1 EMPOWER Emission line Mapping of galaxy POpulations in the cosmic Web EnviRonment)

PI: P. Popesso, European Southern Observatory, Germany

1.1 Background

The EMPOWER (Emission line Mapping of galaxy POpulations in the cosmic Web EnviRonment) is a public KMOS program designed to build a spatially resolved atlas of ∼900 galaxies across three key epochs in cosmic history ($z \sim 0.75$, $z \sim 1.6$, $z \sim 2.3$). The survey addresses a major gap in galaxy–evolution work: the scarcity of environment–aware integral–field spectroscopy (IFS) at high redshift, where quenching and feedback are thought to depend sensitively on halo mass and cosmic–web location.

Scientific motivation and legacy. Existing KMOS surveys have mapped stellar mass and star formation, but typically with limited leverage on environment. EMPOWER is designed to fill this observational gap by sampling galaxies from the field to dense cluster and proto–cluster regions, enabling uniform, spatially resolved measurements of Hβ, [O III], H , and [N II] out to ∼2 effective radii. From these, we will derive gas–phase metallicities, ionised–gas kinematics, AGN diagnostics, and SFR gradients to test how star formation is regulated across the cosmic web. The survey provides the high–z IFS counterpart to local programs (e.g., CALIFA, SAMI, MAGPI, MaNGA) and acts as a spatially resolved follow–up to large spectroscopic efforts (e.g. 4MOST/WAVES, MOONS/MOONRISE, Euclid).

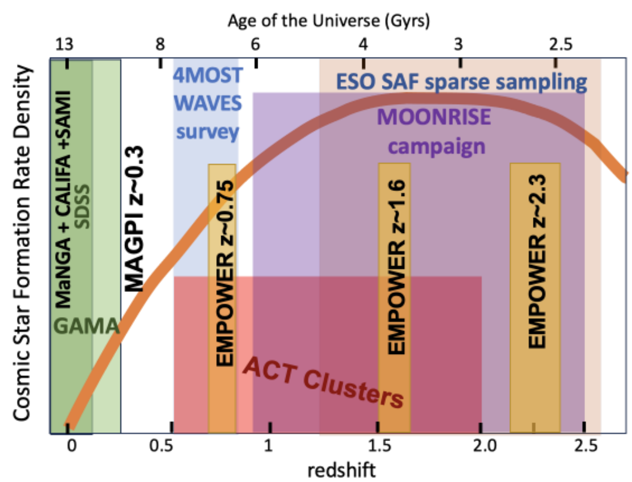

Figure 1: Redshift distribution of IFU (in black) and existing and upcoming spectroscopic surveys (in color). The *EMPOWER* redshift slices are indicated by the orange regions. The solid orange line indicates the evolution of the cosmic star-formation rate density.

Three–tier design ("three surveys in one"). EMPOWER is explicitly structured as a multi–tier program in three independent redshift slices. Observations proceed sequentially from the lowest redshift tier to the highest, and each tier is completed and released as a self-contained public data set before the next begins. This staging delivers early science to the community, ensures homogeneous depth within each slice, and builds cumulative legacy value without waiting for full survey completion.

2 Survey Observing Strategy

EMPOWER is structured as a multi-tier survey, with each tier corresponding to one of the three redshift slices (z∼0.75, z∼1.6, z∼2.3). Observations will proceed sequentially, starting from the lowest redshift tier and advancing to higher redshifts. This design ensures that after the completion of each tier, a fully independent stand-alone and scientifically valuable sub-survey will be immediately available to the community, maximizing early science return and enabling progressive data releases.

The observing strategy of EMPOWER is designed to minimize overheads, streamline OB preparation, and guarantee uniform depth across both emission-line pairs. The approach follows a structured sequence: submit compact and repeatable group containers; reduce and analyse the data immediately after execution; and, when necessary, submit additional exposures to achieve the required SNR, never exceeding the maximum execution times approved in the original proposal.

OB design and waiver.
We adopt a single–mode OB consisting of a brief acquisition followed by repeated on–target/on–sky nod pairs in an ABBA pattern (A = target, B = sky). With the chosen DIT/NDIT and cycle length, this template delivers approximately 70% on–source efficiency per execution. The OB is identical across all KARMA *paf* files and KMOS bands, simplifying Phase 2 preparation and queue operations while ensuring homogeneous depth and calibration.

In SM mode, We will request a waiver to allow **long OBs** with a total execution time of 1h30m (1h45m only for the faintest sources and to optimize overheads), of which approximately 13-15 minutes are overheads. This yields ˜50m n source and 25m (1h of on-source and 30m for the faintest targets) on sky integration per OB. The adoption of longer OBs reduces operational fragmentation and ensures predictable cadence. In VM, the strategy will be adapted with a combination of long and short, depending on the conditions, to make effective use of the available time and conditions. Similarly, the EMPOWER Consortium agrees also that the User support department will coordinate with the EMPOWER survey team to reach a suitable compromise, once the team start preparing the SM observations.

Minimum SNR and maximum execution time per pointing.
Integration depth is managed at the **paf KARMA file** level rather than for individual galaxies. Targets are grouped into pointings according to their luminosity in the observed KMOS band. This design ensures that the *average SNR* measured across a pointing is representative of the expected SNR for the individual targets within it. Observations will achieve $R \sim 4000$ (IZ, YJ, H, K) or $R \sim 2000$ (HK), and a minimum SNR$>$ 3 out to $2r_{\ ff}$ with uniform exposure across the sample. The minimum integration per pointing per band is 4.3 h, achieved with a single *minimum-depth* group container of three identical OBs (3 $\sim$1h20m = 4h of integration time, of which $\sim$2.7h on target, 3 $\sim$1h30m = $\sim$4h30m of execution time). This procedure is implemented separately for the two emission-line pairs: one container for Hβ+[O III] and one for H +[N II]. Both containers must be completed before new targets are initiated, thereby ensuring homogeneity of line coverage.

Each pointing will be observed up to a maximum execution (integration) time designed to reach the desired SNR for the faintest objects in our sample. With the lesson learn from previous shallower KMOS Programs we set the maximum exposure time as follows:
1) H + [NII]: maximum exposure of 10 h, for a total execution time of 16h.
2) Hβ + [OIII]: maximum exposure of 17 h, for a total execution time of 30h, depending on brightness.
3) At $z \sim 2.3$, targets with H in the K band will be complemented with Hβ+[OIII] in the H band with maximum 17h exposure. New targets will be observed in HK at $R \sim 2000$ for maximum 15h exposure (25h execution), enabling simultaneous coverage of all key emission lines.

Cadence and workflow.
OBs will be submitted in **biweekly batches**, with each batch consisting of group containers covering the scheduled pointings and bands. This phased submission prevents the impracticality of preparing hundreds of OBs at once and provides flexibility to respond to actual observing conditions and achieved SNR. A direct contact channel will be established with the ESO KMOS Support Astronomer to adapt the OB submission to the availability of the KMOS SA.

Immediate reduction and SNR evaluation (pointing QC).
Executed containers are reduced within 3 to 5 working days. Because targets within each pointing are *pre-grouped by luminosity in the observed KMOS band*, their SNR response to a fixed exposure and atmospheric conditions is expected to be similar. We therefore evaluate the *average SNR at the band/paf KARMA file level* as a statistically reliable proxy for the per-target SNR, which keeps QC tractable without sacrificing scientific control. For each pointing we compute a central SNR estimator (mean/median) and its dispersion across IFUs; if the central value meets the requirement specified in the approved proposal and no more than a small fraction (e.g. 10–15%) of targets fall below tolerance, the pointing is declared complete in that band. Otherwise, a top-up container is resubmitted in the next two-week cycle, up to (but not exceeding) the maximum execution

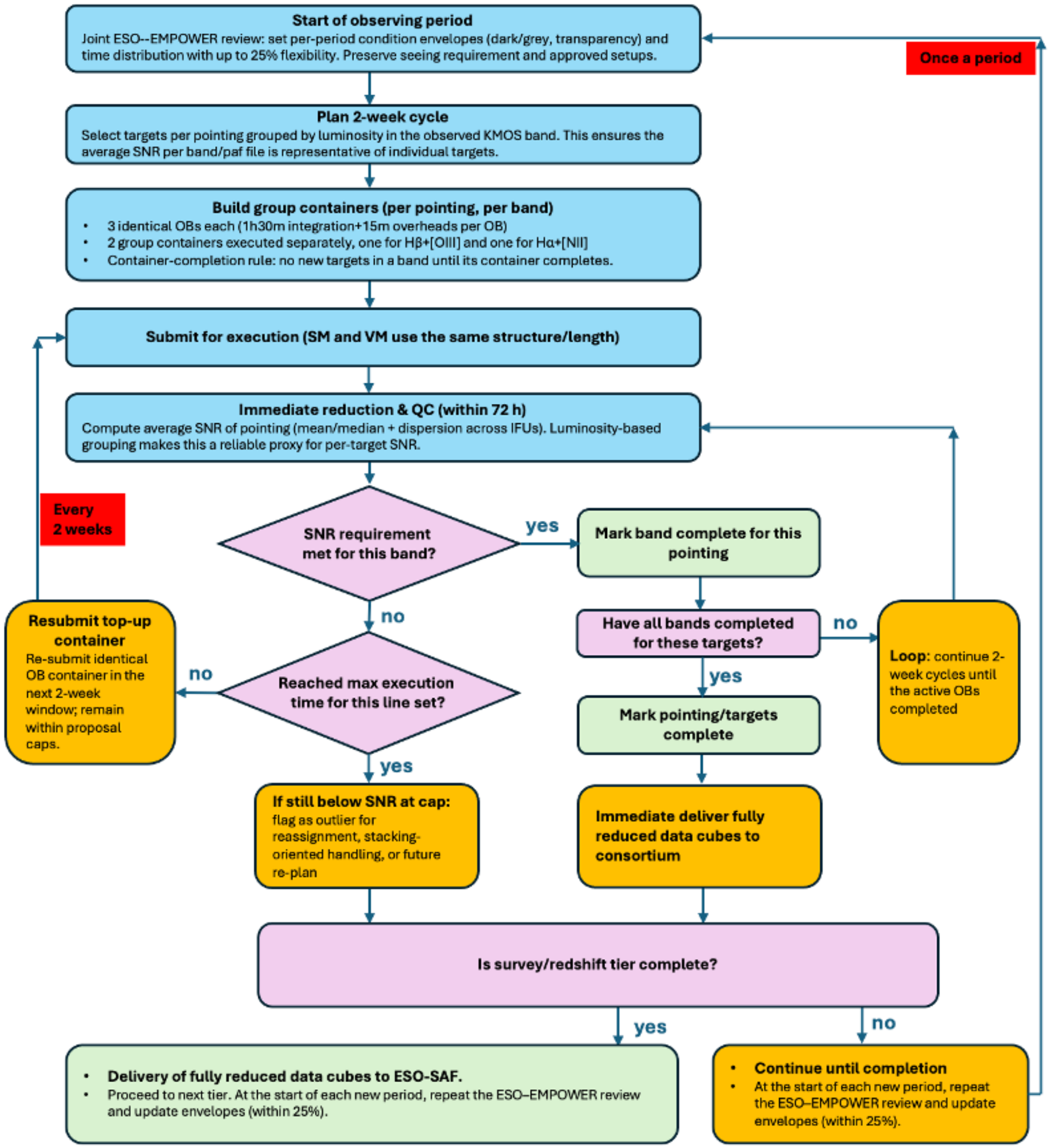

Figure 2: A block diagram synthesizing the survey strategy

time approved for that line set. Outliers (e.g. sources with underestimated extinction or line flux) are flagged for review and, where appropriate, scheduled for additional depth or reassigned to a pointing with more closely matched luminosity. The use of *identical OBs* within each container ensures that SNR assessments are stable and directly actionable.

Completion and resubmission.
Completion criteria and iteration. A pointing is declared *complete* when (i) both emission–line containers

(Hβ+[O III] and H +[N II]) have been executed, and (ii) the minimum SNR specified in the approved EMPOWER proposal is met at the band/paf level. If the threshold is achieved with the minimum–depth container (three identical long OBs), the pointing in that band is closed. If not, an identical top–up container is submitted in the next two–week cycle. Total exposure time is always capped by the maximum approved for the relevant line set. This *minimum* → *assessment* → *top-up* loop directs additional exposure only where it is scientifically warranted and prevents over-exposure.

Outliers. If, after reaching the maximum allowed execution time, the average SNR for a pointing remains below the threshold, the pointing is classified as an *outlier*. In that case, all individual targets within the pointing are reviewed: targets that meet the SNR requirement are marked as *completed*, while only those that fail to reach the minimum SNR are flagged as *outliers*.

Data hand-o and releases. Calibrated L1 cubes from successfully completed pointings are delivered to the Consortium for L2 product generation and initial science exploitation. The observe–reduce–assess cycle continues until a tier is complete. Upon completion of a tier, all enhanced L1 data (see Fig. 3) are submitted to ESO–SAF; L2 and L3 products will be released following publication of the associated papers (see Section 8 for more details).

The survey strategy is described schematically in Fig. 2.

2.1 Scheduling requirements

Service Mode and Visitor Mode Balance. The EMPOWER consortium is fully committed to training PhD students and early-career researchers and welcomes Visitor Mode (VM) as an educational opportunity. Indeed, the original proposal accepted by the OPC included a VM run for each period. That said, we need to set realistic expectations for KMOS as a training platform.

KMOS is operationally straightforward during execution: after a brief acquisition (a few minutes), the OB runs autonomously and there is essentially nothing to "do" at the instrument beyond monitoring. In practice, the most valuable activity for a visiting student during a KMOS exposure is to process previously observed data and perform immediate quality checks—precisely the same workflow that occurs in Service Mode (SM) when the data arrive at ESO the next morning in our scheme.

When problems do arise, they are typically instrumental or cryo-mechanical (e.g., coolhead, pick-off arm malfunctioning) and cannot be addressed by visitors. Effective troubleshooting requires the UT1 Night Astronomer and TIO, whose expertise and access to non-public procedures are indispensable. In other words, KMOS affords little interactive, hands-on learning at the telescope: routine operations are largely automated, and non-routine issues lie outside what a visitor can safely or meaningfully do.

Our proposed mode mix reflects this reality while preserving an educational component. We comply with the requirement that 30% of the time for each period must be in VM and the remaining 70% can be in SM mode, but the last period wich include a lower fraction of the observing time:

P116: 100% VM (established plan; dedicated to onboarding and procedures).
P117: 70% SM / 30% VM.
P118: 70% SM / 30% VM.
P119: 70% SM / 30% VM.
P120: all SM

The agreement with ESO is that, as part of the science policies, both OPO and the ESO KMOS-survey team will monitor the service mode (SM) time allocation to ensure that the accumulation of SM runs is kept at a manageable level. There will be an assessment on the maximum duration for the KMOS public surveys in terms of time- extension to a possible date in the future, after which all the carry-over time would be converted to VM and allocated as such.

Regarding the request for dark/grey time in P116/117, the EMPOWER Consortium is aware that this depends on the OPC allocation in P117. This will be communicated to the Survey team and iterated as needed to reach

Table 1: Scheduling requirements for Visitor mode runs

Period	Start/end date	Number of nights	Number of runs per period	Average run length	Requested month	Moon
P116	01-01-2026 to 30-04-2026	12 (90h)	2	6	–	dark/grey
P117*	01-05-2026 to 30-04-2027	14 (126)	2	7	–	dark/grey
P118*	01-05-2027 to 30-04-2028	14 (126h)	2	7	–	grey/full
P119*	01-05-2028 to 30-04-2029	8 (72h)	2	4	–	full
P120*	01-05-2029 to 30-04-2030	0	–	–	–	–

(*) Yearly cycle

a compromise in the scheduled time allocation, while preserving the three-tier structure of the survey.

Regarding the request for 100% SM in P120, the EMPOWER Consortium agrees that OPO and the ESO Survey Team will monitor the carry-over for the EMPOWER KMOS Public Survey, which may be scheduled in VM mode.

Cadence of OB submission in SM runs. Experience from 4MOST shows that very high operational flexibility—continuous OB resubmission with tight feedback loops—can yield strong science returns, but at the cost of considerable operational complexity. EMPOWER adopts a bounded, ESO–compatible alternative: a *biweekly* cadence with *identical, single–mode OBs*, all at the same priority and with targets equally prioritised within band/paf groups. This design preserves the key benefit of flexibility (rapid, data–driven top–ups) while keeping operations simple: Phase 2 remains straightforward because the OB template is fixed; queue handling does not require fine–grained priority tuning; and the workload for the KMOS SA is contained.

Application to SM and VM; contingencies and time accounting. The same operational procedure applies in **Service Mode (SM)** and **Visitor Mode (VM)**. Data are reduced immediately for quality control, and OBs are reobserved as needed to reach the required depth—never exceeding the maximum execution time approved in the proposal. Because KMOS OBs run largely autonomously after a brief acquisition, visiting students contribute meaningfully through rapid reduction and QC without altering efficiency or the underlying logic of the strategy.

Time accounting and contingencies. To protect survey completion, we distinguish instrument faults from weather losses:

Instrument malfunction. Failures due to mechanical issues or the cryogenic *coolhead*—the most frequent KMOS problems—should not be charged to the survey. When they occur during **SM**, they fall under standard ESO policy. When they occur during **VM**, we request explicit **ESO compensation of the lost time** so that VM nights remain scientifically equivalent to SM time.
Weather. Time lost to poor weather during **VM** is acknowledged as an intrinsic risk and is not subject to compensation.

This policy preserves the educational value of VM while ensuring that exogenous instrument downtime does not jeopardise survey efficiency or uniform depth.

2.2 Observing requirements

Flexibility in observing conditions.
At the start of each observing period, we request the possibility to **revise the distribution of observing constraints and time per run within a bounded envelope of up to 25%**, guided by the two–week feedback loop (average SNR per band/paf and the fraction of targets below threshold) and the period–end QC summary. Concretely, within a given period we may rebalance time among runs and between condition classes (e.g. dark versus grey) while preserving the approved seeing requirement and spectral setups. All revisions

remain strictly within the ranges approved in the proposal and *do not* alter the total time request or interfere with the broader UT1 schedule; a consolidated per–period update will be provided to ESO well before scheduling begins. A concrete demonstration of the flexibility we seek is our response to ESO's mandate to convert and reduce the originally proposed P116 SM+VM runs of 196h in dark and grey time into two VM runs of 90h. This adjustment allows execution primarily in dark time and only partially in grey time. Depending on the achieved SNR, we will need to reallocate the remaining used time in the subsequent period, matched to the most appropriate observing conditions despite initial uncertainty about their availability.

The EMPOWER consortium emphasises that this request is *non-disruptive* and fully compatible with standard ESO procedures. We will provide the revised per-run distribution and condition mix **well before ESO initiates period scheduling**, ensuring adequate lead time for planning. In practice, a rigid, unchangeable run-by-run allocation fixed at the outset of a multi-year survey is inefficient: period scheduling is, in any case, performed anew at the beginning of each period in light of the OPC outcomes at UT1. Allowing a modest (up to 25%) redistribution within the period therefore *does not* complicate operations, but *does* maximise survey efficiency by directing time to bands and pointings where it is actually needed to achieve uniform SNR.

Guardrails and commitments:

No change to the total time, instrument configuration, or the approved constraint ranges; seeing and line/band setups remain as proposed.

Revisions are period–level only (no ad hoc day-to-day changes) and are supplied in a single, consolidated update **prior** to schedule construction.

Redistribution is capped at **25%** among runs/condition classes within the same period and is fully traceable to the feedback-loop QC metrics.

The consortium maintains a single operational contact and adheres to the agreed two–week cadence and 72 h QC turnaround.

This bounded flexibility offers ESO a predictable planning framework while enabling EMPOWER to achieve homogeneous depth across the survey, thereby protecting stacking analyses and the long-term legacy value of the data set.

Collaborative framework.

We envisage EMPOWER as a pilot for a **flexible operational mode** that combines the predictability of standard Service Mode with the efficiency gains of a controlled feedback system. The consortium is committed to:

Delivering quality control assessments within 72 hours of OB execution, based on average SNR at the band level.

Maintaining a single operational contact point for ESO, thereby minimizing communication overhead.

Preparing stable and reusable OBs, identical within containers, to streamline resubmissions.

Strictly adhering to the maximum exposure times and container-completion rules defined in the approved proposal.

Summary.

This strategy combines efficiency, predictability, and scientific rigor. The 1 h 30 m OB format reduces overheads and simplifies scheduling; three-OB containers deliver a robust 4. h first-pass integration; and biweekly submissions provide a rapid, controlled feedback loop without operational overload. Band/paf–level SNR evaluation streamlines quality control and enables straightforward, container-based resubmission, while the symmetry between the two emission-line pairs (Hβ+[O III] and H +[N II]) ensures uniform coverage before new targets are started.

Building on the extragalactic 4MOST experience, EMPOWER adopts the *scientific advantages of flexibility*—a short feedback cycle and targeted top-ups—*without* the operational complexity intrinsic to 4MOST. Specifically, EMPOWER implements a *single observing mode* with *identical, fixed-length OBs* used uniformly throughout the survey, coupled to pre-agreed, bounded adjustments in observing conditions at the period level. This provides the desired flexibility to maximise science outcomes while remaining fully compatible with standard UT1 scheduling. In this way, EMPOWER offers a measured, low-complexity path that captures the benefits

Table 2: Observing requirements for SM

Period	Mode	Req Time (h) (incl. overheads)	Exp. Time (h)	Mean RA or RA range	Priority	Moon	Seeing ”	Spectral bands	Transpa-rency	Contai-ners
			– **SM runs** –							
P116	VM	42	31	3h30, 10h,	1	dark/grey	0.7	IZ/YJ	clear	# group
P116	VM	48	22	3h30, 10h,	1	dark/grey	0.7	IZ/YJ	clear	# group
P117*	SM	86	49	3h30, 10h,	1	dark	0.7	IZ	clear	# group
P117*	SM	30	17	0h22	1	dark	0.7	IZ	clear	# group
P117*	SM	30	17	5h28	1	dark	0.7	IZ	clear	# group
P117*	VM	63	38	3h30, 10h	1	dark	0.7	IZ	clear	# group
P117*	SM	72	40	3h30, 10h	1	grey	0.7	YJ	clear	# group
P117*	SM	15	9	0h22	1	grey	0.7	YJ	clear	# group
P117*	SM	15	9	5h28	1	grey	0.7	YJ	clear	# group
P117*	VM	63	35	3h30, 10h	1	grey	0.7	YJ	clear	# group
P117*	SM	87	48	3h30, 10h	1	full	0.7	HK	clear	# group
P118*	SM	90	50	3h30, 10h	1	grey	0.7	YJ	clear	# group
P118*	VM	63	35	3h30, 10h	1	grey	0.7	YJ	clear	# group
P118*	SM	15	8.5	22h15	1	grey	0.7	YJ	clear	# group
P118*	SM	15	8.5	20h40	1	grey	0.7	YJ	clear	# group
P118*	SM	138	76	3h30, 10h	1	full	0.7	H,K	clear	# group
P118*	SM	63	35	3h30, 10h	1	full	0.7	H,K	clear	# group
P119*	SM	12	7	22h15	1	full	0.7	H,K	clear	# group
P119*	SM	12	7	20h40	1	full	0.7	H,K	clear	# group
P119*	SM	225	125	3h30, 10h	1	full	0.7	H,K	clear	# group.
P119*	VM	72	40	3h30, 10h	1	full	0.7	H,K	clear	# group.
P120*	SM	40	22	11h40	1	full	0.7	H,K	clear	# group.
P120*	SM	50	28	10h	1	full	0.7	HK	clear	# group.

(*) Yearly cycle

Table 3: Cadence for the submission of the OBs and containers for SM runs

Period	Frequency biweekly/monthly etc.	Number of OBs	Average OBs properties
P116	–	–	–
P117*	biweekly	142	Free-dither mode
P118*	biweekly	182	Free-dither mode
P119*	biweekly	214	Free-dither mode
P120*	biweekly	109	Free-dither mode

(*) Yearly cycle

of flexible operations and avoids their drawbacks, delivering consistent, science-grade depth across the survey within the exposure limits defined in the approved proposal.

3 Survey data calibration needs

We have no special calibration requests. The KMOS calibration plan will suffice for the data calibration and processing.

4 Data reduction process

Overview. EMPOWER will adopt the ESO–KMOS pipeline as the core reduction engine, complemented by consortium routines for co-addition of repeated, dithered exposures and optional drizzling to enhance spatial sampling. The PIs and Co-Is include experienced KMOS users (including ESO experts) with a strong track record in observation preparation, pipeline operations, and IFS/NIR data processing. This ensures rapid reaction to instrument-specific issues (e.g. pick-off arms) and guarantees high-quality, homogeneous products for public release. The ESO pipeline has demonstrated robust sky subtraction and stable performance in previous GTO/LP programs.

4.1 Pipeline environment and execution

Reductions will be executed with the current ESO KMOS DRS using EDPS workflows. The pipeline performs: (i) detector and calibration processing (flat-fielding, wavelength calibration, illumination correction), (ii) cube reconstruction with sky subtraction, (iii) telluric modelling with `molecfit` and application of the transmission, and (iv) combination of corrected cubes into one cube per target. The principal recipes are `kmos_sci_red`, `kmos_molecfit_calctrans`, `kmos_molecfit_correct`, and `kmos_combine`. Master calibrations (MASTER_FLAT, XCAL/YCAL, LCAL, ILLUM_CORR, TELLURIC_GEN) are used as specified by ESO. Primary outputs are flux-calibrated 3D data cubes with error cubes and ancillary products (white-light images, exposure maps).

4.2 Calibration preparation

Master frames and look-up tables. Daytime and standard calibrations are reduced to produce the required masters: darks and flats; geometry look-up frames (XCAL/YCAL); wavelength solution (LCAL) from arc lamps; illumination correction; and response/telluric standard products (TELLURIC_GEN). These are certified through ESO QC procedures and tracked via FITS headers and QC flags.

Flux and telluric standards. Standard-star observations provide response curves and atmospheric transmission models. Telluric correction is performed by fitting a physical atmospheric model to the closest-in-time standard (`molecfit`), scaling for airmass differences, and applying the transmission to the science cubes; the pipeline records application status and QC flags for downstream checks.

4.3 Science reduction cascade

(i) kmos_sci_red: For each IFU with object data, the pipeline performs flat-fielding, wavelength calibration, sky subtraction, illumination correction, flux calibration, and single-exposure cube reconstruction. Spectral flexure is corrected using OH lines; error propagation yields a per-cube variance estimate.

(ii) kmos_molecfit_c lctr ns/correct: An atmospheric transmission model is derived from the standard-star spectrum and applied to each IFU/exposure.

(iii) kmos_combine: All exposures of the same target are combined into a single, wavelength/flux-calibrated cube. The combination handles spatial dithers and yields a science cube with a matched error cube; exposure maps are written to document depth per spaxel.

4.4 EMPOWER enhancements and validation

Co-addition of repeated, dithered observations. Beyond the standard `kmos_combine`, we apply consortium-tested routines to co-add repeated visits within the same bandpass and pointing, preserving WCS/LSF homogeneity and robust error propagation via empirical variance estimates across stacks (with outlier rejection).

Drizzling tests. For the first validation set (up to two pointings, ∼40 galaxies), we will test drizzling-based resampling (not part of the standard KMOS pipeline) to improve spatial sampling and contrast, while monitoring correlated-noise amplification. Drizzle parameters, PSF maps, and correlated-noise factors will be documented; adoption into production will be contingent on demonstrated QC gains over the baseline reconstruction.

Standardisation phase. The validation set will be reduced on the ESO workstation to confirm minimum accuracy standards and to lock the reference workflow (recipe parameters, combination policy, error treatment). Subsequently, reductions will be distributed across the Data Reduction Team using version-controlled parameter files to ensure strict reproducibility.

4.5 Quality control, homogenisation, and error handling

QC scope. We monitor (a) technical health (calibration availability/validity, header integrity, QC flags), (b) performance metrics (sky-subtraction residuals, telluric model adequacy, flux consistency across standards/arms), and (c) science validity (line S/N at fiducial radii, PSF/LSF characterisation).

Key quality controls (detector, sky, calibration, astrometry, PSF, LSF). To guarantee uniform, publication–grade data cubes, we will focus on the following control points:

1. **Detector behaviour.** We model and correct frame–level artefacts during master creation and `kmos_sci_red`, including slow bias drifts, alternating column/striping patterns, and the characteristic "picture–frame" imprint. Automated health checks (residual maps, power–spectrum diagnostics) flag problematic exposures for dedicated treatment or rejection.
2. **Removal of sky emission.** The baseline subtraction follows the validated pipeline, augmented by `skycorr` to minimise OH residuals. As a survey sky library accumulates, we will assess a PCA–style residual suppression (a KMOS–adapted variant of ZAP) at the cube level. Adoption will depend on objective metrics (RMS in OH regions, stability of integrated line fluxes) and the absence of artefacts.
3. **Astrometric solution.** The WCS is refined using the combined centroids of the three on–field stars (or a compact QSO when present), delivering sub–spaxel alignment across dithers/IFUs. Solutions are

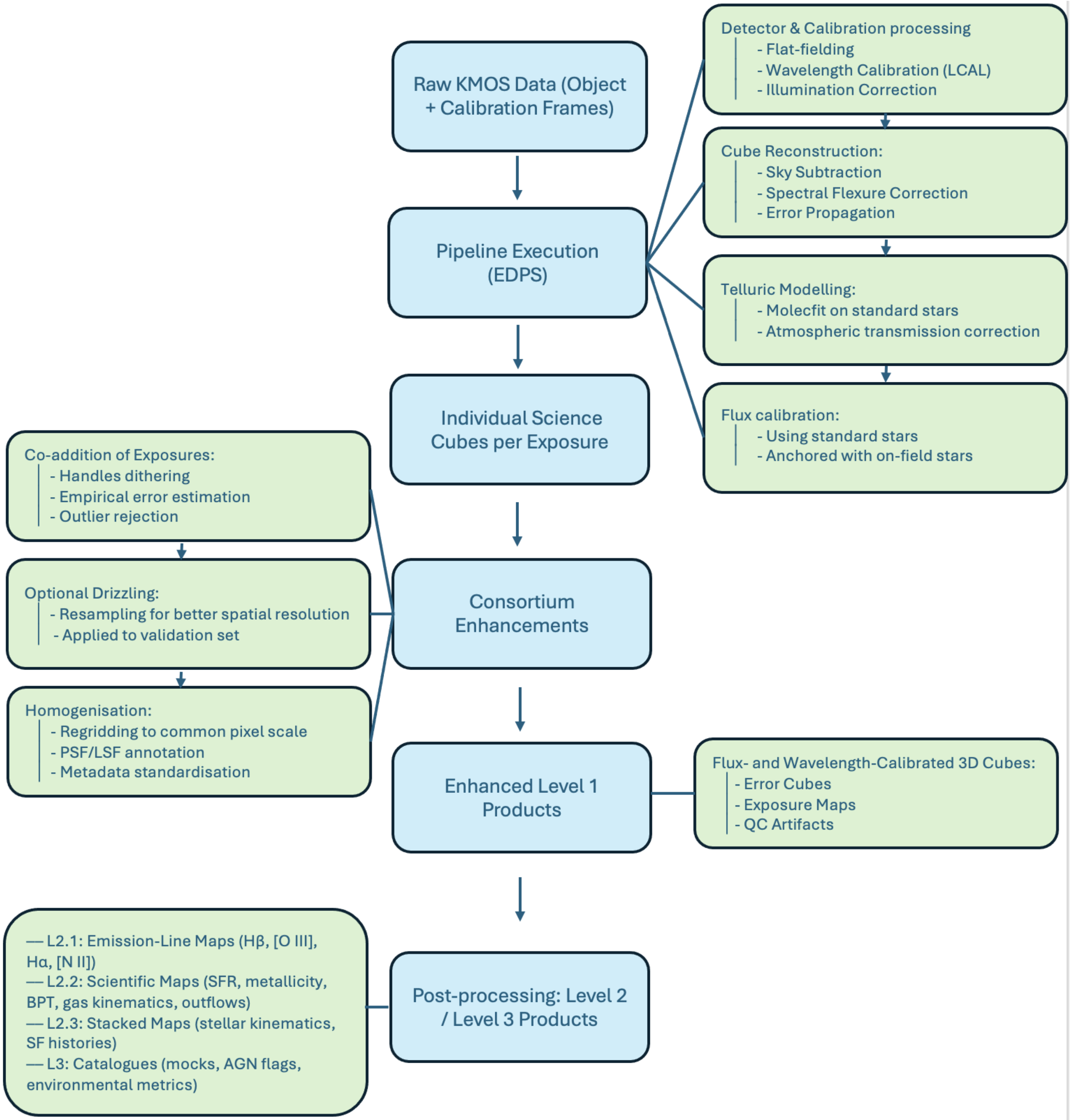

Figure 3: A block diagram synthesizing the data processing strategy . The description of Enhanced L1 data and L2.1, L2.2, L2.3 and L3 products is explained in Section 7.1 "Expected data products and deliverables".

cross–checked against external references (e.g. *Gaia*/HST), and the resulting WCS and uncertainties are written to the FITS headers.

4. **Empirical PSF characterisation.** The same field stars provide a per–pointing PSF (FWHM, ellipticity, wings), representative of the conditions of the science data. These PSF images are used to validate flux

calibration, to inform PSF–aware modelling (e.g. decomposition of outflow components), and to enable accurate aperture/encircled–energy corrections.

5. **Illumination and flux response.** Stars acquired in every object field anchor both the illumination correction and the absolute flux scale, allowing us to match telluric/flux standards to the conditions prevailing during the science exposures. This per–field calibration improves relative throughput across IFUs and stabilises the absolute response.
6. **Spectral resolution (LSF) mapping.** Although arc–line reconstructions yield a first–order dispersion solution, we derive a superior line–spread function by building and combining *sky cubes* and measuring OH line widths. This produces per–IFU, wavelength–dependent LSF maps that are propagated to downstream analysis (line fitting, kinematic modelling).

Error cubes. We retain pipeline error cubes and, for combined products, compute empirical variances at each spaxel/wavelength from stack dispersion (robust statistics) to capture inter-exposure systematics. This follows the DRS design emphasis on data-driven error assessment of combined products.

Homogenisation. All L1 cubes are regridded to common pixel scales per band, PSF-characterised, and annotated with uniform metadata (astrometry, spectral sampling, response version). A central librarian validates completeness/consistency prior to consortium release.

4.6 Post-processing to advanced products

From calibrated L1 cubes, we produce L2/L3 products with established tools. Emission-line modelling, multi-line kinematics, and diagnostics (BPT, metallicity via R3/N2) are derived with `q3dfit` (developed within the team) and companion routines for PSF-aware decomposition (e.g. outflows in [O III] and H). Stacking analyses (L2.3) generate resolved stellar/ISM maps at fixed physical scales with careful control of systematics (kinematic alignment, PSF matching, error propagation). Value-added L3 products (catalogues, environmental metrics, mock images or datacubes in the form of ancillary data) follow ESO Phase 3 conventions.

4.7 Data management and reproducibility

All reductions are tracked with recipe versions, parameter sets, and calibration provenance. Association maps (IFU→target), exposure maps, and QC PNGs are archived alongside cubes. We will maintain a dedicated catalogues whose structure will be discussed and optimized with the Phase 3 team, enabling searches by galaxy properties and links to non-ESO ancillary data, streamlining Phase 3 ingestion and community reuse.

5 FTEs and hardware capabilities devoted to data reduction and quality assessment

Computing infrastructure and release hub. All reductions and release builds will be executed on a **dedicated workstation at ESO** currently operated by the PI under the ERC CoG project LEVeR ("CLuster and group Environment as Vie*w*ed by eROSITA"). The workstation is a Dell Precision 7960 Rack. This is a high-end, 2U rack-mounted workstation engineered for demanding workloads such as simulation, data science, rendering, AI training, and large-scale engineering applications, with a max RAM capacity up to 2Tb. This system provides sufficient CPU/RAM and fast local storage to process and stage large KMOS data sets end–to–end. It will host the version–controlled reduction environment (ESO/EDPS KMOS DRS + EMPOWER add–ons), parameter files frozen for each period, and the full catalogue of QC artefacts. **All public data releases** (enhanced L1 and the subsequent L2/L3 products) will be assembled on this workstation to ensure consistency of software versions, metadata, and file formats prior to submission to ESO–SAF.

Governance. Overall oversight is provided by the **EMPOWER Steering Committee (SC)** composed of 8 permanent members and 4 rotating members drawn from different career stages (including at least one PhD student and one postdoc). The permanent members ensure continuity and policy stability; rotating members bring fresh perspectives and new methods. The SC arbitrates conflicts, sets scientific priorities for data exploitation, and endorses the distribution of projects across the collaboration.

Working groups and day–to–day operations. Day–to–day planning and project approval are delegated to **working groups (WGs)**, each led by a panel of three members with a *single Chair*. The panel fosters collaboration, resolves minor conflicts, and escalates unresolved issues to the SC when necessary. WG panels also act as the *publication board* for their remit. Chairs report decisions and progress to the full consortium on a regular cadence to solicit feedback.

The key WGs at survey start are:

Obs.Prep. (OBs preparation and submission): preparation of KARMA *paf* files, Phase 2 OBs, and two–week resubmissions.
Sam.Sel. (sample selection): definition and maintenance of the target lists. Membership may evolve with the active tier (redshift slice) and field, to leverage specific expertise.
DP. (data processing): routine reductions enabling the $\leq$ 3–working–day feedback loop; direct interface with Obs.Prep. to trigger top–up containers in the two–week cycle and to mark pointings complete. A subset of DP members focuses on *enhanced* L1 and L2.1 products (co–added emission–line maps) immediately after a pointing is completed. An additional segment focuses on compliance with Phase 3 and delivery to ESO-SAF.
Anc.D. (ancillary data): curation and homogenisation of external data products; construction of the ancillary catalogue for the Consortium and ESO–SAF.
Science WGs (x4). Topic–driven groups manage project distribution and coordination within their domains (e.g. environment & quenching; AGN/outflows; morphology & structure; stellar populations). Their Chairs coordinate with DP/Anc.D. for timely inputs and with the SC for policy and authorship guidance.

Team composition. EMPOWER brings together ∼90 members with balanced expertise across KMOS operations, large–survey design, NIR/IFS analysis, and the physics of quenching, AGN activity, environment, and CGM gas flows. The team is geographically diverse (about 31% Germany, 31% Italy, 11% Australia, 7% Chile, 6% USA, 6% rest of Europe, 5% UK, 3% Africa), gender–balanced (48% women), and includes 28% early–career researchers. Dedicated PhD projects will be offered for reduction and scientific exploitation of EMPOWER data. We foresee the following activity and WG distributions:

Sam.Sel. WG : P. Popesso, B. Vulcani, Y. Bahé, J. Kartaltepe, B. Poggianti, C. Sifón, M. Pannella, M. Hilton, A. Puglisi, V. Strazzullo, M. Polletta, P. Tozzi, R.-S. Remus, M. Lepore, G. De Lucia, M. Talia, M. Sargent, M. Bolzonella, A. Noble, T. Nanayakkara, B. Forrest, O. Cucciati
Obs.Prep WG: KMOS experts will optimize the observing strategy in P2 : P. Popesso, E. Sani. B. Häußler, J. Corral Santana, N. de Isidio, D. Mazengo, A. Dev, A. Puglisi and dedicated EMPOWER PhD students who will also take care of the VM runs.
DP WG routine activity: creation of data cubes through ESO KMOS pipeline and *drizzling* technique. **Team**: P. Popesso, E. Sani. B. Häußler, J. Corral Santana, N. de Isidio, V. Toptun, D. Mazengo, A. Dev, A. Puglisi, I. Marini and dedicated EMPOWER PhD students and PostDocs.
DP WP enahnaced L1/L2.1 products: P. Popesso, A. Puglisi, E. Sani. B. Häußler, J. Corral Santana, N. de Isidio, V. Toptun, D. Mazengo, M. Longhetti, F. Ditrani, S. Quai, L. Valenzuela and dedicated EMPOWER PhD students who will take care also of the VM runs.
DP WP enahnaced L2.2 products: dust corrected SFR, velocity/dispersion, BTP diagram, metallicity. **Team**: A. Puglisi, D. Cortese, A. de Cia, N. de Isidio, S. Ellison, A. Fraser-McKelvie, B. Häußler, A. Iovino, M. Longhetti, Maraston C., A. Mercurio, D. Mazengo, M. Pannella, M. Povic, P. Pozzetti, S, Quai, M. Talia, D. Thomas, M. Thorp, F. Valentino., A. Bongiorno
DP WP on Phase 3 compliance: P. Popesso, L. Coccato, V. Toptun, E. Sani, M. Cirasuolo, N. de Isidio, D. Mazengo.

DP WP stacked L2.3 products: P. Pozzetti, S. Quai, M. Talia, M, Bolzonella, S. Ellison, E. Emsellem, H. Kuntschner, A, Fraser-McKelvie, C. Sifon, P. Aucan Verdejo Cortez, V. Strazzullo, C. Maraston, D. Thomas, M. Thorp, F. Valentino, M. Longhetti

Anc.D. WG: EMPOWER will relate each galaxy data to ancillary information:

- *Galaxy groups membership and cosmic web classification*: C. Laigle, M. Magliocchetti, N. Malavasi, C. Gouin, A. Robotham, M. Bravo, E. Tempel, O. Cucciati, R. Gilli, C. Scarlata, A. Noble, K. Kraljic, C. Schmid, L. Davies. S. McGee.
- *LSS analysis and characterization of galaxy and gas content*: P. Popesso, V. Toptun, A. Biviano, V. Strazzullo, V. Biffi, K. Dolag, I. Marini, A. Dev, R. Gilli, M. Bravo, O. Cucciati, P. Rosati, A. Mercurio, M. Hilton, J. Hughes, N. Hatch, M. Donahue
- *Connection with upcoming LSS surveys (WAVES, MOONRISE, Euclid, COSMOS-Web)*: M. Dickinson, M. Bolzonella, B. S. Bellstadt, B. Catinella, L. Cortese, S. Driver, A. Robotham, J. Liske, P. Popesso, M. Magliocchetti, L. Pozzetti, M. Talia, S. Quai, C. Scarlata, C. Sifón. J. Kartaltepe
- *Cluster and proto-cluster properties and galaxy membership*: C. Sifón, M. Hilton, J. Hughes, P. Aucan Verdejo Cortez, T. Mroczkowski, V. Strazzullo, O. Cucciati, A. Noble, P. Tozzi, P. Rosati, E. Daddi, M. Polletta, B. Forrest, B. Lemaux
- *Galaxy kinematic asymmetry and perturbation analysis*: B. Poggianti, Y. Jaffe, B. Vulcani, M. Annunziatella, N. de Isidio, B. Catinella, L. Cortese
- *AGN classification and outflow analysis*: M. Brusa, E. Sani, G. Calistro-Rivera, R. Gilli, M. Magliocchetti, M. Povic, V. Toptun, D. Wylezalek, A. Bongiorno, M. Perna
- *Galaxy morphology*: C. Scarlata, M. Povic, N. de Isidio, D. Mazengo, C. Sifón, P. Aucan Verdejo Cortez, V. Strazzullo, M. Thorp, B. Häußler, A. Puglisi
- *Stellar continuum analysis*: C. Maraston, D. Thomas, T. Nanayakkara, L. Pozzetti, M. Talia, S. Quai, M. Longhetti, A. Iovino
- *QSO mini-survey*: Analysis of QSO continuum absorption: A. De Cia and a PhD student
- *Mock catalogs/observations and simulation predictions*: mock catalogs/observations created through *SimSpin* (developed by a team member) and based on state-of-the-art hydrodynamical simulations: K. Harborne, V. Biffi, K. Dolag, I. Marini, Valenzuela L. R.-S. Remus, S. Vladutesku-Zopp, C. Lagos, G. de Lucia, C. Gouin, T. Costa, Y. Bahe, D. Galarraga-Espinosa.

Scientific exploitation & Dissemination of the results: 4 dedicated WGs.

Outreach WG: A citizen science project with ESO-Supernova will involve visual classification of SFR maps to identify irregular and merging galaxies. **Team**: P. Popesso, I. Marini, K. Dolag, N. de Isidio, D. Mazengo, M. Povic, M. Brusa, Y. Jaffe

The full FTE declaration is provided in Table 4 at the end of this document.

Team and training. All team members involved in data reduction will be trained on a single toolchain (ESO/EDPS KMOS pipeline with the EMPOWER add-ons) and will follow one standard operating procedure (SOP) to guarantee homogeneity and high quality across the full data set. The full reduction environment (recipe versions, frozen parameter files, QC scripts) and the SOP will be finalised before the start of observations, so that onboarding is immediate and reproducible.

To ensure continuity despite natural personnel turnover (PhD students and postdocs), the Consortium will run two data-reduction workshops: (i) a *kick-o workshop* prior to the first observations, covering end-to-end reduction, QC metrics, and release preparation; and (ii) a *mid-survey workshop* to retrain newcomers, incorporate refinements (e.g. sky-residual handling, drizzling settings), and re-certify the team on the current SOP. Training includes hands-on exercises on the validation pointings, checklists for each pipeline stage, and brief certification tasks (successful reproduction of reference L1 cubes and QC metrics).

Operationally, at least three PhD students and two postdocs will rotate through a two-week shift schedule within the DP Working Group. while the Obs.Prep. Working group will take care of the OB preparation and resubmission. This rotation sustains the biweekly OB submission cycle and delivers QC decisions within ≤ 3 working days of execution for each container. All reductions use the same version-controlled parameter sets; changes to parameters or procedures are proposed and reviewed at WG level, and, if approved, propagated to the SOP and applied prospectively only.

This training and governance model—*one toolchain, one SOP, periodic (re)training, and a sta ed rotation*—ensures homogeneous processing, consistent QC, and stable turnaround throughout the survey.

6 Data quality assessment process

Scope and principles. Quality control (QC) in EMPOWER is integrated with the observing strategy and reduction workflow. QC is performed at four granularities: (i) *per exposure* (detector health and calibration availability), (ii) *per container* (three identical long OBs), (iii) *per pointing & band/paf* (SNR gating and homogeneity across IFUs), and (iv) *per tier/period* (trend analysis and condition rebalancing). We leverage the ESO–KMOS DRS QC1 parameters, recipe diagnostics, and product headers, and complement them with survey–specific metrics that reflect EMPOWER science requirements (uniform SNR at band/paf level, PSF-aware mapping, and robust error propagation). All QC artefacts (metrics, plots, exposure maps, WCS/PSF/LSF summaries) are archived alongside the data products and referenced in FITS keywords. These will be made available if necessary in the format suggested by the ESO Phase 3 teams.

6.1 Quality control criteria

Acquisition/conditions. Consistency with approved constraints (seeing better then 0.7 arcsec, transparency class, dark/grey) is verified from headers and Paranal logs. Pointings violating hard constraints are tagged for re-observation.

Detector/calibration health. We check master calibration provenance and QC1 flags; frames with bias drifts, alternating column/picture–frame noise, or saturated flats trigger re–reduction or rejection. Invalid/inactive IFUs (`ARMi NOTUSED`) are tracked to ensure completeness.

Wavelength/telluric/flux. The DRS wavelength solution and `molecfit` diagnostics are inspected; typical telluric fit RMS < 0.04 is used as a reference, and large airmass/ t to standards are flagged. Flux consistency is checked across standards and field stars.

Sky subtraction. Residual OH structure is quantified in sky windows before/after `skycorr`. If the survey sky library permits, a PCA–style residual suppression (KMOS–adapted ZAP) is evaluated on a validation subset and adopted only when it reduces residual RMS without biasing line fluxes. Known edge cases (long DIT, rapidly varying sky) are explicitly monitored.

Astrometry. WCS is refined using the three on–field stars (or compact QSO) per pointing; residuals are measured against Gaia/HST references and written to headers. Cross–IFU alignment is required to be sub–spaxel.

PSF/seeing. Per–pointing PSF images (from the same field stars) deliver FWHM, ellipticity, and encircled–energy curves; these will also serve for image realignment before stacking the data in deep exposure of different OBs.

Spectral resolution In addition to arc–based dispersion, we build combined sky cubes and measure OH line widths to produce wavelength–dependent, per–IFU LSF maps that are propagated to line–fitting/kinematics.

Noise and errors. We retain pipeline error cubes and augment them with empirical variances from the stack dispersion where $N_{\rm xp} \geq 3$ (otherwise running RMS along λ), following the DRS conventions for combined cubes.

SNR gate at band/paf level. Targets are grouped by luminosity in the observed KMOS band within each pointing so that the *average* SNR at band/paf is representative of per–target SNR. For each container, we compute a central SNR estimator (mean/median) and dispersion across IFUs. A pointing/band is *complete* if the central SNR meets the specification and no more than a small fraction (typically 10–15%) of IFUs fall below tolerance; otherwise, a top–up container is scheduled in the next two–week cycle (capped by proposal limits). This criterion is identical in SM and VM.

6.2 Control samples for validation

Internal repeats. (a) The first two pointings (validation set) are fully re–reduced at ESO workstations to pin the reference workflow; (b) a controlled subset (∼10%) of later pointings is repeated to characterise repeatability in fluxes, kinematics, and SNR.

On–field stars/QSOs. Three stars (or a compact QSO) in each field are used for telluric/flux cross–checks, PSF characterisation, and WCS validation.

Sky cubes. Dedicated sky exposures are combined to validate the LSF maps and to quantify any residuals introduced by sky–residual suppression.

External references. Where available, integrated line fluxes/widths are compared with archival spectroscopy (e.g. previous KMOS GTO/LP or large surveys in the same fields) to detect gross calibration drifts. The DRS QC web resources are also consulted for global performance context.

6.3 QA procedures and governance

Turnaround and gates. Within 3 working days of execution, each container is reduced and QC'd; outcomes are GREEN (complete), YELLOW (top–up required), or RED (non–conformant: re–observe or re–reduce). The YELLOW/RED logic triggers automatic tickets to the Obs.Prep. WG. The biweekly cycle ensures timely top–ups and prevents backlog.

Homogenisation. All L1 cubes are mapped to common spatial/spectral grids per band, PSF–characterised, and annotated with uniform metadata (astrometry, sampling, response version). Exposure maps and QC summaries are bundled with deliverables.

Non–conformance handling. Detector effects, poor sky subtraction, mis–matched tellurics, or WCS/PSF failures produce RED status; data are re–reduced with adjusted parameters (e.g. alternative sky association, refined `molecfit` kernel, exclusion of bad frames) and, if needed, re–observed. Instrument malfunctions (e.g. pick–off arms, coolhead) are documented and handled per policy.

6.4 Software and tools

Core processing uses the ESO–KMOS DRS via EDPS; standard outputs include flux–calibrated cubes, error cubes, QC1 parameters, exposure maps, and preview plots. Survey–specific steps employ `skycorr`, a KMOS–adapted ZAP residual suppressor (validation subset), co–addition/drizzling routines, and PSF/LSF/WCS measurement scripts; scientific mapping uses `q3dfit` for line fitting and diagnostics. Interactive inspection is done in QFitsView (ESO). All recipe versions/parameters are tracked in headers and sidecar configuration files, following the guidelines provided by the ESO Phase3 team.

6.5 Validation of tools and procedures

Pipeline validation. The pipeline's own test suite (`make check`) is run on the consortium build to confirm environment integrity; the validation set (two pointings) is processed end–to–end to freeze parameter files and sign–off the reference workflow.

Sky–residual strategy. We compare `skycorr` vs. ZAP–style residual suppression on matched exposures, evaluating (i) RMS in OH windows, (ii) stability of integrated line fluxes/widths in bright sources, (iii) absence of negative bowls/over–subtraction. Adoption requires statistically significant improvement with no science bias.

Drizzling. Drizzle parameters (kernel, pixfrac, output scale) are tuned on the validation set using PSF metrics, contrast in narrowband line maps, and measured noise correlation. Drizzling is adopted only when net gains outweigh correlated–noise penalties.

Release rehearsal. Before each annual data release, a release rehearsal will be conducted to generate a frozen release candidate dataset, including complete QC artefacts and Phase 3–compliant metadata. This rehearsal will allow the team to submit the dataset for preliminary review and to receive any feedback from the ESO–SAF team prior to building the full release. A small-scale rehearsal on a representative subset of data is also planned, depending on the availability of ESO–SAF, before any resubmission (for instance, after reprocessing or the creation of updated products). This stepwise approach will facilitate the injection of data into the Phase 3 system, help identify and resolve potential technical issues early, and ensure a smooth and efficient full data release process.

7 External Data Products and Phase 3 compliance

7.1 Expected data products and deliverables

The PIs and Co-Is have extensive experience with the ESO archive and Phase 3 ADP preparation (e.g. VIMOS–GOODS–S, LEGA–C, VANDELS). If possible and acceptable to ESO-SAF, we plan to collaborative design and maintain a KMOS-dedicated sub-database to enable searches by galaxy properties and to link EMPOWER data with ancillary datasets not generated from ESO instruments. The Consortium will produce the following ADP levels:

1. **Level 1 (L1) Calibrated datacubes** — Enhanced, flux-calibrated IFS cubes that supersede the standard ESO L1, released annually. *Phase 3 category:* `PRODCATG=SCIENCE CUBE IFS`. Required ancillary products include exposure maps and white-light images where applicable.
2. **Level 2 (L2) value-added maps**
   L2.1: Resolved and modelled emission-line maps (Hβ, [O III], H , [N II]) from the L1 cubes (flux, continuum, line width, uncertainties). *Phase 3 category:* `SCIENCE IMAGE` (units and WCS per standard).
   L2.2: Science-grade maps: dust-corrected SFR, BPT diagnostics, gas kinematics (velocity, dispersion), gas metallicities (R3, N2), and 3D PSF-decomposed outflows. *Phase 3 category:* `SCIENCE IMAGE` (with physically correct units; kinematic maps use velocity/dispersion units as prescribed).
   L2.3 (stacking): Stacked resolved products for low-SNR subsets (stellar kinematics/dispersion, stellar metallicities, star-formation histories) with robust error propagation.
3. **Level 3 (L3) catalogues and value-added products in the form of ancillary data** — Source/catalogue BINTABLEs with object-level measurements (integrated line fluxes, gradients, PSF/LSF metrics), environment classifications (group membership, filament/node), AGN/morphology flags, and mock catalogues/ observations. *Phase 3 category:* `CATALOG` (and `SRCTBL` where applicable), with VO-compliant column metadata (TTYPE/ TUNIT/ TCOMM, UCDs).

EMPOWER is designed as a legacy dataset: a spatially resolved atlas of $\sim$900 galaxies spanning a broad range of environments and redshifts, enriched by extensive ancillary data. Beyond L1 and L2.2 maps, we will provide integrated catalogues, environmental metrics, mock datasets (simulated images and catalogs in the form of ancillary data), and QSO sightlines, establishing EMPOWER as a reference dataset. Integration with MOONRISE, 4MOST, Euclid, and COSMOS–Web will maximise long-term impact and community uptake.

The EMPOWER Cosortium is aware that the Phase3 team will contact the PI to start a conversation at the earliest on the object identifiers, catalogue structure and provenance. These metadata and data structure must be agreed and implemented once the data acquisition starts.

7.2 Scope and compliance plan

EMPOWER will deliver Advanced Data Products (ADPs) through ESO Phase 3. We will (i) adopt the ESO Science Data Products (SDP) Standard for all file formats and metadata; (ii) validate every file with the Phase 3 Validator and `fitsverify` prior to submission; (iii) register and manage each release via the Phase 3 Release Manager; (iv) transfer data through the Phase 3 FTP staging area; and (v) supply a Data Release Description

(DRD) documenting content, provenance, calibration/reduction methods, data quality, and formats. Mandatory FITS integrity keywords (`CHECKSUM`, `DATASUM`) and Phase 3 characterisation keywords will be present in all HDUs; provenance, processing software, and product category will be encoded via the prescribed keyword set (e.g. `PROCSOFT`, `PRODCATG`, provenance keywords). Finalisation occurs after ESO's format checks and Phase 3 team in depth validation.

7.3 Documentation, versioning, and reprocessing

Each release is accompanied by a DRD (PDF) and a machine-readable changelog. The `PROCSOFT` and version/date keywords are updated on reprocessing; file-level associations preserve links between L1 and derived L2/L3 products. Any evolution of reduction parameters (e.g. adoption of improved sky-residual suppression or drizzle settings) will be documented and, where appropriate, older products deprecated with clear supersession notes in the DRD and headers.

7.4 Ancillary data and VO/Archive integration

Ancillary catalogues and cross-identifications are distributed as Phase 3 catalogues with full column descriptors and UCDs, enabling discovery and programmatic access via the ESO Archive interfaces and VO tools. The link between the ancillary data and the main science products will be recorded.

8 Timeline delivery of data products to the ESO archive

The observations will be structured to target one redshift slice per year, producing three independent sub-surveys. Each sub-survey will be fully analyzable on its own, enabling early scientific returns while the full EMPOWER Legacy dataset is being compiled. Thanks to extensive ancillary data in COSMOS, GOODS-S, and cluster fields, key parameters such as AGN classification, galaxy morphology, and environmental context will be immediately available. Each sub-survey will address a key question in galaxy evolution:

$z \sim 0.75$: How do feedback, mass and environment co-regulate star formation?
$z \sim 1.6$: When and where do galaxies begin to quench in the Cosmic Web?
$z \sim 2.3$: How is SF regulated in the forming Cosmic Web at high-z?

As shown in the chart of Fig. 4, the initial characterization of each sample will rely on available ancillary data. As EMPOWER progresses, complementary surveys (MOONRISE, WAVES, Euclid, COSMOS-Web) will enhance the environmental and structural mapping within each redshift slice. The proposed Phase 3 data delivery schedule is summarized below:

1. **L1 data products**: Released within one year after each sub-survey is completed.
2. **L2.1 and L2.2 data products**: Delivered at least one year after sub-survey completion to enable scientific validation and exploitation. Delivery will occur upon acceptance of the corresponding peer-reviewed paper. L2.3 stacked products will follow, depending on statistical quality and SNR. Delivery will occur upon acceptance of the corresponding peer-reviewed paper.
3. **Level 3 data products**: Preparation will begin during observations. Mock catalogs, simulated images and related products will be delivered following relevant publications in the form of ancillary data. AGN, morphology, and environmental classifications will be derived from current ancillary datasets and updated as MOONRISE, WAVES, and Euclid results become available. Delivery will occur upon acceptance of the corresponding peer-reviewed paper.

This phased strategy ensures that each redshift slice serves as a self-contained, high-impact dataset, enabling early community science and providing timely feedback to guide and optimize subsequent observations.

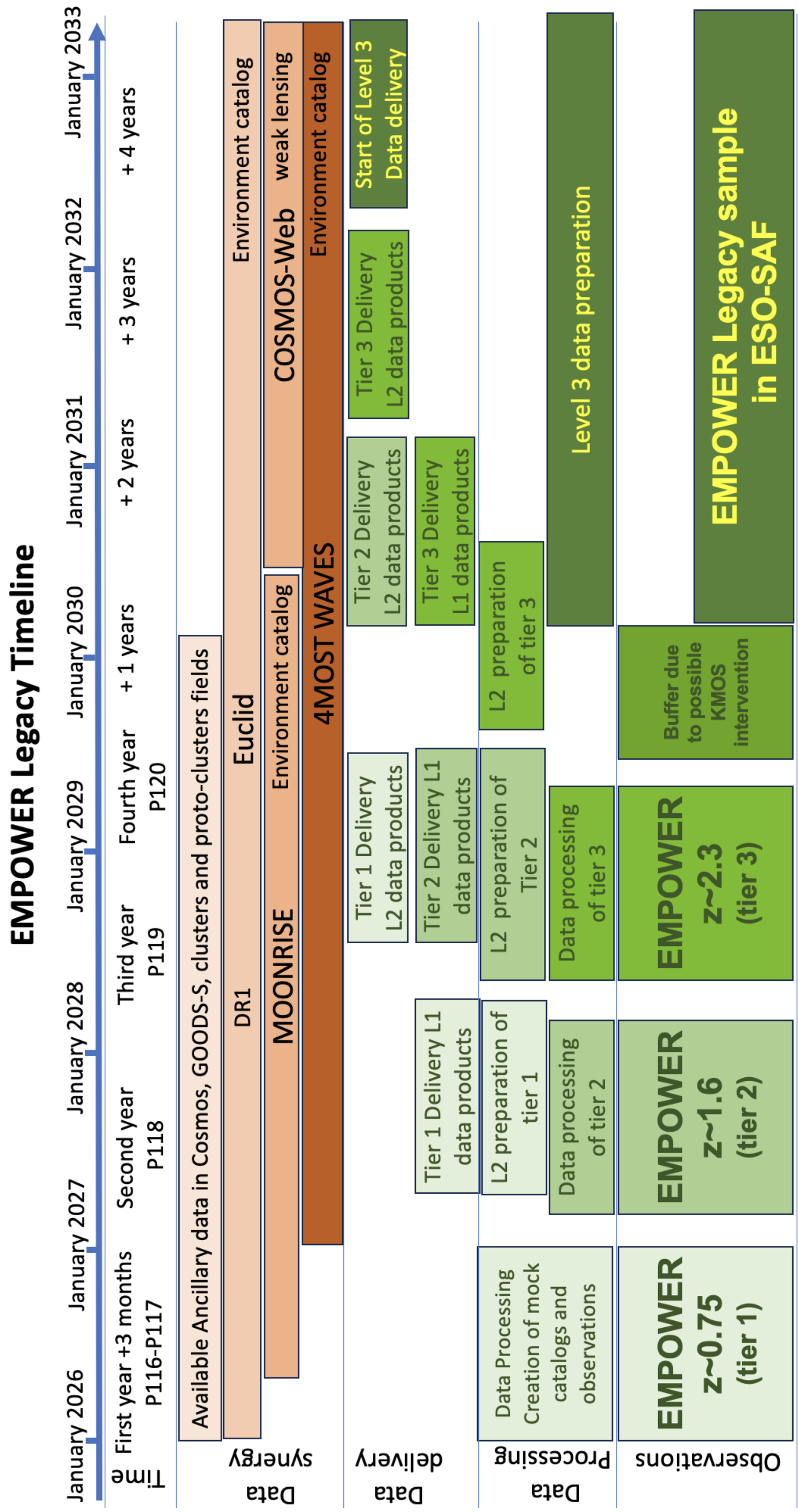

Figure 4: Chart synthesizing the survey timeline

Table 4: EMPOWER Consortium roles and fractional FTE allocations.

Name	Function	A liation	Country	FTE
P. Popesso	PI/Obs.Prep./Sam.Sel./DP	European Soutrhern Observatory	DE	0.3
Y. Bahé	Sam.Sel./Anc.D.	University of Nottingham	UK	0.2
I. Marini	Obs./ DP/Anc.D.	ESO	DE	0.2
V. Toptun	Obs/DP	ESO	DE	0.2
N. de Is´dio	Obs./DP	ESO	DE	0.2
M. Bravo	Sam.Sel./Anc.D.	McMaster University	CAN	0.2
D. Mazengo	Obs./DP	European Southern Observatory	DE	0.2
B. Häußler	Obs./DP	ESO	CL	0.2
E. Sani	Obs./DP	ESO	CL	0.2
M. Curti	Sam.Sel./Anc.D./DP	ESO	DE	0.2
B. Vulcani	Sam.Sel./Obs./Anc.D.	INAF-OAPd	IT	0.15
G. De Lucia	Sam.Sel./Anc.D.	INAF	IT	0.15
M. Cirasuolo	Sam.Sel./Anc.D./DP	ESO	DE	0.1
L. Coccato	DP	ESO	DE	0.1
J. Corral-Santana	Obs.Prep./Obs./DP	European Southern Observatory	CL	0.1
M. Magliocchetti	Sam.Sel./Anc.D.	INAF	IT	0.1
C. Sifón	Sam.Sel./Obs./Anc.D.	PUCV	CL	0.1
M. Longhetti	Obs./DP	INAF	IT	0.1
F. Ditrani	Obs./DP	INAF	IT	0.1
J, Kartaltepe	Sam.Sel./Obs./Anc.D.	Rochester IT	USA	0.1
M. Sargent	Sam.Sel./Anc.D.	EPFL	CH	0.1
S. Vladutescu-Zopp	DP/Anc.D.	LMU	DE	0.1
C. Schimd	Anc.D.	LAM	FR	0.1
B. Forrest	Sam.Sel./Obs./Anc.D.	UC Davis	USA	0.1
A. Noble	Sam.Sel./Anc.D.	Arizona State University	USA	0.1
L. Pozzetti	DP/Anc.D./DP	INAF	IT	0.1
V. Strazzullo	Sam.Sel./Obs./Anc.D.	INAF	IT	0.1
R. Gilli	Sam.Sel./Anc.D.	INAF	IT	0.1
M. Thorp	DP/Anc.D.	AIfA - Bonn University	DE	0.1
L. Valenzuela	VM Obs./DP	LMU	DE	0.1
B.C. Lemaux	Sam.Sel./Obs./Anc.D.	NOIRLab	USA	0.1
O. Cucciati	Sam.Sel./Obs./Anc.D.	INAF	IT	0.1
C. Laigle	Anc.D.	IAP	FR	0.1
B. Poggianti	Sam.Sel./Anc.D.	INAF	IT	0.1

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Name	Function (WG)	A liation	Country	FTE
M. Pannella	/Obs.Prep./Obs./Anc.D./DP	INAF	IT	0.1
M. Bolzonella	Sam.Sel./Obs./Anc.D.	INAF	IT	0.1
M. Talia	Sam.Sel./Obs./Anc.D.	Bologna University	IT	0.1
A. Puglisi	Obs.Prep./Obs./DP	Southamtpon University	UK	0.1
D. Galárraga-Espinosa	Anc.D.	Kavli-IPMU	JP	0.1
M. Brusa	Sam.Sel./Anc.D.	University of Bologna	IT	0.1
K. Dolag	Sam.Sel./Obs./Anc.D.	LMU	DE	0.1
C. Lagos	Sam.Sel./Obs./Anc.D.	ICRAR	DE	0.1
R.S. Remus	Sam.Sel./Obs./Anc.D.	LMU	DE	0.1
C. Maraston	Sam.Sel./Anc.D./DP	Portsmouth University	UK	0.1
D. Thomas	Sam.Sel./Anc.D./DP	Portsmouth University	UK	0.1
K. Harborne	Mock catalogs	Durham University	UK	0.1
M. Polletta	Sam.Sel./Anc.D.	INAF - IASF Milan	IT	0.1
D. Cortese	Sam.Sel./Obs./Anc.D./DP	ICRAR	AU	0.1
B. Catinella	Sam.Sel./Obs./Anc.D./DP	ICRAR	AU	0.1
N. Malavasi	Anc.D./DP	MPE	DE	0.1
T. Costa	Anc.D.	Newcastle university	UK	0.1
D. Wylezalek	Sam.Sel./Obs./Anc.D./DP	MPIA	DE	0.1
M. Hilton	Sam.Sel./Obs./Anc.D.	Wits Centre for Astrophysics	SA	0.05
K. Kraljic	Anc.D.	University of Strasbourg	FR	0.05
L. Davies	Anc.D.	ICRAR	AU	0.05
S. McGee	Anc.D./DP	University of Birmingham	UK	0.05
A. Biviano	Anc.D.	INAF-Triest	IT	0.05
P. Rosati	Anc.D.	University of Triest	IT	0.05
A. Mercurio	Anc.D.	University of Salerno	IT	0.05
J. Hughes	Sam.Sel./Anc.D.	Rutgers University	USA	0.05
N. Hatch	Anc.D.	Notthingam University	UK	0.05
M. Donahue	Anc.D.	Michigan University	USA	0.05
M. Dickinson	Anc.D.	NOIRLab	USA	0.05
S. Bellstadt	Anc.D.	ICRAR	AU	0.05
S. Driver	Anc.D.	ICRAR	AU	0.05
A. Robotham	Anc.D.	ICRAR	AU	0.05
J. Liske	Anc.D.	Hamburg University	DE	0.05
C. Scarlata	Anc.D.	Minnesota University	USA	0.05
P. Aucan Verdejo Cortez	Anc.D.	PUCV	CL	0.05
P. Tozzi	Anc.D.	INAF-Florence	IT	0.05

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Name	Function (WG)	A liation	Country	FTE
E. Daddi	Anc.D.	CEA Saclay	FR	0.05
M. Annunziatella	Anc.D.	CAB	ES	0.05
G. Calistro-Rivera	Anc.D.	DLR	DE	0.05
M. Povic	Anc.D.	ESSTI	ET	0.05
A. Bongiorno	Anc.D.	INAF-Rom	IT	0.05
A. De Cia	Sam.Sel./Anc.D.	ESO	DE	0.05
C. Gouin	Anc.D.	Paris	FR	0.05
E. Emsellem	Anc.D.	ESO	DE	0.05

Table 4: Workload and FTE distribution in the Consortium