Can Weak Lensing Directly Probe the Stellar Mass of Galaxies?

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1. Introduction

- Stellar mass is a fundamental property of a galaxy. But how to measure?
- Existing sophisticated methods succeed but are limited due to their assumptions or restricted samples to conduct analyses.
- Can **weak lensing** become complementary?
- Consistency between SED fitting and weak lensing may put constraint on **IMF evolution** across space and time?

Existing Methods

SED fitting (Galaxy age? Dust extinction? IMF? etc.)
Stellar Kinematics (Velocity dispersion anisotropy?)
Strong Lensing (Only galaxies with strong lensing…)

How about?

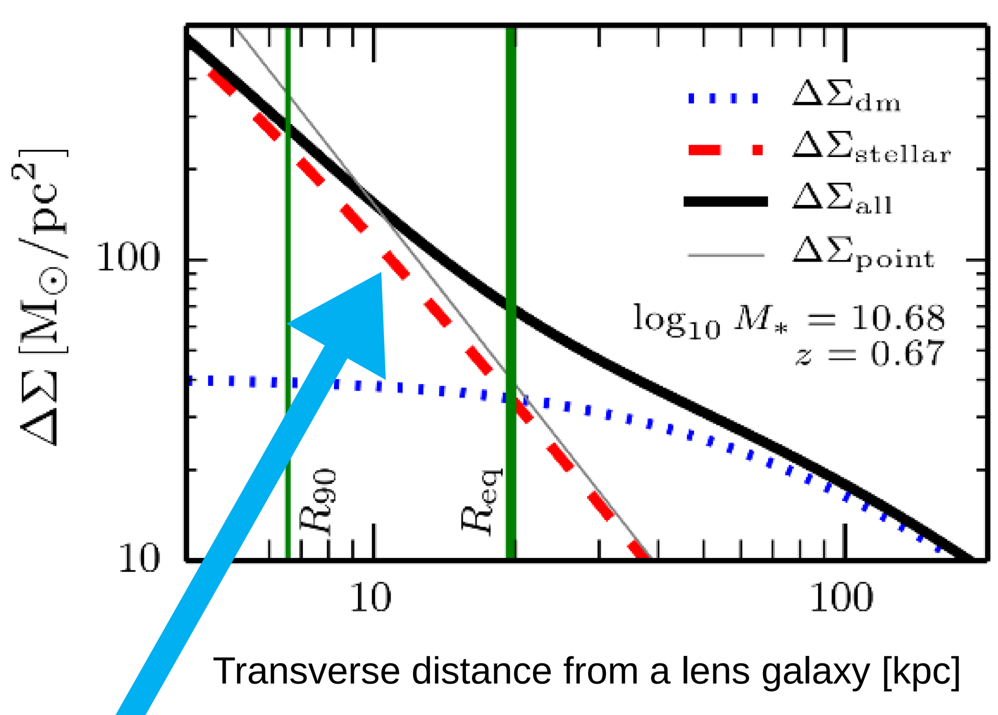
Weak Lensing
1) Direct mass measurement (besides the theory of gravity)
2) Wide range of stellar mass and redshift

→ Our goal: Predictions for future weak lensing surveys to directly probe stellar mass.

2. Mass Distribution around Galaxies and Our Analysis Setup

Weak lensing signal reflects mass distribution around galaxies. → $\Delta\Sigma(x) = \bar{\Sigma}(x) - \Sigma(x)$

$\Delta\Sigma$: Surface mass density excess along the line of sight.
$\bar{\Sigma}(x)$: Mean surface mass density within x.
$\Sigma(x)$: Surface mass density at a radius x.



$\Delta\Sigma$ is additive and can be decomposed into
$$\Delta\Sigma = \Delta\Sigma_{\rm dark\ matter} + \Delta\Sigma_{\rm stellar}$$
1) Dark matter follows the standard **NFW** profile.
2) Stellar mass is a **point like source**.
3) Gas component contribution is negligible.
are assumed, then we **define Req** as
$$\Delta\Sigma_{\rm dark\ matter}(R_{\rm eq}) = \Delta\Sigma_{\rm stellar}(R_{\rm eq})$$

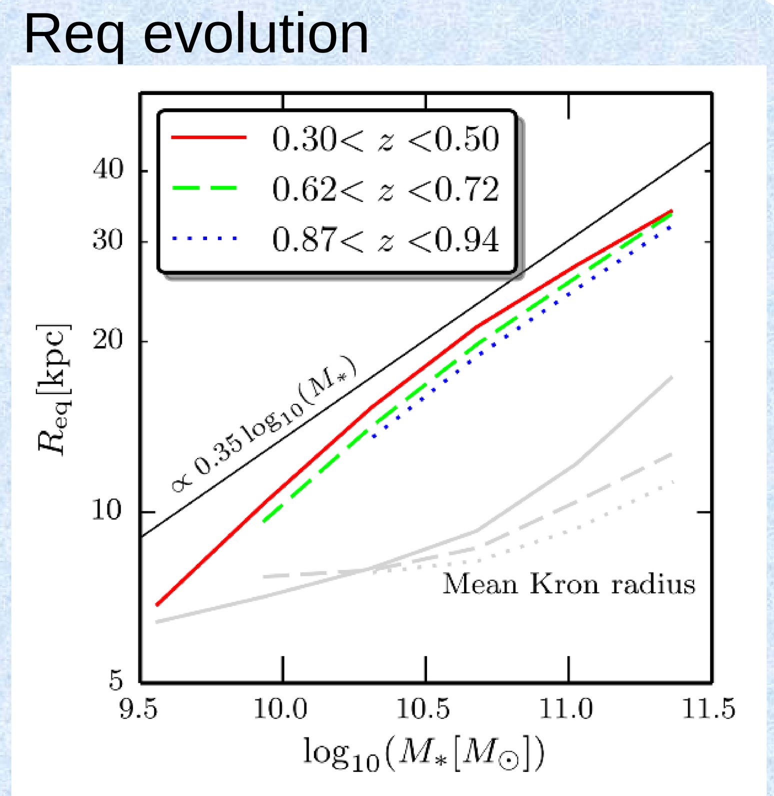
Noise estimation (Leauthaud et al. 2007)
$$\sigma_{\tilde{\gamma}}^2 = \sigma_{\rm int}^2 + \sigma_{\rm meas}^2, \quad \Sigma_{\rm crit} = \frac{c^2}{4\pi G}\frac{D_{\rm s}}{D_{\rm d}D_{\rm ds}}$$
$$\rightarrow \omega_i = \frac{1}{(\Sigma_{{\rm crit},i} \times \sigma_{\tilde{\gamma},i})^2}$$
$$\rightarrow \delta\Delta\Sigma = \left(\sum_i^{N_{\rm pairs}(<R_{\rm eq})} \omega_i\right)^{-1/2}$$

Within Req, stellar mass dominates weak lensing signal. → Predict S/N ($\Delta\Sigma/\delta\Delta\Sigma$) within Req.

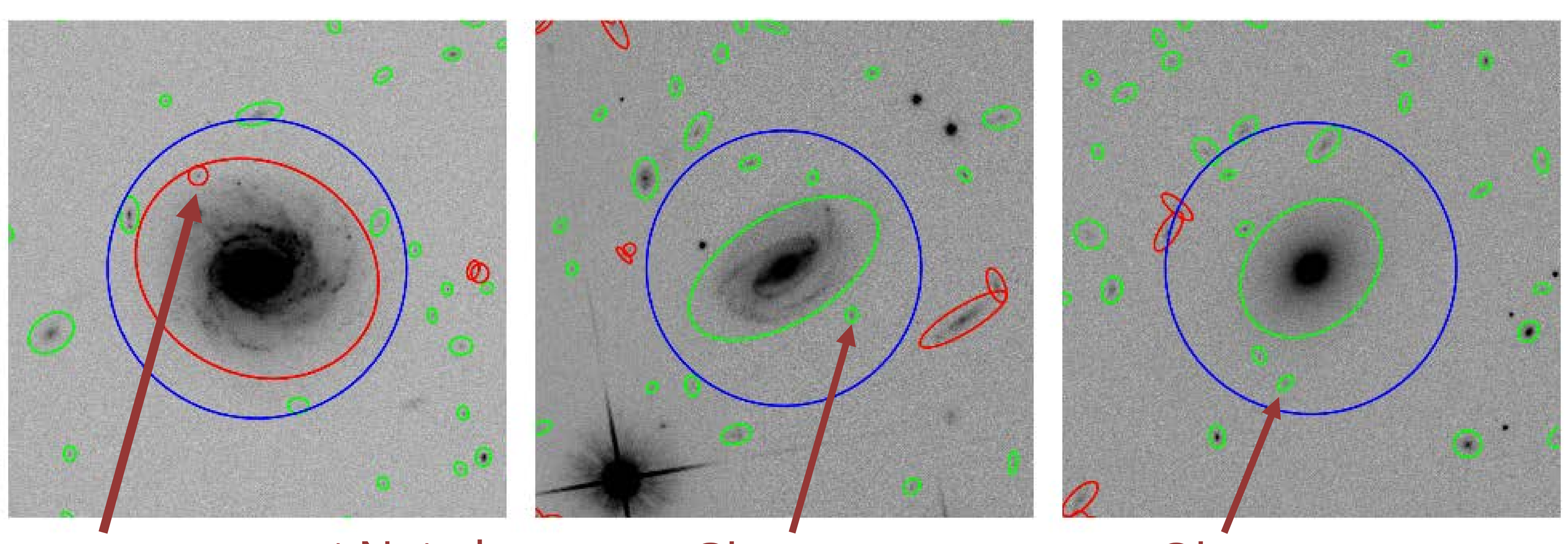
3. Our Data and Results

Use **COSMOS ACS** catalog (Massey et al. 2007, Leauthaud et al. 2007, Rodes et al. 2007, and Leauthaud et al. 2012)

Req evolution



Lens-source pair findings



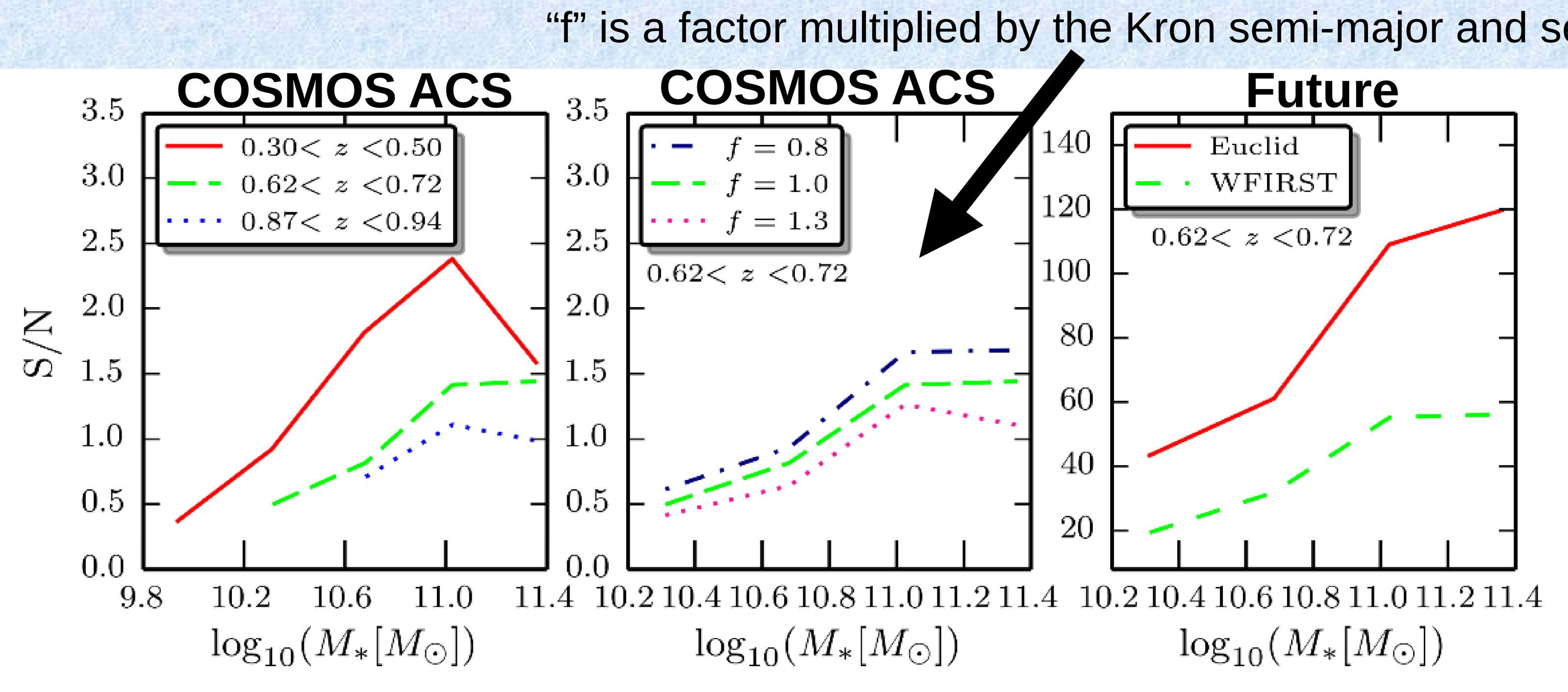
Shape measurement Not okay. Shape measurement Okay.

Green: Kron ellipse
Red: overlapped Kron
Blue: Req

Our criterion:
Reject source galaxies whose **Kron ellipses** are overlapped, which may not receive reliable shape measurements.

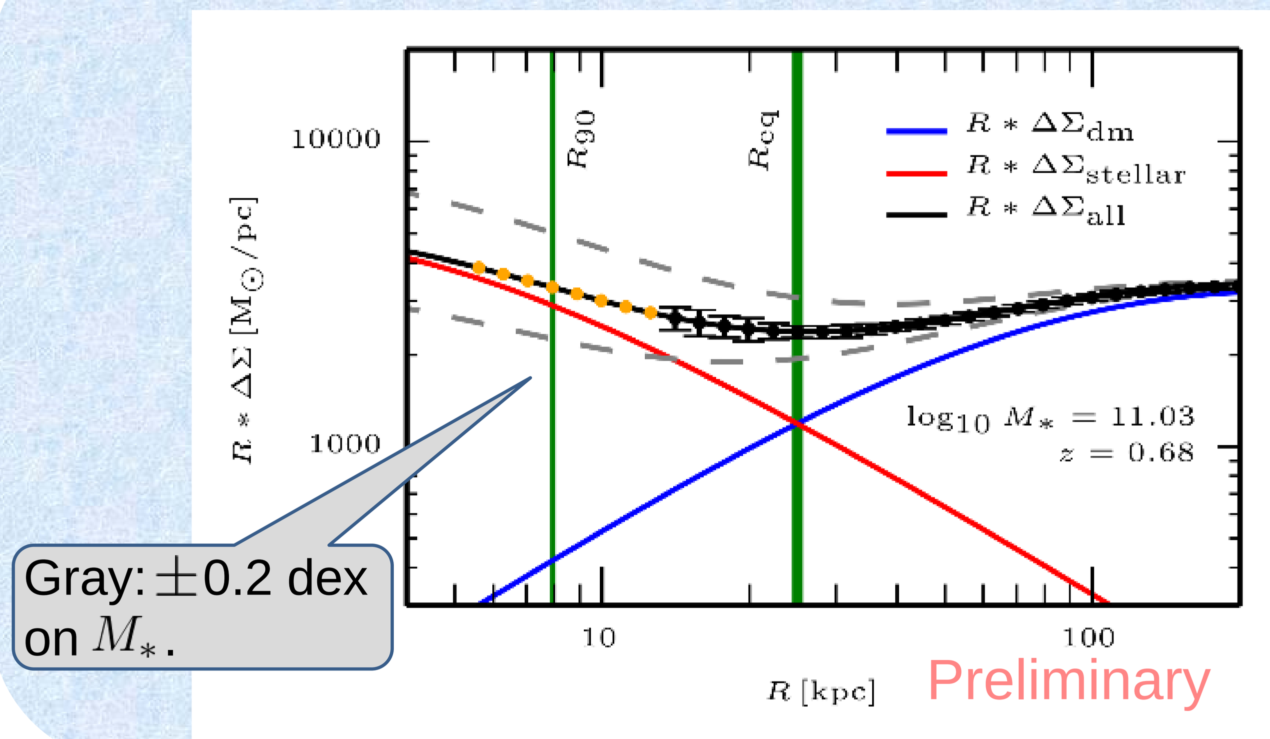
Predicted total singnal-to-noise ratio within Req

"f" is a factor multiplied by the Kron semi-major and semi-minor lengths.



Euclid:
15000 deg²
30 galaxies/arcminute²
WFIRST:
2500deg²
55 galaxies/arcminute²

Euclid: Predicted errors on $\Delta\Sigma$ measurements



4. Summary

- ✓ To directly probe the stellar mass of galaxies, it is needed to conduct weak lensing analysis on the scale within Req, which varies from about 6 to 35 kpc depending on the lens galaxy stellar mass and redshift.
- ✓ Instead of investigating shear bias on that small scale, we test how the expected signal-to-noise ratio varying with Kron ellipse criterion that rejects source galaxies from a weak lensing analysis.
- ✓ From future space-based weak lensing surveys, we may obtain sufficiently large enough signal-to-noise ratio to distinguish Salpeter and Chabrier initial mass function. (Note that this is the average of more than 10 galaxies in a given lens stellar mass and redshift bin.)