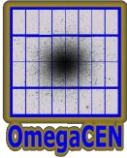


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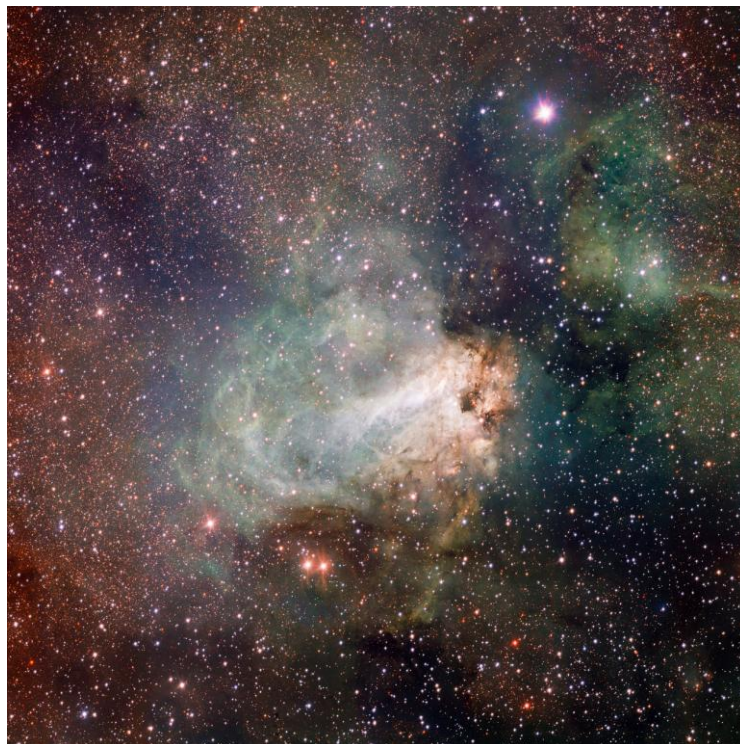


## 1. The OmegaCEN data center

OmegaCEN is the partly NOVA funded national datacenter for wide-field imaging and the expertise center for astronomical information technology. It is situated at the Kapteyn Astronomical Institute of the University of Groningen (RUG). The center is headed by prof Valentijn and brings together astronomers and astronomical IT experts. About 15 scientists (staff, postdocs, PhD students and scientific programmers) work at OmegaCEN and jointly conduct both astronomical research and R&D in astronomical information technology. OmegaCEN is partner in international optical, near-infrared and radio surveys, ESA space missions, ground-based wide-field imagers and spectrographs. OmegaCEN also leads and partners in development and research for both astronomical and multi-disciplinary large-scale complex information systems.

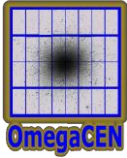
## 2. Commissioning OmegaCAM on ESO-Paranal, Chile

Commissioning of the optical OmegaCAM panoramic imager at the VLT Survey Telescope (VST) has been achieved successfully in 2011. In total 4 commissioning runs were executed between March and August 2011. OmegaCEN led the data flow operations on Paranal with a real-time “back-office” in Groningen. The instrument produces very good image quality (up to 0.6 arcsec seeing) and the wavefront sensing system devised for the camera works well. The OmegaCAM datahandling went smoothly. The 8 Terabyte of OmegaCAM data from commissioning and survey dry runs have tested and sharpened the data handling involving most aspects of OmegaCEN’s survey handling system Astro-WISE.



The first released OmegaCAM-VST image shows the spectacular star-forming region Messier 17, also known as the Omega





Nebula or the Swan Nebula, as it has never been seen before. This vast region of gas, dust and hot young stars lies in the heart of the Milky Way in the constellation of Sagittarius. The VST field of view is so large that the entire nebula, including its fainter outer parts, is captured — and retains its superb sharpness across the entire image. The data were processed at OmegaCEN using the Astro-WISE software system.

### 3. Weak-lensing survey KiDS-VIKING: survey production, early science pilots

Regular Survey Operations with OmegaCAM at the VST commenced October 15, 2011. OmegaCEN leads and coordinates the data handling for the Kilo Degree Survey (KiDS). It is the largest (440 nights) of ESO's Public Surveys with OmegaCAM. KiDS is a 1500 square survey through 4 optical filters (u,g,r,i) with the OmegaCAM wide-field imager at the VST. Survey team kick-off took place November 3 and 4. Since then, the KiDS survey team spread over Groningen, Leiden, Bonn, Munich, Naples and Paris has used Astro-WISE to commission the KiDS pipeline and to produce its first internal delivery of 160 one square degree calibrated and co-added images of KiDS fields (January 2012). VIKING is the near-infrared counterpart of KiDS, using VIRCAM at the VISTA telescope. The VIKING survey products (images and catalogs) are delivered by CASU/WFAU in the UK and are ingested and updated continuously in Astro-WISE. KiDS-VIKING science drivers are dark matter and dark energy through weak-lensing, galaxy evolution in superclusters, high redshift QSOs and extreme Brown Dwarfs. The combined datasets in Astro-Wise deliver 9 band accurate surface photometry. Early science pilots have been initiated in Groningen: searches for high-z QSOs and extremely cool Brown Dwarfs by combining KiDS with the VIKING survey products by Belikov and Verdoes Kleijn.

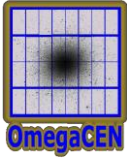
### 4. Multi-survey system Astro-WISE

Astro-WISE is the workhorse for OmegaCEN for survey production and research for KiDS-VIKING and also several other surveys in which the center participates. It is a unique, advanced survey information system for calibration and research dealing with multiple large surveys. Astro-WISE connects in real-time databases, compute and storage grids available at national datacenters and satellite nodes across Europe. Geographically-spread survey teams collaborate in this single virtual research environment. Here, the teams calibrate astronomical wide field imaging data up to the Petabyte regime, do research analysis and publish the results. Astro-WISE was designed and developed in-house and is coordinated by OmegaCEN. A topical issue of Experimental Astronomy is dedicated to the Astro-WISE system and its deployment for other instruments and disciplines — totaling 21 papers to appear early 2012 (see references for 2011 pre-publications). The system has also been presented in five posters and a booth at the ADASS XXI, Paris, November 2011

### 5. Galaxy evolution in cluster and supercluster environments

In 2010-2011, astronomical research using the Astro-WISE system in Groningen was carried out by Valentijn, McFarland, Belikov, Verdoes Kleijn, Peletier, den Brok, Sikkema, Bout and Buddelmeijer. For the **HST/ACS Coma Legacy Survey**, studies were done in the Coma Galaxy Cluster on color gradients in dwarf and giant galaxies, barred galaxies, the Coma intergalactic-globular cluster system (den Brok et al 2010,2011, Hammer et al 2010, Marinova 2010, Peng et al 2011). Also a comprehensive Coma HST/ACS catalog of structural parameters was published (Hoyos et al 2011).





The **Hercules Supercluster Survey** is an OmegaCAM GTO project lead by OmegaCEN. The supercluster is at an optimal distance ( $z=0.036$ ) to study the whole supercluster substructure in 12 pointings while close enough to study the detailed galaxy structures. The supercluster contains clusters in dramatically different stages and rich intercluster regions where galaxies fall into the subclusters and undergo morphological transitions. The goal is to discriminate between the relative importance of the various known transitions models for the variety of environments. Using preliminary data obtained during commissioning, PhD Bout is creating a multi-band structural parameters catalog.

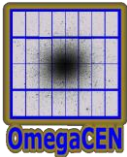


The Hercules galaxy cluster (also known as Abell 2151) lies about 500 million light-years away in the constellation of Hercules. It is unlike other nearby galactic assemblies in many ways. As well as being rather irregular in shape, it contains a wide variety of galaxy types, particularly young, star-forming spiral galaxies, and there are no giant elliptical galaxies in sight. The data were processed at OmegaCEN using the Astro-WISE software system.

Lastly, for the ATLAS3D nearby galaxy survey, the WFC-INT imaging survey was delivered in 2011 via Astro-WISE. The data is used for various ATLAS3D projects (Cappellari et al. 2011, Scott et al 2011).





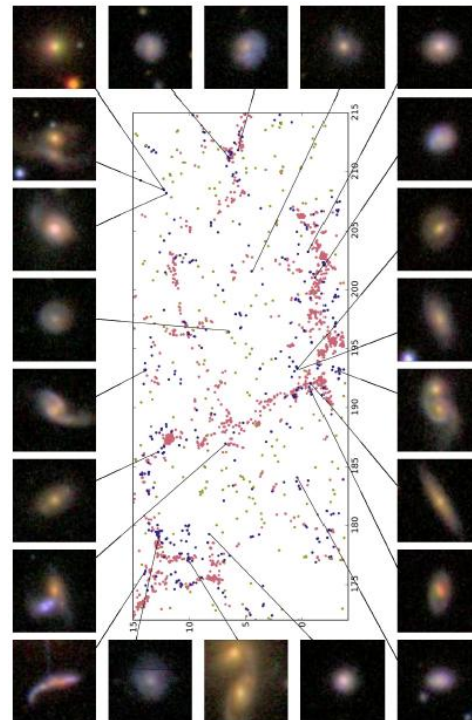
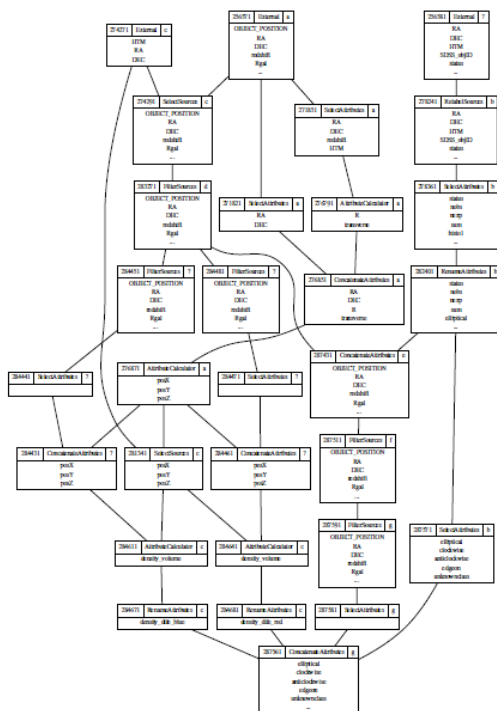


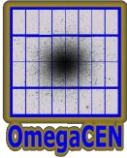
## 6. Astronomical Informatics Research

OmegaCEN's goal is to enable astronomers to efficiently run their mining algorithms, specialized processes and to publish results for a Petabyte-sized ocean of data. This is achieved by imposing extreme data lineage to all processing steps. In fact, OmegaCEN's IT research is on developing datacentric models in which keep track of the processing configuration and propagation of data. This relates to quality controls, distributed users, archiving and query driven visualization.

Mwebaze works on Extreme Data Lineage in a distributed environment (Nuffic-PhD). The aim is to exploit data lineage in scientific pipelines to the sub-image level and eventually couple applied methods and programs to the data in a database. This results of this research building on OmegaCEN's WISE approach have been published in a series of refereed publications (Mwebaze et al., 2010a,b and Mwebaze et al., 2011a,b,c,d,e).

Query-driven visualization of very large catalogues was developed by PhD Buddelmeijer in collaboration with the Scientific Visualization and Computer Graphics research group of the Mathematics and Computer Science department (PhD Ferdosi) in the NWO-STARE programme AstroVIS. The goal is to give within the visualization process direct access to multi-dimensional 10-100Tbyte datasets, which current visualization techniques cannot handle 'stand-alone". It is leading research in a new domain called "query driven visualization" which is currently emerging. Buddelmeijer did his PhD defense in July 2011; a first prototype for query-driven visualization was designed and implemented in Astro-WISE. The Virtual Observatory is accessed from within Astro-WISE using the Plastic/SAMP communication protocol, providing visualization infrastructure for very large, multi-dimensional datasets.





**Left:** A dependency graph, generated by the Query-driven Visualization prototype in Astro-WISE to study galaxies at the edges of clusters (PhD Buddelmeijer). Every box represents a catalog that is derived from the catalog above it. **Right:** Examples of galaxies in edges of clusters, detected with this mechanism. Red dots denote cluster galaxies, blue dots edge galaxies and yellow dots field galaxies.

## 7. Target: LOFAR, EUCLID, MUSE, MICADO, GAIA

As a leading partner in the Target programme OmegaCEN coordinates and supports the development of several very large-scale information systems for astronomy and beyond. This programme was triggered by the unique generic e-science aspects of the Astro-WISE system. Target is coordinated by Valentijn and is a collaboration between 5 public research groups (OmegaCEN-NOVA, LOFAR-Astron, Artificial Intelligence -RuG, Donald Smits Center for Information Technology-CIT-RuG and University Medical Centre Groningen) and 5 high-tech business enterprises (including IBM and Oracle). The Target partners execute a 32 Million Euro, 5 year program since September 2009.

OmegaCEN designed and supports together with ASTRON and CIT the Long Term Archive for LOFAR. Target also participates in the EU EGI project and hosts the Low Frequency Array (LOFAR) application of the EGEE-3 Astronomy and Astrophysics cluster and collaborates with the National Big Grid programme. Together with CIT and Astron a new 58 sixteen-core Grid cluster has been installed December 2011 at the CIT.

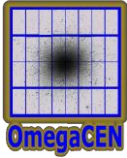
OmegaCEN is involved in the Euclid Consortium (EC) for the development of its huge Science Ground Segment. In 2010 and 2011, OmegaCEN had an important role in the data-handling study for EUCLID which led to the Euclid Definition Study Report in July 2011. The mission was selected on October 4 for launch in 2018/19. The NL contribution to the EC will involve major datahandling research and development. Together with MPE OmegaCEN will lead, build and perform the *ground-based* data handling for ESA's EUCLID space mission, involving KiDS-VIKING, Pan-STARRS and DES (OU-EXT, Verdoes Kleijn). OmegaCEN leads the development of the Euclid Mission Archive (Williams, Belikov, Valentijn, EMA) in close collaboration and partnership with ESA, who have responsibilities for the Euclid Legacy Archive (ELA). The Dutch Science Data Center (SDC, Williams) will be located at the RUG. The Euclid infrared imaging pipeline, to be developed by Leiden Observatory, will be hosted at the RUG.

OmegaCEN/Target submitted a Lol to participate in the GAIA space mission archive preparatory activities (GAP). OmegaCEN was formally accepted as a GAP partner in May 2011. The current activities involve defining use cases and investigating virtualized processing systems.

The MUSE consortium is a scientific customer of Target/OmegaCEN. Target/OmegaCEN is developing a data-handling system for the ESO VLT- Multi Unit Spectroscopic Explorer (MUSE). The prototypes of several MUSE pipelines modules have been successfully embedded in an environment based on existing WISE technology. The prototype MUSE-WISE system is already being used to support MUSE simulations. It is anticipated that the full system will be operational by June 2012. First light for MUSE is planned in 2013.

OmegaCEN is also member of the consortium for the MICADO instrument, which has been selected as a first light instrument for the 42 meter E-ELT. OmegaCEN delivered a Phase A design for its data flow system (see Davies et al. 2010a,b for a MICADO overview).





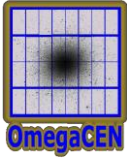
NOVA-OmegaCEN was/is partner for several European Virtual Observatory (EURO-VO) programmes: the EU FP6 EURO-VO Data Center Alliance (EURO-VO DCA) and the FP7 EURO-VO Astronomical Infrastructure for Data Access (EURO-VO AIDA). OmegaCEN team members are members of its Board, Workpackage Management Team and Internal Science Team and Peletier of the Science Advisory Committee. In the framework of these programs OmegaCEN developed the infrastructure to access data residing in Astro-WISE through the Virtual Observatory. OmegaCEN hosted the Dutch Virtual Observatory Day, 27 April 2010, co-organized an interacademial course and gave a masters course on Virtual Observatory and Astronomical Data mining, both in 2010.

### **8. Target-OmegaCEN hardware park operations**

OmegaCEN also builds and operates an extensive hardware park. This includes a database cluster (8 TB storage space and 128 GB internal memory) and 160 TB of file storage space connected to the users via web-portals. The datacenter also runs servers specially equipped for image stacking and on-line image cut-out services. Together with the nodes in Munich (Pan-STARRS), Naples, Bonn and Nijmegen the distributed storage pool of Astro-WISE is near the Petabyte regime.

In 2010-2011 OmegaCEN further extended the collaboration with the RUG's Donald Smits Center for Information Technology (the computing center of the RuG). We now have dedicated access to the University High-Performance Compute Cluster (200 twelve-core nodes), the Big Grid cluster (58 sixteen-core nodes) and 2,700 Tbyte of space reserved on the Target Storage Infrastructure. A number of dedicated server class machines provide access to these facilities. The Target Storage will be further enhanced by a high speed interconnect with the Big Grid cluster in early 2012.





## 9. Workshops and education

The OmegaCEN team has participated in a range of workshops and conferences in 2010-2011. In addition OmegaCEN itself has (co-)organized the following workshops and courses.

- Dutch Virtual Observatory Day, 27 April 2010, at the Kapteyn Astronomical Institute.
- Interacademial Course, Modern Data Mining in Astronomy, Utrecht, Feb-May 2010
- Course on Virtual Observations and datamining in Astronomy, Kapteyn Institute, fall 2010
- National Euclid Day, Donald Smits CIT, 7 April 2011

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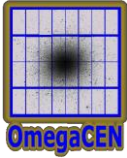
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