COBE (Cosmic Background Explorer) and JWST (James Webb Space Telescope) Science

PI Masters Forum 2

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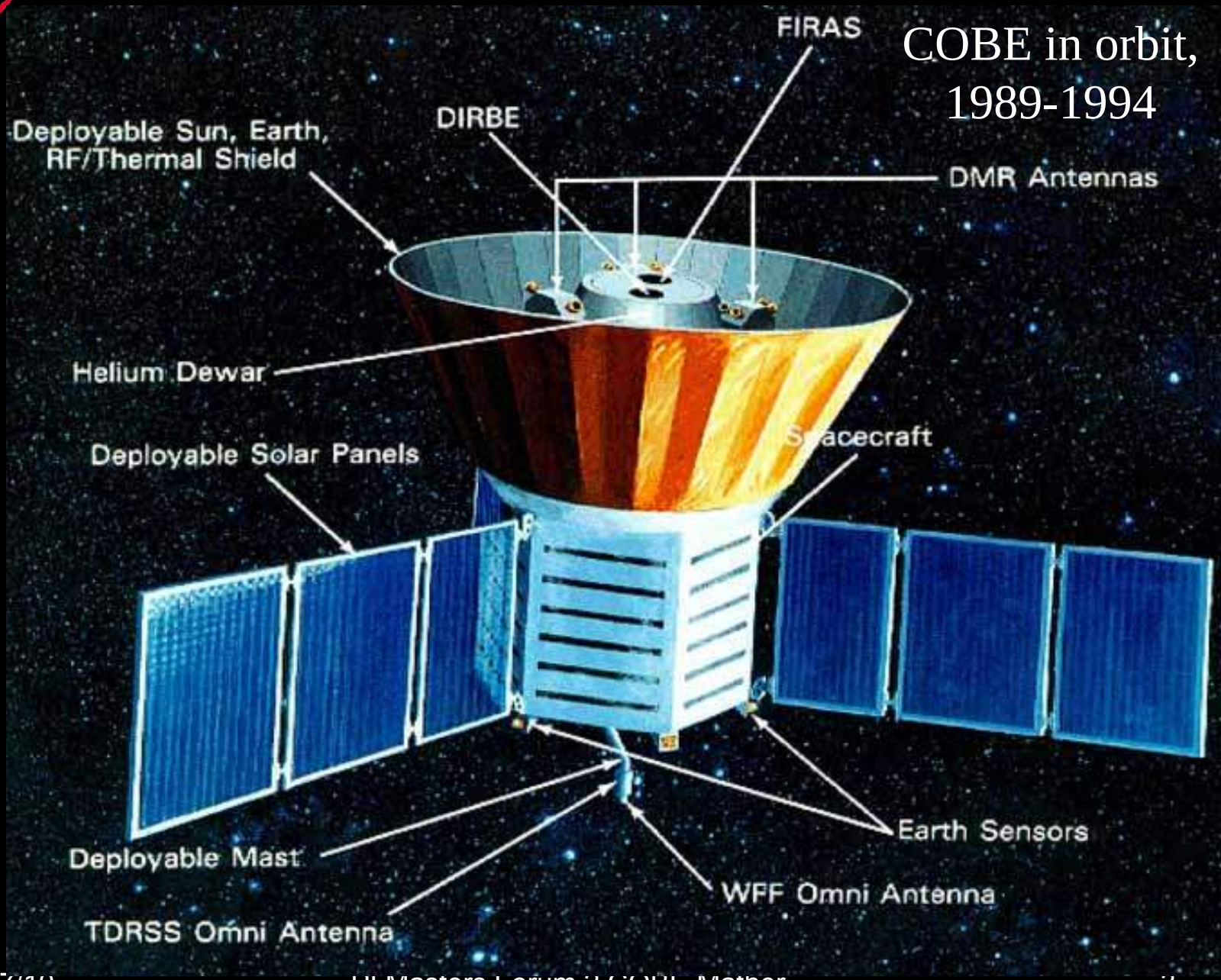
Major Lessons Learned

- Structure of team: bottleneck at top! Get good people, don't do everything yourself
- If you don't test it, it won't work → need 2 ways to know everything important; don't "take risk" for stuff you don't know, you're gambling with public money and your career.
- Your job ←→ systems engineering including the science process; take courses & study it!
- Need wide range of personalities in team → read Pellerin book "How NASA Builds Teams"


COBE in orbit, 1989-1994
FIRAS
DIRBE
Deployable Sun, Earth, RF/Thermal Shield
DMR Antennas
Helium Dewar
Deployable Solar Panels
Spacecraft
Earth Sensors
Deployable Mast
WFF Omni Antenna
TDRSS Omni Antenna

COBE Context

- Proposed 1974, before computer revolution
  - No CAD/CAM, no realistic performance modeling, can't visualize hardware before construction
  - No email, and managers couldn't type
- New Start 1982, Challenger 1986, launch 1989
- Instruments far beyond state-of-the-art
  - Detectors not available
  - Accuracy requirements unprecedented
  - Almost no cryogenic experience in space
- In-house project, largest GSFC ever did
- 2 PI's in house, 1 external (Berkeley) with in-house deputy

Some Science PI Lessons

- Bad idea to have Project Scientist be a PI: not enough time in a day
- Deputies essential: too much for a PI to do, and “the bottleneck is at the top”; hiring freezes (especially under Jimmy Carter) were serious issue
- PI role for in-house projects does not include financial management - but he who has the gold, rules: must be on good terms with Project Management!
- Government lab can’t delegate financial or personnel responsibility to outside PI - delicate situation for DMR PI

COBE Requirements

- Engineers wanted detailed requirements documents flowed down to them
- Scientists couldn't do systems engineering all by themselves
- Systems engineers couldn't do it without many iterations with team
  - But teams didn't like iterations and trade studies
- Nevertheless, close interaction of scientists and engineers allowed relaxation and re-interpretation of requirements when needed
  - Pushed state of the art 1000x

Need Diversity of Personality

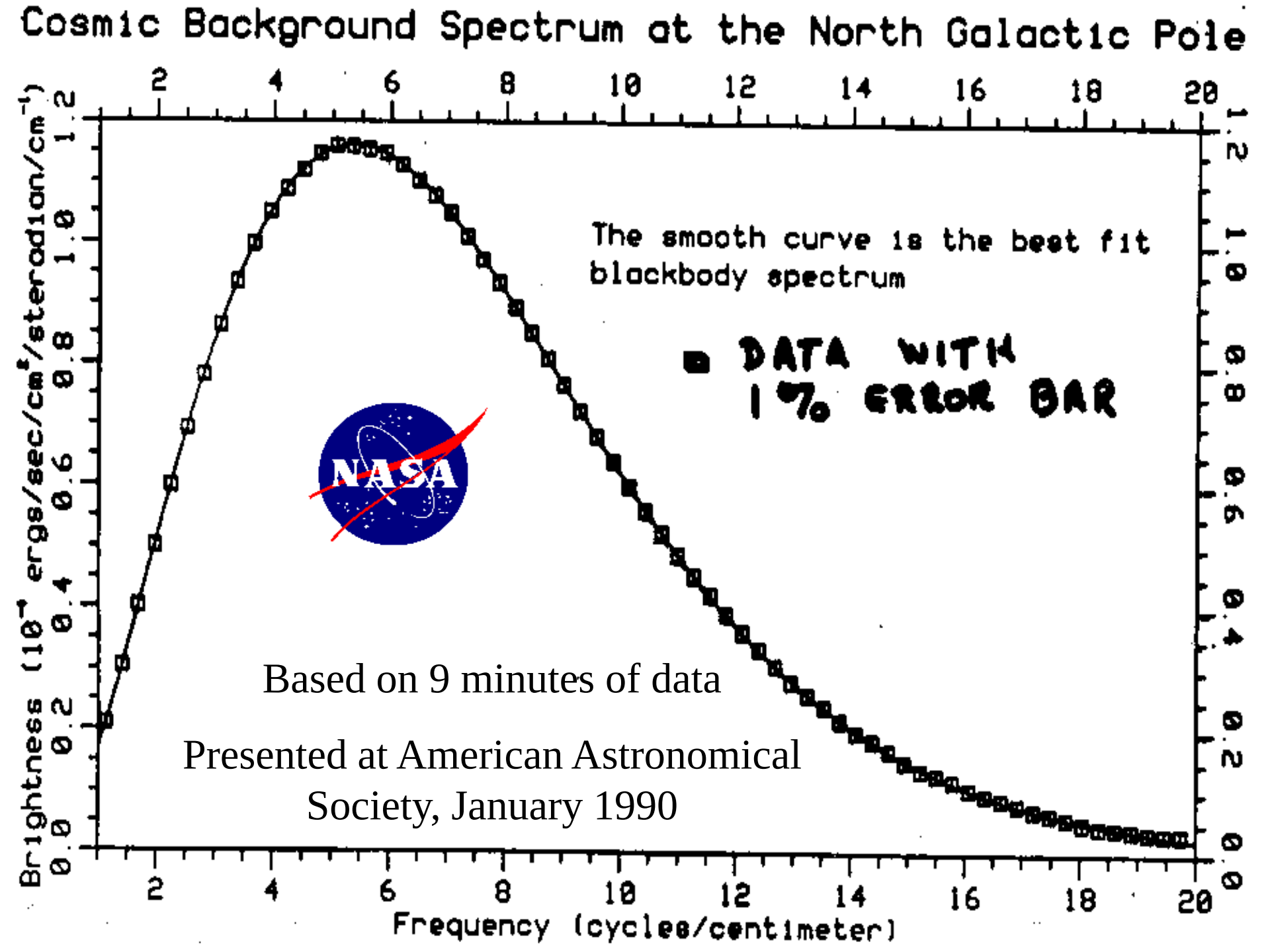
- Visionary - forward looking
- Decision making - taking risks for progress
- Fact checking - detail oriented
- Grouch - test everything enough
- Planning - make things happen
- Organization - proper assignments

Risks of Being Good

- If you're the PI, people may think you are always right: so be careful! You are a single-point failure walking on Earth.
- Make sure your calculations are double-checked by somebody who doesn't know the right answer

Major COBE Risks were social

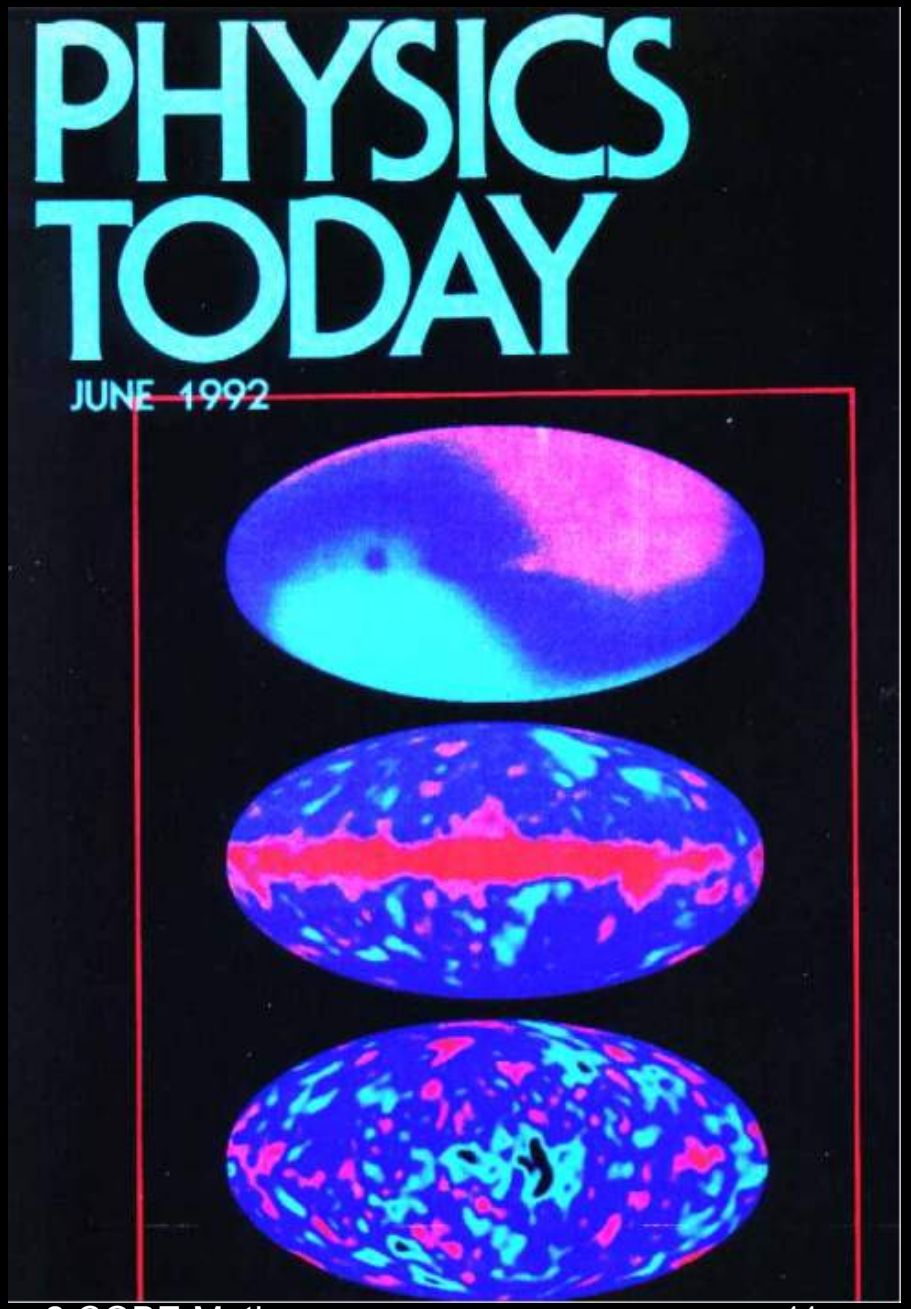
- Concept: what if we forgot to think about a new effect due to cryogenics, noise, superfluid helium, spinning spacecraft, etc.?
  - Cold cables wouldn't flex
  - Aluminum distorted on cooling
  - Systematic errors hidden in noise, averaged for years
    - Magnetic susceptibility of RF switches
    - Electrical interference between computer clock, picked up by the ultrasensitive detectors
  - Light coming up from Antarctica stressed power system
  - Conclusion: PI or team inexperience is a major risk
- Test: what if we can't afford to test something?
  - Nature doesn't care if we can afford it or not
  - What if something breaks in test? We won't have resources to fix it, so why test?
  - After Challenger, Columbia, etc. we can confirm: management (including PI and customer) attitude is a major risk


Cosmic Background Spectrum at the North Galactic Pole
The smooth curve is the best fit blackbody spectrum
DATA WITH 1% ERROR BAR
Based on 9 minutes of data
Presented at American Astronomical Society, January 1990
Brightness (10^{-4} ergs/sec/cm^2/steradian/cm^{-1})
Frequency (cycles/centimeter)

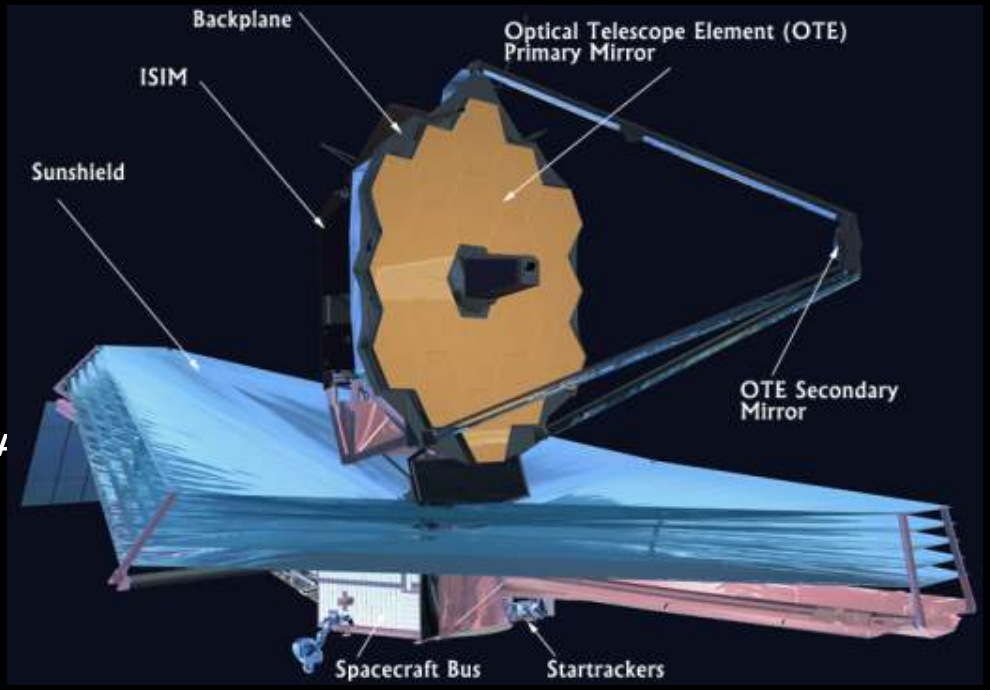
Sky map from DMR, 2.7 K +/- 0.003 K

Doppler Effect of Sun's motion removed (v/c = 0.001)

Cosmic temperature/density variations at 389,000 years, +/- 0.00003 K (part in 100,000)



James Webb Space Telescope (JWST)



Organization

- Mission Lead: Goddard Space Flight Center
- International collaboration with ESA & CSA
- Prime Contractor: Northrop Grumman Aerospace Systems
- Instruments:
  - Near Infrared Camera (NIRCam) – Univ. of Arizona
  - Near Infrared Spectrograph (NIRSpec) – ESA
  - Mid-Infrared Instrument (MIRI) – JPL/ESA
  - Fine Guidance Sensor (FGS) – CSA
- Operations: Space Telescope Science Institute

Description

- Deployable infrared telescope with 6.5 meter diameter segmented adjustable primary mirror
- Cryogenic temperature telescope and instruments for infrared performance
- Launch 2014 on an ESA-supplied Ariane 5 rocket to Sun-Earth L2
- 5-year science mission (10-year goal)

www.JWST.nasa.gov

JWST Science Themes

End of the dark ages: First light and reionization

The assembly of galaxies

Birth of stars and proto-planetary systems

Planetary systems and the origin of life

Choosing JWST Science & Scientists

- HST & Beyond report, 1995 draft, by Alan Dressler et al., recommended > 4 m aperture, near-IR optimized, with shorter and longer wavelengths if affordable
- Anticipated almost all scientific areas of current interest (exoplanets had just been found)

Dominant Science Themes

- First Light: first objects after Big Bang
- Assembly of Galaxies - from small parts?
- Formation of stars and planetary systems
- Evolution of planetary systems and conditions for life
- New things!!

THE END