The Spitzer Source List

Harry Teplitz, Peter Capak, Tim Brooke, Sachin Shenoy, Carolyn Brinkworth, Vandana Desai,Iffat Khan, Russ Laher

Spitzer Science Center
NASA Infrared Science Archive

Introduction

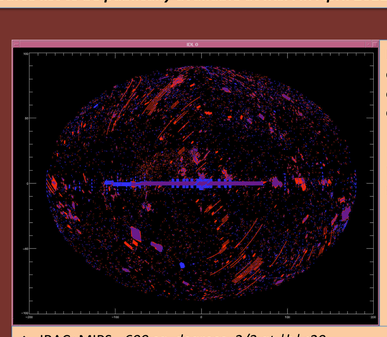
Abstract

The Spitzer Science Center will produce a source list (SL) of photometry for a large subset of imaging data in the Spitzer Heritage Archive (SHA). The list will enable a large range of science projects. The primary requirement on the SL is very high reliability, with areal coverage, completeness and limiting depth being secondary considerations. The SHA at the NASA Infrared Science Archive (IRSA) will serve the SL as an enhanced data product. The SL will include data from the four channels of IRAC (3-8 microns) and the 24 micron channel of MIPS. The Source List will include image products (mosaics) and photometric data for Spitzer observations of about 1500 square degrees and include around 30 million sources. We describe the plans and timeline for development of the Spitzer Source List. We demonstrate the verification of the Source List pipeline using Spitzer Legacy catalogs at "truth tables". Finally, we discuss the range of use cases which will be supported.

INTRO

- We plan to make a Source ***List*** for the Spitzer Heritage Archive, not a source catalog
- We present the plans for generating a list of fluxes of compact sources
- Our goal is to have a lights-out pipeline for processing..
- Final product to be easily searchable, highly documented, list for archive users
- *Must minimize misuse of the list*

- ***Source list to be publically available at IRSA in April 2011***



Distribution of Spitzer observations on the sky

IRAC only
MIPS only
Both

- IRAC+MIPS: *600 sq. degrees; 2/3 at |b|<20*
- IRAC only: *350 sq. degrees; 2/3 at |b|<20*
- MIPS only: *650 sq. degrees; 1/2 at |b|<20*

- >= 30e6 galaxies in ch1
- >= 3e6 galaxies in ch4
- >= 1e6 galaxies in MIPS

Requirements

- Source ***list***, not source *catalog*
  - Need high reliability, but don't have to be complete
  - Mask significant area and when in doubt reject questionable sources
- Limit to common SNR threshold (10 sigma)
- Only point- and compact-sources (FWHM < 2 x PSF)
- No requirement on completeness
  - *80-90% complete compared to Legacy surveys at 10σ*
  - *50-70% compared to deeper, Legacy-survey full catalogs (e.g. c2d "class A+B" sources down to 5σ),*
- Use only subset of the archive to make list feasible
  - Avoid extended sources (local galaxies, etc); very low galactic latitude
  - Minimum AOR requirements (e.g depth of coverage)
  - No 16,70,160 micron data
- Use-case specific namelists for mosaic and photometry
- Need to make super (multi-AOR) mosaics
- Both APEX and SExtractor in the source list pipeline
  - *SExtractor Aperture photometry for IRAC*
    - Report single aperture flux and FWHM
  - *PRF fitting for MIPS*
- Merge source fluxes for each object into single list row entry (Bandmerge)

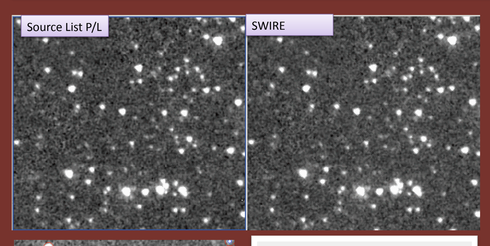
- Extragalactic
  - *SL shall meet reliability level achieved by Legacy teams*
  - *Maximum of 0.01% spurious sources*
- Galactic, without structured background
  - *SL shall meet reliability level achieved by Legacy teams*
  - *Maximum of 0.05% spurious sources when detected at 10 sigma in two bands*
- Galactic, with structure in the background
  - *Maximum of 0.2% spurious sources when detected at 10 sigma in two bands*
- MIPS-only fields (about half of MIPS data)
  - *Extragalactic: 0.05%*
  - *Galactic, low BG: 0.1% (appx, still under study)*
  - *Galactic, structured BG: 0.25% (appx, still under study)*

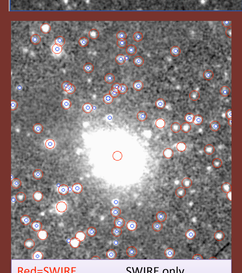
- Galactic with high crowding
  - *Under study*
  - *In the worst case, these fields will have to be rejected*

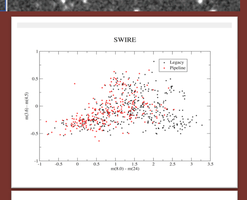
Validation

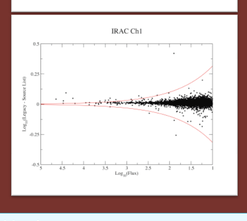
Comparison to SWIRE

- Low coverage, xgal legacy survey (test area 0.2 sq. deg.)
- We can solve this case
  - spurious source rate is < 0.01% (area limited number)
  - Completeness is 80-90% relative to legacy catalog
- Some differences remain (phot. scatter, diff bg sub, SWIRE required ch1+ch2)







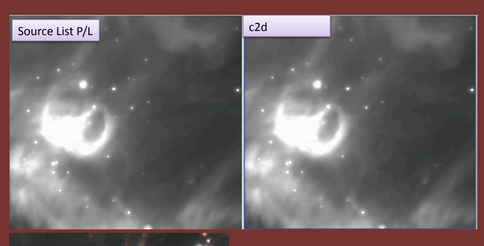


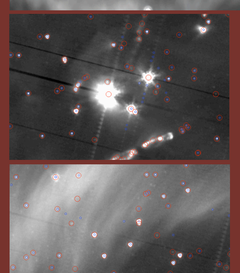
Red=SWIRE sources
Blue=source list extended

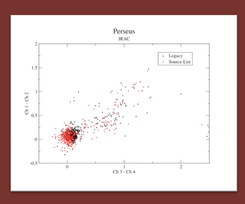
SWIRE only are mostly

Comparison to c2d

- Typical galactic, legacy survey (test area 0.4 sq. deg. In Perseus)
- We can solve this case
  - spurious source rate is < 0.1% (area limited number)
  - Completeness is 80-90% w.r.t. to legacy catalog "class A"
- Some differences remain (photometry differs by ~15%; c2d used DOphot)







Red=c2d
Blue=source list

SL misses source in structureded bg

Pipeline

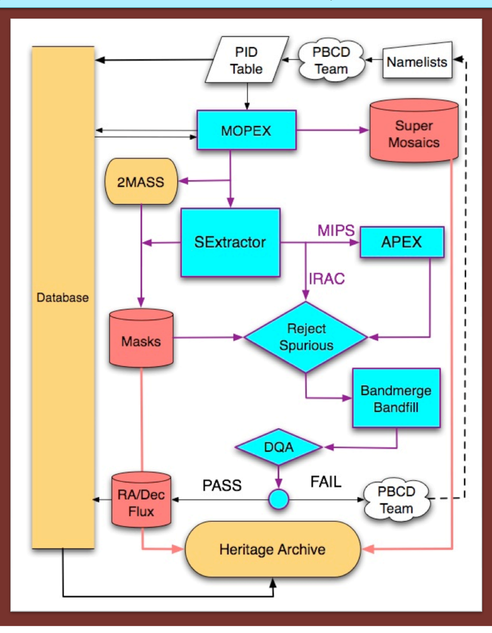
Source List Inputs

Use-case specific namelists for mosaic and photometry

- IRAC, Galactic low bg, Galactic high bg; xgal: shallow, medium, deep
- MIPS, Galactic and extragalactic
- Define Galactic = Extinction E(B-V)>0.2; or as in abstract

Mosaicking and Source Extraction

- Super (multi-AOR) mosaics for each PID (Some broken into smaller mosaics to facilitate processing; max 1 sq. deg.)
- Polled Legacy teams for best practices:
  GOODS, COSMOS, SWIRE, MIPSGAL, NOAO Deep/Wide, etc.
- Use some version of Overlap
- Outlier Rejection:
  Dual outlier + Box + Temporal for coverage <10
  Box and Temporal outlier for coverage >=10
  Higher thresholds used for Galactic case
- Source Extraction with APEX and Sextractor
  SExtractor extended source masks (see below)
  SExtractor Aperture photometry for IRAC
  PRF fitting for MIPS
  Deblending available in both packages
- Initial extraction of many sources, then exclude based on masks and shape parameters
- Bandmerge the list
  Match to closest object by position, report if multiple possible matches exist within positional errors
- Require two-band detection in Galactic cases to reduce spurious sources



Masking

- SExtractor extended source mask for each field to exclude:
  - *Non-compact galaxies*
  - *Extended background structure*
  - *Defines 0.5sigma isophote*
- Mask regions around bright stars
  - *2MASS stars*
  - *Bright, red stars identified by pixel fluxes in BCDs*
  - *include muxbleed spikes*

Reject Spurious Sources

- Exclude sources that are too compact or too extended
  - *Cosmic rays are too compact; galaxies and false detections within extended emission are too extended*
  - *IRAC:*
    - Peak pixel flux divided by aperture flux
  - *MIPS*
    - Central flux (1 PSF) divided by extracted flux
  - *Reject sources with FWHM inconsistent with point source (>2xPSF)*
- Reject source if peak pixel is not within positional uncertainty (0.9 arcsec) of the centroid

Artifact Rejection

IRAC

- Scattered light:
  - *masked in cBCDs*
- Muxbleed:
  - *improved in cBCDs; can be masked*
- False splitting of bright stars:
  - *Bright star mask*
- Unsplit close pairs:
  - *reject as extended or centroid shift*
- Cosmic rays:
  - *reject as too compact*
- CR on top of real source:
  - *Rare; reject as too compact if CR is bright enough*
- Falsely split extended objects
  - *use SExtractor isophote mask*
- Structured background emission detected as object:
  - *isophote mask, reject as too extended*
  - *Rarely survives two-band match*

MIPS

- Cosmic rays
  - *almost never a problem due to higher coverage*
- Latent images
  - *mask with new module*
- False detection in airy rings
  - *Increase size of bright star mask?*
  - *Could add iterative APEX QA*
- Structured background emission
  - *Still under study*
  - *Mask more area?*
  - *Add APEX QA following MIPS-GAL*
- False detection at edges
  - *Mask*
- Asteroids/moving objects
  - *Compare median/mean mosaics*

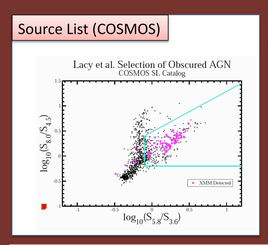
Products

- Mosaics
  - *IRAC data corrected by CBCD pipeline*
  - *MIPS data corrected for Latents, Jailbars and delta-flat*
  - *Will produce super-mosaics crossing AORs and PIDs*
    - Average images
    - Median images
    - Coverage maps
    - Uncertainty maps
    - IRAC color correction maps
- Source list
  - *Will only include compact sources*
  - *Extended sources masked to reduce artifacts and objects with poor photometry due to confusion*
  - *Regions of extended emission have higher S/N cut*
  - *The list is not complete, but is robust and cuts are quantified*

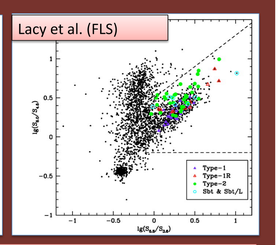
Science Use Cases

- A user would like to know the flux(es) of individual sources selected at other wavelengths
  - *Measuring the 24um flux for a list of SDSS quasars*
  - *Search for Exo-Zodiacal dust around main sequence stars*
  - *MIPS/IRAC fluxes of UV-selected starbursts*
- A user would like to select objects by color and/or flux
  - *Select obscured quasars*
  - *Search for z>5 galaxies*
  - *Search for Y, L, T dwarf stars*
  - *Identify "Missing" evolved stars*
  - *Search for galaxy clusters at z>1*
- A user would like to download photometry for a set of objects to do SED fitting
  - *Line of sight extinction curves*
  - *Photometric redshifts*

Source List (COSMOS)



Lacy et al. (FLS)



- We reproduce the selection of the AGN "wedge" in IRAC color-color plot (Lacy et al. 2004, 2007)

NOTE

Results remain limited in fields with highly structured backgrounds.
Few spurious sources are selected but completeness is compromised.