Kinematic Lensing with DESI

Probing S_8 Tension at very low Redshift

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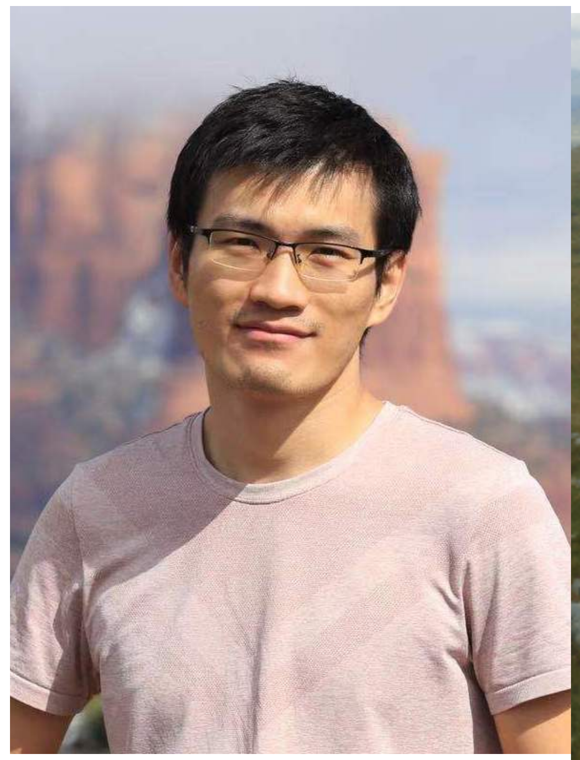
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Yu-Hsiu Huang


Hung-Jin Huang


Elisabeth Krause


Tim Eifler


Spencer Everett


Eric Huff

Weak Lensing of Galaxies

- Core probe for dark energy of future missions (Euclid, LSST, Roman)

- **Concern 1:** Shear and shape degeneracy → irreducible shape noise $\sigma_\epsilon \approx 0.27$ per component (S/N~0.01 per gal)

- **Concern 2:** Systematics (shear and redshift measurement uncertainties, intrinsic alignment, baryonic physics, etc.)

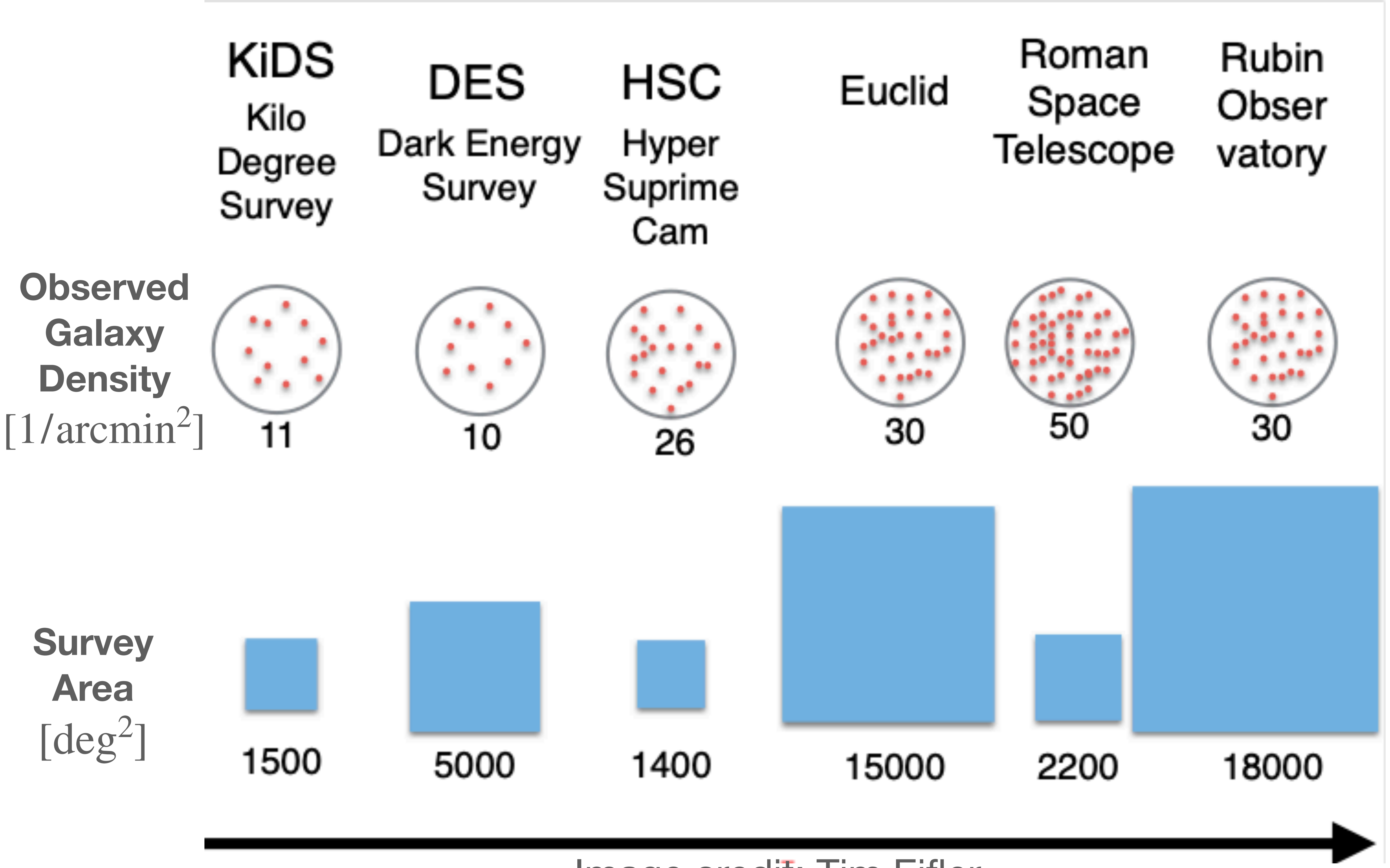


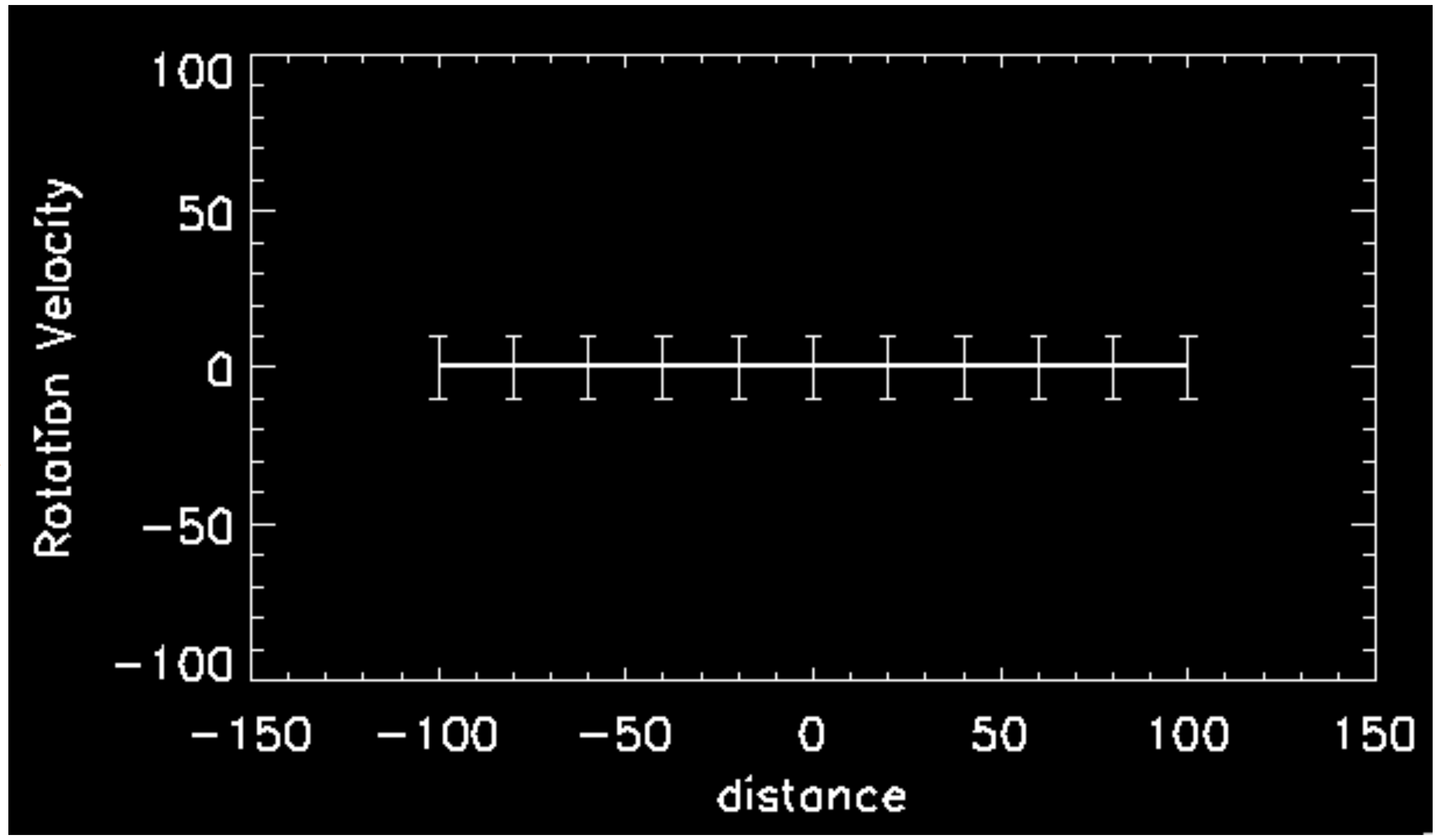
Image credit: Tim Eifler

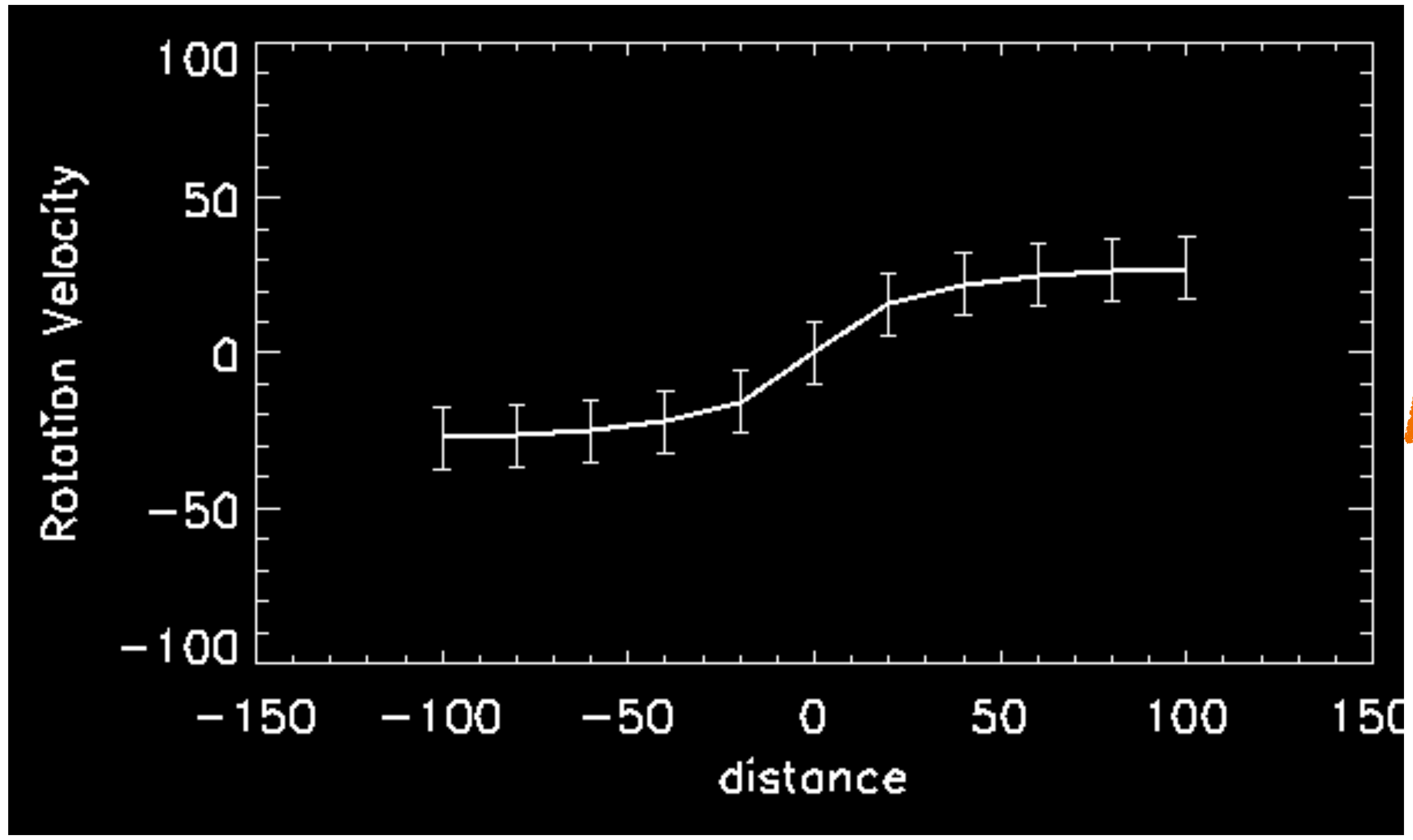
Kinematic Lensing concept

- Largest source of WL shape noise is unknown intrinsic galaxy shape
- For disk galaxies: spectroscopic information allows us to constrain intrinsic ellipticity
- This can reduce shape noise significantly (a factor of ~10)

Kinematic Lensing

Huff+13, Xu+23, Pranjal+23, Huang+24, Gurri+20, DiGiorgio+21, Morales 06,…

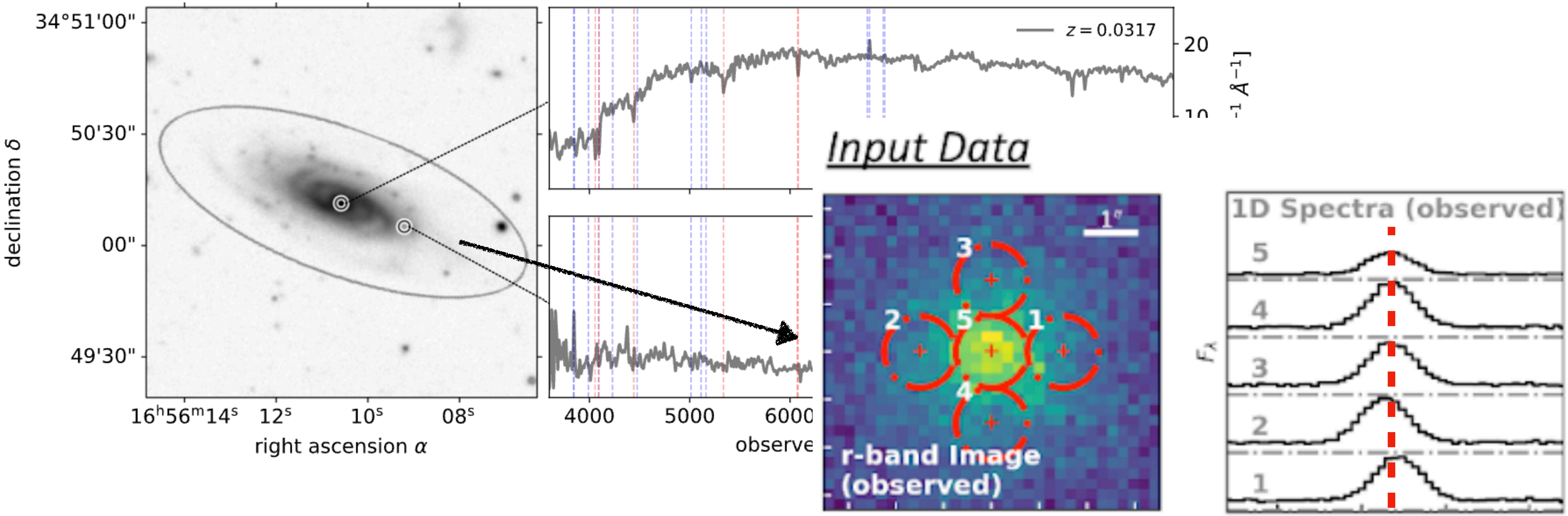




How to measure KL with DESI?

- Similar to the DESI peculiar velocity survey (Saulder+23): put multiple fiber points at different parts of galaxies

- We want many bright, well-resolved, disk galaxies →start from BGS, with imaging from Legacy Survey (possible synergy from LSST coverage)



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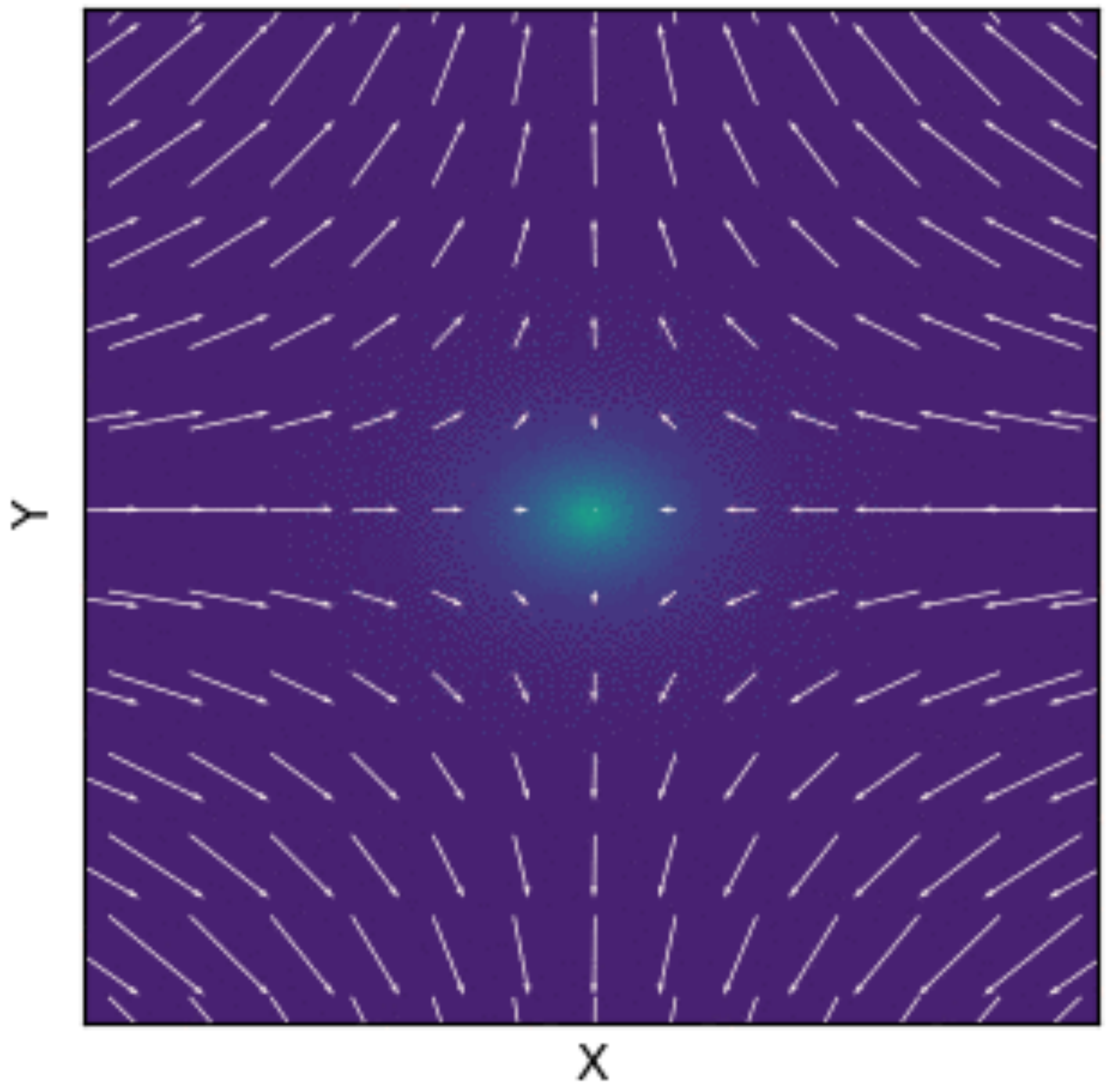

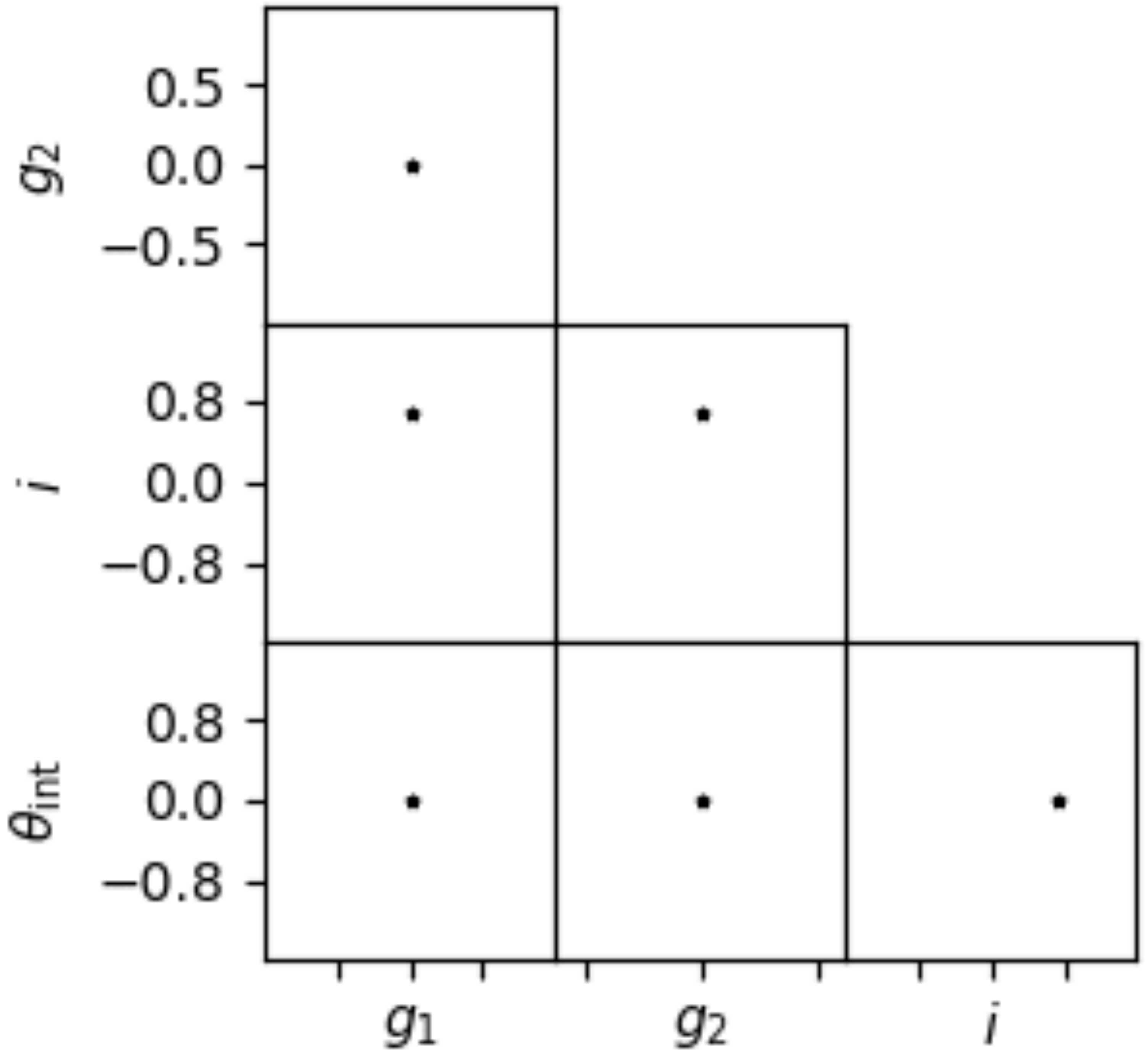

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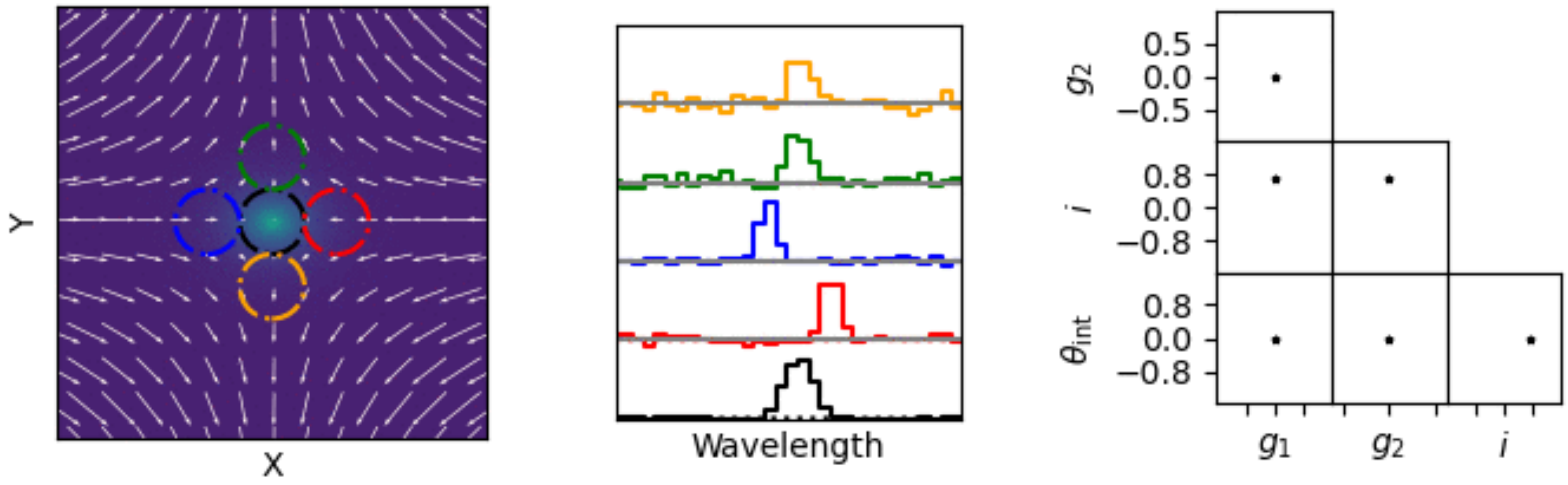
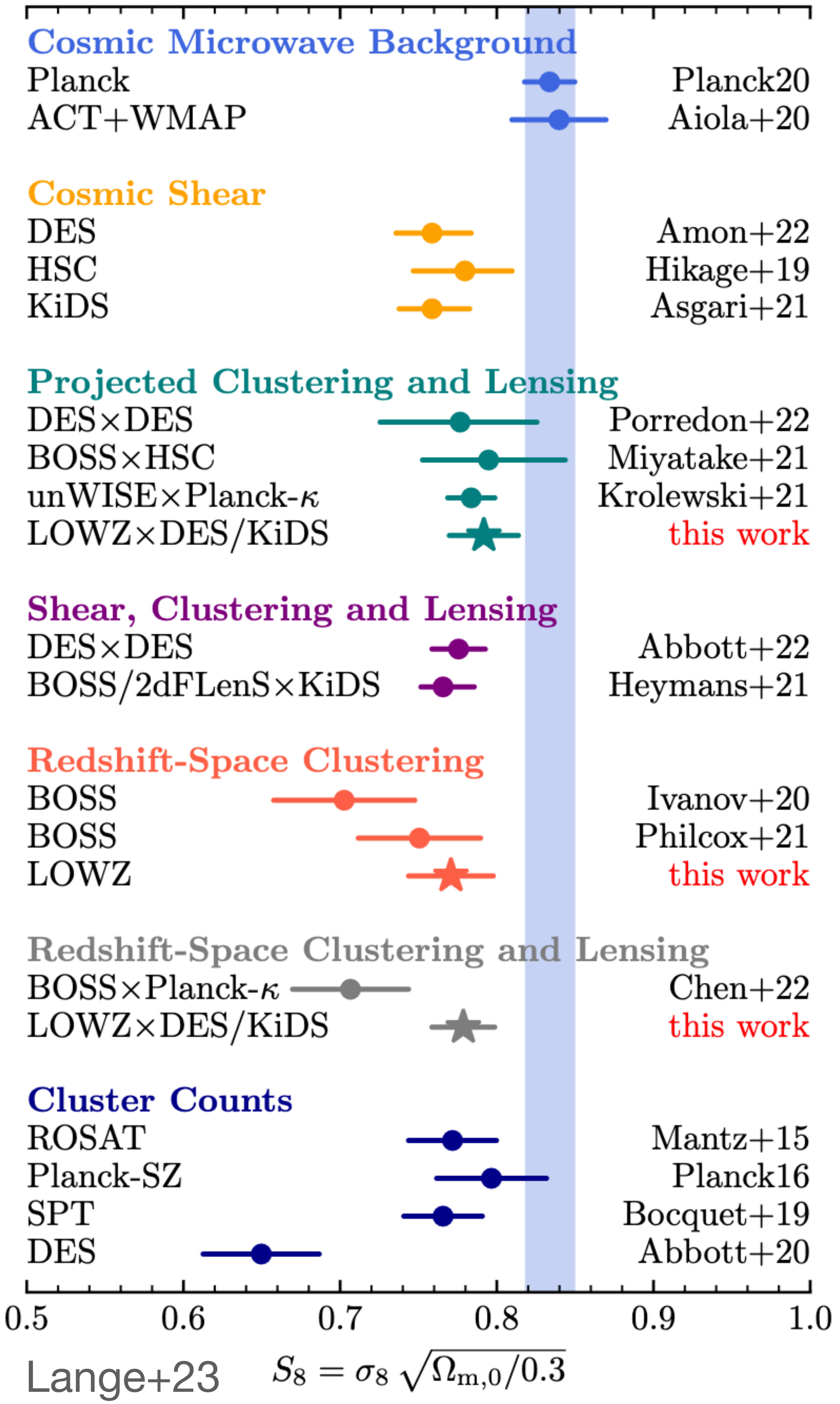


Potential Science Case: Probing S_8 tension at very low-z with DESI-KL

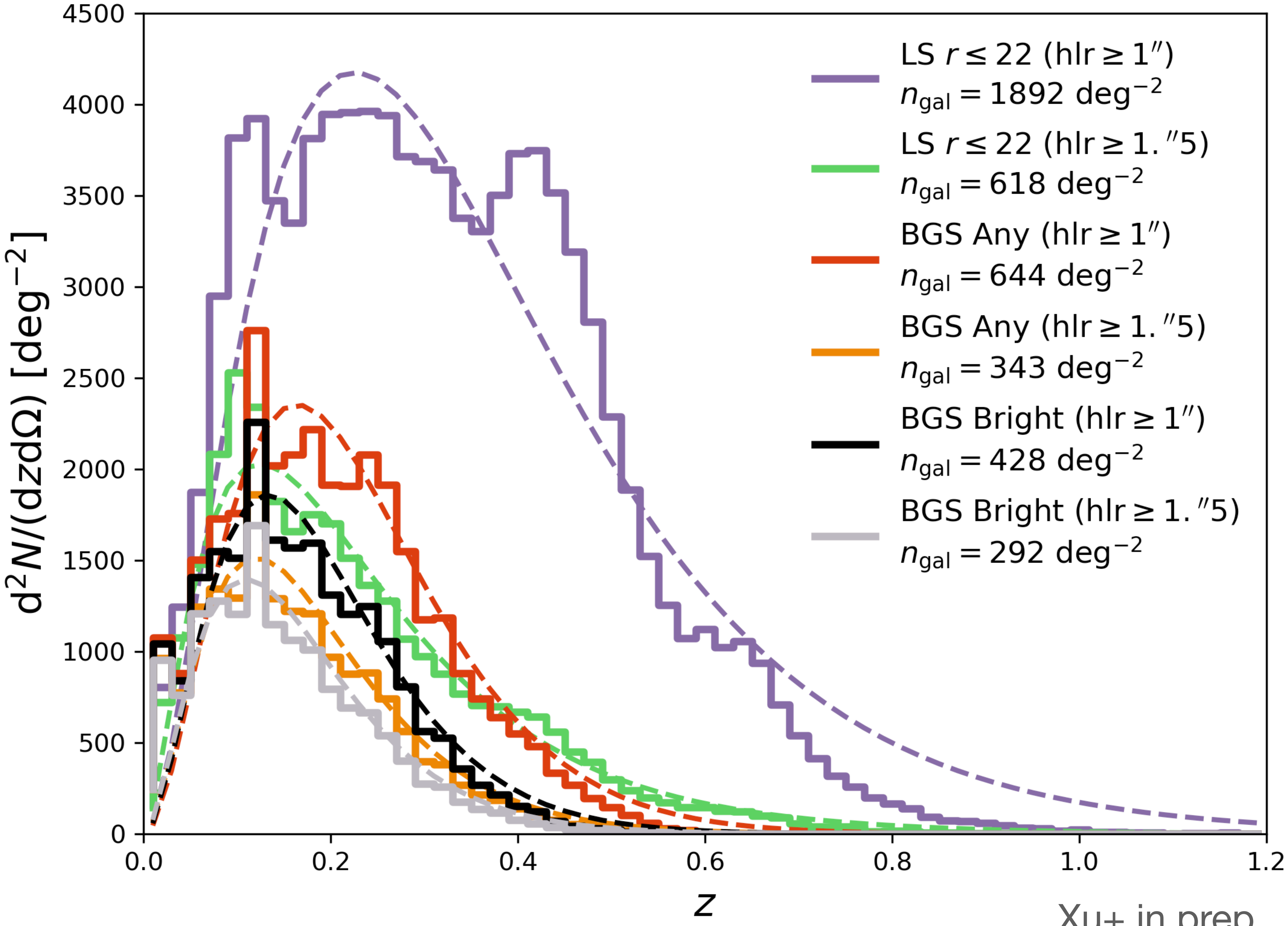
- There is an emerging tension between high-z and low-z S_8
- If tension is real, it will likely to be prominent at very low-z.
- Standard WL are insensitive to very low redshift structures
- KL has lower shape noise → enables lensing measurements at very low-z
- DESI-KL science idea: Measure the the matter density fluctuations $\sigma_8^{\mathrm{low}-z}$ for $z \leq 0.15$ and σ_8 for $z > 0.15$.



Lange+23

Forecasts: Galaxy Sample Definition

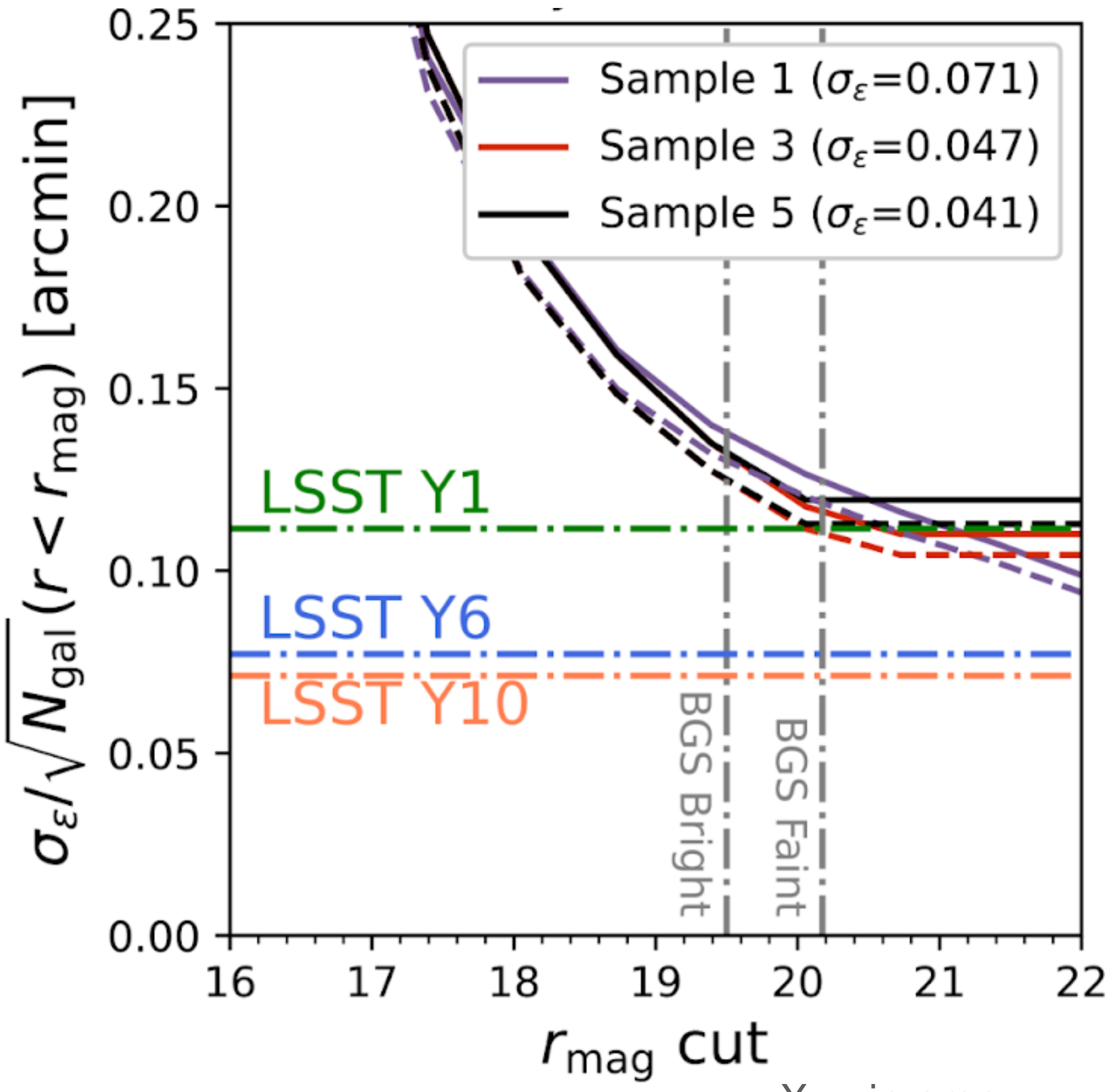
- Sample 1:
  - BGS-like sample (r<=22)
  - Disk morphology & hlr > $1''$
- Sample 3:
  - BGS Bright or Faint
  - Disk morphology & hlr > $1''$
- Sample 5:
  - BGS Bright
  - Disk morphology & hlr > $1''$



Xu+ in prep.

Forecasts: DESI-KL Average Shape Noise

- We build a forward modeling pipeline to generate mock image+spectrum, and estimate shape noise accounting for realistic S/N and instrument capabilities.
- Depending on galaxy sample, the shape noise varies among 0.04~0.08.
- The overall cosmic shear shot noise is similar to LSST Y1 level.



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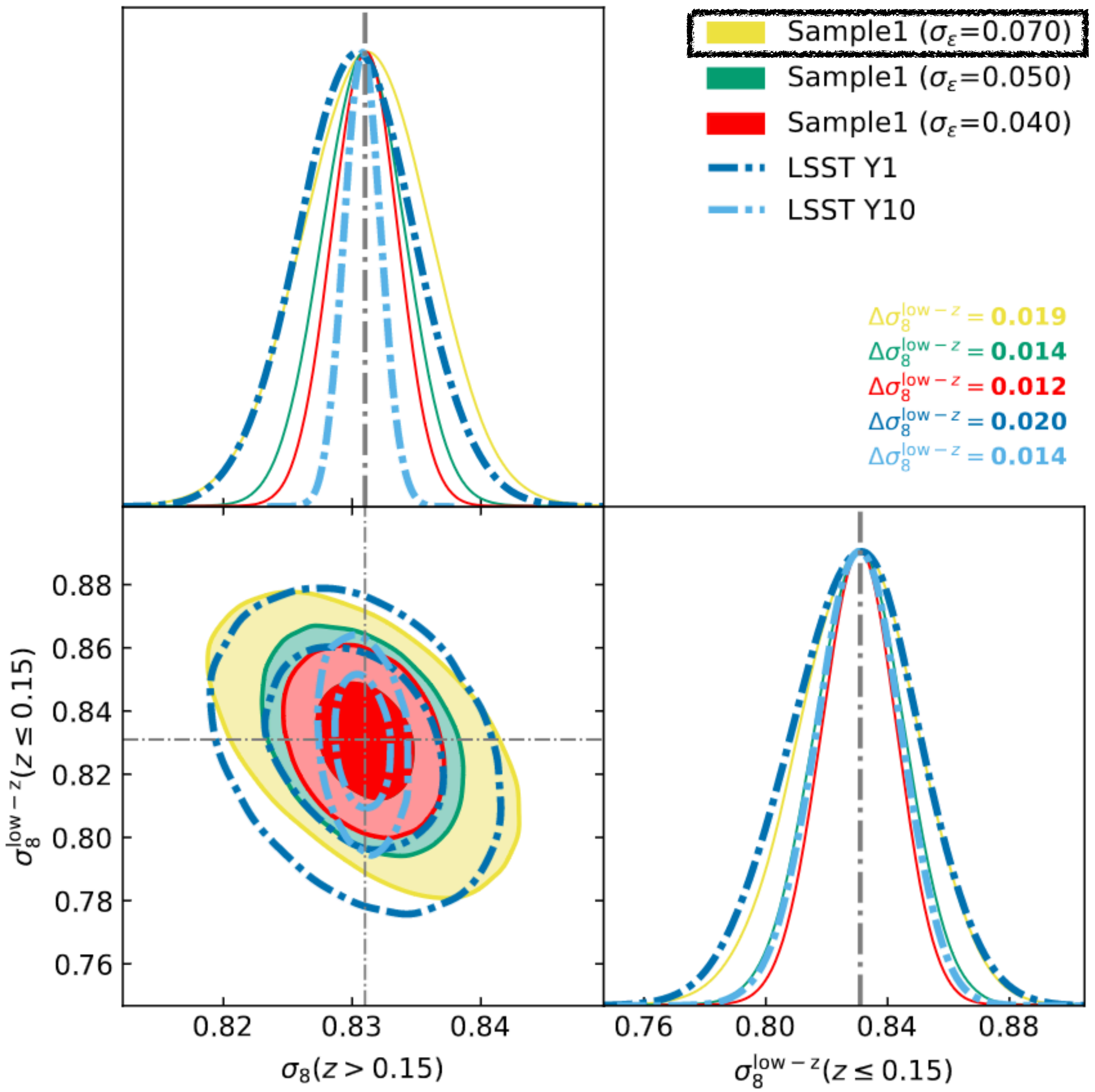
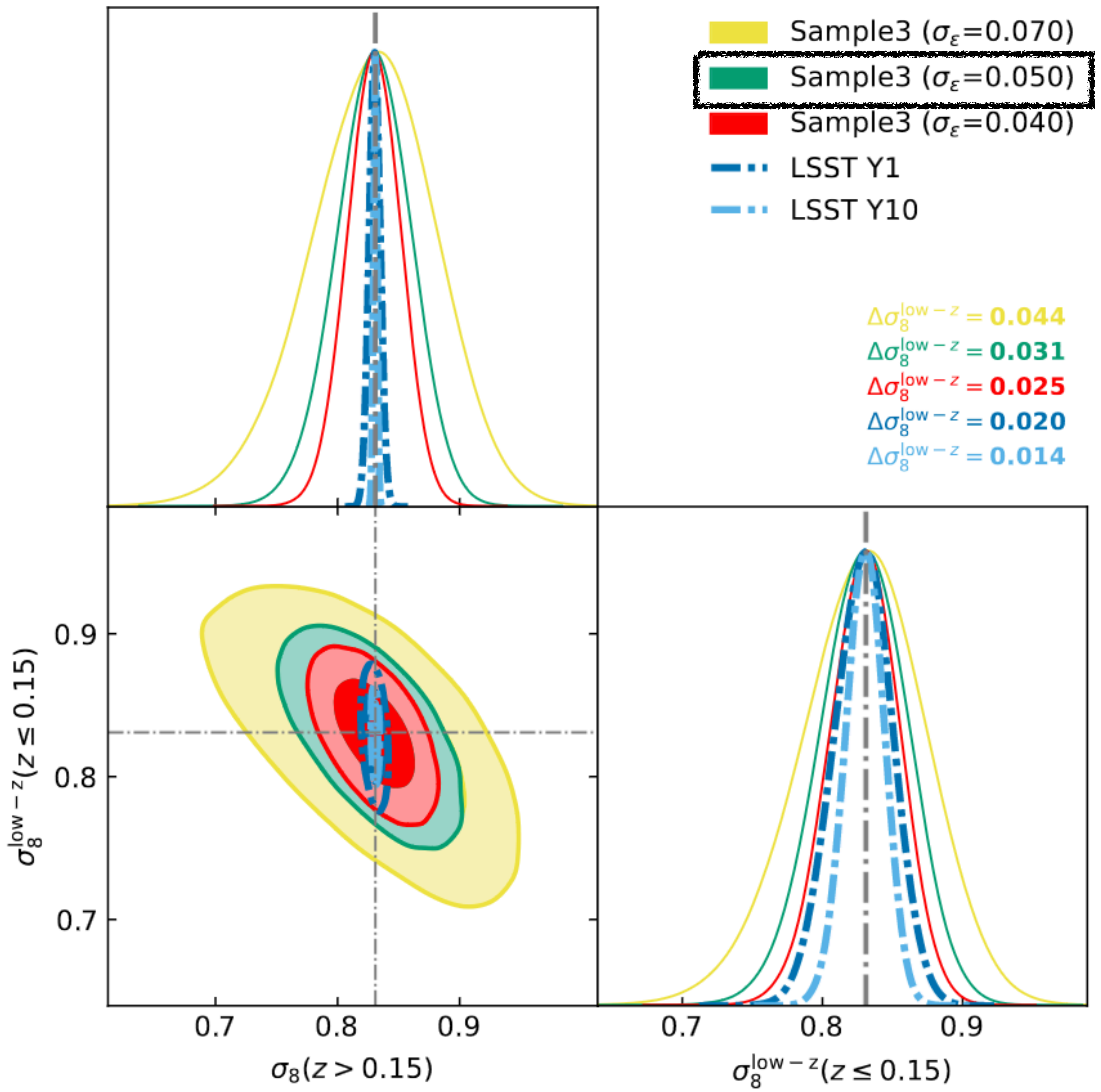
Probing S8 tension at low-z with DESI-KL

- DESI-KL with Legacy Survey can produce $\sigma_8^{\mathrm{low}-z}$ constraints comparable to LSST Y1





Xu+ in prep.

Summary

- Imaging + galaxy kinematics **breaks the degeneracy** of intrinsic galaxy shape and shear.
- 10x reduction in shape noise can compensate for reduced galaxy density.
- KL is robust towards traditional WL systematics.
- Competitive $\Delta\sigma_8^{\mathrm{low-z}}$ constraints feasible with DESI-KL: potentially comparable with LSST Y1/Y10 depending on DESI galaxy sample considered
- Highly synergistic with LSST in terms of footprint, but also in terms of measurement in the overlap regions
- DESI-KL will benefit all lensing based science ideas at low-z, e.g. joint analysis with peculiar velocity measurements or dark matter studies with dwarf galaxies