Gravitational lensing science with WISH

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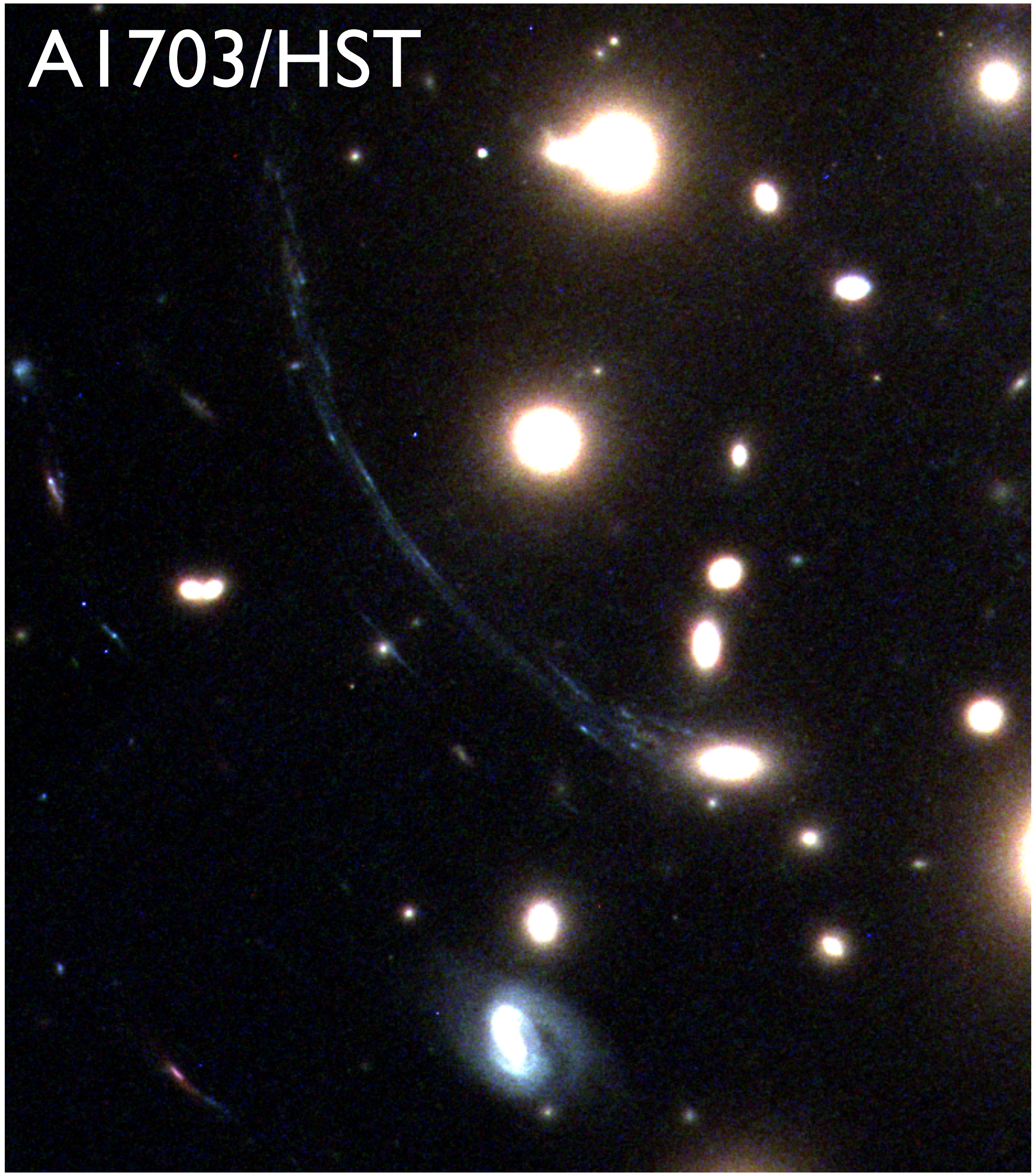
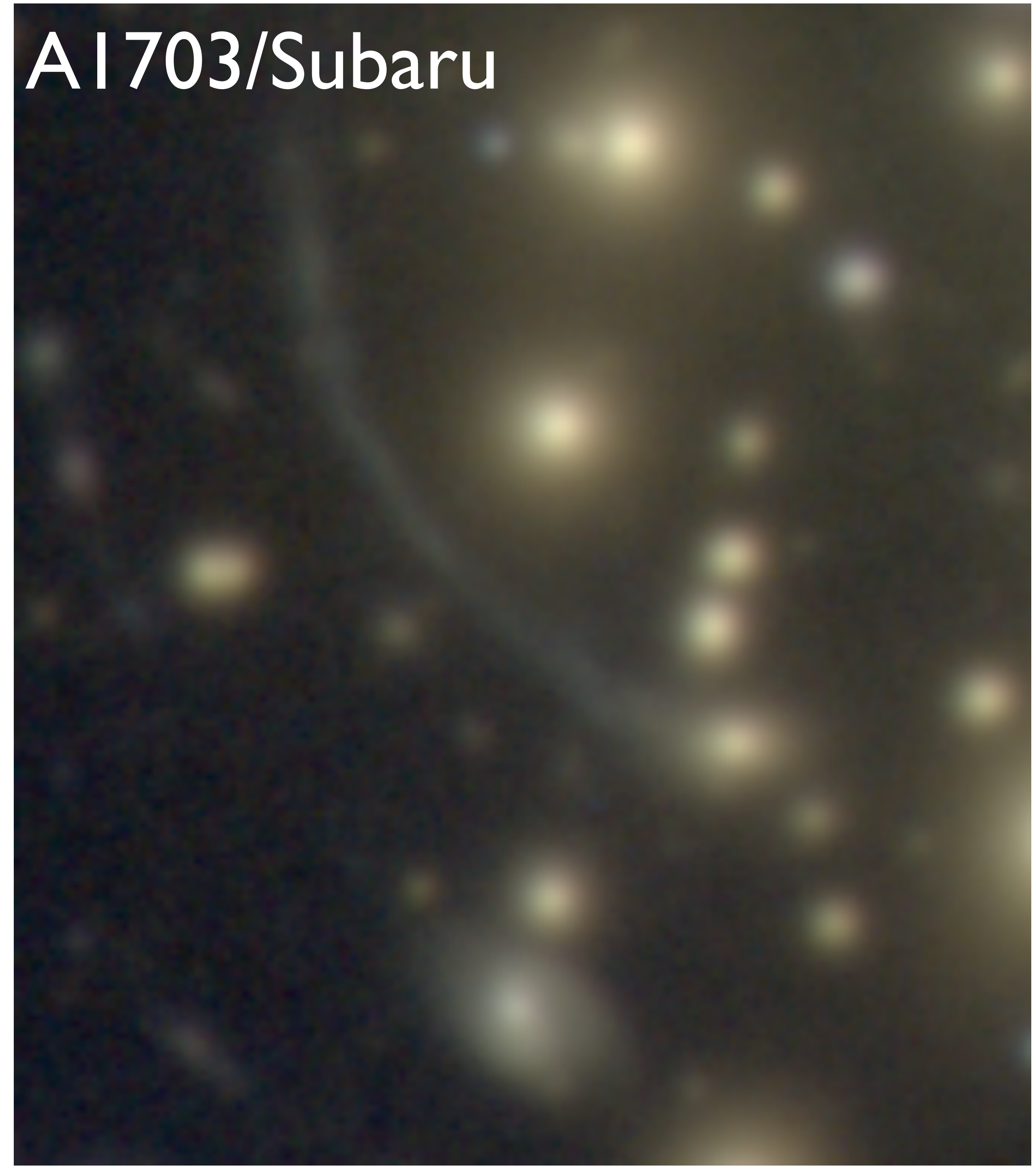
Lensing benefits from space missions





- sharp images lead to accurate astrometry and morp-hology, crucial for both strong and weak lensing!

Weak gravitational lensing

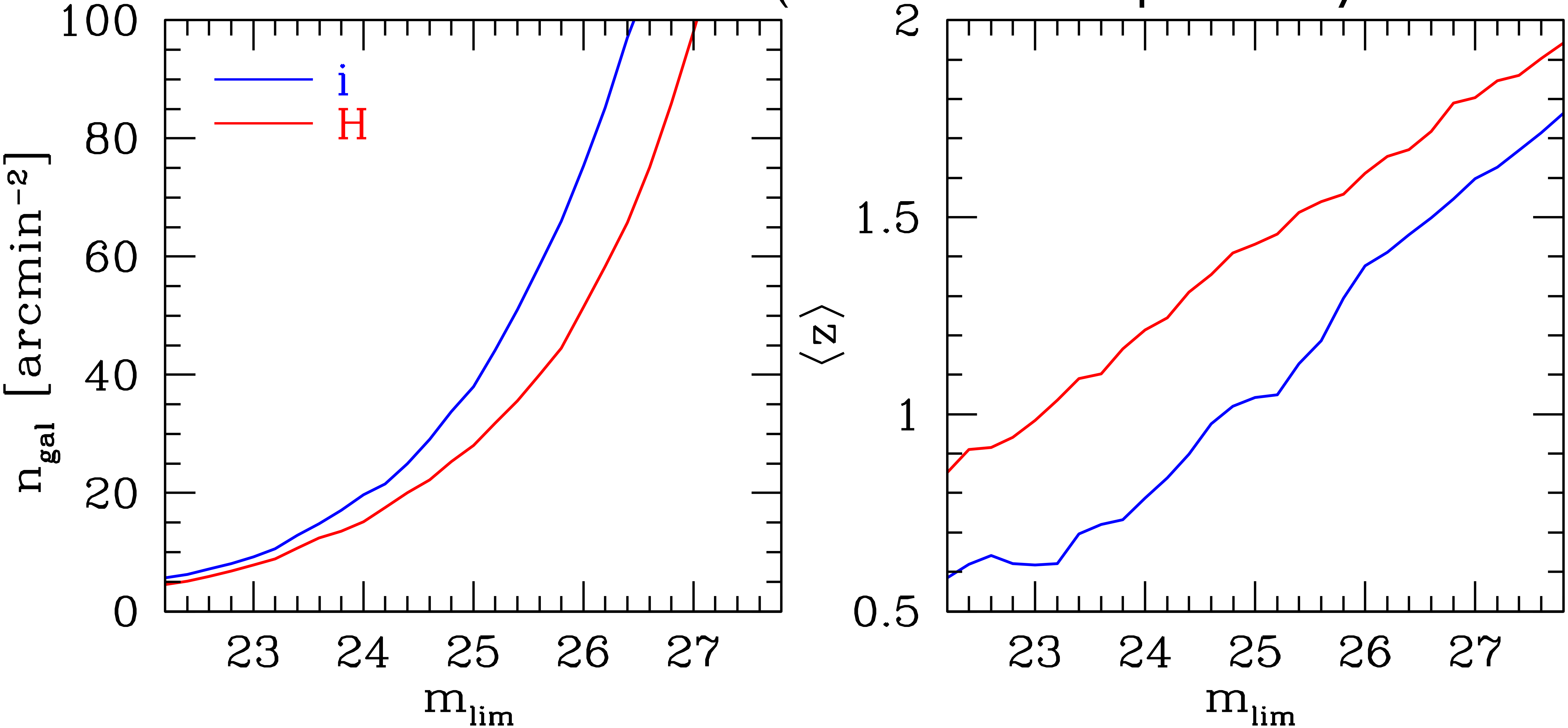
- key science for Euclid/WFIRST
- thought to be a main probe of dark energy and modified gravity for these missions
- what about WISH?

Weak lensing: optical vs near-IR

- in ground observations the sensitivity is much better in optical so that weak lensing in NIR is much less competitive
- in space optical and NIR sensitivities are similar, so weak lensing power can be comparable

Optical/NIR depth comparison

(based on HUDF photo-z by Coe et al.)



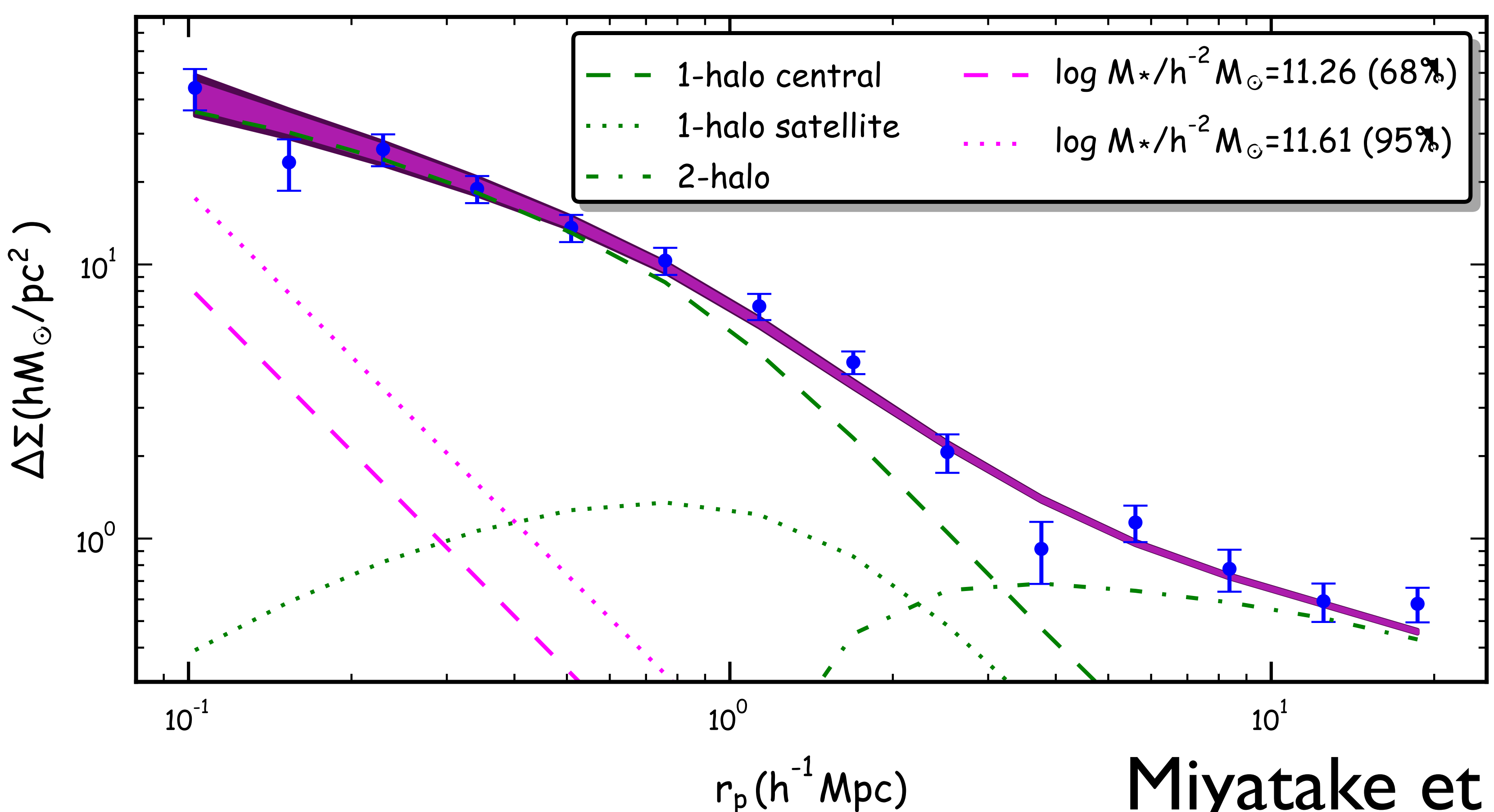
- in NIR number density is slightly less, but mean redshift is higher!

WISH and weak lensing

- WISH has a potential to produce significant weak lensing results comparable to Euclid and WFIRST
- current WISH survey design is not optimized for cosmology
- but weak lensing is not just for cosmology, there are many applications

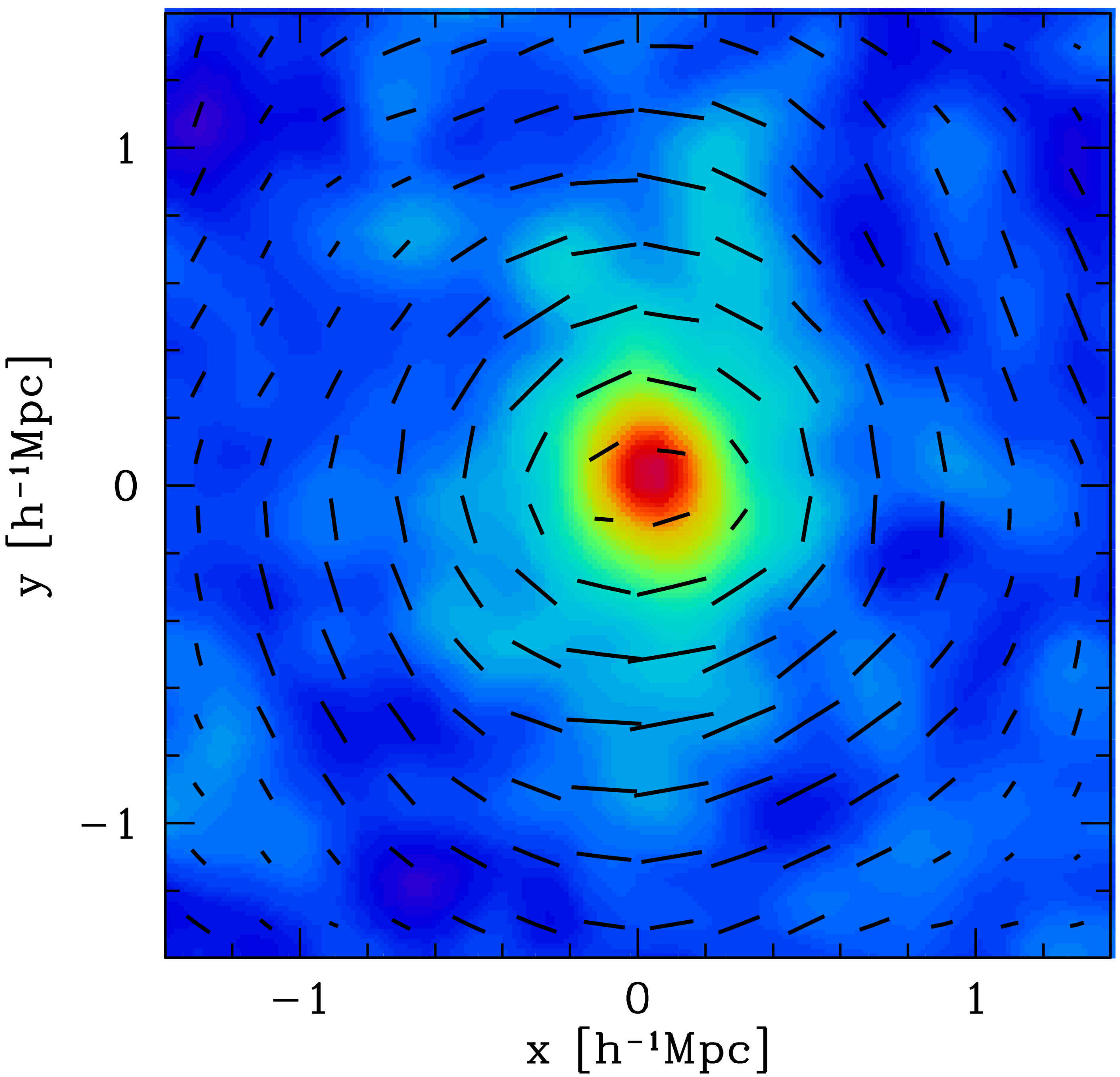
Galaxy-dark matter connection

- stacked weak lensing provides powerful means of studying the connection between galaxies (or clusters, quasars) and dark matter halos
- with WISH we can do this at higher redshifts!



Miyatake et al. (2013)

Dark matter density profile

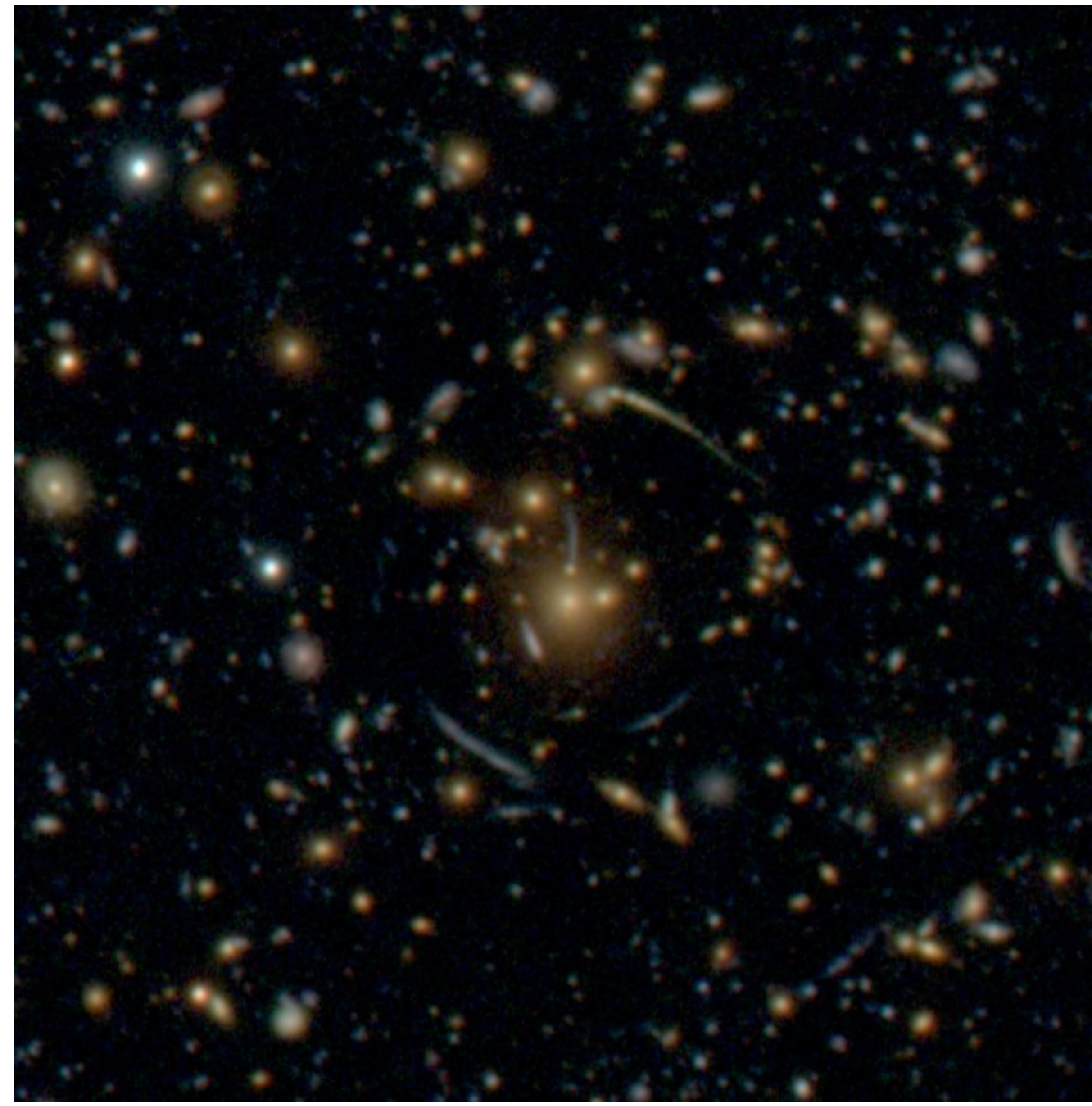


Oguri et al. (2012)

- ΛCDM model predicts NFW-like radial profile and very non-spherical 2D shape
- stacked weak lensing can test this at high precision
  → constraints on DM collision cross section, coldness, ...

Strong gravitational lensing

- many applications
  - cosmology from e.g., time delays
  - galaxy structure and evolution (IMF, dark matter fraction, ...)
  - study of sources with help of magnification (“natural telescope”)

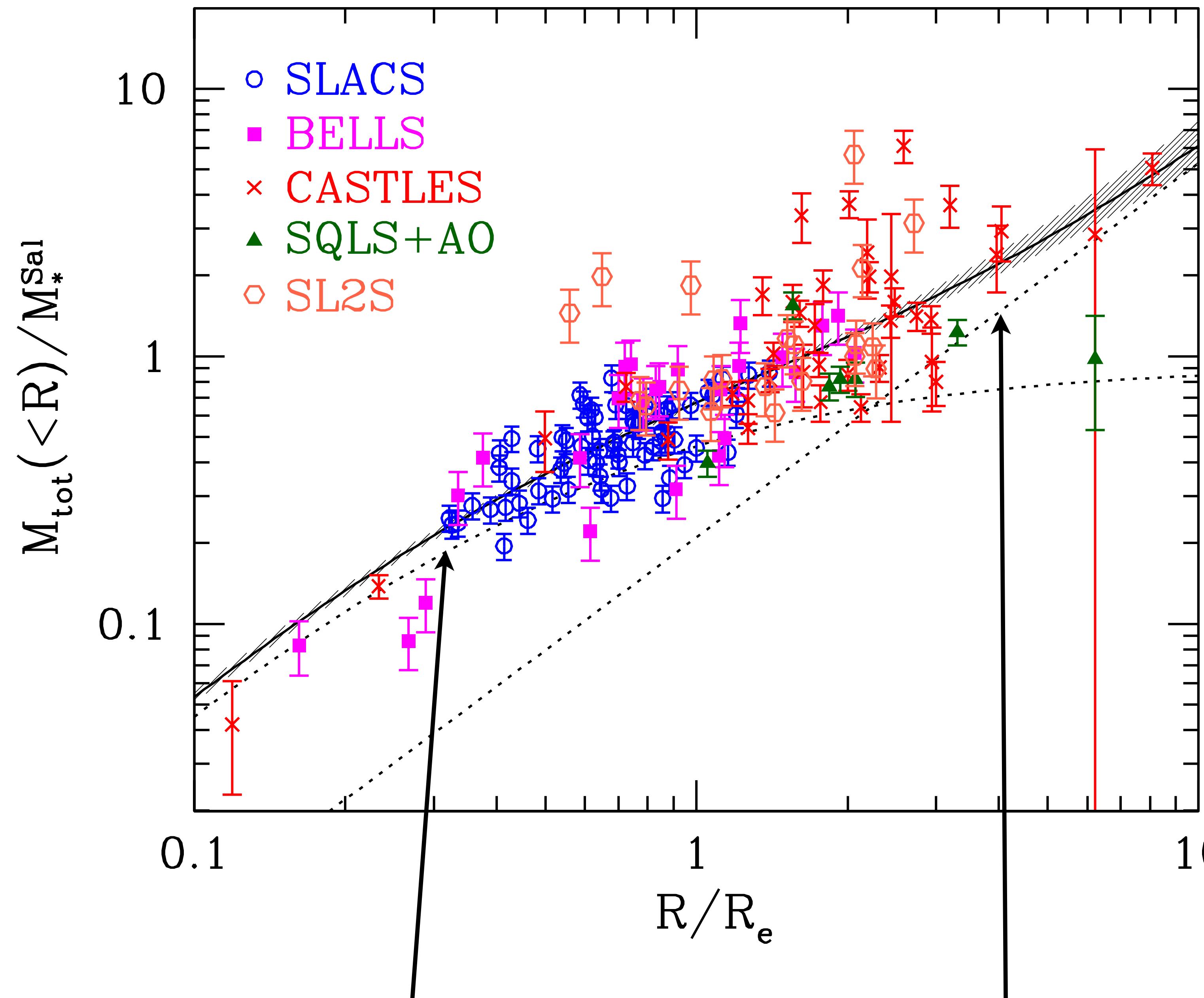


SDSSJ1050+0017/Subaru

Oguri, Rusu & Falco arXiv:1309.5408

Stellar and dark matter distribution

- average mass profile of elliptical galaxies from 161 strong lens
- breaking degeneracy btw stellar and dark mater dist. by quasar microlensing
- prefer Salpeter IMF and NFW-like DM profile without adiabatic contraction

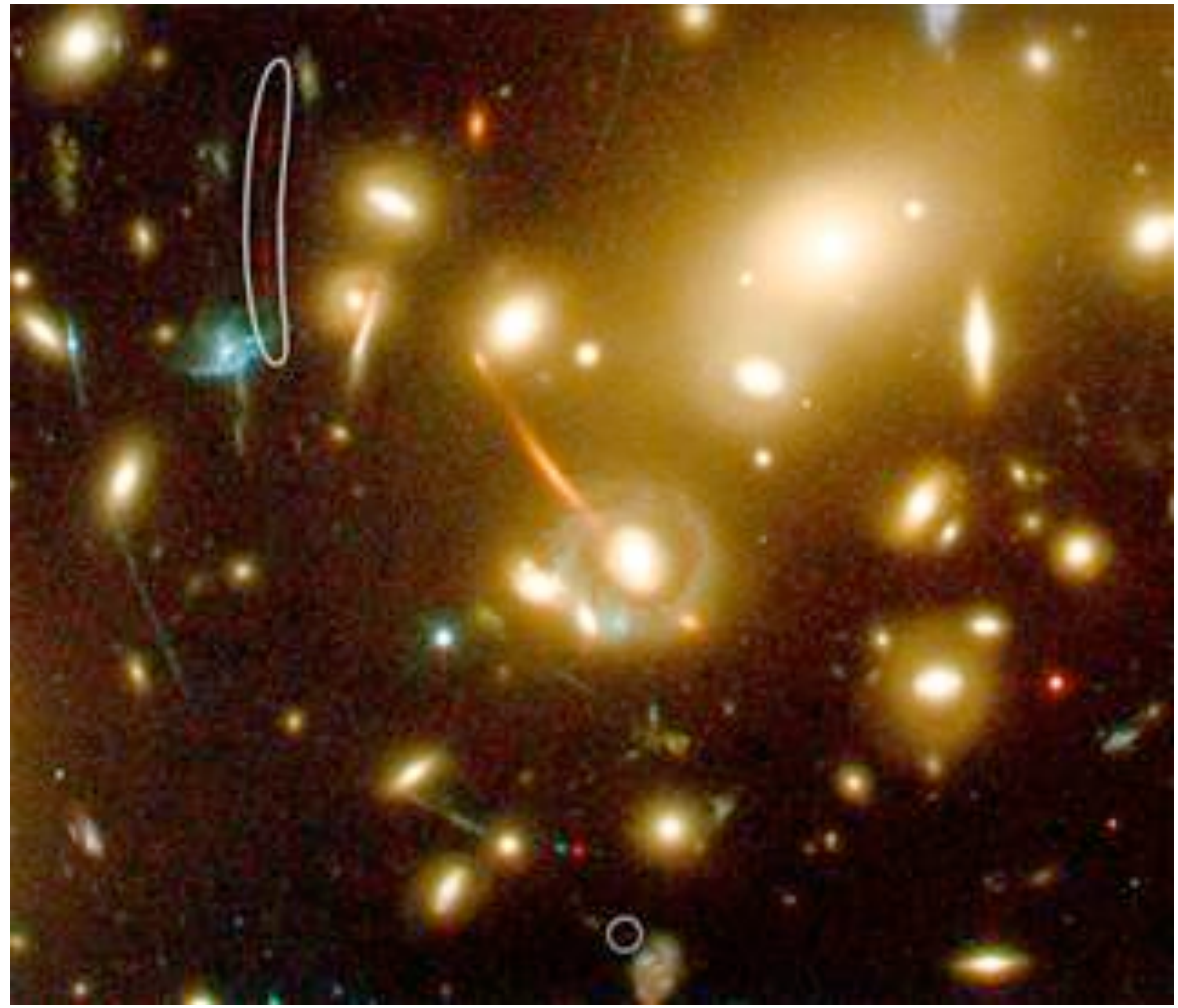


best-fit stellar matter distribution

best-fit dark matter distribution

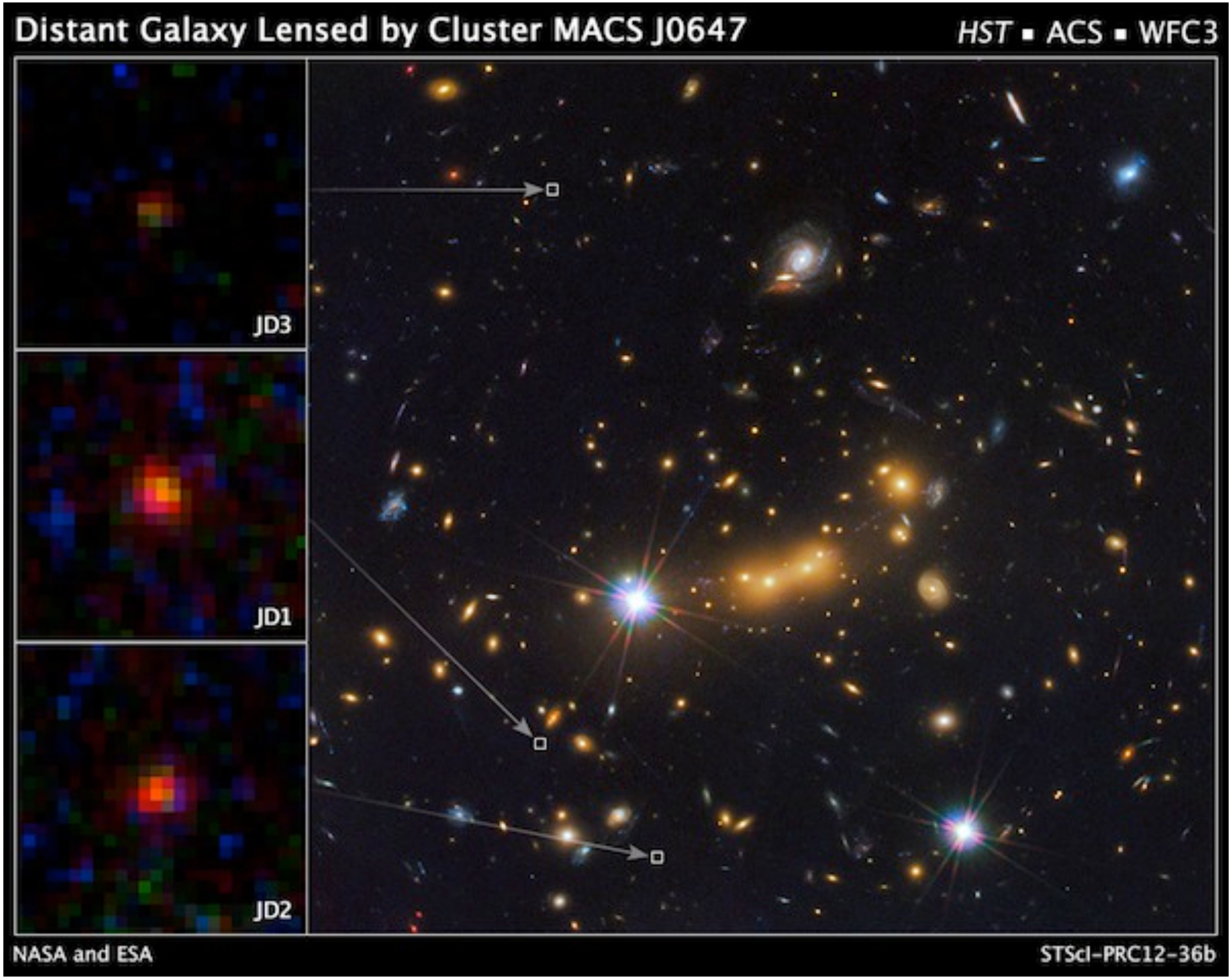
Lensing as a natural telescope

- strong lensing magnifies distant sources
- provide a unique tool to study distant and/or faint galaxies



Kneib et al. (2004)

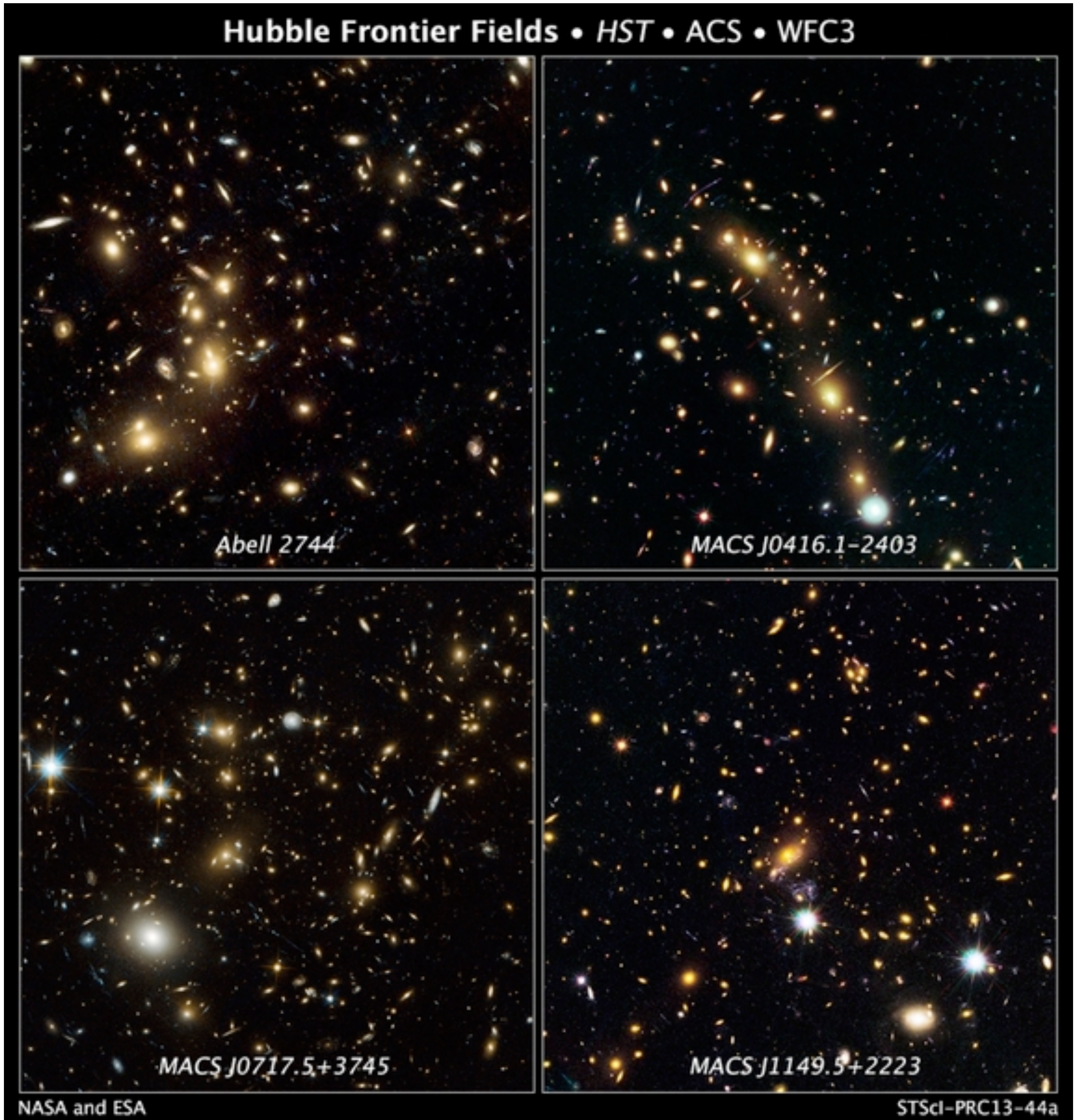
“Most distant” galaxy!



z~11 galaxy lensed into 3 images!

Coe et al. (2013)

Hubble Frontier Fields



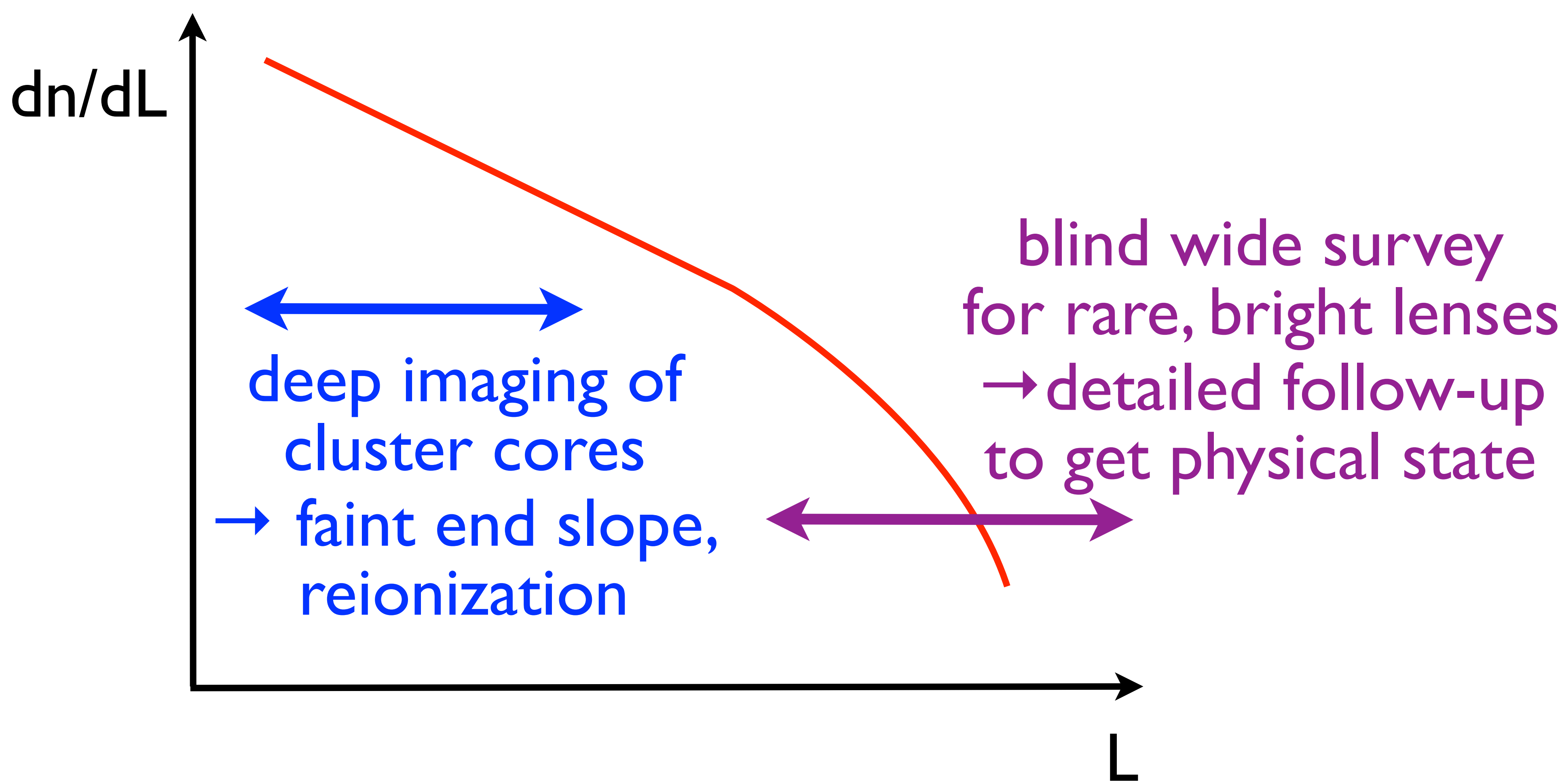
- ultra deep imaging of 4+2 cluster cores with HST
  (140 orbits per cluster)
- much deeper than HUDF with help of lensing magnification
- observations started from 2013 Oct
  − stay tuned!

“Frontier fields” with WISH?

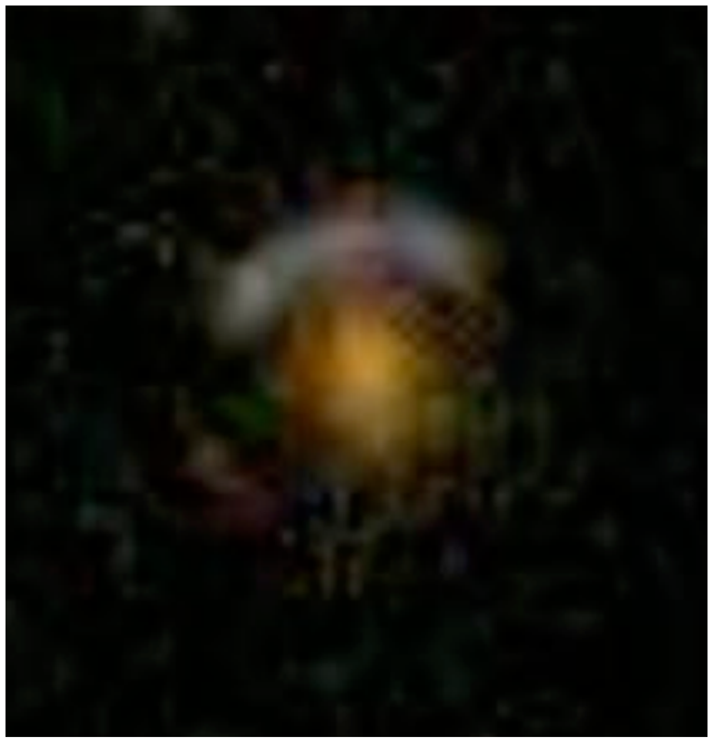
- ultra deep imaging of massive cluster cores with WISH is an interesting option
- however the WISH FOV is much larger than Einstein radii of clusters, so this might not be an efficient use of WISH

Strong lenses in wide-field surveys

- blind wide-field surveys provide an opportunity to find very bright lensed objects
- these are very useful targets for follow-up

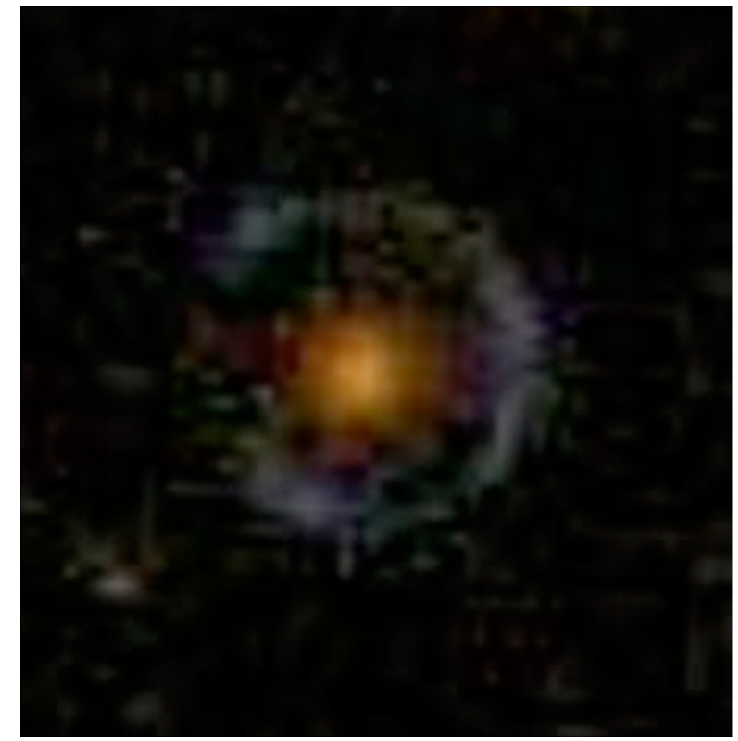


Lessons from SDSS



“8 o’clock arc”
z_s=2.73 z_l=0.38
(Allam et al. 2007)

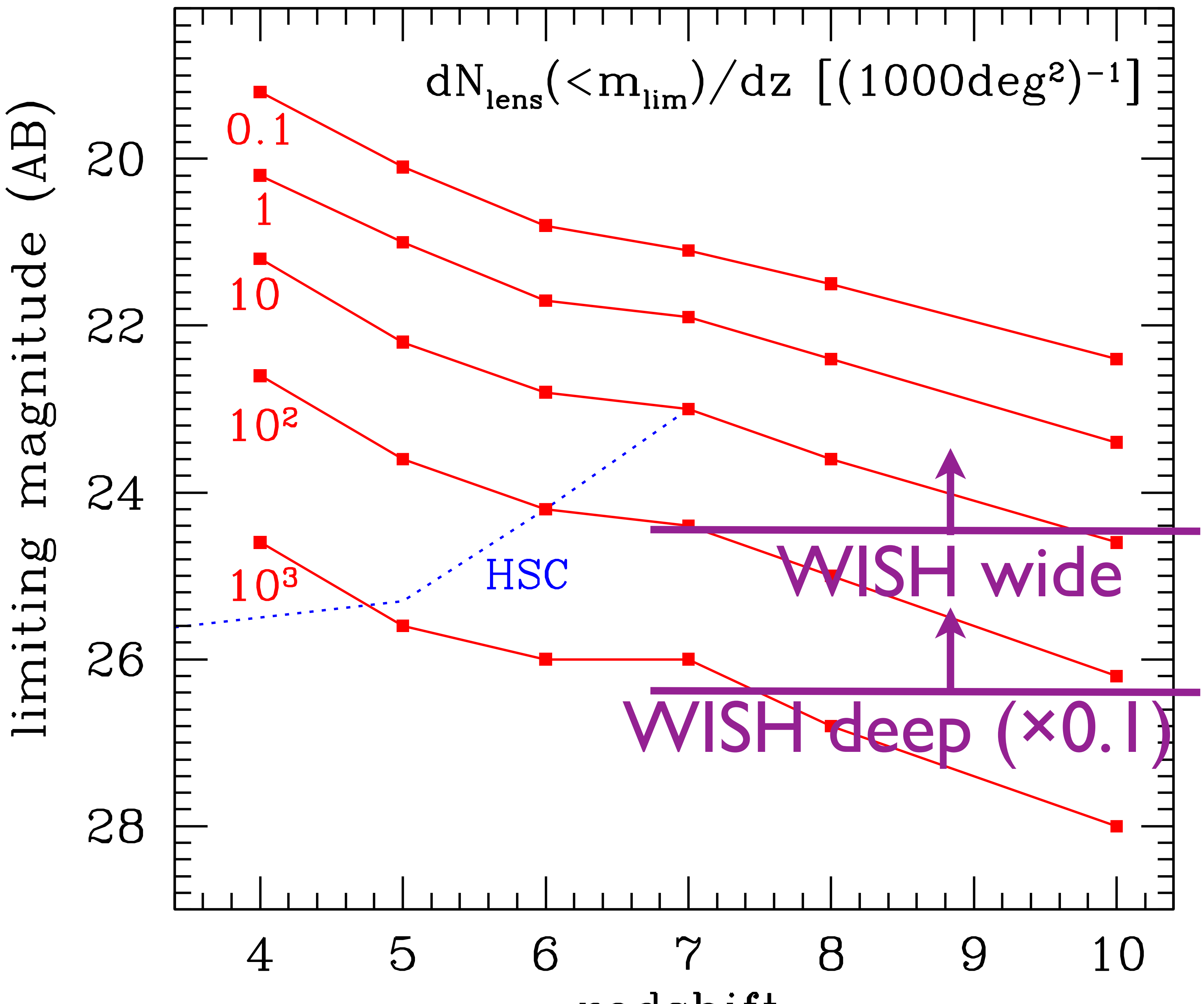
“clone”
z_s=2.00 z_l=0.422
(Lin et al. 2009)



“cosmic horseshoe”
z_s=2.38 z_l=0.446
(Belokurov et al. 2007)

- SDSS is a shallow survey targeting galaxies at z<0.7, yet very bright strongly lensed galaxies at z~2-3 have been discovered!

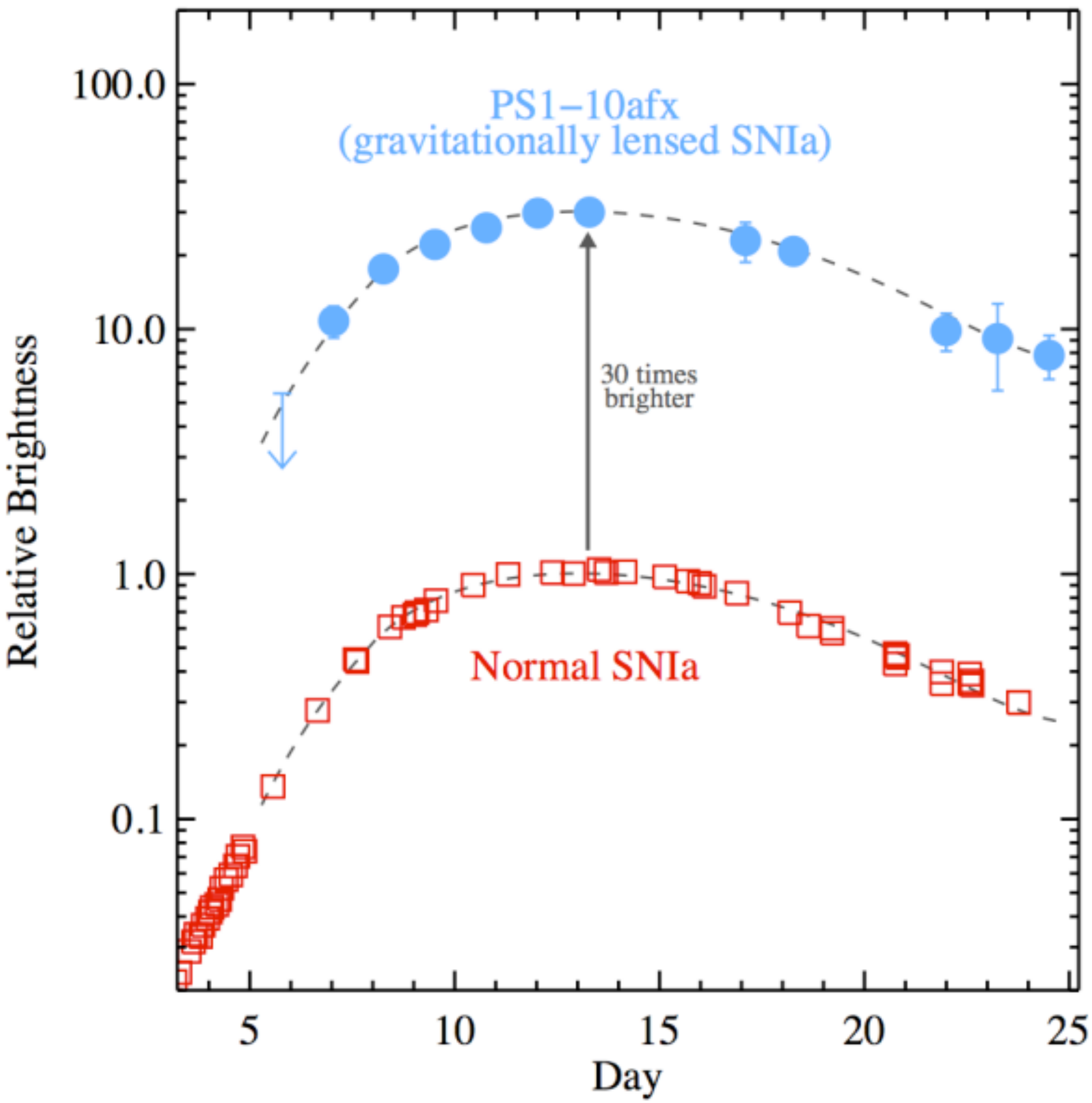
Strongly lensed galaxies in WISH



- ~100 z~8 lensed galaxies
- ~10 z~10 lensed galaxies
- discovered even in wide!

Also talk by Robert Quimby

Gravitationally lensed supernovae



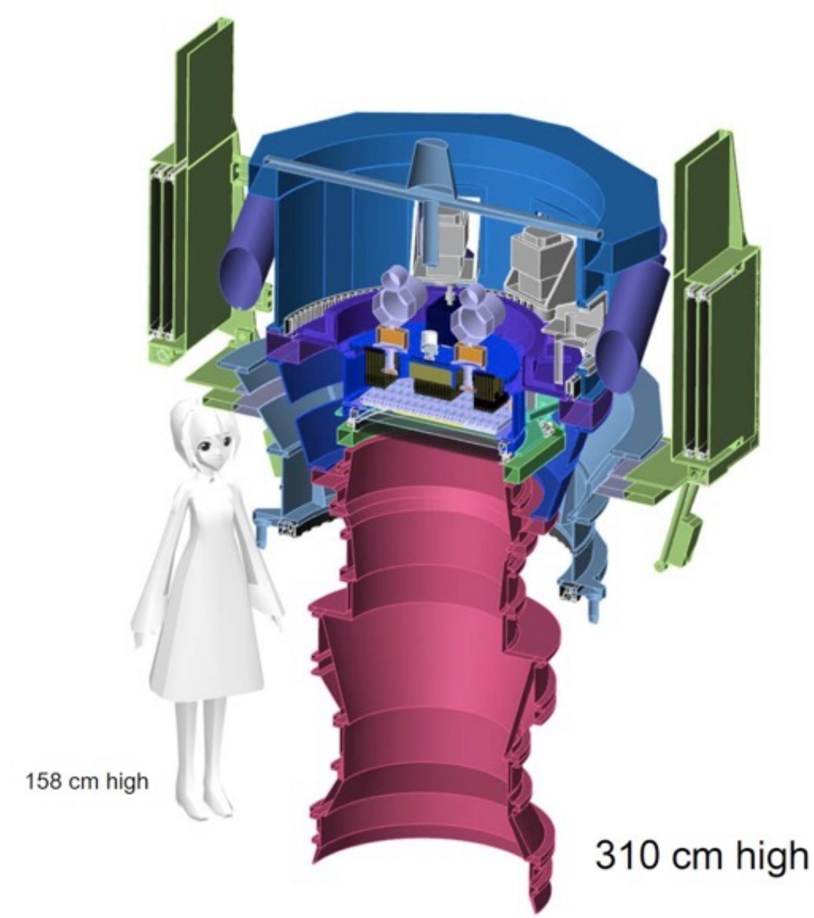
Quimby, Werner, Oguri et al. (2013)

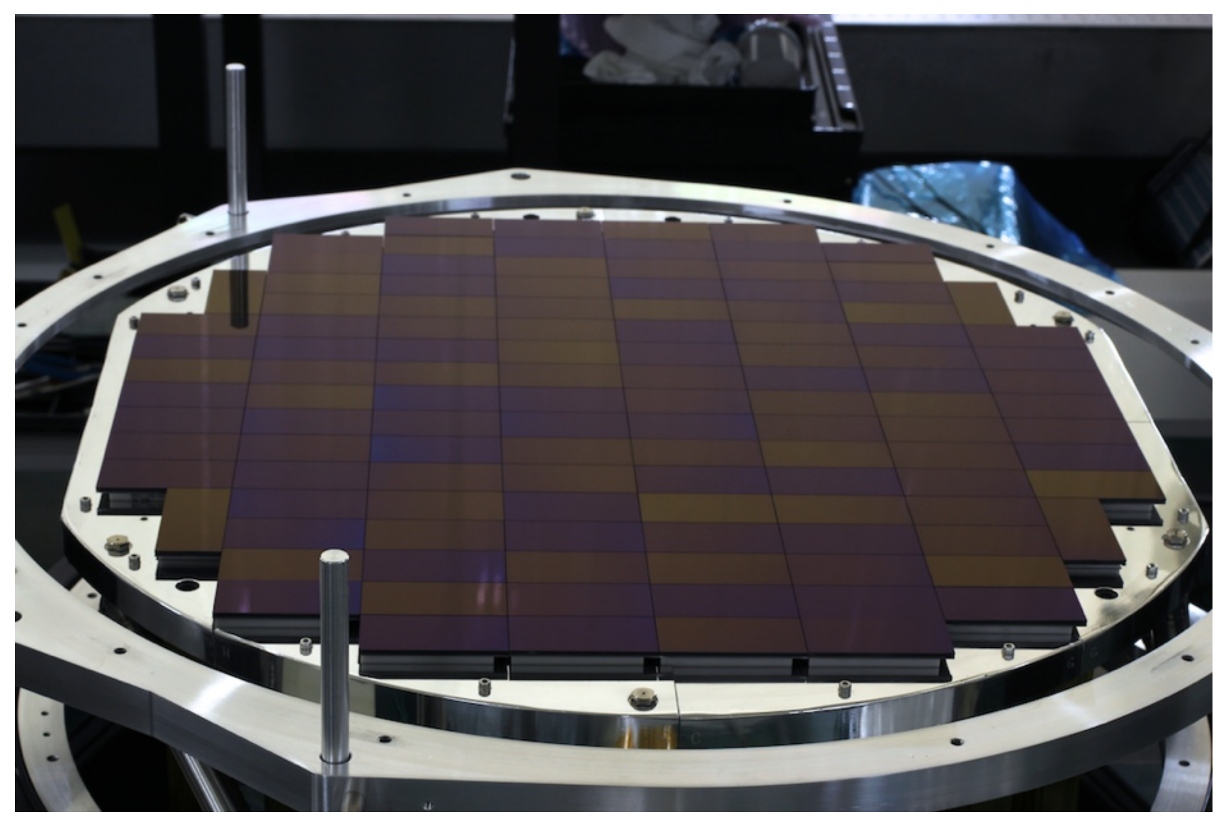
- for type-Ia, we can obtain magnification factor thanks to its standard candleness, which can break various degeneracies
- first strongly lensed SNIa PS1-10afx was discovered recently!
- many more will be discovered in WISH

Also talk by Masayuki Tanaka

Synergy with Subaru

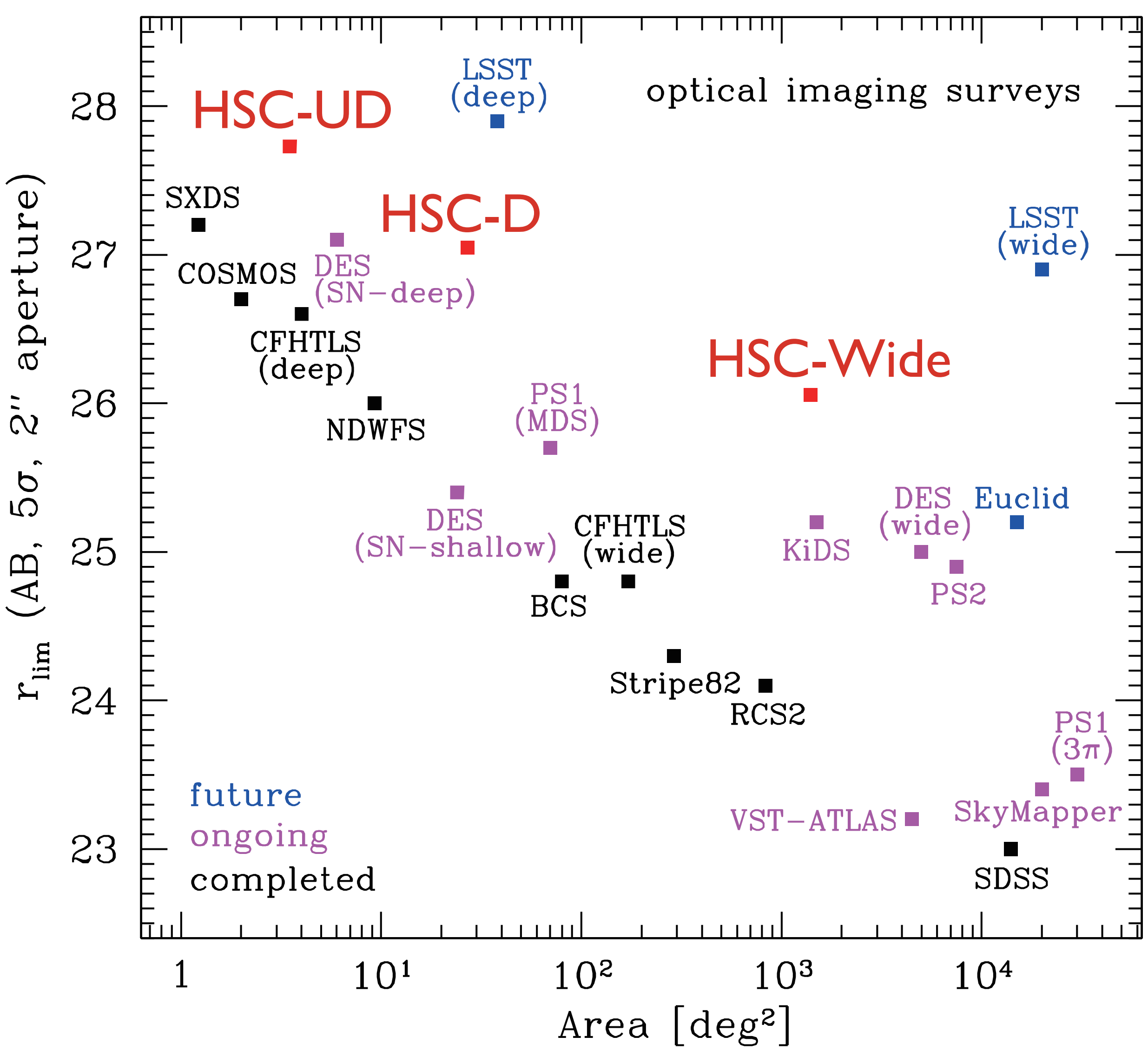
- these gravitational lensing sciences require deep optical images for photo-z etc
- excellent synergy with Subaru Hyper Suprime-cam (HSC) survey

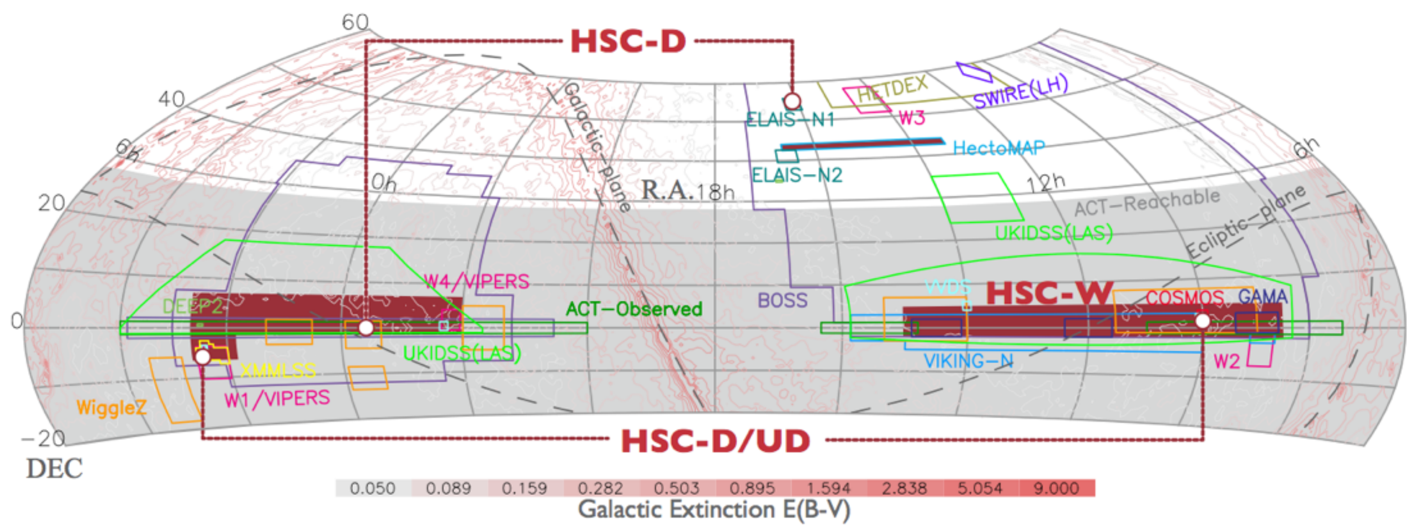




Wide-field Imaging with Subaru HSC

(another WISH!)





both area and depth are in excellent match with WISH survey

Summary

- WISH is an excellent project from the perspective of gravitational lensing science
- its weak lensing power comparable to Euclid and WFIRST satellites, useful both for cosmology and galaxy studies
- many strongly lensed high-redshift galaxies will be discovered in WISH, which will be interesting targets for follow-up with TMT/JWST/...