# IPAC Archive Holdings

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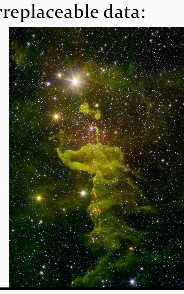
## Why?

- The "I" in NITARP stands for "IPAC", based at Caltech.
- IPAC is not the Astronomy Department!
- IPAC houses several different archives, each with their own goals, methodology, tools, staff, (and sometimes science goals).
- As NITARP educators, you will learn about at least one of our data sets in great detail, but the rest of IPAC's holdings may also prove useful to you in your NITARP project, or your future (post-NITARP) work!
- Essentially all of IPAC has (typically) been consolidated into one AAS booth (for better branding in the community).
- (There are archives based at other places that have other booths here too...)

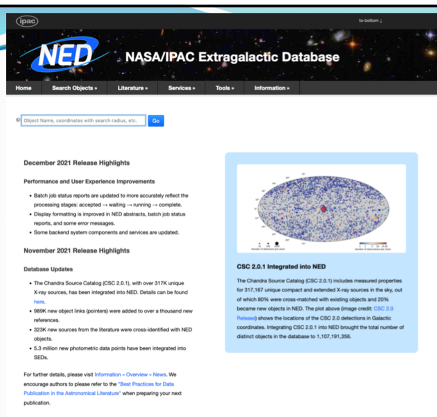
## An archive's job

- Ingest new data (and reprocessing of old data).
- Maintain/serve vital repository of irreplaceable data:
  - Support for observation planning and mission planning.
  - Resource for original science.
  - High level science products.
- Enable cutting-edge research:
  - API and Virtual Observatory.
  - User support by experts.
  - New/enhanced services.
  - Multi-wavelength projects.



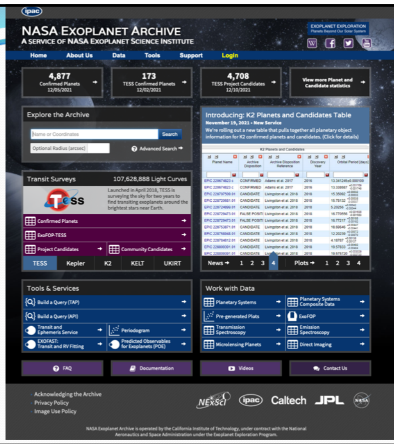
## NED

- NED = NASA/IPAC Extragalactic Database
- Focused on extragalactic science.
- Ingests catalogs and literature tables.
- Hundreds of millions of unique objects!
- Myriad cross-links, notes, etc.
- Updates every few months.
- http://ned.ipac.caltech.edu/




## NASA Exoplanet Archive

- Focused on stars harboring exoplanets, or thought to harbor exoplanets.
- Includes Kepler & K2 data, and US portal to CoRoT data.
- Anyone using Kepler data (none of you this year) will get more of an introduction to this as part of your work.
- Online tools to work with these data, like the periodogram service.
- http://exoplanetarchive.ipac.caltech.edu/




# IRSA

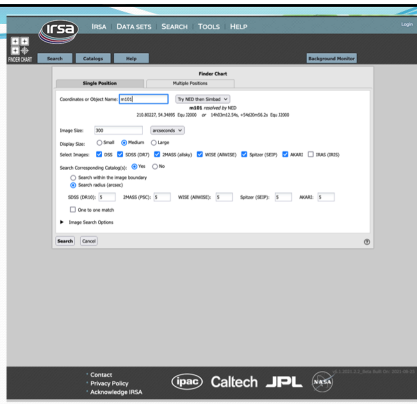
- IRSA = NASA/IPAC Infrared Science Archive
- Charter is to provide interface to all NASA infrared and sub-mm data sets. Has a few others in there too.
- Some are small (e.g., Spitzer Legacy programs), and some are VERY large (all-sky surveys like WISE).
- IRSA datasets are cited in about 18% of astronomical refereed journal articles annually.
- Several of the newest data sets are served via Firefly; the rest are accessible via Atlas or our catalog search tool.
- >1 PB (petabyte) in disk space, 3.5 PB if you include non-NASA data; billions upon billions of rows in catalogs.


# Some IRSA holdings

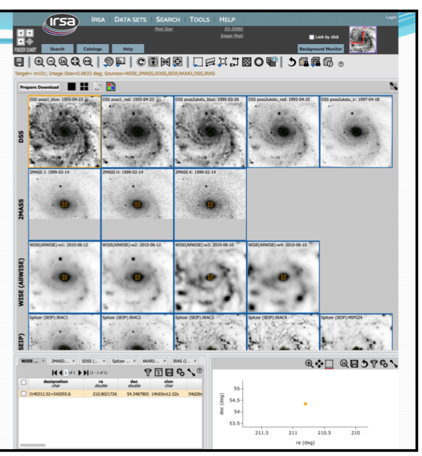
- Infrared Astronomy Satellite (IRAS) – the first all-sky mid- and far-IR survey.
- Two Micron All-Sky Survey (2MASS) – a deep, uniform all-sky survey at J, H, and Ks.
- Spitzer Space Telescope – 3-160 microns, pointed observatory.
- WISE = Widefield Infrared Survey Explorer – all-sky survey at 3-23 um.
- Herschel Space Observatory – 60-670 microns.
- Planck = ESA mission, all-sky survey at 30 to 857 GHz (1 cm to 350 microns)
- Cosmic Evolution Survey (COSMOS) - a multiwavelength survey of a 2 sq. degree field involving every Great Observatory as well as ground-based data.
- BOLOCAM – a millimeter wavelength bolometer array at the Caltech Submillimeter Observatory.
- AKARI – a Japanese IR telescope that surveyed the whole sky at 9-160 microns.
- Midcourse Science Experiment (MSX) – a mid-IR telescope that mapped the Galactic plane and the gaps in the IRAS all-sky coverage.
- Infrared Space Observatory (ISO) – US interface to the ESA archive for ISO.
- ZTF – ground-based optical monitoring of sky visible from Palomar.

Finder Chart

- Access up to 7 surveys at once
- Images and catalogs together
- Easiest "on-ramp" to IRSA services

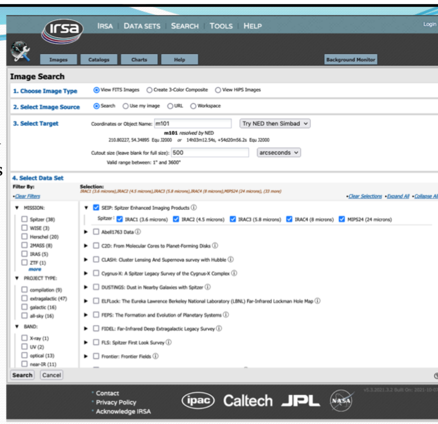



Images, sorted here by survey

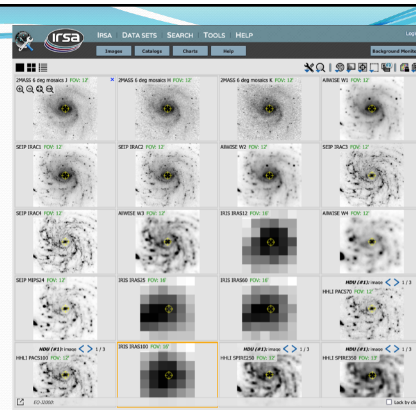



Catalogs (and plots)

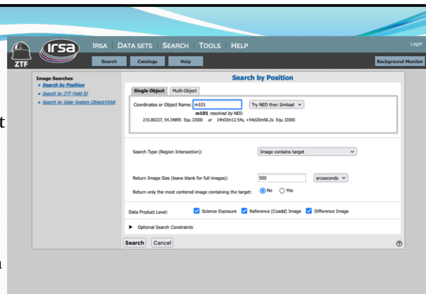
IRSA Viewer
- Generic workhorse
- Access many different sets of images at once
- Does it look at all familiar?



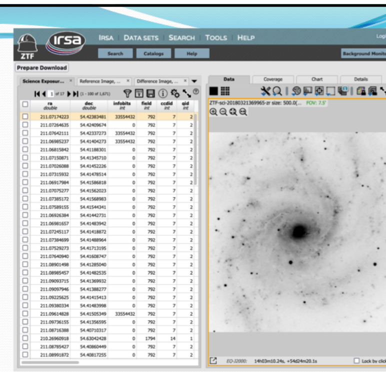
Images, here sorted by wavelength



ZTF Image Viewer
- Searches just the ZTF images
- Can search by position, ZTF field, or Solar System object/orbit
- Does this one look at all familiar?



List of images on left; images shown on right.



## Basic idea

- Many of IRSA's tools have the same look and feel.
- We are updating tools (& data!) all the time. Not everything (yet) is served this way, but we are getting there.
- We will use a LOT of IRSA tools in what we do.
- IRSA can also seamlessly interface with other archives, some more easily than others. This, too, will get easier with time.

## Summary (of this section)

- LOTS of data available to you RIGHT NOW.
- Everything is web-based. Most are intuitive (I hope). Most have on-line help. They are getting more integrated all the time.
- Many have some related material on the IRSA YouTube channel.
- You will learn more about archives specific to you as you work on your project, but don't be afraid to branch out and go exploring!

# Appendix: "kinds" of data

## What do astronomers mean?

- Raw data
- Reduced data
- Calibrated data
- Extracted data

- Real-time data
- New data
- Archival data

## Raw data

- Photons hit detector,
- Photons dislodge electrons,
- Electrons get counted.
- THAT is raw data: DN (data number; =electrons).

- OK, so it is more complicated in the IR because we don't have CCDs, but I'm going for high-level conceptual things here.
- *This isn't useful for doing astronomy… yet.*

## Reduced data

- Each pixel responds a little differently.
- There may be stuff on the optics affecting how light gets through to the detector.
- You have to calibrate each pixel separately.
- Biases, flatfields, etc. take into account detector noise and different responses of each pixel.
- (again, it's more complicated for IR detectors, but I'm going for a high-level summary here.)
- *More* useful for astronomy, but *still not ready to use*.
- ("reduced the data" often means this entire process.)

## Calibrated data

- Now we're talking!
- I know how bright that star is (Vega).
- This star I care about is 5.31 times fainter than Vega.
- **This final step takes into account all prior steps AND compares your target to the brightness of known objects**.
- NOW you are (nearly) ready to do astronomy! You can do your own photometry on these images.

## Extracted data

- If you are lucky enough to work with well-funded observatories, they have someone else writing pipelines that do ALL of this for you.
- The pipelines not only do all the earlier steps, but they ALSO measure the photometry for you and give you a number (and an error!) for the brightness of each object (for each band).
- *This saves you a TON of time. You can just walk in and do science.*
- And, if that information is easy to find and search… **Behold, the power of archives.**
- (Though I HIGHLY recommend reading the docs…)

## Real-time data

- You are sitting at the telescope.
- You read out the detector.
- You run the pipelines (or a portion of them; usually you don't get all the calibrations you need until the end of the night, or your own software).
- You look at the results.
- You adjust your very next observation based on what the results are.
- THAT is real-time data.

## (Also) Real-time data

- Robotic telescopes scan sky for interesting things (supernovae, asteroids/comets, GWs).
- They tell their minders, "hey, this might be interesting."
- Sometimes this requires a human in the loop, sometimes not: small (often dedicated) telescopes slew to follow-up as soon as they can (minutes to hours).
- Humans follow up in hours, days, weeks with larger assets.

## New data

- I wrote the proposal & I won the telescope time, or I built and own the telescope and instrument so I own the telescope time;
- I obtained the data, or I specified the details of the request of the robotic telescope;
- I took all the calibrations too and wrote the code to reduce all the data, or I took the output of whatever pipeline exists and did whatever additional work was required to meet whatever standards I have;
- Then I did science based on the new data.

## Archival data

- Someone else took the data (built the telescope/instrument/pipeline, ran the pipeline, delivered the data where I could get it).
- I downloaded the data and did new science with it.
- I need to acknowledge those people who did all that work, but they are not co-authors on my work.

## Why does any of this matter?

- You don't want to play with "raw data" unless you own your own telescope. You will be *just fine* playing with already-reduced archival data because it is ready-to-use.
- Your work here isn't going to be using "new data" because you're not taking new data.
- You won't have access to "real time" data because those projects that provide "real time" data are using them for their own purposes. *Those data don't hit the archive right away anyway.*
  - Ex: NEOWISE data from 2021 will be publicly available at IRSA in Mar 2022; ZTF does releases about every 2 months, but the released data is at least 18 months old.