Understanding the nature of dusty star-forming galaxies with MAGPHYS

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& ALESS team

Australian Government
Australian Research Council

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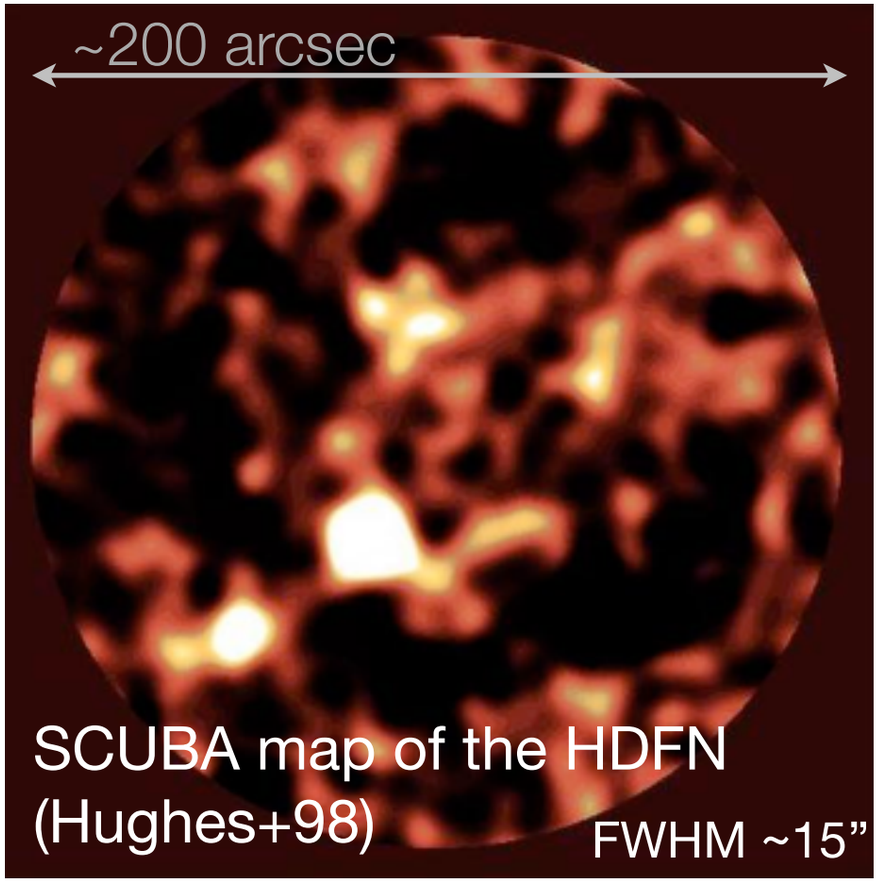
Sub-millimetre galaxies



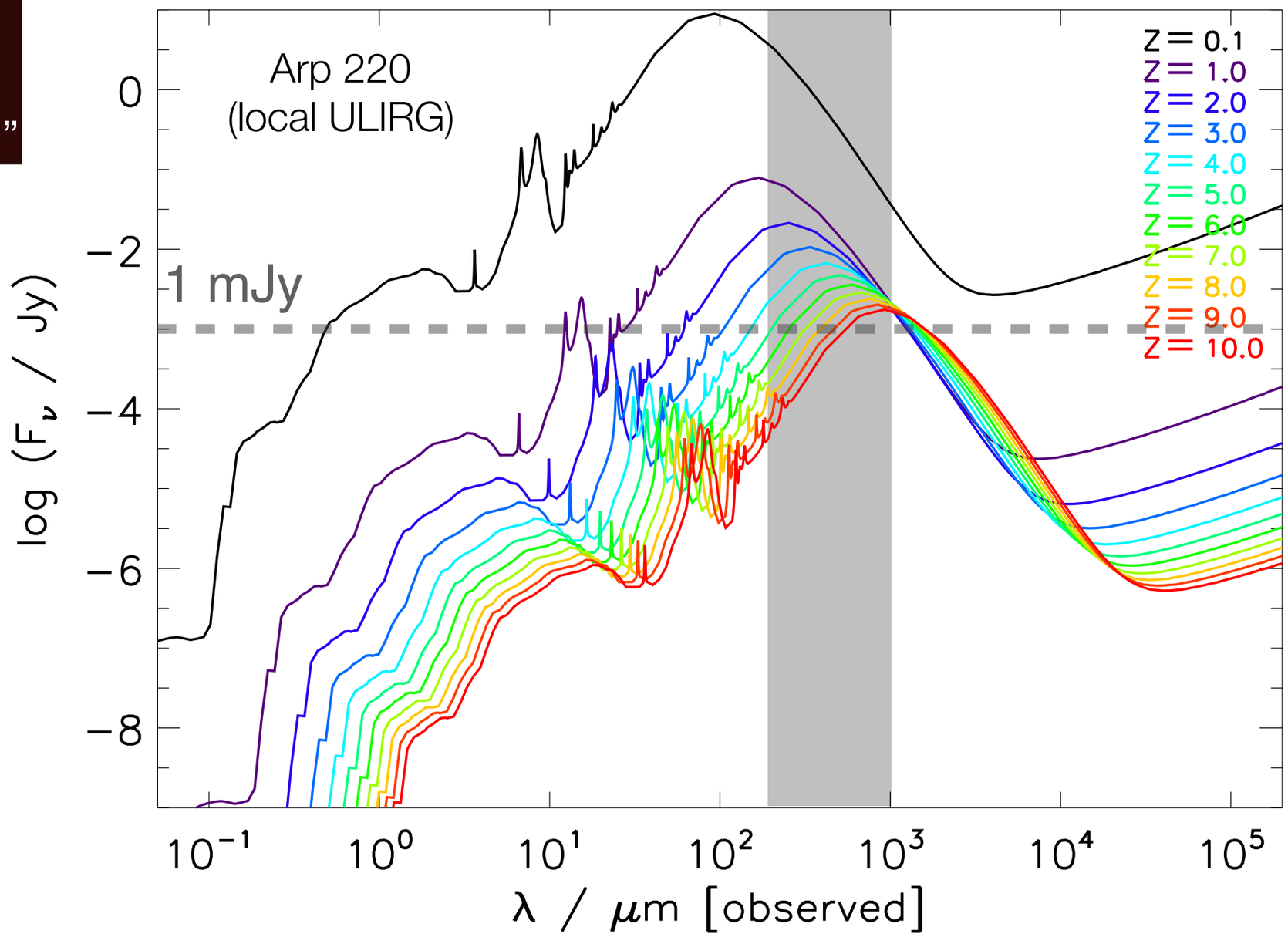
First discovered with SCUBA at 850μm
(Smail+97, Hughes+98, Barger+98)

Fnu(850μm) > 1 mJy

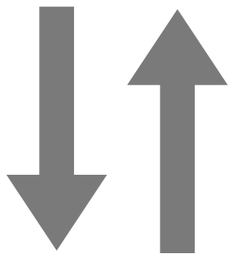
High-z galaxies (z>1) with large infrared luminosities presumably powered by intense star formation (>100 Msun/yr)

Likely progenitors of local ellipticals

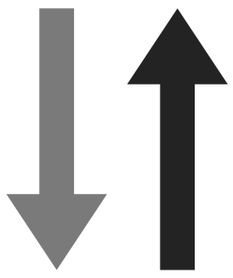
Link to AGN/black hole growth/feedback



Models of SMG formation/evolution in a cosmological context



Physical properties (stellar mass, SFR, age, ISM properties)



Observations / SEDs

Main uncertainties in constraining the physical properties of SMGs:

- **counterpart identification**
  - SMGs are optically faint
  - large beam of single-dish observations

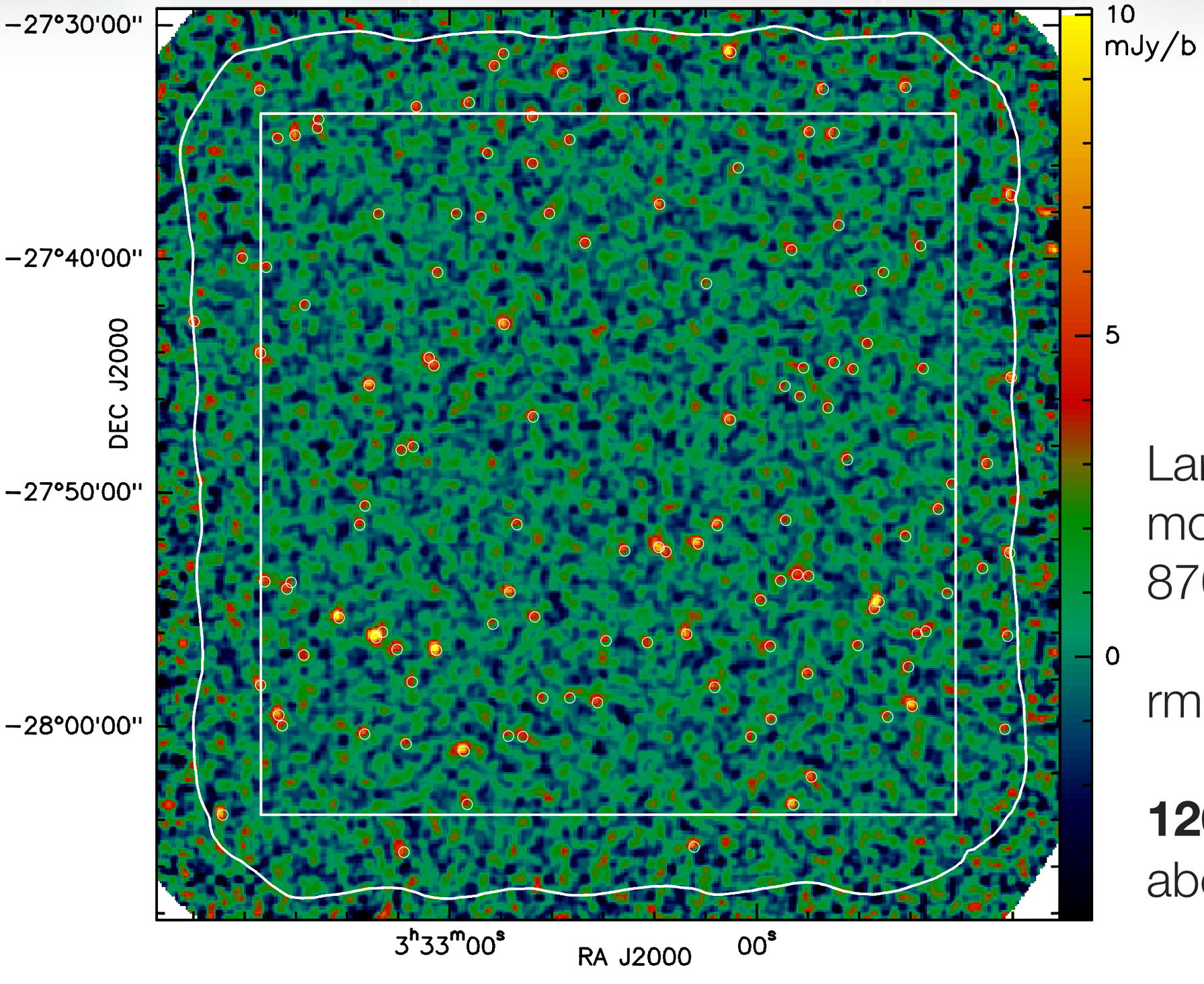
ALMA

- **SED modelling**
  - dust extinction
  - star formation histories (age)
  - degeneracies

MAGPHYS

The LESS survey

LABOCA 870μm map of the ECDF-S (Weiss+2009)



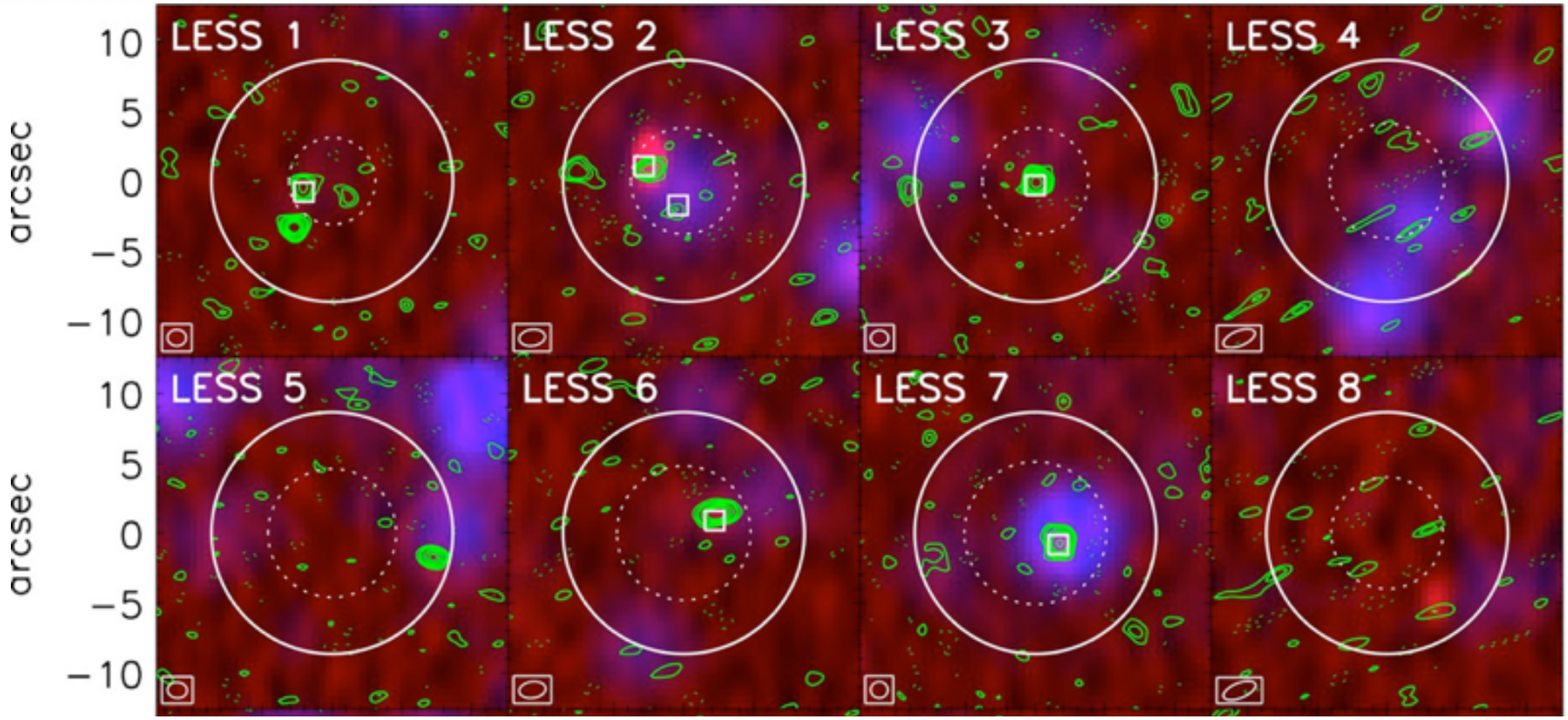
Largest, deepest and most homogenous blind 870μm survey ever made

rms~1.2 mJy/beam

126 SMGs detected above 3.7sigma

ALESS: pin-pointing SMG positions with ALMA

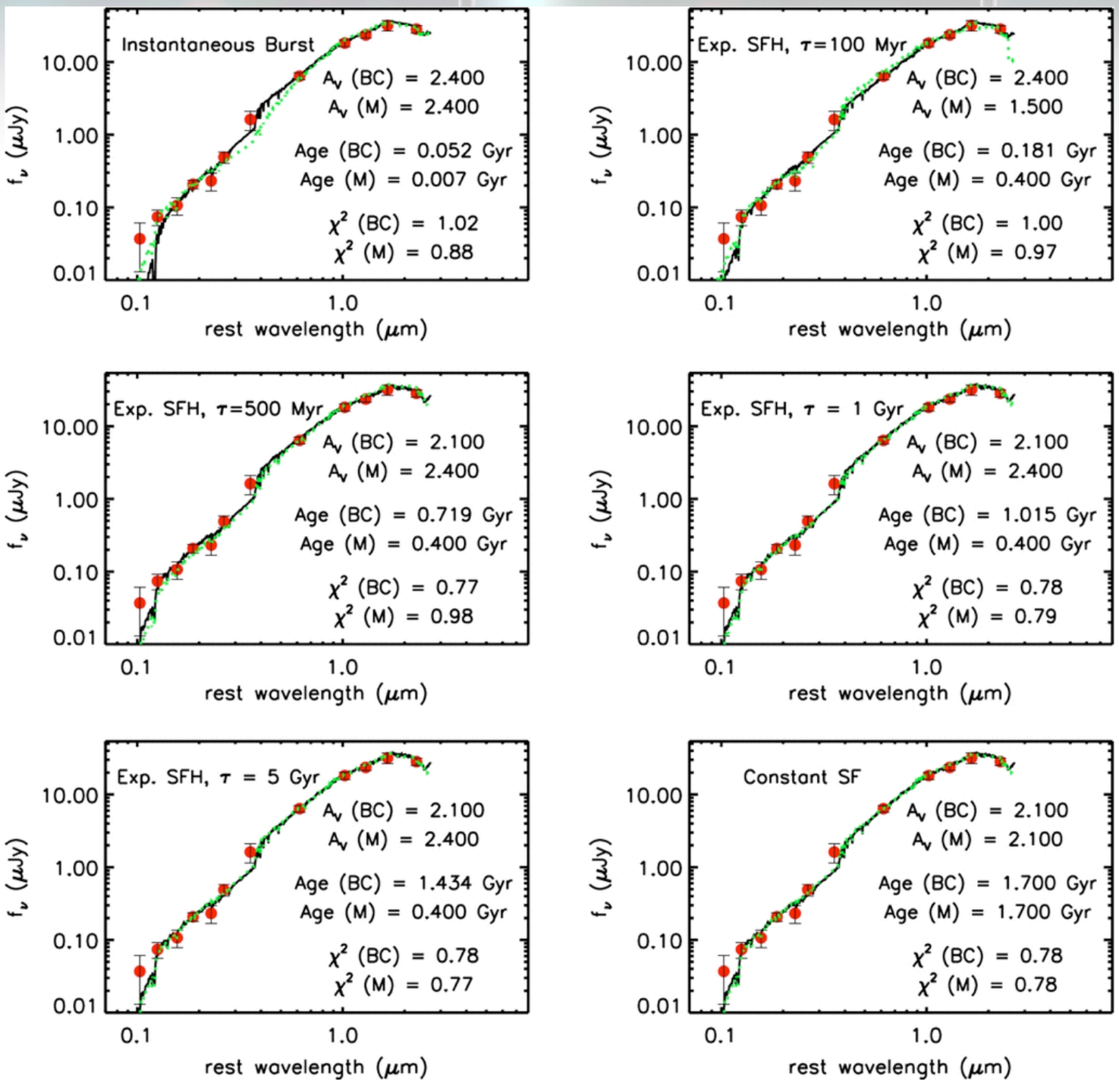
ALMA Cycle 0 follow-up of 126 SMGs identified in the LESS survey (Karim et al. 2012, Hodge et al. 2013).



Hodge+2013

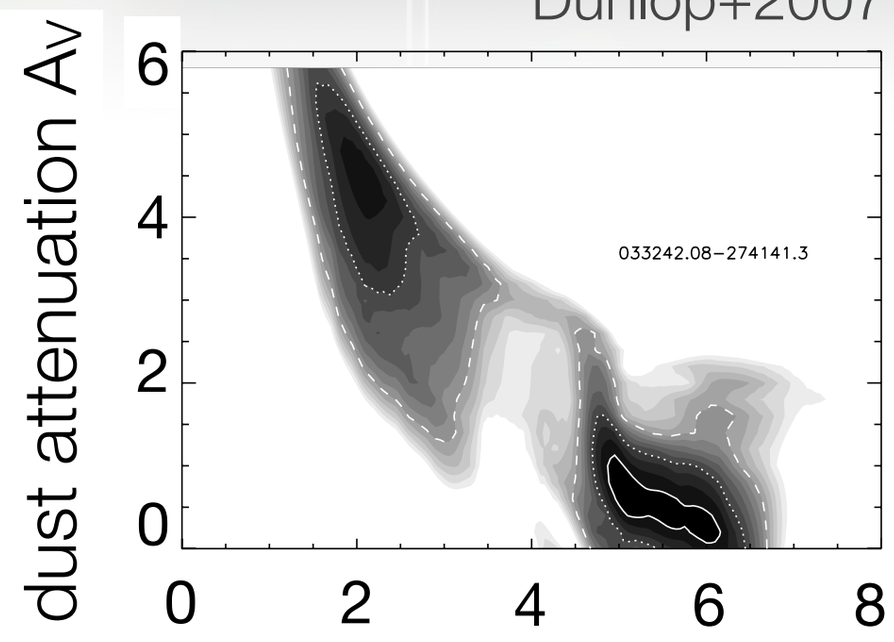
- 30 to 50% of sources resolve into multiple SMGs
- previous statistical methods missed ~45% of counterparts
- statistically reliable survey of SMGs - **unbiased multi-wavelength study**

Degeneracies in optical SEDs



Hainline+2010
see also Michalowski+2014

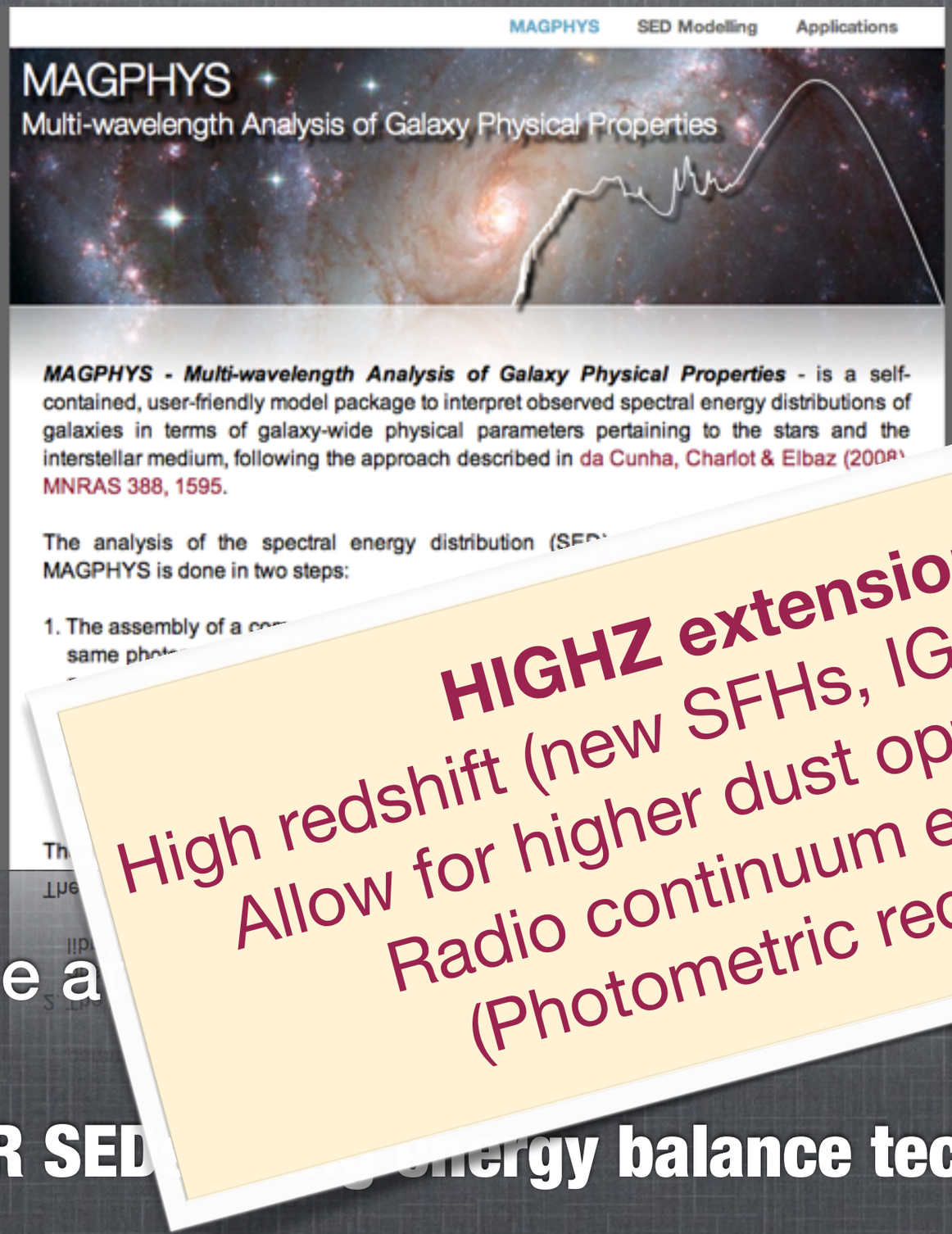
Dunlop+2007



- SFH is usually unknown
- redshift, age, dust and metallicity have very similar effect on the broad-band SEDs

Modelling the SEDs - the MAGPHYS code

da Cunha, Charlot & Elbaz (2008)



HIGHZ extension:

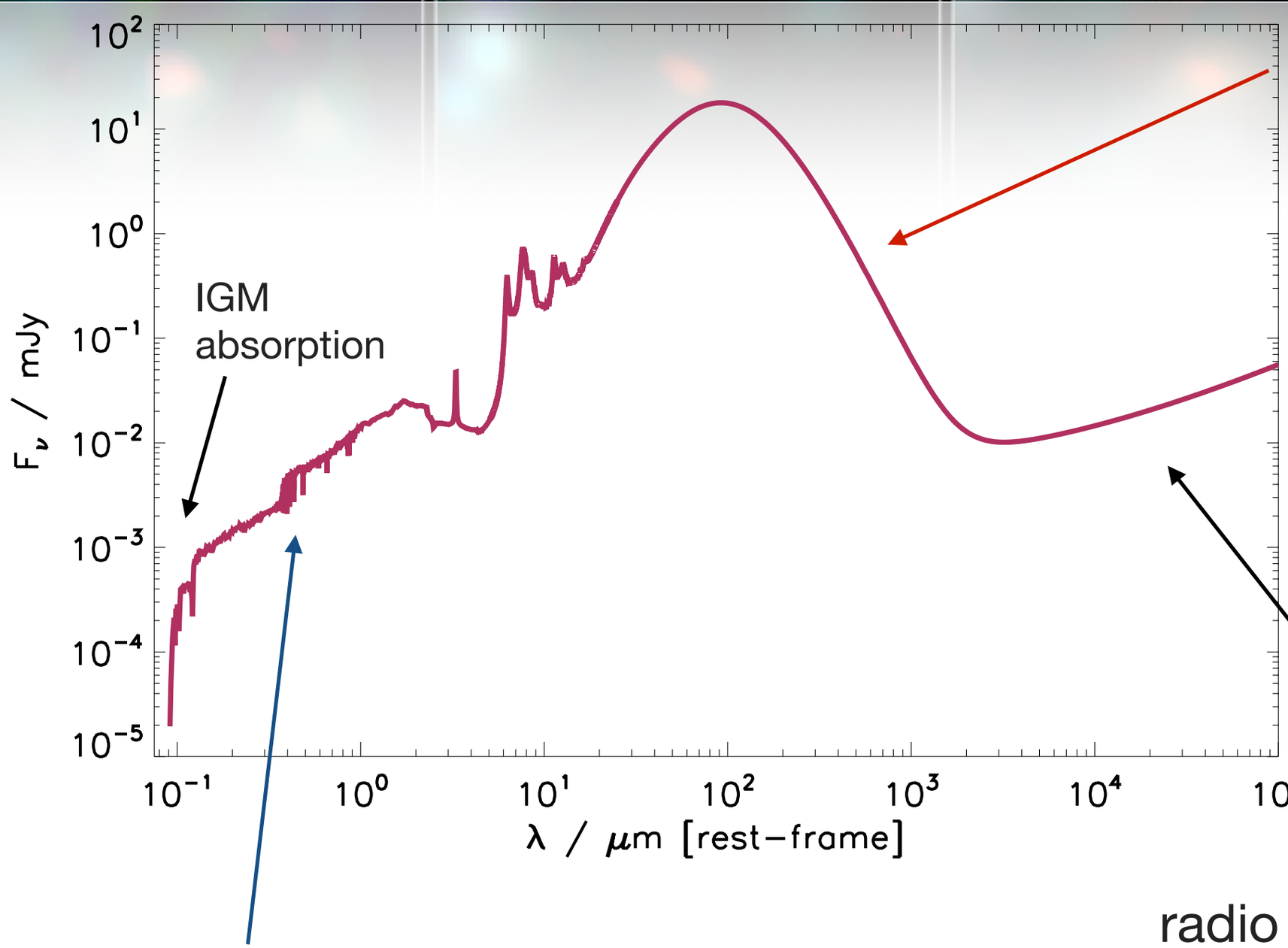
High redshift (new SFHs, IGM absorption)
Allow for higher dust optical depths
Radio continuum emission
(Photometric redshifts)

Publicly available a

Interprets UV-to-IR SED

nergy balance technique

Anatomy of a MAGPHYS galaxy SED



dust emission:

- varying contribution by different dust components: PAHs, mid-IR continuum, dust in thermal equilibrium
- range of temperatures
- energy balance (da Cunha et al. 2008)

dust-attenuated stellar emission:

- Bruzual & Charlot models, fixed Chabrier IMF
- range of star formation histories
- range of metallicities
- two-component dust model (Charlot & Fall 2000)

radio continuum component:
radio/far-IR correlation; fixed thermal/non-thermal contributions

Statistical constraints on physical parameters

MODEL PARAMETERS

PRIOR DISTRIBUTIONS

STOCHASTIC MODEL LIBRARIES

redshifts

OBSERVED GALAXY SED

COMPUTE CHI2 EACH MODEL

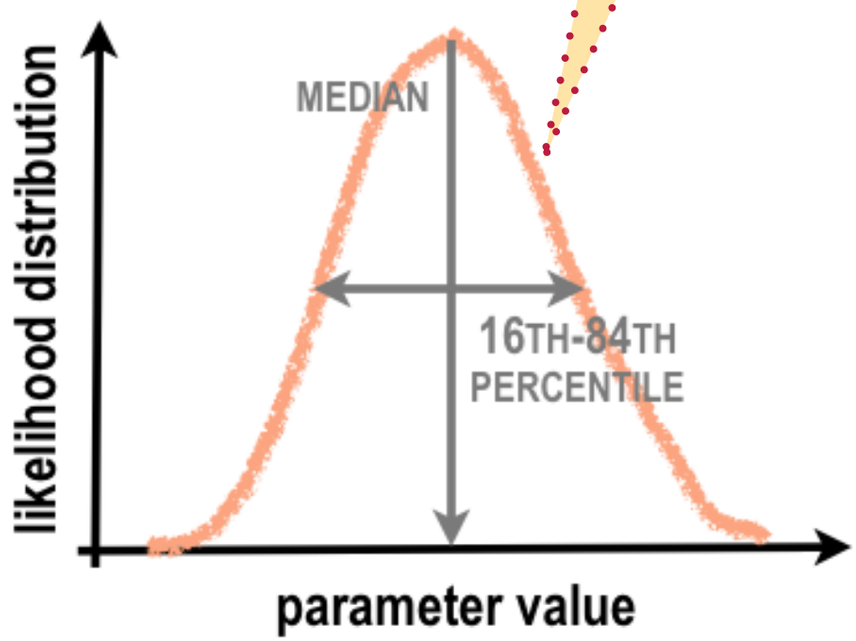
MODEL SEDs

robust parameter estimate + error bar!

For a given model j described by a random set of parameters:

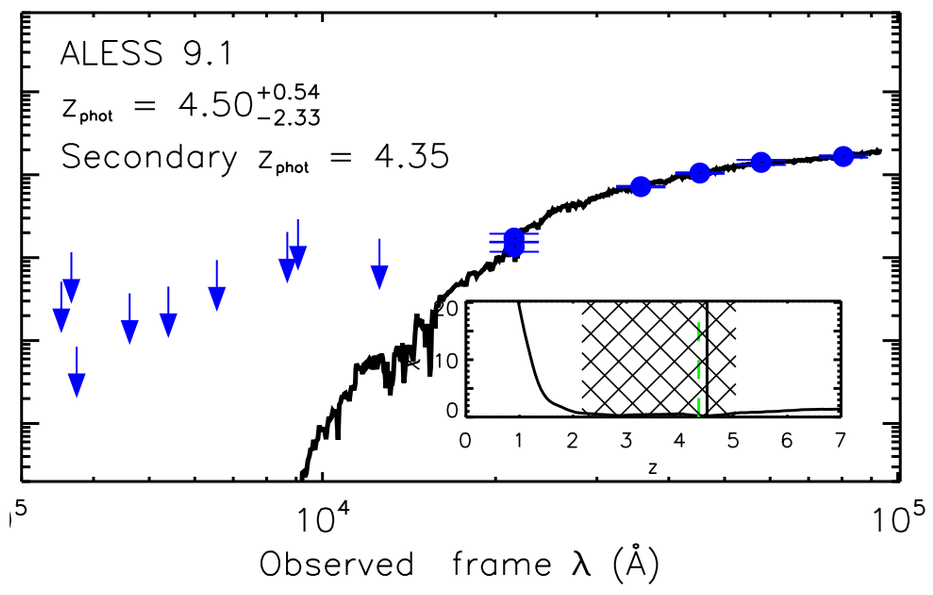
$$\chi^2_j = \sum_{i=1}^{N_{\rm obs}} \left(\frac{L_i^{\rm obs} - a_j \times L_j^{\rm mod}}{\sigma_i^{\rm obs}} \right)^2$$

P=EXP(-1/2 CHI2), MARGINALISE

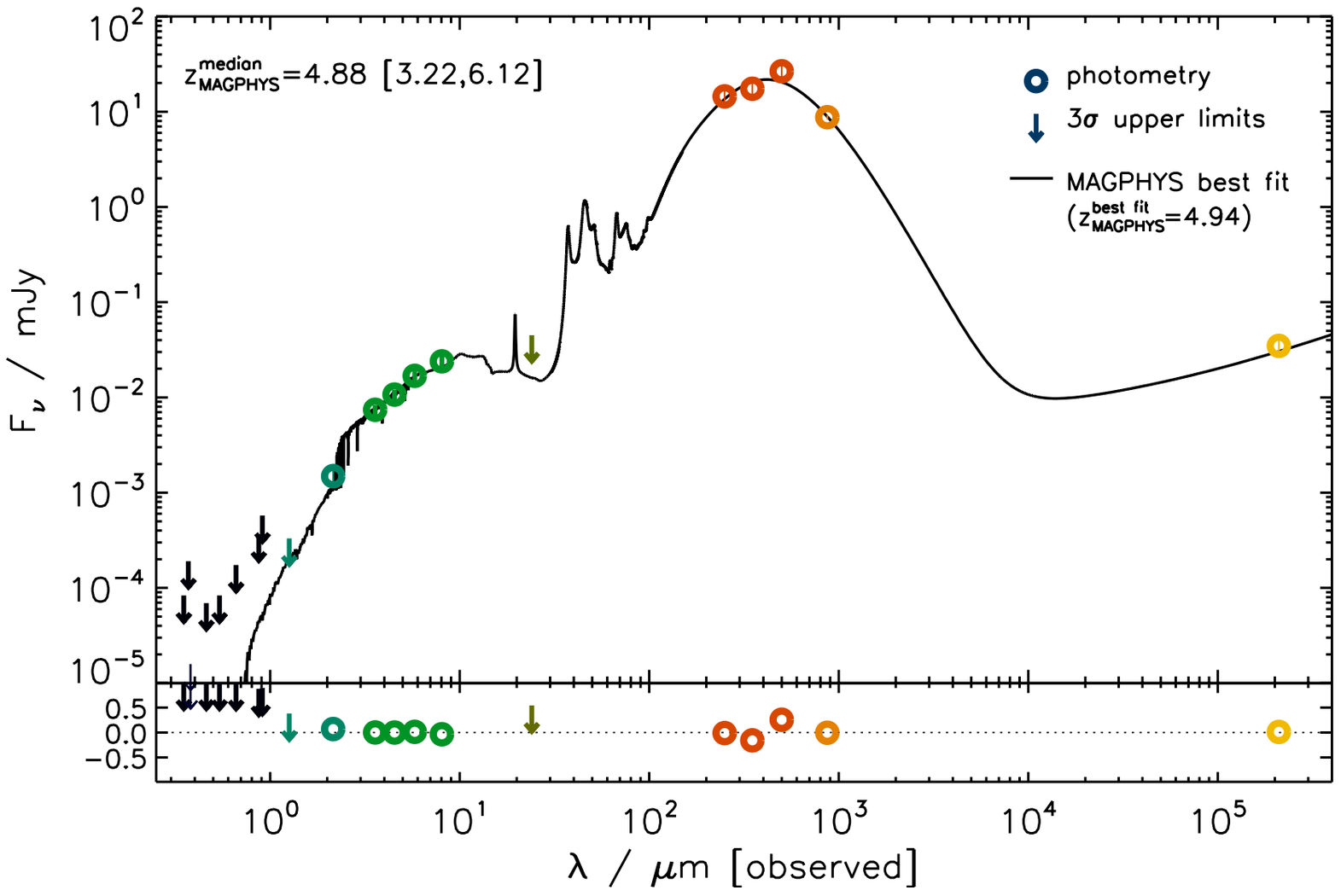


Example SED fit: ALESS009.1

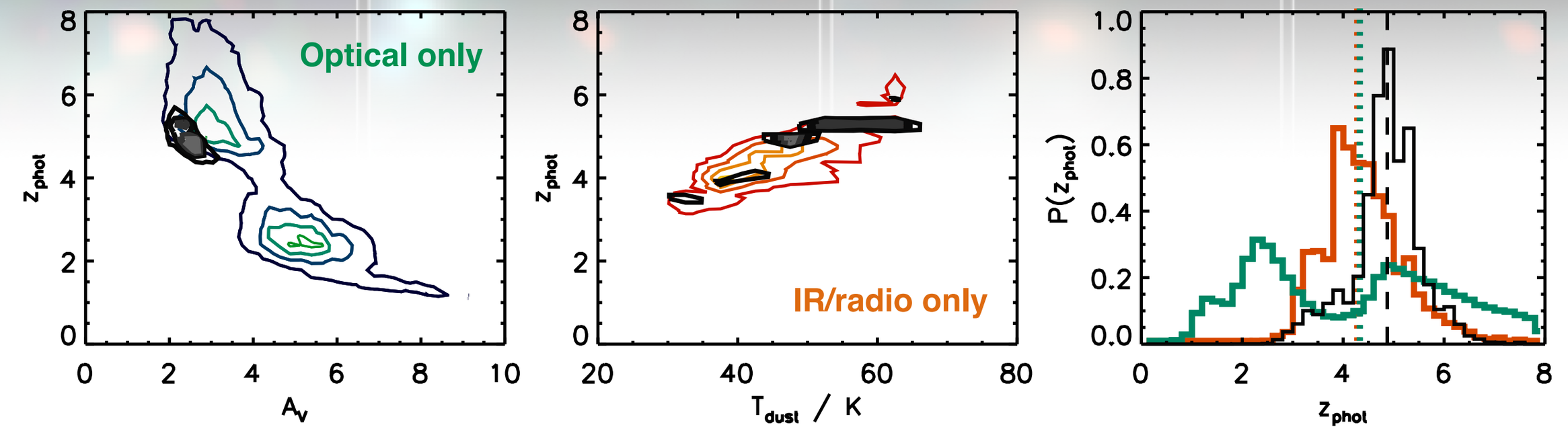
Hyper-z fit (Simpson+2014)



ALESS009.1: MAGPHYS fit

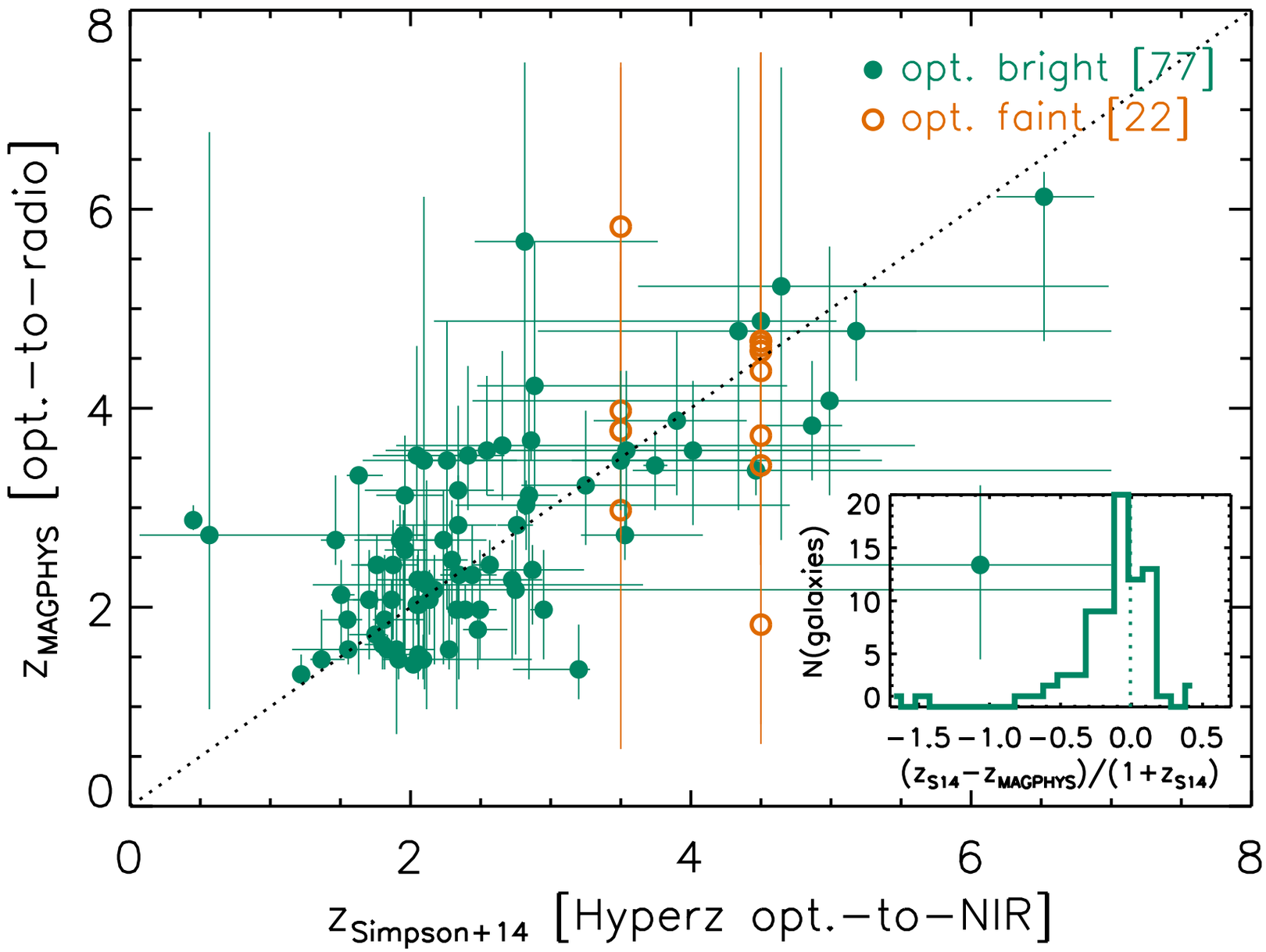


ALESS009.1: parameter likelihood distributions

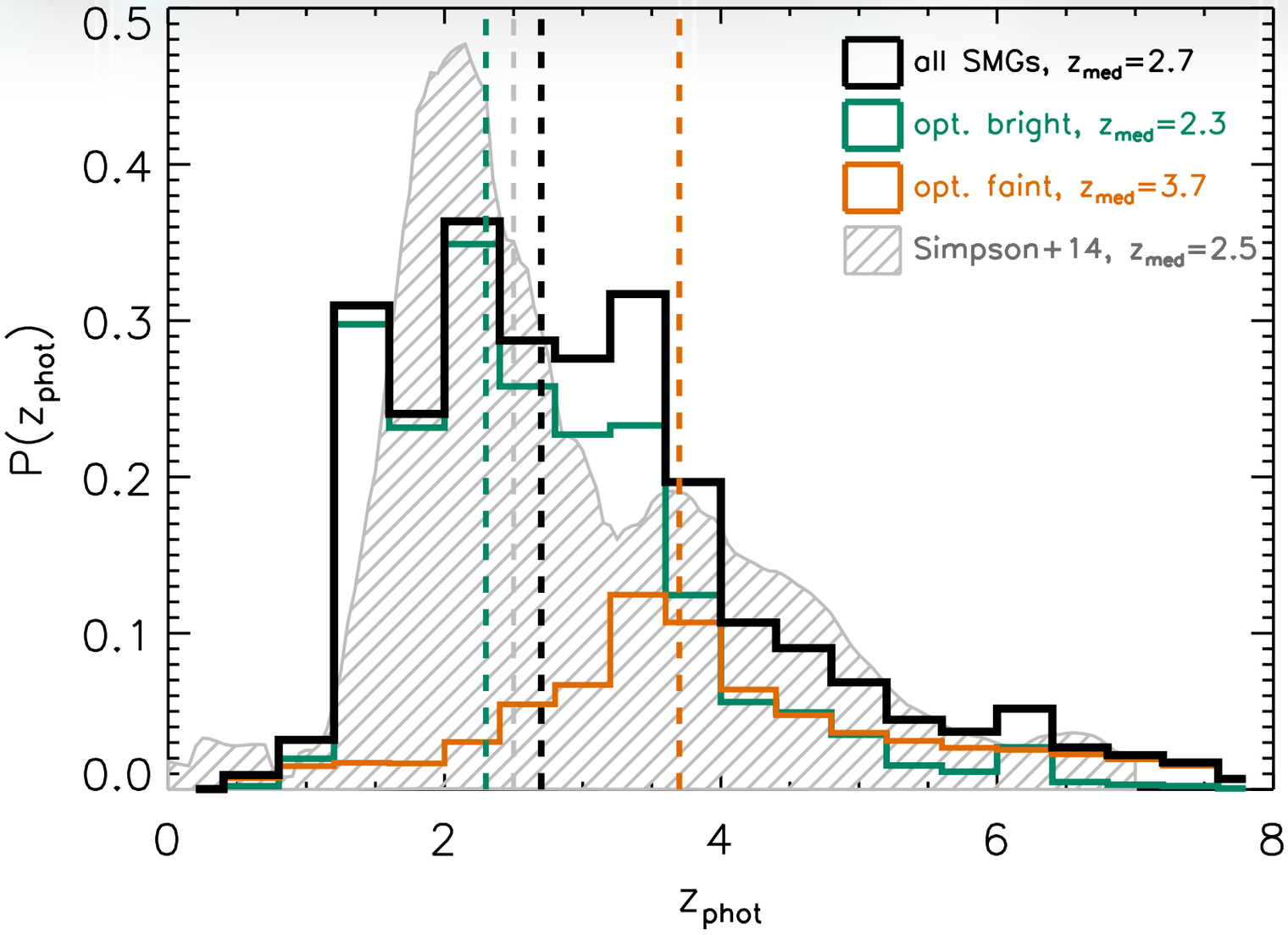


MAGPHYS photometric redshifts

Comparison with Simpson+14 photo-z results which used only optical/NIR information

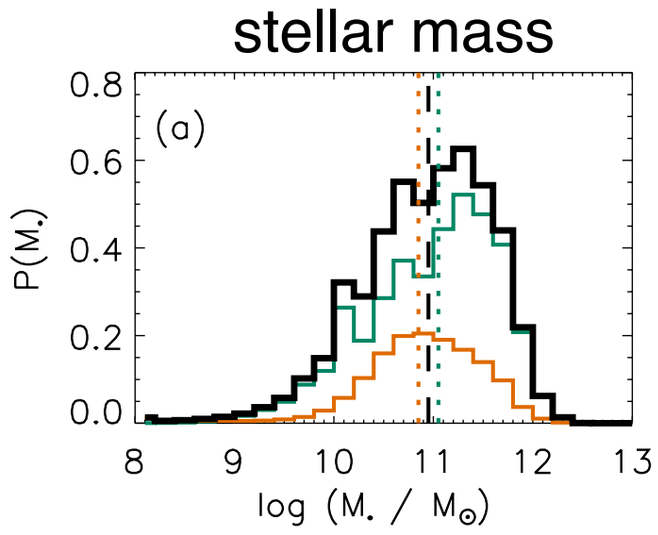


Stacked redshift likelihood distributions



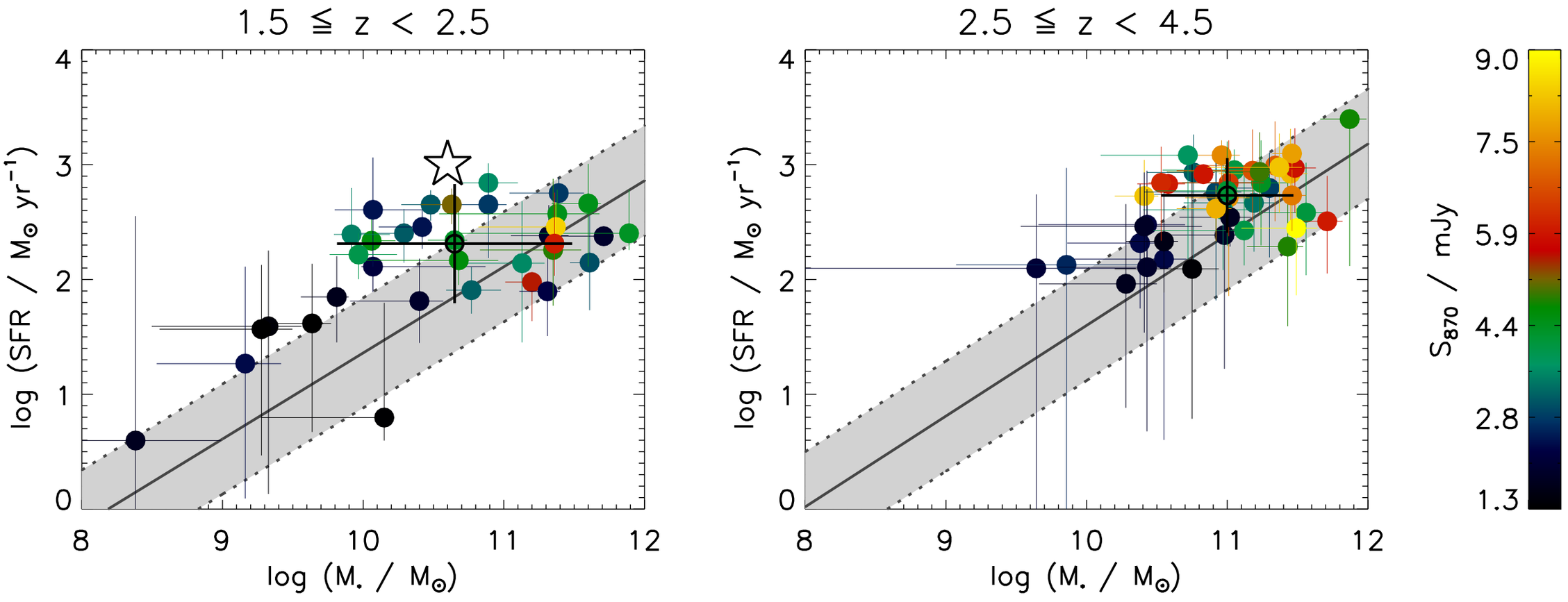
- redshift distribution consistent with previous estimates
- optically-faint SMGs tend to have higher redshifts

Properties of the population of ALESS SMGs



Are the ALESS SMGs on the `main sequence'?

…are they extreme starbursts or just the high-mass end of the main sequence of star formation?



49% significantly above the main sequence.

27% significantly above the main sequence.

Our results suggest that SMGs may not be a uniform galaxy population (as suggested by e.g. Hayward+2011,2012).

Summary & Conclusions

Update of the MAGPHYS code which allows us to fit simultaneously the UV-to-radio SEDs of an unbiased sample of SMGs.

- We obtain **statistical estimates of physical properties & redshifts simultaneously, accounting for degeneracies.** Uncertainties in redshift are naturally included in the uncertainties of other physical parameters (and vice-versa).

- The physical properties of the SMGs resemble those of local ULIRGs: **high SFRs, large dust content** (does not necessarily mean same/similar physical processes are happening).

- 22 **"optically-faint" SMGs** are likely to be at higher redshifts than optically-bright sources; also higher dust attenuation which could imply edge-on or very compact sources.

- Regarding their position with respect to the "main sequence" of star-forming galaxies, the **ALESS SMGs are a mixed population**.