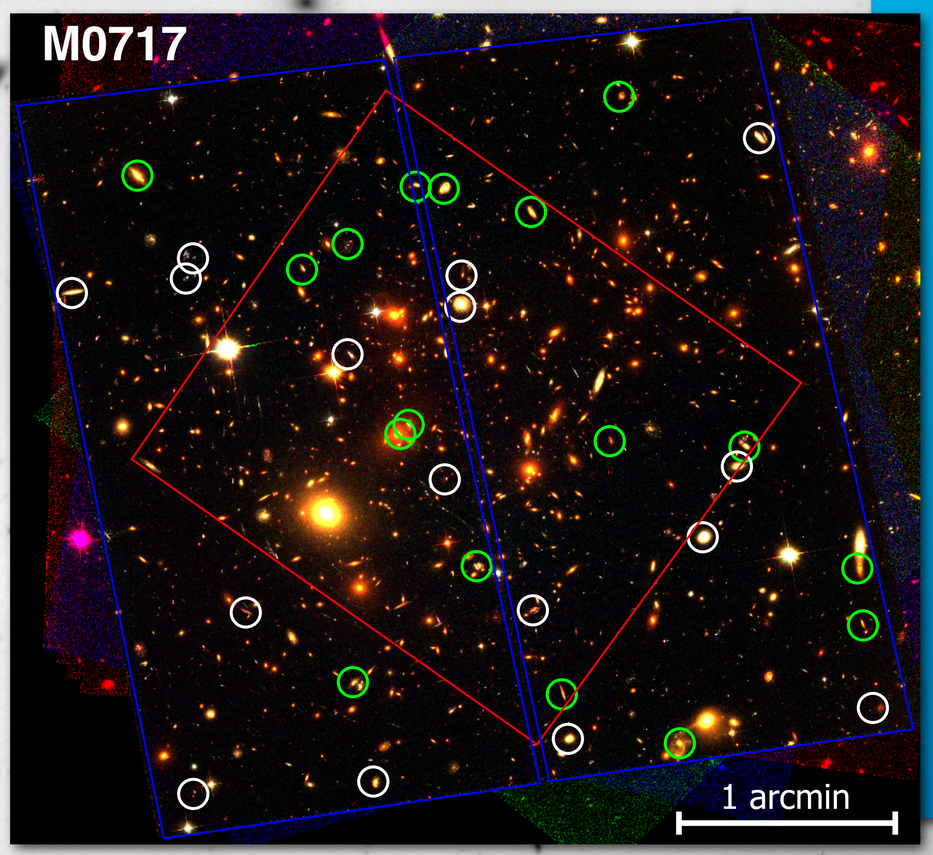
A Complete Census of Herschel sources within the Hubble Frontier Fields

T. Rawle[1,2] (tim.rawle@sciops.esa.int), B. Altieri[2], E. Egami[3], P. Pérez-González[4], J. Richard[5] I. Valtchanov[2], G. Walth[3], and the HLS Collaboration

[1]ESA @ STScI, [2]ESAC, [3]University of Arizona, [4]Universidad Complutense Madrid, [5]Observatoire de Lyon

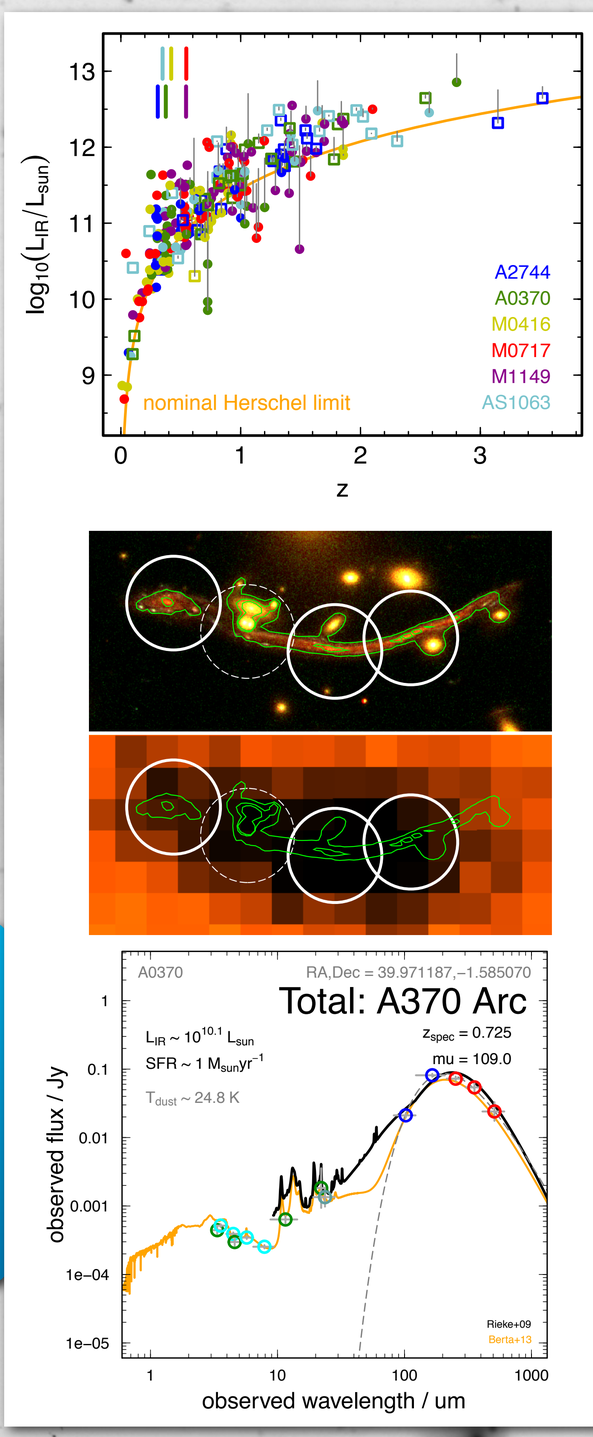


Rawle+16 (arXiv:1508.00586) presents a complete census of all **263** Herschel-detected sources within the six HST Frontier Field (HFF; Lotz+16) clusters.

We provide a robust legacy catalogue of Herschel fluxes, predominantly based on imaging taken by the **Herschel Lensing Survey** (HLS; Egami+10). Photometry is derived via a simultaneous PSF-fit using priors from archival Spitzer IRAC+MIPS imaging.

We optimally combine Herschel, Spitzer and WISE infrared photometry with data from HST, VLA and ground-based observatories, identifying optical counterparts in all cases. Knowledge of the counterpart is vital to gain **a source redshift**, which in turn allows the derivation of magnification factor (μ), intrinsic IR luminosity and characteristic dust temperature. The counterpart catalogue therefore provides a comprehensive view of dusty star formation within the Frontier Fields.

⇐ MACS0717 HST ACS 435/606/814 image with Herschel-detected FIR sources highlighted (green circles have spec-zs, white rely on photo-zs).



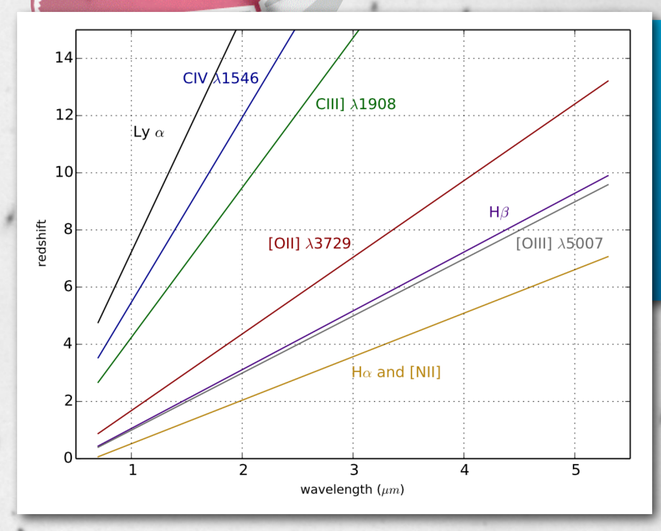
Over all six clusters, the Herschel catalogue contains **163 lensed sources**. Nine are magnified by μ > 4, and 29 are more than doubled in brightness. The sample includes 99 LIRGS (10^{11} < L_{IR} < 10^{12} $L_\odot$) and 23 sub-LIRGs (L_{IR} < 10^{11} $L_\odot$).

⇒ **UPPER PANEL:** All catalogue sources plotted by intrinsic L_{IR}. Magnification effects are denoted by the grey vertical lines for each source. The highest magnification, intrinsically faintest, sources tend to be located at 0.6 < z <1.6.

LOWER PANELS: The highly magnified arc in A370 appears extended in Herschel bands. With μ > 100, the galaxy has a source plane (intrinsic) **L_{IR} ~ 10^{10} $L_\odot$** at z = 0.73.

Unfortunately, for sources with only photo-zs, the derived intrinsic parameters have large uncertainties.

Augmenting Herschel analysis with the JWST NIRSpec MSA



⇐ For optically-faint Herschel samples in crowded lensing cluster fields, **NIR multi-object spectroscopy** can efficiently provide redshift and diagnostic information for sources unobtainable with current optical instruments.

- emission lines for redshift estimation at z ~ 1–3, including those within the optical "redshift desert"
- star formation from Hα emission, and hence obscuration constraints
- metallicity from the [NII]/Hα ratio
- at higher redshift, further lines such as [OIII], Hβ (both for z > 2.5), [OII] (z > 4)

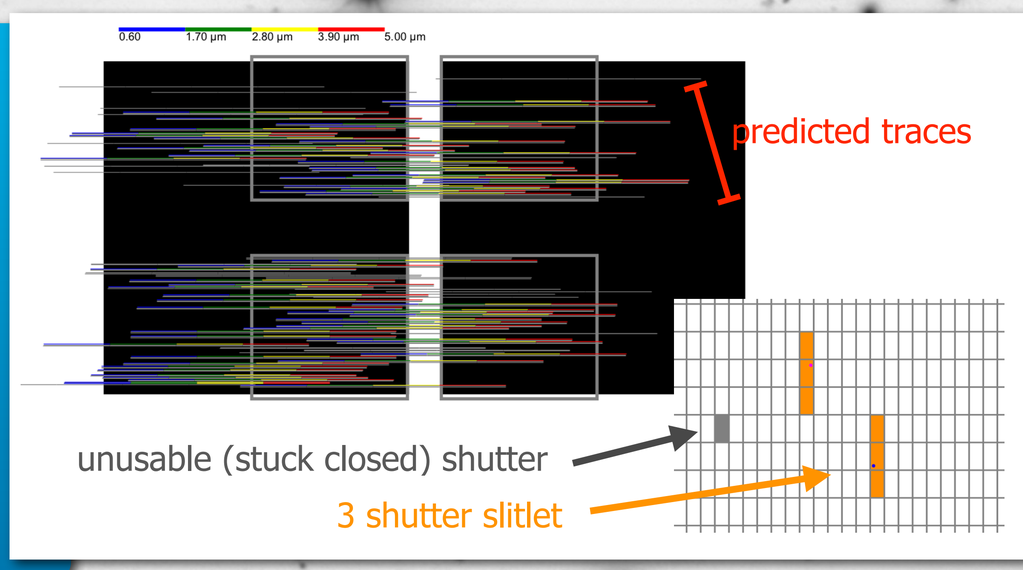
NIRSpec has a suite of selectable optical elements designed to obtain spectra covering 1–5 μm in three bands (1.0–1.8, 1.7–3.1, 2.9–5.2 μm), and at three levels of resolution (R~100 prism, and R~1000 or 2700 grisms).

The **MSA** mode offers an array of ~250,000 configurable microshutters, enabling the selection of up to ~100 simultaneous targets by opening slit-lets (0.2" width) within 4 quadrants covering a 3'x3' field.

We create an example MSA configuration for the Herschel sources within MACS0717. The primary science goals are 1) determine redshifts for optically-faint counterparts, 2) measure Hα to assist in constraining internal extinction. We estimate SFR(Hα) ~ 0.5 $M_\odot$/yr at z~2 corresponds to a (>5σ) detection of F ~ $5x10^{-18}$ erg/s/cm^2, and for galaxies at z>2.5 [OIII] will be comparably bright.

We use the G235H/F170LP elements to yield R~2700 spectra for 1.7–3.1 μm. The sensitivity requirement can be fulfilled in ~40 min on-sky. Including target acquisition and configuration overheads, this can be executed in ~1 hr, and would include a 3-shutter nod pattern along the slit for sky subtraction and dithering in the dispersion direction to remove the detector gap.

⇒ **LEFT:** Our example MSA configuration for MACS0717 includes **22/33** of the Herschel sources (+63 Spitzer fillers). Here we show the predicted traces from the 4 MSA quadrants (grey outline squares) on the NIRSpec detectors (black squares). Note that with the selected filter/grating, traces will be obtained for 1.7–3.1 μm only (green and yellow segments).
RIGHT: Zoom of the MSA surrounding two neighbouring slitlets (each of 3x1 shutters).



Based upon **Rawle et al. submitted (MNRAS); arXiv:1508.00586**

For further information, please contact **tim.rawle@sciops.esa.int**

References: Egami et al., 2010, A&A, 518, 12; Lotz et al., 2016, in preparation