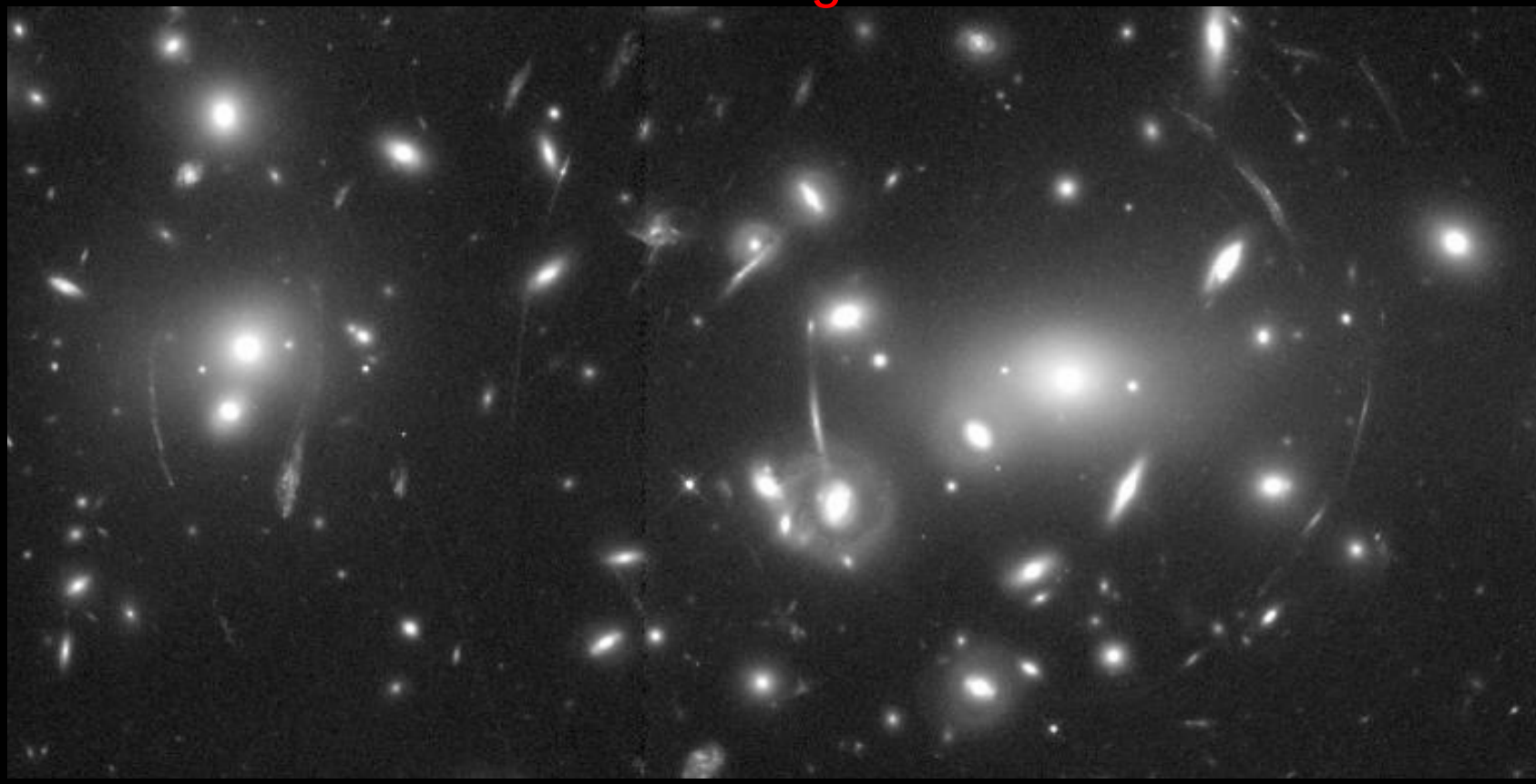
Module 2:
Using Astronomical Databases



## Activity 2:

# Online Observational Data & Image Databases

# Summary

In this Activity, we will continue our investigation of astronomical databases. In particular we will examine:

- how to recover images of astronomical objects using online databases; and
- further astrophysical research tools that are available on the Internet.

# The heavenly art gallery

Now that you have completed some fairly extensive background reading on your astronomical object, it is time to look for some data and images to add to your presentation.

Fortunately, a number of research institutions maintain online image archives that are accessible to the public.

# Choosing your survey

The image database that you choose depends greatly on the astronomical object that you are interested in.

In particular, it is important to know if your source is found inside our Galaxy, the Milky Way, or beyond.

You should also think about the wavelengths at which astronomers observe the object. In general, pulsars, are not visible at optical wavelengths but they are fascinating when you view them with a radio telescope. However, supernova remnants which can arise after the birth of a pulsar can look spectacular at optical wavelengths.

# Introducing the Digitized Sky Survey


For images of galactic astronomical phenomena that are visible at optical wavelengths, the Digitized Sky Survey (DSS) is a good place to start .

After you have finished this Activity, you should visit the DSS website at https://archive.stsci.edu/dss.

# Introducing the Digitized Sky Survey


The DSS is a project to digitize the photographic plates from all-sky surveys of the E, V, J, R, and N bands (optical filters) conducted with the Palomar and UK Schmidt telescopes.

Let’s see if we can find an image of the Crab supernova remnant using the DSS.

# Retrieving an image from the DSS

You should now be quite familiar with completing database query forms. The DSS “Simple Retrieval Form” looks like this:

As astronomical objects often have many different names, image databases usually reference objects by their co-ordinates. Conveniently, the DSS includes a query field for finding your object's co-ordinates.

Let's find the co-ordinates of the Crab pulsar.

---

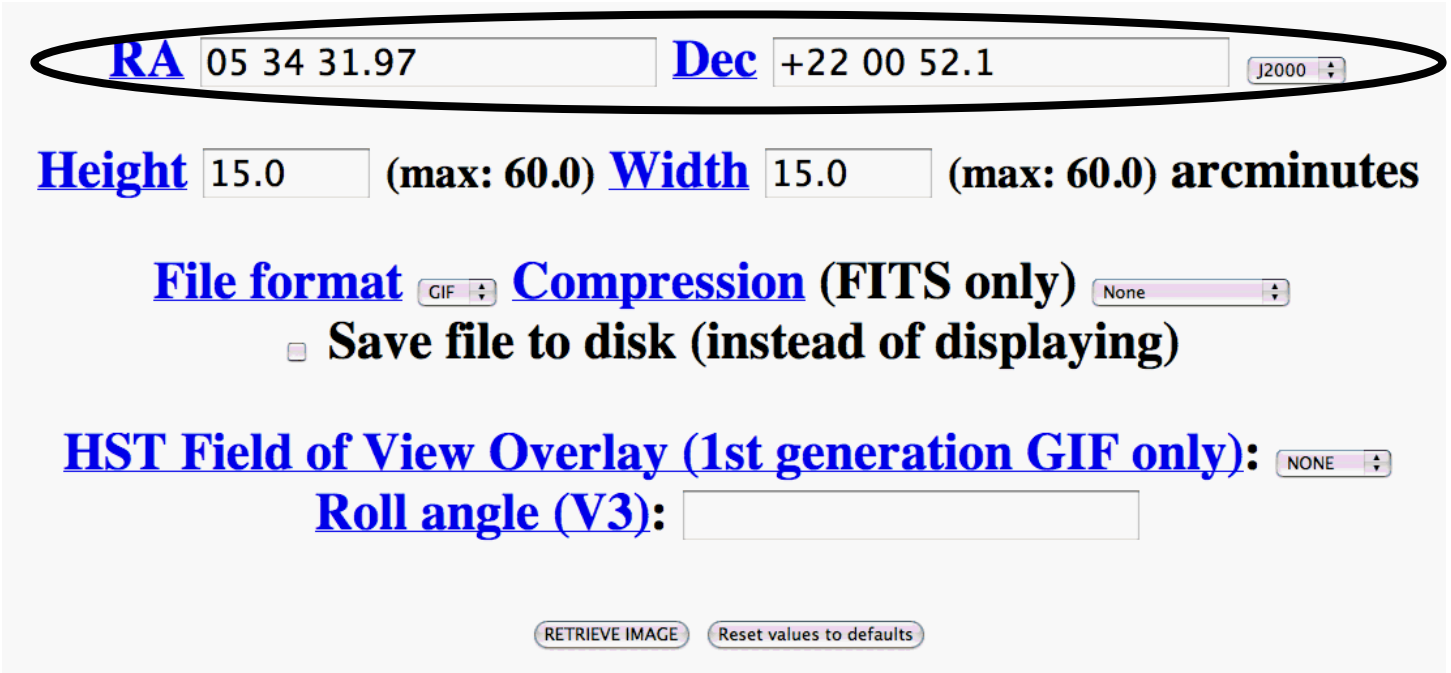
**Get an Object's Coordinates**

**Object name** crab pulsar [GET COORDINATES] [Clear]

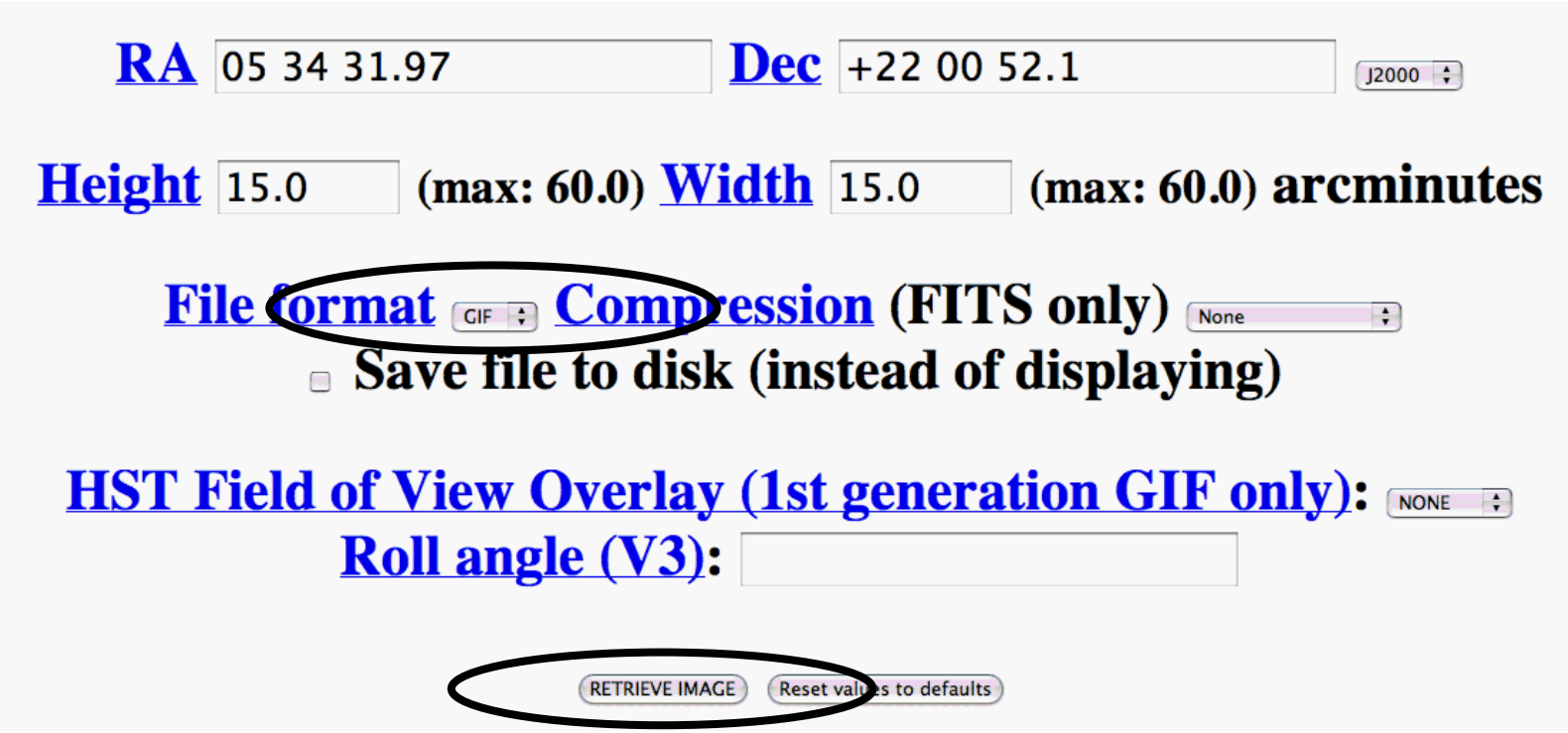
**Get coordinates from** (•) SIMBAD ( ) NED

---

The DSS database returns to the query form, but with the co-ordinates for the Crab pulsar entered.



Choose the file format you want for the image, and then click on Retrieve Image.



DSS gif image of the Crab supernova remnant.

# Astronomy Picture of the Day (APOD)

While not really a scientific resource, the APOD website is a popular tool for those requiring a pretty picture.

Indeed, they strive on collecting the world's best.

The APOD website is https://apod.nasa.gov/apod/

Their collection of images from professional (and amateur) astronomers can be searched by keyword. Although they have hundreds of images, this is not really a very extensive resource considering the number of objects in the night sky.

But where do many of their images come from...

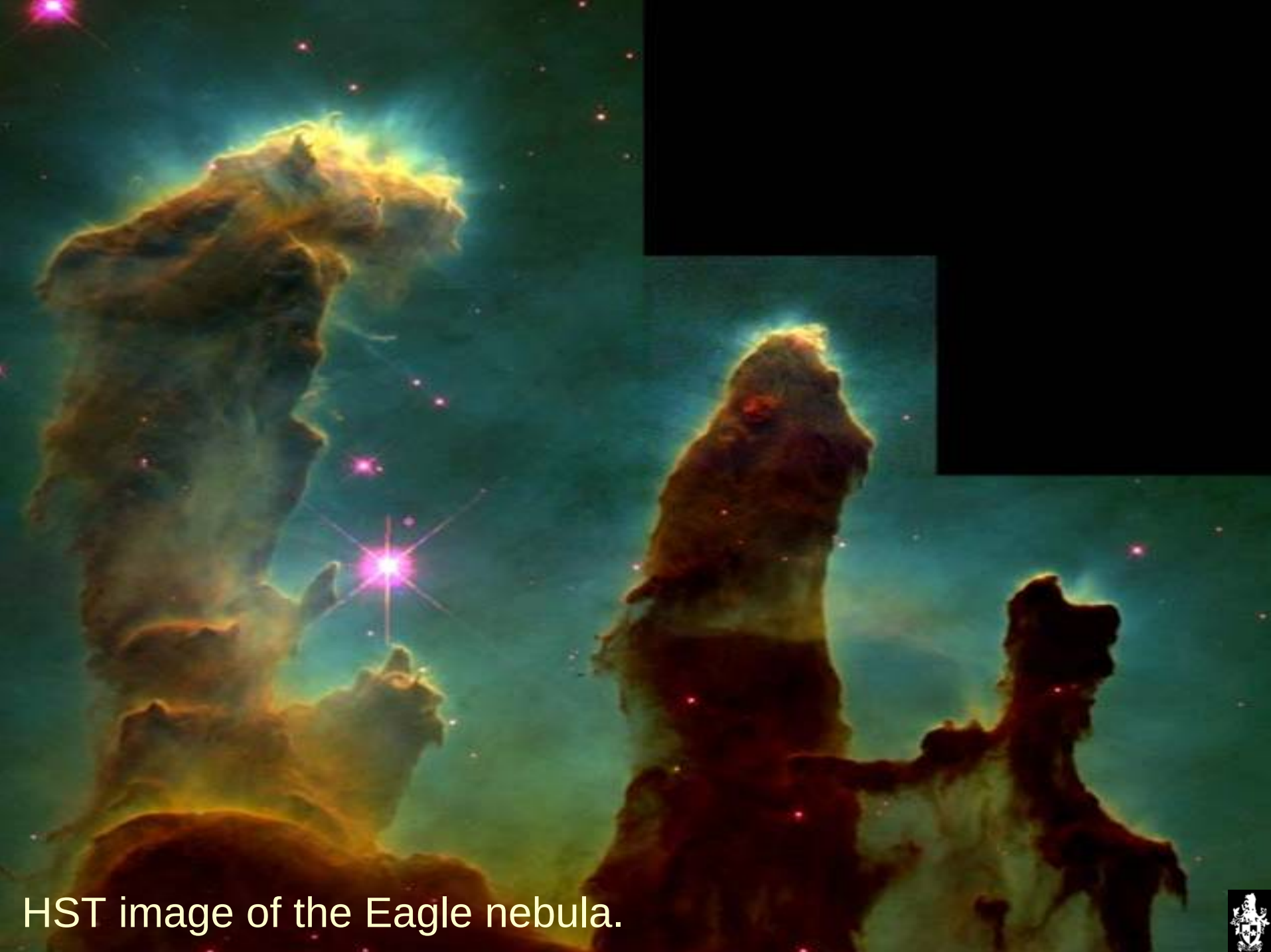
# Introducing the Hubble Space Telescope

One of the most exciting resources that you might use for your presentation is the Hubble Space Telescope (HST).

The HST (or simply 'Hubble') is an observatory that orbits the Earth about 600 kilometres above the planet's surface. Because of HST's location above Earth's atmosphere, it can produce very high resolution images of astronomical objects.

Some of the images produced by HST are spectacular...

HST image of the Crab supernova remnant.



HST image of the Eagle nebula.

HST image of Messier 101

# Introducing the HST database

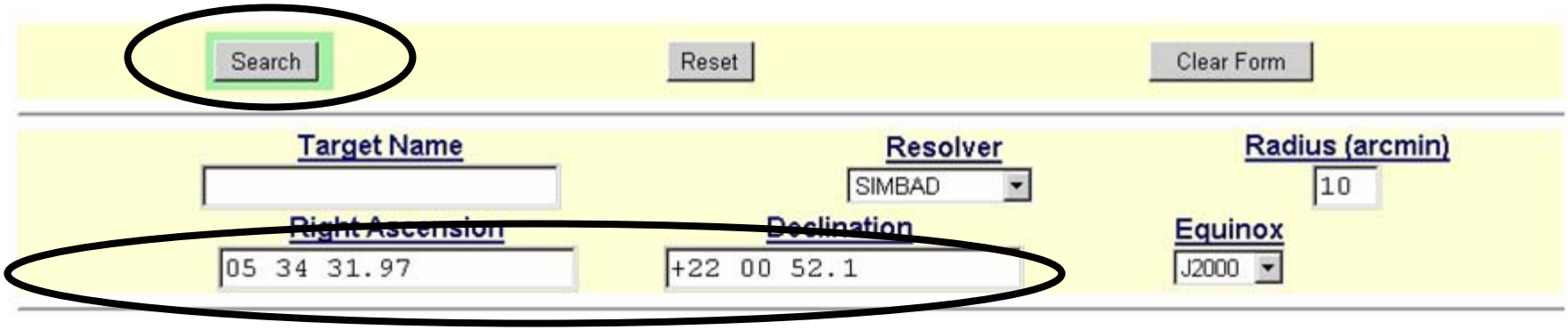
Let's have a look at the HST image database housed at the Multimission Archive at STScI (MAST).

When you have finished this Activity, you should visit the HST database website yourself. The URL is https://archive.stsci.edu.

HST Search Forms are available at:
https://mast.stsci.edu/search/ui/#/hst
or
https://hla.stsci.edu/

# Retrieving an image from the database

The top level of the HST query form is very similar to the DSS form.




You may enter either the name of your object (i.e. Crab pulsar), or you may enter the co-ordinates and then click on Search.

HST searches its database for observations that match these co-ordinates (or the target name).

| Mark | Dataset | Target Name | RA (J2000) | Dec (J2000) | Ref | Start Time | Exp Time | Instrument | Apertu |
|---|---|---|---|---|---|---|---|---|---|
| ☐ | Y2ZM0105T | PSR0531+21 | 05 34 31.97 | +22 00 52.1 | | 1996-01-11 08:16:00 | 759.984 | FOS | 0.25-P. |
| ☐ | Y2ZM0106T | PSR0531+21 | 05 34 31.97 | +22 00 52.1 | | 1996-01-11 09:22:00 | 2430.000 | FOS | 0.25-P. |
| ☐ | Y2ZM0107T | PSR0531+21 | 05 34 31.97 | +22 00 52.1 | | 1996-01-11 10:58:00 | 2430.000 | FOS | 0.25-P. |
| ☐ | Y2ZM0108T | PSR0531+21 | 05 34 31.97 | +22 00 52.1 | | 1996-01-11 12:35:00 | 2430.000 | FOS | 0.25-P. |
| ☐ | Y2ZM0109T | PSR0531+21 | 05 34 31.97 | +22 00 52.1 | | 1996-01-11 14:11:00 | 2430.000 | FOS | 0.25-P. |
| ☐ | Y2ZM010AT | PSR0531+21 | 05 34 31.97 | +22 00 52.1 | | 1996-01-11 15:48:00 | 2430.000 | FOS | 0.25-P. |
| ☐ | Y2ZM010BT | PSR0531+21 | 05 34 31.97 | +22 00 52.1 | | 1996-01-11 17:25:00 | 2430.000 | FOS | 0.25-P. |
| ☐ | Y2I00103T | CRAB-PULSAR | 05 34 31.96 | +22 00 52.0 | | 1994-09-12 23:52:00 | 560.000 | FOS | 4.3 |
| ☐ | Y2I00104T | CRAB-PULSAR | 05 34 31.96 | +22 00 52.0 | | 1994-09-13 00:06:00 | 739.980 | FOS | 4.3 |
| ☐ | Y2I00404T | CRAB-PULSAR | 05 34 31.96 | +22 00 52.0 | | 1995-01-03 16:11:00 | 2319.961 | FOS | 1.0 |

For the Crab pulsar, HST returns an initial list of 100 images (although over 300 are available)!
Let's see how we can refine our search.

# One telescope, many instruments

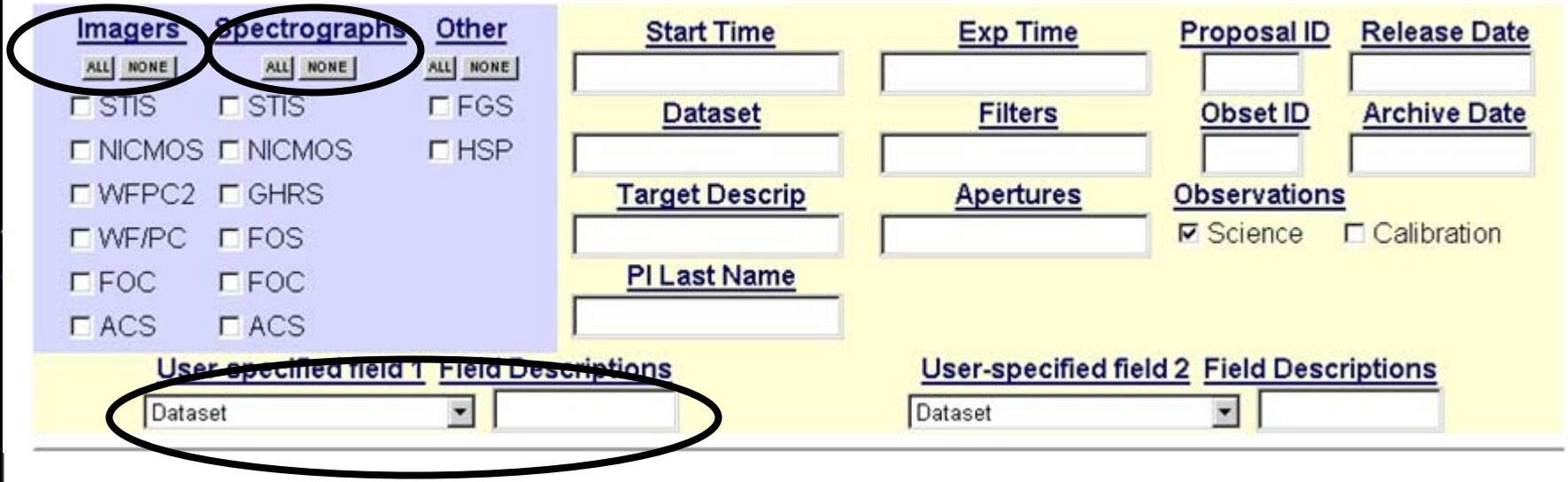
The HST satellite carries a variety of instruments that operate at wavelengths from the ultra-violet to the infra-red.

These instruments include the Wide Field/Planetary Camera 2 (WFPC2), the Space Telescope Imaging Spectrograph (STIS), the Near Infrared Camera and Imaging Spectrograph (NICMOS) and the Advanced Camera for Surveys (ACS).

You can read more about these instruments on the HST website.

# Instrument of choice...

Let's refine our search by limiting which instruments we would like our data to come from.




There are two main types of instruments - imagers and spectrographs.

One could also refine their search by using the user-specified field options (e.g. by limiting the wavelength of the observation).

Let's have a closer look at the results of our search.

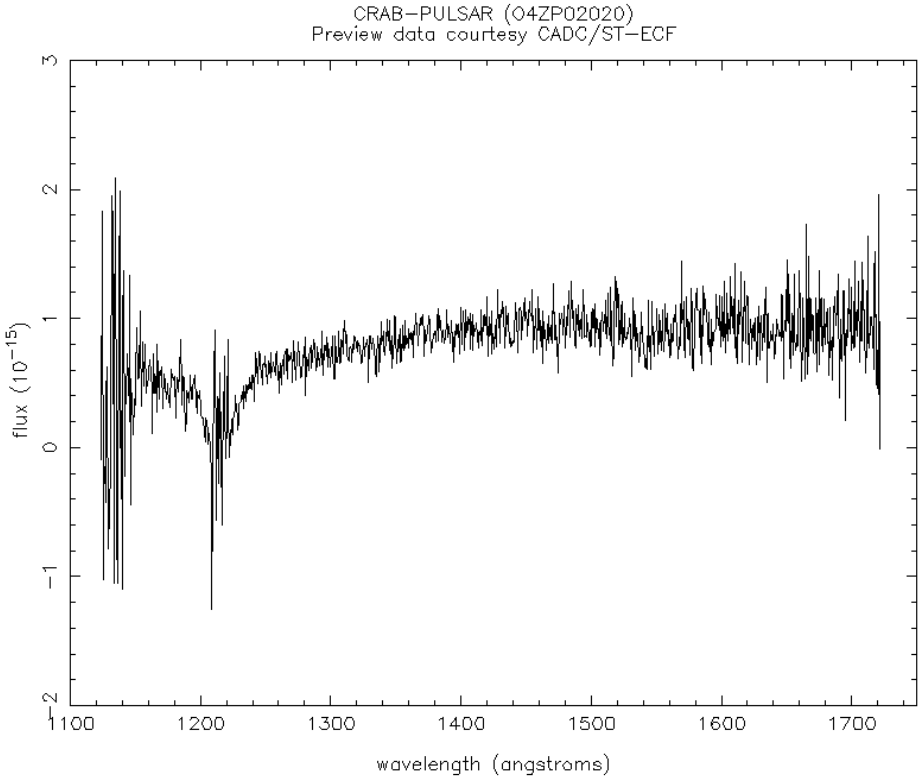
| Mark | Dataset | Target Name | RA (J2000) | Dec (J2000) | Ref | Start Time | Exp Time | Instrument | Apertu |
|---|---|---|---|---|---|---|---|---|---|
| ☐ | Y2ZM0105T | PSR0531+21 | 05 34 31.97 | +22 00 52.1 | | 1996-01-11 08:16:00 | 759.984 | FOS | 0.25-P. |
| ☐ | Y2ZM0106T | PSR0531+21 | 05 34 31.97 | +22 00 52.1 | | 1996-01-11 09:22:00 | 2430.000 | FOS | 0.25-P. |
| ☐ | Y2ZM0107T | PSR0531+21 | 05 34 31.97 | +22 00 52.1 | | 1996-01-11 10:58:00 | 2430.000 | FOS | 0.25-P. |
| ☐ | Y2ZM0108T | PSR0531+21 | 05 34 31.97 | +22 00 52.1 | | 1996-01-11 12:35:00 | 2430.000 | FOS | 0.25-P. |
| ☐ | Y2ZM0109T | PSR0531+21 | 05 34 31.97 | +22 00 52.1 | | 1996-01-11 14:11:00 | 2430.000 | FOS | 0.25-P. |
| ☐ | Y2ZM010AT | PSR0531+21 | 05 34 31.97 | +22 00 52.1 | | 1996-01-11 15:48:00 | 2430.000 | FOS | 0.25-P. |
| ☐ | Y2ZM010BT | PSR0531+21 | 05 34 31.97 | +22 00 52.1 | | 1996-01-11 17:25:00 | 2430.000 | FOS | 0.25-P. |
| ☐ | Y2I00103T | CRAB-PULSAR | 05 34 31.96 | +22 00 52.0 | | 1994-09-12 23:52:00 | 560.000 | FOS | 4.3 |
| ☐ | Y2I00104T | CRAB-PULSAR | 05 34 31.96 | +22 00 52.0 | | 1994-09-13 00:06:00 | 739.980 | FOS | 4.3 |
| ☐ | Y2I00404T | CRAB-PULSAR | 05 34 31.96 | +22 00 52.0 | | 1995-01-03 16:11:00 | 2319.961 | FOS | 1.0 |

Note that each record tells you the start time, the exposure time and the instrument for each observation (have a look at all the columns of the table).

# Example HST observation

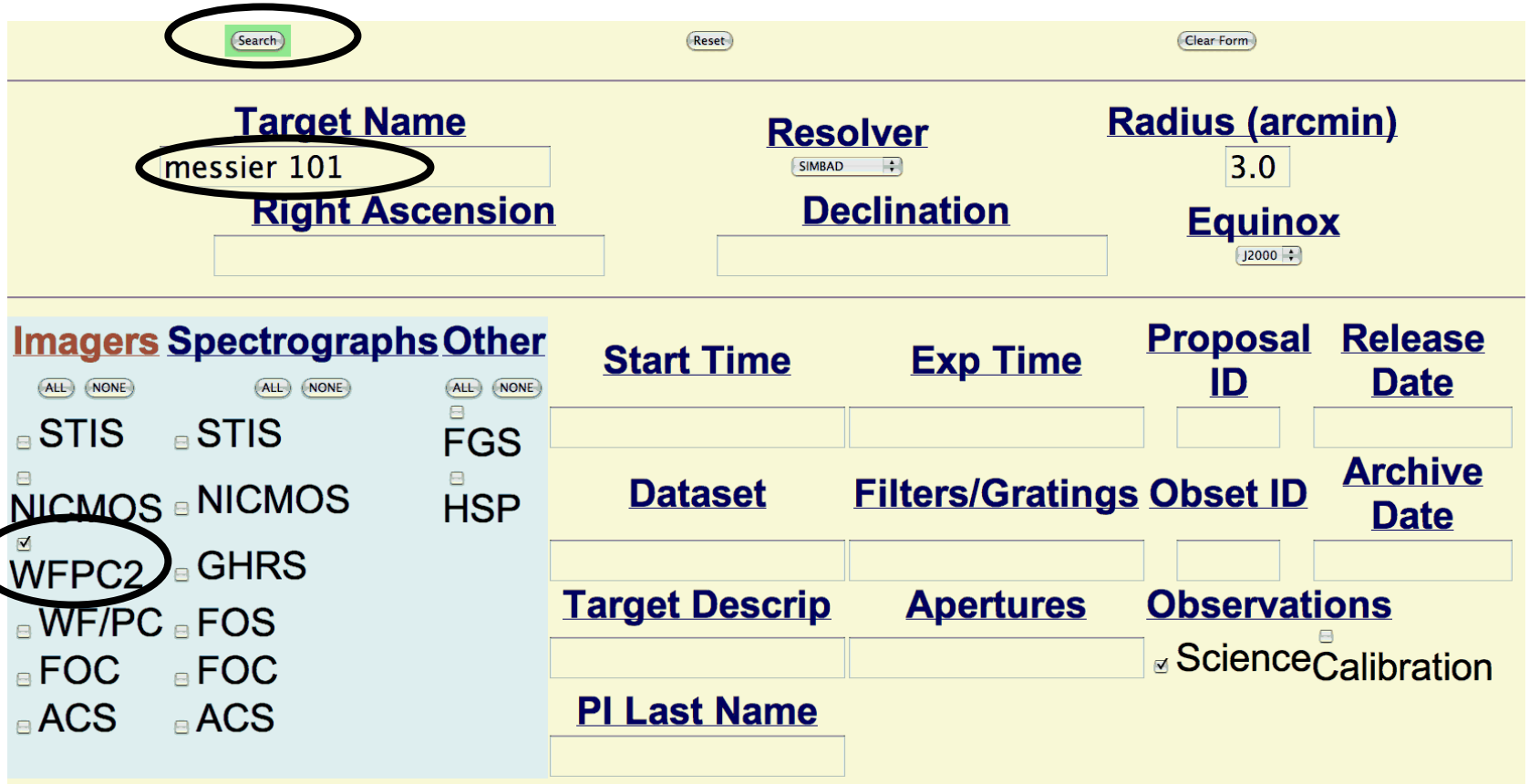
Here is an ultra-violet spectrum of the Crab pulsar taken with HST's STIS, which you can obtain by clicking on the Target Name records in the results table.

A spectrograph measures the light from an object to determine such properties as chemical composition and abundances, temperature, radial velocity, rotational velocity, and magnetic fields. We will explore these issues in modules 5 & 6.



# Instrument of Choice...

This time we will search for a WFPC2 image of Messier 101.



Let's have a closer look at the results of our search.

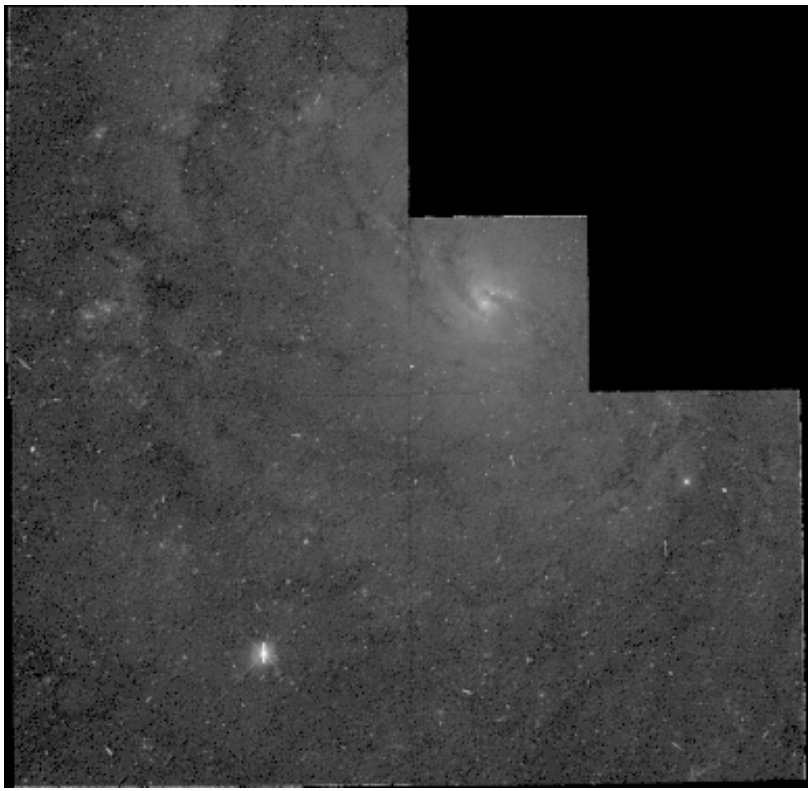
Messier 101 is also known as NGC5457.

Selecting an entry in the column "Target Name" will bring up the actual, monochromatic, science image.

| Mark | Dataset | Target Name | RA (J2000) | Dec (J2000) | Ref | Start Time | Stop Time | Exp Time | Instrument | Apertures | Filters/Gratings |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ☐ | U6712701R | NGC5457 | 14 03 12.38 | +54 21 25.4 | 5 | 2001-04-22 05:42:00 | 2001-04-22 05:48:00 | 400.000 | WFPC2 | PC1 | F547M |
| ☐ | U6712705R | NGC5457 | 14 03 12.38 | +54 21 25.4 | 5 | 2001-04-22 07:27:00 | 2001-04-22 07:28:00 | 100.000 | WFPC2 | PC1 | F656N |
| ☐ | U6712706R | NGC5457 | 14 03 12.38 | +54 21 25.4 | 5 | 2001-04-22 07:33:00 | 2001-04-22 07:41:00 | 500.000 | WFPC2 | PC1 | F656N |
| ☐ | U6712704R | NGC5457 | 14 03 12.38 | +54 21 25.4 | 5 | 2001-04-22 07:16:00 | 2001-04-22 07:22:00 | 400.000 | WFPC2 | PC1 | F547M |
| ☐ | U6712709R | NGC5457 | 14 03 12.38 | +54 21 25.4 | 5 | 2001-04-22 09:18:00 | 2001-04-22 09:26:00 | 500.000 | WFPC2 | PC1 | F656N |
| ☐ | U6712702R | NGC5457 | 14 03 12.38 | +54 21 25.4 | 5 | 2001-04-22 05:53:00 | 2001-04-22 05:59:00 | 400.000 | WFPC2 | PC1 | F547M |
| ☐ | U6712707R | NGC5457 | 14 03 12.38 | +54 21 25.4 | 5 | 2001-04-22 08:52:00 | 2001-04-22 09:00:00 | 500.000 | WFPC2 | PC1 | F656N |
| ☐ | U6712703R | NGC5457 | 14 03 12.38 | +54 21 25.4 | 5 | 2001-04-22 06:04:00 | 2001-04-22 06:10:00 | 400.000 | WFPC2 | PC1 | F547M |
| ☐ | U6712708R | NGC5457 | 14 03 12.38 | +54 21 25.4 | 5 | 2001-04-22 09:05:00 | 2001-04-22 09:13:00 | 500.000 | WFPC2 | PC1 | F656N |
| ☐ | U8OB0101M | M101-POS1 | 14 03 6.91 | +54 21 2.3 | 2 | 2004-02-10 00:09:00 | 2004-02-10 00:29:00 | 1200.000 | WFPC2 | WFALL-FIX | F336W |

# Example HST observation

Clicking on the previous link (at the website) downloads an archived 400 second exposure taken with Hubble's WFPC2 through the F547M (green) filter.



While the true colour of this image is green, the intensity variations are recorded in greyscale.

To acquire the spectacular colour images seen previously, astronomers must carefully combine images such as this, together with similar images taken through different filters.

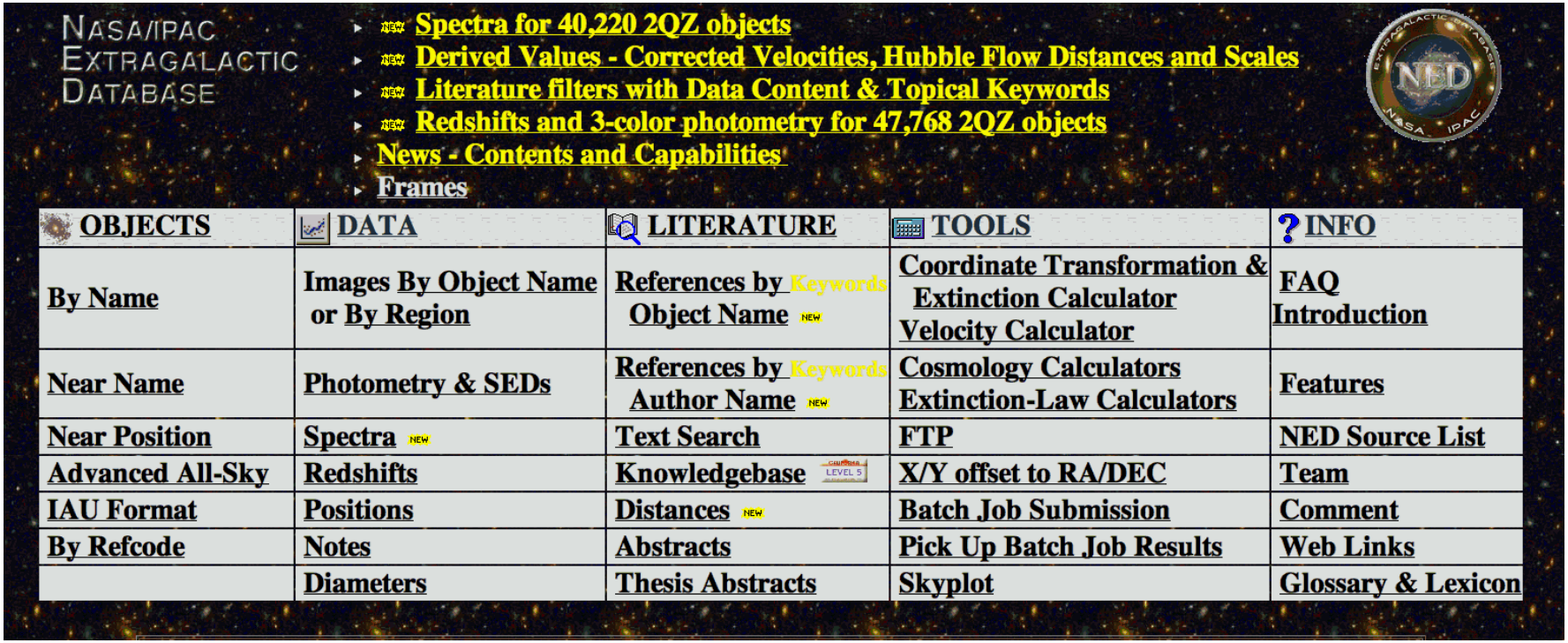
# Introducing NED

Another database that most, if not all, extragalactic astronomers have bookmarked is the NASA/IPAC Extragalactic Database (NED).

NED contains a wealth of data on objects outside of our own galaxy. If, for example, you were doing a presentation on a specific quasar or galaxy, NED would be a good place to look for an image

After you have finished this Activity, you should visit the NED website yourself. The URL is https://nedwww.ipac.caltech.edu.

# NASA/IPAC Extragalactic Database (NED)




By now you should be somewhat familiar with navigating database query forms. Let's look at what kind of information is available from NED.

The images in the NED database come from a variety of sources.

These include the Uppsala General Catalogue of Galaxies, the Third Reference Catalogue of Bright Galaxies, and the Parkes Radio Source Catalogue. You can read about these sky surveys on the NED website.

| OBJECTS | DATA |
|---|---|
| By Name | Images By Object Name or By Region |
| Near Name | Photometry & SEDs |
| Near Position | Spectra NEW |
| Advanced All-Sky | Redshifts |
| IAU Format | Positions |

Again, it is common to search for objects by name. Let's see what information NED has on Messier 101.

# NED entries for Messier 101.

Coordinates on the sky.

G for galaxy

**1 objects found in NED.** Skyplot(first 100)

| No. | Object Name (* => Essential Note) | EquJ2000.0 RA | DEC | Type | Velocity/Redshift km/s | z | Qual |
|---|---|---|---|---|---|---|---|
| 1 | *MESSIER 101 | 14h03m12.6s | +54d20m57s | G | 241 | 0.000804 | |

Recessional velocity in km/s, and as a redshift `z' (i.e, in units of the speed of light).

| Object Names | Type |
|---|---|
| MESSIER 101 | G |
| MESSIER 102 | G |
| NGC 5457 | G |
| UGC 08981 | G |
| ARP 026 | G |
| VV 344a | G |
| VV 456 | G |
| CGCG 272-021 | G |
| CGCG 1401.5+5435 | G |
| MCG +09-23-028 | G |
| IRAS 14013+5435 | IrS |

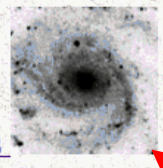
Some of M101's many names.

**Basic Data**

| | | |
|---|---|---|
| Helio. Radial Velocity | : | 241 +/- 2 km/s |
| Redshift | : | 0.000804 +/- 0.000007 |
| Major Diameter (arcmin) | : | 28.8 |
| Minor Diameter (arcmin) | : | 26.9 |
| Magnitude and Filter | : | 8.31 |
| Classifications | : | SAB(rs)cd |

Apparent magnitude (i.e., brightness).

Apparent size on the sky.

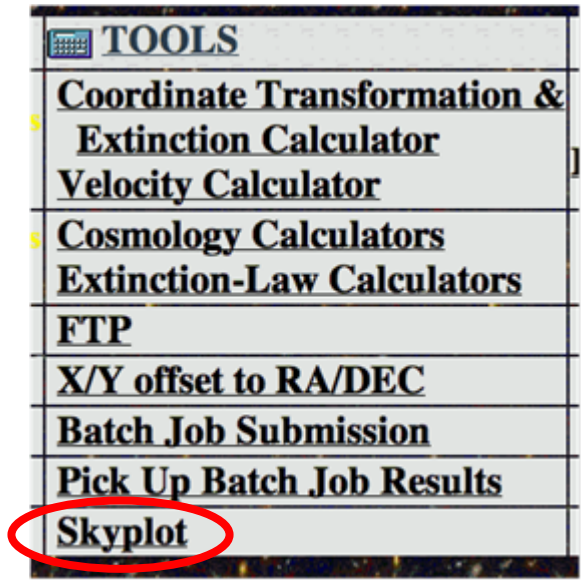


- images
- 1001 reference(s)
- 103 photometric data point(s)
- 6 position data point(s)
- 9 redshift data point(s)
- 8 diameter data point(s)
- 20 note(s)
- UGC data
- RC3 data

Web-links to images.

# Skyplot

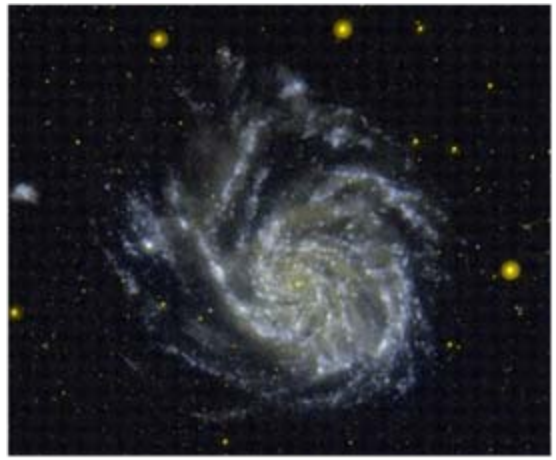
As well as telescope images, you can use NED to create a quick finder chart (or Skyplot) for your object.



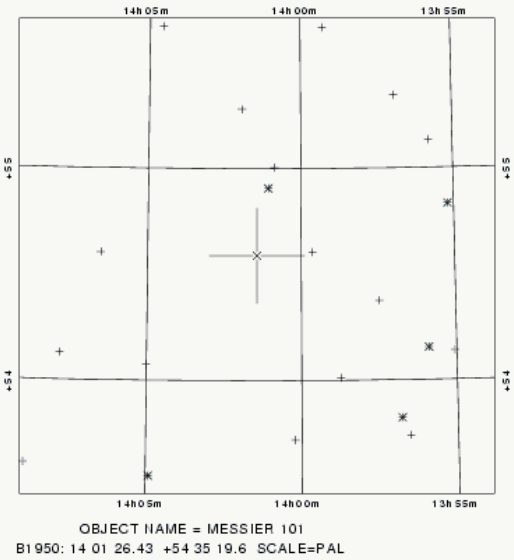

**1 objects found in NED.** Skyplot(first 100)

| No. | Object Name (* => Essential Note) | EquJ2000.0 RA | DEC | Type | Velocity/Redshift km/s | z | Qual |
|---|---|---|---|---|---|---|---|
| 1 | *MESSIER 101 | 14h03m12.6s | +54d20m57s | G | 241 | 0.000804 | |

# Skyplot



## Skyplot for Messier 101




"+" S.A.O. star with magnitude >= 8.0. **(Faint)**
"*" S.A.O. star with magnitude < 8.0. **(Bright)**
"X" Position uncertainty < 1".
"Ellipse" 95% confidence uncertainty for positions.

SCALE:
POSS 67.187"/mm w/ EPOCH=1950. for SAO star proper motion correction
ESO 67.400"/mm w/ EPOCH=1974. for SAO star proper motion correction
XXX User-specifed scale & epoch

# Other Places to look

While NED is useful for researching extra-galactic objects, you may also be interested in an object within our own Galaxy.

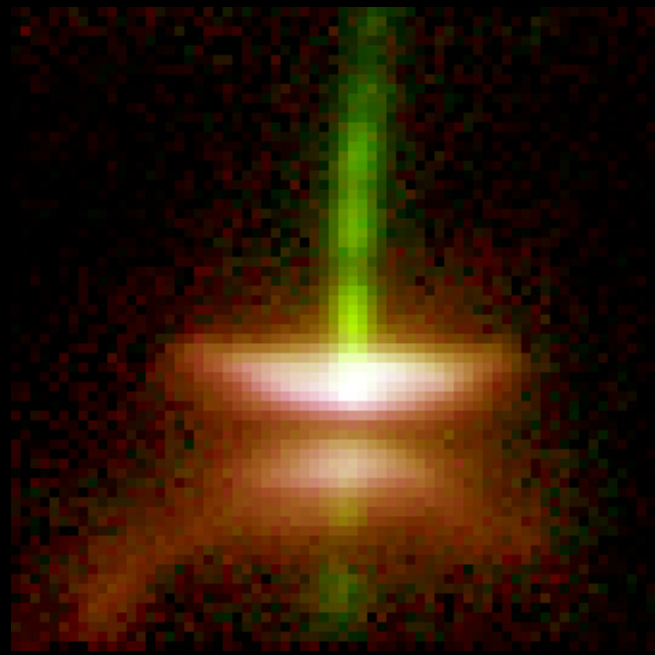
There are numerous specialised online databases that can provide information.  Which is useful depends on what you are looking for.

A large number of catalogues can be found via the website:

https://cds.unistra.fr

# Using databases to find out more about your favourite object

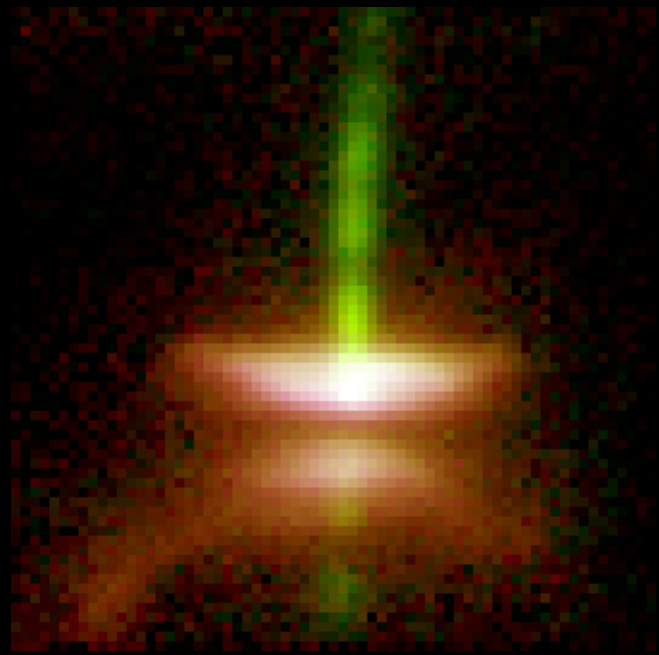
Let's say, for instance, that you come across this picture:



It is simply labelled 'HH 30' but you want to know more about it.

# Using databases to find out more about your favourite object

Using your newly acquired skills, you search ADS and discover that HH 30 is a *Herbig-Haro object* – an object containing a set of powerful, gaseous jets emitted during the birth of a star.



So are there any young star catalogues?

Yes!  You can start with the Herbig-Haro catalogue:

https://vizier.cds.unistra.fr/viz-bin/VizieR?-source=HH

# The Herbig-Haro Catalogue

## Catalogue of Herbig-Haro Objects

| HH | Other designation | α(1950) | δ(1950) | Suspected Source | Region | Dist. [pc] |
|---|---|---|---|---|---|---|
| 161 | LkHα 198B/HH | 0 08 48.9 | +58 32 45 | LkHα 198-B | Cassiopeia | 950 |
| 164 | LkHα 198 jet | 0 08 47.5 | +58 32 48 | LkHα 198 | Cassiopeia | 950 |
| 162 | V376 Cas/HH | 0 08 49.8 | +58 33 27 | V376 Cas | Cassiopeia | 950 |
| 163 | AFGL4029 jet | 2 57 36.0 | +60 17 22 | AFGL 4029 | IC1848A | 2200 |
| 267 | | 3 20 58.3 | +30 49 53 | | L1448 | 300 |
| 268 | | 3 21 17.6 | +30 37 36 | | L1448 | 300 |
| 193 | | 3 21 48.1 | +30 44 22 | | L1448 | 300 |

Here you can find more information such as:

- alternative titles given to the object
- position in the sky
- suspected source
- distance from Earth in parsecs (pc)

# Conclusion

You should now be ready to research for a presentation on astronomy about almost any celestial object that you can think of!

In particular, you should now be able to find information online from,

- ADS and astro-ph, databases for looking up articles and pre-prints about topics in astronomy; and
- astronomical image databases maintained by research institutions such as the Digitized Sky Survey, the Hubble Space Telescope and the NASA/IPAC Extragalactic Database (NED).

# Original Image Credits

Hubble Deep Field (Title Slide)
https://oposite.stsci.edu/pubinfo/pr/1996/01.html

Crab Nebula
https://oposite.stsci.edu/pubinfo/pr/2000/15/

Supernova image 1987A
https://oposite.stsci.edu/pubinfo/pr/1999/04/

Images from the Digitized Sky Survey

https://archive.stsci.edu/dss

Eagle Nebula
https://oposite.stsci.edu/pubinfo/pr/1995/44.html

Messier 101
https://hubblesite.org/newscenter/archive/releases/2006/10/image/a/

# *End of Activity*

***Press the ESC (Escape) key to return to the home page for this Module.***