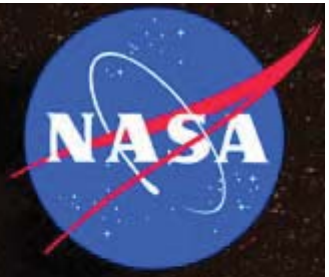
From Bonaventure to Goddard: How I got to NASA and what I am doing there



Kevin H. Miller
NASA Goddard Space Flight Center
November 3rd, 2014

Saint Bonaventure University & Dresser-Rand Challenger Center

Outline

I. Hubble Space Telescope

II. James Webb Space Telescope

III. OSIRIS-REx Asteroid Sample Return Mis

Fast Facts about Hubble

- Launched in 1990
- 354 mi above earth; 97 min per orbit
- Five total servicing missions (SM1, SM2, SM3A, SM3B, SM4)
- Primary mirror—spherical aberrations—necessitated COSTAR
- Key achievements of Hubble (e.g. Hubble constant)
- Future plans for Hubble

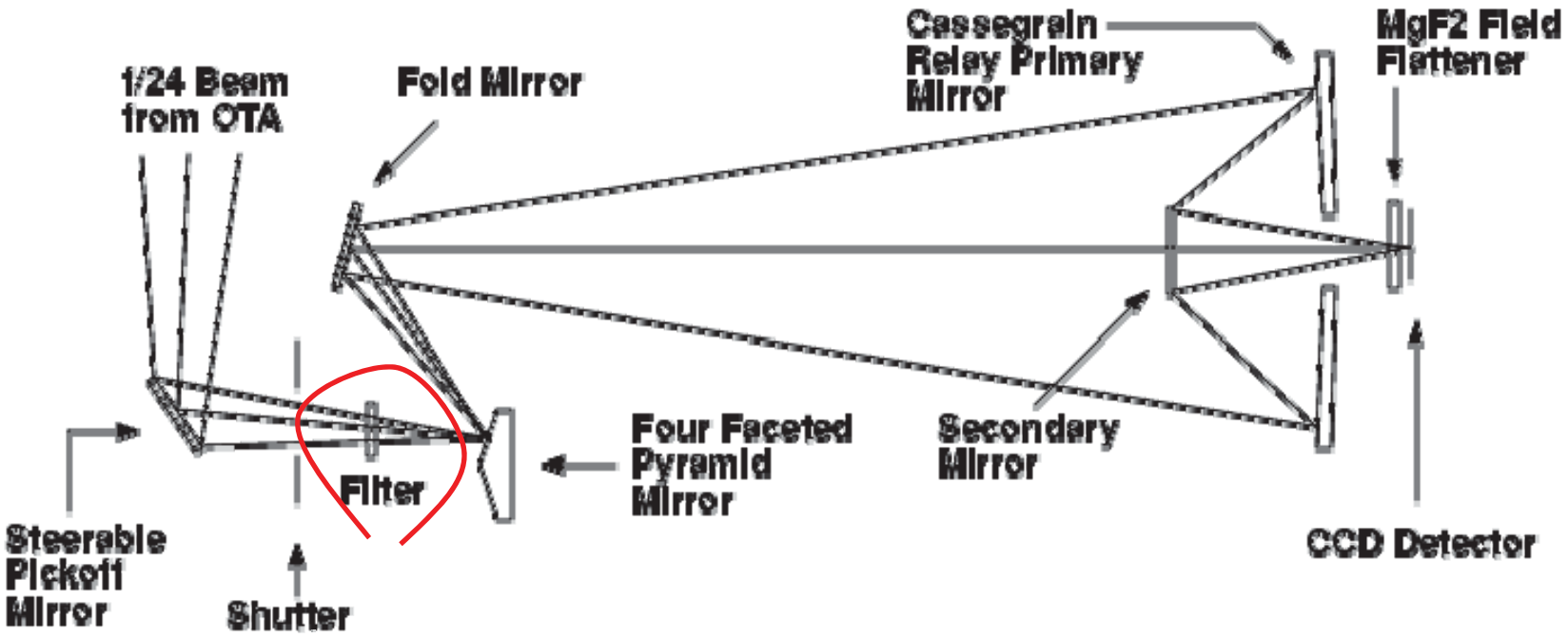
SM4, Atlantis crew (2009)

WFPC2 History

- Built at JPL as backup of WF/PC-1
- Replaced WF/PC-1 during HST first servicing mission December 1993
- 48 different filters
- Contains 4 cameras for imaging: WF2, WF3, WF4, PC
- Recorded 186,481 images
- In orbit through May 2009
- Greatly Reliable despite higher than expected amount of scattered light around bright objects & lower than expected UV efficiency

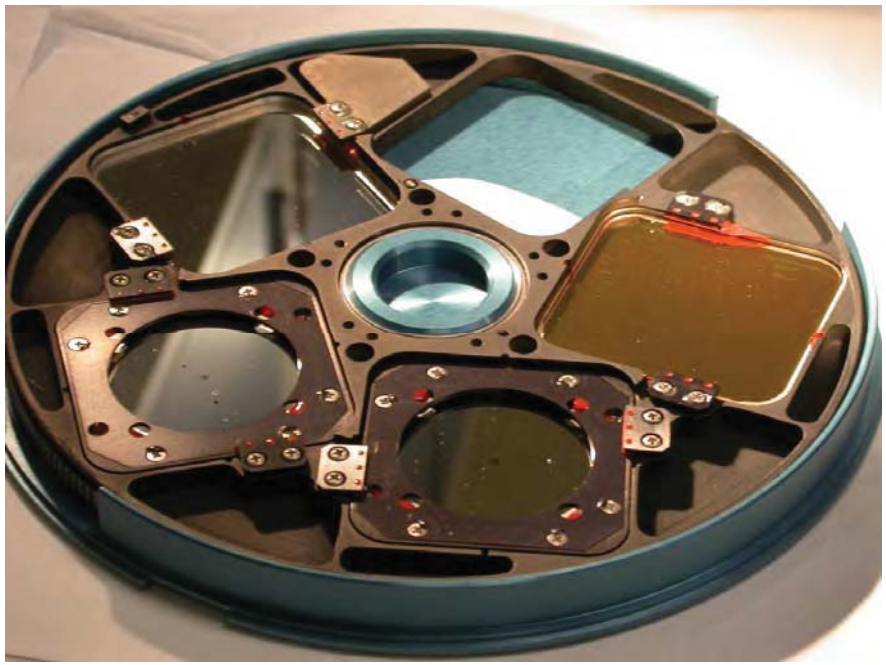
Figure 4. Astronauts removing WFPC2

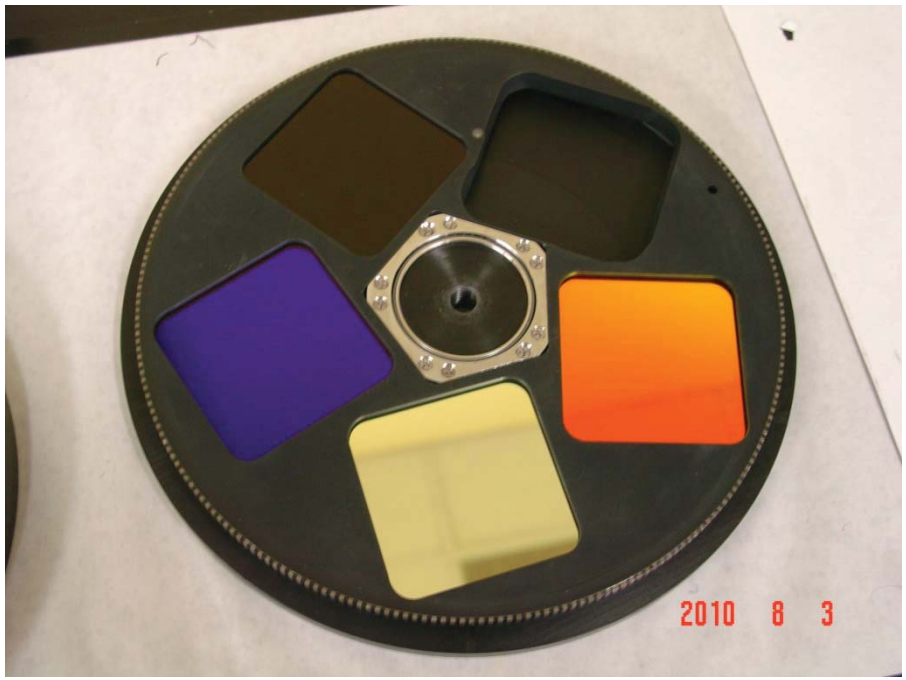
WFPC2 Optical Configuration



Optical Configuration of WFPC2

Filter Wheel Provided



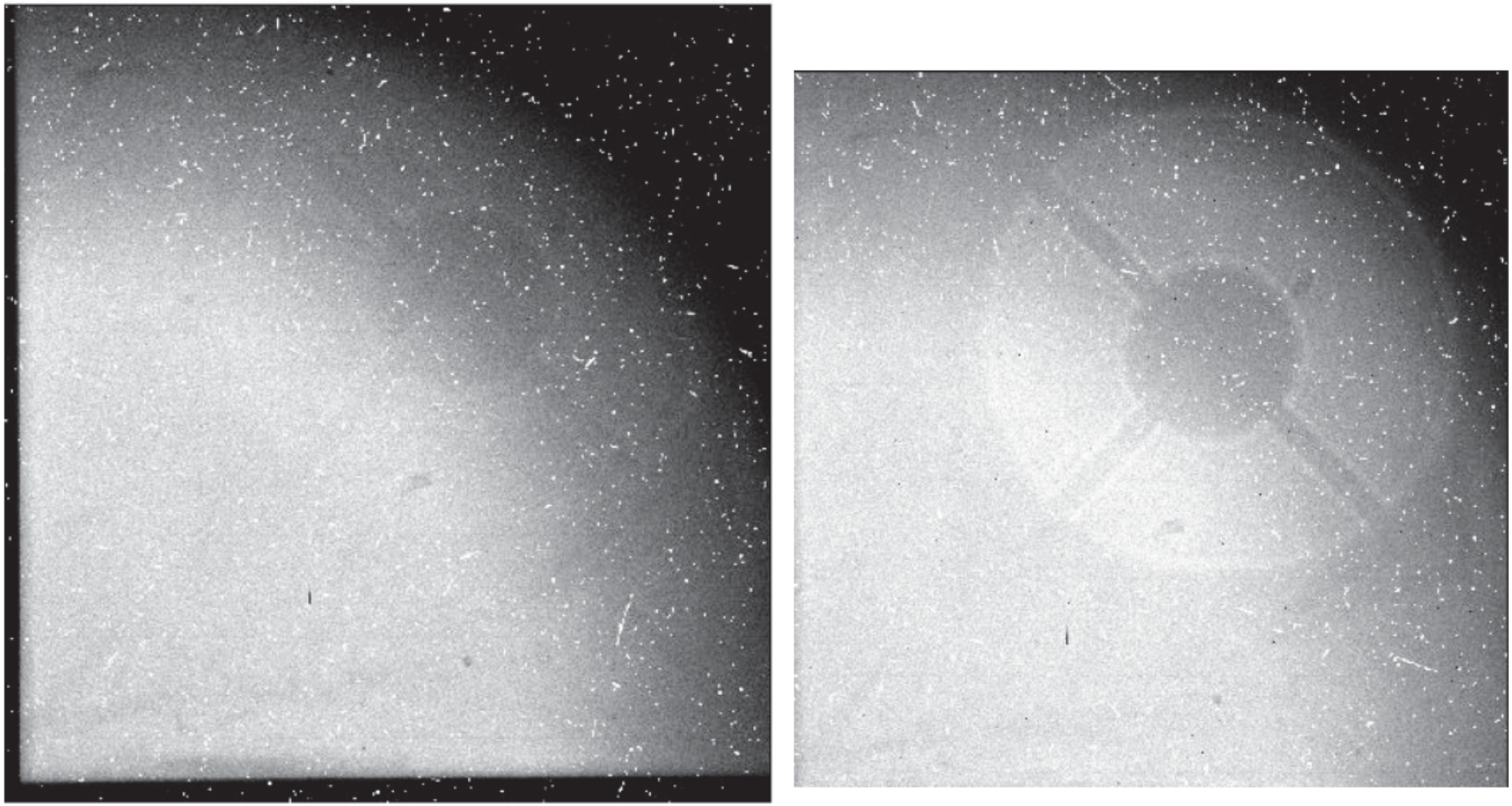


Filter wheel in provided housing (left) & filter wheel in housing with placer to prevent rotation when measuring(right).

Why Measure WFPC2 Filters?

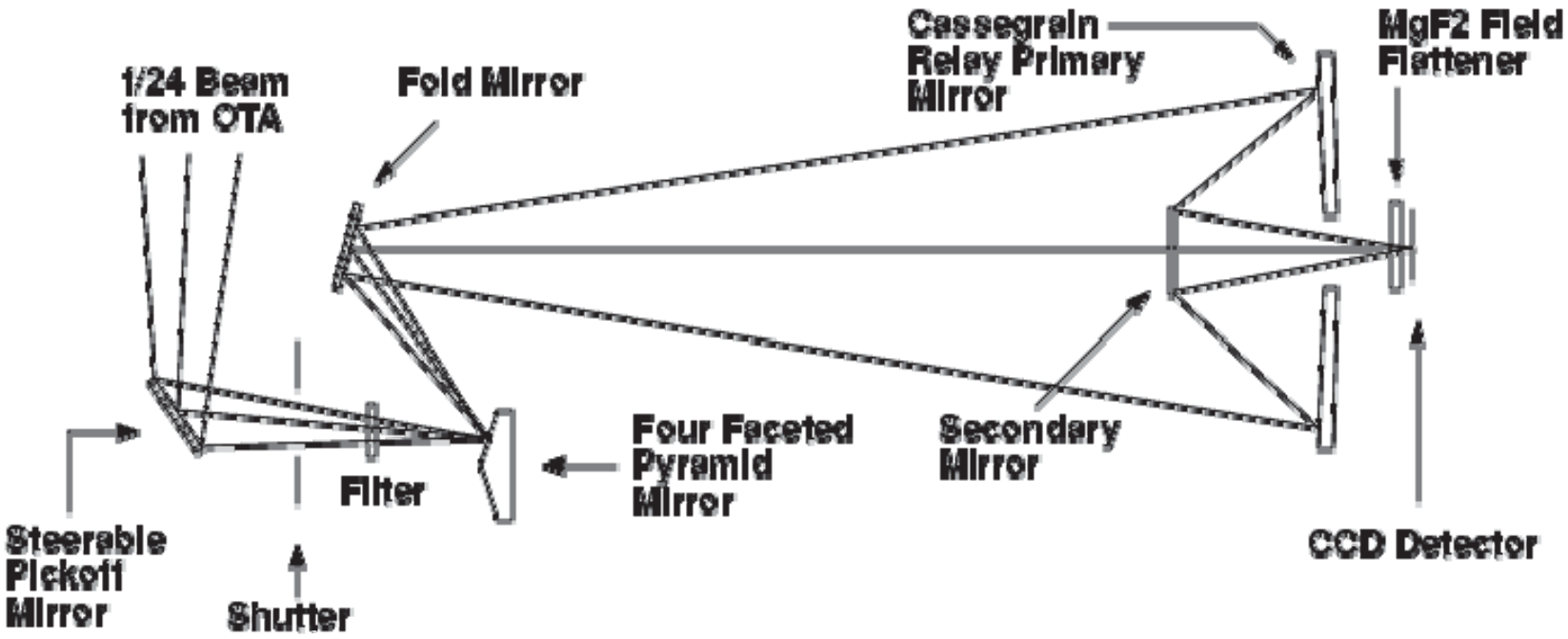
- Improve calibration of data from WFPC2
- Examine the stability of the filters through time in orbit (launch, radiation, temperature, outgassing)
- Engineering new equipment that is unscathed by launch and re-entry

F160BW



WF2 CCD UVFLAT illuminated with deuterium lamp within calibration module using F160BW 1994(left) 2008(right).

WFPC2 Optical Configuration

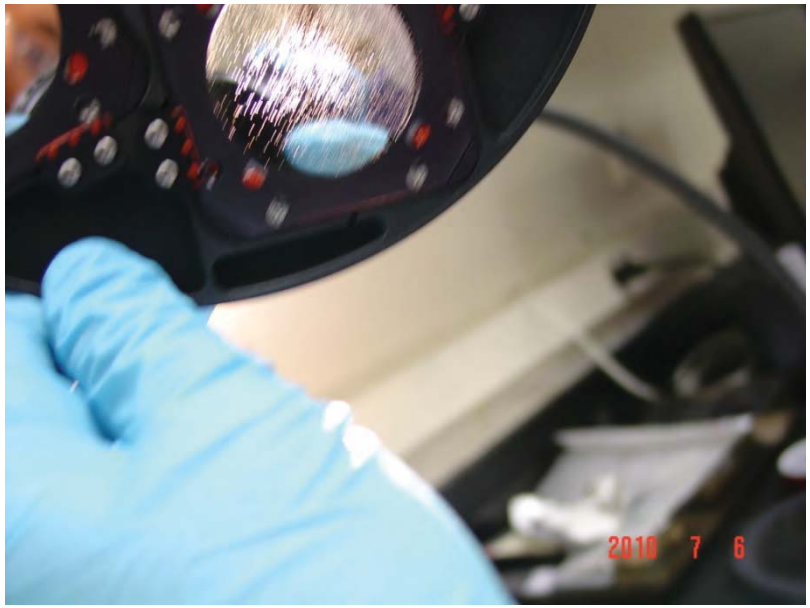


Optical Configuration of WFPC2

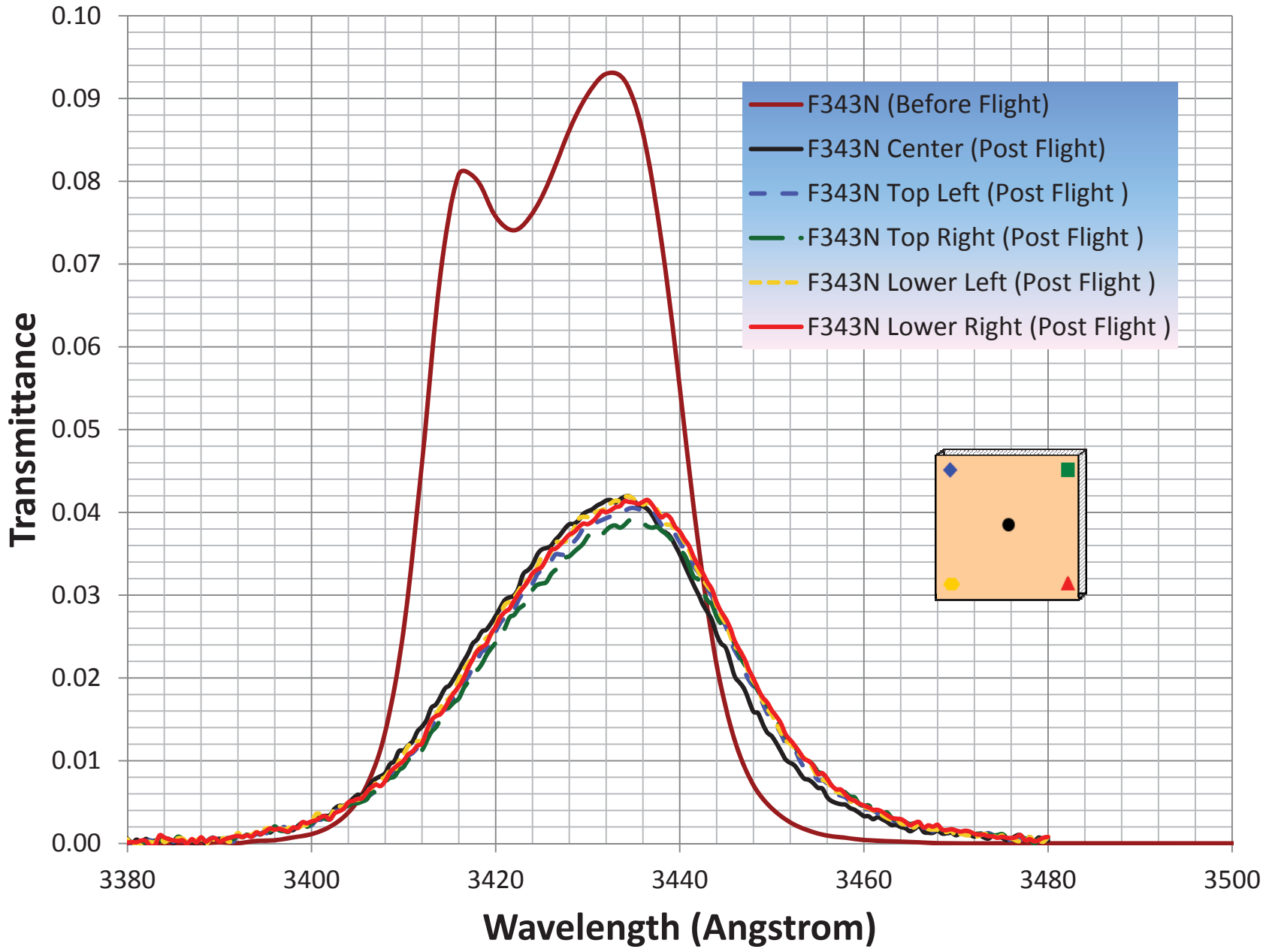
F160BW

- F160 AW was not used in flight due to pinholes
- F160BW now worse than F160AW
- No detectable red leaks of F160BW as of May 2009 (on-orbit)
- F160BW may have worsened during re-entry
- Pin-hole effects may be different in lab than In-flight (lab from pinholes more spread than F/24 OTA and be poorly imaged on CCD (not sharply imaged)

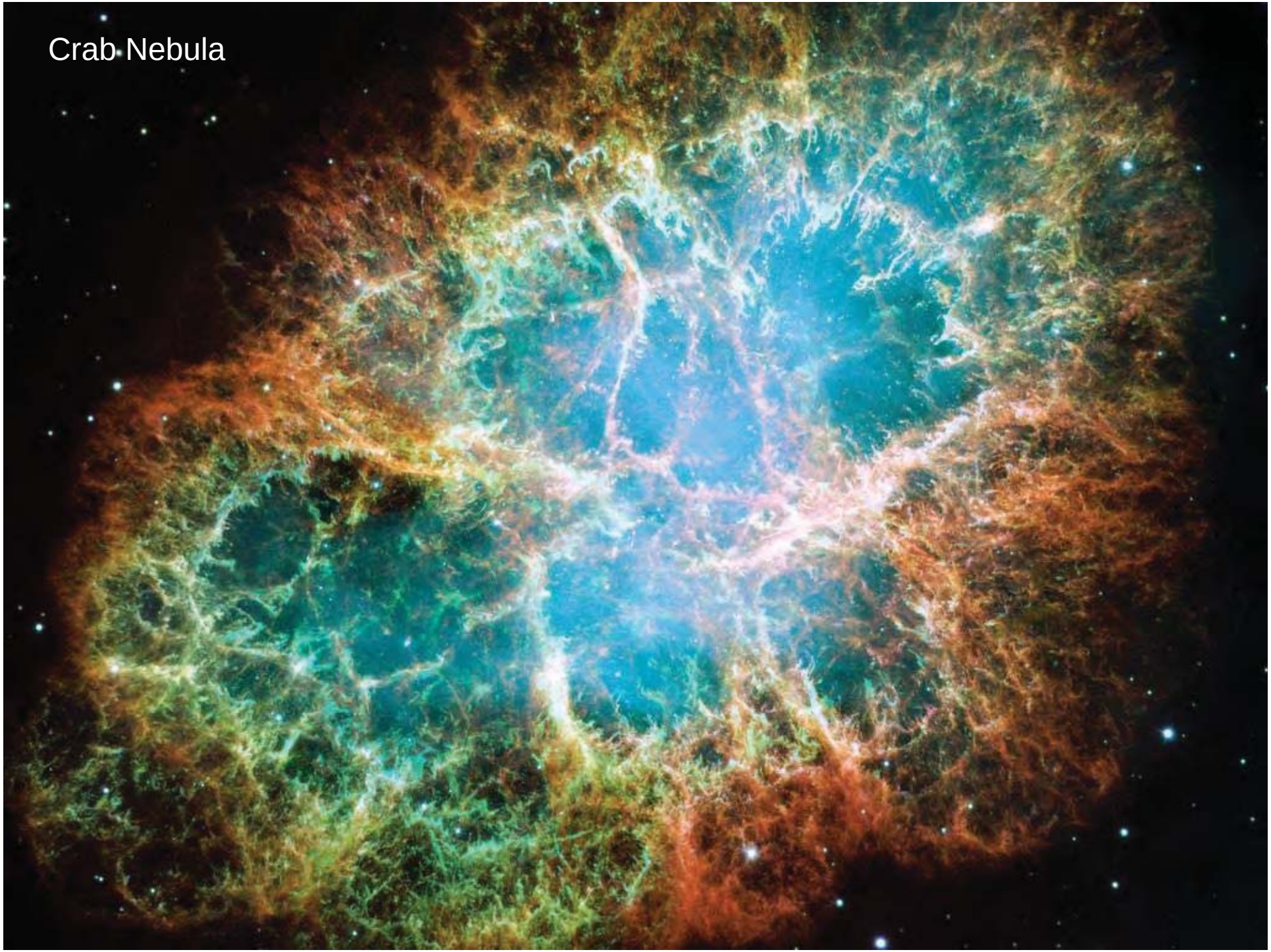
Figure 13. F160BW filter. The pinholes are clearly visible.

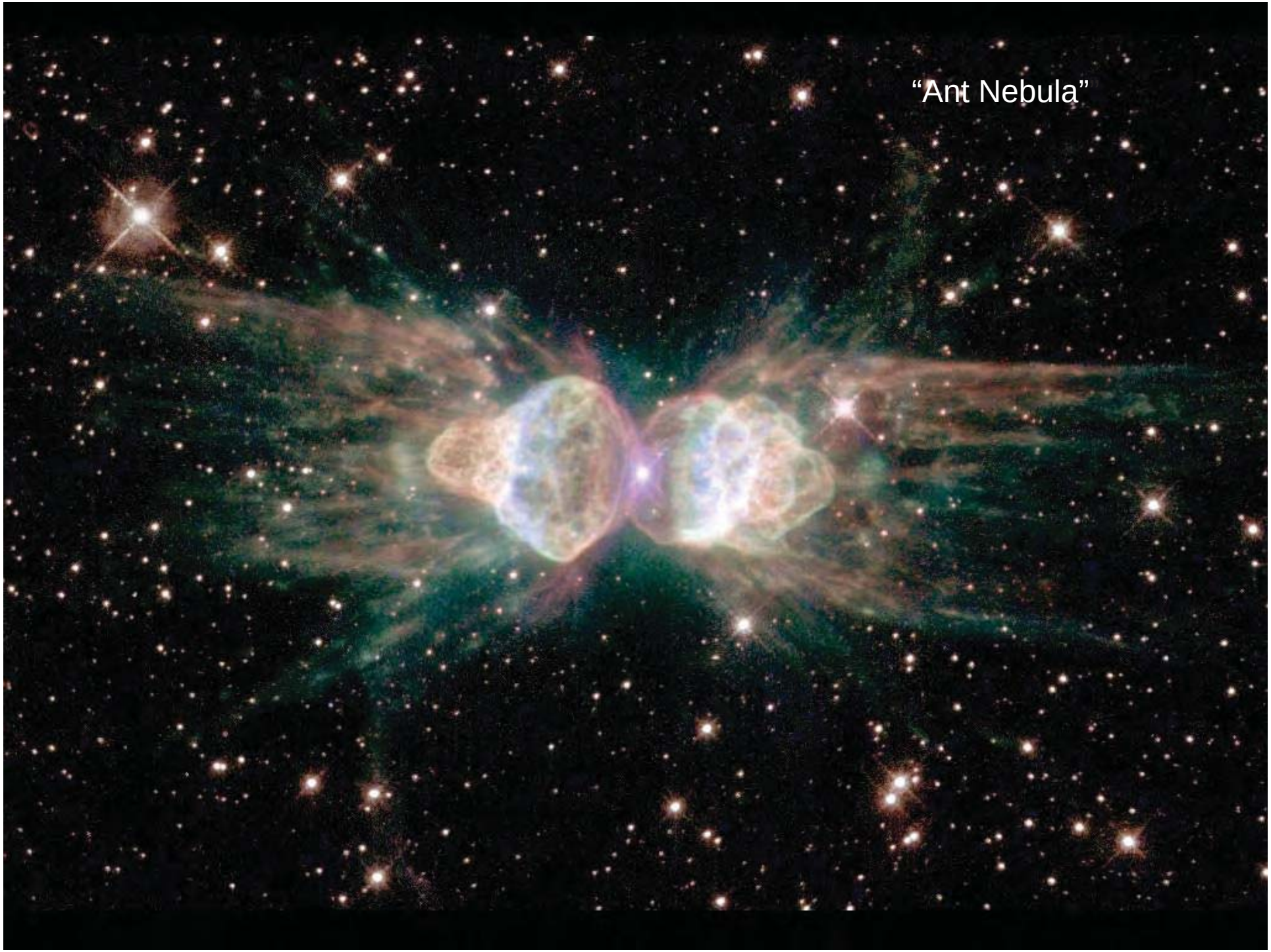


F343N


0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Transmittance
3380
3400
3420
3440
3460
3480
3500
Wavelength (Angstrom)
F343N (Before Flight)
F343N Center (Post Flight)
F343N Top Left (Post Flight)
F343N Top Right (Post Flight)
F343N Lower Left (Post Flight)
F343N Lower Right (Post Flight)


Eagle Nebula


Crab Nebula

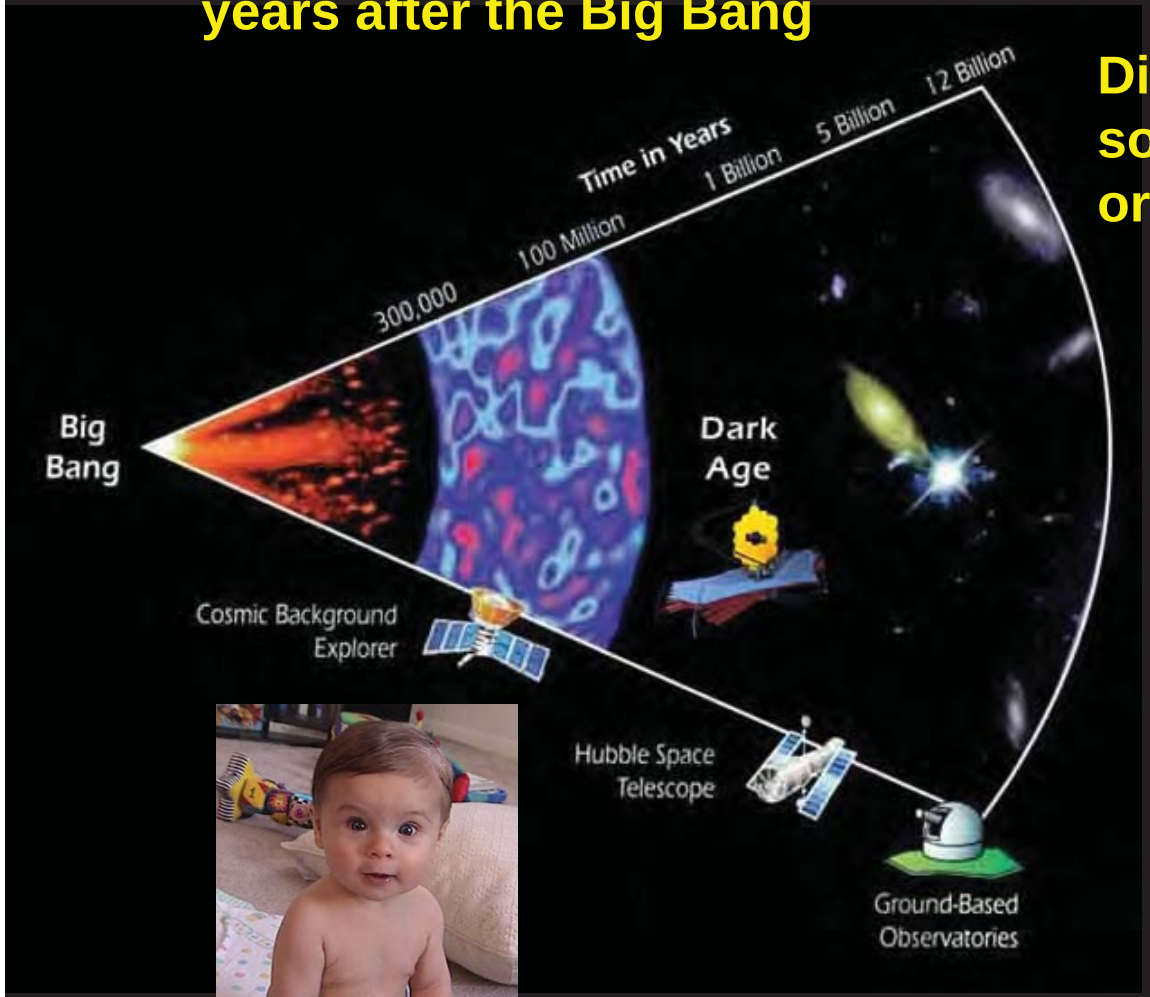

“Ant Nebula”


Whirlpool Galaxy

James Webb Space Telescope (JWST)

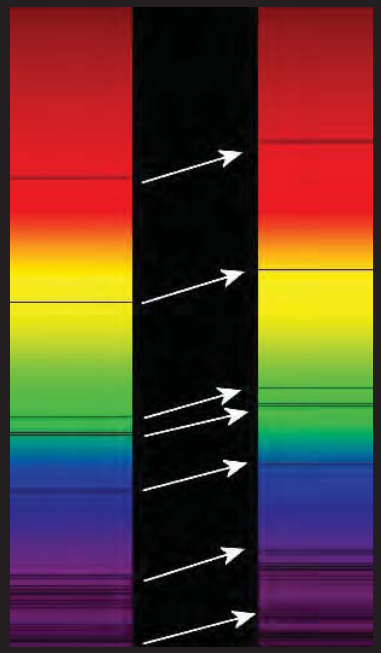
- JWST is the “follow-on” mission to the Hubble Space Telescope (HST)
  - Wavelength overlap with HST but coverage is not the same.
- First space telescope to be “built” on-orbit – too large to be launched already assembled.
- Mission concept formulated in 1995, 2018 launch date.

Primary Science Goal for JWST is to observe the Universe when it first began to emit light, approximately 200 Million years after the Big Bang



Distant astronomical sources have redshifts (*z*) of 10 or more

$\lambda_{motion} = \lambda_{rest} + z\,\lambda_{rest}$

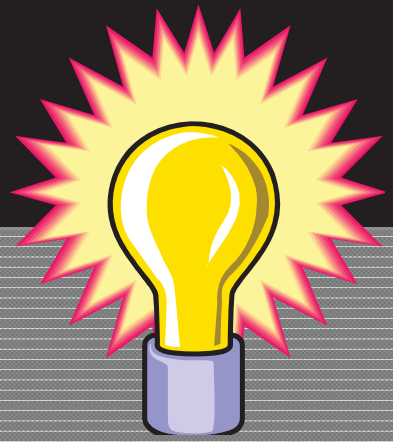


Rest Frame

Relative Motion Frame

Due to the Doppler shift of the emitted light, looking back that far in time requires the ability to make infrared observations

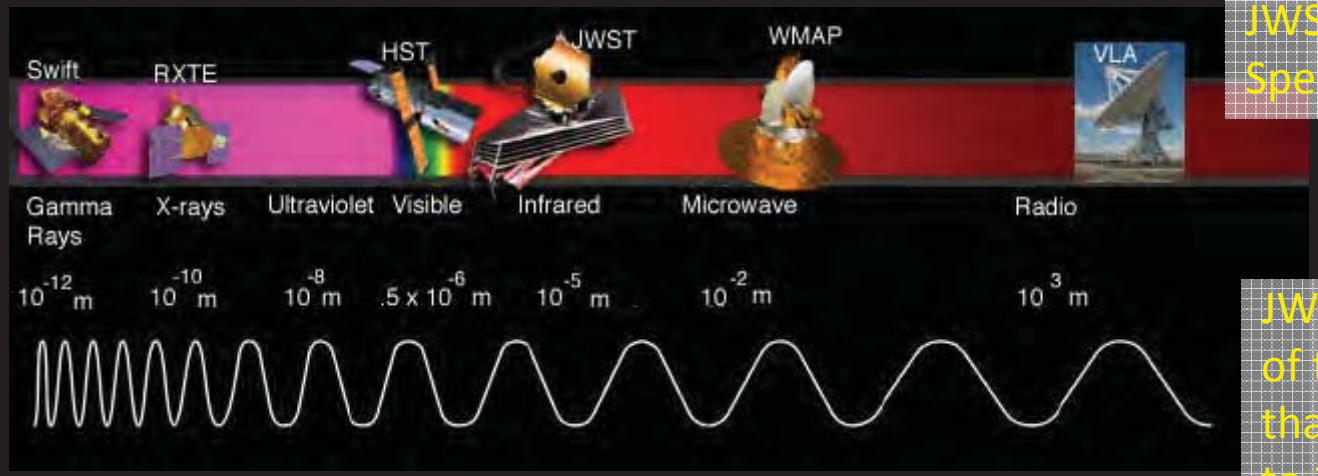
V = 224844 km/s



In the infrared, the hotter an object is → the brighter it appears

410 434 486 656 Infrared →

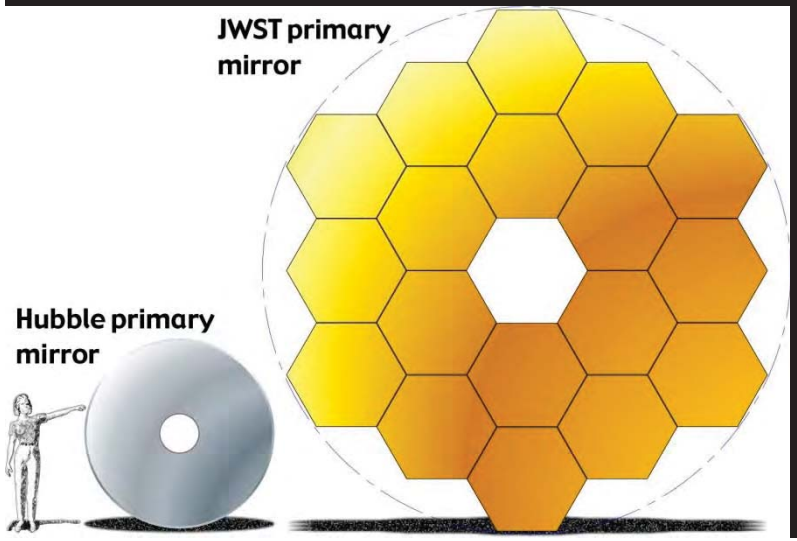
Wavelength (nm)

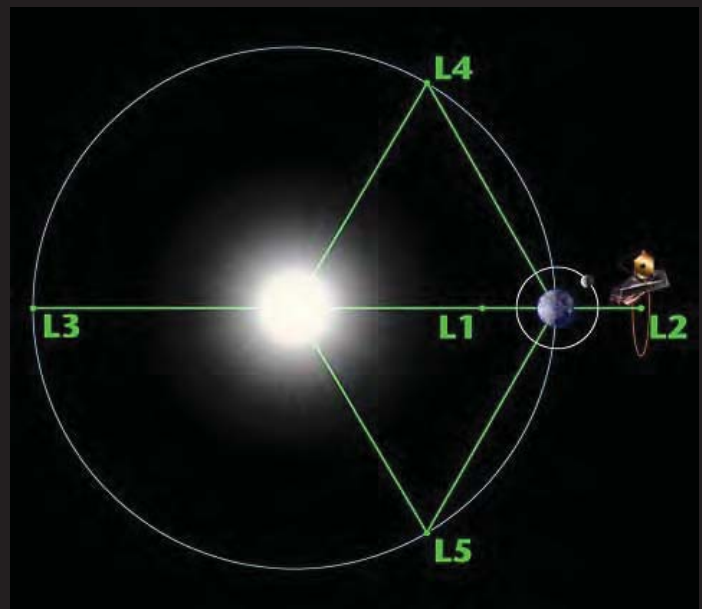


JWST covers the EM Spectrum from 0.6 to 25 μm

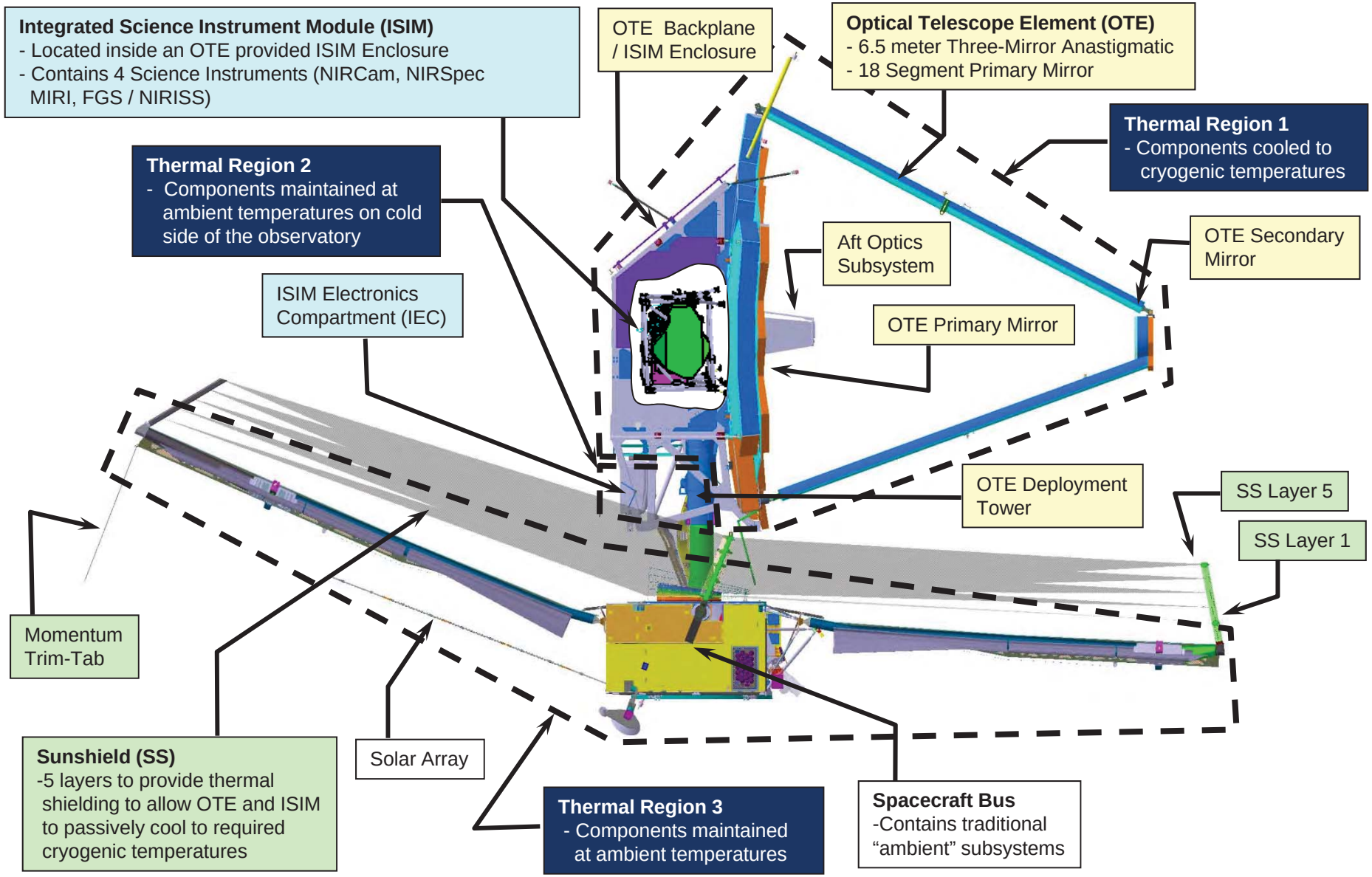
JWST orbits about the L2 point of the Earth-Sun System so that it can be passively cooled to 30-40 K

6.5 m segmented primary versus 2.4 m primary for HST ~7X HST's collecting area → increased sensitivity, higher spatial resolution



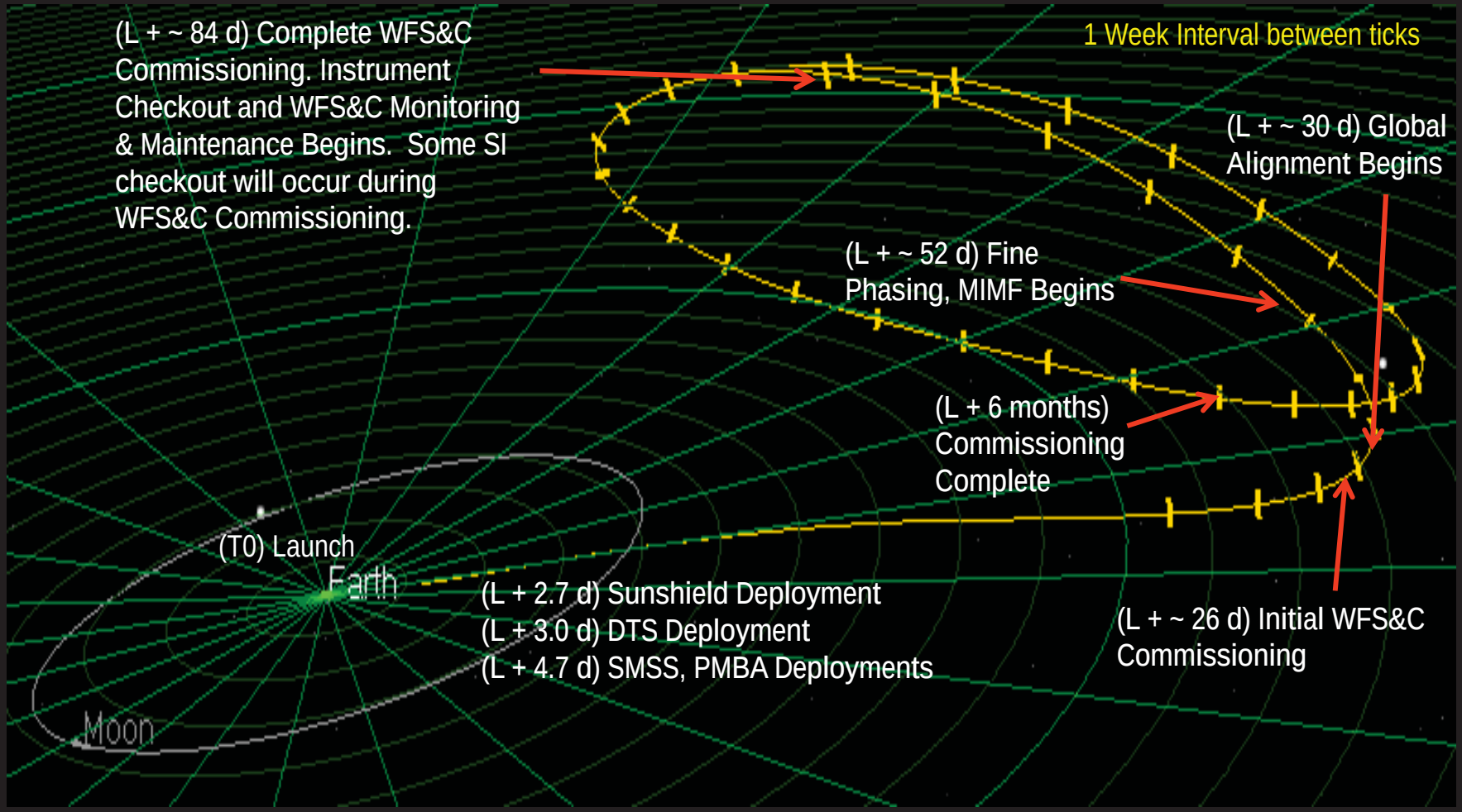


The JWST Observatory Elements and Regions



JWST – NASA's Transformer

JWST is Built (deployed) En Route



It takes a village…

Pre-Configuration

Configuration 1

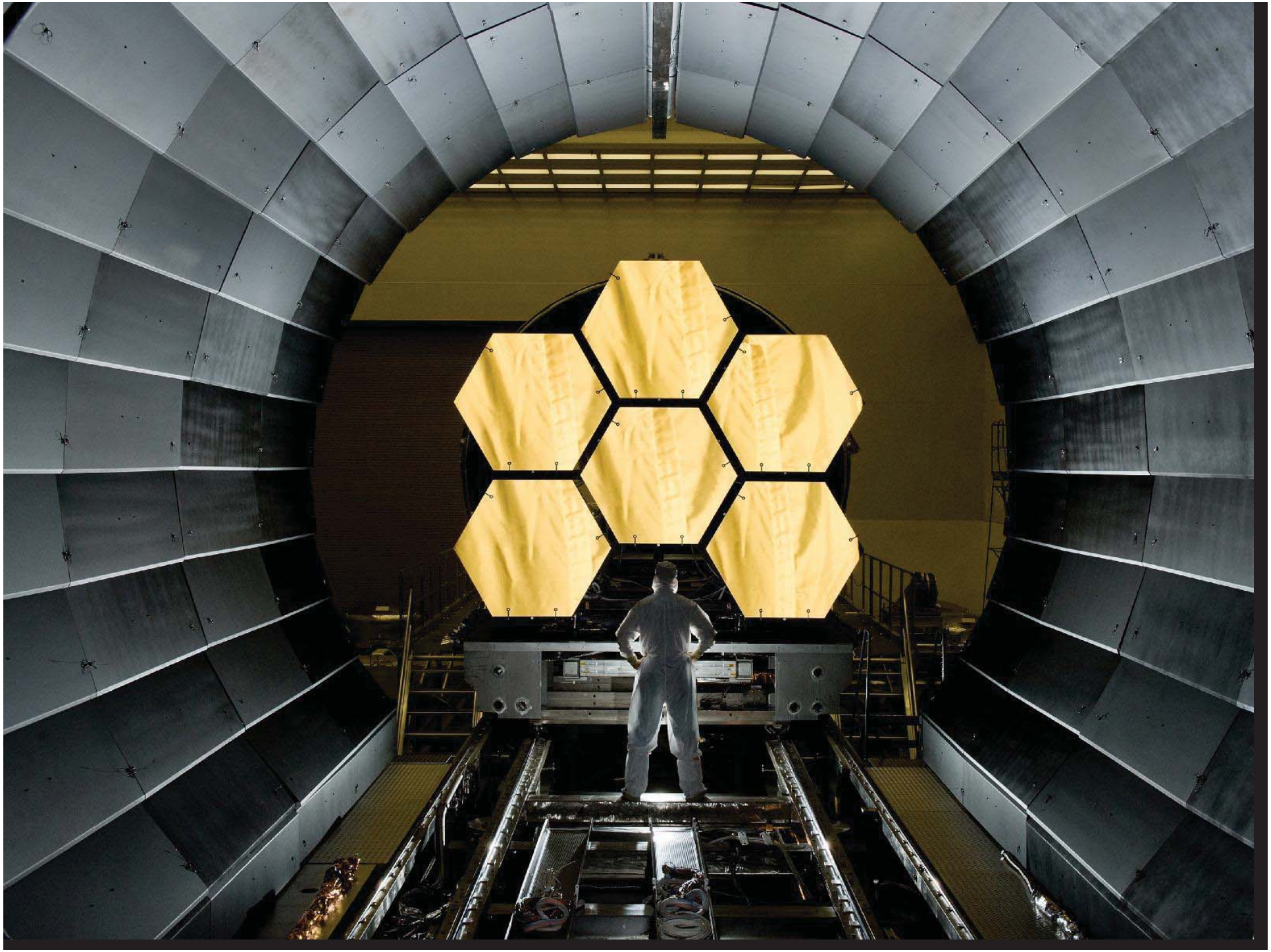
Configuration 2

Configuration 3

Configuration 1

Configuration 2

Configuration 3



Stay Tuned...

Follow OSIRIS-REx on Twitter

@OSIRISRex

Friend OSIRIS-REx on Facebook

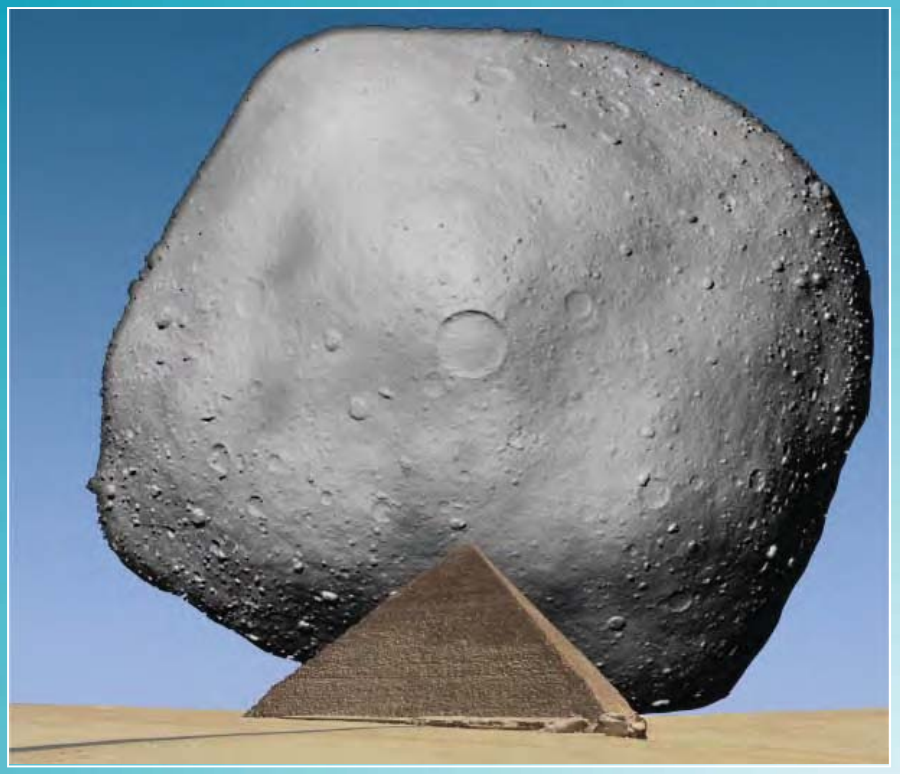
Osiris Rex

OSIRIS-REx

To follow JWST to launch go to www.jwst.nasa.gov

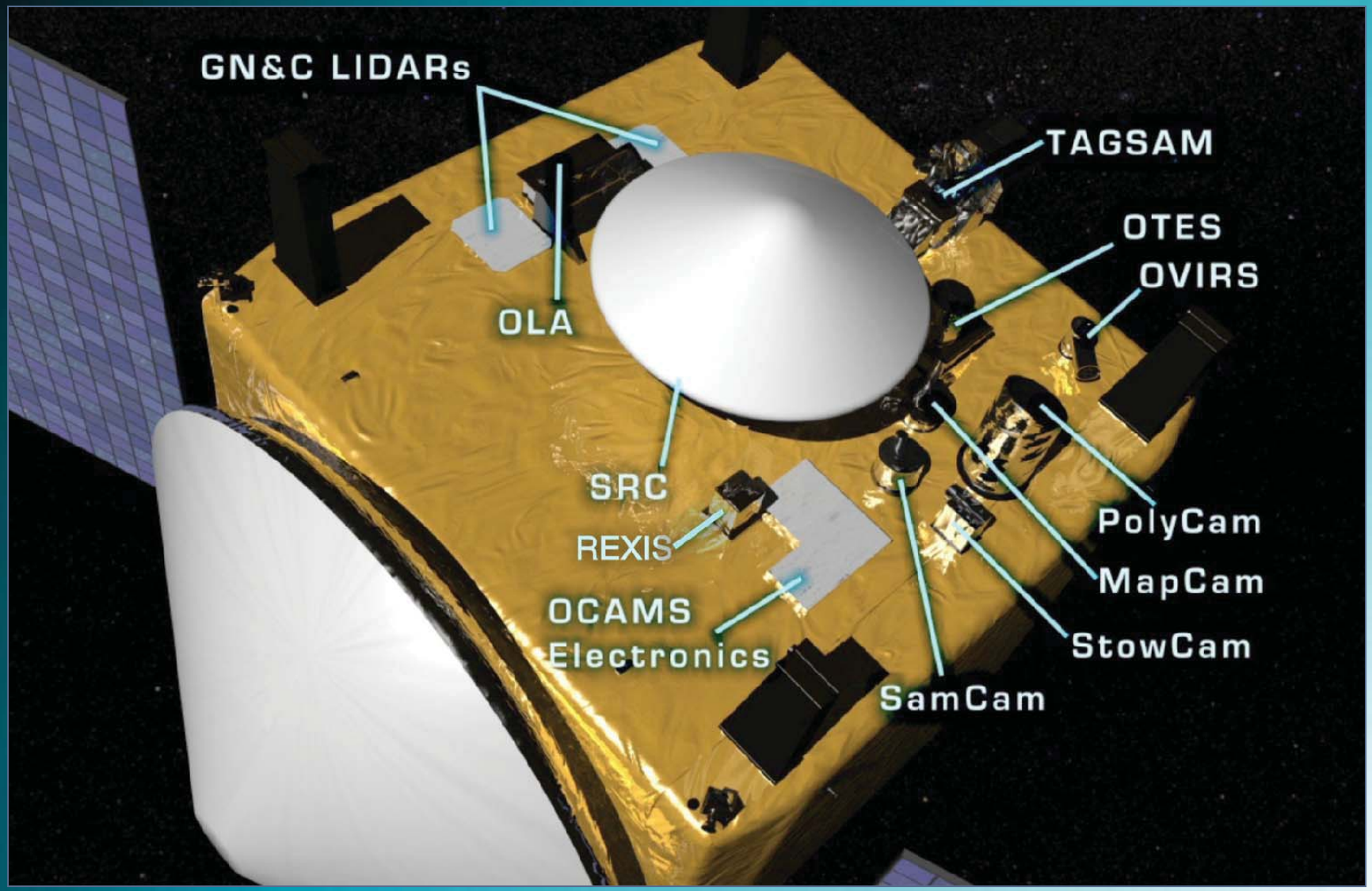
To follow OSIRIS-REx to launch go to www.osiris-rex.lpl.arizona.edu

Size Comparisons

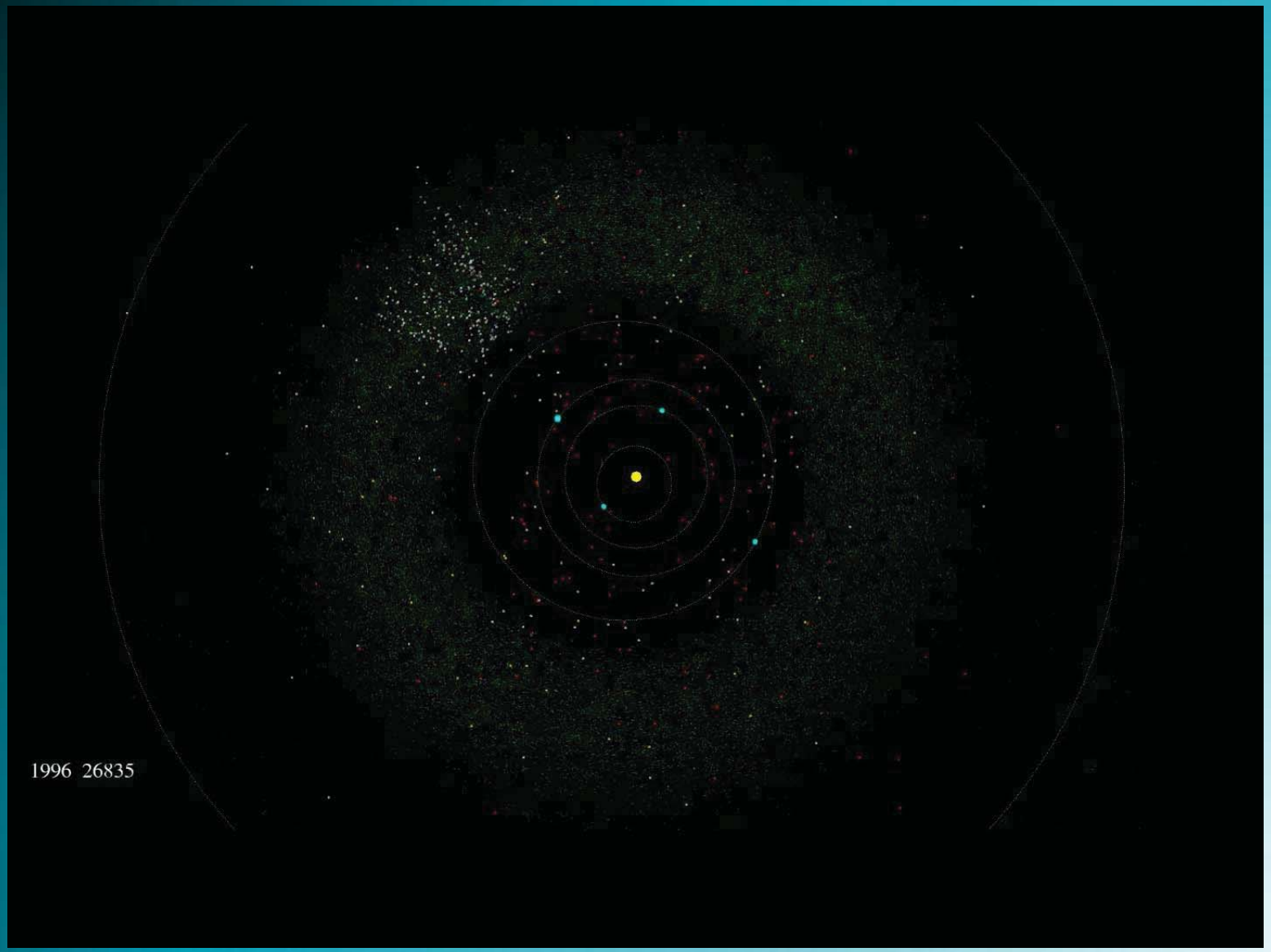


- 2 meters (6.6 feet) per side
- 8.5 m^2 (91 square feet) of solar panels
- Lithium ion batteries
- 5 Instruments:
  - Measurements in x-ray, visible and infrared
  - Laser topography measurements
- Touch-and-Go Sampler
- Sample Return Capsule

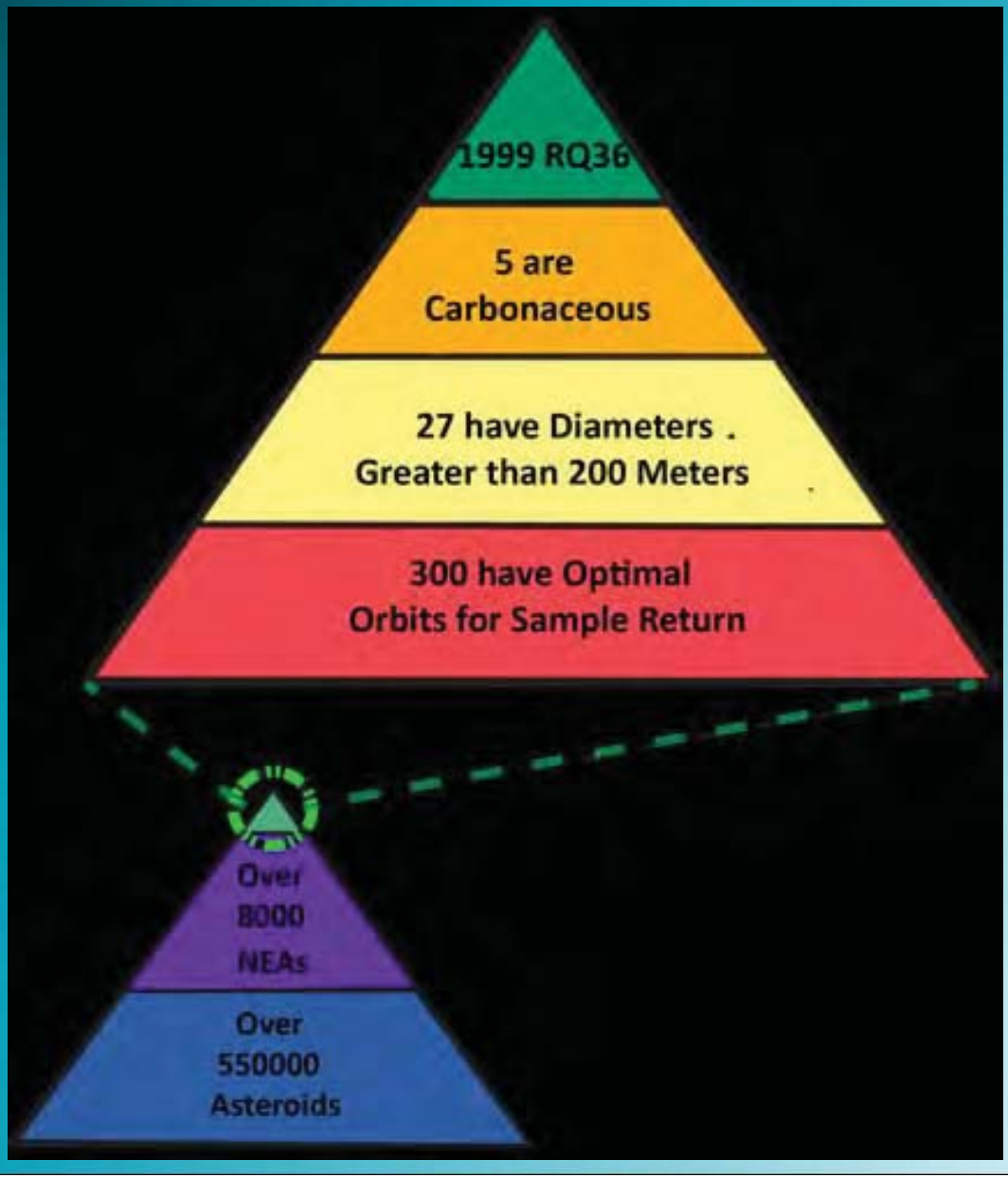
OSIRIS-REx Spacecraft Scientific Instrumentation



Which Asteroid?

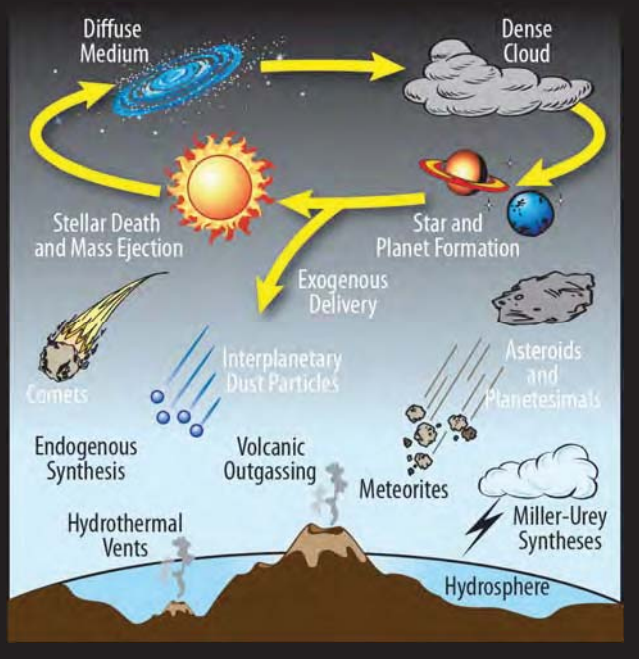


Choosing 1999 RQ_{36} (Bennu)

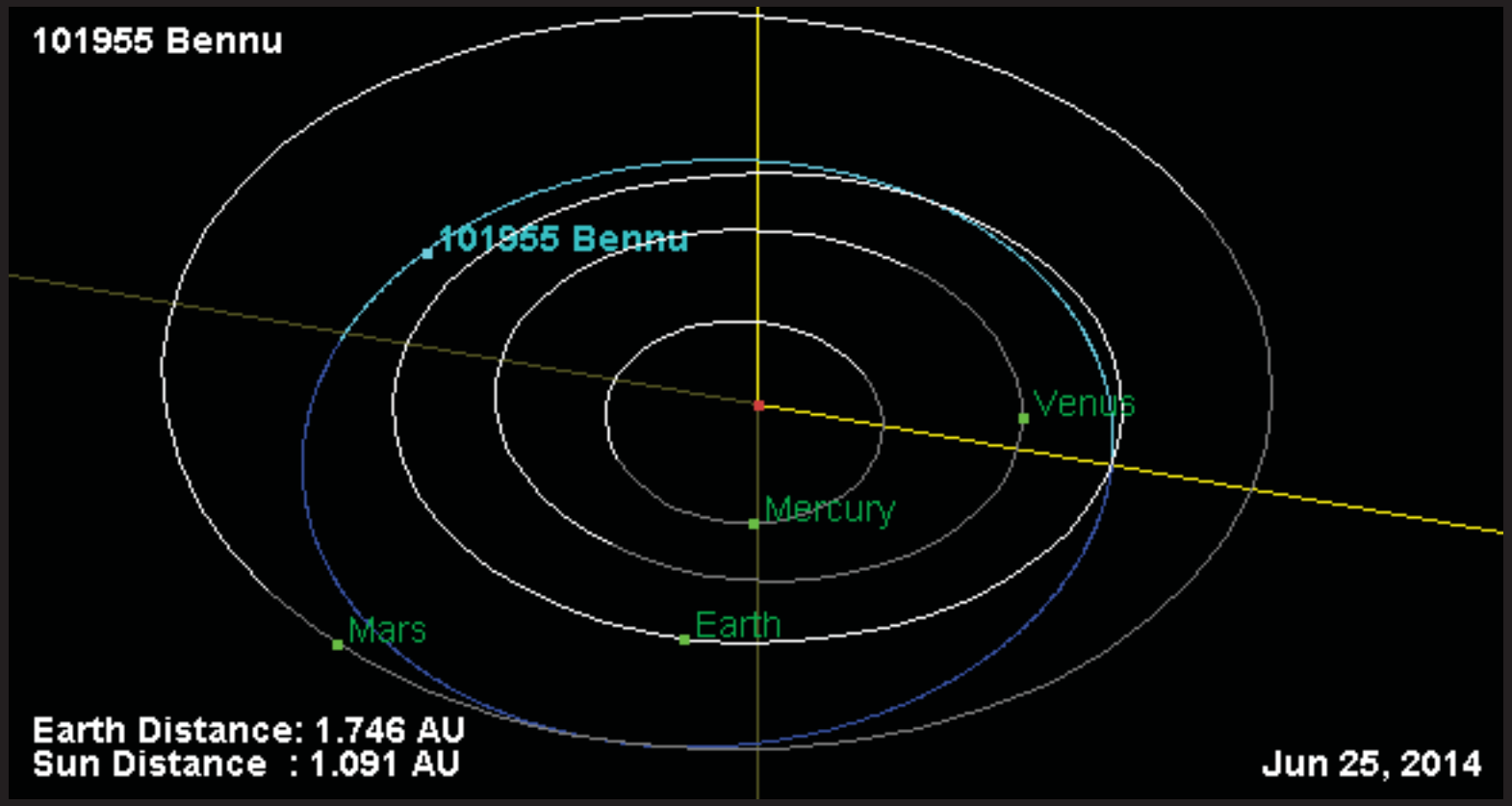


Near Earth Asteroid 1999 RQ_{36}

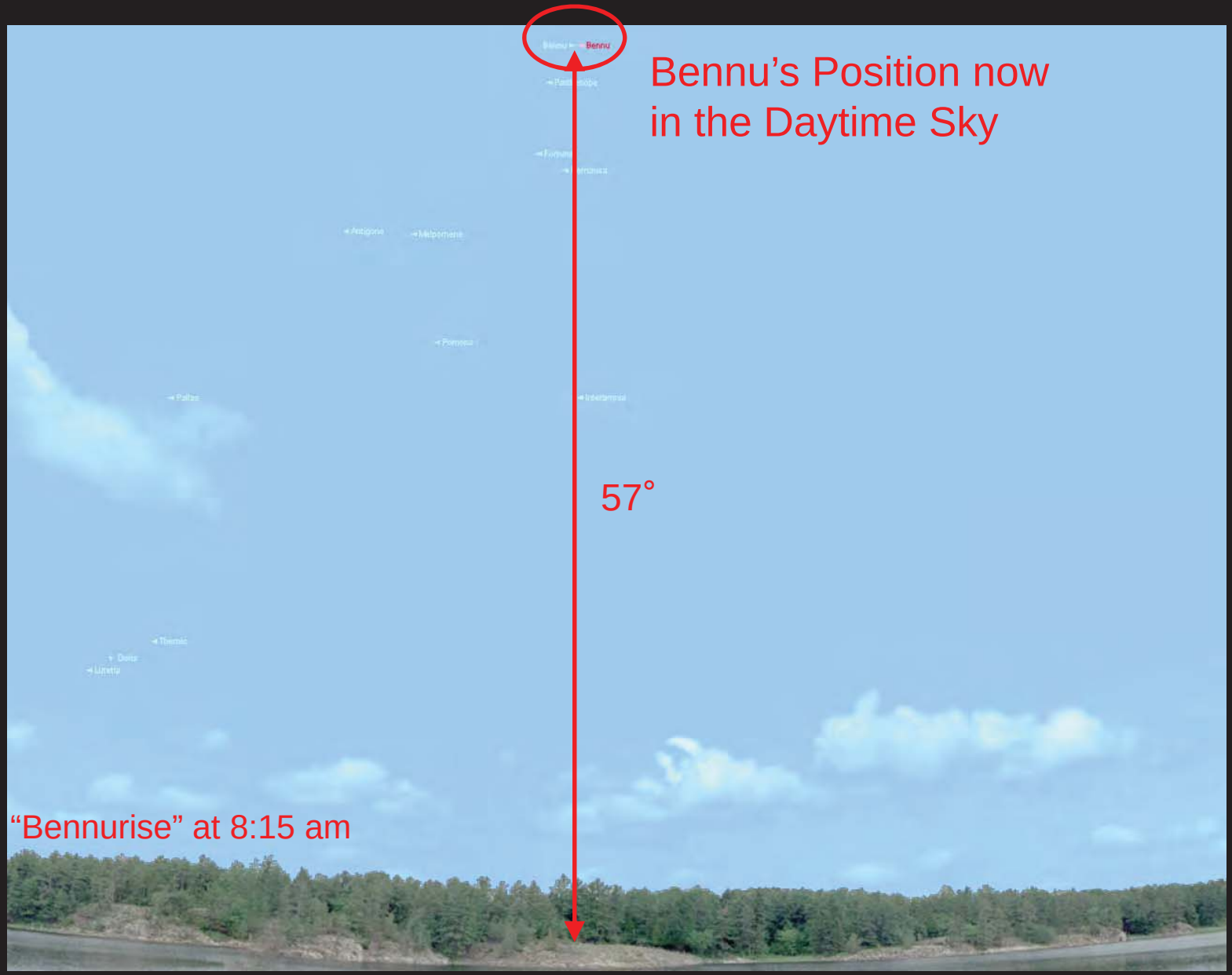
- Discovered during the first half of September in 1999
  - 916th minor planet discovered in the first half of September 1999!
- ~1/3 of a mile in diameter (575 m)
  - Not large enough for gravity to turn it into a sphere.
- Scientifically important for Two Primary Reasons:
  - Carbonaceous asteroid
    - Carbonaceous asteroids could be one of the sources of organics on Earth → life starts with organic material.
  - Could strike Earth as early as 2169
    - Opportunity to study the Yarkovsky effect.



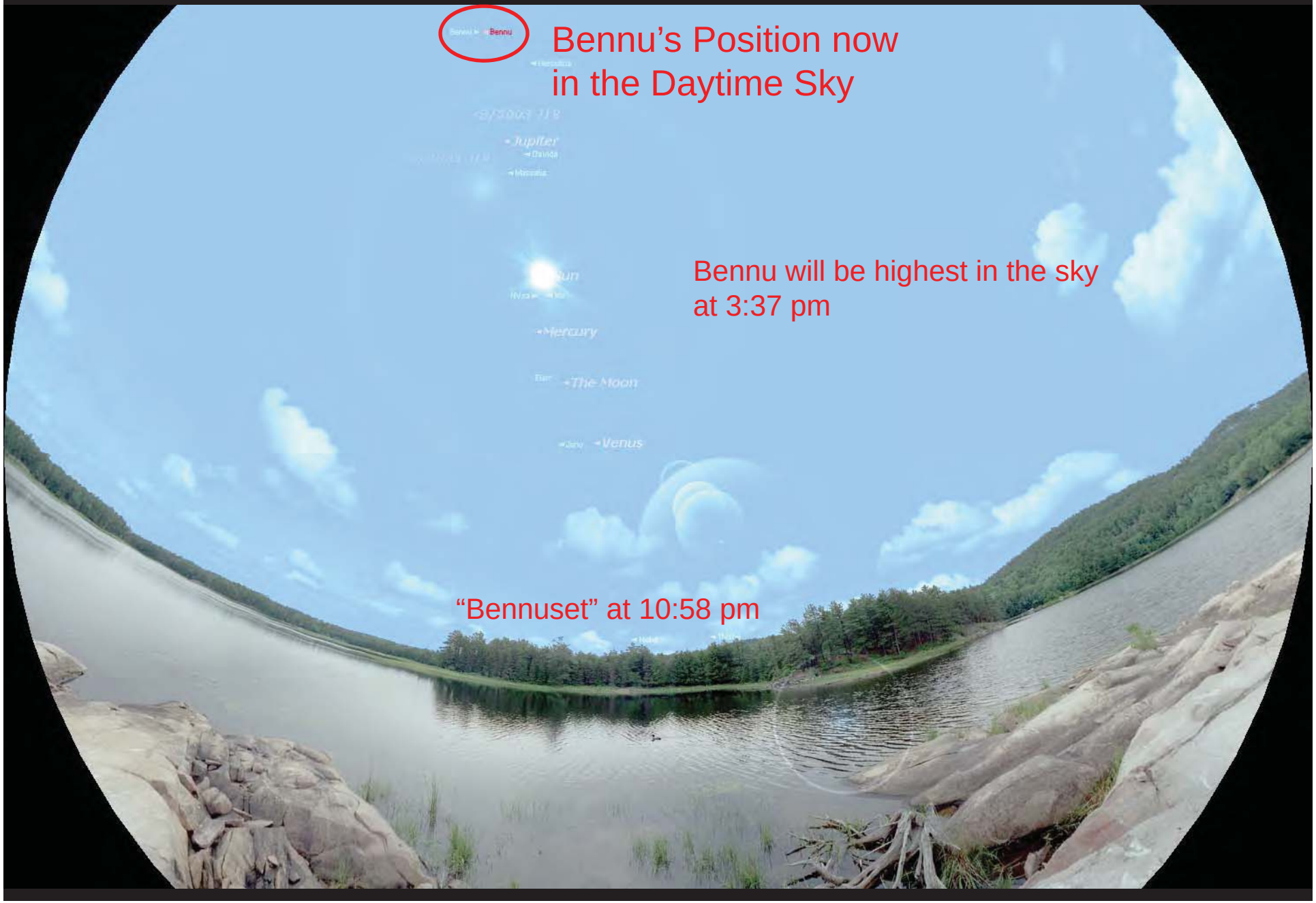
Where is 1999 RQ_{36} (Bennu) Now?



Looking South East



Looking West

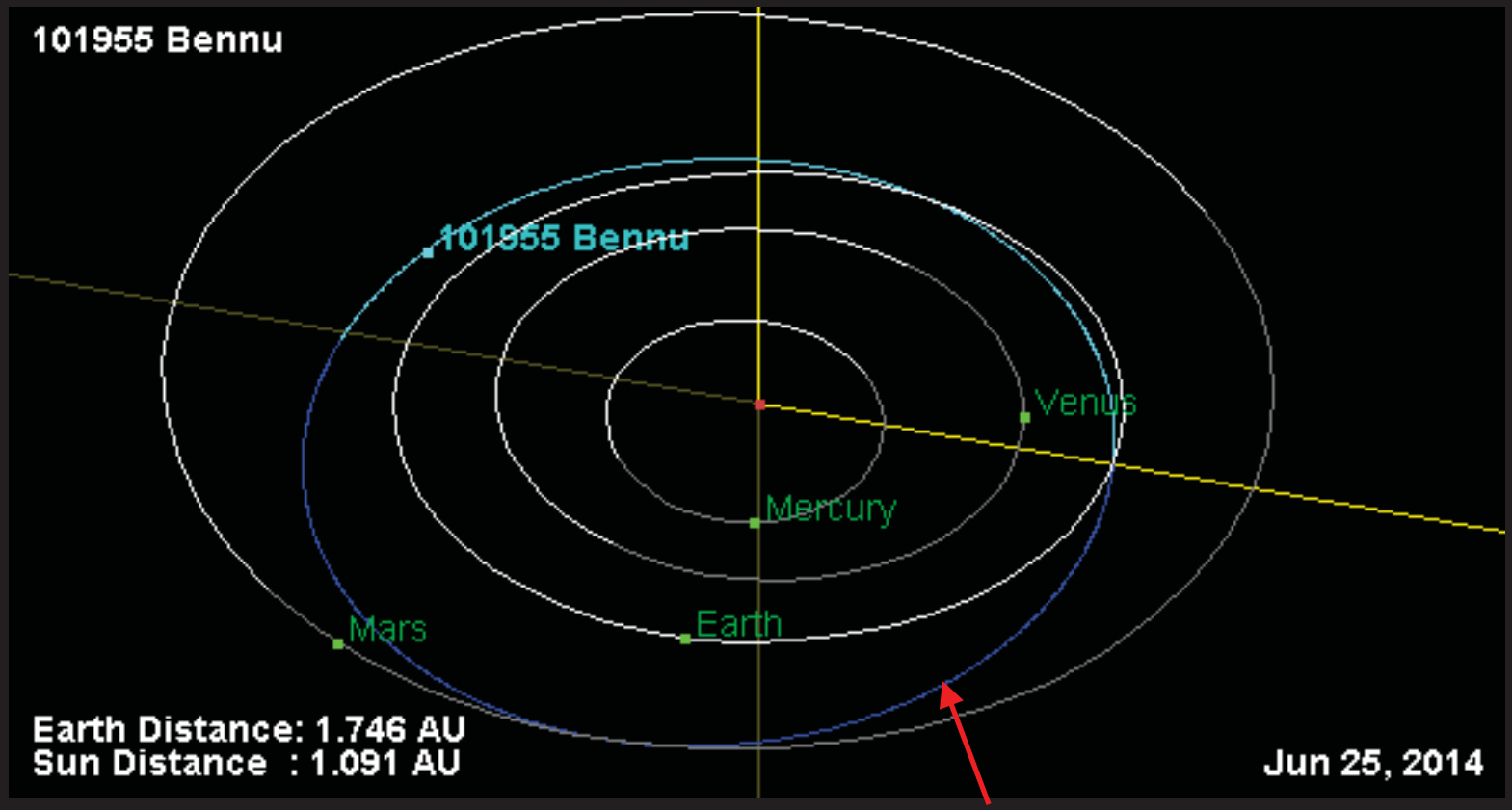


Bennu's Position now
in the Daytime Sky

Bennu will be highest in the sky
at 3:37 pm

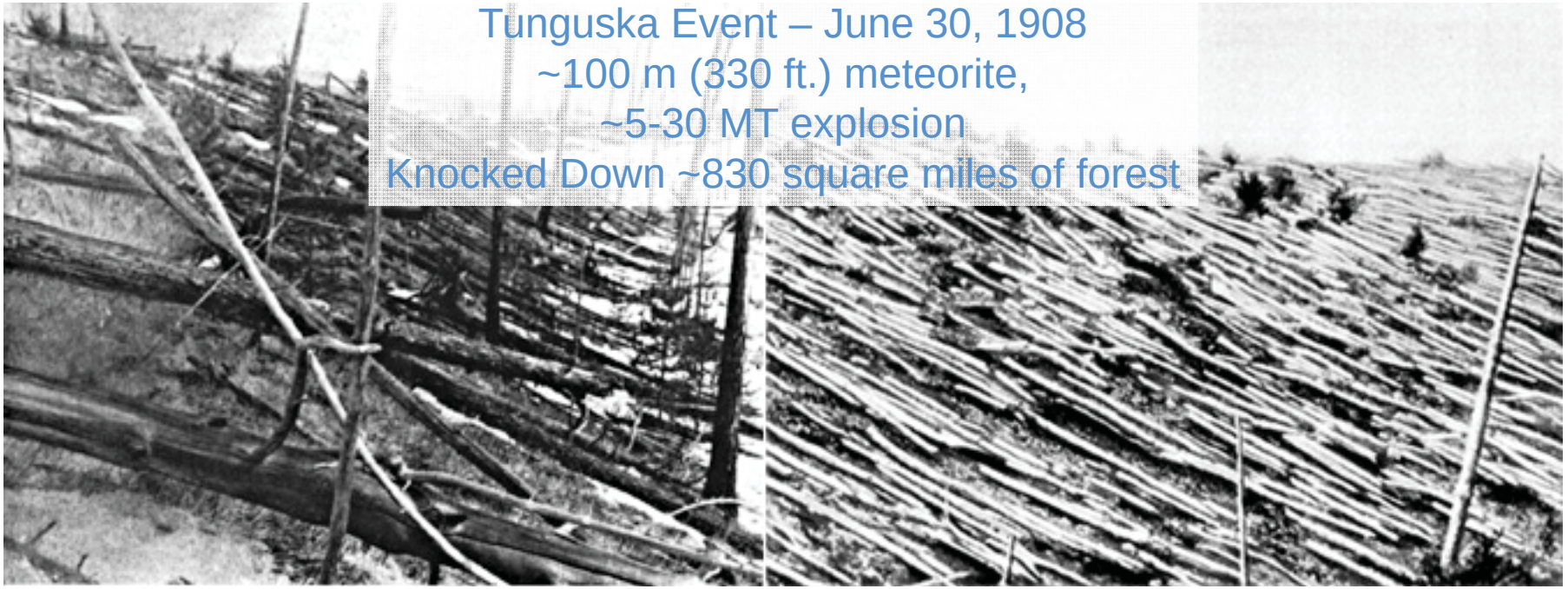
"Bennuset" at 10:58 pm

Yarkovsky Effect and Bennu's Orbit



- Recent observations indicate that the 1999 RQ_{36} orbit has been moved by the Yarkovsky effect by 100 miles over a period of 12 years (takes approximately 474 years to move half an Earth diameter).
- Sunlight force is equal to approximately ½ ounce when the asteroid is at perihelion → extremely small force on a ~68 million ton asteroid but the effect builds up over time.


0.74 miles
~50 m (165 ft.) diameter object → ~10 MT



Tunguska Event – June 30, 1908
~100 m (330 ft.) meteorite,
~5-30 MT explosion
Knocked Down ~830 square miles of forest

101955 1999 RQ36
Earth Impact Table

Date	Distance	Width	Sigma Impact	Sigma LOV	Stretch LOV	Impact Probability	Impact Energy	Palermo Scale	Torino Scale
YYYY-MM-DD.DD	(r_{Earth})	(r_{Earth})			(r_{Earth})		(MT)		
2169-09-24.72	0.10	< 1.e-04	0.00	-0.42	4.54e+04	1.6e-05	2.70e+03	-2.73	n/a
2182-09-24.93	0.30	< 1.e-04	0.00	-0.92	1.84e+03	2.6e-04	2.70e+03	-1.55	n/a
2182-09-24.93	0.60	< 1.e-04	0.00	-0.92	1.51e+03	2.8e-04	2.70e+03	-1.52	n/a
2185-09-24.60	0.10	< 1.e-04	0.00	-0.59	2.57e+04	2.6e-05	2.70e+03	-2.56	n/a
2189-09-24.62	0.50	< 1.e-04	0.00	-0.50	3.80e+04	1.6e-05	2.70e+03	-2.78	n/a
2192-09-24.35	0.10	< 1.e-04	0.00	-1.59	5.11e+03	4.4e-05	2.70e+		
2195-09-24.34	0.10	< 1.e-04	0.00	-0.75	2.99e+04	2.0e-05	2.70e+		
2199-09-25.05	0.10	< 1.e-04	0.00	+1.00	8.93e+03	5.4e-05	2.70e+		n/a

180,000 x more energy than Little Boy

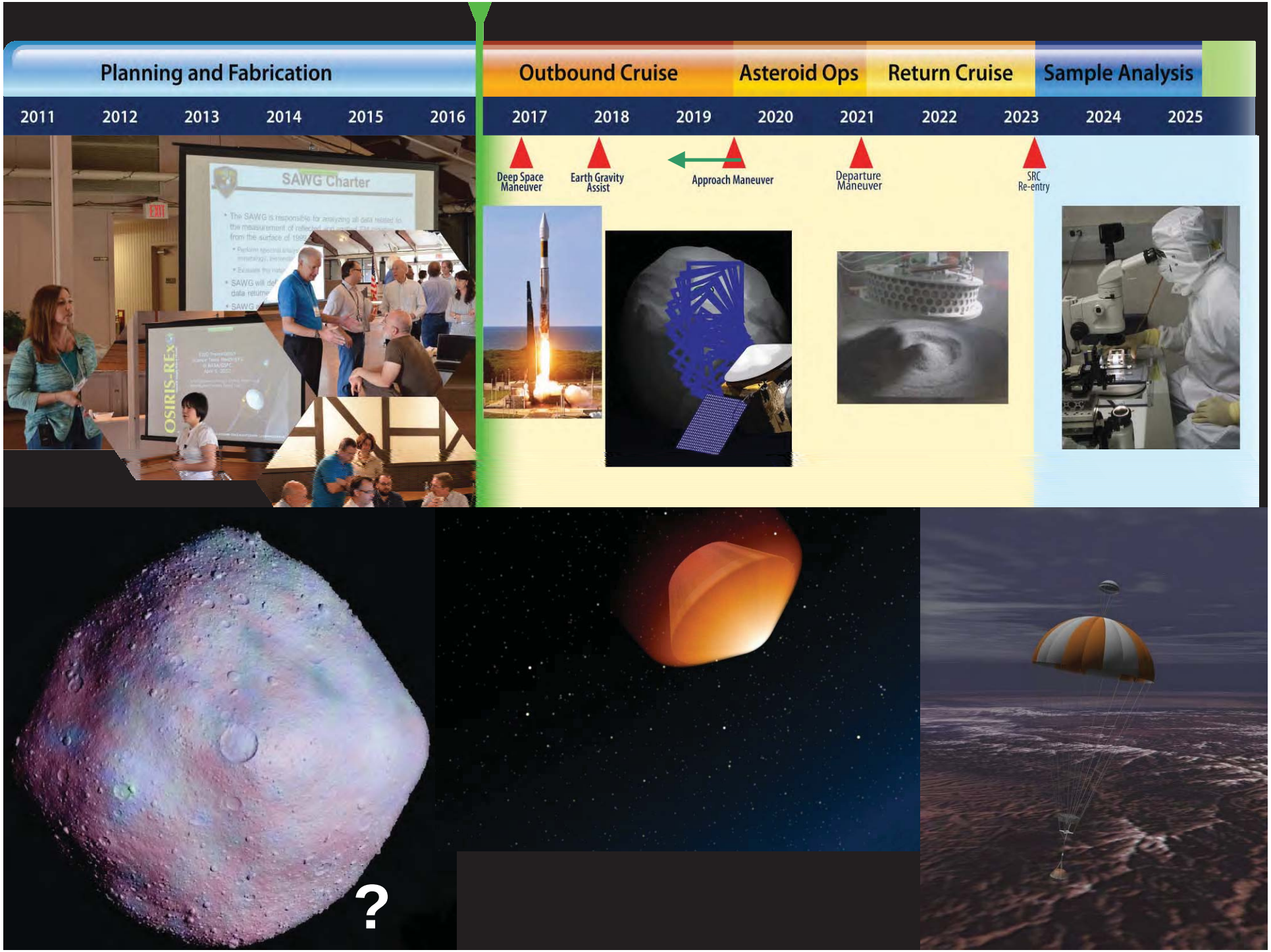
Skyfalls

This map shows the location of every asteroid impact sinc
than 1 kiloton of TNT (the nuclear bomb that destroyed Hi
rom the B612 Foundation, which t
ids, using information from a wo
ed to detect nuclear explosions a
Organisation. Such rocks almost
ts the effects on the ground. But b
ere injured in Chelyabinsk, in Russ
908, 2,000 square kilometres of Siberian forest were flattened by
a 10-15 megaton impact. Since Earth is mostly ocean and countryside, the odds of a strike
on a city are fairly low. But the consequences could be disastrous.

Asteroid impacts larger than 1 kiloton*
2000-13

Source: B612 Foundation
Video: b612foundation.org/portfolio/impact-video/

*Of TNT equivalent


Planning and Fabrication
Outbound Cruise
Asteroid Ops
Return Cruise
Sample Analysis
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
Deep Space Maneuver
Earth Gravity Assist
Approach Maneuver
Departure Maneuver
SRC Re-entry
SAWG Charter
OSIRIS-REx
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