Faint sources detection with ISOCAM

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What is a faint source ?

- **A source whose flux at the peak is lower than 20 σ of the photon and readout noise.**

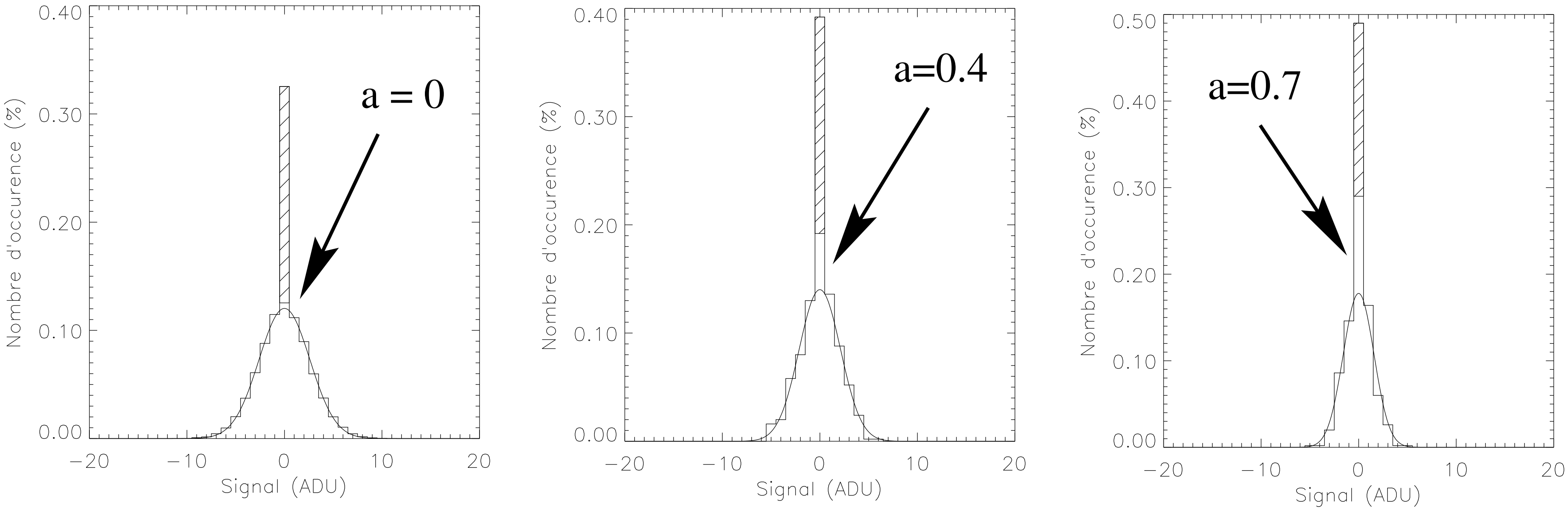
- **A source barely seen in maps with standart CIA reduction.**

- **A source whose brightness is of the order of the brightness of cosmic ray remnants in standard CIA maps.**

$\Longrightarrow$ **Careful examination of all the noise origins**

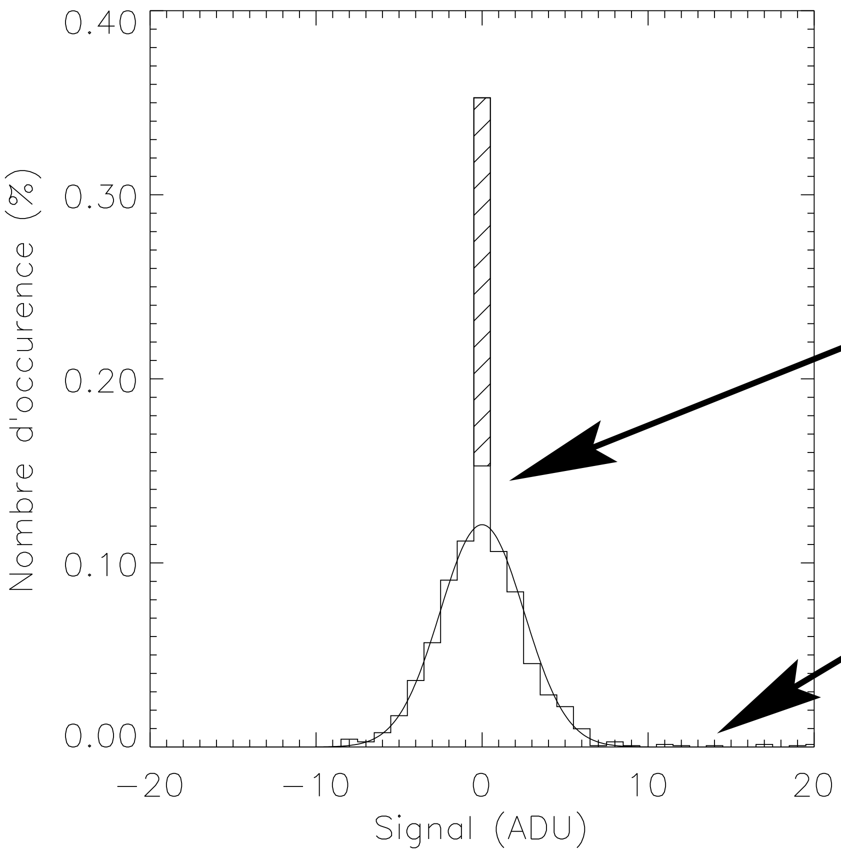
$\Longrightarrow$ **Reduction with special care for transients and cosmic rays.**

Measuring the high frequency (HF) noise with median filtering



Simulations of gaussian noise with various auto-correlation (a) and sampling

Result on LW3 raw data, gain 2, tint = 5s

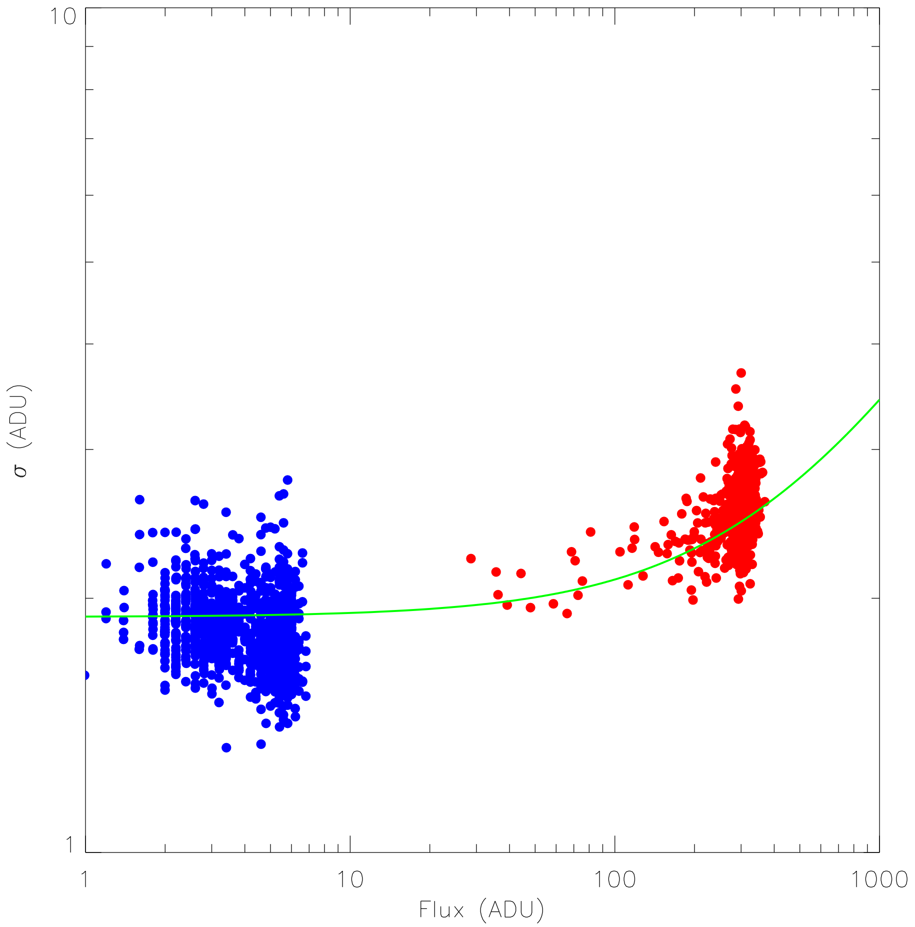


The instrumental HF noise is gaussian.
(Read + photon noise)

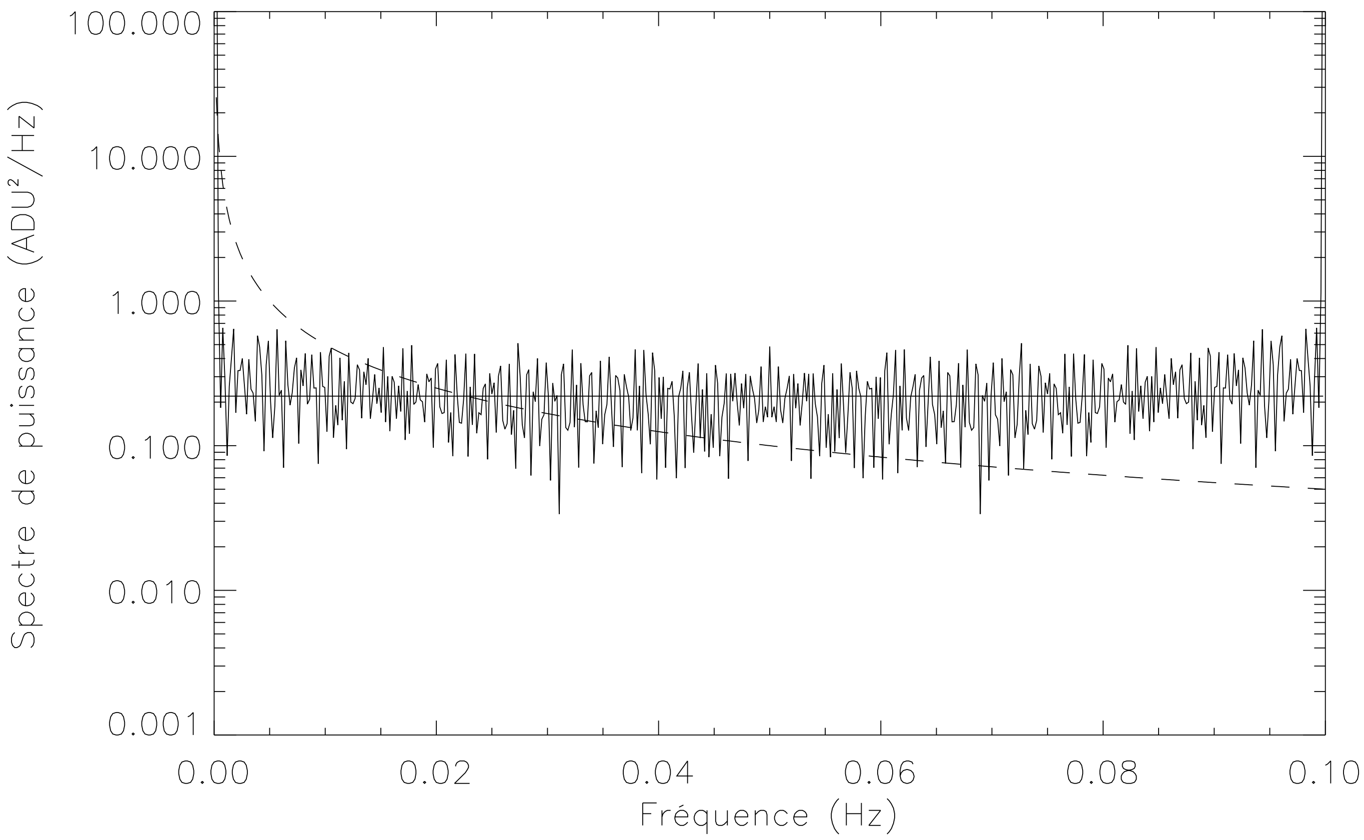
HF autocorrelation is low (< 0.3)

Cosmic rays induce HF non gaussian noise

Read noise / photon noise at gain 2, tint = 5s



Low frequency noise



Power spectrum of a long staring observation

Sources of low frequency (LF) noise

- **1/f noise : negligible**
- **Cosmic rays : main source of LF noise.**
- **Transient : not really a noise.**

What is ISOCAM noise ?

It depends on what how well the data are reduced.

If cosmic rays effect and transients are corrected, then the noise is the HF read and photon noise only.

The ideal package for faint source detection

Two parts:

- **A very accurate clean of each pixel history for transients and cosmic rays that leaves all sources untouched.**
  $\Longrightarrow$ **A simple masking of the dippers and faders leads to loose to much readouts to achieve high sensitivity.**

- **A detection algorithm on reconstructed raster maps taking into account the highly non homogenous noise.**

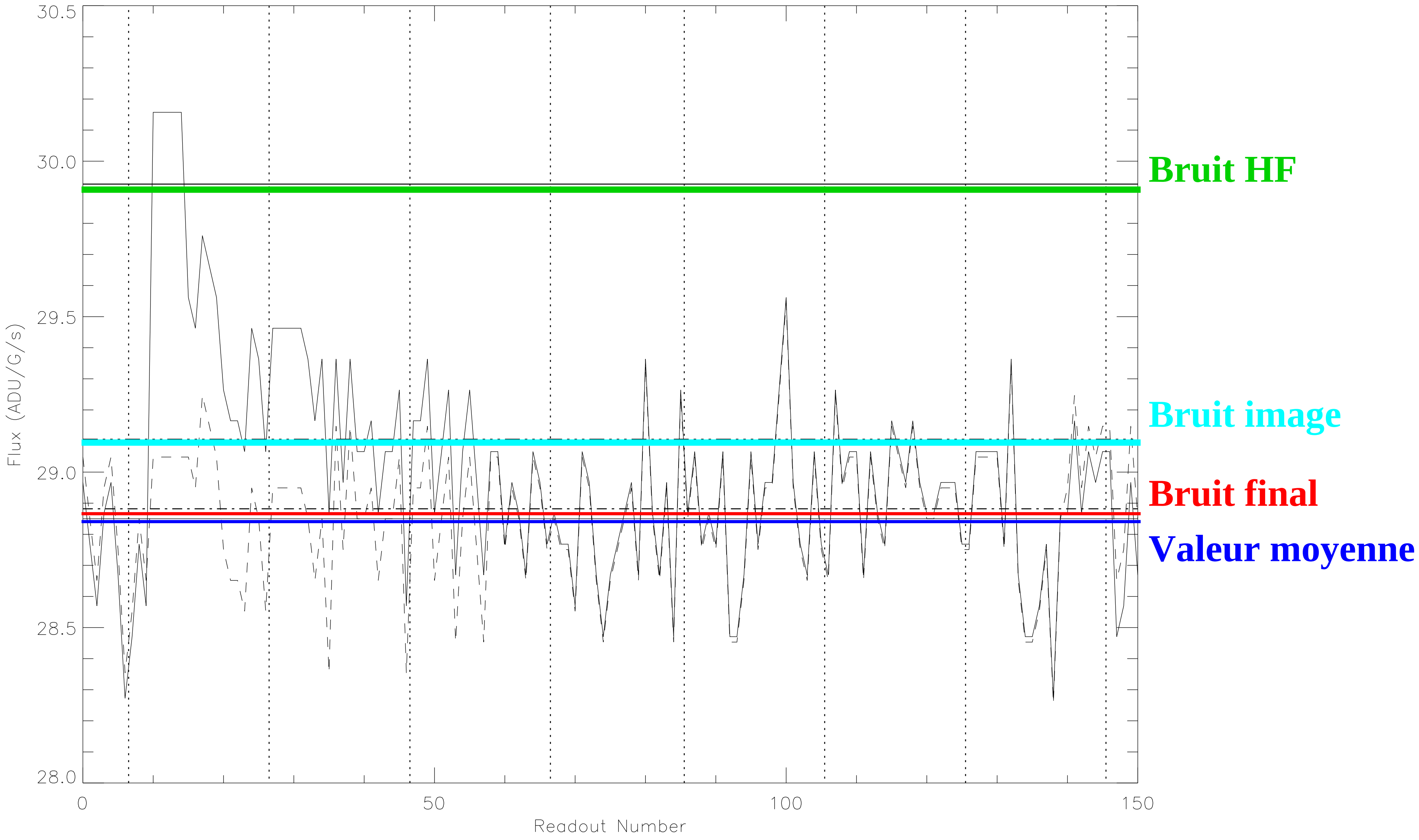
Required byproducts:

- **Completeness (do we miss any sources)**
- **Reliability of the sources (are there fake detections)**
- **Reliability of their photometry**

The sad reality...

For the part cleaning the cube :

- **Transients models are now accurates, but their effect on the noise is not clear.**
- **Only a cosmic ray model (accuracy ?).**
- **Detection of cosmic rays against HF noise : undetected tails remains in the temporal history.**
- **Detection of sources in the temporal pixel history is not efficient if data have a large redundancy. (though some specific cases...)**
- **No algorithm really leaves the sources unaffected.**



30.5
30.0
29.5
29.0
28.5
28.0
Flux (ADU/G/s)
0
50
100
150
Readout Number
Bruit HF
Bruit image
Bruit final
Valeur moyenne

Available tools on the market to clean the data

- **The triple beam-switch method (Desert et al. 1999, A&A 342, 363)**
  - **⟹Transients are corrected with INV (now FS ?)**
  - **⟹Cosmic rays fitted with exponentials**
  - **⟹Raster observation handled as a beam-switch to get rid of the drift.**

Works only on observations on uniform background.

- **PRETI (mr_isocalib) (Aussel et al. 1999, A&A 342, 313)**
  - **⟹Transients are not corrected, unless there are problems with ghosts images.**
  - **⟹Cosmic rays reconstructed from multi-resolution analysis and substrated**
  - **⟹Suppression of a baseline to get rid of the drift**

Works only on observations on uniform background.

- **IRA (Lari)**

  $\Longrightarrow$ Transients are corrected with a fit : noise is not modified ?

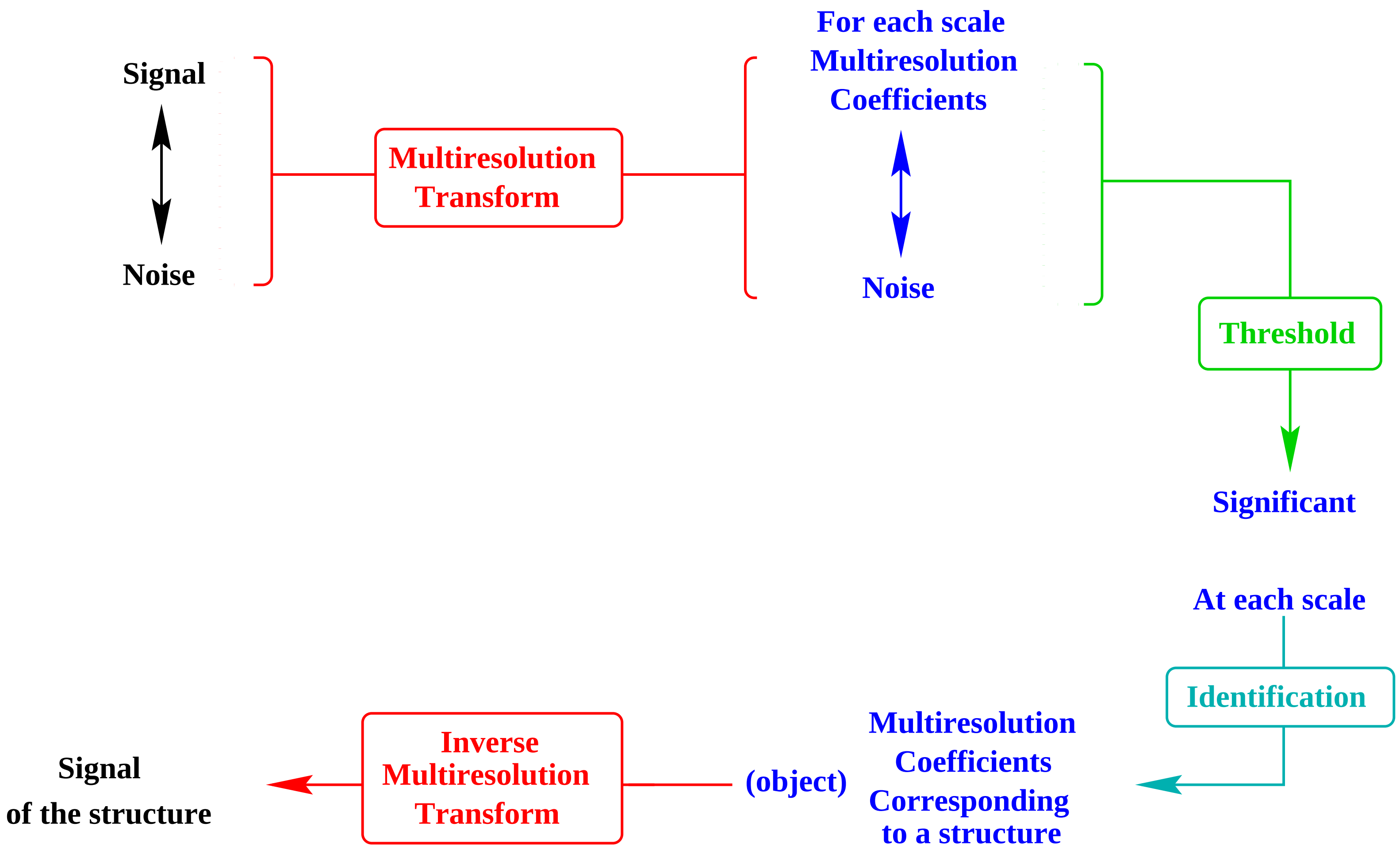
  $\Longrightarrow$ Cosmic rays corrected with a fit of the same model as the transients

  $\Longrightarrow$ Background level is computed.

  Work on observations with non uniform background

- **Other teams have built very efficient tools dedicated to their own observation...**

Principle of PRETI



Available tools on the market to perform a detection

- **The triple beam-switch method (Desert et al. 1999, A&A 342, 363)**
  ⟹Detections searched with a top-hat 2D wavelet.
  ⟹Optimized for point sources (gaussian fit)
  ⟹Beam-switch produces holes in the map (completeness)
  ⟹Inhomogenous noise is taken into account

- **PRETI (mr_detect) (Starck et al.)**
  ⟹No assumption on point sources is made.
  ⟹Noise map is fully taken into account
  ⟹Photometry at low fluxes is poor, unless using PSF.
  ⟹Can work with non constant background

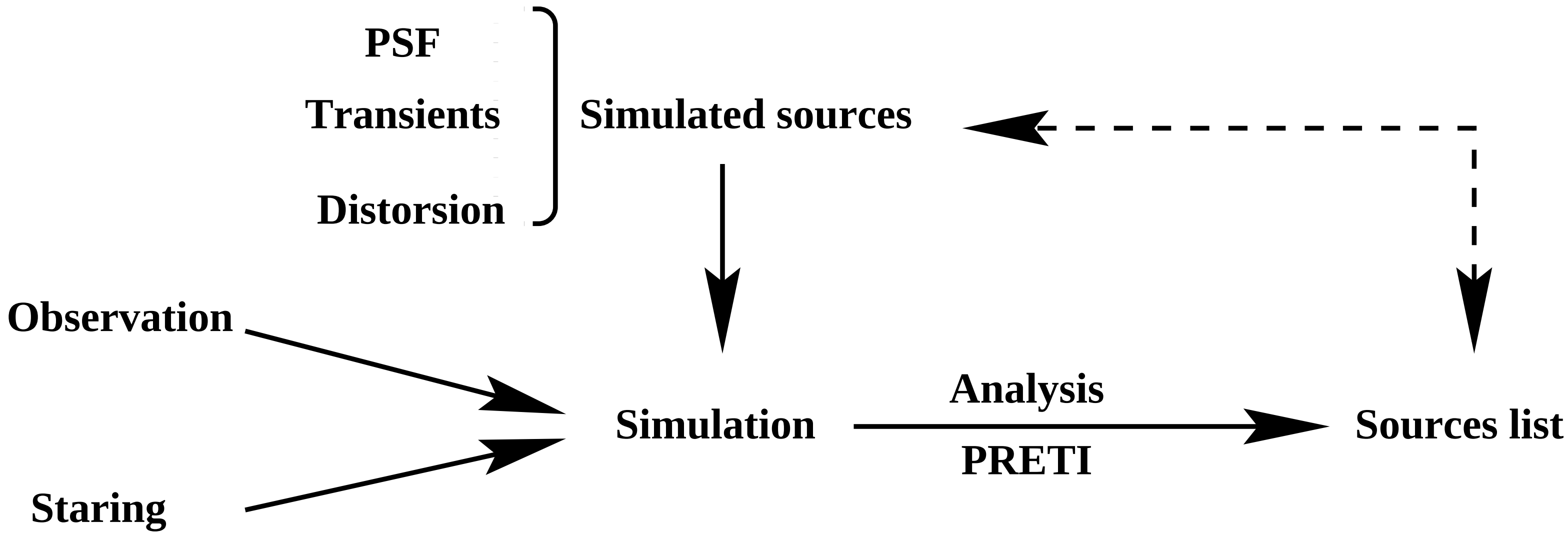
- **Sextractor (Bertin et Arnouts)**
  ⟹ Assumes a homogenous noise in a box of a given size
  ⟹ Assumes a constant background in the box

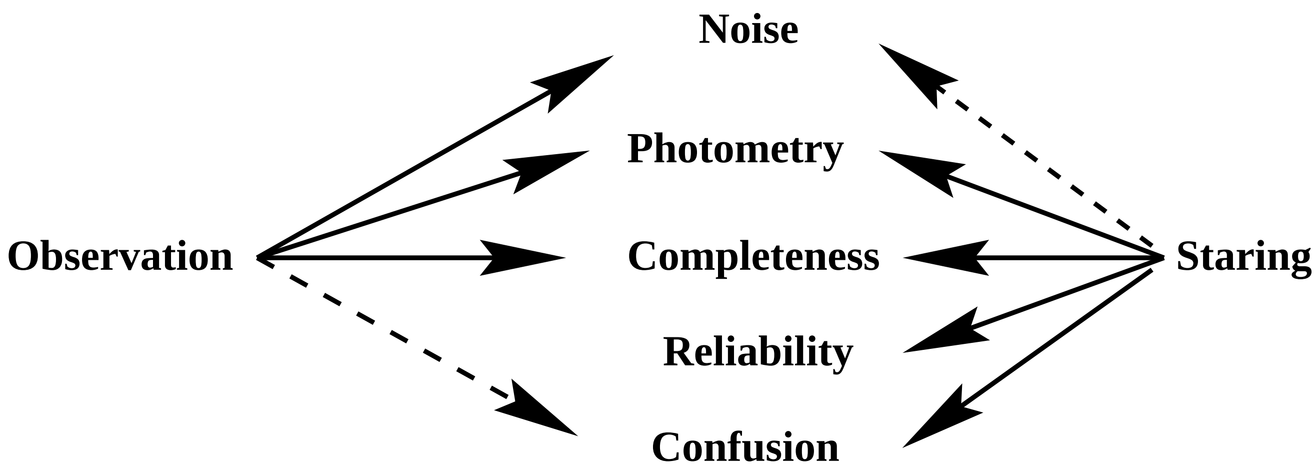
**These three methods give similar results
down to a flux level of 100 μJy
in the ISO-Hubble Deep Field
within 20 % of photometric agreement**

but ...

Simulations are mandatory...

- **To assess photometry**
- **To assess reliability**
- **To assess completeness**
- **To assess confusion**


PSF
Transients
Distorsion
Simulated sources
Observation
Staring
Simulation
Analysis
PRETI
Sources list


Noise
Photometry
Observation
Completeness
Staring
Reliability
Confusion

Conclusion

- **Pushing ISOCAM to its limits require a very careful data analysis**
- **There are no fully-fitted solutions**
- **The quality of the result depends strongly on the observing mode.**
- **A heavy assesement work is mandatory.**
- **Highly redundant observations allow already to reach specified CAM sensitivities**