The TERAPIX pipeline: current status in the perspective of WIRCAM

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1

The tasks of TERAPIX

- Develop and distribute software tools required for the processing of MEGACAM data
  - Software developed in-house
  - Images and catalogs are handled at the MEF level
- Produce and release calibrated, co-added images and catalogs on a regular basis.
  - Handling of data
  - Handling of hardware
- Re-processing cycle for CFHTLS expected to be ~ 6months
  - Better calibration with increasing overlaps
  - Software upgrades
- Provide support to members of the Canadian and French communities

Production pipeline

- **Pre-processing done at CFHT**
  - Weight-maps and flag-maps built at TERAPIX
  - Possibility to correct images at TERAPIX
- **Automatic ingestion of images**
  - StarTap connection to CADC
- **Relative astrometric and photometric re-calibrations encompassing several observing runs**
- **Re-sampling and co-addition**
- **Panchromatic analysis and catalog extraction**
- **Delivery of the reduced data to CADC via internet**
- **Re-processing each 6 months**

Modeling the PSF

- Model the PSF and its variations along the focal plane
  - Automatic identification of stellar candidates
  - Arbitrary shapes allowed for the PSF (bandwidth-limited)
  - Handle undersampled images (down to 1 pixel / FWHM)
  - Takes about 1s/MEGACAM CCD
  - Has succesfully processed 200,000+ MEGACAM CCDs in various parts of the sky (only 2 had an incorrect PSF)
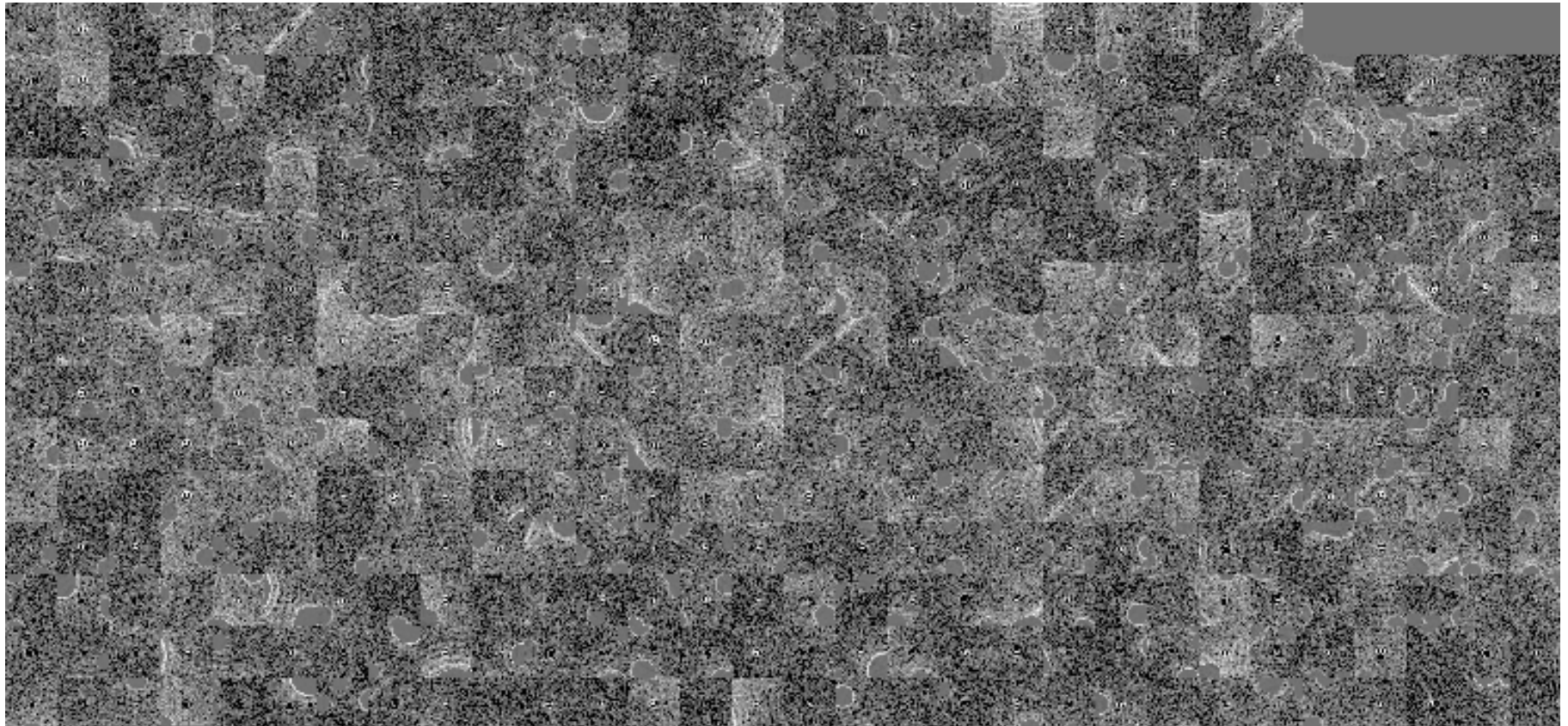 - PSF-fitting will be activated for the second CFHTLS release (2005)
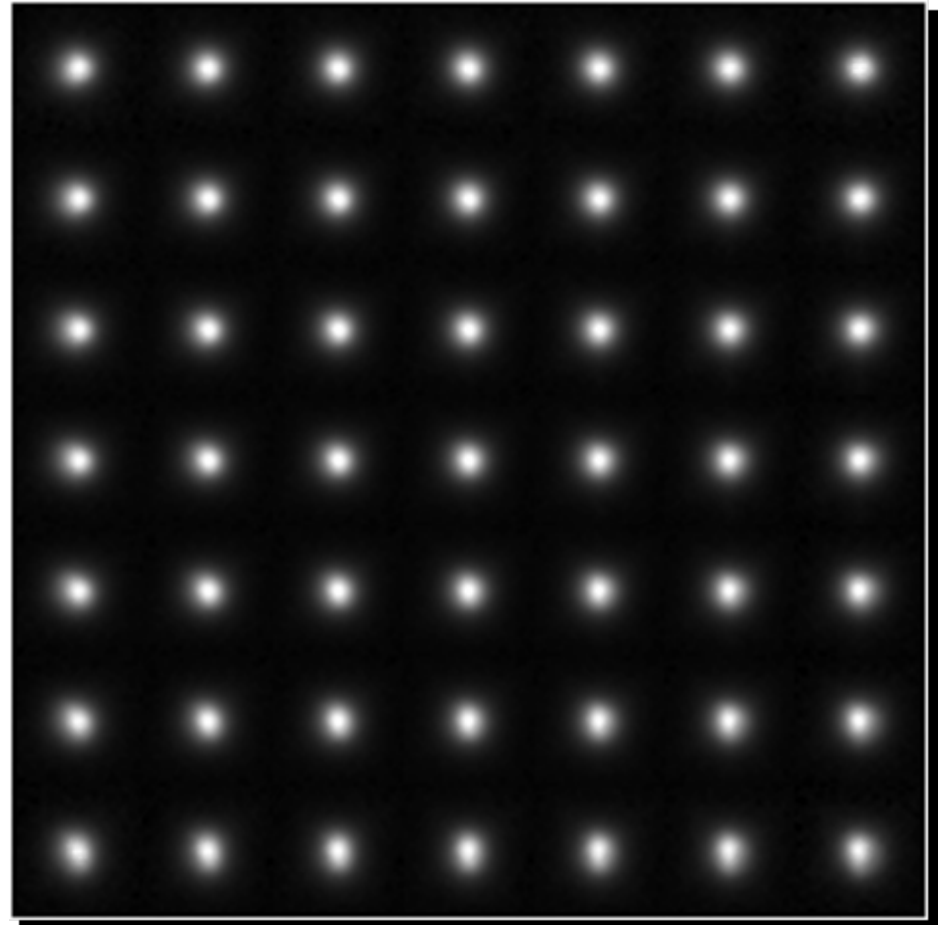
# Recovered PSF with simulated, undersampled data
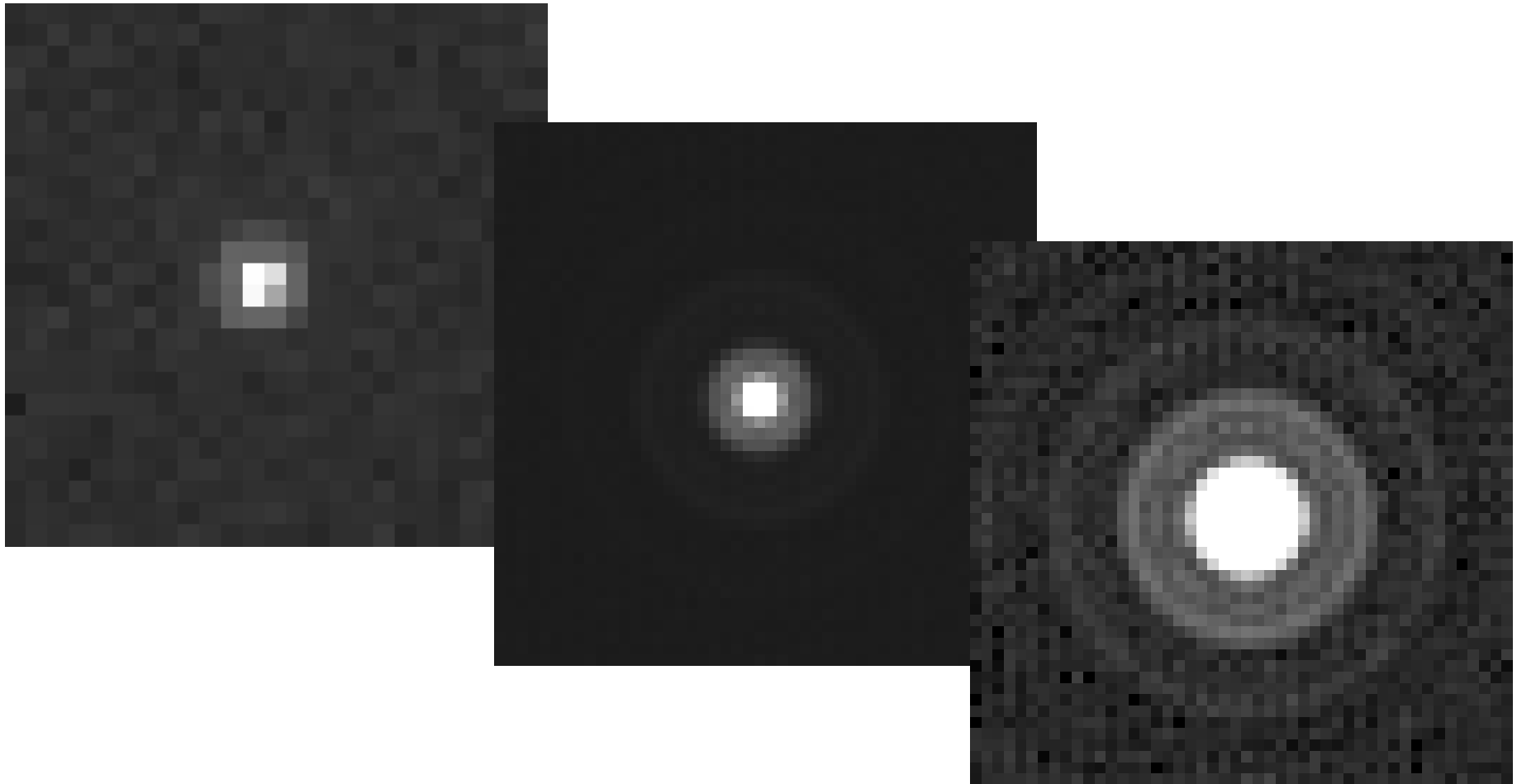
Residuals on simulated, undersampled data
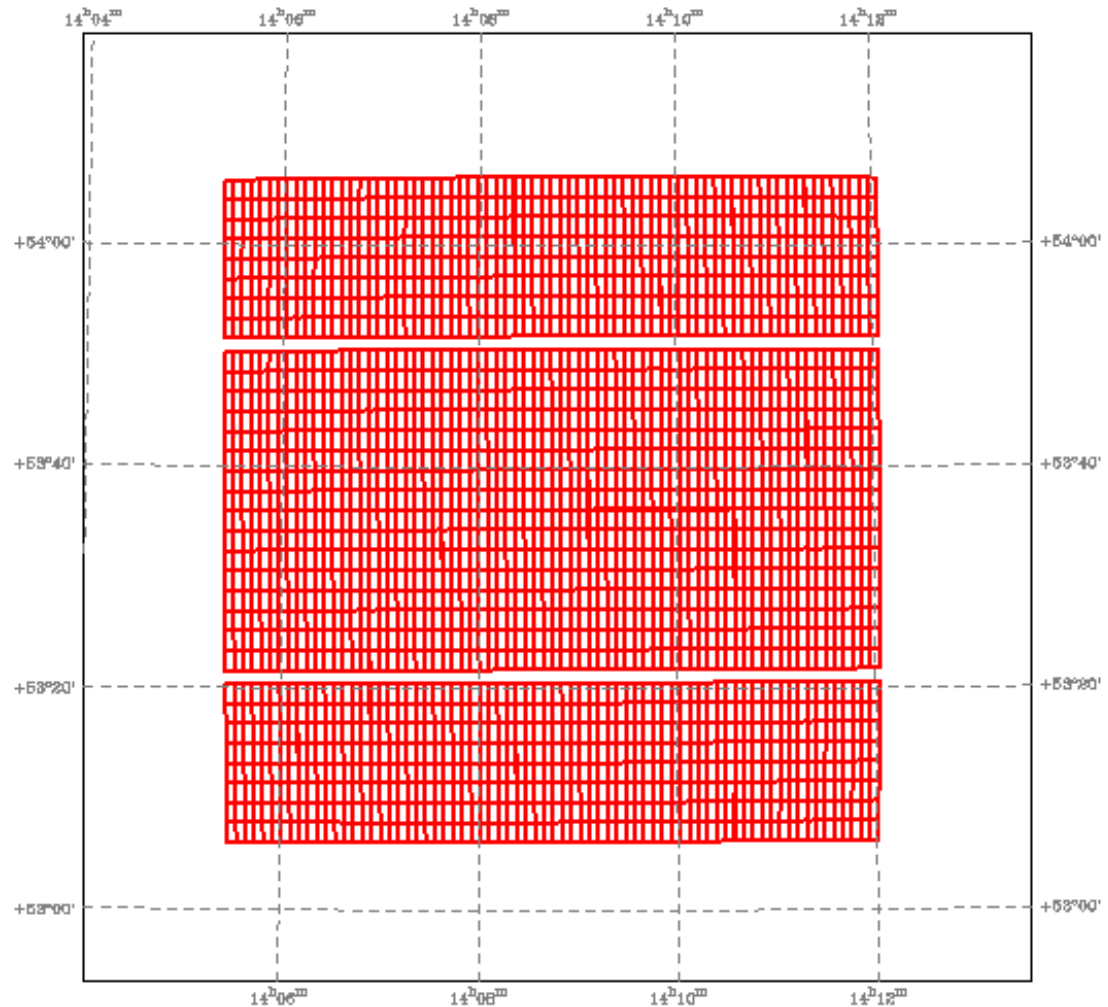
Astrometry: SCAMP

- Compute astrometric and photometric solutions from a series of image catalogs
- Robust pattern matching recovers pixel scales, frame position angle, chirality and shift (up to ~ 1 deg with USNO-B1).
- « Global » solutions derived simultaneously from hundreds of exposures from different instruments
- Flexible choice in the degrees of freedom
  - Manage various survey strategies and instruments.
  - Handle simultaneously several instruments (or filters) and sky areas
  - Special mode for MEGACAM to fix the jittering CCD positions derived by CFHT
- Processing time is about 15s/MEGACAM exposure
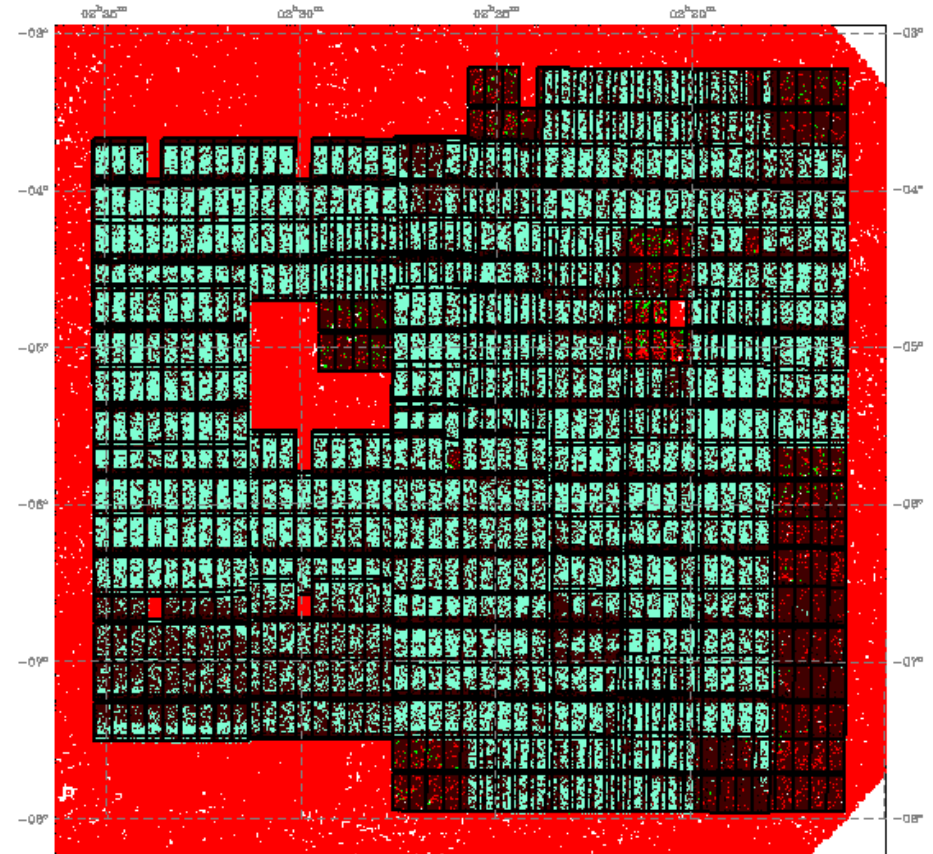
Astrometry: "global" solution

- For maximum robustness, one should keep as few free parameters as possible
  - All CCDs share a common focal plane
    - 20 free parameters (3rd order polynomial) for each CCD in a given "astrometric context"
    - 6 extra free "linear distorsion" parameters common to all the CCDs, for each exposure
    - Instrumental flexures
    - Image anamorphosis due to atmospheric refraction (typ. 0.12% in the visible at airmass=2)
  - Attitude of the telescope or other source- or exposure-dependent parameters may be included as a free parameter in the solution
    - Complex instrumental behaviour
    - Differential chromatic refraction (depends on the source colour)
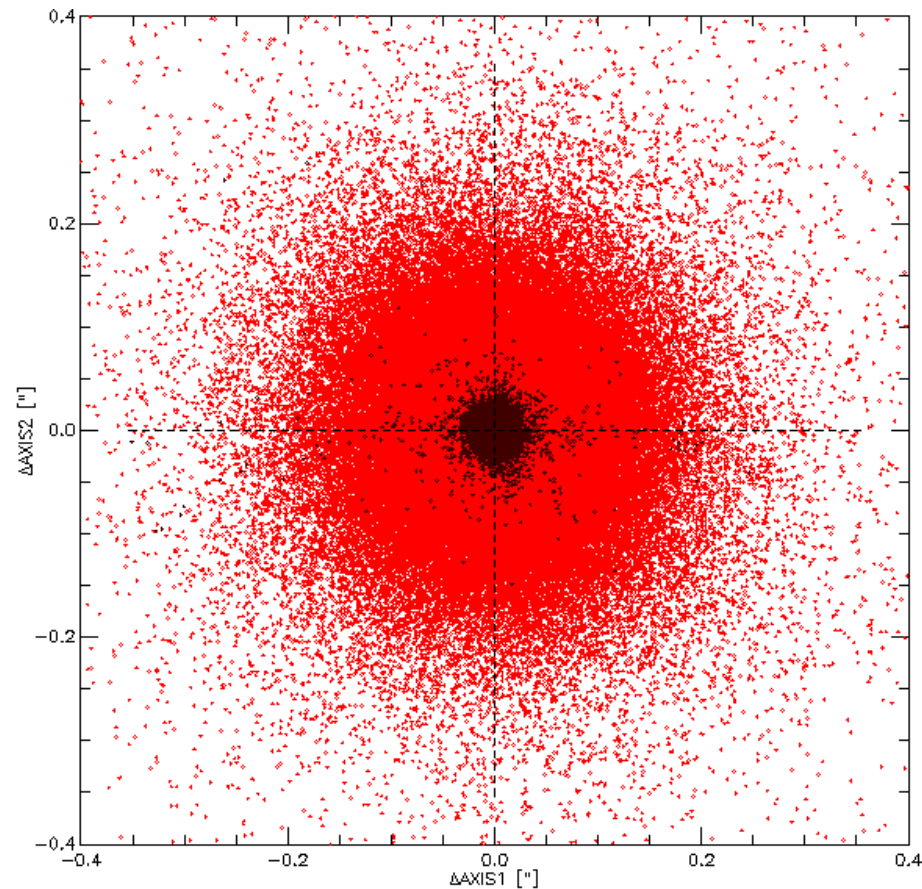   - Not needed so far

Internal astrometric accuracy with *SCAMP* on MEGACAM images
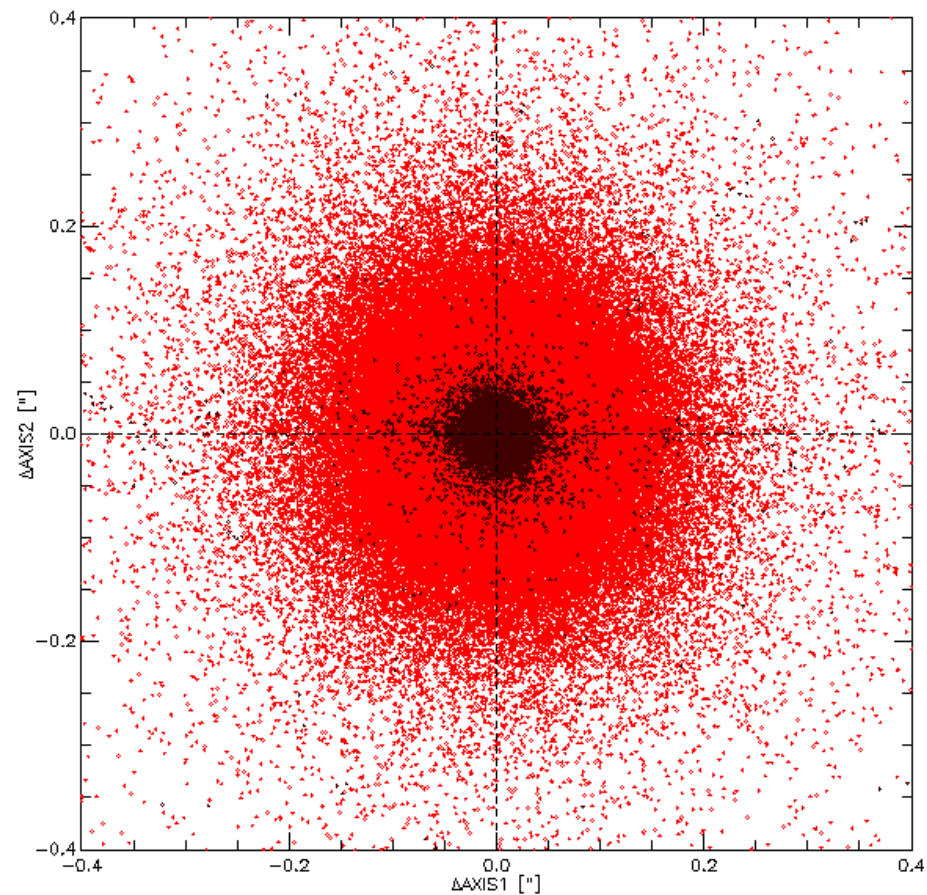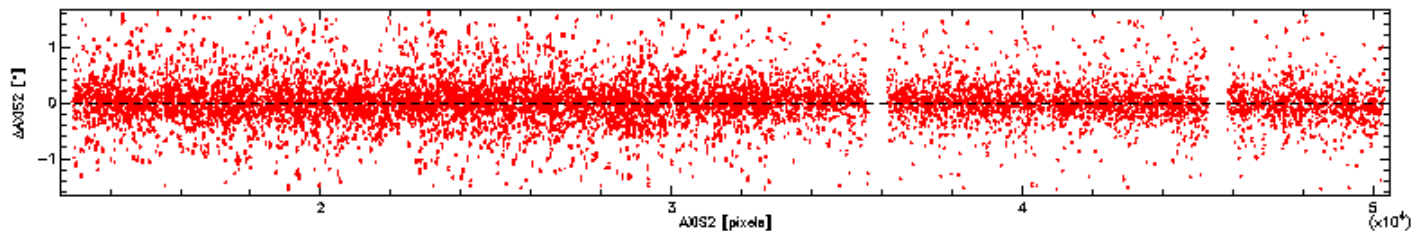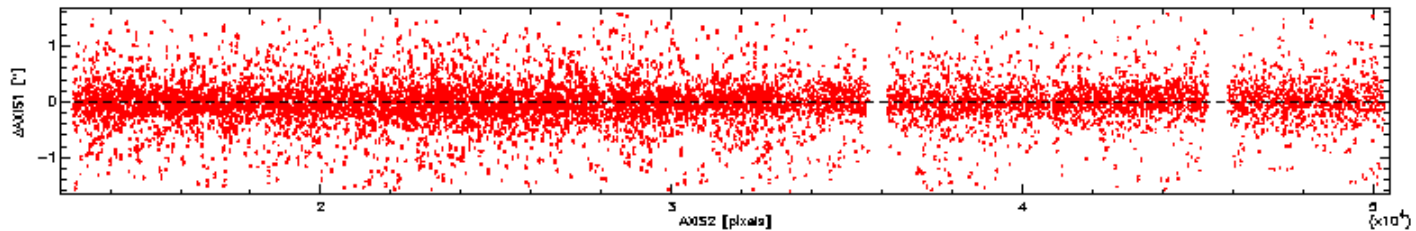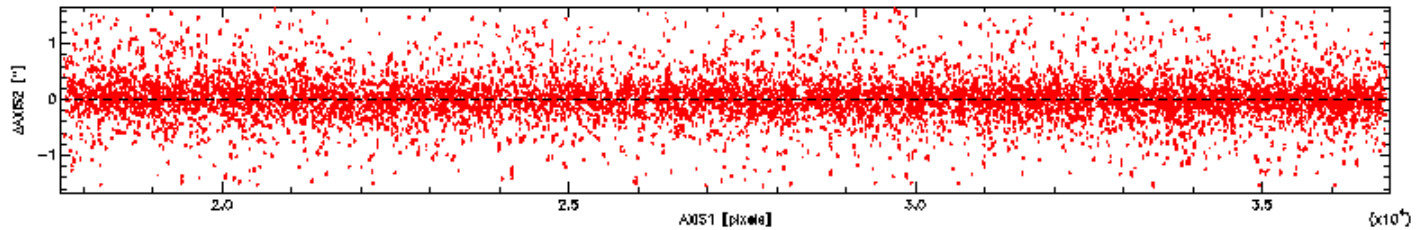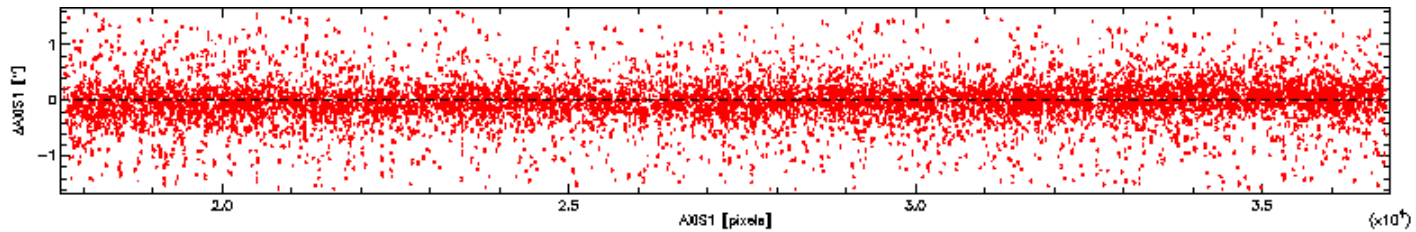

↑ **X_IMAGE**:

σ_x = 21 mas

↑ **XPSF_IMAGE**:

σ_x = 12 mas

Comparison with the reference catalog (USNO-B1)

Tracking photometry zero-points

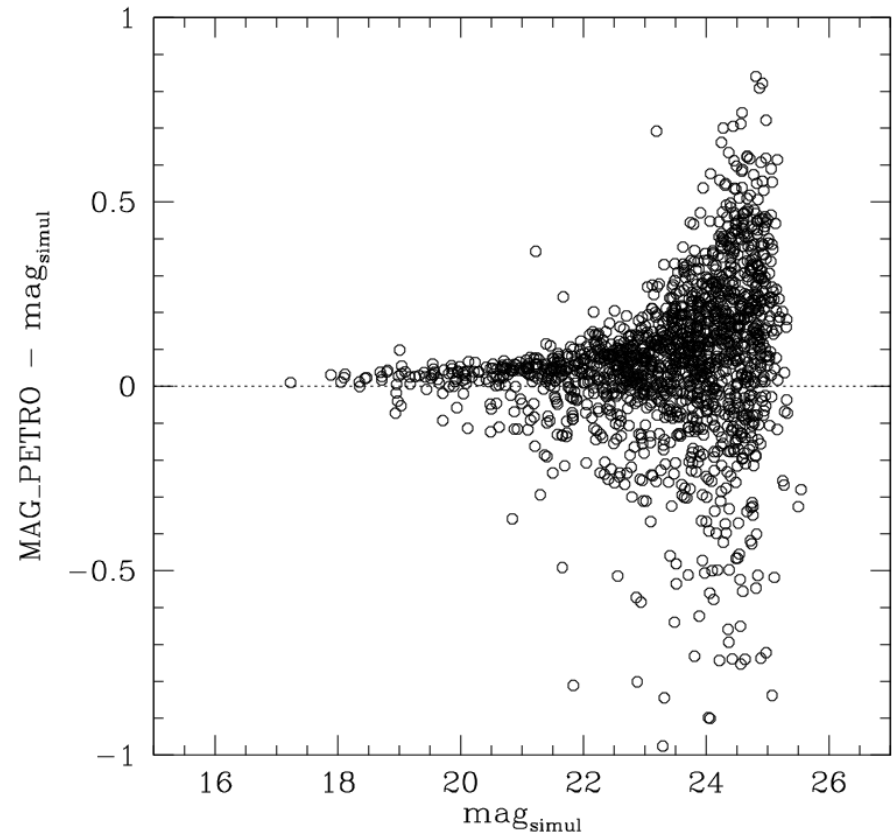# Petrosian magnitudes in SExtractor:
accuracy measured on a simulated galaxy field
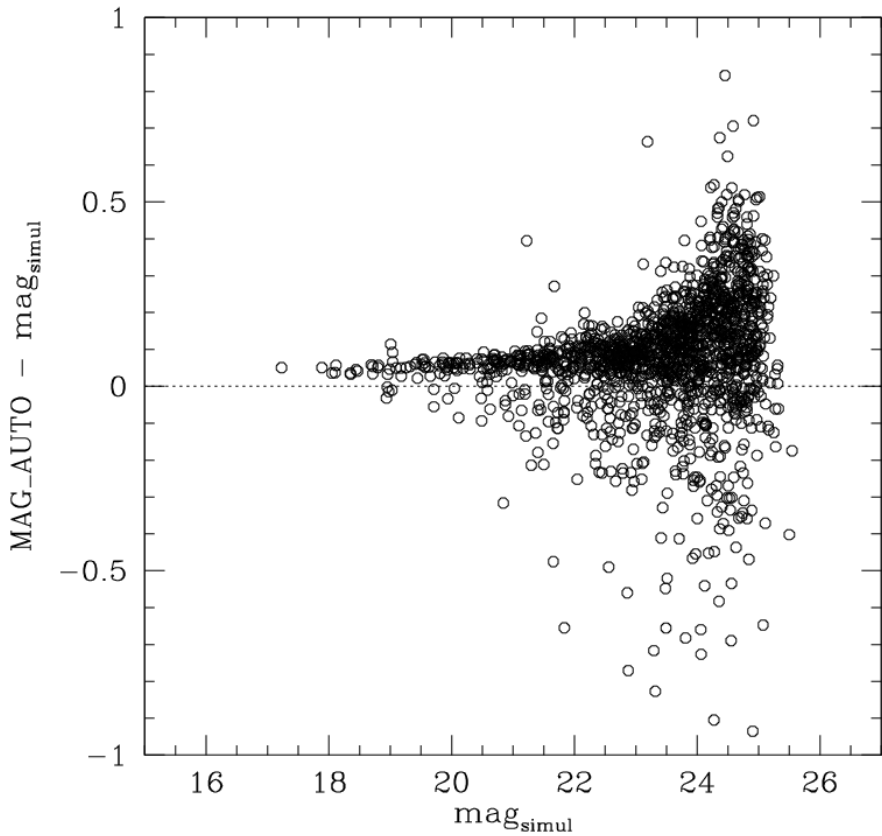
↑ MAG_AUTO:
$\Delta m \circlearrowleft 0.06$

↑ MAG_PETRO:
$\Delta m \circlearrowleft 0.03$
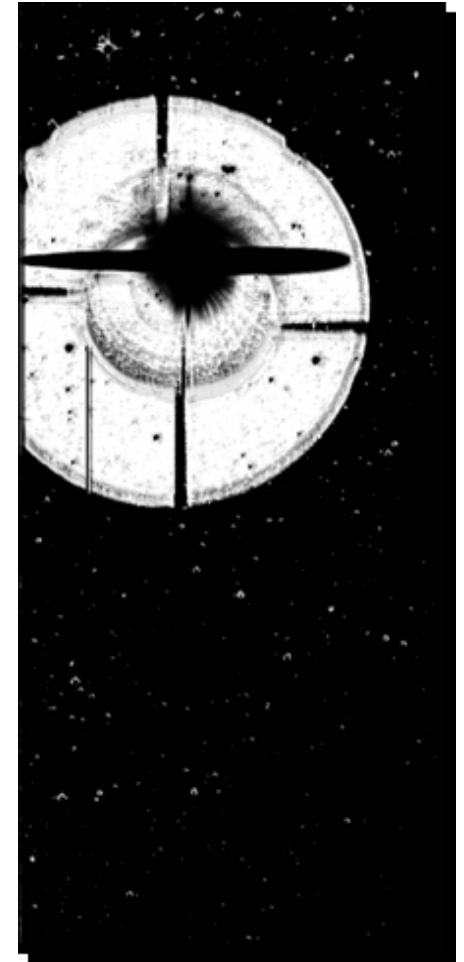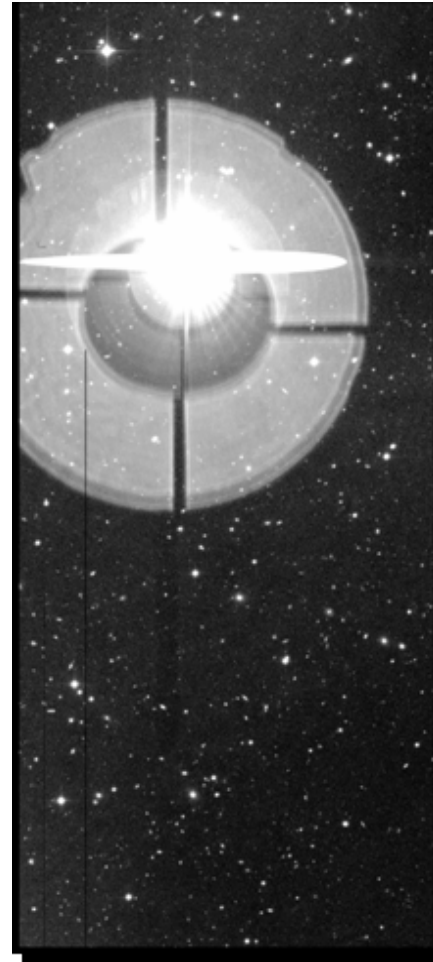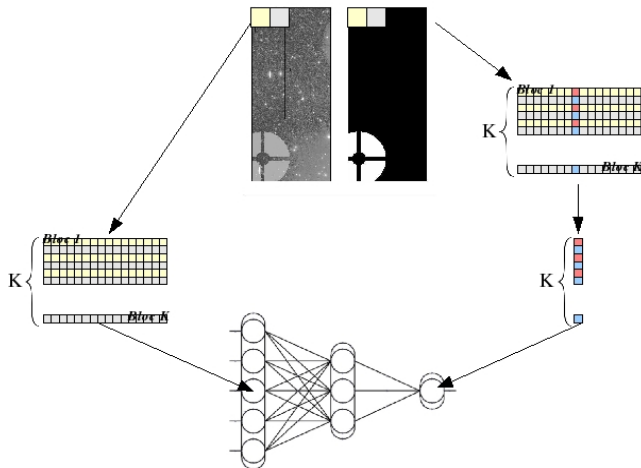
Current software developments: identifying large image defects

- **Defectix**: Automatic identification of large image artifacts (**A. Baillard**)
  - Pattern recognition with machine learning (unsupervised+supervised)
  - Trained with simulated and real data superimposed to sky images
    - Bright star halos
    - Diffraction spikes
    - Satellite trails
    - "Comet tails"
    - Residual fringe patterns
  - <5 minutes per MEGACAM exposure (*vs* 5 hours by hand)

Current software developments: preparing for PSF homogenisation

- Background modeling engine in SExtractor and SWarp is being upgraded
    - Measure the background-noise ACF
    - Multiscale analysis
    - Handle low-count data (narrowband or X-ray images) properly
- Image co-addition strategy re-worked
    - Optimize I/Os for stacking hundreds of MEGACAM exposures
    - Hardware tuning
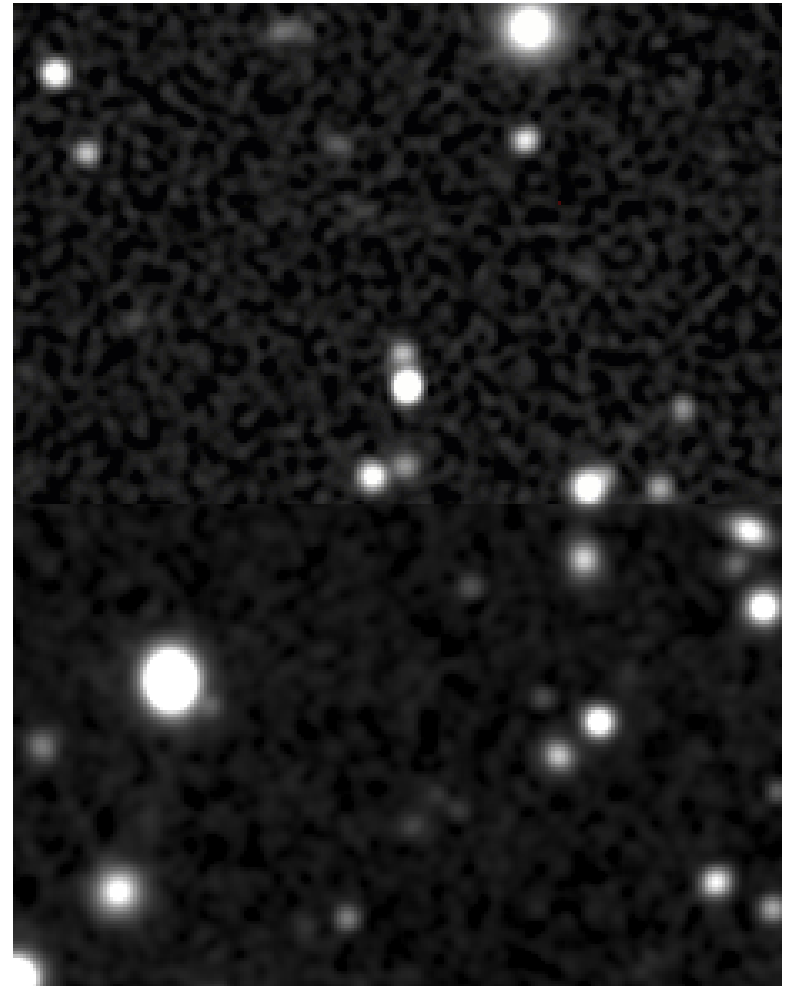
Production: current status of TERAPIX

- The pipeline is operational:
  - ☑ Data transfers from and to CADC
  - ☑ Distributing data between storage nodes
  - ☑ Creation of weight-maps
  - ☑ Automatic astrometric and photometric calibrations
  - ☑ Image resampling and co-addition
  - ☑ Survey follow-ups and Quality control
  - ✗ Scaling and tuning
    - Currently ~10minutes / MEGACAM exposure (including download)
    - Complete the parallelisation of TERAPIX software
  - ✗ Complete the move to x86_64
  - ✗ Advanced image analysis: proper motions, PSF-fitting, PSF-homogenisation, galaxy morphology
  - ✗ Documentation and full software release

On-going software developments (image analysis)

- Proper motions in SCAMP
- PSF homogenisation
  - Simplify the analyses of time-series, panchromatic data and shapes
  - Induces a variable correlation of the noise.
    - Requires significant upgrades to SExtractor and SWarp
- SExtractor 3
  - Multi-scale source extraction
- Fast galaxy morphology
  - EFIGI project in collaboration with LTCI and LRDE laboratories

terapix.iap.fr