Mid to far-IR Observations of High Redshift Radio Galaxies

Nick Seymour (UCL/MSSL)

23rd May 2011
Galaxies, Near and Far (Perugia)

Carlos De Breuck, Joel Vernet, Guillaume Drouart, Bob Fosby (ESO), Daniel Stern (JPL), Partick Ogle (IPAC), Jason Rawlings (MSSL)
and the HerMES Consortium

SPIRE image of HDF North
(250 μm=blue, 350 μm=green, 500 μm=red)

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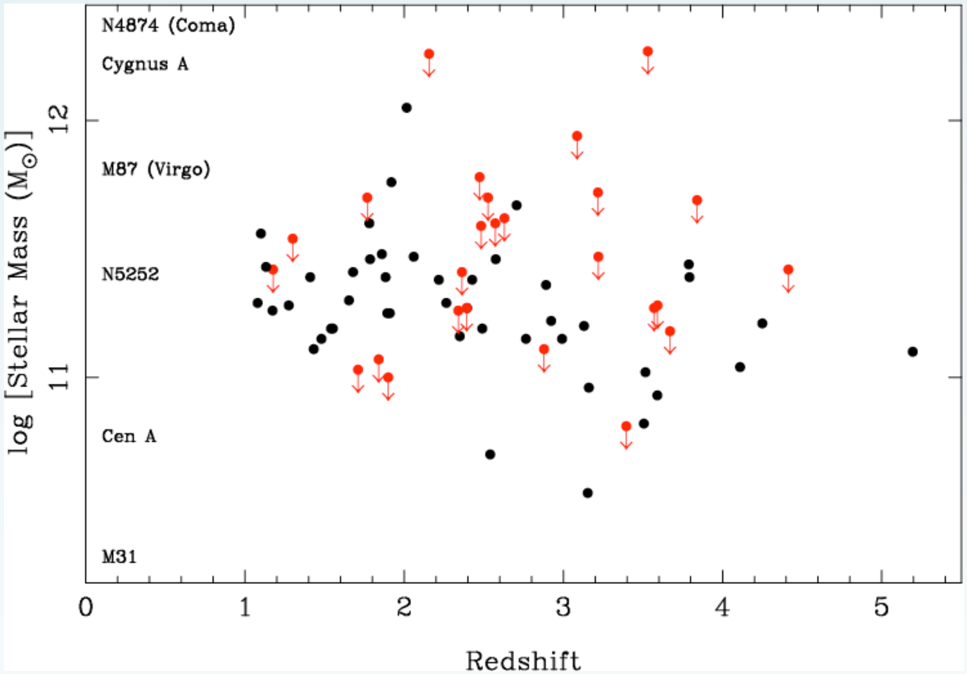
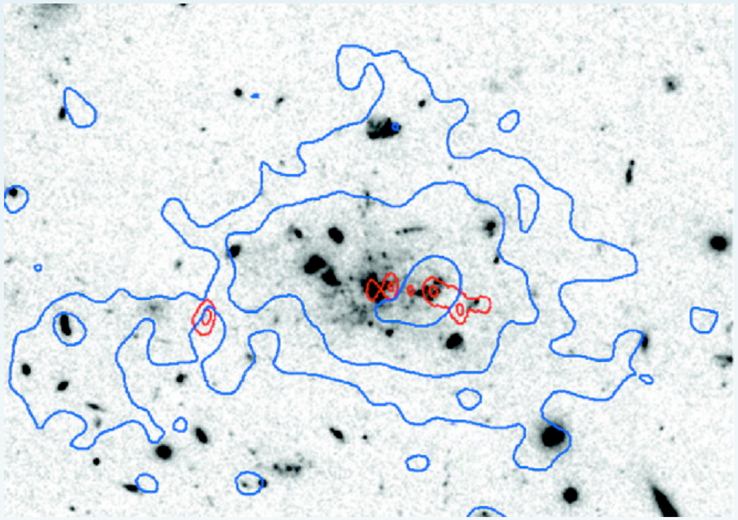
Stellar Masses of HzRGs



MRC 1138-262 (z=2.157)

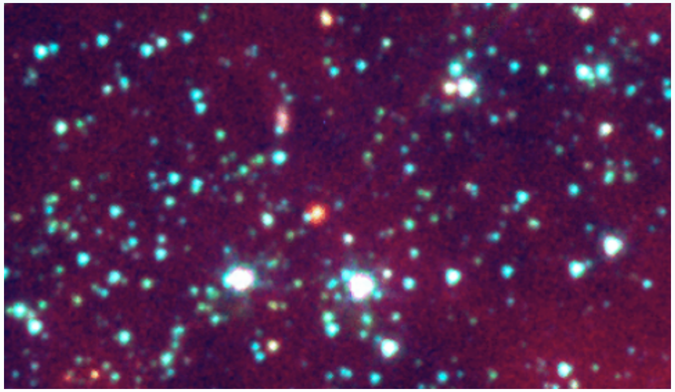


Hatch et al. 2009

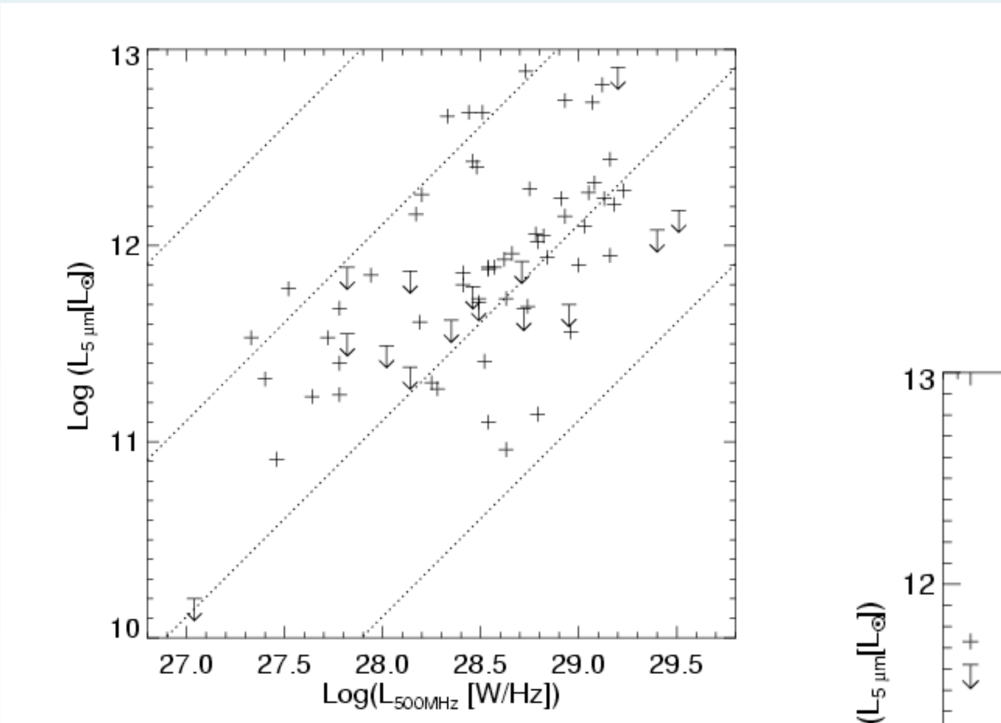
Log(M/M$_{\odot}$) ~ 11.3, but still time to grow a bit more

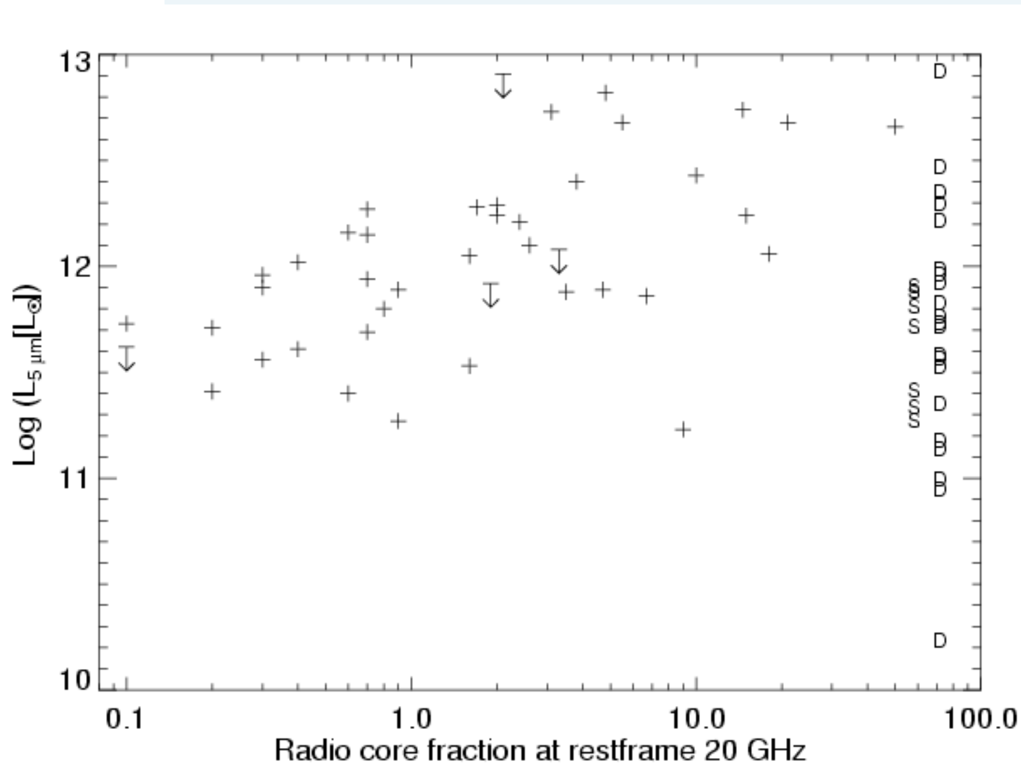
Seymour et al. 2007;
De Breuck et al. 2010

4C23.56 (z=2.48) will have a major merger in ~5Gyr (at z~0.6)



Connection between radio and mid-infrared power in HzRGs



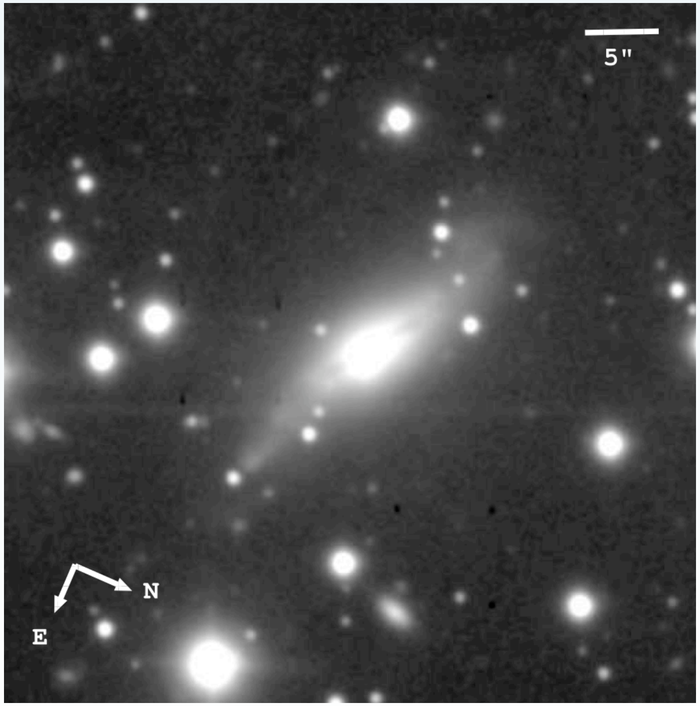


Seymour et al. 2007
De Breuck et al. 2010

Results to date: low redshift

Traditional view: local radio galaxies are hosted by passive gE and cD (Matthews *et al.* 1964).

However, some low redshift radio galaxies (z<0.1, $L_{1.4GHz} \sim 10^{26}\ WHz^{-1}$) exhibit modest star formation:



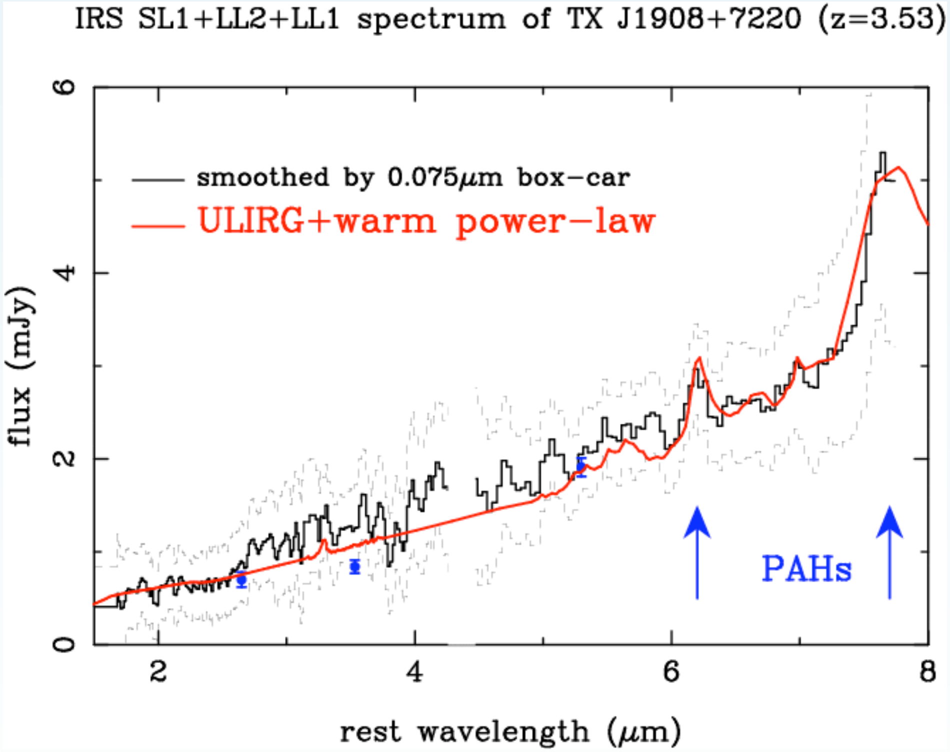
- disturbed optical mophologies
- indications of star formation in optical spectra
- non-AGN excess in far-infrared emission

Holt, Dicken, Ramos Almeida, Tadhunter et al. (works passim)

Results to date: high redshift

High redshift radio galaxies (HzRGs, z>1, $L_{1.4GHz} > 10^{26.5}$ WHz^{-1}) exhibit strong star formation:

- strong sub-mm emission (SCUBA, SHARCII etc.)
- Lymanα haloes consistent with large reservoir of fuel for star formation
- mid-IR spectra:



Seymour et al. 2008

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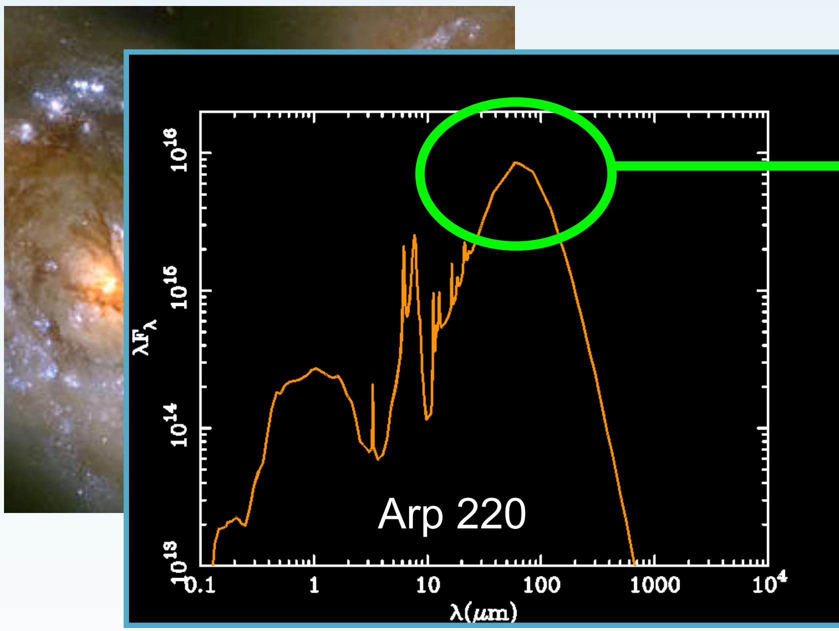
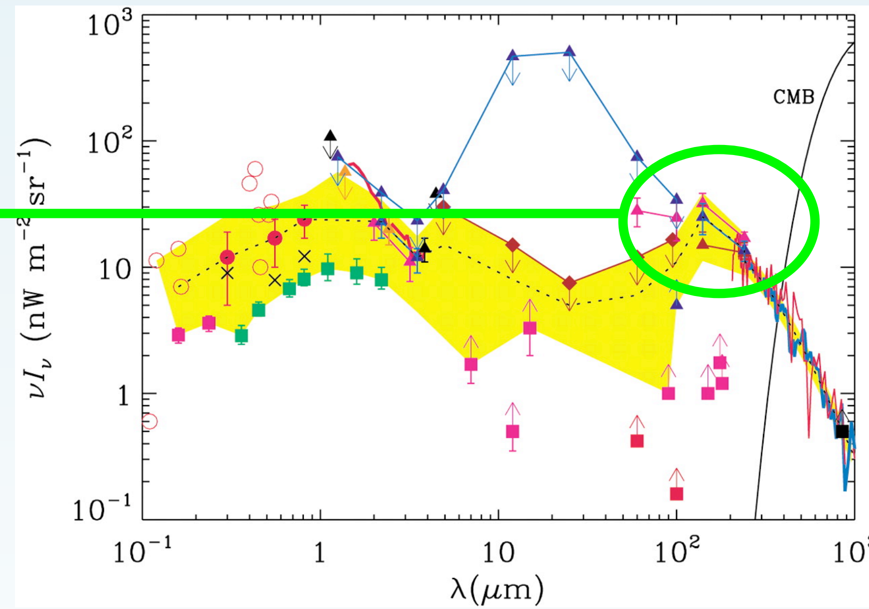
Luminous star forming galaxies are often very dusty.





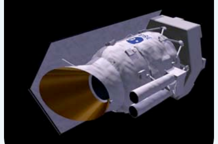
Hauser & Dwek 2001, ARA&A 39,249

- Most of their power comes out in the far infrared.
- This is the best way to measure star formation rates in distant sources dominated by a super-massive black holes.

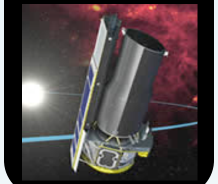
How much of an advance is Herschel?

IRAS
1983
60cm

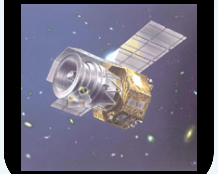
ISO
1995
60cm



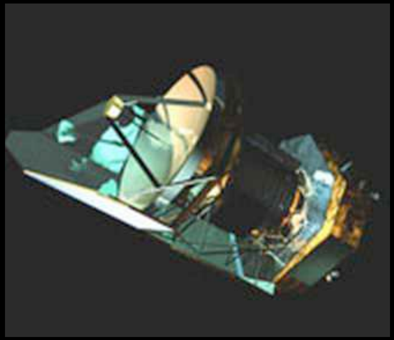
Spitzer
2003
85cm

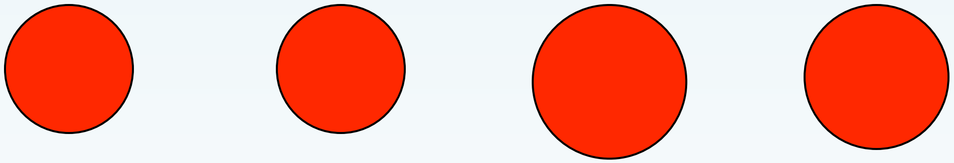


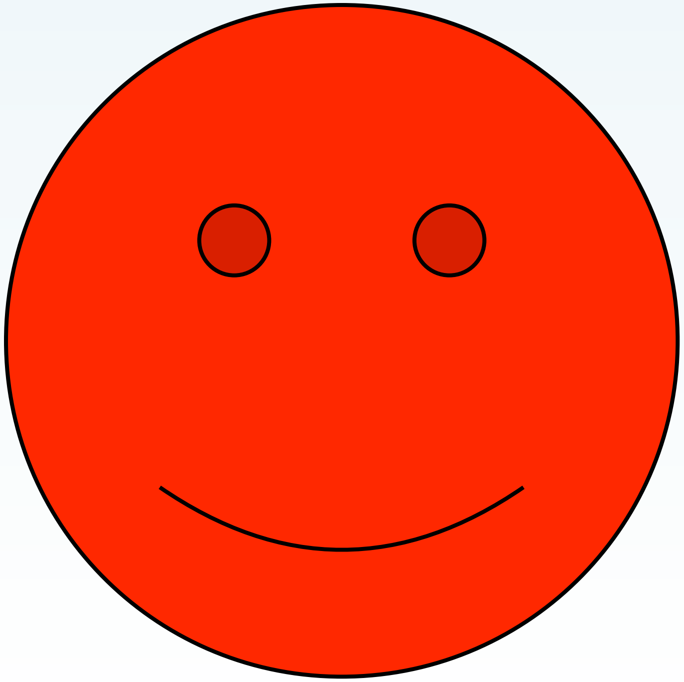
Akari
2006
70cm



Herschel
2009
3.5m



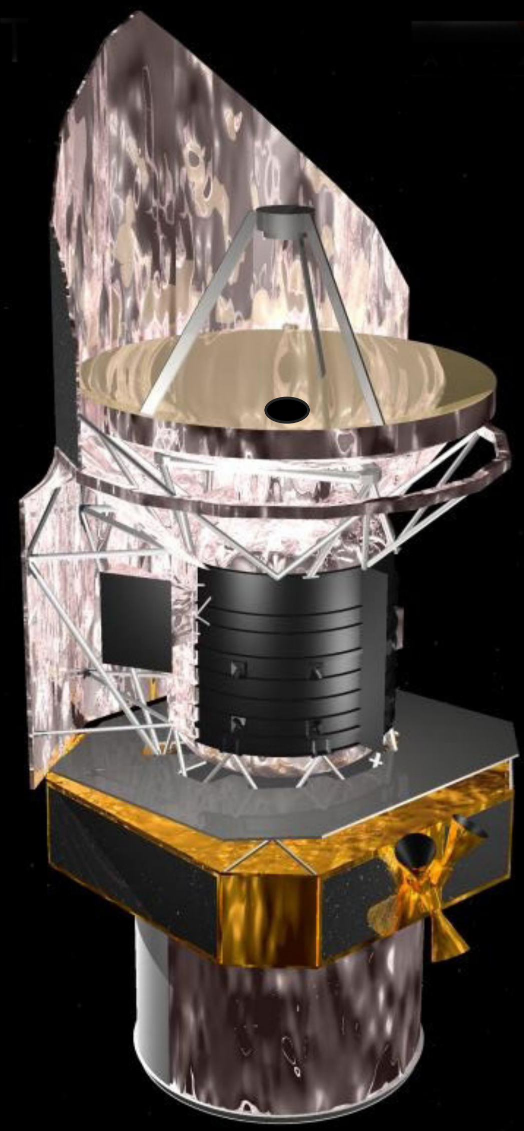




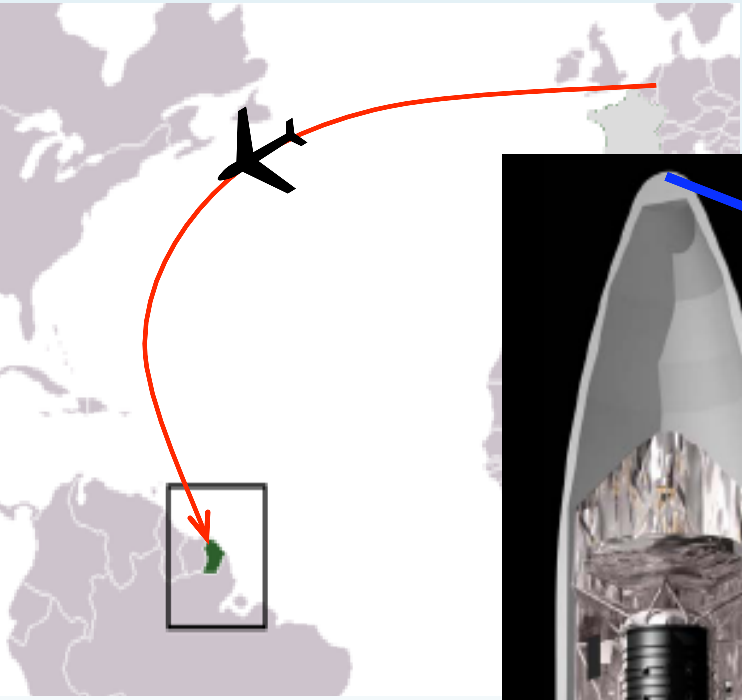
A very very big one.

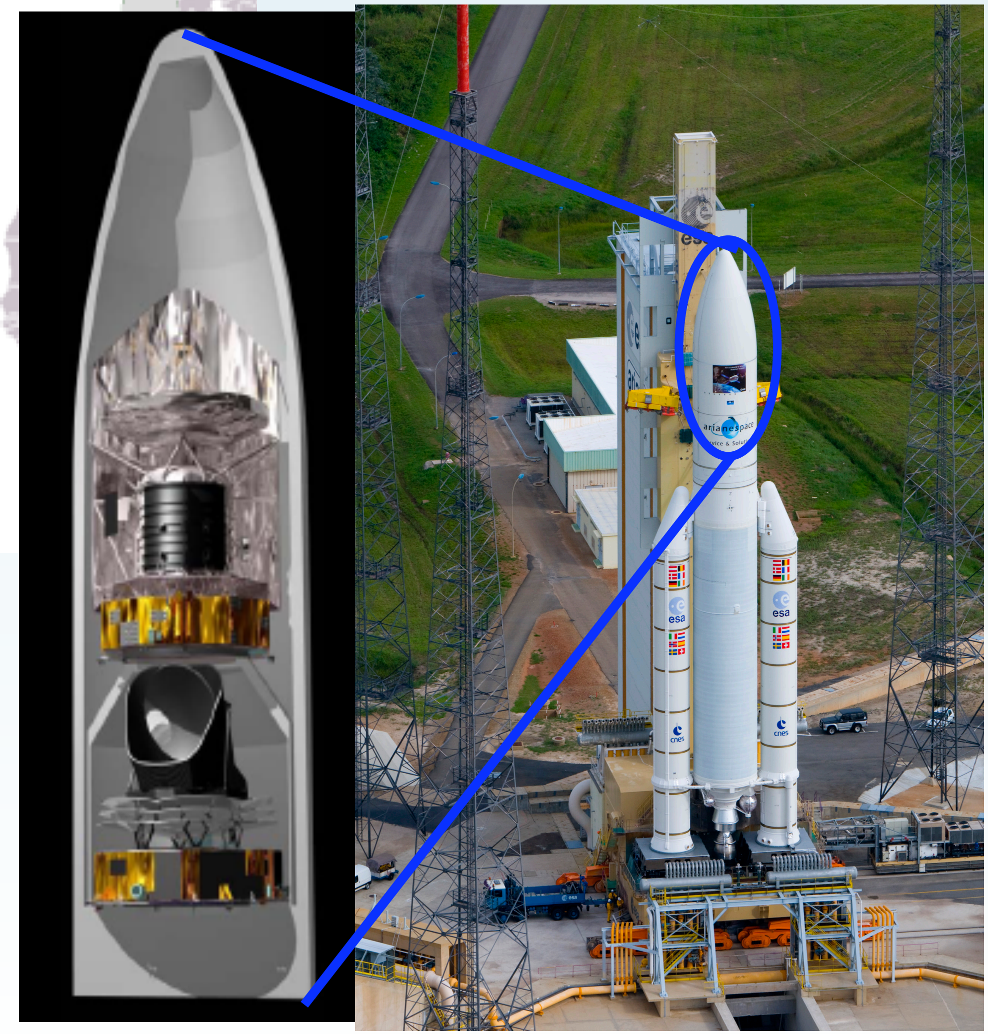
The Herschel Space Observatory

• Telescope diameter	3.5 m
• Telescope temperature	80 K
• Lifetime	> 3 years
• Helium capacity	2200
litres	
• Height	7 metres
• Mass	3.3
Tonnes	
• Wavelength range	60 – 700
μm	

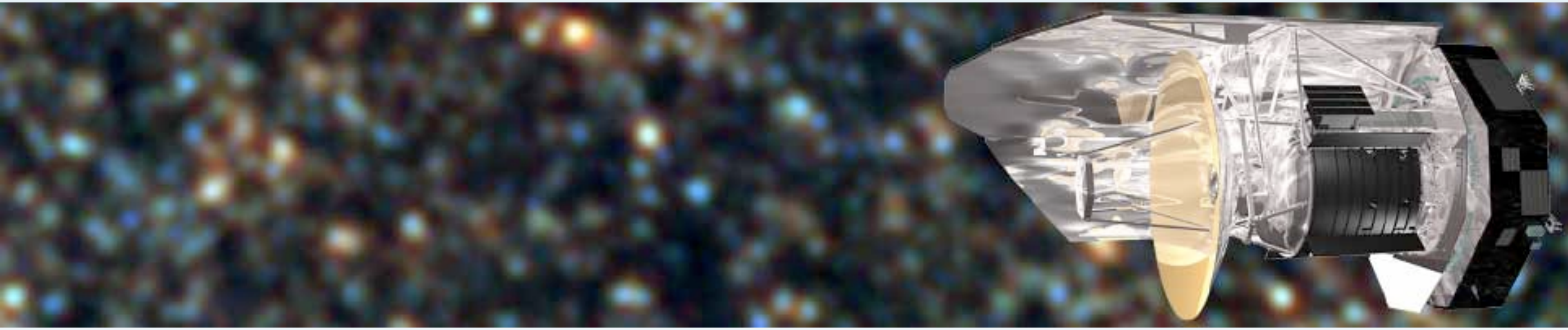


Herschel and Planck Launch (April 2009)





First science data arrived in September 2009 hermes.sussex.ac.uk



HERSCHEL MULTI-TIERED EXTRAGALACTIC SURVEY

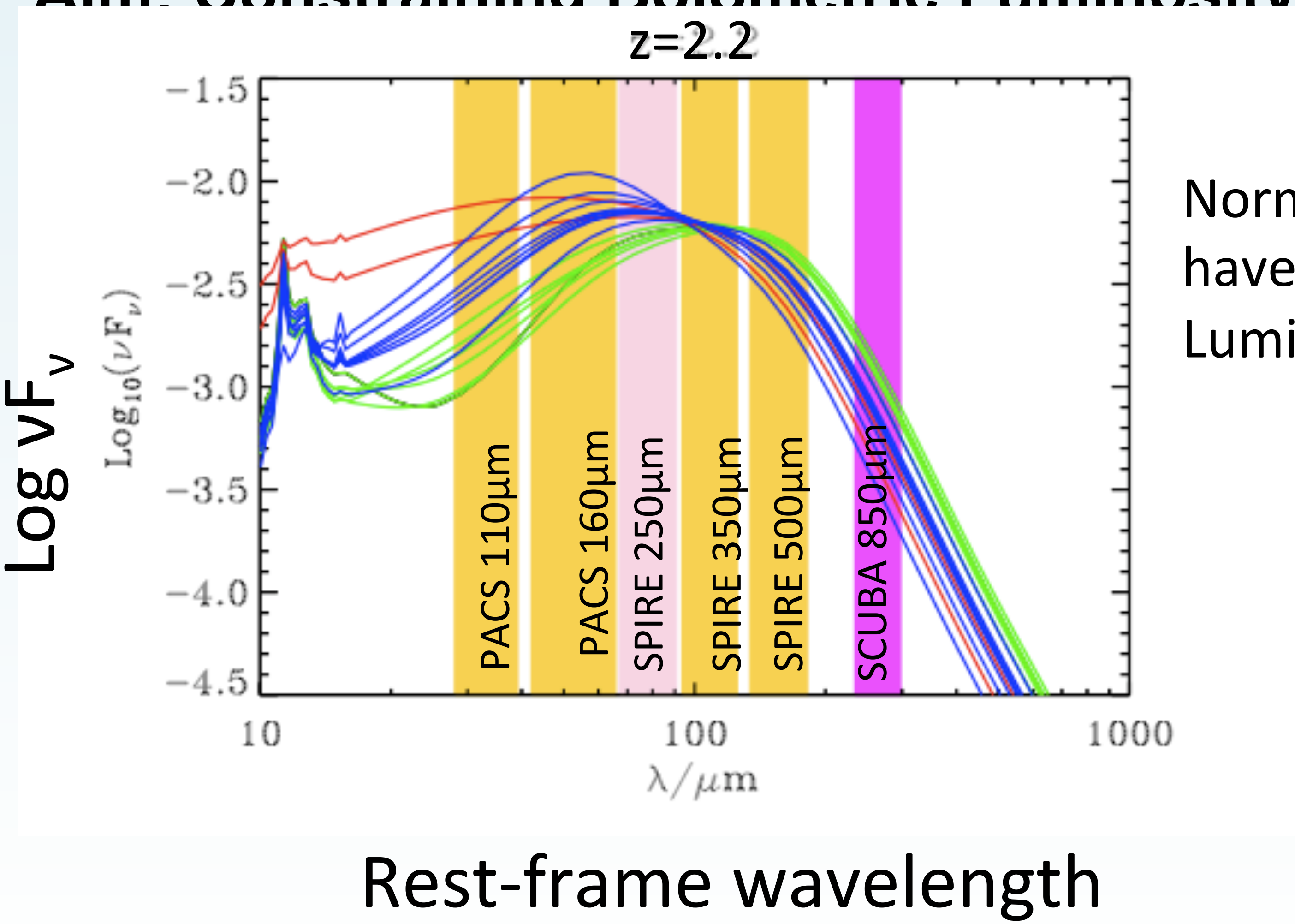
The HERMES Team

Bruno Altieri, Alex Amblard, Vinod Arumugam, Robbie Auld, Herve Aussel, Tom Babbedge, Alexandre Beelen, Matthieu Bethermin, Andrew Blain, Jamie Bock, Alessandro Boselli, Carrie Bridge, Drew Brisbin, Veronique Buat, Denis Burgarella, Nieves Castro-Rodriguez, Antonio Cava, Pierre Chanial, Ed Chapin, Scott Chapman, Michele Cirasuolo, Dave Clements, Alex Conley, Luca Conversi, Asantha Cooray, Emanuele Daddi, Gianfranco DeZotti, Darren Dowell, Naomi Dubois, Jim Dunlop, Eli Dwek, Simon Dye, Steve Eales, David Elbaz, Erica Ellingson, Tim Ellsworth-Bowers, Duncan Farrah, Patrizia Ferrero, Matt Fox, Alberto Franceschini, Ken Ganga, Walter Gear, Elodie Giovannoli, Jason Glenn, Eduardo Gonzalez-Solares, Matt Griffin, Mark Halpern, Martin Harwit, Evanthia Hatziminaoglou, Sebastien Heinis, George Helou, Jiasheng Huang, Peter Hurley, HoSeong Hwang, Edo Ibar, Olivier Ilbert, Kate Isaak, Rob Ivison, Ali Ahmed Khostovan, Martin Kunz, Guilaine Lagache, Louis Levenson, Carol Lonsdale, Nanyao Lu, Suzanne Madden, Bruno Maffei, Georgios Magdis, Gabriele Mainetti, Lucia Marchetti, Elizabeth Marsden, Gaelen Marsden, Jason Marshall, Ketron Mitchell-Wynne, Glenn Morrison, Angela Mortier, HienTrong Nguyen, Brian O'Halloran, Seb Oliver, Alain Omont, Frazer Owen, Mathew Page, Maurillo Pannella, Pasquale Panuzzo, Andreas Papageorgiou, Harsit Patel, Chris Pearson, Ismael PerezFournon, Michael Pohlen, Naseem Rangwala, Jason Rawlings, Gwen Raymond, Dimitra Rigopoulou, Laurie Riguccini, Davide Rizzo, Giulia Rodighiero, Isaac Roseboom, Michael Rowan-Robinson, Miguel SanchezPortal, Rich Savage, Bernhard Schulz, Douglas Scott, Paolo Serra, Nick Seymour, David Shupe, Anthony Smith, Jason Stevens, Veronica Strazzullo, Myrto Symeonidis, Markos Trichas, Katherine Tugwell, Mattia Vaccari, Elisabetta Valiante, Ivan Valtchanov, Joaquin Vieira, Laurent Vigroux, Lingyu Wang, Rupert Ward, Don Wiebe, Gillian Wright, Kevin Xu, Michael Zemcov

Faculty and Researchers PostDocs Students

UCL

Aim: Constraining Bolometric Luminosity



Normalised to have same FIR Luminosity

Clusters

Level1 0.11 deg^2

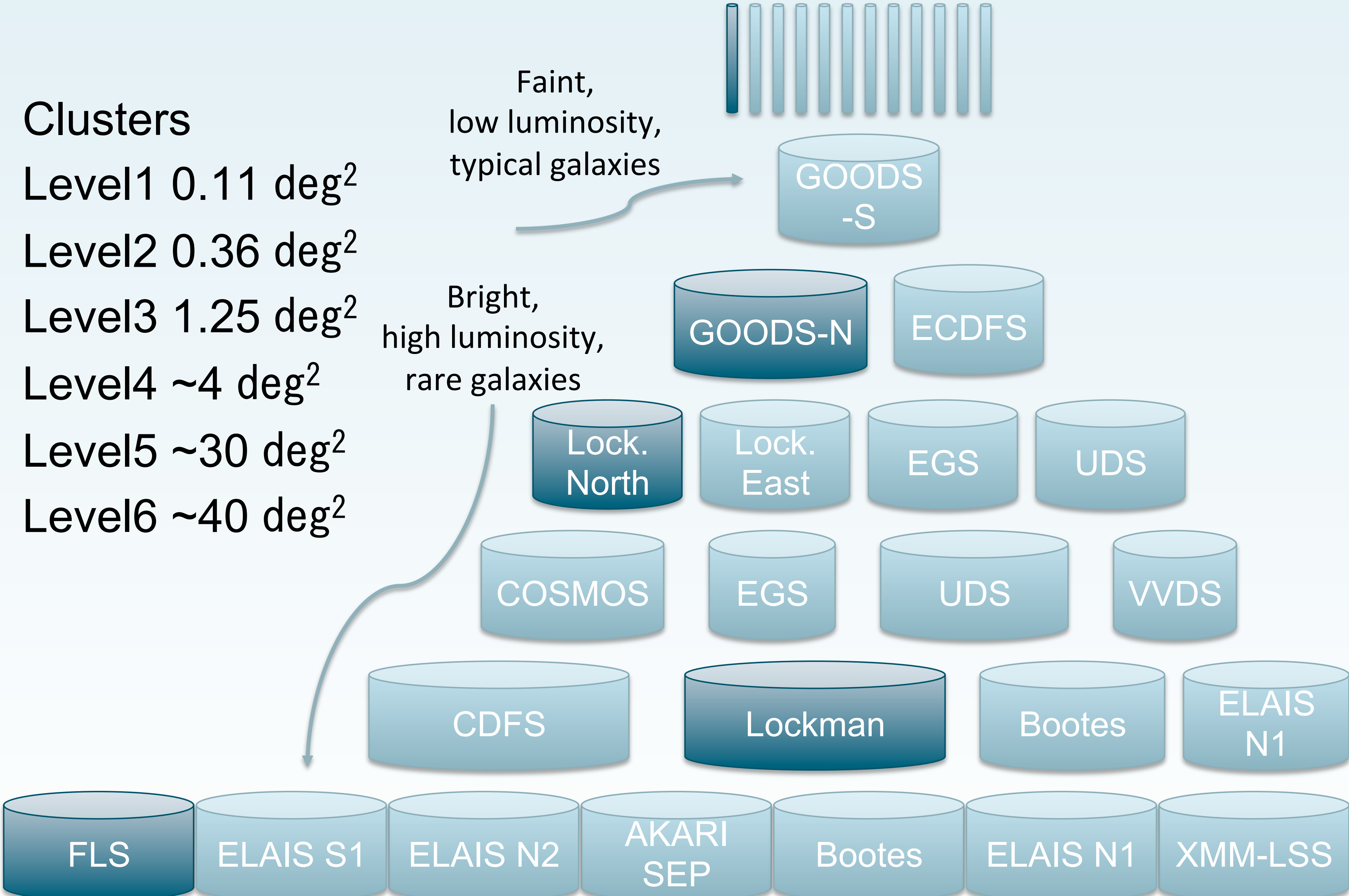
Level2 0.36 deg^2

Level3 1.25 deg^2

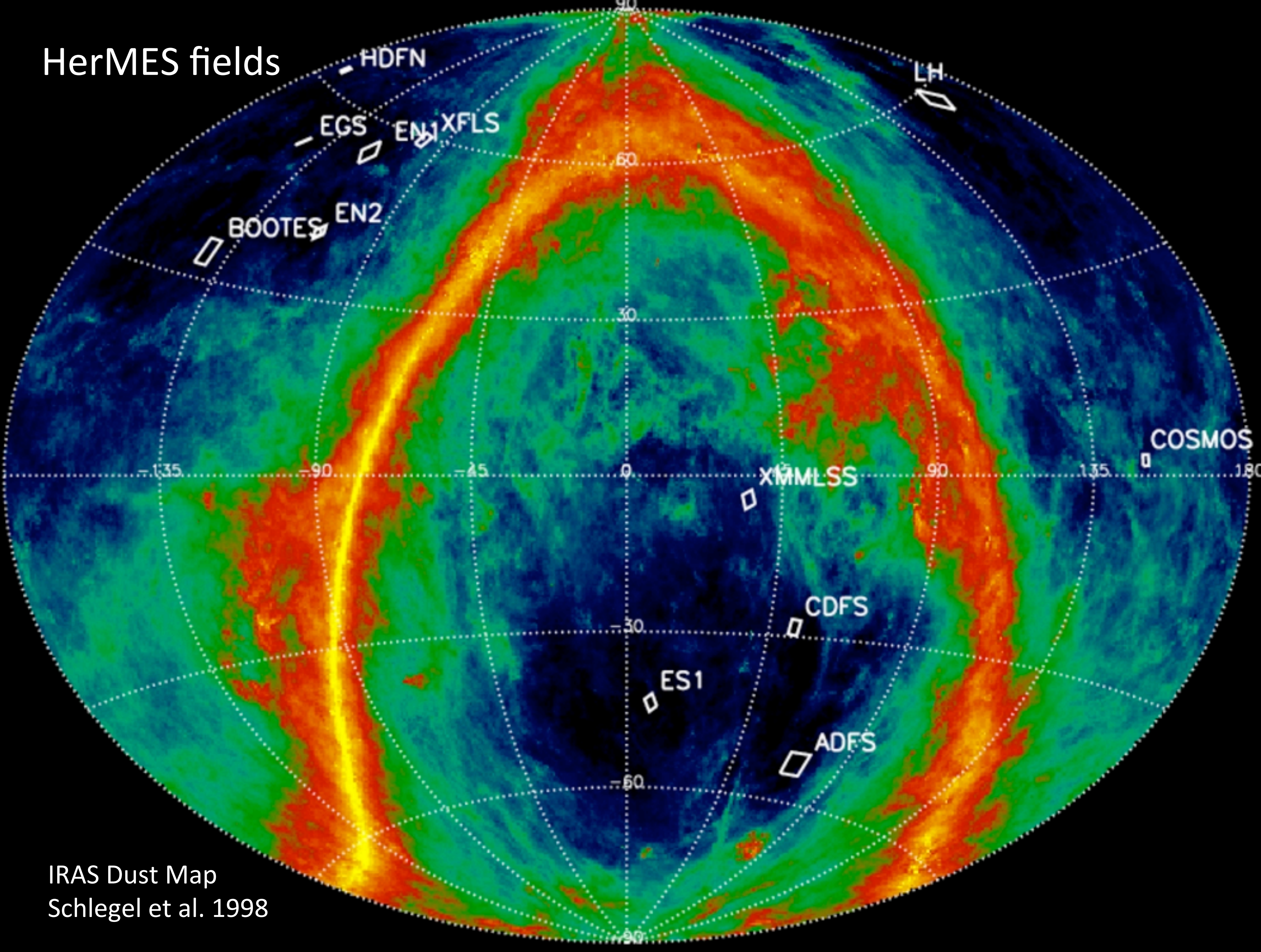
Level4 ~4 deg^2

Level5 ~30 deg^2

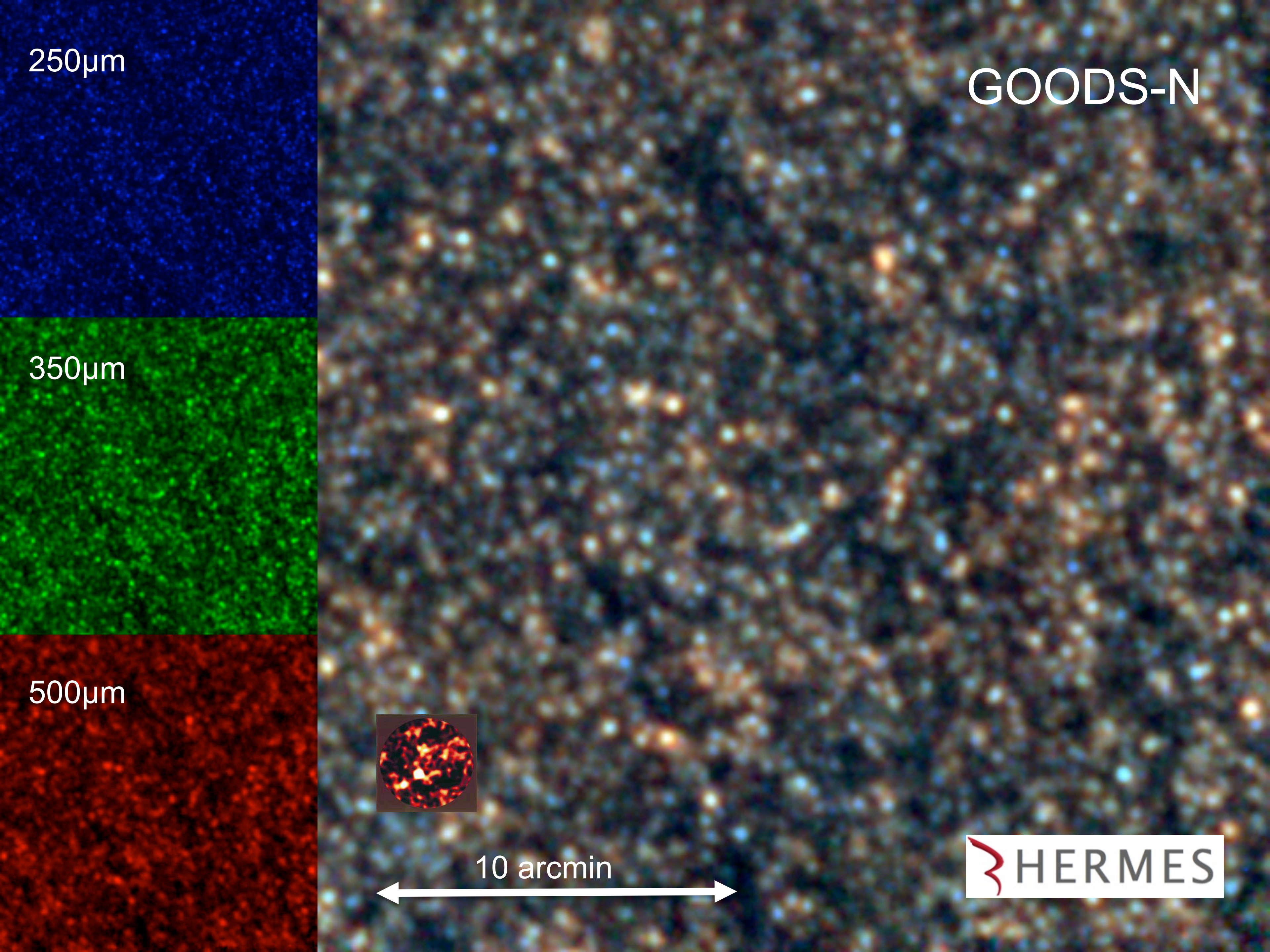
Level6 ~40 deg^2



HerMES fields



IRAS Dust Map
Schlegel et al. 1998


250μm
350μm
500μm
GOODS-N
10 arcmin
HERMES

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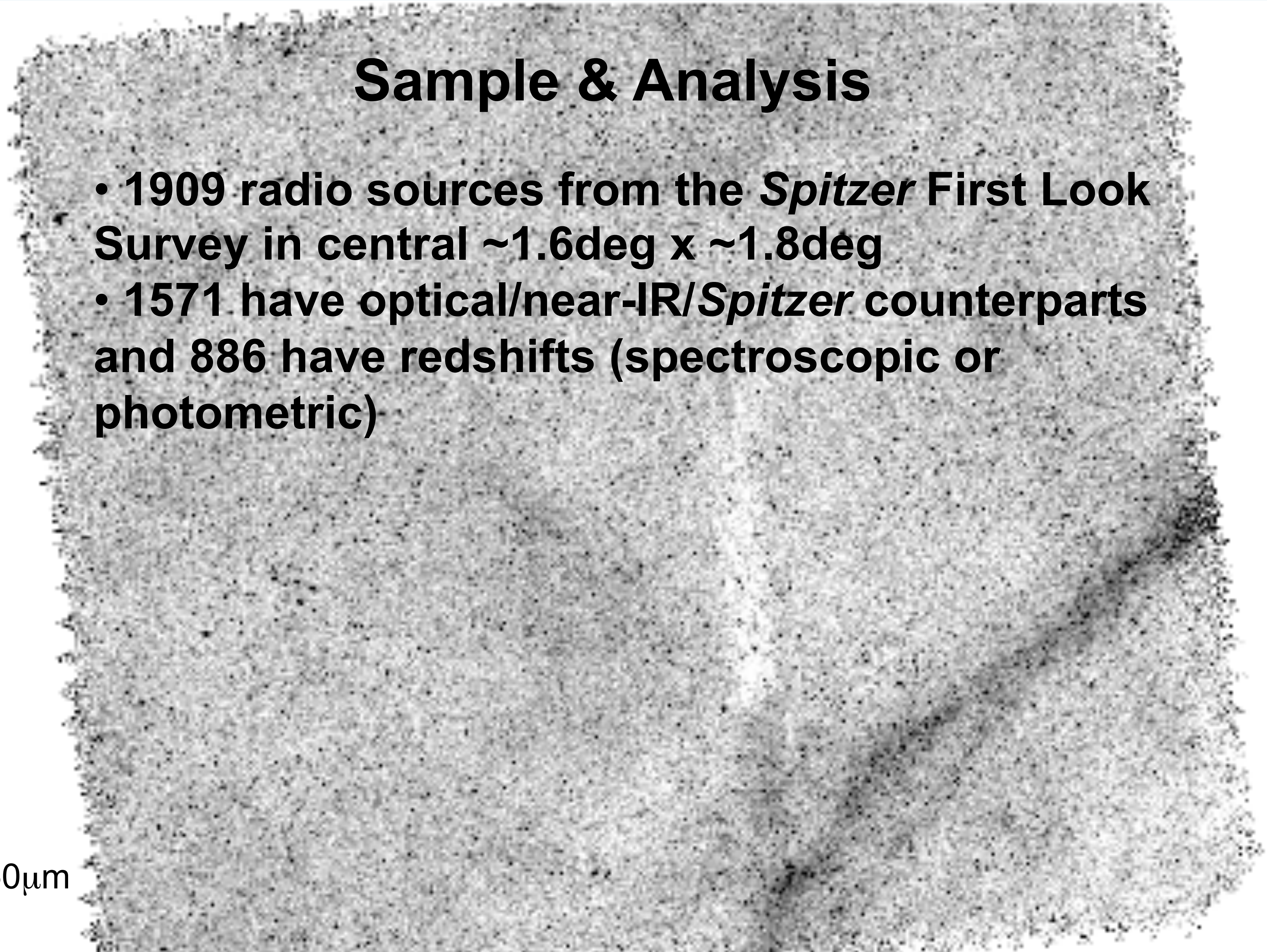
Spitzer First Look Survey Field

Sample & Analysis

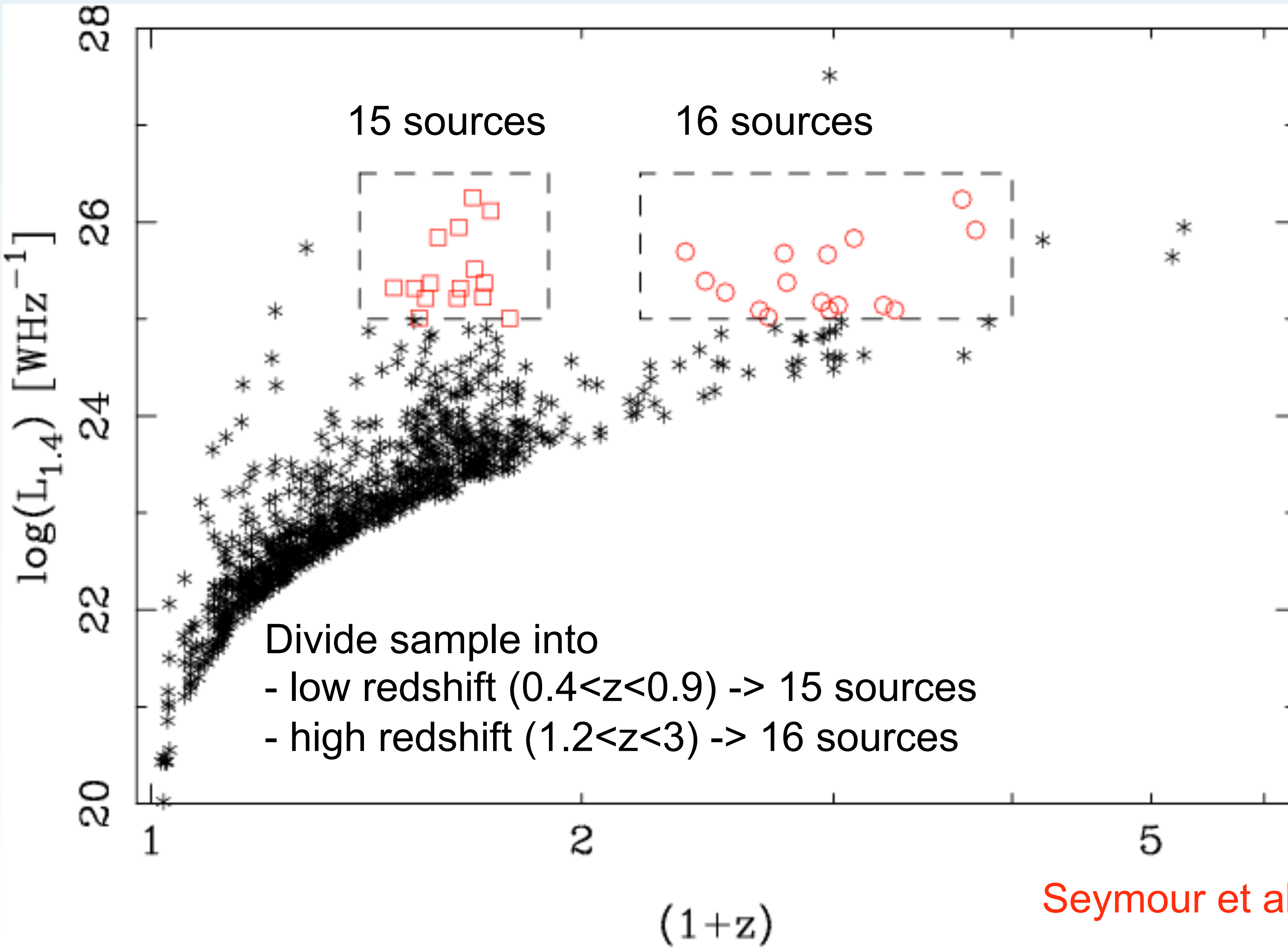
- **1909 radio sources from the *Spitzer* First Look Survey in central ~1.6deg x ~1.8deg**
- **1571 have optical/near-IR/*Spitzer* counterparts and 886 have redshifts (spectroscopic or photometric)**



250μm

The Latest Results from HerMES

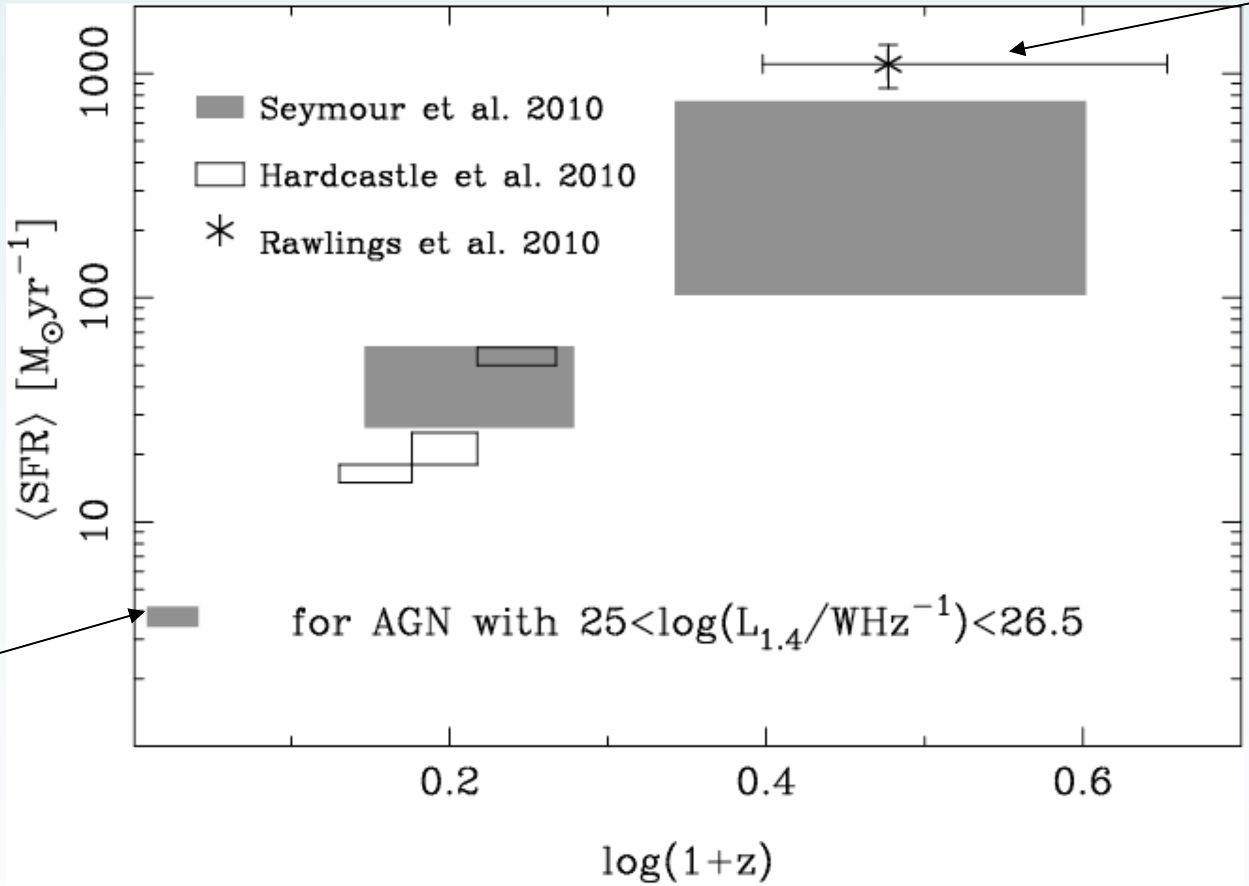
select radio-loud AGN: $L_{1.4GHz} > 10^{25}$ WHz^{-1} from the FLS field



Seymour et al. 2010

Mean Star Formation Rate

From PAHs



Local 3CRR sources

We observe an increasing mean SFR with redshift for radio-loud AGN.

from Seymour et al. 2010

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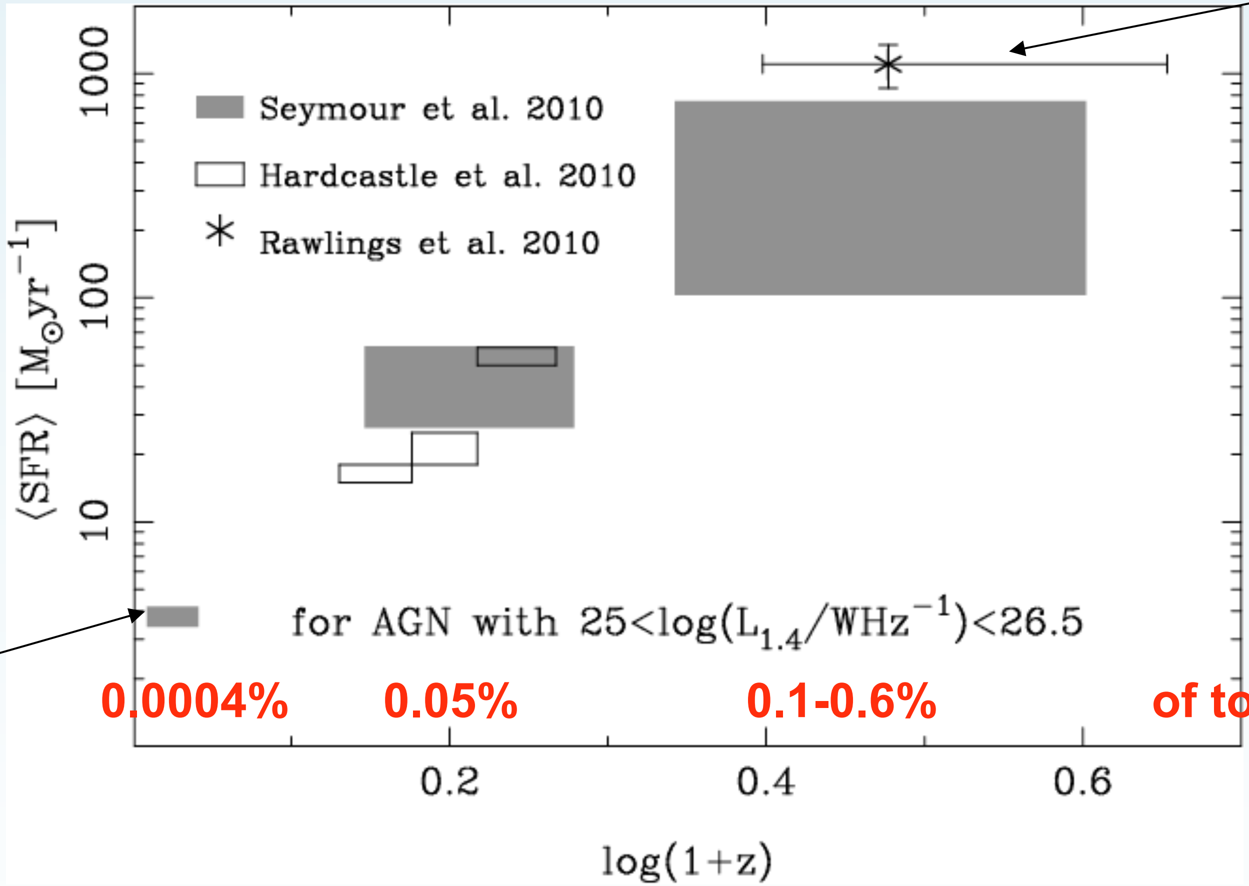

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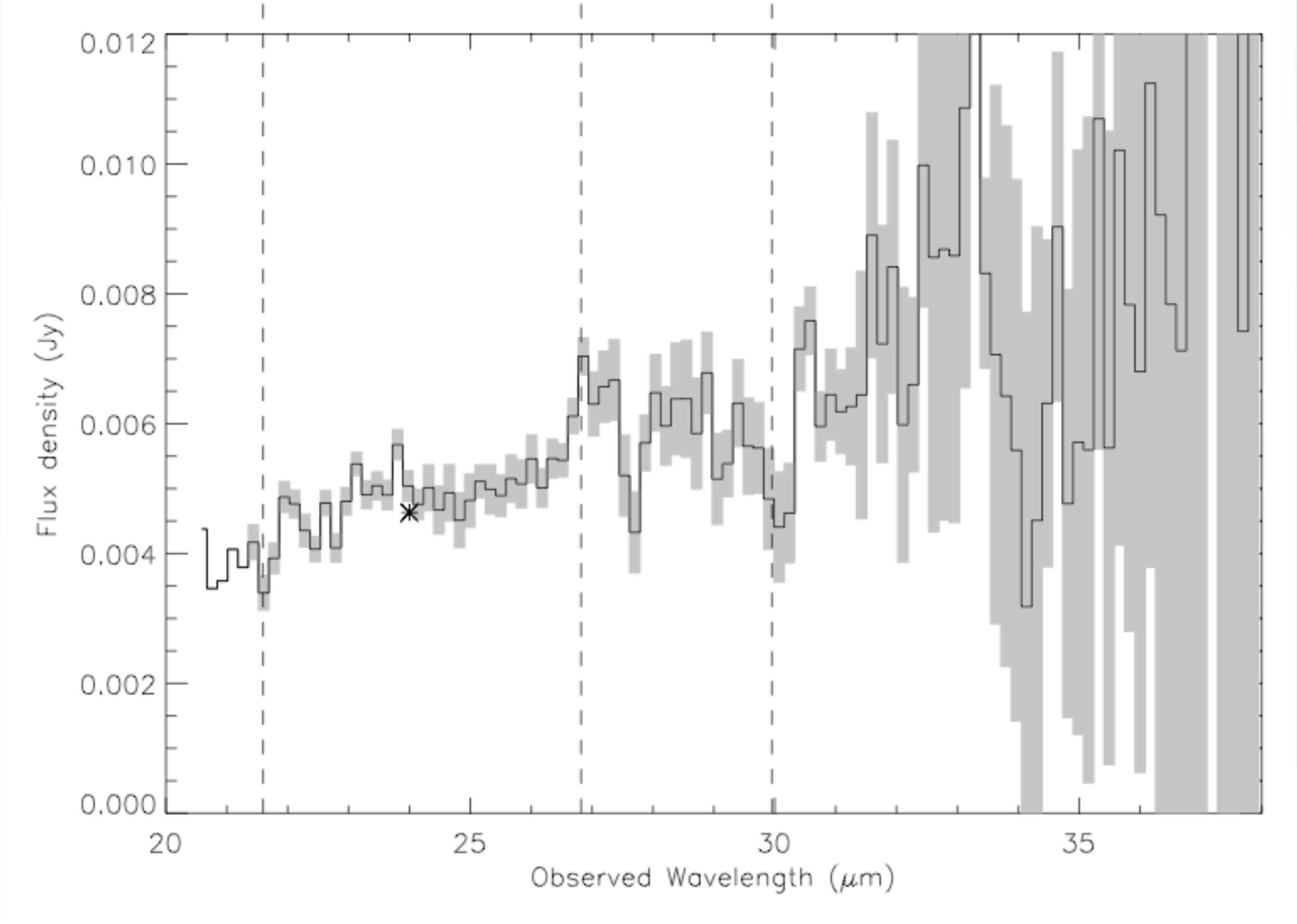
- SFR in high luminosity radio galaxies:
  - mid-IR spectroscopy
  - far-IR photometry

Mid-infrared Spectroscopy of HzRGs

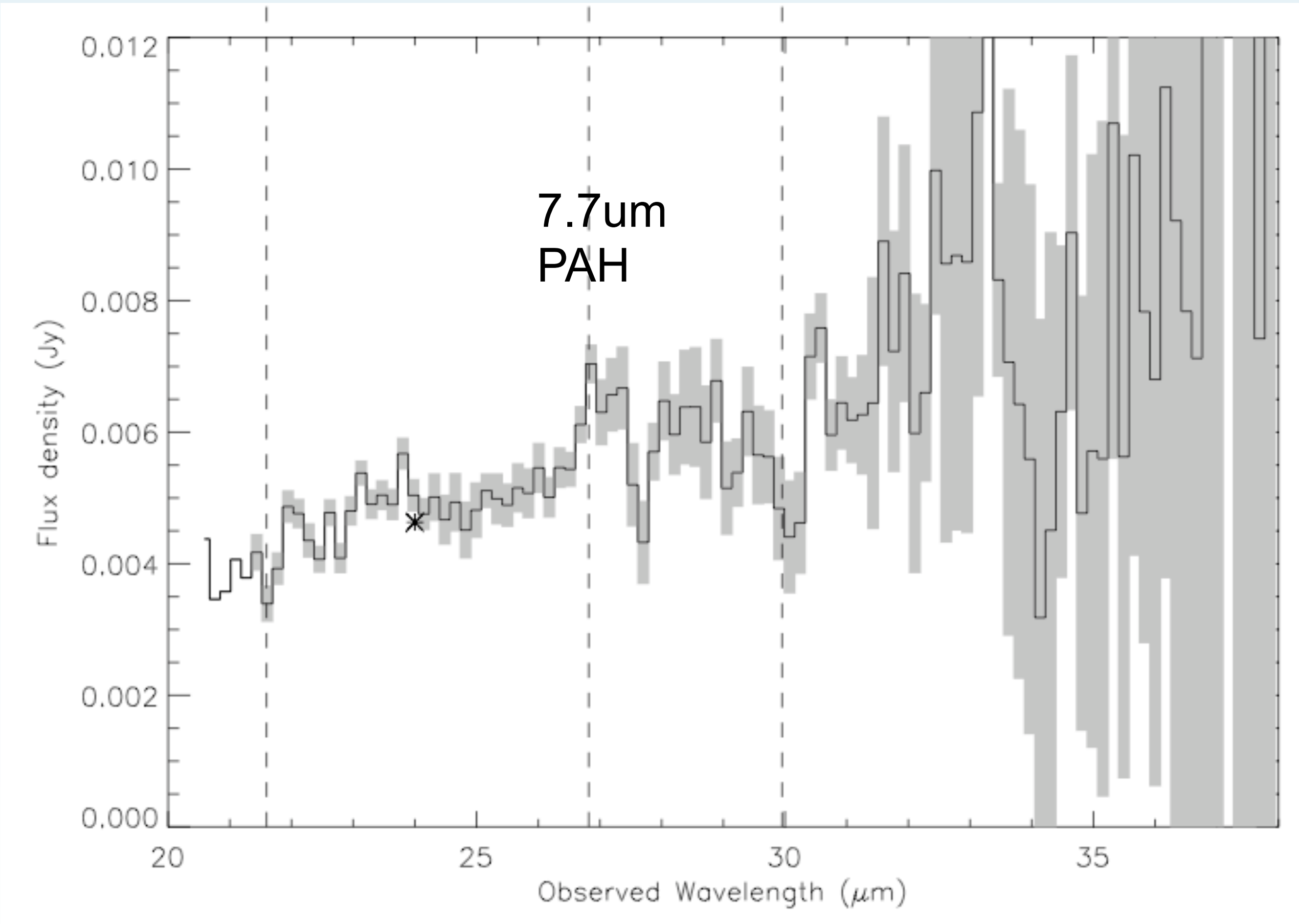


Sample of 9 HzRG (from SHzRG) across 1.5<z<3.6

4C23.56
z=2.48

Rawlings, Seymour et al. 2011

Mid-infrared Spectroscopy of HzRGs



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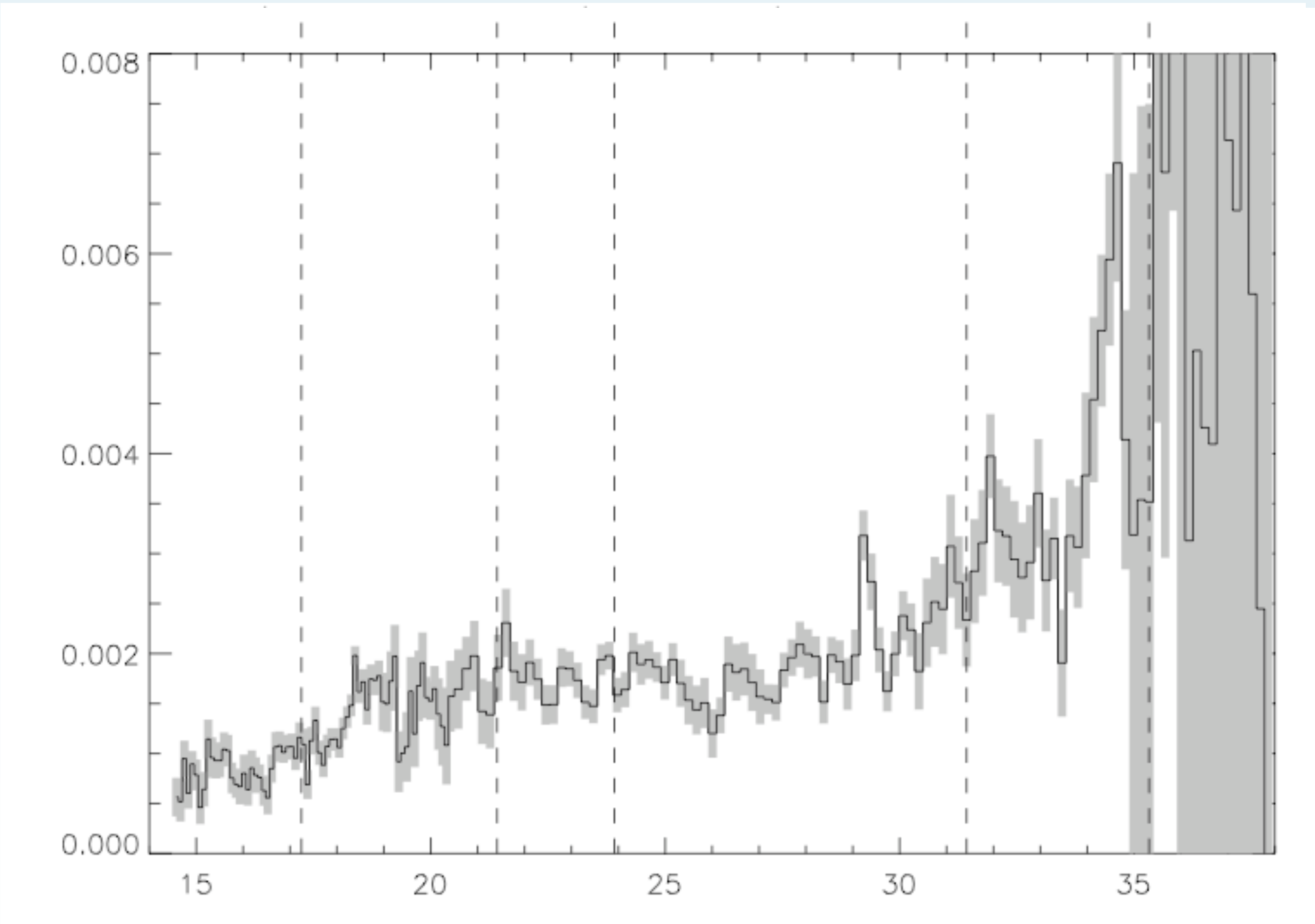

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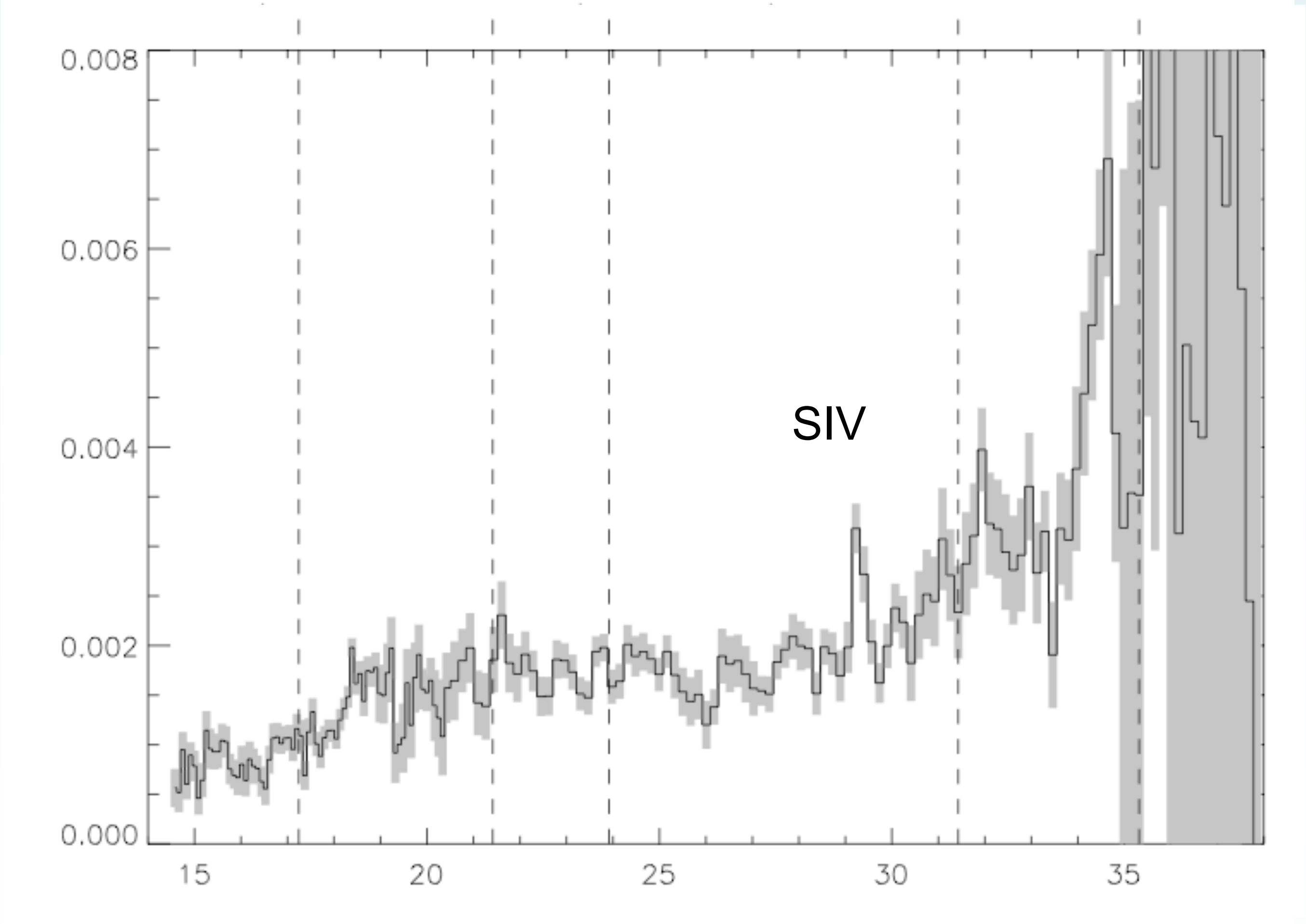
3C239
z=1.78

Rawlings, Seymour et al. 2011

Mid-infrared Spectroscopy of HzRGs



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Rawlings, Seymour et al. 2011

HERschel Radio Galaxy Evolution Project: `Projet HeRGÉ'

- Follow-up to SHzRG to constrain full IR SED and measure SFR.
- Sample of 71 sources with 62 new observations.
- PACS and SPIRE observations to cover the peak of the IR emission
- Combine with the *Spitzer* IRAC and MIPS data to separate the AGN and SFG dust components

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- Observations to date:

PACS:

TN J2007-1316
MRC 2025-218
MRC 2048-272

SPIRE:

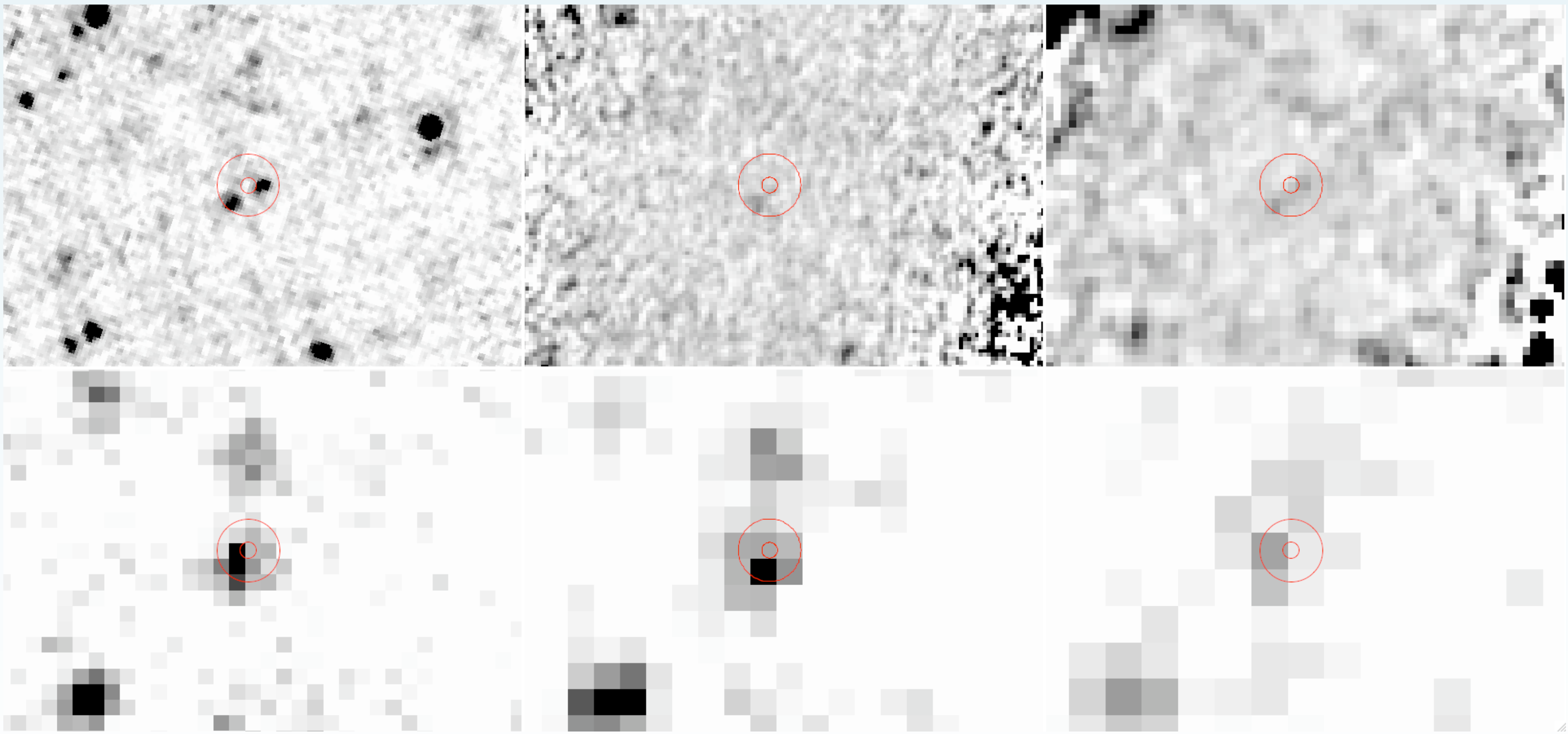
MRC 0251-273
MRC 0316-257
MRC 2048-272
MRC 2104-242
TX J1908+7220
MG 2144+1928
USS 2202+128
WN J1911+6342

Plus most GT data have been taken

HERschel Radio Galaxy Evolution Project: \`Projet HeRGÉ'

MRC2048-272 z=2.06

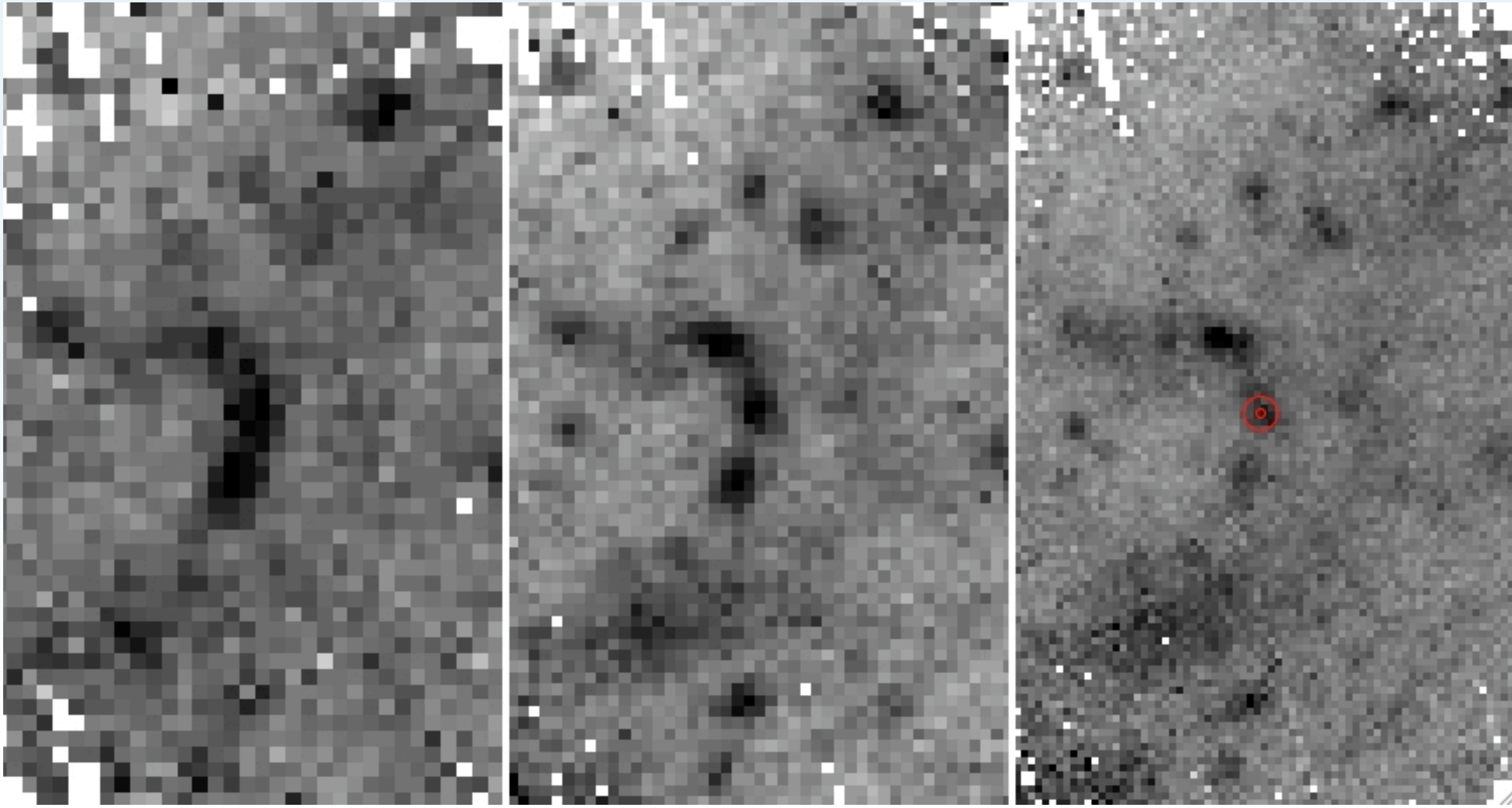
Spitzer/MIPS 24μm *Herschel*/PACS 110μm *Herschel*/PACS 170μm



Herschel/SPIRE 250μm *Herschel*/SPIRE350μm *Herschel*/SPIRE 250μm

HERschel Radio Galaxy Evolution Project: `Projet HeRGÉ'

TNJ1908+7220 z=3.53



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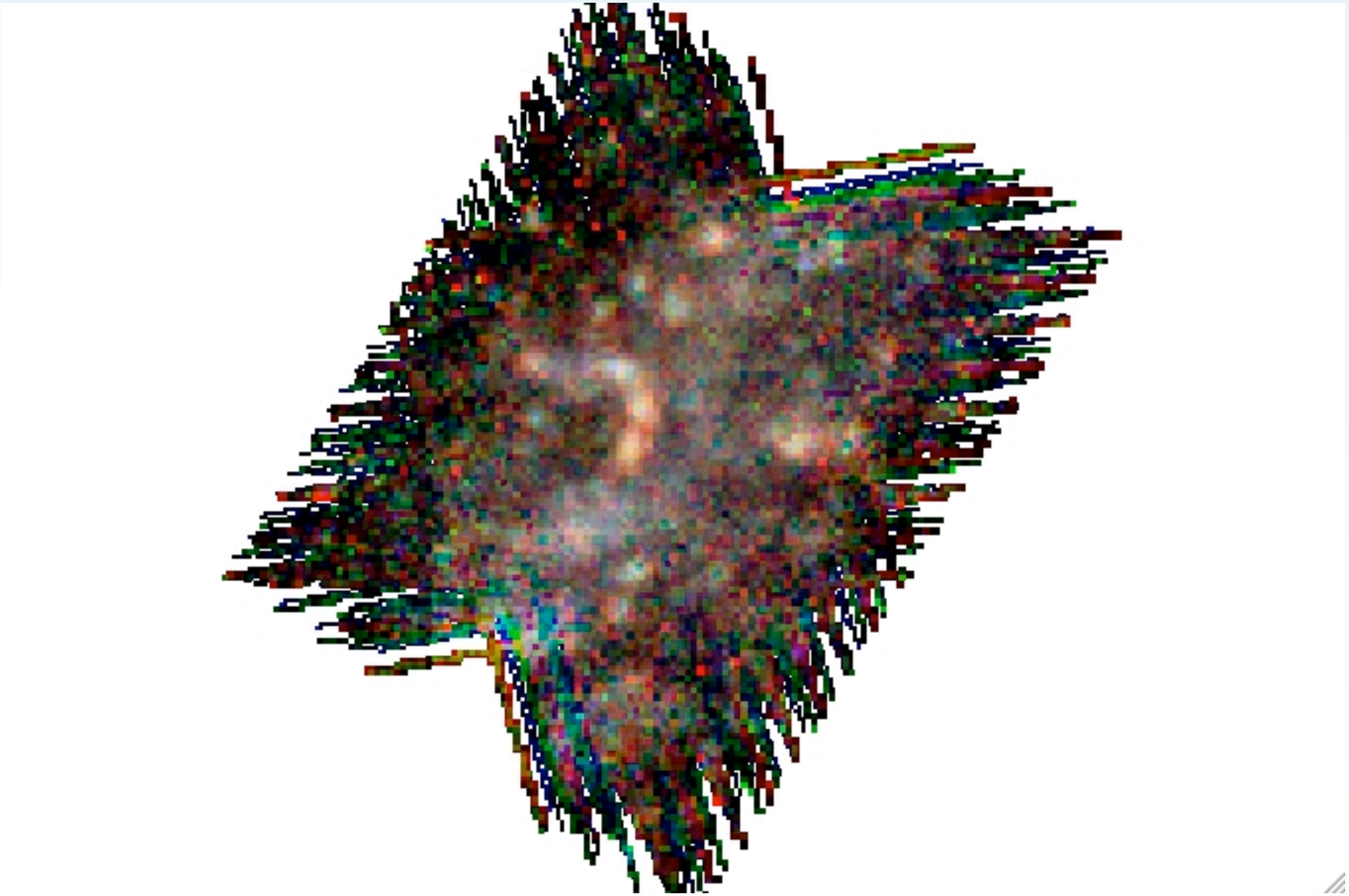

Conclusions

- Moderate radio-loud AGN have high star formation rates similar to the classical high redshift radio galaxies.
- Evidence for mid-IR spectroscopy that many powerful radio-loud AGN are displaying rapid coeval central black hole and galaxy growth.
- Herschel observations of high-z radio galaxies will trace this growth as a function of redshift, stellar mass, accretion rate, radio lobe properties
- SPIRE data covers 5arcminute area permitting environmental studies. This area can be increased by ~50% using ‘turn-around’ data.
- SKA patherfinders will find all HzRGs