Progress of HSC survey weak lensing analysis

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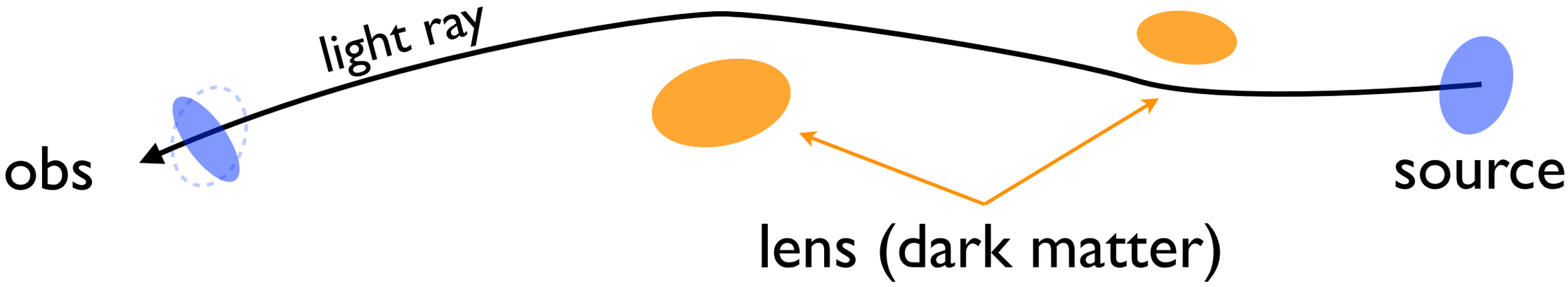
2017/3/9 Why does the Universe accelerate? @KEK

Collaborators

- HSC weak lensing working group
  B. Armstrong, J. Bosch, T. Hamana, C. Hikage,
  F. Lanusse, A. Leauthaud, R. Mandelbaum,
  E. Medezinski, H. Miyatake, S. Miyazaki, S. More,
  R. Murata, A. J. Nishizawa, M. Oguri, N. Okabe,
  Y. Okura, M. Simet, J. S. Speagle, M. Takada,
  K. Umetsu, Y. Utsumi, and more...

Weak gravitational lensing



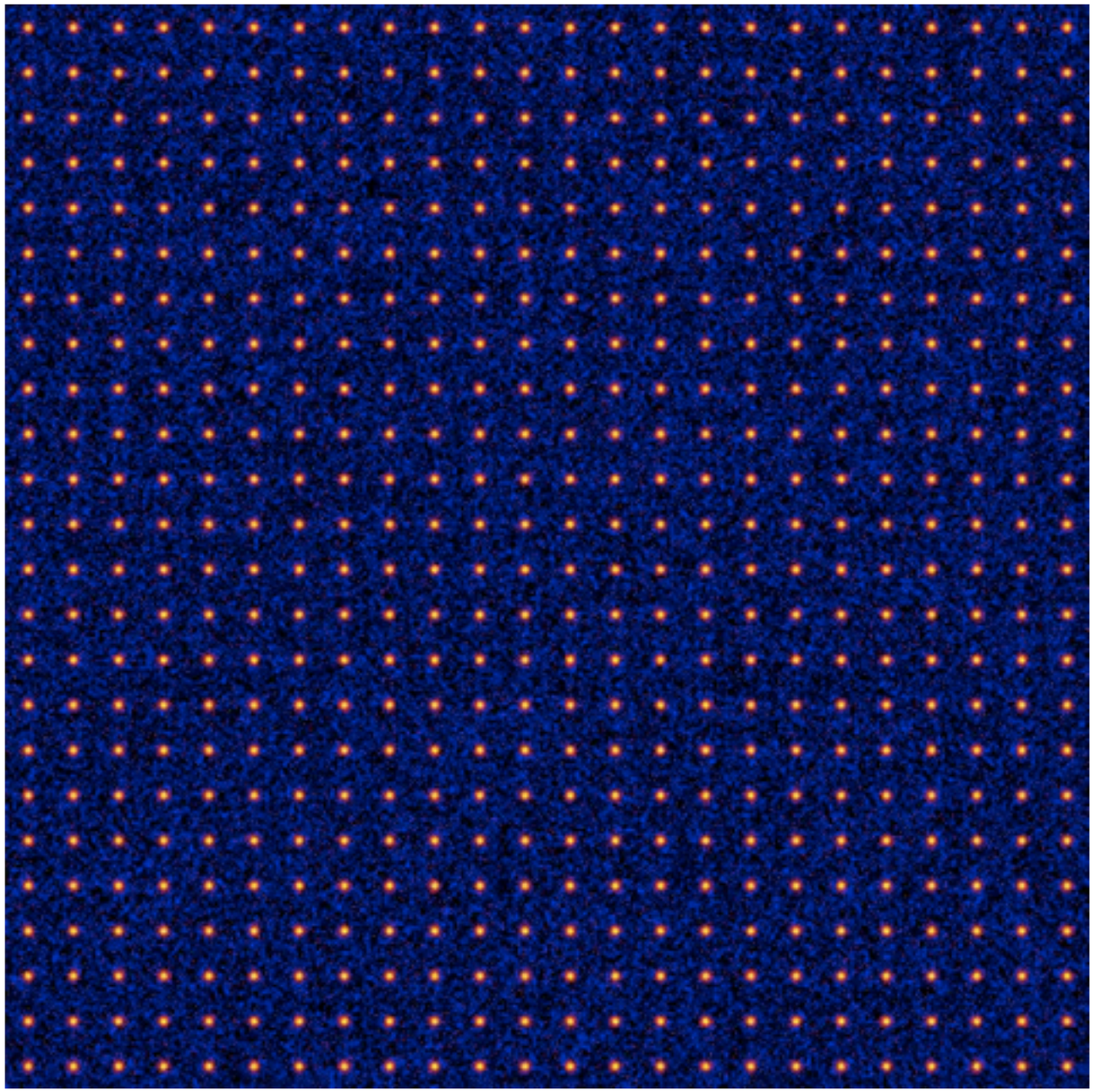
lens potential $\phi = \int d\chi W(\chi)\Phi$

deflection $\alpha_i = \partial_i \phi$

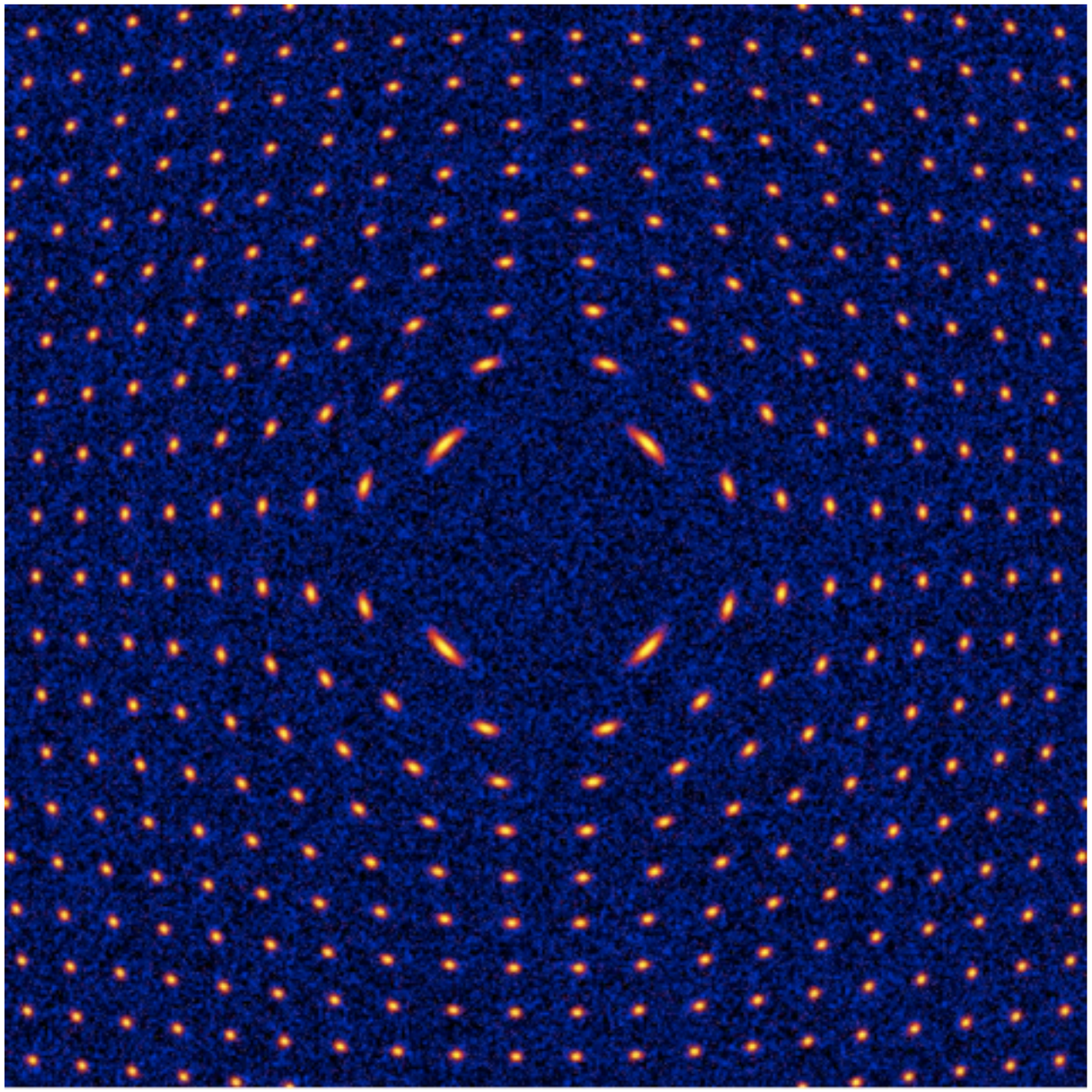
shape distortion $\delta_{ij} - \partial_j \alpha_i = \delta_{ij} - \partial_i \partial_j \phi$

simulated by *glafic*

Lensing effect on galaxies



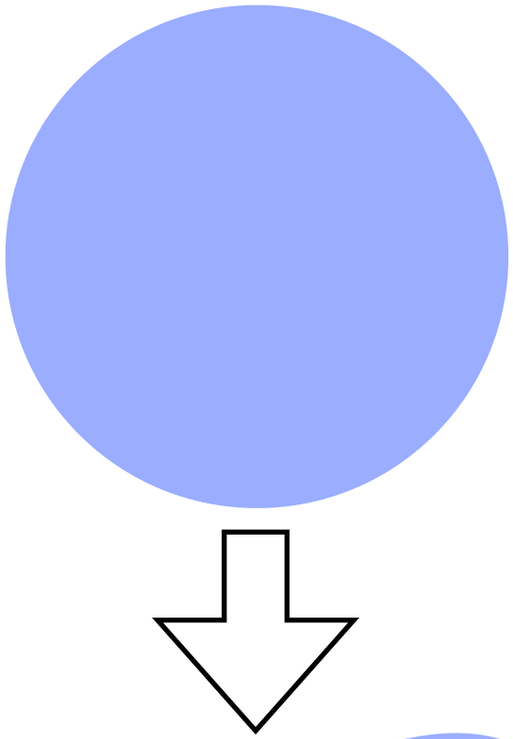
no lensing



lens potential at the center

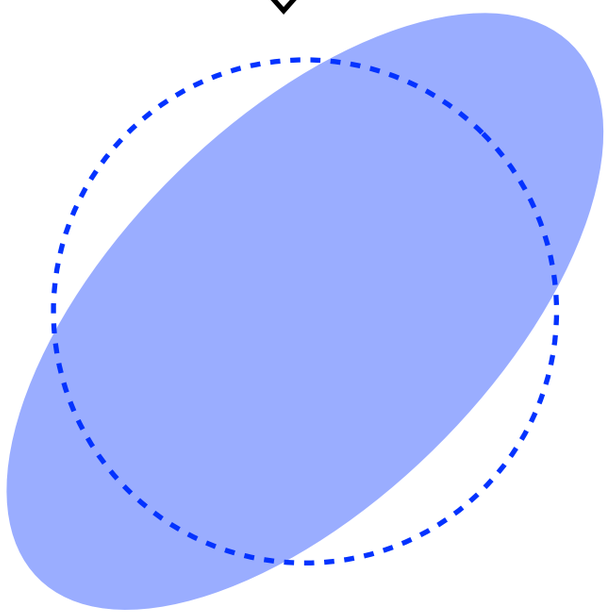
Convergence and shear

original



convergence
κ

$$\kappa = \frac{1}{2}\left(\partial_1^2 + \partial_2^2\right)\phi$$



shear
γ

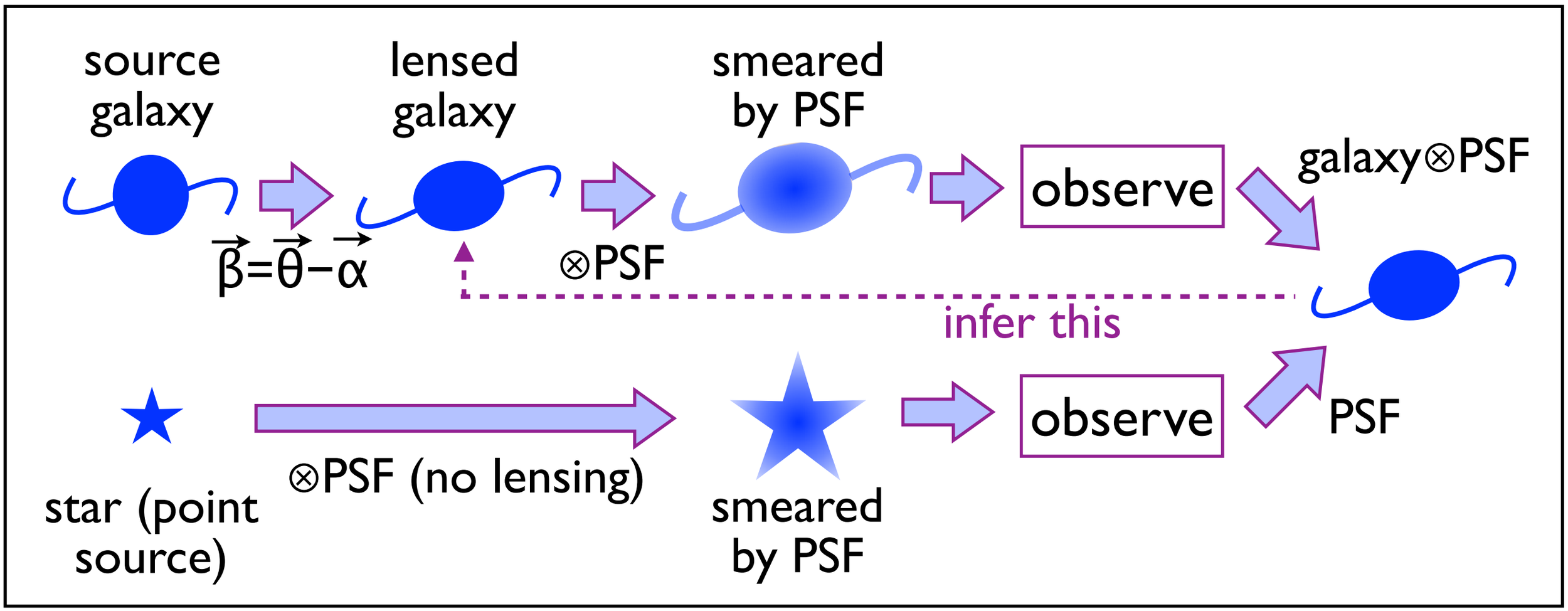
$$\gamma_1 = \frac{1}{2}\left(\partial_1^2 - \partial_2^2\right)\phi \quad \gamma_2 = \partial_1\partial_2\phi$$

- κ is related to mass dist. via Poisson eq.

$$\kappa \propto \int d\chi W(\chi)\rho$$

- we observe γ by averaging many galaxies' shapes

Galaxy shape measurement



- unbiased shear estimate is one of the biggest challenges in weak lensing analysis
- however, it can fully be checked w/ simulations

Shear catalog and validation

- shape measurement methods
  - re-Gaussianization (Hirata & Seljak 2003)
  - Bayesian Fourier Domain available soon

    (Bernstein & Armstrong 2014)

- validation of the shear catalog via null tests and image simulations

  (analysis led by Rachel Mandelbaum)

Mandelbaum et al. in prep.

PSF model test

- model accuracy for Point Spread Function (PSF)

(shading: requirements)

(Figure credit: H. Miyatake)

Mandelbaum et al. in prep.

Null tests

star-galaxy two-point
correlation function
(Figure credit: T. Hamana)

stacked shear around
random points

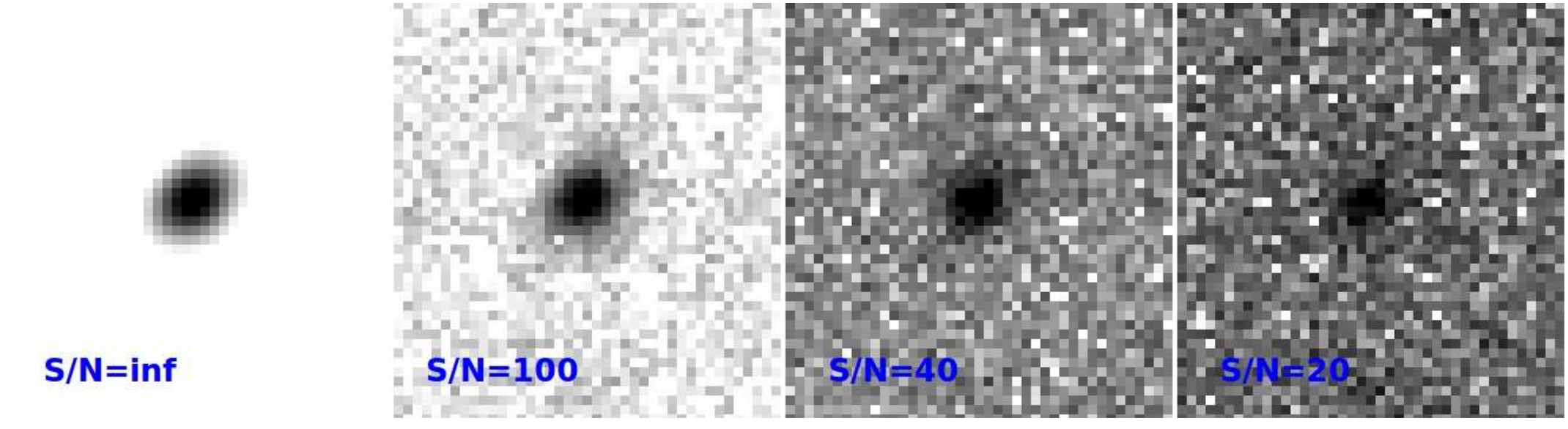
Mandelbaum et al. in prep.

Null tests

E-mode and B-mode PDFs from mass maps (shading: from mocks)

Moments of B-mode PDF

Image simulations



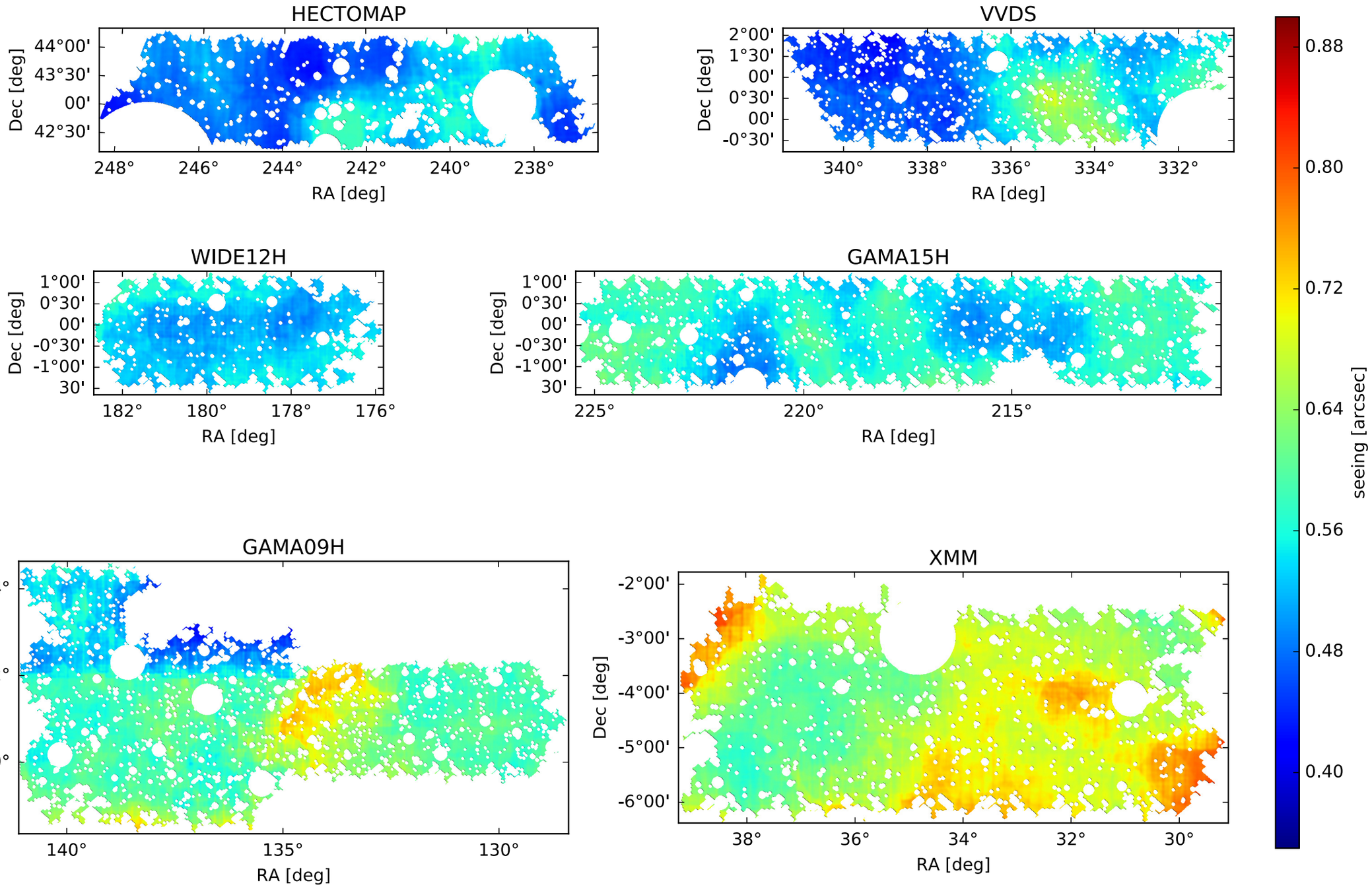
(HSC Science White Paper)

- take real galaxy shapes from HST (COSMOS) and real HSC PSF to create simulated HSC galaxy images with weak lensing effects
- use mock observations of these simulated galaxy images to accurately calibrate shear measurements as a function of gal. properties

“First year” science results

- based on S16A internal release, which include data taken from 2014 March to 2016 April (~163 deg^2 of full-depth full-color regions)
- shape catalog almost ready, waiting for the final calibration from image simulations
- will publish weak lensing science results in spring/summer 2017
- all the results I will show are preliminary

“First year” science results



maps of seeing in i-band images (H. Miyatake)

Oguri et al. in prep.

Weak lensing mass maps

Mass (dark matter) maps from weak lensing

Galaxy mass maps from stellar masses of galaxies

(XMM region, ~30 deg^2)

~1.3 deg

HSC (~20 gals/arcmin^2)

DES-like (~7 gals/arcmin^2)

Oguri et al. in prep.

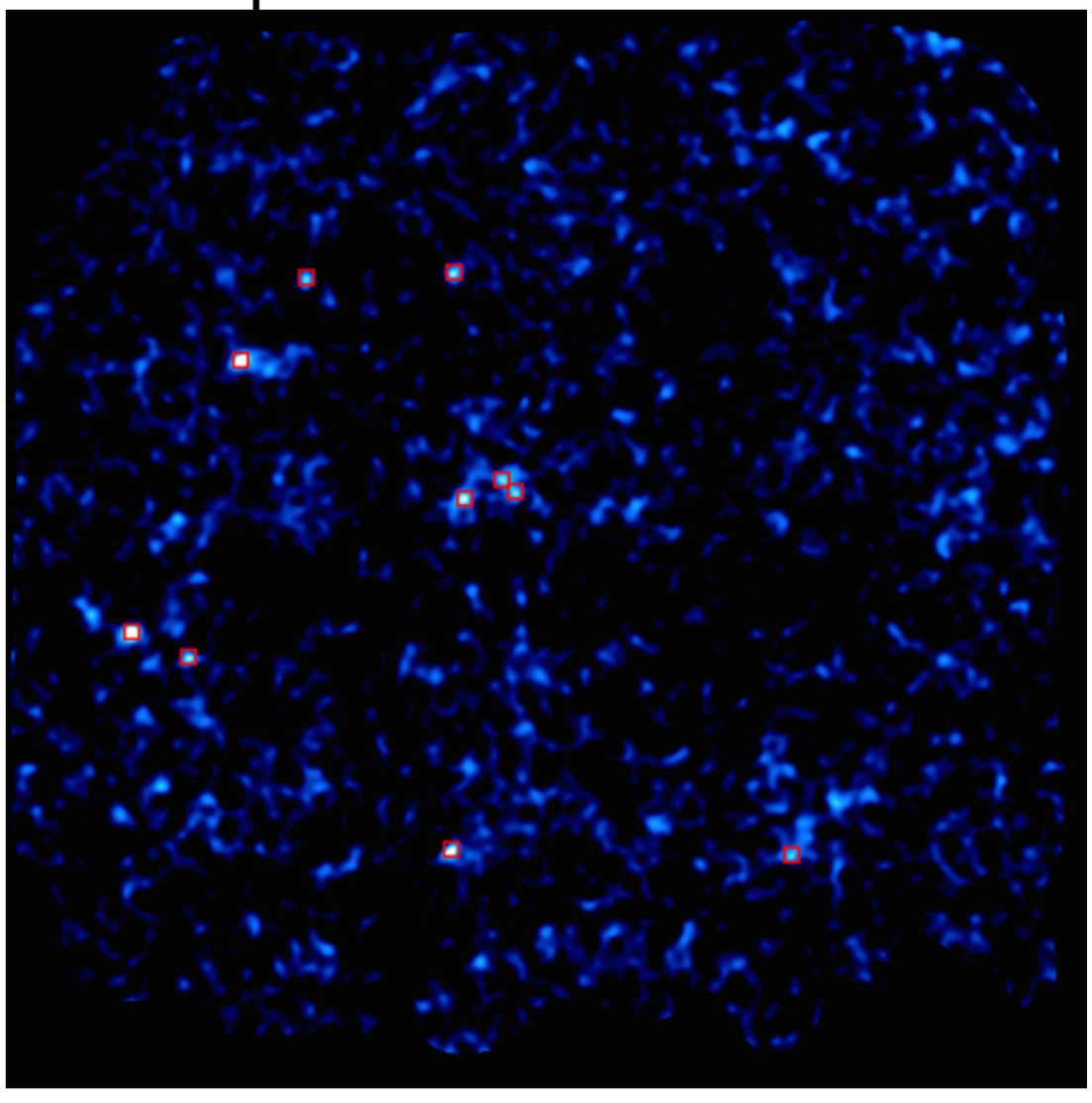
Three-dimensional mass maps

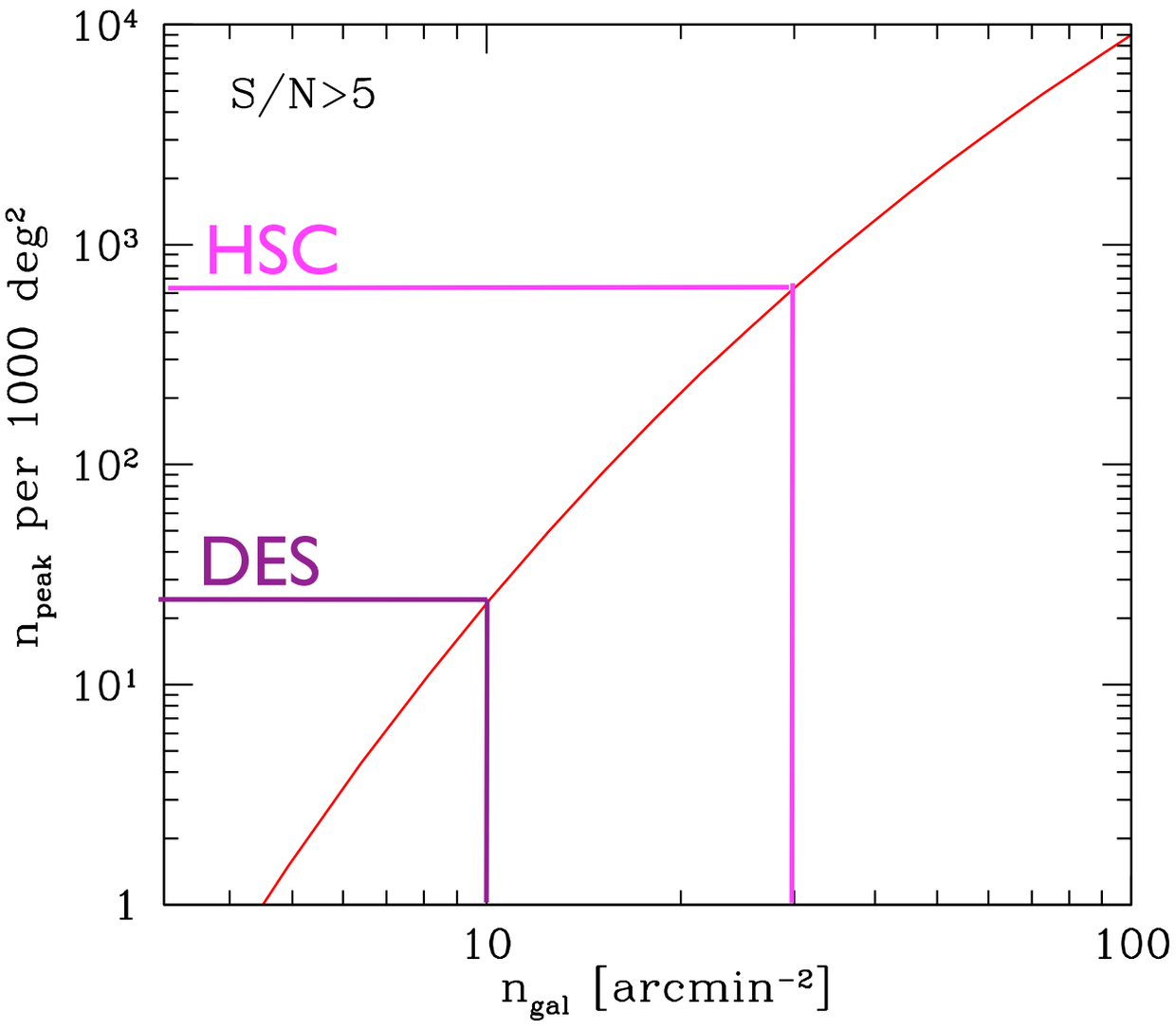
weak lensing mass
(dark matter) map

galaxy stellar
mass map

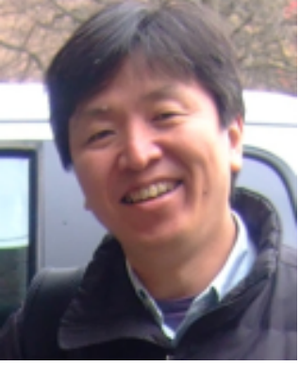
Cluster search in mass maps

mass map from Subaru/HSC





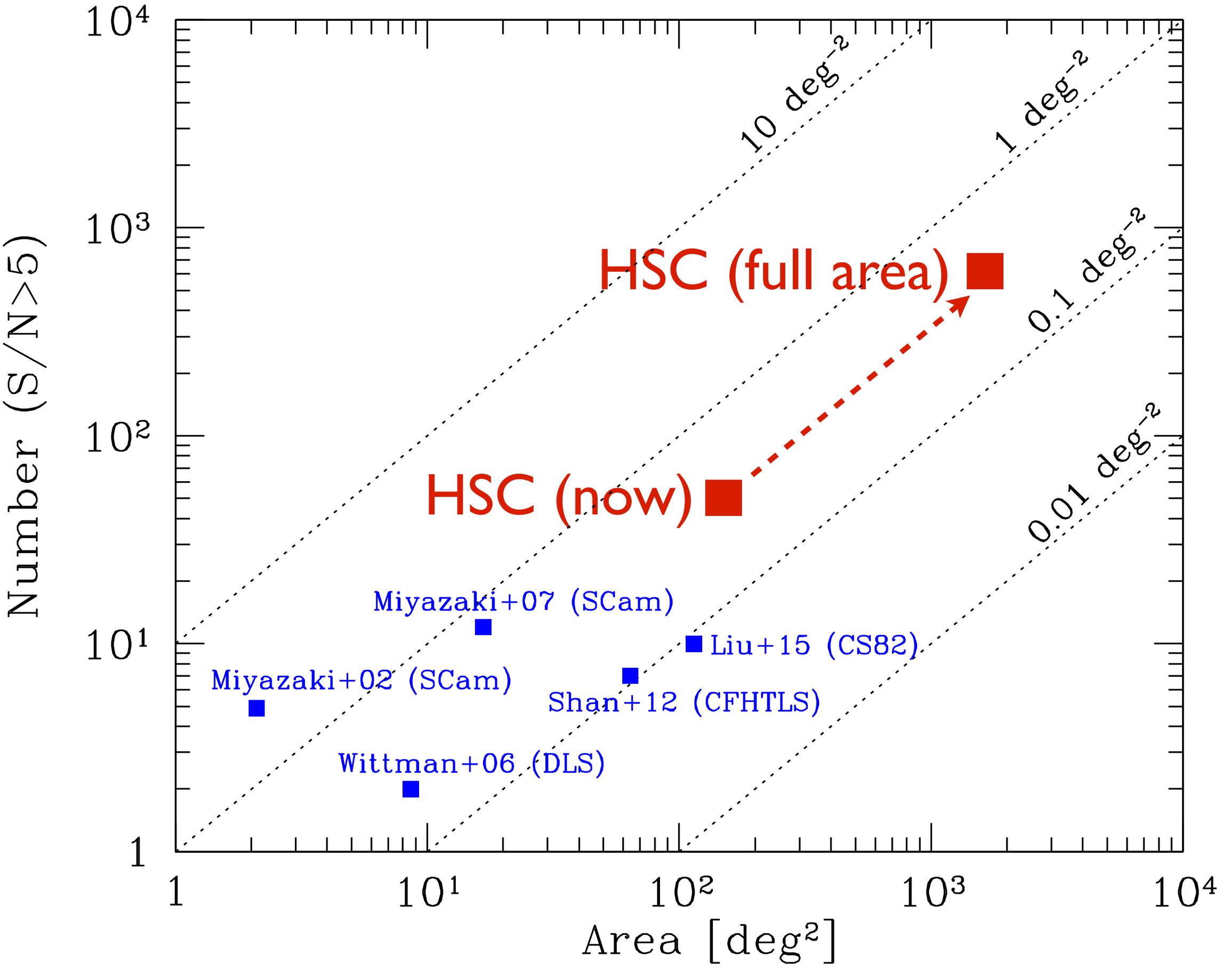
- clusters from peaks in mass maps (“mass-selected”)
- depth of HSC survey is critically important



Miyazaki et al. in prep.

Mass-selected cluster sample

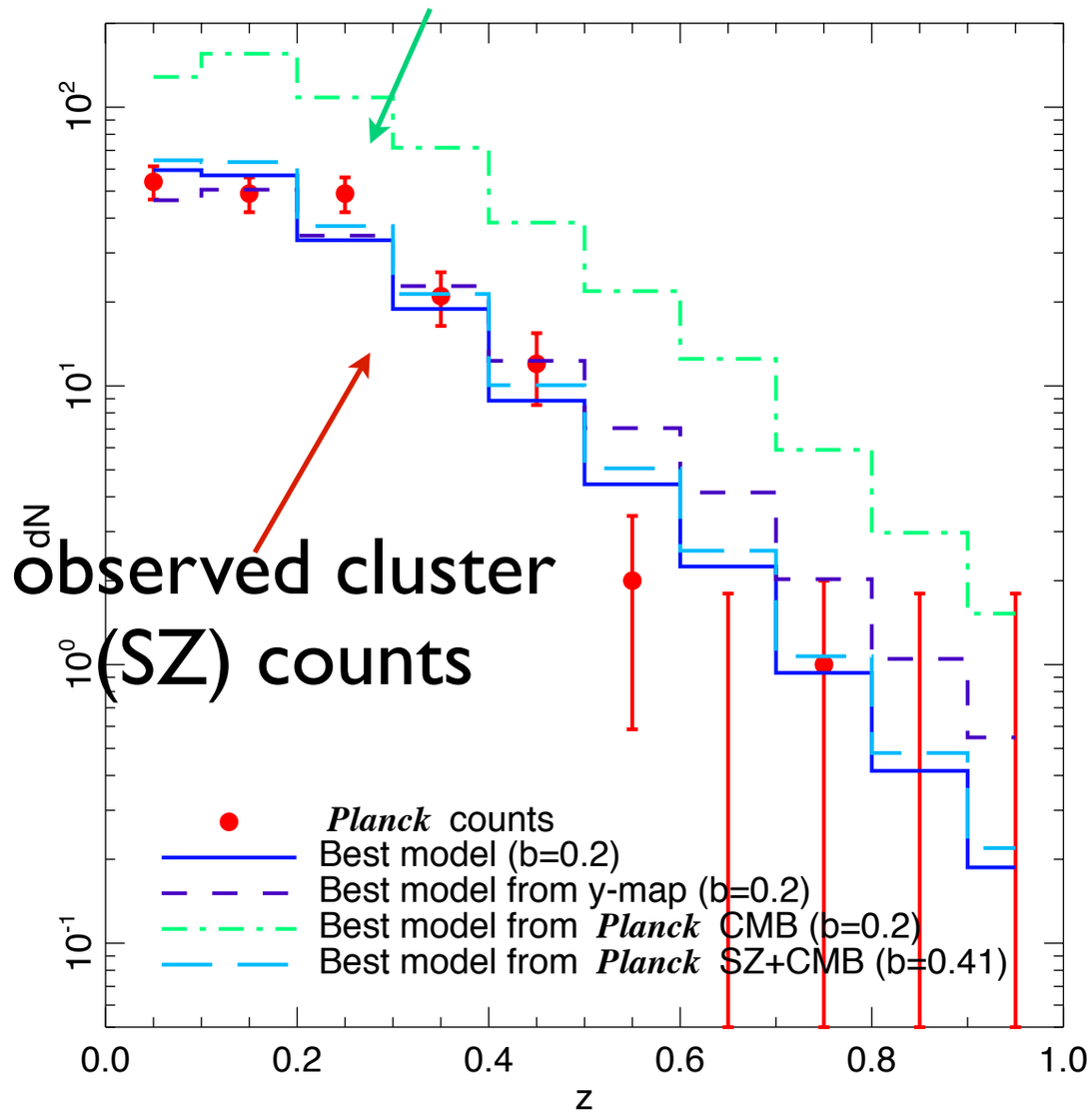
- 71 peaks with S/N>4.7
  → increase mass-selected clusters significantly


HSC (full area)
HSC (now)
10 deg^{-2}
1 deg^{-2}
0.1 deg^{-2}
0.01 deg^{-2}
Miyazaki+07 (SCam)
Liu+15 (CS82)
Miyazaki+02 (SCam)
Shan+12 (CFHTLS)
Wittman+06 (DLS)
Number (S/N>5)
Area [deg^2]
1
10^1
10^2
10^3
10^4

σ_8 crisis?

- Planck CMB results allow us to infer density fluctuations (σ_8) at local Universe (extrapolation from z=1090 to 0)
- Planck σ_8 too large compared with cluster counts?
- cluster mass calibration is the biggest uncertainty

Cluster counts expected from Planck (CMB) result



(Planck 2013)

Medezinski et al. in prep.

SZ cluster mass: Planck

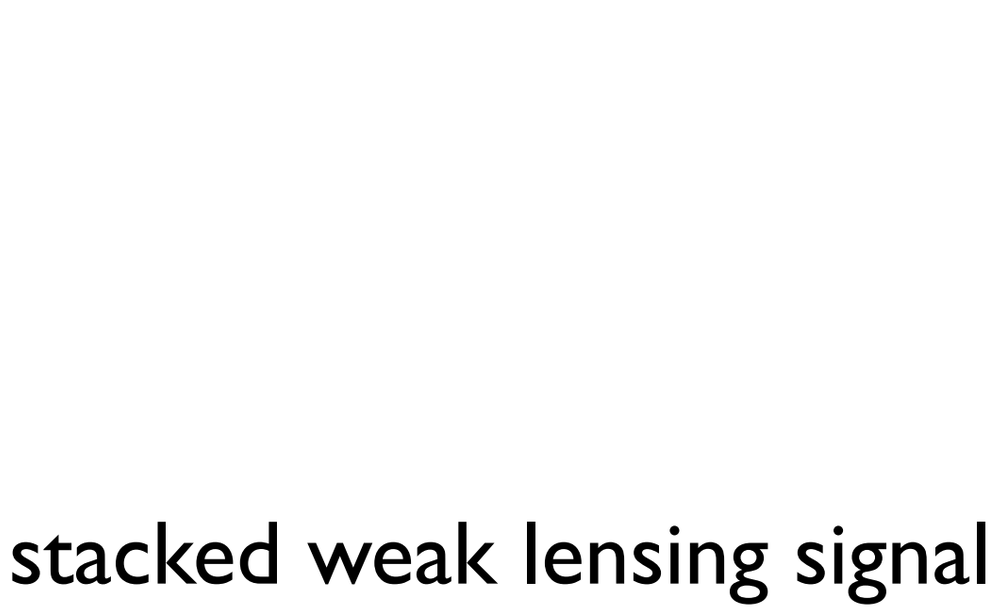
- 5 Planck Sunyaev-Zel'dovich (SZ) selected clusters in the current HSC footprint
- stacked weak lensing signal at 15σ level

stacked weak lensing signal

Miyatake et al. in prep.

SZ cluster mass: ACTPol

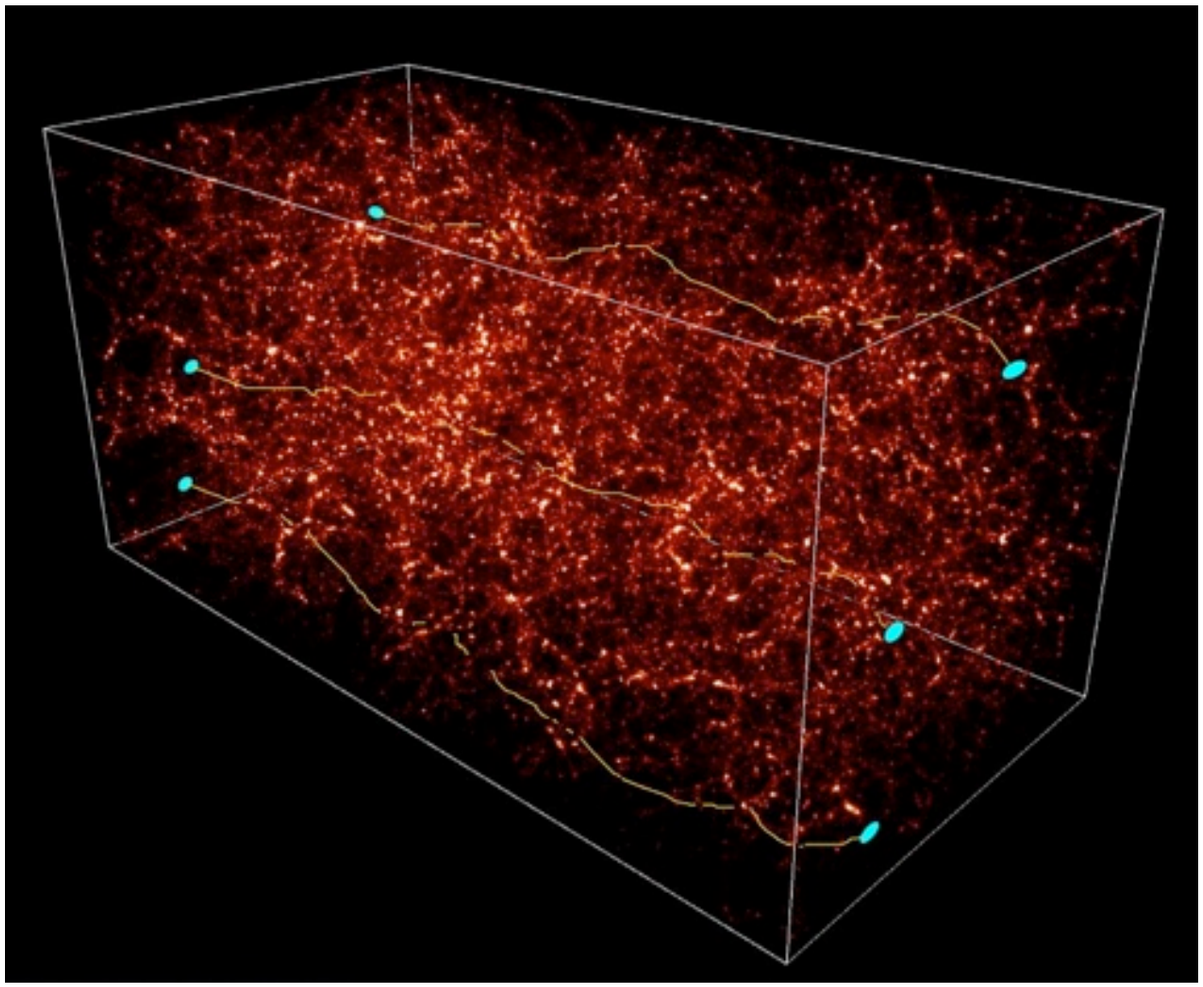
- high resolution CMB survey ACTPol overlap with HSC
- 8 ACTPol SZ clusters in the HSC footprint
- stacked weak lensing signal at 13σ level

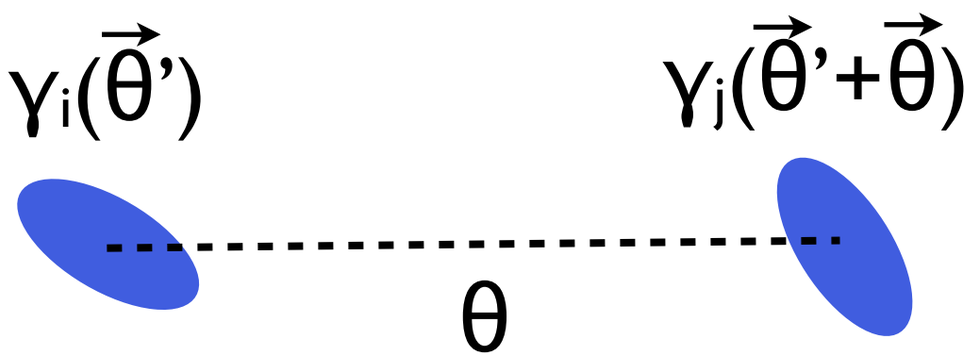


stacked weak lensing signal

Another approach: cosmic shear

- two-point correlation function of shear for direct measurement of matter fluctuations





$$\xi_{ij}(\theta) = \langle \gamma_i(\vec{\theta'}) \gamma_j(\vec{\theta'} + \vec{\theta}) \rangle$$

Hamana et al. in prep.

Cosmic shear: real space

- shear-shear two-point correlation function detected at high SN
- systematics estimated from star-galaxy cross correlation negligible except at very large θ

Hikage et al. in prep.

Cosmic shear: Fourier space

- EB decomposition using pseudo spectrum method (Hikage et al. 2011)
- successful power spectrum (C_l) measurement (S/N ~ 30)

Timeline

- HSC (1400 deg^2, r_{lim}~26.2)
  First year (160 deg^2, full depth) spring/summer 2017
- DES (5000 deg^2, r_{lim}~24.8)
  science verification (150 deg^2, full depth) already out
  Year 1 (1500 deg^2, 40% depth) coming soon
- KiDS (1500 deg^2, r_{lim}~25.1)
  KiDS-450 (450 deg^2, full depth) already out

Summary

- "First year" HSC weak lensing shape catalog is almost finalized
- science analysis is ongoing, and papers will be submitted in spring/summer 2017