ESO Phase 3 Data Release Description

Data Collection	ZCOSMOS
Release Number	2
Data Provider	Simon Lilly
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zCOSMOS Data Release DR3

zCOSMOS (P.I. Simon Lilly) is a large redshift survey undertaken in the COSMOS field using the VIMOS spectrograph mounted at the Melipal Unit Telescope of the VLT at ESO's Cerro Paranal Observatory, Chile. zCOSMOS (ESO Large Programme LP175.A-0839) was awarded about 600 hours of Service Mode observing time on the ESO VLT, which was executed between 2005-2010.

The zCOSMOS redshift survey has been designed to efficiently utilize VIMOS by splitting the survey into two parts. The first, zCOSMOS-*bright*, which is the subject of DR3, aims to produce a redshift survey of approximately 20,000 I-band selected galaxies at redshifts $z < 1.2$. Covering the approximately 1.7 deg^2 of the COSMOS field (essentially the full ACS-covered area), the transverse dimension at $z \sim 1$ is 75 Mpc. The second part, zCOSMOS-*deep*, observed a smaller number of galaxies selected to mostly lie at higher redshifts, $1.5 < z < 3.0$.

This DR3 release is expected to be the final release of the zCOSMOS-*bright* spectroscopic catalogue. The full set of extracted 1-dimensional spectra are being released, plus a catalogue in which we give for each target the 1-D spectra filenames, the I-band magnitude used for the selection, as well as the measured redshift and confidence class. A full description of the survey can be found in Lilly et al. 2007, ApJS, 172, 70, and Lilly et al. 2009, ApJS, 184, 218 and a future paper to be submitted.

The data were reduced by the zCOSMOS team.

Overview of Observations

Observations for the DR3 sample were carried out with the VIMOS spectrograph mounted on the 8m VLT/UT3 telescope during extensive Service Mode runs from 2005 to 2009. Observations used the MR grism with 1.0 arcsec slits, yielding a spectral resolution R~600 at 2.5 Å/pixel and a spectral range 5550–9450 Å. All masks are observed with the slits oriented N-S. The pattern of pointings is such that every target in the central region have had eight opportunities to be selected for observation. The right ascension-declination distribution of the targets is shown in Figure 1. The spatial sampling rate is shown in Figure 2.

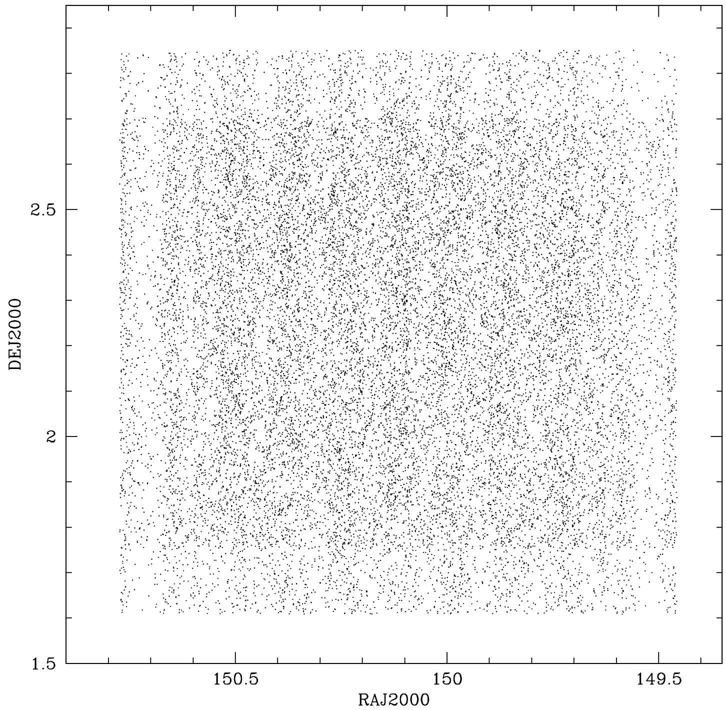

Figure 1: Distribution in right ascension and declination of galaxies observed in zCOSMOS-*bright*.

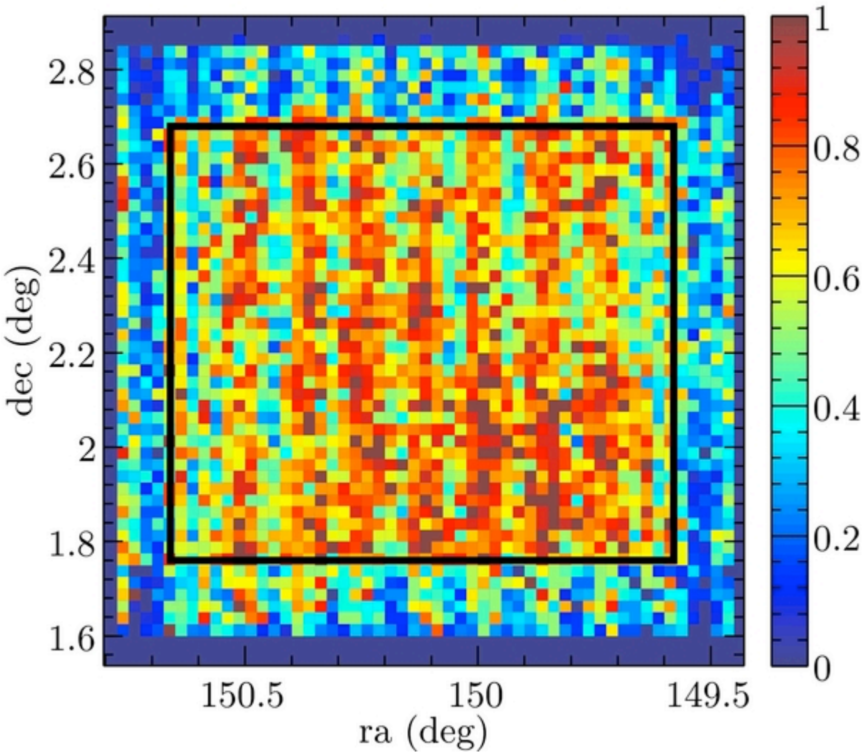

Figure 2: Spatial sampling rate (SSR) of the zCOSMOS-*bright* spectroscopic sample. The color bar indicates the SSR, which is computed in pixels of 1.5 arcmin. The black rectangle shows the central region. The figure is taken from Knobel et al. 2012, ApJ, 753, 2.

Release Content

Spectra for 20,689 objects could be extracted from the VIMOS observations and are presented in this DR3 release. The targets are selected across the whole 1.7 deg^2 COSMOS field centred at RAJ2000 = 10h00m28s and DEJ2000 = 02d13m37s extending over 1.30x1.24 deg in the right ascension-declination plane.

The primary input catalogue for slit-mask design was generated using SExtractor (Bertin&Arnouts, 1996, A&AS, 117, 393) applied to the COSMOS F814W HST/ACS images sampled at 0.03 arcsec/pixel (Koekemoer et al. 2007, ApJS, 172, 196, Leauthaud et al. 2007, ApJS, 172, 219) in a "hot and cold" two-pass process to first identify bright objects. This substantially reduced the tendency of the HST-based catalogue to "over-resolve" extended galaxies into multiple components. This initial SExtractor catalogue was then "cleaned" by carrying out a detailed comparison with one extracted from a stack of i* images obtained with MEGACAM on the 3.6m Canada-France-Hawaii telescope and processed at the TERAPIX data reduction center in Paris. This catalogue was also used to supplement the ACS catalogue for regions where the ACS images were either unavailable or unusable. The zCOSMOS-*bright* target catalogue is intended to be simply defined as having an ACS/HST SExtractor "magauto" brightness in the range $15.00 < I_{AB}(814) < 22.50$.

Generally, objects to be inserted into the slit mask were chosen randomly from the target catalogue. However, a few percent of targets (generally X-ray sources) were designated as "compulsory". These were inserted into the masks with first priority and, as a result, they are about 1.5 times over-represented in the spectroscopic catalogue. Objects strongly suspected of being stars on the basis of morphology and spectral energy distribution were classified as "forbidden" and not included in the mask designs. These comprise about 15% of the $I_{AB} < 22.5$ sample. The criteria for this exclusion were deliberately quite conservative and as a result about 4% of the spectroscopic targets turn out to be stars.

For each slit there was a primary target. Naturally, sometimes other objects in the target catalogue happened to fall in the same slit. These "secondary targets" were reduced in the same way. If these secondary objects were forbidden, their spectra were anyway reduced and included in the catalogue.

Given the inevitable complexity of the sample, users who require statistically complete samples are strongly encouraged to contact the zCOSMOS team for guidance.

Release Notes

Data Reduction and Calibration

The VIMOS observations were reduced using the v1.0 of the VIPGI software package (Scodeggio et al., 2005, Pub.Astr.Soc.Pac., 117, 1284).

The spectra are flux-calibrated, but no attempt was made to correct for slit-losses on these extended objects, and so the calibration should be considered relative and not absolute. As with most multi-slit spectroscopy, even this relative calibration is not perfect, due to variable positions within the slit, differential atmospheric refraction and so on. It is suspected that there are systematic effects in the relative flux calibration at the 15% over the wavelength range of the spectra.

Determination of redshifts was a multi-step process and involved the use of different approaches tailored to the individual spectra. These include first a computer-aided determination based on cross-correlation with template spectra coupled to continuum fitting and principal component analysis, using the EZ software (Garilli et al., in preparation). This preliminary automated step is followed by a detailed visual examination of the one- and two-dimensional spectrograms of every object to critically assess the validity of the automated redshift. In those cases where the automatic procedure fails, a new redshift is computed based on the wavelengths of recognized features. Two fully independent reductions are carried out of each spectrum, yielding two independent redshift measurements. These are compared and "reconciled" (generally in a face-to-face meeting) to yield a final redshift and Confidence Class.

Data Quality

Over 2000 objects were observed more than once, either from repeat observations of whole masks, repeated inclusion in different masks as primary targets, or because an object is a primary target in one mask and a secondary in another. From these repeat observations, the redshift uncertainty in zCOSMOS-*bright* is estimated to be (1 sigma) 107 km/s. For these repeat objects we provide only one redshift and spectra.

In a deep redshift survey such as zCOSMOS, there is inevitably a range of reliability for the redshifts. Each redshift is therefore assigned to a Confidence Class. zCOSMOS Confidence Classes have been developed from those adopted in the CFRS and VVDS surveys. The basic confidence scheme ranges from Class 0 (no redshift obtained) to Class 4 (very secure redshift). In practice there is little real difference between Classes 3 and 4 and they may be safely combined for most purposes. Two additional classes with special meaning are then added. Class 9 signifies a one-line redshift where the line is undoubtedly real, as well as being sufficiently strong and isolated that we can be confident that the line is either H-alpha or [OII] 3727 - yielding two possible redshifts. A Class 18 is also a one line redshift, but for a Broad Line AGN. For these two cases, we use photo-z to check the line identification (see below), finding that we guessed right in over 85% of cases. If not, we modify the redshift to the alternate one if that is consistent with the photo-z.

Confidence Class	**Description**	**Spectroscopic verification rate**	**Photo-z consistency within $\Delta z=0.04(1+z)$**
Class 4	Very secure redshift	99.8%	98%
Class 3	Secure redshift	99%	97%
Class 9	One line redshift (best guess)	95% after correction	81%, increasing to 92% after correction with photo-z
Class 2	Probable redshift	94%	94%
Class 1	Insecure redshift	70%	34%

The basic confidence scheme is then modified with possible preceding digit(s) as follows: An additional "1" digit before the Class (i.e. adding "10" to the Class) signifies a broad line AGN: e.g. Class 13 is a very secure BL AGN redshift. A "2" digit before the Class signifies that the object was a secondary target because it was detected in a slit positioned on another target: e.g. Class 24 is a very secure serendipitous object while Class 213 is a secure serendipitous broad line AGN redshift. Note that Class 0 objects, i.e. primary targets for which no redshift could be assigned, are retained in the catalogue since these objects were in a sense given a "fair trial". Class 20 objects (i.e. redshift failures of secondary targets) have however been removed. For these, the light could have been substantially reduced through misalignment of the secondary target with the slit, and indeed the distribution of Confidence Classes for the secondary targets is noticeably skewed towards lower confidence redshifts.

The statistical reliability of the spectroscopic redshifts in the various Confidence Classes has been assessed by both the agreement or otherwise of redshifts independently derived from repeat observations, and by the consistency or otherwise with photometric redshifts derived from the COSMOS multi-band photometric data using photo-z for AGN (Salvato et al. 2009, ApJ, 690, 1250), stars and galaxies (Ilbert et al. 2009, ApJ 690, 1236) and where these are unavailable, from ZEB-RA measurements (Feldmann et al. 2006, MNRAS, 372, 565). A spectroscopic redshift was considered "verified" if the same redshift was obtained from a second spectrum of equal or higher Confidence Class.

These two approaches show generally good agreement, apart from a "ceiling" in the photo-z reliability of about 98% due to difficulties in the photometry (merged objects etc). This suggests that consistency or otherwise with the photometric redshift can be used to indicate which of the less reliable spectroscopic redshifts are probably right and which are likely to be wrong. We therefore add a decimal place to the Confidence Class to reflect this additional information. The integer part is based solely on the spectrum itself, followed by a decimal place which contains (a posteriori) information on the consistency of the spectroscopic redshift with the photometric redshift, as given in the following table.

Confidence decimal	**spectroscopic/photometric consistency**
.5	Spectroscopic redshift consistent within 0.04(1+z) of the photometric redshift, both for galaxies, stars and AGN.
.4	No photometric redshift available
.3	Special case for Class 18 and 9: Consistent with photo-z only after the redshift is changed to the alternate redshift, a switch which is then applied
.1	Spectroscopic and photometric redshifts are not consistent at the level of 0.04(1+z)

Applying the same spectroscopic repeatability test as above, we then obtain spectroscopic verification rates of:

Confidence Class	Spectroscopic verification
Class 3.x and 4.x	99.8%
Class 2.5 and 1.5	97%
Class 2.1 and 1.1	25%
Recommended sample: Classes 3.x, 4.x, 2.5, 2.4, 1.5, 9.5, 9.4, 9.3	99%

Consistency with the photo-z is clearly an effective way at determining which of the less reliable spectroscopic redshifts are likely to be correct and which are likely to be wrong.

There is an obvious trade-off between reliability and completeness: the two most reliable Classes, 3 and 4, which have spectroscopic repeatability > 99.8% in the above table, comprise about 60% of the zCOSMOS-*bright* sample. However, many users will likely prefer to utilize the photo-z information and use the extended set of Classes comprising all 4's, all 3's, 9.5 + 9.4 + 9.3 + 2.5 + 2.4 + 1.5. These are still 99 % reliable on the basis of spectroscopic repeat observations and comprise about 88% of the overall sample.

Known issues

There is evidence from subsequent CO spectroscopy and from statistical comparison with SDSS and other optical spectroscopy that the original zCOSMOS redshifts were systematically overestimated by about 100 km/s. While this is smaller than the uncertainty in the redshifts of individual objects and while it is irrelevant for most science studies that have been carried out, we have adjusted, for this DR3 data release, all of the redshifts downwards by 100 km/s, i.e. $\Delta z = -0.0003(1+z)$. It should be noted that the spectra have not been adjusted and users should be aware of this when comparing the redshifts with the spectra, or when performing automated measurements from the spectra.

Previous Releases

This release DR3 is expected to be the final release of the zCOSMOS-*bright* dataset. It supersedes, revises and significantly extends the previous releases. The first data release DR1 from October 2007 contained 1264 spectra and a corresponding catalogue. The superseding second data release DR2 from October 2008 contained 10643 spectra and a corresponding catalogue. The ESO Archive Science Group migrated the DR2 release to the Phase 3 infrastructure in February 2014 under Release Number 1. This makes this third DR3 zCOSMOS-*bright* data release archived under Release Number 2 in the Phase 3 infrastructure.

Data Format

Files Types

The zCOSMOS data are compliant with the latest ESO standards. There are 20,689 1D-spectra in fits format. The HST/ACS-images in the F814W filter are available for 20,326 of these and we include the corresponding 5x5 arcsec^2 stamps in both fits and jpg format.

Naming conventions:

1D-spectra

zCOSMOS_BRIGHT_DR3_000nnnnnn_ZCMRaxx_My_Qu_v_w.fits

nnnnnn	6-digits zCOSMOS target catalogue identification number	
xx	2-digits pointing identification	
y	1-digit	mask identification at this pointing (1, 2 or 3)
u	1-digit	VIMOS quadrant in this mask (1-4)
v	-	slit number in this quadrant
w	-	extracted spectrum within this slit

HST imaging stamps

zCOSMOS_BRIGHT_DR3_000nnnnnn_ra_de_F814W.*

where * can be fits or jpg
and
nnnnnn 6-digits zCOSMOS target catalogue identification number (ID)
ra and de are Right Ascension and Declination of the zCOSMOS object with a given ID with a precision of 6 digits

Spectra format:

The 1D spectra are stored in the spectrum binary table format. Each fits file contains only one science spectrum. The spectrum binary table format is composed of one primary header (with no data) and one single extension. The extension has its own header and one BINTABLE unit. The data arrays are stored as vectors in single cells. There are three mandatory fields: WAVE, FLUX_REDUCED and ERR. WAVE contains the wavelength of the array, given in Å. FLUX_REDUCED contains the sky-background subtracted spectrum in erg/cm^2/s/Å. ERR is intended to contain the error spectrum, but since there are no consistently estimated error spectra for all zCOSMOS objects, we artificially set this array to contain only zeroes.

Catalogue Columns

The target catalog 'zCOSMOS_VIMOS_BRIGHT_DR3_CATALOGUE.fits' contains object ID, target position (RAJ2000 and DEJ2000), redshift, confidence class, target magnitude (F814W), four selection flags and a filename of associated 1-d spectra. The four selection flags are: Flag for satisfying bright sample selection (0 or 1), Flag for X-ray selection (0 or 2), Flag for radio selection (0 or 1) and Flag for UV selection (0 or 2).

Acknowledgements

When using data products provided in this release, acknowledgement should please be given in the text to the zCOSMOS project, referring to this release and Lilly et al. 2009, ApJS, 184, 218 until superseded by a later version. Please also make sure that the following statement appears in your Acknowledgements when using these data:
Based on zCOSMOS observations carried out using the Very Large Telescope at the ESO Paranal Observatory under Programme ID: LP175.A-0839.