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Exploring the Deepest-Ever *Herschel* Field

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We have assembled the **deepest-ever** *Herschel* field using stacked calibration data, analysed **galaxy counts**, identified numerous **candidate high-redshift galaxies**, and are now investigating **P(D) analysis** and **XID+** with MIPS catalogues.

1 Introduction

The Herschel Space Observatory (*Herschel*) [1] was the largest space telescope launched to date, covering infrared wavelengths at 250, 350, and 500 microns (inaccessible from the ground) with the SPIRE instrument photometers.

During the mission, SPIRE routinely observed an area of sky for calibration, known as the SPIRE Dark Field. By stacking these ~200 observations, we have assembled the deepest-ever Herschel survey.

- Aim: to probe the star-forming history of dusty, high-redshift galaxies.
- Confusion noise (high extragalactic source density, relative to telescope resolution) dominates.
- Our field is twice as deep as HLS [2], and up to 100 times deeper than H-ATLAS [3] and HerMES [4].

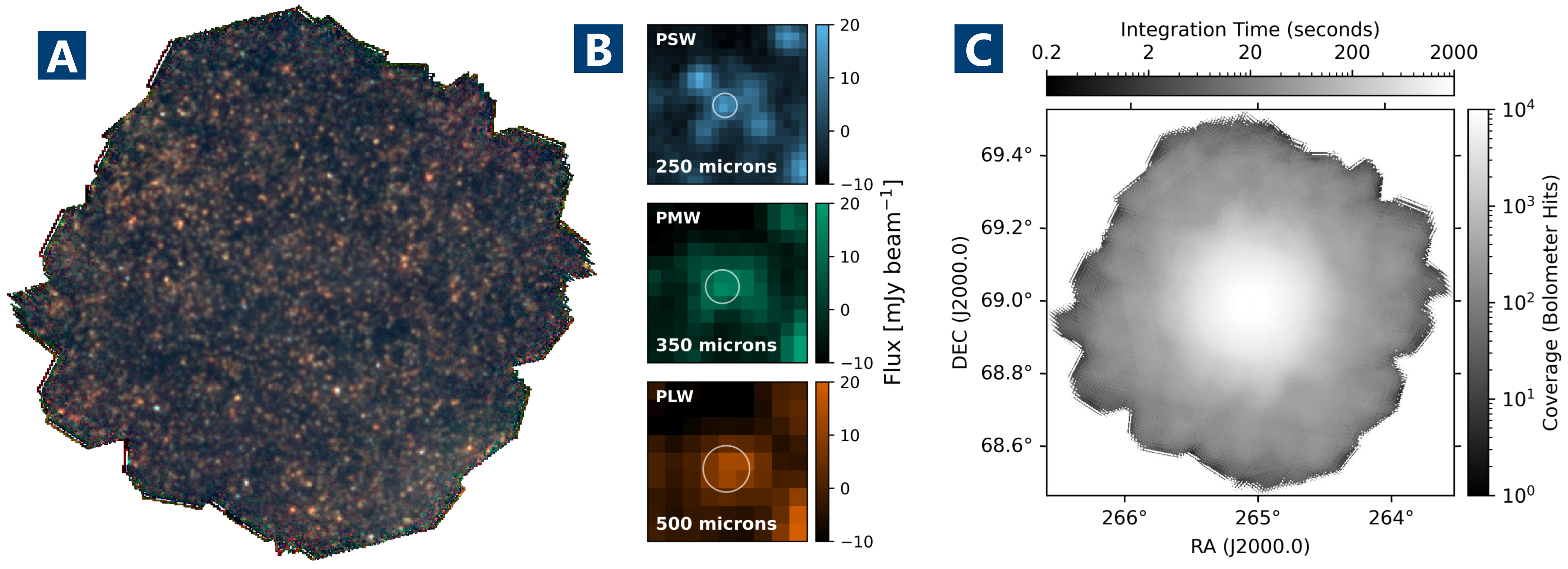

Fig. 1: (Left to right) **[A]** *Herschel* Dark Field image, colourised (Red: PLW 500 μm, Green: PMW 350 μm, and Blue: PSW 250 μm). **[B]** Postage stamp cut-outs of a source, showing increasing pixel size with wavelength. **[C]** Coverage (bolometer hits) map, illustrating total stacked integration time per pixel.

2 Method: Source Extraction

We use the *SUSSEXtractor* [8] algorithm within *HIPE* (Herschel Interactive Pipeline Environment) to perform source extraction.

- Assume Gaussian point-response function (PRF).
- Use full-width half-maxima (FWHM), matching the SPIRE beams.

1) Local background estimated from pixel histograms of regions.
2) Bi-cubic interpolation used to subtract this from the map.
3) Filtering by a convolution kernel derived from the PRF.
4) Smaller peaks above 5σ identified as potential sources.
5) Starting from the most significant peak, a Gaussian is fitted to each peak to estimate its exact position and flux density.

We determined various corrections for statistical selection effects:

- **Completeness:** probability that a real source (at a specified flux) will be extracted by the source extraction method.
- **Reliability**: probability that the source detected is a real source, instead of a false detection (e.g., noise fluctuation).
- **Flux-boosting:** fraction that the flux density is increased by, due to confusion noise.

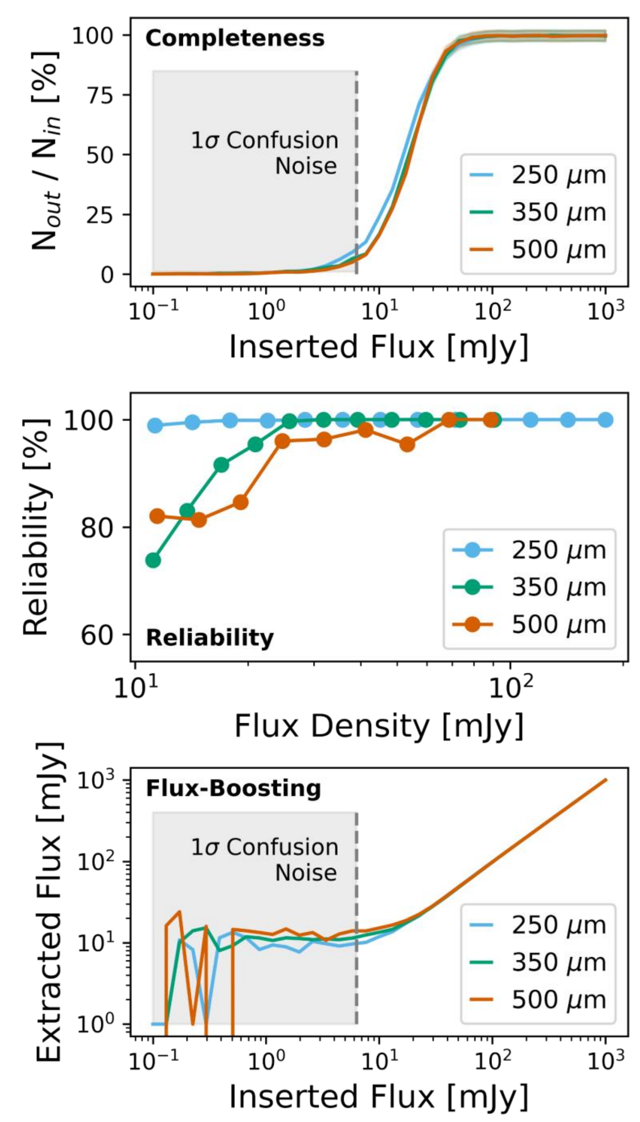

Fig. 2: (Top to bottom). **Completeness**: detected sources as a function of flux. **Reliability:** false source detection at dN/dS bins. **Flux-boosting:** mapping between detected/true fluxes.

3 Results: Galaxy Counts

Our number count results show clear galaxy evolution, in agreement with previous *Herschel* surveys [3, 6].

- dN/dS: number of sources within a flux density bin, per unit area on the sky.
- Euclidean normalized (multiplied by $S^{2.5}$), so dN/dS remains constant if no evolution occurs.
- Steep rise (evolution), leading to a plateau at fainter fluxes, where *SUSSEXtractor* is confusion-limited.

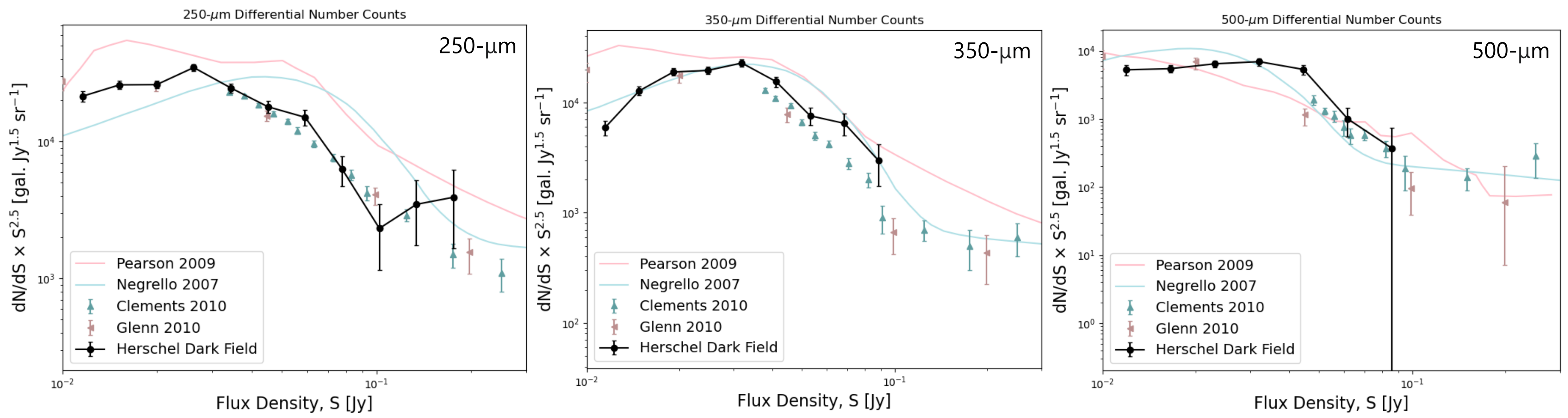

Fig. 3: (Left to right) Differential number count plots (dN/dS) for the three SPIRE bands (250, 350, and 500 μm). Compared with observational results from other *Herschel* surveys [3, 6], and pre-*Herschel* theoretical models [7, 8]. Good agreement at faint flux levels. Bright counts limited by field size.

4 Ongoing and Future Studies

Extending the Counts to the Faintest Levels

- P(D): considers statistical distribution of pixels.
- Pushes beyond typical confusion limit [6].
- We appear to have resolved large fraction of cosmic infrared background (CIB) (see Fig. 4).

Multi-Wavelength Analysis.

- Apply XID+ algorithm, using MIPS priors. [9]
- Breaks degeneracy due to large beam size.

Detecting Exotic Objects

- Identified numerous candidate very-high-redshift galaxies within our survey (Fig. 4).
- "500-risers": sources which exhibit increasing flux from 250-500 microns (e.g. Fig. 1B).

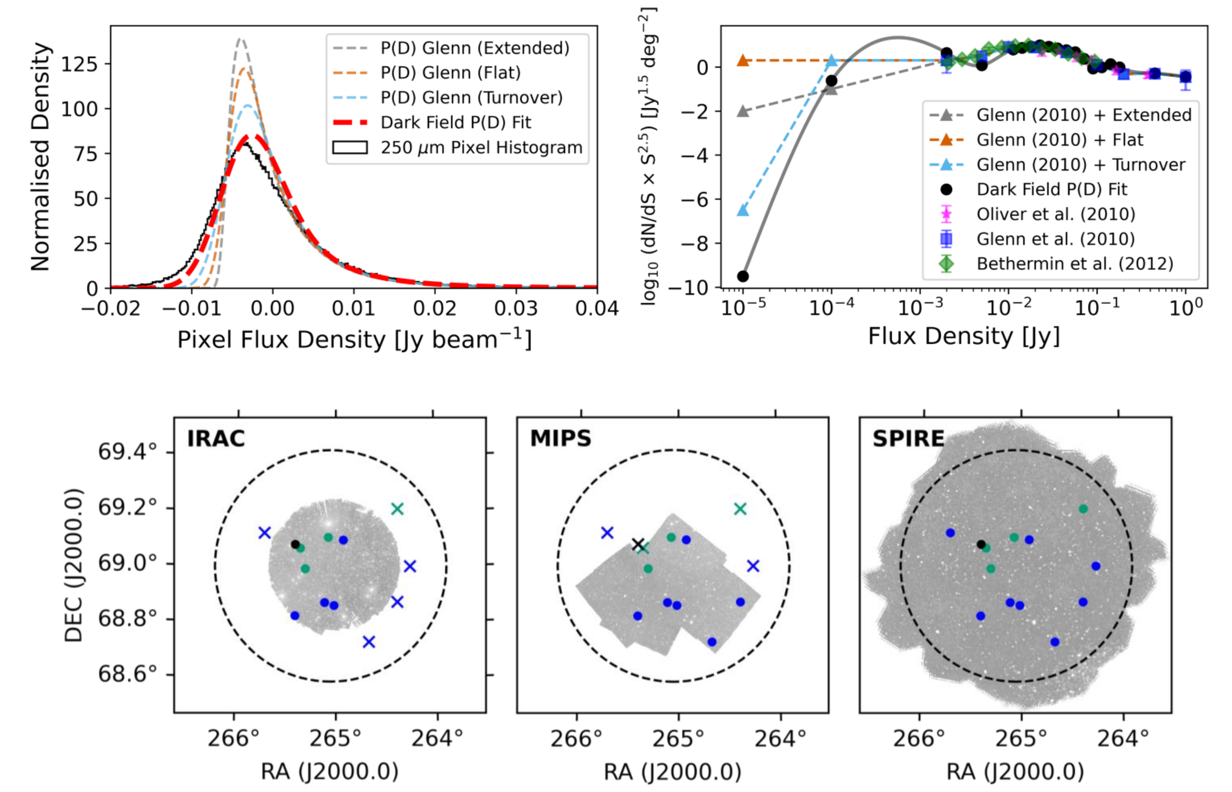

Fig. 4: [Upper] Preliminary P(D) fitting results: LEFT: P(D) compared to pixel histogram, RIGHT: dN/dS model from fitted P(D) [4, 6, 11]. **[Lower]** 500-riser positions. Green: detections in both 250/500 μm bands (considering flux errors), Blue: 250-micron-only detections. Black: position of riser in Fig. 1B.

Conclusions

- Deepest-ever *Herschel* survey, allowing us to extend results to fainter flux limits.
- Clear evidence of galaxy evolution, in good agreement with legacy surveys.
- Evidence of a turnover point in galaxy counts: resolving a large fraction of CIB.

References:
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[6] Glenn et al. 2010, *MNRAS* 409 p. 109.
[7] Pearson and Khan 2009, *MNRAS* 399 L11.
[8] Negrello et al. 2007, *MNRAS* 377 p. 1557.
[9] Roseboom et al. 2010, *MNRAS* 409 p. 48.
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