

Survey on available data and planning of catalogue release



INAF – OAR for the Astrodeep project



ASTRODEEP

"Unveiling the power of the deepest images of the Universe"

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ABSTRACT

In this document will be summarized the list of all currently available data (or in a planned future) that will be analyzed within ASTRODEEP and a planning for the full analysis and release.

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Goal

The ASTRODEEP consortium is committed to processing the data resulting from the deepest surveys of the Universe and to deliver the resulting data products to the worldwide community.

During the meeting of 24 and 25 June 2013 the ASTRODEEP consortium has revised the list of key major extragalactic deep surveys of current (and likely future) interest for studies of the deep Universe. The data considered are either already available or the required observations are approved and scheduled for completion within the formal period of the ASTRODEEP project.

List of fields

After a wide discussion, extending to all ASTRODEEP participants, the ASTRODEEP Executive Committee (AEC) has unanimously approved the following plan:

❖ **ASTRODEEP FIELDS.** The fields of interest for ASTRODEEP are:

- **The five CANDELS fields** (UDS-CANDELS, GOODS-South, GOODS-North, COSMOS-CANDELS, EGS-CANDELS). These five fields have a unique combination of data that include extremely high resolution images (from HST) as well as a suite of images over a very wide range of wavelengths, crucially including at very short wavelengths (XMM and Chandra) in many cases and Spitzer and Herschel at long wavelengths. This combination of data and depth means that these fields offer a unique scientific opportunity, and their analysis requires the development and application of the dedicated tools that ASTRODEEP is committed to develop. Since ASTRODEEP members already have a leading role in the analysis of these fields, the commitment of ASTRODEEP is confirmed at the highest level. ASTRODEEP will maintain its responsibility of processing all the imaging data that are or will be made available during the course of the project.
- The wider **UDS and COSMOS fields**, each covering a sky area of approximately 1 square degree. These two equatorial fields have very deep coverage from ground-based and space telescopes (Spitzer and Herschel, but also XMM and Chandra). The interest on these fields is motivated by their large size compared to the five 200 square arcmin CANDELS fields. This makes it possible to investigate the properties of galaxies at large scales and to identify rare and interesting objects. It is acknowledged that the collaborations that are leading these surveys have already developed data reduction and analysis efforts that are not part of ASTRODEEP, and that the duplication of such work would be a waste of resources. However, it is of interest within ASTRODEEP to analyze at least a subset of the available data, in particular the deepest broad-band images from the ground and the long-wavelength data for two purposes: a) to test the applicability of the ASTRODEEP tools on wider field images, exploiting the possibility of performing a direct comparison with the highest quality data obtained in the smaller CANDELS fields embedded in UDS and COSMOS, and

b) to allow the extension of the scientific analysis performed on the CANDELS field to wider areas and to the very bright end of the luminosity and mass functions. Therefore, ASTRODEEP plans to analyze independently the deepest data in these fields, essentially including the broad band images from the ground and the data from Spitzer, Herschel and X-ray satellites, where available. To avoid unnecessary duplication of the efforts, direct contacts will be established with the leaders of the UDS and COSMOS data processing to exchange data and know-how.

- The **HST Ultra Deep Field**, including the latest campaigns executed in 2012. Although the UDF is embedded in the GOODS-S field, sharing with it the other multiwavelength data, its superior depth and quality demands a dedicated analysis, especially to deal with the extreme confusion in the low-resolution images. As described further below, the UDF data set includes also the planned ALMA observations that will be available in the course of 2014.
- The future generation of **HST Frontier Fields**. This public survey will replicate the existing UDF Parallel fields over 6 intermediate redshift clusters, in each case observing both the cluster target and a parallel ‘blank’ flanking field about 6 arcmin from the cluster. This survey, recently approved by the STScI Director, will provide an ideal data resource for ongoing analysis which will maintain the high visibility and scientific impact of ASTRODEEP, as it is anticipated that the Frontier Fields program will trigger many observations from supporting multi-frequency observations from a range of facilities in the near future (e.g. Spitzer IRAC observations are already underway). ASTRODEEP plans to analyze, in a timely and homogeneous manner, all the data resulting from the HST-FF and ancillary observations from space and from the ground. To coordinate the data processing, direct contacts will be established with the STScI staff.

❖ **ALMA and other long-wavelength data sets.**

Another important update with respect to the original proposal is the inclusion of the future ALMA, SCUBA2 and other long-wavelength observation in the ASTRODEEP database. The first such inclusion will be the ALMA-UDF observations that are currently planned in late 2013. ASTRODEEP plans to take explicit initiatives to coordinate further observing proposals in these regimes, as soon as new opportunities become available.

Timeline for data processing

The current plan is the following:

- The CANDELS fields will be first processed with the available set of tools, in this order: COSMOS, EGS, GOODS-N (note that UDS and GOODS-S have already been processed). They will be re-processed in late 2014-early 2015 once updated software has been developed, and deeper Spitzer imaging has been completed. GOODS-S and UDS will also be reprocessed if deemed worthwhile.

- The COSMOS-wide data will be processed with the current tools after the DR2 release of the ULTRAVISTA near-infrared imaging (expected late 2013). Another processing round is anticipated in 2015, following the public DR3 release. The UDS data will be analyzed in 2014, after completion of the VIDEO VISTA Y-band imaging required to complement the existing CFHT/Subaru optical imaging, and UKIRT WFCAM J,H,K imaging.
- ALMA and SCUBA2 mm/sub-mm imaging will be integrated into the database as soon as possible, once the data are available to the ASTRODEEP consortium.
- In particular, the ALMA observations of the HUDF are at a wavelength of 1.3mm, and aim to reach a 5-sigma flux density limit of $S_{1.3\text{mm}} = 0.15 \text{ mJy}$ at an angular resolution of $\sim 0.7 \text{ arcsec FWHM}$.
- The optical-IR images of the HUDF are being processed now and will be delivered in early 2014.
- Each HST-FF field will be analyzed as soon as the data are available from STScI. The first cluster will be observed at the end of 2013, and the others will follow in the following 2 years. The planning of the FF data analysis is particularly critical since the data will be delivered to the community with a specific timescale. We have therefore prepared a specific plan for the data analysis that is shown below.
- The 4Ms images obtained with the Chandra satellite on the CDFS (that contains the GOODS-S field) will be re-analyzed with a prior-based software, using the positional information extracted from the HST images of the GOODS-S field. The catalog is expected to be assembled in early 2014 and released within half 2104.
- The forthcoming 7Ms observations to be obtained with the X-ray satellite Chandra will be implemented as soon as available. The data are expected to be publicly available at the end of year 2014. We target a release of the prior-based catalog within 2015.
- This plan will be revised in about six months time, in order to keep it updated with the evolving situation of the available data.

Detailed data set

These are the actual images and data sets that we plan to analyze. This is a revised version of the table that was put in the Description of Work, since we have inserted the new ALMA observations of the HUDF field and the observations of the Frontier Fields, that have been recently programmed.

| | | GOODS North | EGS CANDELS | UDS | UDS CANDELS | COSMOS | COSMOS CANDELS | GOODS South | HUDFs | Frontier Fields |
|------------------|-----------------|-----------------------|---------------------------------------------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|-----------------|
| | Area Wave. | 150' ² | 150' ² | 1 ^{o2} | 150' ² | 1 ^{o2} | 150' ² | 150' ² | 15' ² | |
| ALMA | 1.3 mm | | | | | | | | 0.15mJy | |
| HERSCHEL | 500 μ m | 9 mJy | 12.8 mJy | 13.4 mJy | 13.4 mJy | 9.5 mJy | 9.5 mJy | 9 mJy | 9 mJy | |
| | 350 μ m | 7.2 mJy | 8.9 mJy | 9.3 mJy | 9.3 mJy | 6.6 mJy | 6.6 mJy | 7.2 mJy | 7.2 mJy | |
| | 250 μ m | 5.7 mJy | 10.7 mJy | 11.2 mJy | 11.2 mJy | 8.0 mJy | 8.0 mJy | 5.7 mJy | 5.7 mJy | |
| | 160 μ m | 2.7 mJy | | | | 11 mJy | 11 mJy | 2.4 mJy | 2.4 mJy | |
| | 100 μ m | 1.1 mJy | 3.7 mJy | 4.0 mJy | 4.0 mJy | 5 mJy | 5 mJy | 0.8 mJy | 0.8 mJy | |
| Spitzer | 70 μ m | | | | | | | 1.0 mJy | 1.0 mJy | |
| | 24 μ m | 2.4 mJy | 3.5 mJy | 18 mJy | 18 mJy | 10 mJy | 10 mJy | 3.1 mJy | 3.1 mJy | |
| | 16 μ m | 21 mJy | 50 mJy | 230 mJy | 230 mJy | 60 mJy | 60 mJy | 20 mJy | 20 mJy | |
| | 8 μ m | 32 mJy | | | | | | 52 mJy | 52 mJy | |
| | 5.8 μ m | 1.7 mJy | 4.8 mJy | 10.2 mJy | 10.2 mJy | 17.3 mJy | 17.3 mJy | 1.7 mJy | 1.7 mJy | |
| | 4.5 μ m | 1.4 mJy | 3.9 mJy | 8.3 mJy | 8.3 mJy | 13.4 mJy | 13.4 mJy | 1.4 mJy | 1.4 mJy | |
| | 3.6 μ m | 0.2 mJy | 0.6 mJy | 1.2 mJy | 1.2 mJy | 2.0 mJy | 2.0 mJy | 0.2 mJy | 0.2 mJy | 26mag |
| VLT/VISTA/UKIDSS | 2 μ m(K) | 0.1 mJy | 0.3 mJy | 0.6 mJy | 0.6 mJy | 1.1 mJy | 1.1 mJy | 0.1 mJy | 0.1 mJy | 26.6 mag |
| HST-WFC3 | 1.6 | 25.6 | 23.8 | 25.0 | 26.0 | 25.0 | 26.0 | 26.8 | 27.2 | |
| | 1.4 (JW) | 27.8 | 26.7 | --- | 26.7 | --- | 26.7 | 27.8 | 29.9 | |
| | 1.2 μ m(J) | | | | | | | | 29.9 | 28.8 |
| | 1 μ m(Y) | 27.8 | 26.7 | --- | 26.7 | --- | 26.7 | 27.8 | 29.9 | 28.8 |
| VLT/VISTA | 1 μ m(Y) | 28.0 | --- | --- | --- | --- | --- | 28.0 | 30.0 | 28.8 |
| HST-ACS | 0.85 μ m(B) | --- | --- | 24.6 | 26.5 | 26.7 | 26.7 | 26.7 | 26.7 | |
| | 0.75 | 27.6 | --- | --- | --- | --- | --- | 27.6 | 29.4 | 28.8 |
| | 0.6 | 28.7 | 27.8 | --- | 27.8 | 27.2 | 27.8 | 28.7 | 29.9 | |
| | 0.45 μ m(B) | 28.2 | 27.9 | --- | 27.9 | 27.2 | 27.9 | 28.2 | 30.1 | 28.9 |
| CFHT/VLT LBT | 0.36 μ m(U) | 28.2 | --- | --- | --- | --- | --- | 28.2 | 29.7 | 28.9 |
| XMM | 2-10 keV | 28.2 | 27.0 | 27.5 | 27.5 | 27.7 | 27.7 | 28.0 | 28.0 | |
| XMM | 5-10 keV | 1.5x10 ⁻¹⁵ | --- | 3x10 ⁻¹⁵ | 3x10 ⁻¹⁵ | 3x10 ⁻¹⁵ | 3x10 ⁻¹⁵ | 4x10 ⁻¹⁶ | 4x10 ⁻¹⁶ | |
| Chandra | 0.5-2 keV | 4x10 ⁻¹⁵ | --- | 1x10 ⁻¹⁴ | 1x10 ⁻¹⁴ | 1x10 ⁻¹⁴ | 1x10 ⁻¹⁴ | 7x10 ⁻¹⁶ | 7x10 ⁻¹⁶ | |
| | | 2x10 ⁻¹⁷ | 5x10 ⁻¹⁷ erg cm ² s ⁻¹ | --- | --- | 2x10 ⁻¹⁶ | 2x10 ⁻¹⁶ | 1x10 ⁻¹⁷ | 1x10 ⁻¹⁷ | |

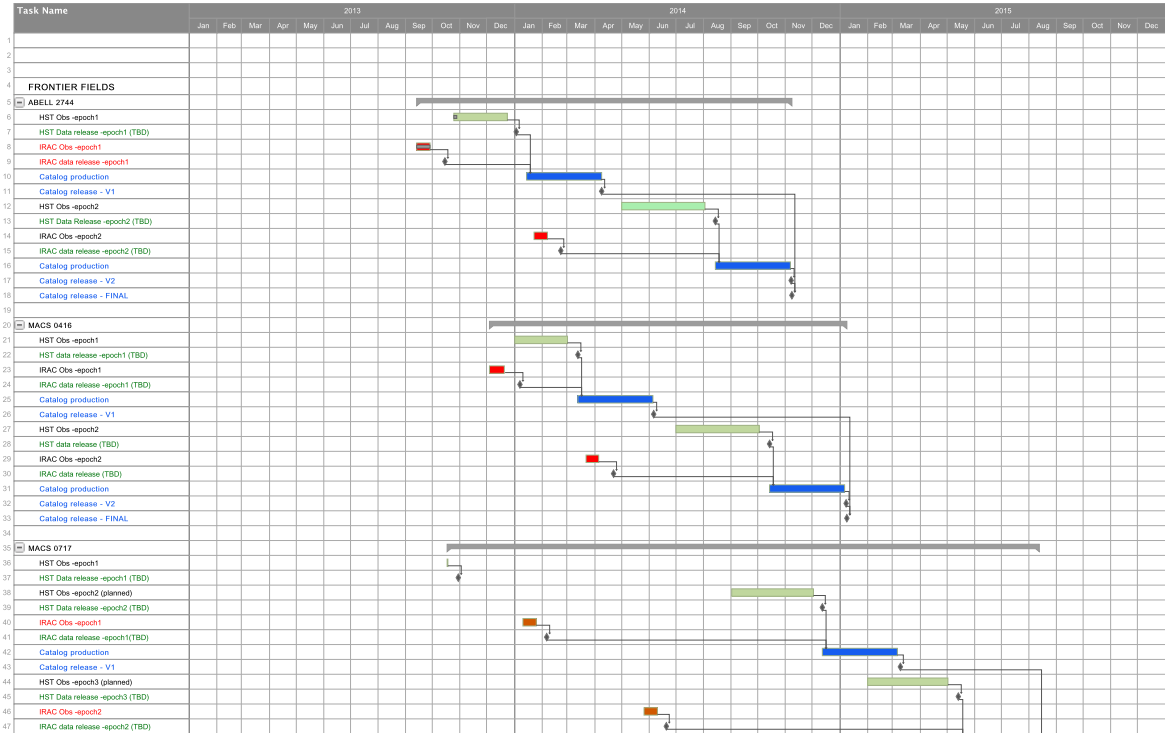
Table 1: Summary of the surveys that will be taken in consideration to build our database. For each field we provide the limiting depth (at 5σ) from the space and ground-based instruments at various wavelengths: flux densities in μ Jy and mJy in the mid to far-infrared, AB magnitudes in the UV/optical/near-IR and flux densities in $\text{erg cm}^{-2} \text{s}^{-1}$ in the X-ray domain. The table includes only approved programs.

Dissemination strategy

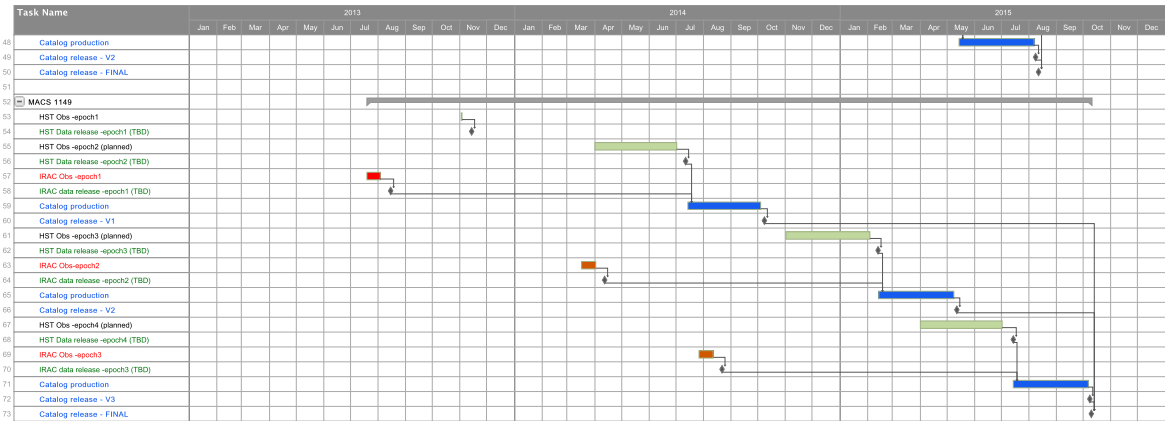
The release of all catalogs and other project products will be through a **WEB-based public repository**. ASTRODEEP will prepare and maintain a section of its website dedicated to a compilation and description of all the data available on these fields, including images, and catalogs, either processed by ASTRODEEP or otherwise available. For each field a specific ASTRODEEP coordinator will be appointed, with the task of maintaining and updating this table throughout the duration of the project.

Frontier Field Data Reduction Plan

Data Reduction Plan



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