

1.2.2. TERAPIX

TERAPIX continuously develops new software tools to increase the efficiency of the pipeline, improve the quality of released data products and to monitor the progress of the survey. Currently, it is also in full “operation” mode and has been processing CFHTLS data for several months now. As a starting point, TERAPIX uses the Elixir data products archived at CADC and produces two types of data which correspond to two steps of the pipeline. In the first, weight and flag map images are generated for each individual image in addition to quality assessment data and an object catalogue. These data are immediately retrieved by CADC and can be used by registered users to work on any CFHTLS data independently. The second data product comprises stacks and fully calibrated images for the Deep, the Wide and the Very Wide surveys. Once validated by the TERAPIX control team, these data are automatically retrieved by CADC and are labeled as “release”. The first step is working well, and CADC has already received two bulks of step 1 data over the past two years. The second step is not yet fully operational. The first release was delivered to CADC by November (T0001), but the second has been delayed several times due to technical problems. This release is in progress and we expect to deliver T0002 to CADC by April and T0003 by end of June.

1. Introduction

TERAPIX has four principal activities:

- Development and release of software tools for processing panoramic images from mosaic detectors and of utilities to handle large images;
- Development of a pipeline for processing automatically Megacam images and the CFHTLS data, starting from Elixir products that are sent to CADC;
- Running and managing this pipeline, and releasing the CFHTLS products to CADC;
- Finally, providing help and assistance to Megacam users. Another important task is to process, on request, PI data obtained with Megacam (25% of TERAPIX activities)

The TERAPIX software tools are made publicly available once they have been tested and validated. Many (for example, Astrometrix / Photometrix, SExtractor, SWarp, QualityFITS, PSFex, STIFF, etc...) are already in use worldwide and have been included in several other public or private pipelines. In conjunction with the pipeline development and handling, software development and maintenance represents the largest fraction of TERAPIX activity.

Starting from the Elixir products, TERAPIX CFHTLS products can be separated in two principal components:

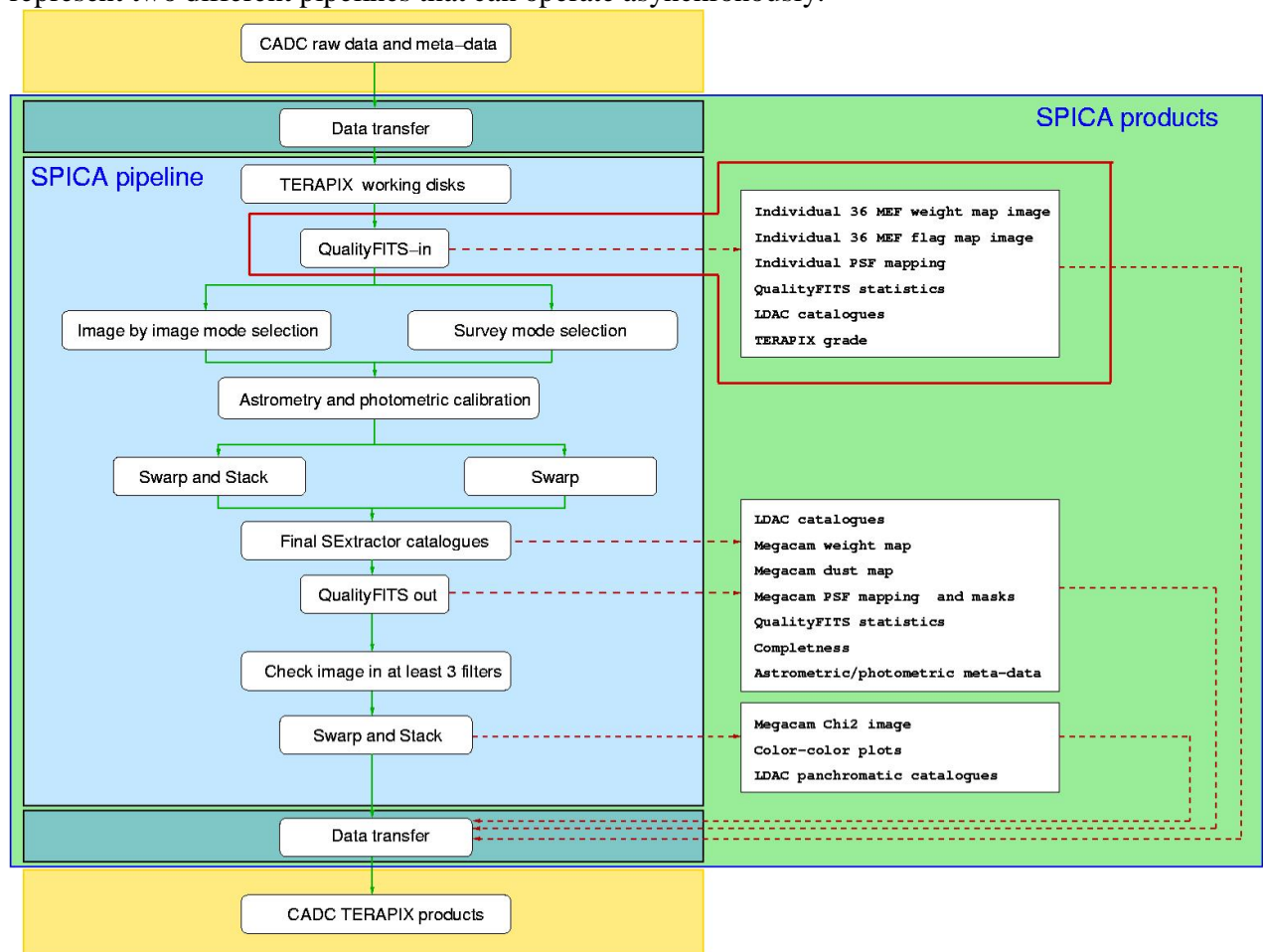
- a full set of individual 36 MEF weight and flag map images, created for each Megacam image received at TERAPIX, which are rapidly sent to CADC,
- processed images which correspond to stacked Megacam images which are sent to CADC as part of CFHTLS releases.

2. Overview

The TERAPIX team comprises 3 astronomers, Y. Mellier (PI), E. Bertin (PS) and H. McCracken; 4 permanent position engineers, M. Dantel-Fort, L. Domisse, F. Magnard and G. Missonnier, and 1 non-permanent position engineer, J.-C. Malapert (contract ending by January 2006).

The TERAPIX processing hardware consists of a cluster of machines linked by gigabit Ethernet on a private sub-network separate from the IAP public computing facilities. In total there is 55 TB of fully secure RAID5 disk arrays distributed over 16 separate nodes running the LINUX GENTOO operating system. These CPUs provide a peak performance of about 150 GFlops. The TERAPIX computing facilities are totally managed by the TERAPIX team. As part of TERAPIX 's service tasks, we make every effort to follow current trends in computing technology and assess which new product are best suited to our processing needs. This information is made publicly available on the TERAPIX web site.

The TERAPIX processing pipeline which controls data and data base managements, file and pipeline configurations, process synchronization, data production and the user interface is called SPICA (Software Pipeline for Image and Catalog Analysis). The SPICA starting point is data transfer from input FTP disk space to TERAPIX network disk space, and the SPICA end point is data transfer to output FTP disk space. SPICA processes images in two steps, corresponding to two different "contexts", a data-ingestion context (step one) and a data processing context (step two). They represent two different pipelines that can operate asynchronously.



Flow chart of the TERAPIX pipeline and data transfer with CADC. Data received from CADC are first processed to produce quality assessments for each image and create the weight and flap map images for each (step1 of TERAPIX processing). These images, as well as primary catalogues and meta-data are immediately sent back to CADC. Hence, CFHTLS registered users can process any CFHTLS images on its own. Step1 is QualityFITS-in and data transfer to CADC of files inside the red line box. It looks like a single box though it indeed consists of several processing steps and several months of processing. Step2 defines the rest of the flow chart. It ends with the production of a "release" such as T0001 .

2.1 Step one: data ingestion context (Data transfer and QualityFITS-in)

The first context is the data ingestion of Elixir products from the CADC. At this level all images are processed using the same “*on the fly mode*” where affiliation to a particular survey program is ignored.

The TERAPIX processing block tools involved in this step are “SNOOPPIX”, “DataTransfer” (input), “QualityFITS-in” and the TERAPIX database.

The original 36-MEF file structure is conserved. Each incoming file is first tested for integrity and content and then registered in the database.

For each science exposure, image quality is automatically evaluated on a per CCD level as well as globally over the Megacam field. Image evaluation and reliability validation for further scientific usage are measured through various statistical tools describing background homogeneity, shape and homogeneity of PSF, statistics of astronomical sources, and defects such as saturated pixels, cosmic ray impacts, glitches, trails, bright spikes and aureoles¹.

At the same time, a weight-map and a flag-map image incorporating masks for the most obvious defects, the masks image and flat fields produced by Elixir are created and assigned to each exposure. These maps keep the 36 MEF files format and are delivered to CADC, so they can be used by any CFHTLS users (or PI users for PI data processed at TERAPIX) that may wish to process CFHTLS data independently.

A shallow source catalog is then extracted using the weight-map to reject image artifacts. A PSF model is constructed for each CCD and used for tracking image sharpness and elongation over the focal plane.

The data ingestion mode products are also used to track several astronomical and technical image properties and to produce statistics that are continuously updated: image quality history, observing time distribution for each program and for each filter. These data are immediately made publicly available to Canadian and French institutes and will be available worldwide after the PI or CFHTLS proprietary period has elapsed. The QualityFITS-in information of each image and all relevant astronomical statistics are available to CFHTLS registered users at the URL <http://clix.iap.fr/steeringroup/>, using the userid and password sent to the CFHTLS mailing list.

The QualityFITS-in mode was also used during the tests of the wide field corrector by CFHT: test images were received at TERAPIX and immediately processed by QualityFITS in order to provide image quality information and PSF anisotropy mapping. Outputs were then returned to CFHT.

Over the past three years, TERAPIX delivered twice to CADC the “step one” products for immediate usage by CFHTLS registered users. For the first delivery, about 5000 weight maps, 5000 flag map images and 5000 catalogues were delivered. The second delivery was in January 2005. About 8000+8000 images were sent to CADC, as well as catalogues and meta-data (2/3 of them were part of the first 5000 but were re-processed to improve data quality).

2.2 Step two: Data processing context (SPICA and data transfer)

The data processing context uses either one of two processing modes: “image by image” or “TERAPIX release”. TERAPIX processing block tools involved in this step are “SPICA”, “QualityFITS-out”, “DataTransfer” (output) and the TERAPIX database.

In contrast with the data ingestion context mode, only user-selected sub-samples of images may go through one of these two modes, depending on scientific goals. Though the two modes produce and handle MEF images, the original 36-MEF file structure of each image is no longer conserved, so

¹ Automatic identification of trails and aureoles will be implemented in the first half of 2005.

individual CCDs of each Megacam image do not exist anymore: the quantum is now a full Megacam image.

Both modes use a global astrometric calibration process that can handle all images located near the target field.

The “image by image” mode works on each single Megacam image that successfully passed the data ingestion process regardless of its RunID. In this mode, each image is individually composed and warped into a pre-defined astronomical projection and astrometric system.

The “TERAPIX release” mode manages image stacking (co-addition), warping and composition (image merging and projection over sky coverage much larger than one Megacam field) steps and can process together several sub-areas of the sky, each covering very large field of views observed in several filters over several years. In this mode, the final stack is also created according to a pre-defined astrometric projection and co-ordinate system.

In all modes, a (non-linear) astrometric solution is computed using an external or an internal reference astrometric catalog. In the “TERAPIX release” mode, the astrometric calibrations also use object cross-identifications from overlapping regions between Megacam images.

A similar method is applied for photometric calibration. Exposures taken during photometric nights are used as anchor points for the zero-point re-scaling. Calibrated images can then be re-sampled, flux rescaled and co-added around each survey region².

Finally, panchromatic source information are used for quality assessments in the final TERAPIX catalogue, provided enough data are available in several filters. Reference panchromatic images are the usual chi-squared images.

The “step two” products correspond to the TERAPIX releases of stacked images for the survey. In contrast with the “step one” production, TERAPIX is late in producing these data to users. T0001 was only released by November 2004 and T0002 has been delayed three times, due to several technical problems (see section describing the T0002 release).

2.3 Frequency and processing strategy for CFHTLS releases

Most survey programs will extend over several MegaPrime runs, and the data products extracted from stacked images will be derived from observing runs spread over several years. This strategy should allow the continual improvement of data quality and the stability of calibrations with time.

However, waiting for several years before releasing the whole survey would be scientifically counter-productive. Therefore, it was decided to run the second part of the pipeline (the data processing context) every six months on all the datasets released so far by CFHT. Successive TERAPIX data releases to CADC at six-month intervals will then be progressively better (deeper, better seeing and more homogenous). This incremental release process of CFHTLS products is optimum for most observing strategies until all data sets can be used together to produce the final versions of the CFHTLS data products. Based on this scheme, new versions of the data products will supersede the previous ones. Their accuracy and homogeneity will benefit from both the increasing number of pointings and calibration files and also from algorithmic improvements and bug fixes in our processing software. However, since Canadian and French astronomers may have already started scientific programs with past releases, all TERAPIX data releases will be archived at CADC for a long period.

² PSF homogenization is planned for implementation at this position in the pipeline in late 2005

3. CHTLS Data and meta-data products produced by TERAPIX

The bulk of data produced by TERAPIX and sent to CADC consists of images, catalogs and auxiliary data generated by the pipeline modules.

The files format transferred will be multi-extension FITS (MEF) for images, binary FITS tables or LDAC format for catalogs, PNG and PS images³ and plots, and ASCII plain text or XML documents.

3.1. QualityFITS-in products

QualityFITS produces a set of basic quality assessments on all input (QualityFITS-in) images and catalogs.

Weight map FITS images are produced in QualityFITS-in using the WeightWatcher software tool. Its header contains some of the detrended image header keywords and new keywords.

Flag map FITS images are produced in QualityFITS-in, also using WeightWatcher. The new header contains some all detrended image header keywords and new keywords. Header is the same as weight map images.

To date, about 9000 weight maps and 9000 flag map images have been created. A part of them have been sent to CADC. The rest are PI data and are delivered to PIs only.

QualityFITS meta-data consist of PNG and PS plots and a summary table to evaluate whether images are valid data and do not significantly deviate from expectations. It helps to reject unexpected bad input images that cannot be used for scientific analysis (e.g. strongly defocused or multiply imaged objects) and to grade all images accordingly for further sample selection. Since it is blindly applied to all images, QualityFITS provides homogeneous and unbiased quality assessments. Note that QualityFITS does not provide astrometric calibration;

The plots produced by QualityFITS describe:

- The background histogram (for QualityFITS-in only), computed from the background estimated on each individual CCD,
- The FWHM histogram (for QualityFITS-in only), computed from the FWHM estimated on each individual CCD,
- Galaxy and star number counts over the whole Megacam field,
- A PSF model, with one sample point per CCD for QualityFITS-in, and one sample point each 10 arc-minutes for QualityFITS-out.
- A series of half-light-radius magnitude diagrams showing sources selected for histograms and ellipticity map plotting.

The summary table provides more quantitative information on data shown in plots and basic statistics on images, for each CCD as well as for each Megacam field as a whole.

Data products consist of:

- Weight-maps, flag-maps FITS images, FITS tables and FITS (.ldac) catalogues, generated for each input science MEF image. All FITS images produced by TERAPIX are 32-bit floating point representations, except the flag map image which is in 8-bit integer;

³ PNG is preferred to JPEG for quality control purposes, to prevent compression artifacts from DCT quantization that affect JPEG image thumbnails (lossless JPEG is not well supported and less efficient).

3.2. Processing modes

For each release, images will be spread into the three survey components, namely the Deep (D), the Wide (W) and the Very Wide (VW).

Because the Very Wide survey primary goals are detection and properties of TNOs, TERAPIX will not stack Very Wide survey images. Each image will be calibrated and a single Megacam image will be produced in an astronomical projection system, according to an astrometric reference system. Since TERAPIX software tools and calibration files are all available to users, anyone has the possibility to stack these images, or to create another single Megacam image in another projection or astrometric reference system.

In contrast, for the Wide and Deep surveys, TERAPIX produces stacked images. The main reason for this is the fact that stacked images are among the basic scientific data products necessary for the primarily science goals of these surveys, and also because TERAPIX must produce the colour-aligned chisquared image for these two surveys. Although, for CPU and disk space capacity reasons, we do not produce unstacked data of each Deep and Wide image, as for the Very Wide, it is worth noticing that the astrometric calibration data attached to each image are also sent to CADDC, so anyone can use these calibration files to carry out an independent image stacking, if needed. This versatile approach allows users carry out their own image selection, that may be different from those taken for Legacy Data.

The following Sections describe each step of the processing mode.

3.2.1 Selection process of released CFHTLS data

Once QualityFITS data products have been created, information regarding each image and relevant for running the next steps of the TERAPIX pipeline are stored in a local data base: location on TERAPIX disks of scientific images and their weight and flag maps, FITS header information, night by night CFHT queue observing meta-data.

Prior to starting the processing mode, *all* images are visually inspected using the QualityFITS-in quality assessment data products by TERAPIX astronomers. Each image is then graded A, B, C or D according to the following criteria.

- Grade A: image does not show any problem and QualityFITS evaluation are close to rough expectations
- Grade B: image is acceptable, though some minor problems have been detected. These problems could be technical, due to the TERAPIX processing during QualityFITS (e.g. wrong sky background estimate), or astronomical (galaxy counts show deviation from expectations)
- Grade C: image is not acceptable and cannot be injected in the fol processing steps. For example, image with multiply-imaged stars due to telescope guiding problem, or image with extremely bright fuzzy halos.
- Grade D: image with partially wrong FITS astrometric keywords that positions one or several CCDs at a wrong position with respect to neighbour CCD. Grade-D image are presently removed from the input image lists, but when this problem is corrected they will be re-injected into the pipeline.

The Grade-A and -B data represent 95% of the sample; about 1-2% are graded C and will be definitely lost.

Beyond this step, only images with Grade A or B will be kept in CFHTLS releases. The image selection process can be refined in order to take into account the specifications of primary science goals (seeing, airmass, extinction, etc..). In the case of the Very Wide, all images will be processed, provided it passed the QualityFITS selection. For the Deep and the Wide, new specific selection criteria are added.

The table below shows the selection criteria used for the T0001 release.

Observation period	From June 1 st , 2003 to July 22, 2004
Exposure time	>60 sec.
Seeing	<1.0 " , but <1.3 for u* data
Airmass	<1.4
Terapix grade	A or B

The stack center position definition is an important point: for the four deep fields, stacks will be centered at the RA and DEC Deep center positions given in the CFHTLS documents and images will be included only if their RunID FITS keyword correspond to Deep survey data. For the wide, each stack will be centered according to the Wide target position provided earlier by the CFHTLS Wide coordinators, and only if the image center lies within 10 arc-minutes from a Wide target center position. This prevents the pipeline to select several times the same image for different Wide stacks, while still permitting to take into account the large dithering pattern.

Moreover, each stacked image will be only one squared degree in size to avoid the creation of giant images that would cover a whole wide field and to keep the CFHTLS Wide product simple and logical with respect to the early survey design. This will avoid mixing Wide targets with different exposure time into a single giant image. Therefore, the TERAPIX Wide image products consist of square images, with a well-defined exposure time, and filling the Wide sky according to the <http://terapix.iap.fr/cplt/Oldsite/Descart/summarycfhtlswide.html> building block definition.

All selected images will be used in the TERAPIX release mode or will be processed according to the image by image processing mode. In addition, since TERAPIX astrometric calibration are computed globally all images can be used to perform the global astrometric solution. However, for practical technical reasons, TERAPIX only uses Megacam images within 2.5 deg radius with respect to a Very Wide image or a Deep or Wide center stack position. The accuracy of the astrometric calibration at a given position may therefore depend on the amount of data available around that position, but should increase with time as more images arrive from CADC. So, for any single image that belongs to a release, two image lists are generated: the "astrometric list", that corresponds to all files that will be used to perform the astrometric calibration of this image, and the "stack list" that correspond to all files that will be stacked together. The astrometric list may contain 10 or 100 times more images than the "stack list".

Remaining stacks

Pending processes (256)									
Image	Stack Mode	Release Version	RmID/ Object	Filter	Ra	Dec	Node	Scamp files	Swparp files
CFHTLS_D_g_022559-042939	4	0002	D	g	02 h 25 m 59	-04 ° 29 ' 39	mix3	475	100
CFHTLS_D_g_100028+021229	4	0002	D	g	10 h 00 m 28	+02 ° 12 ' 29	mix3	493	29
CFHTLS_D_g_141927+524056	4	0002	D	g	14 h 19 m 27	+52 ° 40 ' 56	mix3	447	53
CFHTLS_D_g_221531-174356	4	0002	D	g	22 h 15 m 31	-17 ° 43 ' 56	mix3	477	104
CFHTLS_D_i_022559-042939	4	0002	D	i	02 h 25 m 59	-04 ° 29 ' 39	mix3	451	239
CFHTLS_D_i_100028+021229	4	0002	D	i	10 h 00 m 28	+02 ° 12 ' 29	mix3	493	73
CFHTLS_D_i_141927+524056	4	0002	D	i	14 h 19 m 27	+52 ° 40 ' 56	mix3	448	180
CFHTLS_D_i_221531-174356	4	0002	D	i	22 h 15 m 31	-17 ° 43 ' 56	mix3	458	246
CFHTLS_D_r_022559-042939	4	0002	D	r	02 h 25 m 59	-04 ° 29 ' 39	mix3	473	161
CFHTLS_D_r_100028+021229	4	0002	D	r	10 h 00 m 28	+02 ° 12 ' 29	mix3	493	46
CFHTLS_D_r_141927+524056	4	0002	D	r	14 h 19 m 27	+52 ° 40 ' 56	mix3	447	149
CFHTLS_D_r_221531-174356	4	0002	D	r	22 h 15 m 31	-17 ° 43 ' 56	mix3	469	188
CFHTLS_D_u_022559-042939	4	0002	D	u	02 h 25 m 59	-04 ° 29 ' 39	mix2	242	54
CFHTLS_D_u_100028+021229	4	0002	D	u	10 h 00 m 28	+02 ° 12 ' 29	mix3	493	7
CFHTLS_D_u_141927+524056	4	0002	D	u	14 h 19 m 27	+52 ° 40 ' 56	mix3	446	7
CFHTLS_D_u_221531-174356	4	0002	D	u	22 h 15 m 31	-17 ° 43 ' 56	mix3	471	60
CFHTLS_D_z_022559-042939	4	0002	D	z	02 h 25 m 59	-04 ° 29 ' 39	mix3	510	150
CFHTLS_D_z_100028+021229	4	0002	D	z	10 h 00 m 28	+02 ° 12 ' 29	mix3	493	30
CFHTLS_D_z_141927+524056	4	0002	D	z	14 h 19 m 27	+52 ° 40 ' 56	mix3	460	75
CFHTLS_D_z_221531-174356	4	0002	D	z	22 h 15 m 31	-17 ° 43 ' 56	mix3	497	144
CFHTLS_Pre-W_r_021800-034400	4	0002	Pre-W	r	02 h 18 m 00	-03 ° 44 ' 00	pix9	123	1
CFHTLS_Pre-W_r_021800-041200	4	0002	Pre-W	r	02 h 18 m 00	-04 ° 12 ' 00	pix9	126	1
CFHTLS_Pre-W_r_021800-044000	4	0002	Pre-W	r	02 h 18 m 00	-04 ° 40 ' 00	pix9	127	1
CFHTLS_Pre-W_r_021800-050800	4	0002	Pre-W	r	02 h 18 m 00	-05 ° 08 ' 00	pix9	127	1
CFHTLS_Pre-W_r_021800-053559	4	0002	Pre-W	r	02 h 18 m 00	-05 ° 35 ' 59	pix9	127	1
CFHTLS_Pre-W_r_021800-063159	4	0002	Pre-W	r	02 h 18 m 00	-06 ° 31 ' 59	pix9	126	1
CFHTLS_Pre-W_r_021800-070000	4	0002	Pre-W	r	02 h 18 m 00	-07 ° 00 ' 00	pix9	124	1
CFHTLS_Pre-W_r_021954-034400	4	0002	Pre-W	r	02 h 19 m 54	-03 ° 44 ' 00	pix9	123	1
CFHTLS_Pre-W_r_021954-050800	4	0002	Pre-W	r	02 h 19 m 54	-05 ° 08 ' 00	pix9	126	1
CFHTLS_Pre-W_r_021954-053559	4	0002	Pre-W	r	02 h 19 m 54	-05 ° 35 ' 59	pix9	126	1
CFHTLS_Pre-W_r_021954-060359	4	0002	Pre-W	r	02 h 19 m 54	-06 ° 03 ' 59	pix9	125	1
CFHTLS_Pre-W_r_021954-063159	4	0002	Pre-W	r	02 h 19 m 54	-06 ° 31 ' 59	pix9	123	1
CFHTLS_Pre-W_r_021954-070000	4	0002	Pre-W	r	02 h 19 m 54	-07 ° 00 ' 00	pix9	120	1

RmID/Object	Number of remaining stack
D	20
Pre-W	102
W	134

Node	Number of remaining stack
mix2	87
mix3	19
pix9	150

Filter	Number of remaining stack
g.MP9401	43
l.MP9701	37
r.MP9601	146
u.MP9301	15
z.MP9801	15

Image	Node	Longest stack remaining
CFHTLS_D_i_221531-174356	mix3	246
CFHTLS_D_i_022559-042939	mix3	239
CFHTLS_D_r_221531-174356	mix3	188
CFHTLS_D_i_141927+524056	mix3	180
CFHTLS_D_r_141927+524056	mix3	161
CFHTLS_D_e_022559-042939	mix3	150
CFHTLS_D_e_141927+524056	mix3	149
CFHTLS_D_g_221531-174356	mix3	144
CFHTLS_D_g_022559-042939	mix3	100

User interface showing a sub-set of T0002 fields ready for processing. The two last columns of the left-hand table indicate the number of images used for the astrometric solution and the final stack, respectively.

Construction of command line sequences:

Once all images have been selected and the “astrometric” and “stack” lists done, SPICA automatically generates script-command files, one for each stack, for both the “image-by-image” and the “release” modes. The command file content includes the processing command line sequences, starting from loading and uncompressing all data and meta-data needed, continuing with the astrometric and photometric calibration, then handling the image warping and stacking (when necessary) and ending with the data compression of stacked image, copy to output disks of all data and meta-data sent to CADC. Since all command files are independent, one can process the release according to pre-defined priorities, for example starting with the Deep2-z band or the full set of Very Wide images.

The “image-by-image” and “TERAPIX release” modes can be run independently and simultaneously and on different CPUs as well. Once a stack is terminated, the TERAPIX release control team is informed automatically and SPICA launches the next stack.

The TERAPIX release control team checks each released image produced in both modes and grades it. Images with grade A or B are validated and can be delivered to CADC. Otherwise, the control team writes a very short problem report, the released image and its attached meta-data are examined in details and the SPICA process is ran again, once the problem is fixed.



- Server Admin
Spica -
- Automatic
Survey Mode -



- Automatic Image
Mode -

Coadded fields		5
Spica	2	40 %
Output quality	2	40 %

Filter		
Name	Number	%
i.MP9701	2	40 %

Grade		
Name	Number	%
Not graded	2	40 %

Node		
Name	Number	%
mix2	2	40 %
mix3	1	20 %
pix9	2	40 %

Stack		
Name	Number	%
D	0	0 %
W	2	0 %
VW	0	0 %
Pre-W	0	0 %
PI	0	0 %

PI data access	
Login :	<input type="text"/>
Password :	<input type="password"/>
<input type="button" value="Go"/>	

Stacking in progress... (3)		
CFHTLS_W_i_141754+543030 - mix2 Copy Idac catalog from Qualityfits Scamp running ... Compressing scamp metadata, loading XML into dbspica Look for standard stars from catalog Copy header to swarp Uncompressing weighted file from Qualityfits Running swarp Creating thumbnails Updating release date inside stacked images Copying stacked images into output disk Running sextractor on stack image Copying Idac to output disk Loading XML into dberapix Extracting subsection of image Running Qualityfits Loading XML Qualityfits into dbspica Copying Qualityfits data to output disk Running completeness Updating Qualityfits web page Finalizing ...	CFHTLS_D_i_221531-174356 - mix3 Copy Idac catalog from Qualityfits Scamp running ... Compressing scamp metadata, loading XML into dbspica Look for standard stars from catalog Copy header to swarp Uncompressing weighted file from Qualityfits Running swarp Creating thumbnails Updating release date inside stacked images Copying stacked images into output disk Running sextractor on stack image Copying Idac to output disk Loading XML into dberapix Extracting subsection of image Running Qualityfits Loading XML Qualityfits into dbspica Copying Qualityfits data to output disk Running completeness Updating Qualityfits web page Finalizing ...	CFHTLS_W_i_142939+514230 - pix9 Copy Idac catalog from Qualityfits Scamp running ... Compressing scamp metadata, loading XML into dbspica Look for standard stars from catalog Copy header to swarp Uncompressing weighted file from Qualityfits Running swarp Creating thumbnails Updating release date inside stacked images Copying stacked images into output disk Running sextractor on stack image Copying Idac to output disk Loading XML into dberapix Extracting subsection of image Running Qualityfits Loading XML Qualityfits into dbspica Copying Qualityfits data to output disk Running completeness Updating Qualityfits web page Finalizing ...

SPICA operation interface displaying the T0002 release running on three nodes of the TERAPIX cluster. The green highlight bar shows the on going process of the processing pipeline. The tables at the top provide a continuously updated global status report of the release.

3.2.2. CFHTLS release : output products and filenames

QualityFITS is also the quality assessment tool for all images produced by the “image-by-image” and the “TERAPIX release” modes. The “QualityFITS-out” products are the same as QualityFITS in, except that the final weight map attached to each stacked image is already produced during the stacking step and that QualityFITS-out includes meta-data on completeness limits.

Prior to making data and meta-data available to CADK, final products are visually inspected using the quality assessment meta-data produced by the astrometric/photometric software SCAMP, by SPICA and by QualityFITS-out.

Scientific images produced at TERAPIX are all combined using the “SWarp” software (http://terapix.iap.fr/rubrique.php?id_rubrique=49) with a Lanczos3 interpolation kernel. A new FITS header associated with a processed image is created. This new header contains some existing detrended image header keywords (not modified) and some new keywords. Existing and new mandatory keywords are defined below. Default projection is tangent (TAN) and default astrometric coordinate system is Equatorial J2000 (FK5).

All source catalogues for CFHTLS releases are produced by SExtractor. The default format for RA-DEC data will be decimal degrees. The default equinox will be J2000.0 and default astrometric reference system is FK5. The default aperture diameter will be 3 and 4 arc-seconds, and the default mesh for background estimates will be 256 pixels. All catalogues have a default magnitude zero point set to 30 and the magnitude system is instrumental AB.

All catalogues produced by TERAPIX for CFHTLS releases will contain the 56 parameters listed below:

- NUMBER
- X_IMAGE
- X_WORLD
- XWIN_IMAGE
- ERRWIN_IMAGE
- ALPHA_J2000
- MAG_AUTO
- MAG_ISO
- MAG_APER(2)
- MAG_PETRO
- FLUX_AUTO
- FLUX_ISO
- FLUX_APER(2)
- FLUX_PETRO
- THETA_IMAGE
- THETA_J2000
- THETA_WORLD
- A_IMAGE
- A_WORLD
- B_IMAGE
- B_WORLD
- ISOAREA_IMAGE
- THRESHOLD
- BACKGROUND
- FLUX_MAX
- MU_MAX
- KRON_RADIUS
- FLUX_RADIUS
- FLAGS
- CLASS_STAR
- X2_IMAGE
- Y_IMAGE
- Y_WORLD
- YWIN_IMAGE
- ERROWIN_IMAGE
- DELTA_J2000
- MAGERR_AUTO
- MAGERR_ISO
- MAGERR_APER(2)
- MAGERR_PETRO
- FLUXERR_AUTO
- FLUXERR_ISO
- FLUXERR_APER(2)
- FLUXERR_PETRO
- ERRTHETA_IMAGE
- ERRTHETA_J2000
- ERRTHETA_WORLD
- ERRA_IMAGE
- ERRA_WORLD
- ERRB_IMAGE
- ERRB_WORLD
- ISOAREAF_IMAGE
- MU_THRESHOLD
- Y2_IMAGE
- XY_IMAGE

Some new parameters may be added or removed in future catalogues. If so, TERAPIX will inform CADC by email. Users will be informed using on line explanatory tables about any new features in catalogues.

In general, processing software options in use correspond to those in the default software configuration files. If it is not the case, non-default options superseding those default options are stored in the “COMMAND” tag of the processing meta-data XML file.

All software tools, configuration files, image lists, calibration files, catalogues and TERAPIX or CFHT meta-data that are used to release CFHTLS data will be sent to CADC. So, anyone will have the possibility to check the processing or to process the data in a different way. In particular, the .head file containing the astrometric calibration and the rescaled photometric calibration will be delivered to CADC.

The astrometric and photometric calibration software will be presented in the next section.

In the “image by image mode”, the following products will be sent to CADC:

- Updated headers for the detrended images
- PNG/PS plots attached to the astrometric calibration step,
- PNG/PS plots attached to the photometric calibration step.
- QualityFITS outputs, as described below in the TERAPIX release mode,
- SExtractor source catalogue (.ldac file extension)

“Image by image” data products are available for download by CADC immediately after they are generated at TERAPIX.

In the “TERAPIX Release” mode, data products primarily consist of stacked images. In this mode output data will be generated every six months for archiving at CADC. TERAPIX release data products sent to CADC will be:

- Updated headers for each image contained in the stack;
- Weight-maps, background-maps and binary FITS table generated for each co-added image;
- PNG/PS plots attached to the astrometric calibration step;
- PNG/PS plots attached to the photometric calibration step;
- Co-added images in each filter and their associated weight-maps (both in FITS). Basic “image quantum” will be 1 deg x 1 deg. A 7 deg x 7 deg field will therefore produce 49 image quanta. Quanta will be non-overlapping areas on the sky. Each quantum will occupy a fixed area on the sky that will be covered by more MegaPrime pointings as the survey progresses;
- The “ χ^2 ” images (see Szalay et al. 1999) combining all filters. This image will be provided even for single filter observations;
- Source catalogs based on the “ χ^2 ” images for detection and the co-added images for measurement;
- The “dust” FITS image is created using the Schlegel E(B-V) FITS maps interpolated and re-sampled according to CFHTLS image properties;
- A full machine-readable processing commands in XML format;
- PNG thumbnails of the
 - Binned image content (image)
 - Background level (image),
 - Weight-maps (image),
 - Point Spread Function model (image),
 - Star counts (plot),
 - Galaxy counts (plot),
 - Co-added and “ χ^2 ” images (image),
 - PNG plots related to the quality control of the “final” catalog (including star and galaxy counts, seeing histogram, magnitude completeness limit, two-point star angular correlation function, and, when available, color-magnitude and color-color

diagrams4). The QualityFITS-out will include soon a PSF histogram (not implemented in QualityFITS V.10/V.11 used for T0001 and T0002).

The table given below summarizes the products delivered to CADC . They are discussed in more detail in the interface document. The CFHTLS products will reference to the survey type as follows:

- “W” for Wide,
- “preW” for Pre-survey attached to Wide,
- “VW” for Very Wide, and
- “D” for Deep,

Initial CFHT image name, for the “on the fly” (step1) and “image by image mode”

	« on the fly » mode (Step1)	« image by image » mode (Step2)	« TERAPIX release » mode (Step2)	
Detreted images	546891p.fits	546891p.fits	546891p.fits	546890p.fits
Keywords used in header			Object name Filter	
Processed data	546891p_head.txt ⁵	546891p_V0001.fits 546891p_V0001_head.txt 546891p_V0001_ahed.txt for photometric images	CFHTLS_W_r_135934+533330_T0001.fits 546891p_head.txt and 546890p_head.txt 546891p_ahed.txt ... for photometric images	
Weight-map and flag-map	546891p_weight.fits 546891p_flag.fits	546891p_V0001_weight.fits	CFHTLS_W_r_135934+533330_T0001_weight.fits	
Catalogue	546891p_diag.fits 546891p_ldac.fits	546891p_V0001_diag.fits 546891p_V0001_ldac.fits	CFHTLS_W_r_135934+533330_T0001_diag.fits CFHTLS_W_r_135934+533330_T0001_ldac.fits	
Auxiliary	546891p_bkg_histo.png 546891p_bkg_histo.ps 546891p_bkg_m.png 546891p_ell.png 546891p_fwhm_histo.png 546891p_fwhm_histo.ps 546891p_gal_histo.png 546891p_gal_histo.ps 546891p_m_med.png 546891p_m.png 546891p_psf_m.png 546891p_star_histo.png 546891p_star_histo.ps 546891p_wmm_med.png 546891p_wmm.png 546891p.xml 546891p_rhmag.png 546891p_rhmag.ps 546891p_rhmag_gal.png 546891p_rhmag_gal.ps 546891p_rhmag_star.png 546891p_rhmag_star.ps	546891p_V0001_astr_interror1d_%d.png ⁶ 546891p_V0001_astr_interror1d_%d.ps 546891p_V0001_astr_interror2d_%d.png 546891p_V0001_astr_interror2d_%d.ps 546891p_V0001_astr_referror1d_%d.png 546891p_V0001_astr_referror1d_%d.ps 546891p_V0001_astr_referror2d_%d.png 546891p_V0001_astr_referror2d_%d.ps 546891p_V0001_bkg_m.png 546891p_V0001_cmd.txt 546891p_V0001_comptness.png 546891p_V0001_comptness.ps 546891p_V0001_distortion_%i. ⁷ png 546891p_V0001_distortion_%i.ps 546891p_V0001_ell.png 546891p_V0001_ell.ps 546891p_V0001_fgroups_%d.png 546891p_V0001_fgroups_%d.ps 546891p_V0001_gal_histo.png 546891p_V0001_gal_histo.ps 546891p_V0001_m_med.png 546891p_V0001_m.png 546891p_V0001_phot_error_%d.png 546891p_V0001_phot_error_%d.ps 546891p_V0001_phot_zpcorr_%d.png 546891p_V0001_phot_zpcorr_%d.ps 546891p_V0001_phot_zpcorr3d_%d.png 546891p_V0001_phot_zpcorr3d_1%dps 546891p_V0001_protospf.fits 546891p_V0001_psf_m.png 546891p_V0001_referror1d_1.png 546891p_V0001_referror1d_1.ps	CFHTLS_W_r_135934+533330_T0001_astr_interror1d_%d.png CFHTLS_W_r_135934+533330_T0001_astr_interror2d_%d.png CFHTLS_W_r_135934+533330_T0001_astr_interror1d_%d.png CFHTLS_W_r_135934+533330_T0001_astr_interror2d_%d.png CFHTLS_W_r_135934+533330_T0001_astr_referror1d_%d.png CFHTLS_W_r_135934+533330_T0001_astr_referror2d_%d.png CFHTLS_W_r_135934+533330_T0001_astr_referror1d_%d.png CFHTLS_W_r_135934+533330_T0001_astr_referror2d_%d.png CFHTLS_W_r_135934+533330_T0001_bkg_m.png CFHTLS_W_r_135934+533330_T0001_cmd.txt CFHTLS_W_r_135934+533330_T0001_comptness.png CFHTLS_W_r_135934+533330_T0001_comptness.ps CFHTLS_W_r_135934+533330_T0001_distortion_%i.png CFHTLS_W_r_135934+533330_T0001_distortion_%i.ps CFHTLS_W_r_135934+533330_T0001_ell.png CFHTLS_W_r_135934+533330_T0001_ell.ps CFHTLS_W_r_135934+533330_T0001_fgroups_%d.png CFHTLS_W_r_135934+533330_T0001_fgroups_%d.ps CFHTLS_W_r_135934+533330_T0001_gal_histo.png CFHTLS_W_r_135934+533330_T0001_gal_histo.ps CFHTLS_W_r_135934+533330_T0001_m_med.png CFHTLS_W_r_135934+533330_T0001_m.png CFHTLS_W_r_135934+533330_T0001_phot_error_%d.png CFHTLS_W_r_135934+533330_T0001_phot_error_%d.ps	

⁴ two-point angular correlation function, color-magnitude and color-color diagrams will be implemented later.

⁵ Will be sent later, if strong requests from users are sent to TERAPIX.

⁶ %d is a number going from one to maximum group number

⁷ %i is a number increasing from 1 to the maximum instrument number

⁸ This series of files will be delivered for all C(3,5) filter permutations. Name extensions (_rgi_) will be changed accordingly, as function of filters used for each color-color plot.

	546891p_V0001_referror2d_1.png 546891p_V0001_referror2d_1.ps 546891p_V0001_rhmag_gal.png 546891p_V0001_rhmag_gal.ps 546891p_V0001_rhmag.png 546891p_V0001_rhmag.ps 546891p_V0001_rhmag_star.png 546891p_V0001_rhmag_star.ps 546891p_V0001_star_histo.png 546891p_V0001_star_histo.ps 546891p_V0001_scamp_accept.xml 546891p_V0001_scamp.xml 546891p_V0001_spica.xml 546891p_V0001_wmm_med.png 546891p_V0001_wmm.png 546891p_V0001_reg.txt 546891p_V0001_dust.fits 546891p_gri_V0001_diagcc.png ⁸ 546891p_gri_V0001_diagcc.ps 546891p_gri_V0001_chi2.png 546891p_gri_V0001_chi2.ps 546891p_gri_V0001_chi2.fits	CFHTLS_W_r_135934+533330_T0001_phot_zpcorr_%d.png CFHTLS_W_r_135934+533330_T0001_phot_zpcorr_%d.ps CFHTLS_W_r_135934+533330_T0001_phot_zpcorr3d_%d.png CFHTLS_W_r_135934+533330_T0001_phot_zpcorr3d_%d.ps CFHTLS_W_r_135934+533330_T0001_protopsf..fits CFHTLS_W_r_135934+533330_T0001_psf_m.png CFHTLS_W_r_135934+533330_T0001_referror1d_1.png CFHTLS_W_r_135934+533330_T0001_referror2d_1.png CFHTLS_W_r_135934+533330_T0001_referror1d_1.ps CFHTLS_W_r_135934+533330_T0001_referror2d_1.ps CFHTLS_W_r_135934+533330_T0001_rhmag_gal.png CFHTLS_W_r_135934+533330_T0001_rhmag_gal.ps CFHTLS_W_r_135934+533330_T0001_rhmag.png CFHTLS_W_r_135934+533330_T0001_rhmag.ps CFHTLS_W_r_135934+533330_T0001_rhmag_star.png CFHTLS_W_r_135934+533330_T0001_rhmag_star.ps CFHTLS_W_r_135934+533330_T0001_star_histo.png CFHTLS_W_r_135934+533330_T0001_star_histgo.ps CFHTLS_W_r_135934+533330_T0001_scamp_accept.xml CFHTLS_W_r_135934+533330_T0001_scamp.xml CFHTLS_W_r_135934+533330_T0001_spica.xml CFHTLS_W_r_135934+533330_T0001_wmm_med.png CFHTLS_W_r_135934+533330_T0001_wmm.png CFHTLS_W_r_135934+533330_T0001_reg.txt CFHTLS_W_r_135934+533330_T0001_dust.fits CFHTLS_W_gri_135934+533330_T0001_diagcc.png CFHTLS_W_gri_135934+533330_T0001_diagcc.ps CFHTLS_W_gri_135934+533330_T0001_chi2.png CFHTLS_W_gri_135934+533330_T0001_chi2.ps CFHTLS_W_gri_135934+533330_T0001_chi2.fits
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The meta-data files related to the stacked and composed images are generated by pipeline modules. Filenames will be :

- %s_bkg_m.png for PNG sky/detector background images
- %s_psf_m.png for PNG medium sized PSF map images
- %s_fwhm_histo.png for PNG FWHM histogram (PS format also available)
- %s_star_histo.png for star number count (PS format also available)
- %s_gal_histo.png for galaxy number count (PS format also available)
- %s_wmm_med.png for PNG medium sized weight map images
- %s_wmm.png for PNG weight map images
- %s_ell.png for PNG stellar ellipticity map images (PS format also available)
- %s_rhmag.png for Rh-mag. selection diagram of ellipticity map (PS format also available)
- %s_rhmag_gal.png for galaxy-filtered Rh-mag. diagrams used for galaxy count (PS format also available)
- %s_rhmag_star.png for stellar-filtered Rh-mag. diagrams used for star count (PS format also available)
- %s_cmd for all command files that launch stack processes
- %s_m.png for PNG stacked images
- %s_m_med.png for PNG medium sized stacked images
- %s_protopsf.fits for PSF fitting image maps
- %s.xml for command XML file
- %s_astr_interror1d_%d.png for internal error: 1 dimension astrometric plots (PS format also available)

- %s_astr_interror2d_%d.png for internal error: 2 dimension astrometric plots (PS format also available)
- %s_astr_referror1d_%d.png for external astrometric error with respect to an astrometric reference catalogs (like USNOs or GSCs) ; (PS format also available)
- %s_distortion_%d.png for astrometric distortion map PNG images (PS format also available)
- %s_fgroups_%d.png for image overlays projected in the sky (PS format also available)
- %s_phot_error_%d.png for photometric error plots (PS format also available)
- %s_zpcorr_%d.png for zero point re-scaling plots (PS format also available)
- %s_scamp_accept.xml for astrometric and photometric summary tables
- %s_scamp.xml for XML format astrometric/photometry processing history logs.
- %s_comptness.png for magnitude completeness plots (PS format also available)
- %s.reg for ASCII polygon mask files⁹

where %s is the filename of a TERAPIX release stacked/composed image and %d is the number of photometric group

For each release, TERAPIX may produce new types of data and new files that are not listed below or discussed in previous sections. For example, it is foreseen to produce new masks automatically instead of manually, like the “.reg” (or “_reg.txt”) ASCII files. TERAPIX will also produce PSF-homogenized survey images in the future. Should TERAPIX envision to produce them in a release, it will inform CADC at least three weeks in advance.

3.3 Assignment of dates for the Public Data Releases

For the “on-the-fly” and “image-by-image” mode, the release date of FITS data products (images and tables) will be identical to the release date written in the FITS header of the input detrended images.

For the “TERAPIX release” mode, the release dates for the stacked images and their associated source catalogs correspond to the release date of the most recently-released input detrend images.

All TERAPIX data products will provide release dates at the end of their processing.

3.4 Data transfer mechanism

All data product transfers between TERAPIX and CADC are carried out over a network connection using the BBFTP protocol. We do not use tape media. We selected this method of data transfer based on the following criteria:

- Calibrated images should be transferred to CADC as soon as possible to allow science exploitation to begin immediately;
- The weight and flag map images produced by QualityFITS for each individual incoming image are put in the TERAPIX outgoing data transfer area immediately after they are generated. CADC must be able to access these files for transfer using their tools or using the SNOOPPIX tools developed by TERAPIX;
- Other output files may need more time for processing before they are sent to CADC. The expected time between the arrival of an image at TERAPIX and the delivery to CADC of its complete set of “on-the-fly” and “image by image” data products will be at most 3 weeks;
- RICE data compression will be used whenever possible;
- Data should be transferred automatically.

⁹ This file format is readable with DS9 or SAO image. The creation of mask file is a lengthy process and it will be supplied to CADC later than the associated stacks.

- Transfer cost should be minimal.

Network transfers are the only method which fulfills all these criteria. Over the period 2002 we measure an actual sustained data transfer rate between CADC and TERAPIX of 2.5MB/second, which is fast enough for our purposes.

TERAPIX downloads meta-data archived at CADC via proxy access. SNOOPPIX continuously monitors a CADC "TERAPIX-permitted" archive area and downloads available data whenever necessary. We have allocated a directory space (monitored by CADC software) for outgoing data transfers. The storage capacity at the TERAPIX FTP staging area is 3.6 TB. Once data has been copied to the CADC, TERAPIX will delete data from this staging area to allow transfers to continue.

We also supply to CADC a series of c-shell command files which indicate the sequence of commands used to generate each stack. This file is supplemented by a series of XML files which lists the input images and what processing was applied to each file. Configuration files used in each of TERAPIX modules, and the software version numbers, is also provided. Taken together, this will allow any remote facility to reproduce exactly the series of processing steps used in any TERAPIX data release.

4. SCAMP, the astrometric/photometric calibration tool

SCAMP is the new astrometric and photometric calibration software developed at TERAPIX which will be used for all releases beyond T0001. It replaces Astrometrix and Photometrix which were too slow and difficult to install and maintain (and not very portable). In comparison, SCAMP is about 100 times faster than Astrometrix and is fully parallelised. SCAMP was developed by Emmanuel Bertin and uses plain-text configuration files similar to those of SExtractor and SWarp and can be installed on any POSIX-compliant platform. SCAMP takes as input SExtractor catalogues and produces as output WCS image headers that can be read by SWarp to re-scale, re-sample and co-add the images. SCAMP is expected to be released publicly in Q2 2005.

4.1 Astrometric calibration

With the current generation of TERAPIX hardware (the amount of physical memory is the main limitation) astrometric and photometric solutions can be computed simultaneously for around 2,000 exposures of 30,000 detections each, at once. Once called with a series of catalogues, the first task for SCAMP is to examine the image headers and group exposures by sky area, "astrometric context", and "photometric context". An "astrometric context" defines a set of exposures that have been observed with a common, mechanically stable configuration. For the CFHTLS, these are exposures which share the same filter and QRunID. There is one astrometric solution per astrometric context. Hence, a tight group of overlapping exposures in a given sky area will provide better constraints to the astrometric solution that may benefit more isolated exposures in a different sky area, if they share the same astrometric context. Likewise, a "photometric context" characterises a set of exposures with the same spectral response, that is, with the same filter.

Before proceeding further, the CCDs in each available astrometric context are re-positioned to a common, "median" focal plane, to correct the strong CCD-to-CCD jittering introduced by the Elixir astrometric solutions.

A subset of the reference astrometric catalogue (USNO-B1, Monet et al. 2003) surrounding each identified sky area is automatically downloaded from CDS. Cross-correlation is used to match each exposure with respect to the reference catalogue: pixel scales, frame position angles and shifts in α - δ are determined within around 1" at this stage. Pattern matching is followed by a cross-identification with a search radius of 2" between all overlapping detections.

In the context of the CFHTLS, SCAMP computes a polynomial model of Megacam image distortions by minimizing a weighted, quadratic sum of differences in position between both overlapping detections and matched sources from a reference astrometric object catalogue. Astrometric catalogues currently available at the depth of the individual CFHTLS exposures ($17 < i < 22$) have a typical accuracy of 0.3" on small scales, which is clearly insufficient. Combining the constraints given by the relative positions of overlapping detections and those from the reference catalogue provides both a very accurate adjustment of exposures on small scales, and a correct positioning on the sky on larger scales.

The solution is particularly vulnerable to matching errors and other non-Gaussian sources of noise and so it is very important to achieve maximum robustness at this stage by firstly minimizing the number of degrees of freedom, secondly by maximizing the number of constraints in the overlaps and lastly by clipping outliers.

The first condition is fulfilled by assuming that the astrometric solution is stable within a given QRunID. This proves to be a good assumption for Megacam, once linear distortion terms which apply to the whole focal plane (mostly differential refraction effects) have been taken out. In practice a 3rd order polynomial per CCD, that is, 720 parameters for the whole Megacam field, is used.

In order to maximize the number of detections in the second step, galaxies and all other faint non-saturated, non-corrupted objects are kept and properly weighted in the final solution. Galaxies are the dominant population at faint fluxes and moreover provide a stable reference frame for future proper motion measurements. Therefore, the centroiding routine implemented in SExtractor for astrometric calibrations has been specifically re-designed to produce robust results with non-stellar profiles.

The last condition is met by iterating the solution twice and clipping four-sigma outliers. Less than 1%-2% of detections are typically rejected from the final solution.

Residual position errors give us an approximate idea of quality of the final astrometric solution, although the true quality depends a lot on the exposure dithering strategy and is not easily estimated (from the point of view of astrometric calibration, the dithering strategy of CFHTLS fields is far from optimum). Roughly, large scale (greater than the typical dithering step) errors are dominated by those of the reference catalogue which is typically a few tenths of an arc-second. At the smallest scales, the relative astrometric accuracy is typically 10 to 30 mas RMS, that is, photon-noise-limited for most sources. Note that for release T0002, all positions are expressed in the J2000 system, and ignore proper motion effects (which we expect to add in T0003).

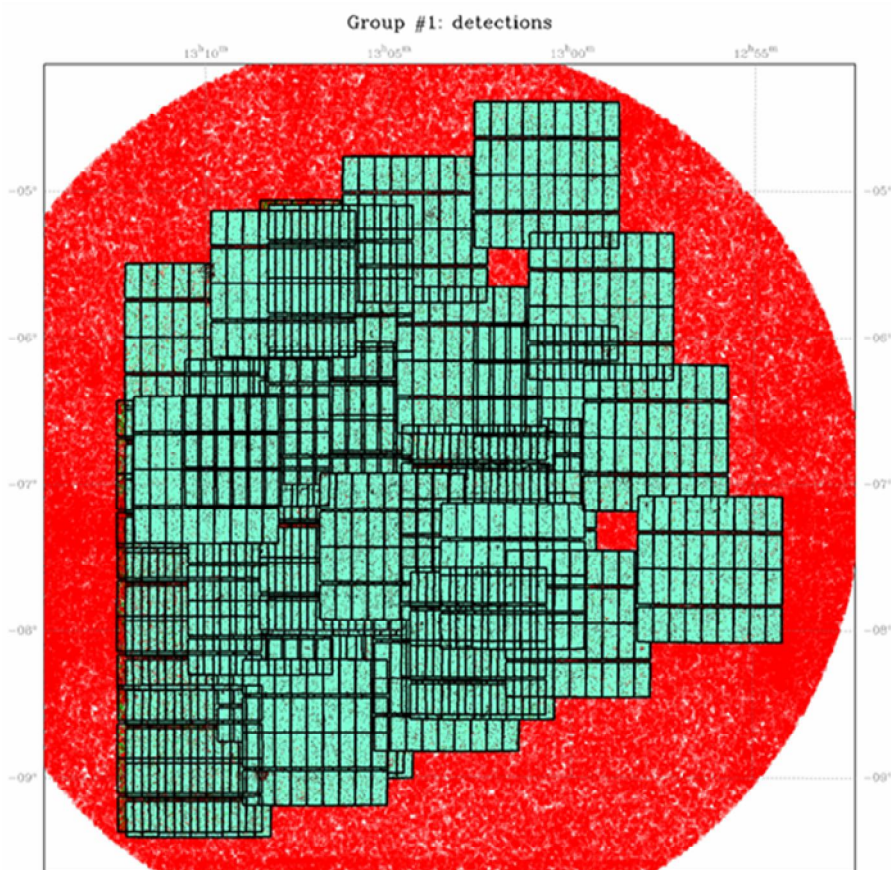
4.2 Photometric calibration

Many CFHTLS exposures are taken in non-photometric conditions. Thus different magnitude zero-point corrections must be computed and applied prior to image co-addition (the magnitude zero-point of the final stacked image is set to 30.0). These zero-point corrections are computed by SCAMP in a way similar to the astrometric distortion coefficients by minimizing the weighted,

quadratic sum of MAG_AUTO magnitude differences from overlapping detections. MAG_AUTO was chosen as it is fairly robust and insensitive to the seeing or the sizes of sources.

Contrary to the astrometric calibration, wide-field reference catalogues are not available. Some exposures are flagged by CFHT as ``photometric" however, which means that they were observed under photometric conditions and that their zero-points are reliably known. They can therefore be used as ``anchors" to fix the global zero-point of an image stack and correct for potential magnitude drifts in wide contiguous survey areas like the CFHTLS-VW (but note that some T0002 frames do not overlap any photometric field and cannot be photometrically calibrated yet).

Adding these photometric constraints in the solution works well, although small zero-point discrepancies of the order approx 1%-2% can be seen amongst overlapping ``photometric" fields. Therefore we chose to relax the condition that the zero-points of ``photometric" fields are known and fixed by allowing them to vary by a few percents around the values derived by Elixir. The resulting residuals on ``bright" object magnitudes ($S/N > 100$) are typically 0.02-0.05 magnitudes RMS, but the relative zero-point uncertainties are much smaller. These zero-point uncertainties are dominated by the effects of CCD-to-CCD variations, seeing changes and residual gradients within a Megacam field, the sum of which are at or below 0.01 mag. This demonstrates the excellent quality of the illumination correction carried out at CFHT.



An example of the global astrometric process of the T0002 release applied to a region of the Very Wide survey. All Megacam images located inside a 2.5 deg radius with respect to the center field are selected for the astrometric calibration. Red dots that cover the whole field are USNO-B1 objects; green dots locate matched sources between USNO-B1 and Megacam catalogues. More than 100 images covering a $5 \times 5 \text{ deg}^2$ with about 3,000,000 object detections are used for this field.

4.3 SCAMP output headers

SCAMP creates output headers that contain astrometric and photometric calibration data, and a series of quality assessments output files. The .head or .ahead files created by SCAMP contains astrometric and photometric calibration data.

The .head or .ahead files are ASCII files that contain a multi-FITS header with keywords providing updated WCS astrometric data and photometric rescaling coefficients attached to each CCD. These headers are produced and delivered to CADC for all input images processed using the image-by-image mode (i.e. one header per image) and for all stacked output images of the TERAPIX release mode. (i.e. one header per stack). Input files are object catalogues produced by SExtractor, so LDAC catalogs produced by QualityFITS can be used.

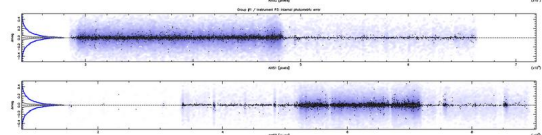
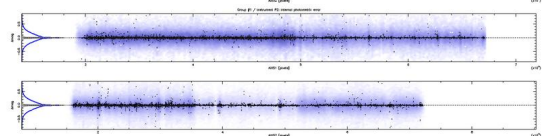
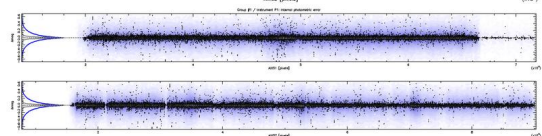
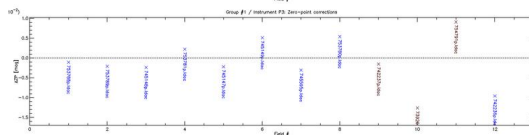
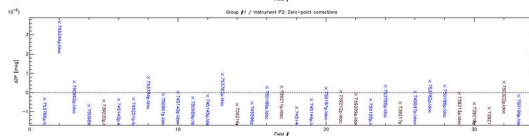
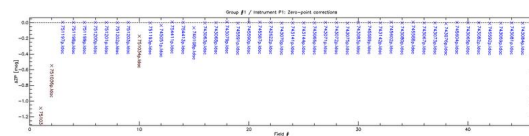
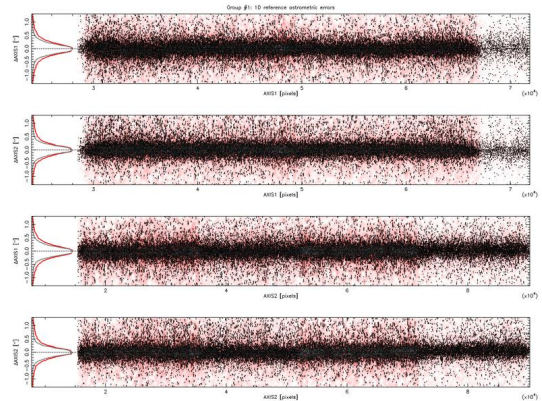
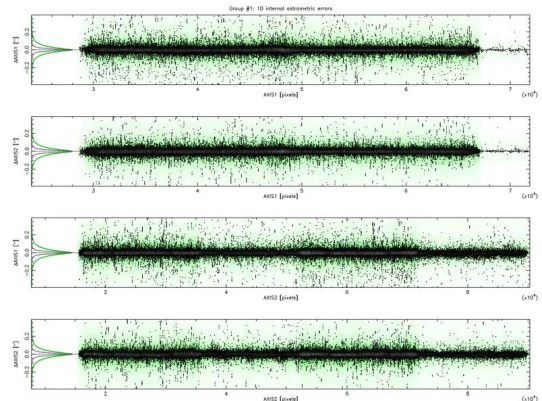
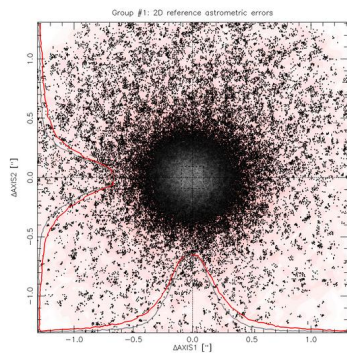
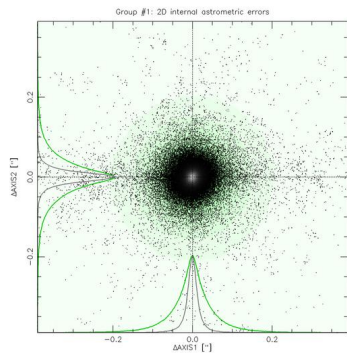
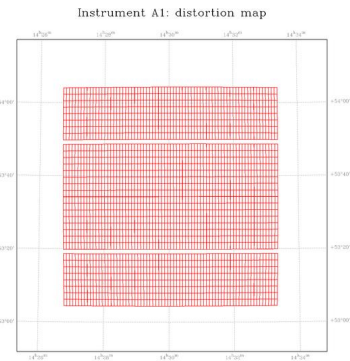
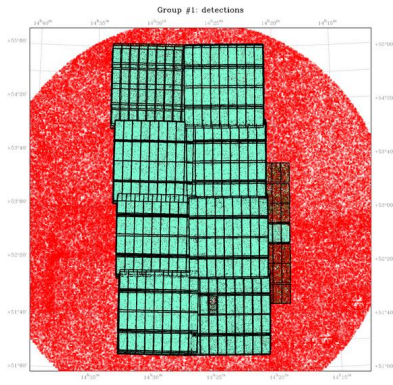
The $PV_{i,j}$ astrometric keywords that are derived by SCAMP are the parameters of the WCS projection system described by Greisen & Calabretta in 1999. The equinox is currently J2000.0 and the astrometric reference system is FK5.

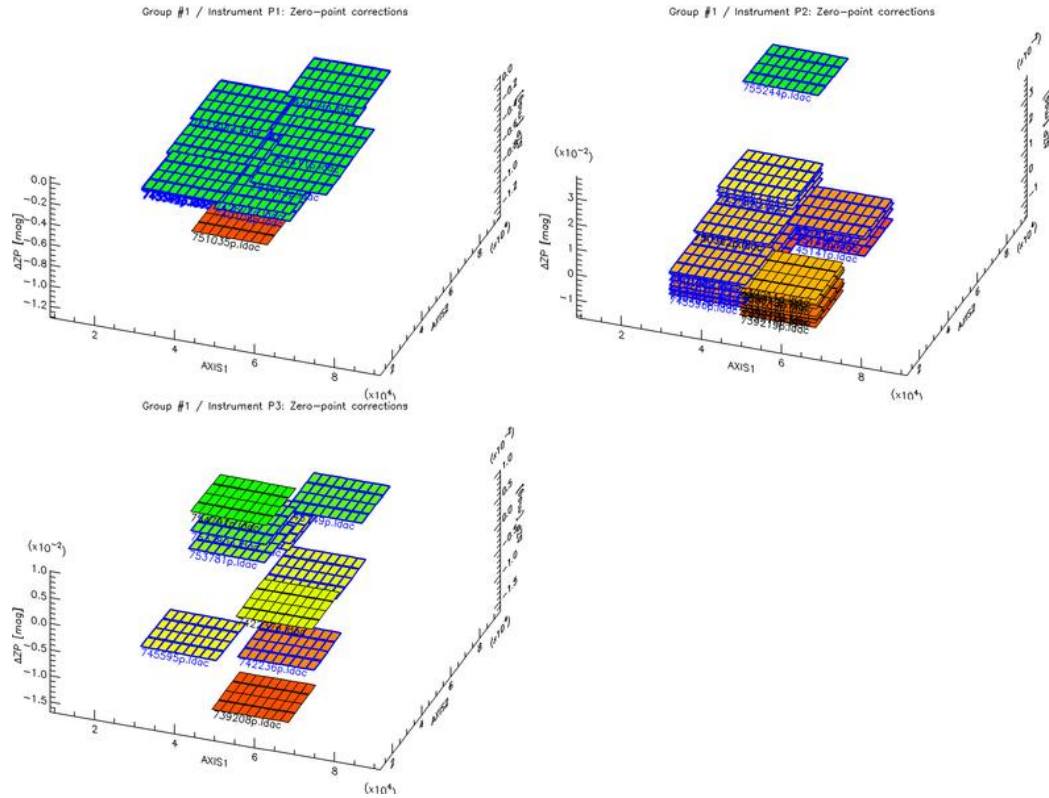
4.4 SCAMP quality assessment meta-data

Quality assessment data comprise a series of figures and plots showing the astrometric and photometric internal and external errors, and the relative photometric re-scaling of stacked images. Plots showing the astrometric and photometric are 2-dimension and 1-dimension error distributions along the two axes are also generated.

Default formats are PNG and PS files. Filenames and file descriptions are given below (see also Section 2.4 and the summary table given in Section 2.6)

- %s_astrometric_interror1d_%d.: PNG and PS file format, contain internal error: 1 dimension astrometric plot
- %s_astrometric_interror2d_%d. : PNG and PS file format, contain internal error: 2 dimension astrometric plot
- %s_astrometric_referror1d_%d.: PNG and PS file format, contain external astrometric error with respect to an astrometric reference catalog
- %s_distortion_%d. : PNG and PS file format, contain the distortion map
- %s_fggroups_%d. : PNG and PS file format, are image overlays projected in the sky
- %s_phot_error_%d. : PNG and PS file format, contain the photometric error plot
- %s_zpcorr_%d. : PNG and PS file format, contain the zero point error plot of each image





A series of quality assessment plots produced by SCAMP during the T0002 release. The target is the Wide W3 field in *i*-band, named *w3+2-1* according to the CFHTLS Wide target definition and *CFHTLS_W_i_143007+533430_**, according to the SPICA naming process of released data.. From top left to bottom right: projected positions of the ensemble of Megacam images used during the global astrometric calibration of the *w3+2-1*. Megacam astrometric distortion grid derived by SCAMP for the *w3+2-1* field. Internal two-dimension and one-dimension errors derived from the astrometric solution, based on the matching process of sources located inside the overlapping regions of Megacam images. External two-dimension and one-dimension errors derived by the matching process of USNO-B1 stars with Megacam images. The bottom panels are photometric calibration plots. Left plot: flux rescaling value derived by SCAMP by matching sources located in overlapping regions. Right: 1-dimension internal photometric residuals derived by SCAMP after the re-scaling. The very bottom plots are 3-dimension views of photometrically rescaled relative position of each Megacam image of each group. The *z*-axis is the zero point offset derived by SCAMP.

The TERAPIX pipeline (SPICA) provides a series of XML files that summarizes the SCAMP processing history: filename table listing the input files used to produce the global astrometric solution and the photometric re-scaling, summary statistic tables describing filter and sky position distributions of input files, and a concise summary table on astrometric and photometric statistics of output data. The summary tables corresponding to the astrometric and photometric calibrations shown above for *CFHTLS_W_i_143007+533430_**, are given below.

scamp (completed on 2021-01-01)				
Number of groups	2			
Number of fields	82			
Number of instruments instrumented	14			
Number of photometric instruments	3			

Group					
Group name	G1	Internal stats (All)	Internal stats (High S/N)	External stats (All)	External stats (High S/N)
Number of fields	90	GA3281 0.129	GA3281 0.04	GA3281 0.127	GA3281 0.332
Count center	14.27 13.20	GA3282 0.138	GA3282 0.048	GA3282 0.148	GA3282 0.34
Count center2	31.50 39	GA2 474588	GA2 11.4822	GA2 94.3128	GA2 30.773
Pixel scale1	0.185	GA2 246404	GA2 282277	GA2 43373	GA2 25613
Pixel scale2	0.185				
Max radius	2.467				

Group					
Group name	G2	Internal stats (All)	Internal stats (High S/N)	External stats (All)	External stats (High S/N)
Number of fields	2	GA3281 0.032	GA3281 0.032	GA3281 0.118	GA3281 0.318
Count center	14.07 13.14	GA3282 0.013	GA3282 0.013	GA3282 0.128	GA3282 0.339
Count center2	53.30 30	GA2 490499	GA2 19.8884	GA2 28.98	GA2 25.992
Pixel scale1	0.185	GA2 35516	GA2 9.36	GA2 3275	GA2 2504
Pixel scale2	0.185				
Max radius	0.71				

Astrom / Photon Instrument			
Name	Number of fields	Key	Mezproc
AI	11	QRIND = GA3281	P
		FLTR = LMG9701	30
		FLTR = LMG9701	30
AM	8	QRIND = GA3281	P
		FLTR = LMG9401	30
		FLTR = LMG9401	30
AH	4	QRIND = GA3281	P
		FLTR = LMG9401	30

Photometric statistics											
P1											
Internal stats (All)	Internal stats (High S/N)	External stats (All)	External stats (High S/N)								
Sigma	Chi2/dof	Dets	Sigma	Chi2/dof	Ndets	Sigma	Chi2/dof	Ndets	Sigma	Chi2/dof	Ndets
0.169	14.8356	0	0.069	104.916	77217	0.127	14.0179	1262848	0.041	92.6516	1262848
P2											
Internal stats (All)	Internal stats (High S/N)	External stats (All)	External stats (High S/N)								
Sigma	Chi2/dof	Dets	Sigma	Chi2/dof	Ndets	Sigma	Chi2/dof	Ndets	Sigma	Chi2/dof	Ndets
0.219	39.1054	0	0.099	420.327	19960	0.113	10.7801	835914	0.025	92.0938	835914
P3											
Internal stats (All)	Internal stats (High S/N)	External stats (All)	External stats (High S/N)								
Sigma	Chi2/dof	Dets	Sigma	Chi2/dof	Ndets	Sigma	Chi2/dof	Ndets	Sigma	Chi2/dof	Ndets
0.13	17.0292	0	0.028	110.551	15227	0.083	9.42984	312523	0.013	66.9782	312523

Summary tables provided by SCAMP to SPICA operation interface and CFHTLS. These tables provides internal and external statistics on the astrometric and photometric calibrations and provide hyper links to more detailed pages.

5. TERAPIX software tools

All TERAPIX software are released under the General Public License (GPL). CADC will be able to use all of the software listed as below as the various modules are released. Note that some are still under development and are therefore not yet publicly. The TERAPIX software suite is available at http://terapix.iap.fr/rubrique.php?id_rubrique=34 . It includes:

- Astrometrix / Photometrix : local and global astrometry and photometry (used for the T0001 release)
- Datatransfer : transfer and distribute data on TERAPIX disks;
- Deadix : detect dead CCDs on Megacam images;
- Defectix: detect, classify and mask defects on Megacam images;
- LibVotable : a VOTable parser;
- MissFits : FITS file management;
- Panorapix : Visualisation tool for very large FITS images;
- PSFEx : constructs a PSF model of a field;
- QualityFITS : input and output quality assessment tools and metadata generation;
- RDBIX : store information in a database;
- SCAMP : new astrometric and photometric software, which will be used for all releases “stacked mode” releases after T0001, and all image-by-image mode releases;
- SExbench : hardware benchmarking software;
- SExtractor : source extraction;
- SkyMaker : image simulation;
- SkyWatcher : monitors the progress of a survey on the celestial sphere;
- SNOOPPIX : monitor data at CADC
- SPICA : image processing pipeline (data management, file and pipeline configuration, process synchronization, data production , user interface)
- Stiff : produces color TIFF images based on FITS file input
- Stuff : simulation of galaxy populations
- SWarp : image re-sampling and co-adding
- WeightWatcher : image weight-map creation

All TERAPIX software is packaged using the GNU autoconf/automake system which allows them to be fully platform-independent. Binary “.rpm” files are also provided which makes installation particularly easy on LINUX systems. Whenever software bugs are found, TERAPIX will notify CADC immediately and will send appropriate patches.

6. TERAPIX releases

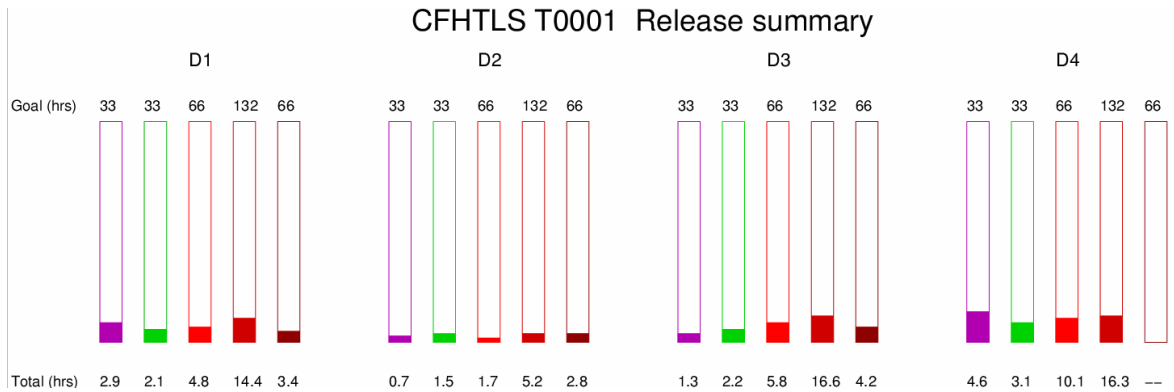
6.1 The T0001 release

The first TERAPIX provided a pre-release in March 2004 (http://terapix.iap.fr/rubrique.php?id_rubrique=170). TERAPIX delivered to CADC images, catalogues and few quality assessment meta-data for the Deep D3 and D4 fields and of the Wide W3 field. These data were made public to all CFHTLS registered users in order to familiarize them with the survey data. The format of this release did not follow any specifications agreed between CADC and TERAPIX.

The first TERAPIX CFHTLS release, T0001 (http://terapix.iap.fr/rubrique.php?id_rubrique=150) was made publicly available to CFHTLS users on Nov.23, 2004, but the “step one” data products were sent to CADC much earlier. These comprised 5000 weight maps and 5000 flag map images and also includes relevant catalogues and meta-data. The T0001 release comprised only CFHTLS Deep fields, D1, D2, D3 and D4 in all filters. As described before, each weight and flag map image had already been delivered in an earlier step to CADC and QualityFITS-in information regarding each image is already available on-line to any CFHTLS registered users. Information regarding all releases and recent news about TERAPIX processing, new software tools can be found here: http://terapix.iap.fr/rubrique.php?id_rubrique=169. The data products sent to CADC did not strictly follow the ICD document in order to speed up the delivery process. CADC kindly accepted this and adapted its tools and users interfaces to make the full T0001 data available to users on a very short time scale.

Individual images were selected according to the selection criteria listed in Table 1. The seeing criterion for the u^* band data was relaxed in order to increase the numbers of images. Since this was the first official release, TERAPIX took great care in delivering only reliable data products, and many cross-checks were carried out. An unexplained astrometric residual was found in D4-z data, so it was decided to remove D4-z from this release.

About 1000 Megacam CFHTLS Deep science images and 1000 weight maps were stacked. Complete details about the release including the selection criteria applied are available at the URL http://terapix.iap.fr/article.php?id_article=382. For each field, T0001 images delivered to CADC were: stacked D1/D2/D3/D4 images in u^*griz filters (with the exception of the D4-z), the weight map associated with each stack, gri chisquared images as well as a map of galactic extinction in $E(B-V)$. Masks were generated by hand (and are provided as a DS9/SAOIMAGE “.reg” file) in WCS coordinate system. All software versions used for the T0001 release are also noted on this page.

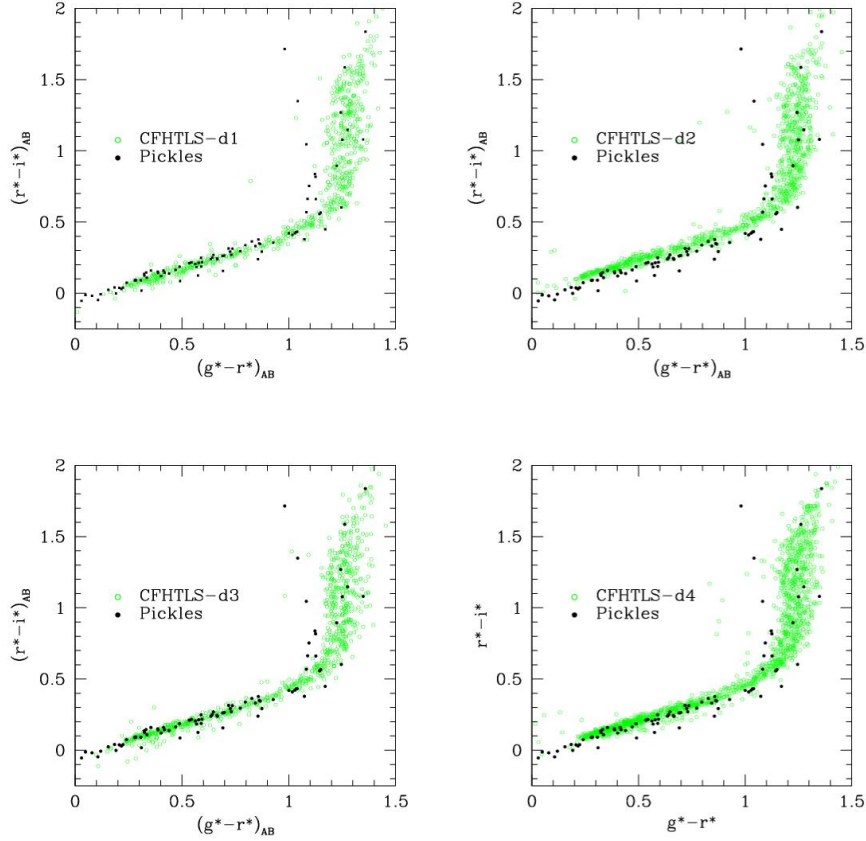


CFHTLS T0001 stack summary as compared to the final goals in each filter. T0001 still does not reach 20% of the final release and a significant deficit is observed in D2 and D3 u^ with respect to other bands.*

An explanatory table describing the data content and details of the processing is available at http://terapix.iap.fr/article.php?id_article=383. A short description of parameter definition, system units or processing methods are described. TERAPIX also delivered binned 2x2 3-color PNG images of each deep field. These images are primarily for public outreach purposes but also allow us to check if any residual astrometric gradients remain between each filter on stacked images. A visual inspection of the most extreme corners of the fields does not reveal any differential effects filter-to-filter, or any significant gradient.

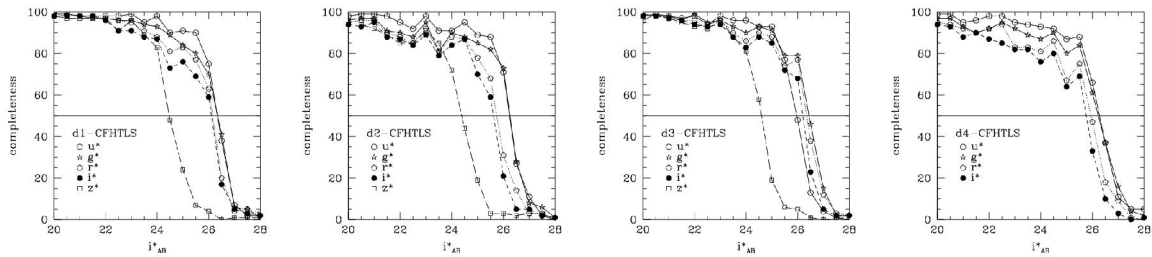
TERAPIX also provides to CFHTLS users a series of plots attached to the summary table which permits users to make a quantitative assessment of data quality. The most important aspects of this Table are described below. The plots shown below are only a fraction of the total.

We use galaxy number counts and stellar colour-colour plots to assess the photometric quality of our final stacks. At $i^* < 22$, the photometric dispersion of stellar objects is less than 0.05 magnitudes, similar in magnitude to the dispersion predicted from the libraries of Pickles et al. or the Besançon population synthesis model. There is also some evidence of a possible systematic residual of 0.05 magnitudes in some filters; this effect is under investigation with CFHT. These residuals are slightly higher than the TERAPIX goals of 0.03 magnitudes for both internal and external photometric errors.



$(r-i)/(g-r)$ stellar colour-colour diagrams for the four deep T0001 fields. Green dots are stellar objects detected on each field by selecting compact objects in the half-light radius versus magnitude plot. Black dots are stellar colour-colour plots as predicted from the Pickles et al. library.

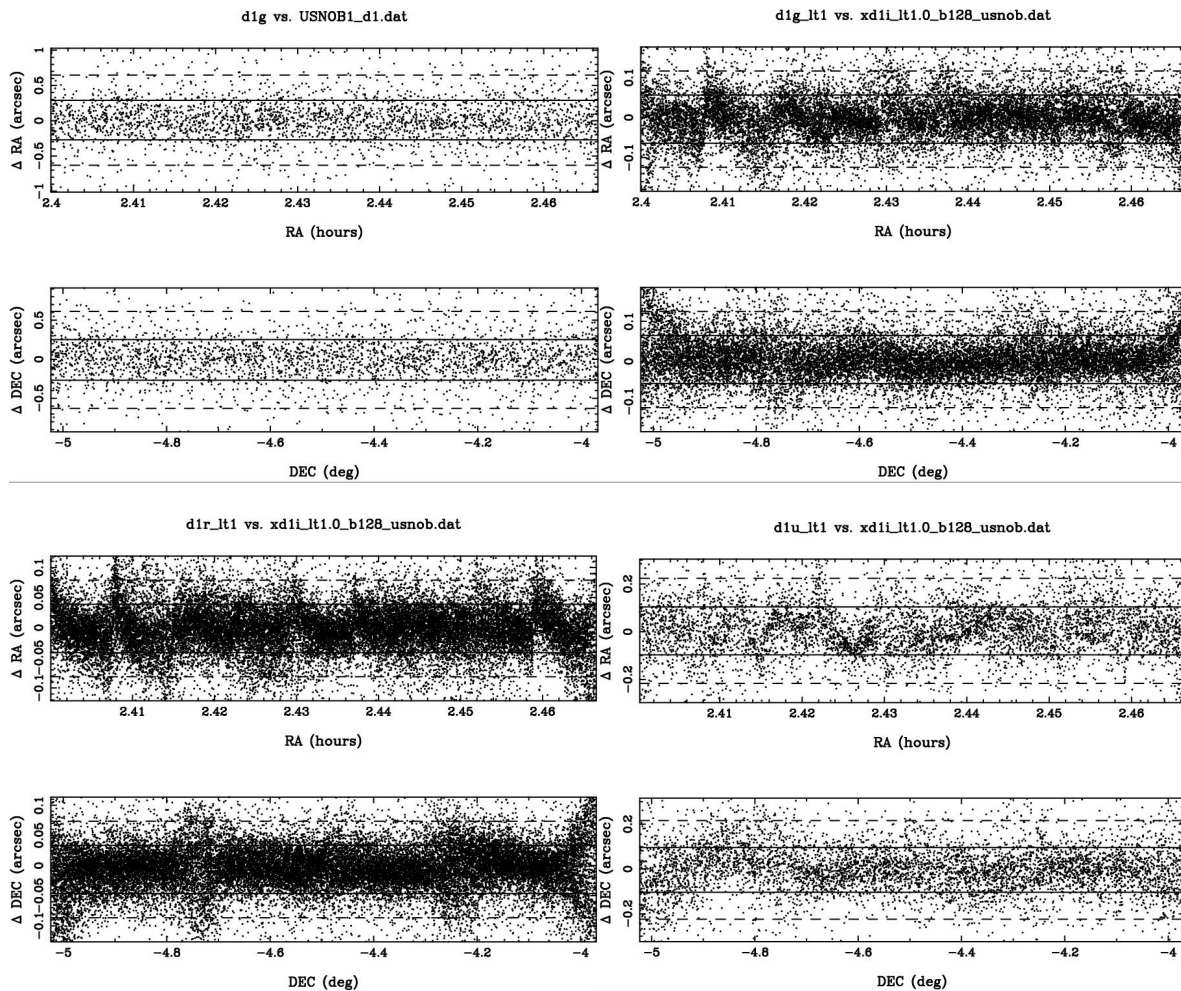
The depth reached for each field is verified using the galaxy counts plots and the peak position of the faintest galaxies based on detection from the chisquared image, together with a completeness limit calculation. The completeness is derived by adding simulated stars to a sub-area of each stacked image. The depth value is then compared to theoretical expectations and to previous results with CFH12K data in order to check consistency.



Completeness plots for the four deep field and in each filter of T0001. As described in the TERAPIX explanatory web page, the completeness is computed by adding simulated stars to each stack and by running SExtractor on it in order to derive the fraction of detected simulated objects.

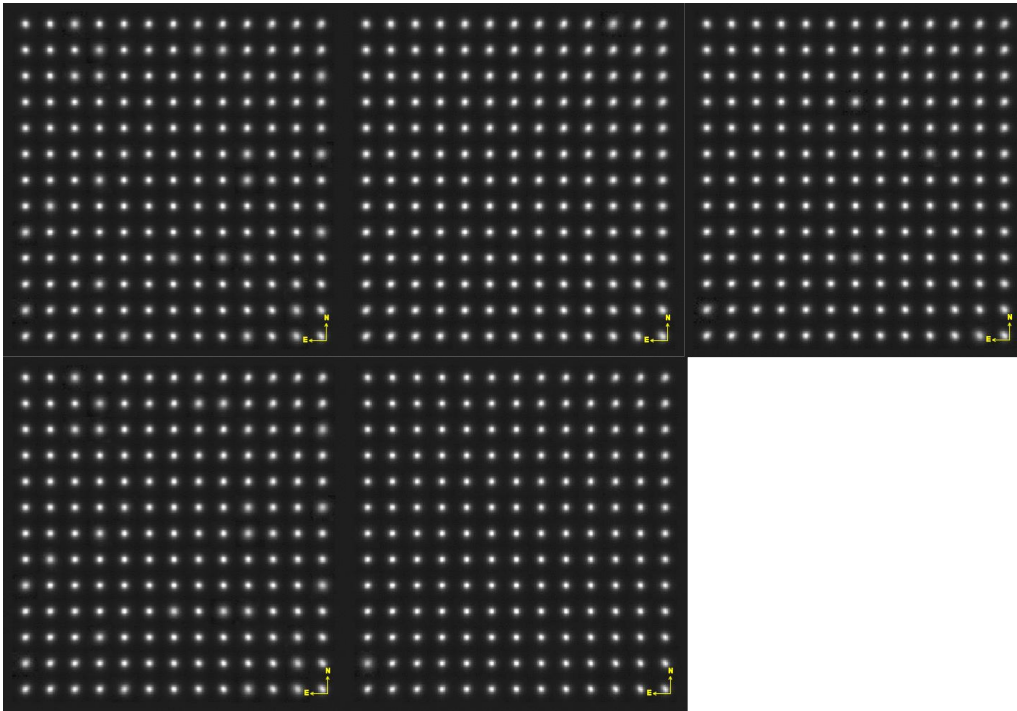
Astrometric calibrations were performed using “Astrometrix”. The astrometric rms internal errors are less than 0.05 arc-second in both axes, while the rms external error is 0.40 arcsecond, as

expected from the USNO-B1 errors. The u^* band astrometry accuracy is slightly worse than for other filters, because the number of u^* images is less in this case; the depth of the stacked image is correspondingly shallower. In addition, the seeing of each image is significantly worse as well. A small residual oscillation is also visible on the internal calibration plots for other filters. These oscillations are due to the small dithering pattern of deep images which prevents very accurate internal calibration in the gaps between CCDs using overlapping sources.



Internal and external astrometric calibration plots. Each plot show the RA or DEC position difference between the external object reference catalogue USNO-B1 or between the internal object catalogue detected in the deep i -band images.

TERAPIX provided also a PSF map image of each stacked deep field in all filters as well as a first estimate of the PSF anisotropy based on an automatic star selection.



PSF map image for the D3 stacks. Each square represents a Megacam image. From top left to bottom right; u^ , g , r , i and z stacks.*

Preliminary science verification studies on stellar populations (see the Section on stellar populations), weak lensing (see section on cosmic shear where it is demonstrated that stacked i and r bands data do not show B-modes. It also indicates that systematic residuals are negligible, and consequently that the TERAPIX T0001 processing did not introduce any significant systematic effects), photometric redshift analyses (see section on the deep survey and on cosmic shear) analyses and deep galaxy photometry demonstrate that the CFHTLS data are indeed very good and the CFHTLS-TERAPIX products are reliable and can be used for science.

6.2 Release T0002

The T0002 release will contain data from the three components of the CFHTLS survey. The amount of images being processed is around 14000 (about 7000 science images and 7000 weight maps attached to RunIDs [03/04][A/B]L[01-06]). Since the Very Wide data are not stacked, the data reduction factor will be smaller than T0001 (a factor 100) and the amount of data sent to CADC will be more than one order of magnitude higher. The selection criteria are the same as T0001 except that the observing period is extended to Nov. 22, 2004. All images will have 19354×19354 0.186 arc-second pixels (1 deg^2). As in T0001, the astrometric reference catalogue is USNO-B1.

The “step 1” processing corresponding to the data ingestion context that produces all weight and flag maps has been completed and all individual image maps have been sent to CADC. They have been available to CFHTLS registered users since Jan. 15, 2005 and consist of about 8000 weight map and 8000 flag map images and relevant catalogues. QualityFITS-in information for each image is also available on line.

The “step 2” processing corresponding to the “image-by-image” or “Release” processing modes has been unfortunately delayed by several months. It was originally scheduled to be completed by December 4th, but was rescheduled due to several diverse problems: technical difficulties related to the integration of the latest hardware components in the TERAPIX cluster, changes in the stacking

strategy of wide data in order so that the stacks to follow the target lists supplied by the wide coordinators, delays in the database, the pipeline and the processing software components and difficulties in achieving the expected percentage accuracy in the photometric rescaling.

Because we moved from Astrometrix to SCAMP, we also had to check that data processed with both software tools provide the same results. The most critical issue was the analysis of systematic residuals for cosmic shear. This control demands to analyse at least 10 deg^2 (because the signal to noise per Megacam field is low) each time new releases of software tools are produced, to measure B-modes and to check they are statistically zero with not systematic discrepancies between SCAMP and Astrometrix (we know from weak lensing analyses of VIRMOS-Descart and T0001 data that Astrometrix does not produce B-modes). So far, we have not found significant differences between both software tools. Similar checks are done to check consistency between photometry and object positions in T0001 and T0002 stacks.

The selection criteria for the T0002 release are the following:

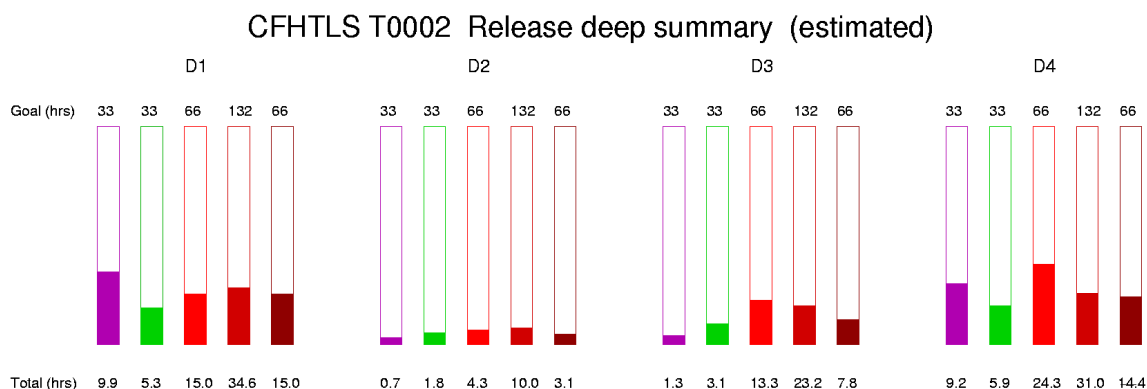
Observation period	From June 1 st , 2003 to November 22, 2004
Exposure time	>60 sec.
Skyprobe	<2.0
Airmass	<1.5
Terapix grade	A or B
Seeing Deep	<1.1" for g,r,i and z <1.3" for u*
Seeing Wide	<1.1" for g,r,i and z <1.4" for u*
Seeing Very Wide	<1.2" for g,r,i and z <1.5" for u*

The Deep, Wide and Wide Pre-survey will consist of 256 stacked images of 1 deg^2 :

- 20 Deep stacks (4 fields, 5 filters),
- 134 Wide stacks and
- 102 Wide Pre-survey (r-band , 1 exposure only per image).

The total sky coverage of the Wide i-band will be 19 deg^2 for W1, 2 deg^2 for W2 and 12 deg^2 for W3. One W1 field has been observed in all filters, with exposure times corresponding to the final exposure of all Wide survey targets

The Very Wide data processed in the “image-by-image” mode consists of 1634 images.



This plot show the anticipated final exposure times of deep T0002 stacked (assuming the on going stacks will be validated). It can be compared to the same plot for T0001

The most innovative technical aspect of T0002 as compared to T0001 SCAMP for the astrometric and photometric calibration and the field to field photometric rescaling. Since SCAMP is based on a global astrometric calibration method, it can use as much images as possible around each field, leading to a more robust solution and a better accuracy than Astrometrix. For each field we required that all Megacam images encompassed inside a 2.5 deg radius circle around each field be included in the astrometric calibration. The local small-scale weak oscillations observed in Deep fields of T0001 should also vanish since the Wide and Pre-survey data (which have large dither patterns) will be also added, together with deep images, in all astrometric calibrations of deep stacks. The plots and tables presented in the SCAMP section show a sample of output meta-data of a T0002 product for the Wide survey:CFHTLS_W_i_14307+533430_*. The summary table of the SWarp stacking process and the QualityFITS-out summary table of this target are shown below.

swarp											
Input files (10)											
File	Object	Ra	Dec	Seeing	Skyprobe	Photom Flag	Airmass	Note	ExpTime	Runid	
File 1 :	751034p.fits	W3+2-1	14:30:06.20	53:34:48.20	0.8	0.285	A	1.222	B	620.183	04AL05
File 2 :	751035p.fits	W3+2-1	14:30:03.29	53:34:17.30	0.91	1.078	A	1.232	B	620.218	04AL05
File 3 :	751036p.fits	W3+2-1	14:30:08.8	53:33:20.10	0.79	0.708	A	1.247	B	620.213	04AL05
File 4 :	751197p.fits	W3+2-1	14:30:06.20	53:34:48.20	0.83	0.093	P	1.215	B	620.195	04AL05
File 5 :	751198p.fits	W3+2-1	14:30:03.81	53:34:18.10	0.79	0.09	P	1.223	B	620.208	04AL05
File 6 :	751199p.fits	W3+2-1	14:30:07.16	53:33:18.10	0.84	0.094	P	1.233	B	620.221	04AL05
File 7 :	751200p.fits	W3+2-1	14:30:08.65	53:35:18.39	0.82	0.098	P	1.246	B	620.228	04AL05
File 8 :	751201p.fits	W3+2-1	14:30:04.65	53:36:20.10	0.86	0.093	P	1.263	B	620.239	04AL05
File 9 :	751202p.fits	W3+2-1	14:30:03.92	53:35:49.39	0.88	0.079	P	1.295	B	620.241	04AL05
File 10 :	751203p.fits	W3+2-1	14:30:07.33	53:33:48.70	0.83	0.093	P	1.318	B	620.237	04AL05

Scamp astrometry statistics extract			Scamp astrometry statistics extract		
chi2_ref		88.97	sigma_ref (axis1) (arcsec)		0.46
chi2_ref_hsn		70.33	sigma_ref (axis2) (arcsec)		0.50
ndets_ref		6111	sigma_ref_hsn (axis1) (arcsec)		0
ndets_ref_hsn		0	sigma_ref_hsn (axis2) (arcsec)		0

4x4 binned chip pixel (1,1) is at lower left	background (ADU)	sigma_bkg (ADU)	background (mag/arcsec ²)	nsexdet	seeing (pix)	seeing (arcsec)	loaded	saccepted	schl2
EXT[0]	-0.1	1.8	1.12	149074	4.46	0.83	4092	3458	2.34

Filename	Runid	Object	ExpTime (s)	Release Date	Date Obs	Utc Obs	Skyprobe	Photom Flag	Note	Seeing (arcsec)	Airmass
751034p	04AL05	W3+2-1	620.183	2006-05-01	2004-06-24	07:30:42	0.285	A	B	0.8	1.222
751035p	04AL05	W3+2-1	620.218	2006-05-01	2004-06-24	07:42:29	1.078	A	B	0.91	1.232
751036p	04AL05	W3+2-1	620.213	2006-05-01	2004-06-24	07:56:06	0.708	A	B	0.79	1.247
751197p	04AL05	W3+2-1	620.195	2006-05-01	2004-06-25	07:16:56	0.093	P	B	0.83	1.215
751198p	04AL05	W3+2-1	620.208	2006-05-01	2004-06-25	07:28:28	0.09	P	B	0.79	1.223
751199p	04AL05	W3+2-1	620.221	2006-05-01	2004-06-25	07:39:46	0.094	P	B	0.84	1.233
751200p	04AL05	W3+2-1	620.228	2006-05-01	2004-06-25	07:51:05	0.098	P	B	0.82	1.246
751201p	04AL05	W3+2-1	620.239	2006-05-01	2004-06-25	08:03:52	0.093	P	B	0.86	1.263
751202p	04AL05	W3+2-1	620.241	2006-05-01	2004-06-25	08:23:41	0.079	P	B	0.88	1.295
751203p	04AL05	W3+2-1	620.237	2006-05-01	2004-06-25	08:35:36	0.093	P	B	0.83	1.318

Stack name	Ra	Dec	Release Version	ExpTime Tot (s)	ZP	Seeing (arcsec)	Background (mag/arcsec ²)	Skyprobe
CFHTLS_W_i_143007+533430	14:30:07	53:34:30	0002	6202.16	30	0.83	1.12	0.299

Completeness

CFHTLS_W_i_143007+533430 - i_MP9701

%

Magnitude

Summary tables of the Wide w3+2-1 processing. top panel: information on the images which were stacked together to produce the final w3+2-1 i-band image. A link to QualityFITS-in allow users to view more detailed information regarding individual input images. Bottom panel: the SPICA/SCAMP/QualityFITS-out output quality assessment summary table and the completeness limit plot.

- Server Admin Spica -
- Automatic Image Mode -



- Automatic Survey Mode -

RunId 2003			RunId 2004			Filter			Node		
Name	Number	%	Name	Number	%	Name	Number	%	Name	Number	%
03AL03	46	0 %	04AL06	49	0 %	gMP9401	79	0 %	pix5	53	0 %
03BL06	30	0 %	04AL03	23	0 %	rMP9601	33	0 %	pix6	49	0 %
						iMP9701	36	0 %	pix7	46	0 %

Images available		8525
CFHTLS images	7927	92 %
PI images	598	7 %
Input quality assessment	8525	100 %
Spica	148	1 %
Output quality assessment	147	1 %

PI data access	
Login:	<input type="text"/>
Password:	<input type="password"/>
<input type="button" value="Go"/>	

Search	Display	Filename	RunId	Filter	Object / Field	Node
<input type="text"/>	10	<input type="text"/>	---	---	---	---
<input type="button" value="Go"/>	RA Min & Max	Dec Min & Max	DateObs Min & Max	Exp. time Min & Max	Spica status	Skyprobe Min & Max
	00 h 03 m 21.85	-27 ° 09 ' 42.89	2003 03 22	1.02 s	V	-0.14
	23 h 56 m 54.53	66 ° 36 ' 31.30	2004 12 16	1200.19 s		8.664

This page is a summary table of the "Automatic image mode" that processes ALL single Megacam scientific image in order to provide astrometric calibration as well as photometric input informations for further image sampling and stacking. The output files and quality assessment data attached to each image are available to all CFHTLS permitted users at TerapiX and at CADC. The TerapiX processing pipeline that provides these output data is called SPICA. The following summarizes the 3 steps of the processing: input quality assessments, SPICA processing and data transfer to CADC. Once a step is done the label move from "N" to "Y" (as No and Yes).

10 images displayed (148 total) [\[Export the whole result in CSV \(ASCII file in Comma Separated Values\)\]](#)

Thumbnail	Image	Object	RunId	Filter	Exp time (s)	CFHT SkyProbe	Utr_obs	Skyprobe	Arrival Date	RA	Dec	Input Quality Assessment	Spica processing	Output Quality Assessment	Sent to CADC	File	Node
	750586p	tmp5 04AL03	i	300.073	2004-06-19	07:31:29	0.063	2004-12-07	13:14:48.39	-07:12:49.39	Y	Y	Y	N	1-W-C	pix5	
	750587p	tmp4 04AL03	i	300.068	2004-06-19	07:24:30	0.062	2004-12-07	13:11:13.55	-06:30:31.30	Y	Y	Y	N	1-W-C	pix5	
	750586p	tmp3 04AL03	i	300.078	2004-06-19	07:17:30	0.077	2004-12-07	13:08:36.50	-06:39:10.59	Y	Y	Y	N	1-W-C	pix5	
	750585p	tmp2a 04AL03	i	180.07	2004-06-19	07:13:11	0.088	2004-12-07	13:01:35.75	-07:37:48.39	Y	Y	Y	N	1-W-C	pix5	
	750584p	tmp2 04AL03	i	180.068	2004-06-19	07:08:11	0.064	2004-12-07	13:07:43.25	-08:16:03.0	Y	Y	Y	N	1-W-C	pix5	

The image-by-image summary operation interface. It provides users access to an overview of the processing and details on each processed image regarding QualityFITS-in, SCAMP and QualityFITS-out.

6.3 Next releases

Provided TERAPIX experiences no further delays, T0003 is scheduled to be delivered to CADC by the end of June 2005. TERAPIX will start running Step 1 by May 1st, so that new weight and flag map images will be delivered to CADC by the end of May. Except for an improvement of source positional accuracy of sources by around 30%, and the possible use of proper motions in the astrometric calibration, we do not foresee innovative development for that release, as compared to T0002.

Beyond T0003, the TERAPIX releases will include two innovative tools:

Defectix: this is an automated masking software tool based on neural network learning process which classifies and masks most common defects present in images: for example, saturated stars, diffuse stellar halos or satellite tracks. It is currently in preliminary test phase and more work is required before it can be implemented in the TERAPIX pipeline. In principle it should (partly) replace the hand-made masking by providing a FITS mask image that will be easily usable in conjunction with the weight map image. We expect defectix to be ready for T0004 (December 2005).

PSF homogenization: this is still in study phase. It will use the PSFex analysis software tool to derive a optimal PSF homogenization of all survey data sets and create a PSF-homogenized set of stacked images.

7. The SkyWatcher CFHTLS survey monitoring tool

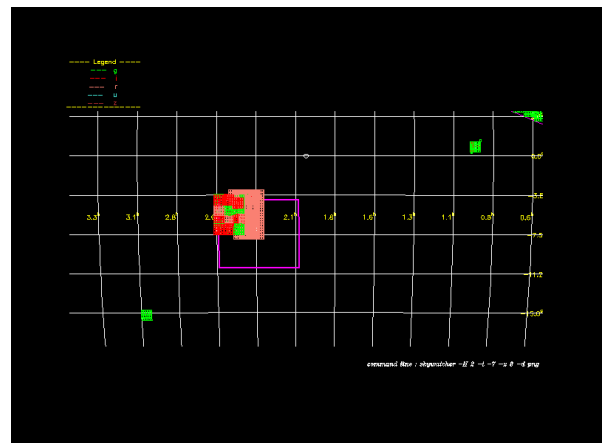
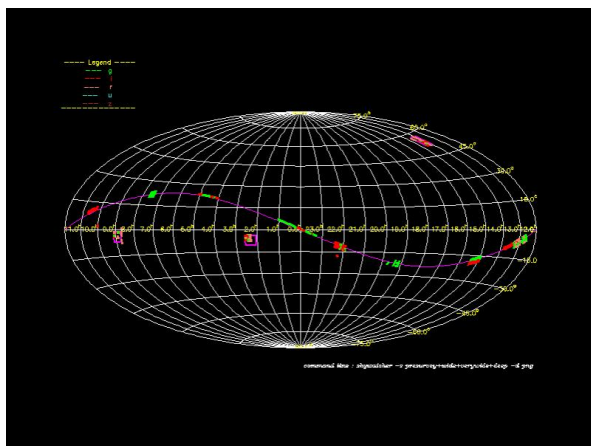
SkyWatcher is a TERAPIX visualisation interface that has been specifically designed to monitor the progress of the CFHTLS. It allow users to view the location of Megacam images on the sky and to follow the progress of “step one” and “step two” processing steps.

SkyWatcher is a C-language program. It uses a VOTable configuration file that contains FITS WCS keywords of all Megacam images loaded on the TERAPIX disks. Each VOTable element is then parsed and inserted in a SQL database.

SkyWatcher uses this database to position Megacam image on the celestial sphere, to compute its projected position and then to draw the outlines of the FITS file. The first SkyWatcher release uses the following projection systems: Aitoff, Parabolic, Mollweide's, Sanson-Flamsteed, Plate carree and cylindrical equal area.

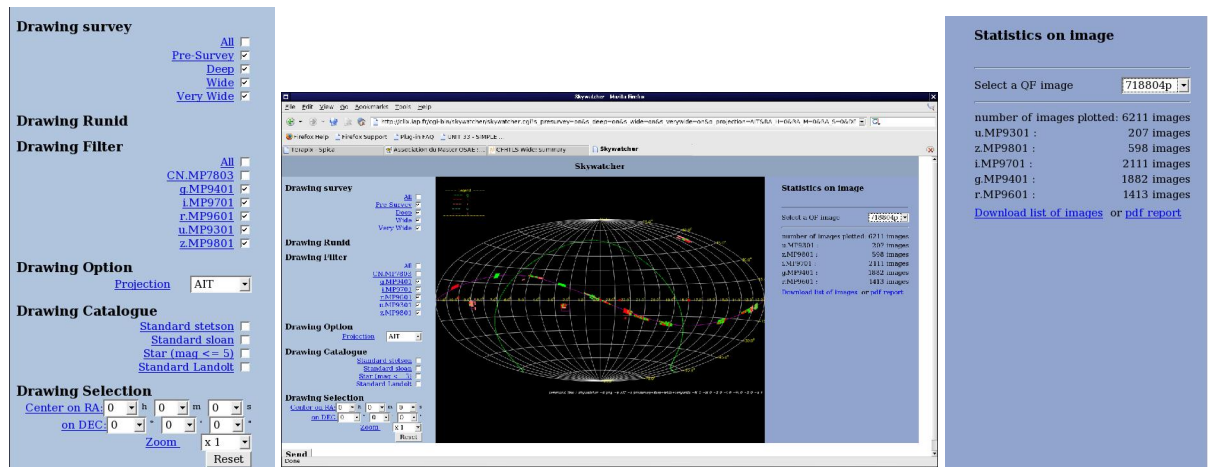
Any FITS image can be handled, so SkyWatcher can draw each CCD of a 36 MEF Megacam image or a big SWarped image of any size. The CFHTLS users can insert contour box in the configuration file in order to view any sky sub-area he may wish so.

In the two figures below, all Megacam CFHTLS images which have arrived at TERAPIX have been loaded. Each filled box represents an image, coloured according to the CFHTLS filter. The large



open boxes have been inserted in the configuration file to show the positions and the size of the three Wide fields.

Drawing options allow users to modify the background and the grid colors, to zoom-in sub-areas, to draw the galactic plane position or any VOTable format object catalogue, like the Landolt and Stetson standard stars catalogues. A pseudo-colour image of the Schlegel's extinction map can also be loaded, with user-defined colour-cuts.



SkyWatcher can be used in two modes :

- A command line interactive mode that produces standard X11 image output
- A CGI script mode that handles a more user friendly remote access to SkyWatcher through the web. Image selections can be done using RunID, survey component, filters, sky positions, etc... with zoom-in/out and centering options. The final image selection is listed and linked to QualityFITS-in data.
- Each user selection can be saved as pdf file.

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