The Tools of Astronomy

Seeing the whole picture

Jonathan Crass

UNIVERSITY OF NOTRE DAME

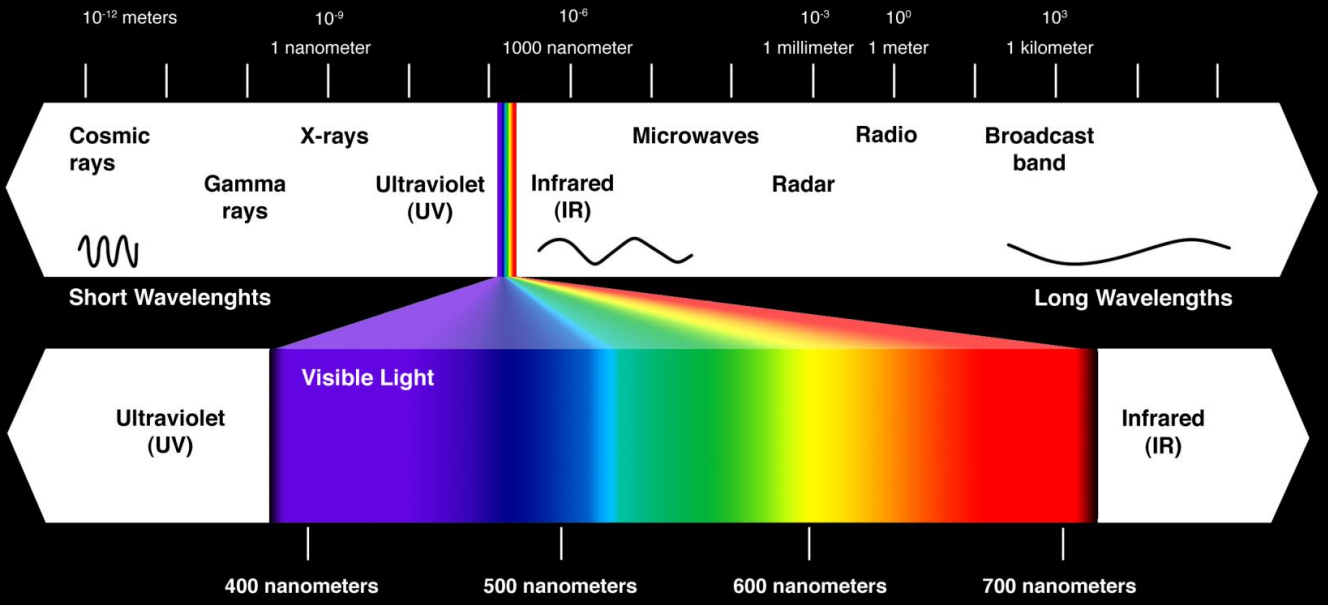
What tools do we need?

- We need to observe the Universe around us
  - The Solar System
  - Galaxies
  - And beyond
- We need to understand what we see
- We need to predict what is going to happen

The Tools of Astronomy

- The Astronomers Toolkit
  - Ground-based telescopes
  - Space telescopes
- The images we see
  - Do they "*really*" look like that?
  - What are they telling us

Observing the Universe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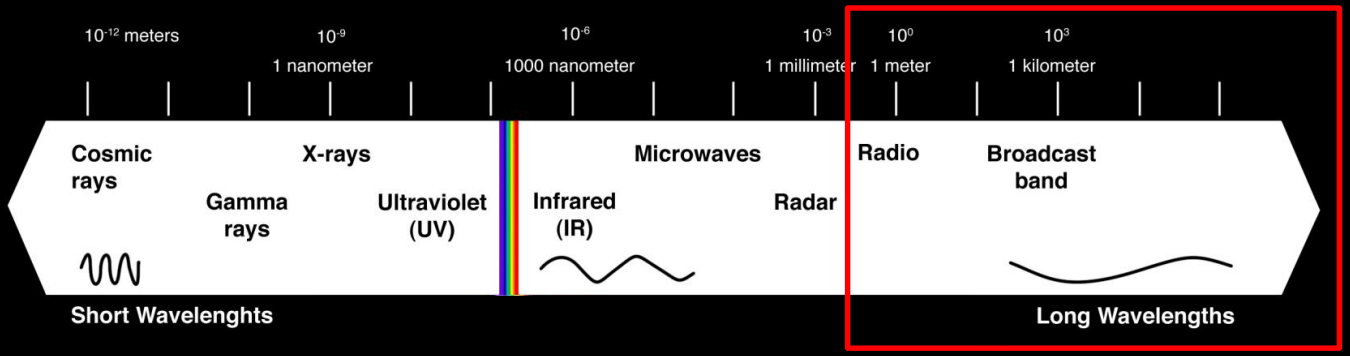
Cosmic rays
X-rays
Gamma rays
Ultraviolet (UV)
Infrared (IR)
Microwaves
Radar
Radio
Broadcast band
Short Wavelenghts
Long Wavelengths
Ultraviolet (UV)
Visible Light
Infrared (IR)
400 nanometers
500 nanometers
600 nanometers
700 nanometers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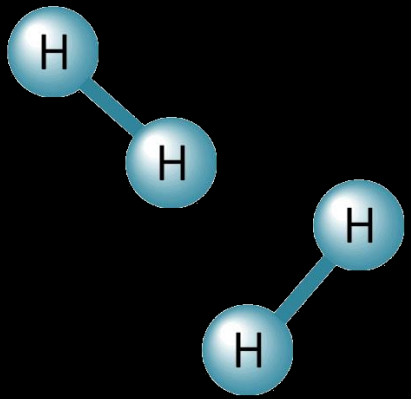
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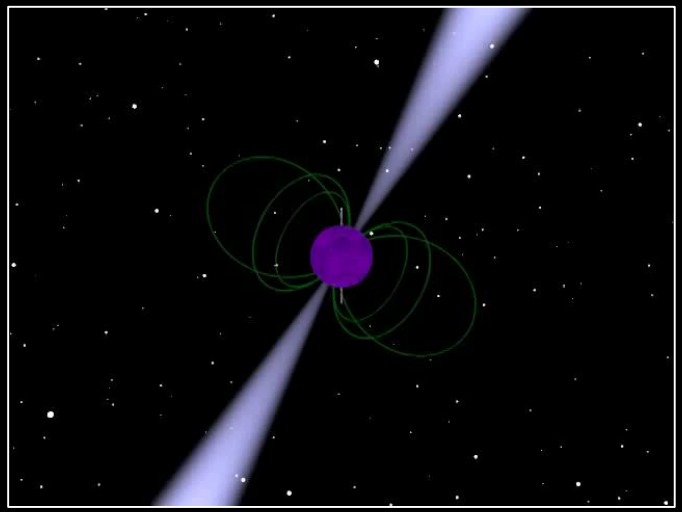

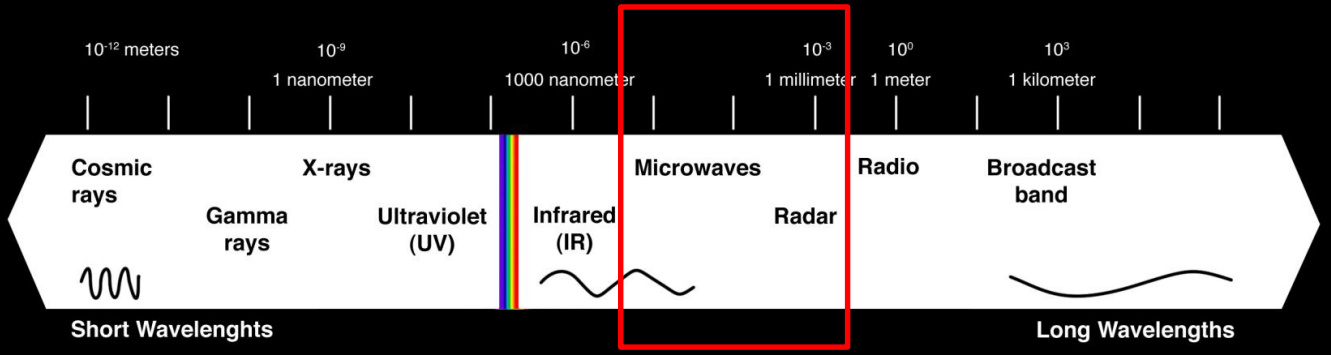
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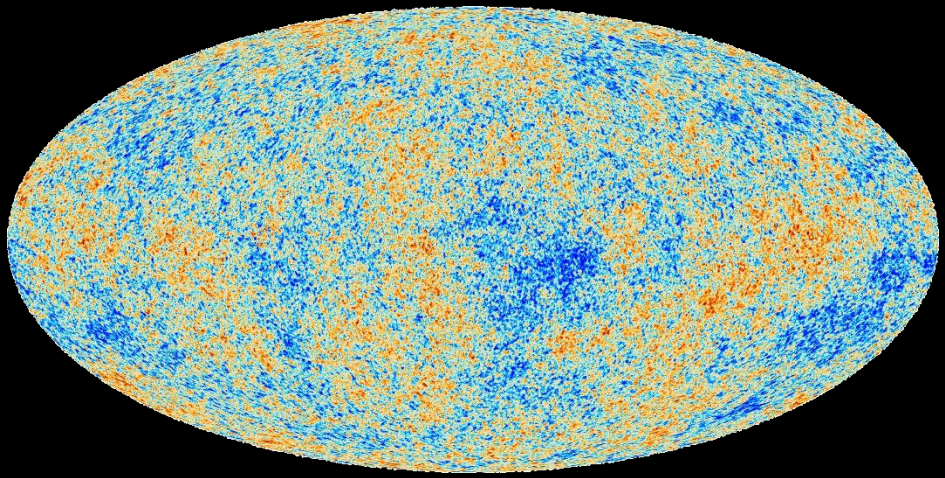

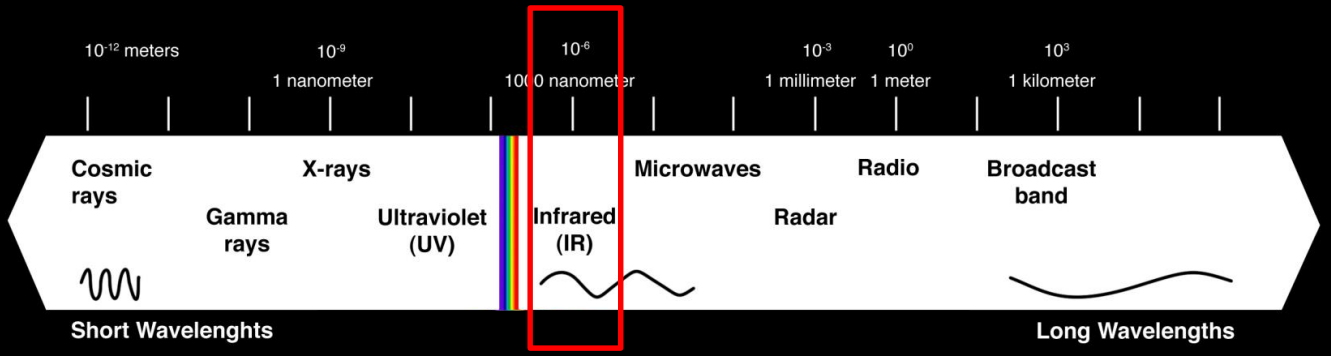
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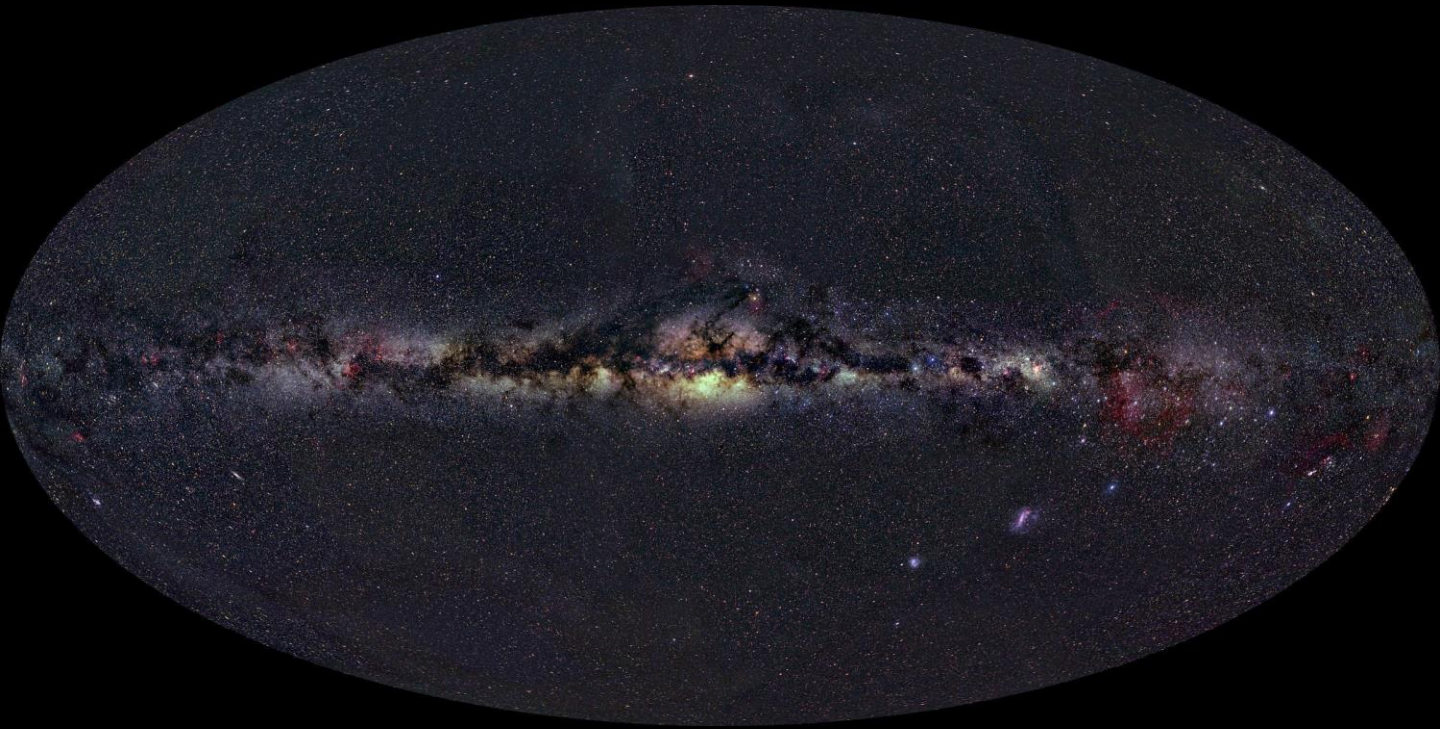

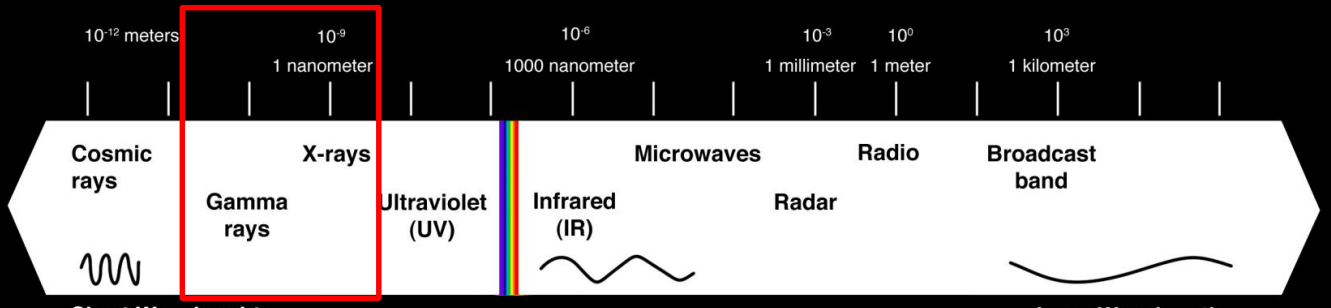
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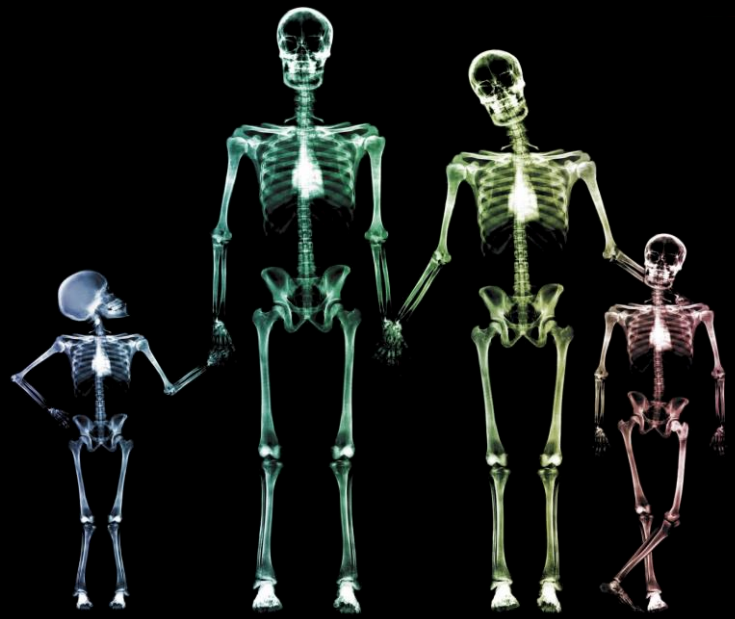
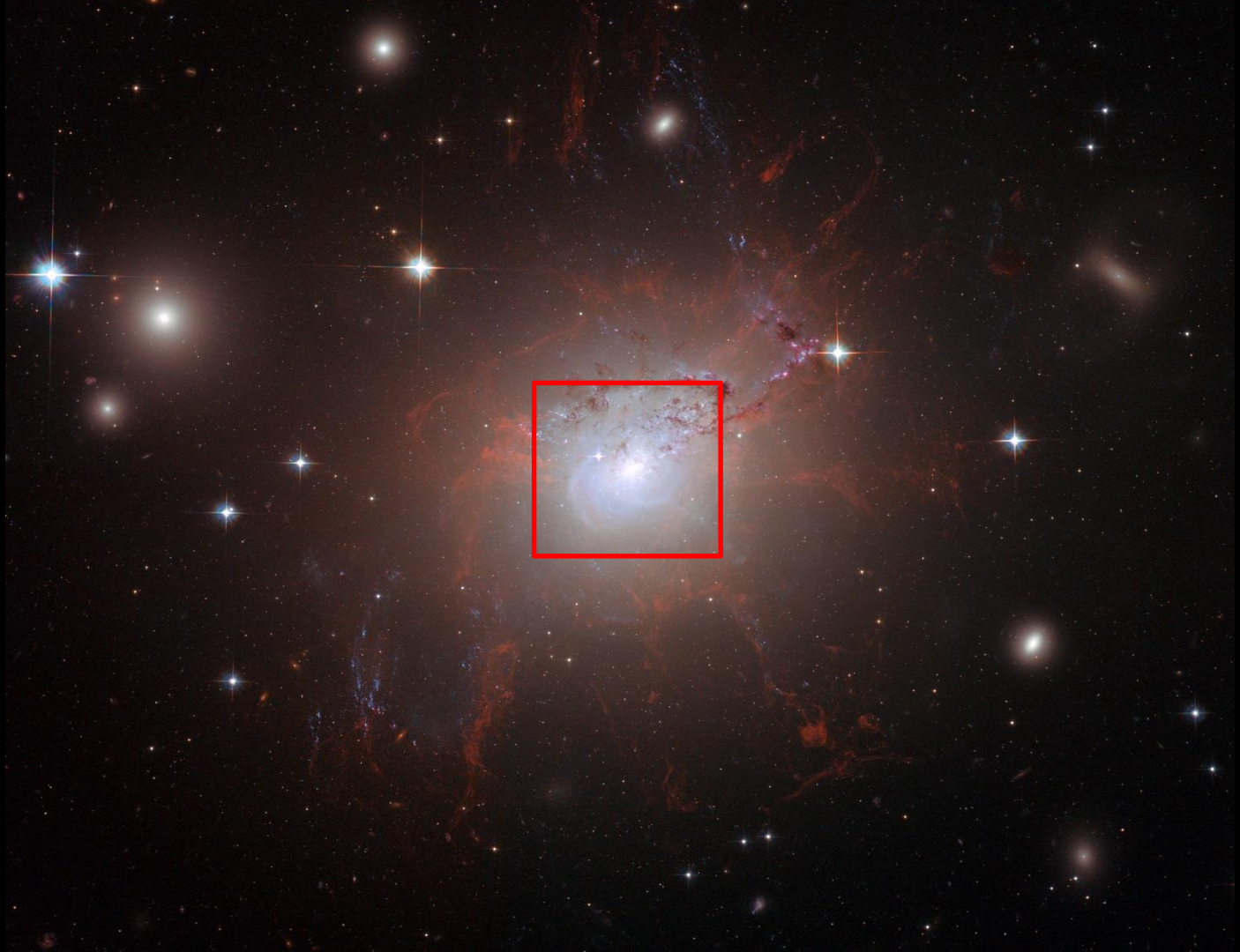


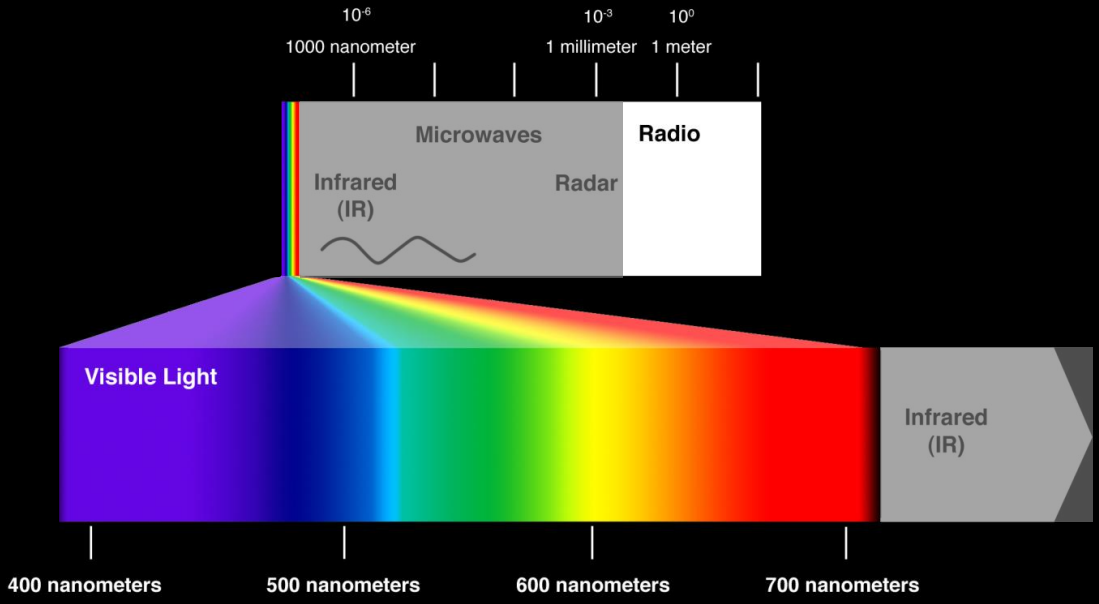


Ground-based telescopes

Ground-based telescopes

1. They're "cheap"
2. They're easier to maintain
3. You can upgrade them
4. You can use different instruments for different types of science

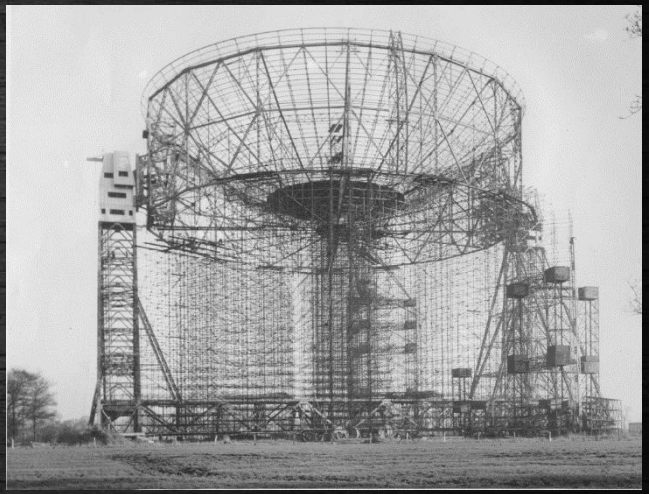
What can we see on the ground?



Radio Telescopes

- First ‘detectors’ built in 1930s
- First ‘dish’ telescope - 1937
- Rap
- By
tele

Mk I Telescope – Jodrell Bank



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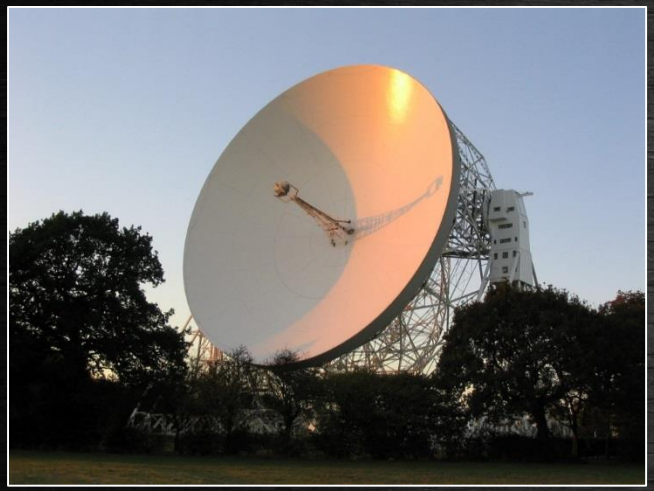


Why are radio telescopes so large?

- Sensitivity

Why are radio telescopes so large?

- All telescopes are limited in resolution

$$\text{Resolution} = 1.22 \times \frac{\text{Wavelength}}{\text{Telescope Diameter}}$$

- Depends on:
  - Telescope diameter
  - Wavelength

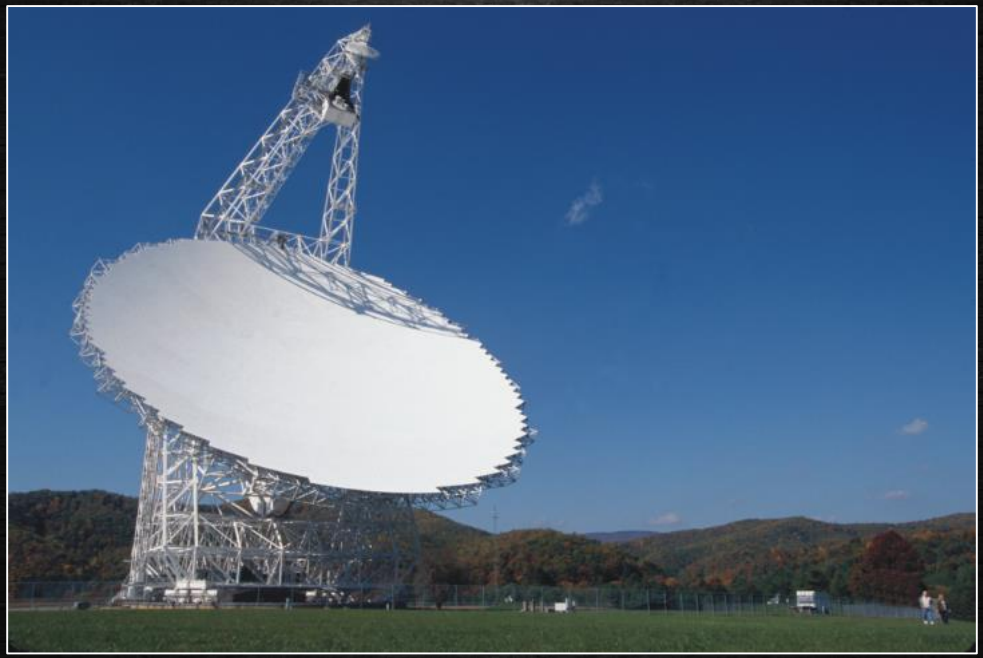
The Biggest Radio Telescopes

- Largest Filled Aperture

Arecibo Radio Telescope – 305m

The Biggest Radio Telescopes

- Largest Fully Steerable



Green Bank Telescope – 100x110m

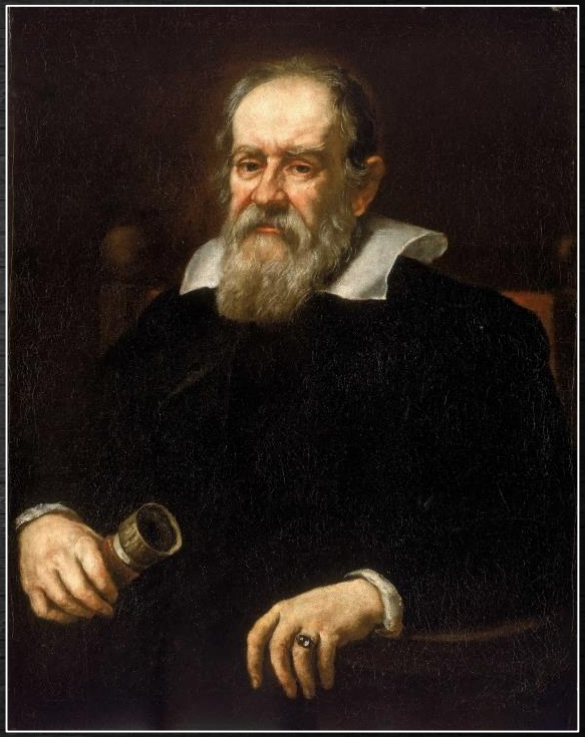
The Biggest Radio Telescopes

- Largest Overall

RATAN-600 – 576m

Optical Telescopes

- Galileo – 1609

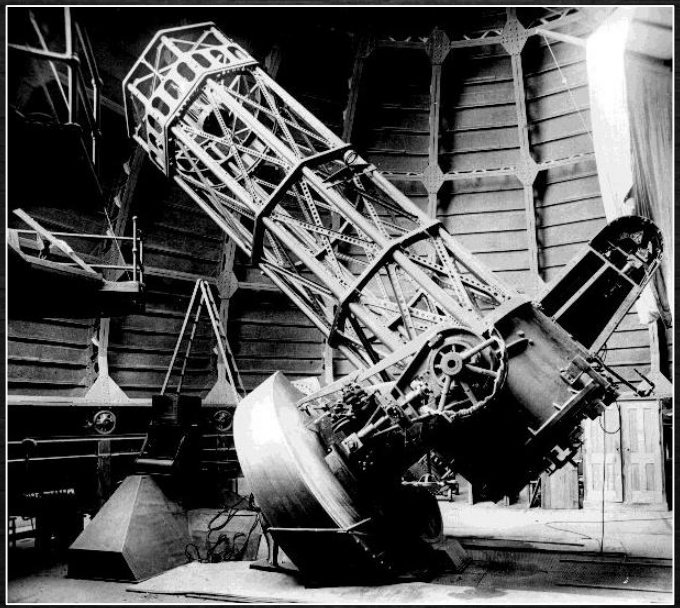


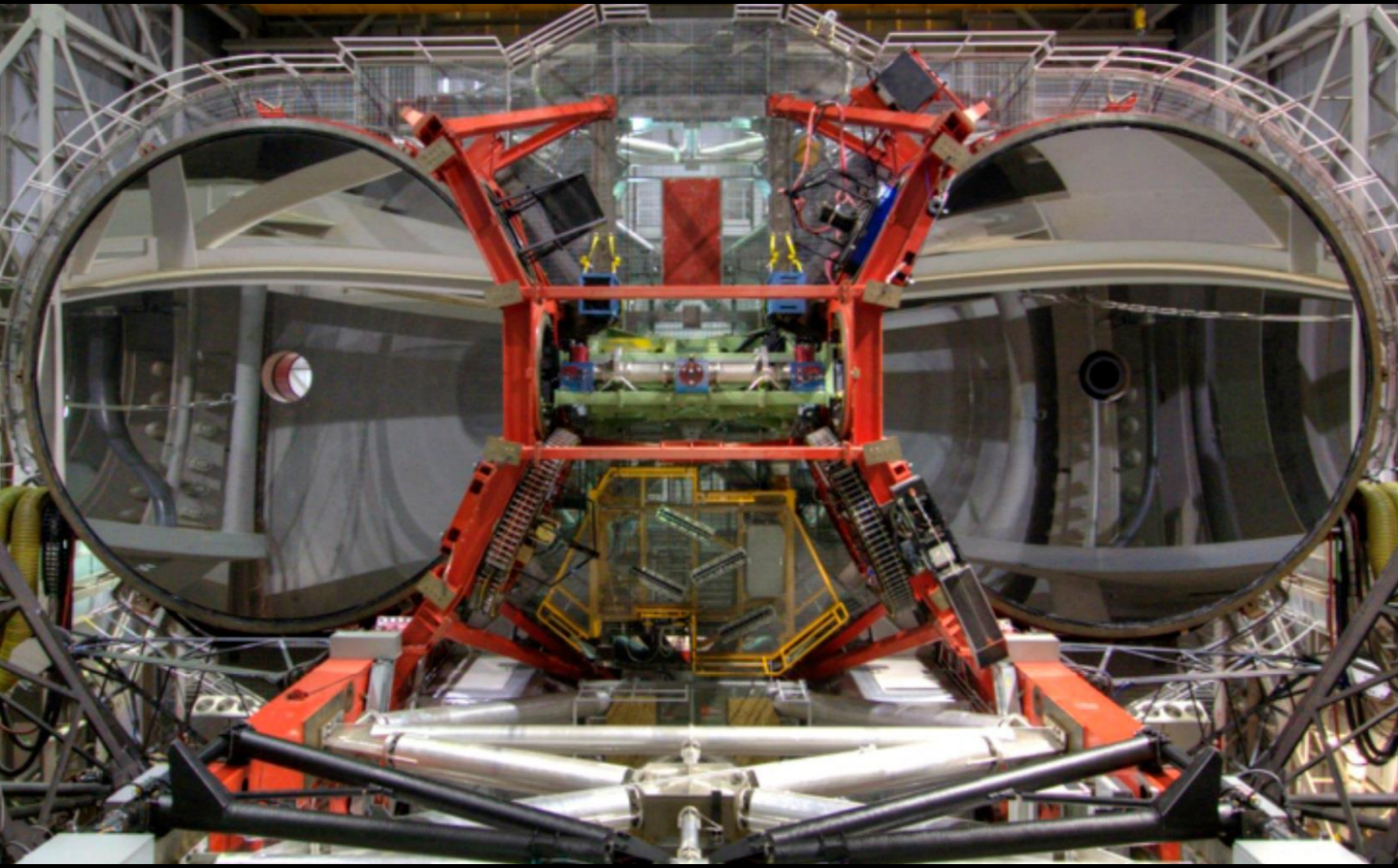
Optical Telescopes

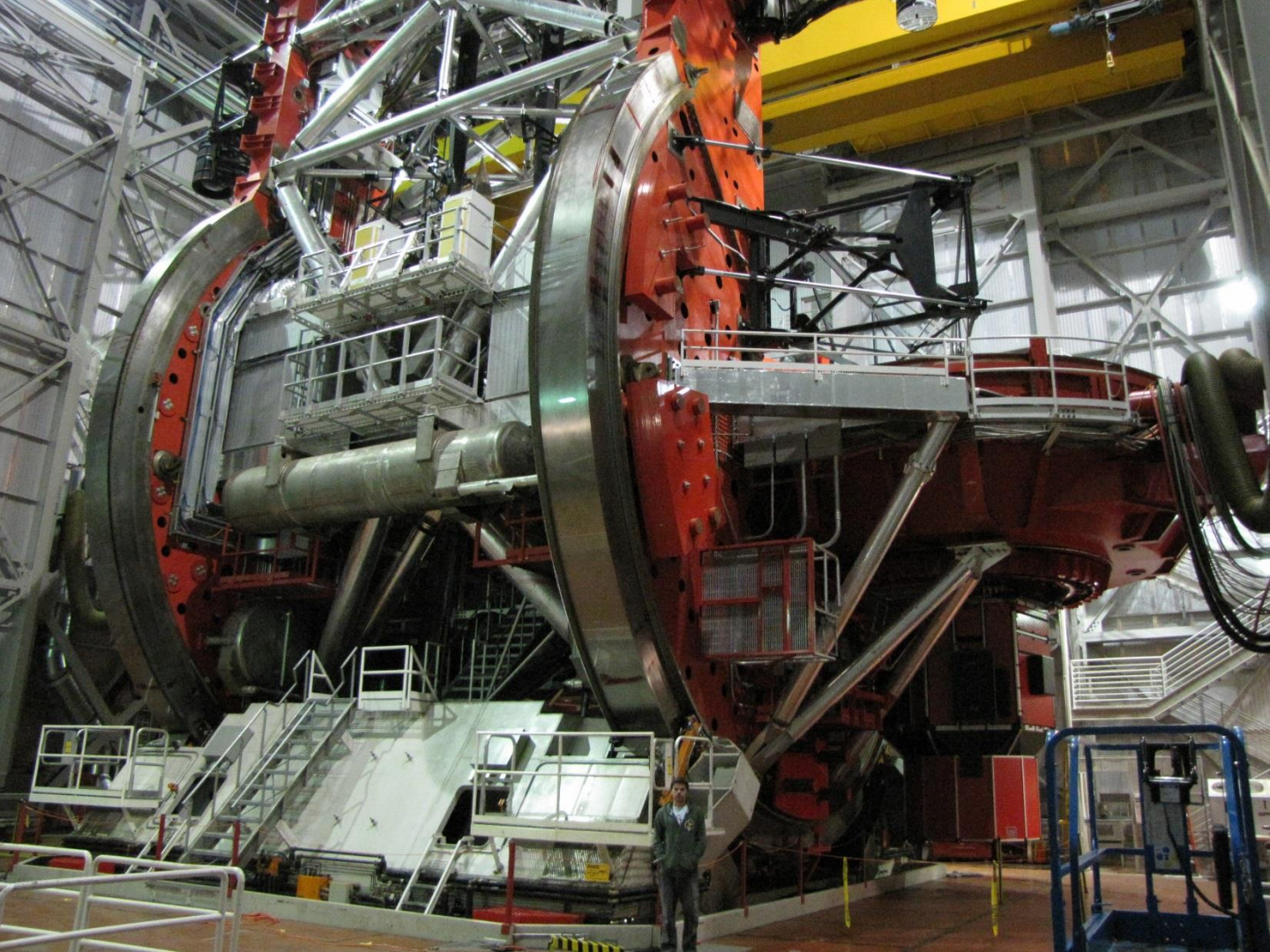
- Refracting Telescopes
  - Limited by size of lens

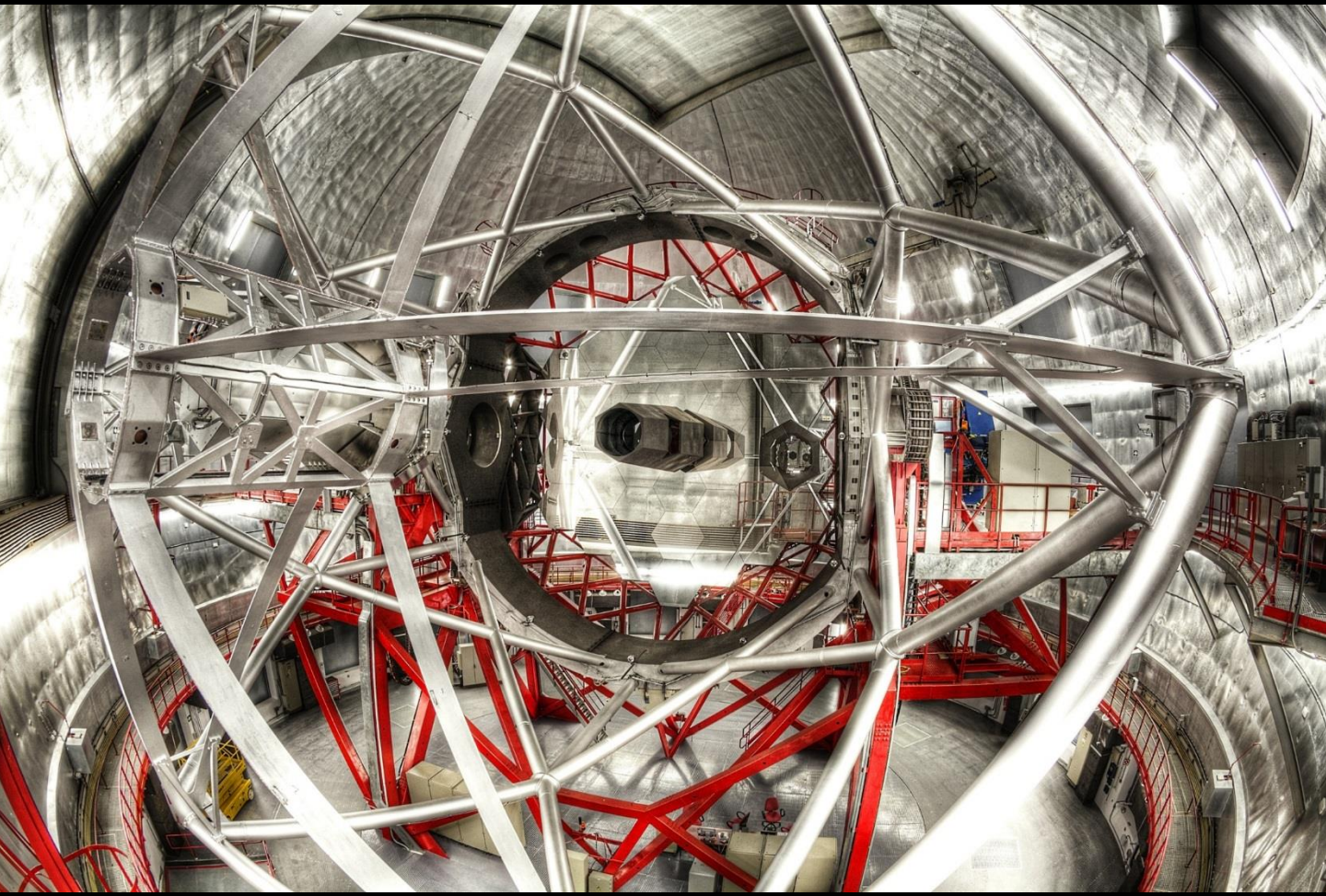
Optical Telescopes

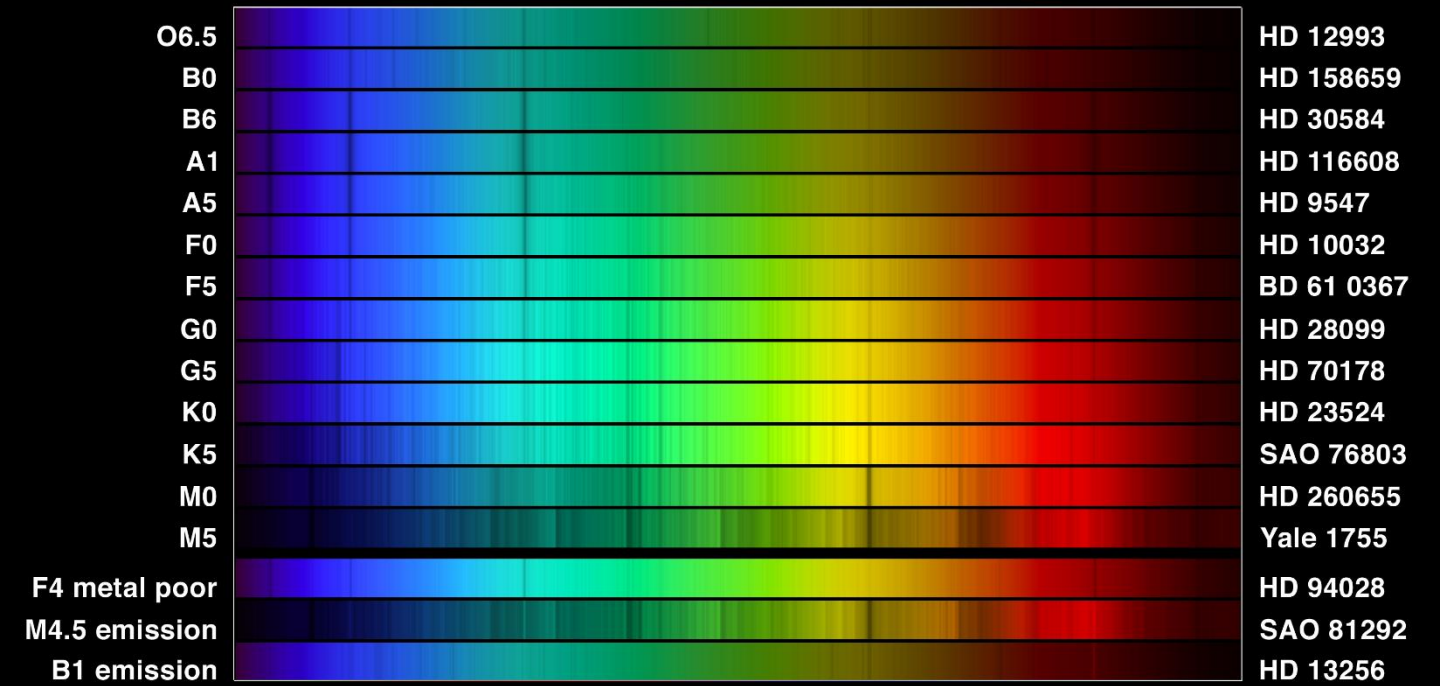
- Reflecting Telescopes
  - Easier to make mirrors







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M0
M5
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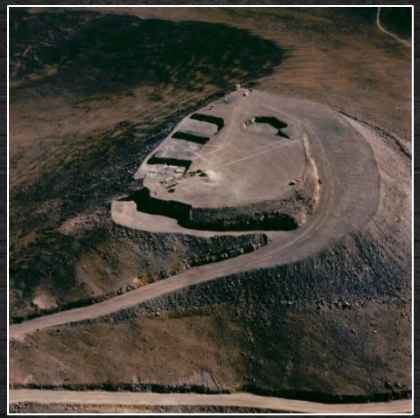
M4.5 emission
B1 emission
HD 12993
HD 158659
HD 30584
HD 116608
HD 9547
HD 10032
BD 61 0367
HD 28099
HD 70178
HD 23524
SAO 76803
HD 260655
Yale 1755
HD 94028
SAO 81292
HD 13256

Building the VLT

- European Southern Observatory
  - Today made up of 15 member states
- Agreed to build VLT in December 1987
- Problem 1: Choose a site
- P
- P
- T

Building the VLT

Cerro Paranal
1991

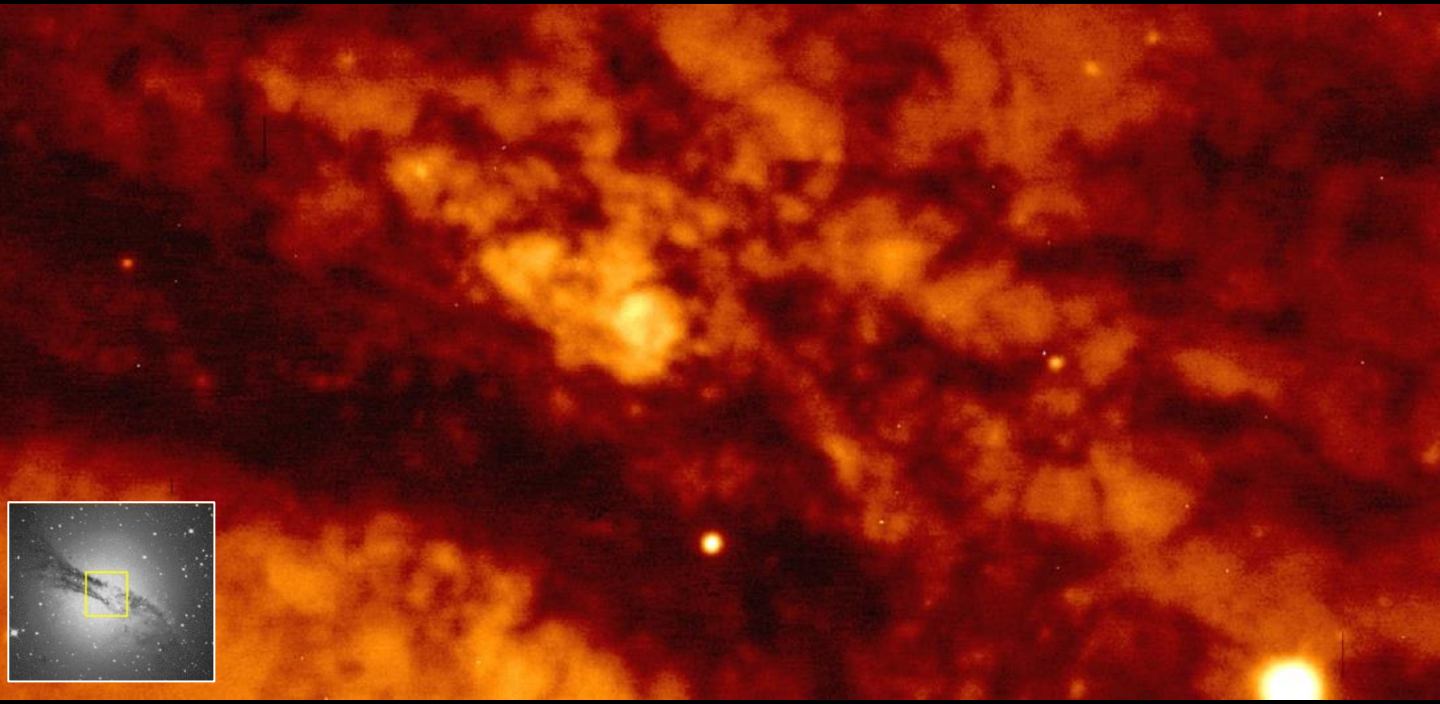


1994

Paranal Observatory
1999


FERROVIAL
IVECO

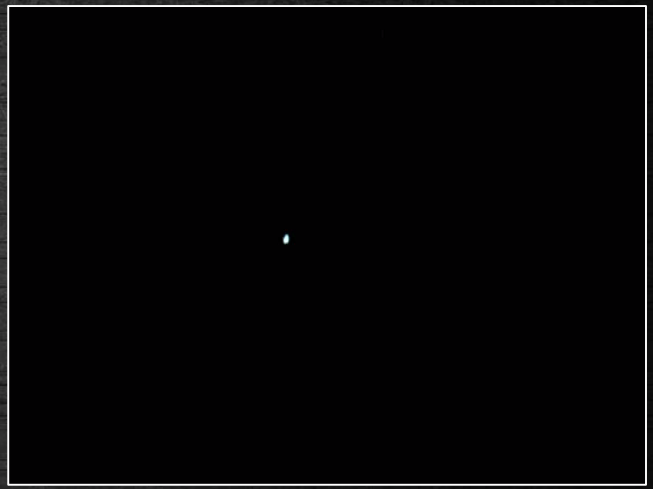

E.S.O. PARANAL
WELCOMES "JOE"
The first VLT Mirror
GONDRAND
REOSC
VERY LARGE TELESCOPE
GONDRAND



The problem with big telescopes

- We have an atmosphere…
- There's a finite size single telescope we can build

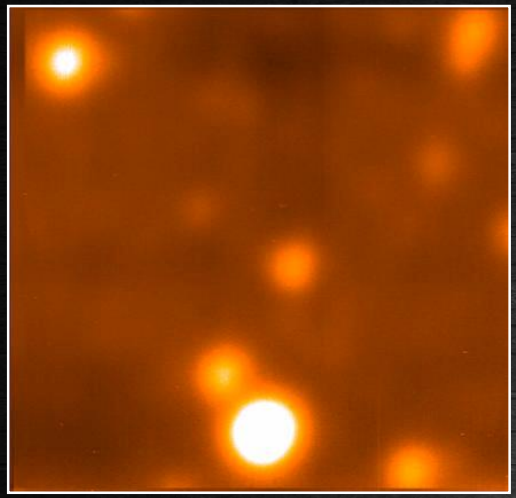
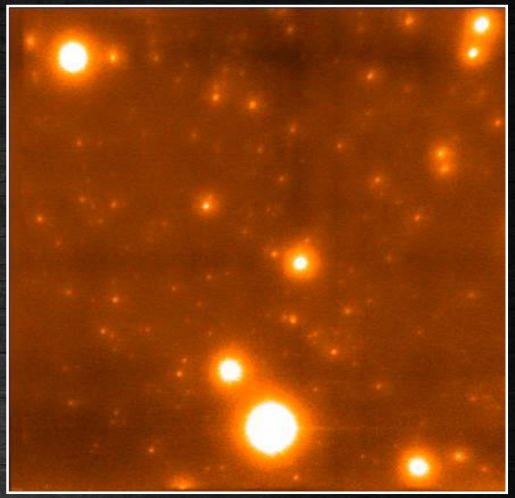
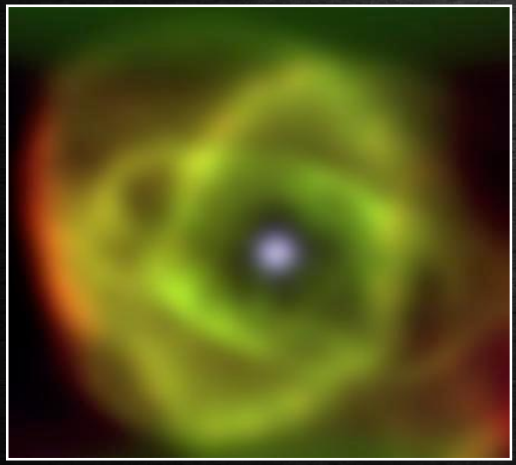
Atmospheric Turbulence



Correcting for the atmosphere

- The simple option:
  - Go to space!
- Correct for the effects on the ground

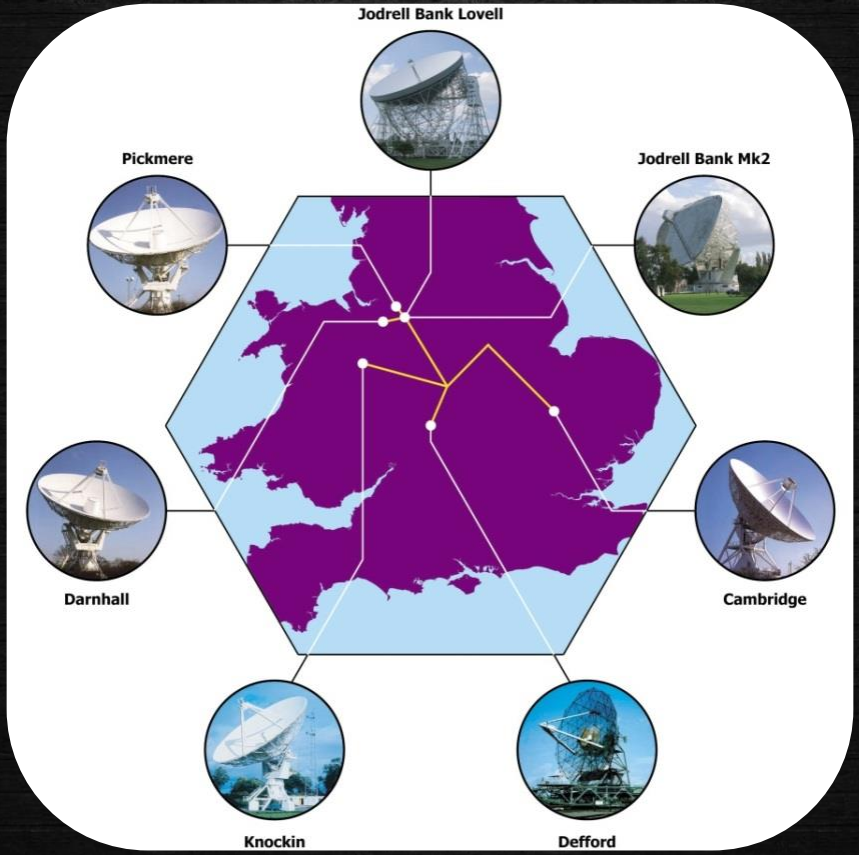
$ £ €

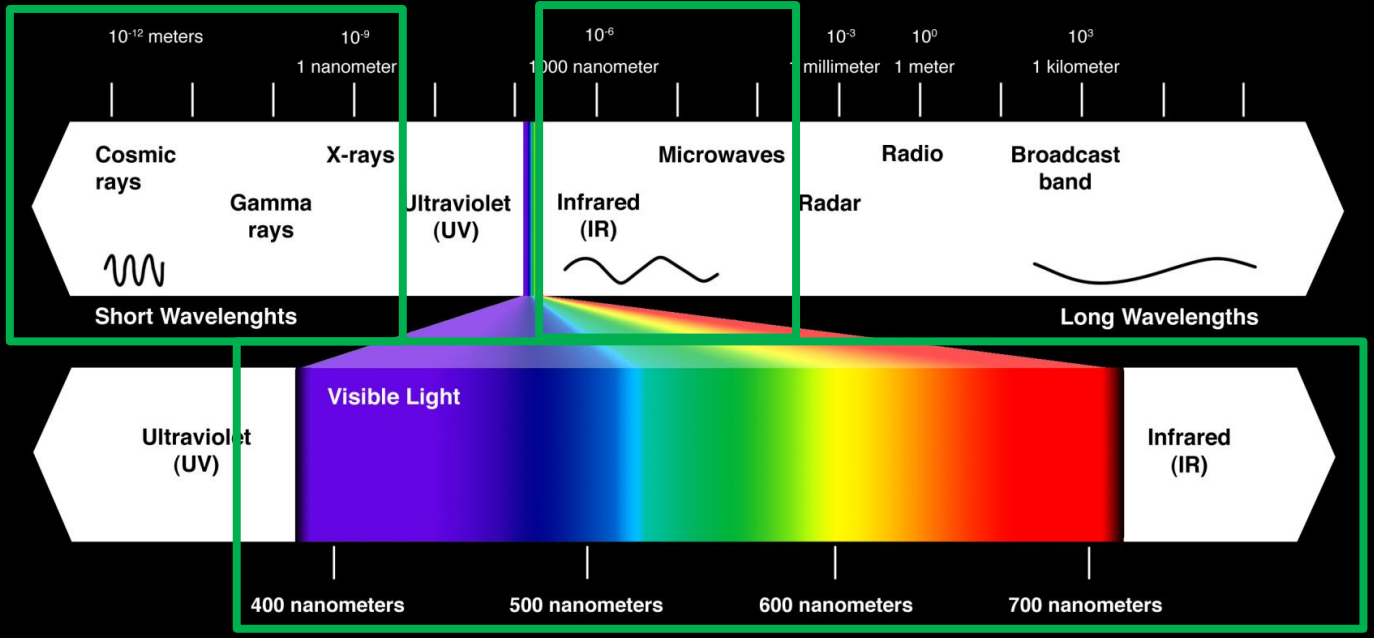

Even bigger telescopes?

- We can combine multiple telescopes together to get even better resolution

Merlin & E-Merlin



Space Telescopes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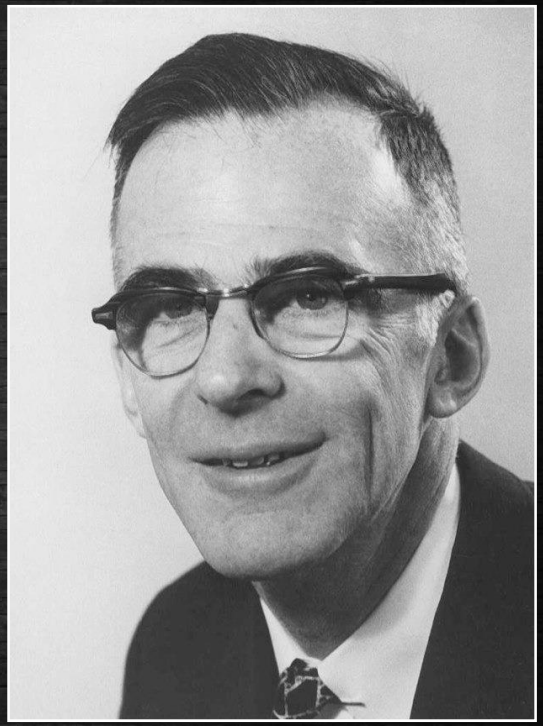
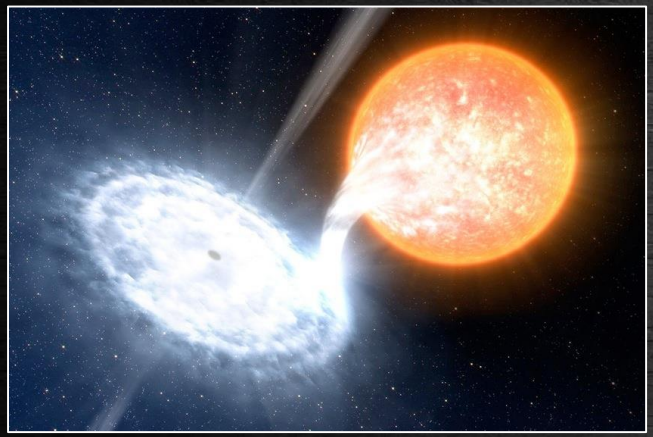
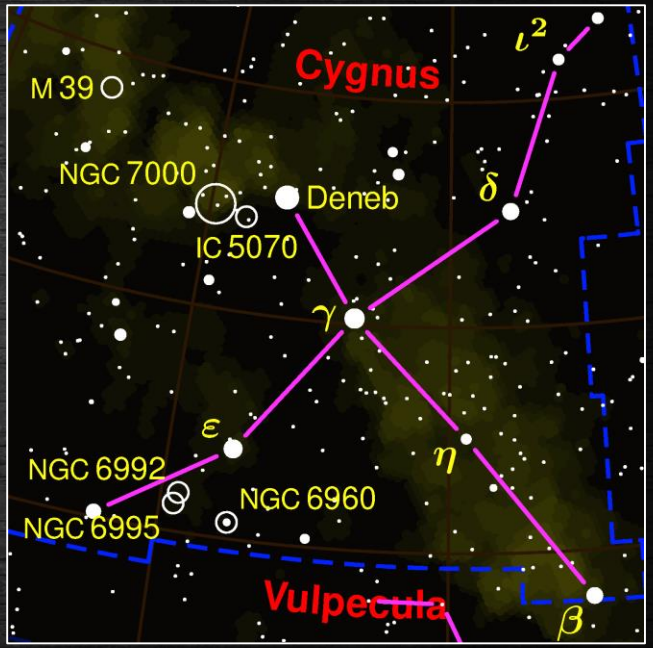
The beginnings of space telescopes

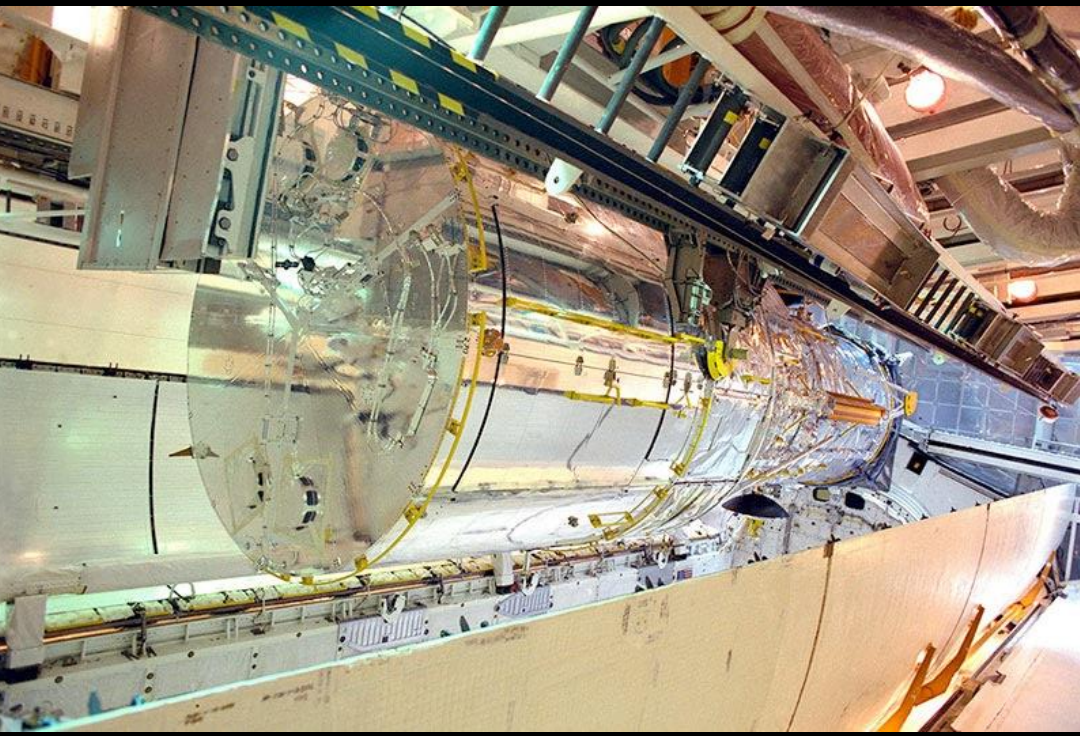
- First proposed by Hermann Oberth in 1923
- Lyman Spitzer, 1946
  - "Astronomical Advantages of an Extra-Terrestrial Observatory"



The First X-ray satellite - Uhuru

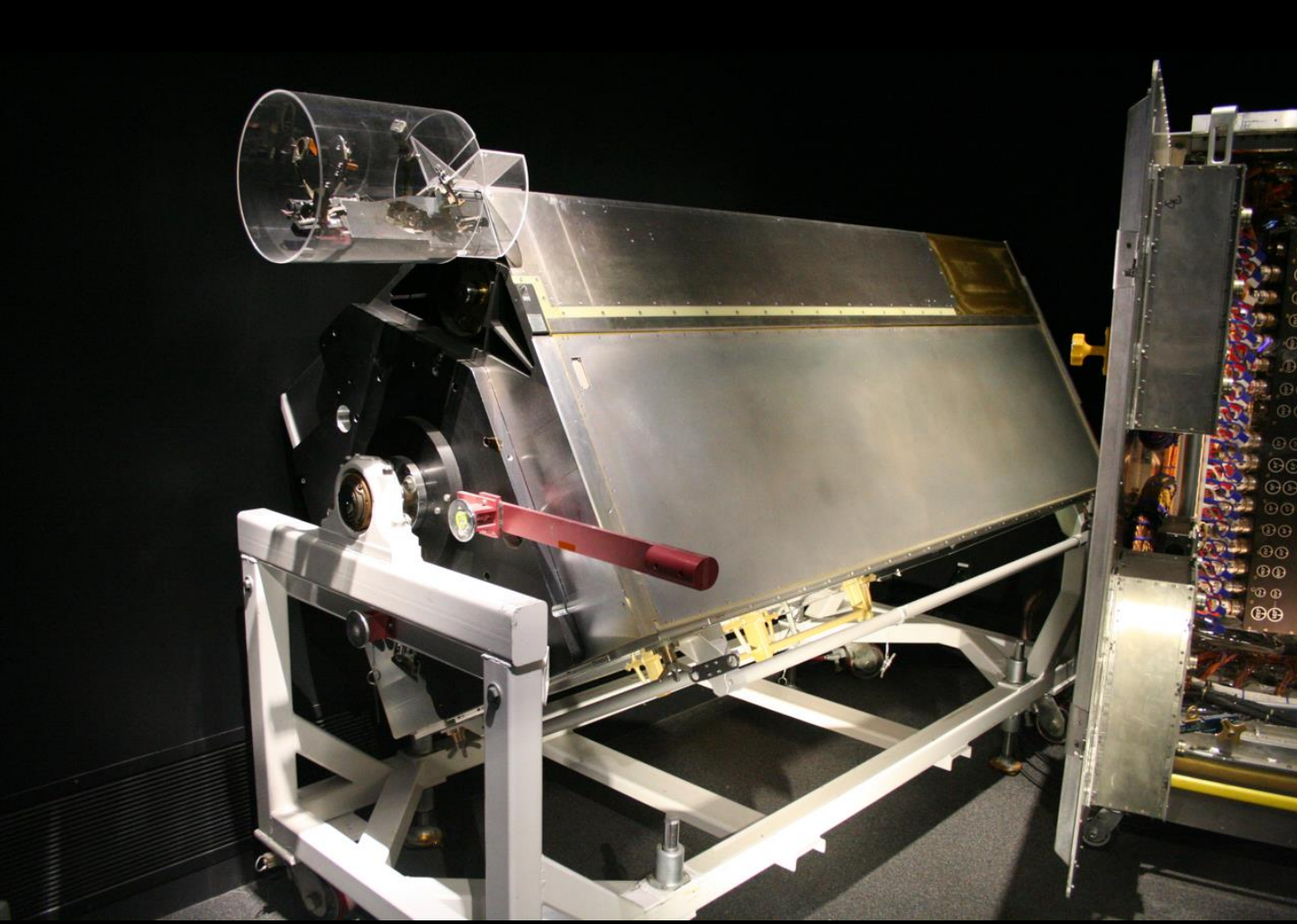


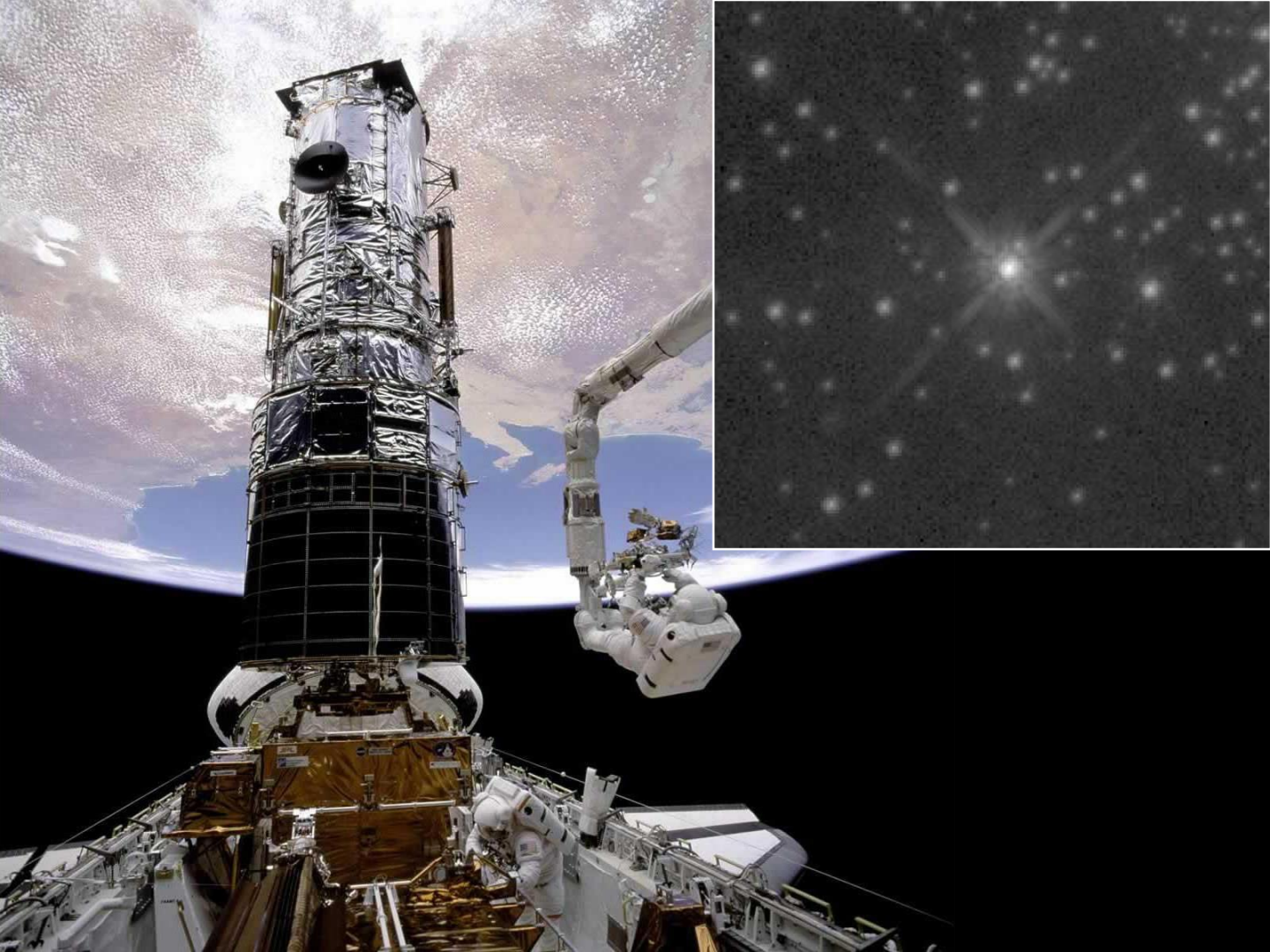





Canada

Pix Nixed as Hubble Sees Double






ACS


COS
HUBBLE SPACE TELESCOPE
COS

Astronomy Images

What astronomy images mean?

- We've all seen the fantastic astronomy images, but what do they mean?

Astronomy Detectors

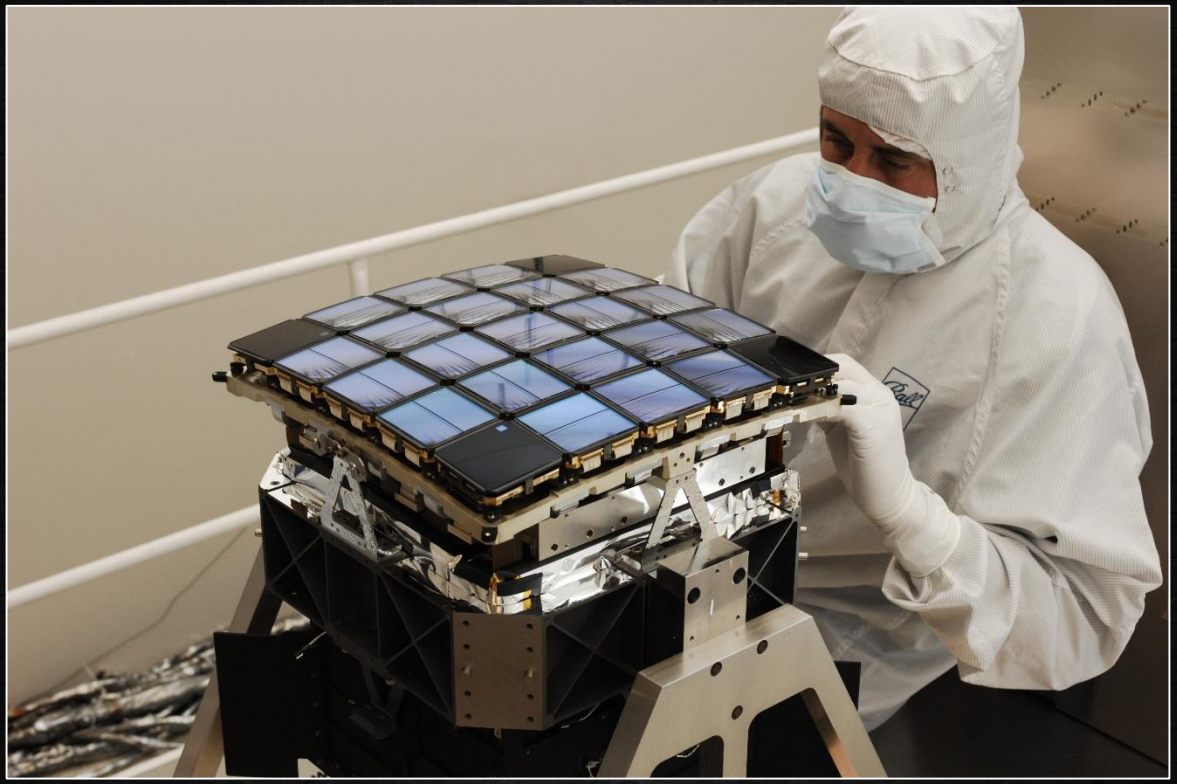
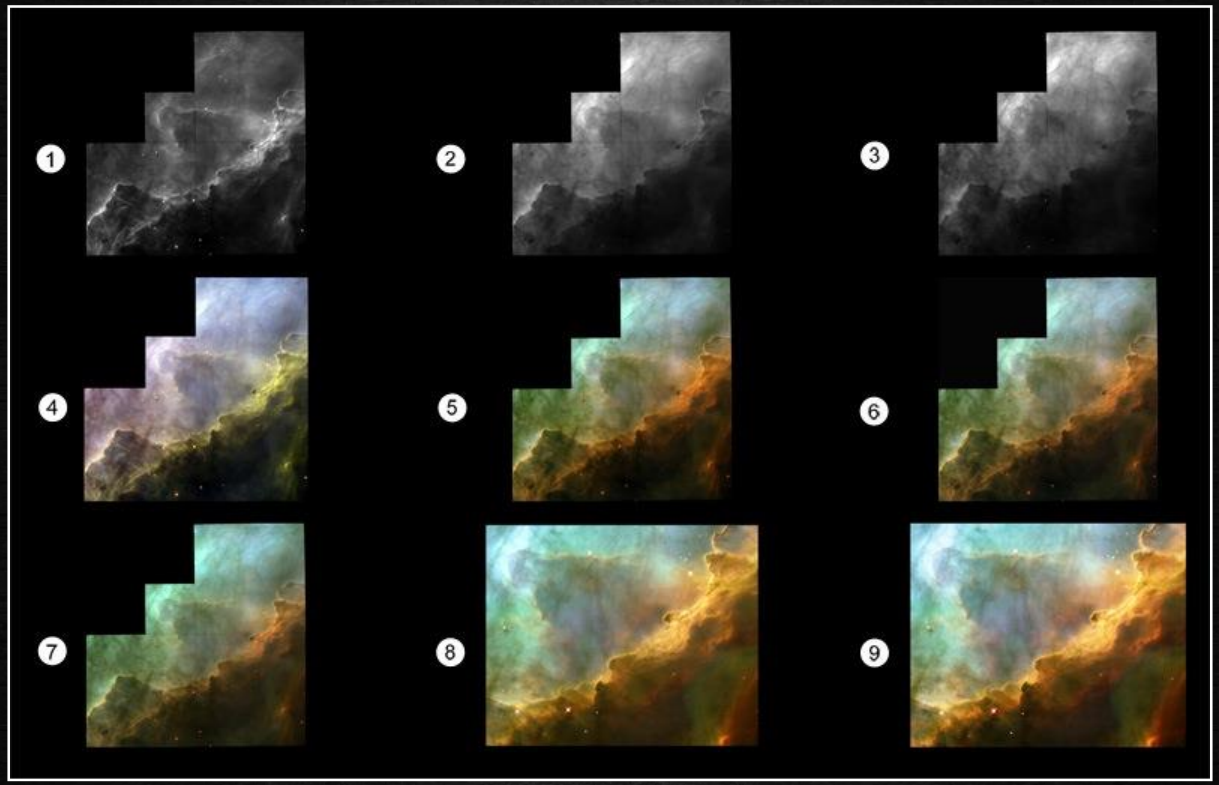
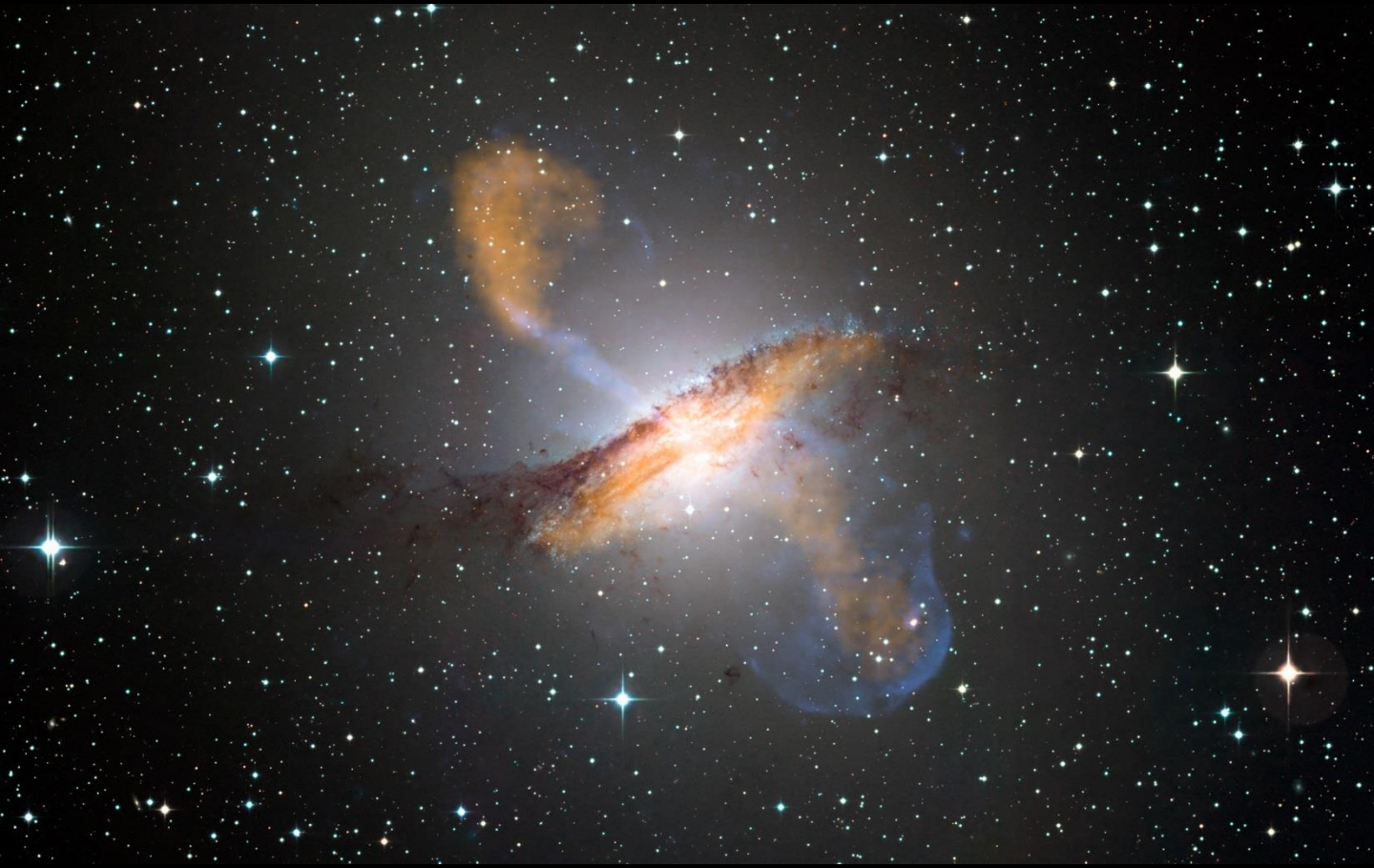
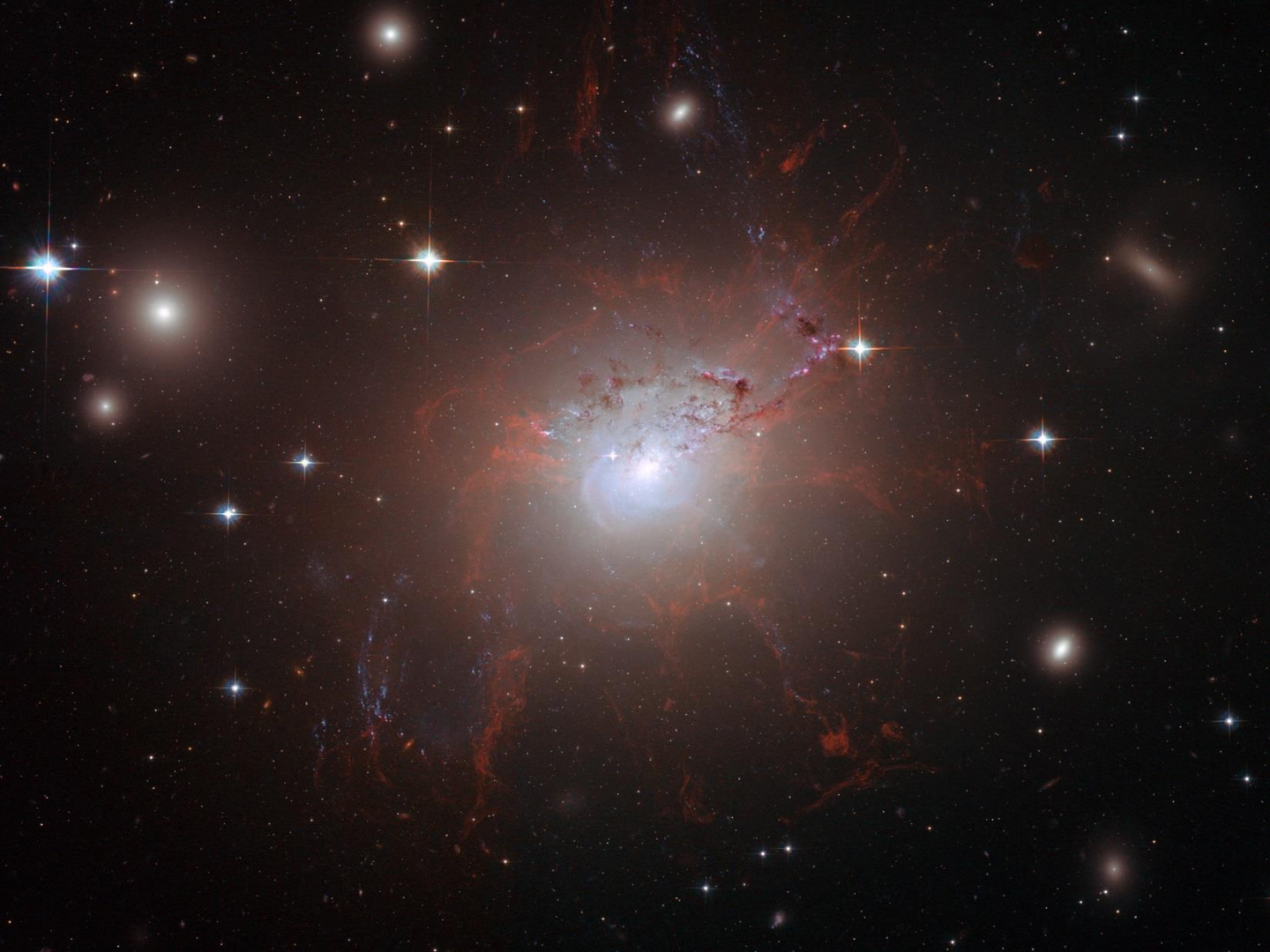
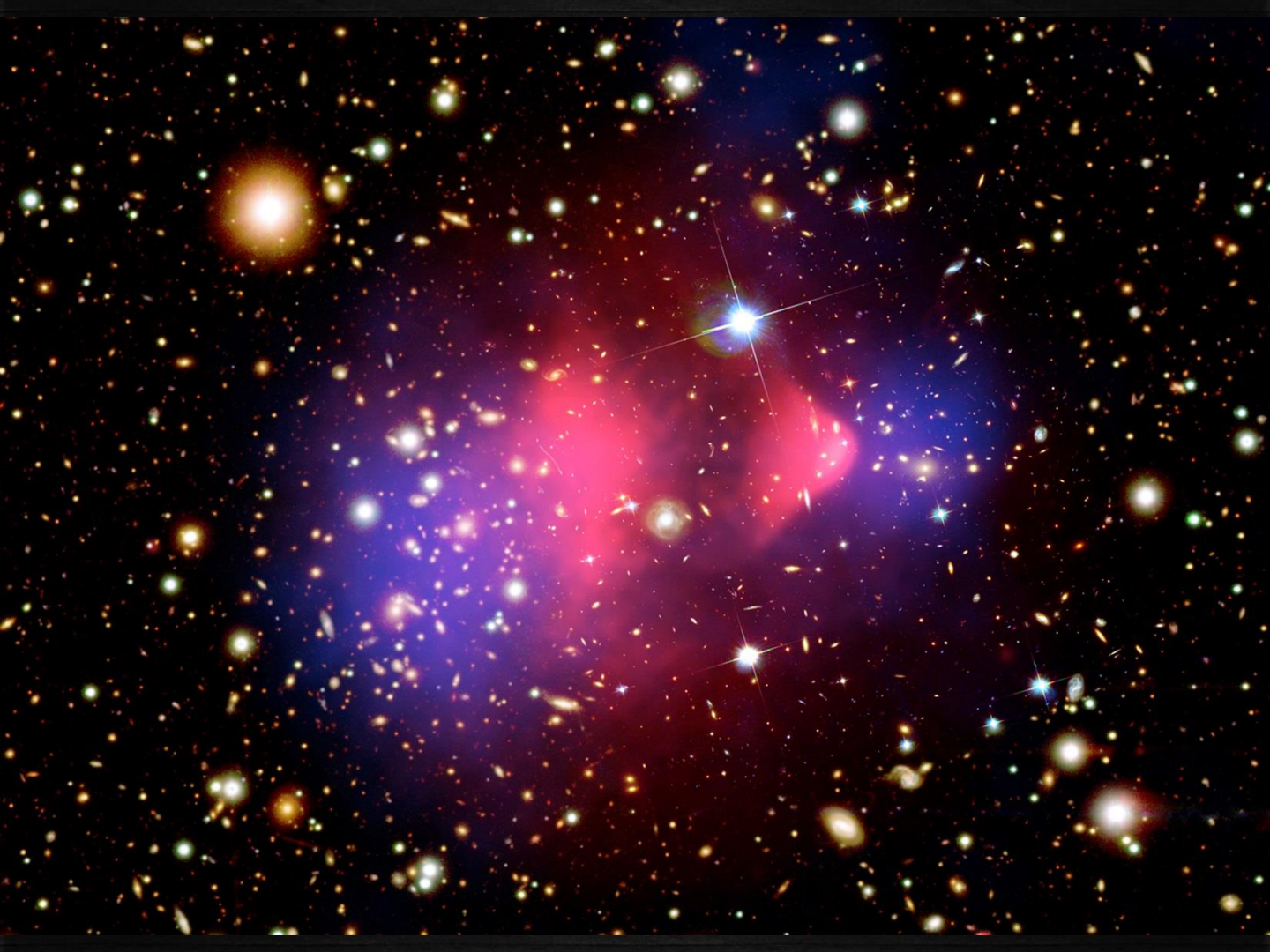


Image processing









Thank you