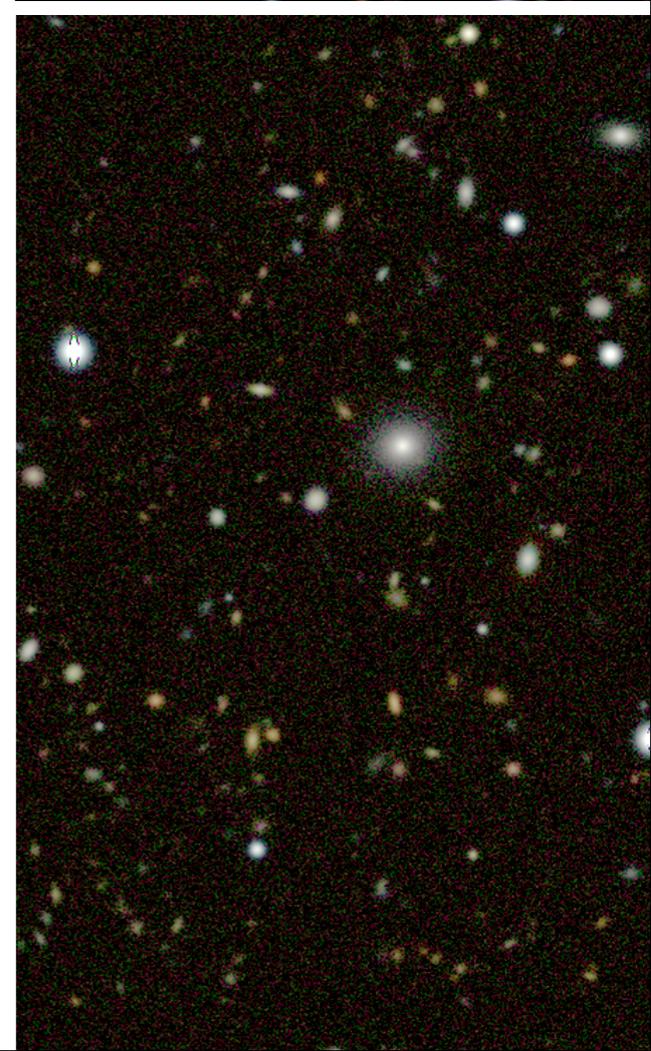


Image Simulations of Two Worlds

03-24-2014, DES-LSST Joint Workshop @ Fermilab

Chihway Chang, ETH Zurich

*Adam Amara, Alexandre Refregier, Claudio Bruderer, Lukas Gamper (ETH)
Risa Wechsler, Michael Busha, Matt Becker, Eli Rykoff, Carlos Cunha (SLAC)*

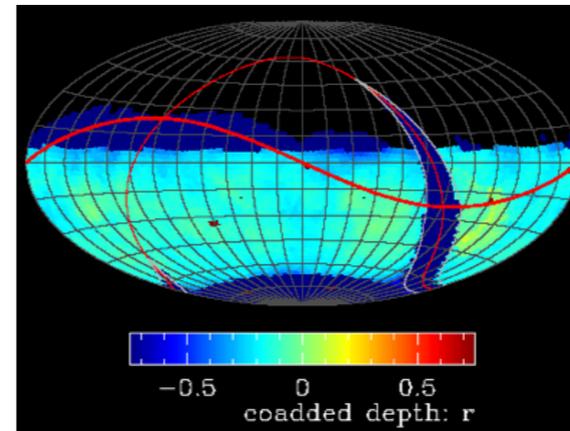
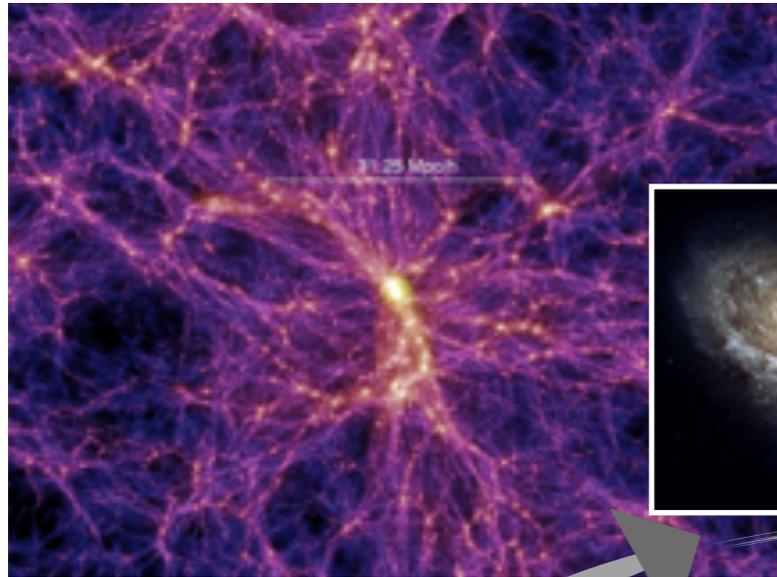


Why Simulate?

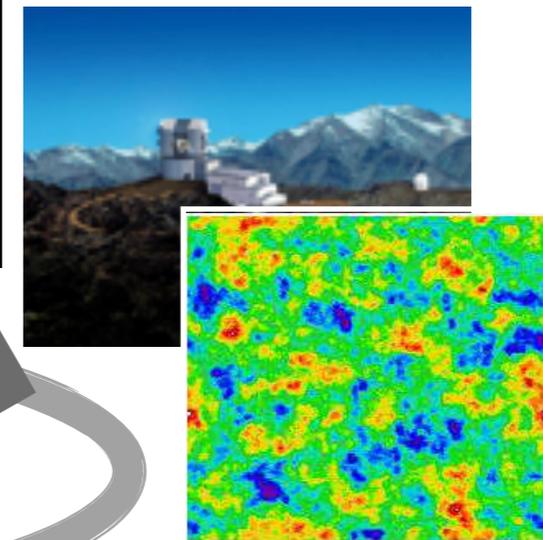
- Cosmology today is driven by **big data** and **high statistics**
- For all cosmology measurements, understanding **systematic effects** is key
- **Forward-modelling, or simulations**, is a way to understand how complicated physical effects and measurement procedures couple into the data analysis
- **End-to-end** simulation: cosmology - instrument - data pipeline
- Simulations are only as good as the level of **physics** we put in

End-to-end Simulation @ LSST

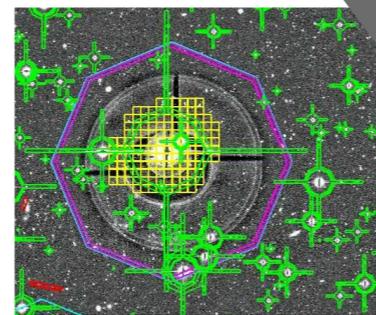
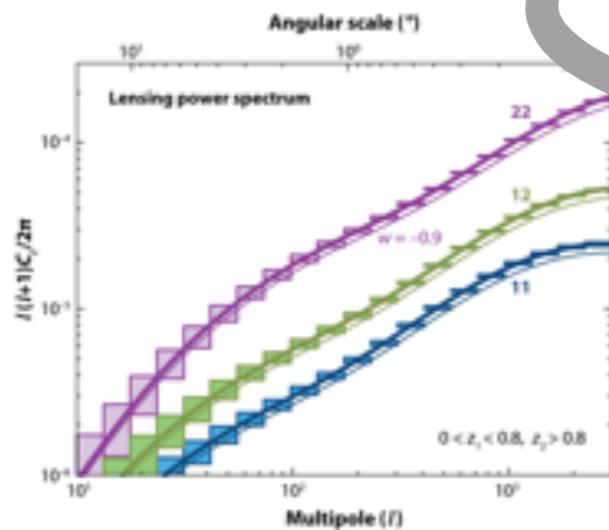
CatSim



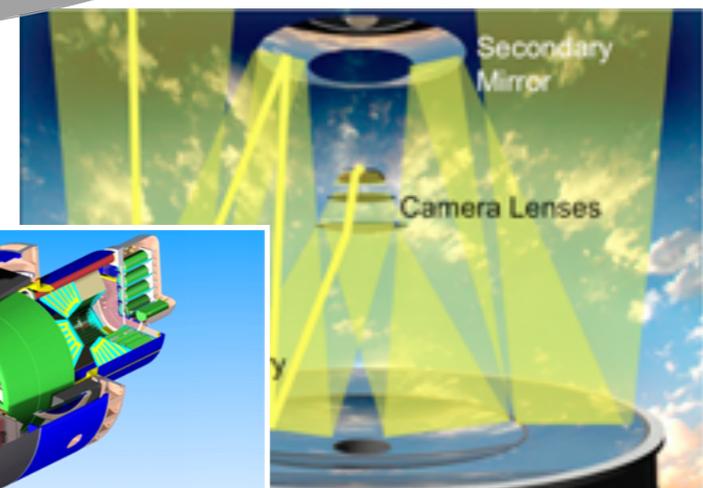
OpSim



Closed-loop Framework

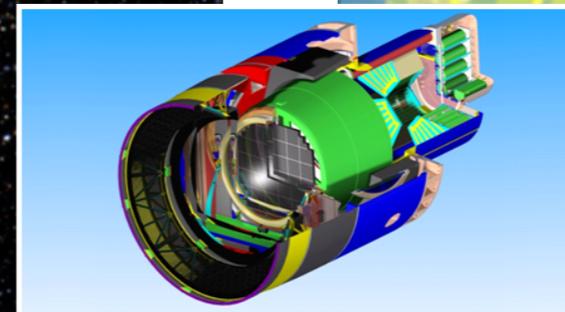
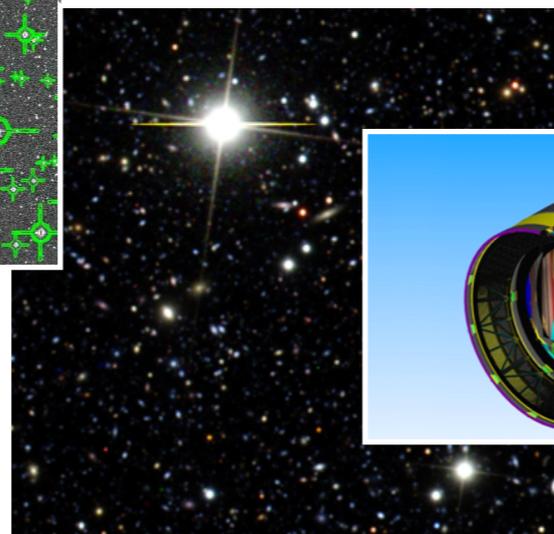


LSST
DM Stack

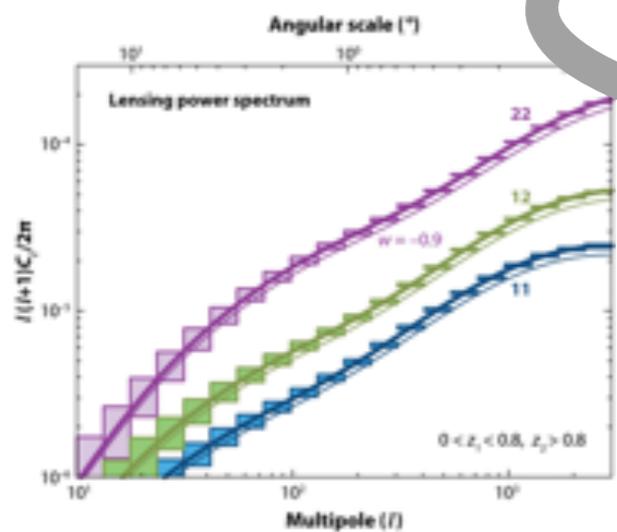
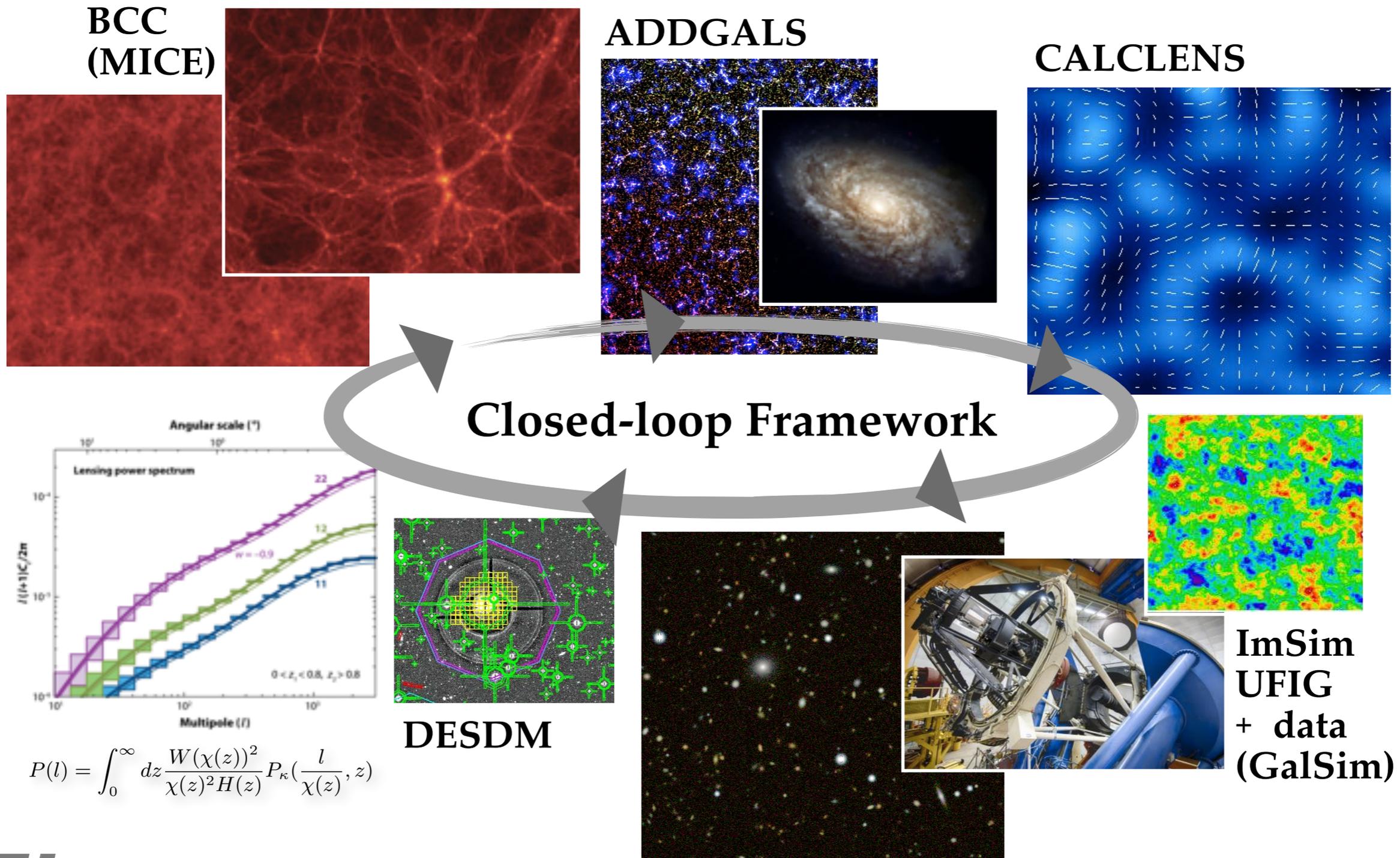


PhoSim

$$P(l) = \int_0^\infty dz \frac{W(\chi(z))^2}{\chi(z)^2 H(z)} P_\kappa\left(\frac{l}{\chi(z)}, z\right)$$



End-to-end Simulation @ DES

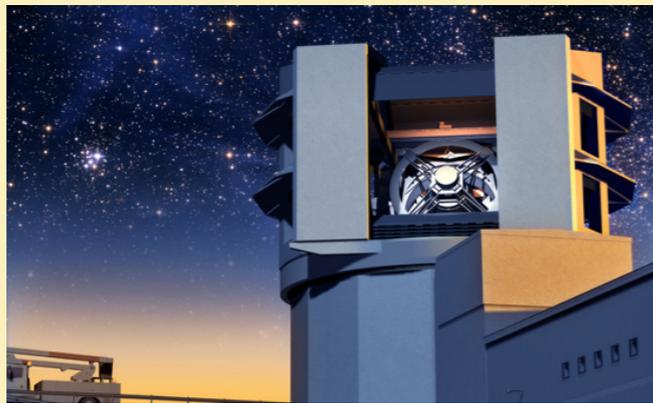


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End-to-end Simulation

- LSST and DES are on **different stages** of the project, and the simulation effort evolves accordingly

LSST



- ➔ tighter science requirements
- ➔ being built at the same time
- ➔ more data, more time

DES

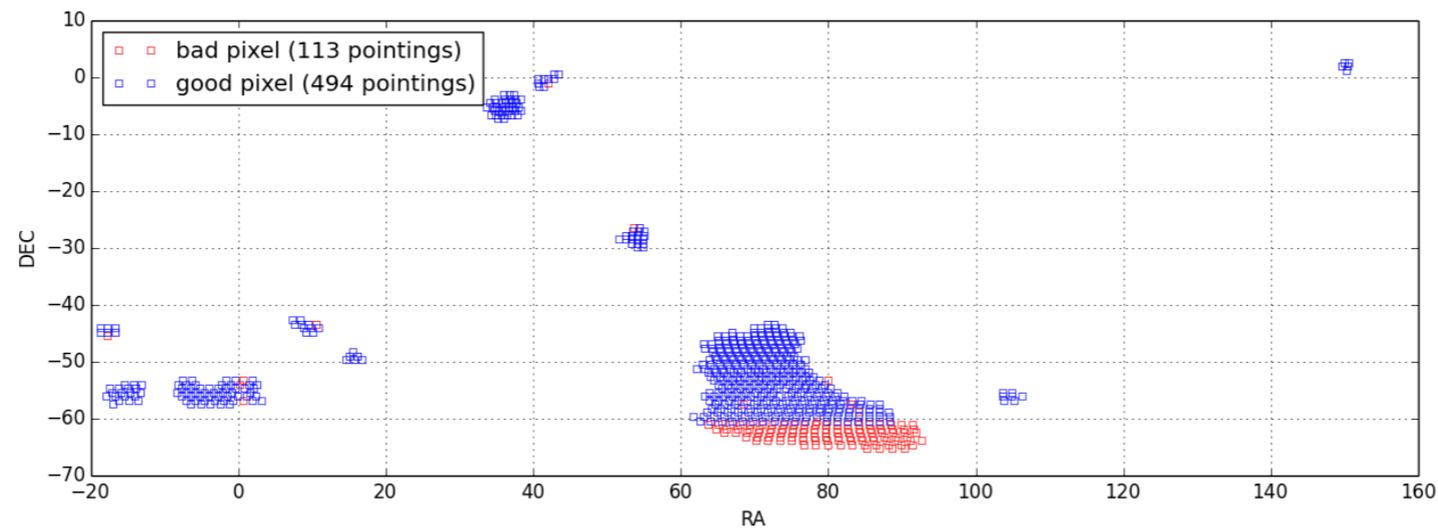


- ➔ smaller scale in all aspects
- ➔ data is coming in!

Application @ DES SV

Application @ DES SV

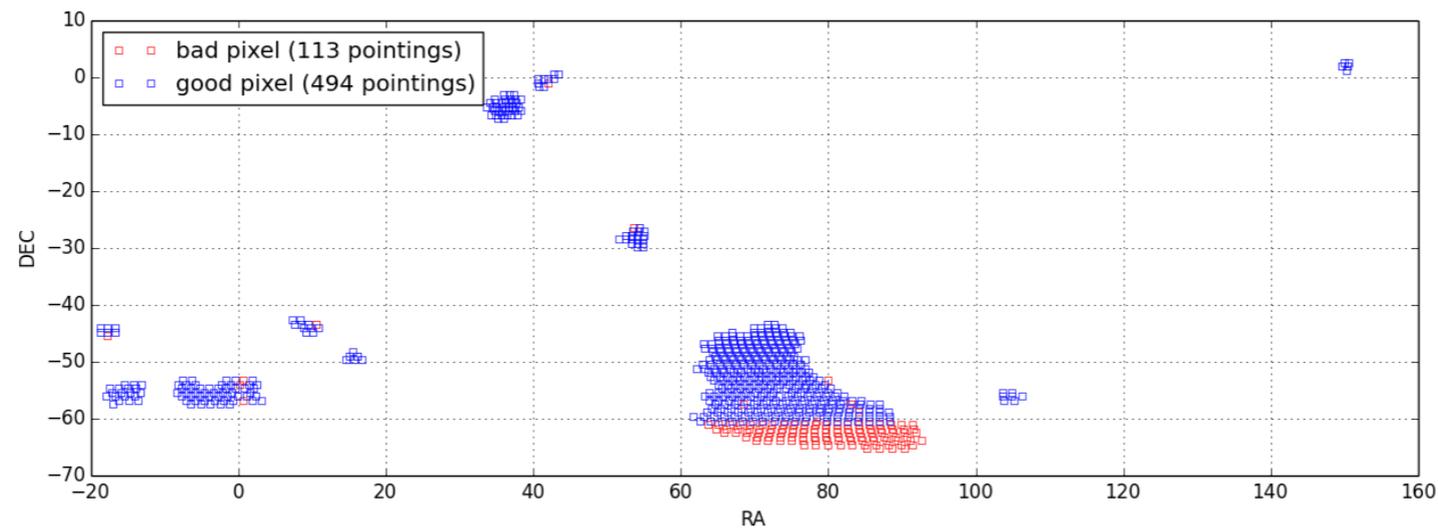
- **Science Verification** data: $\sim 250 \text{ deg}^2$



- Science projects under way and require **validation** on simulations.

Application @ DES SV

- **Science Verification** data: $\sim 250 \text{ deg}^2$



- Science projects under way and require **validation** on simulations.
e.g. what does this actually mean?

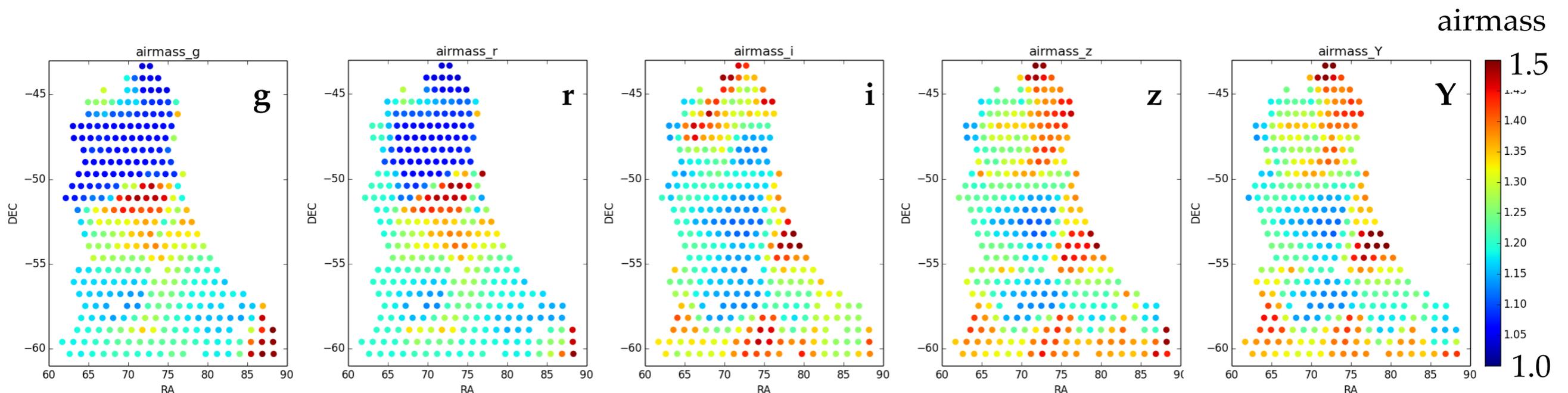
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OR ((SPREAD_MODEL_I + 3*SPREADERR_MODEL_I) < 0.003) OR ((MAG_PSF_I >  
30.0 AND MAG_AUTO_I < 21.0))))
```

Application @ DES SV

- The **BCC-UFIG** project (ongoing):
 - Connecting mock galaxy catalogs (BCC) with pixel-level simulations (UFIG) with catalog-level data products (DESDM)
 - Designed to match the image properties in the **SV data**
 - Simple data model but **self-consistent** cosmology

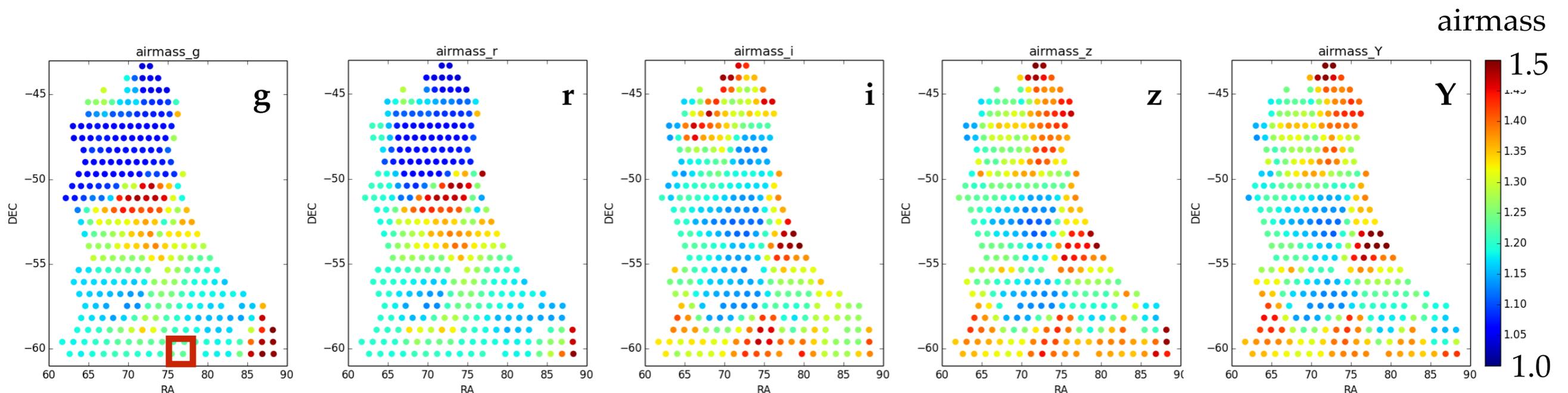
Application @ DES SV

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Application @ DES SV

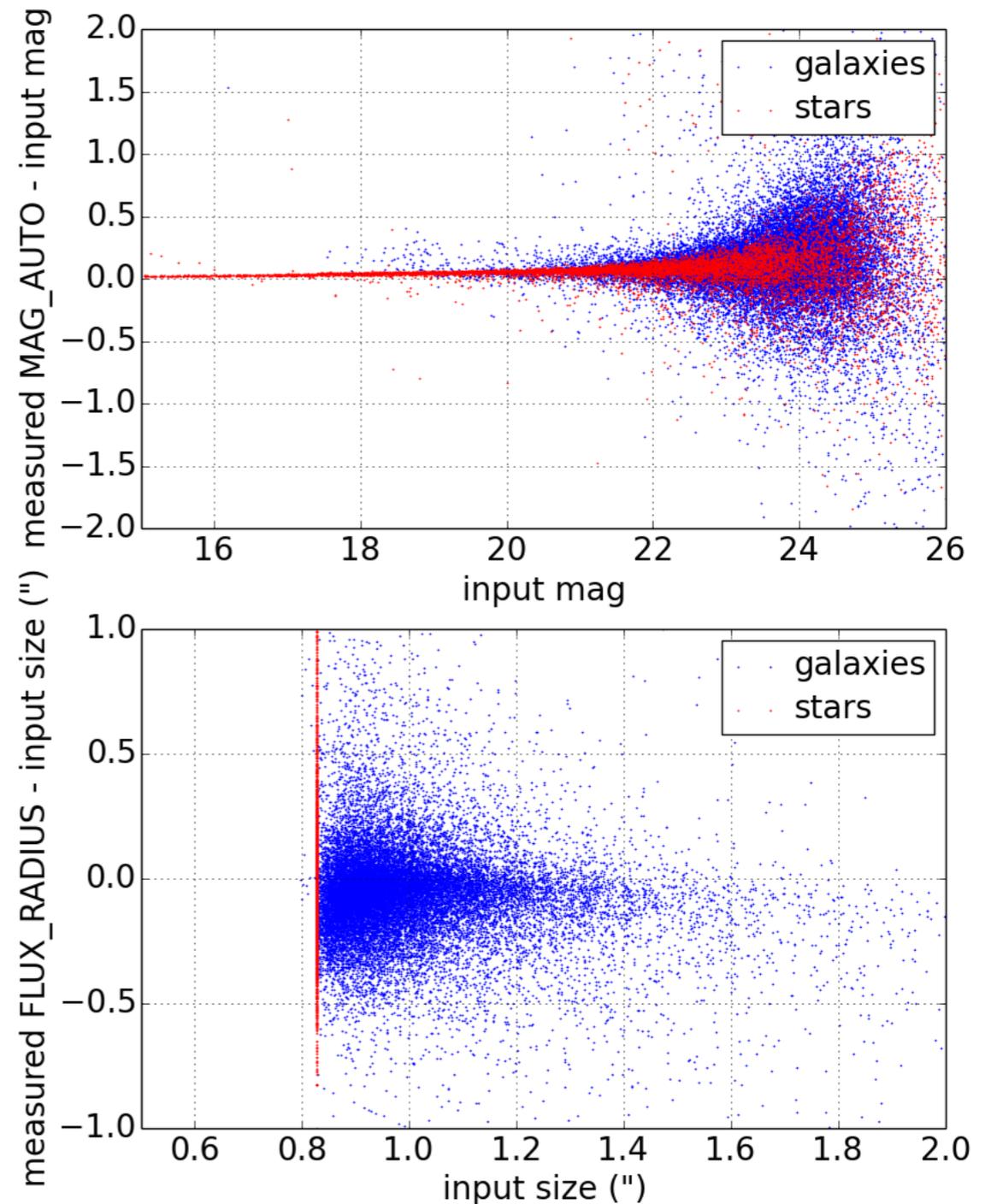
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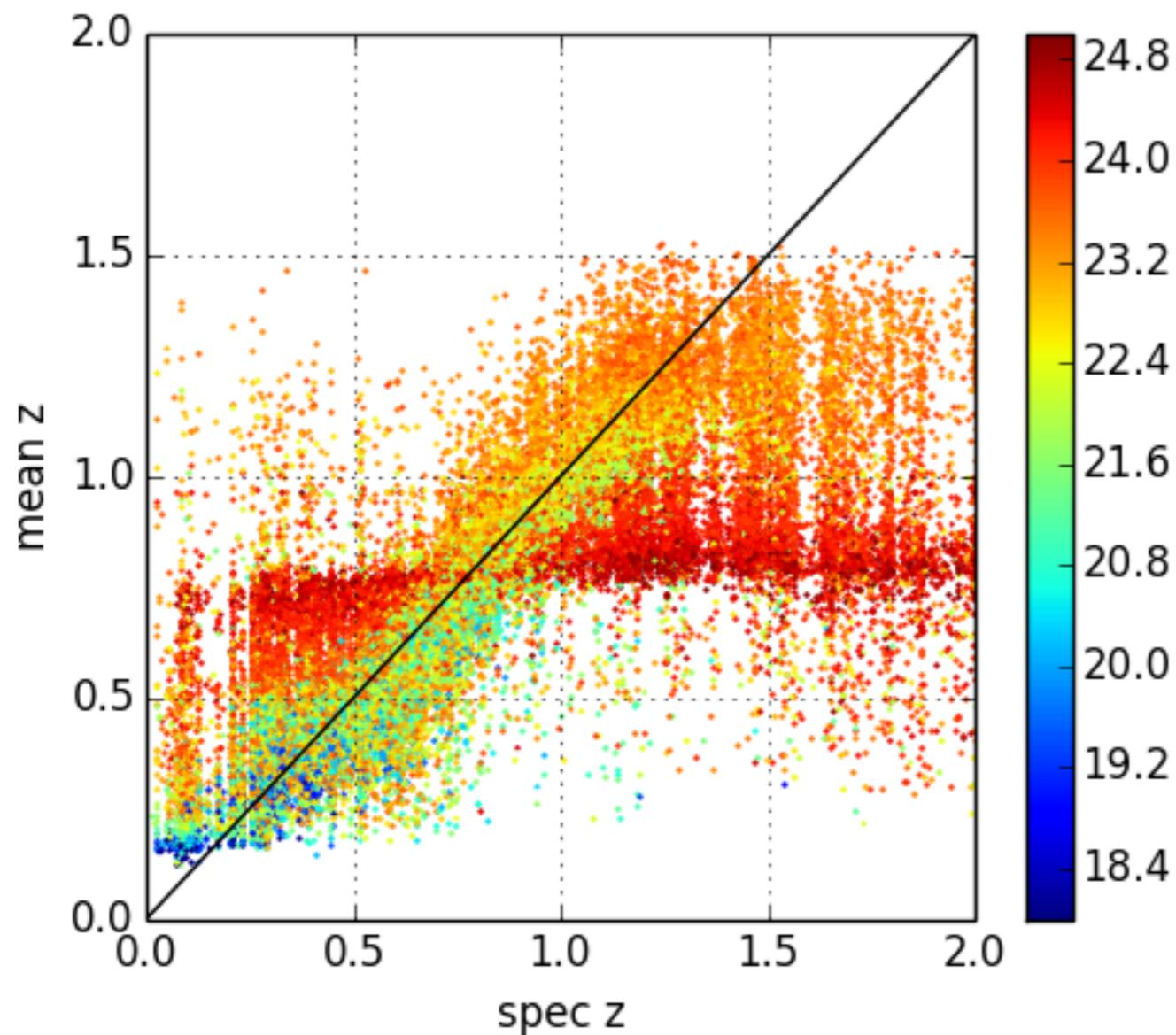
Application @ DES SV



- g-band coadd
- seeing: 1.26''
- airmass: 1.06
- exposure time: 663.2 s
- limiting magnitude: 24.07



Application @ DES SV

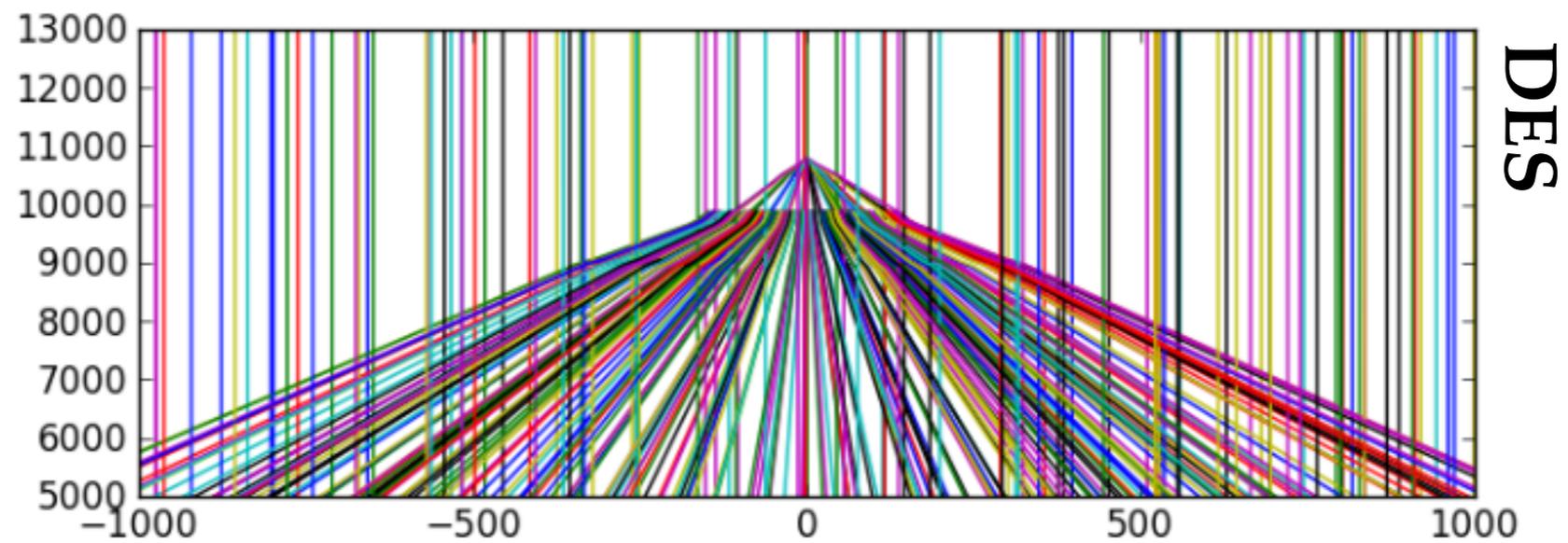
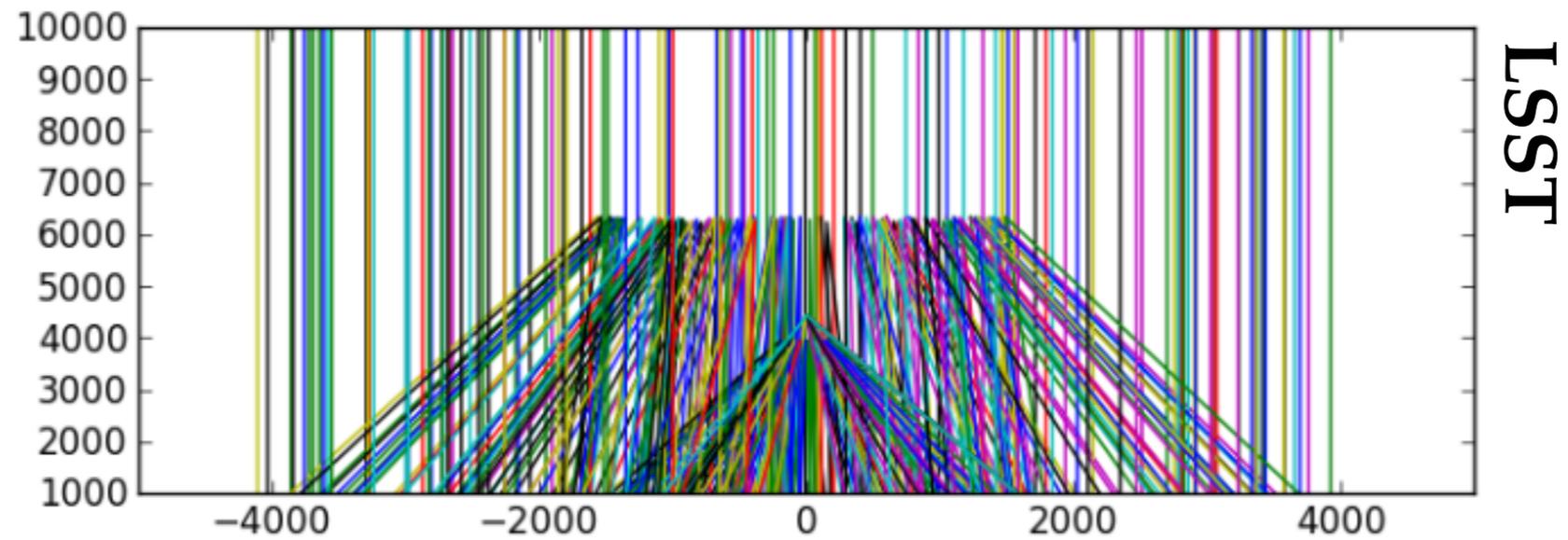


- ➔ simulated training set
- ➔ $p(z)$ code from Carlos C.
- ➔ understand eg. how photometric errors couple with photo-z errors

Summary

- In this generation of cosmology with large surveys, **simulations** play a crucial role in understanding our science analyses.
- Both DES and LSST have plans for an integrated **end-to-end simulation framework**.
- The simulations are developed according to the need of each project, and has of course lots to learn from each other.
- We are implementing the **BCC-UFIG** framework for DES SV data.

Other Entertaining Ideas



Backup Slides

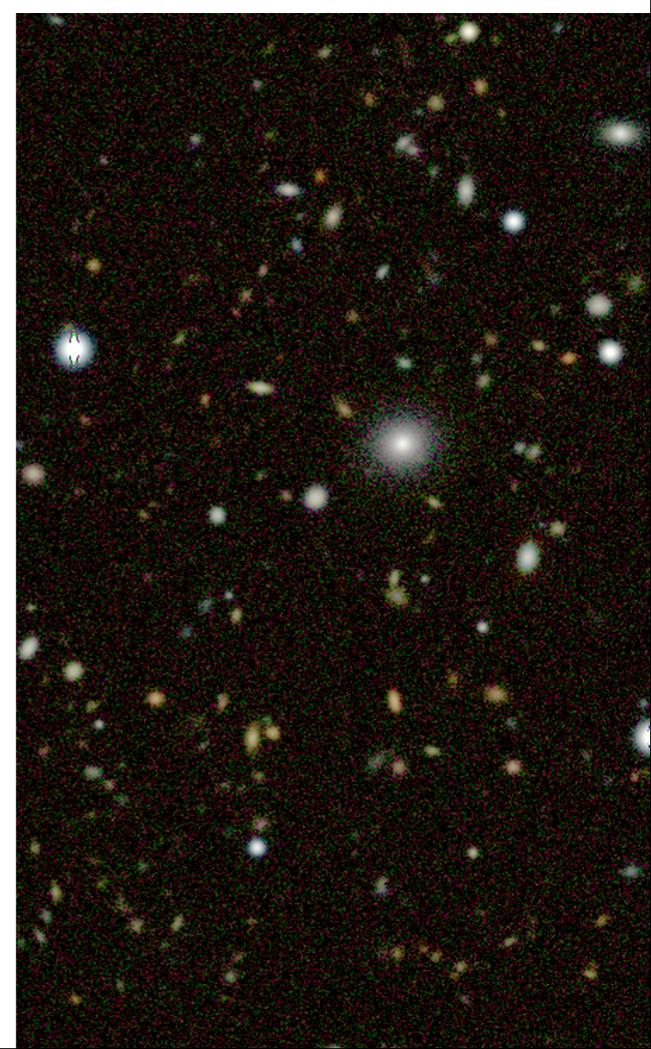


Image Simulation @ LSST

- **LSST Photon Simulator (PhoSim)**: Peterson et al. (in prep)
- Fast Monte Carlo **photon raytracing**
- Detail **physical model** of the atmosphere and instrument

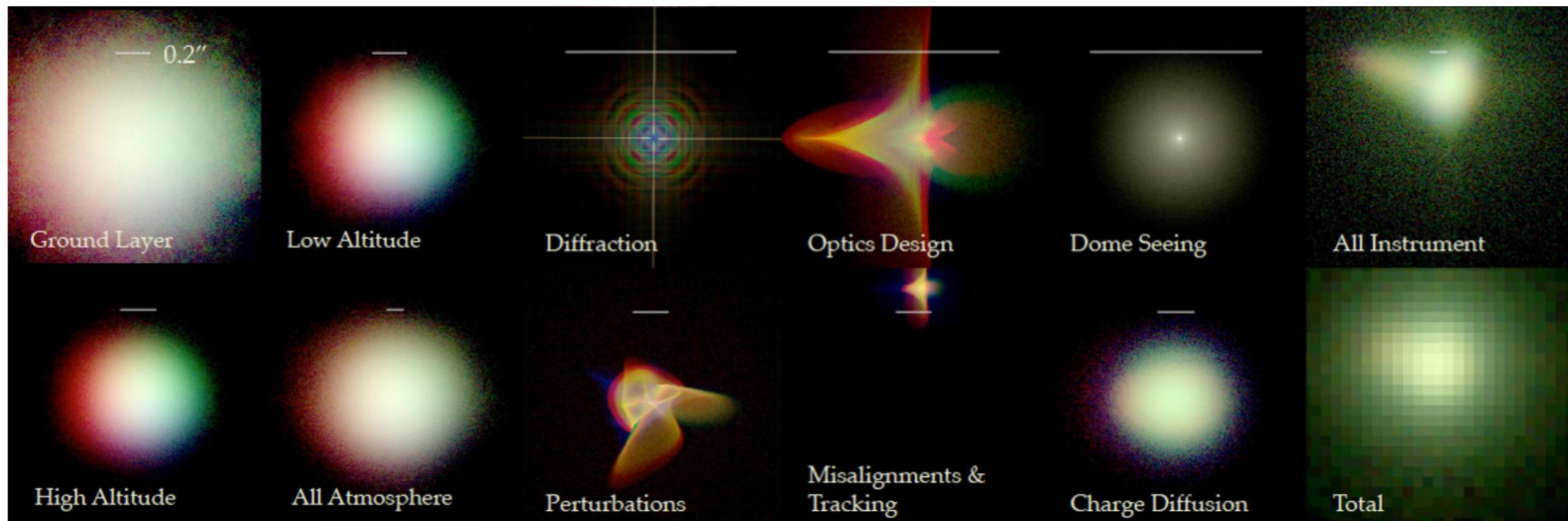
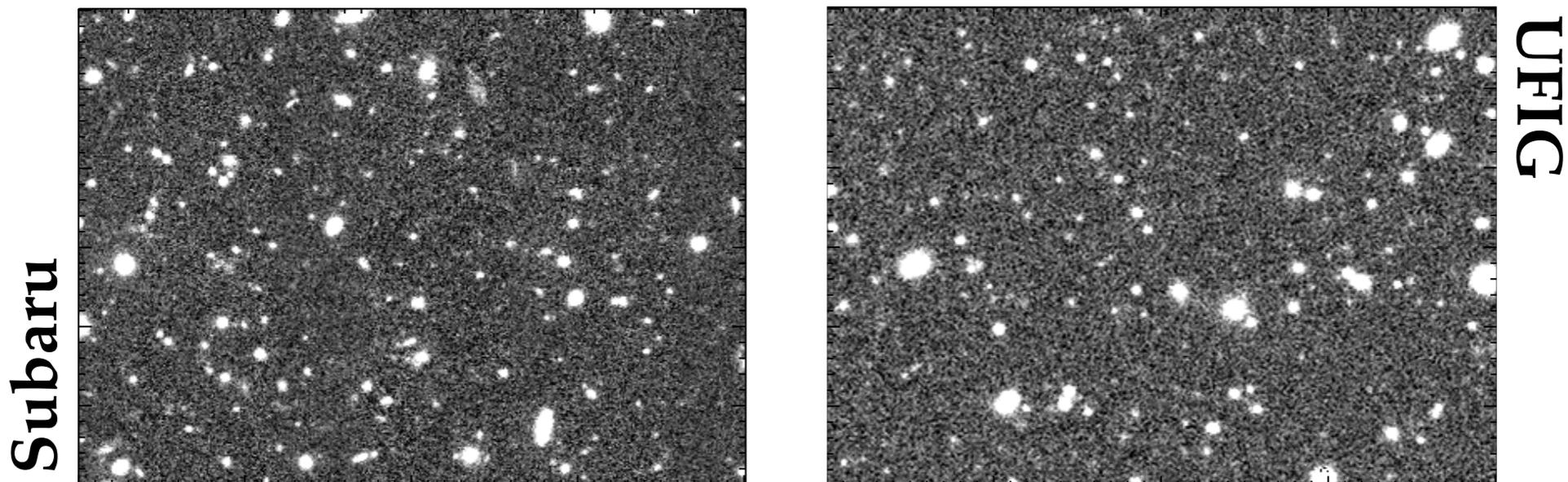


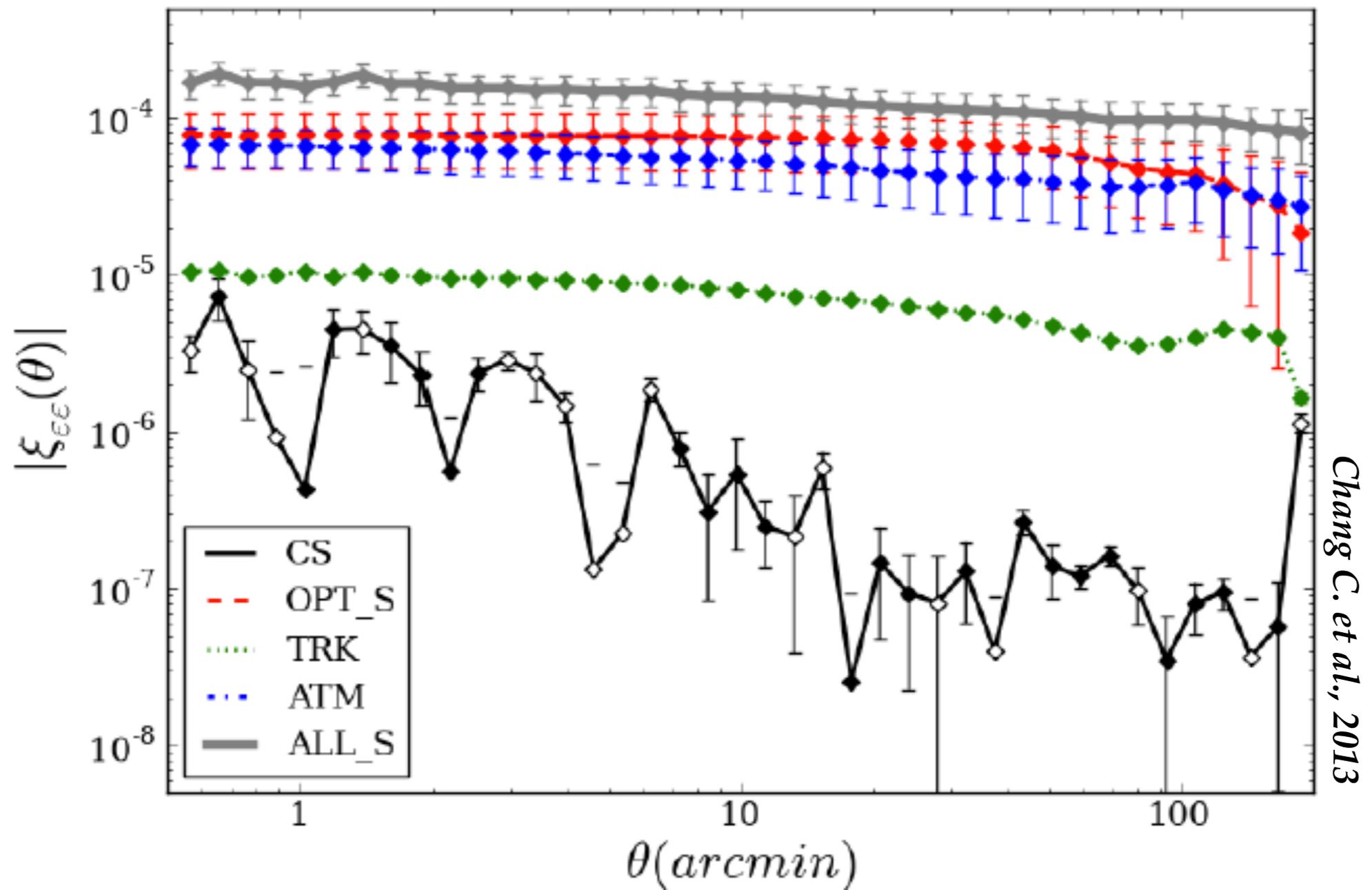
Image Simulation @ DES

- **Ultra Fast Image Simulator (UFIG):** Berge et al. (2012)
- **Speed** ~ SourceExtractor
- Currently with simple models of the atmosphere and instrument
- Well **integrated** in the end-to-end framework



Berge J. et al., 2012

Image Simulation @ LSST



Chang C. et al., 2013

Simulation vs. Surveys

DES



LSST

- Big **data**, big **collaborations**, big **simulations**, big **resource**
- **End-to-end** simulation: cosmology - instrument - data pipeline
- All parts are important, but **connecting** all of them into something coherent and survey-specific is also very important

End-to-end Simulation

- LSST and DES are on **different stages** of the project, and the simulation effort evolves accordingly



LSST

- ➔ tighter science requirements
- ➔ being built at the same time
- ➔ more data, more time

Current usage:

testing DM, algorithm development, estimation/forecast of system performance

End-to-end Simulation

- LSST and DES are on **different stages** of the project, and the simulation effort evolves accordingly



DES

- ➔ smaller scale in all aspects
- ➔ data is coming in

Current usage:

verification of science analyses, calibration, understanding systematic issues