



# Comparing SFR estimators for IR-luminous galaxies at $z \sim 2$ in CANDELS



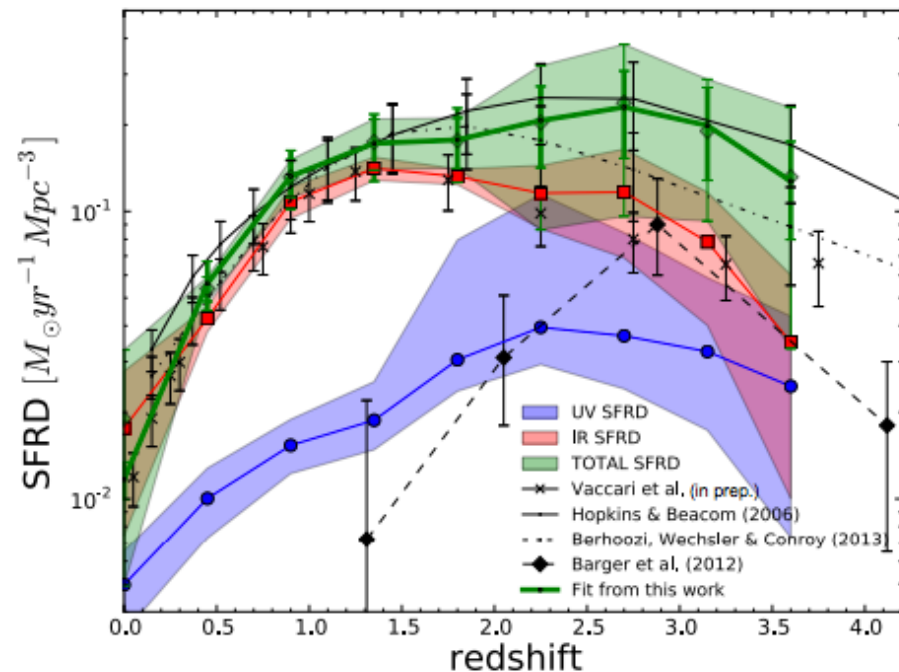
**Janine Pforr (LAM, Marseille),**

Mark Dickinson, Jeyhan Kartaltepe, Hanae Inami, Kyle Penner, and the CANDELS+CANDELS-Herschel teams

Also check out the CANDELS Blog: [candels-collaboration.blogspot.com](http://candels-collaboration.blogspot.com)

# Motivation

Burgarella et al. 2013



- Uncertainties of SED-fit derived properties studied on simulated galaxies (e.g. Lee+2009, Wuyts +2009, Pforr+2012,2013)
- But: extremely dust-obscured and high-SFR galaxies missing
- Aim: understand uncertainties of SED-fit derived properties for those
- far-IR data is not readily available for all galaxies -> Can we find a way to reliably determine SFR from SED-fitting? SFRs for galaxies below the Herschel detection limit?

# The CANDELS survey

PI's: S. Faber and H. Ferguson



- ❑ ~900 orbits of HST
- ❑ GOODS-S+N, UDS, COSMOS, EGS
- ❑ near-IR images with HST/WFC3 to deeper level than previous ground based
- ❑ Extensive ancillary multi-wavelength data from space and ground based observatories (Spitzer/IRAC, HST/ACS, CFHT, Subaru etc.)
- ❑ Aims to study galaxies and their evolution over a wide range of the age of the Universe with specific focus on cosmic high noon ( $z \sim 2$ )

# CANDELS Herschel

- Deepest far-IR coverage with Herschel in PACS and SPIRE from PEP/GOODS-Herschel for GOODS-S+N (PI: D. Elbaz, Magnelli+ 2013) and CANDELS-Herschel for COSMOS and UDS (PI: M. Dickinson)
- Able to probe  $L^*$  (i.e. typical) galaxies out to  $z \sim 2$
- long wavelength detects obscured star formation

# Different SFR tracers:

## *SED-fitting:*

- to optical/NIR multi-wavelength broad-band data
- At fixed redshift using HyperZ (Bolzonella+2000) and Maraston (2005/+2010) templates

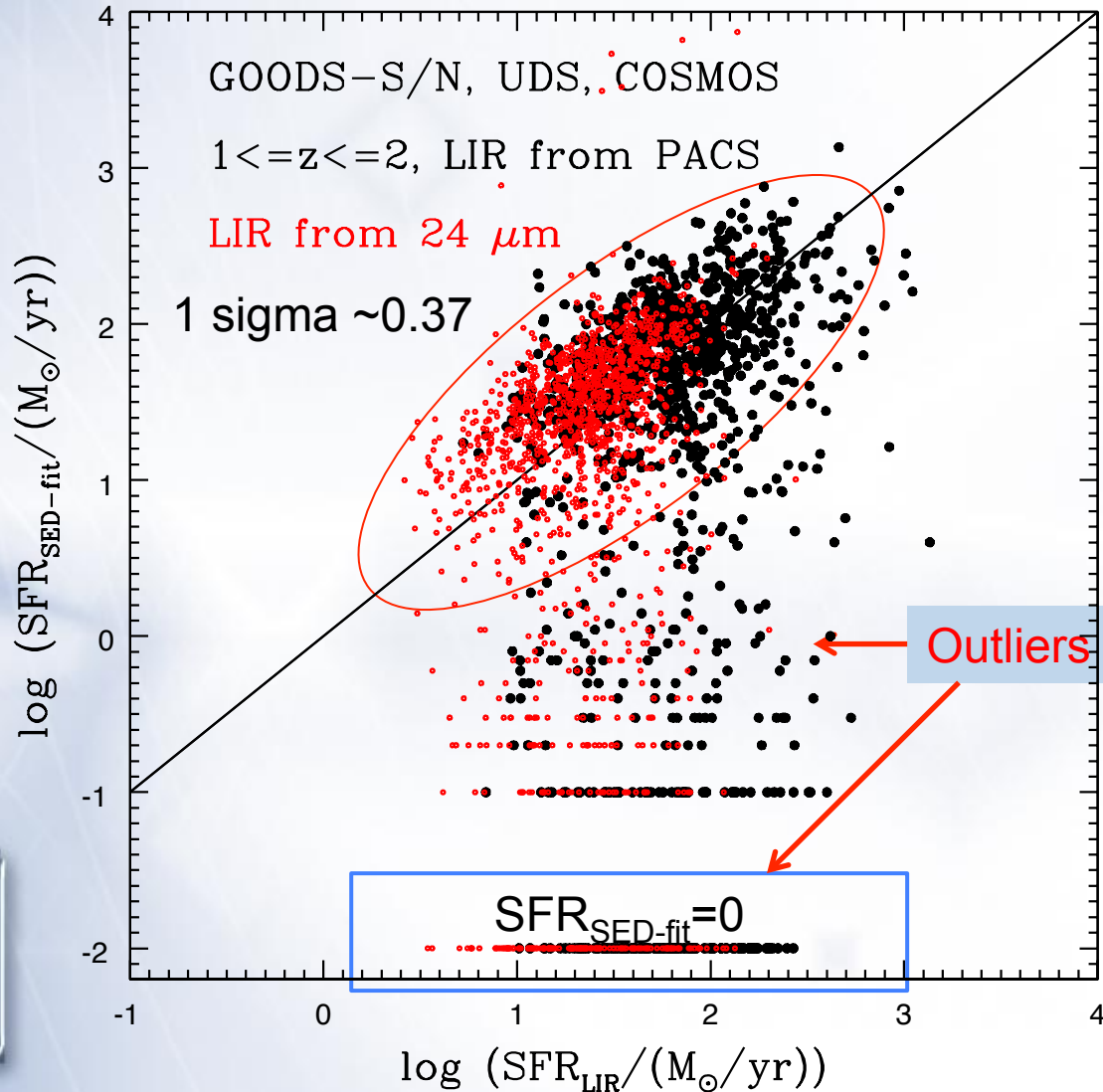
## *Far-infrared luminosity ( $L_{IR}$ ):*

- Comparison of far-IR SED model with observed far-IR SED to get  $L_{IR}$
- HERE: scaling of far-IR flux in one Herschel band to far IR SED model (Elbaz+2011) flux to get  $L_{IR}$  (same for 24 micron)

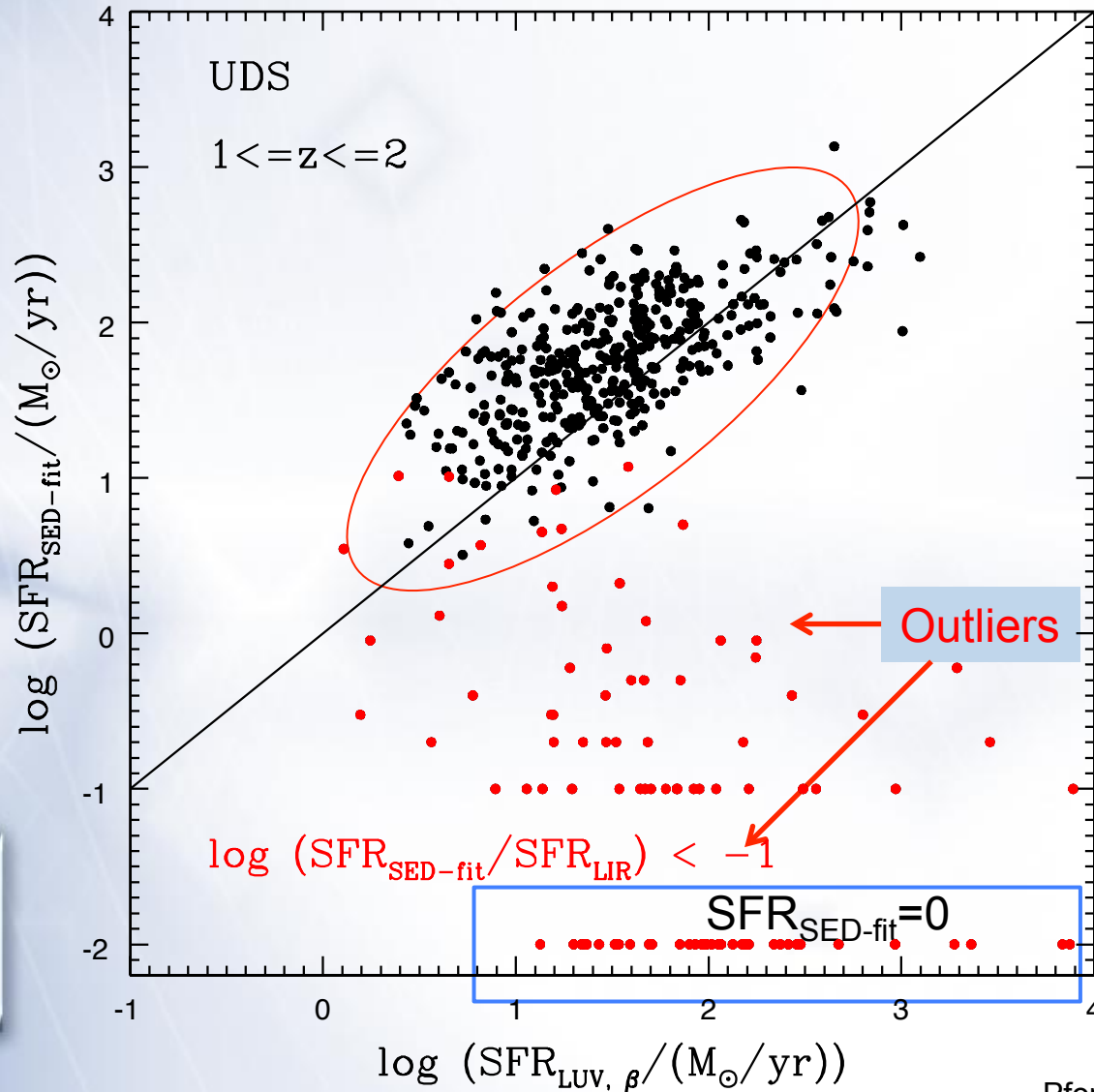
## *UV-luminosity ( $L_{UV}$ ) + UV spectral slope:*

- $L_{UV}$  from power-law fit to rest-frame UV spectral slope (Penner+2012)

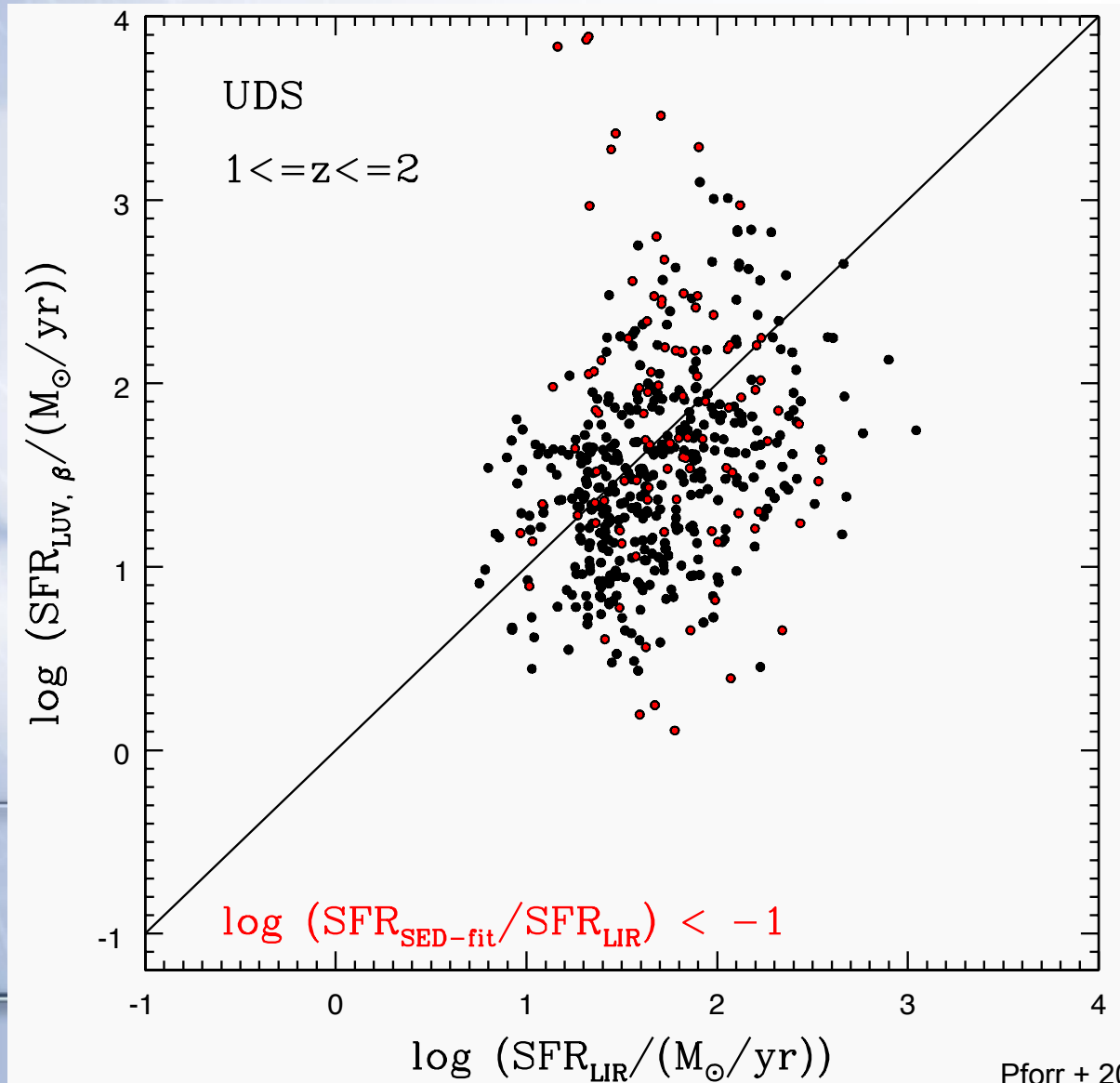
# SFR comparison: optical/NIR - SED vs far-IR



# SFR comparison: optical/NIR - SED vs UV

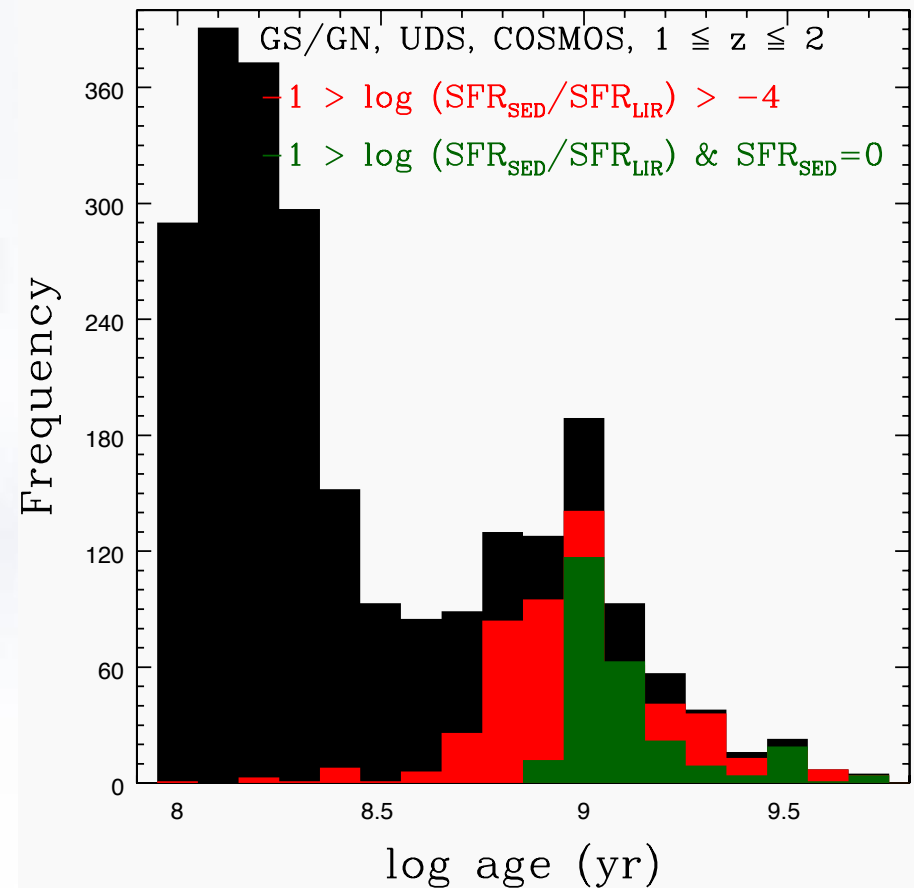
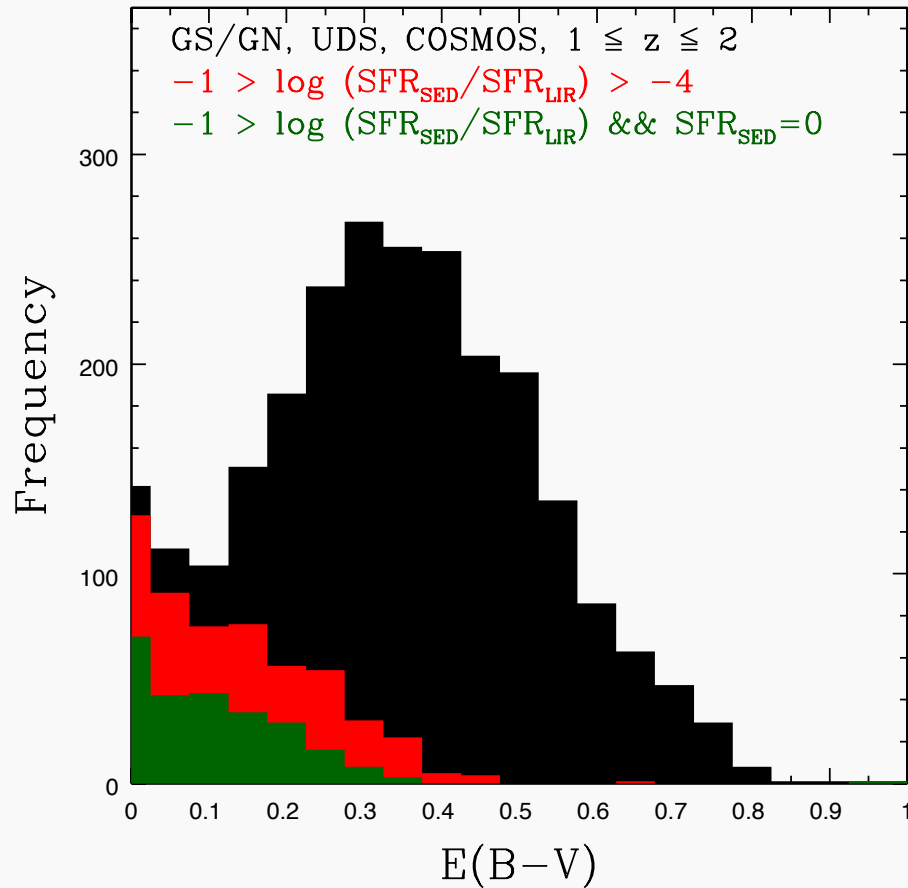


# SFR comparison: dust corrected UV vs far-IR

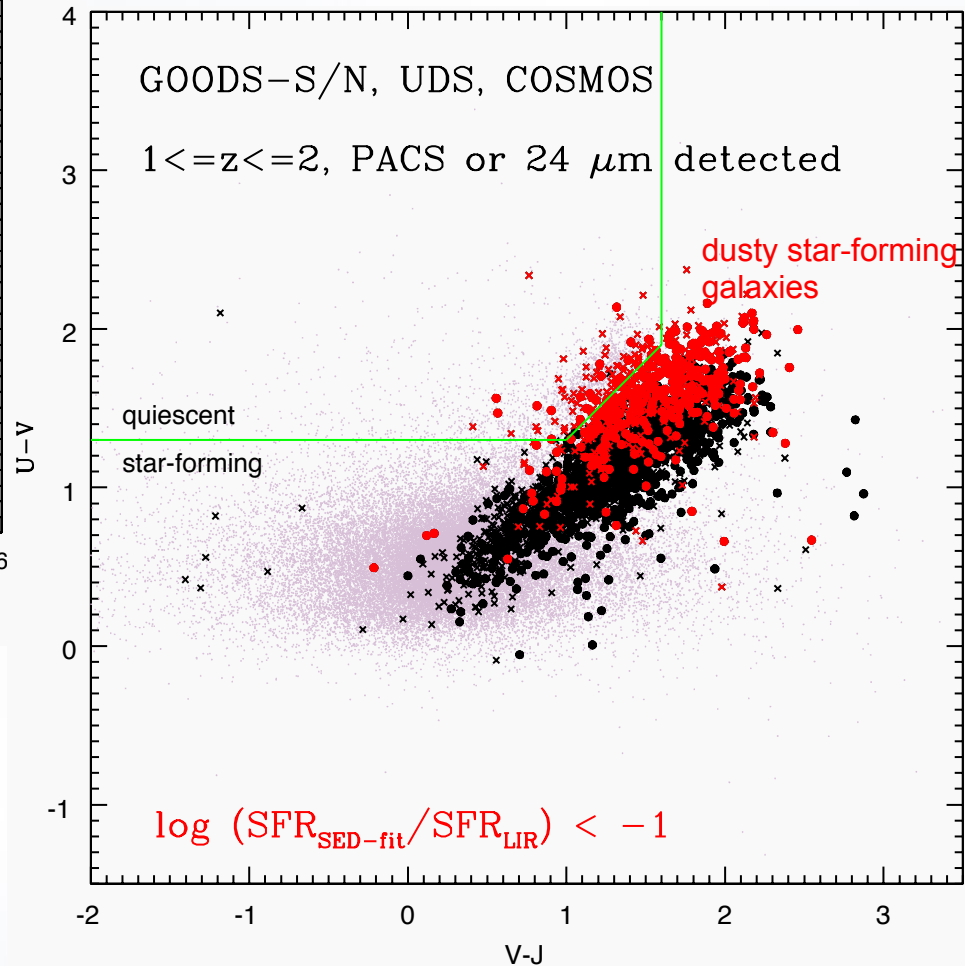
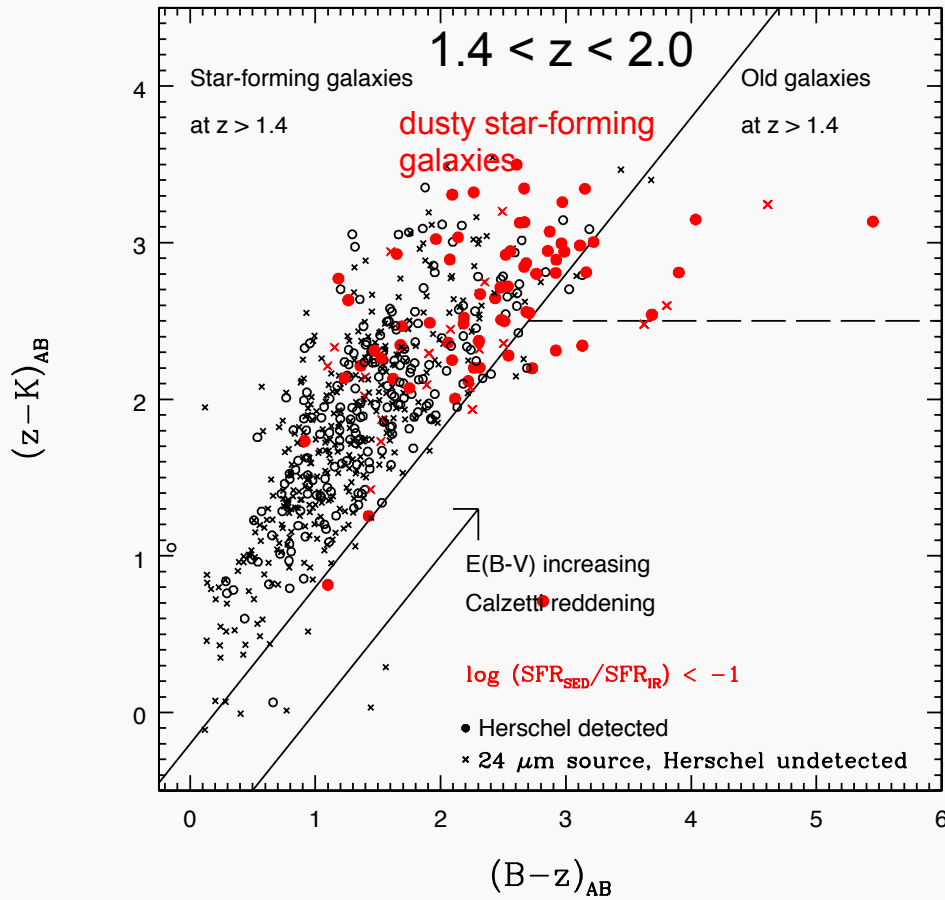




# Galaxy properties from the SED-fitting: Reddening and age distributions



# Nature of the Outliers – are they dustier?



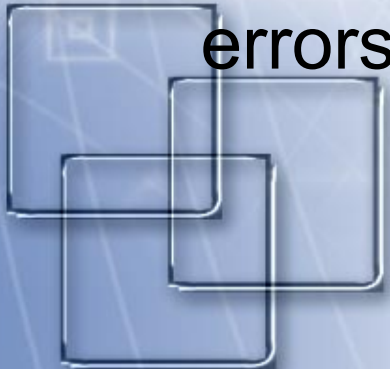
# What we've learned so far:

- dust corrected UV, LIR and SED fit SFRs agree reasonably well with each other
- **BUT**: some sources misidentified as quiescent by SED-fit
  - for few supported by color-color diagnostics
  - most occupy dustiest SF- galaxy space
  - are they just really dusty?



# What now?

- Scenario1: IR-SFR overestimated due to dust heating by sources other than young stars (see talks Tuesday afternoon)
- Scenario2: IR/UV-SFR right, but SED-fit either
  - A) dominated by age-dust degeneracy and fooled by large amounts of dust or
  - B) fit results too unstable given the photometric errors



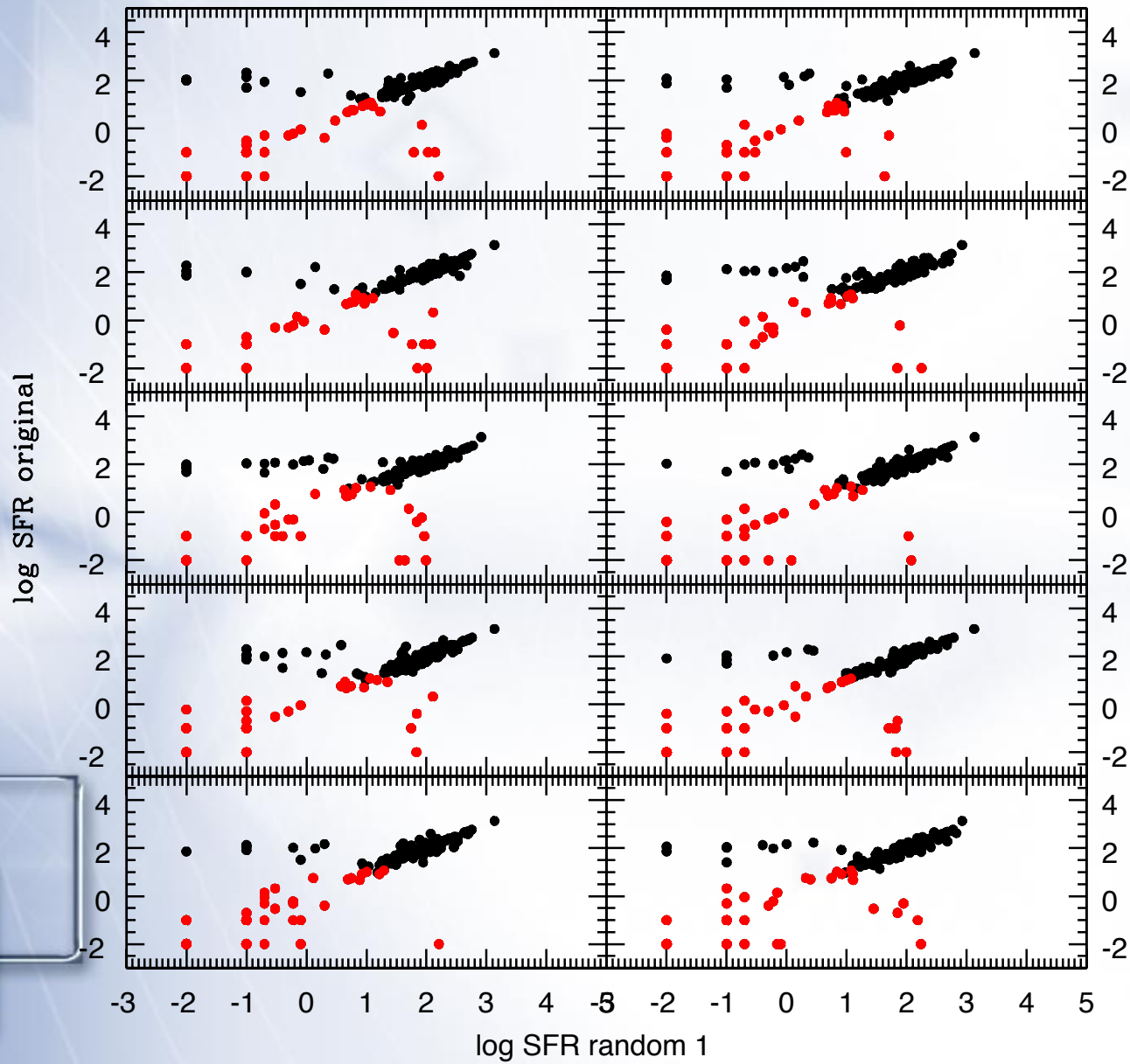
# Possible Solutions:

- 2B): randomize photometry and refit, check what changes



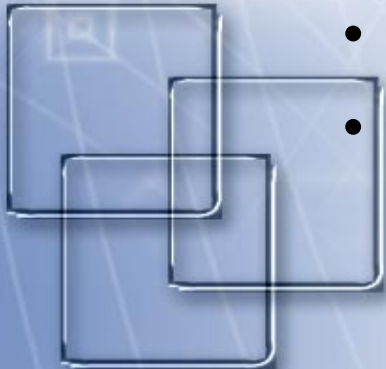
# Solution for 2B: Randomization of photometry to test “stability” of the SED-fit results

UDS



# Possible Solutions:

- 2B: randomize photometry and refit, check what changes -> true for some, but not for all
- 2A: investigate different SFHs and dust prescriptions in the fitting -> currently in the works and some aspects look promising
- 1:
  - Measure dust properties from other sources
  - compare to other SF tracers
  - use e.g. optical or NIR spectroscopy, ALMA etc.



# spectroscopy with VUDS

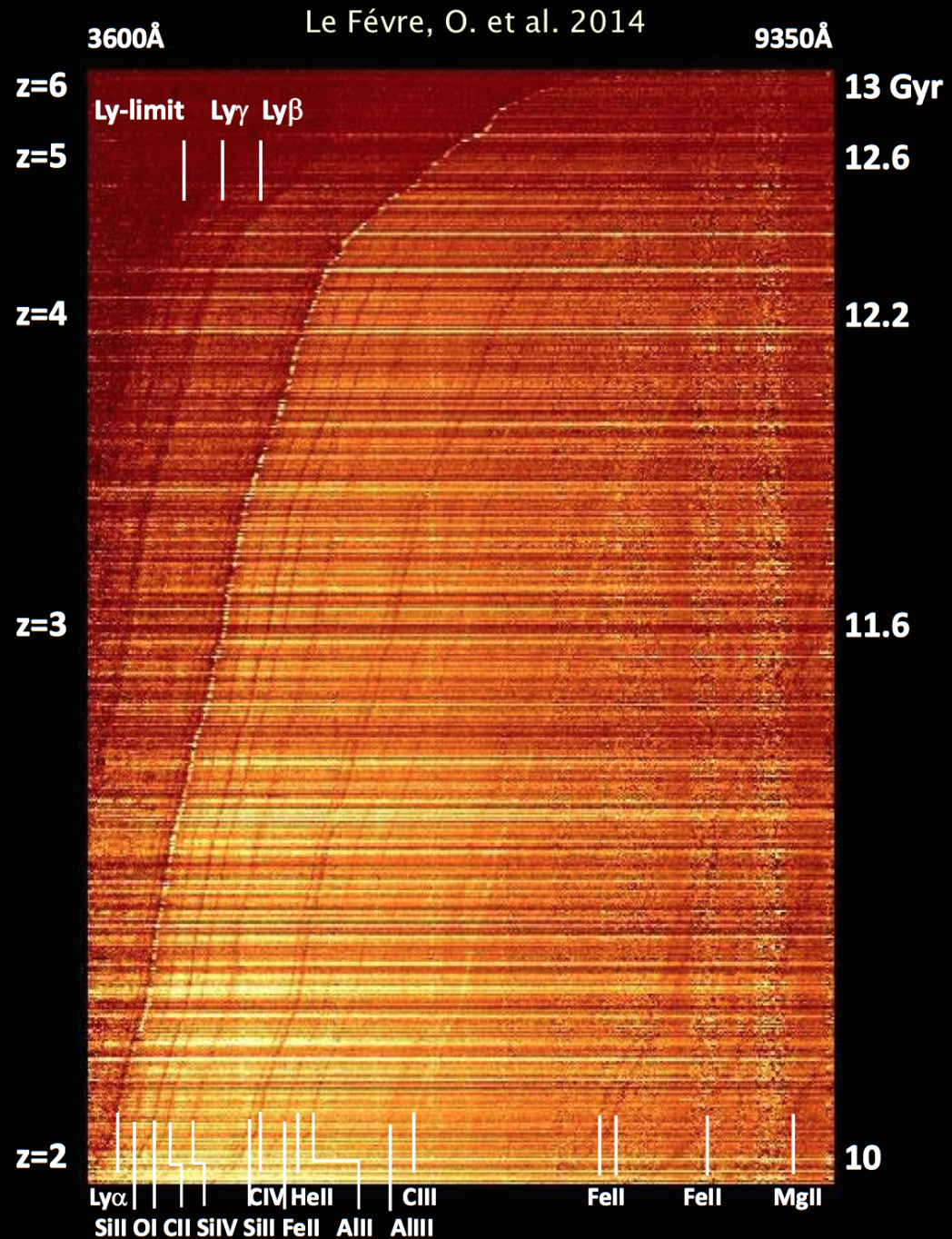
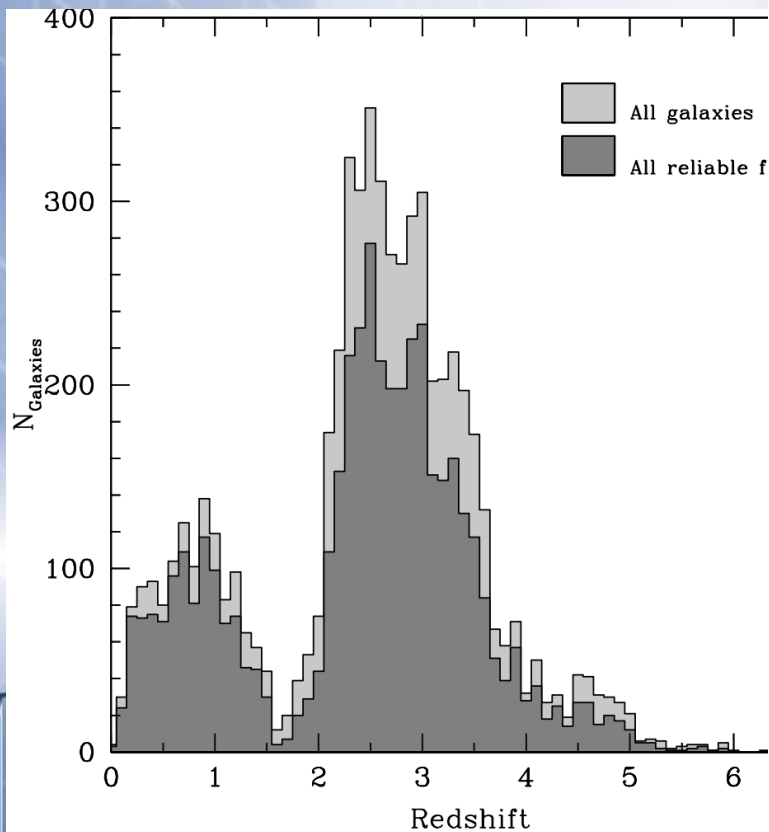
VUDS = VIMOS Ultra Deep Survey  
(PI: Le Fèvre)

- Optical spectroscopic redshift survey of ~10.000 very faint galaxies with  $2 < z \leq 6$  with VIMOS @ VLT -> rest-frame UV spectra
- 1 deg<sup>2</sup> in 3 separate fields: COSMOS, ECDFS, VVDS-02h
- target selection mainly based on photo-z
- integration times of 14h
- 91% completeness in redshift measurement for most reliable measurements down to  $i_{AB}=25$
- ~6000 galaxies with reliable spec-z





# VUDS



# VUDS + CANDELS/Herschel

- VUDS overlaps with CANDELS COSMOS and GOODS-S
- Overlap with my sample: ~50 with good zspec-flags in VUDS



# Summary and Next steps:

- agreement between UV and IR SF tracers
- SED-SFRs agree with UV and IR for most sources
- Investigate “outliers” further through other measurements of dust and SF
- investigate different SFHs and dust prescriptions in the fitting
- Use stacking to extend to galaxies below Herschel detection limit