The MegaCam CFHT CS – StarFEAST and POLU

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We propose two MegaCam CFHT Community Surveys covering a broad range of science: star formation, galaxy evolution, large-scale structure, and cosmology. Our two surveys use narrow- and medium-band filters, an approach that will ensure that CFHT stays relevant even while Rubin/LSST is surveying in broad-band filters.

The first survey, **StarFEAST**, is aimed at studying the relationship between the star formation process and its surrounding environment (infall, feedback, external perturbations) at different scales, from individual star-forming complexes within the Milky Way, in well resolved Local Group galaxies, in nearby large scale structures, and in the distant ($z \simeq 4.5$) Universe. The selected targets will be observed in a narrow-band Hα filter to derive the physical properties of the ionising radiation, tightly related to the star formation activity of the emitting regions with pointed observations over more than 400 deg^2. Milky Way and local galaxies will also be imaged in the narrow-band [OIII] and [SII] filters to identify the dominant radiation sources responsible for the ionisation of the gas. The data will be used to study the distribution of the ionising radiation, quantify the activity of star formation in different environments and at different scales, from individual HII regions at pc scales, up to cosmological scales. Galaxies in local large-scale structures (the Great Wall and Perseus–Pisces Supercluster) will be selected to sample density environments from rich clusters such as Coma and A1367, to groups of intermediate halo mass, down to filaments and walls. Their comparative analysis will be crucial to quantify the role of the environment on the star formation activity of galaxies. The deep narrow-band images will also be used to detect low surface brightness filaments of gas produced during the interactions of galaxies with their surrounding environment, enabling the identification of the dominant perturbing mechanism in different density regions. They will also be used to identify gas expelled from massive stars in local star-forming complexes, or from the nucleus of massive galaxies, and thus study the feedback process at different scales.

The second survey, **POLU**, will cover approximately 4200 deg^2 across both galactic caps and focus on exploring the high-redshift Universe ($z > 2$). By imaging this area with two medium-band filters, covering $4000-4260$Å and $4260-4520$Å, the survey will enable the selection of Lyman-α Emitters (LAEs) in the redshift range $2.3 < z < 2.7$ and Lyman Break Galaxies (LBGs) in the range $2.7 < z < 3.4$. POLU will be part of a broader coordinated effort involving multiple telescopes, including CFHT, Blanco, and Subaru, together covering around 5000 deg^2 with five medium-band filters in the spectral range 4000Å to 5300Å. The scientific motivation is driven by recent results from several cosmological probes suggesting that dark energy (DE) may evolve over cosmic time, a possibility that challenges standard cosmological models. This motivates the need for new high-redshift datasets capable of providing stronger constraints. In this context, the survey will provide more than three million LAEs and LBGs as targets for the DESI-II spectroscopic program starting in 2029, enabling tests of primordial physics and constraints on DE during the matter-dominated era. As a standalone dataset, these samples will already enable robust studies of primordial non-Gaussianity through their angular auto-correlations and cross-correlations with CMB lensing. Additionally, POLU will improve photometric redshift calibration for weak lensing surveys such as Rubin and Euclid, and will also contribute to studies of dark matter in dwarf galaxies.

This proposal will require **700 observing nights in dark and grey time, 270 for StarFEAST and 430 for POLU.** These surveys are of interest for a wide community, covering science related to the ISM, stellar evolution, galaxy evolution, large-scale structure, high-z galaxies, and cosmology. Using narrow- and medium-band imaging will distinguish CFHT from other telescopes, generating a uniquely valuable reference imaging survey for years to come.

Science justification

1. Narrow and medium band filters as a new vantage point to study the extragalactic Universe

We propose a CFHT Community Survey that will complement ground-based broad-band (BB) surveys such as LSST or space-based BB surveys such as Euclid, building on a sky area already mapped to great depth by DES and UNIONS. The project comprises two surveys (see Fig. 3 for footprints), one which takes advantage of narrow-band (NB) filters, **StarFEAST**[1], and the other of medium-band (MB) filters, **POLU**[2]. Collectively, these surveys will advance our understanding of the Universe's structure and geometry, as well as the baryon cycle driving cosmic structure and galaxy formation.

The study of large samples of galaxies detected in wide field, multi-frequency surveys, both in the local Universe and at high redshift, has led to significant progress towards an understanding of the processes at play in galaxy evolution. The sensitivity, angular and spectral resolutions of these surveys have been fundamental in tracing the physical properties of different galaxy components – e.g., stellar populations, multiphase gas, metals, dust, and dark matter – whose content and distribution are tightly connected to the galaxy activity. These achievements have been mirrored by advances in the realism of numerical simulations of galaxy formation (e.g. Pillepich *et al.* 2018; Vogelsberger *et al.* 2020). Both observations and simulations consistently point to two main factors as key drivers of galaxy evolution: the secular evolution tightly related to the dynamical mass of the system (Cowie *et al.* 1996) and the environment in which galaxies reside (Boselli & Gavazzi 2006; Peng *et al.* 2010). The relative importance of these two factors over cosmic time and mass scales, however, remains elusive. Further progress hinges on the characterisation of astrophysical processes, including gas dynamics, radiative cooling, star formation, and stellar/AGN feedback. Among these, a crucial role is played by star formation, the process which transforms the gas reservoir into new stars, self-regulating cooling and collapse through the injection of thermal or mechanical energy, metals, and dust (Lada 1985). At galactic scales, the process of star formation is modulated by the galaxy environment through gravitational (tidal interactions: Merritt 1983; harassment: Moore *et al.* 1998) and hydrodynamic interactions (ram pressure stripping (RPS): Poggianti *et al.* 2017; Boselli *et al.* 2022; thermal evaporation: Cowie & Songaila 1977; starvation: Bekki *et al.* 2002). StarFEAST, with its NB filter sensitivity, will address these questions in a large range of spatial and mass scales, and environments.

At larger, i.e. cosmological, scales, wide galaxy surveys offer a unique opportunity to advance our understanding of DE, inflation and dark matter. Over the past two years, the Dark Energy Spectroscopic Instrument (DESI) has released two sets of cosmological results, revealing evidence for dynamical DE (Adame *et al.* 2025, Abdul-Karim *et al.* 2025). This has been recognised as one of the most significant breakthroughs in physics in 2024 and 2025; each of the two articles has already been cited more than 1,000 times. Mapping the $z > 2$ Universe will provide significant improvements in the knowledge of DE in the matter-dominated era. In order to explore this uncharted territory, POLU will use two MB filters to select novel matter tracers, namely Lyman Break Galaxies (LBG) and galaxies with strong Lyman-α emission known as Lyα Emitters (LAE). Those LAEs and LBGs would be followed up with DESI, as part of the DESI-II program, to measure their redshift, or used directly to study their angular correlation and their cross-correlation with CMB lensing.

We propose two wide-field NB and MB imaging surveys to investigate galaxy formation and cosmology. This project is a timely and scientifically impactful complement to the BB imaging soon-to-be provided by LSST, and is perfectly suited for a Community Survey (CS) since it covers a wide range of topics of major interest for the ISM, stellar evolution, galaxy evolution, large-scale structure, and cosmology, all key areas of interest for the French and Canadian communities. A detailed description of the scientific programs of the two projects follows, along with an analysis of their synergies.

1.1 Scientific Goals of the StarFEAST Survey

StarFEAST is a large, comprehensive, and deep narrow-band (NB) imaging survey of different environments, from star forming complexes within the Milky Way (MW), to local galaxies (LG), in large scale structures including rich clusters, groups of intermediate mass, down to filaments, in the local Universe and at cosmological distances. These data will uncover the physical drivers of the relation between star formation, stellar feedback, and galaxy large-scale environment, i.e. how gas density and temperature, metallicity, kinematics, infall, outflow, and stripping affect and are affected by the formation of new stars from Galactic to cosmological scales. We propose deep MegaCam imaging observations in the Hα (and partially [SII] and [OIII]) line to reach a point source sensitivity of F(Hα) = 4×10^{-17} erg s^{-1} cm^{-2} (5σ) and a

[1] Star Formation in Environments Across Space and Time

[2] Program of blue Observations on the Large-scale Universe, Polū translates to "blue" in Hawaiian

surface brightness sensitivity of $\Sigma(\mathrm{H}\alpha) = 2\times10^{-18}$ erg s^{-1} cm^{-2} arcsec^{-2} (1σ at 3" resolution), a sensitivity $\sim$2 orders of magnitude deeper than any existing data on this large area ($\sim$ 400 deg^2) and range of environments, with the exception of the VESTIGE survey at CFHT (100 deg^2, Boselli *et al.* 2018a), which however focussed on a single massive cluster.

The acquisition, reduction, and exploitation of the data will be structured in different Working Packages (WP):

WP1.1: Galactic science. *(Leads: A. Zavagno, D. Russeil)*

We plan to observe a wide range of star-forming complexes inside and outside the plane of the MW, spanning a broad range of Galactic longitudes and latitudes, metallicities, dust attenuations and star-formation activities, in order to sample the full range of parameters describing star-formation properties (20 targets). We will observe in the rest-frame Hα filter, the off-band Hα filter centred at λ= 6719Å ([SII] doublet) and the [OIII] filter. The data will be used to trace the distribution of ionised gas using Hα emission, an excellent indicator of recent star formation as it is produced by young, massive stars (Kennicutt, 1998). [SII] and [OIII] images will be combined with the Hα data in 2D diagnostic diagrams (BPT; Baldwin *et al.* 1981) to quantify the ionisation state of the gas and find peculiar structures bridging HII regions. When combined with existing data from other wavelengths that sample the physical properties (density, temperature and kinematics) of other gas phases (hot, cold atomic and molecular), dust and free electrons in weak magnetic fields (radio synchrotron and free-free emission; e.g. Fig.1), it will be possible to study the relationship between the cooling processes of the gas, which gives rise to GMCs where star formation occurs, and the impact of stellar feedback on the surrounding medium. This WP is poised to understand the impact of early radiative feedback from massive stars on star formation properties at high angular resolution and sensitivity, finally bridging the gap between Galactic and extragalactic star formation.

WP1.2: Local Galaxies (LG). *(Leads: J. Braine, D. Lokhorst, A.L. Melchior)*

We plan to observe all nearby star-forming galaxies with Dec$\geq -30^\circ$ listed within the WISE catalogue of Jarrett *et al.* (2019) with an angular diameter in the W1 band $D_{W1}\geq$7.5 arcmin (18 objects). These are all nearby objects ($D \lesssim$12 Mpc), including some of the most representative galaxies of the Local Group (M31, M33), spanning a wide range in morphological type (Sab-IBm) and stellar mass ($10^8 \leq M_* \leq 10^{11}$ M$_\odot$). The sample also includes a few edge-on systems, where the impact of the feedback in the ejection of gas outside the galactic plane (galactic fountains) can be studied in detail. It also includes a well known nearby group (M81), where the interaction between their members has produced one of the most interesting and spectacular starburst in the nearby Universe (M82). The imaging data will be crucial to identify LSB extended features escaping from the disc and study at unprecedented angular resolution the statistical properties of individual HII regions. Combined with IFU spectroscopic observations gathered during the MUSE/PHANGS (Emsellem *et al.* 2022) and SITELLE/SIGNALS (Rousseau-Nepton *et al.* 2019) surveys of further galaxies, this will be the ideal sample to study at scales $\leq$ 50 pc the process of star formation and the associated feedback in different systems, making the link between Galactic HII regions and galaxies in a large variety of environments in nearby large scale structures.

WP1.3: Environmentally driven galaxy evolution in local superclusters. *(Leads: A. Boselli, L. Ferrarese)*

To quantify the impact of the surrounding environment on galaxy evolution we need to observe the widest possible range in galaxy density. The Hα-off filter (MP9604) is centered at λ=6719Å and is sensitive to the ionised gas emission of star-forming galaxies at $4700 < v_{hel} < 9600$ km s^{-1}. This redshift range perfectly matches the velocity range of two large scale structures in the local Universe, the Great Wall (GW) in the spring sky and the Perseus–Pisces supercluster (PPS) in the fall sky. These two structures include massive clusters such as Coma and Perseus ($M_h \sim 10^{15}$ M$_\odot$), several intermediate mass ($M_h \sim 10^{13}$ M$_\odot$) groups, and well defined and identified filaments (Geller & Huchra 1989), and are thus the ideal targets for our proposal. We plan to observe $\sim$400 deg^2, and detect $\gtrsim$ 3500 star-forming systems. This deep and large set of data will cover an unprecedented range in halo and galaxy stellar mass ($10^7 \leq M_* \leq 10^{12}$ M$_\odot$), providing us with a new angle to perform a statistical, yet highly resolved, study of the physics of environmental effects on the star forming process in the local Universe. The Hα images will enable us to study the process of star formation down to sub-kpc scales, both in isolated and environmentally affected galaxies down to the dwarf regime. We will also perform a complete census of nuclear outflows, to address the interplay between nuclear starbursts and AGN activity. At the required sensitivity we will detect diffuse ionised gas features extending across several tens of kpc (e.g. Boselli *et al.* 2016, Fig.1) formed after the interaction of galaxies with their surrounding environment. Such processes are thought to play an important, perhaps fundamental, role in the transformation of star forming galaxies into quiescent systems. Identifying the exact nature (ram pressure stripping, harassment, starvation, etc.) of the perturbing mechanisms, as a function of environment (from filaments to groups and massive clusters), is crucial to constrain cosmological models of galaxy evolution. Combined with tuned models of gas stripping and follow-up observations, these data will reveal the fate of this stripped material in a large range of environments and its contribution to the pollution of the IGM. The tails of ionised gas observed in Hα trace the trajectory of galaxies recently accreted in high-density regions (Sun *et al.* 2026). Combined with radial velocities, they will be used

to study the dynamical evolution of the different substructures of the supercluster and the relation between the quenching process and the infall history of galaxies. Finally, we will test with data the predictions of high-resolution cosmological hydro-simulations predicting the presence of widespread star formation activity in the ICM (Ahvazi *et al.* 2024).

WP1.4: A large Volume survey of High-redshift emitters *(Leads: B. Epinat, M. Fossati)*

The Hα NB filter will allow us to identify Lyα, [OII] and [OIII] emission-line galaxies at z=4.5, 0.8, and 0.3, providing a unique sample of star-forming objects over $\sim$400 deg^2. Indeed, the point-source sensitivity of the survey is comparable to the typical Lyα luminosity of z=4.5 galaxies (Ouchi *et al.* 2008). The data will allow us to extend the sampling of the Lyα LF provided by POLU at $2.3 < z < 3.4$ to a significantly greater distance (z=4.5) down to L(Lyα)$\sim$8x10^{42} erg s^{-1}, and will be complementary to the ODIN (Lou *et al.* 2024; Nagaraj *et al.* 2025) and SILVERRUSH (Umeda et al. 2025) surveys on a larger area. From Lyα luminosity functions (LF; Sobral *et al.* 2018, Tornotti *et al.* 2025), supplemented by an analysis of the VESTIGE survey data, we estimate that $\sim$60,000 Lyα and $\sim$15,000 [OII] and [OIII] emitters will be detected. This sample will provide an unprecedented database for characterising the bright end of the high-z emission line galaxy LF, insensitive to cosmic variance, make the first ever estimate of the Lyα correlation function (Kraljic *et al.* 2022) at this redshift, and study the variation of the star formation activity with galaxy density in high-z groups and clusters (Boselli *et al.* 2019, Epinat *et al.* 2024). The data will thus be highly complementary to those obtained in deep targeted imaging and spectroscopic surveys, which are generally limited to $\simeq$1 deg^2 to jointly constrain the bright and the faint end of the LF (Tornotti *et al.* 2025). High-redshift [OII] and [OIII] sources will be identified using photometric redshifts, while Lyα candidates using colour-colour [(Hα-r) vs. Hα] selections (Ouchi *et al.* 2008) or machine-learning codes that our team is developing.

WP1.5: Simulations and models *(Leads: K. Kraljic, F. Renaud, B. Vollmer)*

The observations will provide a complete, homogeneous dataset of star forming galaxies at different redshifts and HII regions in the MW. These data are an ideal testbed for the predictions of hydrodynamic cosmological simulations (IllustrisTNG: Springel *et al.* 2018; EAGLE: Shaye *et al.* 2015; RAMSES: Tessyer 2002; SIMBA: Dave *et al.* 2019), including those developed within the team (NewHorizon: Dubois *et al.* 2021), or semi-analytic models of galaxy evolution (Xie *et al.* 2025). The data will be used across a full range of scales and our goals include: the constraint of the star formation properties of galaxies as a function of halo mass (Boselli *et al.* 2023), the diffuse ionised gas emission of the intracluster component (Ahvazi *et al.* 2024), or made-to-measure magneto-hydro simulations of individual objects, from GMCs to galaxy scales (Renaud *et al.* 2014; Boselli *et al.* 2021, 2026; Vollmer *et al.* 2021) to study the effect of feedback process on the gas dynamics and the stripping process in galaxies. Simulations will also be used to study the role of magnetic field in confining the stripped gas (Tonnesen & Stone 2014), and the fate of the stripped material in the ICM.

Synergy of StarFEAST with other surveys: There is a clear synergy with the most important recent or future MW and extragalactic multifrequency surveys. X-rays data, (hot gas in massive haloes), are becoming available thanks to eROSITA, in addition to pointed observations from Chandra and XMM. The UV spectral domain (young stars) is available thanks to GALEX and UVIT archives, and will benefit from the future UVEX and CASTOR space missions (Côté *et al.* 2025). Imaging data in the optical and near-IR spectral domain (bulk of the stellar emission), are or will be made available by LSST, Euclid and Roman, with spectacular sensitivity and angular resolution. Spectroscopic observations are provided by SDSS or DESI (also taking into account future planned data releases). Mid- and far-IR data (dust) are available from WISE, Herschel, Spitzer, SPHEREx (e.g. H-ATLAS, Eales *et al.* 2010; Hi-GAL Molinari *et al.* 2010) and will be gathered with PRIMA. The radio domain (HI gas content and distribution, free-free and synchrotron emission, magnetic fields) has been covered by LOFAR (LoTSS; Shimwell *et al.* 2017) and GMRT (TGSS, Intema *et al.* 2017), or by targeted surveys such as Apertif at WSRT (Adams *et al.* 2022), or future SKA observations. The choice of fields with such great quality multifrequency data further boosts all our WPs and the legacy value of this large CFHT effort.

1.2 Scientific Goals of the POLU Survey

The second survey, POLU, covering an area of $\sim 4200\,\mathrm{deg}^2$ in both galactic caps, will provide a detailed study of the $z > 2$ Universe. Imaging this footprint with two MB filters spanning 4000–4520Å will allow the selection of $(2.3 < z < 2.7)$ LAEs and $(2.7 < z < 3.4)$ LBGs. POLU will join a coordinated effort among multiple telescopes, similarly to UNIONS, including the IBIS survey using the Dark Energy Camera on the Blanco telescope and the proposed Niji survey using Hyper-SuprimeCam on the Subaru telescope. The coordinated effort by CFHT, Blanco and Subaru will cover $\sim 5000\,\mathrm{deg}^2$ in a total of 5 MB filters from 4000Å to 5300Å.

Recently, the combination of four independent cosmological probes—baryon acoustic oscillations (BAO), cosmic

microwave background, supernovae, and weak lensing—has led to the surprising indication that DE may evolve over cosmic time. Such evolution raises fundamental questions about the early behavior of DE and its connection to primordial cosmology, highlighting the need for new high-redshift datasets capable of providing novel and robust constraints. In this context, these coordinated surveys will provide millions of LAEs and LBGs. These two samples enable robust studies of primordial non-Gaussianity through their angular auto-correlations and cross-correlations with CMB lensing. Follow-up spectroscopy with the second phase of the DESI instrument (DESI-II), beginning in 2029, will extend the standalone science of the imaging survey. It will enable tests of primordial physics and place constraints on DE in the matter-dominated regime, where linear clustering applies and dynamical DE models yield distinct predictions. In addition, POLU will significantly improve photometric redshift calibration for future weak lensing surveys, such as those conducted by Rubin and Euclid, and will also open new avenues for studying dark matter in dwarf galaxies.

The following work packages are designed to include both POLU-only science and that coming from subsequent follow-up spectroscopy.

WP2.1 Dark Energy at z > 2 *(Leads: W. Percival, N. Palanque-Delabrouille)*
The BAO and Redshift Space Distortion (RSD) results from the DESI DR1 & DR2 analyses are indicative of a dynamic DE (Adame *et al.* 2024, Abdul-Karim *et al.* 2025). These results have spurred further exploration of the time history of DE, with explanations that include late-time thawing models, or early-time decaying DE models. The extended DESI survey (2025–2028), in combination with supernova experiments, will explore the late-time (low-redshift) regime. This proposal aims to open a new window on the *higher*-redshift regime. By identifying galaxy tracers of the large-scale matter distribution and observing them with DESI-II (starting late 2029), it will test the evolution of dynamical DE in the phase where its energy density is growing with time. MB imaging efficiently selects high-purity samples of LBGs and LAEs at redshift $z > 2$. In POLU, we will use the two bluest filters of a set of five 260Å-wide filters spanning the g-band. LAEs and LBGs have been successfully identified from DECam imaging using these filters. DESI spectroscopic follow-up confirmed $\sim 72\%$ redshift success rate in 30 minutes of integration (see Technical Justification), yielding ~ 500 deg^{-2} secured redshifts of LAEs and LBGs at $2.3 < z < 3.4$. We forecast that POLU plus the surveys mentioned above using the Blanco, Subaru, and VST telescopes, combined with spectroscopic redshifts from DESI-II, can measure the DE fraction in the redshift range $2.3 < z < 3.4$ with $\sim 2\%$ precision per redshift bin. This corresponds to a detection of $\Omega_{\rm DE} \neq 0$ at better than $3\,\sigma$ at these redshifts (see Fig. 4), which would be a first-time achievement.

WP2.2 Physics of the Early Universe from 2D and 3D Clustering *(Leads: S. Hotinli, P. Zarrouk)*
Primordial non-Gaussianity alters the expected power spectrum of dark matter haloes and introduces a scale-dependent bias into galaxy clustering. POLU's LAE sample can uniquely constrain the level of non-Gaussianity (i.e., $f_{\rm NL}$) using the 2D angular power spectrum and, when combined with DESI-II spectroscopy, in the 3D power spectrum. These high-z clustering measurements, which suffer far less processing of the density field than low redshift ones, will offer deeper insight into the initial conditions set by inflation, and provide a step toward probing inflationary physics with large-scale structure. As the deviation arises on very large scales, we need large survey volumes in order to beat down the uncertainty due to cosmic variance, best achieved by going to high redshifts. The LAEs and LBGs are the most distant matter tracers that are not dominated by shot noise in the $z > 2$ Universe. POLU is a unique survey in this redshift range, selecting millions of LBGs and LAEs at $2.3 < z < 3.4$. We will study primordial non-Gaussianity using two complementary approaches. First, we will use the angular power spectrum of the LAE and LBG photometric samples (Fig. 5, left panel). Second, we will measure $f_{\rm NL}$ from the 3D power spectrum (Fig. 5, right panel) using DESI-II spectroscopic redshifts for LBG and LAE samples. Although the 2D approach is less sensitive than the 3D one for a fixed footprint, it retains much of the large-scale non-Gaussianity information (Slosar *et al.* 2008). This enables an initial $f_{\rm NL}$ measurement with the completed POLU, ahead of a later follow-on, more precise, 3D result with DESI-II.

WP2.3 Cross-correlation science at z > 2 *(Leads: K. Smith, E. Chaussidon)*
The POLU high-z galaxy survey is expected to yield powerful constraints when combined with CMB lensing measurements from Planck, ACT and Simon Observatory (Galitzki *et al.* 2018). Cross-correlating the LAE and LBG samples with CMB lensing maps will provide a number of cosmological constraints that are currently limited by a lack of high-redshift galaxies with narrow, well-characterized redshift distributions. Indeed, CMB lensing can be measured to high redshift, providing access to the underlying matter field without the need to model galaxy bias. Unfortunately CMB lensing alone mostly provides information that is projected along the line of sight (and with a broad redshift kernel). Cross-correlation with large-scale structure (LSS) in several narrow ($\Delta z \approx 0.2$, corresponding to a MB filter) redshift bins, CMB lensing tomography, can break the degeneracy with galaxy bias when using LSS alone and measure the amplitude of perturbations as a function of redshift. This approach provides tighter constraints on modified gravity (Pullen *et al.* 2015), neutrino

masses (Yu *et al.* 2023), and DE (Yu *et al.* 2022), while mitigating some of the possible systematics. At the same time, the cross-correlation of LSS with CMB lensing can potentially improve the robustness of constraints that rely on ultra-large scales, such as measurements of local non-Gaussianity. This method has already been successfully implemented with QSOs (Krolewski *et al.* 2024). We can safely extend it to our sample of galaxies, and it will give a very accurate result even before DESI-II completes. Similarly, the cross-correlation with CMB lensing will provide σ_8 constraints of 2.8%, an order of magnitude tighter than previous studies at similar redshifts (Piccirilli *et al.* 2024).

WP2.4 Galaxy Evolution and Environment at Cosmic Noon *(Leads: A. Man, J. Richard)*
POLU will identify millions of LAEs and LBGs and will be the largest extant sample of high-z galaxies (Mentuch Cooper *et al.* 2023). Since the bulk of LAEs are low-luminosity dwarf galaxies (similar to the LMC), and brighter LBGs are $\sim L^*$ galaxies (Reddy *et al.* 2009, Zhang *et al.* 2021), these data will enable an unprecedented study of the processes important for hierarchical galaxy formation at an epoch shortly before the peak in the Universe's star-formation rate density (i.e., "cosmic noon"). POLU will also help to identify an unprecedented number of Lyα "Blobs", large spatially extended (∼50–100 kpc) nebulae which mark the formation sites of groups of galaxies (Ramakrishnan *et al.* 2023, Steidel *et al.* 2000). The ~ 40 Gpc^3 volume covered by the combination of POLU and IBIS surveys will yield protoclusters at $M_{\rm halo} > 10^{15}$ M$_\odot$ (i.e., Coma progenitors), providing the best opportunity of detecting the most massive systems at these redshifts. In comparison, existing NB surveys at comparable redshift jointly cover $\sim 1/50^{\rm th}$ the volume of our proposed survey (Lee *et al.* 2024). As a result of the DESI-II spectroscopic follow-up, we will be able to study the gas metallicity, dust reddening and stellar ages in these galactic building blocks as functions of local environment, star-formation rates, Lyα escape fraction, large-scale clustering, and redshift with unprecedented precision (Reddy *et al.* 2022). Specifically selecting the largest overdensities of LAEs and LBGs will allow us to identify the most suitable regions with gas filaments forming the cosmic web, one of the most fundamental predictions of ΛCDM (Bacon *et al.* 2021). Direct imaging of these gaseous filaments in Lyα emission will be within reach of the VLT/BlueMUSE instrument (Richard *et al.* 2019) thanks to the cosmological surface brightness enhancement compared to MUSE, while simultaneously probing the CGM emission properties of individual LAEs and LBGs. The unique set of data provided by POLU will thus be ideally suited to link similar studies of the local and the high-z (z=4.5) Universe done within the StarFEAST project.

WP2.5 Photometric Redshifts and Dwarf Galaxies at z < 0.4 *(Leads: J. Taylor, J. Woo)*
Even with the new generation of wide-field multi-object spectrographs, redshift surveys only capture a small fraction of galaxies detected in imaging. Consequently, weak lensing measurements such as those planned by Rubin/LSST and Euclid depend heavily on accurate photometric redshifts. Moreover, precise photometric redshifts are crucial for identifying the hosts of transient phenomena like LIGO events and Fast Radio Bursts. The MB imaging surveys will significantly enhance the accuracy and purity of photometric redshifts compared to conventional methods that rely solely on BB photometry. To illustrate the advantage of using MB filters for photo-z, we have considered dwarf galaxies which offer a powerful probe of small-scale structures, dark matter, and the galaxy-halo connection. Galaxy-galaxy lensing is a powerful way to directly probe to the edges of dark matter halos. Wide and deep field imaging surveys like LSST, Euclid, and Roman will image large numbers of low-mass dwarf galaxies, transforming our understanding of dark matter and galaxy formation at the lowest mass end. However, the main limitation to measuring their dark matter halo profiles is not the lensing signal-to-noise from these surveys, but rather the ability to obtain accurate redshifts for the dwarf galaxy lenses (Leauthaud *et al.* 2020, Luo *et al.* 2024). By combining our MB observations with BB photometry from Rubin, we will achieve a photometric redshift precision of $\sigma_{\Delta z/(1+z)} \approx 0.01$ and a catastrophic failure fraction of $\eta \approx 0.45\%$ to $r \sim 24$ (see Fig. 6). With a 5000 deg^2 footprint we will identify $\sim$ 10M dwarf galaxies with $10^8 < M_* < 10^9$ M$_\odot$ at $z < 0.4$. Such high quality lensing measurements will allow us to constrain the dark matter halo profiles of dwarfs, and thus allow us to distinguish different dark matter models (e.g., CDM vs. self-interacting DM).

2. Suitability of CFHT

Long renowned for its exceptional imaging capabilities, MegaCam is increasingly at risk of being surpassed by the next generation of larger facilities. For wide-area surveying or time-domain monitoring, Rubin/LSST is approximately 25 times faster than CFHT due to field of view, telescope diameter, and readout time. We propose doing *qualitatively different* surveys that take advantage of MegaCam's strengths, leading to science that *cannot be done with LSST*. The VESTIGE project has clearly demonstrated the feasibility and success of such a program. In addition, the DESI Imaging Legacy Surveys (DECaLS, MzLS, and BASS; Dey *et al.* 2019), designed to produce targets for DESI, have generated more than 2000 citations for the Blanco Telescope, demonstrating very broad scientific value beyond their original purpose. Thus, the legacy value of this CS is undoubtedly very high and the data will be a reference for years to come.

3. Risk assessment

The observing strategy and scientific exploitation of the proposed program have been optimised to limit the project risks, while maximising the scientific return. The most significant risk mitigation comes from the experience of the team with similar NB and MB observations (VESTIGE and IBIS surveys), the leadership and ownership of simulation suites required to reach the proposed goals.

Risk 1: Poor weather conditions. MEDIUM risk (Probability: 3/5, Impact: 2/5) All ground-based instruments are at risk from poorer than average weather conditions, limiting the survey progress and efficiency. For both StarFEAST and POLU, we mitigate this effect with a complete RA distribution of the targets, making them observable in both semesters, and by a large variety of targets, some of which requiring less stringent conditions (MW and LG). By acquiring data in multiple epochs, we will average out seeing, sky darkness, and transparency conditions, reducing the magnitude of the risk compared to single pass surveys. In addition, POLU and StarFEAST do not require the same observing conditions (grey/dark sky and seeing), which makes the overall survey flexible and less sensitive to weather conditions.

Risk 2: Instrument failures and reduced completion rate. LOW risk (Probability 2/5, Impact: 2/5) CFHT/Megacam has proven to be a reliable machine. However, aging can increase the failure rate. For StarFEAST, we designed a prioritization strategy to cover the widest range of environments in year 1, ensuring key survey science even if the full program is not completed. In case of a 75% completion rate, most expected results are still obtained although with a lower statistical significance. If completion falls below targets for specific WPs, we will ingest existing shallower or aperture-limited data for the Galactic plane and local galaxies, trading homogeneity for coverage. For POLU, if we cannot cover the planned 4200 deg^2 area at the planned depth with the two bands, we have three mitigation options: a) reduce the surface area; b) reduce the depth, i.e., exposure time per pointing; c) remove one of the two bands. Since we want to maintain a consistent density of selected targets throughout the survey, we cannot change the depth during the survey. This decision can only be made at the outset. Therefore, reducing the size of the footprint in coordination with IBIS would be our best mitigation strategy.

Risk 3: One or more WP leads leave the collaboration. LOW risk (Probability 2/5, Impact: 1/5) While it is possible that one or more WP leads cannot commit the time initially planned to the project, our management scheme has 2/3 co-leads for each WP and our team is large enough that new people can take these leadership roles. These actions significantly mitigate the impact of this risk. In the specific case of POLU, since the scientific program is directly linked to that conducted with DESI-II and DESI-II has more than 200 active researchers, it will be easy to find replacements.

4. Synergies within this CS proposal

There is an obvious synergy between the two surveys of this CS proposal, e.g. the study of the environmentally driven galaxy formation and the identification of LAEs and LBGs at $2.3 < z < 3.4$ through NB and MB imaging. Indeed, although limited on a much smaller area, NB observations in the Hα filter will detect LAEs at $z \simeq 4.5$, thus enabling studies similar to those proposed by POLU at higher redshift. The overlapping regions between POLU and StarFEAST cover at least 30 deg^2 that, added to the 100 deg^2 mapped by VESTIGE, will provide a large 130 deg^2 area covered by NB, MB and BB filters, plus follow-up spectroscopy with DESI. Such extensive synergy will enable new science reach across a significant volume and redshift. Specifically, this collaboration will likely provide additional high-z targets for DESI spectroscopy to further constrain the large-scale structure of the cosmic web and the properties of embedded galaxies. Moreover, DESI data releases will provide an excellent coverage of galaxies across a large range of environments to constrain their dust attenuation, metallicity, and ionisation parameters, further enabling the goals of WP1.3.

POLU and StarFEAST also have strong complementarities that significantly strengthen the overall legacy and science return. StarFEAST plans part of the observations in brighter sky conditions, therefore maximizing the overall efficiency of the combined CS. The observations of POLU are part of a wider effort involving several ground-based facilities (DESI at the Mayall telescope, IBIS at the Blanco, and Niji on Subaru) of interest for a large international community. This will provide high international visibility with an expected high citation rate for the resulting publications, with CFHT as one of the partners. The main publication outcome is expected once a significant fraction of the observations has been completed. StarFEAST, by contrast, is planned to deliver a high publication rate starting early in the project phase. It will give strong visibility for CFHT within the international astronomical community but also for the general public through outreach activities (e.g. spectacular images of resolved galaxies). This approach follows the strategy recommended by the CFHT SAC, as adopted for VESTIGE alongside CFIS-UNIONS.

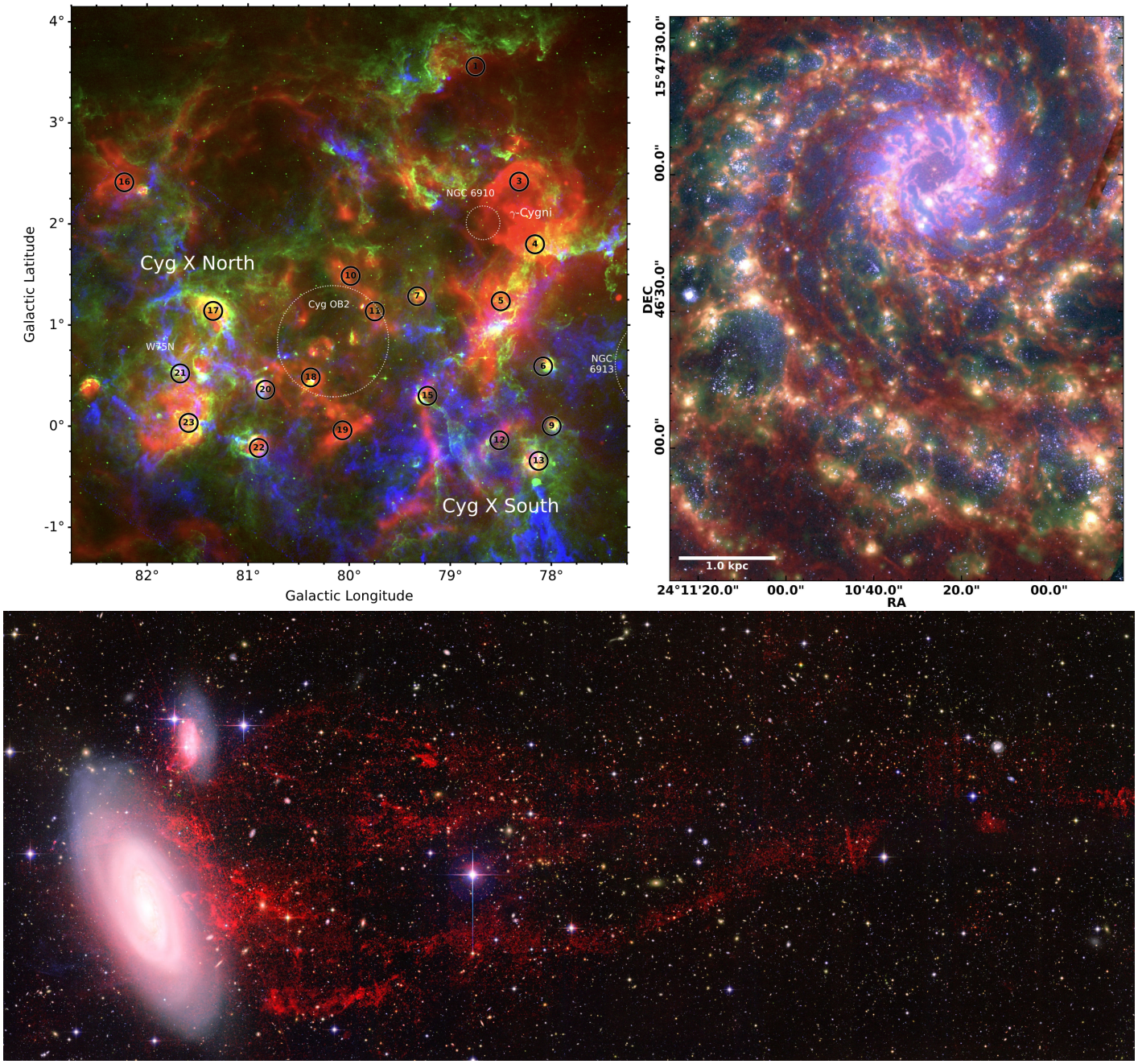


Figure 1. **StarFEAST, upper left**: Colour image (red: 1.4 GHz continuum; green: 8μm PHAs emission; blue: ^{13}CO(1-0) molecular gas) of the Cygnus X star forming complex in the MW (Emig *et al.* 2025). The OB (star forming) associations (black circles) are interacting with the surrounding ISM (gas and dust) via stellar feedback, modifying the distribution, density, and temperature of the gas needed to feed star formation. **Upper right**: Colour image of the galaxy NGC 628 (red: MIRI F770W, green: MUSE Hα, blue: *B*-band HST; Watkins *et al.* 2023). Bubbles formed by stellar winds have strong effects on the surrounding ISM, modulating galactic flows which regulate the star formation process globally. **Lower panel**: Colour image of the massive spiral galaxy NGC 4569 in the Virgo cluster. The red colour shows the ionised gas emission as derived from the Hα NB imaging data gathered at the CFHT during the VESTIGE survey (Σ(Hα) $\simeq$ 2–4$\times10^{-18}$ erg s^{-1}cm^{-2}arcsec^{-2}). The long filamentary structure escaping from the galaxy disc to the west is ionised gas stripped from the galaxy during its hydrodynamic interaction (ram pressure) with the surrounding hot ICM. We expect to detect similar structures in perturbed galaxies in groups and clusters located within the GW and the PPS.

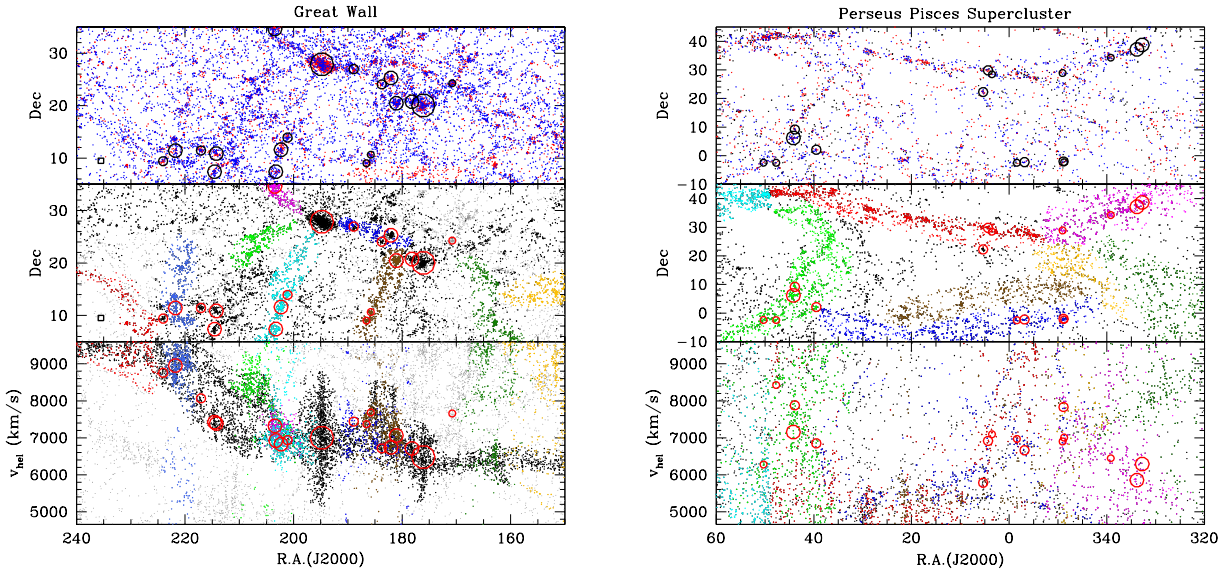


Figure 2. **StarFEAST:** distribution of galaxies at $4660 < v_{hel} < 9600$ km/s covering the range of the Hα NB filter in the GW (left) and PPS (right) regions. **Upper panel:** sky distribution of star forming (blue) and quiescent (red) objects. Black circles indicate the high-density regions with a mean recessional velocity $v_{hel} \pm 3\sigma$ within the filter velocity range, with size depending on their halo mass, which is in the range $10^{13} < M_{halo} < 10^{15}$ M$_\odot$. The massive clusters at RA$\sim$178° and RA$\sim$195° are A1367 and Coma (A1656), the dense region at RA$\sim$50° and Dec$\sim$40° in the right panel is Perseus, which we will not target since it includes galaxies outside the filter range. The black box in the lower left corner is the MegaCam (1 deg^2) FoV. Central panel: same sky distribution but colour coded for the galaxy filament membership. **Lower panel:** RA vs. recessional velocity distribution for galaxies in the declination range 5° <Dec<35° (GW) and −10° <Dec<45° (PPS) chosen for the present survey. The GW (left) structure stretches between $\sim 150° < RA <\sim 240°$ and $6500 < v_{hel} < 9500$ km/s. The selected high-density regions are marked with red circles. The most massive of them show the characteristic finger of God signature due to their high velocity dispersion. Galaxies are colour coded as in the middle panels.

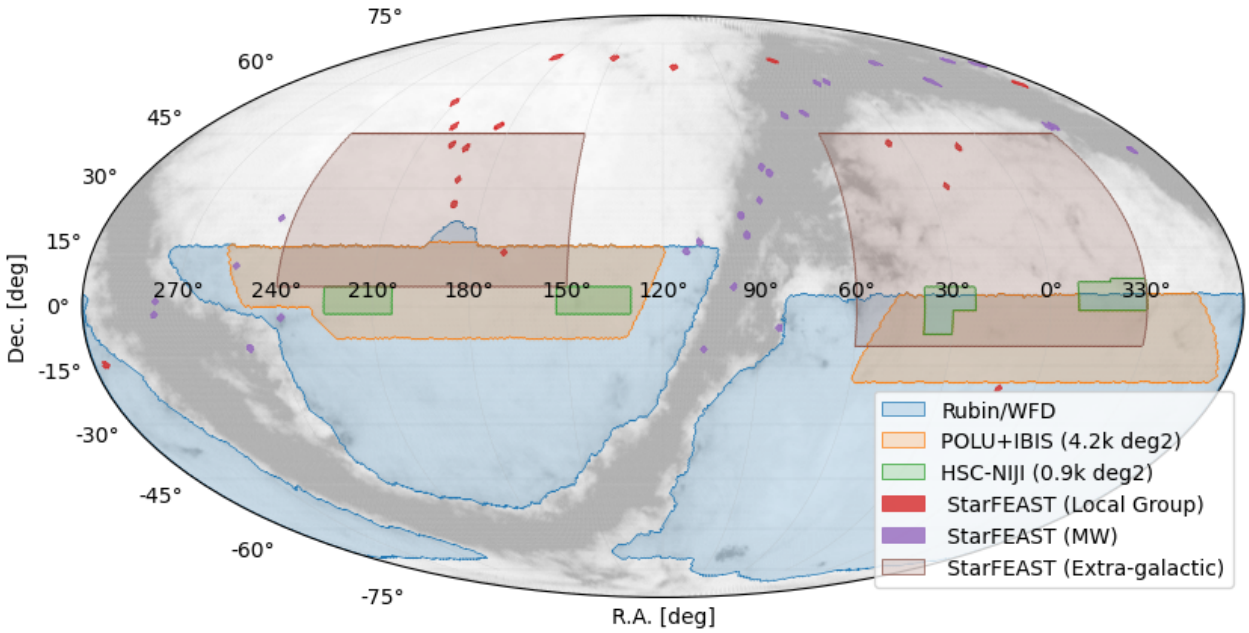


Figure 3. Footprint of the POLU survey (orange boxes), overlaid on the footprint of Rubin/LSST (blue). The grey background shows the Galactic dust. The POLU footprint is split into two equatorial fields in the NGC and SGC (observable during the A and B semesters, respectively) and designed to maximise overlap with data from the other surveys. Footprint of the StarFEAST Survey: sky distribution of Galactic star forming regions (purple circles), Local Galaxies (red circles) and Local Large Scale Structures within the large brown rectangles.

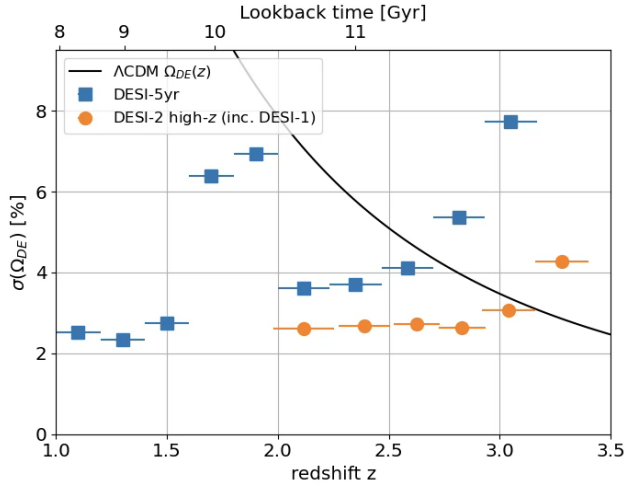


Figure 4. **POLU**, expected precision on $\Omega_{\rm DE}$ for the planned DESI-II survey (orange dots), which requires the targeting data proposed with POLU, compared to forecasts for the completed DESI 5-year survey (blue). The proposed imaging (and subsequent DESI-II follow-up) survey will provide the strongest constraints on $\Omega_{\rm DE}$ at these redshifts for the next decade, as well as advancing the redshift frontier.

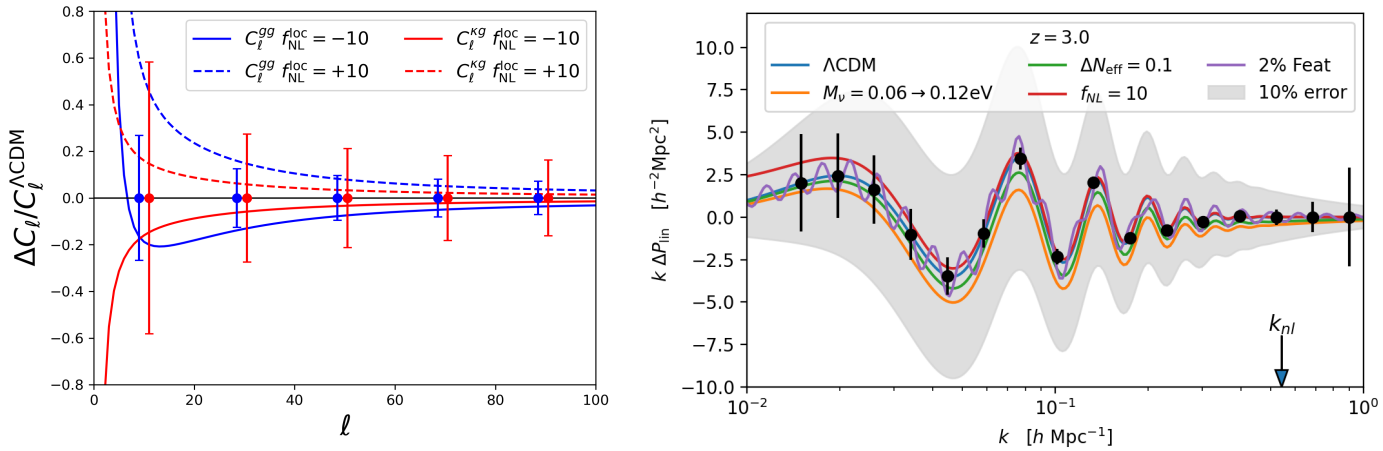


Figure 5. **POLU, left:** 2D angular power spectrum of LBGs and LAEs for $f_{\rm NL} = -10, 10$; in blue the auto-correlation and in red the cross-correlation with CMB lensing. **Right:** 3D power spectrum of LBG and LAE samples in the $2.3 < z < 3.4$ redshift range. The fiducial model (ΛCDM) assumes a summed neutrino mass of 60 meV, while the other curves represent modifications such as a 120 meV neutrino mass, additional relativistic species ($\Delta N_{\rm eff}$), primordial non-Gaussianity of the local form ($f_{\rm NL}$), and primordial features.

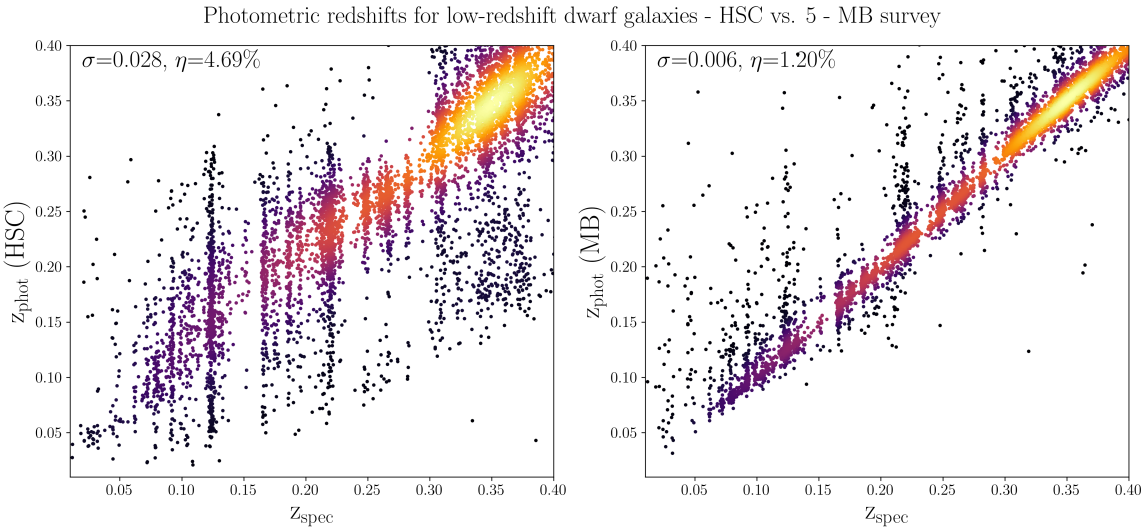


Figure 6. **POLU, left:** Photometric redshifts for low-redshift galaxies computed using only BB *grizy* data from Subaru/HSC. **Right:** Photometric redshifts derived by including medium-bands. Adding the medium-bands results in "precision" photometric redshifts for low-redshift sources enabling faint dwarf galaxies to be identified, their dark matter halos to be studied via lensing, and their detailed spatial distribution within large-scale structure to be better characterised.

Technical justification

1. Design of the Community Survey

1.1 WP-SD: Design of the StarFEAST Survey

1.1.1 SD1.1: Selected sample

Milky Way. To sample the widest possible range in the parameter space required to reach our science goal (study the impact of early radiative feedback from high-mass stars on star formation properties), we selected 20 (essential) to 24 (desirable) star-forming complexes within the MW with different star formation rate, age, metallicity, gas and dust content, Galactic latitude, evolution stage of the ionised region, and strength of the ionising radiation. Furthermore, we are interested in sampling the interface between the ionised region and the photodissociation region. This requires the high sensitivity to LSB that can be achieved with MegaCam. The selected regions are located at all RAs and have Dec $> -15^{\circ}$ (Fig. 7), thus they are easily accessible from the CFHT. Twenty sources are the minimum number required to achieve sufficient statistics to reach our scientific goals. Should the weather conditions not be favorable for the extragalactic surveys, a wider sampling of the selected regions and a few extra targets could be added to increase the sample. NB imaging surveys such as VPHAS+ (VST, Drew *et al.* 2014) and IPHAS (INT, Drew *et al.* 2005) used 2.5 m telescopes to cover the Galactic plane with 360s exposures. Using MegaCam, we gain factors of 2 for the mirror area and 10 in integration time, reaching a mag=23.5 in the NB filter, vs. mag=20 in VPHAS+ and IPHAS for point sources. This turns into deeper sensitivities for extended features which are required to study the interface between ionised, neutral and molecular gas. Some of our primary sources have been partly covered with SITELLE, enabling us to cross-calibrate MegaCam data with spectroscopic measurements. Furthermore, the availability of multi-wavelength and multi-scale data on the selected sources enables in-depth analysis of the physics of early radiative feedback. The primary sample of 20 sources over 64 deg^2 will be observed in three NB and in the g and r filters for a total of 3.87 hr/deg^2. This program requires **250 hr or 50 nights**.

Local Galaxies: The Local Galaxy (LG) sample includes all the star-forming objects with Dec $> -30^{\circ}$, radius $R_{W1} > 7.5$ arcmin in the WISE large galaxy catalogue of Jarrett *et al.* (2019) and A_V <1.0 mag (18 galaxies). Given their angular size—often too large for IFU spectrographs with small FoVs (except SITELLE's 11x11 arcmin^2, while MUSE, PMAS, or MaNGA are $\sim$ 1 arcmin^2)—these are ideal targets for pointed NB imaging. They require 27 pointings in the 3 NB filters and 2 broad g- and r-bands with integration times similar to those proposed for MW HII regions for a total of **105 hr or 21 nights**. Some galaxies have (mainly Hα) NB imaging in the literature (Massey *et al.* 2006), others are partly mapped with IFU spectrographs (e.g. SIGNALS). This survey will provide for the first time a unique, homogeneous, and complete sample with an unprecedented sensitivity in the Hα, [SII], and [OIII] lines suitable for statistical studies.

Large scale structures: The GW and the PPS extend over several thousands of deg^2 and cannot be blindly mapped over their full extension. The GW is located in the region 8h < RA < 17h; 5° < Dec < 44°, and the PPS in 21h < RA < 5h; 25° < Dec < 45° (Fig. 2). The GW and PPS are clearly identified as a network of filaments connecting massive nodes of the cosmic web, so probing their full environmental range requires targeting both massive halos (groups and clusters) and filament-like structures. We select groups and clusters in the GW (spanning the range $\approx 6500 < cz < 9000$ km/s) from the catalogue of Wilman *et al.* (2010). We found 19 high-density regions with halo mass $10^{13} < M_{halo} < 10^{15}$ M$_{\odot}$ and $cz \pm 3\sigma$ within the filter transmission curve (Fig. 7). Two of them have a halo mass $M_{halo} > 10^{14}$ M$_{\odot}$ (Coma, A1367) and have the characteristic finger of God shape due to their high velocity dispersion ($\sim$ 1000 km/s). Although with a lower density, due to the limited depth of the 2MASS redshift survey (Huchra *et al.* 2012), similarly massive haloes can be found in the PPS sky region, where we identified 16 target groups. The catalogued star forming galaxies (blue dots) located within the selected high-density regions are $\sim$ 1500, and the sample size becomes $\sim$ 3000–4000 galaxies once early-type systems are included. These high-density regions will be mapped using mosaicked MegaCam fields, with the mosaic size selected as a function of the angular extension of the target groups. These mosaics range from 4×4 for the most massive clusters down to single pointings for the low mass systems for a total of 197 pointings. This tiling strategy covers up to $\sim 2r_{200}$ of the target groups, including the infalling regions outside of r_{200} where environmental perturbations are starting to become important. Filaments of galaxies are also selected within these regions. We select the structures with an overdensity (compared to the mean galaxy density) at the filament spine $\delta > 5$ and we grow the selection to adjacent galaxies until the average overdensity for each filament is $\delta > 3$ (the lowest density regions will be used as reference sample). Filaments selected in this way are highlighted in different colours in the middle panels of Fig. 2. Given the higher fraction of star forming galaxies in these environments, compared to clusters and groups, we will have at least $\sim$10 star forming galaxies per deg^2. These numbers are lower limits since they correspond to the number of star-forming galaxies with an available

redshift down to the SDSS limiting magnitude r <17.7. We expect to detect weaker sources whose membership to the GW and PPS will be secured by the presence of the Hα line emission within the NB filter. 200 selected fields will be used to map representative regions of 20 different filaments (with a mean of $\approx$ 10 gal/field). This will secure the detection of $\gtrsim$2000 star forming systems, a number comparable to the one reached for the massive haloes and suitable to obtain the same statistical significance on a comparative analysis. The study of environmental effects on galaxy evolution involves a multi-dimensional parameter space, the large number of targets ($\gtrsim$3500 in total) is necessary to split the sample in 4–5 bins of halo mass ($10^{13} < M_{halo} < 10^{15}$ M$_\odot$, or overdensity $1 \lesssim \delta \lesssim 100$), galaxy mass ($10^7 < M_* < 10^{11}$ M$_\odot$), distance from group/cluster core ($0 < r/r_{200} < 10$) or position in the filament, while retaining at least 25 galaxies per bin to ensure a *SNR* $\approx$ 5 on our measurements in each bin, assuming Poisson statistics. Indeed, all the physical variables regulating environmental effects strongly evolve from filaments to groups and to massive clusters: for instance, RPS depends on the galaxy velocity in the halo potential and the IGM density, starvation occurs before or near the halo virial radius. Moreover, the properties of galaxies are regulated by their own potential, often traced via their stellar (+gas) mass. The need for such a number of galaxies is therefore justified by the need to break the covariance among all these parameters. We therefore request 397 pointings, 197 for groups and clusters, 200 for filaments. Assuming 10,080 s per pointing including overheads, and that archival BB imaging exists for a fraction of the footprint, we will require **995 hr or 199 nights**.

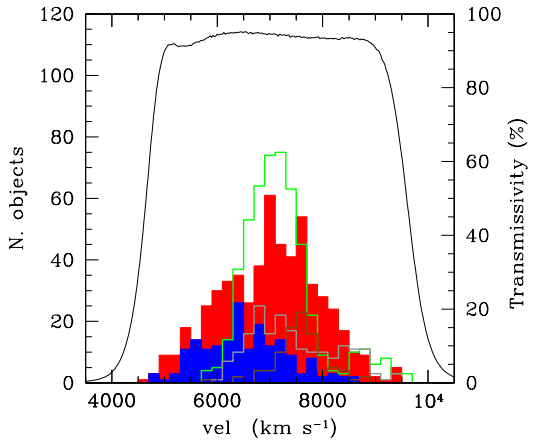


Figure 7. Velocity distribution of galaxies in Coma (red histogram), A1367 (blue), and in the selected groups of mass $5 \times 10^{13} < M_{halo} < 10^{14}$ M$_\odot$ (green), $2 \times 10^{13} < M_{halo} < 5 \times 10^{13}$ M$_\odot$ (grey), and $M_{halo} < 2 \times 10^{13}$ M$_\odot$ (brown). They are all within the plateau of the maximum transmissivity of the 9604 Hα Off filter (and peak QE of the MegaCam CCDs) selected for this survey. This is also the case for galaxies belonging to the selected filaments (see Fig. 2, lower panel).

1.1.2 SD1.2: Integration times.

We propose to survey different representative structures using MegaCam coupled with three NB filters $\simeq$ 100 Å wide and available at the CFHT: 9603 (Hα; λ=6591Å; $\Delta\lambda$=106Å), 9604 (Hα Off; λ=6719Å; $\Delta\lambda$=109Å), and 9501 ([OIII]; λ=5007Å; $\Delta\lambda$=102Å). The Hα and [OIII] filters are designed to observe these lines at rest frame, and will be used for MW and LG systems. The Hα-Off filter is sensitive to the rest frame emission of the [SII] doublet, and will thus be used for the same targets. It is also sensitive to the Hα emission of galaxies with $4660 < v_{hel} < 9600$ km/s, the range of the selected structures (Fig. 2 and 7). Two different observing strategies will be used for MW and LG targets vs the other extragalactic ones. One of the goals of our program is the detection of LSB features frequently observed in nearby cluster galaxies (e.g. Yagi *et al.* 2010) or predicted by hydrodynamic simulations (e.g. Tonnesen & Bryan 2010). Such features have a typical surface brightness of Σ(Hα) $\simeq 2 \times 10^{-18}$ erg s^{-1} cm^{-2} arcsec^{-2}. Similar surface brightnesses must be reached to measure a possible truncation in the Hα distribution (harassment) or faint and fading discs predicted by starvation scenarios. These values are $\sim 60\times$ fainter than those reached in previous Hα NB observations of galaxies in the GW using 2m class telescopes (Gavazzi *et al.* 2013) and have angular sizes of several arcmin at the distance of this structure ($\sim$ 100 Mpc). The Hα observations carried out at the CFHT during the VESTIGE survey (using the MP9603 filter) have shown that these SB limits can be reached in 7200s, and after rebinning the data to 2.8″/pixel, provided that the data are acquired and reduced using the Elixir-LSB pipeline in dark sky conditions. The point source sensitivity is F(Hα) $\sim 4 \times 10^{-17}$ erg s^{-1} cm^{-2} (5σ), sufficient to detect the bright end of the LF of Lyα emitters at z=4.5 (Sobral *et al.* 2018, Tornotti *et al.* priv. comm.). Given the negligible differences in the MP9603 and MP9604 filters ($\pm$3% in band width and 2% in throughput), we estimate these forcasts will be highly accurate for the proposed observations. For the determination and the subtraction of the stellar continuum we will use a combination of the BB r and g filters, which is necessary for an accurate sampling of the intrinsic colour of the observed targets (Boselli *et al.* 2018a). This is particularly important in the inner regions of bright early-type galaxies, which are bright and with rapidly changing colours with radius (age and metallicity effects). These 2 BB filters are $\sim 14\times$ wider than the Hα filter, so the integration time scales accordingly (720s in each band). The BB data should be taken with similar weather constraints (seeing and background illumination) as the Hα frames to minimize flat fielding residuals that could negatively impact the identification of LSB features. With a total integration of 720s in the

r-band and 720s in the *g*-band we will reach a limiting magnitude of $r = 24.5$ AB mag (5σ). To summarize, each of our extragalactic field requires 7200s integration in Hα, and 720s integration in the *r*- and *g*-bands each, for a total of 8640s per survey tile. Each exposure in the 3 filters will be divided in 12 exposures (600s for Hα and 60s for *g* and *r*) optimally dithered to cover the CCD gaps and minimise the possible contamination from the reflections of bright stars. The dithering pattern will be optimised for both contiguous regions within extended structures such as massive clusters, and in more isolated pointings, with procedures developed by our team. Galactic star-forming regions and LG are much brighter and thus require shorter integration times to avoid saturation. We plan to observe them using 12 exposures 300s long for the 3 NB filters and 30s for the *r* and *g* filters. The corresponding total integration time per pointing is 11,520s. These regions are extended several deg^2 on the sky, and thus require ad-hoc mapping as done for the extragalactic sources.

1.1.3 SD1.3: LSB Observing Strategy.

The observing strategy is driven by our scientific goals requiring the LSB observing technique to map faint extended features. We will use the Elixir-LSB pointing strategy successfully developed for VESTIGE and NGVS (Ferrarese *et al.* 2012). The strategy requires an uninterrupted sequence of 6 single exposures to be acquired in an observing group (OG). A large dither strategy, optimised for the LSB mode, will be adopted to cover the gap between the CCDs and to model the sky background even in the presence of extended sources in each exposure, a goal that cannot be reached with filtering based sky subtraction techniques. Our integration times ensure each exposure is background limited even when the moon is below the horizon, a key requirement of the LSB data reduction pipelines. Calibration of the *g*- and *r*-band data will use standard MegaCam/MegaPipe procedures based on stellar photometry from external catalogues (e.g. PS1). For the NB filters we will follow the same procedure successfully used for VESTIGE: i.e., the NB frames are calibrated using colour corrected magnitudes for the stars in the field and then a pure line emission image is generated using a colour-dependent correction for the stellar continuum using the *g*- and *r*-band data. This technique has been proved to reach accuracies of $<3\%$ when compared to spectroscopic MUSE data (e.g. Boselli *et al.* 2021).

Targets are uniformly distributed at all RAs, and are thus observable any time during the year, maximising scheduling flexibility (Fig. 2). The fields will be prioritised in such a way to ensure maximum scientific return as the survey evolves. Considering 40s of overhead per exposure, this leads to 10,080s of telescope time per extragalactic field ($12 \times (600+40)$s for Hα, $12 \times (60+40)$s $\times 2$ for *g* and *r*) and 13,920s per LG and MW source ($12 \times (300+40)$s $\times 3$ for Hα, [OIII] and [SII], plus ($12 \times (30+40)$s $\times 2$ for *g* and *r*). The MW regions we propose to observe covers 65 deg^2, the LG 27 deg^2, while the extragalactic fields $\sim$400 deg^2. The complete StarFEAST survey requires 1350 hr or 270 nights (50 for MW, 21 for LG, 199 for the extragalactic sources). In summary, **the total request for the StarFEAST survey is 270 nights, 65 in grey time and 205 in dark time (see sky conditions)**.

1.1.4 SD1.4 Sky Conditions.

Given the extended, LSB nature of the ionised gas tails, data for this survey can be gathered in standard CFHT seeing conditions ($\leq 1.0''$, with 20% tolerance). Taking the VESTIGE survey as a reference, these constraints lead to a mean Hα seeing of 0.73 arcsec. We assume this value to make forecasts on the limiting luminosity of point sources required by the high-*z* galaxies WP. Due to their large sky extension, Galactic sources can be observed even in poorer seeing conditions (up to ~ 1.5–$2''$). NB Hα observations of extragalactic fields are required to detect faint extended emission features. Our exposure time calculations assume dark sky conditions (Fraction of Lunar Illumination, FLI$<$0.1) or moon below the horizon. Based on the analysis of the VESTIGE images and using the ESO skycalc tool with the Mauna Kea site parameters, we estimate that the exposure times would increase by 35% if the mean FLI is 0.2 or by 100% if the mean FLI is 0.4. As a result, these observations are more efficiently scheduled in dark or moderately grey conditions such that the mean FLI of the 12 visits of each pointing in the sky is $\langle \mathrm{FLI} \rangle \sim 0.1$. We also require a minimum moon-target distance of 50 deg. Similar considerations can be made for the *g*-band and [OIII] NB observations, which are best scheduled in dark conditions. All *r*-band data, and Hα data of MW and LG targets can be gathered in grey time, up to a FLI = 0.4. Observations can be gathered with a moderate < 0.2 mag extinction under thin cirrus, provided that cloudy sky observations are obtained in dark time to avoid light scattering from a significantly illuminated moon. *The 270 nights requested for the StarFEAST program have been estimated using these sky conditions. In case the observations will be gathered in worse seeing and darkness conditions, the total number of nights should be increased accordingly.*

1.1.5 SD1.5 Best use of available data.

BB *r* and *g* imaging data are partially available for the surveyed regions. We plan to use them whenever their quality in terms of sensitivity, uniform illumination, and image quality, grants the best exploitation of the NB imaging data. The main

sources are UNIONS (Gwyn *et al.* 2025) in the GW region and observations from Mondelin *et al.* (2026) in the PPS region. Similar CFHT data are also available for a few LG. Gathered at the CFHT with similar seeing conditions, r-band data reach r=24.2 mag vs. r=24.4 for our survey (10σ in a 2 arcsec aperture) and, whenever available, will be used without any extra observation. UNIONS g-band data come from the Subaru WHIGS survey, and reach g=24.54 mag vs. g=24.92 mag for our survey. An extra exposure of 340s might be necessary to reach the same sensitivity, but we will do that after testing it if necessary.

1.2 WP-SD: Design of the POLU survey

1.2.1 SD2.1: Target selection of LAE and LBG

We will select Lyα Emitters (LAE) targets with line fluxes of F(Lyα) $\gtrsim 1.5\times10^{-16}$ erg s^{-1} cm^{-2} and Lyman Break Galaxies (LBG) targets at $r \leq 24.3$ AB mag, with two complementary strategies, using two medium bands, MB1, $4000-4260$Å (M411) and MB2, $4260-4520$Å (M438), in combination with BB imaging from Rubin/LSST. (In the event that Rubin/LSST imaging is not available, we can also use purely MB-based LAE and LBG selection methods.)

LAEs are young, star-forming galaxies that exhibit strong Lyα lines in their spectra, often with relatively weak continuum emission. Their strong emission lines also offer a high contrast against the BB continuum, enabling both efficient target selection with NB and MB filters and efficient redshift identification. We will select LAE using a traditional approach from MB imaging data based on identifying sources which show a photometric excess in the MB (see Fig. 8-Right). In practice, LAE candidates are selected using the magnitude difference between one of the two MB filters (MB1 or MB2) and Rubin/LSST BB (g or r). This methodology has been successfully tested using DESI spectroscopic follow-up of LAE candidates selected from IBIS imaging. Figure 8-Left shows five examples, for LAE candidates selected using the five MB filters of IBIS. With several DESI-II pilot programs, DESI successfully measured redshifts for the $2.3 < z < 3.4$ redshift range with Lyα line fluxes F(Lyα) $\geq 1\times10^{-16}$ erg s^{-1} cm^{-2} with a 70–80% success rate. In the case of POLU, with the two bluest MB filters, we will cover the $2.3 < z < 2.7$ redshift range.

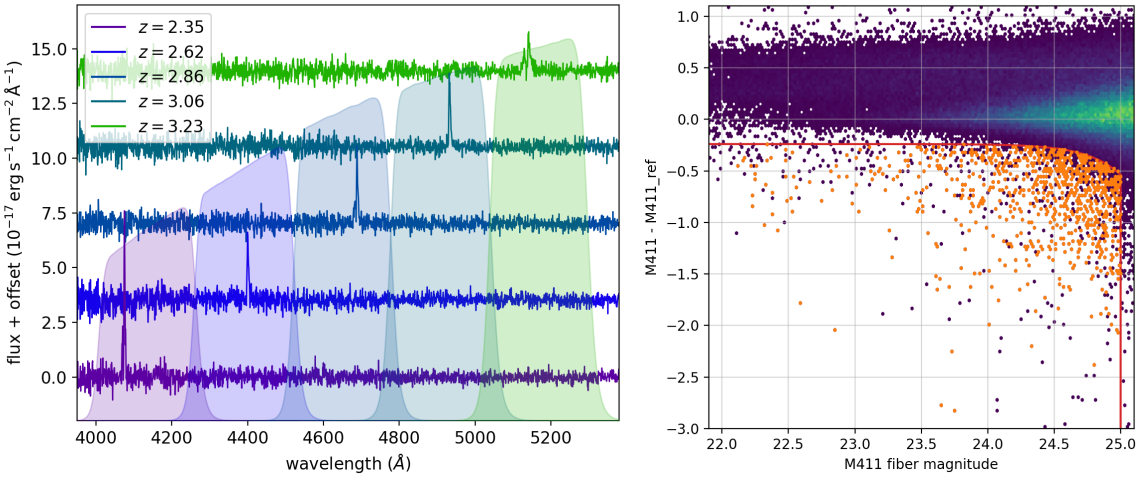


Figure 8. **Left:** Example spectra of LAEs observed in a DESI-II pilot program. They were selected using IBIS imaging. The fluxes are offset for better visibility. Each spectrum has 1 hour of effective exposure time. **Right:** LAE selection with IBIS MB1 ($4000-4260$Å) filter, the red line shows the LAE selection box, the orange dots are confirmed LAEs by DESI.

For selecting LBGs, we will use a standard 'dropout technique', as shown in Fig. 9-Right, which identifies UV-bright high-redshift galaxies based on a continuum break at the Lyman limit and / or at the Lyα line due to absorption by neutral hydrogen (see Fig. 9-Left). This method has been extensively tested using BB imaging, for instance, with CLAUDS imaging (Sawicki *et al.* 2019) in DESI pilot surveys (Ruhlmann-Kleider *et al.* 2024) . What we propose here is a method that builds on this approach. By combining the two MB1 and MB2 medium-band filters, we can use the resulting 520Å-wide composite-band with Rubin/LSST g, r bands to select sources which 'drop out' in the composite band; these are LBG candidates at $2.7 < z < 3.4$.

The POLU survey provides optimal imaging for both LAE and LBG selections, which are complementary in redshift. Our strategy is to divide the five MB filter imaging between the POLU survey at CFHT and the IBIS survey at the Blanco,

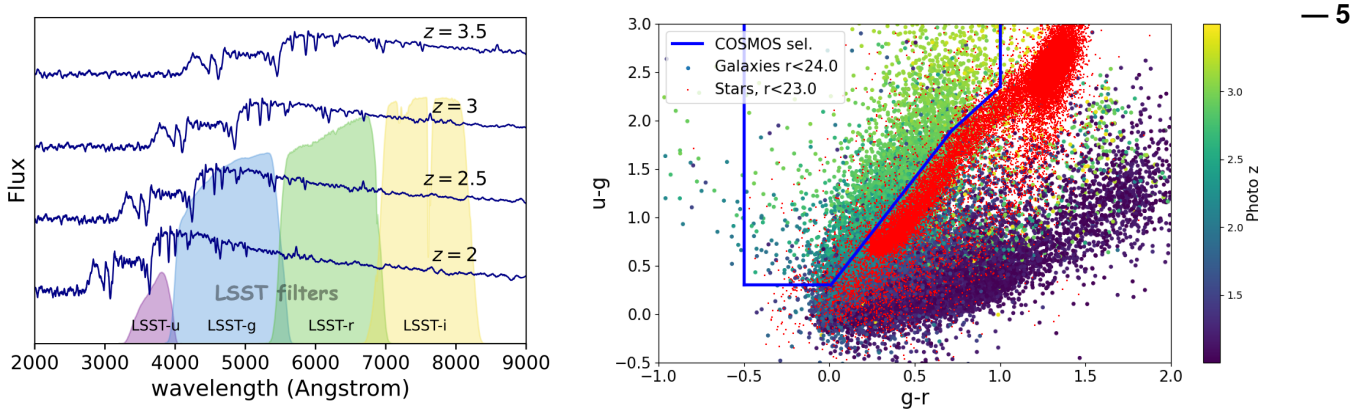


Figure 9. **Left:** Effective DESI LBG spectrum spanning the redshift range $2 < z < 4$, by stacking individual LBG spectra observed with DESI (Ruhlmann-Kleider *et al.* 2024). **Right:** u-dropout selection of LBGs with CLAUDS: the blue line shows the LBG selection box, red dots are HSC stars and medium size dots coloured by photometric redshift (from LEPHARE, Arnouts *et al.* 1999, 2002) are HSC galaxies.

using the two bluest MB for POLU given the sensitivity of MegaCam in the blue. We already have all five filters for DECam and have taken pilot observations in the IBIS survey. This has allowed us to test this target selection of LAEs and LBGs, using the five bands with a follow-up on DESI in COSMOS and XMM-LSS fields. We have demonstrated that we can achieve densities of 1,000 to 2,000 targets per square degree and achieve a probability of determining a secure redshift greater than 70% with exposure times of one to two hours.

1.2.2 SD2.2: Integration times

We have carried out a detailed study to estimate the exposure time required to detect our required density of LAE galaxies. Using Lyα luminosity functions from Konno *et al.* (2016) and Ouchi *et al.* (2008), we choose line fluxes to achieve ~ 140 LAE galaxies per deg^2 in each of the two MB filters. This gives us a target depth of 25.0 AB mag in each filter. We then use the CFHT PyDIET ETC to compute exposure times. The calculations are summarised in Table 1. We assume delivered image quality of 0.84 arcsec, airmass of 1.1, and dark conditions. We plan to use four sub-exposures (with large dithers). We find that we need a total of 943 s for MB1 and 897 s for MB2 for each square-degree pointing. This includes MegaCam readout time. This represents **a total of 2147 hrs or 430 nights for the whole POLU survey**.

We plan to use the dynamic observing time mode (QSO-SNR) in order to produce a survey of the best survey uniformity possible, as demonstrated on CFIS-UNIONS r-band. With our four-pass tiling, we can tolerate some exposures taken in worse IQ conditions (in IBIS we tolerate up to $2''$), though correspondingly longer exposure times will be required. Similarly, we can tolerate mild extinction due to clouds, though moonlit clouds will cause unusably high background levels. Essentially, our science goals depend upon calibratable point-source depth. Once the MB filters have arrived at CFHT (expected May 2026), these depth estimates will be validated and the target depths or survey area will be adjusted to fit within the allocated time. The sister program to this proposal on the Blanco telescope, IBIS (NOIRLab PropIDs 2023B-184194 and 2025B-479281; Schlegel and Dey, co-PIs) uses three redder MBs than the ones proposed here. CFHT time with MegaCam's excellent blue sensitivity is critical to the overall program. IBIS has been assigned 90 nights during the 2023B–2026A semesters followed by 263 nights awarded in 2025B–2028A. We aim to complete the POLU observations on a similar timescale, starting in 2027. It is important to have at least 1000 deg^2 complete by the start of DESI-II in 2029, i.e., at least 100 nights for POLU before 2029.

Since the twilight sky is very bright in the MB filters we are using, POLU observations must wait for 18° twilight. StarFEAST observations may be performed between 12° and 18° twilight. The POLU fields are equatorial and at a wide range of RAs, so should be easy to schedule: airmass and hour-angle limits are not a difficulty.

1.2.3 SD2.3: Footprint and observation strategy

The POLU survey, which will observe equatorial fields, will be associated with the MB surveys, IBIS on the Blanco and Niji on Subaru, and BB imaging such as the Rubin/LSST and Euclid surveys. The POLU and IBIS surveys will share the same coverage, but the former will observe the two bluest bands, while the latter will observe the three reddest MB. Niji, on the other hand, will be completely independent and will observe in the four bluest MBs. The filters for the five bands have been defined in exactly the same way so that the three surveys can be combined into a single survey in the end. The

Filter (Wavelength)	MB1 (4000 – 4260Å)	MB2 (4260 – 4520Å)	Total
Lyα flux [10^{-16} erg s^{-1} cm^{-2}]	1.66	1.43	
Source brightness [mag.]	25.00	25.00	
Sky brightness [mag/arcsec^2]	22.27	22.28	
Exposure time per dither [s]	196	184	380
Total time per tile (1 deg^2) [s]	943	897	1840
Total exposure time for 4200 deg^2 [hours]	1100	1047	2147
Total exposure time for 4200 deg^2 [nights]	220	210	430

Table 1. Exposure times required to detect a Lyα line at a given line strength at 5σ (PSF, model photometry). The total exposure time is computed for 4 exposures with a 40-second overhead and a 4200 deg^2 footprint, assuming airmass of 1.1 and seeing of 0.84″. Calculations are performed using CFHT PyDIET.

final surface area of the combination of the three surveys will be approximately 5,000 deg^2, with 4,200 deg^2 observed by POLU+IBIS and 800 square degrees by Niji. The 4200 deg^2 POLU footprint (see Fig. 3) is divided into two equatorial fields: a 1900 deg^2 rectangular strip in the South Galactic Cap and the union of two rectangular strips in the North Galactic Cap covering 2300 deg^2. POLU will therefore request observing nights split between the A and B semesters with a good balance between the two semesters. The MB filters for POLU are manufactured by Asahi, which produced the same filters with the same specifications for the two associated surveys, IBIS and Niji, making the inter-calibration more robust. Their delivery is expected in May 2026. Tests with these new filters at CFHT will probably take place during the engineering time in June. We have planned five deep fields (including the COSMOS and XMM-LSS fields) for the overall survey (POLU+IBIS), which can be observed alternately throughout the year. We will use one of these five deep fields to validate the new filters on CFHT.

2. Minimum number of nights and survey strategy

This project has been designed for a timely and competitive CS aimed at providing a unique set of data not accessible at any other ground-based or space facility, to address several open questions in astrophysics and cosmology. It is thus of interest for a very wide community, spanning from local studies of star formation and ISM in the MW, to LG, large scale structures, the high-z Universe, and cosmology. The number of requested nights has been designed for this purpose; thus, any significant cut (>10–20%) would automatically result in the exclusion of a community to the dataset, hampering the CS nature of this proposal. Moreover our request of 700 nights is also motivated by the challenging nature of these large time allocations which might reach completion rates of the order of 80–100%. With the weather being the most significant risk of the project we envision a shared risk between the two surveys which will equally share the weather conditions, and a yearly monitoring of the data quality and progress, to evaluate corrections to the overall strategy.

3. Data and Project Management Plan

WP-D.1: Data Reduction and Analysis. Different pipelines optimised for the detection of point sources (POLU) and extended sources (StarFEAST) will be used, as described below:

StarFEAST *(Lead: J.-C. Cuillandre, M. Fossati, E. Mangola)*

The StarFEAST project will benefit from the end-to-end pipeline developed to support the VESTIGE survey. The Elixir data distributed by CFHT will be run through Elixir-LSB – a pipeline developed within the NGVS collaboration (Ferrarese *et al.* 2012) to detect extended LSB features, and later applied successfully to the VESTIGE survey. The Elixir-LSB pipeline has also been automated at CADC for CFIS-UNIONS activities. Global astrometric solutions, image stacking and source catalogues can then be generated at CADC by MegaPipe if the service is presented to us, otherwise our team is equipped to complete the task. Members of our team have developed extensive software for the detection and the analysis of extended and point sources in BB and NB images. The reduced data will be combined with those at other frequencies to produce a complete, unique dataset for the observed regions.

POLU *(Lead: D. Lang, A. Raichoor)*

The aim is to combine the POLU observations with other MB observations and BB observations. The team's philosophy is to make the catalogs available to the astrophysical community as quickly as possible, adopting a similar structure to that used for the DESI Imaging Legacy Surveys (DECaLS, MzLS and BASS; see *https://www.legacysurvey.org/decamls/*). The data reduction plan splits into two efforts. Image-level calibrations will be run at CADC-CANFAR, then copied to the

US National Energy Research Scientific Computing center (NERSC) for catalog-level reductions. Calibrated, coadded images will be provided with the catalog releases (our reductions are performed on individual images rather than coadds, but coadds remain a useful data product for many science cases and other users of the data). Our team has successfully obtained sufficient storage and computing resources at NERSC for the computationally-intensive reductions we have planned, using the *Legacypipe/Tractor* pipeline. These resources are allocated through the US Department of Energy's High Energy Physics program allocation, and has included approximately 10 million core-hours for each of the DESI Legacy Imaging Surveys Data Releases 9 and 10. We expect to successfully compete for sufficient compute resources for the reduction and release of this MB imaging campaign (including POLU and IBIS surveys), along with the corresponding BB imaging.

WP-D.2: Data Distribution and Publication Plan. *(Lead: A. Boselli, C. Yeche, D. Lang, Y. Roehlly, A. Raichoor)* Our proposed community survey will be public with no proprietary period. Both for StarFEAST and POLU, the raw data will be available immediately, with image-level reductions available shortly after each observing run at CADC-CANFAR. Catalog-level data releases will occur yearly, with a first early data release within one year of the first semester of observation. Each data release will reprocess all previous data from this program to take advantage of pipeline improvements and provide uniformity of the data within each release. A final data release with all data will be completed no more than 1 year after the completion of observing. For StarFEAST, the data will be released through a CeSAM (LAM Marseille) dedicated web-interface, as successfully done for several previous projects lead by our team (HRS *http://hedam.lam.fr/HRS/*; GUViCS *https://observations.lam.fr/guvics/*; VESTIGE *https://mission.lam.fr/vestige/*). High level science products and catalogs obtained by ad-hoc analysis for specific science goals will be released after the last data release. For POLU, catalog-level products and calibrated images will be made available through NERSC and through the NOIRLab Science Archive. NERSC access methods include simple https, Globus Online for bulk data transfer, and custom web applications based on the Spin service In addition, we will provide public access to catalogs through the NOIRLab Astro Data Lab service. Finally, all released data will be copied to the NERSC HPSS Archive system for safe, long-term storage. The imaging data will also be served through the interactive sky viewer (*https://www.legacysurvey.org/viewer/*) custom built by co-PI Lang for the Legacy Surveys project. This also provides a compelling public engagement platform, where members of the public can explore the beautiful images collected by these surveys. Our teams are very experienced in the execution of large imaging surveys, pipeline reduction, and the reduction and public release of calibrated, useful, and well-documented survey data products in a timely way.

In addition to the data distribution channels described above, we have been in contact with the CADC leadership and we are committed to collaborating to provide reduced data products (stacked images, catalogs, high-level data products) for distribution and archiving through CADC services, including TAP-enabled databases for catalog products. We may also pursue using CANFAR storage and compute resources for the data reductions, as appropriate. The results of StarFEAST and POLU will be published in refereed journals with an high overall publication rate significantly ($\sim$50 refereed publications within three years of the completion of the survey) given the large involvement of scientists of different communities. Finally, in addition to the large number of CFHT citations and acknowledgements that can be expected from the DESI-II project and the scientific papers using StarFEAST and POLU data, the public catalogs and images will give even greater benefit to the CFHT.

WP-D.3: Outreach. *(Lead: S. Boissier, J.-C. Cuillandre, P. Zarrouk)*
This CS will provide a large number of spectacular images of star forming regions within the MW, of LG, and of interacting systems in large scale structures. These images are perfectly suited for CFHT outreach communications, for the well known CFHT calendar, for planetarium activities, and for dedicated press releases. The entire POLU team will reuse all the infrastructure developed for DECaLS, particularly the sky viewer, *https://www.legacysurvey.org/viewer*, which provides a sky map that offers tremendous benefits for all outreach activities.

WP-D.4: Support Offered to the QSO Team. *(Lead: J.-C. Cuillandre, B. Epinat, D. Lang)*
The StarFEAST team, leveraging two decades of experience with MegaCam and CFHT operations, can provide direct support to the QSO team's daily activities. This contribution would center on the development and deployment of remote monitoring tools to track survey status on both nightly and run-to-run timescales. Coupled with a survey forecasting capability, these tools would support validation and forward planning by clarifying the prioritization across the survey's various Observing Groups (OGs) within the CFHT operational framework.

The POLU team has a strong history of working closely with the DECam/Blanco staff to carry out the DECaLS and IBIS surveys in a way that uses telescope time very efficiently and requires little support from the observatory staff. We have produced real-time monitoring systems to track and adapt to the sky conditions, adjusting exposure times to reach

our target depths, similar to QSO-SNR mode, but fully adaptive to the full range of conditions. This allows us to observe faster in good sky conditions, and also still make good use of less than perfect conditions, in a fully automated fashion. We provide observers for all observing runs, and have made our tools available to other facility users.

WP-D.5: Follow-up observations. *(Lead: D. Lang, F. de Gasperin, P. Serra, M. Sun)*
Multifrequency follow-up observations might be necessary for the best scientific exploitation of the data. Spectroscopic observations, required for the redshift measurement of unclassified local and high-z line emitters, or to supplement the properties of the detected sources ([NII] contamination, dust attenuation, line diagnostic diagrams) will be taken from public archives or from dedicated follow-up campaigns using MOS facilities such as DESI, WEAVE or Subaru PFS. Thanks to the large involvement of the community to this project, we will have access to several ground-based or space-based facilities such as ASKAP, LOFAR, MeerKAT, VLT, DESI, WEAVE, Dragonfly, PRIMA, UVIT, CASTOR, XMM, NewATHENA, granting the access to all the data necessary for the best scientific exploitation of the CFHT data.

4. Team Expertise.

StarFEAST: The team has more than 20 years of expertise in the acquisition, data reduction, and scientific exploitation of MegaCam data. It includes PIs of several successful CFHT LPs (NGVS, Ferrarese; CFIS-UNIONS, Cuillandre; VESTIGE, Boselli). Some team members are deeply involved in the different synergic surveys, others have extensive experience in the acquisition, reduction and analysis of NB imaging (Boselli *et al.* 2018, Lokhorst *et al.* 2022), radio continuum and HI (de Gasperin *et al.* 2025; Serra *et al.* 2023), CO (Braine *et al.* 2010; Jachym *et al.* 2014; Brown *et al.* 2021) and X-rays (Sun *et al.* 2007) data to which Hα data will be confronted. Others have developed SED fitting codes (CIGALE, Boquien *et al.* 2019) or have a unique expertise in 2D chemo-spectrophotometric and dynamical models of galaxy evolution (Boissier & Prantzos 1999) and in hydrodynamic simulations of gas stripping in dense environments (Vollmer *et al.* 2021; Renaud *et al.* 2014; Boselli *et al.* 2021; Woods *et al.* 2024) including cosmological simulations (Ahvazi *et al.* 2024; Kraljic *et al.* 2020) – all powerful tools for the analysis and interpretation of the NB imaging data. Overall, the team includes recognized leaders in the study of star forming regions in the MW (Russeil 2003; Zavagno *et al.* 2006), LG (Boquien *et al.* 2015; Melchior *et al.* 2016; Braine *et al.* 2018; Lokhorst *et al.* 2022), the effects of the environment on galaxy evolution (Vollmer *et al.* 2001; Yagi *et al.* 2010; Kenney *et al.* 2015; Boselli *et al.* 2022), LFs (Ferrarese *et al.* 2016; Cuillandre *et al.* 2025), LSB systems (Boissier *et al.* 2016; Lokhorst *et al.* 2022), star formation (Boselli *et al.* 2009; Braine *et al.* 2010; Boquien *et al.* 2019; Woods *et al.* 2024), dwarf (Côté *et al.* 2009; Taylor *et al.* 2018) and high-z galaxies (Fossati *et al.* 2017), including line-emitting systems (Epinat *et al.* 2012, 2024; Fossati *et al.* 2017), and the dynamical evolution of clusters (Kraljic *et al.* 2018). We therefore have the access, resources, and expertise to fully capitalize on this unique dataset which will also be used to train students, postdocs, and highly qualified personnel.
POLU: A strength of POLU is that it combines the French/Canadian science teams with DECaLS, an international team with extensive data-processing expertise. This group has consistently delivered source catalogs for DESI target selection on time, including DR9 for DESI (Dey *et al.* 2019) and DR11 for the DESI extension. It has also demonstrated its ability to coordinate observations and data reduction for the benefit of other projects (for instance, 4MOST with the DR9 release and eROSITA with the DR10 release). In the field of science, all members of DESI and later DESI-II are recognized as global leaders in the processing of 3D catalogs with redshifts and clustering science in general. The number of publications and citations of their main papers (Adame *et al.* 2025, Abdul-Karim *et al.* 2025),which exceeds 2,500, is a clear indicator of this. In addition to their extensive expertise in 3D catalogs, the entire team has extensive experience in the scientific analysis of imaging catalogs, whether it involves photometric redshift determination (Arnouts *et al.* 1999, Arnouts *et al.* 2002, Ilbert *et al.* 2006), studies of dark matter in dwarf galaxies (Leauthaud *et al.* 2020, Luo *et al.* 2024), directly the measurement of 2D clustering (Payerne *et al.* 2025, Ebina *et al.* 2026) or study of cross correlation with (CMB lensing or kSZ) (Zhou *et al.* 2023, Krolewski *et al.* 2024, Chaussidon *et al.* 2026). For over a decade, the team has worked with DESI to conduct pilot surveys, acquiring deep expertise in identifying star-forming galaxies, including LBGs (Ruhlmann-Kleider *et al.* 2024, Payerne et al 2025) and LAEs (Ebina *et al.* 2024). In addition, the project will enable unprecedented studies of galactic building blocks and cosmic web structures across cosmic time (Bacon *et al.* 2021), while the team's strong expertise in this field ensures they are well equipped to fully exploit these advanced observations with BlueMUSE (Richard *et al.* 2019). In conclusion, POLU's PI team brings well-established expertise in image processing, along with a deep understanding of the scientific knowledge that can be extracted from it. This strength is further enhanced by the DESI environment, which offers access to a broad and highly qualified talent pool.

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