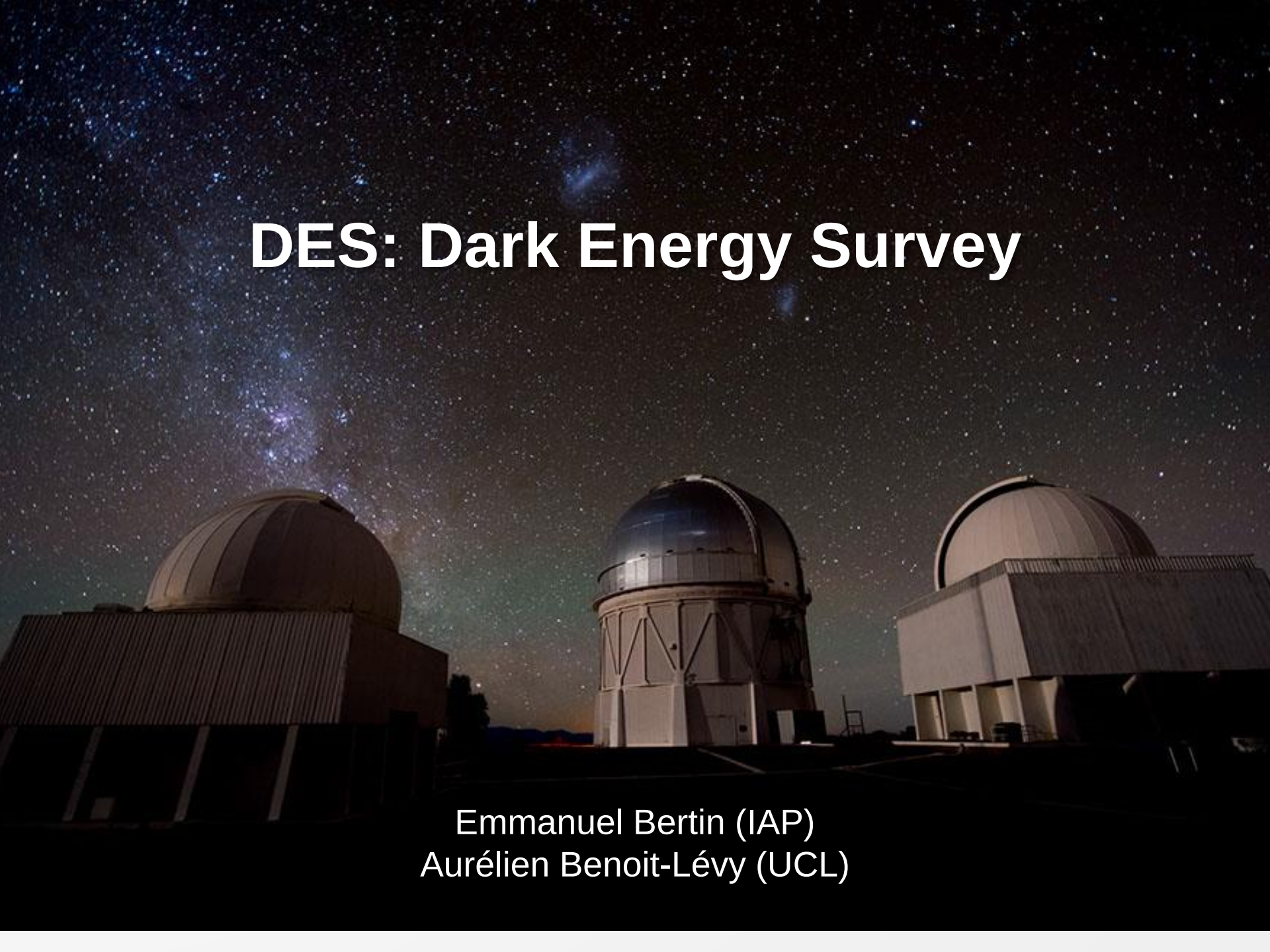


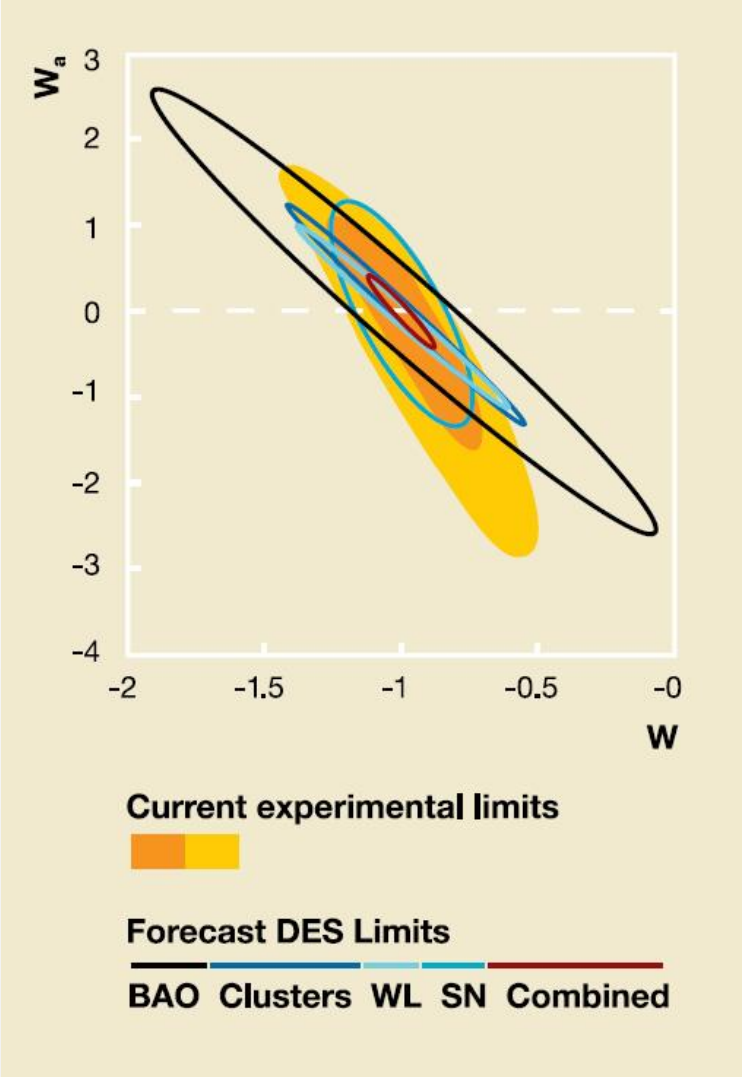
DES: Dark Energy Survey

Emmanuel Bertin (IAP)
Aurélien Benoit-Lévy (UCL)

DARK ENERGY SURVEY

Overview

- Main science drivers: 4 cosmological probes based on distance, geometry and structure growth:
  - Galaxy cluster counts (~100,000) to z~1
  - Gravitational lensing (strong and weak) from 200 million galaxies
  - Baryon acoustic oscillations from 300 millions galaxies to $z \geq 1$
  - 4000 supernova Ia light curves with 0.1<z<1.1
- 5000 sq.degree photometric survey of the southern hemisphere in 5 bands (g,r,i,z,Y) down to 24th mag (galaxies, 10σ)
  - 525 nights over 5 years during 5-month seasons
  - Includes the 2500 sq.degree South Pole Telescope SPT-SZ survey footprint
  - 30 sq.degree repeated ~weekly in g,r,i,z (SN fields)
- Survey started Aug 31, 2013.



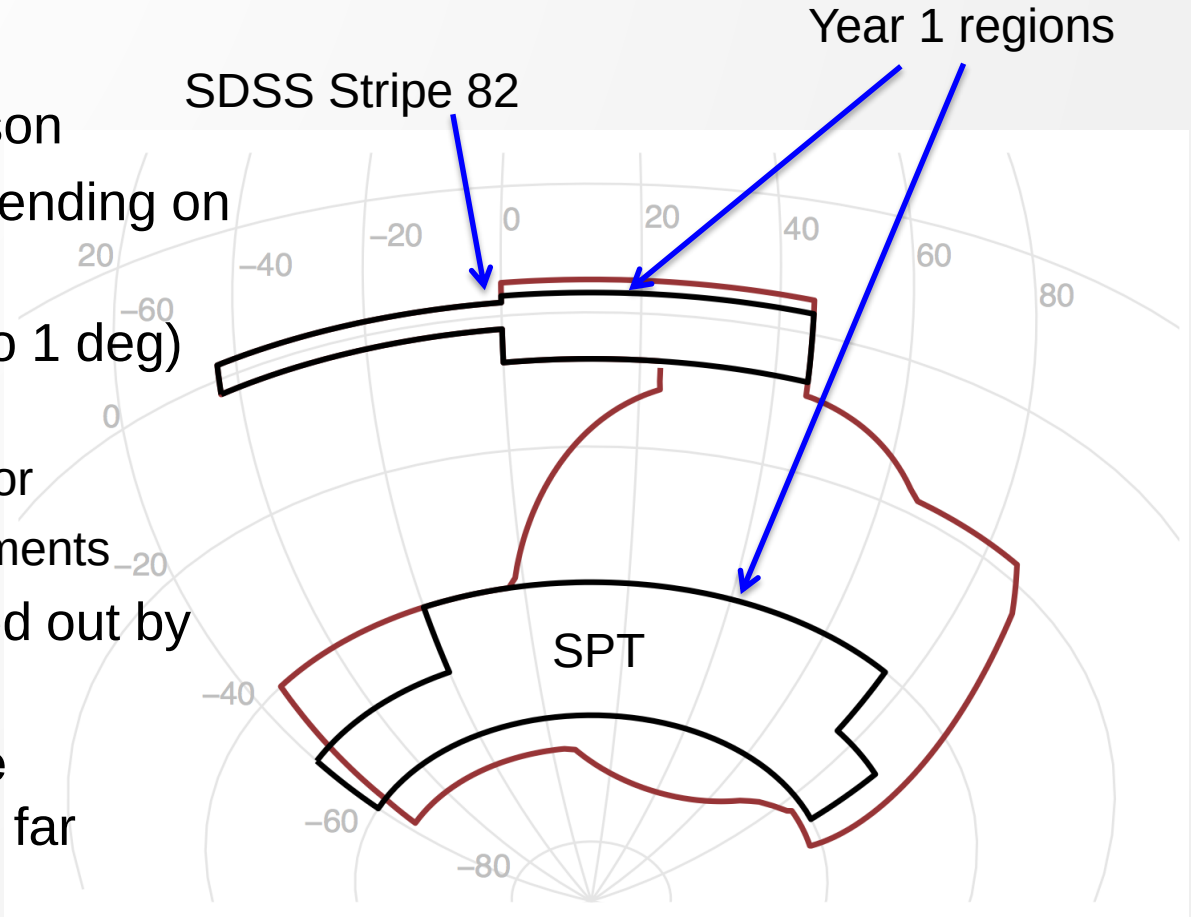
DARK ENERGY SURVEY

The Collaboration

- Josh Frieman, director
- Project initiated in 2004
- 28 institutions, ~200 participants
- Science working groups: Clusters, Galaxy evolution, Large scale structure, Milky Way, Photometric redshifts, QSOs, Strong lensing, Supernovae, Theory, Weak lensing
- Funding: DOE, NSF, DFG, CSIC, CNPq, FAPERJ,FINEP + institutions
- No French institution involved
  - But a few French individuals involved as PhDs, post-docs or external collaborators

Survey and observation strategy

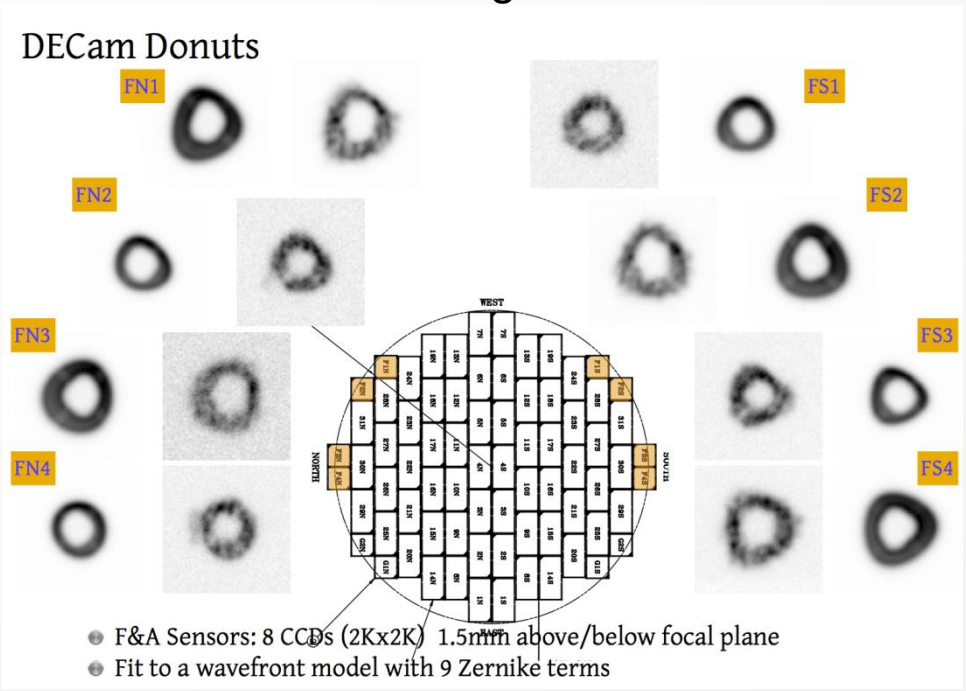
- ~ 90s exposures
- 10 epochs, ~2 per season
- Switch to SN fields depending on observing conditions
- Very large dithers (up to 1 deg) imply
  - PSF homogenization or
  - Multi-epoch measurements
- Observations are carried out by DES members
- >20,000 “good” science exposures observed so far



E. Nielsen

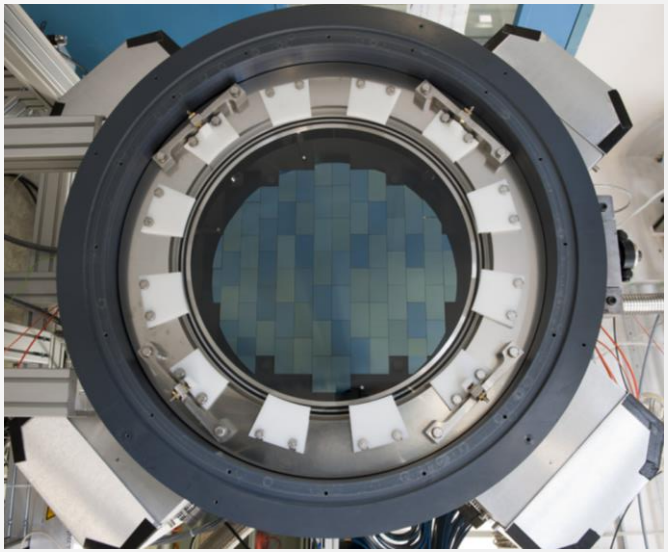
The Instrument: DECam

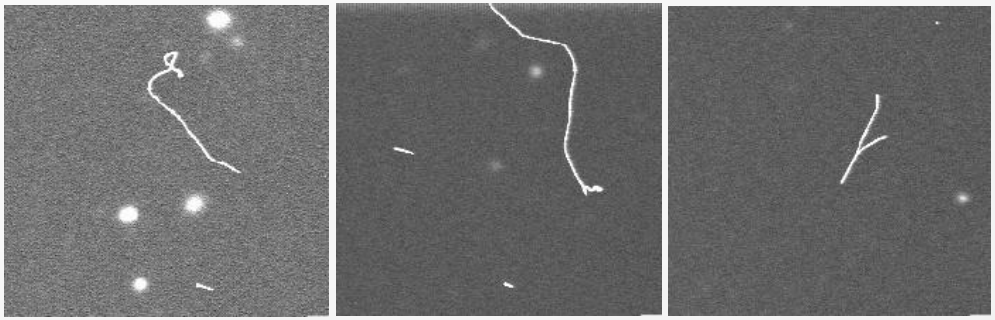
- Installed on the Blanco 4m telescope at CTIO. Seeing (I band) ~0.9”
- 3-sq. degree field of view (2.2 degree diameter).
- Hexapod compensates flexures based on out-of-focus images



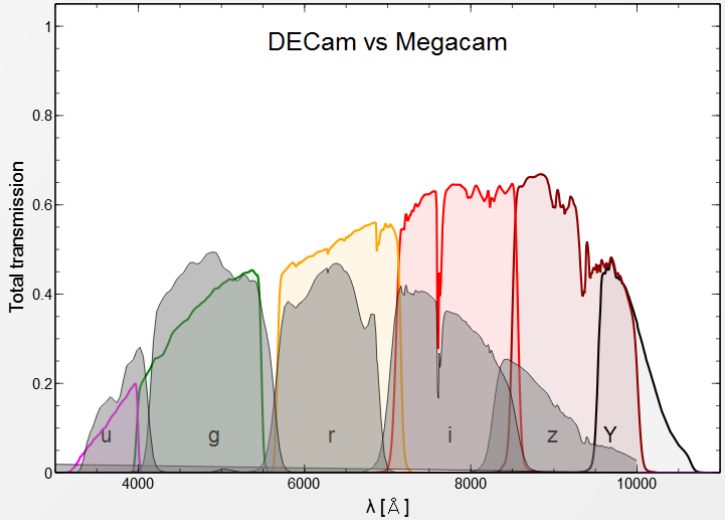
DECam detectors

- 570 Mpixels
- Thick, fully-depleted CCDs
  - Very high Q.E in the red
  - Very little fringing in i and z
  - Care should be taken with strong lighting (super-saturation)
  - Significant distortion of the pixel grid due to lateral electric field variations
    - Static: resistivity variations (“tree-rings”)
    - Dynamic: “brighter-fatter” effect
  - Large cosmic ray trails



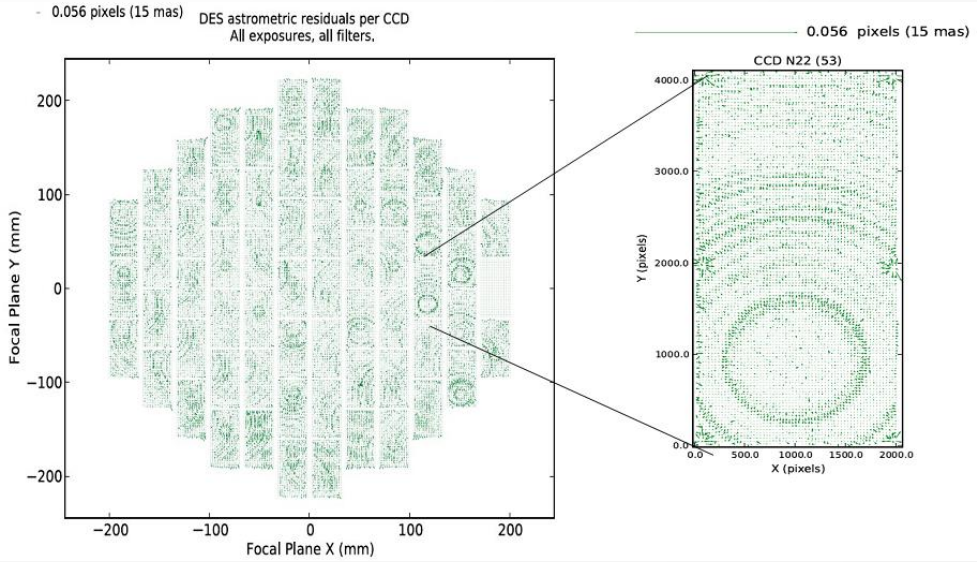


Ohio State University

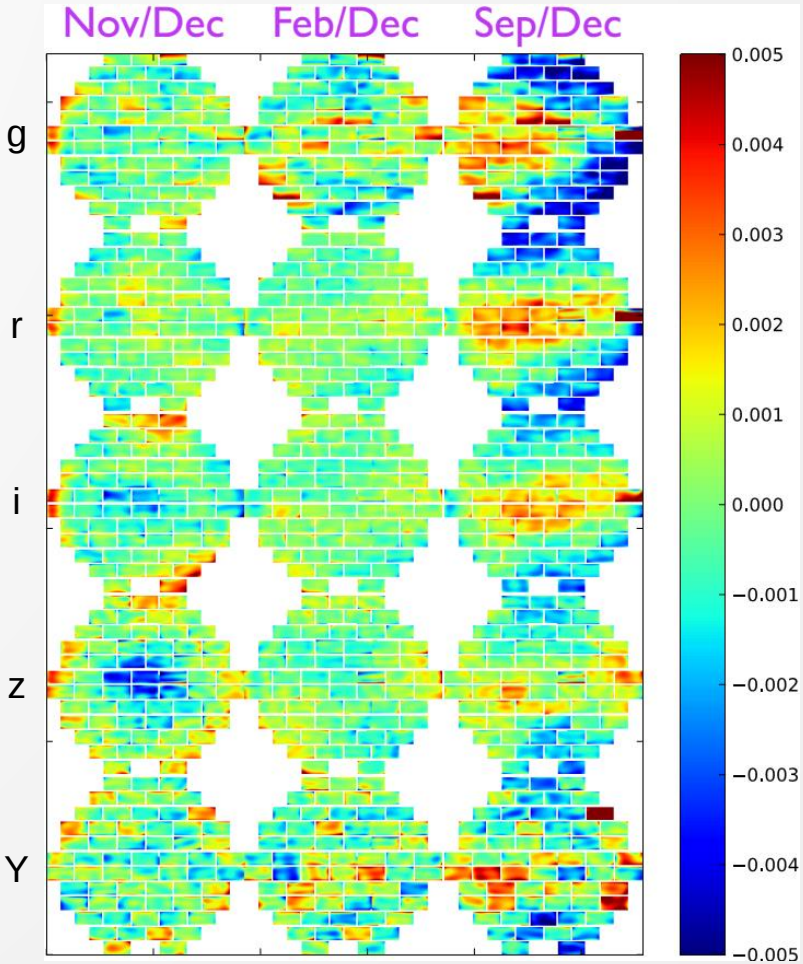


Instrumental calibration

- Photometric response modelled at the millimag level (photometric homogeneity requirement: <20 millimag
- Astrometric response modelled at the mas level (relative astrometry requirement: <15 mas)
- Dedicated calibration devices on-site:
  - Sky thermal emission: RASICAM (all-sky)
  - Atmospheric transmission parameters: aTmCam
  - Follow-up of spectral response using LEDs + Monochromator: DECal



A. Plazas



G.Bernstein

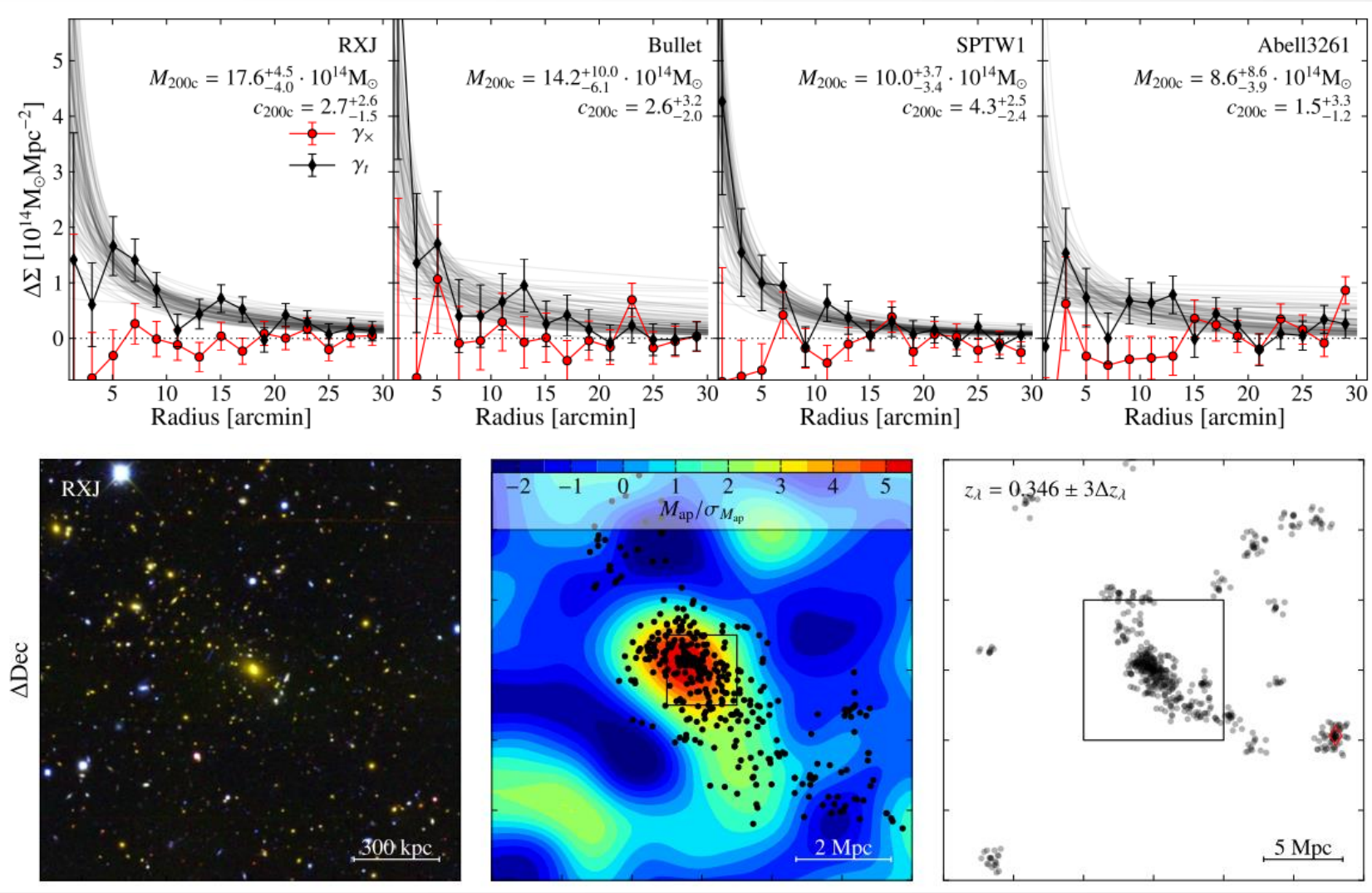
DARK ENERGY SURVEY

Data

- Data throughput 200-400GB per clear night
- Data processed at NCSA (U. of Illinois) through the DESDM (data management) system
  - DECam community pipeline operated by NOAO
  - DES data products readily available to the DES community through the DES archive at NCSA
- Yearly / bi-yearly internal data releases to the collaboration
- Raw data proprietary period is 12 months (NOAO standard: 18 months)
  - can be accessed through the NOAO NVO portal
  - Two public releases of processed data planned during the lifetime of the survey

DARK ENERGY SURVEY

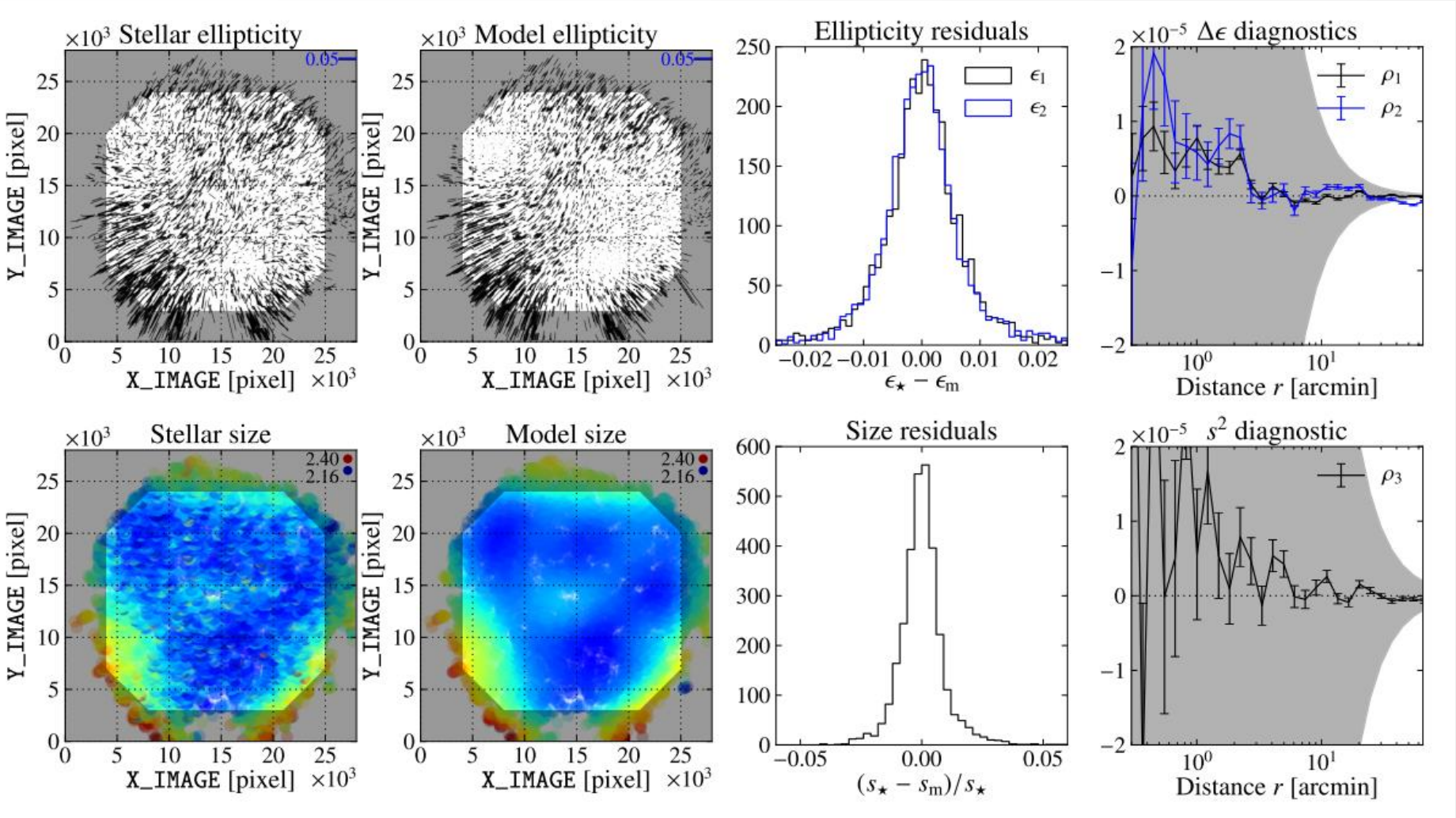
Science verification: galaxy clusters



Melchior et al. 2014

DARK ENERGY SURVEY

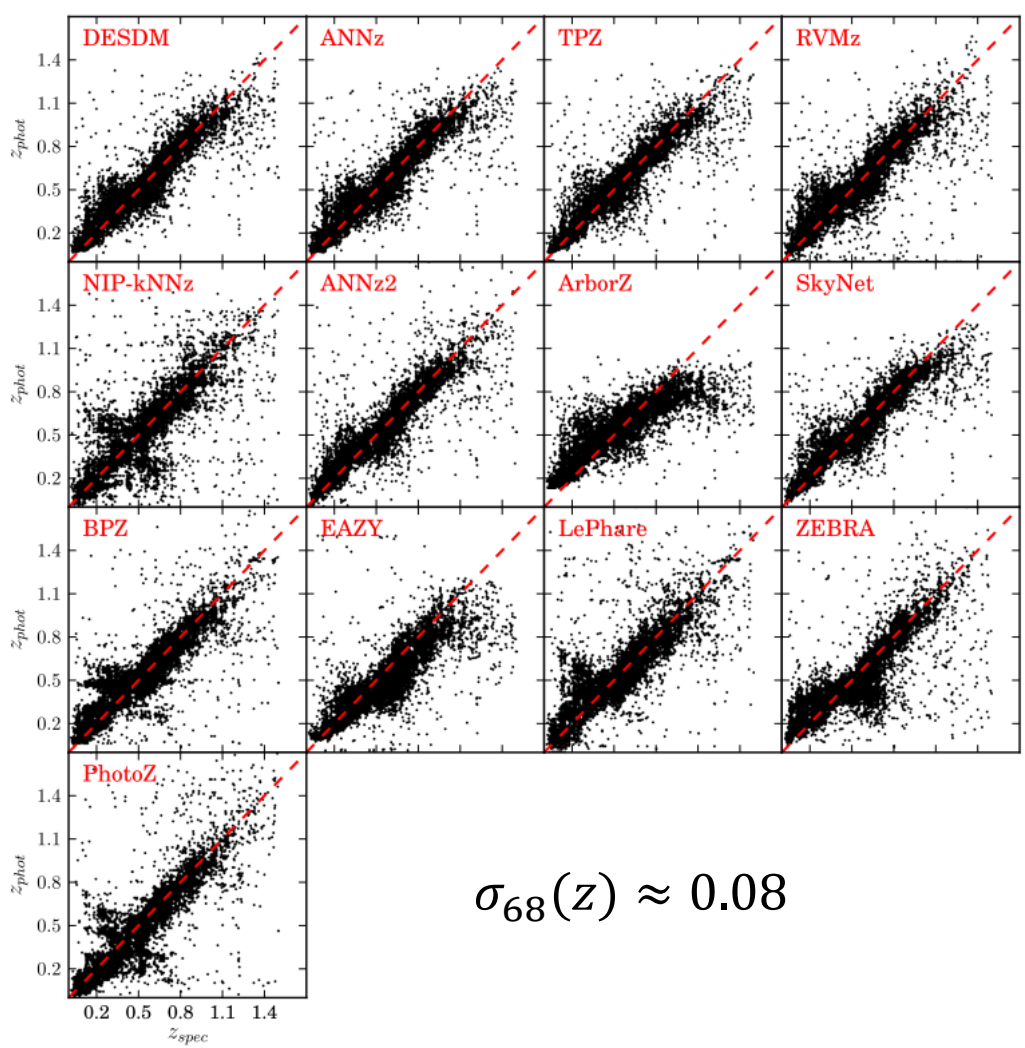
Science verification: galaxy clusters (cont.)



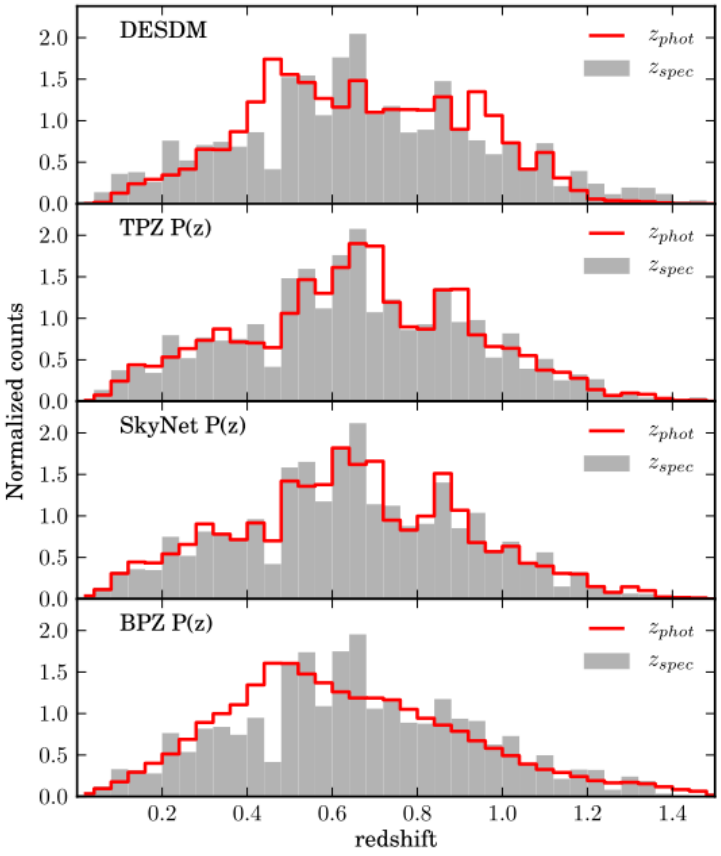
Melchior et al. 2014

Science verification: photometric redshifts

DARK ENERGY SURVEY



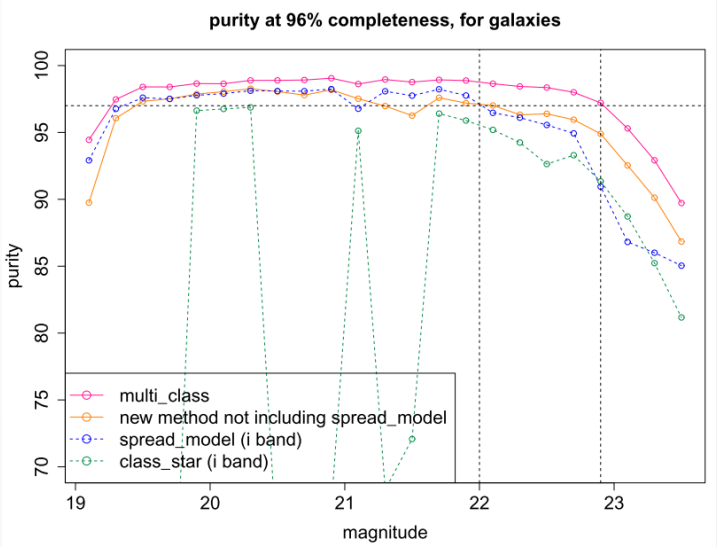
$$\sigma_{68}(z) \approx 0.08$$



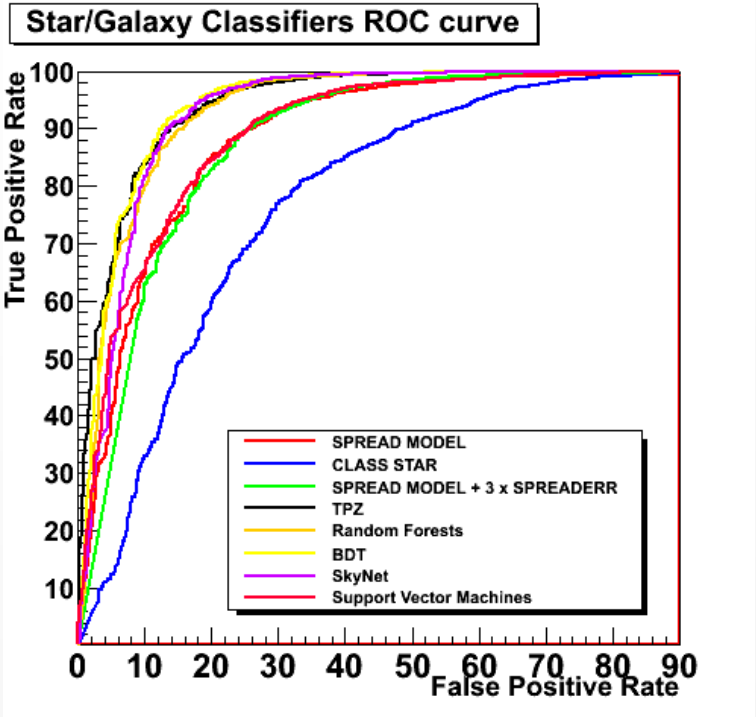
Sánchez et al. 2014

Science verification: star/galaxy separation

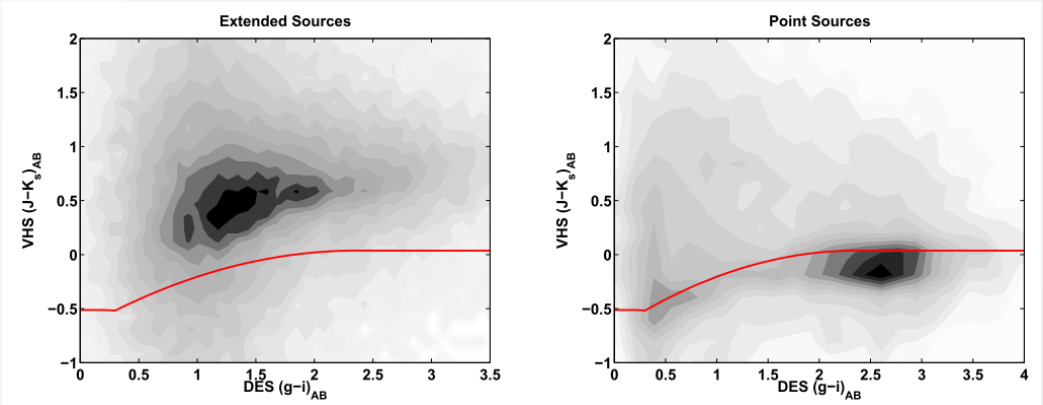
DES requirements for galaxy sample:
purity ≥ 97% at 96% completeness



Soumagnac et al. 2014

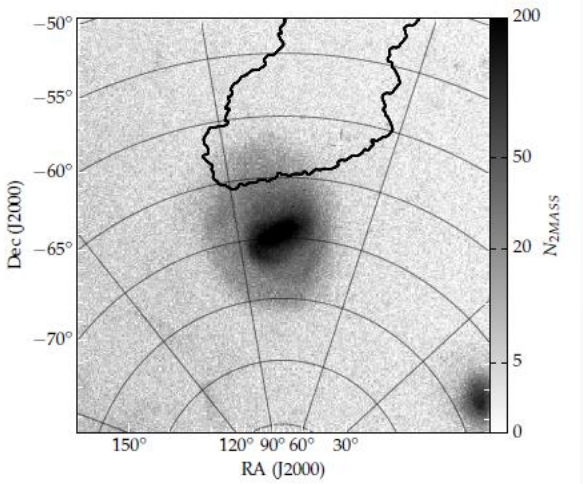


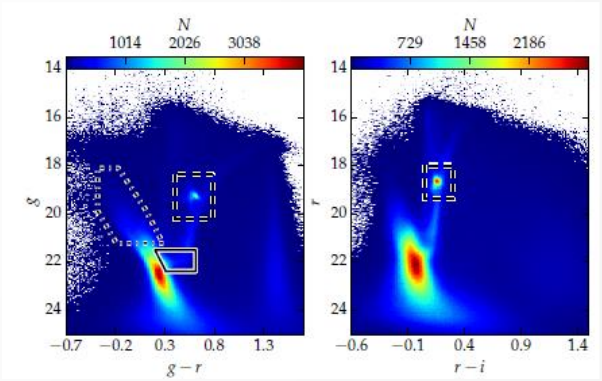
courtesy of I.Sevilla



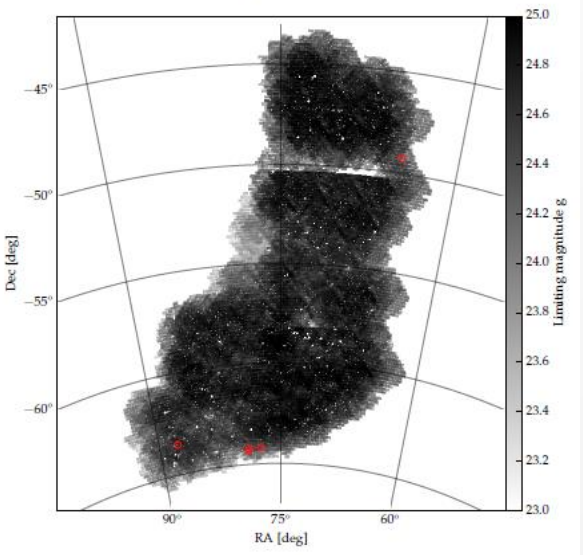
Banerji et al. 2014

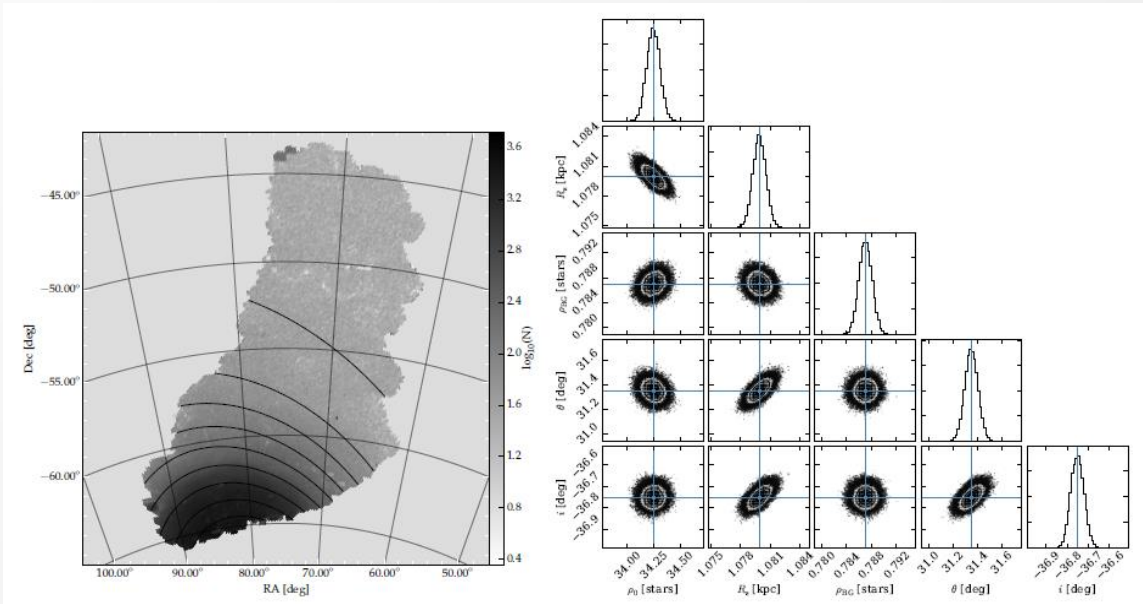
Science verification: LMC star sample





Balbinot et al. 2014





DARK ENERGY SURVEY

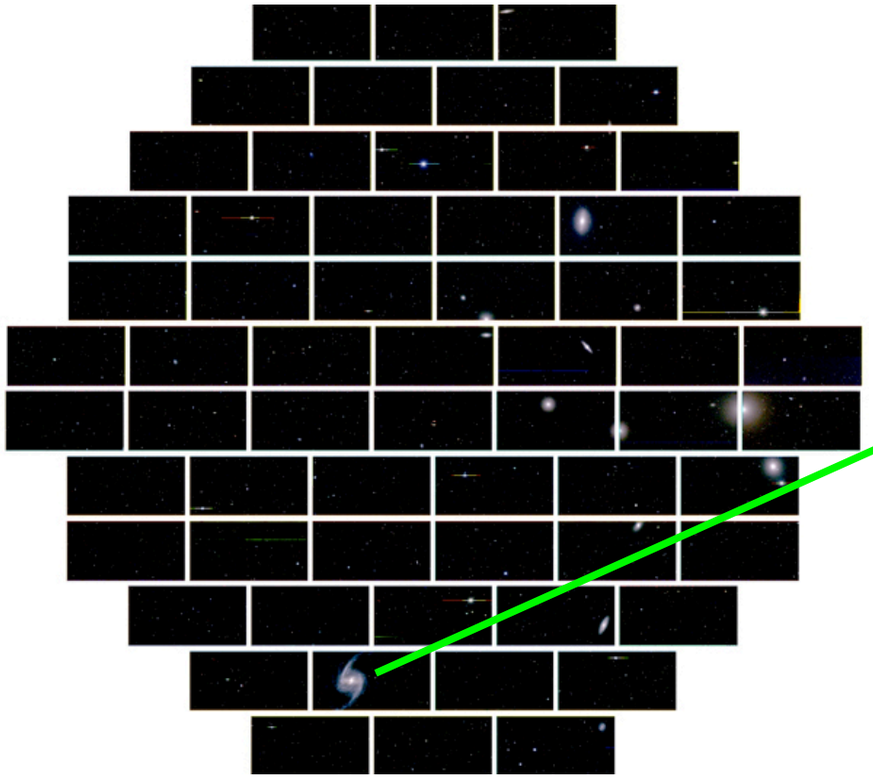
Current status of data processing

- Preparing for year 2 and forthcoming internal releases
  - Pipeline refactoring
  - Corrections for small scale pixel scale distortions and brighter-fatter effect
  - New source deblender
  - Multi-epoch analysis generalized to all measurements

DES timeline

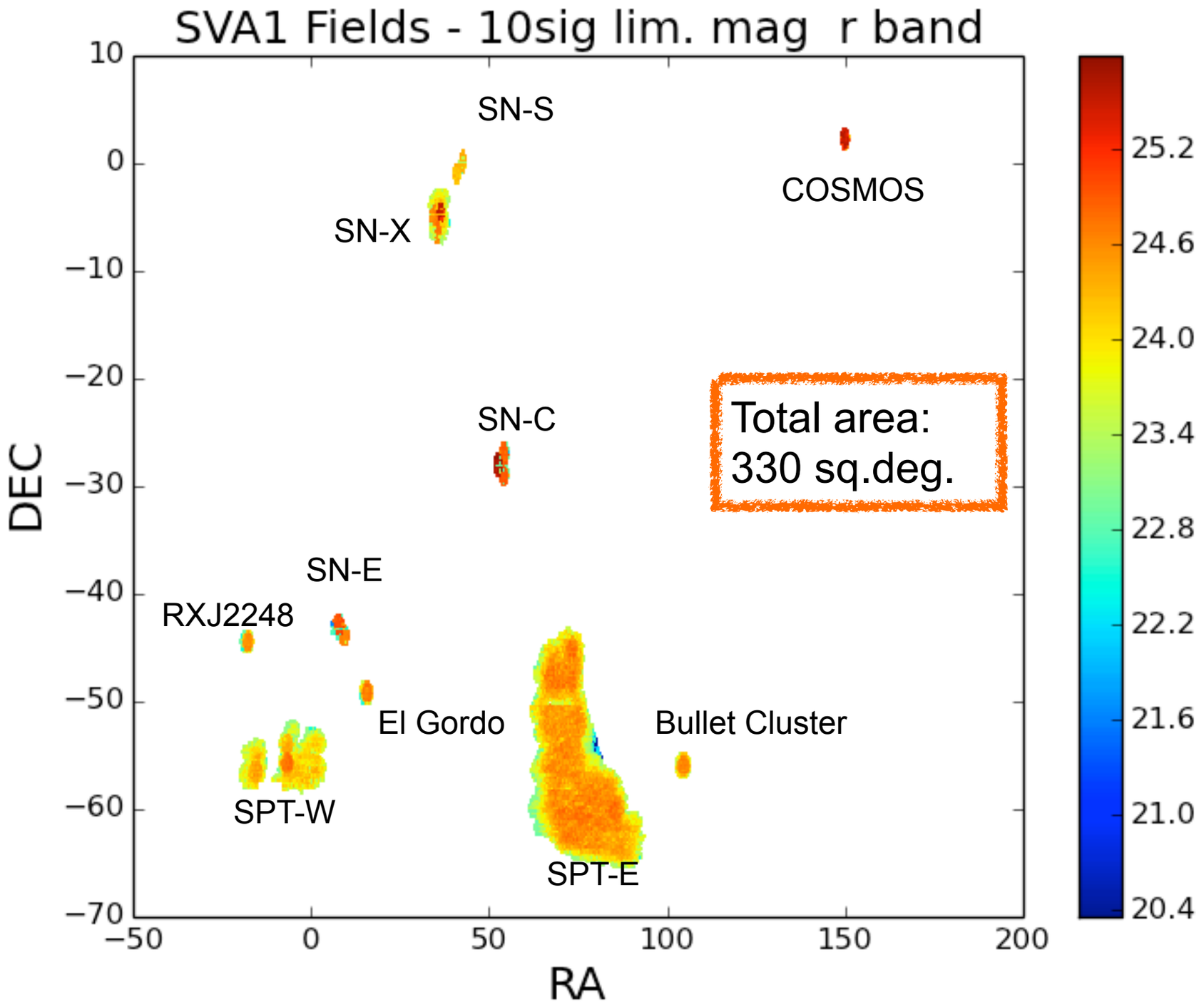
Sept. 2012: First light

Fornax galaxy cluster



NGC 1365

Nov. 2012 - Feb. 2013: Science Verification campaign

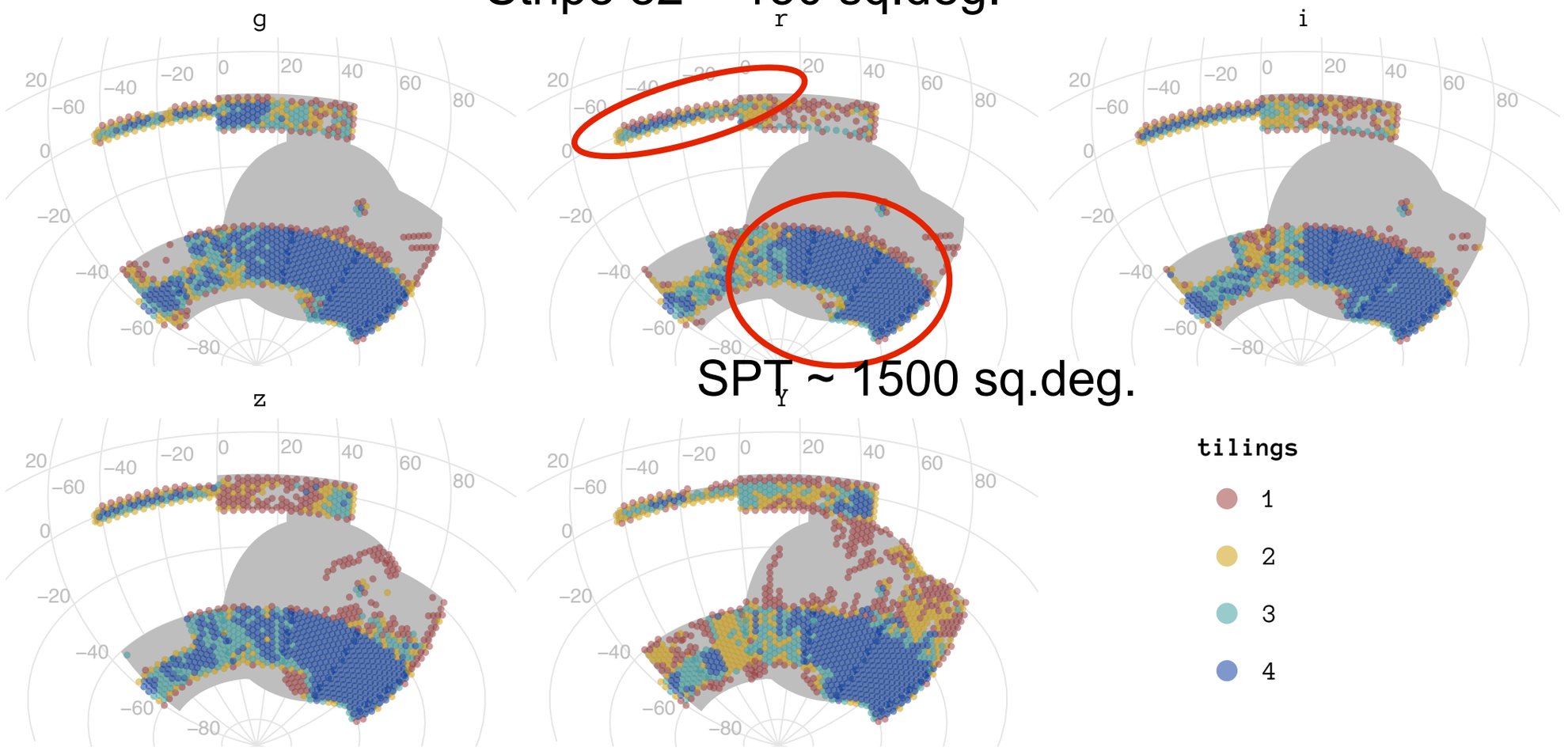


DES timeline

Aug. 2013 - Feb. 2014 (105 nights): 1st year campaign

Stripe 82 ~ 150 sq.deg.

SPT ~ 1500 sq.deg.



E. Nielsen

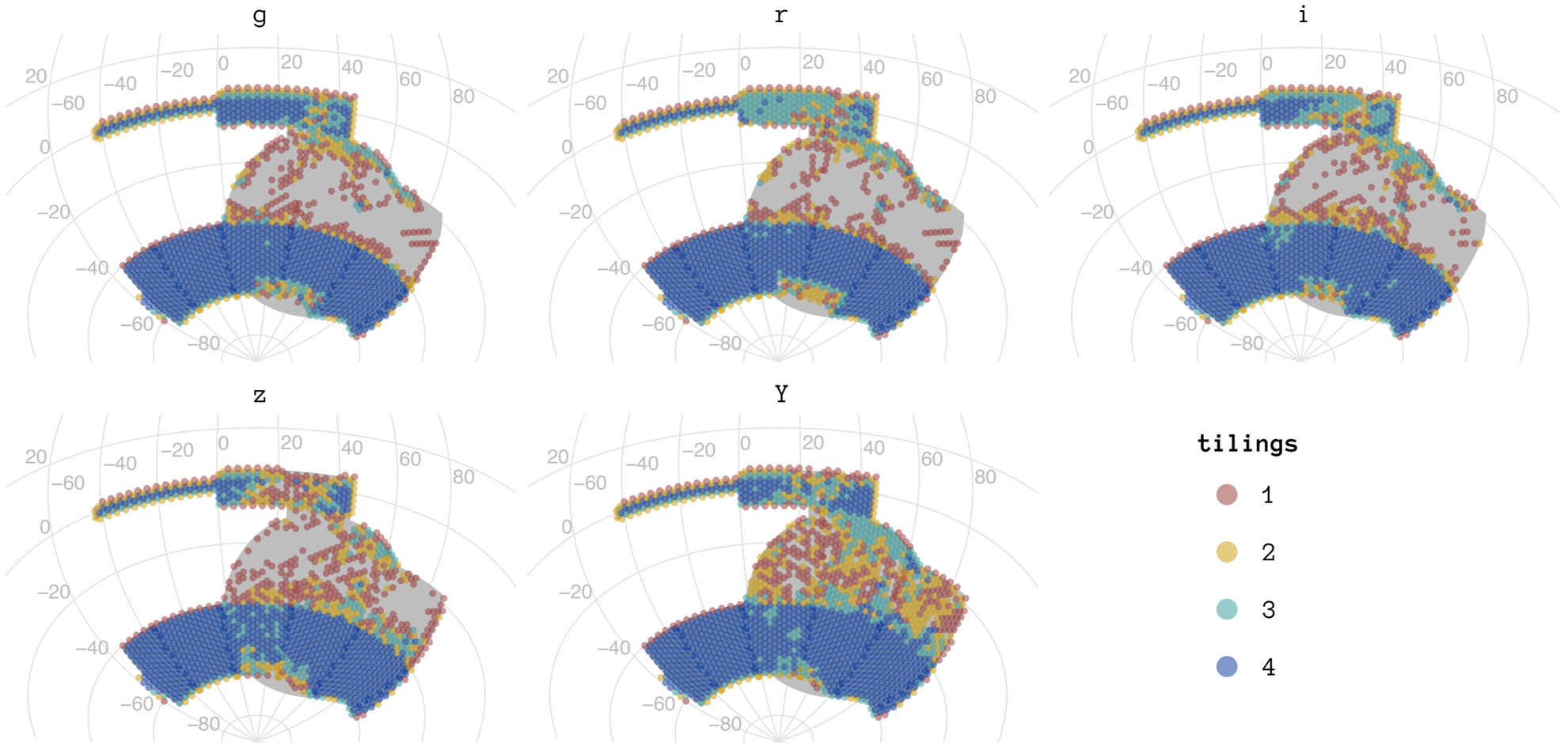
Wide-survey exposures completed in year 1

4

DES timeline

Aug. 2013 - Feb. 2014: 2nd year campaign (on-going)

aim: 5000 sq.deg. at 4 tilings



(as of mid Nov 14)

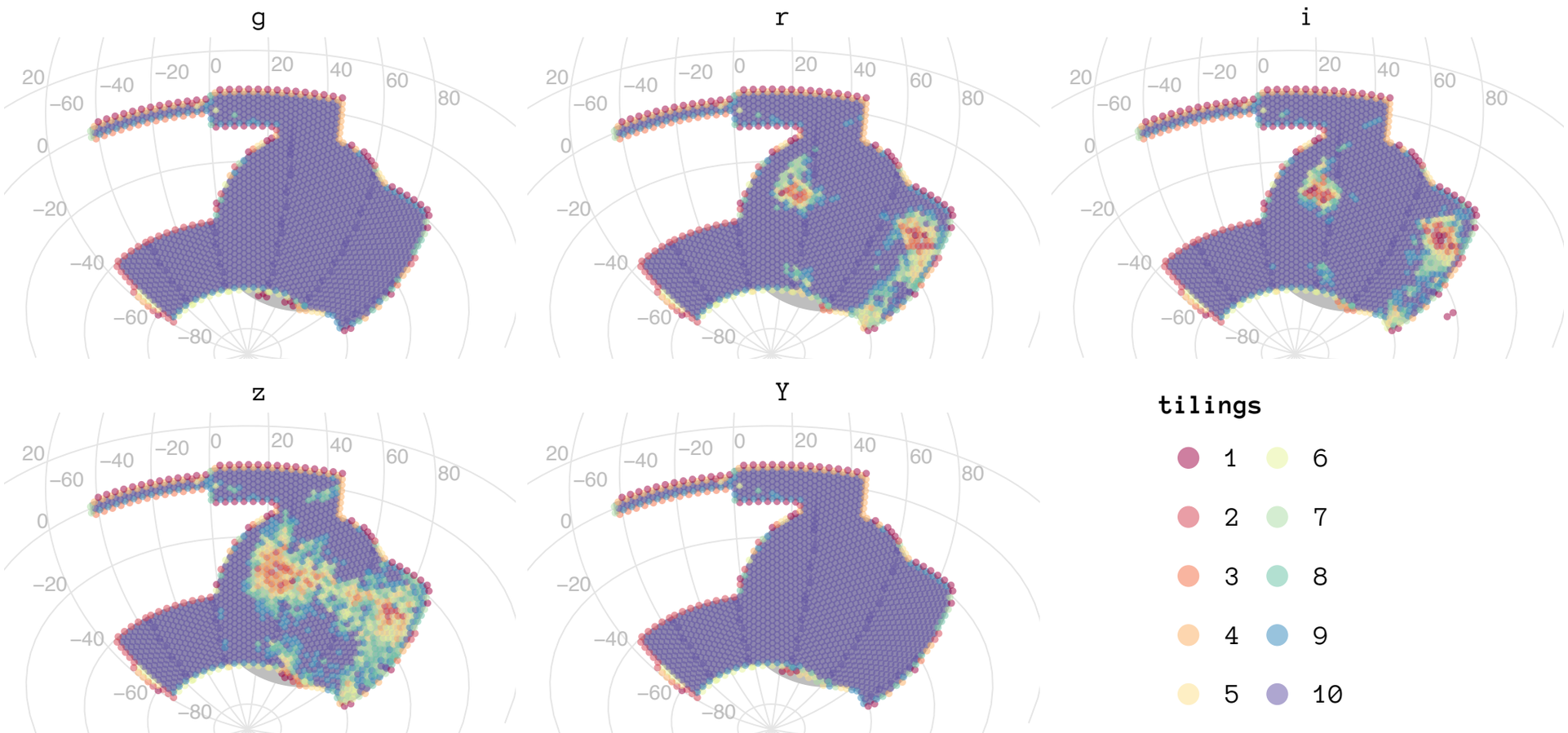
Current wide-survey exposures completed

5

E. Nielsen

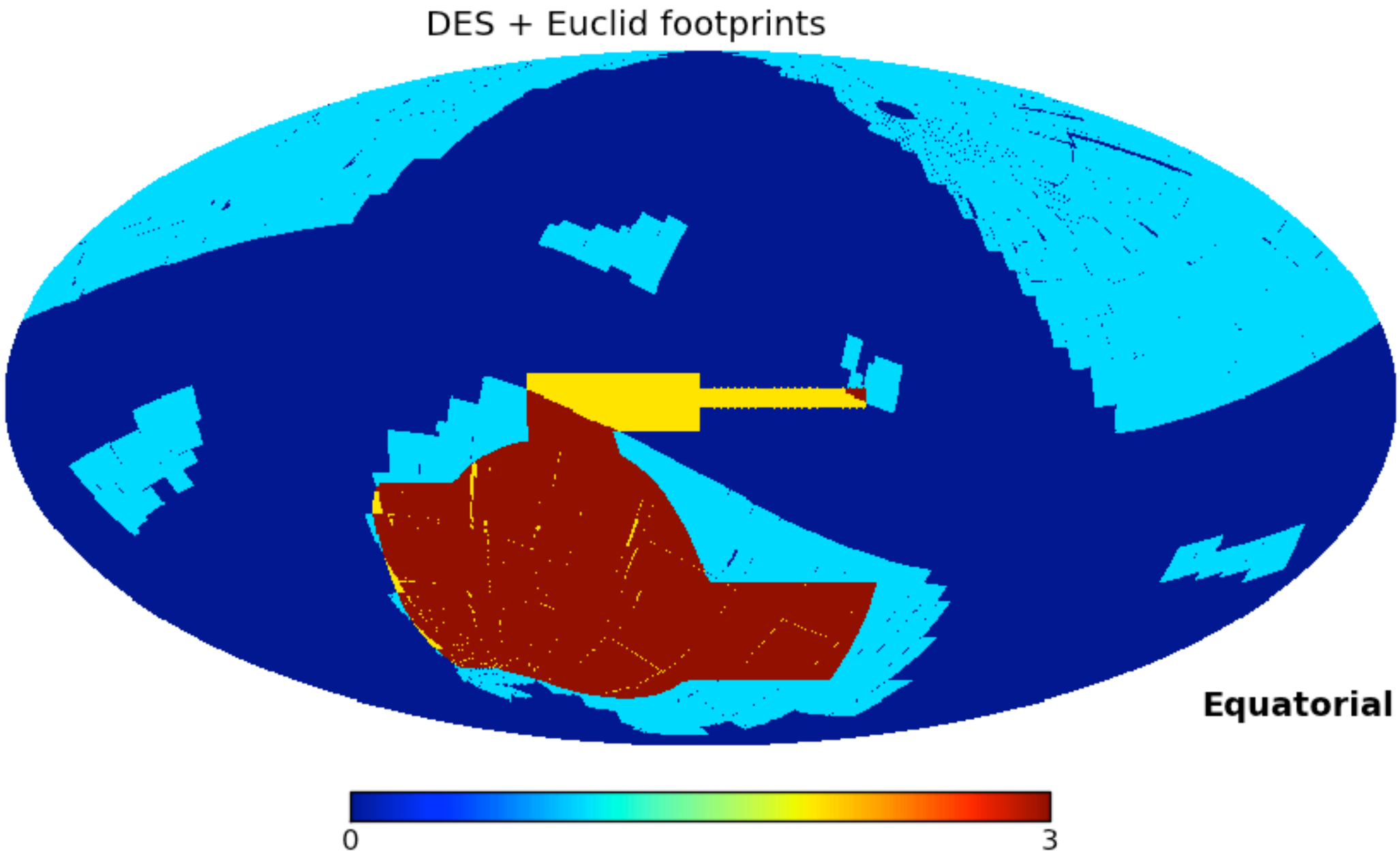
DES timeline

Aug. 2015 - Feb. 2018: 3-5 year campaign (simulation)



E. Nielsen

DES 5yr VS Euclid footprint



This preliminary Euclid footprint is available for the collaboration

DES mask construction

Building the effective mask of the survey that takes into account real life issues such as:

- Gaps between CCD
- Bad images within exposures
- Satellite trails
- Brights stars
- Large CCD defects

DES uses the Mangle package

Mangle is a suite of tools to manipulate polygons of arbitrary shape on the sky.

Weight (noise, seeing, maglim, ...) can be associated with each polygon

DES Mangle pipeline initialy written by M. Swanson

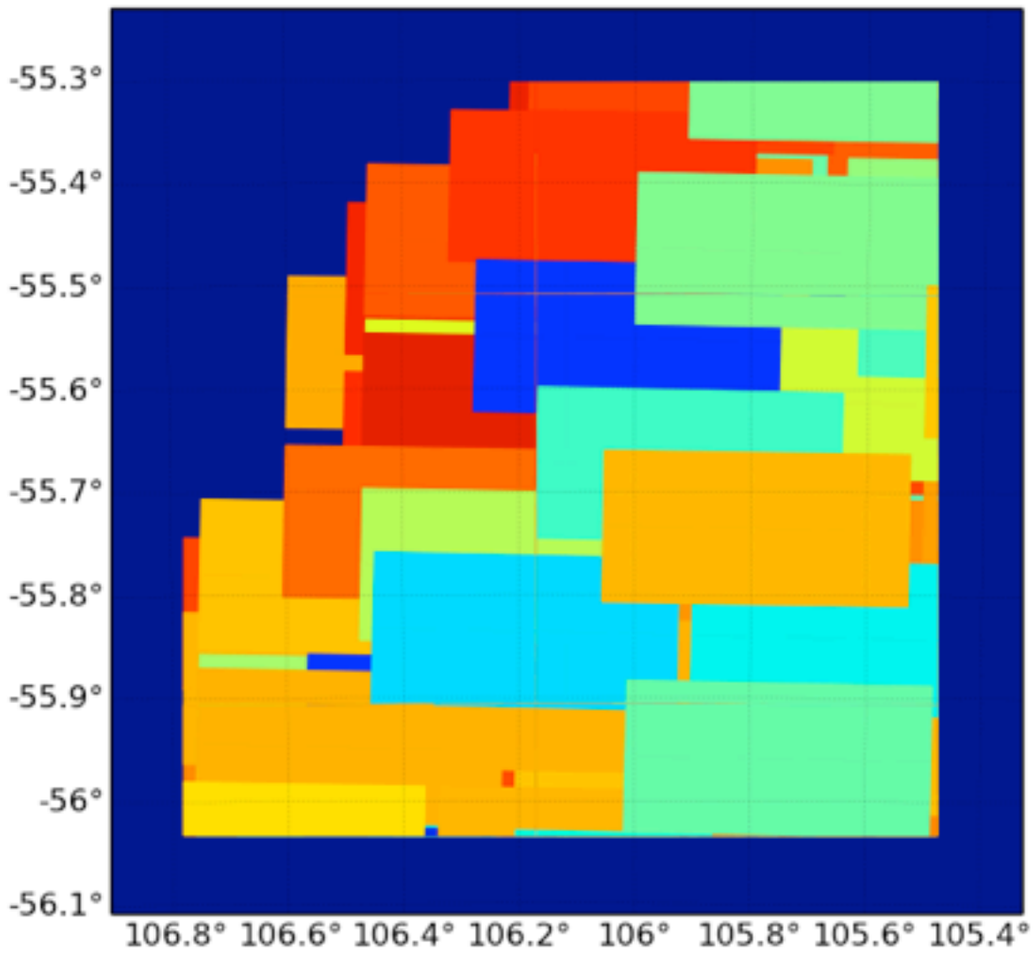
2 main objectives

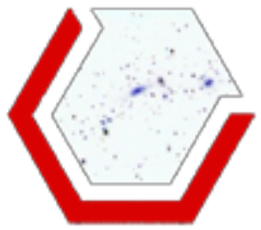
Determine the large and small scale geometry of the survey

Keep track of various quantities and provide fast wast to associate them to million of objects

DES mask construction

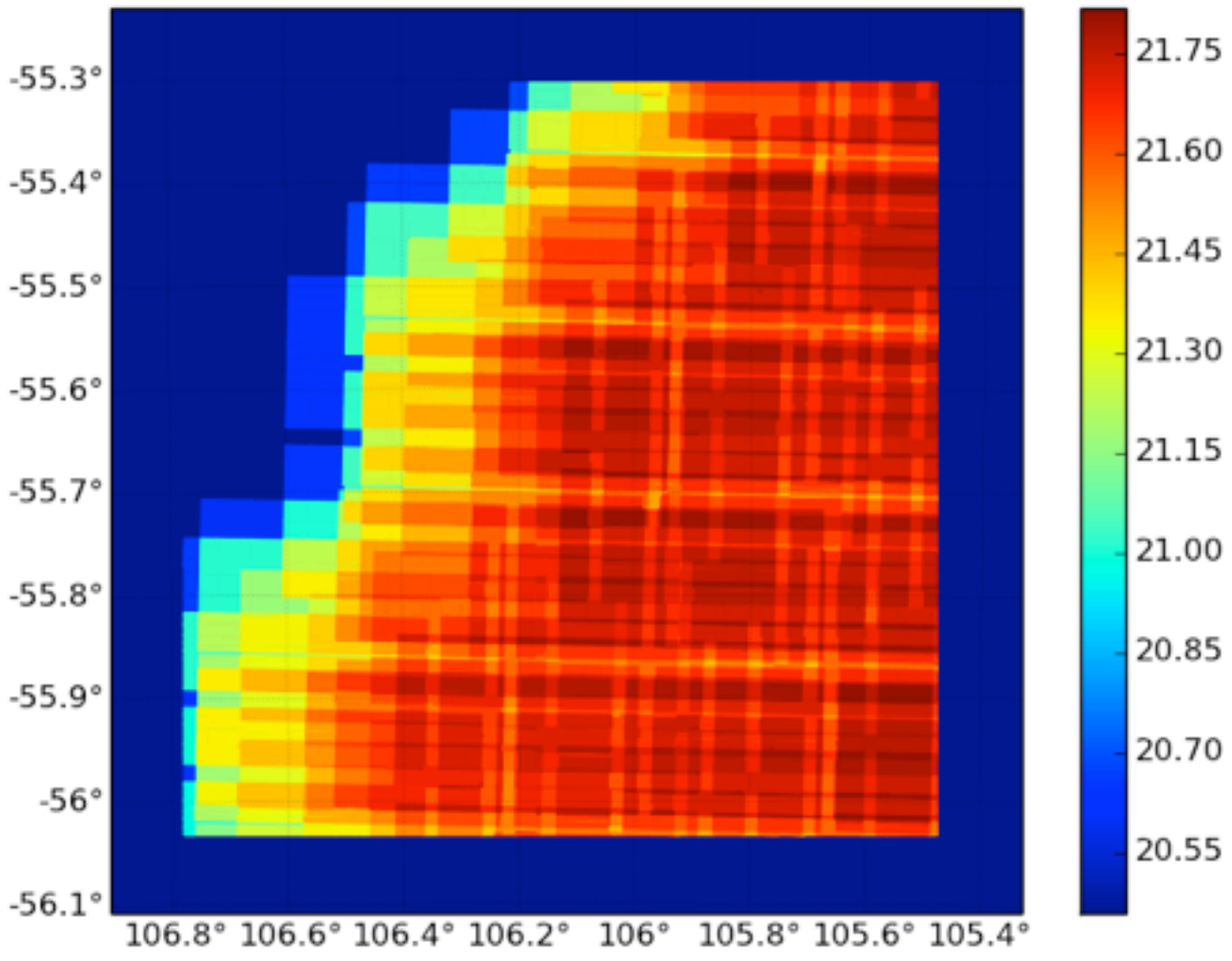
Step 1: overlay CCD footprint





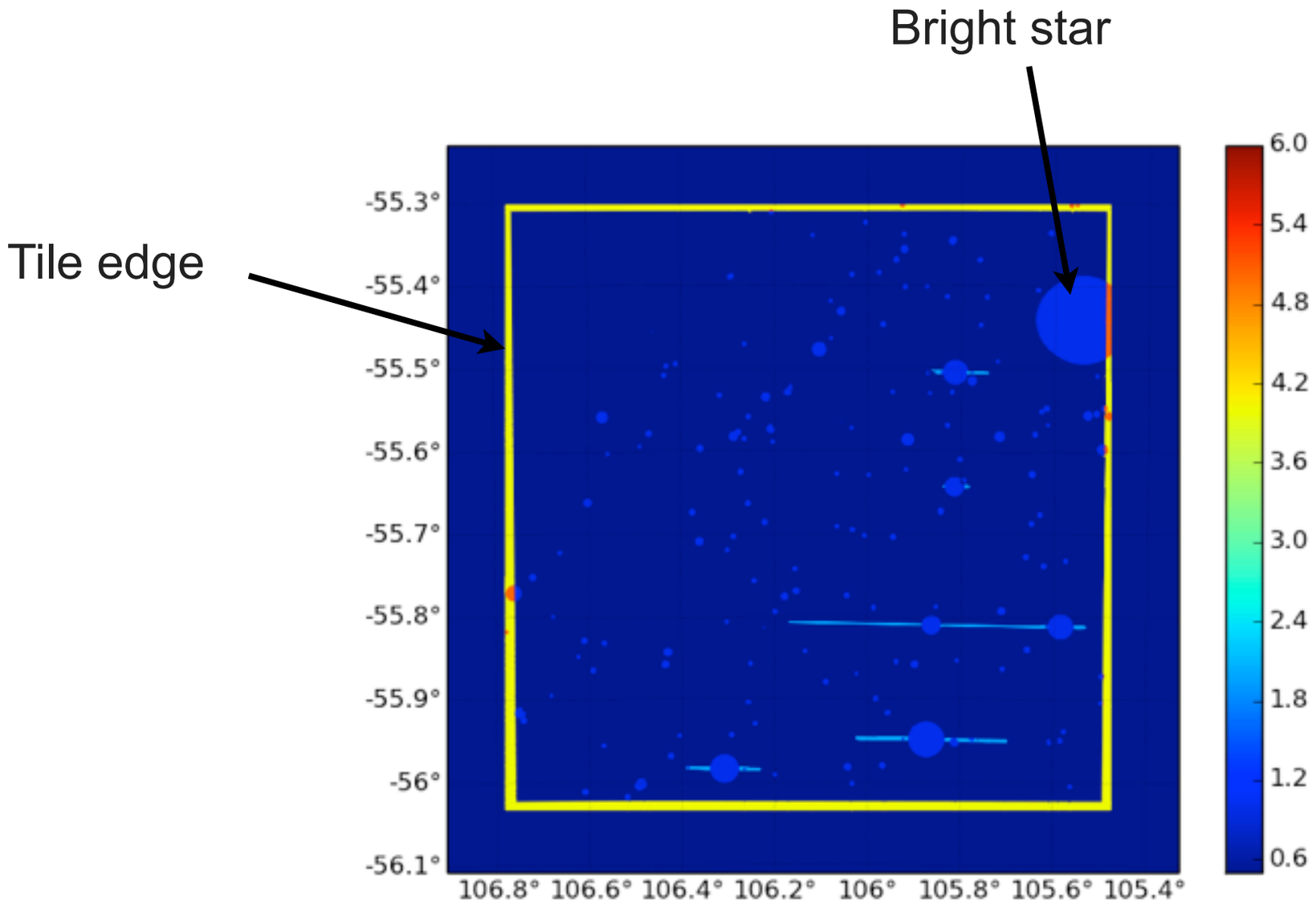
The DES Mangle pipeline

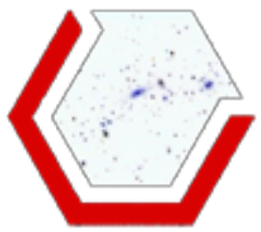
Step 2: split CCD footprints into non-overlapping polygons



The DES Mangle pipeline

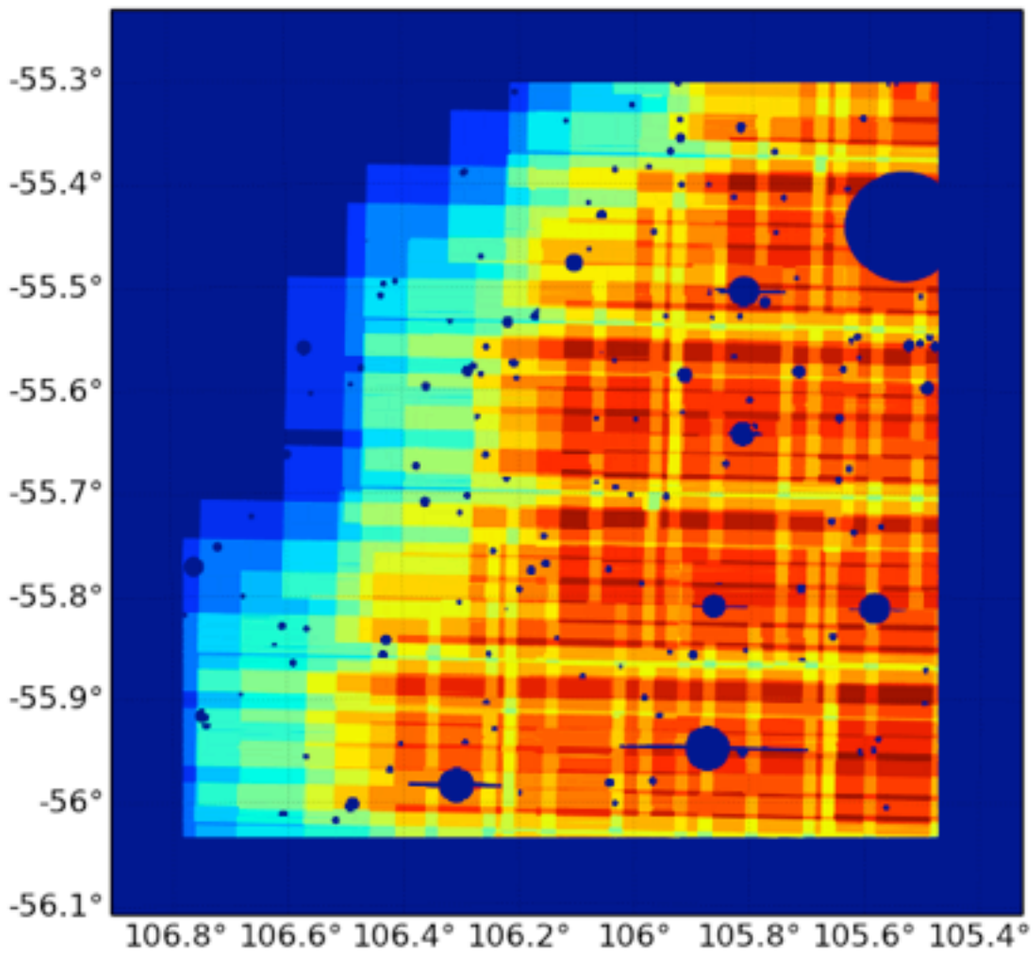
Step 3: construct bitmask

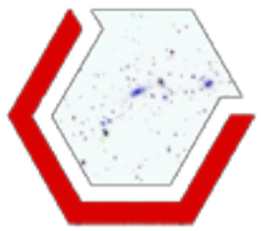




The DES Mangle pipeline

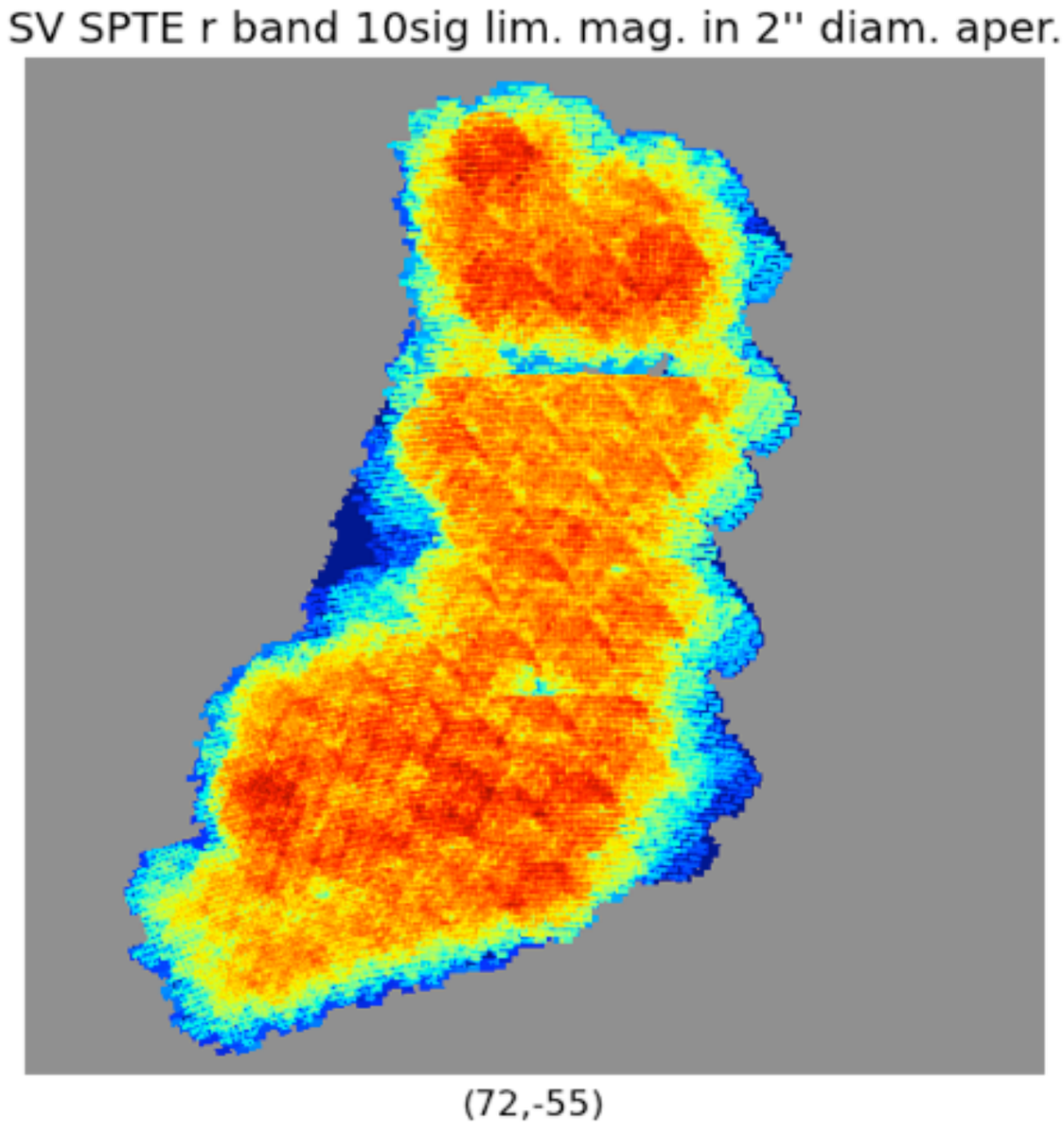
Step 4: merge the masks

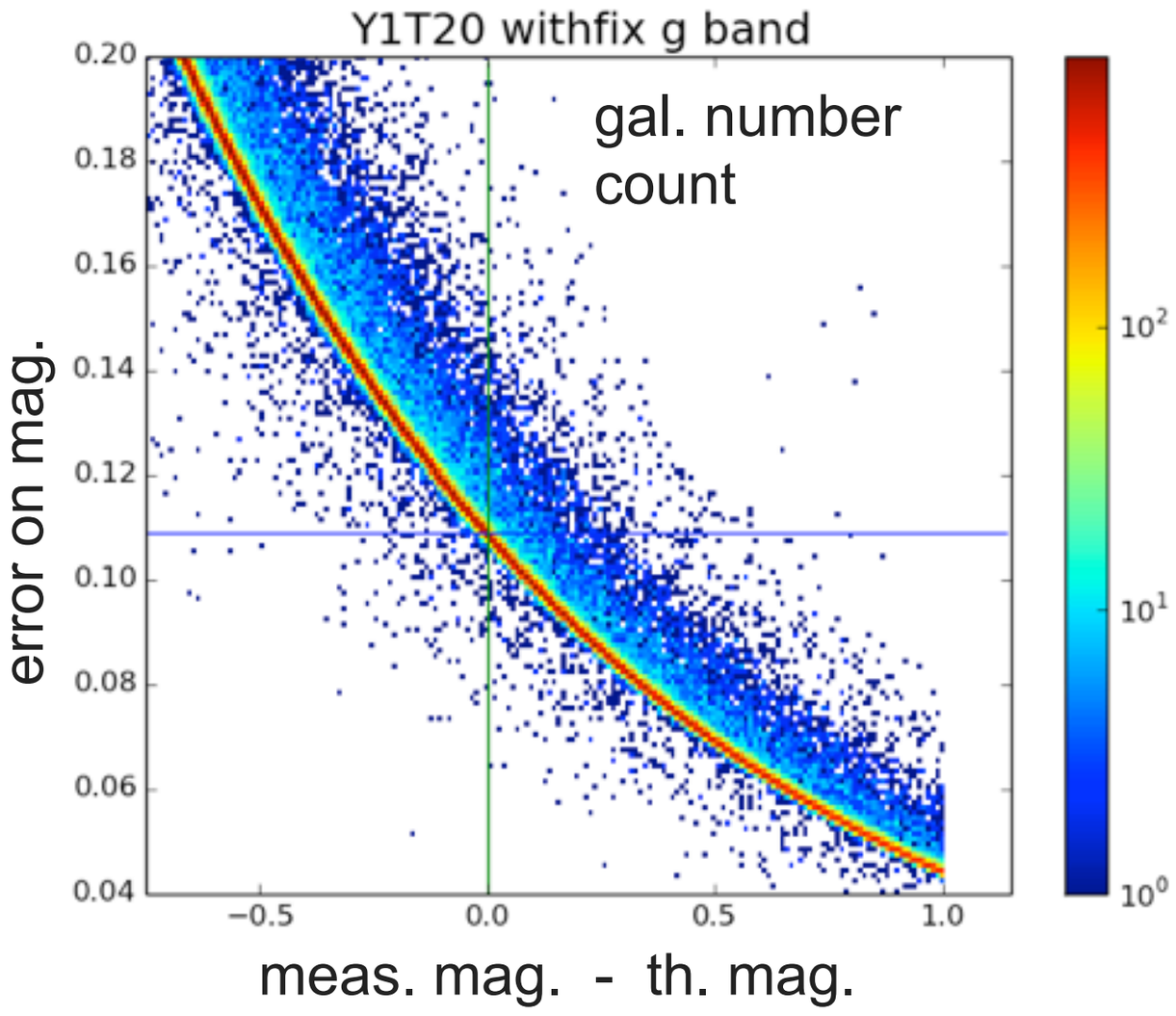




The DES Mangle pipeline

Step 5,6,...: Repeat for each tile, combine and project into a Healpix grid





Cross-correlation DES LSS / SPT CMB lensing

CMB lensing allows for the reconstruction of the matter distribution up to z~1100: the lensing potential

Galaxy selection

18.0 < *i* <22.5

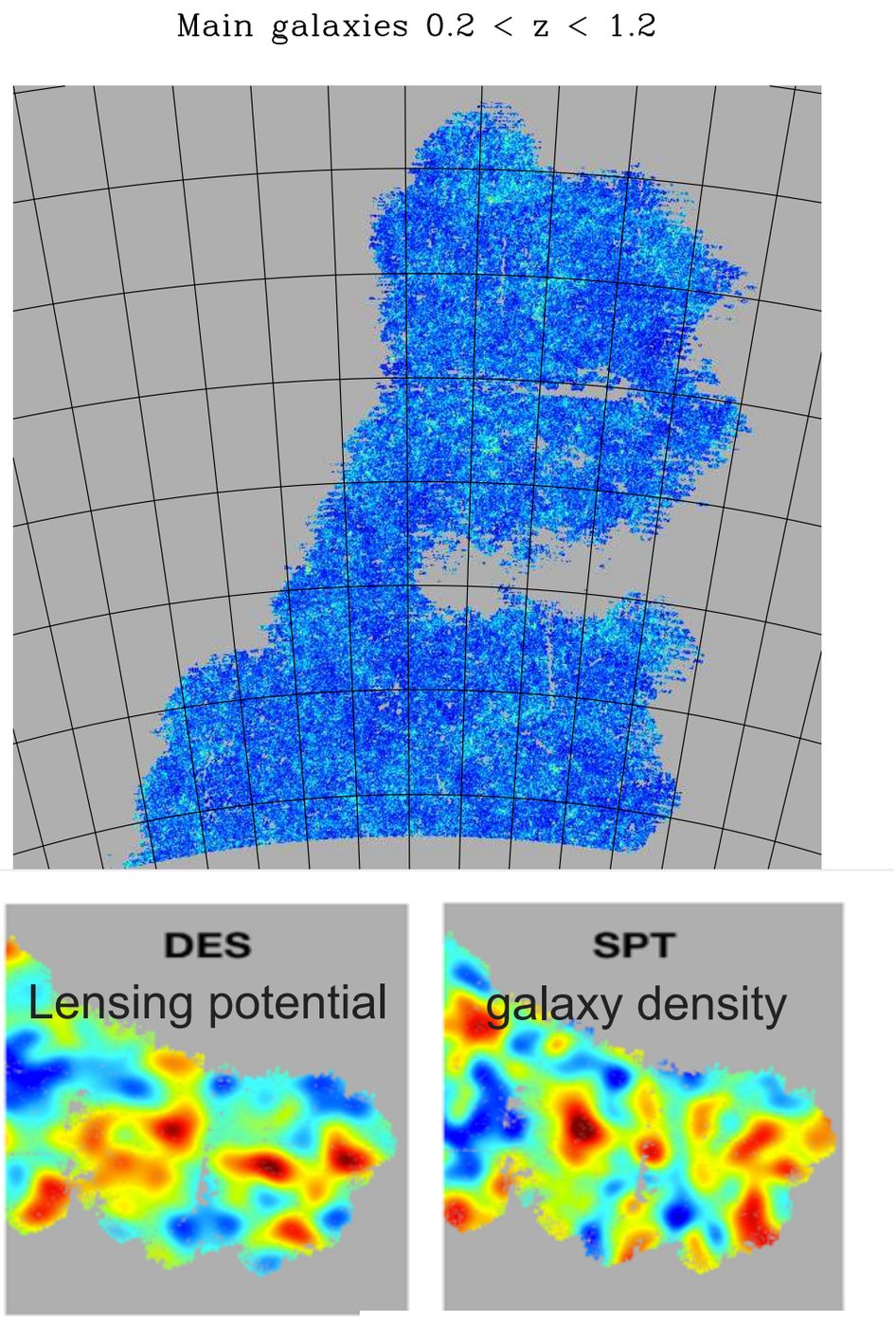
0.2 < photo-z < 1.2

Star-galaxy separation

SPT-E field

~2.6 million galaxies

5.6 gal/ sq. arcmin



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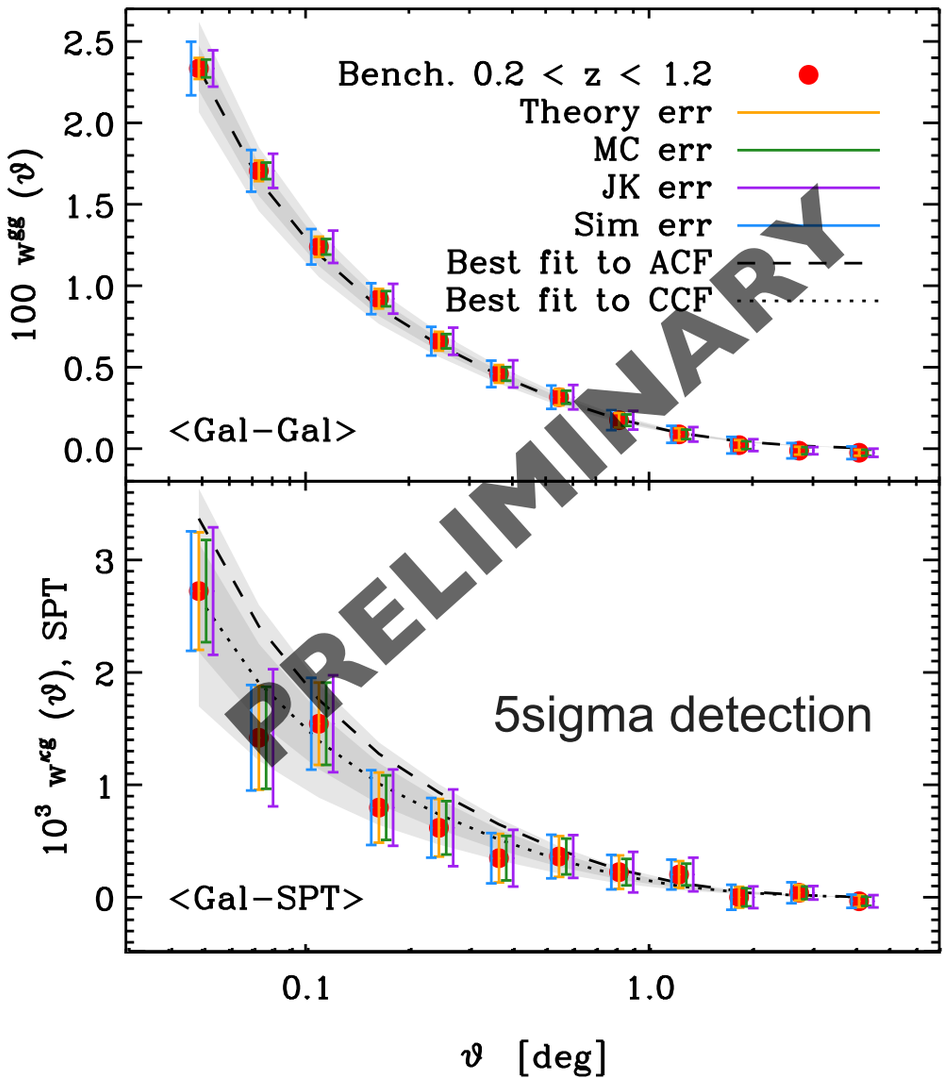

Giannantonio, Fosalba, Elzner, Leistedt, **ABL** et al , in prep.

Thanks to DES depth CMB lensing tomography. Coming soon!

Science papers in preparation with SV data

Galaxy Clustering and validation against CFHTLS

DES SV Galaxies cross-correlated with CMB lensing

SPT-SZE signature of DES SV RedMaPPer clusters

Galaxy Populations within SPT Selected Clusters

DES/XCS: X-ray properties of galaxy clusters in DES SV

The Dark Energy Survey SV Shear Catalogue: Pipeline and tests

Calibrated Ultra Fast Image Simulations for the Dark Energy Survey

The Dark Energy Survey Supernova Survey: Search Strategy and Algorithm

Wide-Field Mass Mapping with the DES SVA1 data

Galaxy bias from cross-correlation of weak lensing and galaxy maps in DES SVA1 data

Measurement of galaxy bias and stochasticity in DES SVA1 data

Galaxy-galaxy lensing with the DES SVA1 data.

etc., etc.

Conclusions

DES started operation in August 2013, end planned in 2018

Preliminary Science Verification data have enough quality to do science.

- Photo-z required precision reached
- Measure galaxy shapes around clusters
- Cosmic shear B-modes consistent with zero!
- Clustering measurement in line with previous results
- ....

DES papers submitted and published. More to come soon.

Year 1 data soon to be released to the collaboration

First competitive scientific results expected from first 2 season of data