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| Use of Blazars for PACS spatial calibration | Page 1 |

Use of Blazars for PACS spatial calibration

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1 Introduction

As pointlike far-infrared sources with accurate positions and red spectral energy distributions, Blazars (a subgroup of AGN with strongly beamed nonthermal emission) can serve several needs of PACS spatial calibration as identified in Section 3 of the PACS calibration Document (PCD). A main property to be considered in planning observations is that the fluxes may vary essentially unpredictably by factors of a few during the mission. Either some risk of poor S/N observations has to be accepted, or sources have to be selected with some brightness margin above the original requirements.

This note discusses some of the relevant constraints and presents a source list. The latter is largely based on a list provided by Jörg Rachen (Planck Team, MPA). It was supplemented by a crosscheck with IRAM pointing sources and a SPIRE list, which in turn relies on JCMT and SEST pointing sources. Sources from these latter references may be less clean in their properties and are hence kept in a separate supplementary list.

2 Use as astrometric references

For initial establishment and later monitoring of the central pointing position (PCD 3.1.1), there is a need for far-infrared sources with accurate (<0.3 arcsec) positions that are pointlike at PACS spatial resolution or almost pointlike but symmetric. $70\mu\text{m}$ flux densities should be at least 150mJy at the time of observation. For the specific case of Blazars, a modest host far-infrared continuum contribution is acceptable as long as it is likely symmetric. Note the similar use of Blazars at major (sub)mm observatories.

3 Use as PSF standards

Because of the wide filter bandpasses, the width of the PACS Point Spread Function (PSF) is expected to vary noticeably with input spectral slope, by up to 11% for the widest (red) filter between a $f_\lambda \propto \lambda^{-4}$ Rayleigh-Jeans slope and a very red $f_\lambda \propto \lambda^2$ slope (see FM test report). For this reason, PCD section 3.1.4 asks for both blue PSF sources (stars) and sources that are red and pointlike within the PACS spectral range.

Blazars are prime candidates for this use. While none of them is bright enough ($>10\text{Jy}$) for quick and optimal PSF characterisation down to the faint wings, several of them are bright enough for a good measurement of the PSF width. Sources for this use should be fully dominated by the pointlike nonthermal emission.

| Ident | RA J2000 | DEC J2000 | S_{130} mJy | PSF? |
|-------------|--------------|--------------|------------------|--------------|
| PKS0420-01 | 04 23 15.801 | -01 20 33.06 | 500 | yes |
| 3C120 | 04 33 11.096 | +05 21 15.62 | 1500 | ? (J.Rachen) |
| OJ287 | 08 54 48.875 | +20 06 30.64 | 1000 | yes |
| PKS1144-379 | 11 47 01.371 | -38 12 11.02 | 600 | yes |
| PKS1244-255 | 12 46 46.802 | -25 47 49.29 | 600 | yes |
| 3C279 | 12 56 11.166 | -05 47 21.52 | 1500 | ? (Haas 98) |
| 1ES1308+326 | 13 10 28.664 | +32 20 43.78 | 600 | yes |
| 3C345 | 16 42 58.810 | +39 48 36.99 | 1000 | yes |
| 1803+784 | 18 00 45.684 | +78 28 04.02 | 600 | yes |
| BL Lac | 22 02 43.291 | +42 16 39.98 | 700 | yes |
| 3C446 | 22 25 47.259 | -04 57 01.39 | 800 | yes |
| 3C454.3 | 22 53 57.748 | +16 08 53.56 | 500 | yes |

Table 1: Blazars suited as PACS spatial calibrators. The PSF column indicates whether further checks are suggested before using the source as PSF standard.

4 Source List

Sources were taken from the list provided by Jörg Rachen, which includes estimates of fluxes at $130\mu\text{m}$ (roughly the center of the PACS range) that are based on literature and archival data including WMAP and IRAS. We include below only sources with estimated $S_{130} \geq 500\text{mJy}$ and where this estimate is somewhat supported by an IRAS measurement. This limit would keep the source above the original flux limit referred to above, even if the flux at the epoch of observation happens to be a factor three lower. More sources could be added if taking more severe risks of fluxes being fainter than estimated, and if accepting fluxes that are solely based on extrapolation from the radio/mm but not supported by IRAS.

Accurate positions from NED were added, proper motions are zero. The positional error is well below 0.3arcsec in all cases. All sources in this list are suited for pointing calibration. We add in Table 1 a comment on possible use for PSF calibration where we have simply assigned a “?” to all sources possible having a significant FIR dust contribution to the SED. Depending on slope of the total SED and spatial structure of the dust emission they may well be fine as red PSF sources, but would require more detailed case-by-case investigations before being sure.

We supplemented this list with further AGN that are mm bright and successfully used for IRAM Mambo pointing and/or PdB phase calibration. We considered the 23 brightest sources from the MAMBO pointing calibrator list, eliminated one galactic source, the targets already in the Jörg Rachen list, and the ones without strong $>0.5\text{Jy}$ IRAS detection (some do have $60\mu\text{m}$ detections at the $\sim 0.2\text{Jy}$ level), and NGC 1275, M87 (complex?). The only remaining source is 3C273. The $130\mu\text{m}$ flux is crudely estimated based on the IRAS or ISO data listed in NED.

The SPIRE pointing source list that was also checked is based on JCMT and SEST pointing calibrators. Extrapolation to shorter wavelengths in this list is done assuming a $f_\nu \propto \nu^{-0.7}$ spectrum which is conservative for Blazars which often have flatter spectra. This also explains the faint predicted fluxes quoted in the SPIRE list for some of our bona fide Blazars. We stick to the more elaborate J.Rachen extrapolations for those sources.

| Ident | Ref | RA J2000 | DEC J2000 | S ₁₃₀ mJy | PSF? |
|-------------|----------------|--------------|--------------|-------------------------|-----------|
| PKS0521-36 | SEST | 05 22 57.985 | -36 27 30.85 | 750 | ? |
| PKS0537-441 | SEST,JCMT | 05 38 50.361 | -44 05 08.93 | 1000 | ? |
| 3C273 | IRAM,SEST,JCMT | 12 29 06.700 | +02 03 08.60 | 1500 | No (Jet)? |

Table 2: Additional IRAM/JCMT/SEST pointing sources with strong IRAS detections, suited as spatial calibrators

We checked the SEST sources from the SPIRE list (based on Adraou et al. 2001) in the following way: For the sources with average 230 GHz flux above 2Jy, we eliminated all sources already in our list, the ones without strong (>0.5 Jy) IRAS detections, and one source with likely complex FIR-morphology (CenA). Two new southern sources remained.

We checked the JCMT source from the SPIRE list in the following way: For the sources with minimum $850\mu\text{m}$ flux above 1Jy we eliminated all sources already in our list, the ones without strong (>0.5 Jy) IRAS detections, and ones with likely complex FIR-morphology (M87, N1275). No new sources were found.

5 References

J. Rachen, private comm., email November 13, 2007
 PACS Calibration Document (PCD) PACS-MA-GS-001, Section 3.1
 Haas, M., et al. 1998 A&A 402, L109
 Padovani, P., et al. 2006 A&A 456,131
 Pointing source list in IRAM pool database, queried 2007-12-18
 Spire_pointing_sources.xls (email Peter Hargrave to Bruno Altieri, Feb 26, 2008
 Adraou, A., et al. 2001, A&A, 376, 1123

6 Document change record

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| 1.0 | 2007-12-18 | DL | First version |
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