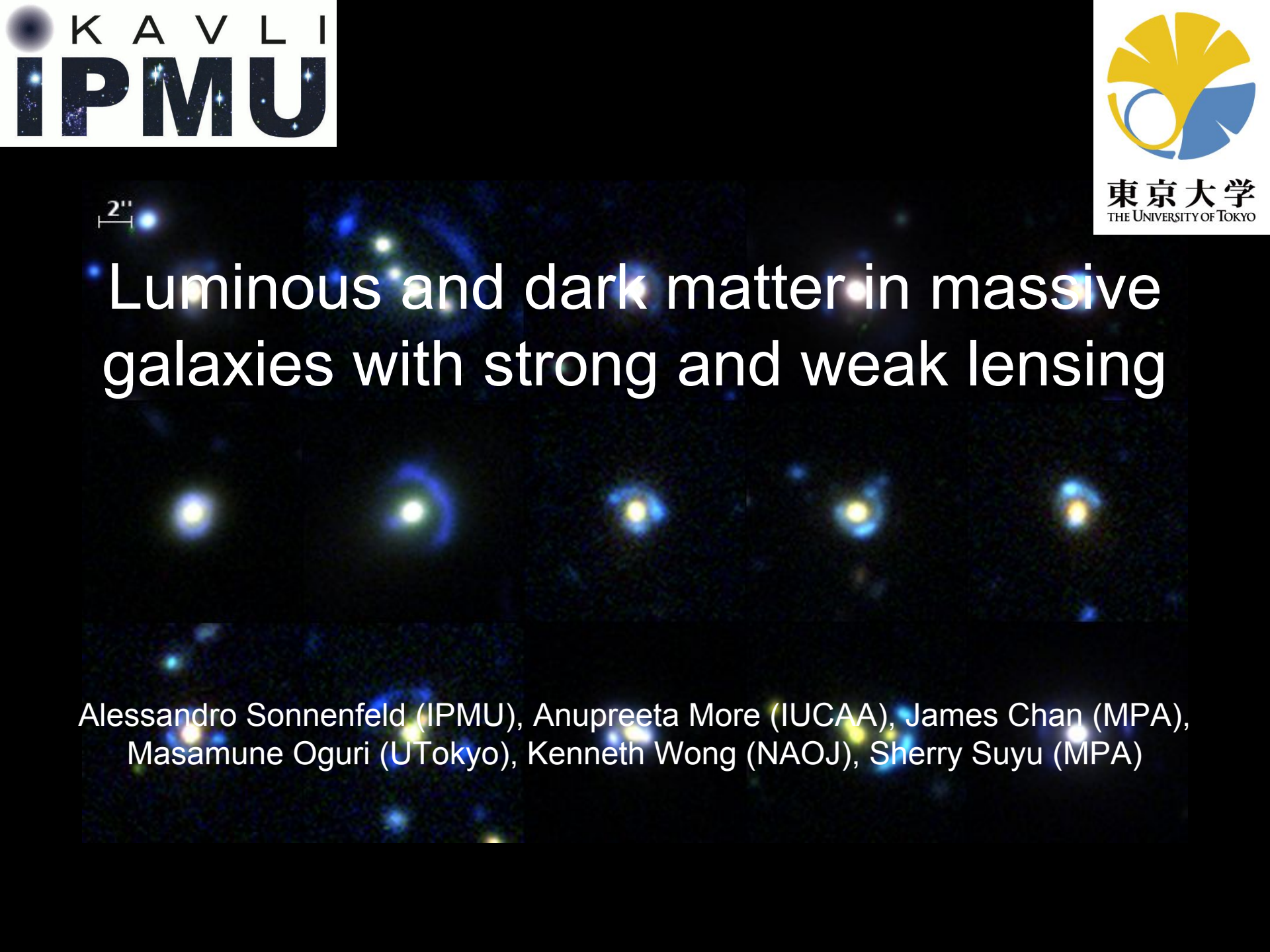
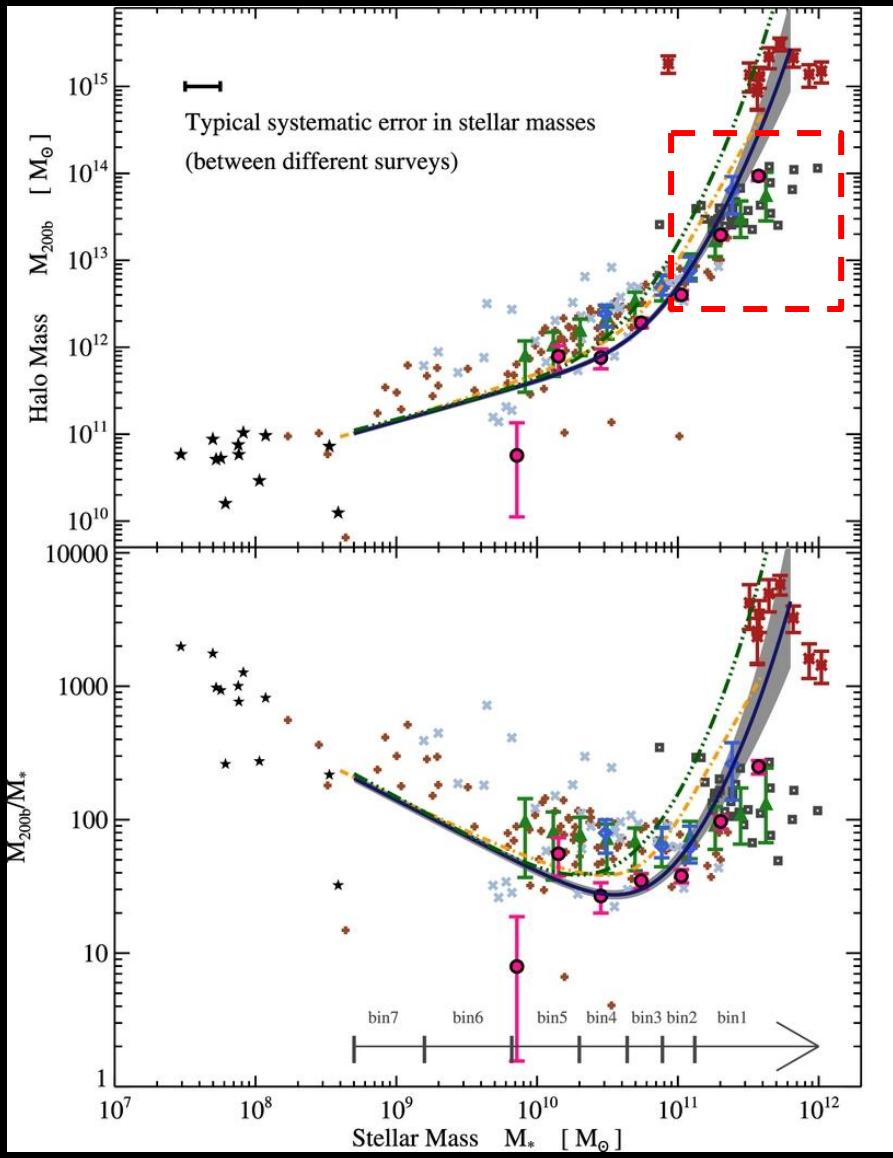


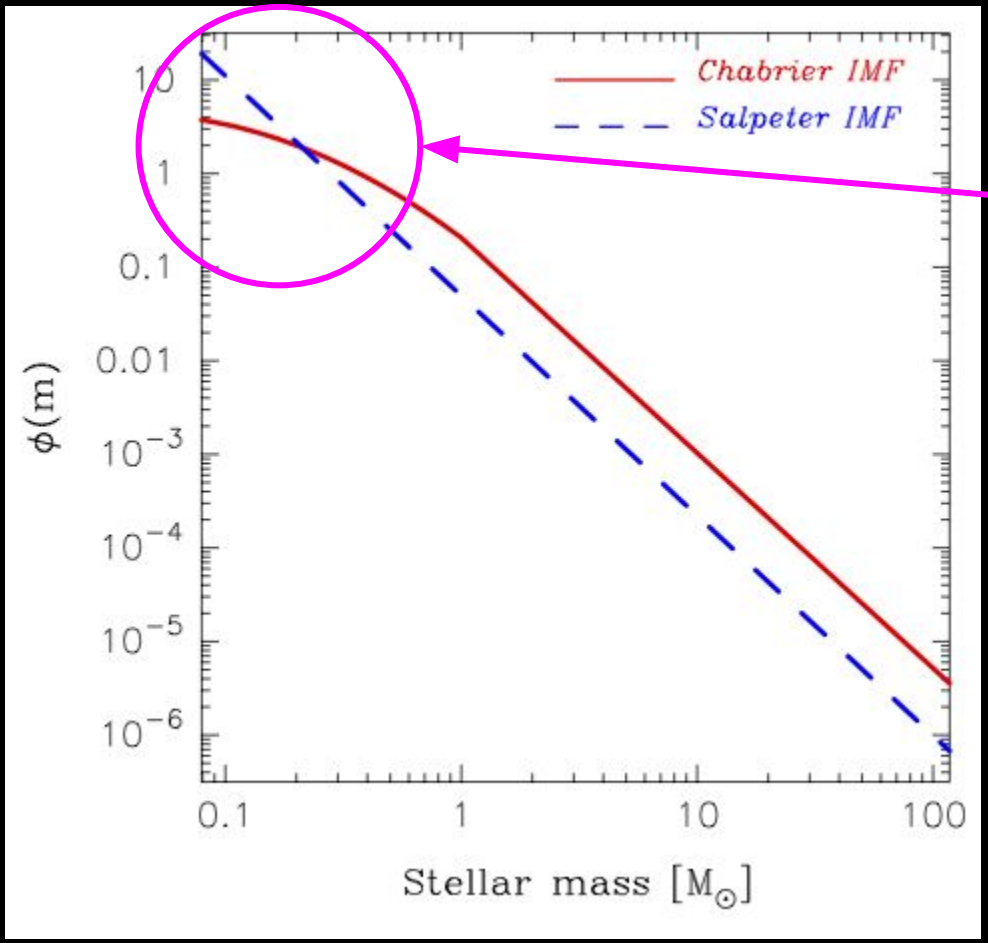
Luminous and dark matter in massive galaxies with strong and weak lensing

Alessandro Sonnenfeld (IPMU), Anupreeta More (IUCAA), James Chan (MPA), Masamune Oguri (UTokyo), Kenneth Wong (NAOJ), Sherry Suyu (MPA)

Early-type galaxies



The stellar initial mass function (IMF)



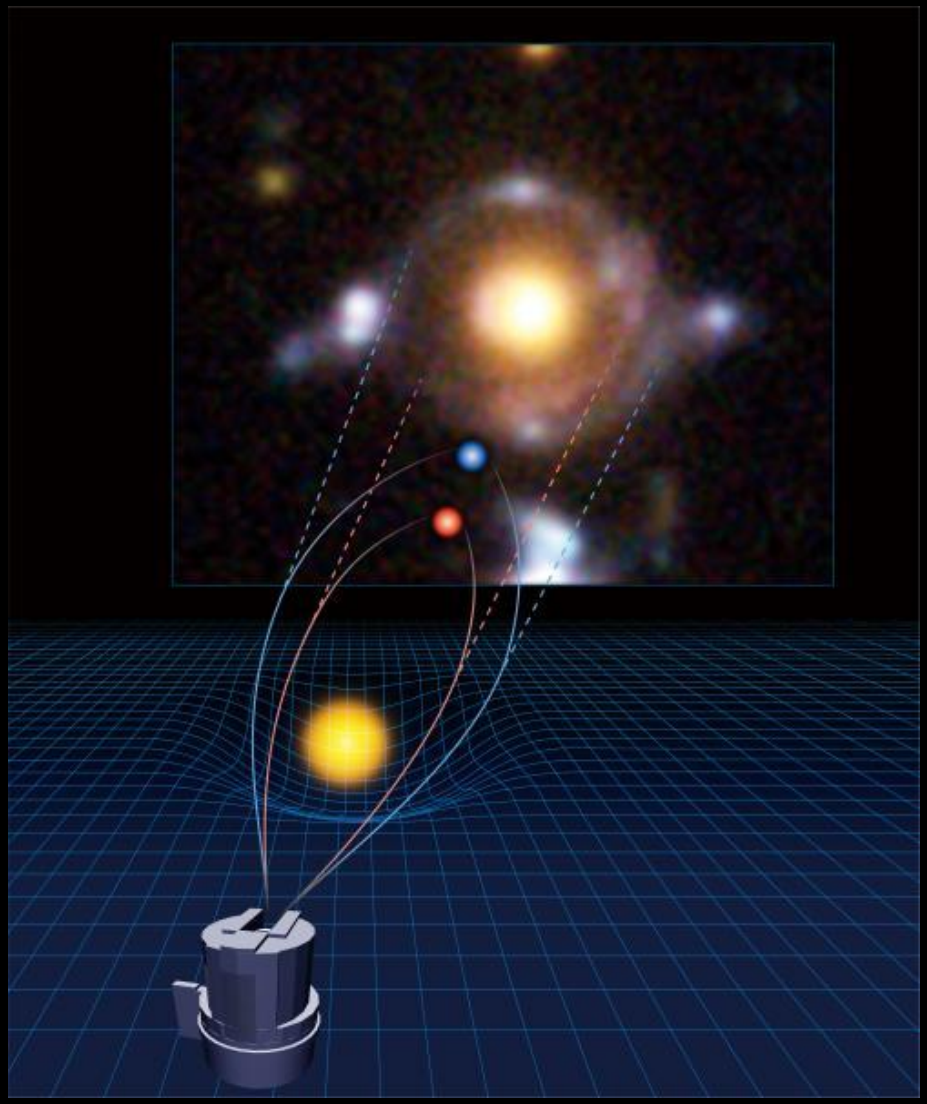
These stars contribute very little to the light of a galaxy, but contribute a lot to the mass: uncertainty in M/L of up to a factor of 2!

- Stellar IMF is the biggest systematic in stellar mass measurements
- Challenge for the measurement of dark matter distribution

Questions

- What is the stellar IMF of early-type galaxies? (Star formation physics)
- What is the dark matter density profile in the inner regions of galaxies? (Dark matter physics, mergers, adiabatic contraction, AGN feedback)

Strong gravitational lensing



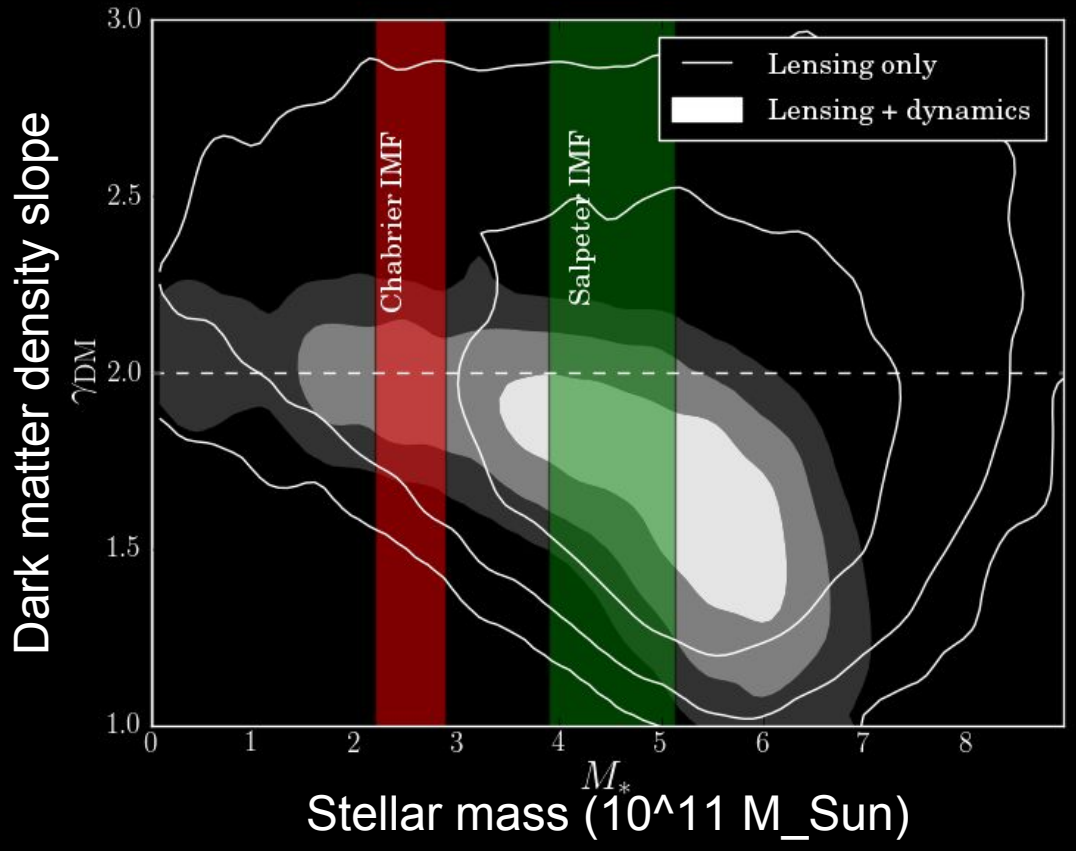
- Typical scale: ~10kpc
- Few % precision in measurement of enclosed projected mass

$$R_{Ein} = \sqrt{\frac{4GM}{c^2}\frac{D_d D_{ds}}{D_s}}$$

Angular diameter distances

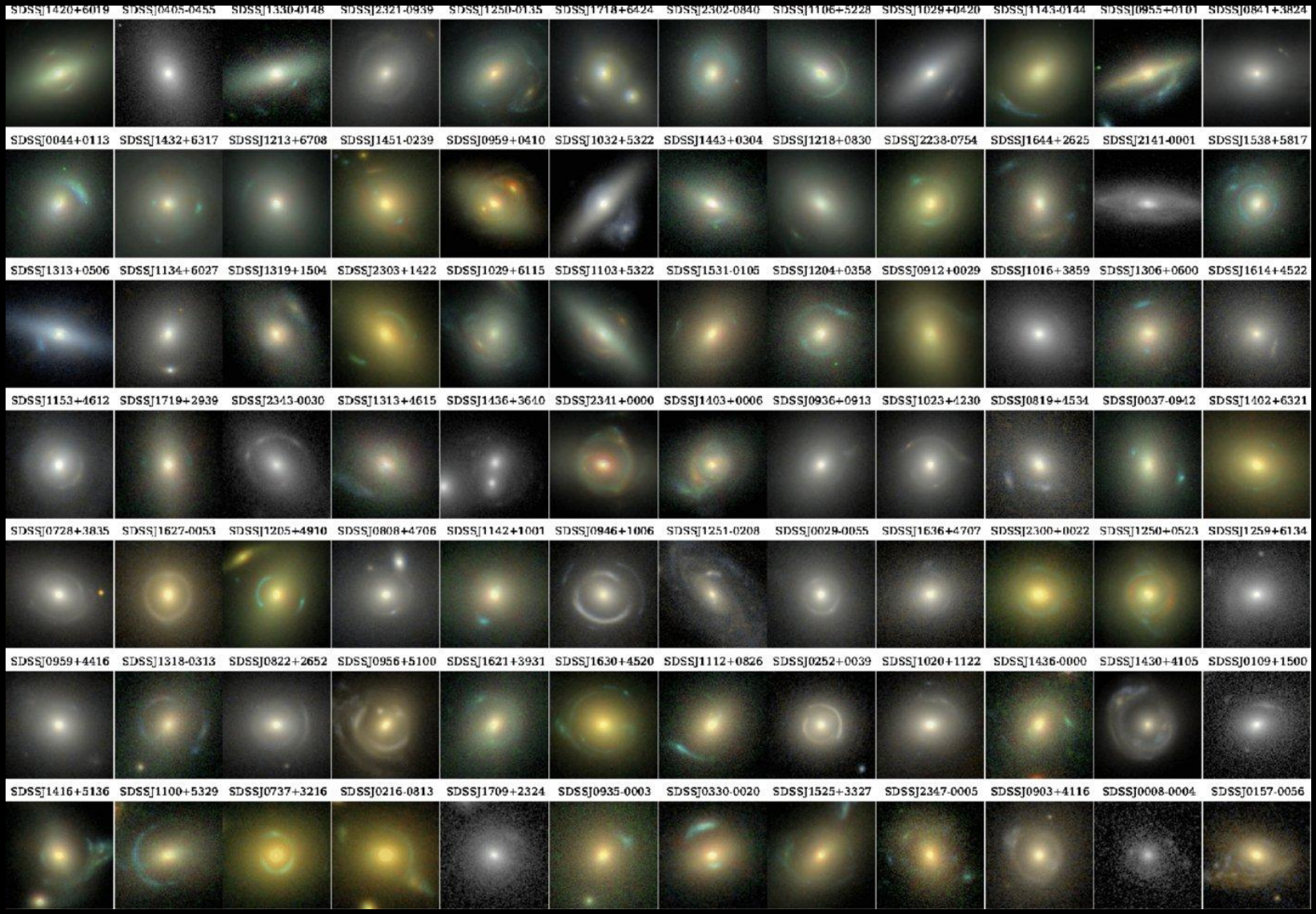
Approach #1: “love a lens”

- “Jackpot lens” (Gavazzi et al. 2008): 2 sources behind lens
- 4h Keck spectrum: velocity dispersion profile
- Stellar dynamics provides independent constraint on density profile



Sonnenfeld et al. (2012)

Approach #2: statistical combination of many lenses



SLACS sample (Auger et al. 2010)

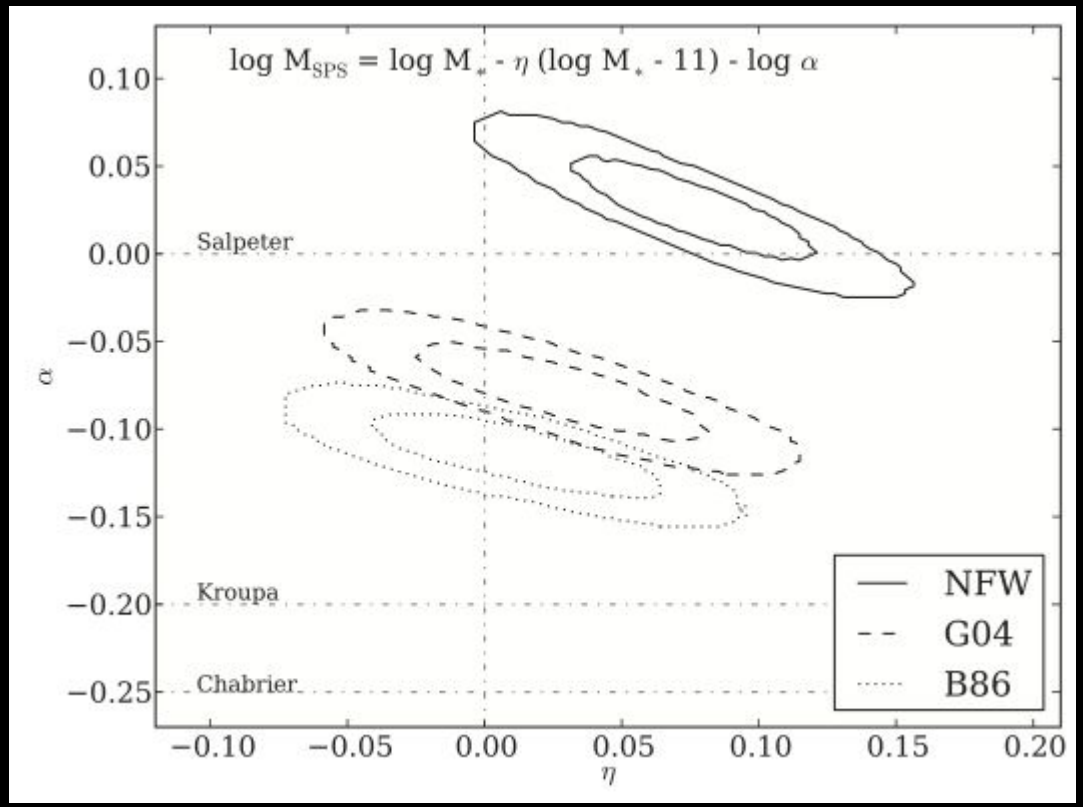
Approach #2: statistical combination of many lenses

$$\alpha_{\rm IMF} \equiv \frac{M_*^{\rm (true)}}{M_*^{\rm (SPS)}}$$

"IMF mismatch parameter"

- 53 strong lenses (SLACS sample)
- 2 constraints per lens: Einstein radius + central velocity dispersion
- Degeneracy between DM density profile and IMF

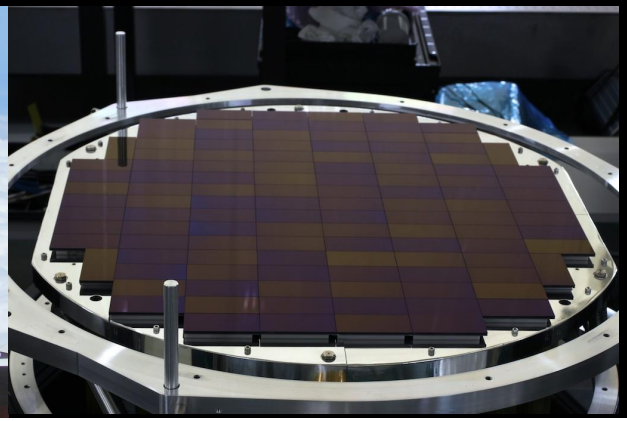
Log10 (IMF mismatch parameter)



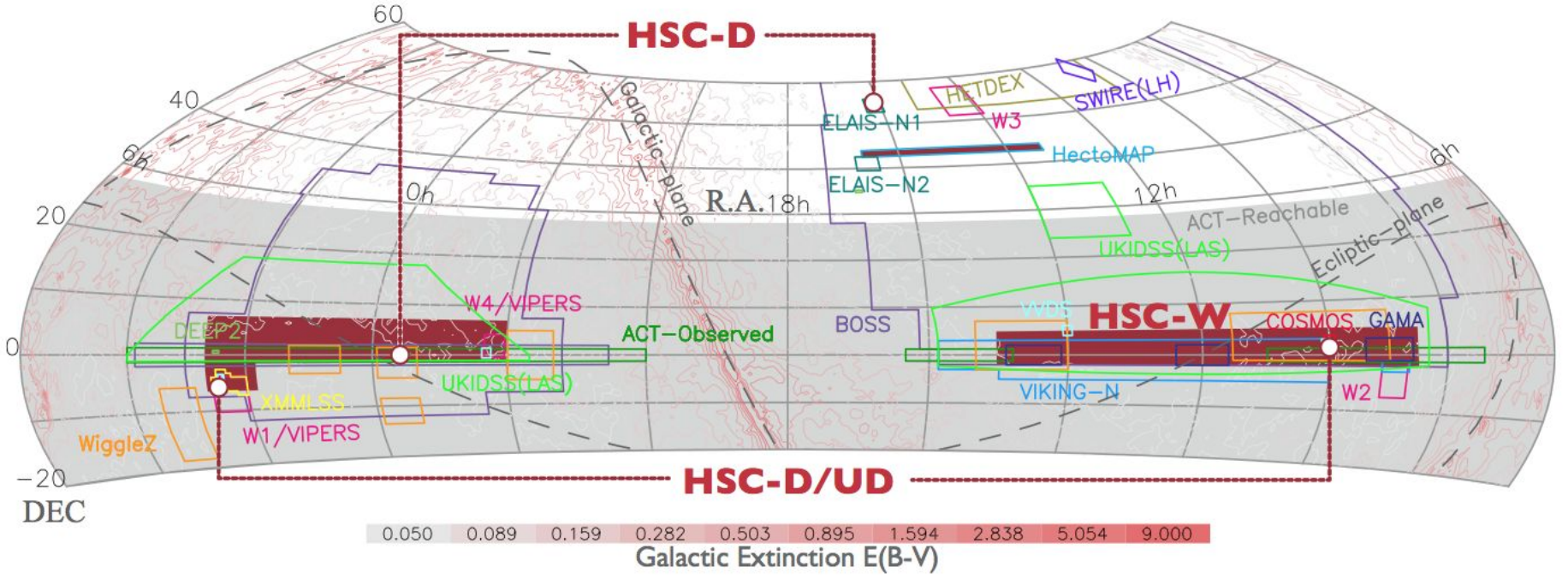
Stellar mass dependence of IMF

Auger et al. (2010)

Strong lensing with the HSC survey



- 1,400 square degrees
- Depth ~26 mag (i-band)
- Typical seeing 0.7”



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Survey of Gravitationally-lensed Objects in HSC Imaging (SuGOHI). I. Automatic search for galaxy-scale strong lenses

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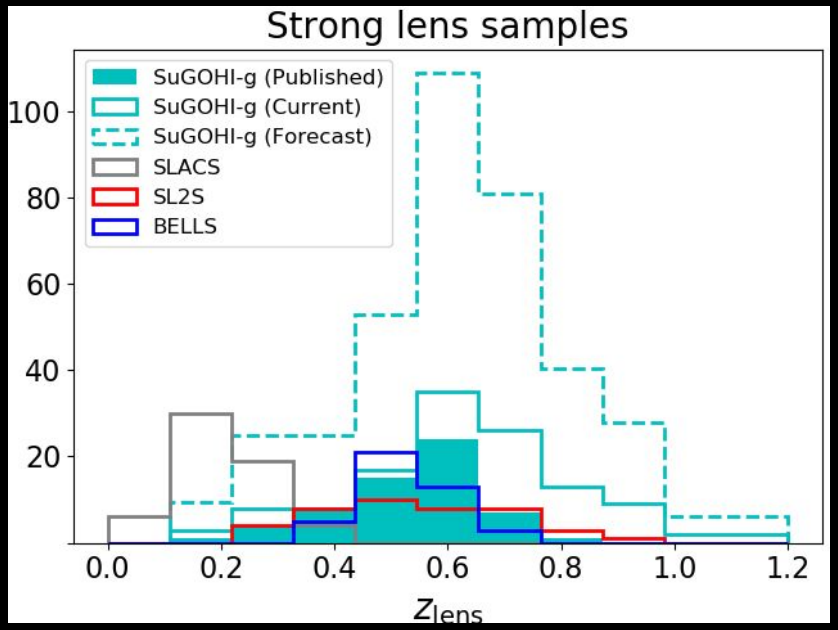
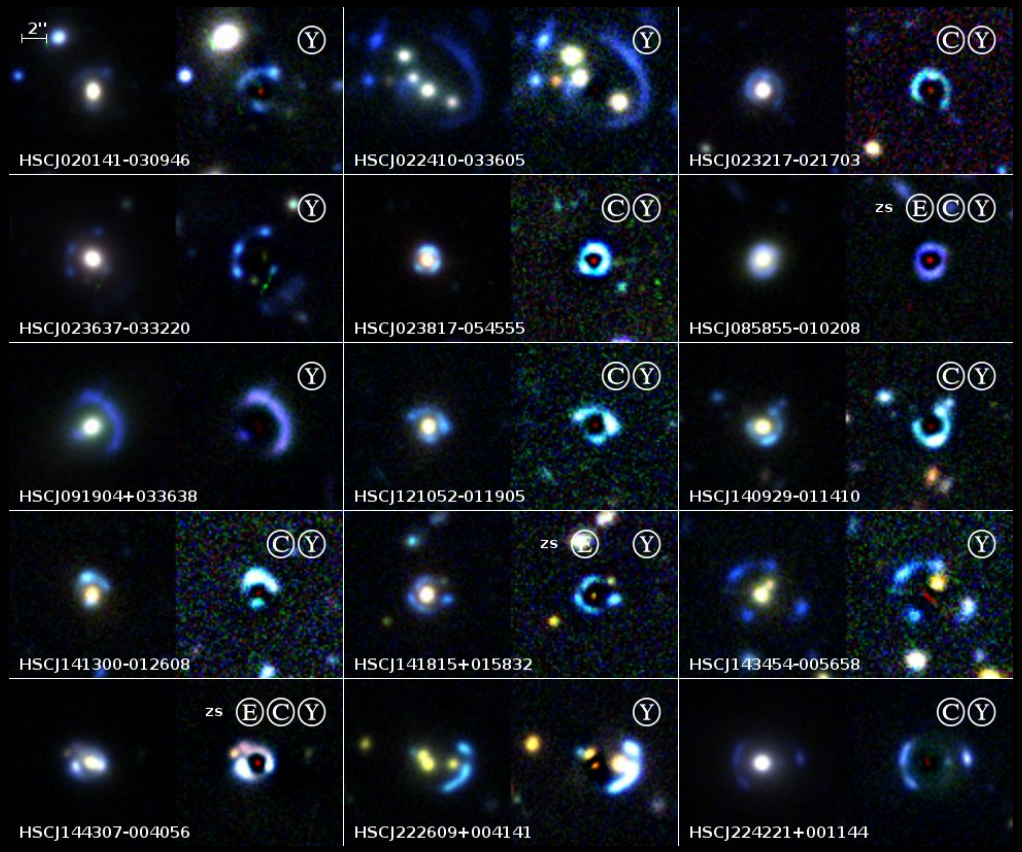
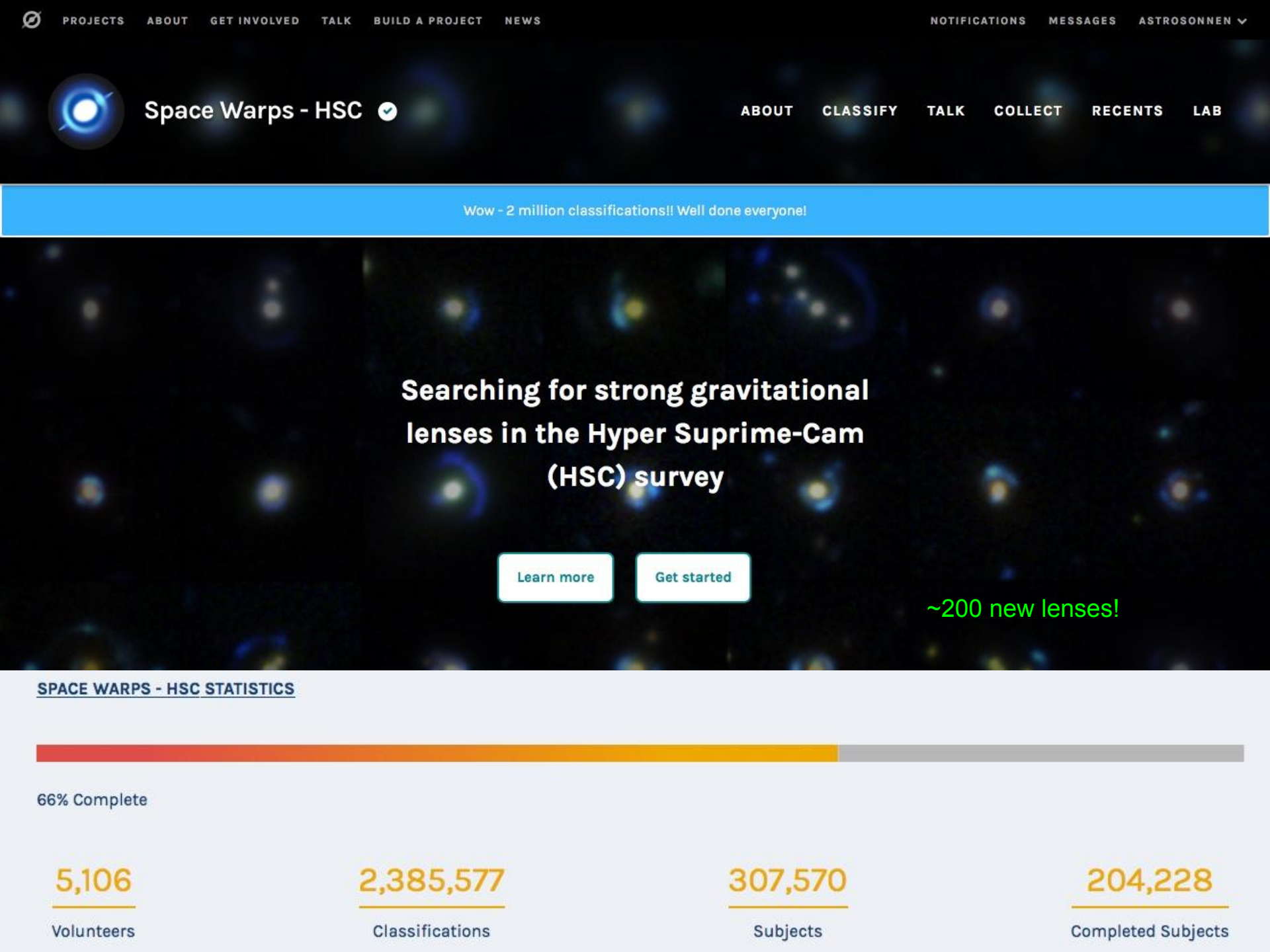
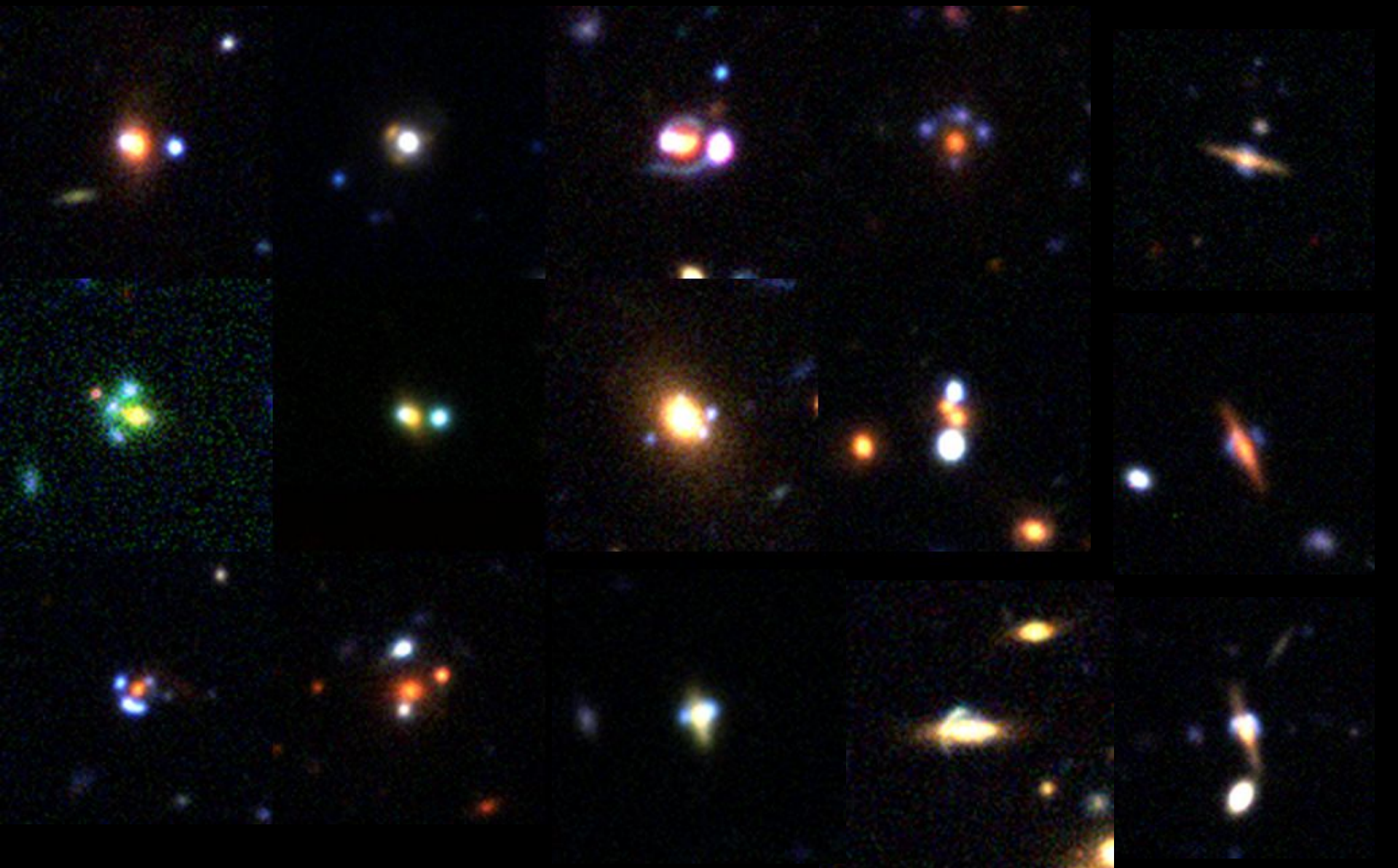




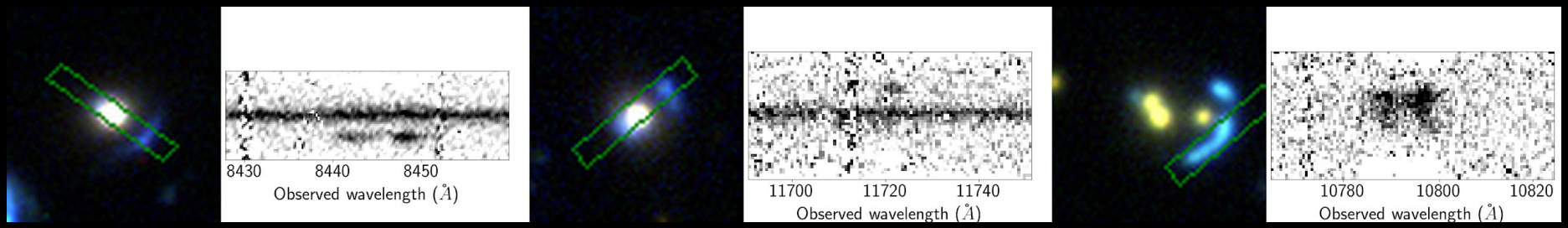

PROJECTS ABOUT GET INVOLVED TALK BUILD A PROJECT NEWS
NOTIFICATIONS MESSAGES ASTROSONNEN
Space Warps - HSC
ABOUT CLASSIFY TALK COLLECT RECENTS LAB
Wow - 2 million classifications!! Well done everyone!
Searching for strong gravitational lenses in the Hyper Suprime-Cam (HSC) survey
Learn more
Get started
~200 new lenses!
SPACE WARPS - HSC STATISTICS
66% Complete
5,106
Volunteers
2,385,577
Classifications
307,570
Subjects
204,228
Completed Subjects

Lenses found by citizens



Spectroscopic follow-up

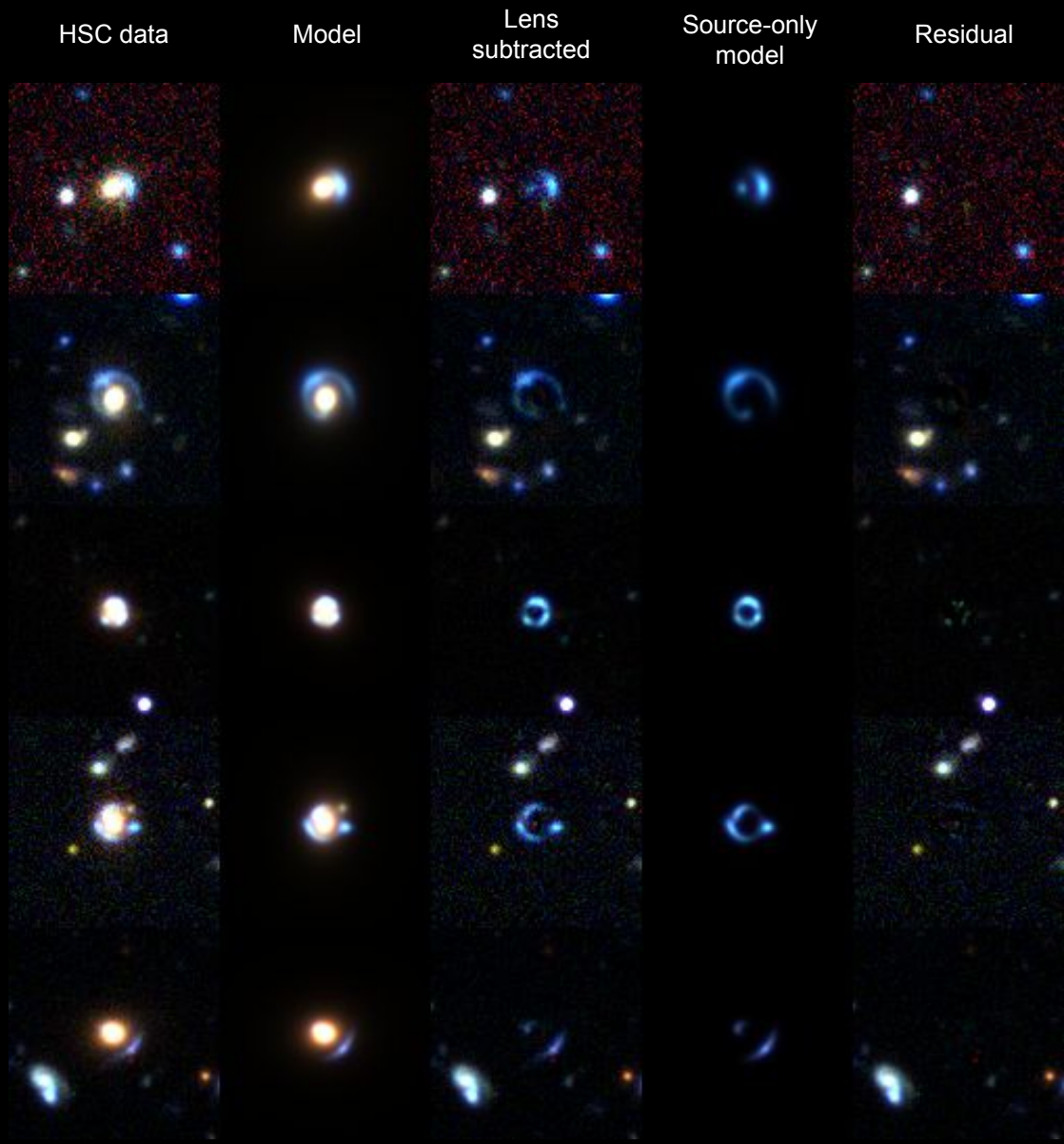
- First batch of 23 candidates followed-up with X-Shooter
- ~80% success rate



- Following-up hundreds of lenses with X-Shooter is a bit unrealistic
- Prime Focus Spectrograph (PFS) could help a lot

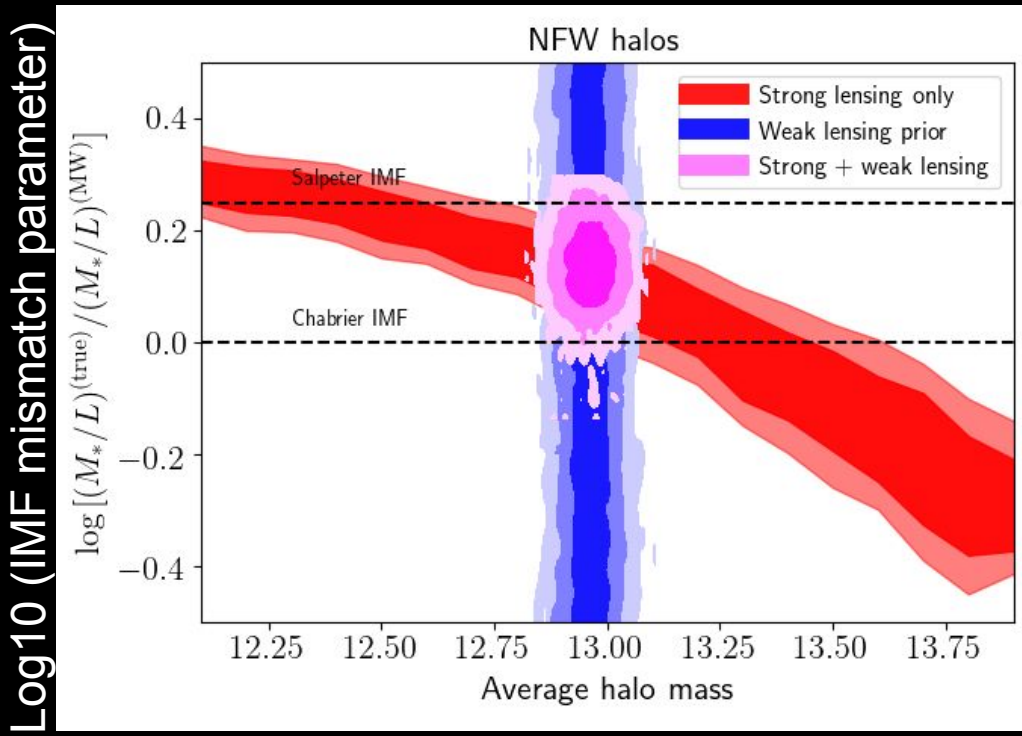
Lens modeling

- Fit model lens mass, lens and source surface brightness profiles to observed images in different bands
- Lens model: singular isothermal ellipsoid
- Light model: Sérsic profile
- Source model: Sérsic profile
- Future plans: fit for source photo-z



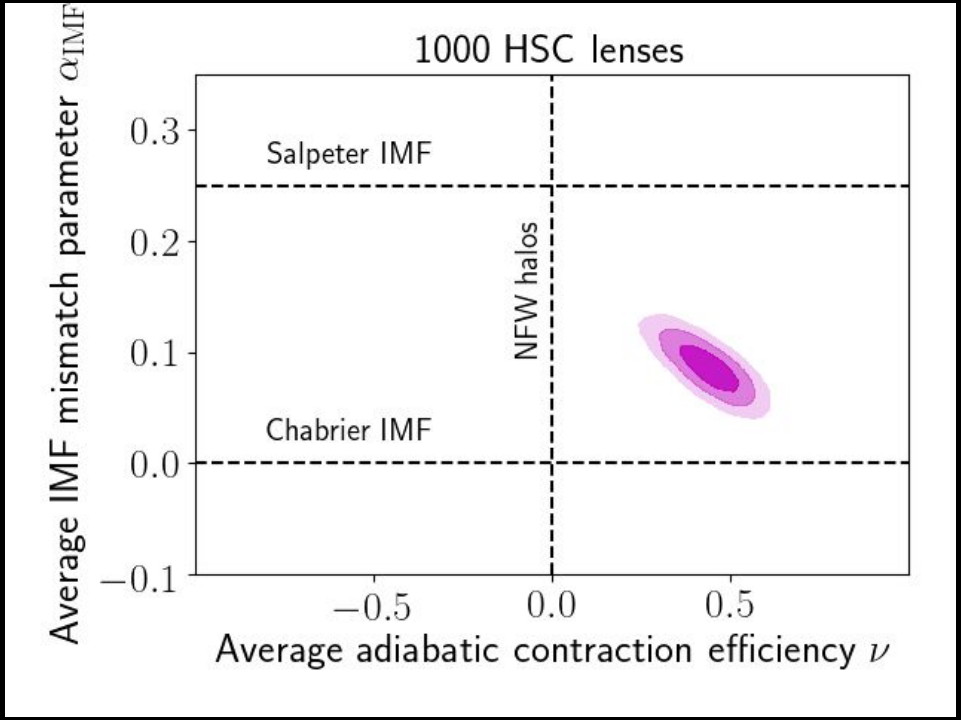
HSC strong lensing: first results

- 20 lenses in HSC survey
- Lens model: NFW (dark matter halo) + Sérsic (stars)
- Use HSC weak lensing to infer stellar-to-halo mass relation
- Put prior on halo mass to break degeneracy between luminous and dark matter



HSC strong lensing: forecast

- 1000 strong lenses from HSC, source redshifts from PFS
- Weak lensing measurements from HSC
- Population model: fitting for the distribution of halo masses, adiabatic contraction efficiency, IMF (Bayesian hierarchical inference method)



We can solve both the IMF and the dark matter profile problems!

Summary

- Strong lensing is a unique probe of matter on scales of ~10kpc
- Current and future surveys, such as HSC, Euclid, LSST will allow us to find thousands of new lenses. New regime: statistical strong lensing
- Measurement of stellar IMF and inner dark matter density profile within reach in the next ~5 years