PEP full public data release (DR1): SPIRE data

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1 Introduction

The *PACS Evolutionary Probe* (PEP, Lutz et al. 2011) is a Herschel guaranteed time deep extragalactic survey, targeting six among the most popular "blank fields", ten lensing clusters of galaxies and two $z \sim 1$ clusters at wavelengths of 160, 100, and partly 70μm. PEP includes SPIRE (Griffin et al. 2010) observations of the two $z \sim 1$ clusters at wavelengths of 250, 350, and 500 μm, while SPIRE coverage of all other fields is available from the HerMES survey (Oliver et al. 2010). In addition, deep SPIRE GOODS-N data are provided by the GOODS-Herschel program (Elbaz et al. 2011).

This release note describes the PEP SPIRE data covering the two $z \sim 1$ clusters MS1054 and RXJ0152, and accompanies the big PEP global public release note that describes all PACS data. We defer to the latter for more information about the PEP survey.

2 Acknowledging PEP data from this release

If data from this release were useful for your research, please adhere to the following guidelines:

• Papers using PEP SPIRE images or catalogs from this release should refer to the PEP survey description paper at an appropriate place, e.g. "Using data from the public data release of the PACS Evolutionary Probe PEP (Lutz et al. 2011)".

• We also recall the usual Herschel conventions of placing a "Herschel is an ESA space observatory with science instruments provided by European-led Principal Investigator consortia and with important participation from NASA." mandatory footnote on the frontpage, and citing the Pilbratt et al. (2010) Herschel seminal paper, as well as the applicable one(s) among the instrument seminal papers (Poglitsch et al. (2010); Griffin et al. (2010); de Graauw et al. (2010)).

3 Contents of the released package

PEP data releases are available at the PEP public website, direct link:
`http://www.mpe.mpg.de/ir/Research/PEP/public_data_releases.php`

The two PEP $z \sim 1$ cluster fields have been observed by SPIRE (Griffin et al. 2010) at 250 μm, 350 μm and 500 μm for a total of 0.84 hours of observation per field.

This release includes:

1. SPIRE maps including flux, error, and coverage
2. observed PSFs,
3. catalogs extracted blindly, down to 3σ significance,
4. curves for completeness and fraction of spurious sources for the aforementioned catalogs,
5. residual maps.

4 General properties of released data

The SPIRE data were reduced within the HIPE environment (version 4.0.1349), using the standard pipeline, and adopting the naive map-making scheme. Maps were then corrected by the appropriate flux correction factors (1.02, 1.05, and 0.94 at 250, 350, and 500 μm, respectively), as prescribed by the SPIRE Photometer Instrument Description[1].

We combined the 5 individual maps of each cluster at each wavelength through a weighted average, based on coverage information. Error maps give the coverage-weighted standard deviation at each pixel position.

For each of the three wavelengths (250, 350, and 500 μm) the data release includes science, error and coverage maps.

4.1 Blind catalogs

As in the case of PACS data, SPIRE blind catalogs have been extracted using the Starfinder (Diolaiti et al. 2000a,b) code. The adopted PSFs used are the standard empirical PSFs determined from observations of Neptune[2] (see the SPIRE Beam Model Release Note, Sibthorpe et al. 2011). For each cluster, the PSF is trimmed and rotated to the position angle of the observations.

The flux errors returned by Starfinder are smaller than the 1 σ noise in the error map by a factor of 1.5-2.0. Because these flux errors are artificially small, we provide in the released catalogs errors and S/N values both from the Starfinder extraction (FLUXERR-SF) and by averaging the error map on a 3×3 pixel area centered on the position of the detection (FLUXERR-MAP). We recommed the use of the latter. The released catalogs include all sources above a given flux. This cut is applied at 10, 8.5 and 10.0 mJy at 250, 350 and 500 μm, respectively.

We produced correlation maps for the SPIRE images, but they reveal that the images do not suffer from correlated noise. Therefore, unlike in the PACS case, we do not correct the flux error further.

[1] see https://nhscsci.ipac.caltech.edu/sc/index.php/Spire/PhotInstrumentDescription.

[2] SPIRE PSFs can be found at the address ftp://ftp.sciops.esa.int/pub/hsc-calibration/SPIRE/PHOT/Beams/

The SPIRE maps are in units of Jy per beam. Assuming that the PSF is perfectly Gaussian, the factor required to produce fluxes in Jy is:

$$(\text{pixelscale})^2 \,/\, \left(\pi \text{FWHM}^2 \,(4 \ln 2)^{-1}\right) . \tag{1}$$

For example, at 250 μm, this would give a factor of 10.31 for a pixel scale of 6 arcsec/pixel and a FWHM of 18 arcsec. The actual factors to use are slightly larger than these theoretical estimates, since the PSFs adopted for the source extraction have been truncated. The appropriate factors are given in Table 1.

Band	RXJ0152	MS1054
250	12.003	11.993
350	8.713	8.689
500	8.948	8.921

Table 1: Flux conversion factors for the SPIRE photometry and the PSFs provided with this data release.

4.2 Simulations

As in the case of PACS data, up to 10000 artificial sources have been added to SPIRE maps, and then extracted with the same Starfinder configuration used for real objects, with the aim to quantify the detection rate and the fraction of spurious sources in the SPIRE PEP catalogs.

Figure 1 shows the results of this analysis and Table 2 summarizes the results of simulations, as well as the main properties of the PEP SPIRE catalogs. The values of noise quoted in this Table were derived from S/N vs. flux diagrams.

Users should keep in mind that deep SPIRE observations are affected by confusion noise (see Nguyen et al. 2010, for an in depth analysis), and special care is required when dealing with faint objects.

Despite fine-tuning, Starfinder tends to overestimate the flux of sources up to $\sim 15-20\%$ at the faintest flux levels, in all bands. **A correction of this effect has already been applied to the released catalogs**, using the functions derived from simulations. Correction curves are provided in the released data package, in case users would like to un-correct fluxes. Curves of the completeness and the fraction of spurious sources as a function of flux are included as well. Figure 1 depicts the analysis of simulations *before* flux-trend correction.

4.3 Coverage value

In the case of SPIRE, coverage maps represent the number of bolometer readouts in a given sky pixel. The readout frequency is 18.6 Hz.

It is not straightforward to convert the number of bolometer hits into exposure per sky pixel. A proxy for a "bolometer exposure" can be derived by dividing the number of bolometer hits in the map by the sampling frequency.

We have computed the values of coverage relative to each source in SPIRE catalogs, by convolving the coverage maps by the SPIRE observed PSF (specific to each field/band, and normalized to a total power of 1.0) and then reading the resulting value at the position of each object. In this way, an

Field & band	S(1σ) mJy	Num. $\geq 3\sigma$	Num. $\geq 5\sigma$	Completeness 3σ	f(spur) 3σ	Completeness 5σ	f(spur) 5σ	S(80%) mJy
RXJ0152 250	4.1	324	125	0.46	0.18	0.91	0.02	18.55
RXJ0152 350	3.4	257	110	0.30	0.36	0.73	0.07	18.90
RXJ0152 500	3.9	78	34	0.22	0.43	0.60	0.19	25.65
MS1054 250	4.1	270	120	0.47	0.16	0.90	0.02	16.70
MS1054 350	3.1	247	113	0.26	0.35	0.75	0.17	17.02
MS1054 500	3.9	80	20	0.24	0.46	0.76	0.09	22.32

Table 2: Statistics of SPIRE blind catalogs for PEP $z \sim 1$ clusters. The 1σ flux value has been computed by rescaling the 3σ and 5σ levels derived from S/N vs. flux diagrams. The completeness and fraction of spurious sources at 3σ and 5σ, as well as the 80% completeness level (last column), were obtained by linearly interpolating the results of simulations before correcting flux trends.

average coverage value, weighted by the profile of the observed PSF is measured. Finally the values extracted from coverage maps have been transformed into "bolometer exposures" as $\mathrm{cov}(s/pix) = \mathrm{cov}/18.6$.

The values thus obtained are included in the PEP SPIRE DR1 blind catalogs.

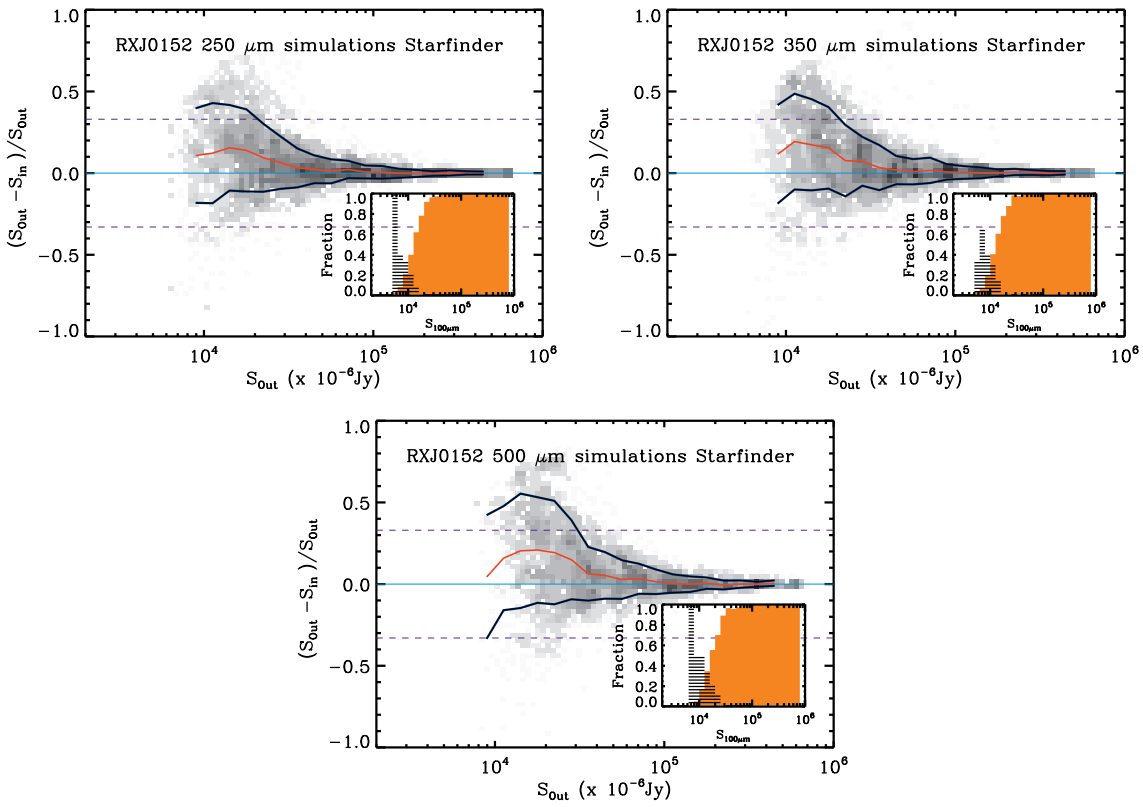

Figure 1: Results of "simulations" for SPIRE blind extraction in RXJ0152, before correcting flux trends. Comparison of input and output fluxes: red lines represent the average photometric accuracy, blue lines set the standard deviation observed in each flux bin (after 3σ clipping). Orange histograms represent the detection rate (or completeness) computed on the artificial injected sources. Completeness is defined as the fraction of sources that have been detected with a photometric accuracy of at least 50% (Papovich et al. 2004). Black hashed histograms show the fraction of spurious sources, defined as sources extracted above 3σ with an input flux lower than $3\sigma(Image)$.

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