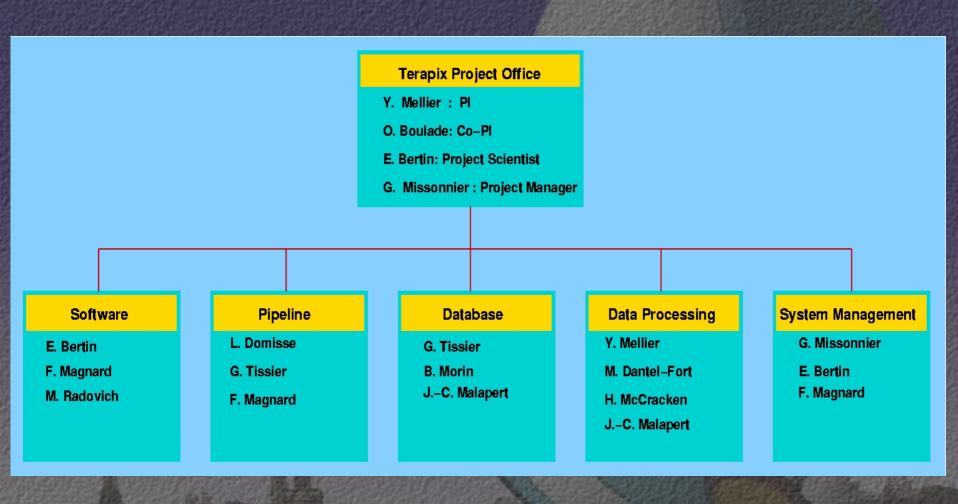
http://terapix.iap.fr



## TERAPIX

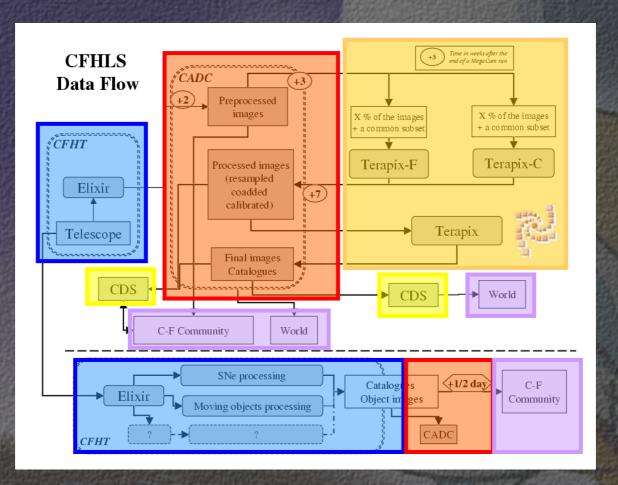
- Production of large, "clean" and well-calibrated science images
  - Production of calibration/data-description images (weight+flag maps)
  - Astrometric and photometric solution
  - Image warping
  - Image homogenization
  - Image co-addition
  - Quality assessments
- Production of "Final" source catalogs
  - Detection
  - Measurement
  - Classification
- Users tools:
  - Automatic pipeline / data base with remote user access
  - vizualisation,
  - survey follow-up, etc...
- User assistance:
  - PI images processed by Terapix
  - or PI does their own at Terapix remotely.
- Funding:
  - INSU + PNC + EC-FP5-AVO + EC-FP5-AstroWise + IAP + CEA

## Terapix organisation

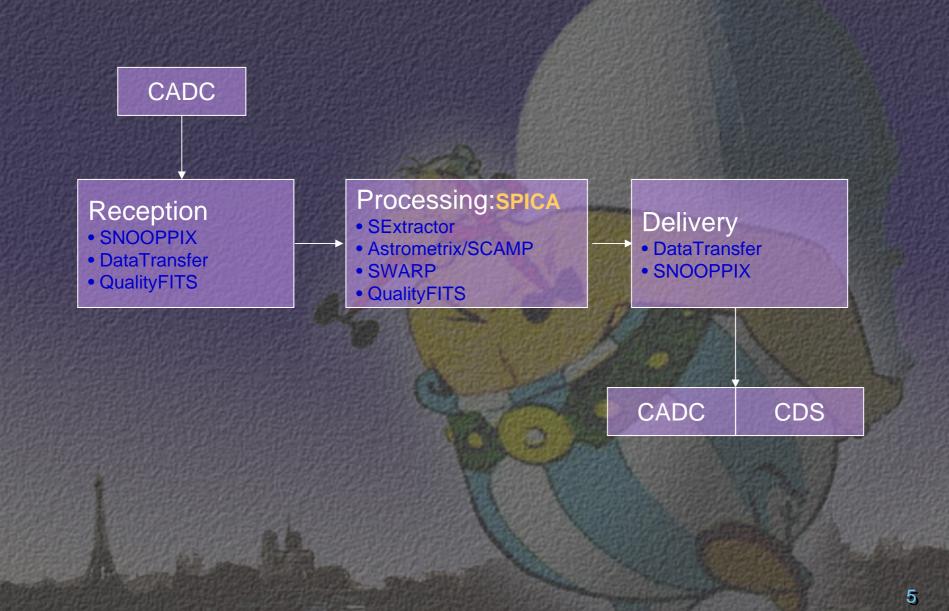


## Data Flow

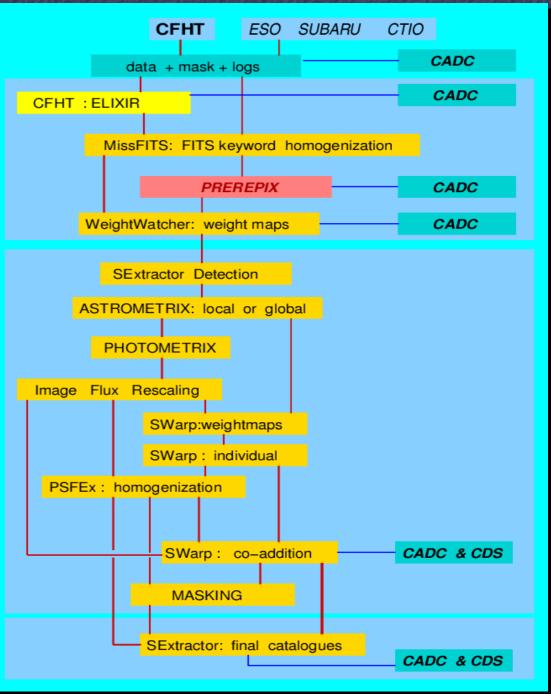
- Terapix reception: 2000-3000 images/run (2.1 TB, maximum),
- Terapix production: Weight+Flag images + stacked images (~ 4.5 TB)
- Goals: 300 Kpixel/sec, 100 object/sec (real working time: 8hrs/24)



## Overview of the TERAPIX pipeline



# Overview of the TERAPIX pipeline



## Software



## Data reduction modules:

## POSIX-compliant C/C++ and/or PDL+PERL-Tk

- Most of them are being developed and are maintained on-site:
  - Perfectly matched to MEGACAM images
  - Perfect control; fast response in case of problems
  - Many tasks are performed within each module
    - Efficiency (minimizes inputs/outputs)
    - Simplifies the pipeline at higher levels
    - Possible thanks to permanent, dedicated, team members
- Distributed to the general community A.S.A.D.
  - Tremendously improves robustness and portability (code, instruments, file formats)
  - Brings up new ideas
  - Helps in forcing people to write a detailed documentation
  - Source packages now comply with GNU standard (Autoconf); binary packages are Linux RPMs
  - Released under GPL

## Software (cont.)



- SNOOPPIX: spots data at CADC
- Datatransfer: send data to Terapix/CADC and organise data on disks
- QualityFITS: input/output quality assessments tools + metadata
- MissFITS: manage FITS files
- WeightWatcher: Create weight-maps for images
- SWarp: Resample and co-add images
- SExtractor: Source extraction
- PSFEx: Build a PSF model of a field
- ASTROmetrix/PHOTOmetrix: local and global astrometry + photometric normalization/calibration
- SCAMP: New Astrometric/photometric software

## Simulation+visualisation tools: C/C++ stand-alone programs

- Stuff: Simulation of galaxy populations
- SkyMaker: Image simulation
- Panorapix: Large image visualisation
- Stiff: image compositing and conversion to TIFF
- SExBench: hardware benchmarking software
- SkyWatcher: Survey/data sky follow up

## Software distribution



#### Home > 1.Activities > 1.Software > SWarp

#### 1.Activities

#### 1.Software

Spica

Database

CVS access

News

Download

SWarp

Links

2.Hardware

News

The Terapix cluster Legacy hardware

Links

3.Documentation

Reports Meetings

Press

#### 2.Agenda

- 1.Calendar
- 2.Meetings
- 3.Locations

#### 4.Tools

1.Instruments

MegaCam

MegaPrime

2.Archives

CADC CDS

3.Data reduction

Spica access

#### 5.Participants

1. Human resources People

Project vacancies

2. Funding agencies

3. Contracts

AVO

ASTRO-WISE

CADC-Terapix

STAR TAP

#### 6.Science

1.CFHTLS

2.DESCART News

SWarp

Updated November 22nd, 2003



#### Subsections



http://terapix.jap.fr/soft/swarp

- SWarp Mailing List
- Bulletin Board

SWarp is a program that resamples and co-adds together FITS images using any arbitrary astrometric projection defined in the WCS standard

#### The author

▶ Emmanuel BERTIN

#### What's new?

- ▶ 11/24/2003: A huge bug has been found in V2.07. This is now fixed in V2.08. Sorry for the mess.
- 11/23/2003: Version 2.07 of SWarp is finally available!! Release highlights:
  - Resampling is 2 10 (!) times faster than in V1.xx
  - Multi-threading and co-addition more efficient (code rewritten from scratch)
  - · Support for BLANK pixels

#### Download the latest version (V2.08)

Both the autoconfigurable source archive and Linux RPM packages for x86 are available below. The RPM versions have been optimized to provide the best possible performance on Linux PCs.

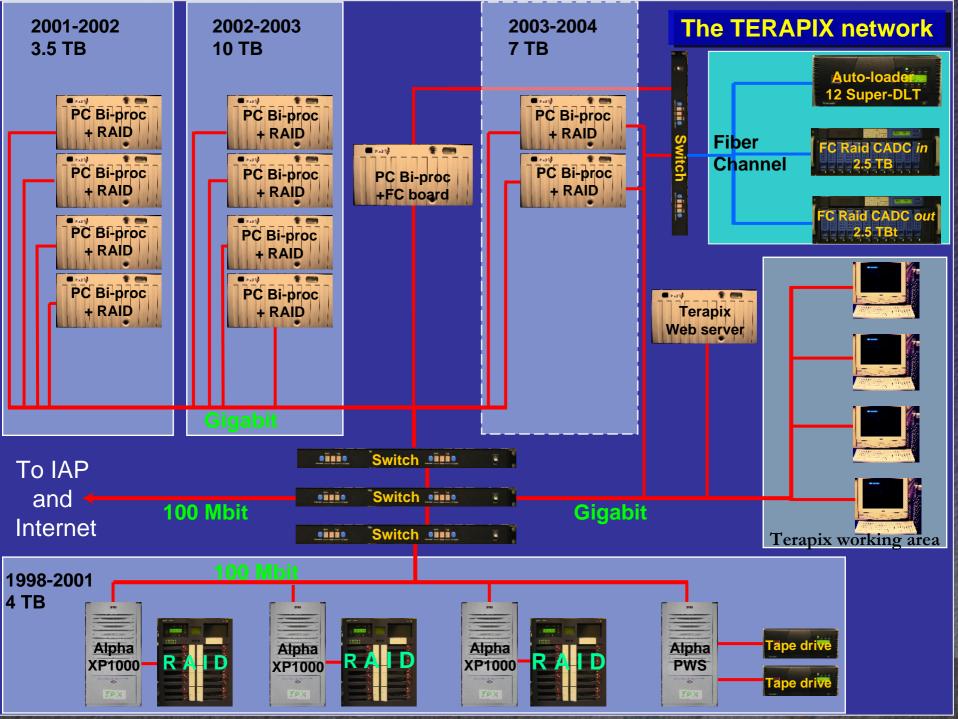


archive



Monoprocessor Multiprocessor





## Snooppix



Welcome to Snooppix





#### Configuration interface for Snooppix

Select a file:

• Log file
• Config file
Select action for
the selected file

Save Open

Daemon action

Start

Stop

Status

Downloaded images

with:

ftp

- Spot the CADC-CFHTLS archive area (Terapix permited)
- Check data having new Elixired history (new or reprocessed by CFHT)
- Get these data to Terapix repository (Fiber Channel Bay). Use ftp or http protocol.
- SNOOPPIX has been cloned at CADC to get Terapixed data from the Terapix repository to CADC

#### Files available in the directory /data/clix/fc1/from\_CADC/headervalid/ and Virtual free disk /data/clix/fc2/from CADC/headervalid/ 652,036 GB Total disk 695665o.fits.fz 🔼 6956660.fits.fz Get the header 695667o.fits.fz node2:33.6 % 695668o.fits.fz RUNIDs available in the directory /data/clix/fc1/from CADC/headervalid/ and node3:33.6 % /data/clix/fc2/from CADC/headervalid/ Runid Number of images Runid size Disk space needed 03AF19 17.786 GB 71.145 GB Virtual free disk: 487.207 GB 03AL01 187.079 GB 748.315 GB Total disk 652.036 GB 03AL02 18,447 GB 73.788 GB 28 03AL03 288 189.720 GB 758.882 GB Virtual free disk 1523 314 GB 03AQ97 52.691 GB 210.764 GB Total disk 1869.964 GB 23.717 GB 03AQ98 5.929 GB please click on the link Virtual free disk: 1306 830 GB Total disk 1869 964 GP Automatic transfer of a RUNID Change it Immediate transfer of a RUNID RUNID immediate transfer Virtual free disk : 1508.813 GB ▼ | Select ☐ Select node8:19.3 % ☐ Select ☐ Select ☐ Select ☐ Select ☐ Select ☐ Select Transfer Transfer status: on going transfers or sleep Automatic mode in 8 minutes and 55 seconds Immediate mode in 0 minutes and 55 seconds Configuration and help Data transfer analysis and control Editing configuration file Runid distribution Color bar legend Transfer history How to configure DataTransfer Received data flow control How to control free disk Runid status control How to transfer a file Filter usage contro How to know transfer history View work in progress with immediate mode How to force a file to be reloaded in the DB View work in progress with automatic mode Copyright @ 2003 Terapix - IAP - J.C. Malapert

Datamans

## Datatransfer

Transfer the data snooped by SNOOPPIX from the data transfer repository disks to Terapix processing disks

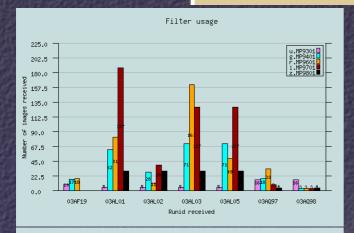
Check the disk space available on each node and send the data on disks that still have enough space to produce weight + flag map images

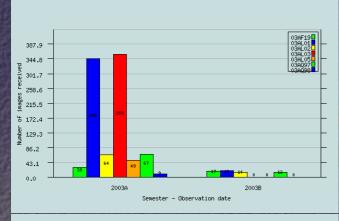
Make statistics on images (period, RunID, filter, etc...) and store meta-data on local DB Can run automatically or manually

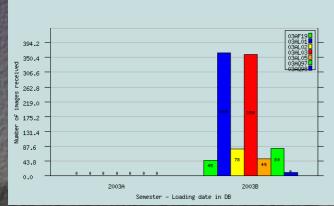


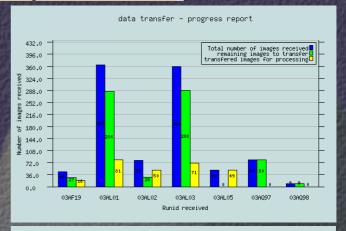
Transfer

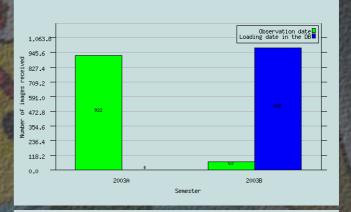
#### Data transfer - progress report

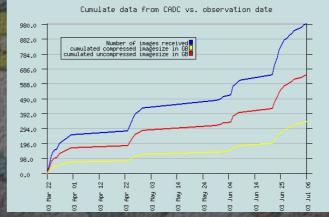












## QualityFITS

- Delivered by Terapix to the AstroWISE consortium
- Provides a complete image analysis of all images
  - Check background
  - Maps the PSF
  - Checks star and galaxy counts
  - Produces weight/flag maps
- Quality assessment for in/out images
- QualityFITS uses:
  - **SExtractor**
  - **PSFex**
  - **SWARP**
  - PLplot library tools
  - Weightwatcher



PSF

Rh-mag orientation diagram

Star counts Galaxy

Summary table

Processed on 08-11-2003 17:35:08

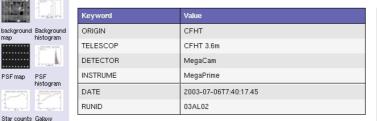
send bug reports to magnard@iap.fr

by magnard with qualityFITS v.1.0

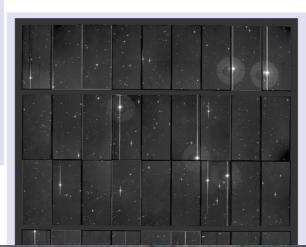


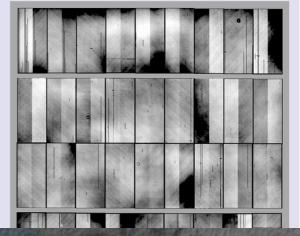


#### Evaluation of 708710o



Keyword	Value
OBJECT	w33-1
EXPTIME	620.166
FILTER	i.MP9701
RA	13:59:34.53
DEC	53:33:30.9
EQUINOX	2000.0
AIRMASS	1.354

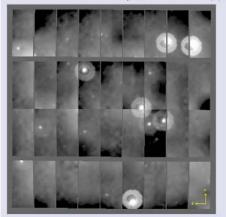






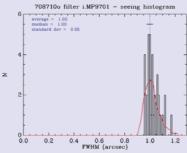


Note to Internet Explorer users: IE is unable to render properly the transparency in PNG images. Prefer mozilla. Cf. test.

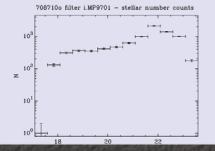


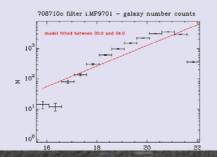
7087100 filter i.MP9701 - background histogram 15 3050 3100 3150 3200 background (ADU)





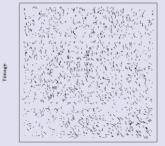
mosaic of PSF



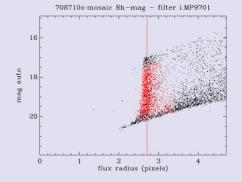


# QualityFITS (cont.)

708710o-mosaic PSF orientation and ellipticity map - filter i.MP9701



PSF orientation and ellipticity map



4x4 binned chip	background	sigma bkg	background	nsexdet	seeing	seeing	sloaded	saccepted	schi
pixel (1,1) is at lower left	(ADU)	(ADU)	(mag/arcsec <sup>2</sup> )		(pix)	(arcsec)			
	<u> </u>								
ccd00	3160.4	123.7	20.28	754	5.72	1.05	29	27	1.65
ccd01	3125.0	125.8	20.30	606	5.35	0.99	52	45	1.30
ccd02	3142.8	117.9	20.30	662	5.34	0.99	48	40	1.26
ccd03	3139.8	126.1	20.31	685	5.39	1.00	43	37	1.27
ccd04	3127.3	120.3	20.31	649	5.49	1.02	52	42	1.27
ccd05	3108.6	122.7	20.32	681	5.69	1.06	52	41	1.32
ccd06	3178.4	123.4	20.29	768	5.79	1.07	60	55	1.48
ccd07	3104.9	128.5	20.31	762	6.04	1.12	38	38	1.57
ccd08	3166.2	141.7	20.28	727	6.34	1.17	29	27	1.85
ccd09	3172.6	119.3	20.29	701	5.26	0.98	50	39	1.19
ccd10	3152.0	132.7	20.31	755	5.19	0.97	39	36	1.26
ccd11	3164.8	134.0	20.31	654	5.20	0.97	45	40	1.24
ccd12	3152.7	125.7	20.31	703	5.35	1.00	50	39	1.25
ccd13	3172.2	122.2	20.31	850	5.42	1.01	67	59	1.22
ccd14	3157.3	136.5	20.31	826	5.50	1.03	43	37	1.15
ccd15	3136.5	129.3	20.32	817	5.55	1.04	51	42	1.21
ccd16	3136.6	126.4	20.31	828	5.70	1.06	53	46	1.22
ccd17	3165.0	124.2	20.29	848	5.92	1.10	43	33	1.29

## Pipeline SPICA: PHP/SQL technologies



#### « web » interface

- Fully portable, used remotely
- Users accounts
- Selection criteria included for user selection of images and configuration files
- Fully automated mode (all images)



#### Spica administration configuration Should be located in a restricted area

#### Config files

Make configuration files	Modify configuration files
You could use as many configuration files as you need.	Use this part if you just need to change some values in your configuration files. This part will load your current data and will allow you to change the values.
Make from previous files	Delete configuration files
If you need to get several configuration files but nearly similar, use this to load an existing configuration file, modify it and save it with another name.	If you want to delete some of your configuration files, this is the right place. Be careful as there is no way to restore them.

(Version 0.01)



Home > Tools > Data reduction > Spic

#### Server Admin Spica - Automatic Image Mode

Input Qualityfits - Spica - Output Qualityfits

Warning node2 is down

Images available	269			
Input quality assessment	231	85 <b>%</b>		
Spica	0	0%		
Output quality assessment	0	0 %		

## SPICA: output

vfits Processed data

Sent to

CADC

Ν

Ν

Ν

Ν

USALUZ

03AL03

03AL05

unId

Number %

18 10 %

20 11 %

50 28 %

37 21 %

49 28 %

Image	RunID	Filter	Exp time	Date	RA	Dec	Input Quality Assesment	Spica processing	Output Quality Assessment	,
707440o	03AF19	r.MP9601	560	2003-06-24	15:08:30.00	5:00:00.0	<u>Y</u>	N	N	
707441o	03AF19	r.MP9601	560	2003-06-24	15:08:28.93	4:59:55.3	<u>Y</u>	N	N	
707442o	03AF19	r.MP9601	560	2003-06-24	15:08:30.30	4:59:45.0	<u>Y</u>	N	N	
707443o	03AF19	r.MP9601	560	2003-06-24	15:08:31.00	5 00:04.4	<u>Y</u>	N	N	
707444o	03AF19	r.MP9601	560	2003-06-24	15:08:29.69	5:00:14.9	<u>Y</u>	N	И	
707445o	03AF19	r.MP9601	560	2003-06-24	15:08:29.29	5:00:10.4	<u>Y</u>	N	И	
										0

Filter									
Name	Number	%							
g.MP9401	37	21 %							
i.MP9701	39	22 <b>%</b>							
r.MP9601	98	56 %							

Node1	49	28 %
Node5	18	10 %
Node6	37	21 %
Node7	59	33 %
Node8	11	6%

Node

Name Number %

SPICA uses and feeds the local Terapix data base DBclient

I	Search	Display	Runld	Filter	Node	Exp_time (min/max)	Airmass (min/max)	Mseeing (min/max) Mbkg (min/max)
I	Go	20				140.032 / 63.943	1.053 / 1.561	0.7336 / 1.9881 18.455 / 21.83

All 20 images displayed. Use the form to select more or less

Warning : node2 is down
Warning : node3 is down
Warning : node8 is down

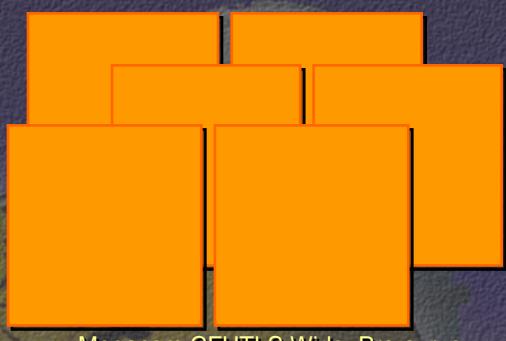
Image	RunID	Filter	ExpTime (s)	Date Obs	RA	Dec	Equinox	Airmass	Mseeing (')	Mbkg (mag)	Node
<u>695703o</u>	03AL05	r	180	2003-03-22	14:08:43.70	53:35:30.9	2000	1.234	0.9009	19.97	Node1
<u>695704o</u>	03AL05	r	180	2003-03-22	14:08:37.98	54:02:30.8	2000	1.246	1.0193	19.96	Node1
<u>6957050</u>	03AL05	r	180	2003-03-22	14:08:32.09	54:30:30.8	2000	1.258	1.0097	19.95	Node1
<u>6957060</u>	03AL05	r	180	2003-03-22	14:08:26.05	54:58:30.9	2000	1.27	1.2213	19.94	Node1
<u>695707o</u>	03AL05	r	180	2003-03-22	14:08:19.83	55:26:30.9	2000	1.283	0.9702	19.93	Node1
<u>6957080</u>	03AL05	r	5	2003-03-22	14:08:13.43	55:54:30.9	2000	1.296	1.2161	19.94	Node1
<u>6958180</u>	03AL05	r	180	2003-03-23	8:40:39.80	-3:18:25.0	2000	1.089	0.9715	20.92	Node1
<u>6958190</u>	03AL05	r	180	2003-03-23	8:40:39.80	-2:51:00.0	2000	1.087	0.9972	20.91	Node1
<u>695820o</u>	03AL05	r	180	2003-03-23	8:40:39.80	-2:23:00.1	2000	1.085	1.0641	20.9	Node1
	6957030 6957040 6957050 6957060 6957070 6957080 6958180 6958190	6957030 03AL05 6957040 03AL05 6957050 03AL05 6957060 03AL05 6957070 03AL05 6957080 03AL05 6958180 03AL05 6958190 03AL05	6957030 03AL05 r 6957040 03AL05 r 6957050 03AL05 r 6957060 03AL05 r 6957070 03AL05 r 6957080 03AL05 r 6958180 03AL05 r 6958190 03AL05 r	6957030         03AL05         r         180           6957040         03AL05         r         180           6957050         03AL05         r         180           6957060         03AL05         r         180           6957070         03AL05         r         180           6957080         03AL05         r         180           6958180         03AL05         r         5           6958190         03AL05         r         180           6958190         03AL05         r         180	6957030         03AL05         r         180         2003-03-22           6957040         03AL05         r         180         2003-03-22           6957050         03AL05         r         180         2003-03-22           6957060         03AL05         r         180         2003-03-22           6957070         03AL05         r         180         2003-03-22           6957080         03AL05         r         5         2003-03-22           6958180         03AL05         r         180         2003-03-23           6958190         03AL05         r         180         2003-03-23	6957030         03AL05         r         180         2003-03-22         14:08:43.70           6957040         03AL05         r         180         2003-03-22         14:08:37.98           6957050         03AL05         r         180         2003-03-22         14:08:32.09           6957060         03AL05         r         180         2003-03-22         14:08:26.05           6957070         03AL05         r         180         2003-03-22         14:08:19.83           6957080         03AL05         r         5         2003-03-22         14:08:13.43           6958180         03AL05         r         180         2003-03-23         8:40:39.80           6958190         03AL05         r         180         2003-03-23         8:40:39.80	6957030         03AL05         r         180         2003-03-22         14:08:43.70         53:35:30.9           6957040         03AL05         r         180         2003-03-22         14:08:37.98         54:02:30.8           6957050         03AL05         r         180         2003-03-22         14:08:32.09         54:30:30.8           6957060         03AL05         r         180         2003-03-22         14:08:26.05         54:58:30.9           6957070         03AL05         r         180         2003-03-22         14:08:19.83         55:26:30.9           6957080         03AL05         r         5         2003-03-22         14:08:13.43         55:54:30.9           6958180         03AL05         r         180         2003-03-23         8:40:39.80         -3:18:25.0           6958190         03AL05         r         180         2003-03-23         8:40:39.80         -2:51:00.0	6957030         03AL05         r         180         2003-03-22         14:08:43.70         53:35:30.9         2000           6957040         03AL05         r         180         2003-03-22         14:08:37.98         54:02:30.8         2000           6957050         03AL05         r         180         2003-03-22         14:08:32.09         54:30:30.8         2000           6957060         03AL05         r         180         2003-03-22         14:08:26.05         54:58:30.9         2000           6957070         03AL05         r         180         2003-03-22         14:08:19.83         55:26:30.9         2000           6957080         03AL05         r         5         2003-03-22         14:08:13.43         55:54:30.9         2000           6958180         03AL05         r         180         2003-03-23         8:40:39.80         -3:18:25.0         2000           6958190         03AL05         r         180         2003-03-23         8:40:39.80         -2:51:00.0         2000	6957030         03AL05         r         180         2003-03-22         14:08:43.70         53:35:30.9         2000         1.234           6957040         03AL05         r         180         2003-03-22         14:08:37.98         54:02:30.8         2000         1.246           6957050         03AL05         r         180         2003-03-22         14:08:32.09         54:30:30.8         2000         1.258           6957060         03AL05         r         180         2003-03-22         14:08:26.05         54:58:30.9         2000         1.27           6957070         03AL05         r         180         2003-03-22         14:08:19.83         55:26:30.9         2000         1.283           6957080         03AL05         r         5         2003-03-22         14:08:13.43         55:54:30.9         2000         1.296           6958180         03AL05         r         180         2003-03-23         8:40:39.80         -3:18:25.0         2000         1.087           6958190         03AL05         r         180         2003-03-23         8:40:39.80         -2:51:00.0         2000         1.087	6957030         03AL05         r         180         2003-03-22         14:08:43.70         53:35:30.9         2000         1.234         0.9009           6957040         03AL05         r         180         2003-03-22         14:08:37.98         54:02:30.8         2000         1.246         1.0193           6957050         03AL05         r         180         2003-03-22         14:08:32.09         54:30:30.8         2000         1.258         1.0097           6957060         03AL05         r         180         2003-03-22         14:08:26.05         54:58:30.9         2000         1.27         1.2213           6957070         03AL05         r         180         2003-03-22         14:08:19.83         55:26:30.9         2000         1.283         0.9702           6957080         03AL05         r         5         2003-03-22         14:08:13.43         55:54:30.9         2000         1.296         1.2161           6958180         03AL05         r         180         2003-03-23         8:40:39.80         -3:18:25.0         2000         1.087         0.9972	6957030         03AL05         r         180         2003-03-22         14:08:43.70         53:35:30.9         2000         1.234         0.9009         19.97           6957040         03AL05         r         180         2003-03-22         14:08:37.98         54:02:30.8         2000         1.246         1.0193         19.96           6957050         03AL05         r         180         2003-03-22         14:08:32.09         54:30:30.8         2000         1.258         1.0097         19.95           6957060         03AL05         r         180         2003-03-22         14:08:26.05         54:58:30.9         2000         1.27         1.2213         19.94           6957070         03AL05         r         180         2003-03-22         14:08:19.83         55:26:30.9         2000         1.283         0.9702         19.93           6957080         03AL05         r         5         2003-03-22         14:08:13.43         55:54:30.9         2000         1.283         0.9702         19.93           6958180         03AL05         r         5         2003-03-23         8:40:39.80         -3:18:25.0         2000         1.089         0.9715         20.92           6958190         03AL05

## Global astrometric solution

Uses both overlapping detections and a reference astrometric catalog

(USNO): automatic access to CADC catalogs

- Works best with a wide dithering pattern
- Current method
  (Astrometrix): iterative
  solution... SCAMP used for
  Megacam images
  - No need to bring coordinates to a common projection



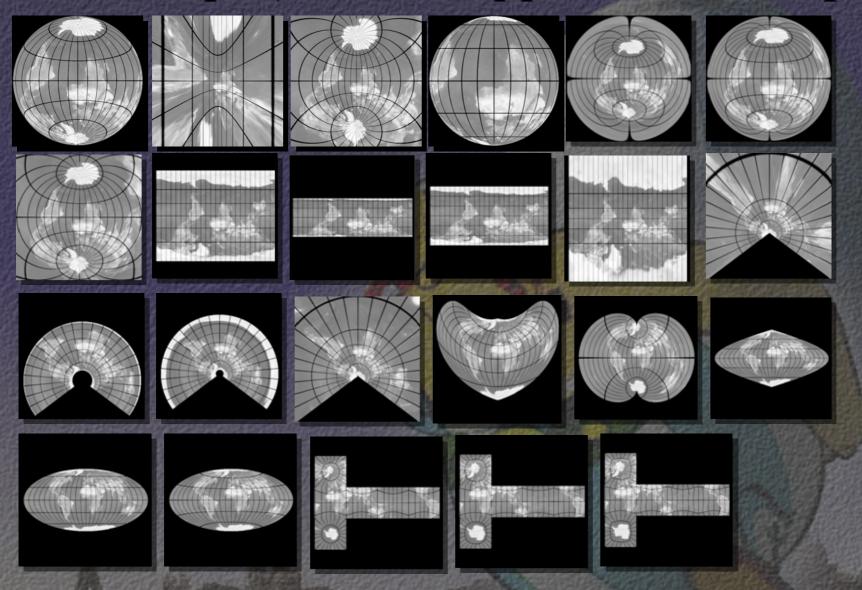
Megacam CFHTLS Wide: Pre-survey

$$\chi^{2} = \sum_{i < j, k \in \Omega_{i} \cap \Omega_{j}} \frac{(x_{ik} - x_{jk})^{2} + (y_{ik} - y_{jk})^{2}}{\sigma_{ik}^{2} + \sigma_{jk}^{2}} + \lambda \sum_{i, k \in \Omega_{0}} \frac{(x_{ik} - x_{0k})^{2} + (y_{ik} - y_{0k})^{2}}{\sigma_{ik}^{2} + \sigma_{0k}^{2}}$$

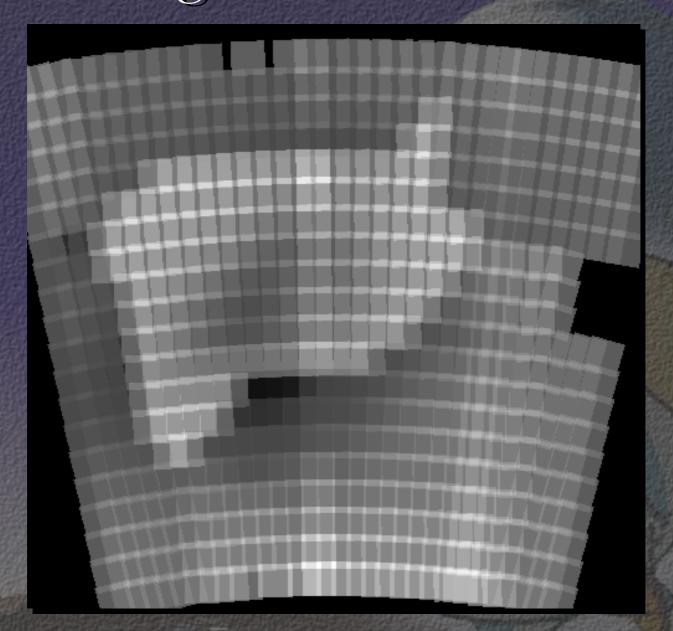
## Image resampling and co-addition: SWarp

- FITS/WCS/TNX in input and output (thanks to a modified version of M.Calabretta's WCSLib v2.6)
- Full handling of weight-maps
- Work with arbitrarily large images
- Up to 9 dimensions (including a maximum of 2 spherical coordinates)
- Choice of interpolation functions (kernels up to 8<sup>n</sup> taps)
- Equatorial/Galactic/Ecliptic coordinates
- Built-in background subtraction and noise-level measurement for automatic pixel weighting
- Automatic centering/sizing of the output field
- Multithreaded
- Speed: typically 500kpix/s on a bi-proc Athlon @1.5GHz

## Some projections supported in Swarp



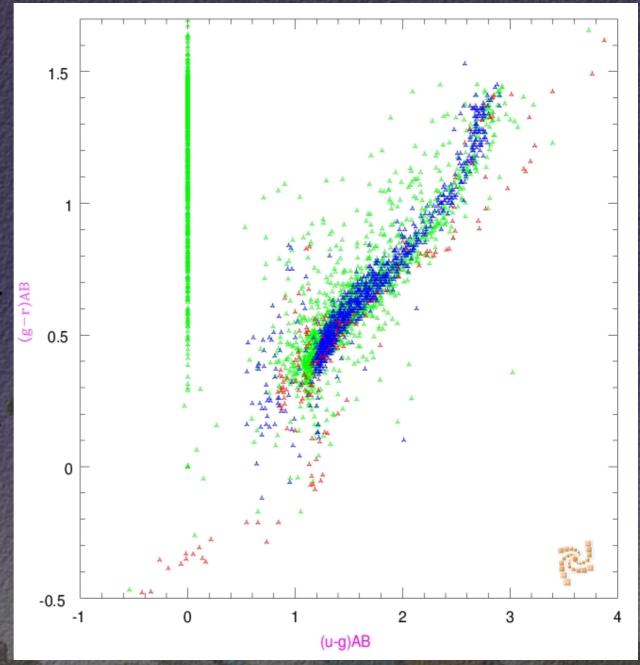
## Weighted co-addition



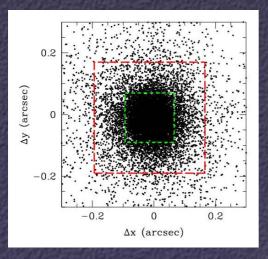
## Application to Megacam:

**SDDS vs. Megacam star** color-color diagram

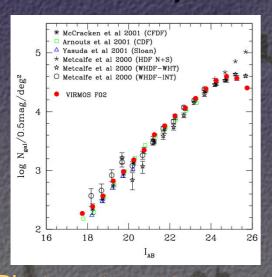
18 x 560 sec. r' + 17 x 560 g' + 13 x 700 sec. u\* Megacam data



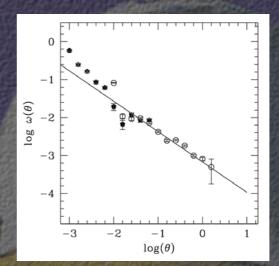
## Scientific applications as test bench for Terapix



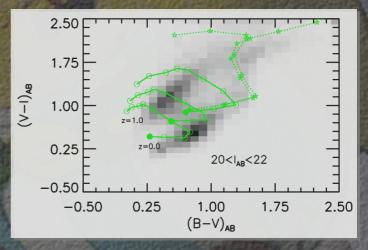
#### **Astrometry**



Photometry: galaxy counts



Photometry: 2-pt galaxy correlation function



Photometry: galaxy color-color tracks

VIRMOS/TERAPIX teams: McCracken et al. 2003

## Performances

### Configuration

Datatransfer + QualityFITS + SPICA (detection, astrometry, warping, co-addition, QualityFITS-out) + DB storage
 10 Bi-proc nodes working

#### Performance

- Data transfer CADC to Terapix: ftp: 20 Megacam (compressed) images/hr
- 1000 Megacam images Nov. 2003: 250 hrs (expected soon: 200 hrs): 30 working days (~ 8hrs/day)

## **Expected** input flow

- Big Megacam run: 10 hrs/night; 15 nights, 5min. Exp. Time: 1800 images
- We are almost ok, but we must think about re-processing: better software tools; faster and more reliable nodes and CPUs; more optimised compilation options

## On going developments and prospects

- Image masking
- PSF homogenization
- Improve/increase quality assessment tools
- Image visualisation: Panorapix
- Survey follow up tools: skywatcher
- Prepare WIRCAM tools, if needed
- More complex and precise galaxy morphology analysis

