Background

The MYStIX project (Massive Young star-forming complex Study in Infrared and X-rays) is compiling comprehensive catalogs of the stellar membership in 18 Galactic massive star-forming complexes (d = 0.4 to 3.6 kpc) [1]. MYStIX is the first project of its kind to study a large sample of Galactic regions in parallel, employing a homogeneous set of multi-wavelength data analysis techniques. Probable stellar members in each target region are identified using X-ray and/or infrared photometry via two pathways: (1) X-ray detections of young/massive stars with coronal activity/strong winds or (2) Infrared (IR) excess–based identification of young stellar objects (YSOs) with circumstellar disks and/or protostellar envelopes.

We present the methodology and initial results of pathway (2), using Spitzer/IRAC, 2MASS, and UKIDSS imaging and photometry. Although IR excess selection of YSOs is well-trodden territory [2,3,4], MYStIX presents unique challenges. The target regions run the gamut from relatively nearby, lower-mass regions in uncrowded fields (e.g., NGC 2264), to massive complexes located at greater distances along complicated, inner Galaxy sightlines (e.g., NGC 6357). We have developed a new procedure combining IR spectral energy distribution fitting [5] with IR color cuts and spatial clustering to separate probable YSO members in each MYStIX target field from the myriad types of contaminating objects that resemble YSOs: extragalactic sources, evolved stars, and polycyclic aromatic hydrocarbon (PAH) nebular knots. Applying this technique consistently across 18 MYStIX complexes, we have produced the MYStIX IR-Excess Source catalog (MIRES).

MIRES Catalog Statistics

**Full MIRES Catalog:**
- 10,127 — probable YSO members
  - 3,059 (30%) — envelope-dominated (Stage 0/I [6])
  - 4,253 (42%) — disk-dominated (Stage II/III [6])
  - 2,815 (28%) — envelope/disk ambiguity [4]
- 1,664 — shocked molecular 4.5 µm emission [4]
- 5,064 — non-member YSOs/evolved stars
- 2,314 — obscured active galactic nuclei (AGN)
- 4,873 — starburst/PAH galaxies
- 1,035 — PAH nebular knots

**MIRES Subset within MYStIX X-ray Fields**
- 5,103 — probable YSO members
  - 1,646 (32%) — envelope-dominated
  - 1,946 (38%) — disk-dominated
  - 1,511 (30%) — envelope/disk ambiguity
  - 210 — shocked molecular 4.5 µm emission
  - 508 — non-member YSOs/evolved stars
  - 592 — obscured AGN
  - 1,495 — starburst/PAH galaxies
  - 351 — PAH nebular knots

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The MYStIX Infrared Excess Source Catalog: The Dark Art of Hunting Young Stellar Objects with Infrared Excess Emission

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- Starburst/PAH galaxies (squares) + AGN (triangles)
- Non-member YSOs/evolved stars

**Figure 1.** — MYStIX “prototype” star-forming complexes NGC 2264 and Trifid, displayed at the same angular scale. Upper panels: Locations of all MIRES catalog entries overlaid on Spitzer/IRAC 3.6 µm images, highlighting the very different levels of field star versus extragalactic source contamination between inner and outer Galaxy sightlines. Lower panels: Locations of MIRES classified as probable YSO members of the MYStIX complexes overlaid on Spitzer/IRAC 8.0 µm images, highlighting PAH nebularity and IR dark clouds.

**Figure 2.** — Four additional MYStIX complexes with probable MIRES YSO members displayed on 8 µm images (common angular scale).

**Figure 3.** — Mid-IR color-color diagrams (CCDs) of the full MIRES catalog. All sources with photometric uncertainties ≤ 0.1 mag in the relevant bandpasses are plotted. (a) 3-band CCD showing color cuts used to identify 4.5 µm shock emission and PAH nebular knots. (b) 4-band CCD with the “disk domain” of Allen et al. (box).

**MYSX Science**

Both the MIRES and full MYStIX young stellar catalogs [7] will be published as electronic tables that will provide the foundation for future studies of diverse phenomena related to massive star cluster formation, including:

- cluster structure and cluster–molecular cloud co-evolution
- circumstellar (including protoplanetary) disk demographics and evolution
- protostars and protostellar outflows
- massive star feedback and triggered star formation
- star formation rates