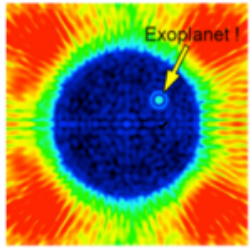
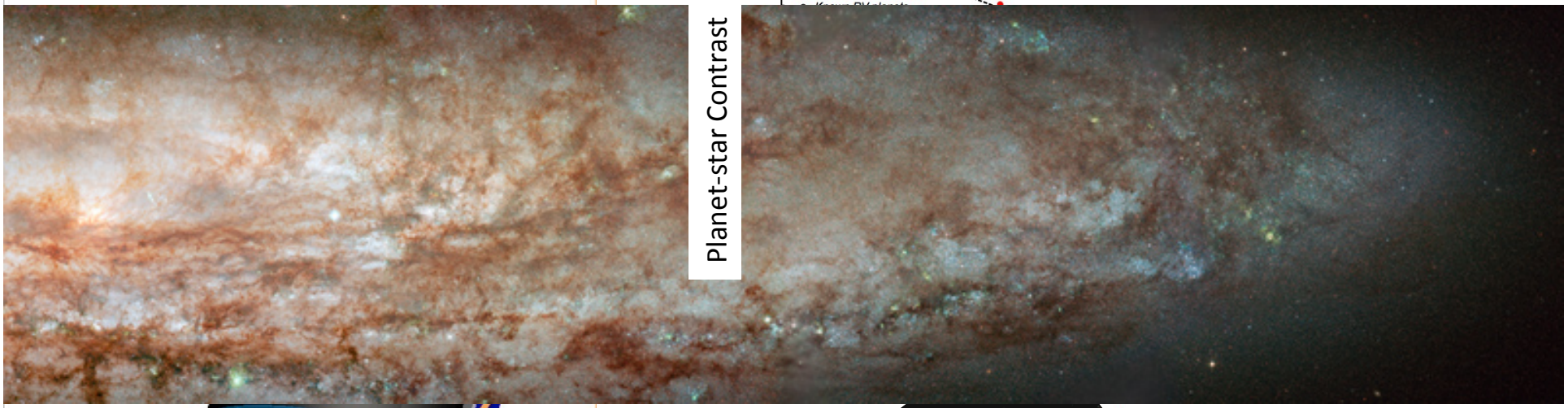
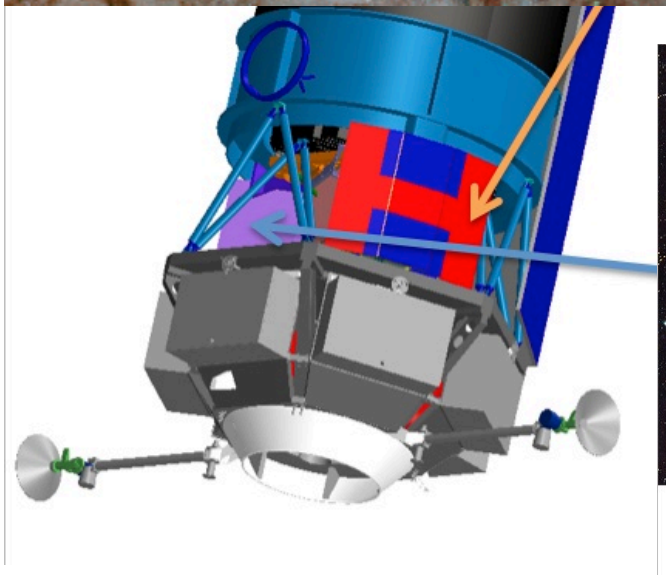
WFIRST-AFTA Mission Science

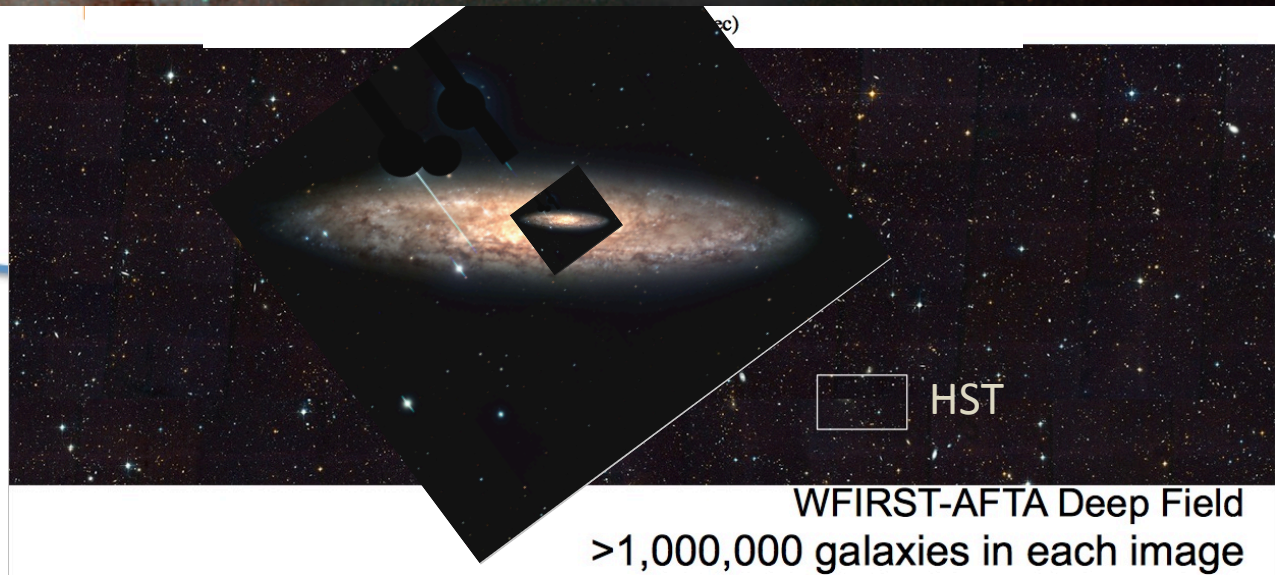
Alan Dressler, AAS Seattle, January 7, 2015

WFIRST-AFTA Instruments

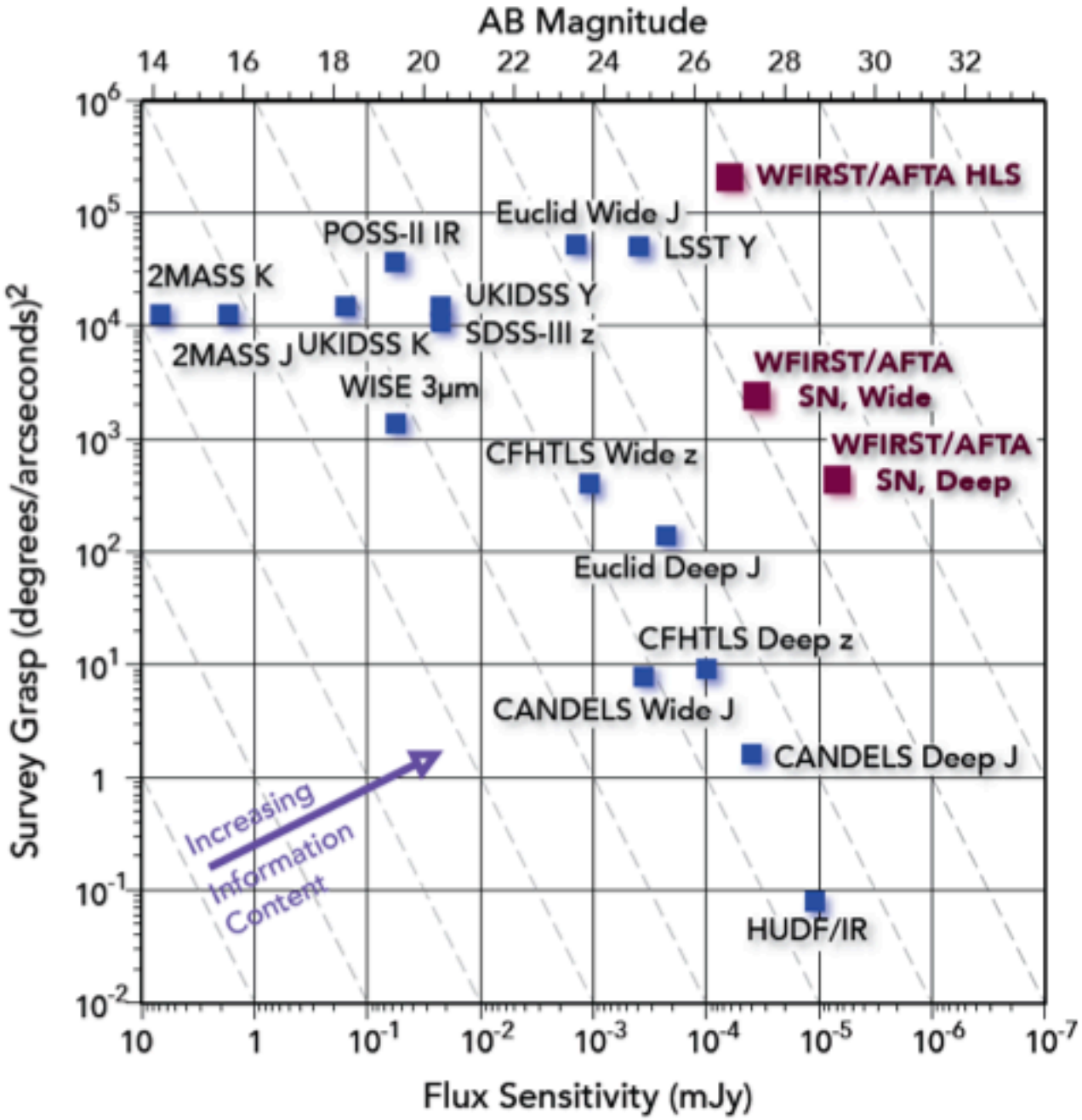








WFIRST-AFTA Deep Field
>1,000,000 galaxies in each image



WFIRST-AFTA SDT Interim Report

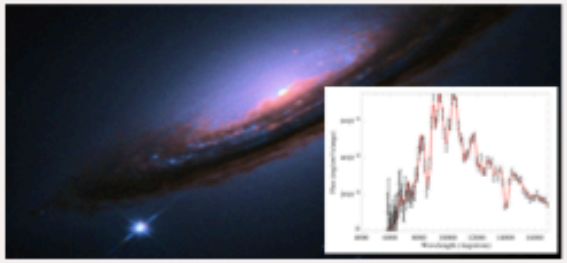
WFIRST-AFTA Dark Energy Roadmap

Supernova Survey

wide, medium, & deep imaging
+
IFU spectroscopy

2700 type Ia supernovae
z = 0.1–1.7

standard candle distances
z < 1 to 0.20% and z > 1 to 0.34%



High Latitude Survey

spectroscopic: galaxy redshifts

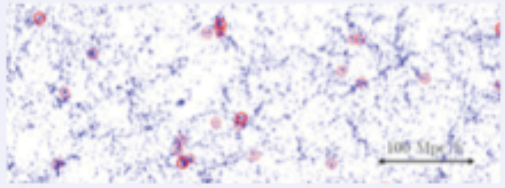
20 million Hα galaxies, z = 1–2
2 million [OIII] galaxies, z = 2–3

imaging: weak lensing shapes

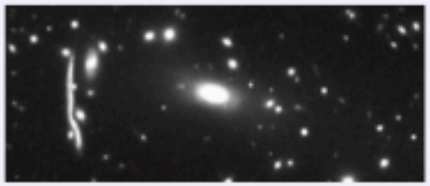
400 million lensed galaxies
40,000 massive clusters

standard ruler

distances	expansion rate
z = 1–2 to 0.4%	z = 1–2 to 0.72%
z = 2–3 to 1.3%	z = 2–3 to 1.8%

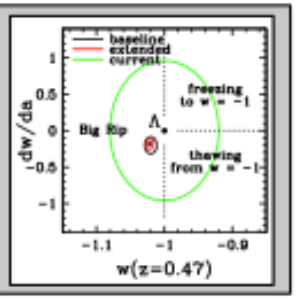


dark matter clustering
z < 1 to 0.16% (WL); 0.14% (CL)
z > 1 to 0.54% (WL); 0.28% (CL)
1.2% (RSD)



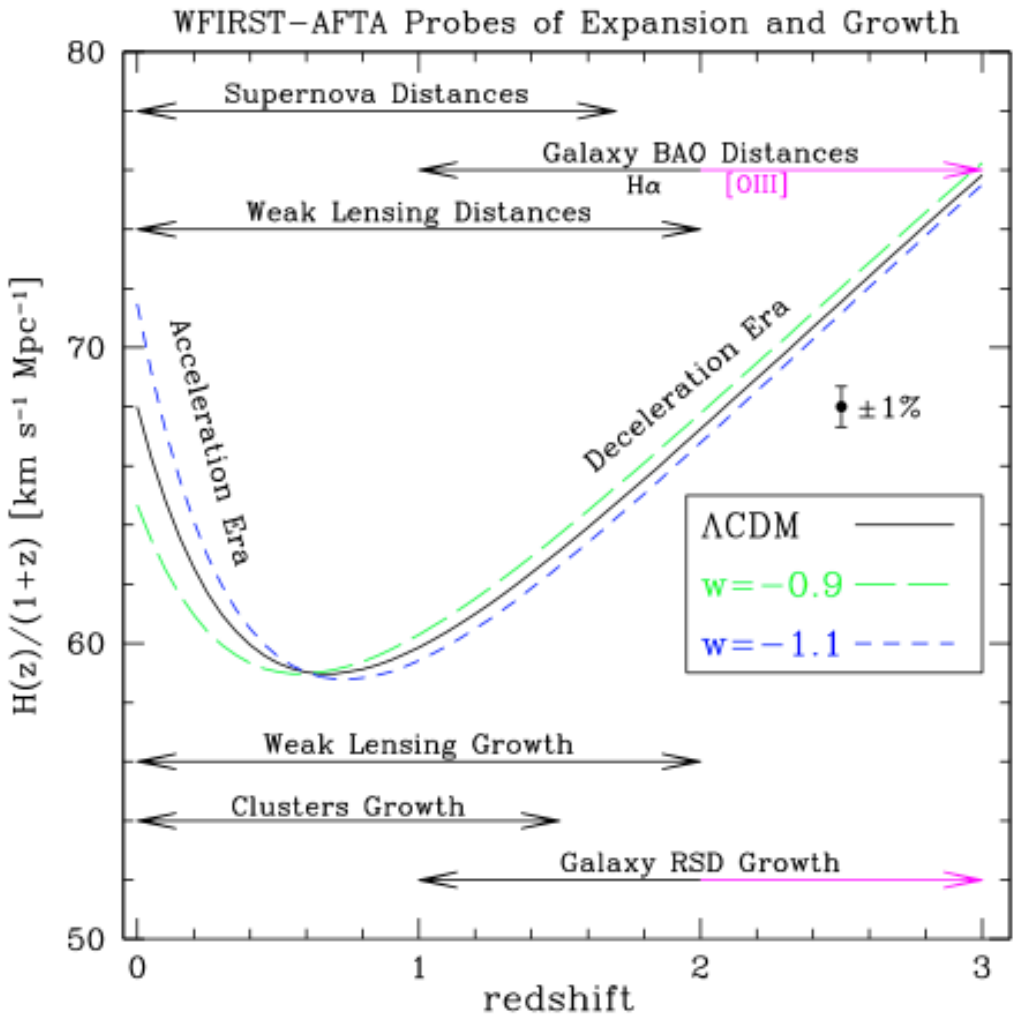
history of dark energy
+
deviations from GR

$w(z),\ \Delta G(z),\ \Phi_{REL}/\Phi_{NREL}$



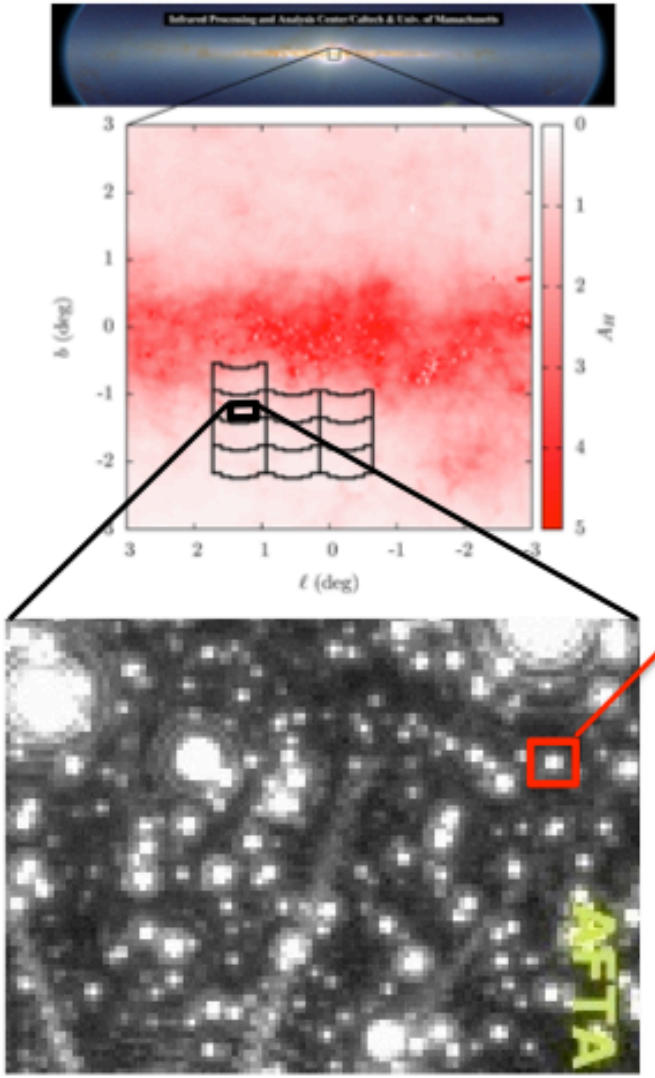
WFIRST-AFTA Dark Energy

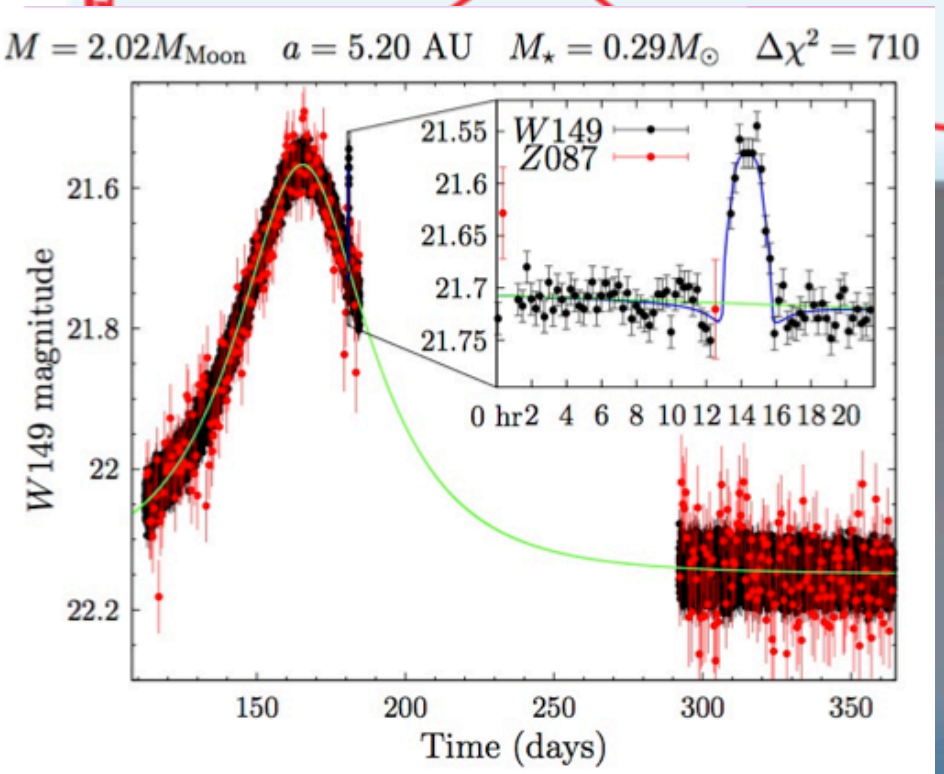
- The WFIRST-AFTA Dark Energy program probes the expansion history of the Universe and the growth of cosmic structure with multiple methods in overlapping redshift ranges.
- Tightly constrains the properties of dark energy, the consistency of General Relativity, and the curvature of space.
- The High Latitude Survey is designed with sub-percent control of systematics as a paramount consideration.



"For each of the cosmological (dark energy) probes in NWNH, WFIRST/AFTA exceeds the goals set out in NWNH" NRC - *Evaluation of the Implementation of WFIRST/AFTA in the Context of New Worlds, New Horizons in Astronomy and Astrophysics*

Detecting Planets with a Microlensing Survey

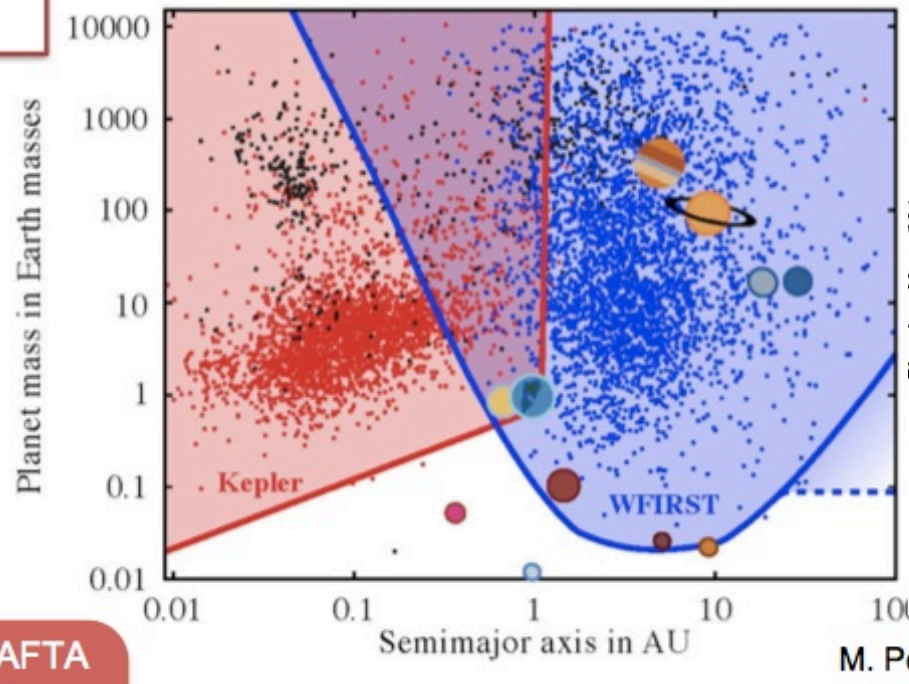




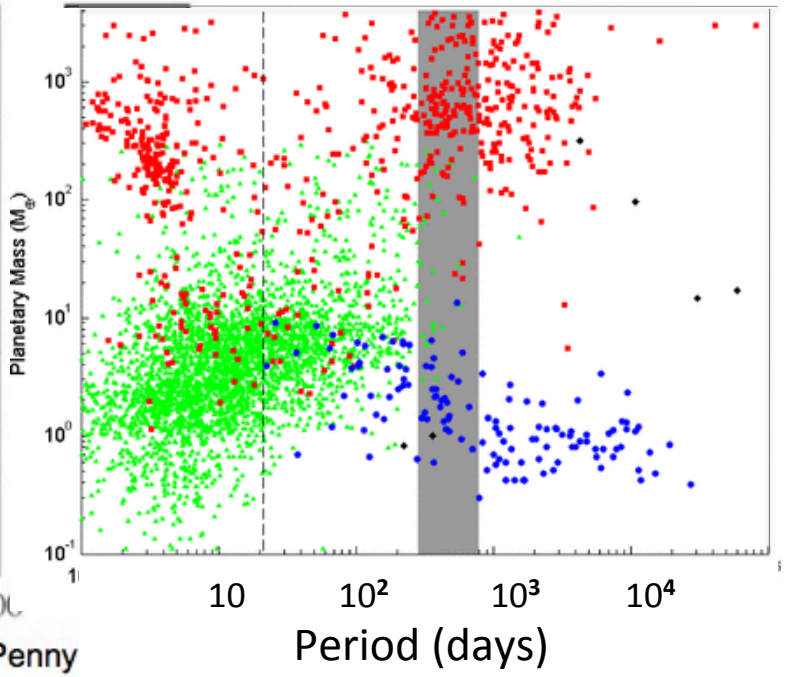
Simulation of a 2 × Mass of the Moon Planet @ 5.2 AU (~27 sigma)

Completing the Statistical Census of Exoplanets

Combined with space-based transit surveys, WFIRST-AFTA completes the statistical census of planetary systems in the Galaxy.



M. Penny

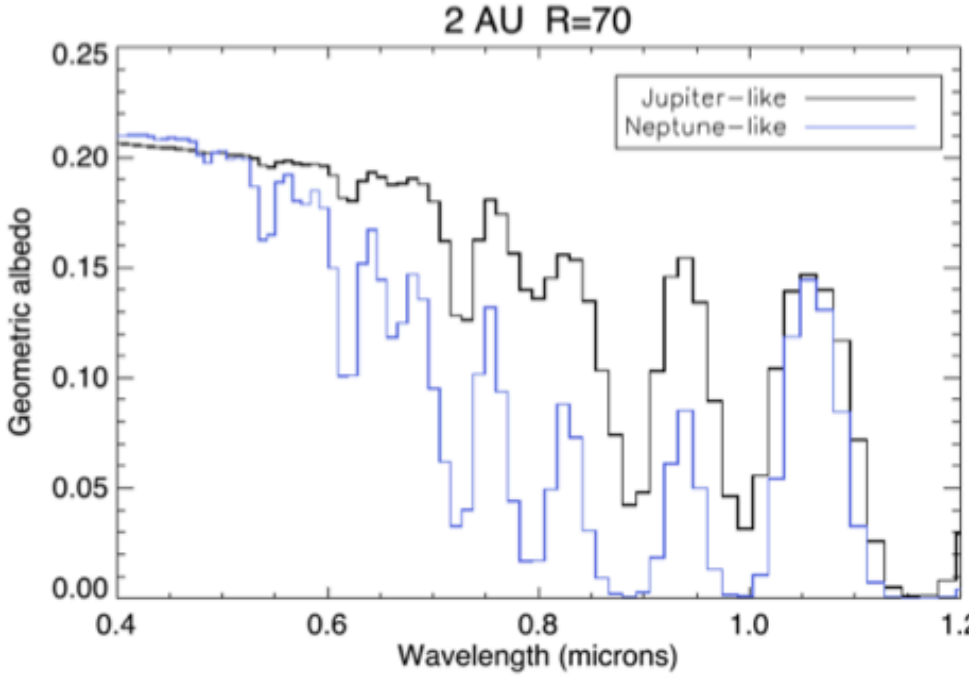


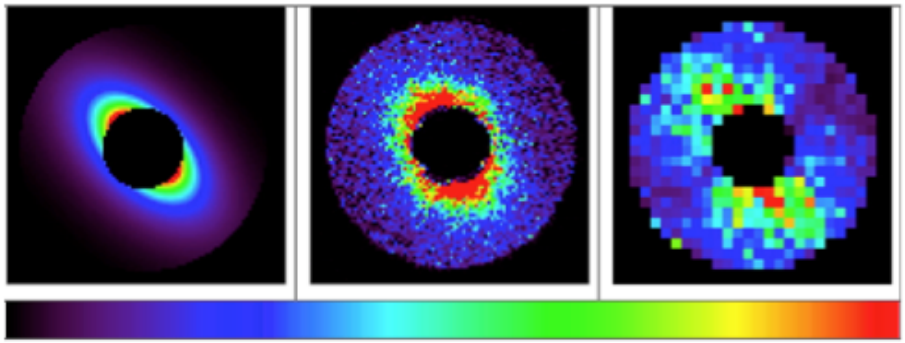
WFIRST-AFTA perfectly complements Kepler, TESS, and PLATO.

- ~3000 planet detections.
- 300 with Earth mass and below.
- Hundreds of free-floating planets.

Coleman & Nelson (2014): blue dots = detailed oligarchic growth & migration model

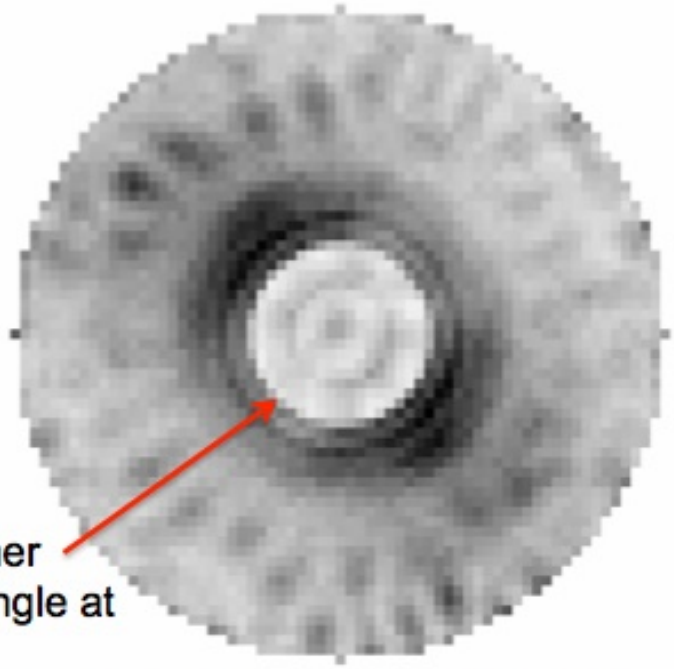
WFIRST-AFTA Coronagraph: Unique Science





WFIRST-AFTA data will:

- Detect molecular species
- Constrain abundances
- Reveal presence & height of clouds

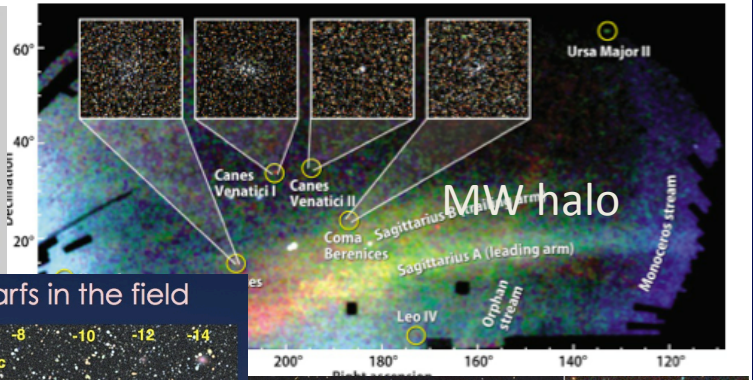


1.1 AU inner working angle at d= 8 pc

Simulation of 20 zodi disk WFIRST-AFTA image (24 h at 8 pc)

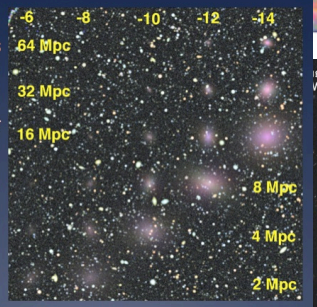
2000 sq deg High latitude Survey

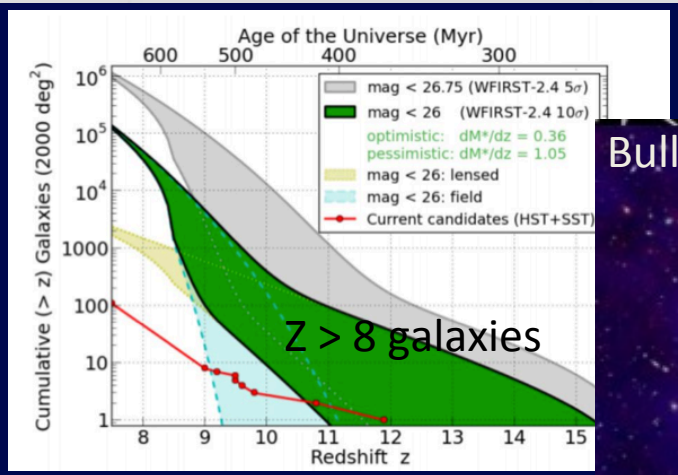
Theory HLS Euclid

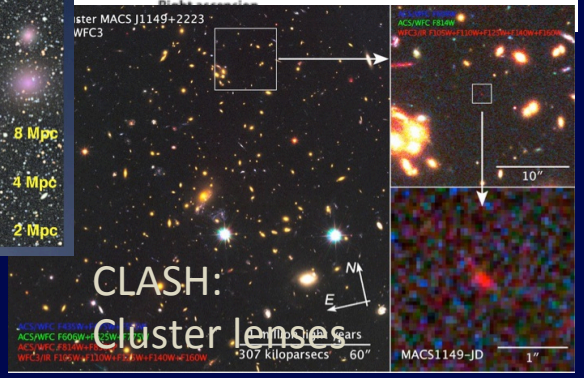


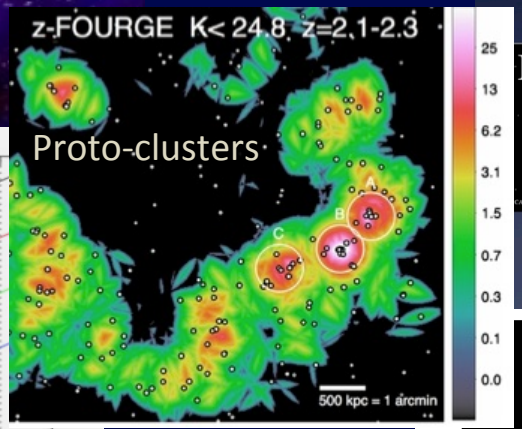
Census of dwarfs in the field

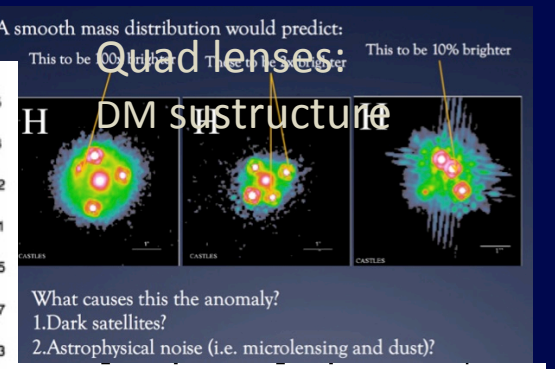
Archival science:
- Expect >1500 dwarfs to M_V = -10 within 32 Mpc in 2000 sq. deg
- Predictions are uncertain by at least an order of magnitude at this luminosity
- TRGB detectable:
  - instant distance estimates

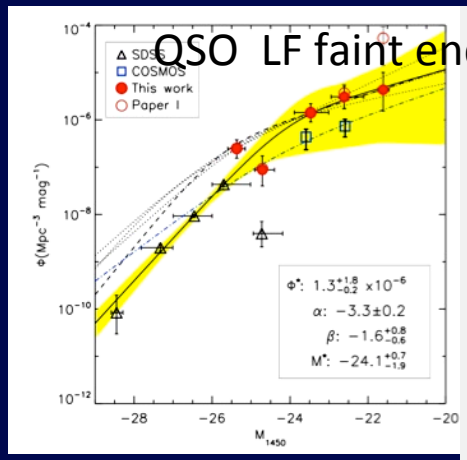


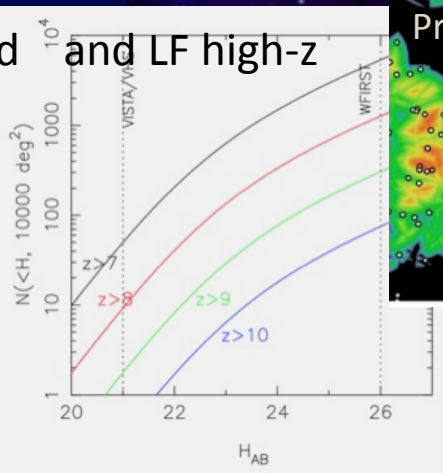


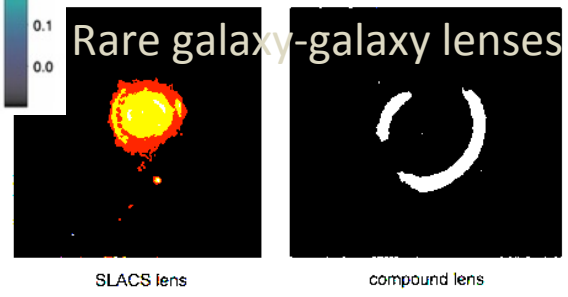










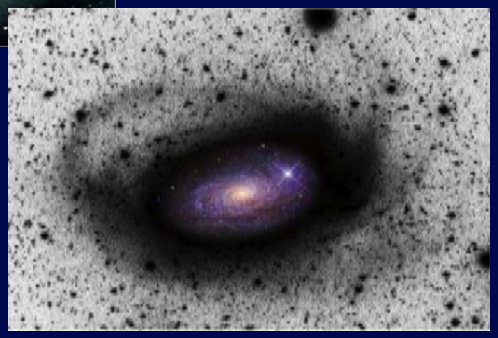


Guest Observer Pointed Observations

PHAT

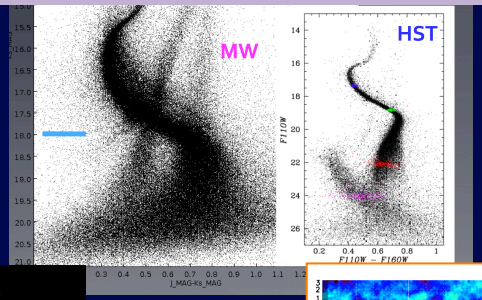
Map diffuse streams, halos, and thick disks with RGB stars for hundreds of nearby galaxies.

Globular clusters, dwarf galaxy comp-anions, stellar pop GB-TGB, streams

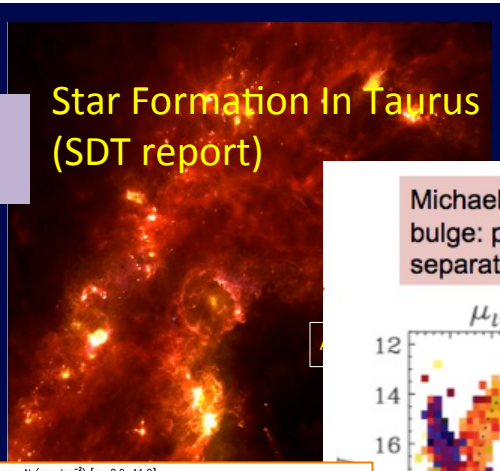


thanks to S. Rubele

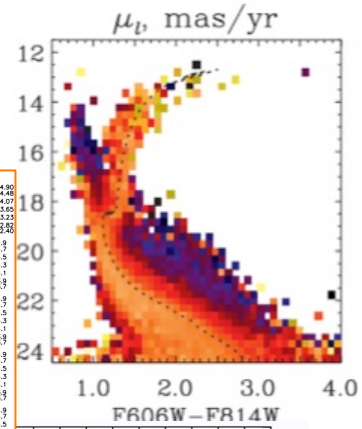
CMD ref

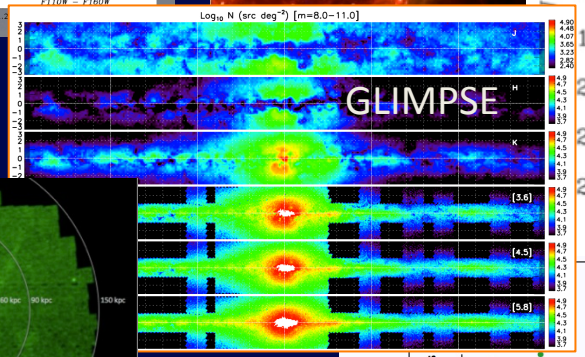


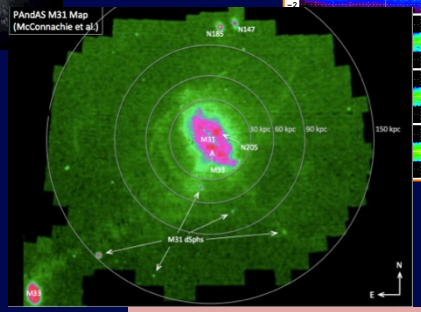
Star Formation In Taurus (SDT report)



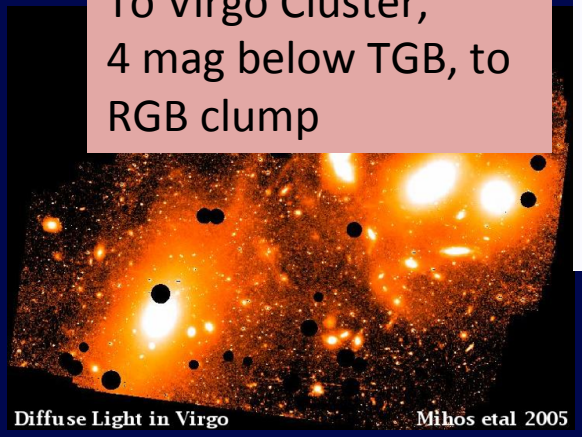
Michael Rich. Galactic bulge: proper motions separate stellar pops

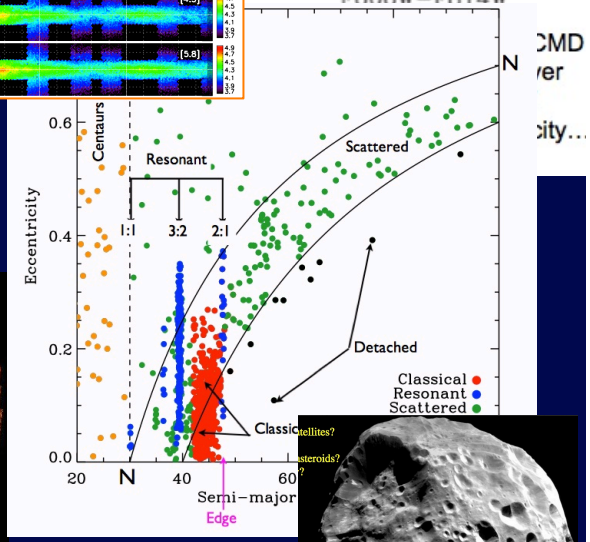






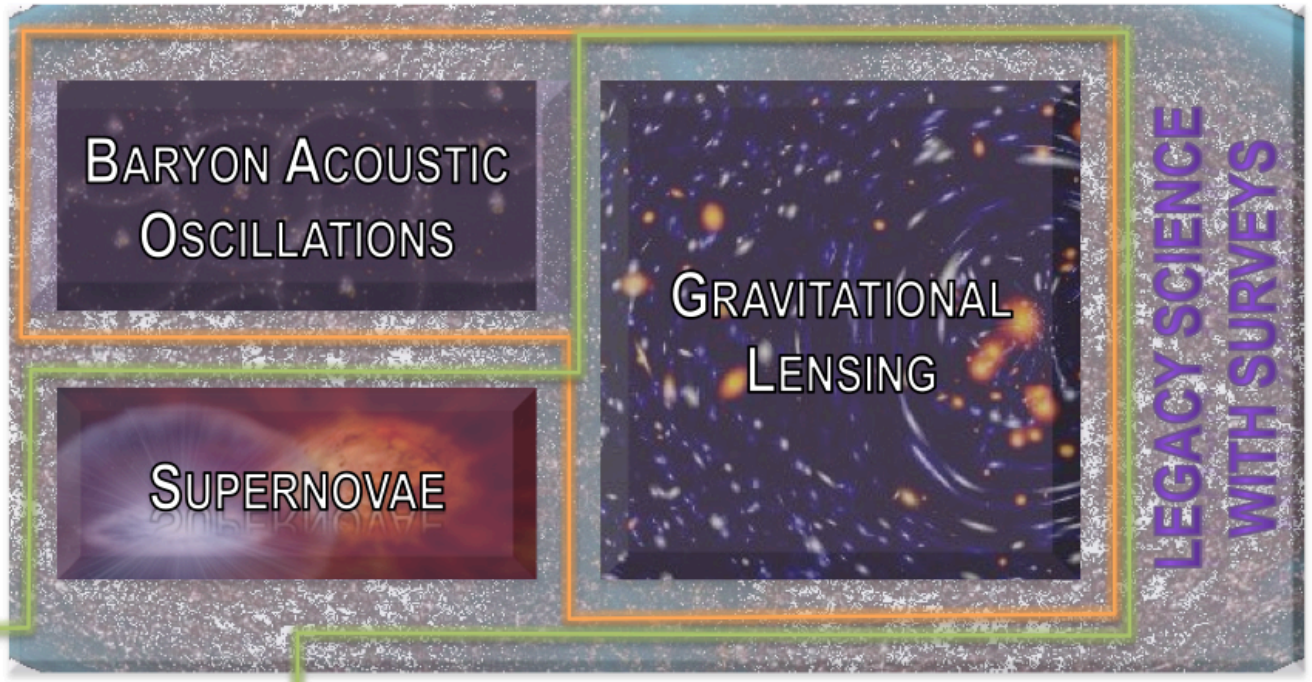
To Virgo Cluster, 4 mag below TGB, to RGB clump



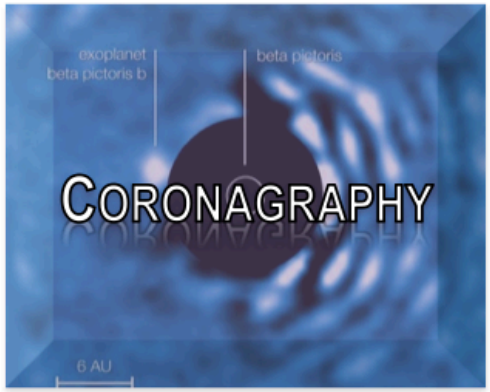


WFIRST-AFTA Science

complements Euclid

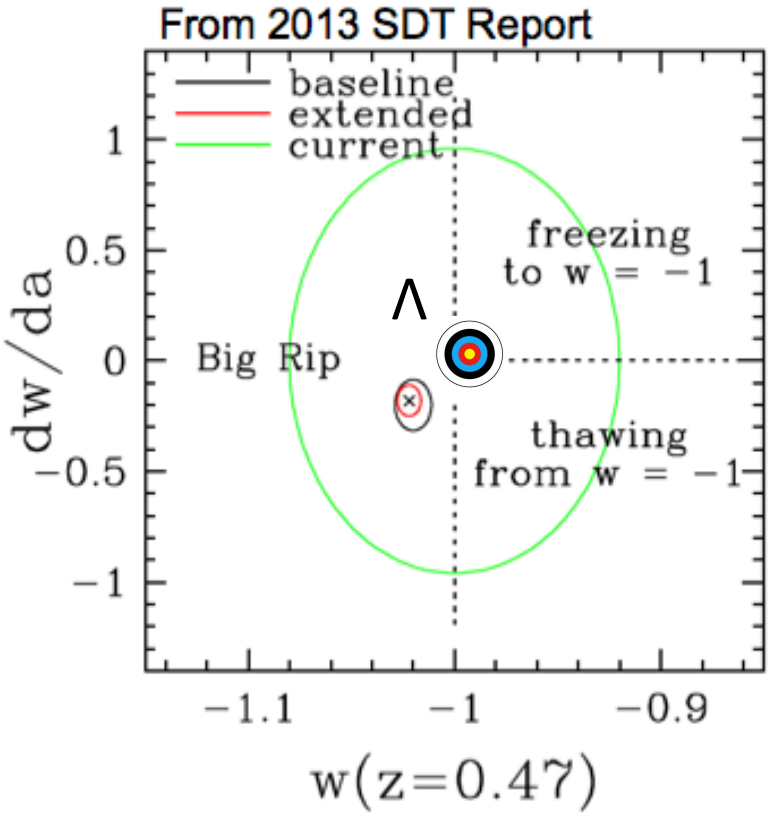


complements LSST



continues Great Observatory legacy

What the EOS Panel was reluctant to focus the WFIRST mission on dark energy



Forecast dark energy constraints from baseline & extended programs, compared to current knowledge. Distinct regions of plane represent fundamentally different physics.

Other facilities focused on this Cosmic Acceleration Program

1. Supernovae Cosmology Project
2. High-z Supenovae Search
3. CFHT Supernovae Legacy Survey
4. DOE: Dark Energy Survey
   DECAM – WL & Supernovae
   DESI (BAO, formerly Big-BOSS)
5. LSST
6. Euclid

What will be the diagram at right look like in early 2020's?

Astro2010: New Worlds, New Horizons

Panel on Electromagnetic Observations from Space

The WFIRST Observatory is a 1.5-m telescope for near-infrared imaging and low-resolution spectroscopy. The Panel adopted the spacecraft hardware of the Joint Dark Energy Mission (JDEM)/Omega mission as proposed to NASA and DOE and substantially broadened the program for this facility. In addition to two dedicated core programs – cosmic acceleration and microlensing planet finding – WFIRST would make large area surveys of distant galaxies and the Milky Way galaxy, study stellar populations in nearby galaxies, and offer a guest observer program advancing a broad range of astrophysical research topics.

WFIRST/AFTA – the Observatory (open, competed access)

\+

Dark Energy – the experiment

\+

Microlensing Planet Search – the program

Note: The 'large recommended facilities" in the 5 previous Decadals were all "observatory" as opposed to P.I.-led projects, both ground and space

Astro2010: New Worlds, New Horizons

Recommendations for New Space Activities—Large Projects

Priority 1 (Large, Space). Wide-Field Infrared Survey Telescope (WFIRST)

WFIRST[14] is a wide-field-of-view near-infrared imaging and low-resolution spectroscopy observatory that will tackle two of the most fundamental questions in astrophysics: Why is the expansion rate of the universe accelerating? And are there other solar systems like ours, with worlds like Earth? In addition, WFIRST's surveys will address issues central to understanding how galaxies, stars, and black holes evolve. WFIRST will carry out a powerful extrasolar planet search by monitoring a large sample of stars in the central bulge of the Milky Way for small deviations in brightness due to microlensing by intervening solar systems. This census, combined with that made by the Kepler mission, will determine how common Earth-like planets are over a wide range of orbital parameters. ..

In a 5-year baseline mission, its observations would emphasize the planet census and dark energy measurements, while accommodating a competed general investigator program for additional surveys that would exploit WFIRST's unique capabilities using the same observation modes. The powerful astronomical survey data collected during all of the large-area surveys would be utilized to address a broader range of science through a funded investigator program. An extended mission, subject to the usual senior review process, could both improve the statistical results for the main science drivers and broaden the general investigator program.

WFIRST is the first general-purpose observatory that includes two, and likely three programs that could have been traditional **team-led** programs typical of competed missions of the Discovery or Probe class. ***This combination of 'observatory model' + 'team' component' is new.***

In my view, the two WFIRST-AFTA Science Definition Teams have, in practice, considered WFIRST-AFTA as a Dark Energy and Exoplanet (microlensing search + coronagraph) mission, with a general astrophysics "add-on."

Will this arrangements continue with the next SDT and the Science team that will be selected for the mission? I believe that allowing the project to be led by a **dark energy team** or **exoplanet team** would be a mistake. I urge NASA to create a new structure that incorporates teams into the observatory model that has been adopted for HST, Chandra, Spitzer, and JWST. After launch, a WFIRST-AFTA **TAC process** should allocate the 25% GO time to achieve a balance between the broadest science program and the highest priority science. After the first 6 years, all programs should be competed – 100% of the observing time should be allocated by the TAC.