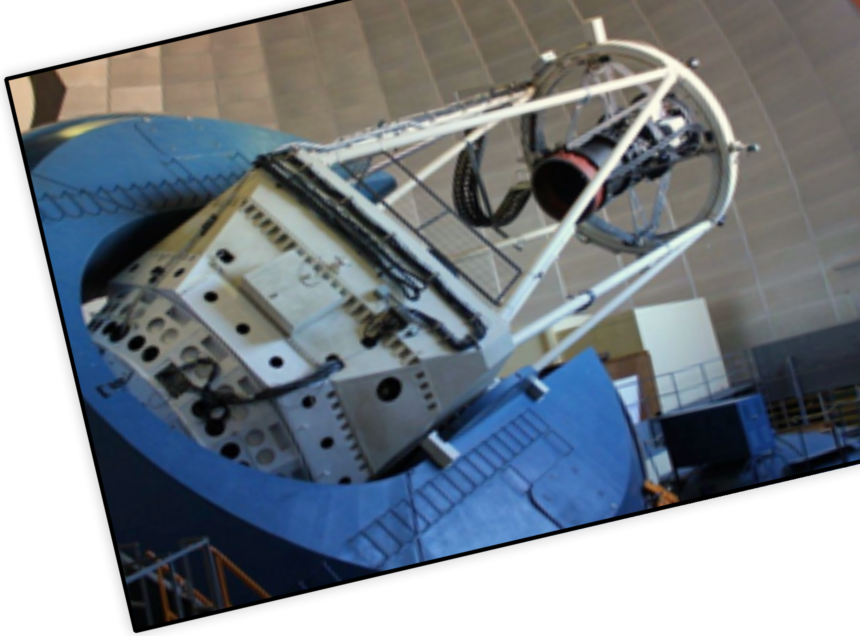

Dark Energy Survey:
First Results on Large Scale Structure

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LIneA Seminar - June 11, 2015

Fermilab

LIneA
Laboratório Interinstitucional de e-Astronomia

Outlines

- Dark Energy Survey;
- Galaxy Catalog;
- Photometric Redshift;
- Galaxy cross correlation with systematics;
- Galaxy Bias evolution;

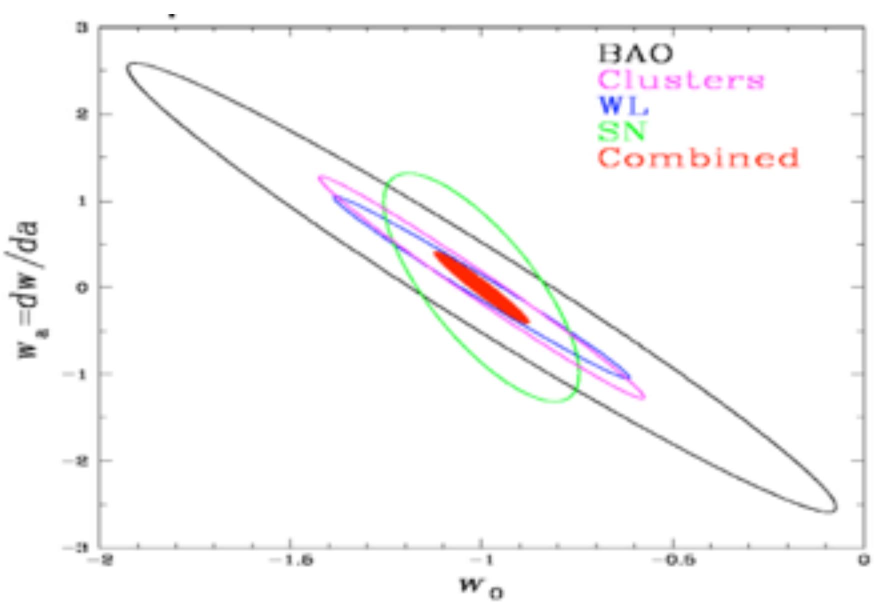
Dark Energy Survey

DARK ENERGY SURVEY

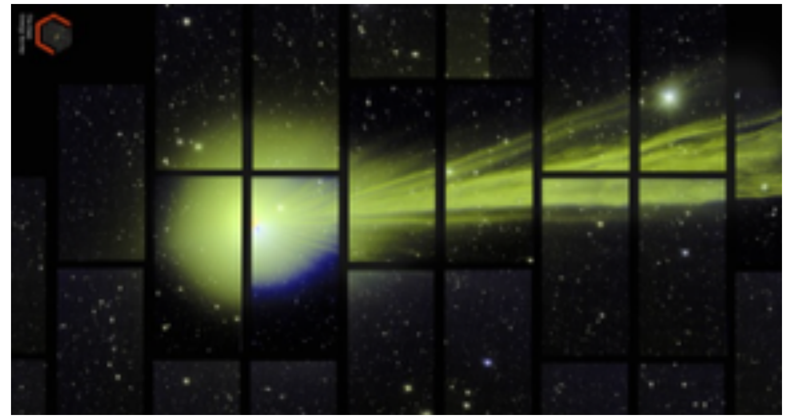
Blanco 4m telescope in Chile, CTIO.
In ~ 525 nights will observe ~ 300 M galaxies in 5000 deg in five filter grizY up redshift z ~ 1.5.

GOAL -> Looking for the nature of dark energy using four probes:

Galaxy Clusters;
Weak Lensing;
Large-Scale Structure (BAO) ;
Supernovae.



Dark Energy Survey Camera



Comet Lovejoy

Jan 2015

62 2k×4k CCDs for imaging and 12 2k×2k CCDs for guiding and focus.

Started operate in 2012

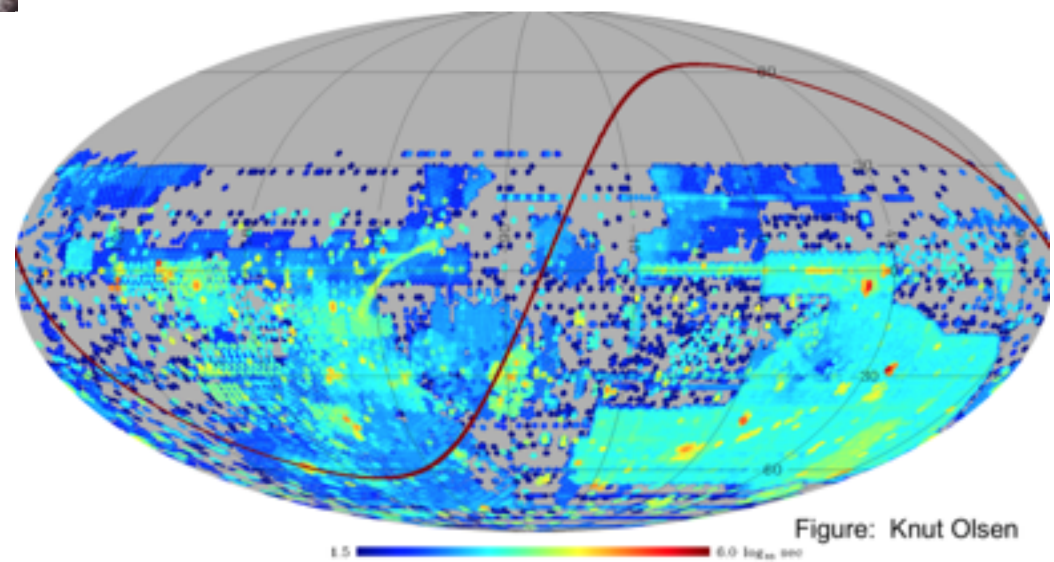
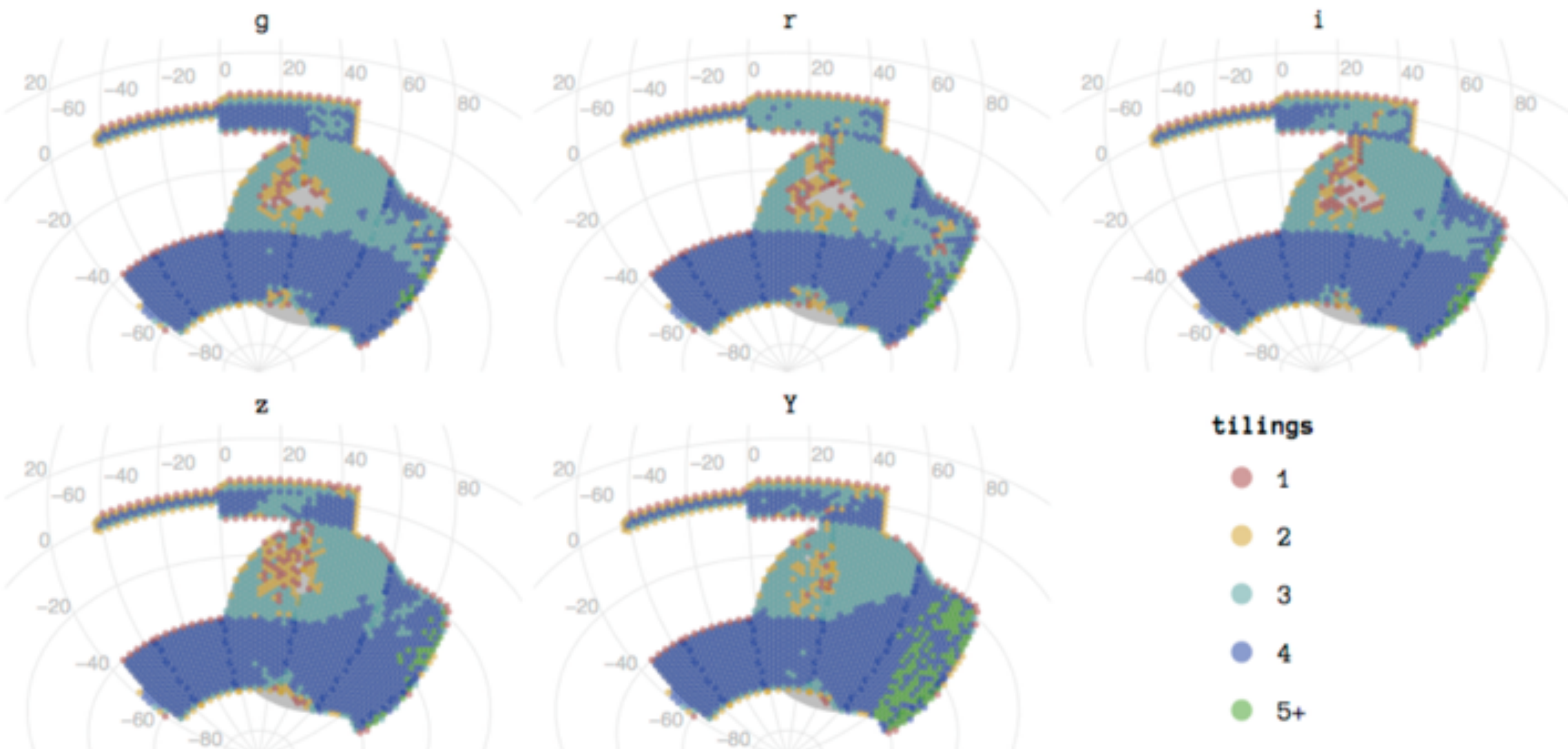


Figure: Knut Olsen

All exposure above 30 secs,
in every band, since SV until Feb 15, 2015.

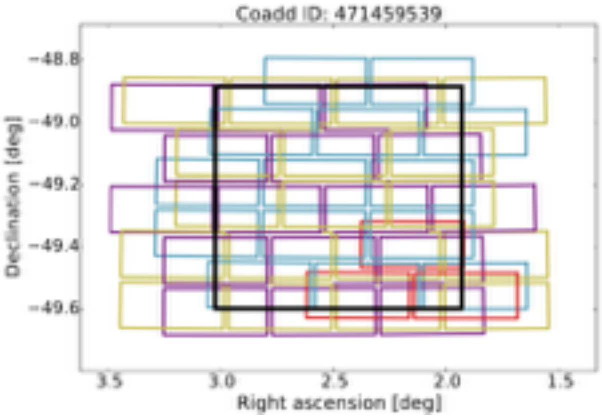
Dark Energy Survey Camera

Wide-survey coverage after year 2 (exposures taken from Aug 2013 to Feb 2015)



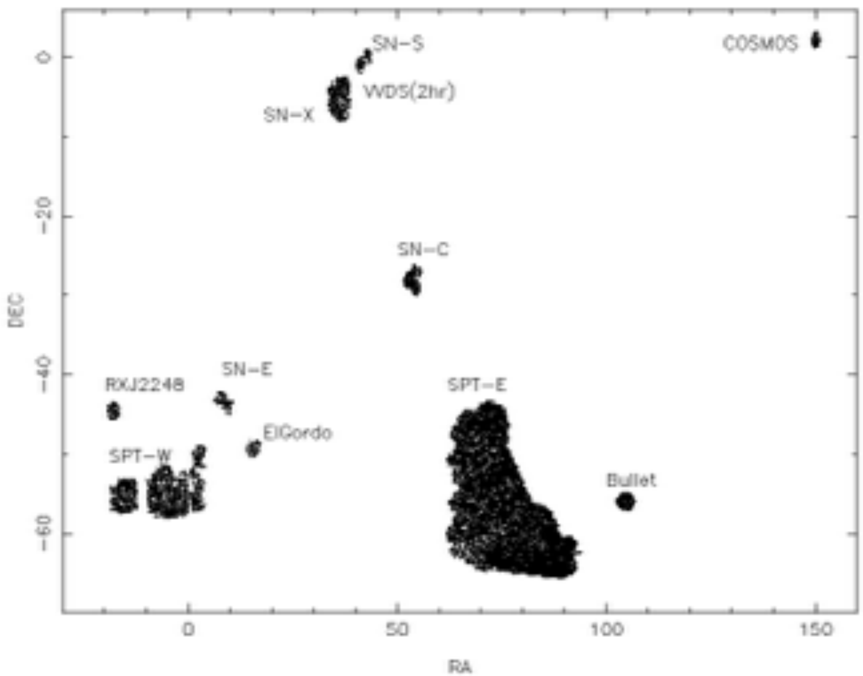
Courtesy from Eric Neilsen

SVA Coadd catalog



- 78 nights between 2012 and 2013
- ~ 250 sq. deg.

Overlap of many single-epoch images.

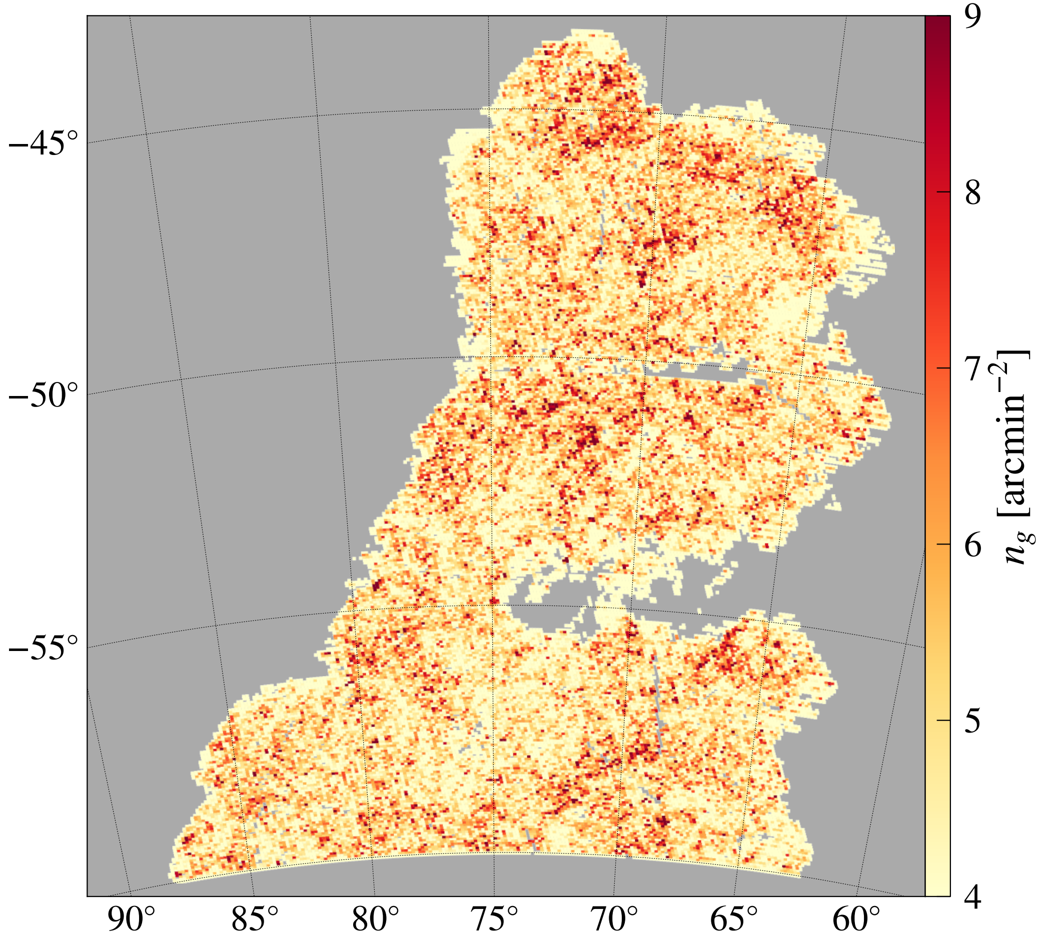


Footprint was choose to contain areas already covered by several deep spectroscopic galaxy survey.

Bench-mark catalog

$60 < RA < 95$

$-60 < DEC < -40$



Magnitude auto

$18 < i_{AB} < 22.5$

remove outliers in the color space

$-1 < g - r < 3$

$-1 < r - i < 2$

$-1 < i - z < 2$

Star/Galaxy separation

spread model > 0.003

DARK ENERGY SURVEY

Mangle Mask

Mangle pipeline runs within Dark Energy Survey data management production environment:
Mask out bright stars, satellites and cosmic rays.

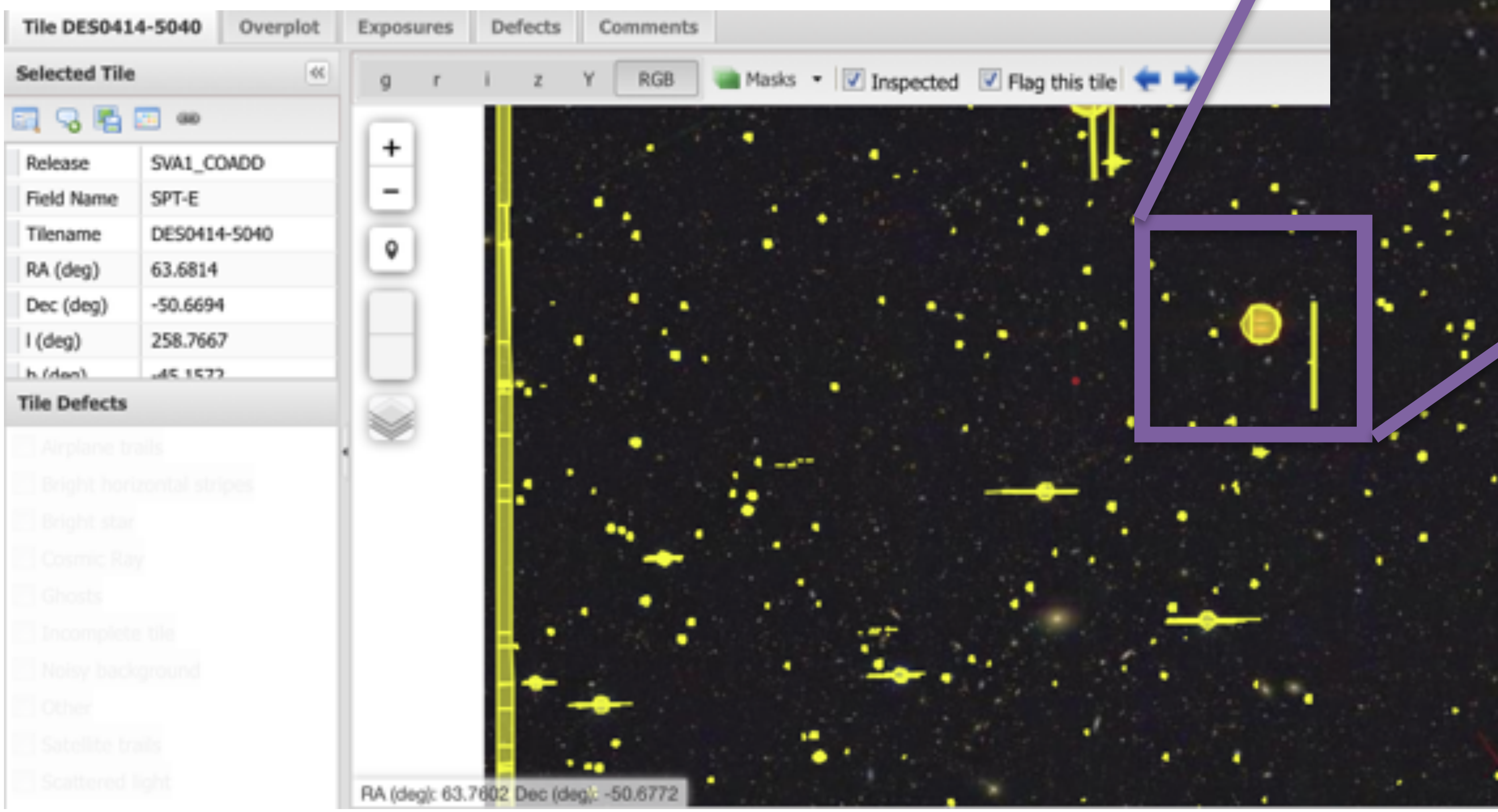
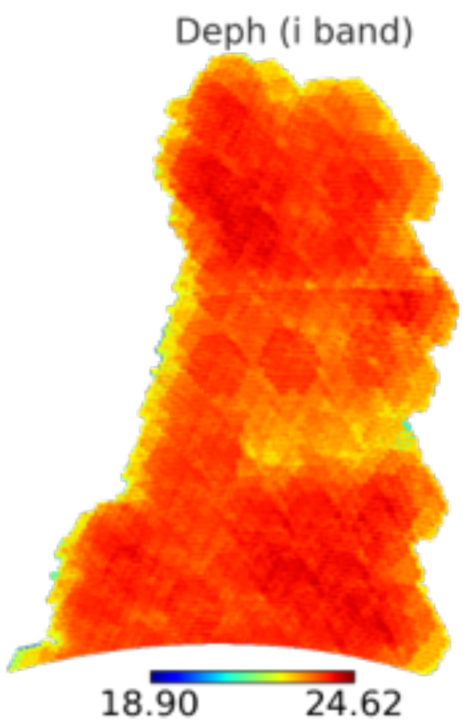
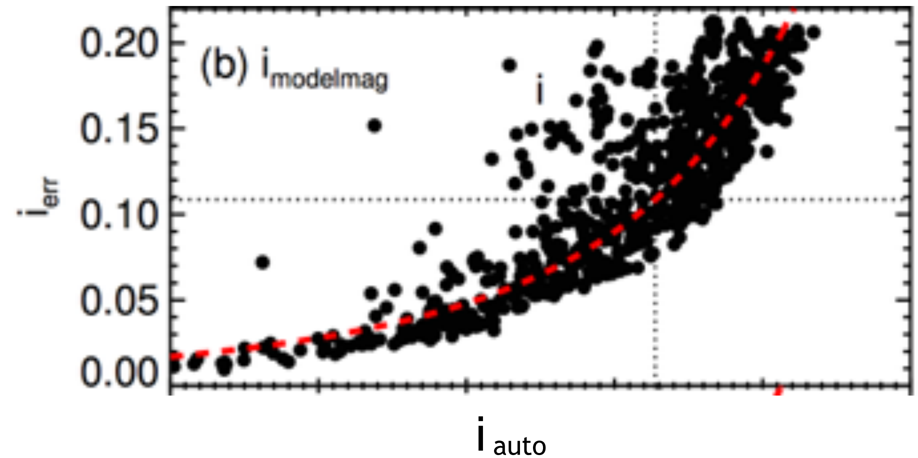


Image from **Science Portal** Tile Viewer.

Depth Maps





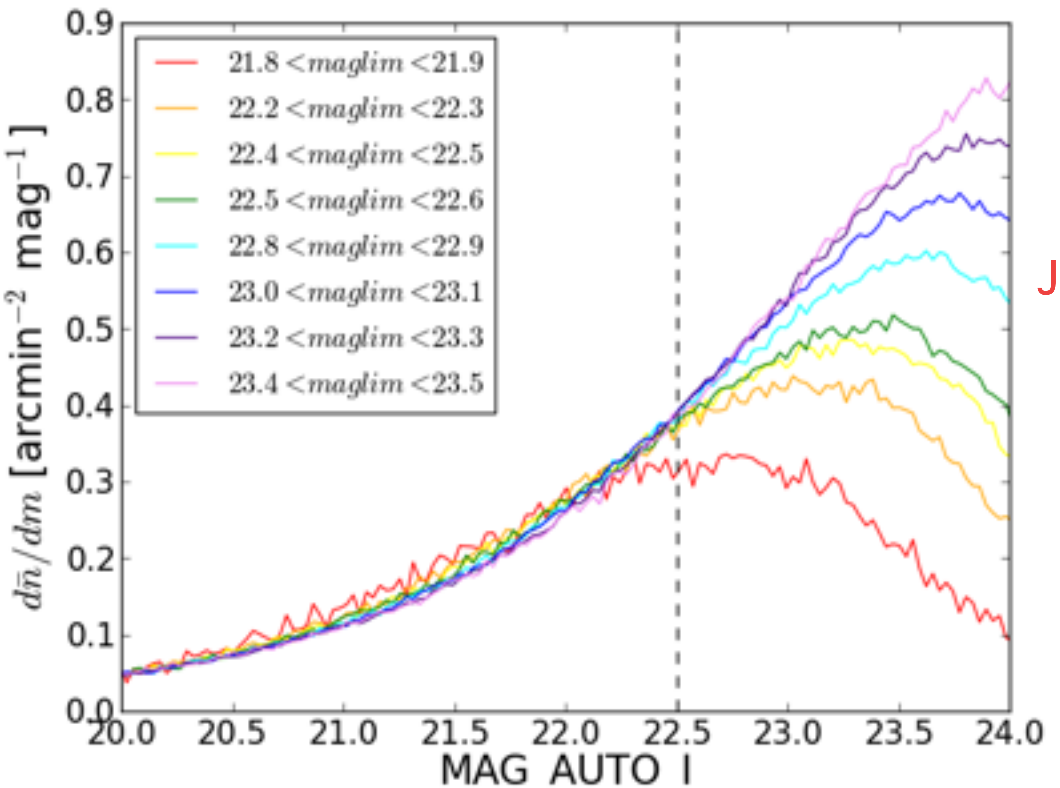
To have high resolution maps we need a good galaxy statistics. But we don't !!

m_{lim} = F(seeing, sky noise, etc)

$$i_{auto} = a_0 + a_1 i_{mangle} + a_2 FWHM$$

Magnitude Cuts

Catalog Completeness



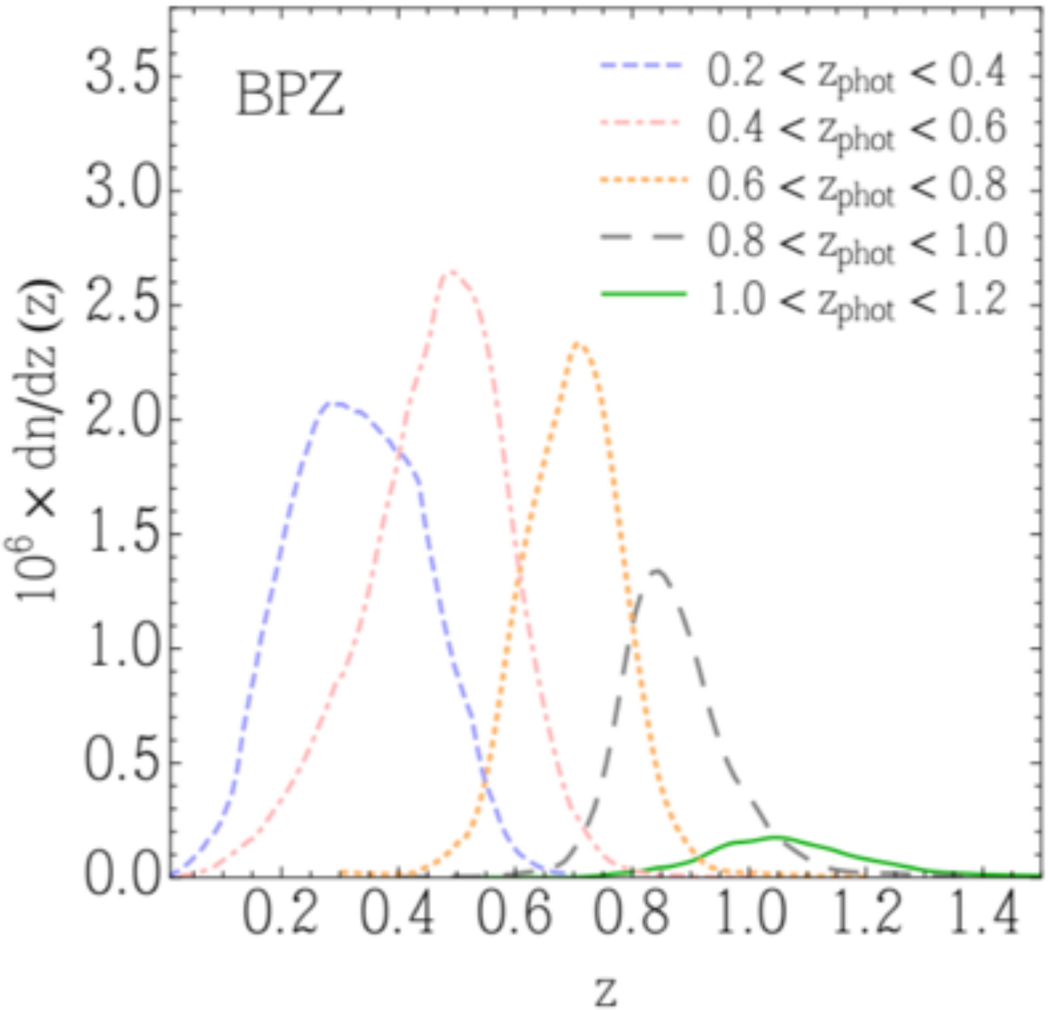
The number of galaxy around the footprint change according to the depth.

Just because observational reasons!

By choosing mag_lim > 22.5 and i_auto < 22.5 we remove problems with depth.

Photometric Redshift

Five redshift bins from 0.2 to 1.2

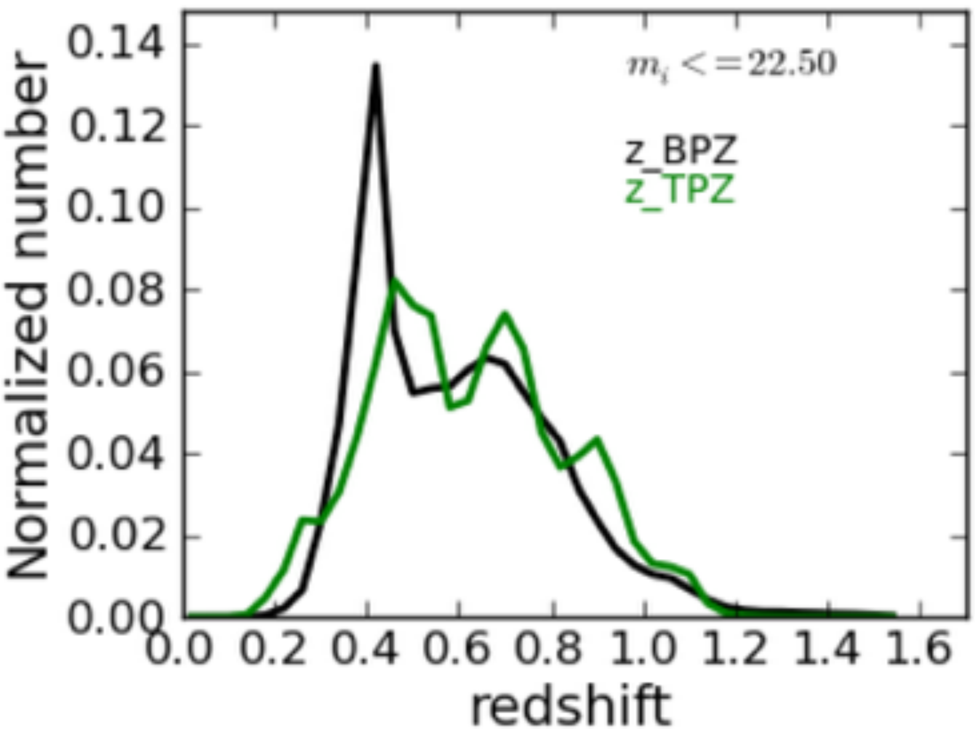


Photoz was calculated via BPZ (Bayesian Photometric Redshift) algorithm based in template fitting methods.

We used the Coleman, Wu & Weedman templates

redshift bin	n_{gal}
$0.2 < z < 0.4$	684,416
$0.4 < z < 0.6$	759,015
$0.6 < z < 0.8$	494,469
$0.8 < z < 1.0$	270,077
$1.0 < z < 1.2$	55,954

Photometric Redshift



Red galaxies sample

We also calculate photoz from TPZ (Machine Learning algorithm).

Although the difference between both results, they perform similarly in terms of clustering.

LSS Clustering - First Measurements

DARK ENERGY SURVEY

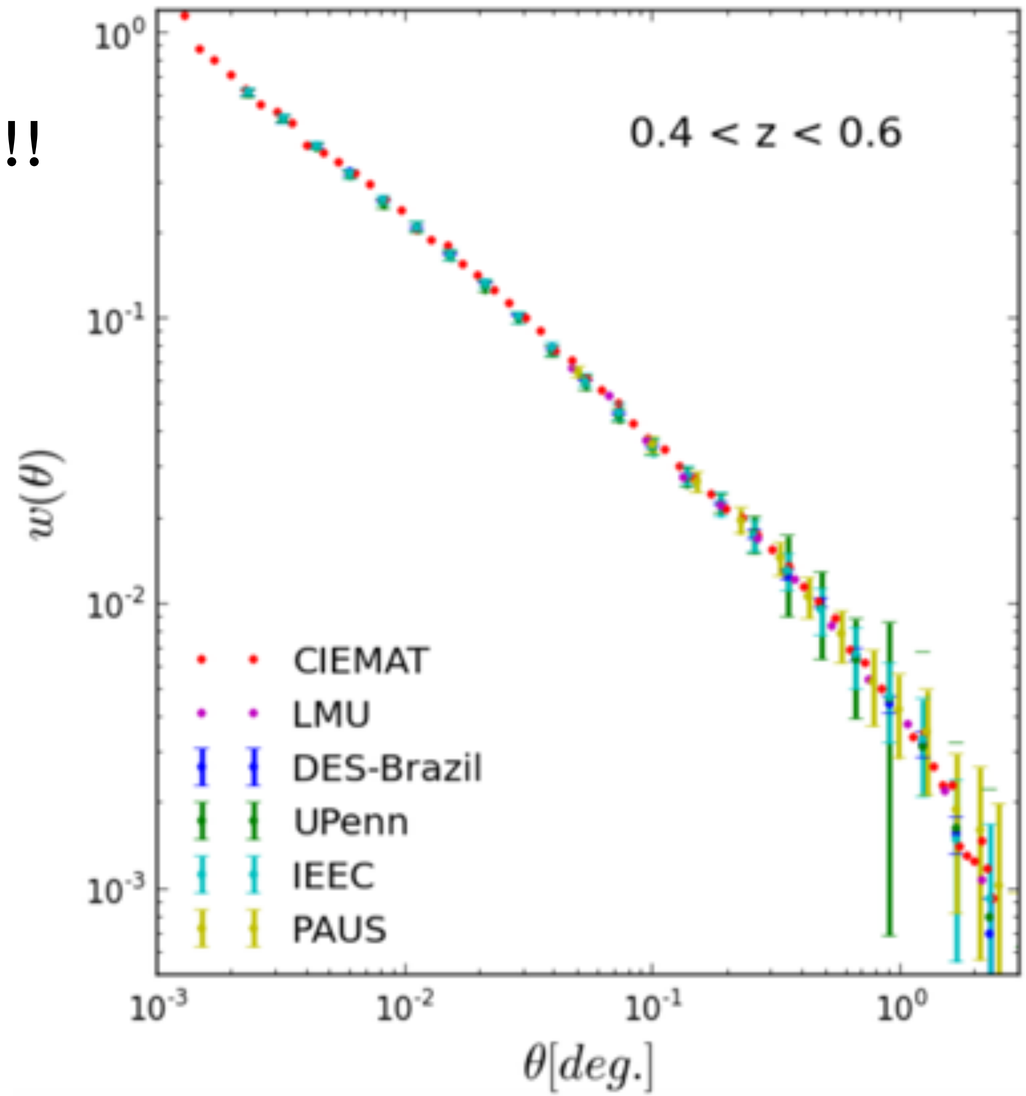
Many people worked on that!!

Separate galaxies in redshift shell and estimate $w(\theta)$

Star/Galaxy separation
18 < mag_i < 22.5

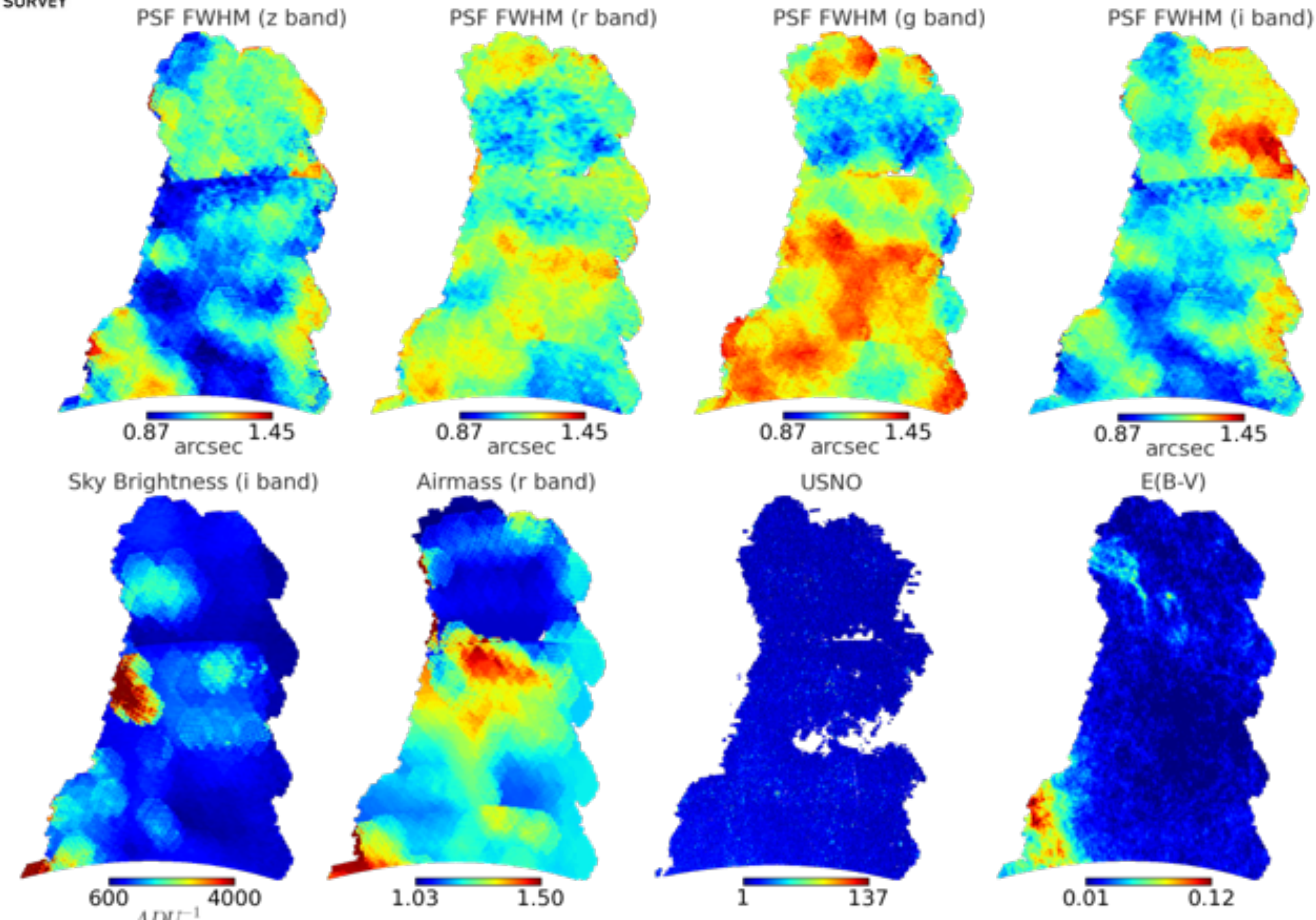
SPTE

60 < RA < 95
-61 < DEC < -40



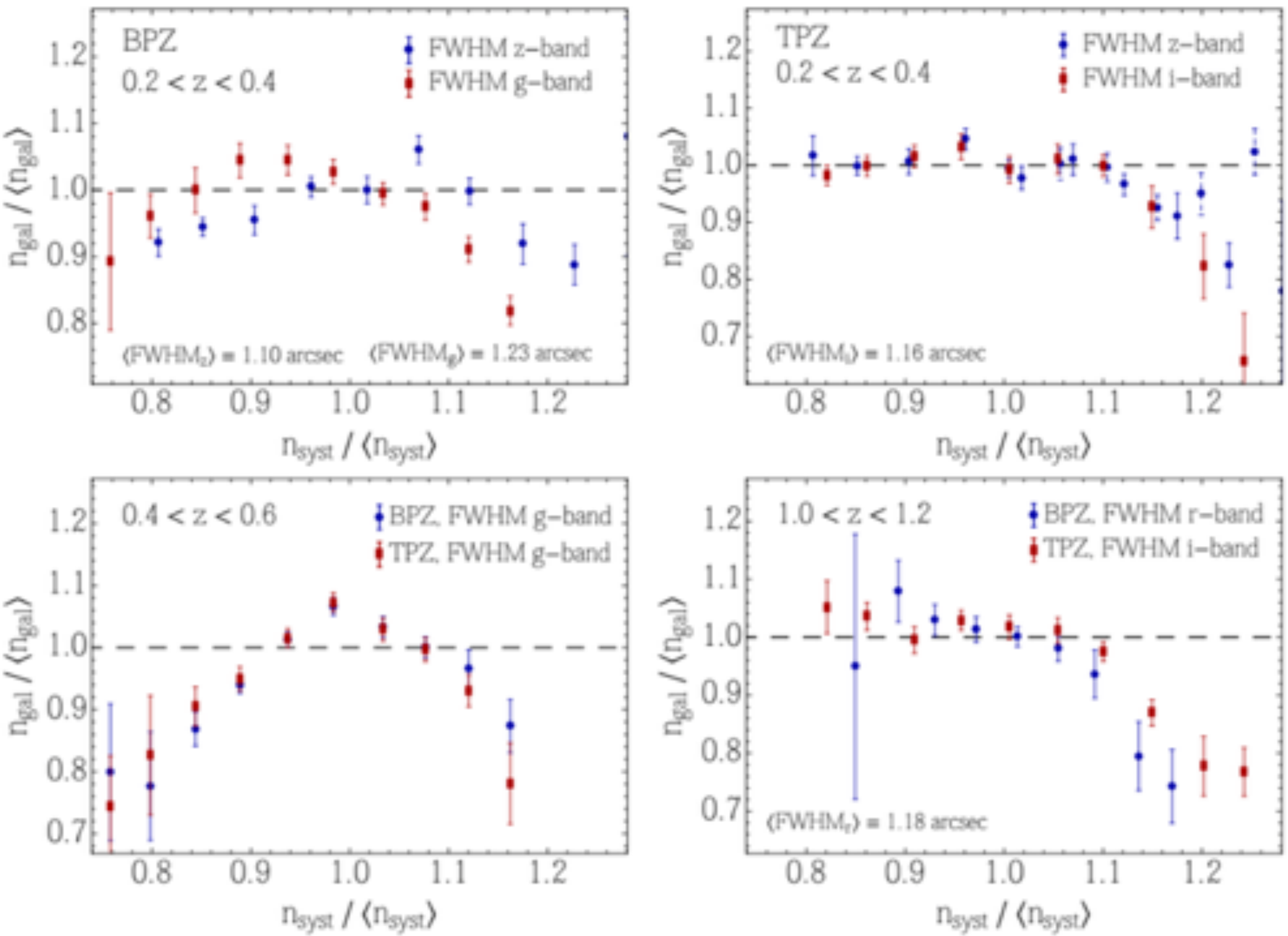
DARK ENERGY SURVEY

Systematics maps

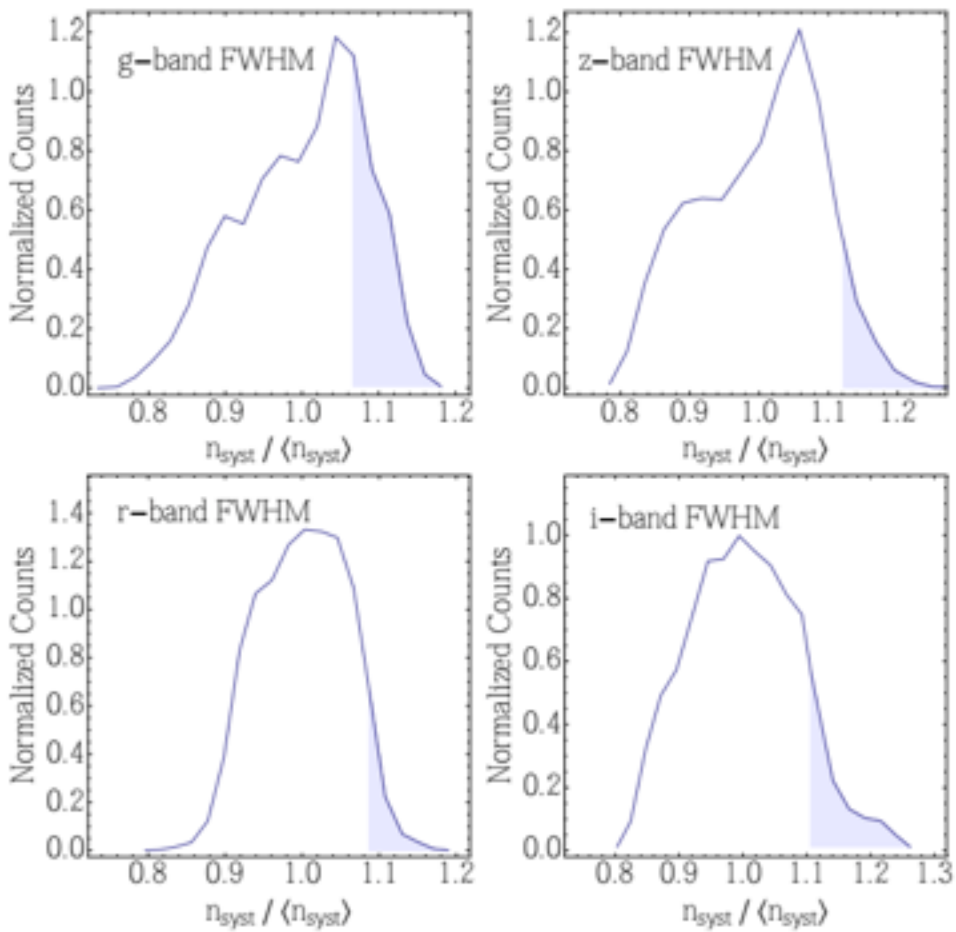


Systematic effects on $w(\theta)$

Attempt 0: Study the galaxy number density in each redshift bin as function of the density of each potencial systematic.

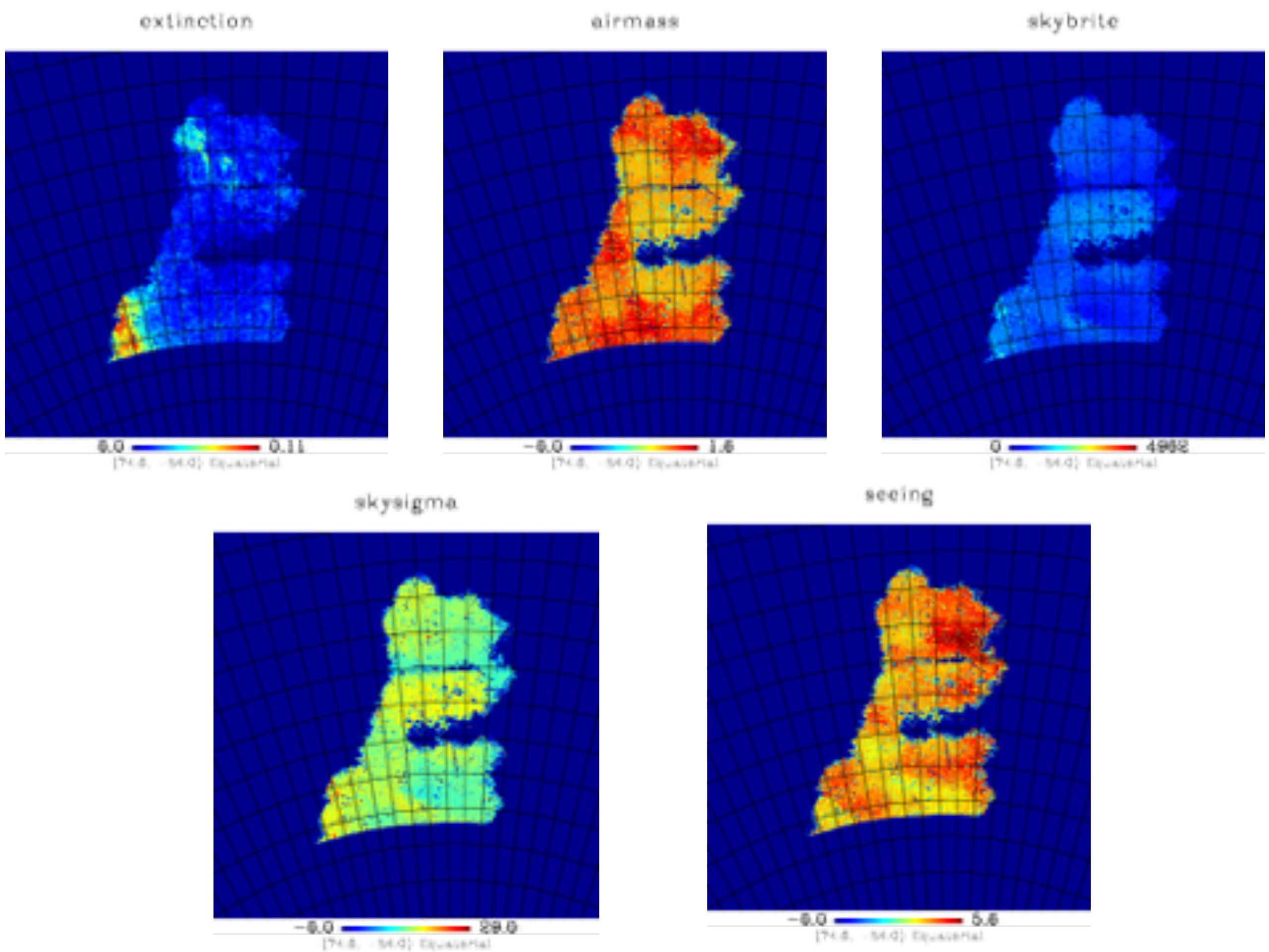


Systematic effects on $w(\theta)$



Attempt 1: Masking out regions of bad systematics no catalog.

Systematic effects on $w(\theta)$



Systematic effects on $w(\theta)$

DARK ENERGY SURVEY

Attempt 2: Correct $w(\theta)$ by doing the cross correlation with systematic maps.

$$\omega(\theta) = < \delta_g^t \delta_g^t >$$

$$\delta_g^o = \delta_g^t + \sum_{i=1}^{N_{sys}} \epsilon_i \delta_i$$

Systematic density

Shirley Ho, 2012

Observed galaxy density

True galaxy density

$$< \delta_g^t \delta_g^t > = < \delta_g^o \delta_g^o > - \sum_{i=1}^{N_{sys}} \epsilon_i^2 < \delta_i \delta_i > - \sum_{i,j(i \neq j)=1}^{N_{sys}} \epsilon_i \epsilon_j < \delta_i \delta_j >$$

Since $< \delta_g^t \delta_i > = 0$, we can find ϵ_i by solving the linear system:

$$\begin{pmatrix} < \delta_1 \delta_1 > & < \delta_2 \delta_1 > & \dots & < \delta_n \delta_1 > \\ < \delta_1 \delta_2 > & < \delta_2 \delta_2 > & \dots & < \delta_n \delta_2 > \\ \dots & \dots & \dots & \dots \\ < \delta_1 \delta_n > & < \delta_2 \delta_n > & \dots & < \delta_n \delta_n > \end{pmatrix} \begin{pmatrix} \epsilon_1 \\ \epsilon_2 \\ \dots \\ \epsilon_n \end{pmatrix} = \begin{pmatrix} < \delta_n \delta_1 > \\ < \delta_n \delta_2 > \\ \dots \\ < \delta_n \delta_n > \end{pmatrix}$$

$\omega^t(\theta) =$

$\omega(\theta)^o - \epsilon_s^2 < \delta^s \delta^s >$

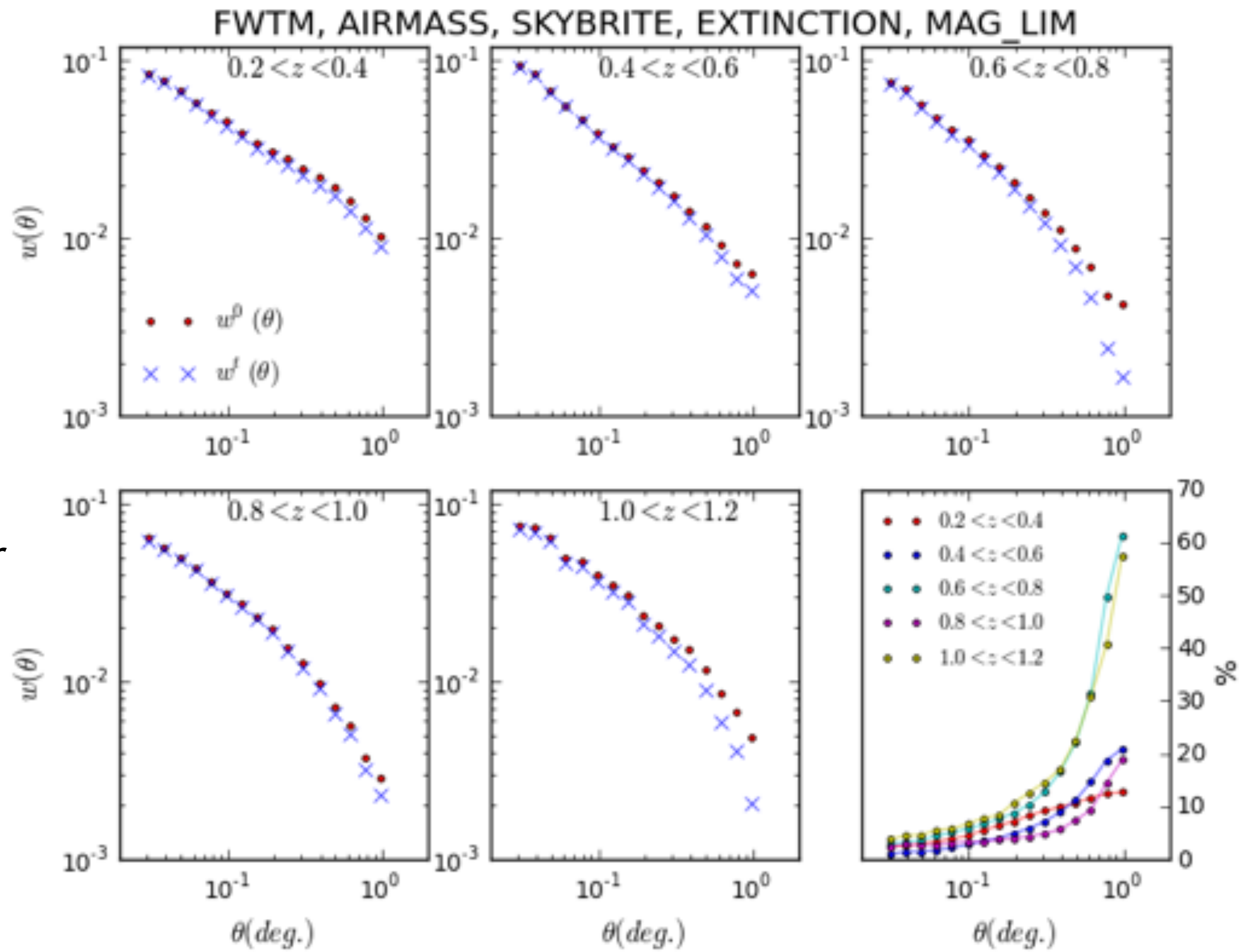
DARK ENERGY SURVEY

Systematic effects on $w(\theta)$

Seeing is the most relevant systematic:

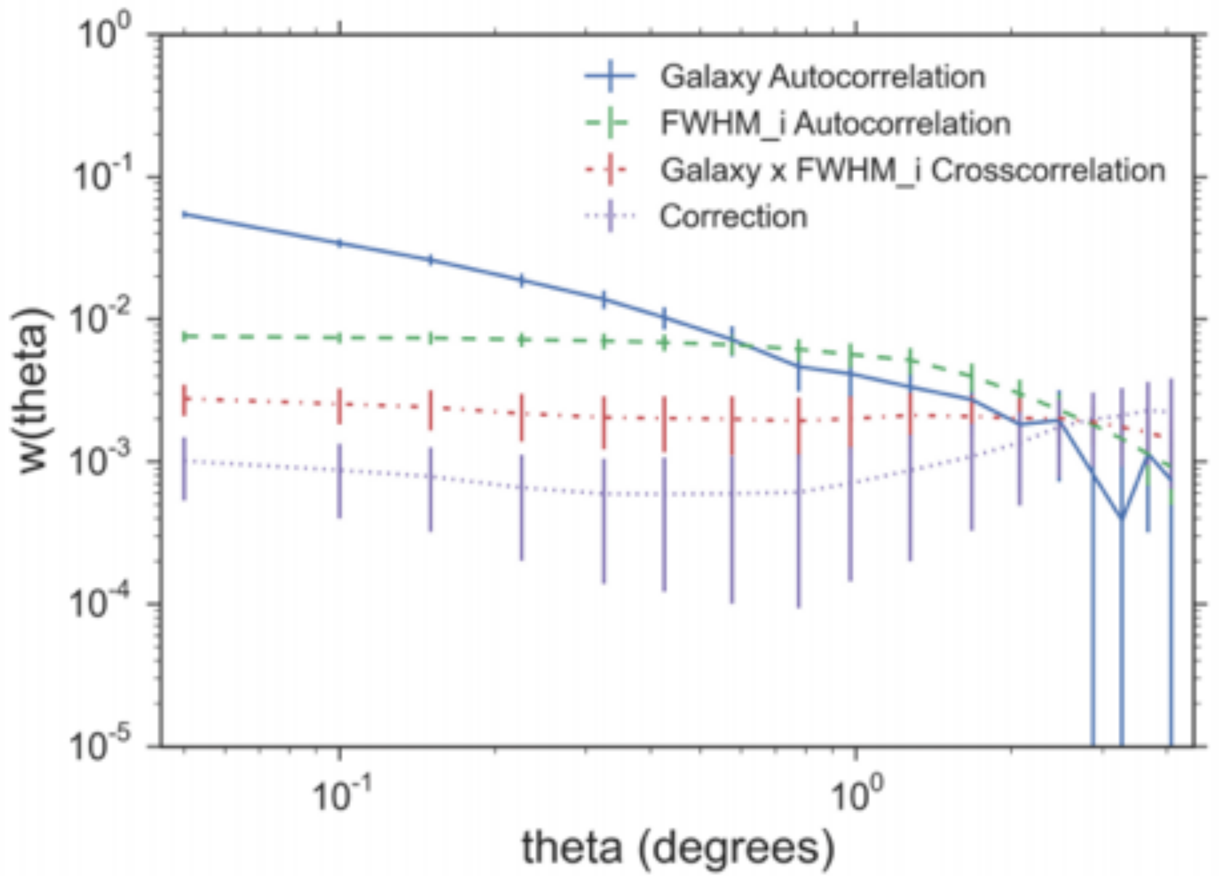
It changes the $\omega(\theta)$ in ~ 48% while 5-systematics together change in ~60% in the redshift shell $1.0 < z < 1.2$.

Filter i



Just a example with DESDM photoz.

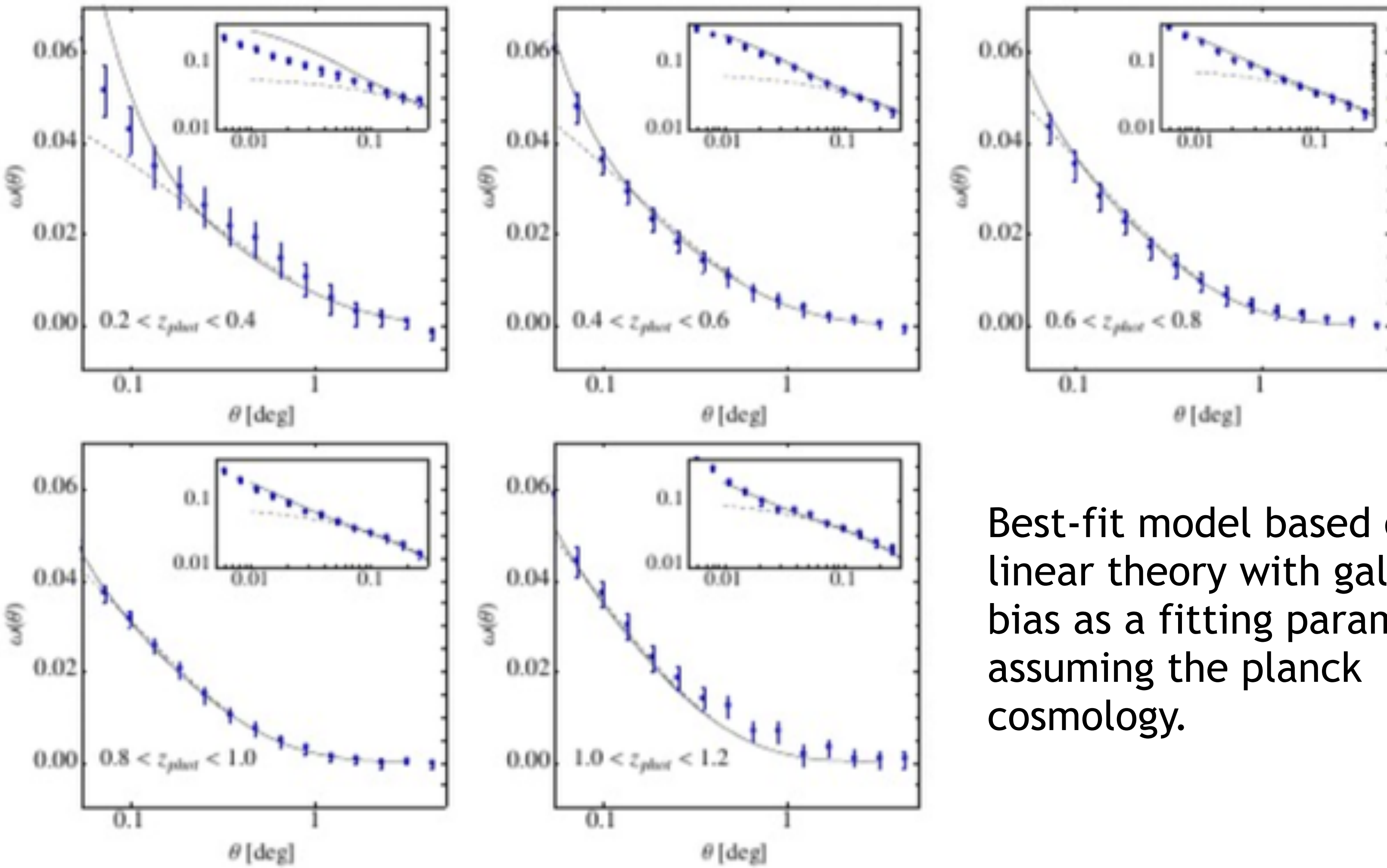
Systematic effects on $w(\theta)$



The effects of correcting the clustering measured in the redshift shell $0.6 < z < 0.8$ for correlation with the maps FWHM_i.

DARK ENERGY SURVEY

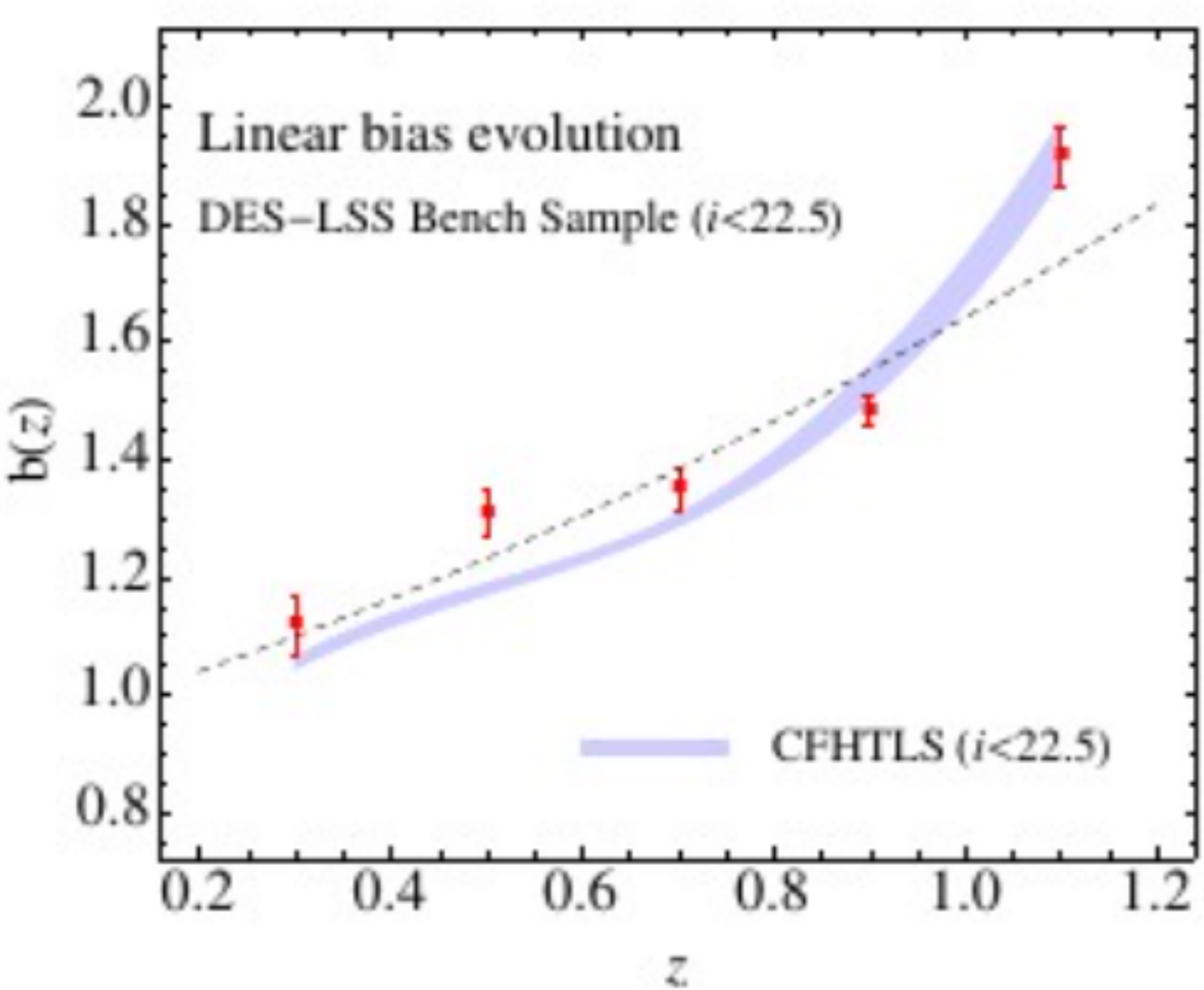
Galaxy Bias



Best-fit model based on linear theory with galaxy bias as a fitting parameter assuming the planck cosmology.

DARK ENERGY SURVEY

Galaxy Bias



Work upcoming

Halo Model: Separate galaxies in colors and estimate the HOD parameters to compare with CFHTLS results.

Warm Dark Matter: Modify HOD theory to introduce WDM and put restrictions in its masses.

Conclusion

DARK ENERGY SURVEY

- We have started to understand the data;
- Systematic effects are extremely important on large angular scales and must be considered;
- The same is true in the harmonic space where systemics are powerful in low multipoles.
- Galaxy bias results is compatible to the with CFHTLS
- Many works in SVA is in the final stage.
- HOD will be applied to validate SVA data against CFHTLS.