# Astrophysical Objects

## Active Galaxies

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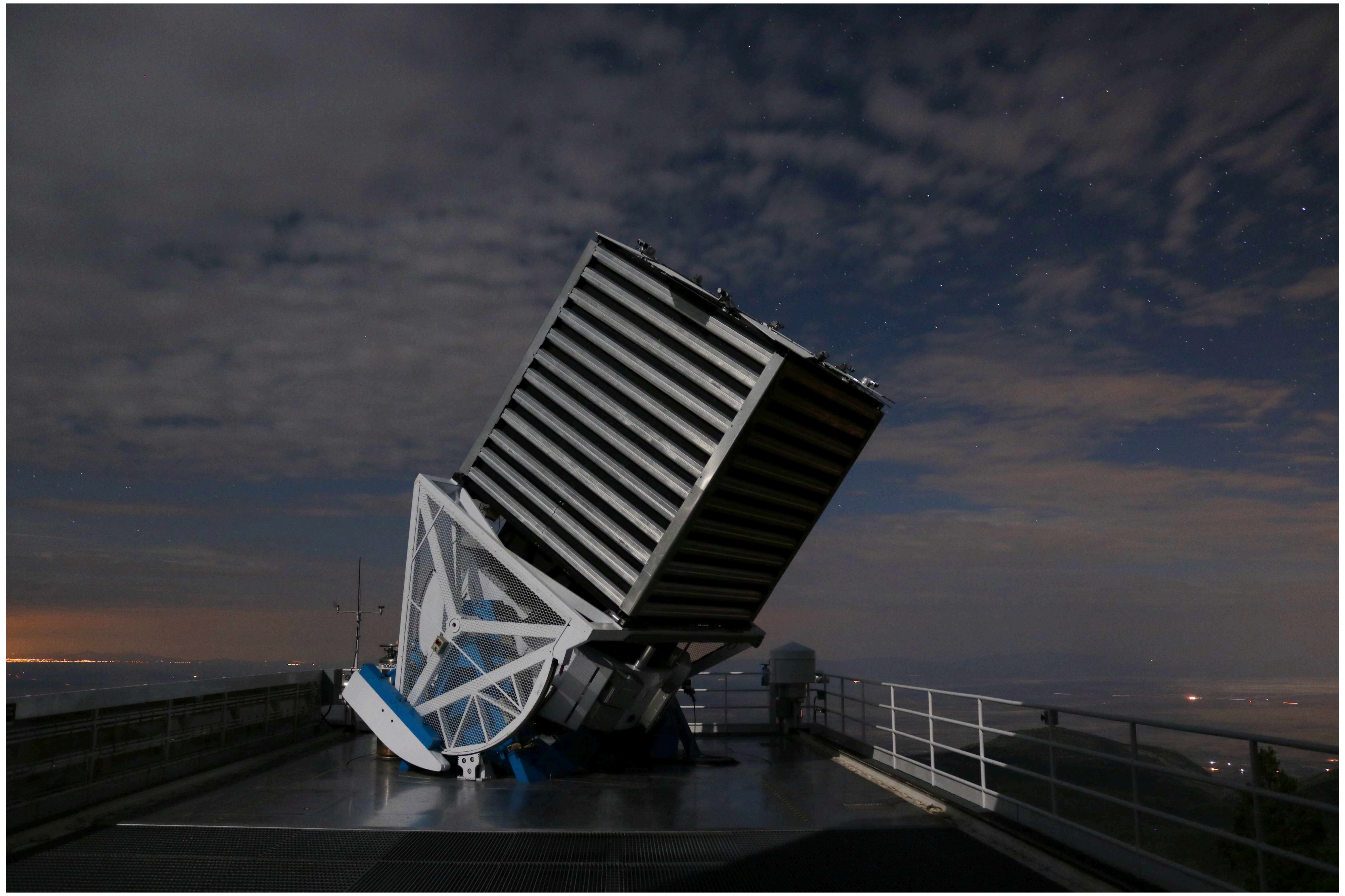
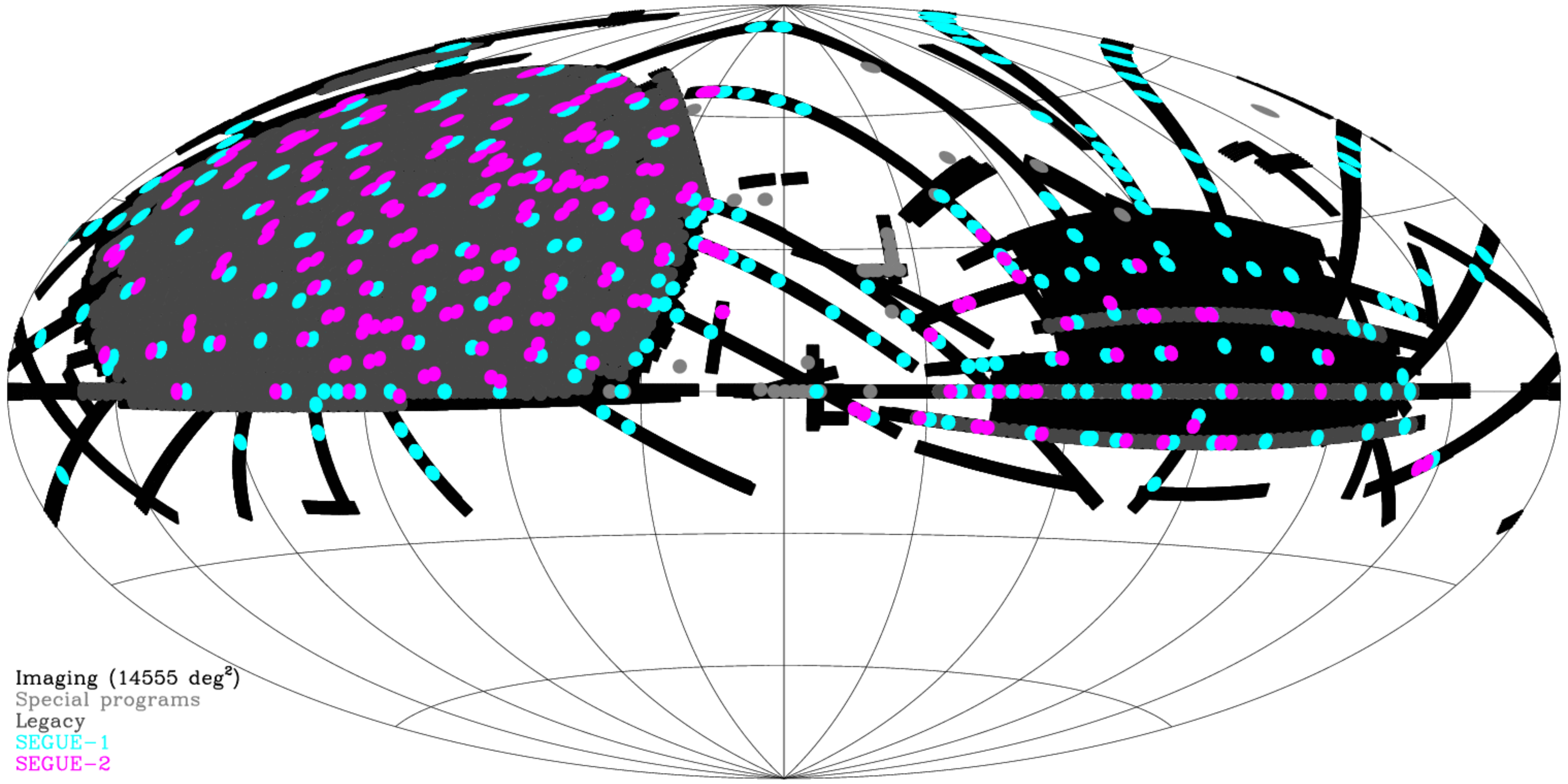
# The Sloan Digital Sky Survey

The Sloan Digital Sky Survey or **SDSS is a major multi-spectral imaging and spectroscopic redshift survey** using a dedicated 2.5-m wide-angle optical telescope at Apache Point Observatory in New Mexico, United States. The project began in 2000 and the imaging part finished in 2009.



The telescope

Sky coverage of the Survey



# The Sloan Digital Sky Survey

Images were taken using a photometric system of five filters (named u, g, r, i and z). These images are processed to produce lists of objects observed and various parameters, such as whether they seem pointlike or extended (as a galaxy might) and how the brightness on the CCDs relates to various kinds of astronomical magnitude.

**SDSS photometric system filters**

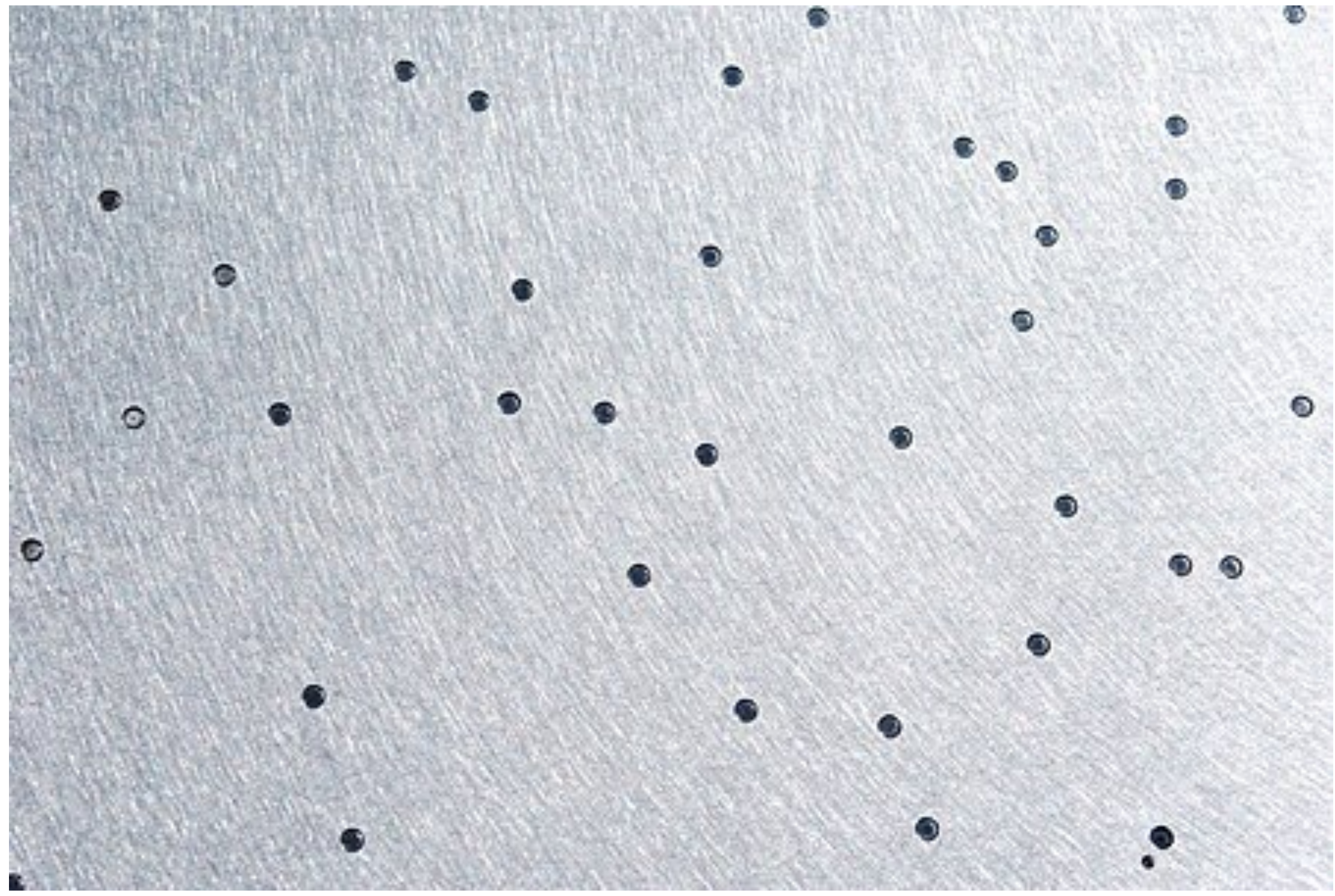
| | u | g | r | i | z |
|---|---|---|---|---|---|
| **Mean wavelength (nm)** | 355.1 | 468.6 | 616.5 | 748.1 | 893.1 |
| **Magnitude limit** | 22.0 | 22.2 | 22.2 | 21.3 | 20.5 |

https://en.wikipedia.org/wiki/Sloan_Digital_Sky_Survey

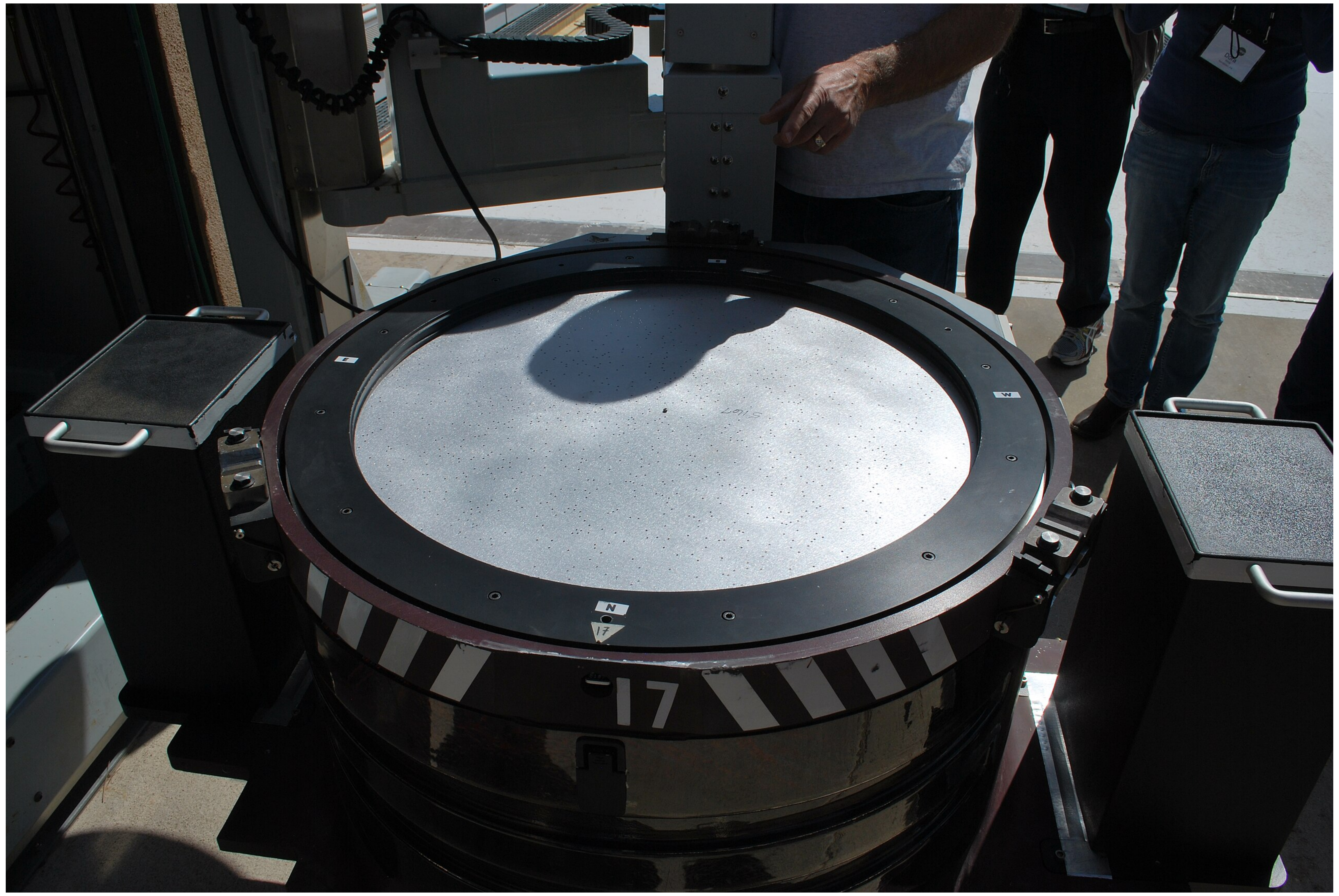
# The Sloan Digital Sky Survey

Using these photometric data, stars, galaxies, and quasars are also selected for **spectroscopy**.
The spectrograph operates by feeding an **individual optical fibre for each target through a hole drilled in an aluminum plate.** Each hole is positioned specifically for a selected target, so every field in which spectra are to be acquired requires a unique plate. The original spectrograph attached to the telescope was capable of recording 640 spectra simultaneously, while the updated spectrograph for SDSS III can **record 1000 spectra at once**. Over the course of each night, between six and nine plates are typically used for recording spectra.

**Every night the telescope produces about 200 GB of data.**



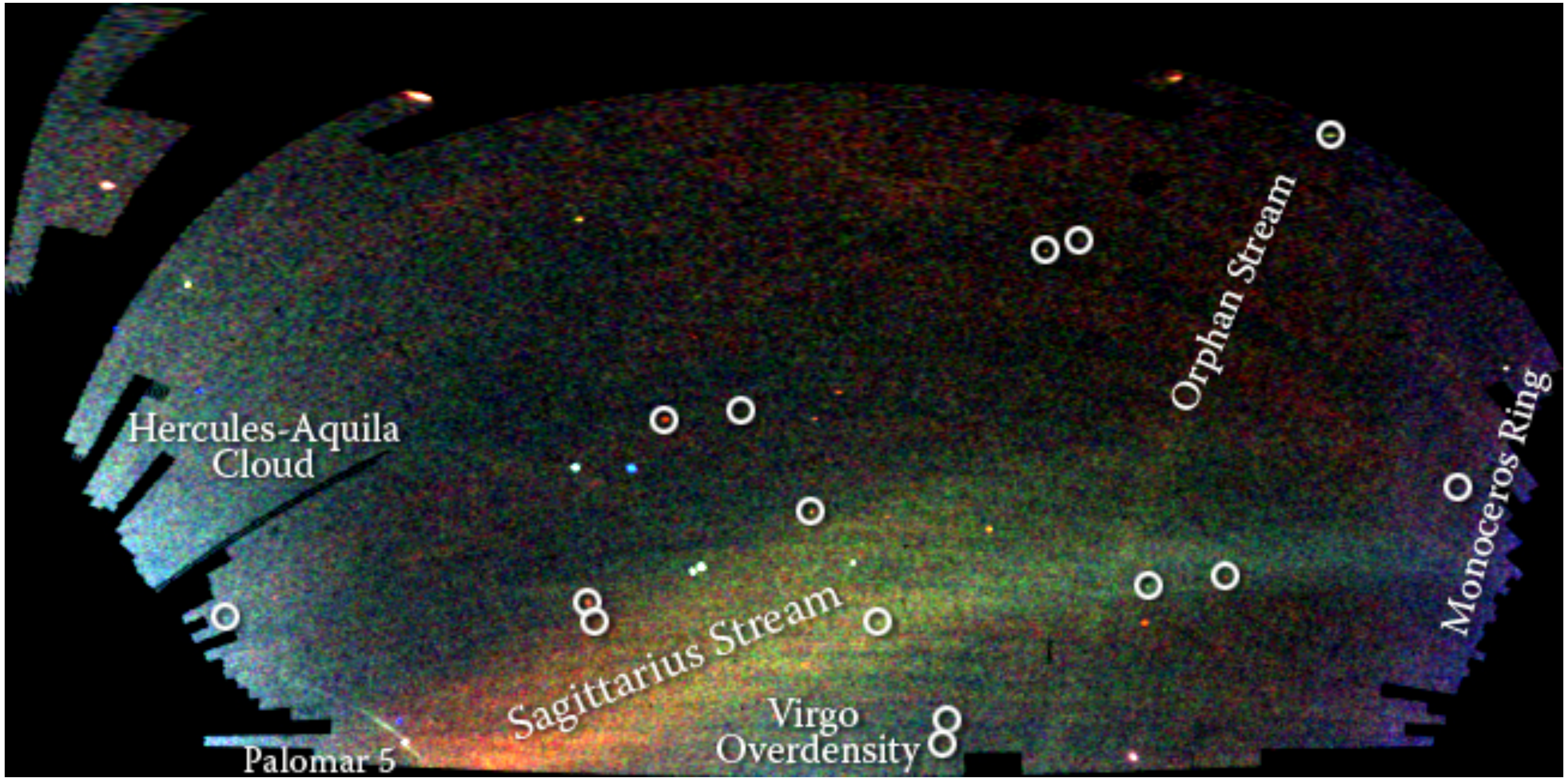
Aluminium plate for spectral observations




https://en.wikipedia.org/wiki/Sloan_Digital_Sky_Survey

# The Sloan Digital Sky Survey

One famous discovery with the survey was the many stellar streams around the Milky Way. These are most likely remains of shredded dwarf galaxies.

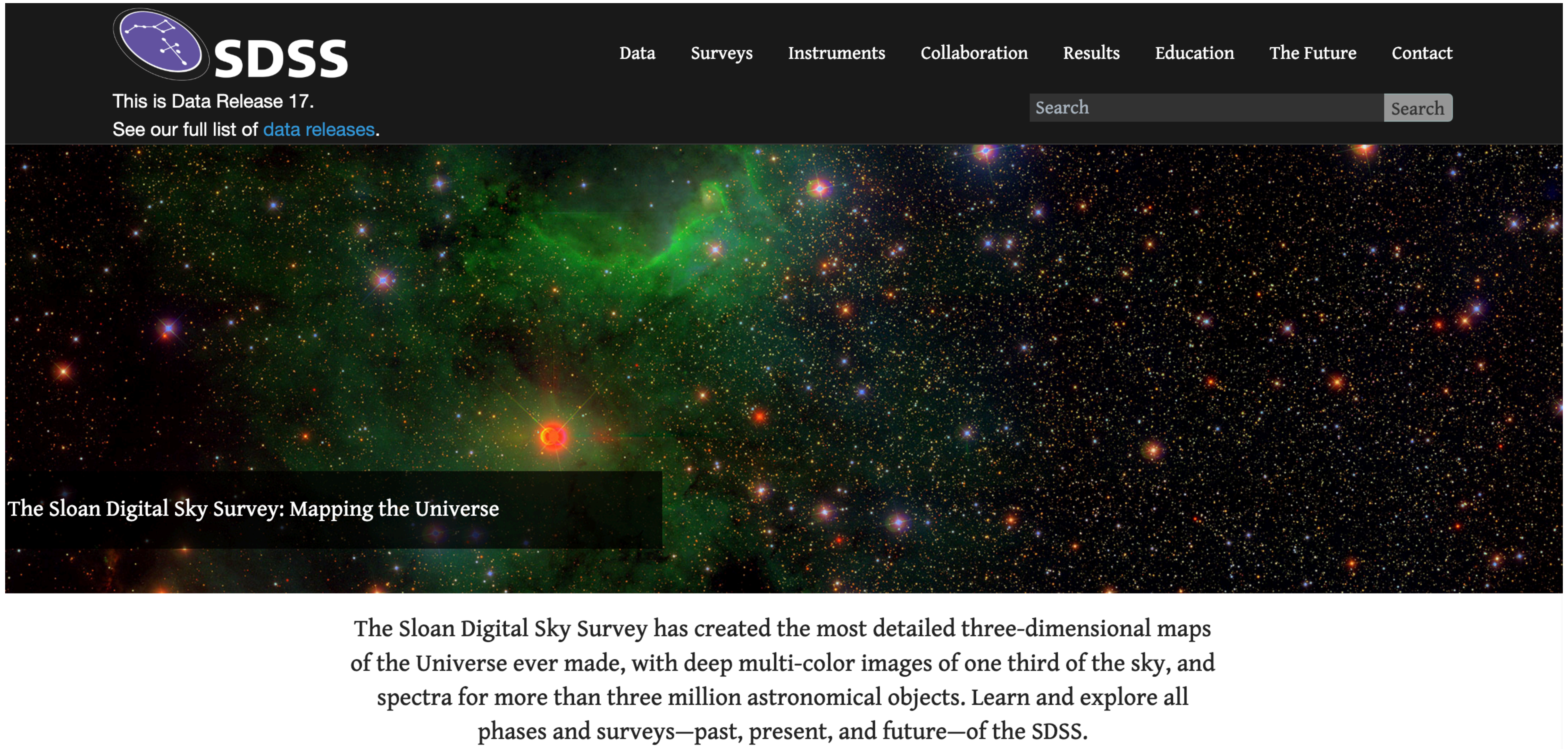


# The Sloan Digital Sky Survey

The survey has also discovered many Supernovae.

# The Sloan Digital Sky Survey

Resources:
The SDSS website: https://www.sdss4.org/
SQL tutorial: https://skyserver.sdss.org/dr14/en/help/howto/search/searchhowtohome.aspx



# BPT diagram

Sometimes, the **AGN is surrounded by gas or dust,** either near the black hole or farther out in the host galaxy. This can make galaxies with AGN **hard to distinguish from galaxies that don't have nuclear activity,** but are undergoing phases of **rapid star-formation which make their spectra look similar.** These obscured AGN are possibly the most interesting objects to study, because it is during this phase that the black hole is thought to produce some of its greatest effects on its host galaxy, for example emitting winds or jets that could shut off star formation. Thus, **being able to distinguish AGN from star-forming galaxies is important**, and for several decades, the most commonly used method has been the **BPT diagram.**

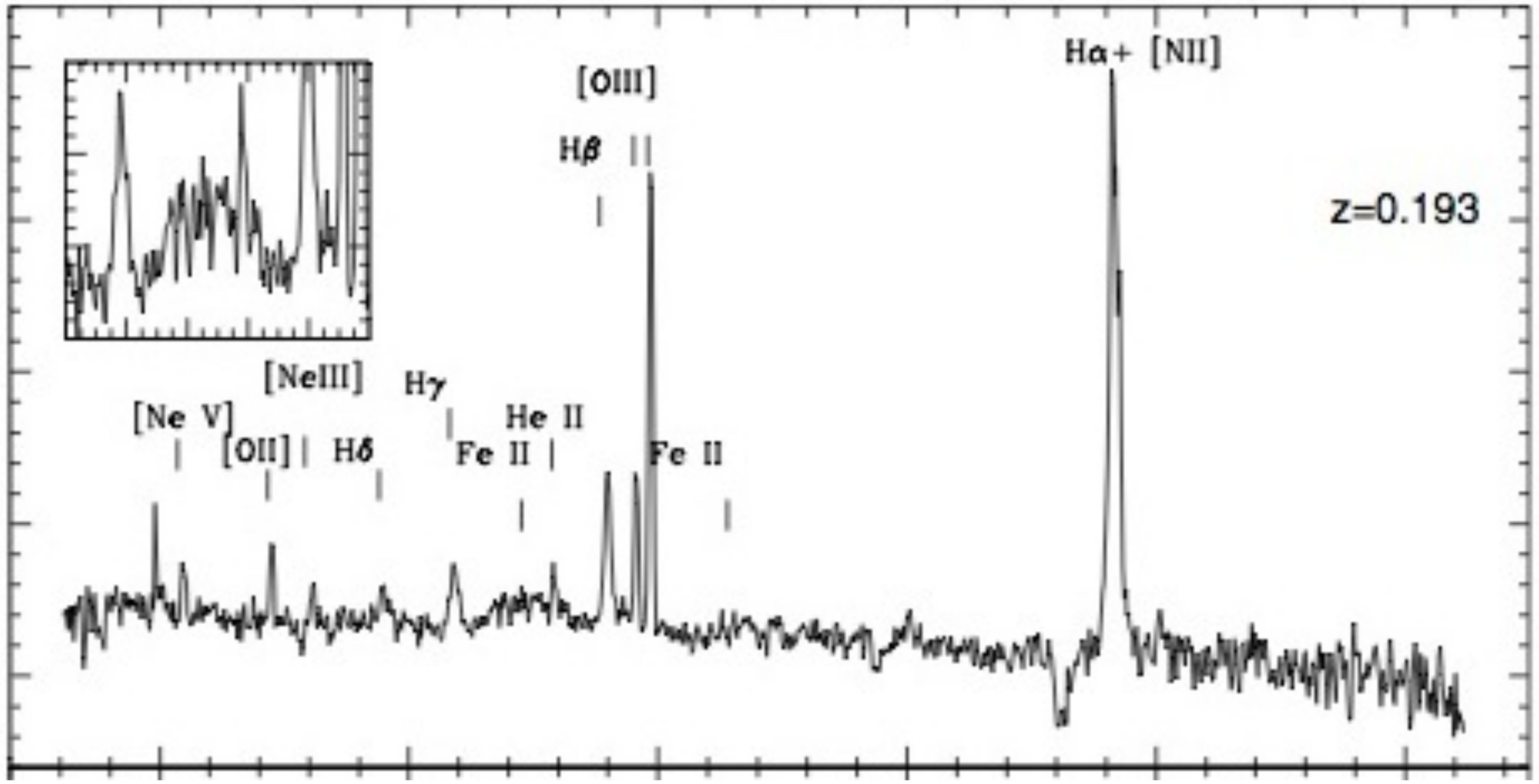
Named after its creators – Baldwin, Phillips, and Terlevich – **the BPT diagram uses the ratios of specific emission lines in galaxy and AGN spectra to distinguish the two**.

Traditionally, the ratios used are **[NII] / Hα** on one axis and **[OIII] / Hβ** on the other. (Why the brackets? Because these lines are "forbidden" transitions, which tend to occur only in the very low densities one finds in space.)

https://astrobites.org/2011/10/05/finding-agn-at-higher-redshifts/

# BPT diagram

You can see all of these emission lines in the two narrow-line AGN spectra in the figure. As the figure shows, these are **among the strongest emission lines in an AGN spectrum,** and therefore usually easy to distinguish. Because lines like **[NII] are only excited by high energy photons**, an **AGN will generally have a higher ratio of [NII] / Hα than a galaxy,** whose highest energy photons are limited to those that can be produced by massive stars.

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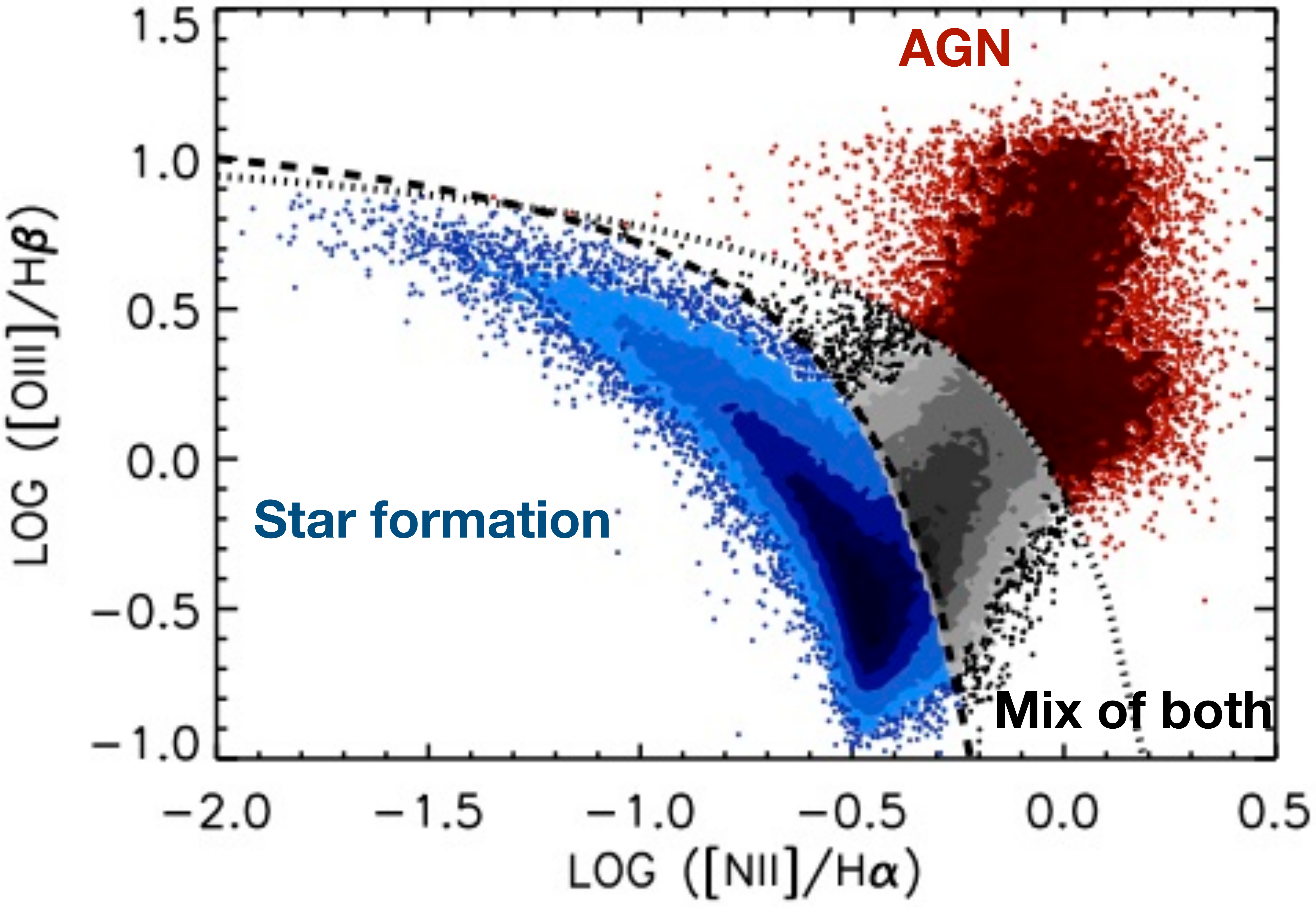
# BPT diagram

An example of a **BPT diagram** created with spectra from thousands of galaxies in the Sloan Digital Sky Survey (SDSS).

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# BPT diagram

Limitations: As one looks to **galaxies that are farther away** (at higher redshift, $z$), the **emission lines** needed to make a BPT diagram quickly s**hift out of the optical window** and **into the infrared**, where getting spectra is much, much harder. In fact, **beyond $z > 0.4$, the BPT diagram can no longer be used!** In 1981, when it was created, a redshift of 0.4 was still relatively high, but now it seems practically nearby.

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