Collaborators:

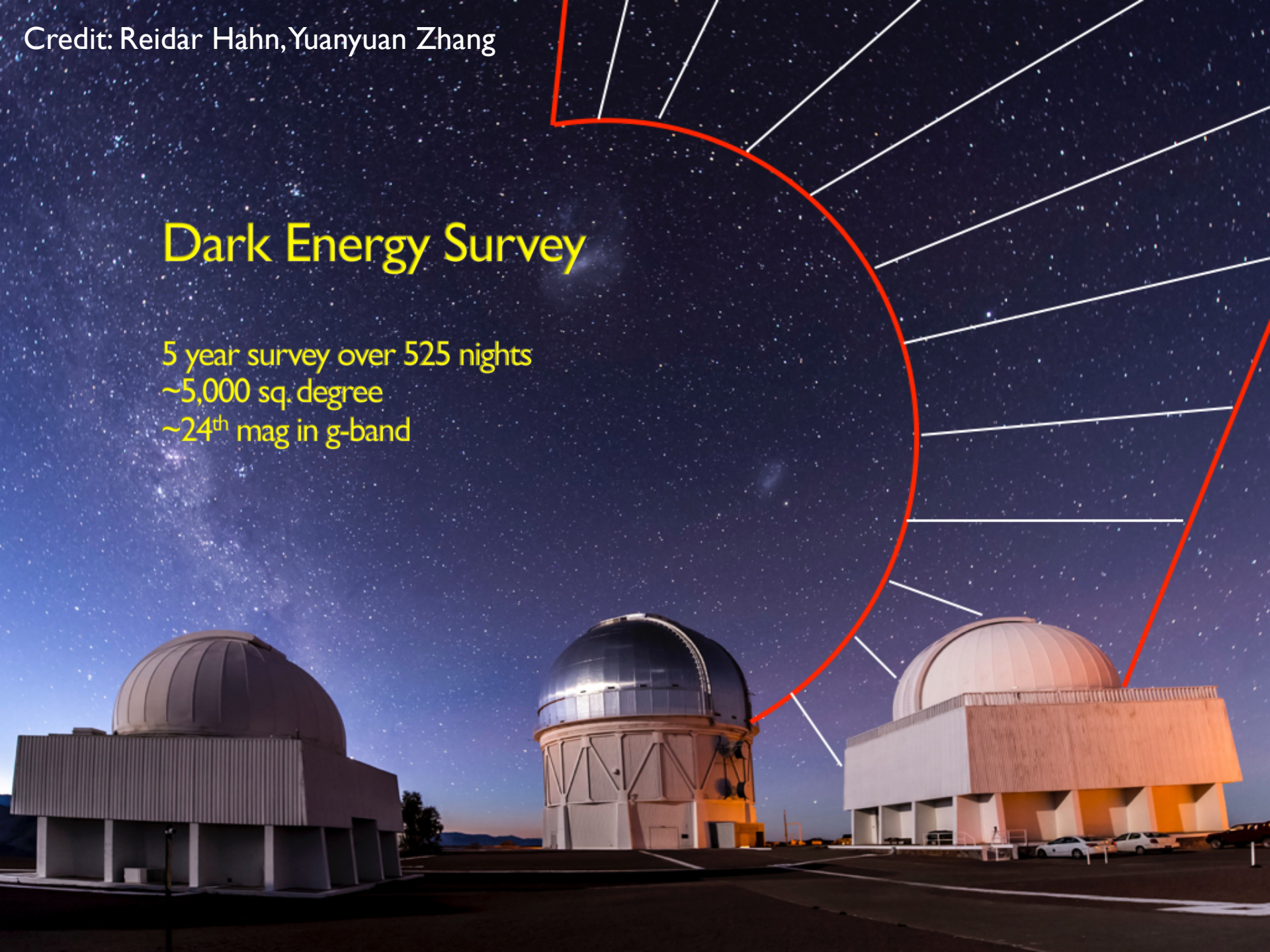
DES collaboration. Jennifer Marshall, Josh Simon, Keith Bechtol, Alex Drlica-Wagner, Louis Strigari, Mei-Yu Wang, Eduardo Balbinot, David James, Basilio Santiago, Brian Yanny and many in DES Milky Way Working Group

Jonathan Hargis, David Sand, Denija Crnojević ……

Studying Milky Way Satellites with the Thirty Meter Telescope

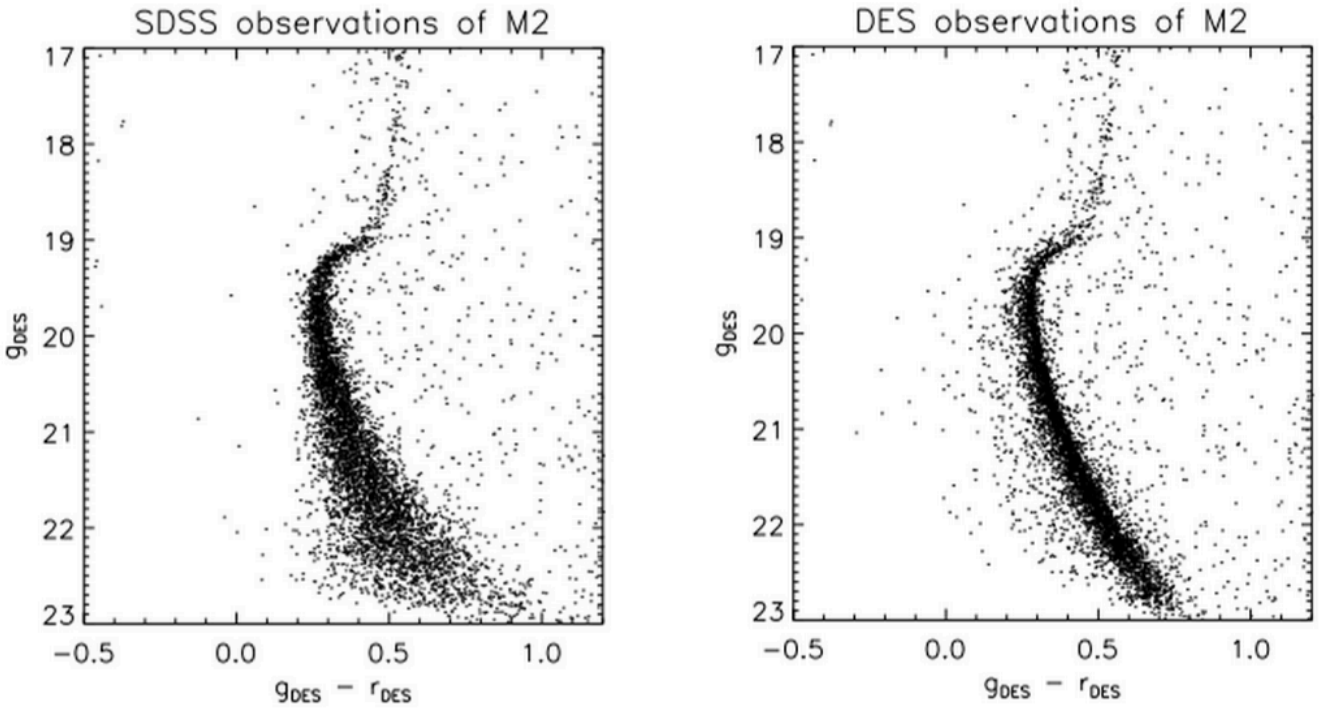
Ting Li
李　婷
李　ティン

Department of Physics and Astronomy
Texas A&M University
TMT Science Forum, June 24, 2015


Credit: Reidar Hahn, Yuanyuan Zhang
Dark Energy Survey
5 year survey over 525 nights
~5,000 sq. degree
~24th mag in g-band

DES Year 1 vs. SDSS on Messier 2

A dramatic improvement in the photometric precision with Blanco+DECam!



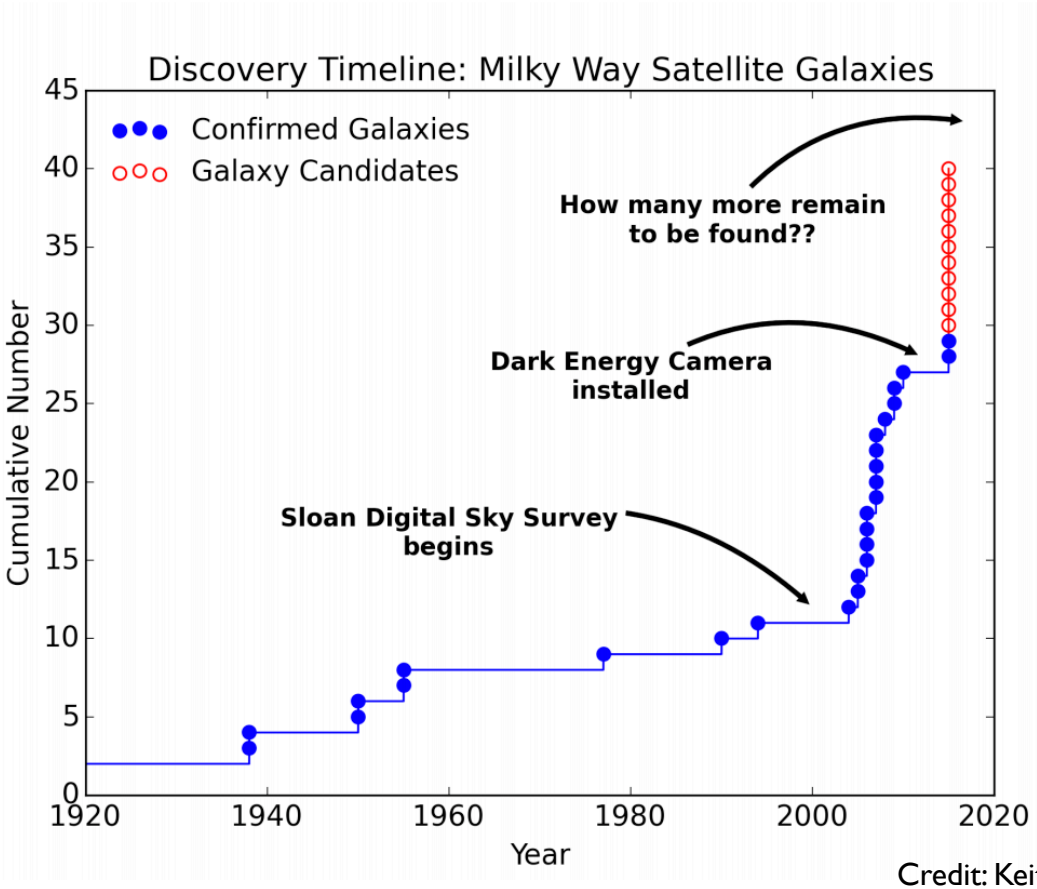
Credit: Josh Simon

And this is just Year 1—deeper, more precise photometry will be produced throughout the five-year survey

THE DARK ENERGY SURVEY

Discovery Timeline

Most satellites discovered in early 2015 involved DECam

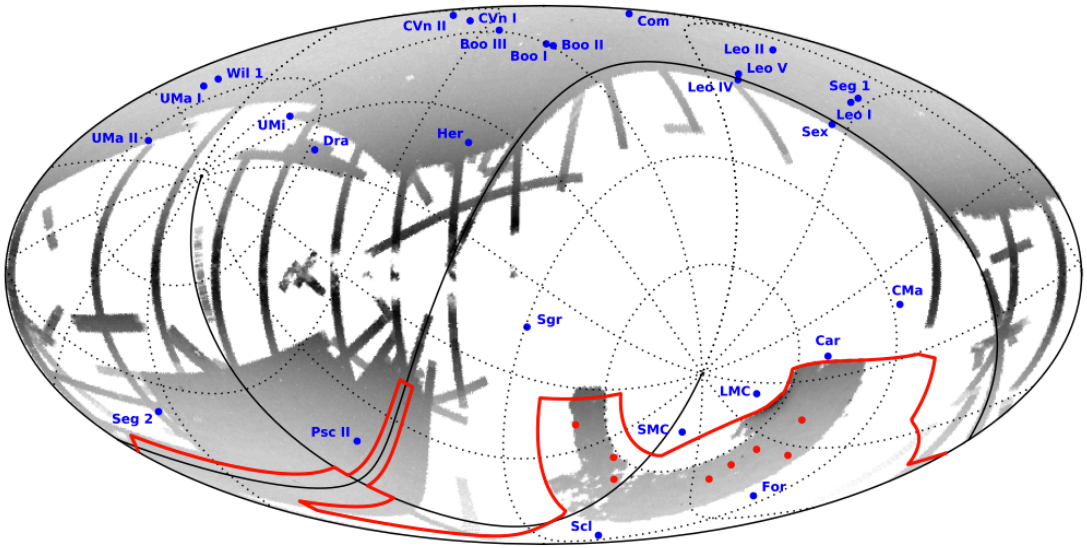


Credit: Keith Bechtol

THE DARK ENERGY SURVEY

Eight Milky Way Satellites Discovered in Year 1 DES data

DES Collaboration
Bechtol et al.
arXiv:1503.02584



Found by non-DES collaboration:

- Gru I (Koposov 2015)
- Kim 2 (Kim 2015a) – Ind I
- Peg III (Kim 2015b) – SDSS DR10
- Hor II (Kim 2015c)
- Hya II (Martin 2015)
- …

Name	α_{2000} (deg)	δ_{2000} (deg)	$m - M$
DES J0335.6-5403 (Ret II)	53.92	-54.05	17.5
DES J0344.3-4331 (Eri II)	56.09	-43.53	22.6
DES J2251.2-5836 (Tuc II)	343.06	-58.57	18.8
DES J0255.4-5406 (Hor I)	43.87	-54.11	19.7
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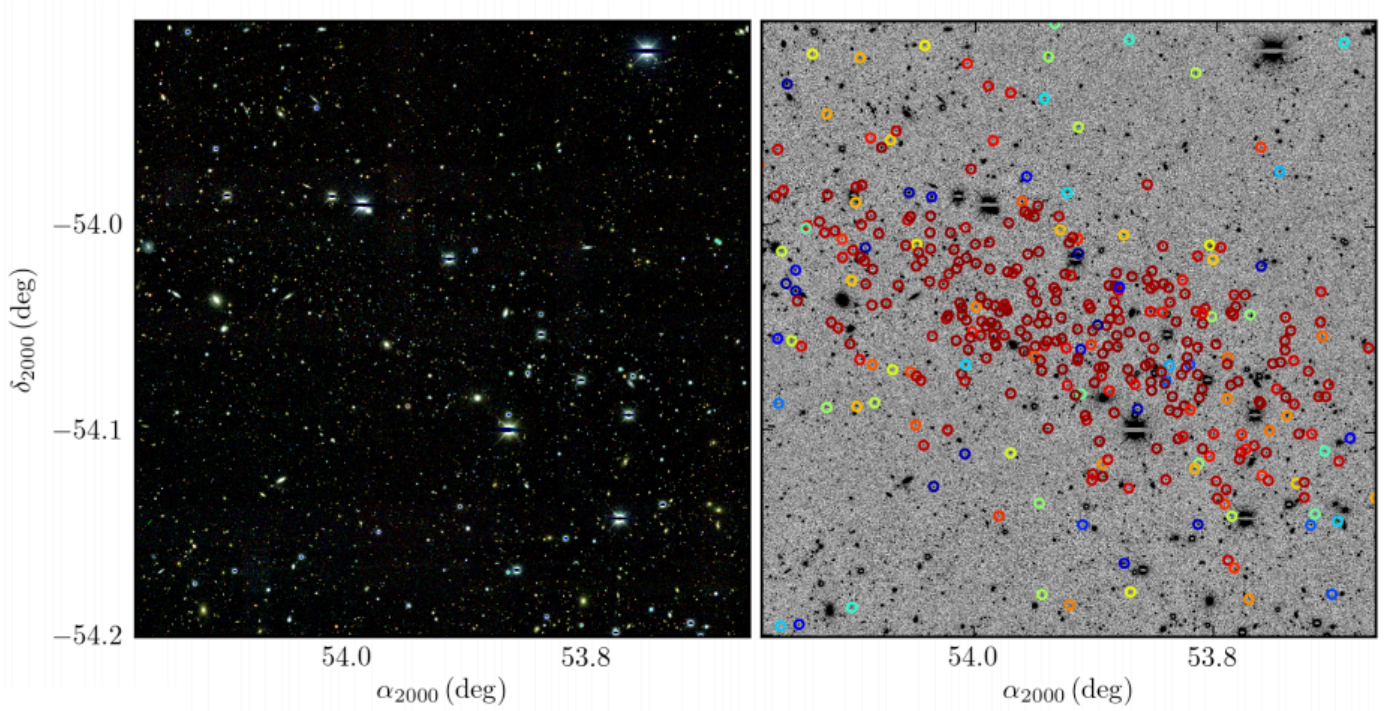
THE DARK ENERGY SURVEY

Spectroscopic follow-up

- Example: Reticulum II



Bechtol et al.
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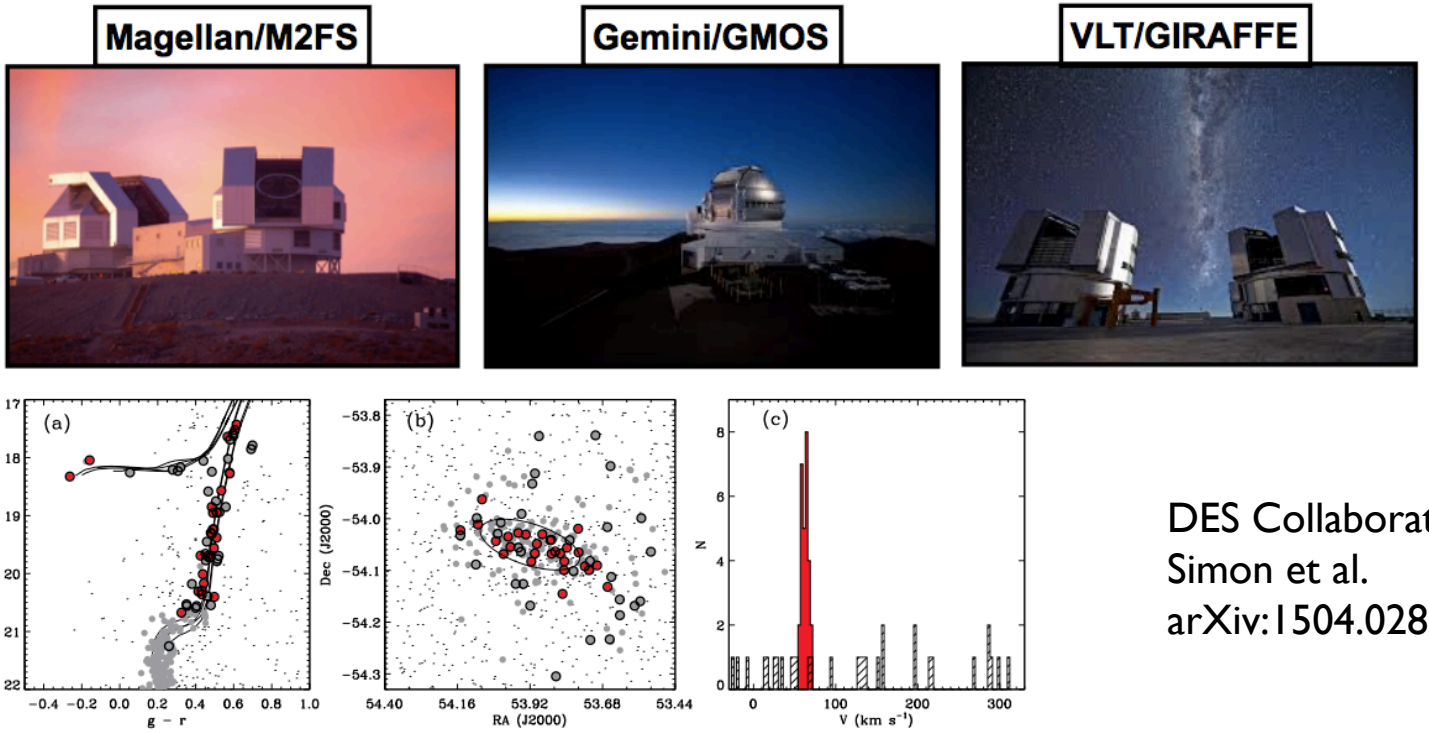
THE DARK ENERGY SURVEY

Spectroscopic follow-up

- Example: Reticulum II



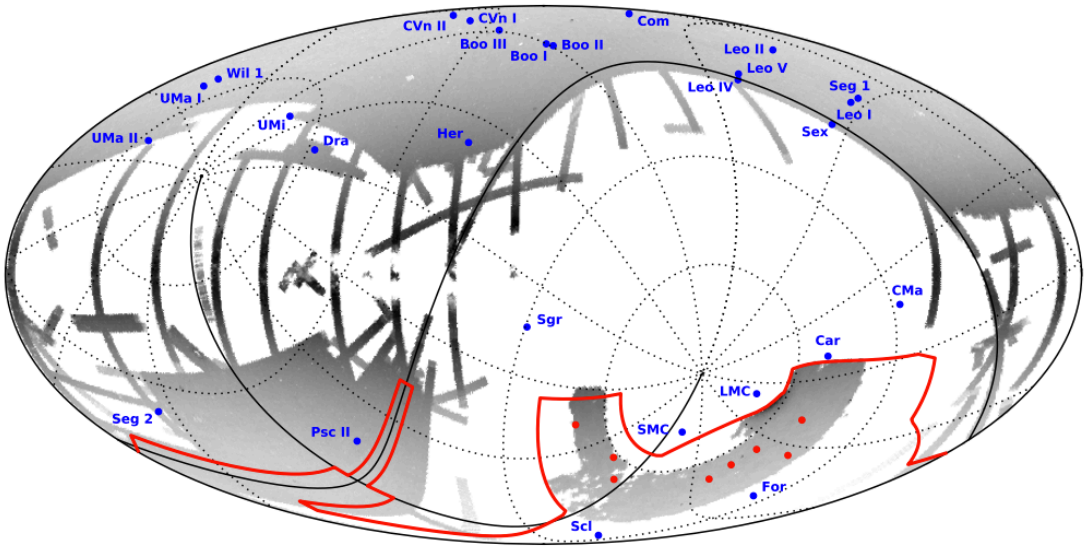
DES Collaboration
Simon et al.
arXiv:1504.02889

velocity dispersion of 3.3 ± 0.7 km/s
mass-to-light ratio 470 ± 210 M_{Sun} / L_{Sun}
$\log_{10}(J) = 18.8 \pm 0.6$ GeV^2 cm^{-5}

THE DARK ENERGY SURVEY

Eight Milky Way Satellites Discovered in Year 1 DES data

DES Collaboration
Bechtol et al.
arXiv:1503.02584



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THE DARK ENERGY SURVEY

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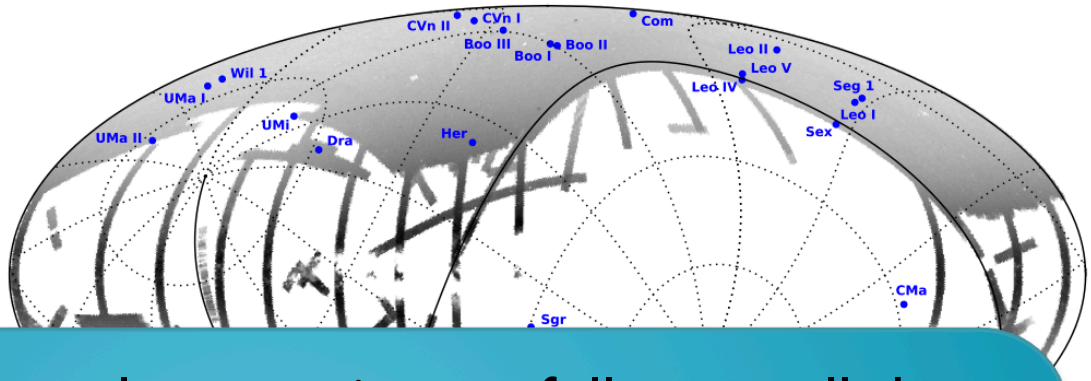

DES Collaboration

400+ hours 8 meter telescope time to follow up all these candidates, in order to confirm whether or not they are dwarf galaxies (~20 stars per dwarf galaxy)

~80 hours for a 30 meter telescope w/ MOS

TMT/WFOS

- Hya II (Martin 2015)
- …

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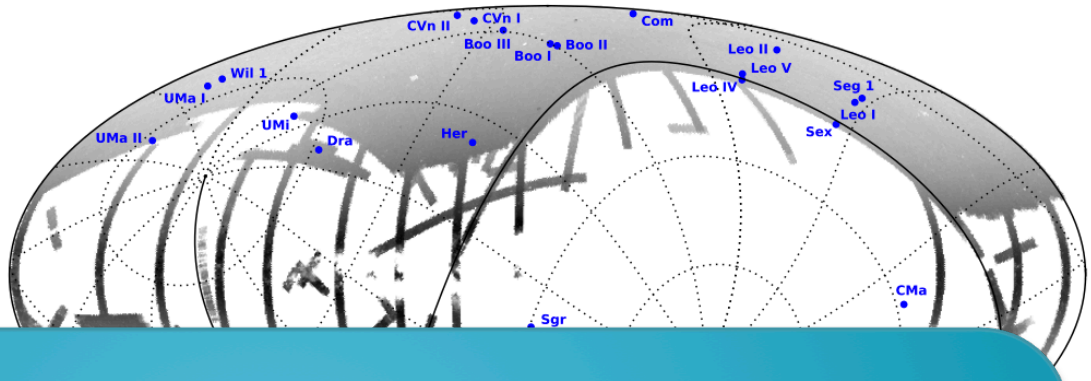
THE DARK ENERGY SURVEY

Eight Milky Way Satellites Discovered in Year 1 DES data



DES Collaboration

most of the sky will have been covered by combination SDSS + PanSTARRS + DES by 2015

newly discovered systems from now on will be even further away / contain fewer bright stars

- Hya II (Martin 2015)
- …

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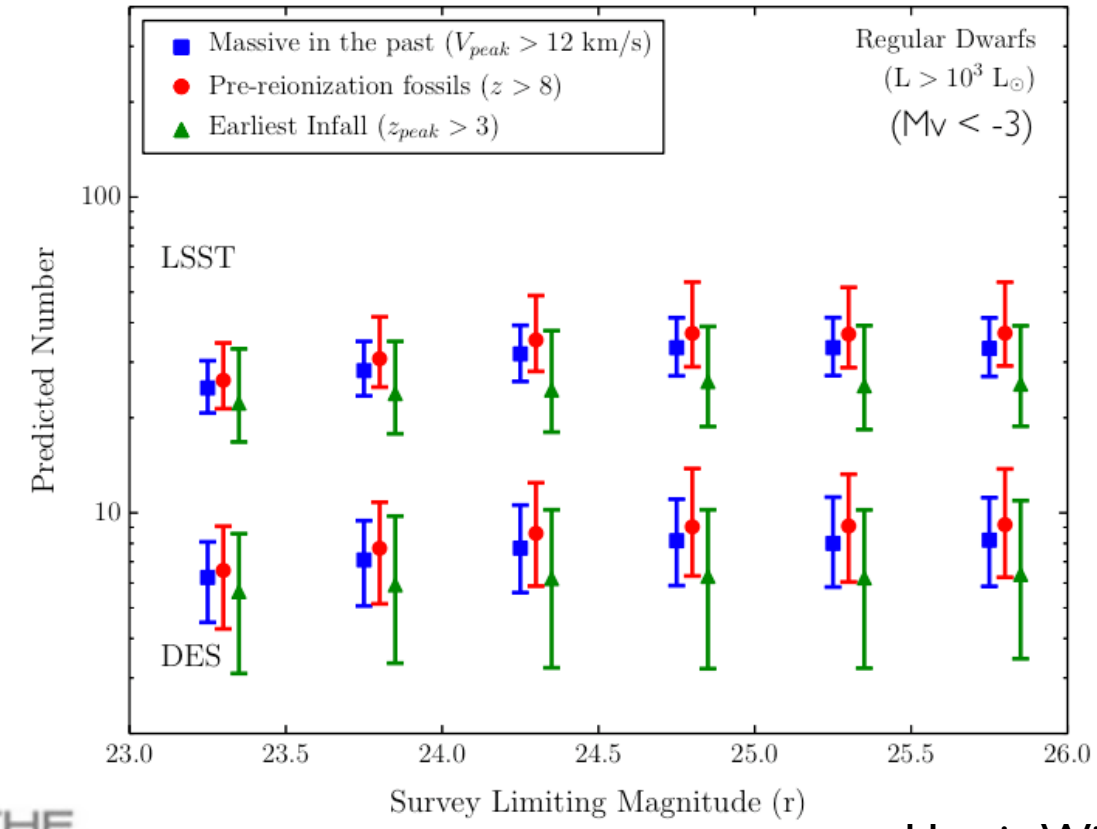
THE DARK ENERGY SURVEY

Predicted numbers of $L > 10^3 L_{Sun}$ dwarfs within 300 kpc for LSST

See more at Hargis' poster!



Prediction:
18-53 in LSST

Number of
$L < 10^3 L_{Sun}$ dwarfs
~ 3-7x larger

Hargis, Willman, & Peter (2014)

THE DARK ENERGY SURVEY

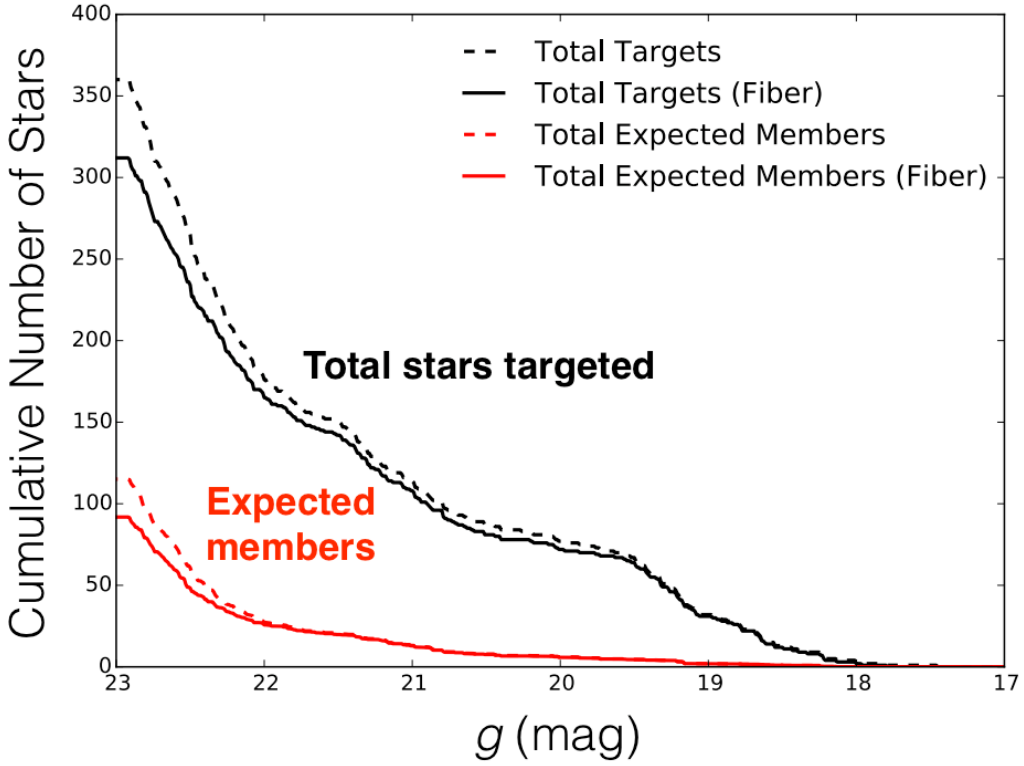
Why TMT?

- Missing Satellite Problem → Confirm more ultra faint dwarf galaxy candidates found by current and future imaging surveys

Why TMT?

- Missing Satellite Problem → Confirm more ultra faint dwarf galaxy candidates found by current and future imaging surveys
- Constrain dark matter model with better measured J-factor (related to the indirect dark matter search with Fermi-LAT)

Planning spectroscopic follow-up for Tuc II



g~21.5, 20 expected members
g~23, 90 expected members
Constrain the J-factor with more members, or higher RV precision

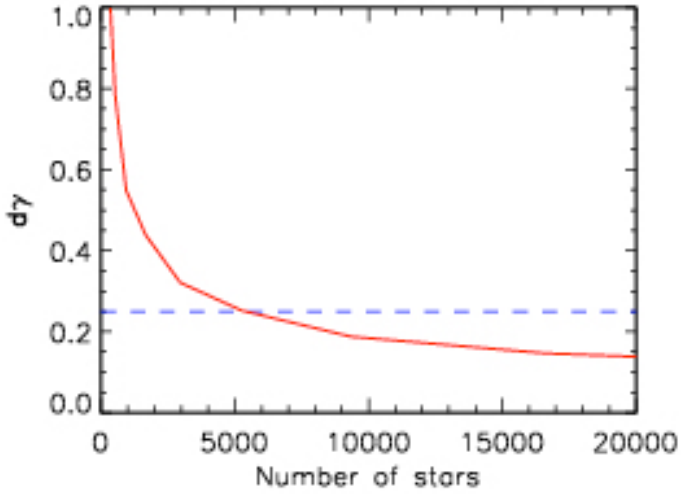
Why TMT?

- Missing Satellite Problem → Confirm more ultra faint dwarf galaxy candidates found by current and future imaging surveys
- Constrain dark matter model with better measured J-factor (related to the indirect dark matter search with Fermi-LAT)
- Cusp/Core problem

Cusp/core problem

Density profile $\rho \sim r^{-\gamma}$

- $\gamma = 0$ core
- $\gamma > 1$ cusp CDM



Strigari et al. 2007

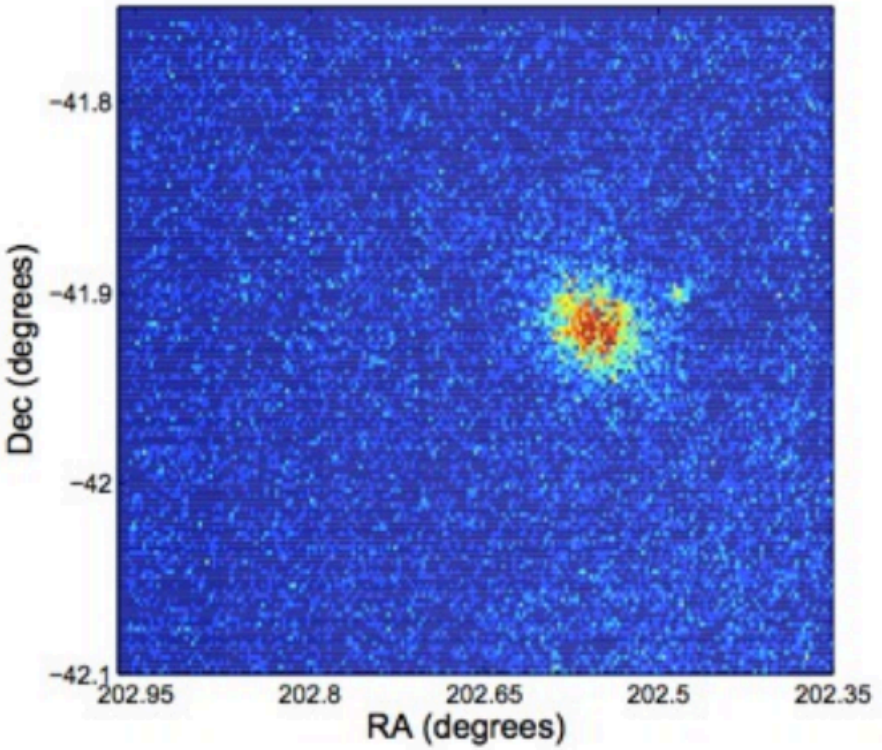
5000 stars to get delta_γ < 0.25
9000 stars to get delta_γ < 0.20
Fornax-like dwarf galaxy
30+ nights per satellite for Keck/DEIMOS, ~8 nights for TMT/WFOS

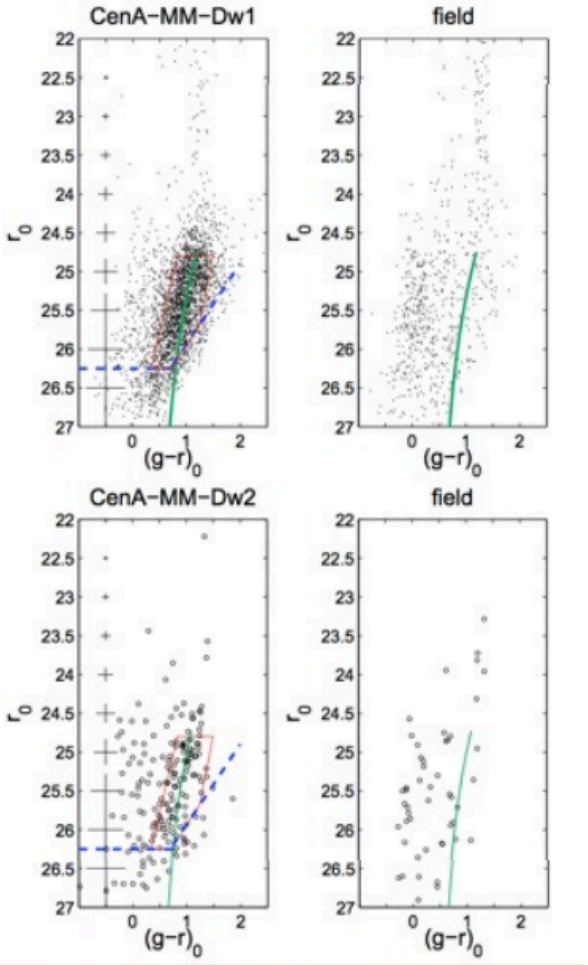
Why TMT?

- Missing Satellite Problem → Confirm more ultra faint dwarf galaxy candidates found by current and future imaging surveys
- Constrain dark matter model with better measured J-factor (related to the indirect dark matter search with Fermi-LAT)
- Cusp/Core problem
- Complete picture of hierarchical assembly of galaxy halos → dwarf galaxies in the Local Group and beyond

A close pair of satellites around Centaurus A

Crnojevic et al. 2014





Pair is projected ~90 kpc from center of CenA.
3 kpc projected separation. Both are at D~3.6 Mpc.

Why TMT?

- Missing Satellite Problem → Confirm more ultra faint dwarf galaxy candidates found by current and future imaging surveys
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Going further!

- TMT/WFOS
  - Low-moderate resolution
  - Membership/Kinematics
- TMT/HROS
  - High-resolution
  - Chemical abundance study

Thanks for your attention and questions?