The ESO Imaging Survey Project - Status and Pipeline Software

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Abstract. The ESO Imaging Survey (EIS) is a major public imaging survey project being conducted by the European Southern Observatory using several different telescopes and detectors at La Silla in Chile. The primary aim is the identification of samples suitable for more detailed study using the ESO Very Large Telescope (VLT). The first part of the project consisted of two parts - EIS-Wide an optical survey to moderate depth ($I_{AB} \lesssim 24$) covering about 20 square degrees and EIS-Deep which covered smaller areas of sky to greater depth ($B_{AB} \lesssim 26.5$) and also included deep near-IR imaging. These surveys are essentially complete and the data are available to users world-wide through the EIS webpages[2].

Following a successful pilot project with the new Wide Field Imager (WFI) on the 2.2m telescope at La Silla the EIS team is now engaged in a public imaging survey using the WFI telescope in conjunction with IR imaging using SOFI on the NTT. Three deep fields of one degree square, including the Chandra Deep Field South (CDF-S) are being imaged in the optical along with smaller sub-areas in IR bands. In addition 160 stellar fields have been imaged as part of the preparations for the use of the FLAMES fibre-feed system for spectrographs on the VLT.

To support the large data volume from this survey and to facilitate its rapid scientific exploitation a complete end-to-end pipeline system has been developed. Here we give a brief outline of the project so far as describe the motivation and architecture for the pipeline software.

1. Origins and Historical Evolution

The ESO Imaging Survey (EIS) was established at the European Southern Observatory in 1997 to perform appropriate public surveys to help identify samples of interesting objects for the ESO Very Large Telescope which was then approaching completion. Existing surveys at that time did not go deep enough to reach the spectroscopic limits of the new generation of large telescopes. A working group was established to oversee the surveys and a visitor programme established to allow experts from the community to

[1]Space Telescope – European Coordinating Facility

[2]`/eis`

be funded to work at ESO as part of the EIS team. EIS aimed to establish a framework for future imaging surveys and foster collaboration with the European astronomical community.

The first phase of the survey was EIS-Wide which was devoted to moderately deep imaging ($I_{AB} \lesssim 24$) in BVI in four patches of the southern sky. A total of 17 square degrees in I and smaller areas in B and V were obtained using the EMMI instrument on the ESO NTT. This was complemented by EIS-Deep which imaged two smaller fields (the Hubble Deep Field South and the Chandra Deep Field South) to greater depth ($B_{AB} \lesssim 26.5$) and also included near infrared imaging with SOFI. Data were made public in 1998 and described in accompanying papers (Nonino et al. 1999; Olsen et al. 1999a; Prandoni et al. 1999; Zaggia et al. 1999; Olsen et al. 1999b; Benoist at al. 1999; Scodeggio et al. 1999).

In 1999 the Wide Field Imager (WFI) on the 2.2m telescope at La Silla was available. This efficient, wide-field mosaic camera system was used in a pilot project to complete EIS-Wide and image many stellar fields. From November 1999 this was extended into a formal Deep Public Survey which is currently in progress. It covers three fields, each 2×0.5 degrees in the UBVRI optical bands and covering 450 sq. arcmins at JKs in the near infrared. This is supplemented by 160 stellar fields in preparation for the FLAMES multi-fibre spectrograph to be installed on the VLT. These and the earlier fields are shown on Figure 1.

2. Science Results and Data Examples

An example of a small piece of one of the EIS-Wide patches is given as Figure 2 and shows how many overlapping small fields, from different telescopes and cameras can be effectively mosaiced and aligned from separate astrometric solutions. Some initial science results on distant galaxy clusters have been published (Olsen et al. 1999a,1999b; Scodeggio et al. 1999) along with preliminary lists of interesting colour-selected point-sources (Prandoni et al. 1999; Zaggia et al. 1999). A much larger area of sky is now available in BVI from the combined pilot and EIS-Wide surveys and is yet to be fully explored. Extensive follow-up observations, with the VLT and other telescopes, are currently in progress.

3. Early Software Approaches

The initial data volume and rate were modest and a pragmatic approach of re-using existing software was adopted (Hook et al. 1998). Tools pressed into service included SExtractor (Bertin & Arnouts 1996) for object catalogue preparation, IRAF for standard frame reduction, Drizzle (in adapted form) for image coaddition and Eclipse (Devillard 1999) for reducing IR data. The LDAC tools, developed for the DENIS survey (Epchtein et al. 1998) were used for the demanding astrometric and photometric calibration steps. These items were controlled from shell scripts. Unfortunately the simultaneous observing, software development, reduction, data-release, science analysis and publication of results by a small team, combined with the increase in data volume from the WFI and critical staff changes led to an impossible situation and a major pipeline overhaul was conducted in 1999.

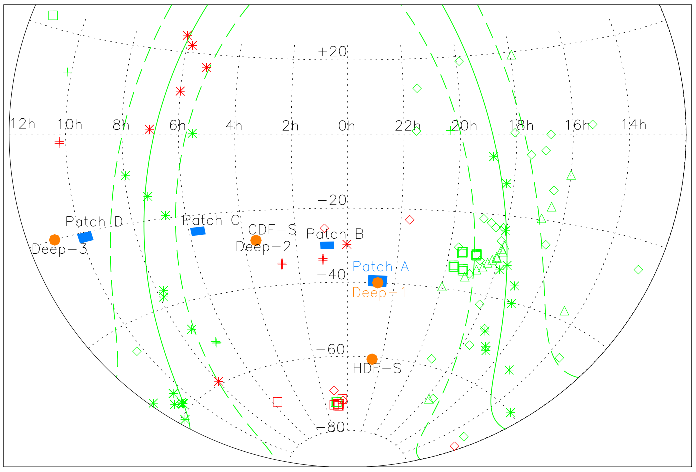

Figure 1. The Southern Sky showing the positions of the EIS fields along with the Milky Way. The main fields are individually labelled. Asterisks are open cluster, diamonds globular cluster, crosses local group galaxies triangles Milky Way bulge/halo fields and squares Sagittarius Dwarf and LMC/SMC fields.

4. The Current EIS Pipeline

The current pipeline design aims for robustness and ease of use but accepts the constraint that it would be impossible to create a fully automatic system using the resources available. Extensive use of a Sybase database allows tracking of the processing and storage of some intermediate information. The use of Objectivity was considered but inadequate resources were available for such an initiative. The ESO archive provides both a repository for the raw data and also a mechanism for distributing the data products to the community. Python has been adopted as the pipeline glue language and has a GUI (written in Tkinter) layered on top for ease of use and training for a rapidly changing group. The GUI provides both high level pipeline control panels and access to lower-level functions for expert use. It is an end-to-end system with components to address aspects of the data-flow from proposal preparation through to catalogue preparation and science backend tasks such as preparing colour-colour plots and determining photometric redshifts. Some components remain from the earlier work but entirely new pipeline software has been created for the Deep and Pre-FLAMES reductions. The pipeline components and infra-structure are mostly in place at the time of writing but not all in full operation.

5. Future ESO Sky Surveys

The current EIS survey is only a small part of the planned European imaging surveys for the near future. Over the next two years the VLT Survey Telescope, a 2.5m dedicated survey telescope to be sited adjacent to the VLT, and VISTA, a UK project for a 4m optical-IR survey telescope, also on the same site, will conduct much larger surveys.

Figure 2. Example of a small piece of EIS-Wide Patch D. The blue and green channels come from 2.2/WFI B and V data and the red from earlier NTT/EMMI I band imaging.

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