RECOVERING THE DUST MASS BUDGET WITH PRIMA

Alberto Traina

Main collaborators: F. Pozzi, F. Calura, M. Costa, L. Bisigello, C. Gruppioni, L. Barchiesi, I. Delvecchio, L. Vallini, C. Vignali, V. Casasola

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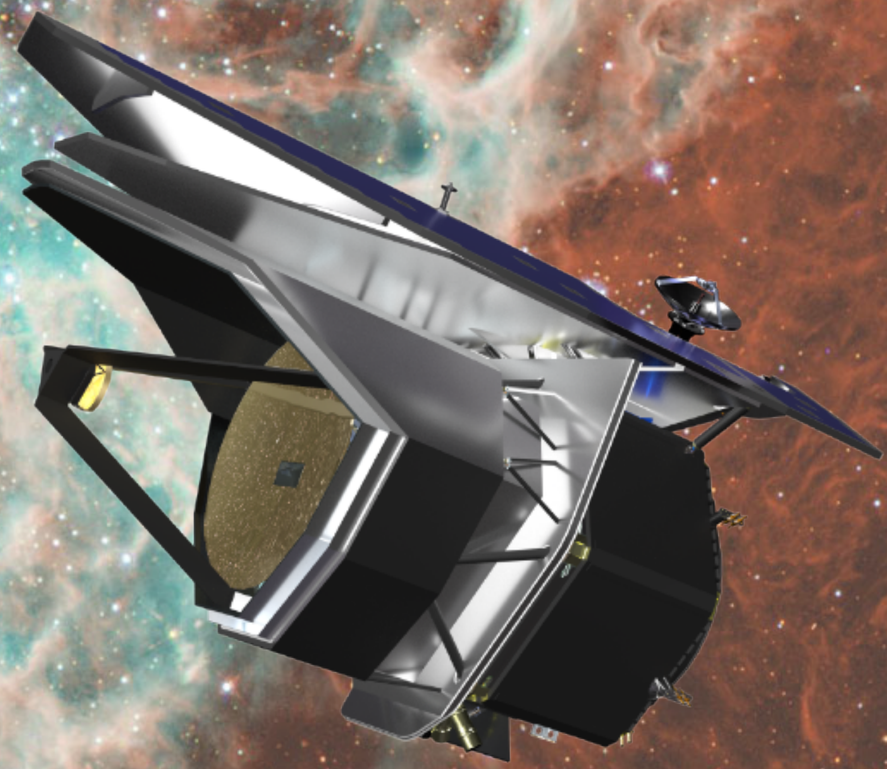

Outline of the talk

- Dust mass budget: where do we stand today

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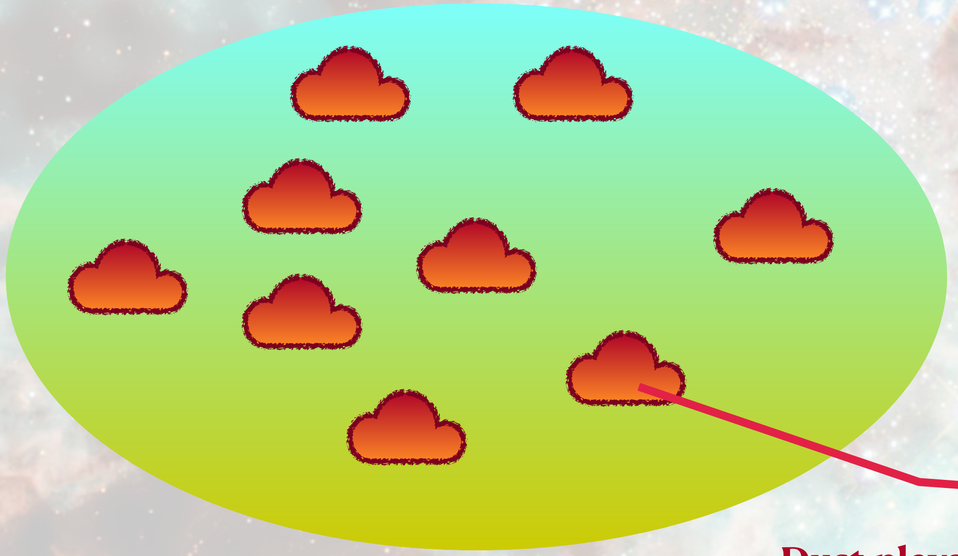
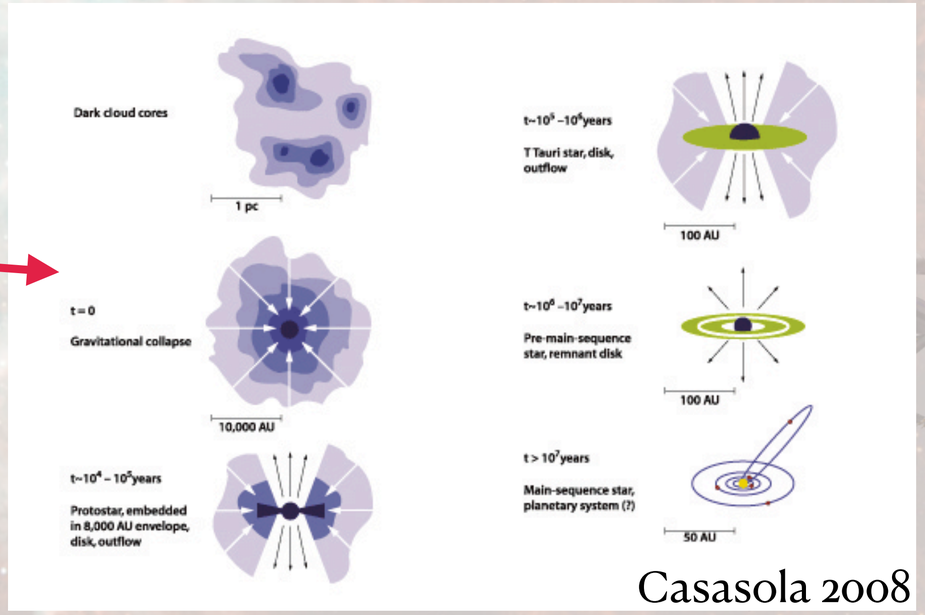
- Dust mass budget: where do we stand today
- The need for PRIMA
- Predictions on the dust mass and DMF with PRIMAger

Dust mass budget in galaxies



Dust plays a fundamental role in favoring the formation of new stars

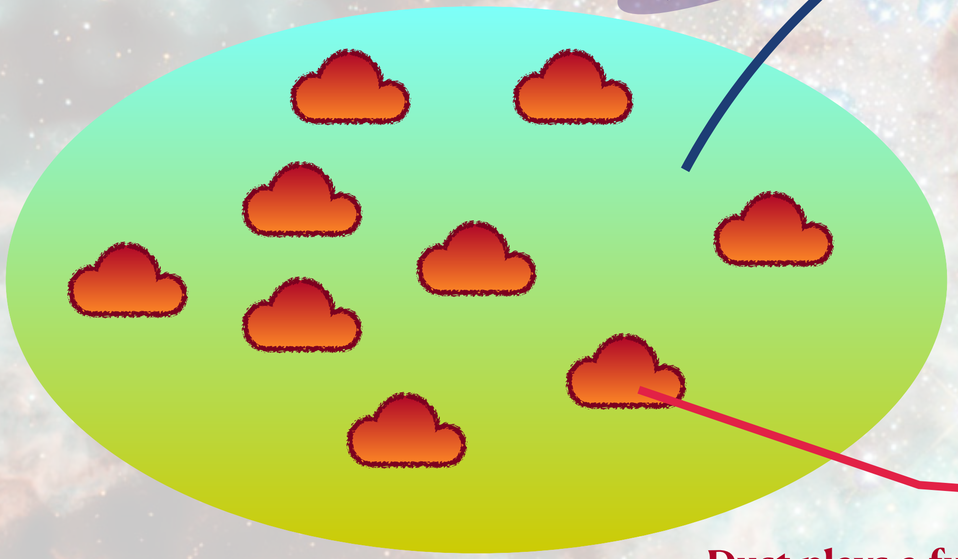


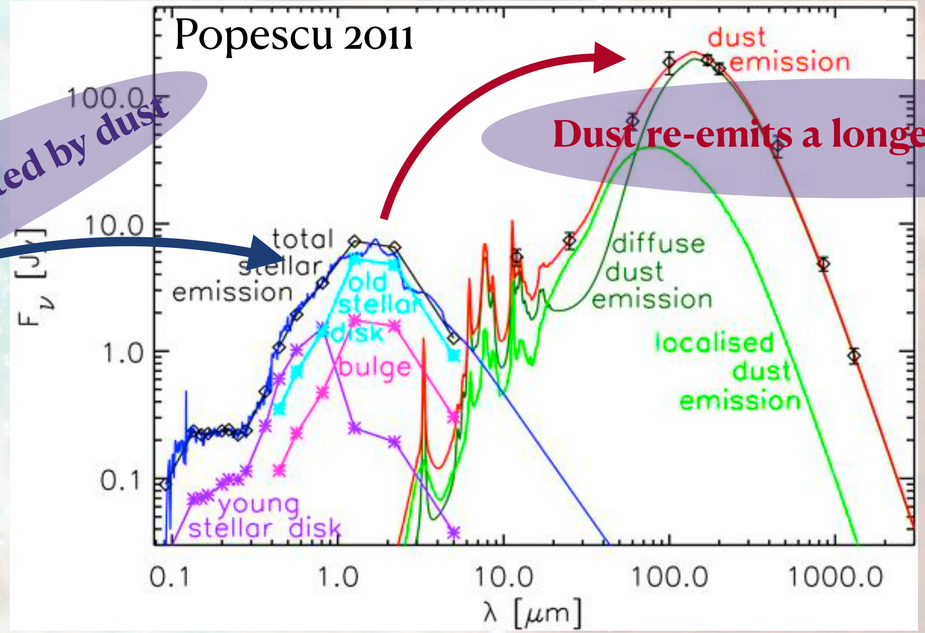
Casasola 2008

See I. Shivaei overwiev on the dust properties

Dust mass budget in galaxies

Emission from stars is attenuated by dust





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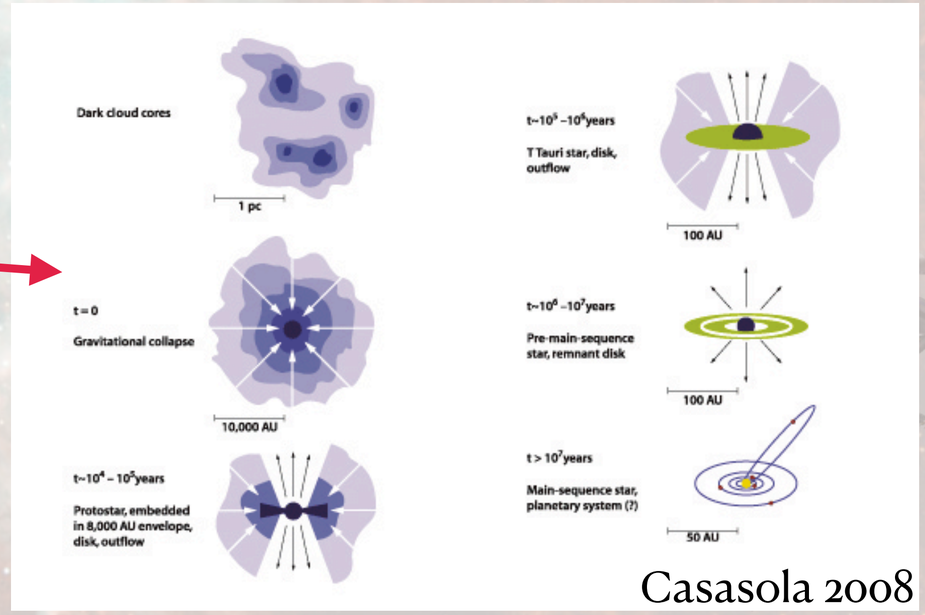
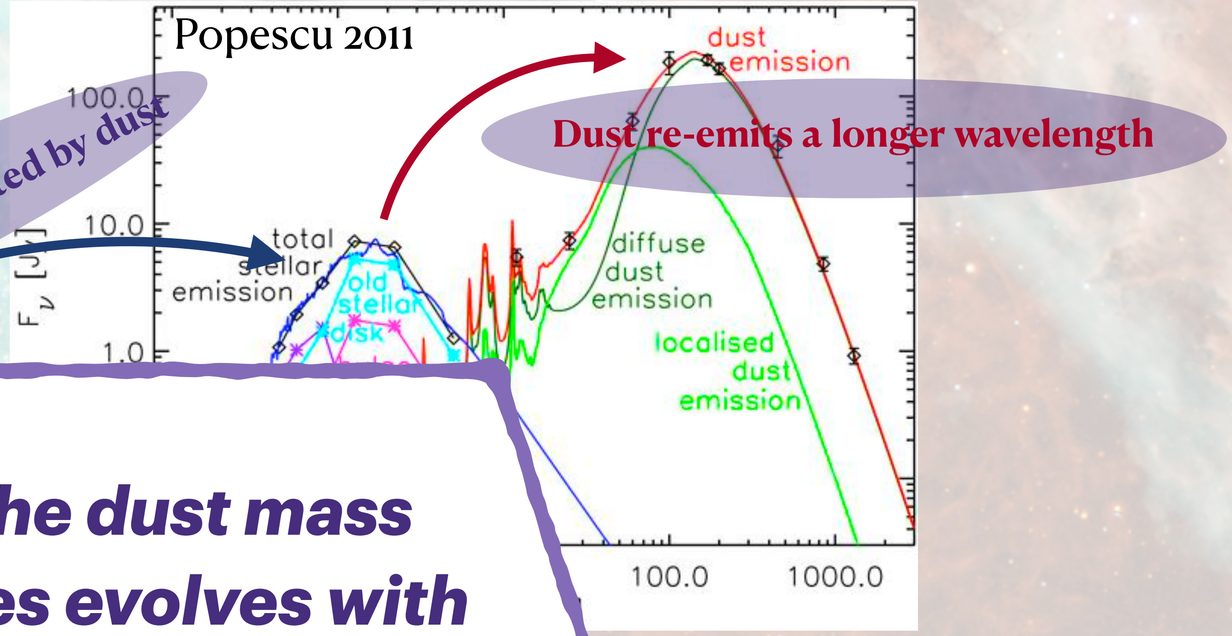


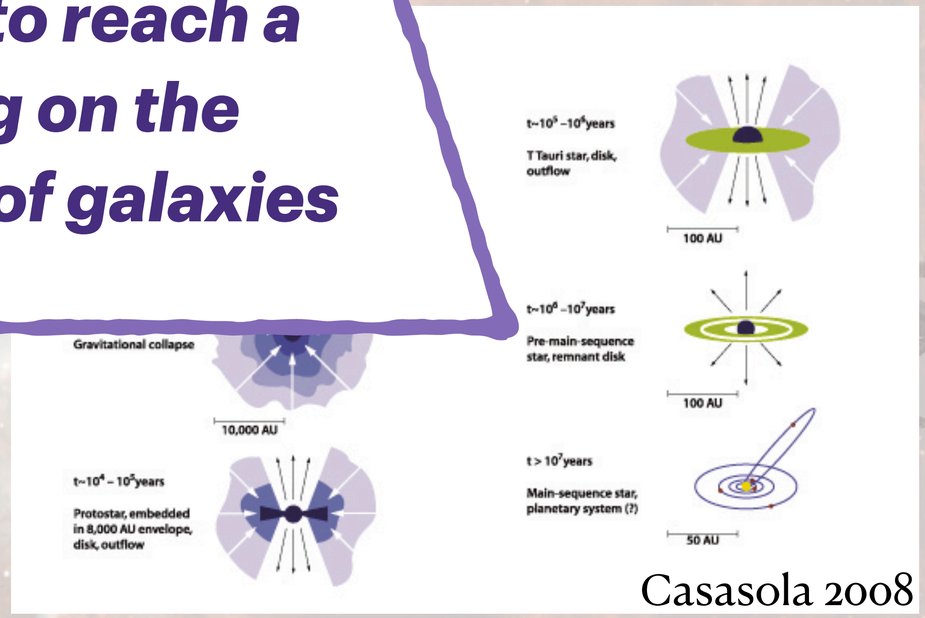
Casasola 2008

Dust mass budget in galaxies



Studying how the dust mass budget of galaxies evolves with cosmic times is crucial to reach a deeper understanding on the formation and evolution of galaxies

role in favoring the formation of new stars



Casasola 2008

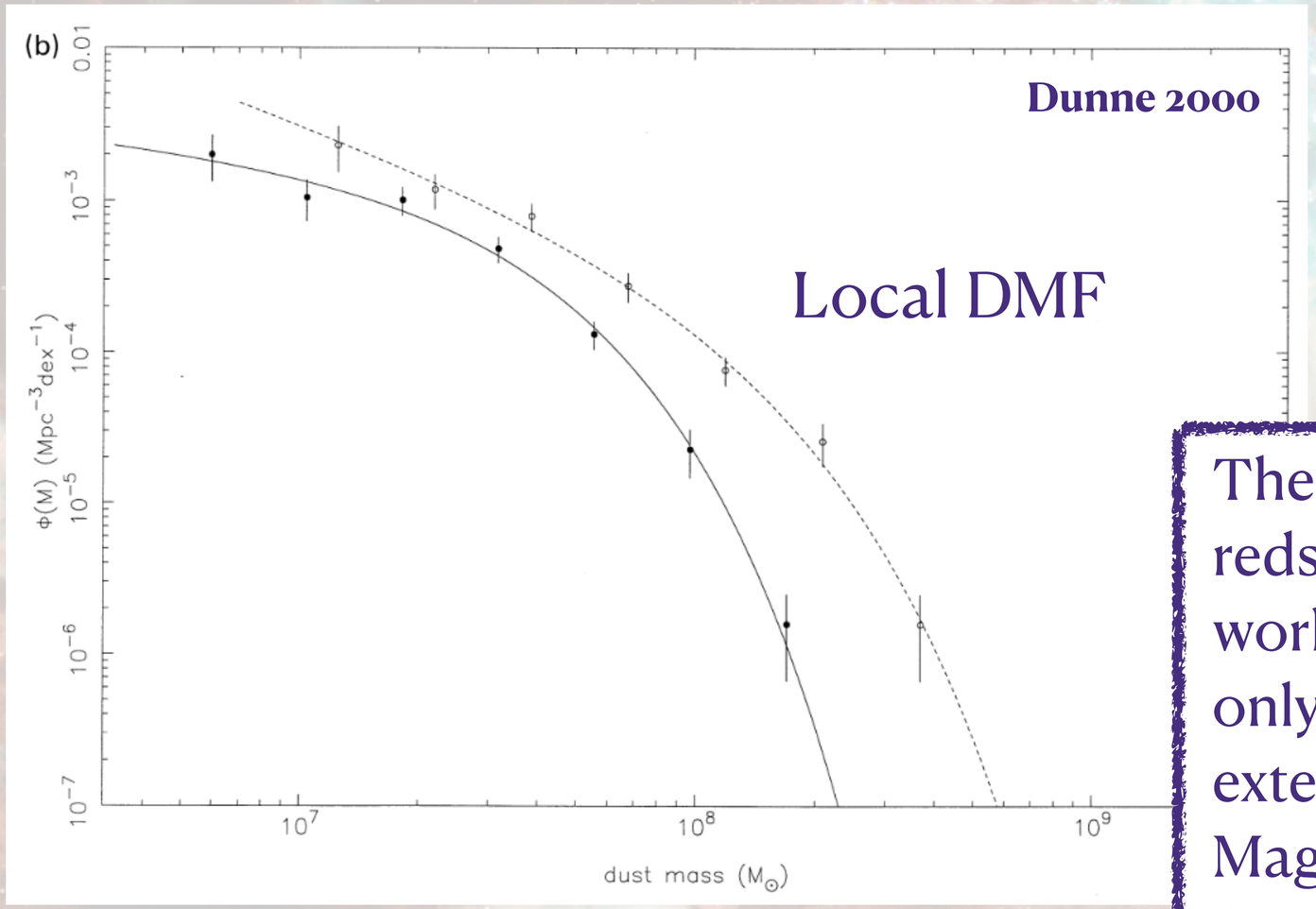
Dust mass budget in galaxies: *evolution with time*

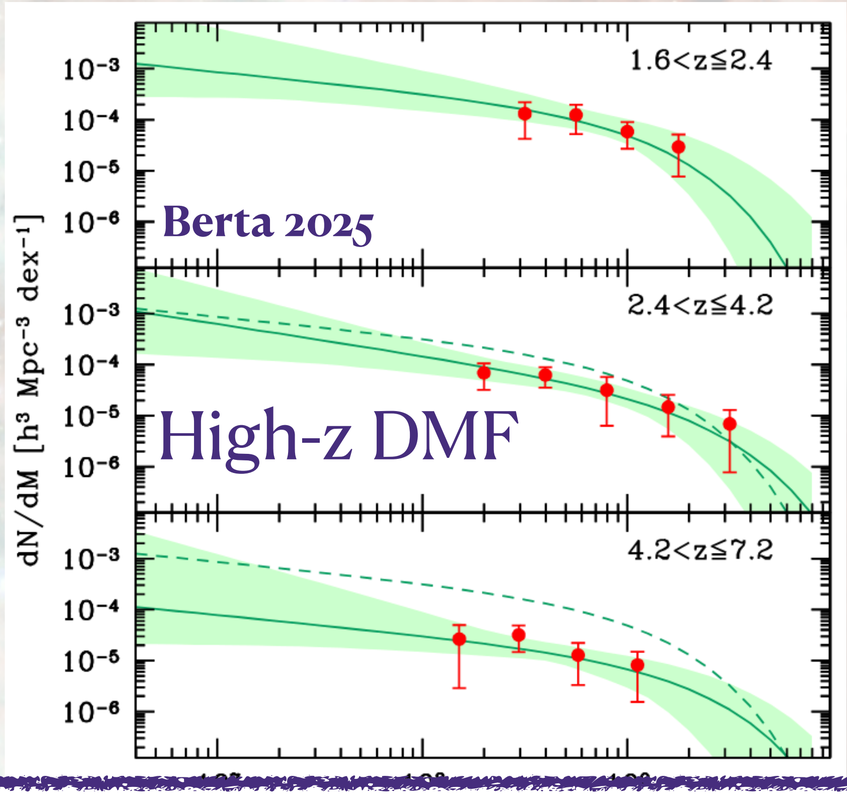
Studying how the dust mass budget of galaxies evolves with cosmic times is crucial to reach a deeper understanding on the formation and evolution of galaxies

The study of the dust properties and their evolution can be done statistically by deriving the ***dust mass function***

This give us informations on how many galaxies populate the Universe with a certain dust mass at a given redshift

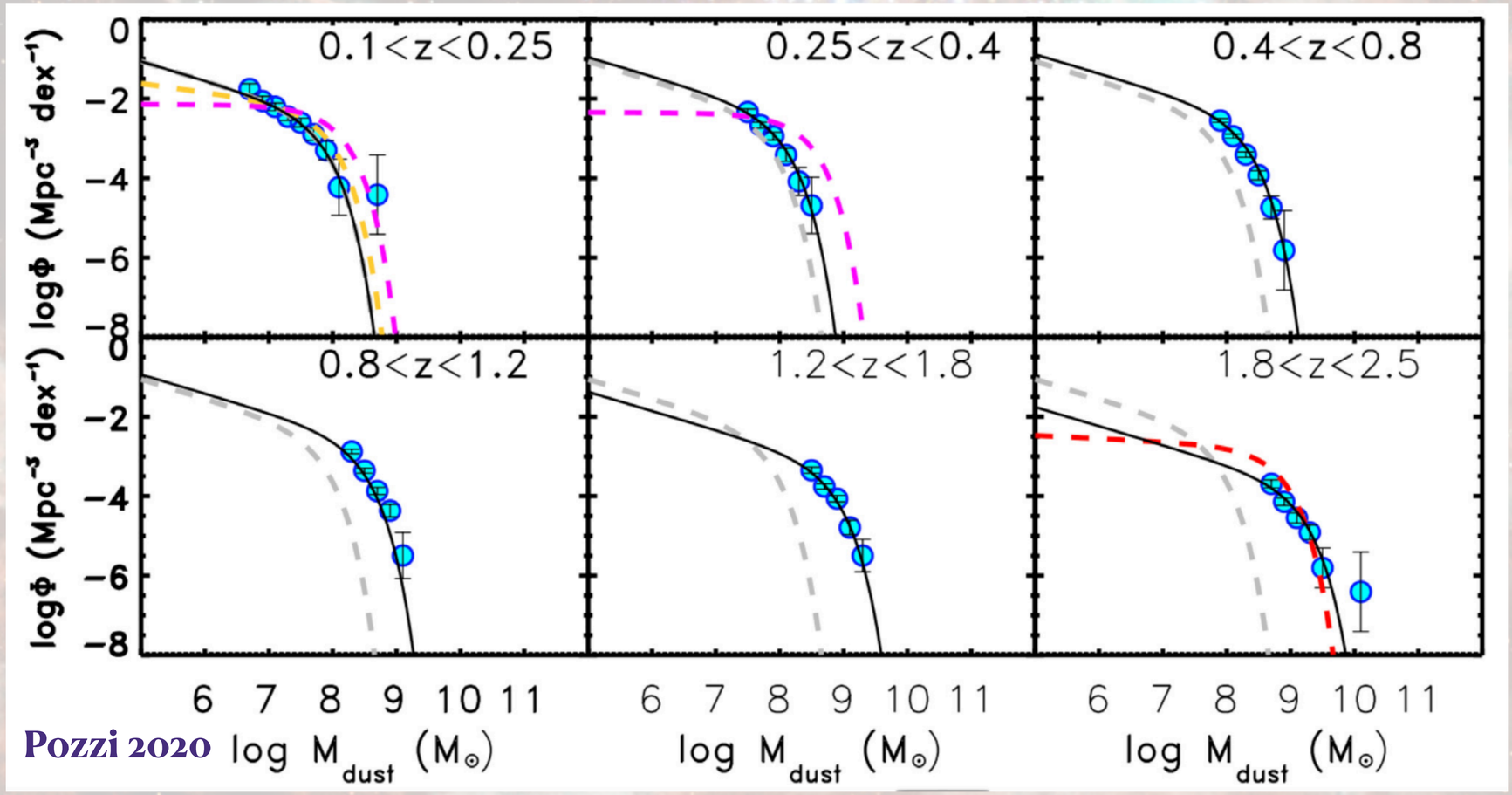
Dust mass budget in galaxies: *the DMF*





The DMF evolution in the local and low redshift Universe has been investigate by a few works (e.g., Dunne+ 2000, Pozzi+ 2020) and only in recent years its study has been extended to higher redshifts ($2.5 < z < 7$ e.g., Magnelli+ 2019, Pozzi+ 2021, Traina+ 2024, Berta+ 2025)

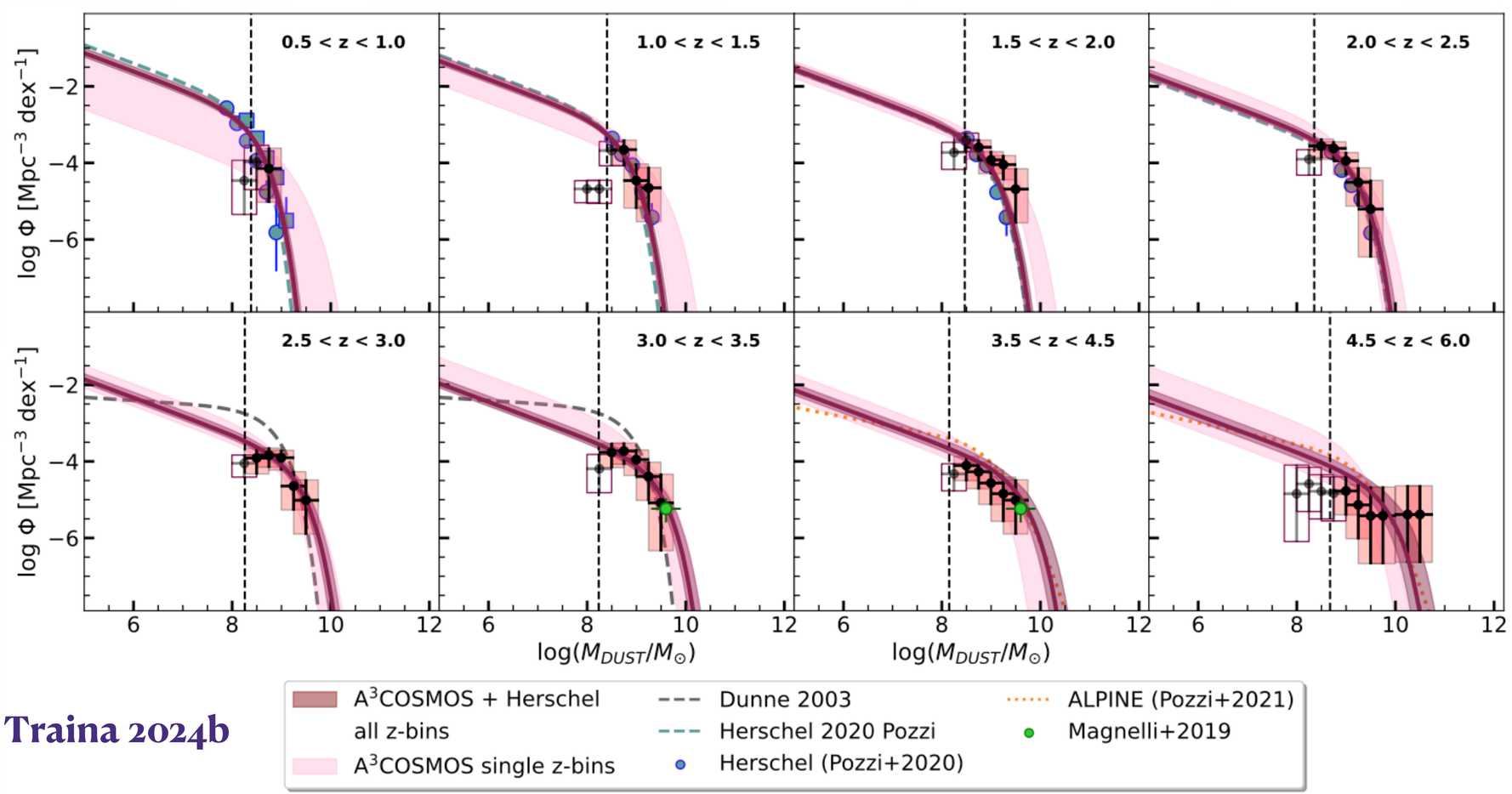
Dust mass budget in galaxies:
the DMF with Herschel



Pozzi 2020

Herschel was able to derive the DMF for a large sample of galaxies (~7000) but it is limited in resolution and sensitivity

Dust mass budget in galaxies:
the DMF with ALMA

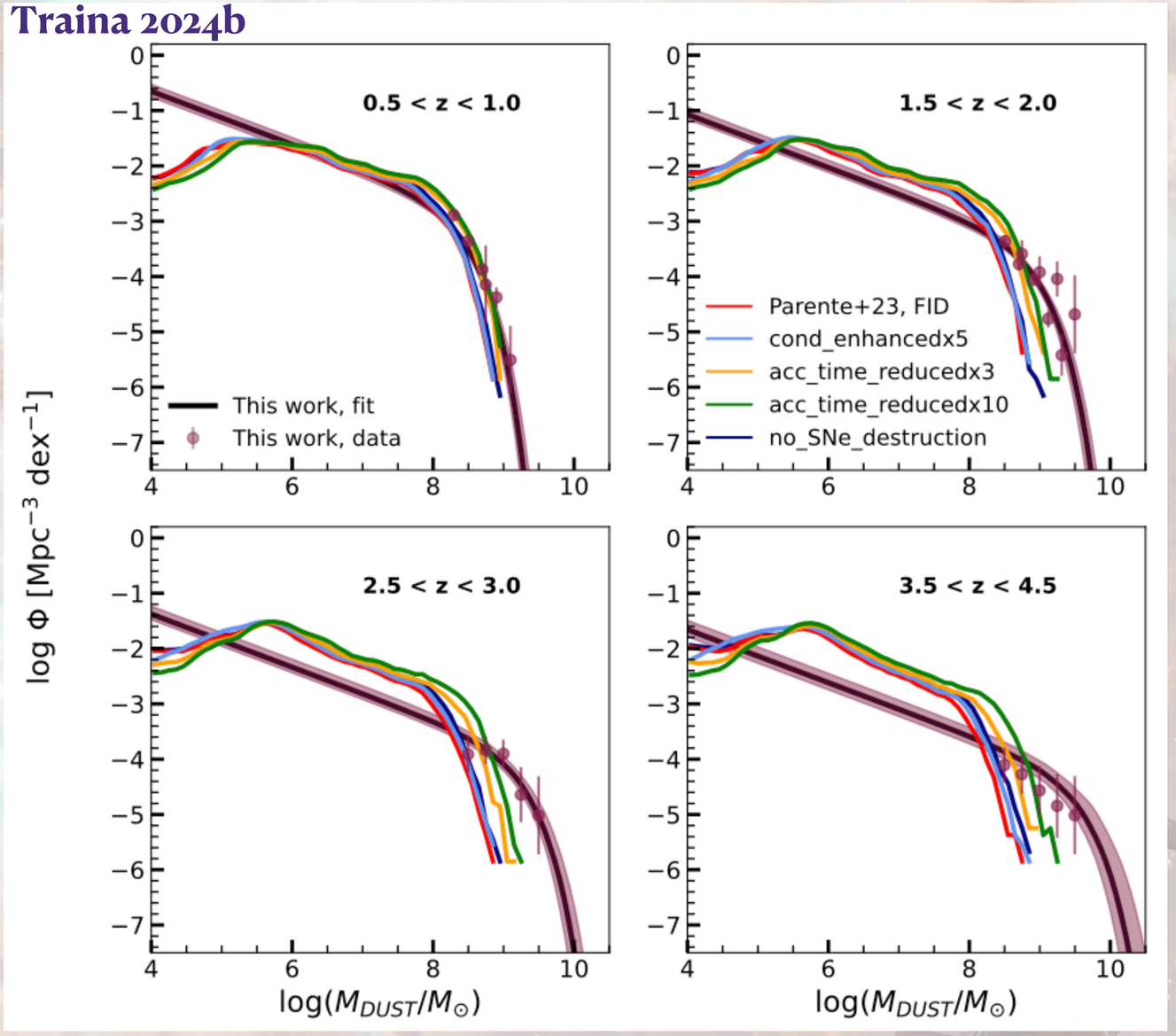


Traina 2024b

ALMA can measure dust masses at much higher redshifts, but it is limited to small samples (e.g., < 200 galaxies in the A3COSMOS)

Dust mass budget in galaxies: *the DMF from simulations*

Studies on the predicted DMF from simulations show that it hardly reproduces observed data ➠ something in our knowledge on the dust production and evolution may still be missing



Deep surveys on large sky areas are required to reduce the uncertainties and detect the faintest galaxies

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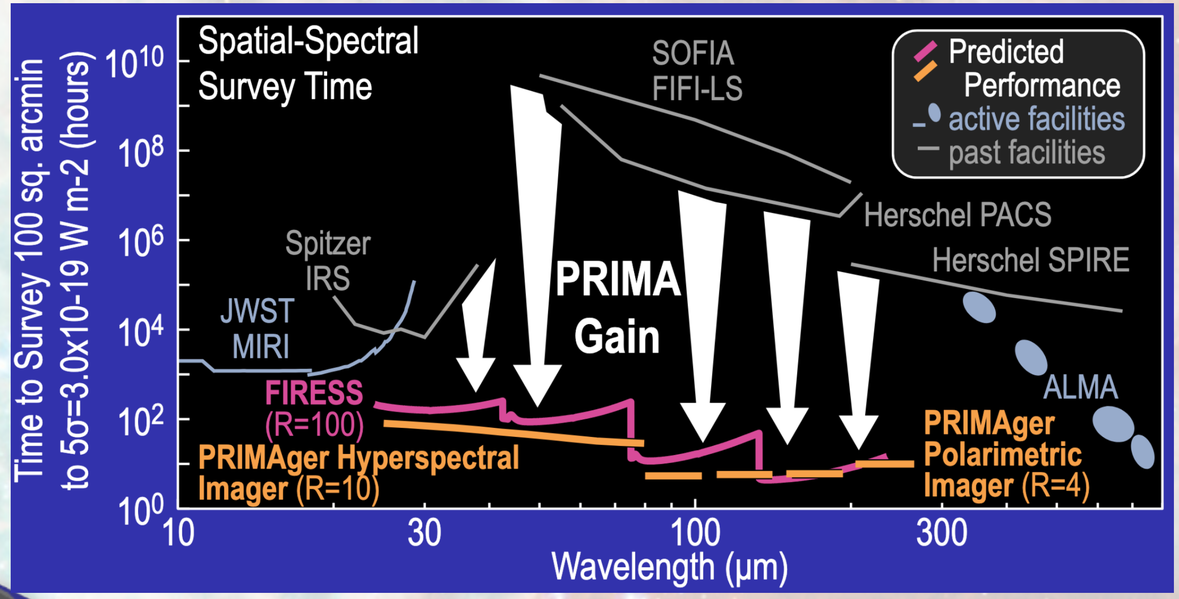
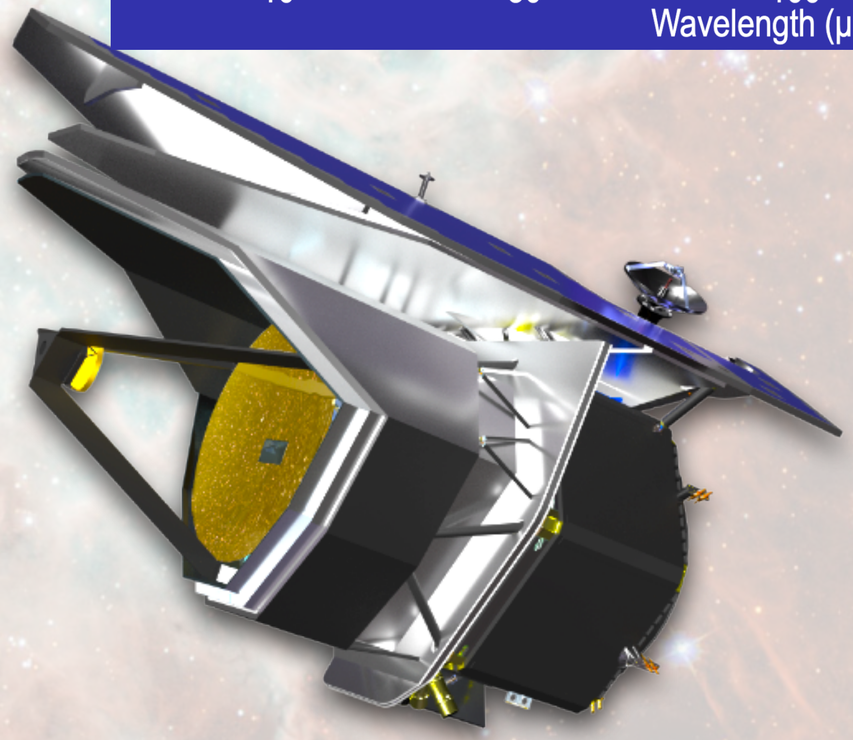


The PRobe far-Infrared Mission for Astrophysics (**PRIMA**) will allow us to perform deep IR surveys for large sky areas

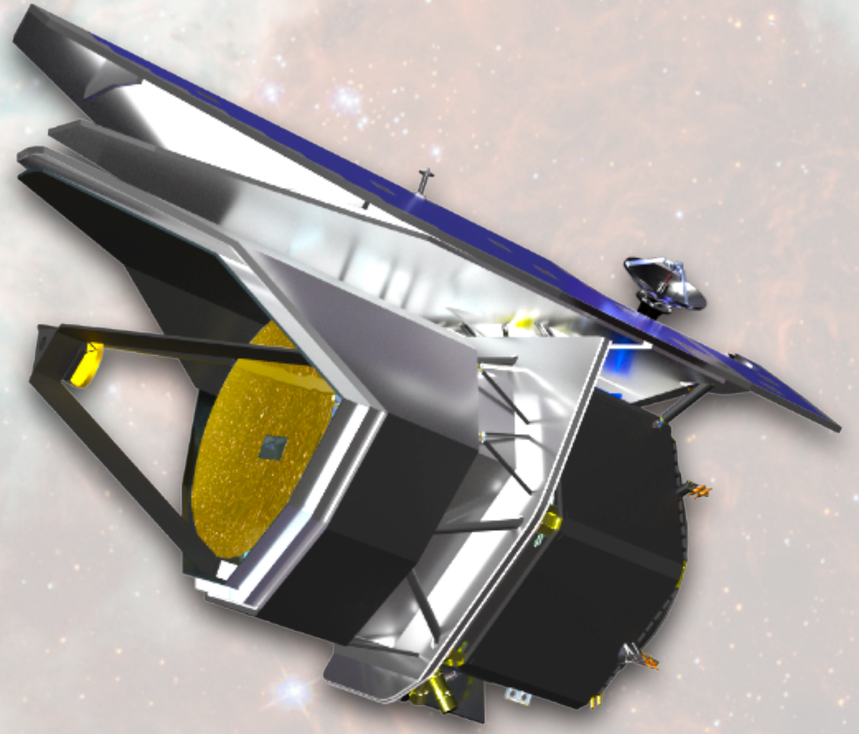


See yesterday PRIMA overview talk by A. Pope

Deep surveys on large sky areas are required to reduce the uncertainties and detect the faintest galaxies

PRIMA will allow us to perform deep IR surveys for large sky areas

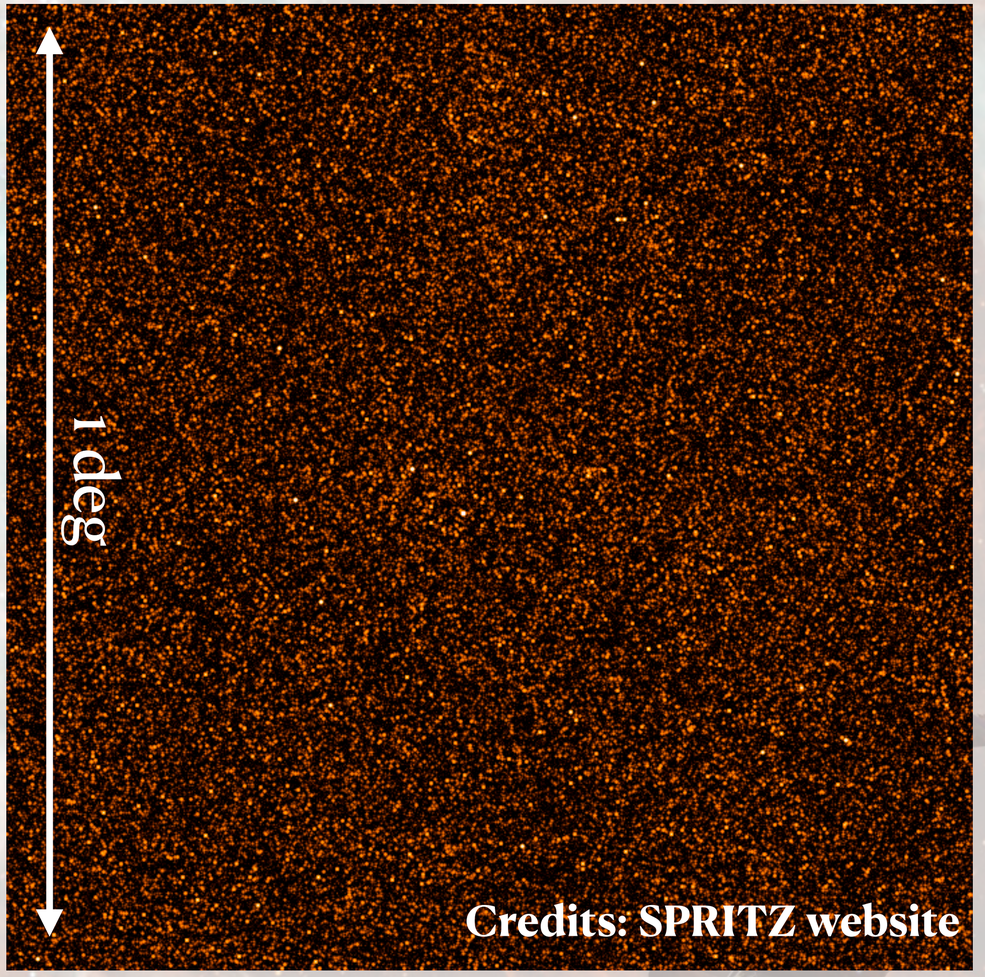
- 1000hr survey on 1 deg^2
- Sensitivity of 0.2 mJy at 60 μm (we consider the PHI2 filter as our “detection” filter to overcome confusion)
- SPRITZ simulation (Bisigello+ 2021) to predict the DMF with PRIMA



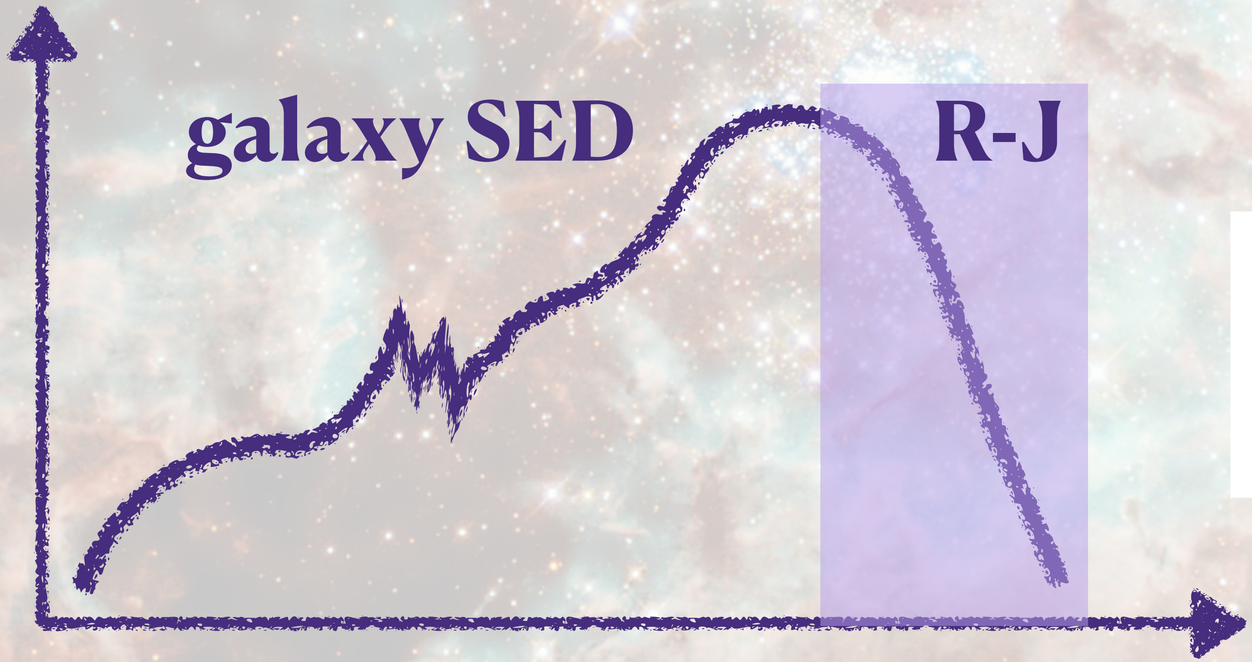
DMF with PRIMA: *the SPRITZ simulation (Bisigello+ 2021)*

- Phenomenological models based on the *Herschel* IR-LF (Gruppioni+ 2013)
- Catalogs of simulated SED with PRIMA photometry (considering >30 templates)
- >**44000** galaxies above detection limit in 1000hr survey on 1 deg^2

The IR sky with SPRITZ



DMF with PRIMA:
dust mass estimation



- R-J part of the SED
- Optically thin regime assumption

Magnelli 2020

$$M_{\rm dust} = \frac{5.03 \times 10^{-31} \cdot S_{\nu_{\rm obs}} \cdot D_{\rm L}^2}{(1+z)^4 \cdot B_{\nu_{\rm obs}}(T_{\rm obs}) \cdot \kappa_{\nu_0}} \cdot \left(\frac{\nu_0}{\nu_{\rm rest}}\right)^{\beta}$$

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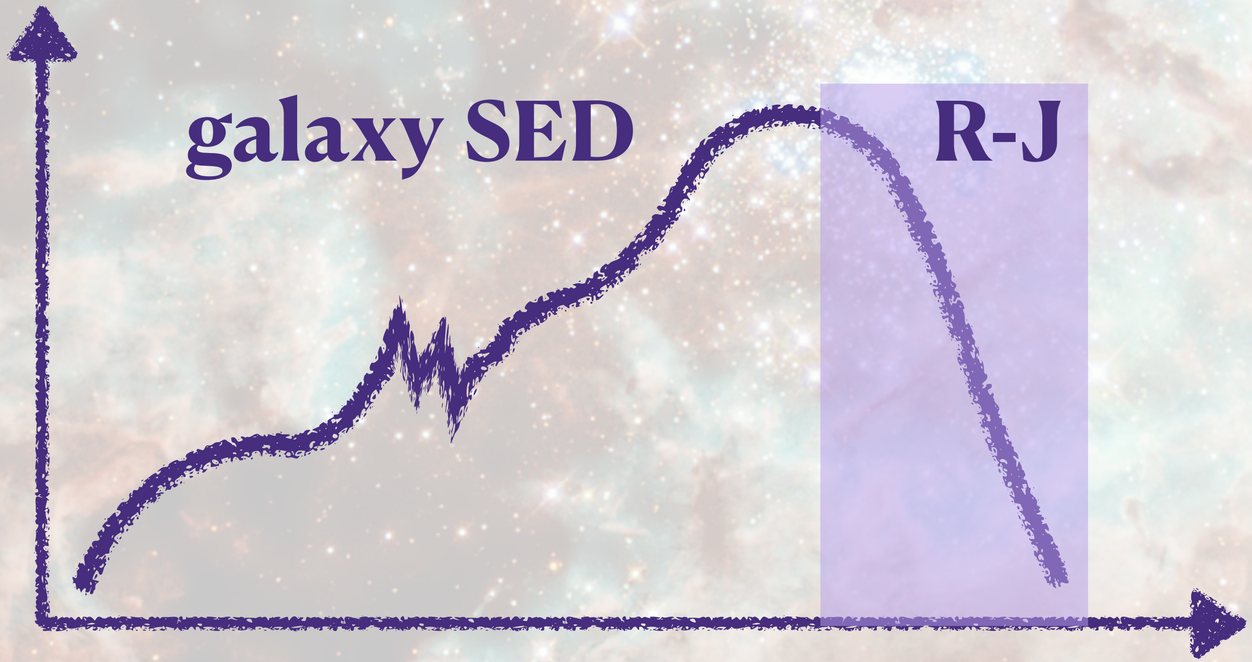

Magnelli 2014

$$T_{\rm DUST} \propto (1+z) \times log(sSFR)$$

The flux must be in the R-J to be measured the cold component (which represent the bulk) of the dust mass in a galaxy

DMF with PRIMA: *dust mass estimation*

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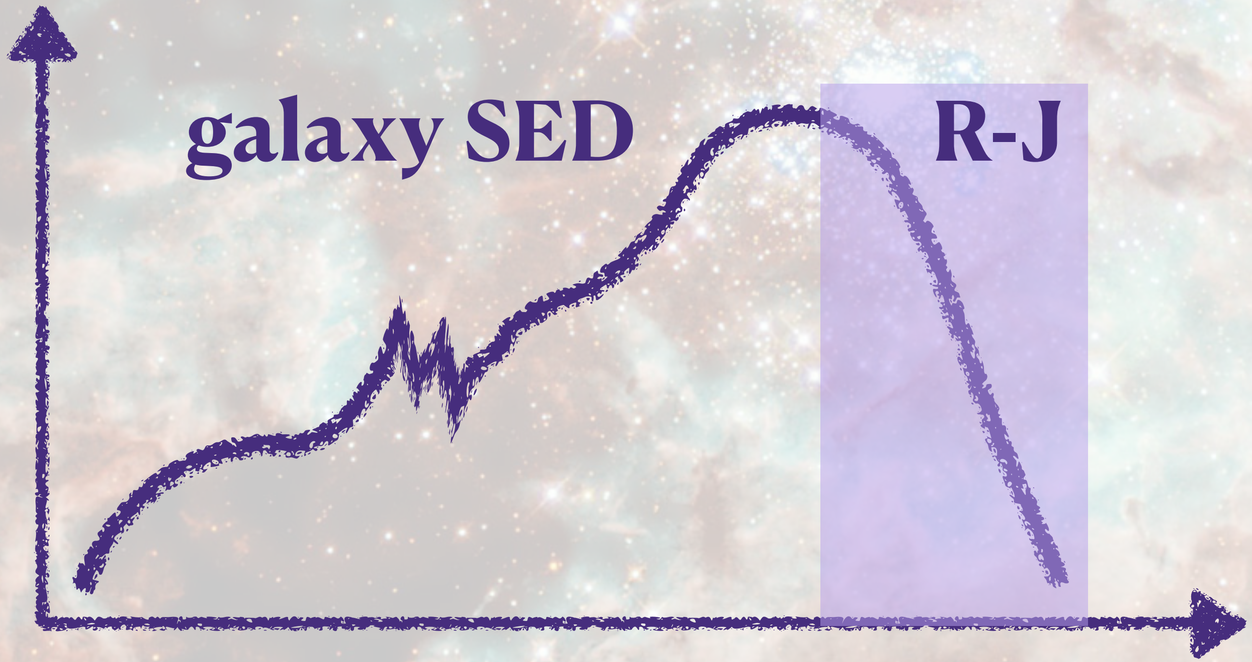

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See the next talk by F. Pozzi on the dust temperature with PRIMA!

DMF with PRIMA:
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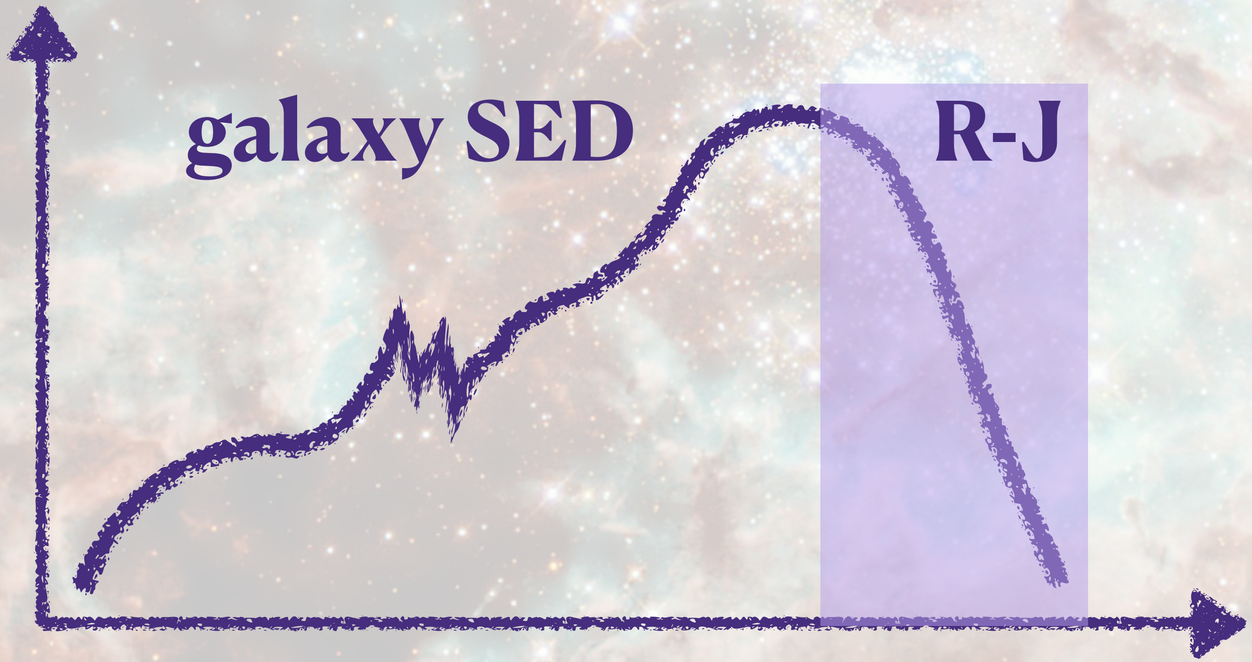
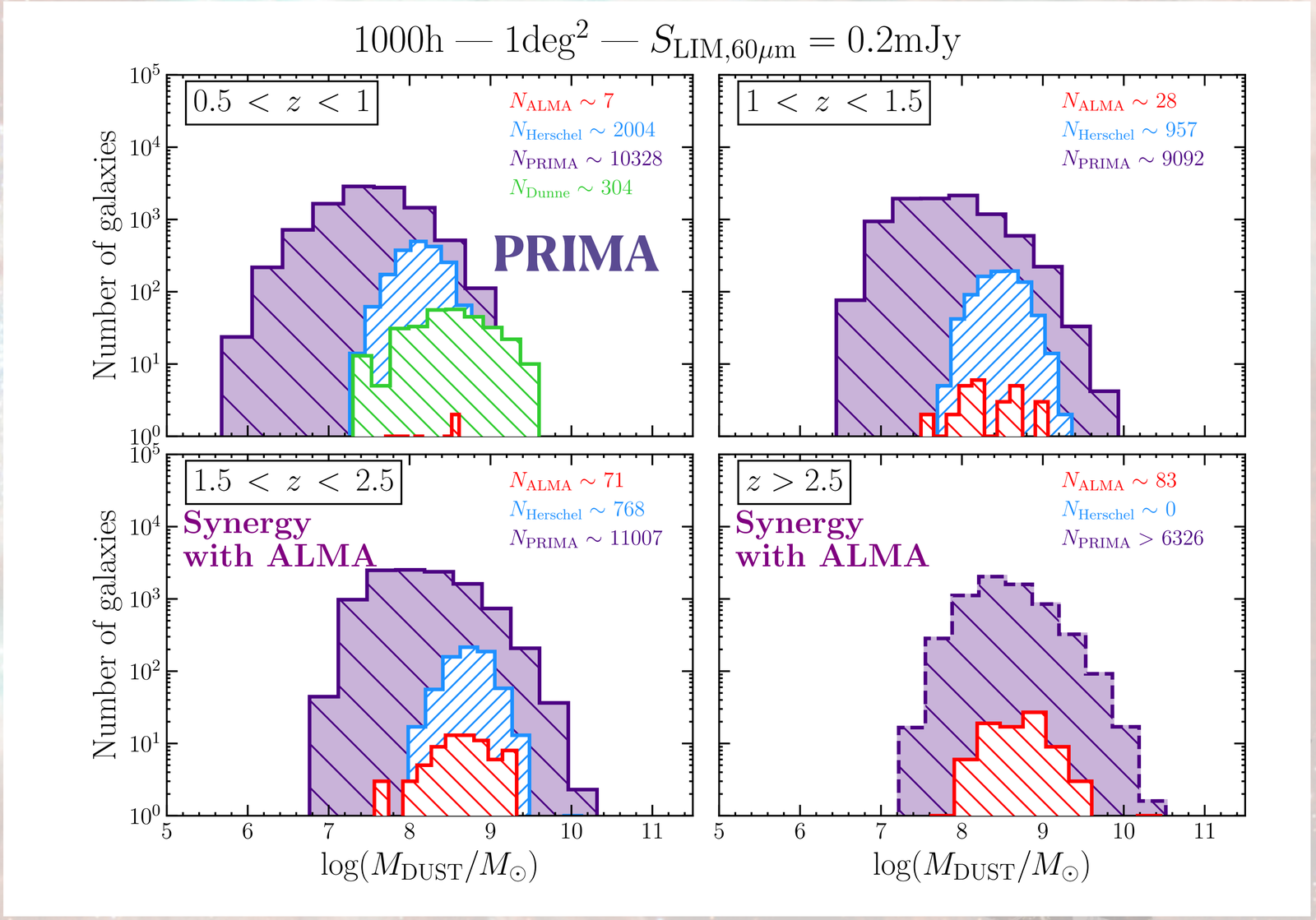


We use PRIMA observed fluxes at 235 μm up to z ~ 1.5 - 2 and the extrapolated SED at higher redshift

DMF with PRIMA: *dust mass estimation*

Traina subm. - JATIS special issue

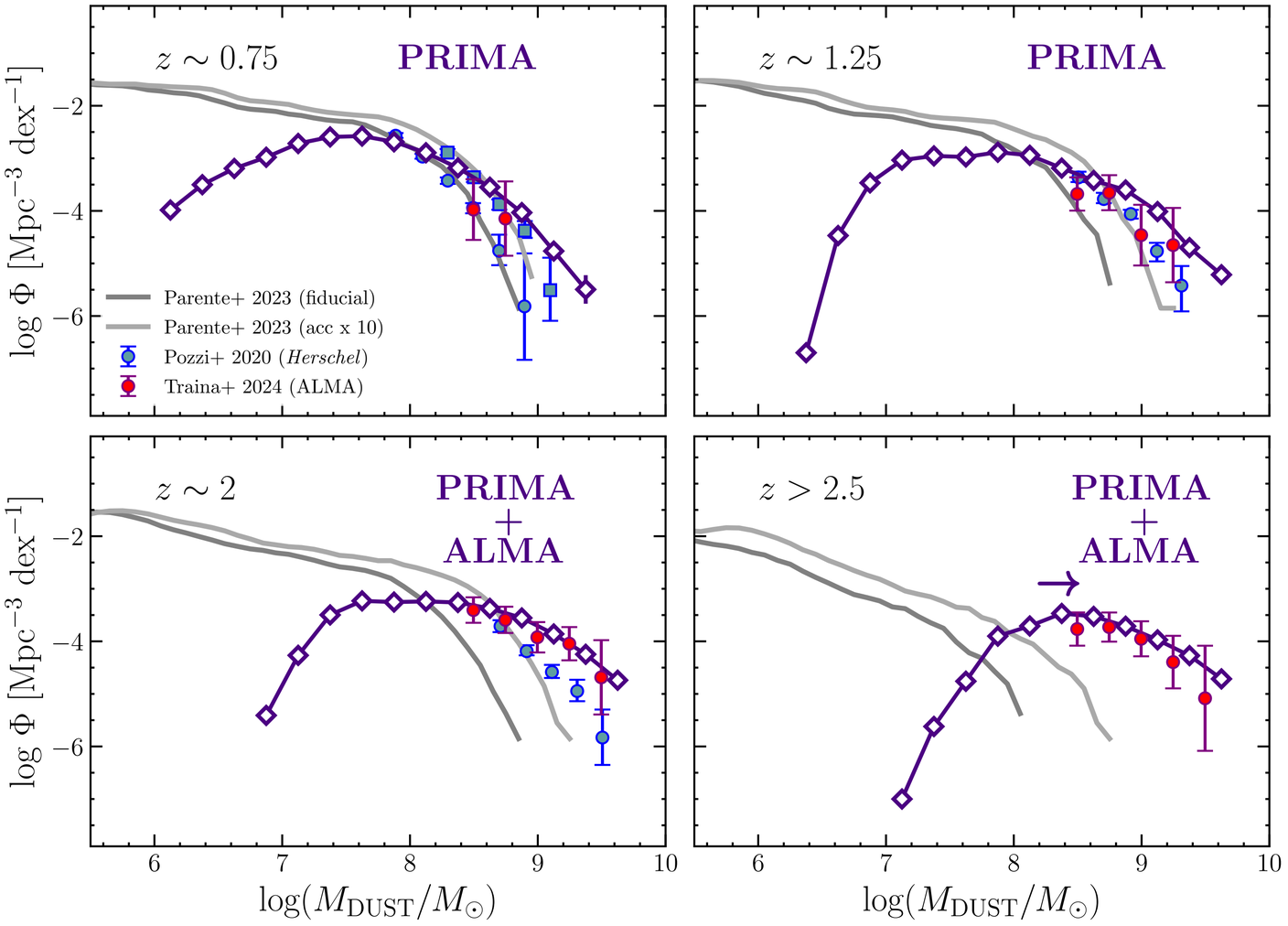
- At low redshift (z < 1.5) PRIMA alone will be able to measure dust masses down to ~ 10^6 $M_\odot$
- At higher redshifts, the synergy with sub-millimeter telescopes will be fundamental (e.g., ALMA, AtLAST, LMT, CCAT)



DMF with PRIMA: *dust mass function*

- PRIMA will cover a wider dust mass range wrt to previous DMF estimates, sampling the faint-end down to ~ $10^{6\text{-}7}$ $M_\odot$
- Thanks to the much larger statistic, PRIMA will be able to determine the DMF with unprecedented accuracy

Traina subm. - JATIS special issue



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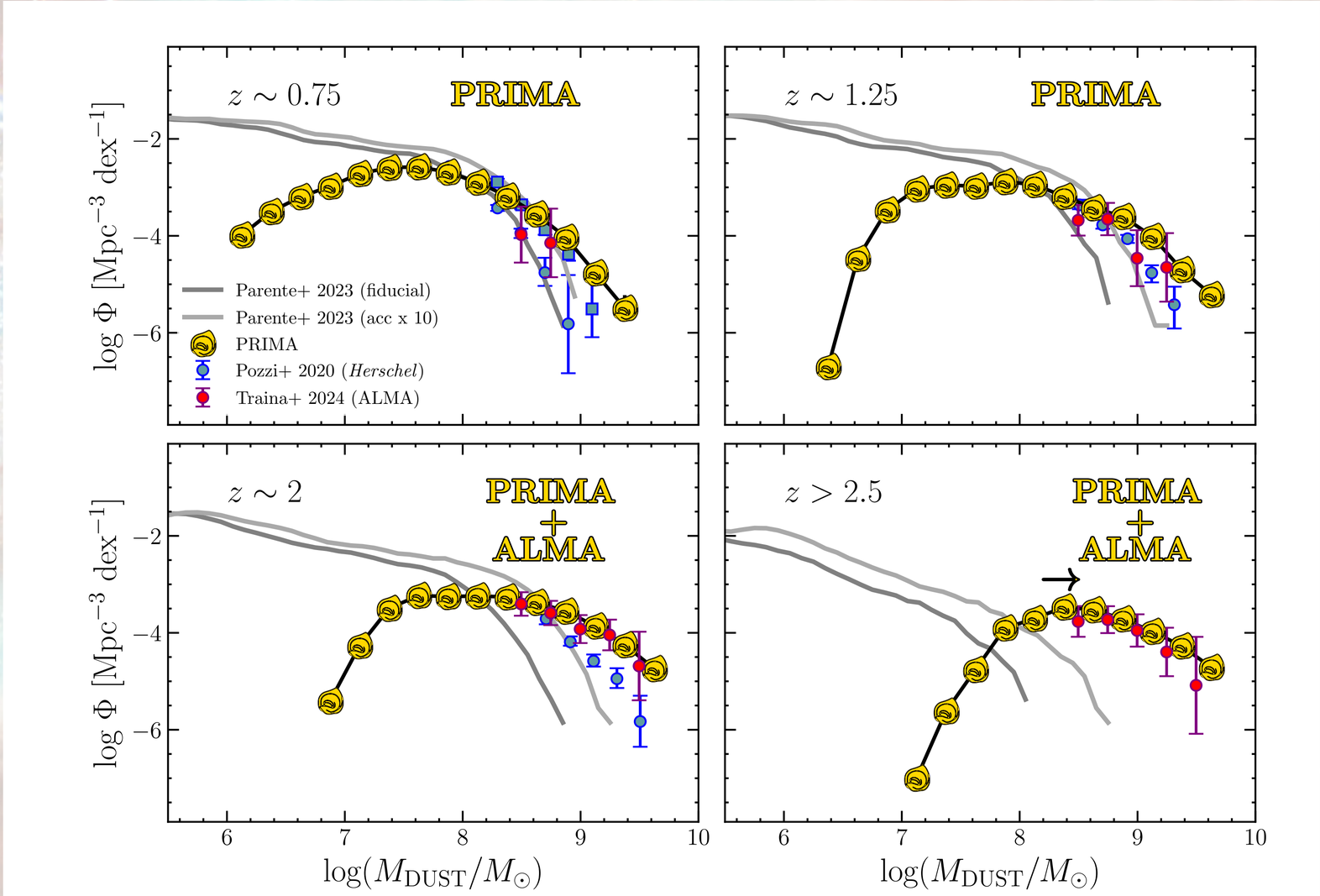
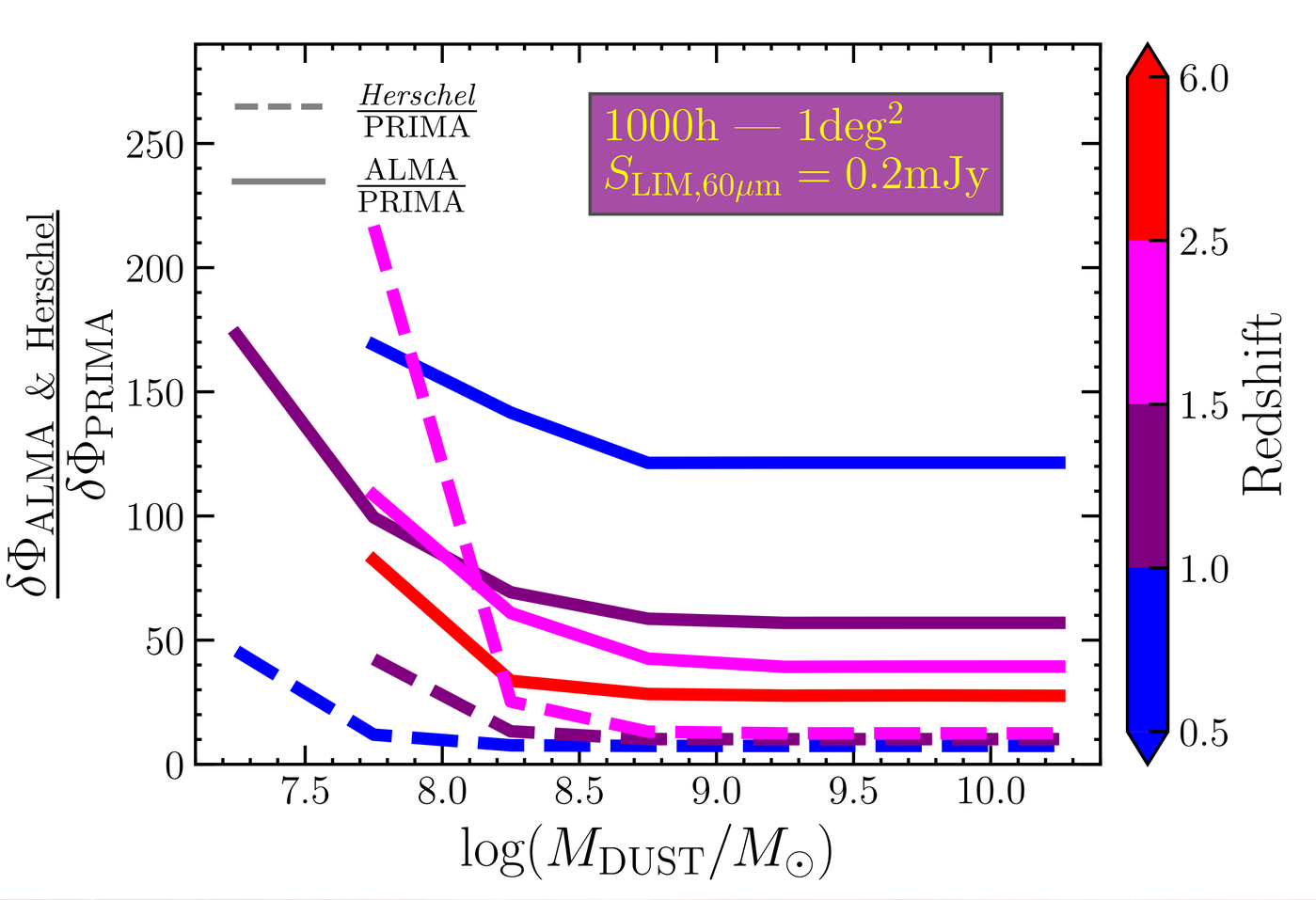
Check out ArXiv for Pastamarkers v2 ! https://arxiv.org/pdf/

pastamarkers 2: pasta sauce colormaps for your flavorful results



DMF with PRIMA:
uncertainties on the DMF

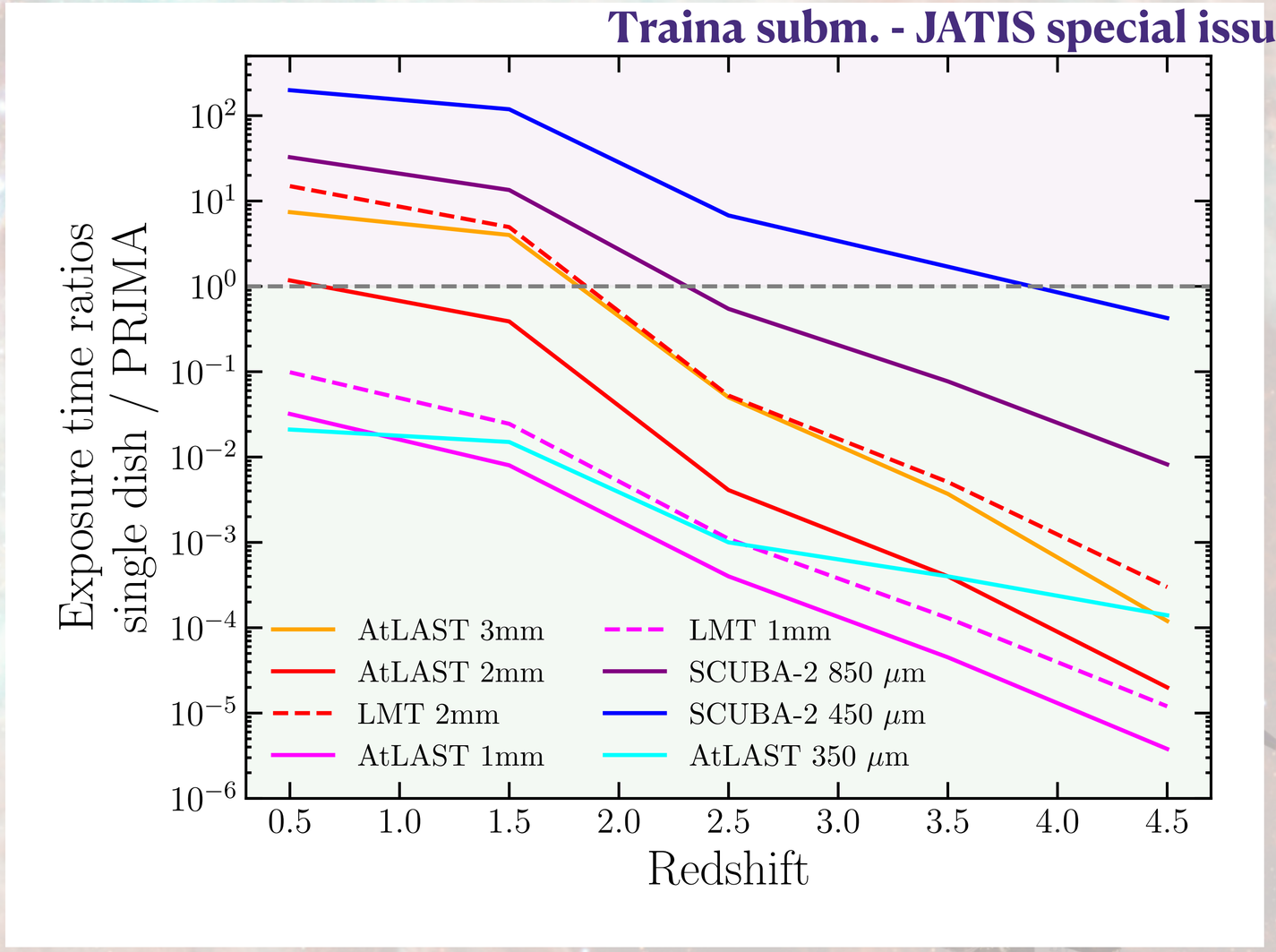


Traina subm. - JATIS special issue

- We predict the uncertainties on the DMF to be reduced by a factor 100 - 200 at low masses
- At higher masses and redshifts, PRIMA is still going to overcome the previous DMF estimates, though with a lower increment

DMF with PRIMA: *synergies with single-dish (sub-)mm telescopes*

- At z > 2, (sub-)mm observations are needed to probe the R-J
- Current and future facilities (e.g., SCUBA-2, LMT, AtLAST) will be able to observe 1 deg² with comparable exposure times



Conclusions

- Thanks to its sensitivity and capability of covering large sky area (e.g. ~ 1 deg²) in relatively short times (~ 1000 hr), PRIMA will allow us to detect ~ 44000 galaxies with a broad range of physical properties

- Using the simulated galaxies from the SPRITZ spectrophotometric realizations, we were able to predict the dust masses of the PRIMA-detected galaxies, finding that they will cover a wide masses range

- We derived the predicted PRIMA-DMF at different redshifts, showing that PRIMA will be able to extends the measurements down to the faint-end

- The synergy with (sub-)millimeter facilities like ALMA, AtLAST, LMT or CCAT will be of key importance to properly study the dust properties of high-z galaxies