

Why did we want a telescope in space?...

Advantages Over Ground Based Telescopes

- ~atmospheric aberration
- ~Ultraviolet and Infrared wavelengths

HUBBLE BEGINNINGS

Hubble Instruments

**Current**

- ~Advanced Camera for Surveys (ACS)
- ~Wide Field Planetary Camera 2 (WFPC2)
- ~Space Telescope Imaging Spectrograph (STIS)
- ~Near Infrared Camera and Multi-Object Spectrometer (NICMOS)
- ~Corrective Optics Space Telescope Axial Replacement (COSTAR)

Advanced Camera For Surveys

~Wavelengths: 1200-10,000 Angstroms (ultraviolet to near infrared)

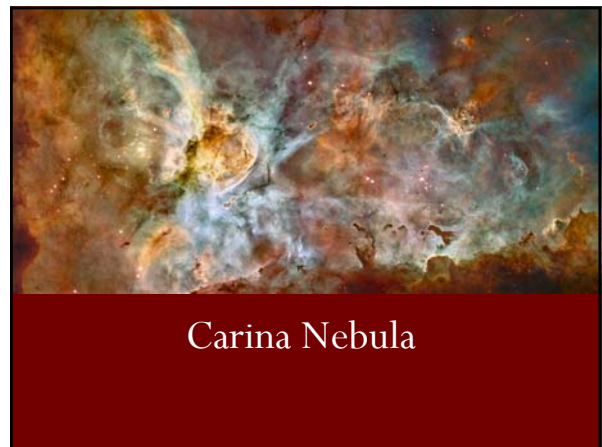
~3 Sub-instruments:

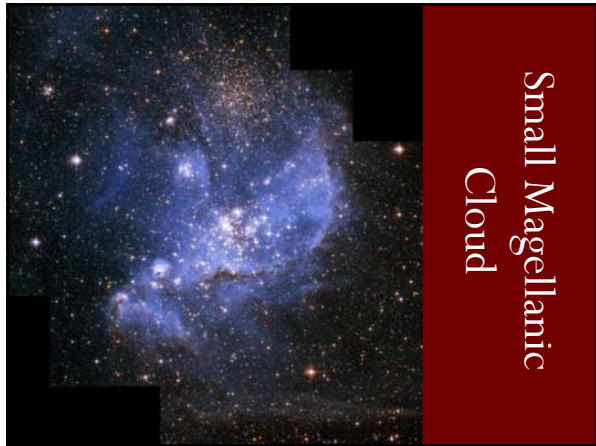
- 1)Wide Field Camera
- 2)High Resolution Camera
- 3)Solar Blind Camera

HD 141569 Circumstellar Disk

NASA, M. Clampin (STScI), H. Ford (JHU), G. Illingworth (UCO/Lick), J. Krist (STScI), D. Ardila (JHU), D. Golimowski (JHU), the ACS Science Team and ESA

STScI-PRC03-02





Small Magellanic Cloud

### Wide Field Planetary Camera 2

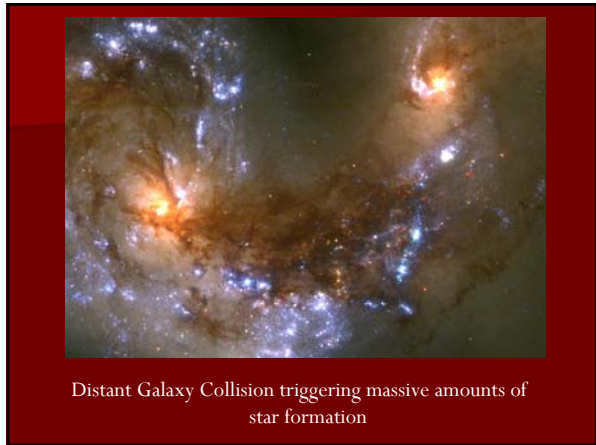
 A black and white photograph of the Wide Field and of Survey Camera (WFPC2) instrument, showing its complex internal structure and various components.
 

- ~Records images through a selection of 48 color filters
- ~Spectral range varies from far-ultraviolet, to visible, to near-infrared
- ~Most used instrument in first 13 years of HST science
- ~Built-in corrective optics

**STATS:**

- Weight: 281kg
- Dimensions: 0.8m \* 2.2m \* 2.0m
- Field of View: 2.7 arcminutes
- Wavelength range: 1200- 10,000 Angstroms

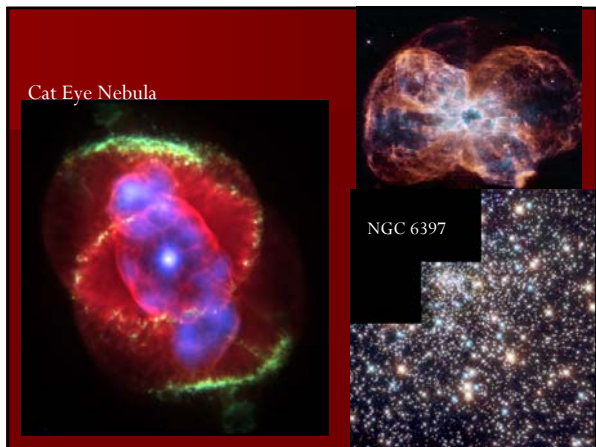
Lets see some results!!!.....



Distant Galaxy Collision triggering massive amounts of star formation

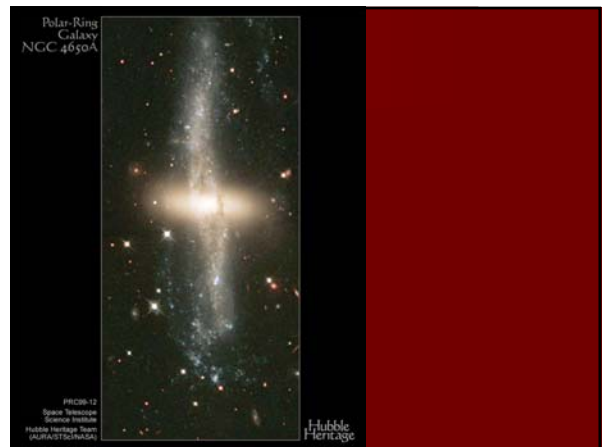


BOOMERANG NEBULA



Cat Eye Nebula

NGC 6397



Polar-Ring Galaxy NGC 4650A

PRC09-12  
Space Telescope Science Institute  
Hubble Heritage Team (AURA/STScI)

Hubble Heritage

## Space Telescope Imaging Spectrograph



~Installed in 1997 to replace the GHRS (Goddard High Resolution Spectrograph)

~Chemical compositions and abundances, temperatures, velocities (radial and rotational), magnetic fields

~2 Modes:

- 1) long slit spectroscopy
- 2) echelle spectroscopy

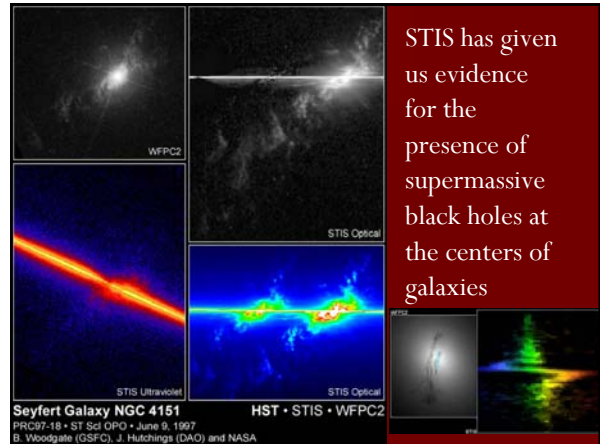
### STATS:

Weight: 318kg

Dimensions: 2.2m \* 0.9m \* 0.9m

Field of View: MAMA 25\*25 arcsec; CCD 50\*50 arcsec

Wavelength Range: 1150-10,000 Angstroms

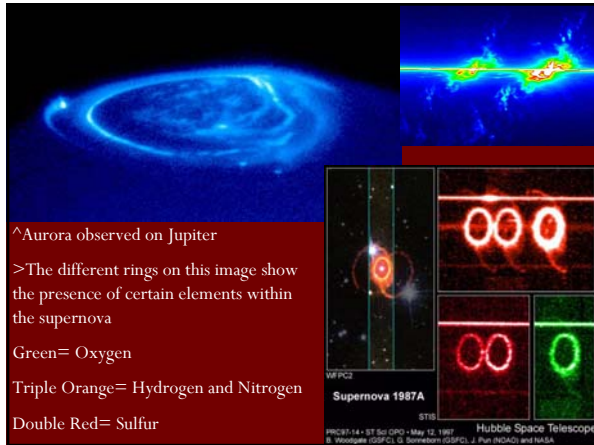


STIS has given us evidence for the presence of supermassive black holes at the centers of galaxies

Seyfert Galaxy NGC 4151

PRC97-18 • ST ScI DRD • June 9, 1997  
B. Woodgate (GSFC), J. Hutchings (DAO) and NASA

HST • STIS • WFC2



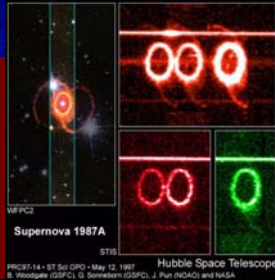
^Aurora observed on Jupiter

>The different rings on this image show the presence of certain elements within the supernova

Green= Oxygen

Triple Orange= Hydrogen and Nitrogen

Double Red= Sulfur



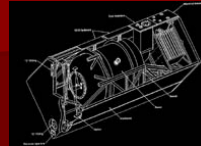
Supernova 1987A  
Hubble Space Telescope  
PRC97-14 • ST ScI DRD • May 13, 1997  
B. Woodgate (GSFC), G. Sornborger (GSFC), J. Paul (NOAO) and NASA

## NICMOS

~three adjacent cameras (operate independently)

~infrared wavelengths only- operates under 77 degrees Kelvin

~detectors cooled



### STATS:

Weight: 370kg

Dimensions: 2.2m \* 0.89m \* 0.89m

Wavelength: 8000-25,000 Angstroms

Resolution:

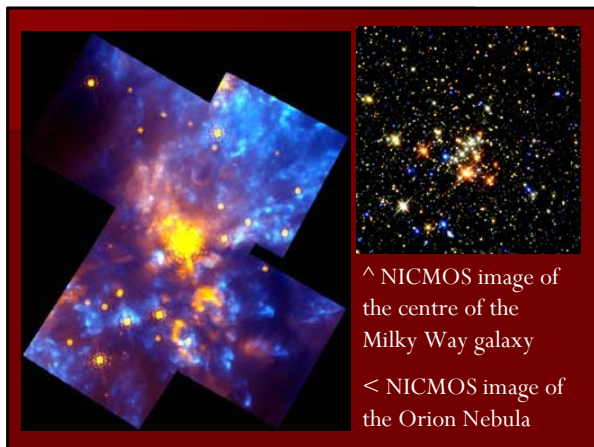
Low: 51.5 \* 51.5 arcseconds

Med: 17.5 \* 17.5 arcseconds

High: 11.0 \* 11.0 arcseconds



Cone Nebula  
ACS • Hubble  
Hubble Space Telescope • NICMOS  
NASA, The NICMOS Group (STScI, ESA), The NICMOS Science Team (Univ. Arizona) • STScI-PRC92-139



^ NICMOS image of the centre of the Milky Way galaxy

< NICMOS image of the Orion Nebula

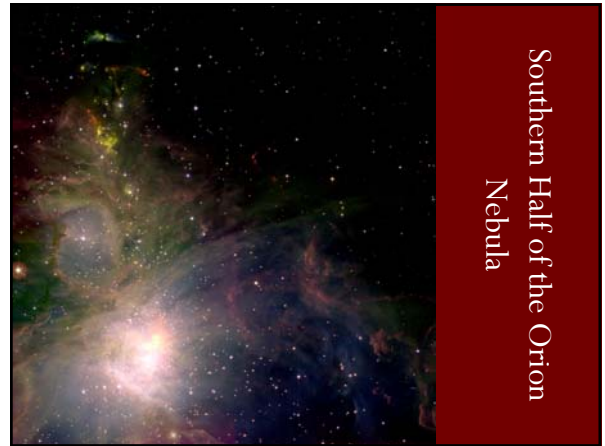
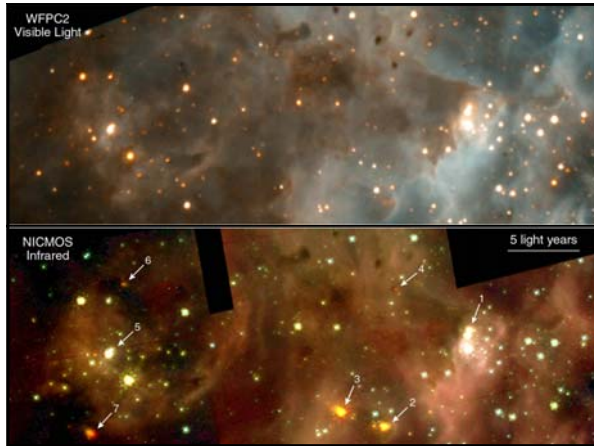


< 4 Galaxy Collision

Young massive star with 6 "baby stars" within a tenth of a light year

Ultraluminous Infrared Galaxy  
IRAS 19297-0406  
NASA, The NICMOS Group (STScI, ESA), The NICMOS Science Team (Univ. Arizona)  
STScI-PRC02-13c

HST • NICMOS



### NICMOS Cooling System (NCS)

- ~experimental technology
- ~circulates cold Neon gas through NICMOS cryostat
- ~low vibration technology
- ~more stable and optimal temperatures than N ice

^NCS Micro-turbine  
 >NCS-its radiator stands approx. 12 ft high  
 \*NCS technology will later be used in the James Webb telescope

In celebration of the 100 Billionth revolution of the cooler turbine...

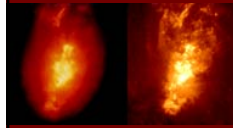
**Egg Nebula**  
 Hubble Space Telescope  
PRC97-11 • ST Sci OPO • May 12, 1997  
 R. Thompson (Univ. Arizona), D. Hines (Univ. Arizona), R. Sahai (JPL) and NASA

## Corrective Optics Space Telescope Axial Replacement



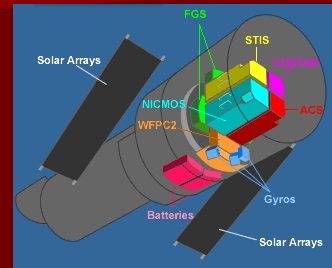
~installed in 1993 to correct the aberration of HST's primary mirror

~instrument is now performing just about up to its theoretical optimum (resolution and imaging)



~since Hubble's servicing mission in 2002, COSTAR's mission has been complete and COSTAR will be removed from the Hubble during the 2008 servicing mission

## Hubble Servicing Mission 4



### New Instruments:

~Wide Field Planetary Camera 3 (WFPC3)

~Cosmic Origins Spectrograph (COS)



>I got a picture of this cat by searching HST, COS and WFPC 3.....>.< ...

## Wide Field Planetary Camera 3

~planned installation during Hubble servicing mission #4 in 2008

~two channels will allow imaging from near infrared to near ultraviolet

~Much better discovery efficiency in both Infrared and Ultraviolet wavelengths



Discovery efficiency = field view \* optical throughput

~mostly being constructed at Goddard Space flight Centre and Ball Aerospace

## Cosmic Origins Spectrograph

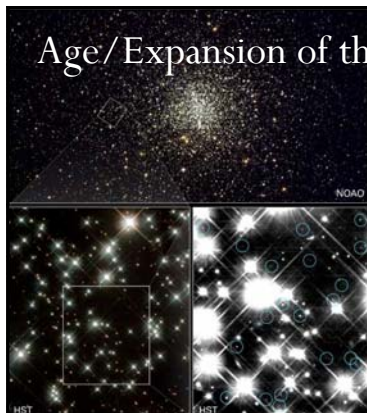


~20 times more sensitive in far ultraviolet

~Science Objectives (core issues of NASA's Origins program)

- Origin of large scale structure and intergalactic medium
- Formation, evolution, ages of galaxies
- Stellar and planetary origins and cold interstellar medium

## Age/Expansion of the Universe

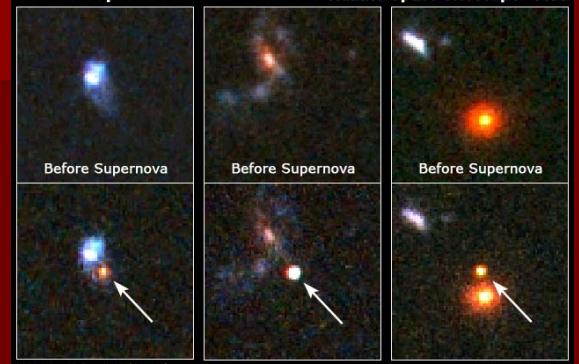


~Measuring the apparent brightness of distant supernovae  
— Accelerating Universe

~Test against oldest star ages

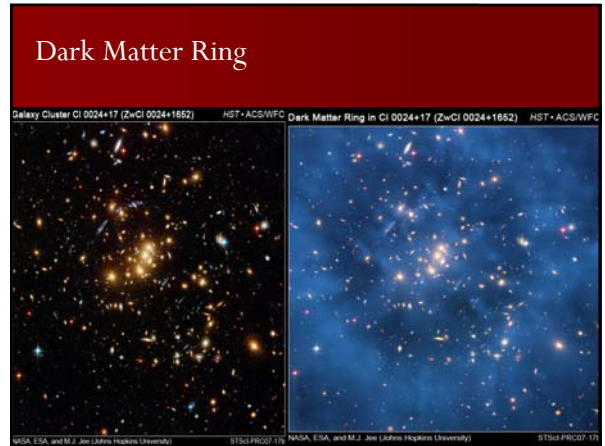
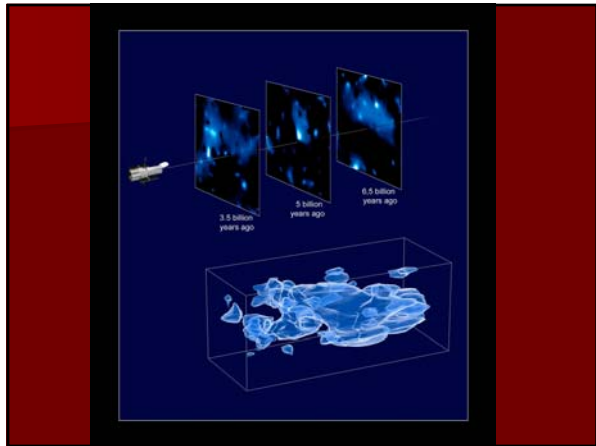
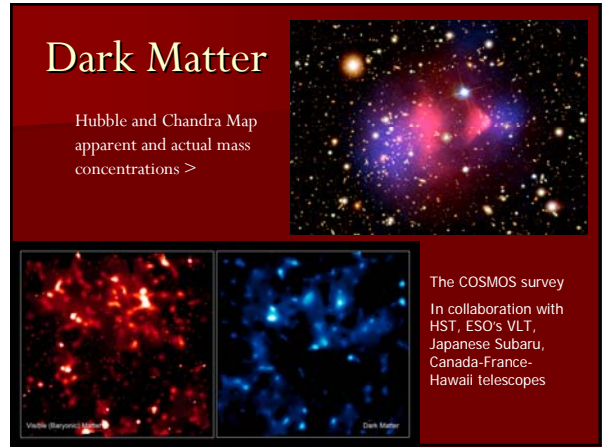
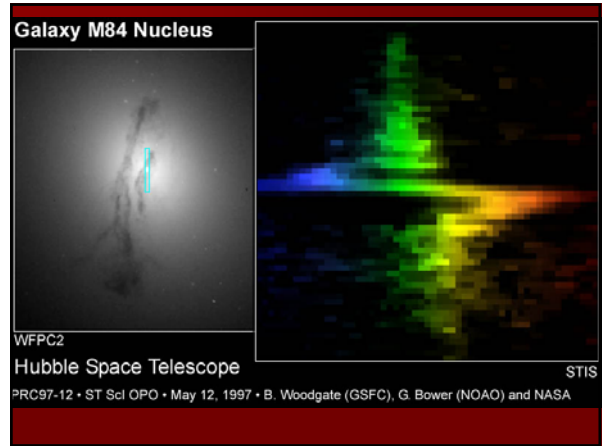
White Dwarf Stars in Globular Cluster M4  
NASA and H. Richer (University of British Columbia) STScI-PRC02-10

## Distant Supernovae



NASA and A. Riess (STScI)

STScI-PRC04-12





# Hubble Space Telescope



- ~Groundbreaking Observations and Discoveries
- ~New technologies that will be used in new telescopes
- ~Lots of work on HST has been done locally at Ball Aerospace!