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Report on the ESO workshop

Galaxies at Crossroads: Outflows and IMF in the VLT/ELT/ALMA/JWST Era

held at Brno Observatory and Planetarium, Czech Republic, 16–20 September 2024

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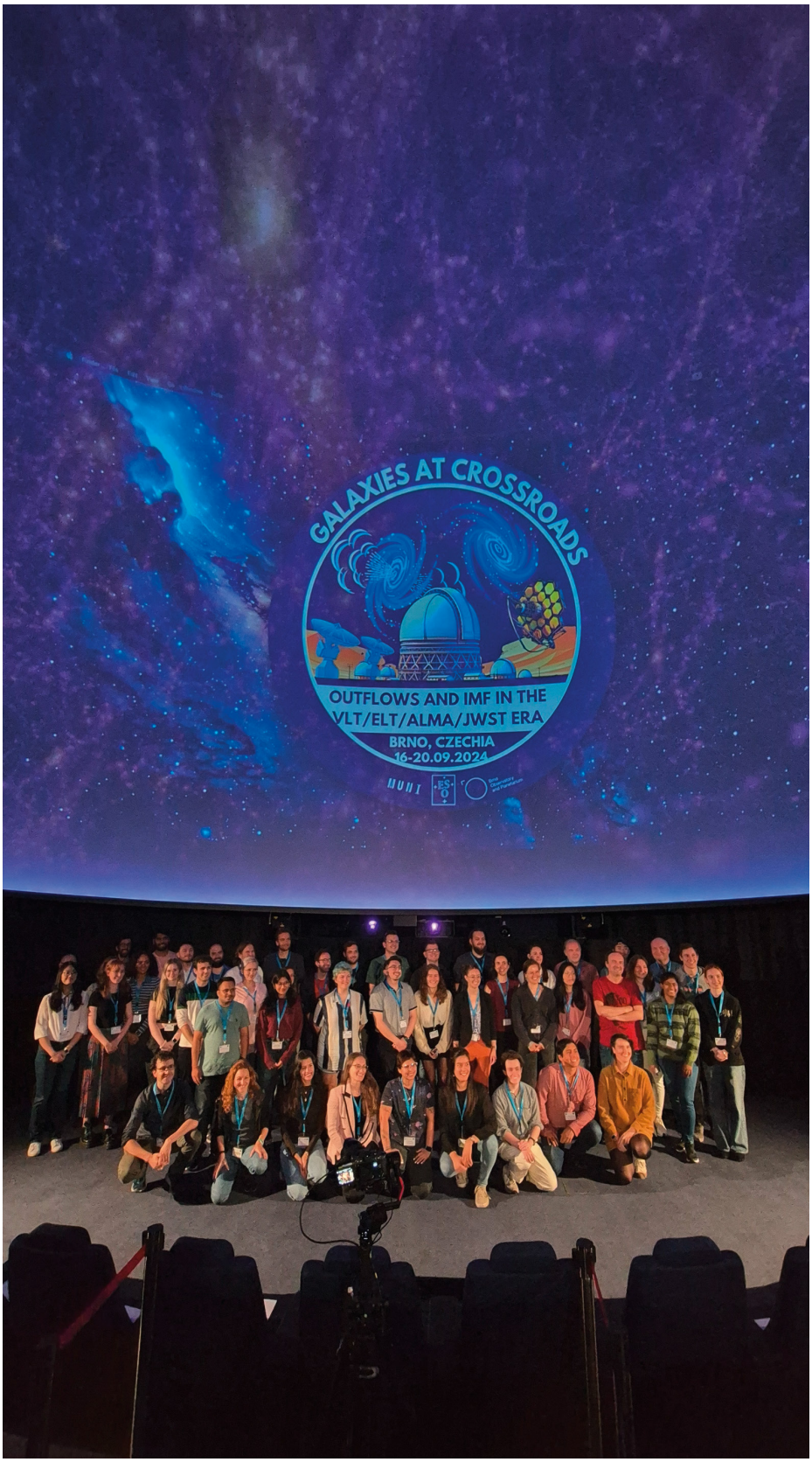
The international workshop Galaxies at Crossroads gathered a diverse group of researchers to address pivotal themes in galaxy evolution, including galactic outflows, the stellar initial mass function, and the mass-metallicity relation. Hosted in collaboration with Masaryk University, the event featured a robust scientific programme complemented by interactive activities, emphasising collaboration and fostering early-career participation. The location in Brno, close to the University of Vienna and the Institute of Science and Technology Austria, provided an ideal and sustainable meeting point in central Europe, easily accessible by train. This report highlights the science, the participant statistics, and how effective it can be when workshops are organised outside of ESO to foster stronger interactions between the community and ESO.



Brno Planetarium

Figure 1. Conference photo.

Motivations

The workshop was driven by the need to address pressing questions in galaxy evolution from different angles and to foster collaboration across different extragalactic research domains. ESO's strategic focus on supporting Member States and strengthening regional scientific communities was central to its objectives.

A major theme of the meeting was bringing together experts on three interconnected yet expansive topics: galactic outflows, the stellar initial mass function (IMF), and chemical evolution. Each of

these areas is often the focus of separate conferences, but this workshop sought to foster interactions among experts across these fields. A particular emphasis was placed on bridging observational and theoretical perspectives, uniting observers, simulators, and theorists to encourage cross-disciplinary dialogue.

Additionally, the workshop aimed to enhance engagement in the central Europe region, which hosts rapidly growing research institutes, and to strengthen ties with ESO and ALMA science. Brno, strategically located between the capital cities Prague and Vienna, served as an accessible and sustainable venue, reinforcing ESO's commitment to supporting research in Member States.

Summaries of talks and highlights from sessions

A major theme of the meeting was to set the stage for collaborative discussions across fields that are often tackled independently. The programme[1] included:

- Setting the Scene: the workshop opened with an overview of active galactic nuclei (AGN) and the Czech Space Telescope QUVIK, presented by Michal Zajacek, followed by Pavel Jachym's update on ALMA science, Czech ALMA Node activities, and jellyfish galaxies. Participant introductions fostered by noughts-and-crosses-style activities (a variation of bingo, which proved to be a great success) during the welcome drinks reception created an engaging atmosphere for networking. The goal was to create an environment in which it was easy to engage with new people, ensuring that participants from three different astronomy fields had the opportunity to connect beyond their usual circles.
- Galactic Outflows: the second day began with Barbara Mazzilli Ciraulo's highlight talk on cold outflow filaments in Generalising Edge-on galaxies and their Chemical bimodalities, Kinematics and Outflows out to Solar environments (GECKOS) winds, followed by Alejandro Olvera's exploration of gas flows in NGC 99. Other highlights included Bronwyn Reichardt Chu's discussion of star formation-driven outflows and Archana Aravindan's focus on AGN-driven outflows in dwarf galaxies. An invited talk by Jorryt Matthee presented future prospects for spectroscopic observations of galaxies in the first Gyr, followed by group discussions led by Filipo Fraternali, Antonino Marasco, Ivanna Langan, Bronwyn Reichardt Chu, and Matej Barta.
- Initial Mass Function (IMF): day three featured invited talks by Zhiqiang Yan on chemical tracers for constraining the IMF and Alina Boeker on observational and simulation-based IMF studies. Highlights included Ankur Upadhyaya's evidence for very massive stars in UV-bright galaxies and Prasad Sawant's unveiling of baryon cycles in $z \sim 5$ galaxies. The discussion session was organised by Ignacio Martin Navarro, Marie Zinnkann, Andrew Hopkins, and Glenn van de Ven, fostering interaction between theorists and observers.
- Mass-Metallicity Relation (MZR): the fourth day began with keynote speaker Allison Strom, who re-examined metallicity through chemical abundance patterns in distant galaxies. Additional highlights included Dirk Scholte's analysis of transitions in the baryon cycle and Gauri Kotiwale's work on galaxy metallicity at the epoch of reionisation. Discussions were facilitated by Belen Alcalde, Zhuang Zhuyun, Gauri Kotiwale, and Ivanna Langan, focusing on integrating observational and theoretical perspectives.
- Final Day Discussions: the workshop concluded with X-ray astrophysics highlights, including talks by Julia Falcone on Seyfert galaxy feedback and Michal Zajacek on ultrafast outflows. Norbert Werner introduced high-energy astrophysics research being conducted at Masaryk University. This was followed by a short wrap-up discussion involving the Scientific Organising Committee and participants, and a planetarium show highlighting synergies between high-energy astrophysics and galaxy evolution research.

Interactive and collaborative activities

The workshop was designed to ensure active engagement and discussions:

- Session Structure: sessions were carefully timed to allow a focus on each presentation, with sufficient breaks to prevent fatigue. This 'light' programme gave participants time to properly digest the talks and engage in meaningful discussions during the breaks and dedicated discussion sessions. The use of different talk lengths — from longer keynote presentations to concise five-minute contributed talks — helped strike a balance between giving space to key topics and allowing more contributors to present their work. In particular, the concise talks proved effective for conveying key science messages and essential details. This approach was inspired by the Lorentz Center workshop "Gravitational waves: a new ear on the chemistry of galaxies" (29 April – 3 May 2024)[2] which demonstrated the value of varying talk formats to maintain engagement while maximising impact. Unlike programmes packed with numerous talks, which can leave attendees drained and skipping sessions, this structure encouraged full participation. It was fantastic to see that everyone stayed engaged throughout, creating a vibrant atmosphere for experts from varied fields to interact and collaborate effectively.
- Discussion Sessions: each scientific topic was paired with a dedicated discussion session. Participants were divided into groups based on career stage and expertise to ensure balanced representation, while other discussions involved all attendees using online tools for real-time voting and comments.
- Group Summaries: after group discussions, joint sessions were held, with early-career researchers bravely presenting their group's findings, fostering inclusivity and confidence.

Main conclusions and ways forward

The workshop achieved its goals of fostering collaborations and advancing discussions on galaxy evolution. Plans to build synergies across related fields were emphasised, as this approach is essential for understanding the full picture, particularly in the context of growing synergies between facilities, such as the JWST, the Atacama Large Millimeter/submillimeter Array, and ESO's upcoming Extremely Large Telescope (ELT). Strengthened networks among early-career researchers were another significant outcome, with mentorship opportunities fostering

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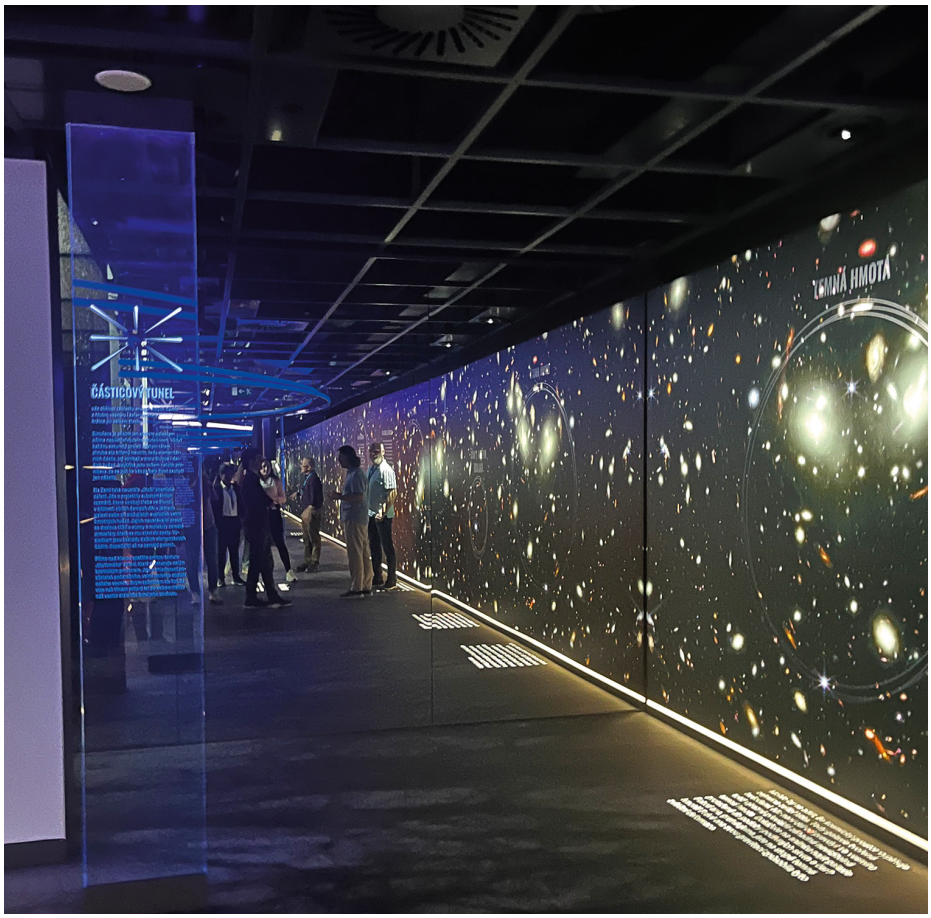

Figure 2. This image is from a sneak preview we received of the exhibition prepared by the Brno Planetarium staff, showcasing their exceptional work and support during the workshop.

inclusivity and development. It was particularly rewarding to witness exceptional collaboration across fields and between early-career and senior scientists. The group dynamics were notably enriched by diverse discussion formats, including small group splits and online tools that allowed anonymised audience input in real time. Additionally, the event fostered new connections between Czech and Austrian institutes, laying the groundwork for future collaborations. Recorded talks and presentations are available on YouTube[3], and are accessible on Zenodo[4]. This workshop exemplifies the potential for similar collaborative efforts, especially in preparation for the ELT and other next-generation observatories.

Demographics

The Scientific Organising Committee sought fair representation from the community. Invited speakers were selected to represent a balance of career stages and scientific expertise. The final programme included 47% female and non-binary participation, aligning with the proportion of female and non-binary participants at the workshop. Additionally, over 70% of attendees were students and postdoctoral researchers, reflecting ESO’s emphasis on fostering the next generation of astronomers. Early-career researchers also contributed as session chairs and discussion leaders, showcasing their leadership potential.

Participants (Figure 1) came from over 20 countries, with notable contributions from ESO Member States and partner institutions. The breakdown of participants by region was:

– 65% from Europe (notably Germany, Italy, Czech Republic, Austria, France, and Spain),
– 15% from North America (USA and Canada),
– 10% from Asia (including China and India),
– 5% from South America (notably Chile and Brazil), and
– 5% from Australia.

The distribution highlights strong engagement from European institutions, with a growing presence from North America and Asia, reflecting the international appeal of the workshop. To further promote inclusivity, pronoun stickers were introduced, allowing participants to display their preferred pronouns on their badges. This initiative, which aimed to create a welcoming environment for all attendees, has since been adopted by other ESO workshops, underscoring its positive impact.

Acknowledgements

The organising committee extends its gratitude to ESO for funding and workshop support, and to the ESO Workshop Selection Committee for endorsing this event. Special thanks go to the Planetarium in Brno[5] for providing an exceptional venue and outstanding technical assistance, which were critical to the workshop’s success (Figure 2). The event also benefitted greatly from the contributions of local students, postdocs, and staff members who provided invaluable support with the organisation. We acknowledge Masaryk University for its collaborative efforts in hosting the workshop. Finally we thank all participants for their inspiring attitude and openness to collaborations and we thank all invited speakers.

Links

[1] Link to workshop programme: https://www.eso.org/sci/meetings/2024/galcross/programme.html
[2] Lorenz Center Workshop: https://www.lorentzcenter.nl/gravitational-waves-a-new-ear-on-the-chemistry-of-galaxies.html
[3] Recorded presentations: https://www.youtube.com/playlist?list=PL-7vLpk0VDrILpaZsWQNntDLVmHav1G7U
[4] Presentations on Zenodo: https://zenodo.org/communities/galcross2024/records?q=&l=list&p=1&s=10&sort=newest
[5] Brno Planetarium webpage: https://www.hvezdarna.cz/en/