

Science from the Next Generation Imaging and Spectroscopic Surveys

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Over 100 participants gathered to present and discuss the first exciting results from the eleven ESO public survey programmes in the context of current and planned major ground- and space-based surveys. The VISTA and VST public surveys presented a wide range of new scientific results. Presentations of other current or planned large ground- and space-based projects provided a benchmark for the ESO public surveys and their relevance worldwide.

Introduction

ESO and European astronomy have firmly entered the era of large public surveys with the addition of the VLT Infrared Survey Telescope (VISTA) and the VLT Survey Telescope (VST) to the Paranal telescope suite and the start of the first spectroscopic public surveys. The official start of VISTA operations was in April 2010, and the six VISTA imaging public surveys have collected over 2.5 years worth of data; the opening day of the workshop coincided with the first anniversary of VST operations. Since January 2012, two public spectroscopic surveys have been collecting data, at the VLT Unit Telescope (UT2) and the New Technology Telescope (NTT). The main aims of the workshop were the presentation of the goals of the ESO public surveys and their first scientific results. The global context of ESO surveys was provided by presentations of other current and planned large ground- and space-based surveys.

ESO public survey science covers a wide range of topics. In only three and a half days, more than 50 talks showed exciting new results in the fields of star formation and the structure of our own Galaxy, the nearby Universe and all the way out to high-redshift studies with both very deep and wide surveys. In addition to the oral contributions, 20 poster presentations covered similar topics, and provided details on survey facility operations and



Figure 1. The conference photograph on the stairs of the entrance hall of ESO Headquarters.

data mining challenges. The presentations are available from the conference web page¹.

The ESO Director General, Tim de Zeeuw, opened the workshop, outlining the key role that surveys play in astronomical research. They provide an inventory of the Universe, allowing astronomers to find rare objects, and, on account of large number statistics, allow measurements of key parameters in cosmology. The scale of current surveys changes the way astronomical research is done by supporting the formation of very large teams and by providing the astronomical community with public data at a high level of processing, for further scientific analysis.

Survey facilities from ground and space were the topic of the first session. M. Capaccioli, the Principal Investigator (PI) of VST, and J. Emerson, the PI of VISTA, described the two latest imaging survey facilities on Paranal, presenting their characteristics and capabilities, together with a short summary of the ESO public imaging surveys (see also Arnaboldi et al., 2007). The European Space Agency Euclid project was presented by Y. Mellier: this imaging and spectroscopic facility, to be launched in 2020, will carry out a survey for 5.5 years, and produce about 10 Pbyte of processed data

by 2028. Mellier emphasised the need for complementary ground-based photometric and spectroscopic observations for the ultimate goal of the mission: understanding the Universe's accelerating expansion by deriving the properties and nature of the dark energy and testing the law of gravity on large scales.

A. Connolly presented the scientific potential of the Large Synoptic Survey Telescope (LSST) and its scientific drivers: dark matter, dark energy, cosmology, time-domain astrophysics, structure of the Solar System and Milky Way structure. These drivers motivate a uniform cadence for multi-epoch observations and 90% of the southern hemisphere accessible from Cerro Tololo observatory will be covered every 3–4 nights. The final survey will accumulate, over ten years, 1000 visits in *ugrizy*-bands to reach $r \sim 27.5$ mag (36 nJy) and ~ 100 Pbytes of data. This unique facility is in its design and development phase, with expected commissioning in late 2020.

The year 2013 will be a decisive one for the next generation of large spectroscopic survey instruments at ESO. M. Cirasuolo and R. de Jong presented the two competing projects: MOONS and 4MOST (Multi-Object Optical and Near-infrared Spectrograph and 4-metre

Multi-Object Spectroscopic Telescope; see also Ramsay et al., 2011). These two spectrographs are quite complementary, the former being designed for the VLT and working in the near-infrared (NIR) with 1000 fibres (Cirasuolo et al., 2011), while the latter expects to go to VISTA and work primarily in the optical with 2400 fibres (de Jong, 2011). Their science cases include Galactic archaeology, galaxy evolution and cosmology, and have strong synergies with the ongoing imaging public surveys.

The core of the workshop programme consisted of invited talks by the 11 ESO public survey PIs. The VISTA Deep Extragalactic Observations (VIDEO) PI, M. Jarvis, described the 12-square-degree survey covering the XMM-Newton Large-Scale Structure (XMM-LSS), Chandra Deep Field-South (CDFs) and European Large-Area Infrared Space Observatory (ELAIS-S1) fields, with the aim of tracing the formation and evolution of galaxies over a large range of redshifts, and over a survey area large enough that the impact of environmental effects can be studied.

The Milky Way galaxy and local Universe

The second session began with an overview of the VISTA and VST imaging surveys of the Milky Way. D. Minniti presented the status and the first results from the VISTA Variables in the *Via Lactea* (VVV) Survey. His talk was followed by several contributions describing the search for RR Lyrae stars (by I. Dekany) and the search for the young star clusters (by J. Borissova) in the VVV area. R. Saito presented the 84-million-star colour-magnitude diagram of the Galactic Bulge: this large dataset can now be analysed in the same way as an external galaxy! The large-scale extinction and metallicity maps for the Milky Way were presented by M. Rejkuba.

The PI of the optical Galactic survey VPHAS+, J. Drew, described how it will be combined with the northern hemisphere Galaxy surveys IPAS and UVEX surveys to contribute to European Galactic Plane Surveys. The northern hemisphere surveys started in 2003, and now VPHAS+ is filling up the 1800 square degrees of the southern Galactic Plane

with ~ 2000 VST/OmegaCAM fields observed in *ugri* and H α filters. This survey will provide a 3D extinction map and the census of the Galactic Disc, enabling detailed study of star clusters and star-forming regions in the Galaxy.

The latest addition to the ESO public surveys exploring the Galaxy is the Gaia-ESO spectroscopic survey led by G. Gilmore and S. Randich. This survey addresses key open issues in the formation and evolution of the Milky Way and its stellar components based on accurate radial velocities and abundances from VLT FLAMES spectra, to complement Gaia observations in the coming years. The science drivers require uniform analysis, resulting in yearly advanced data releases as described by Randich. The Gaia-ESO survey started in January 2012, but the nearly completed RAVE (Radial Velocity Experiment) survey, presented by M. Steinmetz, has already collected more than 500 000 stellar spectra. These are analysed for kinematical tomography of the Galactic Discs and study of the presence of substructure and tidal debris, and large-scale deviations from axial symmetry.

The Local Universe session started with an invited talk on the VISTA Magellanic Cloud (VMC) survey by M.-R. Cioni. The Y, J and Ks filters are used to obtain a deep picture of the Large and the Small Magellanic Clouds as well as of the Bridge and Stream regions. This survey is unique because of its depth and multi-epoch data (12 epochs) that are used to determine the 3D structure of the Magellanic Clouds with Cepheids and RR Lyrae variable stars. Following on, L. Girardi presented the main driver of the survey: the determination of the spatially resolved star formation history of the Magellanic Clouds.

G. Battaglia summarised the main results from the Dwarf galaxies Abundances & Radial velocities Team (DART) VLT/FLAMES spectroscopic survey of dwarf spheroidal galaxies. She concluded that it is necessary to look at many stars in order to derive velocity and metallicity gradients as well as to explore the significance of the multiple kinematic components in these small galaxies. This survey has implications for the current

models of galaxy formation since its results show that it is difficult to make the whole Milky Way halo out of low luminosity dwarf spheroidals.

High-z Universe, galaxy evolution and cosmology

The high-redshift Universe session started with the Ultra-VISTA survey results presented by H. J. McCracken. The wide part of the survey covers 1.5 square degrees in the Cosmic Evolution Survey (COSMOS) field, and is now completed. The deep and the narrow-band (using the NB118 filter) survey components are still ongoing. The narrow-band part of this survey is designed to find $z \sim 7$ Lyman-break galaxies and $z = 8.8$ Lyman-alpha emitters, and has already identified four robust sources with mean redshift 6.98 ± 0.05 . At the same time the deep NIR Ultra-VISTA data has uncovered the real nature of several other luminous sources that were originally claimed to be at $z > 7$, but turned out to be at much lower redshifts (“only” $z = 2-4$) instead. Another source of contaminants for these high-redshift objects are T-dwarf stars — a treasure trove for low-mass star formation studies.

The VISTA Hemisphere Survey (VHS) and the VST ATLAS survey were presented by their PIs, R. McMahon and T. Shanks respectively. These are wide-area surveys that will enable studies of rare sources at all redshifts, from nearby L-dwarfs to highly obscured broad line quasars at $z = 2$, as well as very rare luminous quasars up to $z \sim 7$. These two surveys will be used to determine the dark energy equation of state by detecting “baryon wiggles” in the power spectrum of about half a million galaxies.

The Kilo-Degree (KIDS) and VISTA Kilo-degree Infrared Galaxy (VIKING) surveys, presented by PIs K. Kuijken and W. Sutherland, respectively, constitute another pair of complementary VST and VISTA public surveys. The combination of optical and NIR photometry enables a clear separation of galaxies from stars, hence creating highly complete galaxy samples that are useful for weak lensing studies. Since the image quality of the VST is about a factor two better than the

Sloan Digital Sky Survey (SDSS), these surveys provide a detailed picture of the structure of galactic halos as function of galaxy type and environment. KIDS and VIKING have already uncovered quasars at $z > 6.5$, with three candidates spectroscopically confirmed (talk by B. Venemans).

S. Smartt presented PESSTO, the spectroscopic public survey aimed at exploring the physics of supernova explosions and a detailed study of transients, unusual, and currently unknown, types of variable sources. The targets for this survey come primarily from the La Silla–QUEST variability survey described by C. Baltay (see the article on p. 34).

Pipelines, data mining and survey data products

The last session of the workshop was dedicated to pipelines, data products and data mining. The KIDS team with Astro-WISE has an integrated data handling system presented by G. Verdoes-Kleijn, while R. Smareglia presented the data handling and archiving system of PESSTO. The six ESO public surveys with VISTA rely on the data processing carried out in the UK centres, Cambridge Astronomical Survey Unit (CASU) and the Wide Field Astronomy Unit (WFAU) in Edinburgh, and the latter was presented by N. Cross. The workshop closed with the presentation of M. Romaniello on the ESO Phase 3 process for the reception, validation and publication of data prod-

ucts from ESO public surveys and large programmes (see also Arnaboldi et al., 2011), and a live demo by J. Retzlaff of the new ESO catalogue query interface, now deployed in the ESO Science Archive Facility.

References

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Links

¹ Conference web page: <http://www.eso.org/sci/meetings/2012/surveys2012.html>

Retirement of Preben Grosbøl

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On 31 October, exactly half a year after Klaus Bense's retirement (Ballester & Péron, 2012), Preben Grosbøl, the other father of ESO's former MIDAS image processing system, retired, marking the end of an era. Preben's contributions to develop and promote MIDAS, ranging from specialised numerical algorithms to fundamental over-arching concepts, were central to the success of MIDAS (and its predecessor IHAP). However, his lifetime achievements go far beyond that. The third of a century of his affiliation with ESO was devoted to the support of many other initiatives to serve optimally the community's needs for efficient, reliable and versatile data reduction capabilities.

Preben was born in Denmark and obtained his PhD from the University of



Figure 1. Preben Grosbøl at his retirement party at ESO Headquarters receiving a framed photograph from the Director General Tim de Zeeuw.

Copenhagen in 1977. For his thesis, he worked closely with George Contopoulos in Thessaloniki, Greece, where he also met his wife Barbara. Throughout his scientific career, Preben studied the properties of spiral galaxies: structure,

dynamics, star formation and evolution. He combined careful optical and infrared observations with detailed theoretical model calculations; the results have materialised in several dozen refereed publications. After his retirement, Preben