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DOCUMENT

PACS Spectrometer Beams as Ancillary Data Products: release notes

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1 INTRODUCTION

The PACS spectrometer beam efficiencies are maps of the response of each detector on the sky. They describe the (relative) coupling of a point source to each spaxel as a function of its (the source) position in the 60" field-of-view.

2 DESCRIPTION OF THE ANCILLARY DATA PRODUCTS

2.1 Scope and method for the product generation

In order to characterise the PACS Spectrometer beam, an assembly of Neptune raster maps were observed throughout the mission:

- 1 Coarse 40x40 raster map at 62 μm, asymmetric chopping, step size 2.5", at chopper position 0.
- 7 Coarse 25x25 raster maps, asymmetric chopping, step size 2.5", at chopper position 0.
- 32 Fine 5x5 raster maps, asymmetric chopping, step size 2", at 4 positions offset by 1", covering only the central spaxel, at chopper position 0.

The data were processed using the telescope background normalisation scheme to obtain the telescope-normalised signal per spaxel in its asymmetric-chop flavour. The synthetic beam efficiencies were constructed at each wavelength merging the coarse- and fine-grid data. The final beam efficiencies were normalised so that a point source of flux 1 at the centre of spaxel 12 has an integral of the instrument response equal to 1. Details of the processing are provided in Spectrometer Beam Profile Section in the PACS Handbook, and in HERSCHEL-HSC-TN-2117

The beams coordinate reference system y,z is defined with respect to the centre of the beam in the central spaxel. The WCS associated with the beam .fits image extension is in sky coordinates for position angle 0 and the pixel angular size is 0.5 arcsec. With a map size of 109x109 pixels, it results in a total field of view of approximately 60".

Figure 1 illustrates the beam profiles obtained for two spaxels (modules) at different wavelengths.
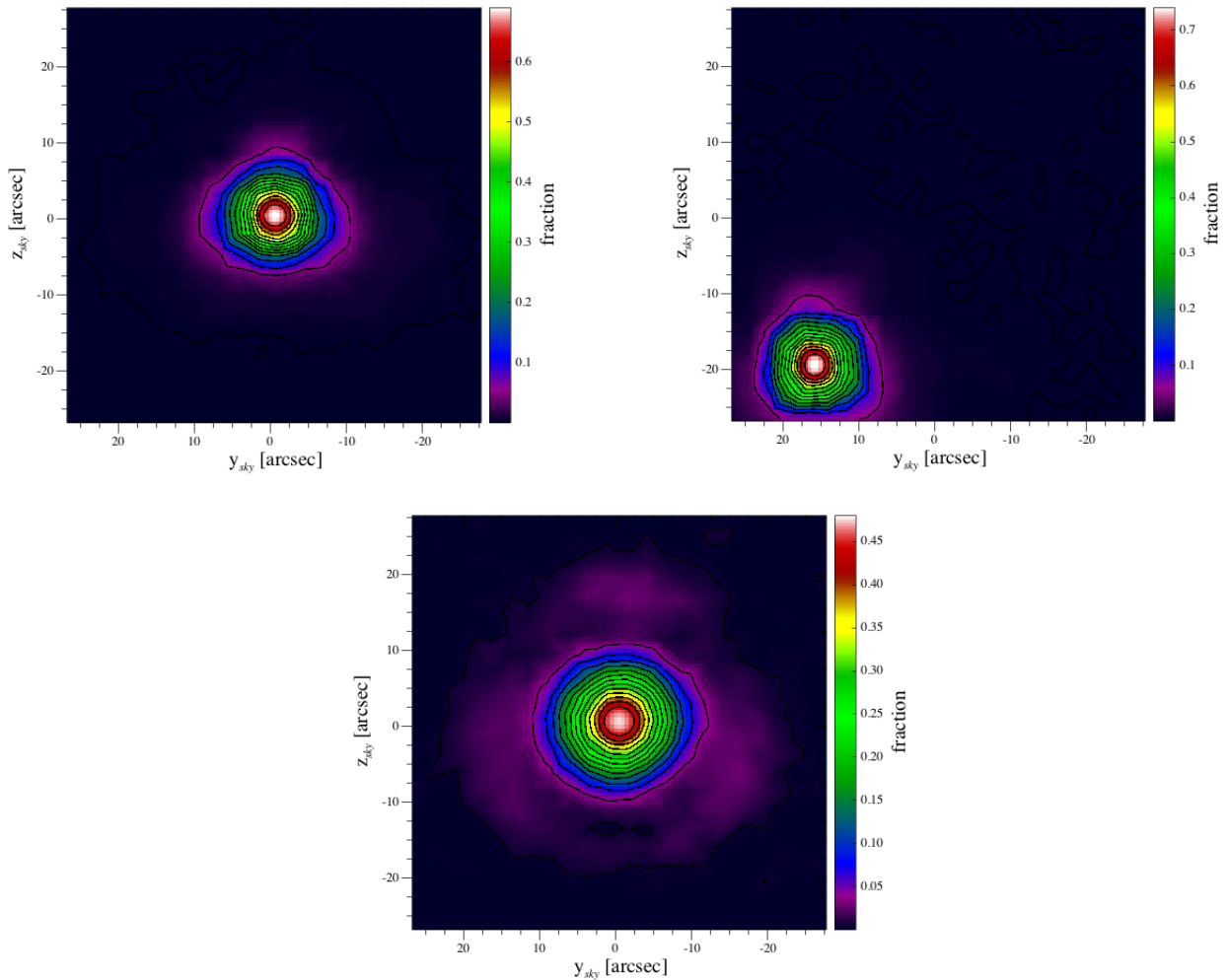
Figure 1. Sample beam efficiencies for modules (spaxels) 12 and 0 at 68 mm (top) and module 12 at 168 mm

The final version of the synthetic beam efficiencies is FM v6.

Alongside with the final synthetic beams, the raw data from which the PACS spectrometer beams have been derived is also provided as tables.

These files are the basis for all beam-based calibrations, namely:
- Spaxel's spatial calibration
- Point-source correction factor
- Extended-source correction factor
- Extended-to-point correction and forward model tool
- Pointing offset correction

2.2   Content of the Ancillary Data Products

2.2.1   Deliverable format and structure

The synthetic beam efficiencies are provided for each of the 25 PACS spaxels (modules) at 14 wavelengths: 1 in B3A, 3 in B2A, 4 in B2B and 7 in R1 (see Table 1).

B3A	B2A	B2B	R1
68 μm	55 μm	73 μm	110 μm
	62 μm	75 μm	125 μm
	68 μm	84 μm	136 μm
		94 μm	145 μm
			150 μm
			168 μm
			187 μm

Table 1 Wavelengths at measured beam efficiencies for PACS Spectrometer.

In total, the PACS Spectrometer Ancillary Data Product archive is wrapped in a gzipped tarball called `PCalSpectrometer_Beam_v6.tar.gz`. This file is 18 MB in size. It contains 375 files named after the convention

`PcalSpectrometer_Beam_<band><wavelength>_<module>_FM_v6.fits`,

where `<band>` is the spectral band (B3A, B2A, B2B and R1) , `<wavelength>` is one of the 14 wavelengths observed, and `<module>` is the spaxel module number (from 0 to 24).

This information can be found as part of the .fits header, as follows:

WAVELNTH= 68.0 / [] Wavelength [micrometer]
BAND = 'B2A ' / PACS spectral band
META_0 = 12 / [] Module number
META_1 = 2 / [] Spaxel column (Spacecraft Y)
SPAXROW = 2 / [] Spaxel row (Spacecraft Z)
CALFILEV= 6 / [] Calibration file version

Central spaxel

`SpecSpatial_BeamEfficiency_central_spaxel_tables_v1.tar.gz` - 123 KB

contains a FITS file for each wavelength (15 in total) named after
`SpecSpatial_BeamEfficieny_wXXX_<add>_central_spaxel_coarse_and_fine_table.fits`,
With `XXX` being the wavelength, and the additional field `2nd/3rd` to discriminate between B2A and B3A, respectively.
These are raw data of the coarse and fine rasters measured for the central spaxel only,

combined. The array dimension of the fits file is [3,npoints] where the first column gives the y raster position, the 2nd column the z raster position and the 3rd column the normalized flux measured at this raster position.

Coarse Grid (All spaxels)

The raw measurements of the PACS beam efficiencies coarse raster are provided in
`SpecSpatial_BeamEfficiency_tables_v1.tar.gz` – 2.8 MB

This file contains 15 .fits files named after `SpecSpatial_BeamEfficieny_wXXX_table.fits`, each file corresponds to one wavelength. Each file contains the data for all spaxels of the coarse raster measurement only. Each .fits file holds an array of 3x25x25x25 where: (0,25,25,25)=y raster position, (1,25,25,25)=z raster position, (2,25,25,25)=flux normalised to the central spaxel. The second and third dimensions are the raster position indices (y and z) and the last dimension is the module number (=spaxel number).

2.2.2 Beam Efficiencies Data Product queries in the HSA

Like any other Ancillary Data Product archives served by the HSA, the data products are provided as a single compressed archive from the Ancillary Data Product query menu. This archive contains all the gzipped FITS files mentioned above and amounts to 20 MB in total size.

Alternatively, the products can also be fetched from the Herschel Science Centre portal –see
https://www.cosmos.esa.int/web/herschel/ancillary-data-products .

3 Appendix material

3.1 WCS

```
NAXIS   =                 2 / Dimensionality
NAXIS1  =               109
NAXIS2  =               109
CDELT1  =              -0.5 / [] WCS: Pixel scale axis 1, unit=Angle
CRVAL1  =               0.0 / [] WCS: First coordinate of reference pixel
CRPIX1  =              54.0 / [] WCS: Reference pixel position axis 1, uni&
COMMENT t=Scalar
```

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```
CUNIT1  = 'ARCSEC '         / WCS: Unit axis 1, default=""
CTYPE1  = 'LINEAR '         / WCS: Projection type axis 1, default="LINEAR"
CDELT2  =             0.5 / [] WCS: Pixel scale axis 2, unit=Angle
CRVAL2  =             0.0 / [] WCS: Second coordinate of reference pixel
CRPIX2  =            54.0 / [] WCS: Reference pixel position axis 2, uni&
COMMENT t=Scalar
CUNIT2  = 'ARCSEC '         / WCS: Unit axis 2, default=""
CTYPE2  = 'LINEAR '         / WCS: Projection type axis 2, default="LINEAR"
```

3.2   Module to spaxel indices

The term "module" refers to the detector array column corresponding to a spaxel. The use of module to label spaxels was circumscribed to calibration work, but transcended in parts of the documentation. The spaxel indices corresponding to each module are provided in Table 2.

Module	Spaxel Indices (x,y)	
0	0	0
1	1	0
2	2	0
3	3	0
4	4	0
5	0	1
6	1	1
7	2	1
8	3	1
9	4	1
10	0	2
11	1	2
12	2	2
13	3	2
14	4	2
15	0	3
16	1	3
17	2	3
18	3	3
19	4	3
20	0	4
21	1	4
22	2	4
23	3	4
24	4	4

Table 2 Module to spaxel indices (x,y) in column, row

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