The MUSE Hubble Ultra-Deep Field surveys

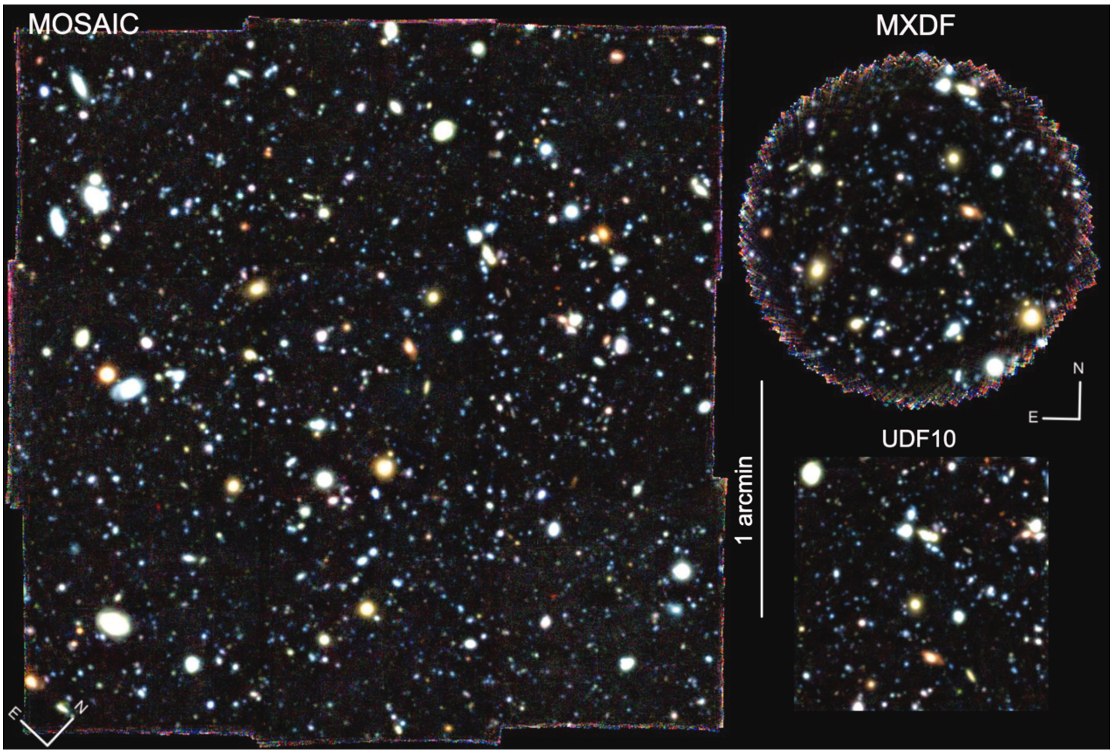

Figure 1: Reconstructed pseudo-color images of the MOSAIC, MXDF, and UDF-10 data sets.

Important Note

The data release has been extensively described in the paper ***The MUSE Hubble Ultra-Deep Field surveys, Bacon et al, 2023, A&A 670, A4*** *(hereafter DR2)*. We give here just a brief description of the content of the data release, for further information please refer to the paper.

This data release paper (DR2) was preceded by a first paper (DR1) ***The MUSE Hubble Ultra Deep Field Survey: I. Survey description, data reduction, and source detection, Bacon et al, 2018, A&A 108, A1.*** This DR1 paper did not lead to an ESO phase-3 release. All DR1 data products (e.g. catalogs) are superseded by the DR2 release.

This ESO phase 3 data release currently contain only the datacubes and the main catalog. Sources catalogs are available through CDS https://cdsarc.cds.unistra.fr/viz-bin/cat/J/A+A/670/A4 as well at https://amused.univ-lyon1.fr. In addition, detailed information on each MUSE source can be found on the AMUSED advanced data products public web interface (https://amused.univ-lyon1.fr).

Abstract

We present the second data release of the MUSE Hubble Ultra-Deep Field surveys, which includes the deepest spectroscopic survey ever performed. The MUSE data, with their 3D content, amazing depth, wide spectral range, and excellent spatial and medium spectral resolution, are rich in information. Their location in the Hubble ultra-deep field area, which benefits from an exquisite collection of ancillary panchromatic information, is a major asset. This update of the first release incorporates a new 141-h adaptive-optics-assisted MUSE eXtremely Deep Field (MXDF;1 arcmin diameter field of view) in addition to the reprocessed 10-h mosaic (3×3 arcmin^2) and the single 31-h deep field (1×1 arcmin^2). All three data sets were processed and analyzed homogeneously

using advanced data reduction and analysis methods. The 3σ point-source flux limit of an unresolved emission line reaches 3.1×10^{-19} and 6.3×10^{-20} erg s^{-1} cm^{-2} at 10- and 141-h depths, respectively. We have securely identified and measured the redshift of 2221 sources, an increase of 41% compared to the first release. With the exception of eight stars, the collected sample consists of 25 nearby galaxies ($z < 0.25$), 677 [O ii] emitters ($z = 0.25–1.5$), 201 galaxies in the MUSE redshift desert range ($z = 1.5–2.8$), and 1308 Lyα emitters ($z = 2.8–6.7$). This represents an order of magnitude more redshifts than the collection of all spectroscopic redshifts obtained before MUSE in the Hubble ultra-deep field area (i.e., 2221 versus 292). At high redshift ($z > 3$), the difference is even more striking, with a factor of 65 increase (1308 versus 20). We compared the measured redshifts against three published photometric redshift catalogs and find the photo-z accuracy to be lower than the constraints provided by photo-z fitting codes. Eighty percent of the galaxies in our final catalog have an HST counterpart. These galaxies are on average faint, with a median AB F775W magnitude of 25.7 and 28.7 for the [O ii] and Lyα emitters, respectively. Fits of their spectral energy distribution show that these galaxies tend to be low-mass star-forming galaxies, with a median stellar mass of 6.2×10^8 M and a median star-formation rate of 0.4 M yr^{-1}. We measured the completeness of our catalog with respect to HST and found that, in the deepest 141-h area, 50% completeness is achieved for an AB magnitude of 27.6 and 28.7 (F775W) at $z = 0.8–1.6$ and $z = 3.2–4.5$, respectively. Twenty percent of our catalog, or 424 galaxies, have no HST counterpart. The vast majority of these new sources are high equivalent-width $z > 2.8$ Lyα emitters that are detected by MUSE thanks to their bright and asymmetric broad Lyα line. We release advanced data products, specific software, and a web interface to select and download data sets.

Overview of Observations

Two sets of observations have been used for this data release. The first set was conducted between September 2014 to February 2016 and lead to the UDF-10 and MOSAIC datacubes. The second one was conducted between August 2018 to January 2019 and lead to the MXDF datacube.
For further information consult the DR2 paper, section 2, and DR1 paper, section 2.

Release Content

Exposures are located within the Hubble Ultra Deep Field

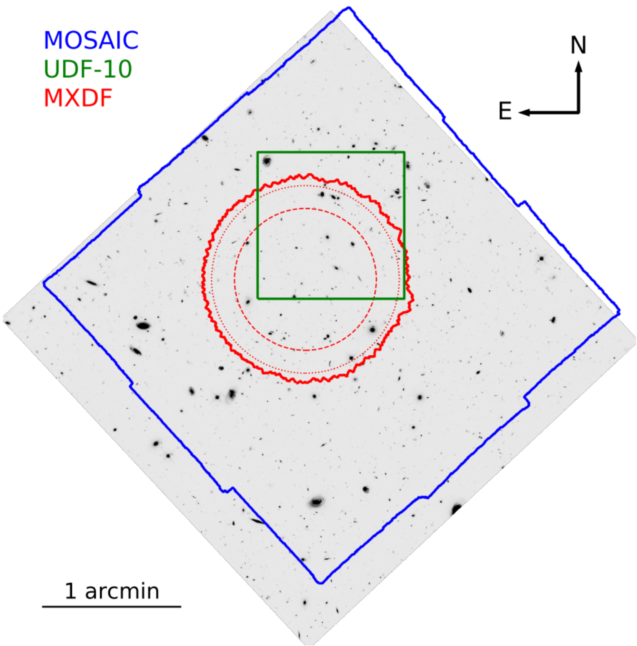

Figure 2: Location of the three deep fields: MXDF 141-hour depth, MOSAIC 10-hour depth, and UDF-10 31-hour depth overlaid on the HST F775W UDF image. The dotted and dashed red circles show the MXDF 10- and 100-hour exposure time isocontours, respectively.

Datacubes

- MXDF center: RA 03:32:39.48 DEC -27:47:06.83 (J2000 FK5) area 1.4 $arcmin^2$ Depth 141 hours
- UDF-10 center: RA 03:32:38.68 DEC -27:46:43.66 (J2000 FK5) area 1 $arcmin^2$ Depth 31 hours
- MOSAIC center: RA 03:32:38.63 DEC -27:47:14.70 (J2000 FK5) area 9 $arcmin^2$ Depth 10 hours

Spectral resolution R~3000, Wavelength range 4800-9300 A

White light Images

For each datasets (MXDF, UDF-10 and MOSAIC), the corresponding white light image is computed by computing the mean flux over all wavelengths.

Exposure Maps

For each datasets (MXDF, UDF-10 and MOSAIC), an exposure map datacube give the number of 25 mn exposures that have been combined at each voxel. The corresponding mean exposure map image (taking the mean of the exposure map over all wavelengths) is also given.

Field Map

The MOSAIC dataset result of a mosaic of 9 MUSE 1 $arcmin^2$ fields (numbered 1-9). A field map fits file give the fields identifiers which have been combined together. To see how the information is encoded see the MPDADF manual at https://mpdaf.readthedocs.io/en/latest/muse.html#muse-mosaic-field-map.

Catalog

The main catalog is a table with 2221 entries, one line for each source. This catalog was taken from CDS (J/A+A/670/A4). It contains a subset of the main measured properties (i.e., the main emission and absorption line flux) and can be used standalone. The full set of measurements is available at the AMUSED web interface (https://amused.univ-lyon1.fr).

Data Reduction and Calibration

The data reduction consists of two major steps: the production of a datacube from each individual exposure and the combination of the individual datacubes to produce the final datacubes. The process is complex and involve many steps which are describe in the DR2 paper, section 4 and appendix. It includes self-calibration algorithm, sky-subtraction with the Zurich Atmospheric Purge (ZAP) software, and the use of a "superflat.".

Data Quality

The spatial PSF was measured on each final datacube. The corresponding FWHMs are 0.55, 0.62 and 0.64 arcsec at 7000A for the MXDF, UDF-10 and MOSAIC datacubes, respectively. The LSF FWHM is similar for all datacubes and varies between 3A at 4800A to 2.5A at 7000A. The average astrometric error is 0.1 arcsec with respect to HST astrometry. More detail can be found in the DR2 paper, section 4.

Known issues

None

Previous Releases

Previous release DR1 is not available via the ESO Archive.

Data Format

Files Types

Images and datacubes are in the multi-extension FITS format, with a data and optionally a variance extension. Masked data have NaN values. The primary header of each file contain a WCS extension and a number of keywords, including the spatial PSF model polynomial coefficients (DR2 Sect. 4.2.1). The file format is described in detail in the corresponding MPDAF documentation. These files can be used directly with any FITS reading tool (e.g., fitsio, ds9), but we recommend using MPDAF (https://mpdaf.readthedocs.io/en/latest/) , which contains an easier and advanced manipulation of these files.

Acknowledgements

According to the Data Access Policy for ESO data held in the ESO Science Archive Facility, all users are required to acknowledge the source of the data with appropriate citation in their publications.

Any publication making use of this data, whether obtained from the ESO archive or via third parties, must include the following acknowledgment:

- The MUSE Hubble Ultra-Deep Field surveys, Bacon et al, 2023, A&A 670, A4.

Since processed data downloaded from the ESO Archive are assigned Digital Object Identifiers (DOIs), the following statement must be included in all publications making use of them:

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