Technical Note on Cube Interpolation Validation

Elena Puga

26 November 2014

Abstract

Validation summary for specInterpolate, a new gridding algorithm to be used with undersampled PACS spectral cubes (like pacsRebinnedCube) to produce a regularly gridded cube. The flux conservation validation has been performed on a point source observation of RDor OBSID=1342246386.

1 Relevant JIRA tickets

- HCSS-15474: suggestion to use http://www.cs.bgu.ac.il/~benmoshe/DT/Delaunay%20Triangulation%20in%20Java.htm. Elena Puga imports external .jar http://www.cs.bgu.ac.il/~benmoshe/DT/DT1.2.jar into HIPE and demonstrates applicability for pacsRebinnedCubes.
- PACS-5345: introduction of package herschel.pacs.share.jdt in pacs_share, including the necessary classes to run the Delaunay Triangulation.
- PACS-5364: creation of task specInterpolate.

2 Implementation of specInterpolate

`specInterpolate` makes an extension of `specProject` to make use of all its functionality, but changes the projection gridding algorithm by the class `SpecInterpolationMapper` that implements the Delaunay Triangulation method. It is also located in `herschel.pacs.spg.spec`

3 Validation strategy for Point Sources

Comparison for oversampled (5×5 $2''\!.5\times2''\!.5$) cubes:

- Drizzle (flux reference and reference for map pixel grid) $pixelSize_d = \frac{FWHM_{\mathrm{fit}}(\lambda)}{(oversample \times upsample)}$
- SpecProject $pixelSize_p = pixelSize_d$
- SpecInterpolate $pixelSize_i = pixelSize_d$

Comparison for undersampled cubes (taking only central raster position of 5×5 map):

- Drizzle (flux reference from oversampled map)
- SpecProject $pixelSize_p = 4''\!.7$
- SpecInterpolate $pixelSize_i = 4''\!.7$
- Central spaxel spectrum + Point Source Correction

4 Footprints

When comparing the different gridding algorithms, the spectral maps footprint differ because specProject can reach as far as there is an overlap of one spaxel with the fiducial grid. However, since specInterpolate does not extrapolate outside of the irregular triangles created spatially by the Delaunay algorithm, the footprint is smaller. Even using the WCS generated by specProject in the parameter `outputGrid=myWcs`, specInterpolate will respect the input WCS, but place NaNs differently. The difference is not much for oversampled spectral cubes, but it is significant for undersampled cubes (pacsRebinnedCube).

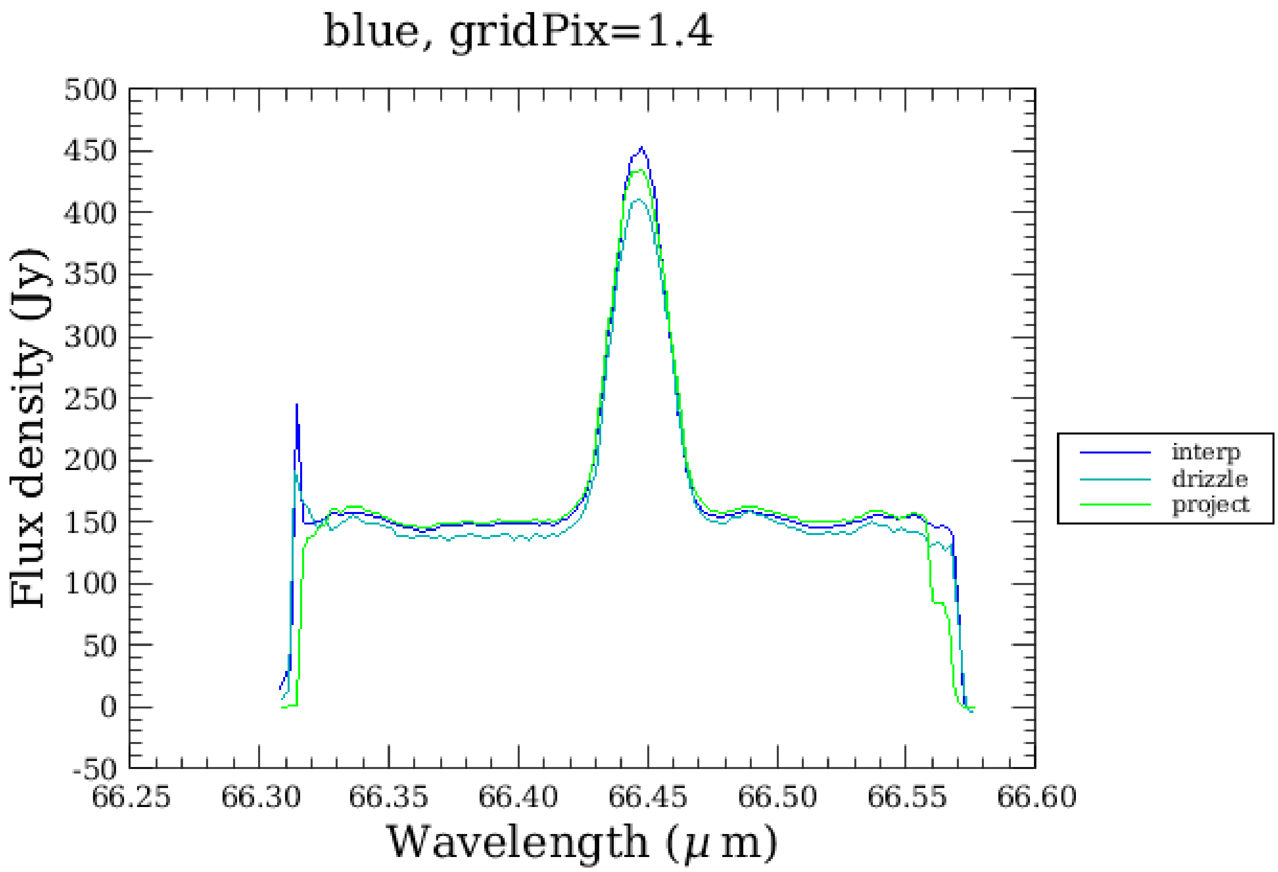

Figure 1: Extracted spectra over entire field-of-view of oversampled spectral cube using same grid pixel size $1.''38$ for the three gridding algorithms.

5 Flux conservation testing and validation

specInterpolate and specProject have the parameter `conserveFlux` to ensure that the total flux in the map is conserved when changing the spaxel sizes. `conserveFlux=True` (default) is equivalent to

$$fluxcons = \frac{9.2 \times 9.2}{(cdelt1 \times cdelt2 \times 3600. \times 3600.)} \tag{1}$$

5.1 Oversampled cubes (Point Sources)

- The comparison of extracted spectra in a sufficiently large aperture (i.e. the entire field of view) shows very good agreement between the three gridding algorithms. Slight differences are expected considering that the footprints of the maps are slightly different (see Fig. 1).

5.2 Undersampled cubes (Point Sources)

- The comparison of extracted spectra over the entire field of view for the specProject and specInterpolate cubes, using only the central raster position of the spectral map (undersampled map), shows good agreement, also when comparing to the extracted spectrum of the central spaxel, with point source correction (using c1 of extracCentralSpectrum)

- The comparison between the previous extracted spectra (for undersampled cubes) and the extracted spectra of the oversampled drizzled cube shows a large discrepancy of 20% in total line flux (see Fig. 2)

  An intermediate check with Nyquist sampled spectral cubes constructed with a sub-collection of the 25 raster positions [0,4,20,24], and [0,4,12,20,24] reveals that the extracted spectra converges toward the extracted spectrum of the drizzle oversampled spectral map [0...24]. See Fig. 3.

  This is understood when considering the field-of-view homogeneity raised during the beam characterization. At 66 microns, offsets of $2.''5$ away from the central spaxel cross several contours that correspond to a signal dropping of 10% of the peak value. An additional test to confirm this is the spectra extraction over the entire

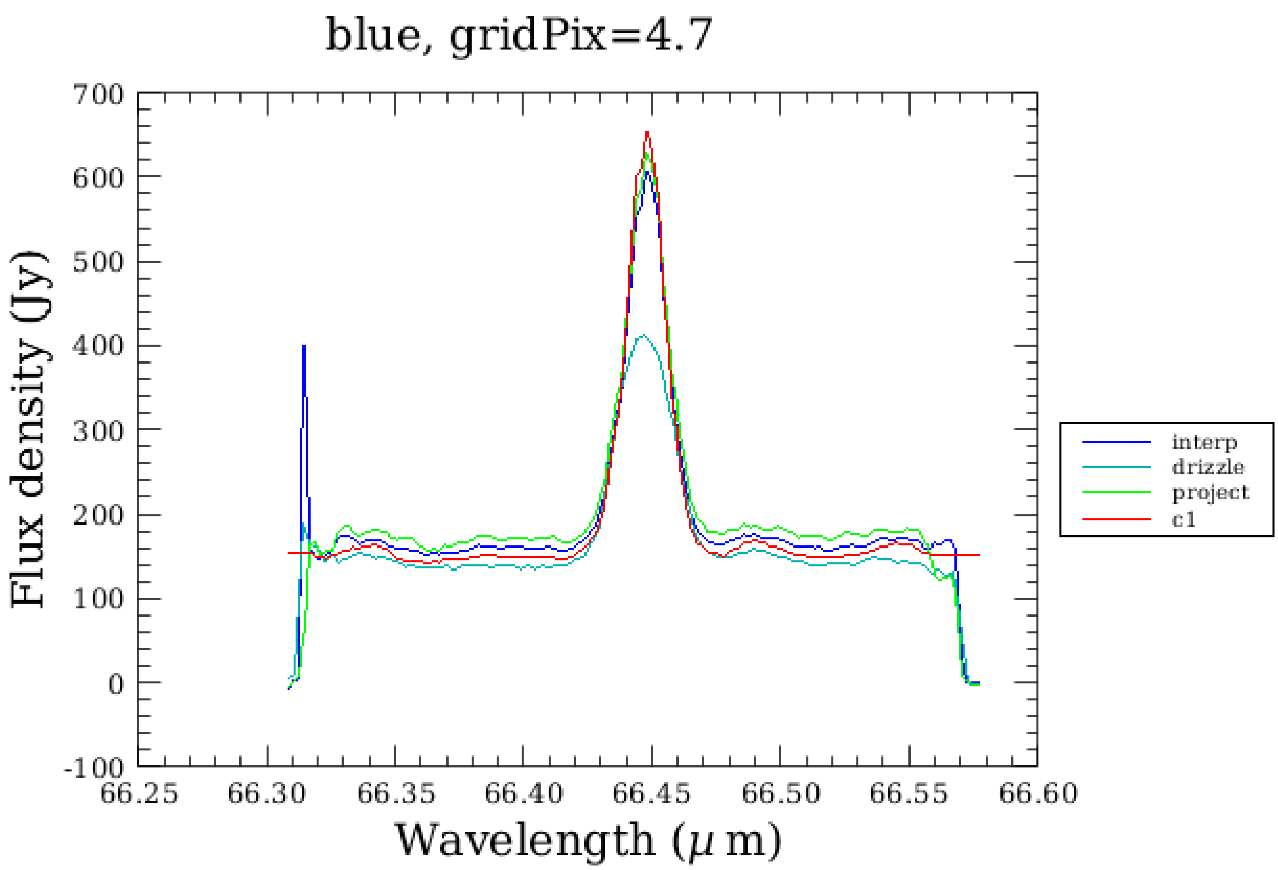

Figure 2: Extracted spectra over entire field-of-view of undersampled spectral cube (raster position [12]) with a grid pixel size 4.″7 for specProject and specInterpolate. Also, extracted spectrum of the central spaxel with point source correction. We also display the extracted spectrum over the entire field-of-view of the oversampled spectral cube obtained with drizzle for comparison.

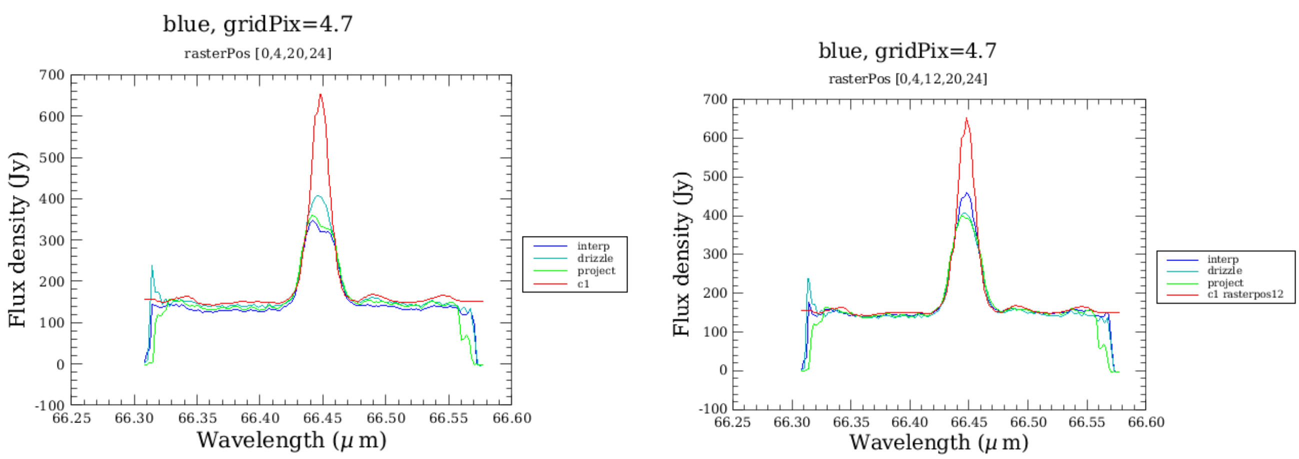

Figure 3: Comparison of extracted spectra over entire field-of-view for different Nyquist sampled spectral cubes. As more raster positions are included, the behaviour of specInterpolate and specProject on the spectral cubes gets closer to that of the oversampled drizzled spectral cube.

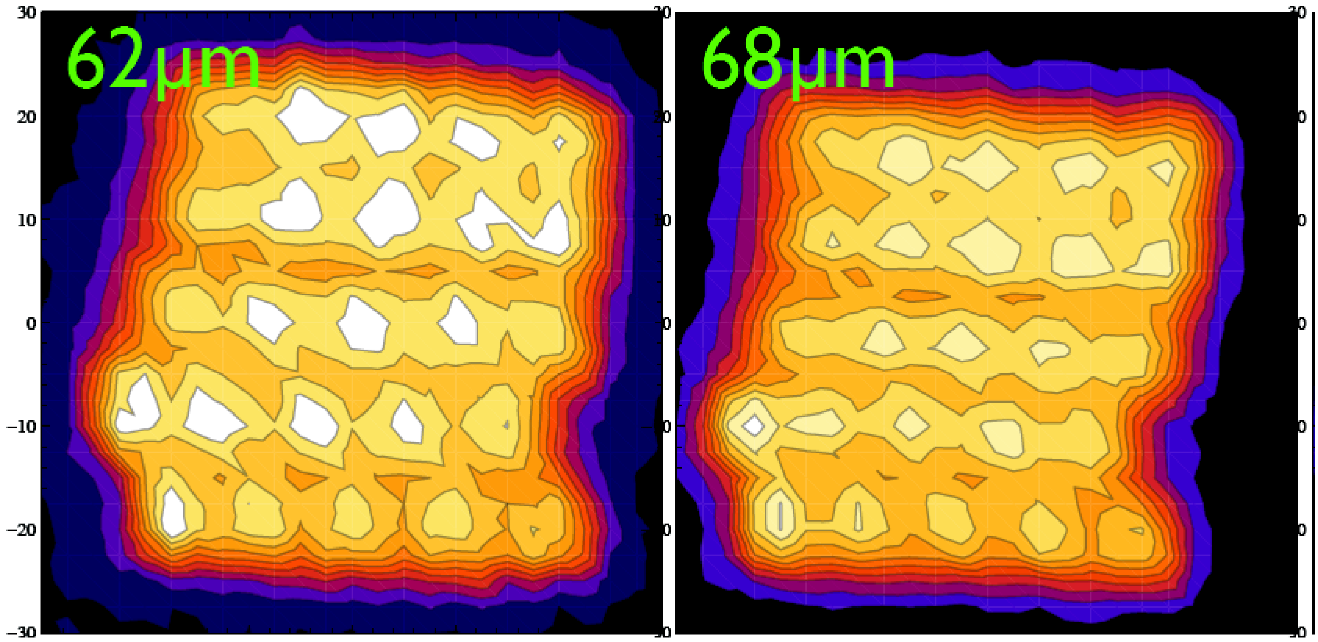

Figure 4: Field-of-view inhomogeneity at the closest wavelengths.

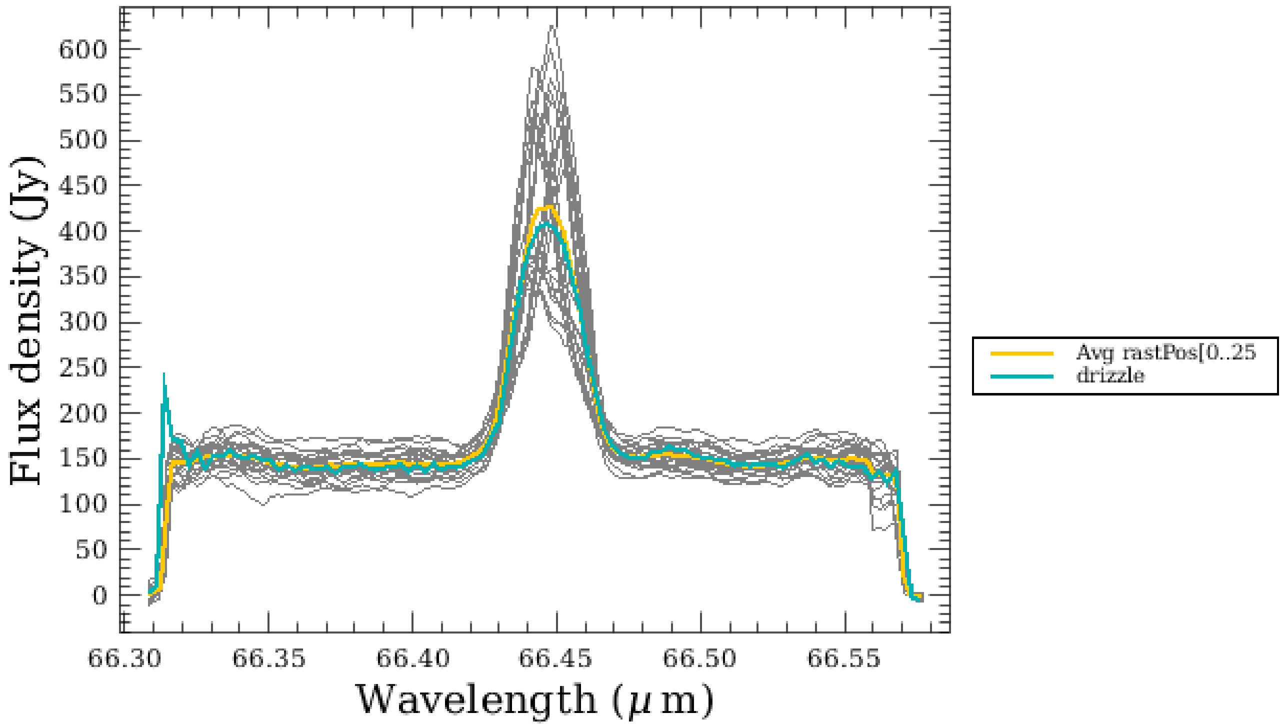

Figure 5: Gray: Extracted spectra over entire field-of-view of the 25 pacsRebinnedCubes in the spectral map. Orange: Average spectrum of the gray spectra, green: extracted spectrum over the field-of-view of the drizzled spectral cube.

field-of-view for each pacRebinnedCubes that conform the spectral map (25 raster positions). The average of these spectra is consistent with the extracted spectrum of the oversampled drizzle spectral cube.