OmegaCAM: The 16k x 16k Survey Camera for the VLT Survey Telescope

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ABSTRACT

The OmegaCAM consortium, in collaboration with ESO and the ASTRO-WISE consortium, is building a survey system for the OmegaCAM 16k x 16k wide field imaging optical camera, which is expected to become operational in 2004 at ESO's VLT Survey telescope (Paranal). The camera will be the only instrument on the VST for an anticipated 10 years of operations. It maps one square degree of sky with 0.21 arcsec sized pixels. Both individual programs, including monitoring programs, and large sky survey programs are planned. Here we present the integrated design of the VST-OmegaCAM survey machine, including the hardware (large filters and shutter, cf [4836-34]), the VLT compliant control software (cf [4848-10]) and the strongly procedurized observing and calibration strategies. The strict data taking procedures facilitate pipeline data reduction procedures both for the calibration and the science data. In turn, the strongly procedurized data handling allows European-wide federations of data-products. On-the-fly re-processing of archival data on the request of individual users with their own plugs-ins or newly derived calibrations sets are facilitated in an internationally distributed system. Compared to the classical more static wide-field image archives the newly designed system is characterized by a much more dynamical type of archiving.

Keywords: Survey system, federations of archives

1. INTRODUCTION

OmegaCAM (www.astro.rug.nl/~omegacam) is an optical 16k x 16k CCD camera, currently being built for the 2.6 m VLT Survey Telescope on ESO's Paranal site. The camera maps one square degree of sky with a pixel size of 0.21 arcsec. It will be the only instrument on the VST for at least the first five of its anticipated ten years of operations, which are expected to start in early 2004.

An international consortium builds the camera from three European countries: the Netherlands, Germany and Italy. In each of these countries a leading institute coordinates the national contributions: the Kapteyn Institute Groningen (PI - Kuijken), the Universität Sternwarte München (co-PI Bender), and the Osservatorio de Padua (co-PI Cappellaro). In addition, ESO's optical detector group (Iwert) participates in the consortium.

The instrument will execute dedicated observing programs defined by individual users or teams. About 2/3 of the available observing time will be allocated by ESO's Observing Programme Committee. The remaining time is labelled as guaranteed time for the consortia involved in the construction of the telescope and the camera. Both small dedicated programs and large wide-field sky surveys are expected.

The VST and OmegaCAM are built to provide an observing facility to allow selection of targets for follow-up observations with the VLT. It will also conduct stand-alone observing programs that require wide-field imaging. The camera and its associated data reduction will facilitate accurate photometry (nominal ±0.05 mag, exceptionally ±0.01 mag) and astrometry (nominal 0.1 arcsec rms) over its entire field of view.

Section 2 gives a very brief overview of the instrument and its characteristics. Elsewhere in this conference detailed descriptions of hardware components are given, cf [4836-34] [4848-10]). Here, we focus on the processing of the huge amount of data produced by the VST/OmegaCAM. Section 3 gives an overview of the processing

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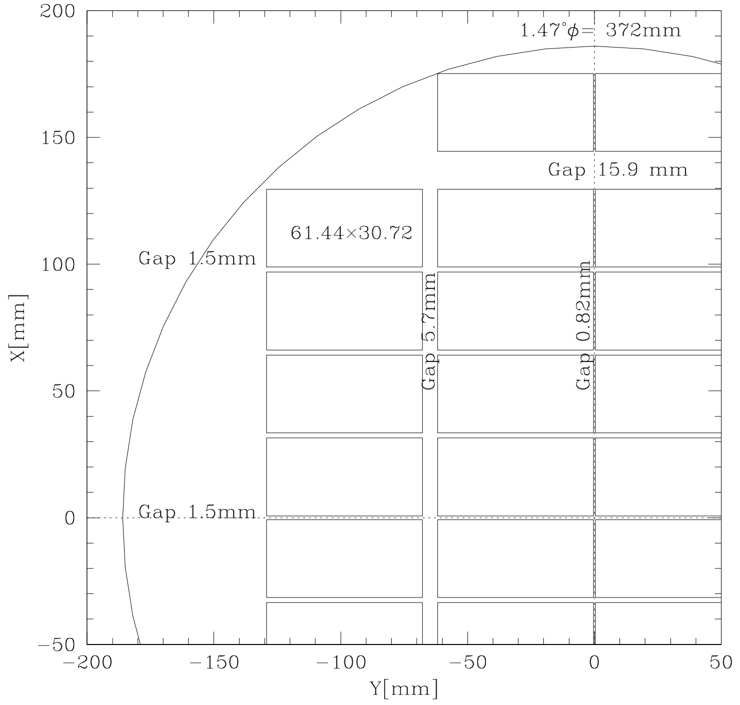

Figure 1. Sketch of layout of a quadrant of the CCD arrays. Units of X and Y axes are in mm.

aspects involved in the reduction of the OmegaCAM data, highlighting the problematic areas of processing large quantities of data. Section 4 presents our solution to these problems and sketches a new paradigm in scientific research with huge datasets.

2. THE INSTRUMENT

OmegaCAM is a wide field optical imager, featuring a 4 × 8 mosaic of 4k × 2k pixels Marconi (formerly EEV, now E2V) thinned CCD's with a total imaging area of 16k × 16k pixels. The mosaic will cover the VST field of view of 1° × 1° and at the same time it will adequately sample even the best seeing conditions, ∼0.4-0.5 arcsecond, foreseen at Paranal. The standard observing mode is with a two-lens field corrector. In addition, a single lens plus atmospheric dispersion corrector can be used.

The instrument features a two-blade photometric shutter. An exposure is started by moving the blade that obscures the CCD's to a rest position, and is finished by moving the other blade from its rest position to the position that obscures the CCD's.

2.1. CCD's

The layout for the CCD array is sketched in Fig. 1. It consists of a, roughly square, science array of 16384×16384 pixels, and four auxiliary CCD's for guiding and image analysis.

With the preferred LL,RR arrangement for orientations of the CCDs' readout ports the gaps between sensitive areas are 5.61 and 1.5 mm. Vertically there will be seven 1.5 mm gaps, leading to a total gap of 10.5 mm vertically.

16384 pixels of 15μm comprise 246mm. Adding in the gaps, the total light-sensitive part of the science array is thus 259 x 260mm in size. The full unvignetted field of the VST is 1.47 degrees, or 372mm in diameter. The planned array with gaps fits in the field.

2.2. Filters

The OmegaCAM filters are decided on jointly by the VST, OmegaCAM consortium and ESO. ESO has set up a VST/OmegaCAM Instrument Science Team (IST) for advice on such issues.

The primary filter set of OmegaCAM will be a set of Sloan u'g'r'i'z' filters. In addition, there will be Johnson B and V filters for cross-calibrating the photometric systems and for stellar work (the g' filter is rather broad for many applications). Also, a set selected narrow-band filters is planned, such as Hα at redshifts up to 8000 km/s.

Because of the large size of the filters involved (about 300mm on a side) it may be necessary to construct some of these filters as mosaics of filters, mounted on a common base plate.

In addition, a composite filter, comprising a u', g', r' , and i' filter in the four quadrants, is envisioned for rapidly obtaining photometric calibrations and to monitor the atmospheric conditions.

For more details on the filters see contribution [4836-34] by H.E. Nicklas, K. Kuijken, U.Hopp, K.Reif and E. Cascone.

2.3. Instrument Control

For a detailed description of the OmegaCAM instrument control software see contribution [4848-10] by A. Baruffolo, A. Bortolussi and L. De Pizzol.

3. LARGE DATA VOLUME

The data volume produced by OmegaCAM will be huge. At a rate of 5 dithered exposures on a particular field in 30 minutes and with 300 nights per year of observing time, the VST/OmegaCAM will produce over 30 Terabyte of raw data per year. This raw data volume contains roughly 10 Terabyte of calibration data and 20 Terabyte of raw science data. Data processing will then produce another 10 Terabyte of reduced science data and may create, with about 100,000 astronomical objects per OmegaCAM field of one square degree, enormous catalogues. The astronomical source lists, containing valuable key galaxy parameter values can easily accumulate to 3-5 Terabyte per year!

The scientific analysis of all this data requires an advanced archiving system. A major portion of the data reduction aspects for large amounts of data and numerous individual images is administrating, characterizing and selecting the input data for further processing. When this is thoroughly done, scientific research can be solely archive based.

Also, the machine handling of the large images and the big data volumes is non-trivial: particularly the pipeline data reduction, image comparisons and combinations, working with source lists, and visualization are all demanding tasks, even with modern hardware. In order to commonly develop and share large data volume handling facilities, both for archiving and visualizations the ASTRO-WISE consortium has been founded (see section 3.2.2).

3.1. Concepts for the solution

To face the data volume problems it is advantageous to build an environment that provides, in a systematic and controlled manner, access to all raw and all calibration data, keeping track of all processing and data products in a wide area network, connecting data warehouses at the various data production sites (in our case data centers at Groningen, Munich, Paris and Napoli).

This environment should allow the astronomer to plan, modify and rerun the reduction and calibration pipelines to fit his particular needs according to the astronomical questions posed to the data. In addition, the environment provides systematic and controlled ways of running source extraction algorithms such that other astronomers could benefit from the obtained results. The archives should thus store the reduced data and source lists, or allow regeneration of these data dynamically. Because of the large data volumes and the limitations of local data centers, this archive must be federated to link different data centers, building a full-fledged federated database. Users at one data center can then profit from activities at other data centers, where new and possibly better calibrations have been built.

This dynamical archive continuously grows as more raw data enters the system and as more data reductions and calibrations take place. It can be used both for ‘small’ and for large science projects generating and checking calibration data and exchanging methods and scripts.

A key functionality is the *link* back from derived source data to the original raw pixel data, associated calibration files and *all* other data items that went into the result. This allows the user of the system to:
— verify the processing steps that have led to a certain product, and
— to qualify the product in terms of personal scientific exploration
— rederive the result with up-to-data calibration, thus providing the basic logistics for on-the-fly re-processing.

3.2. How to use this

In order to appreciate the above concepts in practical terms, we mention some sample cases.

In the case of survey observations of deep multi-color fields the system allows to split the observations over many observing campaigns (VST is operated in service observing mode) because all data will be accessible and calibrated in a similar fashion. The combination of data can be done by selecting observations of a particular quality, as quality information is a standard attribute to the archived data. Quality can sometimes only be assessed at the final stages of data reduction, so the linking information back to the raw data will help to build a homogeneous final survey input dataset.

Facilitating source list production from well documented final survey images allows the astronomer to select sources on a 1 to 1,000,000 basis as true interesting and not spurious sources, for the quality of each individual source extraction is an integral part of the source properties.

With the capability of extracting, in a homogeneous way, sources automatically from all reduced frames, variability studies (such as proper motions of asteroids or nearby stars, or just flux variations), can be easily facilitated.

The archive system is the best place to monitor the instrument as all calibration files are tediously administered. The trend analysis of instrumental properties becomes essentially a button-click operation.

A database environment is the perfect place to plan observations because one can get an easy overview of the quality of existing data and plan for filling the gaps in the spatial and quality domain. With the existing information addition of more filters, increase in exposure time or requirements for better seeing conditions can be identified and translated in an observing plan. For surveys the feedback between the data reduction/archive stage and the observations scheduling is essential for creating homogeneous input datasets.

All this is done in the continuously growing archive.

3.2.1. Philosophy

The system that should provide above functionality will not be geared to a single data product, but should be a flexible tool. In fact many observations done with VST/OmegaCAM will be for special projects, not explicitly part of an all-sky survey. To facilitate this diversity, flexibility is essential.

Furthermore, the enormous data volume of VST/OmegaCAM together with the complexity of the scientific research questions, forces to reconsider the old-fashioned ‘finite’ survey technique with a single, homogeneous dataset with static data release(s). Re-processing the whole data-volume when a new method becomes available, to create a new release, is not practically possible anymore. Instead, the archive and data reduction system is perfectly suited for on-the-fly creation of survey-like datasets, suited for addressing a particular research item. The system could, however, be used for the static data release paradigm too.

The environment should optimise the interaction between users and their data, giving the user easy access to all aspects (attributes) and processing (pipelines) of the data. This, ever growing, dynamic archive will be geared to optical (IR) wide-field image data.

3.2.2. ASTRO-WISE

In order to achieve a common European infrastructure for wide field imaging, the OmegaCAM and VST consortia together with ESO have started the ASTRO-WISE initiative (www.astro-wise.org). ASTRO-WISE is Research and Technical Development (RTD) program funded by the European Community Action "Enhancing Access to Research Infrastructures". It is a partnership of NOVA/Kapteyn Institute, Groningen - NL, Osservatorio Astronomico di Capodimonte, Napoli - I, Terapix, IAP, Paris - F, ESO, Garching bei München -D, Universitäts-Sternwarte München - D, VISTA - UK, and is co-ordinated by NOVA - NL. It strives to develop, maintain and provide access to a computational environment to process wide-field imaging data. It will also develop and disseminate, in the community, software tools needed to access the wide-field image data. To perform individual research programs - tools are essentially search and visualization tools, scalable to Terabyte regimes. The provided infrastructure will be used for the production and dissemination of survey data (multicolor, wide area calibrated images and source catalogues), to be accessed by virtual observatories.

The achievement of the ASTRO-WISE goals involves advances and upgrades of existing infrastructure that includes setting of standards and designing and implementing a federated data model to support the exchange of data, computer code and all data-reduction related administration between the various National data centers engaged in the processing and distribution of the wide-field imaging data. This also involves exchanging of programmer expertise and collaboration between the experts at the different sites. It serves also as a test bed 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.

4. SOLUTION

To efficiently archive and handle the data volume, the OmegaCAM data acquisition, calibrations and pipeline reductions are strictly procedurized. These procedures are integrated in the design of the pipeline data reductions. Thus the design of calibration and scientific data reduction procedures has focussed on developing standard observing scenarios. It uses object-oriented methods to implement the associated data reduction procedures.

4.1. Procedurizing

The two major components of the data taking are the scientific and calibration observations. Both need to be procedurized and the associated observations should be performed automatically. This can be achieved by carefully defining observing modes and observing strategies that cover all observational conditions both for building a homogeneous survey and for doing arbitrary scientific observations. The next sections give an overview of these modes and strategies.

4.1.1. Observing modes

The basic technique to overcome any gaps or artifacts in the CCD pixels is to take more exposures of the same field with slightly shifted field center (dithering) and to co-add the images off-line in the pipeline process. Furthermore, the presence of bad -hot or cold- pixels, either clumps or whole columns or rows, and the effect of cosmic ray events will create holes-in-the-sky without appropriate dithering.

We distinguish the following observing modes:

Dither has offsets matching the maximum gap between arrays ~ 400 pixels. It will be operated with N pointings on the sky, where N=5 is the standard. Although this will nearly cover all the gaps in the focal plane and maximizes the sky coverage, the context map will be very complex. An advantage, though, is that it will be relatively easy to couple the photometry among the individual CCDs.

Jitter has offsets matching the smallest gaps in CCDs ~ 5 pixels. It is the mode that optimises for maximum homogeneity of the context map and will be used during observations for which the wide CCD gaps are not critical. Note that in this mode all the data from a single sky pixel originates from a single chip.

Stare allows reobserving one fixed pointing position multiple times. It is the main workhorse for monitoring the instrument and allows detection of optical transients.

SSO is the mode for observing Solar System objects. It has non-siderial tracking and the auto guiding is switched off.

4.1.2. Observing strategies

An observing strategy employs one or a combination of the basic observing modes. It also defines a number of additional instructions for the scheduling of the observations. The observing strategy will be recorded in the FITS headers of the observations. Optionally, this header information can be used in data reduction pipelines, particularly those operated by the Consortium when addressing the combination (e.g. stacking) of images. It is not expected that the ESO pipeline will recognize strategies, as the standard ESO pipeline will not combine various runs.

We discriminate among the following strategies:

standard which consists of a single observation (observation block),

deep which does deep integrations, possibly taken at selected atmospheric conditions over several nights,

freq which frequently visits (monitors) the same field on timescales ranging from minutes to months and has overriding priority on the telescope schedule,

mosaïc maps areas of the sky larger than 1°, which is essentially an item for the scheduling, as the pipeline has to produce uniform quality data anyway. The combination of various field centers into one image is not considered a standard pipeline task.

4.2. Processing

The observing modes and strategies are fully integrated with the data reduction software. The precisely defined and limited number makes it possible to design a closely linked data model, in the form of classes, that drives the pipeline design for data reduction and calibration. Once the data operations, types and classes are defined the pipeline design is relatively straightforward. We discriminate between a *calibration pipeline* producing and qualifying calibration files, often involving a trend analysis (see 2) and an *image pipeline* that operates as a black box. By passively applying the calibration files (CalFiles) the *image pipeline* transforms the raw data into astrometrically and photometrically calibrated images (see 3). At ESO headquarters these pipelines will run under the Data Flow System pipeline infrastructure. At the national data centers these pipelines will run in an integrated environment where all data and data reduction steps are archived. Because algorithms for data reduction in the optical wide-field imaging arena are well established we can concentrate on other aspects of the data reduction scheme. We can view the pipeline as *an administrative problem*, where most attention should be paid to what ancillary information should be available when.

4.2.1. Calibrations

The *calibration pipeline* is the collection of tools specifically designed to obtain all required calibration files (Calfiles). The requirements for these tools are specified as baseline requirements on OmegaCAM calibrations (Valentijn et al 2001). The plan includes an extensive overriding photometric program, together with its trend analysis in the pipeline. At the moment we have identified about 35 requirements, ranging from "check the focus" to "determine and monitor the atmospheric extinction". Each of these requirements are fulfilled by dedicated procedures both for the data acquisition at the telescope and for the calibration pipeline. The implementation of these requirements will result into go-no-go flags and the calibration pipeline will produce calibration files. In fact, with the settling of the baseline requirements and the calibration plan all 'classes' in the data reduction have been defined.

The objective is to have a minimum of interdependence between these procedures. Thus, the calibration pipeline can run the various derivations of calibration files at various time scales, independent of the derivation

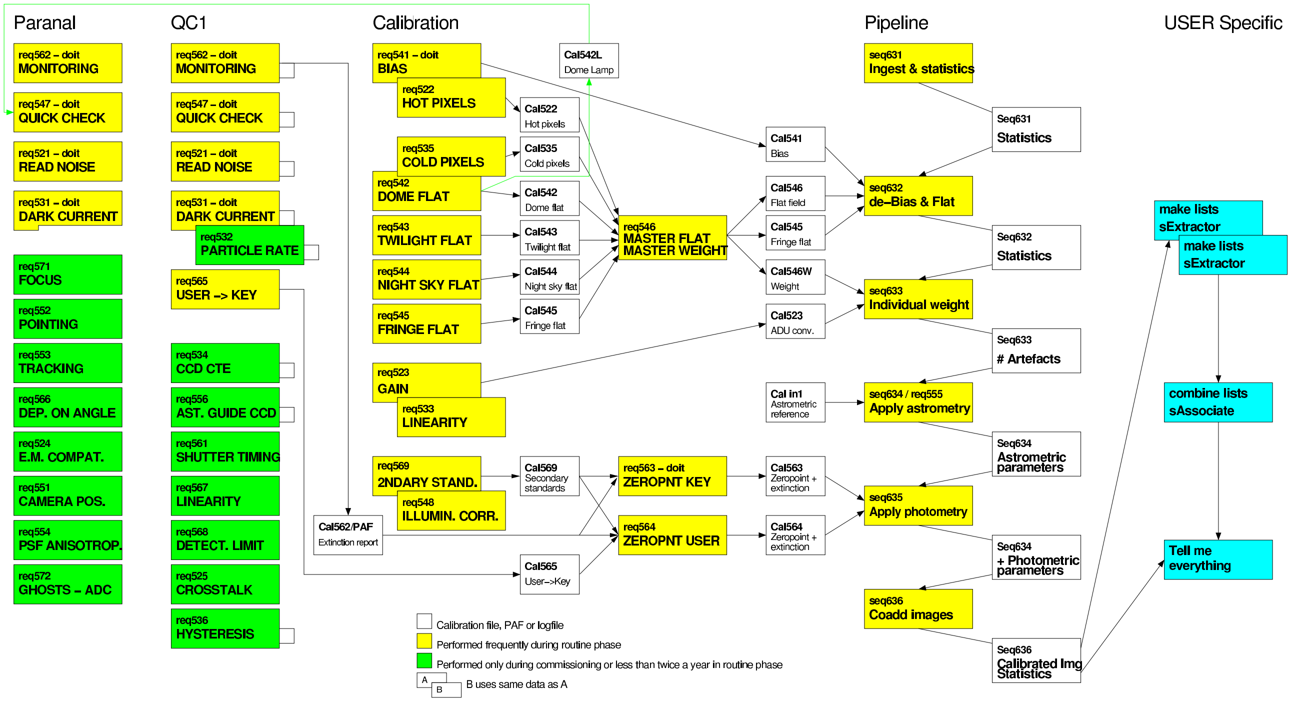

Figure 2. The OmegaCAM datamodel with local quality control procedures highlighted in green (B/W dark) and persistent operations, ie. visible and re-runable by the end-user highlighted in yellow(B/W light) .

of other calibration files. For example, the derivation of the master bias CalFile is done at a frequency of twice a week, master flat fields once a week, photometric zero point once a night and the cross calibration of filters once a year, with a minimum of interdependence between these processes. The execution frequency of the different procedures of the calibration pipeline is tied to the frequency of the corresponding observations. As a baseline, the various frequencies for different calibration observations are highly standardized. The creation mechanism of the CalFiles includes a time stamping module which, as a result of a trend and/or quality analysis, assigns a time range for which the CalFile is valid. The image pipeline recognizes timestamps.

4.2.2. Science observations

The *image pipeline* transforms the raw science data into calibrated images and passively applies the calibration files (CalFiles) made by the *calibration pipeline*. (Note, the image pipeline is also used in calibration procedures where required). Thus, the image pipeline produces the calibrated science images, and together with the CalFiles, which were used to derive these images, sets the end product ready for the astronomer for detailed scientific analysis. Contrary to the calibration pipeline, the image pipeline does not produce any CalFiles.

The descriptor data of the reduced science images are stored in the database. These descriptors contain a copy of all the FITS header items, but they also contain links to all the data items (i.e. objects) which were used to derive the particular result. The CCD pixel data, are not stored in the database. Instead, a reference (link) to a frame is added to the descriptor.

The *image pipeline* has many steps; although it is designed to function as an automated 'streamer', the intermediate results are stored in so-called SeqFiles, again containing FITS-headers, statistics, intermediate results and links to data items. The descriptor will be used to store data of persistent value, and references to the descriptors can be used to track input and output of the various pipeline operations. For example: SeqFile 636 (co-added image) will have a reference to a list of SeqFiles (SeqFile 633 –Astrometrically calibrated image), which were used as input. The descriptors of these SeqFiles can be used to determine, for instance, the

Table 1. An overview of the OmegaCAM calibration timetable for routine phase operations and maintenance.

Req.	Description	Frequency	DayTime	NightTime
	DAILY CHECKS / also after each maintenance activity		TIME NEEDED/DAY	
5.2.1	CCD read noise - doit	1/day	5 m	0
5.4.1	Bias - doit	1/day,(1)	15 m	0
5.4.2	FF - dome key bands + user bands - doit	1/day	10 m	0
5.4.3	FF - twilight	2/day	25 m	0
5.4.4	FF - night sky	1/day	0	0
5.4.5	FF - Fringing	1/lngwvscience	0	0
5.4.6	FF - master flat and weight map	1/new_ff	0	0
5.4.7	Quick check - doit	1/day	3 m	0
5.6.2	Photometry - monitoring	3/night	0	12 min
5.6.3	Photometry - zeropoint key bands - doit	1/night	0	12 min
5.6.4	Photometry - zeropoint user bands	1/night	0	5 m/fltr
	Total daily		58 m	24 min
	WEEKLY CHECKS		TIME NEEDED/WEEK	
5.2.2	Hot pixels	2/week	0	0
5.2.3	CCD gain	1/week	1 h	0
5.3.1	CCD Dark Current - doit	1/week	3 h	0
5.3.2	CCD Particle Event Rate	1/week	0	0
5.3.3	CCD Linearity	1/month	0	0
	Total weekly		4 h	0 h
	QUARTERLY - YEARLY CHECKS		TIME NEEDED/OPERATION	
5.3.4	CCD Charge Transfer Efficiency	2/year	30 m	0
5.3.5	CCD Cold pixels	4/year	0	0
5.3.6	CCD hysteresis, strong signal	-	0	0
5.4.8	Illumination correction	1/year	0	0
5.5.1	Position of Camera in focal plane	1/fltrchng,1/year	0	2 h
5.5.2	Telescope Pointing	1/year,1/pntngchng,(1)	0	10 m
5.5.3	Telescope and Field Rotator tracking	(1)	0	2 m
5.5.4	PSF Anisotropy	4/year,1/optclchng	0	10 m
5.2.4	Electromagnetic Compatibility	1/year,1/syschng,(1)	4 h	0
5.6.1	Shutter Timing	4/year,(1)	1 h	0
5.5.5	The astrometric solution for templates - doit	-	0	0
5.5.6	The astrometric solution for Guide CCD's	-	0	0
5.6.5	Filter band passes - user bands vs key bands	-	0	0
5.6.6	Dependency on angle ADC, rotator	-	0	0
5.6.7	Linearity (as a function of flux)	-	0	0
5.6.8	Detection limit and ETC calibrations	-	0	0
5.6.9	secondary standards	first year of operations	0	2 bright nights/month

(1) To Be Determined by Experience

distribution of seeings or zero points in the input data, even though the image data for these input images may no longer exist.

4.2.3. Share the load

The huge amount of data that needs to be processed in a limited amount of time necessitates the use of high powered CPUs and large bandwidths. Due to the physical nature of the OmegaCAM camera a natural parallelism is introduced where frames from the 32 CCD's can be processed quite independently through major portions of the data reduction pipelines. The level of parallelization is rather coarse-grained and the implementation of choice is a Linux Beowulf cluster. Having a very large bandwidth for communication between the processing units is essential to allow rapid dissolving of data across the cluster.

Data storage with significant amounts of fast and local disk space (10 - 100 Terabyte), is needed to minimize network traffic and at later stages allow distributed storage of processed data.

The data reduction will go in two stages. First the calibration is derived and CalFiles produced, then the image pipeline is run (at speeds of at least 1 Mpix/s) to produced calibrated science images.

The storage media need to have enough room for the images created throughout the lifetime of the project. This amounts to several 100's Terabyte. The archival storage of source parameters, depending on the use of the system and the total number of users, can easily go beyond the 10 Terabyte level.

In the federated environment the network plays an essential role. In an ideal world there is no need for replication of data, when information stored at a remote data center is needed it is delivered at the time of processing to the processing unit. This requires sustained network connections of 200 Mb/s or better. Such networks are becoming reality in the academic world these days. When the networks speeds are below this critical limit, however, a 5 Mb/s network allows full replication of all OmegaCAM data on the 24 hours per day basis.

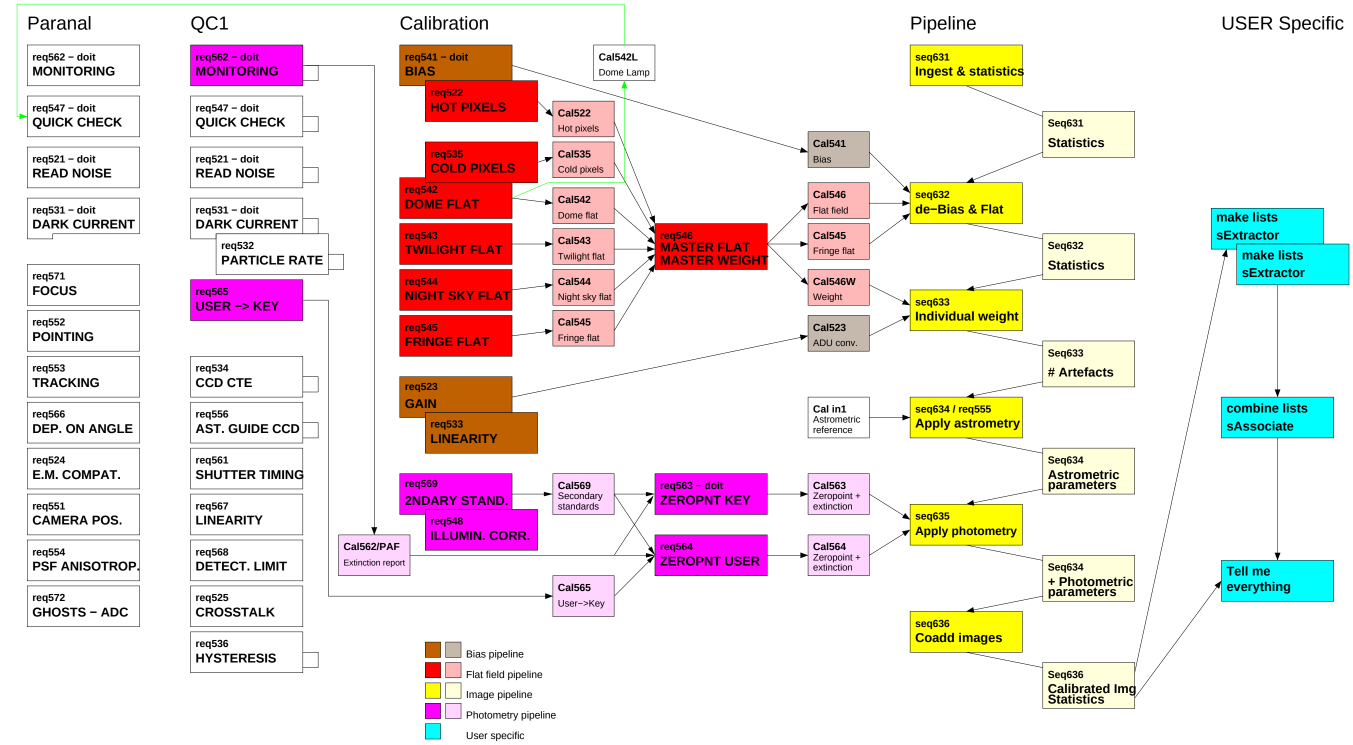

Figure 3. The OmegaCAM datamodel with reduction pipeline procedures indicated by shades of gray.

4.3. Federation

The federated database is the archive where *all* information regarding the data and the processing of OmegaCAM will be stored. First of all the raw data are accessible from the archive. The raw data itself will not reside inside the database, but the description of the data, including its location, will be available. This means that the data can only be manipulated through interaction with the database. In fact the methods (or pipelines) for processing of all kinds are also part of the federated database. When these methods are executed, they will interact with the database making sure it correctly describes the state of the OmegaCAM data repository.

Next to the raw data, calibration results, reduced images and source lists (possibly in the form of catalogs) will also be stored in the federated database, either as fully integrated objects or as descriptors.

4.3.1. Concepts of the federation

A federation is a database environment that is spread over different physical locations but maintains a single database in the true nature of the word. The consortium is currently building such a system using Oracle -9i with SQL and Python interface. According to Oracle: "A federated database is a logical unification of distinct databases running on independent servers, sharing no resources (including disks), and connected by a LAN."

In this environment full history tracking of all input will be done. So everything in terms of processing that went on producing a result is readily available. The system should also provide on-the-fly reprocessing. To tag data and attributes in this very dynamical archive, context areas are introduced in the object attributes. Objects in this terminology are the persistent forms of the Object Oriented programming objects (used in the Python scripting language) that are the software counterparts of all OmegaCAM entities (of which a number are displayed in Figs. 2 and 3 and the next paragraph). Some of these contexts can be:
— Project, with possible values Calibration, Science, Survey, or Personal
— Owner, with possible values pipeline, developer, or user,

— Strategy, with values Standard, Deep or Freq (monitoring),
— Mode, with values Stare, Jitter, Dither or SSO and
— Time, with time stamping.
These context areas can be used to partition off areas of the database for certain projects but also for public access and provides a mechanism to interface the database to public browsers such as envisioned by the Virtual Observatories.

The federated database makes the Object Oriented programming languages objects persistent. Therefore any creation of a persistent object in the pipeline automatically has a counterpart that will be stored in the database. Because all data processing (intermediate) products have been defined in the OmegaCAM data model, classes can be programmed in the Python scripting language. The Object Oriented inheritance is also available from the persistence implementation, usually in terms of object links. For each (persistent) class a number of methods are defined which directly interact with the federated database, thus insuring database integrity.

The actual implementation of the database connectivity from the Python scripting language allows for a 'file structure' implementation of the database environment as well, thus allowing the pipeline to operate on files in a directory structure, completely independent from a federated database. In this case many of the advantages of a global environment are lost.

The current planning is to have the system ready for data acquisition by the end of 2003, to test and populate it in 2004 and to prepare it for further mass production for 2005 and beyond. The system will be deliverable to satellite nodes at other European locations.

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Germany - Universitäts-Sternwarte Göttingen: R. Harke, H. Nicklas, W. Wellem
Germany - Sternwarte der Universität Bonn: K. Reif
Italy - Astronomical Observatory of Capodimonte- Napoli: E. Cascone
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