DARK ENERGY SURVEY

DES-BRAZIL

LIneA
Laboratório Interinstitucional de e-Astronomia

# The Dark Energy Survey: an overview


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ICTP-SAIFR

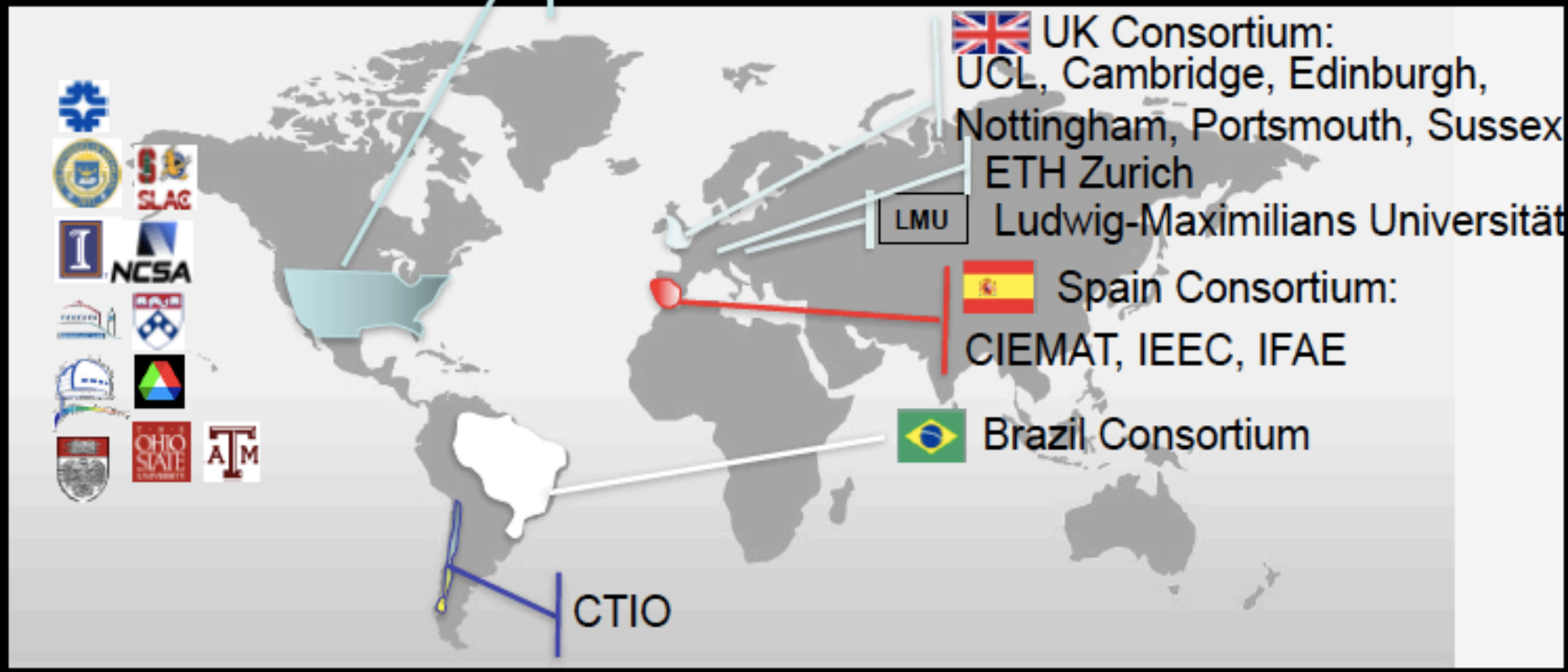
LIneA


# DARK ENERGY SURVEY COLLABORATION

Josh Frieman – Project Director
John Peoples was 1st director

~300 scientists

Fermilab, UIUC/NCSA, University of Chicago, LBNL, NOAO, University of Michigan, University of Pennsylvania, Argonne National Lab, Ohio State University, Santa-Cruz/SLAC/Stanford, Texas A&M



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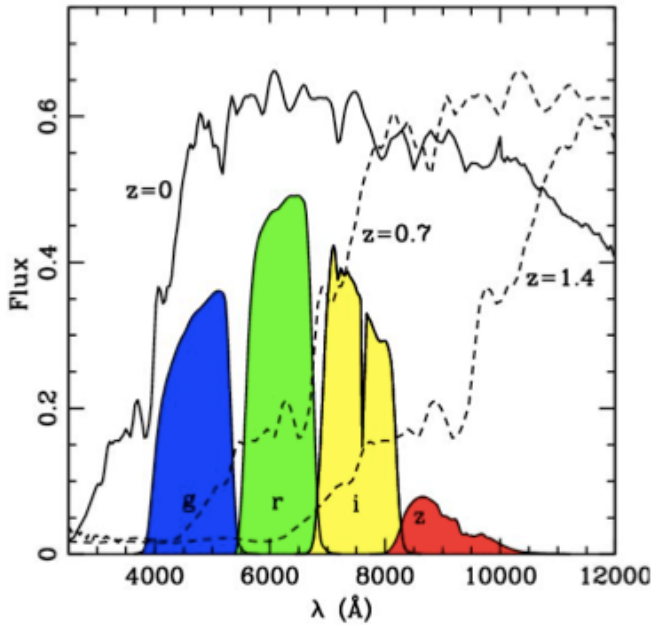
# DES Project

- Survey of 5000 deg$^2$ (~ 1/8 of the sky)
- 300 millions of galaxies up to z~1.4
  (+ 100,000 clusters + 4,000 SN Ia)
- Photometric redshift with 5 filters
- Blanco telescope (4m, CTIO)




- DECam – 62 (+12) CCDs - 570 Megapixels

# DES Project Timeline

NOAO Blanco Announcement of Opportunity 2003

DECam R&D 2004-8

Camera construction 2008-11

First light DECam on telescope September 2012

Science Verification (SV) run: Sept. 2012 - Feb. 2013

First Season (Year 1): Aug. 31, 2013 - Feb. 9, 2014

Second Season (Year 2): Aug. 2014 - Feb. 2015

Planning on 5 105-night seasons

DES site: 4m Blanco telescope at the Cerro Tololo Inter-American Observatory (CTIO) in Chile

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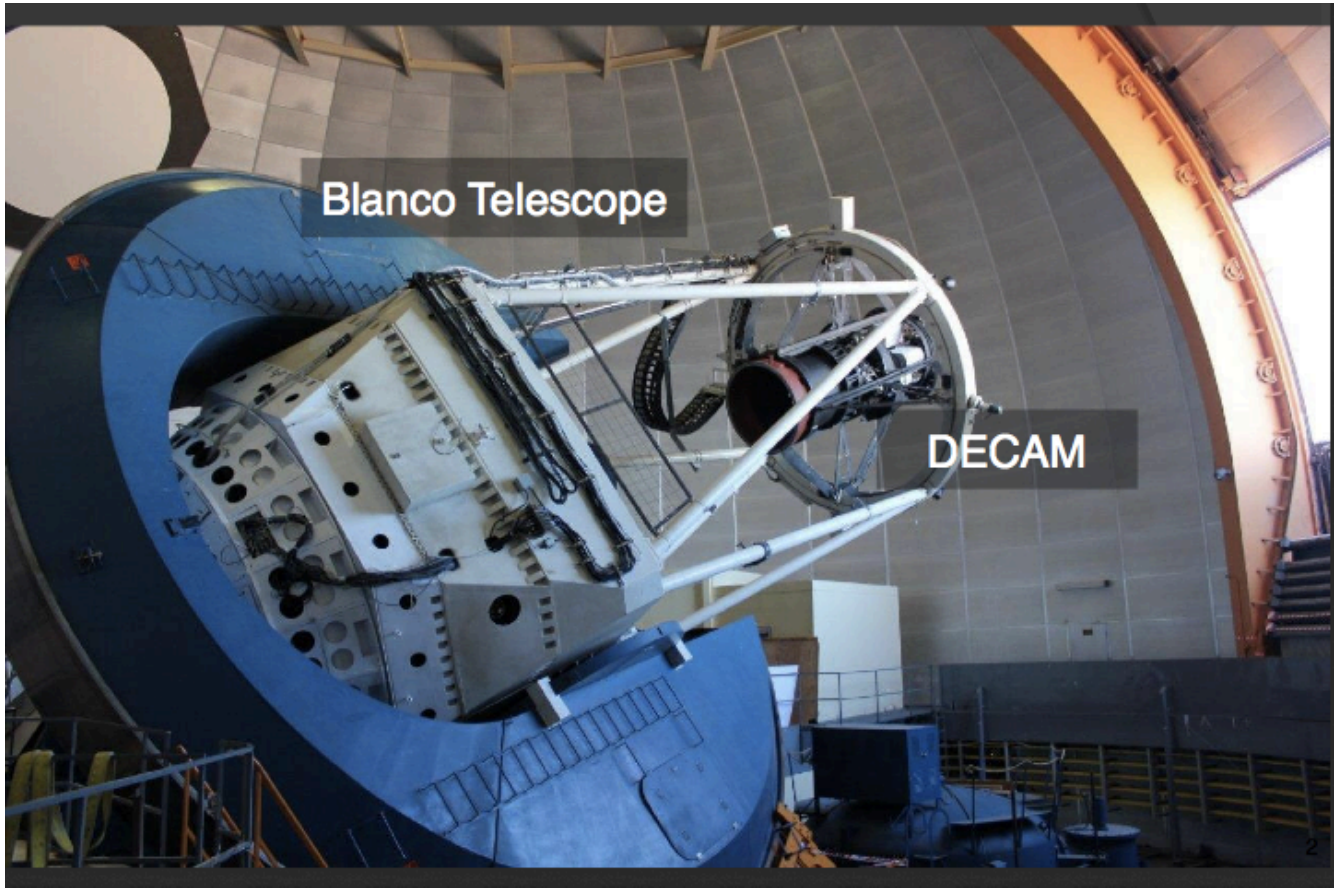
# DECam

Able to see light from more than 100,000 galaxies up to 8 billion light-years away in each snapshot. Weighs ~4 tons!



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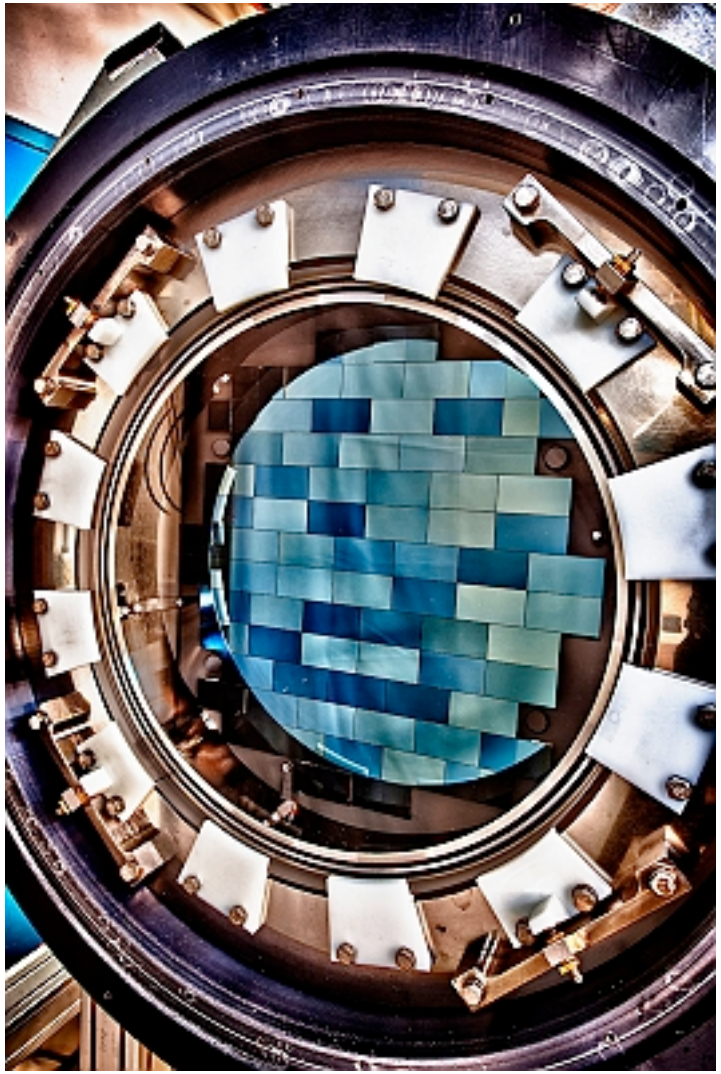
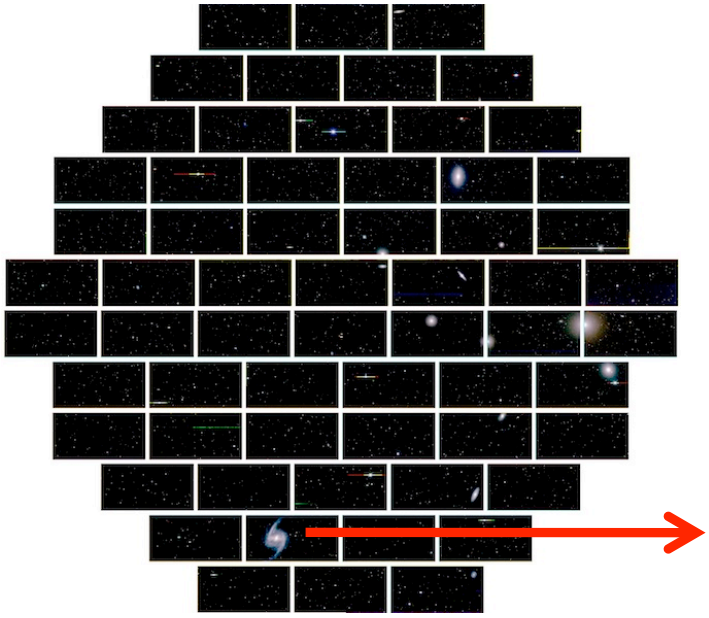
# DECam



arXiv:1504.02900



Fornax cluster of galaxies

Barred spiral galaxy NGC 1365 in the Fornax cluster of galaxies

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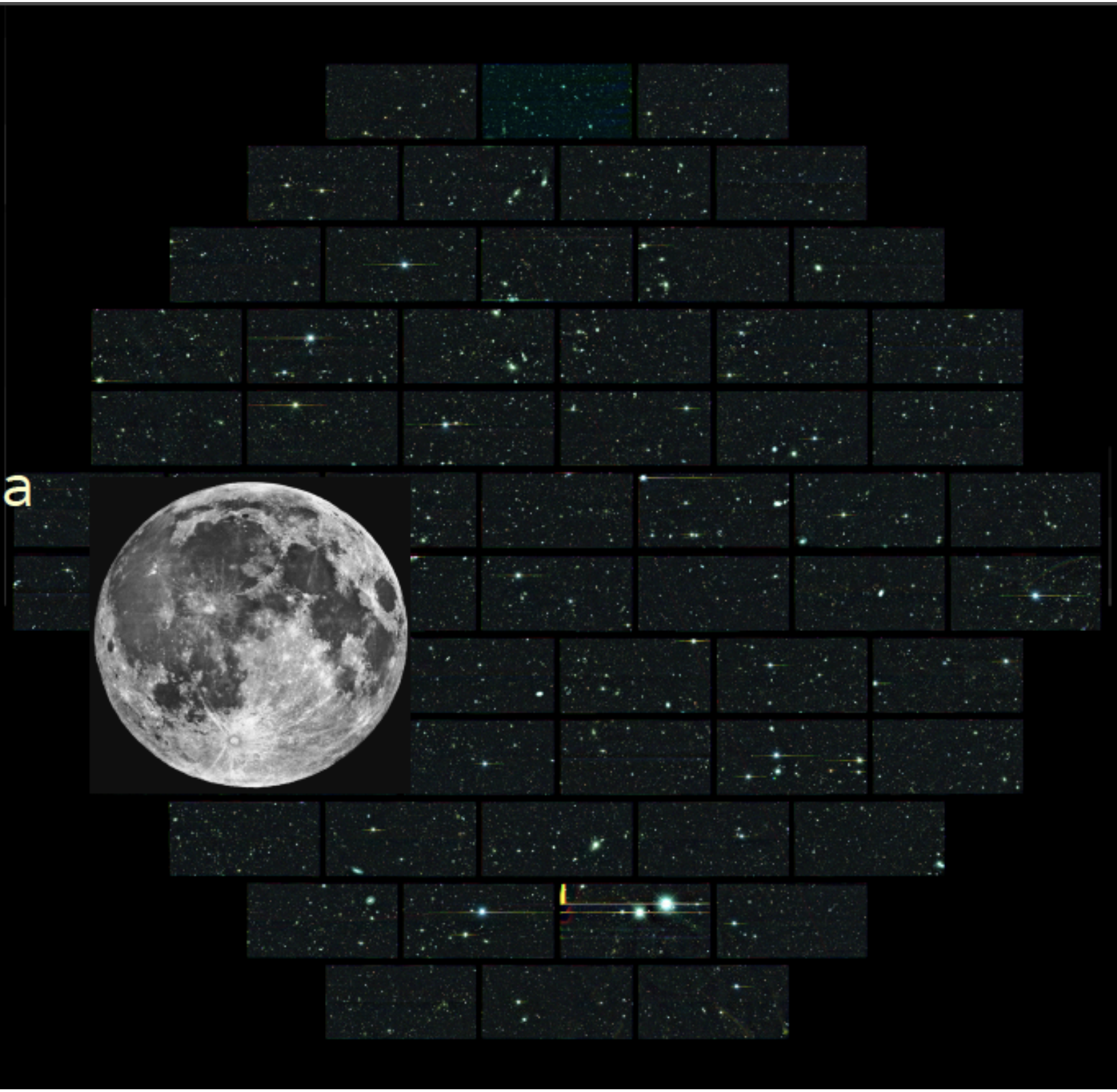
# DES SV image of a deep SN field



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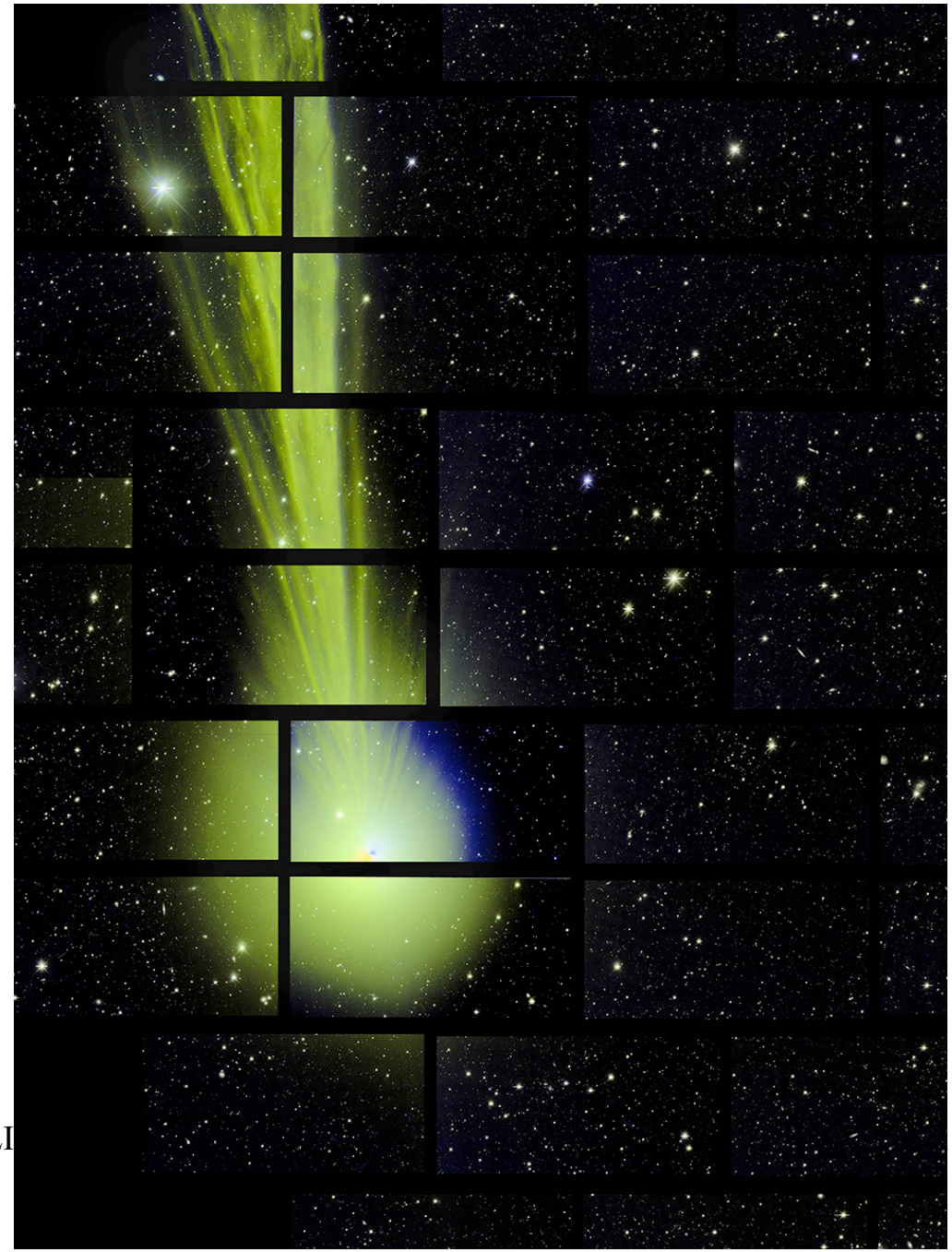
# Dark Energy Camera catches breathtaking glimpse of comet Lovejoy

December 27 2014

82 million km away



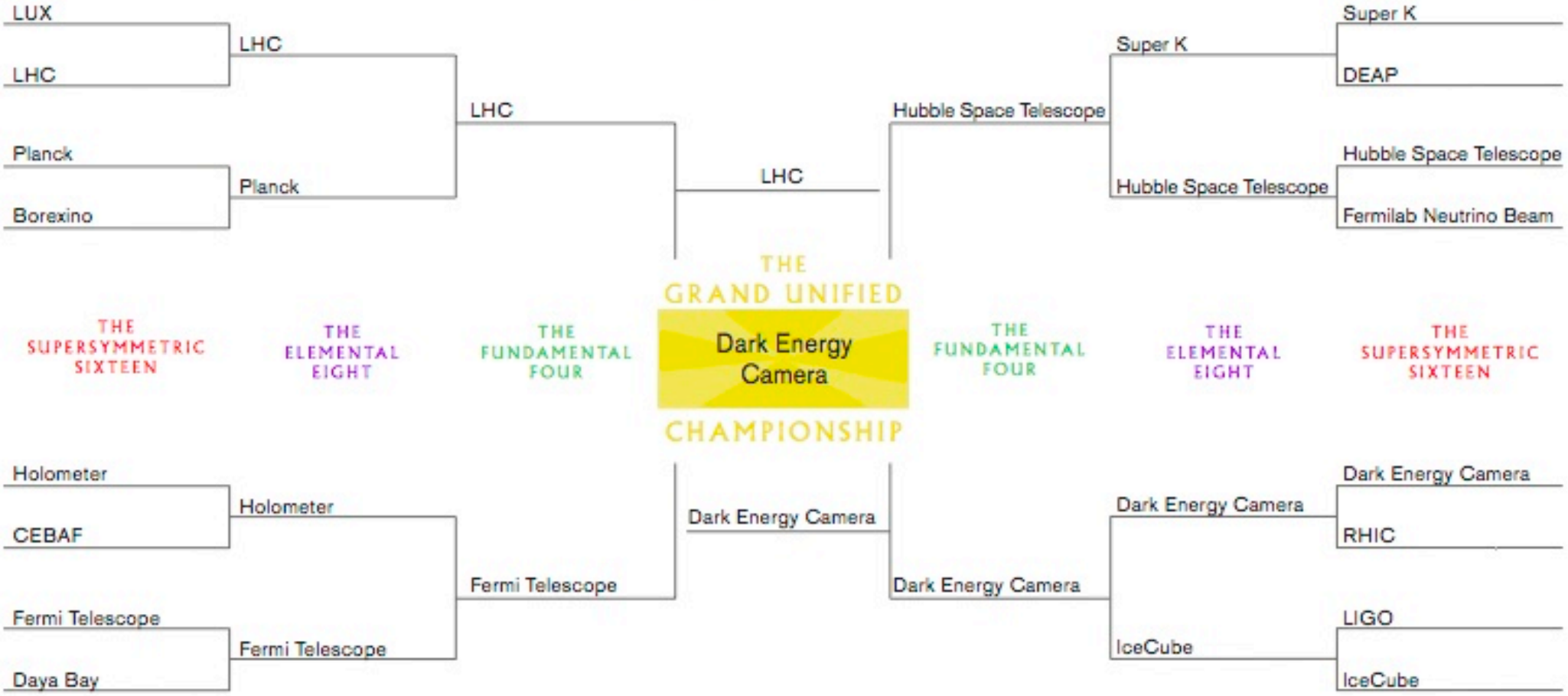
contest

April 06, 2015

Artwork by Sandbox S

# Physics Madness Grand Champion

## And your 2015 winning physics machine is…






# DES Data Management

Each exposure (in a given filter) generates 500Mb

300 exposures/night – 150 Gb/night

Transferred and processed at NCSA in Urbana

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# DES-Brazil is a LIneA Project

http://www.linea.gov.br

LIneA is supported by the following institutions:
Observatório Nacional
Rede Nacional de Ensino e Pesquisa
Laboratório Nacional de Computação Científica

DES-Brazil has researchers from:
ON - Observatório Nacional
IF- Universidade Federal do Rio Grande do Sul
IF- Universidade de São Paulo
IFT- Universidade Estadual Paulista

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# Brazilian infrastructure contribution

- QuickReduce: software for fast assessment of image quality at CTIO

- The Science Portal: Data Server, Value Added Catalogs and scientific pipelines

Creating a science-ready catalog is the crux: selection of objects, photo-z, systematic effects, …

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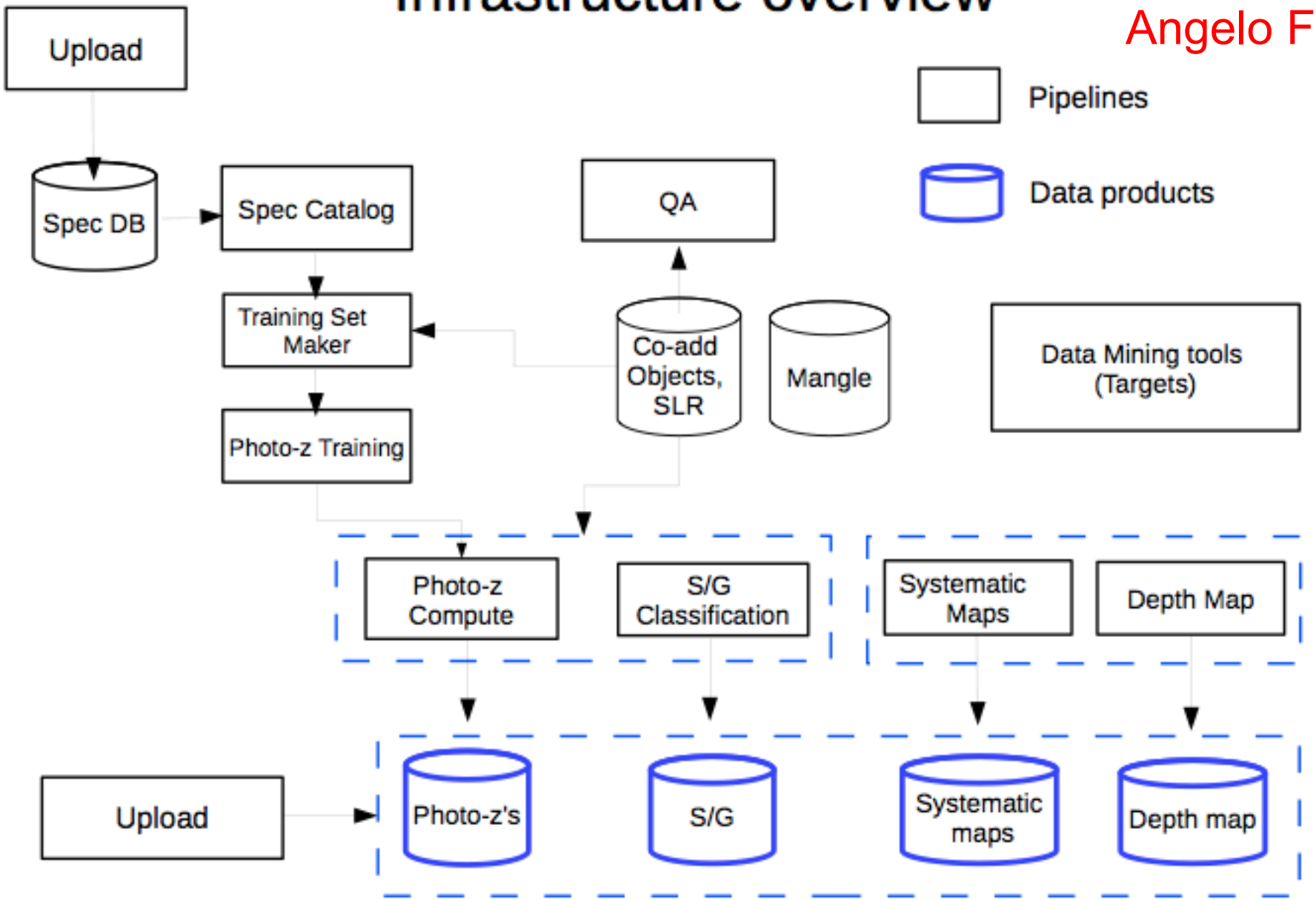
# Infrastructure overview

Angelo Fausti



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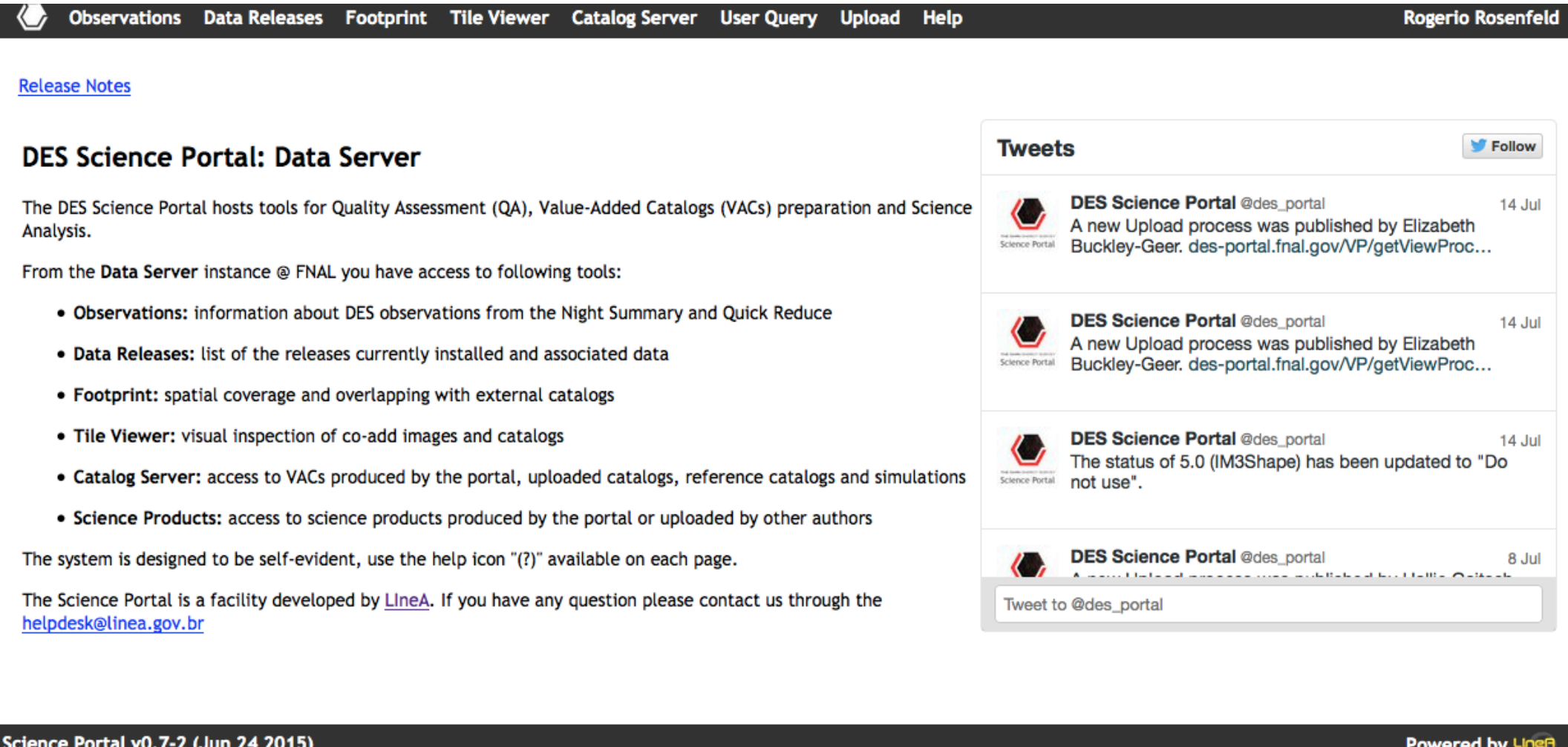
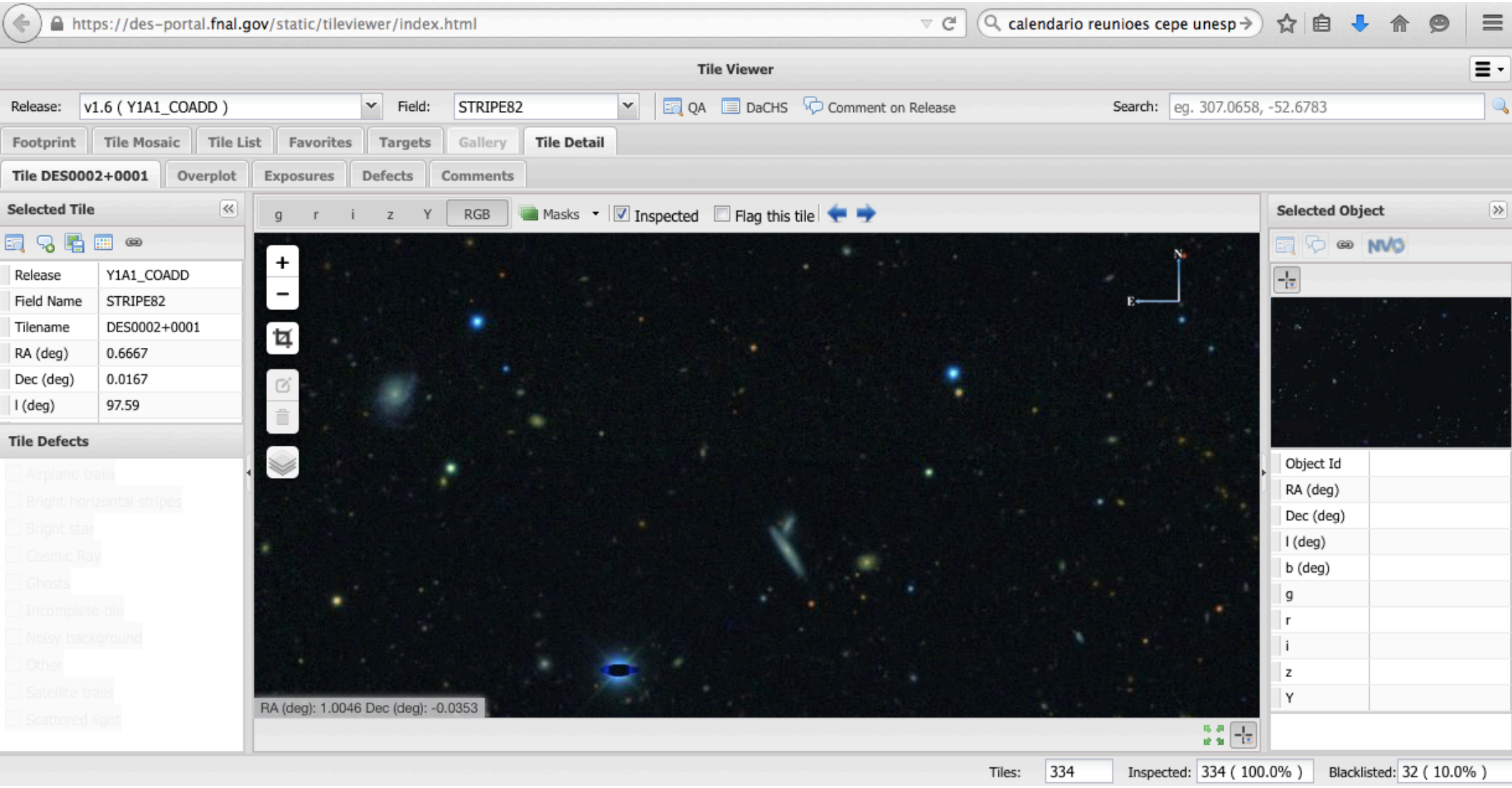
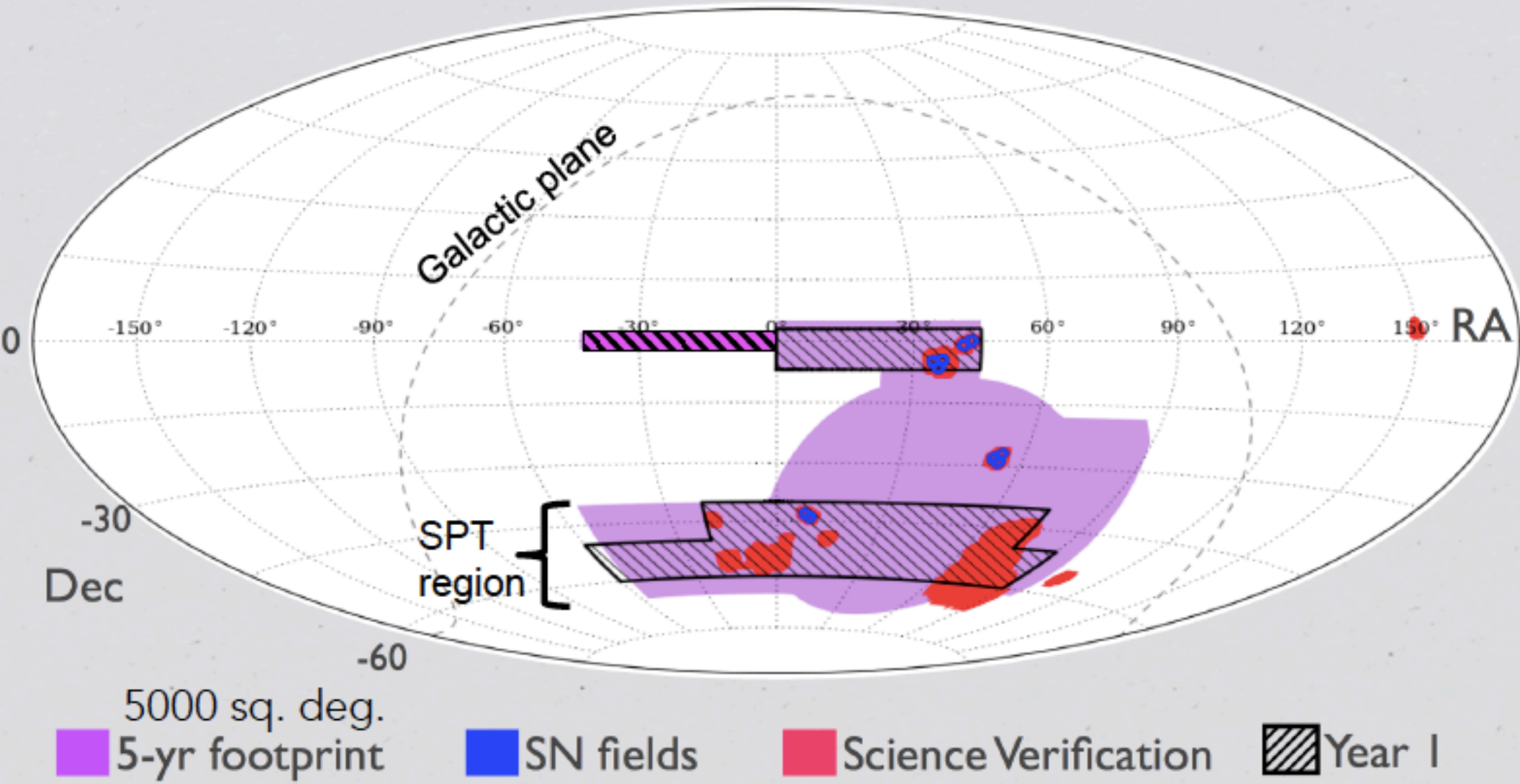
https://des-portal.fnal.gov/




https://des-portal.fnal.gov/static/tileviewer/index.html
calendario reunioes cepe unesp
Tile Viewer
Release: v1.6 ( Y1A1_COADD )
Field: STRIPE82
QA
DaCHS
Comment on Release
Search: eg. 307.0658, -52.6783
Footprint
Tile Mosaic
Tile List
Favorites
Targets
Gallery
Tile Detail
Tile DES0002+0001
Overplot
Exposures
Defects
Comments
Selected Tile
Release Y1A1_COADD
Field Name STRIPE82
Tilename DES0002+0001
RA (deg) 0.6667
Dec (deg) 0.0167
l (deg) 97.59
Tile Defects
Airplane trails
Bright horizontal stripes
Bright star
Cosmic Ray
Ghosts
Incomplete tile
Noisy background
Other
Satellite trails
Scattered light
g r i z Y RGB
Masks
Inspected
Flag this tile
N
E
RA (deg): 1.0046 Dec (deg): -0.0353
Selected Object
Object Id
RA (deg)
Dec (deg)
l (deg)
b (deg)
g
r
i
z
Y
Tiles: 334
Inspected: 334 ( 100.0% )
Blacklisted: 32 ( 10.0% )

# DES Survey Footprint




- Science Verification (SV): ~250 sq. deg. to ~full depth; 45 M objects
- Year 1 (Y1): ~2000 sq. deg; overlap SPT, SDSS: 4/10 tilings; 140 M objects

# DES Science Summary

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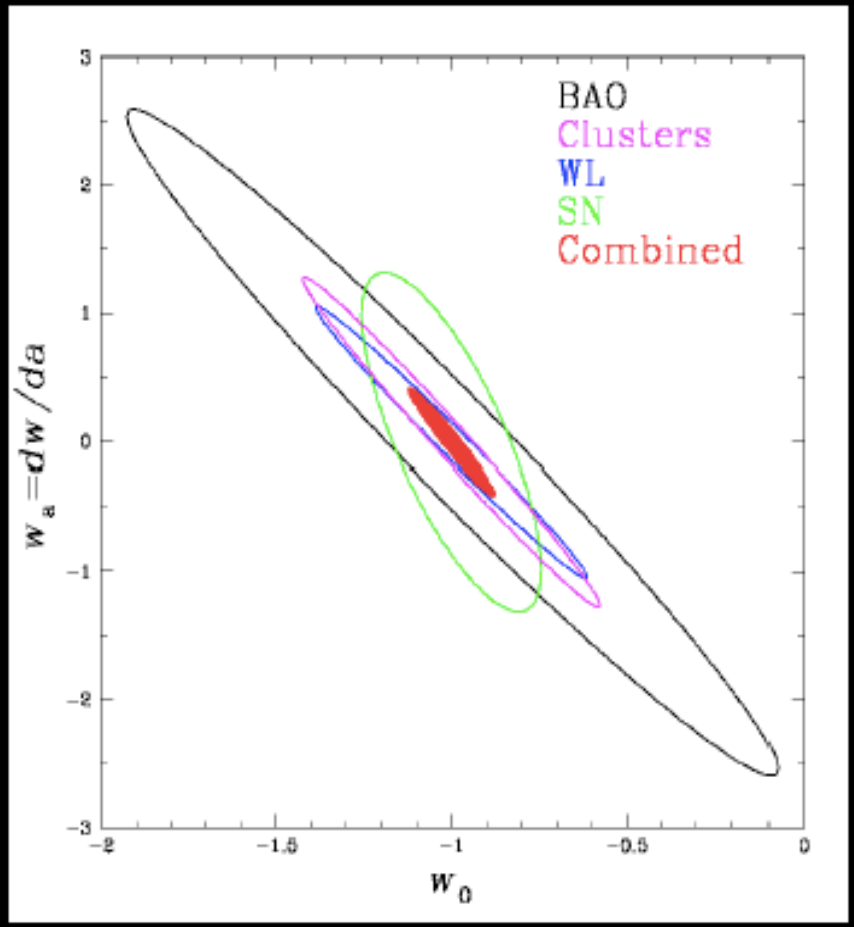
## Four Probes of Dark Energy

- Galaxy Clusters
  - Tens of thousands of clusters to z~1
  - Synergy with SPT, VHS
- Weak Lensing
  - Shape and magnification measurements of 200 million galaxies
- Baryon Acoustic Oscillations
  - 300 million galaxies to z = 1 and beyond
- Supernovae
  - 30 sq deg time-domain survey
  - 3500 well-sampled SNe Ia to z ~1

Forecast Constraints on DE Equation of State

$$w(a) = w_0 + w_a(1 - a(t)/a_0)$$




DES forecast




# Some recent results

# DES is not only about Dark Energy!

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## Eight New Milky Way Companions Discovered in First-Year Dark Energy Survey Data

**1503.02584**

27 Milky Way satellite galaxies known before DES – now 35
Crucial contribution from Basilio Santiago's team

Closest and best characterized one is Reticulum II (32 kpc). Mass-to-light ratio is

$$240 \pm 80\, M_\odot / L_\odot$$

Strongly dark matter dominated system!

## Search for Gamma-Ray Emission from DES Dwarf Spheroidal Galaxy Candidates with Fermi-LAT Data

**1503.02632**

## On The Gamma-Ray Emission From Reticulum II and Other Dwarf Galaxies

Dan Hooper, Tim Linden

*(Submitted on 20 Mar 2015)*

"The significance of this emission is greater than that observed from 99.84% of randomly chosen high-latitude blank-sky locations, corresponding to a local detection significance of 3.2 sigma."

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# 10+2+2 papers with SV data in July 21-22

Weak lensing by galaxy troughs in DES Science Verification data - 1507.05090
The Difference Imaging Pipeline for the Transient Search in the DES - 1507.05137
Observation of Two New L4 Neptune Trojans in DES SN Fields - 1507.05177
Joint Analysis of Galaxy-Galaxy Lensing and Galaxy Clustering: Methodology and Forecasts for DES - 1507.05353
Galaxy clustering, photometric redshifts and diagnosis of systematics in the DES Science Verification data - 1507.05360
redMaGiC: Selecting Luminous Red Galaxies from the DES SV Data - 1507.05460
CMB lensing tomography with the DES Science Verification galaxies - 1507.05551
Cosmology from Cosmic Shear with DES Science Verification Data - 1507.05552
Cosmic Shear Measurements with DES Science Verification Data - 1507.05598
The DES Science Verification Weak Lensing Shear Catalogs - 1507.05603
Mapping and simulating systematics due to spatially-varying observing conditions in DES Science Verification data - 1507.05647
Redshift distributions of galaxies in the DES SV shear catalogue and implications for weak lensing - 1507.05909
Wide-Field Lensing Mass Maps from DES Science Verification Data: Methodology and Detailed Analysis - 1504.03002 (accepted PRD)
Wide-Field Lensing Mass Maps from DES SV Data - 1505.01871 (accepted PRL)




*NATURE* | NEWS

# Dark matter mapped at cosmic scale

**Survey charts clusters and voids of invisible matter over hundreds of millions of light years.**

**Davide Castelvecchi**

13 April 2015

Wide-Field Lensing Mass Maps from DES Science Verification Data: Methodology and Detailed Analysis - arXiv:1504.03002

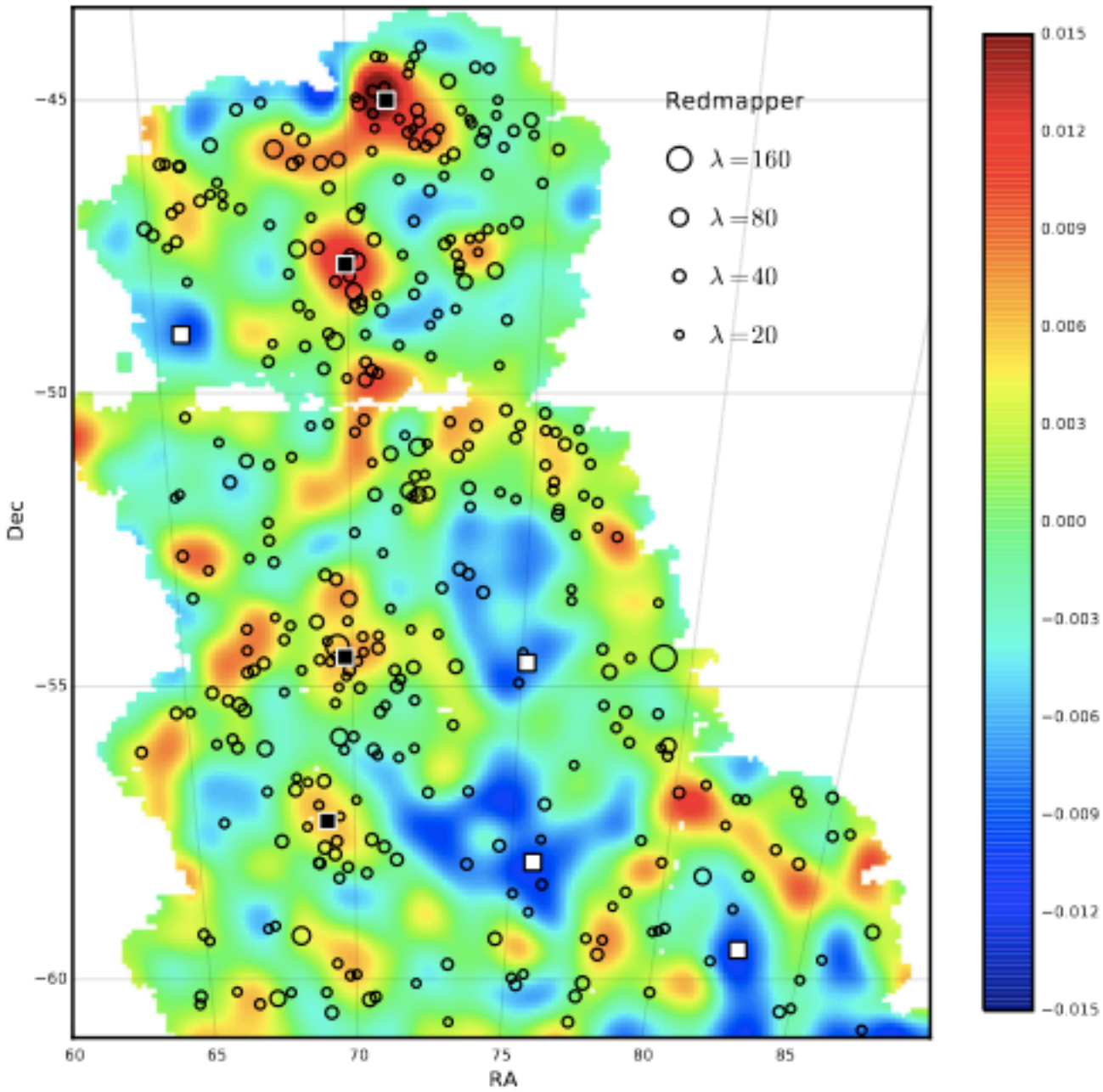


FIG. 4: The DES SV mass map along with foreground galaxy clusters detected using the Redmapper algorithm. The clusters are overlaid as black circles with the size of the circles indicating the richness of the cluster. Only clusters with richness greater than 20 and redshift between 0.1 and 0.5 are shown in the figure. The upper right corner shows the correspondence of the optical richness to the size of the circle in the plot. It can be seen that there is significant correlation between the mass map and the distribution of galaxy clusters. Several superclusters (black squares) and voids (white squares) can be identified in the joint map.

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# Some highlights: measuring bias

Baryons are only ~ 15% of the total matter in the Universe!

Galaxies are a biased tracer of the total matter distribution.
DES measures the distribution properties of galaxies.

$$\delta_g(\vec{x}) = b(z)\delta(\vec{x})$$

galaxy overdensity

bias

matter overdensity (cosmological model)

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# Benchmark catalogue: contiguous area of 116.2 deg$^2$ to a depth up to i= 22.5

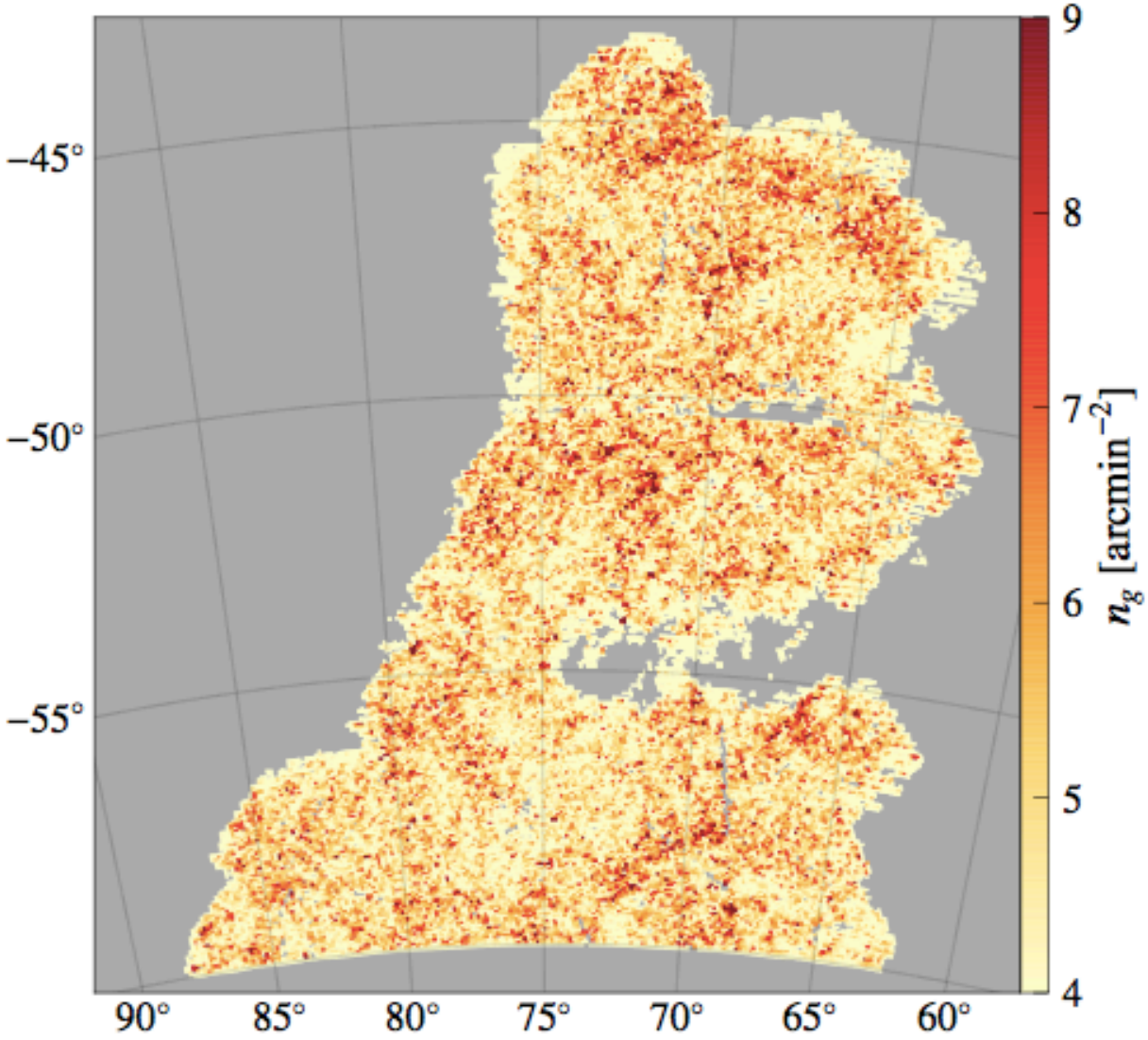


**Figure 3.** The distribution of LSS bench-mark sample galaxies over the angular footprint defined by regions with survey limiting magnitude in the $i$-band $> 22.5$. The sample is selected to be flux limited to $i \leqslant 22.5$ and has a mean density of 5.6 arcmin$^{-2}$. All the regions considered provide at least $S/N$ 10 measurements for objects at $i$-band $= 22.5$. This choice balances concerns between using the maximum depth and area possible, as described in the text. The x-axis (y-axis) corresponds to right ascension (declination) measured in degrees.

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Galaxy clustering, photometric redshifts and diagnosis of systematics in the DES SV data - 1507.05360

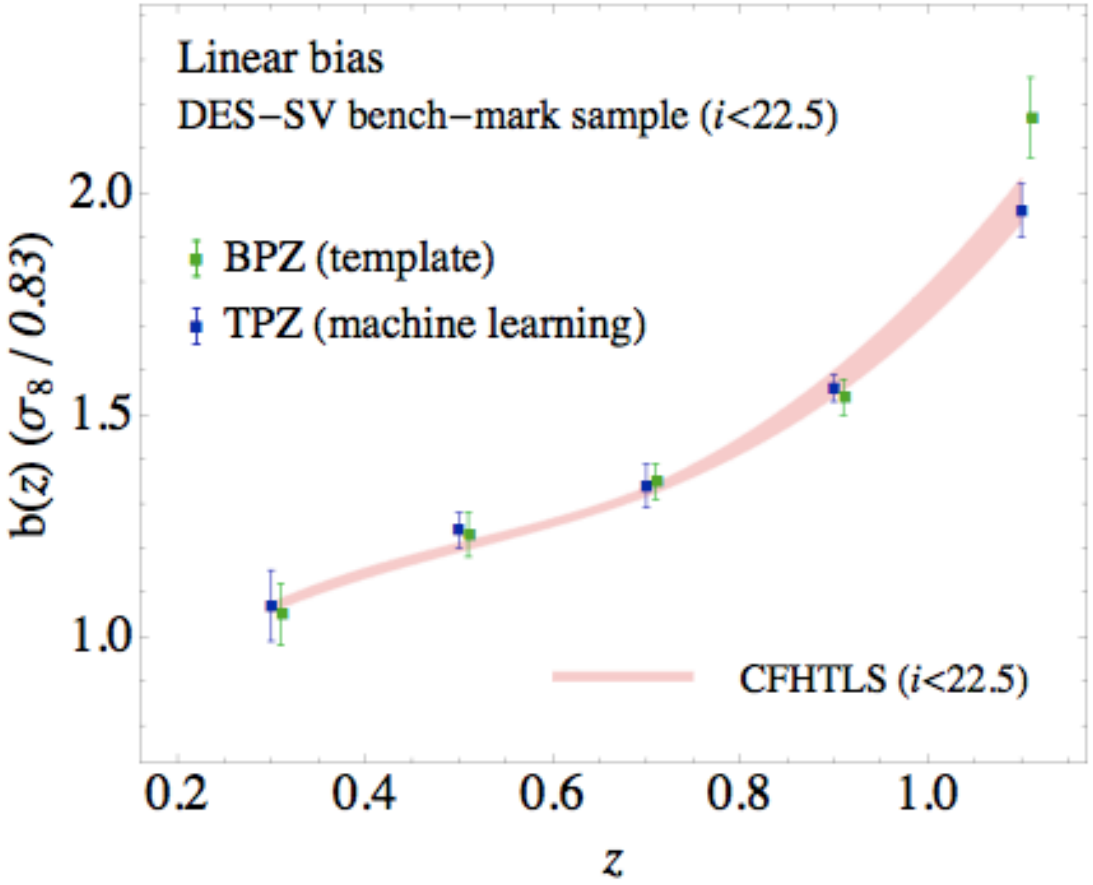


**Figure 11.** Comparison of the large-scale bias measured in a DES-SV flux limited sample ($i < 22.5$) to equivalent measurements from CFHTLS derived from Coupon et al. (2012). We present DES results for two different photometric redshift catalogs, one obtained using a template method (BPZ), another with a machine learning approach (TPZ). The overall agreement between the two DES samples as a function of redshift is better that 2 per cent for $z < 1$. At $z > 1$ is difference is not statistically significant ($\sim 2\sigma$). This represents a non-trivial test for DES-SV photometric redshift estimation. Our results are also in good agreement with those from CFHTLS, with $\chi^2/d.o.f = 4/5$ for TPZ and $8.7/5$ for BPZ, representing a cross-validation of data quality and sample selection.

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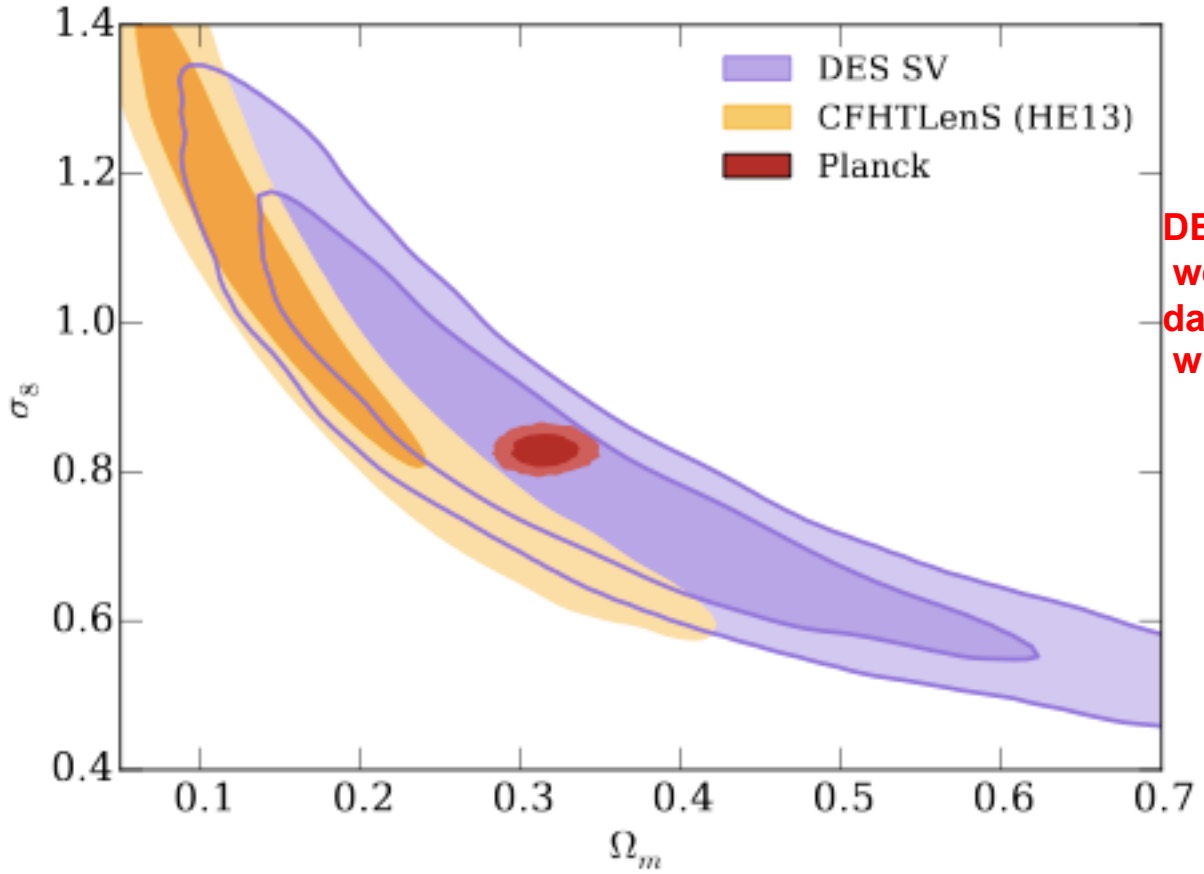
# Some highlights: first cosmological constraints

Cosmology from Cosmic Shear with DES Science Verification Data - 1507.05552

Uses 139 square degrees of SV data, which is less than 3% of the full DES survey area




**DES SV alone places weak constraints on the darkenergy equation of state w < -0.68 (95%)**

DES SV and CFHTLenS are marginalised over the same astrophysical systematics parameters and DES SV is additionally marginalised over uncertainties in photometric redshifts and shear calibration.

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# Conclusions

- Dark Energy Survey third season (Y3) is about to start
- DECam is working to specification
- Pipelines for data analysis are in place (still work to do)
- Catalogue creation for Y1/Y2 in the making
- Some results from the Science Verification data (less than 1/10 of total area already interesting) – catalogues for LSS and shear are fine!
- DES is a precursor to the LSST (8.4 m telescope in Chile – CTIO)