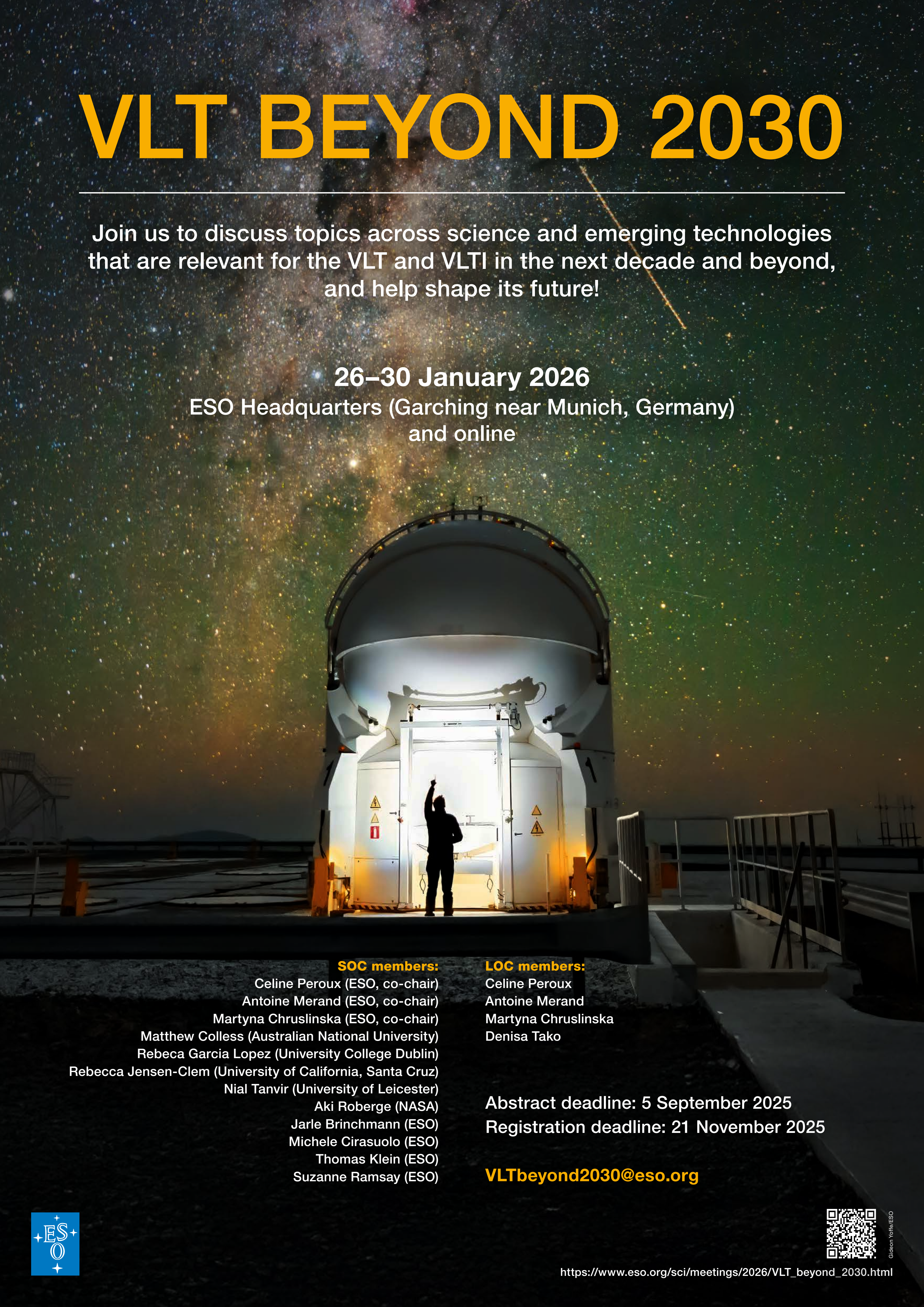

VLT BEYOND 2030

Join us to discuss topics across science and emerging technologies that are relevant for the VLT and VLTI in the next decade and beyond, and help shape its future!

26–30 January 2026
ESO Headquarters (Garching near Munich, Germany)
and online

SOC members:
Celine Peroux (ESO, co-chair)
Antoine Merand (ESO, co-chair)
Martyna Chruslinska (ESO, co-chair)
Matthew Colless (Australian National University)
Rebeca Garcia Lopez (University College Dublin)
Rebecca Jensen-Clem (University of California, Santa Cruz)
Nial Tanvir (University of Leicester)
Aki Roberge (NASA)
Jarle Brinchmann (ESO)
Michele Cirasuolo (ESO)
Thomas Klein (ESO)
Suzanne Ramsay (ESO)

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Abstract deadline: 5 September 2025
Registration deadline: 21 November 2025

VLTbeyond2030@eso.org

https://www.eso.org/sci/meetings/2026/VLT_beyond_2030.html

Gideon Yoffe/ESO

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Jarle Brinchmann
ESO

Space facilities and science landscape

Gaitee Hussain
ESA

Multi-frequency facilities and science landscape

Silvia Piranomonte
Istituto Nazionale di Astrofisica

Technology and Astronomy: Rethinking ESO's Model for the 2030s

Paulo Garcia
Universidade do Porto & CENTRA

In Cosmic Discovery, Martin Harwit argued that theory drives astronomical progress less than technology. His case rests on the transformative role of radars and receivers in radio astronomy and digital detector arrays in optical and infrared work. Since the 1980s, this view has only strengthened: supercomputers

now enable high-bandwidth radio telescope correlation, adaptive optics deliver diffraction-limited imaging on large telescopes, photonics empowers optical interferometry, and holographic gratings advance spectroscopy. While there are counterexamples, here we focus on Harwit's thesis in the context of the La Silla Paranal Observatory during ELT operations. ESO has historically devoted little of its budget to technology development, leaving most innovation to member states and adapting only proven methods at later stages. Given limited resources, this strategy has been reasonable. Yet, to maintain leadership into the 2030s, we propose that La Silla Paranal allocate a significant fraction of the available budget and telescope time to technology experiments—even if immediate astronomical return is modest. This "open-sky technology lab" model, where technology is determinant to selection rather than purely astronomical merit, would have multiple benefits: fostering a vibrant visitor programme, attracting top engineering talent to the organisation, and positioning ESO to harness new frontiers, building on quantum optics, free-space optical communications or AI.

An overview of ESO's sustainability plans

Claudio Melo
ESO

ESO's value proposition to society can be understood through a set of interconnected value chains. These include enabling frontier scientific research, designing, building, and operating state-of-the-art observatories and instruments, developing highly skilled human capital, and inspiring society through education and outreach. These value chains are embedded in, and interact with, both society and the natural environment, influencing and being influenced by broader environmental, social, and economic systems. In this talk, I will present ESO's approach to sustainability, including its strategic objectives, key targets, and implementation roadmap. Particular emphasis will be placed on how sustainability considerations are planned to be integrated into the development of new instruments and future facilities.

Advancing life cycle assessment and ecodesign for sustainable space programmes: lessons learned, industry collaboration, and the path forward

Aurelie Gallice-Tanguy
ESA

The European Space Agency (ESA) aims to address critical societal needs with its space programmes, while championing responsible space activities. In its strategy towards 2025 and 2040, the Agency aims to minimise the environmental impacts of its own operations, both on Earth and in space. To implement this vision, the Agency has adopted an ESA Green Agenda (EGA) along five high-level objectives and is updating its organizational GHG assessment on a yearly basis. In particular, ESA Green Agenda ambition to be a role model in the systematic implementation of ecodesign into space programs.
With over a decade of experience in conducting life cycle assessments (LCAs) of its space programmes in collaboration with industry partners, ESA through its Clean Space office has focussed on identifying

environmental hotspots and ultimately integrating eco-friendly solutions into mission design. Indeed, ESA has been pioneering the application of LCA for space projects and has conducted several LCA on all the three segments of space: space segment, launch transportation segment and ground segment.
The ecodesign approach starts from early development phases when trade-offs and design choices can be made. Ecodesign continues all along the project lifecycle and requires complex data gathering process, followed by a comprehensive modelling and analysis of environmental impacts throughout the life cycle of each space mission. This allows the implementation of solutions and the development of sustainable technologies roadmaps. A cornerstone of the ESA's LCA and ecodesign approach is the development tailored methodology and database specific to the unique challenges of space projects. ESA is committed to guiding the space ecosystem in this effort, aiming to streamline the process for all stakeholders, from direct suppliers to distant links in the supply chain.
To this end, various working groups were created comprising ESA and partners from the space ecosystem (e.g. academia, industry). This collaborative effort allows for discussion on different key topics and focuses on co-developing best practices in data collection, experts' trainings, LCA delivery, reporting, ecodesign solutions, etc. The insights gained directly inform the ongoing update of the ESA space system LCA guidelines, providing a robust framework for conducting space-specific assessments.
A notable enhancement in the recent guidelines update is the introduction of a simplified LCA approach. This innovation is crucial for performing high-level LCAs in early phases of projects, enabling the identification of ecodesign solutions in a cost-effective way, when design options are still flexible. Dedicated tools are being developed, some being specific to launchers.
The presentation will delve into the challenges of conducting LCAs for space missions and explore how ESA and space industry partners are collaborating to make this process more efficient. From simplifying data collection to developing comprehensive guidelines for simplified LCAs and fostering a collaborative working group, the European space sector is paving the way for a more sustainable future in space exploration.

Towards Unified Vibration Control for the VLTI: Multi-Sensor Data Fusion as a Path Beyond GRAVITY+

Nuno Morujao
Faculdade de Engenharia da Universidade do Porto

The identification and correction of vibrations remain among the key limiting factors of the Very Large Telescope Interferometer (VLTI). Despite active control at telescope level, recent GRAVITY+ results show median fringe tracker phase residuals of 100 nm on the Auxiliary Telescopes and ∼150 nm on the Unit Telescopes, well above the fundamental limits. We present new results from a data-fusion analysis that jointly exploits telemetry from adaptive optics, MANHATTAN-II accelerometers, and the GRAVITY fringe tracker. Analysis of pseudo-open-loop fringe tracker data confirms the presence of long-lived vibration modes that propagate through the optical train. Correlations with accelerometer and AO telemetry help separate their contributions, though a full quantification of their impact on the residual error budget is still in progress. Preliminary results nonetheless indicate that structural vibrations remain an important limitation. The multi-source analysis makes it possible to separate local from system-wide vibration modes, providing a basis to estimate how much a unified controller could improve over current schemes. Establishing the viability of such hybrid strategies is therefore a key step before considering an upgraded RTC that integrates multi-sensor telemetry. Such a system-wide approach, together with hardware upgrades, would represent the next logical step beyond GRAVITY+ and outline possible pathways and requirements for a future upgrade.

Light at the Horizon: Black Holes in High Definition with the VLT and VLTI

Taro Shimizu
MPE

High-angular-resolution astronomy at Paranal has brought black holes into sharp relief and I will review this topic in the first part of the talk. VLT adaptive-optics imaging and integral-field spectroscopy, together with VLTI near-infrared interferometry, have turned the Galactic Center into a precision-gravity laboratory: stellar orbits deliver the mass and distance of Sgr A and reveal both gravitational redshift and Schwarzschild precession; and tens-of-microarcsecond astrometry at minute cadence tracks polarized flares whose centroid loops trace hot spots only a few gravitational radii from the horizon. On extragalactic scales, VLTI spectro-astrometry across broad emission lines measures microarcsecond photocenter shifts that resolve the gas kinematics around quasars , enabling direct black-hole masses and revealing the dynamical structure of the black hole environment. Mid-infrared interferometry is beginning to image the warm dust in AGN, exposing polar outflows and clumpy, temperature-stratified structures that link the torus to the narrow-line region. The second part of the talk will focus on the future including what the ELT will bring and what parameter spaces new instruments and infrastructure at the VLT/VLTI could open up. This includes pushing ever closer to the event horizon in the thermal regime, measuring black hole spin directly, discovering black hole binaries across cosmic time, and tracing black hole growth together with galaxies at high precision.

Detectors future

Matthew Soman
ESA

Astronomical transients in the multi-messenger era

Antonio de Ugarte Postigo
Laboratoire d'Astrophysique de Marseille

Astronomical transients are a hot topic in modern astrophysics, encompassing a broad range of phenomena. They can involve extreme physics, the most massive stars, neutron stars, black holes, explosions, mergers, or gravitational disruptions. They teach us about the limits of our Universe and are key to understanding the evolution of stars and galaxies, as well as the enrichment of the interstellar medium. The study of transients

is benefiting from the advent of new observational techniques, such as the use of gravitational waves, neutrinos, and cosmic particle showers. In the electromagnetic regime, observatories and instrumentation need to adapt to the specific requirements of rapid response and coordination.
In this talk, I will review the different transient phenomena and their observational needs, how observing facilities have adapted to reach our current capabilities, and what prospects can be expected in the years to come. Progress in the study of astronomical transients is driven not only by optimised telescopes and instrumentation, but also by advances in observational techniques, data management, analysis tools, multi-observatory coordination, and the rapid and efficient communication of results.

Follow-up of transients in the 2030's

Michael Andersen
Niels Bohr Institute, University of Copenhagen

Followup observations of transients has been a rapidly evolving field during the life time of the VLT. The ESO community has played a prominent role in this field, not the least by utilising X-shooter. New opportunities through space missions continue to emerge, and in the 2030 Gravity Wave observatories will change the field dramatically. Yet, the ELT will not for the first many years of operation be equipped with instrumentation well suited for contributing in this field. Notably, a visible spectrograph with high throughput will not be available. Detector technologies, higher efficiency optical coatings and AO assisted operation will allow to push the limits of the VLT further than what was achieved with X-shooter. Particularly, lower read noise/photon counting detectors, will allow to push towards medium-high resolution ($\sim$30.000), where an instrument will also become relevant for stellar spectroscopy. We propose to study an instrument concept with similar wavelength coverage as X-shooter, but with a single slit, higher resolution and with a goal of reaching 50% efficiency. A limited multi-object capability, allowing observing of a handful of objects, using periscopes, over the $\sim$20' FoV of a VLT UT will allow pushing the limits of stellar spectroscopy. Specifically, it will become possible to do transmission spectroscopy of exoplanets, while simultaneously observing similar bright comparison stars, and without any modal noise, which limits spectroscopy through fibers.

Evaluating detector technologies for astronomy beyond 2030

Naidu Bezawada
ESO

The ESO detector group has been designing a new controller for a future generation of astronomical systems as well as evaluating new detector technologies for future ELT instruments and other possible ESO telescopes. For example, we have recently done a down select trade-off study between various CCD and CMOS devices for a second-generation ELT instrument. We are also evaluating the potential and working with manufacturers for curving large detectors for future instruments. Likewise, we have been characterising very large format near infrared (NIR) and shortwave infrared (SWIR) detectors for the ELT instruments. Our new detector controller not only functions with typical detectors such as CCDs, CMOS and eAPDs but also the next generation of detectors which are fully digital such as Geosnap for METIS. We are looking to miniaturise this controller even more for future instruments. We are also evaluating the performance of large format eAPD detectors to see if they are a real competitor to the ubiquitous H2RG / H4RG devices. We will present some results on the performance of our new controllers with the above detectors, results from our detector characterisation as well as summarising the state of the next generation of curved, large format fully digital CMOS detectors. We will also give a personal indication of where we are now and need to go in the next decade.

Low surf brightness and short wavelength facilities

Deborah Lokhorst
National Research Council Canada

Extragalactic science and cosmology

Ryan Cooke
Durham University

Atomic Data for the Next Generation of Astrophysical Spectroscopy

Christian Clear
Imperial College London

Atomic data are the foundation of astrophysical spectroscopy. Our ability to extract physical meaning from spectra depends critically on the availability and accuracy of atomic parameters. Yet these data, even for the most astrophysically-important elements, are often incomplete, low-accuracy, or based on decades-old measurements. New instruments and upcoming facilities are exposing the limitations of existing atomic datasets and placing renewed pressure on laboratory astrophysics to deliver the precision and completeness required for modern analyses. Despite the increasing need for high-accuracy atomic data, laboratory astrophysics faces an uncertain future, with a shrinking number of laboratories worldwide, loss of expertise, and chronic underfunding of atomic data research. The accelerating pace of observational astronomy is outstripping the atomic data available to support it; without coordinated international effort, this disparity will seriously undermine the scientific return of next-generation instruments. Atomic data must be treated as critical infrastructure for the next generation of astrophysical research. As ESO plans the future of the VLT/I in the ELT era, there is a unique opportunity to embed atomic data needs into instrument design, science planning, and community support. This talk will outline a vision for sustaining and expanding atomic data capabilities to ensure that spectroscopy remains a powerful and reliable tool for discovery in the decades ahead.

Advancing Hollow Cathode Lamp Calibrations for Next-Generation Spectrographs

Lawrence Bissell
UK Astronomy Technology Centre

Wavelength calibration for multi-object spectrographs commonly relies on hollow-cathode lamps, which provide many well-characterised lines in the visible and near-infrared. However, these lamps are dim and struggle to illuminate large focal planes in the VLT and ELT era. Problems have also arisen in the procurement of Thorium cathode lamps, a standard in the field, due to contamination issues and manufacturers withdrawing them from the market. We present a technology development project focusing on the design and manufacture of hollow cathode lamps tailored for astronomical purposes to enhance their output flux, stability, and line ratios. In our custom-built units we are optimizing the cathode design, material, and current, allowing the mosaicking of configurable cathodes. The choice of filler gases and the pressure of the system is similarly being optimized. We finally present work on characterisation of Cerium cathodes, identified as a potential alternative to Thorium and Uranium due to favourable nuclear properties. This work represents a step towards robust, scalable calibration solutions for future spectroscopic facilities.

Is there any need for Laser-Frequency Comb at the VLT beyond 2030?

Francesco Pepe
University of Geneva

The first time Laser-Frequency Combs (LFC) have been considered for the use in astrophysical experiments was back in 2007 in the context of CODEX@OWL. Their main purpose has immediately been identified to serve precise and accurate wavelength calibration of high-fidelity spectrographs such as HARPS and later ESPRESSO. In the meantime, almost every EPRV spectrograph around the world integrates such an LFC with more or less success. Nevertheless, none of them meet all the performance requirements and the reliability originally specified. In my talk I will try to summarise the requirements towards an LFC necessary to high-fidelity spectrographs, and give an overview of present achievements and limitations. I will also try to illustrate why such LFCs will be of valuable use beyond 2030, once the original requirements will have been met.

Reaching cm/s radial velocity accuracy with the next generation of Astrocombs

Oliver Pfuhl
ESO

Almost two decades ago, the idea emerged to use Laser Frequency Combs as ideal calibrators for astronomical spectrographs. The first generation of Astrocombs however struggle with reliability issues and limited wavelength range. Since then new technologies such as electro-optic components, microresonators and waveguide based frequency multiplication have matured. Those recent advances have the potential to overcome the limitations of the first generation of Astrocombs. Photonic chip based systems, will allow compact monolithic assemblies, ultra-wide bandwidth from the UV to the NIR with up to THz tunable line spacing and frequency broadening at low pulse energies. This will enable the next generation of Astrocombs. Several prototype developments by ESO and other observatories, exploring different technological avenues, show promising results in terms of stability and wavelength coverage. The science cases of future instrument, such as the search for Earth-like exoplanets and the direct measurement of speculated variations in cosmological constants need a cm/s level accuracy of the calibration. This can only be achieved with the next generation of Astrocombs I will discuss recent advances, prototyping results and potential future developments.

Low-Surface Brightness research in the Next Era of Astronomy

Enrichetta Iodice
INAF-Astronomical Observatory of Capodimonte

The new generation of all-sky surveys is pushing the observational frontier into the low-surface-brightness (LSB) regime, where the most sensitive diagnostics of galaxy mass assembly across environments are found. Tracing these faint structures provides stringent constraints on galaxy formation within the Λ-cold dark matter paradigm. Over the past two decades, deep imaging and spectroscopic campaigns—including extensive programs at ESO-VLT—have significantly advanced the study of galaxy assembly in diverse environments. These efforts have enabled detailed analyses of light and color distributions, kinematics, and stellar populations of galaxies, complemented by discrete tracers such as globular clusters and planetary nebulae, extending into stellar halos and intra-group/cluster regions. In this talk, I will provide a concise overview of: - the current state of the art in LSB research, with a focus on the formation and evolution of intra-cluster light (ICL), the growth of stellar halos in massive galaxies, and the structure and origin of extreme LSB systems such as ultra-diffuse galaxies; - the pivotal role of ESO-VLT in achieving major breakthroughs in this field; - which are the requirements for future instrumentation at the VLT to deliver competitive results in the era of new large-area and/or high-resolution survey facilities (e.g. Euclid, JWST, Rubin-LSST, and ESO-ELT).

Cosmology with VLT spectrographs in 2030s

Dinko Milakovic
INAF

In 2030s, cosmologist will be working with the vast cosmological datasets produced by Euclid, DESI, and Vera Rubin Observatory, and many others. The incredible amount of available data will allow precise measurements of key cosmological parameters and possibly answer some famous tensions of contemporary cosmology. At this point, we might have a new cosmological paradigm with new degrees of freedom to explain the observed phenomena. Investigating variations in the values of fundamental constants is one particularly promising and exciting method of constraining models beyond LCDM, and will be used in combination with other cosmological probes to put tight bounds on viable models. Measurements of fundamental constants in the early universe have demanding requirements (collecting area, spectral resolution, wavelength calibration) that can only be achieved on large telescopes such as the VLT. I will discuss why the VLT will continue to be extremely useful for this line of research, extending into and beyond 2030s and the era of the ELT, with a particular focus on ESPRESSO and the proposed multi-object high-resolution spectrograph, HRMOS.

Wide-field/multiplex/integral-field spectroscopy

Johan Richard
Centre de Recherche Astrophysique de Lyon

Galaxy formation in the 2030s: Connecting scales with the VLT

Jorryt Matthee
Institute of Science and Technology Austria (ISTA)

In my talk I will focus on various connected science topics within the broad field of extra-galactic astrophysics. My aim is to highlight some key open questions, in particular those that bridge different scales and branches of astrophysics, rather than focussing too much on my expectations based on instrumentation development. Themes that I aim to cover are the baryon cycle in and around galaxies, the growth of supermassive black holes, first stars and chemical enrichment and cosmic reionization. I will also aim to discuss the role of the VLT in the 2030s in the context of recent new insights in the properties of early galaxies and active galactic nuclei obtained with the JWST.

Nano to pico degree optical astronomy: in quantum physics we trust!

Roland Walter
Department of Astronomy, University of Geneva

In most AGNs a high pressure and low density plasma forms. The EHT has resolved such flows and could detect particles accelerated close to the horizon. For higher accretion rates, momentum is dissipated and disk-shaped structures form. Their apparent sizes are $\sim$10 μarcsec in nearby quasars and of $\sim$0.1 μarcsec in of low mass X-ray binaries. Hanbury-Brown & Twiss invented intensity interferometry and measured the size of bright stars. Large telescopes, 10ps resolution photon detectors and synchronous spectrometers bring the key improvements to reach in the optical angular resolutions better than these achieved in the radio by the EHT and to reconstruct the first images of accretion disks. We already demonstrated a system of synchronized photometers and correlators providing a resolution of 20ps RMS and have designed a detector array (at the Silicon foundry), an efficient synchronous spectrometer (under test), and an FPGA-based data processing chain. All these elements will be combined in 2026 and could be used on VLT and VISTA (disks in CVs) and on VLT and ELT opening nano-degree resolution in the optical (disks in AGN, SN geometry). Extending to continental (disks in LMXB) or Earth scale infrastructures (pico-degree resolution) requires a few additional steps.

Massive Spectroscopy in Dense Environment - from emerging technologies to new science

Jean-Paul Kneib
EPFL

In this presentation, we will present new revolutionary developments in terms of miniaturisation of robotic fiber positioning system (now reaching 6.2mm of pitch) conducted at EPFL. Although this technology development was initiated primarily by cosmology science case, porting these developments on the VLT will open new opportunities in particular regarding massive spectroscopy in dense environment (galaxy clusters, star clusters, complex nebulae, spectroscopic transients ...).

The need for a wide-field IFU at 1 micron

Nicolas Bouché
CRAL

A wide-field IFU (1’x1’) sensitive to near-IR light at 950 to 1300nm is a key missing parameter space for the VLT ESO facilities. Such an IFU could characterize the universe during reionization at redshifts 7-10, using Ly-alpha emitters, and measure the sizes of ionization bubbles. Such an IFU could detect key spectral lines, such as Hα and [O III], which are redshifted into the near-IR at intermediate redshifts.

Such a wide-field near-IR IFU would complement the near-IR capabilities of the ELT. We will present key science cases for such an IFU and discuss possible concepts.

Cosmology with VLT spectrographs in 2030s

Michael Ireland
Australian National University

The pressure factor on UT4 has been high ever since the commissioning of the highly successful MUSE instrument. Commissioning of MAVIS by 2030 will bring another internationally unique facility to UT4, further increasing pressure. However, neither of these instruments harness the full predictive adaptive optics power of a single telescope equipped with LGS, combining LGS with NGS for extreme adaptive optics. Gravity+ will bring in the era of LGS on all unit telescopes, but will be limited by only having the laser pointed at the science target and not the fringe tracking star. I will show how in addition to single telescope modes, 4 laser guide stars per telescope will enable more than double the effective sky coverage for interferometry in a quad star mode, in addition to astrometry significantly better than Gaia and enabling coherent integration for interferometric spectroscopy at shorter wavelengths. This staged facility upgrade would ensure VLT/I remains highly unique and competitive beyond 2040.

Towards Full-Sky Adaptive Optics with Laser Guide Stars: Overview of the ANU Program on LGS Tip-Tilt

Joschua Kraft
Australian National University

Laser Guide Star Adaptive Optics (LGS AO) has transformed ground-based astronomy by compensating for atmospheric turbulence and enabling near-space-quality resolution. Current systems extend sky coverage of AO–corrected instruments to $\sim$80%, but full-sky correction remains limited by the tip–tilt indetermination problem. At the Australian National University, we have established a fully funded research program on Laser Guide Star Tip–Tilt (LGS TT), staffed by 3 researchers and 2 PhD students full time, to investigate solutions for this fundamental limitation in next generation Laser Guide Star facilities. The performance of LGS AO systems depends critically on the availability of natural guide stars for tip–tilt measurement. Even under optimistic assumptions (using a magnitude 20 star in the IR), less than 10% of objects at the Galactic pole and less than 80% in the Galactic plane can currently be observed near the diffraction limit. To address this, we are investigating multiple approaches for LGS TT retrieval, leveraging national laser development programs and collaborating with international partners including ESO and ESA. Our efforts target applicability to 8-m class telescopes such as the VLT, with the goal of ultimately enabling diffraction limit across the full sky. During the talk, we will present an overview of the different techniques under investigation and highlight the science cases that could be enabled by this emerging technology..

Advanced laser guide stars for future AO facilities

Felipe Pedreros
ESO

Laser guide star technology developed at ESO provides reliable LGS-assisted Adaptive Optics observations, as demonstrated with 10-years operations of AOF-4LGSF at VLT. This is the result of seminal research and development of a robust laser system at ESO, advanced engineering with industry, and a continuous technical-support strategy in operations. Although VLTI/Gravity+ and ELT will employ the same type of 20W guide star lasers as VLT-AOF, recent progress in LGS technology opens new possibilities for future AO facilities. In this direction, high-power guide star lasers, laser splitting methods, current LGS R&D activities at ESO and their potential benefits for adaptive optics will be presented and discussed in this talk.

XAO performance with an Orbiting Configurable Artificial Star

Jalo Nousiainen
ESO

The Orbiting Configurable Artificial Star (ORCAS) mission is designed to function as a hybrid space–ground observatory. ORCAS would deliver a bright, tunable point source for adaptive optics (AO) wavefront sensing, spanning a wide range of magnitudes and covering optical to near-infrared (NIR) wavelengths. This enables AO corrections at both visible and NIR wavelengths from ground-based telescopes. Such a system would achieve diffraction-limited image quality in regions of the sky lacking sufficiently bright natural guide stars. Thanks to its high, well-calibrated flux and the absence of chromatic errors, ORCAS could even outperform natural guide stars in AO performance. This makes it highly attractive for extreme AO (XAO) high-contrast imaging applications, including the direct detection of exoplanets. Through analytical modeling and numerical simulations, leveraging state-of-the-art reinforcement learning control, we assess the advantages of ORCAS for XAO with VLT & ELT in terms of Strehl ratio (critical for starshade-assisted observations) and contrast (essential for high-contrast imaging). This is part of the Caltech Keck Institute for Space Studies (KISS) study program on hybrid ground-space observatories.

Perspectives for the VLT Interferometer in stellar astrophysics

Pierre Kervella
CNRS IRL FCLA & LIRA, Paris Observatory

The high surface brightness of stars historically made them natural targets for large optical arrays, and over the last few decades, the VLT Interferometer has brought major contributions in stellar astrophysics.

The extraordinary diversity of the physics governing the structure, evolution and environment of stars offers rich perspectives to improve our understanding of various fundamental physical phenomena. Energy and angular momentum transport, gravitation, matter accretion and mass loss, magnetism, star-planet interactions and habitability, novae and supernovae... are only a few examples of key astrophysical topics where optical interferometry can bring decisive contributions. Ultra-high angular resolution combined with high spectral resolution and polarimetry could offer essential benefits. In this brief and incomplete presentation, I will attempt to provide food for thoughts on potential future contributions of an enhanced VLTI in stellar astrophysics.

Exoplanets - a VLT perspective

Julia Seidel
Observatoire de la Côte d'Azur

This review talk highlights current spectrographic capabilities of the VLT in the context of exoplanet science. It provides an overview of the science conducted in the field with current ESO facilities, from planet detection to the detailed analysis of atmospheres, from ultra hot planets on small orbits, to cool planets beyond 10 au. In light of the conference scope "VLT beyond 2030", I then present a few windows of opportunity from an exoplanet perspective where the uniqueness of the VLT can truly shine in the 2030s, from the VLTI to polarimetry and beyond.

High-angular resolution facilities

Sebastiaan Haffert
Leiden University

La Silla as proof of concept for future VLT instrument

François Bouchy
Geneva Observatory

The HARPS/NIRPS tandem on ESO 3.6m telescope has recently demonstrated its high efficiency for exoplanets detection and atmospheric characterization thanks to cutting-edge technologies such as AO, fibre scrambling, cryogenics, ultra-high stability, high-resolution spectroscopy, and high-precision radial velocity. In P116 period, HARPS/NIRPS was the most demanded ESO instrument, with a combined request of 3277 hours. These high-precision spectrographs are key facilities for long-term monitoring and large dedicated survey in support of space mission such as TESS, Gaia, and PLATO, and with complementary characterization with VLT facilities. We present a mono-mode fibre-fed K-band spectrograph for

simultaneous observation with HARPS and NIRPS with the objective of covering 378 – 2400nm in one shot. Several developments are also underway on laser frequency combs for accurate and precise wavelength calibration, with the unique possibility of testing and validating them at La Silla on state-of-the-art spectrographs. In addition of being scientifically perfectly complementary to VLT, these programs and instrumental developments will also be relevant in demonstrating proof of concept for future VLT (and ELT) instruments and will constitute the ideal training ground for engineers and astronomers. For these and even more reasons, these projects, and particularly the K-arm of NIRPS, should be integrated into the strategic discussion and brainstorming of the “VLT beyond 2030”.

Vipa-based Instrument for Oxygen Loaded Atmospheres (VIOLA) for VLT2030 and beyond

Suri Rukdee
MPE

Understanding the chemical composition of exoplanet atmospheres is key to identifying habitable worlds and potential biosignatures. Current instruments face challenges in detecting weak atmospheric signals from small-sized exoplanets due to telluric contamination, spectral overlap, and limited resolution. To address this, we are developing VIOLA (Vipa-based Instrument for Oxygen Loaded Atmosphere), a compact, high-throughput, ultra-high-resolution spectrograph designed to target the J (1.1–1.3 μm) and H (1.45–1.65 μm) bands in a single exposure, with an additional channel for simultaneous stellar monitoring. VIOLA uses a Virtually Imaged Phased Array (VIPA) as its primary disperser, reaching a spectral resolution of R = 300,000, enabling the detection of key atmospheric molecules such as O_2, CH_4, CO_2, CO, H_2O, OH, and HCN around nearby M-dwarf super-Earth, sub-Neptune exoplanets from a ground-based observatory. By combining innovative optics with a flexible design compatible with multiple front ends, VIOLA will bridge the gap between current ground-based facilities and future ELT-class instruments. This development aligns with ESO’s long-term strategy for the VLT and VLTI to remain at the forefront of astrophysics in the ELT era, enabling experimental exobiology in exoplanet atmospheres.

MICHELANGELO: a mid-infrared high dispersion spectrograph dedicated to exoplanet atmospheres studies

Leonardo Testi
ALMA Mater Studiorum - Università di Bologna

We present the concept for a next generation mid-infrared, adaptive optics fed, high dispersion spectrograph for the VLT dedicated to the study of exoplanetary atmospheres. The instrument will allow to cover in a single exposure all the L and M bands with a resolving power of at least R$\sim$50000. Compared to CRIRES+, the proposed concept will allow a speed up by at least a factor of $\sim$8-10 for the detection of exoplanetary atmospheres.

ESPRESSOred. What else? A NIR extension for ESPRESSO

Xavier Dumusque
Observatory of Geneva

NIRPS has revolutionized the exoplanet field in only 2.5 years, by reaching an RV precision of 1 m/s, which is a game changer for the follow-up of the terrestrial found by TESS. NIRPS also allows measuring, with unprecedented precision, the composition of transiting planet atmospheres including atmospheric escape signature through helium absorption. However, for many science cases, accessing to the photon collective power of the VLT would be critical, like ESPRESSO compared to HARPS. By 2030, PLATO will unveil hundreds of temperate transiting planets orbiting late M-dwarfs, for which NIR high-resolution spectroscopy and RVs will be required to get mass, characterize their atmospheres and constrain orbital architecture. By that date, GAIA will have completed the identification of late-type dwarfs (M5 and later). NIR High-resolution spectroscopy and RV follow-up of these targets will allow to study the mass-age-metallicity-luminosity and uncover the occurrence of low-mass planets at the bottom of the main sequence. Those scientific drivers motivate the need of a VLT NIRPS-like instrument, as CRIRES+ only offers a limited NIR coverage in one shot and an RV precision of 5 m/s. The proposed instrument would reach R=100'000, a RV precision of 0.5 m/s, would cover the Y, J, H and potentially K band, and would be AO plus mono-mode fiber fed to reduce the spectrograph size and cost. ANDES with its NIR arm will never get enough telescope time to fulfil the discussed RV science cases.

Pioneering exoplanet reflected-light spectroscopy with RISTRETTO: a pathfinder for ANDES and PCS

Christophe Lovis
University of Geneva

RISTRETTO is a proposed visitor instrument for the VLT which will combine high contrast and high spectral resolution at the diffraction limit of the telescope to probe exoplanets in reflected light. It will be able to characterize our nearest neighbour Proxima b, a temperate rocky world. It will also explore super-Earths, Neptunes and cold Jupiters around nearby stars. Moreover, RISTRETTO will address accreting protoplanets through their H-alpha emission and the kinematics of protoplanetary disks through Doppler shift measurements in scattered light. It will also offer new capabilities in the field of stellar physics. In this contribution I will discuss the science cases and present the current status of the instrument. The spectrograph is in the integration phase, and first laboratory results will be presented. I will also show innovative concepts for the adaptive optics front-end which have been successfully demonstrated: a coronagraphic integral-field unit and an infrared, 3-sided unmodulated Pyramid wavefront sensor. I will present the RISTRETTO end-to-end simulator, which shows that molecular absorption in the atmosphere of Proxima b can be detected in about 85 hours of observing time for an Earth-like composition. Finally, I will discuss how RISTRETTO can be used as a pathfinder for the SCAO mode of ANDES and the future PCS instrument at the ELT.

Data Analysis Software in the 2030s for panoramic Integral Field Spectrographs

Angela Adamo
Stockholm University

Current panoramic IFS are proving overwhelming information content that cannot be fully harvested because of the target-oriented approach to data analysis, and limited human resources. In the 2030s, when BlueMUSE will operate at full capacity alongside MUSE and other IFS, a tremendous numbers of sources will be left unnoticed and uncatalogued in our datasets and archives. A paradigm shift in the way we approach data analysis is necessary to make the next scientific leaps in many astrophysical areas. I will present automated Data Analysis Software (DAS) principles that are in development for MUSE & BlueMUSE surveys. The DAS concept will be optimized for both galaxy surveys/deep-fields and resolved galaxy observations, and is designed to operate end-to-end without intervention. The workflow currently consists of four modules that: (1.) identify sources; (2.) extract spectra/images; (3.) classify sources, estimate reshifts and measure continuum & emission line fluxes; and (4.) produce catalogs and meta-data. Each step of the DAS interacts with a local database and can also be coupled with dedicated visualization tools for inspection, parameter optimization, and for re-running steps. DAS will be used by individual researchers to accelerate science, and at the level of observatories to exploit the large volumes of unused data, distribute high-level source catalogs. Such methods are the only way to fully utilize the information content provided by VLT and other facilities in 2030s.

Stars and Stellar Evolution

Ylva Gotberg
Institute of Science and Technology Austria (ISTA)

High-resolution facilities for stellar astrophysics

Stefan Kraus
University of Exeter

High-resolution instrumentation on the VLT/I beyond 2030 will enable transformative advances in stellar astrophysics through technological innovations in spectroscopy, interferometry, and polarimetry. Next-generation spectrographs will combine high stability, broad wavelength coverage, and multiplexed observing modes to efficiently capture chemical abundances, kinematics, and ages across stellar populations. Interferometric capabilities will be a key technological driver, delivering direct measurements of fundamental stellar parameters, surface features, and accretion/mass-loss processes from stellar birth to the late stages of stellar evolution. Augmented with advanced spectropolarimetric capabilities, VLT/I could constrain magnetic field topologies and circumstellar dust properties in unprecedented detail. These new capabilities on spectral, spatial, and temporal resolution, will position the VLT/I as versatile platform for high-precision stellar science.

HRMOS: a very high-resolution; multi-object spectrograph for the VLT

Sofia Randich
INAF-Osservatorio Astrofisico di Arcetri

HRMOS (https://www.hrmos.eu/) is a new instrument we plan to propose for the VLT, building on the initial idea presented at the "The Very Large Telescope in 2030" conference in June 2019. That idea has since then matured into a solid concept that combines very high spectral resolution (R = 80,000), multiplex capability (> 50 fibers), blue wavelength coverage down to 385 nm, and excellent radial velocity precision (requirement 10 m/s). With this unique combination, HRMOS will crucially fill the gap in the landscape of current and planned instrumentation, offering capabilities that are essential to address transformative science questions across a broad range of areas. Also, the spectrograph design is devised to allow flexibility and possible future upgrades. The main science case includes surveys of hot Jupiters in dense stellar environments, extending beyond the Milky Way (MW); probing hierarchical galaxy assembly in the MW closest companions; alternative constraints on cosmological parameters through accurate and precise stellar age dating. At the same time, HRMOS will enable novel and detailed investigations of young stars and their magnetic phenomena, origin of chemical elements and nucleosynthesis, Galactic archaeology, star cluster science, interstellar medium abundances. The talk will provide an overview of the science drivers, instrument top level requirements, concept design and innovative technological solutions, feasibility and challenges.

HRMOS: Instrument architecture and main features

Marco Riva
INAF - OA Brera

The Very High-Resolution Multi-Object Spectrograph (HRMOS) will be proposed as a new instrument for the ESO VLT. HRMOS will enable groundbreaking scientific investigations that would otherwise remain inaccessible. These include the study of extrasolar planets in crowded stellar environments, testing hierarchical galaxy formation scenarios in dwarf galaxies, and providing alternative constraints on cosmological parameters through precise age determinations of the oldest stellar populations. At the same time, HRMOS will also be unique in complementing spectroscopic surveys done at lower resolution, allowing detailed investigations of young stars and their magnetic phenomena, stellar physics and nucleosynthesis, star cluster science, and interstellar medium abundance measurements. It will be an High Resolution spectrograph able to provide a resolving power of 80000 in three spectral window of approx. 140nm each. It will have Multiplexing capabilities in the range of 50 to 80 and will be carchterized by a radial velocity precision of 10m/s. In this paper we will present the instrument architecture detailing the main technical carachteristics. The instrument front end that will pick up the stars and correct the atmospheric dispersion, the fiber link that will bring the light to the spectrogrpah by providing slicing and scrambling features and the spectrograph concept will be described in this paper.

Filling the Gap: High-Resolution; Multi-Object Spectroscopy for the Local and Distant Universe

Laura Magrini
INAF

In the era dominated by big data and machine-learning approaches in Galactic science, high-resolution spectroscopy with high signal-to-noise observations remains an indispensable reference. Equally, the understanding of the Milky Way and of very nearby galaxies remains a cornerstone for interpreting the distant Universe. We will present several key scientific cases that require access to a high-resolution, multi-object spectrograph, stable in radial velocity. A resolving power of at least R=80000 is essential to meet these challenges, as lower resolutions fail to provide the precision needed for disentangling nucleocosmochronology signatures, resolving isotopic ratios, and detecting minute radial-velocity shifts. Among the highlighted cases, we will discuss precise age measurements via nucleocosmochronology and their implications for cosmology; the determination of abundances and isotopic ratios of heavy elements and their role in identifying production sites, including those traced by gravitational-wave events; detailed chemical studies of bright stars in nearby galaxies to constrain hierarchical galaxy formation at the low-mass end; and the detection of giant planets across a wide range of environments, from young star clusters to the oldest ones, spanning the Galactic bulge to nearby dwarf galaxies. Together, these science cases demonstrate a clear instrumental gap, making a high-resolution, multi-object spectrograph a critical next step for the community.

Probing Neutron-Capture Nucleosynthesis in the Early Galaxy with HRMOS

Emma Fernandez-Alvar
Universidad de La Laguna

Understanding the origin of chemical elements is a central challenge in astrophysics. While hydrogen, helium, and traces of lithium formed minutes after the Big Bang, heavier elements arise through stellar evolution, supernovae, and mergers. The production sites and evolutionary stages of elements beyond iron, synthesized via neutron-capture reactions, remain uncertain. These reactions proceed through slow (s-) and rapid (r-) processes, with an intermediate (i-) process potentially contributing at different metallicities. Each process leaves distinct isotopic fingerprints that can help trace their origin. Current instruments lack either the resolution or the sample size needed to disentangle these processes. HRMOS, with its high resolution, multi-object capabilities, and access to blue wavelengths, will overcome these limitations by providing precise measurements of heavy-element abundances and, in some cases, isotopic ratios across large stellar samples. In this talk, we will highlight the particular elements and isotopes that HRMOS is capable of measuring, demonstrating how these observations can help to make a leap forward to understand the neutron-capture nucleosynthesis pathways.

The role of HRMOS to the comprehension of planetary systems across time and space

Camilla Danielsky
University of Valencia

Recent advances in exoplanet research increasingly seek to identify the fundamental factors that shape planetary systems. An emerging novel approach aims at placing planets within the broader context of the Milky Way—considering stellar populations, galactic dynamics, and the influence of their birth environments. The more homogeneous studies are conducted on host-star populations, the clearer it becomes that the characteristics of planetary systems are intrinsically linked to the environment conditions under which they form. Within this framework, the HRMOS instrument is poised to make a significant contribution to understanding the galactic planetary population. By targeting stellar clusters with well-constrained ages and chemical compositions, HRMOS will enable systematic exploration of the parameter space of planetary systems. This approach will allow detailed studies of planetary properties across a range of stellar masses, clarifying how host characteristics influence planet formation. Equally important, HRMOS will provide the means to compare systems in clusters of different ages, adding a temporal dimension to planetary evolution. This will make it possible to trace how planetary architectures arise and evolve, ultimately determining the fate of planetary systems. In this talk, I will outline the pivotal role HRMOS can play in advancing our understanding of the Galactic planetary population and the broader processes that shape planetary systems across the Milky Way.

VIPER: a Visible and Infrared spectroPolarimetER for the VLT

Pascal Petit
IRAP

We present VIPER (Visible and Infrared spectroPolarimetER for the VLT), a next-generation high-resolution spectropolarimeter built to unveil the magnetic universe. Covering the full spectral range from 330 to 1700 nm in a single exposure, VIPER will deliver spectra at a resolution of $\sim$100,000, simultaneously recording circular or linear polarization alongside intensity. Beyond serving as the natural successor to UVES, VIPER's unique polarimetric capability —unmatched by upcoming ELT spectrographs— will open new discovery space. With the VLT's collecting power, VIPER will enable transformative science: tracing the role of magnetic fields in the birth and evolution of stars and planetary systems, probing magnetospheric star–planet interactions, unveiling the magnetism of the most massive stars in our Galaxy and beyond, assessing the asphericity of supernova explosions, and mapping the geometry of the central engines powering active galactic nuclei.

From Large Telescopes to Tiny Chips: Astrophotonic Perspectives for the VLT/I

Elsa Huby
LIRA Observatoire de Paris

While telescopes are becoming larger to increase sensitivity and angular resolution, astrophotonic devices pursue the opposite approach, enabling compact instruments with stable and versatile architectures. In this presentation, I will review recent developments in astrophotonics that could enhance the capabilities of the VLT and VLTI in the near future. Ongoing efforts focus on the design of short-wavelength beam combiners, which require advanced fabrication technologies to achieve high-performance integrated optics chips with low insertion and propagation losses, as well as reliable polarization control. Moreover, integrated optics offer a wide range of functionalities, such as on-chip active phase control, or complex routing schemes like the back-propagation of a metrology laser source, enabling precise measurement of the instrumental phase (could be used for an upgrade of the GRAVITY metrology system). Finally, astrophotonic devices such as photonic lanterns provide an efficient way to decompose the incident telescope beam with high photon efficiency. These devices could significantly strengthen the VLT capabilities in areas such as wavefront sensing and high-angular-resolution spectro-astrometric imaging.

Astrophotonics: recent and future developments

Simon Ellis
Macquarie University

Astrophotonics is a burgeoning field that lies at the interface of photonics and modern astronomical instrumentation. Traditionally, optical fibres have been used in innovative ways to vastly increase the multiplex advantage of an astronomical instrument, e.g. the ability to observe hundreds or thousands of stars simultaneously. But modern instruments are using many new photonic functions, some emerging from the telecom industry, and others specific to the demands of adaptive optics systems on modern telescopes. I will present an overview of cutting-edge astrophotonic instruments including miniature photonic spectrographs, OH suppression fibres, and wave-front sensors, as well as looking to a future in which instruments could exploit the properties of individual photons through quantum entanglement and quantum networks to provide extremely long baseline optical interferometry.

Science drivers for a shorter wavelength; high-sensitivity 3rd-generation VLTI instrument

Mathias Nowak
Observatoire de Paris

We present the science case and design considerations for a 3rd generation VLTI instrument operating in the YJH bands. Extending the VLTI to shorter wavelengths will open a new observational window, providing complementary spectral diagnostics to current VLTI instruments. The expanded spectral coverage will give access to molecular tracers of exoplanet atmospheres and diagnostic lines of accretion and outflow processes, enabling mapping of magnetospheric regions, disk winds, and circumplanetary environments around young and forming planets. Shorter wavelengths, combined with vibration control at the VLTI, will provide improved astrometric precision enabling the detection of exomoons, searches for intermediate-mass black holes, and resolved microlensing studies probing the lower mass gap between neutron stars and black holes. High-contrast dual-field capability will allow spectroscopy of giant and rocky planets in the 30 mas–1 range, including systems from GAIA DR4 and RV surveys. Polarimetry will constrain cloud, haze, and surface properties, while spin-axis measurements of host stars will test spin–orbit alignments, providing key insights into the dynamical evolution of planetary systems. In the extragalactic domain, resolving the broad-line regions of AGNs for large samples will enable dynamical mass measurements and reverberation mapping campaigns. In synergy with the ELT, these will contribute to resolving the Hubble tension.

The VLTI: a unique facility for exoplanet detection

Sylvestre Lacour
Observatoire de Paris

In the era of the ELT, will the VLTI remain competitive in the study of exoplanets? The answer is yes. Thanks to its unique angular resolution, the VLTI will continue to excel: enabling detections at very small angular scales, constraining orbital parameters through astrometry, and providing imaging capabilities to resolve circumplanetary environments. I will present an overview of what the VLTI will require to remain competitive in this field over the next 20 years, and introduce a concept for an instrument designed to meet these needs.

Demonstrating the combination of AT-UT baselines: VLTI as a true coherent array

Guillaume Bourdarot
Max Planck for Extraterrestrial Physics

In this talk, we present the experimental advances to recombine the Unitary Telescope (UTs) and Auxiliary Telescope (ATs) of the Paranal Observatory. The on-site tests were carried on VLTI in 2025, using GRAVITY for the beam-combination. The functional tests validate the possibility to use VLTI/GRAVITY in a hybrid mode. Combined with the on-going upgrade of the delay-lines to have automated relocation of M12, the automatic recombination and AT-UT combination would open up instantaneous, reconfigurable geometry of the VLTI among the 28 baselines of the array, a true leap in imaging capability at VLTI. Instantaneous, snapshot imaging capability is of fundamental importance, in particular for science involving short-term variability, such as the imaging of protoplanetary disks at terrestrial orbits (keplerian timescales). On a fundamental level, AT-UT demonstration is a crucial step to validate the scaling of sensitivity and field-of-view with different telescope diameters into large interferometry array in the future.

STELLIM: Fast Interferometric Imaging of Stellar Surfaces

Xavier Haubois
ESO Chile

Current interferometric imaging of stellar surfaces faces significant temporal limitations, requiring weeks of data collection to produce reliable images. STELLIM represents a revolutionary advancement that will enable interferometric imaging of bright stellar objects within a few hours of observation. The system combines light from 13 telescopes in the visible, leveraging the existing VLTI infrastructure to achieve milli-arcsecond resolution imaging capabilities. The interferometer employs single-mode optical fibers to transport light from telescopes to VLTI delay line tunnels. A mirror switchyard system enables sequential selection of various 7-telescope combinations. STELLIM's primary scientific objectives focus on imaging stellar surfaces to diagnose stellar dynamics and mass loss phenomena resolved on hourly timescales, including detection of oscillation modes, large-scale photospheric structures, convection patterns and outflows. The system will provide unprecedented spatio-temporal characterization of surface and circumstellar structures in cool evolved stars, particularly red supergiants whose complex dynamics and photometric variability remain poorly understood. Beyond its immediate scientific applications, STELLIM serves as a critical technology demonstrator for opening the visible observing window at VLTI and for future interferometric facilities, testing key operational concepts for next-generation astronomical interferometry.

VLTI extensions and limiting sensitivity: how to win on both counts

Romain Petrov
University Côte d'Azur - Lagrange Laboratory

There is a general belief that increasing the number of apertures in an interferometer comes at a cost in terms of fringe tracking sensitivity. We have developed, tested on an optical bench and fully simulated a fringe tracking concept which has the remarkable property of having a sensitivity independent of the number of apertures. The limiting sensitivity of this hierarchical fringe tracking (HFT) concept is this of a two telescopes fringe tracker using all the flux of a pair of telescopes, whatever the total number of apertures. Within that sensitivity, the tracking accuracy globally increases with the number of apertures, particularly on the longest baselines. Compared with the "pairwise" and "all-in-one" concepts, the HFT offers a gain in sensitivity for a NT apertures interferometer of at least NT-1. This sets new parameters for an extension of the number of VLTI apertures. This presentation will discuss the sensitivity limits and some science benefits of several VLTI extensions, with more UTs, more ATs or combinations of UTs and ATs.

Perspectives for the Asgard Visitor Instrument Suite for VLTI in the 2030s

Stefan Kraus
University of Exeter

The 'Asgard Suite of visitor instruments' will open new frontiers for VLTI by pushing towards higher sensitivity (with a novel fringe tracker and 2nd-stage adaptive optics system), shorter wavelengths (with a Y/J/H-band, dual-field, high-spectral resolution instrument), and higher contrast (with an L-band nulling instrument). In this talk, we will highlight how the Asgard instruments could pave the way for the future of VLTI: (a) as testbed for characterising the VLTI infrastructure and for exploring its current limitations; (b) by conducting exploratory science studies that will showcase the huge untapped potential of VLTI in key science areas from exoplanets to AGNs, and by nurturing a user community around these novel science capabilities; (c) as platform for demonstrating the on-sky performance of novel technologies that could have a transformative impact for realising future facility instruments. Leading into the 2030s, Asgard could demonstrate novel 3D-photonics beam-combiner technology, photonic-laterns for wavefront sensing, near-infrared nulling, and large-format APD detectors/multi-wavelength metrology control for achieving long coherent integrations. Finally, we will discuss the prospect for a VLTI 3rd-generation facility instrument that would break new grounds in sensitivity, astrometric precision, and contrast by building on Asgard, while benefiting from the deeper integration and infrastructure upgrades that are only achievable with a facility instrument.

MATISSE and mid-infrared interferometry at the VLTI post-2030

Florentin Millour
University Côte d'Azur - Lagrange Laboratory

Based on what has been achieved with the second-generation interferometric instrument MATISSE, we provide a plan for the future. Within the context of the ELT, and in particular METIS, the support of extending ground-based mid-infrared capabilities is critical. Possible upgrades to MATISSE are wide-field observations, metrology for phase referencing for improved sensitivity, upgraded detectors, a combination of the AT and UT telescopes for improved uv coverage, and the combination of observations from the ELT and VLTI. Because of the large apertures required for sensitive observations with respect to the thermal background, an evolution of the VLTI infrastructure involving a fifth UT or larger diameter ATs with longer baselines naturally pushes us to a new instrument combining more than four telescopes. In this contribution, we present several possibilities for expanding the realm of high-resolution science cases in the fields of active galactic nuclei, young stellar objects and evolved stars, with an active element on discussions for stepping into the next era of high-resolution astronomy together.

Astrophysics at high spectral and spatial resolution with the VLTI

Andreas Quirrenbach
Landessternwarte

The combination of high spectral and spatial resolution (of order R = 100,000 and 1 mas, respectively) at the VLTI would open new vistas in stellar astrophysics, with important applications to planetary systems. Measuring radii and limb darkening profiles of late-type stars probes the stratification and extension of cool star atmospheres, enables critical tests of three-dimensional stellar atmosphere models, and provides crucial information for the interpretation of high-resolution spectra taken during planetary transits. Tracing the evolution of convection cells in supergiants, following shocks in Mira atmospheres, and Doppler imaging of stellar surfaces are examples of applications that benefit strongly from the combination of spatial and spectral information. Measuring the phase shift between the red and blue wings of photospheric absorption lines provides direct information about the rotation rate and orientation of the rotation axis, an important piece of information on the geometry of stellar binaries and planetary systems with orbits determined by Gaia astrometry. The fringe-tracking stability achieved by Gravity makes it possible to use an instrument requiring long integration times as the science beam combiner, opening the path to using ”standard” cross-dispersed echelle spectrographs for this purpose. I will discuss the science drivers for a high-spectral-resolution addition to the VLTI, and present a concept how this could be implemented with modest resources.

Abstracts of posters

The Blue Multi Unit Spectroscopic Explorer (BlueMUSE) - science drivers and synergies

Johan Richard
Centre de Recherche Astrophysique de Lyon

BlueMUSE (Blue Multi Unit Spectroscopic Explorer) is a blue-optimised, medium spectral resolution, panoramic integral field spectrograph under development for the Very Large Telescope. With an optimised transmission down to 350 nm, a large FoV (1 arcmin2) and a higher spectral resolution ($\lambda/\Delta\lambda \sim$ 4000) compared to its predecessor MUSE, BlueMUSE will open up a new range of galactic and extragalactic science cases allowed by its specific capabilities. Among the science goals available with BlueMUSE, it will survey large sample of massive stars in our galaxy and the Local Group, study ionized nebulae, starburst and low surface-brightness galaxies. At high redshift, it would allow us for the first time to detect the IGM unambiguously in emission, as well as study the evolution of the CGM properties near the peak of the Cosmic Star formation history. BlueMUSE will have very strong synergies with other VLT2030 instruments (CUBES, MAVIS) and will be highly complementary to the ELT. We will present an overview of the BlueMUSE instrument science requirements and design, as well as the synergies with upcoming facilities.

Technologies challenges and developments for HRMOS

Andrea Bianco
INAF-Osservatorio Astronomico di Brera

The Very High-Resolution Multi-Object Spectrograph (HRMOS) will be proposed as a new instrument for the ESO VLT. The target resolving power is 80000 in three spectral windows with a total range of 140nm. It will have Multiplexing capabilities in the range of 40 to 80 and will be characterized by a radial velocity precision of 10m/s. Such an ambitious instrument presents some technological challenges to be addressed that will turn into important “enabling” technological activities. They will be crucial for the instrument itself, but they align with known challenges in ELT instrumentation. Examples of these tech bricks are: -Large size and high dispersion diffraction gratings will be necessary in HRMOS. Innovative VPHGs will be developed using big holographic setup under construction at INAF-OABr. -Large size dichroic mirrors are required in this kind of spectrographs to split the light into the target channels and they are difficult to produce with the required performances. A different approach will be used that consists in splitting the spectral range in a small “photonic” module, one for each fiber. -As for AR coatings, approaches beyond the multilayers will be explored, such as innovative nanostructured coating with an important advantage in terms of complexity, costs and complexity. -CMOS detectors will be considered instead of CCD, according

to the photonic trend. The workshop contribution will highlight these technological developments, showing the impact on HRMOS.

The BlueMUSE "Distant Universe" Science Cases

Tanya Urrutia
Leibniz Institut für Astrophysik, Potsdam

The BlueMUSE instrument is expected to be installed at the VLT in the early 2030s. The original MUSE instrument has been a game changer in terms of surface brightness sensitivity, uncovering diffuse gas in emission around high redshift galaxies, in particular in Lyman Alpha due to its resonant scattering properties. BlueMUSE offers a particular opportunity in expanding our understanding this diffuse emission and gas flows in the Universe due to its targeting a lower redshift ($z\sim1.9$-3.3) regime in Lyman Alpha. For one, this represents a particular interesting time in the Universe: the end of Cosmic Noon and the start of galaxy cluster assembly. In addition, the diffuse emission will be a factor $\sim$4-8 brighter due to the inverse $(1+z)^4$ surface brightness dimming. Knowing the interplay of how gas feeds and escapes galaxies will help us explain the relationship and evolution of feedback and star-formation in them.

Mapping Quasars Outflows with VLT/I and Gravitational lensing

Rachana Rachana
Indian Institute of Science (IISc)

We propose a new study using the Very Large Telescope Interferometer (VLTI) and gravitationally lensed broad absorption line (BAL) quasars to directly map the detailed structure of quasar outflows. Magnification increases the flux above VLTI detection limits and effectively stretches the apparent source, improving visibility and differential-phase signals at a specific baseline. By comparing differential interferometry and high-resolution spectroscopy across multiple lensed images, this method reveals outflow clumpiness, geometry, and kinematics. VLTI empirically anchors the outflow size, opening angle, inclination, and velocity fields. These measurements, combined with VLT spectroscopy, provide strong constraints on the mass outflow rates and kinetic luminosities of quasar winds, enabling improved calibration of AGN feedback models. While there are currently few suitable lensed BAL quasars, upcoming surveys like GAIA and LSST will provide enough statistically significant samples. This approach will transform our understanding of quasar-driven feedback, wind physics, and their role in the evolution of galaxies.

Nucleochronology with HRMOS

Tadafumi Matsuno
Heidelberg University

Radioactive nuclei in the Universe provide a unique way to constrain stellar ages without relying on stellar evolution models. Thorium and Uranium are of astrophysical interest because their most stable isotopes, Th 232 and U 238, have half-life times of 14 and 4.5 billion years, respectively. HRMOS will provide high-resolution spectra that will enable measurements of Th abundances, and its multiplexing capability will allow observations for an unprecedented number of stars. In this talk, I will present a feasibility study for using HRMOS to measure Th abundances and introduce science cases it can address, such as constraining the age of the Universe from old stars.

The challenging spectroscopic analysis of young stars and the key-role of HRMOS

Martina Baratella
ESO

In recent years, the spectroscopic analysis of stars in Galactic open clusters showed some peculiarities in their chemical composition. On one hand, young stars in the solar neighborhood appear to have a sub-solar metallicity when compared to the Sun. On the other hand, barium is enriched in clusters younger than 200 Myr reaching values larger than +0.6 dex over solar. This trend is not followed by the other neutron-capture elements in particular those produce by the s-process. These chemical anomalies might be related to the effects of stellar activity in shaping the stellar spectral lines, affecting not only the inferred stellar parameters, but also the individual abundances. However, a definitive explanation is still lacking and highly wanted. New multi-object spectrographs (such as WEAVE, 4MOST or MOONS) will unlock the observations of many more young stars in our Galaxy, filling the gap of chemically characterized objects. However, given their limited resolution and/or spectral coverage, they might not be enough to investigate further, e.g., the link between stellar activity and s-process elements. In this talk, I will focus on the crucial role that a new instrument like HRMOS will play in this topic and on the importance of a dedicated analysis of young stars.

Measuring the Cosmic Redshift Drift with the VLT: A Long-Term ESPRESSO Program into the ELT Era

Andrea Trost
INAF

The arrival of the ELT in the coming decade will reshape the scientific landscape, but it will also open unique opportunities for the VLT. With the gradual decommissioning of current instruments, we expect that significant observing time will become available for ambitious, time-intensive experiments that are difficult to accommodate today. I will present our vision for exploiting this opportunity by dedicating all dark time of a single VLT Unit Telescope ($\sim$1000 h/yr) to a focused, long-term ESPRESSO program targeting a small set of seven bright quasars. Such a program, started with a limited integration time in 2022 ($\sim$22h) to test systematics and scaling predictions, has the potential to deliver the first direct detection of the cosmological redshift drift by 2080, probing the expansion history of the Universe in a model-independent way. The impact of this project can be accelerated by exploiting synergies with ANDES at the ELT through coordinated parallel observations. These complementarities would not only enhance the sensitivity of the drift measurement but also provide as a legacy a powerful framework for addressing instrumental systematics, data reduction strategies, and cross-facility data combination as well as unique high quality QSO spectra. In this talk, I will outline the scientific rationale, observational requirements, and instrumental opportunities, highlighting how the VLT can remain at the forefront of fundamental cosmology well into the ELT era and beyond.

Enhancing JWST asteroid discoveries with the VLT

Nicolas Crouzet
University of Groningen

Asteroids are remnants of the early Solar System and are possible reservoirs of organic compounds that can be delivered to planets. Collisions with large asteroids can alter the evolution of planets and their moons, and impacts of small asteroids can affect their surface. Measuring the properties and distribution of asteroids is key to understand their role in the formation of the Solar System and the origin of life on Earth, and can serve as a benchmark for exoplanetary systems. Besides, potential collisions with large asteroids pose a threat for life on Earth. We will present our project on detecting and characterising asteroids via their thermal emission using the JWST Mid-Infrared Instrument (MIRI) in the context of Solar System science and planetary defence. JWST MIRI opened up a new window to detect small (10 - 100 m) and cool asteroids by observing at long wavelengths (5 - 28 micron) with unprecedented sensitivity. After four years of operation, a wealth of archival MIRI imaging data is available for mining. To characterise the orbits and the physical properties of these small asteroids, complementary observations with large telescopes in the visible will be crucial. We will present our method and first results in the search for unknown asteroids in MIRI images acquired via MINDS (MIRI Mid-INfrared Disk Survey), a MIRI European Consortium Guaranteed Time Observation program, and illustrate how follow-up observations with the VLT can enhance these discoveries.

Public Surveys beyond 2030: lessons learned from public surveys before 2030 – VVV/VVX and KMOS

Valentin Ivanov
ESO

The VISTA Variables in Vía Láctea public surveys – VVV and its extension VVVX – have proved to be a very productive usage of 4-m telescope time in the era when the 8-10-m class telescopes were the flagships of the ground-based observational astronomy. We argue that the public surveys with 8-10-m class telescopes will likely become the most productive usage of the time at these telescope in the era of the 30-40-m flagship telescopes, based on our experience with the VVV/VVVX and the incoming KMOS VVVX-GalCen public survey of the inner Milky Way. We will review the most prominent scientific results from these surveys – both expected and surprising ones, analyze the publication metrics, and compare it with the production from similar instruments that have not been used in survey mode. We will also share the best practices that a decade of survey experience has though us. Finally, we underline that the mode of operation may be just as important for the scientific impact of a telescope as the available instrumentation.

Open Loop AO Instruments: High Stability DMs enable new concepts

Stefan Ströbele
ESO

Conventional deformable mirror (DM) technologies are limited by actuator creep and hysteresis, leading to surface errors that prevent open-loop operation in near–diffraction-limited astronomical systems. While MEMS DMs offer sufficient stability, their limited size and stroke constrain system design. Within ESO's technology development program, Bertin-Alpao has developed a high-stability DM technology scalable to large formats. A 92 mm diameter DM with over 3000 actuators demonstrates excellent yield, homogeneous stroke, high linearity, and outstanding stability, with surface drift small enough to enable open-loop operation and diffraction-limited performance in the V band over typical observations, opening new possibilities for advanced adaptive optics assisted astronomical instrumentation.

How to make VLTI visible

Florentin Millour
Observatoire de la Côte d'Azur, Laboratoire Lagrange

Visible light hosts numerous metallic lines and strong hydrogen features, making it a privileged domain to probe the physics of stars, planets, and galaxies. Opening VLTI to the visible thus provides a unique opportunity to advance the characterization of exoplanet host stars, to unravel the mechanisms of mass loss in evolved stars, to refine our understanding of Cepheids (a cornerstone of the cosmic distance ladder), and to study the progenitors of gravitational waves, among many other cases. Compared to the infrared, visible interferometry delivers intrinsically higher angular resolution for the same baselines. Recent technological advances — from improved detectors and adaptive optics to fringe tracking, optical fibers, and integrated optics — now make such science within reach. The motivation for extending VLTI into the visible is particularly strong, as the infrared has already been thoroughly explored at ESO. This presentation will outline a possible path toward a dedicated visible instrument, emphasizing science-driven specifications and the advantages of a survey-style observing program to fully exploit its potential.

Nearby Galaxies in the ELT Era: Synergy Between Infrared and VLT Observations

Uzay Aydın
Erciyes University

Starburst galaxies, characterized by intense episodes of star formation, play a key role in tracing galaxy evolution and feedback processes across cosmic time. Infrared and radio observations are crucial to reveal obscured star-forming regions and synchrotron emission from energetic processes.
In this contribution, I will present an overview of my work-in-progress on compiling and analysing multi-wavelength data (radio and infrared) of starburst galaxy candidates in the nearby Universe. By combining archival and recent surveys, I aim to assess star formation rates, dust content, and potential AGN contribution.
This project explores how current and future VLT/VLTI capabilities — in synergy with facilities such as ALMA and upcoming mid-infrared instruments — can enhance our understanding of the interplay between dusty starburst cores and their larger galactic environment. I also intend to discuss perspectives for high-resolution follow-up observations, possible new instrumentation requirements, and how this science case fits into the broader context of optimising VLT's scientific output in the ELT era.

VPHG@INAF-OABr: Toward very large size dispersing elements for UV-VIS-NIR

Andrea Bianco
INAF-Osservatorio Astronomico di Brera

Dispersing elements are key components in astronomical spectrographs, because they define the dispersion and have a large impact on the total throughput. For next generation VLT instruments and for ELT spectrographs, there are strong requests for large size gratings providing large dispersion, which are not finding an easy response. Among the different technologies for their production, Volume Phase Holography (VPH) has attracted a special attention thanks to some unique features, such as the high diffraction efficiency and easy customization. At INAF-OABr, we have been working for more than 10 years on developing an innovative production process for VPHGs operating from 330nm to 2500nm (covering from UV to NIR) characterized by simplicity and reproducibility. The next step, we are completing, is the building of a new facility for the realization of very large VPHGs, up to 450mmx650mm to satisfy the requests of large size spectrographs. The facility will be ready in April and first results are expected by late Summer 2026. We are discussing with different instrument consortia about the requirements of their dispersing elements.

Expanding the benefits of infrared interferometry with the VLTI

Paul Boley
Max Plank Institute for Astronomy, Heidelberg

Optical/infrared interferometers provide some of the highest spatial resolutions available in astronomy, but obtaining model-independent images is often complicated by sparse uv coverage, and/or changes in target appearance due to source variability while the uv plane is being filled. In this contribution, we show the limitations of the current four-telescope second generation interferometric instruments at the VLTI based on previous experience, and quantitatively consider the solutions offered by utilizing all six available delay lines of the VLTI simultaneously for a six-telescope beam combiner instrument.

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