Cosmology with the High Latitude Survey

Nancy Grace Roman Space Telescope Science Investigation Team

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Image Credit: Illustris TNG

https://roman-hls-cosmology.space

STUDYING THE HLS AS A WHOLE

- This team was selected (in December 2015) to address the stringent challenges of the Roman dark energy (DE) program through the Project's formulation phase.
  - ➡ This SIT has elected to address Galaxy Redshift Survey (GRS), Weak Lensing (WL) and Cluster Growth (CL) of the WFIRST Science Investigation Team (SIT)

- We decided to address these DE probes as a unified team:
  - ➡ These investigations are tightly linked at both the technical level and the theoretical modeling level.
  - ➡ Imaging and spectroscopic elements of the High Latitude Survey (HLS) will be realized as an integrated observing program, trying to solve the same question
  - ➡ Jointly impose requirements on payload performance, operations, and data transfer
  - ➡ Methods for simulating and interpreting WL lensing and GC observations largely overlap. Many members of our team have expertise in both areas.

STUDYING THE HLS

- Roman is designed to be able to deliver a definitive result on the origin of cosmic acceleration.
  - ➡ If the growth rate of structure (WL, RSD) is inconsistent with the evolution of the Hubble constant (SNe, BAO), this would be the signature of the breakdown of General Relativity on cosmological scales.
  - ➡ If the evolution of the Hubble constant is consistent with the growth rate of structure but inconsistent with vacuum energy, then this would imply that dark energy is dynamical.
  - ➡ Either result would have a profound impact on our understanding of physics.
  - ➡ The Roman HLS is not optimized for Figure of Merit sensitivity but for control of systematic uncertainties in the astronomical measurements and for having multiple techniques each with multiple cross-checks.

- Our SIT work focuses on understanding the potential systematics in the WFIRST dark energy measurements. Define a survey that satisfies the Roman science goals.

HOW WE DID IT: A GREAT TEAM

- Anahita Alavi (Caltech/IPAC)
- Rachel Bean (Cornell)
- Andrew Benson (Carnegie)
- Ami Choi (OSU)
- James Colbert (Caltech/IPAC)
- Miles Cranmer (Princeton)
- Matthew Digman (OSU)
- Olivier Doré (JPL/Caltech, PI)
- Cyrille Doux (Penn)
- Tim Eifler (U. Arizona)
- Xiao Fang (U. Arizona)
- Henry Gebhardt (JPL)
- Siyu He (CMU/Berkeley)
- Chen Heinrich (JPL/Caltech)
- Katrin Heitmann (ANL)
- George Helou (Caltech/IPAC)
- Shoubaneh Hemmati (Caltech/IPAC)
- Eric Huff (JPL)
- Shirley Ho (CCA, Flatiron Institute)
- Bhuvnesh Jain (Penn)
- Mike Jarvis (Penn)
- Arun Kannawadi (CMU, Princeton)
- Alina Kiessling (JPL/Caltech)
- Elisabeth Krause (U. Arizona)
- Chris Hirata (OSU, Weak lensing lead)
- Alexie Leauthaud (UCSC)
- Chien-Hao Lin (CMU, Duke)
- Robert Lupton (Princeton)
- Chien-Has Lin (CMU)
- Niall MacCrann (OSU)
- Silva Makana (OSU)
- Rachel Mandelbaum (CMU)
- Dida Markovic (JPL)
- Elena Massara (U Waterloo)
- Dan Masters (Caltech/IPAC)
- Vivian Miranda (U. Arizona)
- Alex Merson (Caltech/IPAC)
- Hironao Miyatake (Nagoya U.)
- Atsushi Nishizawa (Nagoya U.)
- Nikhil Padmanabhan (Yale)
- Shivam Pandey (Penn)
- Kris Pardo (JPL)
- Andy Park (CMU)
- David Pearson (KSU, PSU)
- Andrés Plazas Malagon (Princeton)
- Anna Porredon (OSU)
- Alice Pisani (CCA/Cooper Union/Princeton)
- Eduardo Rozo (U. Arizona)
- Lado Samushia (U. Kansas)
- Mike Seiffert (JPL/Caltech)
- Charles Shapiro (JPL/Caltech)
- David Spergel (Princeton, CCA, Flatiron Institute)
- Tomomi Sunayama (Nagoya U.)
- Masahiro Takada (U. Tokyo, IPMU)
- Peter Taylor (JPL)
- Harry Teplitz (Caltech/IPAC)
- Michael Troxel (Duke)
- Francisco Antonio Villaescusa Navarro (CCA,Princeton)
- Anja von der Linden (Stony Brook University)
- Yun Wang (Caltech/IPAC, Galaxy redshift survey lead)
- David Weinberg (OSU, Galaxy clusters lead)
- Lukas Wenzl (Cornell)
- Hao-Yi Wu (OSU)
- Zhongxu Zhai (Caltech/IPAC)

Partially supported 11 graduate students, 15 post-docs, 10 of which moved on to permanent positions in the field

THE ROMAN COSMOLOGY VISION WE DEVELOPED OVER THE YEARS

- This vision emerged through close interactions with FSWG colleagues, the Roman adjutants, and the Roman Project Office
  - ➡ Thank you Julie McEnery, Jeff Kruk, and David Spergel for leading us efficiently and thoughtfully over these eventful years
  - ➡ Thank you to the HLS Cosmology Team for a productive and fun collaboration throughout
  - ➡ We went through a lot, but also accomplished a lot!

- Roman (and the HLS) is the space-based probe of DE the community needs in the mid-2020s
  - ➡ It is *agile* enough to address the key questions that we drive the field when Roman launches, ie after WL results from DES, KIDS and HSC are finalized, after most of the BAO/RSD results from DESI are out, and after early data from first Rubin/LSST, Euclid, and SO
  - ➡ It will uniquely address "tensions" (if there are any), hints of new physics, or simply increased our knowledge of the LCDM model dramatically in combination with these surveys.
- Roman unique control of systematics and multi-probe approach will bring extreme robustness to the cosmology of the late 2020s
  - ➡ The whole is greater than the sum of each probe
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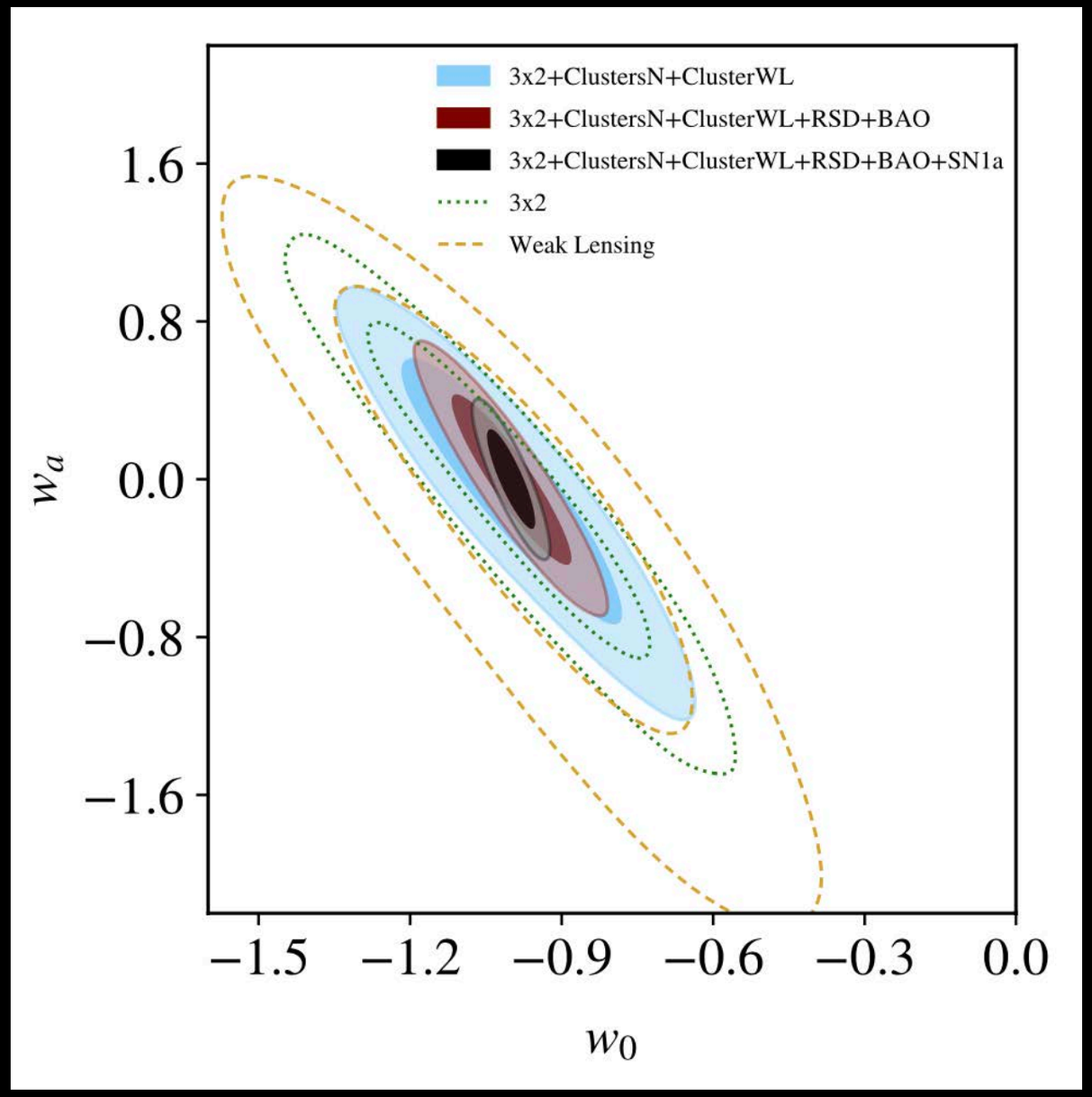
- This vision for Roman truly motivated our work

ROMAN MULTI-PROBE ANALYSIS



Eifler++20

Adding one Roman DE probe at a time starting from WL alone

Even richer analysis will happen when *multi-probe* becomes *multi-survey* with Rubin, DESI, Euclid, SPHEREx, SO, S4, …

WHAT WE ACHIEVED

- In our initial proposal, we promised 12 deliverables (detailed in OD++17 arXiv:1804.03628) and we completed (or are about to) all:

1. Full requirement slowdown,
2. Cosmological forecasts,
3. Simulated data-sets,
4. Prototype pipelines,
5. Calibration strategies,
6. Strategy for photometric redshifts,
7. Modeling/interpretation methods,
8. Detailed operations concept,
9. Pilot surveys plan,
10. Plan observations w/ other facilities,
11. Simulated Light-cone Observations,
12. Community engagement.

- In the coming 3 hours, you will hear highlights of most of these efforts by their leaders and the more junior team members who contributed to them
- While working on these deliverables, we published 79 papers on directly relevant topics
- Roman will be a formidable cosmological mission in the coming years and the HLS survey, in its future shape will be groundbreaking, for DE cosmology, and for astrophysics as a whole.
- Scientific discoveries with the HLS are guaranteed
- Thank you for joining us and enjoy this session!