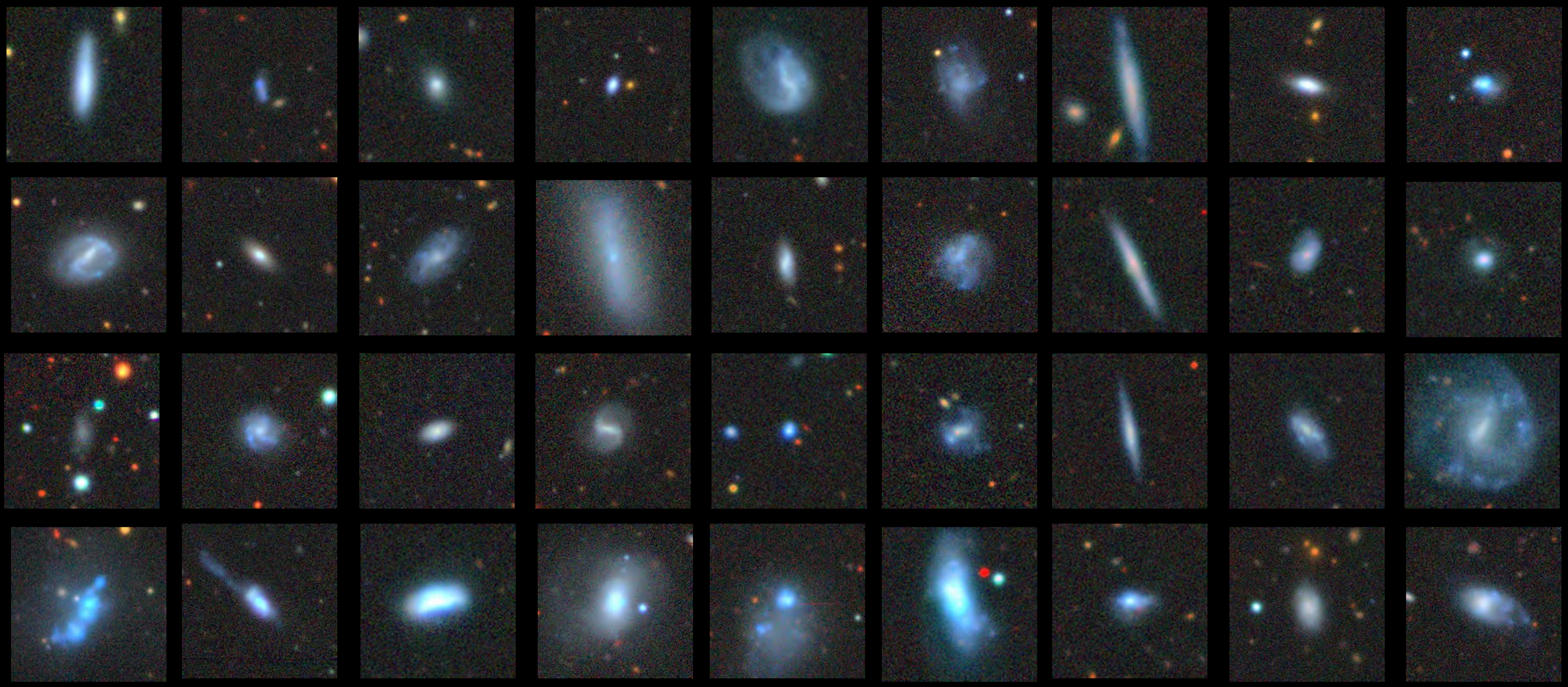
A New Population of Supermassive Black Holes in Dwarf Galaxies



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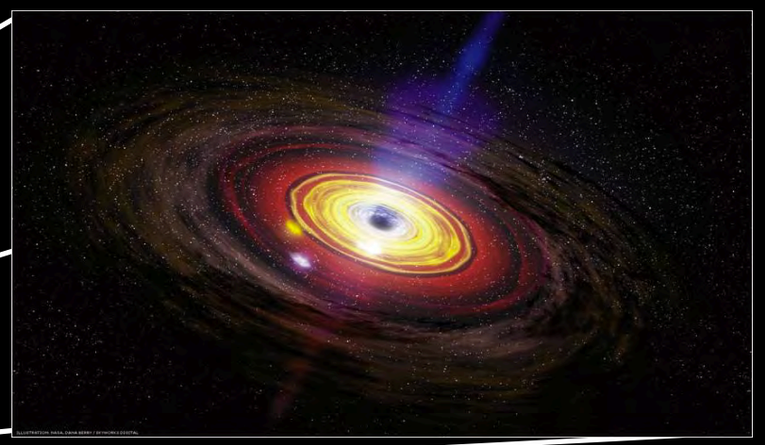
Galaxies are a collection of different astronomical objects



A supermassive black hole resides in the center of most massive galaxies.

Outside of the center there are stars, dust and gas.

Galaxies are a collection of different astronomical objects

How did the first black holes form in the early Universe?

of most massive galaxies.

Outside of the center there are stars, dust and gas.

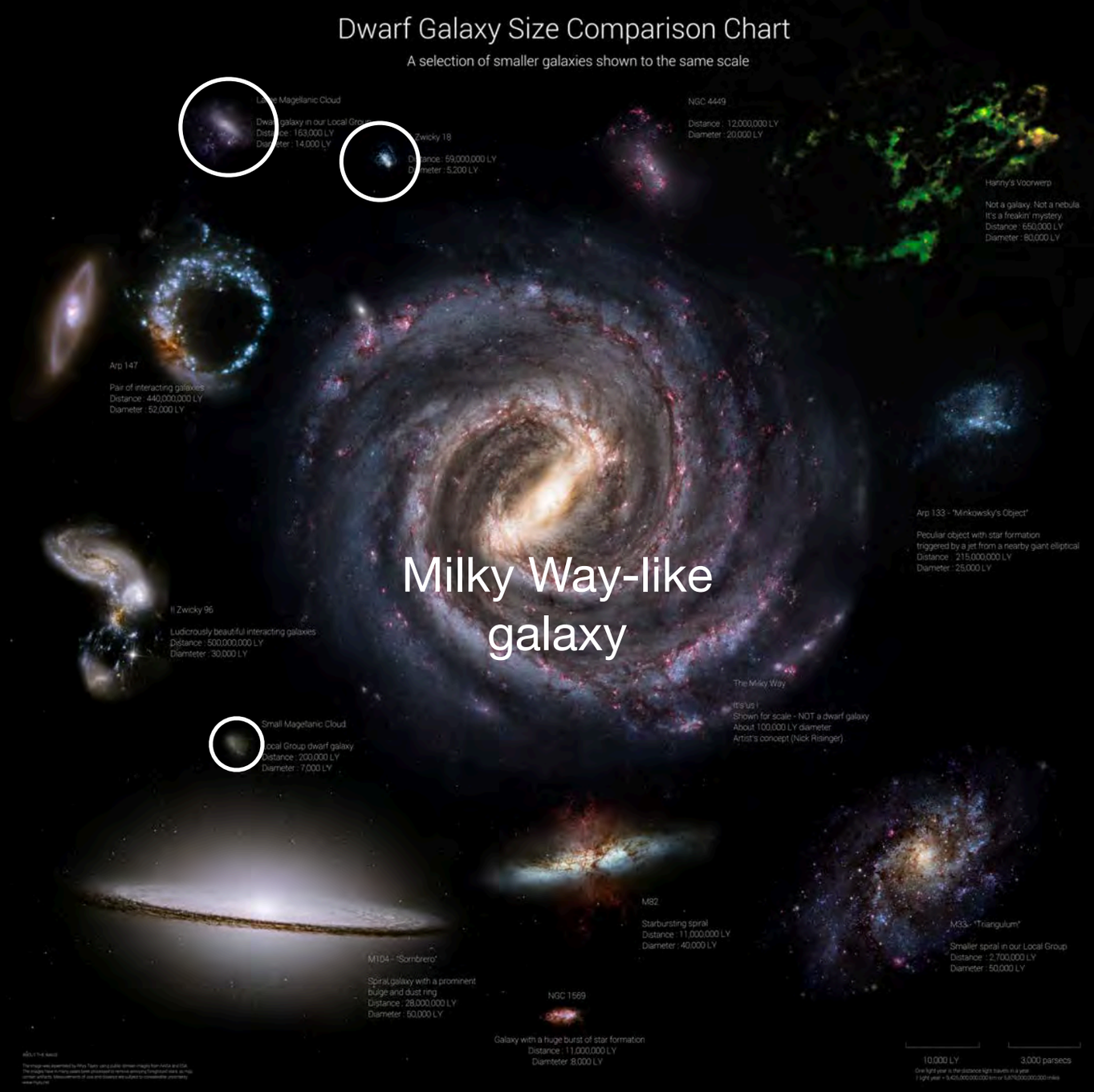
Detecting the first generation of black holes in the early universe is not currently possible

We can only detect ***the total*** light from galaxies in the early universe.

Only quasars, with ~1 billion solar mass black holes that ***outshine their entire galaxy,*** are confidently detected.

Supermassive black holes in nearby dwarf galaxies provide clues about the first generation of black holes

- Dwarf galaxies are 10–100 times smaller than Milky Way
- Dwarf galaxies are relatively untouched over cosmic time
- The supermassive black holes found in dwarfs are typically 100,000 solar masses

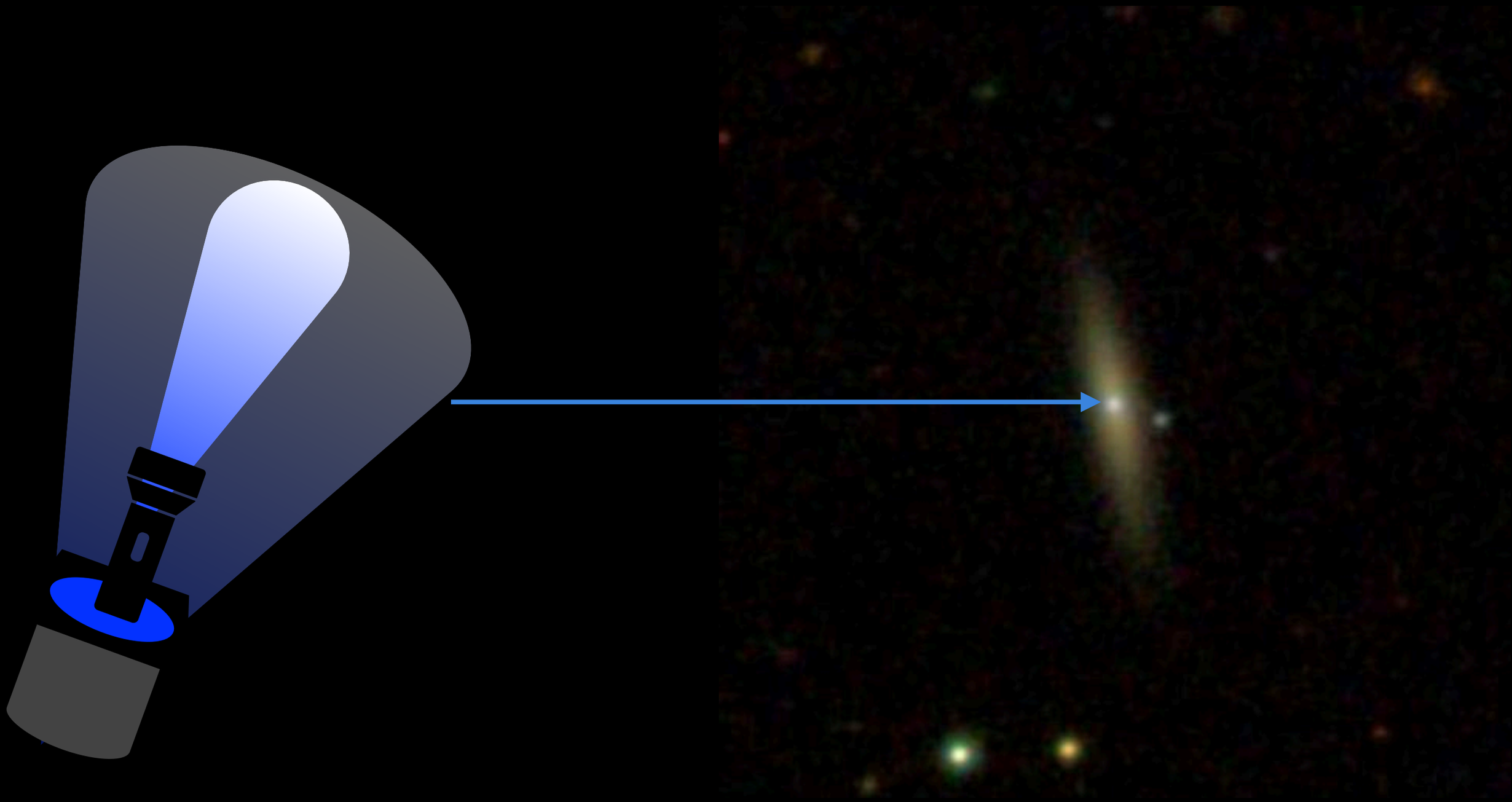


Supermassive black holes in nearby dwarf galaxies provide clues about the first generation of black holes

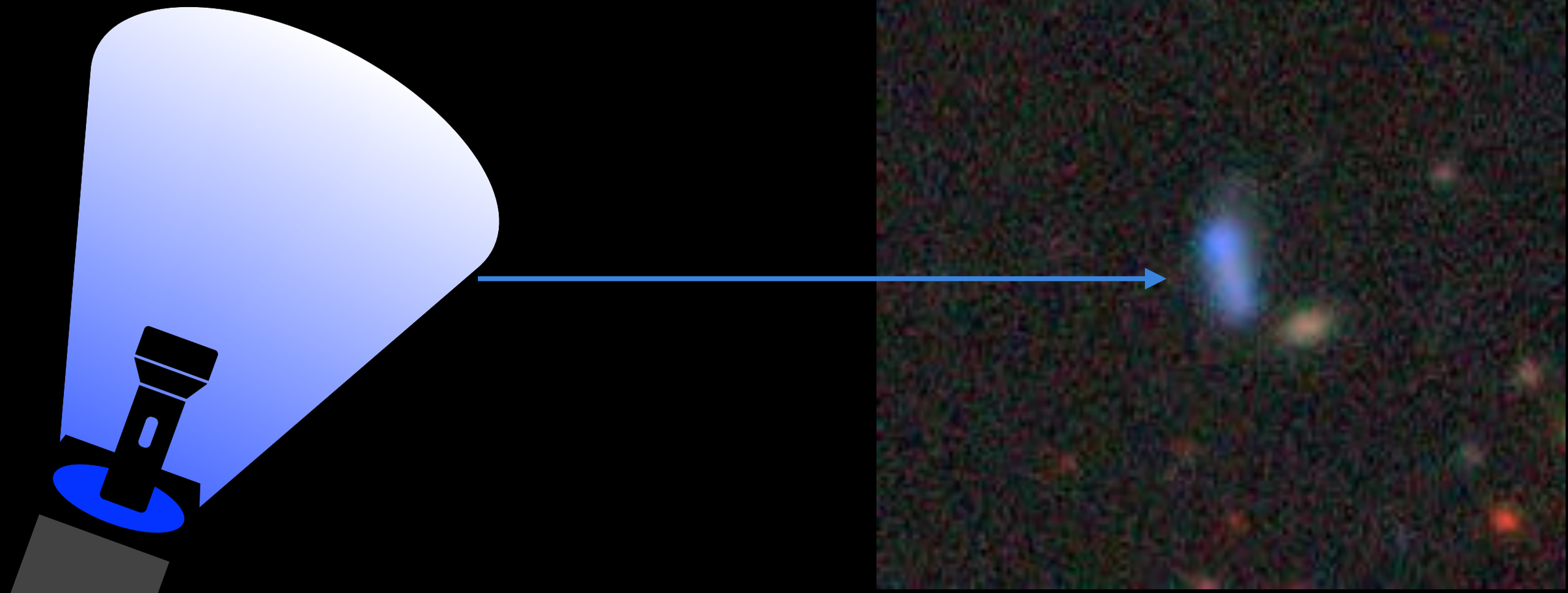
- Dwarf galaxies are 10–100
  found in dwarfs are typically
  100,000 solar masses

Since supermassive black holes in dwarf galaxies are *smaller and less luminous*, they are harder to detect

Traditional Optical Methods look for Supermassive Black Holes that can outshine the host galaxy

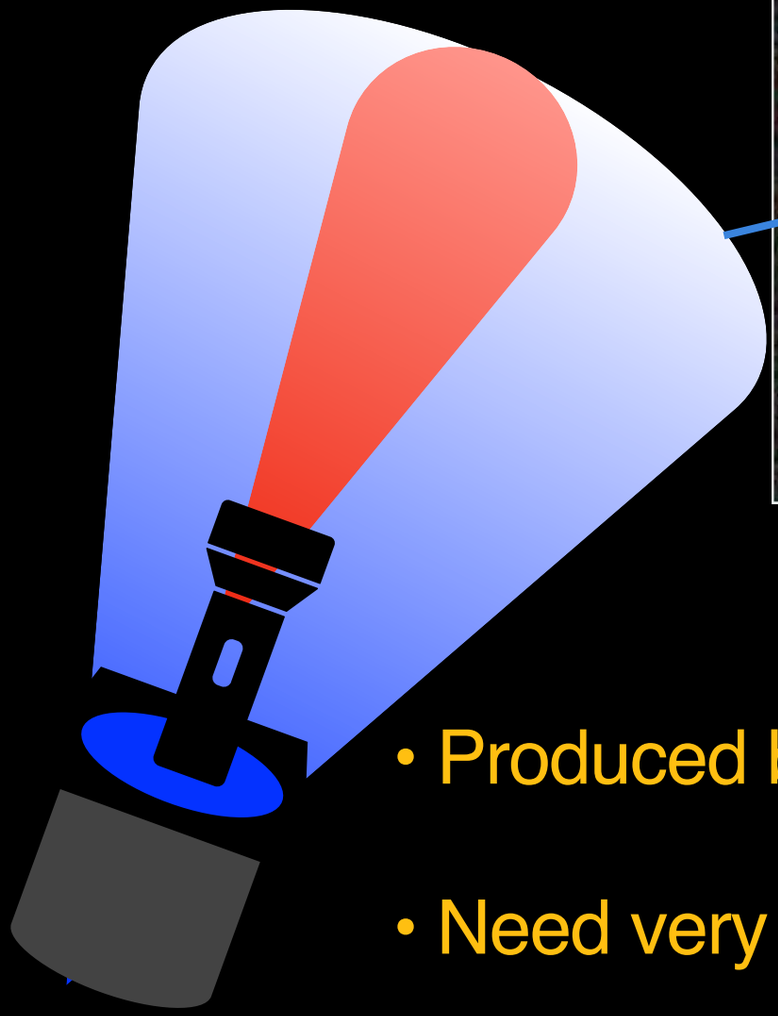


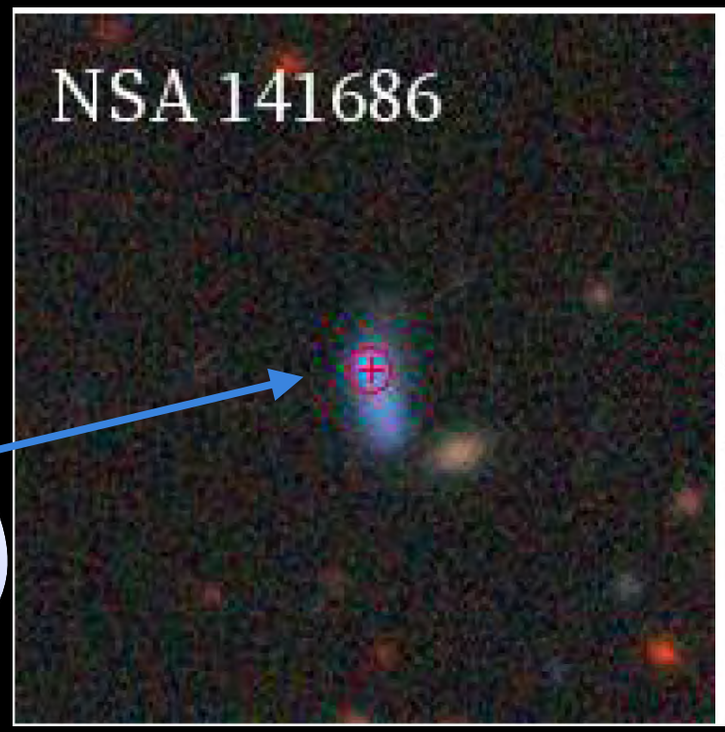
When the star formation is too high, we can’t see the signal from the black hole

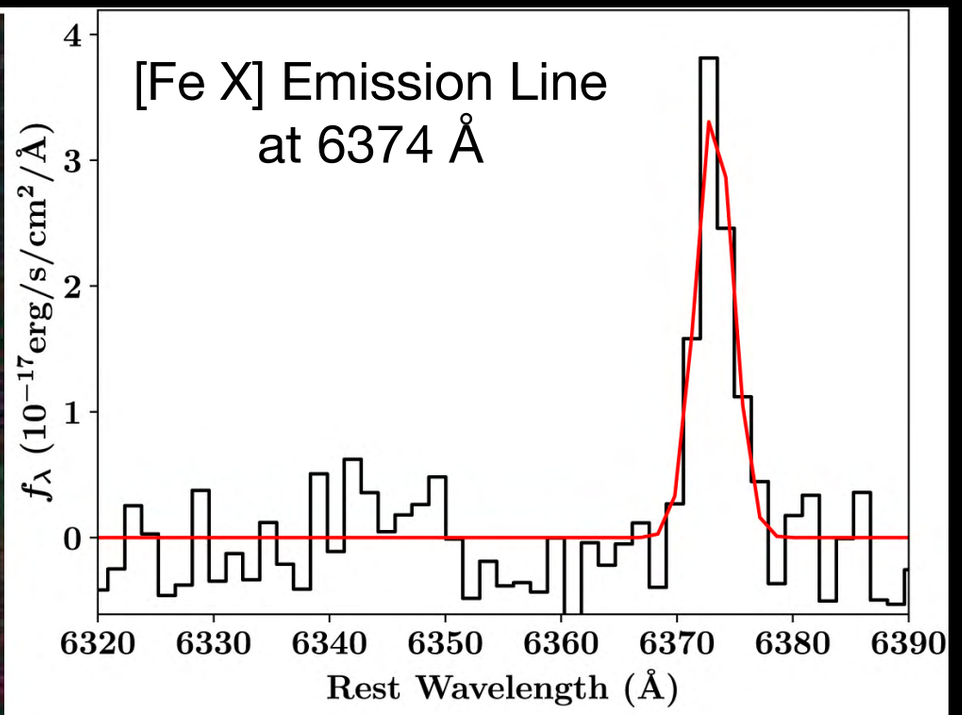


Is there a way to cut through that star formation to find black holes in these galaxies?

Coronal Line [Fe X]λ6374: A New Method to search for Black Holes in Dwarf Galaxies



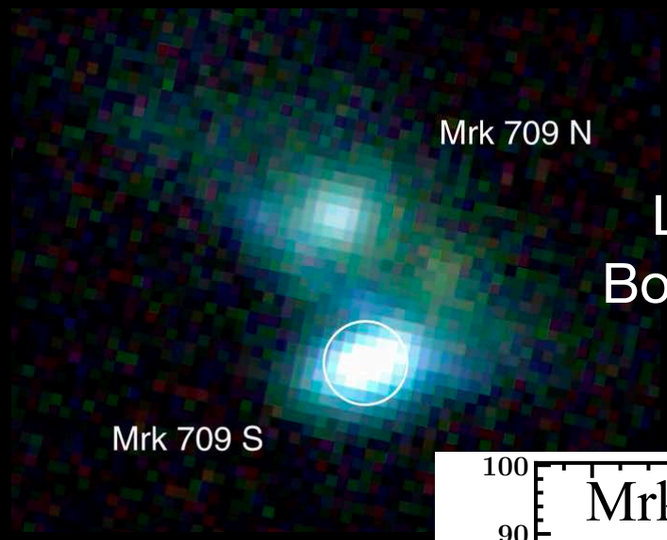




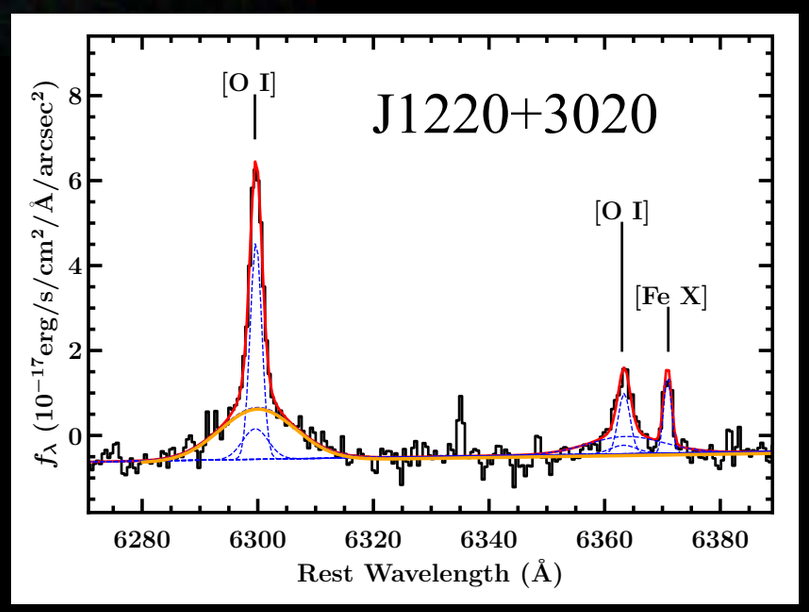
- Produced by hot X-rays or outflowing winds from black hole
- Need very high energy photons not easily produced by stars
- Previously seen in spectra of two black holes in dwarfs

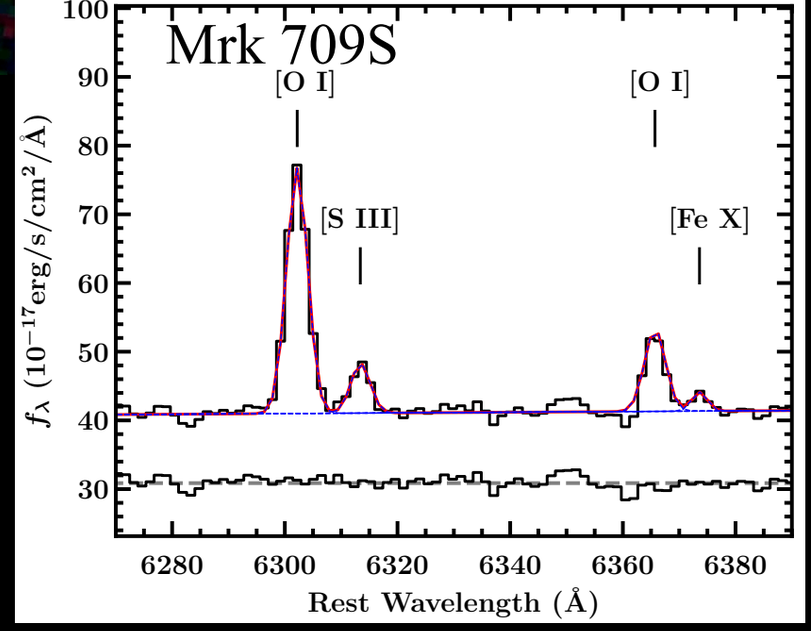
[Fe X] detected in two galaxies where the black hole missed by traditional optical techniques

Left: Reines et al. (2020)
Bottom: Molina et al. (2021a)



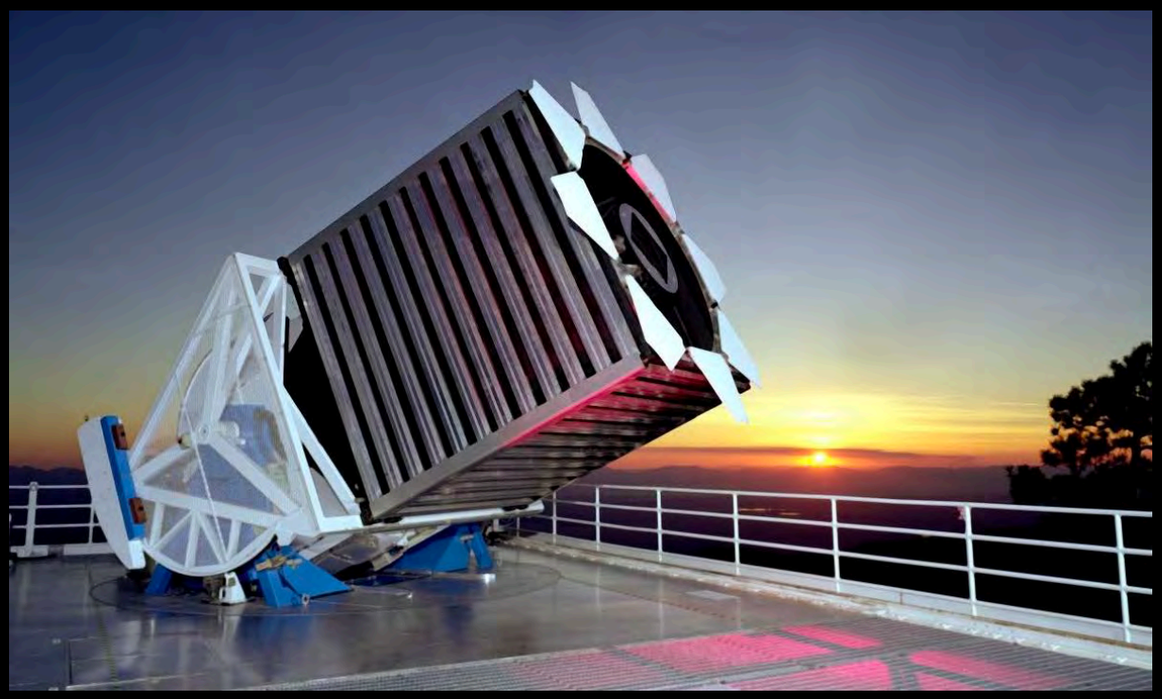
Left: Reines et al. (2014)
Bottom: Kimbro et al. (2021)





Could [Fe X] help us find black holes in dwarf galaxies otherwise hidden by star formation?

First Systematic Search for [Fe X] in Dwarf Galaxies



Used Optical Data from the Sloan Digital Sky Survey

Identified ***81 black holes*** in dwarf galaxies with detected [Fe X] emission.

"A Sample of Massive Black Holes in Dwarf Galaxies Detected via [Fe X] Coronal Line Emission: Active Galactic Nuclei and/or Tidal Disruption Events"

Molina, Reines, Latimer, Baldassare & Salehirad 2021,
The Astrophysical Journal, 922, 2 (arXiv: 2108.09307)

First Systematic Search for [Fe X] in Dwarf Galaxies

Almost all had [Fe X] emission too bright for stellar processes

[Fe X] emission is consistent with an accreting supermassive black hole

About 50% showed additional signatures of black hole activity

"A Sample of Massive Black Holes in Dwarf Galaxies Detected via [Fe X] Coronal Line Emission: Active Galactic Nuclei and/or Tidal Disruption Events"

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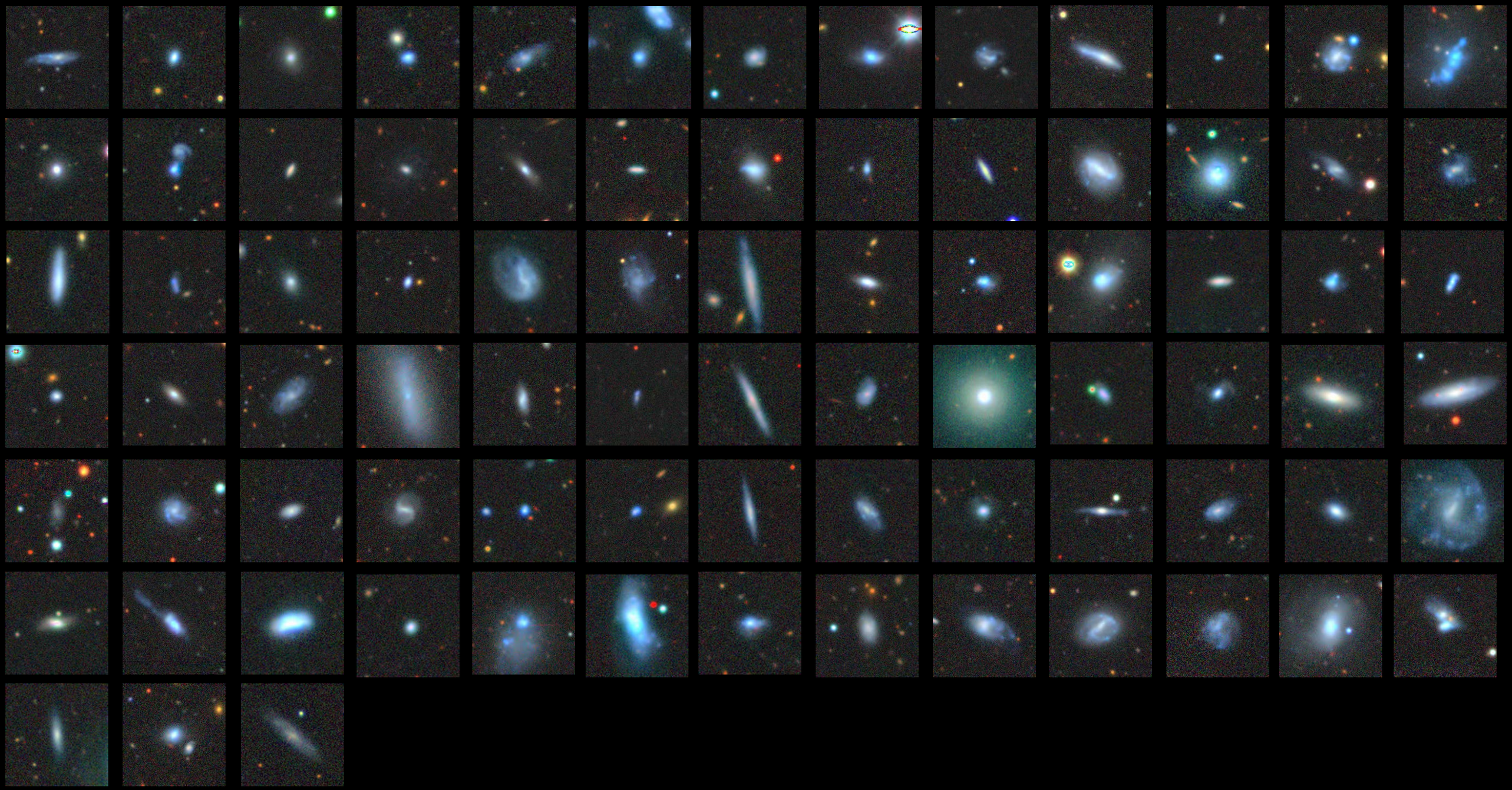
[Fe X]-Selected Black Holes Found in Blue (Actively Star-Forming) Dwarf Galaxies



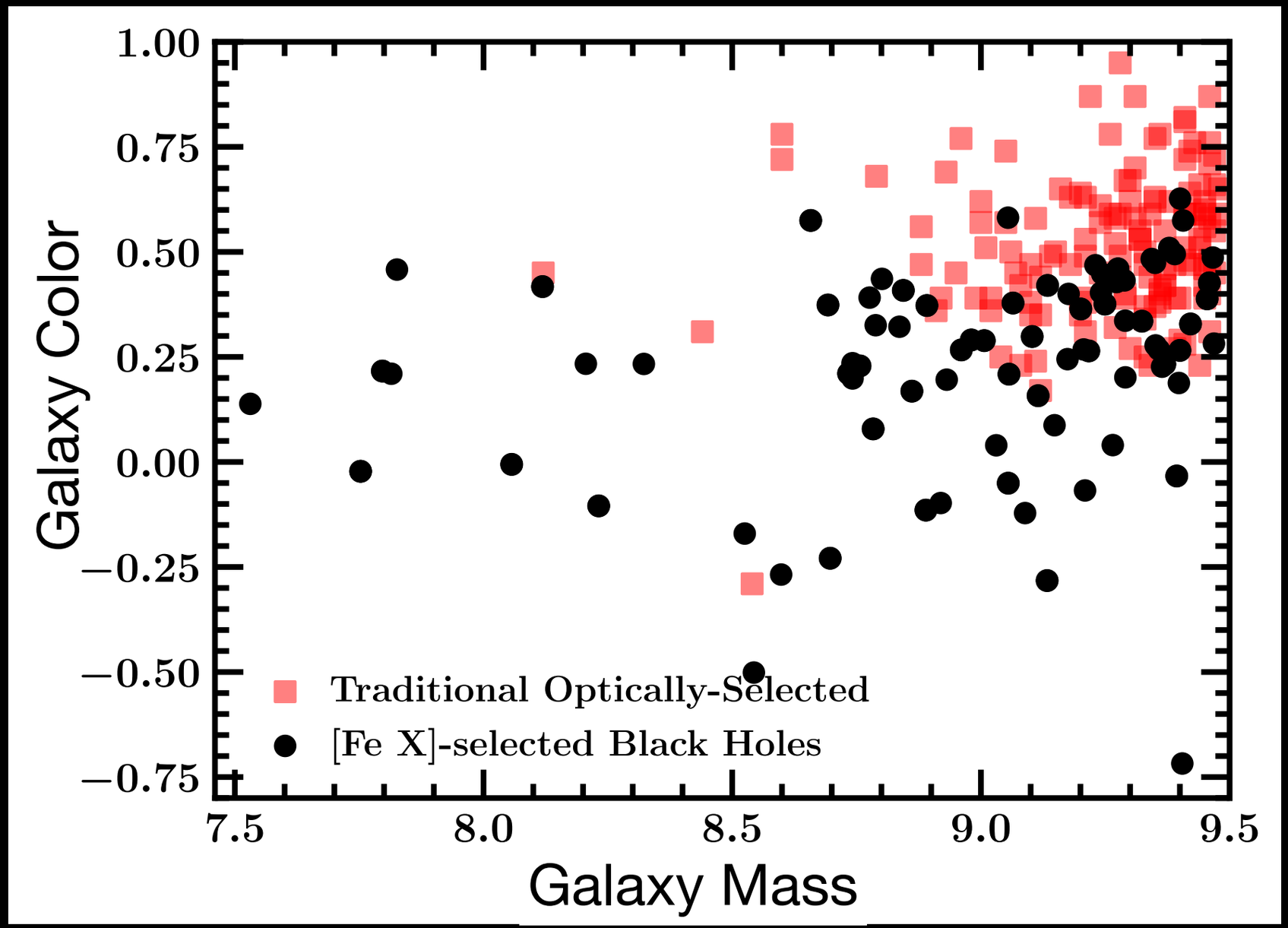
[Fe X]-Selected Black Holes Found in Bluer (Actively Star-Forming) Lower-Mass Dwarf Galaxies

Redder Galaxy

Bluer Galaxy

Low Star Formation

High Star Formation



Less Massive Galaxy → **More Massive Galaxy**

[Fe X]-Selected Black Holes Found in Bluer (Actively Star-Forming) Lower-Mass Dwarf Galaxies

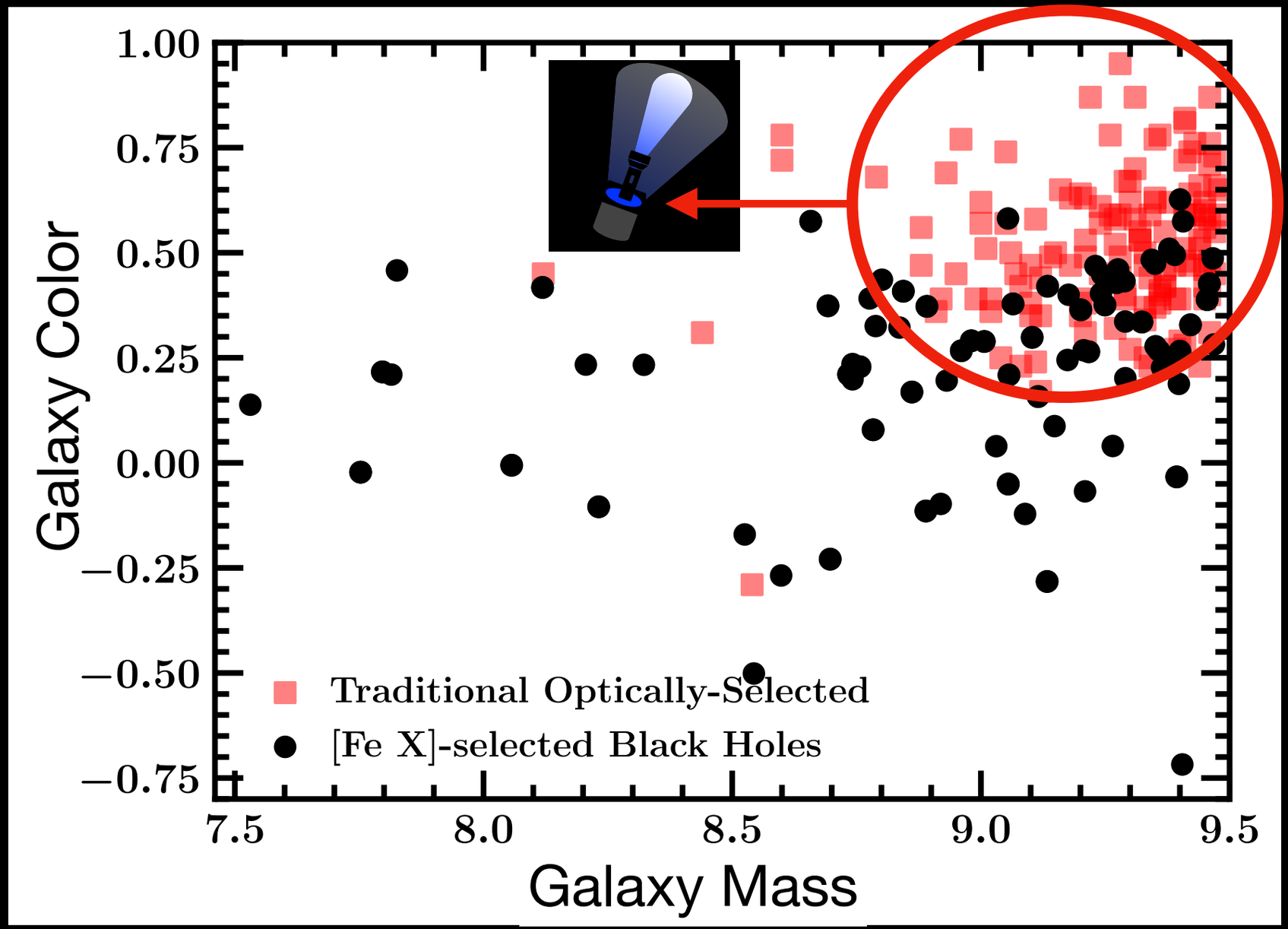
Redder Galaxy

Bluer Galaxy

Red and Massive

Low Star Formation

High Star Formation



Less Massive Galaxy → More Massive Galaxy

[Fe X]-Selected Black Holes Found in Bluer (Actively Star-Forming) Lower-Mass Dwarf Galaxies

Redder Galaxy

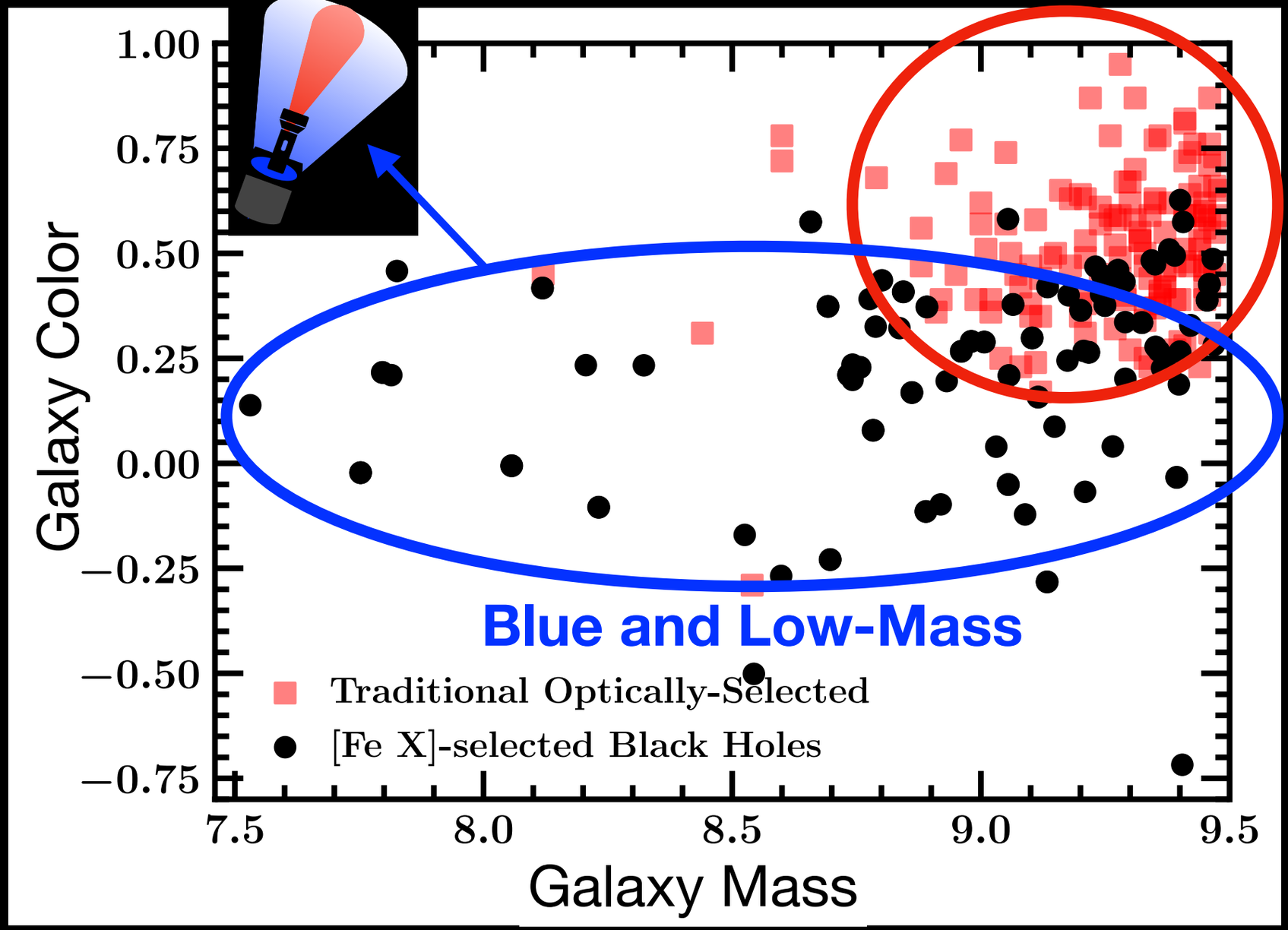
Bluer Galaxy

Red and Massive

Low Star Formation

Blue and Low-Mass

High Star Formation



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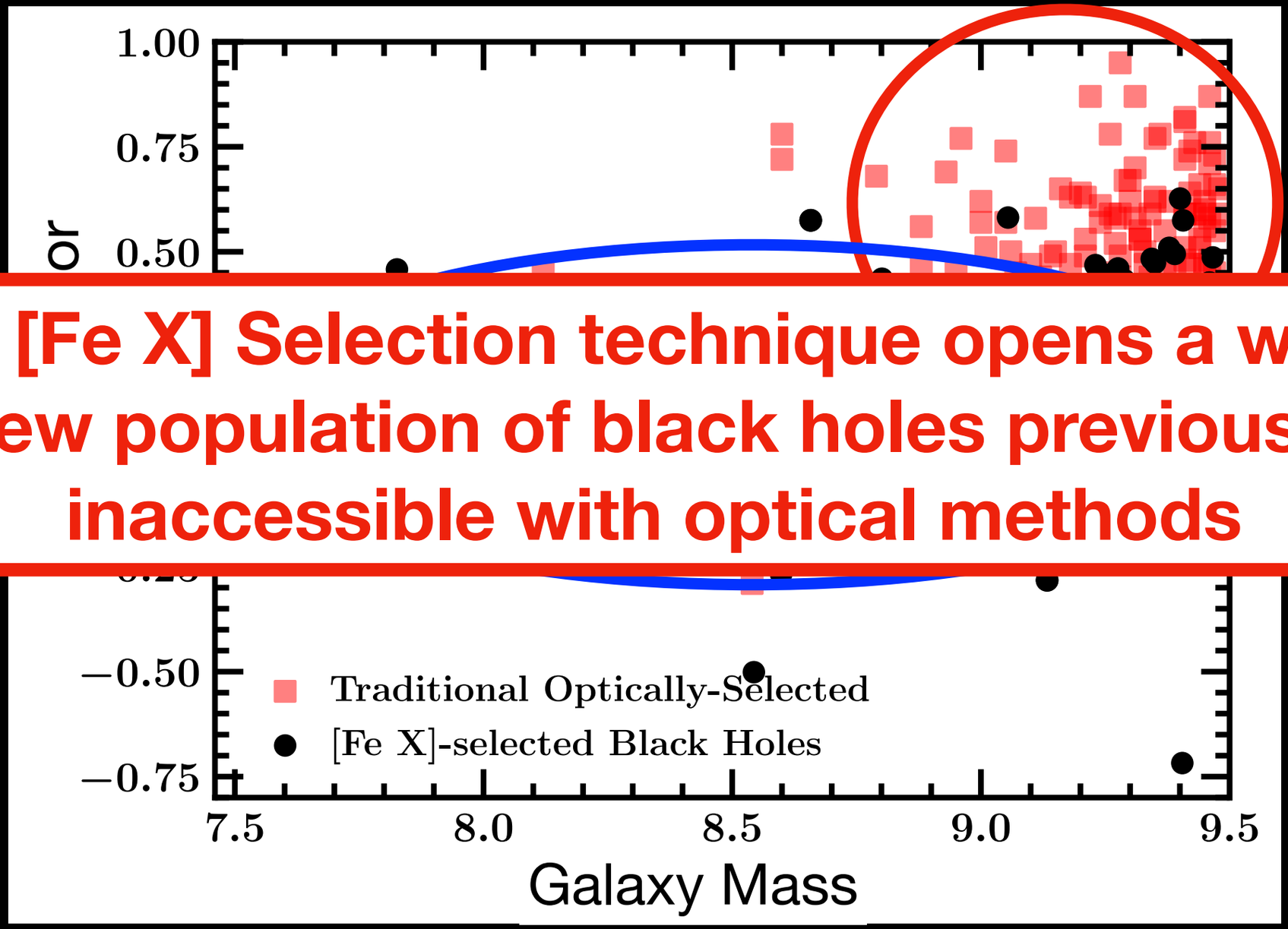
Redder Galaxy

Low Star Formation



The [Fe X] Selection technique opens a whole new population of black holes previously inaccessible with optical methods

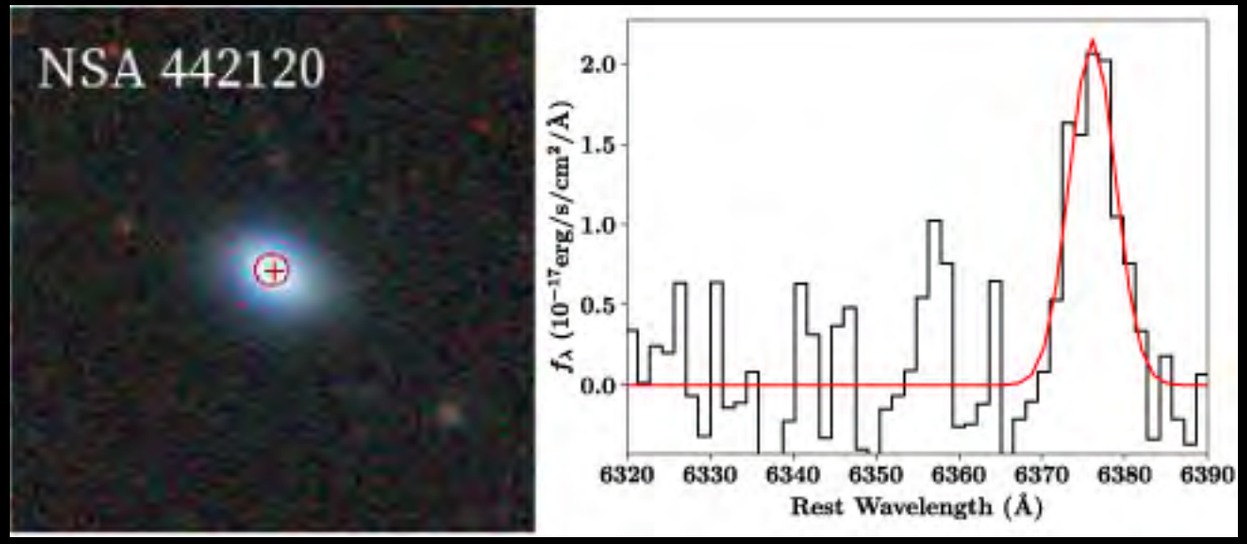
Bluer Galaxy

High Star Formation

Less Massive Galaxy → **More Massive Galaxy**

Summary

- First systematic search for coronal-line [Fe X] in dwarf galaxies
- Identified 81 dwarfs with supermassive black holes
- A new population of black holes inaccessible with traditional methods
- Stronger, new constraints on the origins of supermassive black holes



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