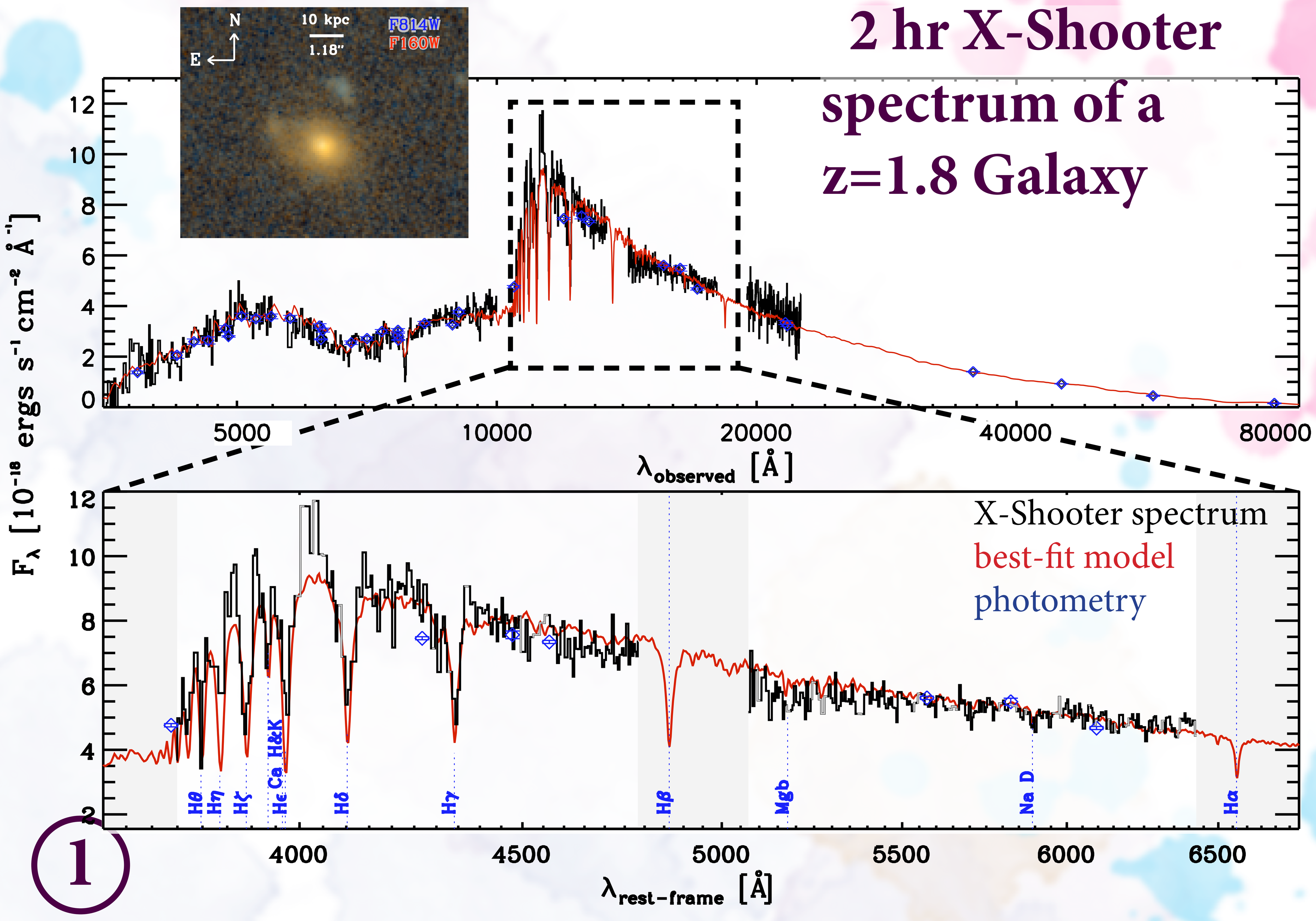
Recent photometric studies have shown that quiescent galaxies at fixed stellar mass were smaller and denser at earlier times, and grow in size by a factor of 3-5 from redshift ~2 to the present day. However, **stellar mass estimates suffer from large uncertainties.**

Direct kinematic mass measurements are needed to confirm the high stellar masses and densities of these galaxies. Here (1.) we show a high-quality spectrum with full UV-NIR wavelength coverage of such a compact massive galaxy obtained with X-Shooter on the VLT, from which we determine the velocity dispersion.

2 hr X-Shooter spectrum of a z=1.8 Galaxy



Spectroscopy of a Compact Massive Galaxy at z=1.8

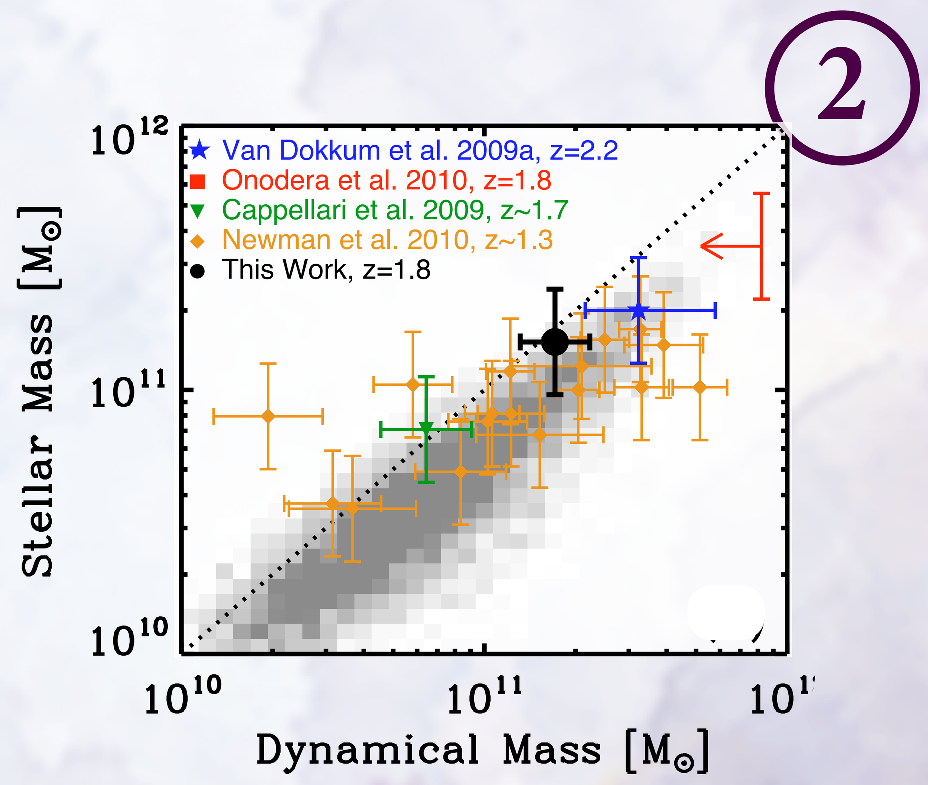
Jesse van de Sande

Mariska Kriek, Marijn Franx, Pieter van Dokkum

The Stellar Mass and Dynamical Mass are in good agreement

From our high-S/N spectrum we determined a velocity dispersion of 294±51 km/s. Combined with the effective radius of 1.64±0.15 kpc (from HST-WFC3 F160W observations) we find a dynamical mass of 1.7±0.5 × $10^{11} M_{sun}$. The stellar mass of 1.5 × 10^{11} M_{sun} was obtained by fitting the full spectrum with stellar population synthesis models.

Below (**2.**) we compare our result (black circle) with results from other high-redshift studies and with results for quiescent low-redshift galaxies in the SDSS (grey scale). **The dynamical and stellar masses are consistent**, but differ by a constant factor, which can be due to dark matter and systematic effects on the stellar mass estimates.



Evolution with Redshift

In figure **3.** on the right we show the effective radius vs. dynamical mass **(a)** and velocity dispersion vs. dynamical mass **(b)**. The dashed grey lines are the best-fit low-redshift relations.

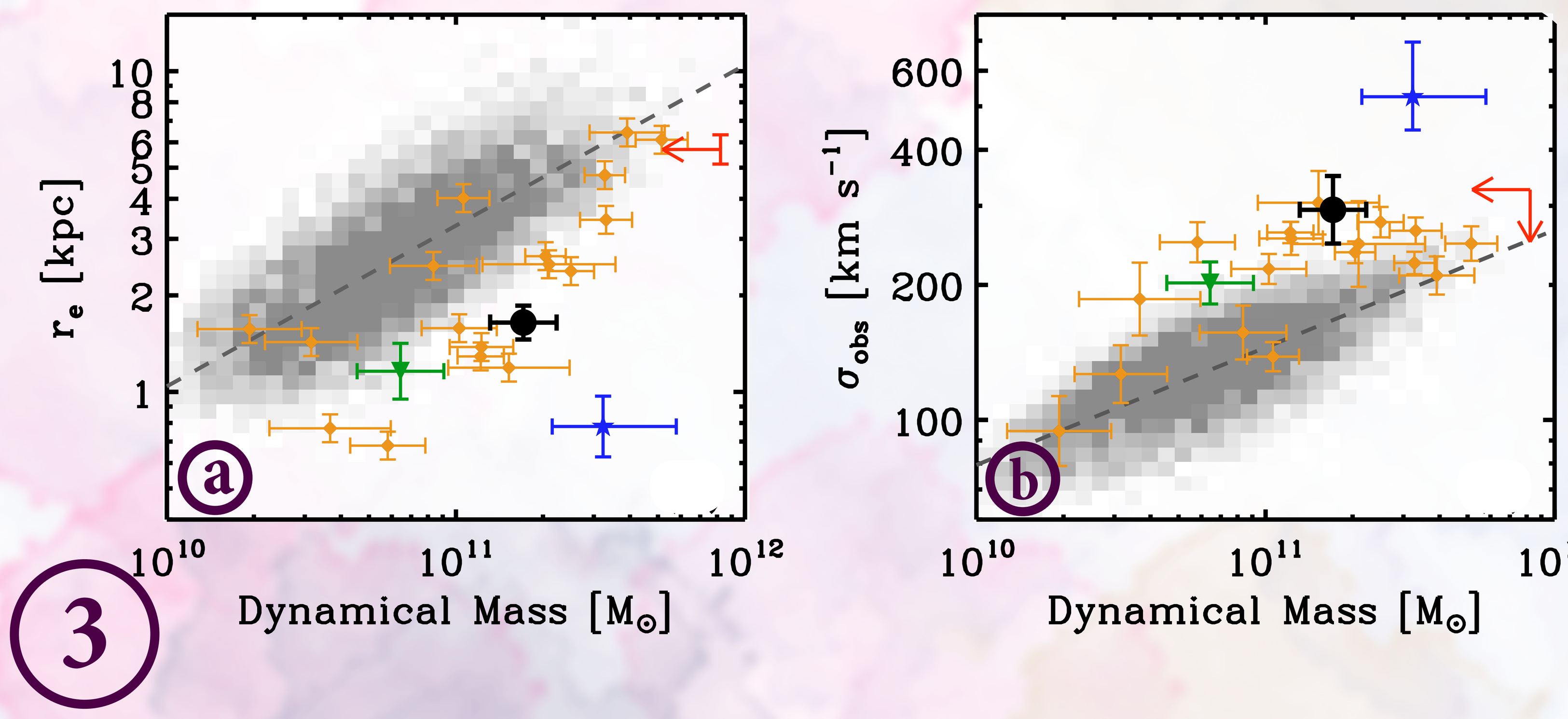
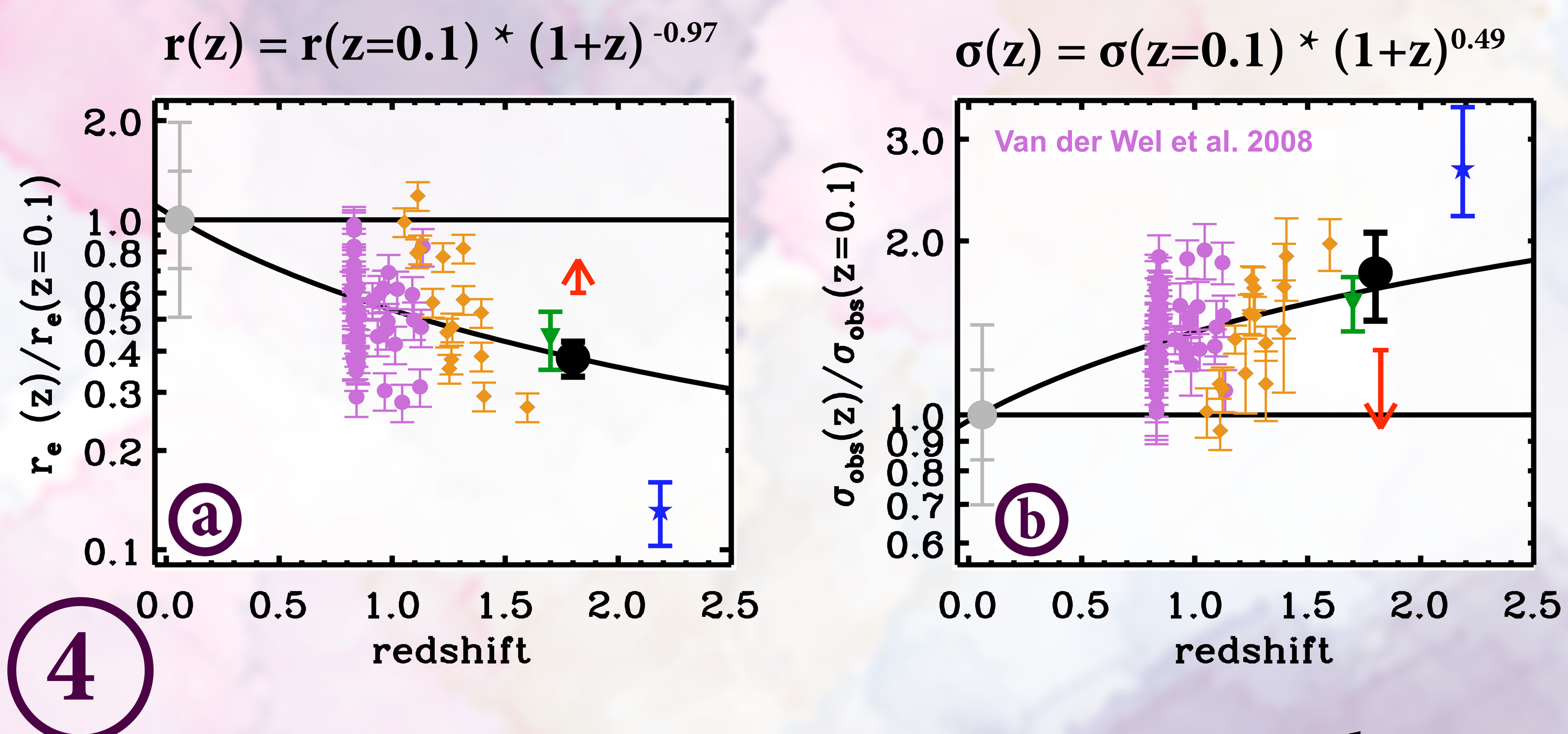
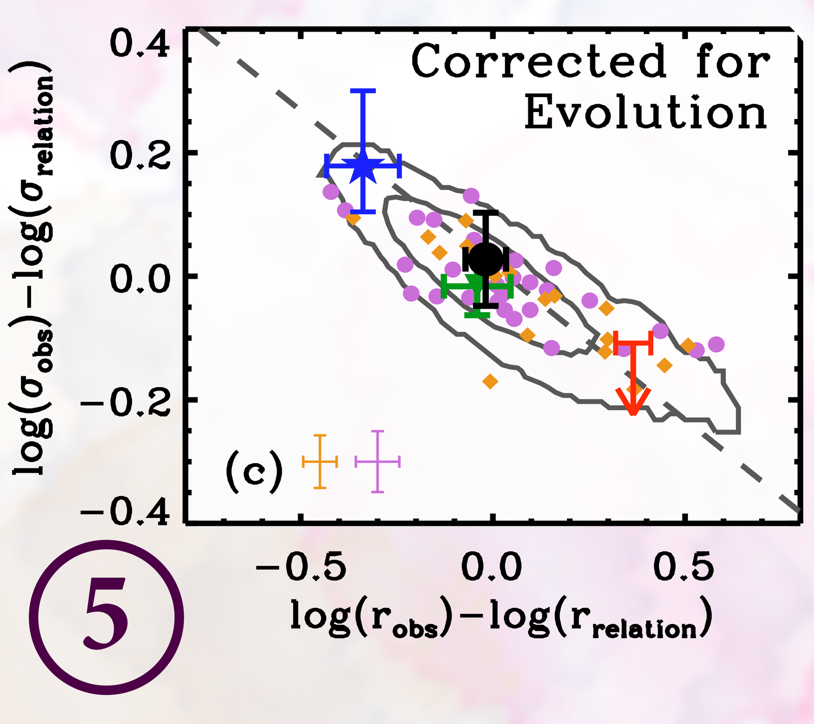


Figure **4.** shows the evolution in effective radius **(a)** and velocity dispersion **(b)** at fixed dynamical mass, thus corrected for the $M_{dyn} - r_e$ and $M_{dyn} - \sigma_{obs}$ relations. The solid lines show a simple best fit to the data.



When comparing this galaxy to low-redshift early-type galaxies, we find that it is structurally different. At fixed dynamical mass, it is smaller by a factor ~2.5, and has a higher velocity dispersion by a factor of ~1.8.



On the left (**5.**) we have the scatter in the $M_* - r_e$ relation versus the scatter in the $M_{dyn} - \sigma_{obs}$ relations, together with the 1- and 2-σ contours of the SDSS galaxies, all corrected for evolution. **The discrepancy between the different measurements is expected based on the intrinsic scatter in the low-redshift relations.**

The mass densities of quiescent galaxies were higher at earlier times and this result is not caused by systematic measurement errors.

In collaboration with Rachel Bezanson, Katherine Whitaker, Gabriel Brammer, Ivo Labbé, Paul Groot, Lex Kaper

Based on:

2011, ApJL , 736, L9

or scan this QR-code:

Sterrewacht Leiden

e-mail: **sande@strw.leidenuniv.nl**