PACS photometry on extended sources

Total flux experiments

Bruno Altieri on behalf of Marc Sauvage

1. Point-source photometry status
2. Prospect on extended emission photometry from theory
3. Results from simulations
4. Total photometry on large galaxies (M.Sauvage)
5. Pixel-to-pixel comparison on KINGFISH galaxies
6. Conclusions

1. Point-source sensitivity

- Excellent absolute calibration coming up in FM Responsivity v6 with new PSFs:
  - ✓ **3% at 70 and 100μm**
  - ✓ **5% at 160μm**

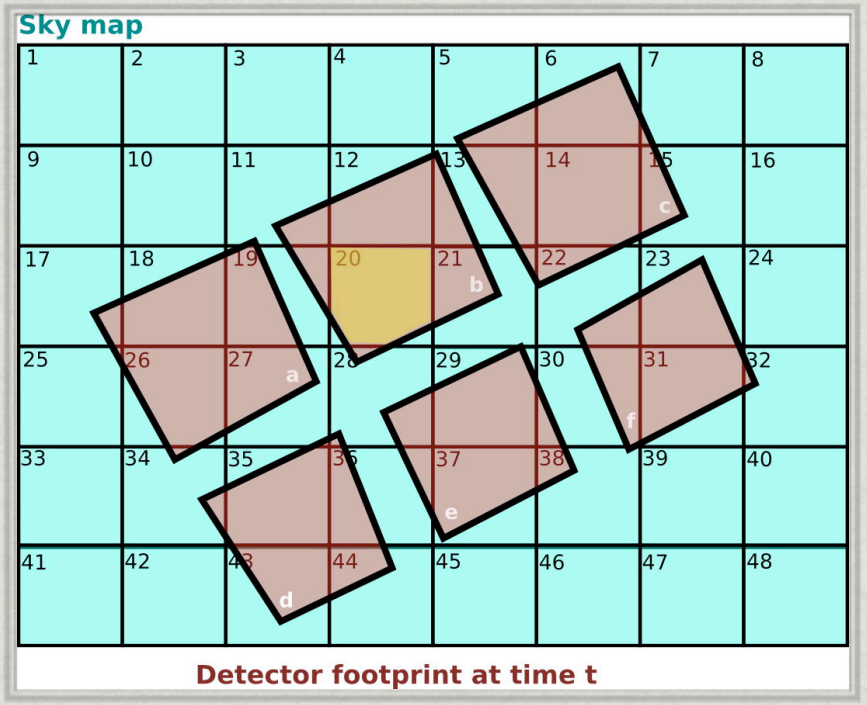
Table 8: Observed and calibrated ("FM, 6") monochromatic flux densities at 70, 100, 160 μm divided by the corresponding model predictions for all 5 fiducial stars.

Target		blue obs/model				green obs/model				red obs/model		
name	no.	median	mean	stddev	no.	median	mean	stddev	no.	median	mean	stddev
β And	2	—	**1.011**	0.015	2	—	**1.013**	0.010	2	—	**0.993**	0.018
α Cet	3	—	**1.011**	0.008	3	—	**1.007**	0.005	3	—	**0.999**	0.020
α Tau	4	—	**0.987**	0.011	4	—	**0.979**	0.009	5	—	**0.978**	0.011
α Boo	3	—	**1.000**	0.012	3	—	**1.000**	0.009	3	—	**1.007**	0.012
γ Dra	23	**0.985**	0.983	0.009	8	**1.000**	0.991	0.016	28	**1.010**	1.016	0.039
mean/stddev		**0.999±0.013**				**1.000±0.013**				**0.997±0.013**		

2. Map-making

- The relation between sky map (**x**) and signal (**y**) is represented by a projection matrix **P** whose elements are built from the geometrical intersection between the detector pixels and the sky pixels.

$$\mathbf{y} = \mathbf{P}\mathbf{x} + \mathbf{n}$$

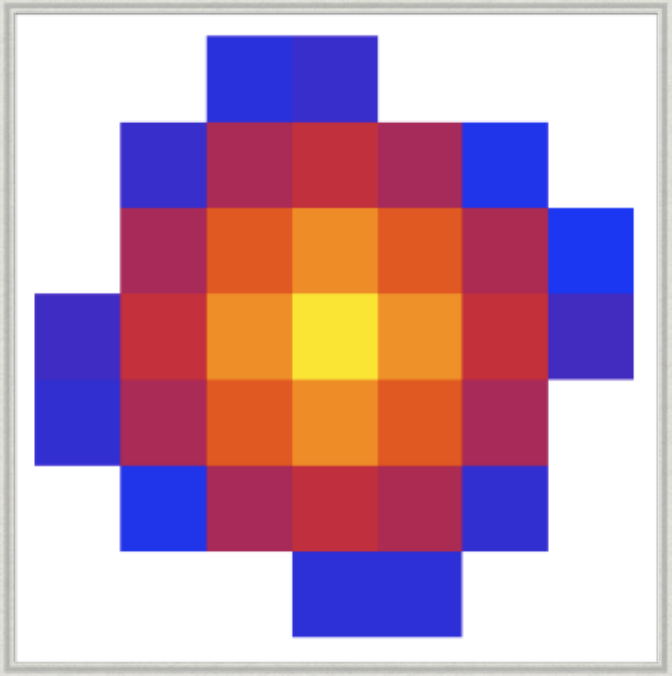


2. Map-making

- Most map-making algorithms do not invert **P** but try and estimate a map knowing the signal and **P**.
- photProject uses: $x_{phP} = \frac{P^T y}{P^T 1}$
- One can show that the algorithm is «flux conserving» even when an error is made on the detector pixel size.
- Flux conserving: the total flux of the objects is preserved by the map-making algorithm.
- An error in the pixel size translates in a multiplicative factor on the map (which is «calibrated out»).

2. Map-making

- Looking at the code, map-making should not be responsible for a distortion affecting only the extended sources.
- The map-making algorithm realizes a supplementary convolution of the data with a kernel that has a size comparable to the detector pixel size.



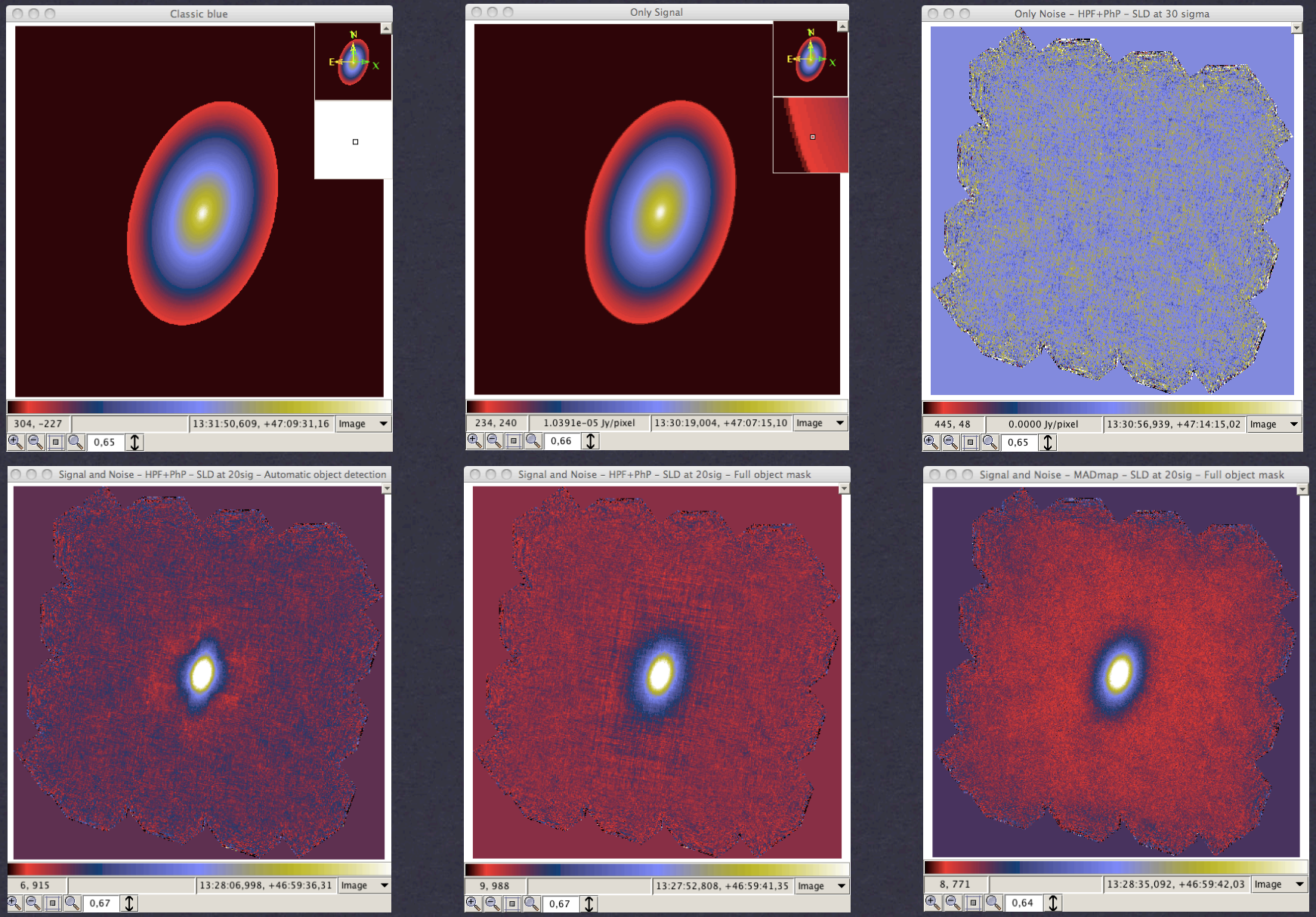
Example of the map-maker convolution kernel with map pixels of 4" while the detector is assumed to have pixels of 6.4"

2. Conclusions (theory)

- There is no reason to believe that the photometry of extended sources should follow a different scale from that of point sources.
- Total flux comparisons are simpler to interpret than pixel-to-pixel comparisons, because of the complex PACS PSF and the often neglected convolution performed by the map-making algorithms.

3. Simulations

- Take a "galaxy" of known surface brightness distribution.
- Simulate its observation (with YAPS, not taking into account bolometer time constants, PSF).
- Add actual noise and glitches (taken from LF Noise measurements in PV).
- Process it through my scan map pipeline using various options (HPF+PhP, MADmap, object masks of different size).



From simulation to reconstruction

variable paramters: 2nd level deglitching, size of the object mask

3. Photometric results

Integration of the flux in the image over an elliptical aperture including the object completely.
Errors combine photometric and data reduction errors.
Object flux should be 163.4 Jy at 70 and 160 μm.

Effect of the nσ parameter in 2nd level deglitching on pure noise image

nσ	20	25	30	25MAD
70 μm	-1.38±0.65	-1.44±0.65	-1.35±0.65	-25.87±0.44
160 μm	-0.30±0.49	0.26±0.49	-0.28±0.49	-9.20±0.54

Effect of the object mask definition on signal and noise image

Mask size	Full		1e-4 of Peak		1e-3 of Peak		1e-2 of Peak		Auto
Map Style	HPF+PhP	MADmap	HPF+PhP	MADmap	HPF+PhP	MADmap	HPF+PhP	MADmap	HPF+PhP
70 μm	160.57±0.64	110.13±0.45	161.94±0.65	109.83±0.45	159.44±065	110.58±0.45	143.83±0.65	110.67±0.45	77.53±0.65
160 μm	163.97±0.49	138.91±0.55	164.20±0.49	139.58±0.55	161.08±0.49	139.87±0.55	145.41±0.49	140.51±0.55	83.62±0.50

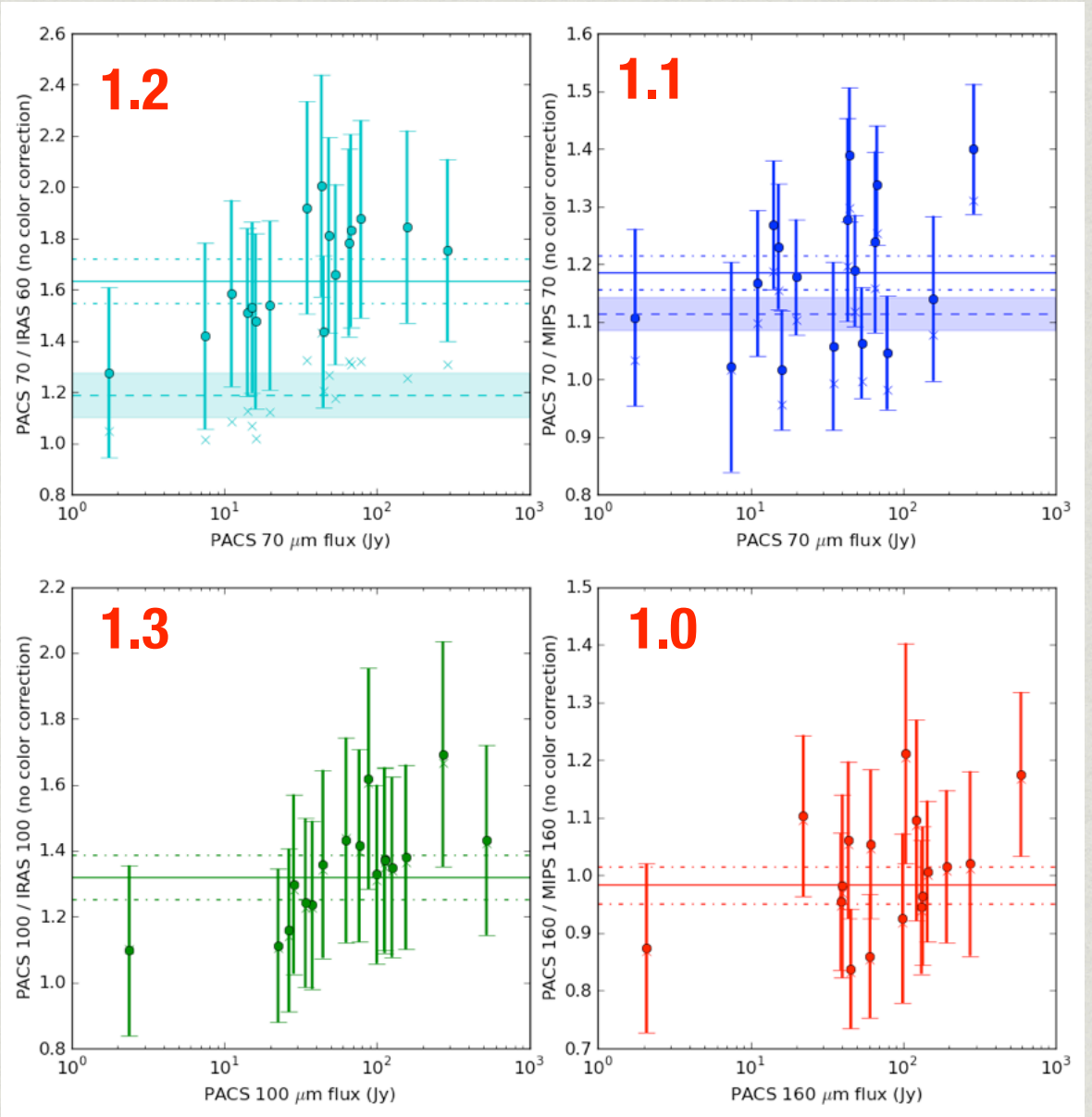
The effect of nσ is not really severe on the map quality, so larger value are recommended.
MADmap photometry is driven by the curvature of the background.
Proper object masking is critical in the HPF+PhP branch, but mostly irrelevant in MADmap.

4. Total flux on large galaxies, no convolution, (M. Sauvage)

- PACS photometry from Hipe 6 private reduction (using the MIPS apertures).
- MIPS and IRAS photometry from Kingfish Twiki.
- Filled symbols: measured total flux ratio (no color correction).
- Crosses: color-corrected ratio (based on [60]/[100] and Dale & Helou's SED library).
- horizontal line: uncertainty-weighted average flux ratio and associated uncertainty (shaded areas for color-corrected average ratio when significantly different).
- PACS is compatible with MIPS (remember the beam underestimation).
- Possible systematic gain difference with IRAS (20-30%), which can possibly be attributed to IRAS rather than PACS.

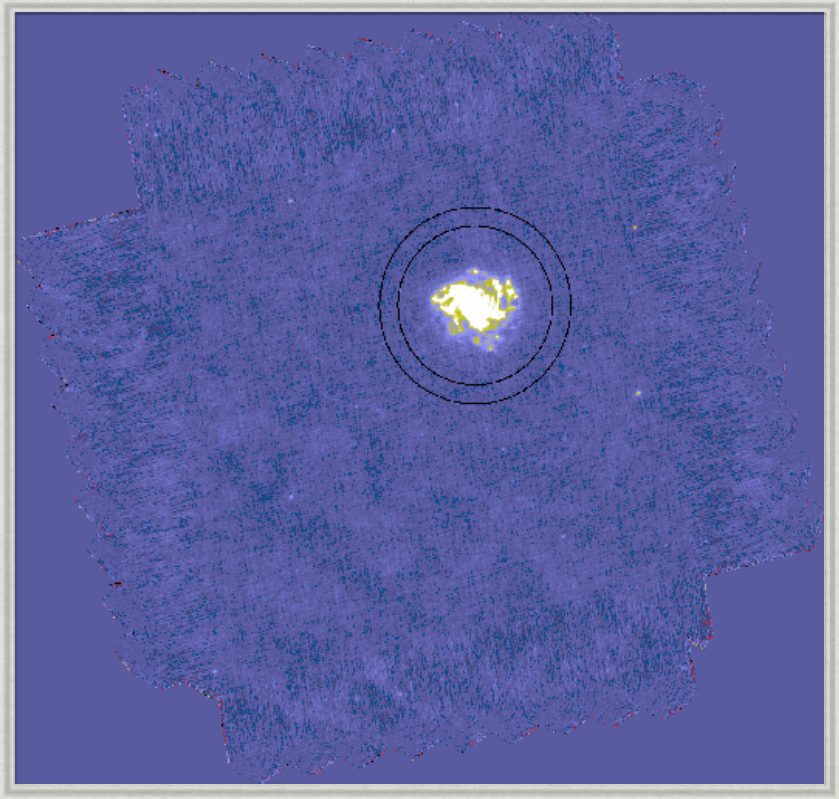
PACS compared to

IRAS **MIPS**



Reproducibility?

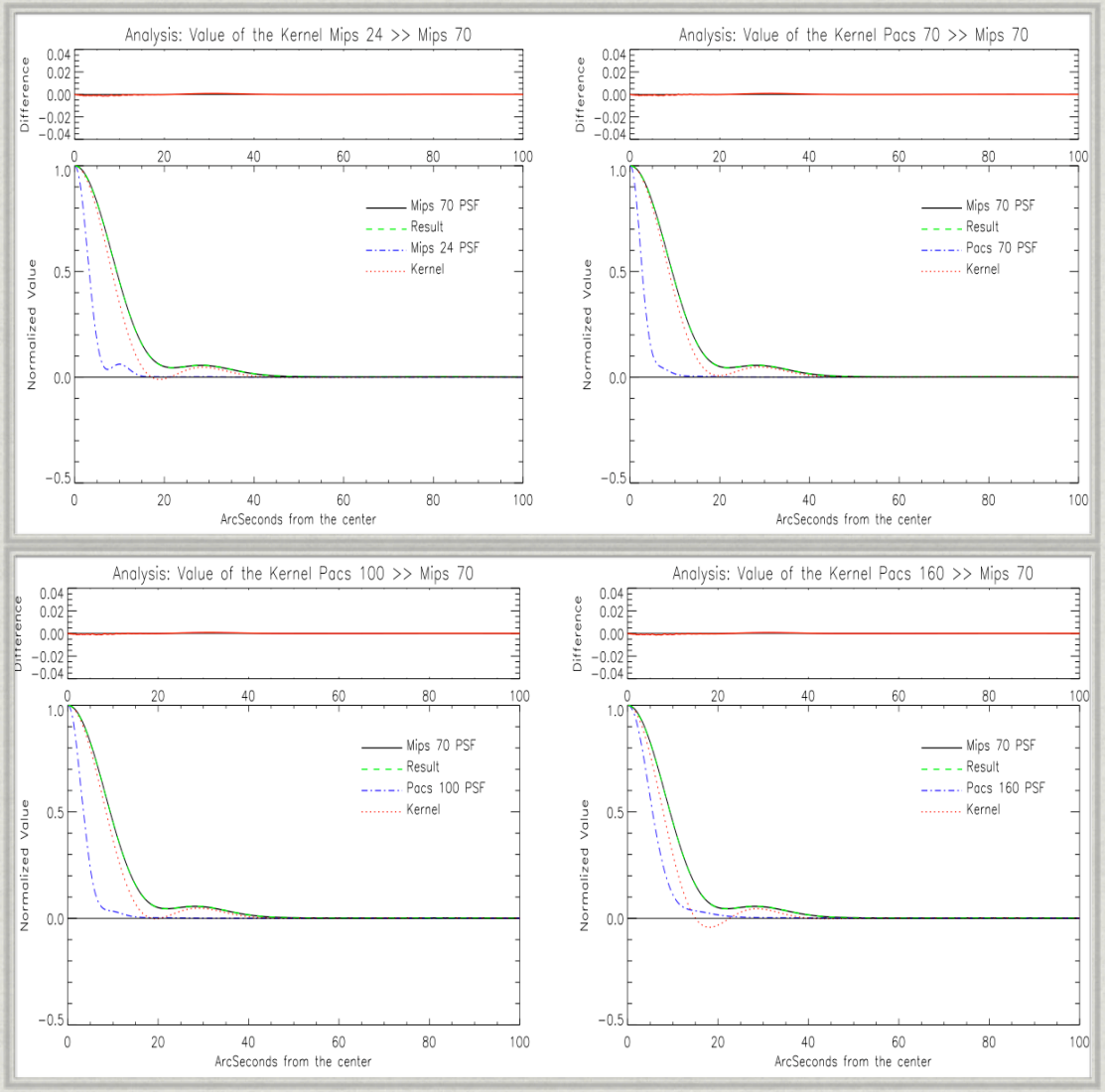
- NGC 6946 was observed in 09/09 in slow and fast parallel mode, and on 03/10 in prime mode for KINGFISH
- Total flux @ 160/100 μm:
  - Prime: 591 / 289.97 Jy
  - Parallel Slow: 609 / 293.48 Jy
  - Parallel Fast: 629 / 294.48 Jy
- Variation is compatible with calibration.
- Some systematics?

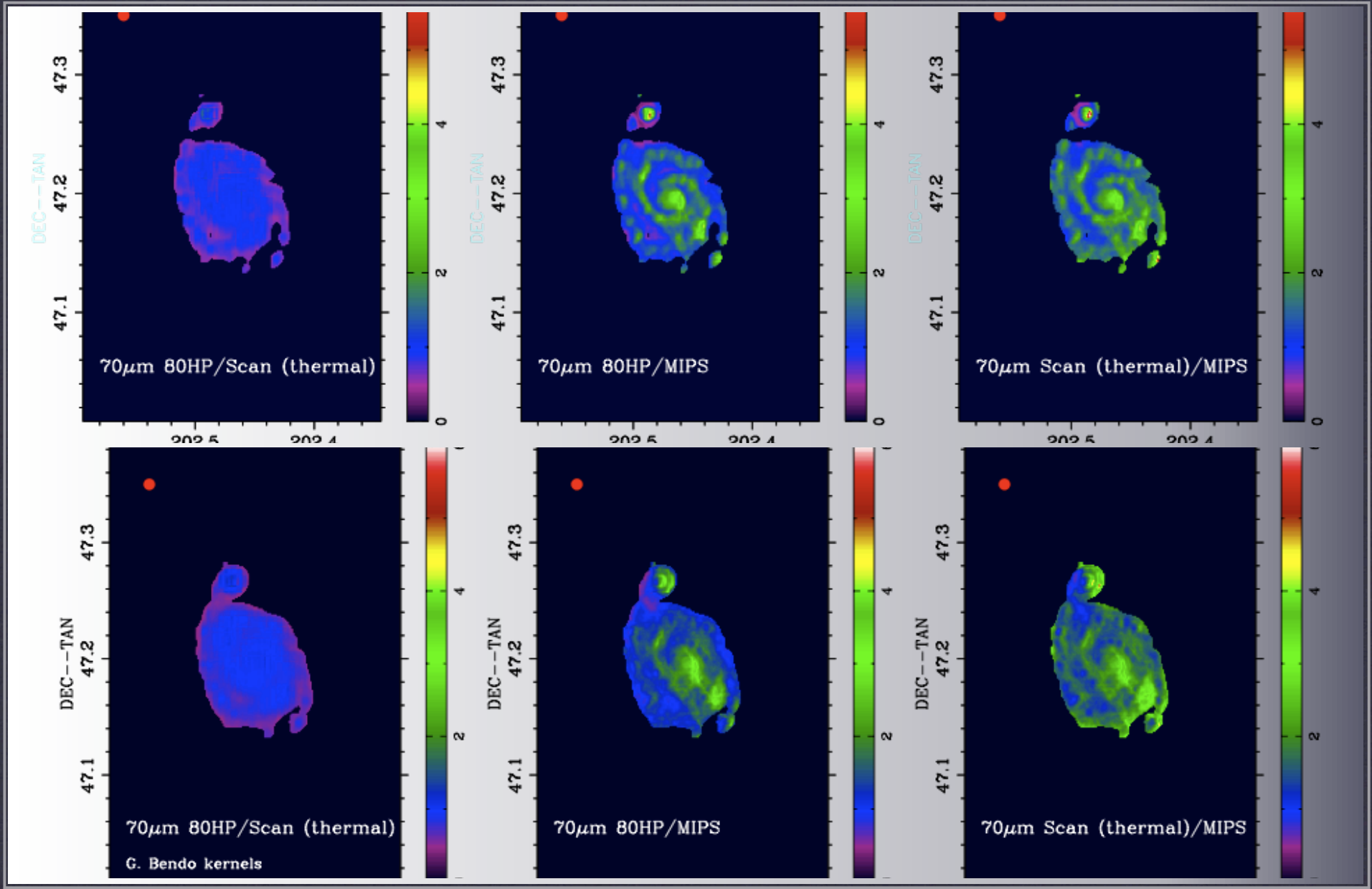


5. New convolution kernels

- Gonzalo Aniano (Princeton, Kingfish) has produced new convolution kernels
- He uses circularized PSF, and for PACS he is using the PSFs we have published.
- Experiments made with these kernels are much more satisfying.
- This is still with the old r=60”-normalized PSFs on 12 KINGFISH KP large galaxies

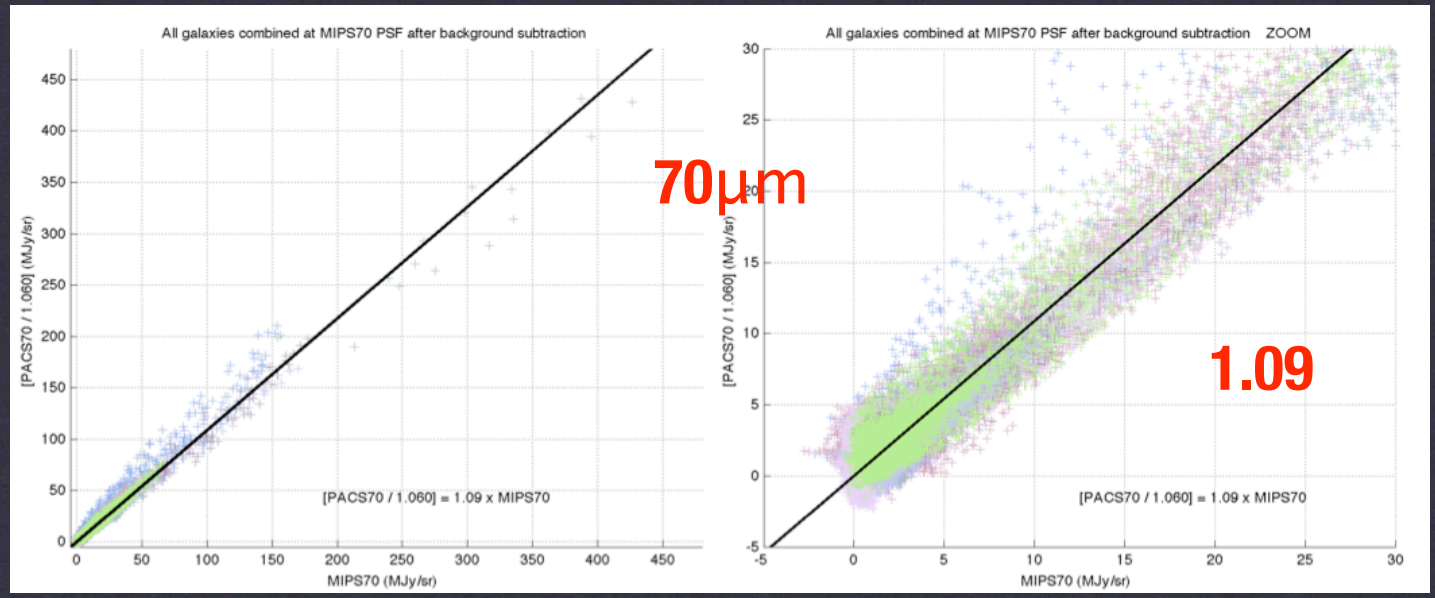
5. New convolution kernels

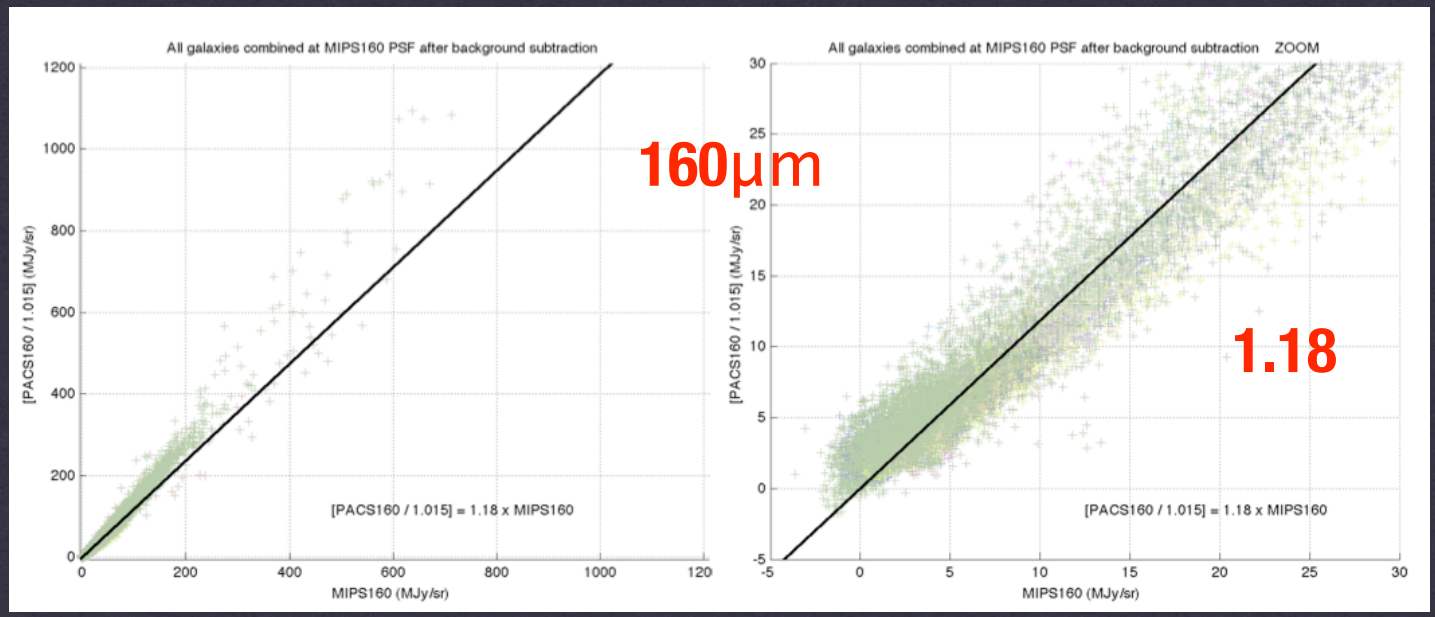




Top: old Kernels, Bottom: new ones

Systematics still seen but more compatible with MIPS transients.





Pixel-to-pixel PACS-MIPS comparison

Convolved to MIPS beam, color-corrected

6. Conclusions

- ✓ No reason to believe there is a problem of PACS extended emission flux calibration / photometry
- ✓ **PACS vs MIPS**:
  - Total flux : good agreement already, new sensitivity expected to improve it even further slightly.
  - Surface brightness (pixel-to-pixel), currently within 20% (red) and 10% (blue), should go down to <10% with new PSF kernels.
- **PACS vs IRAS**: within 20-30%