Visible MCAO supported spectro-imager: the BATMAN family

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+ BATMAN French-Italian team

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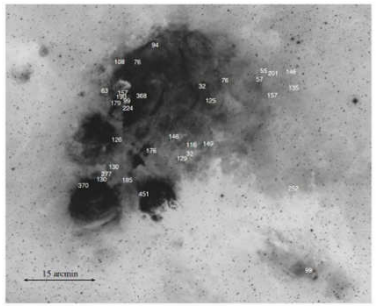
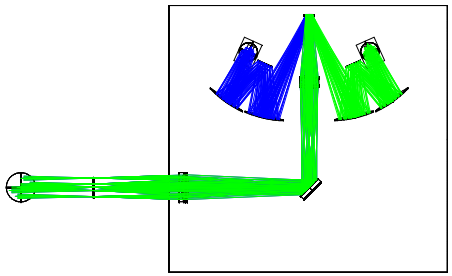
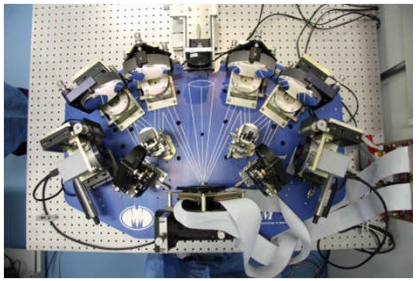
[3] INAF/IASF Bologna, Italy
[4] INAF - Telescopio Nazionale Galileo, Spain
[5] INAF-OAT, Osservatorio Astronomico di Trieste, Italy



VLT AO community days, 20-21 Sept. 2016

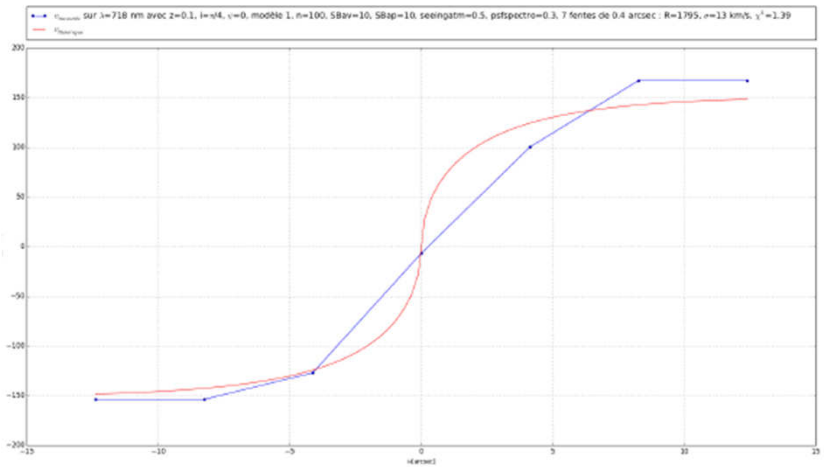
Extragalactic physics and cosmology

Dynamical model reconstruction of local structure growth

- Velocity survey of large galaxies FOV
- $z_{spectro} = z_{cosmo} + v_p / c$
- By Tully-Fischer, Vmax gives the intrinsic luminosity and then z_c
- Determination of the dynamical model / structure growth

Instrument parameters

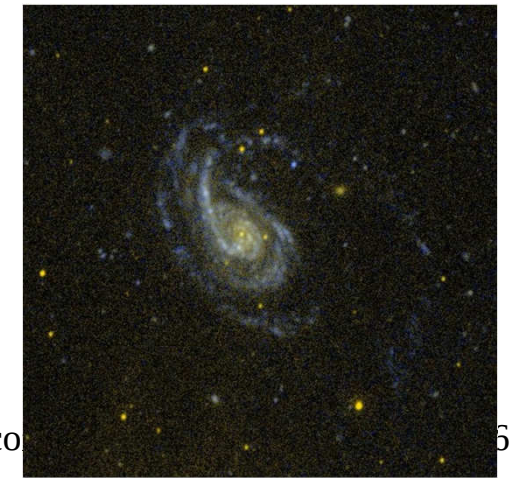
- Complete multiplexing of the FOV
- Optical spectroscopy (R 1500)
  7 velocity meas. across the gal.
  (0.2-0.4” slits)
- Study at z=0.5 (z=1)
- Flux calibration



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)

Stellar physics

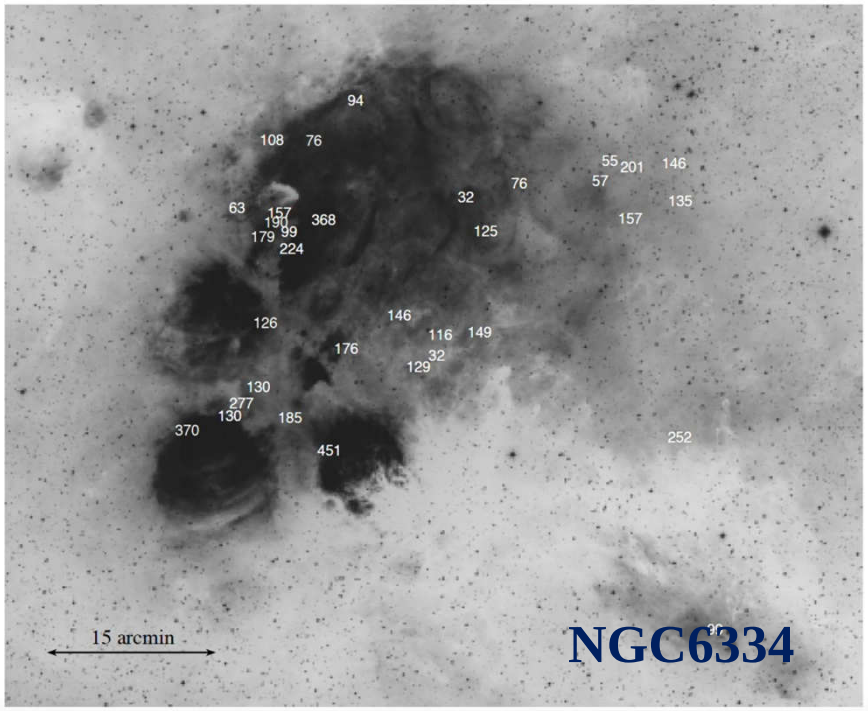
♦Open clusters: characterization of the stellar content, especially the PDMF (present day mass function)

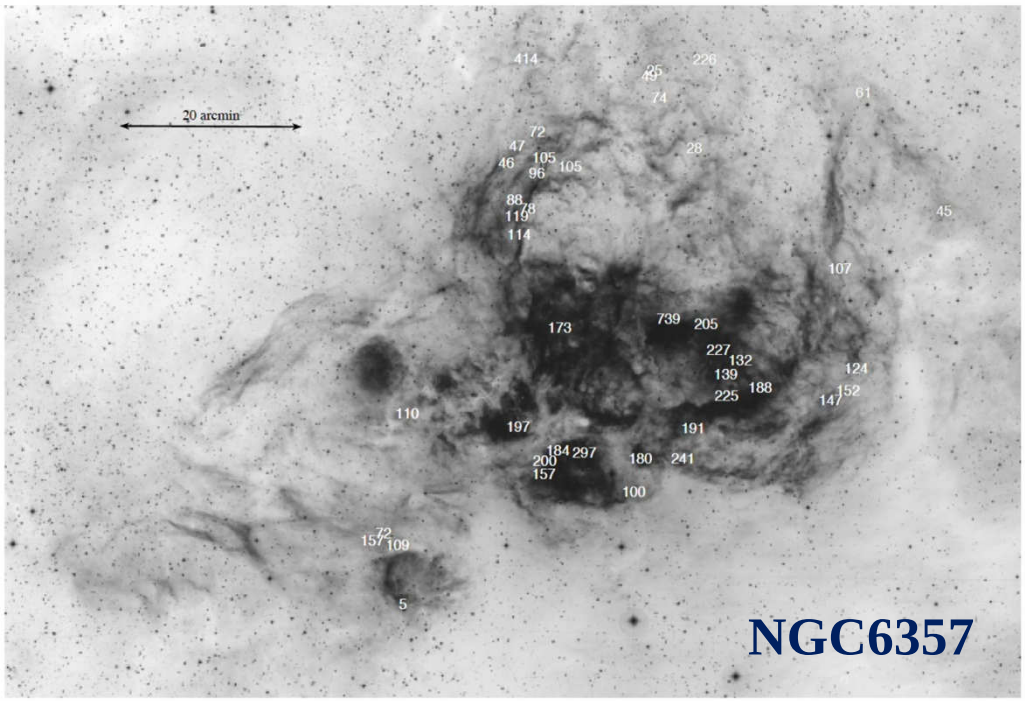
- Stellar physics and star formation in the Galactic center
- Clusters in the local group (Magellan clouds)
- Spectroscopic analysis of stars

  - 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





Instrument parameters

- Complete multiplexing of stars in the FOV
- Requires flux calibration
- Spatial resolution 0.15” – 0.2”
- Optical spectroscopy, R 1500 (5000)

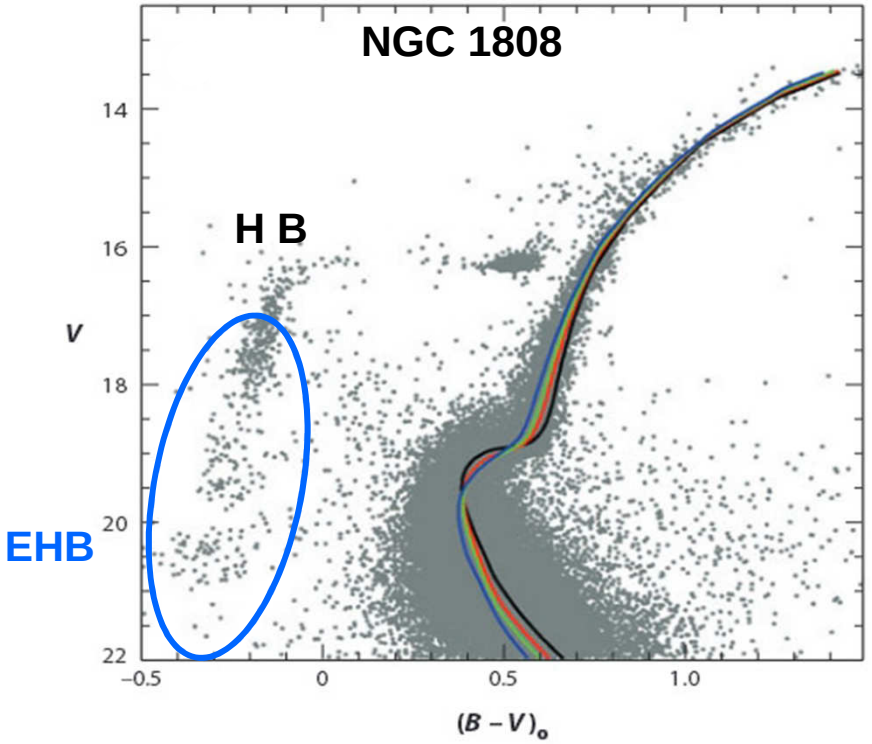
Stellar physics

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

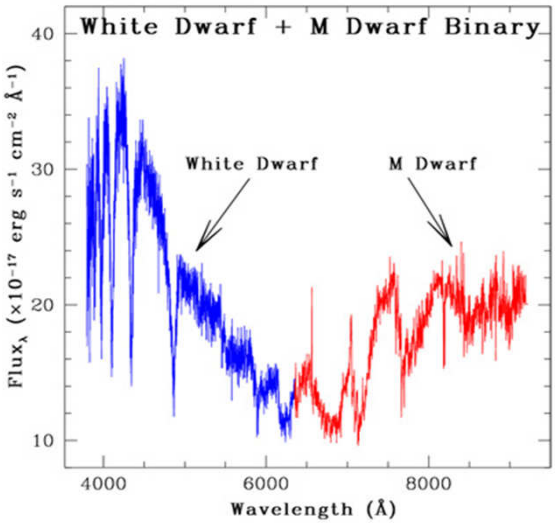
- Multiplexing of stars in the FOV
- Optical spectroscopy, R 1500
- Spatial resolution 0.2”
- Imagery for selection of objects (color-magnitude diagram det. by imagery in different bands)

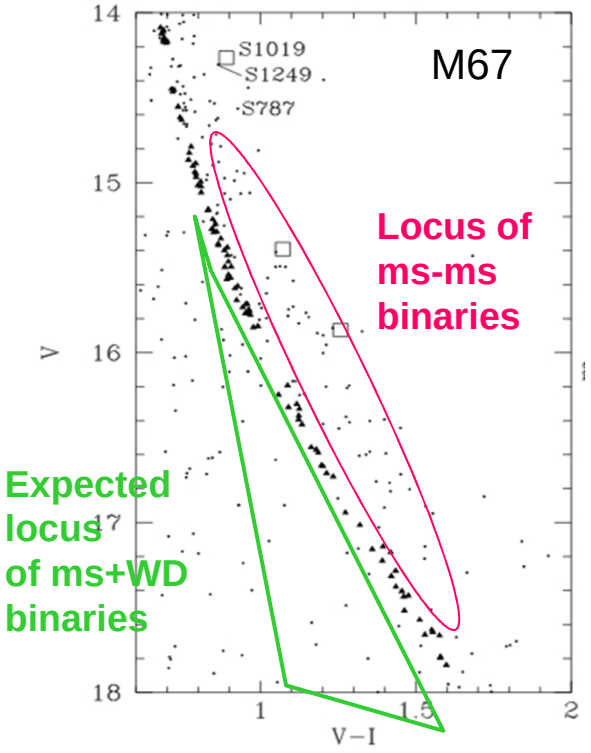


Stellar physics

- **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 0.2”
  - Very good photometry





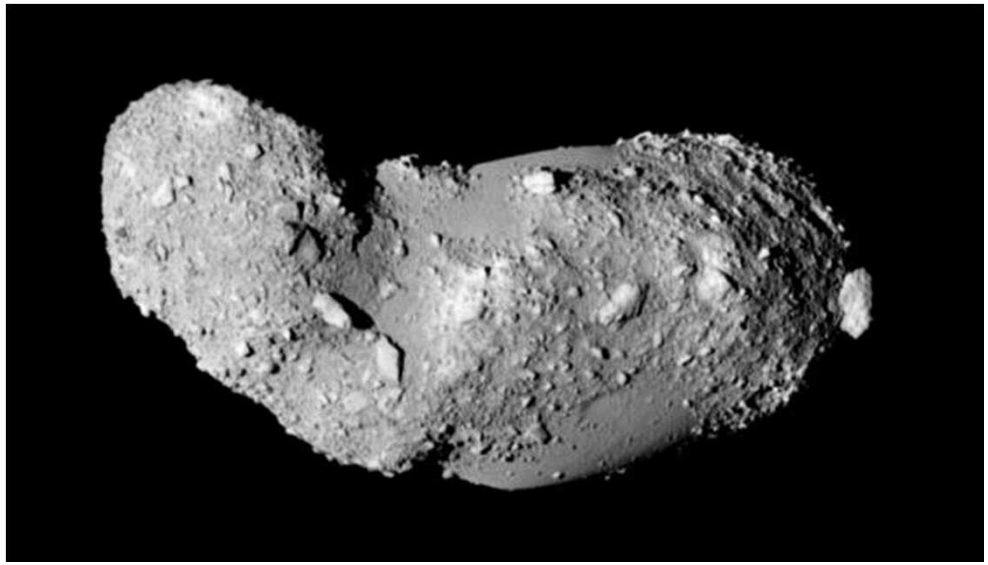
Solar system objects

Near Earth Objects detection and characterization

- V = 1.5 arcmin / hour
- mag_{vis} = 16 – 19
- Simultaneous spectro of G2 stars
- Extension to asteroïds

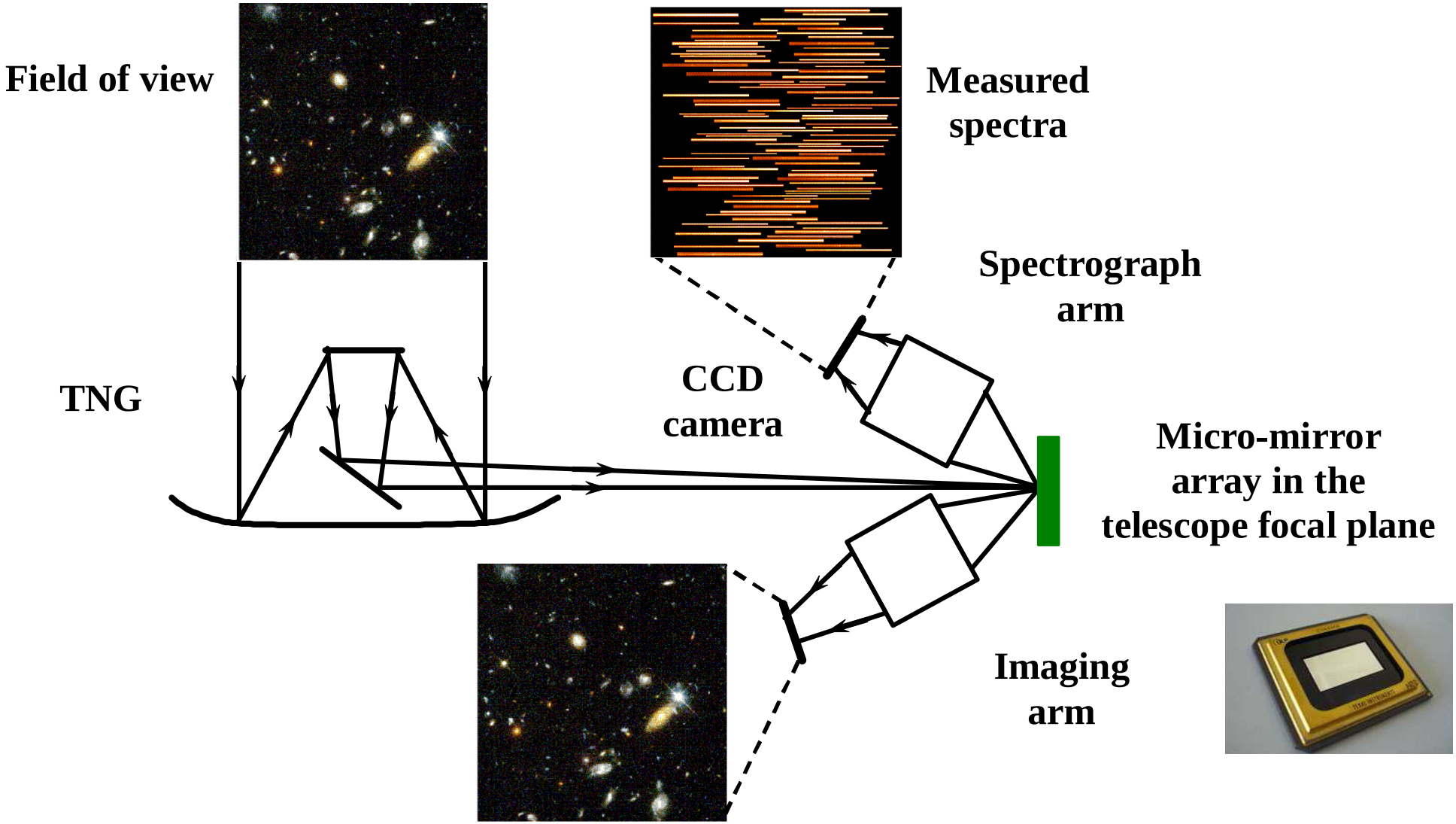
Instrument parameters

- Imagery: detection and trajectory determination
- Optical spectroscopy R 300 - 500
- Adjustable integration time
- **Follow the object**

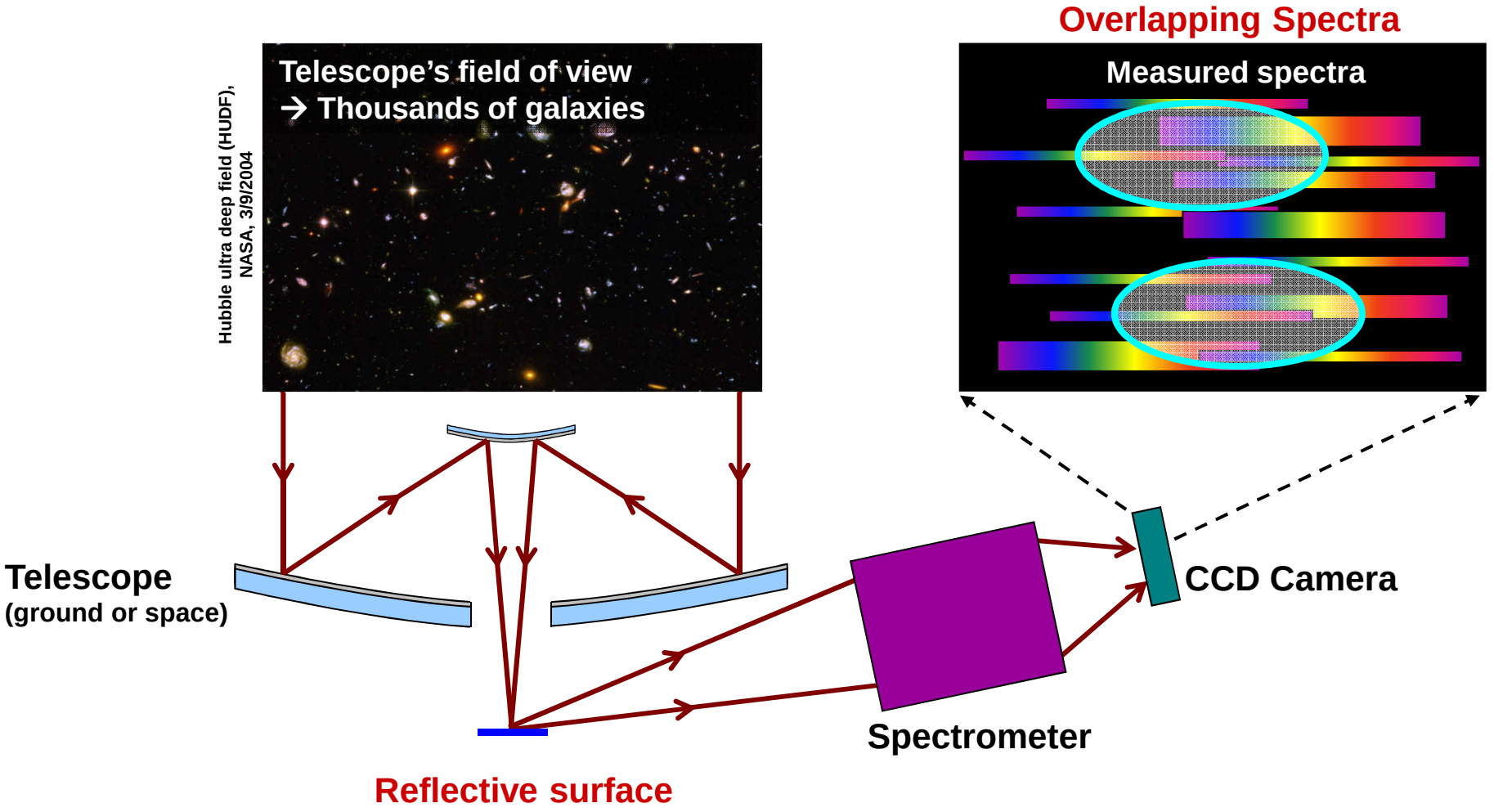


Itokawa (Hayabusa)

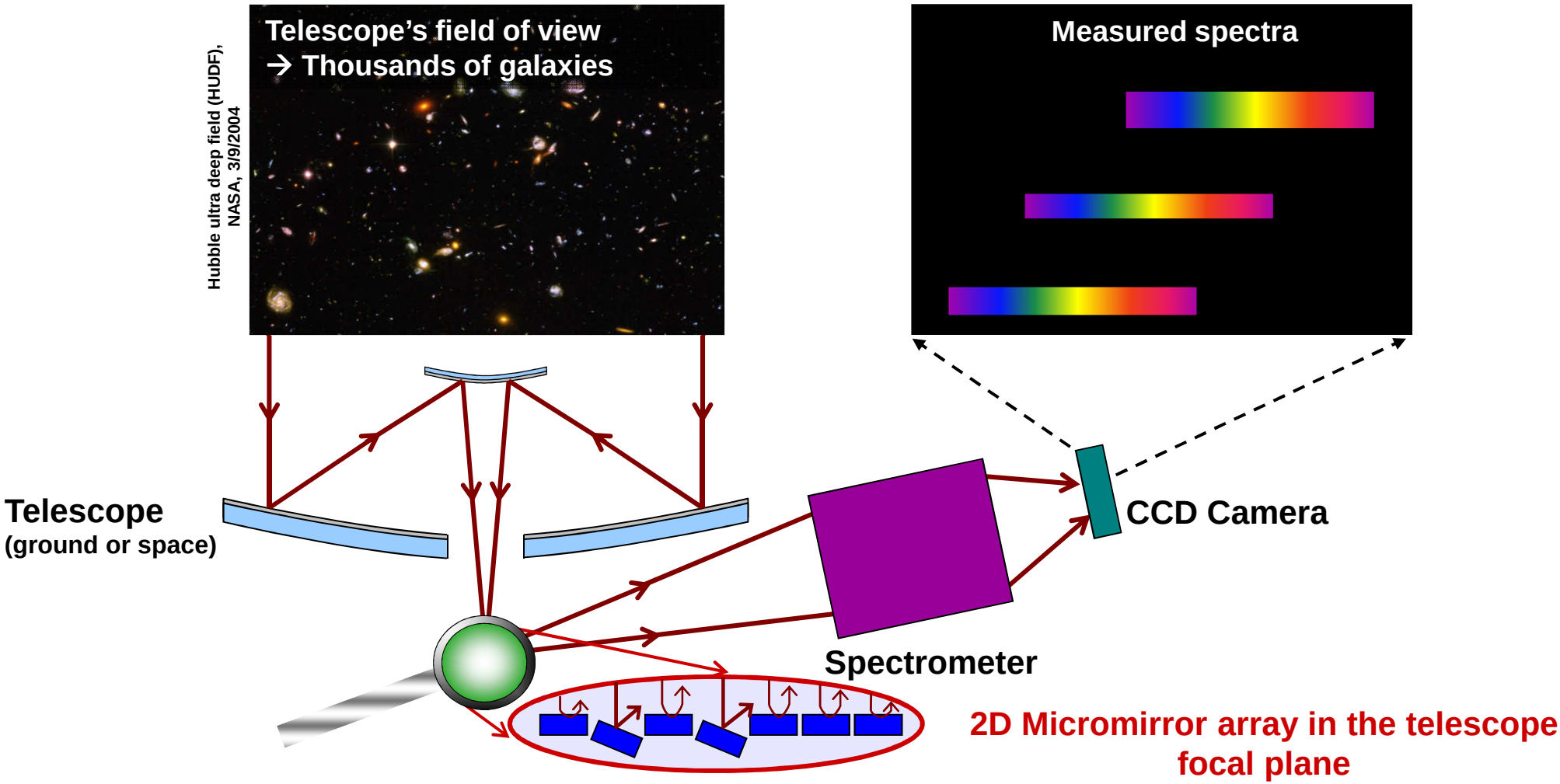
BATMAN concept: a MOEMS-based spectro-imager



Multi-object spectroscopy

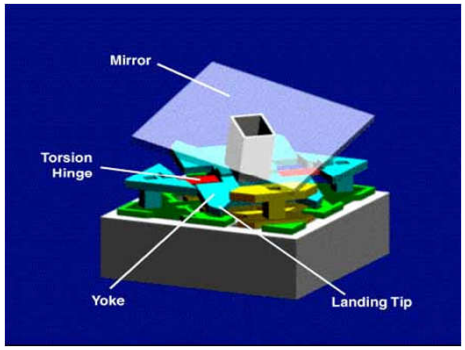


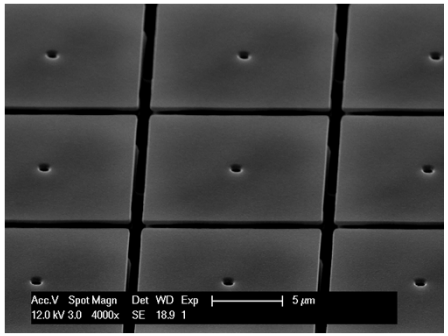
Multi-object spectroscopy

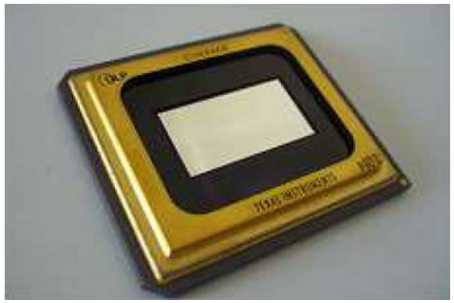


Texas Instruments DMD

- Most popular MOEMS devices available
- Micro-mirrors
  - 2048x1080 individually tiltable
  - 13.68µm pixel pitch,
  - Tilt angle of 12°
- Numerous applications
  - Prime use displaying images
  - No customization possible
- Space qualification tests (ESA contract)
  - -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**







esa

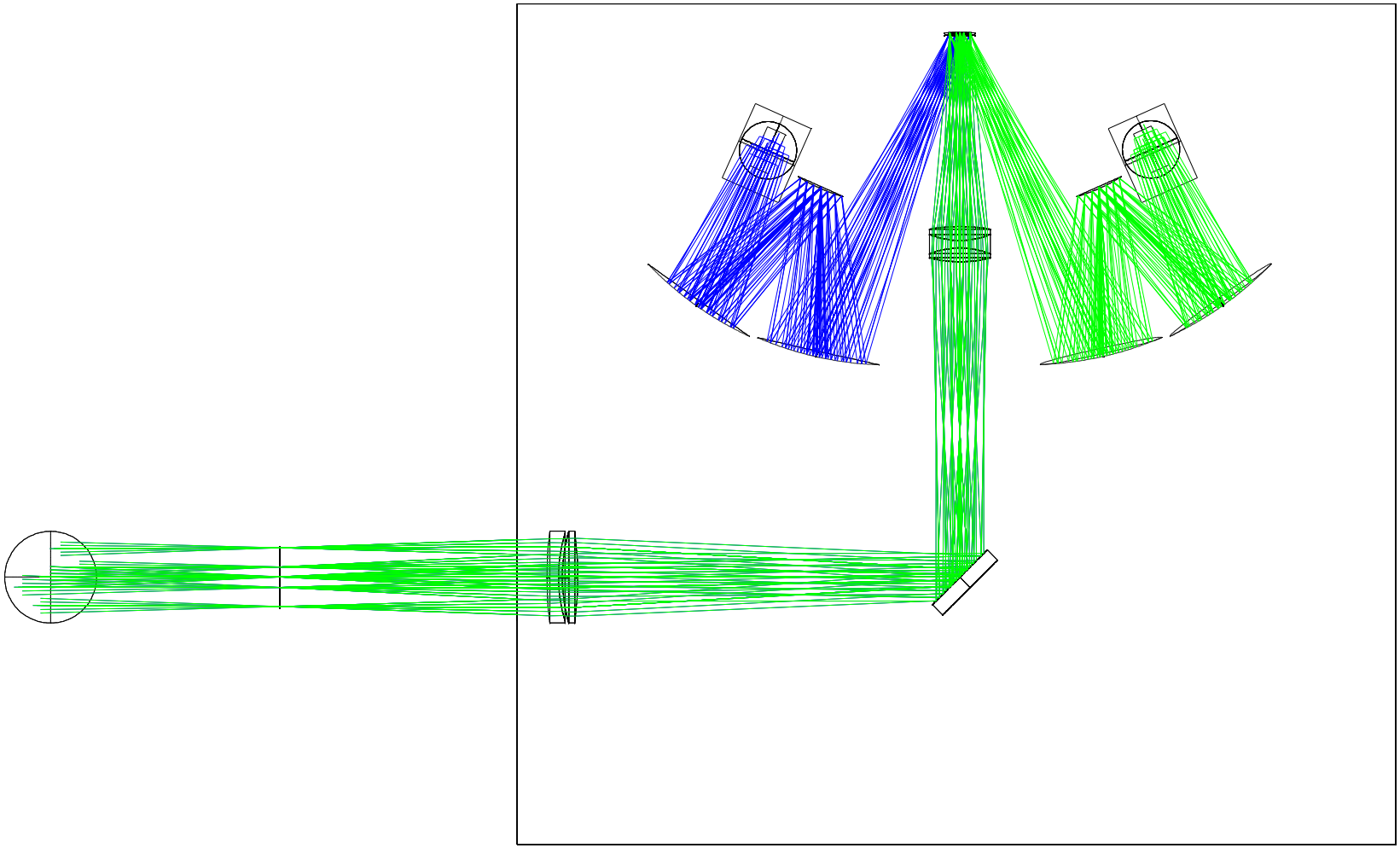
VISITECH

Zamkotsian et al., SPIE 6884, 2008

Parameters (BATMAN at TNG)

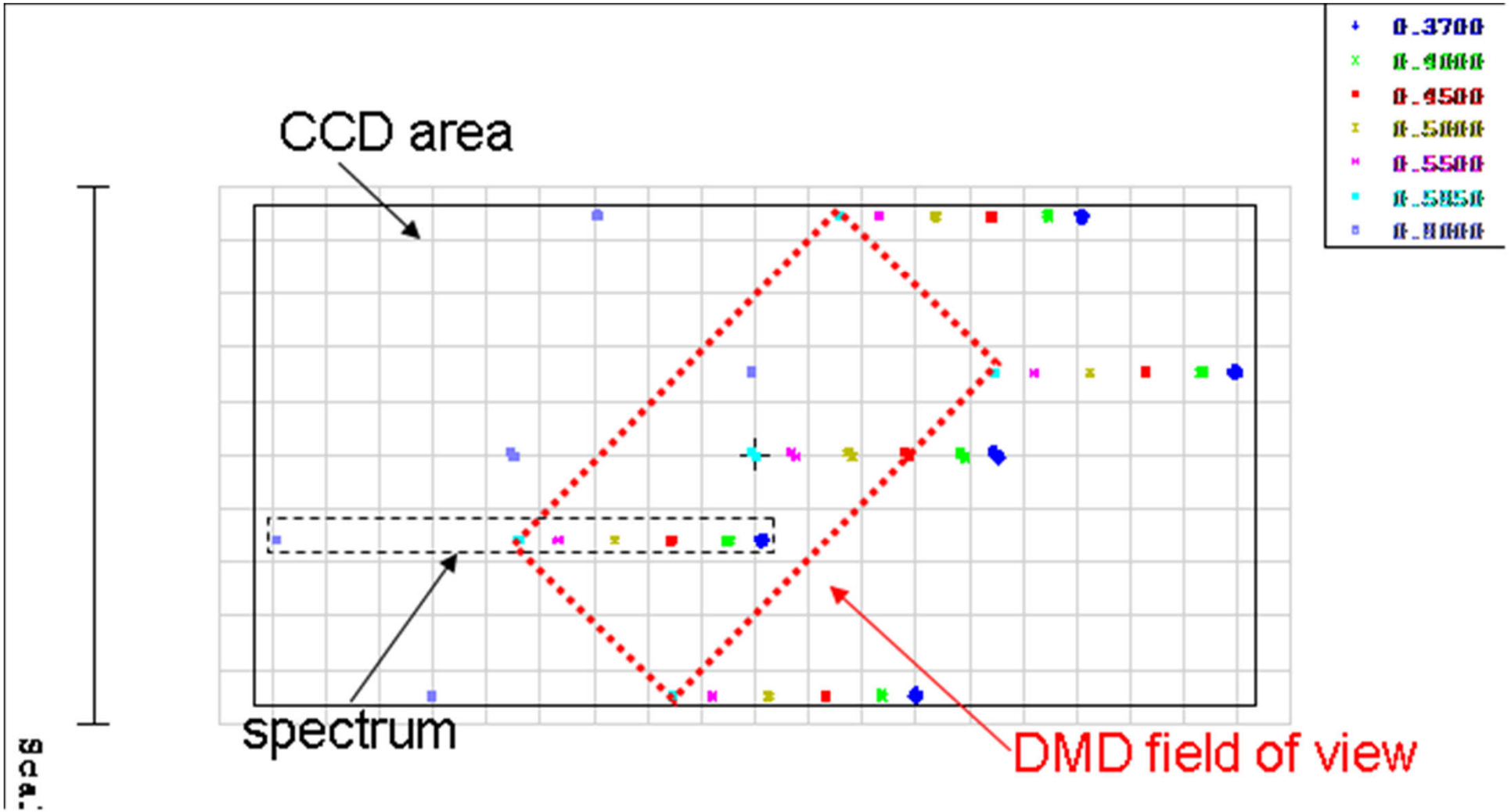
Field of view	6.8 arcmin x 3.6 arcmin
Focal ratio	F/4 on DMD (scale = 0.2 arcsec per micromirror)
Beams on DMD	incoming light at normal incidence out-coming light at 24° DMD orientation at 45°
Wavelength range	400 - 800 nm
Spectral resolution	R = 560 for 1 arcsec object (typical slit size)
Two arms instrument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

Optical design



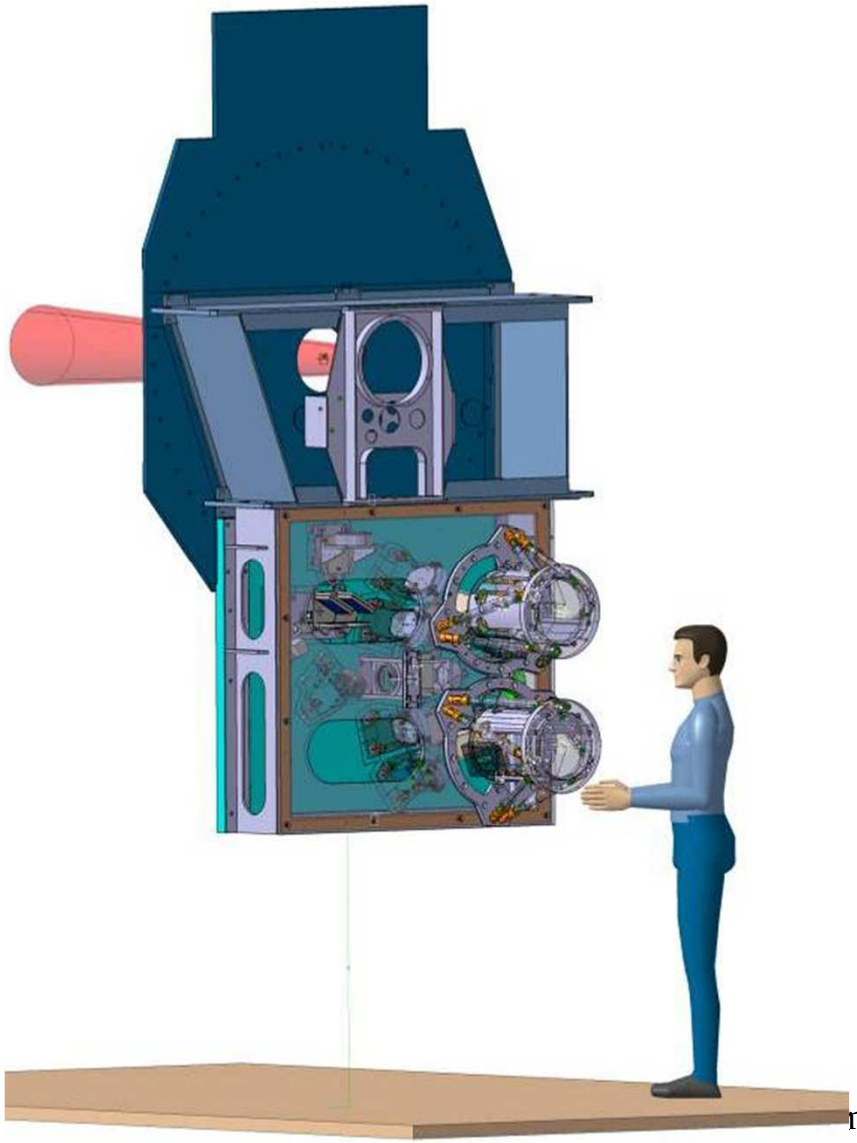
Simulated spectra

- Simulated spectra (400 – 800 nm)



BATMAN: the opto-mechanics

- General design

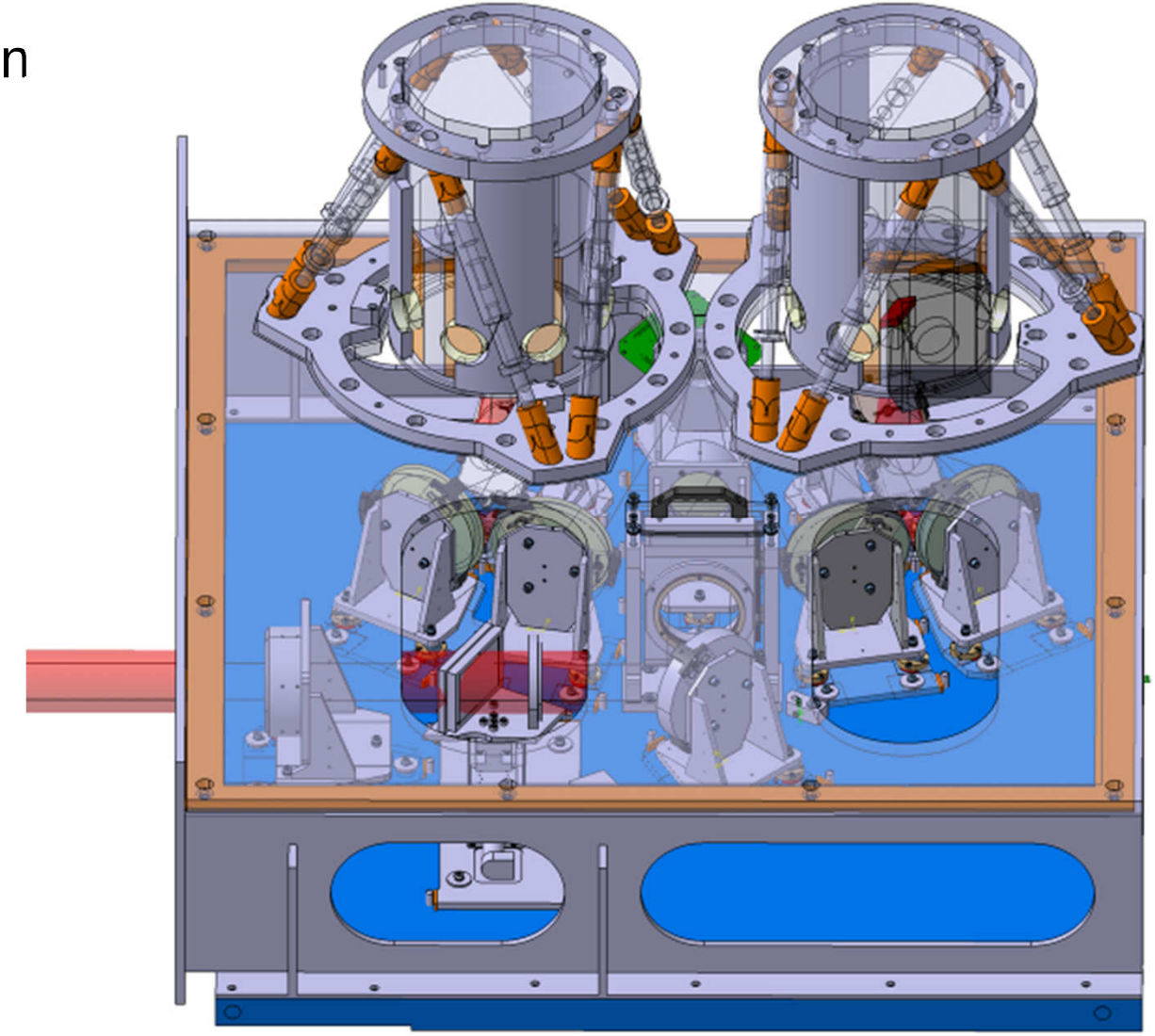


Zamkotsian et al.,

SPIE 9908, 2016

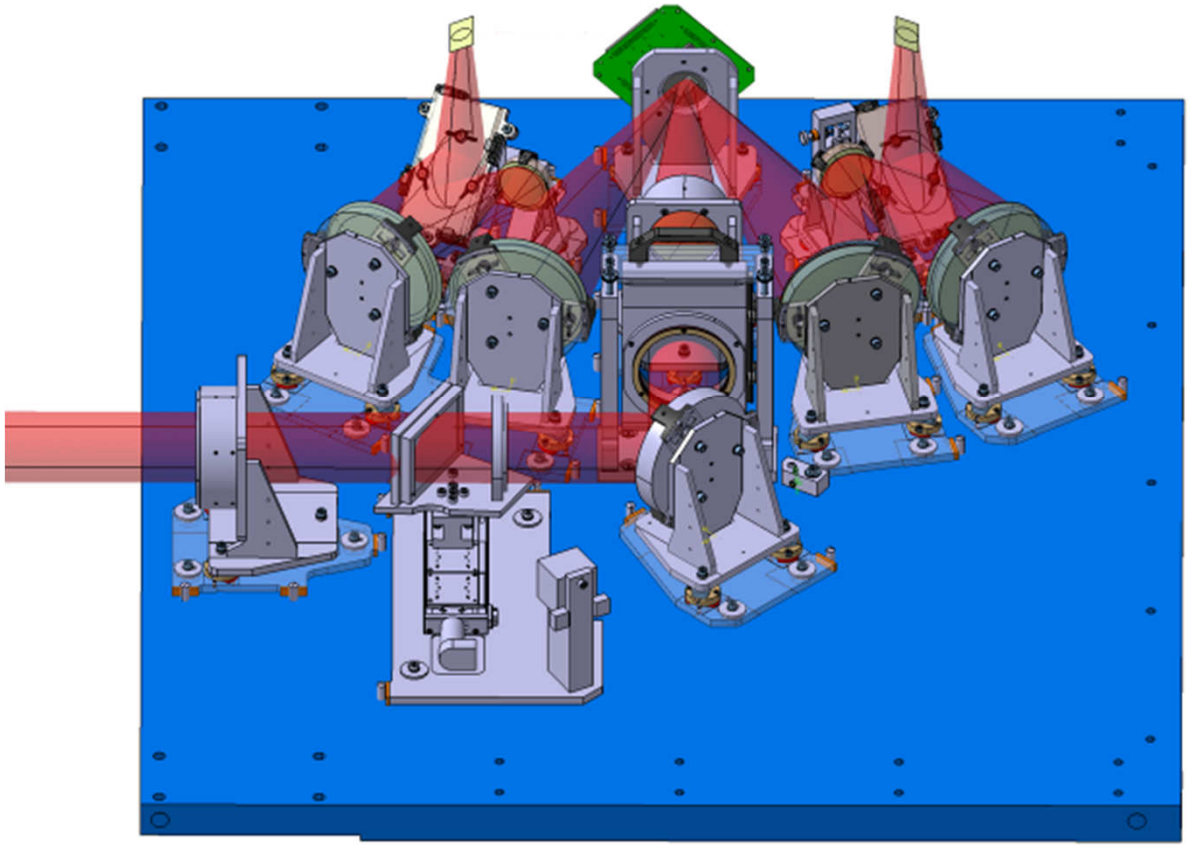
BATMAN: the opto-mechanics

- General design

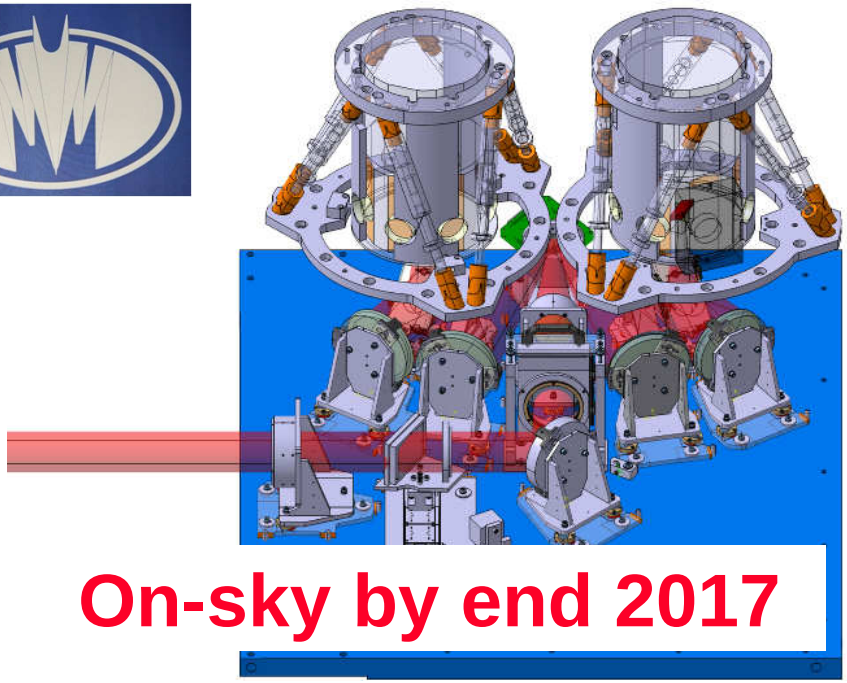


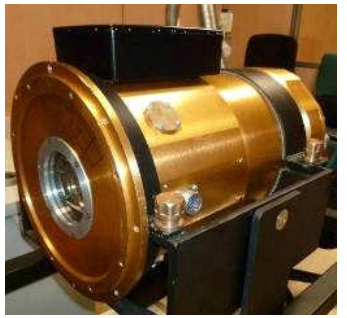
BATMAN: the opto-mechanics

- General design

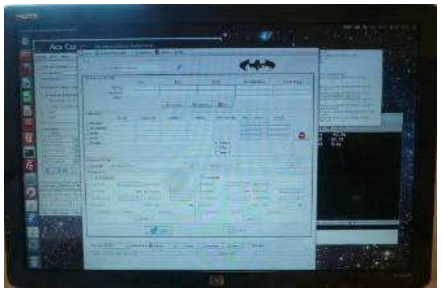


Detector

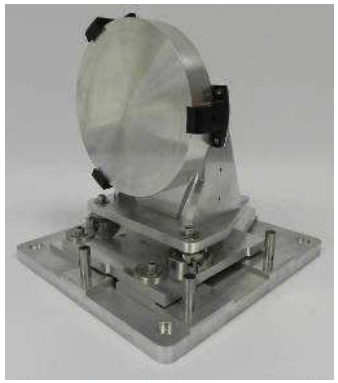




Detector



Instrument software



Mirrors mount

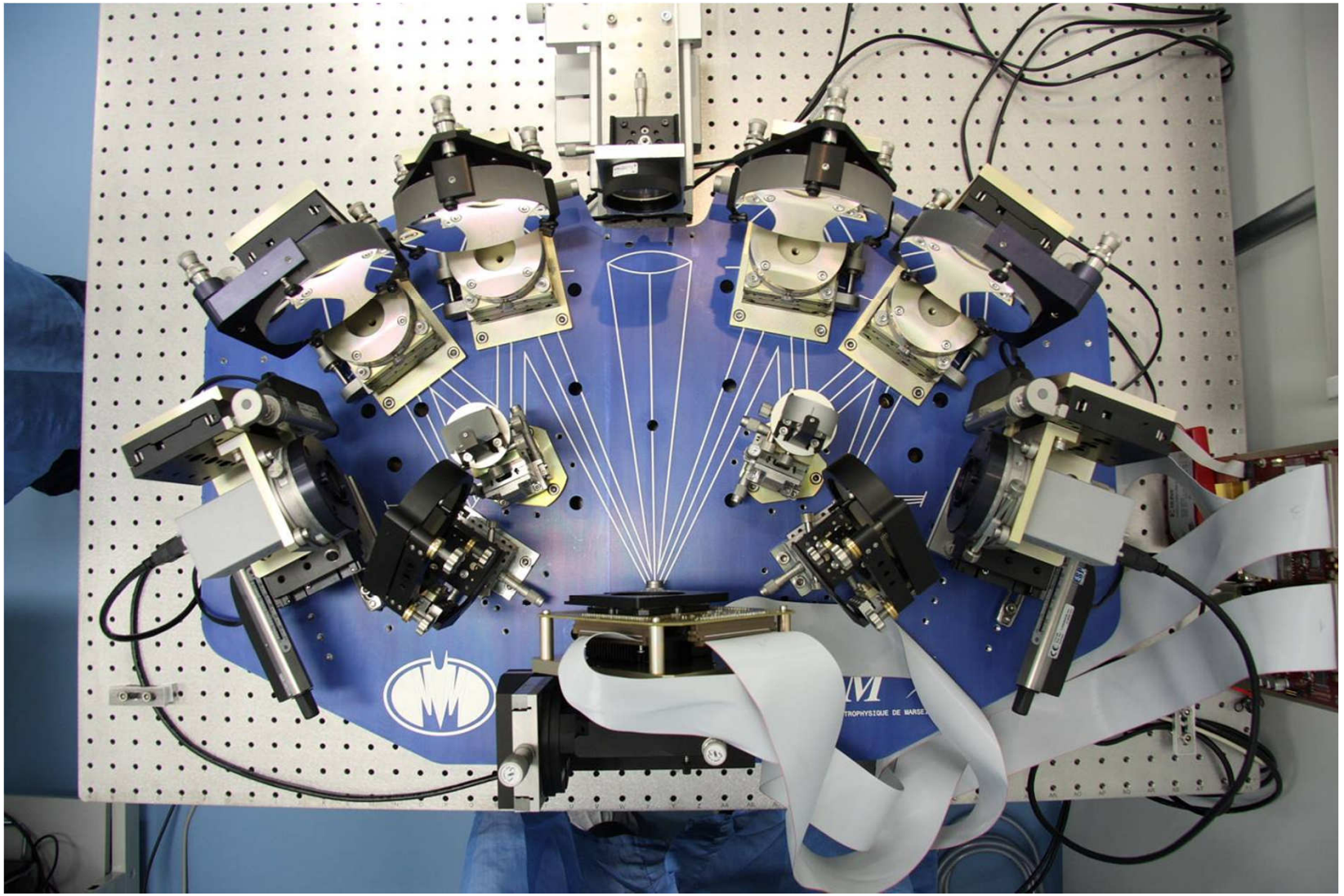
Mirrors / grating

Fore-optics

Hexapods

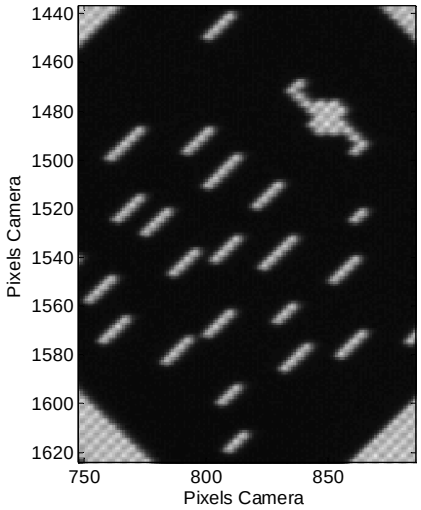
Calibration unit

ROBIN

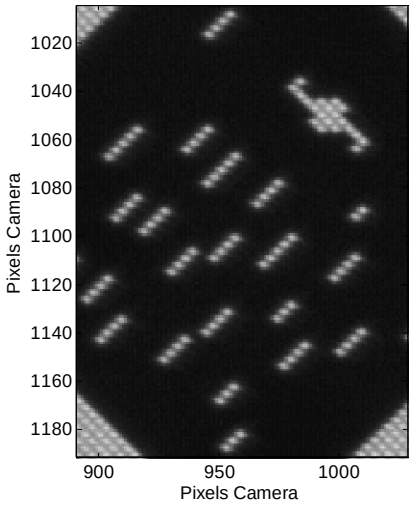


ROBIN: imagery

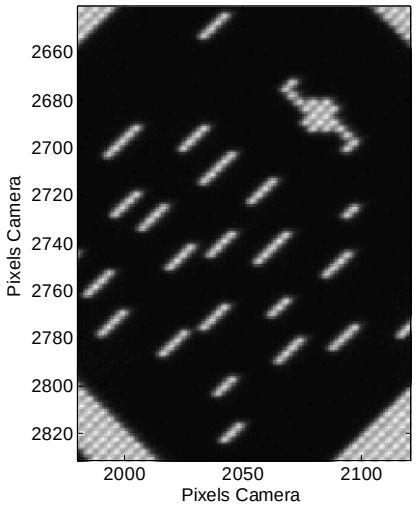
z00 pattern2



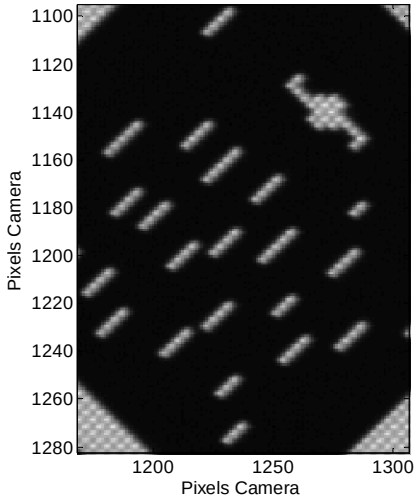
z09 pattern2



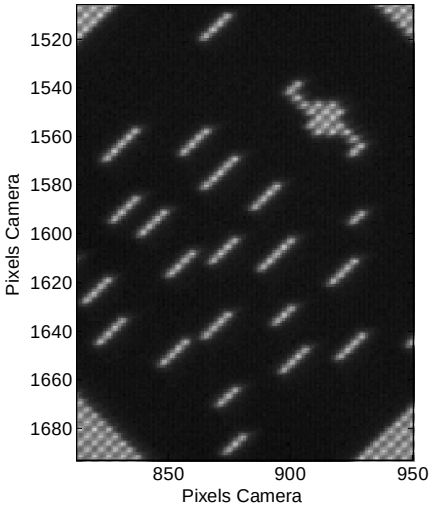
z20 pattern1



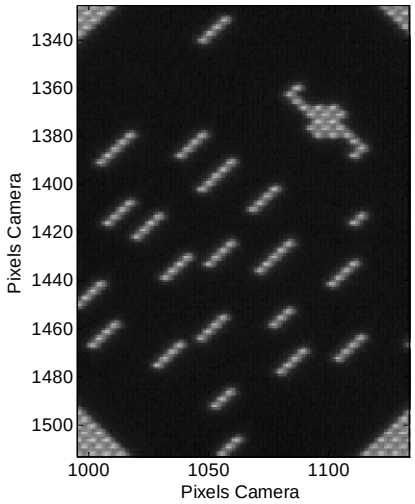
z25 pattern1



z40 pattern1



z49 pattern2



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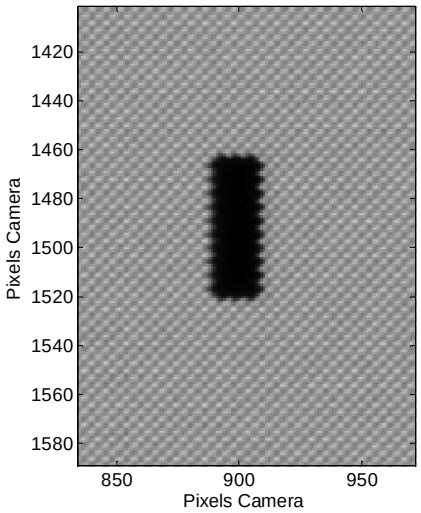
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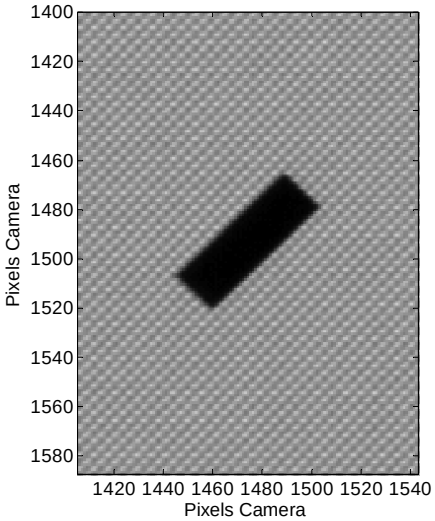
Pixels Camera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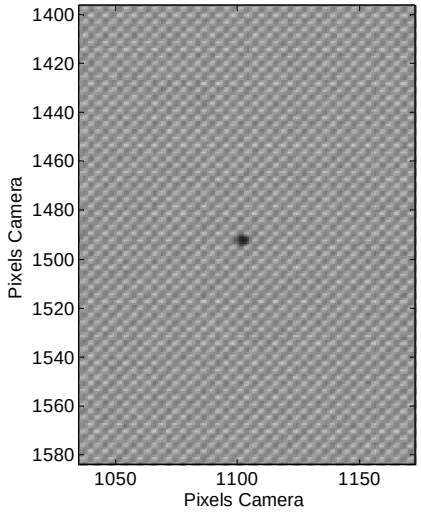
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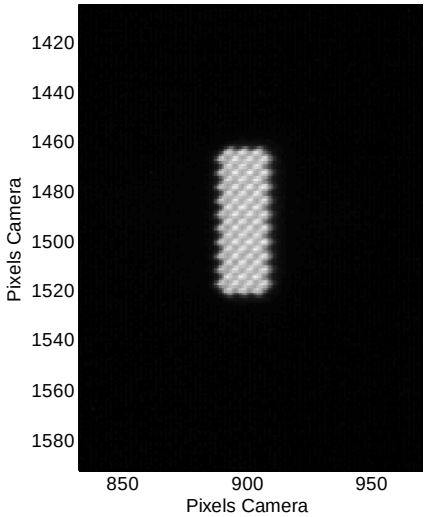
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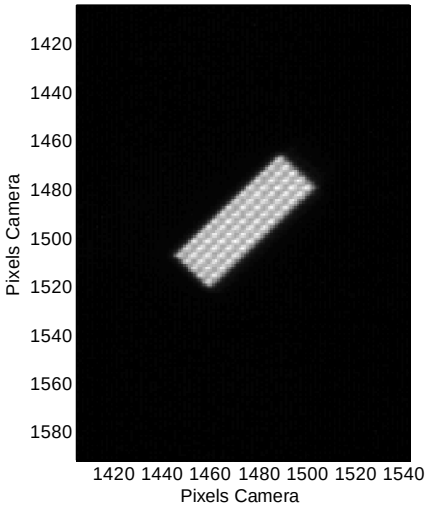
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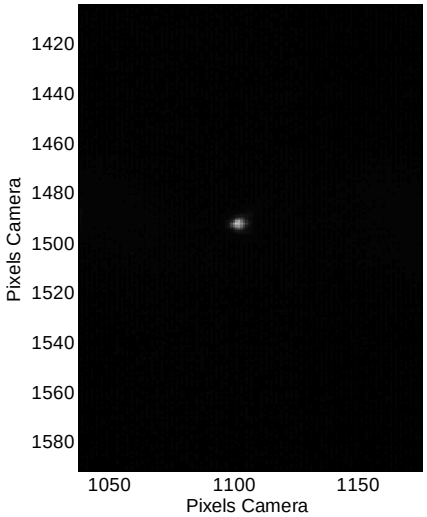
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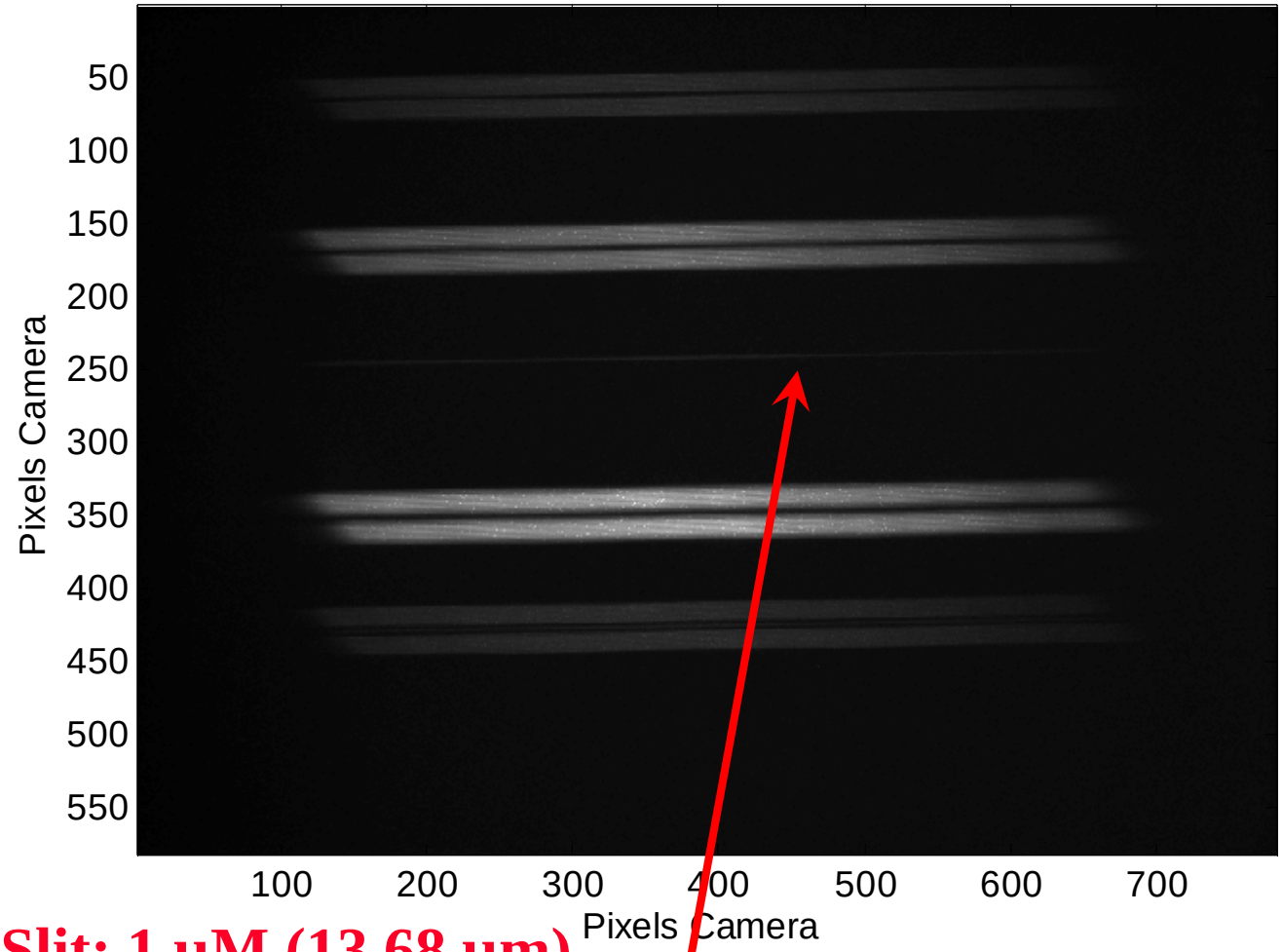
Pixels Camera

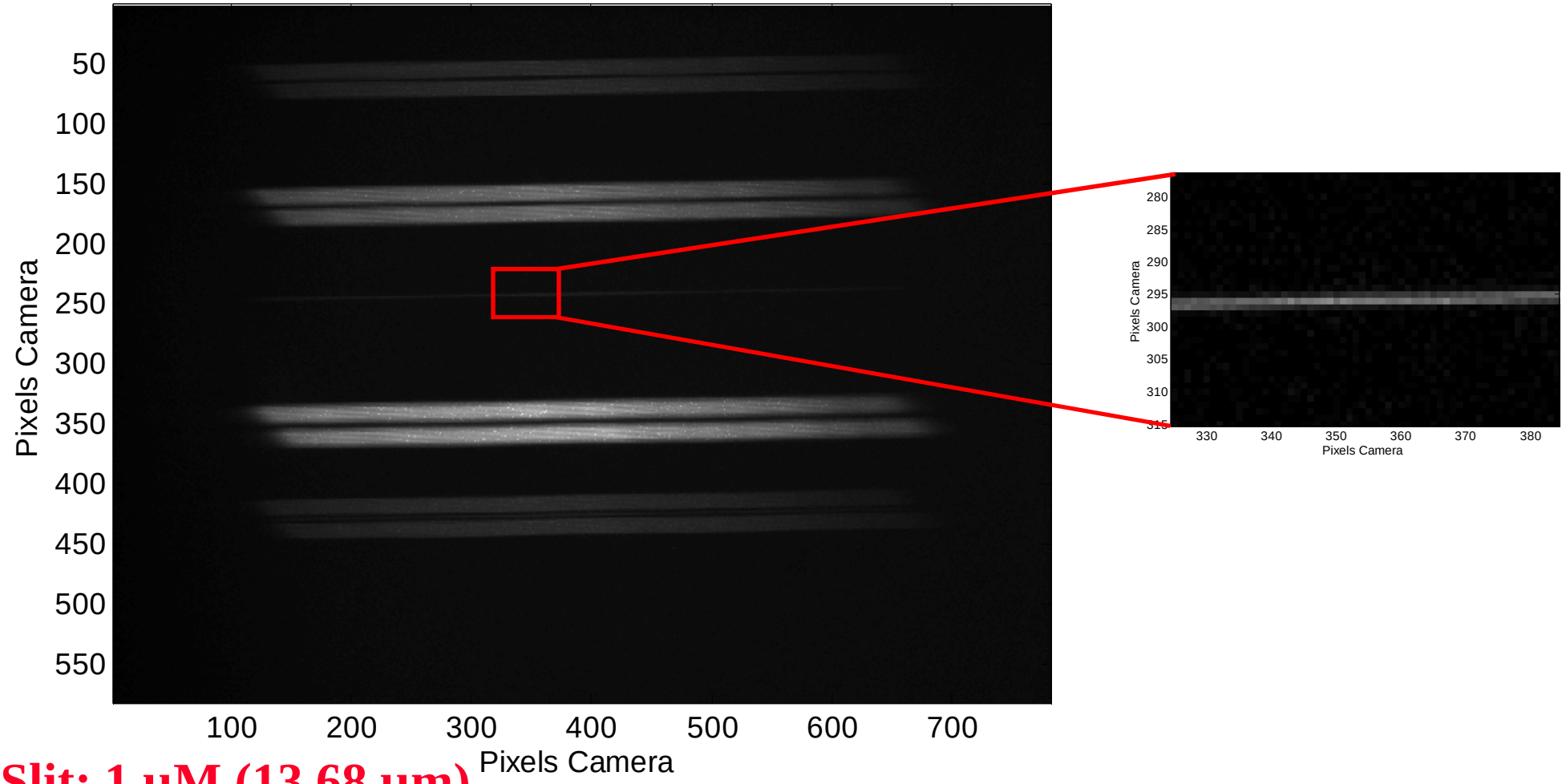
ROBIN: spectra



Slit: 1 µM (13.68 µm)

Spectrum on 1.5 detector pixel (8,3µm) in 450-650nm wavelength range

ROBIN: spectra



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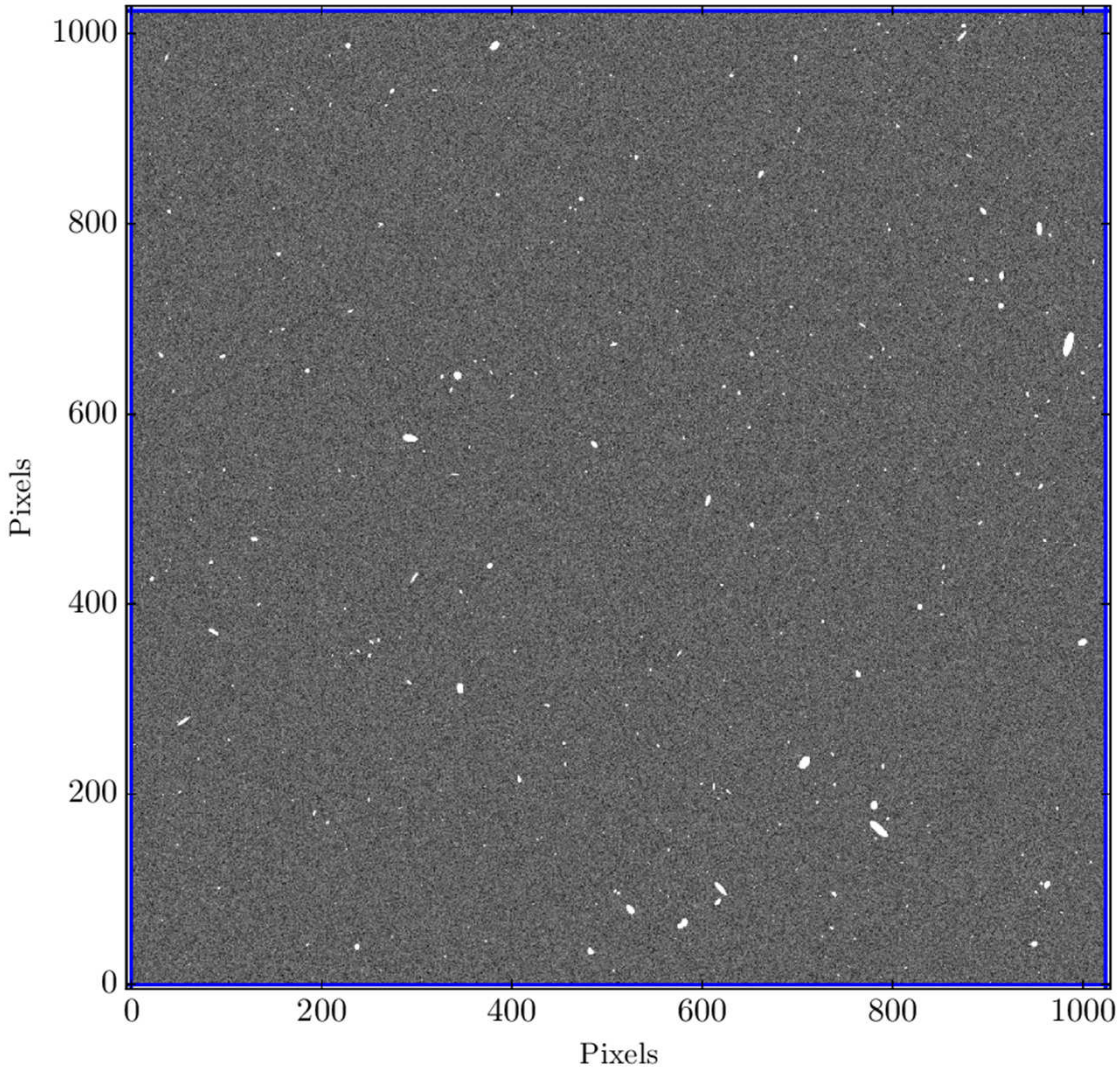
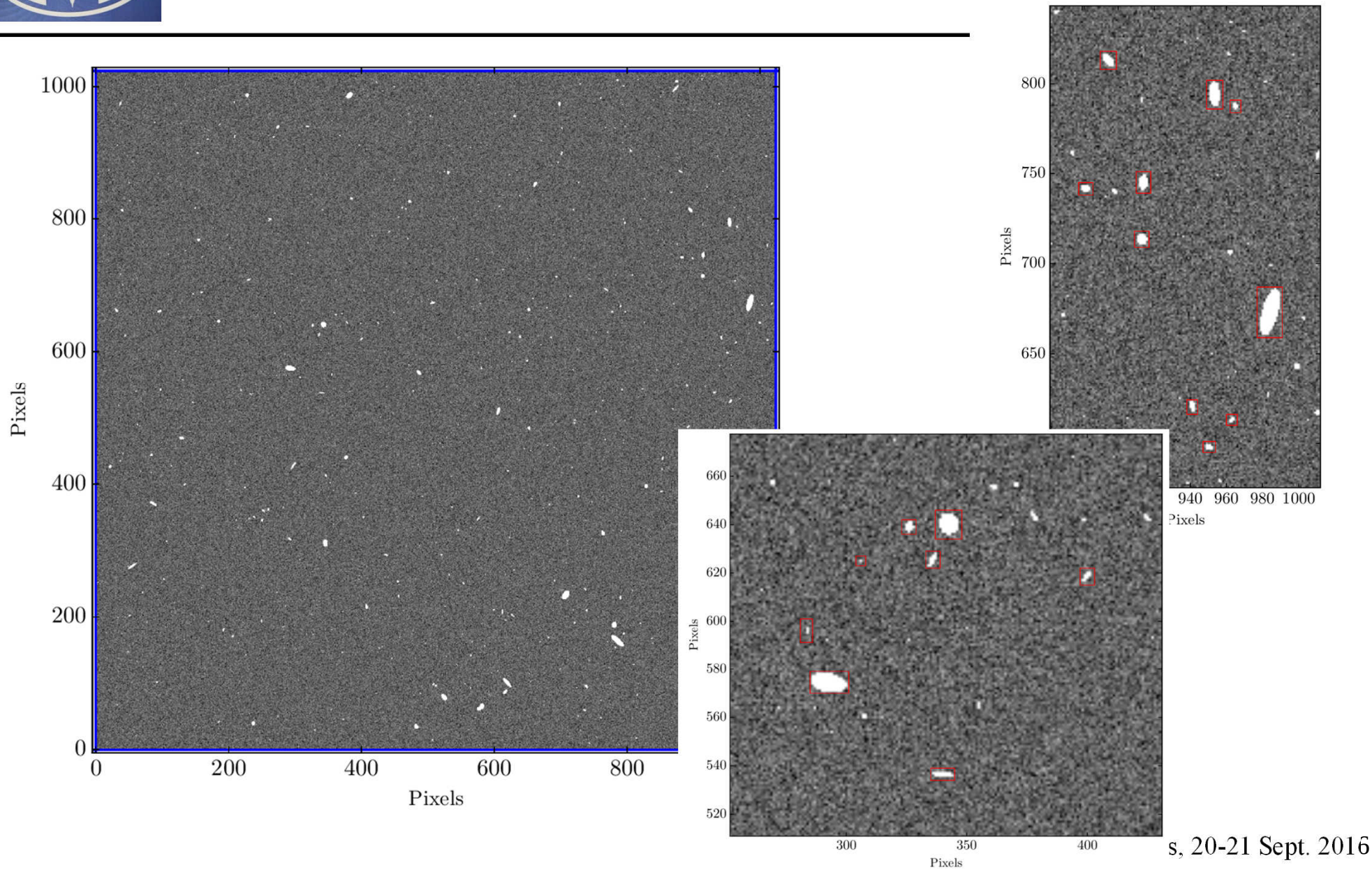
Spectrum on 1.5 detector pixel (8,3µm) in 450-650nm wavelength range

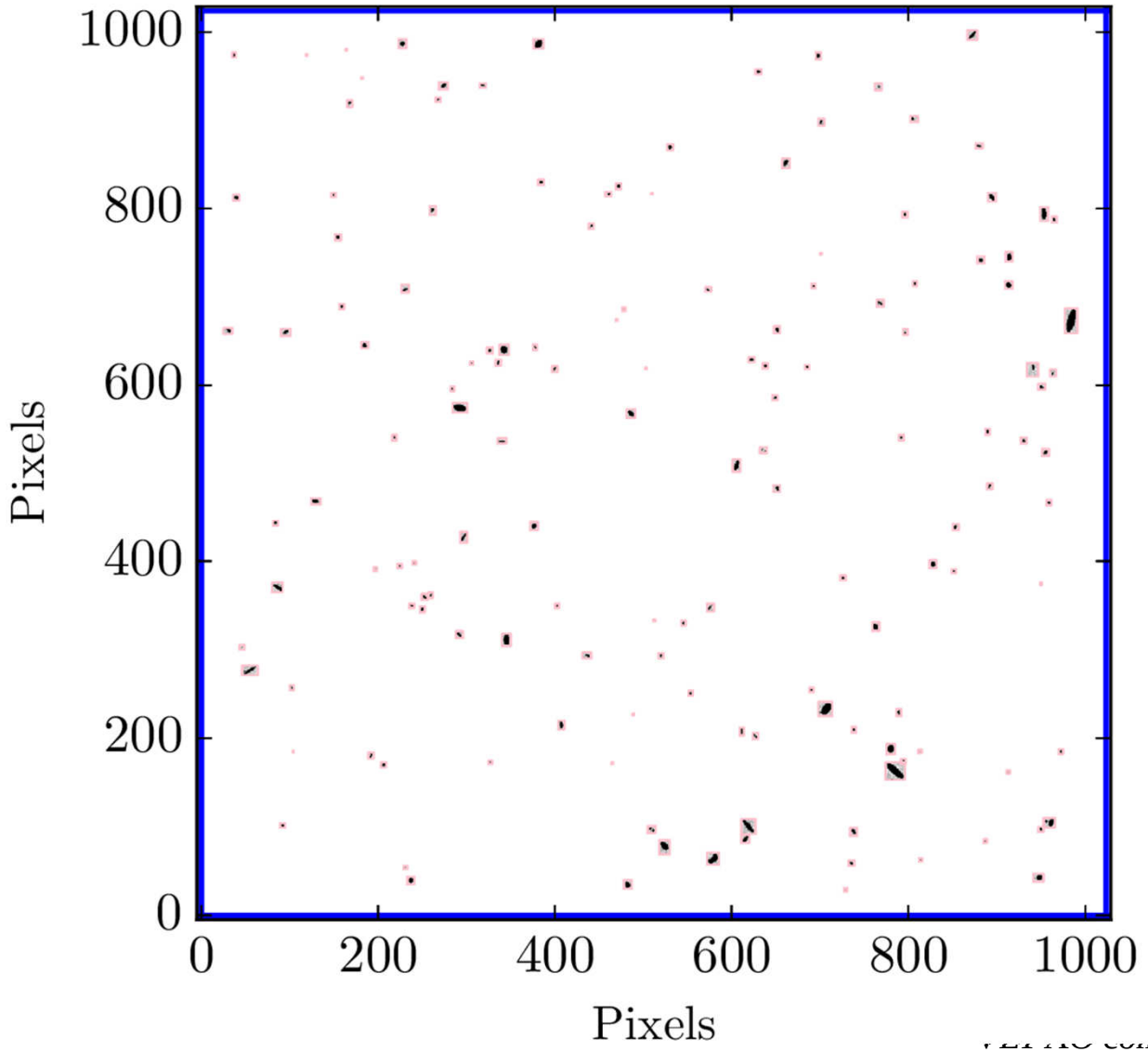
BATMAN: the simulator



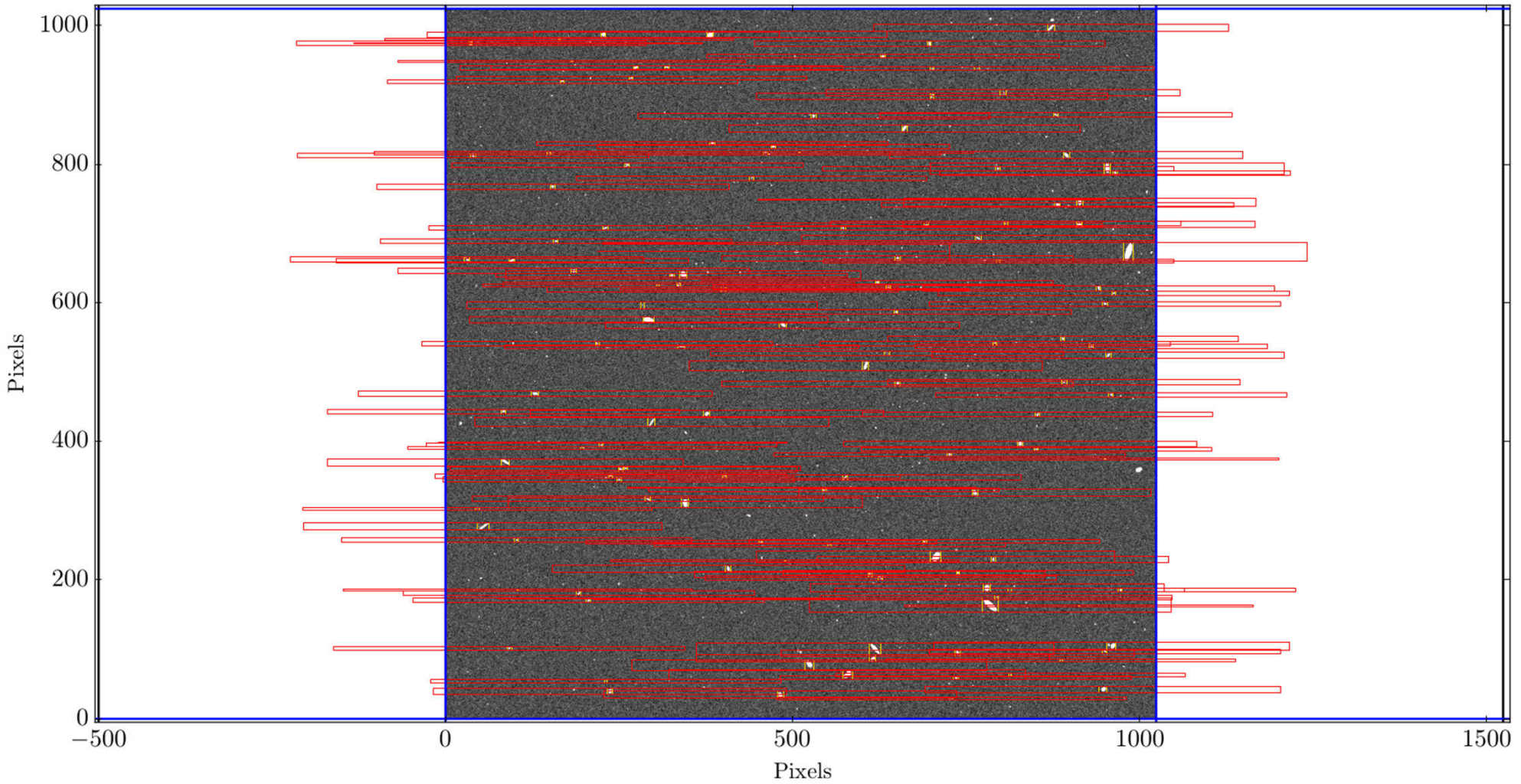
BATMAN: the simulator



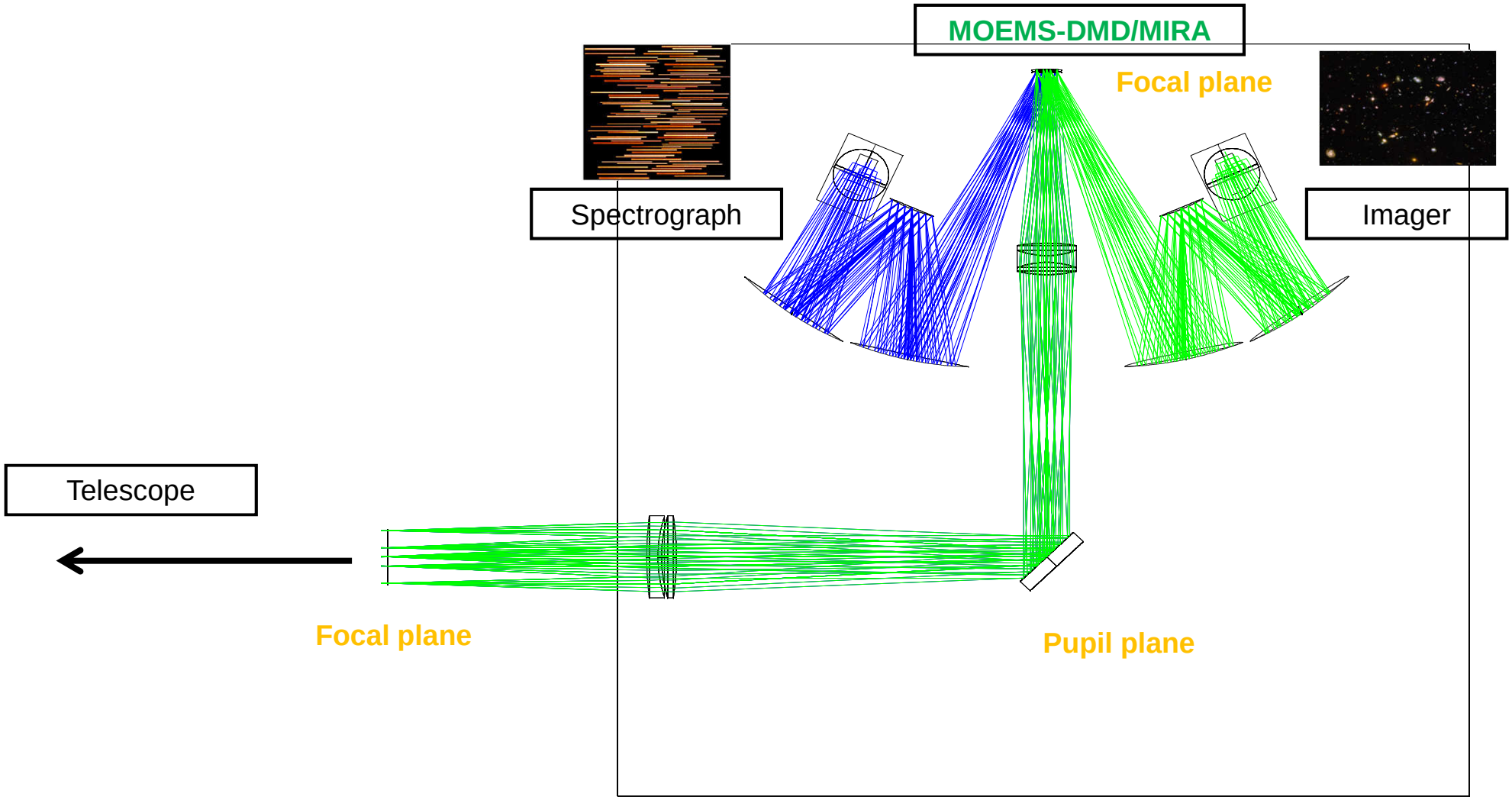
BATMAN: the simulator



BATMAN: the simulator

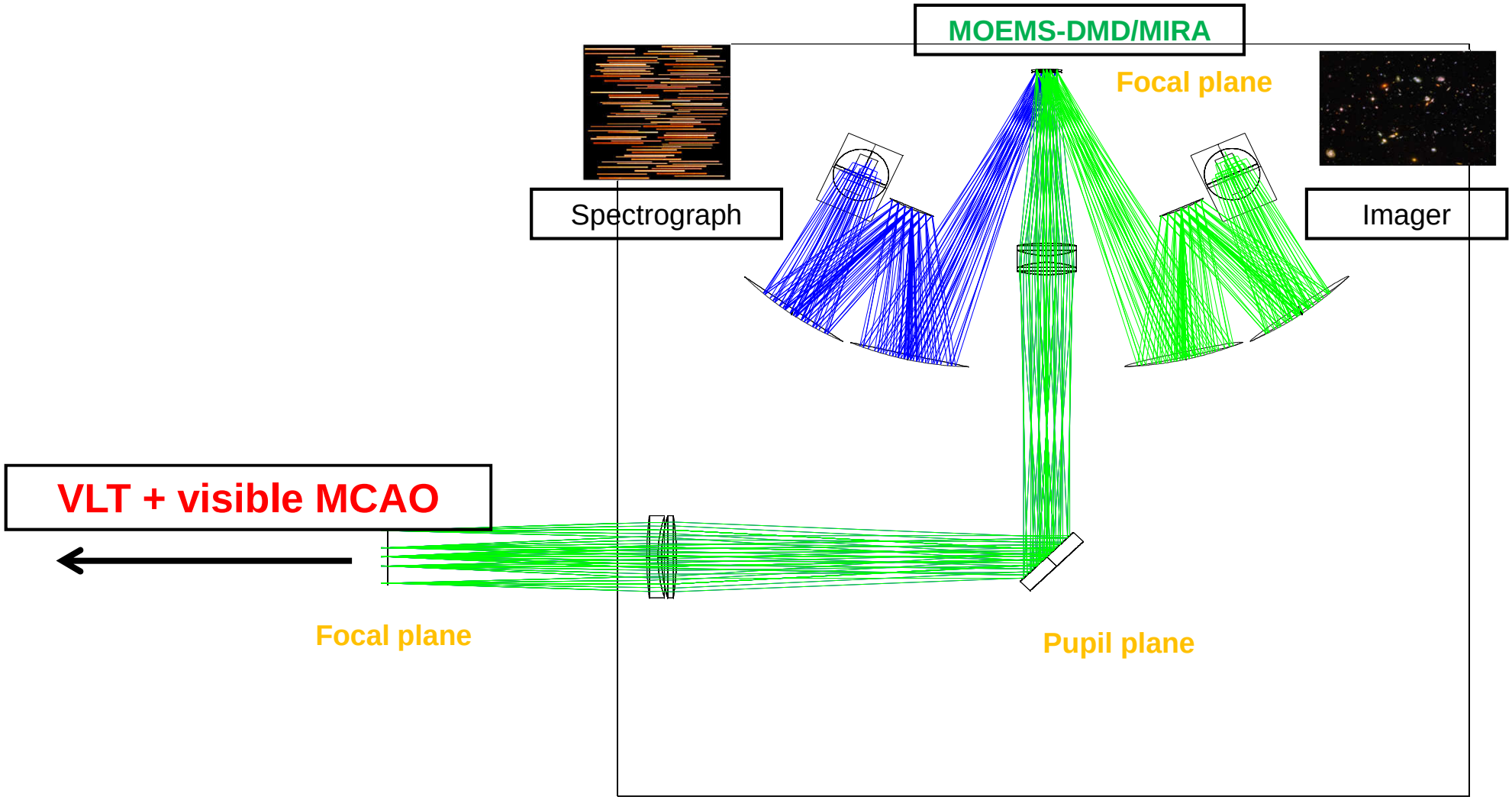


BATMAN for TNG



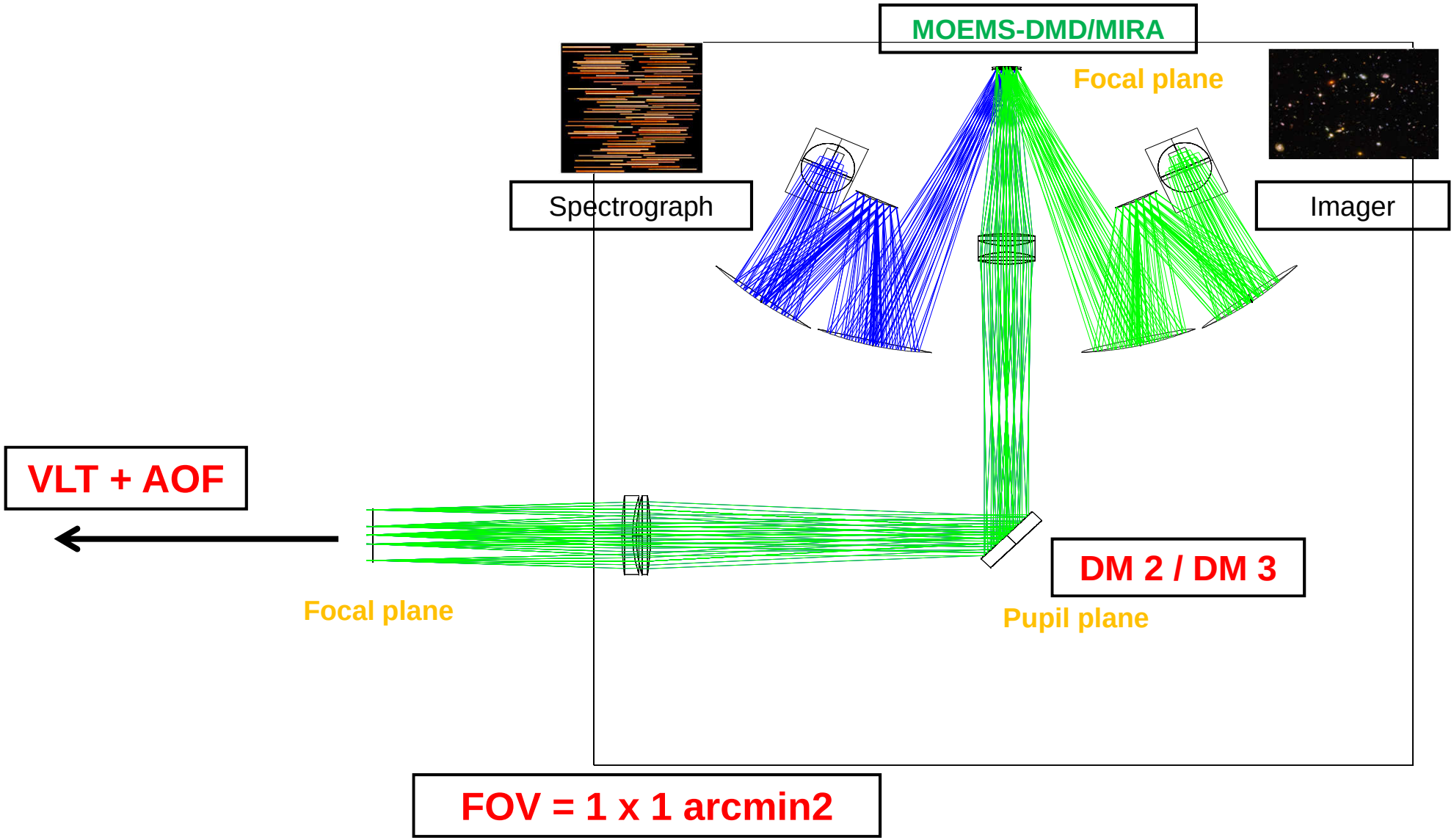
FOV = 6.8 x 3.6 arcmin2

BATMAN for VLT

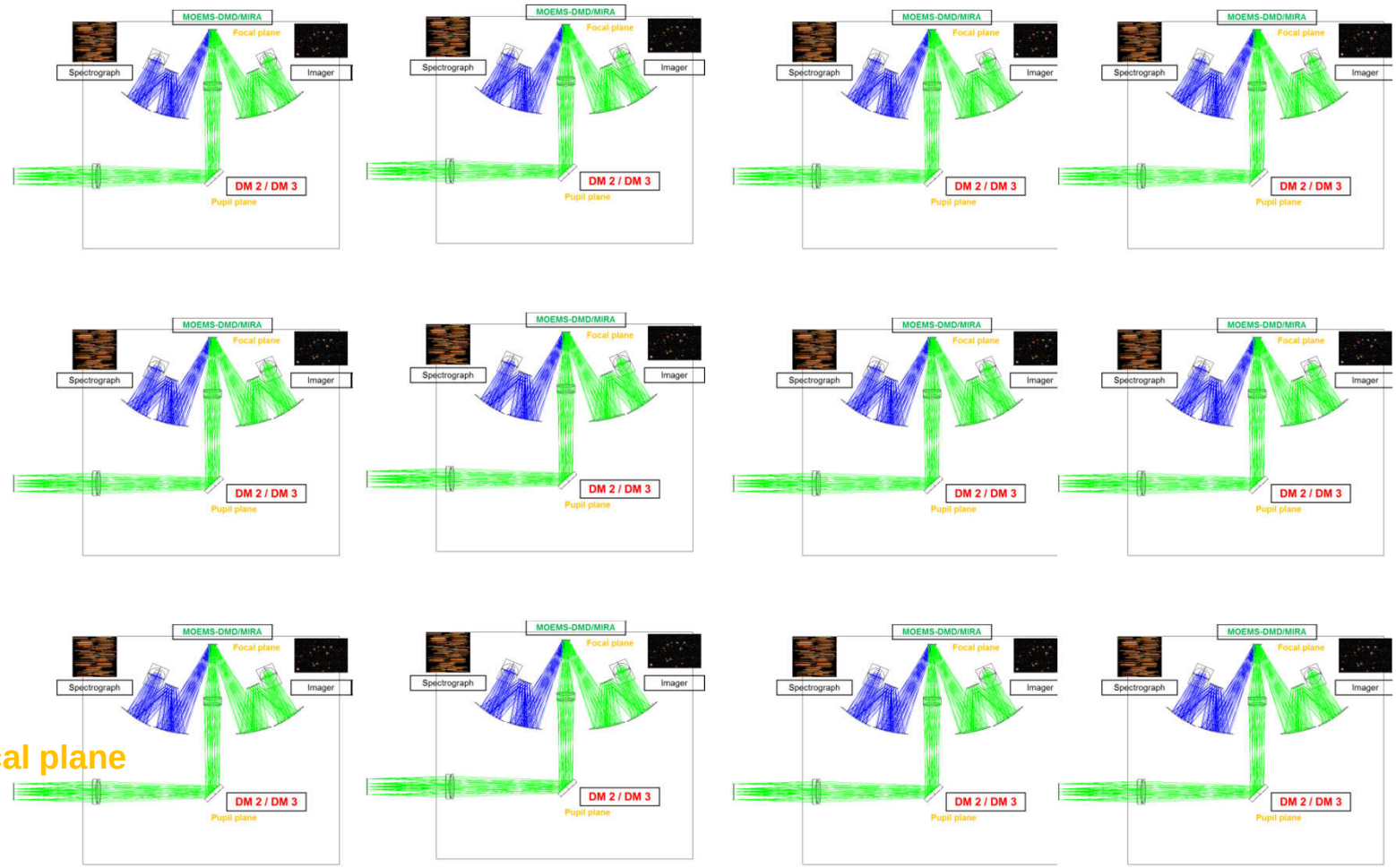


FOV = 1 x 1 arcmin2

BATMAN for VLT



BATMAN for VLT



VLT + AOF

Focal plane

FOV = 12 x [1 x 1 arcmin2] or any combination in wavelength bands

BATMAN unique abilities

- **Large FOV**
  - Single large FOV
  - Segmented FOV
- **SNR-limited observation**
  - New observational mode
  - Optimize scientific return
  - Homogeneous samples, easier to reduce
- **Versatility IN the FOV**
  - MOS + IFU + Imagery
  - Photometric calibration quasi-simultaneous
  - Photometric selection / z selection with the imagery
  - Transients live detection and characterization
- **Spatial and spectral resolution diversity in the FOV**

Visible

+ IR ?

Parameters BATMAN for VLT3: TBD

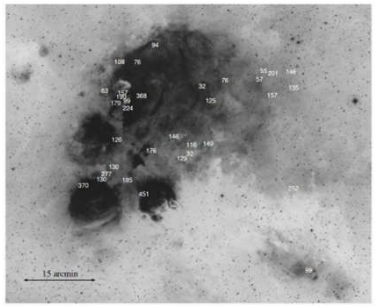
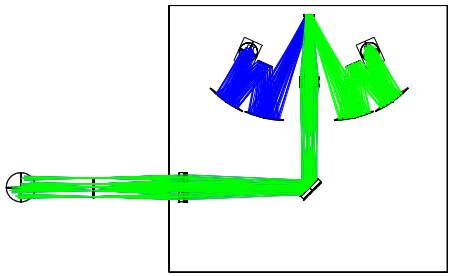
Field of view	**1 x 1 arcmin2 ++ ?**	
Focal ratio	F/4 on DMD (scale = 0.2 arcsec per micromirror)	
Beams on DMD	incoming light at normal incidence out-coming light at 24° DMD orientation at 45°	
Wavelength range	400 - 800 nm **+ IR ?**	
Spectral resolution	R = 500 – 1500 **up to 5000 ?**	
Two arms instrument	one spectroscopic channel one imaging channel	
Detectors	Two 2k x 4k CCDs	

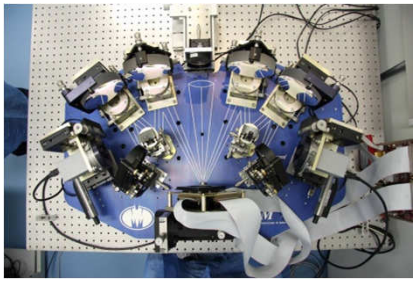
Visible MCAO supported spectro-imager: the BATMAN family

Frederic Zamkotsian, Romain Thomas, Julien Zoubian, Carlo Schimd, Sylvain de la Torre, Eric Jullo, Olivier Ilbert, Samuel Boissier, Georges Comte, Jean-Claude Bouret, Delphine Russeil, Audrey Delsanti, Pierre Vernazza, Benoit Neichel

+ BATMAN French-Italian team

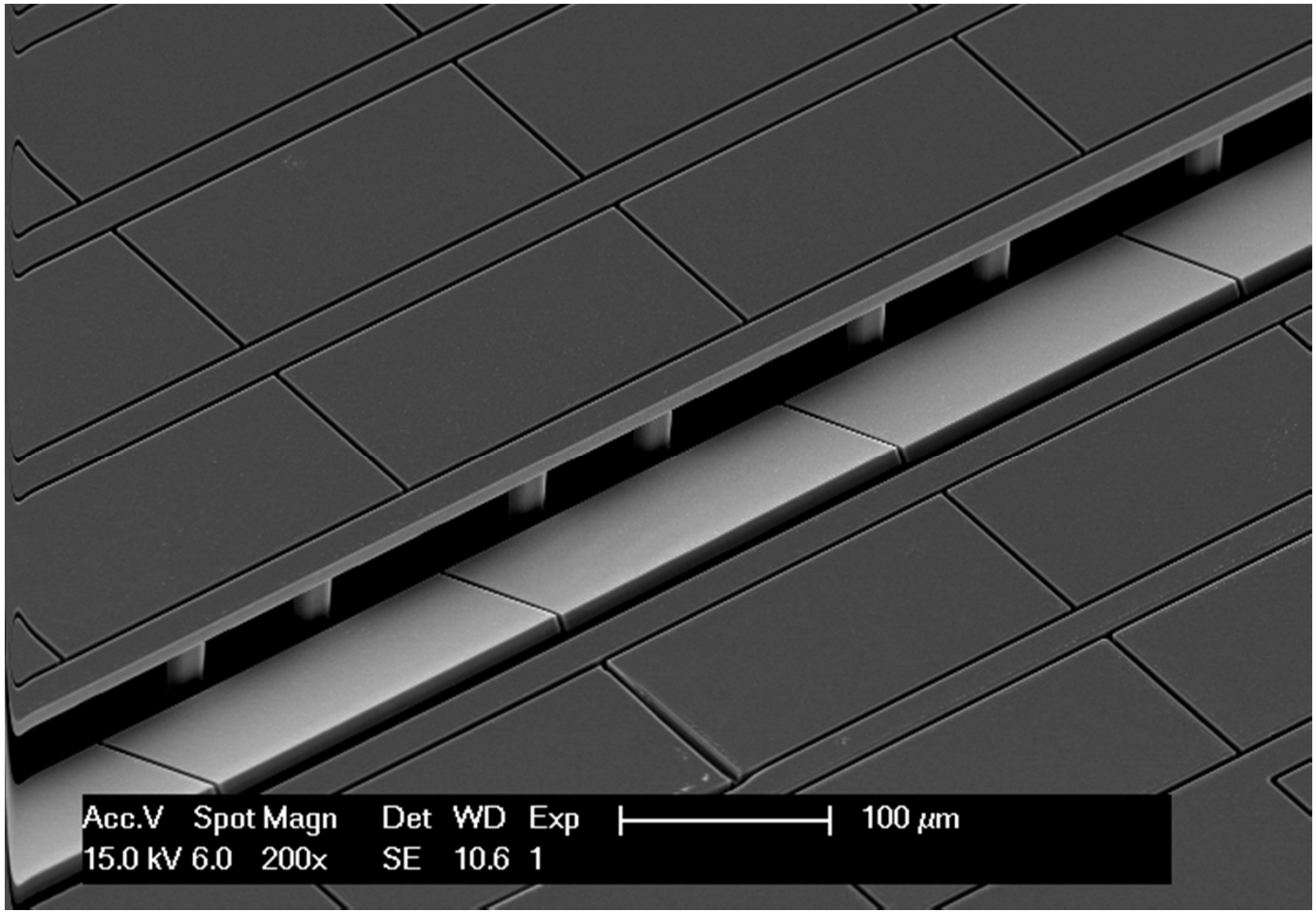
[1] Laboratoire d'Astrophysique de Marseille, France
[2] INAF Osservatorio Astronomico di Brera, Italy
[3] INAF/IASF Bologna, Italy
[4] INAF - Telescopio Nazionale Galileo, Spain
[5] INAF-OAT, Osservatorio Astronomico di Trieste, Italy



VLT AO community days, 20-21 Sept. 2016

Extra-slide, MIRA: the European Micro-Mirror Array



Waldis et al., SPIE 6887, 2008

Canonica et al., JMM, 2013