Dust, a key- tool for probing galaxy evolution

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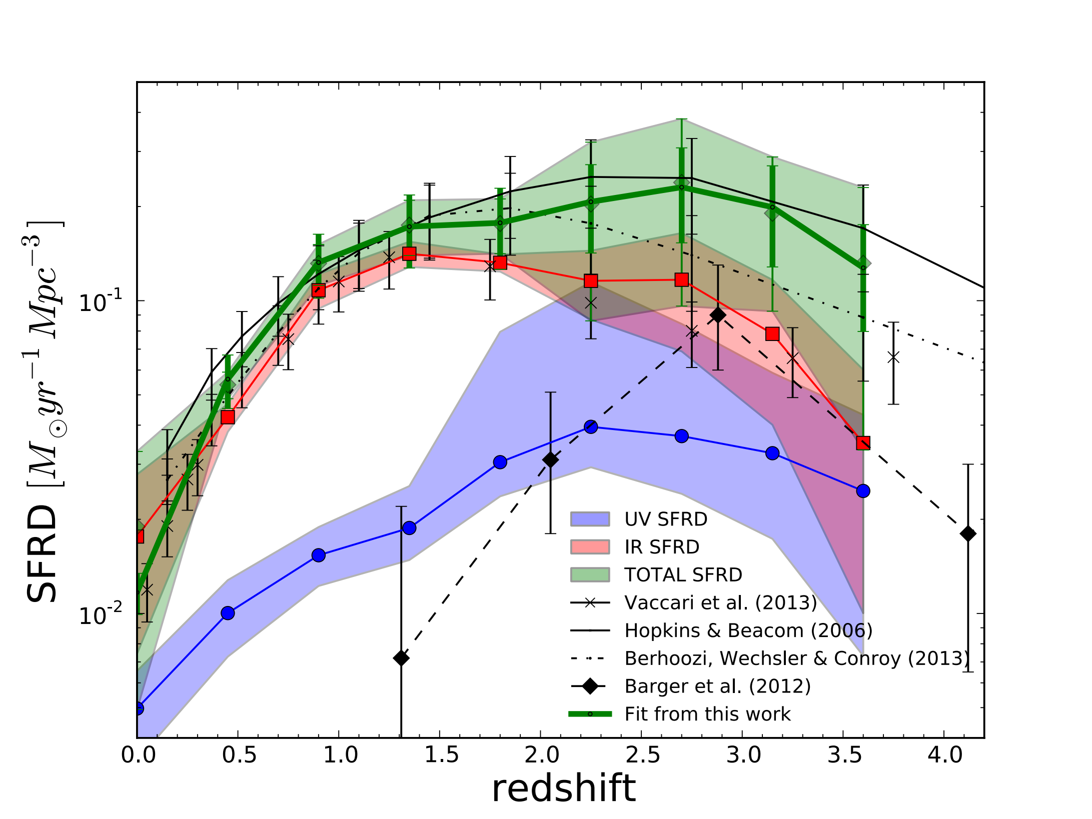
The need for IR studies

- How do galaxies form, evolve and accrete their mass ?
  <u>Star formation history.</u>



Burgarella+2013

Talk outline

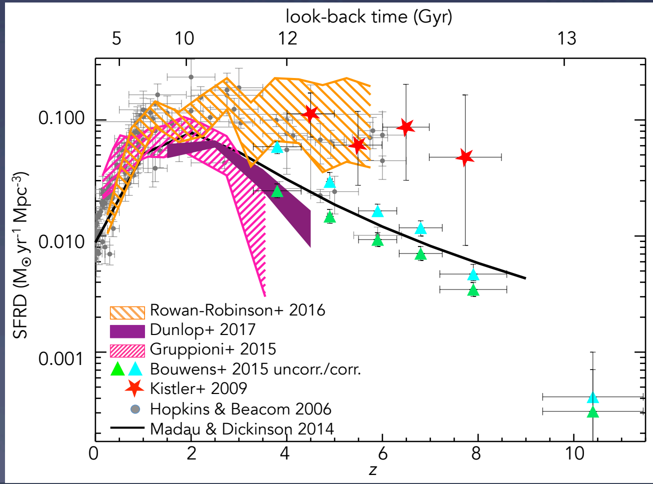
1. Herschel IR luminosity functions

2. Simple (not cosmological) model to interpretate the Herschel LF and how do they evolve into the galaxy we see in the local Universe.

Implementation of chemical model from Calura+09 to treat the dust

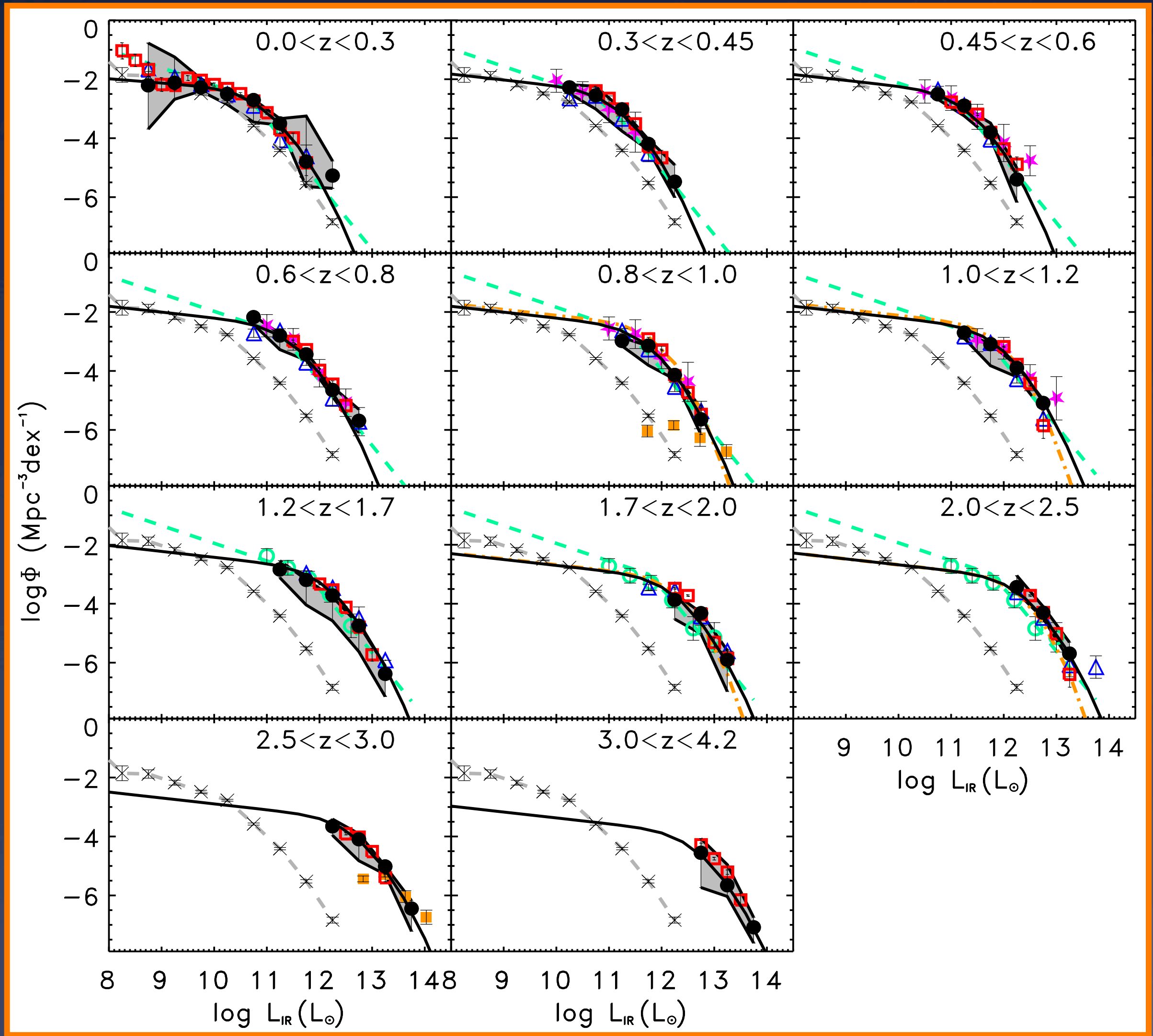
3. The future IR SPICA mission

Gruppioni et al.17



I: The IR luminosity function from HERSCHEL survey

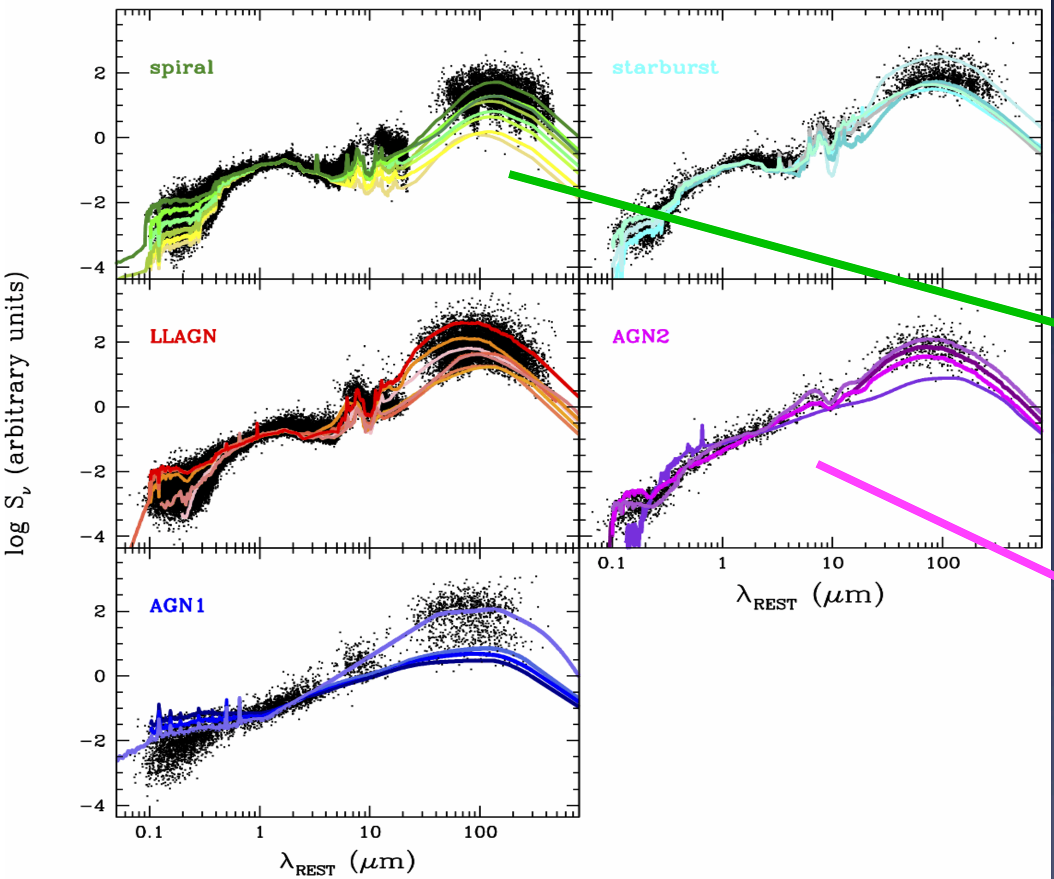
Gruppioni, Pozzi+13

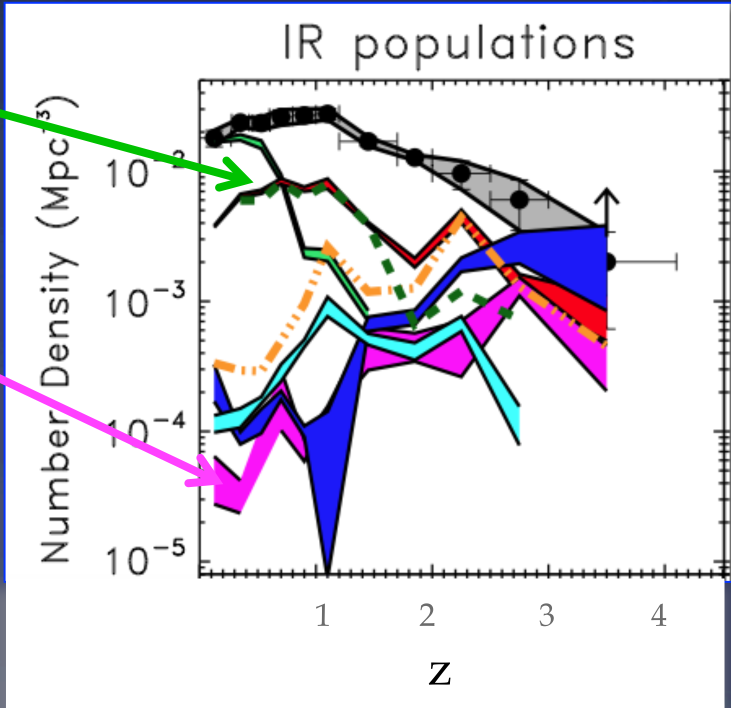


- 3<z<4 : first LF
- z<2.5 agreement Spitzer-based LF
- Strong evolution compared to local

● —	PEP Gruppioni+13
X - - - -	Sanders+ 03
■ sub-mm	Chapman 05
* 24 μm	Le Floc'h+ 05
O 24 μm	Magnelli+ 09, 11
△ 24 μm	Rodighiero+ 11
□ HerMES	Vaccari+ in prep.

Strong global evolution ….but different populations evolve very differently….





Gruppioni, Pozzi+13

II : Simple (not cosmological model)

Pozzi, Calura, Gruppioni+15

I) What we ask the model

To link what we observe in the IR (*SF-galaxies*) with the local dichotomy

SF-galaxies — *Early-type galaxies* **(Age ≥ 8-9 Gyrs, z_{form}≥1-1.5)**

- **Reproduce the IR observables (i.e. SFR)**
- **Reproduce the K-band observables (i.e. Stellar Mass)**
- **Reproduce the Mass down-sizing**

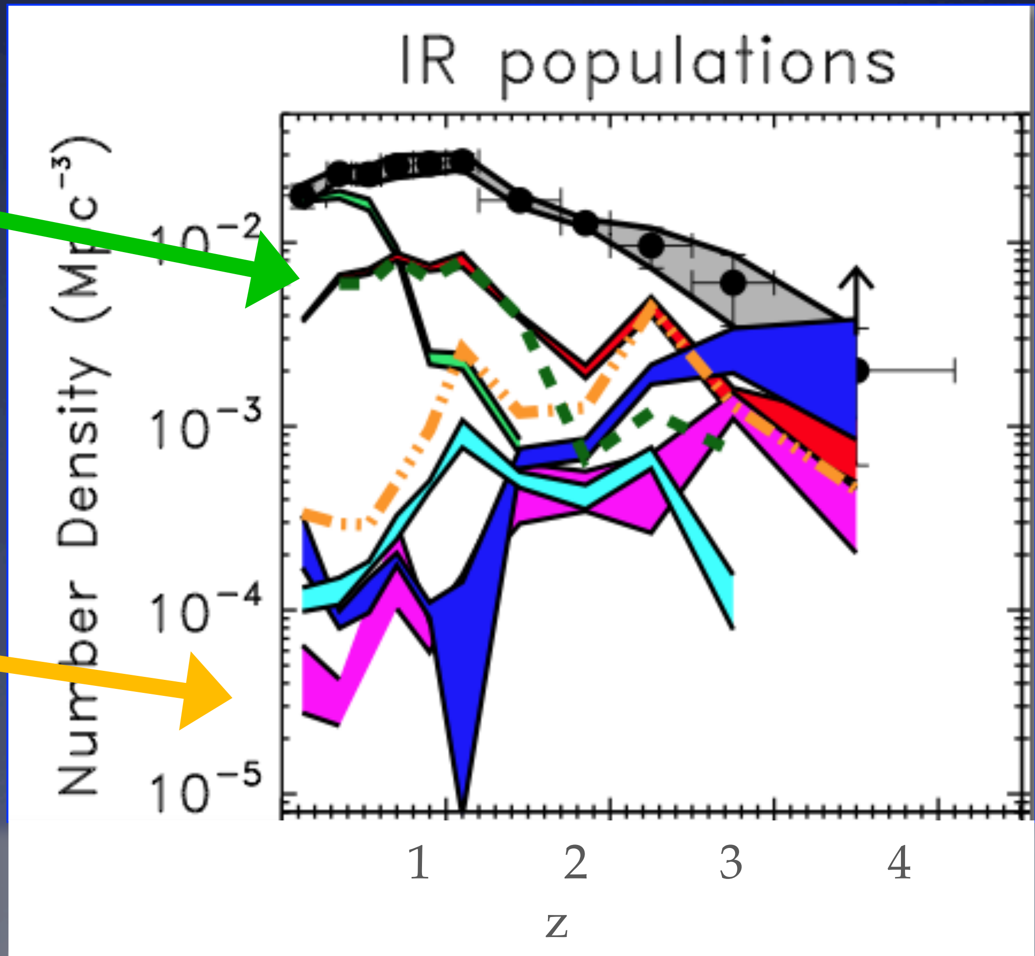
II) What IR sources should be considered as proto-spheroids ?

What Herschel sources are potentially proto-spheroids ?

Population of IR sources that decline in number

Non proto-spheroids
Spiral,
SFR-AGN (gal)

Proto-spheroids
SFR-AGN(SB)
Starburst
AGN1 AGN2



II : Simple (not cosmological) model

Phenomenological Hybrid model

Pozzi, Calura, Gruppioni+15

Phenomenological hybrid model
the statistics of spheroidal galaxies are determined purely on a phenomenological basis.

Late-type Galaxies

Backward model based

LF (z) : LLF(z=0)+evol($\varphi^{\star}$, $L^{\star}$)

SED(z): from best-fit SED

(see see also *LeBorgne+09, Valiante+09, Franceschini+10, Gruppioni+11*)

Proto-spheroid galaxies

Physical modeling (*Calura+08*)

Evolution with time of the SED

Proto-spheroids model

Simple chemical monolithic model from *Calura+08* (see Matteucci 1994, Larson 1976)

Rapid collapse of a homogeneous sphere of gas

Main model properties

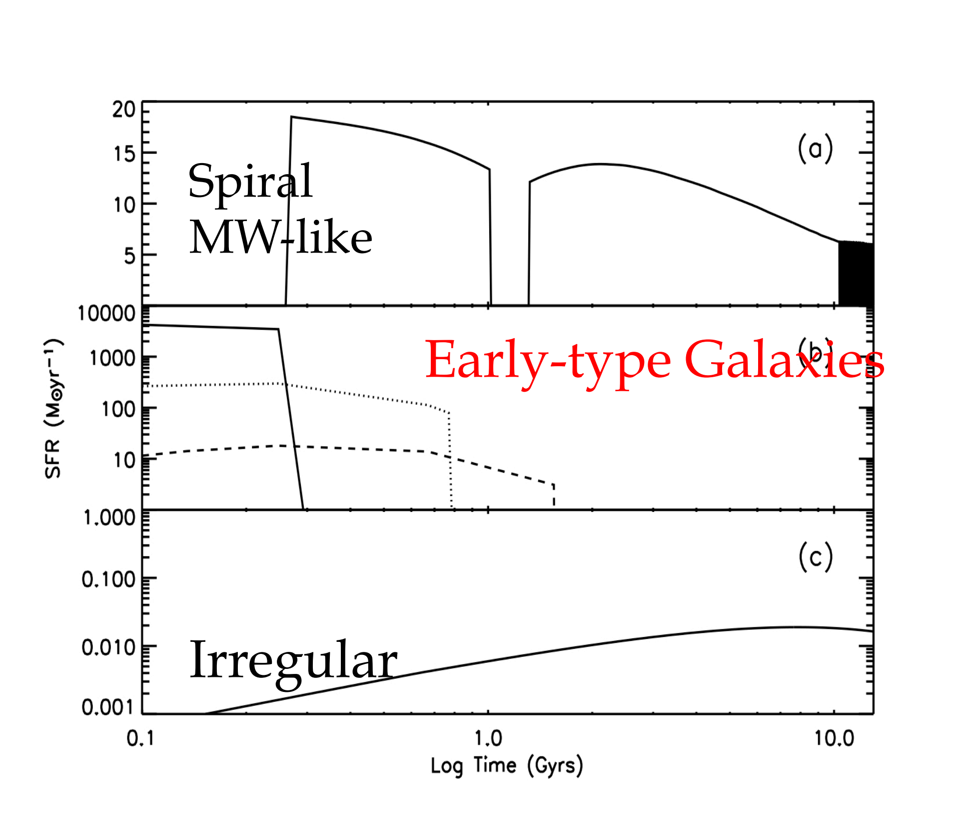
➢ *Calibrated against local chemistry of early-type galaxies*

➢*In comparison to 'standard' chemical model*
- Dust/gas ratio **evolves**
- Dust composition evolves

➢Star-formation halted by stellar winds and SNe explosions.

No feedback from AGN

Galactic SF histories



Proto-spheroids model

Chemical model *(Calura+08)*

\+ Interfaced

Spectro-photometry including dust
GRASIL *(Silva+98)*

↓

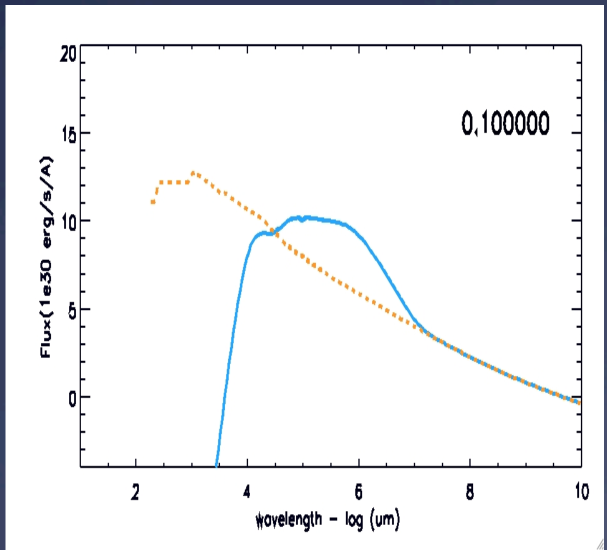
Evolution of SED from optical to IR as a function of time

Proto-spheroids model

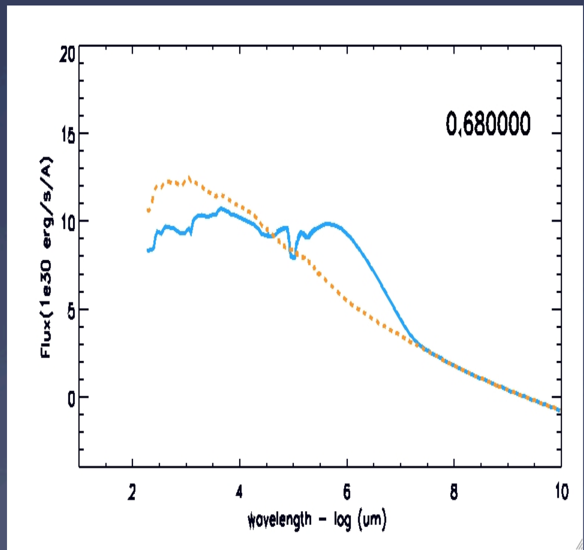
Unextincted composite Stellar Pop

Extincted composite stellar Pop+dust

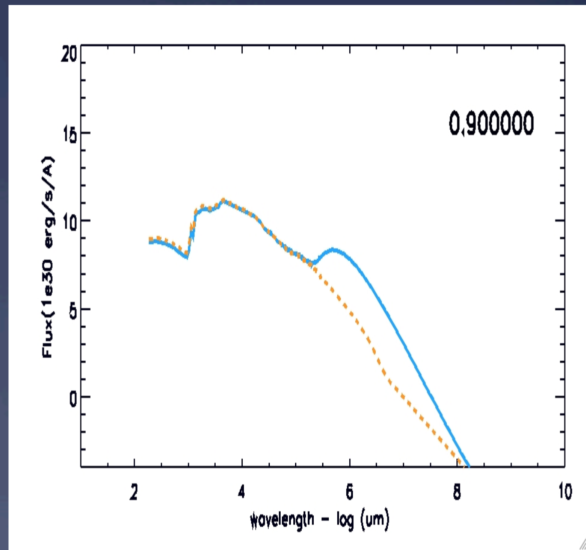
0.1 Gyrs



0.68 Gyrs



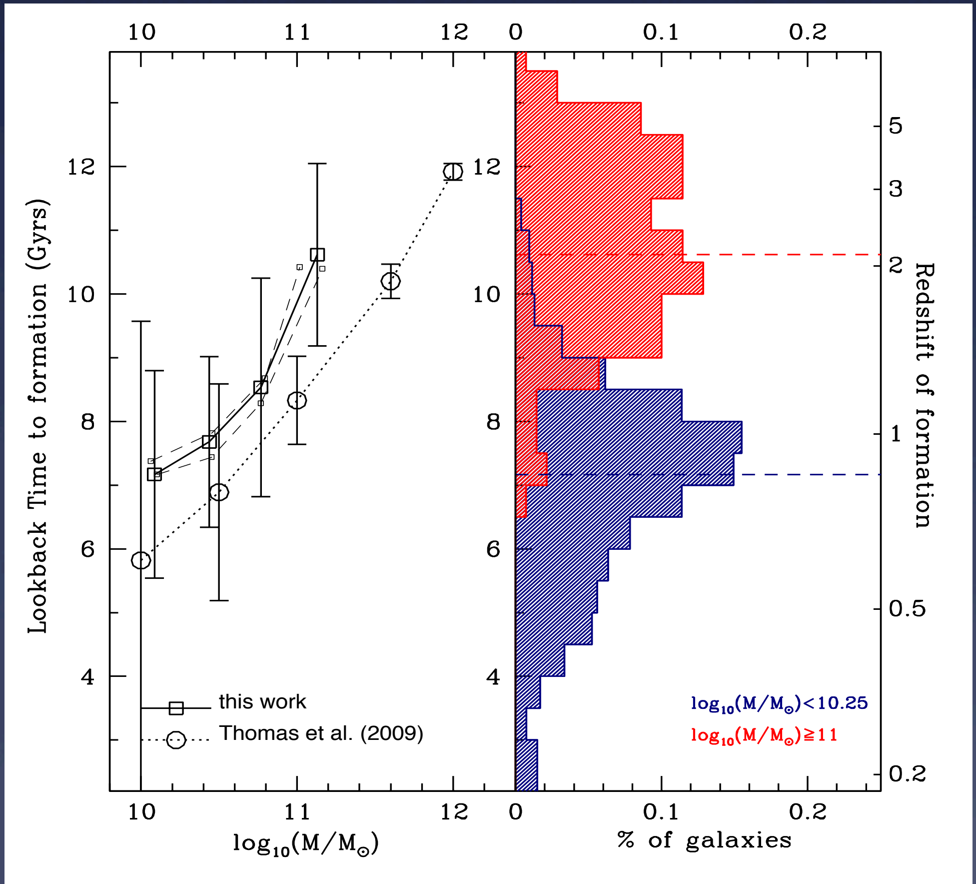
0.9 Gyrs



Calura+08

➢ proto-spheroids at which z did they form?

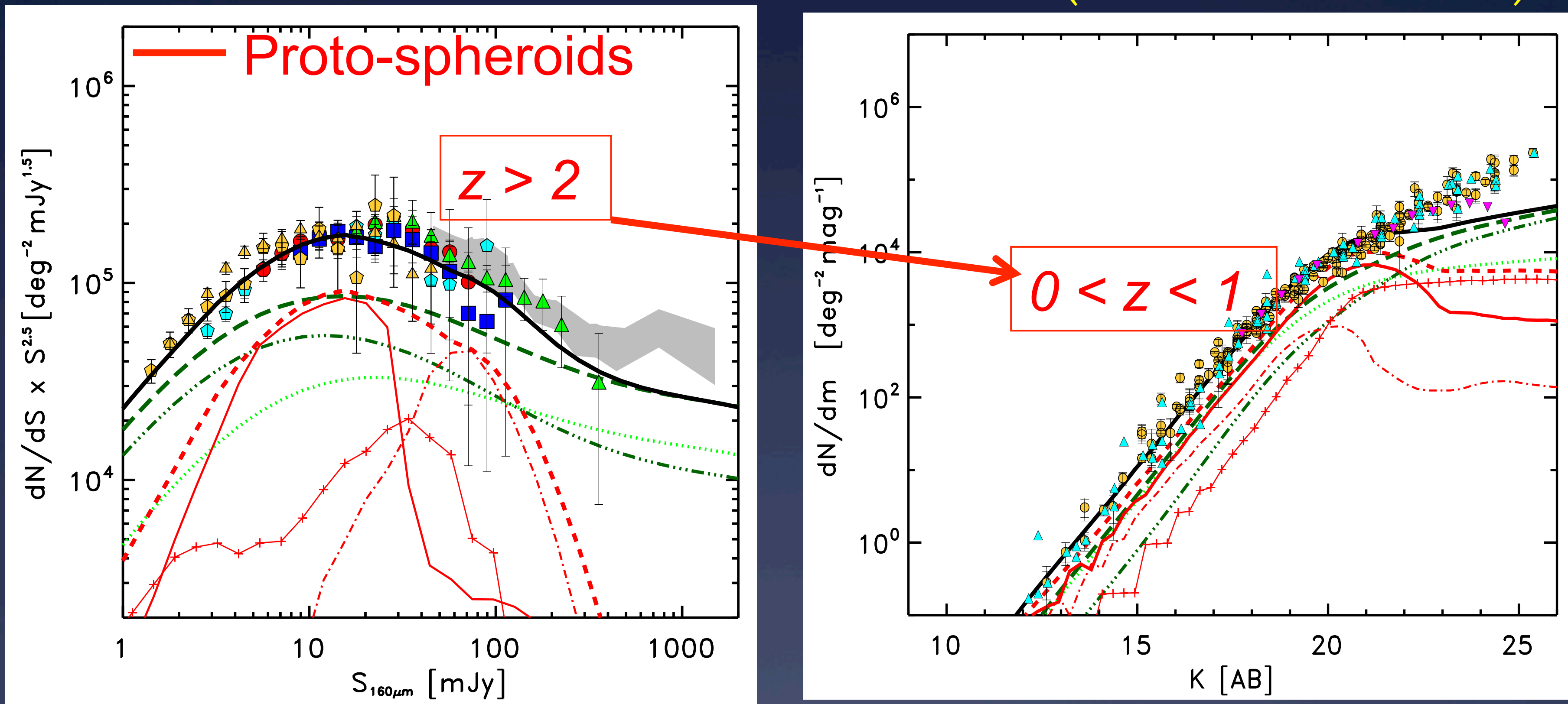
Implemented the mass downsizing



Moresco, Pozzetti,Cimatti+10

Results

HERSCHEL –IR (i.e. SFR) K-band (i.e. stellar mass)



The results obtained in this case confirm the validity of our approach, i.e., *the IR-selected galaxies at z > 2 are progenitors of local spheroids caught during their formation*

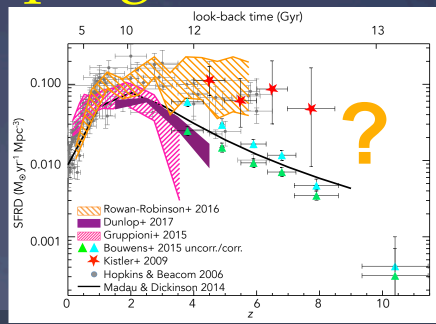
Pozzi, Calura, Gruppioni+15

What have we learnt ?

- Backward model: **Spheroids modeled by means of the chemical model from Calura+08.** *Reproduced IR sources up to z ~4. The Herschel galaxies at z > 2 are progenitors of local spheroids caught during their formation.*

Doubts on the dominant role of mergers in driving the star-formation (see also Lapi+11, Mancuso+16) - observation of systems with regular kinematics @ z~2 (Förster Schreiber et al. 09)

AGN-feedback is not the major process in shaping the bulk of the galaxy populations



- Future: SPICA mission

SPICA: the next generation Infrared Space Telescope

- ESA-lead mission with large JAXA partecipation
- PI SPICA Europe: P.Roelfsema
- 2.5 m telescope
- 12 - 230 μm spectroscopy

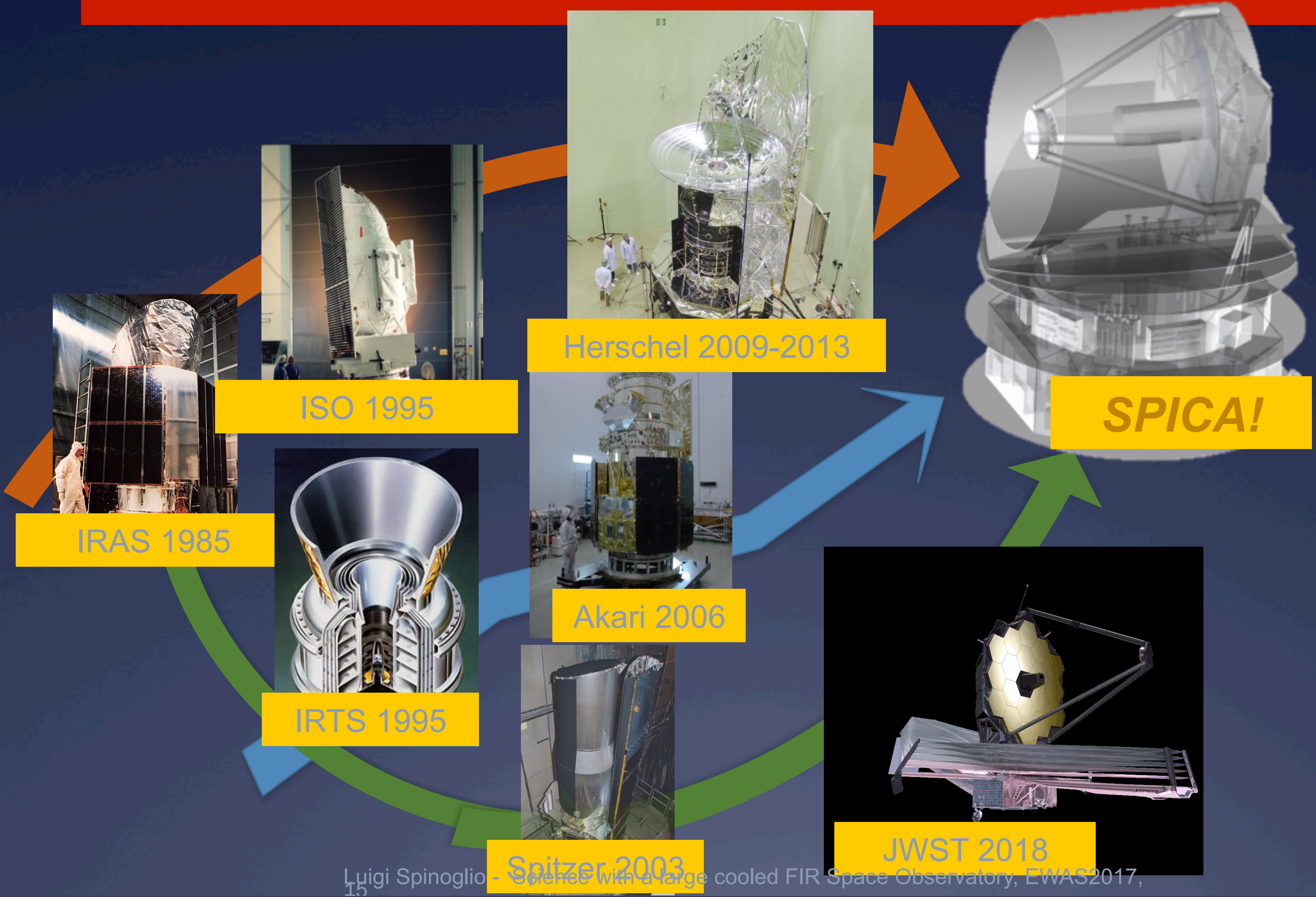
  MIR imaging spectroscopy SMI

  FIR spectroscopy SAFARI

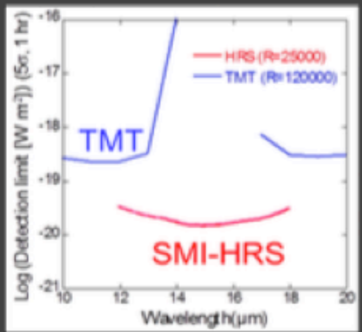
  FIR imaging polarimetry
- Launch: ~2030

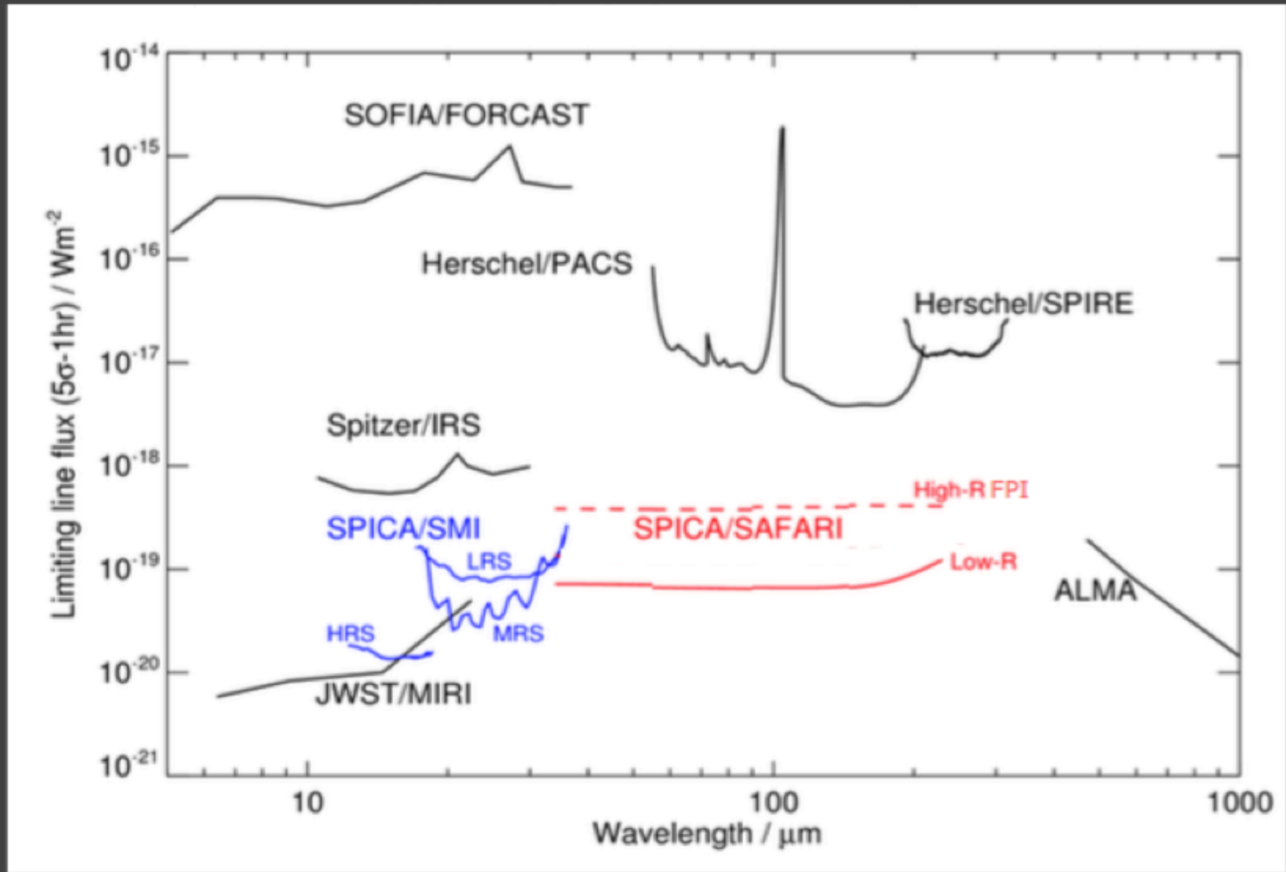
Selected by ESA as M5 candidate !!

Infrared Space Observatories



SPICA's sensitivity; making a huge leap forward!





Raw sensitivity improvement **>2 orders** of magnitude
Instantaneous full spectra → huge step in efficiency

SAFARI

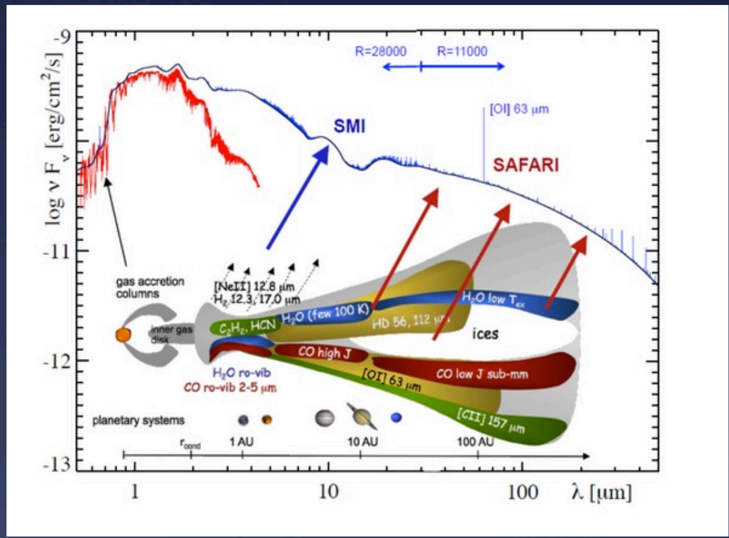
JWST / MIRI vs. SPICA / SMI: FoV: ~1'x2' vs. ~10'x10'

Main science drivers for SPICA

See white papers on PASA journal late 2017

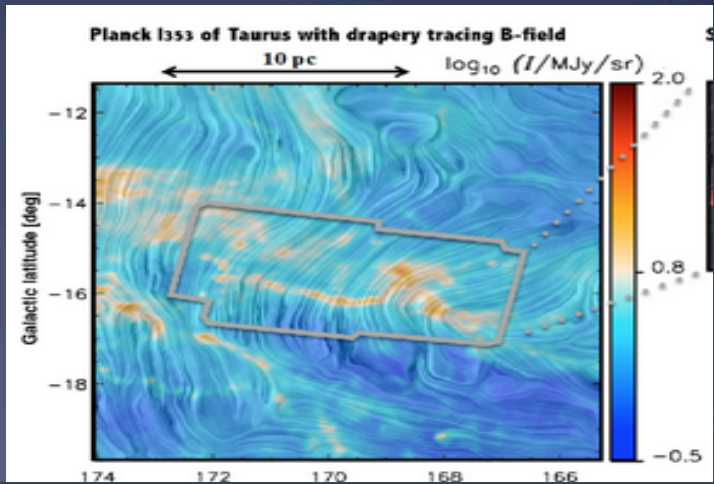
1) **Proto-planetary Disk Evolution**

How do planets evolve from proto-planetary disks to habitable worlds?

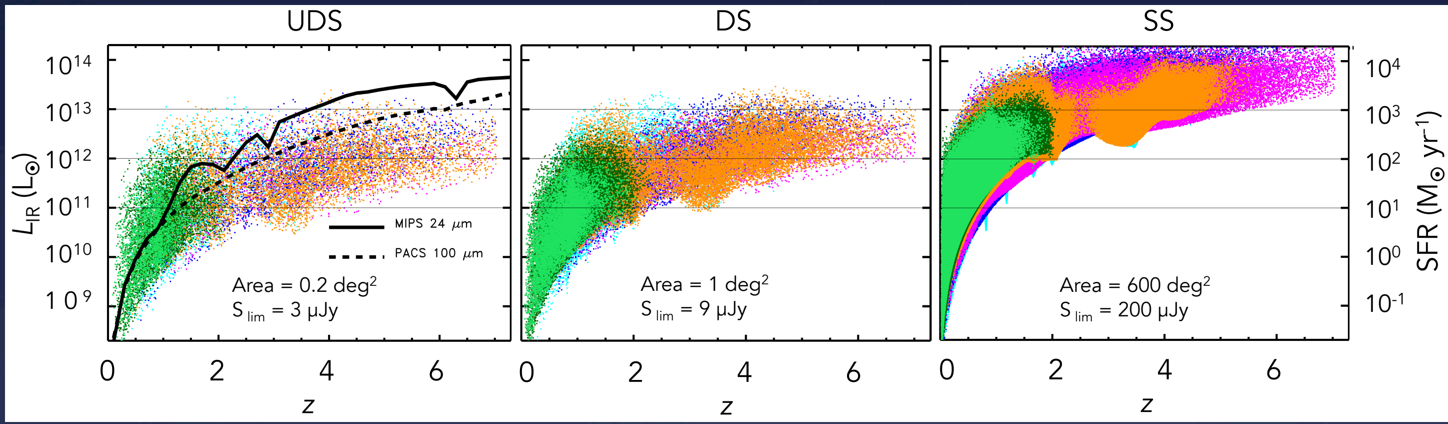


2) Unraveling magnetic fields and turbulence in the star formation process.

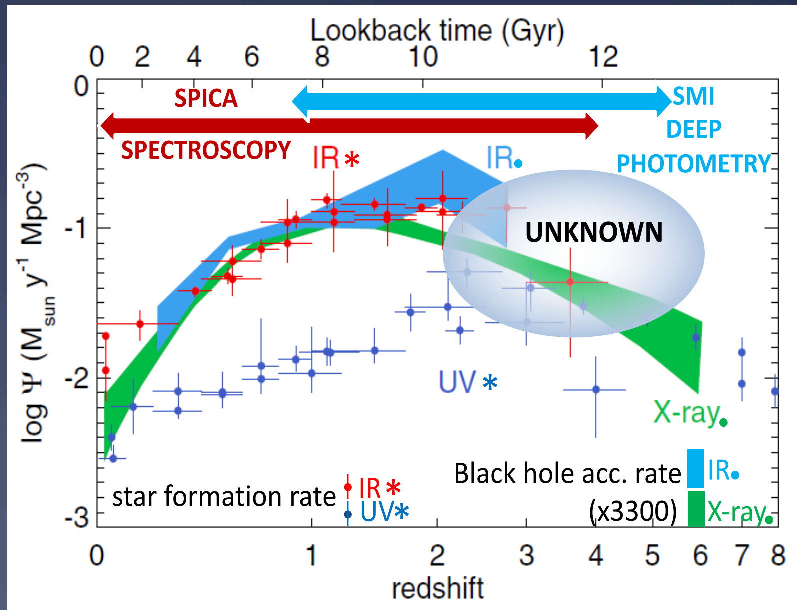
They must be important agents in the formation of structure in the ISM



3) Which processes regulate the growth of galaxies and blackholes? What is the history of metal and dust production over the age of the Universe?



Gruppioni et al.2017
using extrapolation from *Pozzi et al. 2015*



Spinoglio et al. 2017

Summary

➢Importance of IR cosmological surveys to uncover the dusty/obscured star-formation

➢Herschel heritage:

LF : Strong evolution of up to z~4.
Reproduced by means of a models composed by late type galaxies and proto-spheroids that takes into account the SED evolution (chemical model of Calura et al. 2008)

➢ Next IR SPICA mission

SFRD up to z~6,7