ASTRO-WISE
Astronomical Wide-field Imaging System for Europe
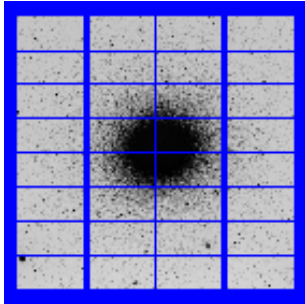
Wide field imaging of the sky

The recent rapid development of large digital CCD detector devices allows an old dream of astronomers to become true: a deep and ultra sharp imaging of the complete sky at different colours of the spectrum. To this end, both in the Northern and at the Southern hemisphere dedicated wide field imaging cameras are in an advanced phase of construction. At ESO's new site Paranal (Chile), next to the VLT telescopes, a new telescope is under construction which will be entirely dedicated to the wide field imaging of the sky - the VLT Survey Telescope (VST). These wide angle cameras will in one 'picture' image an area of the sky as large as 4 times that of the full moon (1 square degree) in an array of 16000 times 16000 pixels, thus producing 256 Million pixel images in an unprecedented combination of *BOTH WIDE AND SHARP* (note- compare this with the best commercial photocameras which contain 1-2 Million pixels per photo). Such wide field images will be used by individual researchers in the EU to perform their own dedicated scientific research. Many of the anticipated research programmes focus on the detection and discovery of rare objects, sometimes yet unknown objects, ranging from new asteroids near Venus, planetoides beyond Pluto to quasars at high redshifts or instantaneous light fluctuations due to gravitational lensing effects. Dozens of different science programmes are in preparation with objectives ranging from understanding the formation of the solar system to dark matter in external galaxies. Newly discovered objects can be further studied in detail with ESO's 8 meter VLT telescopes, which detect fainter light but whose narrow (telelens) field makes them inefficient survey telescopes.

The enormous data volumes produced by these wide field imagers brings the astronomical research again at the edge of the possibilities of modern information technology. For the camera at the VST, OmegaCAM, an annual rate of about 30 Terabyte (1 Tbyte = 1000 Gbyte) of raw science image data is expected, which after cleaning up will deliver about 10 Terabyte/year of image data ready for scientific research. Each of these images will contain about 100 000 astronomical objects and the estimated yearly production of new tables containing valuable scientific properties of these objects (such as brightness, position, shape descriptors) is of the order of 1 Terabyte/year.

This new branch of observational astronomy is now well on its way: the VST will be delivered in 2002/2003, together with its wide field camera (OmegaCAM). At Hawaii, French astronomers plan to commission the Northern hemisphere counterpart camera (MegaCAM). A few years later, ESO will install VISTA at Paranal, a wide field telescope optimized to the near infrared wavelength.

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In Germany (München), Italy (Napoli), France (Paris) and the Netherlands (Groningen) national datacenters will support their users community and provide the infrastructure for the handling, storage, distribution and processing of the enormous data volumes. The centers will operate Beowulf Linux 32 node computer clusters and provide many Terabyte direct access storage. National datacenters will also replicate to smaller satellite centers in e.g. Leiden and Padua. These national centers have started a partnership, together with ESO, to commonly build a *survey system* to reduce and disseminate wide field imaging data and support individual scientists to do their particular research on the data.

The partnership involves the building of software tools and the exchange of both expertise and image data, as well as all auxilliary data and code. The mission of this collaboration is to provide the users community with the access and tools to do active research on the wide field imaging data and to populate and distribute databases which can be accessed by future world wide Virtual Observatories, such as AVO. ESO participates in this initiative in the context of their public survey activities.

The specific objectives of ASTRO-WISE are:

- to develop, maintain and provide access to a computational environment to process wide-field imaging data; the EU-wide shared environment will house both up-to-date calibration data and software, such as automatic pipelines, to process the raw data.
- to develop and disseminate in the community software tools needed to access the wide-field image data, to perform individual research programmes - tools are essentially search and visualisation tools, scalable to Terabyte regimes.
- the provided infrastructure will be used for the production and dissemination of survey data (multicolour, wide area calibrated images and source catalogues), to be accessed by virtual observatories.

The achievement of these goals involves advances and upgrades of existing infrastructure including:

- the setting of standards and the design and implementation of a federated data model to support the exchange of data, computer code and all data-reduction related administration between the various National data centres engaged in the processing and distribution of the wide-field imaging data.
- exchange of programmer expertise and collaboration between the experts at the sites.
- a testbed for at-the-edge-of-technology handling of large amounts of data for the European community - in close co-ordination with AVO and ASTRO-GRID.

The implementations of these objectives in the Terabyte regime differ from the *old era static* approach in which raw data is processed with a standard pipeline to deliver a catalogue. Instead, in the *new era, dynamical* approach the result can be re-derived. The various calibration data and other input files are distributed over the network which connects the data centers. This way the manpower load is efficiently spread over the community and for the production of survey results each site benefits from the work done elsewhere. In turn, the end-user can profit from these achievements when doing research. The user can query the system but can also re-derive results with the addition of own "plug-ins". The system would provide a first necessary step towards the building of a Virtual Observatory.
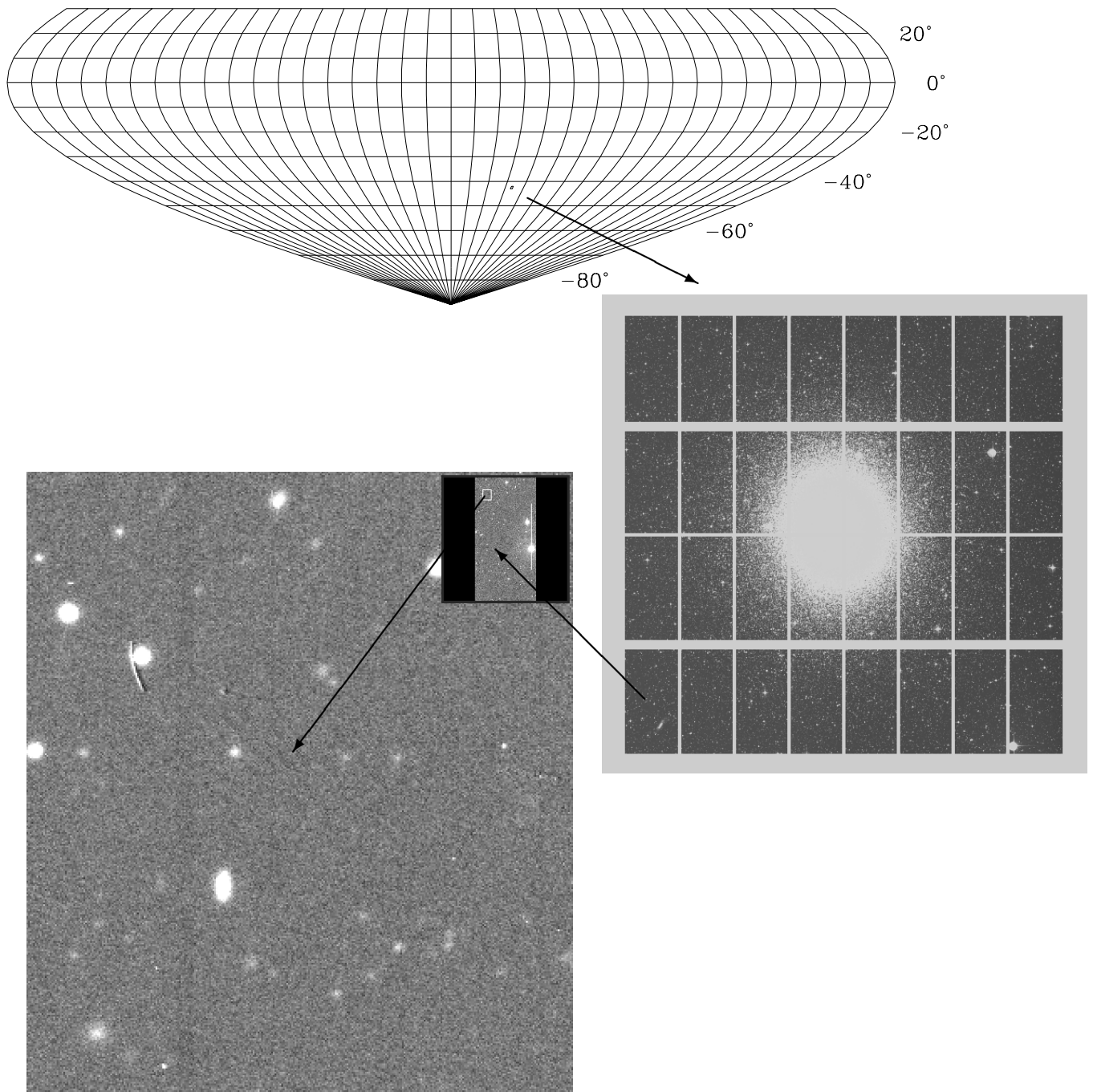
Figure 1: Illustration of the volume of data to be expected from a sky surveying instrument. *Top:* Raster of 10×10 degrees on the Southern sky. The small square is one square degree, the size of the field covered by a single OmegaCAM exposure. *Right:* Simulated OmegaCAM exposure. The 32-CCD mosaic is clearly visible. Each CCD has 2k×4k pixels, which makes for a total of 256 Mpixels per exposure. *Bottom left:* An actual CCD image, made with the camera on the Isaac Newton telescope on La Palma. The small inset shows the full CCD (which covers roughly the same amount of sky as each OmegaCAM CCD will) , the main image is a cutout of roughly 0.02×0.025 degrees. In this 0.05% of an OmegaCAM field, some 50 sources, mostly distant galaxies, are present!

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VISTA: **www.vista.ac.uk/**
VST: **vst.na.astro.it/**

The Project

The current ASTRO-WISE programme is planned for 4 years: 2002, 2003, 2004 and 2005.
The ASTRO-WISE team involves ∼35 persons at 7 sites together providing ∼ 60 fte, of which roughly 1/3 is funded by the EC.
Excluding the computing hardware, which will be provided by the partners, the eligable costs of the current programme amounts to ∼4.5 Meuro, of which 1.5 Meuro is funded by the EC.
The NOVA office keeps the financial administration; the project coordination is based at the NOVA site the Kapteyn Institute at the University of Groningen.

Contact

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Appendix: Workpackages

WP1 Provide and operate processing facility of raw image data
objective:
- develop, implement and operate a full wide-field imaging pipeline from raw data to astrometrically and photometrically calibrated images
- populate the database with the necessary calibration information
work description:
- implementation of existing pipeline modules
- implementation of interface to data base for all calibrations and survey system results
- further develop, benchmark astrometric calibration, co-addition methods eg SWARP, multi-resolution decomposition of images
- further develop techniques for reduction of IR data
- operational tasks of populating database and maintaining pipeline

WP2 Provide tools for quering, searching and visualistion
objective:
- provide tools for the end user and qualify through the involvement of academic research
work description: design, develop, implement and qualification of:
- extract source list tool- including artificial intelligence methods
- associate source list tool
- search database tools
- visualisation tools
- relay to the user all existant data in the data base related to a particular astronomical object

WP3 Provide Federated database
objectives:
Design and implement federated databases that distribute documentatation, source code, tools, pipeline administration, and calibration data over the participating sites as a support tool for WP1 and WP2.
This wp provides the project management's backbone of the survey system.
work description:
- define classes/standards
- select data base engines
- define interfaces to pipeline and tools environment /implement
- define query language/method /implement
- define scripting /implement
- implement classes interfaces to data bases

WP4 provide parallel processing power to ASTRO-WISE
objectives: provide the necessary computing power to the prime data centers; install and operate Linux-Beowulf 32 Gigabit PC parallel clusters
work description:
- hardware procurement and installation
- upgrading and export to other main sites of existing 4 PC clusters
- maintenance

WP5 Provide data storage to ASTRO-WISE
objectives: provide the necessary direct acces data storage to the prime data centers; typically 1Tbyte/ site direct access, upgradable to 10 Tbyte/site within two years.
work description:
- hardware procurement and installation
- hardware maintenance

WP6 Coordination
objective:
Coordinate WP001-005 into a coherent survey system; exportable to satellite sites, accessible to the community, and coordinated with future Virtual Obervatory enterprises.
work description:
- Provide strong Project management structure
- Supervise the coordination of the components of Wp001-005 into a coherent survey system
- meetings, travel, document
- coordinate with future surveys such as VISTA
- coordinate with future customers, such as AVO, AstroGrid
- coordinate with future Infrastructure providers such as DataGRID and AVO.