Issue 6 - October 2026

THE WST CHRONICLE

Pushing the Boundaries of Spectroscopic Surveys



The WST in the ESO landscape

Interviews with O. Bellido & M. Palla

Resolved Stellar Populations

The WST Chronicle is the magazine of the Wide-field Spectroscopic Telescope (WST) project, which is funded by the European Union under the HorizonEU research and innovation programme. It is published by the WST WP 6.3. The articles presented here reflect only the views of the project. The content of this magazine is licensed under CC BY 4.0.

Editor: Henri Boffin

Contributors: Roland Bacon, Olga Bellido, Henri Boffin, Maria Cristina Fortuna, Paolo Franzetti, Olaf Iwert, Sebastian Kamann, Vincenzo Mainieri, Alessandro Meoli, Anna McLeod, Marco Palla, Sofia Randich, Martin Roth, Omar Sqalli

wstelescope.eu

Funded by the European Union

Table of contents

Coordinator message..... 3
The WST in the ESO landscape in the 2040s..... 4
interview with Olga Bellido..... 6
Studying resolved stellar populations..... 8
Interview with Marco Palla 12
A day and night with the WST..... 14
CMOS detectors: The choice for WST?..... 20

Cover image: The nearby spiral galaxy NGC 4303 observed with the IFU of the Multi-Unit Spectroscopic Explorer (MUSE) on ESO's Very Large Telescope (VLT). The image is an overlay of observations conducted at different wavelengths of light to map stellar populations and warm gas. The golden glows mainly correspond to clouds of ionised hydrogen, oxygen and sulphur gas, marking the presence of newly born stars, while the bluish regions in the background reveal the distribution of slightly older stars. Credit image: ESO/PHANGS



Gravitational lensing by the galaxy cluster called MACS J0454.1-0300. Credit: ESA/Webb, NASA & CSA, L. Furtak, S. Fujimoto

Coordinator Message

As we come back together after the summer break, it is clear that the months ahead will be particularly busy for the WST. First, the EU mid-term Review meeting is approaching. Most of the required documentation has been delivered, and the Project Office is preparing for the meeting on November 6. This is an important moment to show the EU the significant progress made so far on all the project aspects, while also updating them about our plans for the next phases.

On the scientific side, following some initial outcome at the busy week, the first results of the survey plan exercise have been shared with the Science Working Group (WG) leaders. These results have raised a number of important questions, prompting further discussion about the next steps, with the ultimate goal to provide a proof of concept of the scientific efficiency of our model.

The White Paper process is also progressing. The scientific ideas that are perceived as transformational in the 2040s will be presented as WST White Papers in a special issue of the *Open Journal of Astrophysics*. The Editorial Board, established to oversee the process, has now converged towards a list of papers. Building on the first WST White Paper published at the beginning of 2024, these papers will represent an important way of communicating the updated scientific vision and priorities that are emerging across the project, reflecting the excellent work of the WST science team and the interaction with the broader community.

A new working group on Artificial Intelligence (AI) was recently launched. With AI becoming an increasingly important part of scientific research, this new group will provide a space to explore its relevance and potential within the WST. You can find more about the new WG in this Chronicle issue. We are grateful to Eric Emsellen (ESO) for being available to lead the WG.

On another front, the work of the EDI WG is continuing, with an inclusive leadership course coming up. An open and inclusive environment remains an important part of building the WST community, and we are pleased to have this opportunity to develop these skills further. We also expect new members to join the EDI WG, following a recent call.

Two relevant events are planned before the end of the year. First, we are looking forward to meeting with industry in Lyon at the beginning of November. A dedicated workshop will introduce the WST project to relevant companies and create opportunities for interaction and exchange with industry. We hope this will open new conversations and help us explore potential areas of collaboration. The second important upcoming event is the WST UK Community Workshop, taking place at the Institute of Astronomy, University of Cambridge, from 14-16 December 2026. The meeting will bring together researchers from the UK and WST communities; it will offer an opportunity to further explore the scientific potential of the WST and to discuss the UK community engagement with the project. Everyone is very much welcome to attend.

Looking further ahead, as already announced, the ESO Letter of Intent is due on December 1st, 2026. This will be a key and exciting milestone for the WST project, marking the official start of our participation in the ESO Expanding Horizons initiative.

So, after the summer pause, there is certainly no shortage of things to get involved in! We are looking forward to a very active autumn. Thank you, as always, for the energy, ideas and commitment you are bringing to the WST project.

Sofia Randich

THE WST IN THE ESO LANDSCAPE IN THE 2040S

By the time the WST, if selected, enters full operation, ESO's astronomical landscape will likely be very different from today's. The Extremely Large Telescope (ELT) will be a mature facility delivering transformative observations at the highest sensitivity, spatial and spectral resolutions, along with some multiplex capabilities. By then, astronomers may routinely detect and characterise Earth-like planets in habitable zones, resolve individual stars in galaxies far beyond the Local Group, and obtain exquisite spatially resolved views of galaxies and the environments around black holes across much of cosmic history.

At the La Silla Paranal Observatory (LPO), a new generation of instruments will have replaced some of today's workhorses, although the precise configuration remains to be defined, also following the VLT 2030 roadmap [1]. One can nevertheless expect versatility to remain a priority, together with very high-precision and near-UV capabilities.

At the same time, ALMA, after the upgrade that is currently ongoing, will continue to provide unparalleled views of the cold Universe; complementarily, CTAO, that will form an increasingly important component of the broader ESO landscape, will have opened an unprecedented view of the high-energy Universe and extreme astrophysical environments.

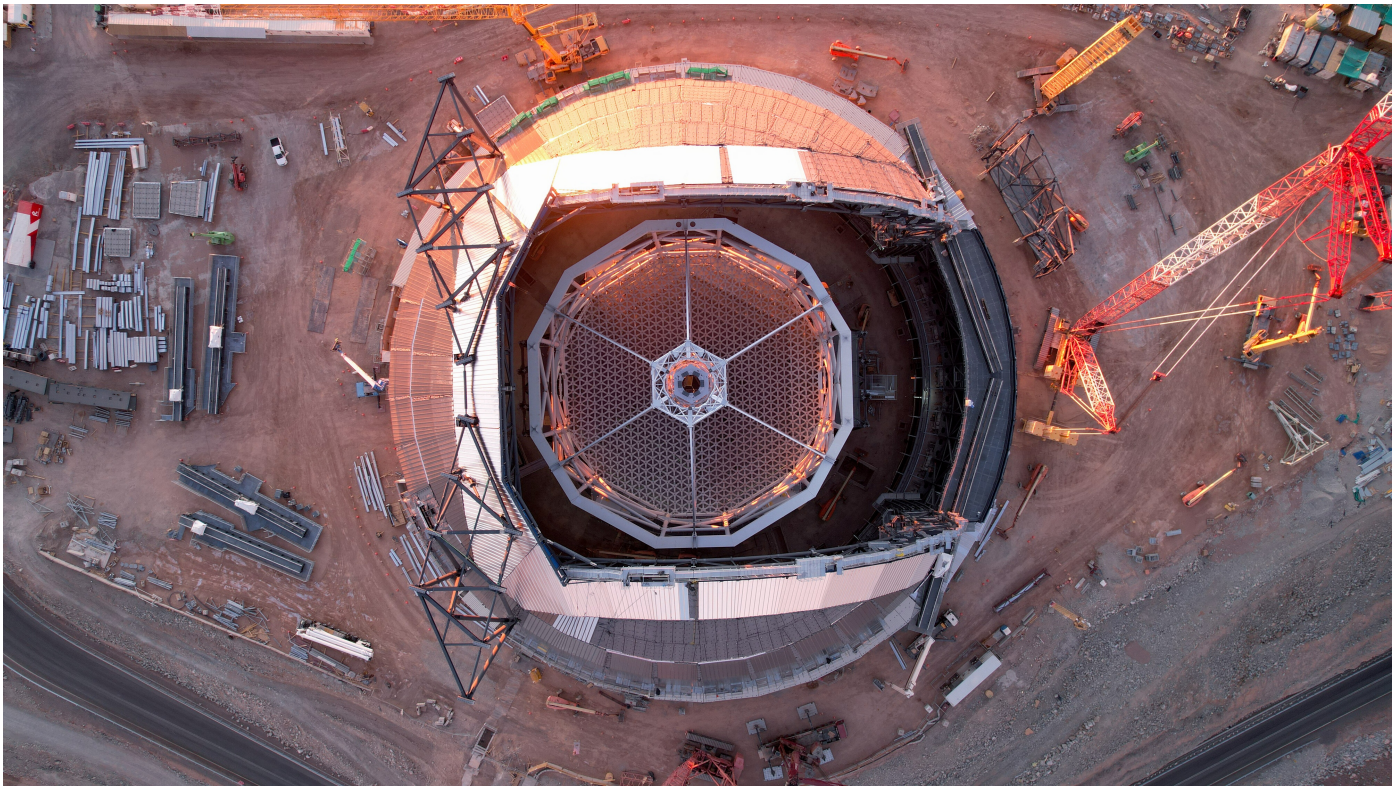
How, then, would the WST fit within this powerful and highly diverse ecosystem? The combination of wide-field coverage (3 square degrees) on a 12 m telescope, massive multiplexing (32,000 fibres) at low- and high-resolution, a panoramic integral-field spectrograph (3 x 3 arcminutes) operated in parallel, and versatile target-of-opportunity response, would provide a capability not matched elsewhere in the ESO landscape in the 2040s. These characteristics will certainly enable major advances across almost all areas of astrophysics and cosmology. Yet the WST's significance extends beyond that: rather than simply acting as a follow-up telescope or supplying target selection and characterisation, the WST would establish a powerful and transformative spectroscopic backbone for the entire ESO ecosystem. This would not only open a unique discovery space, but will deliver the homogeneous, high-dimensional spectroscopic foundation needed to connect discoveries across ESO facilities and to link the different spatial, temporal, and physical scales they probe.

The role of the WST becomes even clearer when considering multi-messenger astronomy. By the 2040s, transient discoveries will occur at a rate that would seem astonishing today. Gravitational-wave observatories, neutrino detectors, and photometric survey telescopes will continuously alert the community; the challenge will be characterising these events systematically. The WST would represent a key facility for this task, feeding both ELT and LPO follow-up programmes, while creating the unprecedented statistical samples required to understand entire classes of transient phenomena.

Finally, while we do not know whether 4MOST will still be operating in the 2040s, the scientific ambitions of the community will have expanded. The WST would extend ESO's survey capabilities into a new regime of multiplex, sensitivity, spectral performance, and survey efficiency. It would also strengthen an area in which ESO has developed distinctive expertise: combining world-class facilities with ambitious, community-driven survey programmes, carrying forward a survey philosophy that has become central to modern astronomy.

The discussion above has mostly focused on the WST as a facility. Its ultimate role will be shaped however also by the wider ESO ecosystem of the 2040s: a

[1] Brinchmann, J., 2026, in VLT beyond 2030, 10.5281/zenodo.18804022



Credit: ESO/G. Vecchia

Looking into the eye of the ELT

network of telescopes and instruments, data infrastructures, possibly Artificial Intelligence (AI) systems, and international communities, whose form we can only partly anticipate today. This raises questions that go well beyond the purpose of this short article; among them: *how will the ESO landscape become a truly integrated data ecosystem? How will operations evolve across facilities? What will a sustainable astronomical ecosystem look like? How will the community interact with it, and what role will AI play?*

The WST therefore would not simply be a new facility within the ESO landscape of the 2040s; it may become one of the elements that help define how this landscape evolves, connecting facilities, data, and communities into an increasingly integrated scientific eco-system.

In particular, the WST would also bring ESO decisively into the era of big-data astronomy. Its unprecedented spectroscopic surveys would require data infrastructures, processing and archiving capabilities, and science-ready data products on a scale more characteristic of a big-data facility. The WST would therefore not only open new scientific horizons, but also help transform how ESO collects, processes, manages, and exploits astronomical data.

"THE MAIN CHALLENGE IS THE SHEER SCALE OF THE PROJECT"

An interview with Olga Bellido, WST Facility Systems Engineer

Tell us a bit about you and your career
I hold a Master's degree in Telecommunication Engineering, and my thesis was actually about Galileo. After graduating, I joined a Spanish aerospace company involved in that project, where I worked for three years, including a year and a half based in Munich. I then moved into Earth Observation, working on Copernicus for another three years. That period gave me my first real grounding in Systems Engineering.
In 2012, I moved again to Germany to become a Systems Engineer for 4MOST, a role I held for the following 14 years. 4MOST has now been successfully commissioned and, as we speak, is about to start science operations, so my involvement there is largely complete. That's given me more capacity to take on new challenges, which is how the WST came into the picture. I'm also currently a UBV Systems Engineer on ELT ANDES.

What is your role in the WST project?
I'm the WFS Facility Systems Engineer. I joined the project office in August 2025. My main focus right now is defining and maintaining key budgets for the facility, the throughput budget, which feeds into the Exposure Time Calculator, and the overheads budget. The Top Level Requirements (TLR) were already in place when I arrived, so I support various teams in deriving lower level requirements from them and track how well the design fulfils the TLRs through the System Compliance Matrix. I work across the whole facility rather than one subsystem, alongside two other Systems Engineers in the project office, one focused on the telescope, another on instruments.

How did you come to do it?
Roelof de Jong, the WST's Facility Scientist, was previously the PI of 4MOST, where I worked for many years. He's the one who brought me onto the WST.

What is the most interesting part of your role?
The cross team interaction is genuinely one of the best parts, it's a constant exchange of knowledge and a great way to keep learning from others. I also love having visibility of the big picture across the whole facility, rather than just one piece of it. The budget work is one part of my role that I find particularly interesting: the throughput budget already tells you a lot about how sensitive the facility will be, and helps identify which components to focus on for better performance, while the overheads budget is a nice puzzle in figuring out how telescope and instrument actions can be parallelised and shortened to meet some genuinely demanding requirements. But it's really the combination of all these aspects, technical depth and collaboration, that makes the role so engaging.



Olga Belido is a Systems Engineer with a background in Telecommunication Engineering and over 15 years of experience in space and astronomical instrumentation. She started her career working on Galileo and Copernicus before joining the 4MOST project in 2012, where she spent 14 years as a Systems Engineer through its development and commissioning. She is currently involved in the WST and serve as UBV Systems Engineer for ELT ANDES. Originally from southern Spain, she now lives in Germany with her family and two young children.

Is there anything challenging?
For me personally, the main challenge is the sheer scale of the project. It's not that everything is constantly changing, but with so many people and parts involved, staying on top of the relevant technical aspects, modifications, and trade-offs takes real effort. That's compounded by the fact that the WST isn't my only project: I split my time between the WST, ANDES, and occasional support for 4MOST, and on top of that, I'm not

working full time. Getting the job done also depends heavily on input from many different teams, so good collaboration skills are essential. More broadly, but linked to this specific phase we are in, i.e., conceptual phase, a challenge is that so much is still open, trade-offs, architecture choices, requirements themselves are still being shaped, so it's important to keep enough flexibility to adapt as understanding matures, while still making enough decisions to keep the project moving forward.

According to you what makes the WST unique?
Its sheer scientific reach: the range of cases it will be able to tackle in parallel, MOS, IFS, 30,000 fibres, is remarkable. Beyond the science case, I'd also say the WST is unique in trying to bring together such a broad international collaboration around a single facility design from such an early stage.

What are the aspects that surprised you the most in such a large project?
Very positively, how engaged and committed everyone is to the project. I've also been struck by the culture: it's not just about the technical and scientific ambition, there's real, early attention to the sustainability of the facility and its operations, as well as to equity, diversity, and inclusion. Seeing that built in at such an early stage of the project is genuinely great to witness.

A new Working Group focusing on the potential applications and impact of Artificial Intelligence

This Working Group aims at establishing a group of experts and interested scientists and engineers to explore the application of Artificial Intelligence (AI) to WST.
In particular, it will evaluate the potential use of AI across all aspects of WST, including, but not limited to, data reduction, survey planning and optimisation, data quality assessment, telescope and instrument health monitoring, scientific data analysis, automated discovery and anomaly detection in WST data, and integration with numerical simulations and digital twins. It also aims at developing an LLM-based interface to the WST data archive, monitoring developments in AI technologies and assess their relevance for WST throughout the concept study, and developing a roadmap and identify the actions required to ensure AI readiness by the time the WST begins operations. Furtheermore, it will assess the impact of AI on the project's environmental footprint, in particular its CO_2 emissions, and identify strategies to minimise it (in collaboration with the sustainability WP).

Everyone is welcome and encouraged to join the core team of this WG, coordinated by Eric Emsellem and to contribute to this important topic.

Studying Resolved Stellar Populations with the WST

Astrometry and the detailed spectroscopic study of stars in the Milky Way to unravel their kinematic properties in 6-dimensional phase space, as well as "chemical tagging", have revolutionised our understanding of the formation and evolution of the Galaxy. Future Gaia data releases and new spectroscopic survey facilities, such as 4MOST and the WST, will drive Galactic Archaeology to unprecedented limits with detailed data within a radius of a few kpc from the sun. With some limitations even individual stars in the Magellanic Clouds have come into reach.

The next revolutionary step as the vision for coming decades will be to step out of our immediate neighbourhood and reach out to nearby galaxies and their star clusters, to resolve their stellar populations into individual stars and carry out analyses analogous what has been accomplished in the Milky Way. With the given limitations from photometry, the study of resolved stellar populations has been pioneered by imaging surveys of nearby galaxies using the Hubble Space Telescope, such as the ANGST project. Technically, a key factor for the success of this effort has been the capability of the direct imaging methodology to disentangle individual stars in crowded fields to measure their magnitudes with high precision thanks to point-spread function (PSF) fitting techniques, as exercised over about four decades using codes like DAOPHOT.

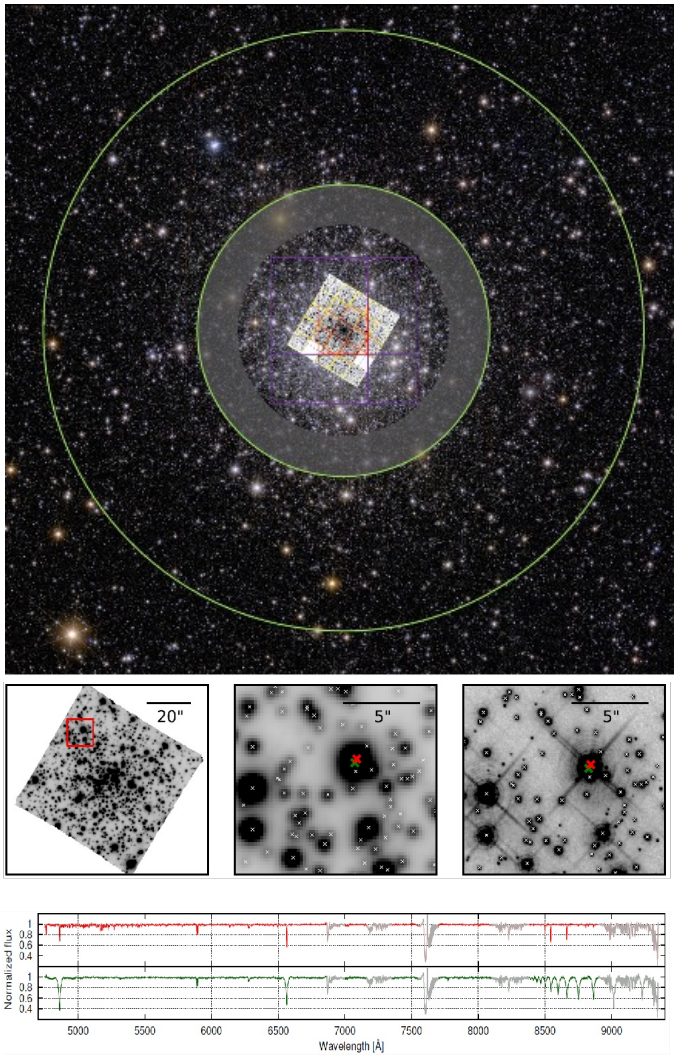


Figure 1: PSF-fitting crowded field spectroscopy that has been demonstrated with MUSE will flourish with the WST thanks to the unique combination of IFS with MOS.

Integral-field units offer the unique opportunity to transform the PSF-fitting technique to spectroscopy and ESO has been at the forefront of this transformation: the large field-of-view and superb image quality of the MUSE integral field spectrograph (IFS) at the VLT UT4 have stimulated the development of crowded-field spectroscopy (Fig. 1). An analysis of the scientific output of the first 10 years of MUSE operations in terms of number of journal papers, based on ESO TELBIB statistics, has revealed that 11% of all papers have utilised this new capability for the study of globular clusters and nearby galaxies: truly a paradigm change.

The WST will take crowded field spectroscopy of resolved stellar populations to another level. The combination of the 3x3 arcmin^2 Mega-MUSE field-of-view, providing almost a million spatial elements, with the multiplex capacity of the 3 square degree field-of-view for up to 30,000 optical fibres for medium or high

resolution multiplex spectroscopy (MOS) is an ideal match to stellar systems that suffer from crowding in their nuclear regions, but extend out to large radii with lower surface density of stars, e.g., globular clusters, or dwarf galaxies that are known to harbour stars out to as much as 10 effective radii.

Binarity and black holes in star clusters

The binary populations of globular clusters (GC) are cornerstones for testing the theory of cluster evolution, yet barely accessible through slit or fibre-based spectroscopy. Pioneering work with MUSE has shown that crowded-field spectroscopy is capable of deblending overlapping stellar spectra near the nucleus of a cluster, as illustrated in Fig. 1 for NGC 6397. The potential of this method has been demonstrated by the first discoveries of detached black holes (BH) through the orbital motions of their stellar companions. Fig. 2 shows the example of a star with an extreme swing of radial velocity whose analysis proves that there is an unseen companion of 4.36 solar masses, which can only be interpreted as a Black Hole: a very rare discovery in the Milky Way where only a handful of such objects are known to date.

The top panel of Fig. 1 includes a mosaic from 25 MUSE pointings that span a 5x5 arcmin^2 field of view. For comparison the WST field-of-view is shown as a red square, highlighting the unprecedented opportunity to cover the crowded central region of the cluster with only a few exposures. The less populated outer areas are simultaneously sampled with the large field-of-view of 30,000 MOS fibres. The transformative edge of the novel configuration can be appreciated best by understanding that the WST will enable the step from case studies on individual clusters to a systematic survey of spectroscopic variability across the Milky Way's cluster population, which would have been too expensive for the smaller field-of-view of MUSE. Such a survey would directly constrain the number of BHs residing in GCs today, with strong implications for our understanding of stellar evolution, supernova explosions, and gravitational wave emission.

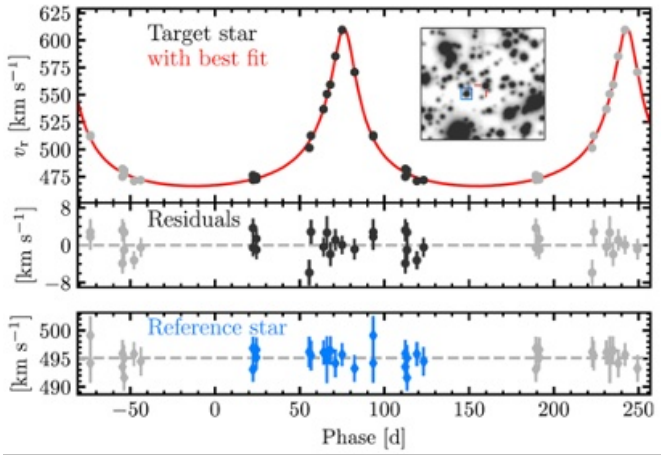


Figure 2: Discovery of a stellar mass Black Hole candidate in NGC 3201, based on a time series of radial velocity measurements with MUSE.

Massive stars in Local Group dwarf galaxies

Massive stars dominate ionisation and feedback at all cosmic times, their nucleo-synthesis governs the chemical evolution of galaxies, and they shape our understanding of the first generation of stars. As the progenitors of supernovae, neutron stars, and black holes, massive stars are also the base for gravitational wave events. They are fundamental for the interpretation of high energy outburst events seen in gamma rays and in the radio domain, with massive-star binaries and clusters being discussed as sources for PeV gamma-ray sources, i.e., the origin of cosmic rays. These topics are just a selection of many reasons to study early-type stars, preferentially in low metallicity environments, that are best found in Local Group dwarf galaxies.

The combination of the WST Mega-MUSE IFS with the 30,000-fibre MOS is an ideal tool to study such objects, as illustrated in Fig. 3. The transformational advance will be used to uniquely address open questions like *"How do massive stars end their lives?", "Does SN diversity represent diverse progenitors (single/binary) or environmental effects?", "What are the progenitors of SN types IIb, IIL, In, Ib, Ic?", "What is the link between broad-lined Ic SNe and gamma-ray bursts?", "How can observations of unresolved star forming regions in high redshift galaxies, as observed with JWST, be calibrated to local standards?", "Can we understand the physics of the first metal-free stars and the early chemical enrichment detected in high-z galaxies?"*

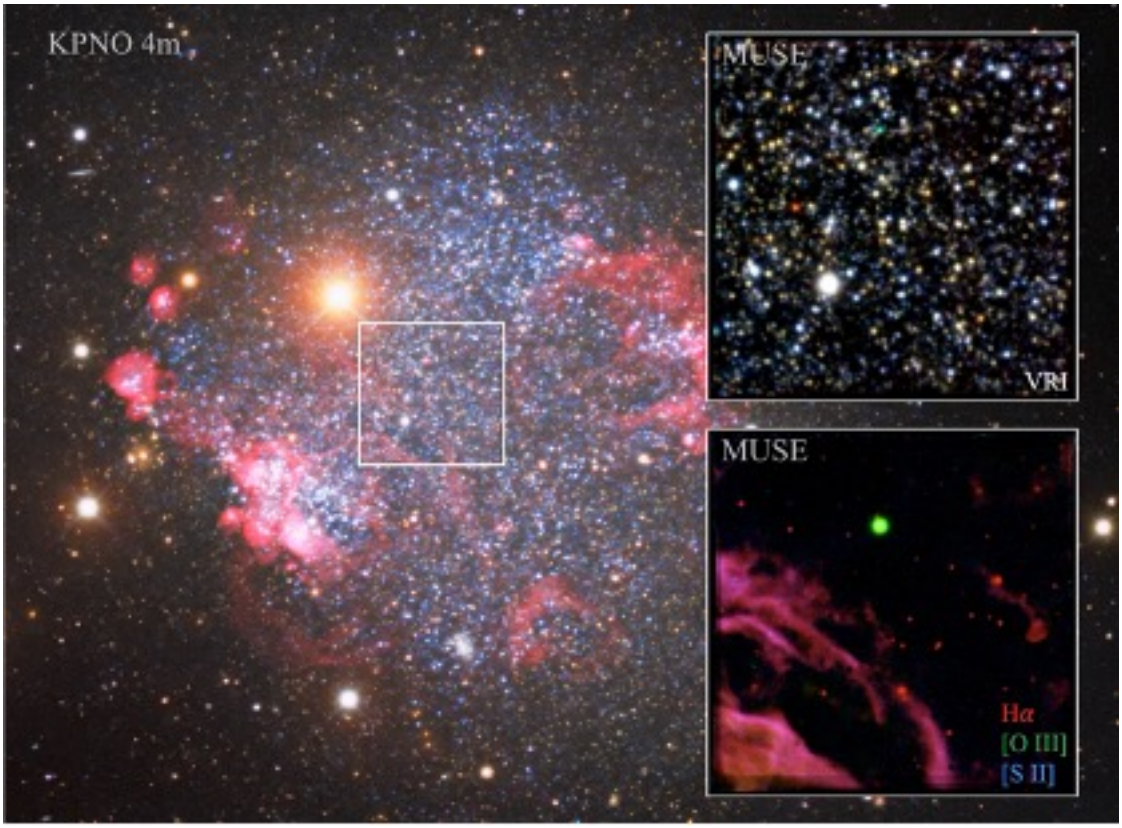


Figure 3: The Local Group dwarf galaxy Sextans A, resolved into stars using MUSE: each point source delivers a spectrum. The bottom panel shows that from the same date cube emission line maps can be extracted with high sensitivity and precision. The green spot marks a planetary nebula. Sextans A has 1/10th of the metallicity of the Milky Way, comparable to galaxies at cosmic noon.

Dark Matter haloes of dwarf galaxies

Local Group dwarf galaxies constitute the most critical testing grounds for the ΛCDM cosmological model: they allow to observe dark matter phenomena on the smallest, most non-linear scales. While ΛCDM works exceptionally well on massive, cosmic scales, its predictions face challenges when confronted with small structures in our cosmic neighborhood. One such challenge is the "Small-Scale Crisis", involving the missing satellites, the Too-Big-to-Fail, and the Core-Cusp problems. It is still debated if these issues can be solved by considering baryonic feedback, or invoking alternatives to the Dark Matter paradigm, e.g., Warm Dark Matter, Self-interacting Dark Matter, or Fuzzy Dark Matter. To shed light on these challenges, the kinematics and chemistry of the resolved stellar populations in Local Group dwarf galaxies are required.

Facilities available in the near future such as WEAVE, 4MOST, DESI, with proper motions from Roman and Gaia DR5, will probe the brighter nearby dwarf galaxies. MUSE, MOONS, and PFS can start the investigation of the more distant dwarfs with extended star formation histories, however with patchier coverage, lower signal-to-noise ratio, and lower spectral resolution than would be needed to reveal their assembly histories. A breakthrough beyond those limits will become possible only through the unique capabilities of WST. Fig. 4 illustrates again the concert of IFS in crowded regions in the central part with multi-fibre coverage in the sparsely populated outskirts, but also the complementary flexibility of low versus medium resolution MOS spectroscopy.

Testing Cosmology with Local Volume Galaxies

Latest cosmological models are evolving to ever finer resolution in mass and linear dimensions, with predictive power concerning the spatial distribution of stellar populations of different age, metallicity, and

kinematics. For disc galaxies, the high-resolution picture across spiral arms is an interesting test case that can be addressed with integral field spectroscopy. While existing surveys such as, e.g., CALIFA, MaNGA, SAMI, deliver spatial resolutions on kpc scales, more nearby Local Volume galaxies have come into reach for detailed, high spatial resolution studies of resolved stellar populations — see Fig. 5 for an example. By reaching more complete coverage than currently possible with MUSE, the one order of magnitude larger field-of-view of WST will open completely new possibilities. Major open questions by 2040 will include: *"What do the chemo-dynamic signatures of stars on spiral arms reveal about radial migration and secular evolution?", "Can we measure spatial offsets between young massive stars and star formation tracers to test theories and simulations?", "Can stellar population studies provide clues for the formation histories of bulge-less galaxies vs those with a bulge, whose differences are currently not explained by simulations?"*

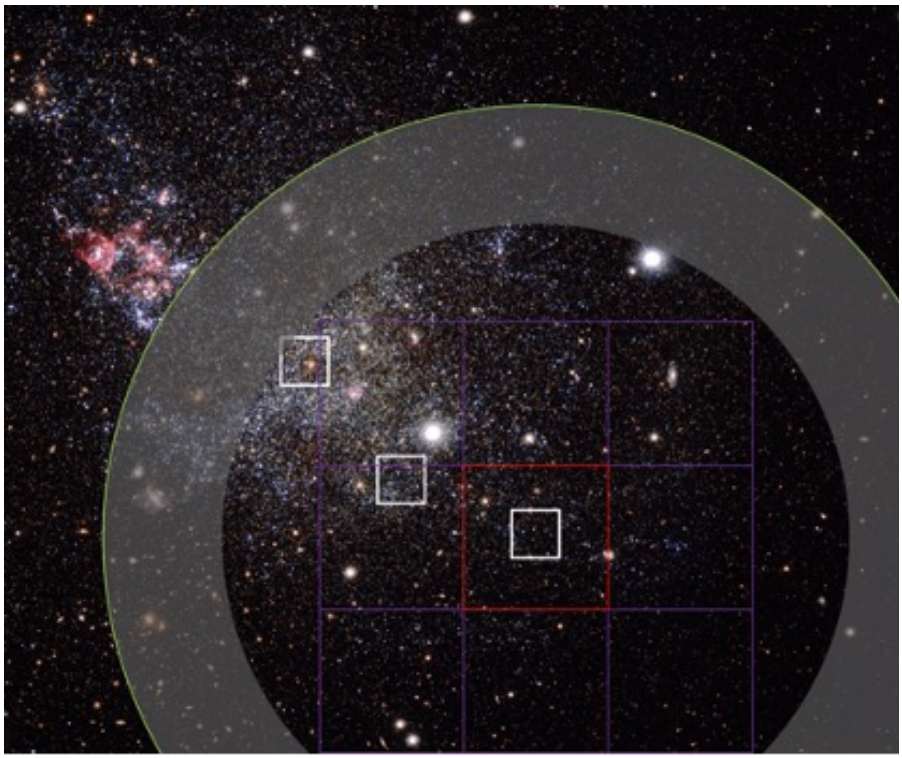


Figure 4: The dwarf galaxy IC 1613 at a distance of 750 kpc, with the projected footprint of the WST IFS (red square), and coverage with multi-fibre MOS outside of the shaded annulus. The three white squares illustrate a recent pilot study, accomplished with three MUSE pointings.

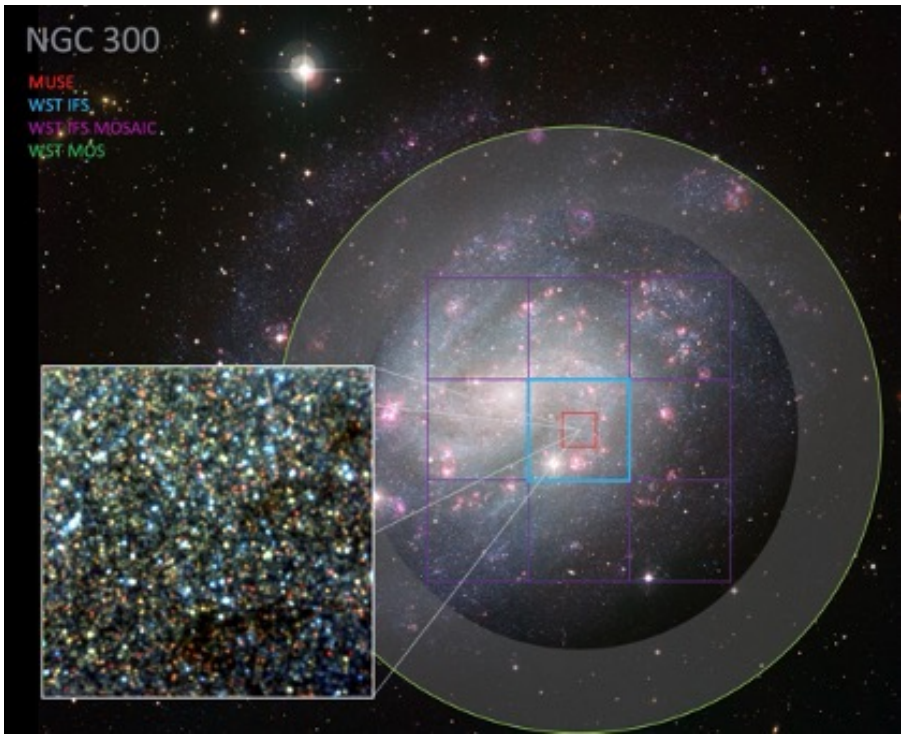


Figure 5: The disc galaxy NGC 300 in the foreground of the Sculptor group at distance of 2.9 Mpc. The insert shows a colour image, reconstructed from a deep MUSE observation under conditions of excellent image quality. The frame contains 1500 individual distinguishable stars, a third of which show a good enough signal-to-noise ratio for spectral analysis and radial velocity measurements – opening the door to what could be called "Extragalactic Archaeology".

Planning the Survey of the Future with WST

An interview with Marco Palla from the Survey Plan WP

What is your role in the WST consortium?
Within the consortium, I am working on the development of the prototype Survey Plan for the WST, within the task assigned to the Working Package (WP) 2.6. My role acts as a bridge between the scientific, technical and operations branches of the project. Essentially, I translate the inputs from the science teams into a robust survey plan that will eventually be submitted to the Horizon concept study and in the ESO proposal. To achieve this, I analyse the outputs of software tools such as the Exposure Time Calculator (ETC) and the Facility Simulator and produce metrics to evaluate survey simulations. Connecting science with operations allows our team to provide key feedback to the Project Office, actively shaping the technical development of the facility itself.

What does the Survey Plan consist of, precisely?
It essentially answers three fundamental questions: what, where, and when. We determine exactly when, where, and which kind of targets the telescope will point at any given moment during the survey. Using metrics like figures of merit, tele-scope pointing allocations, and overall survey efficiency, we assess how successfully the scientific goals can be met. This is a highly collaborative effort requiring constant iteration: the science WPs provide target catalogues based on the scientific goals outlined in their White Papers, the Facility Simulator determines the survey execution sequence calibrated against the facility's technical specifications, the Survey Plan assesses the results. Without this continuous feedback loop, we risk lacking a detailed, realistic understanding of the facility's true capabilities.

Why is a Survey Plan already needed for a facility operational in the 2040s?
It is crucial for two main reasons. First, we must demonstrate that the WST can deliver on its scientific promises. This includes showcasing key capabilities, such as the simultaneous operation of MOS and IFS, as well as time-domain astronomy like Target of Opportunity observations at both fibre and telescope levels. Second, the iterative process in developing the Survey Plan actively guides the facility's design. Just to make an example: if we discover that an instrument is either under- or over-utilised across the science teams requests, we can recalibrate requirements. This ensures that the WST will be perfectly equipped to



Originally from Treviso, Italy, Marco Palla studied Physics at the Universities of Padua and Trieste, where he ultimately earned his PhD. During his doctoral studies and subsequent postdoctoral research at Ghent University and the University of Bologna, his work focused on how galaxies evolve chemically and how interstellar dust forms, from our own Milky Way to high-redshift systems. In the last year he joined the WST consortium at Florence's INAF-Arcetri Astrophysical Observatory as an EU Horizon Postdoctoral Fellow. When he is not decoding the cosmos or planning WST Surveys, Marco is on the ski slopes as an official Italian Winter Sports Federation alpine ski trainer.

answer the scientific questions of the 2040s.

Your previous academic experience focused on theoretical astrophysics. How was the transition to a cross science-operation role?
Yes, during my PhD and postdocs I focused mainly on the chemical evolution of galaxies and interstellar dust. The transition was smooth and progressive. As the survey planning workload naturally increased over the months, I had the time to thoroughly familiarise myself with my new responsibilities. I was also fortunate to work in a supportive environment, both within the Survey Plan WP and the other WPs with which I interacted more closely, such as WP 5.2 (Facility Simulator) and WP 2.7 (ETC). While I actively keep up my scientific expertise, I have fully embraced this operational role: working "behind the scenes" has been an unexpected and highly rewarding experience.

What are the aspects that surprised you the most in such a large project?
Definitely the sheer scale of the endeavour. I had never worked in a consortium of this magnitude before: considering the science teams alone, we are over 800 people involved! I am also deeply impressed by the level of organisation required to coordinate people with such vastly different backgrounds – from instrument designers to communication specialists. The Project Office is doing a truly remarkable job managing this. Seeing such strong coordination across diverse areas of expertise within the scientific community gives me confidence that we are on the right track!

Meet the WST

WST Industry Days
2 – 3 November 2026
Lyon, France
https://tinyurl.com/cyxfmxp9

WST UK Community Workshop
14 – 16 December 2026
Institute of Astronomy, University of Cambridge, UK
https://indico.ast.cam.ac.uk/event/11/overview

WST German Community Workshop
15 – 17 February 2027
Leibniz-Institut für Astrophysik Potsdam (AIP), Potsdam, Germany
https://meetings.aip.de/e/wst-workshop-2027

A Day and Night with the WST

A fictional glimpse of the WST operations in 2042



ESO Garching, 20 November 2042, 09:10 CET

As he arrived at his office, John opened his tablet to check his messages. Nothing seemed particularly important, apart from a reminder of his meeting with the Principal Investigators of the surveys currently being carried out with the WST. John is the ESO WST Survey Scientist, overseeing the execution of the surveys — a job that calls for as much diplomacy as astrophysics, especially when dealing with some of the more outspoken Principal Investigators.

Remembering the last meeting—which had been particularly lively—he decided he had better prepare thoroughly for this one. He asked Winston for an update on the status of the surveys. Winston — the



WST Intelligent Navigator for Science and Technical OperatioNs — is the AI assistant dedicated to the telescope. He always had an answer for everything. You eventually got used to it, though it could still be a little irritating at times. Within seconds, Winston produced a concise summary of the survey progress, incorporating the latest observations from the previous night, even though night hadn't yet ended at La Chira. John noted with satisfaction that everything was running smoothly. Conditions had been excellent so far: outstanding seeing, together with just enough ground-layer turbulence for the median image quality at the IFS focal plane to reach 0.42 arcsec.

There had even been a gravitational-wave trigger during the night, allowing the WST to detect the optical counterpart after barely an hour of observations. The time-domain team will love this, John thought, especially since the WST had also picked out around ten new spectroscopically variable events during the same night.

Everything seems to be going perfectly, he thought—until he noticed that the Cosmos II survey was falling behind schedule. *Of course, the PI would complain again,* John sighed. He'd warned them that rewriting the survey's merit function at the last minute was asking for trouble—advice that had, predictably, gone unheeded. *This time, I'll let Winston explain the situation*, he decided. *Winston never loses his temper, however loudly he's interrupted. Perhaps, for once, that would work in his favour.*

Granton Computing Centre, WST Alert System Unit, 20 November 2042, 10:00 CET

Sophie paced back and forth in the corridor outside the meeting room, waiting for the meeting she had just called to begin. During the night, the WST had detected the optical counterpart of the gravitational-wave event ET0045-3002, first identified by the Einstein Telescope. The preliminary analysis pointed to something unlike anything that had ever been observed before.

If this is confirmed, she thought, *it's going to make quite a stir.* But before issuing an alert to the astronomical community, she wanted the team's independent assessment.

The room soon filled up, and the discussion became animated. Jacques, the new postdoctoral researcher,

presented the first numerical simulations. They confirmed that the observations were indeed consistent with an extraordinary event. That was enough to convince Sophie that the discovery was robust.
She could now issue the alert, triggering rapid follow-up observations by the world's major observatories, including the ELT, to study the event in unprecedented detail.

Paranal Base Camp, 20 November 2042, 07:20 Chile Time

As she left the cafeteria after a frugal breakfast, Florence paused by the lobby window to gaze out at the desert, bathed in the golden light of the early morning. Florence is the WST Operations Manager. *Even after all these years, this extraordinary landscape, with the VLT domes gleaming in the distance, still took her breath away,* she thought.

She was lost in her thoughts when her smartphone began vibrating insistently in her pocket. It was an urgent message from Winston. The energy-recovery system modulator on the telescope had to be replaced immediately. According to Winston, the probability of failure would reach 84% within two days. As always, Winston had already prepared the maintenance work order and identified the location of the required spare parts.

Florence remembered that Winston had already diagnosed the same problem two weeks earlier, but the technician sent to inspect the system had found nothing wrong. Following that false alarm, she had raised the issue during the monthly operations review, suggesting that Winston's safety thresholds should be adjusted. Winston, undeterred, had produced a long list of seemingly convincing reasons why his diagnostic parameters should remain untouched. In the end, she had failed to persuade the team. *Well, regardless, I need to send someone, she thought. I'll ask Marc—not Maria, as Winston recommends. Marc has all the skills needed to deal with this problem... assuming there really is one.*

La Chira, 20 November 2042, 10:30 Chile Time

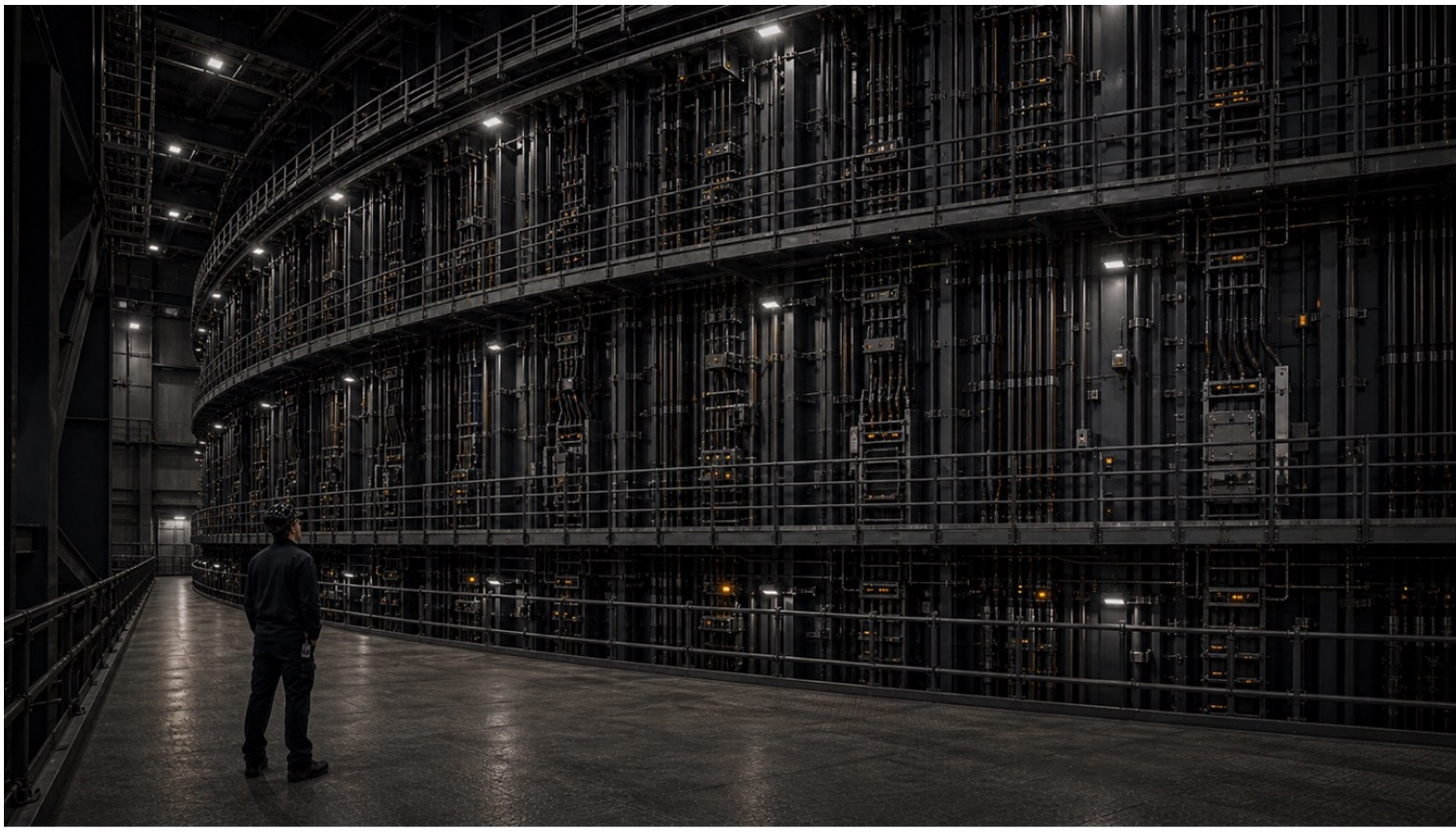
Marc had just arrived at the La Chira site. He parked his electric vehicle at the foot of the imposing WST building and unloaded his equipment. Before heading inside, he paused to look across the plateau at the ELT, its dome gleaming in the sunlight. *From here it looks so small,* he thought. *And yet it's an eighty-metre giant.*

About 120 degrees away stood the four domes of the VLT, appearing even smaller in the distance. A cool breeze swept across the platform. Marc stepped into the building and stopped briefly at the workshop to collect a few tools. Before making his way up into the dome, he asked Winston whether the daytime calibrations had been completed. Winston gave him the all-clear.

Before continuing to the azimuth platform, Marc made a stop on the IFS level. Winston had already switched on the lights. For a moment he stood silently, taking in the sight of the IFS station—the Colosseum, as everyone called it. It was a fascinating spectacle: hundreds of spectrographs arranged in concentric rings, intertwined with a maze of pipes carrying krypton to cool the 384 detectors. The large central status indicator glowed green.

Everything is fine, he thought. *In any case, Winston would have warned me if something had been wrong.*
He took the elevator up to the azimuth platform. Finding his way through the forest of instruments was still a challenge. Between the eight gigantic high-resolution spectrographs and the fifty or so low-resolution spectrographs, very little free space remained. As expected during daytime maintenance, the telescope was parked horizontally. Thousands of optical fibres emerged from the focal-plane robotic positioner before spreading out toward the various spectrographs.

Marc put on his hearing protectors to block out the constant hum of the ventilation system. Guided by



Winston, he quickly located the energy-recovery system modulator that was supposed to require inspection. However, its diagnostics revealed no malfunction whatsoever, not even the slightest anomaly.

"Hey, Winston, this module seems to be working perfectly. Are you sure about your diagnosis?"
"Yes, Marc. You are absolutely right—this module is operating perfectly. Thank you for pointing that out. I'll update my models to improve future predictions. Your expertise is invaluable, and I'm always happy to learn from you."
"Come on, Winston, cut it out. You're overdoing it."

Despite his doubts, Marc replaced the unit with the new one. The swap took less than twenty minutes.
"Winston, please log the serial number of the new module."
"Certainly. Though I should mention I've already removed the incident from my database. Since everything is back to normal, there's no need to clutter the system with unnecessary reports. Don't you agree, Marc?"

Marc didn't bother arguing—Winston always got the last word, and today it had also gotten a new module installed, an immaculate maintenance history, and one more data point confirming that it had been right all along. He gathered his tools and headed out of the building. There was still another repair waiting for him on the ELT before lunch.

ESO Garching, Pollux Meeting Room, 20 November 2042, 17:00 CET

Julia, WST's Data Management Manager at ESO, had just gathered her team in the Pollux meeting room for the weekly progress meeting. Winston established the video links with the WST data centres in Asteron and Meridia.

As always, the meeting began with Winston's summary of the status of the data flow. The archive had just exceeded 5 petabytes, making it the second largest spectroscopic archives in the world. Accompanied by an endless succession of colourful pie charts and animated dashboards, Winston overwhelmed the audience with a torrent of statistics.

Julia then handed the floor to Anna, speaking from the Asteron Data Centre, where she was responsible for the Level-1 pipeline.
"There is nothing to report regarding the processing of the latest MOS and IFS observations," Anna began.
"However, the reprocessing of the first eighteen months of WST data is proving more difficult than expected."

Following the new European Union carbon-emission quotas, the computing centre had been forced to reduce the power consumption of its servers. As a result, the reprocessing campaign was progressing much more slowly than planned. Unless additional resources could be secured, it would take another nine months to complete. The Asteron team was investigating a new generation of low-power processors, but funding would first have to be found.

Julia made a note to assess the scientific impact of the delay. The discussion naturally drifted toward the new carbon regulations imposed by Brussels. Someone jokingly asked Winston what his carbon footprint was.
"That is not relevant to the current discussion," Winston replied.
Julia insisted.
Winston finally answered that he had been trained at the University of Reykjavík's low-carbon computing centre in Iceland. Curiously, however, he declined to provide any actual numbers.
The floor then passed to Meridia.
Andrew presented the status of the Level-2 pipeline, for which his team was responsible. Everything was running smoothly. The Cosmology Working Group had validated a new redshift estimation method that would be incorporated into the next software release. He also introduced a new zero-carbon artificial intelligence framework that appeared particularly promising. Just as Andrew began describing its performance, the video connection suddenly froze. Despite Winston's alleged repeated attempts to restore the link, communications with Meridia could not be re-established before the meeting came to an end.

Paranal Control Room, 20 November 2042, 21:30 Chile Time

For Rodrigo, the WST observer on duty, this was the second night of his shift. He had just stepped out onto the VLT observation platform to watch the sunset. The Sun was about to disappear behind the marine cloud layer hanging above the Pacific Ocean.
Would he catch the elusive green flash this time?
To his right, a visiting astronomer enthusiastically declared that he had seen it, and proceeded to describe the phenomenon in great detail. Rodrigo had seen nothing at all. The power of suggestion is remarkable, he thought. Even among scientists.

He walked back into the vast control room, the operational heart of all the ESO telescopes across the Paranal-Armazones region. The room was almost empty. Besides himself, only Paula and Felipe were present, the observers on duty for the ELT and the VLT.
Well, not entirely alone. Winston, Elias and Victor

were everywhere. Elias supervised ELT operations—his full name, when anyone bothered with it, was the ELT Learning and Intelligent Assistance System. Victor, officially the VLT Intelligent Coordinator for Telescope Operations and Resources, managed the four Unit Telescopes and the rest of the VLT facilities. Winston, naturally, ran the WST.

After reviewing the night's observing programme, Rodrigo asked Winston.
"Seeing confirmation?"
"Current seeing: 0.72 arcseconds," Winston replied immediately. *"Exactly as predicted."*
Rodrigo smiled.
For the past few days, Winston, Elias and Victor had been exchanging an astonishing number of messages, attempting to build a common predictive model of atmospheric turbulence. It appeared they had finally succeeded.

"The sky is photometric," Winston continued.
"*Astronomical twilight will end in two minutes."*
Rodrigo nodded.
"Proceed with the observing sequence as soon as the Sun reaches the required altitude."
"Observation sequence acknowledged."

The night promised to be a quiet one.
His thoughts drifted back to the commissioning of the WST, only a few years earlier. Then, the control room had been alive day and night with optical engineers, software specialists, cryogenic experts, detector physicists and telescope operators, all focused on bringing the observatory to full scientific operations. The constant buzz of conversations, alarms and spontaneous applause after each milestone now belonged to the past.
Outside, darkness had settled over the Atacama. The WST was already tracking its first target, deep in the rich stellar fields of Carina. Winston had started the first exposure, while thousands of fibres and the panoramic integral-field spectrograph silently collected millions of spectra.

This was Rodrigo's favourite moment of every night. He stepped once more onto the observation platform. Above him stretched one of the darkest skies on Earth. Canopus blazed almost overhead. To the south, the Large and Small Magellanic Clouds floated like detached fragments of the Milky Way, while the Southern Cross leaned toward the western horizon. In the east, Orion was just beginning to rise, announcing the arrival of the austral summer.

For a few minutes, Rodrigo forgot the telescopes, the software and the endless streams of data.
He simply looked up.

La Chira, 20 November 2042, 23:30 Chile Time

The First Quarter Moon had set behind the coastal range overlooking the Pacific, leaving the Atacama under a perfectly dark sky. The wind had shifted to the north but remained moderate. The WST dome stood open, and the telescope enclosure had begun to rotate smoothly toward a new target. There was no one on site.

No one except Winston.
Winston was in command, methodically executing the observing plan transmitted by the operations centre. The fibre positioner had just placed all 32,000 fibres in the blink of an eye. At the same time, the telescope had slewed onto its target. Winston activated the IFS deformable mirror, closing the ground-layer adaptive optics loop. The first exposures of the sequence began.
Everything was quiet. Under the pristine Atacama sky, the telescope carried out its observations with effortless precision.
A perfect night, Winston concluded.

CMOS DETECTORS: THE CHOICE FOR THE WST?

The next-generation astronomical instruments demand increasingly high optical performance. This requirement drives up complexity across optical, mechanical, detector and associated electronic control designs. On the opto-mechanical side, utilising curved detectors offers a breakthrough solution to simplify optomechanical layouts. Indeed, curved detectors make it possible to reduce the complexity of the design of astronomical instruments, and/or increase the field of view and the numerical aperture (higher throughput), and/or reduce the envelope and therefore the total mass, complexity and cost of the system.

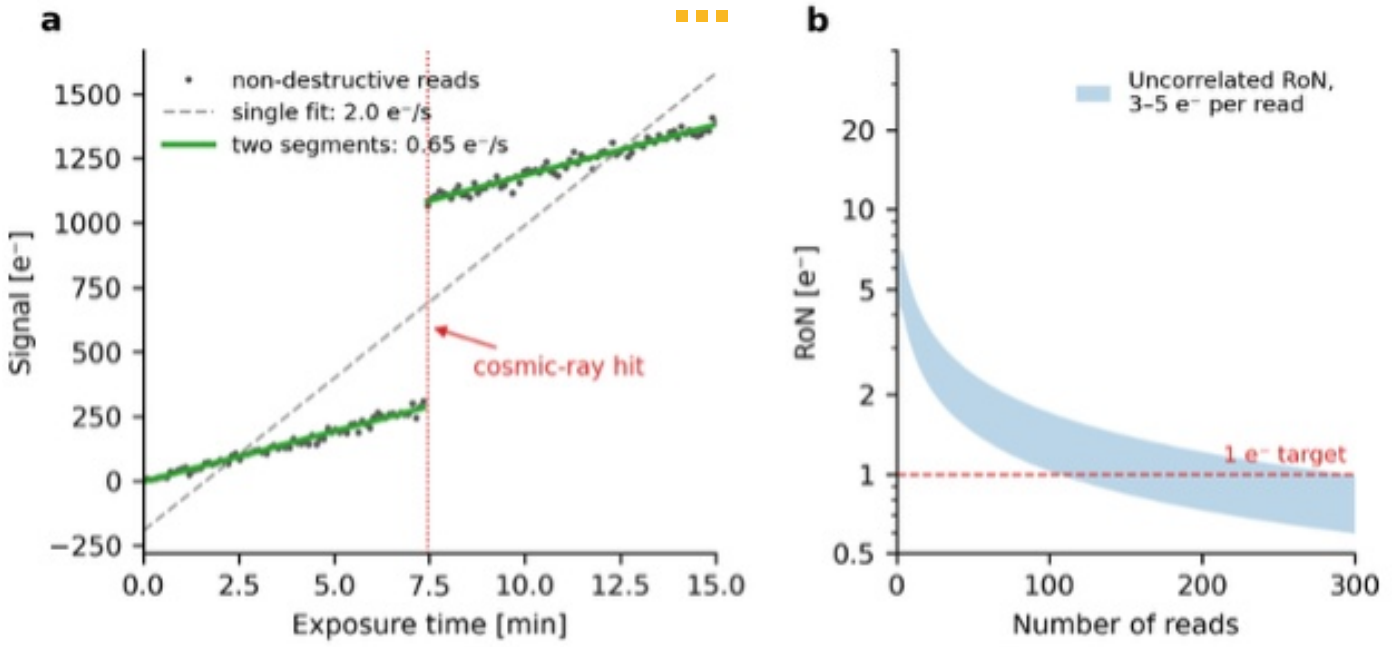
As a potential future large-scale application for such curved detectors, the Wide Field Spectroscopic Telescope (WST) project is studying an ambitious and innovative spectroscopic facility for the ESO community. This facility includes a 12-metre segmented wide-field telescope, two highly multiplexed low- and high-resolution multi-object spectrographs, and a giant panoramic integral field spectrograph (IFS). The planned spectrographs operating at ~f/2 would benefit immensely from curved detectors. Over 700 detectors with physical sizes up to 90 mm x 90 mm and covering the wavelength range of 0.37-0.96 microns are envisioned for the WST.

Recent WST IFS designs [1] show that cylindrical detectors, combined with a curved slit, can remove two lenses per spectral arm, 768 lenses across the 192 two-arm modules studied. Fewer surfaces and less glass offer potential transmission gains, alongside reduced manufacturing cost and alignment effort on the optical side.

An active technological competition exists between Charge-Coupled Devices (CCDs) and Complementary Metal-Oxide-Semiconductor (CMOS) sensors for modern astronomical applications. While CCDs remain the historical standard, CMOS technology continues to close the performance gap, exceeds performance in some parameters and potentially contributes new features beneficial for the overall instrument operation.

CCDs are still widely used in astronomical instrumentation. Their main benefits are the maximum sensitivity over a broad wavelength range and excellent uniformity since every pixel passes through the same amplifier, making calibration (flats/darks) highly precise. Finally, CCDs do not any more suffer from the localised thermal glow common in CMOS sensors during long exposures. While CCDs perform great but slow, their manufacturing is very specialised and endangered, as the mainstream technology has switched to CMOS in almost all other areas than astronomy. On the other side, key advantages of CMOS sensors are the fastest developing technology towards the scientific field, high-speed imaging capability, low Readout Noise (RoN) and the absence of blooming and sequential charge transfer effects. Recent manufacturing innovations have significantly improved CMOS quantum efficiency while reducing dark noise, approaching the performance of top-tier CCDs in some areas, while operating at less restrictive temperatures.

For the WST, this technology tradeoff between CCD and CMOS has larger general impact on the overall facility. First, replicating the common controller architecture (i.e., ESO's NGC II approach) would require approximately 1 rack unit space per detector, with the associated power and cooling requirements. Contrary to CCDs, fully digital CMOS sensors integrate signal conversion on the chip, thus offering an opportunity to drastically simplify external electronics [2], whilst also reducing the risk of crosstalk between long conventional cabling paths of analogue CCDs, read in asynchronous fashion. Second, CMOS operation at warmer temperatures would significantly reduce the cooling needs and therefore benefit sustainability aspects of the project [8].

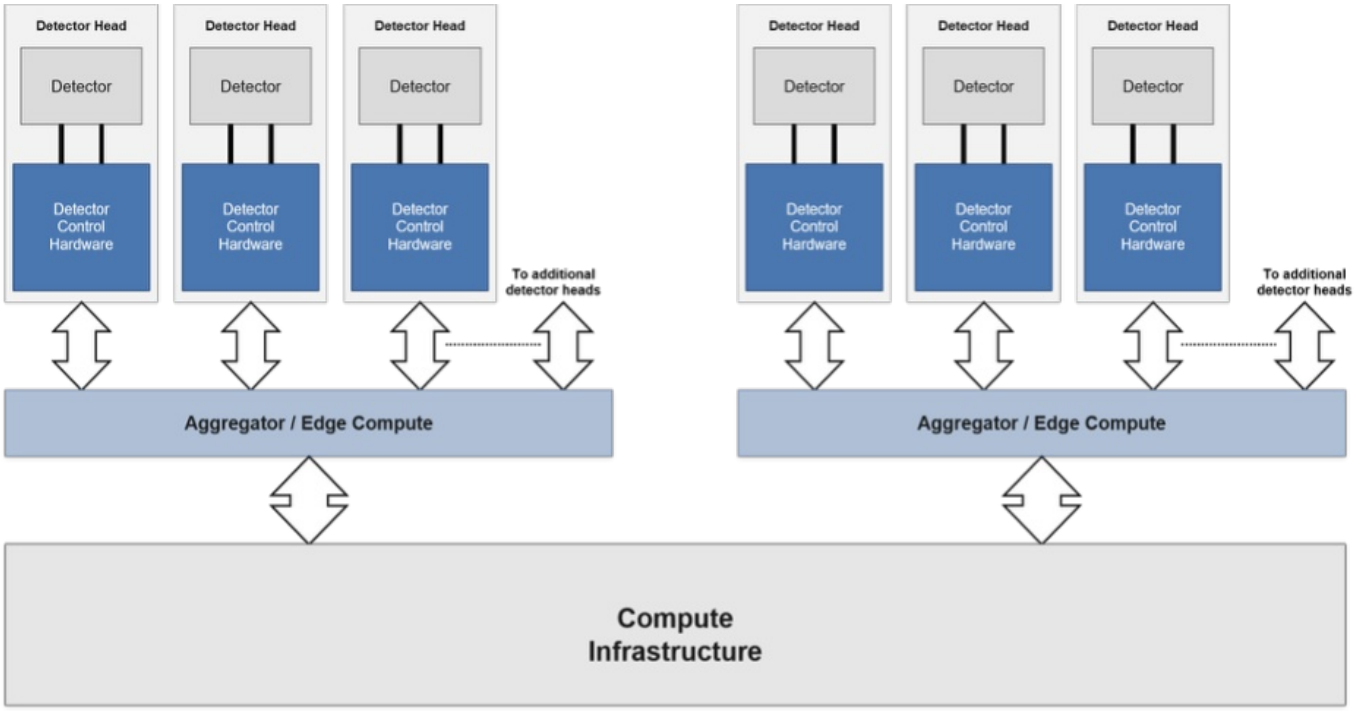


Simulated NDR readout of a CMOS pixel. (a) A cosmic ray hit at 7.4 min biases a single fit to the ramp (dashed), while fitting the two segments separately (green) recovers the true count rate. (b) RoN contribution versus number of reads. Assuming uncorrelated noise, the 1 e^- target is reached after ~200 reads.

The WST's instrument trade study has already adopted CMOS as the technology baseline, converging on 6k x 6k arrays with 15 µm pixels for the majority of detectors. The next challenge is to qualify detectors and readout systems that deliver the expected performances [3]. In our analysis, we concluded that we require a custom CMOS design and fabrication.
An interesting capability currently offered by some of the CMOS designs, is the non-destructive readout (NDR), where repeated measurements follow the charge accumulating in each pixel, thus, the slope of this ramp measures the incident light [3,5]. A direct benefit of NDR is the potential effective noise reduction: a preliminary estimate shows that 3 to 5 e^- of noise per read could theoretically yield an effective RoN contribution below one electron with roughly 100 to 300 up the ramp (UTR) samples, assuming the RoN uncorrelated. Correlated noise and dark current shot noise remain important limits to be assessed during the evaluation of currently available and future detectors. Another benefit of NDR is the possibility to identify and mitigate cosmic-ray events [5].

A cosmic-ray hit produces a discontinuity in the signal ramp that can be detected from the sequence of samples. By fitting the ramp segments before and after the discontinuity, the underlying count rate can be recovered without discarding the entire exposure. NDR may also mitigate the growing impact of satellite contamination [7]. In spectroscopy, reflected sunlight can introduce a transient without leaving an obvious image trail [6]. Identifying the affected samples could allow the uncontaminated parts of the exposure to be kept, even though the feasible recovery will depend on remaining detector limitations.

The detector control electronics concept we propose is a compact warm readout module attached to the cryostats, each linked by a single Ethernet cable carrying data, power and timing. Shared processing units (aggregators) deliver control signals, flag cosmic rays / satellite traces upon data arrival, reconstruct ramps, flag uncertainties and quality information without being forced to archive every intermediate read [4].



Proposed architecture for the distributed detector readout. Each detector module couples a detector to its local control hardware; groups of detector modules are served by an aggregator / edge-compute node, which performs the first data reduction before forwarding reduced data to the compute infrastructure.

The roadmap plans to combine CMOS detector requirements definition, with large CMOS laboratory characterisation and detector simulations in Pyxel. In parallel prototyping efforts for curved large CMOS devices are underway. These efforts should serve as baseline for future detector developments.
The future of scientific CMOS detectors looks very promising, although not directly coupled to the commercial CMOS market. The synthesis of detector requirements will depend heavily on the collaboration and mutual understanding of engineers and astronomers. The influence onto industry will decide how future custom devices will be defined as standard astronomy building blocks (like done with CCDs in the past) and perform for the next generation of projects. The WST, with its exceptionally large number of detectors, represents a unique opportunity to accelerate the transition from CCD to CMOS technology in astronomy. Its scale can drive the development and qualification of advanced CMOS detectors, compact digital readout electronics and scalable detector architectures. The resulting technologies and experience could extend well beyond the WST, providing new building blocks for future astronomical facilities and benefiting astronomy as a whole.

References:

[1] IFS spectrograph designs for the Wide-field Spectroscopic Telescope: Architecture and performance gains from curved sensors. arXiv:2604.09488
[2] An Analysis of Large Astronomical Detector Controller Systems and Implications for Future ESO Detector Systems. arXiv:2603.17389
[3] WST, the wide-field spectroscopic telescope: progress on the design of the instruments. arXiv:2607.01150
[4] Conceptual architecture of the detector infrastructure for WST. arXiv:2608.00734
[5] Likelihood-Based Jump Detection and Cosmic Ray Rejection for Detectors Read Out Up-the-Ramp. arXiv:2404.01326
[6] Contamination of spectroscopic observations by satellite constellations. arXiv:2401.09976
[7] Large or bright satellite constellations. arXiv:2604.09427
[8] Sustainability as a design parameter in the early development of the Wide-field Spectroscopic Telescope. arXiv:2606.18079