Astronomy Data

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The positions of the constellation figures shown on the Farnese Atlas point to a date of 125 BC, matching that of a long-lost star catalog by ancient Greek astronomer Hipparchus.Gerry Picus, courtesy Griffith Observatory

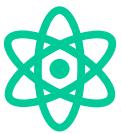
Data.... in present times

- Digital data
- In depth study of individual objects
- Survey data of larger (or complete) sky
- ESO-VISTA 150TB/per year, LSST 500 TB/month
- Simulations TNG 300 +TNG 100 > PB data (2018 release)
- Data Centres
- Jupyter Notebooks

Types of Data: Images

Images (datacubes)

Catalogs



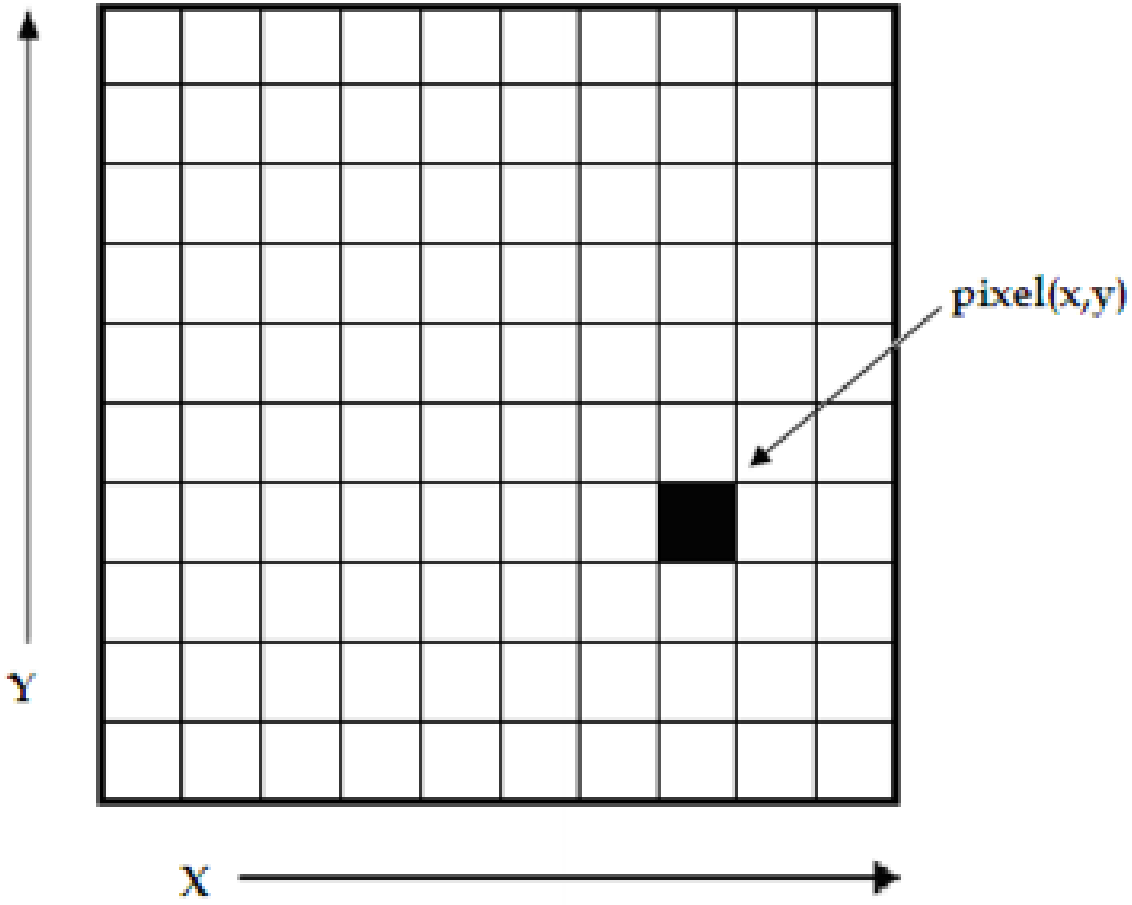
Spectra

Time-series

Polarization

Types of Data: Images

- 2-D array, pixel value- brightness
- RBG images
- Artificial colors
- (related to wavelength/energy)



Basics of Data: Images

Point sources

Extended sources

CCDS

Figure 1.9. Willard S. Boyle (left) and George E. Smith, inventors of the charge-coupled device at the Bell Labs research center at Murray Hill, New Jersey in December 1974 when they received their patent for the CCD. Credit: Lucent Technologies Bell Labs.

Colors: Bayer filter (Eastman Kodak)

- Color filter array (CFA) for arranging RGB color filters on a square grid of photosensors. The filter pattern is 50% green, 25% red and 25% blue
- used in digital cameras, camcorders, and scanners to create a color image.

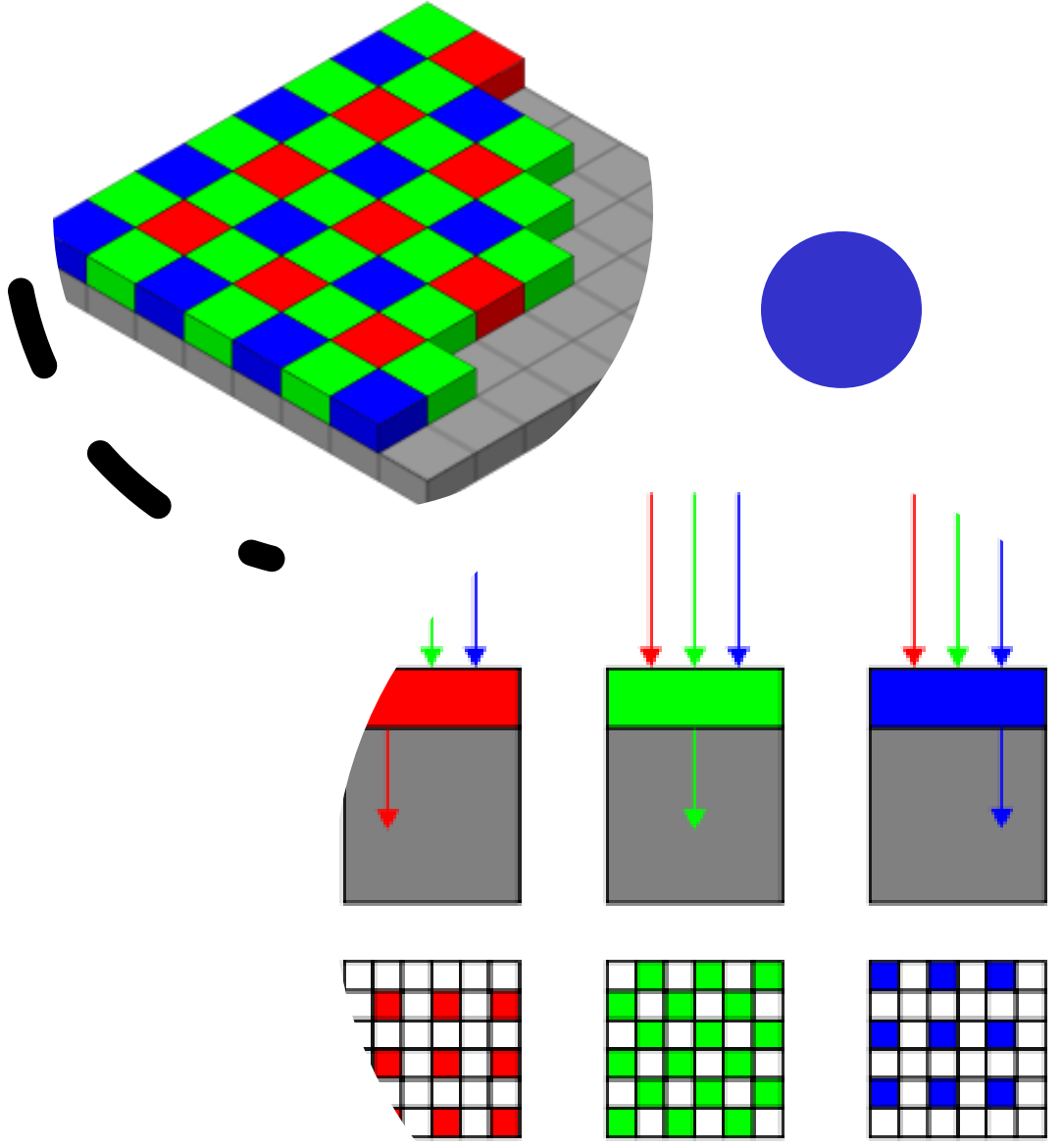


Figure 3: Two images of Westerlund 2. Image credit left: 2 m Faulkes Telescope operated by Las Cumbres Observatory at Siding Spring under license CC BY-2.0. Image on the right: NASA, ESA, the Hubble Heritage Team (STScI/AURA), A. Nota (ESA/STScI), and the Westerlund 2 Science Team

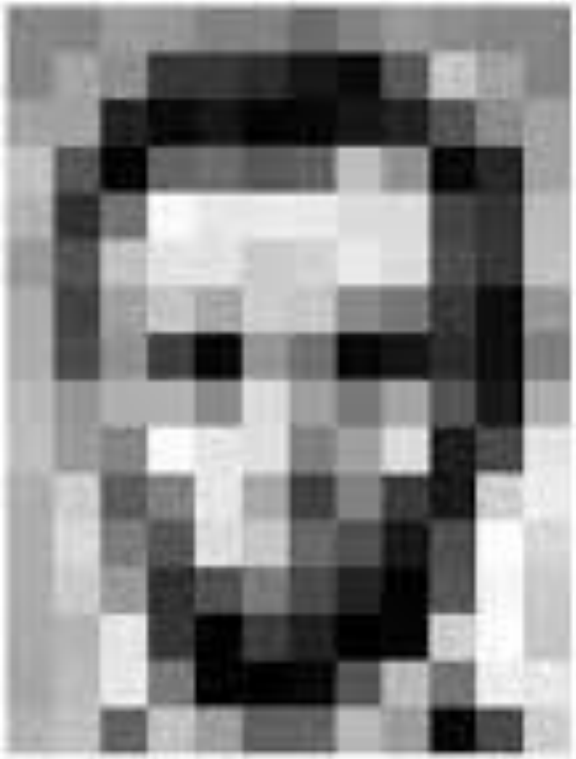
Astronomy Images

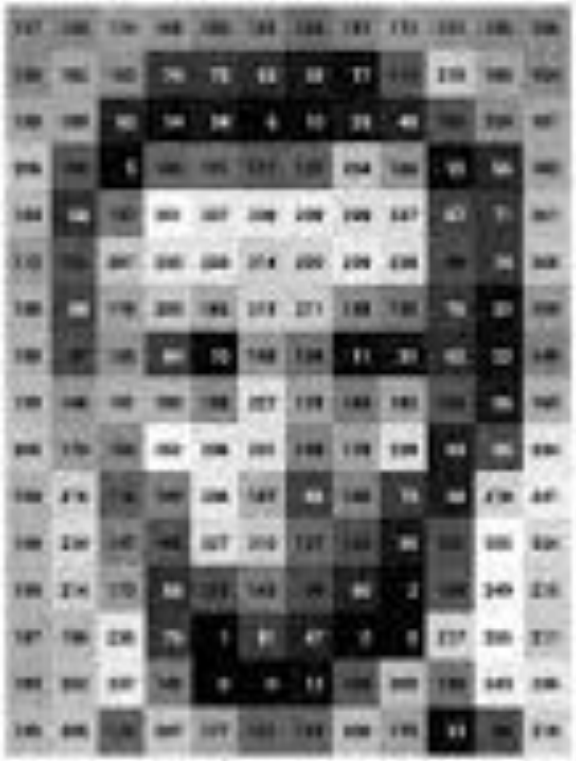
- Filters in succession
- Create RGB images
- Artificial colors

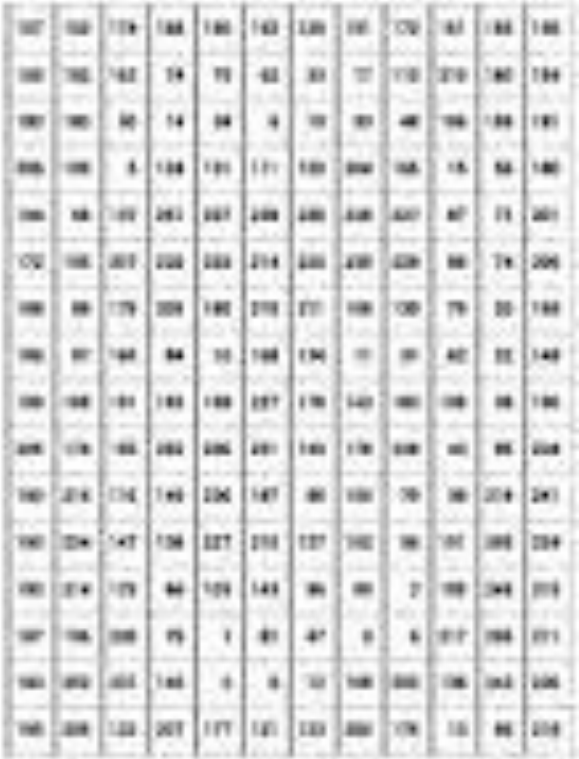
FITS

- Flexible Image Transport System (FITS) is an open standard defining a digital file format useful for storage, transmission and processing of data: formatted as multi-dimensional arrays (for example a 2D image), or tables.
- FITS was designed specifically for astronomical data
- Includes provisions such as describing photometric and spatial calibration information, together with image origin metadata.
- FITS is also often used to store non-image data, such as spectra, photon lists, data cubes, or structured data such as multi-table databases. A FITS file may contain several extensions, and each of these may contain a data object. For example, it is possible to store x-ray and infrared exposures in the same file.

Image as a matrix







Brightness

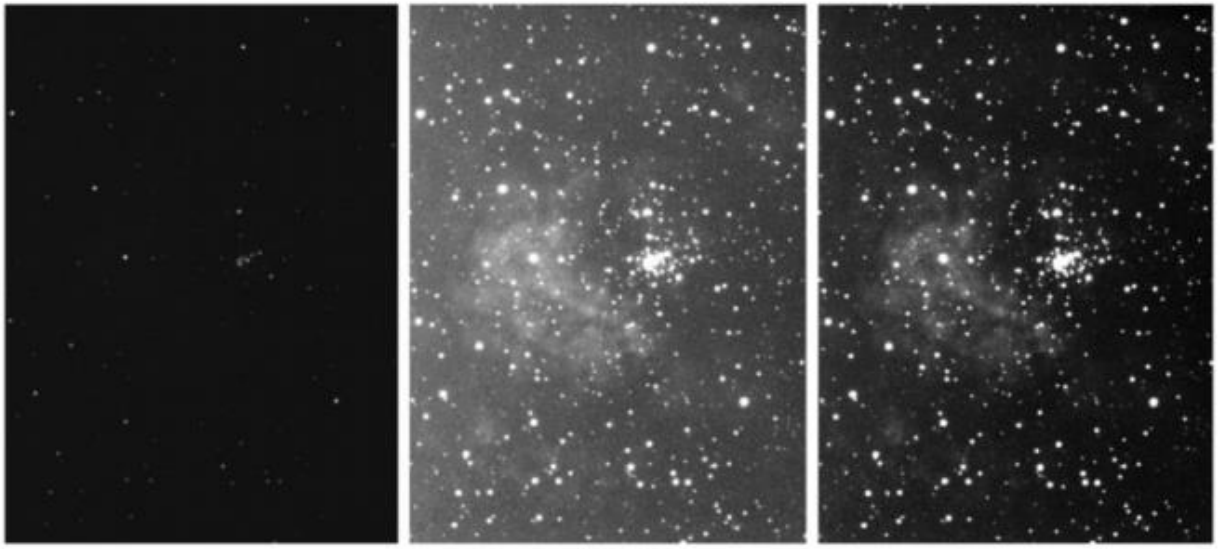
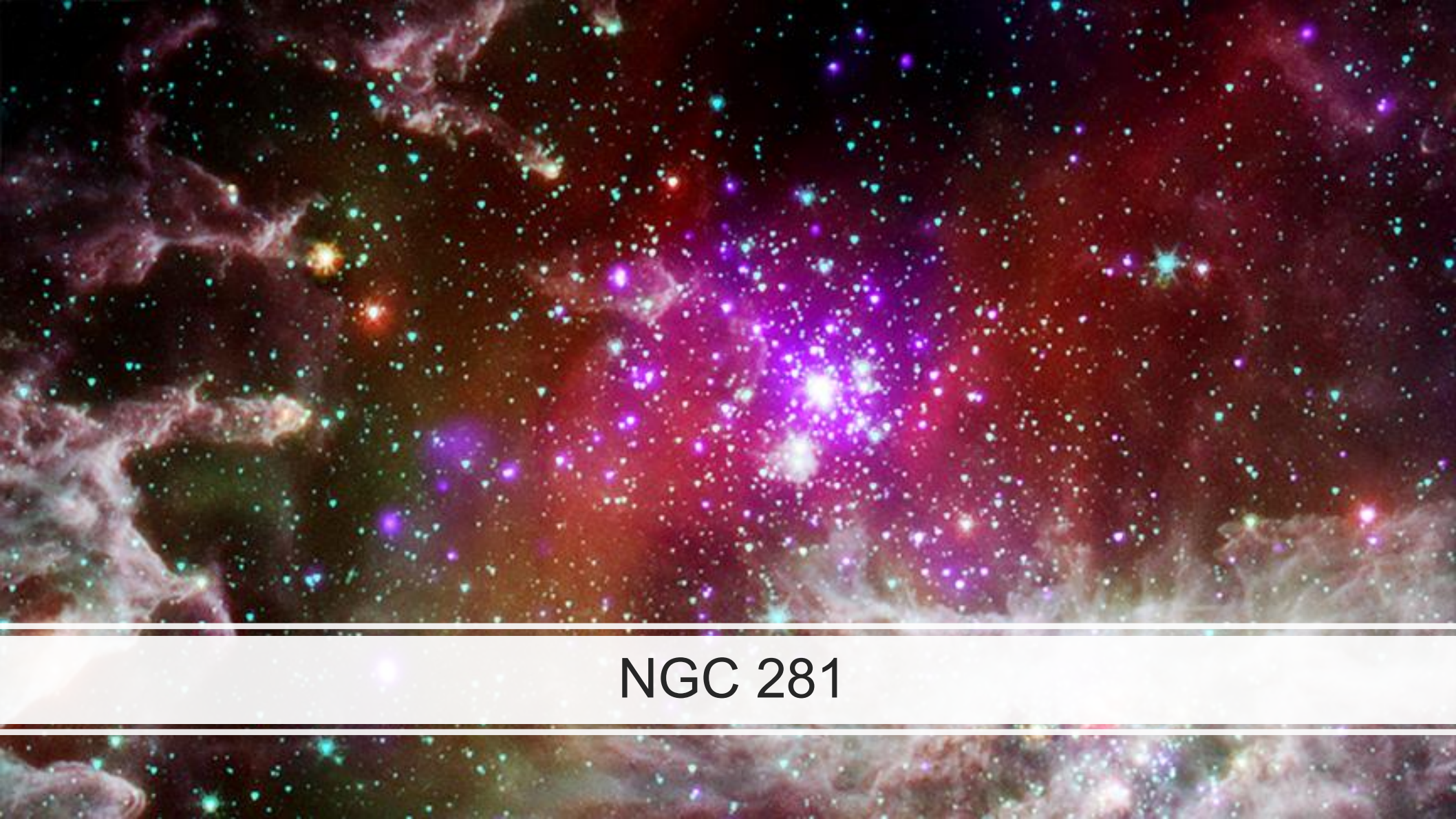


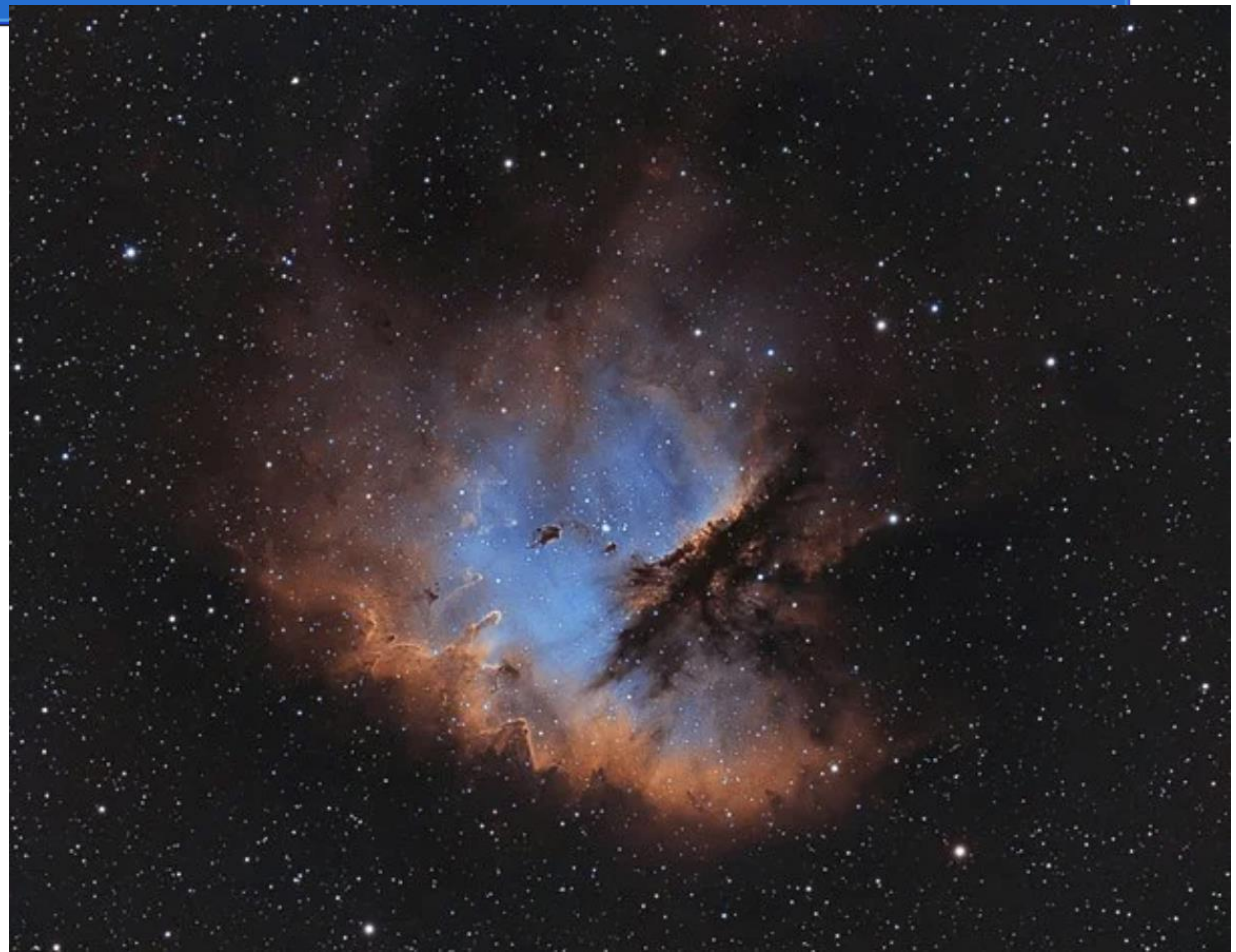
Figure 4: Part of the Westlund 2 image taken through an R (red) filter in April 2017 with the 2 m Faulkes Telescope operated by Las Cumbres Observatory at Siding Spring in Australia with different scaling. Left: Linear scaling from 0 to 65536. Center: Linear scaling from 4572 to 6002. Right: Square scaling from 4572 to 6002

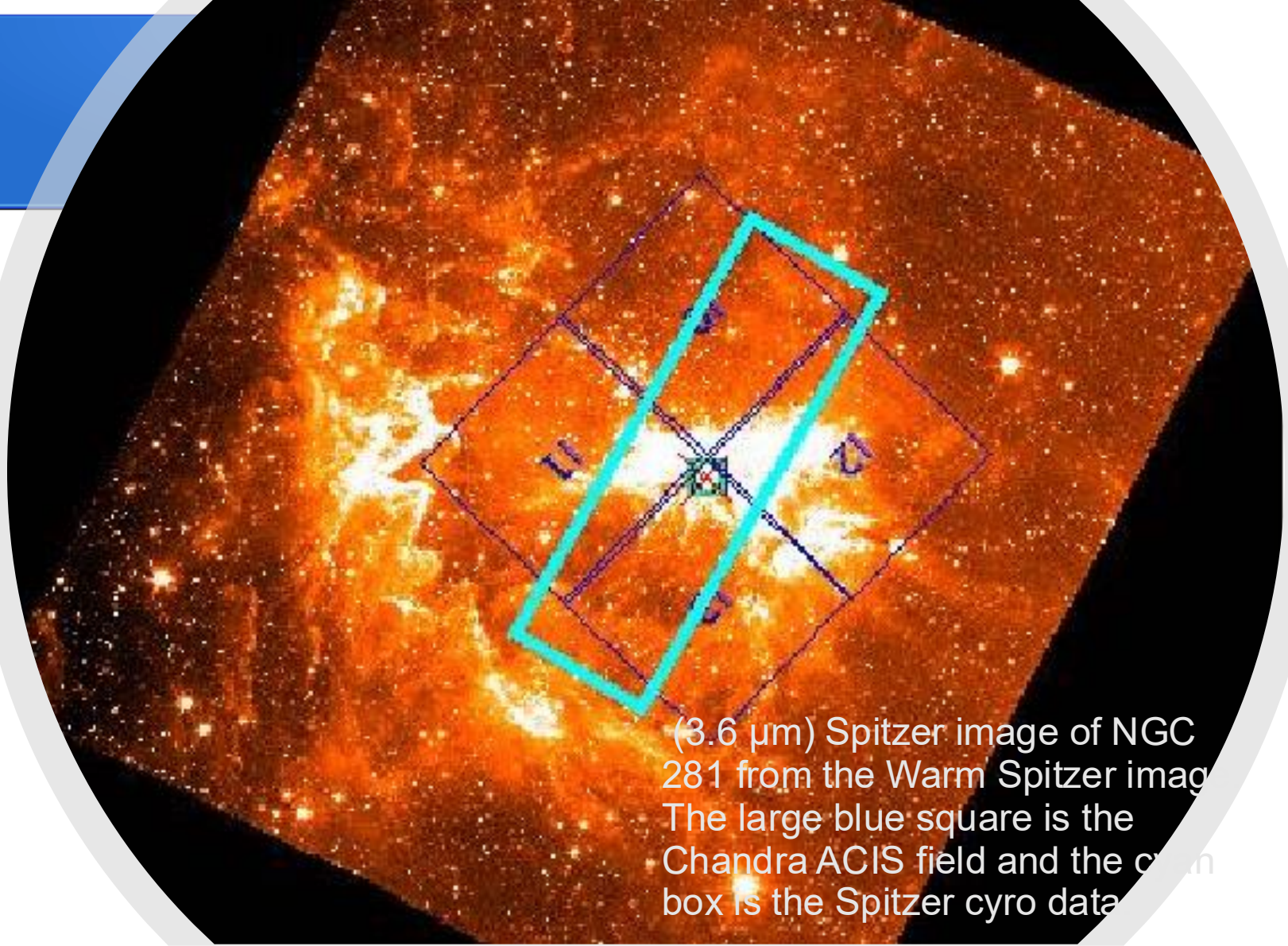
$2^{16}=65536$



NGC 281

NGC 281





(3.6 μm) Spitzer image of NGC 281 from the Warm Spitzer imag
The large blue square is the Chandra ACIS field and the c n box is the Spitzer cyro data

NGC 281 by Chandra

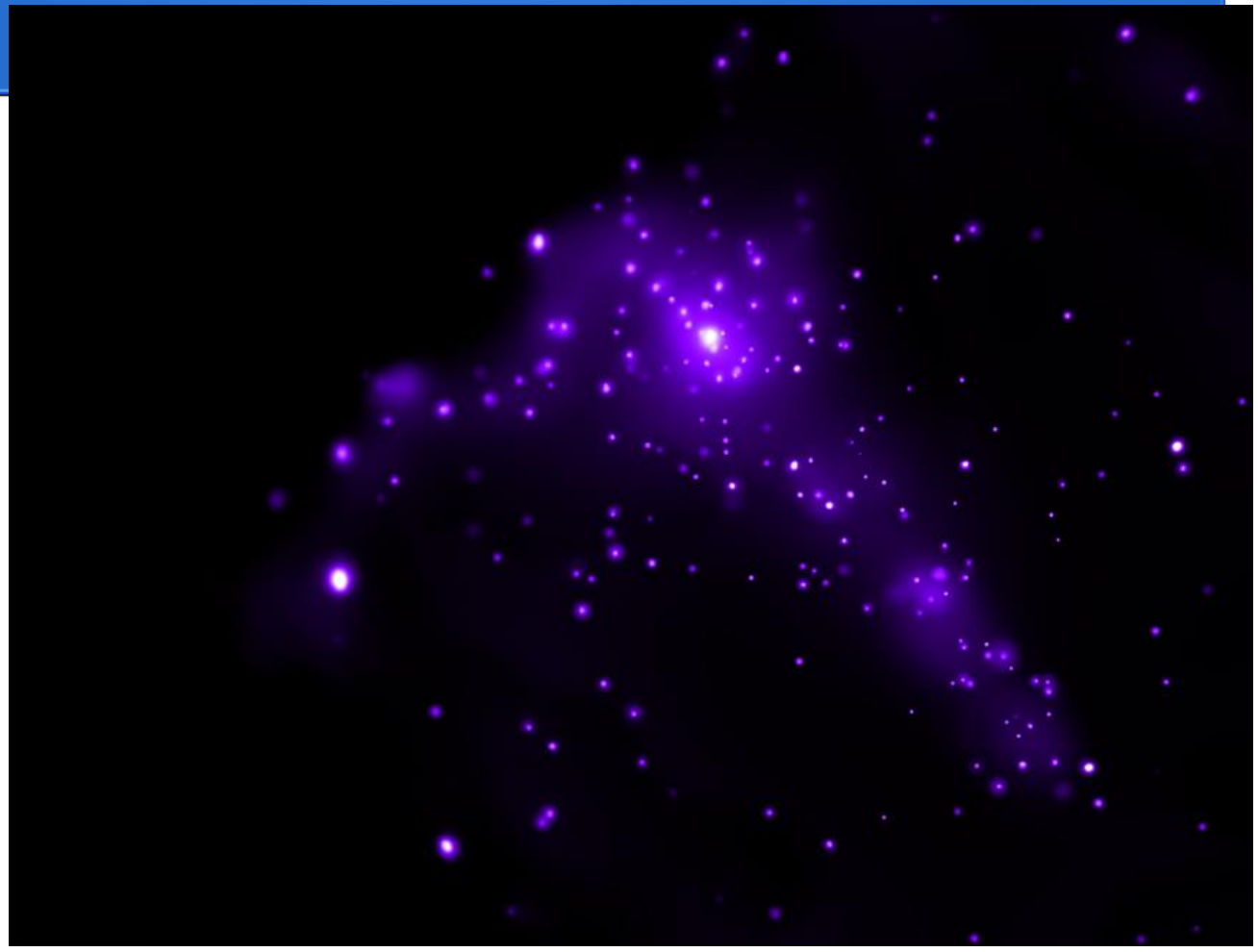
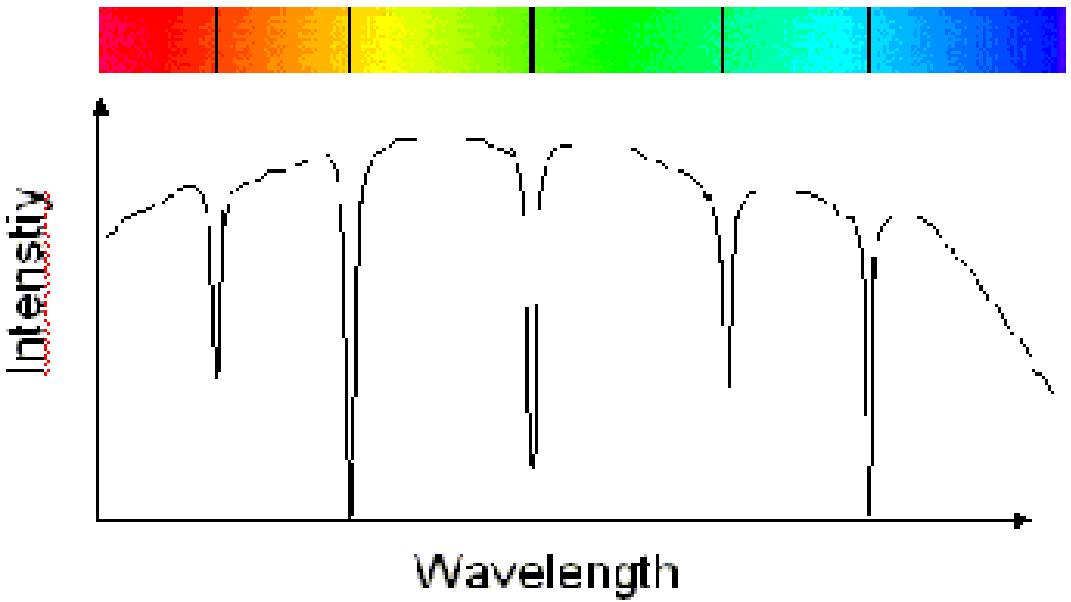


Image processing…

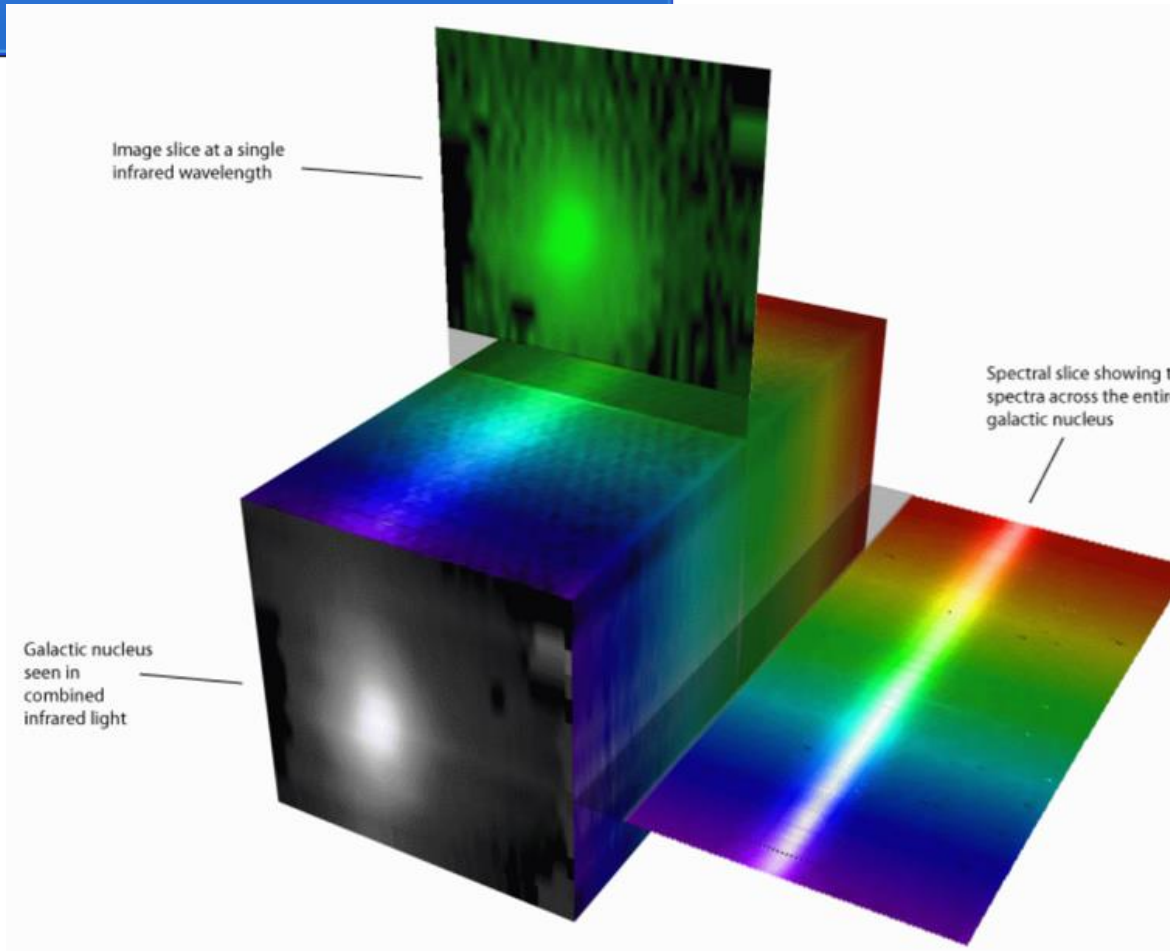
Types of Data: Spectra



- 1D data
- Energy distribution among diff wavengths
- Contribution of light from that particular wavelength region

Types of Data: Data Cubes

- 3D data
- For example, Integral Field Spectroscopy (IFS)
- Each pixel has a whole spectrum received from the pixel



Types of Data: Catalog Data

TOPCAT(1): Table Browser

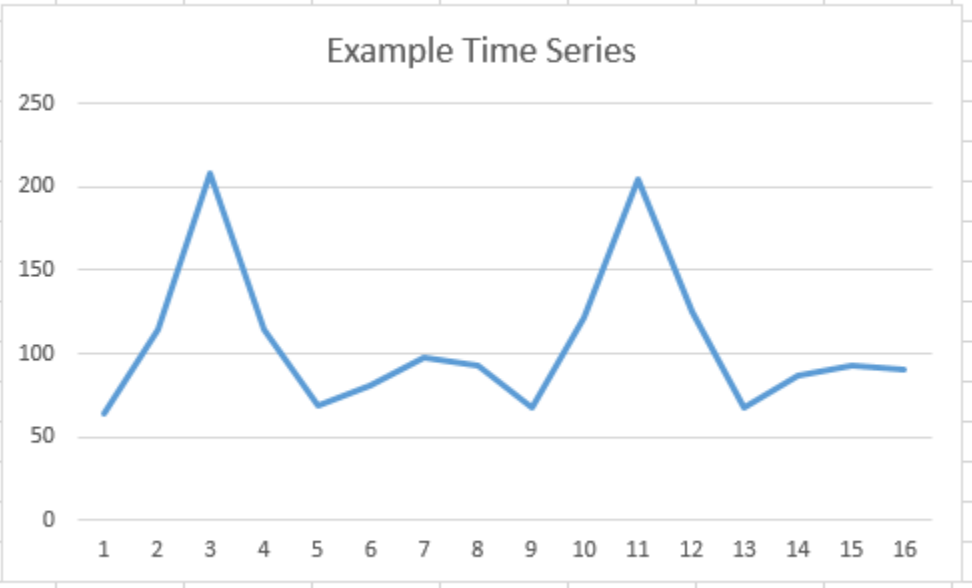
Window Subsets Help

Table Browser for 1: cantat_cat.vot

	Cluster	RAJ2000	DEJ2000	GLON	GLAT	r50	Nstars	pmRA	pmDE
1	ASCC_10	51.87	34.981	155.723	-17.77	0.558	71	-1.737	-1.368
2	ASCC_101	288.399	36.369	68.028	11.608	0.372	75	0.934	1.288
3	ASCC_105	295.548	27.366	62.825	2.063	0.648	127	1.464	-1.635
4	ASCC_107	297.164	21.987	58.904	-1.901	0.174	59	-0.155	-5.156
5	ASCC_108	298.306	39.349	74.378	6.074	0.537	230	-0.519	-1.69
6	ASCC_11	53.056	44.856	150.546	-9.224	0.312	276	0.926	-3.03
7	ASCC_110	300.742	33.528	70.411	1.378	0.203	70	0.271	-3.132
8	ASCC_111	302.891	37.515	74.714	2.056	0.537	156	-1.15	-1.524
9	ASCC_113	317.933	38.638	82.877	-6.589	0.529	196	0.8	-3.679
10	ASCC_114	324.99	53.997	97.082	1.028	0.216	150	-3.716	-3.421
11	ASCC_115	329.28	51.558	97.528	-2.504	0.25	39	-0.549	-0.543
12	ASCC_12	72.4	41.744	162.986	-1.893	0.303	162	-0.634	-2.794
13	ASCC_123	340.299	53.986	104.434	-4.141	1.294	55	12.093	-1.407
14	ASCC_127	347.205	64.974	112.349	4.232	0.627	122	7.474	-1.745
15	ASCC_128	349.949	54.435	109.77	-6.078	0.513	72	1.236	0.186
16	ASCC_13	78.255	44.417	163.502	3.122	0.609	110	-0.473	-1.743
17	ASCC_16	81.198	1.655	201.139	-18.373	0.376	226	1.355	-0.015
18	ASCC_19	81.982	-1.987	204.914	-19.438	0.605	188	1.152	-1.234
19	ASCC_21	82.179	3.527	199.938	-16.598	0.41	131	1.404	-0.632
20	ASCC_23	95.047	46.71	167.472	14.416	0.319	129	1.098	-0.598
21	ASCC_30	103.571	1.67	214.742	0.128	0.127	54	1.009	1.019

Time series data

T_t	C_t (p=8)	S_t (p=4)	N_t	Y_t
100	1	0.6	1.06	63.6
101	1.2	1	0.94	113.928
102	1.4	1.4	1.04	207.9168
103	1.2	1	0.93	114.948
104	1	0.6	1.1	68.64
105	0.8	1	0.96	80.64
106	0.6	1.4	1.09	97.0536
107	0.8	1	1.09	93.304
108	1	0.6	1.04	67.392
109	1.2	1	0.93	121.644
110	1.4	1.4	0.95	204.82
111	1.2	1	0.94	125.208
112	1	0.6	1.01	67.872
113	0.8	1	0.96	86.784
114	0.6	1.4	0.97	92.8872
115	0.8	1	0.98	90.16



Tools:

- Image Visualization: ds9
- Catalogs: TOPCAT
- Programming Languages: Python ....modules, libraries
- Not to be used as black boxes

Meta-Data

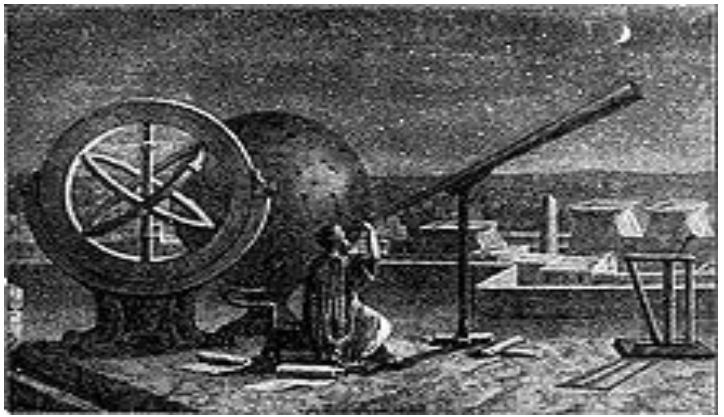
- Descriptive information about the data
- Images: Telescope, exposure time....
- Simulations
- Spectra

What is an Astronomy Archive?

Organised, systematic information about the sky above us, we will call as an astronomy archive.

Today's archives are many terabytes and sometimes even petabytes in size

Astronomy Archives



- Hipparchus (190 – c. 120 BC)

850 stars, 1-6 mag

- Tycho Brahe (1546 – 1601)

positions of the naked eye planets as a function of time

- Used by Kepler (first example of archival data!!)

- 1603, Bayer, compiled his star catalogue, labeling every star in a constellation by its brightness.
- 1771, Charles Messier catalogue of nebulous objects ~ 100
- 1888, Dreyer: NGC catalogue > 7,000

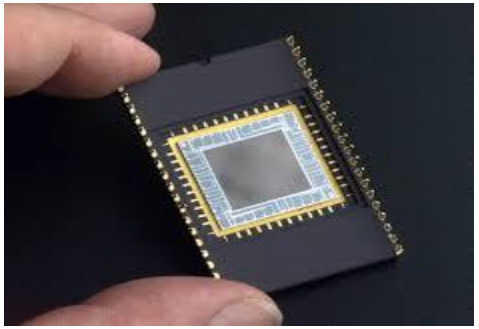
Organised data!!!

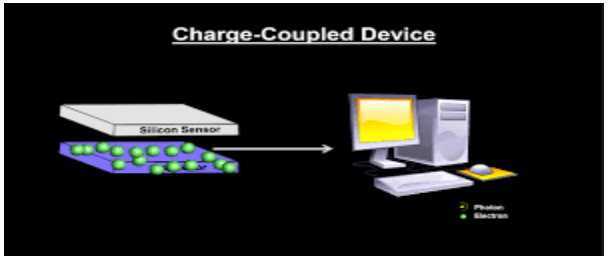
Palomar sky survey

1950-1957, Oschin Schmidt Telescope at the Palomar Observatory, California, USA.

2,000 photographic plates of the night sky (14-inch (35.5-cm) square photographic plates, each covering 36 square degrees of sky)

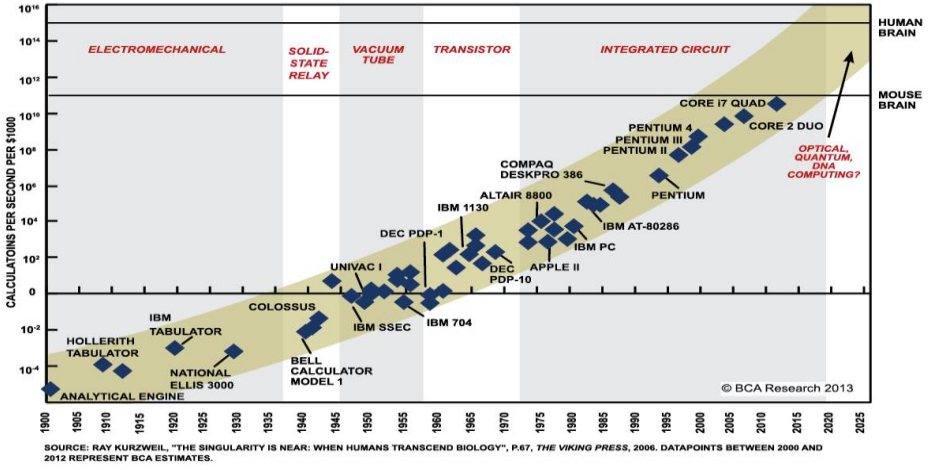
1990s: DPOSS





And then Technology...

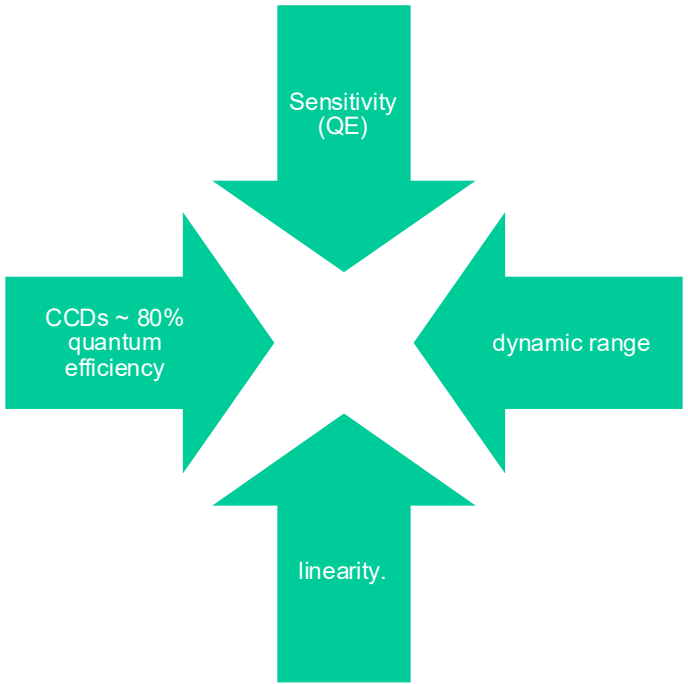
Digital data, QE, linear response

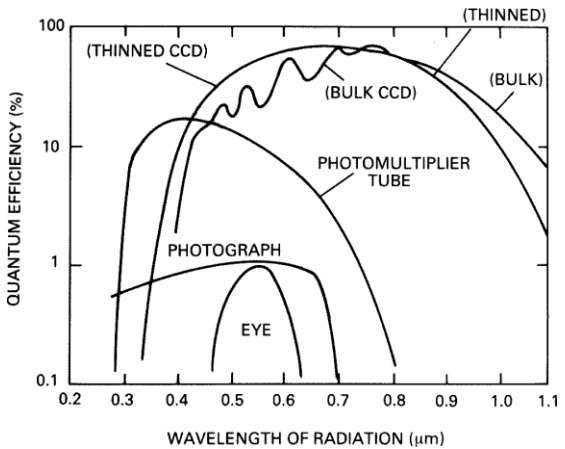


SOURCE: RAY KURZWEIL, "THE SINGULARITY IS NEAR: WHEN HUMANS TRANSCEND BIOLOGY", P.67, *THE VIKING PRESS*, 2006. DATAPOINTS BETWEEN 2000 AND 2012 REPRESENT BCA ESTIMATES.

Citizen science projects

CCDs





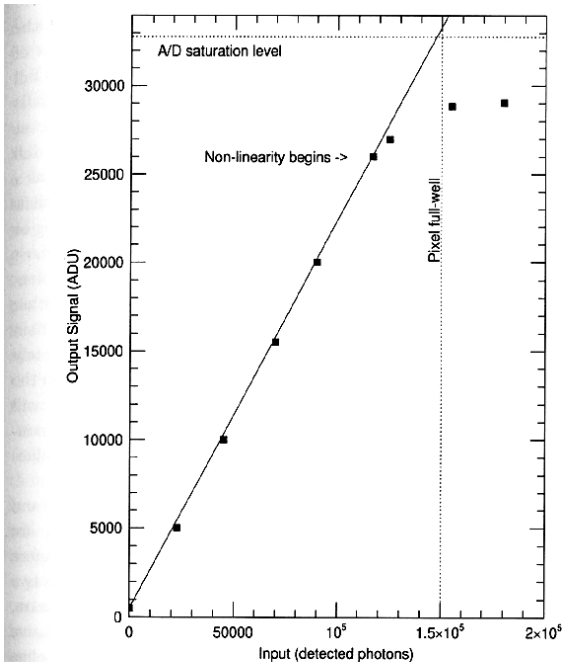
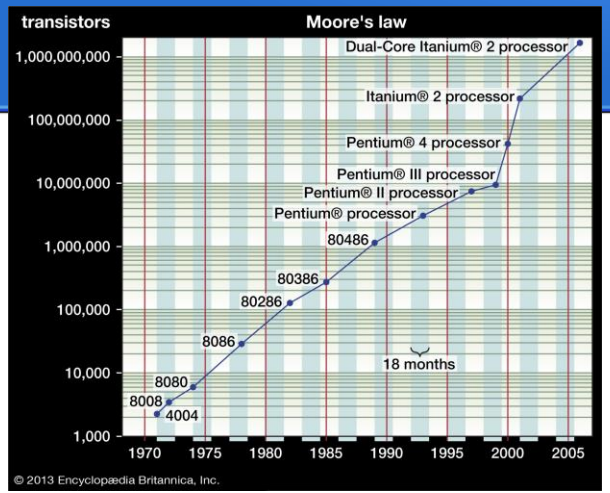


Fig. 3.6. CCD linearity curve for a typical three-phase CCD. We see that the device is linear over the output range from 500 ADU (the offset bias level of the CCD) to 26,000 ADU. The pixel full well capacity is 150,000 electrons and the A/D converter satuartion is at 32,767 ADU. In this example, the CCD nonlinearity is the limiting factor of the largest usable output ADU value. The slope of the linearity curve is equal to the gain of the device.

Digital is better than digitised!!!

In other wavelengths too.....

Similar growth in radio, Xray, etc



Technology goes hand-in-hand....

Astronomy Archives

In the true spirit of science

Available to all

(ex instrument groups, proprietary period, etc)

Citizen Science projects: SETI, Galaxy Zoo,

Data Archives

VizieR: access to the most complete library of published astronomical catalogues and online data tables

Simbad: Astronomical database which provides basic data, cross-identifications, bibliography

NED The NASA/IPAC Extragalactic Database (NED): multi-wavelength fusion of data for millions of objects outside the Milky Way galaxy.

SDSS DR14 Sloan Digital Sky Survey: systematic map of a quarter of the sky, producing new catalogues for deep-sky.

2MASS Two Micron All Sky Survey (2MASS) : map of the entire sky in near-infrared.

ESO data archive: ESO observational data

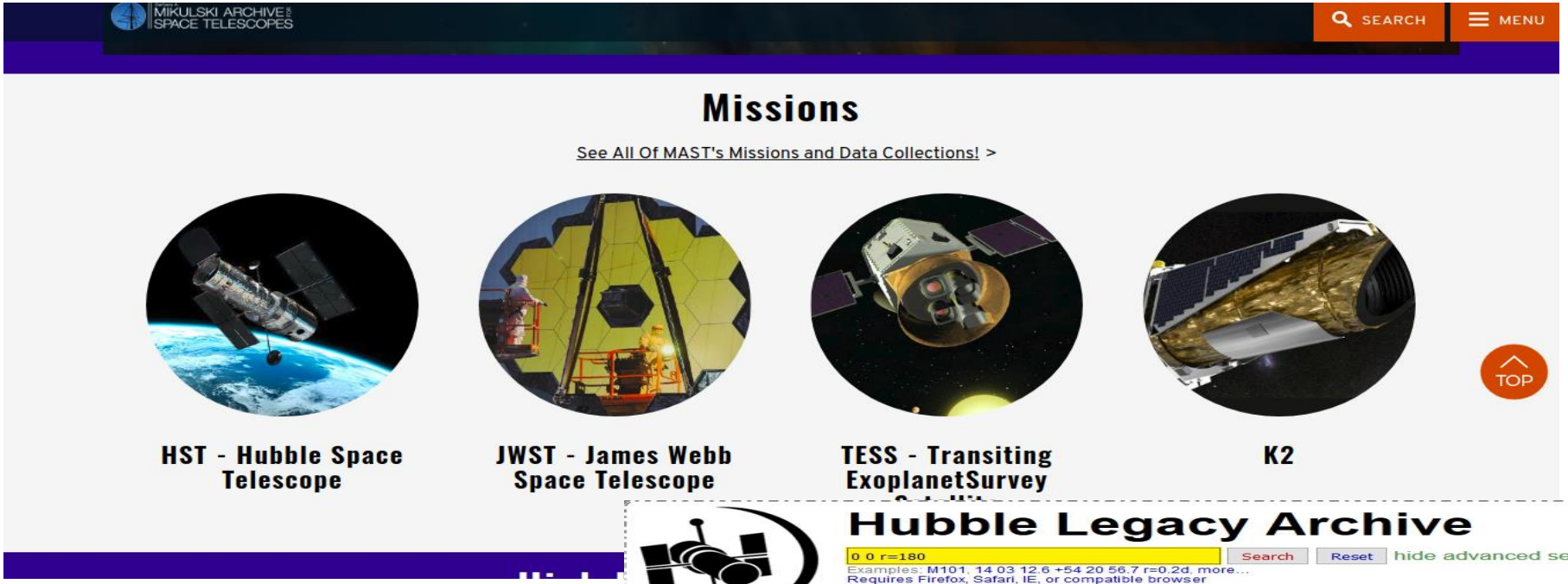
MAST The Multimission Archive at STScI: scientifically related data sets in the optical, ultraviolet, and near-infrared parts of the spectrum.

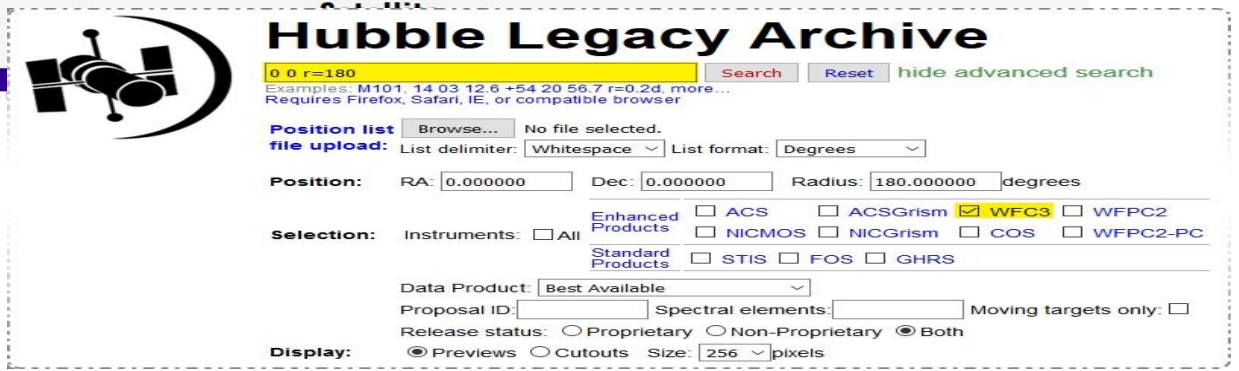
2dFGRS The 2dF Galaxy Redshift Survey (2dFGRS) is a spectroscopic survey and spectra is obtained for 245591 objects, mainly galaxies.

IPAC/IRSA: NASA's infrared and sub-millimeter astronomy projects and missions.

HLA The Hubble Legacy Archive (HLA): optimize science from the HST providing online, enhanced Hubble products and advanced browsing capabilities.

Hubble MAST


MIKULSKI ARCHIVE FOR SPACE TELESCOPES
SEARCH
MENU
Missions
See All Of MAST's Missions and Data Collections! >
HST - Hubble Space Telescope
JWST - James Webb Space Telescope
TESS - Transiting ExoplanetSurvey
K2
TOP


Hubble Legacy Archive
0 0 r=180
Search
Reset
hide advanced search
Examples: M101, 14 03 12.6 +54 20 56.7 r=0.2d, more...
Requires Firefox, Safari, IE, or compatible browser
Position list file upload:
Browse...
No file selected.
List delimiter: Whitespace
List format: Degrees
Position:
RA: 0.000000
Dec: 0.000000
Radius: 180.000000 degrees
Selection:
Instruments: All
Enhanced Products
ACS
ACSGrism
WFC3
WFPC2
NICMOS
NICGrism
COS
WFPC2-PC
Standard Products
STIS
FOS
GHRS
Data Product: Best Available
Proposal ID:
Spectral elements:
Moving targets only:
Release status: Proprietary Non-Proprietary Both
Display:
Previews
Cutouts
Size: 256 pixels

Hubble MAST

MAST Observations: Millions of observations from Hubble, Kepler, GALEX, IUE, FUSE, and more.

Virtual Observatory: Search thousands of astronomical data archives from around the world for images, spectra, and catalogs.

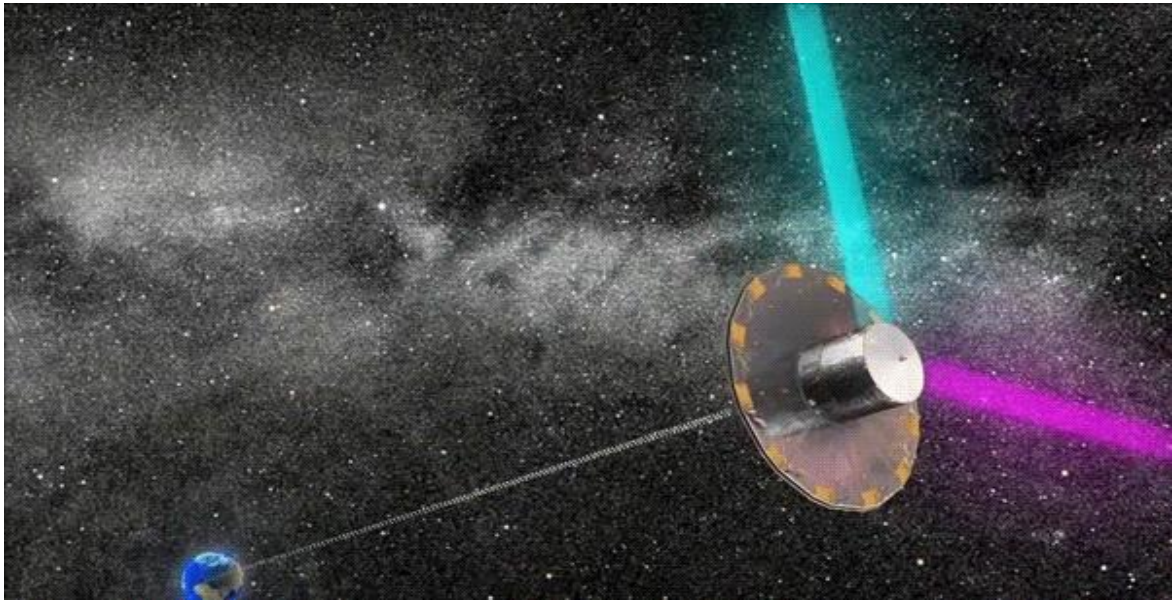
Hubble Source Catalog: A master catalog with a hundred million measurements of objects in Hubble images.

MAST Catalogs: Access to catalog data such as Gaia and TESS Input Catalog, with more coming soon.

GAIA: 6D revolution

RA, Dec, parallax, RV, pmra, pmdec

Two identical, three-mirror anastigmatic (TMA) telescopes, with apertures of
1.45 m × 0.50 m pointing in directions separated by the basic angle
(Γ = 106 ◦ .5)
Accuracy of 24 microarcsec= 42 kpc,
0.06arcsec pixels



Galactic Archealogy!!! Imagine!!!

Help | Log

GMRT Online Archive

This interface allows one to view the data. In order to download the data you have to log in.

Search

Proposal Level Search

Proposal Code:

Principal Investigator:

Proposal Title:

Proposal Submission Year: Start Year | End Year

Time Allocated: Less than | Time | hrs

Scientific Category: Select Category

Observation Type: Select Observation Type

Reset | Search

Observation Level Search

Scan Level Search

Proposal code:

Principal Investigator:

Near Object: SIMBAD | NED

Near Co-ordinates: RA (J2000) | DEC (J2000) | Search Radius arcmin

Frequency Band: Select

Frequency Value: Less than | Value | MHz

Channel Spacing: Select

Time On Source: Less than | Time | Mins.

ChaSeR
Chandra Source Catalog ♦ CSCview
Chandra Footprint Service
Request for Acknowledgement

SEARCH CXC.HARVARD.EDU
Google Custom Search Search

- The Archive
- Search and Retrieve Data
- Advanced Data Services
- Archive User Services
- Chandra Aggregated Datasets
- Publishing Chandra Results

Data Analysis Links

WELCOME TO THE CHANDRA DATA ARCHIVE

The Chandra Data Archive (CDA) plays a central role in the operation of the Chandra X-ray Center (CXC) by providing support to the astronomical community in accessing Chandra data. The CDA offers access to digital archives through powerful query engines, including VO-compliant interfaces and also serves as a permanent storage repository of contributed data products by authors who have processed images or other pertinent and valuable datasets that are essential to their publications.

Access the Chandra Data Archive

- ChaSeR: Search & Retrieval interface for scientists, allowing specification of detailed selection criteria. Chandra Fast Image is a simplified quick search tool for *Chandra* X-ray images and other data for the general public.
- FTP: Direct FTP access to the primary and secondary data products for all observations that are publicly released.
- Cool Chandra Targets (formerly known as CATs): the list of approved Cool Chandra Targets (CCTs) programs, including the PI names, titles and abstracts.
- Footprint Service: A search by position or object name overlays the footprints of *Chandra* Observations on Digital Sky Survey images, allowing further selection and retrieval of observations.
- Chandra MOCs: Multi-Order Coverage maps (MOCs) for public Chandra observations, that can be used to visualize and analyze the global Chandra footprint.
- Chandra Source Catalog: The most comprehensive catalog of sources detected in public Chandra Observations. The catalog can be accessed through CSCview.
- CIAO Tools: There are command-line scripts for finding and downloading publicly-available

CDA STATUS

The archive is fully functional.

REPROCESSING STATUS

Reprocessing has been completed for
Phase I: 2005-11-13 to 2011-12-31
Phase II: 2000-01-30 to 2005-11-13

CURRENT SOFTWARE RELEASES

ASCDSVER: 10.8
CALDBVER: 4.8.3

ANNOUNCEMENTS

Chandra Footprint Service
2018-05-14
The new secure Footprint Service can be found here

Global Chandra Coverage
2018-02-14
Check out the new Chandra MOC page.

Browsers security warnings
2017-12-22
Are Chandra Data Archive pages

SDSS

This is Data Release 15.

Data Surveys Instruments Collaboration Results Education The Future Contact

Search www.sdss.org Search

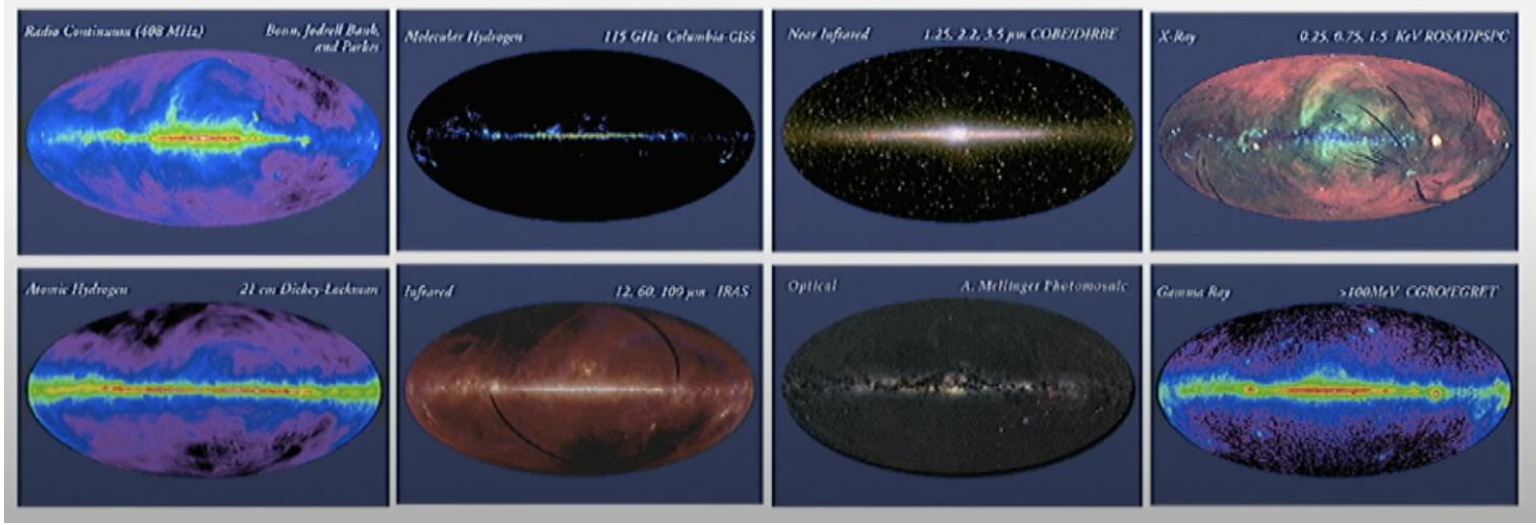
The Sloan Digital Sky Survey: Mapping the Universe

The Sloan Digital Sky Survey has created the most detailed three-dimensional maps of the Universe ever made, with deep multi-color images of one third of the sky, and spectra for more than three million astronomical objects. Learn and explore all phases and surveys—past, present, and future—of the SDSS.

The astronomer researcher view ....

What is the Virtual Observatory?

A multi-wavelength digital sky that can be searched, visualized, and analyzed in new and innovative ways



from Giuseppina Fabbiano (CfA)

The astronomer data provider view ....

What is the Virtual Observatory?

The VO is the latest stage of good data practices in astronomy

- Each data center / archive with different file structure, metadata, table organization
- The data is there, but it takes work to access it, especially if several data sets are used together

- FITS provided a first standardization

- The Virtual Observatory is the natural progression towards interoperability of data, services and tools

from Giuseppina Fabbiano (CfA)

The VO is a Framework

- For Data Archives to organize access to their astronomical data holdings in commonly agreed, shared data structures (i.e. according to defined data models)
- Software Providers to offer a variety of compatible analysis and visualization tools and user interfaces
- Data Centers to provide co-operating data services

IVOA

International Virtual Observatory Alliance

- IVOA was formed in June 2002
- Mission:
- To "facilitate the international coordination and collaboration necessary for the development and deployment of the tools, systems and organizational structures necessary to enable the international utilization of astronomical archives as an integrated and interoperating virtual observatory."
- The IVOA now comprises 23 VO projects.
- Self-funded