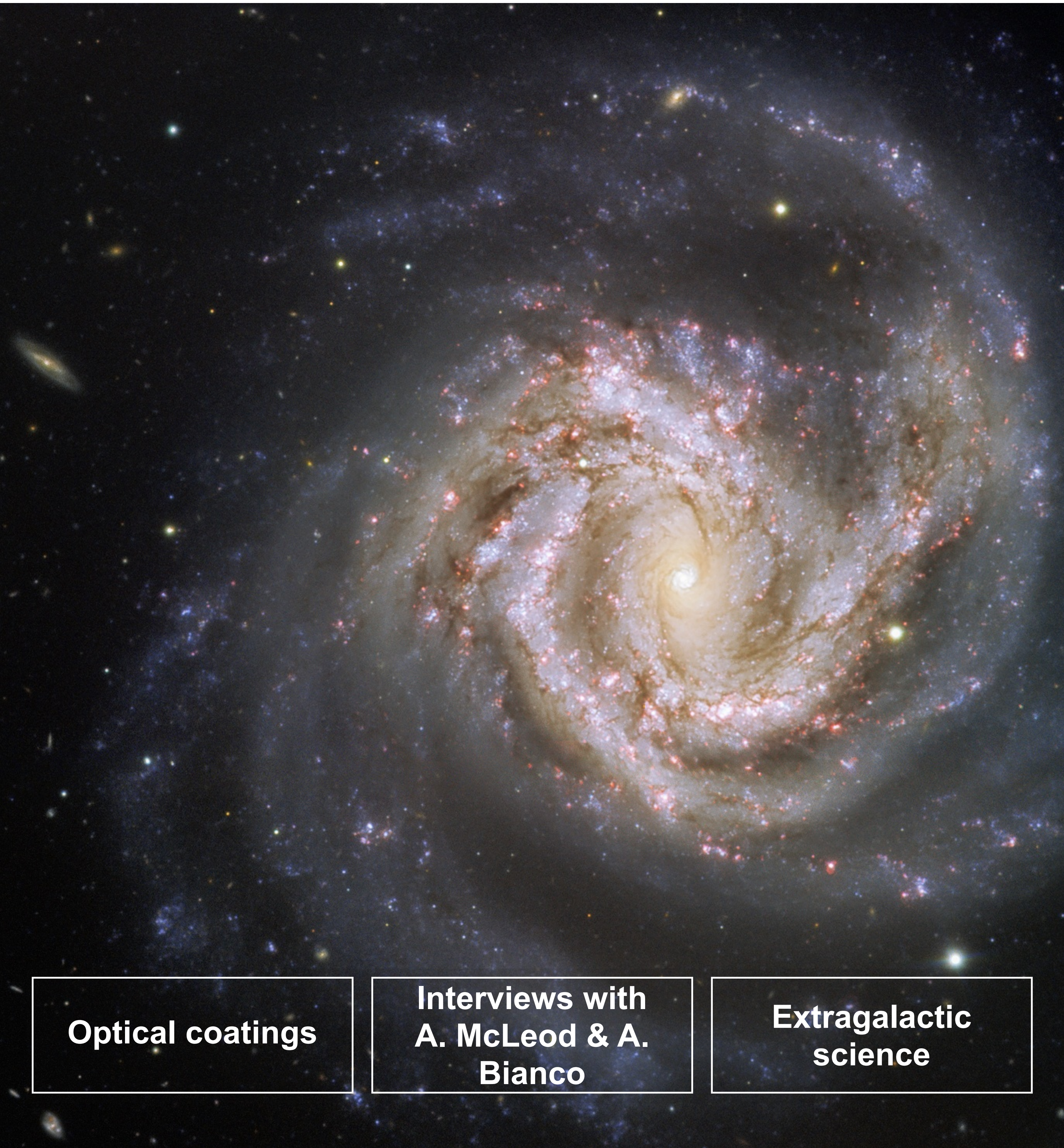
Issue 4 - April 2026

THE WST CHRONICLE

Pushing the Boundaries of Spectroscopic Surveys



Optical coatings

Interviews with A. McLeod & A. Bianco

Extragalactic science

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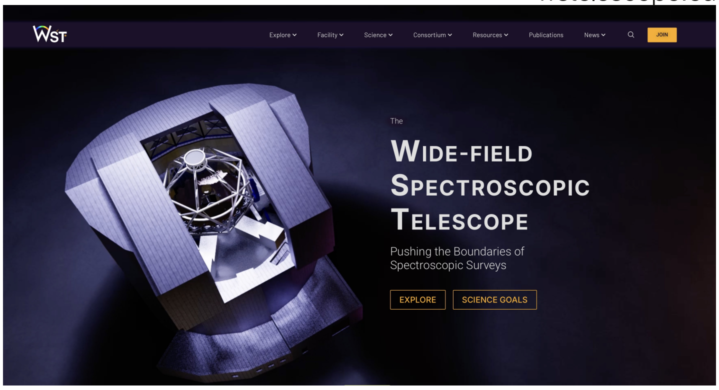

A NEW DIGITAL HOME FOR THE WST

The launch of the new WST website marks an important step in the project's communication strategy. The platform has been conceived as a modern, flexible and future-oriented digital environment: one that responds to the needs of today's core audience — scientists, researchers and institutional stakeholders — while already being prepared to welcome broader audiences as the project progresses into future development phases.

At present, the WST community remains the website's primary reference point. For this reason, particular attention has been devoted to information clarity, rapid access to scientific and technical content and an intuitive structure that enables users to find what they need efficiently. Whether looking for project documents, governance information, scientific updates, technical milestones or opportunities to engage with the consortium, visitors are guided through a coherent experience.

At the same time, the redesign reflects a longer-term vision. As the WST advances and its public profile grows, the website will increasingly need to address not only

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COORDINATOR MESSAGE

As the WST project continues to gather momentum in 2026, this new issue of the *Chronicle* provides an excellent opportunity to highlight new important mile-stones achieved by the consortium in the last three months or so, as well as the activities that lie ahead.

First, the new WST website was publicly launched on 24 April. The website is not only highly professional, but also aesthetically refined and engaging. It will play an essential role in communicating to the broader community and to our stakeholders all aspects of the WST project, along with its ambitions.

Another very positive development is the expansion of the consortium. We are indeed very pleased to welcome three new partner institutes: the University of Cambridge (Institute of Astronomy, Cavendish Laboratory Department of Physics, and Kavli Institute for Cosmology) in the UK, the Instituto de Astrofísica de Andalucía in Spain, and Stockholm University (Department of Astronomy) in Sweden. While these institutes are not directly involved in the current activities, they expressed strong interest in participating in the future phases of the WST, should it be selected by ESO as the next programme to follow the ELT. Their membership was ratified during the recent Steering Committee meeting, and each of these institutes will nominate a non-voting observer to the board.

On the technical side, a major step forward was achieved during the recent trade-off meeting at the end of February at UKATC in Edinburgh, where reference designs were selected for most of the instruments and sub-systems. This represents an important milestone in the maturation of the project and provides a solid baseline for the next phases of the concept study and for the proposal to ESO. In parallel, a final decision on the implementation of ground-layer adaptive optics (GLAO) for the Integral Field Spectrograph (IFS) was made on a solid basis, thanks to the contribution of people at ESO, INAF, and ONERA in Marseille. The GLAO for the IFS is now included in the baseline, promising improved perspectives for the performance of the WST. Indeed, current simulations show that a gain of 15-20 % in survey speed is within reach. Still on the technical side, interaction with industry partners is continuing, with the next important step being the development of preliminary cost estimates for the facility.

Equally important, developments are taking place on the science side. An online two-day science meeting was held at the beginning of March, to discuss the next steps toward consolidating and communicating the WST science case. One of the key outcomes of these discussions is the decision to publish in a refereed journal a collection of consortium white papers that will further convey and articulate the transformative science enabled by WST in the 2040s; the white papers will also provide the opportunity to recognise the work of the science working groups and their members. Crucially supporting these efforts, the first version of the Exposure Time Calculator has now been released; also, the survey plan and operation teams are working together to deliver a first, preliminary survey concept. Progress is successfully ongoing on the other key aspects of the project, like the sustainability and site selection. The EDI group are also planning new initiatives aimed at fostering a fair, respectful, and inclusive WST community.

The coming months will offer several opportunities to present the project to the broader astronomical community. Noticeably, the Expanding Horizons workshop, organised by ESO and to be held in Garching on 13–17 July, will offer an important occasion to showcase the scientific and technical vision of the WST to both the community and the ESO Senior Science Committee. The synergies between the WST and the other major facilities will be discussed during the Special Session “WST in the 2040s landscape: the power of synergies” at EAS 2026 in Lausanne. The previous week several consortium members will attend the SPIE conference in Copenhagen, which will offer an excellent platform to present the WST and its technological challenges and progress. I hope many of you will be able to attend these meetings.

Before the SPIE conference, many of us will gather in Aussois in France for the consortium Busy Week; let me stress that this will be a particularly valuable opportunity to meet in person, exchange ideas across the different work packages and activities, and continue building the shared vision that drives this project forward.

I would like to thank once again all members of the consortium for their continued dedication and commitment and I hope you will enjoy this new issue of the *Chronicle*, which reflects the depth and diversity of the work underway throughout the consortium.

Sofia Randich

A MATTER OF SCALE, ENVIRONMENT, AND EFFICIENCY

From the Solar System to the observable Universe, astrophysics spans roughly fifteen orders of magnitude in distance—one of the largest ranges encountered in science, rivaled only by the extremes explored in fundamental particle physics. This vast dynamic range is what makes astrophysics so fascinating, but also particularly challenging. Understanding the physical processes at play requires a genuinely multi-scale approach.

The WST has been specifically designed to address this challenge. Its scientific reach extends across the entire hierarchy of astrophysical scales, from small Solar System bodies such as comets and asteroids to objects at cosmological distances (Fig. 1). In addition, its two instruments—the Multi-Object Spectrograph (MOS) and the Integral Field Spectrograph (IFS)—probe very different spatial regimes.

The MOS, with its 3 square-degree field of view and 32,000 fibers, enables wide-area surveys with extremely high multiplexing, albeit in a necessarily sparse sampling mode. By contrast, the IFS covers a much smaller field of 9 arcmin^2 but provides continuous spatial coverage at a much finer spatial sampling of 0.25 arcseconds.

Many WST science cases exploit the inherently multi-scale nature of astrophysical processes. A compelling example is the growth of galaxies through gas accretion. Understanding this process requires tracing the flow of gas across a vast range of scales: from the cosmic web, where megaparsec-scale filaments channel matter through the large-scale structure of the Universe, to the circumgalactic medium surrounding galaxies, and ultimately into the galaxies themselves, where the gas becomes part of the interstellar medium and fuels star formation.

The WST is uniquely designed to address this problem. The IFS will resolve galaxies and their circumgalactic medium at high spatial resolution in absorption and in emission, while the MOS will simultaneously trace the surrounding large-scale structure. Because both instruments operate in parallel, a single observation can deliver a coherent multi-scale view of the processes that link galaxies to their cosmic environment.

The combination of IFS and MOS is particularly well suited to observe massive star clusters at large distances in the Milky Way and up to the Magellanic Clouds. Their dense cores are best explored with the IFS,

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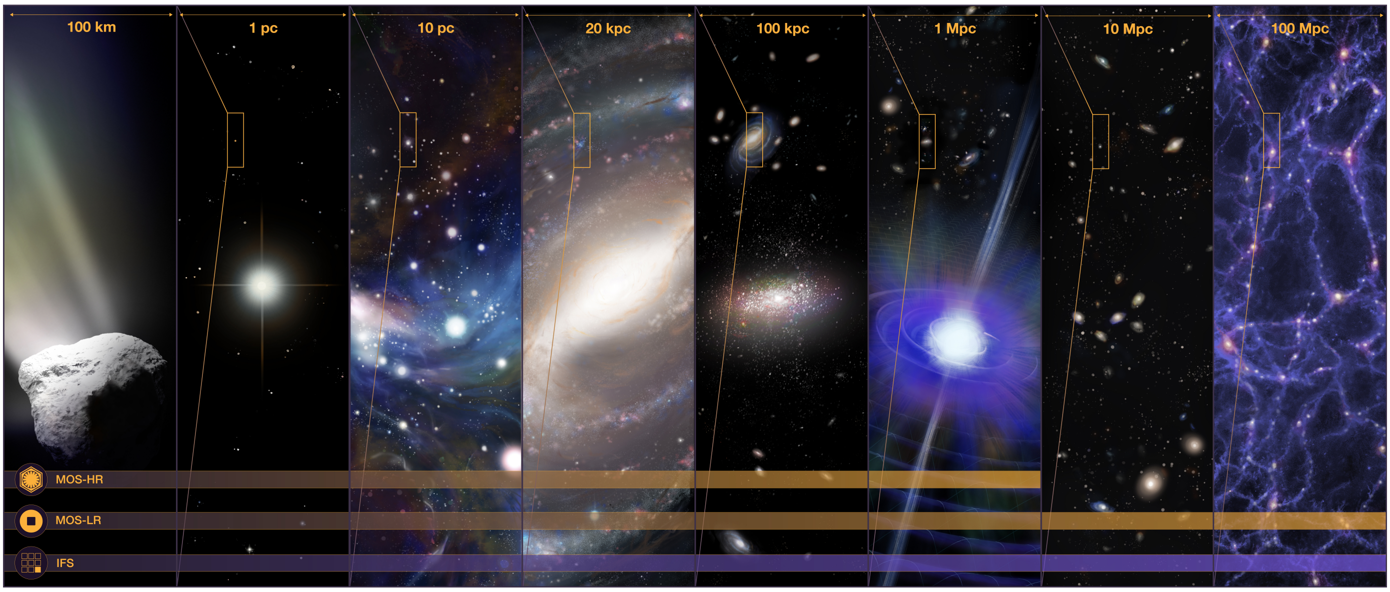

Figure 1. The WST is designed to address key scientific questions across all astrophysical scales, from our solar neighbourhoods to the cosmological scale. Artist's impression. Credits: M.C. Fortuna

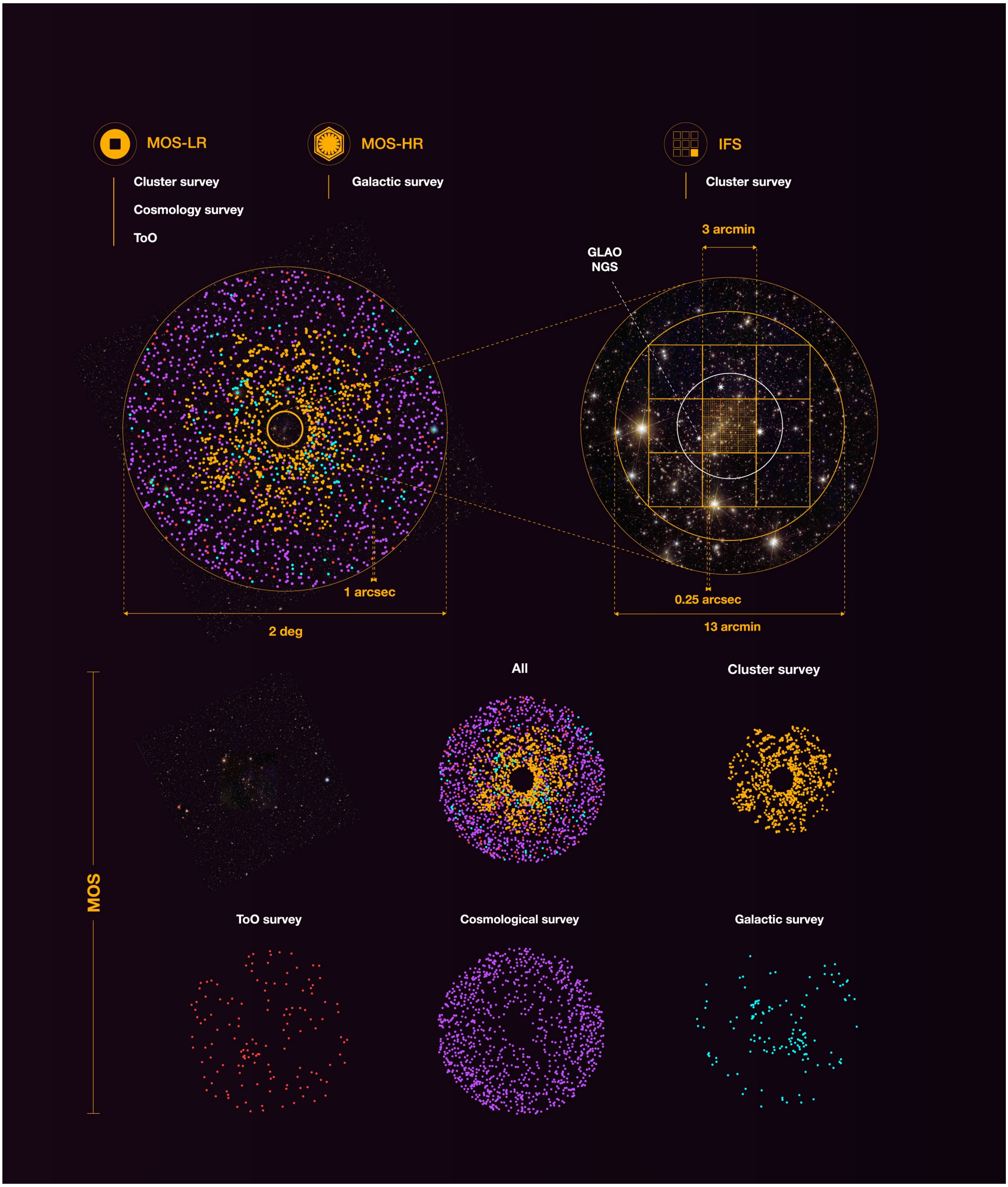

Figure 2. The massive cluster survey is an example of multi-scale, multi-survey optimum use of the WST capabilities. The central region of the Abell 2390 cluster will be imaged by the IFS, whose field of view is ideally suited to probing the strong lensing region, either with a single 3×3 arcmin^2 pointing (700 kpc at the cluster distance) or through a mosaic of IFS observations. Sufficiently bright stars are present within the surrounding 6 arcmin diameter technical field of view to enable effective GLAO correction, delivering superb image quality across the IFS field. At the same time, a fraction of the 30,000 MOS-LR fibers can be dedicated to tracing the distribution of cluster galaxies on Mpc scales, providing key insights into the cosmic web structure surrounding the massive cluster. The remaining MOS-LR fibers can be used in parallel for large-scale cosmology surveys, while MOS-HR fibers will measure chemical abundances in Milky Way halo stars. Finally, alerts from photometric time-domain surveys (e.g., LSST) will enable the observation of targets of opportunity (ToO), using a pre-allocated subset of MOS-LR fibers. Credits: M.C. Fortuna and R. Bacon. The Abell 2390 central image is from Euclid: ESA/Euclid/Euclid Consortium/NASA, image processing by J.-C. Cuillandre (CEA Paris-Saclay) and G. Anselmi. The large scale 2-degree image centered on the cluster is from Pan-Starrs (Pan-STARRS1 Surveys (PS1), Institute for Astronomy, University of Hawaii).

which can cope with the high level of stellar crowding, while the MOS is more efficient at targeting stars in the lower-density outer regions. The WST is therefore particularly well matched to such observations, with the IFS, positioned at the center of the MOS field of view; this naturally reflects the geometry of these systems and enables a highly efficient observational strategy.

For example, in young clusters this approach will allow the WST to collect information on statisti-cally sound populations of stars and to constrain the models of star+disc and cluster evolution in these representative environments of star formation. Likewise, the parallel use of the IFU + MOS mode will be key to fulfill the requirement of a large total number of targets in Local Group dwarf galaxies and a dense sampling of the innermost regions; this is crucial for the dynamical modeling and for probing the hierarchical build-up of galaxies down to the smallest mass end.

A similar multi-scale approach applies to the study of massive galaxy clusters. The IFS is ideally suited to probe the dense cluster core, where measurements of strong gravitational lensing will provide an unprecedented view of the dark matter distribution. At the same time, MOS observations will map the surrounding large-scale structure, revealing how cosmic filaments feed the cluster and shape its growth (Fig. 2).

Even when WST science cases do not require simultaneous IFS and MOS observations, the two instrument can still be operated in a highly complementary and efficient way, by conducting multiple surveys in parallel. For example, when the telescope pointing is driven by the IFS, the MOS can advance surveys that benefit from the same pointing (e.g., wide cosmological surveys). Conversely, when the pointing is driven by MOS observations, the central IFS can be used to conduct blind surveys, turning every exposure into a chance to expand the discovery space.

This capability for parallel, multi-scale observations is a defining feature of the WST. It is made possible by an innovative telescope architecture that allows the MOS and IFS focal planes to operate fully independently. This design is ideally matched to the inherently multi-scale nature of astrophysical processes, while at the same time maximising the scientific return of every observation. By enabling two complementary observing modes to operate simultaneously, the WST turns every pointing into a multi-purpose experiment, dramatically increasing survey efficiency and scientific discovery potential. In effect, the WST delivers the power of two complementary observatories operating at once.

Come and meet us at the following meetings

EAS 2026	29 June - 3 July 2026	Lausanne, Switzerland
SPIE 2026	5-10 July 2026	Copenhagen, Denmark
UK WST workshop	14-16 December 2026	Cambridge, UK

“JOINING THE WST MEANS HELPING SHAPE A MAJOR NEW FACILITY”

An interview with Anna McLeod, co-lead of the resolved stellar populations

When did you join the WST and what motivated you to get involved?

I became actively involved with the Wide-field Spectroscopic Telescope in early 2023, largely thanks to Roland Bacon visiting Durham. It quickly became clear that the WST would be the natural next step for the questions I care about most: how massive stars shape their environments and how resolved stellar populations encode the evolutionary history of galaxies. Coming from years of work with integral-field spectrographs (IFS) like MUSE and KMOS on the VLT, I could immediately see that the WST’s combination of a wide-field IFU with massive multiplexed spectroscopy would allow us to move from a handful of spectacular case studies to a systematic, galaxy-by-galaxy view of stellar feedback and galaxy evolution. In many ways, the WST turns the spatially resolved feedback work we currently do in nearby star-forming regions into a truly panoramic Local Group and Local Volume experiment.

What do you find most exciting in your current role?

What excites me most is helping shape a facility whose design is genuinely driven by the science. As a co-lead of the resolved stellar populations working group, I work at the interface between ambitious science—stellar feedback, chemical enrichment, dark matter in dwarfs, black hole seeds, cluster dynamics—and practical design choices such as spectral resolution, wavelength coverage, multiplex, cadence, and operations. It is rare to help design a facility while incorporating lessons learned from instruments like MUSE and KCWI: that spatial resolution, spectral coverage, and survey efficiency must be optimised together to make real progress in this field.

What are the key scientific questions that resolved stellar population studies aim to answer in the next decades?

Resolved stellar populations let us read the fossil record of galaxy evolution star by star. Key questions include: *How universal are the laws of chemical enrichment? What is the nature of dark matter on small scales? How do massive stars behave at very low metallicity, and how did they power reionization? How and where do intermediate-mass black holes form? How do clusters, binaries, and compact objects co-evolve? And how do galaxy discs, halos, and intracluster light assemble?*

Together these questions transform resolved stars from “pretty pictures” into precision probes of dark matter, stellar evolution, black hole seeding, and galaxy assembly. ■■■

Anna McLeod grew up in the Swiss Alps and pursued her studies in physics and astronomy across Europe. She earned her BSc from Ludwig-Maximilians-Universität Munich, followed by an MSc in Astrophysics at Radboud University Nijmegen, and a PhD at ESO. She then held a Marsden Fellowship from the Royal Society of New Zealand at the University of Canterbury in Christchurch, and later a NASA Hubble Fellowship at the University of California, Berkeley. In 2020, she joined Durham University as a faculty member. Her research focuses on massive star formation, stellar feedback processes, gravitational-wave progenitors, and galaxy evolution. Alongside her academic work, she is actively engaged in science communication and currently leads the development of a public outreach observatory in southern Switzerland, where she has also presented a TEDx talk.

What are the main limitations of current or planned facilities in addressing these questions? In what ways will the WST overcome them?
Looking at galaxies in the Local Group, having enough spatial resolution in crowded regions, and very high multiplex over wide areas. Current facilities typically provide only two of these at once. IFS such as MUSE deliver exquisite spatially resolved data but lack the field of view and multiplex to survey many galaxies efficiently. Classical multi-object spectrographs (MOS) provide large stellar samples but struggle in crowded environments. ELT instruments will deliver extraordinary detail in small fields but cannot economically conduct homogeneous surveys across many systems. The WST is designed to overcome this limitation. Its 12-m class aperture, wide-field IFS, and thousands of MOS fibres over several square degrees allow crowded centres and sparse halos to be mapped simultaneously, delivering precise velocities and detailed abundances at true survey scale.

Which aspects of the instrument design and operations are most critical for advancing research in your field?
Three aspects are crucial. First, the simultaneous IFU+MOS multiplex, allowing deep contiguous mapping in crowded regions while sampling thousands of stars in galaxy outskirts. Second, blue–optical spectral coverage with resolutions around R ≈ 4 000–6 000 in the IFU and R ≈ 40,000 for high-resolution MOS, enabling detailed abundance work and km/s-level velocities. Third, survey operations built for legacy and time-domain science, including multi-epoch observations to identify binaries and robust calibration tying IFU and MOS abundance scales.

How will the WST complement or work in synergy with other major facilities in addressing the scientific questions you mentioned?
The WST will act as the spectroscopic backbone of the coming imaging revolution. Surveys from Rubin/LSST, Euclid, and Roman will map the structure and proper motions of galaxies and halos; the WST adds the missing dimension of velocities and chemical abundances. JWST and ELT instruments will provide deep zoom-in studies of the faintest or most extreme systems that WST surveys first identify statistically.

If you have to make a bet, what do you think will be the most transformative science case from your field that will be solved by the WST, and why?
My bet would be the combination of dwarf-galaxy chemo-dynamics and low-metallicity massive-star physics. The WST will measure inner density profiles for a statistically meaningful sample of Local Group dwarfs, helping distinguish between feedback-driven cores and alternative dark matter models. At the same time, complete spectroscopic censuses of massive stars at SMC metallicity and below will anchor models of stellar winds, rotation, and binarity in the regime that sets the ionising photon budget in the early Universe.

Imagine young researchers or students are reading this article and you have this chance to convince them to join your working group: What would you say?
If you want to turn beautiful images of galaxies and clusters into quantitative tests of fundamental physics, this is an exciting time to join the field. The WST will measure the chemistry, dynamics, and feedback of individual stars across entire galaxy ecosystems—from dwarf galaxies to spiral discs and intracluster light. Joining now means helping shape a major new facility while asking questions that connect the lives of stars to the evolution of galaxies and the Universe. ■

EXTRAGALACTIC SCIENCE WITH THE WST

Galaxies are highly dynamic systems, shaped by a complex interplay of baryonic processes that operate across a wide range of physical scales, from the subparsec to the kpc and Mpc regimes. The accretion and cooling of gas together with its cycling through the circumgalactic medium (CGM) and the interstellar medium (ISM) eventually leads to star formation, itself regulated by the physical conditions of star-forming clouds (< pc). Stellar feedback chemically enriches the ISM, shaping future stellar generations while injecting energy and driving outflows into the ISM and CGM (~kpc), whereas dynamical processes such as mergers redistribute gas and stars, contributing to the assembly of galaxy substructures (~kpc). Central supermassive black holes (SMBHs) (< pc) further modulate this cycle by heating or ejecting gas, preventing or even triggering star formation. Yet, these intricate processes do not unfold in isolation, but within dark matter halos (~kpc-Mpc), which grow through hierarchical assembly throughout the time-evolving large-scale structure of the Universe (~Mpc-Gpc). The large-scale structure consists of a cosmic web of dense nodes connected by filaments, delimited by sheet-like walls and vast underdense voids. Understanding galaxy evolution therefore requires a multi-scale perspective that simultaneously captures the full cycle of baryons, and how it is shaped by hierarchical structure formation and the underlying density field across time.

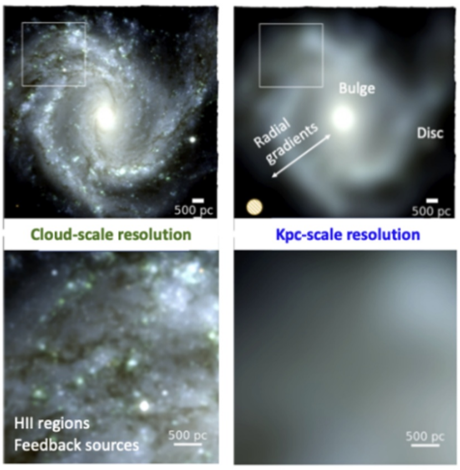

Figure 1: Comparison between a nearby galaxy mapped both at cloud-scale and kpc-scale resolution. This illustrates the ability of the WST's cloud-scale survey to better resolve galaxy structures and H II regions. Adapted from Emsellem et al. 2022.

The WST will deliver a multiscale view of the stellar and gaseous components that shape galaxies, from subparsec star-forming regions to Mpc-scale cosmic web filaments, across time: from $z=0$ to $z=7$. The WST will build on large wide-field imaging surveys from leading facilities of the 2020-2040s, such as Euclid, Rubin/LSST, and Roman that lack the spectroscopic depth and high-multiplexing capability of the WST to characterise physical properties of galaxies: their stellar populations, ISM, and CGM, as well as their large-scale environment. The WST will also represent a step change with respect to high-sensitivity spectroscopic narrow-field facilities such as VLT/MUSE, VLT/MOONS, the ELT, and JWST in terms of statistical power. A key aspect of the WST is its synergy with facilities such as SKA and NewAthena, enabling a multi-wavelength picture of the baryon cycle by spectroscopically following up source populations detected at radio and X-ray wavelengths.

Below, we describe in detail the four extragalactic surveys that tackle this challenge across different physical scales, baryonic components, and cosmic epochs.

Cloud-scale census of nearby galaxies

A key challenge in understanding the baryonic processes that shape galaxy formation is connecting the cloud-scale physics that regulates star formation to the assembly histories of galaxies and the growth of their structural components on kpc scales. The WST will bridge this gap by delivering the first statistically large, mass-complete, volume-limited Integral Field Spectroscopic (IFS) census of the local Universe at cloud scales (~10-100 pc; Fig. 1). In parallel, SKA and New Athena will provide a complete picture of current accretion states of SMBHs in nearby galaxies, while the WST will enable the search for feedback signatures and link SMBH activity to the multi-phase CGM, on scales of kpc, by targeting background quasars. Combined, these observations can provide a simultaneous view of the host galaxies and their halos, linking small-scale processes that regulate star formation and feedback to the stellar assembly and gas cycle on kpc

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scales. These data will help us answer key questions such as *how is star formation and chemical enrichment regulated by feedback? How do different galactic subcomponents assemble? How does the relation between the disc and the halo shape the baryon cycle?*

The co-evolution of galaxies and the cosmic web

Understanding how the assembly histories and chemical evolution of galaxies depend on the hierarchical growth of structure and the cosmic web remain open questions. The low-resolution mode of the multi-object spectrograph (MOS-LR) can map the large-scale galaxy distribution as a tracer of the cosmic web with unprecedented statistics (~6 million galaxies), high completeness and spatial sampling at $0.3<z<1.3$ (Fig. 2). With this survey, the WST will reconstruct the 3D cosmic web on scales of tens to one hundred Mpc, from filaments to groups and rich clusters, and robustly identify galaxy groups to trace dark matter halos. In parallel, the IFS will also resolve cosmic web filaments on sub-Mpc scales, and provide exquisite 2D mapping of the kinematics and physical properties of stellar populations and ISM on kpc scales, enabling constraints on galaxy alignment with respect to cosmic web structures. Together, the MOS-LR and IFS can trace the multi-scale cosmological environment of galaxies, probing how dark matter halos, proximity to filaments on sub-Mpc scales, and location within the cosmic web govern their evolution. Jointly, SKA and the WST will identify active galactic nuclei (AGN) activity, enabling to study the co-evolution of AGN and their host galaxies in the cosmic web. These surveys will answer the questions: *how does the position of galaxies within the cosmic web affect their star formation history and evolution? How does the cosmic web impact a galaxy's angular momentum?*

Mapping the CGM and cosmic web in emission

Gas channelled by large-scale filaments toward dark matter halos is predicted to play a key role in fuelling star formation in galaxies. The link between these filaments and the galaxies' ISM is mediated by the CGM, a dynamic multiphase gas reservoir filling their dark matter halos. Yet, the mechanisms regulating gas accretion along the filaments through the CGM onto the ISM remain poorly understood, and the impact of the large-scale structure on the CGM itself is unclear. In this context, the WST will be crucial to track the cycle of gas from the cosmic web through the CGM. The IFS will map the 3D large-scale distribution of

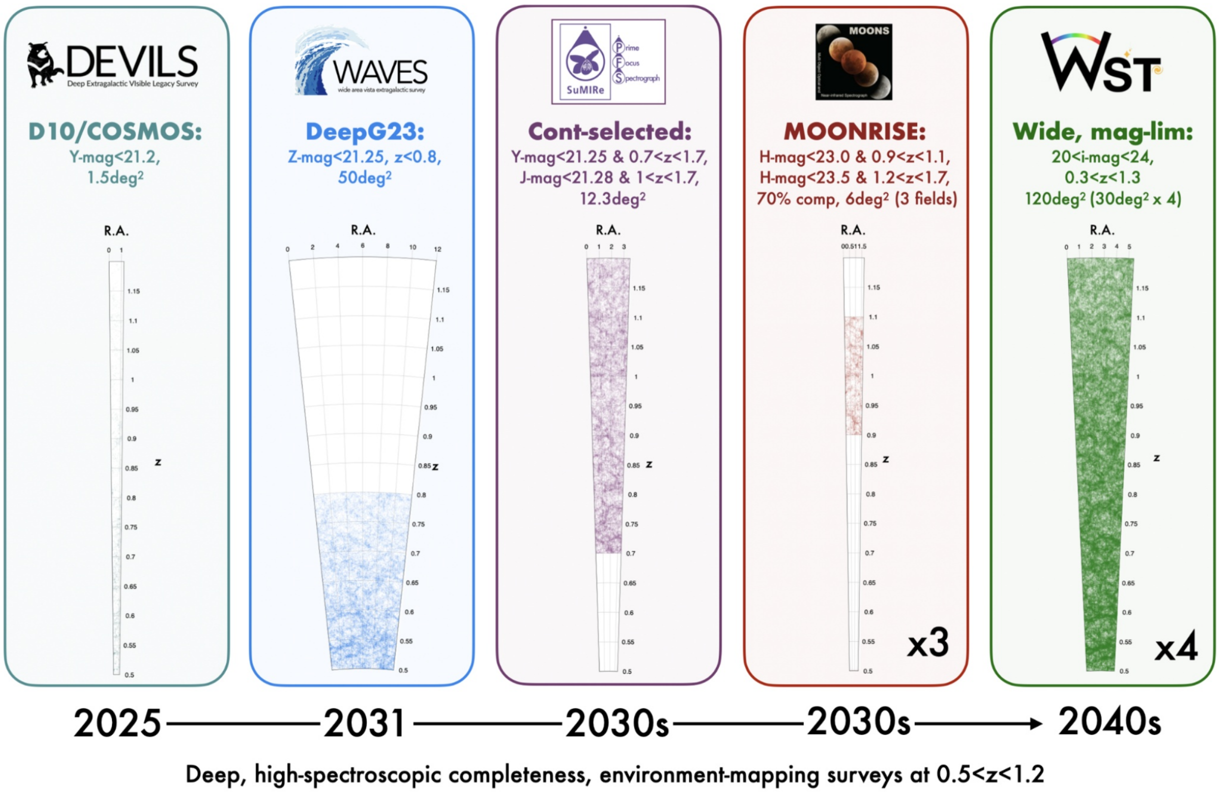

Figure 2: Comparison between the WST magnitude-selected z=1 survey and current and upcoming spectroscopic surveys mapping the large-scale structure at $0.5<z<1.2$. The sketch highlights the high completeness, statistical power, spatial density, and deeper faint limit of the WST survey.

diffuse gas from the cosmic web in emission at 2<*z*<5 up to unprecedented scales of 35 comoving Mpc (cMpc) in cosmologically representative environments, from voids to rich overdensities (Fig. 3). At the same time, the IFS will measure the CGM gas in emission for millions of star-forming galaxies residing in a wide range of environments (e.g., field, filaments, clusters) at 2<*z*<7. Simultaneous MOS-LR observations will place these cosmic web and CGM measurements within their large-scale context by enabling a tomographic mapping of the distribution of background galaxies on scales up to 200 cMpc. These observations will address the key questions: *how is a galaxy's CGM shaped by the large-scale environment? How do cosmic filaments feed star formation?*

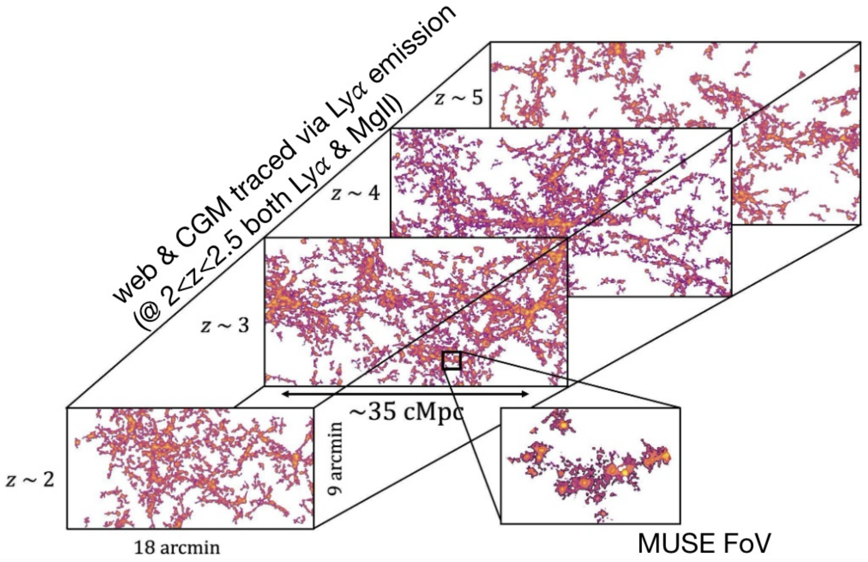

Figure 3: Sketch of a simulated light cone of Lyα emission in a strip of the WST IFS cosmic web survey. Shown is a ~35 cMpc stretch of the cosmic web captured by WST over the redshift range z~2-5, with filaments originating from the large-scale structure, out of which a smaller-scale web connecting halos emerges. The area accessible by MUSE deep pointings (inset) enables the mapping of a single segment of a filament across a handful of galaxies. Image credit: Davide Tornotti

Unveiling the reionisation era

The progression of cosmic reonisation, when the neutral gas in the intergalactic medium (IGM) transitioned to a fully ionised state, remains a major missing piece in our reconstruction of the history of the Universe. While the leading picture is that early star-forming galaxies initiated this process by releasing energetic UV photons into the IGM, the precise timing and duration of reionisation remain poorly constrained, and the roles of early galaxies and AGN as ionising sources are still unclear. In this context, the WST, in combination with SKA, will play a central role in unveiling the physics of reionisation (Fig. 4). While the 21 cm line probed by SKA-Low will chart the 3D state of the neutral and ionised IGM during reionisation, the WST will determine precise redshifts and ionising properties of the galaxies and AGNs detected by SKA. This synergistic tomographic campaign will answer the questions: *What is the nature of the sources contributing to reionisation? When and how did galaxies and AGN transform the IGM?*

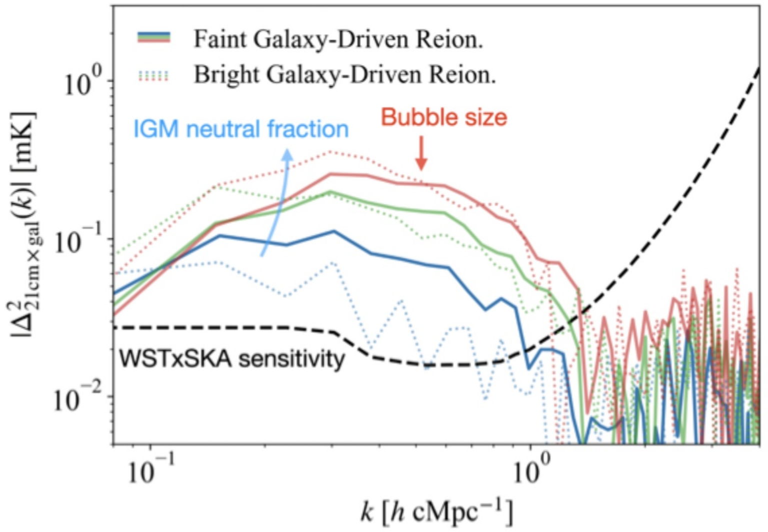

Figure 4: Predicted galaxy-21cm cross-power spectra (adopted from Hutter et al 2021, 23a, 23b) for different source models, IGM neutral fractions, and reionisation morphology. The forecasted WST x SKA sensitivity is shown by the black dashed line. The galaxy-21cm cross-power spectra contain a wealth of information on reionisation physics, such as which sources dominate, the IGM neutrality and bubble size function.

WST MEETING IN FRANCE

A WST workshop for the French community was held in Nice from March 25 to 27. It was organised by Roland Bacon (CRAL) and Vanessa Hill and Georges Kordopatis from the Observatoire de la Cote d'Azur (OCA). The meeting took place at the Hôtel Saint-Paul, ideally located on the seafront under the Riviera's blue skies. It was very well attended, with more than 60 participants from across the country.

The first day opened with a presentation of the *Expanding Horizons* ESO initiative by Jarle Brichmann, followed by a general overview of the WST project. The scientific sessions began with Galactic science, highlighting in particular the strong synergies between Gaia and WST. In the evening, participants travelled to the Observatoire for a guided visit of the site and its historic large refractor. The day concluded with a sunset overlooking the Baie des Anges, followed by a reception under one of the largest domes in France. While the WST would not fit inside, the building remains truly impressive.


Group photo on the steps of the Hôtel Saint-Paul.

The second day focused on cosmology and time-domain science. The complementarities with Euclid and the Einstein Telescope were emphasised. The day ended with a round-table discussion on the big-data and operational challenges of the WST. The data management approaches from ESO, Euclid, Rubin/LSST, Gaia, and SKAO were extensively reviewed, along with lessons learned and their relevance as possible models for the WST. The potential role of artificial intelligence was also discussed.

The third day continued with extragalactic science, including synergies with the ELT, the SKAO and New Athena. The meeting concluded with closing remarks. Participants unanimously agreed that the workshop was highly successful and represents an important milestone in strengthening French involvement in the WST. ■

The round table discussion, from left to right: Pierre Ferruit (ESA, Euclid), Jarle Brinchmann (ESO), Fabio Hernandez (Rubin/LSST, IN2P3), Marc Huertas (AI expert, IAC), Pasquale Panuzzo (Gaia, Paris Observatory) and Chiara Ferrari (SKAO, OCA).

“WE ARE BUILDING A TECHNOLOGICAL ROADMAP”

An interview with Andrea Bianco, lead of the Advanced Technologies WP

You joined the WST project when it was still taking its shape as a Consortium. How did you get involved?
To be honest, it was a bit of a chance encounter. The first people to mention it to me were Pietro Schipani and Sofia Randich. They told me about a project Roland Bacon was leading and that they wanted to develop. At that time, it hadn't yet received funding from the European Union. At one point, Roland wanted to organise a “busy week”. I suggested holding it in Villa Monastero, near Lecco, a beautiful place often used for scientific events. I ended up organising the logistics of that meeting. It was 2023. The busy week was great: the weather was amazing and the atmosphere was really enthusiastic. From there, my involvement really took off. I had worked with Roland on the gratings for *Blue Muse*, and he suggested that, since there would be plenty of gratings to make, I should take charge of the work package on dispersers. But all stemmed from that “busy week”. you see.

Now you lead the Advanced Technologies work package. What does it mean in practice? In what does it differ from working on the instruments or the telescope?
The group was originally established as “Dispersers and Detectors”. The reason was that these were two critical components of the infrastructure: detectors for the transition between CCD and CMOS technologies, as well as for curved detectors and diffraction gratings. In addition to this, there is the cryostat component linked to the detectors. This is not extremely critical in itself, but it becomes so as the numbers scale up. Each instrument has at least two, three or four detectors. Considering hundreds of instruments, the numbers reach such levels that this aspect requires attention too, especially for the energy consumption. It was only later that the focus shifted more broadly to new technologies. We are now beginning to coordinate and identify the technologies or components that require development within the infrastructure, in order to build a technological roadmap. Currently, the workflow is highly granular: each team develops its own component (tools, fibre positioner, fibre link). These elements are then integrated into the instruments, which is assessed for its overall feasibility, including any critical issues. At this stage, the technologically relevant aspects are revisited. Our work package therefore does not focus on specific aspects (such as detector development or active data collection), but rather provides an overall view.

How does the WST balance the uncertainties of emerging technologies with the need to build prototypes and advance the instrument design?
At this stage, the focus is on feasibility. We will identify which technologies are already mature and which require further development, such as prototyping or process updates. In this regard, the concept of Technology Readiness Level (TRL) is fundamental because it provides a standardised ■ ■ ■

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scheme of the technological development. The time-related aspect of the project certainly presents a mixed picture. On the one hand, it creates uncertainty regarding what technologies will look like in 10 years' time. On the other hand, it provides an opportunity to engage private and public stakeholders in developing roadmaps that are also relevant to the WST. We must be efficient in this task!

What determines the boundary of what is technologically "possible"? How do you anticipate which advancements may be achievable between now and the start of construction?
It's not easy to give a straightforward answer to this question. Something is technologically possible if there is a suitable process, material or approach available. However, that does not mean that the technology in question is applicable. It needs to be reliable and sustainable. In fact, when building research infrastructure, we must use low-risk, tried-and-tested technologies. This is why the TRL (Technology Readiness Level) scale exists*. The different levels define how ready a technology is for exploitation. Those involved in technological research hope to "move up" the TRL scale.

Current technologies support roughly 2 000 fibres, while WST targets around 30,000 for the MOS-LR. What is the strategy for scaling up to such a remarkable number?
This is one of the interesting aspects of this project, which involves technologies that have already been tested and have a high TRL, to the extent that they are used in current MOS instrumentation. See the recent examples of WEAVE@WHT and 4MOST@VISTA, which are spectrographs on 4-metre telescopes. In the WST, it is crucial to pursue industrial-scale development with the aim of speeding up manufacturing processes and, above all, obtaining products with very similar performance: all preparation procedures relating to optical fibres, the bonding of opto-mechanical components and final installation must be automated. Robotic automation approaches could provide an effective solution. It will therefore be necessary to involve specialist companies that probably never worked in "astronomy". It is not unreasonable to envisage a fully robotised laboratory/facility for the preparation of the 30,000 fibres ready for assembly in the spectrographs.

How does your WP collaborate with the sustainability WP? In your view, how can emerging technologies help reduce the impact of future astronomical facilities, and where do you see the greatest potential?
This is a very important point and one that interests me greatly. Now, the main focus is on life-cycle assessment and on the energy consumption of the WST. The sustainability group is primarily engaging with the various subsystems rather than the technological innovation group. For instance, the group dealing with detectors and cryostats — the components that consume most of the energy — works closely with the sustainability group. Same for the spectrograph, although it has an impact mainly during the construction phase and is subsequently a passive element. In general, it is stimulating to find technologies that minimise the environmental impact considering also the "mass production" of spectrographs and their components that WST could bring.

Another aspect of sustainability concerns not only environmental impact, but also social impact. Our field is unique in that the infrastructure serves only the astronomical community. Unlike other fields, such as particle accelerators, which also have a service component and therefore generate an economic return, our infrastructure does not serve industries while operating. Once operational, our infrastructure is solely dedicated to research and represents a cost. However, there is an impact on the social fabric during the production, design, training, technological develop-ment, and transfer of skills to industry phases. I believe this is where technological research, in collaboration with industry, can play an important role. It raises the standard of the production system. When making investment decisions involving very large sums, these aspects carry weight because a direct economic return cannot be demonstrated. Nevertheless, the impact is evident in discoveries, dissemination, training and the involvement of young people. All of these aspects are becoming increasingly important. Simply saying '*it produces high-level science*' is unfortunately no longer enough: today, it is essential to measure the social and environmental impacts as well. I think quantifying this impact will also be a major challenge. ■

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* For a summary, see https://euraxess.ec.europa.eu/career-development/researchers/manual-scientific-entrepreneurship/major-steps/trl

wstelescope.eu

A NEW DIGITAL HOME FOR THE WST

(continued from page 2)

■ ■ ■ specialists, but also journalists, decision-makers, educators and the wider public. The new architecture has therefore been developed with scalability in mind, so that content pathways and navigation logic can evolve naturally alongside the project's communication needs.

A Stronger Visual Identity

One of the most visible developments of the new website is the enhanced role of imagery. This direction builds on the broader reflections set out in the WST strategic communication plan and on the editorial activities already underway across the project. Visual storytelling has progressively become an important part of the WST's communication, helping to translate complex scientific ambitions into engaging narratives.

On the website, imagery contributes to a richer, more immediate user experience, conveying the ambition, scale and scientific excitement of the WST project. Large-format visuals, dynamic layouts and a more immersive design language strengthen the narrative dimension of the platform while reinforcing the WST's identity as a forward-looking international research initiative.

While remaining consistent with the project's already established and recognisable image, selected colours, graphic elements and iconography have been refined to convey greater dynamism, coherence and immediacy across the browsing experience.

Inclusive by Design

Accessibility and inclusion have been key priorities throughout the redesign process. Significant effort has gone into ensuring that the new website aligns with current European accessibility regulations, but compliance was never the sole objective. Above all, the work reflects a genuine commitment to making WST content open and usable for everyone.

From carefully selected colour contrasts and highly legible typography to clear page structures and comprehensive alternative text for images, every essential element has been developed to support an inclusive browsing experience. Particular attention has been given to users with visual impairments, so that they can access, navigate and fully benefit from the site's content with the same ease and completeness as any other visitor. This approach is not an additional layer, but an integral part of the project's wider vision: a scientific initiative that aims to be open, responsible and accessible from the outset.

Putting People at the Centre

The new website also gives greater prominence to the people behind the project. The WST is a collaborative endeavour shaped by researchers, engineers, technical experts and institutions working together across countries and disciplines. Highlighting the individuals and teams involved helps communicate the human dimension of the project and makes the initiative more transparent, relatable and engaging.

This commitment will continue to grow with the development of dedicated spaces such as the forthcoming People page, designed to further showcase the community that is building WST and shaping its future.

Smarter Content, Better Navigation

A key objective of the redesign has been to organise content so that it is immediately accessible, without sacrificing depth. Information is presented with a clearer hierarchy and simplified user journeys that reduce friction and improve usability.

The website is structured around the project's main dimensions — Facility, Science and Consortium — complemented by sections dedicated to news, publications, resources and future developments. This organisation allows users to move naturally between technical, scientific and organisational aspects of the WST.

Special emphasis has also been placed on transversal navigation. Rather than treating each page as an isolated destination, the new site encourages exploration through cross-references, thematic links, tags and related content paths. Users arriving for one specific piece of information are naturally invited to discover connected topics, deepening their understanding of the project and its many dimensions. This approach reflects the nature of the WST itself: an interconnected ecosystem of science, technology, people and vision.

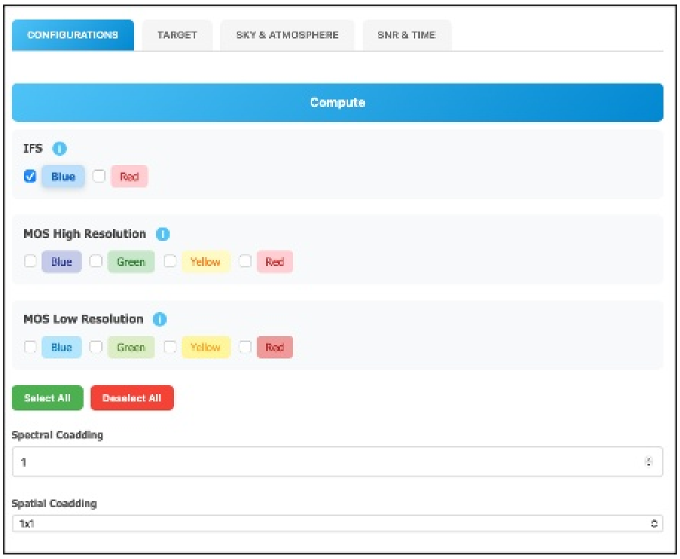
Acknowledgements

We would like to extend our sincere thanks to the entire WP 6.3 team for their support, dedication and the many valuable moments of discussion and exchange that accompanied every stage of the redesign process. Their collective commitment and shared vision were essential in shaping the new website. Our sincere thanks also go to *Deep Studio*, the Italian web agency that co-designed the website with us, bringing creativity, technical expertise and a collaborative spirit throu-ghout the process. We would also like to acknowledge that, while the website has been curated and coordinated within WP 6.3, its content is the result of a truly collective effort. Contribu-tions from across the Work Packages and many individual colleagues have helped ensure that the platform reflects the richness, accuracy and shared vision of the WST community. Our hope is that the whole community will recognise itself in this new digital home and that it may become a shared space where the identity, ambition and future of WST can continue to grow.

THE WST EXPOSURE TIME CALCULATOR

An Exposure Time Calculator (ETC) is a crucial element in an observatory's data workflow and in particular is key to optimise the use of telescope times. During instrument development, such a tool is also essential to provide feedback on the options considered by the various work packages, and for all science teams to determine how feasible their scientific objectives are. Thus, the WST also needed to have its own ETC.

Built on a prototype made by Roland Bacon, the WST ETC has been developed under the leadership of Matteo Genoni and Henri Boffin, with most of the work being done by Matteo Ferro, supported by the whole WP 2.7*. Taking some inspiration from the ESO ETC 2.0, the WST ETC covers both the Multi-Object Spectroscopic (MOS; low- and high-resolution and their four channels) and the Integral Field Spectroscopic (IFS; 2 channels) modes (Fig. 1).



IFS
☑ Blue ☐ Red

MOS High Resolution
☐ Blue ☐ Green ☐ Yellow ☐ Red

MOS Low Resolution
☐ Blue ☐ Green ☐ Yellow ☐ Red

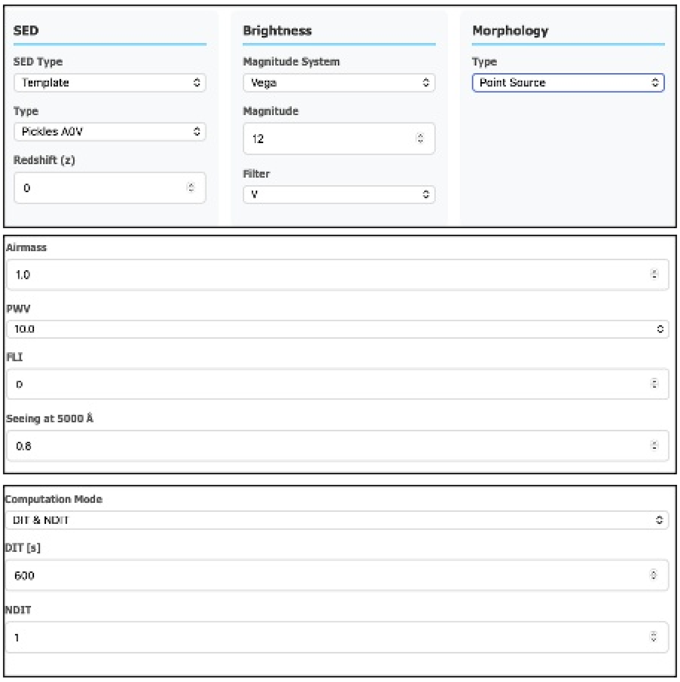
Spectral Coadding
1

Spatial Coadding
1x1

Figure 1: The web front end of the WST ETC, showing the four tabs to define the settings as well as the various configurations of the instrument. According to the different instrument and channel selection, specific settings related to the instruments are displayed — in the example above, the spectral and spatial coadding for IFS.

The WST ETC has the purpose to produce reliable simulations representing the different WST facility instrumentations and operative/instrument modes and to output the achievable signal-to-noise ratio (SNR) given the observation set-up or the required total exposure time (combination of detector integration time, DIT, and the number of integrations/exposures, NDIT). The WST ETC backend is written in python and is available via a web frontend, available at http://192.167.39.206/.

The ETC frontend presents the user with four tabs, by which they can select the instrument configuration (Fig. 1), the properties of the target, the sky conditions, and, finally, the computation mode (Fig. 2). For the target's properties, the user can define the Spectral Energy Distribution (SED) based on a variety of templates (stellar and galactic), as well as some functional form (power law; uniform; blackbody), or as an emission line. The brightness of the target is then provided as a magnitude in the Vega or AB system (for extended objects, this is the magnitude per arcsec



SED Type
Template

Type
Pickles A0V

Redshift (z)
0

Magnitude System
Vega

Magnitude
12

Filter
V

Type
Point Source

Airmass
1.0

PWV
10.0

FLI
0

Seeing at 5000 Å
0.8

Computation Mode
DIT & NDIT

DIT [s]
600

NDIT
1

Figure 2: The three other tabs of the WST ETC frontend. Top panel: target, central panel: sky, and lower panel: computation.

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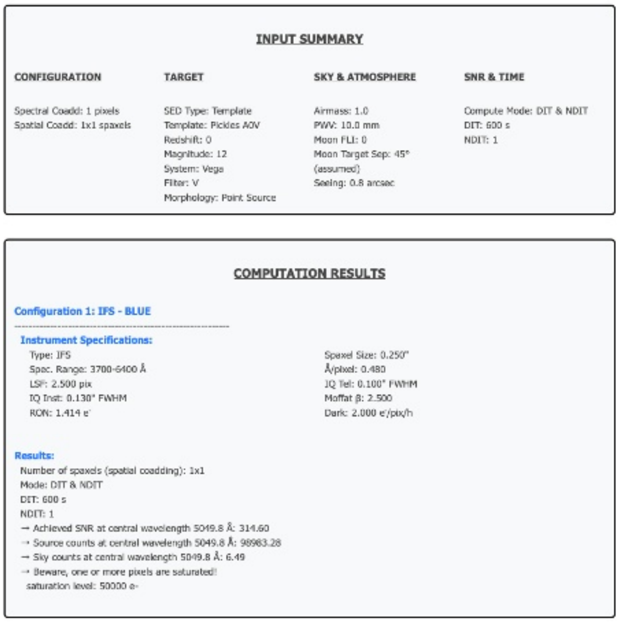
*The WP 2.7 WST ETC is composed of Matteo Genoni, Matteo Ferro, Marco Landoni, Andrea Scaudo (all INAF-OABr), Henri Boffin (ESO), Jose Schiappacasse (INAF-Arcetri), Alessio Mucciarelli, Carmela Lardo, Cristian Vignali, Margherita Talia, and Michele Moresco (all Unibo).

squared) and with a choice of filters (Bessell, Cousins, Gaia, SDSS, and LSST). The user can then indicate whether this is a point source or an extended object. The Sky tab allows the user to indicate the airmass of the object, the water vapour content of the atmosphere, the lunar phase (expressed as FLI from 0 to 1), and the seeing at 500 nm.

The fourth tab, entitled SNR and DIT, allows to choose which computation method to use and then provide the necessary input. The user can select the traditional DIT and NDIT mode. In this case, the ETC will provide the signal-to-noise ratio (SNR) reached for each of the modes and channels selected. The DIT & SNR mode is the one where the user inputs a given exposure time and the tool will compute how many exposures (NDIT) are needed to achieve the requested SNR (at a given wavelength they must provide). The NDIT & SNR mode is similar, with DIT and NDIT swapped from the previous example. Finally, the mode “Best Combination (SNR)” allows the user to indicate which SNR they want at a given wavelength and the ETC will provide the best values of DIT and NDIT to reach this SNR, while avoiding any saturation. This is likely the most useful mode to use.

Once all parameters are indicated, the ETC can do its computation. It will return a summary of the input as well as the results of the computation (one for each of the configurations selected; Fig. 3). A set of plots, chosen by the user with a flagging list, are also produced — see the example of the SNR curve for the MOS-LR in Fig. 4. All results can be downloaded as either Ascii or FITS files.

In addition to the web frontend that is useful for doing experiments on single targets, an API will soon be available that allows user to call the ETC on many targets, via a python wrapper. This will be most useful for the survey plan WP to run simulations on millions of targets to predict how best to carry out their observations.



INPUT SUMMARY

CONFIGURATION	TARGET	SKY & ATMOSPHERE	SNR & TIME
Spectral Coadd: 1 pixels Spatial Coadd: 1x1 spaxels	SED Type: Template Template: Pickles A0V Redshift: 0 Magnitude: 12 System: Vega Filter: V Morphology: Point Source	Airmass: 1.0 PWV: 10.0 mm Moon FLI: 0 Moon Target Sep: 45° (assumed) Seeing: 0.8 arcsec	Compute Mode: DIT & NDIT DIT: 600 s NDIT: 1

COMPUTATION RESULTS

Configuration 1: IFS - BLUE

Instrument Specifications:

Type: IFS	Spaxel Size: 0.250"
Spec. Range: 3700-6400 Å	Å/pixel: 0.480
LSF: 2.500 pix	IQ Tel: 0.100" FWHM
IQ Inst: 0.130" FWHM	Moffat β: 2.500
RON: 1.414 e⁻	Dark: 2.000 e⁻/pix/h

Results:

Number of spaxels (spatial coadding): 1x1
Mode: DIT & NDIT
DIT: 600 s
NDIT: 1
→ Achieved SNR at central wavelength 5049.8 Å: 314.60
→ Source counts at central wavelength 5049.8 Å: 98983.28
→ Sky counts at central wavelength 5049.8 Å: 6.49
→ Beware, one or more pixels are saturated!
saturation level: 50000 e-

Figure 3: The result page of the WST ETC.

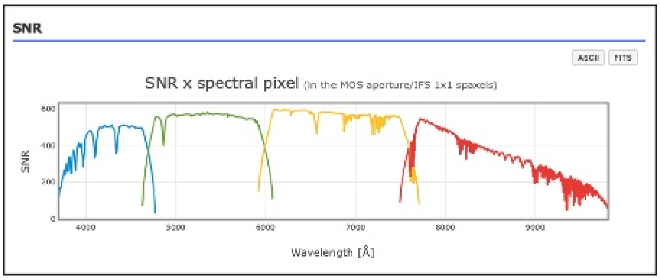


Figure 4: An example of one of the plots produced by the WST ETC. In this case for the four arms of the MOS-LR spectrograph.

GATHERING PHOTONS: THE CHALLENGE OF HIGH-PERFORMANCE OPTICAL COATINGS

The WST features a 12m aperture, corresponding to twice the collecting area of one of the Unit Telescopes of the Very Large Telescope (100 m^2 versus 50 m^2). Such a large aperture is required to reach the faint objects targeted by the science cases, which remain inaccessible to current spectroscopic facilities based on 4m-class telescopes. However, the telescope aperture alone does not determine the facility performance. The overall throughput also depends on the efficiency of the optical train, which includes numerous mirrors and lenses used to relay the light to the instruments' focal planes. Indeed, the wide-field focal surface is reached after two reflecting and six refracting surfaces, while the integral-field one is reached after 11 additional reflecting and four refracting surfaces. Perfect reflective or transmissive surfaces are not feasible and optical losses occur each time light impinges a surface. The total throughput of an optical system can then drop quickly as the number of optics increases.

Minimum total efficiencies of 64% and 66% are required for the MOS and IFS paths, respectively, to guarantee a sufficient flux over the whole spectral range. The IFS is clearly the most demanding since the number of surfaces is the largest. In theory, an efficiency close to 97% per surface would be enough to meet the requirement, but the performance varies significantly with wavelength. For instance, materials exhibit higher optical absorption in the UV range that damage the performance of optical coatings. In the case of classical coatings for mirrors and lenses, we may expect less than 5 % of yield in the UV range, which fully justifies a special effort in defining high performance optical coatings.

Maximising Mirror Performance

High mirror performances can be achieved thanks to a metallic coating based on aluminum or silver layers with a capping layer to prevent corrosion and increase the lifetime of the mirror. The main advantage is a reflectance quite constant according to the wavelength and the angle of incidence. Aluminum-based coatings offer wider spectral range with special recipes developed for the UV range. The average reflectance is, however limited to 90%. In contrast, silver-based coatings exhibit higher reflectance above 97%, but it decreases sharply in the UV range (Fig. 1).

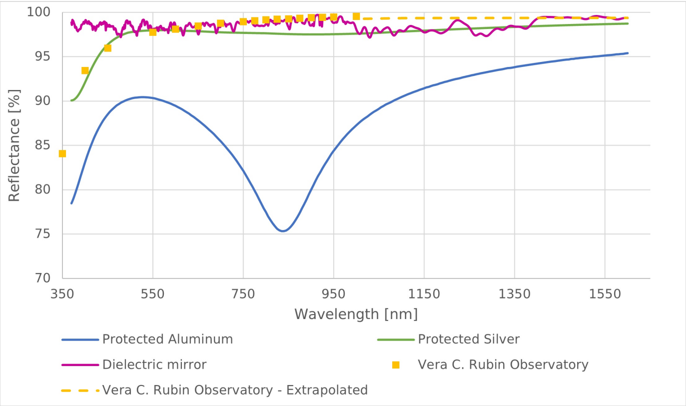


Figure 1: Reflectance of different reflective coatings solutions. The data labelled "Vera C. Rubin Observatory" represents the reflectance measured on the M1M3 (8.4m) mirror [2]. Data are then extrapolated for the purpose of the WST.

For the WST, the mirrors must have a reflectance higher than 97% what can be achieved using dielectric mirrors. They take advantage of the interference effect between the multiple reflections at the interfaces of a multilayer stack. By tuning the layers thickness accordingly, the reflectance can be maximised close to 100% with very limited optical losses (below 0.002% [1]). The drawback of this technical solution is a quite narrow bandwidth and a reflectance sensitive to the angle of incidence. The outcome is a more complex multilayer stack than a metallic coating.

Dielectric mirrors can be produced over large dimensions typically metre scale (Fig. 2). However, producing such mirrors on the large scales required for the WST, some up to 3.5m in diameter, is a significant challenge. Hence, the strategy for the largest mirrors is to consider the state-of the art in large telescopes covering similar spectral range as WST. An inspiring solution comes from the Vera C. Rubin Observatory. They developed a dedicated recipe using protected silver that enables reflectivity higher than 97% over the M1M3

■■■

Figure 2: Large coating machines available at LMA-IP2I (Villeurbanne- France). Right: Large Ion Beam Sputtering chamber. Left: Large Ion Assisted Deposition chamber. © Cyril FRESILON / LMA / CNRS Phothotèque.

mirror of 8.4 m in diameter [2]. Typical reflectance curves are shown in Figure 1.

Letting Light Through

For lenses, the transmittance must be maximised instead of the reflectance. Multilayer antireflection coating is a common solution applied on large optics [3]. In this case, the layer thicknesses are optimised in such a way that the reflected beams at each interface cancel each other out. This approach has some intrinsic limitations. The lowest residual reflectance increases with the bandwidth and/or the angle of incidence. Under ideal conditions, a transmission close to 99.5% should be possible but the result is very sensitive to manufacturing errors and the actual transmission would be significantly lower. For instance, the large lenses produced for the Vera C. Rubin Observatory that have comparable diameter than the ones needed by the WST, offer a transmission of ~98.8% per surface that is not sufficient for the WST.

A promising alternative, currently investigated, is the graded refractive index layer. The coating is limited to a single layer with a controlled refractive index gradient in the depth. The layer matches the air on one side and the substrate at the other. Recent works [4] report reflectance of 0.3% in average over the 350-1100 nm range and interesting omnidirectionality. While this technology is still emerging—primarily used in solar cells—it holds great potential for the WST (Fig. 3). For that reason, a dedicated test plan has been drawn up in order to assess its performance and environmental survivability.

Looking ahead

By combining dielectric mirrors, state-of-the-art protected silver coating and innovative antireflective coating, a minimum throughput of 80% and 70% may be expected for the MOS and IFS paths, respectively. These preliminary results meet the requirements with some comfortable margins. However, further work is needed in order to validate the proposed baseline, assess the mechanical strain that can bend the optical surface and develop methods for in-situ cleaning. In the end, every photon matters—optimising the WST's optical coatings will directly enhance its scientific impact.

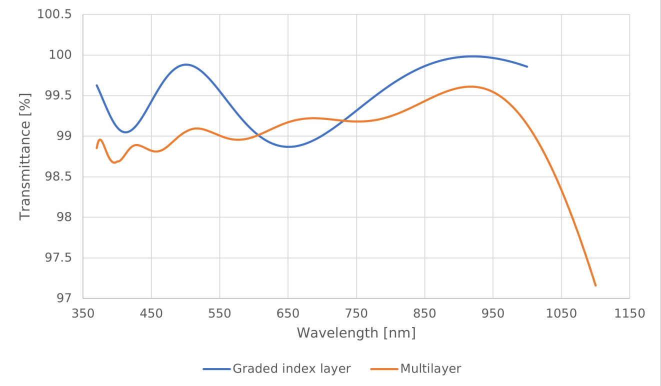


Figure 3: Transmittance for graded index layer solution and the classical multilayer antireflective coating.

References

[1] Degallaix et al., 2019, JOSA 36, 11 C85-C94 (2019)
[2] Vučina et al., 2024,in 67th Annual Technical Conference Proceedings, Society of Vacuum Coaters
[3] https://github.com/lsst-pst/syseng_throughputs/tree/main/components/camera]
[4] Yin et al., 2021, OME 11,3, 875-883 (2021)

WST INSTRUMENTS TRADE STUDY MEETING

The UK Astronomy Technology Centre in Edinburgh had the pleasure of hosting the WST instrument trade study meeting in February 2026. Colleagues from the UK, Europe, and Australia attended both in person and online for five days of detailed discussions on the instruments. The purpose of the meeting was to review the instrument designs developed over the first year of the WST concept study and apply a trade study methodology to select the best solution to be the baseline for development in the next phase of the project.

The Positioners, Fibres, MOS-LR, MOS-HR, IFS, Detectors, Dispersers, Cryogenics, and Calibration teams presented design concepts for evaluation in the trade study. The trade study assessment was done using a decision matrix containing weighted metrics such as cost, throughput, and sustainability. For the positioners (see Chronicle 3), the novel Flex positioner was selected as the reference design due to its large patrol field of view enabling high survey efficiency. The theta-phi robots and the tilting spine positioner concepts were identified as backups with very high technology readiness levels. For MOS-LR, a 4-channel spectrograph with 9 cm flat detectors was chosen. The baseline MOS-HR will also use flat detectors and 1 to 7 fibre splitting to enable high resolution to be achieved. The IFS baseline will be a 2-channel spectrograph with dioptric cameras, but either curved or flat detectors can be used. The spectrograph designs are compatible with various disperser options. The baseline detector choice is CMOS, which has performance and sustainability advantages over CCDs. For the fibres, calibration, and cooling systems, on-going studies will continue before the trade study is finalised.

The next stage is to further develop and cost the baseline designs, integrate the instrument CAD models with the telescope, update operations planning, and prepare technology roadmaps for the new technology needed for the WST. ■