

Report on the ESO Workshop

Galspec21: Extragalactic Spectroscopic Surveys: Past, Present and Future of Galaxy Evolution

held online, 12–16 April 2021

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In April 2021 more than 200 participants gathered on Zoom for a meeting to discuss what we have learned about galaxy evolution using spectroscopic surveys, and to pay a special tribute to the Visible Multi-Object Spectrograph (VIMOS), which carried out some of the largest spectroscopic galaxy surveys to date and helped to pave the way for ongoing and future facilities. Despite being delayed twice and having to be adapted to an online format, the meeting was well received and many high-impact results were presented by a diverse body of participants. We present the organisation, lessons learned, and legacy of this workshop.

Motivation

Our understanding of galaxy evolution has changed dramatically in the last decade. One of the main advances has undoubtedly been the emergence of both large-scale and and/or deep surveys with multi-object spectrographs (MOS) and integral field units (IFU). These vast datasets have brought into focus the complex interplay between the ages, metallicities and kinematics of galaxies, as well as their masses, sizes, structures, nuclear activity and environments. Still, many open questions remain.

At the end of March 2018 the Visible Multi-Object Spectrograph (VIMOS), one of ESO's workhorses in Paranal observatory, was decommissioned from Unit Telescope 3 after nearly 15 years of service. During this time, VIMOS had amassed over 9700 hours of science data, mostly devoted to spectroscopic surveys of galaxies across cosmic time. To commemorate this milestone, we thought it appropriate to celebrate the achievements of this amazing instrument with a five-day workshop. The goal of this ESO workshop was also to bring

together the low- and high-redshift extragalactic communities to review where we stand and prepare for the challenges ahead.

Run-up

We settled on a date in late 2019, to give the largest and latest VIMOS surveys (the Large Early Galaxy Astrophysics Census [LEGA-C] and VANDELS) enough time to produce some early scientific results using their final datasets and to present to the broader extragalactic community the vast set of raw and enhanced data that both surveys had publicly released. The date also coincided excellently with the planned arrival at ESO of new MOS facilities, such as the Multi-Object Optical and Near-infrared Spectrograph (MOONS) in 2021 and the 4-metre Multi-Object Spectroscopic Telescope (4MOST) in 2022, and elsewhere, such as the Multi-Espectrógrafo en GTC de Alta Resolución para Astronomía (MEGARA) at the Gran Telescopio Canarias and the WHT Enhanced Area Velocity Explorer (WEAVE) at the William Herschel Telescope. Further MOS and IFU instruments for future 30–40-metre-class telescopes are also appearing on the horizon, such as the Multi-Object Spectrograph for Astrophysics, Intergalactic medium studies and Cosmology (MOSAIC) and the High Angular Resolution Monolithic Optical and Near-infrared Integral field spectrograph (HARMONI) at ESO's Extremely Large Telescope, the Wide-Field Optical Spectrometer (WFOS) and the InfraRed Imaging Spectrograph (IRIS) at the Thirty Meter Telescope and the GMT Multi-object Astronomical and Cosmological Spectrograph (GMACS) and GMT Consortium Large Earth Finder (G-CLEF) at the Giant Magellan Telescope.

In June 2018 ESO approved financial support for our proposed workshop entitled Extragalactic Spectroscopic Surveys: Past, Present and Future of Galaxy Evolution (GalSpec19), to be hosted at the ESO offices in Vitacura, Santiago, Chile in November 2019.

We received well over 100 excellent abstracts, and the scientific organising committee (SOC) put together a well

rounded programme. By mid-October 2019 everything was set for a successful workshop, bringing together experts from all over the globe to discuss the latest and most exciting results.

However, around this time a wave of social unrest in Chile began. The associated protests worried many workshop participants, so to avoid cancellations it was decided to postpone the meeting until a later date, aiming for March/April 2020, hoping that the unrest would have subsided by then. After checking with the registered participants, we decided to keep the same programme and the same participants, so Galspec19 became Galspec20, and we decided to hold it in October 2020 to avoid direct competition or overlap with other meetings.

We updated websites and started advertising the new dates. We had of course heard in the news that there was a new virus spreading, but like everybody else we did not make much of it at first, so we started replanning the workshop. Before we had even sent out anything concrete, however, the COVID-19 pandemic had reached Chile in full swing and by mid-March it was getting less and less likely that we could confidently plan a (in-person) meeting for October, with the observatory and much of the country going into lockdown, and no possibility of making a decision in May or June. Instead, we decided to postpone the workshop once again and within a few months decided to aim for April 2021 for one last try at hosting this workshop, ideally in person but with the possibility of holding it online or elsewhere (Garching, for example) if the pandemic would not allow a meeting in Santiago. And so Galspec20 became Galspec21.

By then the original workshop had been delayed by more than 18 months. As that would mean that the programme and talks would be quite outdated, we decided to start from scratch with a new abstract deadline in December 2020 and a final decision on whether the workshop would be held in person or virtually at around the same time. As the pandemic rolled on, we decided in November to hold the meeting online, with a reduced, half-day schedule. However, to allow additional talks we decided to try a



Figure 1. The Galspec21 workshop poster.

mixed scheme in which each session additionally featured several pre-recorded talks that participants could watch at their leisure, with discussion on these talks on Slack, along with long (~ 45 minutes) poster sessions on the video chat platform Gather, to allow as much personal interaction between participants as possible. The advantage of this setup was that the financial support provided by ESO more than covered the costs of the entire workshop, so registration was free for all participants. As travel costs also did not have to be covered, we received more than 140 abstracts for ~ 50 talk and ~ 50 poster slots and more than 250 registrations. We even had to close registration to avoid the workshop's becoming too big to handle, as we wanted the in-person contact to be an important element of the meeting, including discussion and Q&A sessions and person-to-person interaction during our poster sessions. Figure 1 shows the workshop poster.

Workshop and Legacy

Finally, in the second week of April 2021 and after 3 years of planning, up to 250 participants logged into our Zoom

sessions, our Slack channels, and Gather for our poster sessions in a meeting that covered a wide range of topics:

- Stellar Populations and Star Formation History
- Stellar and Gas Kinematics
- Environment and Intergalactic Medium
- Star Formation and Interstellar Medium
- Upcoming Instrumentation

All contributions to the workshop were excellent; picking out one or two highlights would not do the other contributions justice and would present a very biased view. However, all talks (except for the discussion sessions) have been recorded and are available on YouTube¹, posters and talk slides have all been uploaded to Zenodo², and additional information is available on our website³.

The talks given and the posters presented highlighted well that not only did VIMOS work efficiently as a redshift machine (see VIPERS, z-COSMOS, VVDS, VANDELS, and other surveys), but was also extremely successful as an instrument used to derive properties of galaxies (see, for example, Sessions 1, Stellar Populations and Star Formation History, and 2, Stellar and Gas Kinematics) and to study the influence of environment on galaxy properties and active galactic nuclei (see, for example, Sessions 3, Environment and Intergalactic Medium, and 4, Star Formation and Interstellar Medium). VIMOS has left behind a vast dataset on the ESO archive, which will allow further studies to be carried out for years to come.

However, as well as VIMOS data, results using other instruments were also discussed during all the sessions. The Multi Unit Spectroscopic Explorer (MUSE) featured prominently as an instrument well suited for galaxy surveys, and results from the Atacama Large Millimeter/submillimeter Array (ALMA), the *K*-band Multi Object Spectrograph (KMOS) and other instruments were also discussed. These, and other upcoming instruments (see Session 5, Upcoming Instrumentation) will help us to answer outstanding questions in galaxy evolution. Important advances on future key issues were already presented during the workshop:

- How do gas and stellar kinematics evolve with redshift?

- How do gas accretion and outflows shape galaxy properties?
- Are rotation curves flat or declining at $z > 1$?
- How does environment impact the formation and evolution of galaxies?
- What is the redshift evolution of galaxy properties and scaling relations?
- How are metals distributed in galaxies and how are they modulated by accretion of gas, outflows, feedback and star formation?

The workshop was an excellent example of why we need these workhorse instruments on large telescopes to carry out large surveys of statistically significant samples over a large range of redshifts. Luckily, the next generation of such instruments, for example 4MOST, MOONS and the blue-optimised integral-field spectrograph BlueMUSE in the case of ESO instrumentation, and the next generation of dedicated survey telescopes (for example the Simonyi Survey Telescope at Vera C. Rubin Observatory, the EUCLID space telescope and others) are already well advanced or in development. They will be starting to take data in the coming years, opening yet another window onto the distant Universe, with even larger statistical samples and more interesting science to be done.

Demographics

Although it is hard to tell who actually participated in which sessions during an online meeting, the 251 registered participants signed up from 26 different countries from all continents (48% Europe, 21% South America, 13% North America, 10% Asia, 7% Australia, and two participants from Africa; see Figure 2). Of the 142 abstracts received, 64 (45%) were submitted by women, 78 (55%) by men, 40 (28%) by students, 50 (35%) by postdocs/fellows, and 52 (37%) by senior astronomers. Thanks to our amazing SOC, these fractions are nearly exactly represented in the 96 poster and talk contributions to the workshop (see Figures 3 & 4): 44 (46%) by women, 52 (54%) by men, 28 (29%) by students, 39 (41%) by postdocs/fellows, 29 (30%) by senior astronomers. Four out of the eight invited talks were given by women.

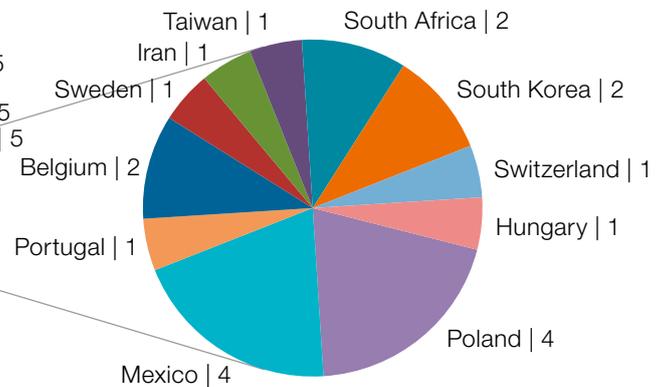
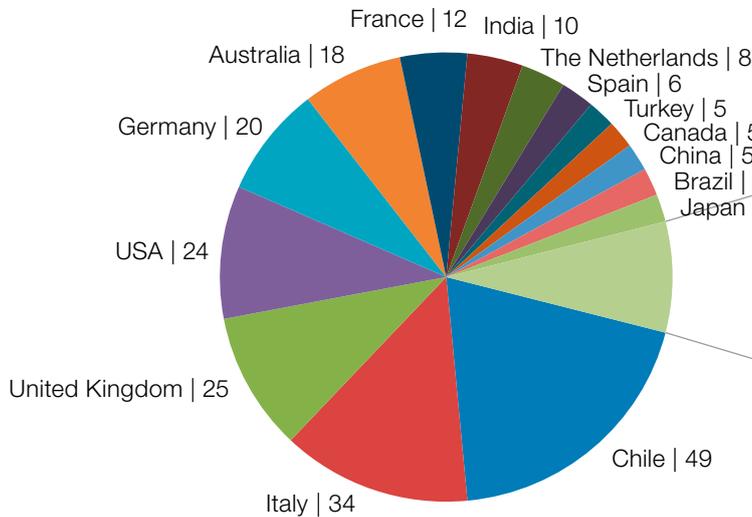
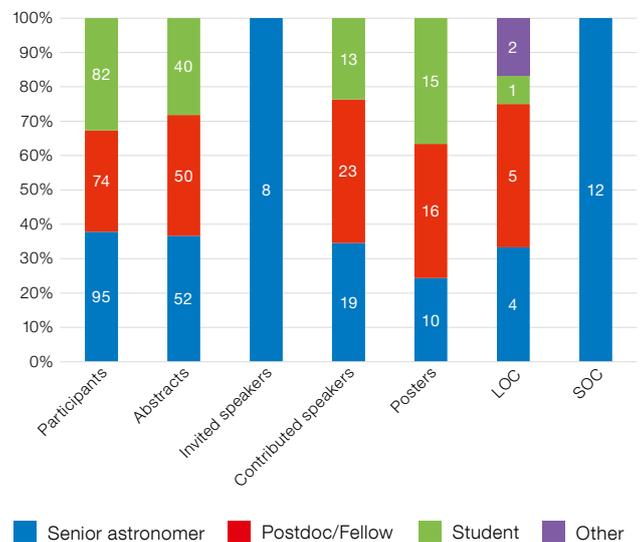
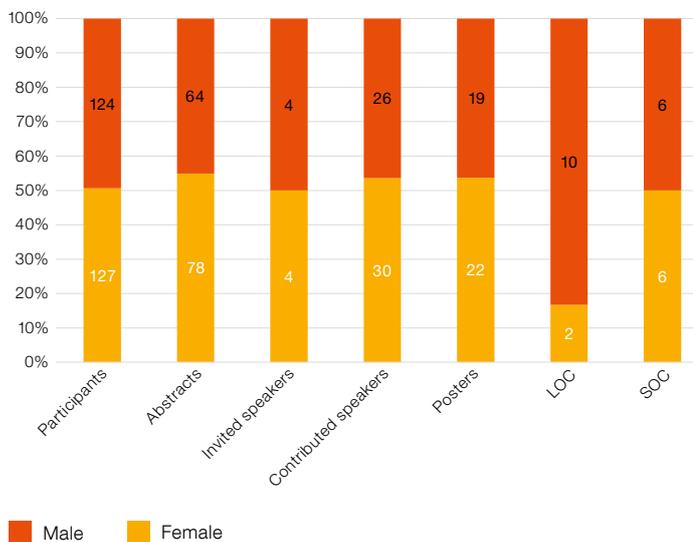


Figure 2. (Above) These pie charts show the countries hosting the workshop participants.

Figure 3. (Below left) Gender balance of presenters (talks and posters), which very closely resembles the gender distribution in the abstracts submitted.

Figure 4. (Below right) Distribution of seniority of presenters (talks and posters), which very closely resembles the distribution in the submitted abstracts.



Main conclusions & ways forward

Overall, we found that the online setup of the workshop worked surprisingly well, and we can recommend a similar combination of tools for other workshops that are held online in the future. We found, however, that it was critical to have very long poster sessions on Gather (see Figure 5) despite the half-day schedule of the meeting, in order to foster in-person contact and trigger discussion. This

seemed to work very well, although it certainly required some getting used to. We had also outsourced the video editing for YouTube, which could in principle have been done by one of us but would have been a full-time job. The company we used was superb and got all talks online within a few hours, despite its being the end of the day at their location, so people around the world could watch them before we even met for the following day.

Acknowledgements

Throughout these troublesome times and multiple re-starts of the organisation, the support from everybody was outstanding. Our SOC stayed together and everybody was happy to contribute despite being thrown around by us and the pandemic. Nearly all of our invited speakers were also happy to give their talks, despite our significantly changing their scope, given the reduced, half-day, schedule. The support from ESO, both in Chile and Garching, was also great throughout this time. Our funding was flexible enough to be moved by two (!) financial years, while Claudio Melo (the ESO representative in Chile at the time) and Rob Ivison

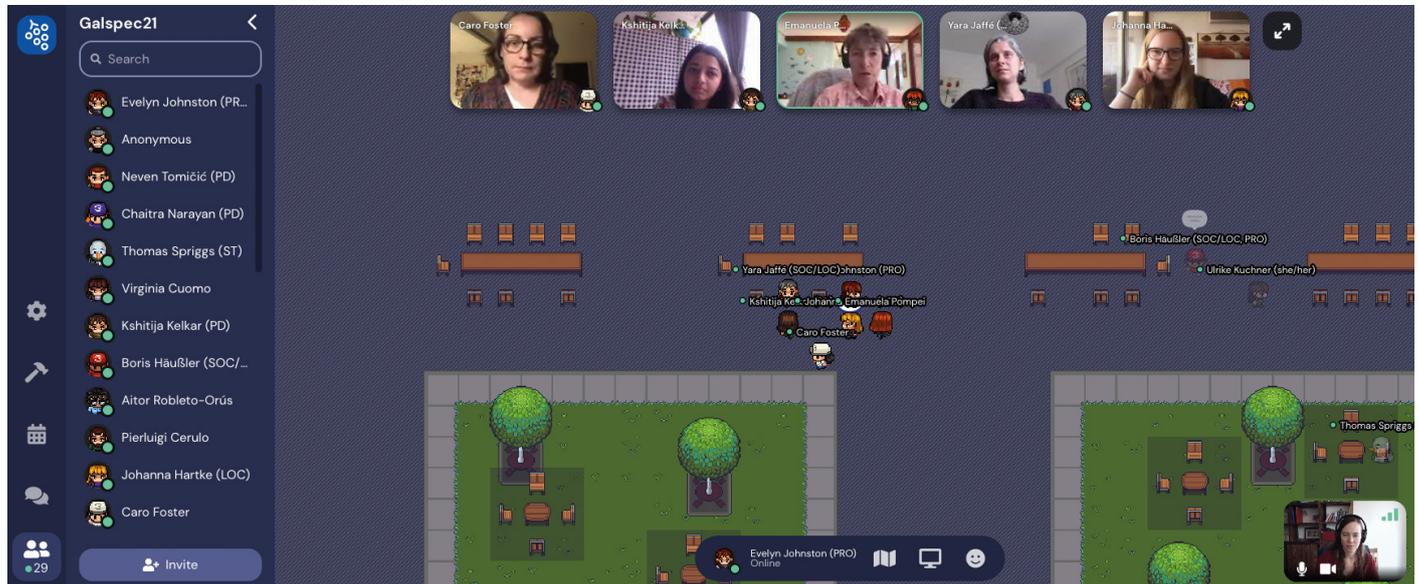


Figure 5. This picture shows a small screenshot from our space on Gather which was used for poster sessions, including two separate discussion groups.

(ESO’s Director for Science) were very supportive of all our decisions and gave us the background and information that we needed to make them. Our thanks go to everybody who supported this workshop throughout, not least the amazing speakers and participants, and who made this workshop a success.

No scientific workshop can be successful without interesting science and the people behind it. We wish to remember the principal investigator of VIMOS, Olivier Le Fèvre, who died in 2020 after a serious illness. The extragalactic community and his family and friends were deeply saddened by this loss, but the news also hit those of us who met Olivier personally during the many VIMOS commissioning or first science runs and had the opportunity to know and appreciate his passion for his work and his dedication. We were truly sorry that he was not with us to discuss both the excellent results obtained with his instrument and also the interesting challenges for the future. A big thank you goes to

Olivier and to all the supporting staff for making a dream instrument come true!

Links

- ¹ Galspec21 YouTube channel: https://www.youtube.com/channel/UC7tsM_Uwa48BJEYICjYumvA/ playlists
- ² Zenodo for posters and slides: <https://zenodo.org/communities/galspec2021>
- ³ Workshop website: <https://www.eso.org/sci/meetings/2021/galspec2021.html>

ESO/PHANGS



The Physics at High Angular resolution in Nearby Galaxies (PHANGS) project is making high-resolution observations of nearby galaxies with telescopes operating across the electromagnetic spectrum. Here five of its targets are shown: NGC 1300, NGC 1087, NGC 3627 (top, from left to right), NGC 4254 and NGC 4303 (bottom, from left to right). The images were taken with the Multi-Unit Spectroscopic Explorer (MUSE) on ESO’s Very Large Telescope (VLT). Each individual image is a combination of observations conducted at different wavelengths of light to map stellar populations and warm gas. The golden glows mainly correspond to clouds of ionised hydrogen, oxygen and sulphur gas, marking the presence of newly born stars, while the bluish regions in the background reveal the distribution of slightly older stars. Read more in press release: [eso2110](https://www.eso.org/sci/press-releases/pr02110.html).