

ESO–GOODS: Closing the Book, Opening New Chapters

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The Great Observatories Origins Deep Survey (GOODS) was the first public multi-wavelength survey with an extensive coordination between space- and ground-based observations. ESO–GOODS, a public Large Programme carried out with ESO facilities, has provided essential complementary data to this project that have allowed the full scientific exploitation of a very rich multi-observatory dataset in the Chandra Deep Field South. The public release of all advanced data products from ESO–GOODS, completed in December 2009, is summarised here.

The GOODS survey originally covered two 150 square arcminute fields, centred around the Hubble Deep Field North and the Chandra Deep Field South (CDFS). It was the first coordinated effort to combine the deepest survey data over the widest wavelength range (from X-ray through radio) from space- and ground-based observatories, setting the stage for many other multi-wavelength surveys that have been carried out over the last decade. Observations were designed to promote major advances in our understanding of the mass assembly history of galaxies over a broad range of cosmic time, to obtain a census of energetic output from star formation and supermassive black holes, and to trace the star formation history out to $z \sim 7$. The same dataset and synergy between the Hubble Space Telescope (HST) and the largest ground-based telescopes were also utilised to discover many Type Ia super-

novae with crucial implications for understanding the cosmic expansion.

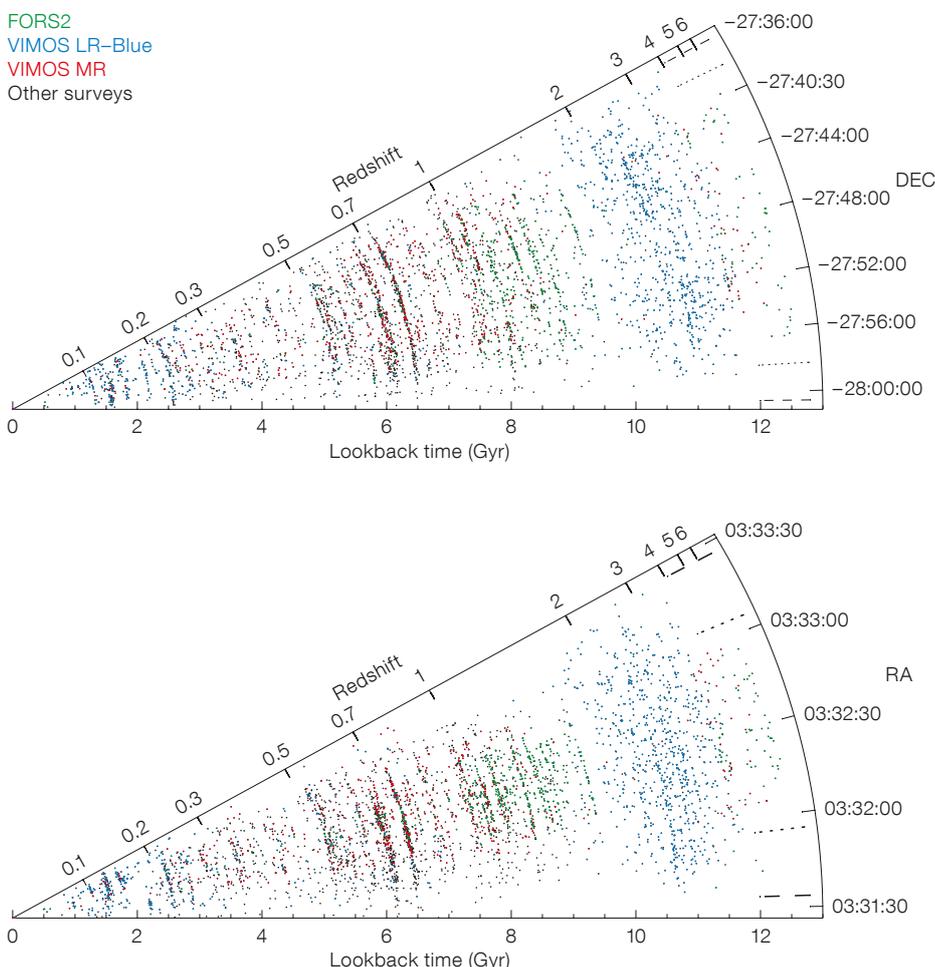
Nearly ten years ago, ESO embarked on a public project consisting of a number of observing campaigns in the CDFS field, primarily with the VLT, designed to complement the capabilities of HST prior to Servicing Mission 4. The VLT campaign was conducted under the programme, The Great Observatories Origins Deep Survey (GOODS): ESO Public Observations of the SIRTf Legacy/HST Treasury/Chandra Deep Field South, with PI Catherine Cesarsky, over the periods

P68–P77. Science-ready data products were prepared by the ESO–GOODS Team, which included members from the Space Telescope European Co-ordinating Facility (ST–ECF) and the community. The team publicly released these data into the ESO Archive in a progressive manner within 6–12 months of the conclusion of each observing run.

The ESO–GOODS programme reached the final milestone in December 2009 by completing the public release of all advanced science-ready data products consisting of (see Table 1):

1. deep near-IR coverage of the GOODS region in the *JHK* bands with ISAAC;
2. very deep *U*-band imaging of the entire CDFS area with VIMOS;
3. an extensive spectroscopic campaign with FORS2 and VIMOS which has yielded ~ 2700 secure source redshifts.

Figure 1. Wedge diagrams showing two projections of the spatial distribution of galaxies with lookback time from all publicly available redshifts in the CDFS as of the end of 2009 (from Balestra et al., 2010). Different spectroscopic surveys are colour-coded as indicated. Only 4234 reliable redshifts are considered here: 2574 from ESO–GOODS (green, blue and red dots), 1660 from other surveys (black dots).



* A number of students, post-docs and staff members have contributed to the ESO–GOODS Team over the years. These included Italo Balestra, Catherine Cesarsky, Vincenzo Mainieri, Paolo Padovani, Paola Popesso, Alvio Renzini, Jörg Retzlaff, Alessandro Rettura, Benoît Vandame from ESO; Bob Fosbury, Jonas Haase, Richard Hook, Harald Kuntschner from ESO/ST–ECF; Stefano Cristiani, Mario Nonino, Eros Vanzella at INAF–Trieste; and Mark Dickinson (NOAO) and Mauro Giavalisco (UMass) from the US GOODS collaboration.

Table 1. Summary of ESO–GOODS observations and data releases.

Campaign	Description	Observing time (hours)	Data release/date	Publications
Near-IR imaging	ISAAC in <i>J</i> -, <i>H</i> -, <i>Ks</i> -bands, 170 arcmin ² to 25 AB mag (5σ)	476.0	ISAAC v2.0/2007-09-10	Retzlaff et al., 2010
	<i>Ks</i> -band of the HUDF ¹ to 25.6 AB mag, 0.36" seeing	25.3	ISAAC HUDF v1.0/2010-03-02	
<i>U</i> -band imaging	VIMOS <i>U</i> - and <i>R</i> -band, 400 arcmin ² , to $U \sim 29.8$	40.0	VIMOS img v1.0/2009-04-24	Nonino et al., 2009
<i>R</i> -band imaging ¹	and $R \sim 29$ AB (1σ)	16.3		
FORS2 spectroscopy	300l grism (0.55–1.0 μ m), 1635 spectra of 1236 targets, 887 redshifts out to $z = 6.3$	130.0	FORS2 v3.0/2007-10-31	Vanzella et al., 2008
VIMOS spectroscopy	LR-B grism (0.35–0.7 μ m), 3634 spectra of 3271 targets, 2040 redshifts ($1.8 < z < 3.5$)	120.0	VIMOS v2.0/2009-12-15	Popesso et al., 2008
	MR grism (0.4–1.0 μ m), 1418 spectra of 1294 targets, 882 redshifts ($z < 1$ and $z > 3.5$)			Balestra et al., 2010

¹ Based on other programmes in the ESO Archive.

A summary of the spectroscopic effort in the CDFS is shown in Figure 1, which includes redshifts from both ESO–GOODS and a number of additional VLT programmes. To facilitate the utilisation of such a large investment of VLT spectroscopic time (over 500 hours), an up-to-date database of all publicly available spectra obtained in the GOODS/CDFS area has been constructed by ESO and the ST-ECF and made accessible with a search-engine interface. We plan to keep this spectral database up to date in the coming years, as more reduced spectra become available, including those derived from the slitless modes of HST.

The ESO–GOODS public data products have remained in great demand over the last four years and have fueled a large number of high-impact publications. While we close this book on the ESO–GOODS programme, new chapters are being opened as this rich dataset continues to stimulate several VLT follow-up programmes, which will benefit from future observations, for example with the refurbished HST, and with Chandra and Herschel.

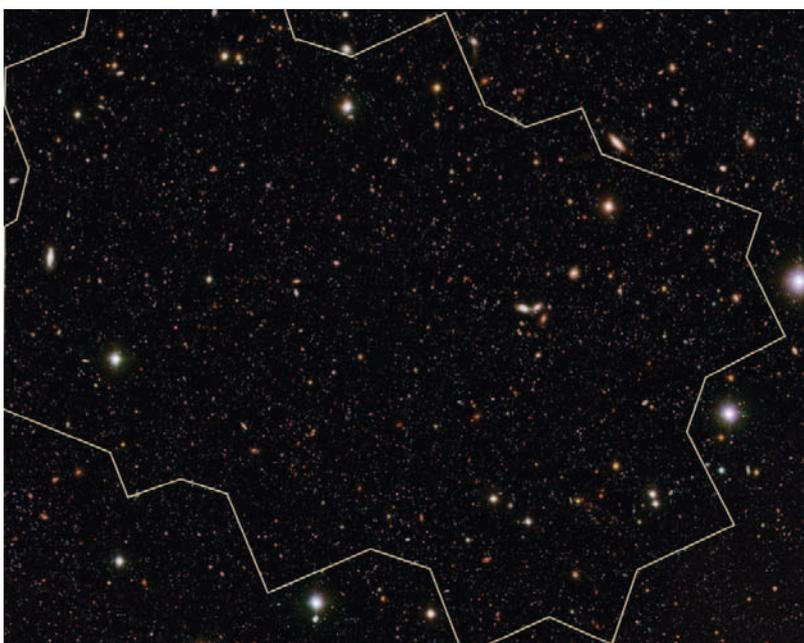
With the deployment of the LABOCA bolometer array on the 12-metre APEX Telescope, the ESO–GOODS multi-wavelength dataset has recently been extended to the sub-mm region. A public

legacy survey has covered the 0.5×0.5 degree Extended CDFS field at 870 μ m to a depth of ~ 1.2 mJy (Weiss et al., 2009); the resulting map has also recently been released in the ESO Archive.

Detailed information and relevant links on the ESO–GOODS project can be found at <http://www.eso.org/sci/activities/projects/goods/>.

References

- Balestra, I. et al. 2010, A&A, 512, 12
- Nonino, M. et al. 2009, ApJS, 183, 244
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- Vanzella, E. et al. 2008, A&A, 478, 83
- Weiss, A. et al. 2009, ApJ, 707, 1201



UBR colour composite image of the GOODS-South region obtained combining the deep VIMOS *U*- and *R*-band observations with a WFI *B*-band image. The contour indicates the HST-ACS original coverage. See release eso0839 for details.