Space Telescopes Users Council

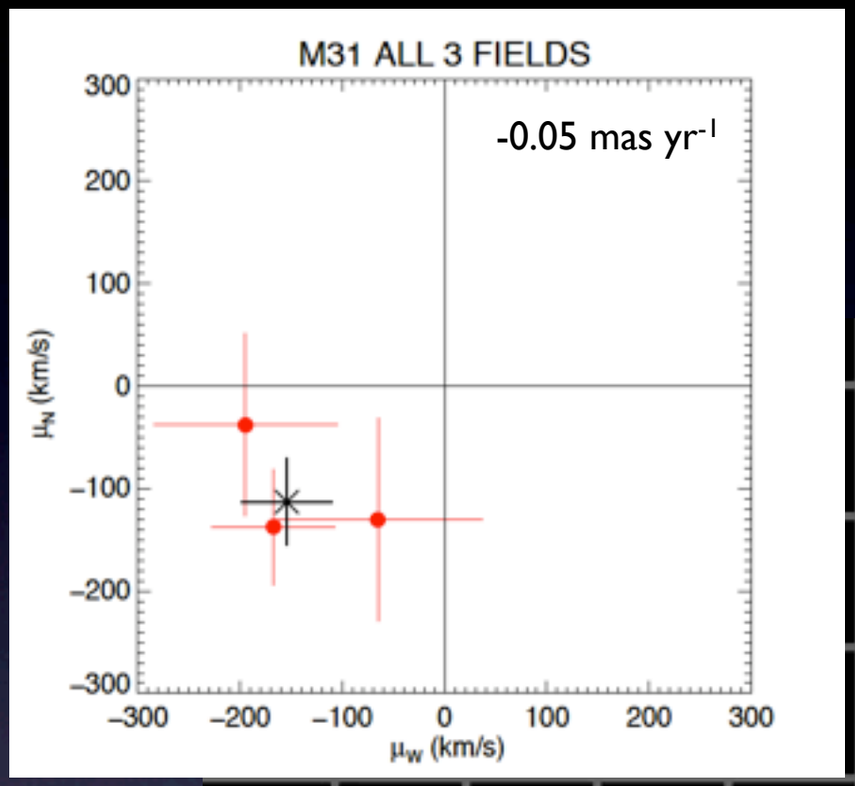
April 2012

Overview

- Senior Review
- "Lessons Learned" workshop
- Questions for STUC
- JWST

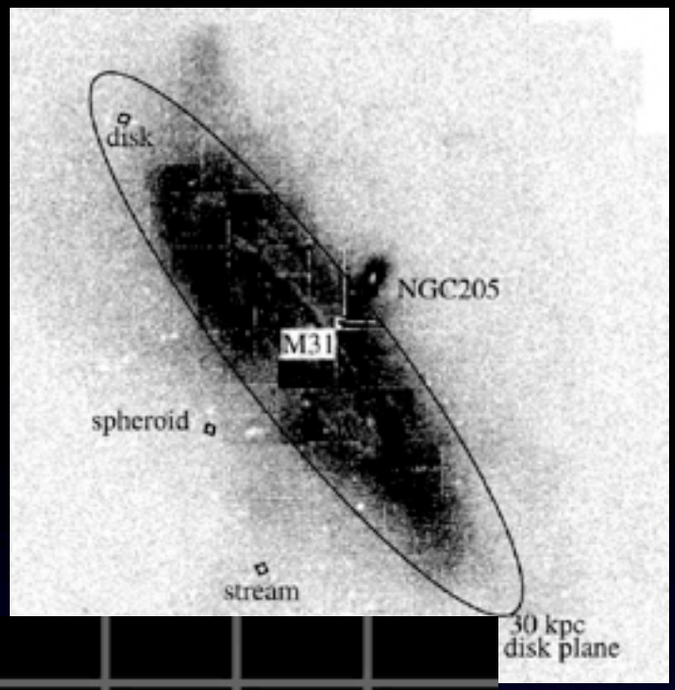
Matt Mountain

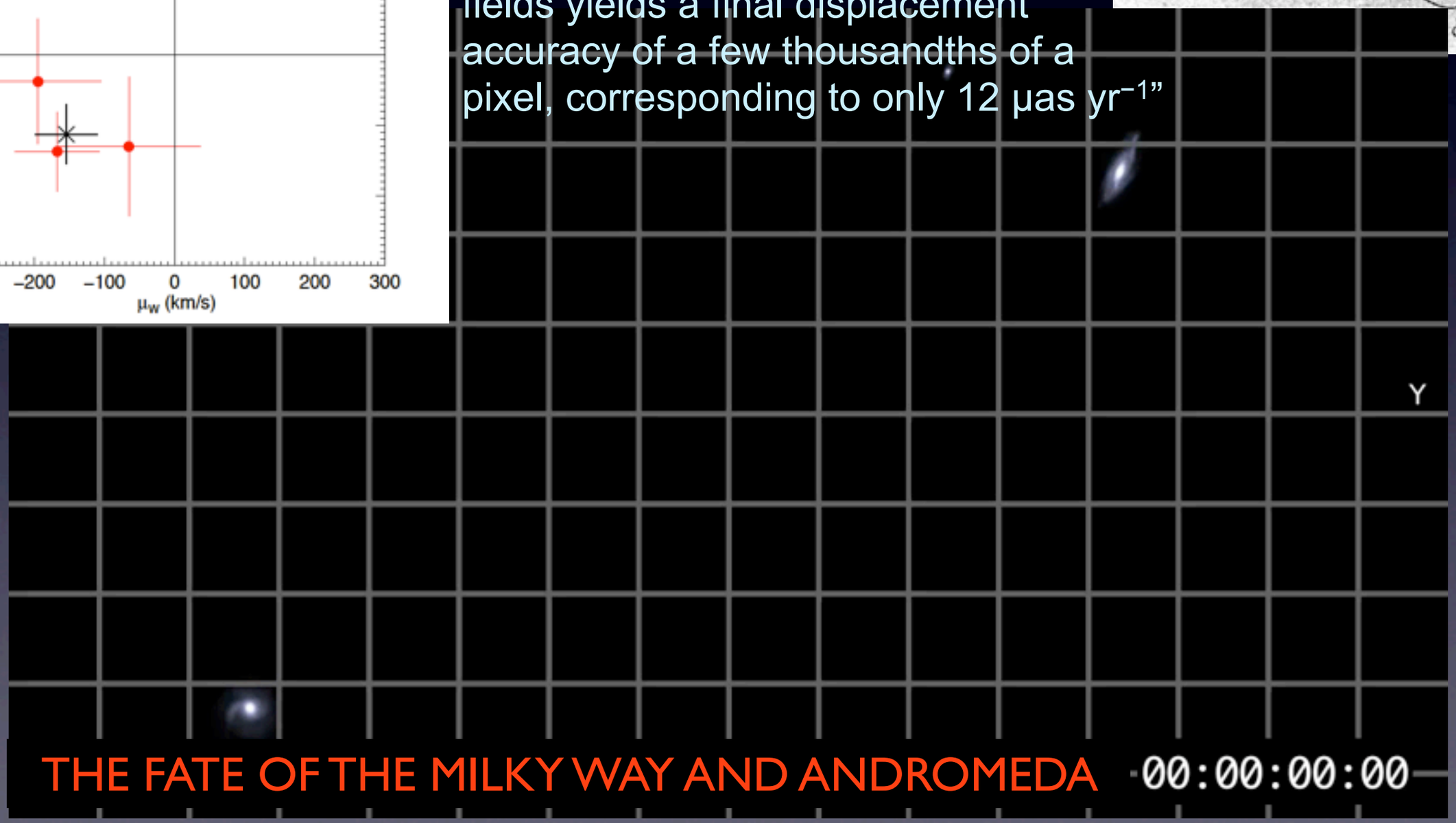
First measurement of the proper motion of the galaxy M31



HST data provide 5–7 year baselines

"The ability to average over large numbers of objects and over the 3 fields yields a final displacement accuracy of a few thousandths of a pixel, corresponding to only 12 μas yr^{-1}"

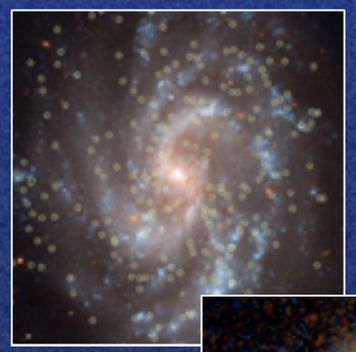


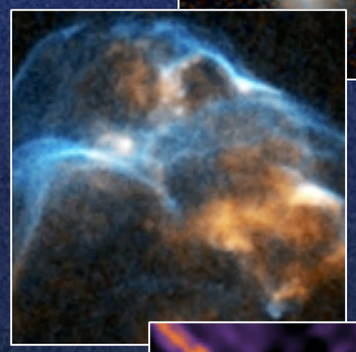


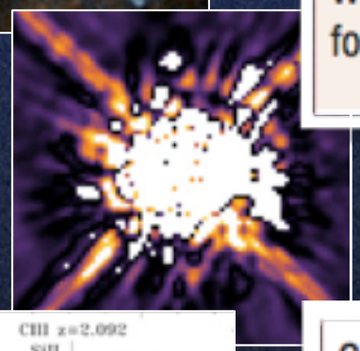
Sohn et. al. 2012

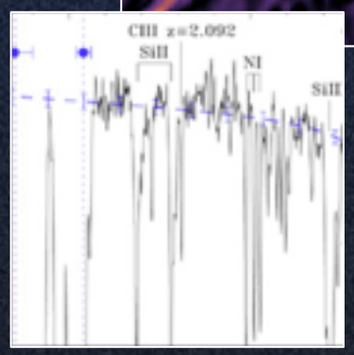
EMBARGOED

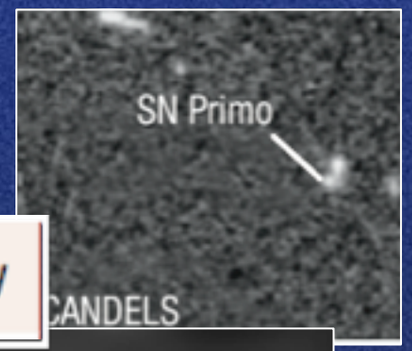
Senior Review - HST science continues to be revolutionary

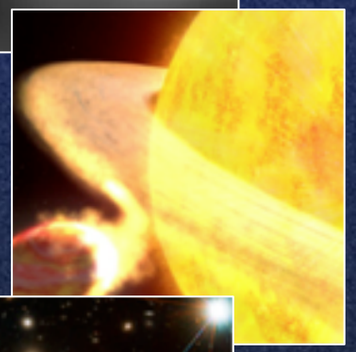


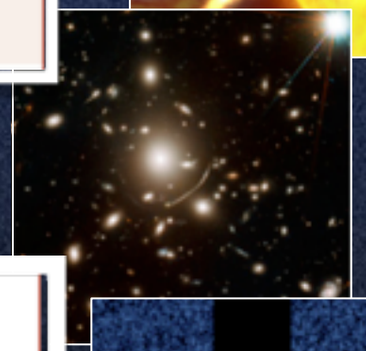












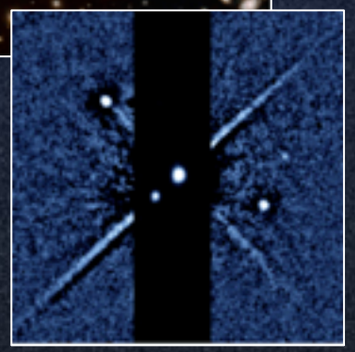
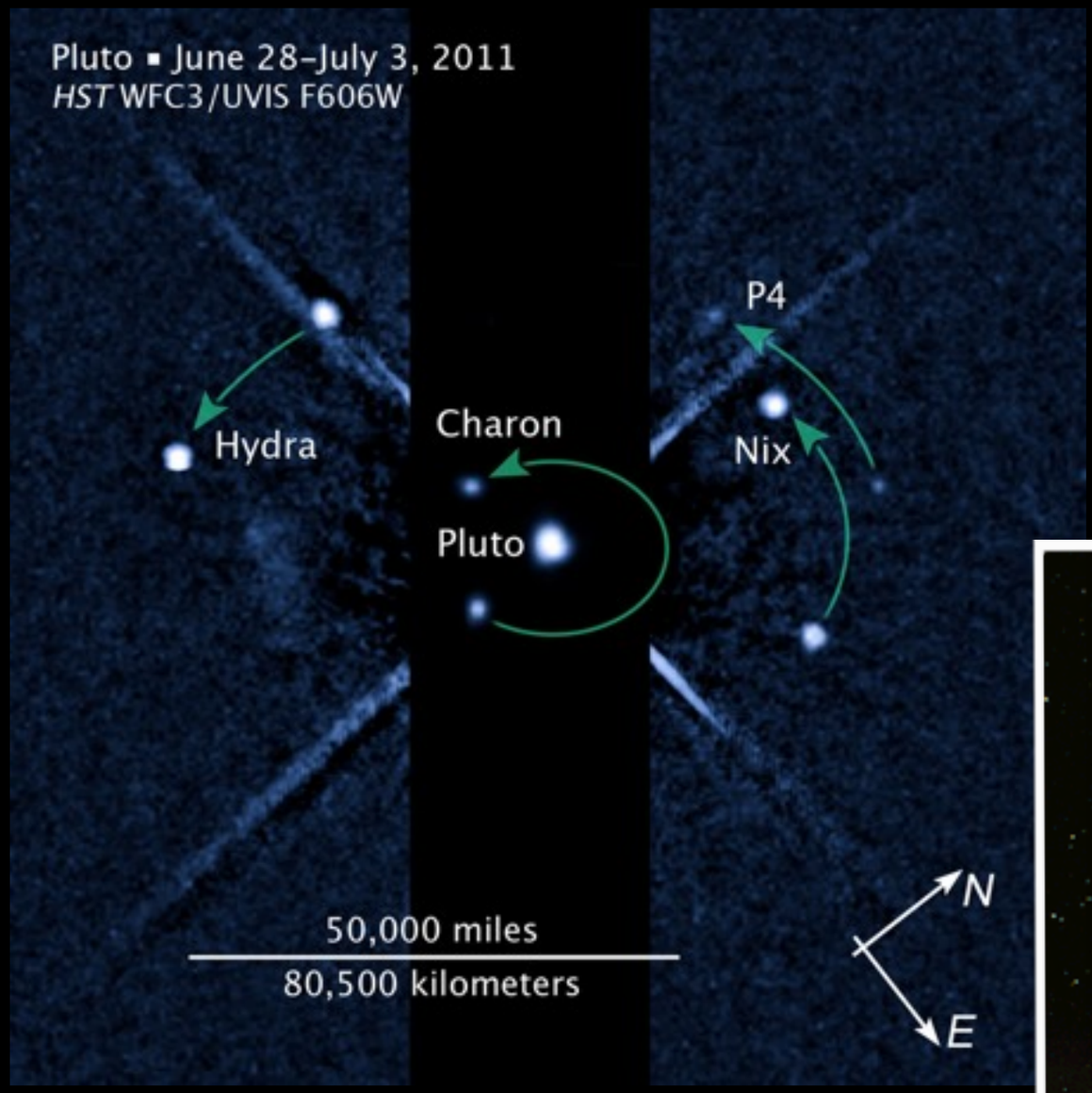
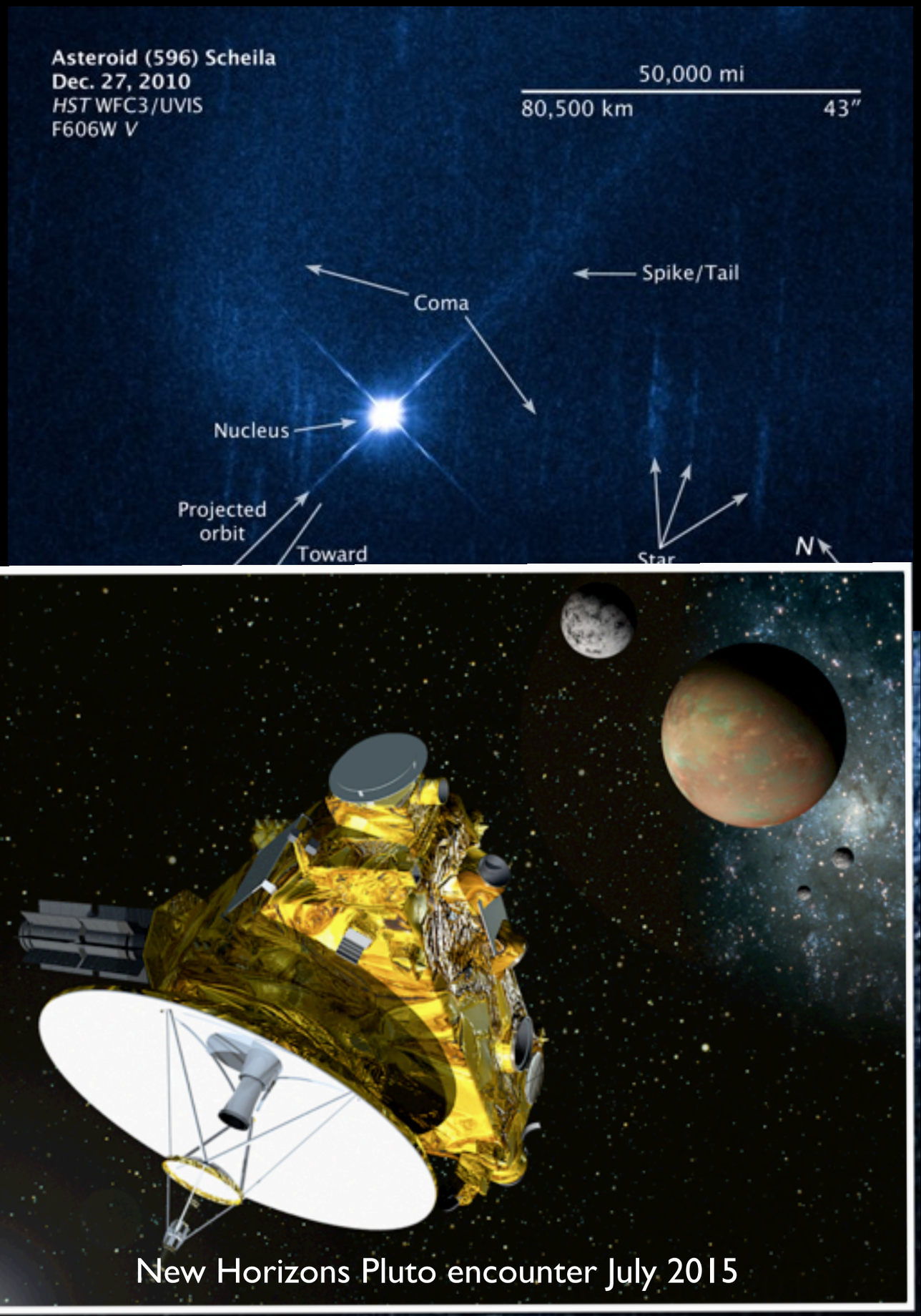


Table 1.2: Hubble Highlights and Science Goals

SM1, SM2, SM3A	SM3B	SM4
1990-1999 Hubble 1st Decade	**2000-2009 Hubble 2nd Decade**	**2010-2016 Hubble Goals**
H_0 measured to 10% accuracy	H_0 measured to 3 % accuracy	Measure H_0 to 1 % accuracy
—	Dark energy is dominant (73%) component of the accelerating universe	Characterize SN Ia evolution at z > 1.5 to constrain dark energy equation of state
Merging galaxies are common at high z; cosmic SFR peaks at z~2 (HDF)	Detection of galaxies at z = 6-8 (UDF and HUDF09)	Measure cosmic variance at high-z in several deep fields
Mass of supermassive black hole in M87 is determined	Supermassive black holes exist in most galaxies	Detect isolated, stellar-mass black holes
Witness planetary disk formation (Orion proplyds)	First exoplanet atmospheric composition measurement; direct imaging of exoplanets	Measure water vapor in exoplanet atmospheres
Deep color-magnitude diagrams for clusters/galaxies	Multiple stellar populations in globular clusters (ω Cen)	Map star-formation history of M31
Gravitational lenses used to test cosmology	First maps of dark matter in galaxy clusters	Map cluster DM and observe structure in high-z galaxies
Collisions still happen in the solar system (Comet SL-9)	Some KBOs are larger than Pluto (Is Pluto a planet?)	Two new Pluto moons discovered; maybe more
Lyα forest thins out rapidly at low redshift	Warm-hot IGM is significant baryon reservoir (O VI)	Find the "missing" baryons in the cosmic web
SN1987A ring structure and shock wave interaction	Long-duration GRBs arise predominantly in Irr galaxies	Witness next nearby SN explosion?

Solar System "debris"

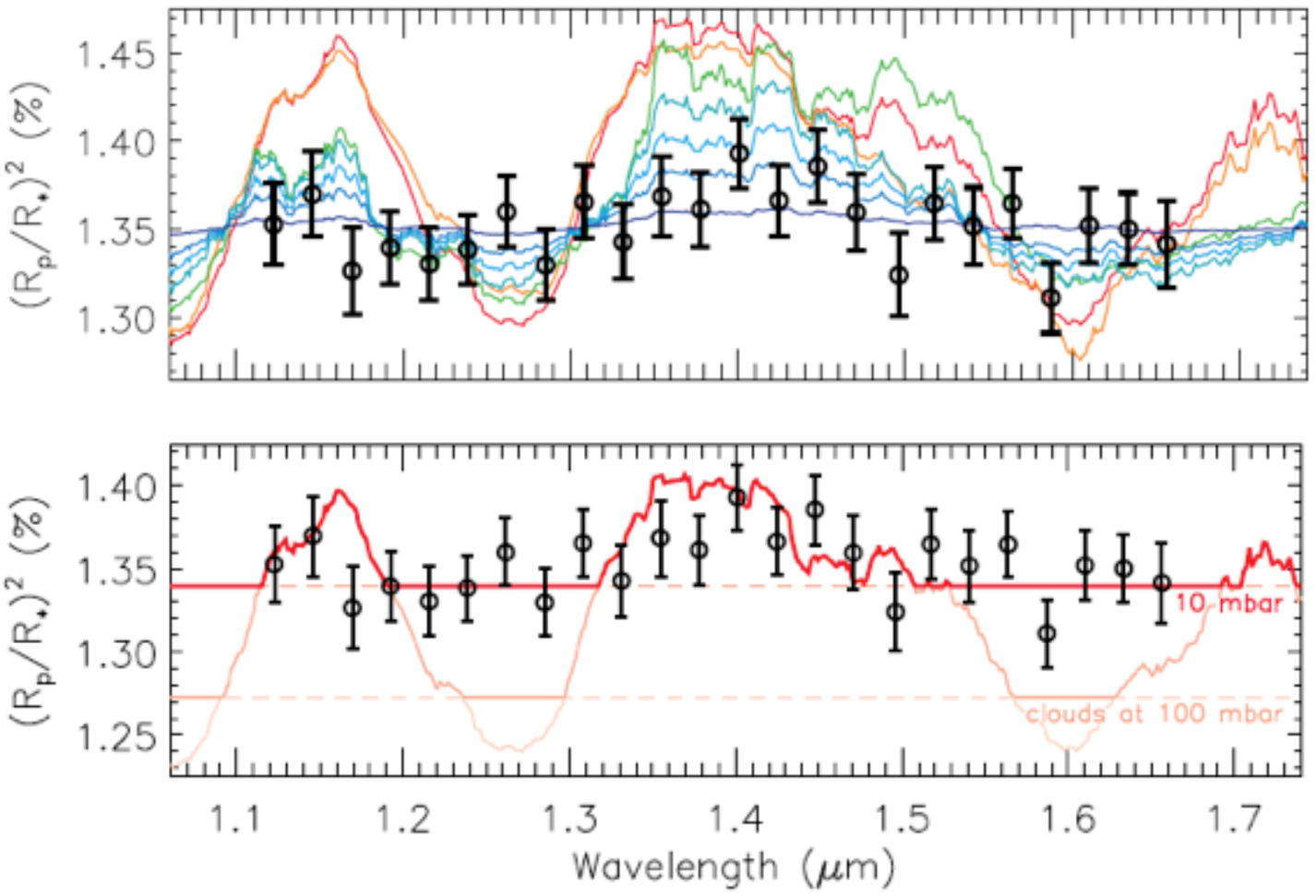


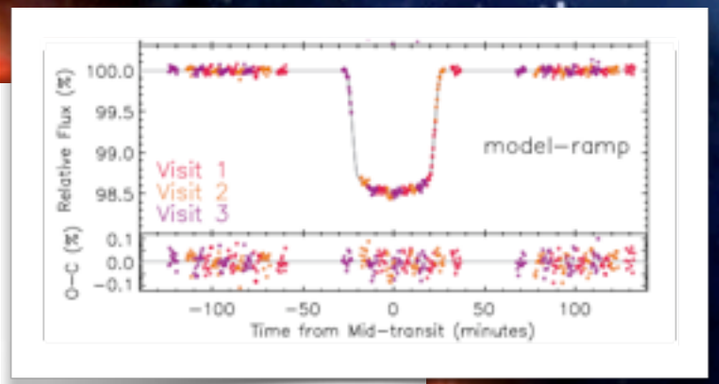


Water in ‘super-earth’ GJ1214b

“Based on our observations, this atmosphere would likely consist of more than 50% water by mass or a mean molecular weight of $\mu > 4$.”

WFC3 grism





Berta et al. 2011

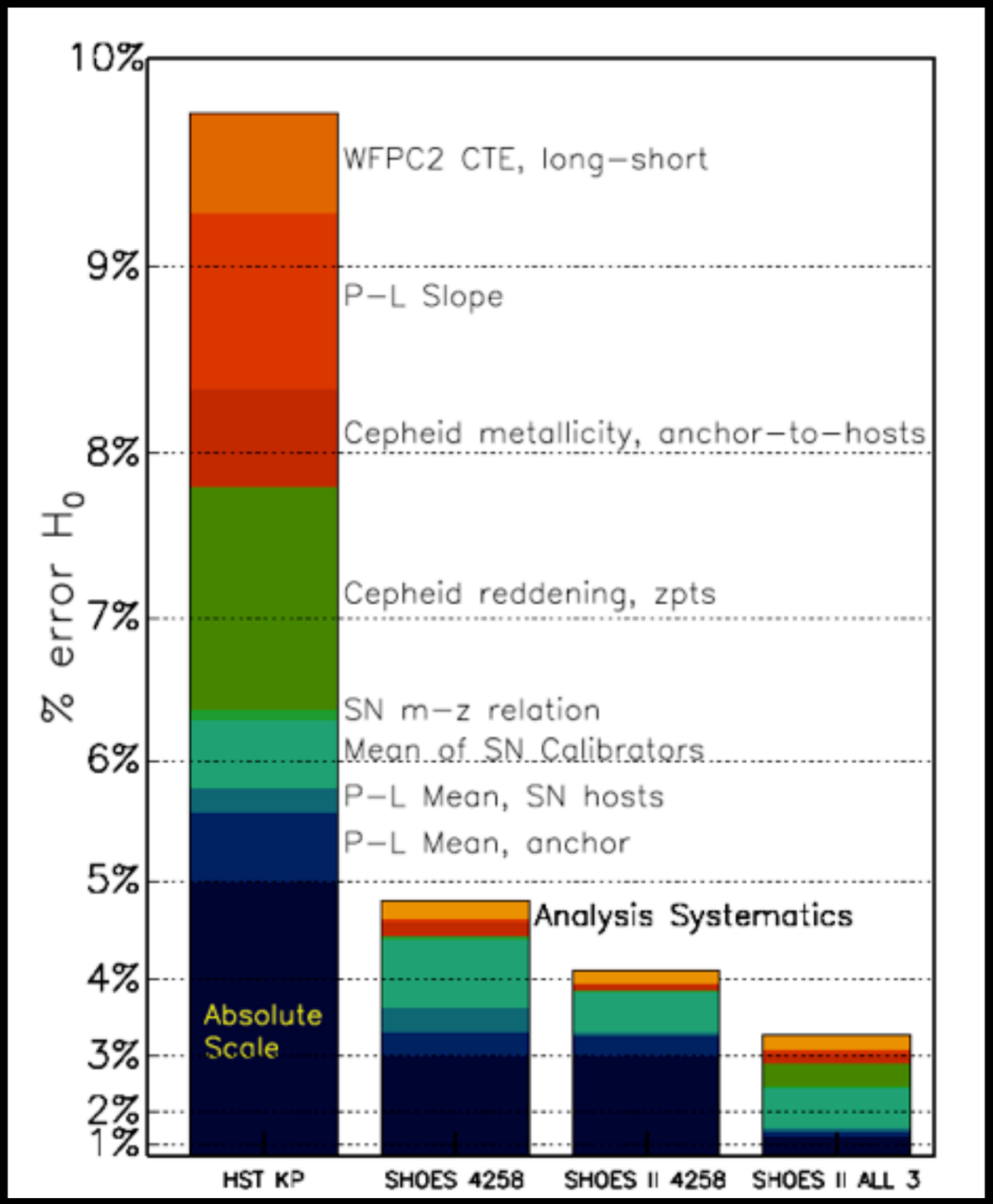
“we made new measurements of the GJ1214b's transmission spectrum using HST/WFC3. Reaching a precision of $\sigma_{Rp} / \sigma_{R^*} = 0.0009$ in 24 simultaneously measured wavelength bins.

GJ1214b is a 6.55$M_\oplus$ exoplanet 13 parsecs away

“We are confident that WFC3 will serve as a valuable tool for exoplanet atmospheric characterization in the years to come.”

Error Propagation to H_0

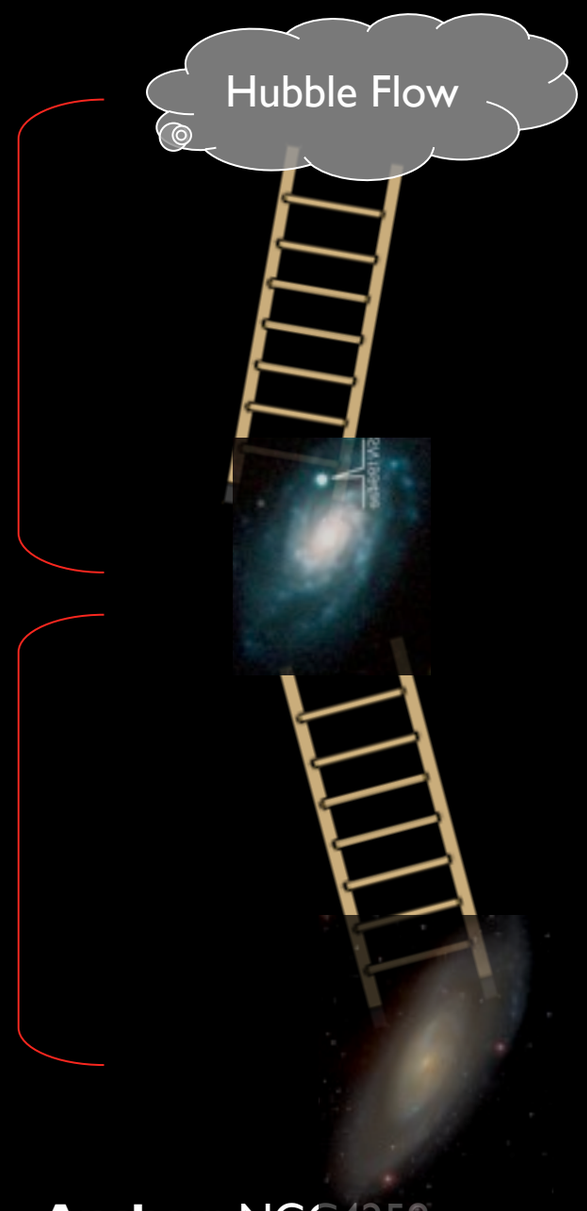
NEW LADDER (100 Mpc)



SN Ia in
Cepheid hosts,
To Hubble flow

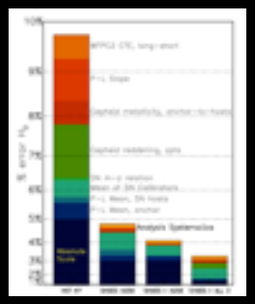
Cepheids in
anchor, to
SN Ia hosts

3.4% error

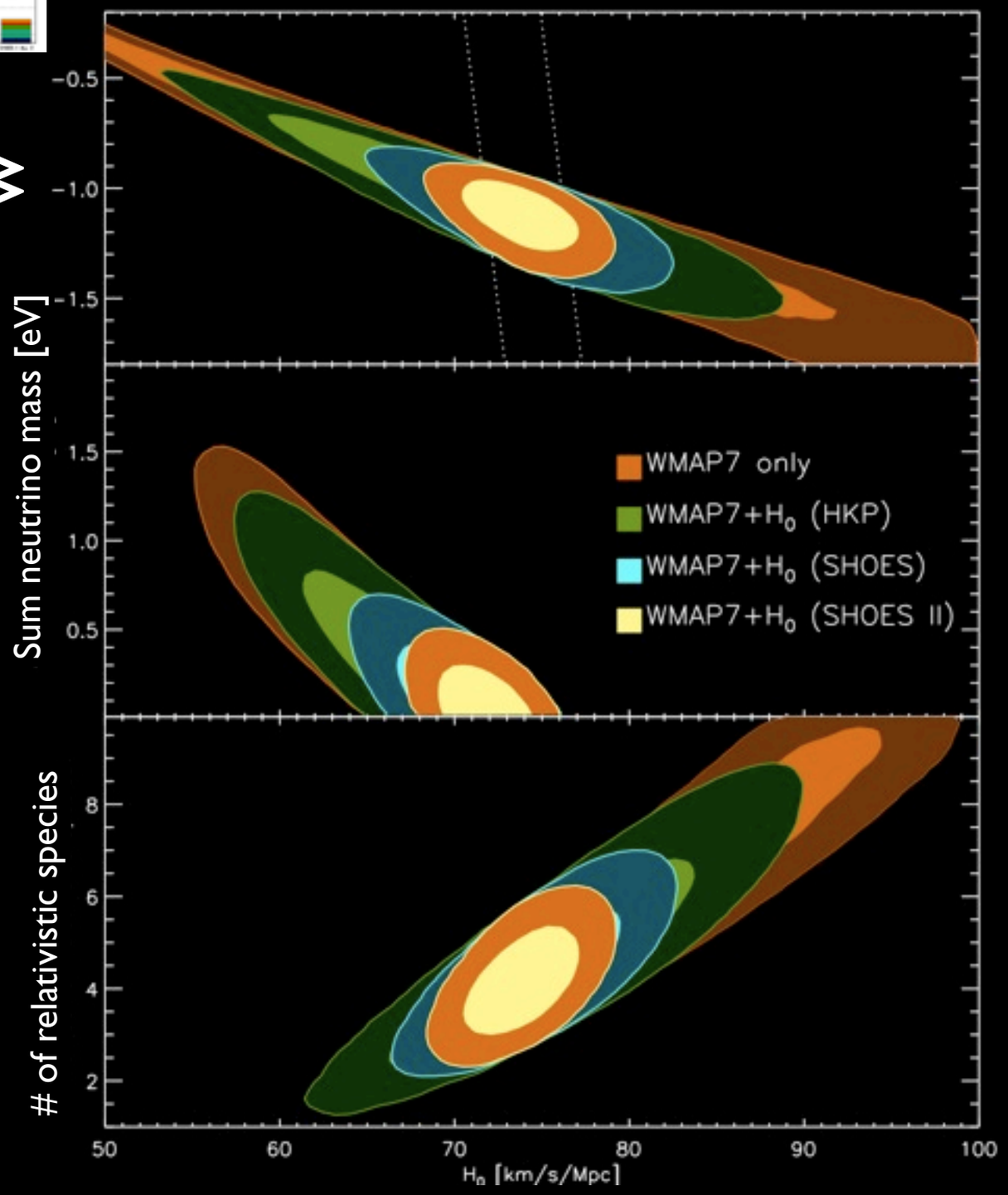


Anchor: NGC4258,
MW Cepheid parallax

courtesy A. Riess



Dark Energy and Neutrinos



Is dark energy Λ?
(w=-1.08 +/-0.10 from only H_0, WMAP)

How do neutrinos get their mass?
(Which hierarchy of mass eigenstates?)

Is there a species beyond known 3?
(present 4.2 +/- 0.7 close to resolving)

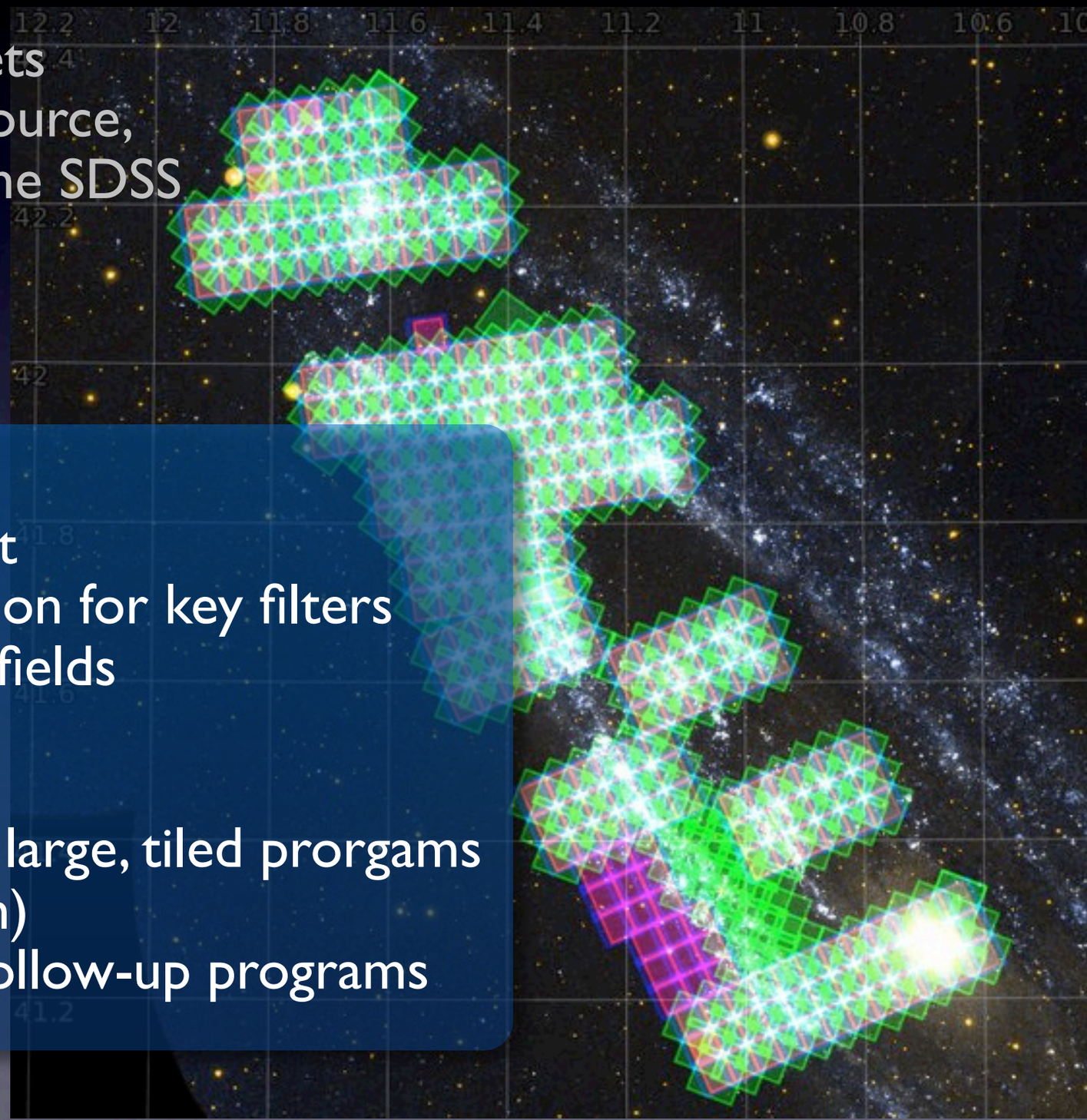
Further precision appears feasible with HST…1% becoming possible

courtesy A. Riess

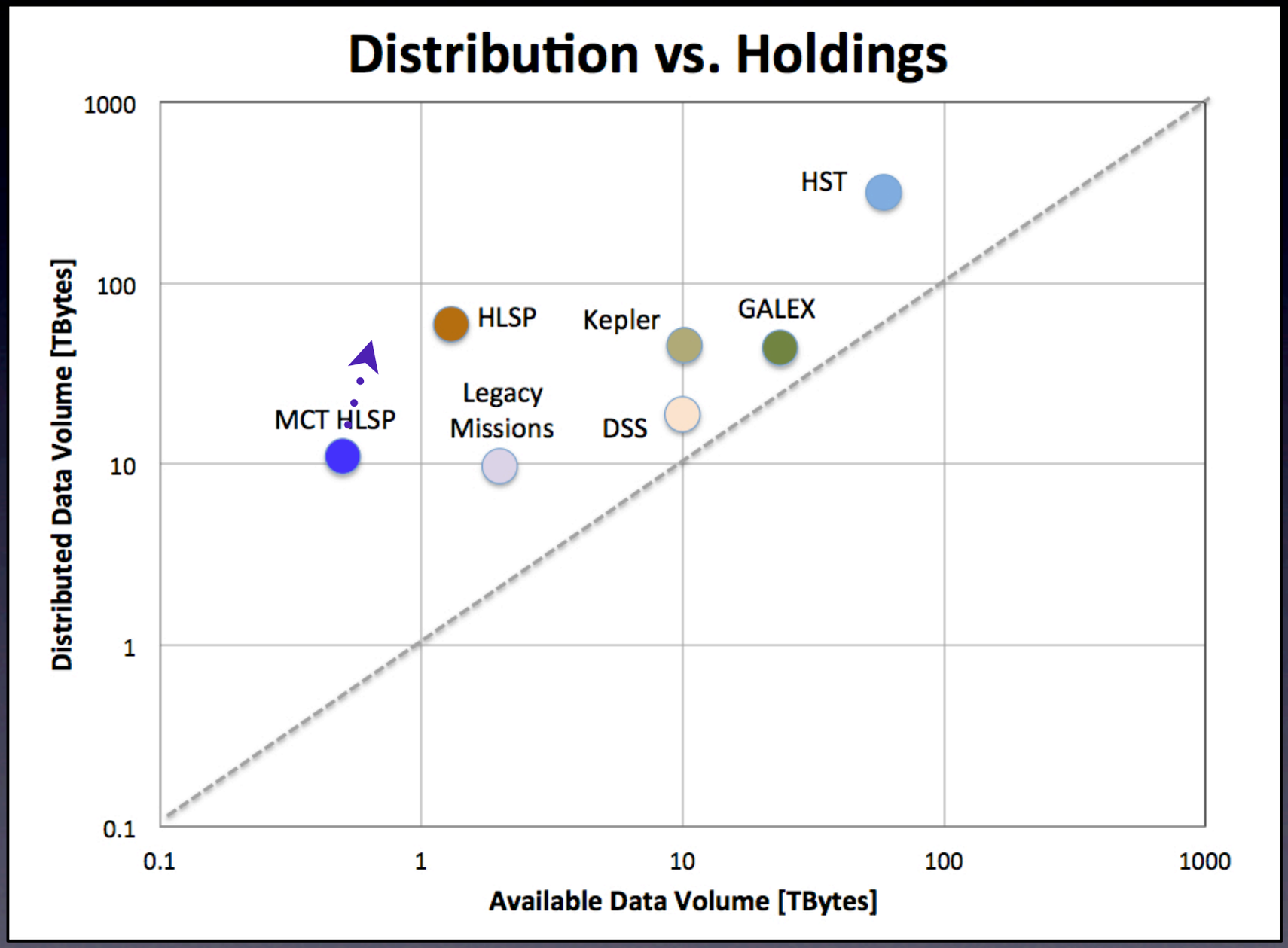
MCT - large, complex programs tackling scientific questions that can only be addressed by programs of this scale

Together, they are expanding HST's capabilities in many areas:

- Storage and analysis of large datasets
  - PHAT already has >90 million source, equivalent to more than 30% of the SDSS catalogue
  - Cloud computing techniques
- Improved calibration techniques
  - Multi-field astrometric alignment
  - Photometric & flat field calibration for key filters
  - PSF reconstruction in crowded fields
- Improved scheduling efficiencies
  - Optimal scheduling for multiple large, tiled prorgams
  - UV imaging for GOODS (North)
  - ToO turnaround time for SNe follow-up programs



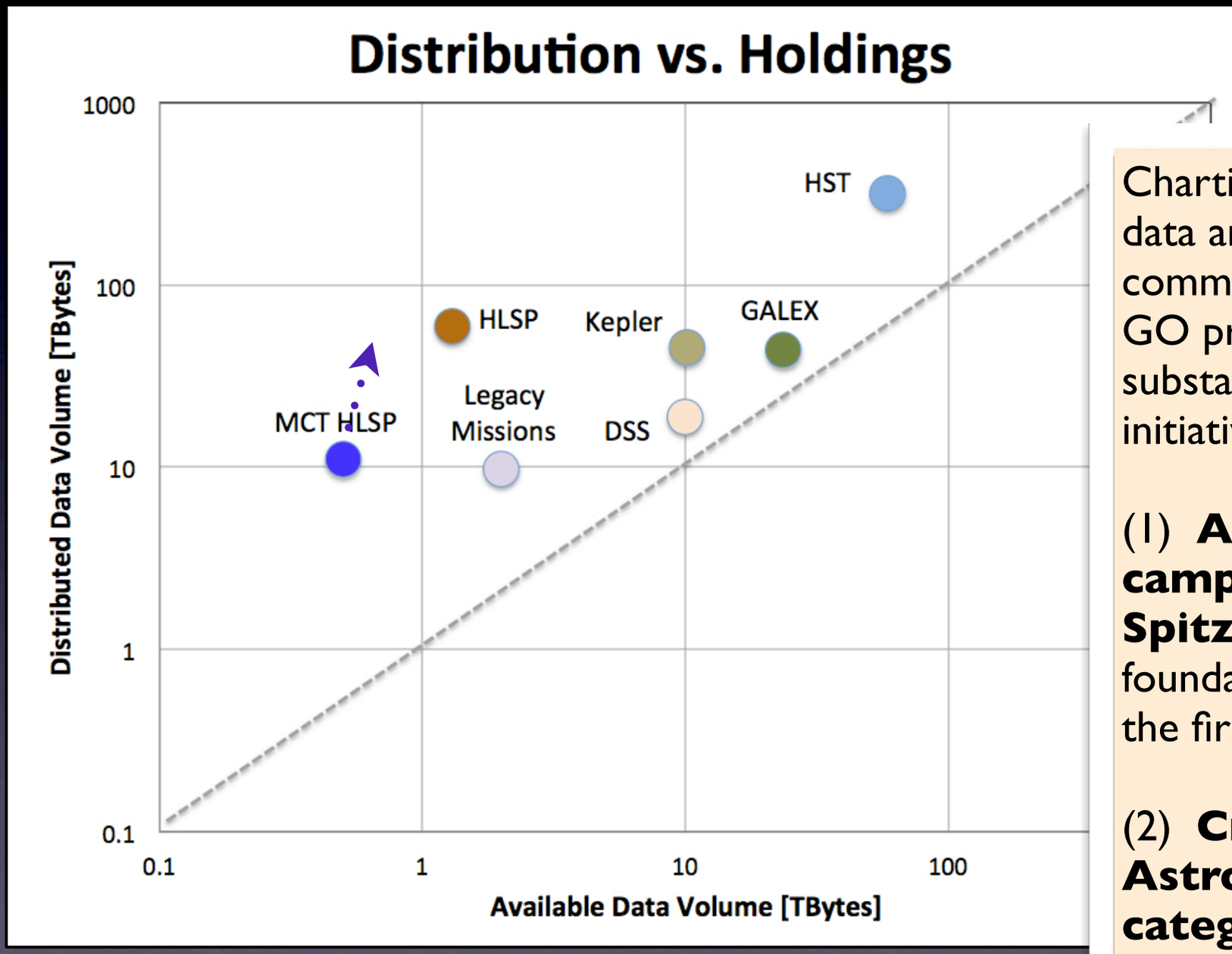
Impact for the community



MCT extragalactic datasets in the HST archive are used extensively by the community at large:

CANDELS Treasury program High-Level Science Product (HLSP) downloads are already 20x greater than available data volume

Impact for the community



Charting a new path, to increase the data and science return to the community beyond the traditional GO programs, Hubble will focus substantial resources on two, new initiatives:

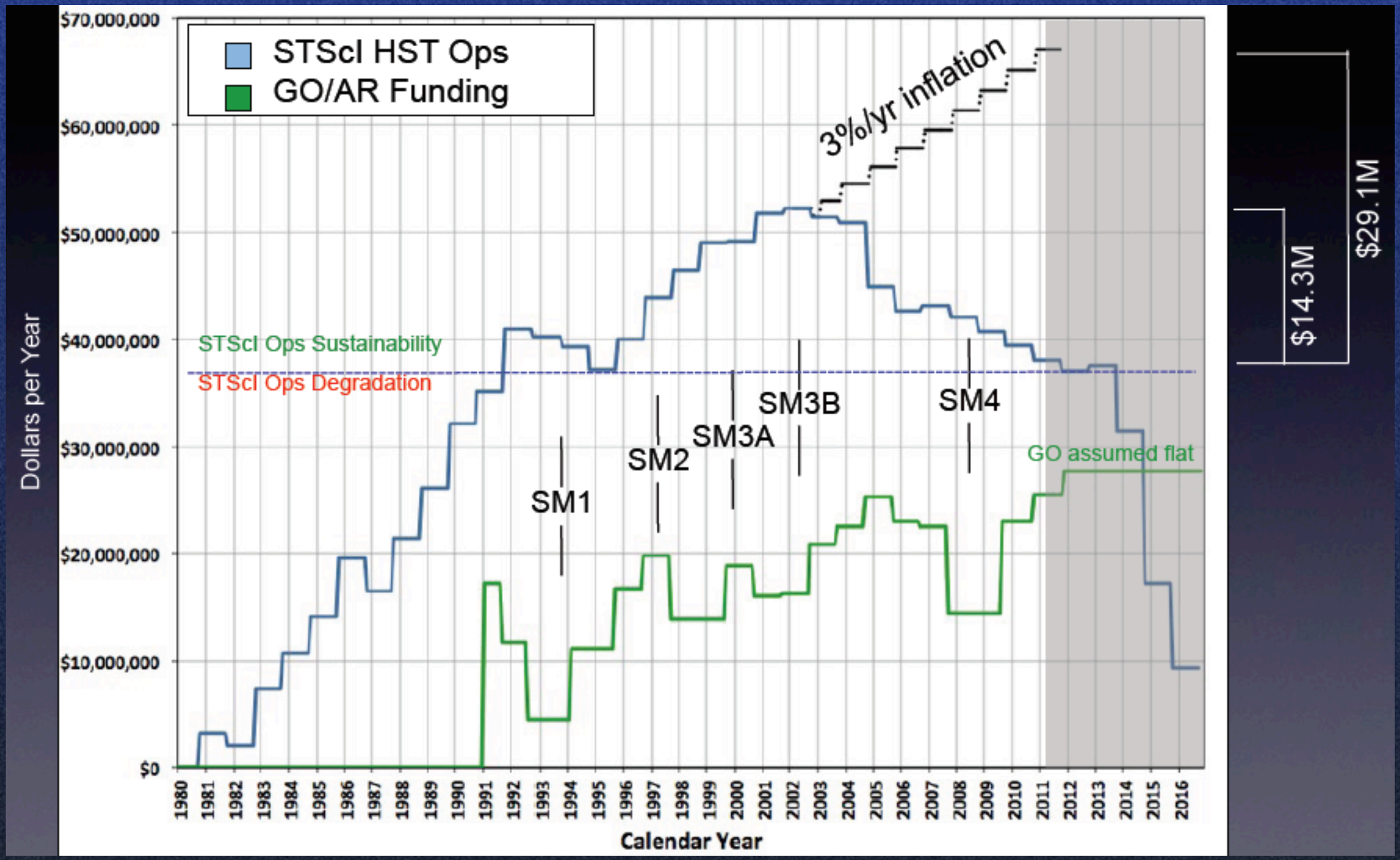
(1) **A deep-field imaging campaign in concert with Spitzer and Chandra** to lay the foundations for the exploration of the first galaxies

(2) **Creation of an Ultraviolet Astrophysics legacy proposal category** to exploit Hubble's unique UV capabilities

2012 NASA
Senior Review

Hubble
Space Telescope

Post-SM4 HST Operations Are Leaner Than Ever

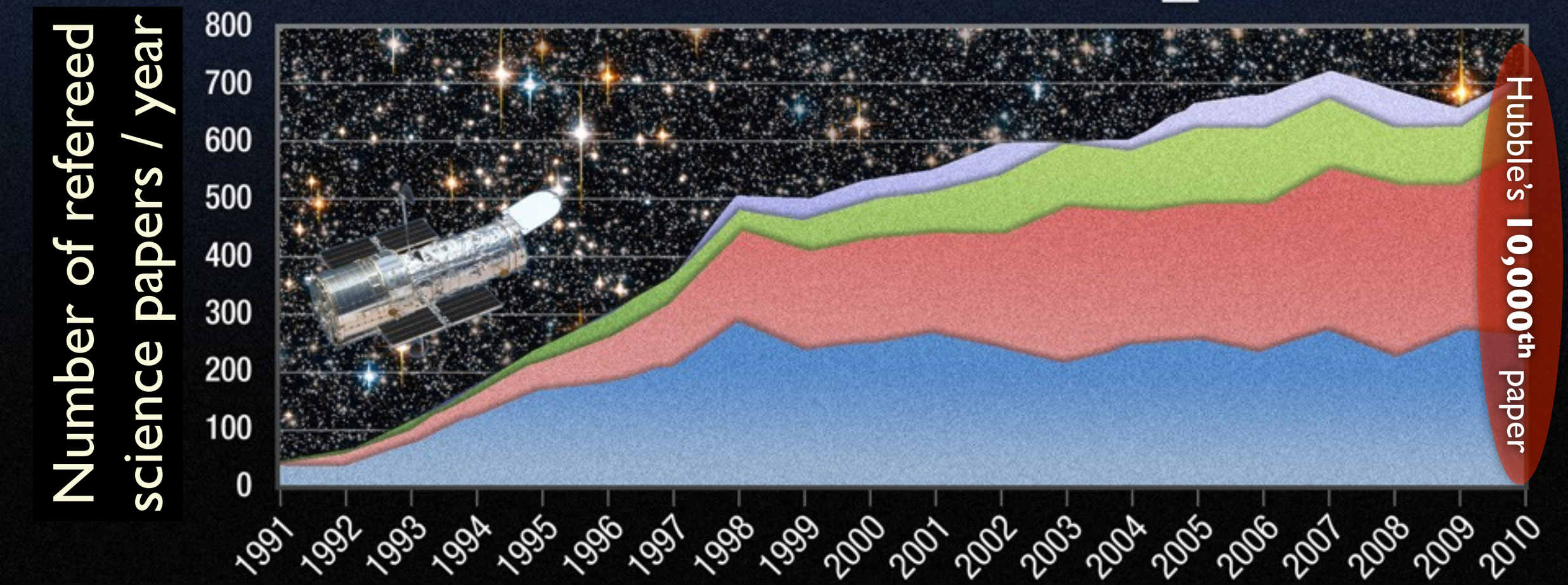


HST budget :	1/3 GO/AR grants	1/3 STScI SOC + OPO	1/3 GSFC FOC

Hale 5m : **4155** (limited to 1948-2012)
Shane 3m : **8672** (limited to 1959-2012)
Mayall 4m : **1973** (limited to 1973-2012)
(refereed papers in ADS, courtesy J. Largerstrom)
SLOAN DSS : **4000** (limited to 1998 - 2011)

HST Science Publications

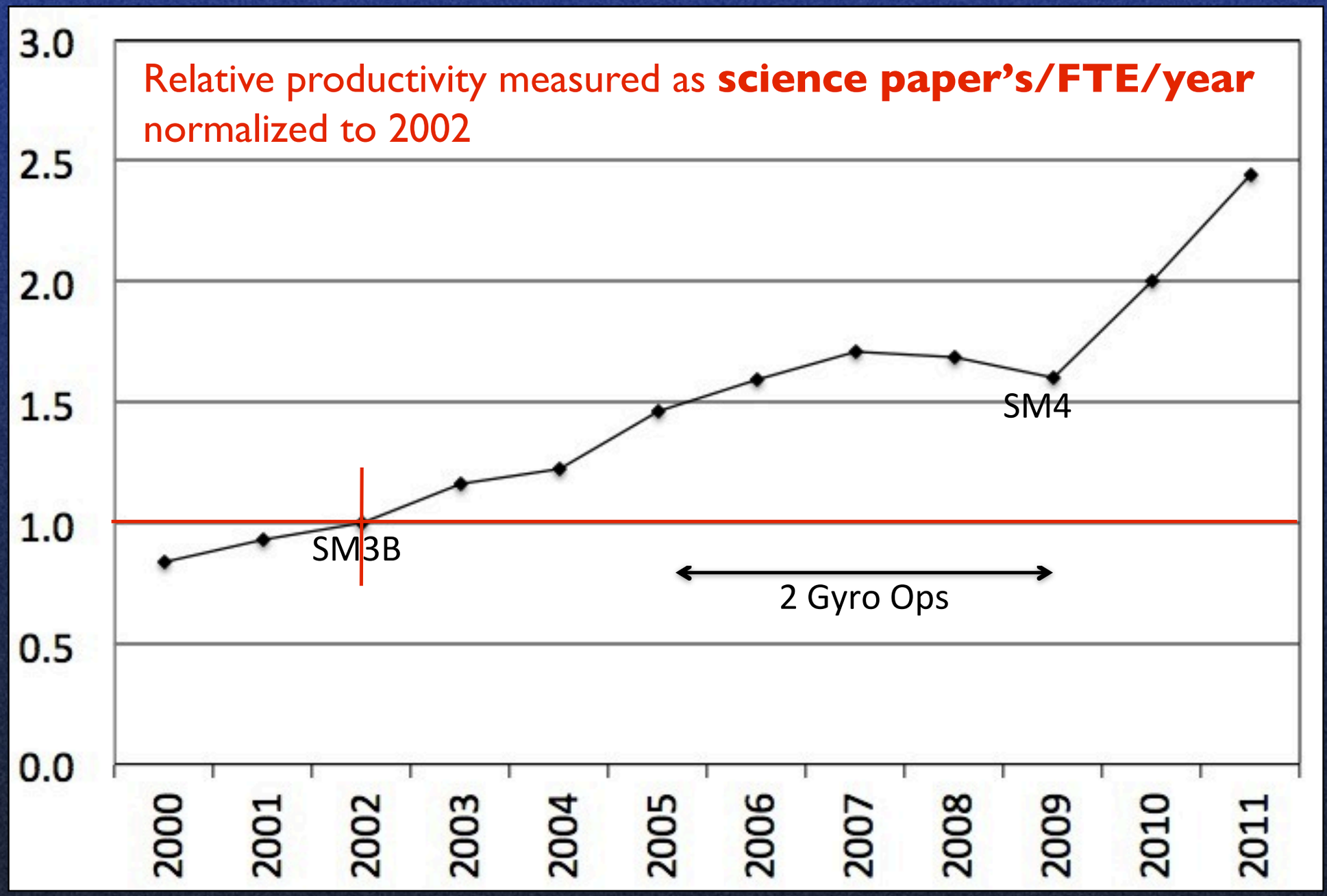
General Observer (GO)
Archival (AR)
Both GO and AR
Other



2012 NASA Senior Review

Hubble Space Telescope

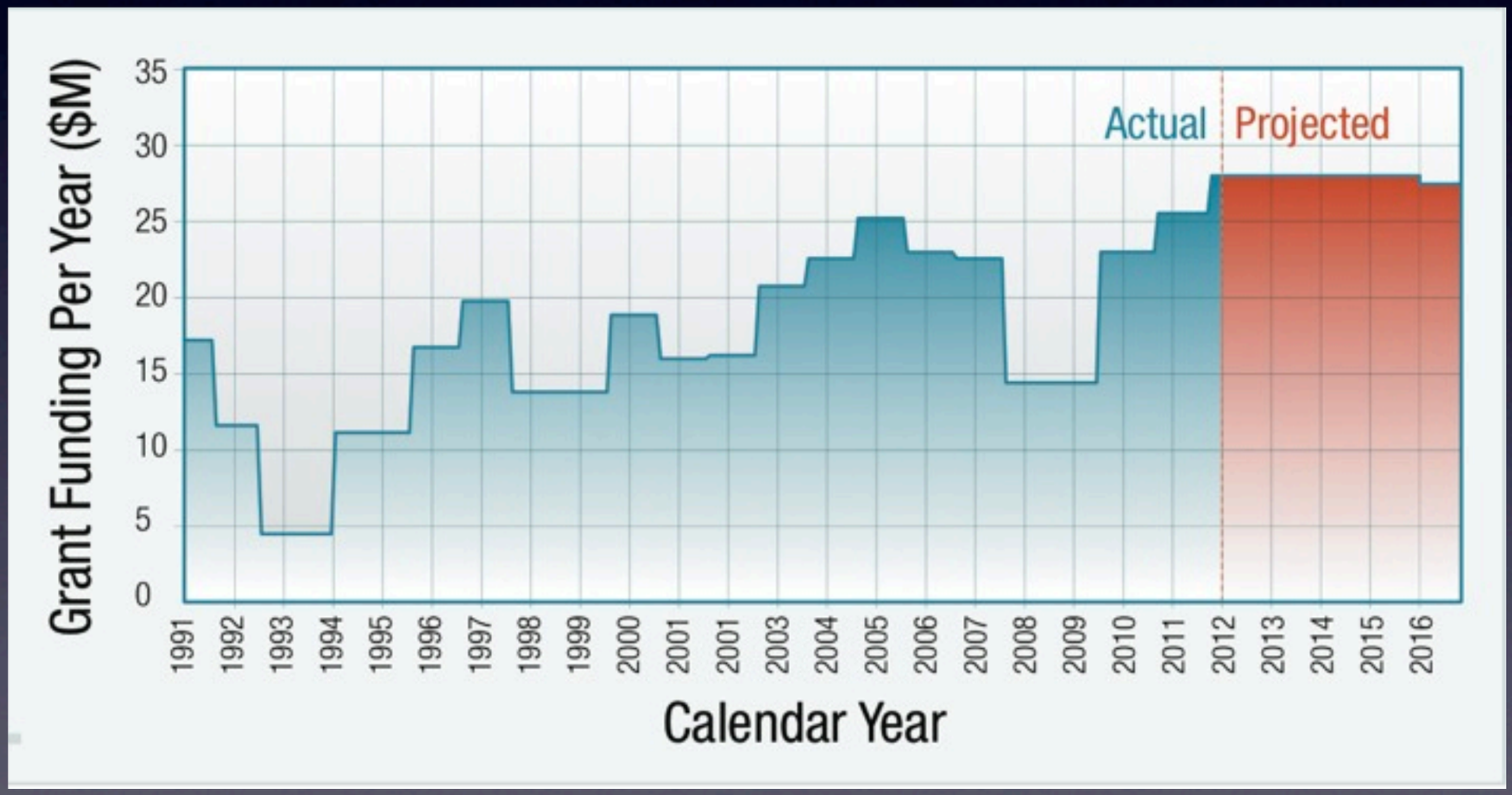
HST is giving its highest ever science return on investment

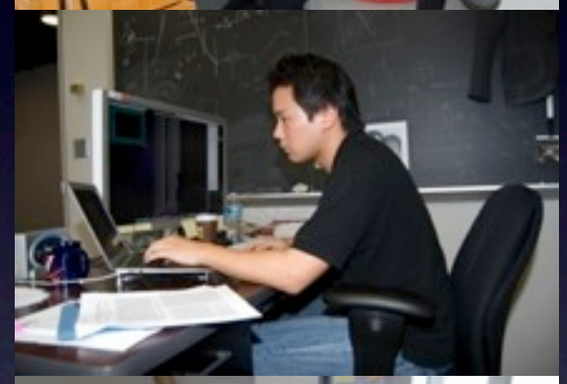


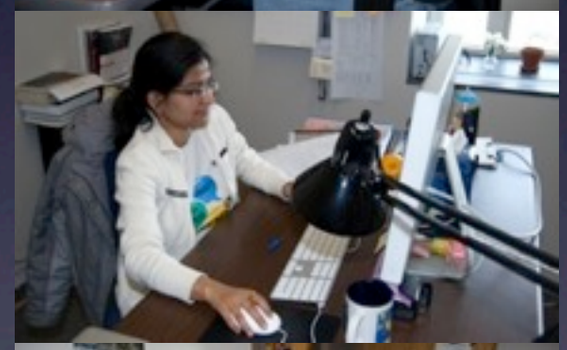
Hubble Supports Young Researchers

results
- science
- community trust
- return on investment

- Hubble has trained multiple generations of postdocs and graduate students
- A significant fraction (~50%) of Hubble GO/AR funding currently provides support for the next generation of researchers







(1) Actual person, FTE, and funding levels based on Cycle 17 and 18 proposals. U.S investigators only.
(2) Estimated person, FTE, and funding levels based on actual cycle funding corrected for inflation, assuming similar Person:FTE:Funding ratios throughout HST lifetime.

2012 Senior Review of Operating Missions in the NASA Astrophysics Division

February 28 – March 2, 2012

MISSION	DISCOVERY SPACE	LONG TERM IMPACT	PUBLICATION/$	SYNERGY	CRITICAL CAPABILITY	HEALTH OF SCIENCE PROGRAM (RYG)
CHANDRA	9	9.5	7	9	9.5	G
FERMI	7.5	7.5	7	8	9	G
HST	9.5	9.5	7	9.5	10	G
KEPLER	9	9	7.5	8	9.5	G
PLANCK	7	10	6	8.5	9.5	G
SPITZER	9	8	6.5	9	9.5	G
SUZAKU	8	8	10	7.5	9	R
SWIFT	9	9	9.5	10	9.5	Y
XMM	8	9	9.5	9	9	R

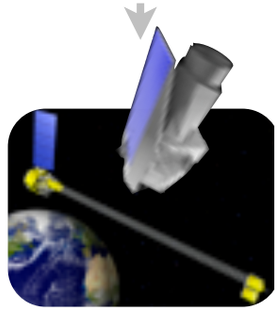
“Big Science” Models

Instrument Team 1

Instrument Team 2

Instrument Team 3

Distinct multi-disciplinary teams



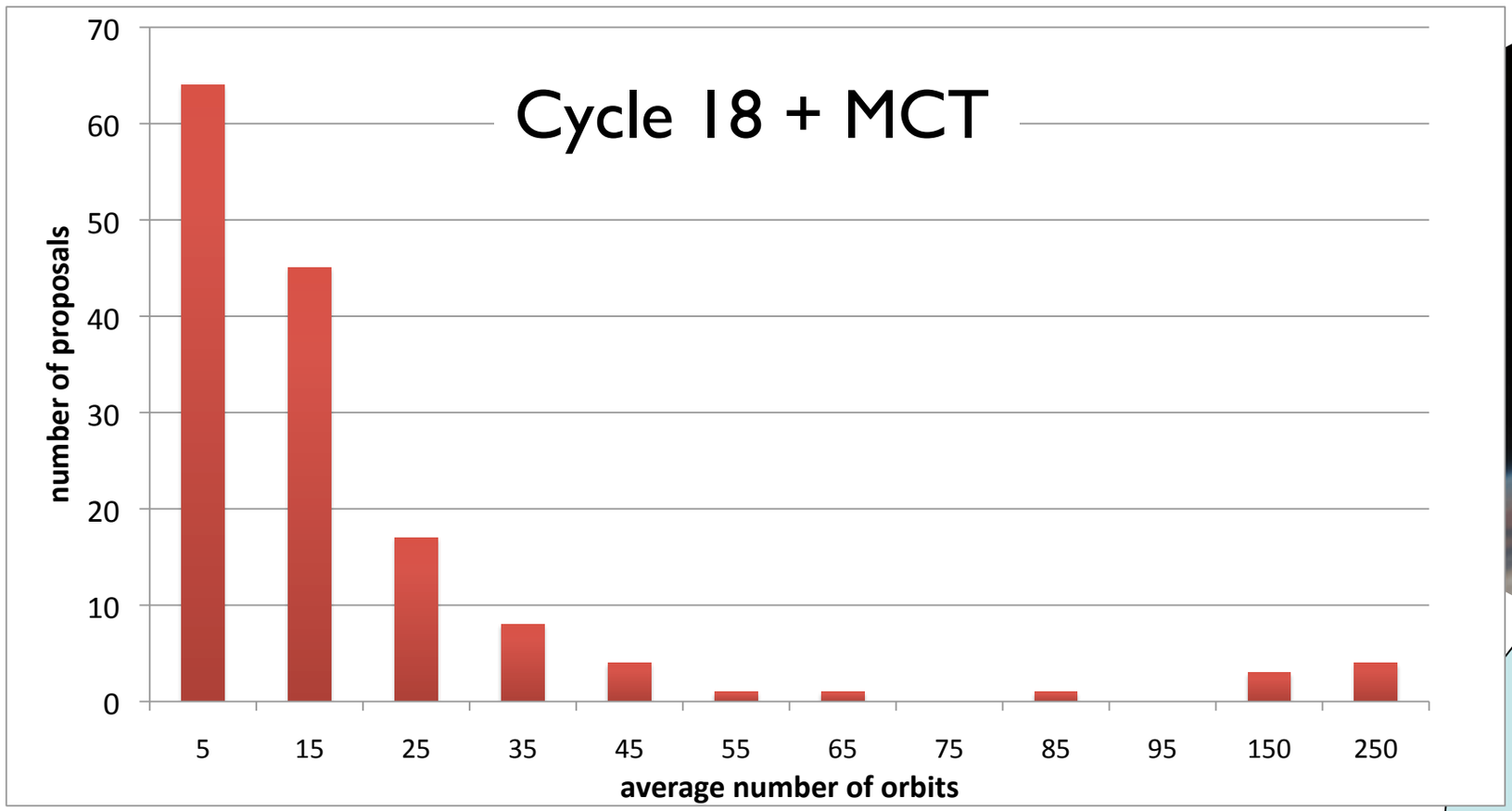
Explorer or M/S class missions

Great Observatories

diverse sustainable communities ~8,000

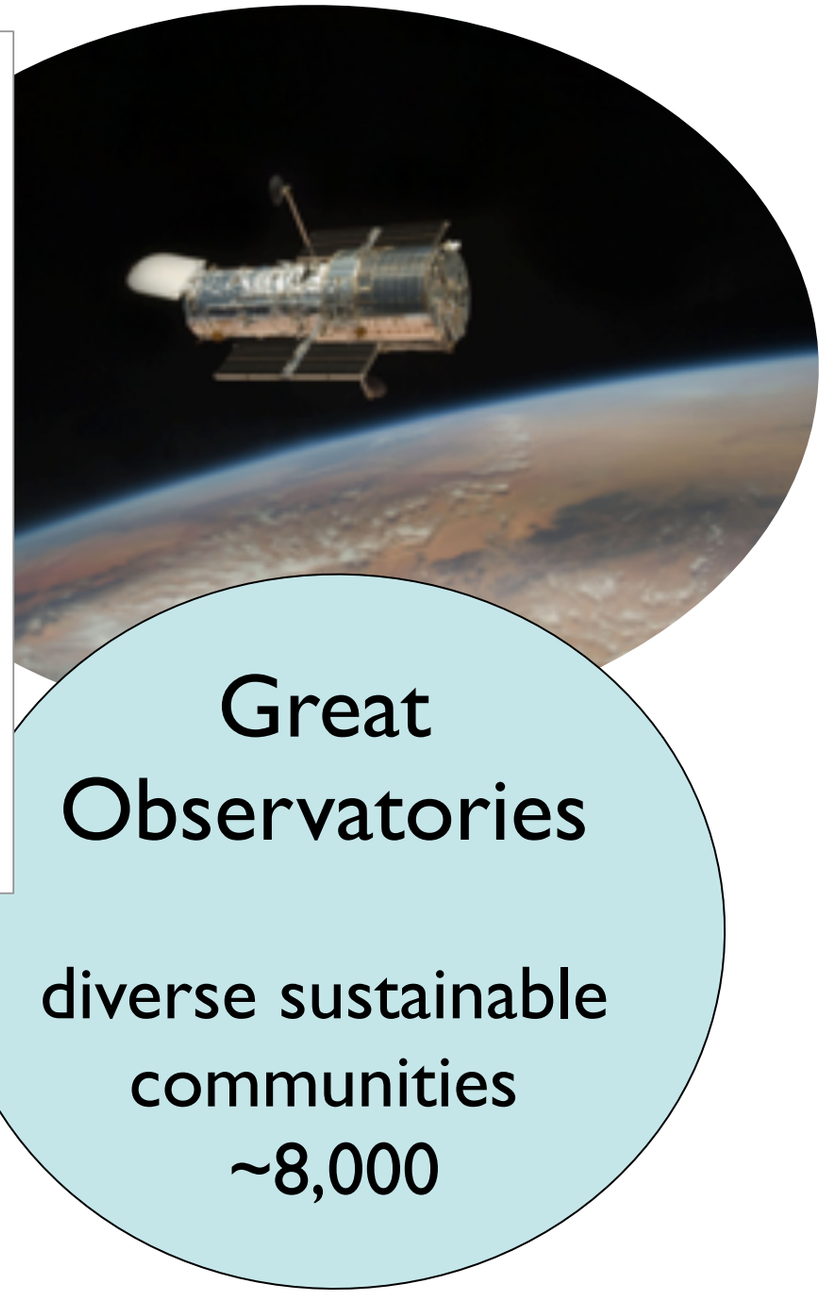
“Giacconi Model”

“Big Science” Models



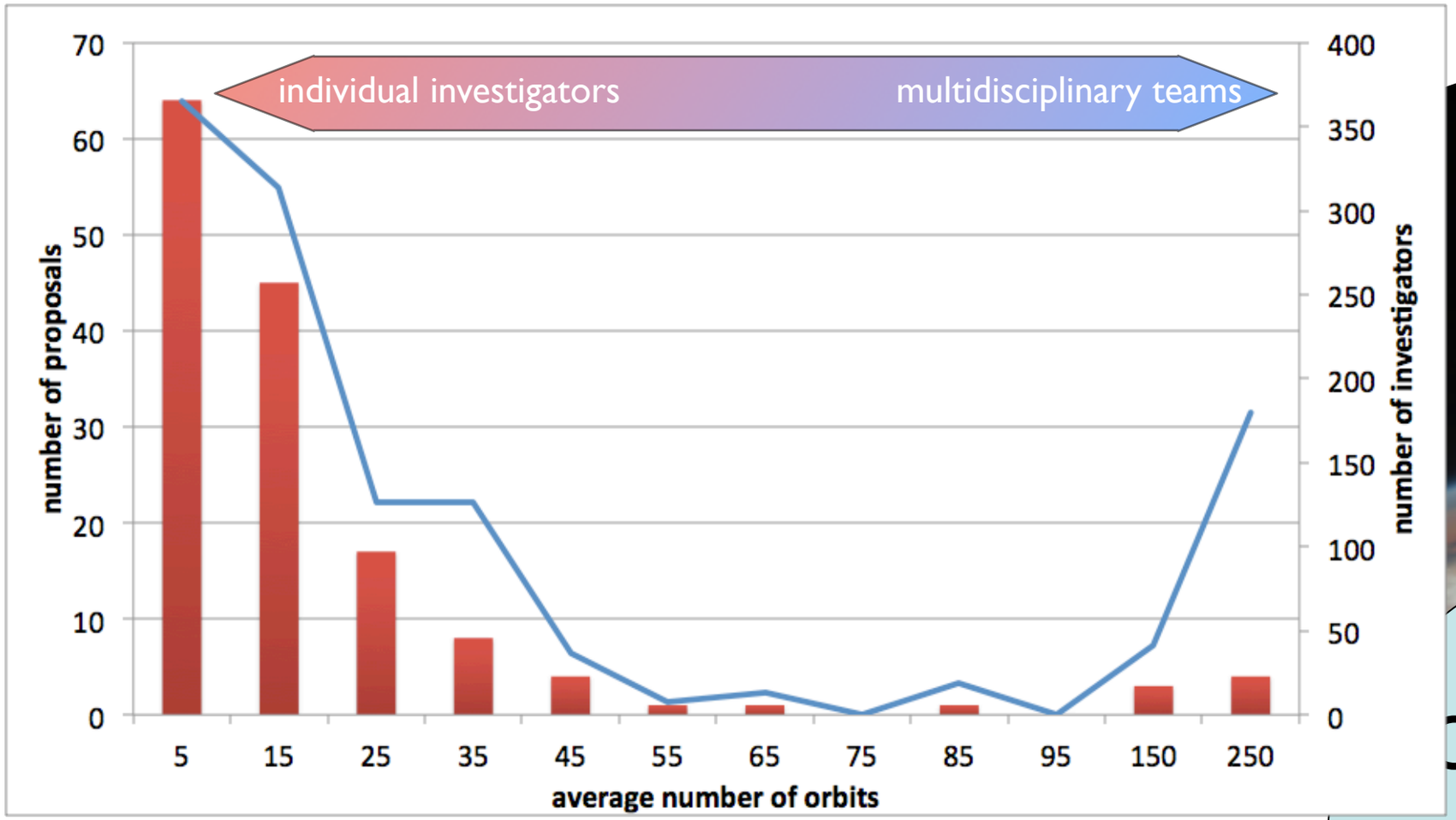
number of programs as a function of size

enables science at all scales



“Giacconi Model”

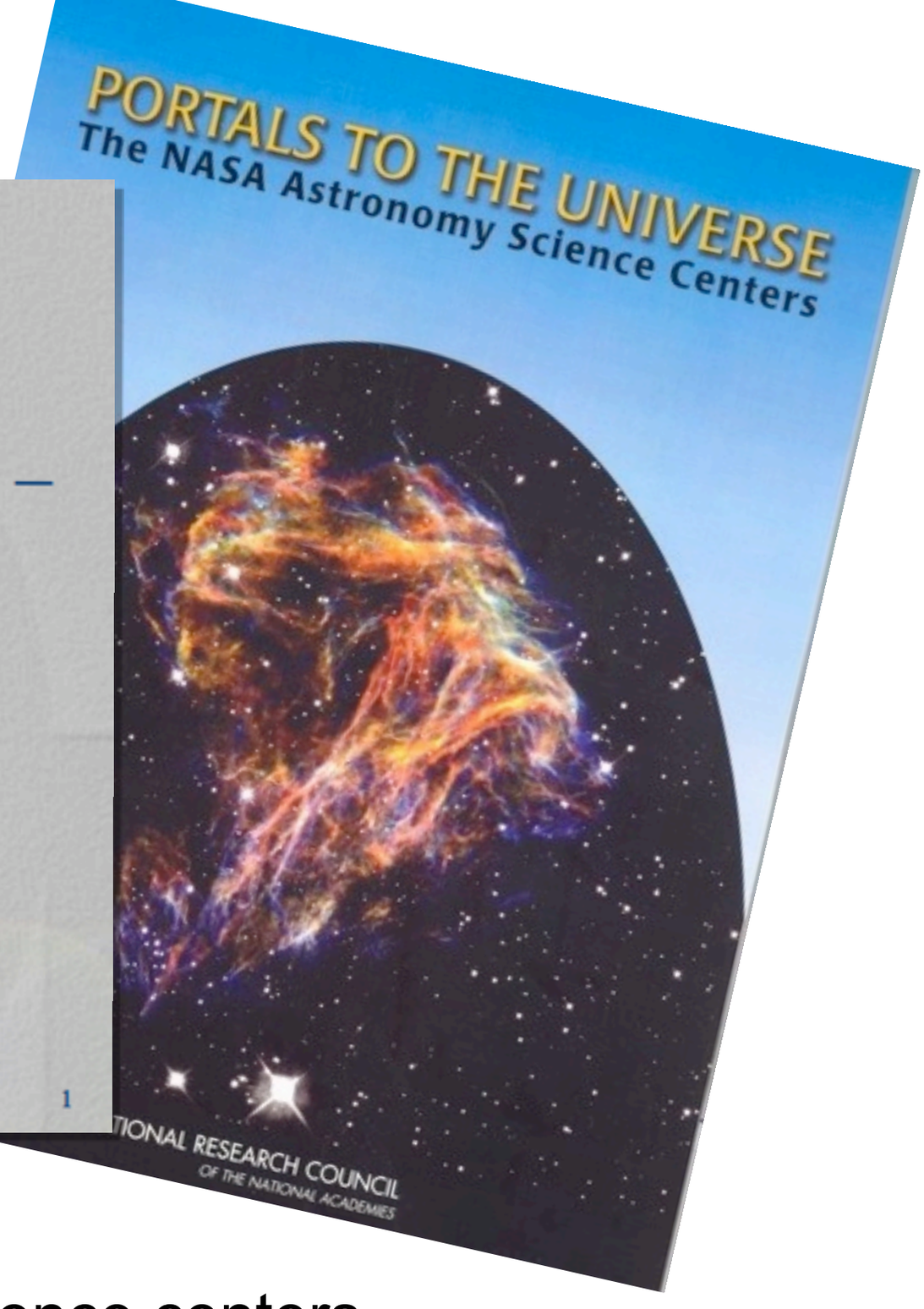
The Hubble Model



number of programs as a function of size

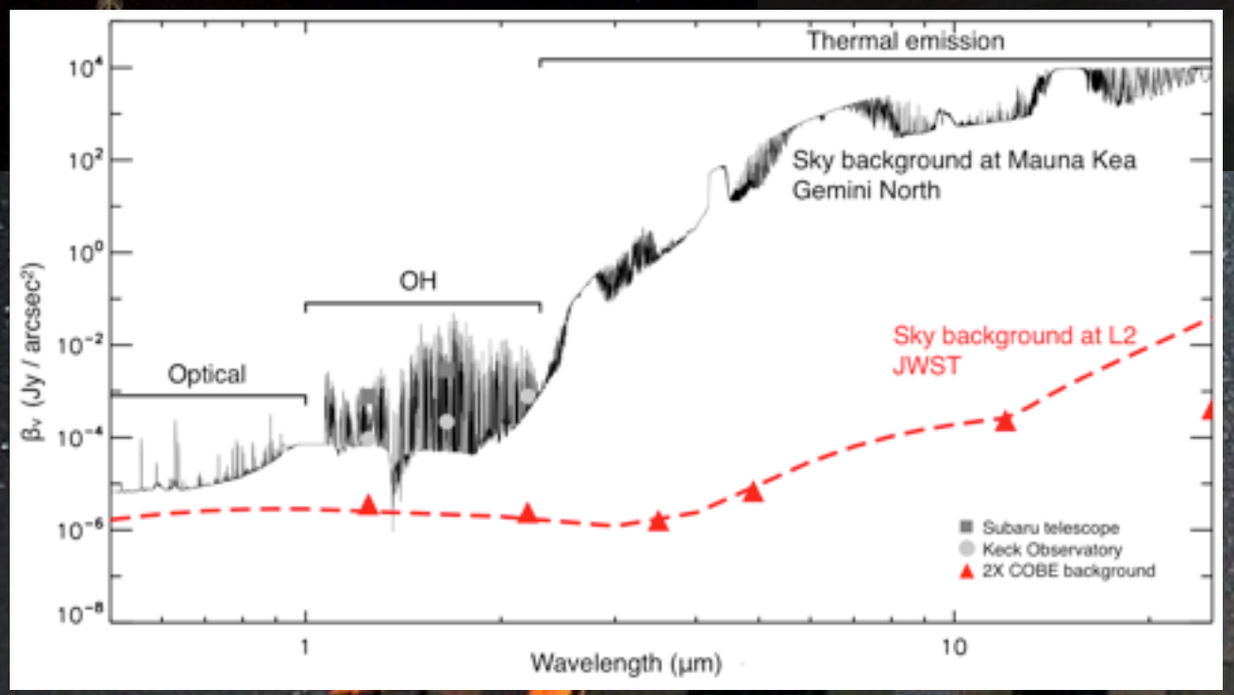
number of supported investigators

Community science enabled **at all scales** by peer review

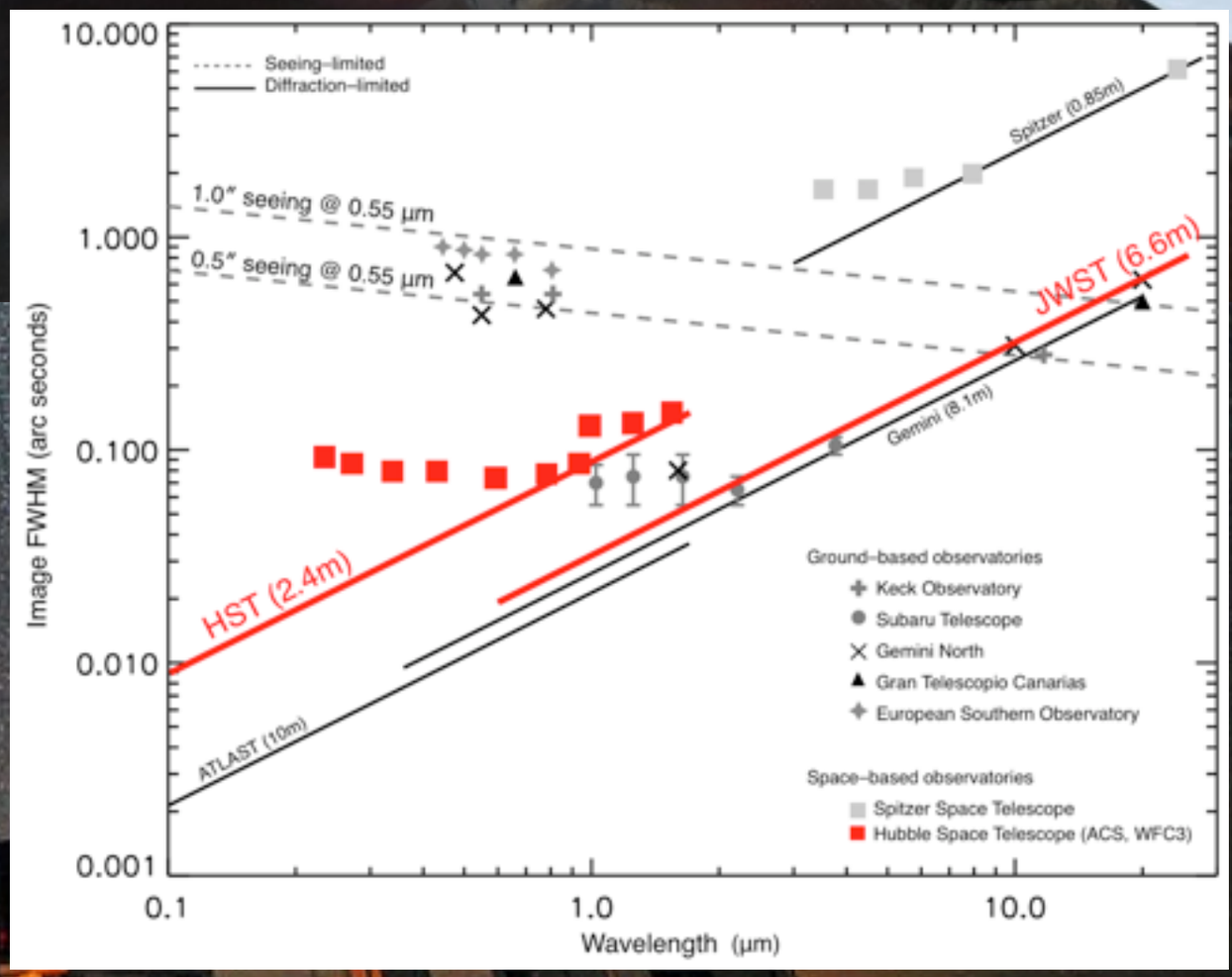


Common themes across all science centers
- utility of science staff
- enhanced data products and archives
- analysis software

Hubble compared to ground-based telescopes



relative background[1].



relative image quality[1].

1. courtesy Ubeda, 2012

UVIS Sensitivity: HST Compared with Ground based 8m class telescopes: Exposure Times (seconds) required to reach listed magnitude at S/N = 5
The time estimates for ground observations using average conditions are 4 to 30 times larger than those using UVIS.

	UV	U	B	V	R	I	Z
Vega magnitude	**25**	**25**	**27**	**27**	**27**	**26.5**	**25**
HST/WFC3/UVIS	3100. (F225W)	1100. (F336W)	2200. (F438W)	1300. (F555W)	2600. (F625W)	3000. (F814W)	1700. (F850LP)
Gemini/GMOS		13500. (u') **x12**	16200. (g') **x7**		53100. (r') **x20**	61200. (i') **x20**	33300. (z') **x19**
VLT FORS1		33000. (U_{Bessel}) **x30**	12000. (B_{Bessel}) **x5**	8300. (V_{Bessel}) **x6**	12000. (R_{Bessel}) **x4**	37000. (I_{Bessel}) **x12**	28000. (Gunn Z) **x16**

Notes: All Calculations done using a Pickles M0V stars, flux normalized in to the filter listed or the closest available one.
WFC3/UVIS: All exposures using CR-SPLIT=2, average background and earthshine.
GMOS: Silver coating, 0.80" seeing, airmass < 1.5. Using 50 percentile sky transparency, and average sky, optimum S/N with aperture ratio = 1.
FORS1: 0.80" seeing, airmass = 1.5, and sky level 10 days from new moon.
All numbers derived using the latest available ETC and ITCs as of March, 25, 2010.

courtesy Pirzkal, 2012

Gemini Observatory, GeMS-GSAOI first light

NGC288, H band
13mn exposure
Field of View 87"x87"
FWHM = 0.080"
FWHM rms = 0.002"

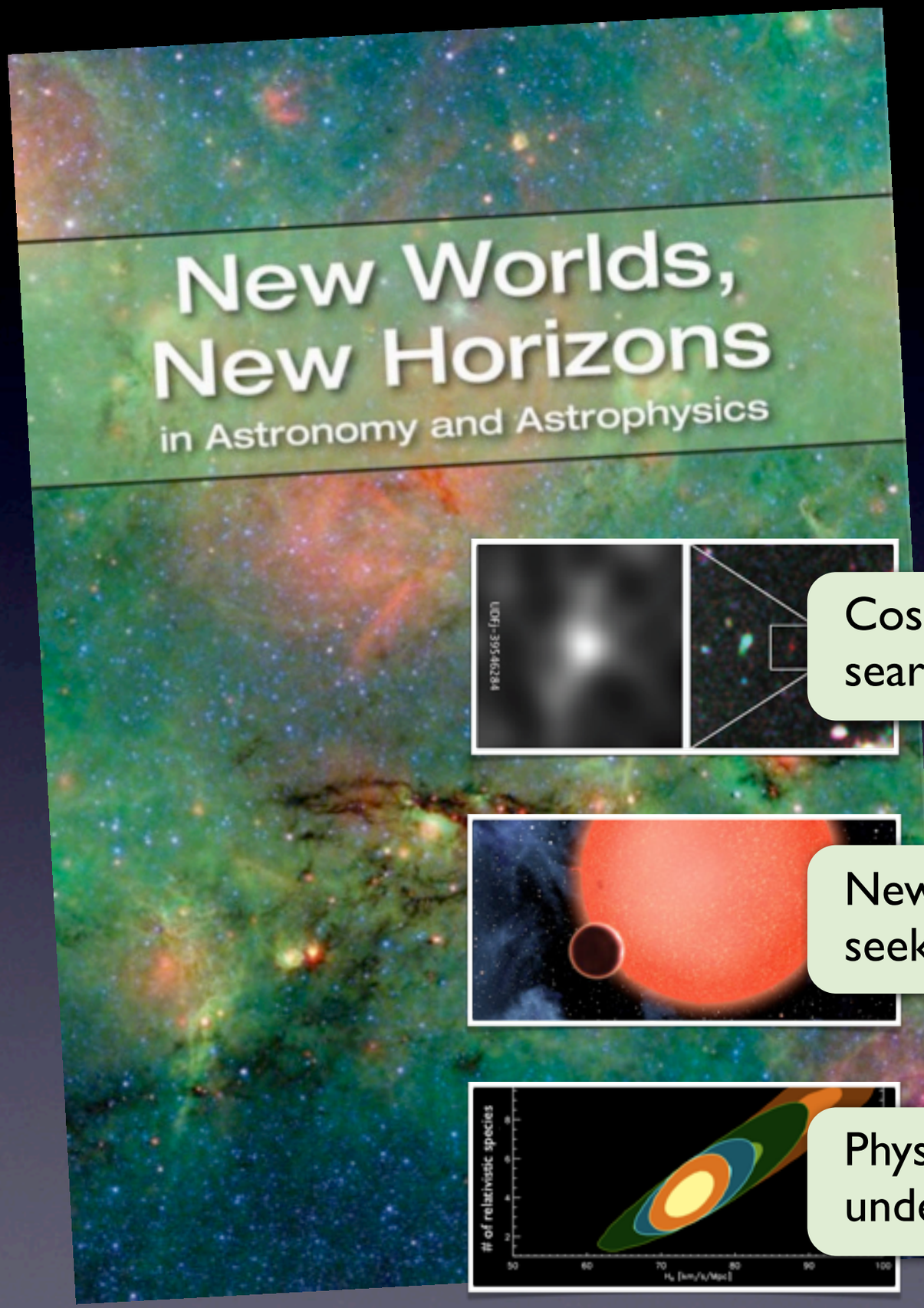
90 arcsecs

IR Sensitivity: HST Compared with Ground-based 8m class Telescopes: On-source Exposure Time Required to Reach S/N=5 (hours)

		J=25.2	H=24.5	K=23.2
HST		**F110W**	**F160/165W**	**F205W**
WFC3/IR	123” x 136”	0.14	0.30	
NICMOS/NIC3	51” x 51”	0.55	0.72	
NICMOS/NIC2	19” x 19”	1.17	1.47	6.4
NICMOS/NIC1	11” x 11”	3.1	3.6	
8m with AO		**J**	**H**	**Ks**
Gemini/NIRI+Altair	22” x 22”	5.7 -- 22	10. -- 32.	0.6 -- 2.0
VLT/NAOS+CONICA	27” x 27”	11. -- 12.4	2. -- 2.85	0.6 -- 0.8
8m without AO		**J**	**H**	**Ks**
Gemini/NIRI	120” x 120”	7.6 -- 17.	16. -- 37.	1. -- 2.3
VLT/ISAAC	154” x 154”	11.2	25.9	9.1

Notes: Input SED: M0V Pickles star, Vega magnitudes.
HST/NICMOS/WFC3: 1 orbit = 2400s; average zodiacal and earthshine background
Gemini & VLT: airmass = 1.2, estimates using both observing conditions with best 20% and 70% percentiles shown separated by --
HST/NICMOS/WFC3 and Gemini & VLT with AO: aperture radius = 0.3”
Gemini & VLT no AO: aperture radius = 2x seeing
All numbers derived using the latest available ETC and ITCs as of March, 25, 2010.

courtesy Pirzkal, 2012



Over the next 5 years
Hubble will continue
to enable transformational
science which responds to
the themes of Astro 2010:

Cosmic Dawn:
searching for the first stars, galaxies and black holes

New Worlds:
seeking nearby habitable planets

Physics of the Universe:
understanding scientific principles

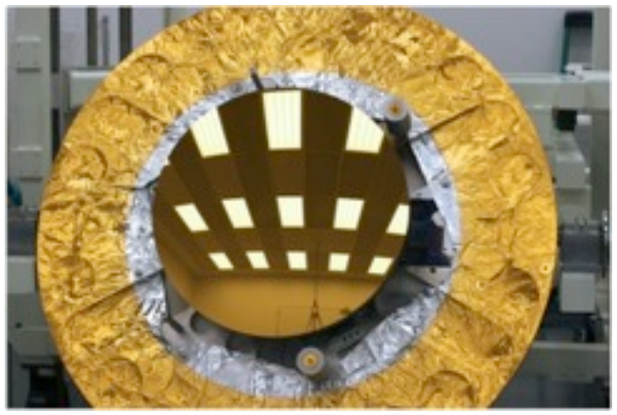
Questions for the Space Telescope Users Committee

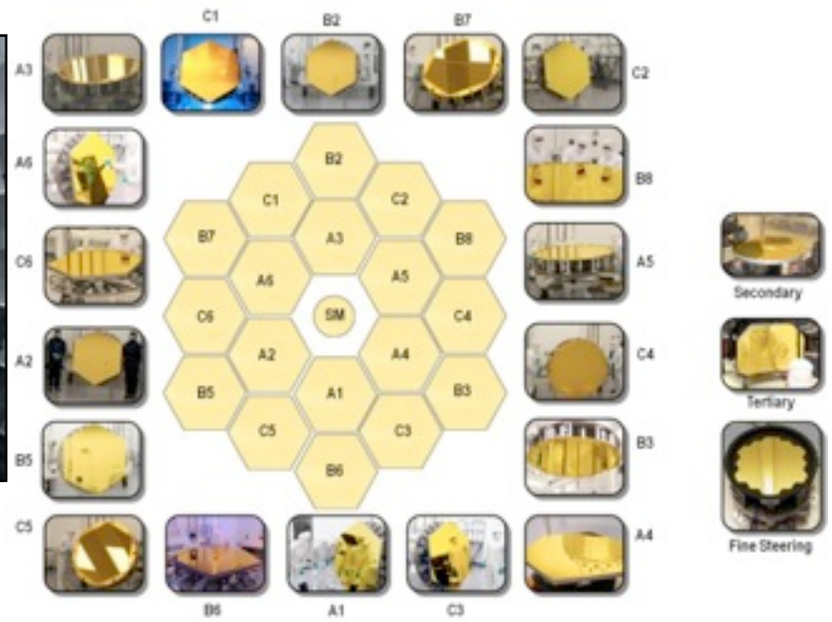
- What science areas/themes are we under-exploiting or ignoring in Hubbles next five years?
- How do we look beyond Hubble and JWST?

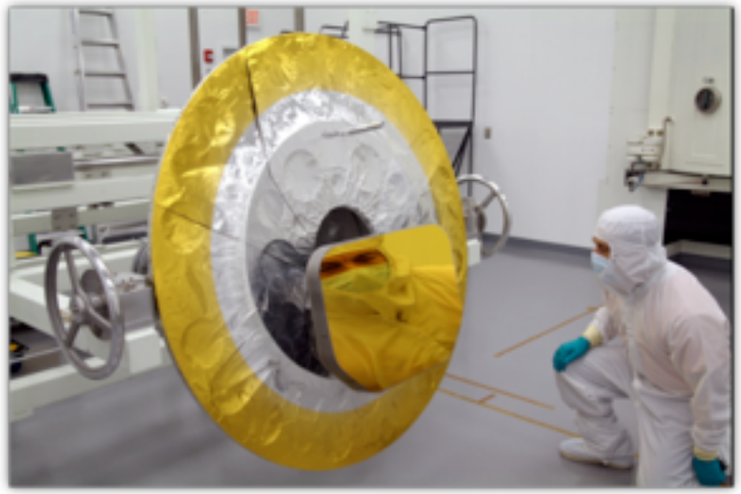
What astrophysics will be enabled through **future Optical/UV observations?**

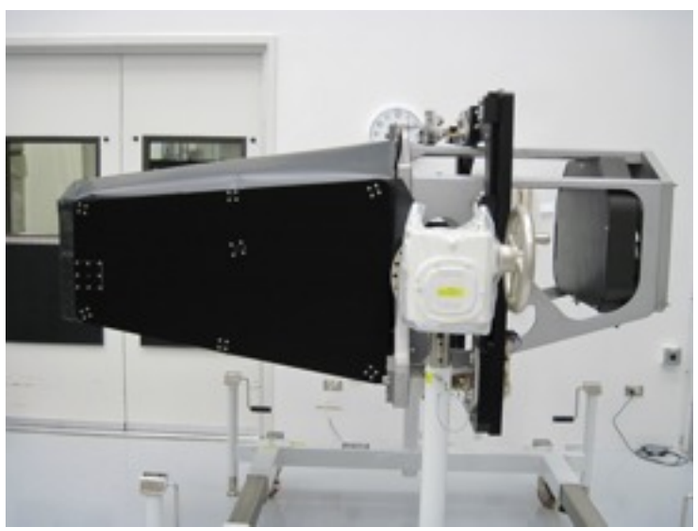
JWST

ALL JWST Flight optics complete

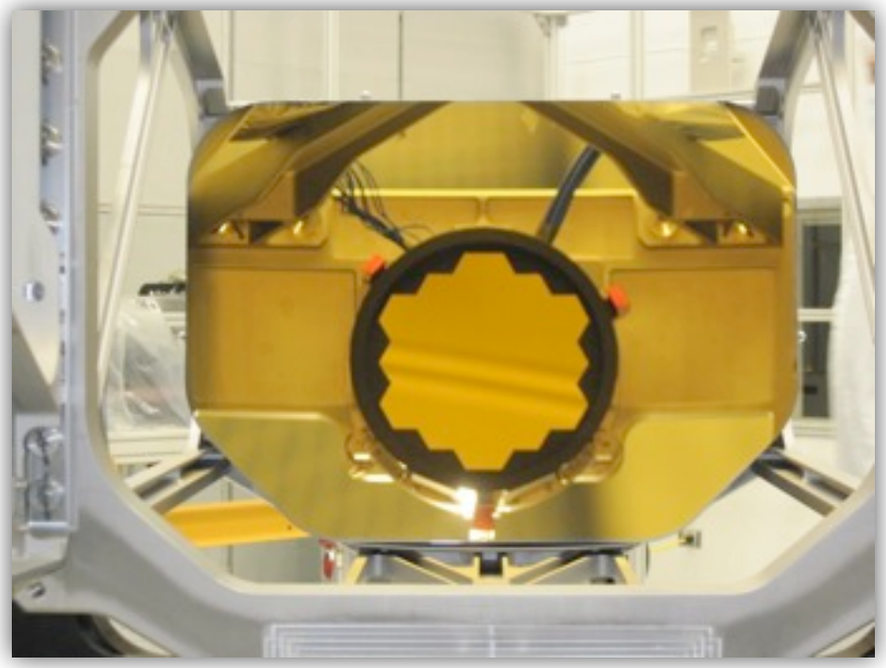




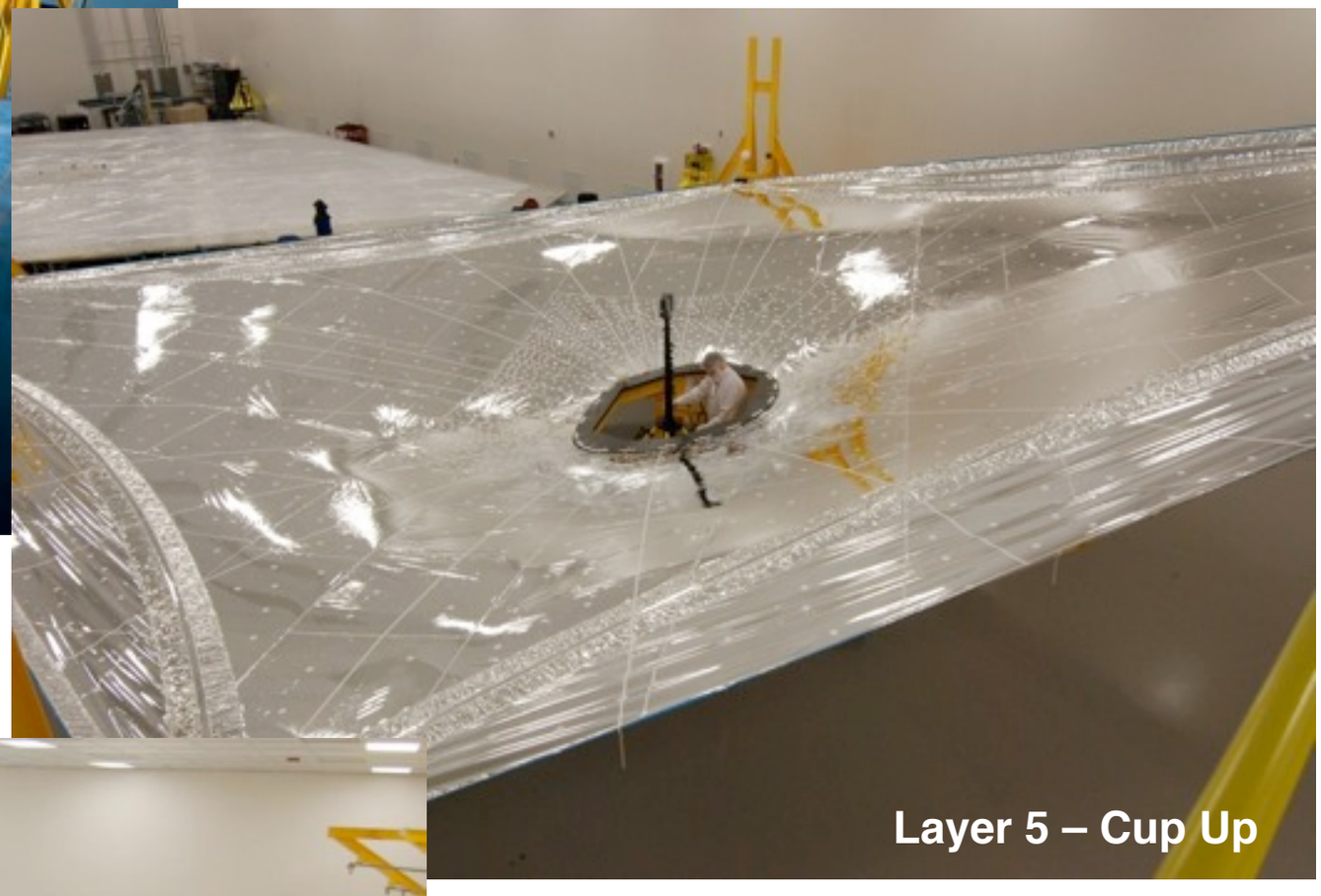


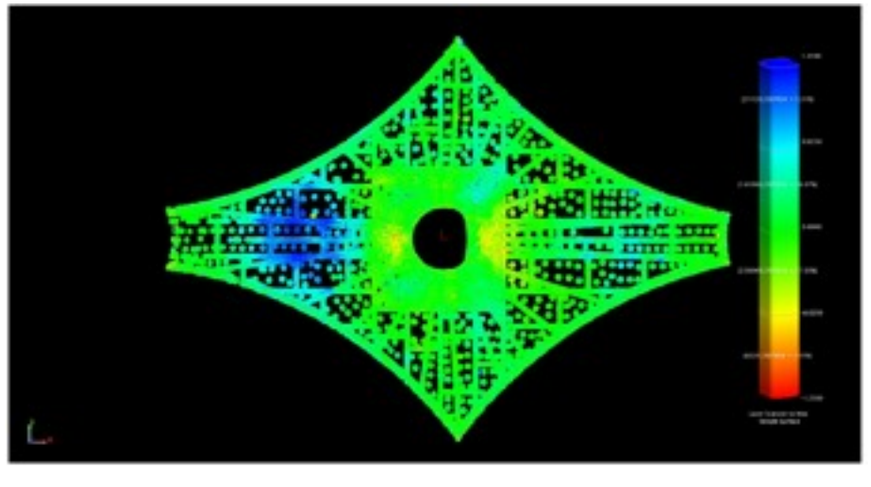


- **All mirror are Complete!**
  - **Polished, coated, vibed, cryo tested**
  - **Approximately 6 weeks ahead of schedule**
- **Aft Optics Assembly (AOS) integration complete**
- **Primary Mirror segments awaiting gear motor replace and repair**
- **Flight Cryo Electronics on track for incremental deliveries over the next year**

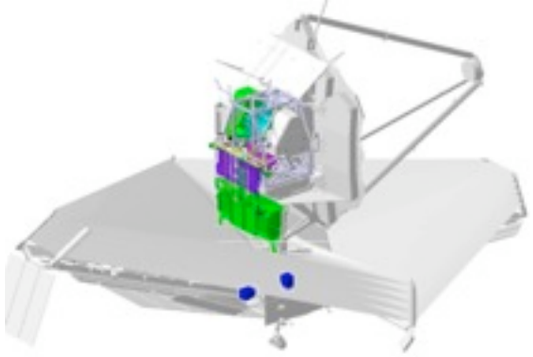


Sunshield Template Membranes



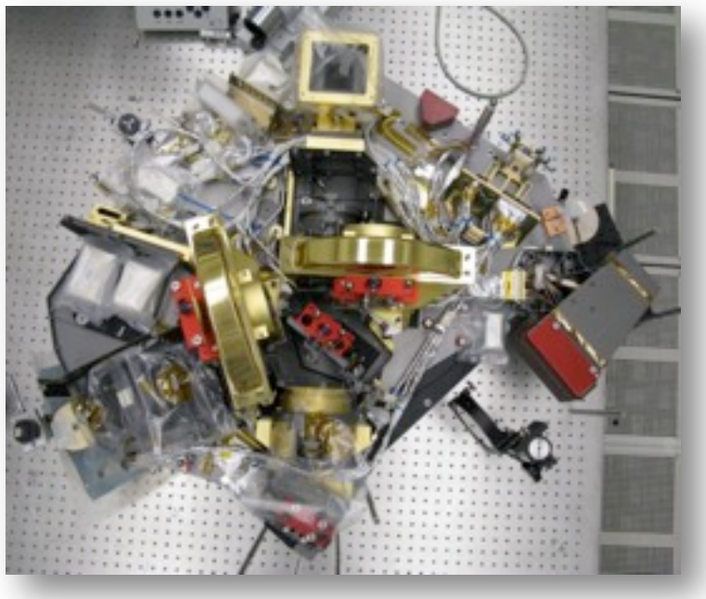


Instrument Systems

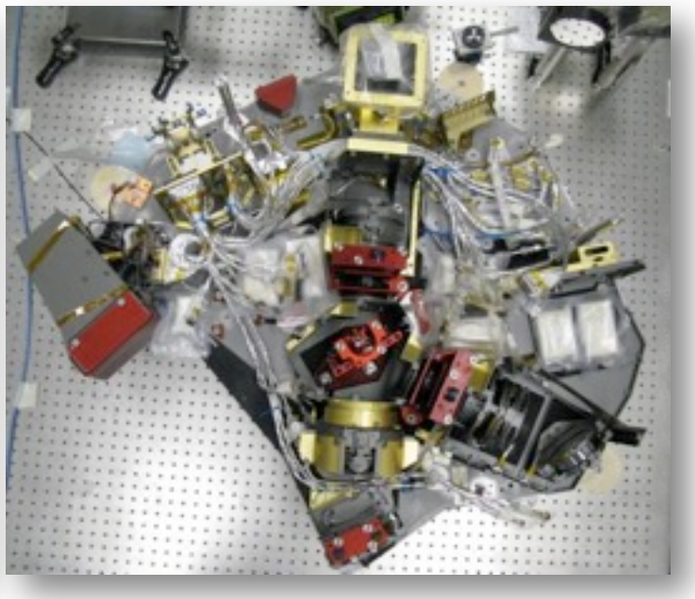


NIRCam

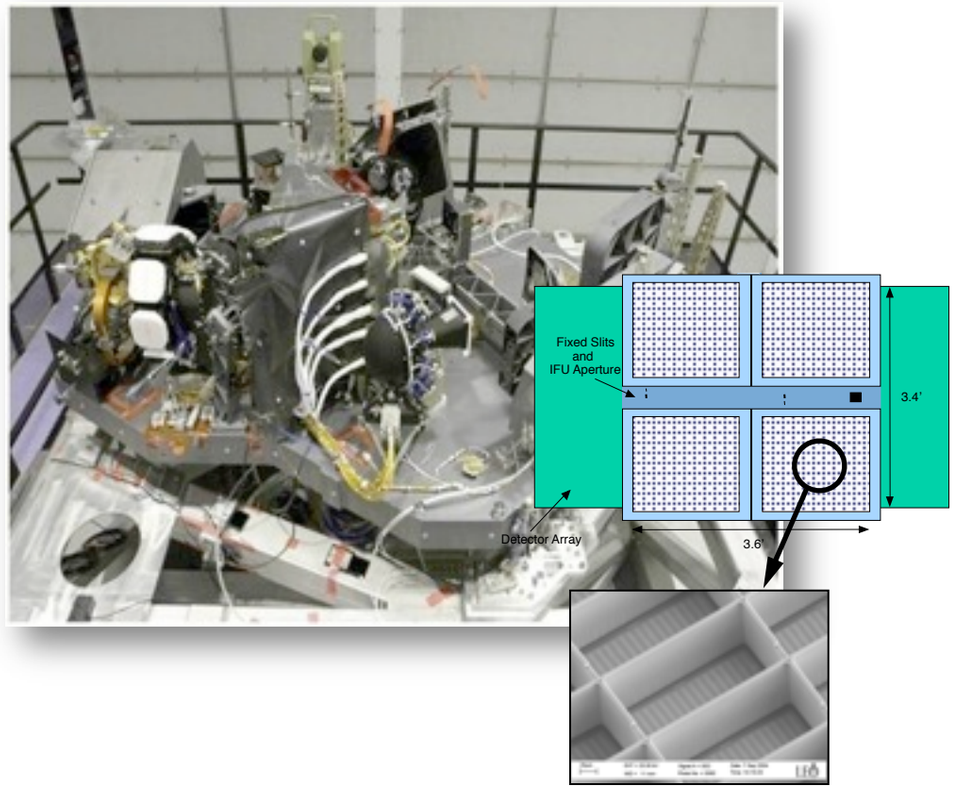
Module A

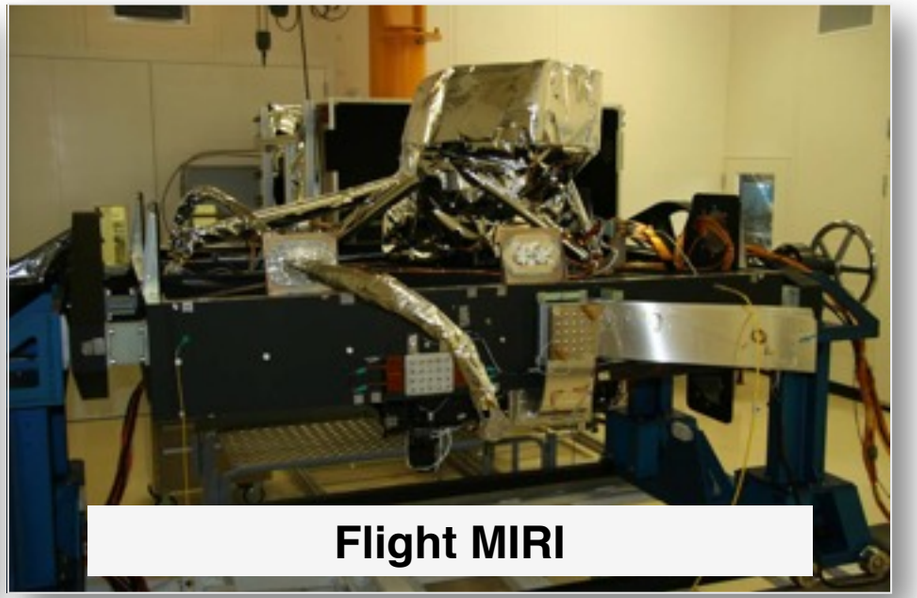


Module B

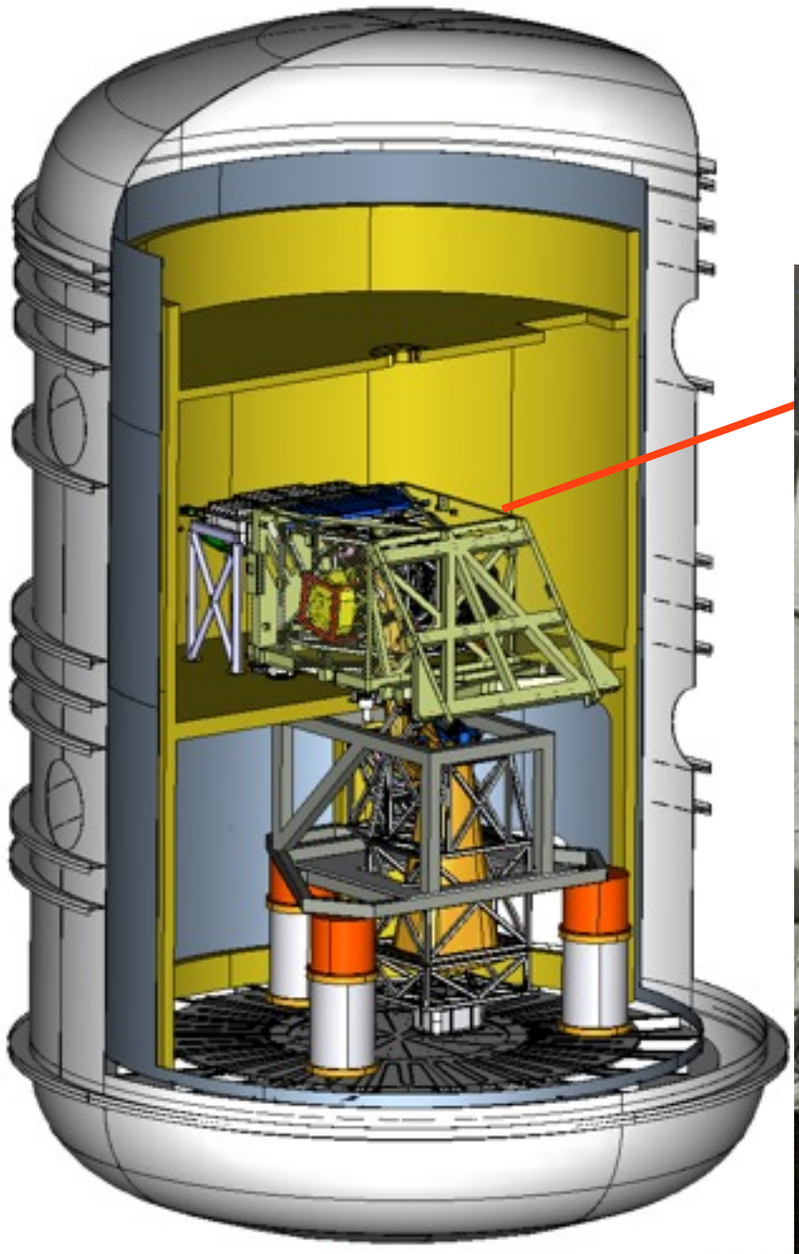


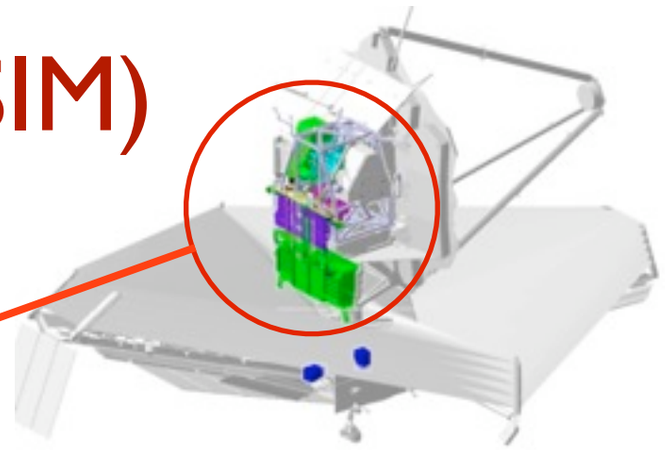
NIRSpec





Optical Telescope Element Simulator (OSIM)





FY13 President's Budget

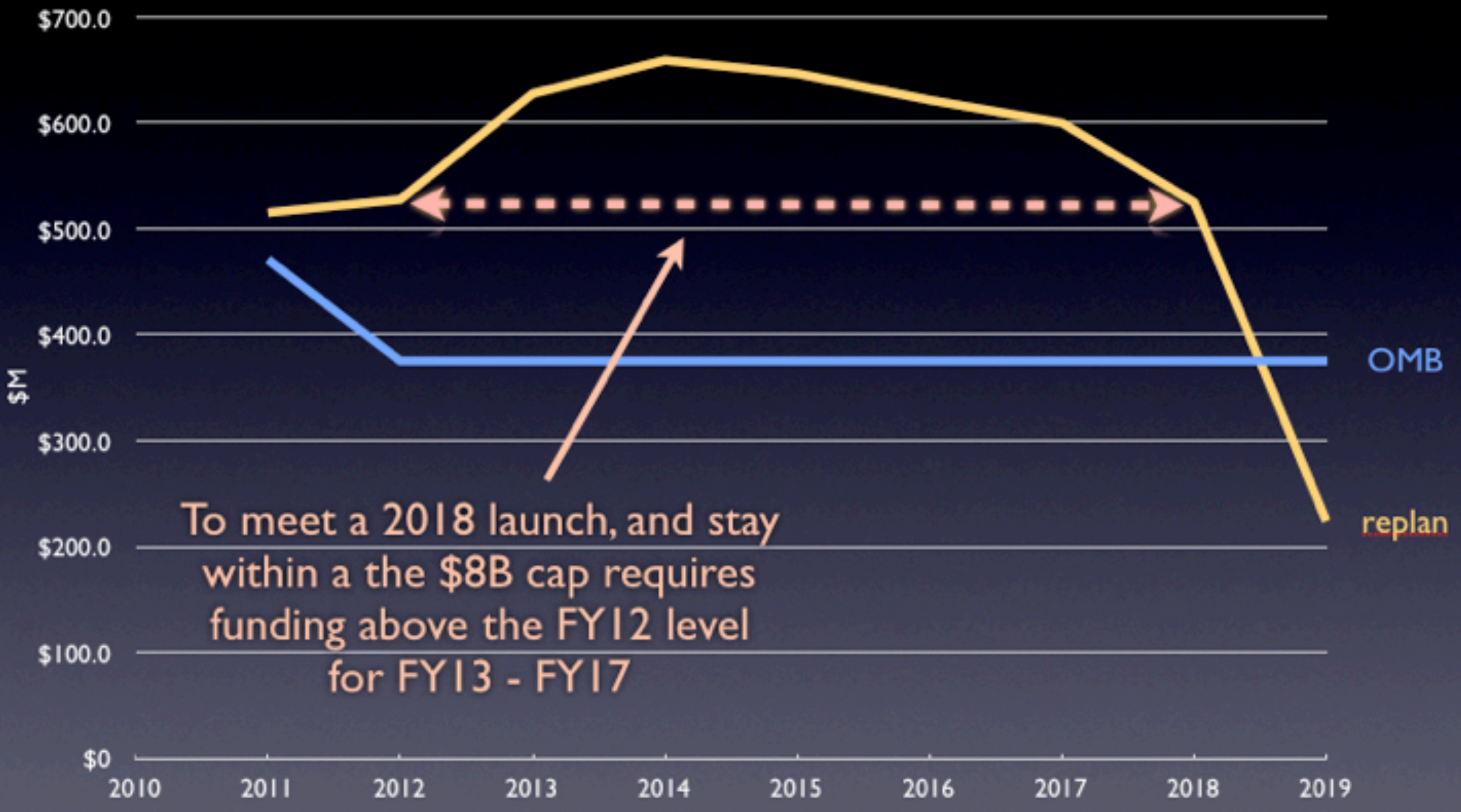
JWST Life-Cycle Cost
As in Breach Report (October 2011) *

Budget Authority ($millions)	Spent to Date	FY 2010 Actual	FY 2011 Enacted	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	Budget to Complete	LCC Total
Revised Profile	2,552.30	461.4	515.3	527.6	627.6	659.1	646.6	621.6	2,223.60	8,835
PBR** FY12			471	375	375	375	375	375	2,346.00	
Delta to PBR			44.3***	152.6	252.6	284.1	271.6	246.6	1,251.80	

+$100M

NASA committed to make JWST an Agency wide priority
JWST will contribute to the pressure on science ***BUT***
the biggest cut to NASA Science ***did not*** come from JWST

JWST: HQ response to enabling a 2018 LRD



Note: NGAS total $1.8B
NASA's internal cost models estimate $4.9B to launch
Contains ~ $1B of uncommitted reserves

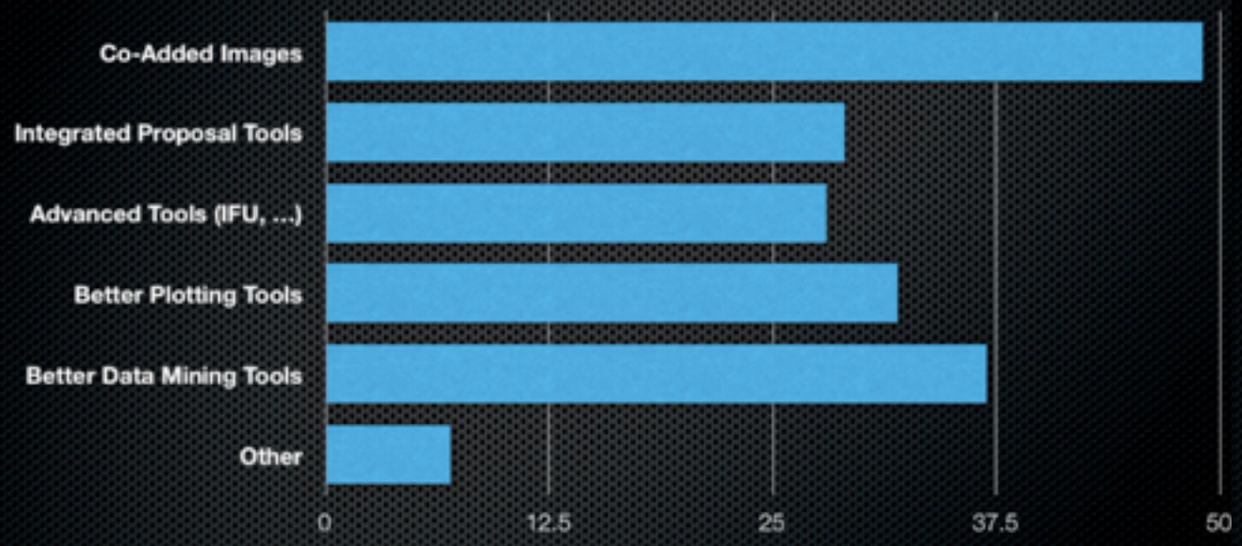
JWST FY12 Milestones

Note: Milestones assume the budget approved in APMC Decision Memo of 9/23/11,.

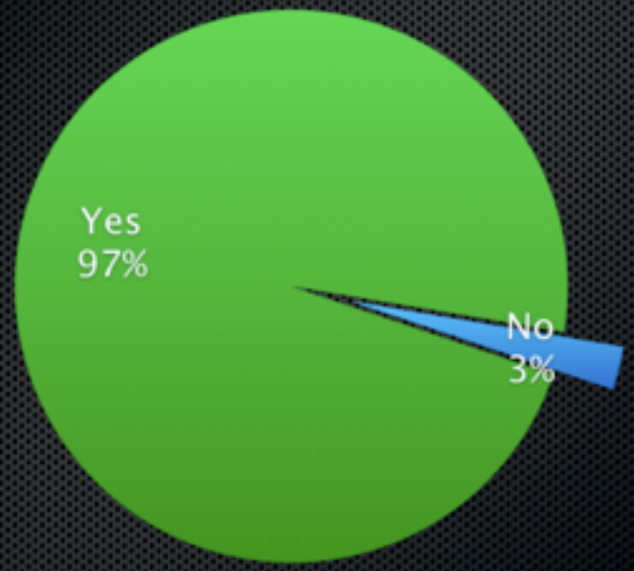
As of 3/31/12

Month	Milestone	Responsible	Comments
Oct '11	Initiate Delivery of Ambient Alignment Optical Stand (AOAS) to GSFC	ITT	Completed 10/4
Nov '11	ISIM Electronics Simulator Engineering Model Test Bed Complete Software Development & Verification Simulator Delivery to Software Development Lab	ISIM NGAS	Completed 11/15 Completed 10/27
Dec '11	JSC Helium (GHe) floor shroud installed ESA NIRSpec preliminary root cause and corrective action assessment	JSC ESA	Completed 10/26 Completed 12/15
Jan '12	Spacecraft-Optical Telescope Element (OTE) Vibration Isolation IDR 3/4 (CDR) Center of Curvature Optical Assembly (COCOA) Assembly complete S/C equipment panel Mechanical Ground Support Equipment (MGSE) Preliminary Req Review Complete Aft Optic System Integration & alignment Update Program Plan and Program Commitment Agreement to reflect replan	NGAS ITT/GSFC NGAS NGAS/Ball HQ	Completed 12/15 Completed 1/13 Completed 12/1 Completed 12/22 Completed 1/28
Feb '12	Complete assembly & verification testing (MSFC testing) of Primary Mirror Segment Assemblies (PMSAs) JSC GHe wall shrouds installed	NGAS/Ball JSC	Completed 12/19 Completed 12/29, all other panels installed 2/2
Mar '12	Complete System Engineering Team thermal margin assessment Optical Ground Support Equipment (OGSE) -1 Test Concept assessment complete	GSFC GSFC	Completed 3/19 Completed 3/1
Apr '12	ICDH Flt #2 delivered to ISIM I&T Flight MIRI delivery Sunshield Support Structure IDR 3/4 (CDR) Deployable Tower Assembly (DTA) Composite flight components fabrication complete	ISIM ESA NGAS NGAS/ATK	SDRAM part failure in T/V. Part replaced, delivery in early May Delayed to May - no impact Completed 3/21 Completed 2/28
May '12	Complete COCOA assessment at ITT Complete Sunshield template layer 5 shape verification Conduct review of initial implementation of replan	ITT/GSFC NGAS/Nexolve HQ/SRB	Completed 3/9
Jun '12	JSC Chamber mods complete Communications support structure IDR 3/4 (CDR) complete Hardpoint Offloader Support System (HOSS) & Upper Suspension Frame Design Audit Complete Sunshield deployment MGSE PDR	JSC NGAS ITT/GSFC NGAS	
Jul '12	Program Office agreement on FY13 spending plan Flight FGS delivered ISIM Flt S/W Integrated Construction 12.6("Build" 12.6) to ISIM I&T Solar array Preliminary Design Audit Cryo Cooler Cold Head Assembly delivered to ISIM I&T Complete flight Secondary Mirror Support Structure End Fitting Fabrication	HQ/GSFC CSA ISIM NGAS NGAS/JPL NGAS/ATK	Flight CHA to be delivered in June 2013. No impact, work around in place.
Aug '12	Order remaining Chamber A isolators from Minus K	ITT/GSFC	
Sept '12	Flight NIRCam Delivered OTE Simulator delivered to ISIM I&T Start Photogrammatry (PG) canister cryo test Complete Primary Mirror Backplane Support Structure center section Flight NIRSpec delivered	UoA/LMATC ISIM ITT/GSFC NGAS/ATK ESA	Delivery date moved to 4/13. No impact to, work around in place.

Q1. What kind of data reduction tools would you like to see for JWST that are not available today for Great Observatories such as Hubble, Spitzer, and Chandra?



Q2. Would you be comfortable if all of JWST's documentation is distributed ONLY electronically?



Q3. How important is it for you to be able to access JWST documentation on a mobile device (e.g., iPad, Tablet, iPhone)

Q4. How important is it for JWST's pipeline to release Level 4 data products (e.g., photometry catalogs, star galaxy separation)?

AAS User Survey

Summary of feedback

By 2018 users will expect:

- Full on-line access through a variety of devices
- Pre-processed data and data-mining tools tailored to JWST (particularly important for 3-D data cubes)
- High-level data products such as catalogues

- The community expects to be able to "hit the ground running"
- They will expect to be able to build on lessons learned from HST, Chandra, Spitzer etc