Simulating Surveys for ELT-MOSAIC: Status of the MOSAIC Science Case after Phase A

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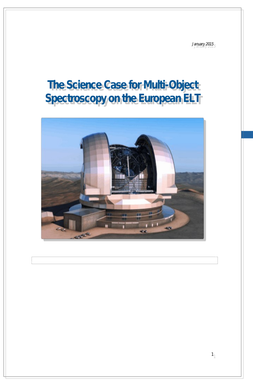
SCIENCE INPUTS



The **ELT-MOS White Paper** released in 2013 and updated in 2015 collected a 'wish-list' from the European MOS community.

Flow-down of instrument requirements from each science case and consolidation into Top Level Requirements: see Sánchez-Janssen et al., this conference.

Science trades during Phase A:

- Inclusion of K-band: unrealistic within the current financial constraints combined with the large parameter range required for the other cases → red cut at 1.8 µm.
- Blue-visible performance: the combined efficiency of the ELT and MOSAIC at <0.4 µm is sufficiently low that a blue-optimised instrument on the VLT could potentially be competitive (principally due to the properties of the coatings of the ELT mirrors) → blue cut at 0.45 µm.
- High spectral resolution in the NIR: studies of stellar populations and distant dwarf galaxies motivated to add a HR (R>18,000) setup in H-band.

MOSAIC OBSERVING MODES

The four MOSAIC observational modes (see Jagourel et al., this conference for details):

- **High Definition Mode (HDM):** 8 IFUs deployed over 40 arcmin^2; R~5000; FoV=1.9'' hexagons; 80 mas/spaxel; 0.8-1.8 µm wavelengths (one band).
- **Vis. IFU mode (VIFU):** same as HDM in the Vis (0.45-0.92 µm); FoV= 2.3'' hexagons with 138 mas/spaxel.
- **High Multiplex Mode in the NIR (HMM-NIR):** 80 fiber bundles (19 x100 mas fibers); 0.5'' diameter apertures.
- **HMM in the Vis (HMM-VIS):** same as HMM-VIS in the NIR (19x168 mas fibers); 0.84'' diameter apertures.

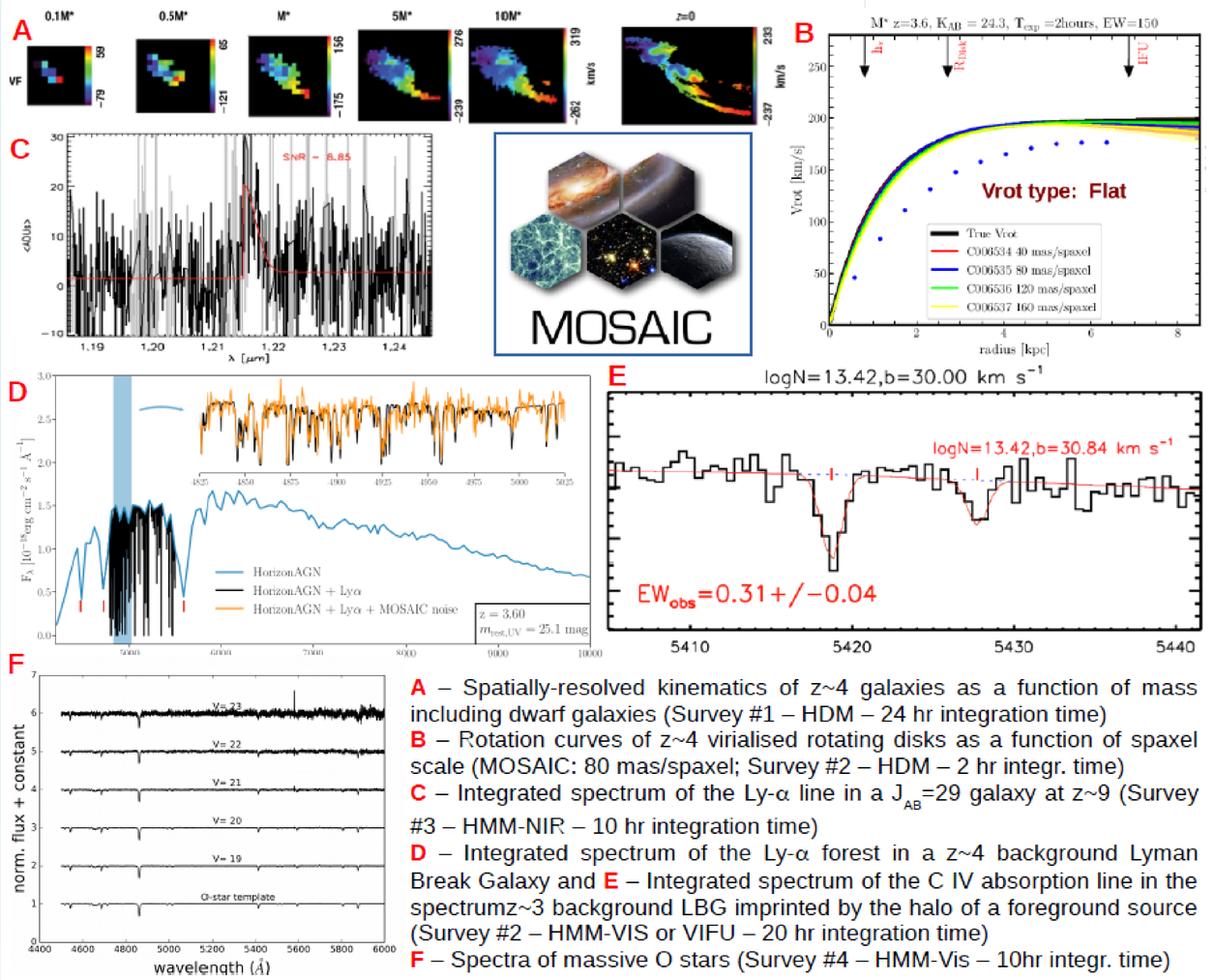
MOSAIC PRIORITISED SURVEYS

The MOSAIC science case spans six broad topics, which were revised and extended during phase A compared to the original cases described in the White Papers (see paper for description). As a conclusion to Phase A and a colloquium that took place in Toledo in Oct. 2017, four highlight cases were identified that will help drive future decisions on instrument capability and will form the basis for future surveys:

Table 1: High-priority MOSAIC surveys (not in a ranked order).

Survey & related Science Case(s)	Primary/essential (secondary/beneficial) modes
1. Evolution of dwarf galaxies SC2: mass assembly; SC1: contribution to reionisation	HDM (HMM-NIR)
2. Inventory of matter SC2: IGM tomography; SC2: missing baryons; SC3: dark matter profiles in high-z galaxies	HDM + HMM-Vis (VIFU)
3. First-light galaxies SC1: the sources of reionisation	HMM-NIR (HDM)
4. Extragalactic stellar populations SC5: evolved populations beyond the Local Group	HDM (HMM-NIR)

Illustrative simulations of typical MOSAIC observations:



A – Spatially-resolved kinematics of z~4 galaxies as a function of mass including dwarf galaxies (Survey #1 – HDM – 24 hr integration time)
B – Rotation curves of z~4 virialised rotating disks as a function of spaxel scale (MOSAIC: 80 mas/spaxel; Survey #2 – HDM – 2 hr integr. time)
C – Integrated spectrum of the Ly-α line in a J_{AB}=29 galaxy at z~9 (Survey #3 – HMM-NIR – 10 hr integration time)
D – Integrated spectrum of the Ly-α forest in a z~4 background Lyman Break Galaxy and **E** – Integrated spectrum of the C IV absorption line in the spectrumz~3 background LBG imprinted by the halo of a foreground source (Survey #2 – HMM-VIS or VIFU – 20 hr integration time)
F – Spectra of massive O stars (Survey #4 – HMM-Vis – 10hr integr. time)

SURVEY SPEED COMPARISON

Key metric for comparing facilities or observing modes:

$$SurveySpeed = \frac{Multiplex}{ObservingTime} \propto D^2 \times Throughput \times Multiplex$$

	Survey Speed MOSAIC / other	Limiting factor
HMM-Vis vs. TMT-WFOS	**~ 0.7 (±0.2)**	ELT throughput in the blue
HMM-NIR vs. TMT-IRMS	**~ 2.9**	Collecting surface of the telescope & Multiplex
HMM-Vis vs. VLT/Dedicated Vis MOS	**~ 0.6***	ELT throughput in the blue
HMM-NIR vs. VLT/MOONS	**~ 1.9**	Collecting surface of the telescope
HDM vs. ELT/HARMONI (R=3500)	**~ 25** (~3 for a single IFU)	Multiplex & spaxel surface (HARMONI: 30x60 mas^2)

*** IMPORTANT: Survey #2 would require integration times > 100 hr on the VLT, which remains to be demonstrated**

CONCLUSION

The unique parameter space of MOSAIC:

- **Multi-IFUs in the NIR at R~5000:** resolving UV spectral features in *JWST* sources; 3D kinematics of ~ 1000 galaxies at 2<z<4 and resolving rotation curves in virialized rotating disks.
- **High R (~20,000) MOS in the NIR:** resolving internal motions in z~2-3 dwarfs.
- **MOS at both Vis and NIR:** flexible facility for matter inventory at z~3, and stellar physics.
- ***MOSAIC Phase B to start ~ early 2019***