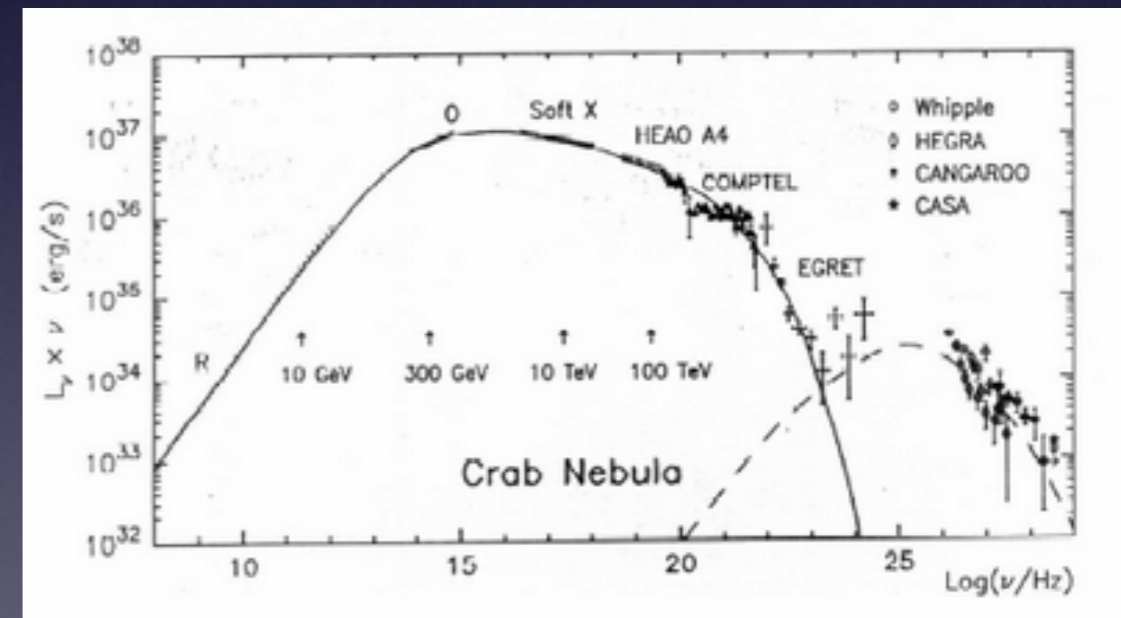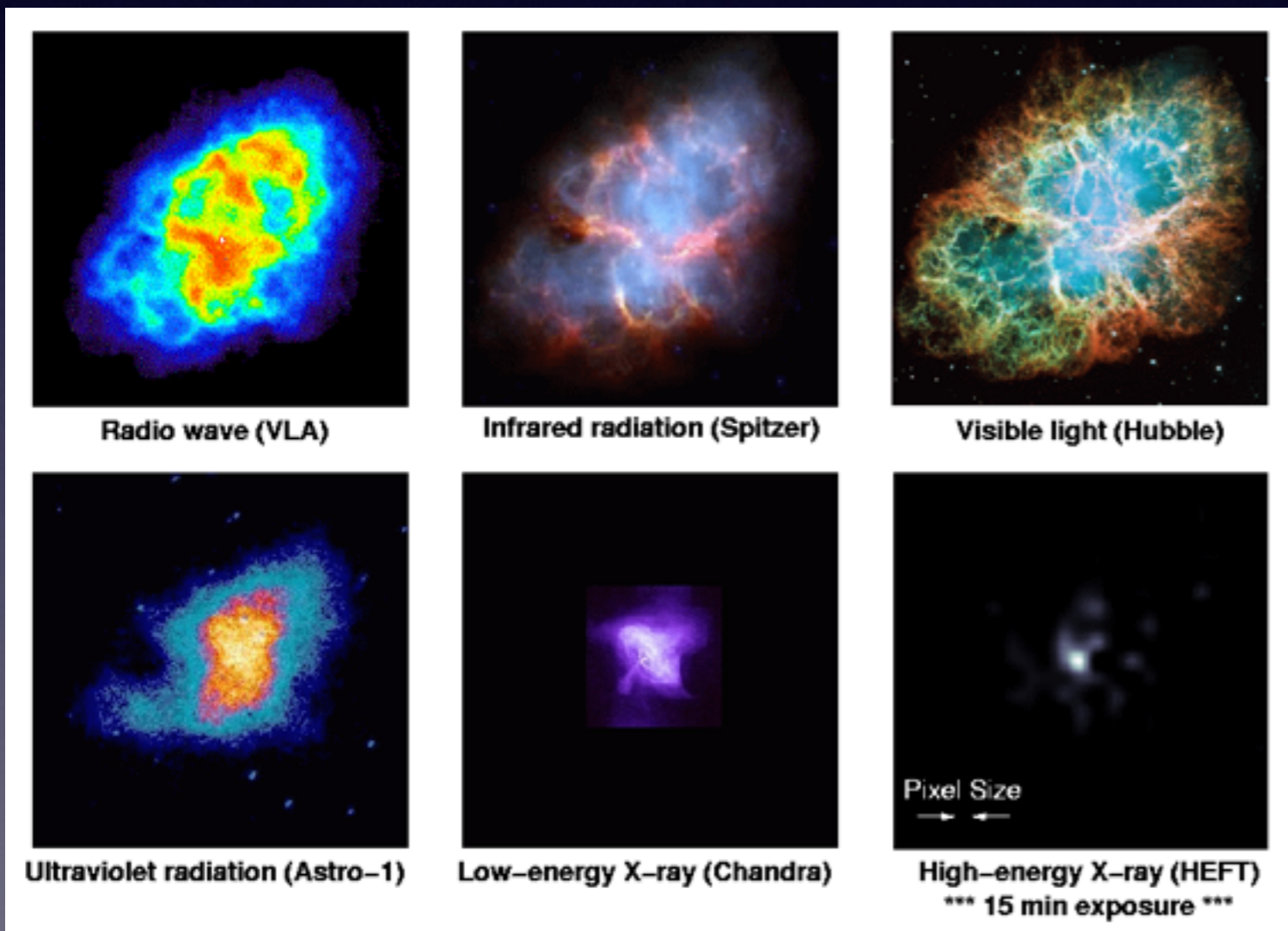# Digitizing the Universe

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Astronomy

- Astronomy has a long history as a science

- Many objects and structures in the Universe are not yet fully understood

- Universe is a large 'lab'

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Information channels

- Two types: Imaging and Spectroscopy

- Additionally: Time domain

Radio wave (VLA)

Infrared radiation (Spitzer)

Visible light (Hubble)

Ultraviolet radiation (Astro–1)

Low-energy X–ray (Chandra)

High-energy X–ray (HEFT)
*** 15 min exposure ***

Pixel Size

Crab Nebula

History of taking observations

- At first, by eye writing down positions and magnitudes

- First, progress to improve eyesight:

  - Tycho Brahe's mural quadrant (~1600)

  - Telescope (~1610)

- Then, eliminate the need of looking through telescopes

  - Chemical plates: Wet (~1850), Dry (~1880), Kodak plates (~1900)
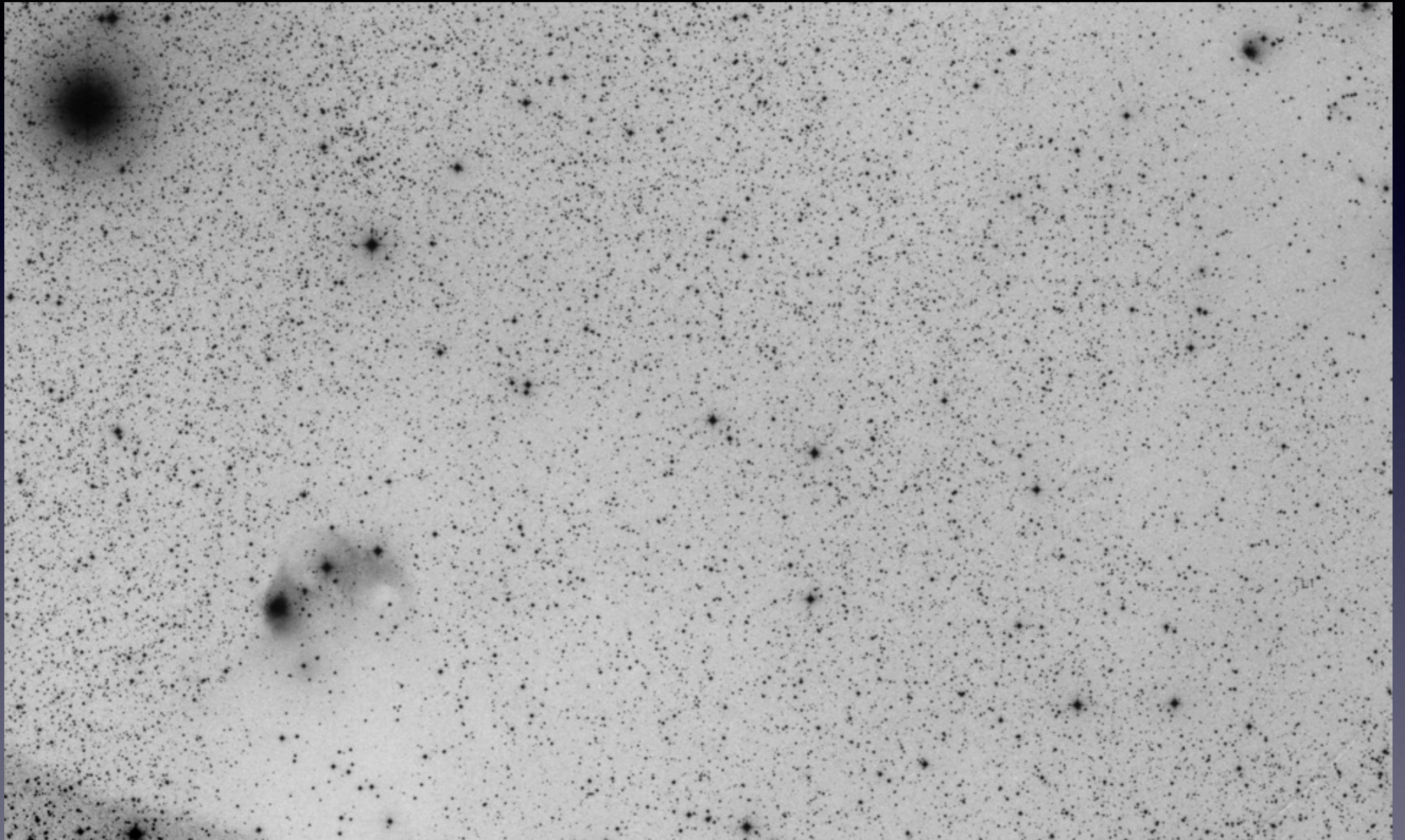
  - CCD (~1970)

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History of taking observations

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Past, current, and future surveys

- Completed: COSMOS, SDSS, …

- On-going: DES, KiDS, HSC, …
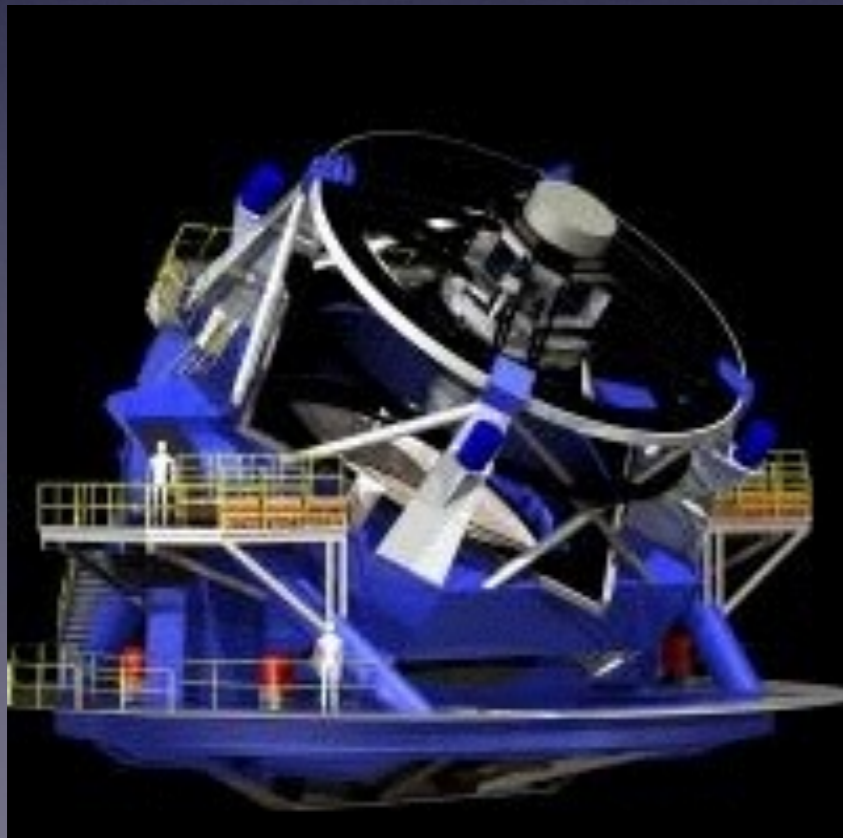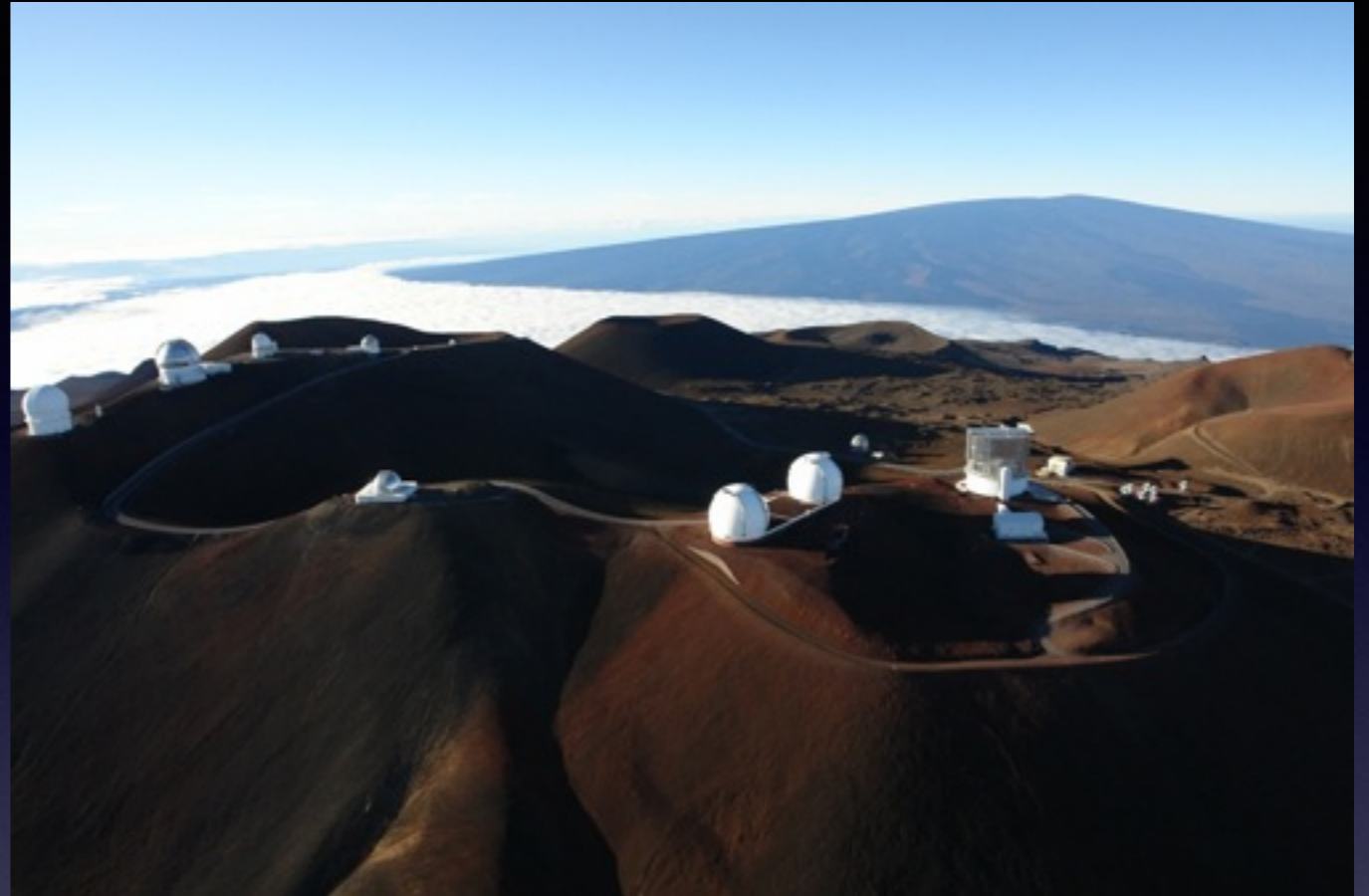
- Future: Euclid, LSST, WFIRST, …

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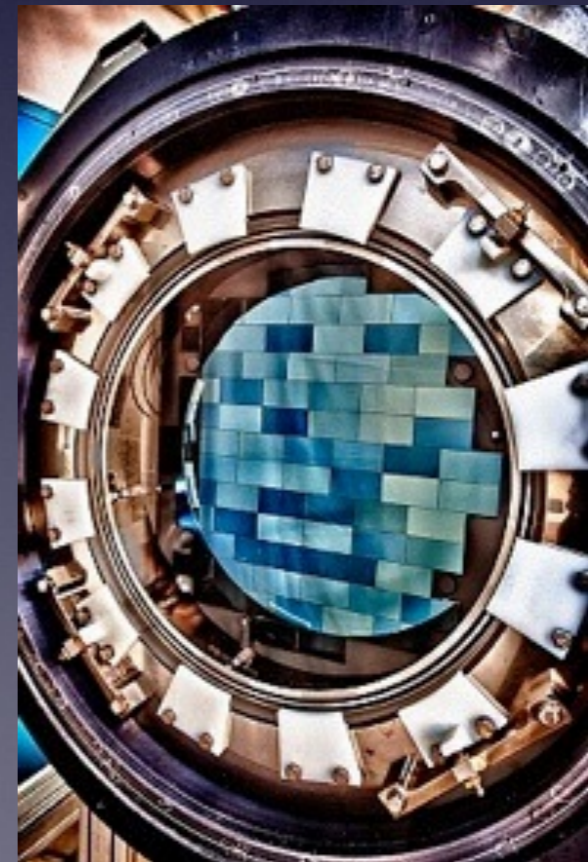
Dark Energy Survey

Blanco 4m at CTIO (Chile)

2.2 deg Field of View
62 2Kx4K CCDs, 0.26''/pix
g,r,i,z,Y to mag ~24
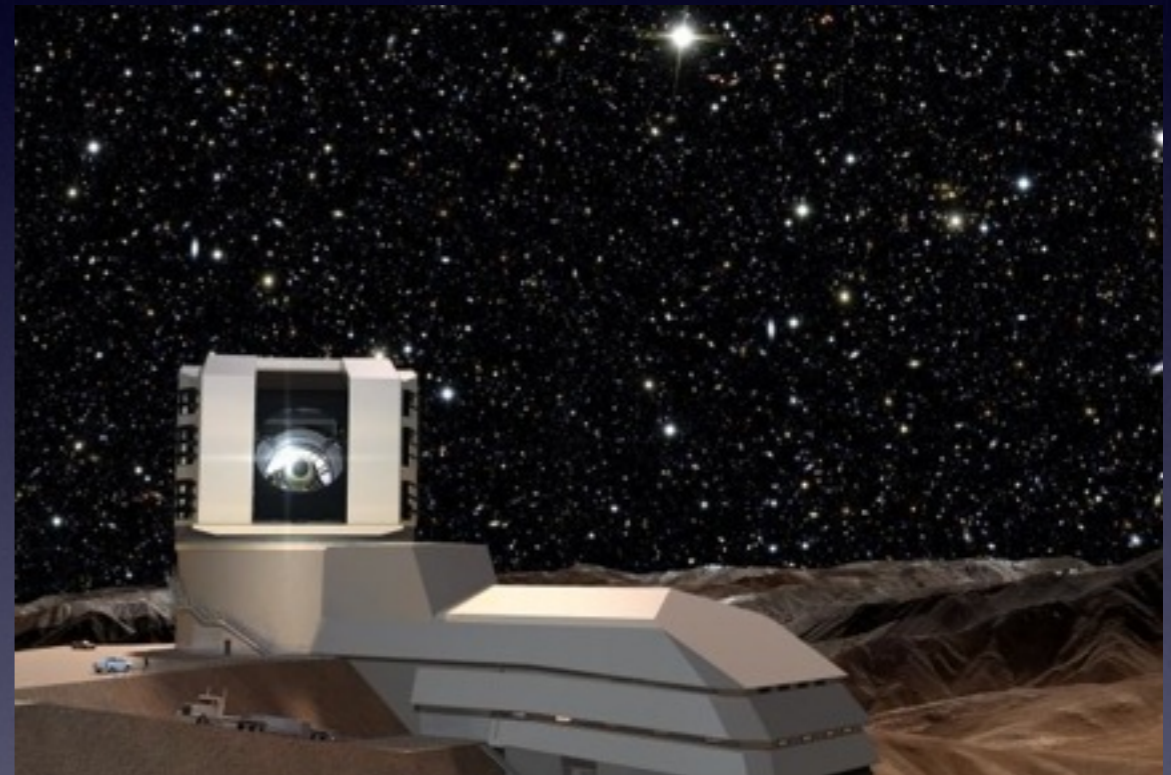
5 yrs, 5000 deg^2 in Southern Sky

Survey started in Sept. 2013!

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Mapping the Sky

- Pixel scale: 1 pixel ≜ 0.2 arcsec

- Whole Sky: ~ 40'000 sq. deg.

- Bits per pixel: 16 Bits

- Thus, whole Sky: ~ 25 TB

- LSST (20'000 sq. deg):

  - Total survey (6 bands, 150 visits): ~ 12 PB

 - Daily volume: 8 TB

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Flexible Image Transport System (FITS)

- Commonly used file format

- Multiple extensions, each split in 'header' and 'data'

- 'Header':

  - Contains information to interpret data ('metadata')

- 'Data':

  - Stores images, tables, spectra, data cubes
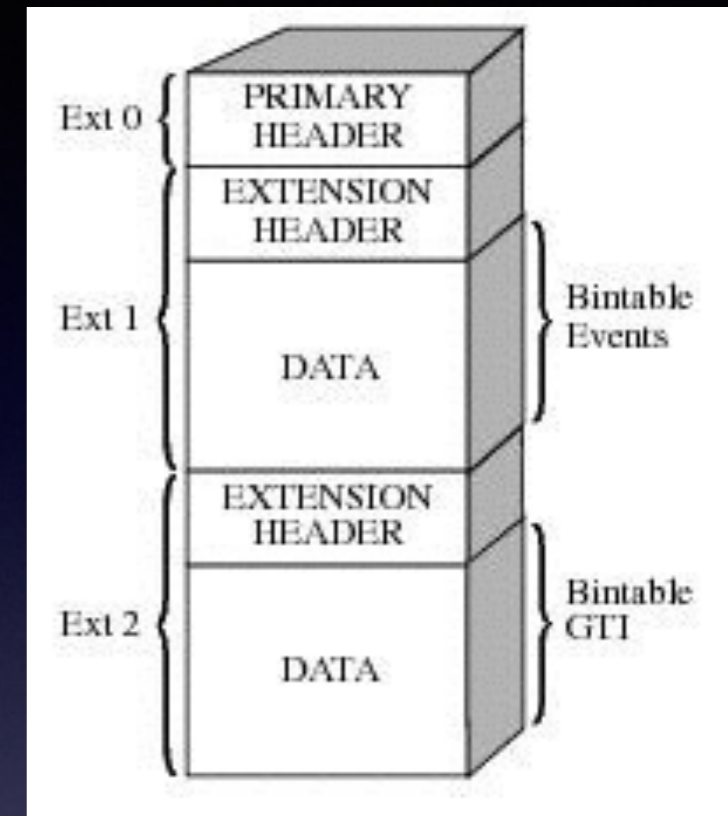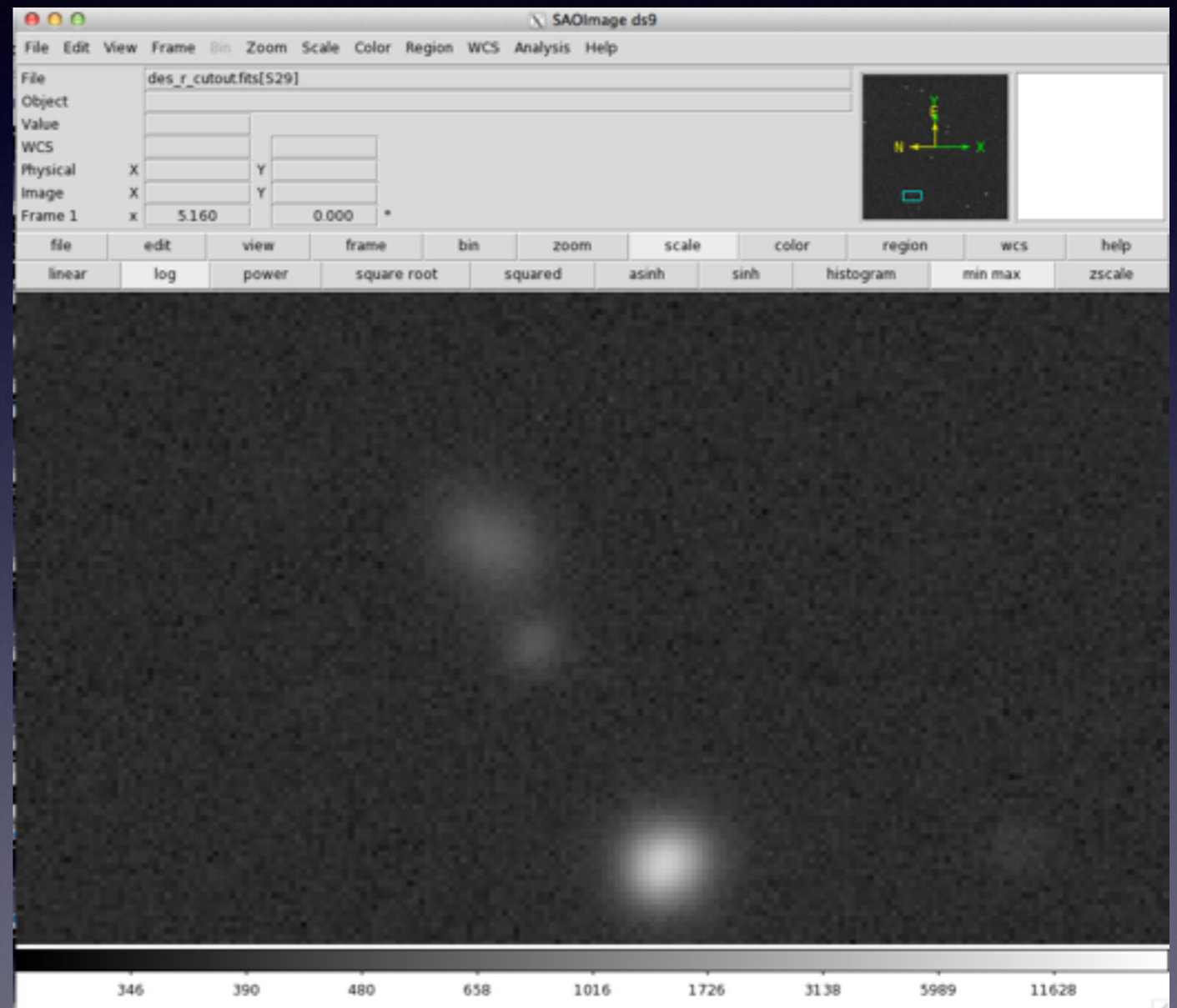
Challenges I: Identify objects

- Visually inspect images (with DS9)

- Extract sources with dedicated software (SExtractor)

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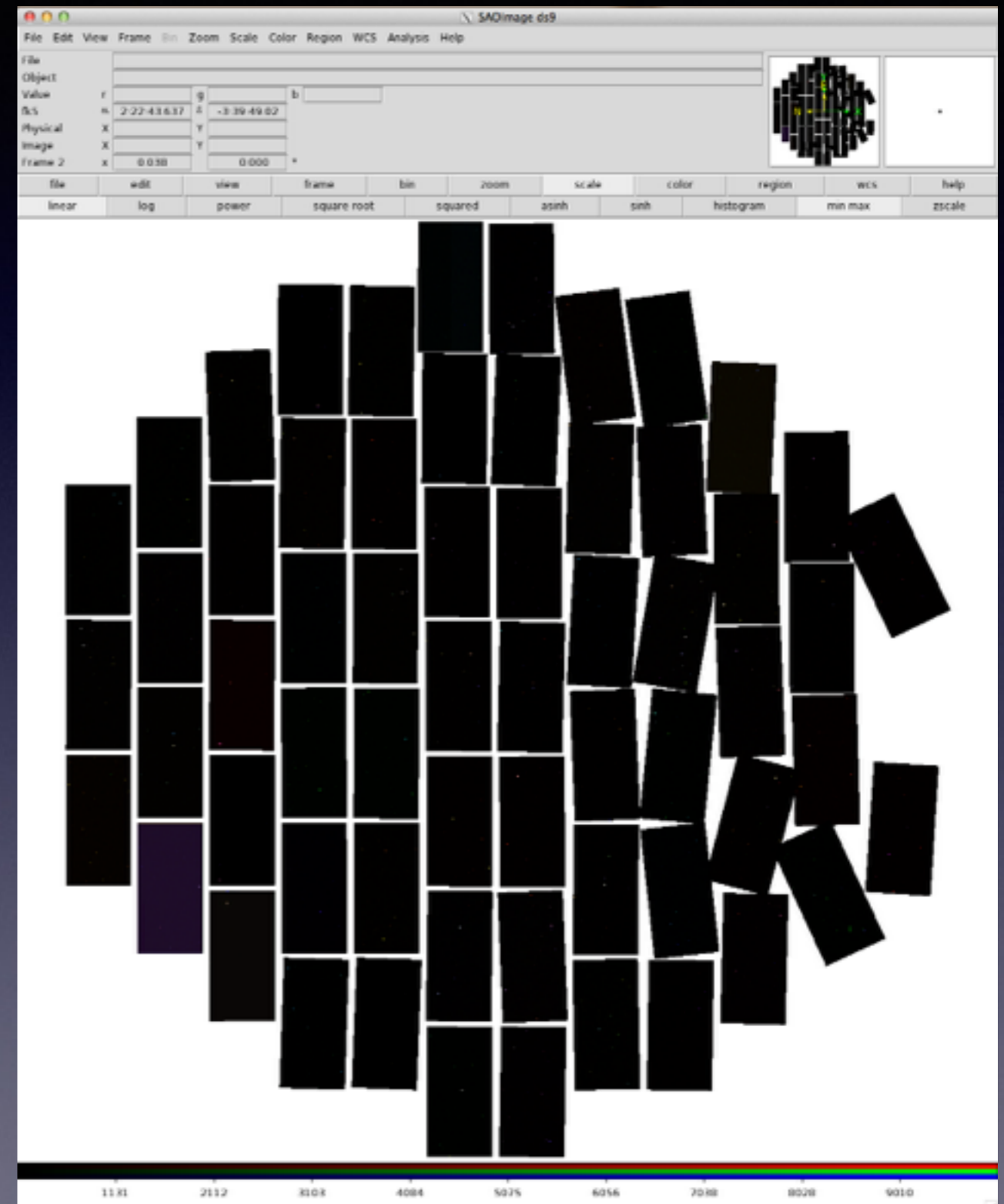
Challenges II: Characterize objects

- Measure properties of objects identified in image

- Common question: Is an object a galaxy or a star?

  Relevant for: Object selection, PSF estimation (Unfolding)

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Challenges III: Interpret data

- Apply methods from previous challenges to test hypothesis: Is the Universe static?

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