O Dark Energy Survey: de objetos trans-Netunianos à Cosmologia

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DES-Brazil

DES collaboration

LineA Bootcamp, 9/2019

Breve histórico do projeto

- Proposta ao NOAO – 07/2004
- Construção da DECam : 10/2012
- Science Verification: 11/2012 a 02/2013
- Coleta de dados: 8/2013 a 1/2019
- Primeiro data release: 7/2018 (DES Collaboration, ApJS, 239, 18)
- Previsão para data release final: 2021?

Membros do DES

- 25 instituições/grupos, incluindo o consórcio DES-Brazil (LineA) → 7 países (EUA, UK, Espanha, Brasil, Alemanha, Suiça, Austrália)
- 400+ pesquisadores

Participação brasileira

- Consórcio DES-Brazil: 10 pesquisadores seniors + Pos-Docs, estudantes
- Contribuição para infra-estrutura: Quick Reduce, Quality Assurance, Tile Viewer, Portal Científico → 9 builders do DES
- Das 13 teses do LineA, >7 usaram dados do DES
- Pelo menos metade das 19 dissertações também

DES Collaboration Meeting
Campinas, Brasil, 12/2018

Dark Energy Survey (DES)

Photometric survey in several filters:

- 5000 deg^2 in grizY down to gri ≈ 24 mag, z~23, Y~21.5
- 30 deg^2 : 5 exp/month → SNe search

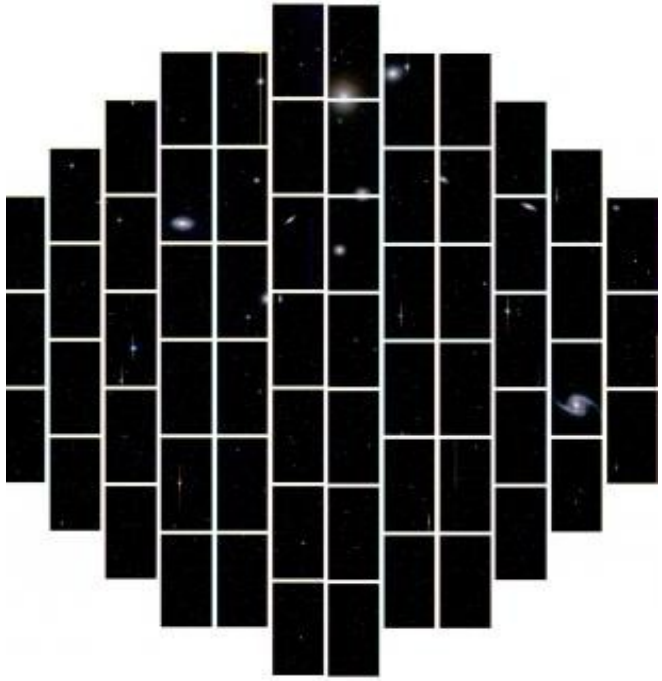
Initiated on 31/08/2013

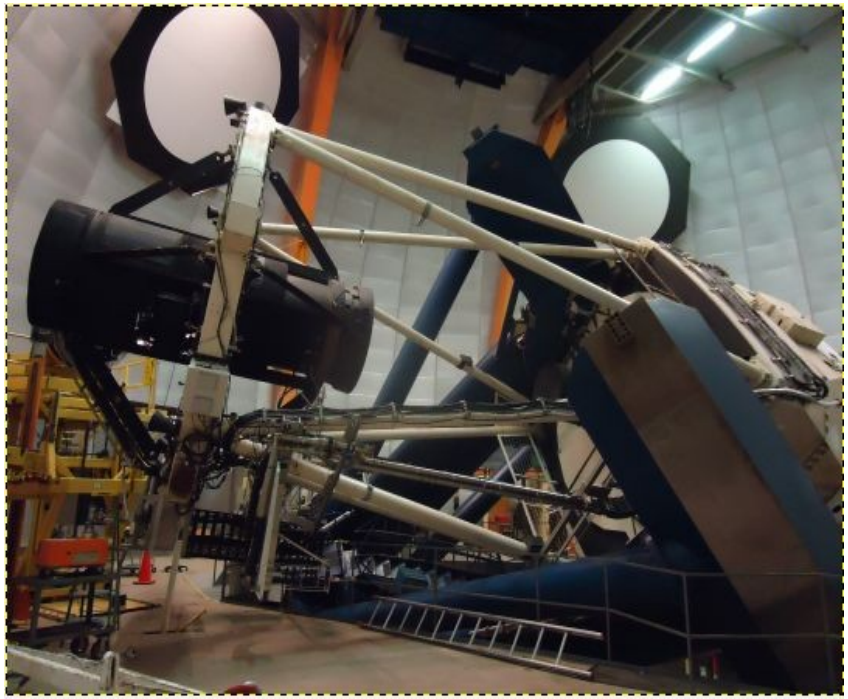
Terminated on 01/2019

CTIO – 4m Telescope

A Dark Energy Camera (DECam)

- 62 red sensitive CCDs
- A field of 3 deg^2
- On PF of 4m at CTIO



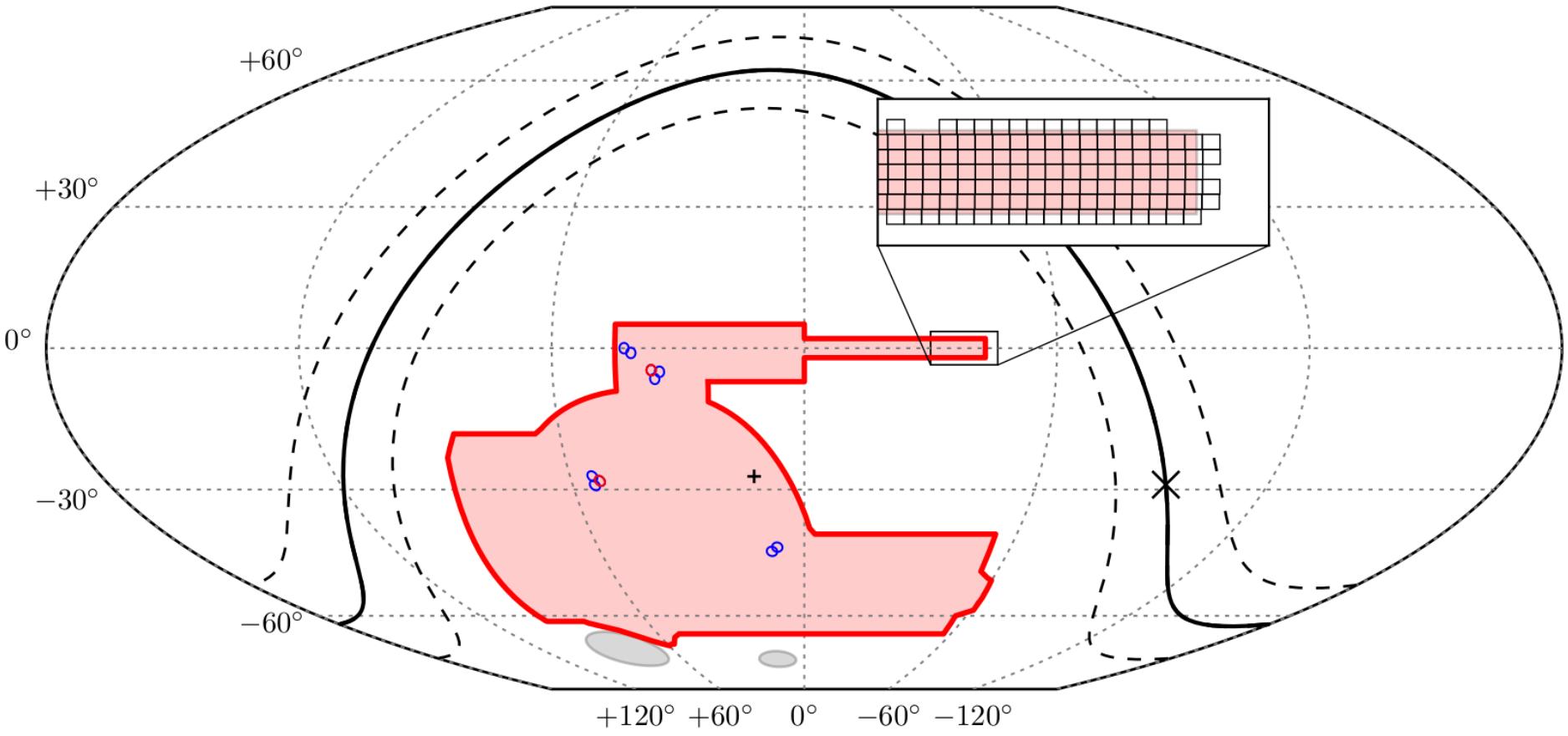


1st light in 09/2012

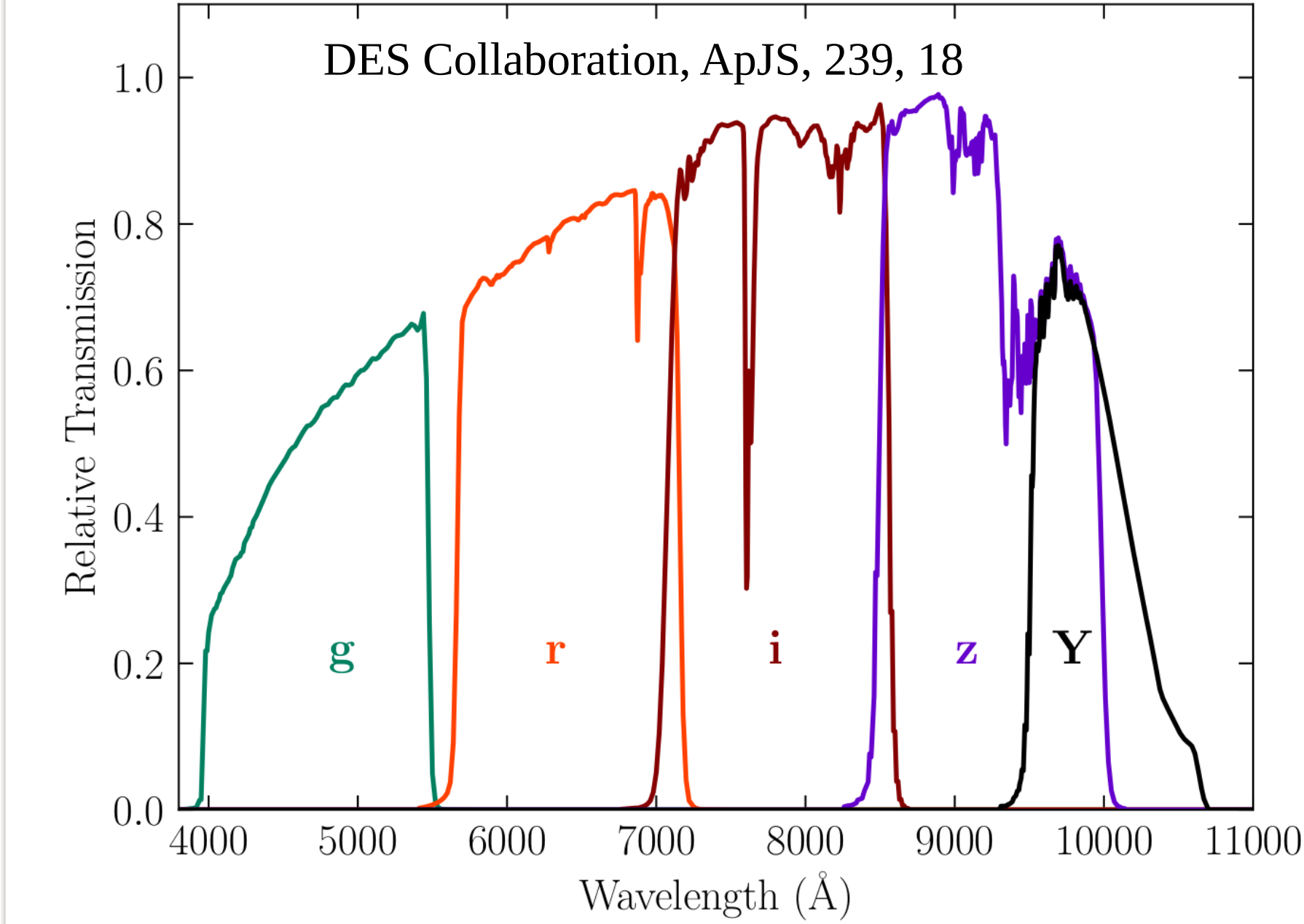
Science verification from 09/2012 to 02/2013

Região coberta (footprint)

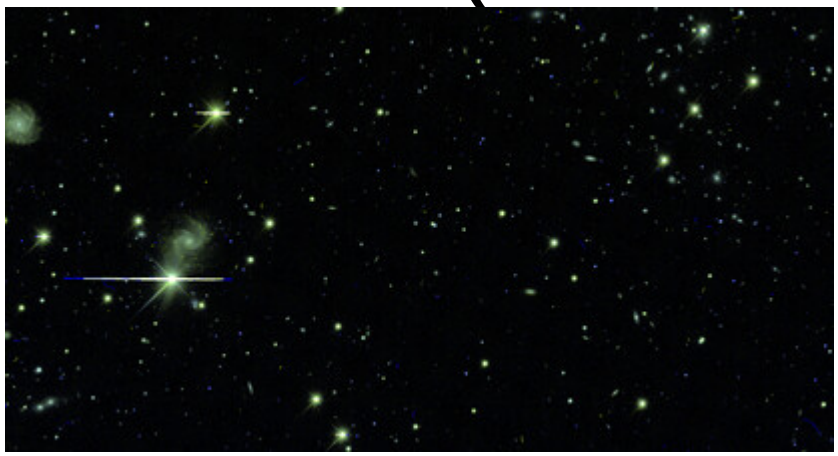
DES Collaboration, ApJS, 239, 18

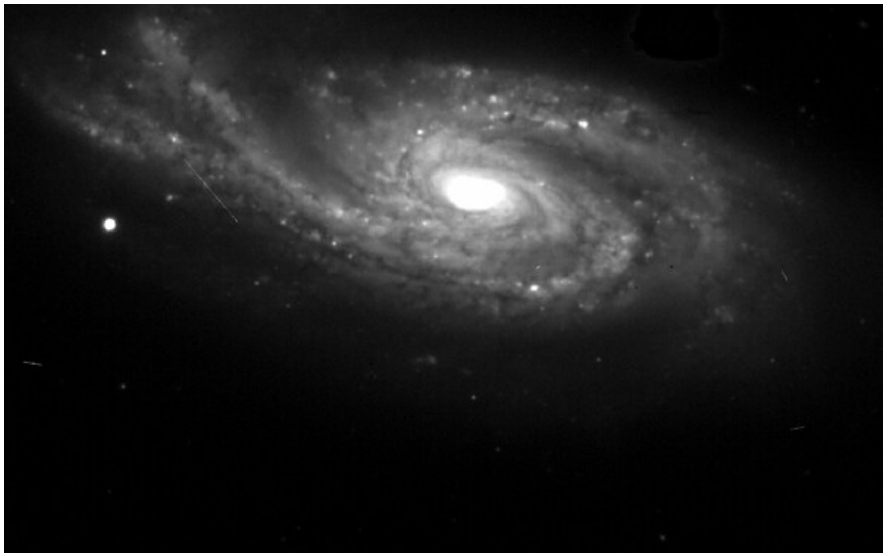


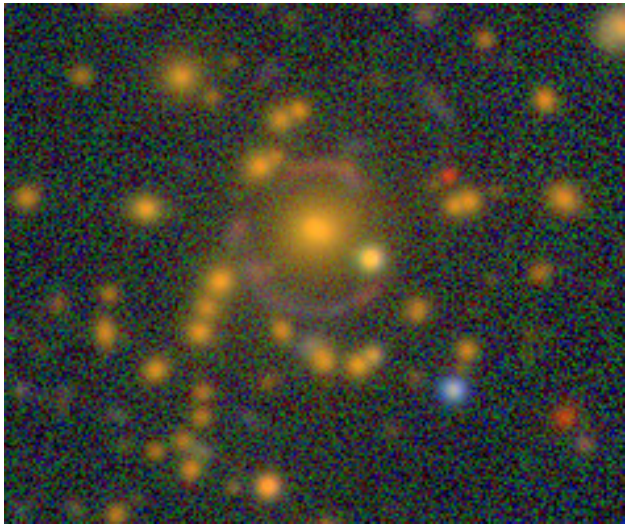
DECam filters



DECam images
(DES Image Gallery)







DES in numbers

- 150+ scientists from >20 institutions; 400+ people total
- 20+ people only in the DES Data Management (DESDM)
- 525 nights at CTIO/DECam (late 2013-early 2018 + Y6: 2018/2019)
- ~ 300 Gb of raw data per night
- ~ few Pb of data in total
- ~3 10^8 galaxies
- ~10^8 stars
- ~ 10^6 QSOs, ~10^5 galaxy clusters, ~10^3 gravitacional arcs, and a lot more...

DES Science

- Focus on Cosmology (but it is not a Cosmological project) → Ω_m, Ω_{DE}, w
- Ancillary Science: Stellar Populations, QSOs, Galaxy Evolution, Strong Lensing, Solar System objects...
- MW science: ~ 10^8 stars, most of them in MW thick disk and halo (Rosseto et al 2011).

Standard Cosmology

Probing Dark Matter & Dark Energy

- Through the history of the expansion rate:

$$H^2(z) = H_0^2 \; [\Omega_M (1+z)^3 + \Omega_{DE} (1+z)^{3(1+w)}] \qquad \text{(flat Universe)}$$

matter dark energy (constant w)

$P = w \rho$

- Comoving distance $r(z) = \int dz/H(z)$
- Standard Candles $d_L(z) = (1+z)\, r(z)$
- Standard Rulers $d_A(z) = (1+z)^{-1}\, r(z)$

- The rate of growth of structure also determined by H(z) and by any modifications of gravity on large scales

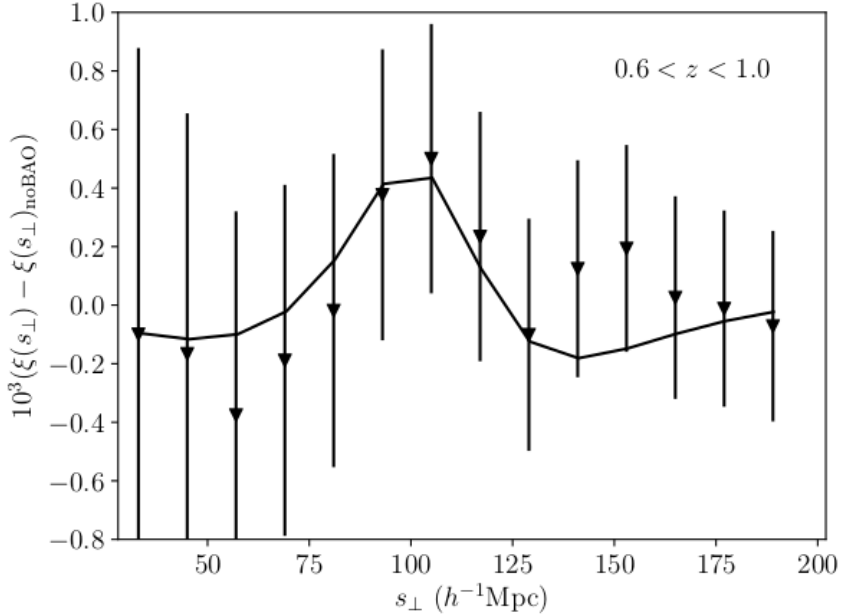
Courtesy of: Ofer Lahav (UCL/UK)

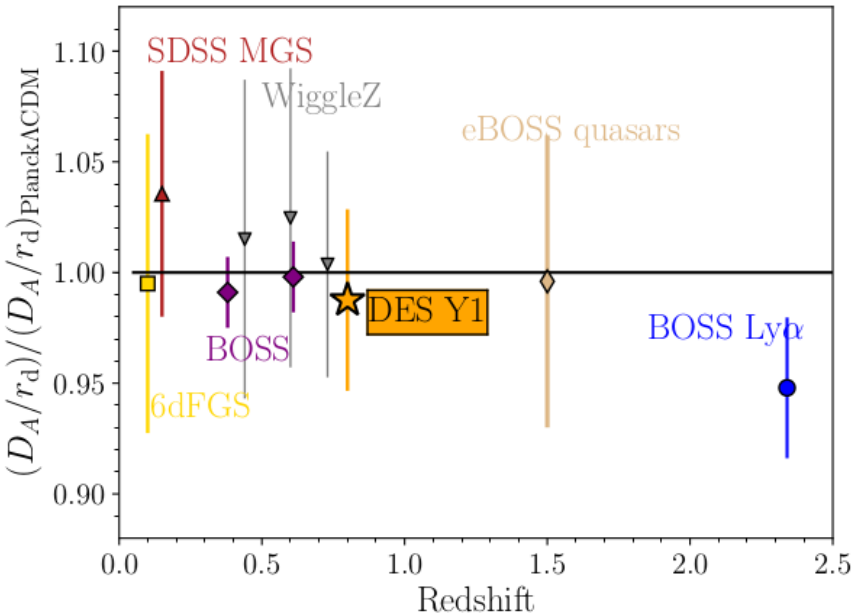
DES and dark energy

Four basic tools to constrains cosmological parameters (Ω_{DE},Ω_m,w (ou w_0,w_a)):

- Supernovae Ia → std candles → luminosity distance (d_L)-*redshift (z) relation.*
- Number of galaxy clusters ($N_{agl}(z)$) → structure growth → H(z)
- Large scale structure: correlation *statistics → growth of structure → H(z); clustering scales: ex.: BAOs (standard rule) → angular distance (d_A) - redshift (z) relation.*
- Weak gravitational lensing: shear maps → *growth of structure → H(z)*

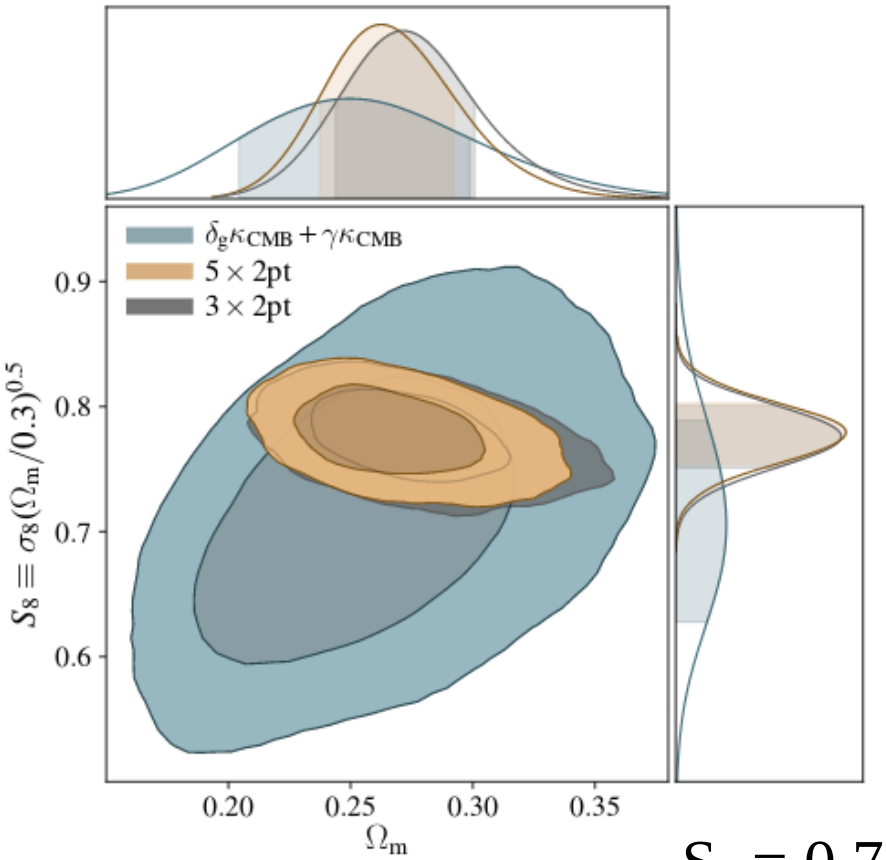
Baryonic Acoustic Oscilations from DES Y1 data

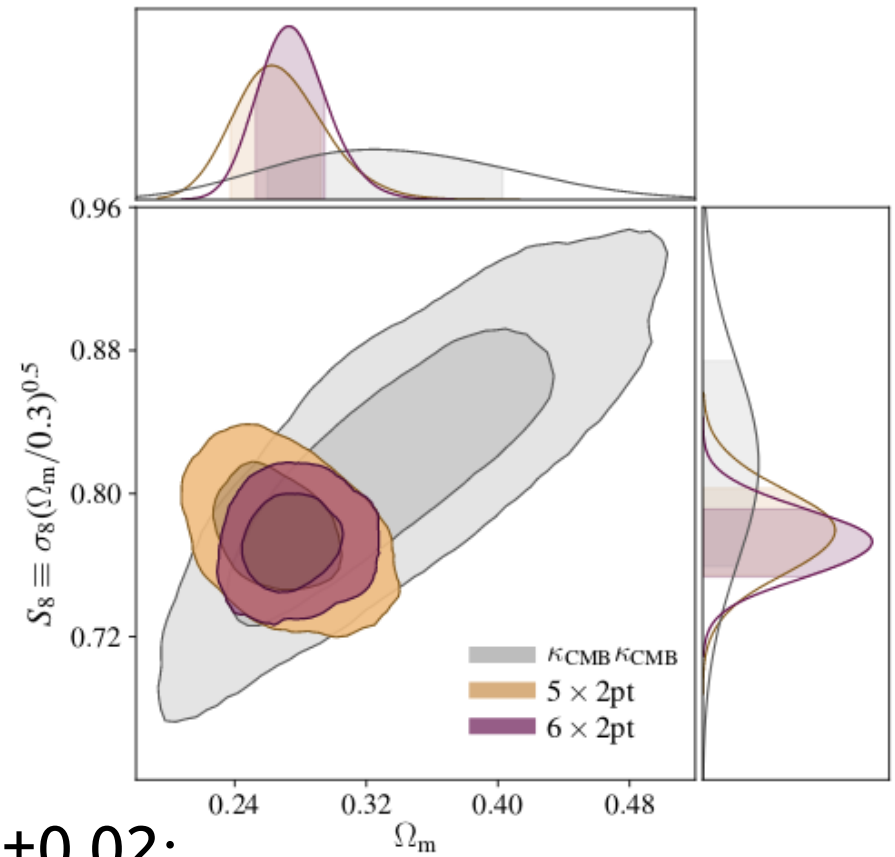




DES Collaboration 2019, MNRAS, 483, 4866

Galaxy Clustering DES + CMB



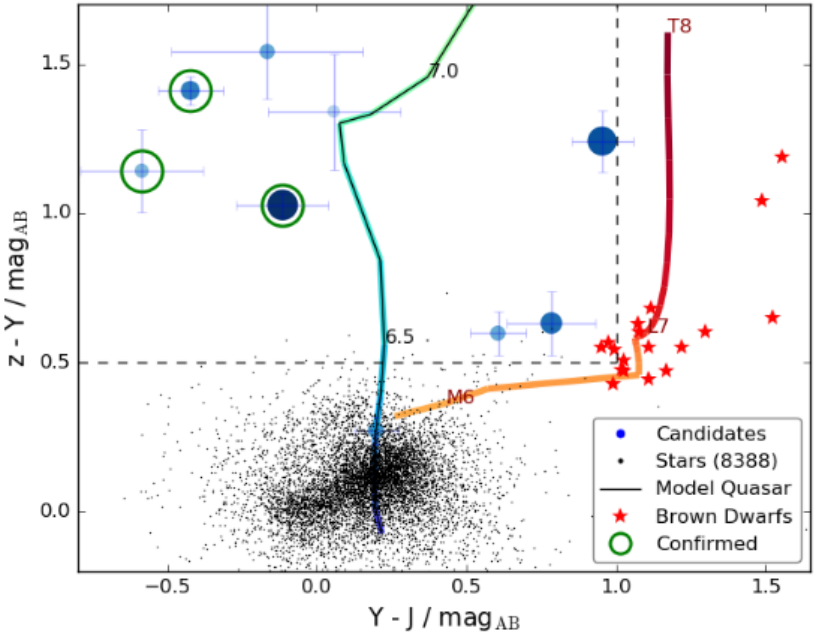


$S_8 = 0.776 \pm 0.02$;

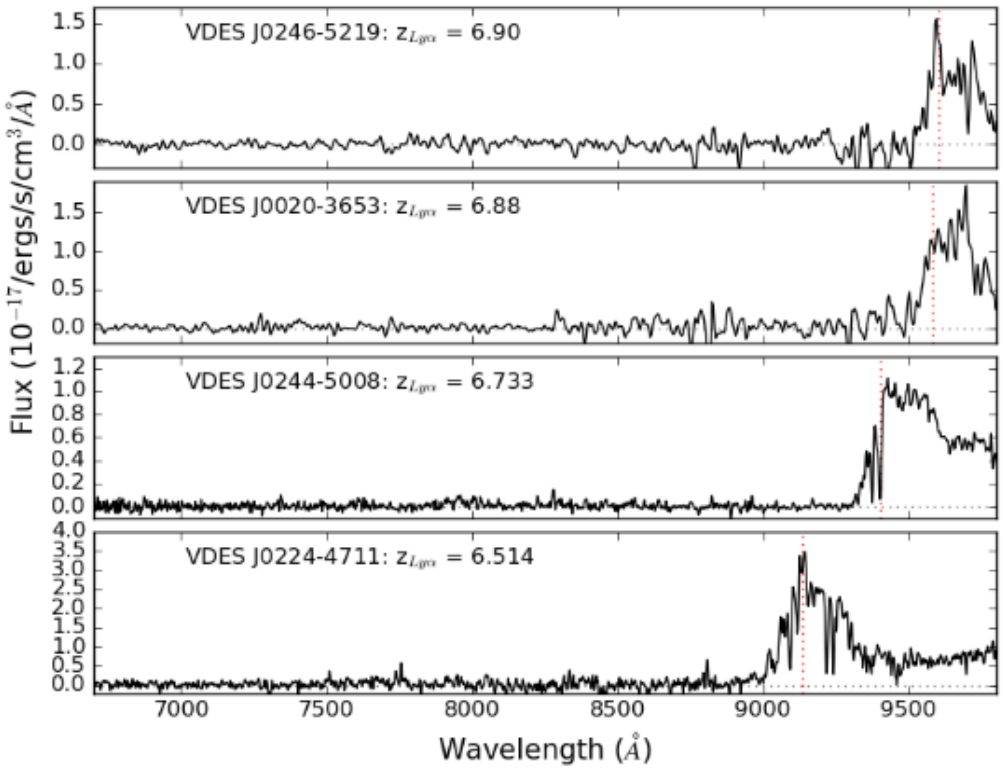
$\Omega_m = 0.271 \pm 0.02$

DES Collaboration, Physical Review D, Volume 100, Issue 2, id.023541

High-z Quasars

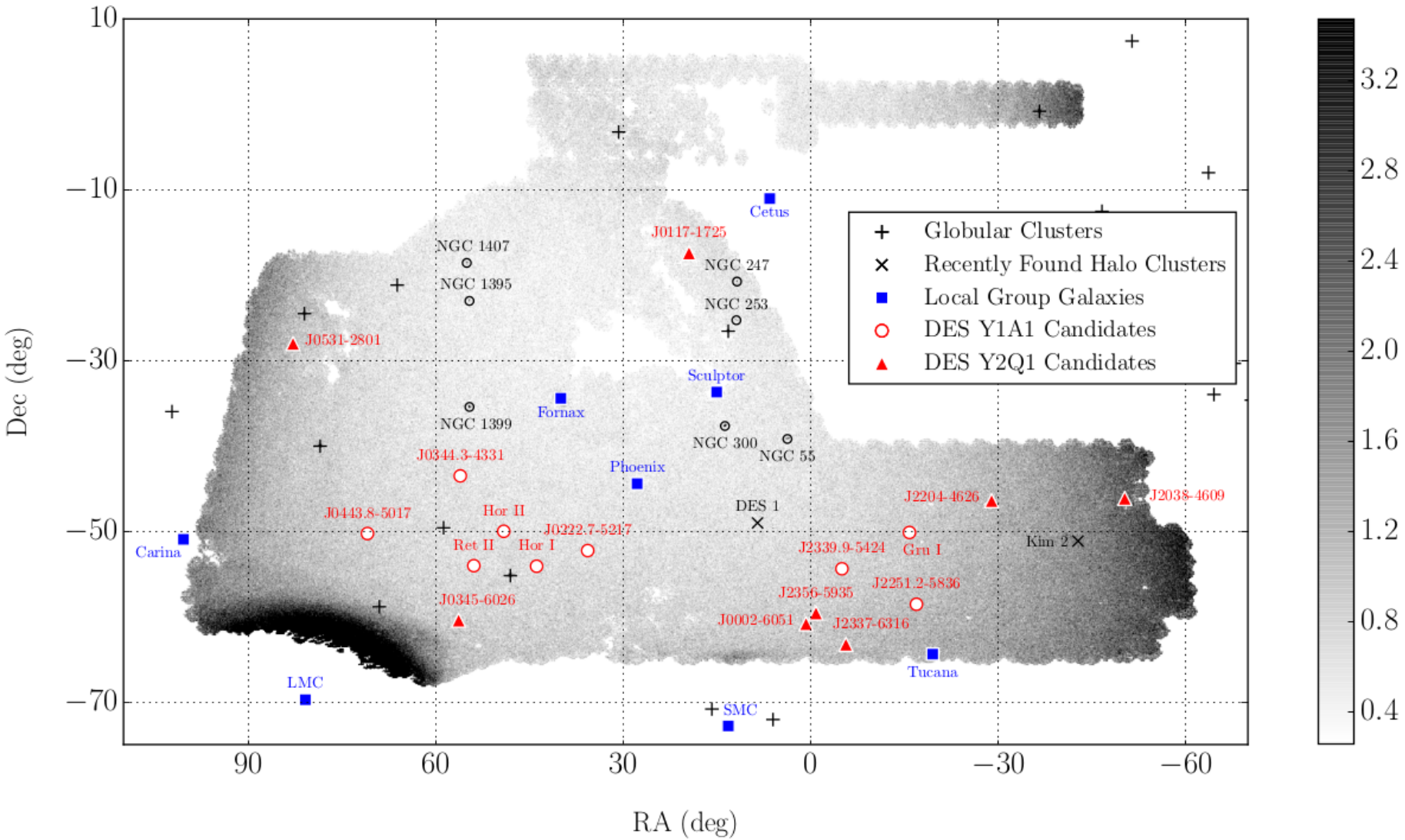


Reed et al 2019, MNRAS, 487, 1874



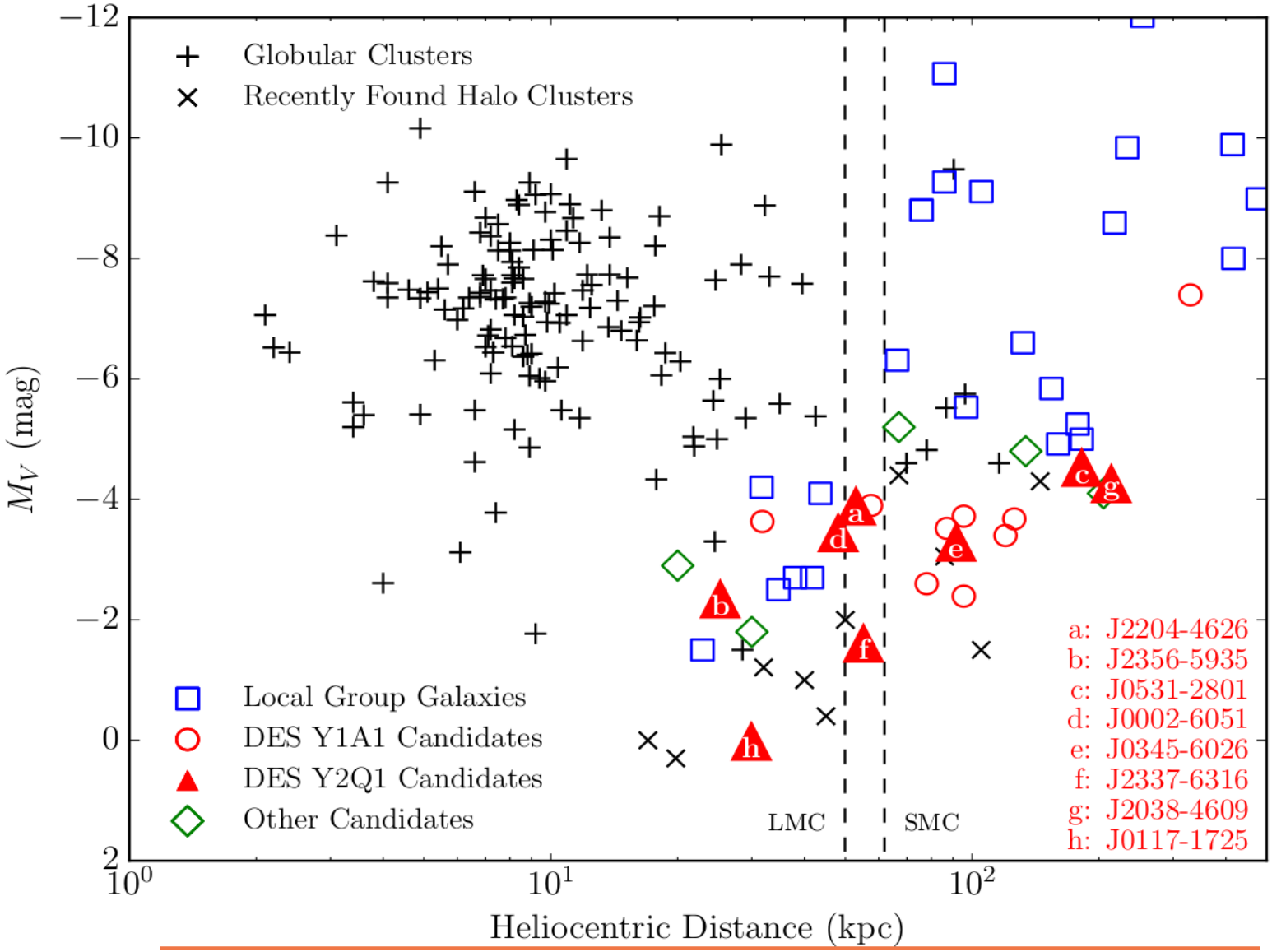
New Ultra-faint dwarfs galaxies (UFDs)

DES Collaboration 2015, ApJ, 813, 109



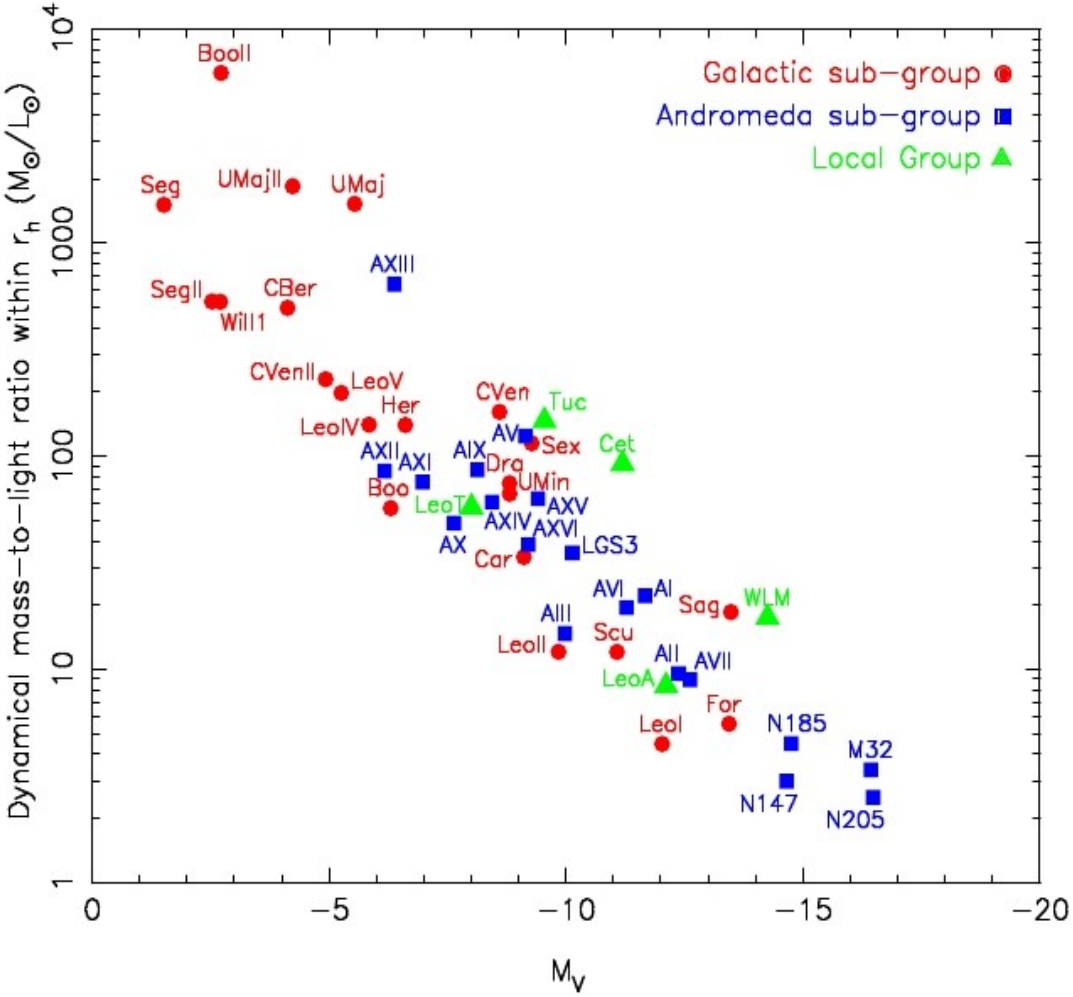
UFDs: Luminosity vs distance

DES Collaboration 2015, ApJ, 813, 109



UFDs – dark matter rich

- DM rich
- Candidates for DM subhalos seen in simulations
- Promissing sites of DM anihilation → DM particles



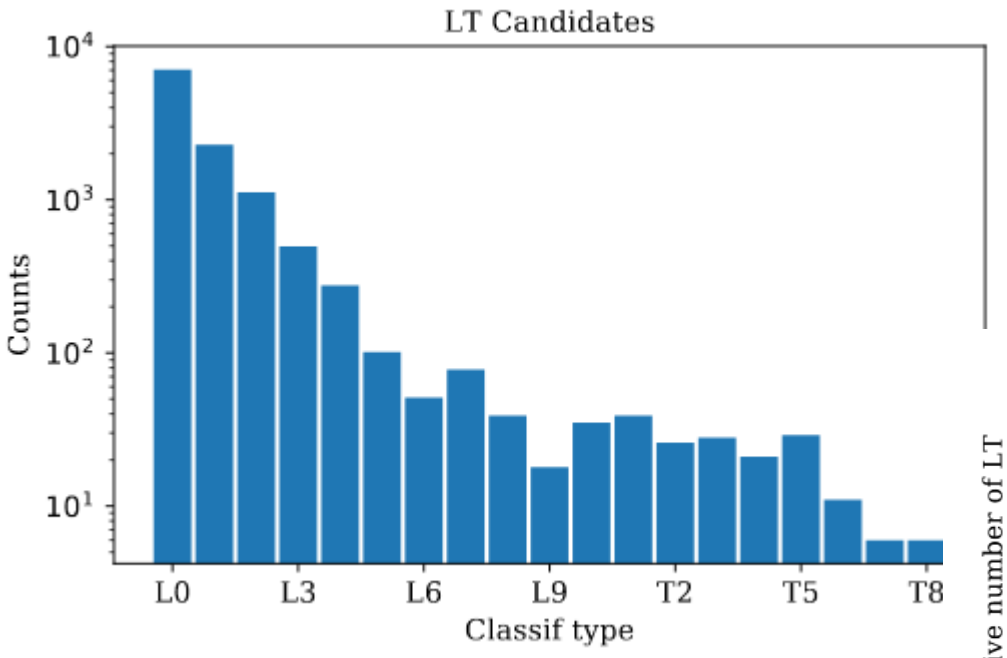
McConnachie 2012

Several other MW related results

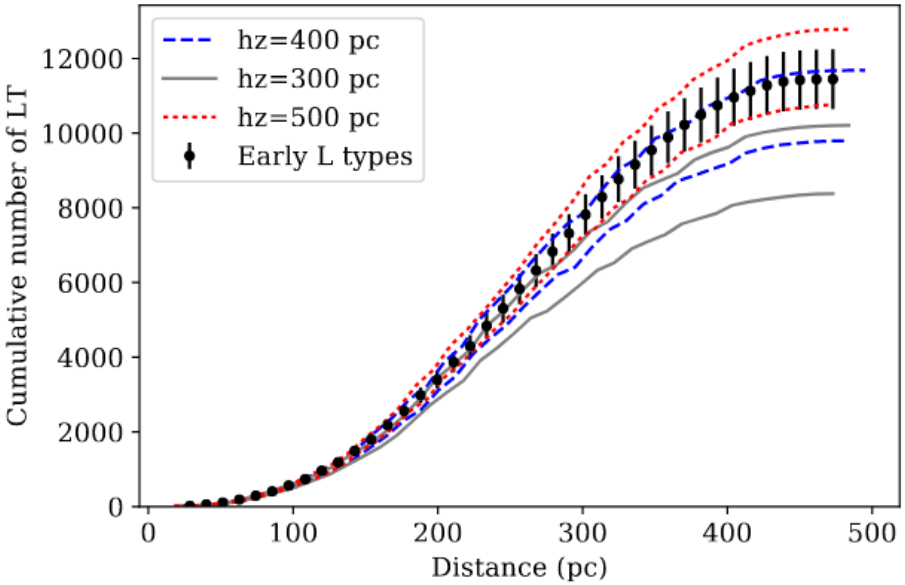
- >100 novos aglomerados estelares nas regiões externas da Grande Nuvem de Magalhães (LMC), Pieres et al 2015
- Estrutura do disco externo da LMC (Balbinot et al 2014)
- Novos aglomerados estelares distantes do Halo da MW: Luque et al 2016, 2018
- Candidatas a anãs ultra-tênues satélites da anã de Sagitário: Luque et al 2017
- Vários candidatos a correntes e nuvens estelares da MW: Shipp et al 2018, Balbinot et al 2016, Li et al 2016
- Subestrutura estelar nas regiões externa da Pequena Nuvem de Magalhães, Pieres et al 2017.

Largest sample of L/T dwarfs

Carnero-Rossell et al. 2019, MNRAS, in press: > 11700 L/T candidates.

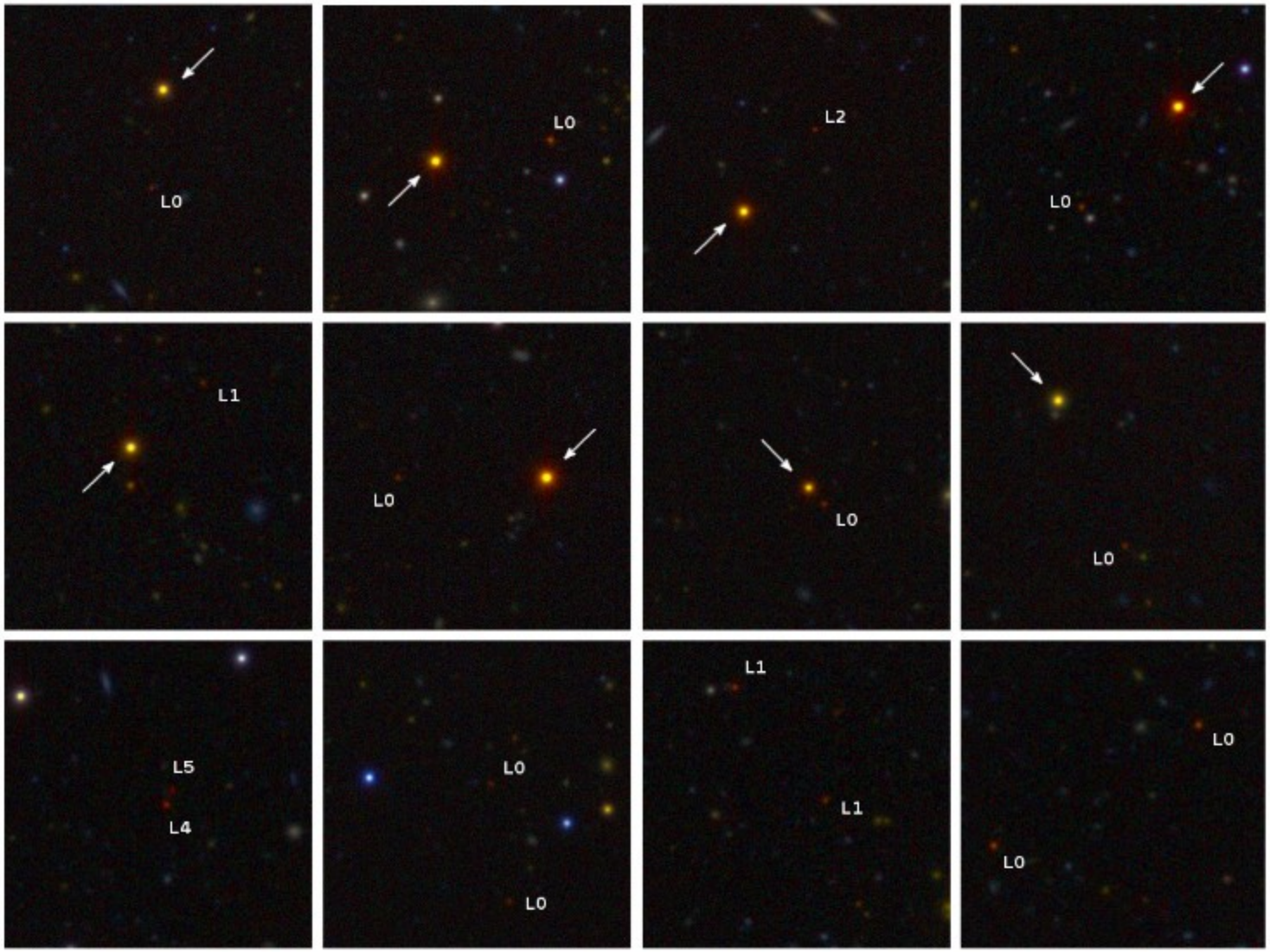


$h_z \sim 450$ pc



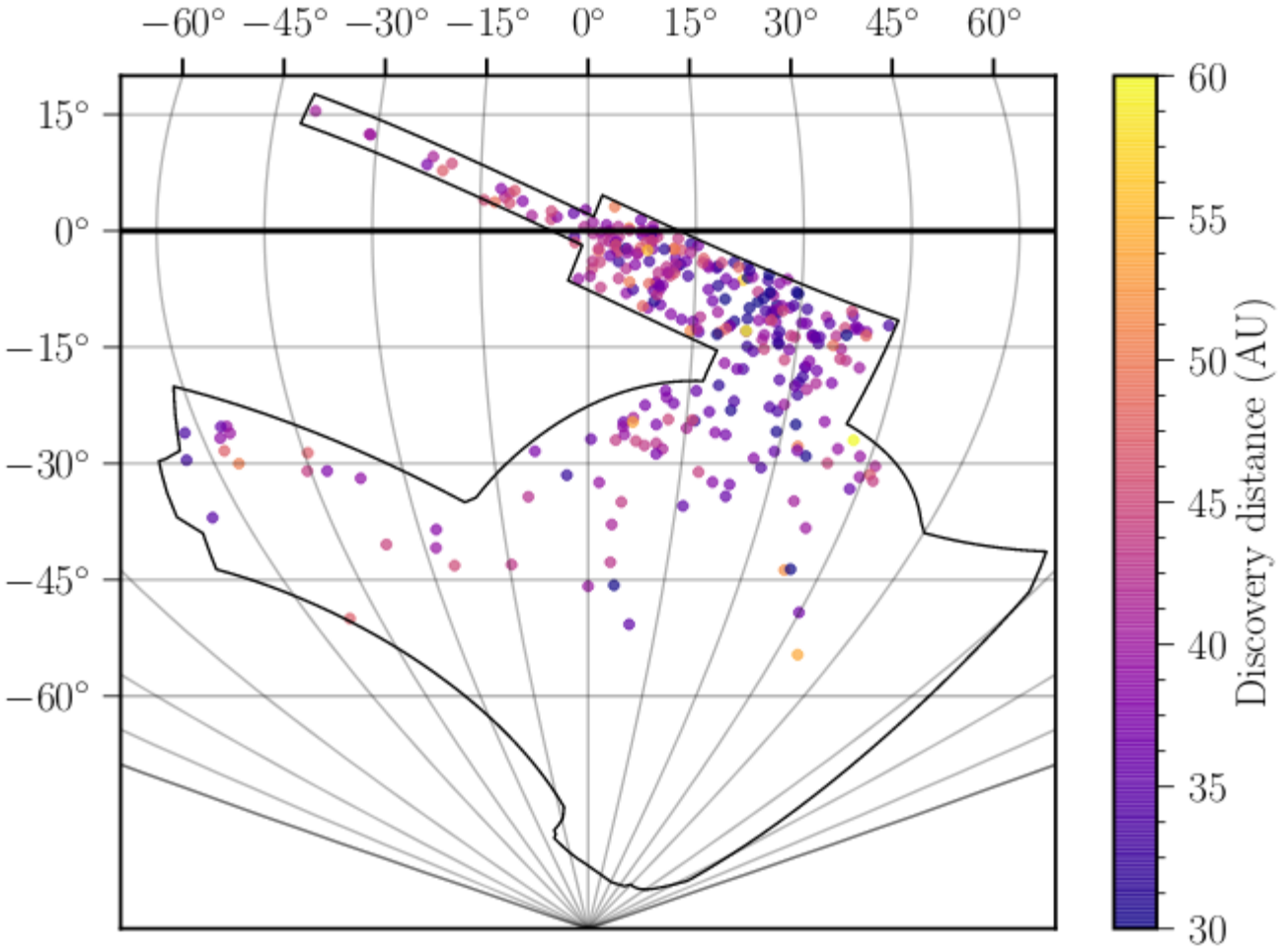
L/T dwarfs in wide binary systems

(Dal Ponte et al 2019, in prep.)

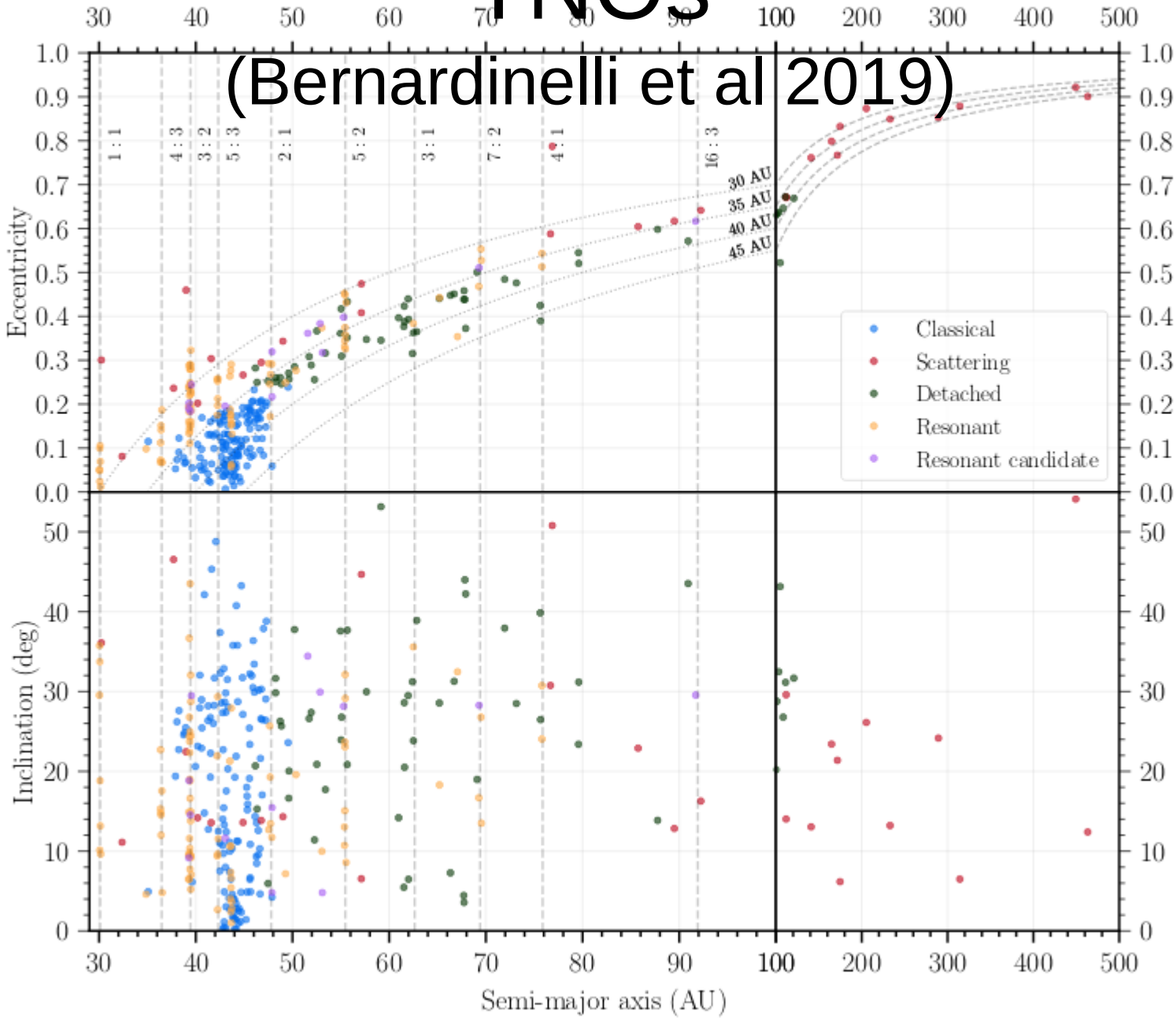


Objetos Transnetunianos (TNOs)

(Bernardinelli et al 2019)



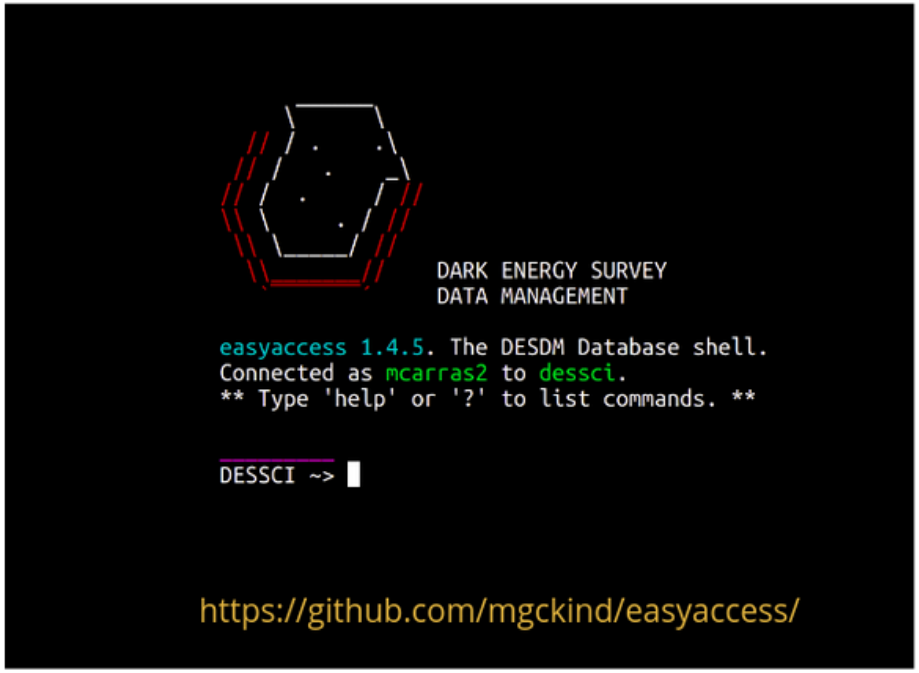
TNOs
(Bernardinelli et al 2019)



DES data access
Marina Dal Ponte

Easyaccess

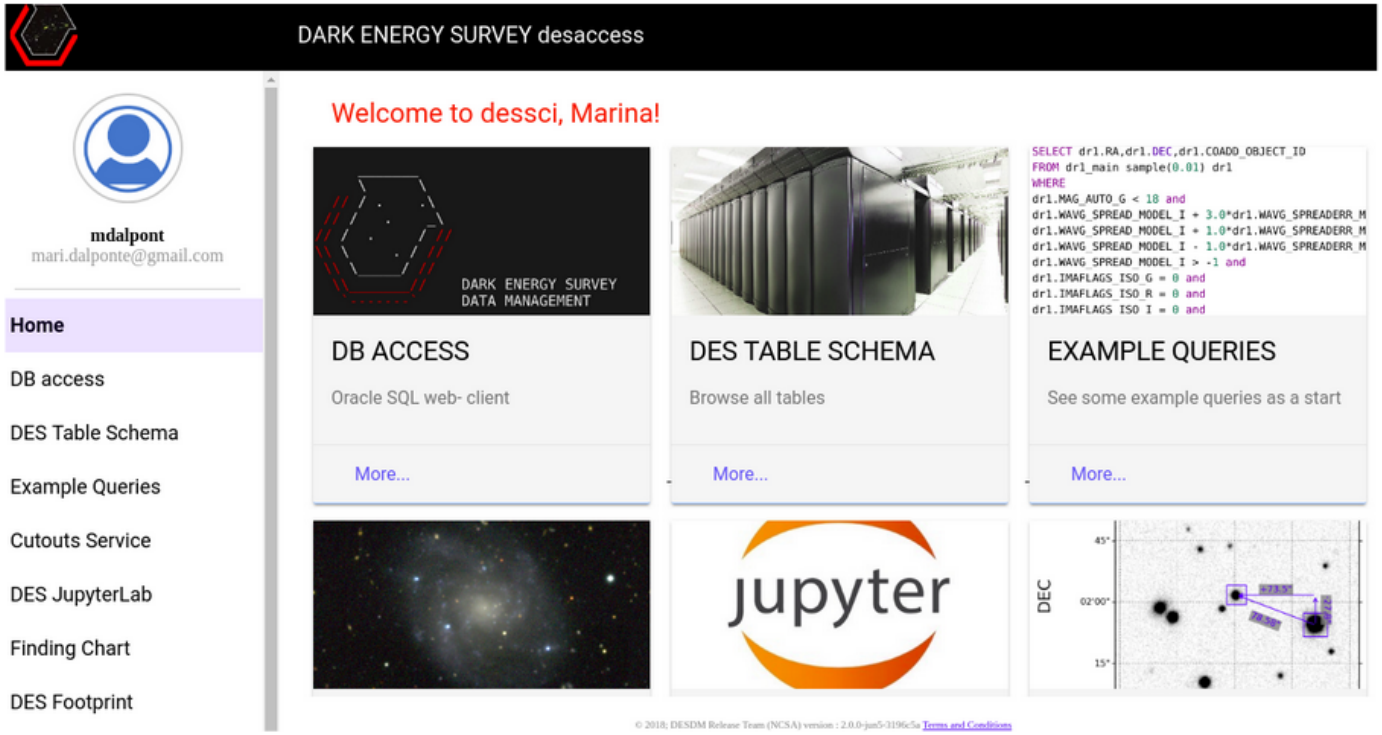
- **easyaccess** is an enhanced command line interpreter and Python package created to facilitate access to the data stored in SQL Databases
- For a short tutorial of installation and documentation: http://matias-ck.com/easyaccess/#/Home
- To create an account: https://des.ncsa.illinois.edu/easyweb/signup/



DES data access
Marina Dal Ponte

DES Labs

To access the web page use the same user and password as the easyaccess.



http://deslabs.ncsa.illinois.edu/easyweb/

Divulgação e educação científica

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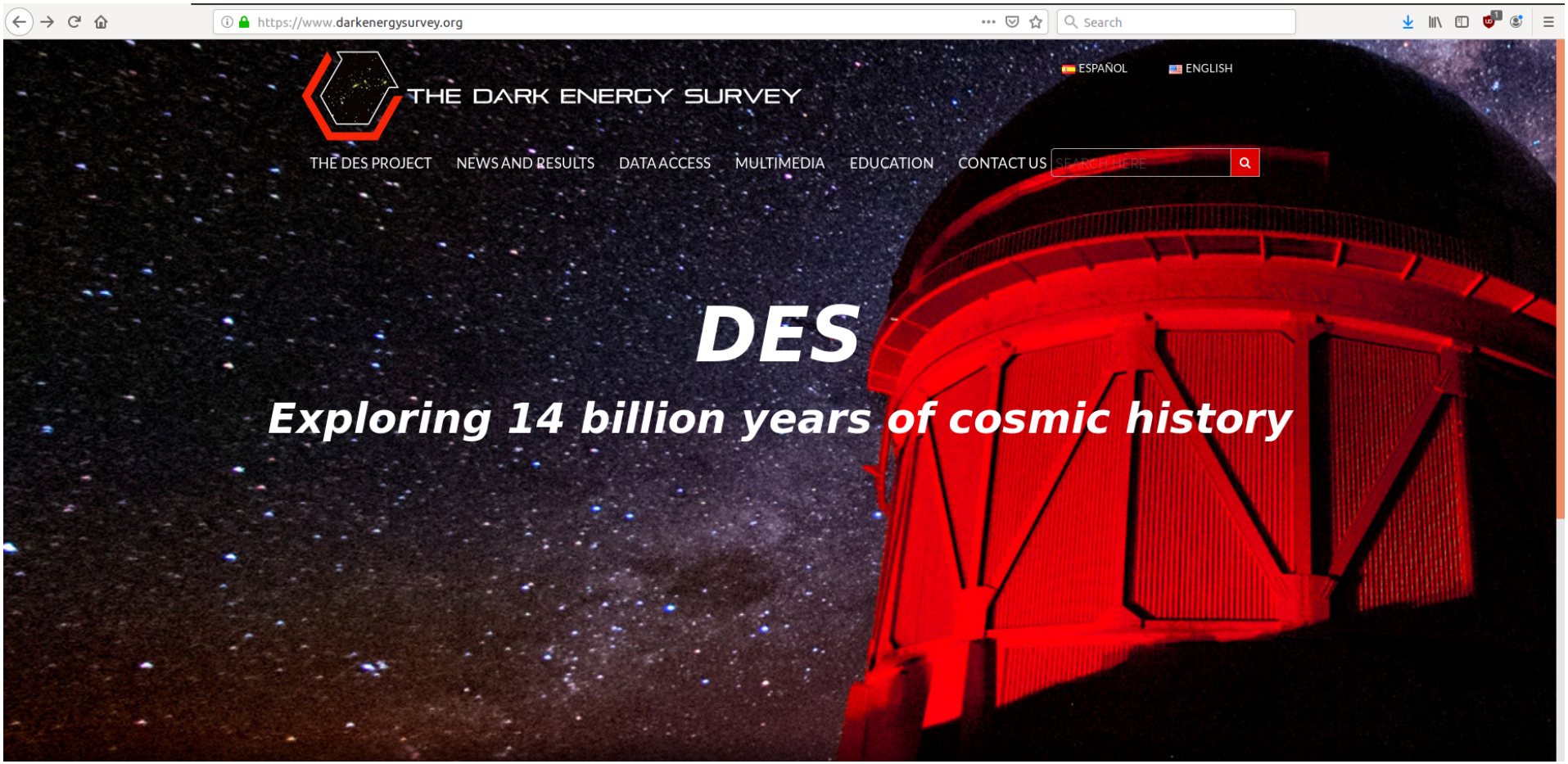

The DES Book
(finalizado em 04/2019, World Scientific)

The Dark Energy Survey: The Story of a Cosmological Experiment

Editors
Ofer Lahav, Lucy Calder,
Julian Mayers, Josh Frieman

Dedication: To everyone who has been involved in DES