Optimal Flux Estimation for Mispointed PACS observations

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We present a method to derive accurate flux densities for observations with large pointing errors, which affected some of the Taurus observations in the GASPS OT key program. Sincethe continuum emission is unresolved in all sources (except T Tau), we can use thecontinuum to find where we were pointed. For this we use the the observed continuum levelin all 25 spaxels and theoretical PSFs to do a least squares fitting to find the true position of the star. Once the pointing offsets are known we compute the fraction of the flux predicted by the theoretical PSF in each spaxel. We then calculate an optimal flux value via an error weighted average for spaxels with a S/N > 5. Comparison with well pointed observations confirm that the method is accurate. Furthermore, pointing offsetsobtained with this method agree with those obtained from completely independentphotometry observations. This is to be expected, because when large pointing errors wereobserved, they were systematic and repeatable.

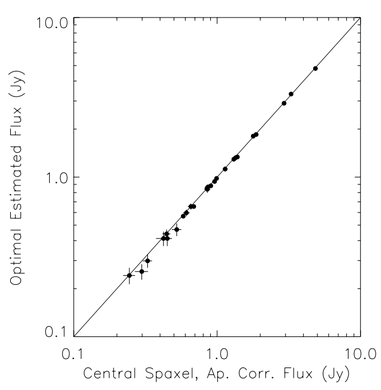
Three-step process:

- Simulate the observations for a range of offsets:
  - Model PSF (http://pacs.ster.kuleuven.ac.be/pubtool/PSF) for the appropriate λ
  - Position in spacecraft coordinates of each spaxel relative to central spaxel
  - Step the spaxel array across a PSF (step size is selectable; we used 0.5")
  - For each offset (y and z spacecraft coordinates), compute the fractional flux (p_i) in each spaxel, as well as flux relative to maximum
  - Output is a file containing fractional and relative fluxes in each spaxel for each offset position
- Determine the offset of the source from the central spaxel:
  - Perform least squares fit between observed continuum fluxes (f_i, σ_i) in each spaxel (relative to the maximum value) and those for each offset to determine best offset value
- Compute the total source flux using:
  - Best fit spatial offset (y and z)
  - Fractional fluxes (p_i) computed above for the specified offset
  - 'Optimal' calculation (weighted mean) including ***all*** spaxels (n) with S/N above some threshold limit (usually 5):

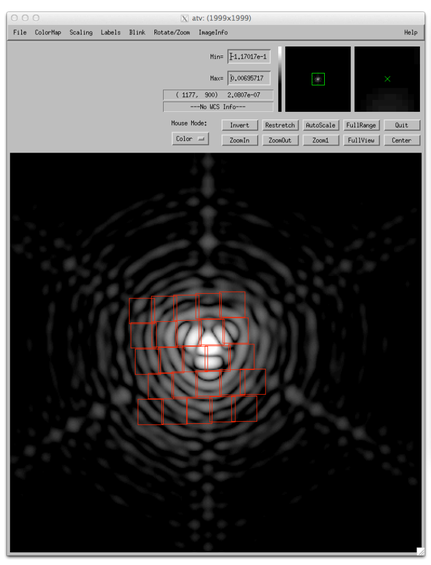
$$F_{opt} = \frac{\sum_{i=0}^{n} w_i \bullet f_i}{\sum_{i=0}^{n} w_i} \quad ; \quad \sigma_{opt} = \left(\sum_{i=0}^{n} w_i \right)^{-0.5} \quad ; \text{ With weights given by } \quad w_i = \left(\frac{p_i}{\sigma_i} \right)^2$$

Testing

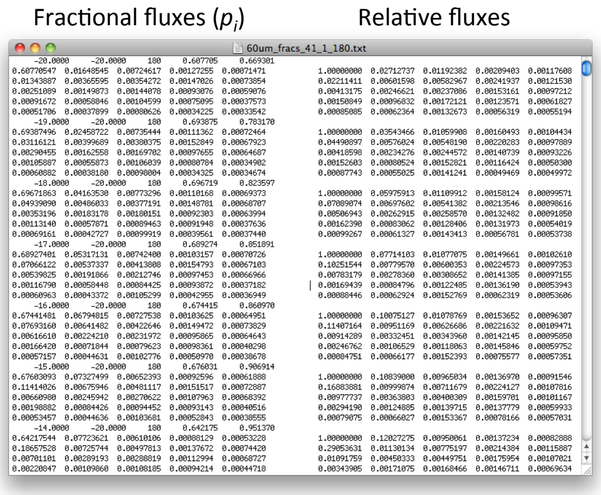
- For sources well-centered (< 3.5" from center) in a single spaxel, the method gives fluxes consistent with HIPE reductions and aperture corrections:
  - Mean Diff = 17 mJy
  - RMS Diff = 21 mJy
- Positional uncertainties of 1σ ≤ 0.5"
- Offset positions for same source at different wavelengths agree to within ~1"
- Optimal fluxes have relatively small uncertainties (~50 mJy)



Simulated Observations



Fractional fluxes (p_i) Relative fluxes

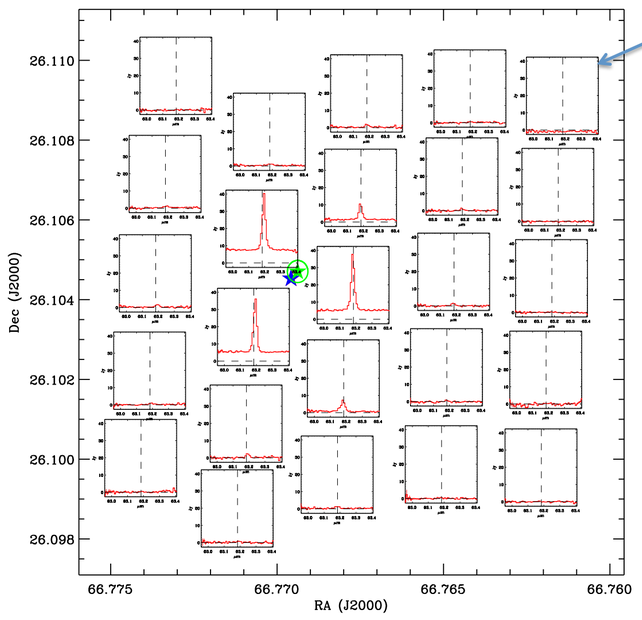


IDL codes pacsfracsim.pro & getfracs.pro used to generate output file of model fluxes and hersch_phot.pro for determining spatial offsets (via χ^2 minimization) and optimal flux and error estimates.

Multiple Sources

- Method can also treat multiple, well-separated sources
- Weights of spaxels corresponding to second source are set to zero and position and flux of primary source is determined
- Repeat to determine position and flux of second source

Example

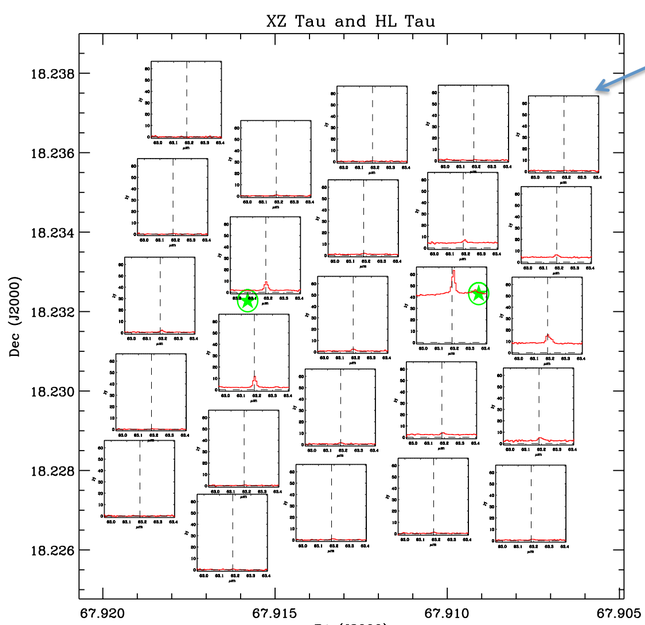


Spaxel projected onto sky

Note relative continuum levels, not line strengths

★ est. pos. with 1" unc.
★ Simbad position

Example



Spaxel projected onto sky

Note relative continuum levels, not line strengths

★ est. posns. with 1" unc.