processing of NIKA2 data
with (a variant of) Scanamorphos

designed mainly to subtract the low-frequency drifts in OTF data
while preserving extended emission (no filtering)

developed for *Herschel* (PACS and SPIRE)
variants also implemented for ArTéMiS (similar to PACS but on APEX)
and PILOT (similar to PACS but with polarization, ongoing)

in principle, the atmospheric emission can be removed
as part of the drifts, provided there is adequate redundancy

tests on NIKA2 observations of NGC891 (edge-on galaxy, i.e. 1D-extended)

→ wishes as to the observation strategy

→ problems encountered and effects to better take into account

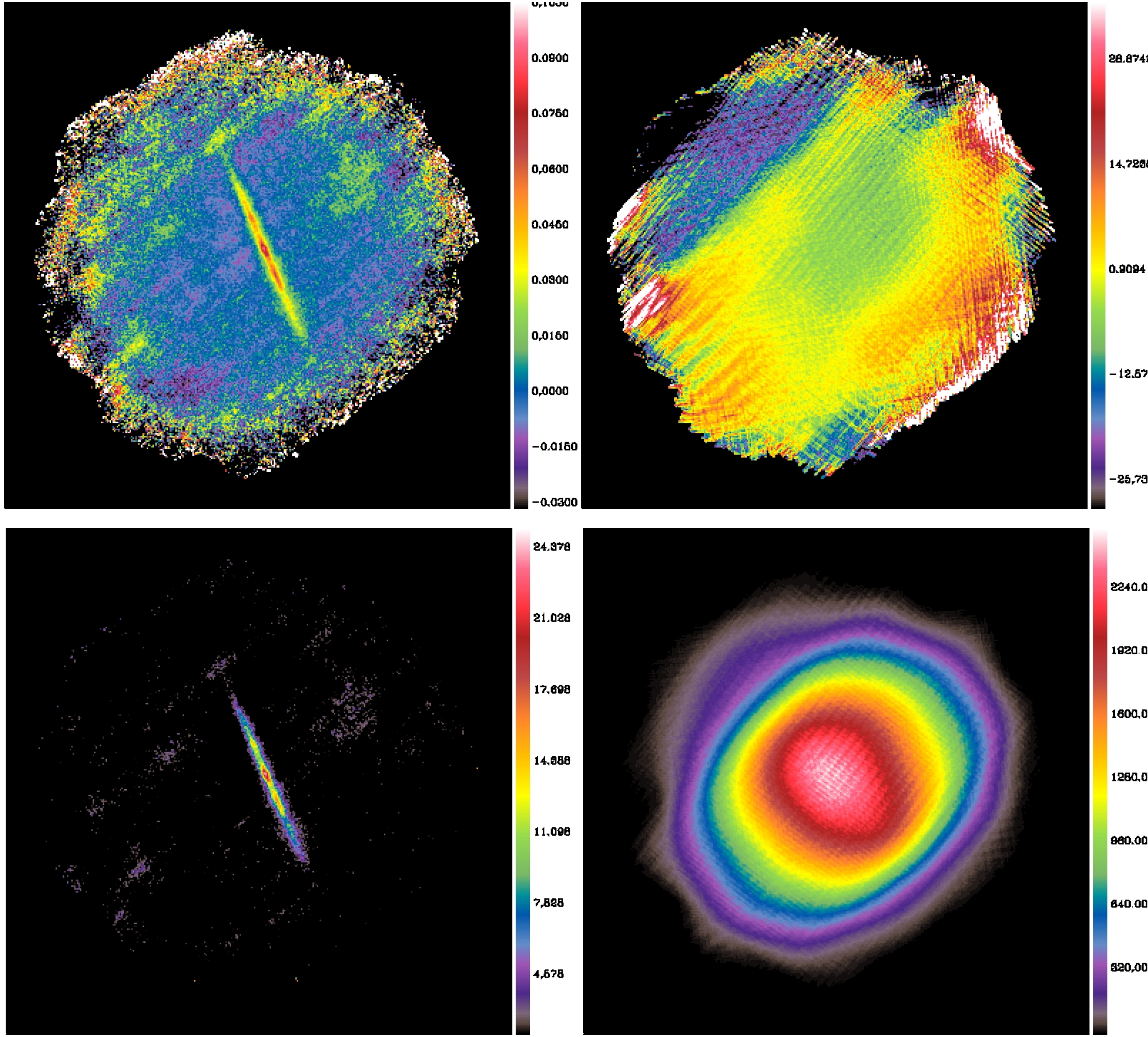
17 scans on 2015-11-08 and 09
646 detectors (67 masked out entirely as unstable)

results at 1mm :

step between scan legs: 20”

scan speed: 40”/s

$\tau \sim 0.11$ to 0.17



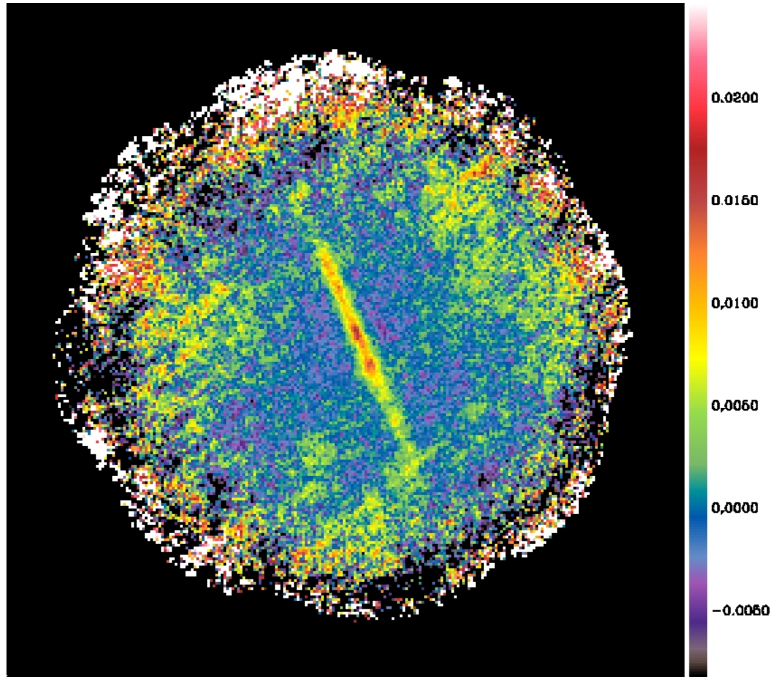
drifts (without offsets)

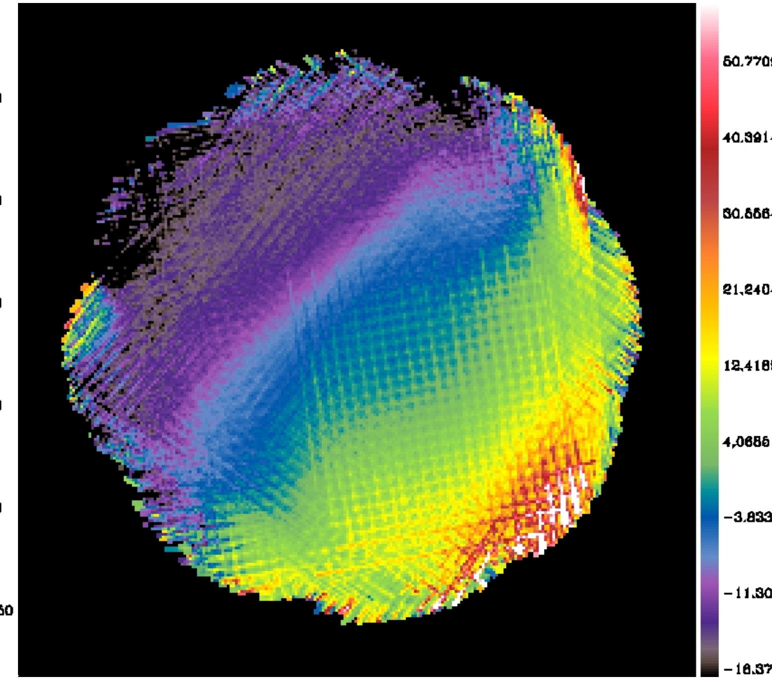
weight map

SNR map (above 2)

680 detectors (78 masked out entirely as unstable)

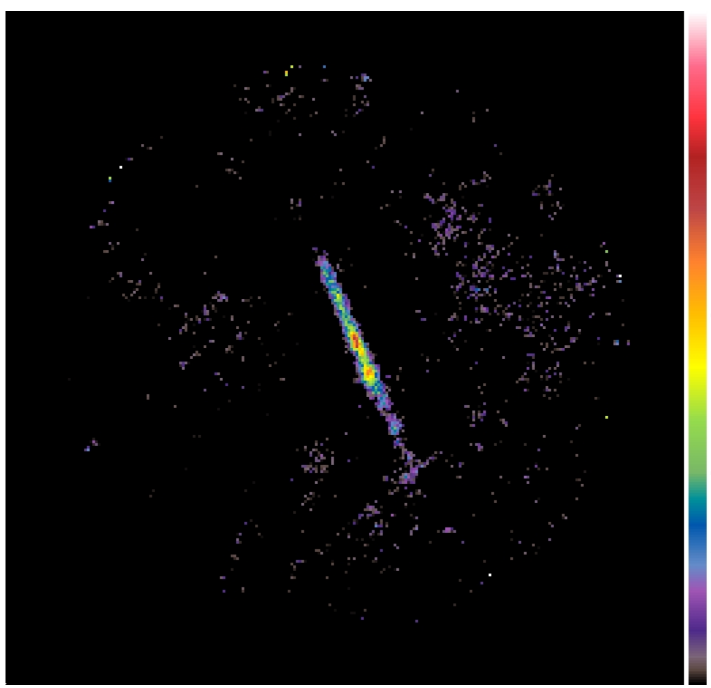
results at 2mm :

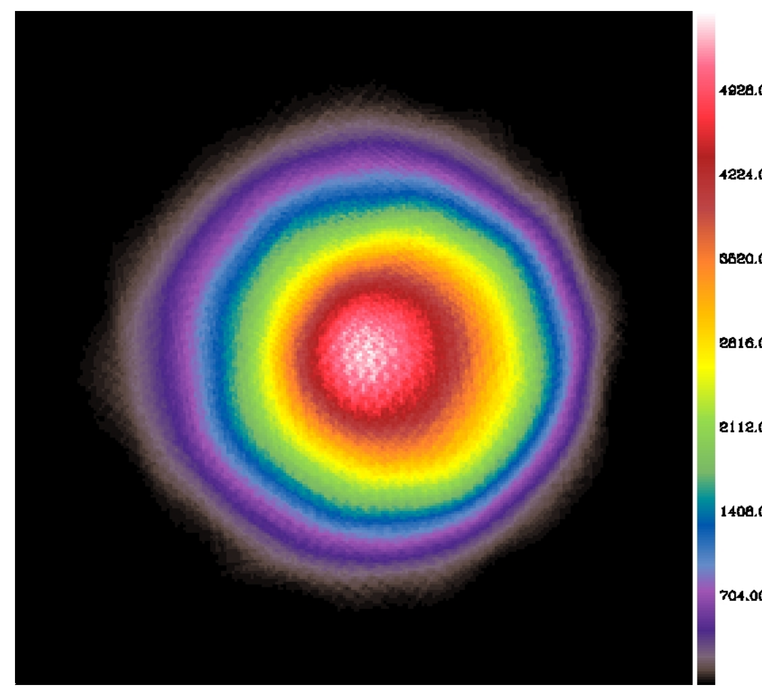




drifts (without offsets)

SNR map (above 2)



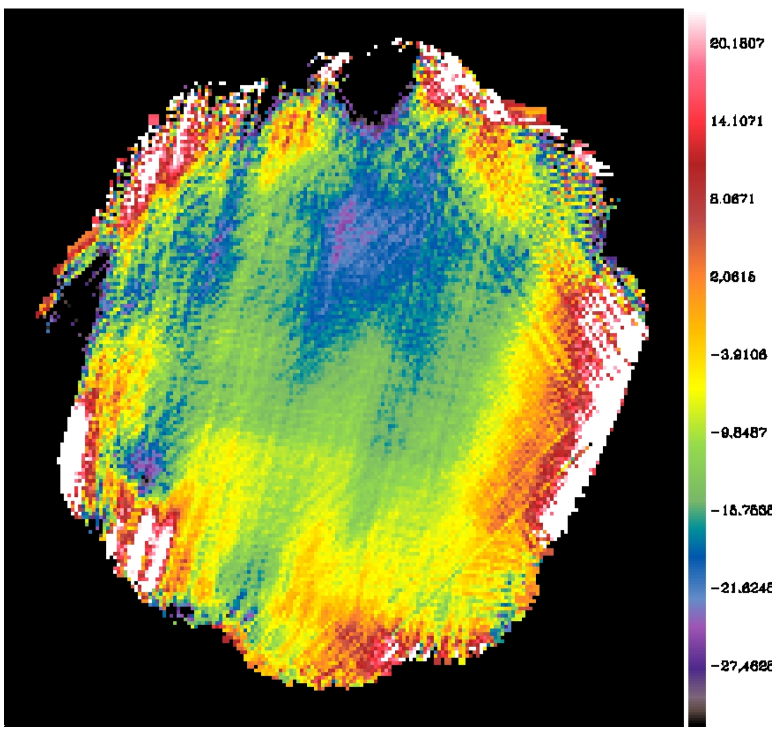


weight map

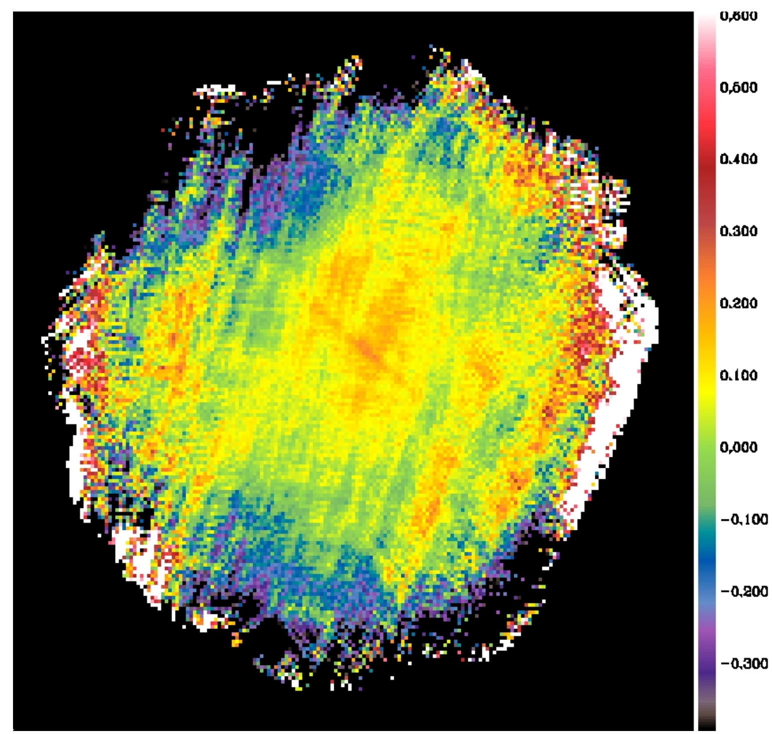
illustration of the results of the first steps of the drift subtraction:
(data projected on an intermediate spatial grid)

1) subtraction of linear baselines (per detector, per scan leg):

iterative procedure
includes the protection of sources by means of a mask automatically defined and adjusted, to avoid masking predominantly the map edges



raw data
(only global offsets subtracted)



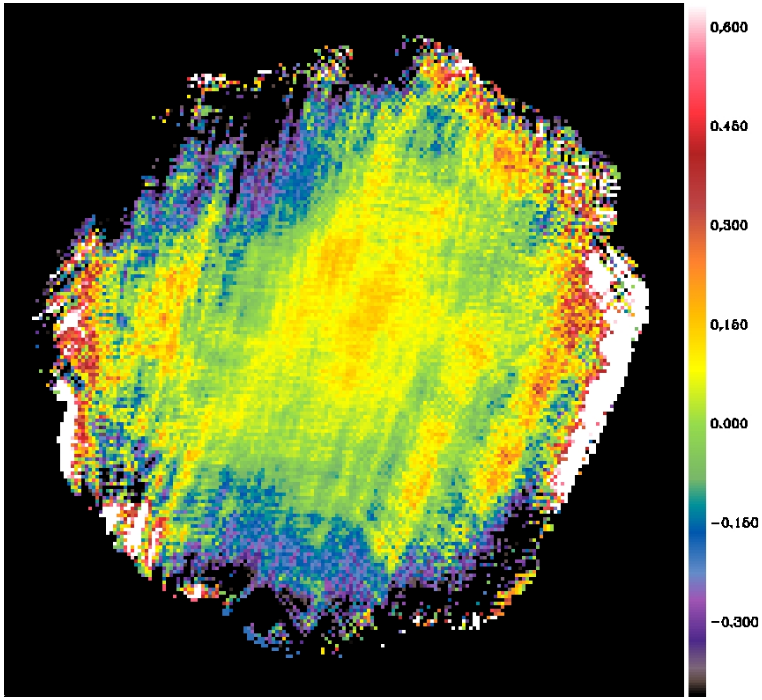
after subtraction of linear baselines
(notice the different brightness scale)

2) subtraction of the average drift (a single function of time for all detectors):

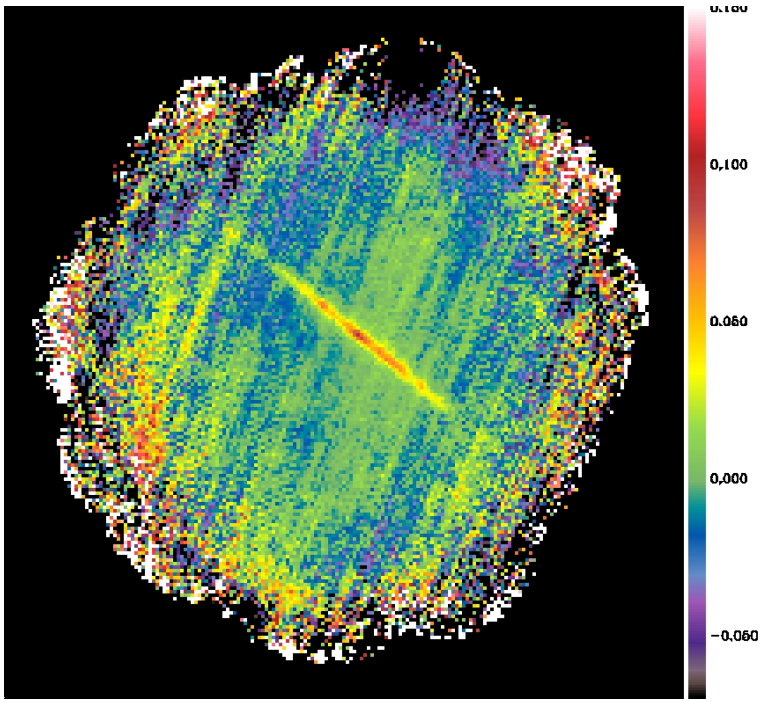
uses purely the available redundancy to compute $\overline{D}(t1) - \overline{D}(t2)$
for all pairs of time steps (t1, t2)
and then to deduce $\overline{D}(t)$ from the $\overline{D}(t1) - \overline{D}(t2)$ matrix

For a description of the algorithm, please see 2013PASP..125.1126R

main modification to the original algorithm:
"excess drift" not estimated from the recovered drift itself, but with baselines



projection of the average drift

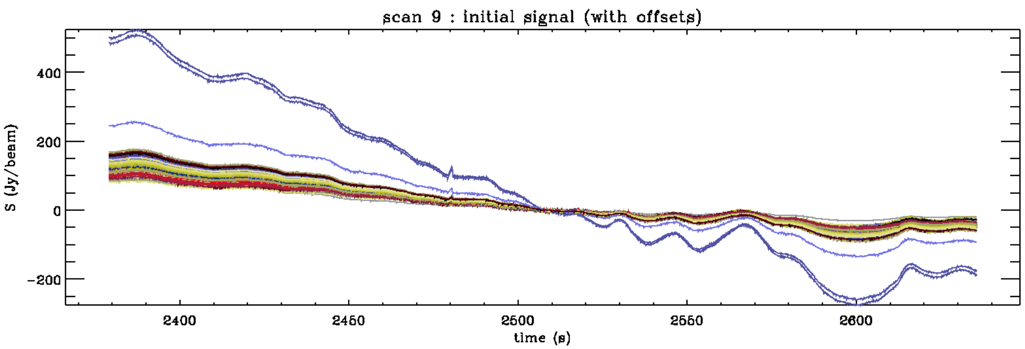


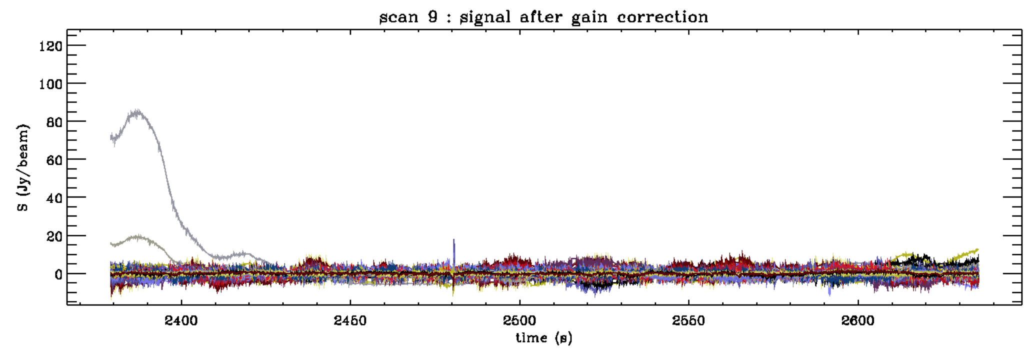
after subtraction of the average drift
(first iteration)

The response of detectors varies significantly across the array(s).

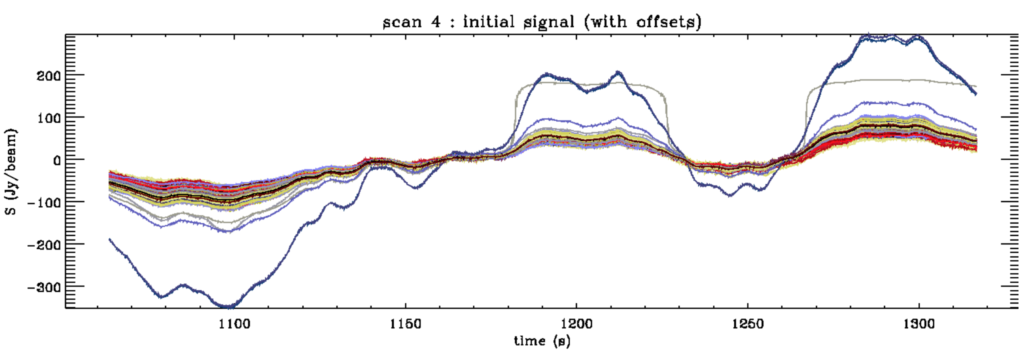
left column:
initial signal of all detectors
in a given scan (1mm)

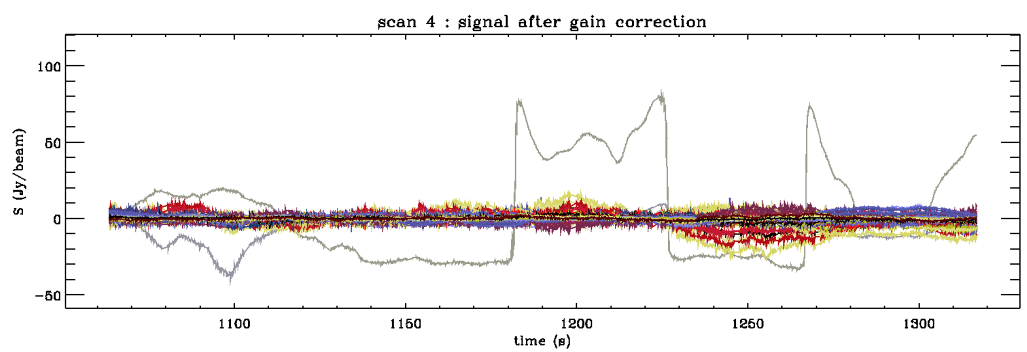
right column:
after subtraction of $g \times \overline{S}$
$\underline{g}$: gain (specific to detector)
$\overline{S}$: median of S / g
S : recorded signal





(notice the different brightness scale)





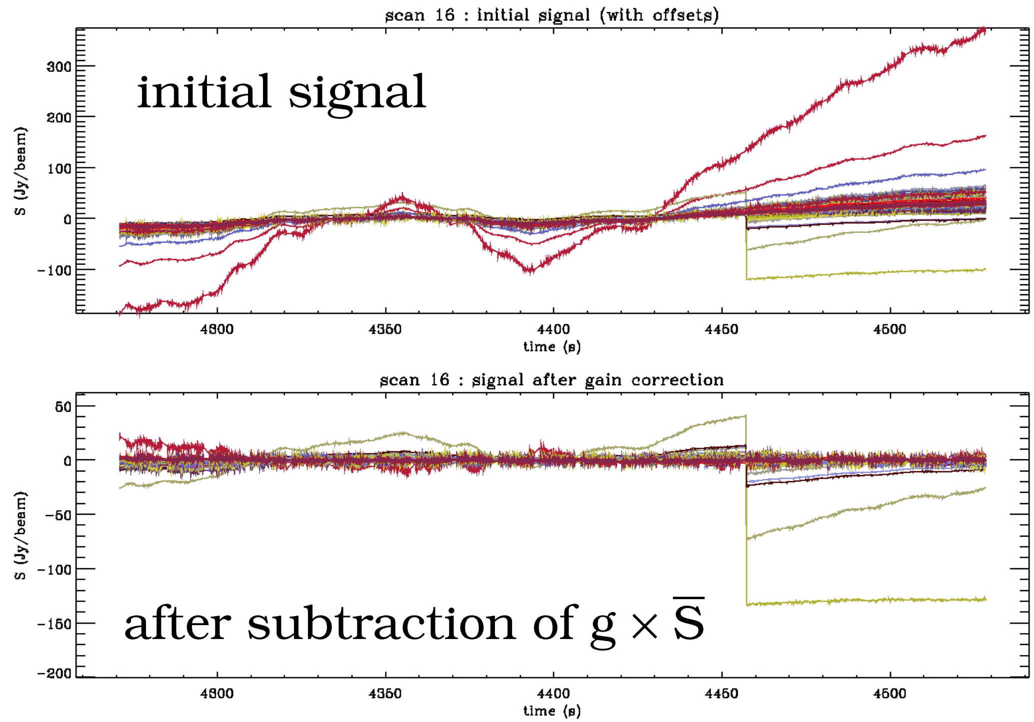
a few very unstable detectors

N.B. $g \times \overline{S}$ subtracted only to compute standard deviations,
not subtracted from the signal to be processed

other examples at 2mm :

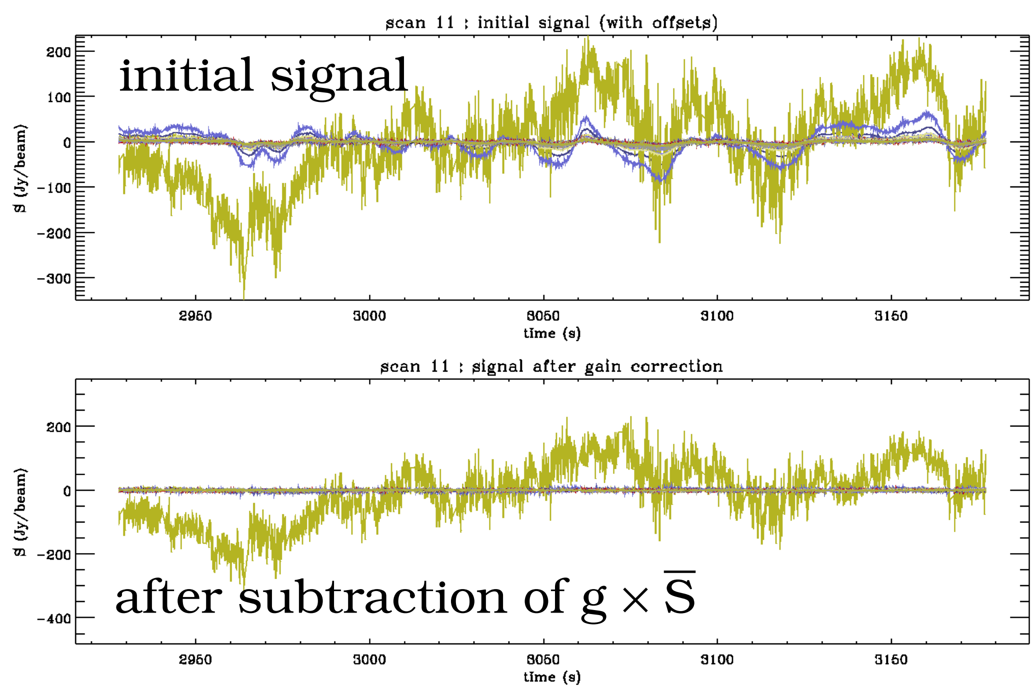
occasional jump for a subset,
affecting several detectors
at the same time

→ affected detectors masked out
for the whole scan
(they tend to be less well
correlated with median signal
even before or after the jump)

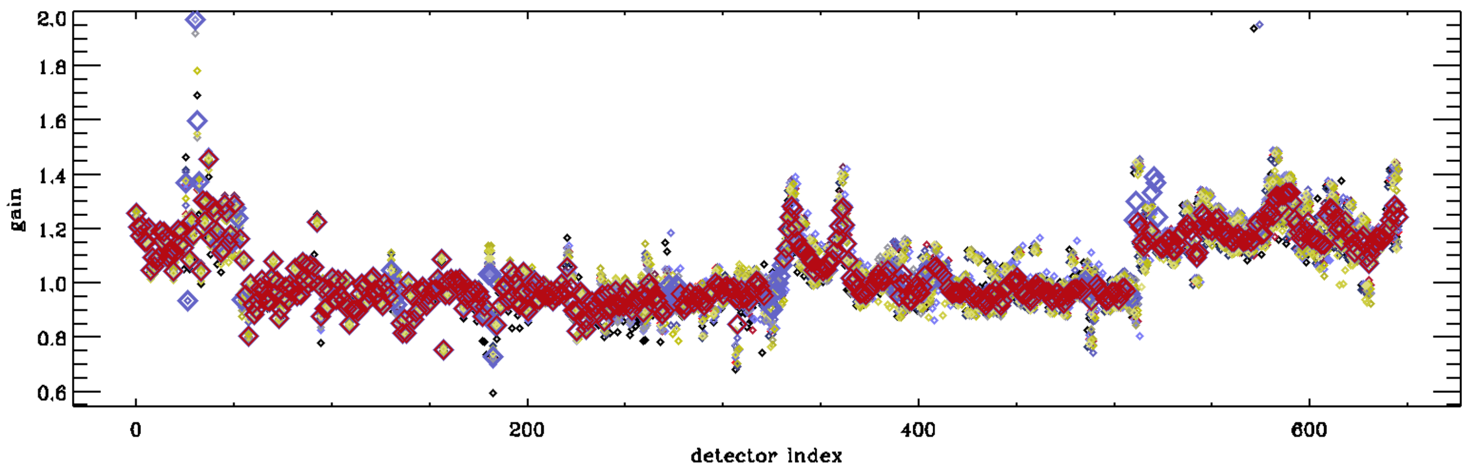


rogue detectors
(intermittent effect)

→ masked out
in the relevant scan(s)
if > 15 σ outlier for 5 s



derived 1mm gains as a function of detector index :

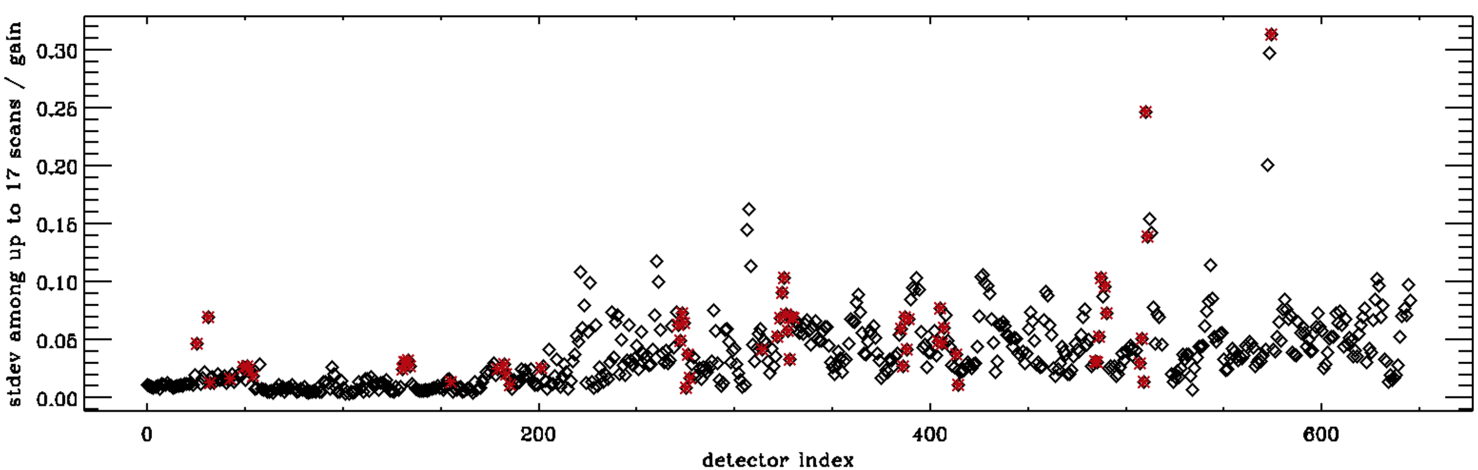


small symbols: individual scans

big red symbols: valid gains

big blue symbols: gains of unstable detectors

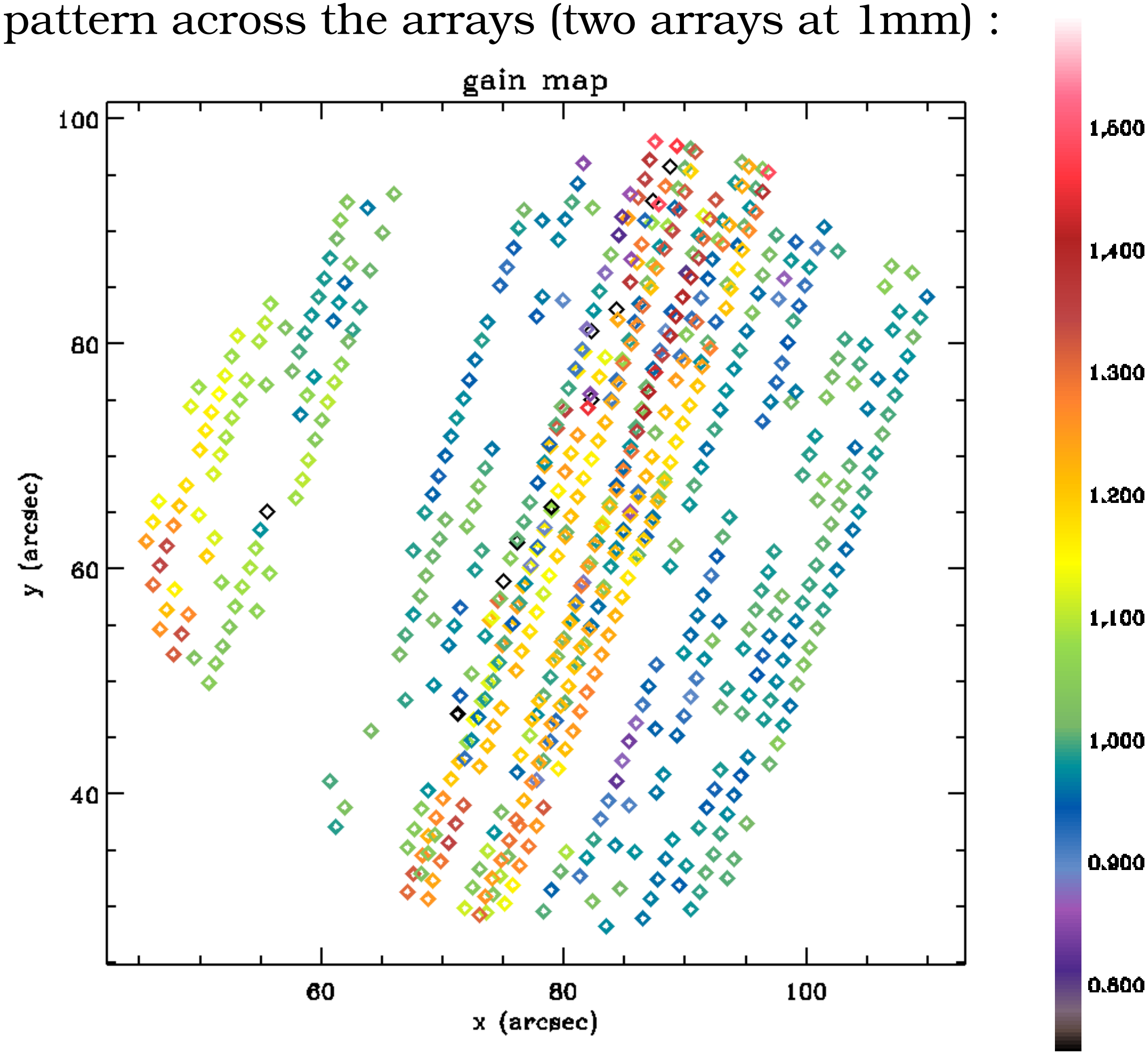
dispersion of 1mm gains among scans :
→ stable within this observation (on two successive days)



(discarded detectors in red)

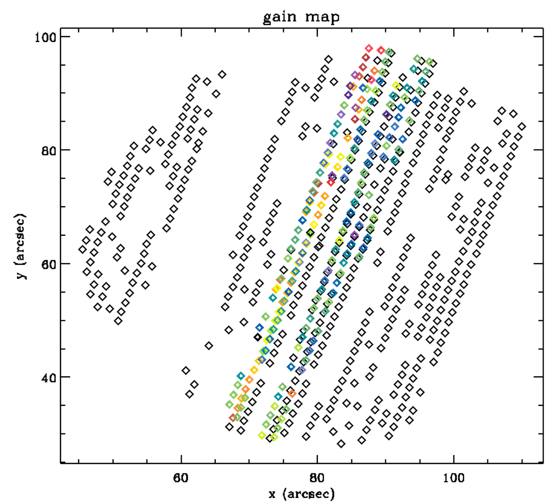
Will these multiplicative effects go away with a better calibration ?
Do they remain stable as long as the configuration is not changed ?

pattern across the arrays (two arrays at 1mm) :

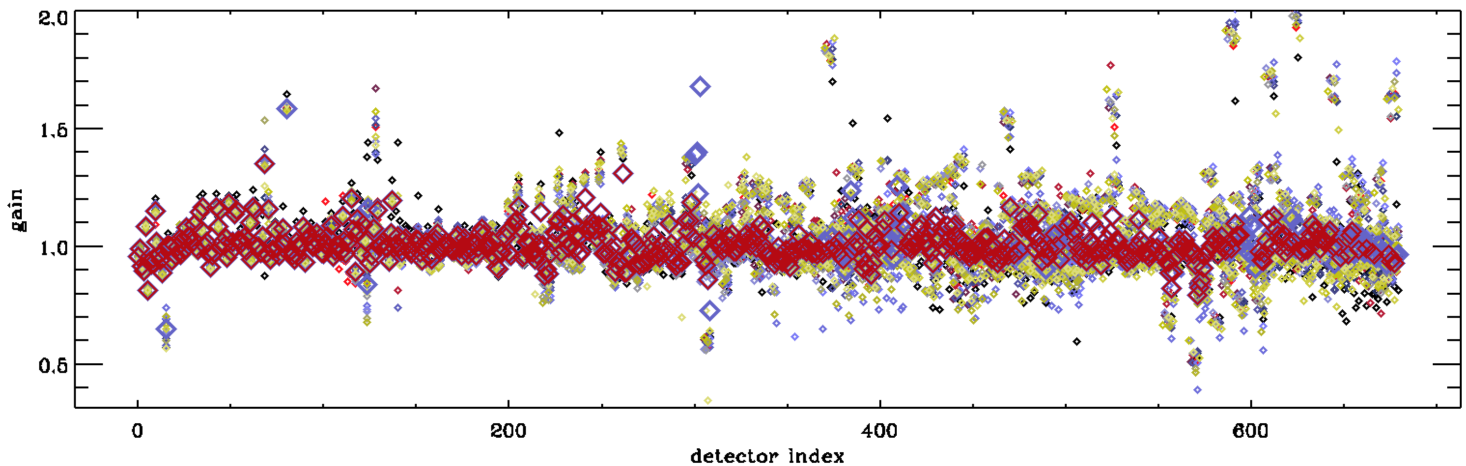


detectors with the smallest inter-scan dispersion (0 to ~200) :

corresponding to array 3 ?



N.B.: symbol size unrelated to beam size derived 2mm gains as a function of detector index :



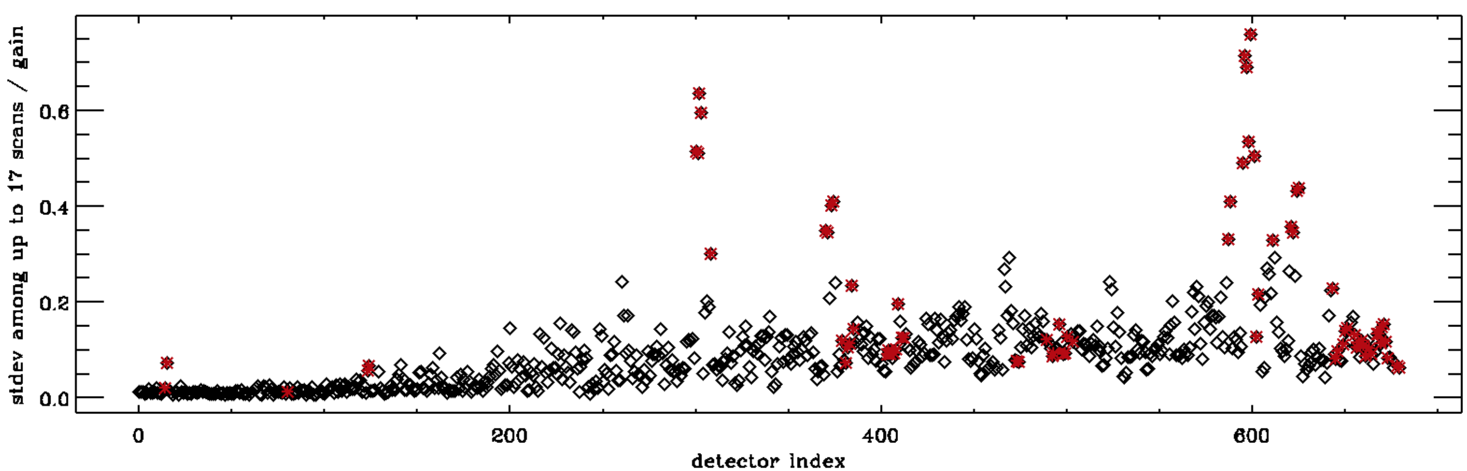
small symbols: individual scans

big red symbols: valid gains

big blue symbols: gains of unstable detectors

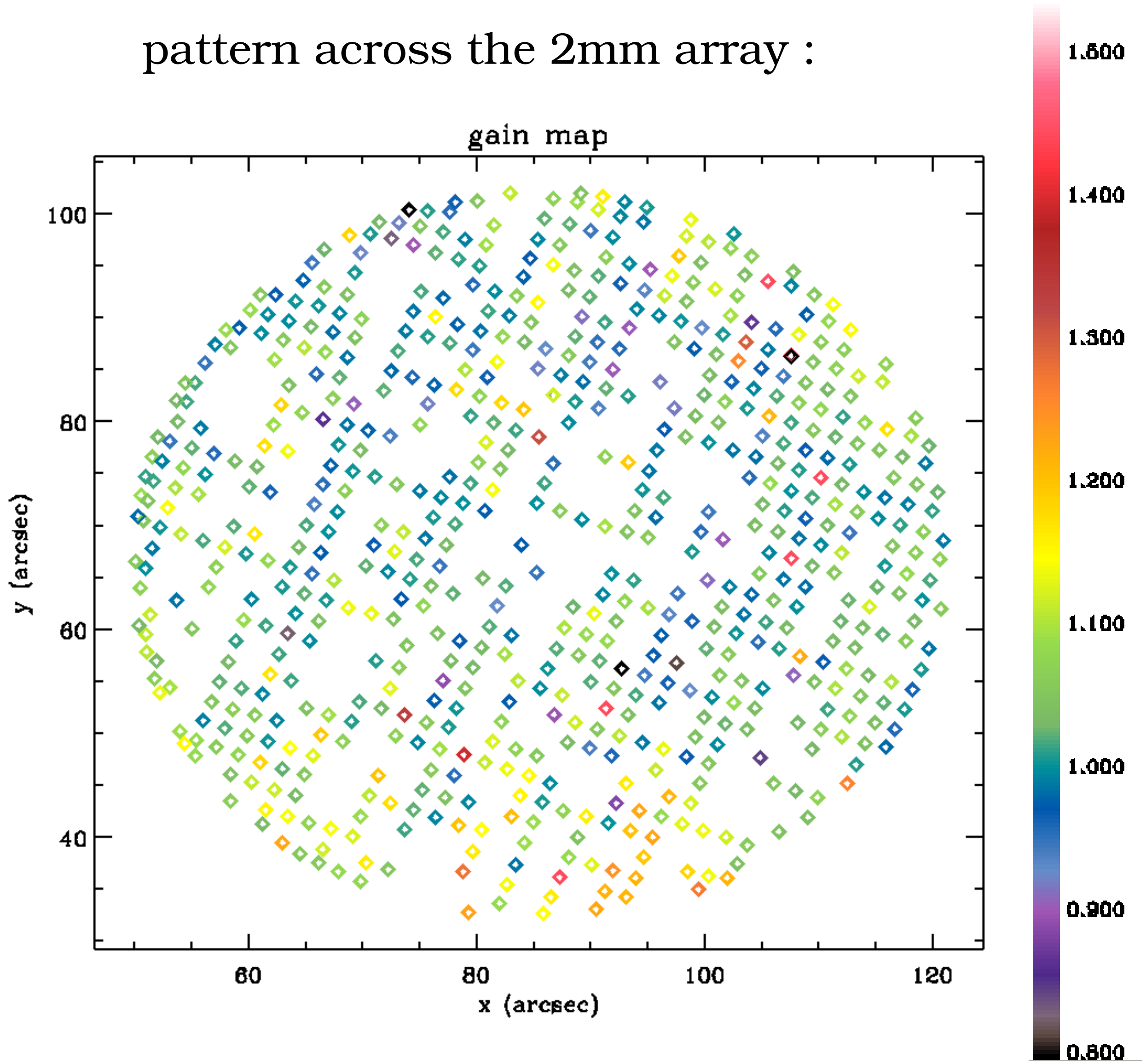
dispersion of 2mm gains among scans :

→ less stable than at 1mm (but smaller gain variations among detectors)



(discarded detectors in red)

pattern across the 2mm array :



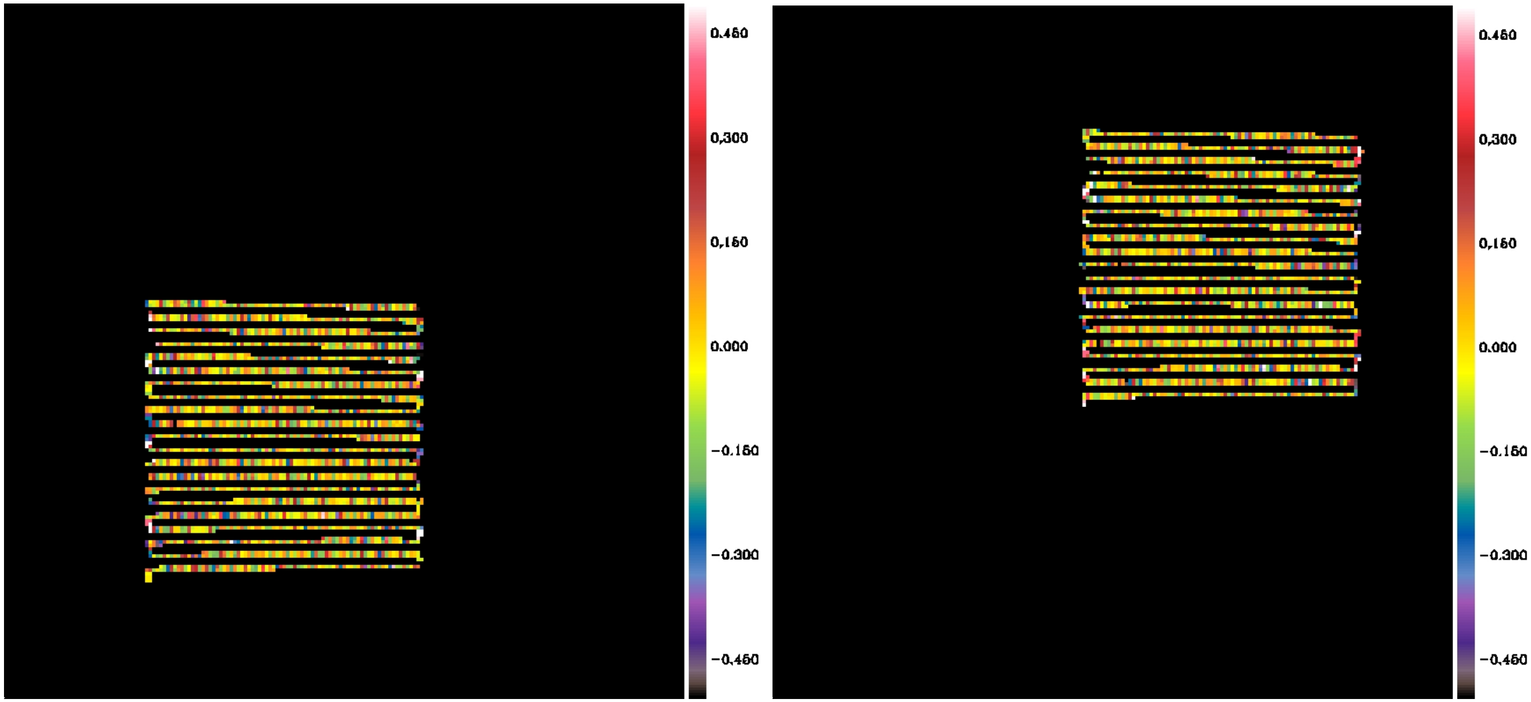
concerning the observation strategy (map size)

destriping (the step immediately after baseline subtraction for Herschel data processing)
not possible on these data

- because the map is too small
- because individual detectors have significantly different fields of view, including large regions with not enough redundancy

N.B. first scan leg almost always has to be discarded (too short)

fields of view of 2 detectors in the same scan: little overlap !



concerning the observation strategy (map size)

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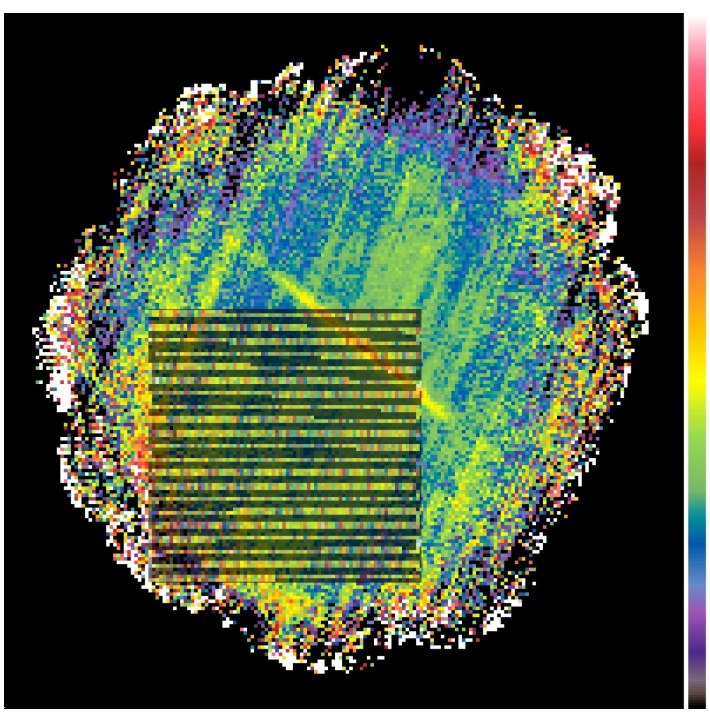
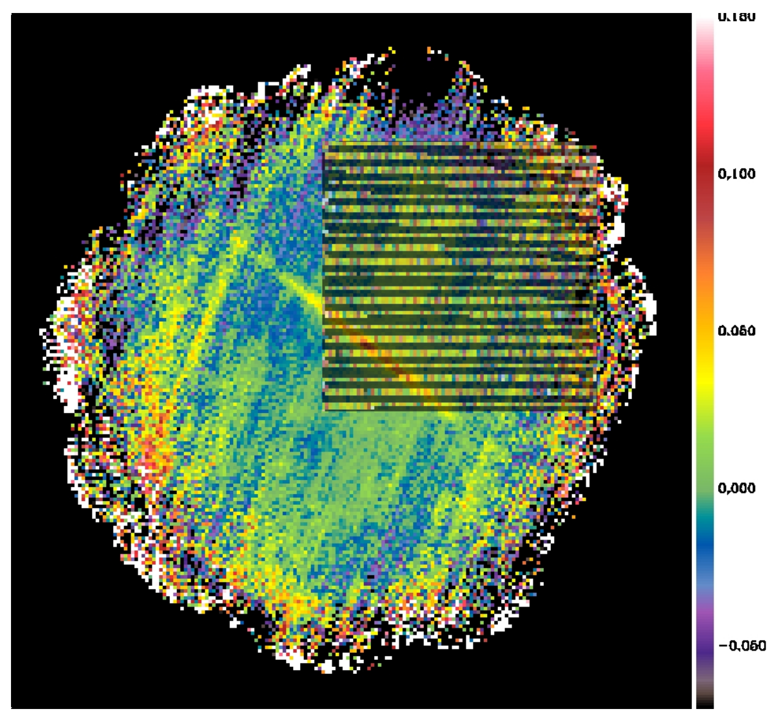
- because individual detectors have significantly different fields of view, including large regions with not enough redundancy

for detectors that are not at the array center:

sparse coverage of the source

source falling mostly on scan leg edges → very bad for the baselines !

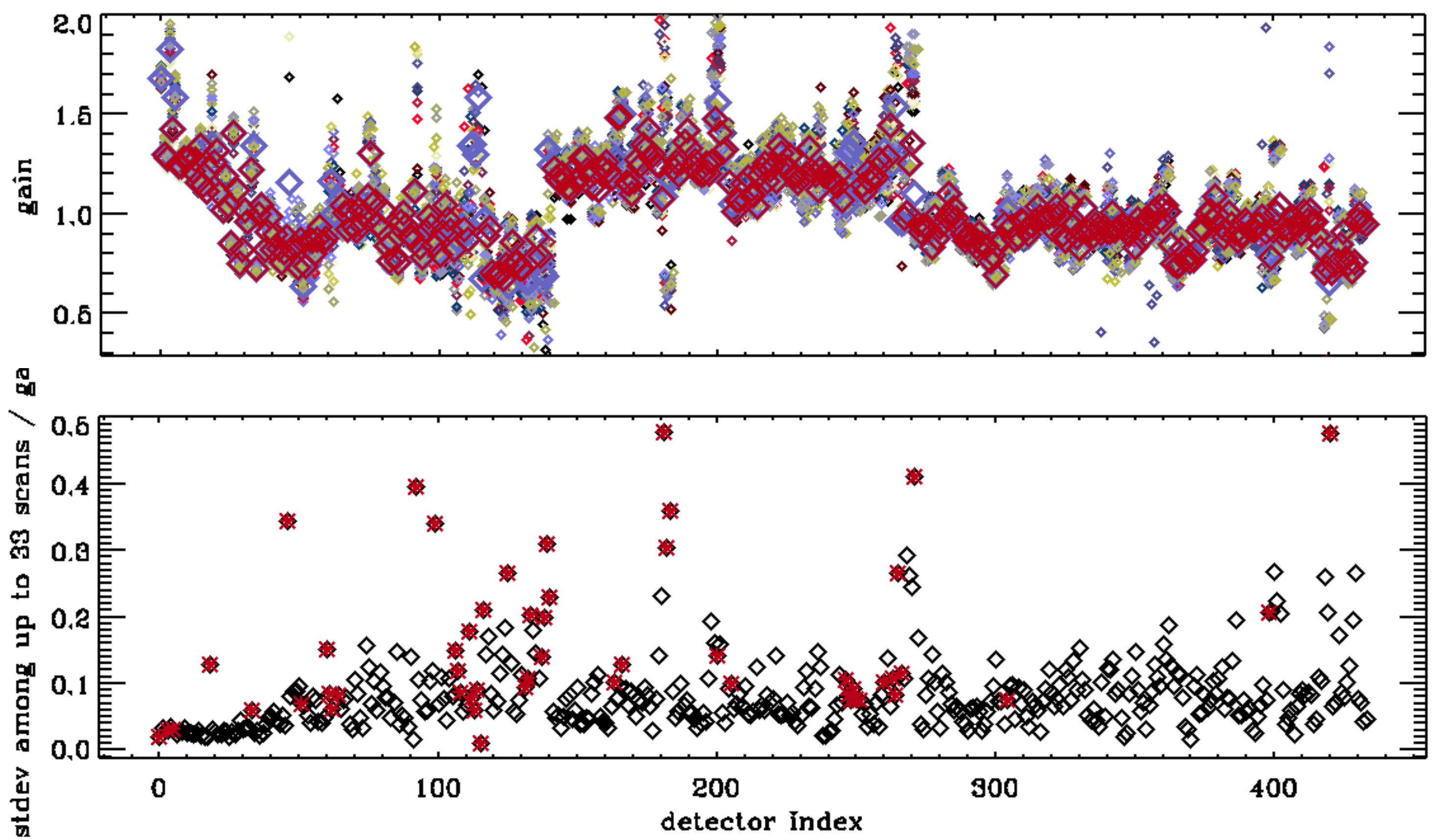




tests on NGC7538 : 434 detectors at 1mm (54 to 63 masked out)
different scan parameters available

on 2015-10-29 : 12 scans with v_{scan} = 30″/s , τ(1mm) ~ 0.5-0.6
8 with step between scan legs of 15″ (4 angles stepped by 45°)
4 with step between scan legs of 30″ (4 angles stepped by 45°)
20 scans with v_{scan} = 60″/s , τ(1mm) ~ 0.6-0.7
4 with step between scan legs of 15″ (4 angles stepped by 45°)
16 with step between scan legs of 45″

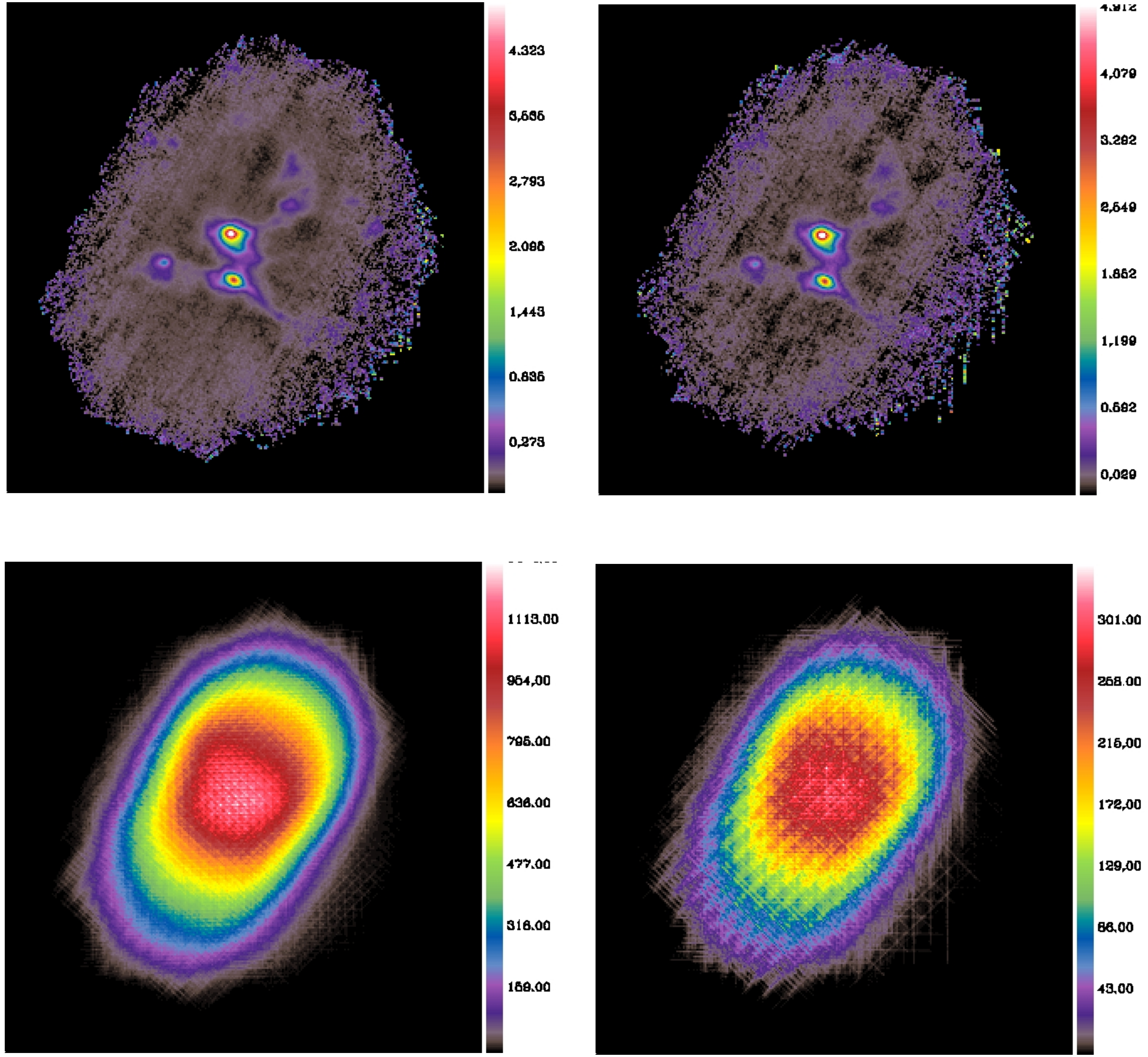
combined gains:



30″/s

left: 15″ step

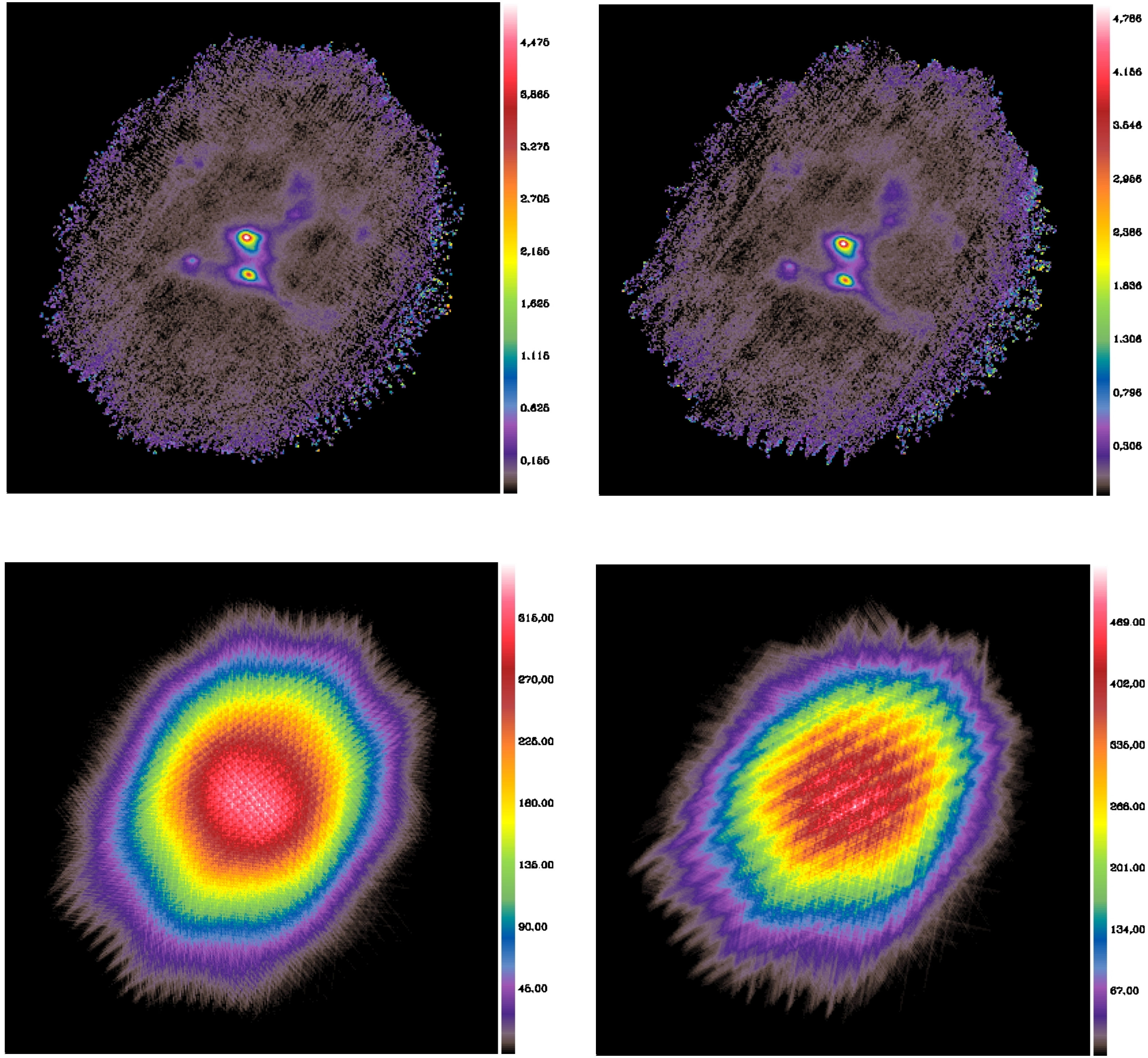
right: 30″ step



60″/s

left: 15″ step

right: 45″ step



From the tests on NGC7538, it seems that more diffuse emission is recovered at 60″/s than at 30″/s, even though the maps are shallower. But this may be simply because the maps are also a bit larger, allowing slightly better baselines...

The separation between scan legs does not seem to be a crucial parameter. If the destriping is deactivated as here for these tests, it can be smaller than the beam FWHM (implemented and tested on NIKA1 data). However, we will need to make sure it is not too small if we want to implement the destriping for large maps (too small = smaller than 2 $\times$ beam FWHM).

The crucial limitation for a code using the redundancy is the map size.
$\rightarrow$ **make sure that the baseline edges are as free as possible of sources for all detectors in all scans**
(except of course for wide maps with sources everywhere)

for better coverage homogeneity: avoid large collection of scan angles
Two scan directions (if possible orthogonal) should be enough !

need for realistic simulations to better test the influence of obs. parameters
(ideally, taking the noise from actual observations of a dark field, and simulating the scan geometry)