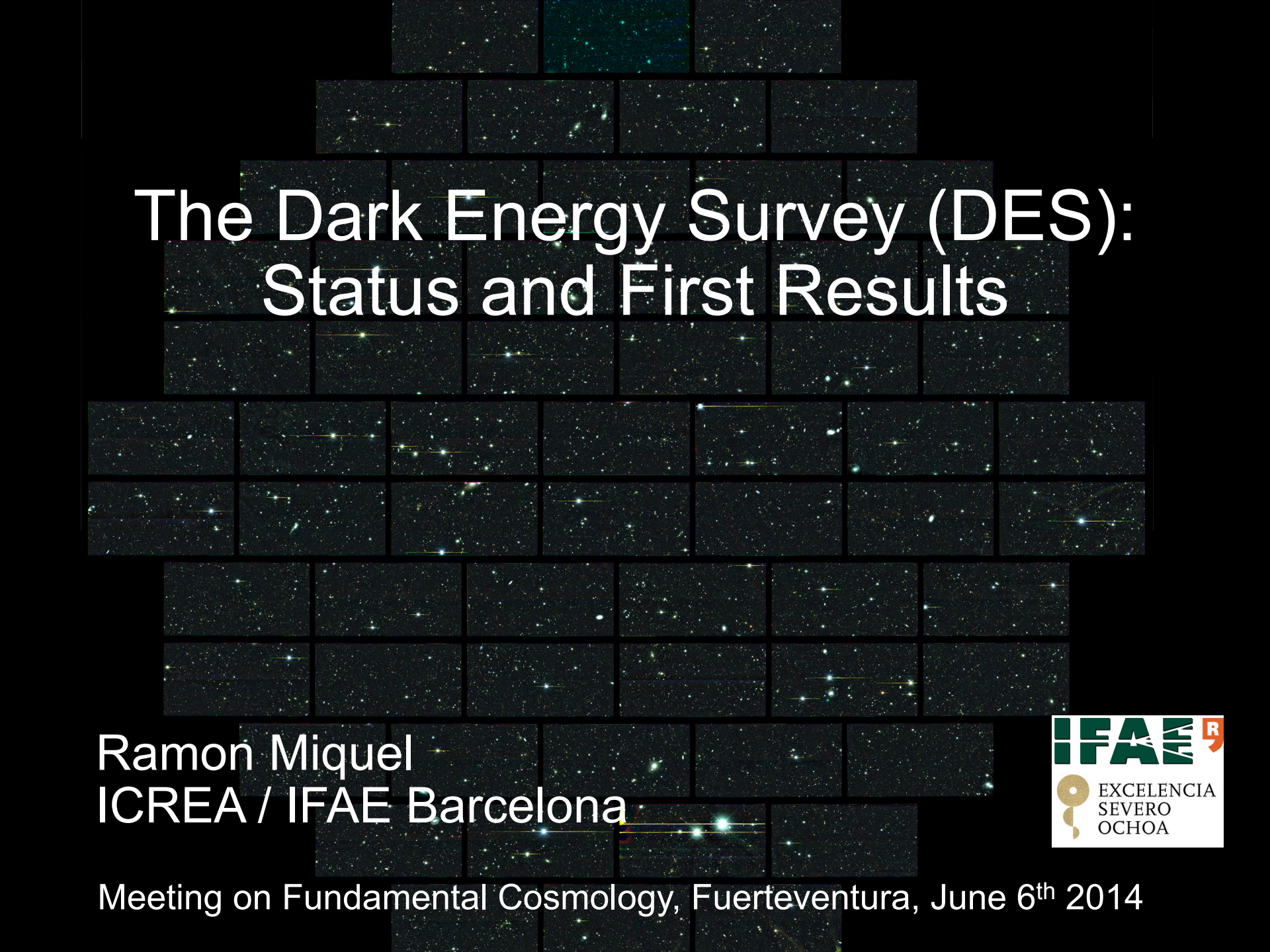


The Dark Energy Survey (DES): Status and First Results

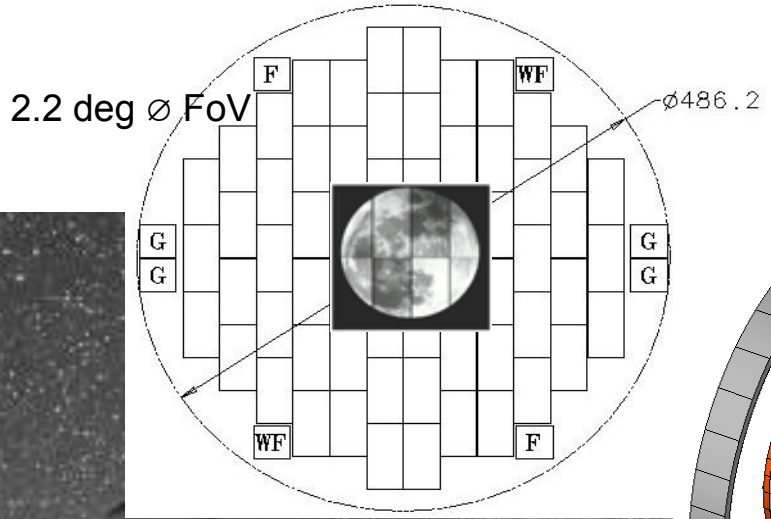
Ramon Miquel
ICREA / IFAE Barcelona

Meeting on Fundamental Cosmology, Fuerteventura, June 6th 2014

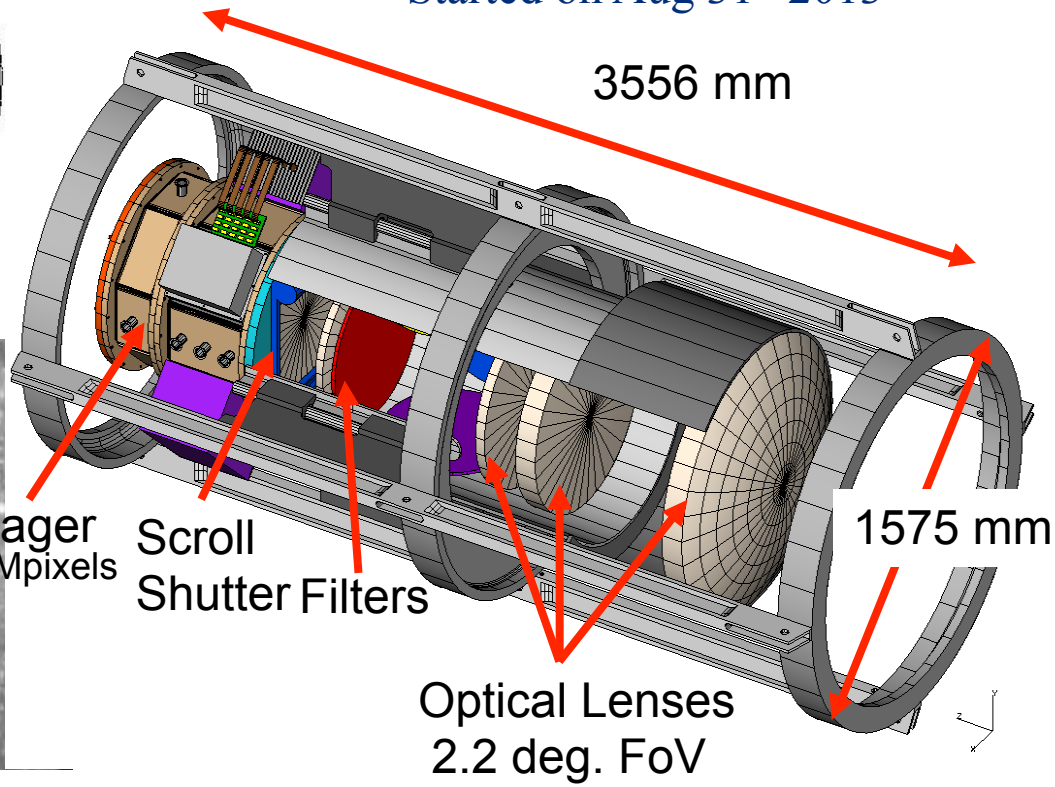
DES: Dark Energy Survey

DARK ENERGY SURVEY

- 5000 deg^2 galaxy survey to $i_{AB} < 24$ in grizY. 300M galaxies up to z < 1.4. Also 4000 SNe.
- Involves groups in USA (led by FNAL), Spain, UK, Brazil, Germany, Switzerland.



- 525 nights in 5 years
- Started on Aug 31st 2013



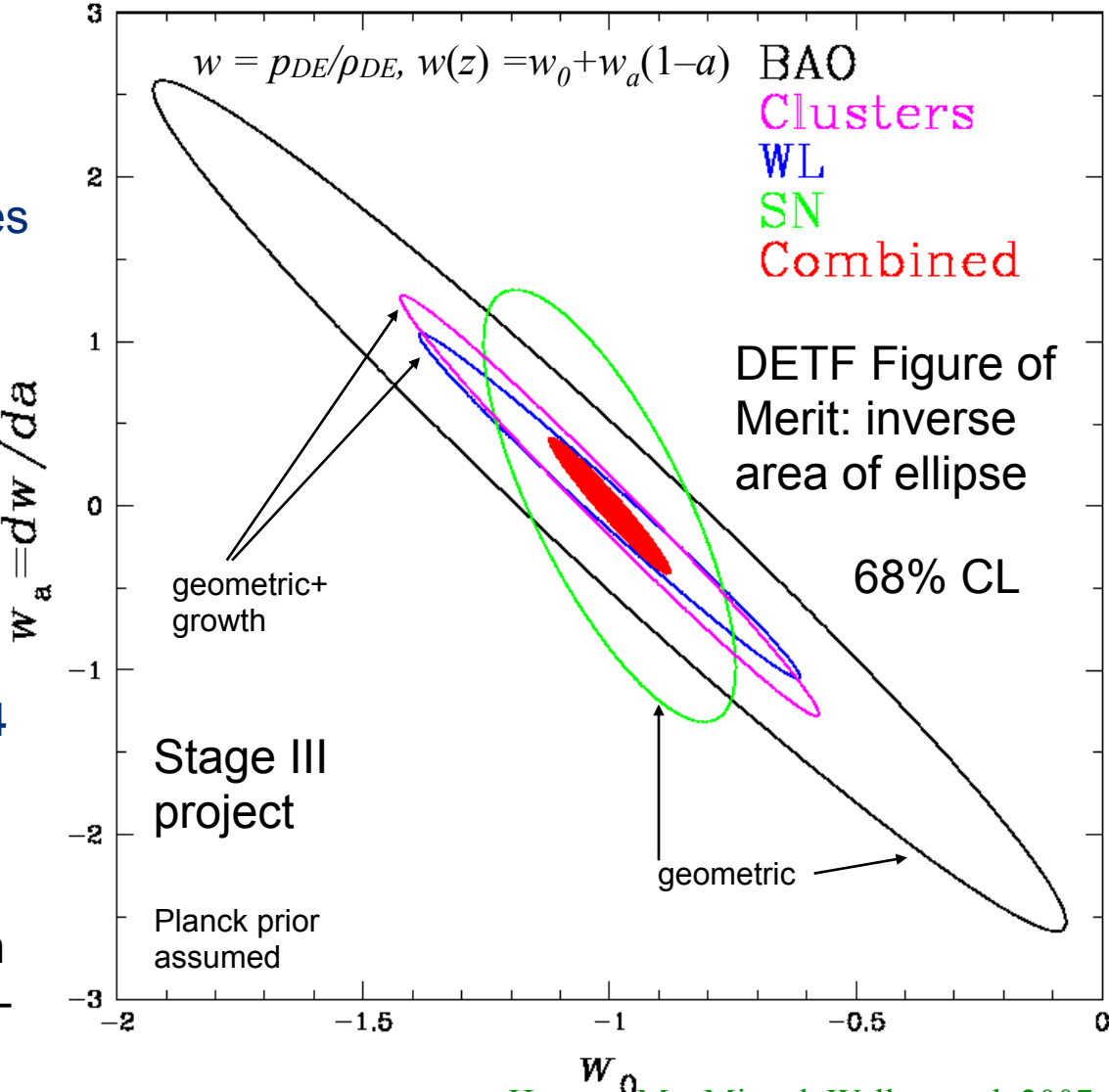
DES Science Program

DARK ENERGY SURVEY

Four Probes of Dark Energy

- Galaxy cluster counting: N(M,z)
  - Measure redshifts and masses
  - ~10,000 clusters to z>1 with $M > 2 \times 10^{14} M_{\odot}$
- Weak lensing (shear)
  - >200 million galaxies with shape measurements to z>1
- Large-scale structure (LSS). Includes BAO
  - ~300 million galaxies to z<1.4
- Supernovae
  - ~4000 type-Ia SNe to z>1

Probes are complementary in both systematic error and cosmological-parameter degeneracies



Huterer, Ma, Miquel, Weller, et al. 2007

DARK ENERGY SURVEY

The DES Collaboration

Fermilab — The Fermi National Accelerator Laboratory

Chicago — The University of Chicago

NOAO — The National Optical Astronomy Observatory

United Kingdom DES Collaboration

- UCL - University College London
- Cambridge - University of Cambridge
- Edinburgh - University of Edinburgh
- Portsmouth - University of Portsmouth
- Sussex - University of Sussex
- Nottingham - University of Nottingham

DES-Brazil Consortium

- ON - Observatorio Nacional
- CBPF - Centro Brasileiro de Pesquisas Fisicas
- UFRGS - Universidade Federal do Rio Grande do Sul

OSU — The Ohio State University

TAMU — Texas A&M University

Munich—Universitäts-Sternwarte München

- Ludwig-Maximilians Universität
- Excellence Cluster Universe

UIUC/NCSA — The University of Illinois at Urbana-Champaign

LBNL — The Lawrence Berkeley National Laboratory

Spain DES Collaboration

- IEEC/CSIC - Instituto de Ciencias del Espacio,
- IFAE - Institut de Fisica d'Altes Energies
- CIEMAT - Centro de Investigaciones Energeticas, Medioambientales y Tecnologicas

Michigan — The University of Michigan

Pennsylvania — The University of Pennsylvania

ANL — Argonne National Laboratory

Santa Cruz-SLAC-Stanford DES Consortium

- Santa Cruz - University of California Santa Cruz
- SLAC - SLAC National Accelerator Laboratory
- Stanford - Stanford University

ETH-Zuerich — Eidgenoessische Technische Hochschule Zuerich

DARK ENERGY SURVEY

DES/Spain

CIEMAT
E. Sánchez
I. Sevilla
F. J. Rodríguez, J. de Vicente
M. García, R. Ponce, F. J. Sánchez

ICE/IEEC
F. J. Castander, E.Gaztañaga, P. Fosalba
A. Bauer, M.Crocce
S. Serrano
K. Hoffman, A. Izard, A. Pujol

IFAE
E. Fernández, R. Miquel
J. Aleksić, Ch. Bonnett, A. Kovács (starting in September)
O. Ballester, L. Cardiel
P. Martí, C. Sánchez, I. Troyano

UAM
J. García-Bellido
D. Sapone, S. Nesseris, R. Villamariz
S. Ávila, A. Salvador,

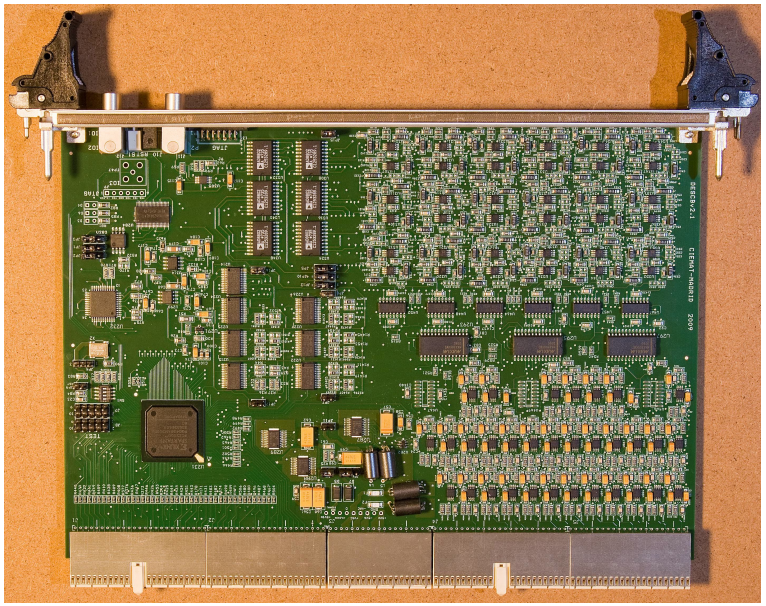
Color Code

Senior Scientists
Post-docs
Engineers
Doctoral Students

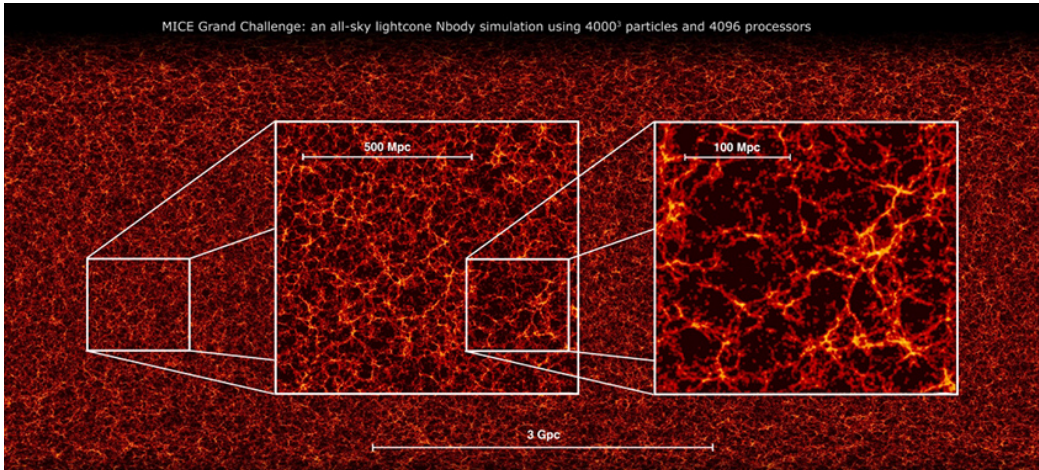
Main Spanish Contributions to DES

DARK ENERGY SURVEY

- Electronics:
  - Design of the Clock & Bias Board (CIEMAT), Transition Board (IFAE / CIEMAT) and Master Control Board (IFAE)
  - Production, test and commissioning of the whole read-out electronics for DECam: 108 boards, finished in 2010 (IFAE / CIEMAT)
  - CCD characterization (CIEMAT / IFAE / ICE)



- Simulations:
  - Large-scale simulations of the universe (ICE)
  - Data management (IFAE / PIC)
  - Data quality checks (CIEMAT)



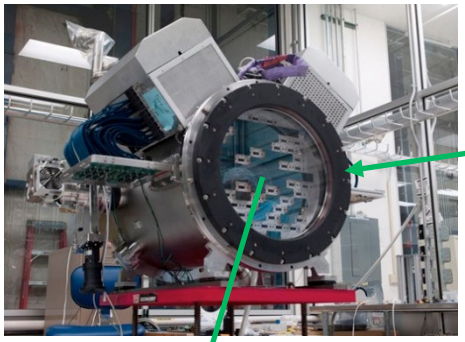
DARK ENERGY SURVEY

DES/Spain in DES Governance

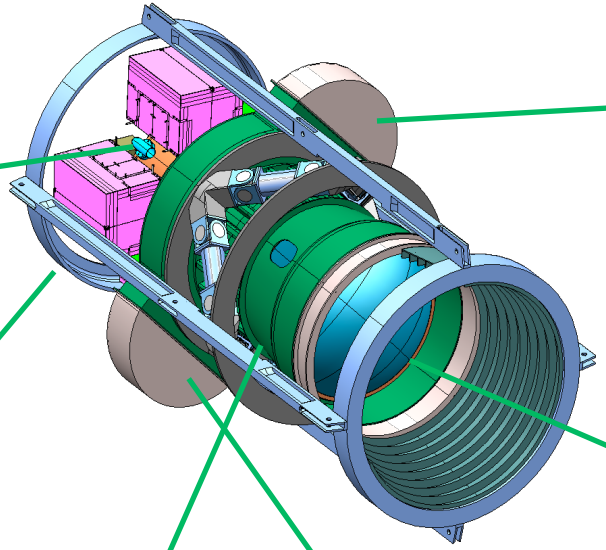
- Two voting members in Management Committee (EG, RM)
- Science Working Group coordination:
  - Large-scale structure (including BAO) (EG)
  - Photo-z (FC)
- Publication board (RM)
- Membership committee (ES)
- Data Management users coordinator (IS)
- Speakers bureau (RM, Chair)
- Builders committee (EF)
- Publication policy committee (RM)
- Membership policy committee (ES)
- Search committee for new DES director (RM)
- Front-end electronics panel (ES, GM, MM (Chair))
- Organized three DES Collaboration meetings: 2006, 2010, 2013

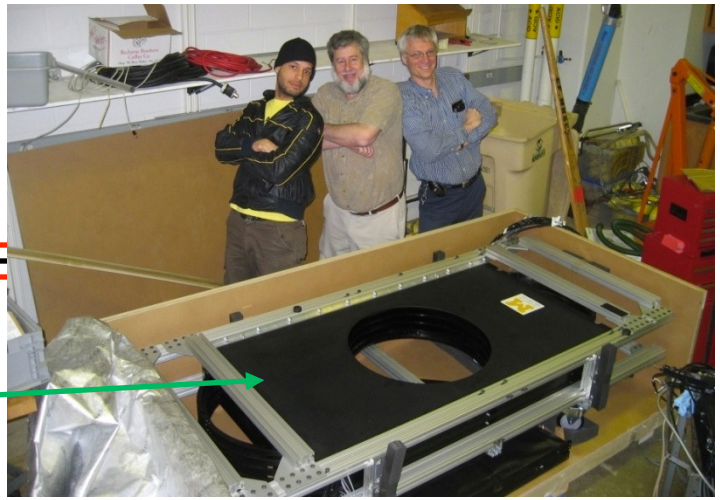
DECam Systems

DARK ENERGY SURVEY

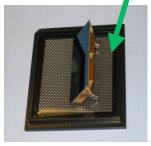


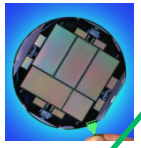
Imager, FNAL





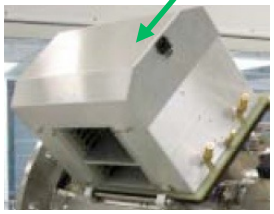
Filter changer, Univ. of Michigan





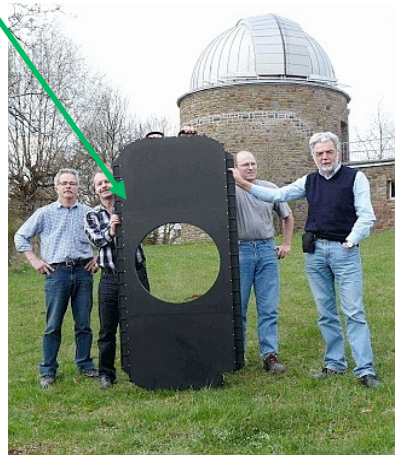
CCDs, wafers from LBL, packaged at FNAL

Barrel and cage, FNAL

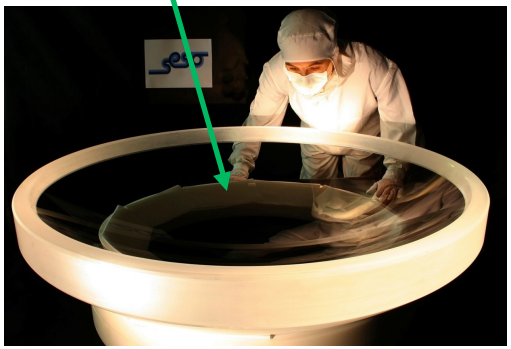


Electronics, Spain and FNAL

Hexapod, Italy



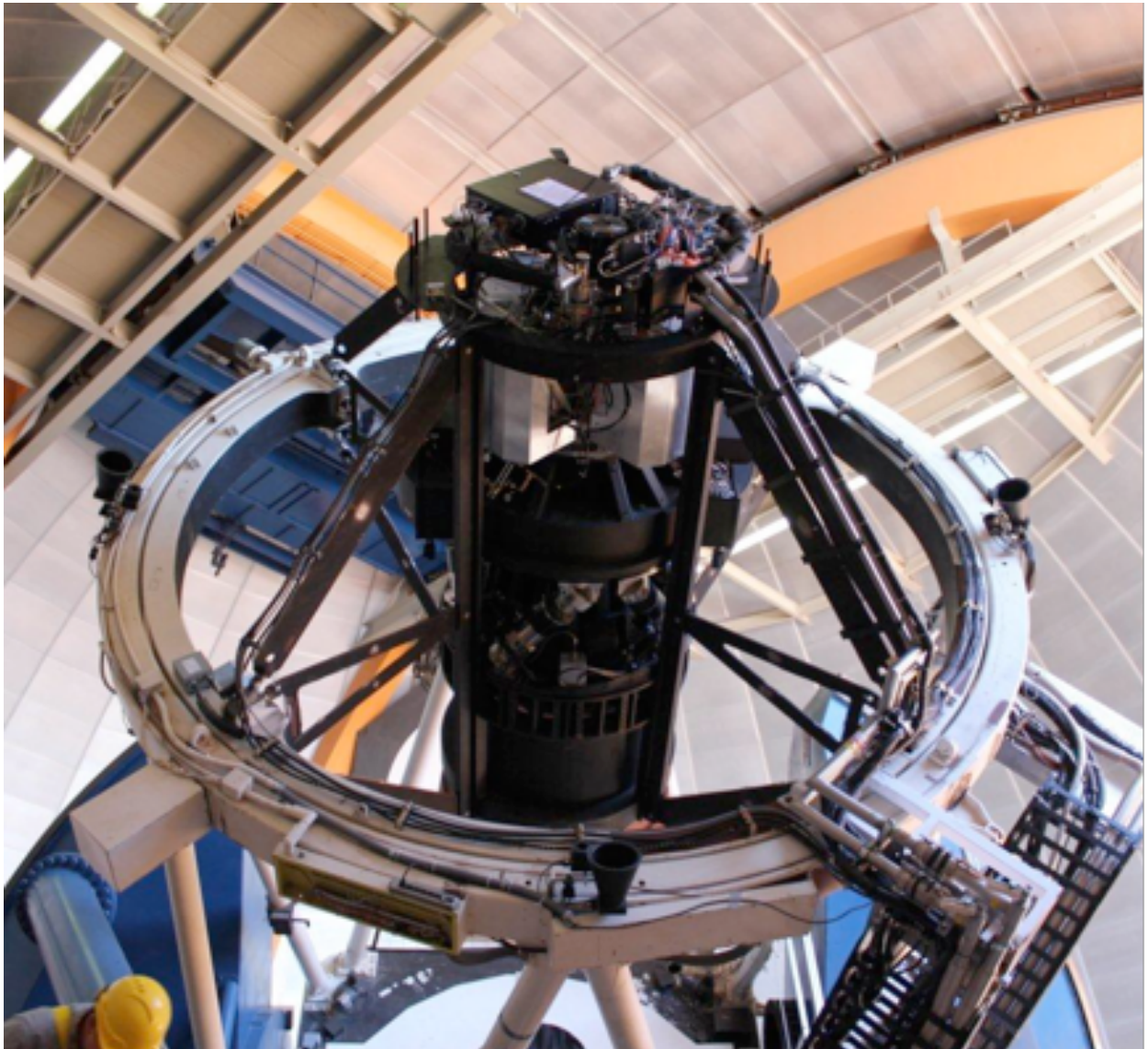
Shutter, Germany



Lenses, UK

DARK ENERGY
SURVEY

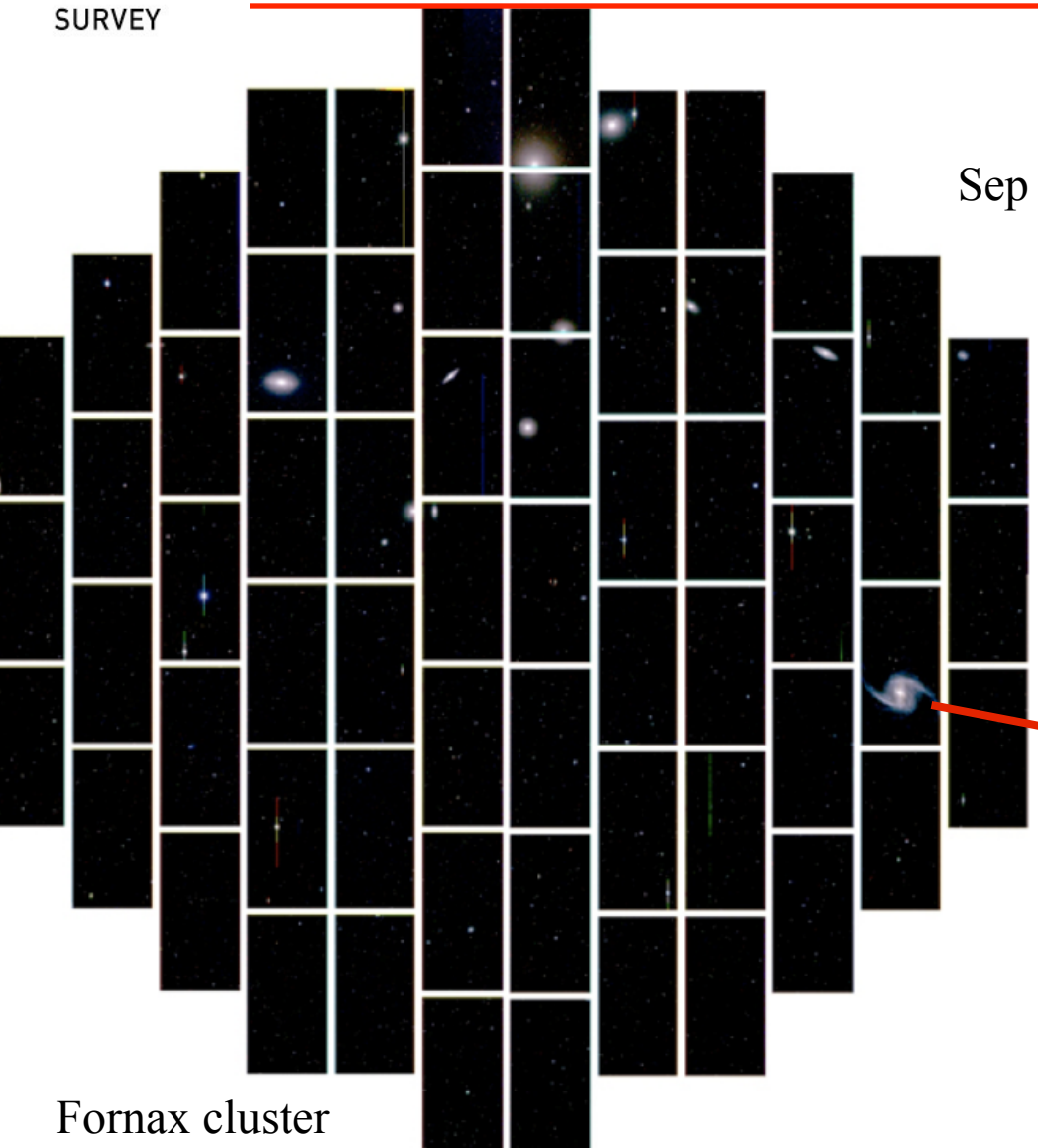
DECam on the Blanco (Sep '12)



First DECam Image

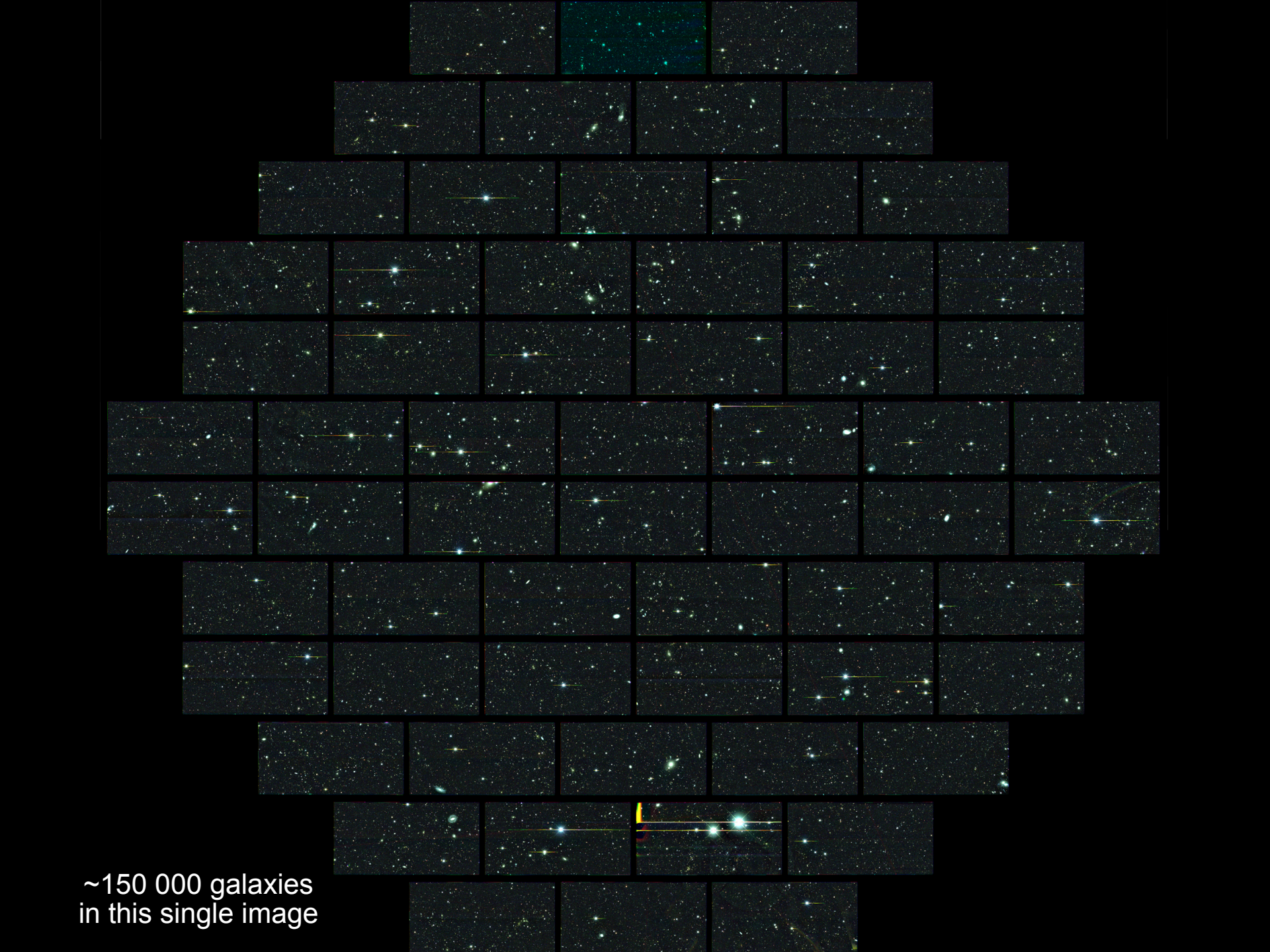
DARK ENERGY SURVEY

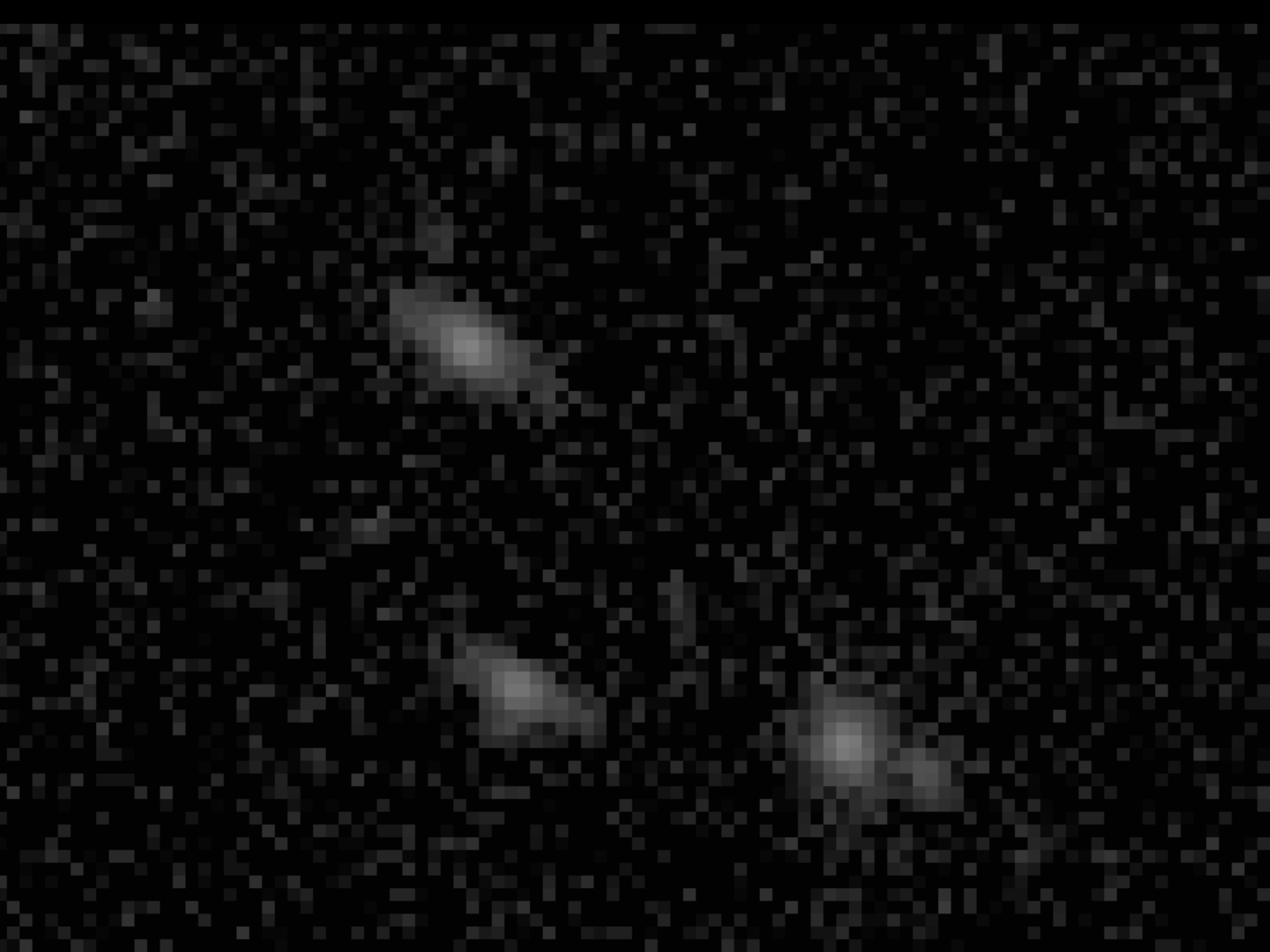
Sep 12, 2012



Fornax cluster

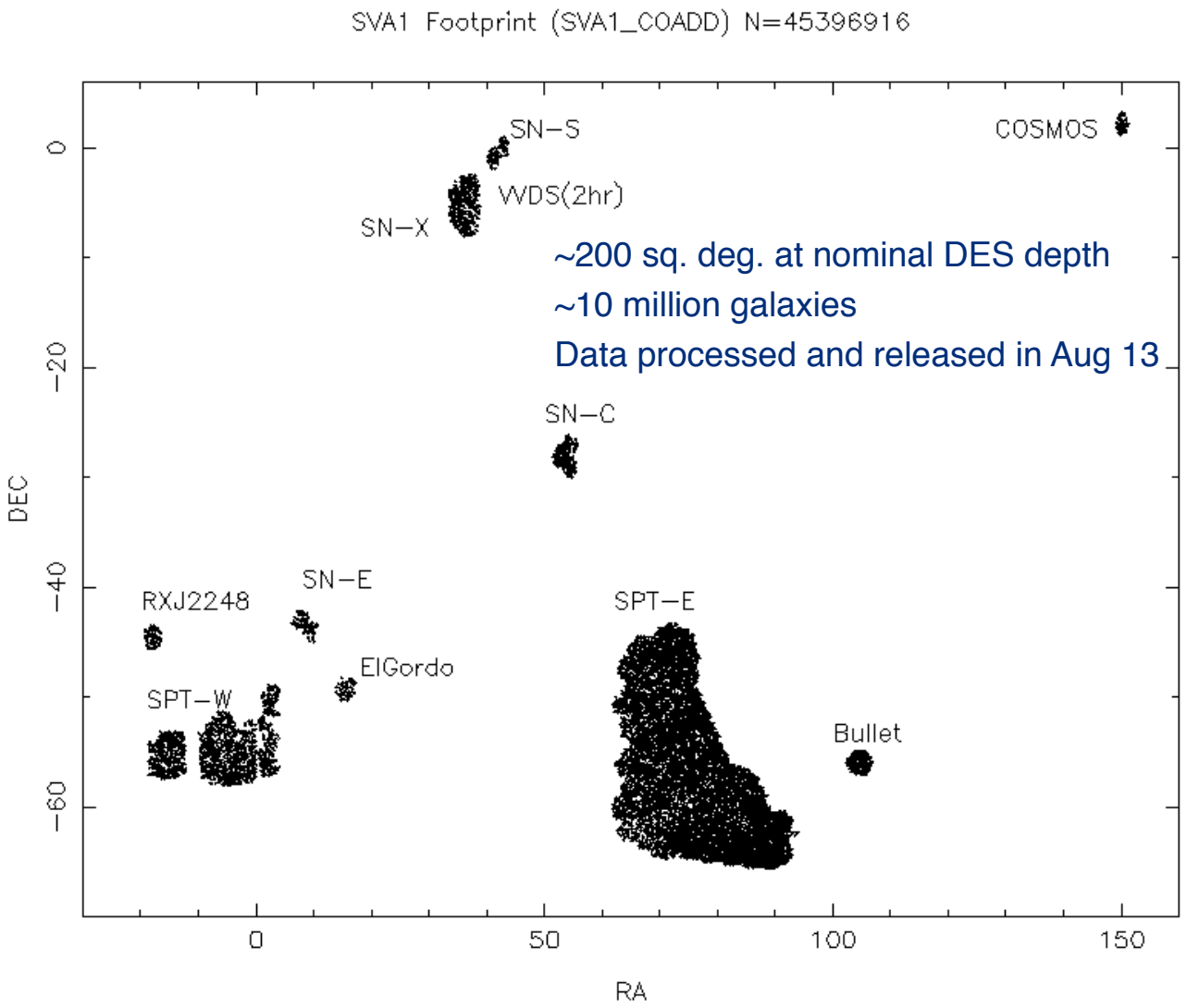
NGC 1365


~150 000 galaxies
in this single image



Science Verification (SV): Nov 12 - Feb 13

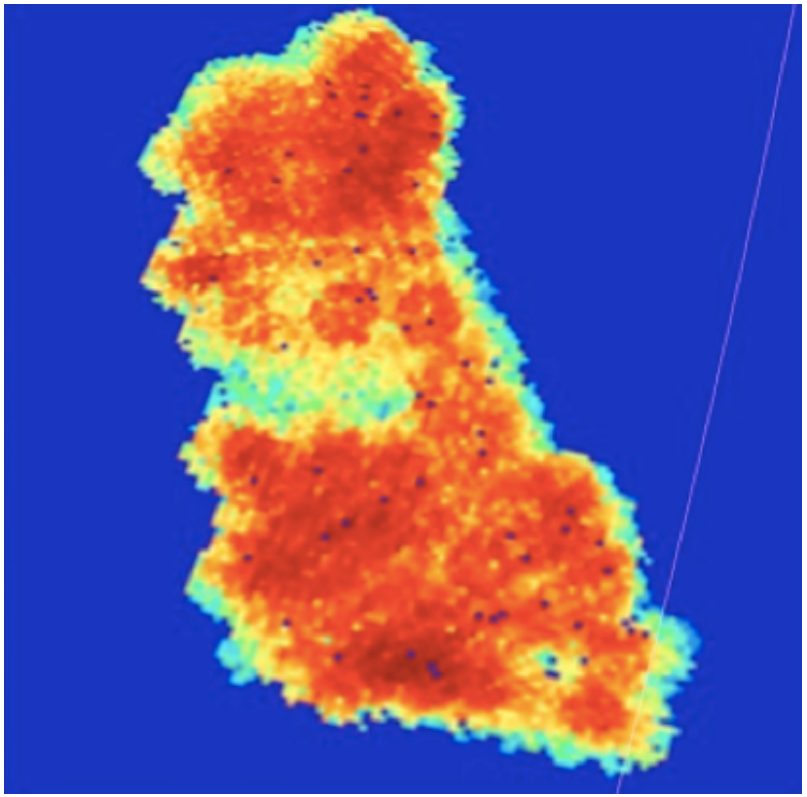
DARK ENERGY SURVEY



SV Data Analysis. Pre-requisites

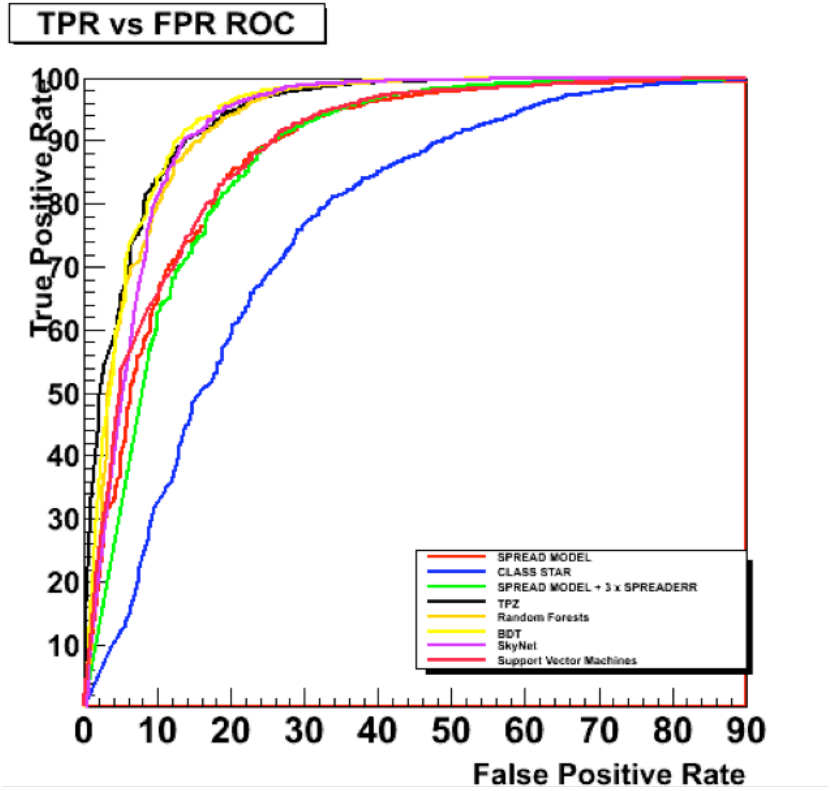
DARK ENERGY SURVEY

Mask: knowledge of the depth of the survey at each point in the footprint



i-band mask for the SPT-E area

Star / galaxy separation: main source of contamination



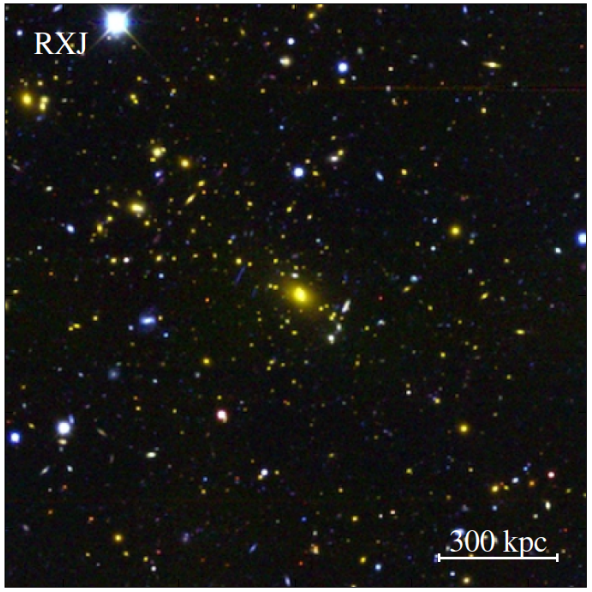
Eff. vs. bgnd. for several methods of s/g sep.

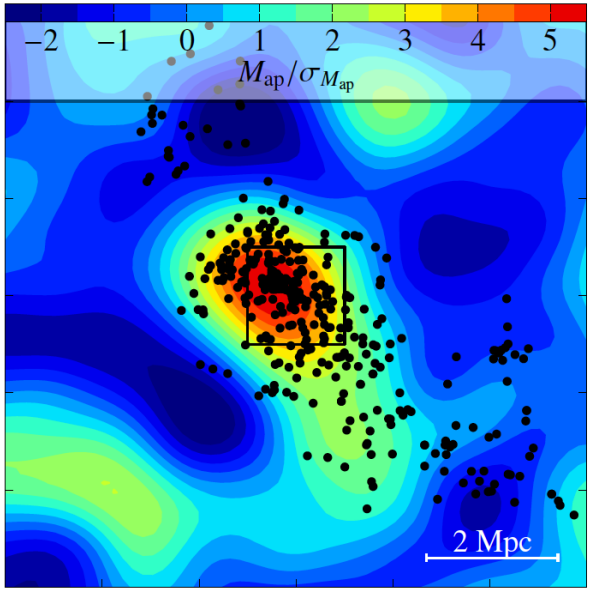
DES/Spain heavily involved in (or leading) these crucial efforts

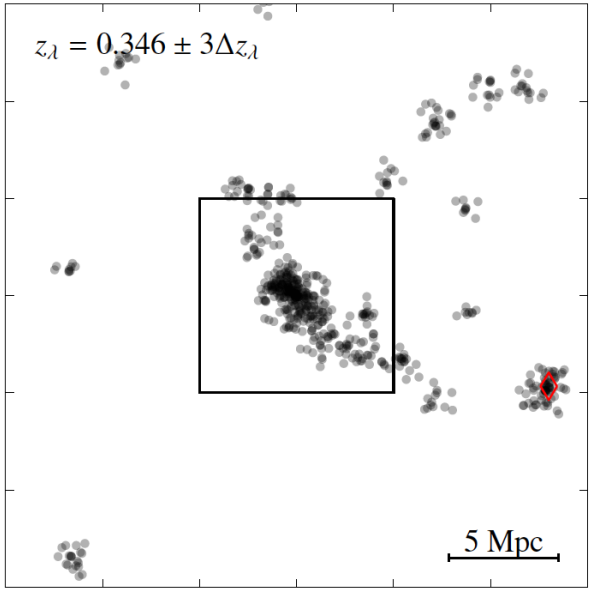
First DES Paper Out on May 16th

DARK ENERGY SURVEY

P. Melchior et al. **Mass and galaxy distributions of four massive galaxy clusters from Dark Energy Survey Science Verification data**







ΔDec

First DES Paper Out on May 16th

DARK ENERGY SURVEY

P. Melchior et al. **Mass and galaxy distributions of four massive galaxy clusters from Dark Energy Survey Science Verification data**

Table 4. Weak lensing masses M_{200c} in units of $10^{14}M_{\odot}$ (with a flat prior on c_{200c}), redMaPPer richness λ and redshift estimate z_{λ}, and their statistical errors (see Section 3.2 and Section 5.1 for details). The literature mass estimates are derived from weak lensing, galaxy dynamics (D) or optical richness (R).

Cluster name	M_{200c}	λ	z_{λ}	Literature value M_{200c}
RXC J2248.7-4431	$17.6^{+4.5}_{-4.0}$	203 ± 5	0.346 ± 0.004	$22.8^{+6.6}_{-4.7}$ (Gruen et al. 2013b), 20.3 ± 6.7 (Umetsu et al. 2014), 16.6 ± 1.7 (Merten et al. 2014)
1E 0657-56	$14.2^{+10.0}_{-6.1}$	277 ± 6	0.304 ± 0.004	17.5 (Clowe et al. 2004)[i], 12.4 (Barrena et al. 2002, D)
SCSO J233227-535827	$10.0^{+3.7}_{-3.4}$	77 ± 4	0.391 ± 0.008	$11.2^{+3.0}_{-2.7}$ (Gruen et al. 2013a), $4.9 \pm 3.3 \pm 1.4$ (High et al. 2010, R)
Abell 3261	$8.6^{+8.6}_{-3.9}$	71 ± 3	0.216 ± 0.003	—

[i] We converted the measured r_{200c} from Clowe et al. (2004), which lacks an error estimate, to M_{200c} using the critical density in our adopted cosmology.

This paper proves that DES can measure galaxy shapes, even in the Science Verification preliminary data set.

Photometric redshift analysis in the Dark Energy Survey Science Verification data

C. Sánchez[1⋆], M. Carrasco Kind[2], H. Lin[3], R. Miquel[1,4], F. Abdalla[5], A. Amara[6], M. Banerji[5], C. Bonnett[1], R. Brunner[2], A. Carnero[7,8], F. J. Castander[9], L. A. N. da Costa[7,8], C. Cunha[10], A. Fausti[8], D. Gerdes[11], N. Greisel[12,13], J. Gschwend[7], W. Hartley[6,14], S. Jouvel[5], O. Lahav[5], M. Lima[15,8], M. A. G. Maia[7,8], P. Martí[1], R. L. C. Ogando[7,8], F. Ostrovski[7,8], P. Pellegrini[7], M. M. Rau[12,13], I. Sadeh[5], S. Seitz[12,13], N. Sevilla[16], A. Sypniewski[11], J. de Vicente[16] + *builders*

[1] *Institut de Física d'Altes Energies, Universitat Autònoma de Barcelona, E-08193 Bellaterra (Barcelona), Spain*
[2] *Department of Astronomy, University of Illinois, Urbana, IL 61820 USA*
[3] *Center for Particle Astrophysics, Fermi National Accelerator Laboratory, P.O. Box 500, Batavia, IL 60510, USA*
[4] *Institució Catalana de Recerca i Estudis Avançats, E-08010 Barcelona, Spain*
[5] *Department of Physics & Astronomy, University College London, Gower Street, London WC1E 6BT, UK*
[6] *ETH Zurich, Institut fur Astronomie, HIT J 11.3, Wolfgang-Pauli-Str. 27, 8093 Zurich, Switzerland*
[7] *Observatório Nacional (ON/MCT), Rua General José Cristino, 77, Rio de Janeiro 20921-400 - RJ, Brazil*
[8] *Laboratório Nacional de e-Astronomia, Rua General José Cristino, 77, 20921-400 São Cristóvao, Rio de Janeiro, RJ, Brazil*
[9] *Institut de Ciències de l'Espai (ICE, IEEC/CSIC), E-08193 Bellaterra (Barcelona), Spain*
[10] *Kavli Institute for Particle Astrophysics and Cosmology, 452 Lomita Mall, Stanford University, Stanford, CA 94305, USA*
[11] *Department of Physics, University of Michigan, Ann Arbor, MI 48109, USA*
[12] *University Observatory Munich, Scheinerstrasse 1, 81679 Munich, Germany*
[13] *Max Planck Institute for Extraterrestrial Physics, Giessenbachstrasse, 85748 Garching, Germany*
[14] *University of Nottingham, School of Physics and Astronomy, Nottingham NG7 2RD, UK*
[15] *Departamento de Física Matemática, Instituto de Física, Universidade de Sao Paulo, Sao Paulo, SP CP 66318, CEP 05314-970, Brazil*
[16] *Centro de Investigaciones Energéticas Medioambientales y Tecnológicas, Av.Complutense 40, 28040 Madrid, Spain*

21 May 2014

ABSTRACT

We present results from a study of the photometric redshift performance of the Dark Energy Survey (DES), using the early data from a Science Verification (SV) period of observations in late 2012 and early 2013 that provided science-quality images for almost 200 sq. deg. at the nominal depth of the survey. We assess the photometric redshift performance using about 15000 galaxies with spectroscopic redshifts available from other surveys. These galaxies are used, in different configurations, as a calibration sample, and photo-z's are obtained and studied using most existing photo-z codes. A weighting method in a multi-dimensional color-magnitude space is applied to the spectroscopic sample in order to evaluate the photo-z performance with sets that mimic the full DES photometric sample, which is on average significantly deeper than the calibration sample, due to the limited depth of spectroscopic surveys. Empirical photo-z methods using, for instance, Artificial Neural Networks or Random Forests, yield the best performance in the tests, achieving core photo-z resolutions $\sigma_{68} \sim 0.08$. Moreover, the results from most of the codes, including template fitting methods, comfortably meet the DES requirements on photo-z performance, therefore, providing an excellent precedent for future DES data sets.

Photometric redshift analysis in the Dark Energy Survey Science Verification data

C. Sánchez[1⋆], M. Carrasco Kind[2], H. Lin[3], R. Miquel[1,4], F. Abdalla[5], A. Amara[6], M. Banerji[5], C. Bonnett[1], R. Brunner[2], A. Carnero[7,8], F. J. Castander[9], L. A. N. da Costa[7,8], C. Cunha[10], A. Fausti[8], D. Gerdes[11], N. Greisel[12,13], J. Gschwend[7], W. Hartley[6,14], S. Jouvel[5], O. Lahav[5], M. Lima[15,8], M. A. G. Maia[7,8], P. Martí[1], R. L. C. Ogando[7,8], F. Ostrovski[7,8], P. Pellegrini[7], M. M. Rau[12,13], I. Sadeh[5], S. Seitz[12,13], N. Sevilla[16], A. Sypniewski[11], J. de Vicente[16] + *builders*

[1] *Institut de Física d'Altes Energies, Universitat Autònoma de Barcelona, E-08193 Bellaterra (Barcelona), Spain*
[2] *Department of Astronomy, University of Illinois, Urbana, IL 61820 USA*
[3] *Center for Particle Astrophysics, Fermi National Accelerator Laboratory, P.O. Box 500, Batavia, IL 60510, USA*
[4] *Institució Catalana de Recerca i Estudis Avançats, E-08010 Barcelona, Spain*
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[7] *Observatório Nacional (ON/MCT), Rua General José Cristino, 77, Rio de Janeiro 20921-400 - RJ, Brazil*
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[10] *Kavli Institute for Particle Astrophysics and Cosmology, 452 Lomita Mall, Stanford University, Stanford, CA 94305, USA*
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[12] *University Observatory Munich, Scheinerstrasse 1, 81679 Munich, Germany*
[13] *Max Planck Institute for Extraterrestrial Physics, Giessenbachstrasse, 85748 Garching, Germany*
[14] *University of Nottingham, School of Physics and Astronomy, Nottingham NG7 2RD, UK*
[15] *Departamento de Física Matemática, Instituto de Física, Universidade de Sao Paulo, Sao Paulo, SP CP 66318, CEP 05314-970, Brazil*
[16] *Centro de Investigaciones Energéticas Medioambientales y Tecnológicas, Av.Complutense 40, 28040 Madrid, Spain*

21 May 2014

ABSTRACT

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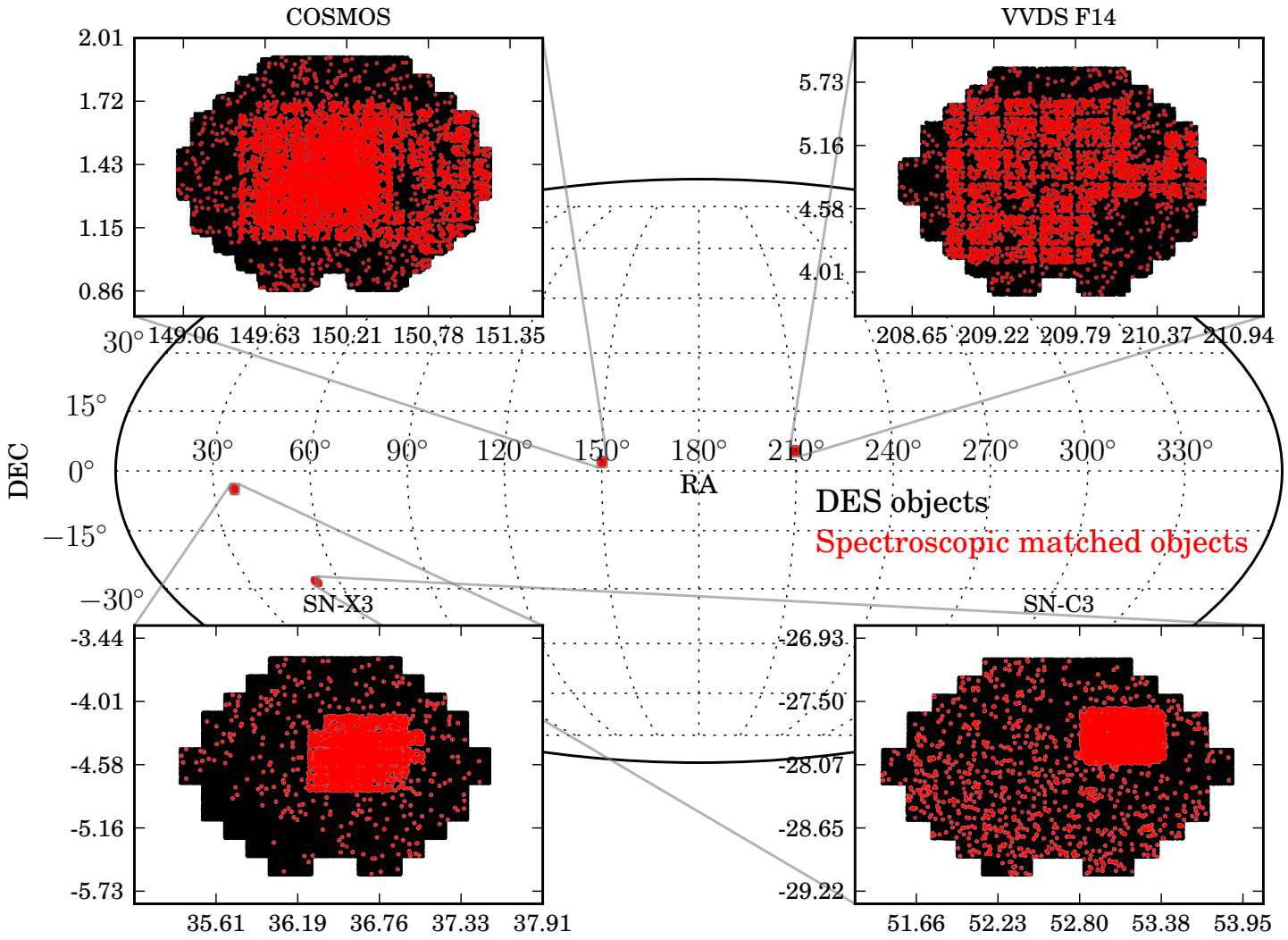
Photo-z Calibration Fields in DES SV

DARK ENERGY SURVEY

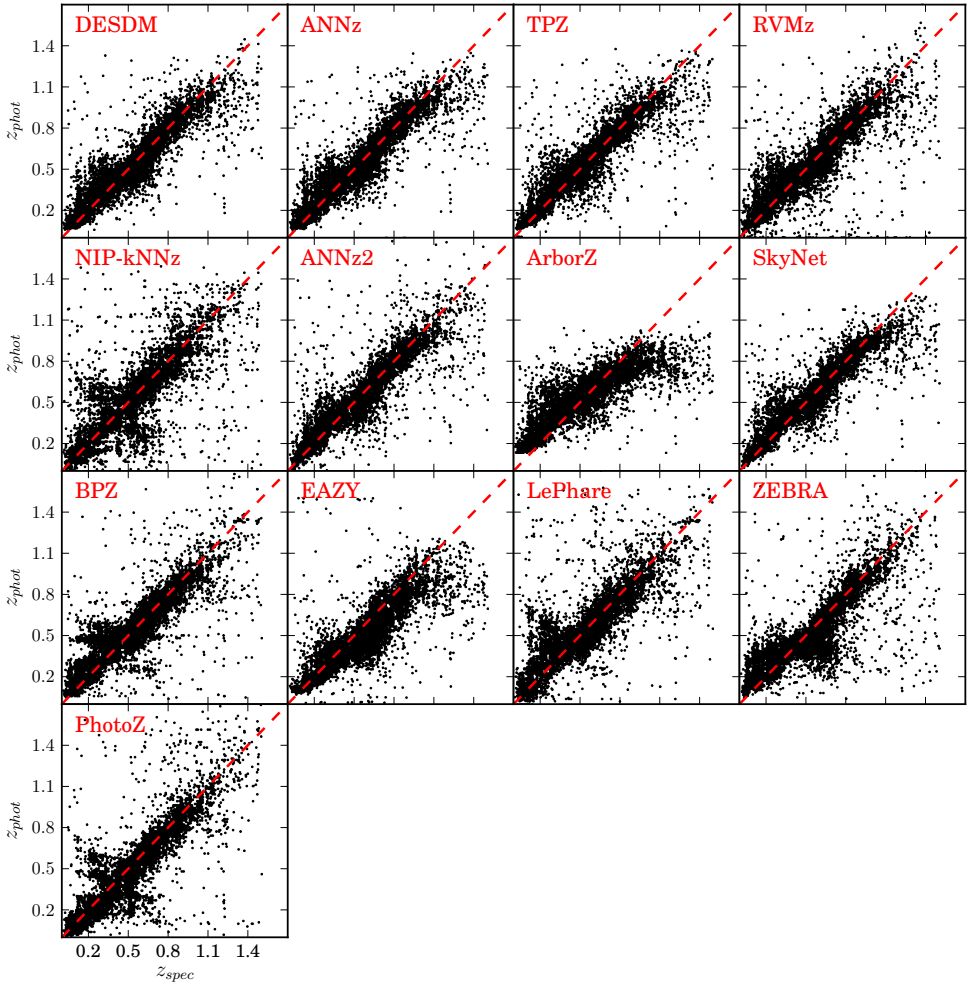


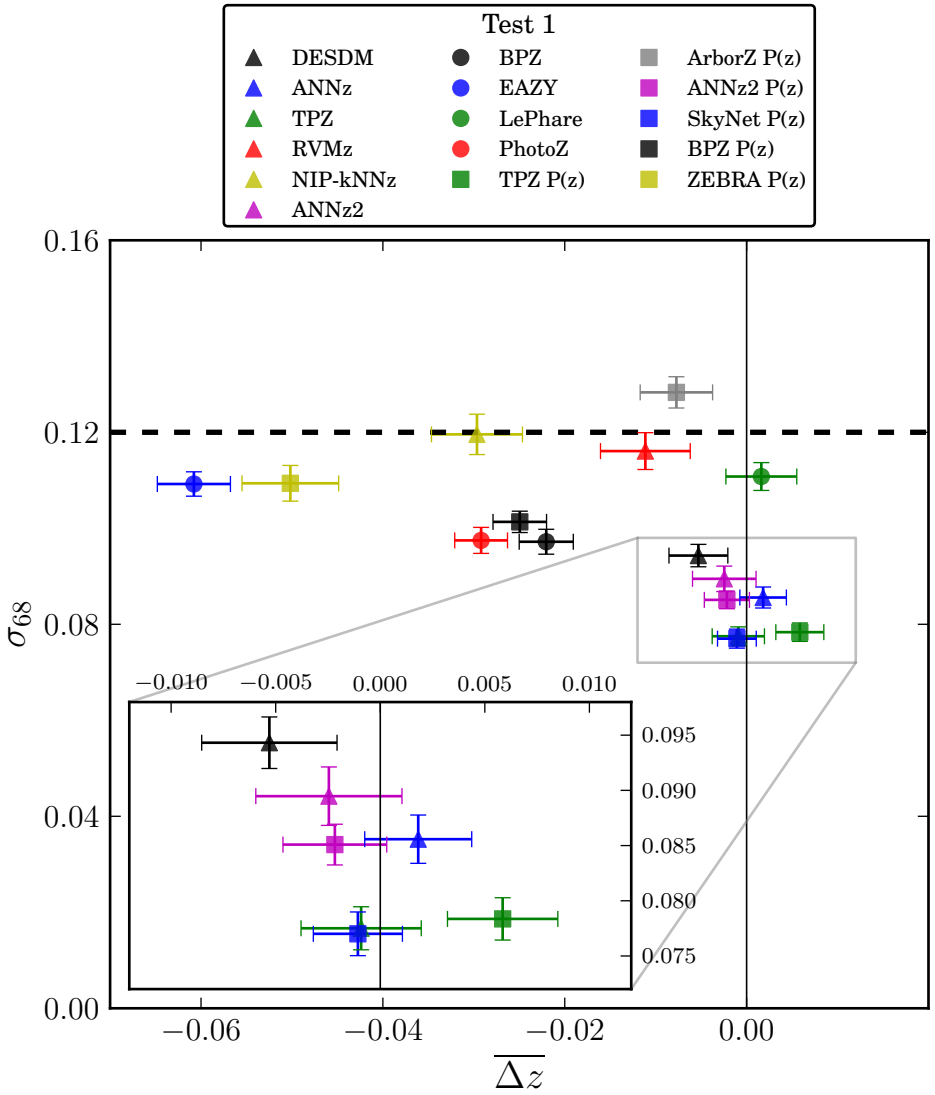
Photometry:
grizY
$18 < i_{AB} < 24$
$0 < g\text{-}r < 2$
$0 < r\text{-}i < 2$

Spectroscopy:
$0.01 < z < 1.4$
$3 \leq z\_flag < 5$
about 15600 gal

13 Photo-z Algorithms Have Been Tried

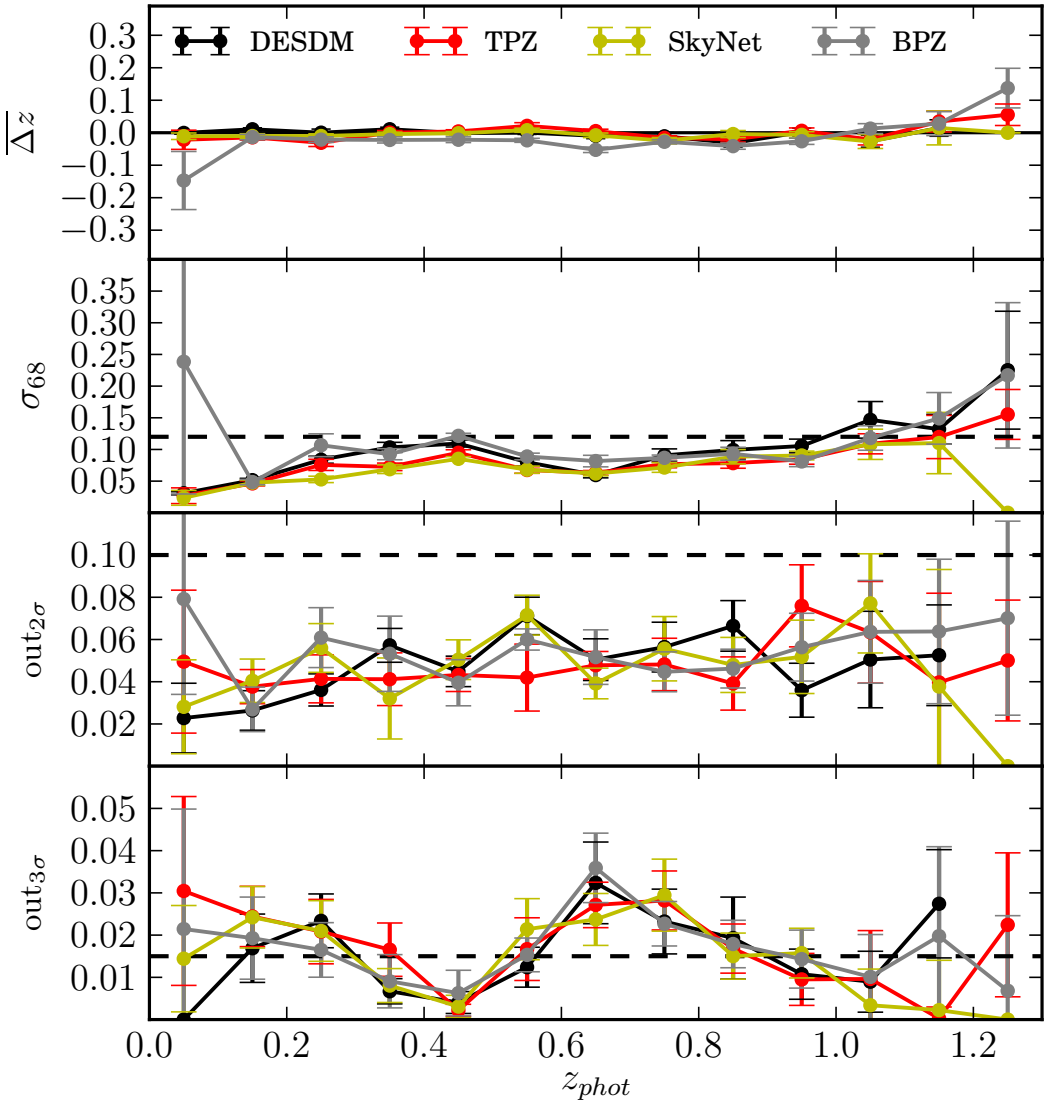
DARK ENERGY SURVEY





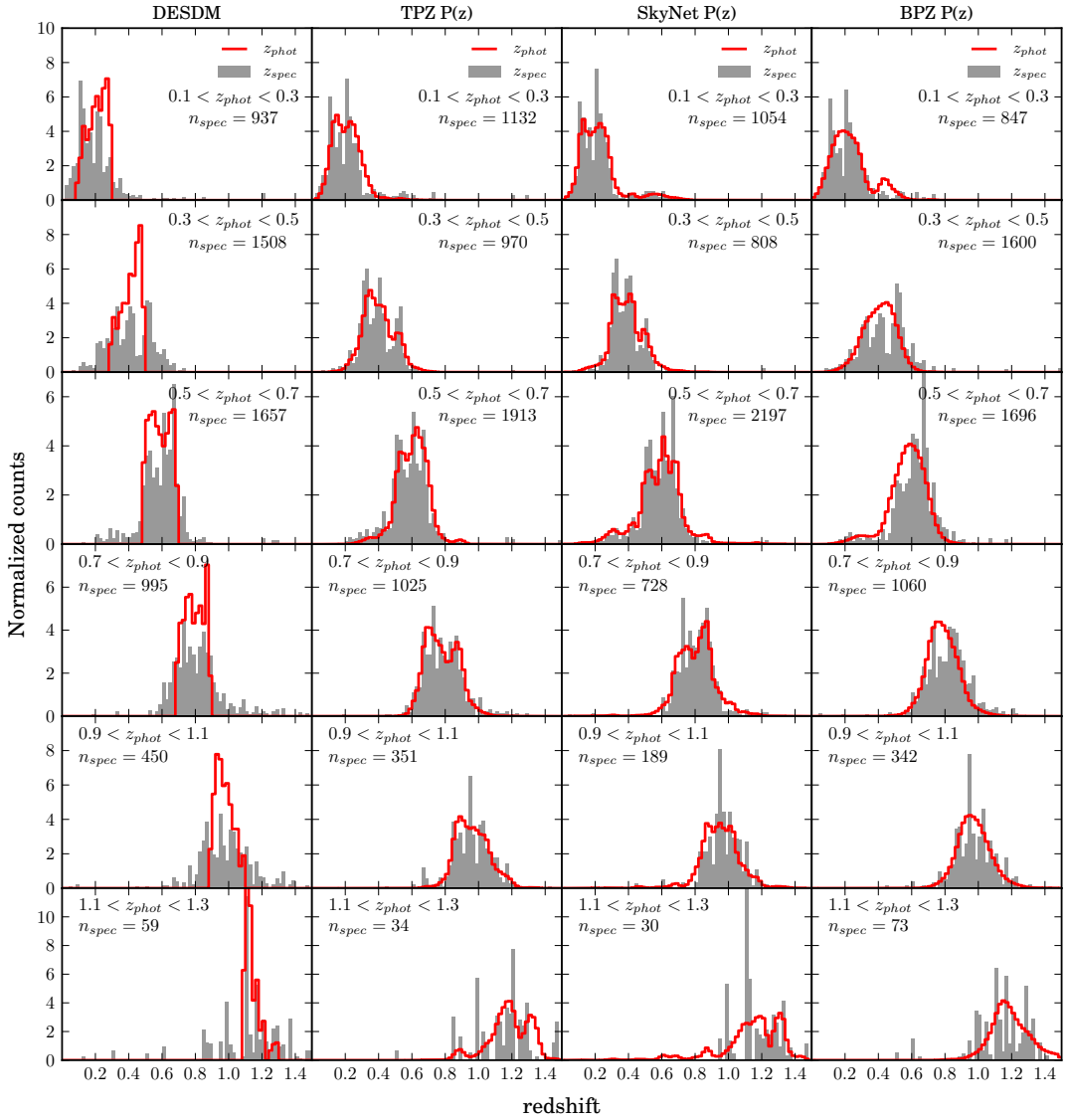
DARK ENERGY SURVEY

Four Algorithms Studied in More Detail



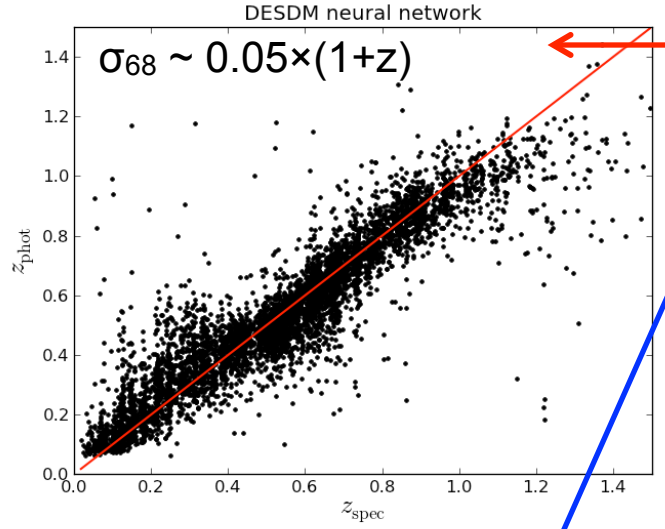
DARK ENERGY SURVEY

Calibrated True N(z) in Photo-z Bins

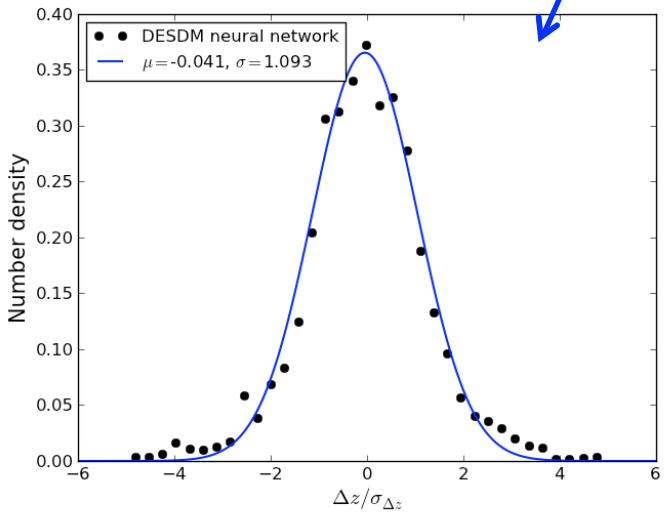


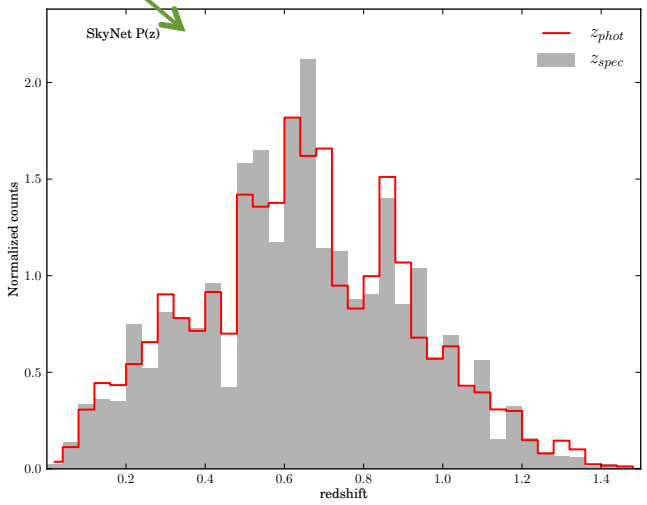
Example: DESDM Artificial Neural Net

DARK ENERGY SURVEY



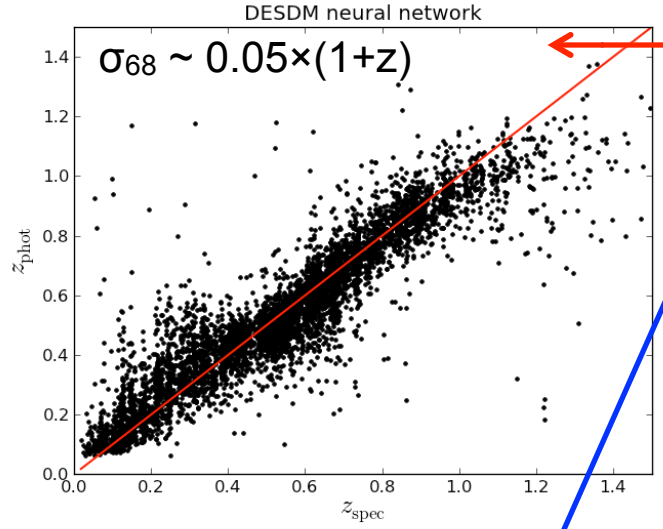
- Photo-z vs. spectroscopic z
- Pull distribution:
  (photo-z − spec z) / σ(photo-z)
- Photo-z distribution compared to spectroscopic z distribution





Example: DESDM Artificial Neural Net

DARK ENERGY SURVEY



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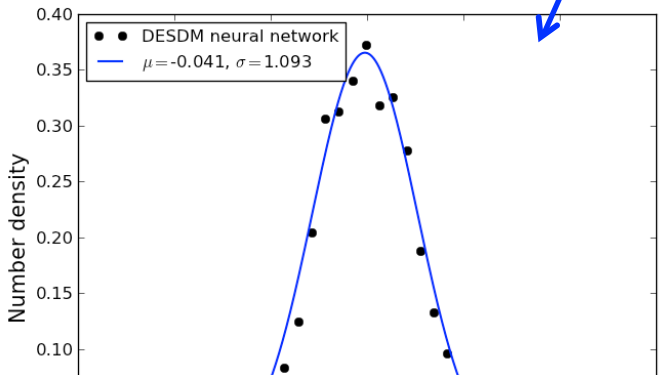
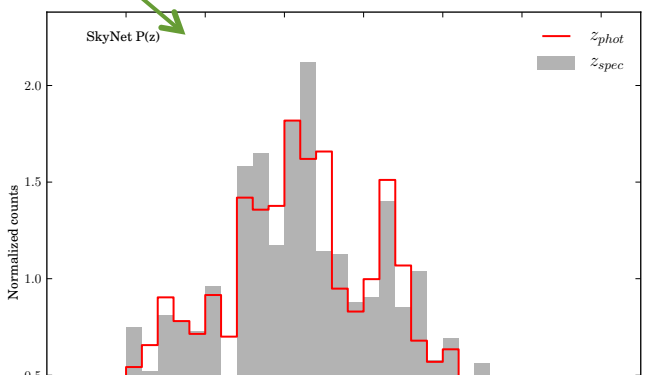




This paper proves that DES can measure colors, even in the Science Verification preliminary data set.

DARK ENERGY SURVEY

Other SV Analyses in the Pipeline

Galaxy Clustering and validation against CFHTLS

DES SV Galaxies cross-correlated with CMB lensing

SPT-SZE signature of DES SV RedMaPPer clusters

Joint Optical and Near Infrared Photometry from DES and VHS

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

DES13S2cmm: The first Super-luminous Supernova from DES

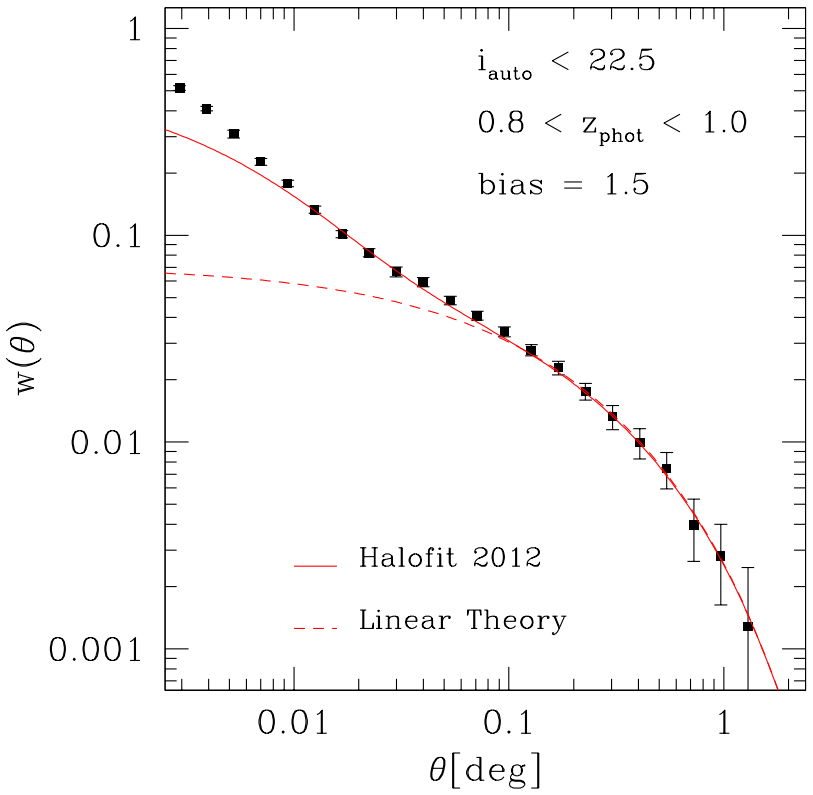
The Dark Energy Survey Supernova Survey: Search Strategy and Algorithm

Wide-Field Mass Mapping with the DES SVA1 data

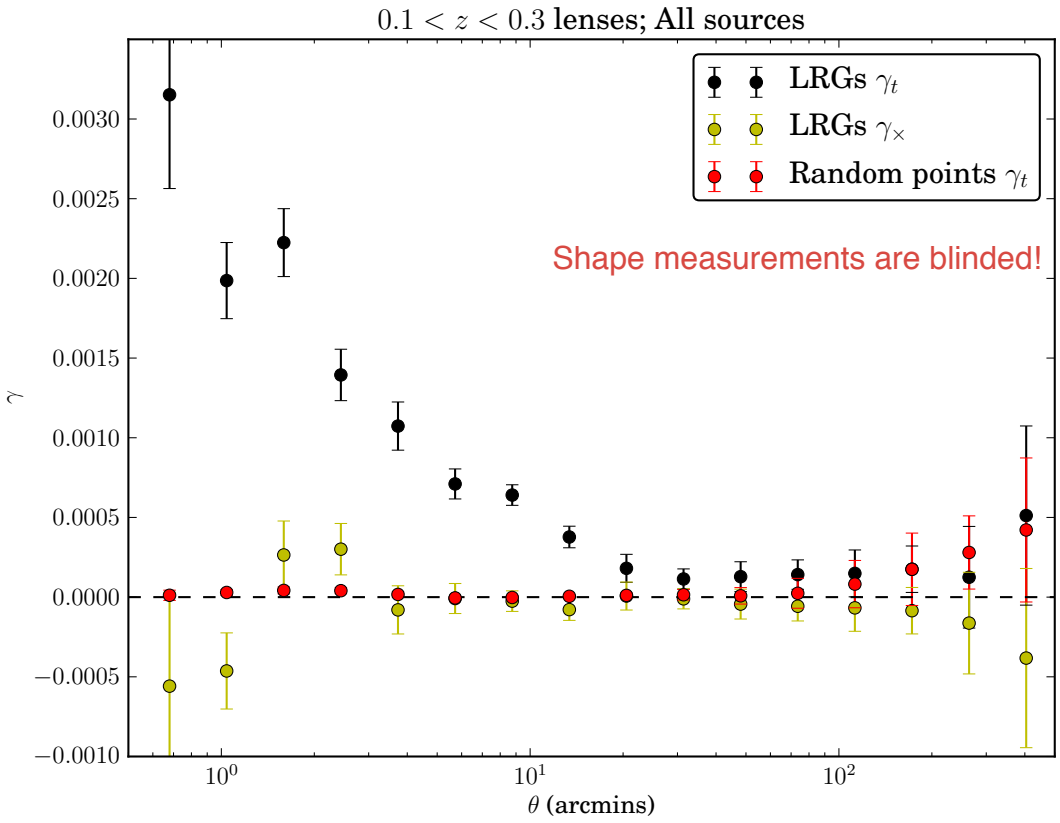
SV Data Analyses

DARK ENERGY SURVEY

LSS: Galaxy-galaxy correlations



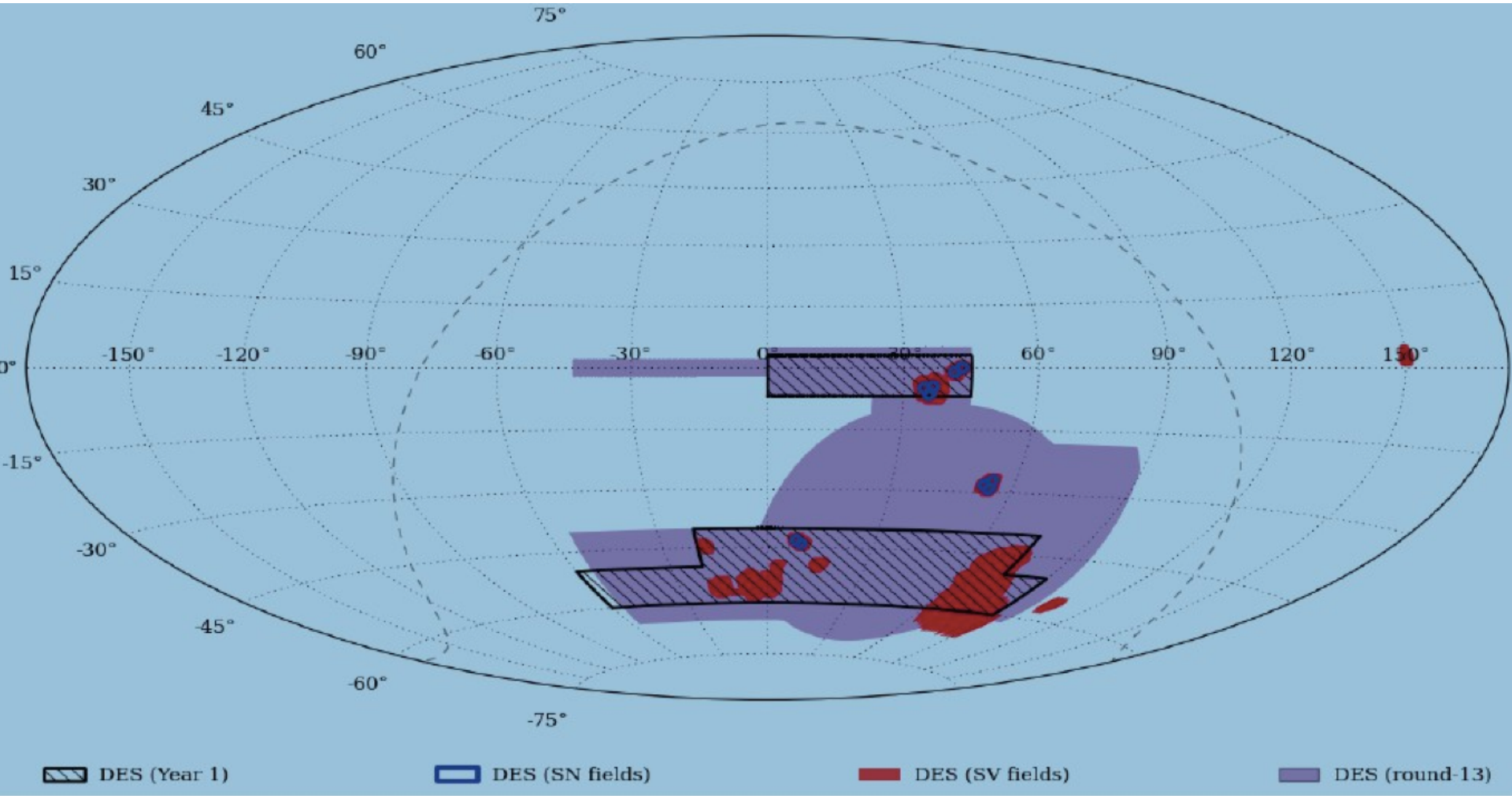
Weak lensing: Galaxy-shear correlations



Analyses on LSS and on WL+LSS combination in DES-SV are led by DES/Spain scientists

Year 1 of 5 (Sep ’13 - Feb ’14)

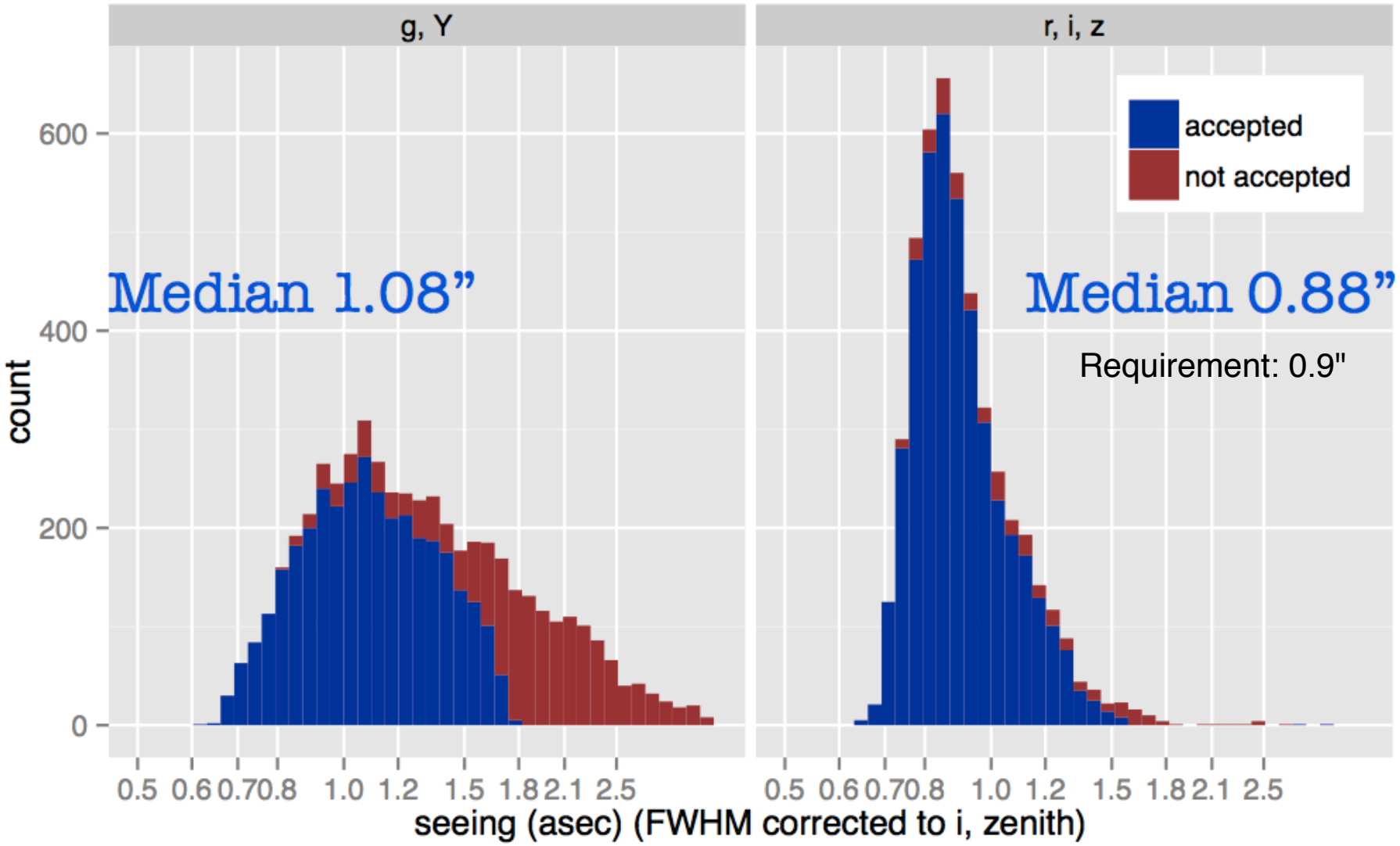
DARK ENERGY SURVEY



2000+ sq. deg., 4 tilings grizY + SN fields Data being processed

PSF FWHM for Y1 Data

DARK ENERGY SURVEY



DARK ENERGY SURVEY

Summary

- DES successfully started data taking in Nov. 2012, with a Science Verification (SV) period.
- Science Verification data have enough quality to do first science with them.
- DES/Spain leading in several areas of SV analysis: calibration, photo-zs, galaxy-galaxy correlations, galaxy-galaxy lensing.
- Very fruitful collaboration between DES/Spain institutions: CIEMAT / ICE (IEEC-CSIC) / IFAE / UAM.
- DES survey started in Aug. 2013, will last till Feb. 2018.
- Looking forward to analyses with Year 1 data sample and beyond.