5MUSES: 5 Milli-Jansky Unbiased Spitzer Extragalactic Survey

First Data Delivery

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1. Introduction

This document describes the first data release (DR1) of the Spitzer Legacy Program 5MUSES (PI: George Helou). The 5 mJy Unbiased Spitzer Extragalactic Survey (previously known as the 5 mJy Extragalactic Spectroscopic Survey) is a mid-infrared spectroscopic survey of 330 galaxies with $f_\nu(24\,\mu m)>5$ mJy, observed with the Infrared Spectrograph (IRS) on board the Spitzer Space Telescope. It provides a representative sample with a modeled 10th to 90th percentile range of $1\times10^{10}\,L_\odot$ to $2\times10^{13}\,L_\odot$ and z=0.05 to z=0.75, and bridges the gap between nearby spirals and ULIRGs (z∼0), and the much fainter and more distant sources pursued in most IRS follow-up work to date (z∼2). This delivery contains highly reduced spectroscopic data for 100 galaxies in the 5MUSES sample. We list the content of the first data delivery in Section 2. In Section 3, we provide a description of the post-BCD processing for IRS data.

The 5MUSES public website is currently hosted at:
http://5muses.ipac.caltech.edu

2. Content of the data delivery

2.1 Sample

The 100 galaxies included in this first delivery were selected from the 5MUSES sample so that they reproduce the 24 μm flux density distribution of the whole sample (see Figure 1). We divide the sources into four flux bins and select ∼1/4 to 1/3 of the sources from each bin (see Table 1).

In this data release, we deliver the IRS spectra in the Short Low (SL) and Long Low (LL) modules, therefore covering the whole range of observed wavelength from 5.3 to 38 μm. The IRS spectra are in ASCII (*.tbl) format and the flux units are Jy. Information on the sources in the current release is given in Table 2, in which we list the object names, RA and Dec positions, as well as their aorkeys and 24 μm flux densities measured from 12.7 arcsecond diameter aperture using SExtractor.

2.2 File Naming Convention

For each galaxy, the IRS spectrum is delivered in two segments, one for each of the IRS low-resolution modules. The files follow the naming convention of rxxx_md.tbl, where “xxx” is the aorkey of the source, and “md” is the module, either “ch0” for SL, or “ch2” for LL. For multiple sources observed in fixed-cluster mode, we differentiate them by adding an alphabetical suffix, eg. r24148992b_ch0.tbl is the SL spectrum of the second source observed in aorkey 24148992. All spectra are formatted as ASCII files in the IPAC table format. The headers are reproduced from the first data collection event in each module.

3. IRS data Processing

3.1 Sky subtraction

All 5MUSES observations are taken in the IRS staring mode. For the low resolution spectra, off-source observations are used for sky subtraction. We take the median of all images from the off-source part of the slit and then subtract it from the image on the source. Then we combine the images by taking the mean of all images at one nod position. The sky-subtracted images are then cleaned with IRSCLEAN to remove the bad pixels using the default parameters. The rogue pixel mask is produced "on-the-fly" by setting the "getFmask" keyword. Typically $\sim$120 NaN pixels are masked by the program.

3.2 IRS spectral extraction

The background-subtracted cleaned image fits files of each order at each nod position are then processed with the Spitzer IRS Custom Extraction (SPICE) for extraction of spectra. The input files also include the cleaned bmask and uncertainty files. We use the default extraction aperture, and the point-source calibration. We specify the order of images so that SPICE sums in columns the pixel values of that part of the image, and select the peak of the spatial profile. Then we run the extraction process and SPICE sums in rows the pixel values in the extraction aperture. The output from SPICE produces one spectrum at one nod position (1st or 2nd) for each order (1st and 2nd/3rd) of each module (SL or LL).

Spectra at nod position 1 and 2 are then combined with a clipped mean. To remove the hot pixels, we flag pixels when the difference between two nod positions exceed 0.005 Jy. For the flagged pixels, we take the average of adjacent pixel values for each nod position. Then we compare the flagged pixel value with the average of its adjacent pixels, and adopt the pixel value from the nod position that has the smaller local deviation. Then the average spectra from different orders within each of SL and LL are averaged together where they overlap. We do not use any scaling factors between adjacent orders and order mis-match is only detected in a few sources (see section on individual objects). We also trim the end of the orders where the noise rises quickly (see Figure 2 for sample spectra). The final product we deliver runs from 5.25 μm to 14.23 μm for SL and 13.98 μm to 38.37 μm for LL.

3.3 Notes on individual objects

Order mis-matches are sometimes seen in the IRS spectra between the 1st order of SL (SL1) and 2nd order of LL (LL2), at $\lambda\sim20\,\mu$m. Two objects in this data release have mis-matches: 1NW 026 and SDSS J171430.76+584225.4.

For some objects, the continuum of the LL2 spectra at the red end of one nod position ($\sim 18-20\,\mu$m) drops abnormally and does not agree with that of the other nod position, nor with the blue end of LL1. For these cases, we discard the spectra at the discrepant nod position. The following is a list of such objects:
2MASX J10542172+5823445, SDSS J155936.13+544203.8, SDSS J160128.54+544521.3, 2MASX J16125088+5323045, SBS 1614+546, SDSS J104132.48+565953.1, SBS1607+567, SDSS J104131.77+592258.6, SDSS J172228.04+601526.0 and SDSS J171419.98+602724.6.

Table 1: Sample Selection

Flux Range	**Total Number of Objects**	**Number of Objects in this delivery**
5 mJy<f≤10 mJy	230	75
10 mJy<f≤15 mJy	50	12
15 mJy<f≤20 mJy	17	5
20 mJy<f	33	8

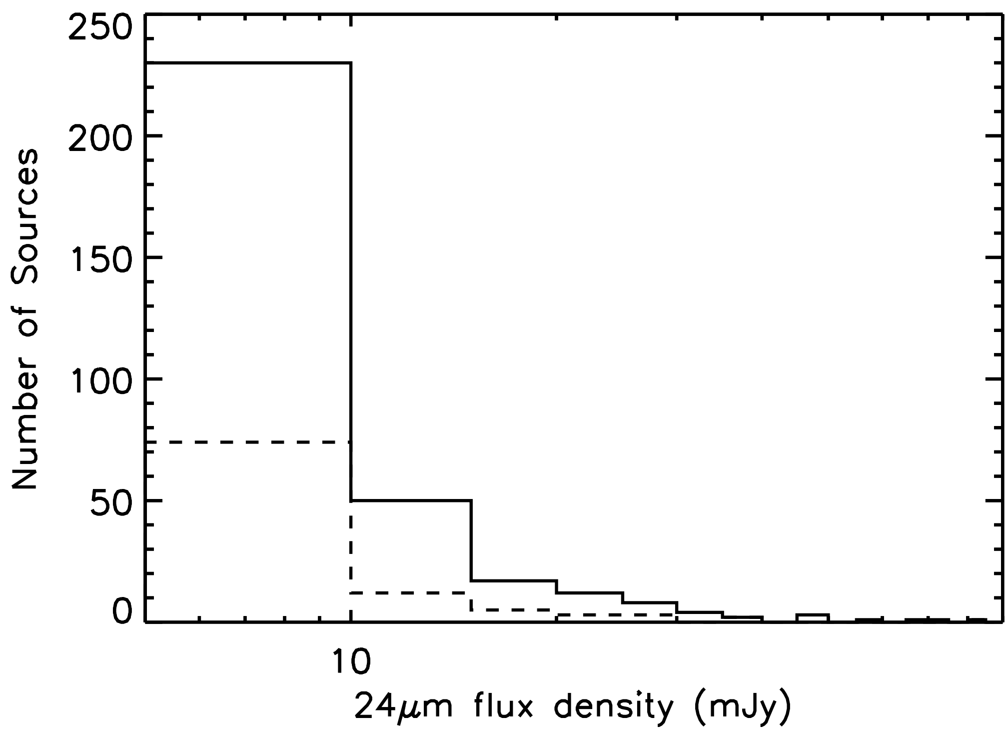

Figure 1: A histogram of the 24 μm flux densities of the whole 5MUSES sample, in comparison with the sources selected for this data release (dashed line).

Table 2: 5MUSES Sources in Data Release 1

Object	**RA (J2000)**	**Dec (J2000)**	**AORKEY**	**F$_\nu$(24 μm)**
2MASXJ10345056+5844181	10h34m50.50s	+58d44m18.2s	24153088	20.131
1NW026	10h35m13.72s	+57d34m44.6s	24151296a	5.501
SDSSJ103542.77+583313.2	10h35m42.76s	+58d33m13.1s	24166656b	6.632
SDSSJ103803.35+572701.6	10h38m03.35s	+57d27m01.5s	24169984	15.432
SDSSJ104131.77+592258.6	10h41m31.79s	+59d22m58.4s	24188416	7.020
SDSSJ104132.48+565953.1	10h41m32.49s	+56d59m53.0s	24166400	8.346
SWIREJ104303.50+585718.1	10h43m03.50s	+58d57m18.1s	24167936b	5.449

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Table 2 – continued from previous page

Object	RA (J2000)	Dec (J2000)	AORKEY	$F_\nu(24\,\mu m)$
2MASXJ10443291+5640420	10h44m32.94s	+56d40m41.6s	24201472	28.712
CGCG290-067	10h44m38.21s	+56d22m10.7s	24154112	80.648
SDSSJ104454.08+574425.9	10h44m54.08s	+57d44m25.7s	24160256b	6.538
NVSSJ104516+592303	10h45m16.02s	+59d23m04.7	24153344a	5.076
2MASXJ10464333+5847154	10h46m43.26s	+58d47m15.1s	24153344b	5.400
SDSSJ104729.85+572842.8	10h47m29.89s	+57d28m42.9s	24144384	6.203
SDSSJ104907.11+565715.3	10h49m07.15s	+56d57m15.3s	24153600b	9.674
2MASXJ10500589+5614599	10h50m05.97s	+56d15m00.0s	24163584	14.811
SDSSJ105047.79+590348.0	10h50m47.83s	+59d03m48.3s	24143104b	5.160
SDSSJ105106.12+591625.1	10h51m06.12s	+59d16m25.3s	24143104c	5.397
1EX076	10h51m28.05s	+57d35m02.4s	24143616	9.988
SDSSJ105158.52+590652.0	10h51m58.53s	+59d06m52.0s	24143104d	5.373
2MASXJ10520659+5809476	10h52m06.56s	+58d09m47.1s	24178944	16.691
SDSSJ105404.10+574019.7	10h54m04.11s	+57d40m19.7s	24194560b	8.536
2MASXJ10542172+5823445	10h54m21.65s	+58d23m44.6s	24156928	16.781
SDSSJ105636.94+573449.4	10h56m36.95s	+57d34m49.3s	24158464a	6.390
SDSSJ105641.79+580046.1	10h56m41.81s	+58d00m46.0s	24158208a	7.500
VIIZw353NOTES01	10h57m05.43s	+58d04m37.4s	24145408	16.528
2MASXJ10573350+5657376	10h57m33.53s	+56d57m37.4s	24145152a	5.599
SDSSJ105740.55+570616.5	10h57m40.55s	+57d06m16.4s	24145152b	6.085
SDSSJ105903.47+572155.1	10h59m03.47s	+57d21m55.1s	24146176b	13.778
SDSSJ105959.93+574848.1	10h59m59.95s	+57d48m48.1s	24158208c	9.063
SDSSJ110223.56+574436.2	11h02m23.58s	+57d44m36.2s	24146176c	10.182
SDSSJ155936.13+544203.8	15h59m36.12s	+54d42m03.7s	24172288	14.467
1RSXJ160114.0+551306	16h01m14.49s	+55d13m04.1s	24149760b	7.877
SDSSJ160128.54+544521.3	16h01m28.52s	+54d45m21.3	24147712	12.813
IRASF16022+5450	16h03m22.77s	+54d42m37.3s	24148992b	5.720
2MASXJ16034131+5526135	16h03m41.30s	+55d26m12.7s	24167424b	5.310
ELAISC15J160408.4+542530	16h04m08.18s	+54d25m31.2s	24148992c	5.013
2MASXJ16040835+5458125	16h04m08.30s	+54d58m13.0s	24142848	26.224
2MASXJ16044063+5534089	16h04m40.64s	+55d34m09.2s	24194816	22.851
SDSSJ160630.60+542007.5	16h06m30.59s	+54d20m07.4s	24190464a	5.526
SDSSJ160655.34+534016.8	16h06m55.35s	+53d40m16.9	24151040	14.647
ELAIS09(R)J160655.8+541500	16h06m55.82s	+54d15m00.7s	24189952	17.743
2MASXJ16074309+5544161	16h07m43.09s	+55d44m16.5s	24185600b	9.597
NPM1G+56.0211	16h08m01.79s	+55d53m59.7s	24162560c	6.235
ELAIS02(R)J160832.6+552927	16h08m32.59s	+55d29m26.9s	24190720	5.925
2MASXJ16083973+5523305	16h08m39.73s	+55d23m30.6s	24181504a	5.832
SBS1607+567	16h08m47.02s	+56d37m02.2s	24190208	8.273
2MASXJ16085842+5530105	16h08m58.38s	+55d30m10.2s	24184064b	8.843
ELAIS02(R)160907.6+552428	16h09m07.56s	+55d24m28.4s	24184064c	7.705
ELAIS02(R)J160908.3+552241	16h09m08.28s	+55d22m41.4s	24181504b	6.561
2MASXJ16092670+5516424	16h09m26.69s	+55d16m42.3s	24181504c	6.817
ELAIS09(R)160931.5+541827	16h09m31.55s	+54d18m27.3s	24190464d	5.560

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Table 2 – continued from previous page

Object	RA (J2000)	Dec (J2000)	AORKEY	$F_\nu(24\,\mu m)$
2MASXJ16093749+5412594	16h09m37.48s	+54d12m59.2s	24190464e	5.664
2MASXJ16110373+5443215	16h11m03.73s	+54d43m22.0s	24190464f	6.642
ELAIS06(R)J161123.4+545158	16h11m23.44s	+54d51m58.2s	24171776a	5.488
2MASXJ16122335+5403393	16h12m23.39s	+54d03m39.2s	24189440	12.991
2MASXJ16123349+5456309	16h12m33.43s	+54d56m30.4s	24188672a	8.292
ELAIS06(R)J161241.0+543956	16h12m41.05s	+54d39m56.8s	24171776b	5.748
2MASXJ16125088+5323045	16h12m50.85s	+53d23m04.9s	24187392	17.880
2MASXJ16125415+5455261	16h12m54.17s	+54d55m25.4s	24188672b	7.975
2MASXJ16130186+5521231	16h13m01.82s	+55d21m23.0s	24166144	36.281
ELAIS10S(R)J161357.0+534105	16h13m57.01s	+53d41m05.3s	24175360a	6.503
2MASXJ16140306+607564	16h14m02.98s	+56d07m56.9s	24174848	20.988
ELAISC15J161406.8+551451	16h14m06.87s	+55d14m51.9s	24188672c	9.155
SBS1614+546	16h15m21.78s	+54d31m48.3s	24171776c	5.101
2MASXJ16154211+5618146	16h15m42.10s	+56d18m14.7s	24151808a	13.742
ELAISC15J161546.5+550331	16h15m46.51s	+55d03m30.9s	24188672d	8.854
2MASXJ16154834+5345515	16h15m48.31s	+53d45m51.1s	24183808	7.458
ELAISJ161551.3+541536	16h15m51.45s	+54d15m35.9s	24175360e	6.282
2MASXJ16165997+5600276	16h16m59.95s	+56d00m27.2s	24151808b	10.830
SBS1616+546	16h17m18.94s	+54d32m42.6s	24171008b	14.248
2MASXJ16181934+5418587	16h18m19.31s	+54d18m59.0s	24160512	28.317
2MASXJ16184802+5358378	16h18m48.03s	+53d58m37.5s	24181248c	7.215
2MASXJ16203398+5423237	16h20m33.98s	+54d23m23.5s	24154368b	9.097
2MASXJ16212802+5514527	16h21m27.98s	+55d14m52.9s	24149248f	5.614
2MASXJ16215086+5530091	16h21m50.85s	+55d30m08.8s	24149248g	6.635
2MASXJ16220405+5505312	16h22m14.77s	+55d06m14.1s	24180992d	7.376
2MASXJ16231310+5511114	16h23m13.11s	+55d11m11.5s	24150016	6.624
SDSSJ171033.21+584456.8	17h10m33.21s	+58d44m56.8s	24193536a	6.122
SSTXFLSJ171233.3+583610	17h12m33.38s	+58d36m10.5s	24193536b	5.051
SDSSJ171233.77+594026.4	17h12m33.77s	+59d40m26.4s	24191488	5.079
2MASXJ17131650+5832349	17h13m16.50s	+58d32m34.9s	24193536c	6.730
SDSSJ171414.81+585221.5	17h14m14.81s	+58d52m21.5s	24192256a	9.044
SDSSJ171419.98+602724.6	17h14m19.98s	+60d27m24.6s	24191744	5.584
SDSSJ171430.76+584225.4	17h14m30.76s	+58d42m25.4s	24192256b	8.314
SDSSJ171446.47+593400.1	17h14m46.47s	+59d34m00.1s	24187648a	7.533
SSTXFLSJ171447.3+583806	17h14m47.31s	+58d38m05.9s	24193536d	5.434
SDSSJ171513.88+594638.1	17h15m13.88s	+59d46m38.1s	24189184a	5.102
SDSSJ171544.03+600835.3	17h15m44.03s	+60d08m35.3s	24188928a	6.894
SDSSJ171614.48+595423.8	17h16m14.48s	+59d54m23.8s	24188160a	8.589
2MASXJ174751+5932581	17h17m47.51s	+59d32m58.1s	24189184b	5.342
SDSSJ171933.37+592742.8	17h19m33.37s	+59d27m42.8s	24178688a	7.589
2MASXJ17194484+5957071	17h19m44.91s	+59d57m07.7s	24182784	14.428
SDSSJ172043.28+584026.6	17h20m43.28s	+58d40m26.6s	24178432	9.739
SSTXFLSJ172044.8+582923	17h20m44.86s	+58d29m24.0s	24176640	5.266
2MASXJ17215943+5950343	17h21m59.43s	+59d50m34.3s	24178688b	9.744

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Table 2 – continued from previous page

Object	RA (J2000)	Dec (J2000)	AORKEY	$F_\nu(24\,\mu m)$
SDSSJ172219.58+594506.9	17h22m19.58s	+59d45m06.9s	24178688c	7.839
SDSSJ172228.04+601526.0	17h22m28.04s	+60d15m26.0s	24175872a	7.166
SDSSJ172313.06+590533.1	17h23m13.06s	+59d05m33.1s	24187136	6.170
2MASXJ17235597+5940476	17h23m55.97s	+59d40m47.6s	24183552a	5.170
SDSSJ172402.11+600601.4	17h24m02.11s	+60d06m01.4s	24175872b	8.037

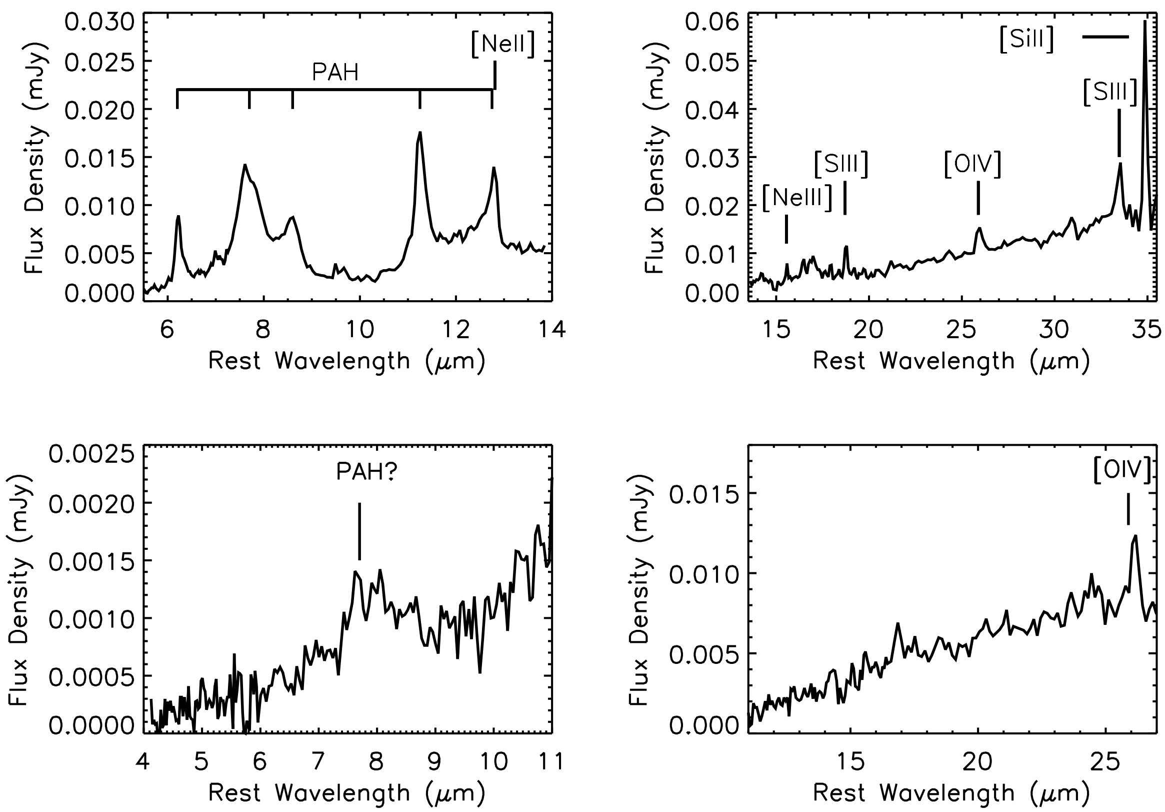

Figure 2: Sample SL and LL spectra of two sources from 5MUSES. The upper panels display a source that is dominated by PAH emission. The lower panel shows a source with power-law continuum, with possible 7.7 μm PAH emission.