The Herschel/PACS Point Source Catalog

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Outline

- Rationale, goals
- PACS parameters
- Methods & testing
- Test results, current status
- Future tasks
- Summary

Rationale, goals

- Key programs deliver own catalogues
  - Looking for specific source content (extragalactic sources, YSOs, etc., but not all at the same time)
  - Different methods for source detection and photometry - inhomogeneity
  - At the moment they cover just a fraction of the observations (~50% in the future)
- **Scan-map mode observations are used (no chop-nod observations)**
- **Homogeneous extraction and photometry**
- **High reliability point sources will be extracted and catalogued**
- **Wide range of scientific use (statistical studies, new discoveries, flux values for SED)**
- **Newest, higher level data is used**
- PACS and SPIRE catalogues are different efforts and teams - but many commonalities
- BUT: no band-merging

Global parameters

- PACS
  - Simultaneous 70/100 & 160 μm observations (blue, green, red)
  - PSF FWHM: 5.6”, 6.8”, 11.5” for blue, green, red at 20”/s scan speed
  - somewhat larger and elongated at 60”/s scan speed and parallel mode
  - Pointing accuracy assumed to be ~2”

- Modes to be used
  - MiniMap
  - ScanMap
  - ParallelModeMap

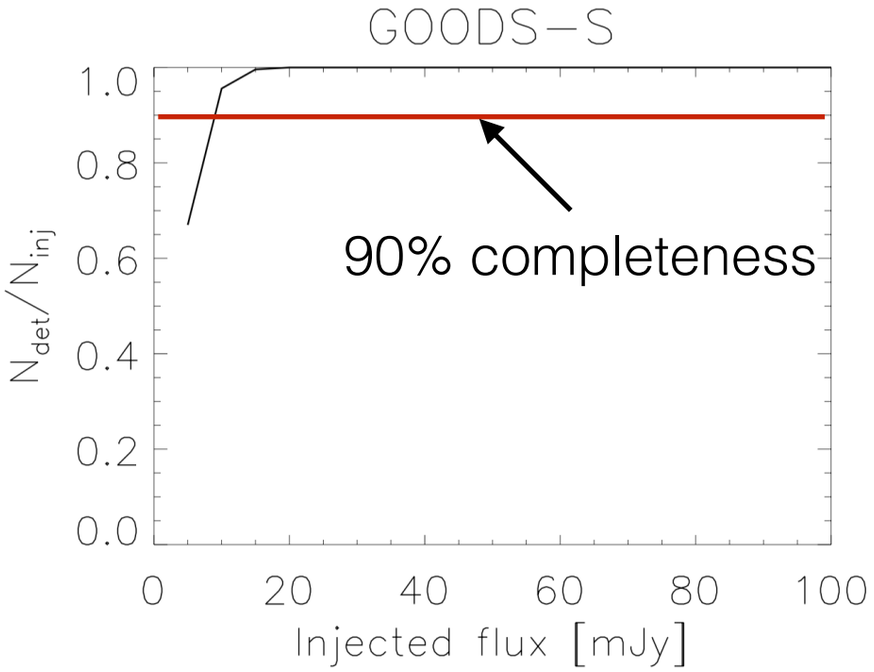
- Number of maps to be used, incl. L2.5&L3:~8000

Source Extraction Test

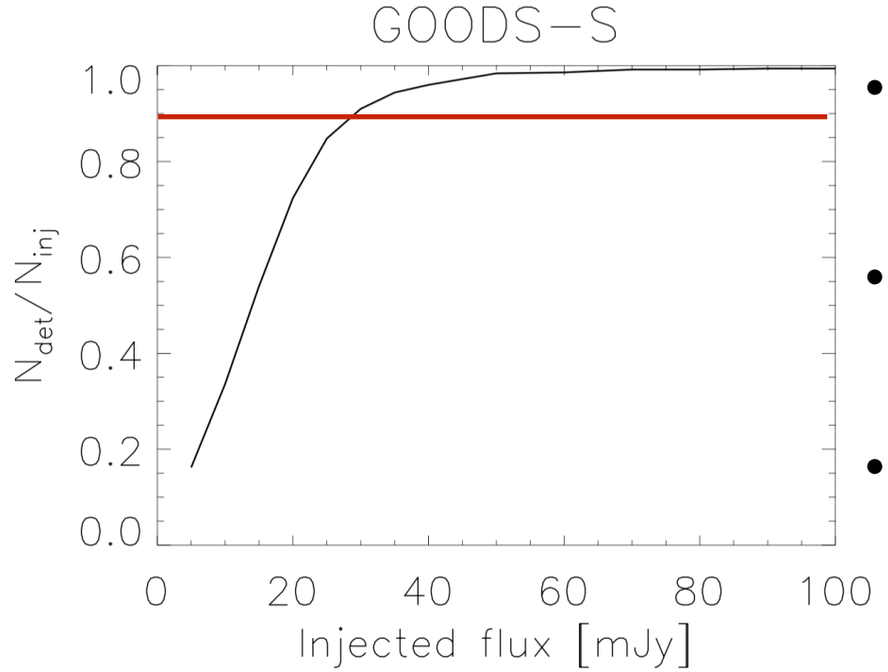
	Environment	Detection performance	Photometry	Speed	Easy to use & implement
Sussextractor	**HIPE**	**5**	**4**	**5**	**5**
Daophot	**HIPE**	**2**	**5**	**5**	**5**
Starfinder	**IDL**	**5**	**5**	**4**	**3**
Getsources	**Fortran+C**	**5**	**5**	**3**	**3**
Cutex	**IDL**	**5**	**4**	**5**	**3**

Performance results are based on artificial source injection trials performed with PACS data of several fields (A370, G128.78 and IC348).

PACS source extraction

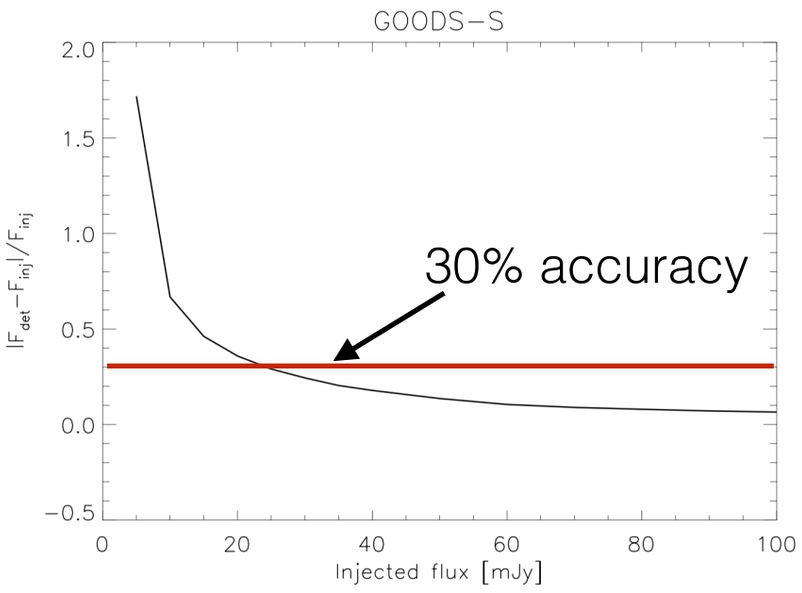


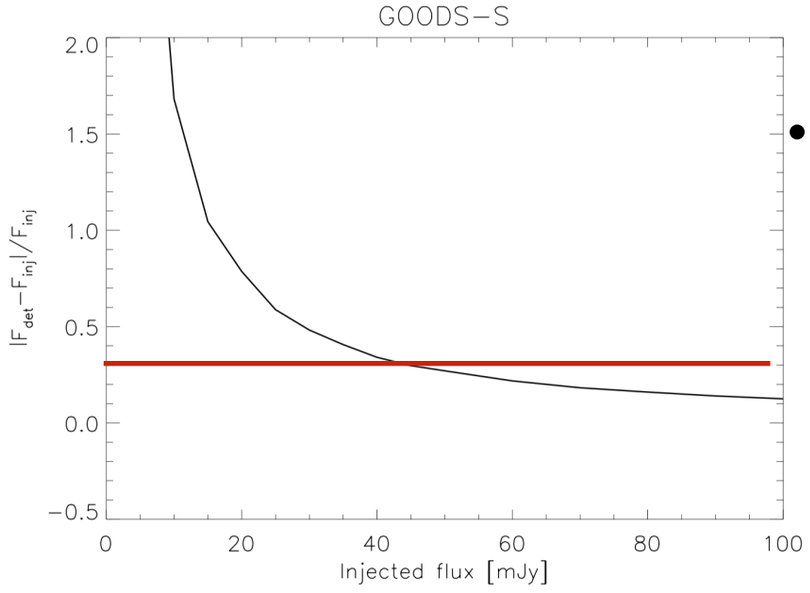
green



red

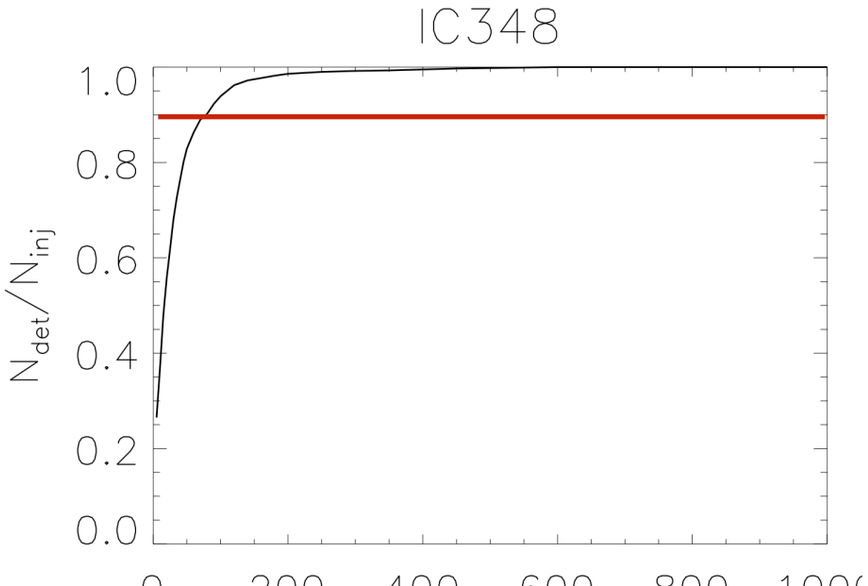
- Injecting sources into GOODS-S - extragalactic observation
- Levels 5,10,15,20,25,30,35,40,45, 50, 60,70…200 mJy.
- 90% of sources (red line) are found at ~15 mJy (green) and ~30 mJy (red)



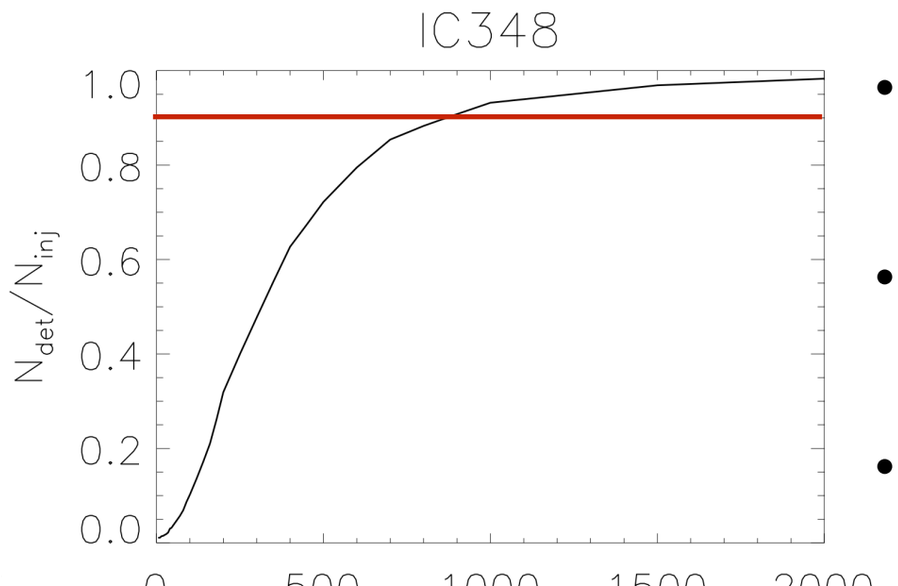


- 30% photometric accuracy (red line) reached ~20 mJy (green) and ~45 mJy (red)

PACS source extraction

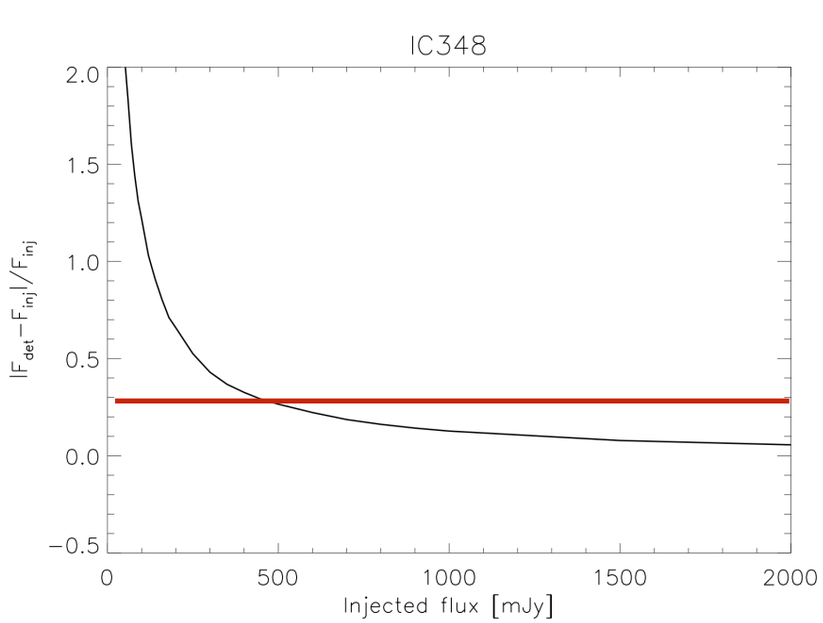


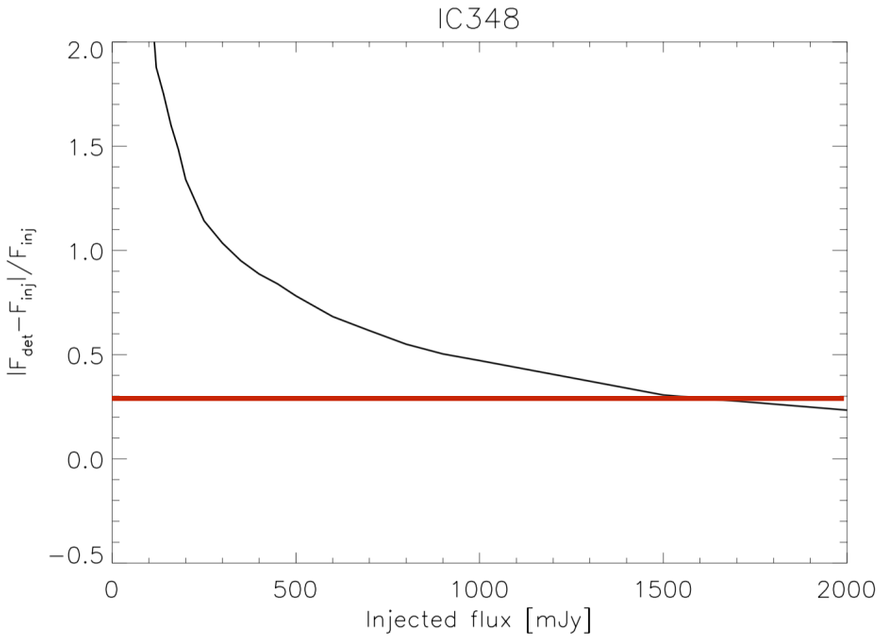
blue



red

- Injecting sources into IC348 - star forming region
- Levels 5,10,15,20,25,30,35,40,45, 50, 60,70…2000 mJy.
- 90% of sources are found at ~100 mJy (blue) and ~900 mJy (red)

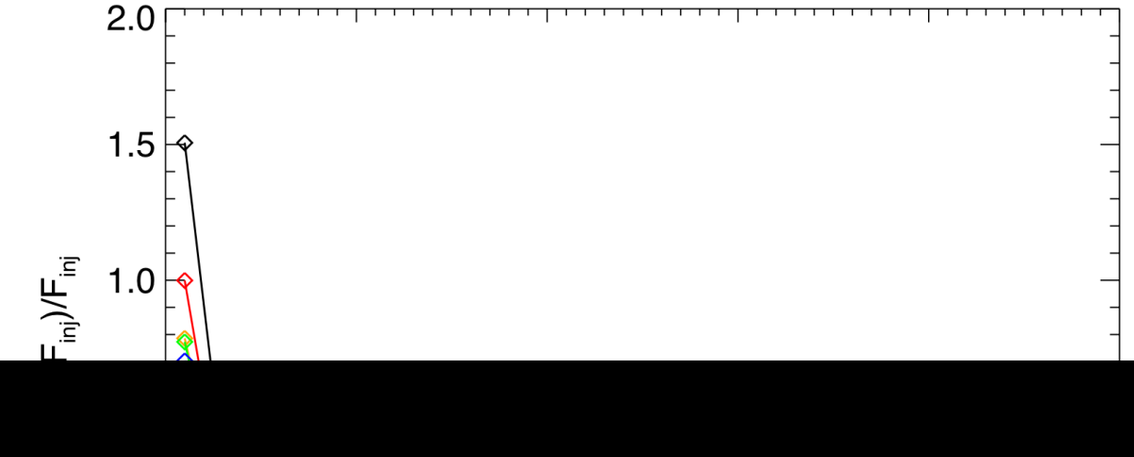


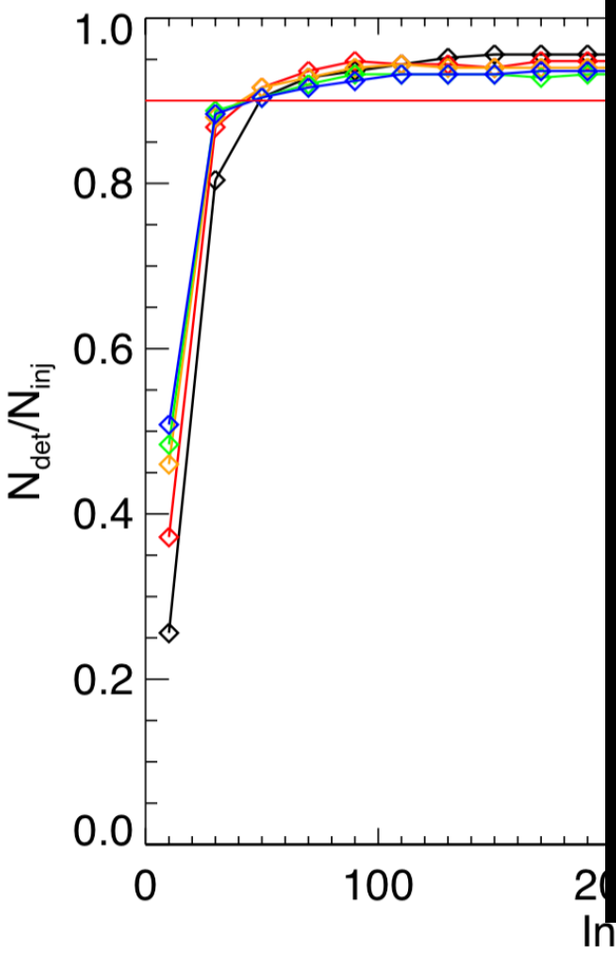


- 30% photometric accuracy reached ~500 mJy (blue) and ~1.5 Jy (red)

PACS source extraction

- Injecting sources into 5 GOODS-S observations
- Nr. of co-added maps: 1,2,3,4,5
- We simulate the depth of observations
- The photometric accuracy increases with the increasing





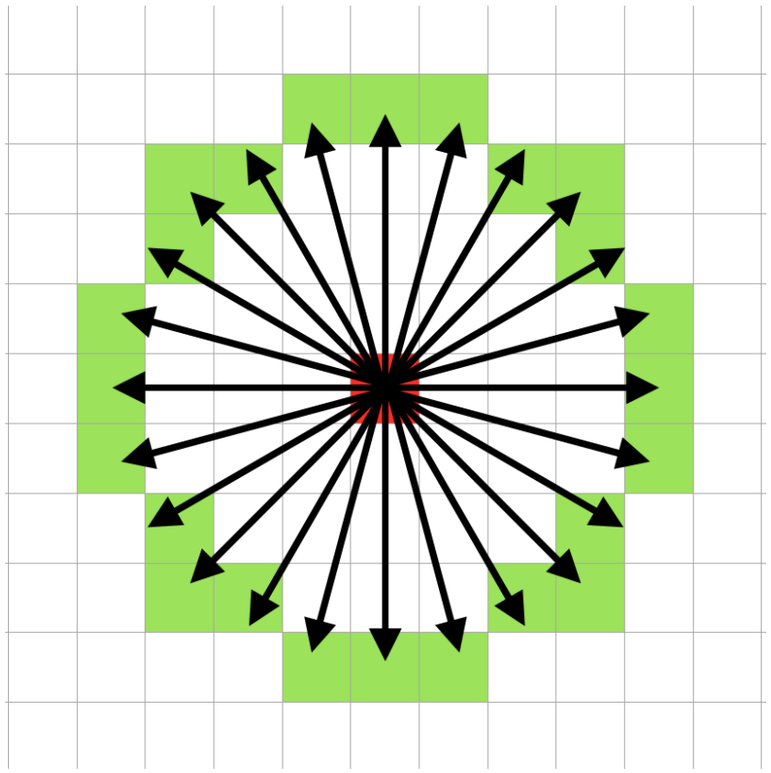
Extraction depends on the

celestial environment and als

on the coverage!

How to describe the environme

Structure noise



- Fluctuation of neighbouring pixels (green) around a given point in the sky (red)
- Can be translated into the power spectrum of the neighbouring areas, but
- Gives a local information
- Describes the close vicinity of each detected source.

, where $d_i = \left| F_{x_t,y_t} - F_{x_i,y_i} \right|$

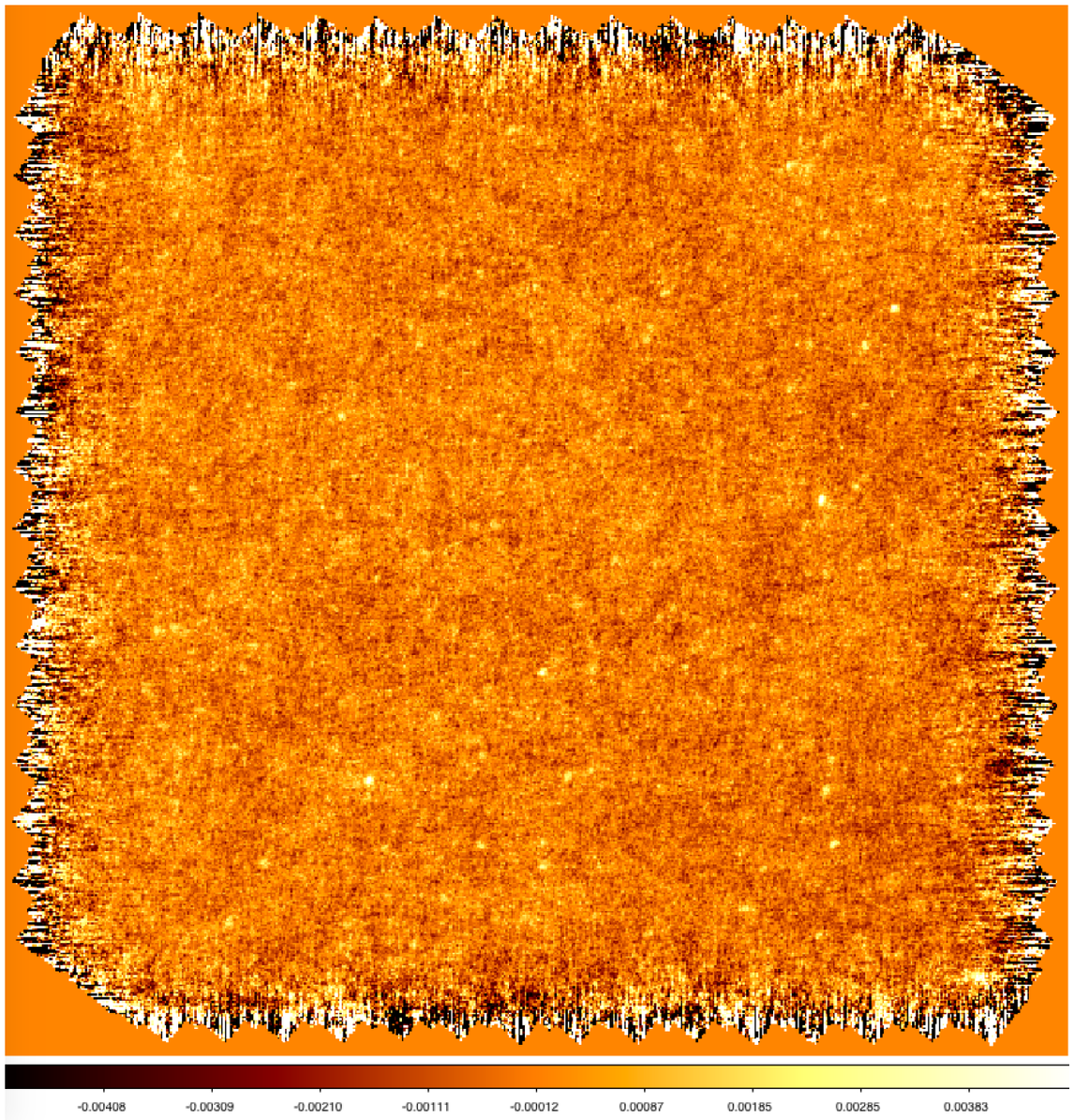
and μ is the mean value of the d_i values.

$$N_S = \sqrt{\frac{1}{24}\sum_{i=1}^{24}(d_i - \mu)^2}$$

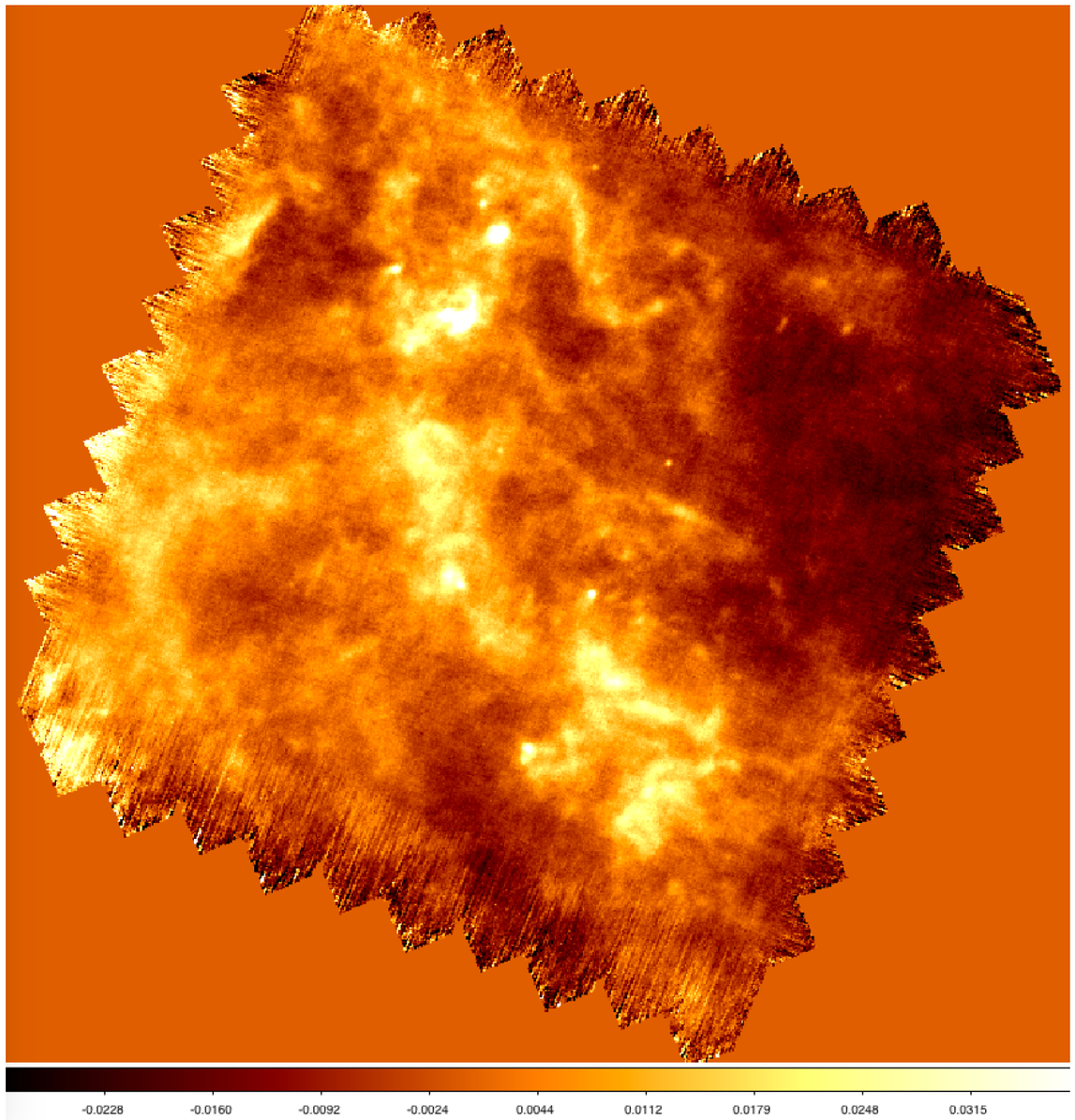
Structure noise

Original maps in the red band

The Lockman Hole (KPGT_dlutz_1)



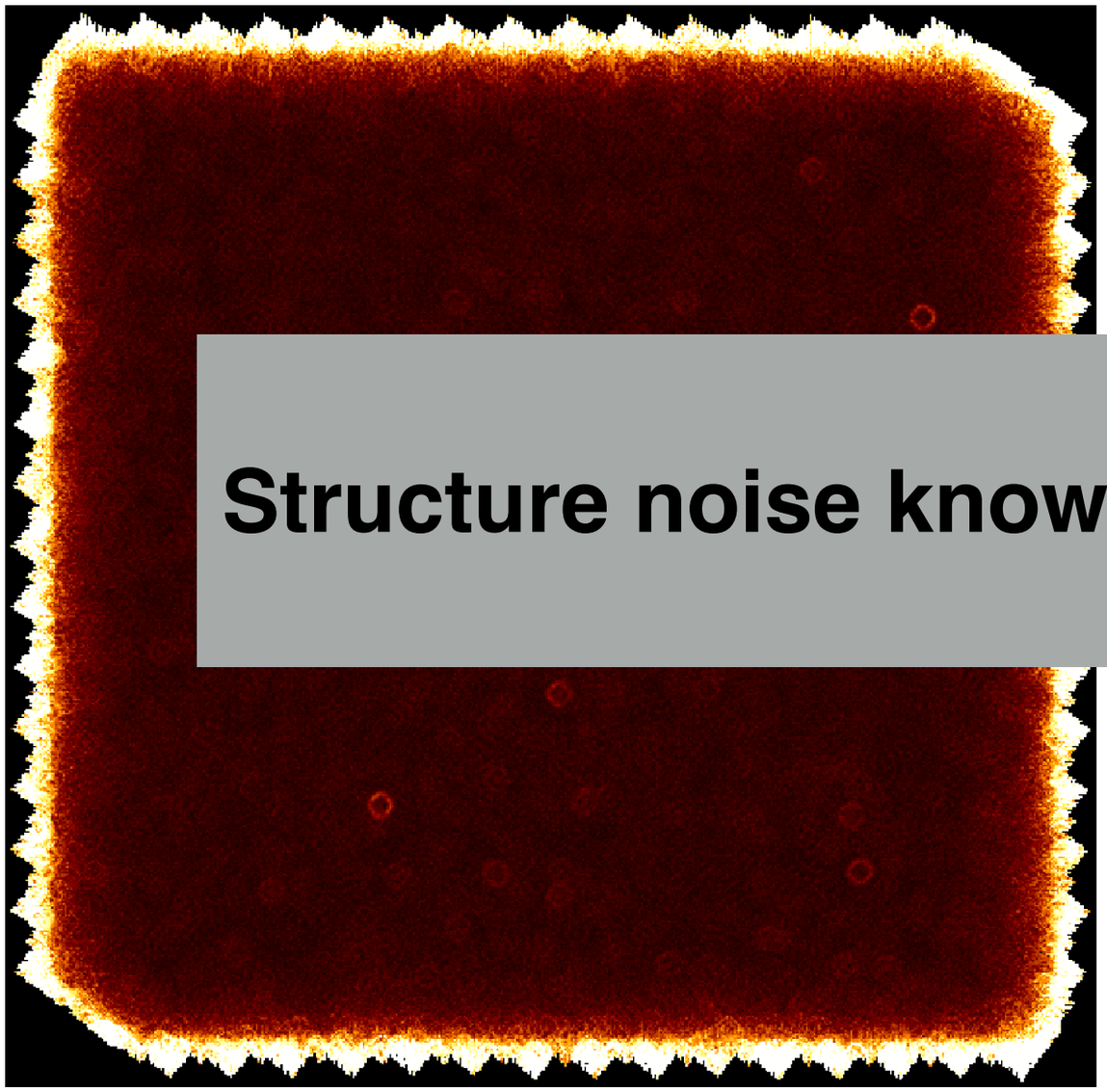
Field G334.65+2.67 (KPOT_mjuvela_1)



Structure noise

Structure noise maps

The Lockman Hole (KPGT_dlutz_1)

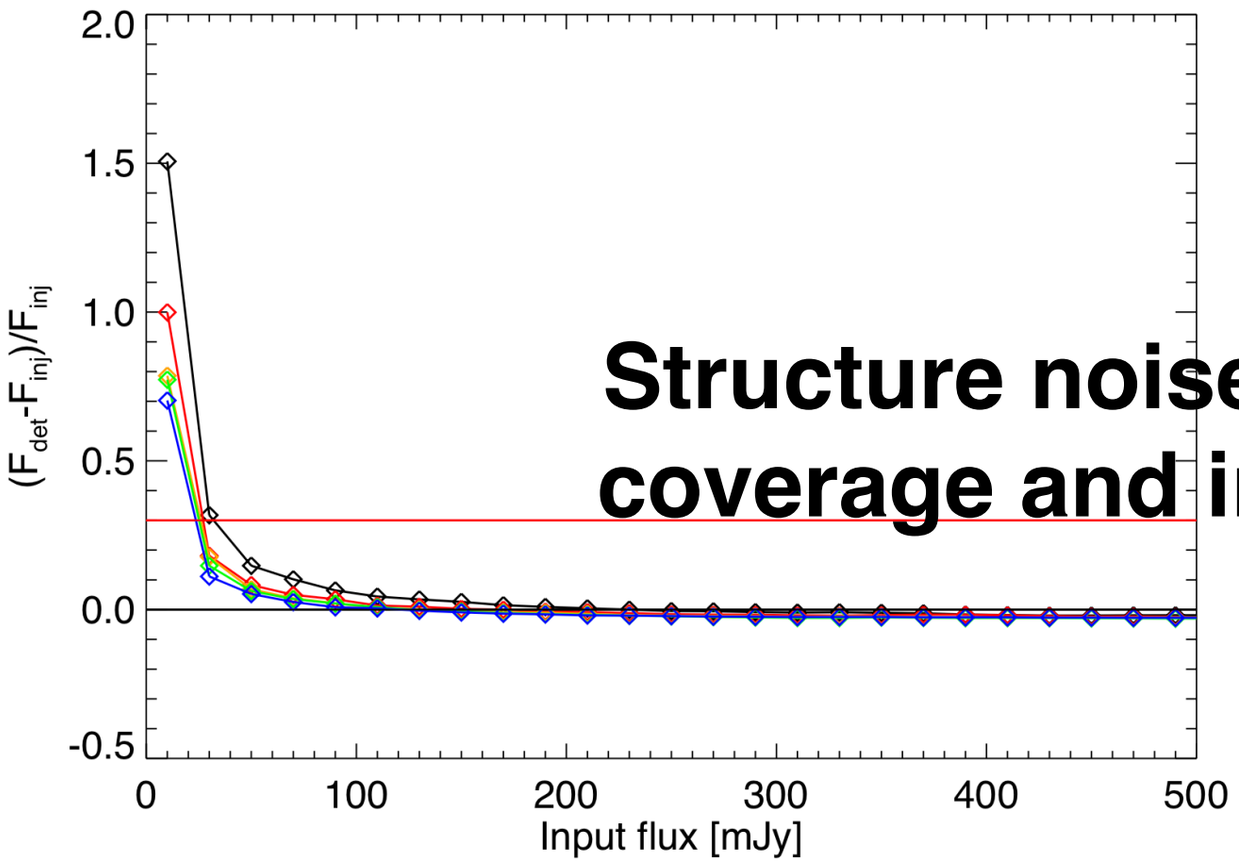


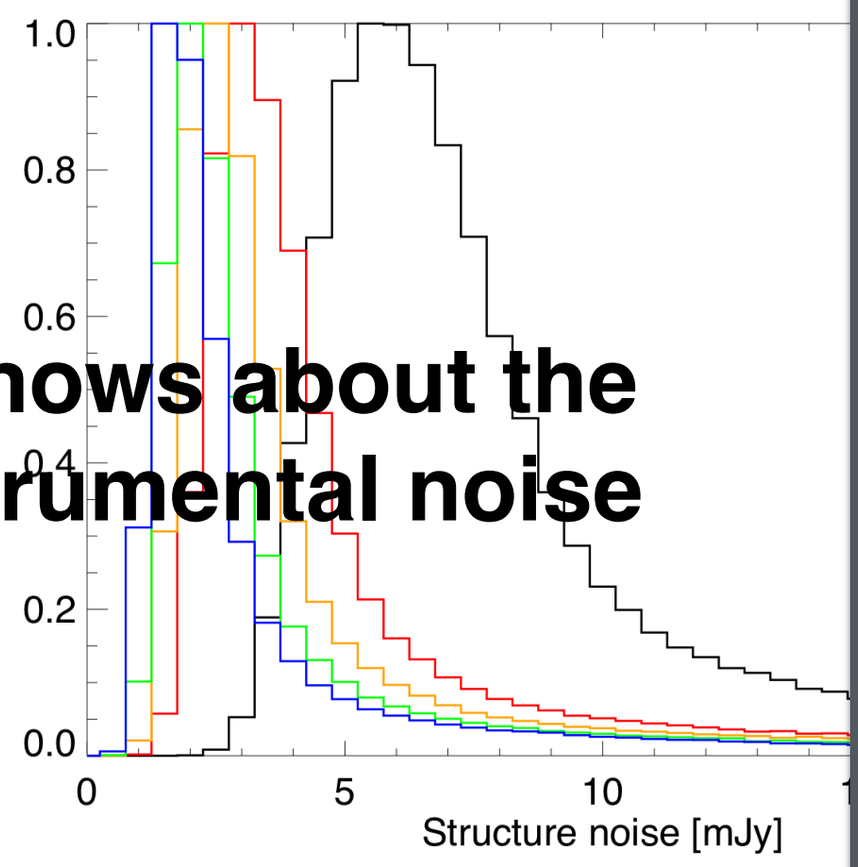
Field G334.65+2.67 (KPOT_mjuvela_1)

Structure noise knows about the environment

Images are shown on the same scale

Structure noise



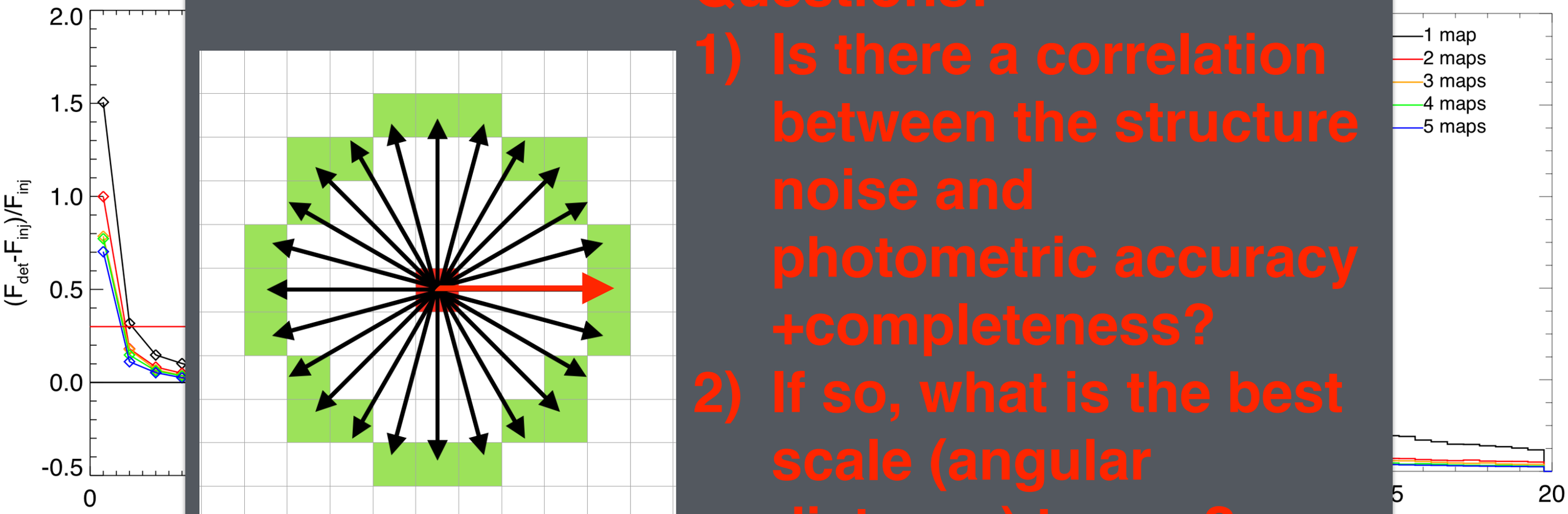


Structure noise knows about the coverage and instrumental noise

Reminder: photometric accuracy (and detectability) increases with coverage, because S/N becomes higher

Structure noise decreases with coverage, because instrumental noise is included

Structure noise



Questions:

1) **Is there a correlation between the structure noise and photometric accuracy +completeness?**
2) **If so, what is the best scale (angular distance) to use?**

Re… accuracy (and detectability) increases with coverage, because S/N becomes higher

…es with coverage, because instrumental noise is included

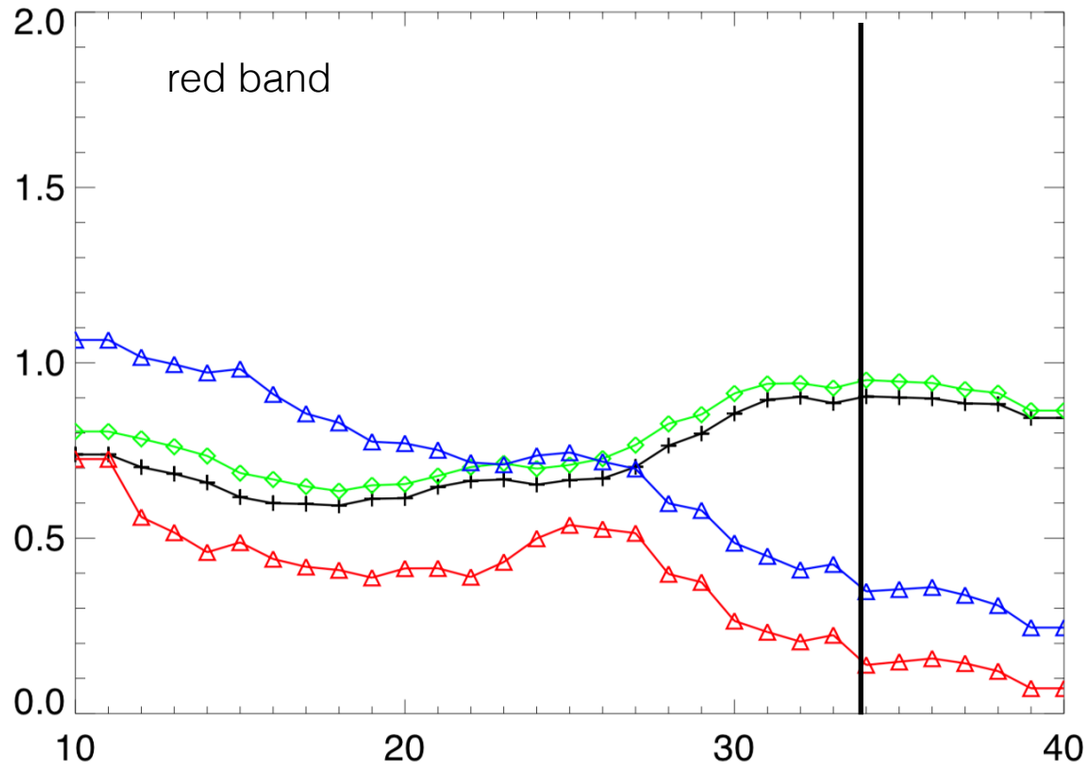
Structure Noise datasets

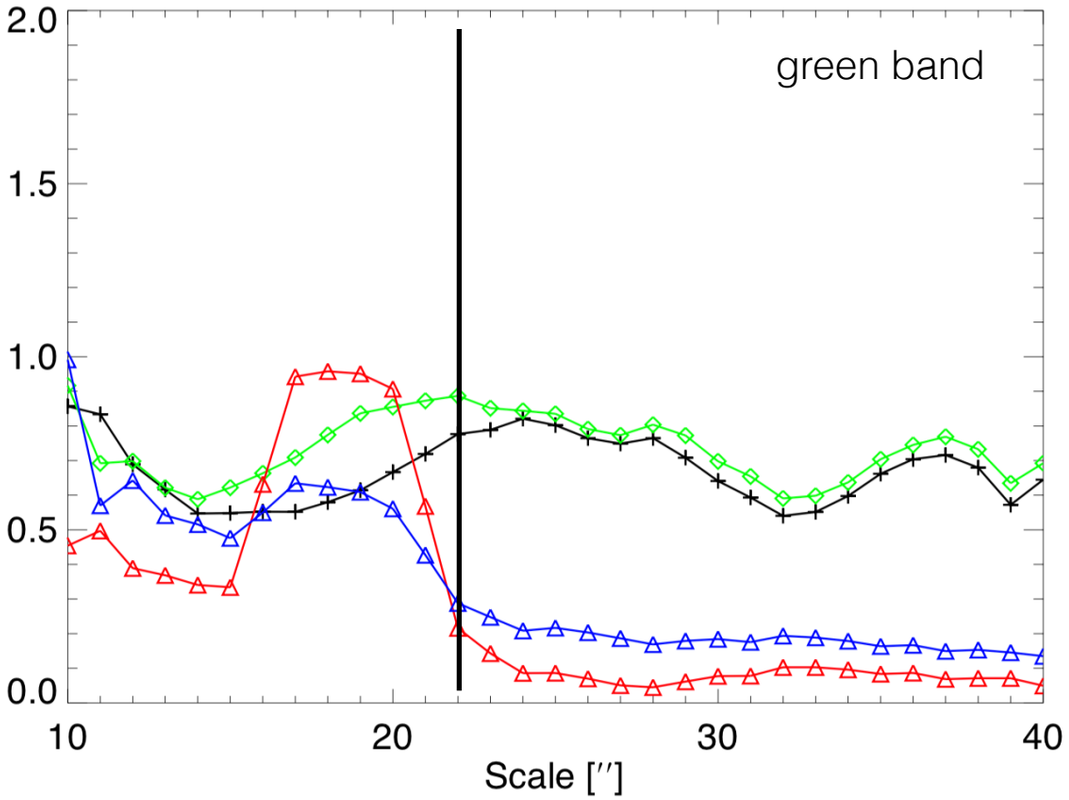
- Goal of the test: to find out which angular scales to use for the structure noise calculation
- Red fields:
  - Rosette - structured
  - RCW120 - structured
  - N6334 - structured
  - LDN1780 - flat with structure in the centre
  - GOODS-S - flat
  - Crab - flat with structure in the centre
- Green fields:
  - G343.64 - small structures
  - G334.65 - small structures
  - GOODS-S - flat
  - AFGL4029 - highly structured
  - LDN1780 - flat with structure in the middle
  - RCW120 - structured
- Blue fields:
  - rho Oph - highly structured
  - GOODS-S - flat
  - N6334 - structured
  - IC348 - structured
  - NGC253 - resolved galaxy, flat, structure in the centre

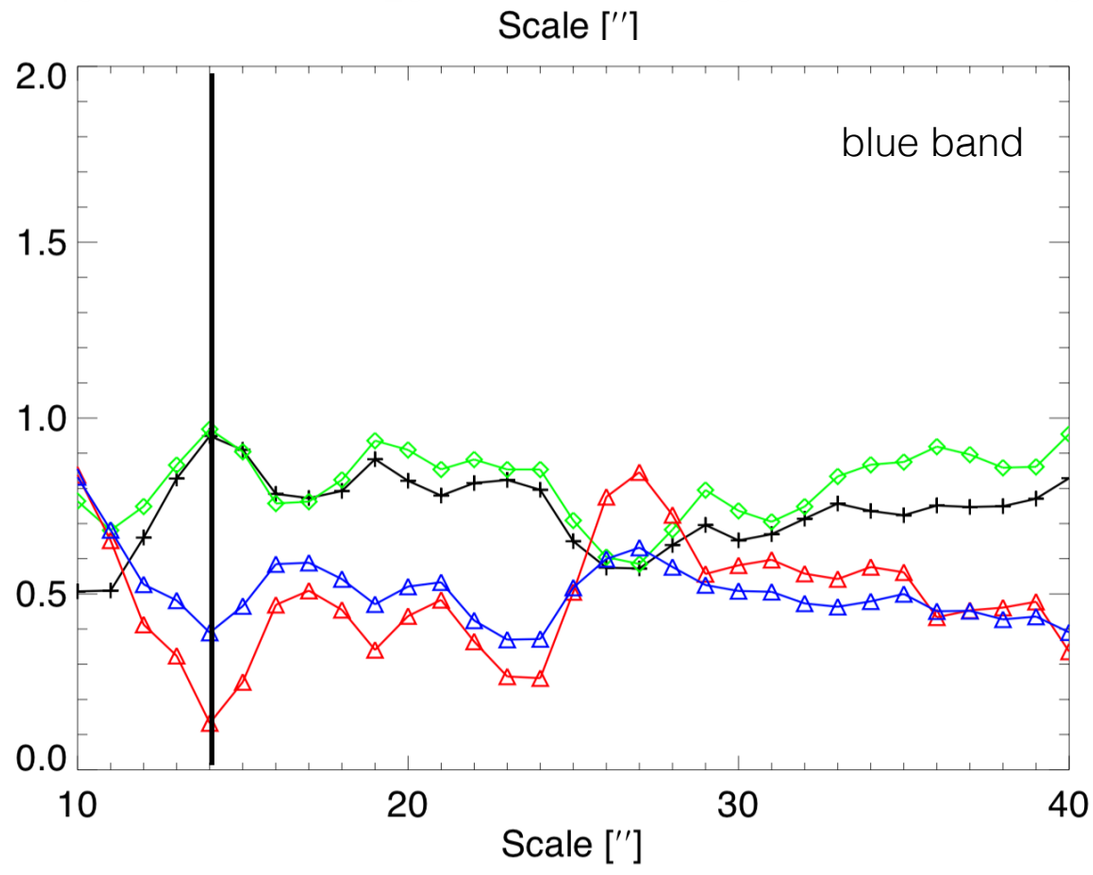
Structure noise calibration

- As a function of structure noise photometric accuracy can be studied - correlation is described with:
- Pearson's correlation coefficient
- Spearman's rank correlation coefficient
- χ^2 value of a 2nd order polynomial fitting
- total 1σ uncertainty of the 2nd order fitting coefficients

These values represent the strength of the correlation between the structure noise and the photometry
In the red band: 34".
In the green band: 22".
In the blue band: 14".

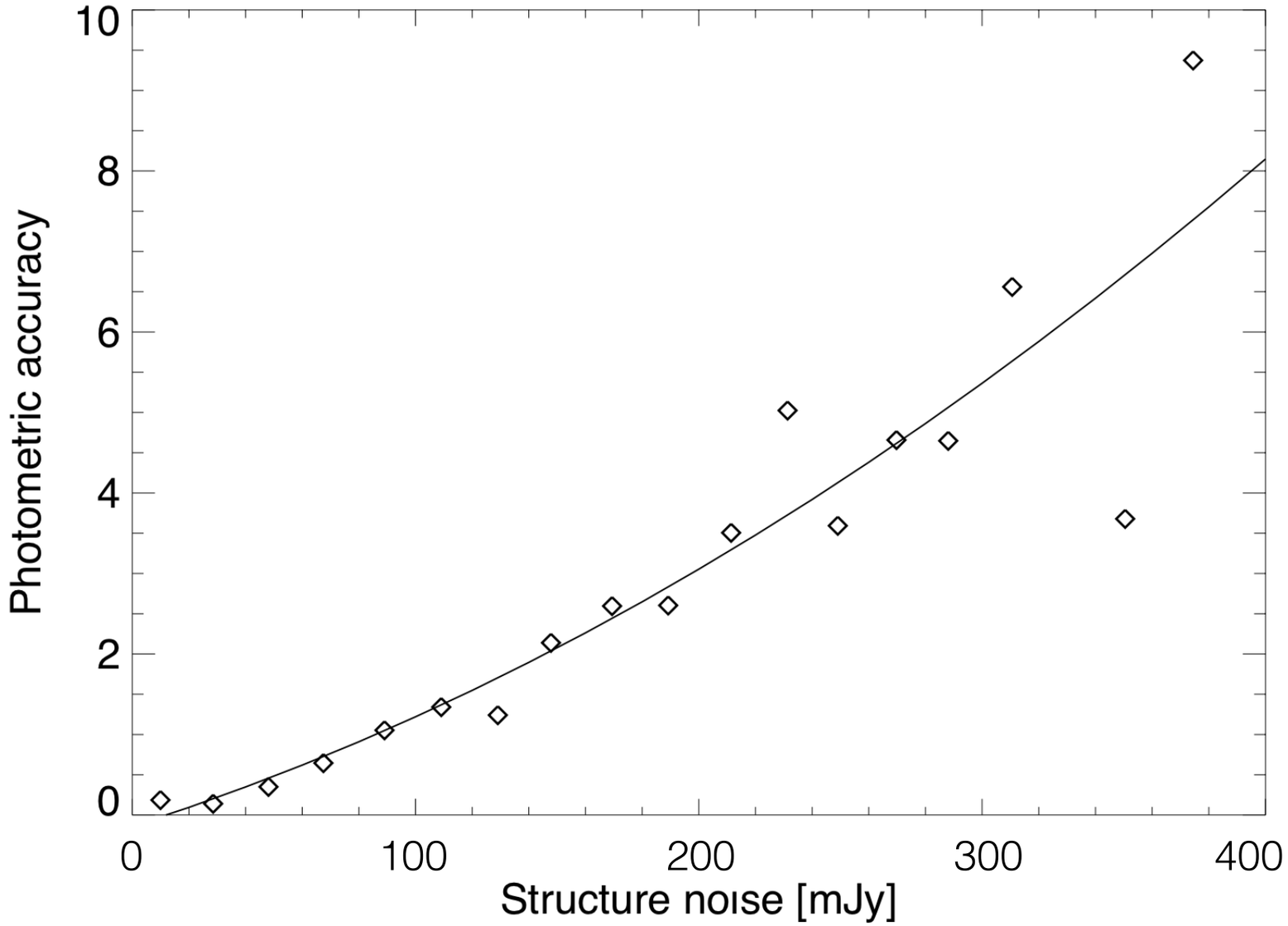






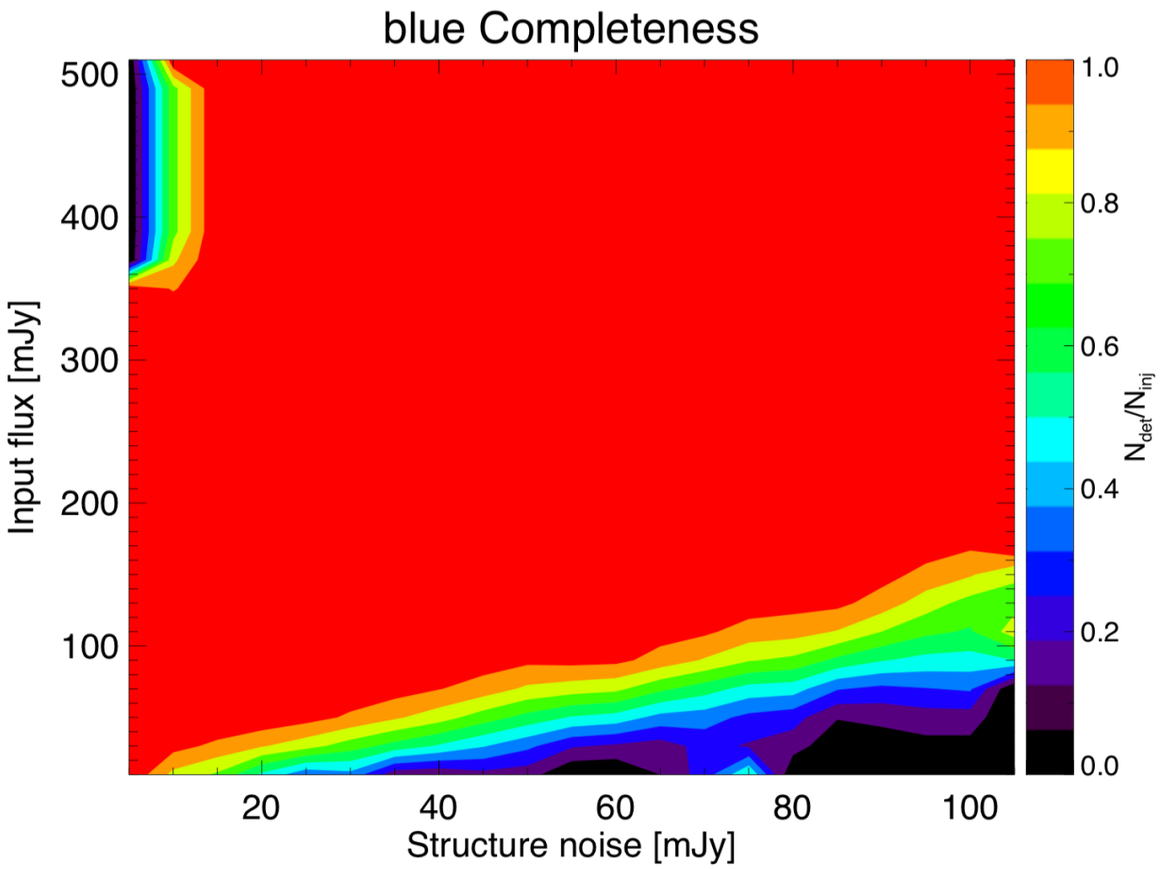
Structure noise calibration

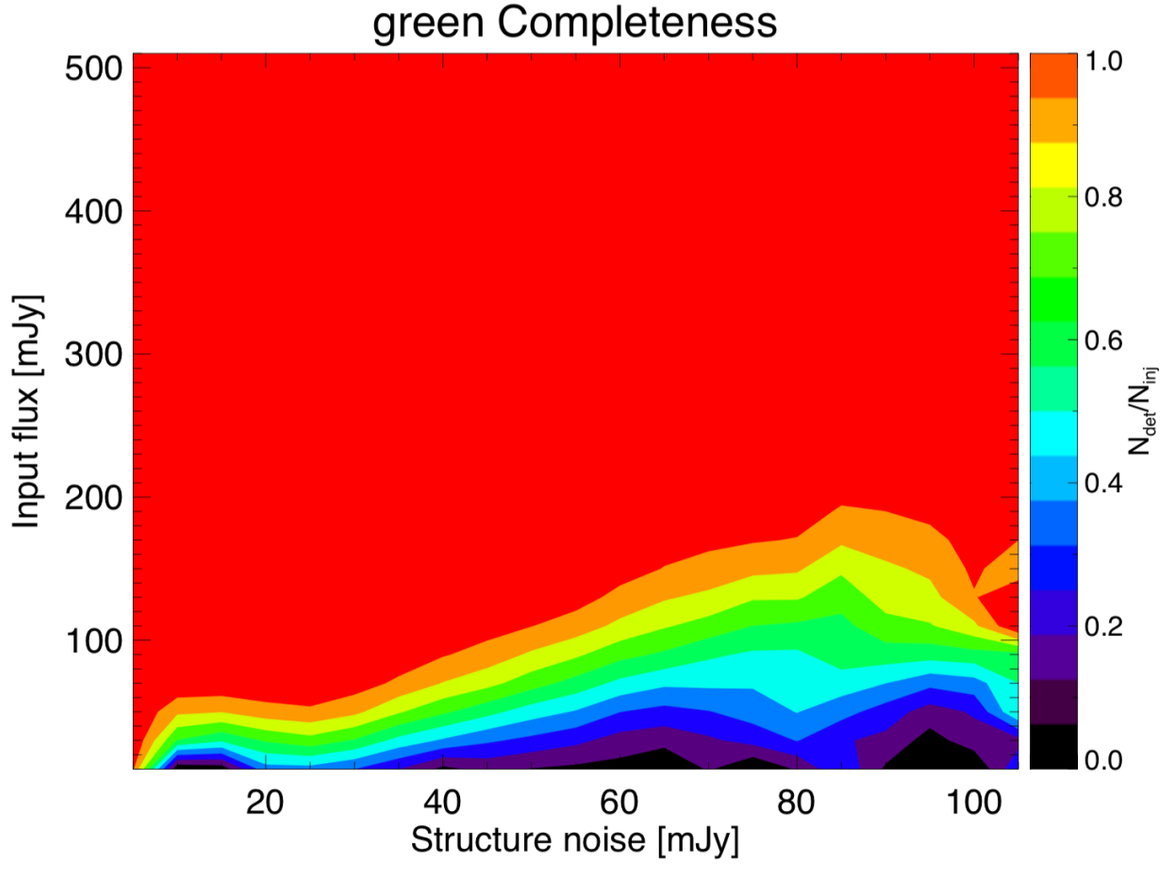
red band



The photometric deviation (1-|F_{obs}/F_{inj}|) as a function of the structure noise on angular scale of 34” in the red band. Each point covers a bin of 1 mJy in the structure noise [mJy/pixel].

Completeness vs. Structure Noise vs. Input Flux

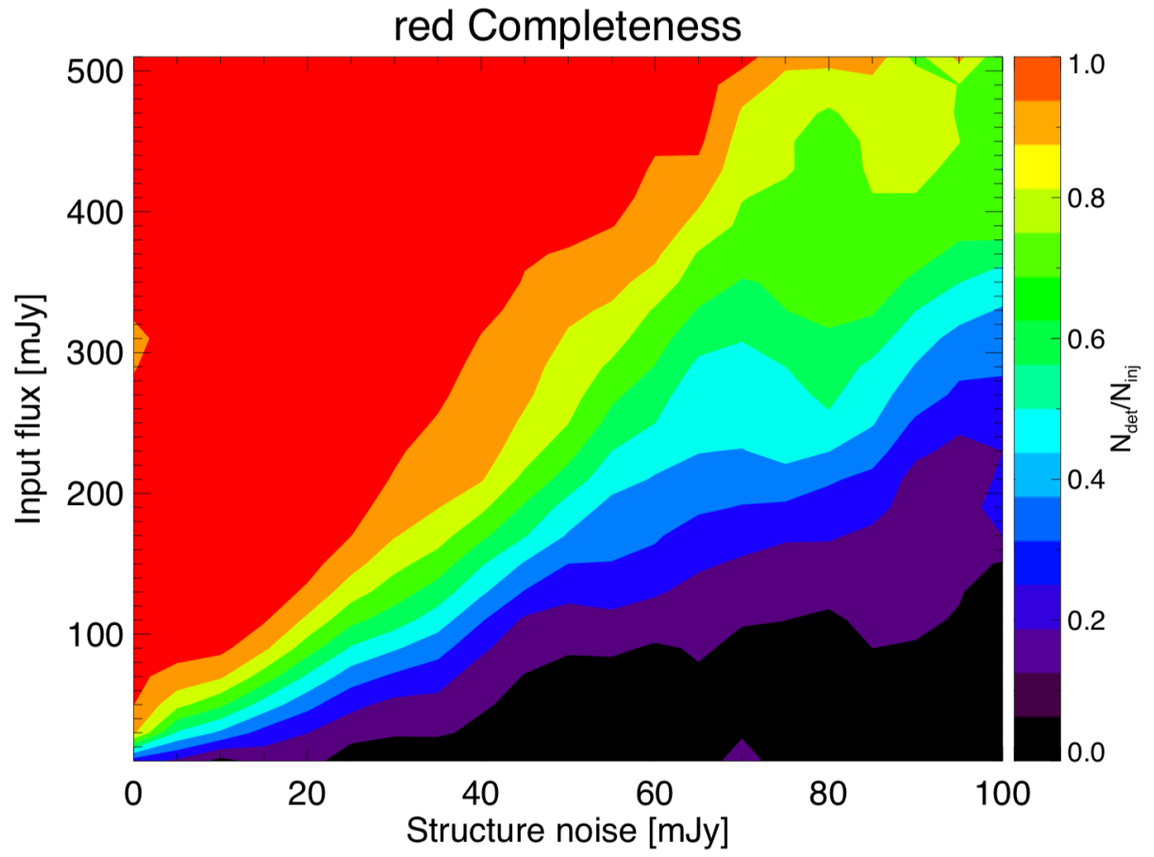




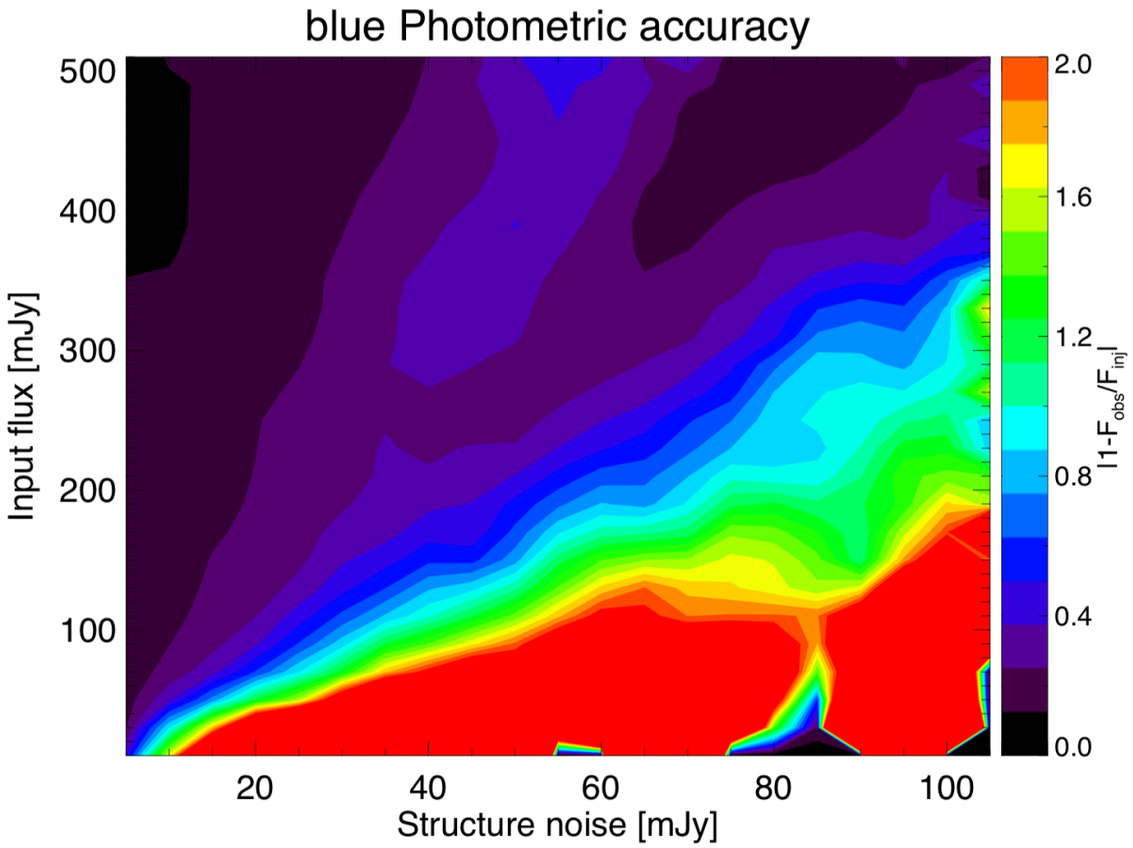
Flux levels: 10 - 510 mJy, interval 20 mJy

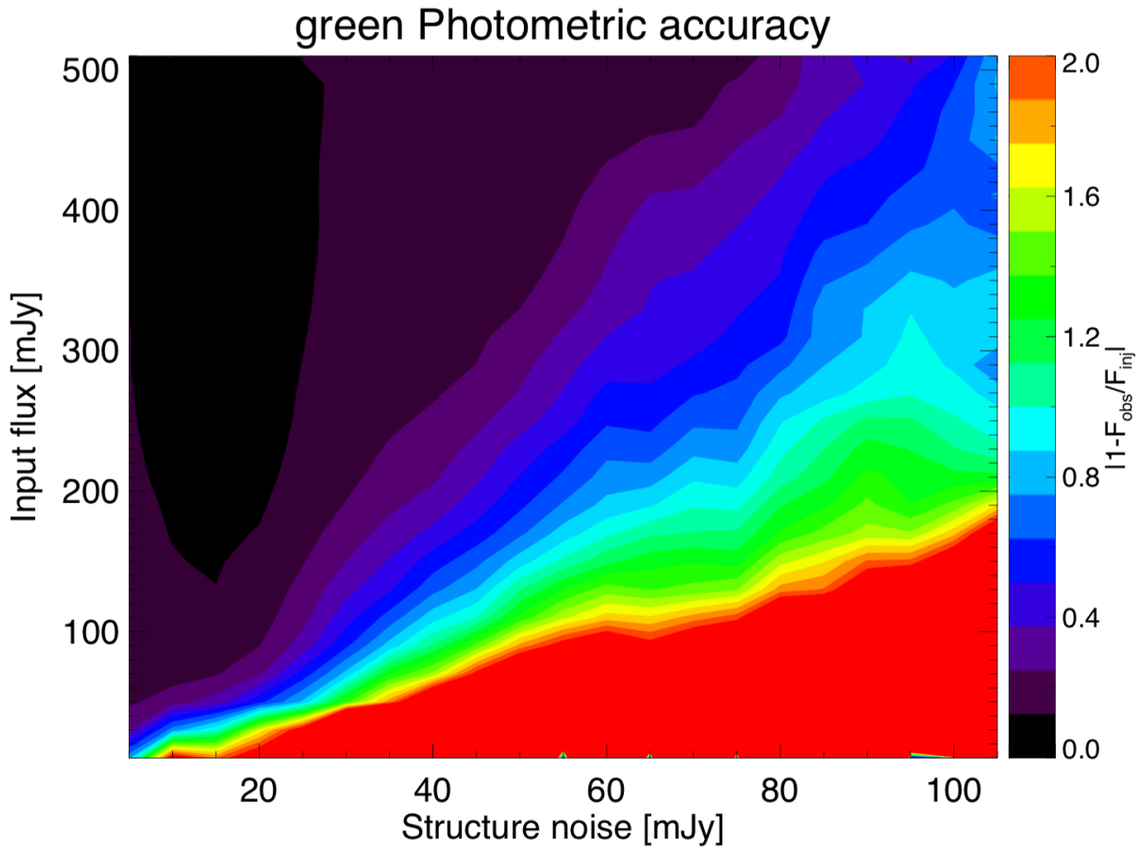
At low structure noise levels sources above 10 mJy can be detected reliably in blue and green, ~30 mJy sources can de detected in red

At high structure noise levels completeness becomes lower



Photometry vs. Structure Noise vs. Input Flux

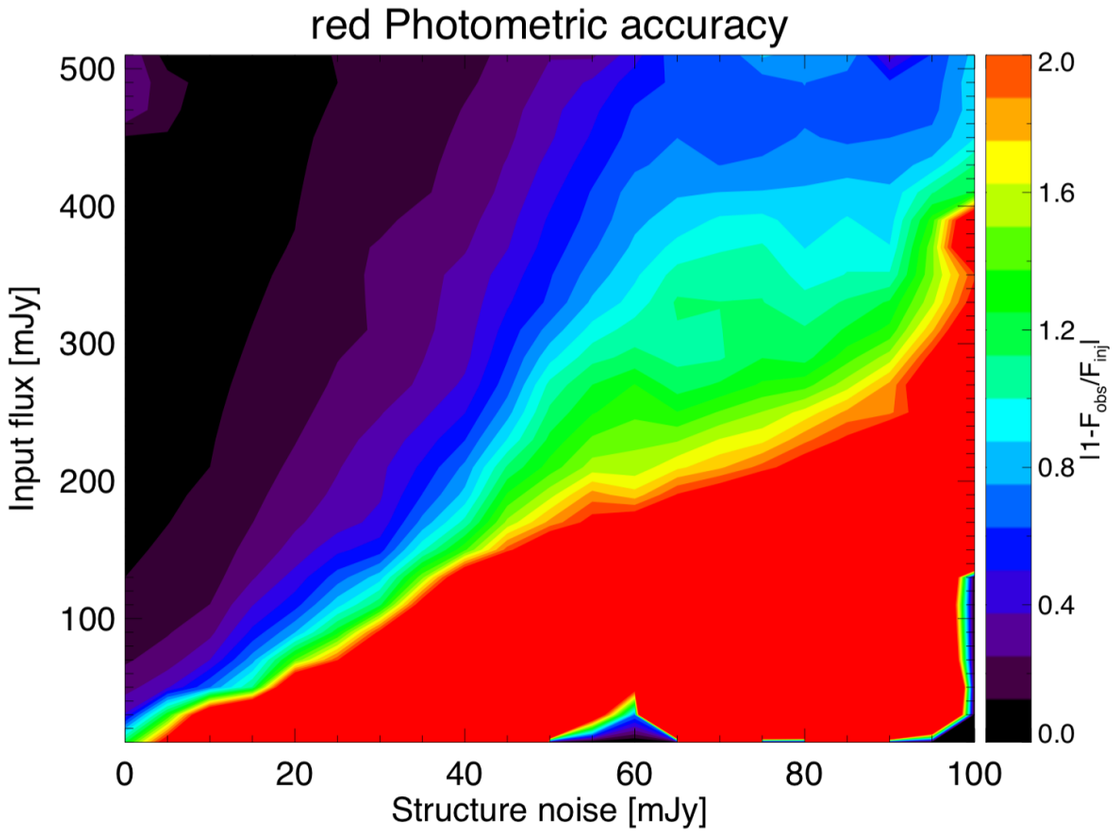




Flux levels: 10 - 510 mJy, interval 20 mJy

At low structure noise levels sources above ~20 mJy can be measured accurately

At high structure noise levels the photometry is not reliable



The PACS point source extraction pipeline

START

Next unprocessed Input map Level3 or 2.5

Detect sources with Sussextractor

Pass source list to Daophot

Attach Daophot results to source list

Calculate structure noise map

Attach structure noise values of each source to source list

Add tables to database

Database

To be continued…

Next talk:

B. Schulz on the SPIRE PSC

Summary

- The possibility and feasibility of a general Herschel/PACS Point Source Catalog was investigated
- The catalogue aims to include data from all PACS scan map observations, which cover about 10% of the sky
- Several methods were tested for source detection and photometry. We selected Sussextractor for source detection and Daophot for photometry.
- A prototype pipeline was created. We use tasks inside the HIPE which allows us to optimise the speed of the process and it is the easiest way to access the Herschel data
- The completeness and photometric accuracy was tested in different celestial environments
- Calculating the structure noise for each source is an excellent way to determine whether the photometry of the sources are reliable or not
- The main benefit for the astronomy community is a well-characterised far-infrared point source catalog including homogeneously extracted sources

- TIMESCALE of tasks - in general, we are doing our best
  - E2E testing: end of April
  - Source extraction from all maps: before summer break
  - Quality assessment: fall of ’15
  - First release: before the end of this year

Acknowledgement: SPIRE PSC WG: B. Schulz[2], K. Xu[2], T. Lim[3], I. Valtchanov[3], N. Lu[2], D. Shupe[2], A. Papageorgiu[4], J. Rector[2], C. Pearson[5]

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