WFIRST: WHAT IT IS *NOT*

a dark energy mission
an exoplanet microlensing mission
an infrared sky survey
the creation of Astro2010
Euclid

WFIRST: WHAT IT *IS*

A Wide-Field Infrared Survey Telescope

imager to 2.4 μm with 2×10^8 HgCdTe pixels
a 205K unobstructed *three* mirror anastigmat
slitless spectrometer: $R = 75$ & $R = \frac{200''}{\theta_{FWHM}}$

General Considerations

$$\begin{pmatrix}\text{solid}\\ \text{angle}\end{pmatrix} = \left(\frac{\text{diffraction limit}}{1.5}\right)^2 \times \begin{pmatrix}\text{number of}\\ \text{pixels}\end{pmatrix}$$

$$\begin{pmatrix}\text{focal}\\ \text{ratio}\end{pmatrix} = \left(\frac{1.5 \times \text{pixel size}}{\text{wavelength}}\right)$$

"1.5" is a subject of great debate

WFIRST's Multiple Incarnations

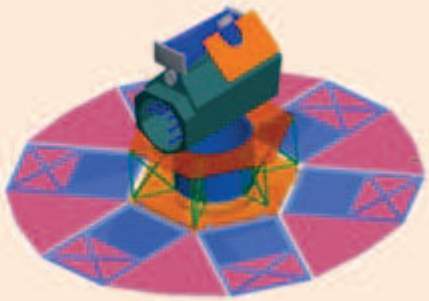
version	CATE DATE	diameter	obstructed	red limit	number cameras	detectors
JDEMΩ	2010	1.5-m	yes	2.1μ	3	36 H2RG-18
IDRM	2011	1.3-m	no	2.1μ	3	36 H2RG-18
DRM1	(2012)	1.3-m	no	2.4μ	1	36 H2RG-18
DRM2	2012	1.1-m	no	2.4μ	1	14 H4RG-10

Design Reference Mission Options

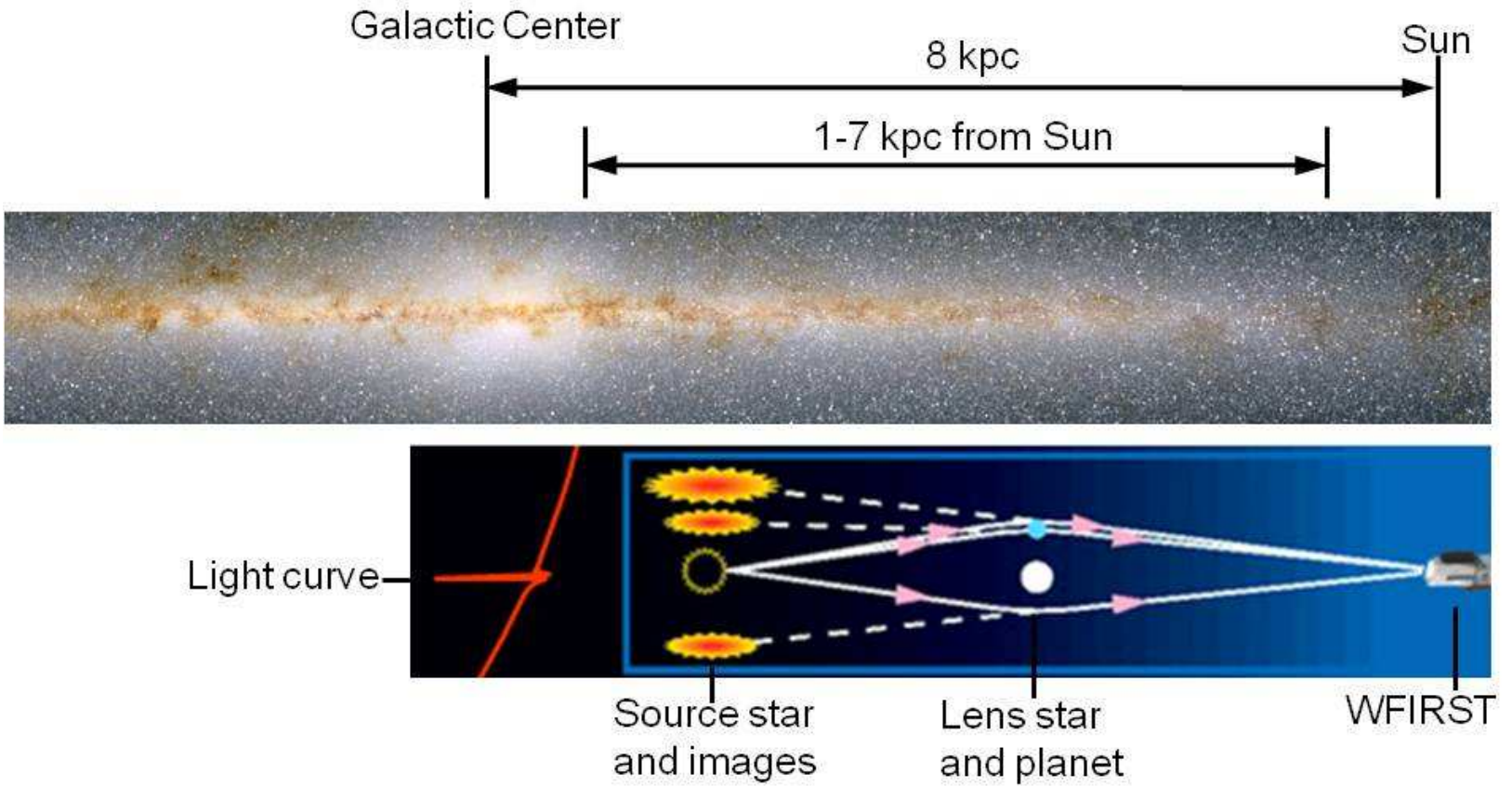
- **IDRM**
  - 1.3 meter off-axis telescope
  - 3-channel payload
  - 5 year mission
  - Atlas V Launch Vehicle

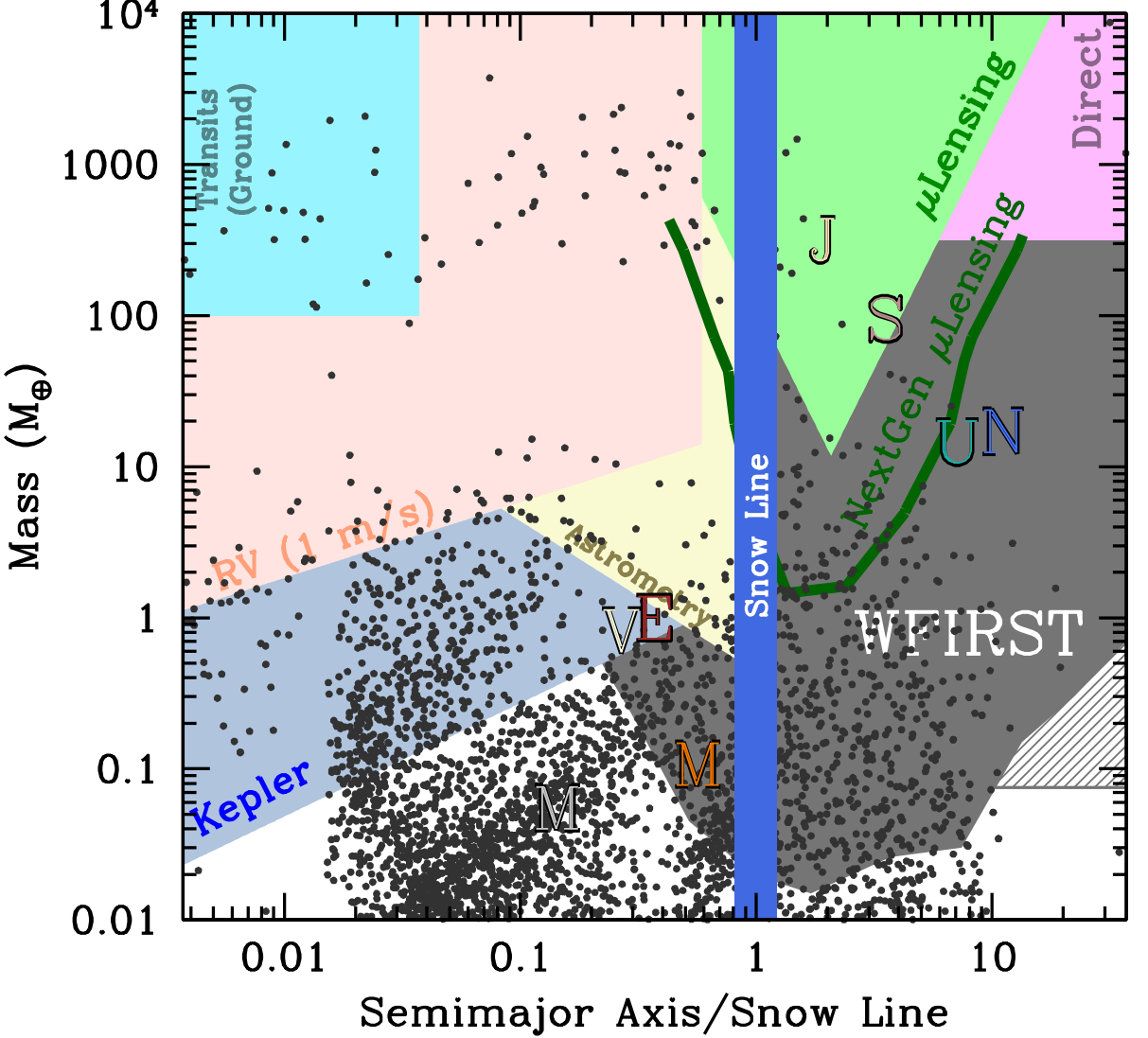
- **DRM1**
  - 1.3 meter off-axis telescope
  - Single channel payload
  - 5 year mission
  - Atlas V Launch Vehicle

- **DRM2**
  - 1.1 meter off-axis telescope
  - Single channel payload
  - 3 year mission
  - Falcon 9 Launch Vehicle



Planetary Microlensing




Transits (Ground)
RV (1 m/s)
Astrometry
Kepler
Snow Line
μLensing
Direct
NextGen μLensing
WFIRST
J
S
UN
VE
M
M
Mass (M⊕)
Semimajor Axis/Snow Line
10⁴
1000
100
10
1
0.1
0.01
0.01
0.1
1
10

18 December 1998

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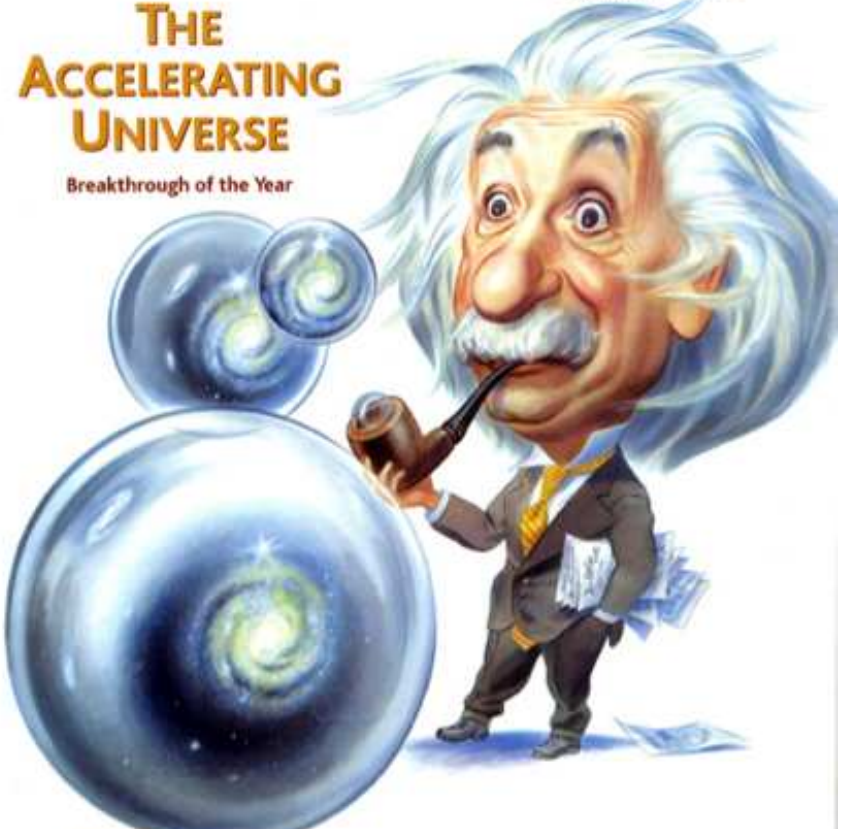
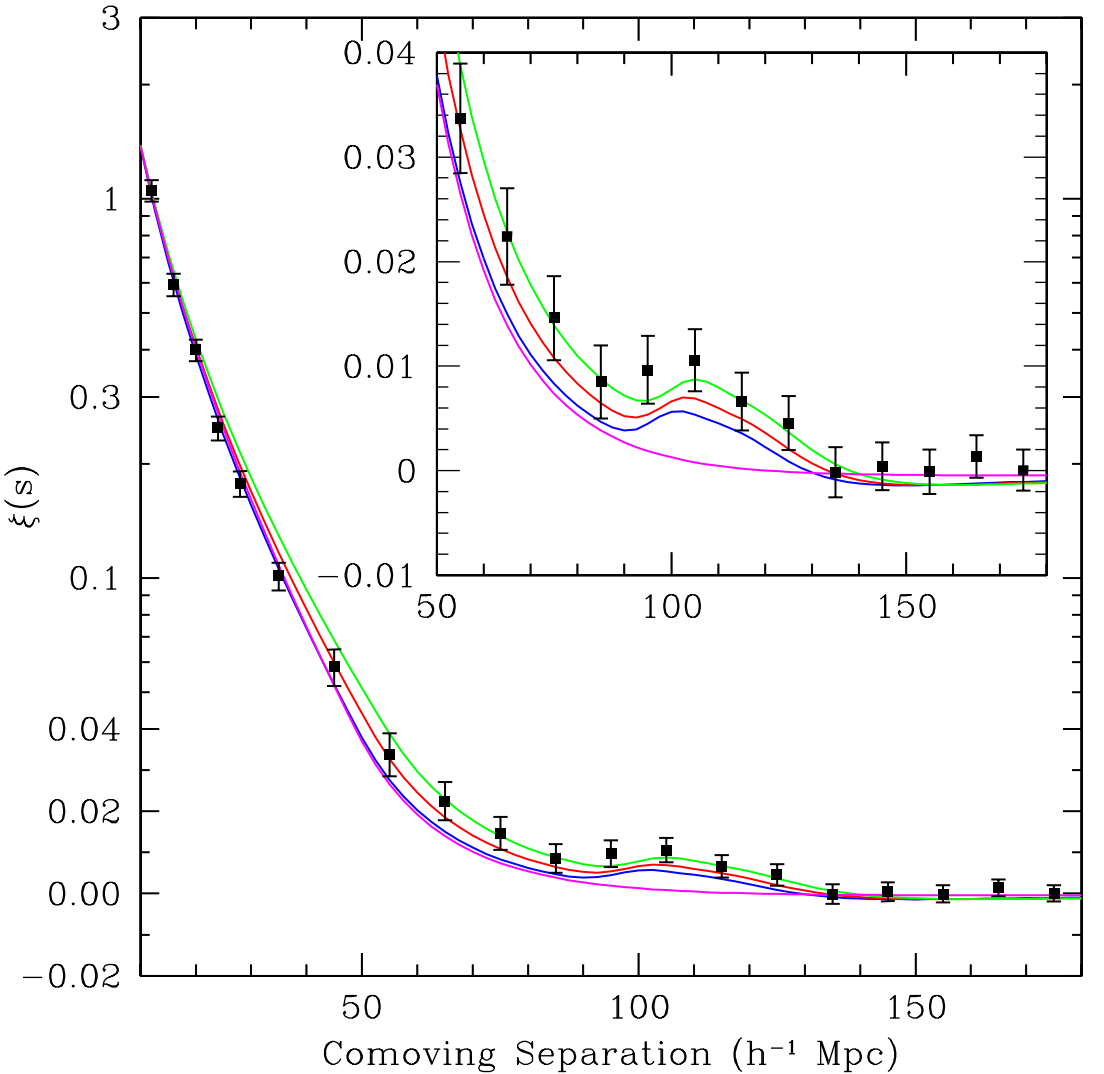
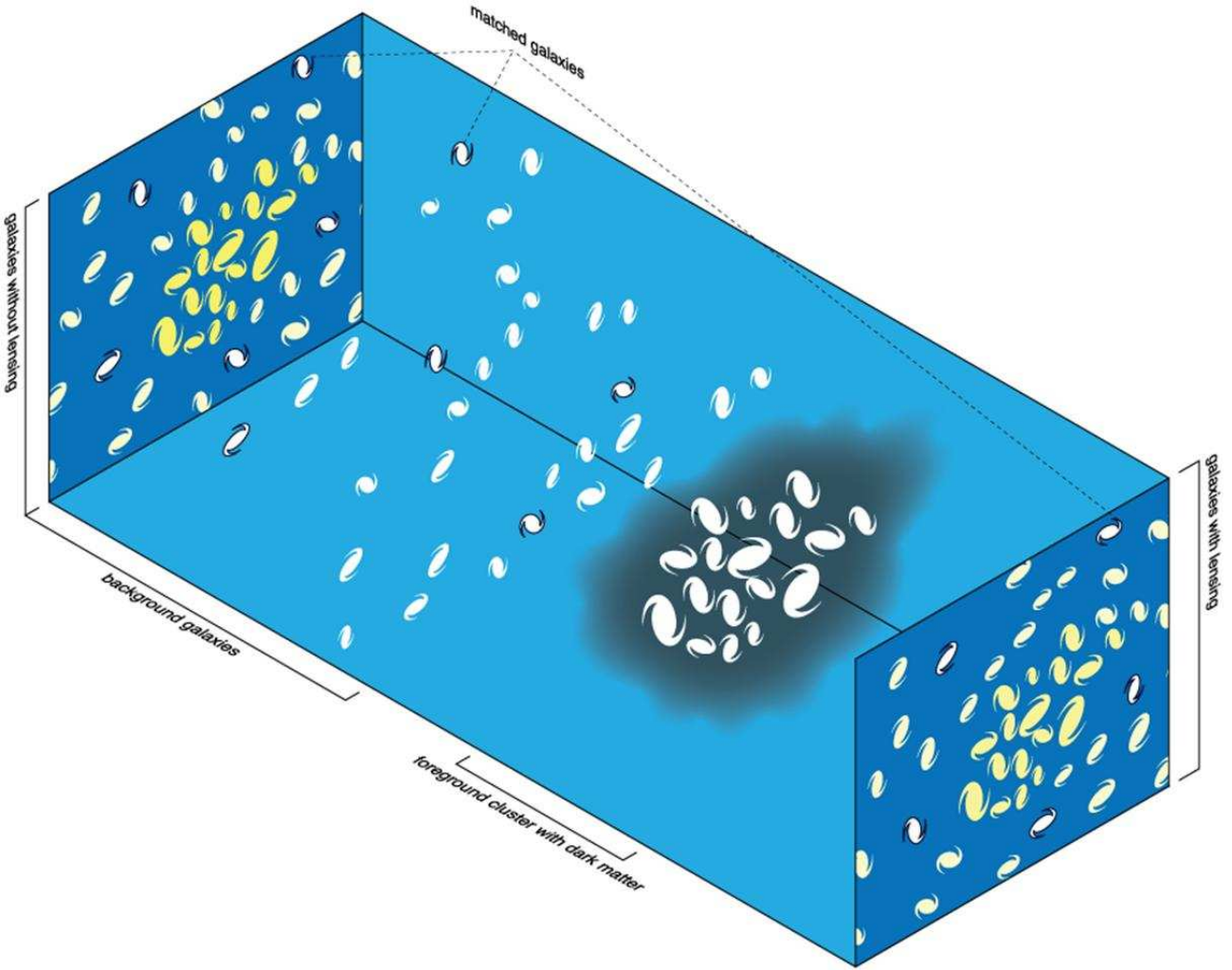
THE ACCELERATING UNIVERSE

Breakthrough of the Year



AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE


3
1
0.3
0.1
0.04
0.02
0.00
−0.02
ξ(s)
50
100
150
Comoving Separation (h⁻¹ Mpc)
0.04
0.03
0.02
0.01
0
−0.01
50
100
150


matched galaxies
galaxies without lensing
background galaxies
foreground cluster with dark matter
galaxies with lensing

$$\begin{pmatrix} \textbf{uncertainty in local} \\ \textbf{mean image ellipticity} \end{pmatrix} < \mathbf{0.0005}$$

Cosmic Acceleration History DRM1 Capabilities

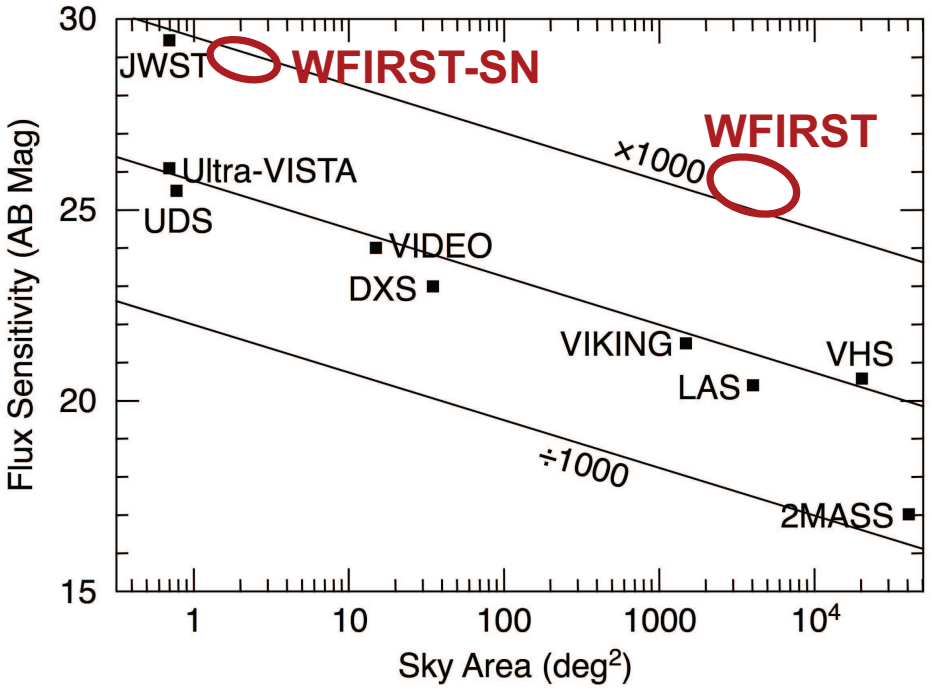
- BAO/RSD: covers >1400 deg2 per year to a limiting Hα flux of 1 × 10−16 ergs/cm2/sec (7σ) at resolution R = 600 over the redshift range 1.3 < z < 2.7.

- Weak Lensing: covers >1400 deg2 per year to a limiting magnitude AB = 26 each in the Y, J, H and K filters yielding 30 galaxies/arcmin2 in J, H and K.

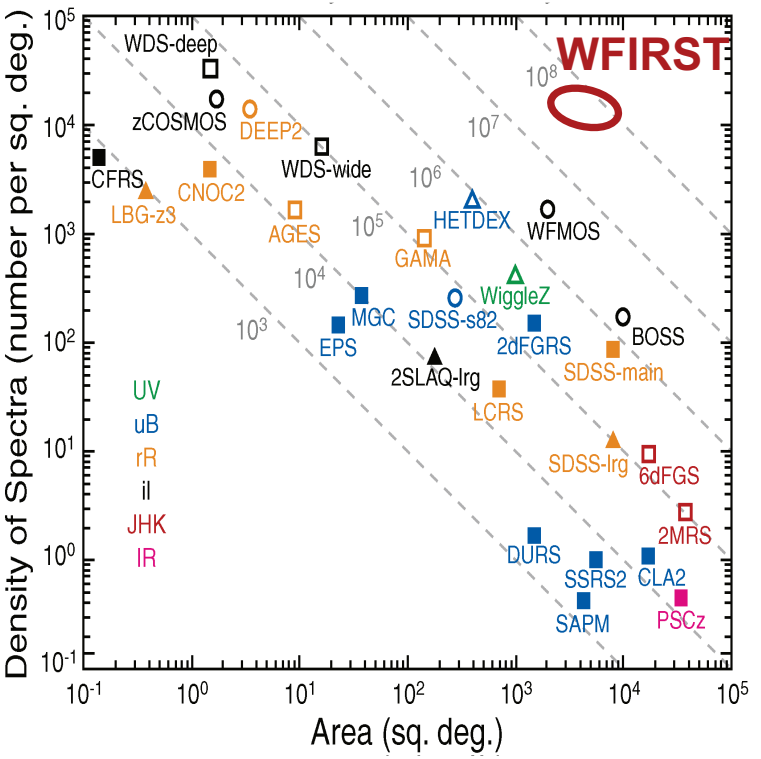
- SNe-Ia: 2 tiered survey covering 6.5 deg2 and 1.8 deg2 with a five day cadence over 1.8 years yielding ~100 SNe per $\Delta z = 0.1$ bin for $0.4 < z < 1.7$.

WFIRST NIR Surveys

NIR Imaging Surveys



NIR Redshift Surveys



WFIRST provides a factor of 100 improvement in IR surveys

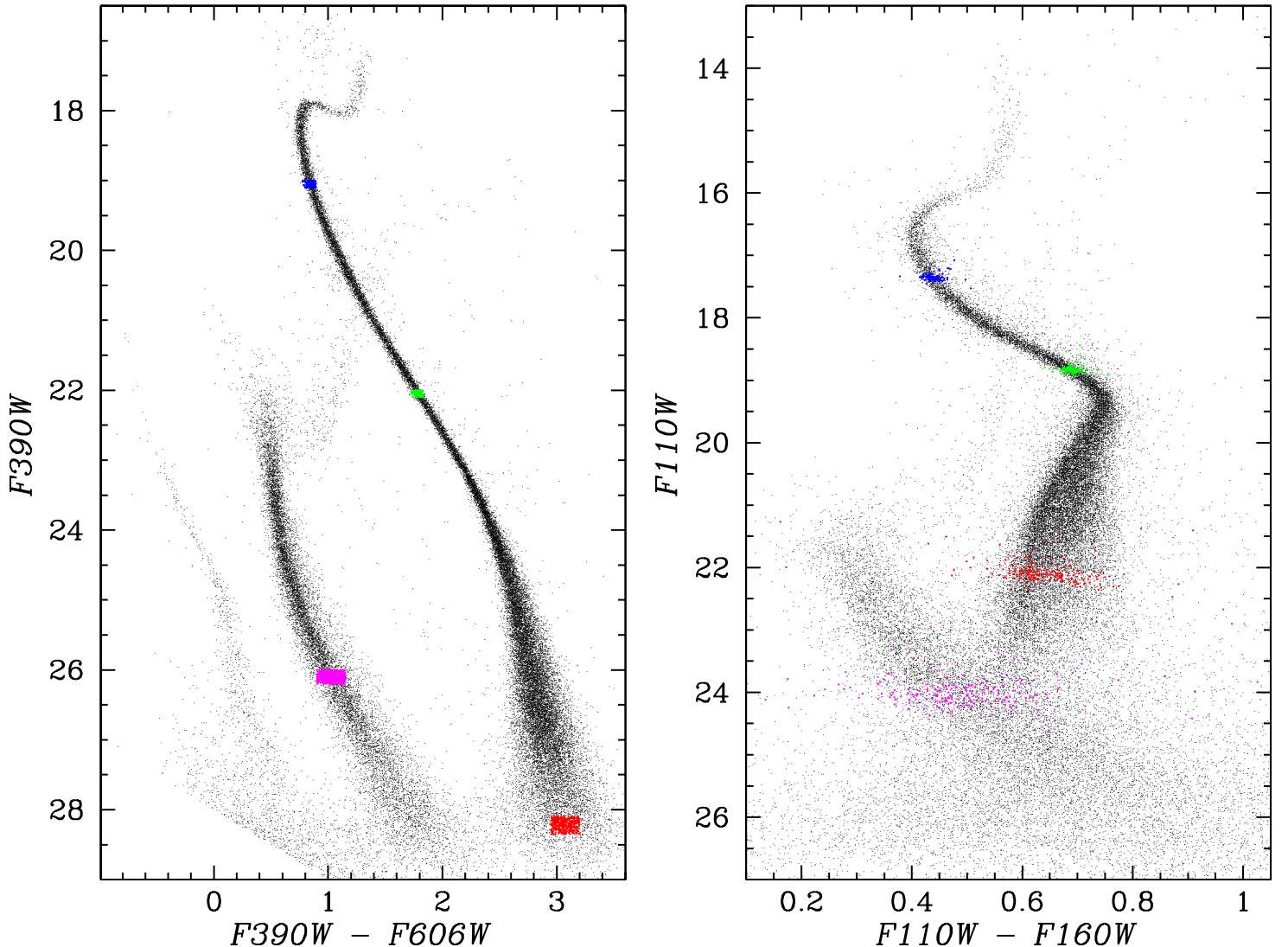
NOTIONAL GENERAL INVESTIGATOR PROGRAMS

Search for Kuiper Belt objects

Open cluster mass functions to $25M_{Jup}$

Stellar populations in nearby galaxy halos

Lower main sequence in globular clusters

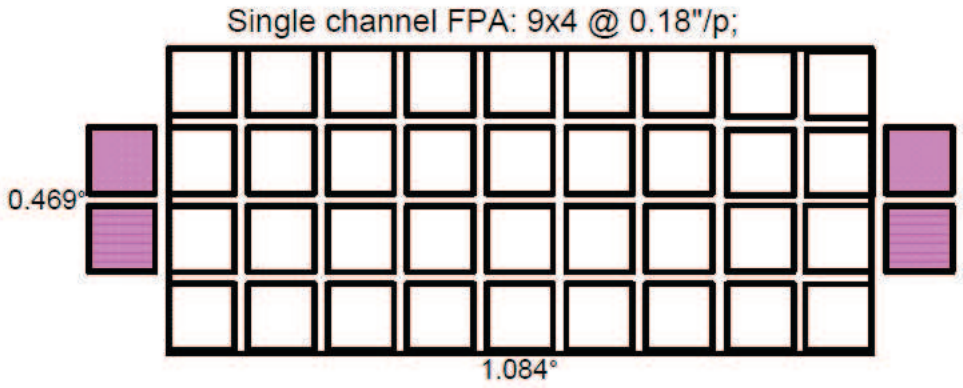

F390W
F390W − F606W
F110W
F110W − F160W

DRM1 Field of view & focal plane layout

Channel field layout for WFIRST DRM1

1.3m uTMA, 9x4 single channel @0.18"/H2RG pixel

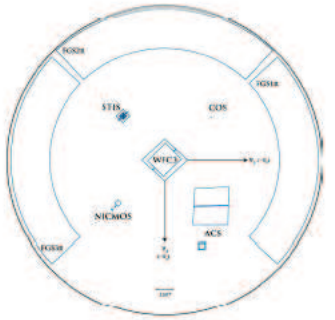
The Field of view of the single imaging & spectroscopy channel is shown to scale with the Moon, HST, and JWST. Each square is a 4Mpix vis-NIR sensor chip assembly (SCA)




Auxiliary Fine Guidance System


Moon (average size seen from Earth)


JWST [all instruments]


HST [all instruments]

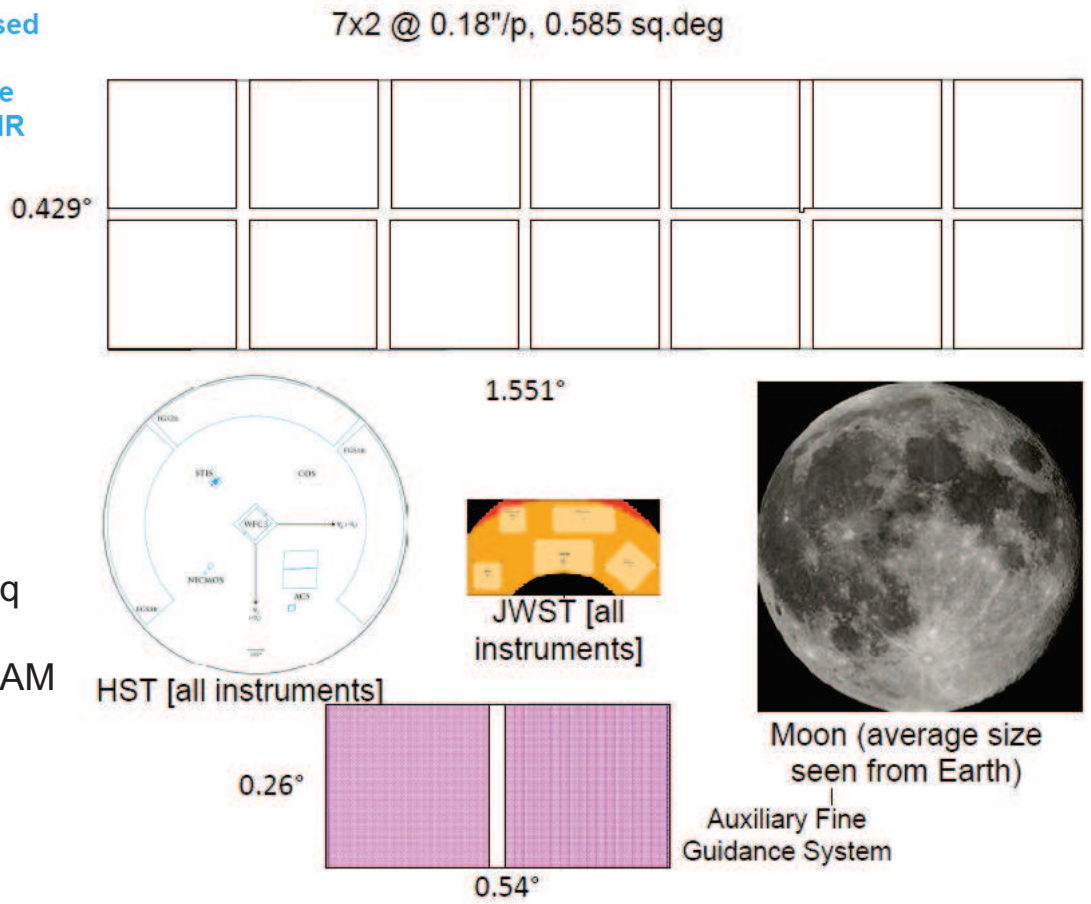
WFIRST-JWST Focal plane Comparison

- Area is 145x larger than NIRCAM (0.375 vs. 0.00259 sq degrees
- Focal plane has 5x more pixels than NIRCAM short wave cameras (150 vs 33 Mpix)

DRM2 Field of view & focal plane layout

Channel field layout for WFIRST "DRM2"

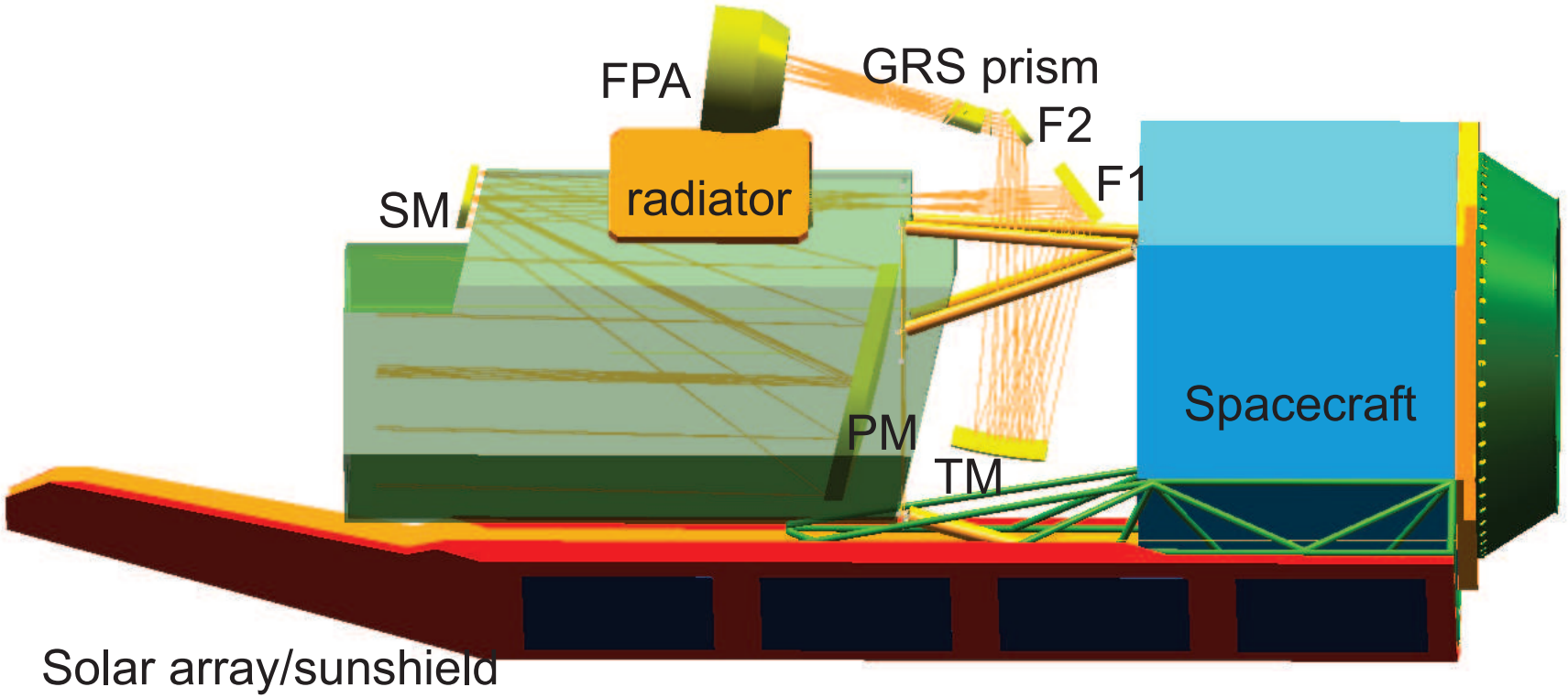
The Field of view of the single channel which can be used in imaging (Im), BAO spectroscopy (Sp), or SN spectroscopy (SNSp) mode is shown to scale with the Moon, HST, and JWST. Each square is a 16Mpix vis-NIR sensor chip assembly (SCA), 10 um pixels



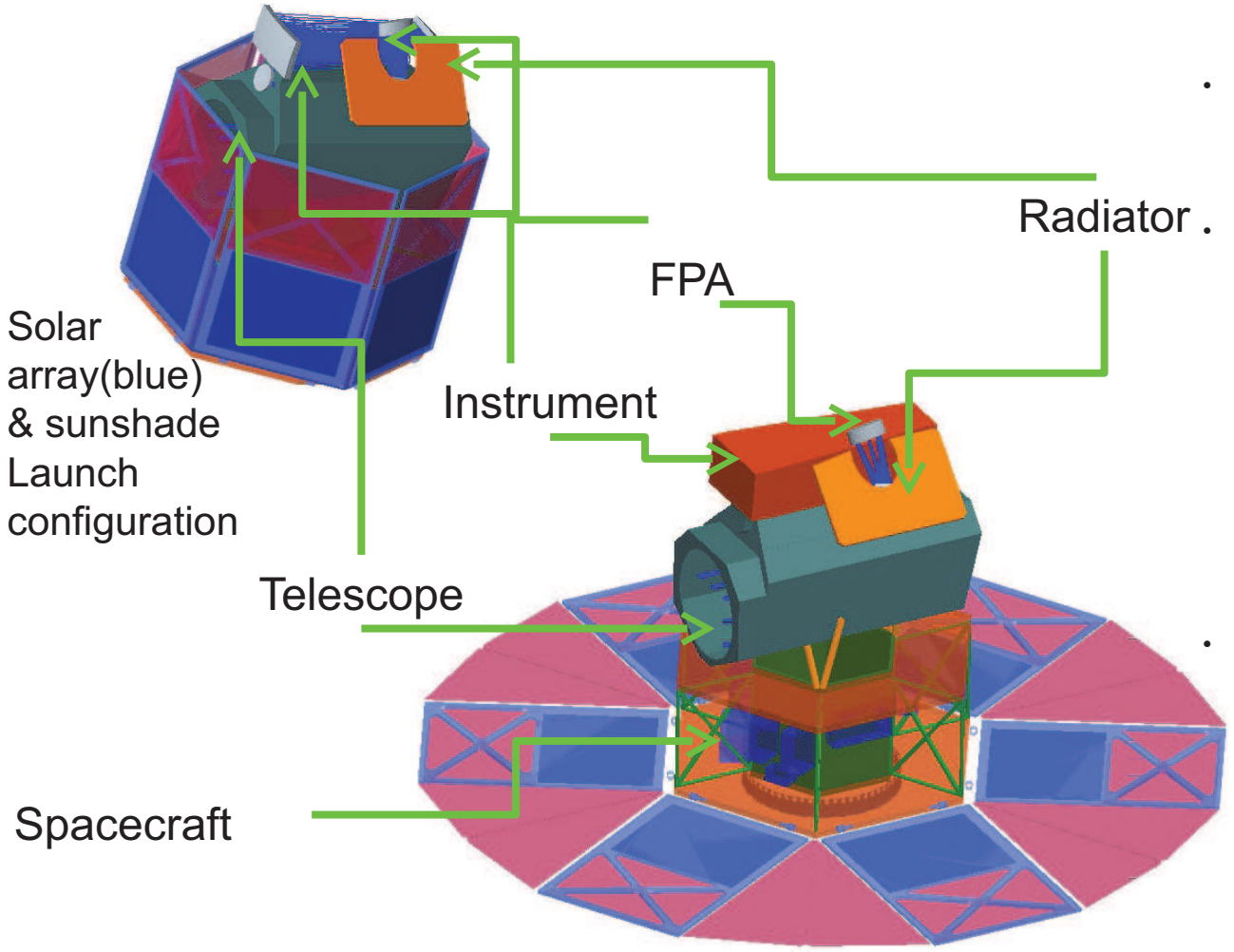
WFIRST-JWST Focal plane Comparison

- Area is 226x larger than NIRCAM (0.585 sq vs 0.00259 degrees)
- Focal plane has 7x more pixels than NIRCAM short wave cameras (235 vs 33 Mpix)

WFIRST DRM1
Observatory Layout & Ray Trace



WFIRST DRM2 Observatory Layout



Solar array(blue) & sunshade, deployed

- Sun is at bottom in this view
- WMAP-like progression from warm solar array (300K) to cold focal plane (100K) from bottom to top
- Overall dry mass 500+ kg less than DRM1

Cost Estimates

- The WFIRST Independent Cost Estimate by Astro2010 (based on JDEM configuration) was $1.6B
- The Project Office cost estimates indicate that DRM1 would have a full cost less that $1.6B due to single instrument channel and reduced mass.
- The Project Office cost estimates indicate that DRM2 would have a full cost of <$1B due to the smaller telescope, significantly reduced mass, 3 year operation, Falcon 9 launch
- NASA HQ has funded the Project for an Independent Cost Estimate of DRM2. That is in work, with results expected by end of the summer.

Conclusion

- The SDT and Project have completed the action of developing two compelling mission concepts.
- DRM1: Fully responsive to the objectives of NWNH at reduced cost
- DRM2: Extraordinary low-cost near-infrared survey opportunity. The limited 3 year life precludes full compliance with NWNH goals.
- Recommended path forward:
  - The optimizations developed for DRM2 indicate that there is a scientifically compelling, medium-cost trade space, for developing a near infrared survey mission.
  - Refine the innovations developed in DRM2 into a "DRM1-like" mission concept; determine whether performance of this new concept can be fully responsive to NWNH.

- ***DRM1 and DRM2 are both compelling opportunities for wide-field near-infrared surveys of critical importance to a broad spectrum of astronomical disciplines.***
- ***Incorporating the optimizations that enabled DRM2 into DRM1 has the potential of creating an extraordinary opportunity to deliver the science required of NWNH at a medium class budget.***

SCIENCE DEFINITION TEAM

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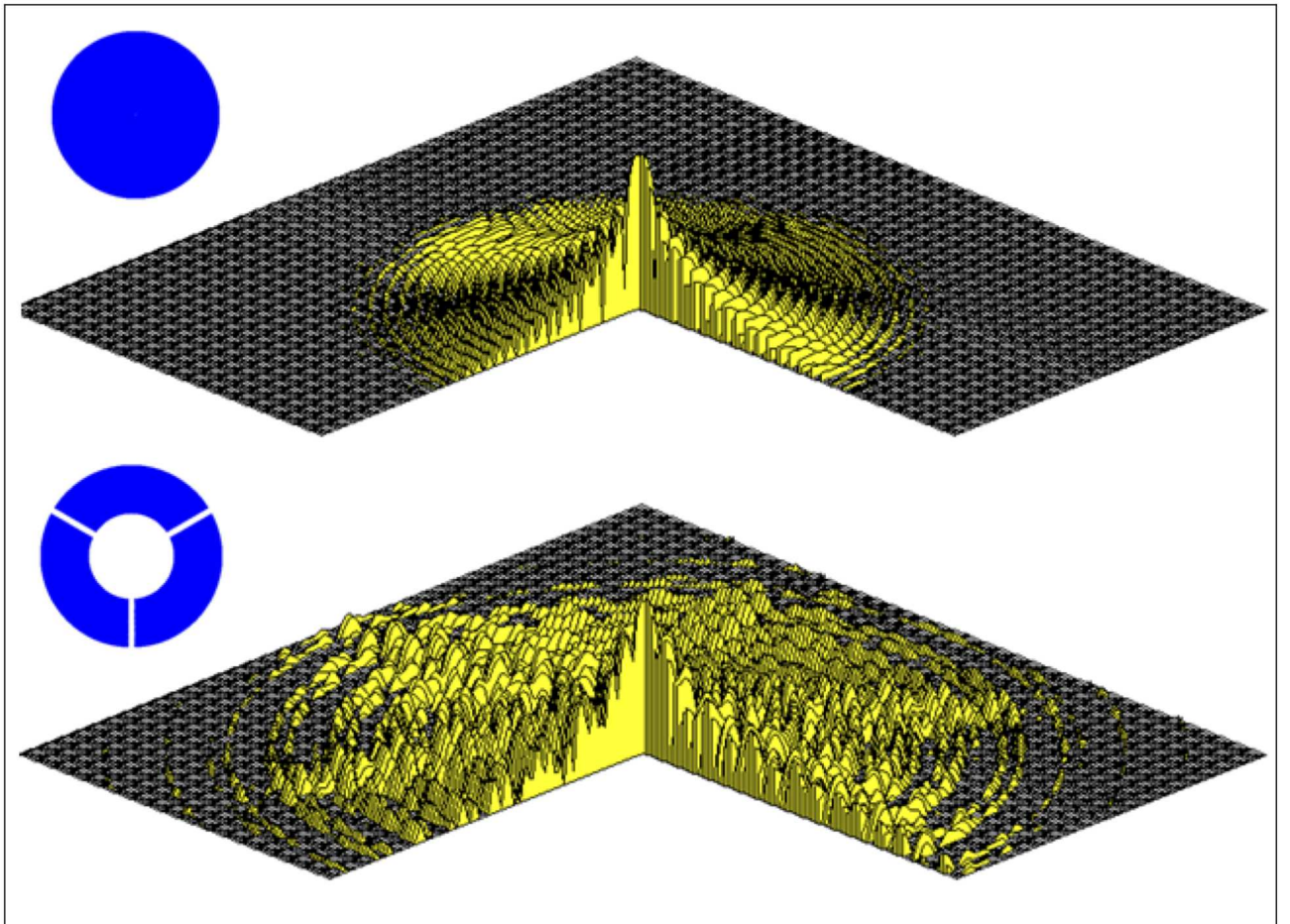


Figure 7: Monochromatic diffraction for unaberrated pupils. Top: an unobscured pupil. Bottom: pupil obscured by a centered 50% linear disk and three spider legs. Pupils are shown at the upper left. Logarithmic vertical scale spans four decades. Fresnel-Kirchoff diffraction assumed.

Kocevski et al. http://www.arxiv.org/pdf/1109.2588

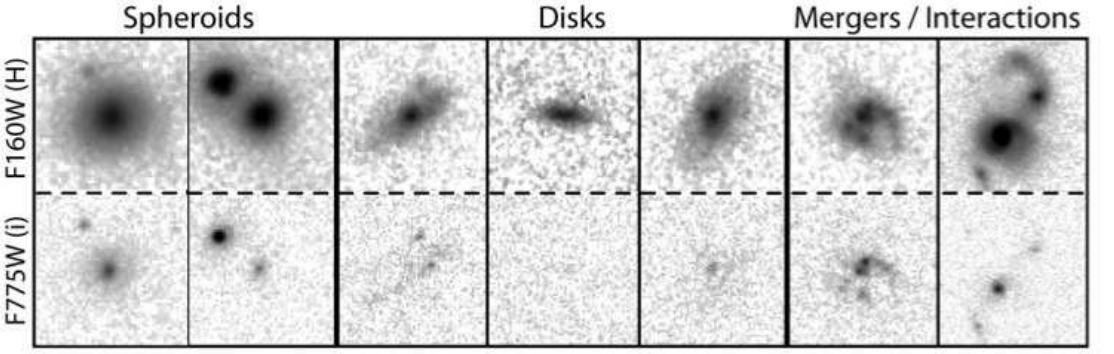
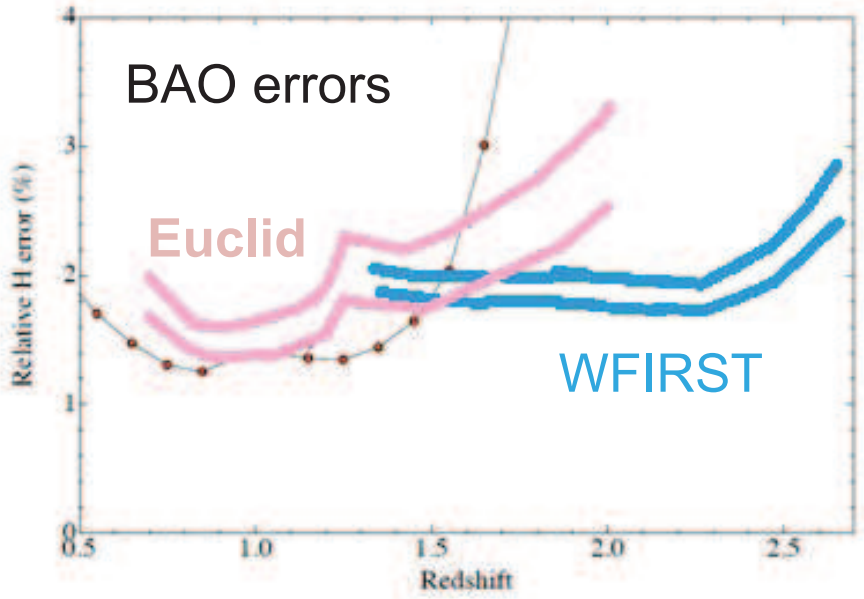


FIG. 3.— Examples of AGN host galaxies that were classified as having spheroid and disk morphologies, as well as two galaxies experiencing disruptive interactions. Thumbnails on the top row are WFC3/IR images taken in the F160W (H) band (rest-frame optical), while those on the bottom row are from ACS/WFC in the F775W (i) band (rest-frame ultraviolet). These images demonstrate that accurately classifying the morphology of these galaxies at $z \sim 2$ requires H-band imaging.

WFIRST – Euclid Comparison

Parameter	WFIRST	Euclid
Mirror diameter	1.5m (effective)	1.2m
Visible imager	none	36 CCD's
NIR imager spec	0.75x36 HgCdTe's	0.25x18 HgCdTe's
NIR pixel scale	0.18 " / pixel	0.30 " / pixel



Wang & Bennett 2011