κ_d

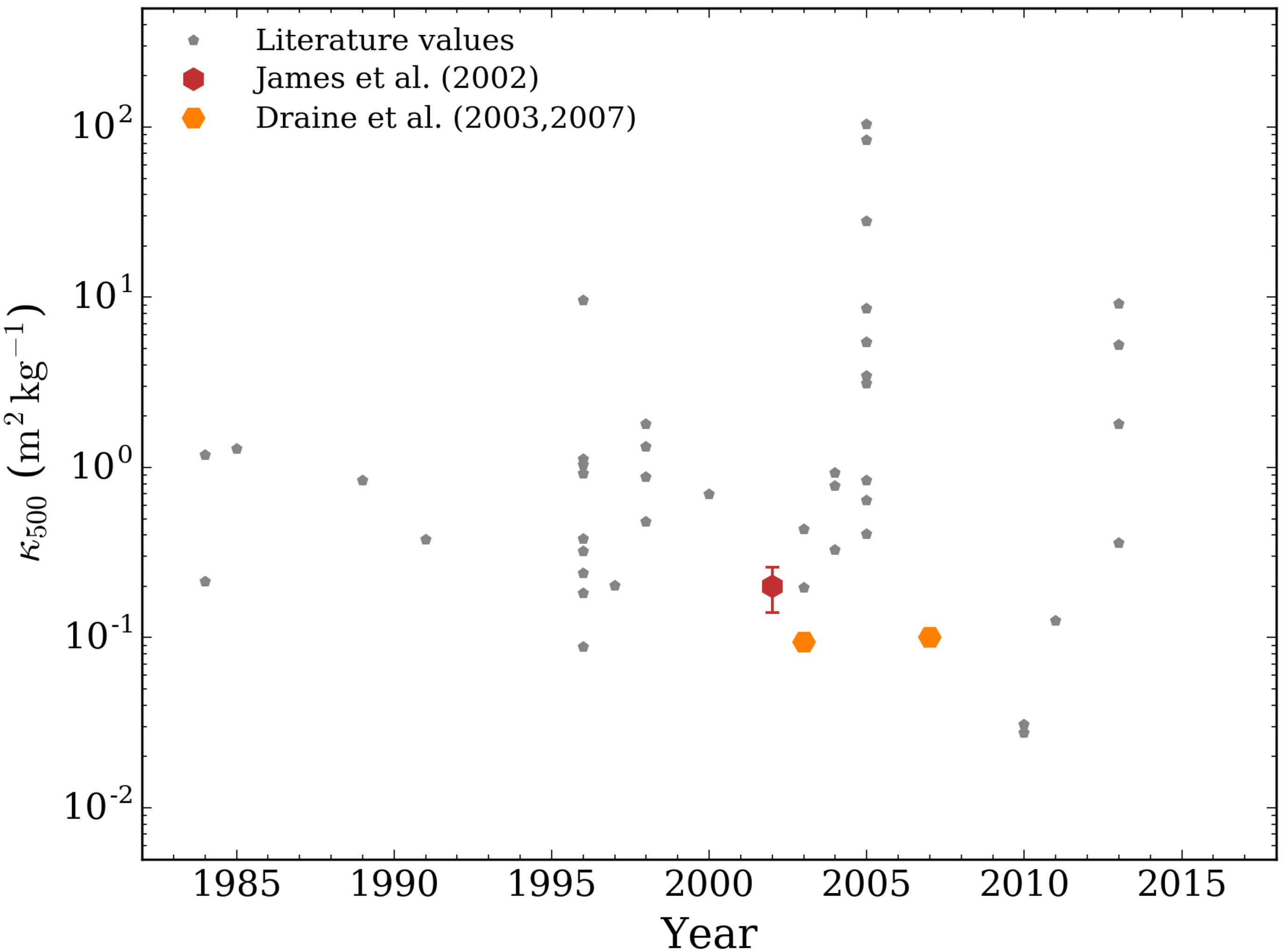
Chris Clark

Simon Schofield

Haley Gomez

Jonathan Davies

The Elusive $\varkappa_d$



Chris Clark

$$M_d = M_g \, \varepsilon_d \, f_Z$$

M_d = Dust mass

M_g = Gas mass

ε_d = ISM dust-to-metals ratio = 0.5 +/- 0.1

f_Z = ISM metal mass fraction (ie, ISM metallicty)

Chris Clark

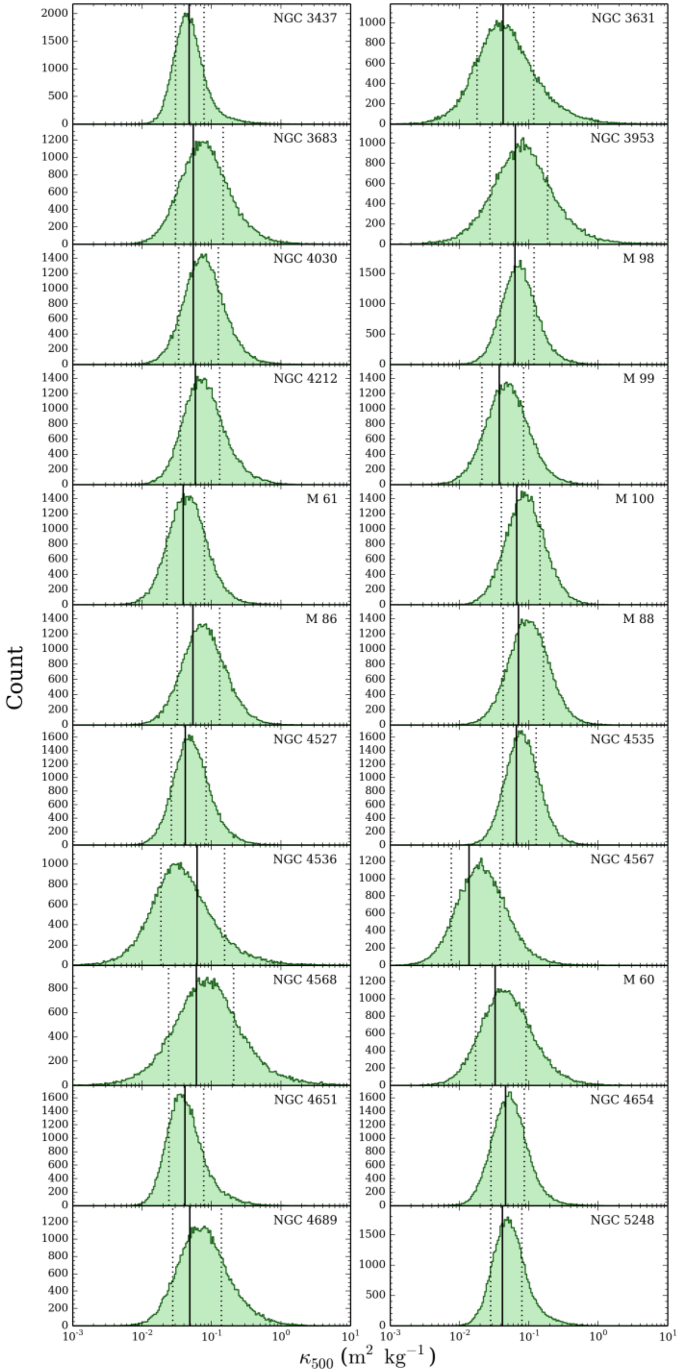
Improvements Over James et al (2002)

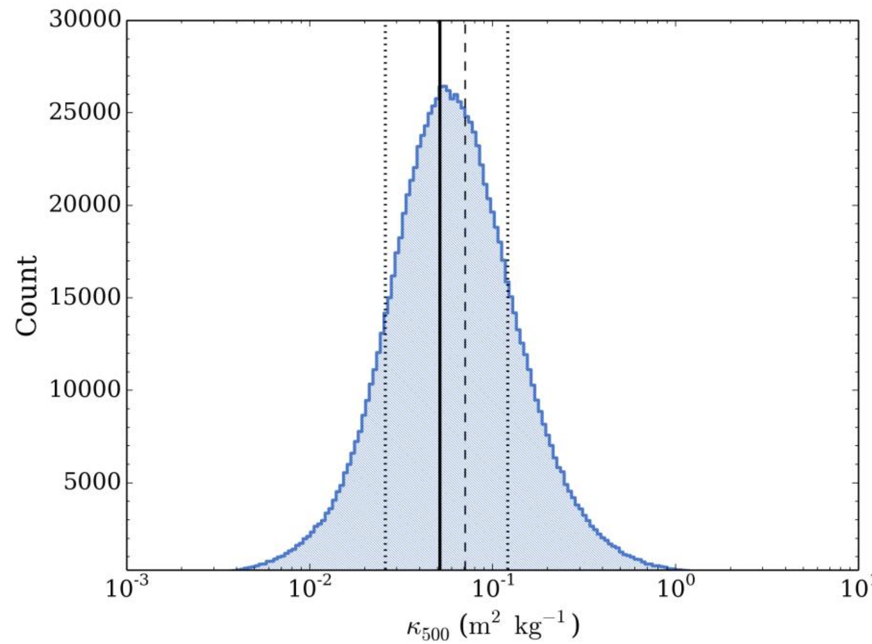
Using data from the HRS

- We now have *Herschel* photometry; James et al only had IRAS & SCUBA, and so could not constrain dust temperature.
- We have integrated (and normalised) ISM metallicites from drift-scan spectroscopy
- We have integrated CO maps; they only had central pointings.
- James et al did not consider the effect of oxygen depletion on their metallicites – we do.
- James et al did not account for Helium or gas-phase metals in their ISM masses – we do.

$$\kappa_\lambda = \frac{D^2}{\xi\,(M_{HI} + M_{H_2})\,\varepsilon_d\, f_{Z_\odot}\, Z} \left(\frac{S_{\lambda_w}}{B_\lambda(T_w)} + \frac{S_{\lambda_c}}{B_\lambda(T_c)} \right)$$

Chris Clark

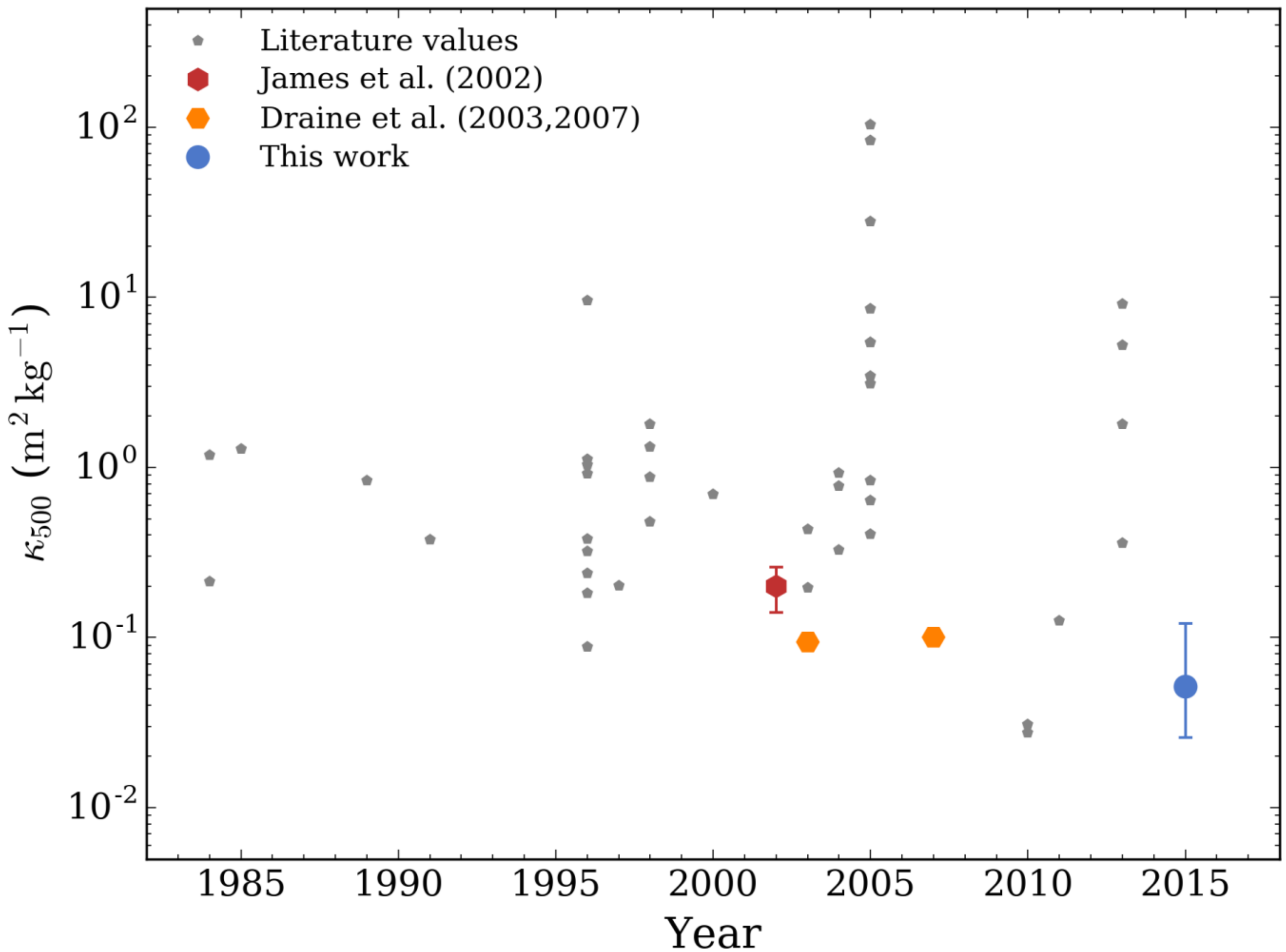

NGC 3437
NGC 3631
NGC 3683
NGC 3953
NGC 4030
M 98
NGC 4212
M 99
M 61
M 100
M 86
M 88
NGC 4527
NGC 4535
NGC 4536
NGC 4567
NGC 4568
M 60
NGC 4651
NGC 4654
NGC 4689
NGC 5248
Count
κ_{500} (m^2 kg^{-1})


Count
κ_{500} (m^2 kg^{-1})

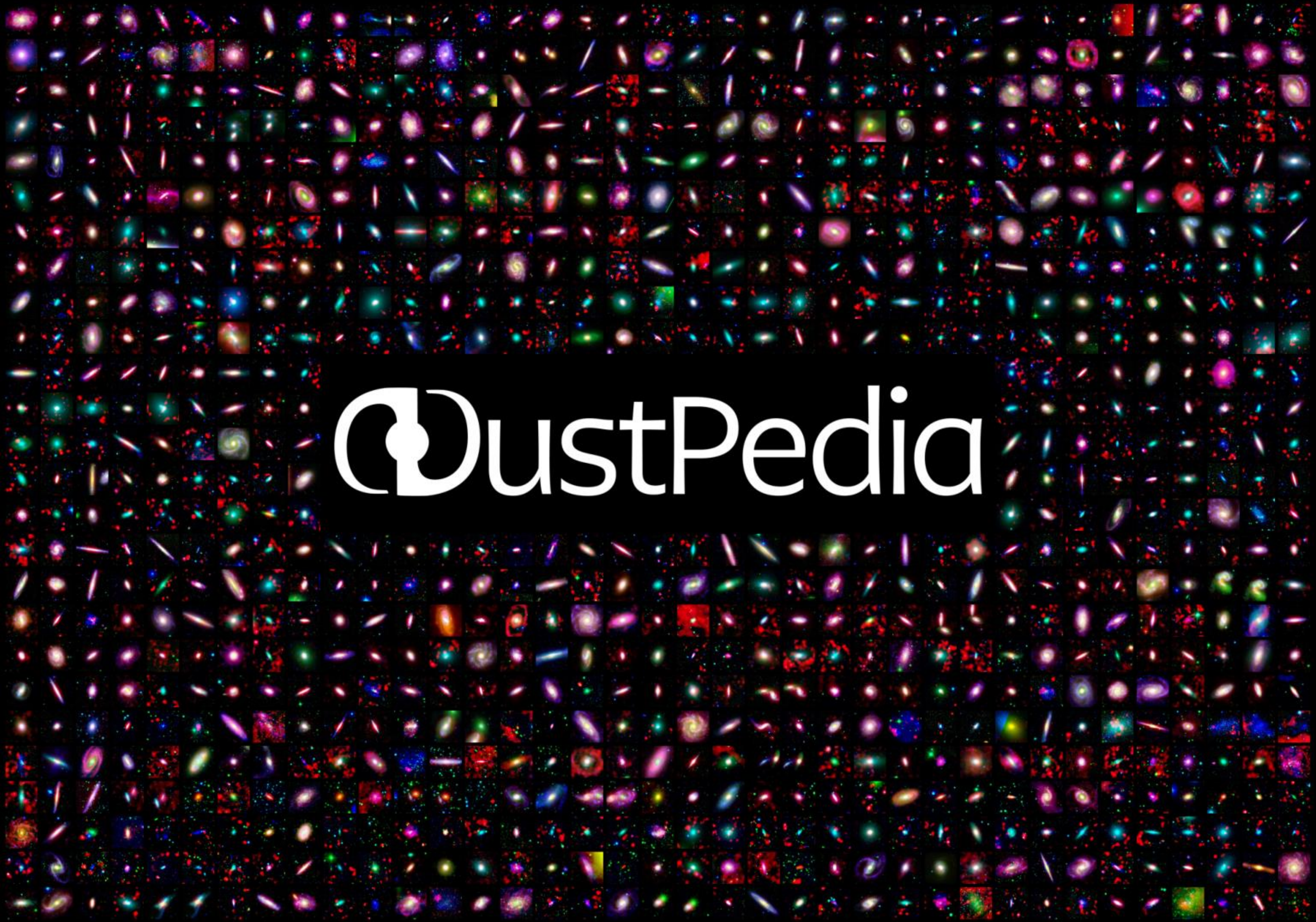
Chris Clark

An Empirical Value For κ_d

$\kappa_{500} = 0.051\ m^2\ kg^{-1}$ (+/- ~0.24 dex)



Chris Clark

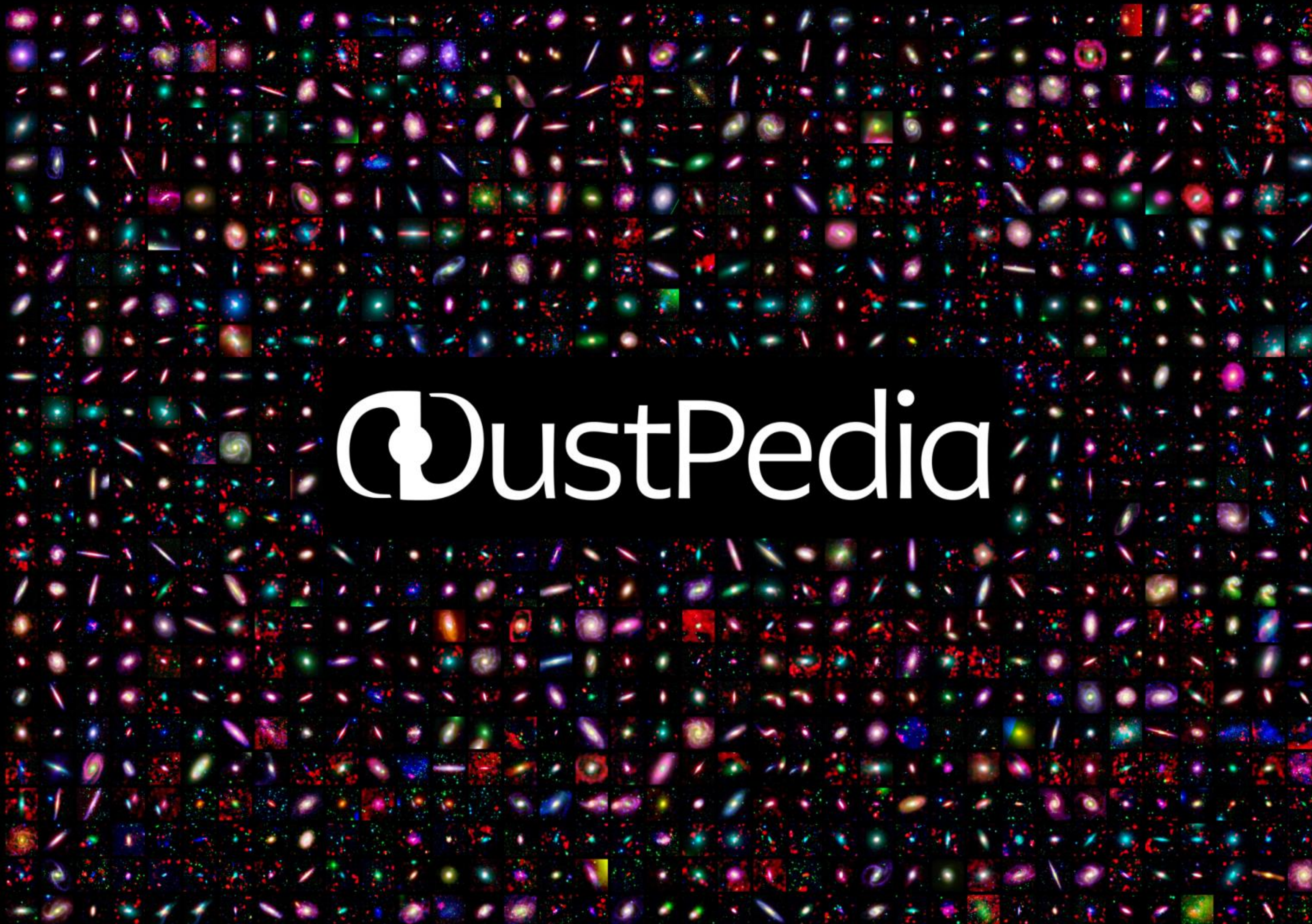


Chris Clark

DustPedia Overview

- THEMIS – A physically-motivated dust model based upon laboratory observations of astrophysical minerals (see papers by A Jones, N Ysard).
- SKIRT – Radiative transfer modelling suite that can fit a dust model to galaxy observations in 3D (see papers by M Baes, P De Camps, S Verstoken).
- A hierarchical Bayesian SED fitting toolkit that can be used to model both galaxies both globally and pixel-by-pixel (see papers by F Galliano).
- A database of multiwavelength imagery and photometry database for all 876 nearby galaxies observed by *Herschel* for which V<3000 km/s and D25<1’ (see upcoming paper by me).

Chris Clark



Chris Clark

Young, Blue, and Cold

A Blind Survey of Nearby Dusty Galaxies with *Herschel*-ATLAS

Chris Clark

Haley Gomez

Loretta Dunne

Pieter De Vis

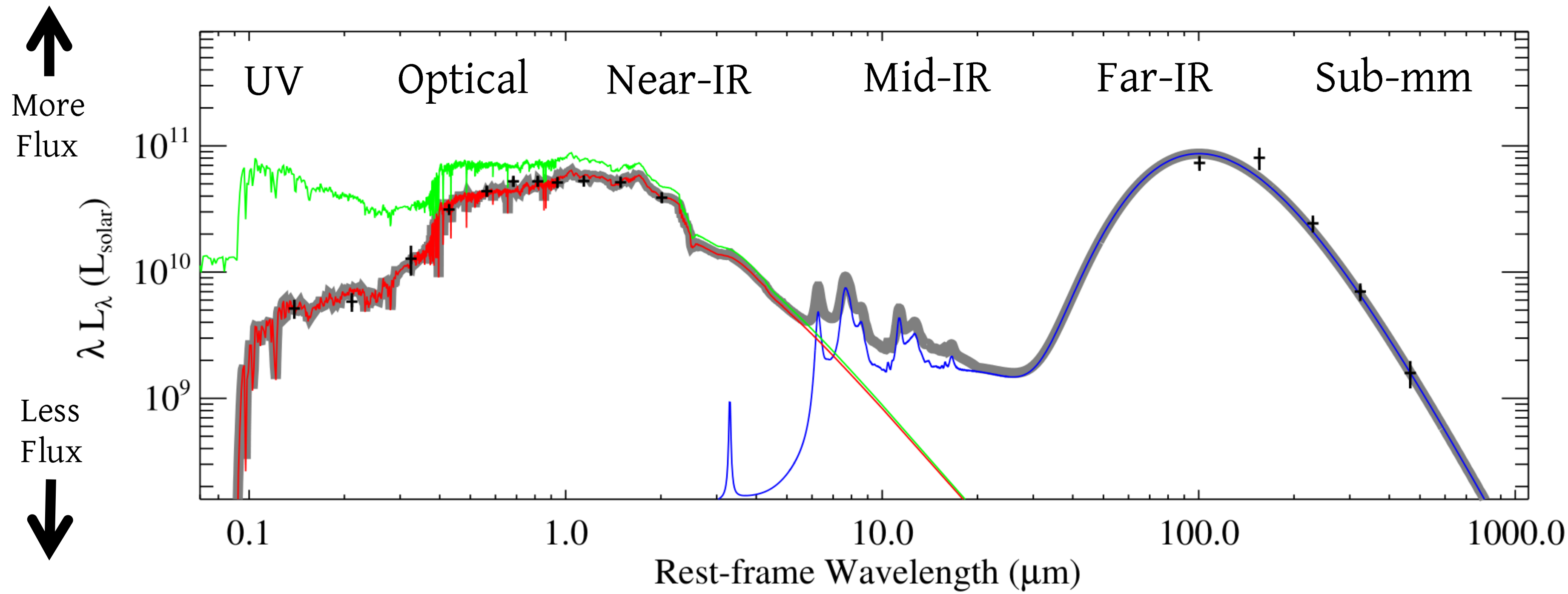
Steve Maddox

Simon Schofield

(with the *H*-ATLAS team)


By Matt Smith

Typical SED of a Dusty Galaxy



Un-attenuated stellar emission

Observed stellar emission

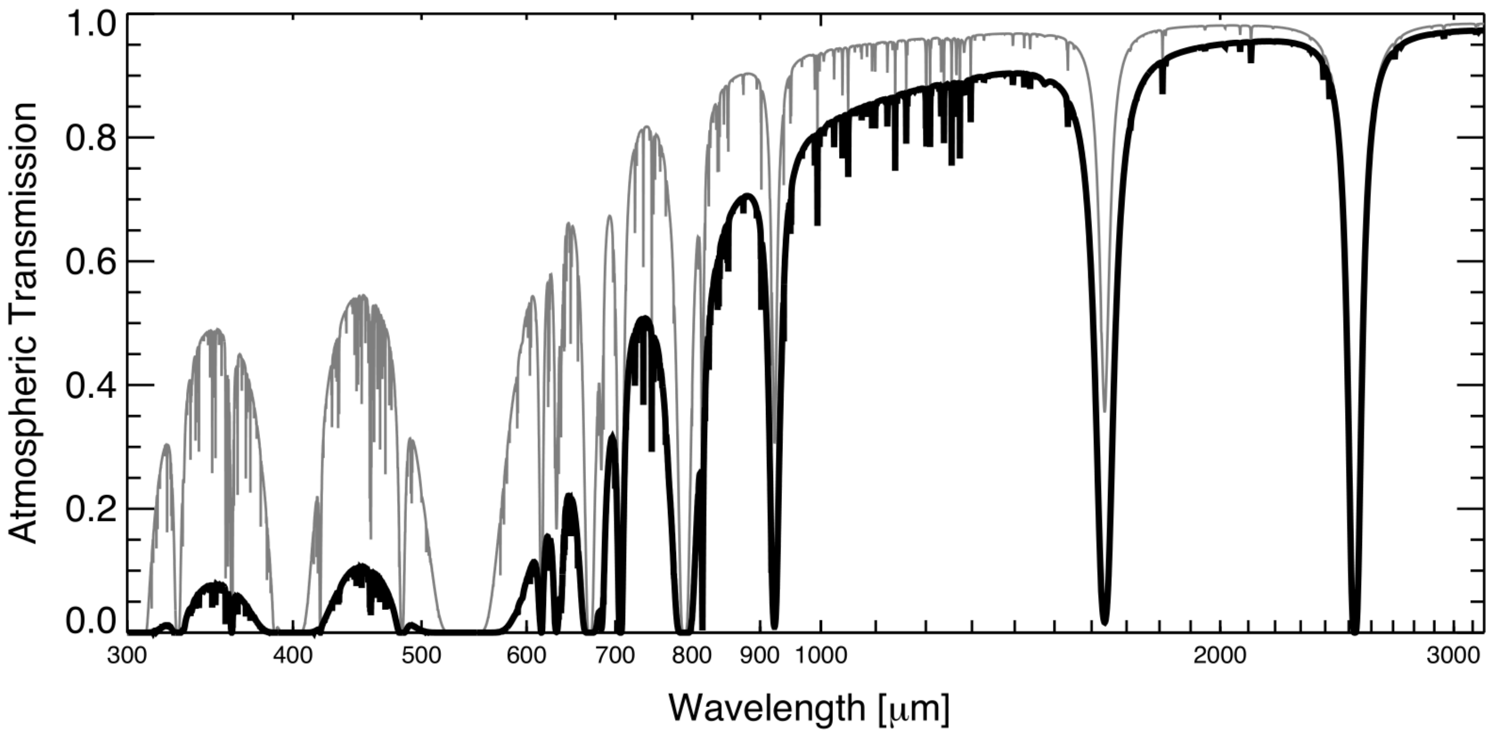
Observed dust emission

Combined observed emission

DJB Smith et al (2012)

da Cunha et al (2011)

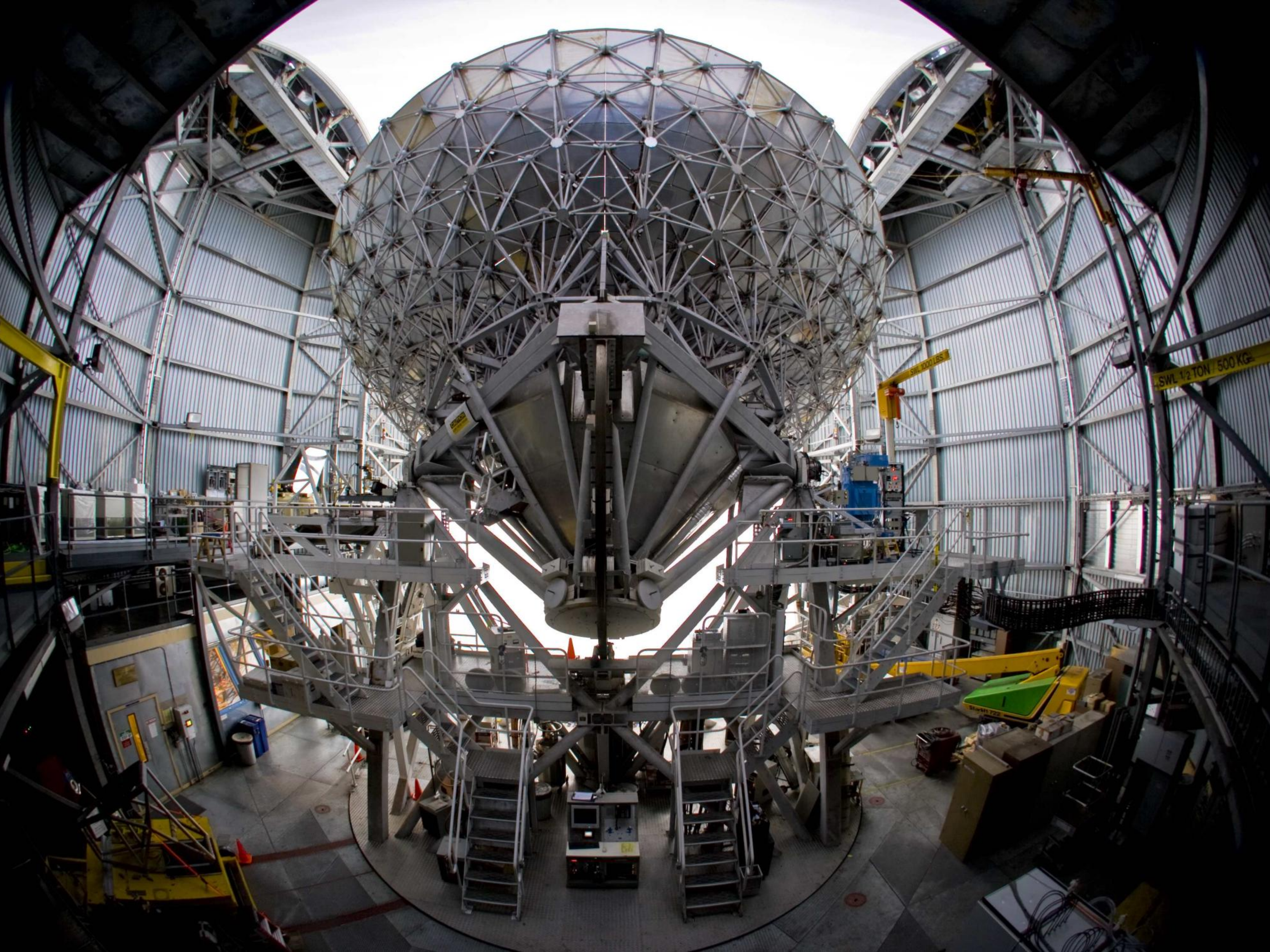
The Atmosphere Hates You



<10% of nights a year

<1% of nights a year

Casey et al (2014)



SWL 1000 LBS.
SWL 1/2 TON 500 KG


IRAS (1983)
12–100 μm


ISO (1995)
2.5–240 μm


Akari (2006)
9–160 μm

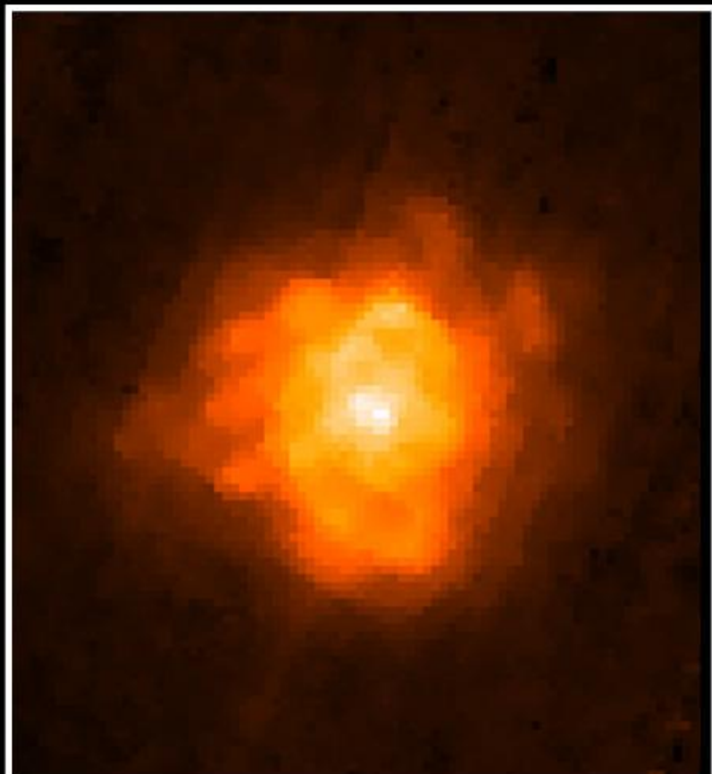

Spitzer (2003)
3.6–160 μm

Herschel (2009–2013)

52–670 µm

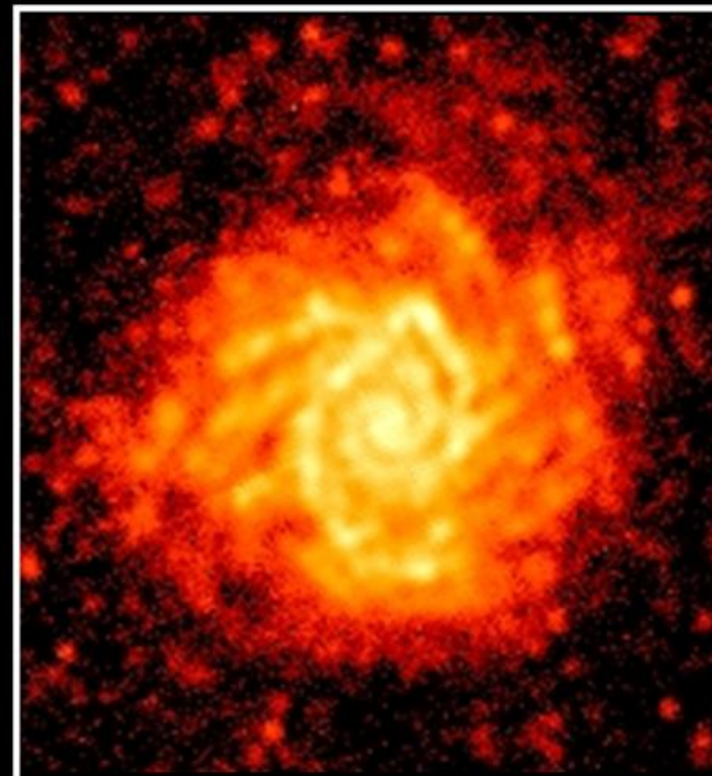
Chris Clark

M74 *Spitzer* 160 μm



NASA / *Spitzer* SINGS

M74 SPIRE 250 μm



ESA and the SPIRE Consortium

Chris Clark

Previous Surveys of Dust in Galaxies

SINGS

Spitzer Infrared Nearby Galaxy Survey

SLUGS

SCUBA Local Universe Galaxy Survey

KINGFISH

Key Insights on Nearby Galaxies Far-Infrared Survey with *Herschel*

HRS

Herschel Reference Survey

IRAS

InfraRed Astronomical Satellite

Planck

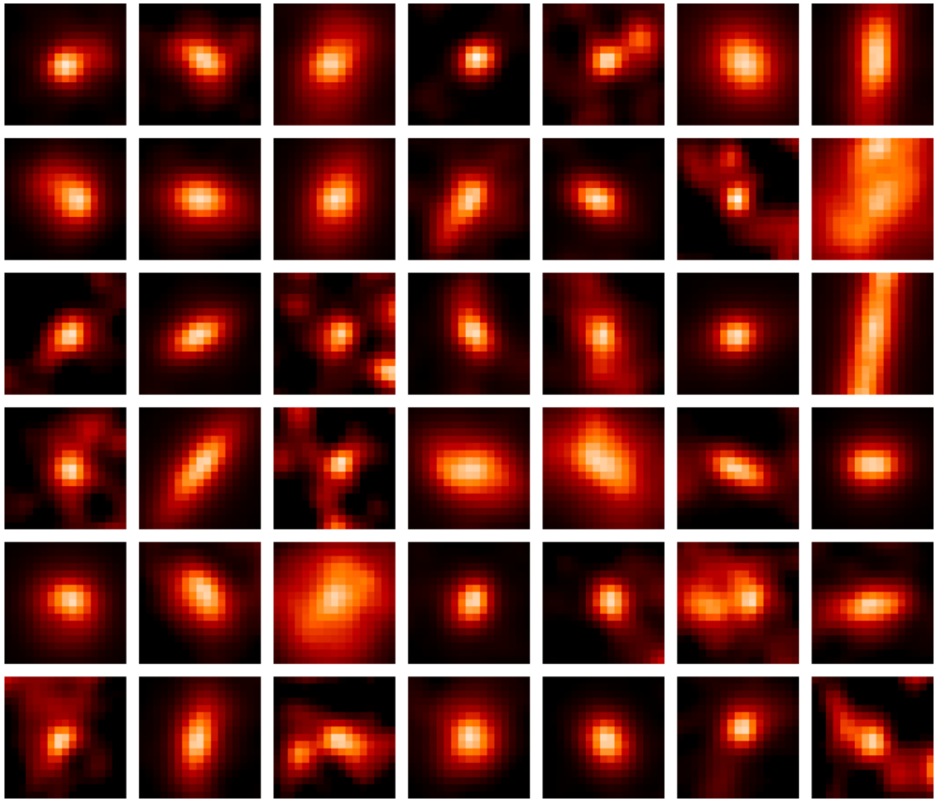
Surprisingly, not an acronym

Chris Clark

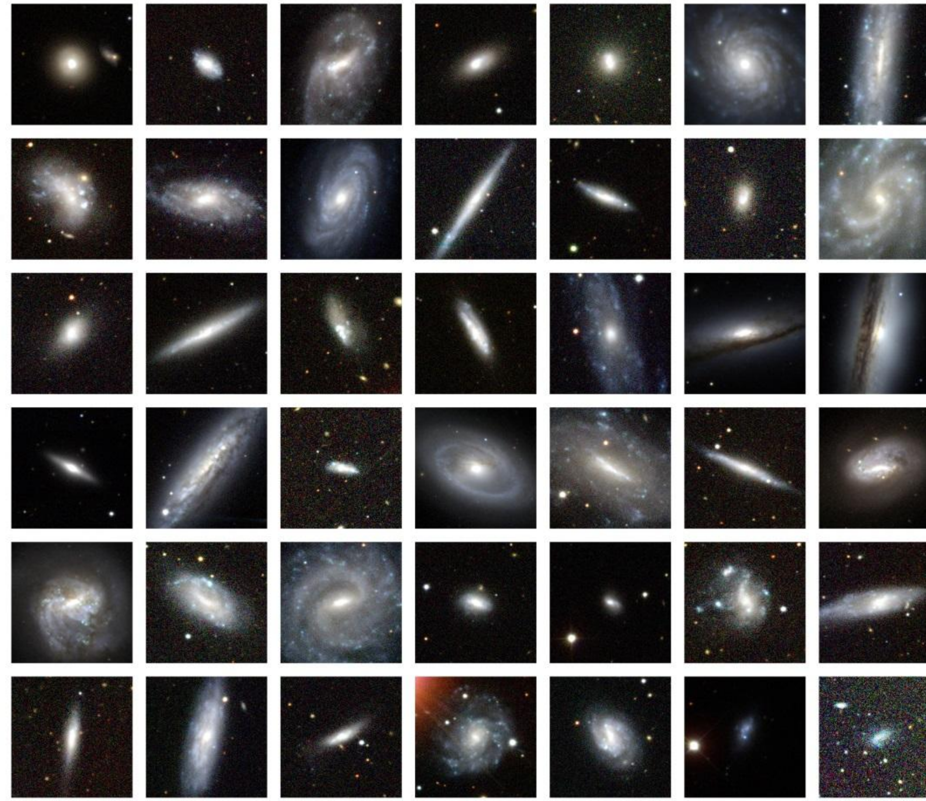
*H*erschel **A**strophysical **T**erahertz **L**arge-**A**rea **S**urvey

Principal Investigators: Steve Eales & Loretta Dunne

A Dust-Selected Local Galaxy Sample



H-ATLAS 250 μm



SDSS *gri*-bands

15 < D < 46 Mpc

Chris Clark

BADGRS: Blue And Dusty Gas Rich Sources

GALEX Far-UV

Optical SDSS *gri*

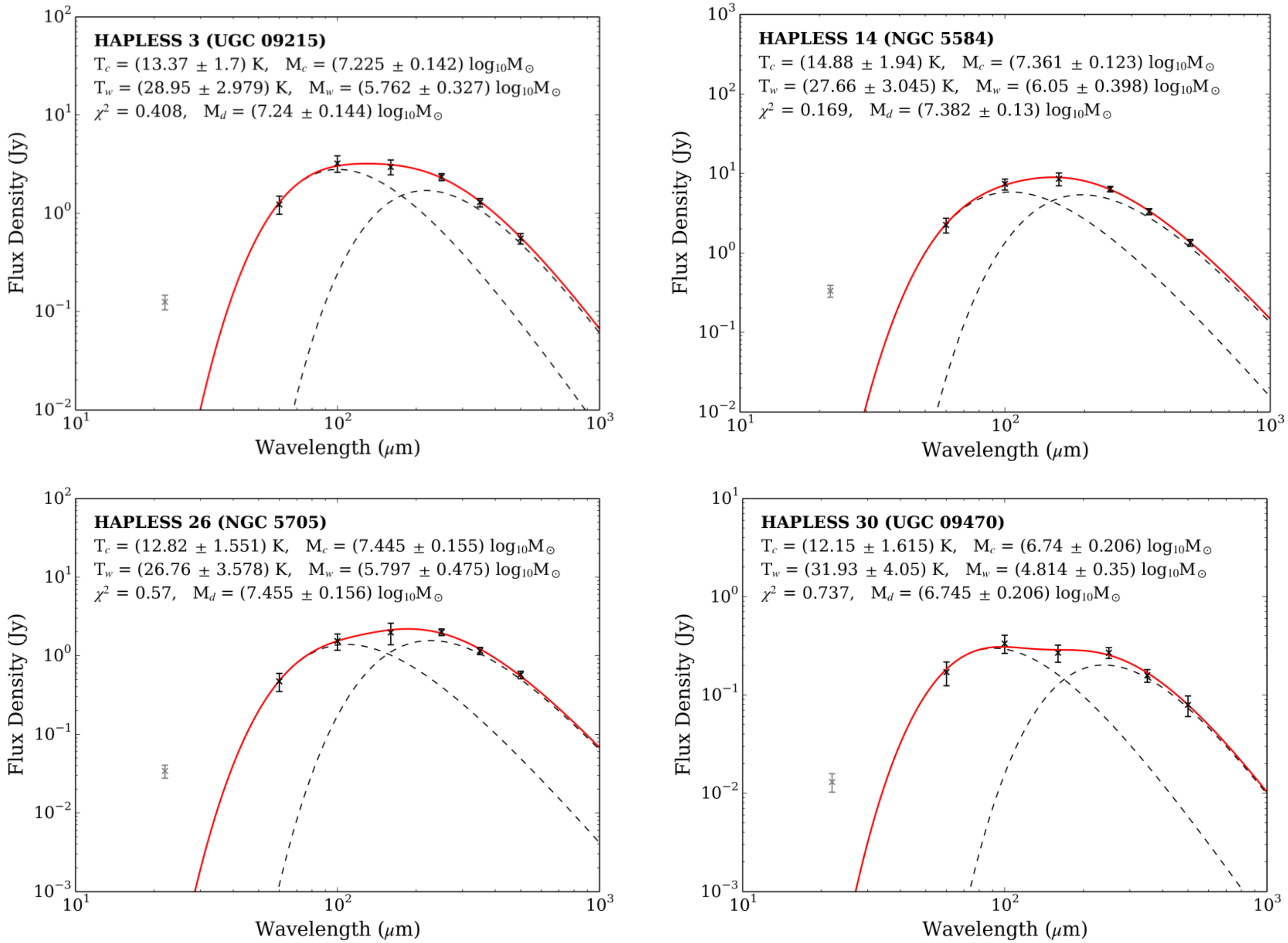
Near-IR VIKING K_s

H-ATLAS 250 μm

$$\mathrm{FUV}\text{-}K_s < 3.5_{\mathrm{AB}}$$

Chris Clark

Dust SED Fitting



BADGR dust temperatures typically 11–16 K

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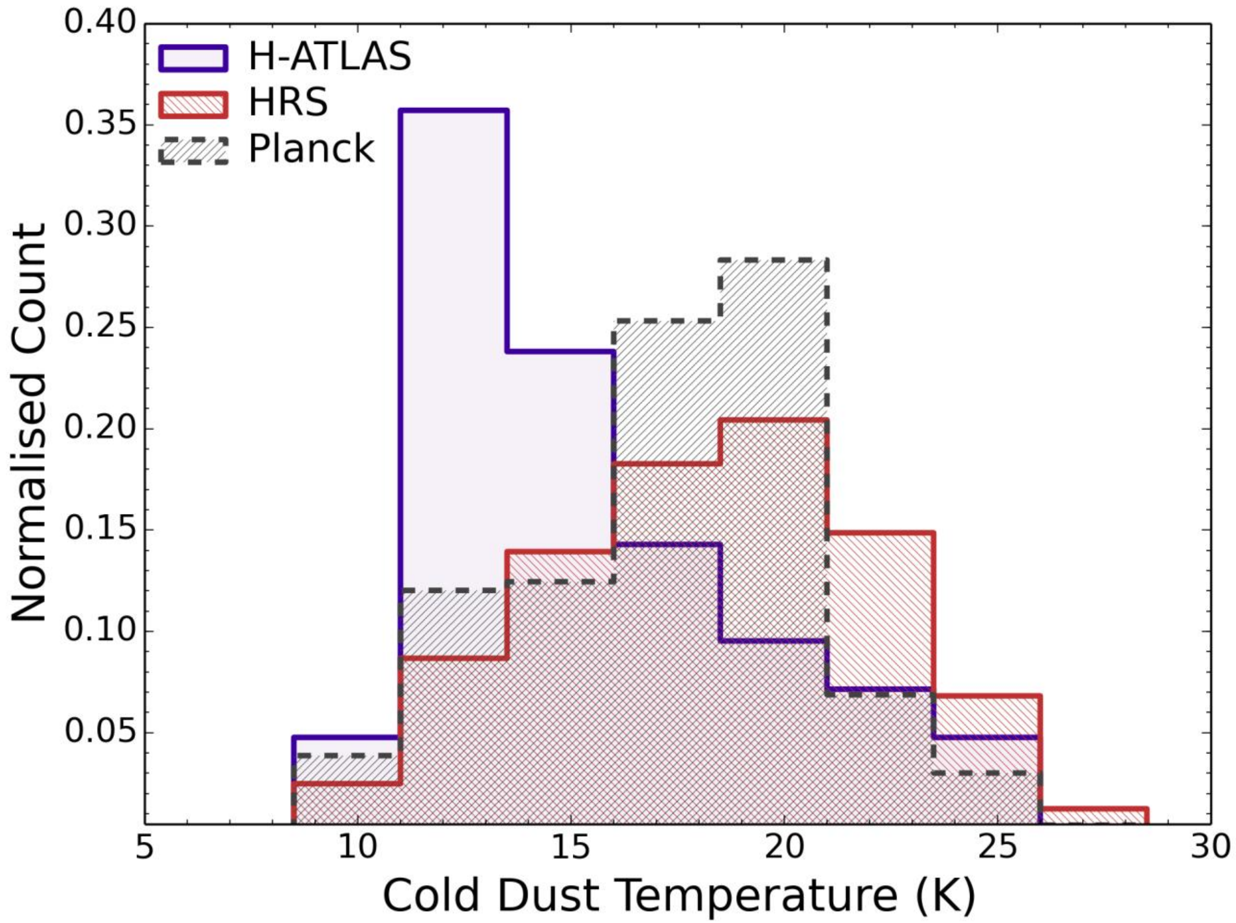
Previously Overlooked Cold Dust



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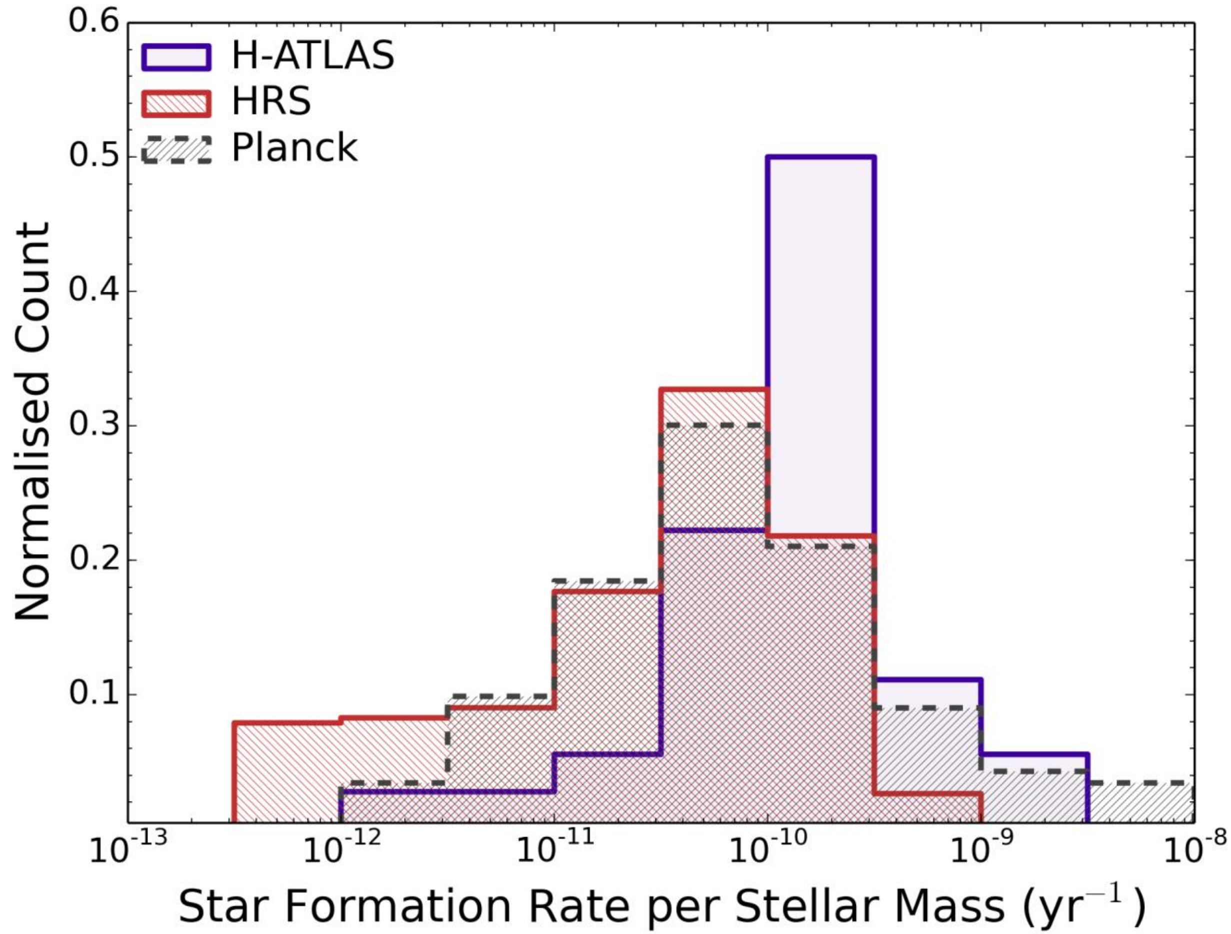
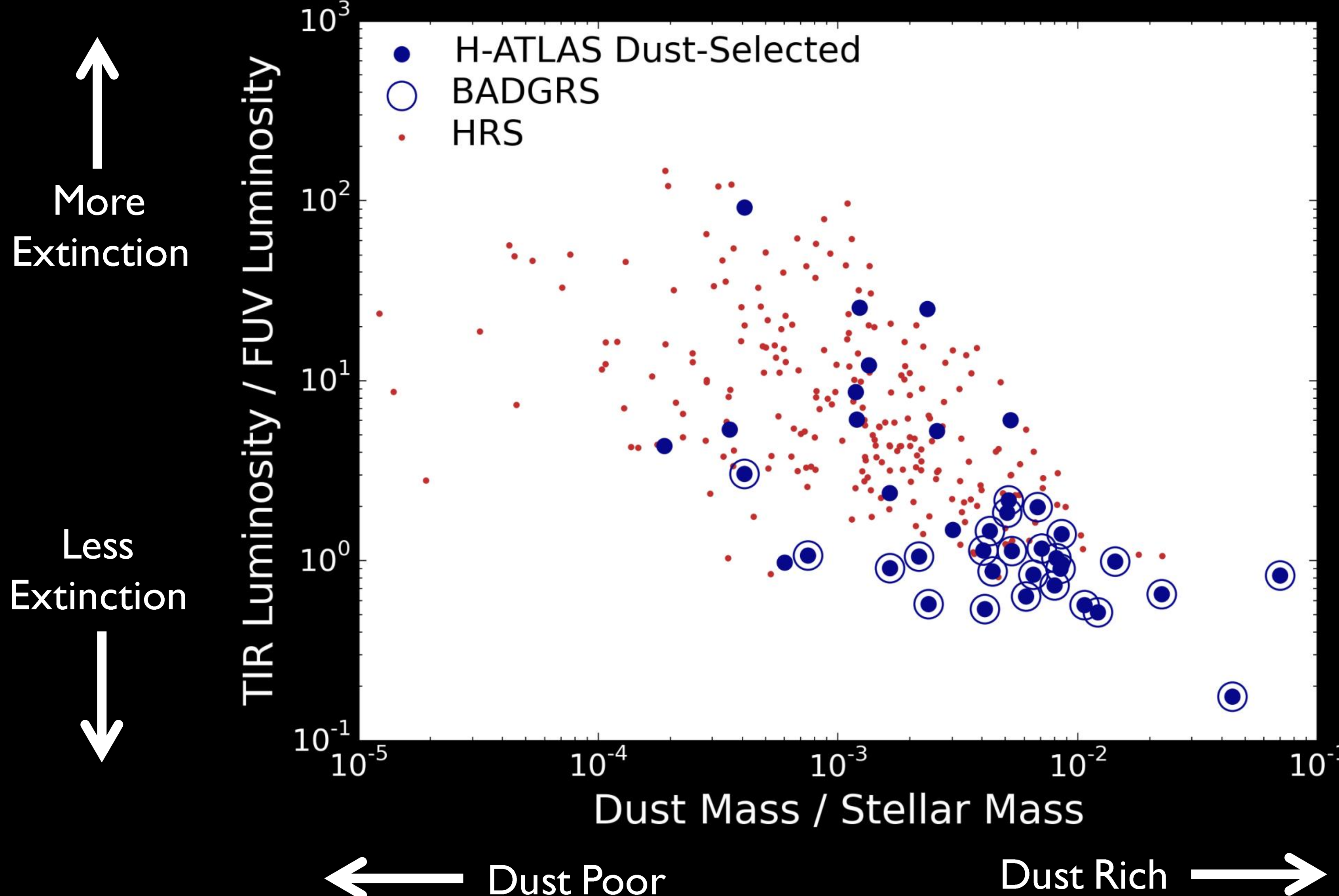
Cold Dust, But Lots Of Heating…?



Average SSFR of dust-selected *H*-ATLAS sample is 4–5 times higher than average of HRS or *Planck* samples

Chris Clark

Lots of Dust, Little Extinction



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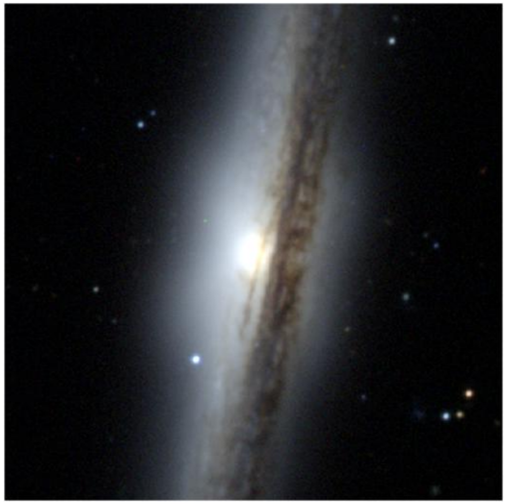
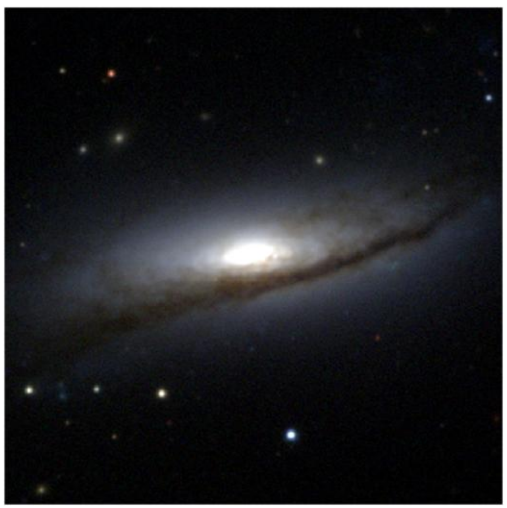
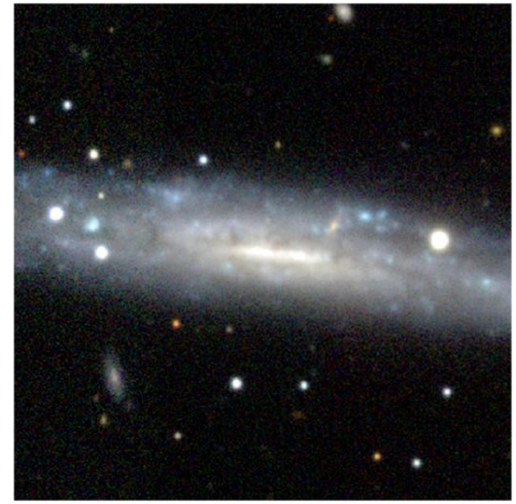
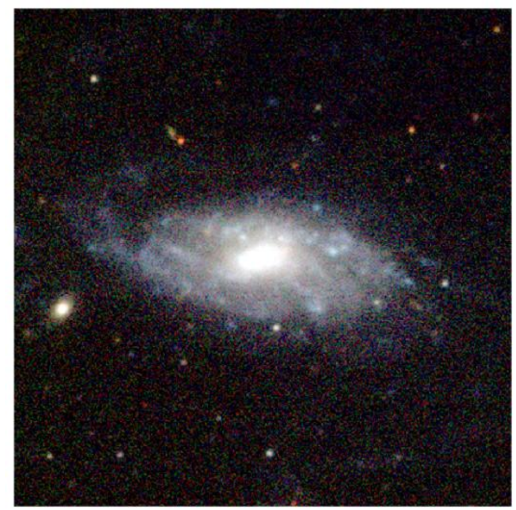
Dust Lanes ≠ Dust Rich





$M_D/M_S \sim 0.0005$





$M_D/M_S \sim 0.01$

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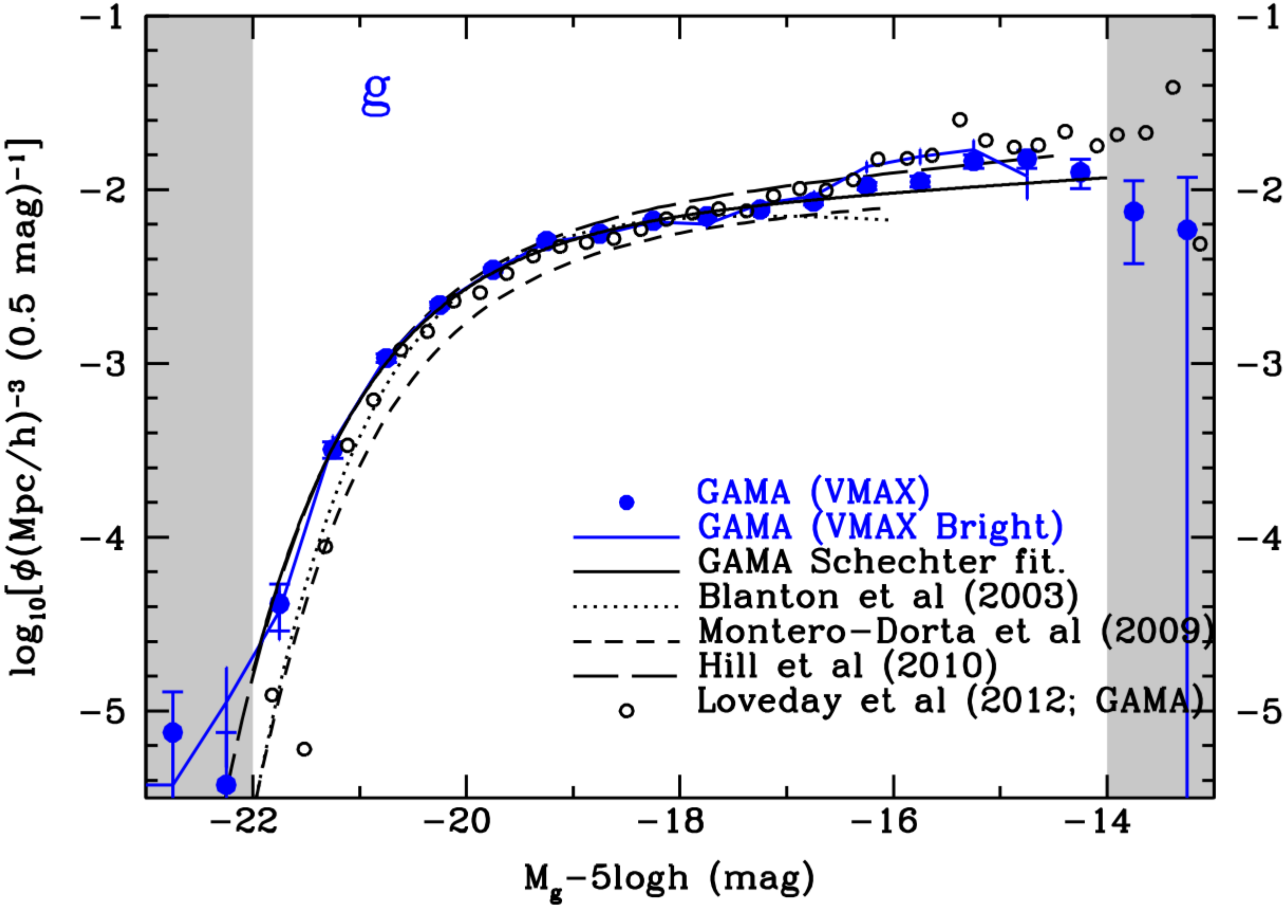
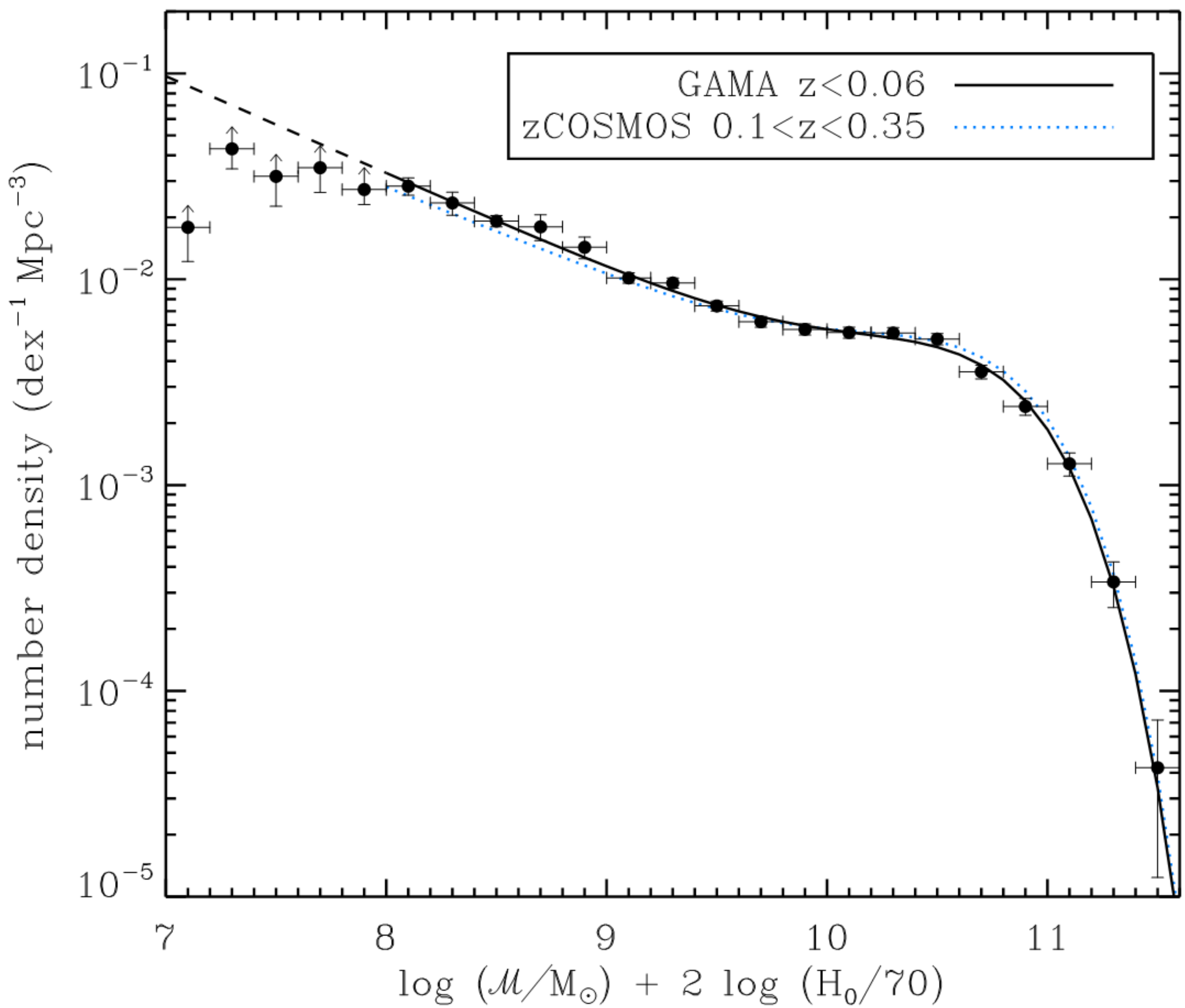
Luminosity Functions…



$$\phi = \phi^\star \left(\frac{L}{L^\star}\right)^\alpha e^{-\frac{L}{L^\star}}$$

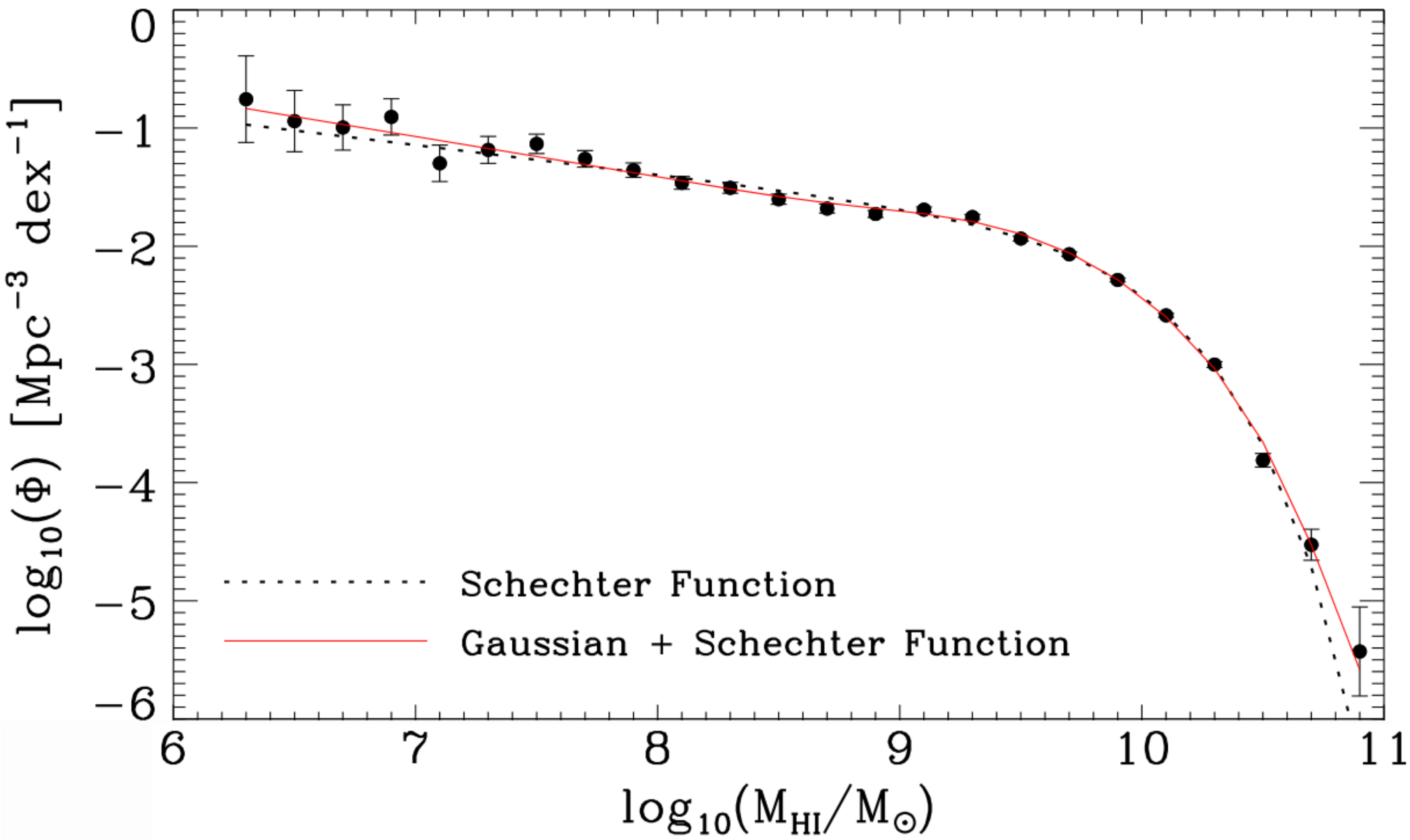
From Loveday et al (2012)

…And Stellar Mass Functions…



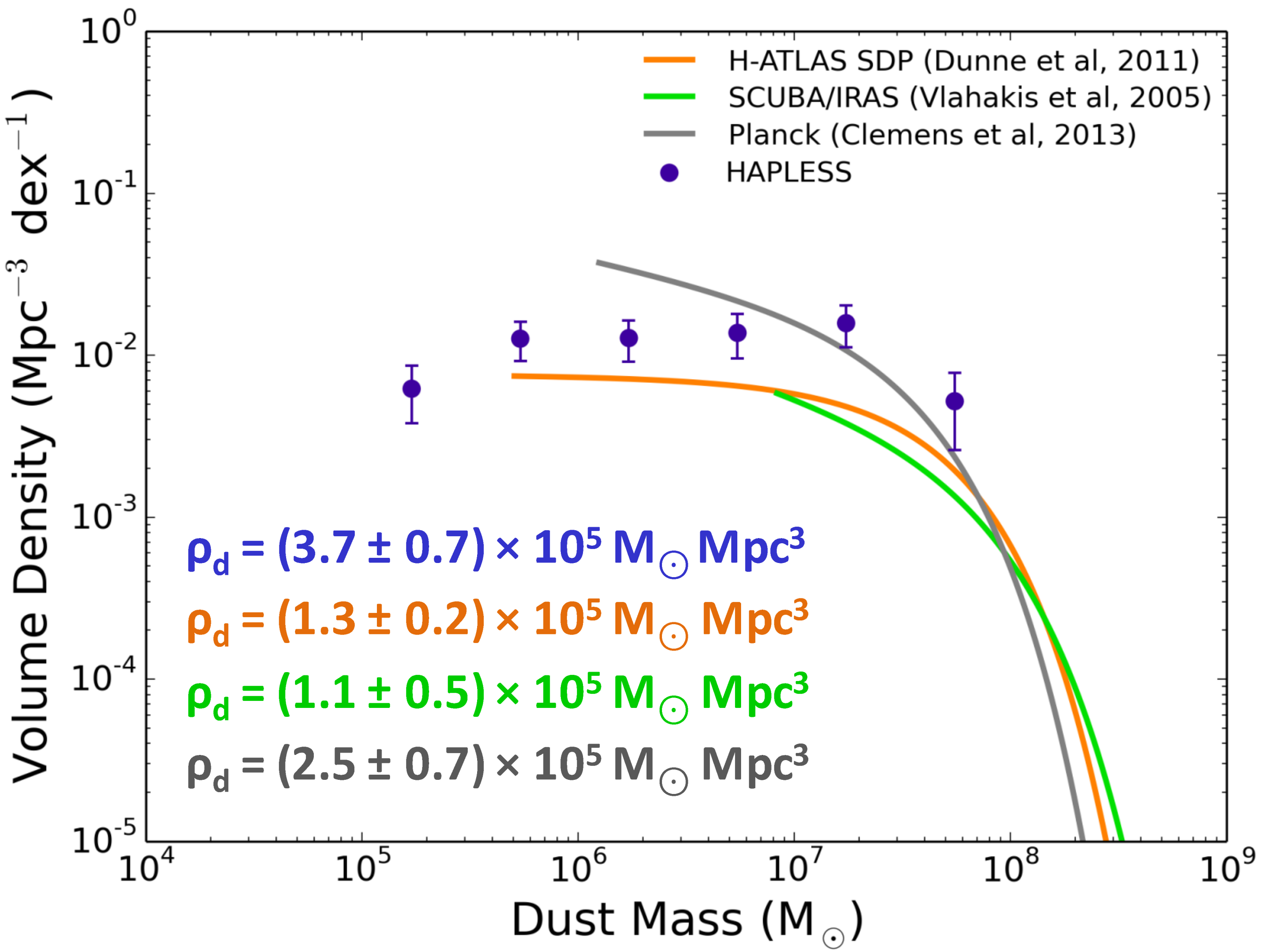
From Baldry et al (2012)

…And HI Mass Functions…



From Martin et al (2014)

The Dust Mass Function



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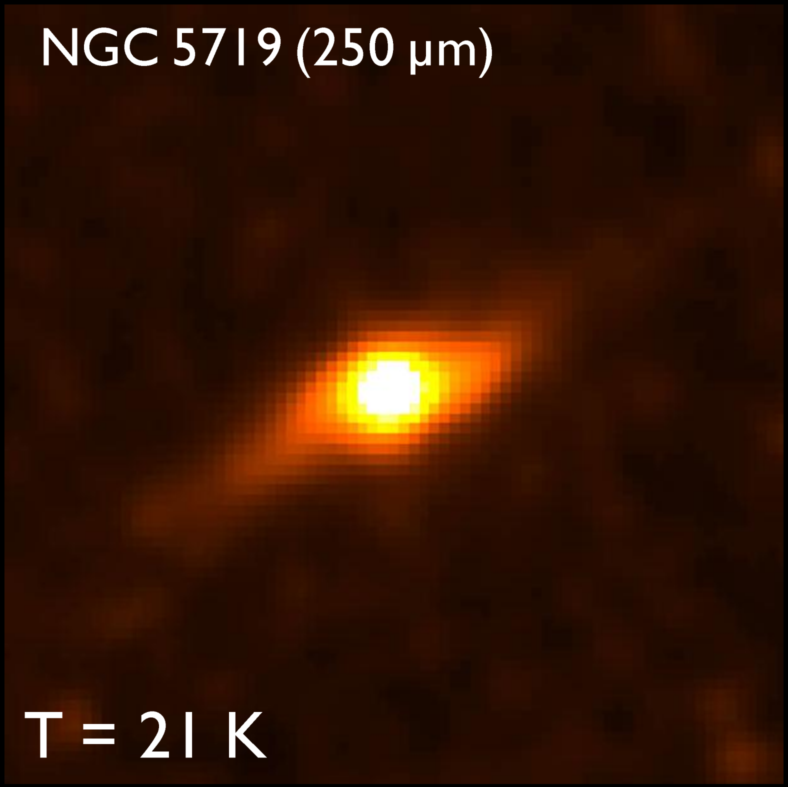
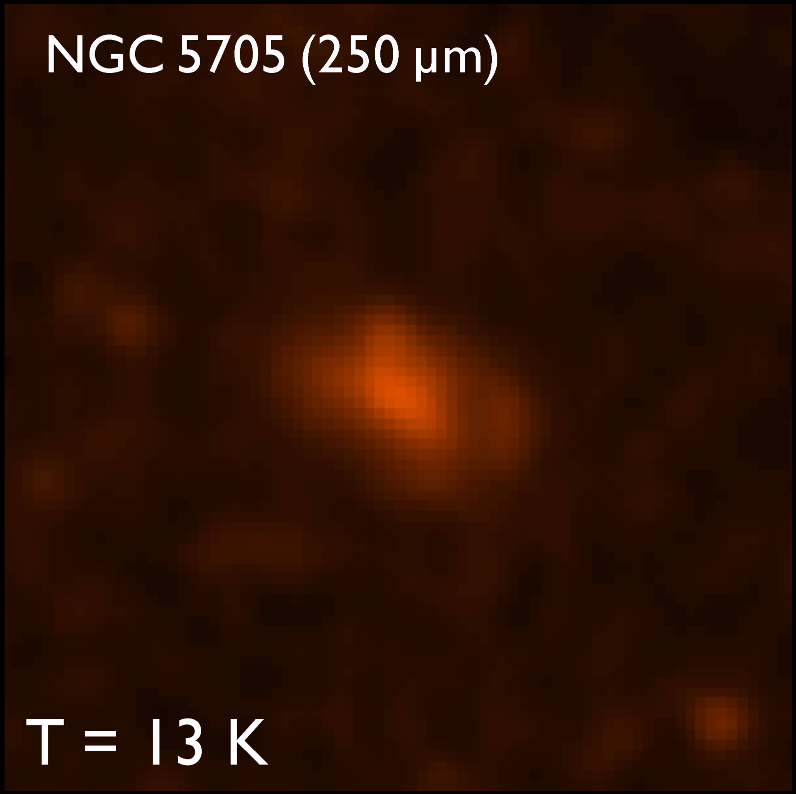
Cold & Very Faint



"Normal" galaxy



BADGR

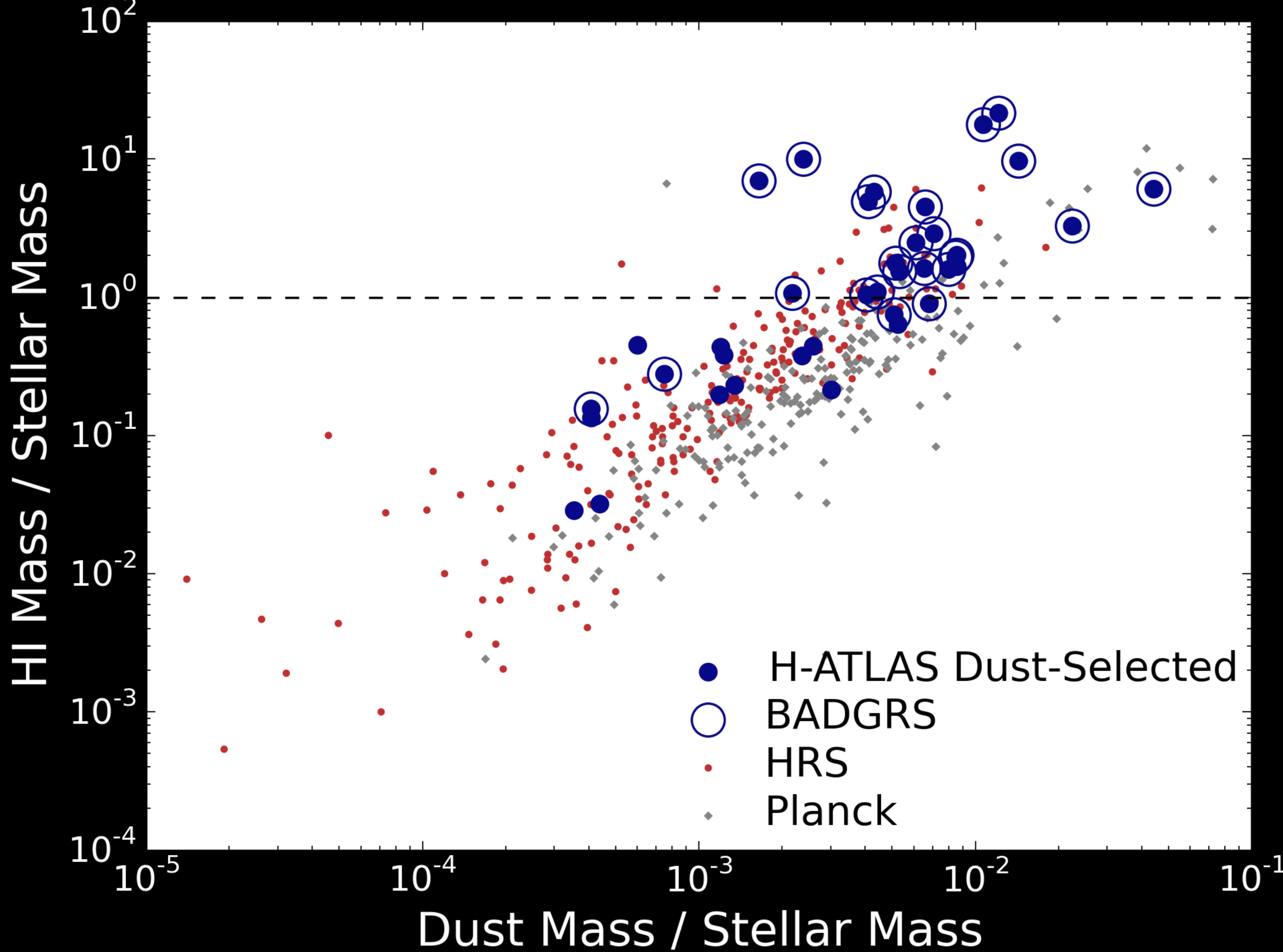
Blue And Dusty Gas Rich source

Chris Clark

Dust-Rich and Gas-Rich

Atomic Gas Rich

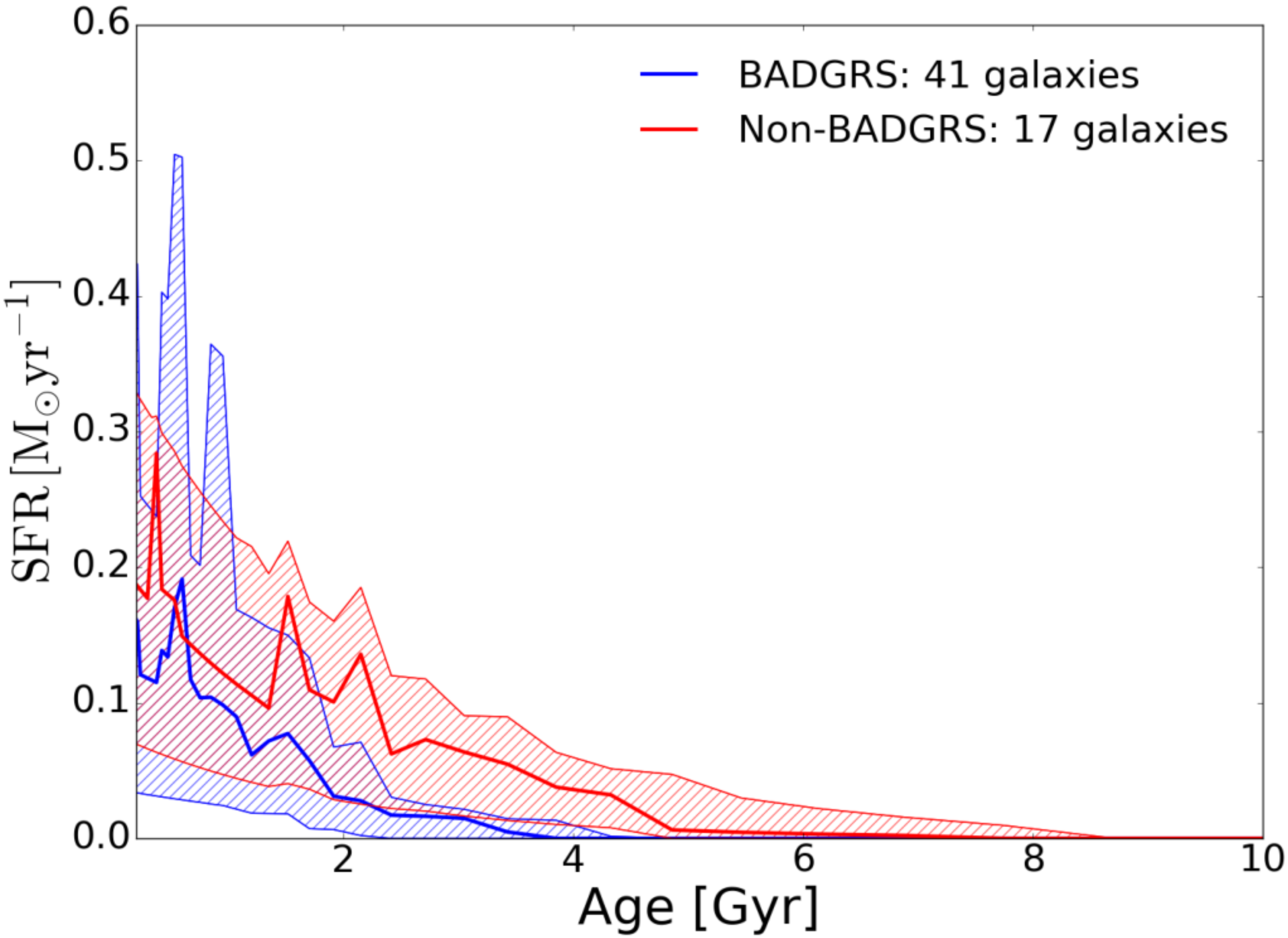
Atomic Gas Poor



Dust Poor

Dust Rich

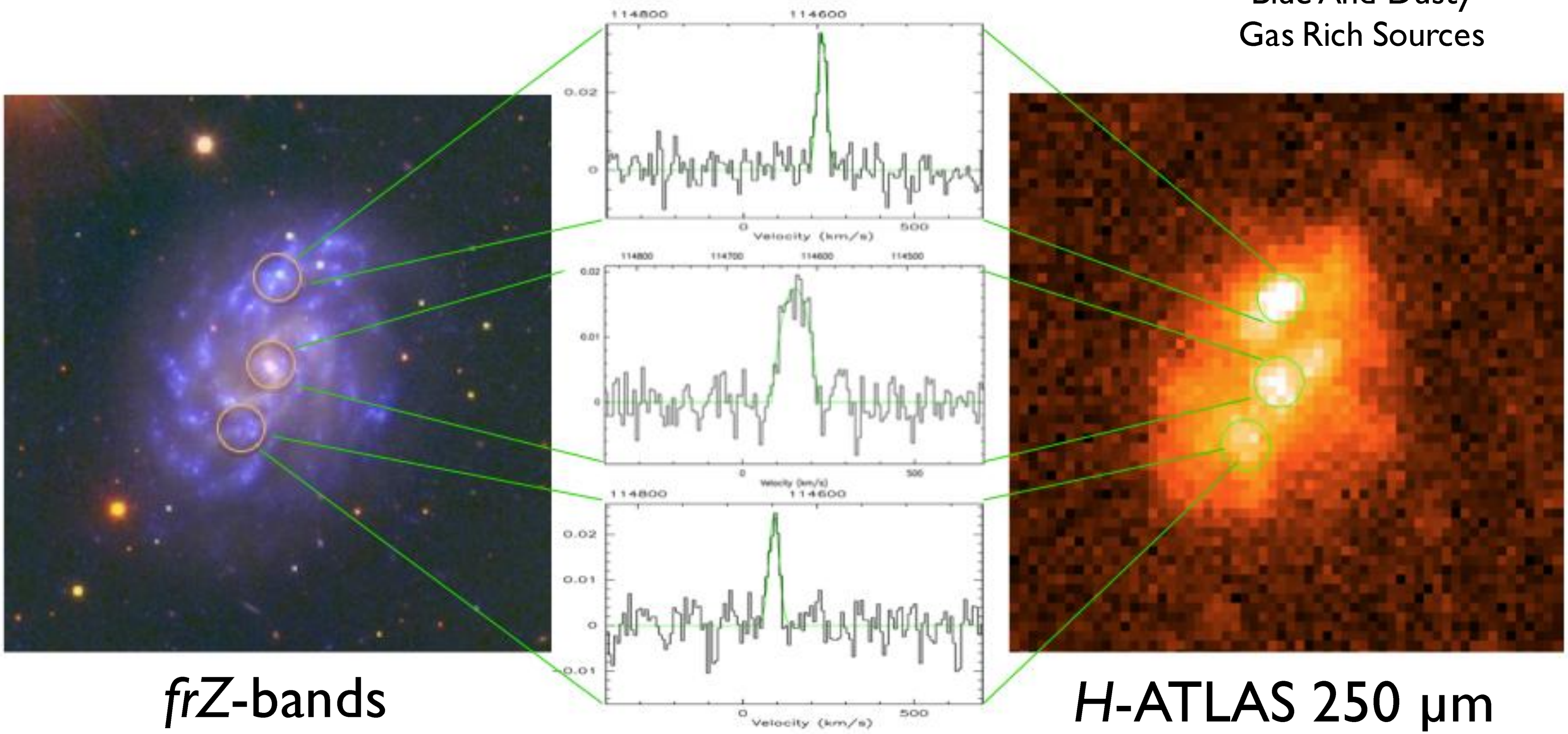
Star Formation Histories of BADGRS



By Simon Schofield

The Highly Unusual ISM of BADGRS

Blue And Dusty
Gas Rich Sources



IRAM CO(1–0)

I_{CO} = 0.2–2 K km s^{-1}

FWHM = 30–100 km s^{-1}

M_{H2}/M_d = 2–27 (MW X_{CO})

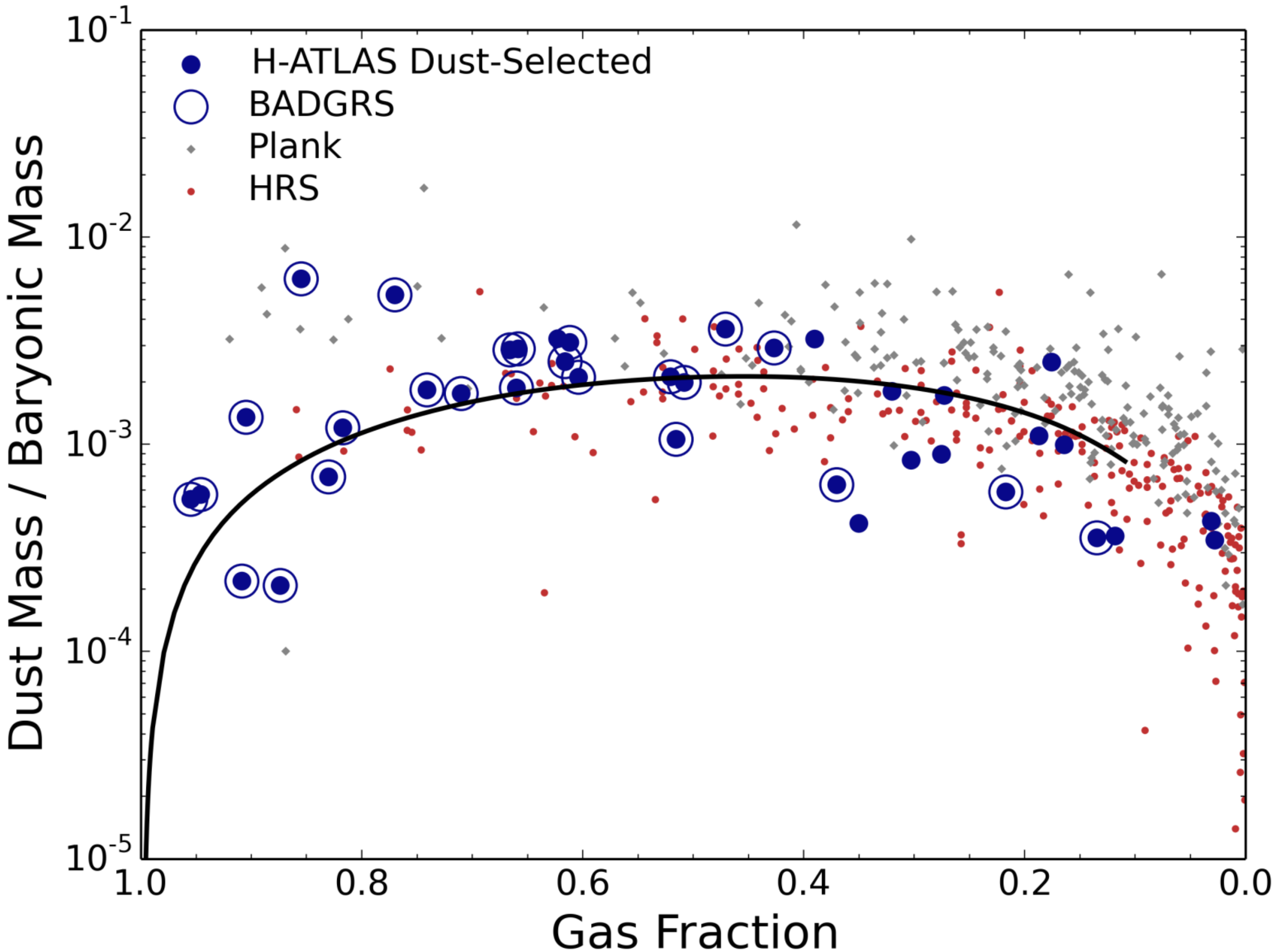
Z = 0.5–1 $Z_{\odot}$

Chris Clark

A Dusty Window On Young Galaxies

Dust Rich

Dust Poor



Younger

Older

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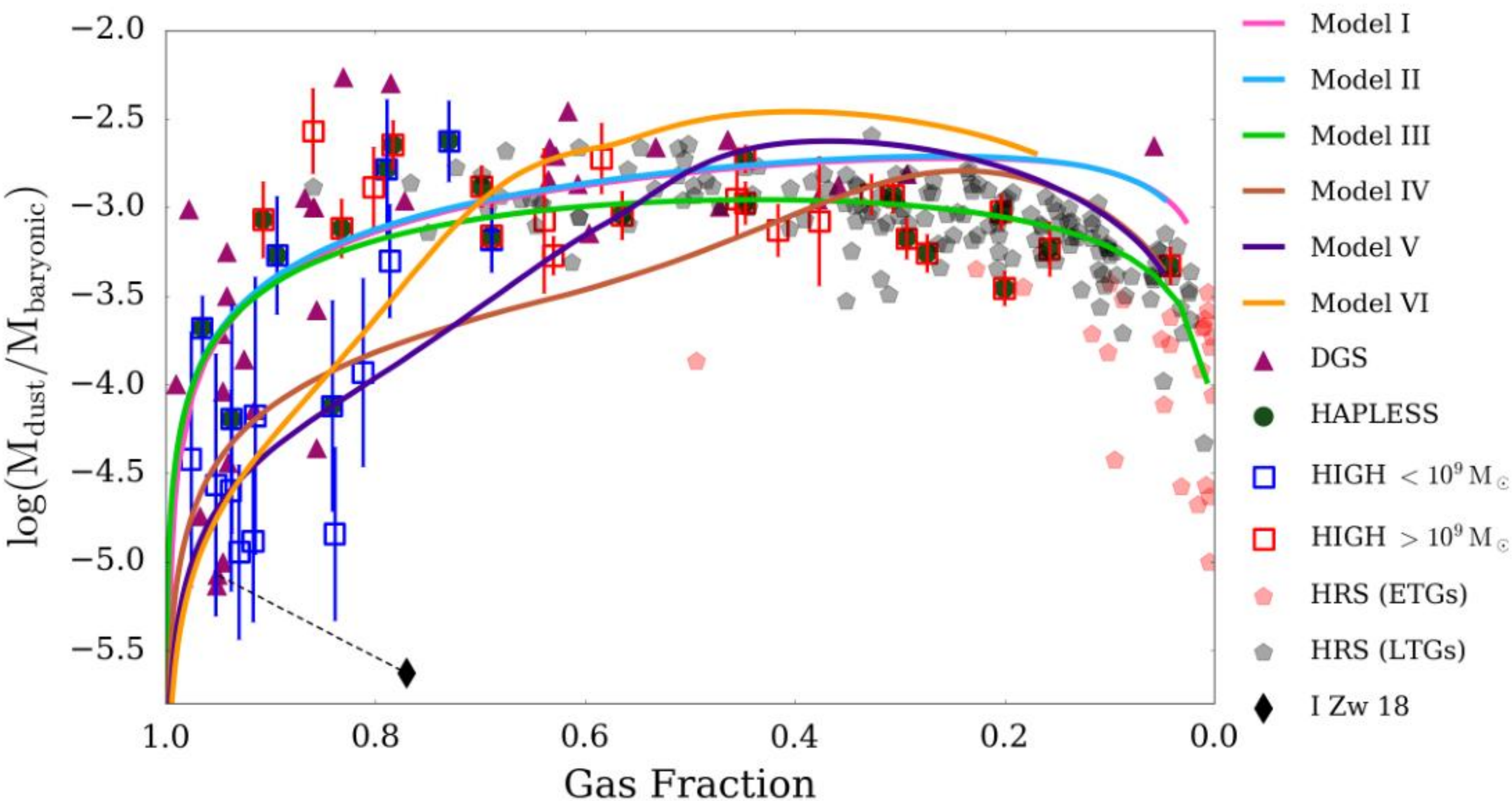
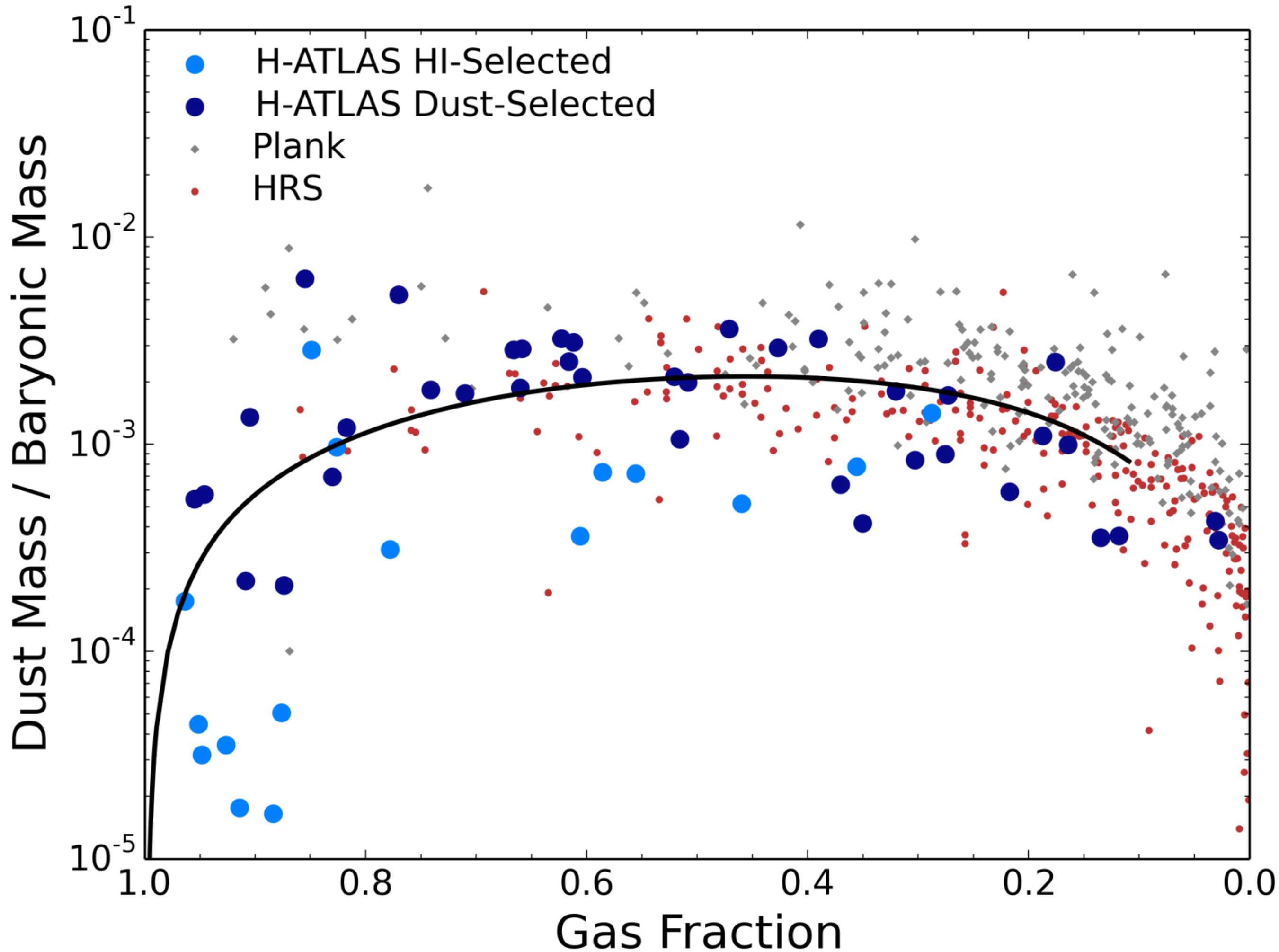
Chemical Evolution in Action



By Simon Schofield

Extremely Young, Dust-Poor Galaxies

Dust Rich



Dust Poor

Younger

Older

Chris Clark

Part II - Key Results

- A dust-selected nearby galaxy survey with *Herschel*-ATLAS reveals that very blue (FUV-K_S<3.5) irregular/flocculent galaxies dominate the local dusty universe.
- These **B**lue **A**nd **D**usty **G**as **R**ich **S**ources – **BADGRS** – have been severely under-sampled by previous surveys. They account for 5% of the stellar mass, 35% of the dust mass, and 50% of the HI mass in our dust-selected sample.
- The more dust-rich a galaxy, the less UV absorption occurs; hence the BADGRS have very cold dust temperatures of 11–16 K.
- The BADGRS appear to be in an intermediate stage of evolution; they contain more HI than stars, but have processed a lot of raw material into dust very quickly.

Chris Clark