Weak lensing Study in VOICE Survey

（VST Optical Imaging of the CDFS and ES1 fields）

Liping Fu

Shanghai Normal University

Collaborated with:

-- Zuhui FAN (PKU&YNU), Dezi LIU (YNU), Xiangkun LIU (YNU), Chuzhong PAN (PKU);

-- Giovanni Covone (Univ. Napoli Federico II), Mattia Vaccari (Univ. Western Cap), Mario Radovich (INAF-Padova)

Alino Grado (INAF-Napoli), Lance Miller (Univ. Oxford) + VOICE-SUDARE team

Dec 18-21, 2018, ISSI, Bern

I. VOICE shear catalog (Fu+ 2018)

- ✓ Data selections
- ✓ Shear measurement
- ✓ Systematic checking
- ✓ Cosmological application

II. VOICE imaging simulation (Liu, Fu+ 2018)

- ✓ Simulation build
- ✓ Shear bias calibration

III. Voice photometric redshift estimation (Amaro+ in preparation)

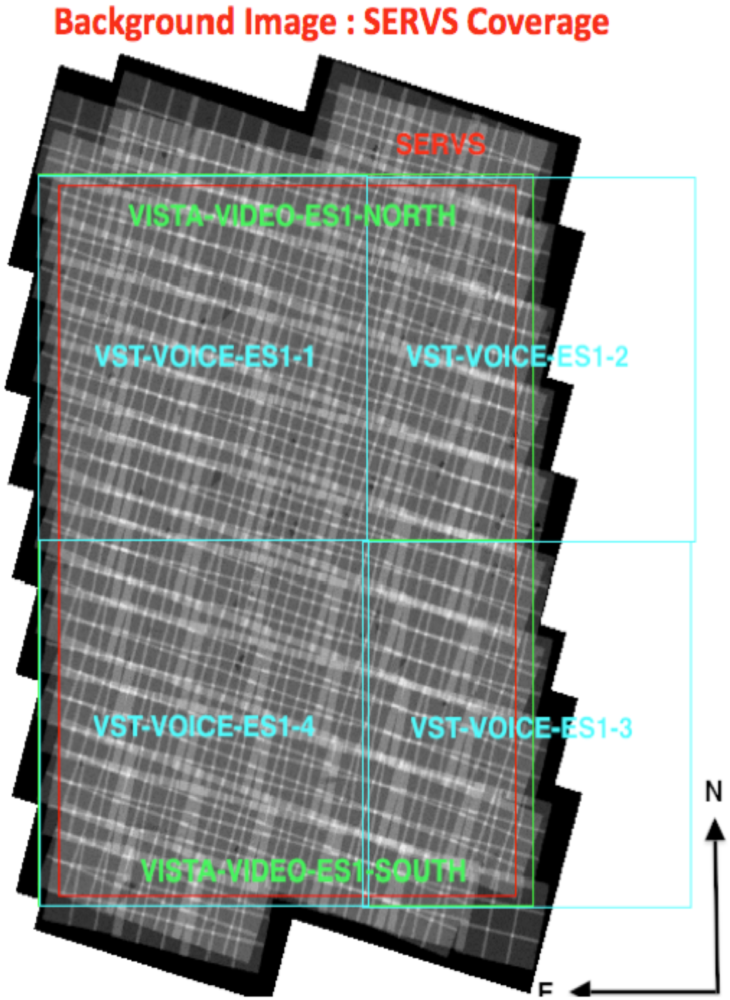
- ✓ BPZ
- ✓ METAPHOR (Machine-learning Estimation Tool for Accurate Photometric Redshifts)

I. VOICE（VST Optical Imaging of the CDFS and ES1 fields）

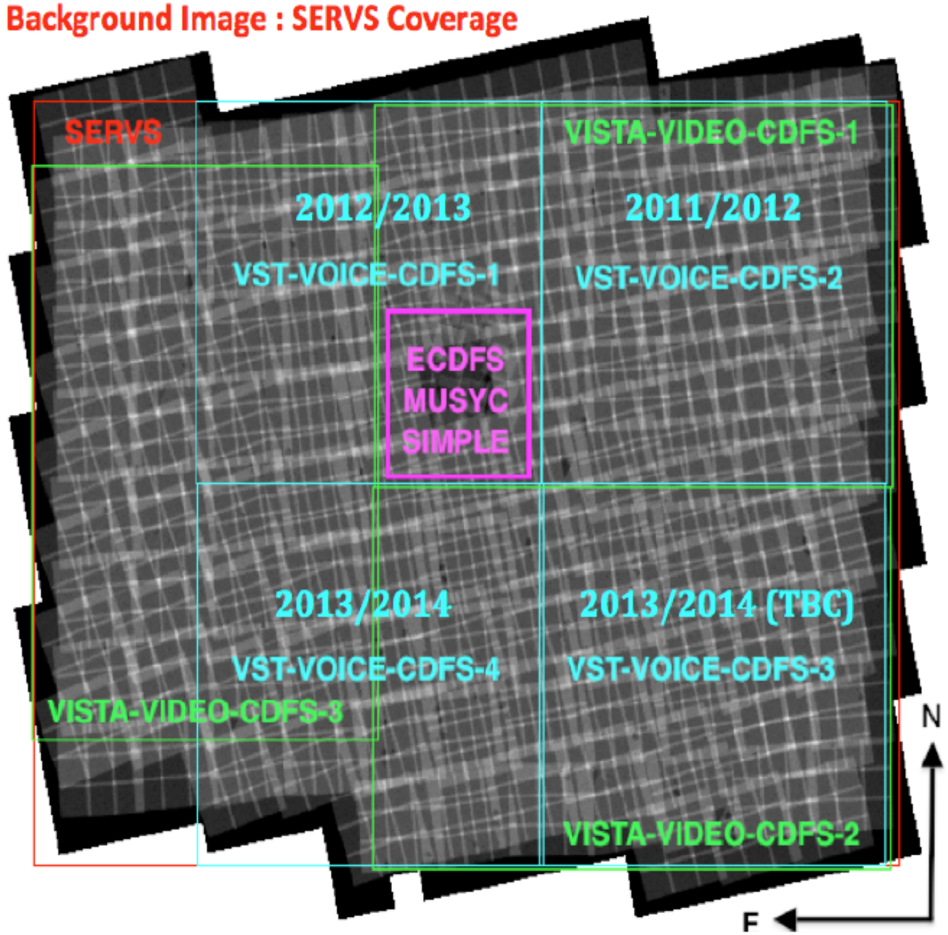
co-PIs: Giovanni Covone & Mattia Vaccari

-- GTO program of VLT Survey Telescope @ Chile;

ES1



CDFS



I. VOICE（VST Optical Imaging of the CDFS and ES1 fields）

co-PIs: Giovanni Covone & Mattia Vaccari

-- Together with SUDARE, uniform & deep optical (ugri) coverage：CDFS & ES1;

Spitzer SWIRE (IR), VISTA-VIDEO (NIR),Spitzer-SERVS (MIR), Herschel-HerME (FIR), GALEX (UV) and ATLAS(radio).

→ Custers detection (high z) ← weak lensing & color + photo-z

→ Mass distributions ← weak lensing

VOICE vs KiDS

-- Kilo Degree Survey @ VST (VLT survey telescope): 1500 deg2, r_{lim} = 24.9

-- Same instrument (u, g, r, i)

-- KiDS: each pointing, one epoch (5 consecutive exposures);

-- VOICE: multiple-epoch observations (> 100 exposures, r band, over 4 years);

-- r_{lim} = 26.1 (point source, 5σ) → ~ 1.2 magnitude deeper than KiDS.

Shear catalog

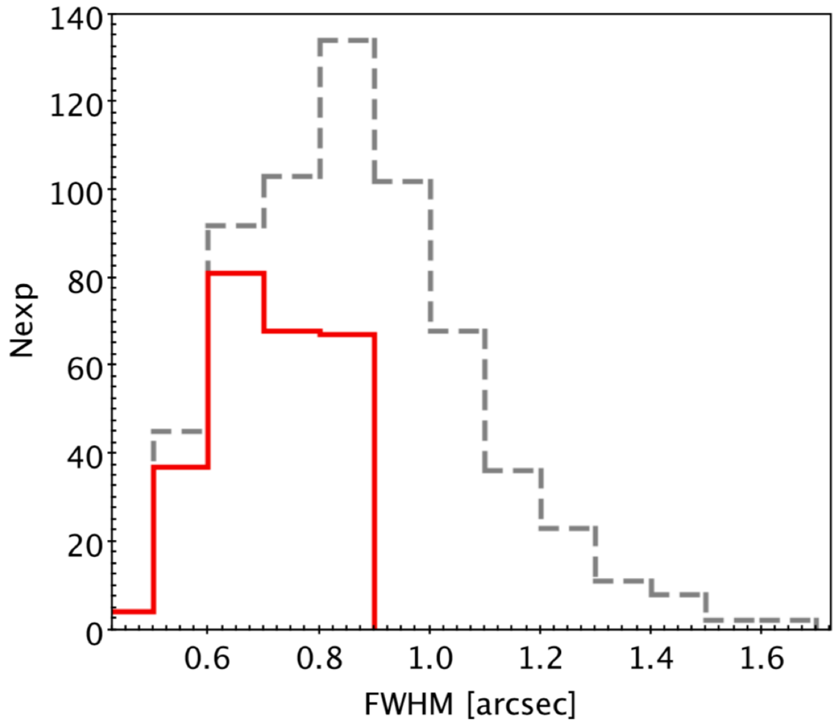
Weak lensing Study in VOICE Survey I: Shear Measurement

Liping Fu[1⋆], Dezi Liu[2,3,1], Mario Radovich[4], Xiangkun Liu[3], Chuzhong Pan[2]
Zuhui Fan[3,2], Giovanni Covone[5,6,7], Mattia Vaccari[8,9] , Maria Teresa Botticella[7],
Massimo Capaccioli[5], Enrico Cappellaro[4], Demetra De Cicco[5], Aniello Grado[7],
Lance Miller[10], Nicola Napolitano[7], Maurizio Paolillo[5], Giuliano Pignata[11]

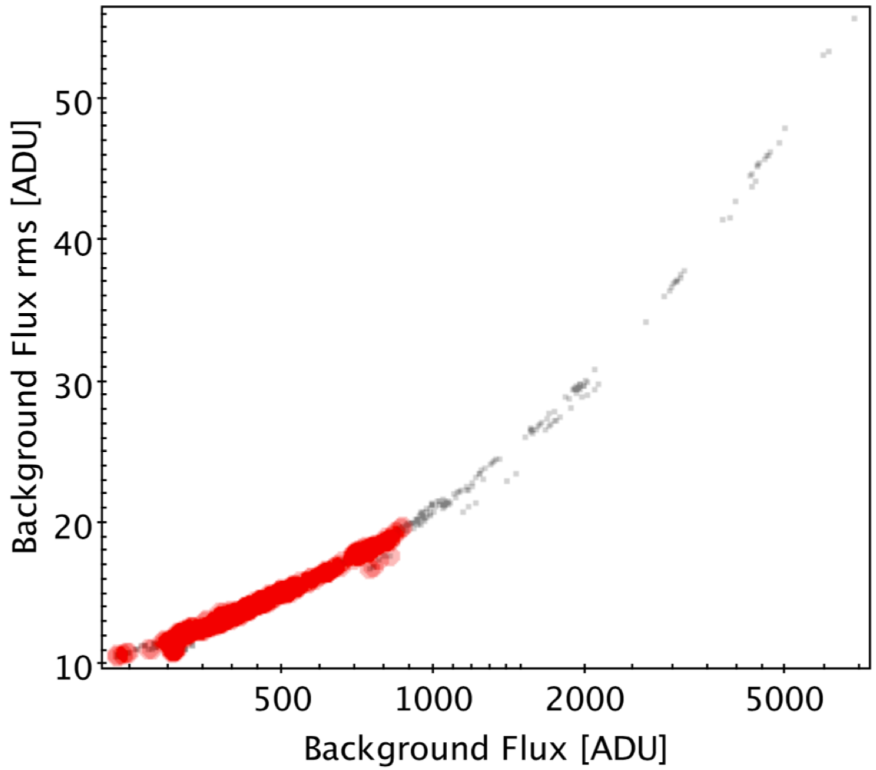
[1]*Shanghai Key Lab for Astrophysics, Shanghai Normal University, Shanghai 200234, China*
[2]*Department of Astronomy, Peking University, Beijing 100871, China*
[3] *South-Western Institute for Astronomy Research, Yunnan University, Kunming 650500, Yunnan, China*
[4] *INAF - Osservatorio Astronomico di Padova, via dellOsservatorio 5, I-35122 Padova, Italy*
[5]*Dipartimento di Fisica "E. Pancini", Università degli Studi Federico II, Napoli 80126, Italy*
[6]*INFN, Sezione di Napoli, Napoli 80126, Italy*
[7]*INAF–Osservatorio Astronomico di Capodimonte, Salita Moiariello 16, Napoli 80131, Italy*
[8]*Department of Physics & Astronomy, University of the Western Cape, Robert Sobukwe Road, 7535 Bellville, Cape Town, South Africa*
[9]*INAF - Istituto di Radioastronomia, via Gobetti 101, 40129 Bologna, Italy*
[10]*Department of Physics, Oxford University, Keble Road, Oxford OX1 3RH, UK*
[11]*Departemento de Ciencias Fisicas, Universidad Andres Bello, Santiago, Chile*

Weak lensing selection criteria

Seeing < 0.9”



BG Flux rms < 20 ; BG Flux <900

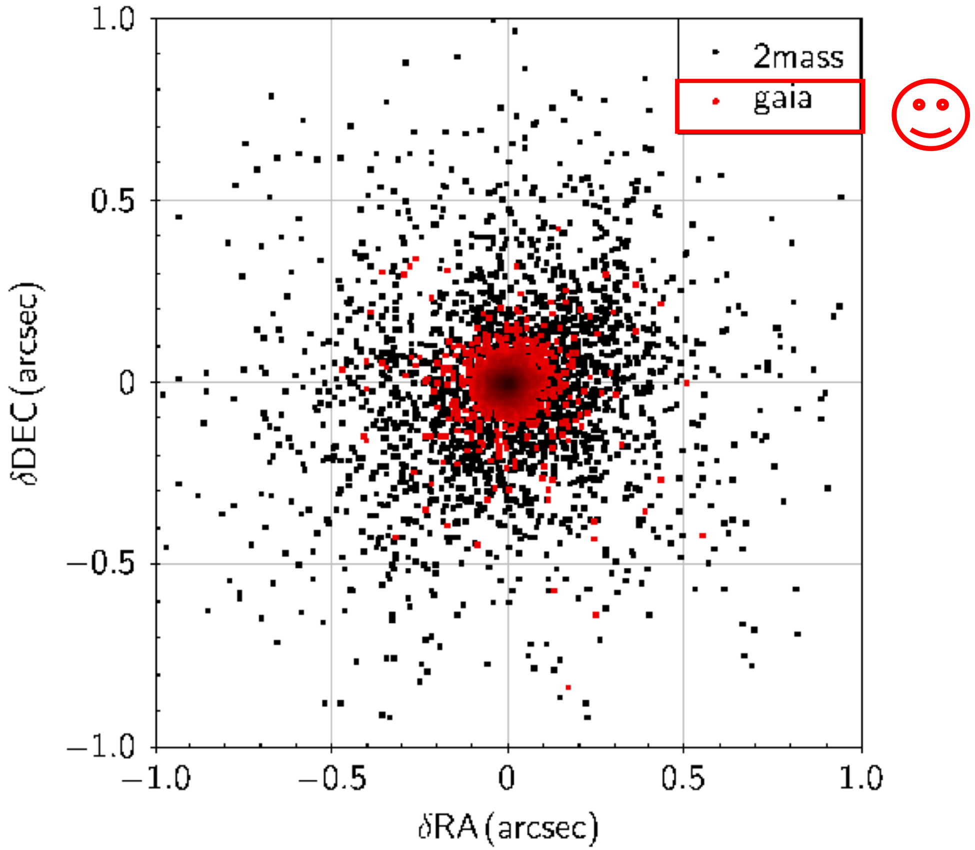


r	N_{exp} observed	N_{exp} selected
CDFS1	209	62
CDFS2	153	54
CDFS3	206	79
CDFS4	185	62

r_{lim} = 26.1 (point source, 5σ)

~ 1.2 magnitude deeper than KiDS.

Astrometric calibration

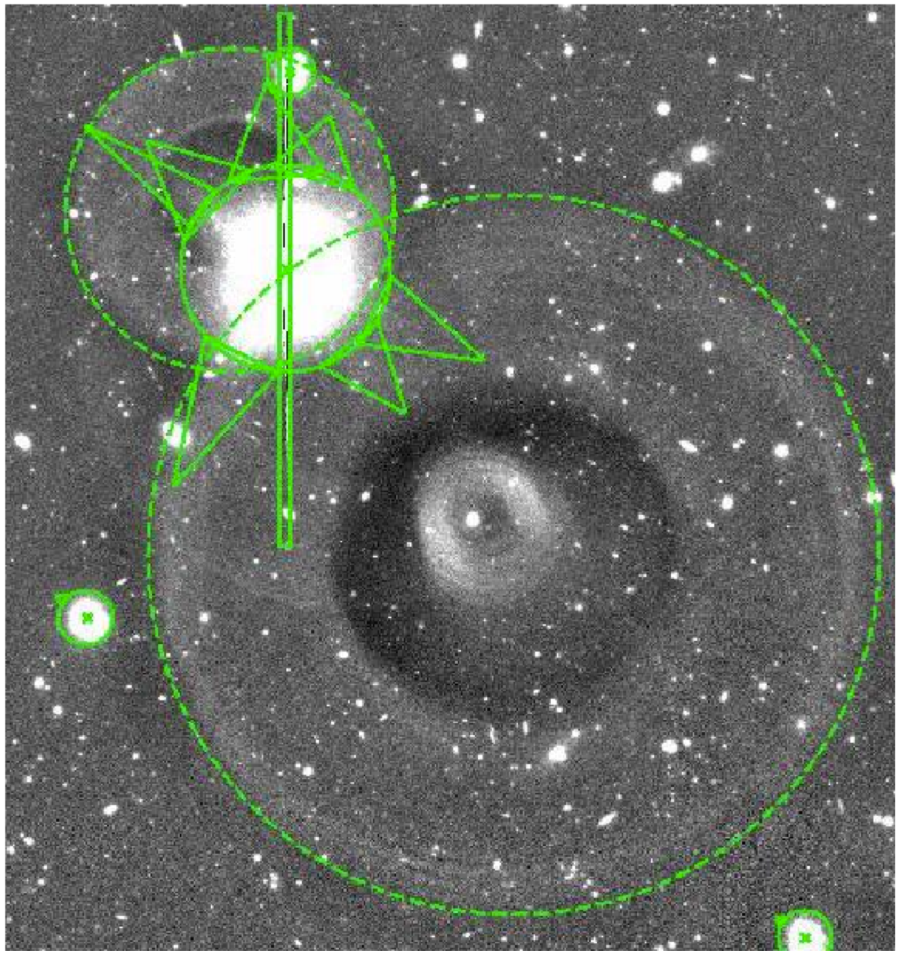


δ_{gaia} = 0.056" δ_{2mass} = 0.19"

-- GAIA

- smaller intrinsic astrometric uncertainties
- more matched stars with respect to 2MASS.

Mask



-- Pullecenella (Zhuoyi Huang)

-- Effective area fraction 84%

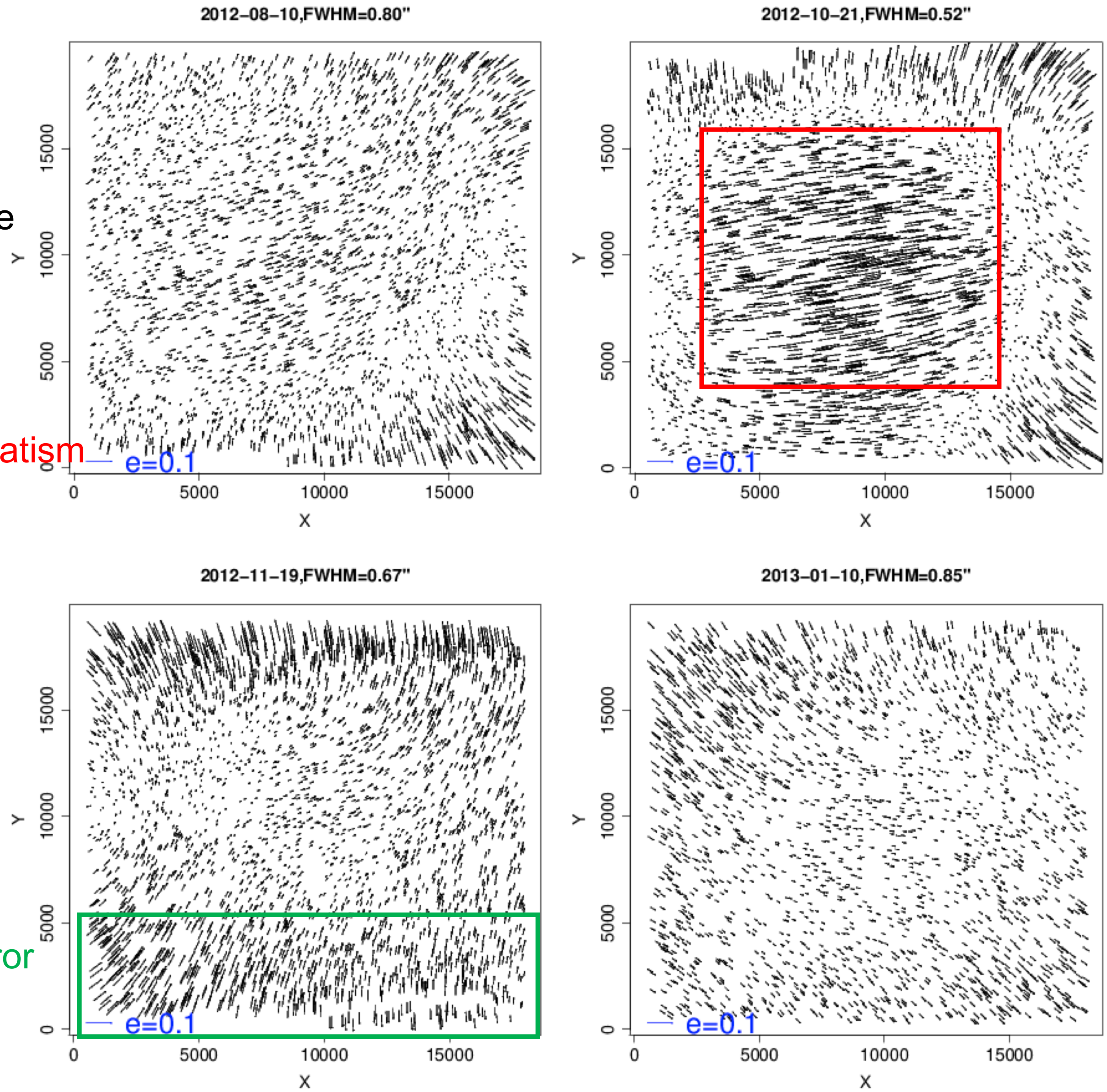
PSF example

-- CDFS1, different epochs

-- PSF model fitting on single exposures

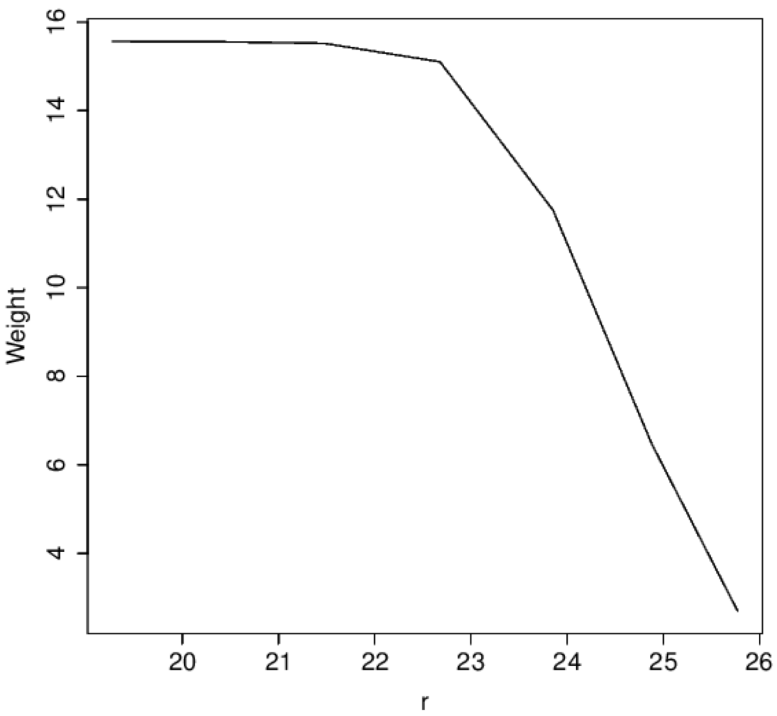
-- The primary mirror astigmatism of the curved focal plane

-- a tilt of the secondary mirror



Shear measurement: Lensfit (CFHTLenS, KiDS, Miller+ 13)

- Bayesian model fitting code;
- Galaxy model fit (position, flux, scale-length, bulge-to-disc ratio, ellipticity);
- PSF and galaxy model on single exposure;
- Multiple exposures joint fit → Likelihoods of each galaxy;
- Lensfit first time applied on few tens exposures ← calibrated from VOICE imaging simulation.
- 3×10^5 galaxy (weight > 0) → n_{eff}=16.4 gal/arcmin^2 ~ twice of KiDS';



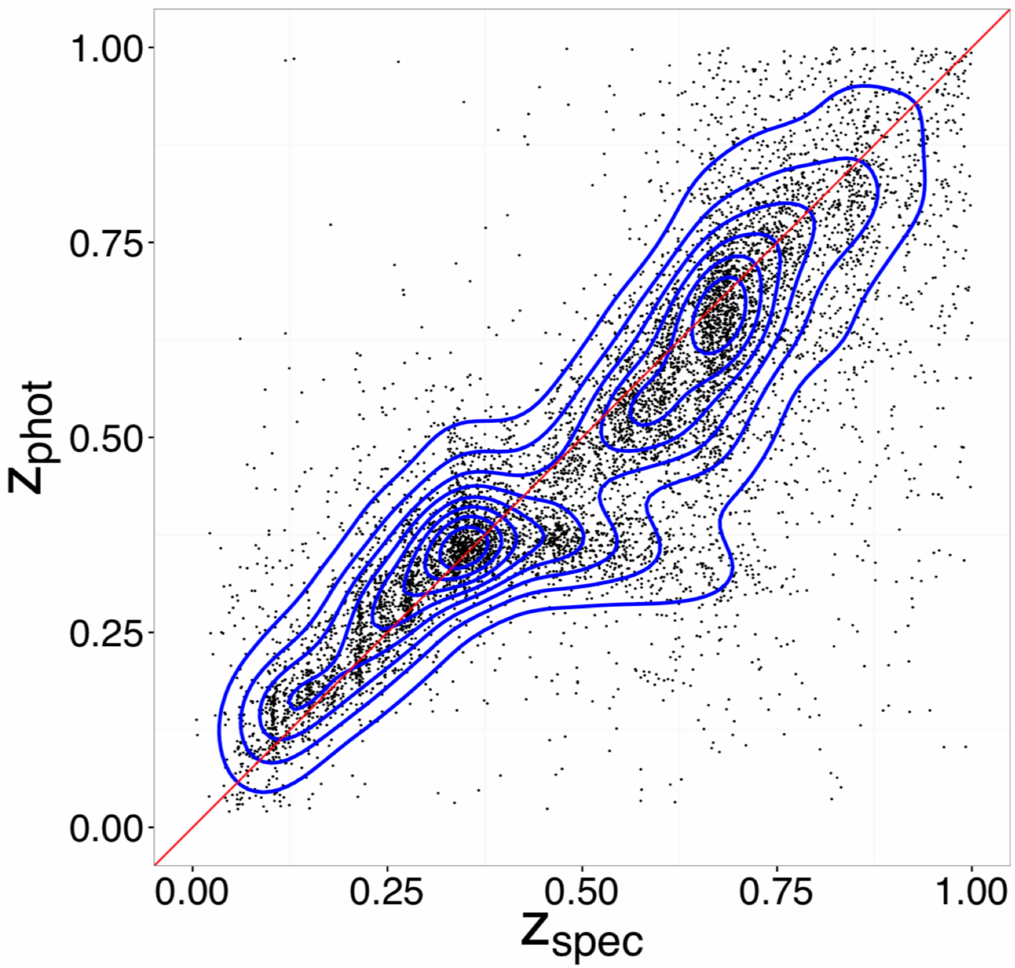
	CDFS1	CDFS2	CDFS3	CDFS4
N_{star}	2878	2807	2851	2774
N_{gal}	129505	125032	126360	125295
N_{shear}	84406	83425	78445	77499
$N_{exclude}$	24686	22946	25830	23914
N_{wzero}	20413	18661	22085	23882

Photometric redshift catalog

-- VOICE ugri + VIDEO YJHKs

Exposure time (hour)

	u	g	r	i
CDFS1	5.20	5.64	20.90	8.41
CDFS2	6.50	4.83	15.30	4.38
CDFS3	0.83	6.94	20.60	9.47
CDFS4	0.83	5.43	18.50	8.51



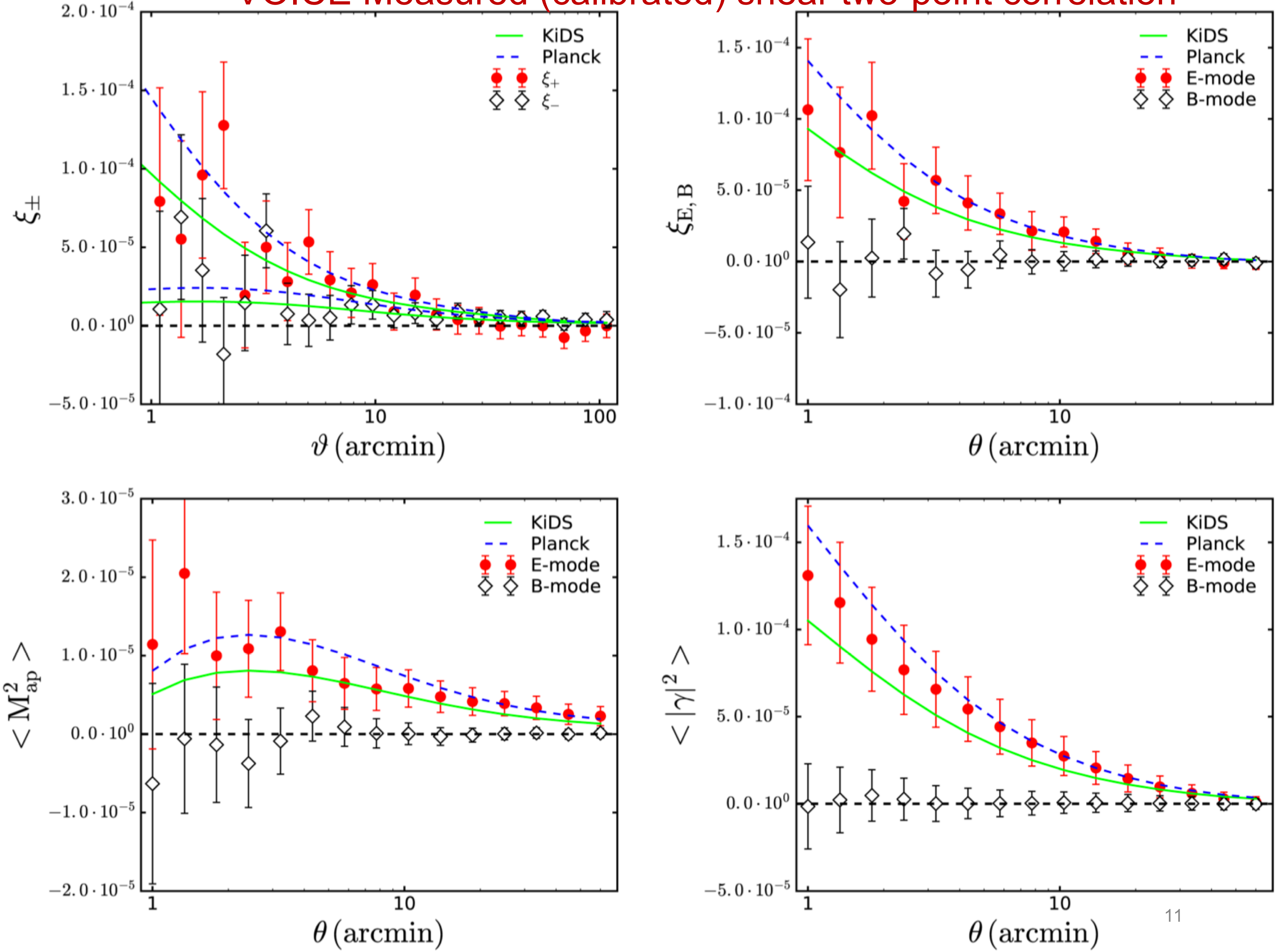
-- BPZ

-- Shear catalog: <z> = 0.87; z_{median}= 0.83

-- Z_spec: 23638

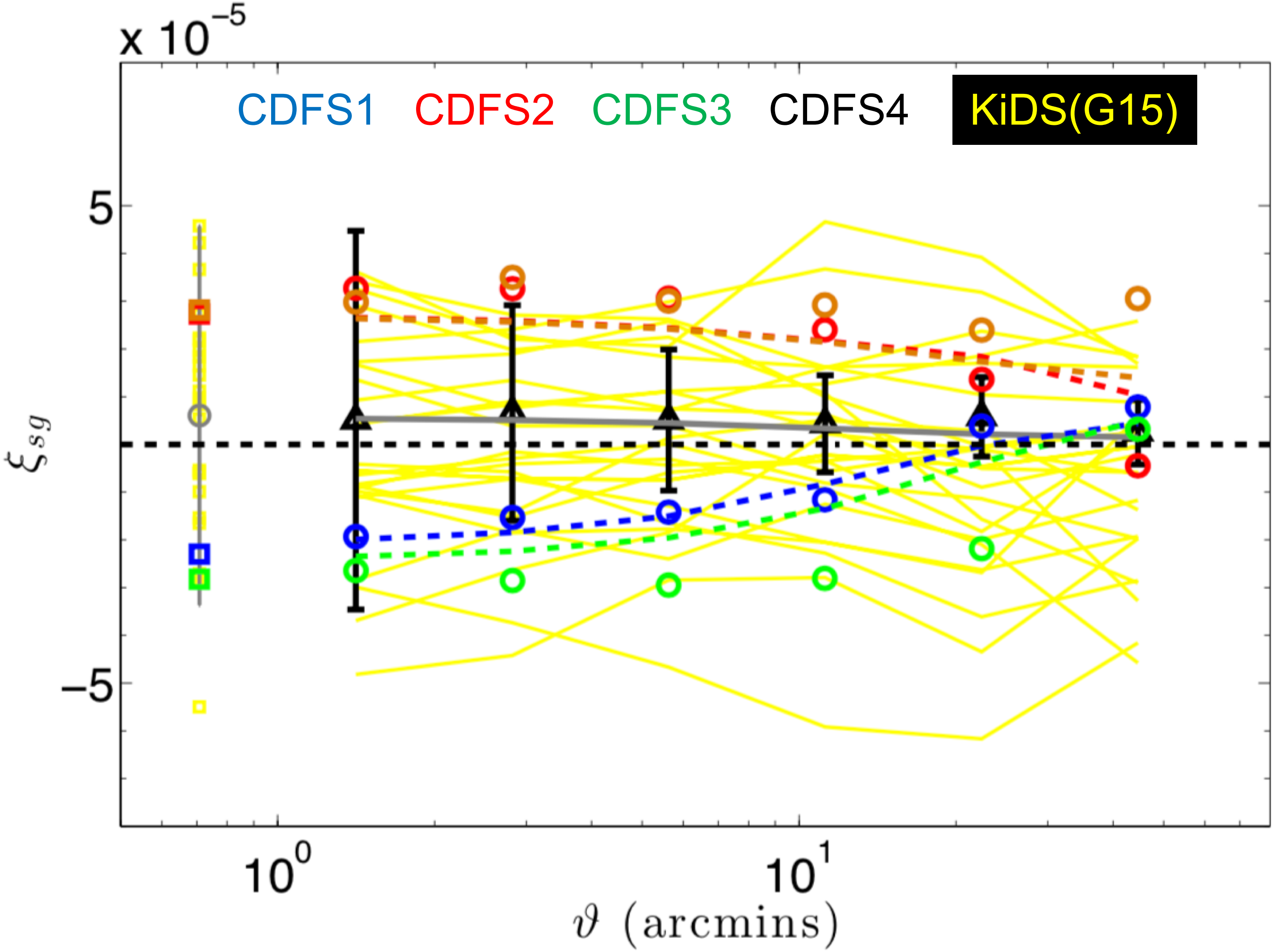
-- δz = (Photo-z–Spec-z) / (1+Spec-z)
= -0.008

VOICE Measured (calibrated) shear two-point correlation



Sanity checks

1. Star-galaxy correlations → check PSF correction

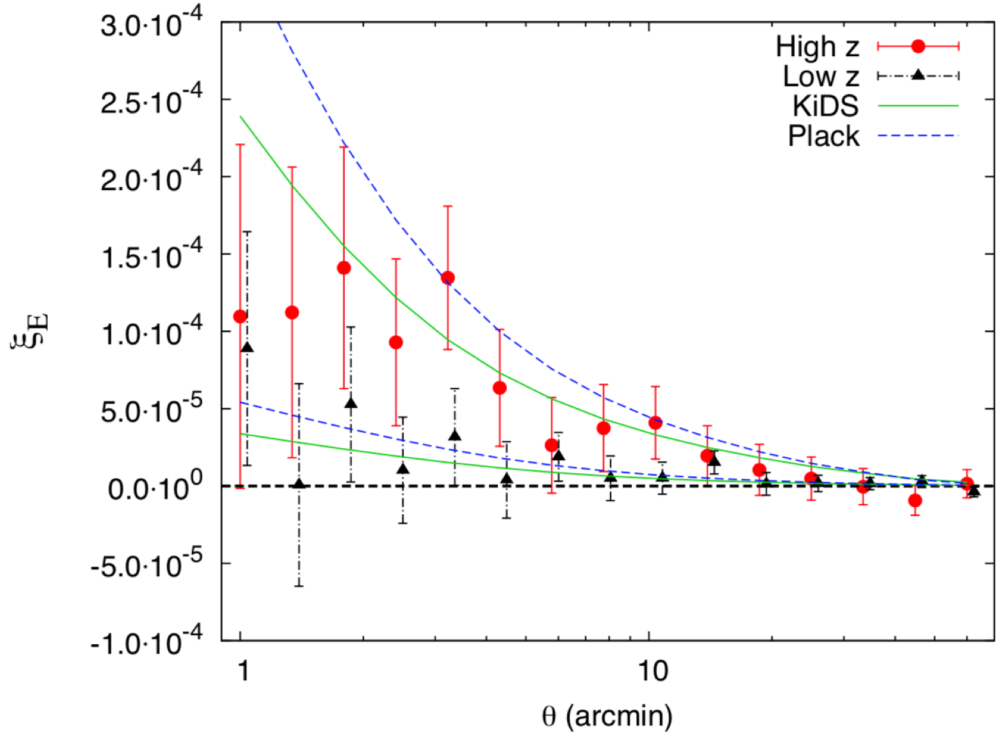


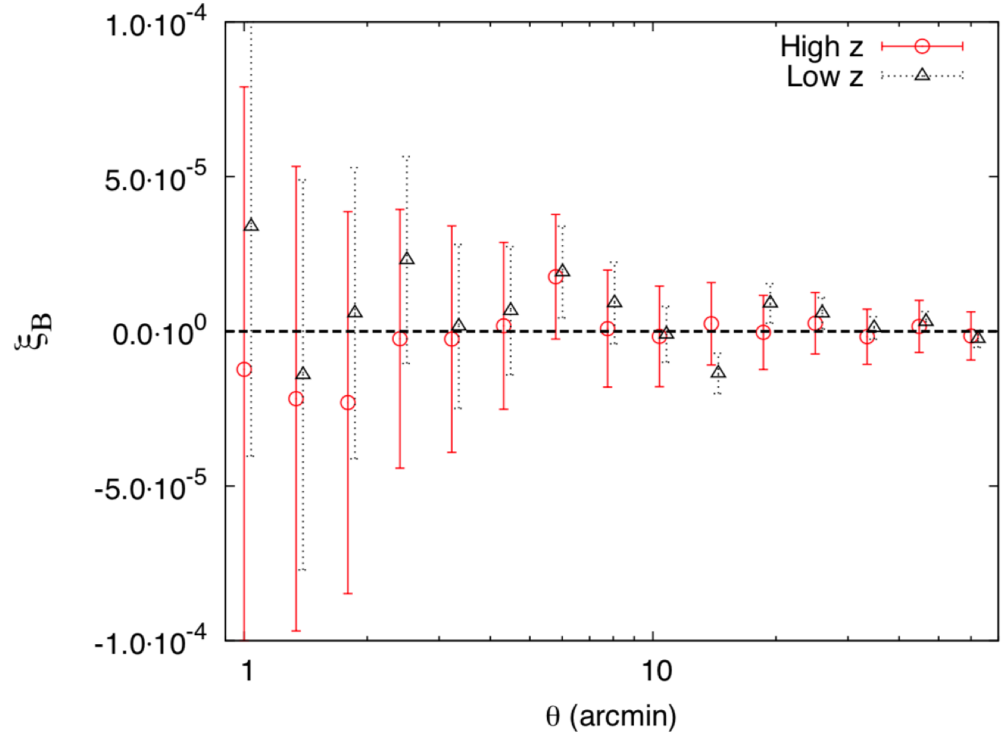
2.Tomography check

		Ngal	δz
8-band photo-z	all	23638	−0.008
	low-z	19389	−0.012
	high-z	4069	0.022

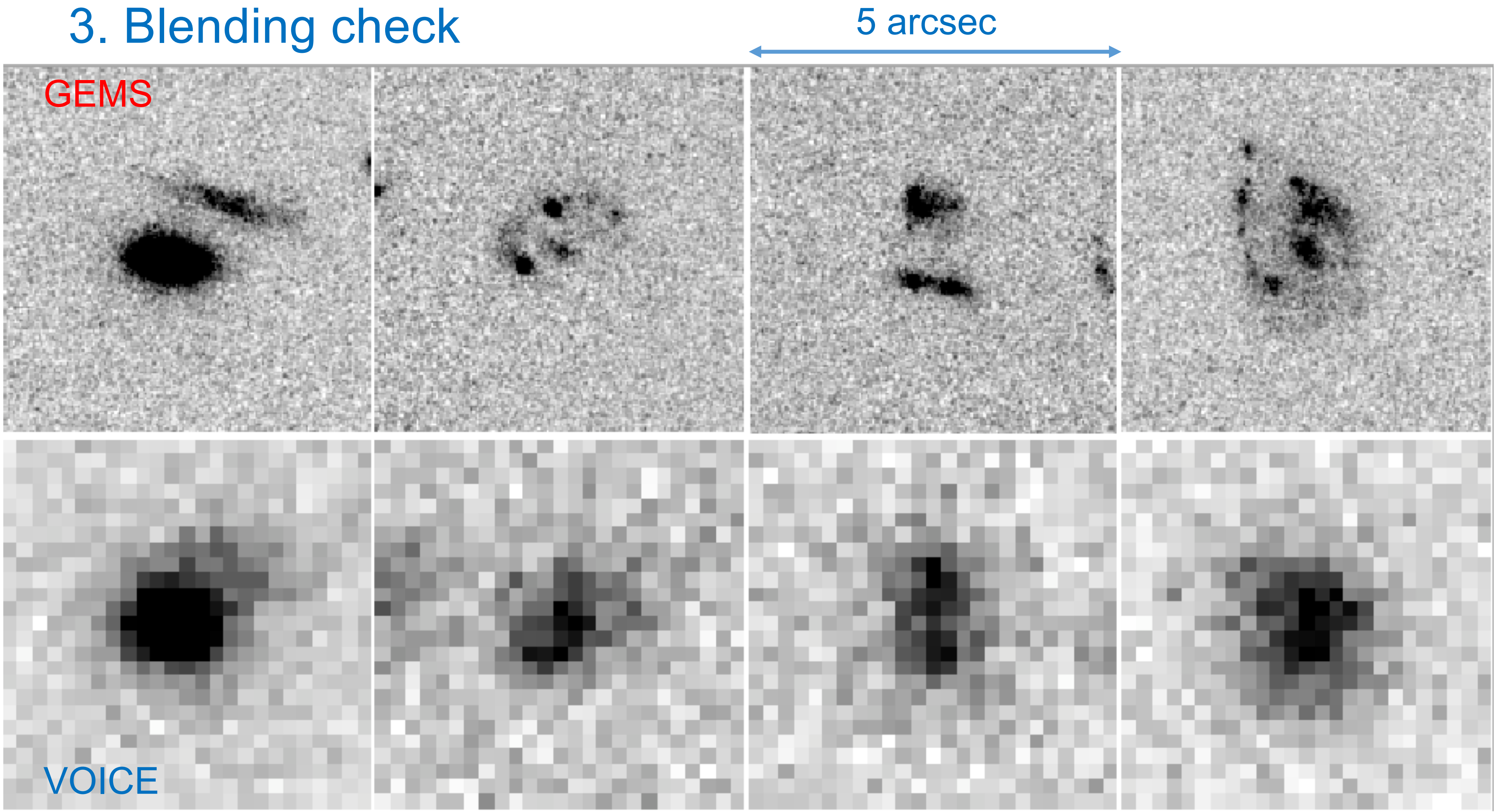
High-z: z >= z_{median} (0.83);

Low-z : z < z_{median} (0.83);





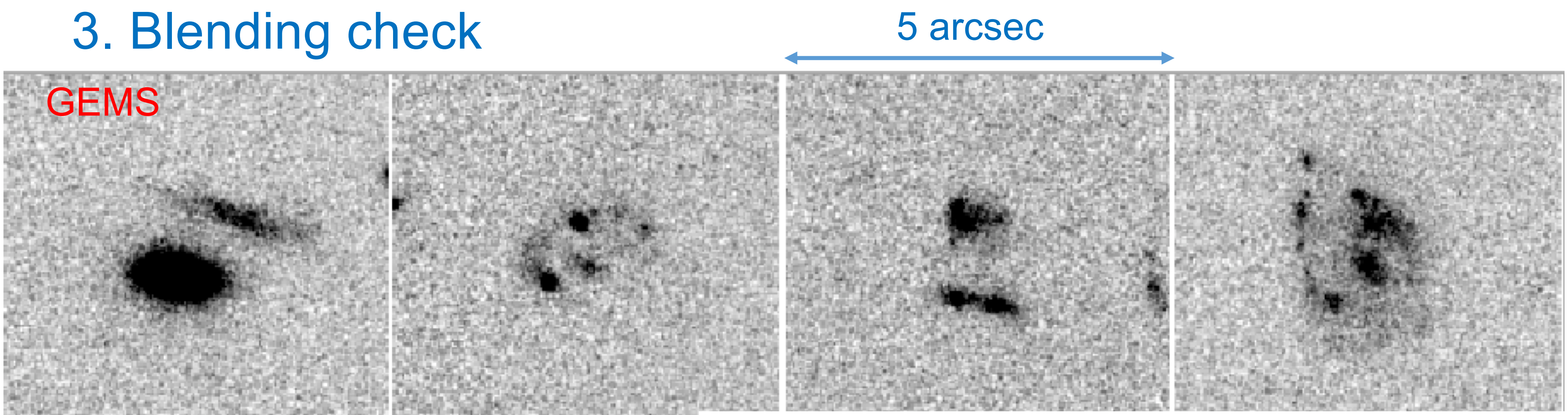
3. Blending check

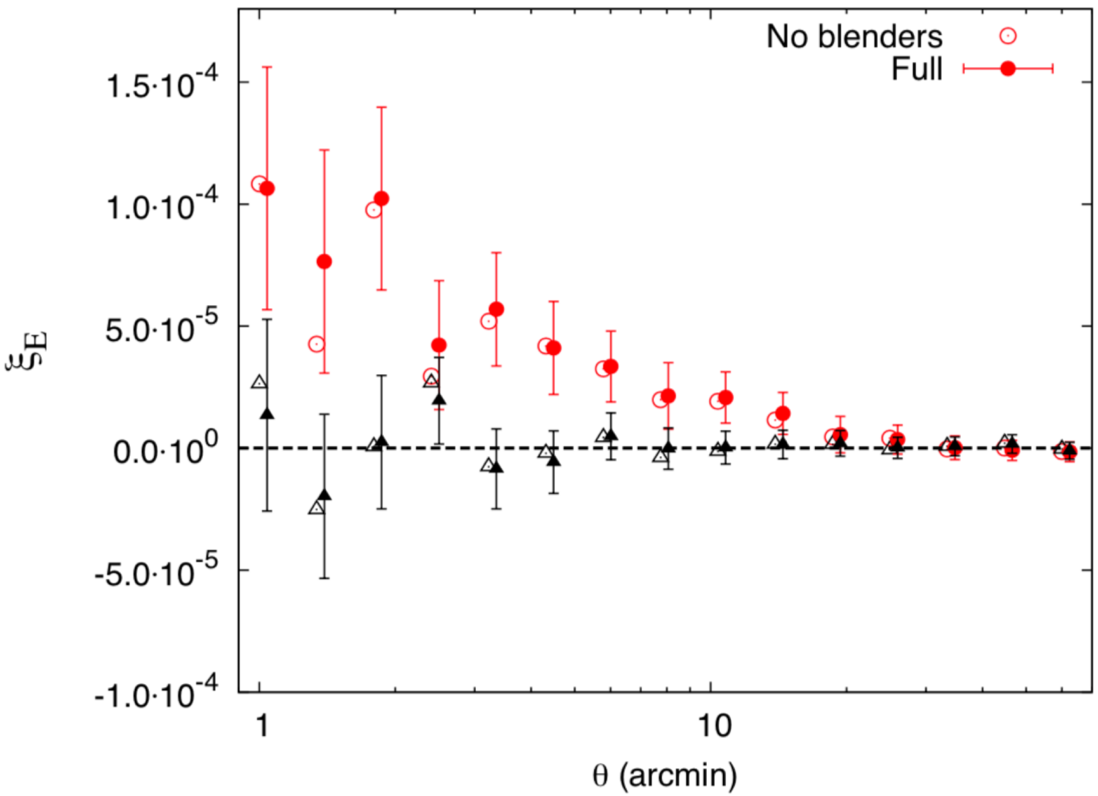


Blender: separation < 3”

-- 8% of shear catalog (weight > 0)

3. Blending check





Blender: separation < 3”

-- 8% of shear catalog (weight > 0)

-- Minor effects on two-point correlations

Cosmological application using $\langle M_{\rm ap}^2 \rangle$

-- No-systematics (no baryons, no photo-z err., no Intrinsic Alignment)

-- Weak lensing most sensitive to:

Small-scale density-fluctuations amplitude σ_8
Total matter density Ω_m

Flat ΛCDM

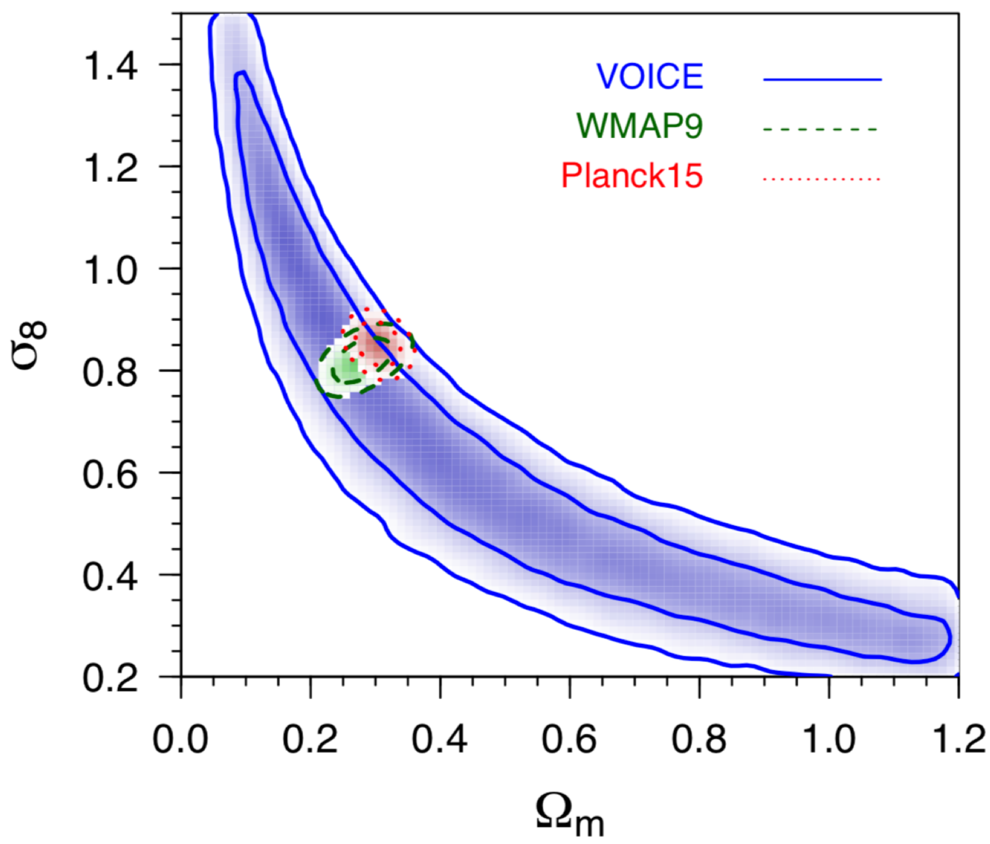
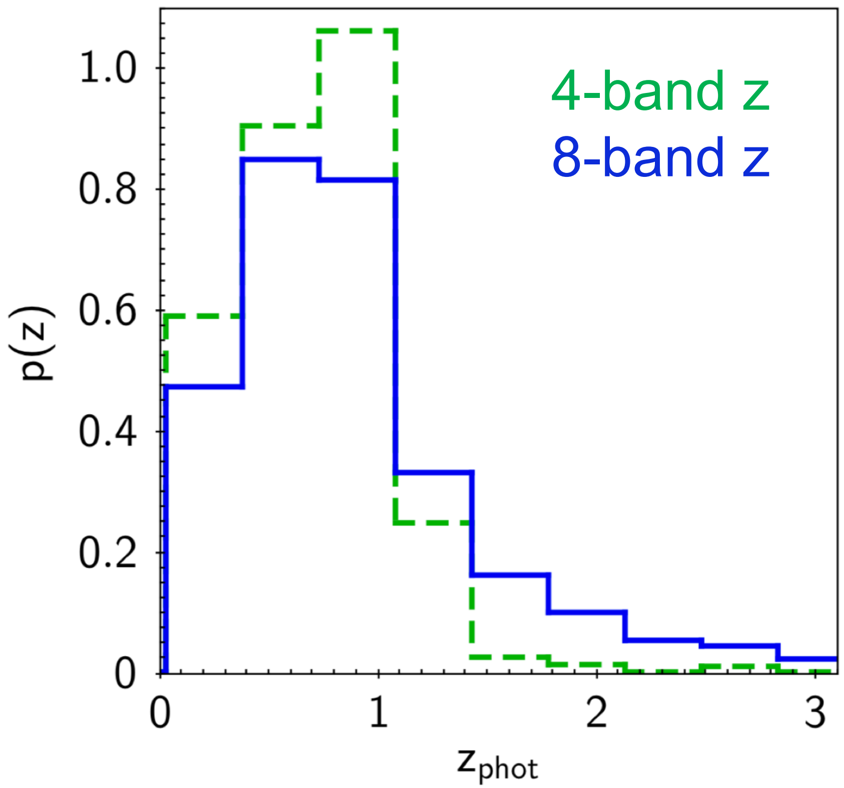
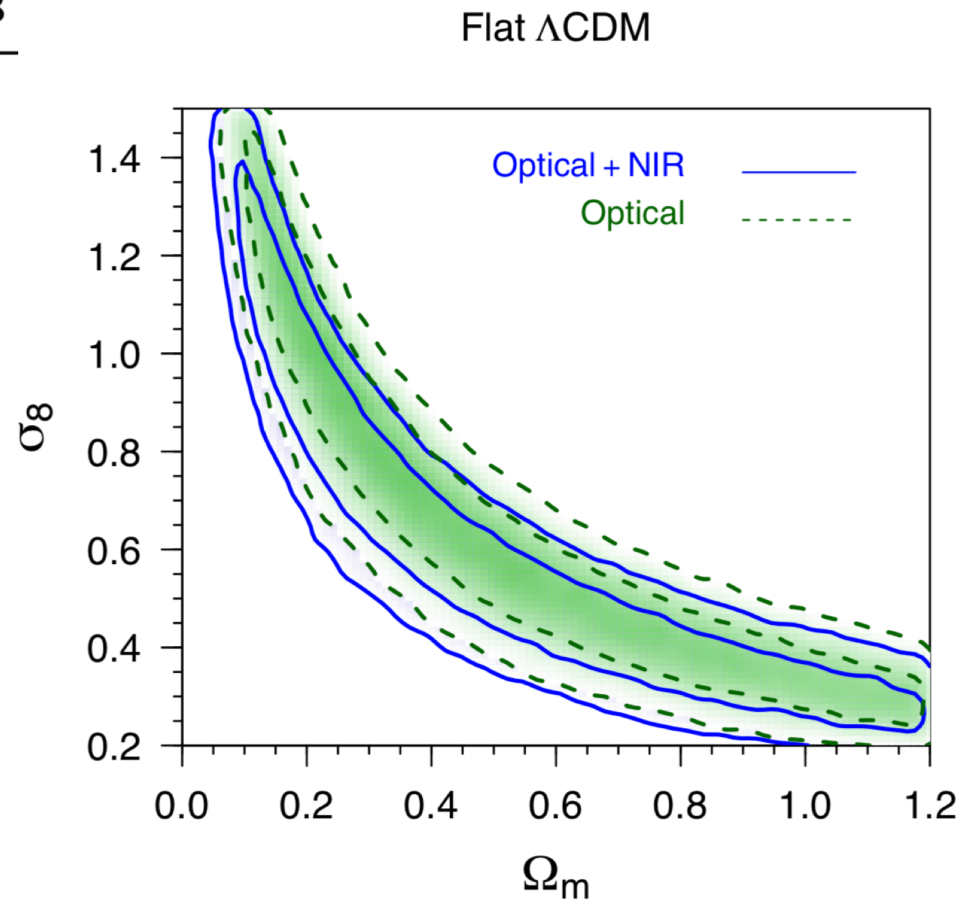


Photo-z using optical bands only (ugri)

		Ngal	δz
8-band photo-z	all	23638	−0.008
	low-z	19389	−0.012
	high-z	4069	0.022
4-band photo-z	all	23638	−0.010
	low-z	20168	−0.015
	high-z	3300	0.063





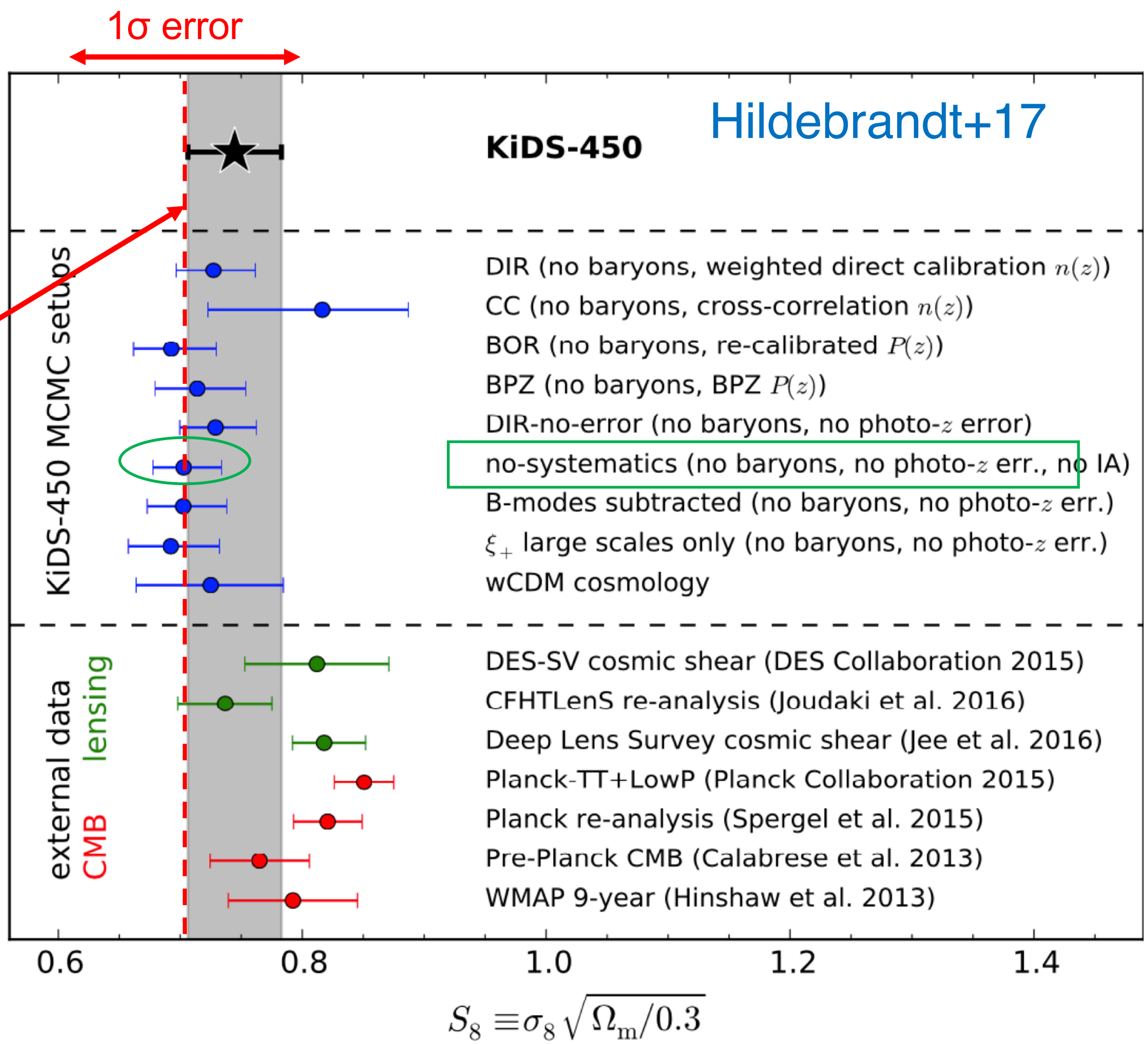
Cosmological application using $\langle M_{\rm ap}^2 \rangle$

-- No-systematics (no baryons, no photo-z err., no Intrinsic Alignment)

VOICE

$$\Sigma_8 = \sigma_8(\Omega_{\rm m}/0.3)^{\alpha}$$

Parameter	flat ΛCDM	flat wCDM	curved ΛCDM
Σ_8	$0.704^{+0.111}_{-0.121}$	$0.691^{+0.135}_{-0.129}$	$0.688^{+0.148}_{-0.138}$
α	0.637 ± 0.016	0.65 ± 0.04	0.739 ± 0.009



II. VOICE-like imaging simulation

Weak Lensing Study in VOICE Survey II: Shear Bias Calibrations

Dezi Liu[1,2,3⋆], Liping Fu[2†], Xiangkun Liu[3], Mario Radovich[4], Chao Wang[1], Chuzhong Pan[1], Zuhui Fan[1‡], Giovanni Covone[5,6,7], Mattia Vaccari[8,9], Maria Teresa Botticella[7], Massimo Capaccioli[5], Enrico Cappellaro[4], Demetra De Cicco[5], Aniello Grado[7], Lance Miller[10], Nicola Napolitano[7], Maurizio Paolillo[5], Giuliano Pignata[11]

[1] *Department of Astronomy, School of Physics, Peking University, Beijing 100871, China*
[2] *The Shanghai Key Lab for Astrophysics, Shanghai Normal University, 100 Guilin Road, Shanghai 200234, China*
[3] *South-Western Institute for Astronomy Research, Yunnan University, Kunming 650500, China*
[4] *INAF–Osservatorio Astronomico di Padova, vicolo dell'Osservatorio 5, Padova 35122, Italy*
[5] *Dipartimento di Fisica "E. Pancini", Università degli Studi Federico II, Napoli 80126, Italy*
[6] *INFN, Sezione di Napoli, Napoli 80126, Italy*
[7] *INAF–Osservatorio Astronomico di Capodimonte, Salita Moiariello 16, Napoli 80131, Italy*
[8] *Department of Physics & Astronomy, University of the Western Cape, Robert Sobukwe Road, 7535 Bellville, Cape*
[9] *INAF - Istituto di Radioastronomia, via Gobetti 101, 40129 Bologna, Italy*
[10] *Department of Physics, Oxford University, Keble Road, Oxford OX1 3RH, UK*
[11] *Departemento de Ciencias Fisicas, Universidad Andres Bello, Santiago, Chile*

Goal

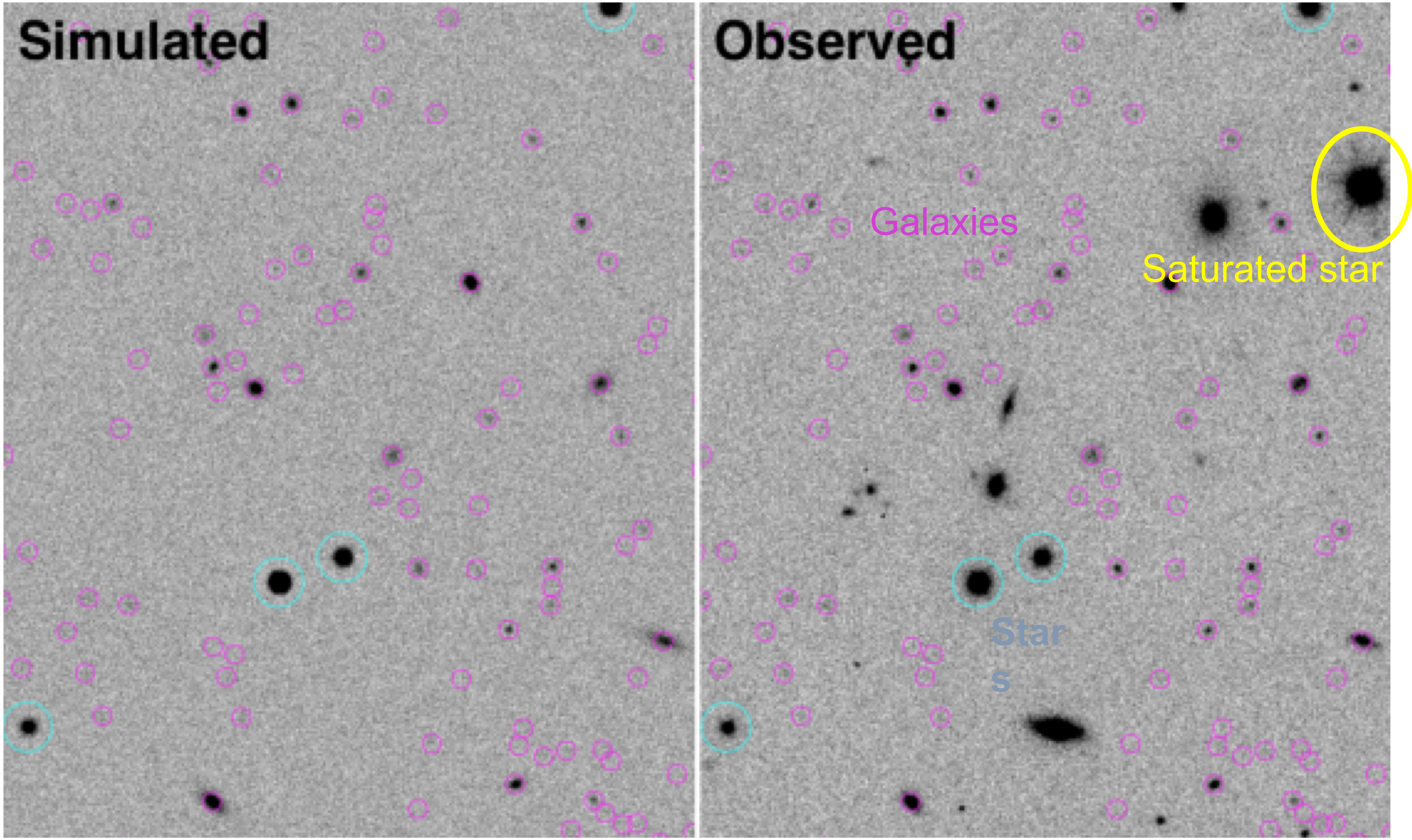
- Build “realistic” simulation for Deep image: deblending, dithering, complex PSF
- Optimize parameters of Lensfit
- Estimate and calibrate shear bias
- Impact of blending galaxies
- Impact of galaxies below detection limit

Simulation toolkit: Galsim (Rowe et al, 2015)

- S/G catalog: from observation (numbers, positions)
- Star (PSF) model: spatially varied PSF from observation (PSFEx)
- Galaxy model: exponential disc + De Vaucouleurs bulge

- Assign scale-length, ellipticity and shear components to every individual galaxy
- Weak lensing signal predicted by power spectrum
- Apply Gaussian noise with observed sigma of individual CCD

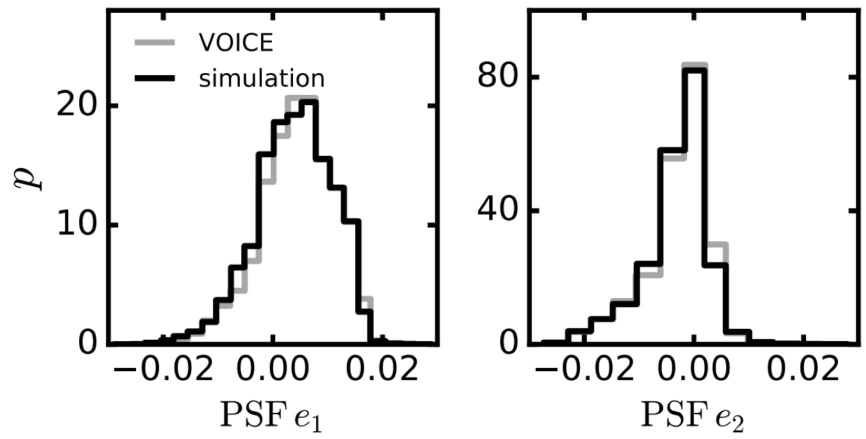
- Simulate for each individual exposure of VOICE



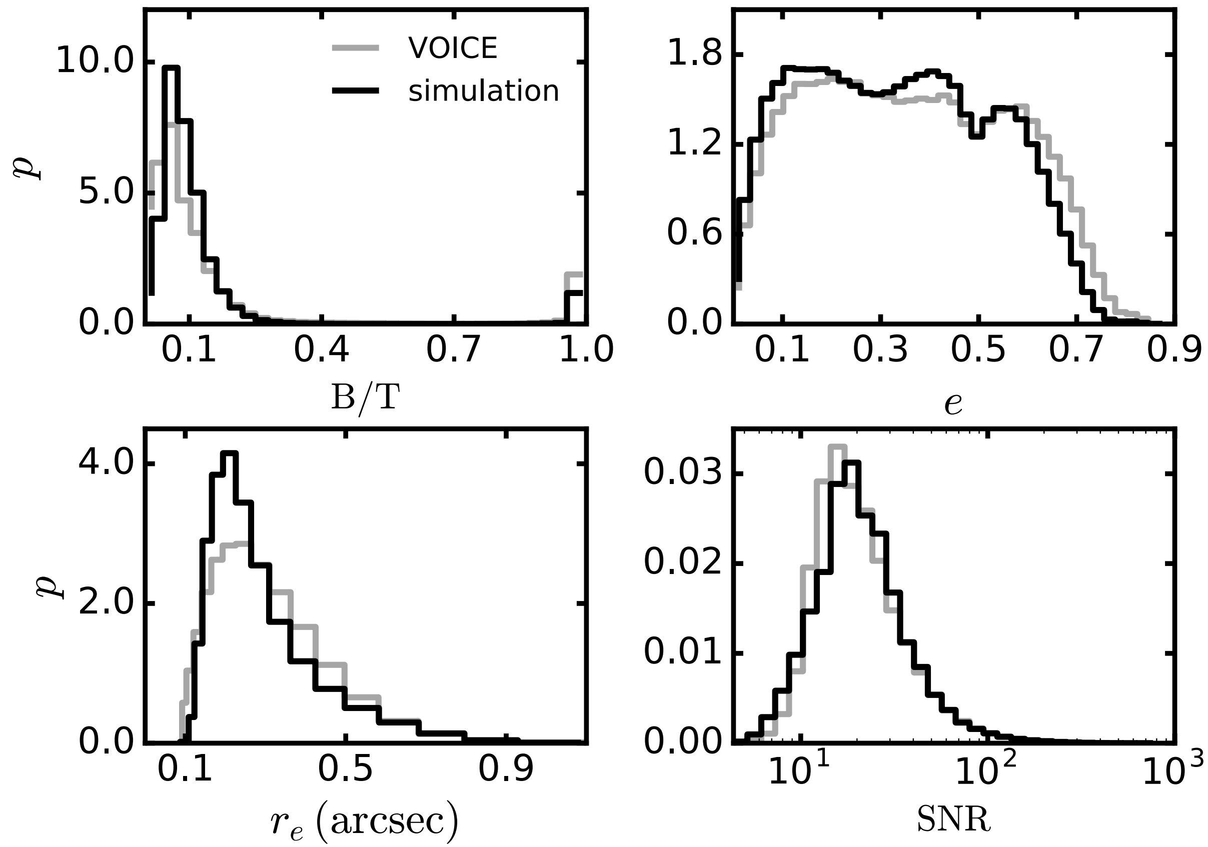
- Real S/G position
- Real PSF
- Same noise level

Distributions

Stars



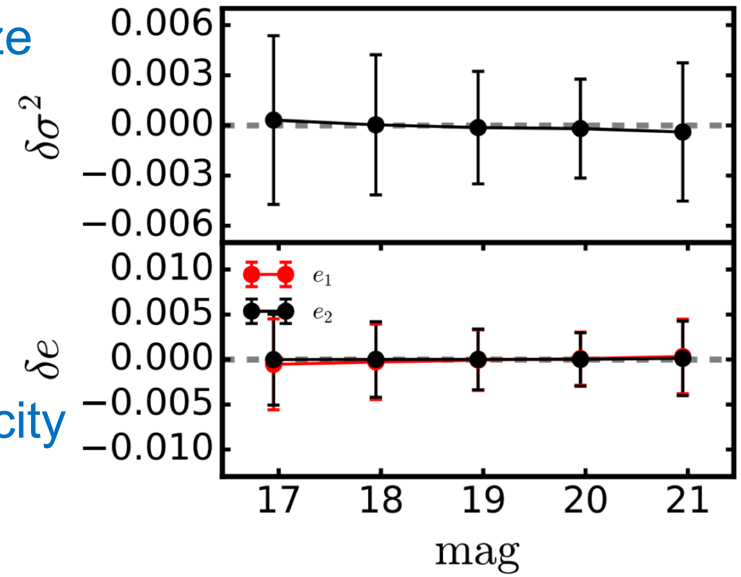
Galaxies



Residual of PSF model

size

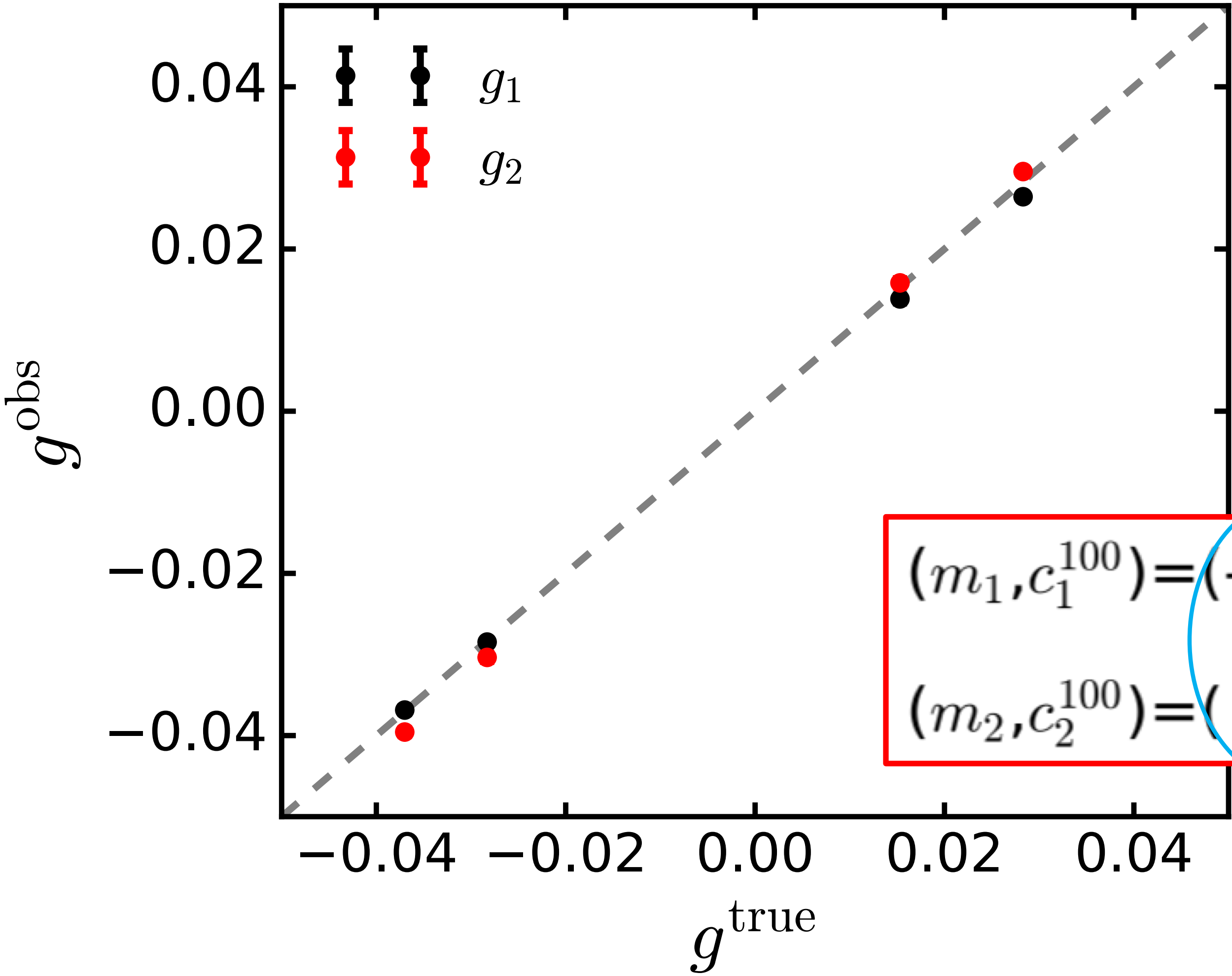
ellipticity



Two sets of images with orthogonal ellipticity;

$g = 0.04$;

$(g1,\ g2) = (\pm 0.0283,\ \pm 0.0283)$; $(+0.0153, -0.0370)$; $(-0.0370, +0.0153)$



$$\boldsymbol{g}^{obs} = (1+\boldsymbol{m}) \times \boldsymbol{g}^{true} + \boldsymbol{c}$$

$(m_1, c_1^{100}) = (-0.03 \pm 0.01, -0.10 \pm 0.02)$

$(m_2, c_2^{100}) = (\ 0.06 \pm 0.01, -0.04 \pm 0.02)$

*10-2

III. VOICE photo-z estimation

METAPHOR

Machine-learning Estimation Tool for Accurate Photometric Redshifts

Multi Layer neural network

+Collaboration with: V. Amaro, S. Cavuoti, M. Brescia, C. Vellucci, G. Longo

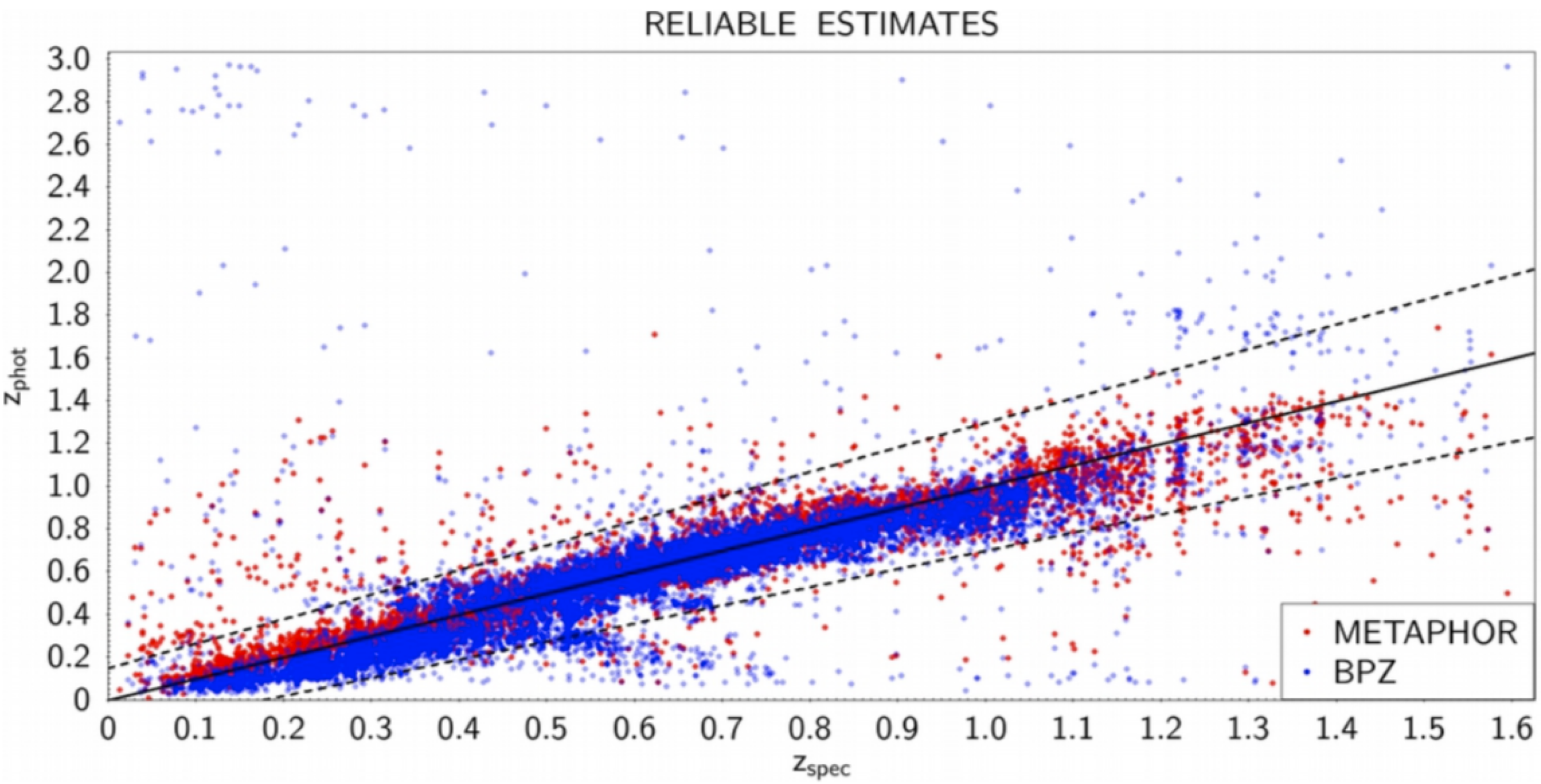
VOICE: photo-z vs spec-z

-- ~23000 spec-z, up to 1.6

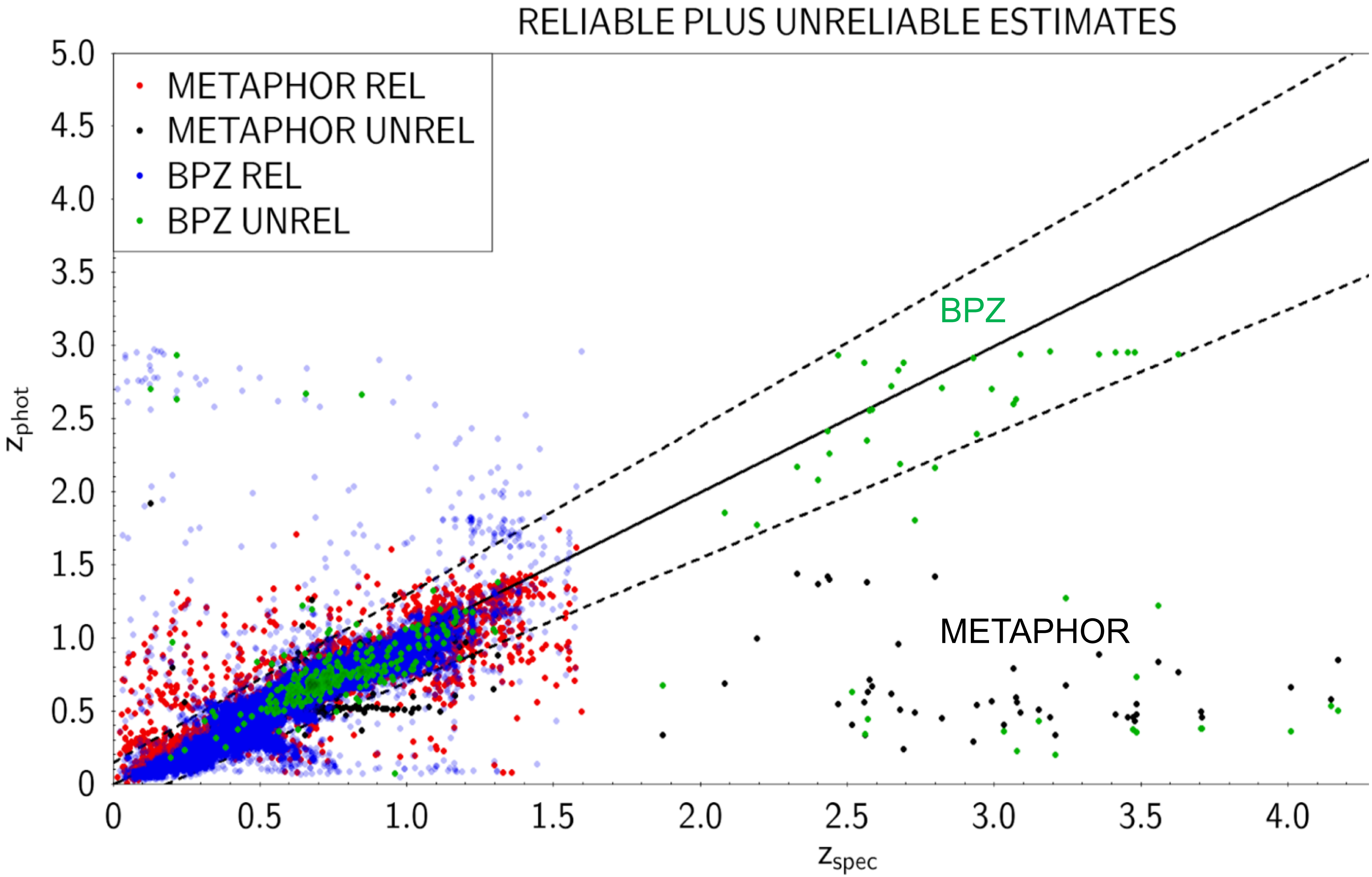
-- BPZ, shear cat & spec-z matching: 1 arcs → ~13000 objects

-- METAPHOR:

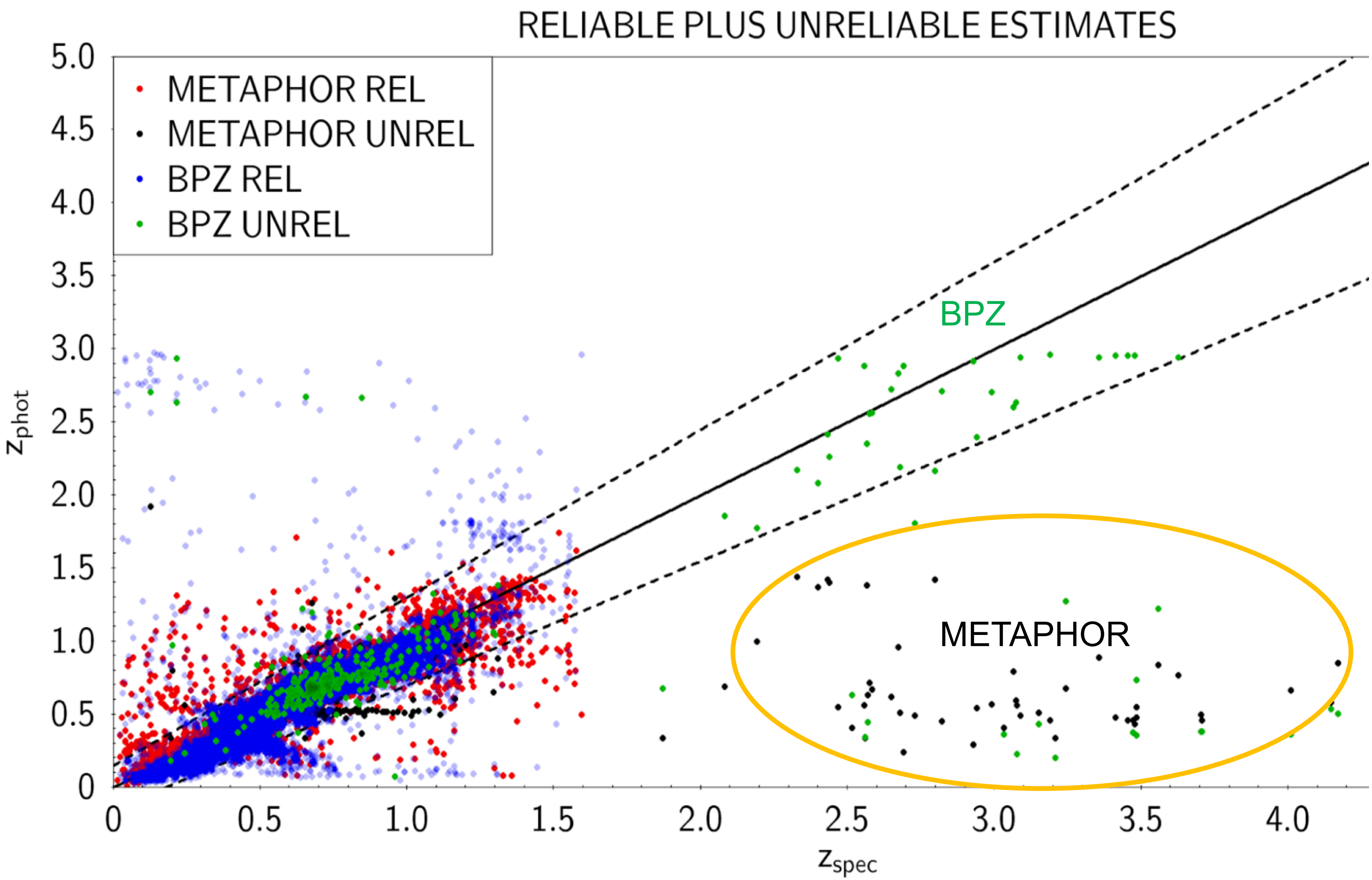
- feature selection: optimize of parameter space (photometry, colors, morphology);
- require all bands detection



METAPHOR unreliable objects



METAPHOR unreliable objects



METAPHOR vs BPZ

Estimator	Reliable (#11,997) zspec<=1.6		unreliable (#286) zspec<=1.6		unreliable (#48) zspec>1.6	
	METAPHOR	BPZ	METAPHOR	BPZ	METAPHOR	BPZ
|bias|	0.001	0.015	0.030	0.025	0.570	0.275
sigma	0.065	0.154	0.136	0.253	0.118	0.083
NMAD	0.027	0.053	0.075	0.047	0.083	0.189
Skew	-3.7	-9.9	-6.3	-7.1	-1.3	0.5
Kurtosis	44.5	142.1	71.8	55.3	0.6	-1.5
out_norm>0.15	2.8 %	6.4%	14.3%	5.6%	100%	41.7%

METAPHOR next steps

- Missing bands of photometry → losing objects

  -- down weight of missing bands? Fake value from neighbor galaxies?

- The up limit of spec-z → the up limit of photo-z

  -- high z spectrum → training sample

- For current deep survey,

  -- METAPHOR (z < zspect & reliable) + BPZ (z > zspect & unreliable)

  -- How to combine them? Systematics?

Summary

- Cosmic shear is measured using VOICE deep survey (CDFS 4 deg^2), n_{eff}=16.4/$arcmin^2$, r_{lim}=26.1, $3x10^5$ galaxies with shear + photo-z;
- The reliability of Lensfit applied on deep image is optimized using VOICE imaging simulations;
- The shear signal has been calibrated using simulations;
- The shear two-point correlations have passed a few nulling systematic checks.
- Next step:

✓ cosmological analysis + systematics + intrinsic alignment;

✓ cluster searching: color-photoz;

✓ lensing mass map;

✓ tomographic lensing;

✓ peak statistics…


点击查看源网页
Thank you