Vienna ELT Science and Simulations Workshop #2

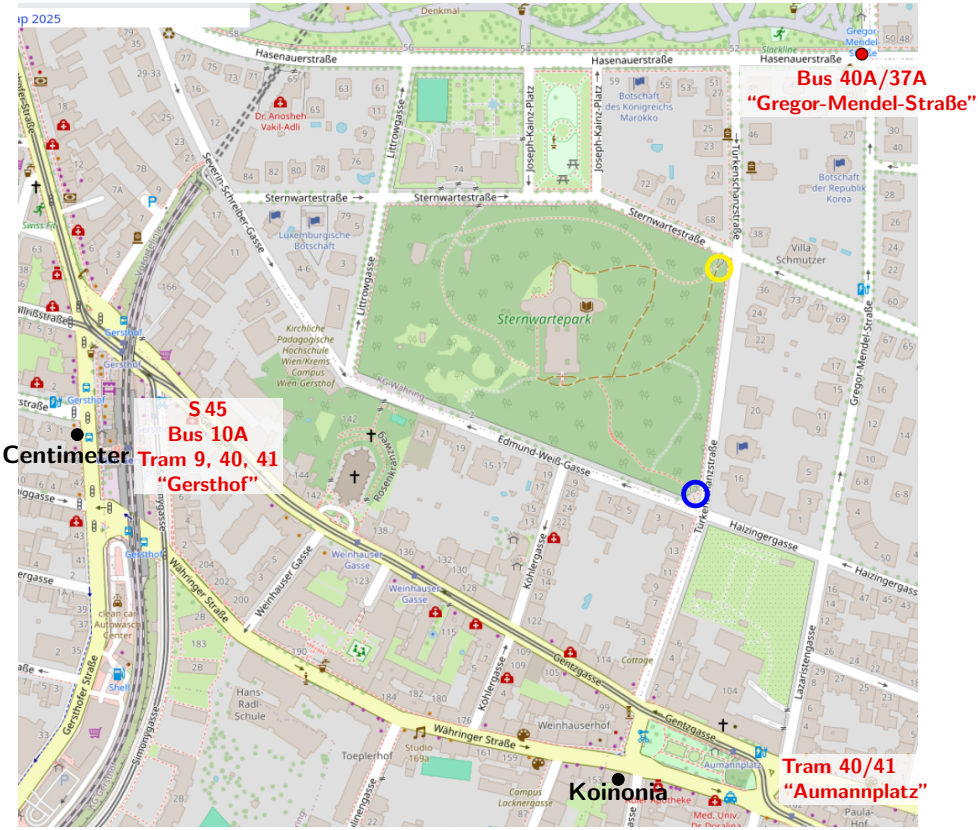
22–24 September 2025
University Observatory, Vienna

universität wien
Institut für Astrophysik

ÖAW AUSTRIAN ACADEMY OF SCIENCES

How to get to the Observatory

Universitätssternwarte Wien
Institut für Astrophysik
Türkenschanzstraße 17
1180 Wien



There are two entrances to the observatory park, both on the east side:

Main entrance (marked yellow)

The main entrance to the Observatory park is located at the corner of Türkenschanzstraße and Sternwartestraße. Use this entrance when you arrive with bus 37A or 40A (nearest stop *Gregor-Mendel-Straße*). You can also reach if from *Gersthof* if you walk parallel (to the left) to the railway (a few steps marked in red) and then along Sternwartestraße.

Lower entrance (marked blue)

This is a side entrance (you will have to climb some stairs), located on the corner of Türkenschanzstraße and Edmund-Weiß-Gasse. To open the gate, press the gray switch ("Türtaster") to the right of the gate. Use this entrance if you arrive at the tram stop *Aumannplatz* (40 and 41). You can also reach if from the S-bahn station *Gersthof* by walking along Gentzgasse to Aumannplatz.

Remote participation

The talks will be streamed via the following zoom link (no password required):

https://tinyurl.com/AstarZoom

The presentations should be uploaded to and are accessible on the following google drive folder:

https://tinyurl.com/EltVienna25Presentations

Lunch Menus

Monday: Koinonia — Währinger Str. 151

1. **Sushi Bento** [ABDN] – 5 pcs sushi, sashimi, maki
2. **Sushi Set** [BD] – 5 pcs sushi, 3 pcs maki
3. **Maki Bento** [DN] – assorted makis
4. **Luxury Bento** [ABDFN] – 5 pcs sushi, tempura, glass noodles with beef and vegetables
5. **Bulgogi Bento** [ADFN] – marinated beef finely grilled, and 2 pcs sushi, 3 pcs maki
6. **Salmon Teriyaki Bento** [ADFN] – grilled salmon with vegetables and 2 pcs sushi, 3 pcs maki
7. **Chicken Teriyaki Bento** [ADFN] – grilled chicken with vegetables and 2 pcs sushi, 3 pcs maki
8. **Yaki Soba** [AFN] – noodles with chicken and finely fried vegetables
9. **Ramen** [ACF] – noodle soup with chicken, egg
10. **Duck** [AFN] – crispy fried duck with vegetables and teriyaki sauce

Tuesday: Centimeter — Gersthofer Str. 51

1. **Wiener Schnitzel** [ACM] – From chicken, with homemade potato salad
2. **Cheeseburger** [ACGM] – With French fries and smoky BBQ sauce
3. **Cheese Dumplings (Käsespätzle/Nockerl)** [ACGM, vegetarian] – With roasted onions and green salad
4. **Crispy Chickpea Balls** [AFMN, vegan] – On mixed salad with avocado and olives

Wednesday: Pizza — at the Observatory

Declared Allergen Information

A – Cereals containing gluten (wheat, rye, barley, oats, spelt, etc.)
B – Crustaceans (e.g., shrimp, crab) and products thereof
C – Eggs and products thereof
D – Fish and products thereof
F – Soybeans and products thereof
G – Milk and lactose
M – Mustard and products thereof
N – Sesame seeds and products thereof

Schedule for Monday, 22 September

10:00	Coffee	
10:40	Kieran Leschinski	Logistics
11:00	Joël Vernet	ELT Overview
11:20	Mario van den Ancker	From Dust to Planets: New Perspectives on Transition Disks with ELT Observations
11:40	Ric Davies	MICADO: The Start of Integration
12:00	Stefan Gillessen	Gas, Stars and Black Holes Around Sgr A* with MICADO
12:20	Lunch at *Koinonia*	
14:00	Carmelo Arcidiacono	MORFEO Overview
14:20	Giorgia Girardi	HIEROs: Characterizing Dust-Obscured Galaxies in the Early Universe
14:40	Letizia Scaloni	Galaxy Structures and Stellar Population Properties with MICADO & MORFEO
15:00	Violeta Gámez Rosas	A catalogue of absolute spectral-flux calibrators for VLTI/MATISSE and future IR instruments
15:20	Coffee	
16:00	Practical Session HS: Beginners SE1: Advanced (Introduction)	

19:00 Conference Dinner at *Einstein*

Koinonia: Währinger Straße 151 (see map)
Einstein: Rathausplatz 4

Schedule for Tuesday, 23 September

09:00	Alessandro Marconi	Introduction to ANDES: Scientific
09:20	Livia Origlia	Introduction to ANDES: Technical
09:40	Erik Zackrisson	High-Redshift Science with ANDES
10:00	Chiara Selmi	High-Contrast Exoplanet Imaging with ANDES
10:20	Coffee	
11:00	Roser Pelló	MOSAIC for the ELT: Current Status
11:20	Mathieu Puech	MOSAIC: Scientific Contributions
11:40	Nicolas Laporte	Protoclusters at High Redshift with MOSAIC
12:00	Davide Savio	Unveiling the Mysteries of Modal Noise
12:20	Lunch at *Centimeter*	
14:00	Panel Discussion	(all instrument representatives)
	"What keeps me awake at night…"	
15:00	Coffee	
15:30	Practical Session	
	HS: Beginners	
	SE1: Advanced ("Hackathon")	

20:00	**Observatory tour (telescope, museum, drinks?)**

Centimeter: Gersthofer Straße 51 (see map)

Schedule for Wednesday, 24 September

09:00	Wolfgang Brandner	METIS Overview
09:20	Iain Hammond	Protoplanets with METIS
09:40	Cade Bürgy	Terrestrial-Planet forming regions of discs with METIS
10:00	Danny Gasman	Uncovering the Structure of Circumplanetary Disks using CO Profiles Observed with METIS
10:20	Coffee	
11:00	Frédéric Merlin	Solar System Investigation Using ELT-MICADO
11:20	Camille Chatenet	Trans-Neptunian Objects with MICADO
11:40	Gabriele Cugno	Circumplanetary Disks and Moon Formation
12:00	Wolfgang Brandner	Science with the ANDES K-Band Spectrograph
12:20	Lunch (pizza)	
14:00	Practical ScopeSim Session + Helpdesk HS: Imaging SE1: Spectroscopy	

Joël Vernet **ESO**
ESO

ELT Overview

Mario van den Ancker **ESO**
ESO

From Dust to Planets: New Perspectives on Transition Disks with ELT Observations

Transition disks represent a brief but crucial stage in disk evolution, when protoplanetary material is being cleared and the first planetary systems may be emerging. With the unprecedented angular resolution and sensitivity of the Extremely Large Telescope (ELT), we will be able to probe structures of these systems such as cavities, spirals, and asymmetries that trace the interplay between gas, dust, and young planets. I will discuss the new possibilities which the first generation of ELT instruments will offer for observing transitions disks, including the peculiar case of HD 152384, alongside comparisons with well-studied disks such as β Pictoris and HD 141569. These cases illustrate the diversity of morphologies seen in transition disks and highlight the role of dynamical clearing, dust grain growth, and residual accretion in shaping their evolution.

Ric Davies
MPE Garching

MICADO: the start of integration

Stefan Gillessen
MPE Garching

MICADO

Gas, stars and black holes around Sgr A* with MICADO

Carmelo Arcidiacono
INAF Padova

MORFEO Overview

Giorgia Girardi **MORFEO**
Laboratoire d'Astrophysique de Marseille

HIEROs: Characterizing Dust-Obscured Galaxies in the Early Universe

Studies with Spitzer, JWST, and more recently Euclid have revealed a population of extremely red galaxies at $z > 3$, known as HIEROs ($H - IRAC2 > 2.25$), which are typically missed by UV-based Lyman-break selections due to heavy dust obscuration. In two recent works, we exploited Euclid ERO and Q1 data, combined with ancillary Spitzer observations, to identify and study HIEROs over areas of $\sim 230\,\mathrm{arcmin}^2$ and $\sim 63\,\mathrm{deg}^2$, respectively, finding thousands of candidates with stellar masses up to $10^{12}\,M_{\odot}$ and high dust attenuation ($A_V > 3$). Using the ERO data, we computed the stellar mass function at $3.5 < z < 5.5$, confirming that these sources dominate the high-mass end at $z > 3$ and are crucial to understanding early star formation. Euclid's upcoming DR1 will provide statistically significant samples of these rare objects. Their extreme properties and compact morphologies make them ideal targets for spatially resolved follow-up with ELT, particularly using MORFEO and MICADO. The unprecedented resolution and sensitivity of ELT will enable the first detailed morphological and kinematic studies of this elusive population, bridging photometric detections with the physical mechanisms driving massive galaxy formation in the early Universe.

Letizia Scaloni **MORFEO**
INAF OAS (Bologna)

Probing Galaxy Structures and Stellar Population Properties with MICADO & MORFEO: Insights from ScopeSim simulations

MICADO and MORFEO at the ELT will enable the study of galaxies on $\leq 100\,\mathrm{pc}$ scales across the entire Universe. This unprecedented spatial resolution will revolutionize our understanding of galaxy morphology and internal physics across cosmic time. Current spatially resolved studies, at kpc and sub-kpc scales, in the local Universe suggest that star formation is regulated by physical processes that could be universal across various scales. Extending such investigations to higher redshifts, especially around cosmic noon ($z \sim 1-3$), is essential to assess the role of internal morphological substructures in galaxy evolution and to identify potential quenching mechanisms.

Thanks to the exceptional sensitivity and spatial resolution of JWST, spatially resolved analyses of galaxies at these redshifts are now feasible. In this talk, I will present preliminary results from ScopeSim simulations of galaxies at cosmic noon, as they will be observed with MICADO and MORFEO. I will also compare them with JWST observations, focusing on the capability of detecting morphological features such as bars, spiral arms, and clumps, and discuss the implications for future studies of galaxy evolution with the ELT.

Violeta Gámez Rosas **METIS**
Université de Liège

A catalogue of absolute spectral-flux calibrators for VLTI/MATISSE and future IR instruments

Observing faint sources with the MATISSE instrument at the VLTI presents significant technical challenges, especially in data processing within the "correlated flux mode" that requires absolute flux calibration across the L, M and N bands in the mid-infrared. A critical limitation is often the absence of a spectral-flux calibrator in close proximity to the target. To address this, we are developing an all-sky catalogue of calibrators that spans from optical to infrared wavelengths and includes hundreds of thousands of stars. This represents a substantial expansion from our previous catalogue, which contained 464 spectra. Our approach utilises the high-precision data from GAIA DR3, incorporating the most reliable stellar parameters and apparent magnitudes from various bands from different satellites and ground-based surveys. By employing synthetic models of stellar atmospheres, we can also derive stellar radii, crucial for ensuring the accuracy of interferometric observables such as visibilities and correlated fluxes. The value of this catalogue extends beyond merely augmenting MATISSE's capability to observe its faintest targets because it is these very same faint targets that are at the *bright* end of JWST's capacity. This approach allows us to juxtapose detailed observations of astronomical objects with the highest spatial resolutions achieved in infrared wavelengths and sensitive measurements of their surroundings, offering a more complete view of these astronomical phenomena. This is especially important for the study of Active Galactic Nuclei (AGN), protoplanetary discs, and Young Stellar Objects (YSOs), for example. We foresee that the use of this catalogue will also be important for future observations with the Extremely Large Telescope (ELT), expected to see first light in the coming years.

Alessandro Marconi **ANDES**
INAF Arcetri

Introduction to ANDES, pt. 1: Scientific Overview

Livia Origlia **ANDES**
INAF Bologna

Introduction to ANDES, pt. 2: Technical Overview

Erik Zackrisson **ANDES**
Uppsala University

High-redshift science with ANDES

Through high-resolution spectroscopy of bright sources at high redshifts, ANDES will provide new constraints on cosmic reionization, the nature of the first stars and the environments of transients in the early Universe. In this talk I will review the top science cases studied by the Galaxies and Intergalactic Medium working group of the ANDES science team, and explain potential synergies between ANDES and other telescopes/instruments in the study of the high-redshift Universe.

Chiara Selmi **ANDES**
INAF – Osservatorio Astronomico di Brera

High-contrast Exoplanet Imaging with ANDES

ANDES is the ELT's instrument for very high-resolution spectroscopy at $R = 100,000$, leading to outstanding science as exo-planets' atmosphere characterization. Thanks to the combination with a SCAO system feeding the IFU coupled to the YJH spectrograph, ANDES aims at 10^{-3} of contrast at a few tens of mas from the AO reference source. The addition of a coronagraph, currently under study, will allow to push even more the contrast goal. We present the results of end-to-end simulations developed either for the evaluation of the control strategy and expected performance of the SCAO system, either for the definition of the coronagraph design and estimation of the performance gain. Concerning the SCAO simulations, we present the PSFs and contrast profiles, showing the capability to achieve contrast values up to 10^{-5} in H band and 5×10^{-5} in R band and to provide AO correction for magI > 14. Regarding the coronagraph simulations, we present the results on a science case involving young Jupiters detected via direct imaging, showing that gas giant planets with contrasts down to 10^{-7} could be detected at separations down to 30 mas. Ongoing studies will enable us to explore more challenging cases like the golden sample of exoplanets down to 15 mas.

Roser Pelló
Laboratoire d'Astrophysique de Marseille

MOSAIC for the ELT: current status

MOSAIC is the multi-object fibre spectrograph for ESO's 39-m Extremely Large Telescope (ELT). MOSAIC offers unique capabilities for a gigantic telescope in terms of multiplexing, wavelength coverage and spectral resolution. It covers the visible ($0.39-0.95$ microns) and NIR ($0.95-1.8$ microns) wavelength domains, with medium ($R\sim4000-5000$) and high ($R\sim18000$) resolving powers, respectively. It has been designed to cover the largest possible area ($\sim40\,\mathrm{arcmin}^2$) on the ELT focal plane. MOSAIC is optimised to provide maximum efficiency for surveys, and to achieve the best possible signal-to-noise ratio for the observation of the faintest sources, from stars in the local Universe to galaxies at the epoch of the reionisation. With its multi-object and multi-IFU capabilities, MOSAIC would be an ideal survey machine for following up sources discovered by current and future large facilities, such as the James Webb Space Telescope, Euclid, Roman, SKA or LISA. The presentation will focus on describing the instrument architecture, observation modes and capabilities, together with the latest updates on the project status.

Mathieu Puech **MOSAIC**
LUX – Observatoire de Paris

MOSAIC: Scientific Contributions

MOSAIC is the Multi-Object Spectrograph (MOS) for the 39 m Extremely Large Telescope (ELT) of the European Southern Observatory (ESO), with unique capabilities in terms of multiplex, wavelength coverage and spectral resolution. It is a versatile multi-object spectrograph working in both the Visible and NIR domains, designed to cover the largest possible area ($\sim 40\,\mathrm{arcmin}^2$) on the focal plane, and optimized to achieve the best possible signal-to-noise ratio on the faintest sources, from stars in our Galaxy to galaxies at the epoch of the reionization. We will review the main expected scientific contributions of MOSAIC.

Nicolas Laporte **MOSAIC**
Laboratoire d'Astrophysique de Marseille

Protoclusters at High Redshift with MOSAIC

The current paradigm of galaxy formation suggests that the first galaxies likely emerged within large dark matter haloes. The fragmentation of these massive haloes led to the formation of galaxy protoclusters, which typically consist of one or a few bright galaxies surrounded by numerous fainter, less massive objects. These early structures may have played a significant role in the reionization of neutral hydrogen during the first billion years of the Universe, especially if their number density was high. Thanks to the unprecedented sensitivity of the James Webb Space Telescope (JWST), galaxy protoclusters are now being detected at redshifts as high as $z = 10.6$. However, obtaining comprehensive spectroscopic follow-up across a broader field of view than the JWST can offer remains a challenge beyond the capabilities of current $8-10\,$m class telescopes. The advent of the first Extremely Large Telescopes (ELTs) in the next decade will revolutionize our understanding of these primordial structures, enabling confirmation of their nature, probing metal distributions within protoclusters, and investigating the properties of the brightest galaxies in the protocluster cores, as well as their spatial extent. In this talk, I will present an overview of protoclusters at $z > 7$ (up to $z \sim 11$) identified in JWST data, along with recent spectroscopic follow-up observations using ground-based telescopes (e.g., VLT and Keck) and JWST. Additionally, I will share preliminary results on the distribution of galaxies from the first deep JWST surveys. Finally, I will highlight a use case study involving the new MOSAIC/ELT architecture, focused on one of the protoclusters identified by JWST.

Davide Savio **ANDES**
INAF–Osservatorio Astrofisico di Arcetri

Unveiling the Mysteries of Modal Noise: From Laboratory Experiments to Simulations and Scientific Impact on ANDES/ELT

Modal noise is a common, yet often underestimated, source of systematic errors introduced by optical fibres, and is particularly relevant for fibre-fed spectroscopic instruments, especially those designed for high-resolution spectroscopy. I will introduce the physical principles behind modal noise and explain why it represents a serious challenge for modern astronomical instrumentation. I will then present results from our laboratory tests using different fibre types and configurations, providing insight into the empirical behaviour of modal noise under various conditions. Starting from these results I developed a simulation tool that reproduces modal noise consistent with both laboratory data and real instruments like GIANO. This tool is integrated into an end-to-end simulator for the upcoming ANDES spectrograph at the ESO-ELT, to evaluate its expected performance, particularly for its flagship science case: the precise atmospheric characterisation of Earth-like exoplanets. I will demonstrate how modal noise impacts high-resolution spectroscopy if not properly mitigated, and discuss detectability limits emerging from my simulations.

Wolfgang Brandner **METIS**
MPIA Heidelberg

METIS Overview

Iain Hammond **METIS**
MPIA Heidelberg

Protoplanets with METIS: Strategy and Predictions for First Light

Many protoplanets are inferred to exist due to the presence of substructures in protoplanetary discs. While we have observed a handful of confirmed protoplanets, many others remain ambiguous or undetected due to disc contamination, sensitivity or bright speckle noise. The angular resolution and sensitivity of the ELT will revolutionise our view of protoplanets, enabling confirmation, detection of emission lines and characterisation of protoplanets in gaps. I will present our state-of-the-art imaging techniques for discs, as learnt by current-generation instruments, and our selected first-light targets for the protoplanets reference program with METIS. I will also present ScopeSim predictions in HCI mode of discs, produced with hydrodynamical simulations coupled to radiative transfer, to provide a first estimate of METIS performance in the context of protoplanet detection.

Cade Bürgy **METIS**
MPIA Heidelberg

A preview onto the scientific potential of METIS: Zooming into the terrestrial-planet forming regions of discs

In recent years, (sub-) mm studies have revealed in-depth information about the composition and structure of gas in protoplanetary disks. However, these studies are limited to the outer disk ($> 10\,$au) due to limited angular resolution, leaving out the regions where the bulk of planets are being formed. Observations in the infrared on the other hand probe warm gas in the inner terrestrial-planet forming region, enabling its chemistry and kinematics to be revealed. Such regions will be directly mapped with the ELT, for example with METIS. Building towards this goal, we conducted a high-resolution spectroscopic survey of transition disks using CRIRES+ in the M-band. In this talk, I will present the first results of our survey probing the CO emission in the inner regions of those disks likely shaped by giant planets. We study the resolved line profile and reconstruct its emission region accounting for contributions from a range of radii and temperatures. This reveals emission down to sub-au scales, and allows us to kinematically distinguish between disk or wind contributions. Combining the analysis of the resolved line profile with its spectro-astrometric signature, we can spatially map the emitting region, and constrain its radial temperature structure, a first step for further thermo-chemical modelling of the inner disk. This study forms a critical step toward making predictions for the first-light observations with ELT instruments.

Danny Gasman **METIS**
MPIA Heidelberg

Uncovering the structure of circumplanetary disks using CO line profiles observed with METIS

The 40-m diameter mirror of the ELT will provide unprecedented spatial resolution and sensitivity. This opens up the possibility to characterise a lesser-studied class of objects: protoplanets. Studying planets as they are forming will provide invaluable insights into the link between the protoplanetary disk and the resulting planet. The direct connection between the two is likely visible in the circumplanetary disk (CPD); the disk of material a planet gathers around itself, akin to a miniature protoplanetary disk. Since these objects are typically relatively close to the central star, the spatial resolution of the ELT is required to separate the host from the secondary. Furthermore, infrared wavelengths are where planets and disk are brightest, meaning METIS is the best instrument for the job. The high spectral resolution of the IFU, covering the CO ro-vibrational modes, combined with the improved sensitivity, will allow us to, for the first time, characterise the structure of the CPDs. By decomposing the velocity components of the CO emission, we can infer the presence and size of an inner cavity. In turn, this information can provide the distinction between accretion scenarios, or perhaps even the presence of proto-moons.

Frédéric Merlin **MICADO**
LIRA – Obervatoire de Paris – UPC

Solar system investigation using ELT-MICADO

Observations of the various populations of the solar system have already provided clues about the formation and evolutionary processes that led to its current architecture, as well as the variability of its composition, which depends mainly on the heliocentric distance and the size of the objects. Previous analyses, based on telescopes up to 8 meters, have also provided in-depth information on the evolution and chemical composition of many objects in the solar system. However, many questions from the decadal survey remain unanswered and will be investigated using the capabilities of the ELT, which combines high spatial and spectral resolution. The presentation will focus on the different classes of objects from which new-generation instruments, such as MICADO, will be able to answer these current questions. This concerns the chemistry of the asteroids, of the giant planets and their satellites, as well as those of the cold and distant minor bodies such as Centaurs and trans-Neptunian objects, from which the JWST has obtained groundbreaking information, opening up important new questions. All these different cases require extensive simulations to study the limitations of these imaging and spectroscopy studies for which ScopeSim was designed.

Camille Chatenet **MICADO**
UTINAM, Besançon

Trans-Neptunian Objects with MICADO

The Transneptunian objects (TNOs) are small bodies orbiting beyond the orbit of Neptune. Currently, about 4,000 are known, some of which are multiple systems (binaries for example). Astrometric observation coupled with the dynamic studies of these multiple systems allows constraining the mass and density of these objects. Thus, studies of their composition are possible. Transneptunian objects having changed little since their formation, such results would provide a better understanding of the primordial Solar System. MICADO (Multi-AO Imaging Camera for Deep Observations) will be mounted on the Extremely Large Telescope (ELT), the new European Southern Observatory (ESO) telescope, currently under construction on Cerro Armazones (Chile). It will deliver unparalleled performance, especially regarding astrometric resolution in the near-infrared.

I will present how simulation tools such as ScopeSim can generate synthetic populations of transneptunian multiple systems, incorporating realistic distributions for orbital separation, orientation, morphology, component mass ratios, and apparent magnitudes. These simulations can further be used to optimize future observational strategies, particularly for binary TNOs.

Gabriele Cugno **METIS**
University of Zürich

Circumplanetary Disks and Moon Formation

Moon formation has, until now, been explored almost exclusively through theory and simulations, as direct observations of circumplanetary disks (CPDs) – the cradles of moon systems – are challenging due to the angular resolution and contrast requirements, and the limited atmospheric throughput at mid-infrared wavelengths. JWST has opened a new window onto CPDs around widely separated planetary-mass companions, yet disks orbiting protoplanets on Solar System scales, like PDS 70 c, remain beyond reach. The upcoming Extremely Large Telescope (ELT) will push these boundaries further, though wavelength coverage and throughput will still challenge CPD characterization. In the future, the most powerful approach will likely combine lessons from JWST's studies of wide-orbit companions with ELT's insights into protoplanets, providing the most complete picture of CPDs to date.

In this talk, I will review the latest insights from JWST and ALMA, and highlight the unique capabilities ELT instruments will bring to this field. I will focus on two key diagnostics, dust evolution via silicate features and molecular gas chemistry, that together hold the clues to the ultimate architecture of moon systems.

Wolfgang Brandner **ANDES**
MPIA Heidelberg

Science with the ANDES K-band spectrograph