Modelling Empirically the Ridge-line Between SF and Q Galaxies in the Re～M* Plane

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Outline

1、Motivation

2、Modelling

3、Discussions

4、Summary

1. Motivation

Surveys of multi-wavelength : wide + deep + spectroscopic

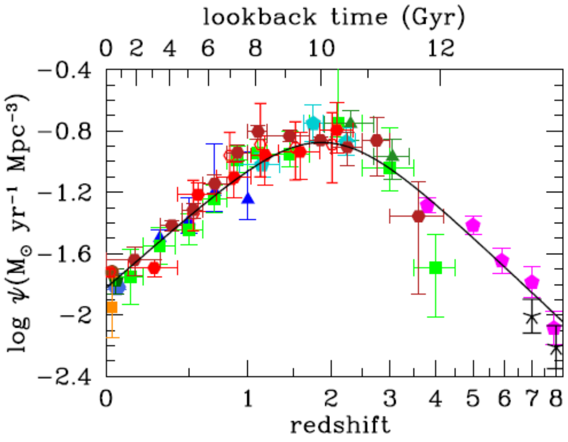
SDSS, COSMOS, DEEP, CANDELS, +, WISE, HICAT, Herschel, + Chandra, ...

----- large samples of galaxies at a wide range of redshifts

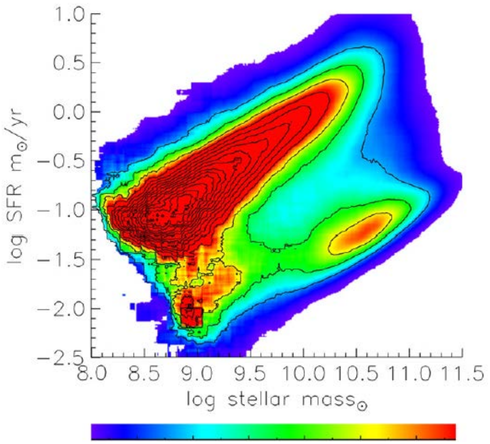
----- unprecedented details results

cosmology,
galaxy formation and evolution,
local Universe

see review and contribution talks in the conference.



Madau & Dickinson, 14



Renzini & Peng, 15

Thanks to the CANDELS

---- SF and Q galaxies from *UVJ*, sSFR & Av

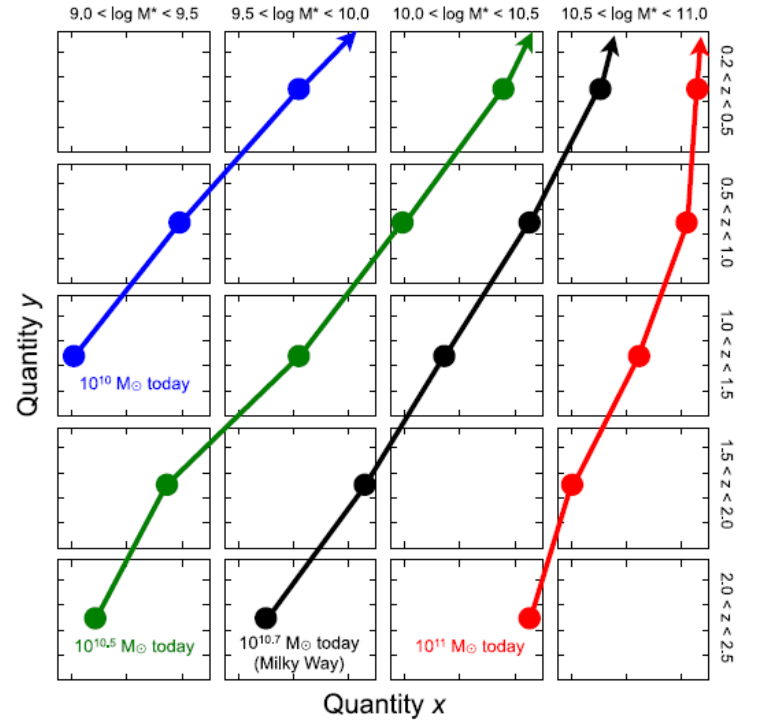
---- SFMS;

---- $R_{eff} \sim M_*$;

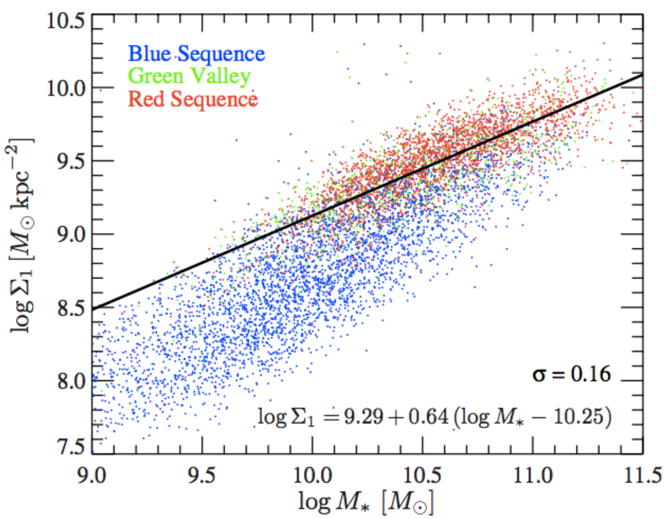
---- $\Sigma_1 \sim M_*$;

---- sSFR (*R*)

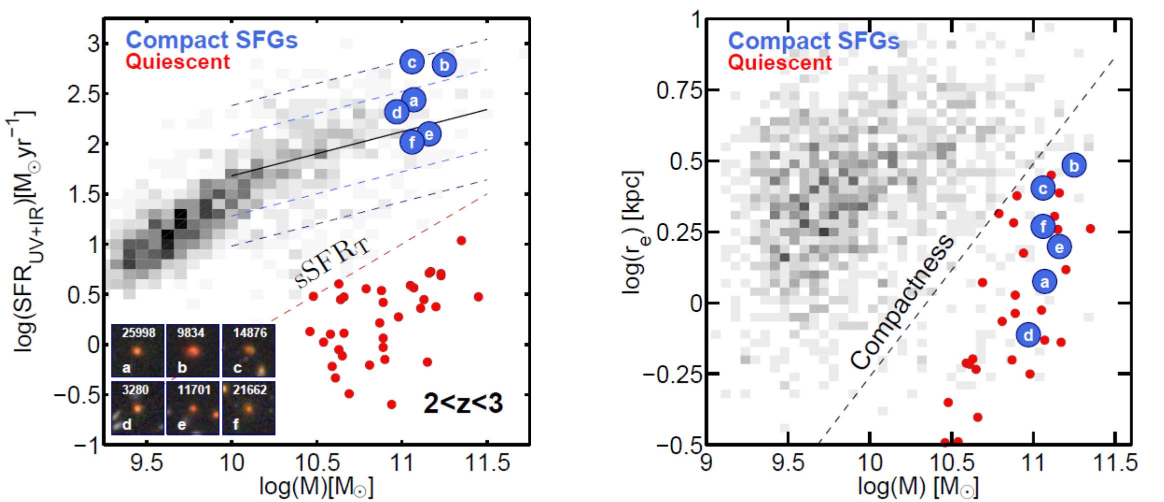
----- tracks of galaxy evolution



cf. Faber +, 07; Guo +, 13, 15, 18; Liu +, 16; Fang+,13, 18; Baro +, 17; van del Wel +14; van Dokkum +, 15; Wang +, 17; ……….



Fang + 13

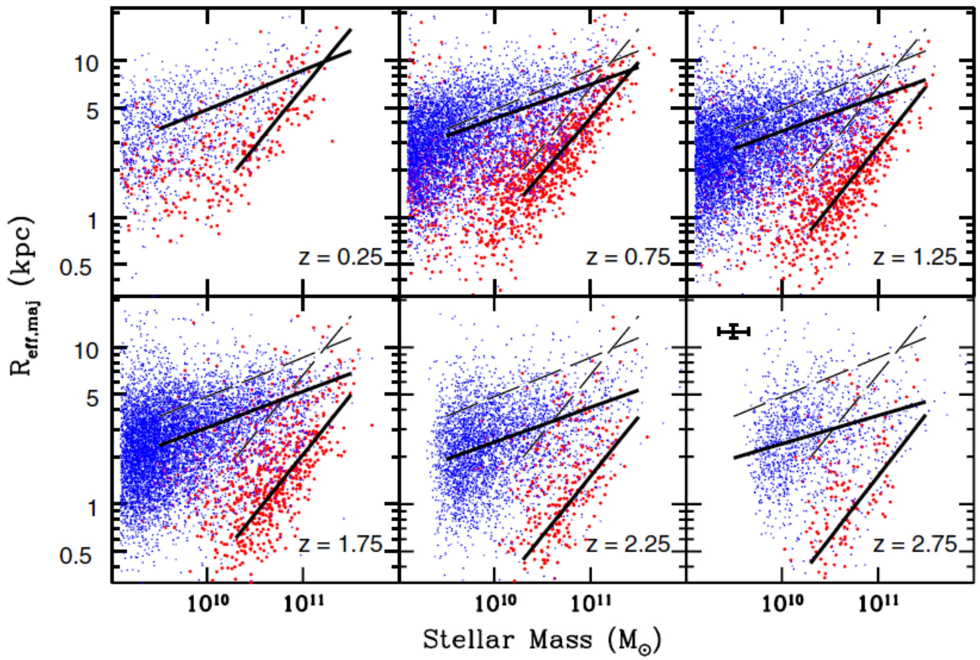


Baro +, 17

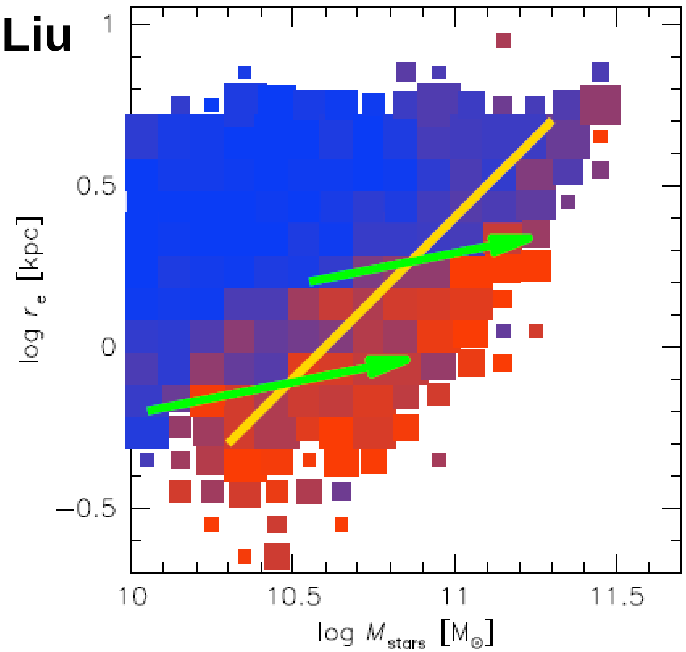
$R_{eff} \sim M_*$ relation

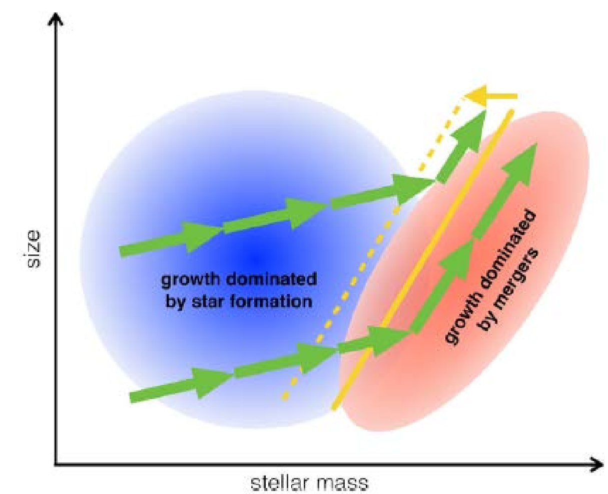
cf. Talks by Faber, Chen, Liu

van del Wel +, 14



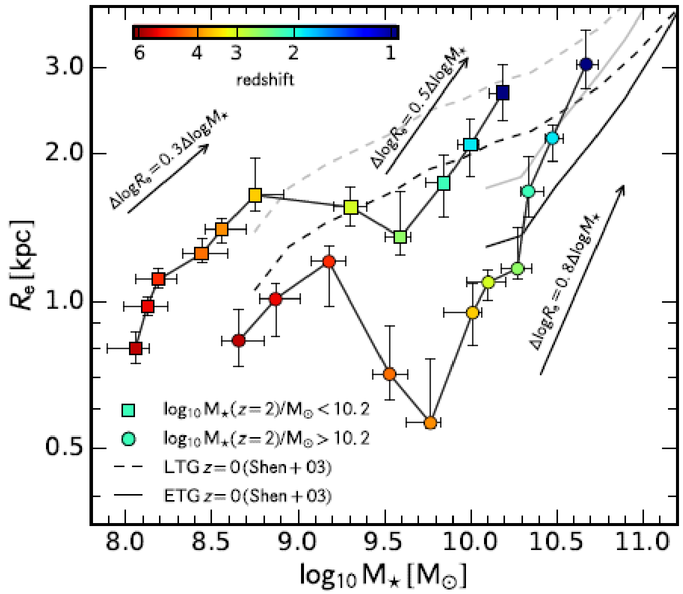
	Early-type Galaxies			Late-type Galaxies		
z	$\log(A)$	α	$\sigma \log(R_{eff})$	log A	α	$\sigma \log(R_{eff})$
0.25	0.60 ± 0.02	0.75 ± 0.06	0.10 ± 0.02	0.86 ± 0.02	0.25 ± 0.02	0.16 ± 0.01
0.75	0.42 ± 0.01	0.71 ± 0.03	0.11 ± 0.01	0.78 ± 0.01	0.22 ± 0.01	0.16 ± 0.01
1.25	0.22 ± 0.01	0.76 ± 0.04	0.12 ± 0.01	0.70 ± 0.01	0.22 ± 0.01	0.17 ± 0.01
1.75	0.09 ± 0.01	0.76 ± 0.04	0.14 ± 0.01	0.65 ± 0.01	0.23 ± 0.01	0.18 ± 0.01
2.25	−0.05 ± 0.02	0.76 ± 0.04	0.14 ± 0.02	0.55 ± 0.01	0.22 ± 0.01	0.19 ± 0.01
2.75	−0.06 ± 0.03	0.79 ± 0.07	0.14 ± 0.03	0.51 ± 0.01	0.18 ± 0.02	0.19 ± 0.01



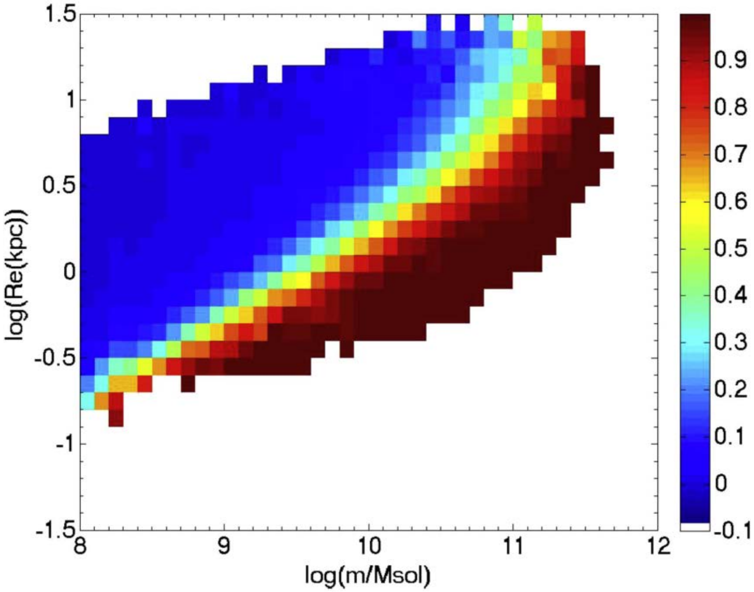


van Dokkum +, 15

Theoretically:



Tacchella, Dekel, +, 16



Lilly & Carollo, 16

The goal is to investigate the ridge-line in the Re~M* plane empirically by

(1) taking the observational results as inputs and

(2) together with simple prescriptions.

2. Modelling

(1) Star forming main sequence (SFMS):

a star forming galaxy is always defined as

SFR > $\overline{\text{SFR}}$ **(cf. Kennicutt 83, Brinchmann + 03; Elbaz +, 07; 13)**

SFR > 2 $\overline{\text{SFR}}$ starburst

SFR < $\overline{\text{SFR}}$, quiescent, quenched

Observationally

SFMS adopted as (Speagle +, 2014)

$$\log \psi(M_*, t) = (0.84 \pm 0.02 - 0.026 \pm 0.003 \times t) \log M_* - (6.51 \pm 0.24 - 0.11 \pm 0.03 \times t), \quad (28)$$

t **is the age of the universe in unit of Gyr**

Define:

t* / 2 = M*/ SFR, (cf. Elbaz +, 11)

the star forming timescale of a star forming galaxy

(2) Estimation of the amount of cold gas in a galaxy

Adopted the star formation prescription of Kennicutt (1998)

$$\Sigma_{SFR} = 2.5 \times 10^{-10} \left(\frac{\Sigma_{gas}}{M_\odot \, pc^{-2}} \right)^{1.4} M_\odot \, yr^{-1} \, pc^{-2}$$

Assuming a surface density profile of gas, we get easily get the total amount of cold gas in a galaxy based on its SFR and radius.

For an exponential surface-density profile, the estimated total amount of the cold gas M_g (Shu et al ,01)

$$\left(\frac{M_g}{10^{11}\,\mathrm{M}_\odot}\right) \approx 0.9\times 10^{-2}\left(\frac{\dot{M}_*}{\mathrm{M}_\odot\,\mathrm{yr}^{-1}}\right)^{0.71}\left(\frac{R_{\mathrm{eff}}}{\mathrm{kpc}}\right)^{0.57}.$$

$\dot{M}_* = \mathrm{SFR}$ **and** R_{eff} **its effective radius in UV (SFR)**

Not sensitive to the profile assumed !

Define the gas consuming timescale of a SF galaxy

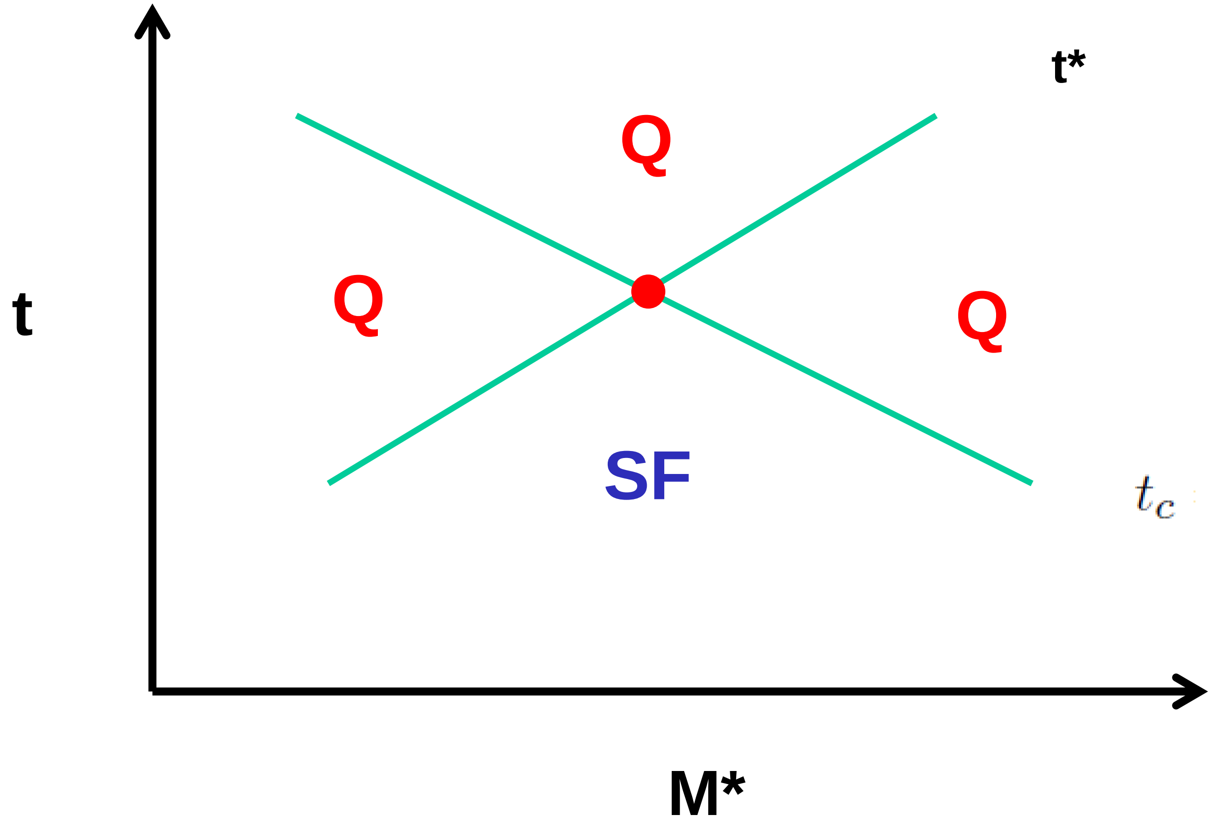
$$t_c = \mathrm{M_g/SFR} \;=\; 0.9\mathrm{Gyr}\;\;\left(\frac{\dot{M}*}{\mathrm{M_\odot yr^{-1}}}\right)^{-0.29}\;\;\left(\frac{R_{\mathrm{eff}}}{\mathrm{kpc}}\right)^{0.57}$$

Note : t_c **is independent of total baryons in a galaxy halo;**

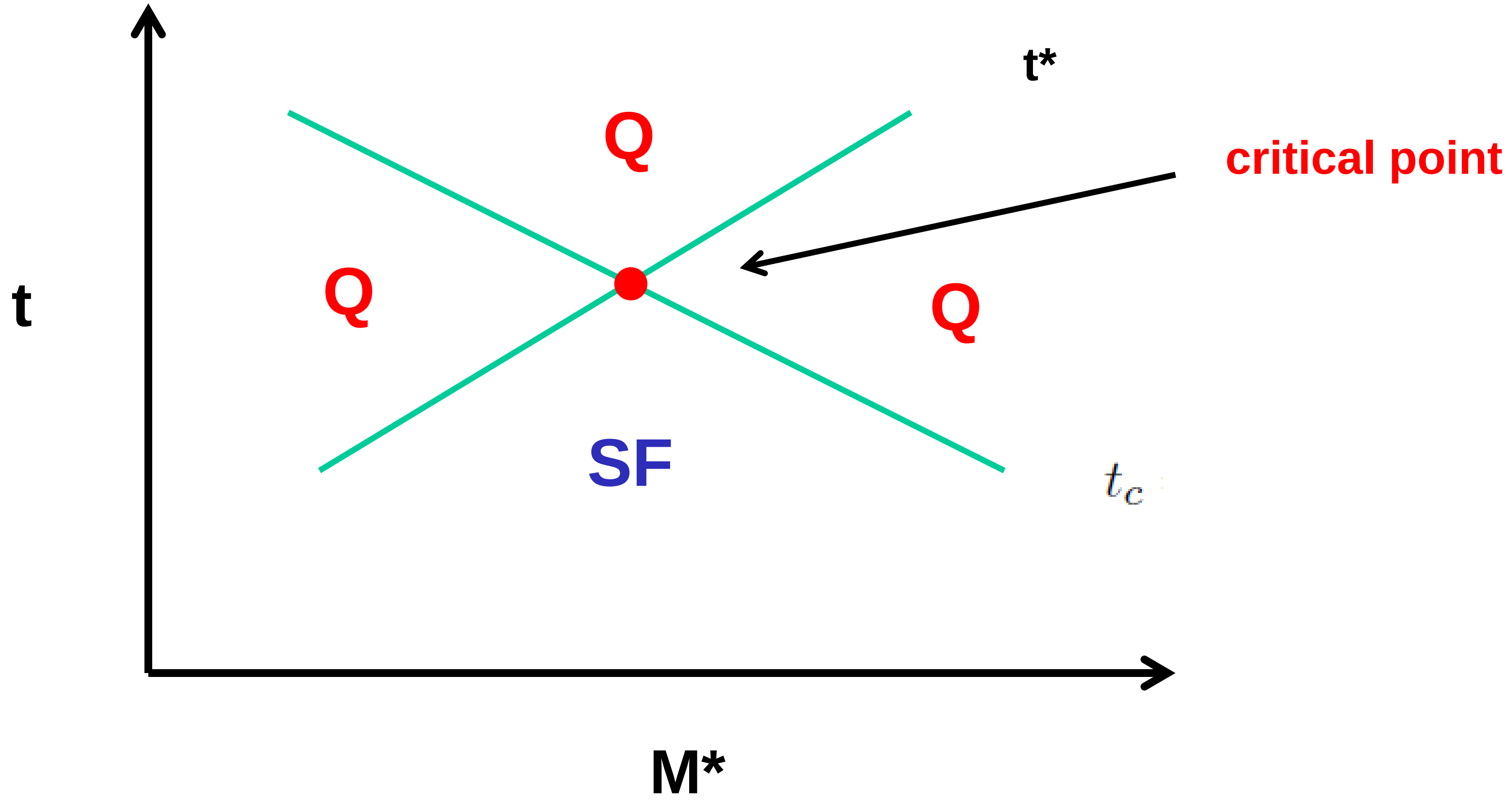
relates to V_{cir} and λ implicitly;

ONLY valid for SF galaxies, since the timescale is much shorter than the timescale of mass accretion.

in the age (t) – M* plane, a galaxy displays as



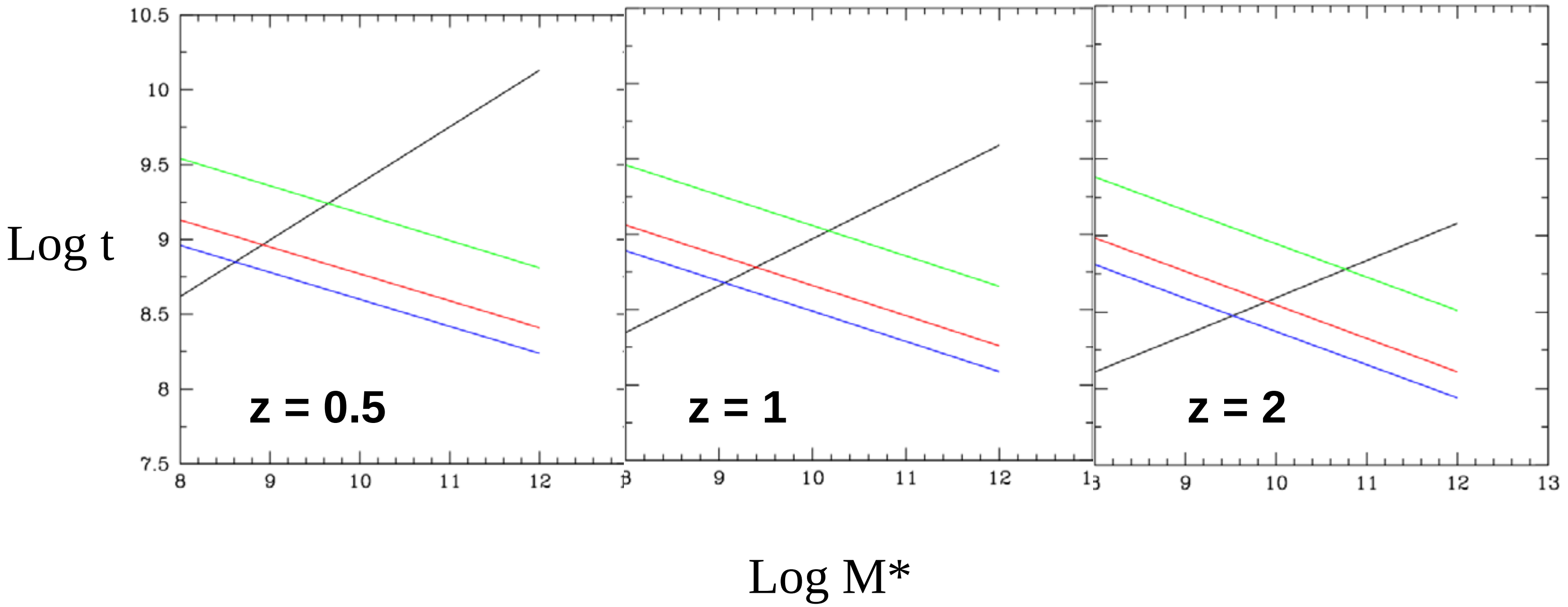
in the age (t) – M* plane, a galaxy displays as



points of t* ~ tc will give the ridge-line

--------- t* at z = 0.5, 1.0 and 2.0, from left to right

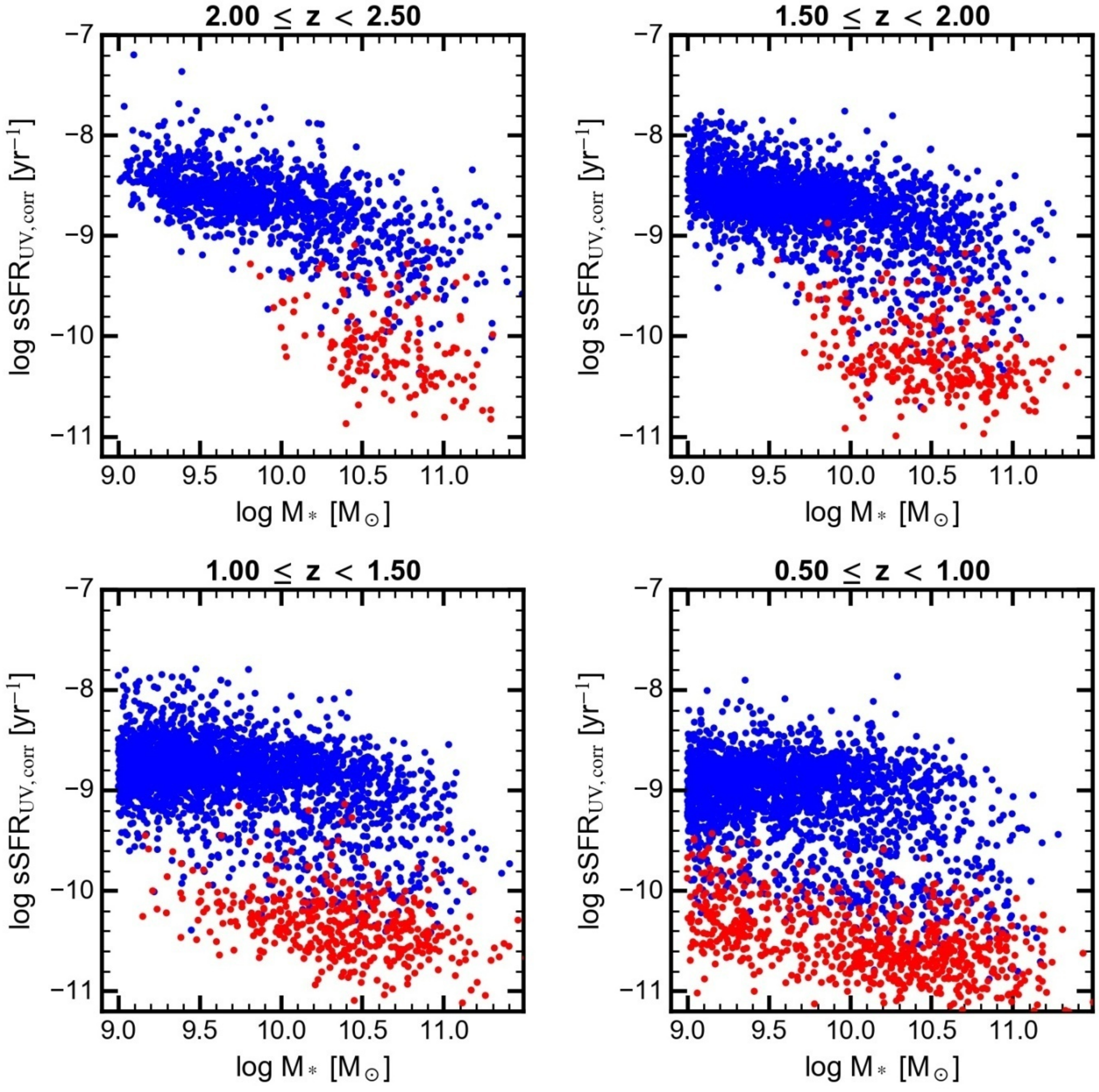
---------- tc with size of 0.5 kpc, 1 kpc and 5 kpc from bottom



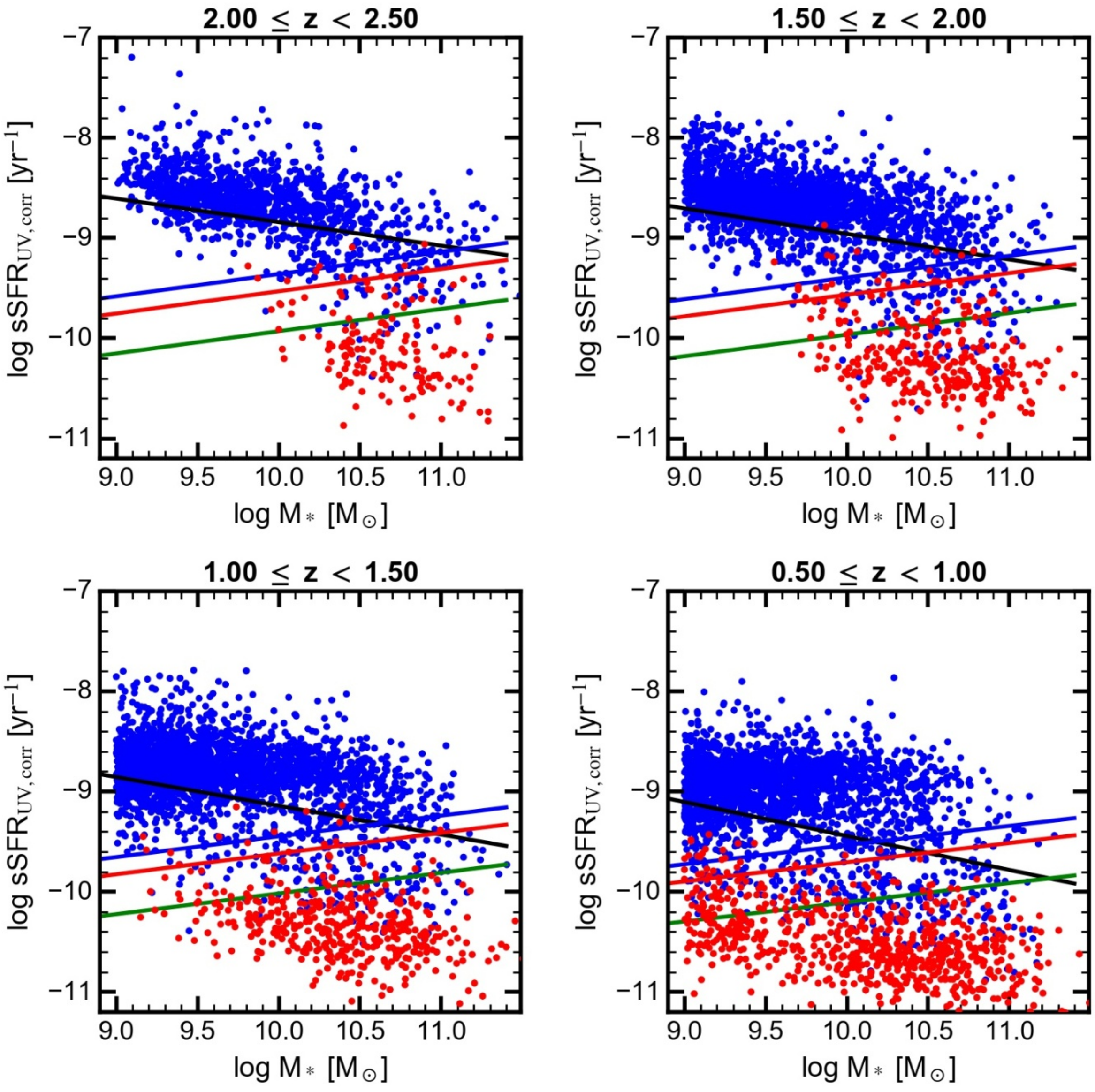
Given size, massive galaxies quenched earlier;

Given stellar mass, more compact galaxies quenched earlier;

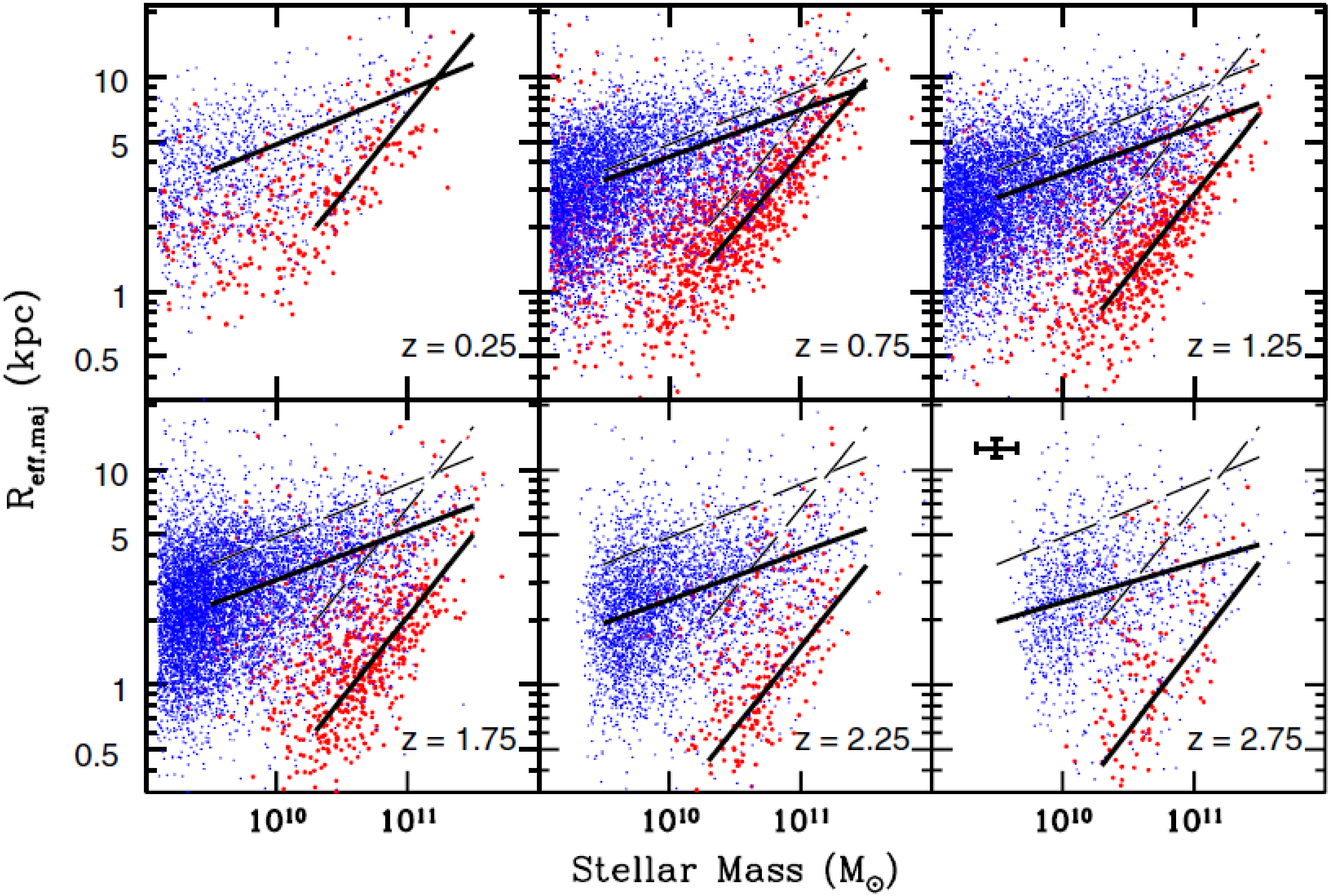
Comparing with observations



Comparing with observations (with size of 0.5 kpc, 1 kpc and 5 kpc)

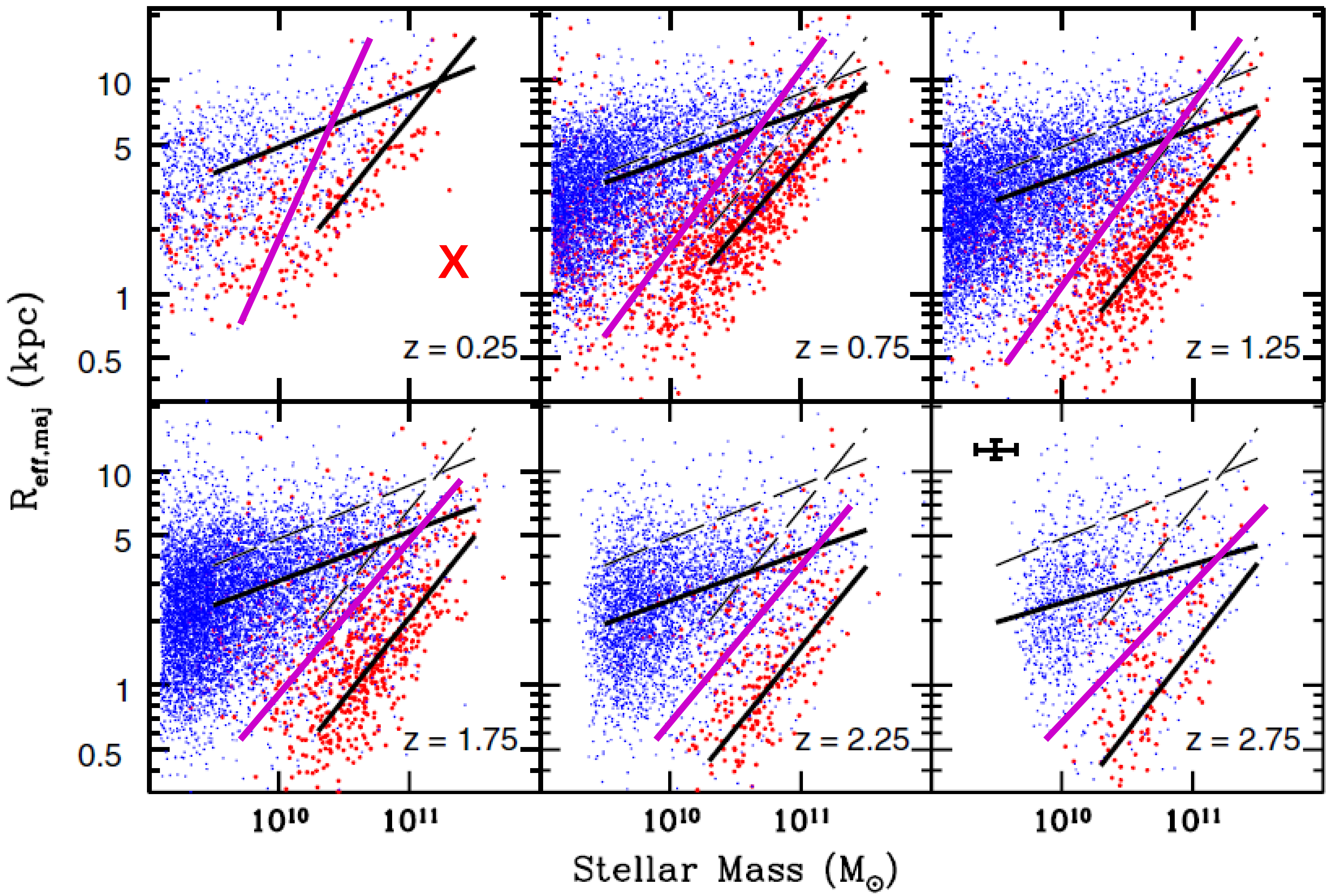


The predicted ridge-lines of SF and Q galaxies in the $R_{eff} \sim M^*$ plane



van del Wel +, 2014

The predicted ridge-lines of SF and Q galaxies in the R_{eff} ~ M* plane

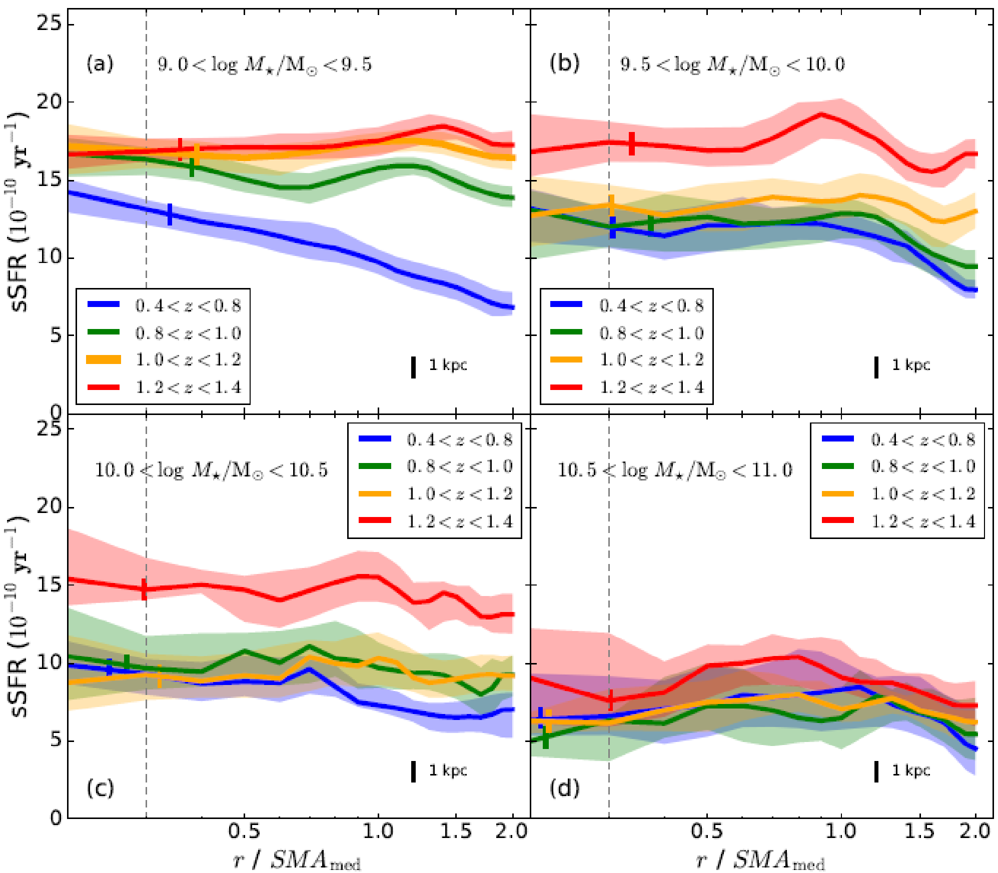


3. Discussions

(1) Why the model prediction does not work at z~0.5:

assuming R_{eff} ~ R_{e*} in the modelling

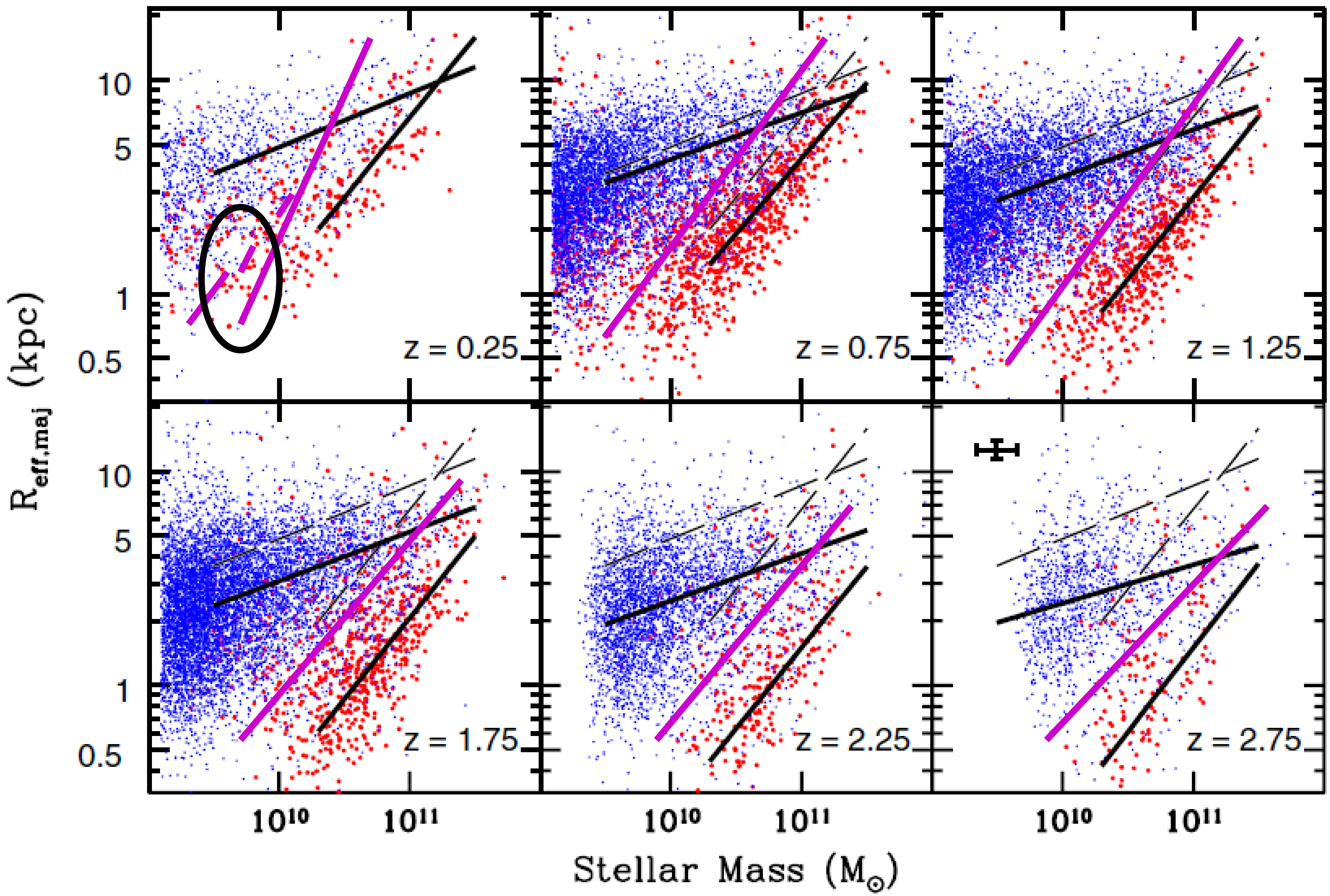
not valid for SFMS galaxies with 9.0 <Log M* < 9.5 at z < 0.8



(Wang, Faber + ,17)

R_{e*} flatter than R_{eff} !

The predicted ridge-lines of SF and Q galaxies in the $R_{eff} \sim M^*$ plane



(2) the surface density profile of cold gas

not sensitive to the profile assumed.

for a flat disk with a finite radius

$$t_c = \mathrm{M_g/SFR} = 0.95\mathrm{Gyr}\ \left(\frac{\dot{M}*}{\mathrm{M_\odot yr^{-1}}}\right)^{-0.29} \left(\frac{R_{\mathrm{eff}}}{\mathrm{kpc}}\right)^{0.57}$$

only 0.90 → 0.95, slop will not change !

(3) the power index n (1<n<2) : $\Sigma_{\mathrm{SFR}} \propto \Sigma_{\mathrm{g}}^{\mathrm{n}}$

at a give redshift z, SFMS : $\mathrm{Log}\dot{M}_* = \alpha\ \mathrm{Log}M_* + \beta$

the slop "*k*" of the ridge-line in the R_{eff} ~ M* plane

$$k = \frac{1}{2} + \frac{1-\alpha}{2(n-1)} \approx 0.82 \qquad \Delta\mathrm{n} = \pm 0.1,\ \ \Delta\alpha = \pm 0.15\ (0.5 < \mathrm{z} < 2.5)$$

$k_{\mathrm{obs}} \approx 0.78$, estimated by eye as paralleled to the R_{eff} ~ M* for QGs

4. Summary

Estimating total cold gas empirically +

Taking the SFMS as an input ;

Comparing SF and gas consuming timescales;

Predicted ridge – line in the R_{eff} ~ M* plane can match observations well.

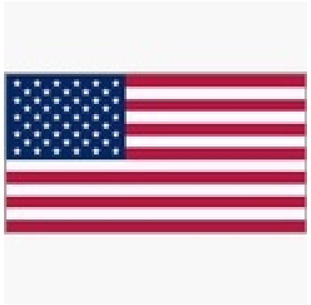
Discussions are presented.

LCT（ Leighton Chajnantor Telescope ）

Moving Caltech Submillimeter Observatory (CSO) to CBI site

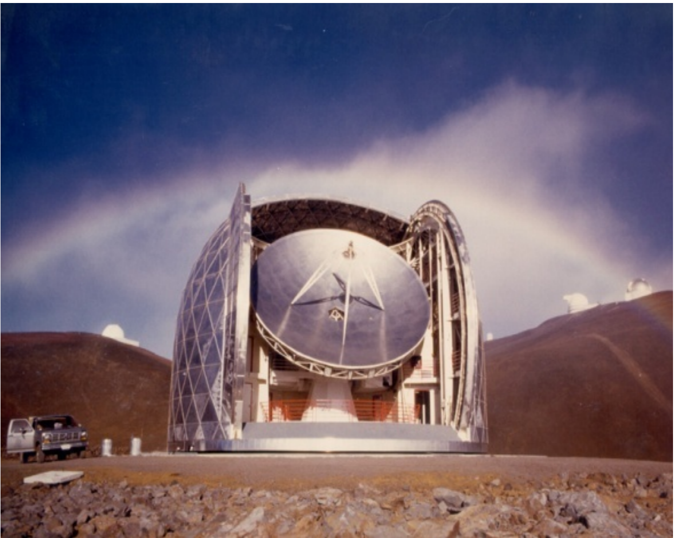
as a Shanghai “owned” submm telescope after upgrated

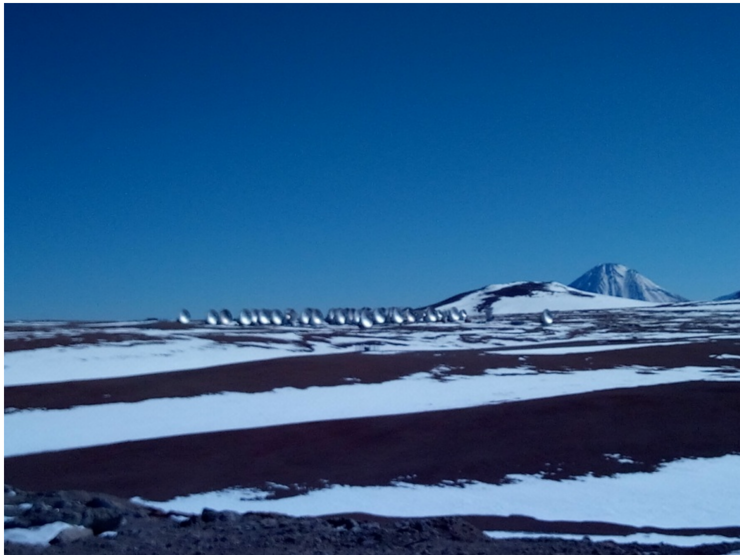
ShNU



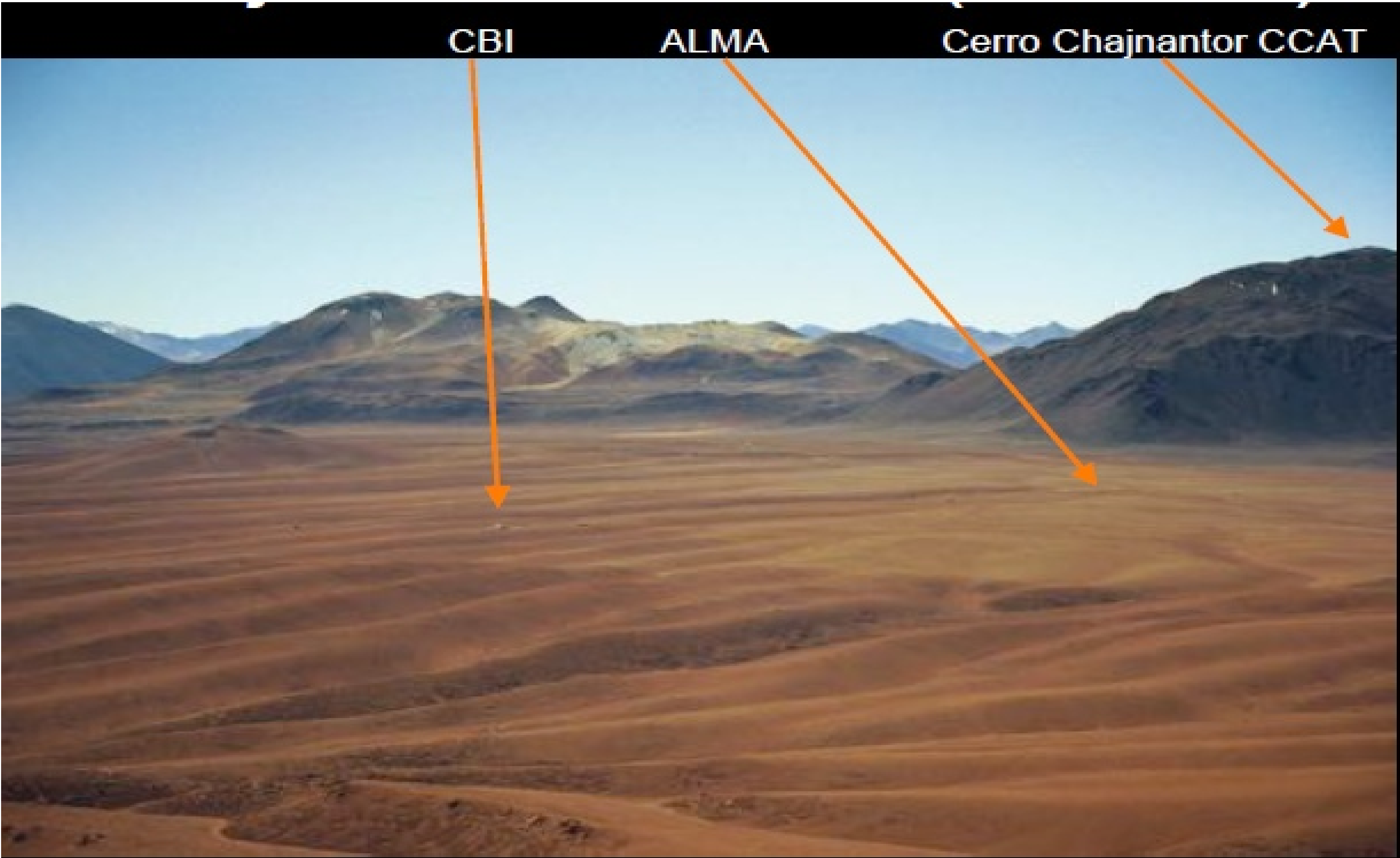
Caltech

UdeC





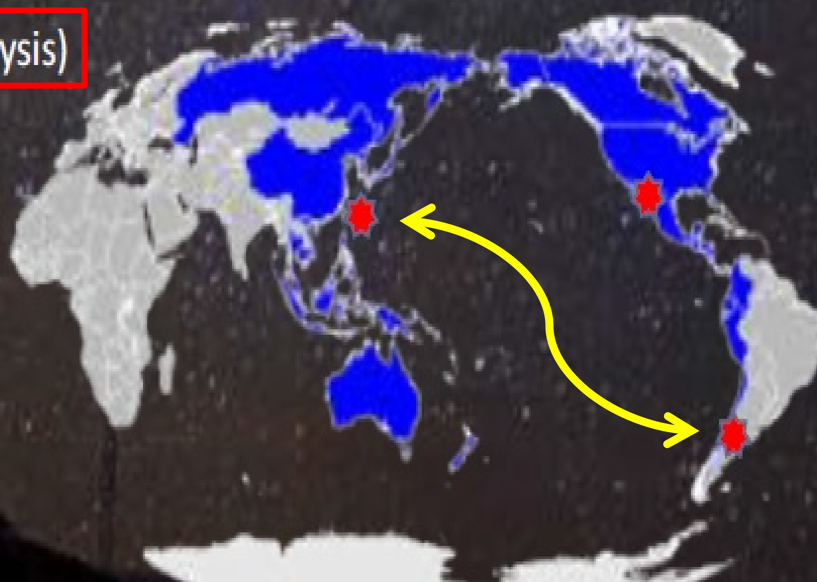
Altitude 5050m，closed to ALMA center



Staffing Plan

- Three main operational stations:
  - San Pedro (onsite op)
  - Santiago (sci op & data)
  - Concepcion (sci op & data)

- Two satellite locations:
  - Shanghai (monitoring/analysis)
  - Pasadena



Steps:

(1) Disassembly the CSO from Mauna Kea;

starting from the end of 2018, 6 months

(2) Shipping to Antofagasta, then San Pedro

6 months

(3) Assembly in San Pedro for testing

12 months

(4) Moving to the plateau (higher site) taking the telescope as a whole and further testing

6 months

(5) First light no later than the end of 2021.

Current status:

(1) MoU signed;

(2) Team has been established

(3) Funding

~1/3 of the Chinese funding available from Shanghai;
NSF funding applied this year, supported by Caltech;
UdeC obtained the supports from CONYCIT etc;

(4) MoU-2 will be signed soon.

Thank you!

For a finite exponential disk

The model uncertainty is

R ~ 5.5 rd , 5%

R~ 4 rd, 10%

R ~ 3 rd, 20 %