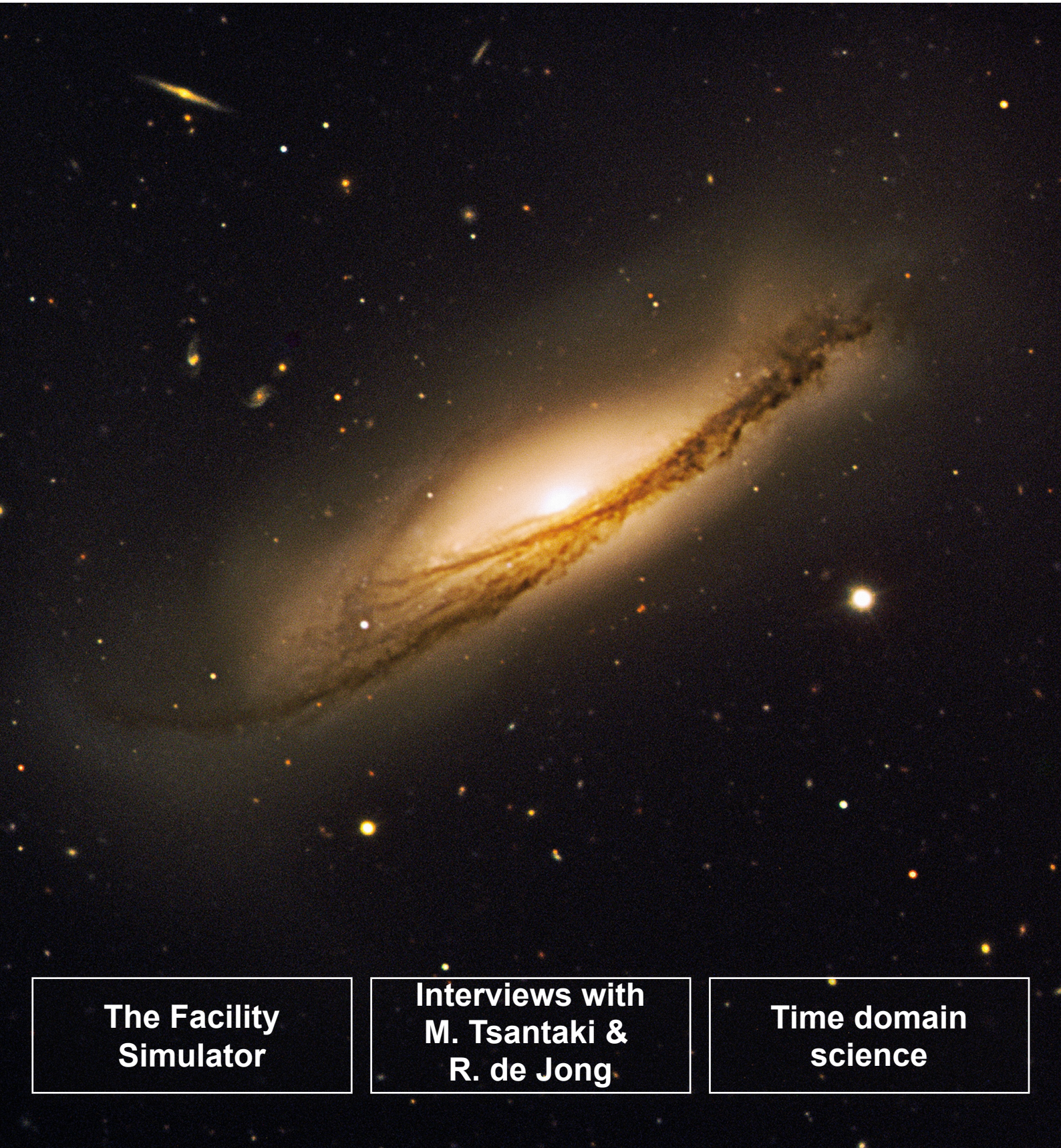


Issue 5 - July 2026

THE **WST** *CHRONICLE*

Pushing the Boundaries of Spectroscopic Surveys



**The Facility
Simulator**

**Interviews with
M. Tsantaki &
R. de Jong**

**Time domain
science**

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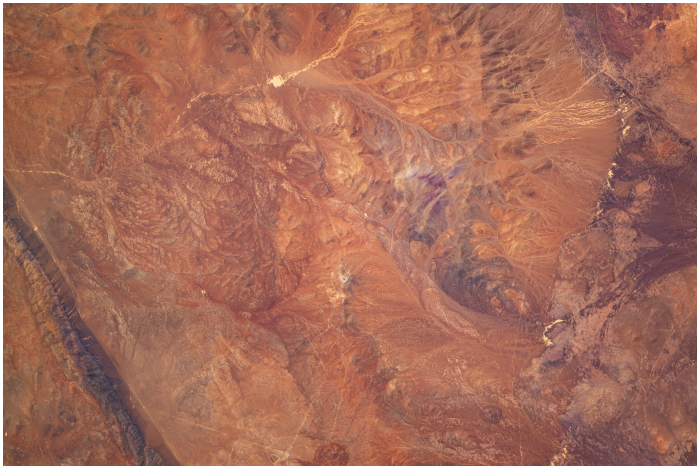


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Cover image: The beautiful edge-on spiral galaxy NGC 3190 with tightly wound arms and a warped shape that makes it resemble a gigantic potato crisp, as seen by ESO's Very Large Telescope. Supernova SN 2002bo is found in between the 'V' of the dust lanes in the south-western part of NGC 3190. This issue of the Chronicle presents an overview of how the WST will allow studying time domain science. Credit image: ESO/H. Boffin



Armazones, the site of ESO's Extremely Large Telescope, seen from the International Space Station by ESA astronaut Sophie Adenot. Credit: ESA – S. Adenot. CC-BY-SA 3.0 IGO

COORDINATOR MESSAGE

As we approach the summer break in Europe, it is a fitting time to publish the fifth issue of the *WST Chronicle*. I hope you will enjoy reading it—whether you are relaxing on a beach, hiking in the mountains, or simply taking some well-deserved time off at home.

The collective efforts of the consortium over the past few months have culminated in four major events: the *WST Busy Week* in Aussois, the annual EAS meeting in Lausanne, the SPIE Astronomical Telescopes+Instrumentation conference in Copenhagen, and, last but not least, the Expanding Horizons workshop at ESO in Garching.

While the Busy Week was an internal consortium meeting, both EAS and SPIE were major international conferences that provided an excellent opportunity to present the WST to the broader astronomical community. This issue includes detailed reports on all three events and highlights the many scientific and technical discussions that took place.

The Expanding Horizons workshop, entitled “*What are the astronomical challenges of the 2040s?*” and jointly organised by the Science Senior Committee and ESO, was particularly significant. It marked the first opportunity to present our science case directly to the committee that will ultimately evaluate the future flagship projects. All the major concepts were represented, including ALMA2040, AtLAST, the Time-Domain Telescope, and the Kilometre Baseline Interferometer, alongside several broader review presentations.

The WST was exceptionally well represented, with around fifteen presentations either fully dedicated to the project or discussing science areas in which the WST plays a central role. Together, they demonstrated both the transformative potential and the remarkable breadth of the WST science case. Our strong visual identity also made a noticeable impression. Thanks to the excellent presentation template developed by the

communication team—and consistently adopted by all speakers—the project was presented with a high level of professionalism and coherence.

The workshop also provided an update on the Expanding Horizons process from Jarle Brinchmann, ESO Director of Science. As anticipated, the Letter of Intent will be due on 1 December 2026, while the deadline for the full proposal has been postponed by six months to 1 December 2027. This revised schedule aligns almost perfectly with the completion of our Horizon Europe concept study on 1 February 2028. The Project Office will assess the implications of this updated timeline and adjust our planning accordingly. We also learned that the evaluation phase is expected to last approximately two years, with a decision by the ESO Council anticipated in 2029–2030. As always, these dates remain dependent on the progress of the ELT programme.

Looking back at EAS, SPIE, and the Expanding Horizons workshop, it is fair to say that the WST made a strong and positive impression on the scientific, engineering, and industrial communities alike. We received many encouraging comments on both the ambition of the science programme and the maturity of the project. These achievements are the direct result of the remarkable commitment and hard work of the entire consortium. Although much remains to be done, the project is progressing in the right direction, and there are many reasons to be optimistic about the road ahead.

I would like to conclude by wishing all of you a pleasant and well-deserved summer break—or a wonderful winter break for our Australian colleagues. I hope you have the opportunity to recharge your batteries before we embark on the next exciting phase of the WST adventure.

Roland Bacon

“JOINING THE WST CONSORTIUM WAS AN EXCITING EVOLUTION FOR MY CAREER”

An interview with Maria Tsantaki, co-lead of a Galactic sub-working group

What is your role in the WST consortium?

I am the co-leader of the Galactic sub-working group (WG) dedicated to the “*Origins of stars and planets – characterisation of planet-host stars and environmental dependence of planet formation*,” together with Katia Biazzo (INAF). Our goal is to define how the WST, with its high-resolution and high-multiplexing capabilities, can address some of the most important questions in exoplanet science. Since the formation and evolution of planets cannot be understood in isolation from their stellar and Galactic environment, we want to address the role of the environment in the formation and diversity of planetary systems. We, therefore, investigate how stellar properties and chemical composition in different Galactic populations influence planet formation and evolution. The WST will enable us to perform a large-scale, high-resolution spectroscopic survey of planet-host stars and polluted white dwarfs, across a wide range of Galactic locations on an unprecedented scale.

How did you get involved in the WST?

My research has always focused on stellar spectroscopy and on the interplay between stars and their planets. Being based at the Arcetri

Astrophysical Observatory (INAF) in Florence, an institute with a long tradition in stellar spectroscopy, I have had the opportunity to work with colleagues who are deeply involved with the WST both in science and in technology. Given my work on linking the properties of stellar populations with planet demographics, joining the WST consortium was an exciting evolution for my career.

Why is the WST useful for your science?

To truly understand how planets form and evolve, we cannot look at them in isolation but in the context of their stellar and Galactic environments. Currently, the detailed high-resolution characterisation of exoplanet hosts is largely limited to the solar neighbourhood. The WST will completely lift this limitation. With its 12-meter aperture, the WST will allow us to observe faint planet-host stars and polluted white dwarfs across a broad range of Galactic populations. For my science, this means we can move from studying small, localised samples to a massive, homogeneous chemical census. We will be able to determine precise stellar parameters, elemental abundances, and properties to investigate how Galactic chemical evolution shapes the architectures, ■ ■ ■



Maria Tsantaki grew up on the island of Crete and studied Physics at the University of Athens. She later completed a Master's at the University of Crete, followed by a PhD in Astronomy at the University of Porto, where she also continued as a postdoctoral researcher. She held a fellowship at UNAM in Mexico, then returned to the Instituto de Astrofísica e Ciências do Espaço in Porto for a postdoctoral appointment, and is currently a postdoctoral researcher at the Arcetri Astrophysical Observatory (INAF) in Florence. Her work focuses on stellar spectroscopy and the characterisation of planet-host stars, with a particular interest in the link of stellar and planetary properties to better understand planet formation across our Galaxy. She is actively involved in the preparation for ESA's Ariel mission, as well as in the upcoming HRMOS instrument and WST facilities.

■ ■ ■ composition, and diversity of planetary systems. By WST's *First Light*, the number of exoplanets will explode to tens of thousands reaching fainter magnitudes than ever before. The WST will timely complement ongoing and upcoming planet-search missions (*Gaia*, *TESS*, *Roman*) and will provide the most complete chemical census of planet-host stars which will be an essential reference for models of planet formation and evolution.

You are involved in other projects as well. How do you see the complementarity of the WST with other facilities?

My primary collaboration at the moment focuses on the characterisation of planet-host stars for the preparation of ESA's *Ariel* mission which will study the atmospheres of hundreds of exoplanets to be launched in 2031. *Ariel* is teaching us that understanding exoplanets requires knowing their host stars with equal precision. The WST will extend this approach to a much larger scale. In the exoplanet field, complementarity between facilities is essential. Space missions like *Gaia*, *TESS*, and the upcoming *Roman* will deliver

thousands of planet candidates. However, high-resolution spectroscopy is needed to fully exploit these datasets and the WST will fill this gap. The WST has a dedicated sub-WG to provide the detailed stellar characterisation. The synergy with *Roman* is particularly exciting. Many planetary systems detected by *Roman* will be too faint for detailed study with existing facilities. The WST is currently the only planned facility capable of obtaining high-resolution spectroscopy for such large samples.

Do you have any special moment related to the WST that you would like to share?

When participating for the first time in a dedicated WST session at the EAS 2025 meeting, I was very

impressed by the variety of science topics the WST will deliver. Seeing the immense scope of the WST presented so cohesively really highlighted how transformative this facility is going to be.

Is there anything you wish people would know about the WST?

I am quite impressed by the consortium's commitment to environmental sustainability which has been embedded in the project from the very beginning. Moreover, I also greatly value the strong dedication to Diversity, Equity, and Inclusion within the collaboration. This focus on both our environmental responsibility and our human community is very relevant today, showing that the WST is being built with the future in mind. ■



Artist's impression of an ultra-hot Jupiter transiting its star (Credit: ESO/M. Kornmesser)

REAPING THE TIME DOMAIN HARVEST WITH THE WST

The dimension of time is the new great frontier in astrophysics — crucial to understand the Universe and its constituents on all observable scales. Temporal variations render otherwise inconspicuous objects interesting because they reveal distance, physical state, mass, size, density, among other properties, and simultaneously observed variations establish causality. Certain events can only be observed at specific times, such as eruptive events or objects propagating within the Solar System, and persistent objects may exhibit repeating or stochastic variations unravelling internal physical processes, constitution, companions, and much more. Temporal resolution thus complements all sorts of astronomical investigations, providing a small relief to the dilemma of our passivity as observers.

Unsurprisingly, virtually all large (photometric) astronomical surveys nowadays collect time-resolved observations, thus effectively recording chromatic all-sky video of variable frame rate. For example, the Vera C. Rubin Observatory's Legacy Survey of Space and Time (Rubin/LSST) observes each sky region roughly once every three nights at unprecedented depth (beyond 24th mag) thanks to its 8-m primary aperture, whereas the ESA Gaia mission recently completed its decade-long survey of the entire sky down to 20.7 mag. Time resolution has also become increasingly important for large spectroscopic surveys, such as the fifth data release of the Sloan Digital Sky Survey (SDSS-V), the Dark Energy Spectroscopic Instrument (DESI), and ESO's 4MOST. In the Zwicky Transient Factory (ZTF), spectroscopic follow-up is an integral part of the survey and has been identified as the key bottleneck for event characterization; of course, additional surveys probing ever fainter targets rapidly exacerbate this situation. Clearly, a major investment towards a spectroscopic complement to all-sky photometric video is urgently required.

Multi-messenger astrophysics, enabled by gravitational wave observatories from the ground (LIGO/Virgo/Kagra, Einstein Telescope, Cosmic Explorer) and space (LISA, TianQin) as well as by astroparticle observatories (IceCube, KM3Net, Kamiokande, CTA) also

require spectroscopic follow-up on short timescales. The $1/r$ attenuation of gravitational waves requires particularly large collecting areas beyond currently available or planned facilities to unlock the cosmological potential of multi-messenger events. The time-domain Working Group ensures that the WST will meet these vital needs of astrophysics and cosmology in the 2040s, addressing some of the biggest questions of humanity. We consider all science applications where timing or temporal resolution are relevant; a few of them are listed below. Of course, sky coverage, depth, and cadence compete in a survey of fixed duration. We have therefore adopted a multi-pronged approach combining target-of-opportunity (ToO) observations marked by short lead times, focus fields where deep and long cadences can be obtained, and a limited all-sky cadence of at least three repeat observations to serve as a filter for further targeted follow-up facilities. We are thus imbuing the facility with a time-domain mindset to meet the significant follow-up capabilities from other facilities, while incorporating operational flexibility to ensure that the WST will respond to the state-of-the-art in the time domain when it comes on-line. Crucially, we are designing the system to enable serendipitous new discoveries by developing novel strategies for data collection and processing that create unprejudiced opportunities for discovery.

A “spectroscopic LSST” capable of telescope-level target-of-opportunity observations for Multi-Messenger astrophysics

Spectroscopy is crucial to characterising electromagnetic counterparts of gravitational wave events, such as mergers of binary neutron stars (BNS) or neutron star-black hole pairs. For cosmology, combining the WST with BNS kilonovae from the Einstein Telescope (and/or Cosmic Explorer) creates a unique opportunity for measuring the local expansion rate of the Universe, Hubble's constant H_0 , to within an accuracy of 1% by relating luminosity distances measured by the gravitational wave chirp signal to kilonova redshifts. Such accuracy would be highly

- ■ ■ significant for cosmology, weighing in on the Hubble constant tension, the cosmological principle, and possible extensions to the physics encapsulated by cosmological models.

The WST thus requires the ability to conduct telescope-level ToO observations (TL-ToO) with sufficiently rapid reaction times (12-24h). However, only a relatively small fraction of the facility ($< 10\%$) will be used to characterise live transients within reported sky localization regions. Thus, TL-ToOs will primarily modulate the pointing schedule while allowing survey operations to continue. The WST's IFS will provide optimal capabilities in densely populated regions, e.g., galaxy clusters, while the wide field-of-view of the MOS allows to scout all known live transients in the same region. To support TL-ToOs and other time-domain science, we are currently considering an auxiliary telescope (AuxTel) as an extension to the WST baseline design. The WST's AuxTel would provide a real-time view of live transients immediately prior to target acquisition for TL-ToO observations while delivering simultaneous multi-band photometry to aid the interpretation of variability signals.

Minor Bodies

Small bodies in planetary systems are key leftovers from the planetary formation process that reveal the physical conditions of protoplanetary discs and provide an essential mechanism by which material is transported within planetary systems. Studying the chemical makeup of a range of minor bodies, both within our own solar system where bodies can be studied individually in great detail, and in other fully formed and forming planetary systems is thus essential to understanding the formation and evolution of planetary systems and how they can support the existence of life. The WST will allow us to build an unprecedented picture of small body population, composition and dynamics in planetary systems. The IFS will probe the morphology and

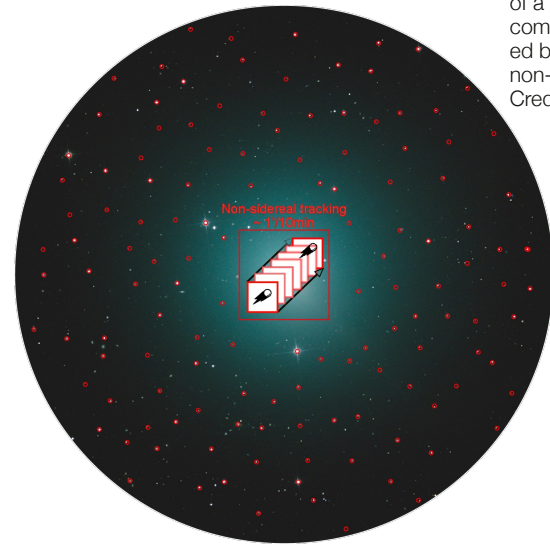


Figure 1: Illustration of a Solar System comet being observed by the IFS using non-sideral tracking. Credit: Cyrielle Opitom

composition of solar system (Fig. 1) or interstellar comets, the surface composition of asteroids and trans-Neptunian objects. The MOS will observe large samples of exocomets and monitor white dwarf atmospheres contaminated by disrupted planets or large planetesimals, allowing us to build statistically significant samples to understand the architecture, composition, and evolution of planetary systems.

Variable stars

Variability signals due to pulsations, rotation, magnetism, accretion, mass-loss, eruptions, shocks, companions and binary interactions, among others, serve as powerful laboratories of stellar astrophysics across the Hertzsprung-Russell Diagram. Time-dependent spectroscopic signatures manifest as radial-velocity shifts, line-profile variations, including appearing and disappearing lines or line features, signatures of multiple sources even in single spectra, and yield time-resolved changes in physical quantities such as temperature, surface gravity, mass-loss or accretion diagnostics, among many others. By the start of the WST, Gaia and Rubin/LSST (and many other facilities) will have surveyed stellar variability from naked eye stars to 24th magnitude, resulting in a dire ■ ■ ■

need for spectroscopic follow-up to understand the recorded variations. The low- and high-resolution MOS of the WST will revolutionise the understanding of white dwarfs as the endpoints of stellar evolution for most stars as well as the precursors to supernovae, detect unprecedented numbers of stellar-mass (dormant) black holes, and provide detailed chemical and astrophysical parameters of millions of pulsating stars.

Extragalactic Variables

The extragalactic time-domain science cases span a broad range of phenomena united by the need for systematic, wide, and deep spectroscopic coverage, probing variability timescales from minutes in the case of gamma-ray burst afterglows to months and years for active galactic nuclei (AGNs), as well as a broad range of luminosities (Fig. 2). A reverberation mapping campaign targeting hundreds of thousands of AGNs will directly constrain the black hole mass

function from intermediate-mass to supermassive regimes (10^4 – $10^{10} M_{\odot}$) out to $z \sim 2$ –5, while simultaneously enabling the identification of close-binary SMBH candidates through radial velocity variations. Nuclear transients, including TDEs, changing-look AGNs, and ambiguous nuclear transients, will be systematically observed using dynamic fibre assignment (i.e., fibre-level ToO). At the shortest timescales, rapid spectroscopic capture of gamma-ray burst afterglows will probe the intergalactic medium, host galaxy environments, and progenitor properties across cosmic time. Cadenced observations will classify and characterise hundreds of thousands of supernovae and related transients down to 24th magnitude, covering standard types, superluminous explosions, impostors, and fast-evolving phenomena. The IFS will complement the MOS by enabling the serendipitous detection of off-nuclear events and spatially resolved studies of host galaxies, providing constraints on stellar populations, star formation

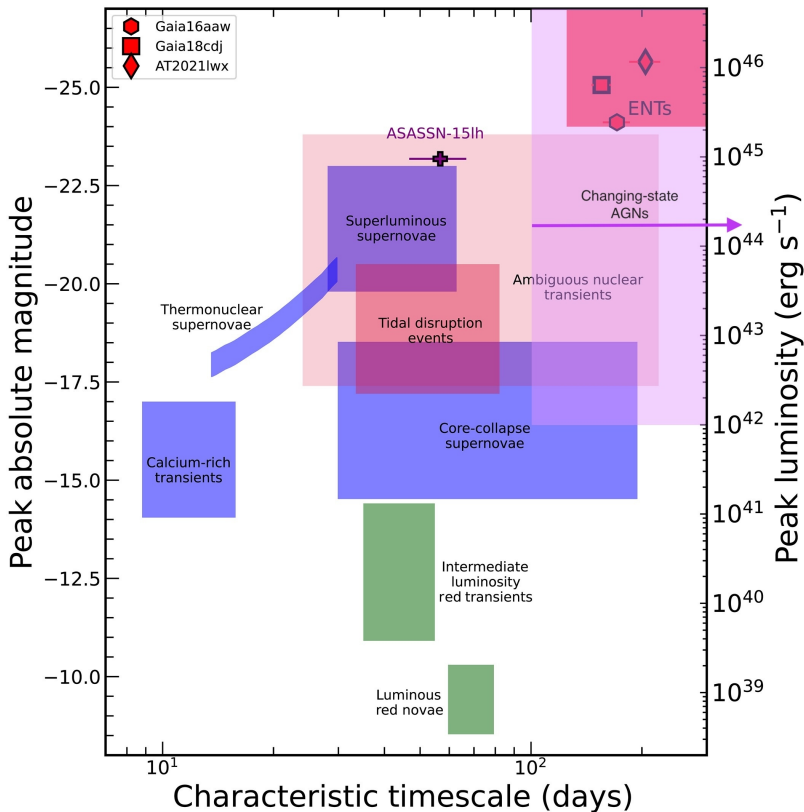


Figure 2: The WST will systematically follow-up and serendipitously discover a wide array of transient phenomena, uniquely opening up the currently unexplored low luminosity, fast timescale parameter range. Figure adapted from Hinkle et al. (2025, SciA 11, 74H)

- ■ ■ histories, and local environments that shape and are shaped by these energetic events.

Spectroscopic Alerts Systems/ Transients

Time-domain astronomy is about to unleash an unprecedented data avalanche requiring rapid reaction and coordination. LSST, Gaia, Roman, Euclid, the SKA, and other next-generation facilities will produce up to one billion alerts per year of which only a few percent will be spectroscopically followed-up, leaving a critical gap between event discovery and physical understanding. The WST spectroscopic alerts system will close this gap by issuing notifications when a source shows significant spectral evolution, such as new emission or absorption components, changing ionisation states, or shifting velocity structures (Fig. 3).

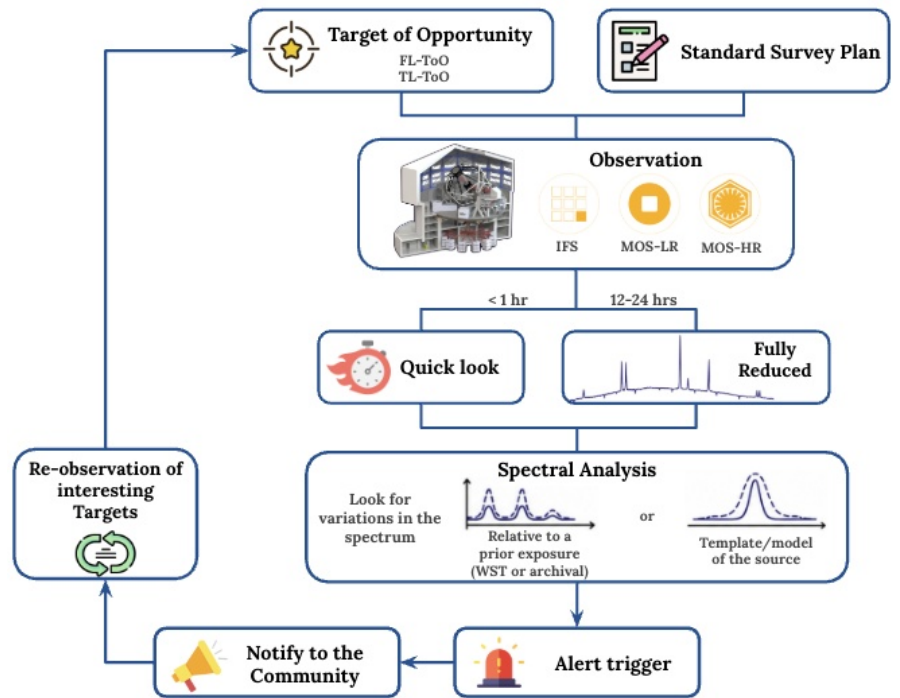


Figure 3: Schematic flowchart of the WST's spectroscopic alerts system. Credit: Alejandra Melo

These real-time alerts will render the WST a transformative time-domain facility capable of surveying tens of thousands of evolving objects per night and automatically flagging interesting events ranging from exocomet transits to stellar accretion bursts, supernovae, tidal disruption events, changing-look AGN, gravitational wave counterparts, and much more. The alerts system will thus turn the WST both into an

efficient follow-up machine and a spectroscopy-native discovery engine fit for the 2040s. Crucially, the WST will provide a unique capability within a networked time-domain landscape, allowing the community to react faster, coordinate resources better, and to discover the unexpected. ■



A field of stars in the constellation Lupus observed by the Vera C. Rubin Observatory. Credit: NSF-DOE Rubin Observatory/NOIRLab/SLAC/AURA

THE WST BUSY WEEK

The WST Busy Week took place at the Centre Paul Langevin in Aussois, in the French Alps. The Centre Paul Langevin is a CNRS conference centre that hosts scientific workshops and schools outside the holiday season. The meeting brought together 85 participants, with an excellent balance of scientists and engineers. All countries and institutes of the consortium were represented, and we were especially pleased that several of our Australian colleagues made the long journey to join us. Although the venue could not accommodate everyone involved in the project, we achieved a good representation of all work packages and science working groups.

We spent the week together from 22 to 26 June, enjoying the fresh mountain air while much of Europe was experiencing an intense heatwave. The meeting was deliberately scheduled at the midpoint of the *Horizon Europe* concept study and almost exactly one year before the expected submission of the WST proposal to ESO. Since the official start of the project in February 2025, the WST has made significant progress, making this the ideal time to meet face-to-face, review achievements, and identify the key issues requiring broader discussion. It had also been nearly three years since the previous *Busy Week*, held in October 2023. During that time, many new colleagues joined



the project and became actively involved, making this gathering an excellent opportunity to strengthen personal interactions beyond our regular video meetings.

The programme combined plenary sessions each morning with parallel splinter meetings in the ■■■





■ ■ ■ afternoons. With 32 plenary presentations and 30 parallel sessions, the *Busy Week* certainly lived up to its name. It provided an excellent forum for scientists and engineers to exchange ideas, review progress, and learn from one another. Every work package and science working group presented updates on their activities and achievements.

The splinter sessions addressed a broad range of topics, including the organisation of the science white papers, interfaces between the science working groups, the potential need for an auxiliary telescope, the first results of the survey planning effort, the packaging of the 192 integral field units, the use of CMOS detectors, trade-offs for the high-resolution spectrograph, the possible implementation of ground-layer adaptive optics, data volume management, and many other technical and scientific challenges. These focused discussions enabled participants to examine key issues in depth, evaluate different options, and converge towards well-informed decisions that will shape the next phases of the project.

On Wednesday morning, we took a half-day break. Most participants enjoyed a guided hike through the magnificent landscapes of the Vanoise National Park, providing a welcome opportunity to relax and continue discussions in a less formal setting.

After a week of intensive presentations, discussions, and brainstorming, the project office concluded each top-level workpackage — science, system, telescope, instruments, operations — with a summary of the main outcomes, decisions, and newly defined action items.

Overall, the *Busy Week* was unanimously regarded as both highly productive and enjoyable. It reinforced the strong momentum of the project and made an important contribution to team building. For many participants, it was the first opportunity to meet in person colleagues with whom they had previously interacted only through video meetings. The four pillars of the *Busy Week*—learn, discuss, decide, and deliver—were all successfully achieved. And a fifth pillar, equally important—enjoy—was fulfilled as well. The *Busy Week* marked an important milestone for the WST concept study, providing the scientific and technical convergence needed to prepare the project for its next phase and, ultimately, for the submission of the ESO proposal. ■

THE WST AT THE EAS



A Special Session (SS24) dedicated to the WST was held on July 2, 2026, at the annual European Astronomical Society meeting in Lausanne (Switzerland). The aim of this special session was to discuss with the broad astronomical community the strong synergies that the WST will have with other major astronomical facilities in the next decades. The meeting was very well attended and included 17 talks, between invited and contributed, covering the broad range of synergies that such facility will allow across the electromagnetic spectrum and beyond. The open-ing talk was given by Roland Bacon, the coordinator of the WST Horizon concept study, who summarised the scientific motivation of this new facility and gave a general update on the significant progress made on the design of the WST facility. It was then followed by invited and contributed talks to highlight the huge scientific potential in a synergistic use of WST with other facilities. Sara Bonito highlighted the importance to have a spectroscopic counterpart to the imaging data provided by the LSST, and Avraham Binnendijk and Fatemeh Zahra Majidi discussed the time domain aspects in the studies of stellar variability and young stellar objects. Anthony Brown showed how the legacy of Gaia will greatly be enhanced with appropriate optical spectroscopic capabilities from the ground, and the strong scientific potential in combining the WST and GaiaNIR. To understand the dependency of planet formation on the stellar environment, Katia Biazzo stressed the role that the WST will have in



Credit: R. de Jong

characterising the host stars of planets detected by future space missions such as the Nancy Roman Telescope. Martin Roth presented the strong synergies that the WST will have in the study of resolved stellar populations, and Giuseppina Battaglia the large potential in using local group dwarf galaxies to probe dark matter. In the domain of multi-messenger astrophysics, Marica Branchesi, Sofia Bisero and Nicola Borghi described the strong synergies between the next generation of gravitational wave detectors, such as the Einstein Telescope, and the WST: for the identification and characterisation of the electromagnetic counterparts of binary neutron star mergers and as a fundamental tool for cosmology. Moving to the radio regime, Naomi McClure-Griffiths showed how the combination of SKA and the WST can provide transformational science in a broad range of topics, including how to treat very large volumes of data. Yannic Pietschke showed the power in combining SKA and the WST to identify the sources responsible for cosmic reionisation, and Filippo Maccagni the great synergy between these two facilities to study the flow of baryons on multiple scales and multiple gas phases. Stefania Barsanti presented the combined use of the WST and other facilities (e.g., Rubin, Roman, SKAO) to map galaxy angular momentum across the Cosmic Web, Floriane Leclercq showed how transformational the WST will be to study the circum-galactic medium across time and galaxy properties, and Laura Scholz Diaz how the WST will allow to link the study of the physical properties of galaxies to their cosmological environment at $z \sim 1$.

This special EAS 2026 session clearly highlighted how the WST is the missing facility in the 2040 astronomical landscape! ■



“WE ARE IN AN EXPLORATORY PHASE WHERE EVERYTHING SEEMS POSSIBLE”

An interview with Roelof de Jong, WST Facility Scientist

What does the role of a Facility Scientist consist of?

The Facility Scientist forms the interface between the scientists and the engineers, communities that speak entirely different languages. So, on the one hand I work on translating the science goals from the astronomers into hardware and operations requirements for the engineers, while on the other hand I oversee the verification that the solutions proposed by the engineers are indeed delivering the science that we want to do. Furthermore, I make sure that the overall architecture of the facility and the operations model is feasible and cost efficient.

How do you address it in the WST?

To develop initial requirements and possible top-level architectures we were using at the start strongly the experience in the Project Office with precursor facilities like MUSE, MOONS, and 4MOST. However, pretty soon we had to iterate with the science team to work out the specific details both in terms of hardware (for instance spectral resolution) and operations (for instance time scales involved in transient research). Particularly challenging is the decision to operate the MOS and IFS simultaneously. This has many knock-on effects both in the hardware and at operational levels, that we will have to consider at each step when we develop the system in more and more detail. It is worth it however, because it nearly doubles the science output of the facility.

How has your experience with 4MOST shaped the way you approach this role?

When I started 4MOST, I had very limited experience with the details of system engineering. Now fifteen years later, I have gone through the full cycle of setting the requirements, developing and building the system, and verifying the performance against the requirements in continuous back-and-forth between science and engineers. I now realise how important it is to develop a good set of requirements very early on. I was told at the beginning of 4MOST that ninety percent of the cost of a project is determined in the first ten percent of the time of the project. I now understand how important it is to do a good job early on to make the work of the engineers much easier and to make sure that the scientists get the facility that they need and can use.

What does it mean to act as the interface between science and instruments?

Reading through the different science cases and listening to science presentations, I try to make sure that the current facility design still fits in the realm of expectations of the different science groups. I in particular try to keep my ear open for any new goals or requirements that are not yet covered by the current plans. If I hear such things I will talk to the system engineers and other experts on the feasibility of such requests. On the flip side, I sometimes go ■■■



Roelof de Jong is head of the Milky Way and the Local Volume section at the Leibniz Institute for Astrophysics Potsdam (AIP). His research centres on the observational aspects of the stellar populations and dynamics of disk galaxies in the context of hierarchical galaxy formation. He is PI of the HST GHOSTS survey of nearby disk galaxies and PI of the 4MOST multi-object spectrograph facility on ESO's VISTA telescope. He is leading the development of the FLEX positioner concept for the WST.

■■■ back to the scientists with some new technical capabilities that may be on the horizon in the time frame of WST development that might be possible, but are not driven by any science interest, we will not pursue it as any new technology is likely to drive up cost, but if there is a strong science interest, we will do a cost/benefit analysis.

What tools and systems are planned or already in place to ensure that the facility delivers the expected scientific outcomes?

The Exposure Time Calculator (ETC) and the Facility Simulator to test the combined survey strategy of many science cases are the most important tools at this stage of the project. The current Facility Simulator necessarily uses a number of simplifications that will get more refined and realistic over time. Once the WST gets adopted, the underpinning of the ETC will be much better detailed in a full instrument simulator. I expect for the instrument simulator we will build on the latest engineering techniques like developing digital twins of subsystems, where you use detailed simulations to improve your subsystems, but vice versa use actual measurements in the lab to implement actual instrument behaviour in your instrument simulator applying machine learning techniques to cover effects over a large parameter space. Such simulations are critical to develop the optimal calibration strategies and to prepare data reduction pipelines.

How do you see your role evolving as the project becomes more mature?

We are currently still in an exploratory phase where everything seems possible, but we are already seeing some feasibility issues in some areas. So, I expect that we will continue to do various trade-offs in design options. Furthermore, once designs are becoming more mature, you start doing more detailed simulations about various effects to make sure that the performance will be as expected. At the end, we will have to start worrying more about issues like installation, commissioning, maintainability, safety, etc. You do not want to get cornered in a beautiful design that is impossible to integrate or has no access to critical parts.

What do you appreciate the most about your current managerial role(s), and what do you miss from the early stages of your career?

I really like the creative process we are in right now and that will continue for the next few years. Spotting potential issues and working with the team to find the solutions. It is just such a privilege to work with so many talented people and build something unique. What I miss from the early career is having the time and sit down for a day or even a number of days and really carefully take the time to figure out something entirely new. I am glad if I find the a few hours to work on something non-stop. Now I find myself quickly turning to team members, students and postdocs for them to work out the answer.

What excites you most about the science that the WST could enable?

A long time ago I decided to make Dark Matter the focus point of my career (this was before Dark Energy was discovered). And while I have not worked on it as much as I would have liked, my hope is that 4MOST and later especially the WST can make important contributions about the statistical properties of Dark Matter on smaller scales, both within the Milky Way and its satellites as well at galaxy group scales.

On a more personal note, we've all enjoyed your photography work within the consortium. How did that passion start, and does it connect in any way to your scientific work?

My photography passion started in my student years in Groningen. I joined a photography group that worked on what we called social photography, closely related to what now is called street photography. We made many exhibits about topics of social injustice and problems in the society ranging from student housing, attracting women into STEM studies, to gay rights and football hooligans. I spent many days in the darkroom at the time. What I learned there was that it is important to tell a logical story and that good visualisations can be a key to that. It is key to good presentations and science communication to the larger public. ■

ORCHESTRATING THE SURVEYS: THE WST FACILITY SIMULATOR CALCULATOR

The Facility Simulator is the prototype survey planner and target allocation tool developed within the Operations work package. It will be used by the Survey Plan team to optimise the global WST survey before the first observation is even taken.

Planning a comprehensive spectroscopic survey is far more than just a sequence of telescope pointings. Allocating targets efficiently — spanning millions of sources, dozens of target classes, and years of observing time — is a major scientific and operational challenge. Poor allocation means science programs compete for fibres rather than complement each other; effective allocation means the survey delivers on its full potential from the very first night. The Facility Simulator is being designed exactly to balance efficiency across multiple simultaneous surveys, both MOS-driven and IFS-driven, maintaining the operational agility required by the Time Domain programs and retaining the flexibility to accommodate last-minute adjustments for Targets of Opportunity. It ingests science specifications, reference survey definitions, and target catalogues provided by the Science Groups, and produces a time-ordered sequence of observations — which fields to observe, in what configuration, with which instrument mode.

As science requirements evolve, survey designs are refined, and operational assumptions shift, hence, the Facility Simulator is built to adapt. Observing rules and optimisation parameters are configurable without modifying the underlying code, meaning a change to patrol area geometry or target priorities can be quickly explored. The tool processes catalogues of millions of sources on timescales useful for trade-off analysis, and — critically for a collaborative

consortium — identical inputs always produce identical outputs, ensuring meaningful comparisons between planning scenarios.

The Facility Simulator relies on the Exposure Time Calculator to determine the exposure time required for each object in the input catalogues to achieve the signal-to-noise ratio specified by the proposed science case. It then computes the optimised survey planning through its three main components.

The Visit Planner

The Visit Planner determines the pointing pattern on the sky that optimally covers the survey's footprint. Starting from the science catalogues defined by each Science Group, it tiles the sky into a set of discrete fields, accounting for overlaps between adjacent pointings needed to ensure uniform target accessibility.

The Target Allocation Tool

For any given field, the Target Allocation Tool determines which targets receive fibres. This is a constrained optimisation problem: positioners have finite patrol areas and cannot be placed arbitrarily close to one another; some fibres are designated for low-resolution modes, others for high-resolution; target classes carry different scientific priorities; and calibration fibres must be accommodated alongside science targets. The tool satisfies all these constraints simultaneously, producing an allocation that honours scientific priorities as closely as the focal plane geometry permits.

In its current form, the tool uses a computationally efficient statistical algorithm, well suited to the trade- ■■■

off studies the consortium requires at this stage. The modular design means that more sophisticated allocation algorithms, also capable of taking into account the hardware details of the positioners, can be incorporated in the future (see figure 1).

The Scheduler

Finally, leveraging the geometric tessellation of the footprint and the fibre assignment capabilities defined by the target allocation tool, the Scheduler translates field-by-field allocations into a comprehensive, realistic survey plan. It supports mixed observing strategies combining multi-object spectroscopy and integral field observations, distributes calibration overheads realistically across the schedule, and produces an output that reflects what can genuinely be achieved at the telescope during the 5-year survey (see figure 2).

The Facility Simulator is an evolving tool, designed to grow alongside the instrument and the consortium's understanding of the survey. Early results that will be presented during the *Busy Week* will already inform critical survey planning trade-offs. As the code development moves on, the simulator will become an increasingly precise model of what

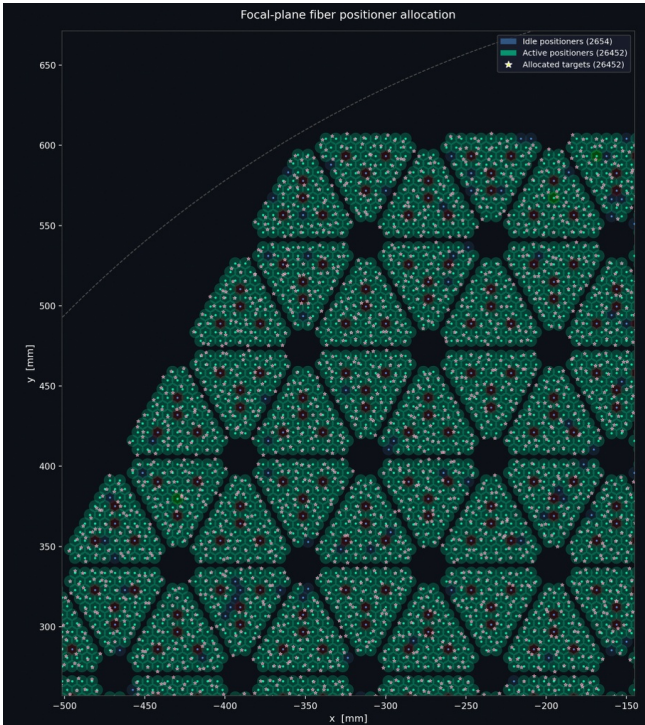


Figure 1: A screenshot showing the results of the fibre allocator algorithm using the focal plane layout for the EPFL positioner design.

the telescope can achieve and a shared language for the Survey Plan team to turn scientific ambition into operational reality. ■

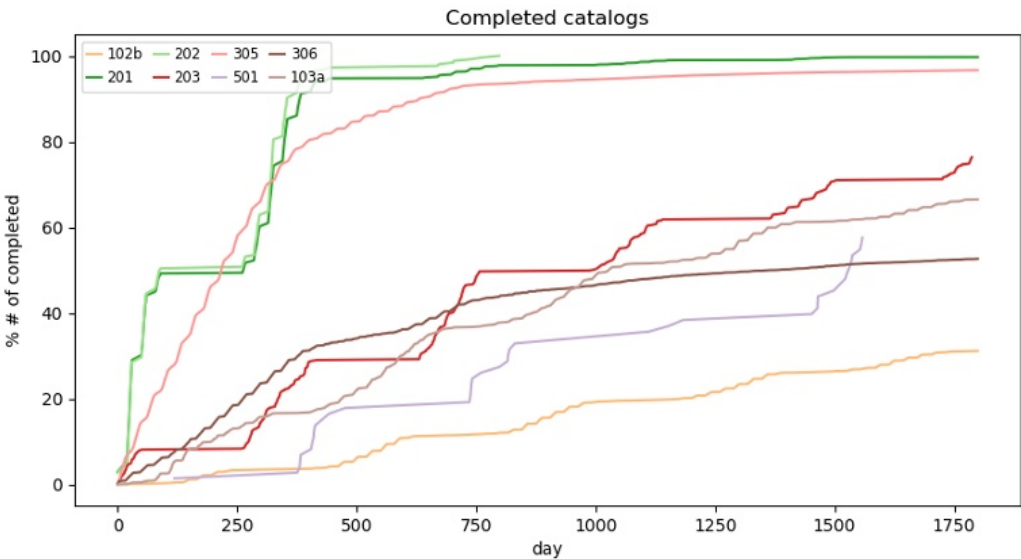


Figure 2: An example of the working progress of the survey completeness evaluation.

THE WST AT SPIE



The SPIE Astronomical Telescopes and Instrumentation conference took place from 5th to 10th July at the Bella Center in Copenhagen. This important technical conference provided an exciting opportunity to raise awareness of the WST project with a worldwide audience and showcase our transformational design. The WST project was well represented at the conference with over 20 papers covering EDI, sustainability, ETC, telescope and instrument design, etc., and Roland Bacon's invited paper "*WST: the next leap in wide-field spectroscopy*".

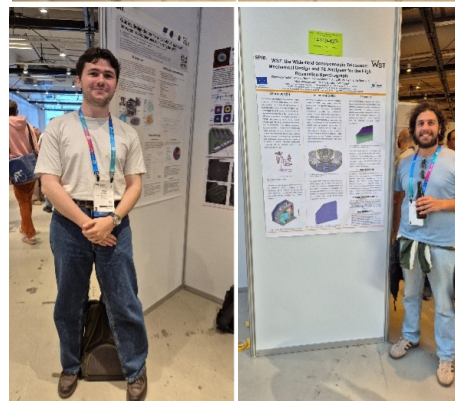
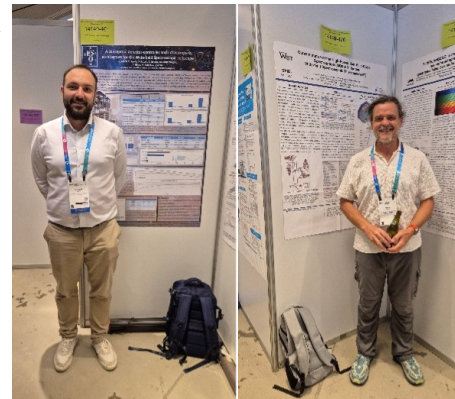
From start to finish the conference was filled with talks and posters of interest to the WST project team. Indeed, the first presentation of the conference was given by Teledyne and provided a comparison of CMOS sensors with CCDs, of interest since the WST has selected the use of CMOS technology during the trade-study meeting. It was interesting to see progress of other wide-field facilities and their technology development, including fibre positioner systems and alternative telescope designs. One of the final talks in the instrumentation conference was about the design of the

Vera C. Rubin Observatory flat-field calibration system and of great interest to the WST telescope and calibration teams.



The conference exhibition provided an excellent opportunity to discuss the WST's hardware needs with potential suppliers and advertise the forthcoming "Industry Days" on 2nd and 3rd November in Lyon. Meetings were held with suppliers of detectors, dispersers, small and large optical components, robotic positioners, observatory software, and telescope systems.

Most importantly the SPIE conference provided an opportunity for the WST team to meet others working on similar projects and discuss new ideas, designs, collaborative efforts, and lessons learned. The WST facility will be built using new and innovative technology and most of it was presented at SPIE! ■



THE CARBON FOOTPRINT AS A TRADE-OFF PARAMETER IN WST'S INSTRUMENT DESIGN

Sustainability, defined as meeting the needs of the present without compromising the ability of future generations to meet their own needs¹, is especially important for astronomical research infrastructures, which often take decades from conception to operation. The development of the WST could span a couple of decades. Bringing environmental considerations at the earliest stage presents a real opportunity to reduce environmental impact in meaningful ways, ensuring the facility is developed and operated with the smallest possible impact. The carbon footprint has been adopted by the Project Office as one of the trade-off parameters for the WST design. As a first step, the sustainability study focuses on the spectrograph systems (IFS and MOS), which have been selected as a representative case because their large number is expected to make them a significant contributor to the facility's overall energy consumption.

The goal of the carbon footprint analysis was threefold. First, we wanted to compare the carbon footprint of CCD detector technologies cooled by a mechanical cryocooler and of CMOS detectors cooled by a liquid refrigerant (CO₂) coupled to a thermoelectric cooling device. Second, we wanted to estimate the share of the carbon footprint attributable to the construction and operation phases.

Finally, we were also interested in comparing different designs within an instrument to determine whether designs with more spectrographs, but lighter weight, have a smaller carbon footprint than designs with fewer spectrographs but heavier weight.

To tackle these questions, we conducted a life cycle assessment to evaluate the environmental impact of

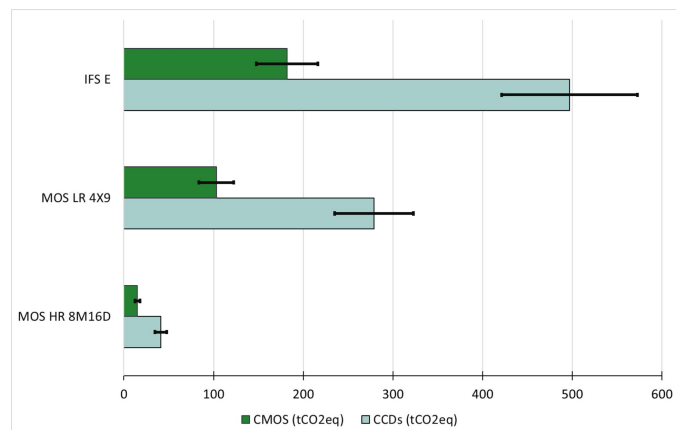


Figure 1: Comparison of the 1-year operation carbon footprint for options with CDDs (blue green) and with CMOS (dark green) for one design of the IFS (upper), MOS LR (middle), and MOS HR (lower)

these design options from raw material extraction to operation. We investigated the carbon footprint of 26 different designs for the IFS and of four designs for the MOS-HR and the MOS-LR.

We found that using CMOS detectors, a CO₂ cooling system, and field-programmable gate array (FPGA) electronics cuts the carbon footprint by ~60% compared to using CCDs, mechanical cryocoolers, and New General detector Controller II electronics (Fig. 1). This is mainly because CMOS detectors can run at higher temperatures, which lowers cooling needs, and the FPGA electronics use much less energy. The CO₂ cooling system is also very efficient and can serve several instruments.

The distribution of impact between construction and operation depends heavily on the energy grid's consumption and intensity during operation. An efficient cooling system and renewable energy will shift the burden on the construction. ■■■

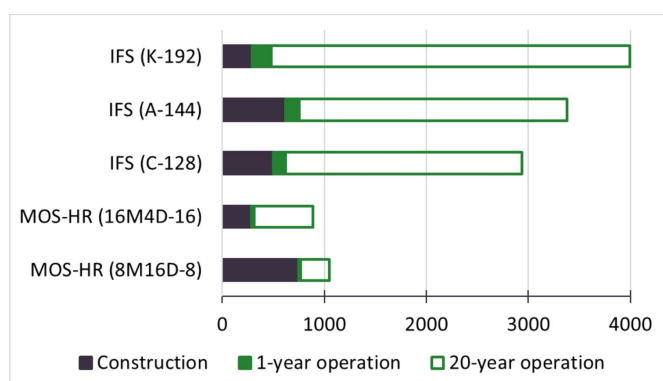


Figure 2: Comparison of the carbon footprint (in tCO₂eq) from construction and operation for three different design options for the IFS and two for the MOS-HR, using CMOS. The options range from 128 spectrographs (Design C), to 144 spectrographs (Design A), to 192 spectrographs (Design K), for the IFS, and 8 and 16 spectrographs for the MOS-HR (Designs 8M16D and 16M4D respectively)

■ ■ ■ In general, lighter spectrographs, though more numerous, tend to have a smaller construction carbon footprint than heavier alternatives with a smaller total number of spectrographs (Fig. 2). For example, for the MOS HR options, the construction carbon footprint ranges from 750 tCO₂eq for the option with 8 spectrographs to 286 tCO₂eq for the option with 16 spectrographs, resulting in a 62% decrease. This is mainly due to the considerable mass of aluminium required for the enclosure and mechanical support of the spectrographs, as well as heavier optics.

However, the construction's smaller carbon footprint is directly offset by increased energy consumption due to more detectors requiring cooling during operation. Assuming the current Chilean energy grid mix, the option with 16 spectrographs is only 21% less carbon-intensive than the option with 8 spectrographs. After 50 years, the former surpassed the option with fewer spectrographs by 47%.

In June 2022, Chile signed a legally binding agreement to achieve carbon neutrality by 2050². Therefore, it is highly likely that Chile's carbon intensity mix will decrease relative to the current values used in this analysis, potentially to ~22 gCO₂eq/kWh³ (a factor more than 10 compared with 253 gCO₂eq/kWh currently⁴). Whether the WST connects to the Chilean grid or the ESO solar panel farm, or develops its own solar panel farm, the operational footprint of instruments is likely to decrease relative to current estimates. Mitigating construction is more complicated, as it often relies on resource extraction and high-intensity manufacturing processes. This kind of comparative carbon footprint analysis is an important first step toward making environmental sustainability a core part of the design of future facilities and instruments. ■

Notes

¹ Definition by the United Nations Brundtland Commission (1987)

² <https://www.gob.cl/en/news/a-milestone-in-chiles-environmental-history-from-today-we-have-our-first-framework-law-on-climate-change/>

³ <https://eneroutlook.enerdata.net/forecast-world-co2-intensity-of-electricity-generation.html>

⁴ <https://lowcarbonpower.org/map-gCO2eq-kWh>

WST UK Community Workshop: 14-16 Dec 2026

This Cambridge workshop will bring together researchers from the WST community, the UK, and the wider international community to explore the science potential of the WST and shape future engagement with the project. The meeting will highlight key science drivers, survey strategies, synergies with facilities such as WEAVE, MOONS, DESI, 4MOST, Gaia, PLATO, Euclid, Rubin/LSST, Roman, JWST, ALMA, SKA, and CMB experiments, and opportunities for community participation.

Where/When: Institute of Astronomy, University of Cambridge / 14–16 Dec 2026

Website and Registration: <https://indico.ast.cam.ac.uk/e/WST-UK-2026>

Abstract submission deadline: 30 September 2026.



NIRCAM on the JWST reveals the brainy appearance of the nebula PMR 1. Credit: NASA, ESA, CSA, STScI, Image Processing: Joseph DePasquale (STScI)