



Herschel Extragalactic
Legacy Project



The *Herschel* Extragalactic Legacy Project (HELP)

The final word on Herschel extragalactic fluxes?

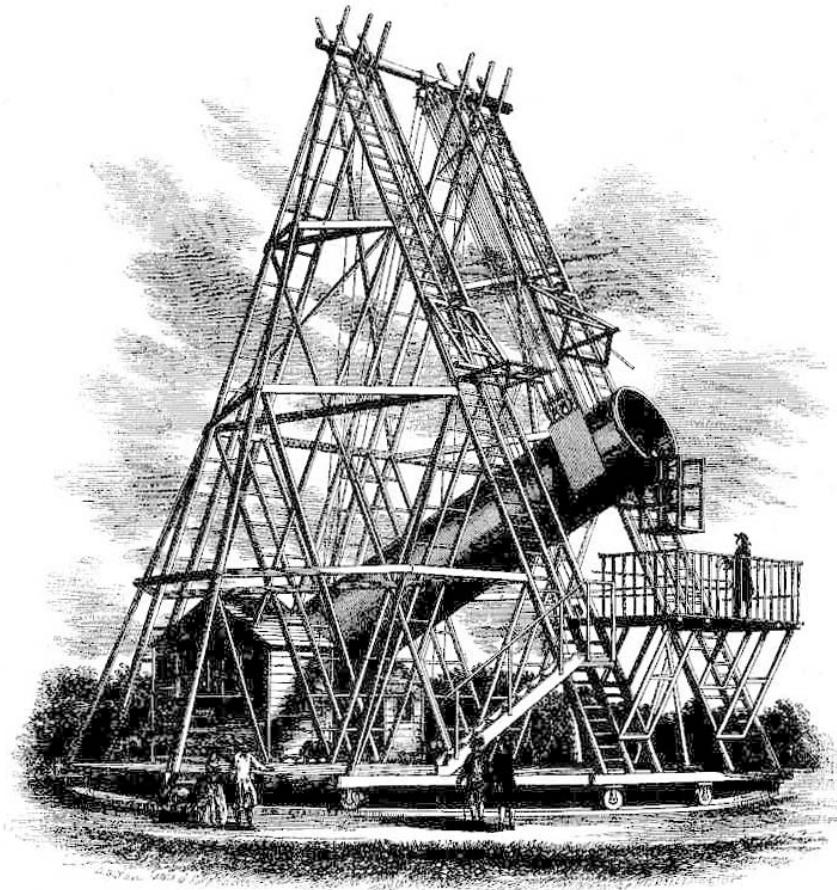
The ‘masterlist’, full pipeline and data dissemination tools.

Raphael Shirley (University of Sussex, Instituto de Astrofísica de Canarias)

13 May 2019
ESAC, Madrid

Herschel's great telescope – Subtilize it!

“Is it not curious, that so vast a being as the whale should see the world through so small an eye, and hear the thunder through an ear which is smaller than a hare’s? But if his eyes were broad as the lens of Herschel’s great telescope; and his ears capacious as the porches of cathedrals; would that make him any longer of sight, or sharper of hearing? Not at all.- Why then do you try to “enlarge” your mind? Subtilize it.” – Moby Dick.



Herschel (3?)

- Instruments:
 - Photodetector Array Camera and Spectrometer (PACS); 70, 100, 160 μm images
 - The Spectral and Photometric Imaging Receiver (SPIRE); 250, 350, 500 μm .



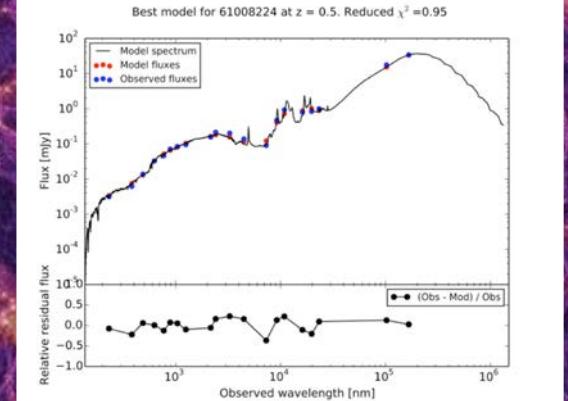
We need large fields & multi- λ

3° at z=1

125 Mpc/h

ASTRODEEP
fields

Typical HerMES
field



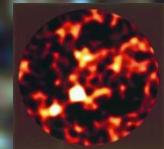
$\Delta z = 0.1$ at $z = 1$

250 μ m

350 μ m

500 μ m

GOODS-N



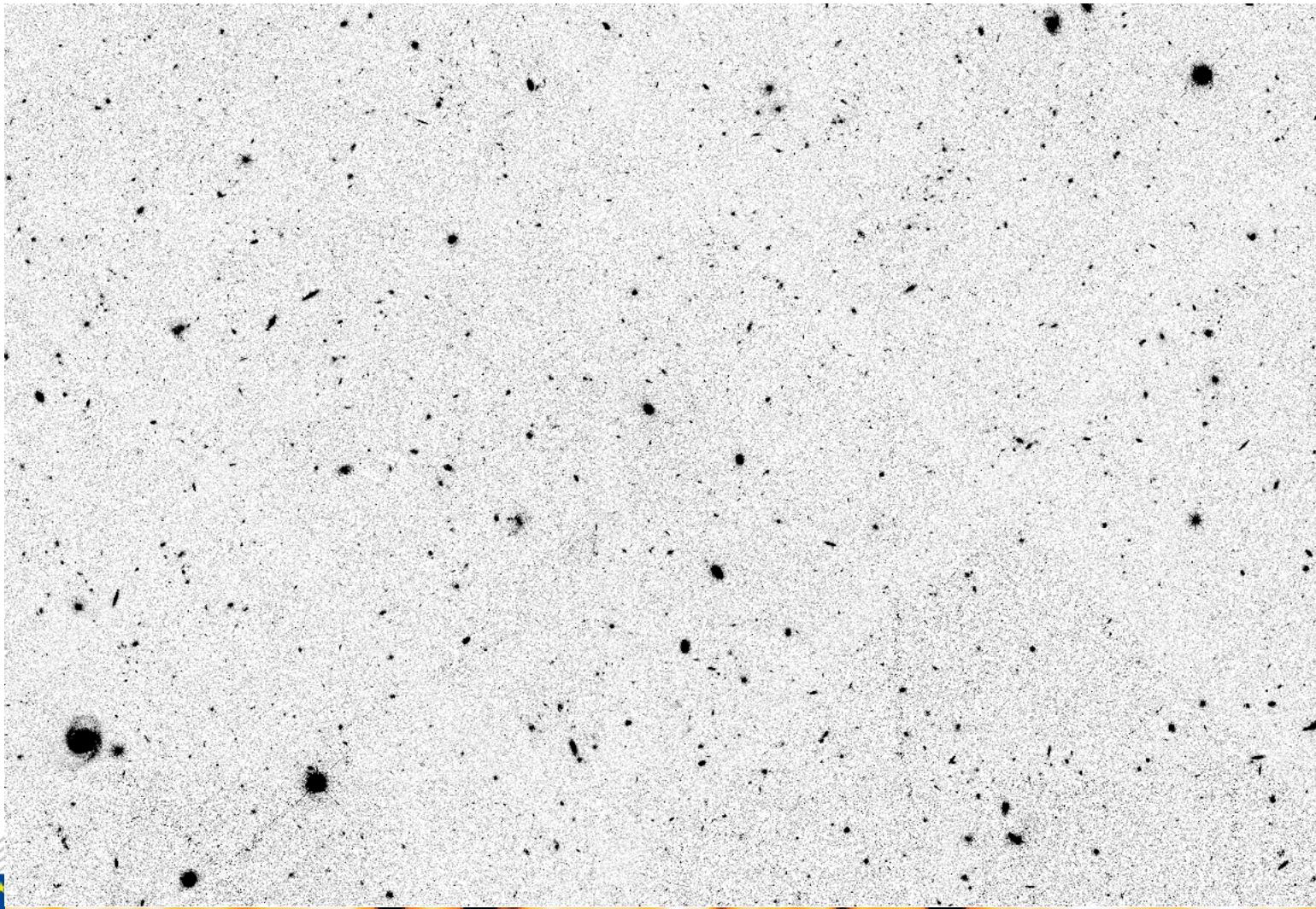
↔ 10 arcmin ↔

The power of multi-wavelength imaging against confusion

500um 350um 250um 160um 100um 24um 3.6um 0.8um

<http://www.sussex.ac.uk/Users/sw376/XDF/MultiWave/>

7.5' x 6.5' zoom on the GOODS-North field (10' x 15')



6.5'



<http://herschel.sussex.ac.uk>

7.5 arcmin

 HELP
Herschel Extragalactic Legacy Project
David Elbaz

HELP! Overview

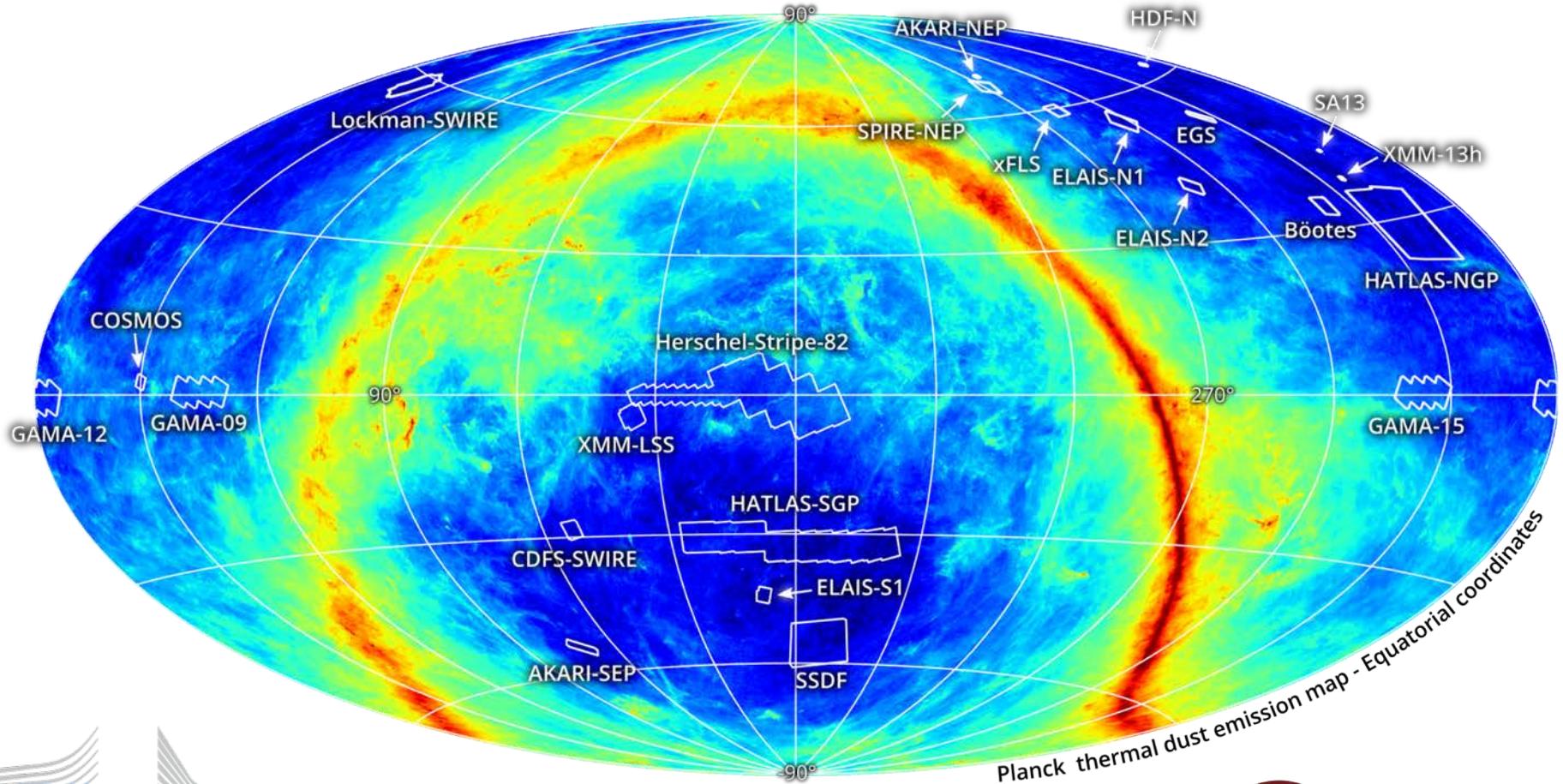
- European Commission funded project
- Provide a multi- λ database over 1,300 deg.²
- Remove the barriers to multi- λ statistical survey science
- Produce value-added resources for astronomers to easily interpret the high redshift Universe
- Develop innovative tools to make Herschel surveys easy to use ... rethinking data



<http://herschel.sussex.ac.uk>



HELP fields



<http://herschel.sussex.ac.uk>



Herschel Extragalactic
Legacy Project

Pristine catalogues



Masterlist

Photo-z

CIGALE SEDs/
physical properties

End user

XID+ fluxes

Herschel maps



<http://herschel.sussex.ac.uk>



Herschel Extragalactic
Legacy Project

Open and reproducible science



<http://herschel.sussex.ac.uk>



Pristine catalogues

Table A2. Overview of data included on all HELP fields. We chose the deepest public data available.

Survey	Telescope	Instrument	Filters	Reference
Two Micron All Sky Survey (2MASS)	2MASS dedicated telescopes	Dedicated instrument	J, H, Ks	Skrutskie et al. (2006); Cutri et al. (2003)
All-wavelength Extended Groth strip International Survey (AEGIS)	Palomar Observatory	WIRC	J, Ks	Bundy et al. (2006)
Optical-NIR catalog of AKARI NEP Deep Field	Canada France Hawaii Telescope (CFHT)	MegaCam, WIRCam	u, g, r, i, z, Y, J, Ks	Oi et al. (2014)
VST ATLAS SURVEY	VLT Survey Telescope (VST)	OmegaCAM	u, g, r, i, z	Shanks et al. (2015)
3D-HST-CANDLES catalog	Hubble Space Telescope (HST)	Wide Field Camera 3 (WFC3)	5 HST bands (125nm–606nm)	Skelton et al. (2015)
Cosmic Near-Infrared Deep Extragalactic Legacy Survey (CANDLES)	HST	WFC3 , Advanced Camera for Surveys (ACS)	10 HST bands (98nm–850nm)	Grogin et al. (2011)
WIRCam Deep Survey (WIRDS)	CFHT	WIRCAM	J, H, Ks	Bielby et al. (2012)
Canada-France-Hawaii Telescope Legacy Survey (CFHTLS)	CFHT	MegaCam	u, g, r, i, z	Hudelot et al. (2012)
The CFHT Lensing Survey (CFHTLenS)	CFHT	MegaCam	u, g, r, i, z	Heymans et al. (2012); Erben et al. (2013)
Classifying Objects by Medium-Band Observations 17-filter survey (COMBO-17)	MPG/ESO 2.2m-telescope (La Silla)	Wide Field Imager (WFI)	UBVRI, 12 narrow bands (420nm–914nm)	Wolf et al. (2004)
DECam Legacy Survey (DECaLS)	Bok 2.3-m telescope, Mayall telescope, Blanco Telescope, CFHT	90Prime camera, MOSAIC-3 camera, Dark Energy Camera (DECam)	u, g, r, i, z, Y	Blum et al. (2016)
DEEP2 Galaxy Redshift Survey	CFHT	CFHT12K	B, R, I	Coil et al. (2004)
Dark Energy Survey (DES)	Blanco Telescope	Dark Energy Camera (DECam)	u, g, r, i, z, Y	Abbott et al. (2018)
DataFusion-Spitler catalogues (SERVS and SWIRE)	Spitzer	IRAC, MIPS	IRAC1234, MIPS123	Vaccari (2015)
ESO-Spitler Imaging extragalactic Survey (ESIS)	2.2-m MPG/ESO telescope at La Silla	Wide Field Image (WFI)	B, V, R	Berta et al. (2006)
FIREFWORKS photometry of GOODS CDF-S	ESO/MPG 2.2m telescope, HST, VLT, Spitzer	ESO/WFI, HST/ACS, VLT/ISAAC, Spitzer/IRAC	16 bands UV to FIR	Wuyts et al. (2008)
GOODS ACS Treasury program	HST	ACS	b, i, v, z	Giavalisco et al. (2004)
Hyper Suprime-Cam Subaru Strategic Program (HSC-SSP)	Subaru	Hyper Suprime-Cam (HSC)	g, r, i, z, y, N821, N816	Aihara et al. (2018)
Hawaii Hubble Deep Field North (Hawaii-HDFN)	KPNO, Subaru, and University of Hawaii 2.2m telescope	MOSAIC prime focus, Suprime-Cam, and QUIRC	U, B, V, R, I, z', HK'	Capak et al. (2004)
Infrared Bootes Imaging Survey (IBIS)	National Optical Astronomy Observatory (NOAO)	NEWFIRM	J, H, Ks	Gonzalez et al. (in prep)
Wide-field optical imaging on ELAIS N1, ELAIS N2, First Look Survey and Lockman Hole	Isaac Newton Telescope (INT)	Wide Field Camera (WFC)	u, g, r, i, z	González-Solares et al. (2011)
UV-to-FIR Analysis of Spitzer/IRAC Sources in the Extended Groth Strip Multiple Kilo-Degree Survey (KIDS)	Multiple	Multiple	Multiple	Barro et al. (2011)
Spitzer First Look Survey (FLS) - NOAO Extragalactic - R	VLT Survey Telescope (VST)	OmegaCAM	u, g, r, i	de Jong et al. (2013)
Legacy Surveys	Kitt Peak 4m telescope	MOSAIC-1	R	Fadda et al. (2004)
NOAO Deep Wide-Field Survey (NDWS)	Bok 2.3-m telescope, Mayall telescope	90Prime camera, MOSAIC-3 camera	u, g, r, i, z, Y	Zou et al. (2017); Silva et al. (2016)
Pan-STARRS1 Survey Telescope and Rapid Response System (PanSTARRS1) 3pi Steradian Survey (3SS)	NOAO 4m telescope, Pan-STARRS1 (PS1, Haleakala, Hawaii)	MOSAIC-1	R, i, Bw, Ks	Jannuzi et al. (2016)
Red Cluster Sequence Lensing Survey (RCSLenS)	CFHT	Gigapixel Camera 1 (GPC1)	g, r, i, z, y	Chambers et al. (2016)
Sloan Digital Sky Survey (SDSS) - DR13	Sloan Foundation 2.5m Telescope	MegaPrime/MegaCam	g, r, i, z, y	Hildebrandt et al. (2016)
SDSS - Stripe 82	Sloan Foundation 2.5m Telescope	SDSS camera	u, g, r, i, z	Albareti et al. (2017)
Instituto de Astrofísica de Canarias (IAC) Stripe 82 Legacy Project	Sloan Foundation 2.5m Telescope	SDSS camera	u, g, r, i, z	Viero et al. (2014)
Spitzer Deep, Wide-Field Survey (SDWFS)	Spitzer	IRAC	IRAC1234	Fliri & Trujillo (2016)
Spitzer/HETDEX Exploratory Large-Area (SHELA) survey	Spitzer	IRAC	IRAC12	Ashby et al. (2009)
Spitzer-IRAC/MIPS Extragalactic Survey (SIMES)	Spitzer, Herschel	IRAC, MIPS, SPIRE	IRAC12, SPIRE250,350,500	Papovich et al. (2016)
SPFLASH-SXDF Multi-Wavelength Photometric Catalog	Several	Several	Several	Baronchelli et al. (2016)
Spitzer-South Pole Telescope Deep Field (SSDF)	Spitzer	IRAC	IRAC12	Mehtha et al. (2017)
Subaru/XMM-Newton Deep Survey (SXDS)	Subaru	Suprime-Cam	B, V, r, i, z	Ashby et al. (2013)
Spitzer Adaptation of the Red-sequence Cluster Survey (SPARCS)	CFHT	MegaCam	u, g, r, i, z	Furusawa et al. (2008)
Spitzer IRAC Equatorial Survey (SpIES)	Spitzer	IRAC	IRAC12	Tudorica et al. (2017)
Spitzer UKIDSS Ultra Deep Survey (SpUDS)	Spitzer	IRAC	IRAC1234	Timlin et al. (2016)
UKIRT Hemisphere Survey (UHS)	United Kingdom Infrared Telescope (UKIRT)	WFCAM	J	Dunlop et al. (2007)
UKIDSS Deep eXtra-galactic Survey (DXS)	UKIRT	WFCAM	J, K	Dye et al. (2018)
UKIDSS Large Area Survey (LAS)	UKIRT	WFCAM	U, J, H, K	Swinbank (2013)
UKIDSS Ultra-Deep Survey (UDS)	UKIRT	Wide Field Infrared Camera (WFCAM)	J, H, K	Lawrence et al. (2007)
Ultra-Deep Ks Survey in the GOODS-N	CFHT	WFCAM	J, K (plus IRAC crossmatches)	Almaini et al. (2007)
VISTA-CEHRT Stripe 82 Survey (VIC882)	OFHT, VISTA	CFHT/WIRCam, VISTA/VIRCAM	J, Ks	Wainscoat et al. (2010)
VIERS Multi-Lambda Survey (MLS)	CFHT + others	WIRCam (+ others)	Ks selected multiband	Geach et al. (2017)
Visible and Infrared Survey Telescope for Astronomy (VISTA) Hemisphere Survey (VHS)	VISTA	VISTA InfraRed CAMera (VIRCAM)	Y, J, H, Ks	Moutard et al. (2016)
VISTA Deep Extragalactic Observations (VIDEO) Survey	VISTA	VIRCAM	Y, J, H, Ks	McMahon et al. (2013)
VISTA Kilo-Degree Infrared Galaxy Survey (VIKING)	VISTA	VIRCAM	Y, J, H, Ks	Jarvis et al. (2013)
zBootes - z-band Observations of the NOAO Deep Wide-Field Survey Bootes Field	Bok 2.3-m telescope	90Prime imager	z	Edge et al. (2013)
				Cook (2007)



Pristine catalogues

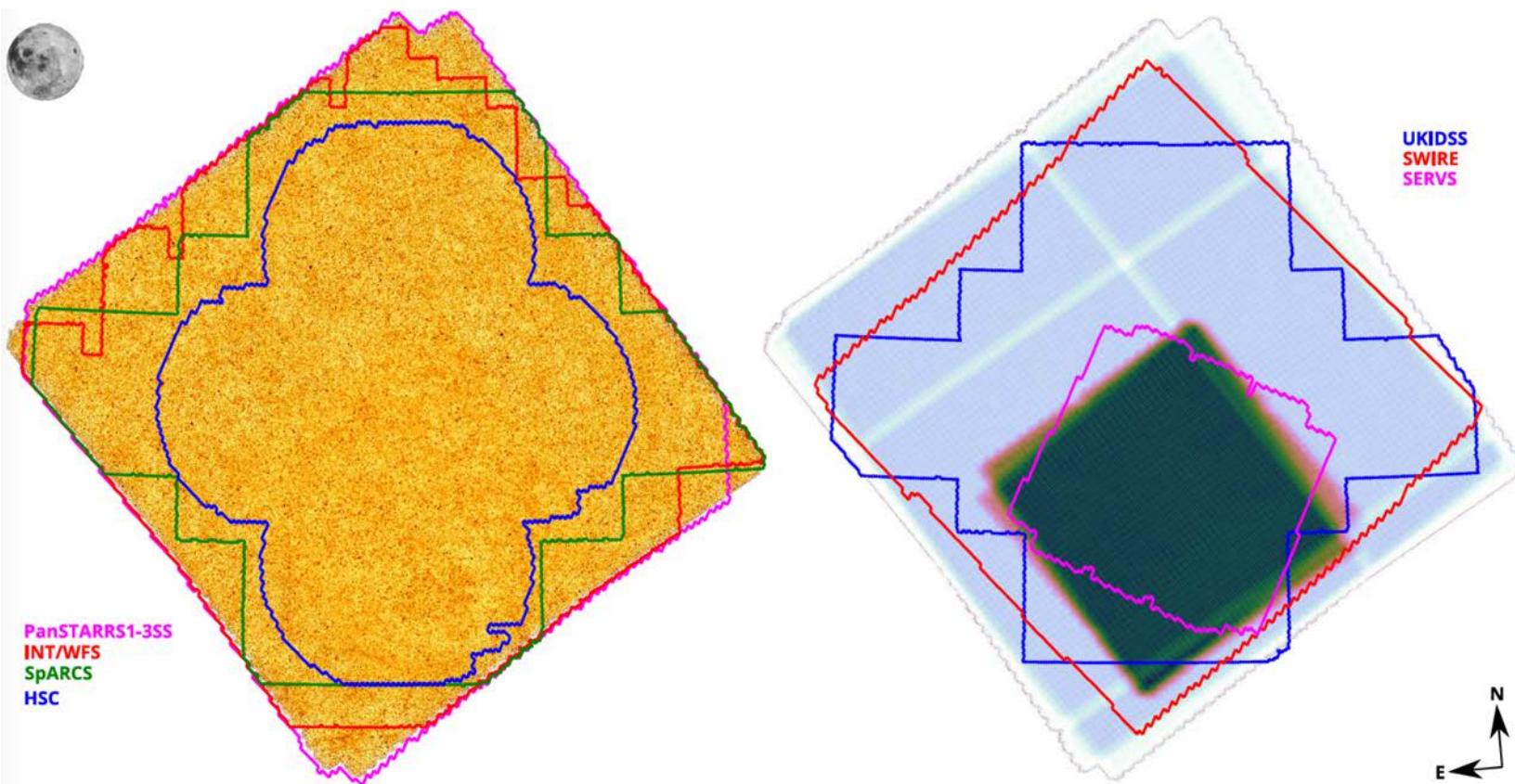
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DEEP2 Galaxy Redshift Survey	DECam	DECam	B, R, I	Coil et al. (2004)
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FIREFWORKS photometry of GOODS CDF-S	2.2-m PG, CfA telescope at La Silla, ESO/G 3.6m telescope, HST, VLT, Spitzer	ESO WFC, ACS, WFC, SAA, Spitzer, IRS	bands UV to FIR	Wuyts et al. (2008)
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UV-to-FIR Analysis of Spitzer-IRAC Sources in the Extended Groth Strip Multiple Telescopes (UGS-MT)	Multiple telescopes	MegaPrime/MegaCam	MegaPrime	Barro et al. (2011)
Kilo-Degree Survey (KiDS)	LT Survey Telescopes (LT)	MEGA	u, g, r, i, z, Y	de Jong et al. (2013)
Spitzer First Look Survey (PS1) - ACO	Keck Peak telescope	MEGA	u, g, r, i, z, Bw, Ks	Fadda et al. (2004)
R	Bok 2.3-m telescope, Mayall telescope	90Prime camera, MOSAIC-3 camera	u, g, r, i, z, Y	Zou et al. (2017); Silva et al. (2016)
Legacy Surveys	NOAO Deep Wide-Field Survey (NDWFS)	MOSAIC-3	u, g, r, i, z, Y	Jannuzi et al. (2016)
Pan-STARRS1 Survey Telescope and Rapid Response System	Pan-STARRS1 (PS1), Haleakala, Hawaii	Gigapixel Camera 1 (GPC1)	u, g, r, i, z, Y	Chambers et al. (2016)
(Pan-STARRS1) 3pi Steradian Survey (3SS)	CFHT	MegaPrime/MegaCam	g, r, i, z, Y	Hildebrandt et al. (2016)
Red Cluster Sequence Lensing Survey (RCSSLens)	Sloan Foundation 2.5m Telescope	SDSS camera	u, g, r, i, z	Albareti et al. (2017)
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Spitzer UKIDSS Ultra Deep Survey (SpUDS)	United Kingdom Infrared Telescope (UKIRT)	WFCAM	J	Dye et al. (2018)
UKIRT Hemisphere Survey (UHS)	UKIRT	WFCAM	J, K	Swinbank (2013)
UKIDSS Deep eXtra-galactic Survey (DXS)	UKIRT	WFCAM	U, J, H, K	Lawrence et al. (2007)
UKIDSS Large Area Survey (LAS)	UKIRT	Wide Field Infrared Camera (WFCAM)	J, H, K	Almaini et al. (2007)
UKIDSS Ultra-Deep Survey (UDS)	UKIRT	WFCAM	Ks (plus IRAC crossmatches)	Wainscoat et al. (2007)
Ultra-Deep Ks Survey of the GOODS-N	CFHT	VISTA	J, Ks	Geach et al. (2017)
VISTA-CEHRT Stripe 82 Survey (VIC8S2)	OFHT, VISTA	CFHT/WIRCam, VISTA/VIRCAM	Ks selected multiband	Moutard et al. (2016)
VIPERS Multi-Lambda Survey (MLS)	CFHT + others	WIRCam (+ others)	VISTA InfraRed CAMera (VIRCAM)	McMahon et al. (2013)
Visible and Infrared Survey Telescope for Astronomy (VISTA) Hemisphere Survey (VHS)	VISTA	VIRCAM	Y, J, H, Ks	Jarvis et al. (2013)
VISTA Deep Extragalactic Observations (VIDEO) Survey	VISTA	VIRCAM	Y, J, H, Ks	Edge et al. (2013)
VISTA Kilo-Degree Infrared Galaxy Survey (VIKING)	Bok 2.3-m telescope	90Prime imager	z	Cook (2007)
zBootes - z-band Observations of the NOAO Deep Wide-Field Survey Bootes Field				

60 surveys
500Gb catalogues



ELAIS-N1 pilot field

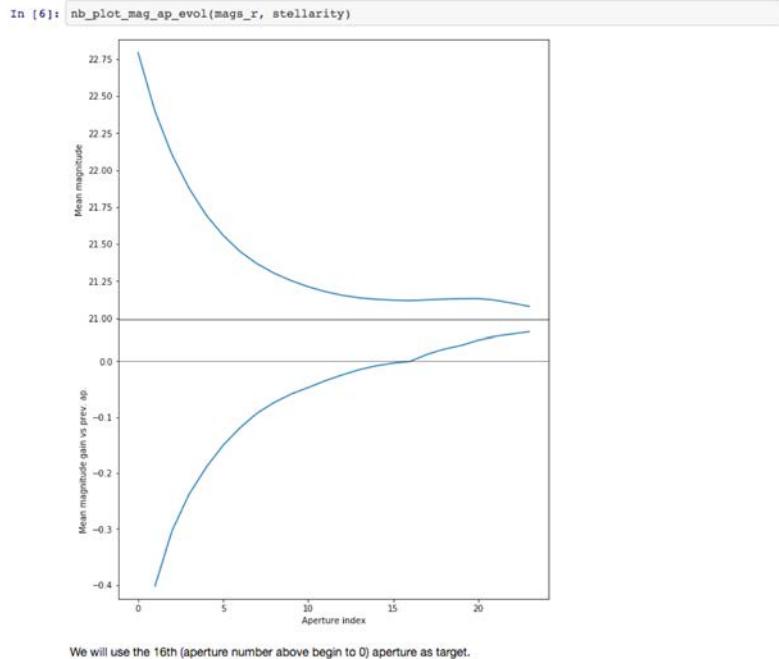


<http://herschel.sussex.ac.uk>

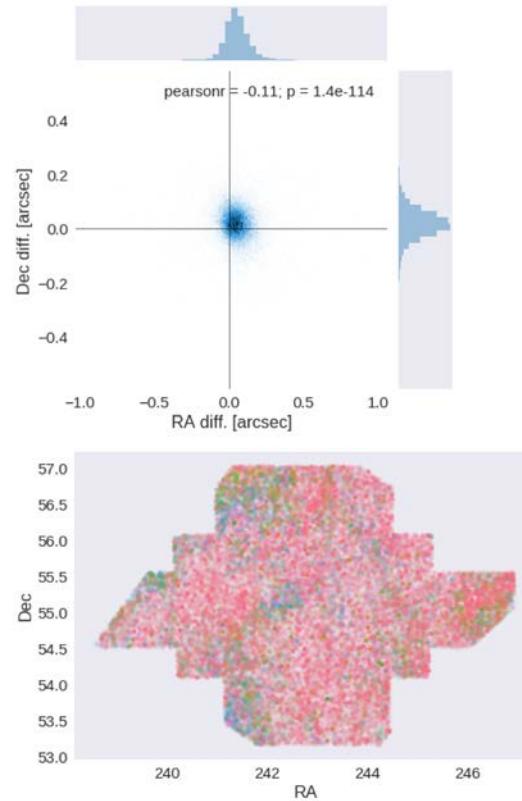


Homogenise input surveys

Aperture correction



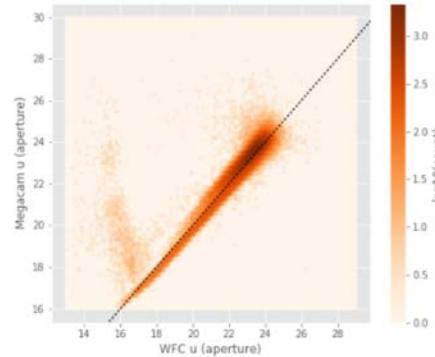
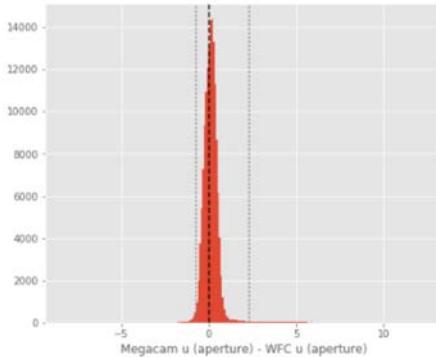
Astrometry correction



Checks and diagnostics

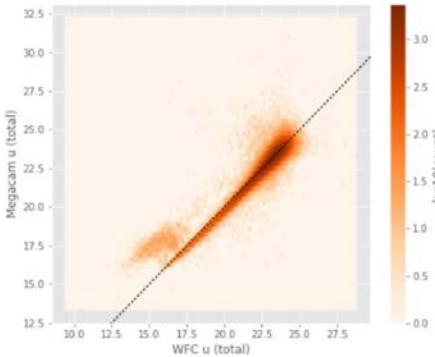
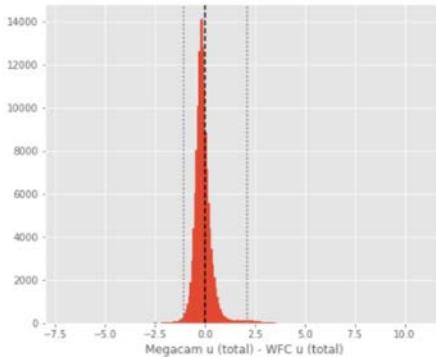
Megacam u (aperture) - WFC u (aperture):

- Median: 0.10
- Median Absolute Deviation: 0.24
- 1% percentile: -0.7272730255126953
- 99% percentile: 2.3119604682922468

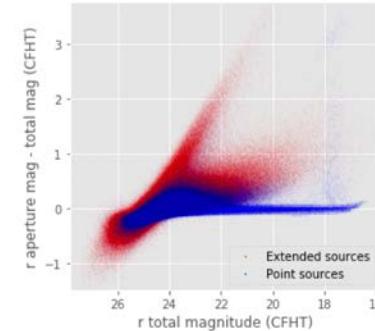
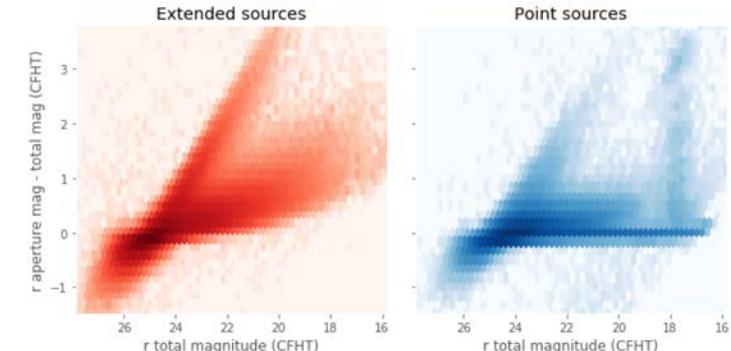


Megacam u (total) - WFC u (total):

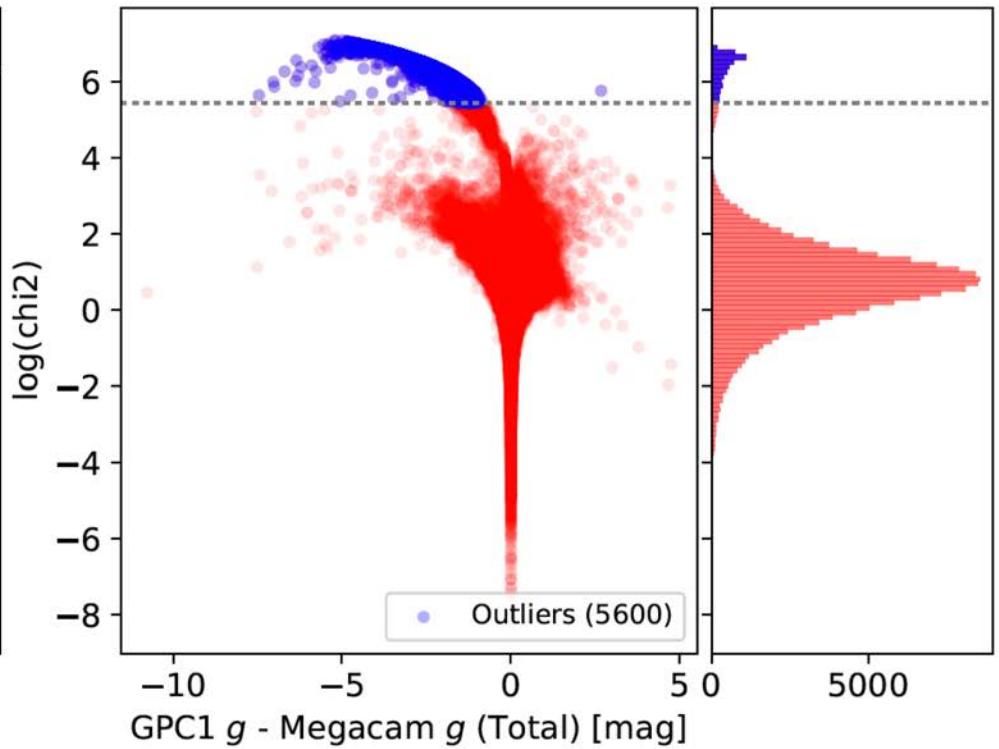
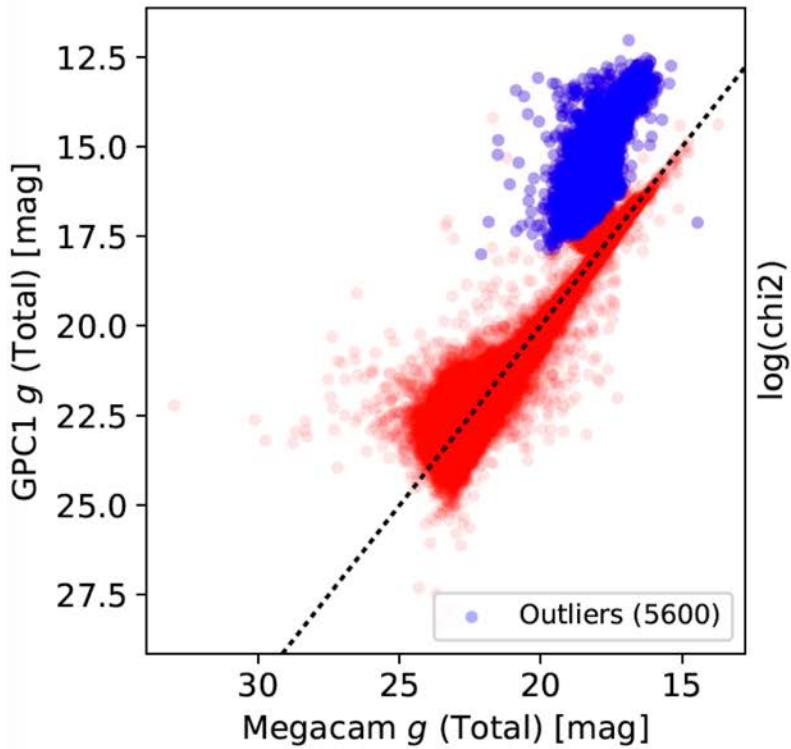
- Median: -0.15
- Median Absolute Deviation: 0.21
- 1% percentile: -1.0918270874023437
- 99% percentile: 2.1320125770568796



Number of source used: 1487529 / 4026292 (36.95%)



Flag outliers



<http://herschel.sussex.ac.uk>

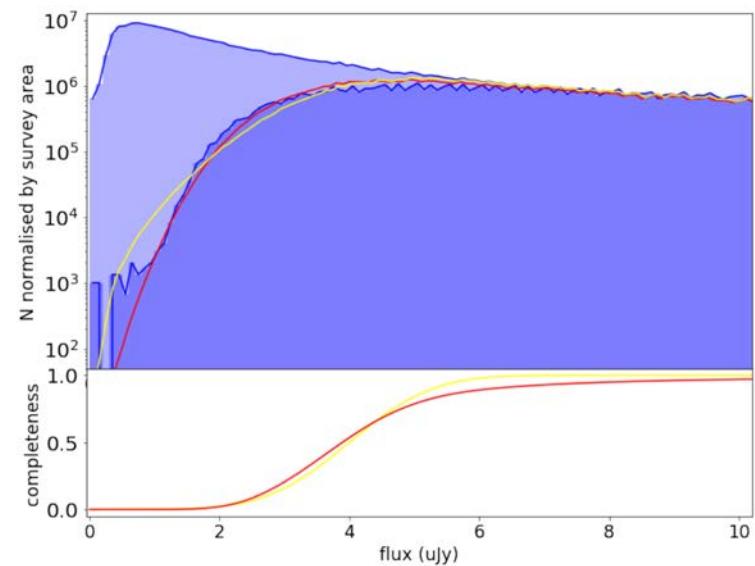
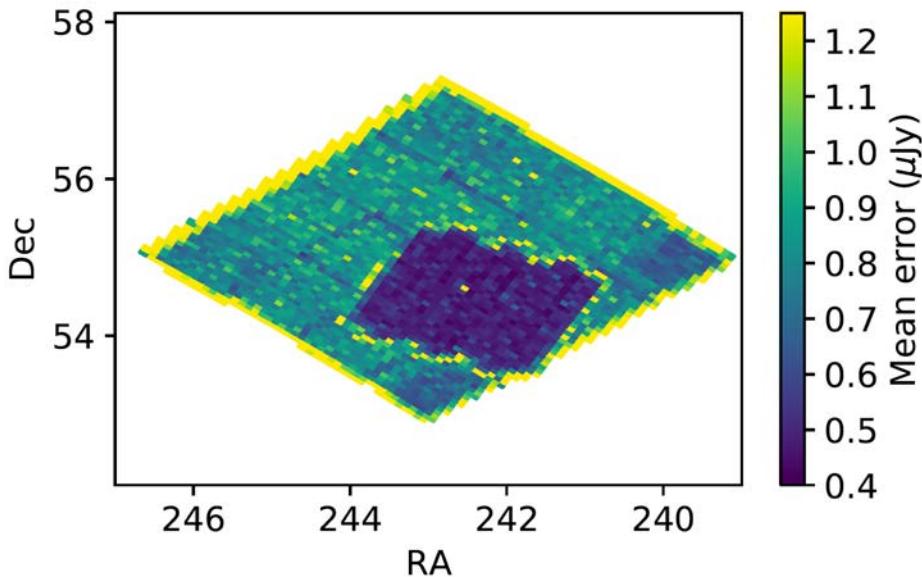


Selection functions

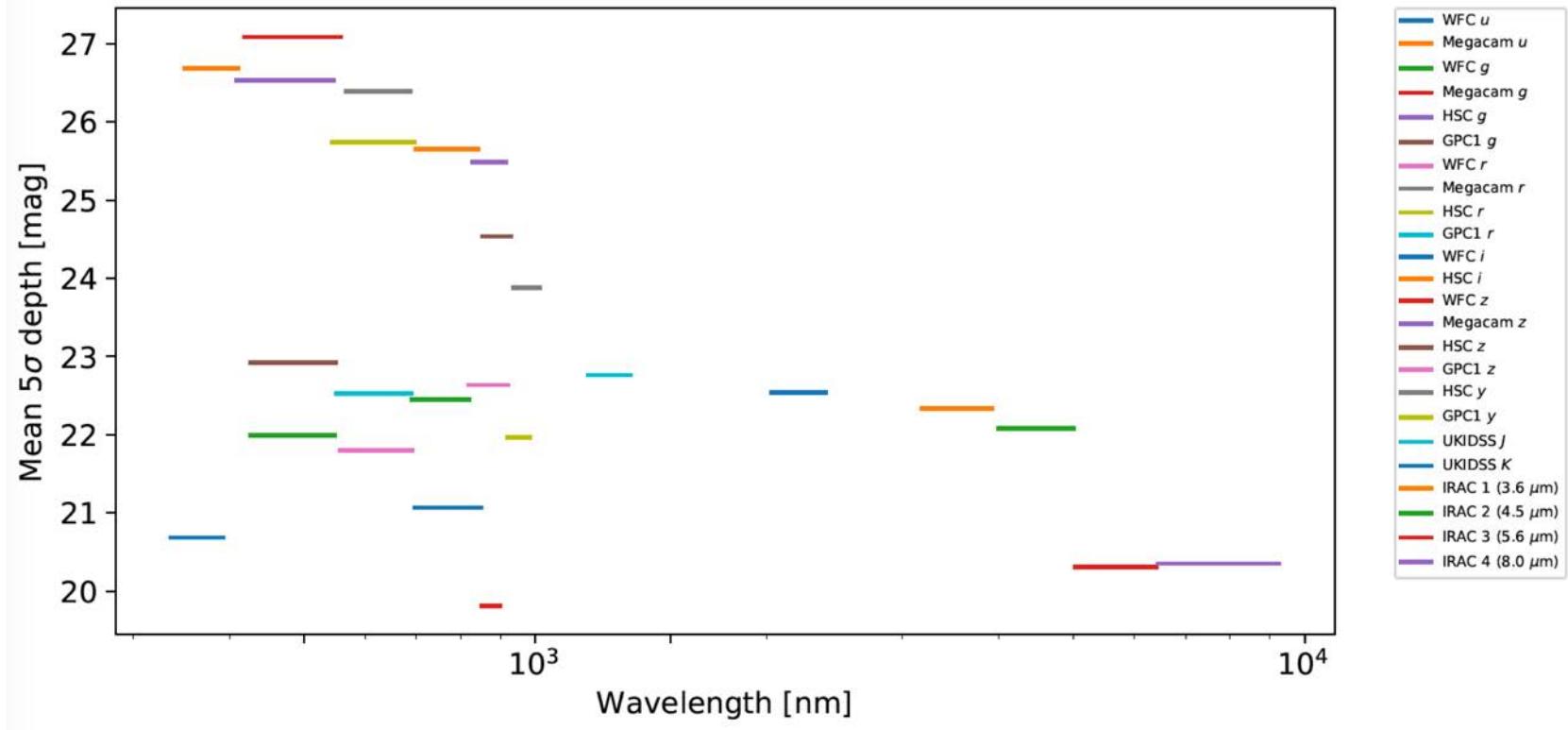
- Mean error as proxy for depth

$$P(\text{detection} \mid f_{\text{true}}) = P(f_{\text{measured}} > n\sigma_{\text{mean}})$$

$$\Phi(x) = \frac{1}{\sqrt{2\pi}} \int_x^{\infty} e^{-t^2/2} dt$$



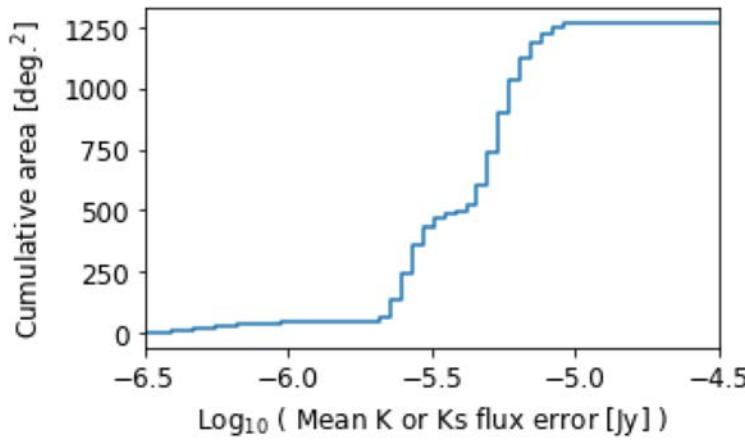
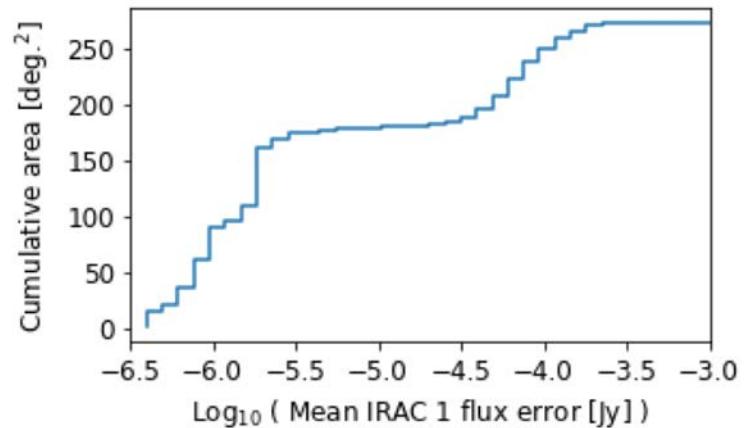
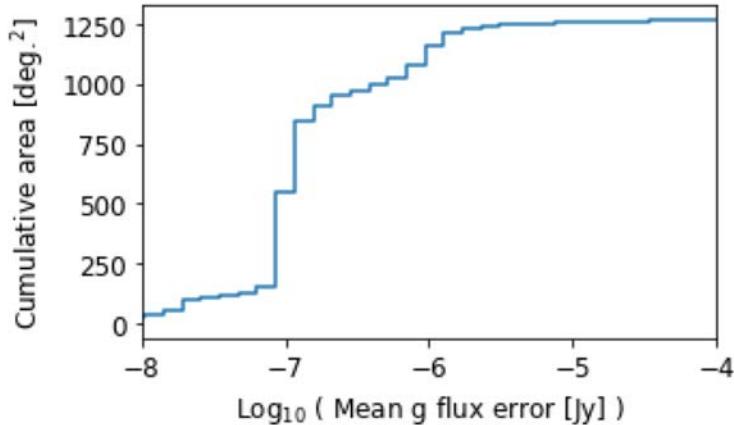
ELAIS-N1 mean depths



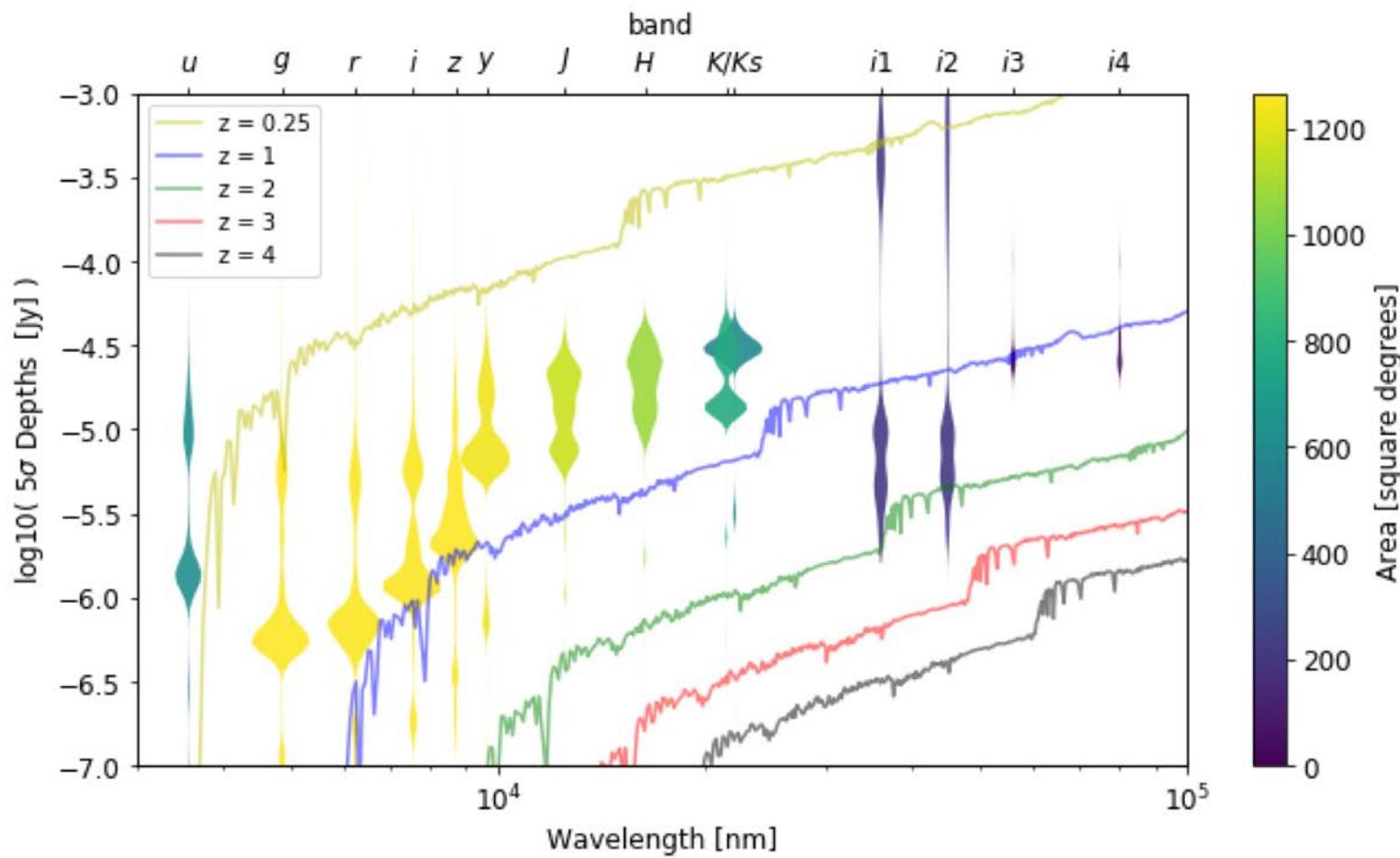
<http://herschel.sussex.ac.uk>



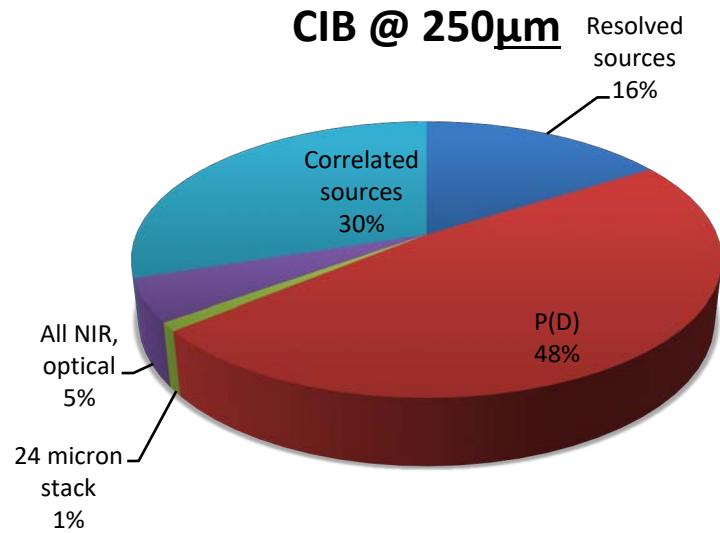
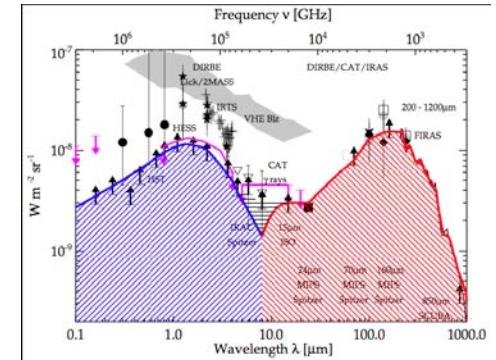
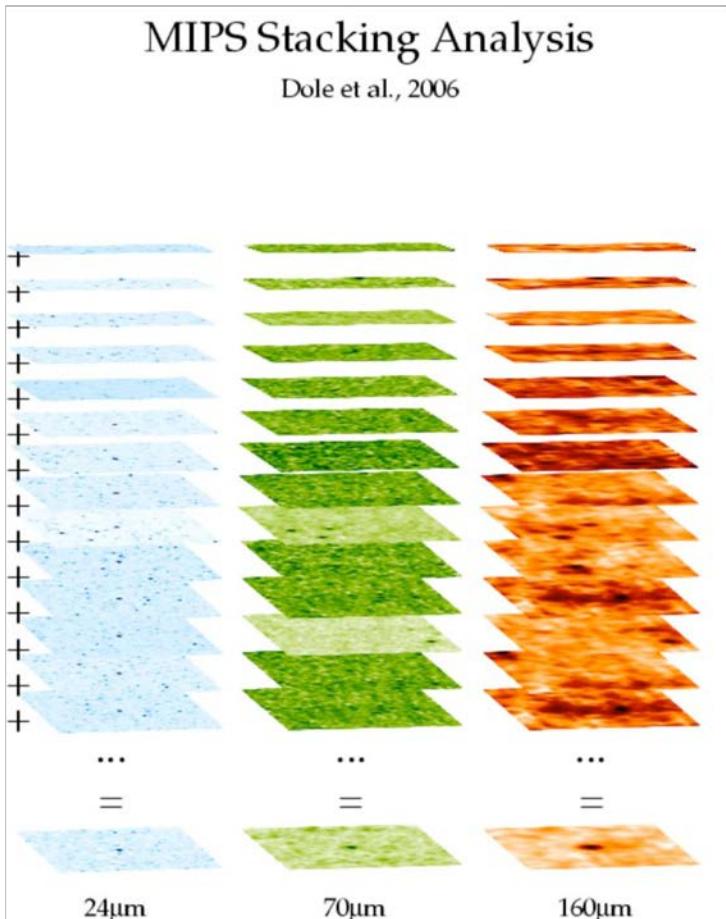
Depth summary



Depths



Stacking to understand CIB



Bethermin et al. 2012

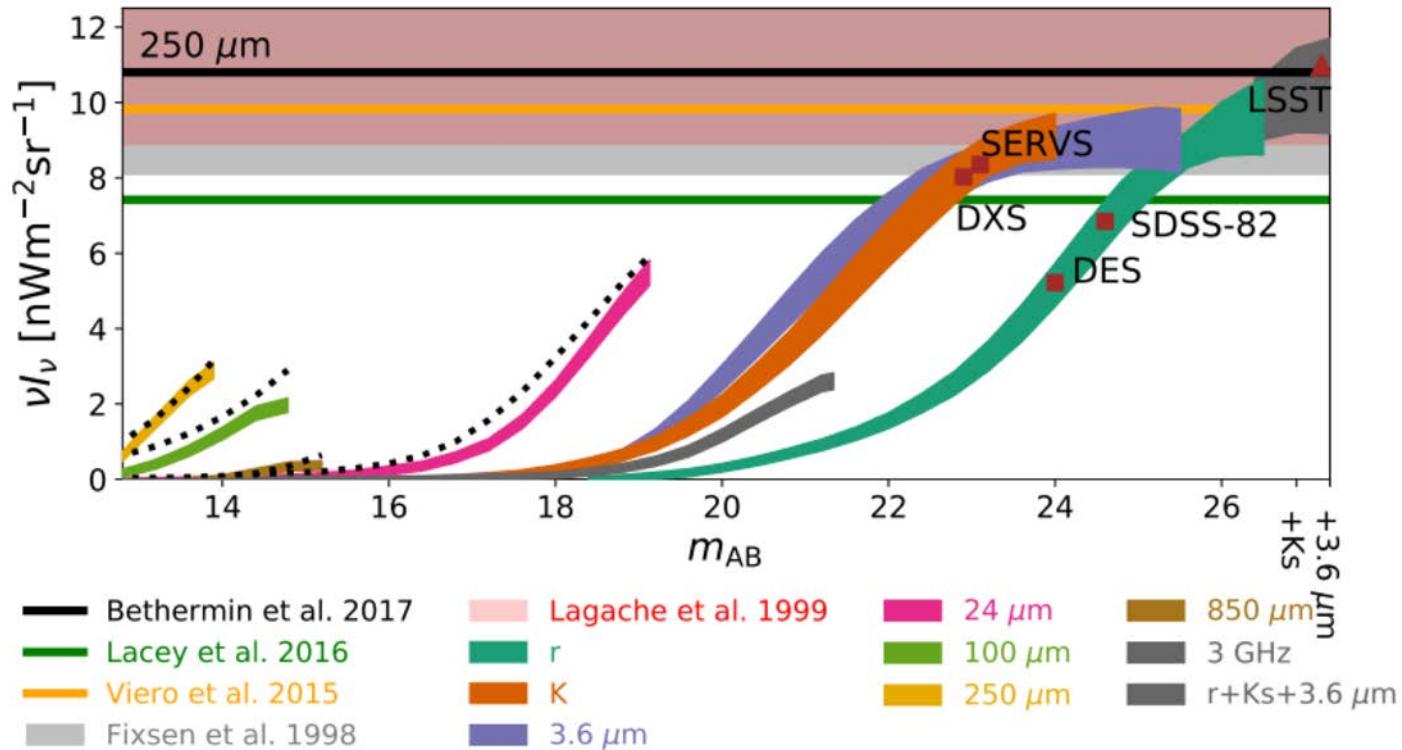
Viero, M.P. et al., 2013.

HerMES: The Contribution to the Cosmic Infrared Background from Galaxies Selected by Mass and Redshift.

arXiv.org, 1304, p.446. 2013arXiv1304.0446V

Viero et al. 2015 HerMES: Current Cosmic Infrared Background Estimates are Consistent with Correlated Emission from Known Galaxies at $z < 4$ [arXiv:1505.06242](https://arxiv.org/abs/1505.06242)

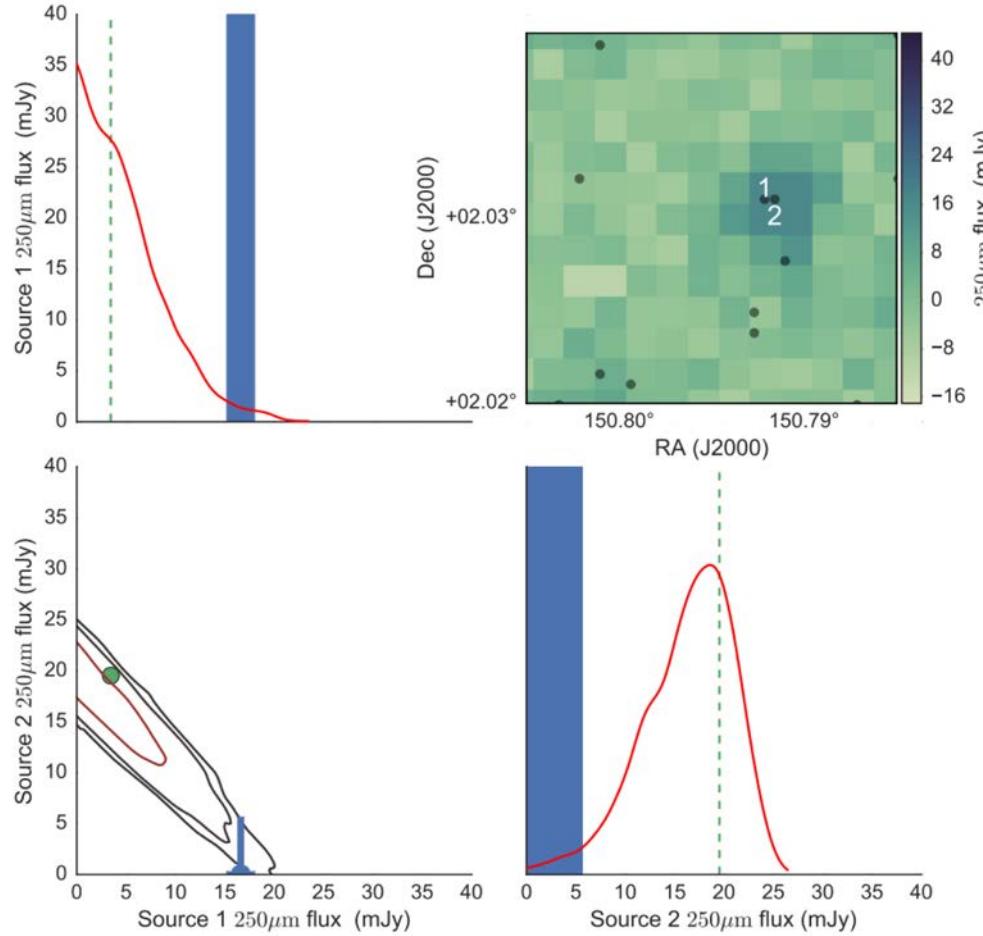
Stacking



Duivenvoorden et al (in prep)



Modelling far infrared images: forced photometry with XID+



Hurley et al. (2017)



Performance on simulated images

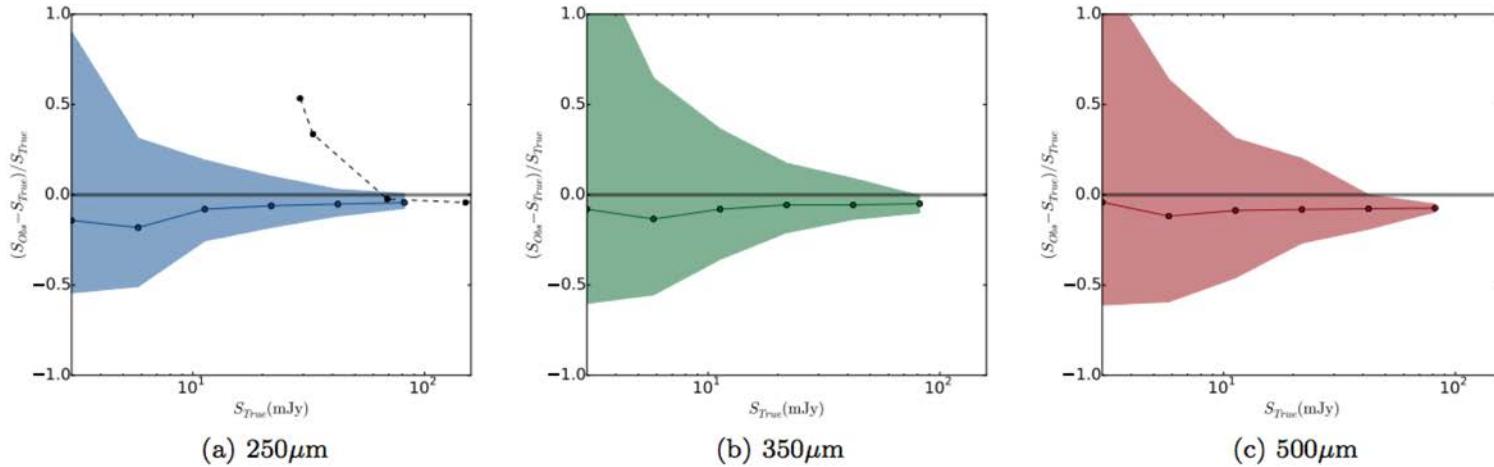
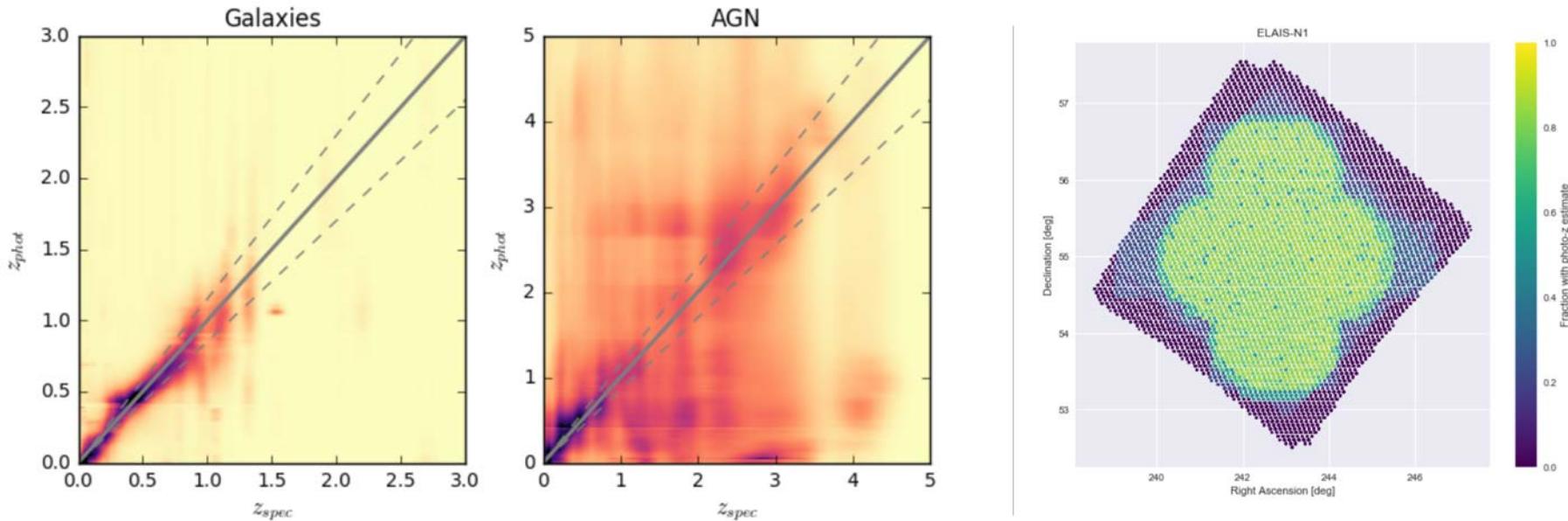


Figure 8. The 16th, 50th and 84th percentiles for flux accuracy of XID+ (coloured line and shaded region) and the median flux accuracy for LAMBDAAR (black dashed line), as a function of true flux, for the 250 (blue), 350 (green) and 500 (red) μm SPIRE bands. A horizontal thick line is shown at zero for clarity.



Photometric redshifts



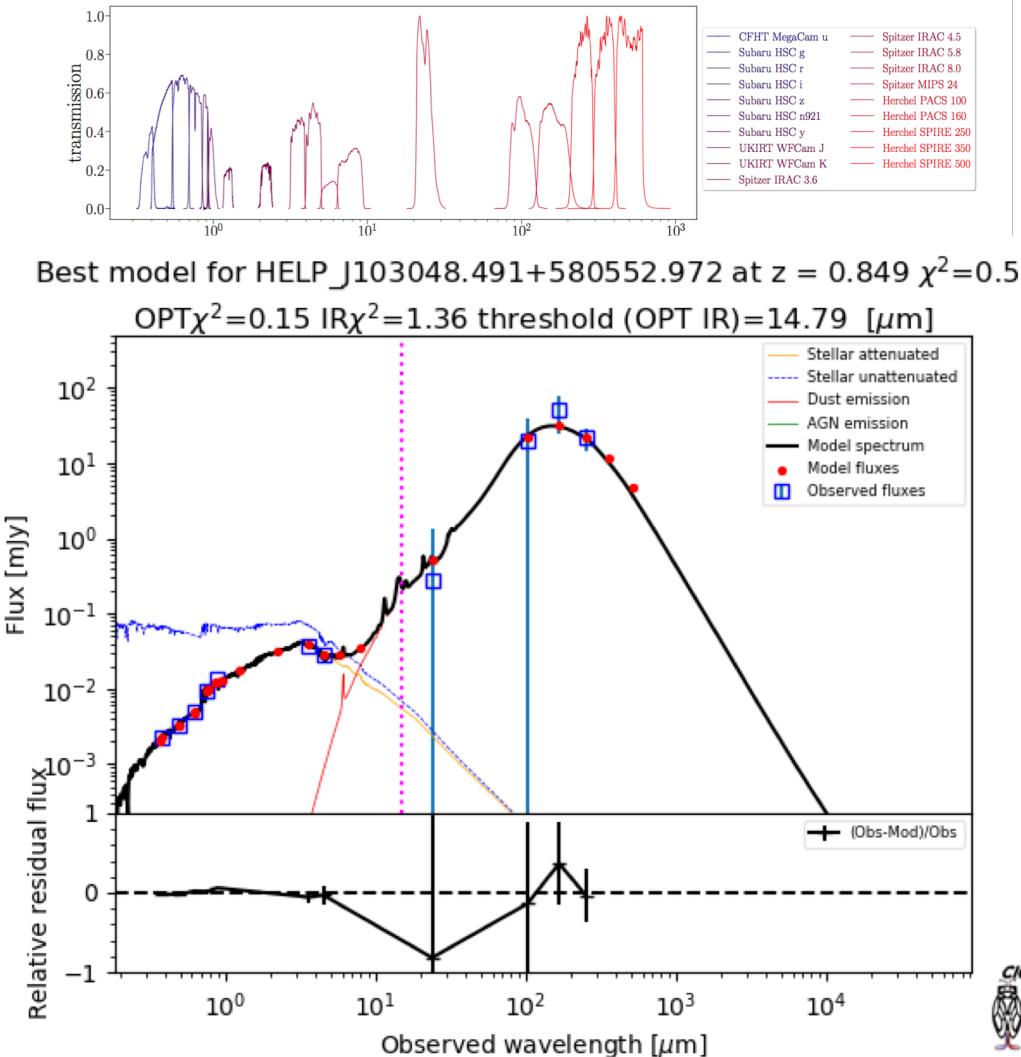
Duncan et al. (2017)



<http://herschel.sussex.ac.uk>

 Herschel Extragalactic Legacy Project

The Code Investigating GALaxy Emission (CIGALE)



Małek et al. (2017)



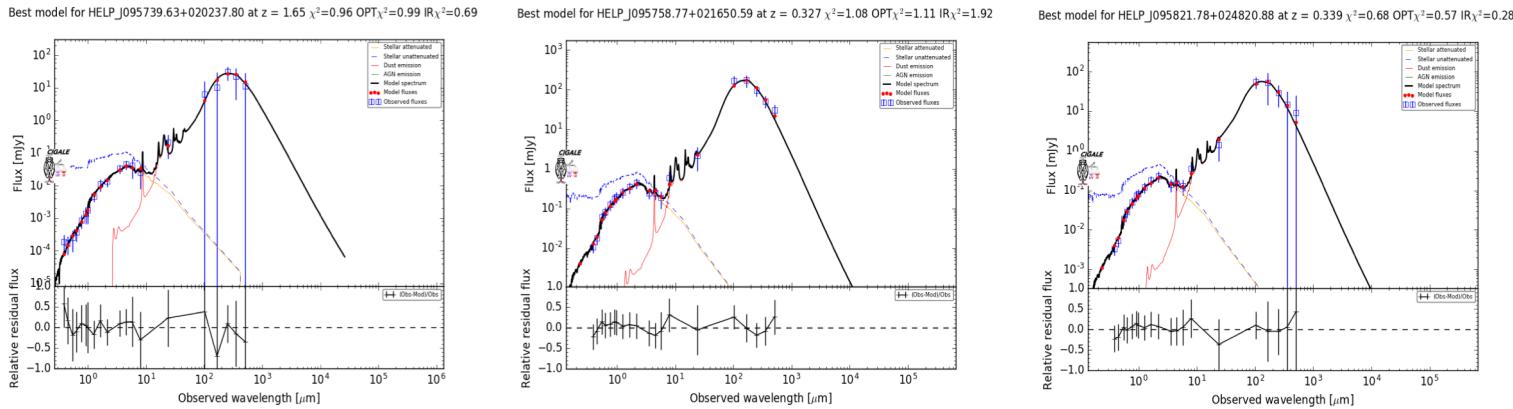
<http://herschel.sussex.ac.uk>



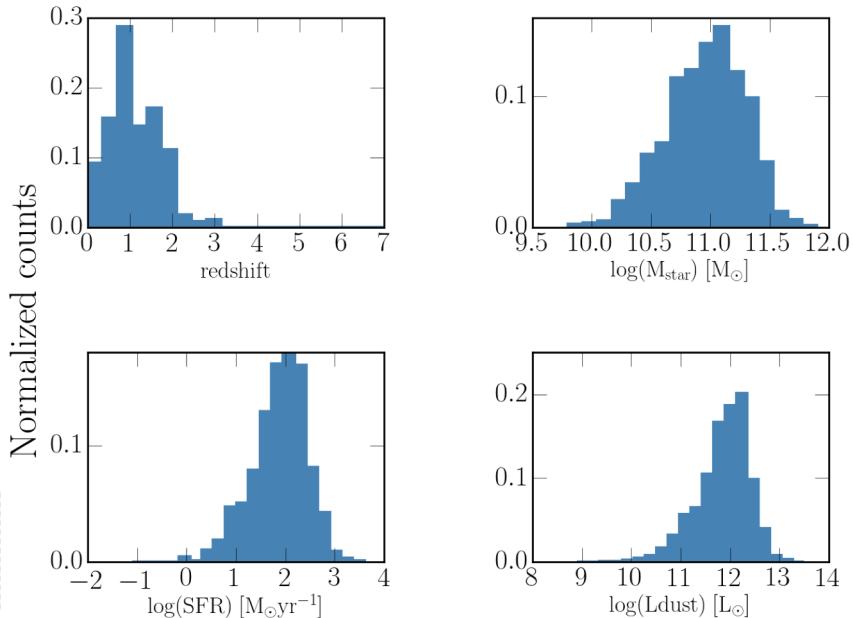
Herschel Extragalactic Legacy Project

CIGALE & HELP-Cosmos survey

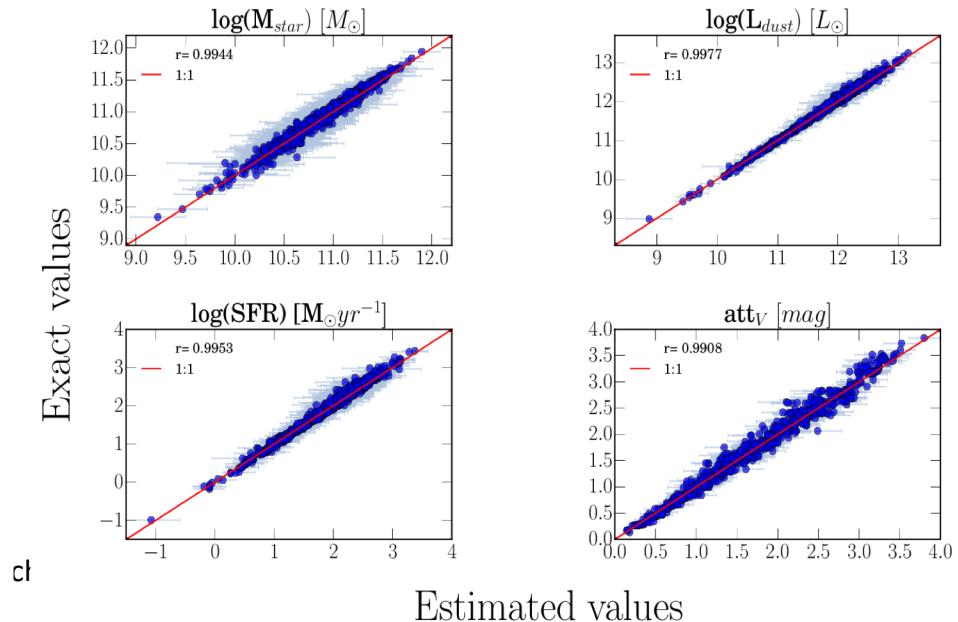
1. A few SEDs,



2. main physical properties, and



3. reliability check of physical parameters (mock catalogue)



Pipeline overview

Table 2.1: Overview of data processing by HELP field.

field	area [sq degrees]	objects	xid fluxes	photo-zs	cigale SEDs
AKARI-NEP	9.19	531746	0	0	0
AKARI-SEP	8.71	844172	0	0	0
Bootes	11.43	3481661	0	0	0
CDFS-SWIRE	12.97	2171051	240489	139532	9308
COSMOS	5.08	2599374	44310	694478	15747
EGS	3.57	1412613	0	1183490	0
ELAIS-N1	13.51	4026292	120282	2885116	50129
ELAIS-N2	9.17	1783240	0	0	0
ELAIS-S1	9.00	1655564	194276	1102319	25393
GAMA-09	62.01	12937982	1386659	8834023	130293
GAMA-12	62.71	12369415	1099477	8591676	108139
GAMA-15	61.70	14232880	1236395	10109159	117234
HDF-N	0.67	130679	0	0	0
Herschel-Stripe-82	363.23	50196455	0	21613821	0
Lockman-SWIRE	22.41	4366298	242065	1382438	46719
NGP	177.70	6759591	0	3175339	0
SA13	0.27	9799	0	0	0
SGP	294.57	29790690	3511594	17057212	352804
SPIRE-NEP	0.13	2674	0	0	0
SSDF	111.12	12661903	0	9268783	0
xFLS	7.44	977148	0	0	0
XMM-13hr	0.76	38629	0	0	0
XMM-LSS	21.75	8705837	0	6152920	0
Totals:	1270	171 570 436	8075547	92190306	855766
area processed:			(543.97 sq deg)	(1221.34 sq deg)	(543.97 sq deg)



Herschel Database in Marseille

- “*Flat file*” data products (nearly 5 TB).
- Combine both the data and the code to produce it in Jupyter notebooks.
- Data and notebooks organised by *data management units* (DMUs) and fields.

<http://hedam.lam.fr/HELP/>

Herschel-HELP

Home Coverage Data products



HERSCHEL EXTRAGALACTIC LEGACY PROJECT
Data site

The data available on this site is a work in progress. The final data will be released on October 1st, 2018.

Welcome on the section of the *Herschel Database in Marseille* dedicated to hosting the data products of the *Herschel Extragalactic Legacy Project* (HELP). For more information about the project, please visit the [HELP main web site](#).

This site contains the individual “*flat file*” data products. The main HELP data is also available through Virtual Observatory protocols at the [Virtual Observatory at susseX \(VOX\)](#) database.

DATA ORGANISATION

HELP work relied a lot on the [Jupyter notebook](#) technology to achieve some *reproducible science* goals. The Python notebooks are used both to process our data, to diagnose potential problems with a lot of plots and to document the work. All the pristine and intermediate data files are provided so that everyone can reproduce the work that has been done, even adding new data, new diagnostics or new data processing.

Within HELP, the work was organised in “*data management units*” (DMU), each one responsible of some specific tasks. The table below lists all the DMUs and their responsibilities. The file products of all the DMUs is available in the [data products](#) part that is browsed as a directory. Each DMU has its own folder, generally with a sub-folder per HELP field.

This directory structure is mirrored [on GitHub](#), under the [H-E-L-P organisation](#) but with a big difference: **the actual data is not stored on GitHub**. The data is only present in the `data/` sub-folders on HeDaM. GitHub is nevertheless better suited to display the readmes and the notebooks, because it render them in HTML.

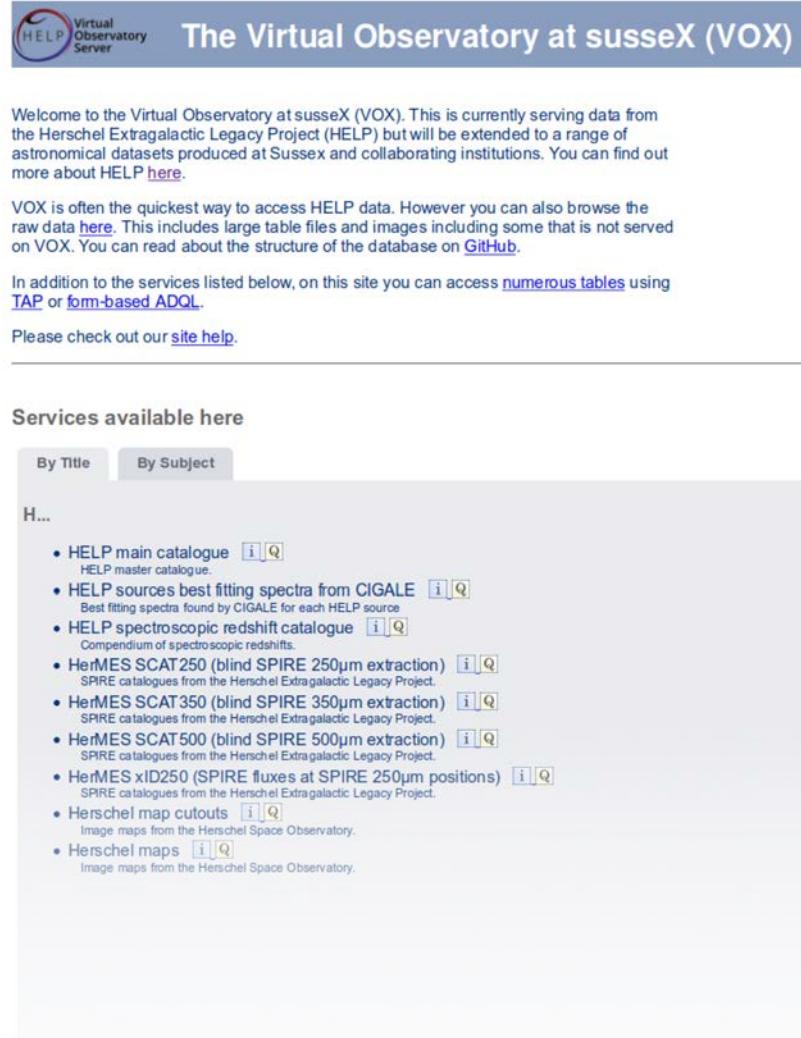
DMU#	Responsibility	Link
0	Pristine catalogues	dmu0
1	Masterlist data	dmu1
2	Field definitions	dmu2
3	Morphologies (Shapes & Sizes) of Objects	dmu3
4	Bright Star Mask	dmu4
5	Known Star Flag	dmu5
6	Optical photometry validation	dmu6
7	Optical photometry	dmu7
8	Radio data - LOFAR & FIRST/NVSS/TGSS	dmu8
9	Radio data - JVLA-DEEP & GMRT-DEEP	dmu9

<http://herschel.sussex.ac.uk>

Virtual Observatory at susseX (VOX)

- “Real” database.
- Allows complex queries to leverage the richness of the data.
- VO standards

<https://herschel-vos.phys.sussex.ac.uk/>



The screenshot shows the homepage of the Virtual Observatory at susseX (VOX). At the top right, there is a logo for "Virtual Observatory Server" with a blue and red circular icon. To its right, the text "The Virtual Observatory at susseX (VOX)" is displayed in a white box. Below this, a welcome message reads: "Welcome to the Virtual Observatory at susseX (VOX). This is currently serving data from the Herschel Extragalactic Legacy Project (HELP) but will be extended to a range of astronomical datasets produced at Sussex and collaborating institutions. You can find out more about HELP [here](#)." Another message below states: "VOX is often the quickest way to access HELP data. However you can also browse the raw data [here](#). This includes large table files and images including some that is not served on VOX. You can read about the structure of the database on [GitHub](#)." A note below says: "In addition to the services listed below, on this site you can access [numerous tables](#) using [TAP](#) or [form-based ADQL](#)." A link to "site help" is also present. A section titled "Services available here" follows, with tabs for "By Title" and "By Subject". Under "By Title", a list of services is provided:

- HELP main catalogue [\[i\]](#) [\[Q\]](#)
HELP master catalogue.
- HELP sources best fitting spectra from CIGALE [\[i\]](#) [\[Q\]](#)
Best fitting spectra found by CIGALE for each HELP source
- HELP spectroscopic redshift catalogue [\[i\]](#) [\[Q\]](#)
Compendium of spectroscopic redshifts.
- HerMES SCAT250 (blind SPIRE 250μm extraction) [\[i\]](#) [\[Q\]](#)
SPIRE catalogues from the Herschel Extragalactic Legacy Project.
- HerMES SCAT350 (blind SPIRE 350μm extraction) [\[i\]](#) [\[Q\]](#)
SPIRE catalogues from the Herschel Extragalactic Legacy Project.
- HerMES SCAT500 (blind SPIRE 500μm extraction) [\[i\]](#) [\[Q\]](#)
SPIRE catalogues from the Herschel Extragalactic Legacy Project.
- HerMES xID250 (SPIRE fluxes at SPIRE 250μm positions) [\[i\]](#) [\[Q\]](#)
SPIRE catalogues from the Herschel Extragalactic Legacy Project.
- Herschel map cutouts [\[i\]](#) [\[Q\]](#)
Image maps from the Herschel Space Observatory.
- Herschel maps [\[i\]](#) [\[Q\]](#)
Image maps from the Herschel Space Observatory.

VO server – data access

- Through the web interface
- Programmatically, e.g. in Python with pyVO.
- Through VO protocols e.g. with Topcat.

The Virtual Observatory at susseX (VOX)

Welcome to the Virtual Observatory at susseX (VOX). This is currently serving data from the Herschel Extragalactic Legacy Project (HELP) but will be extended to a range of astronomical datasets produced at Sussex and collaborating institutions. You can find out more about HELP here.

VOX is often the quickest way to access HELP data. However you can also browse the raw data directly via the Herschel Legacy Project Data Catalogue which is not served on VOX. You can read about the structure of the database on GitHub.

In addition to the services listed below, on this site you can access [numerous tables](#) using TAP or form-based ADQL.

Please check out our [site help](#).

Services available here

By Title By Subject

H...

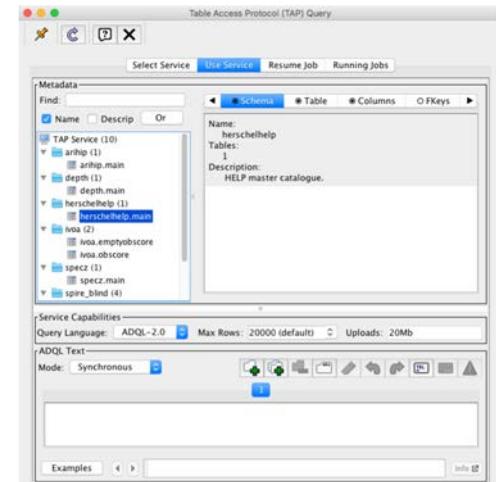
- HELP main catalogue [\[1\]](#) [\[2\]](#).
Main HELP catalogue.
- HELP sources best fitting spectra from CIGALE [\[1\]](#) [\[2\]](#).
Best fitting spectra found by CIGALE for each HELP source.
- HELP spectroscopic redshift catalogue [\[1\]](#) [\[2\]](#).
Cross-correlation redshifts.
- HerMES SCAT250 (blind SPIRE 250μm extraction) [\[1\]](#) [\[2\]](#).
Sources from the Herschel Extragalactic Legacy Project.
- HerMES SCAT350 (blind SPIRE 350μm extraction) [\[1\]](#) [\[2\]](#).
Sources from the Herschel Extragalactic Legacy Project.
- HerMES SCAT500 (blind SPIRE 500μm extraction) [\[1\]](#) [\[2\]](#).
Sources from the Herschel Extragalactic Legacy Project.

```
In [24]: #Then we establish the VO connection to our database
service = voдал.TAPService("https://herschel-voxsussex.ac.uk/_system/_tap/run/tap")

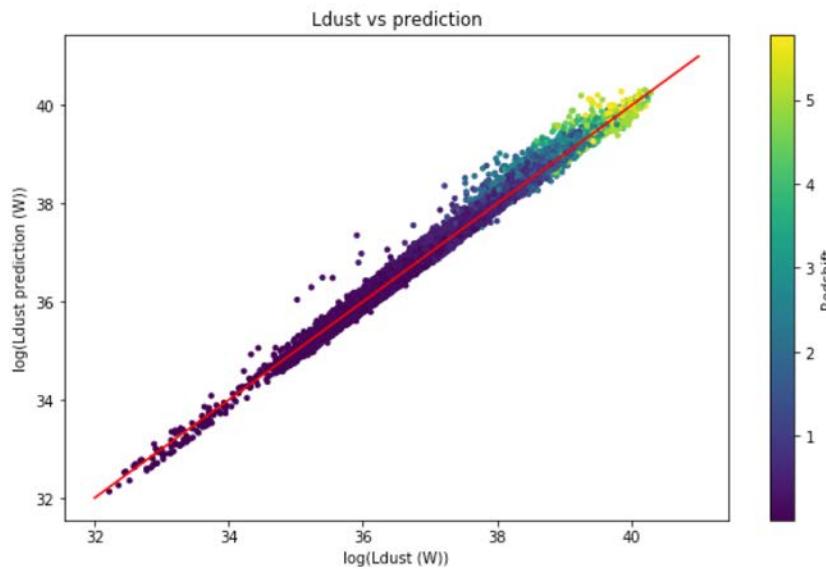
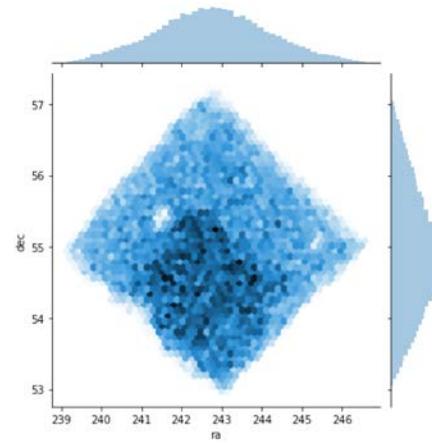
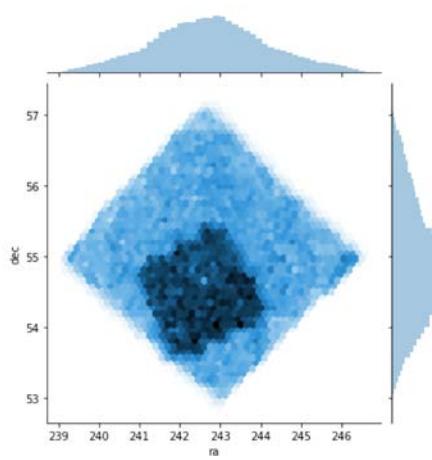
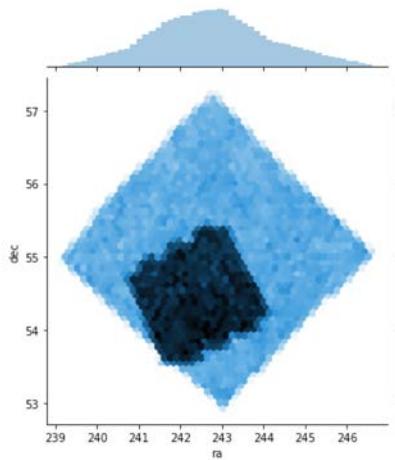
In [25]: #Then we execute the query
resultset = service.query("example_query")
WARNING: W27: None:2:1174: W27: COOGRS deprecated in VOTable 1.2 (astropy.io.votable.tree)
WARNING: W04: None:2:1247s: W04: Invalid ODF 'phys.dust:phys.luminosity' + Unknown word 'phys.du
[astropy.io.votable.tree]

In [26]: resultset.table
Out[26]: Table masked=?ue length=8557
```

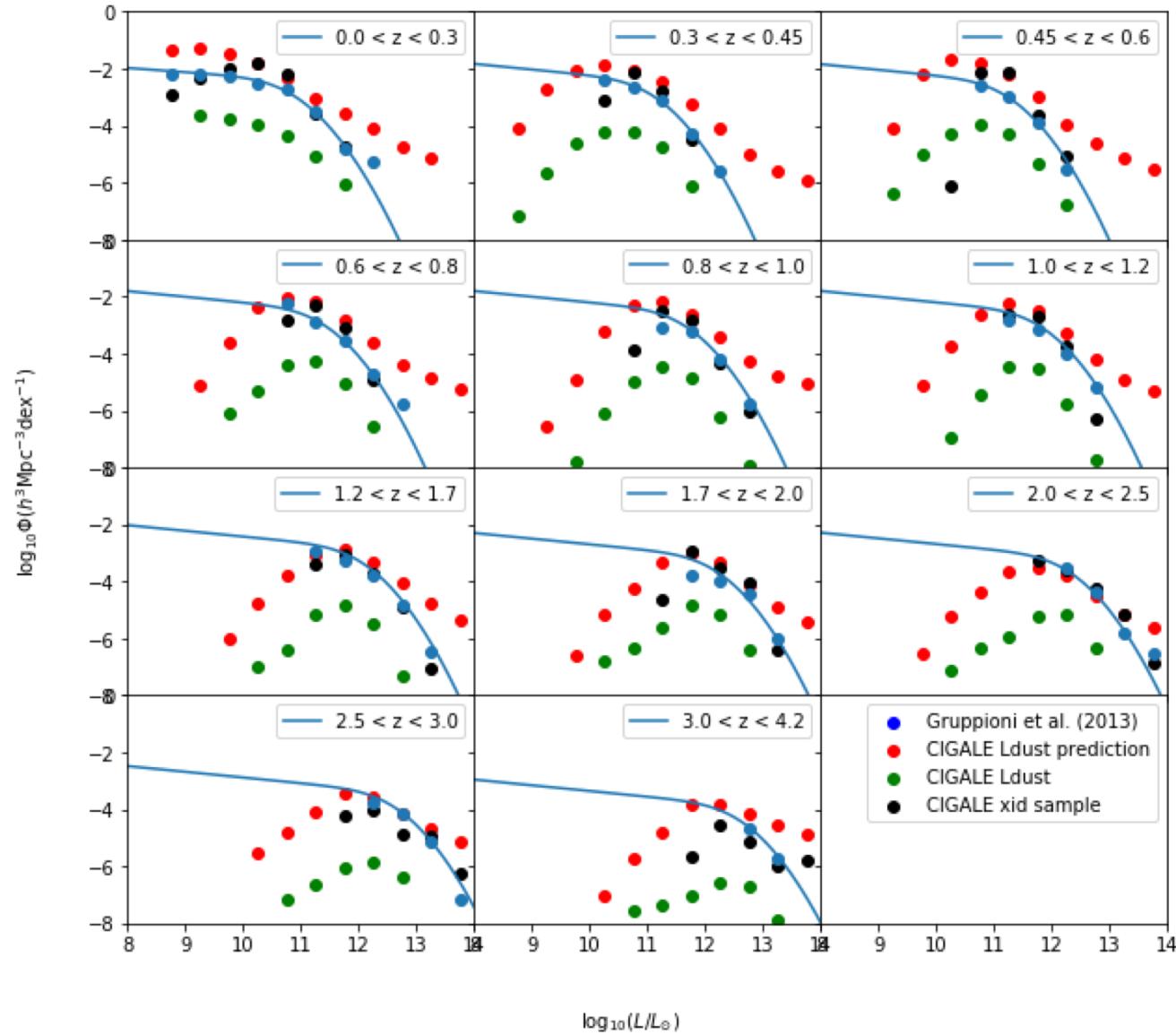
ra	dec	redshift	cigale_dustlumin
deg	deg		W
float64	float64	float32	float64
246.555662513057	55.0035510594990301	4.5766001	--
246.549474785057	54.99702013490301	4.8196998	--
246.3971525469037	54.9273814624992098	4.2312999	--
246.3941428705699	54.952376668499298	4.8771	--
246.391144082057	54.9366872434993	4.0481	--
246.44518433205701	55.00396006499301	5.04052002	--
246.41164064105701	55.0204406554993	5.0925999	--
246.413862278057	55.005413174993	4.6992	--
246.401366544027	55.012446608499299	4.9246001	--
...	--	--	--
239.10977233905701	54.042360668499303	4.6788998	--



Multi stage selection function



Luminosity functions – in progress



Summary

- Pipeline – Optical data -> photometric redshifts -> far infrared fluxes -> spectral energy distributions
- Selection functions and luminosity functions in progress.
- Virtual Observatory at susseX (VOX) – available to you.



<http://herschel.sussex.ac.uk>



Thank you



<http://herschel.sussex.ac.uk>

