ASTROPHYSICAL
TERAHERTZ
LARGE
AREA
SURVEY

SALT Spectra of Gravitationally Lensed Herschel Systems

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University of South Africa

in collaboration with the H-ATLAS team

and SALT Partner Members!!

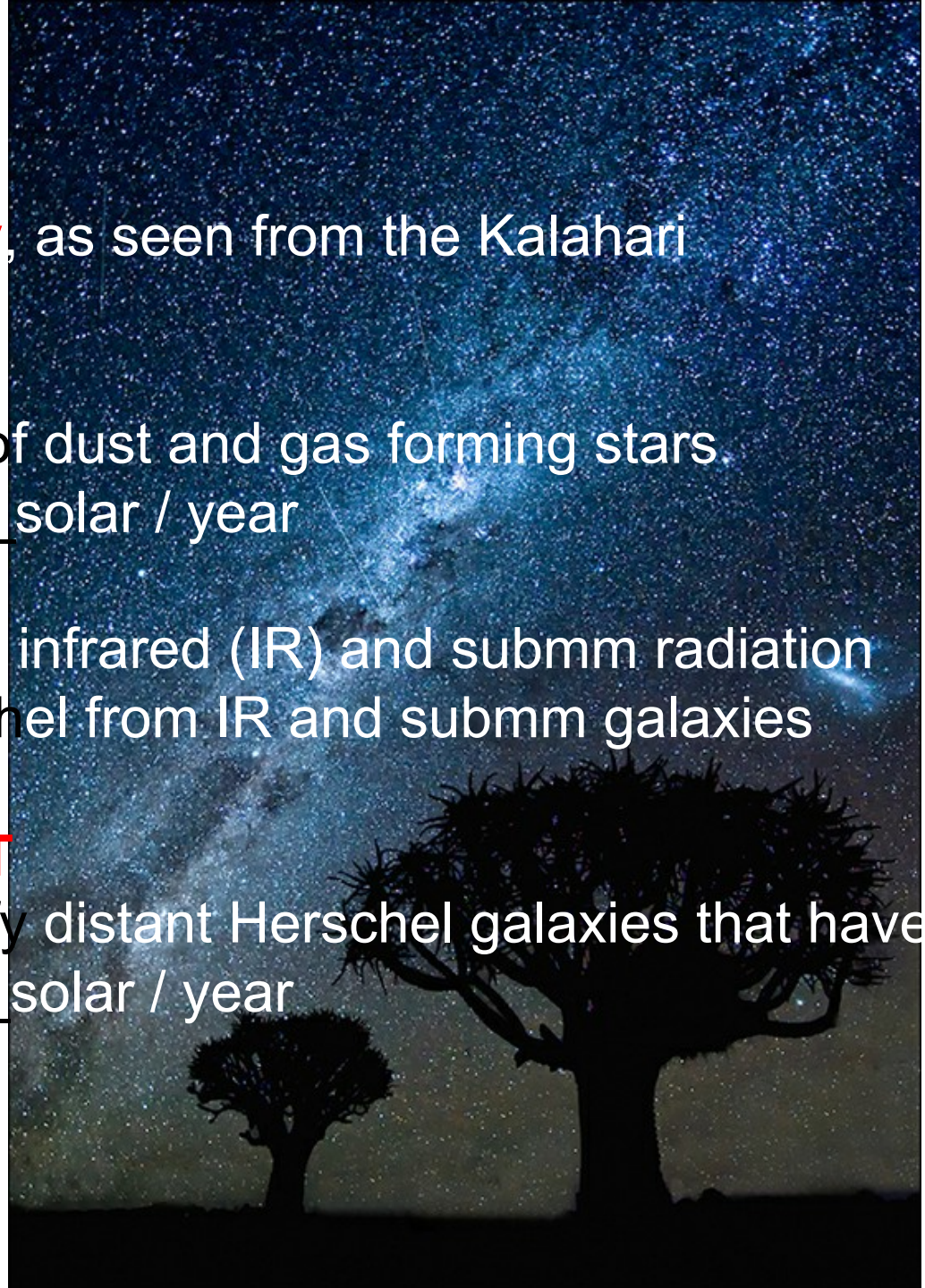
(http://www.h-atlas.org/)

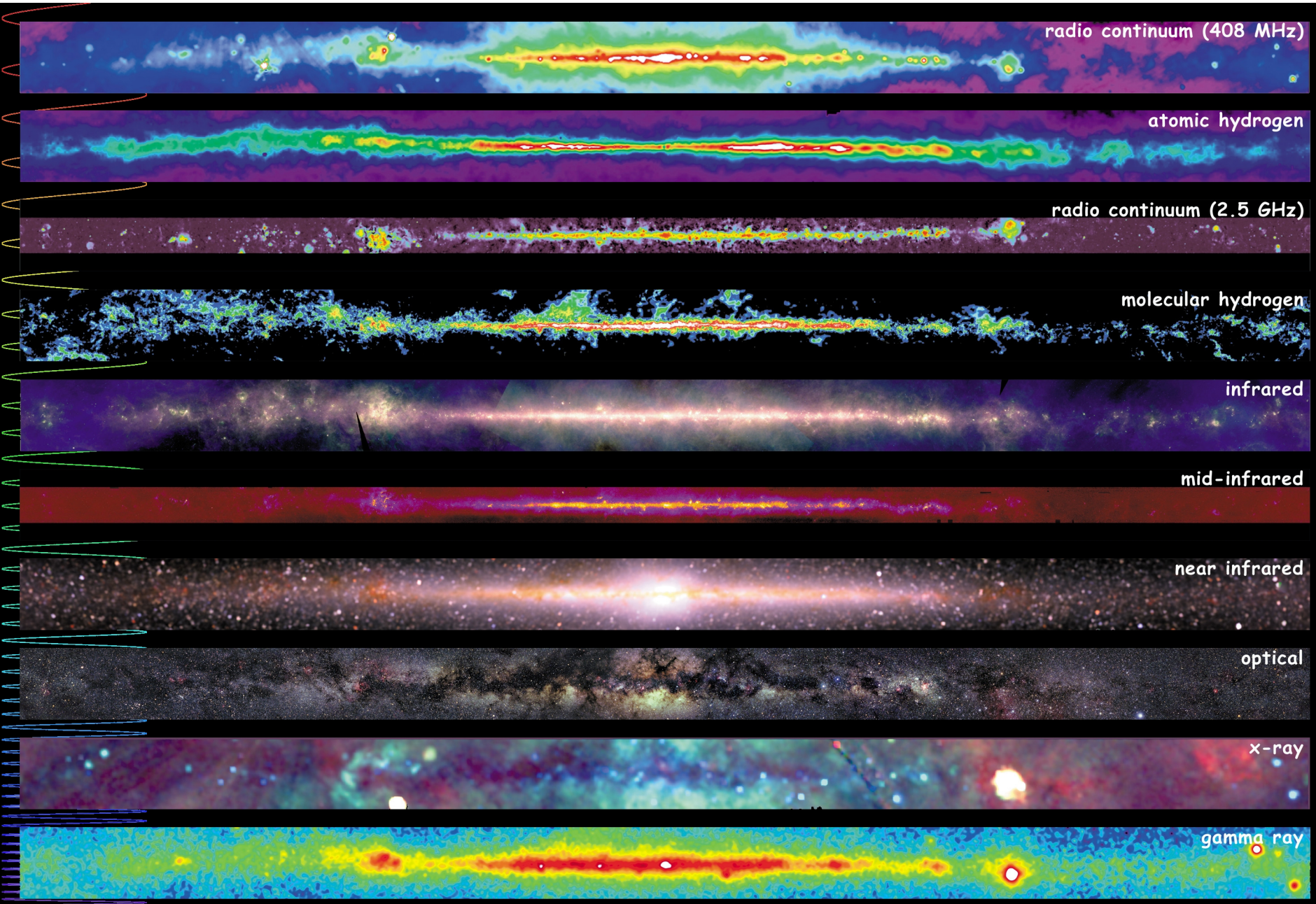
***Molagodimo*, the Milky Way**, as seen from the Kalahari in the optical.

Dark patches of dust and gas forming stars.
At 0.5 to 10 M_solar / year

The dust emits infrared (IR) and submm radiation seen by Herschel from IR and submm galaxies

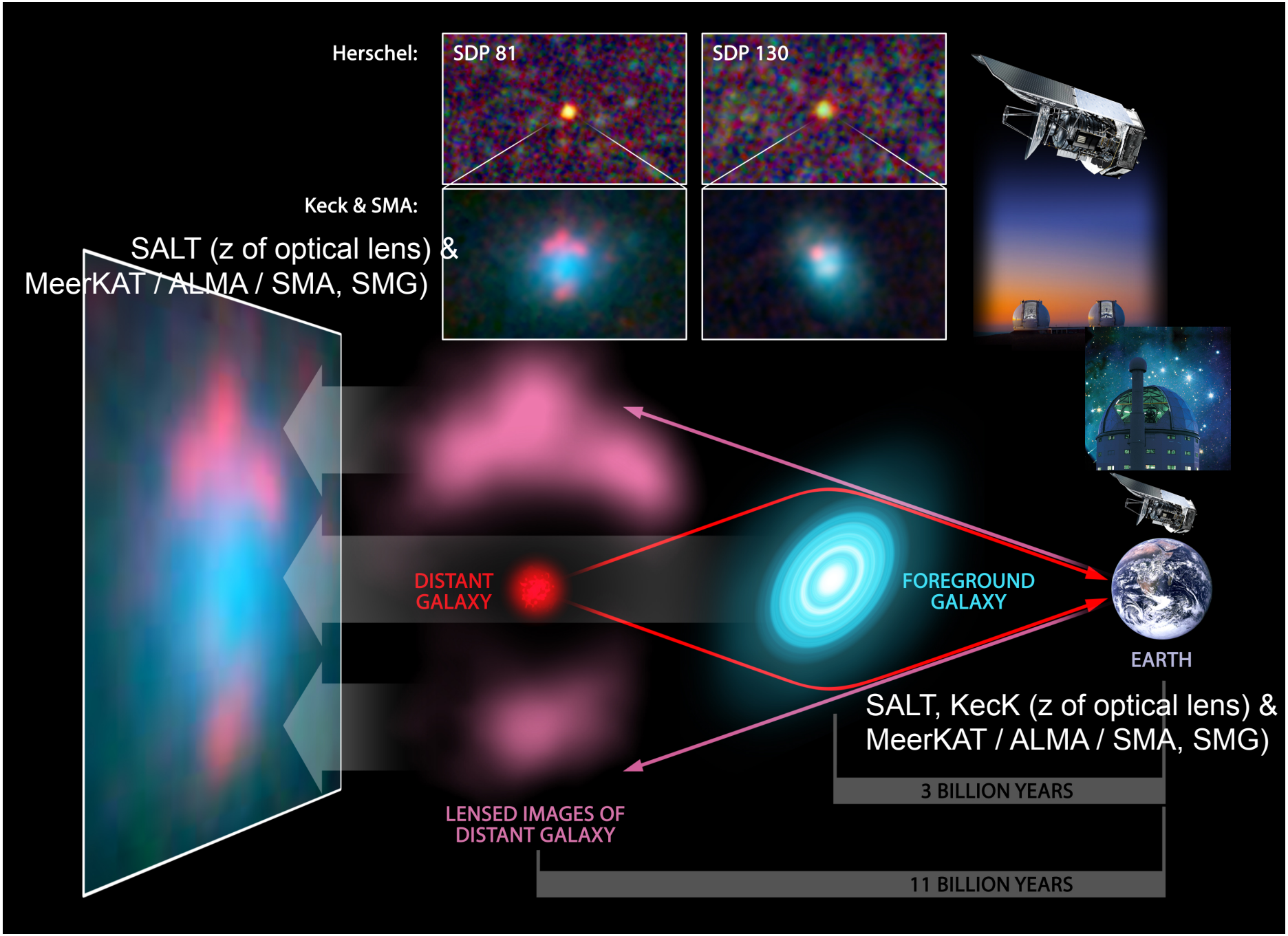
Optical / SALT
Lenses magnify distant Herschel galaxies that have upto ~1000 M_solar / year



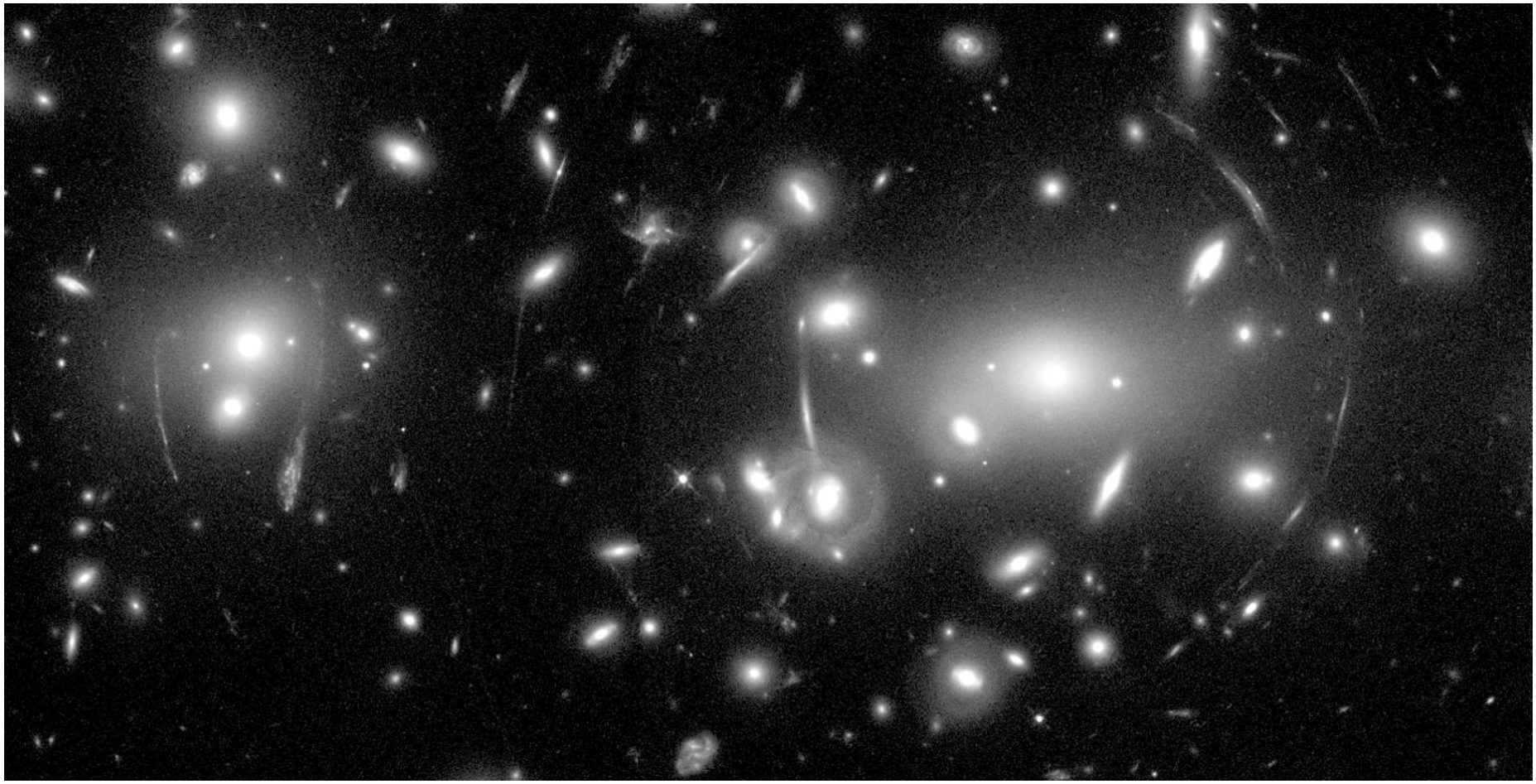


Multiwavelength Milky Way

http://adc.gsfc.nasa.gov/mw



CREDITS: ESA/NASA/JPL---Caltech/Keck/SMA



Hubble Space Telescope Image of Abell 2218

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The Hershel Space Observatory

The Hershel-ATLAS

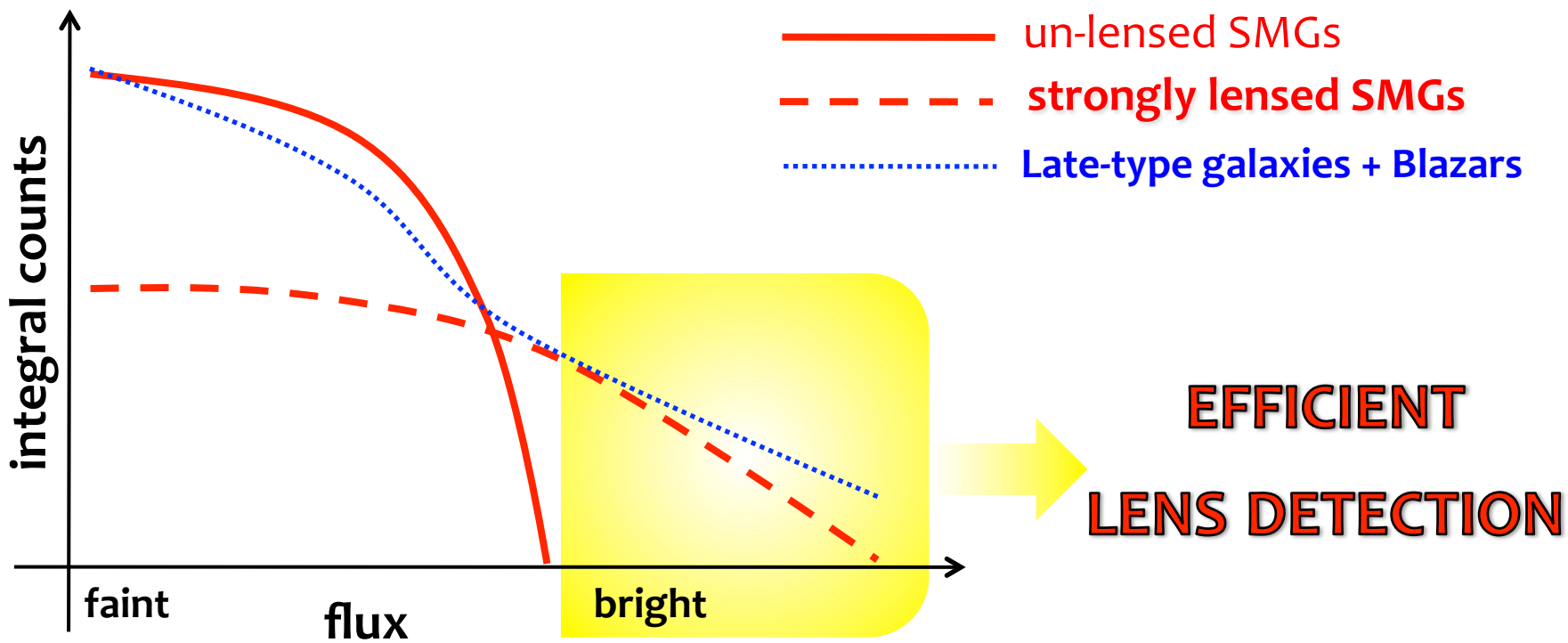
- Largest Open Time Key Project on Herschel (Eales et al. 2010)
- 600 hours for about 550 deg^2 in N, S, and Equatorial fields
- PACS+SPIRE: 110, 160, 250, 350, and 500μm
- ~9", ~13", ~20", ~30",and ~40' '
- Led by Steve Eales (Cardiff) & Loretta Dunne (Nottingham + NZ) + 150 co---ls

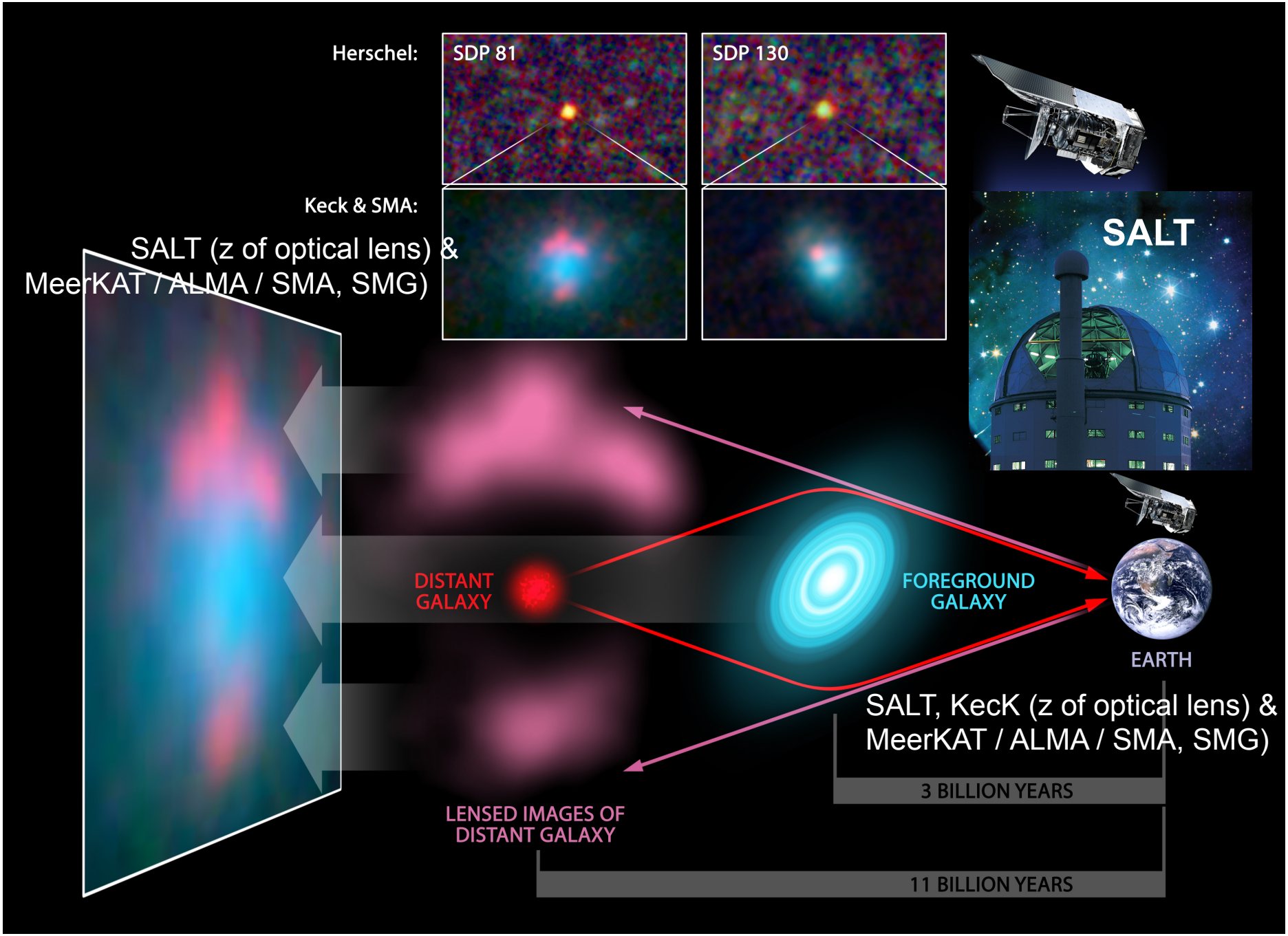
A LENSING SCIENCE CASE FOR H-ATLAS

Sub-mm surveys are ideal for finding lenses

*Blain (1996), Perrotta et al. (2003), Negrello et al. (2007, **2010**)*

- **high redshift** → **high efficiency for lensing**
  Chapman et al. (2005)
- **steep counts** → **strong *magnification bias***
  Coppin et al. (2006)





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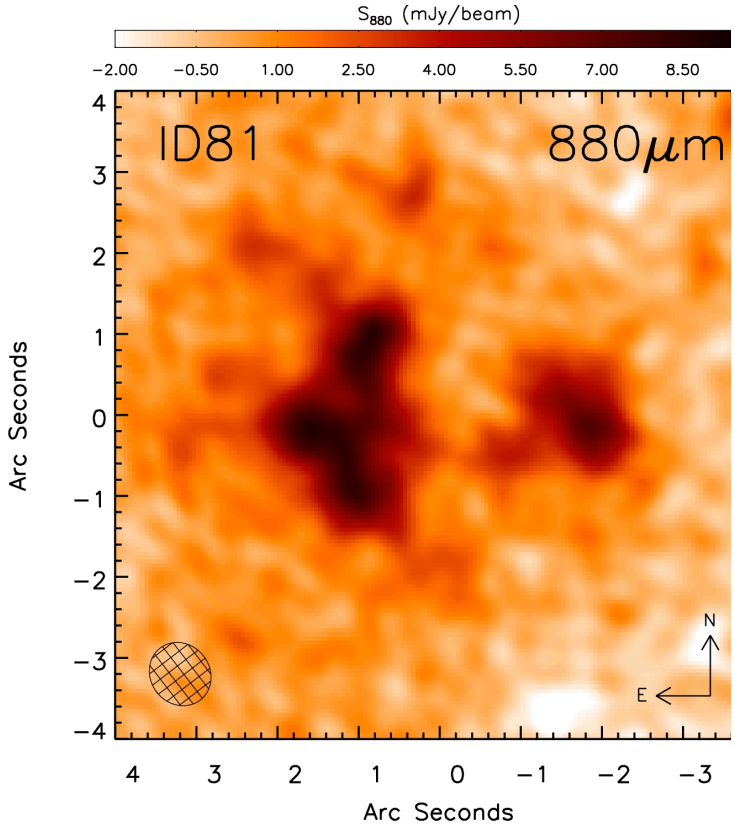
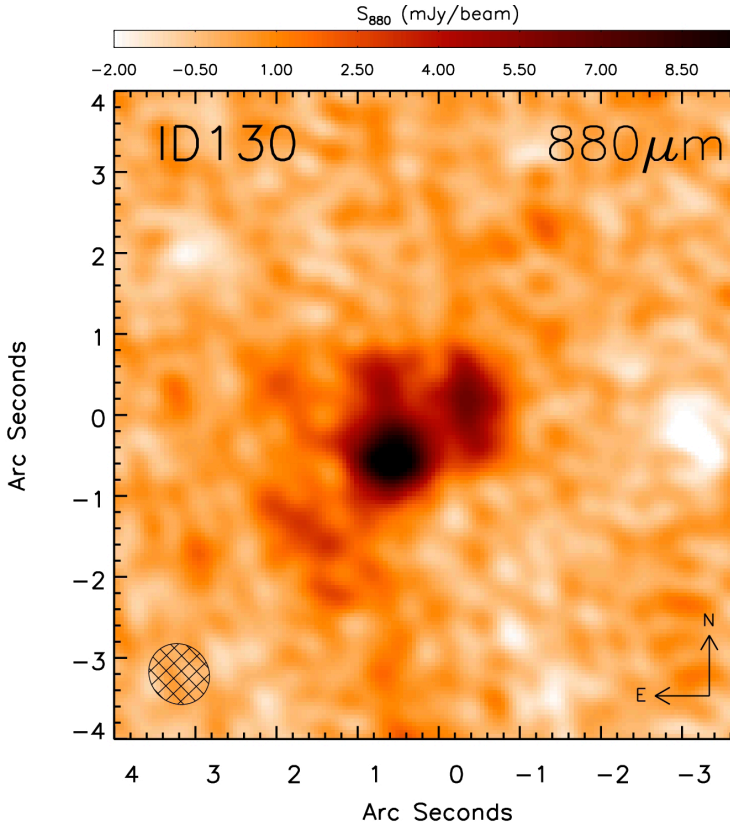
Evidence for Gravitational Lensing –

Multiple Peaks in High Resolution Submm Imaging with the **SMA, Negrello et al. 2010**

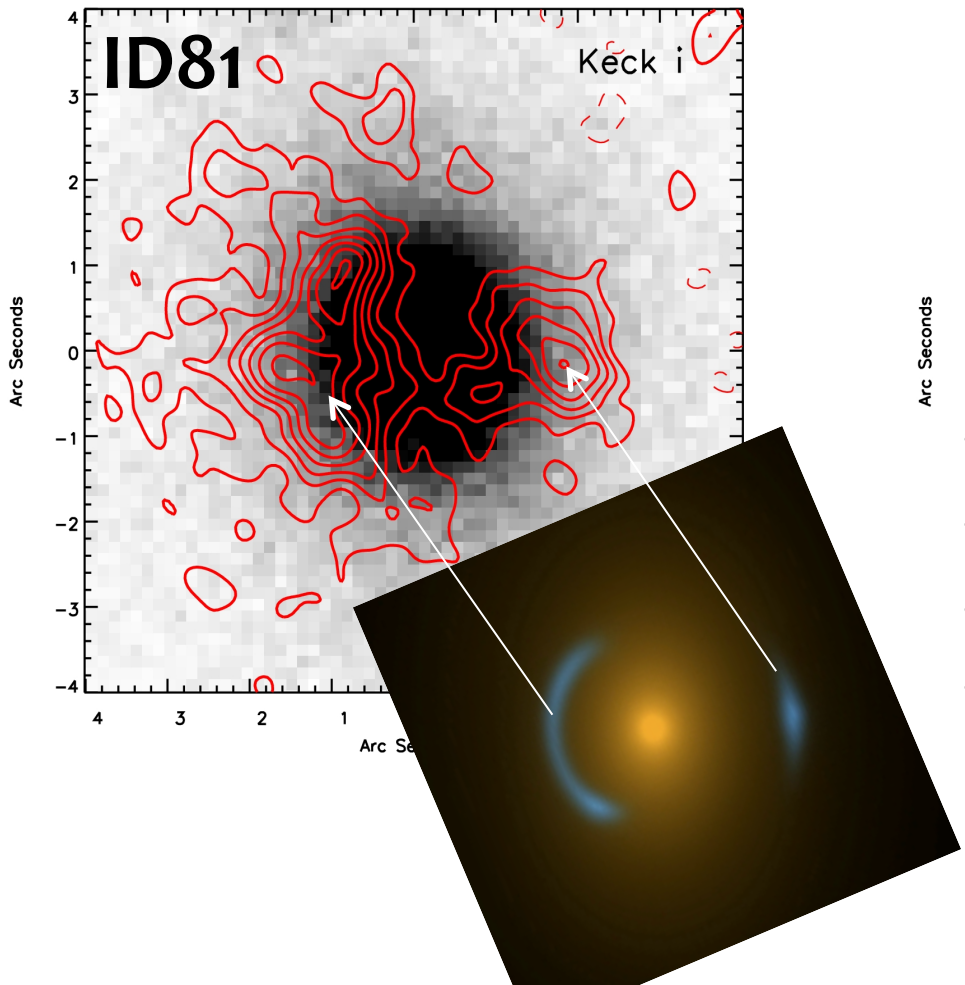


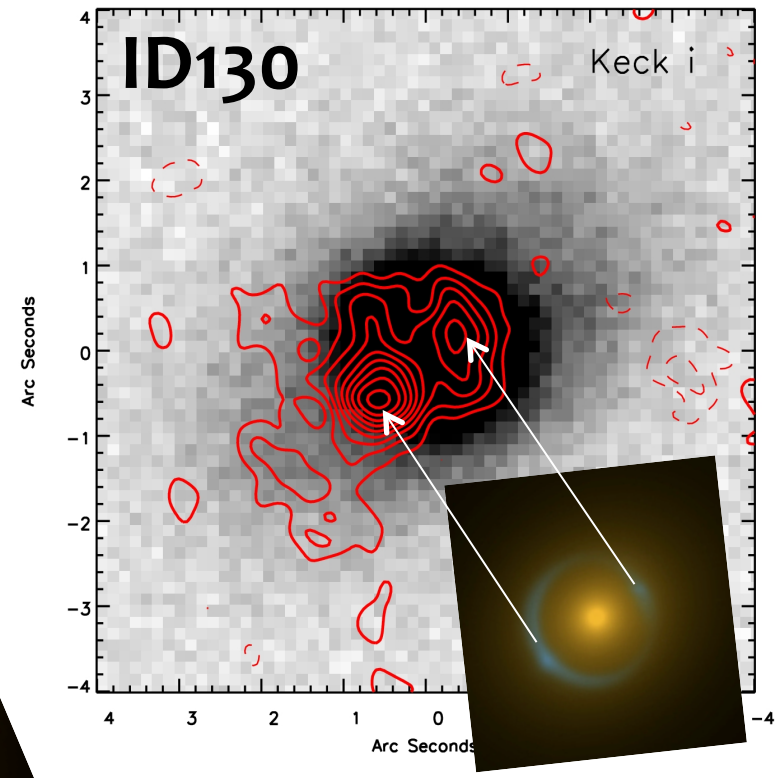


Gravitational Lens candidates ID81 – ID130

Sub **M**illimeter **A**rray follow-up at **870 μm**

(*very-extended*, *sub-compact* and *compact* configurations)





from http://www.slacs.org

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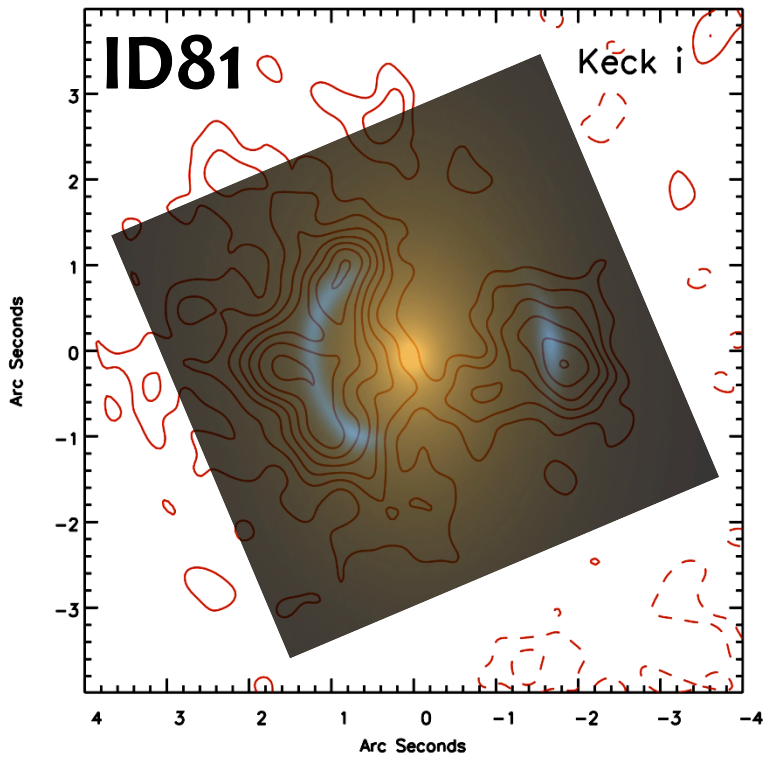
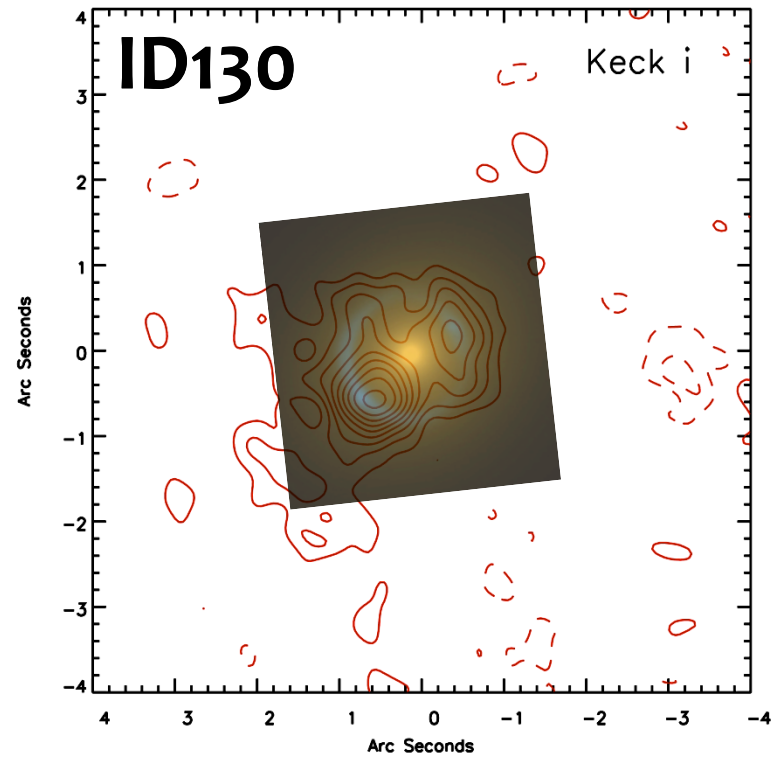
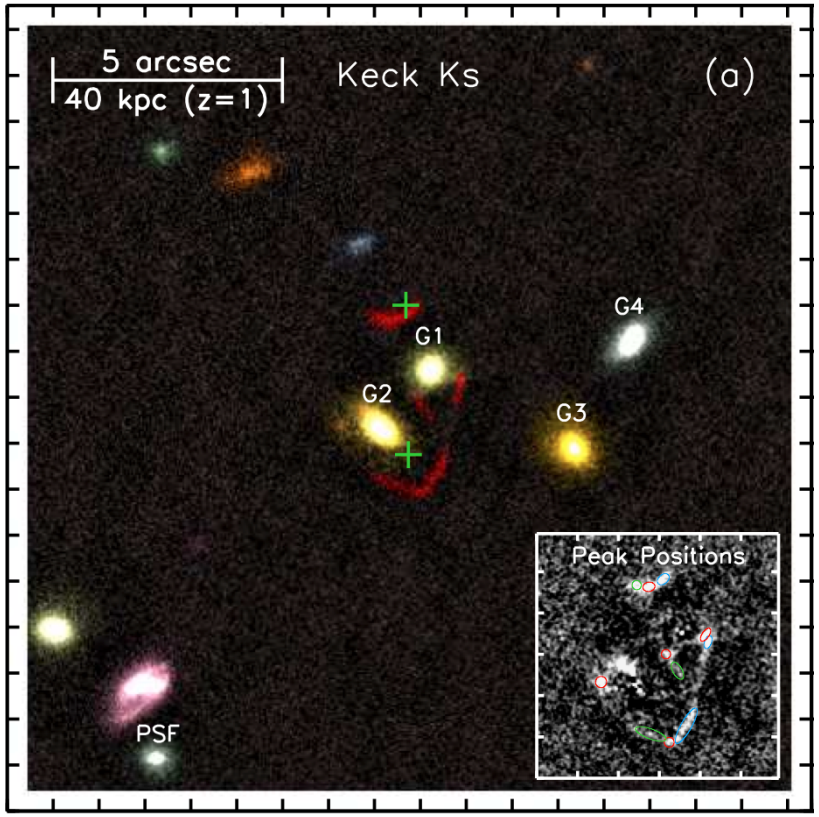
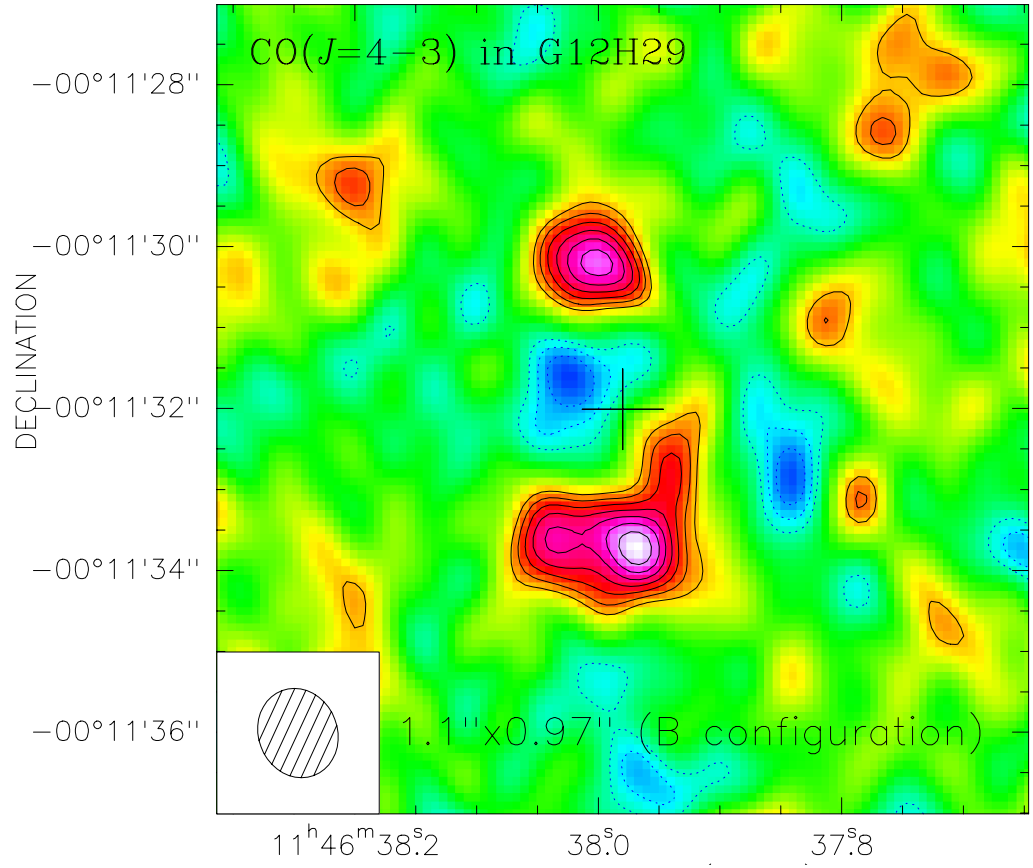




from http://www.slacs.org

KECK Imaging and CARMA CO Maps of H-ATLAS G12H29 (z=3.259), a possible proto-Galaxy also detected with Planck

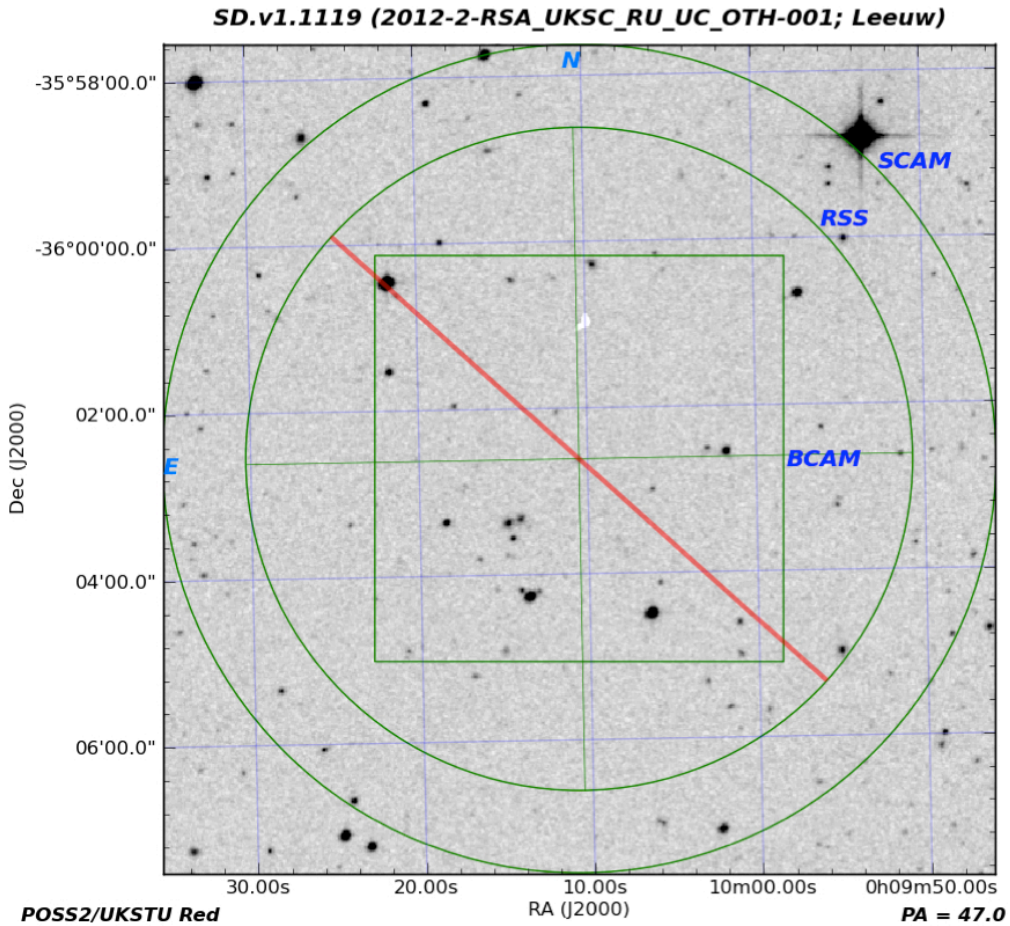




Left: Fu et al 2011. Right: Leeuw et al. in prep

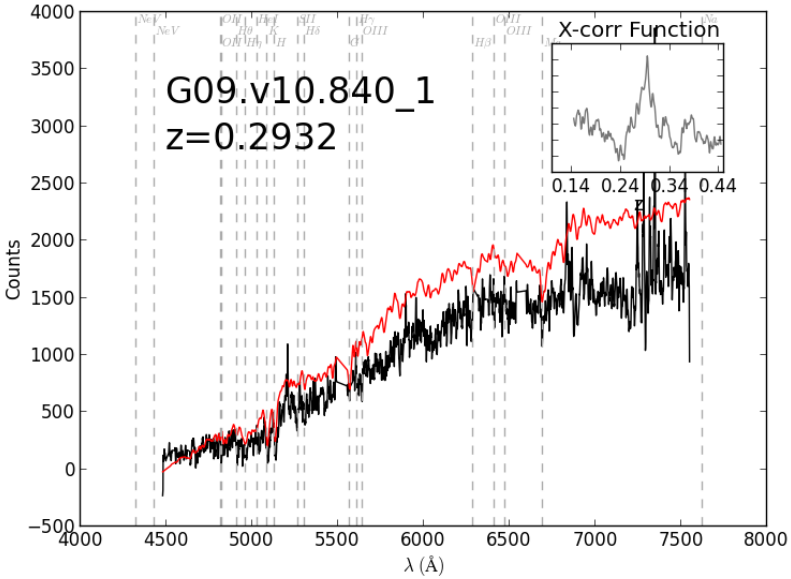
SALT: Lens Redshift + MeerKAT: Masers + Conti + >> z CO

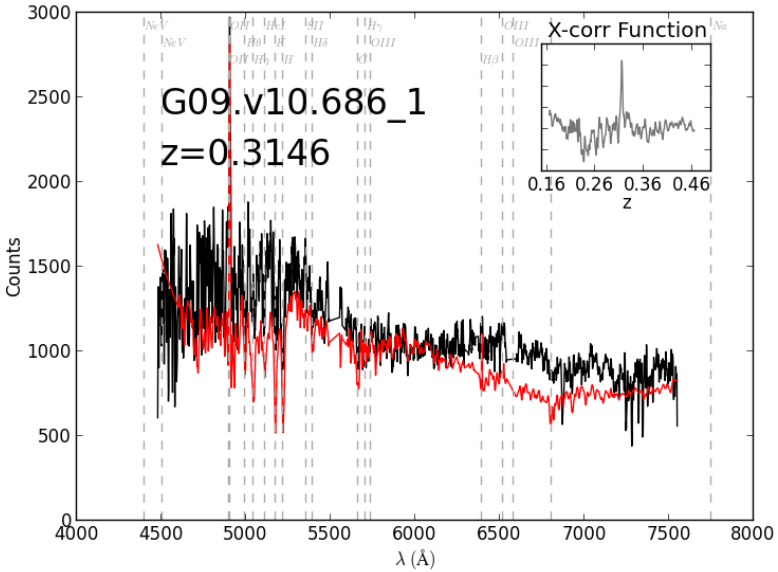
Typical SALT Finding Chart
HATLAS Lens SDv1.1119 (V~20) with z = 0.443



Leeuw, Crawford, H-ATLAS-team et al. SAIP 2013

SALT Detected Spectra and Determined Redshifts





Leeuw, Crawford, H-ATLAS-team et al. SAIP 2013

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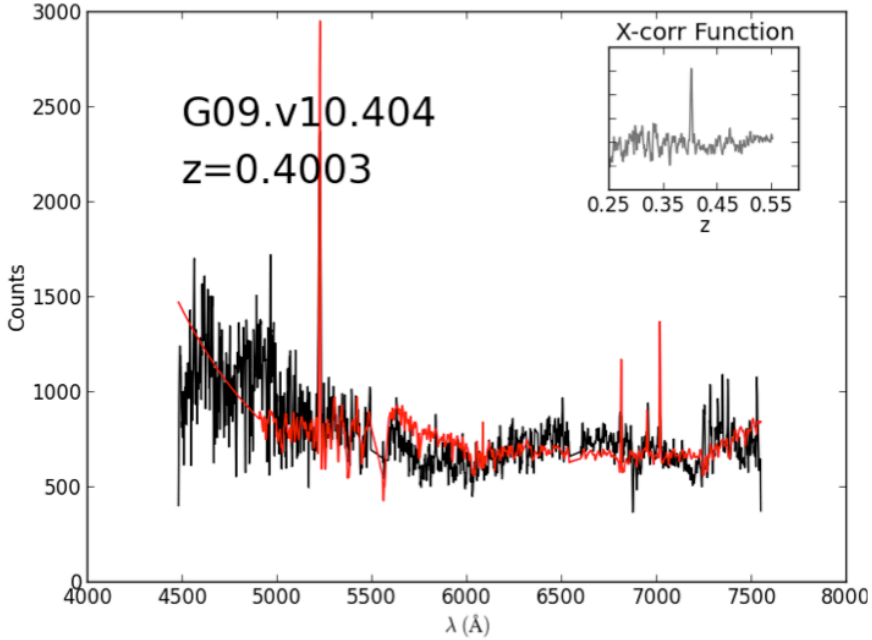

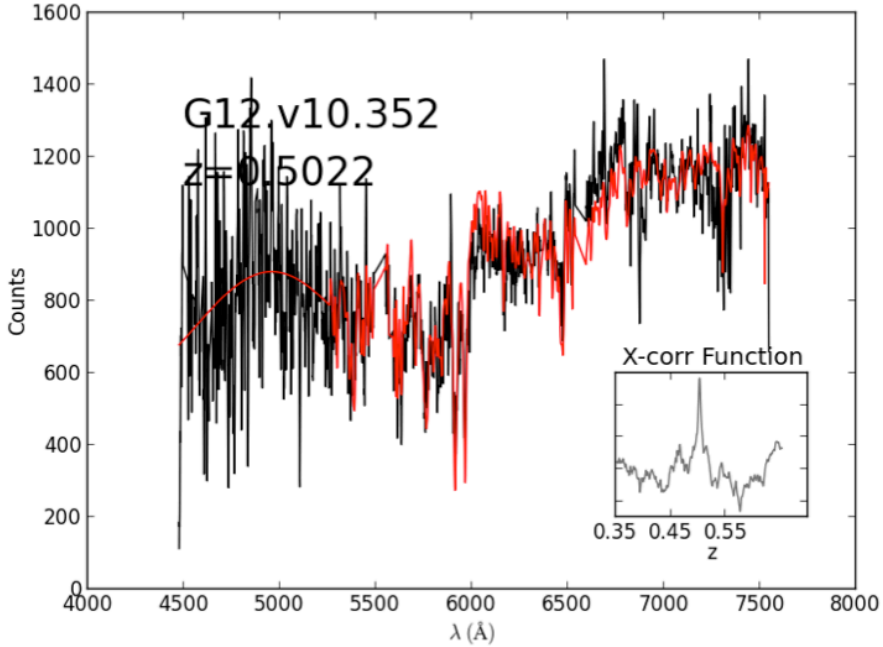

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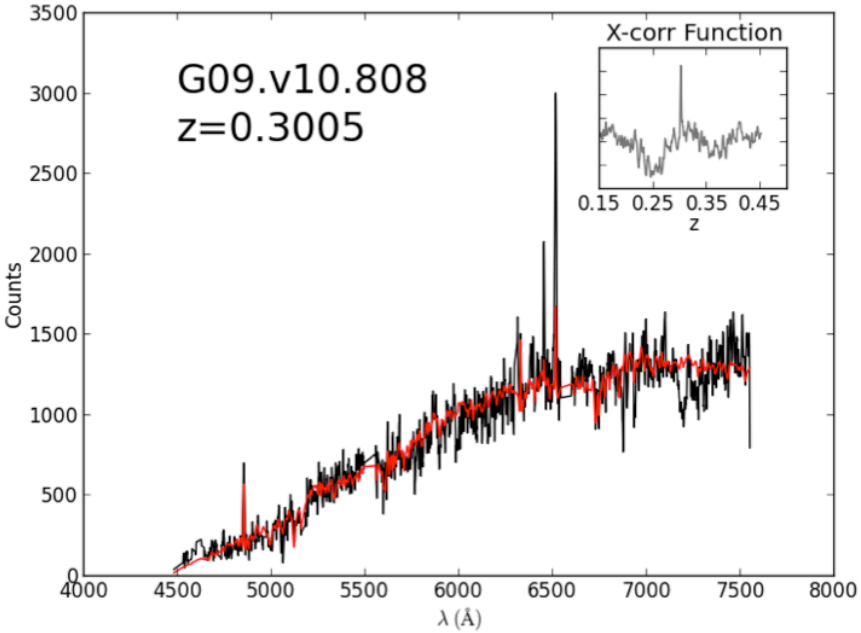

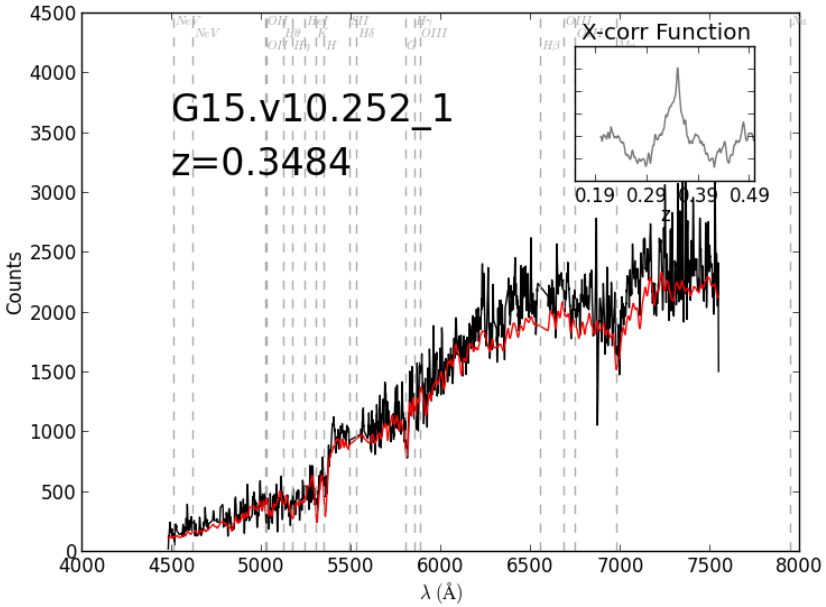

Leeuw, Crawford, H-ATLAS-team et al. SAIP 2013

Implications of the SALT data

- The SALT spectra are confirming the foreground distance ($0.2<z<1$), first estimated from photometry, of the candidate optical lensing galaxies, constraining their redshifts by z+/- 0.002.

- Thus the data will constrain the lensing geometry, mass and magnification, with implications on constraining the physical properties of the lensed and lensing galaxies.

- About 1000 lenses are estimated to be discovered by the H-ATLAS survey, allowing samples large enough to help test galaxy evolutionary models and dark matter distribution and nature, by exploiting mass determinations of both baryonic and non-baryonic matter of the gravitational lenses.

Acknowledging Collaborators and Funders

- HATLAS-Core Team – Eales et al.
- HATLAS-Lensing Team – M. Negrello, S. Sergeant, S. Ambrose, A. Baker, L. Dunne, D. Riechers (**SALT**
- **Partner Members)**
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