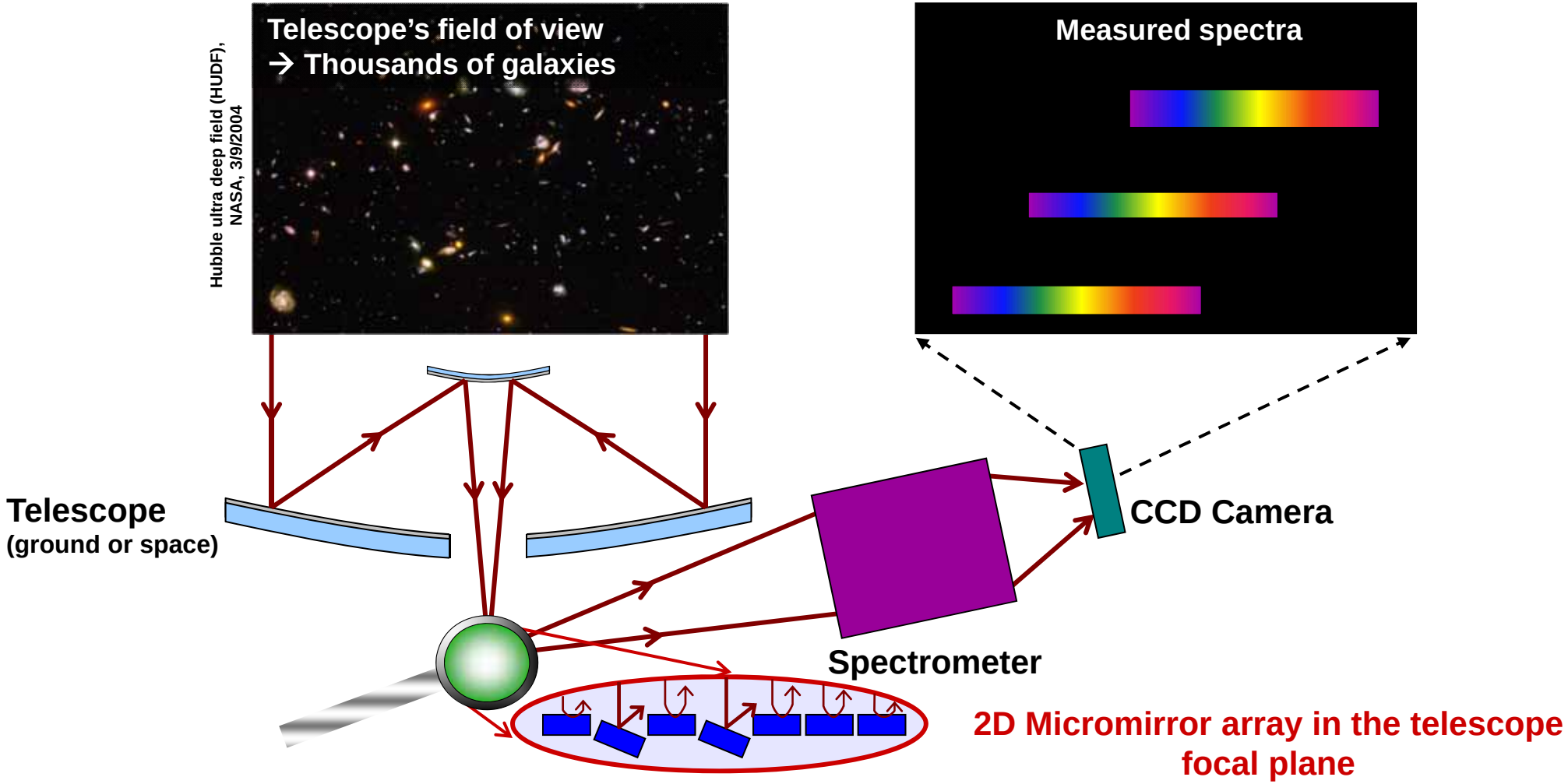
BATMAN concept



Multi-object spectroscopy

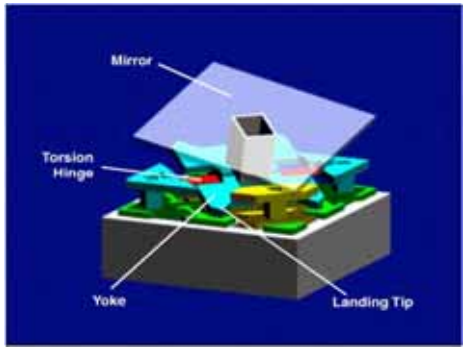


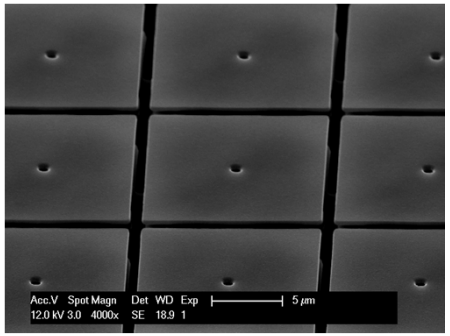
Multi-object spectroscopy

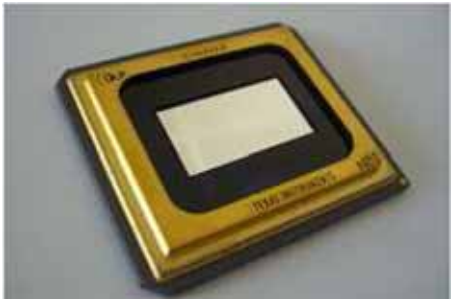


Texas Instruments DMD

- Most popular MOEMS devices available on the market.
- Micro-mirrors
  - 2048x1080 individually tiltable **(> 2 millions mirrors)**
  - 13.68µm pixel pitch,
  - Tilt angle of 12°
- Numerous applications
  - Prime use displaying images
  - No customization possible
- Space qualification tests (ESA contract, EUCLID)
  - -40°C in 10^{-5} mbar vacuum
  - Micro-mirrors in position for > 1500s
  - DMD fully operational
  - 1038 hours life test, radiations, vibrations
  - No show-stopper for space application



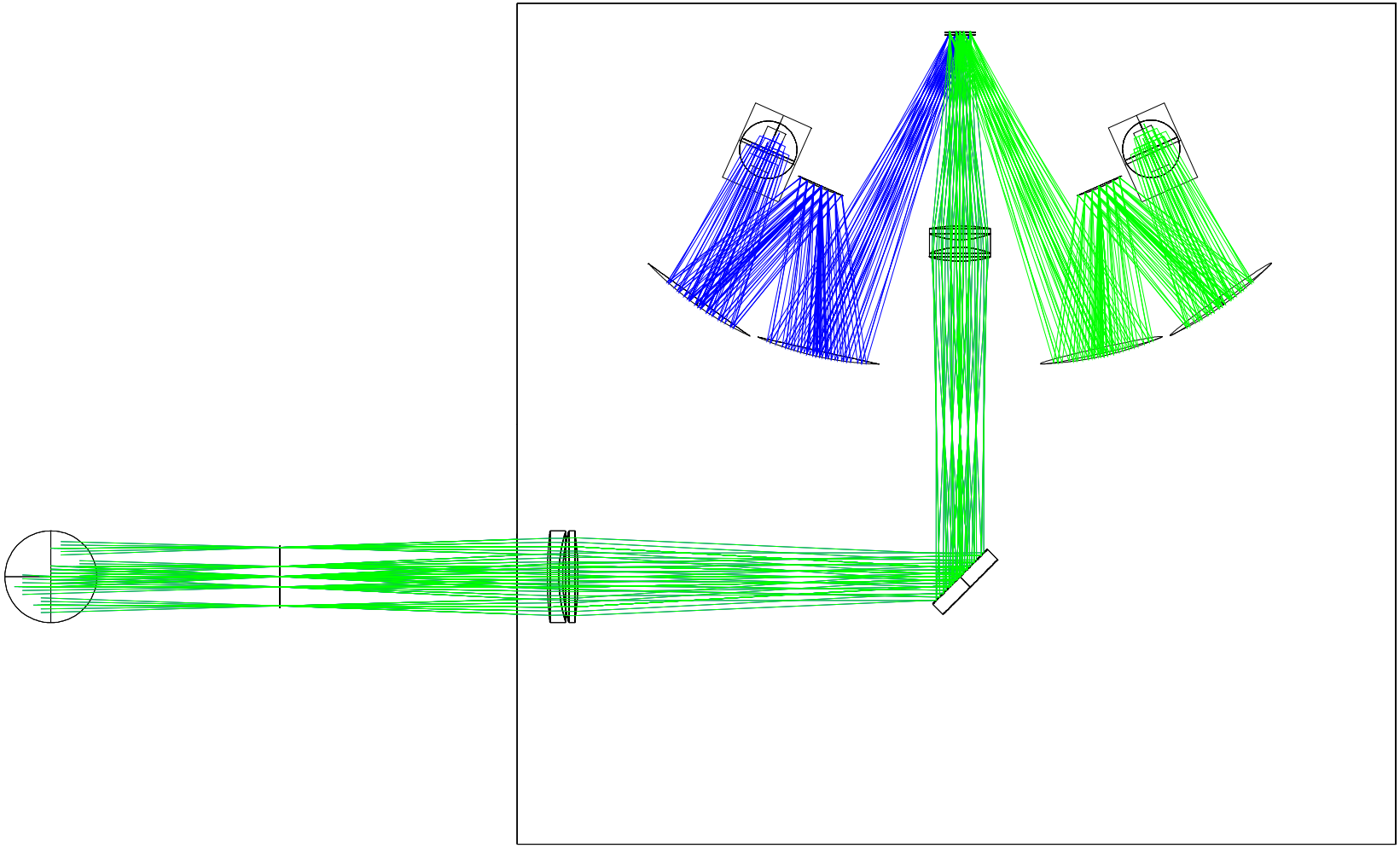




Parameters: BATMAN@TNG

Field of view	6.8 arcmin x 3.6 arcmin
Focal ratio	F/4 on DMD (scale = 0.2 arcsec per micromirror)
Beams on DMD	incoming light at normal incidence out-coming light at 24° DMD orientation at 45°
Wavelength range	400 - 800 nm
Spectral resolution	**R = 560** for 1 arcsec slit to **2000** for 0.2 arcsec slit
Two arms instrument	one spectroscopic channel one imaging channel
Detectors	Two 2k x 4k CCDs

Optical design



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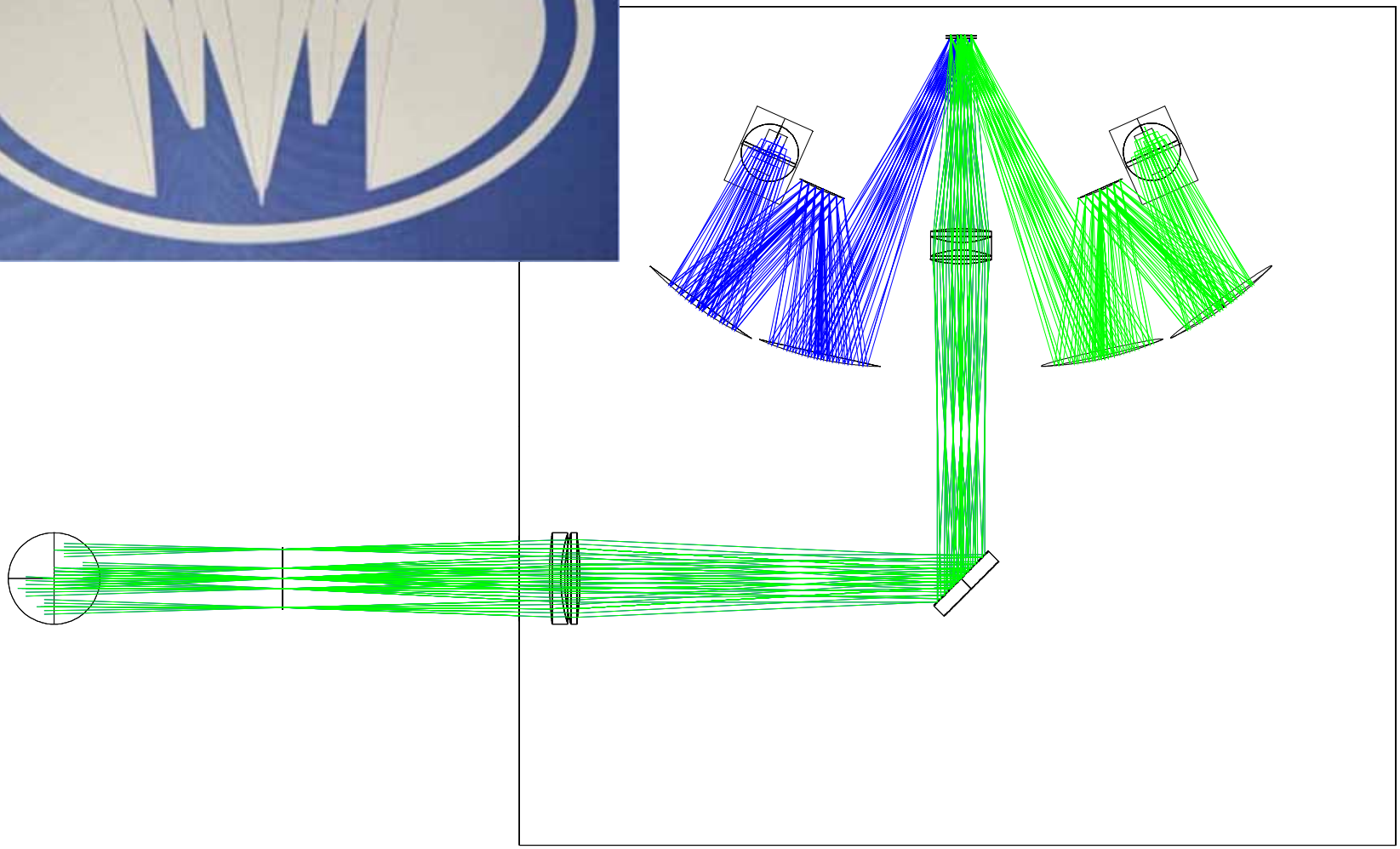
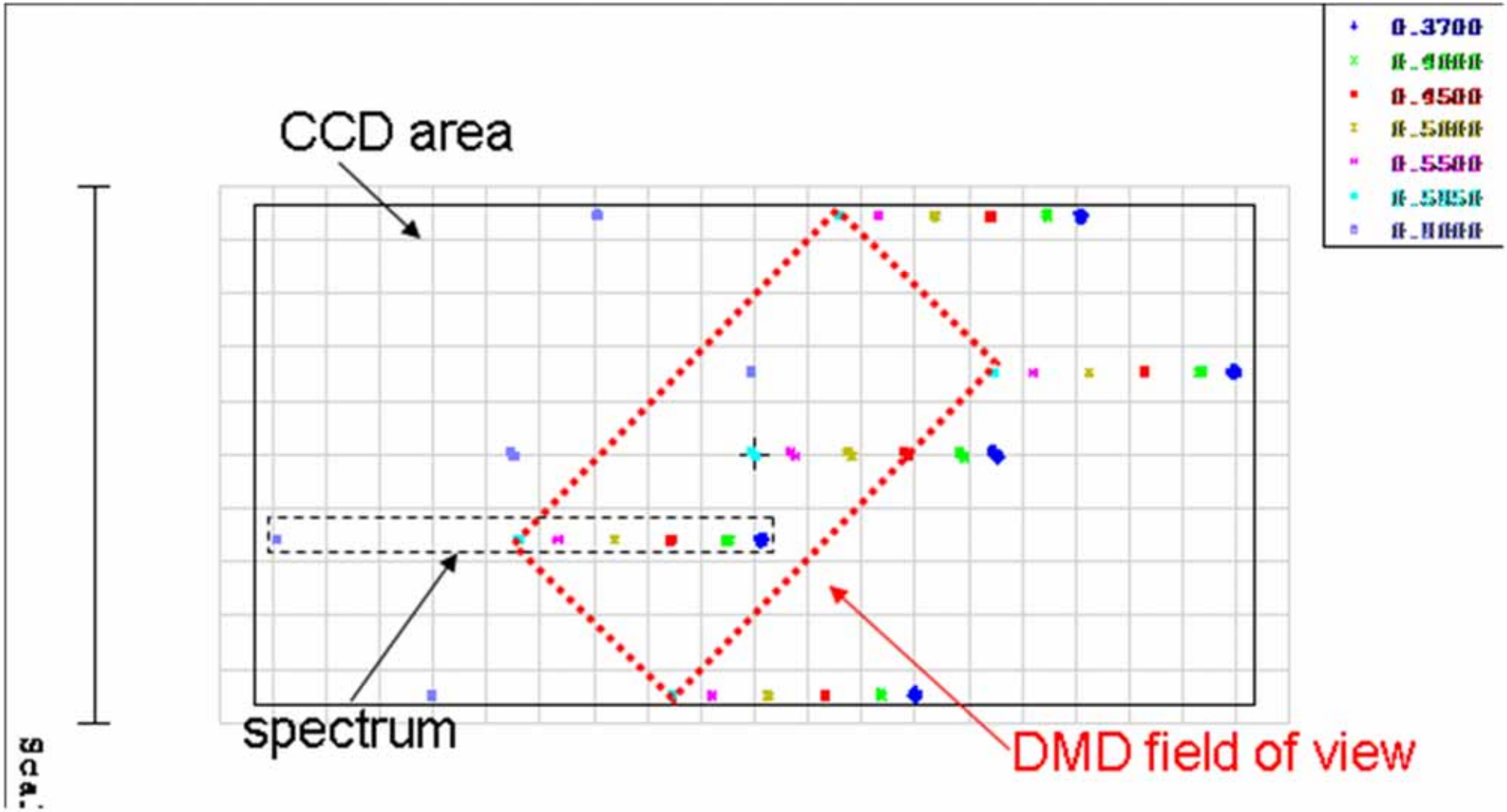
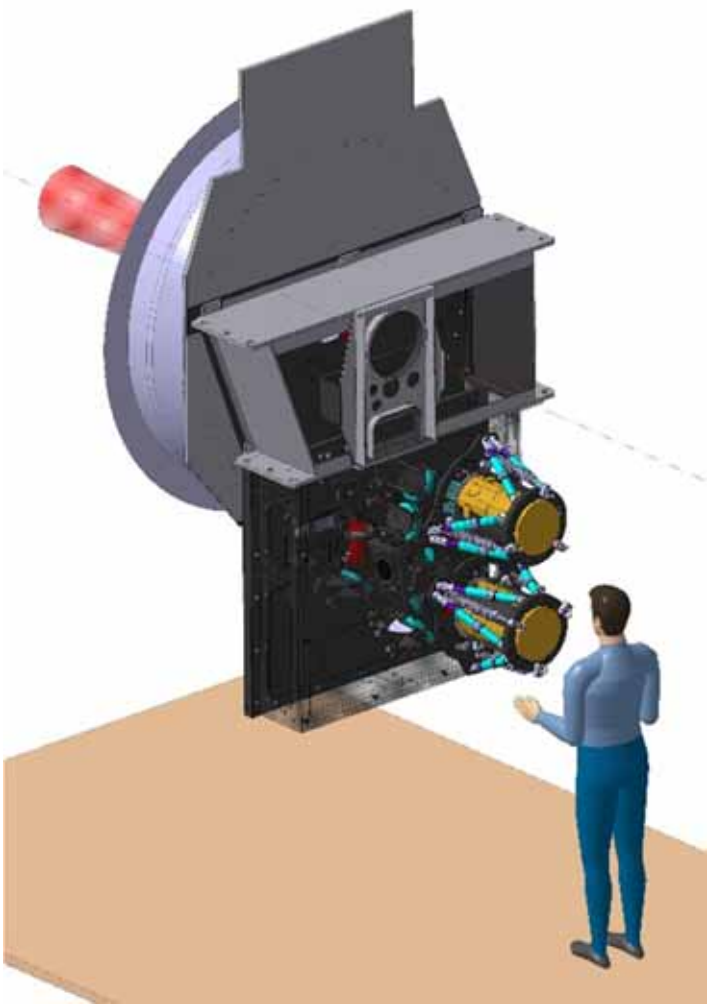


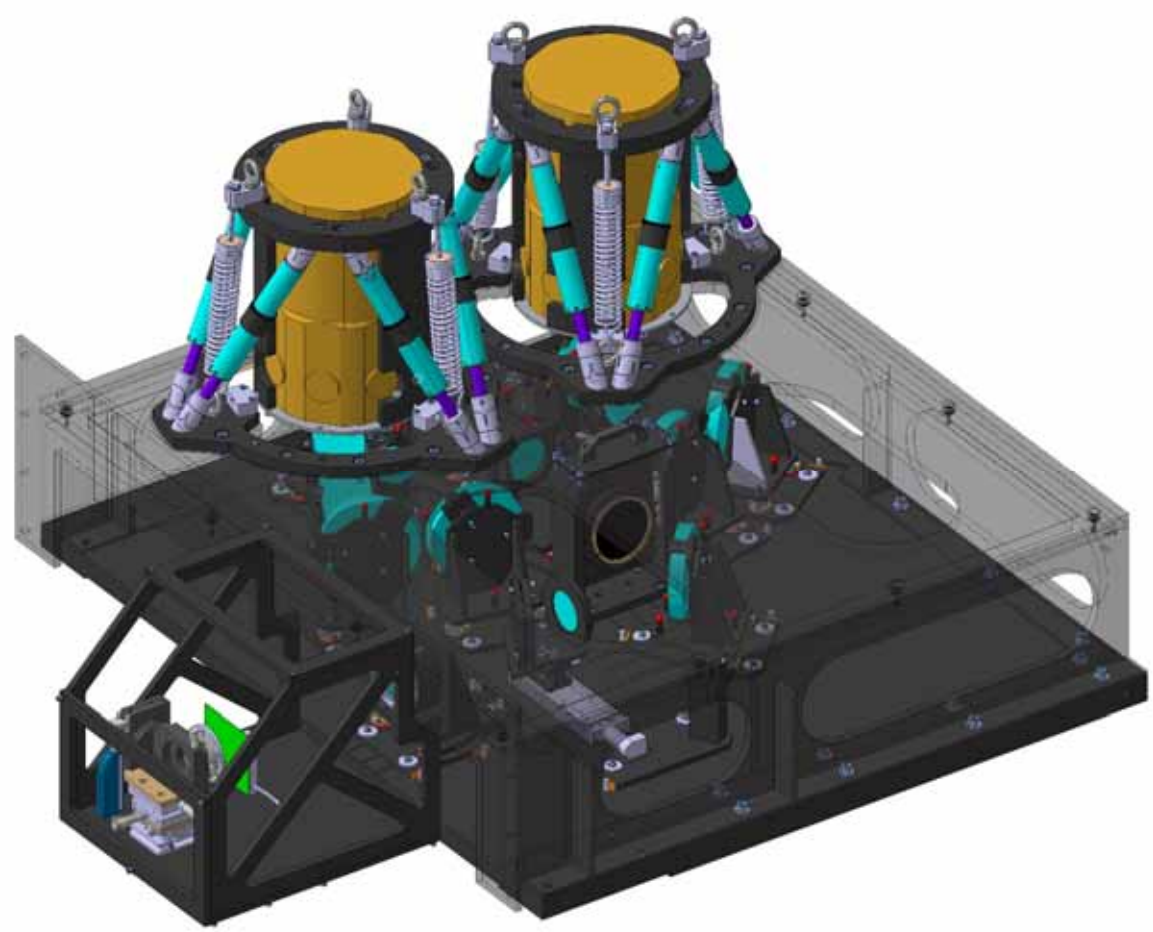
Simulated spectra

- Simulated spectra (400 – 800 nm)

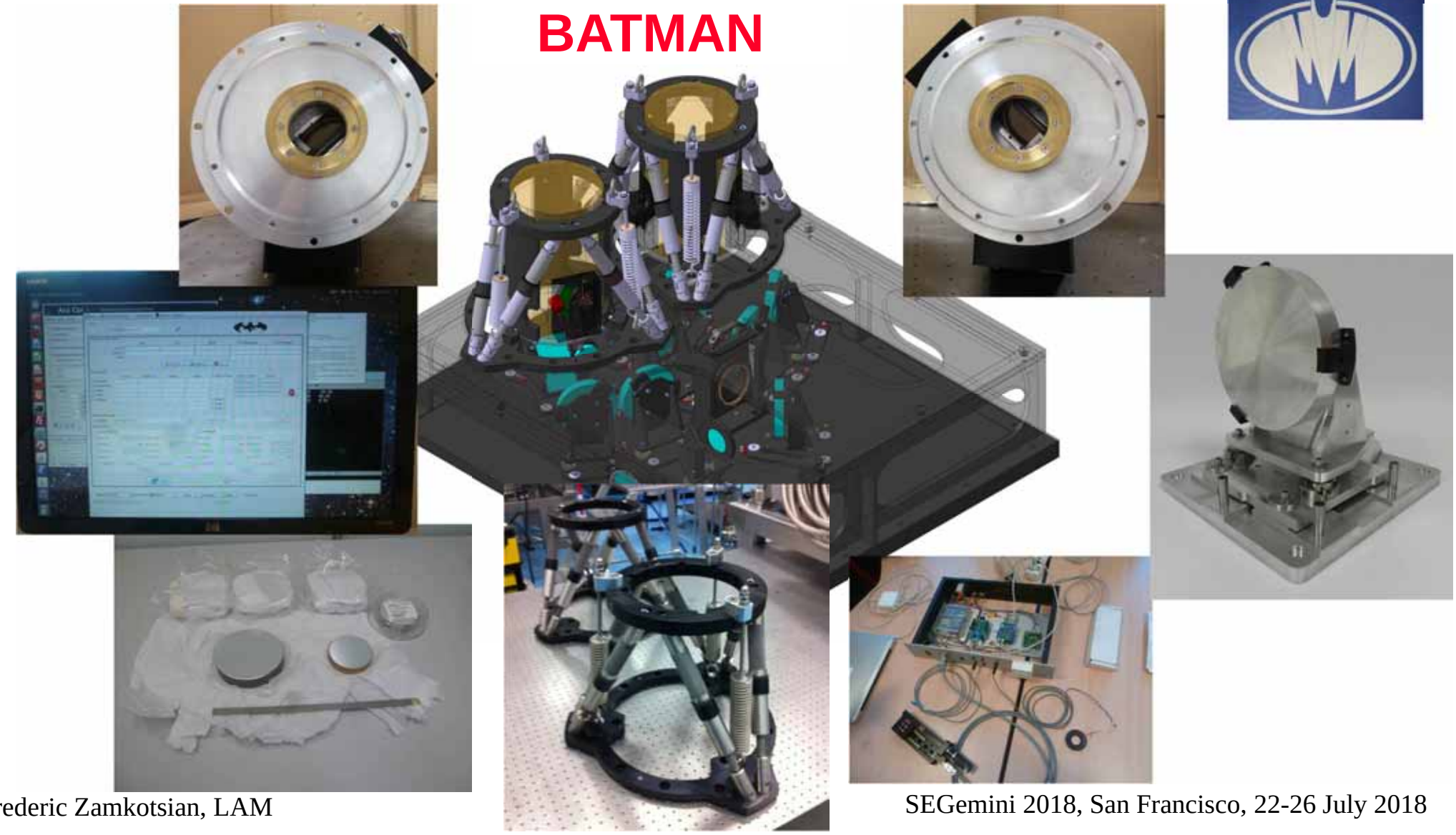


BATMAN: the opto-mechanics



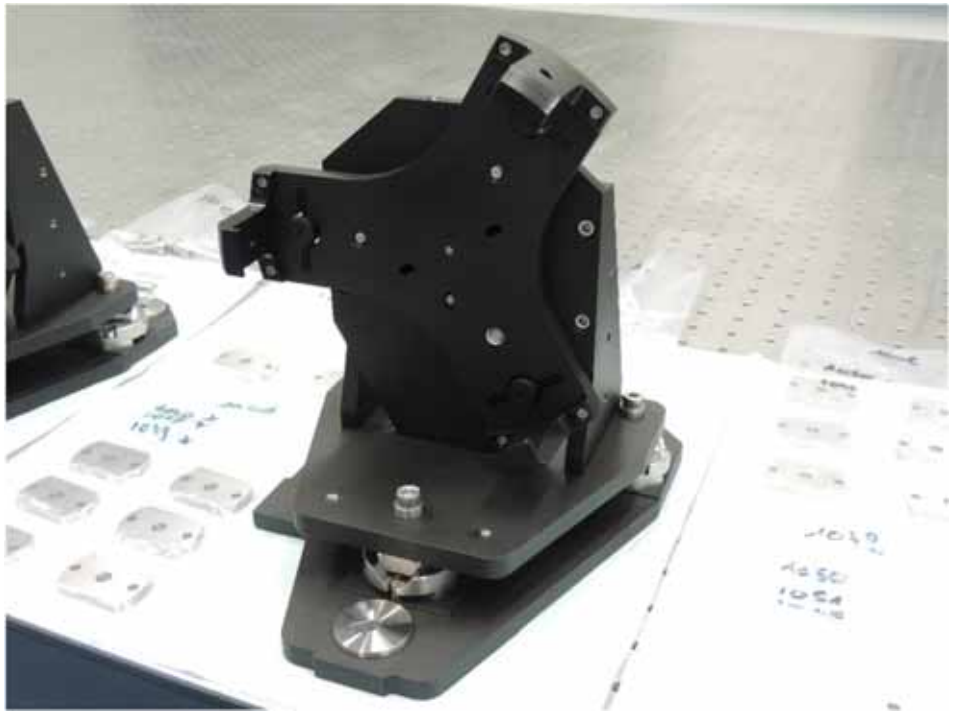


BATMAN



Frederic Zamkotsian, LAM

BATMAN is under construction



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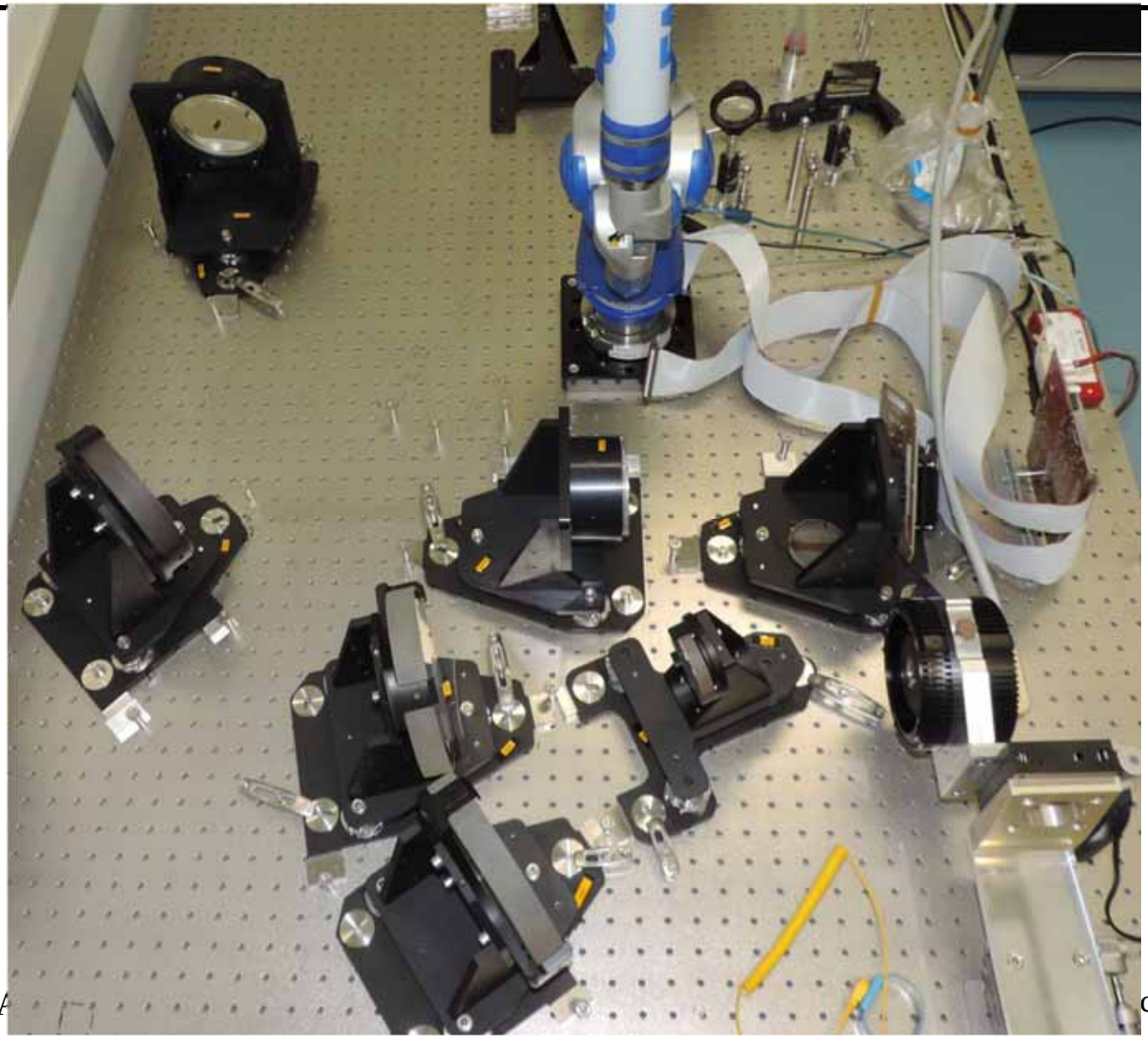

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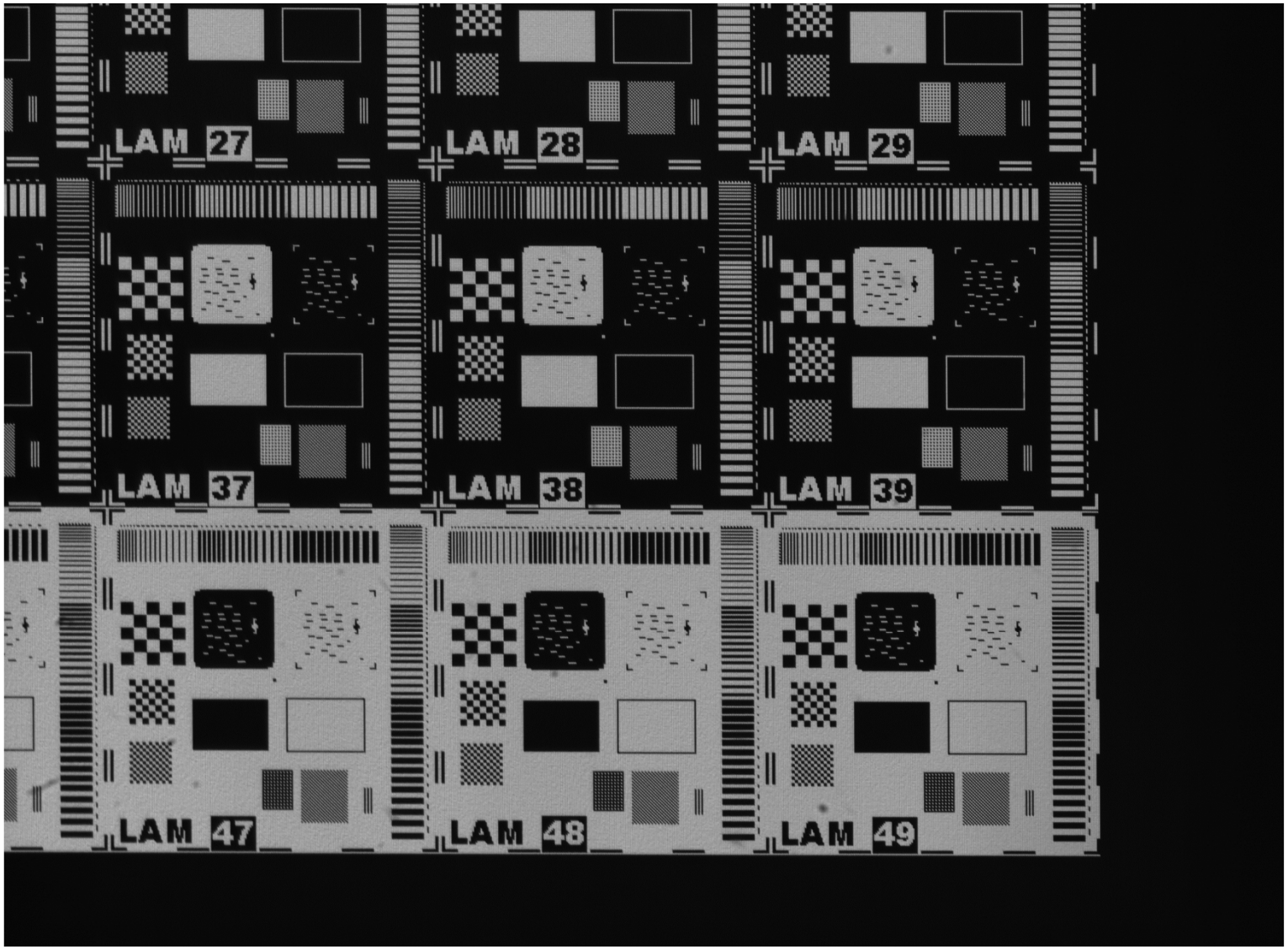

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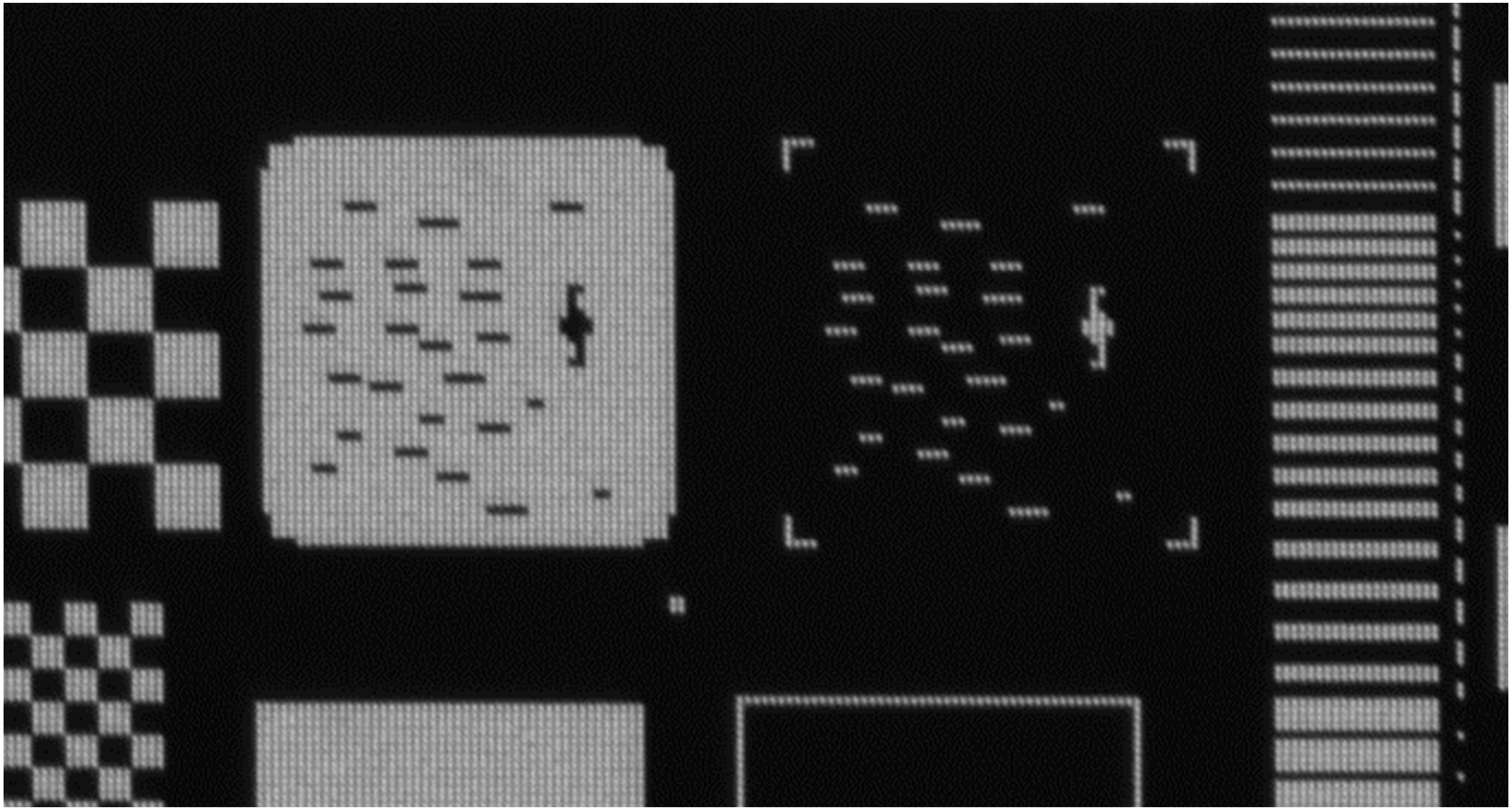

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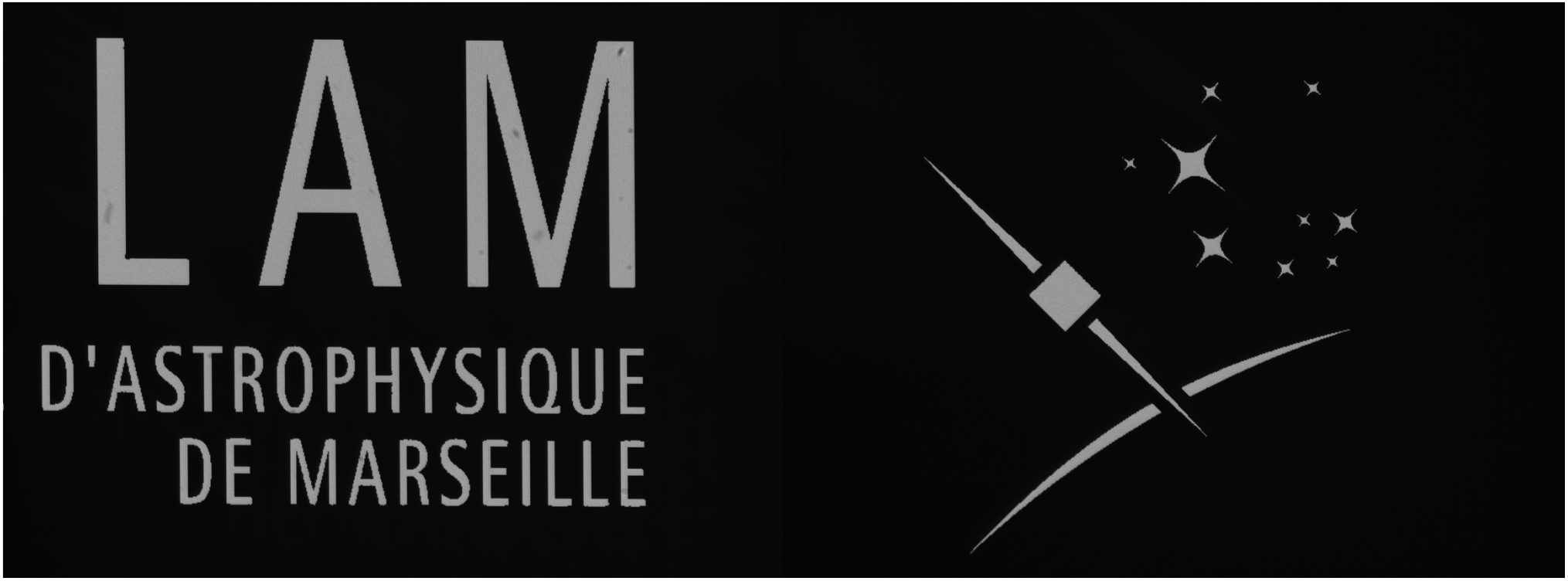

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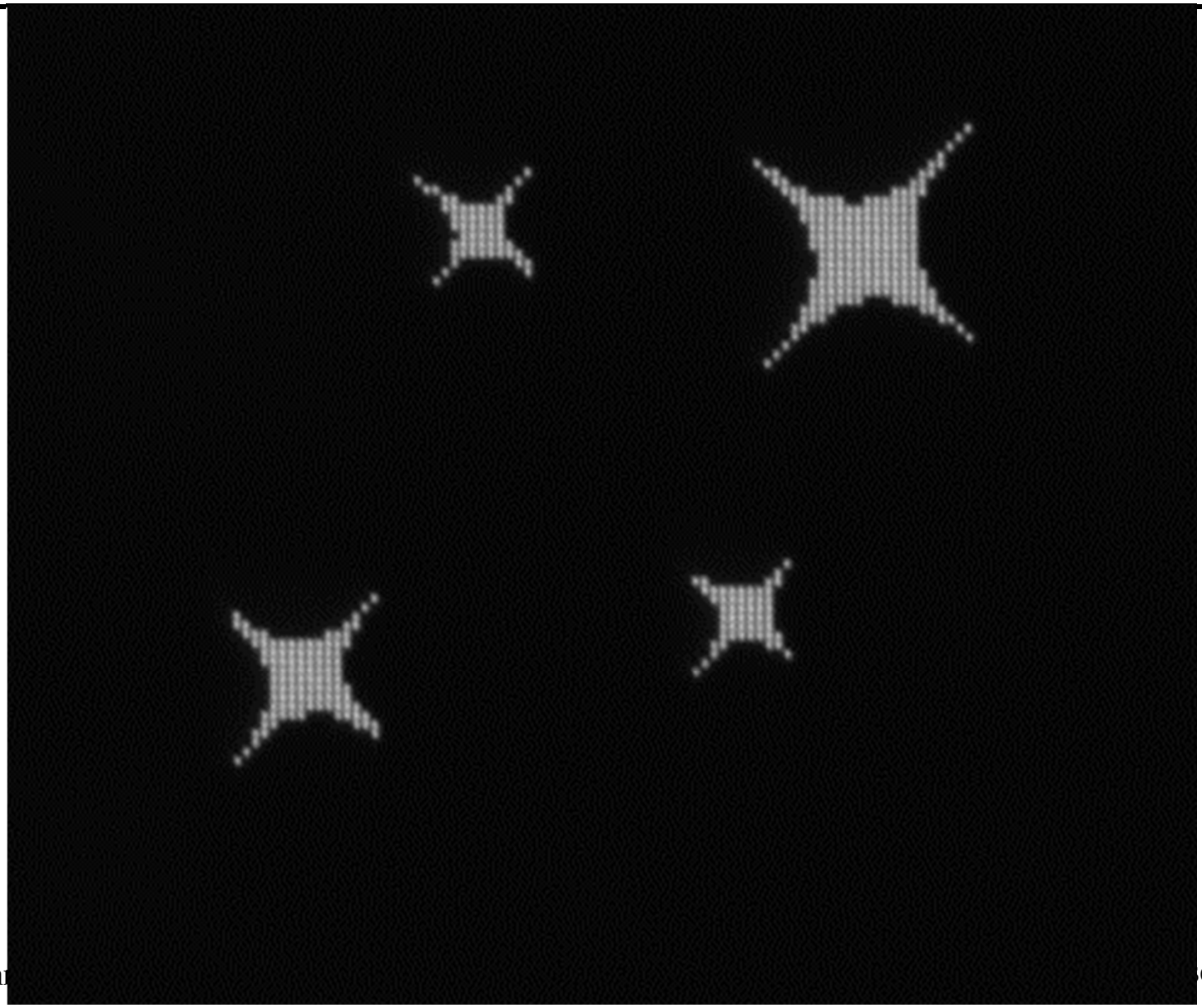

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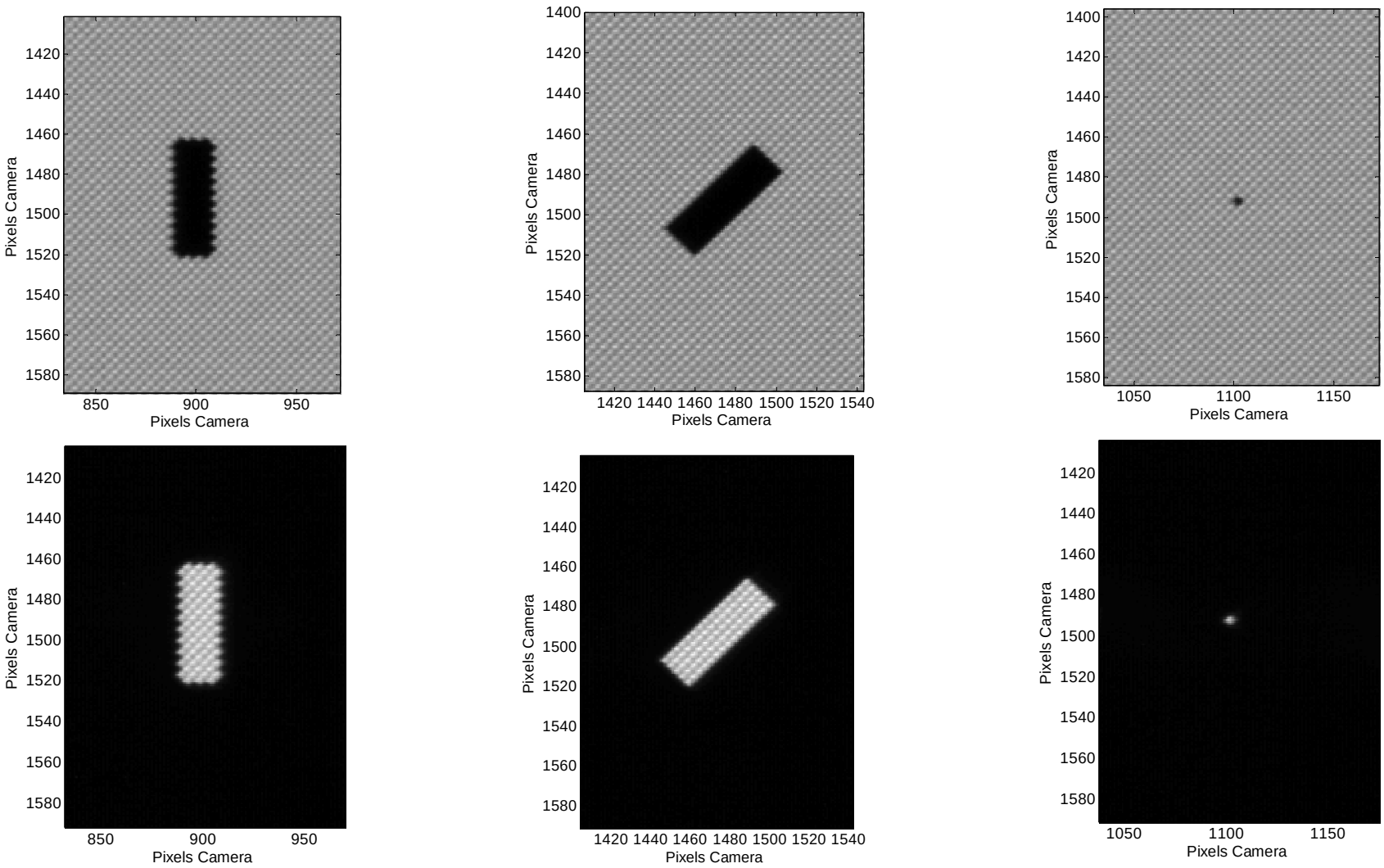

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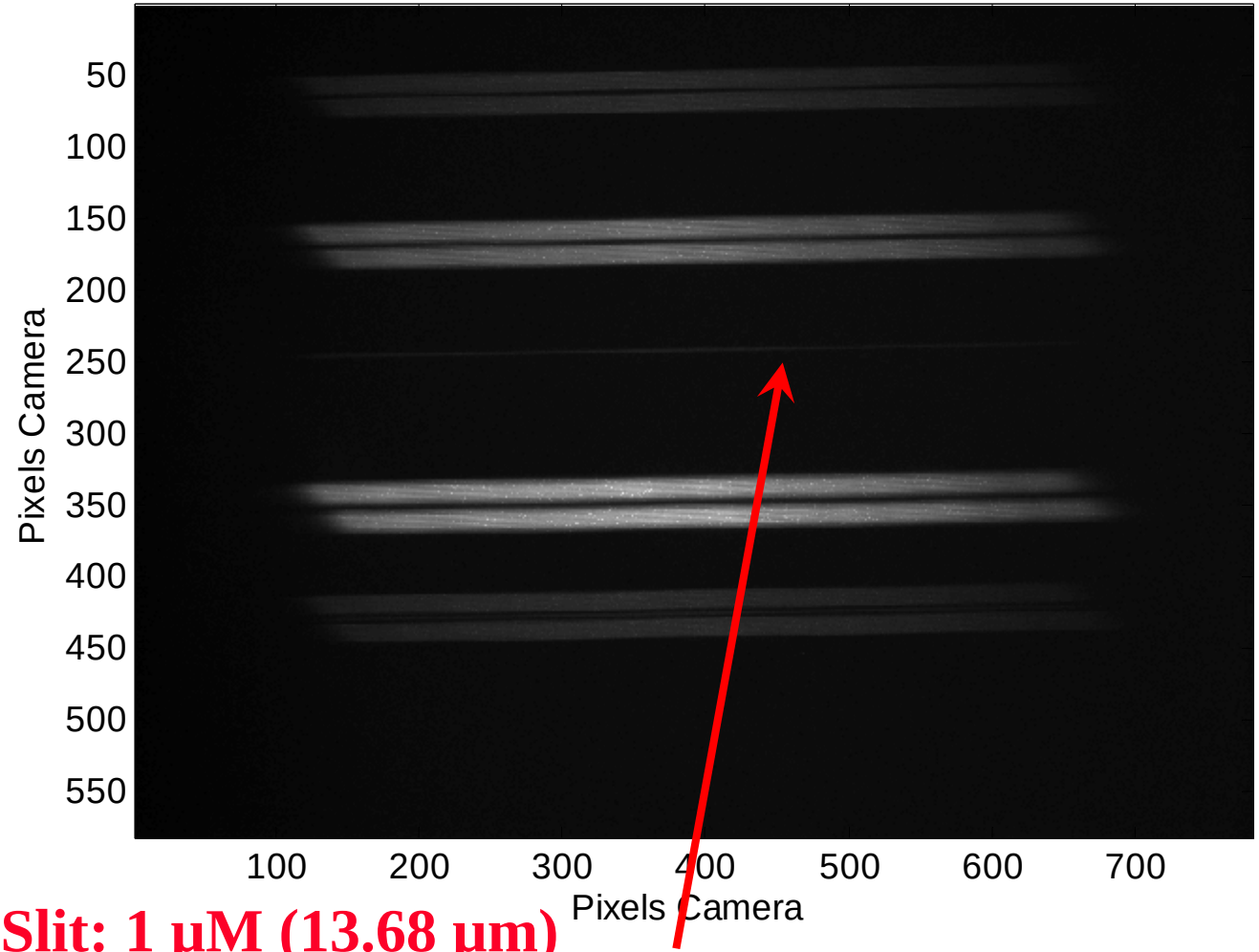
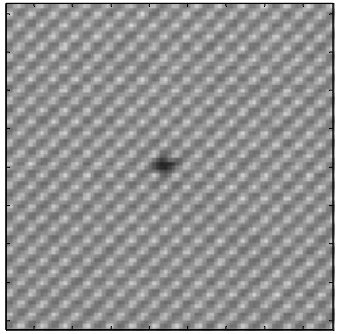
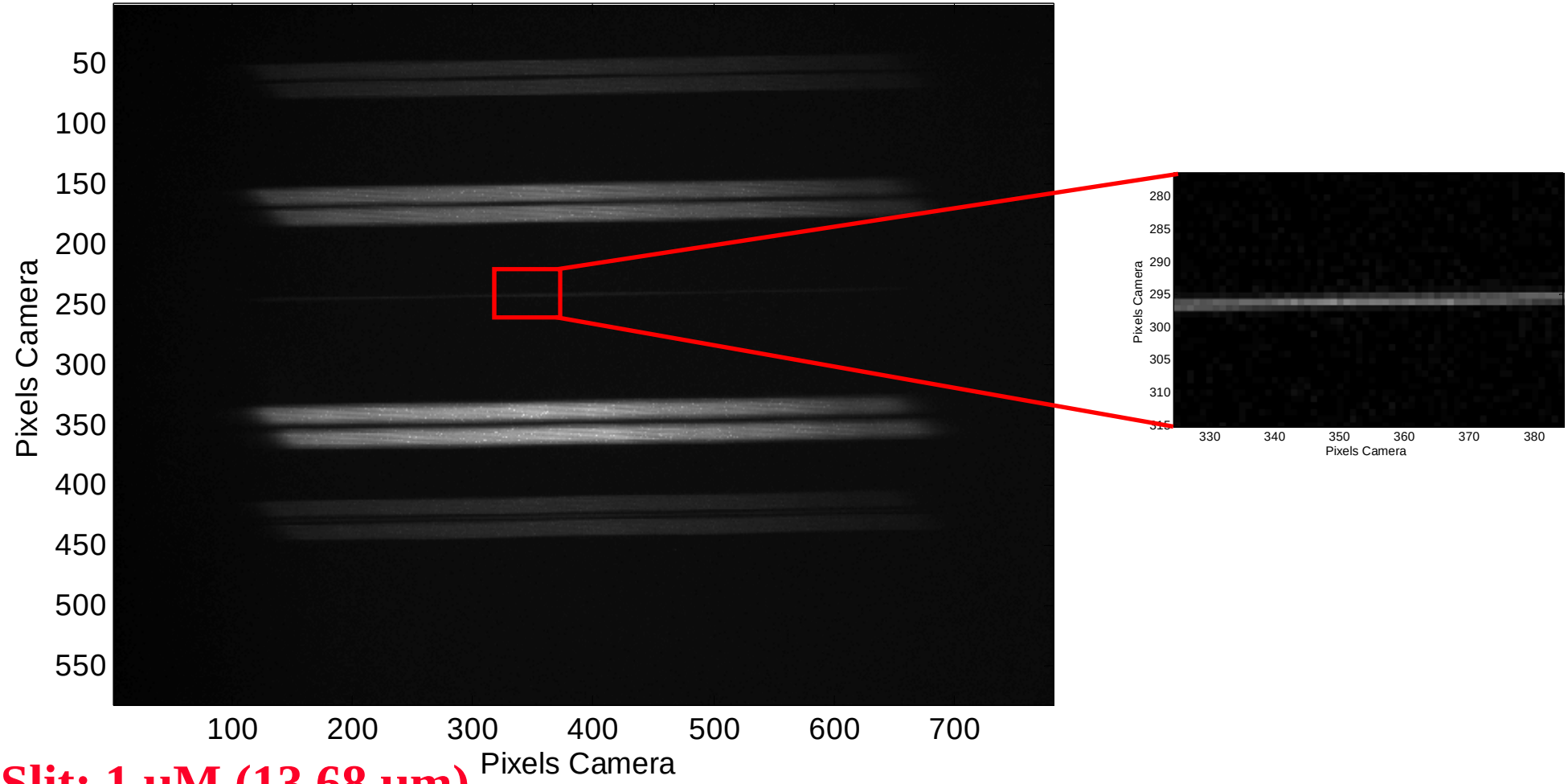




Slit: 1 µM (13.68 µm)

Spectrum on 1.5 detector pixel (8,3µm) in 500-600nm wavelength range

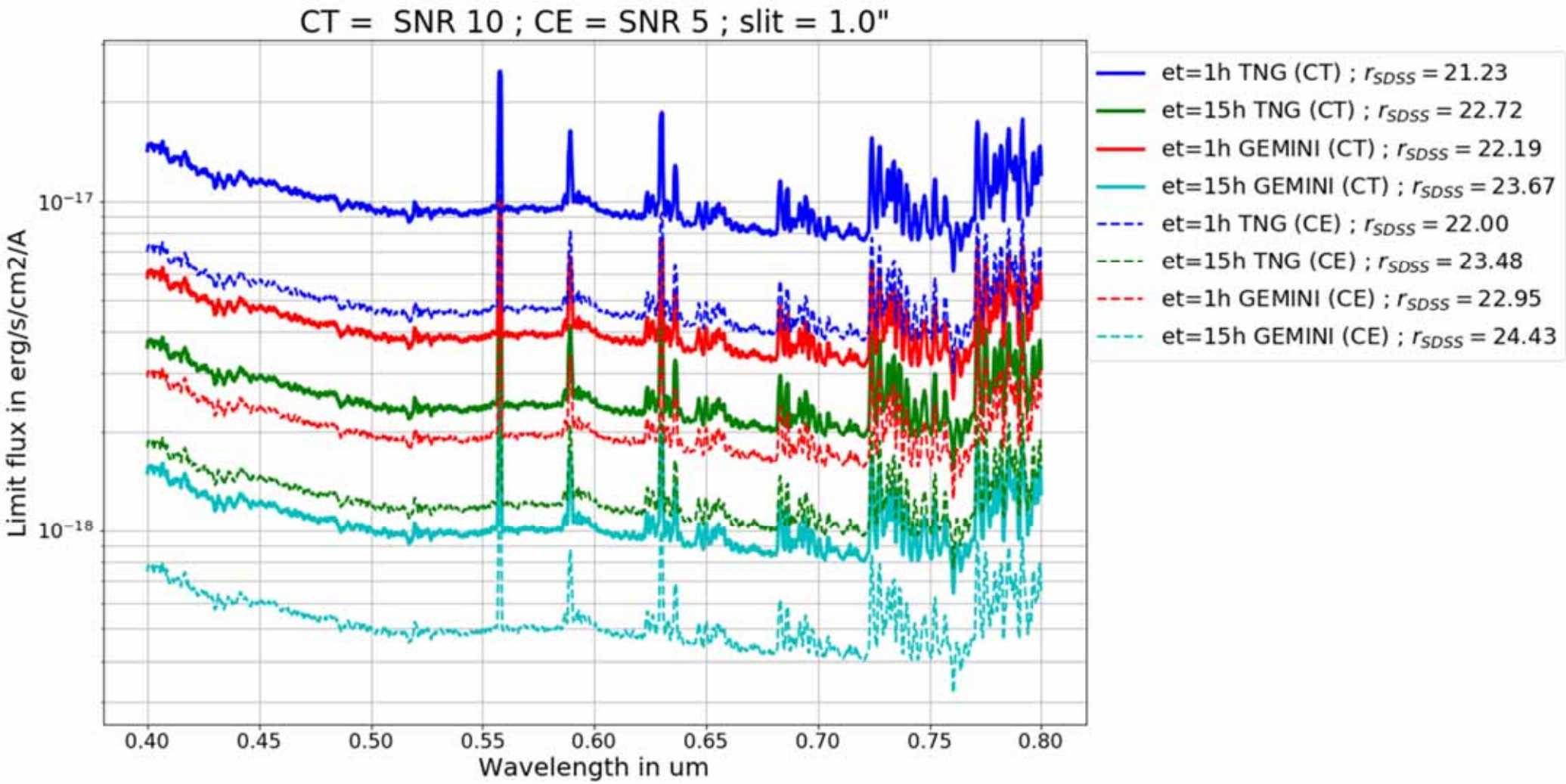
BATMAN is under construction



Slit: 1 µM (13.68 µm)

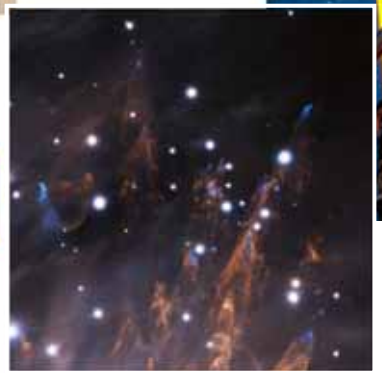
Spectrum on 1.5 detector pixel (8,3µm) in 500-600nm wavelength range

Simu BATMAN : limiting magnitude

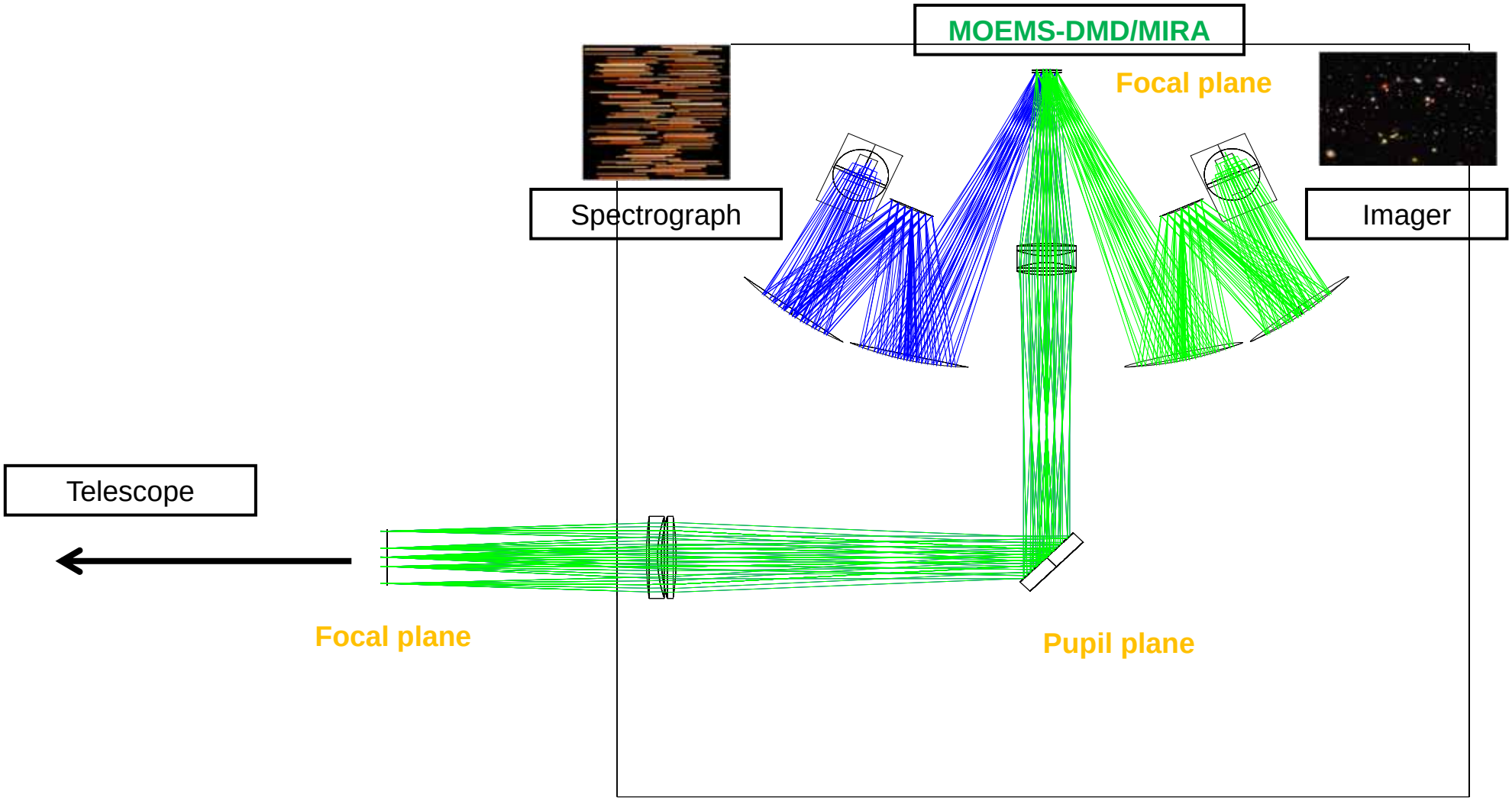


BATMAN @ _____

- **BATMAN @ TNG (2019 – 2021+)**
  - Italian telescope ∅**3,6m**
  - Seeing-limited
  - First Science Cases
- **BATMAN @ Gemini (2022 – 2025+)**
  - US telescope ∅**8,2m**
  - MCAO (GeMS)
  - 90 mas resolution
- **BATMAN @ VLT (2025 – 2030+)**
  - European telescope ∅**8,2m**
  - Visible MCAO (MAVIS)
  - 20 mas resolution

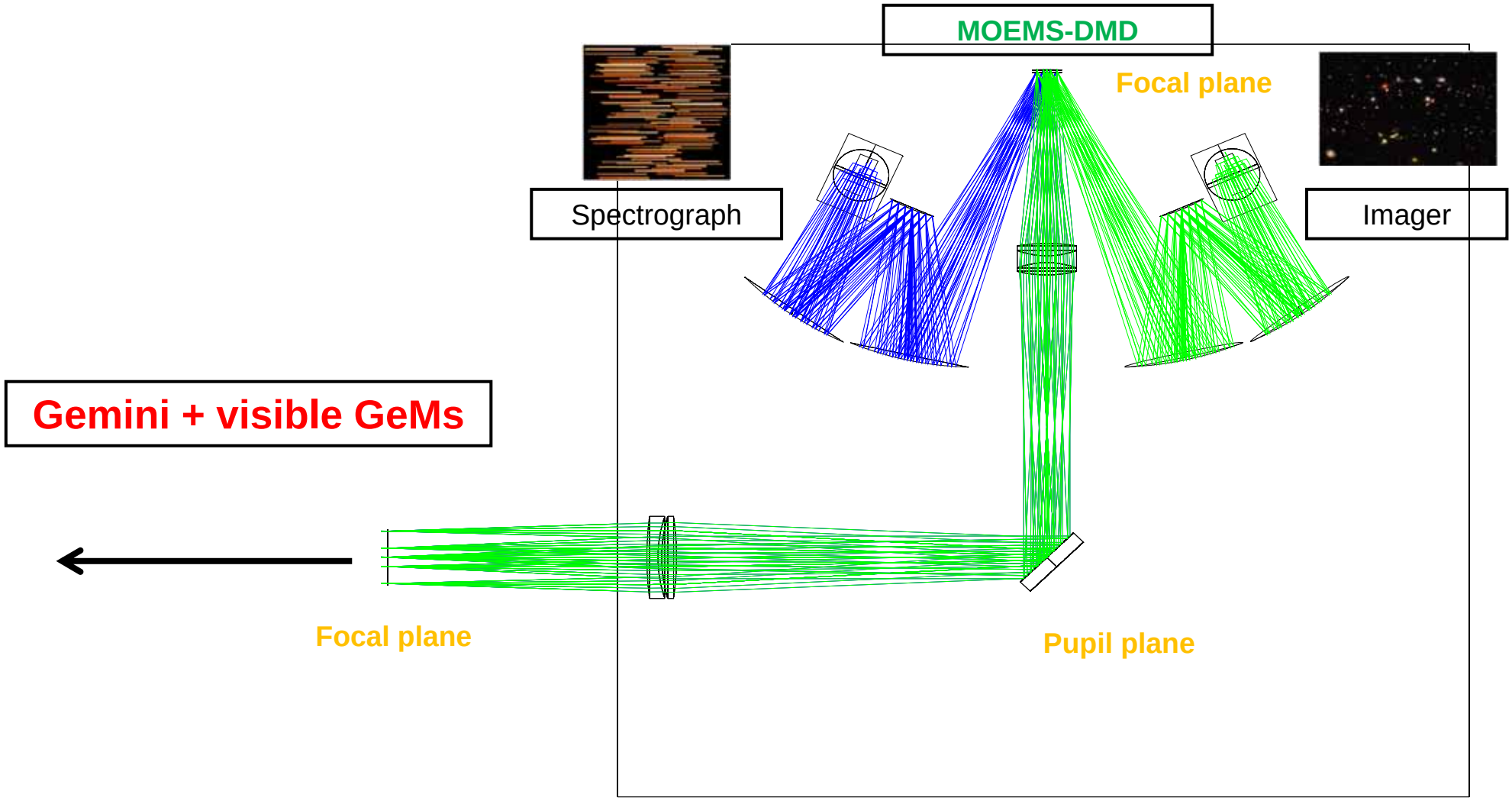


BATMAN @ TNG



FOV = 6.8 x 3.6 arcmin2

BATMAN @ Gemini



FOV = 1.5 x 1.5 arcmin2

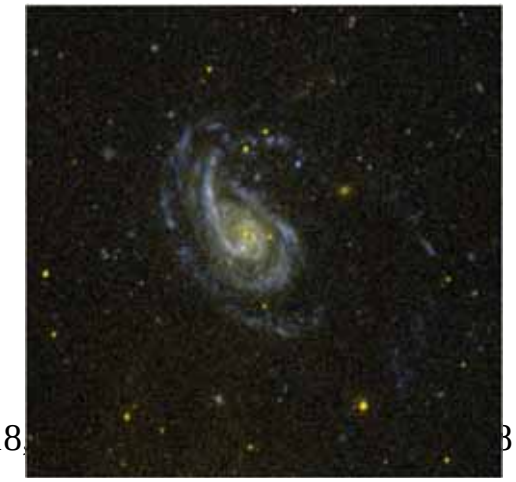
Parameters (TNG / Gemini)

	Spatial resolution	Field of view
TNG (F/4) 3.6m	0.2”	6.8 x 3.6 arcmin2
Gemini + GeMS (F/4) 8.2m	0.088”	3 x 1.5 arcmin2
Gemini + GeMS (F/8) 8.2m	0.044”	1.5 x 0.8 arcmin2

Nearby galaxies physics

♦Nearby galaxies characterization (ex: XUV galaxies)

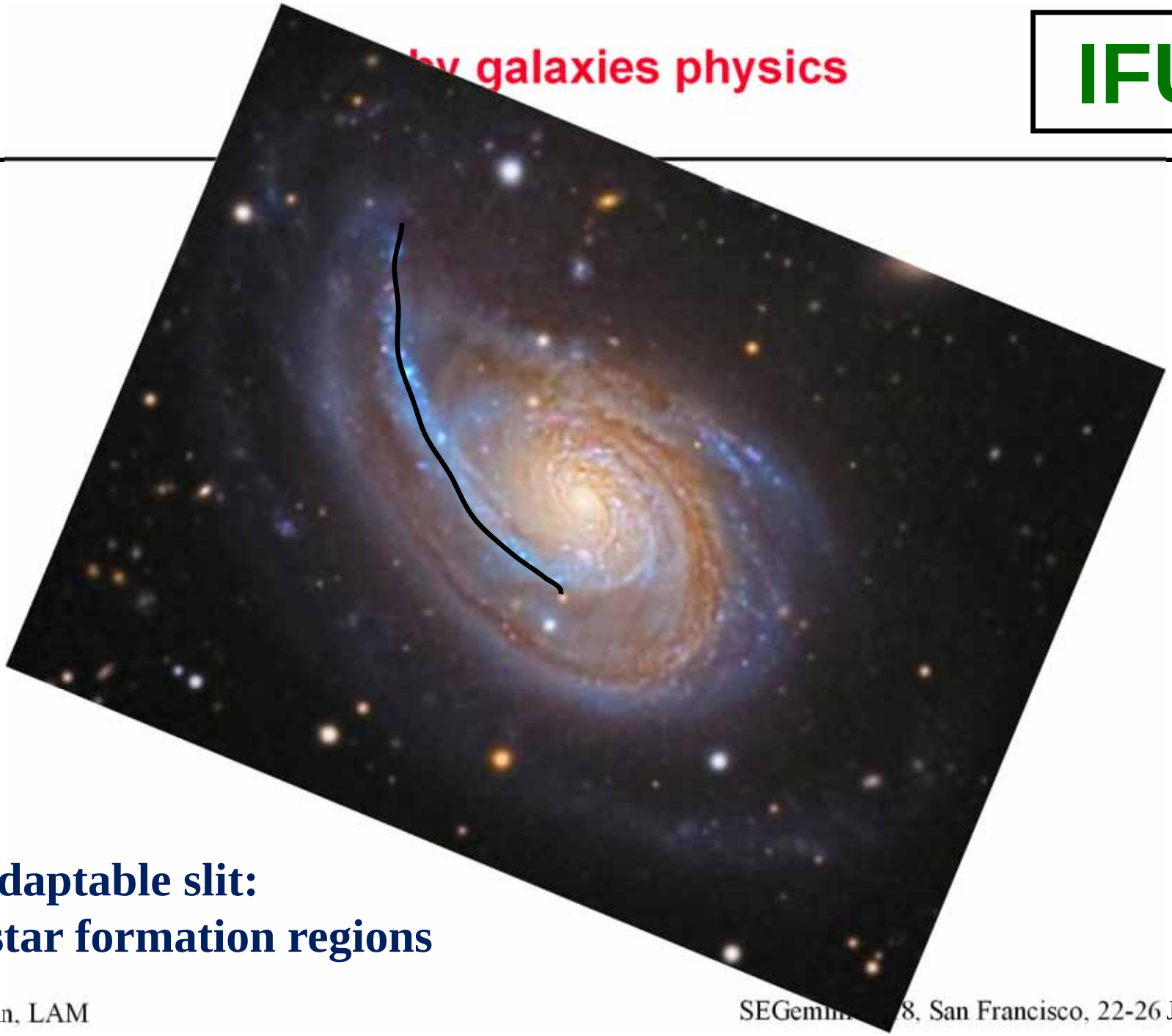
- Short time-scale star formation rate (Halpha), the dust distribution (Balmer ratio), the kinematics, the nucleus physics (AGN vs starburst), abundances)
- For instance, study of NGC772
  - central part of gal. / nucleus
  - kinematics of the elongated spiral arms
  - star forming regions in the disk
  - star forming region in the XUV part of gal.
  - comparison with regular part of disk (metallicity, IMF, star forming history)



♦Instrument parameters

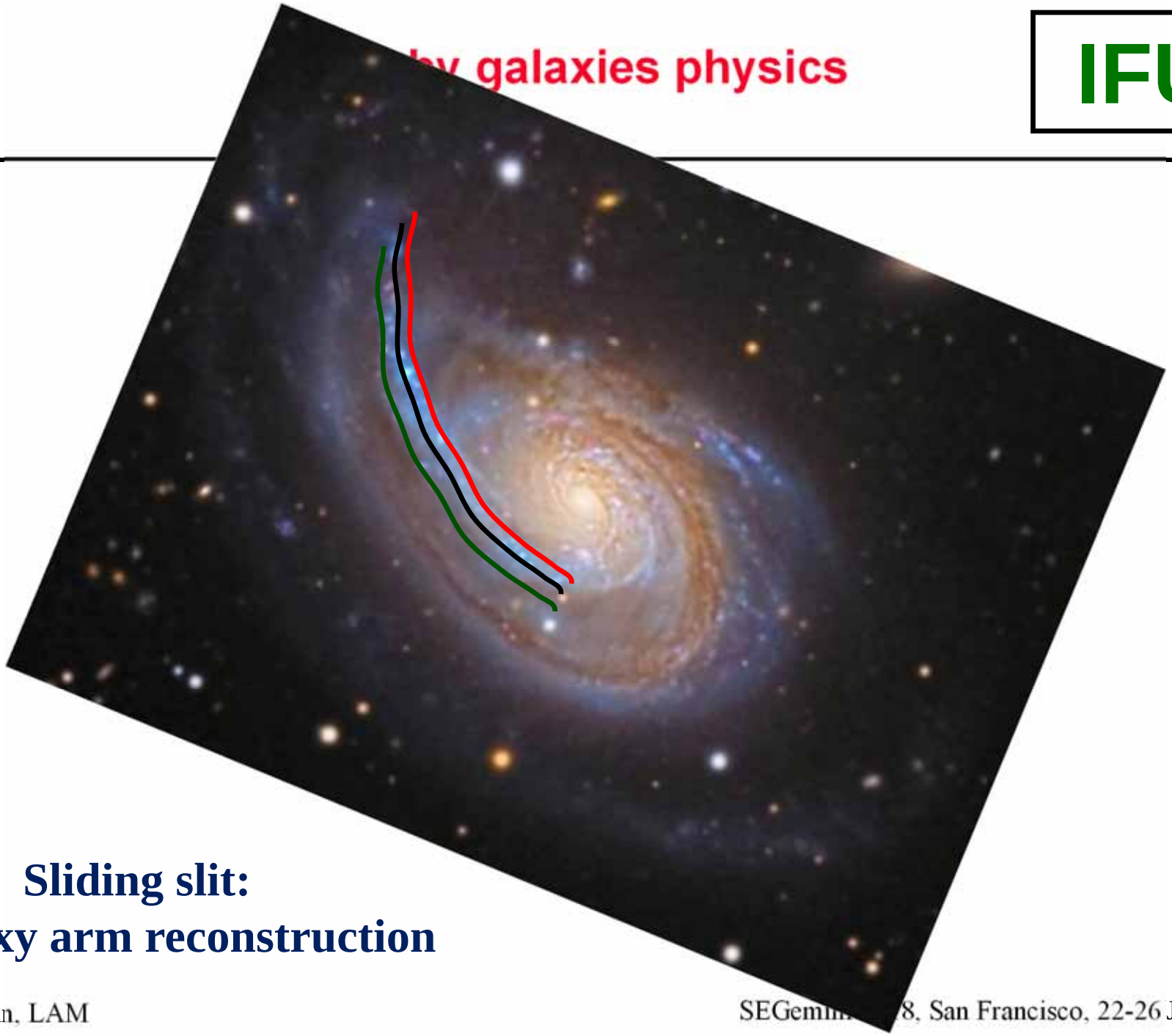
- Complete multiplexing of all regions in the FOV
- Optical spectroscopy (R 1000-1500)

IFU

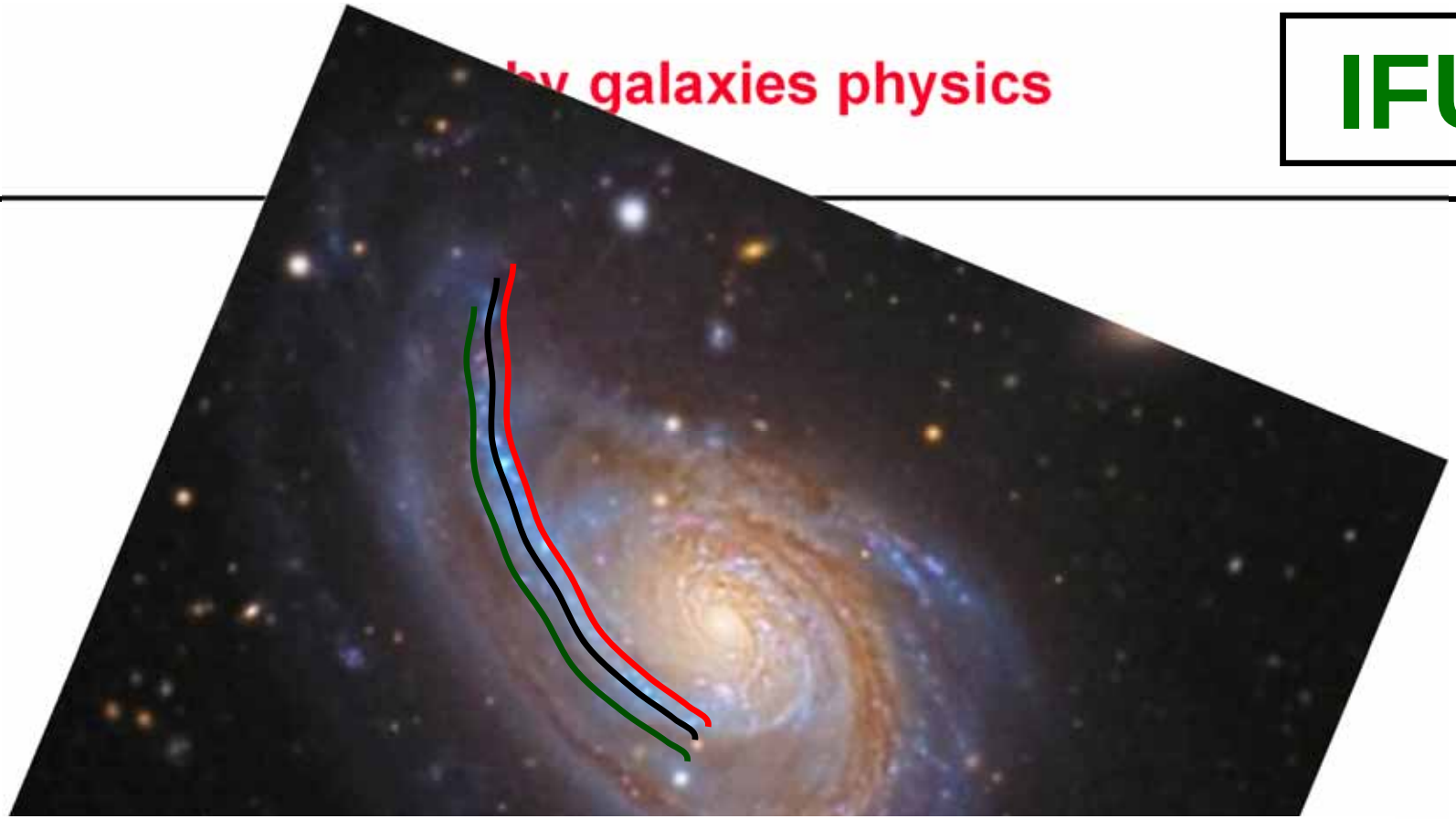


Adaptable slit:
following star formation regions

IFU



Sliding slit:
3D galaxy arm reconstruction



IFU

Gemini + GeMS + BATMAN =

from nearby to remote galaxies

Sliding slit:
3D galaxy arm reconstruction

Stellar physics

♦**Open clusters: characterization of the stellar content, especially the PDMF (present day mass function)**

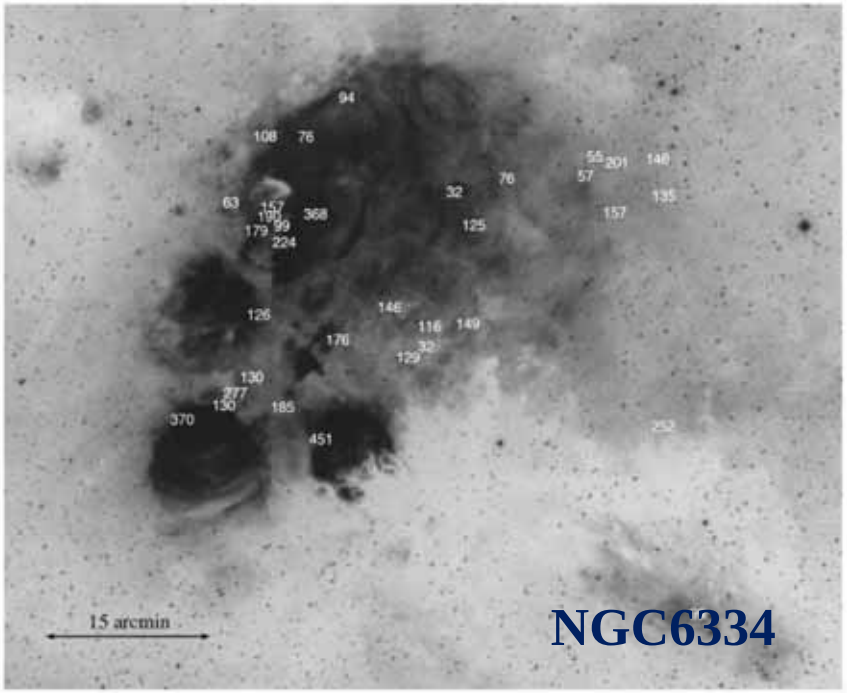
- Stellar physics and star formation in the Galactic center
- Clusters in the local group (Magellan clouds)
- Spectroscopic analysis of stars

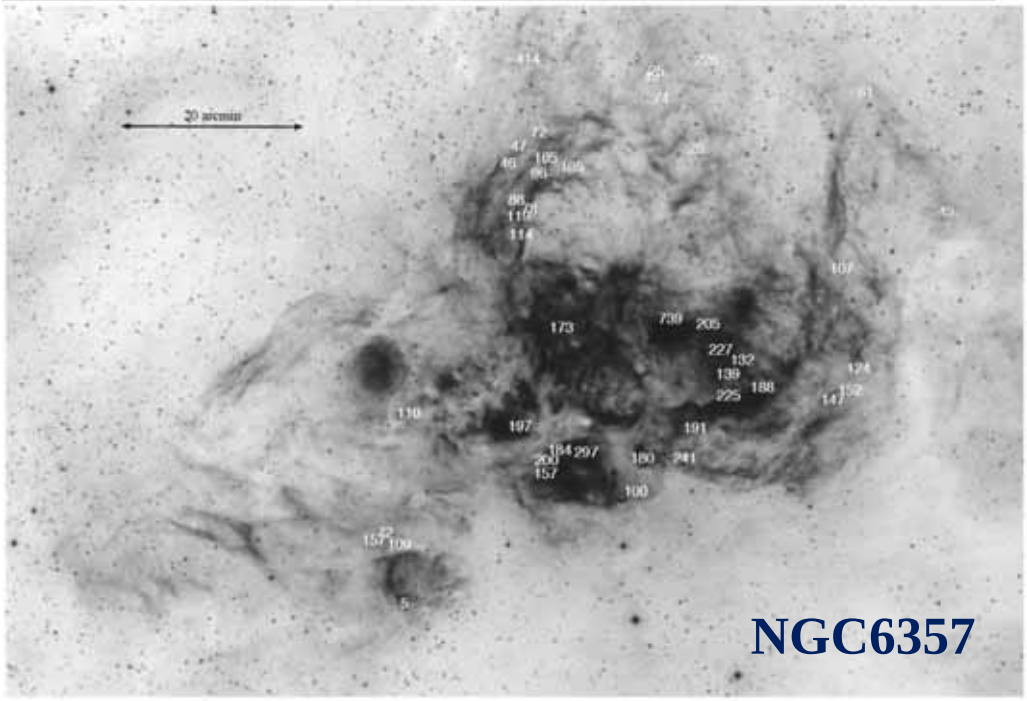
  - distribution of stellar classes/types within the cluster (e.g. does the cluster core harbors the most massive stars?) → constraints on IMF scenarios
  - physical distance of the cluster and location with respect to galactic arms (requires flux calibration) → constraints on star formation
  - establish the evolutionary status of stars in the cluster (HR diagram) → pinpoint empirical evolutionary links between different types of stars (e.g. massive dwarfs vs masive giants/supergiants, WRs) → test whether single star evolutionary tracks can account for the observed stellar population
- Spectroscopic analysis of the diffuse matter in the cluster

  - derive ionization parameters, abundances , kinematics, selective extinction physics of HII regions etc)

Stellar physics

MOS





♦Instrument parameters

- Complete multiplexing of stars in the FOV: MOS with 100s objects
- Requires flux calibration
- Spatial resolution 0.6” down to 0.08” with Gemini+GeMS (access to the core of the clusters)
- Optical spectroscopy, R 1500 (5000)

Stellar physics

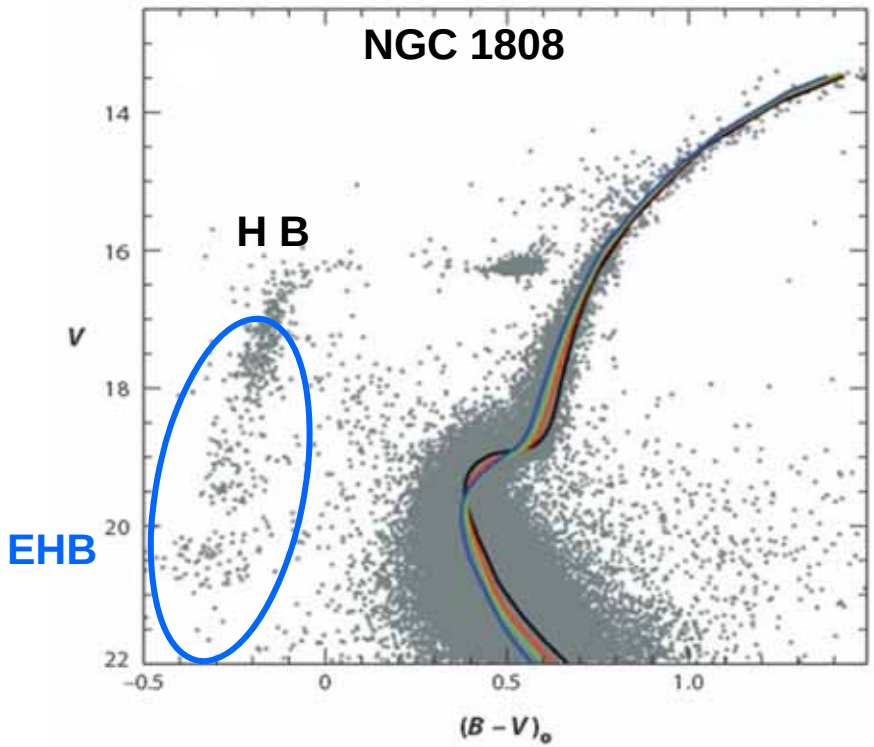
MOS

♦The EHB (Extreme Horizontal Branch) stars in globular clusters

- Faint blue stars (high Teff, lower luminosity, higher gravities)
- Physics of these objects
  - Variable surface abondance of He
  - Surface gravity
  - Fitting of Balmer lines profiles to Stark effect models

♦Instrument parameters

- Multiplexing of stars in the FOV
- Optical spectroscopy, R 1500
- Spatial resolution 0.6” to 0.08”
- Imagery for selection of objects (color-magnitude diagram det. by imagery in different bands)

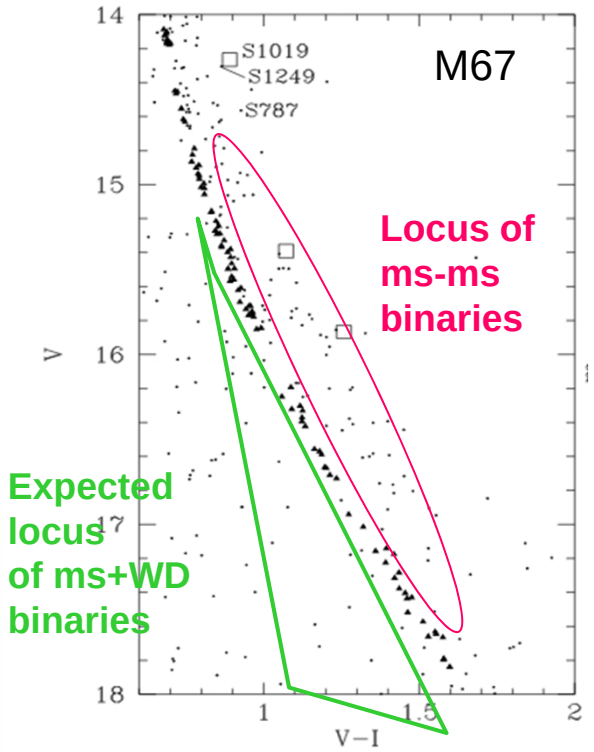


Stellar physics

MOS

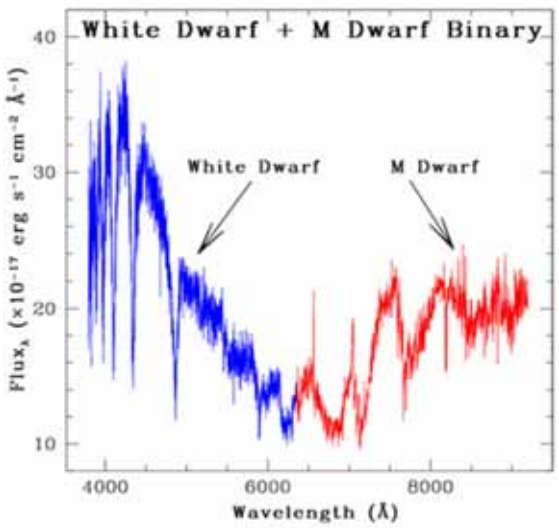
♦**Binaries: what is the fraction of Mdwarf – WhiteDwarf binaries? Is there a clue to the apparent deficit of isolated WD in cluster populations ?**

- Search of WD binaries
- Simultaneously check on normal main sequence binary pop.



♦**Instrument parameters**

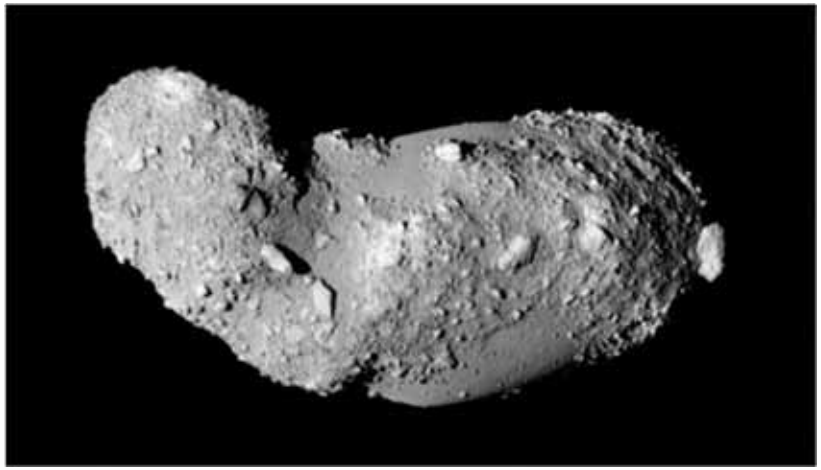
- Multiplexing of stars in the FOV
- Optical spectroscopy R 500
- Spatial resolution 0.08”
- Very good photometry



Solar system objects

Transients

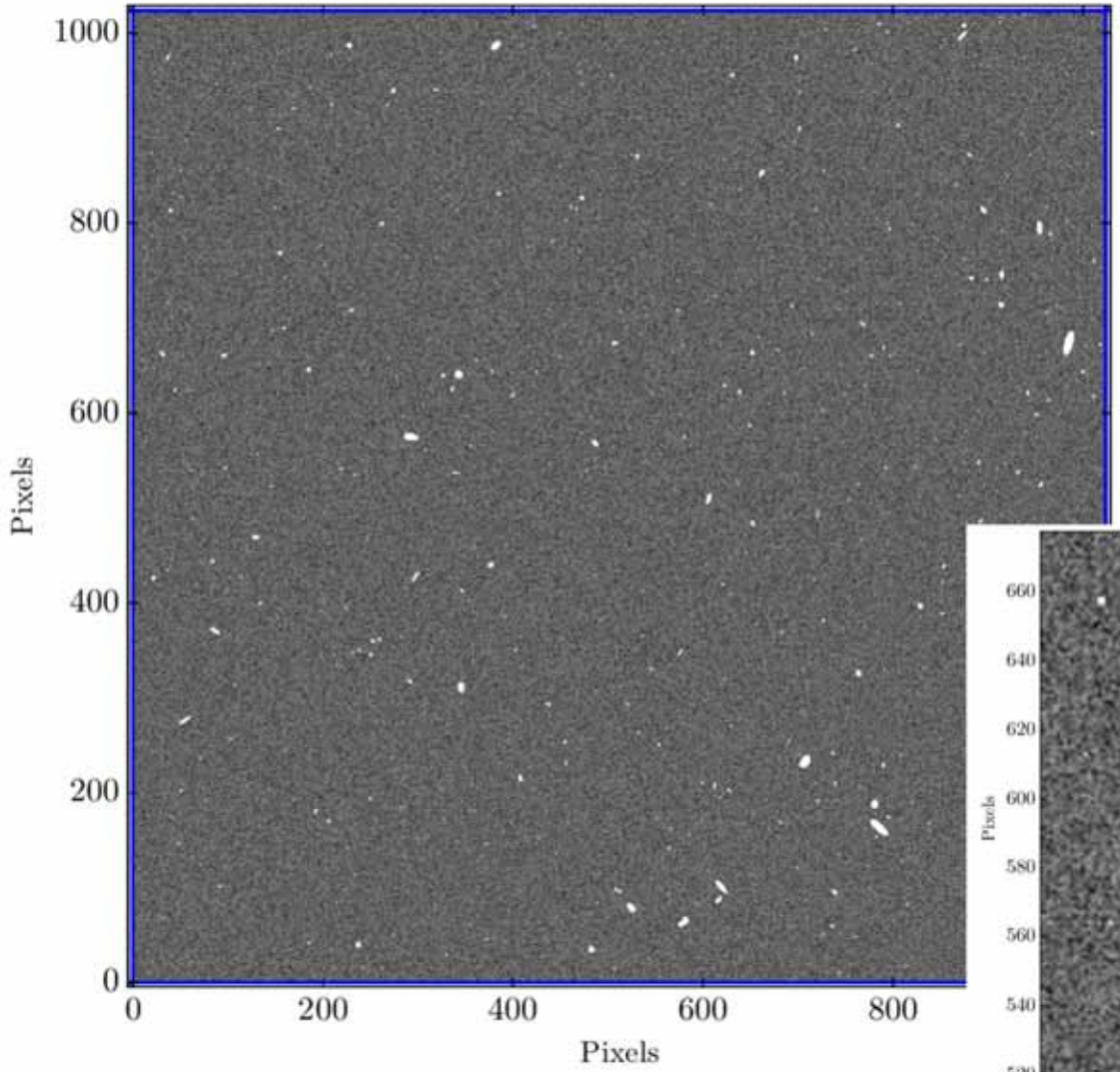
- **Near Earth Objects detection and characterization**
  - V = 1.5 arcmin / hour
  - mag_{vis} = 16 – 19
  - Simultaneous spectro of G2 stars
  - Extension to asteroïds

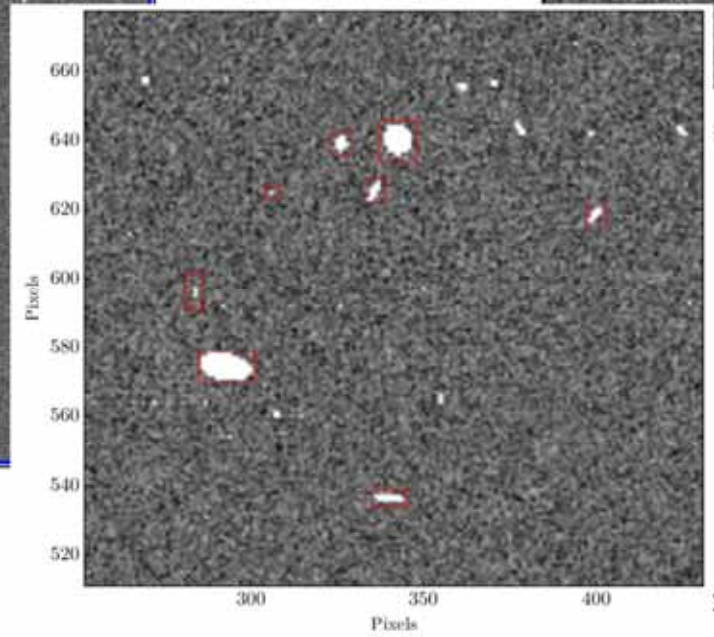


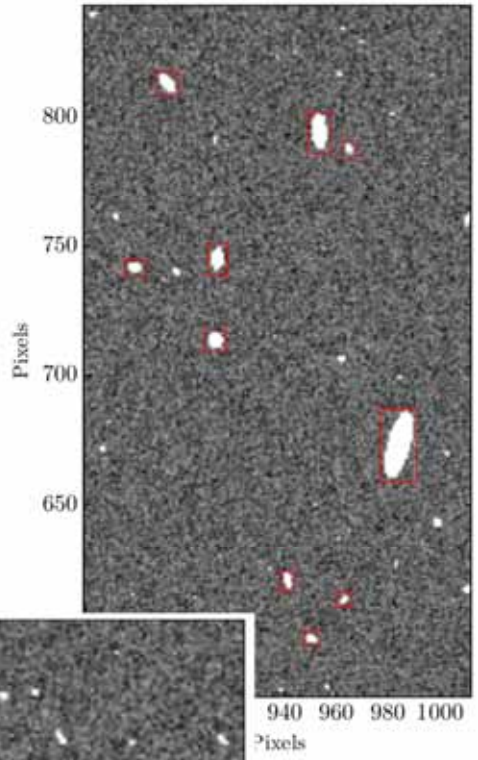
Itokawa (Hayabusa)

- **Instrument parameters**
  - Imagery: detection and trajectory determination
  - Optical spectroscopy R 300 - 500
  - Adjustable integration time
  - **Follow the object (imagery to spectroscopy in 1ms after alert)**

BATMAN: the simulator







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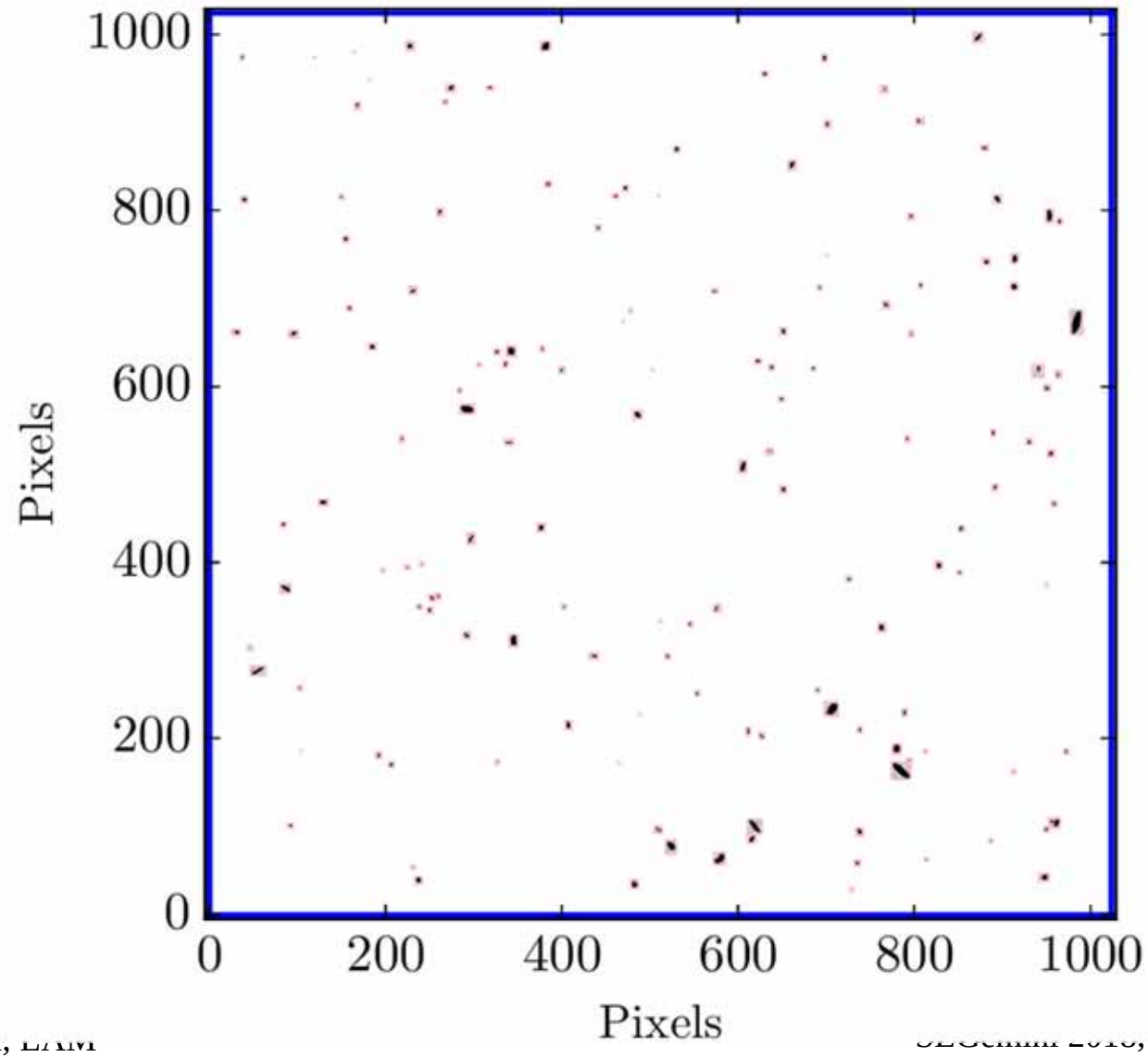
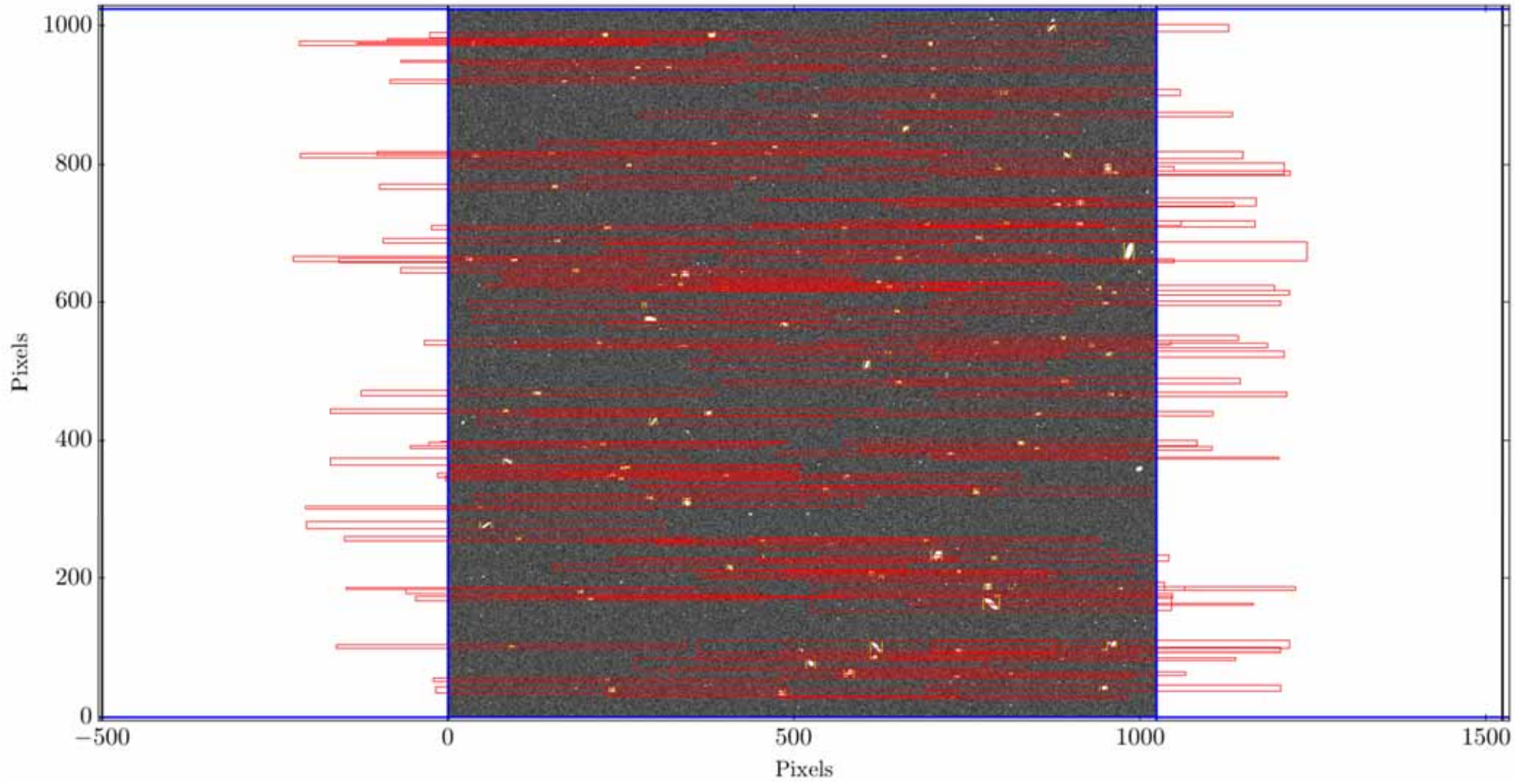


BATMAN: the simulator



on

GEMINI OBSERVATORY

Exploring the Universe, Sharing its Wonders

MOS

IFU

Transients

♦ Key numbers

- FOV 1.5 x 0.75 arcmin^2 (+)
- Spatial sampling 45mas / µM / detector pixel
- Imagery: multi-band filters
- Spectro: spectral resolution 500 – 2000 (+)
- Spectro MOS: 1 – several 100s objects
- Spectro IFU: FOV 1” up to 90” (sequential)

♦ Unique abilities

- Imagery and spectroscopy in parallel (high accuracy photometry)
- Highly flexible (any combination of MOS, IFU, spectral resolution …)
- Transients (spatial, temporal), like SNe, NEO, AGN

♦ Schedule

- BATMAN on Gemini in 2021-22