UGC 2885, Rubin's Galaxy, A Gentle Giant

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Motivation

Massive galaxies have a violent history

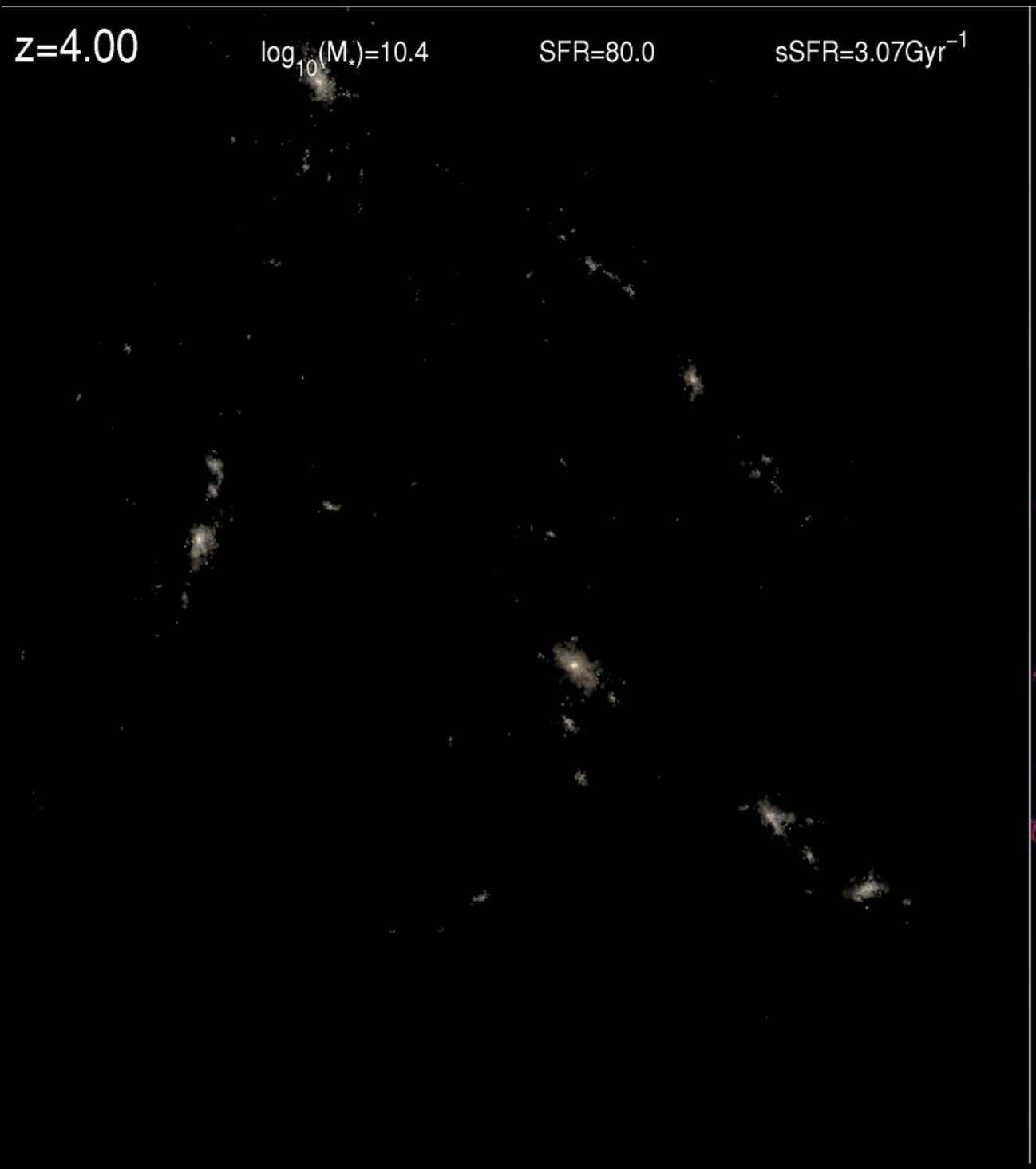
- Galaxies have grown through mergers.

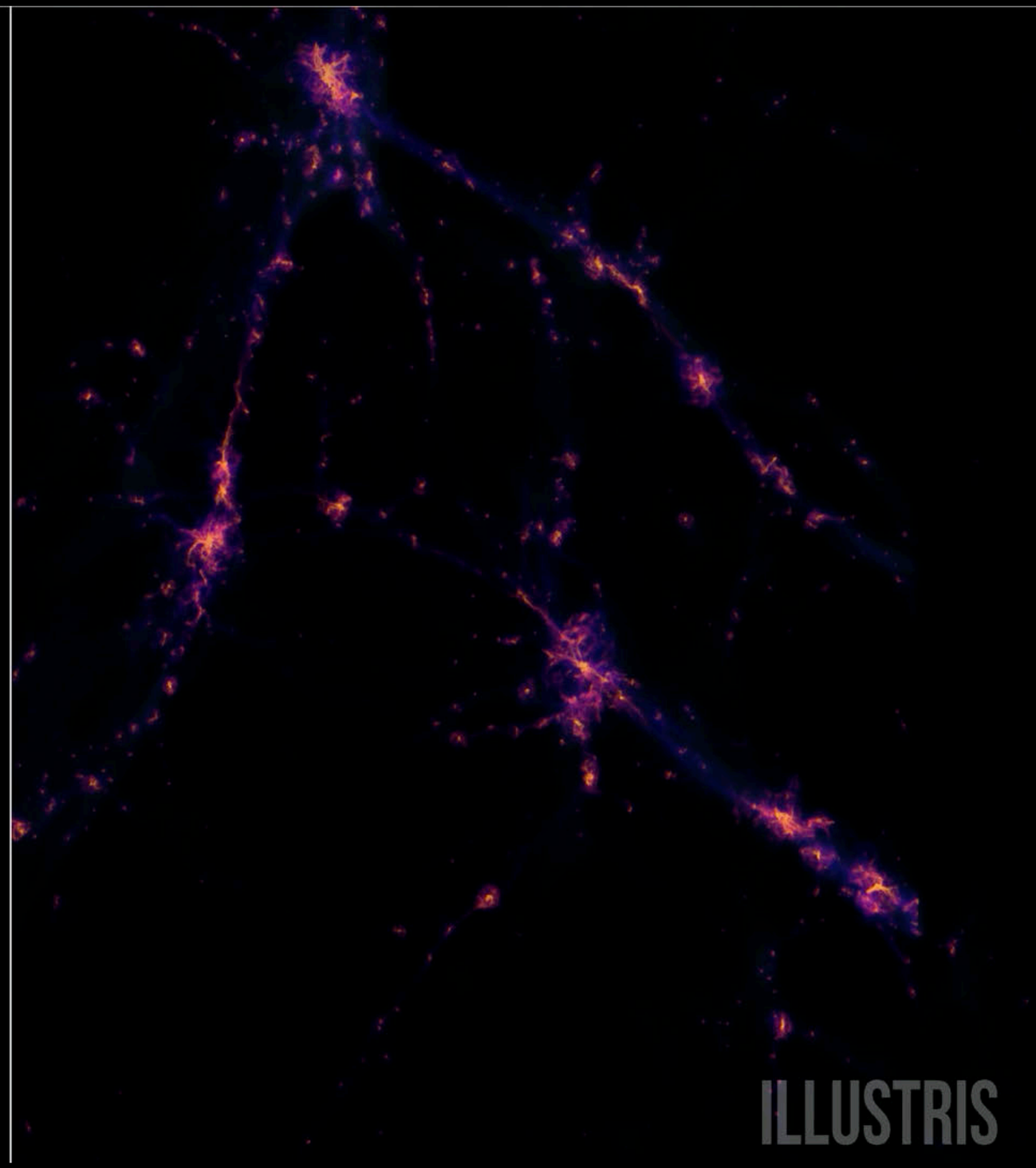
- Bigger galaxies show multiple populations of predecessors (often in the halo).

- The globular cluster population reflects the merger history.

Stars

Dark Matter

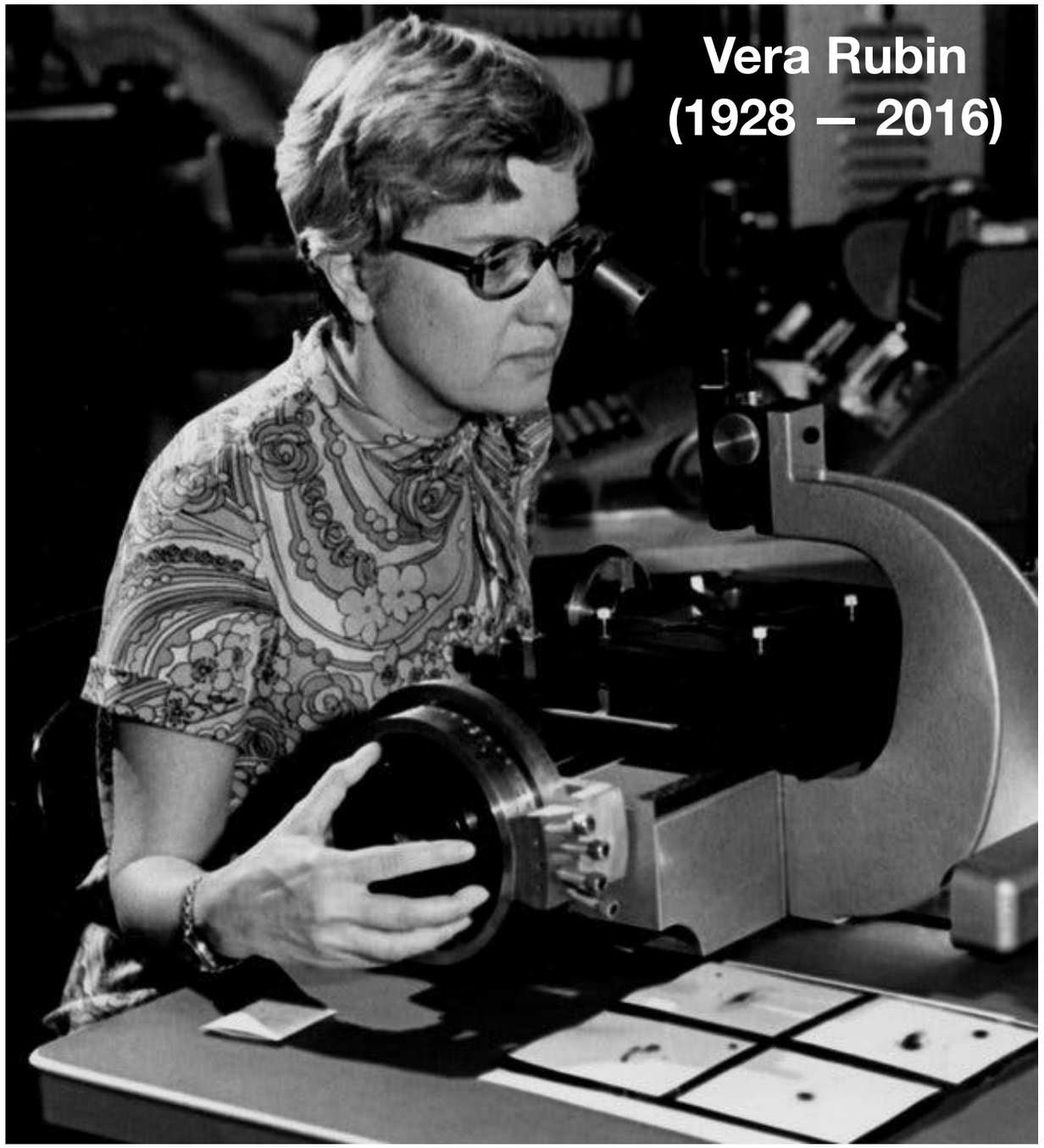




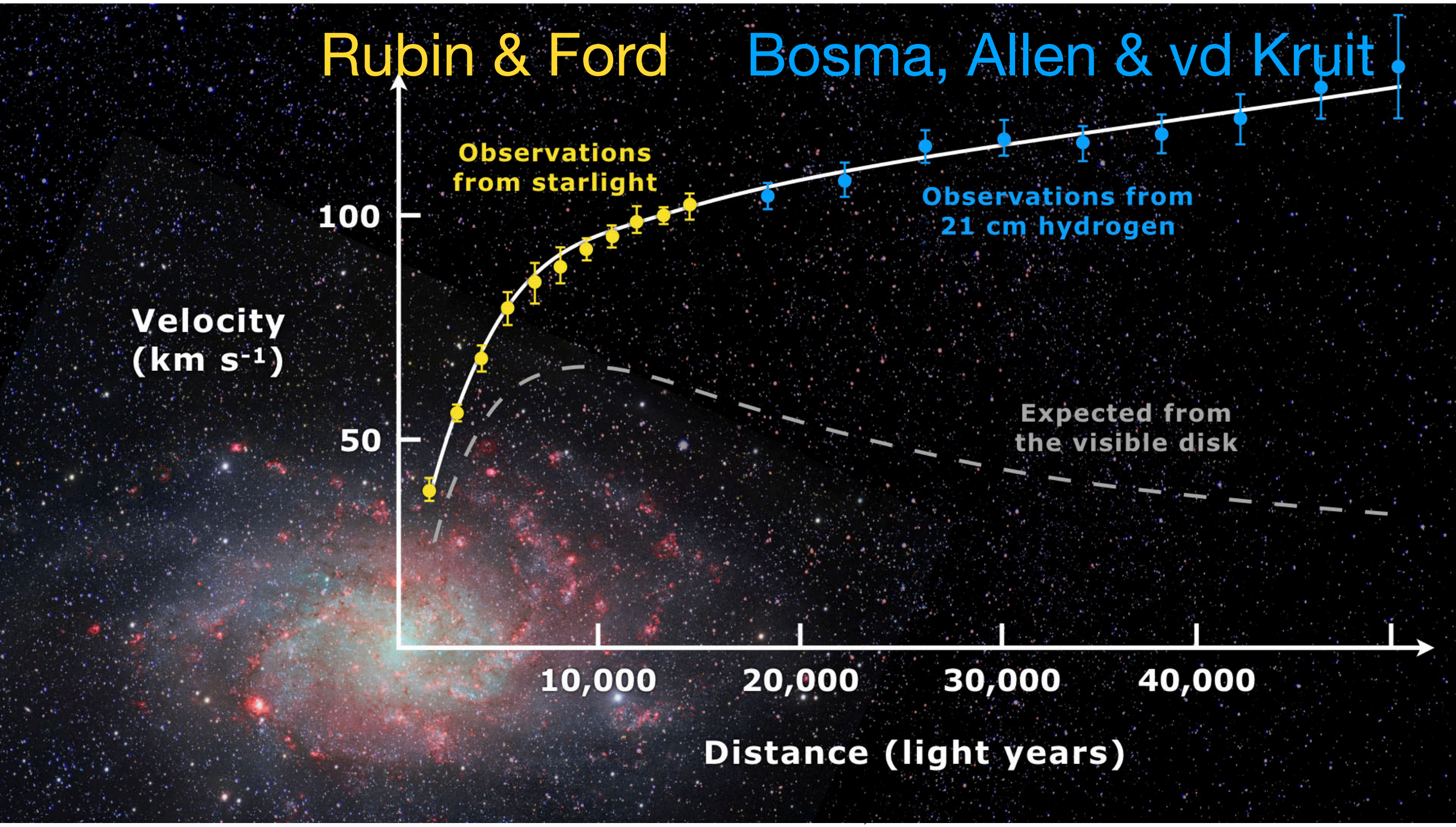
Vera Rubin

- Published one of two studies showing evidence for dark matter in galaxies from their rotation.

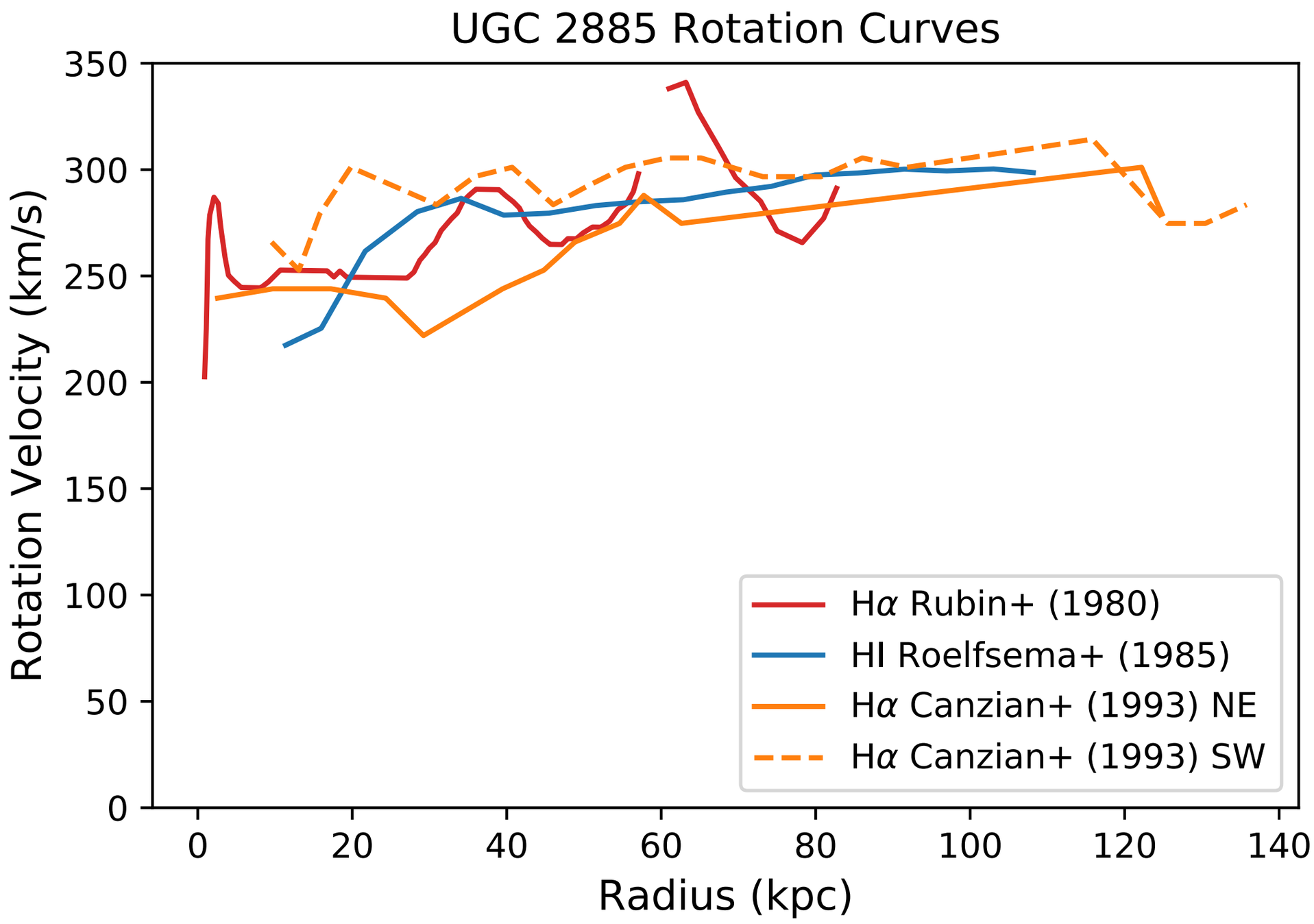
- Encouraged and supported young scientist throughout her career.



Galaxies Rotate



One of the original rotation curves.



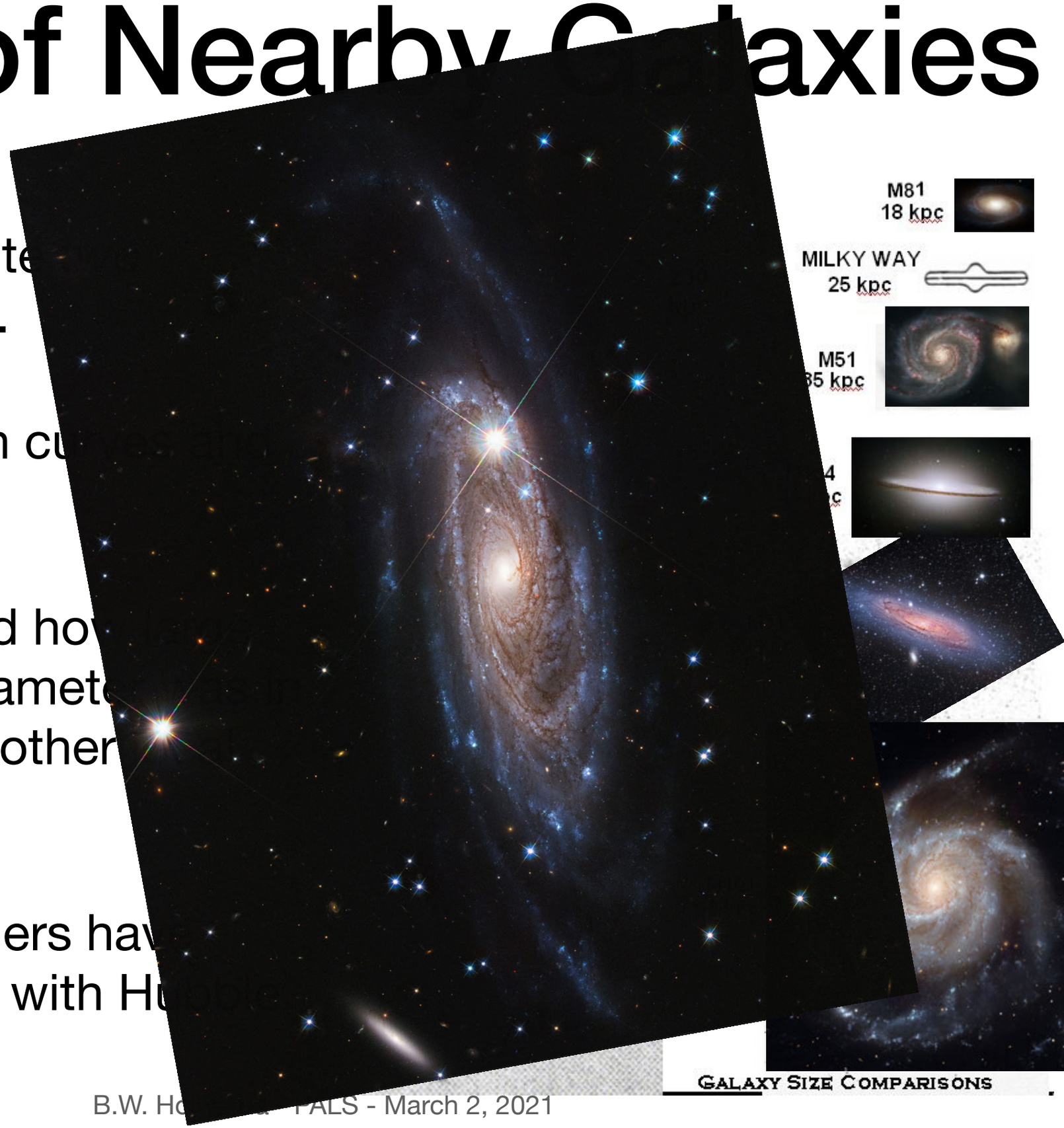
Sizes of Nearby Galaxies

- Vera Rubin wrote
  papers in 1980.

- One on rotation cu
  dark matter.

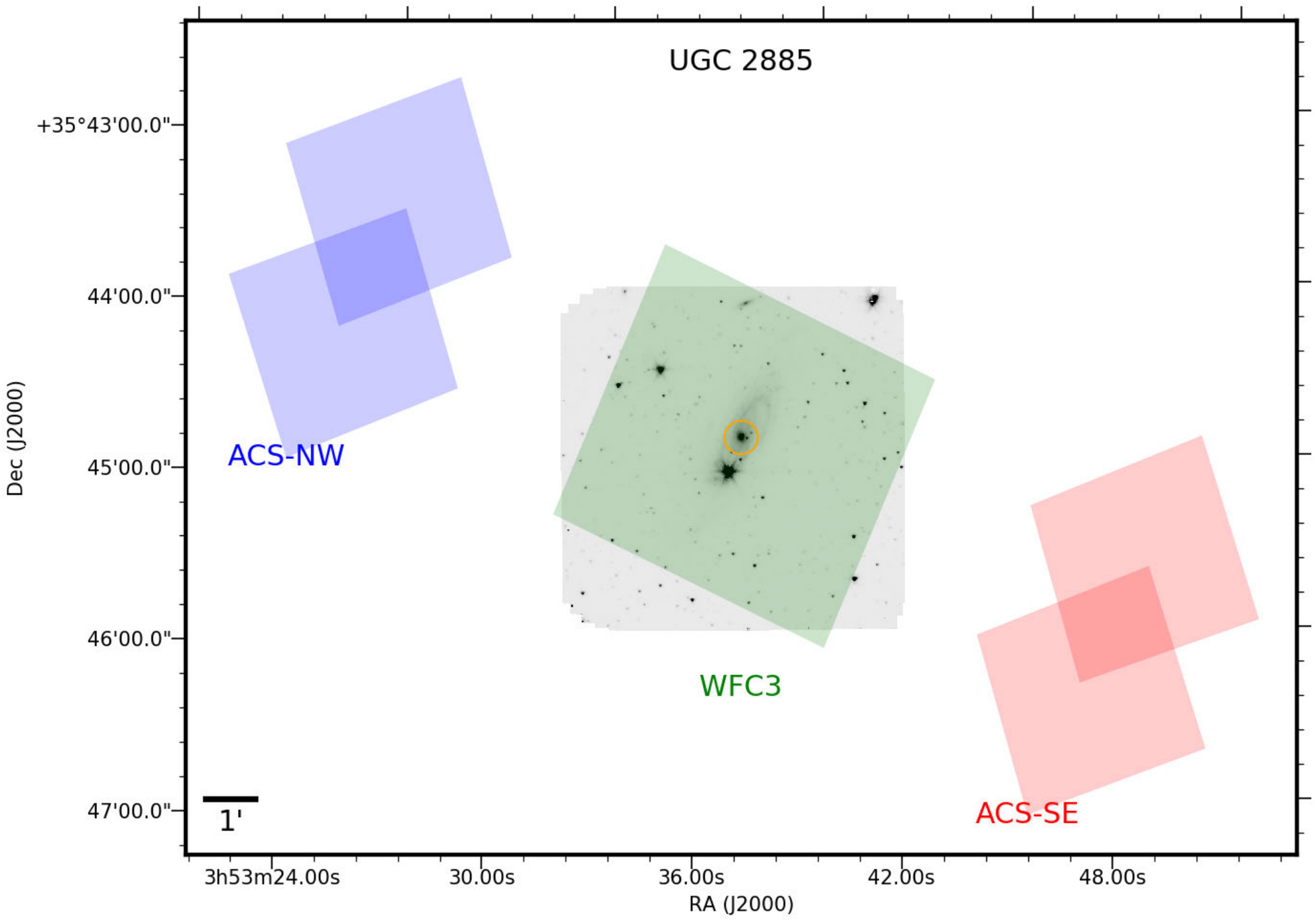
- The other noted ho
  UGC 2885's diamet
  comparison to other
  galaxies.

- Each of the others hav
  been observed with Hu



Zoom in on UGC 2885

Hubble Observations



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Astronomy Picture of the Day

Discover the cosmos! Each day a different image or photograph of our fascinating universe is featured, along with a brief explanation written by a professional astronomer.

2020 January 25

Rubin's Galaxy
Image Credit: NASA, ESA, B. Holwerda (University of Louisville)

Explanation: In this Hubble Space Telescope image the bright, spiky stars lie in the foreground toward the heroic northern constellation Perseus and well within our own Milky Way galaxy. In sharp focus beyond is UGC 2885, a giant spiral galaxy about 232 million light-years distant. Some 800,000 light-years across compared to the Milky Way's diameter of 100,000 light-years or so, it has around 1 trillion stars. That's about 10 times as many stars as the Milky Way. Part of a current investigation to understand how


UGC 2885
"RUBIN'S GALAXY"
REVEALING MYSTERIES OF GALAXY ASSEMBLY
HUBBLE
WEBB
WFIRST

How to grow A Giant?

- Rubin's Galaxy is much more massive and bigger than any typical spiral galaxy.

- The question is how to grow a disk galaxy that big without merging two mid-sized galaxies together.

- Mergers leave a mark in the population of globular clusters in and around the galaxy. We see a range of ages of the globular clusters.

- It seems to have relatively few Globular Clusters for its size implying a gradual acquisition of mass.

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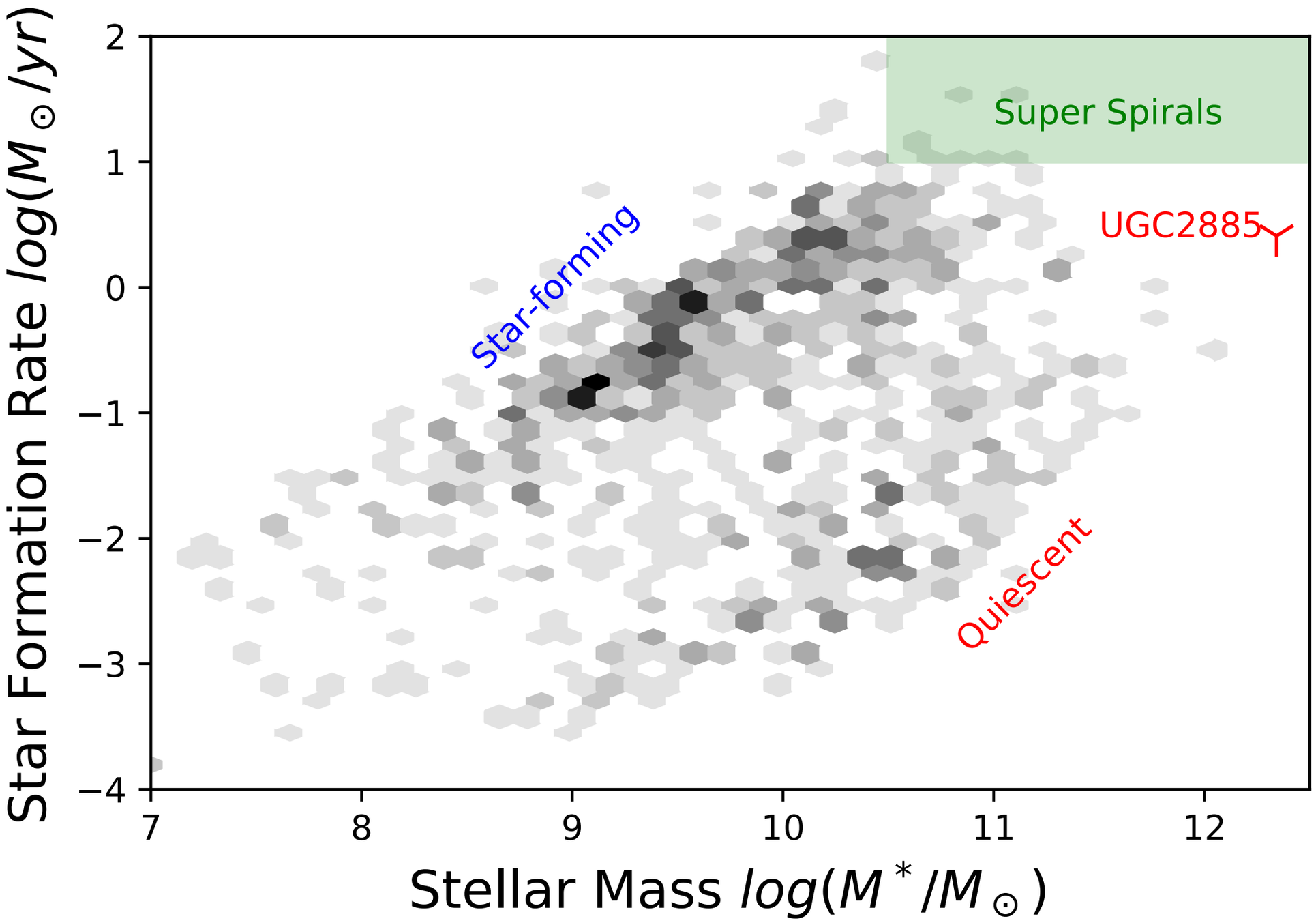
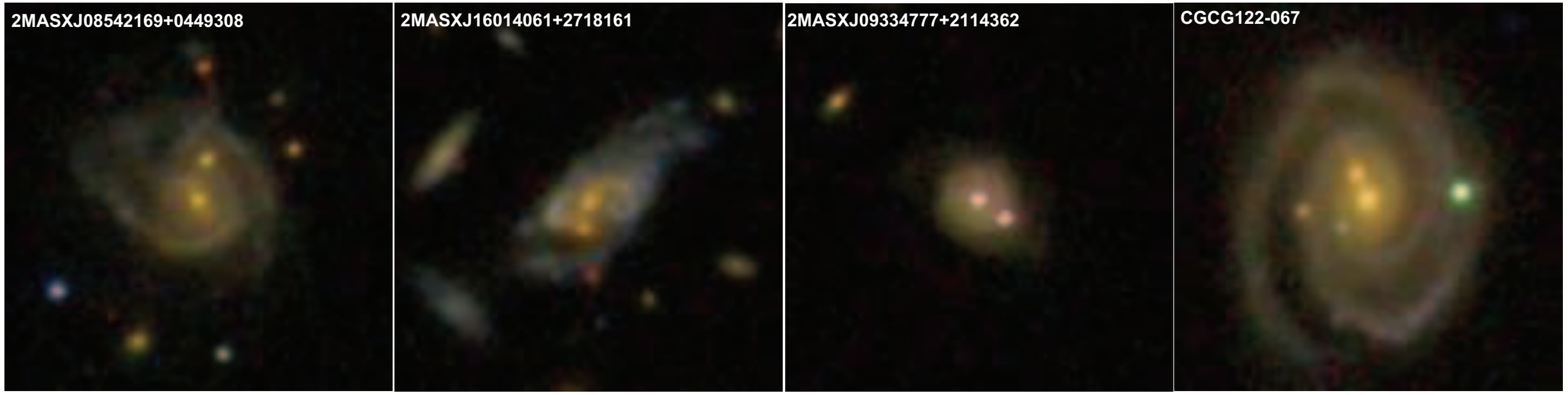
Massive and still low-key star forming



Super-Spirals

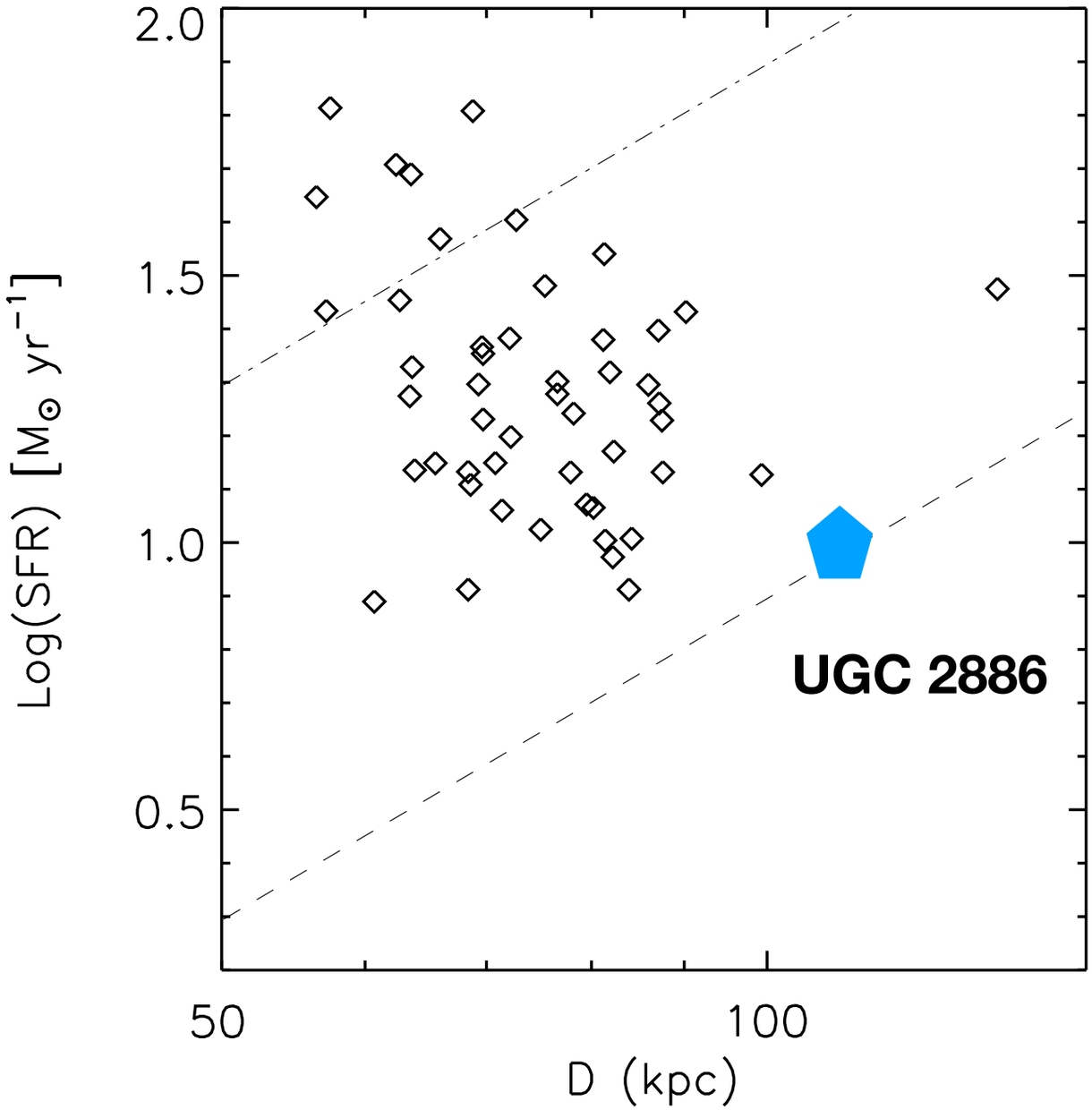


- High stellar mass, pure disk, star-formation on the SFR-M* relation.
- Super Spiral disks are all not just massive but show evidence of recent mergers (Ogle+ 2015, 2019).
- Most often found in groups and denser environments.

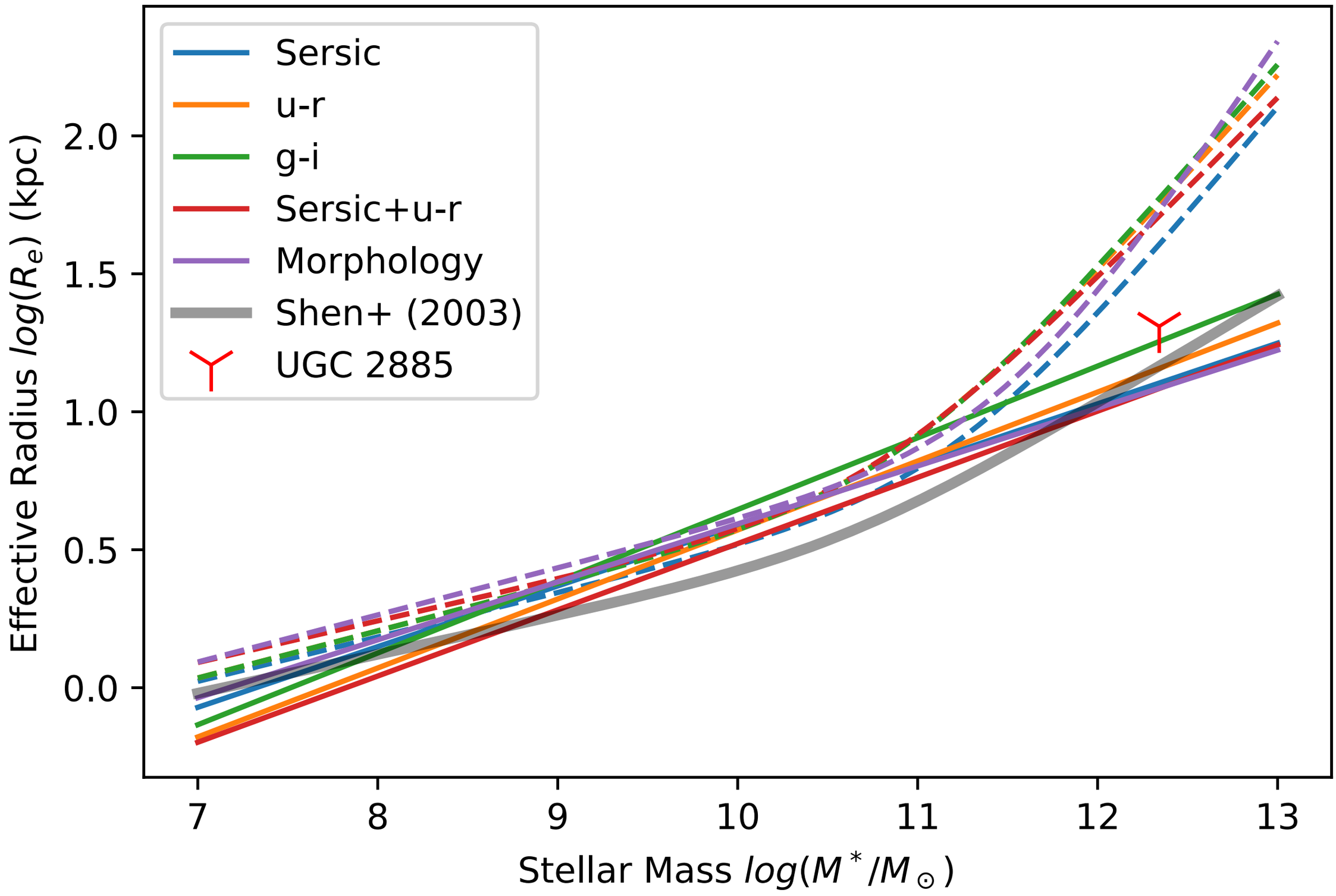
Exception?

- How well does Rubin's Galaxy fit with the super spiral population?

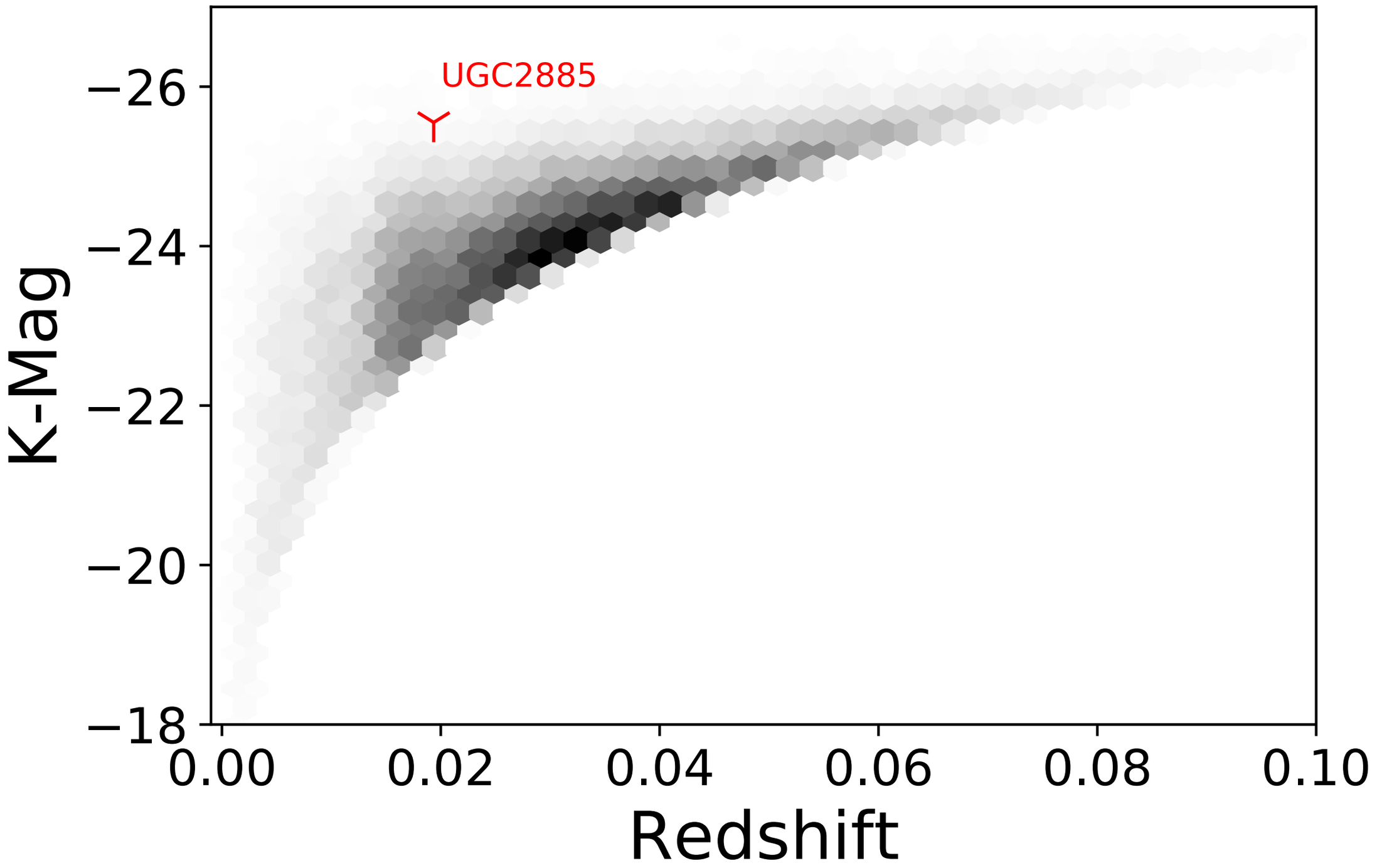
- It does not show many of the class' characteristics (recent merger, in groups).



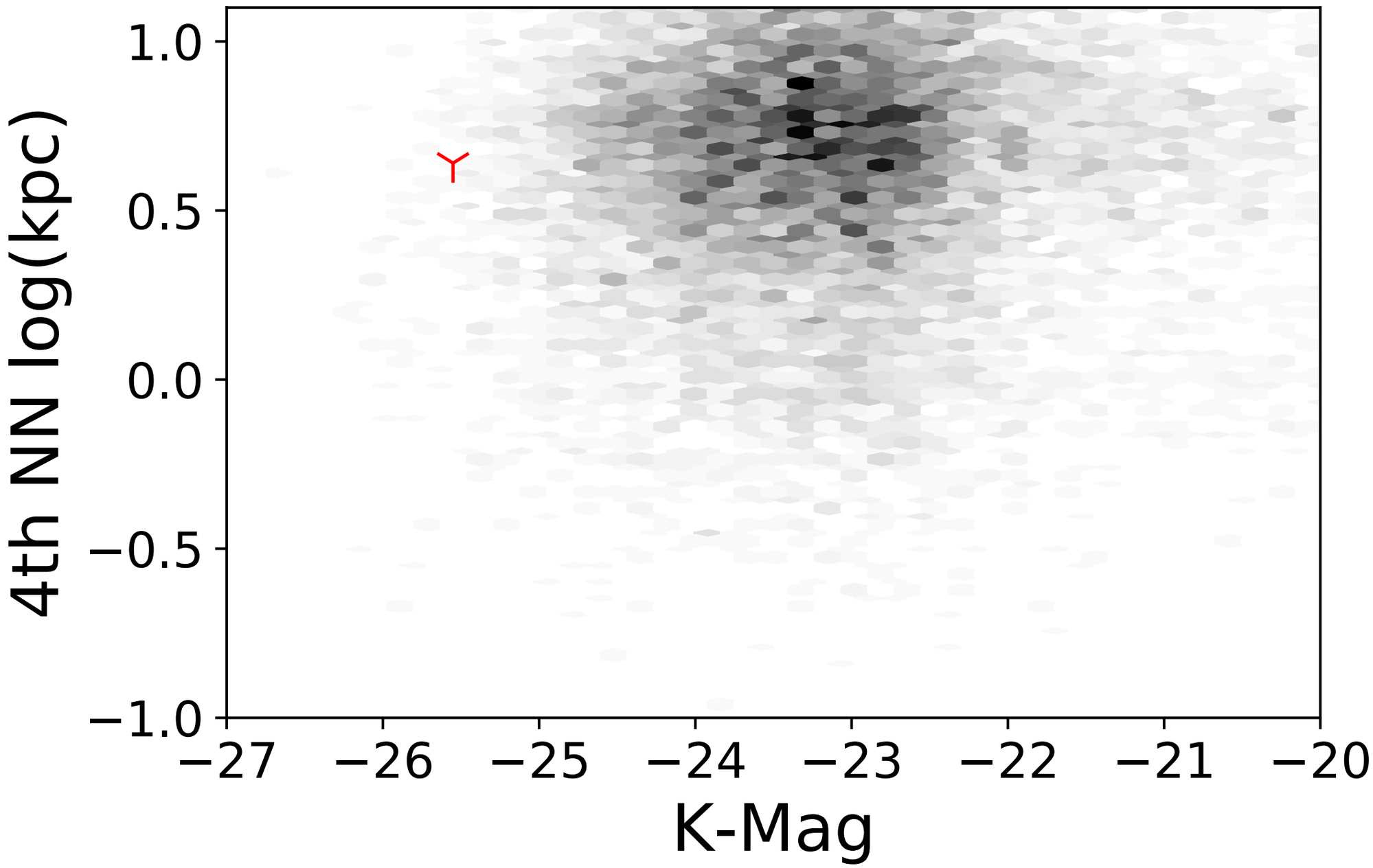
Normal size? Yes



Rare?



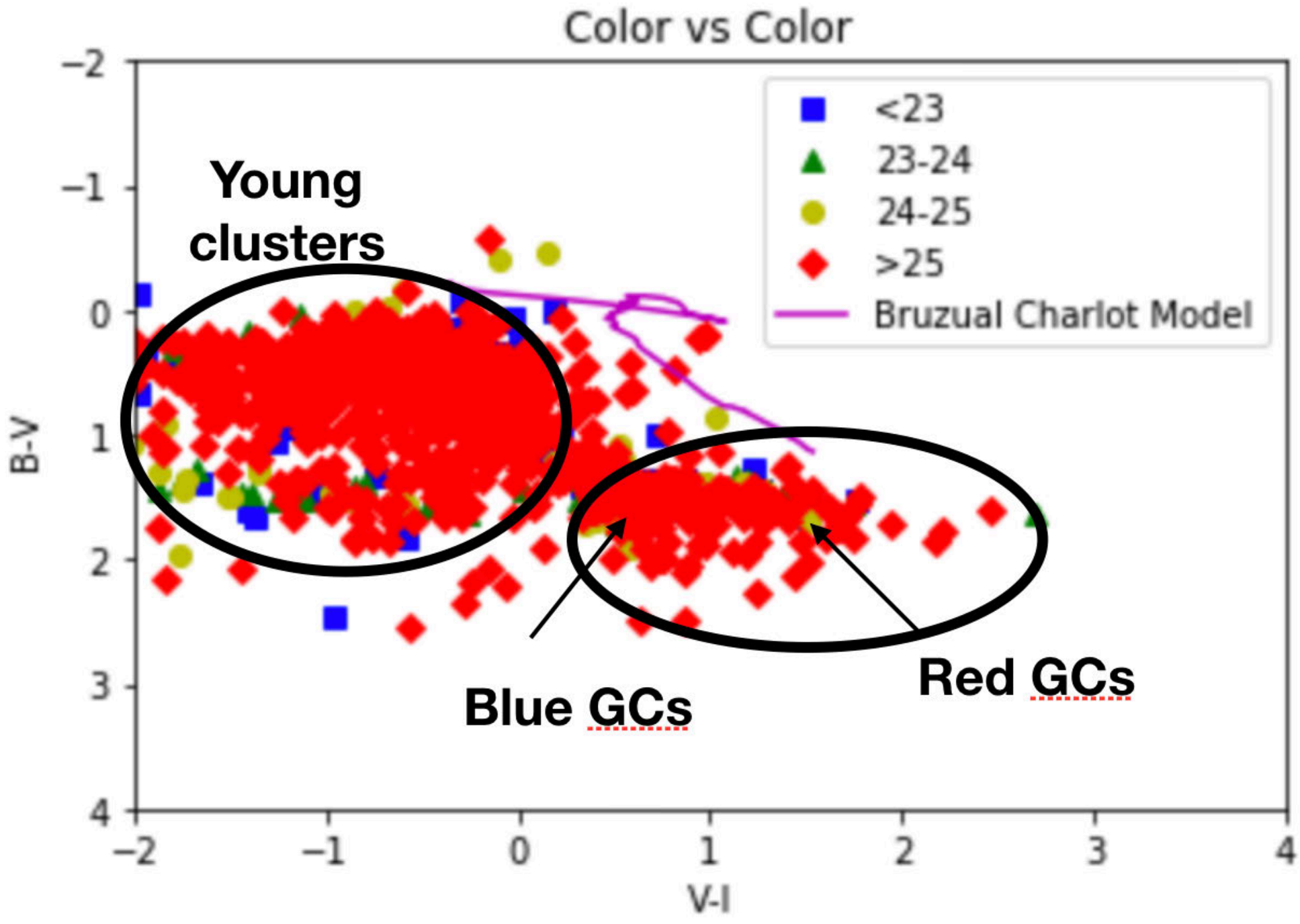
Environment?



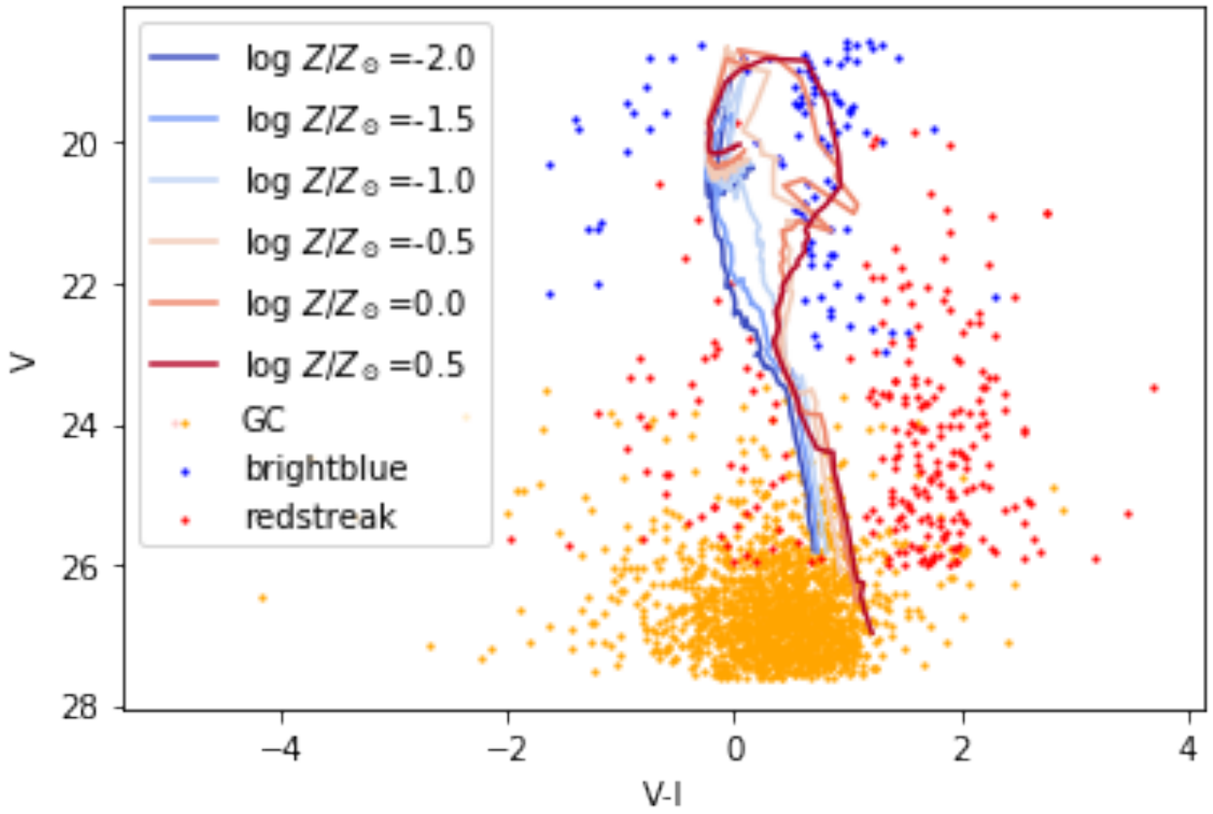
Rubin's Galaxy

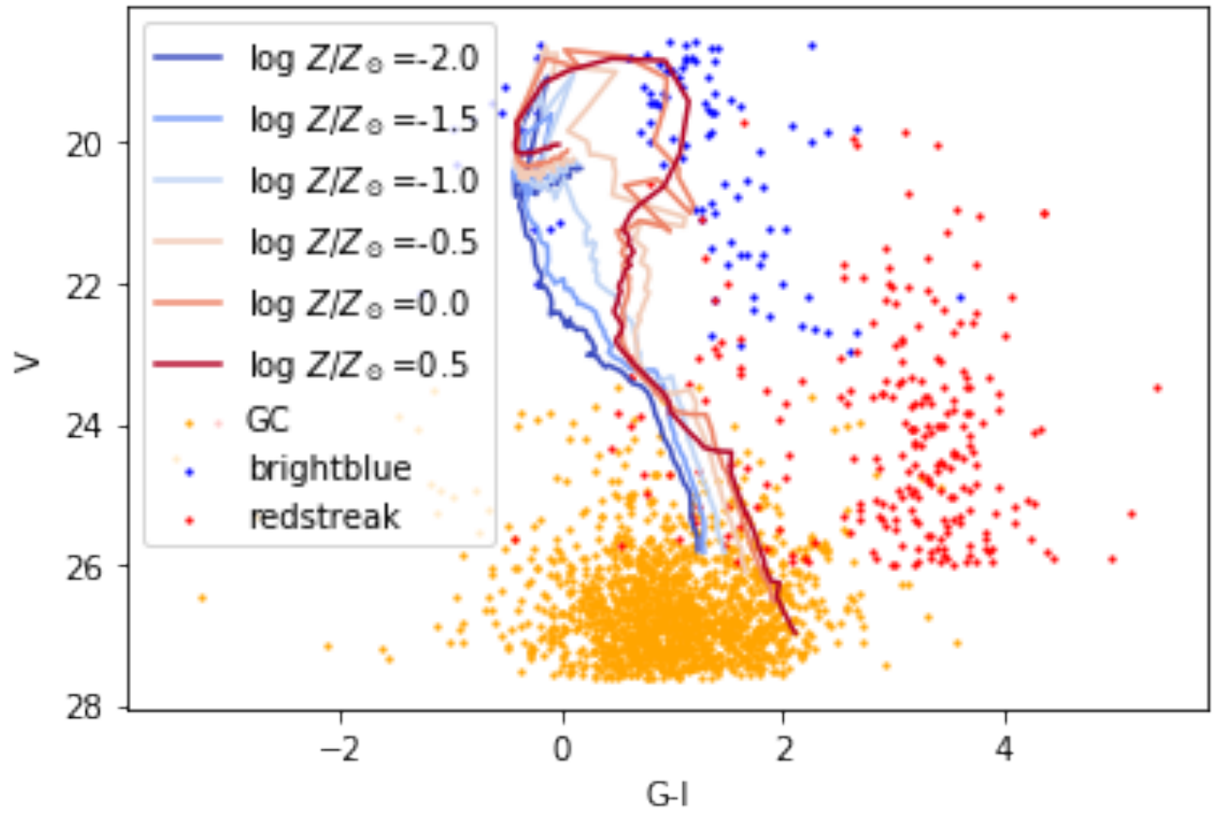
- An Sc galaxy that sits on all the scaling relations for disk galaxies.
- Massive at $(M* = 10^{12.5} M_{\odot})$ slowly forming stars.
- In relative isolation.

Color-Color Plot

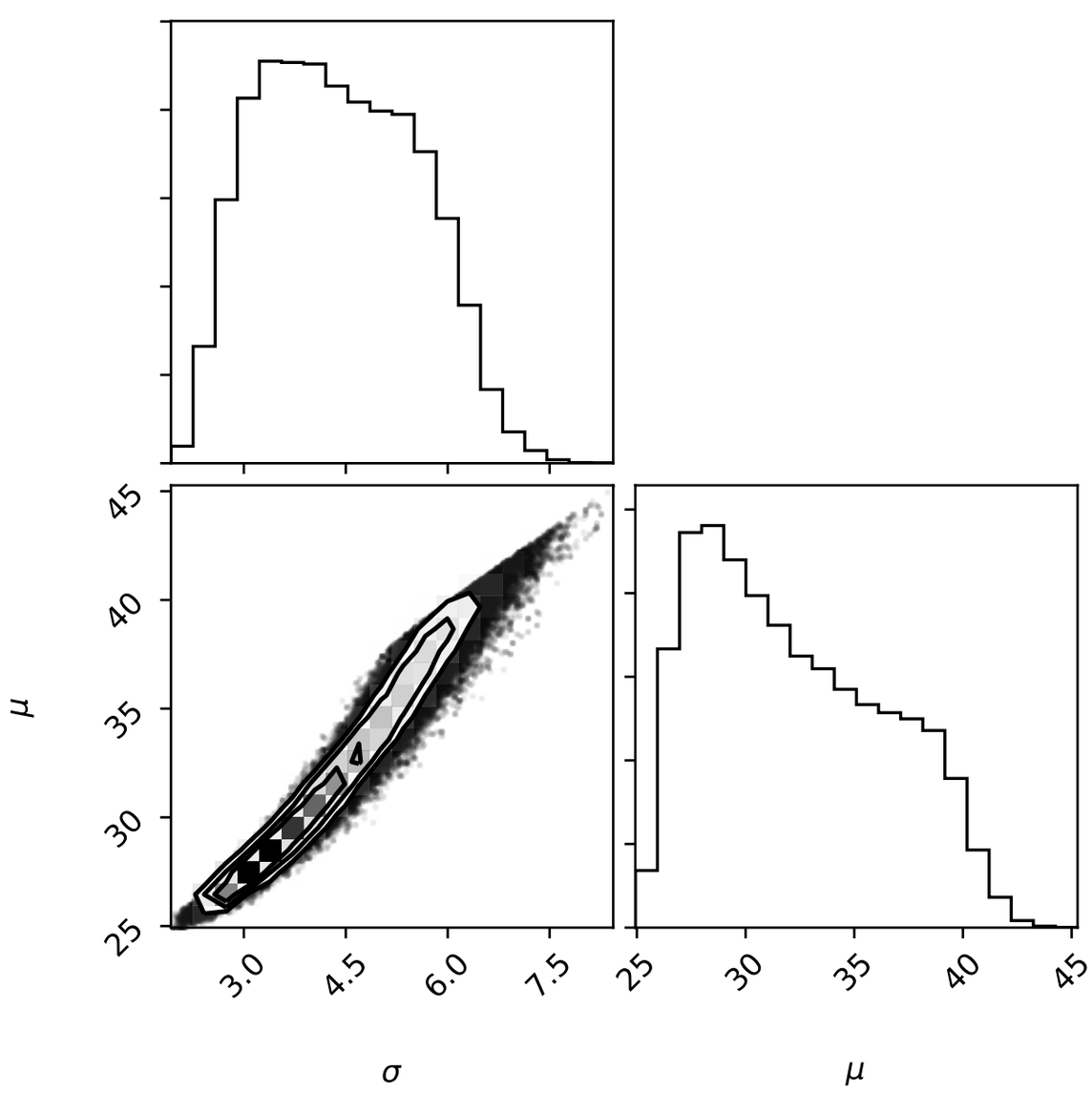


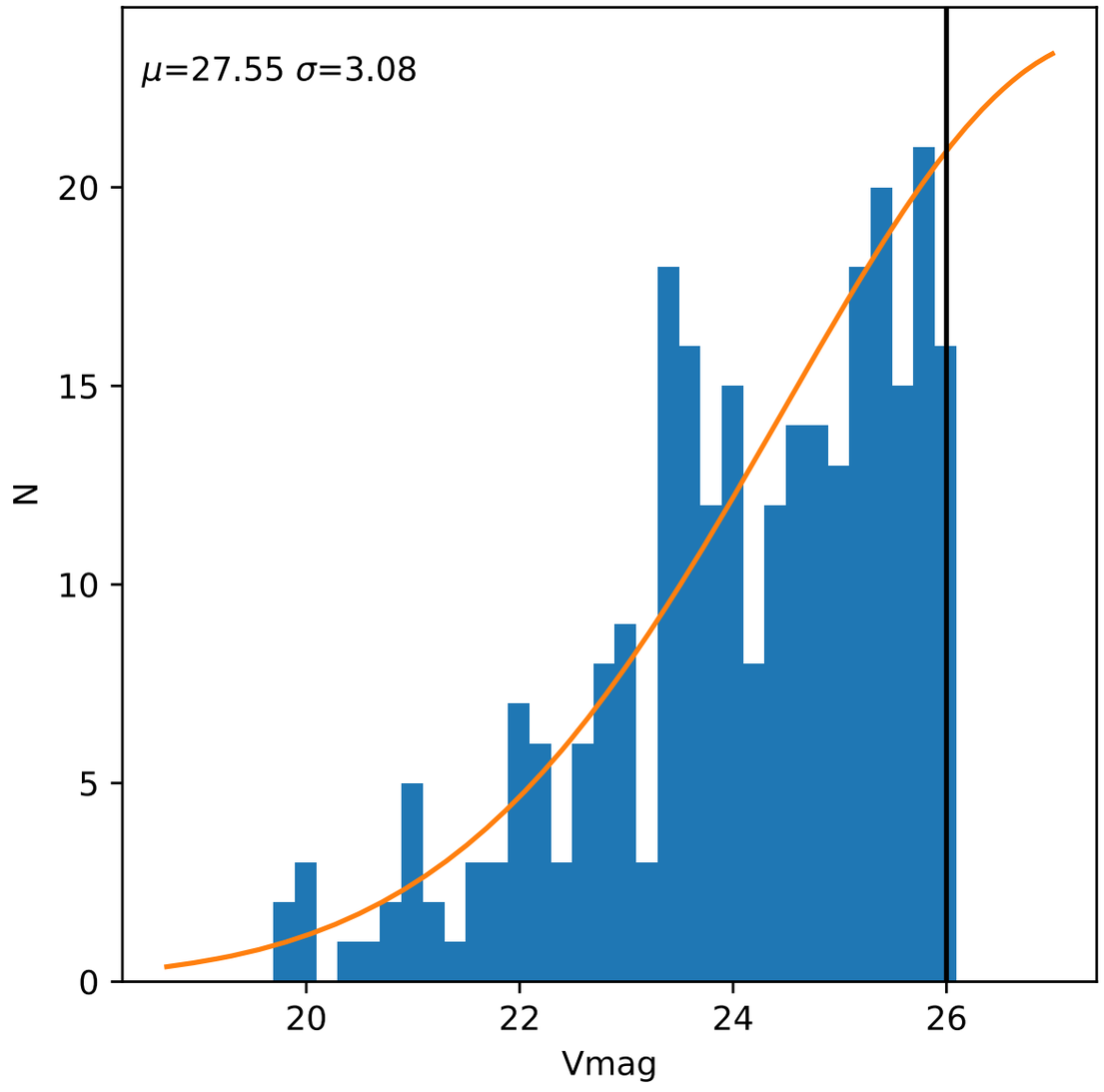
Color Magnitude Diagram



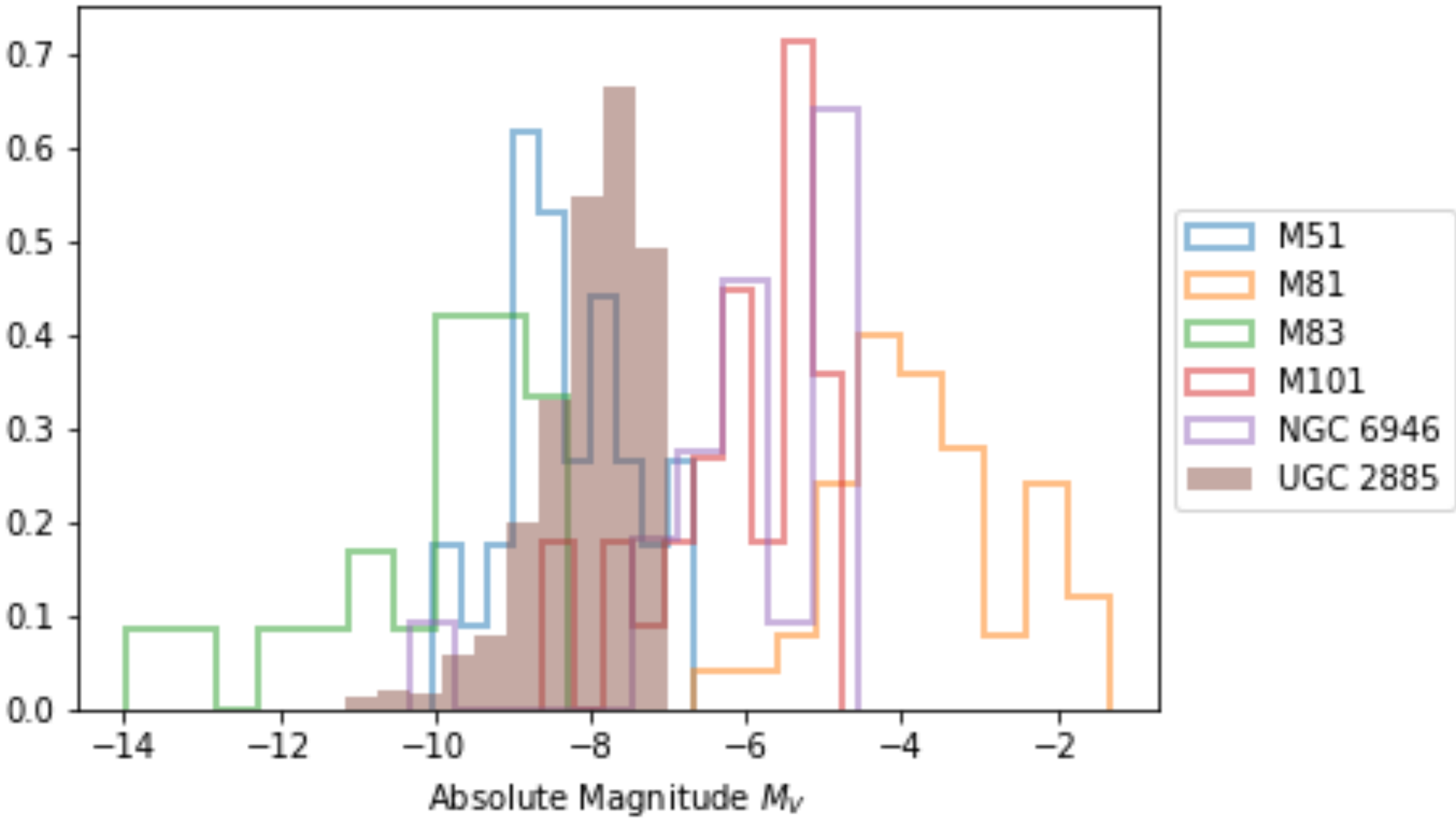


Starcluster Population

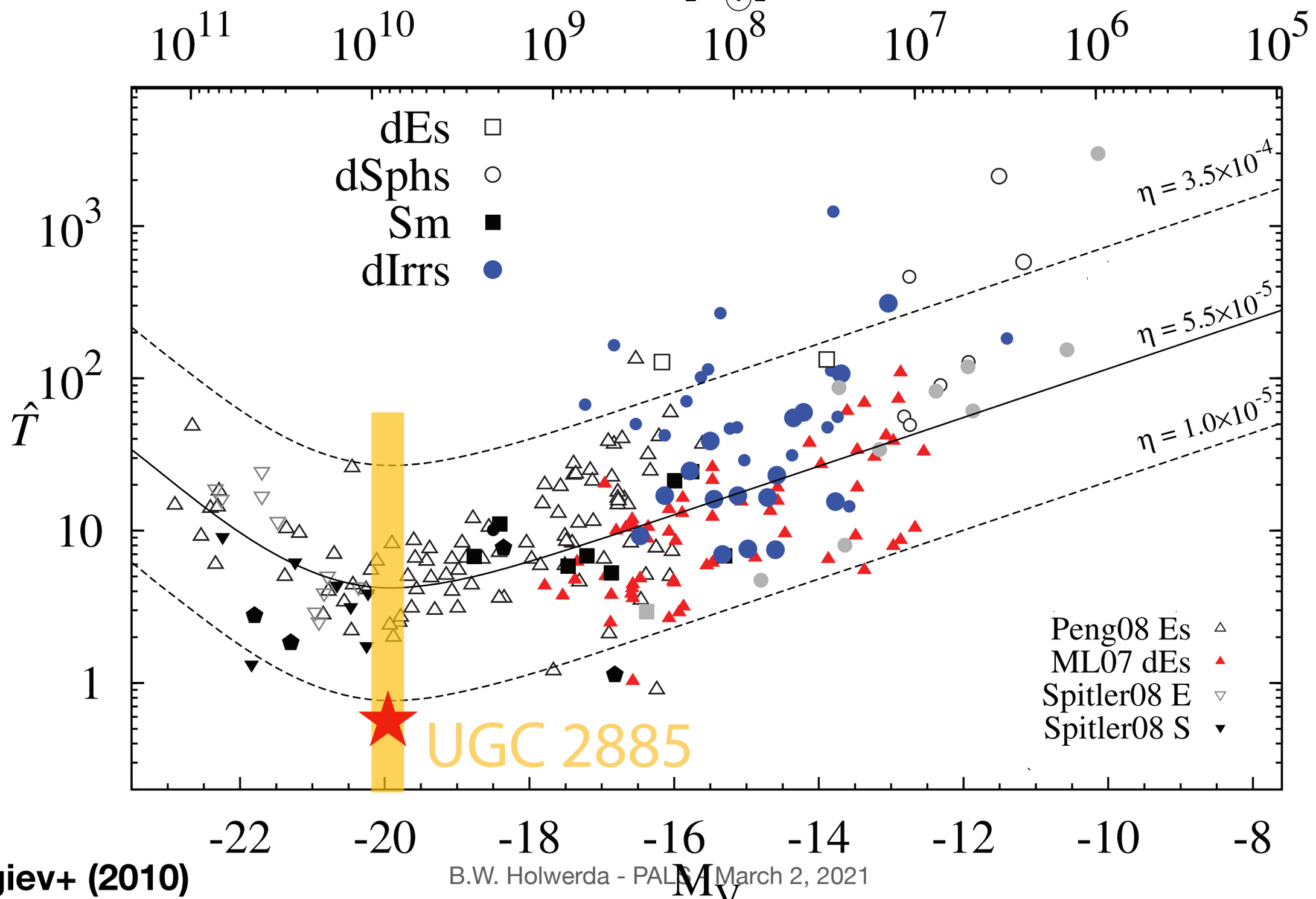




Luminosity Functions



Specific Incidence of GC



Georgiev+ (2010)

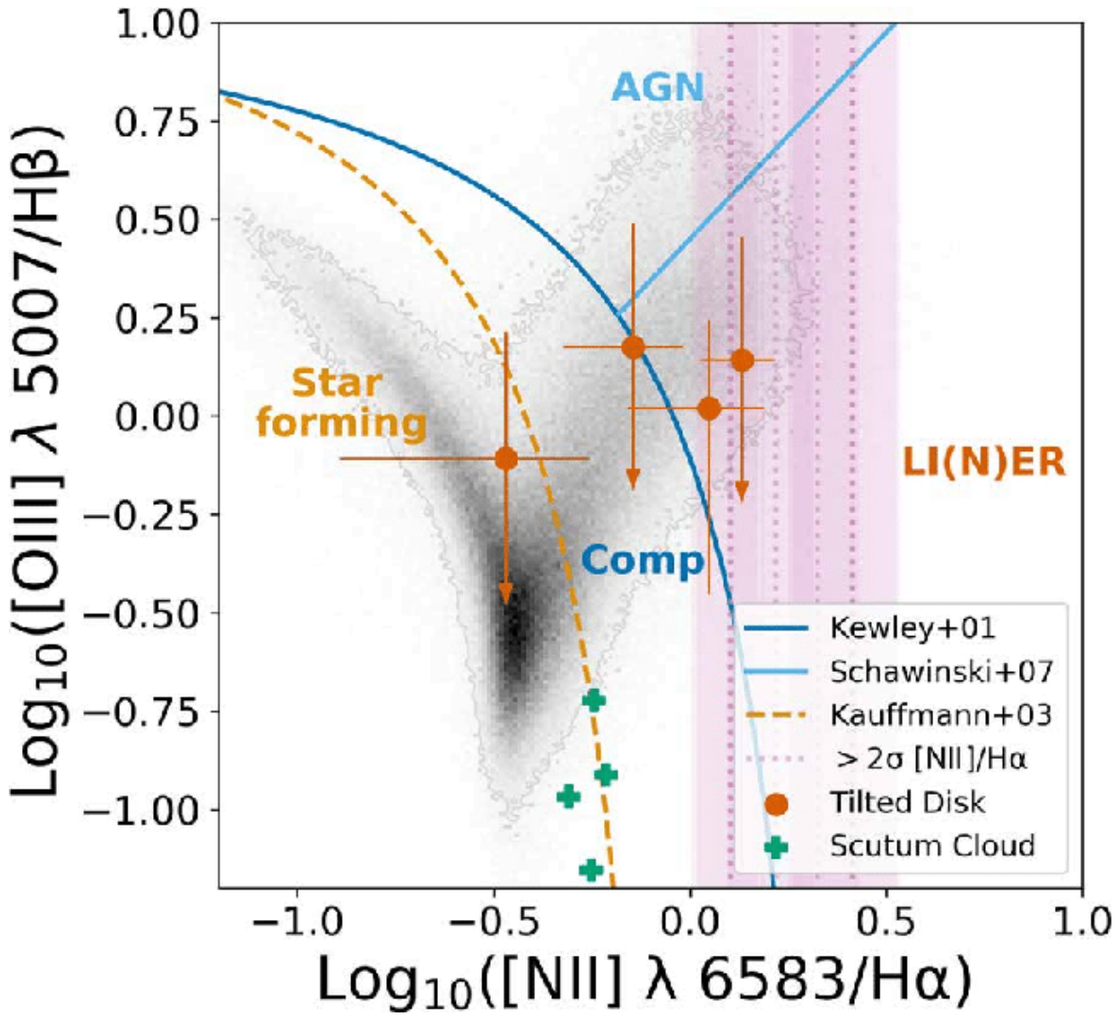
Rubin's Galaxy

- Relatively isolated.
- No sign of recent or much ancient mergers (GC population).
- GC population resembles that of a much smaller disk.
- Gradually grown giant disk galaxy.

Is there a monster here?

We need a spectrum

- Each element has specific wavelengths it emits light at.
- How bright these lines are depend on the environment: near young stars or a black hole means different lines light up.



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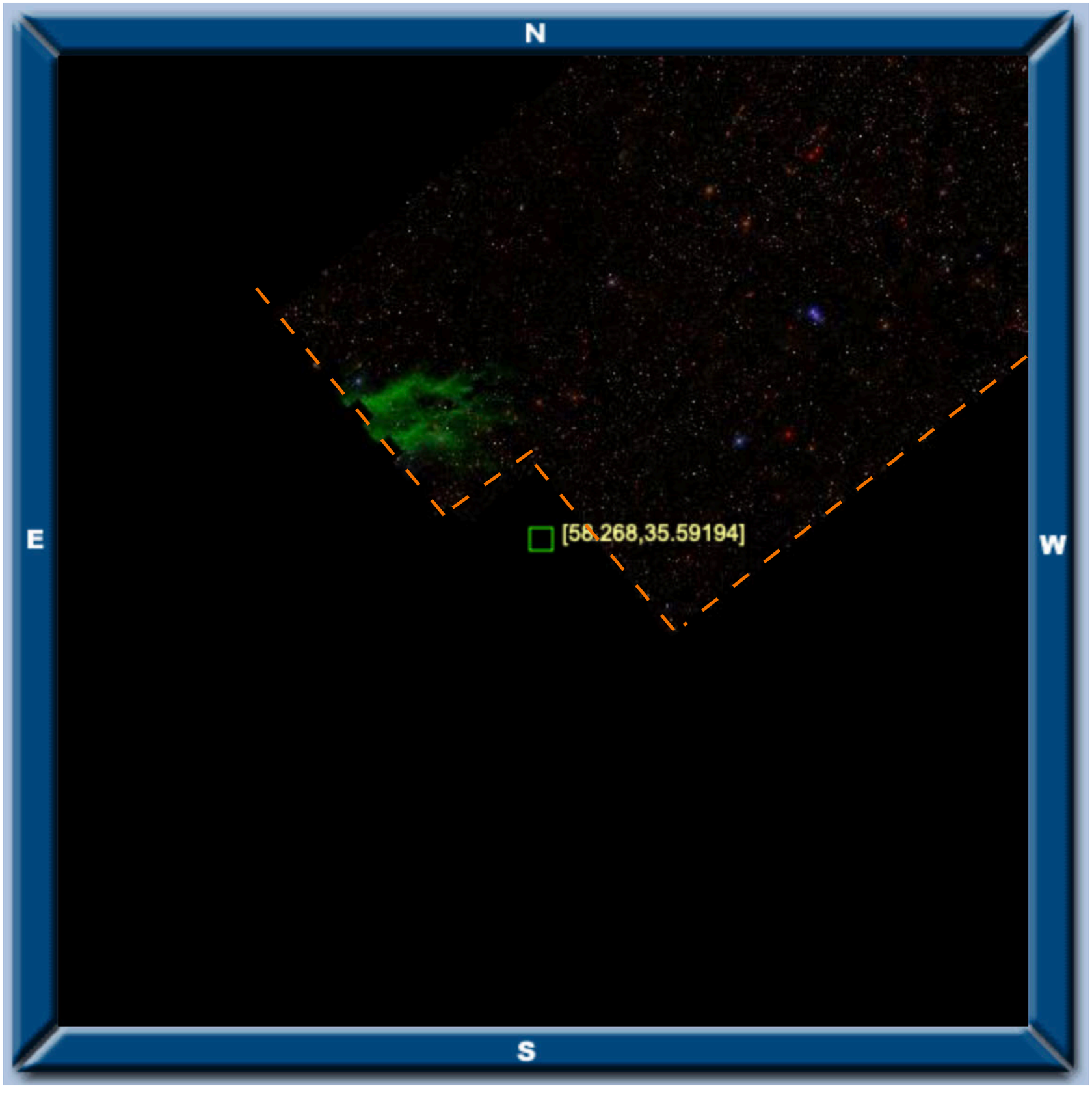
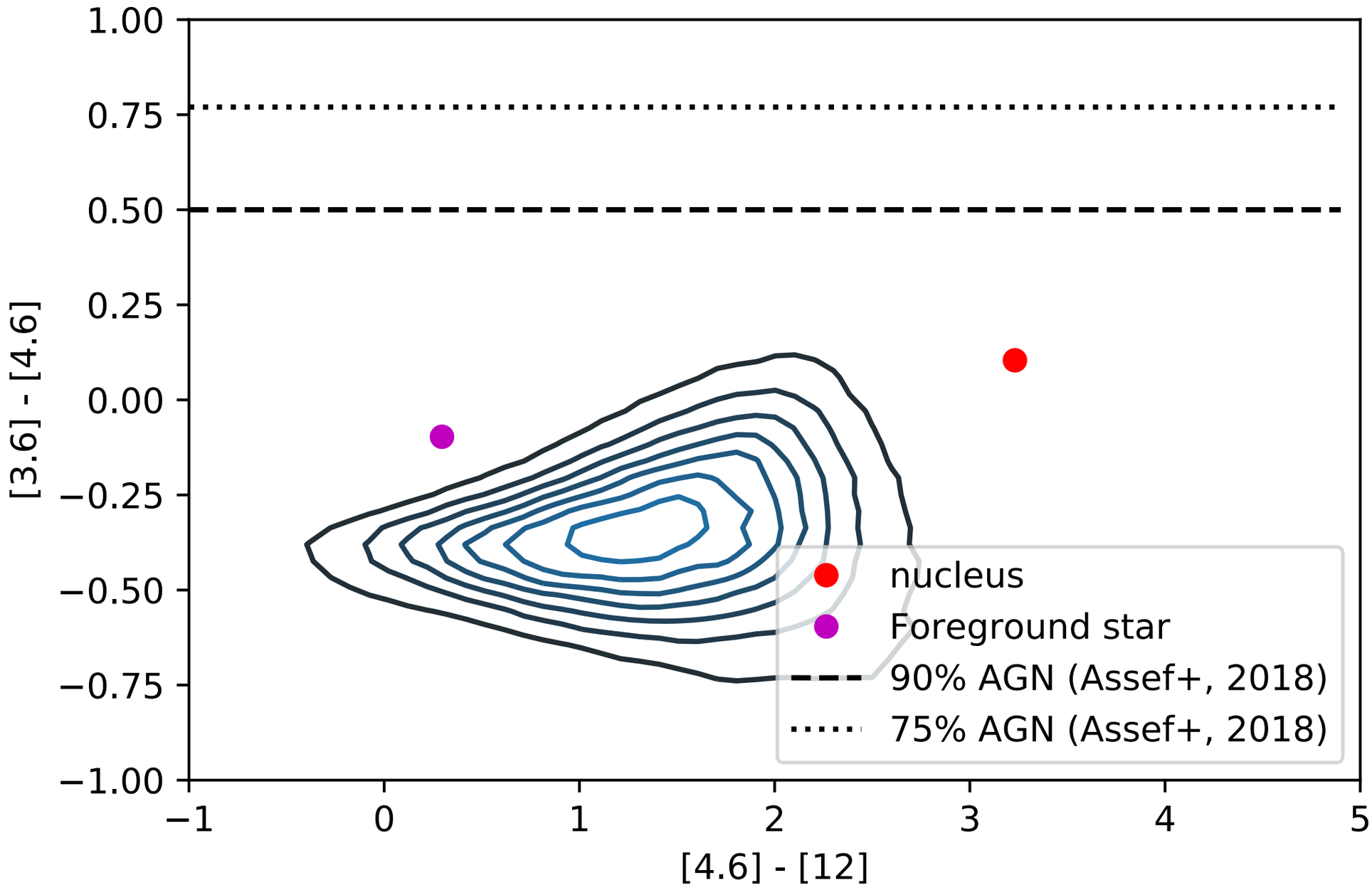

N
E
W
S
[58.268,35.59194]

Maybe I can see the disk?

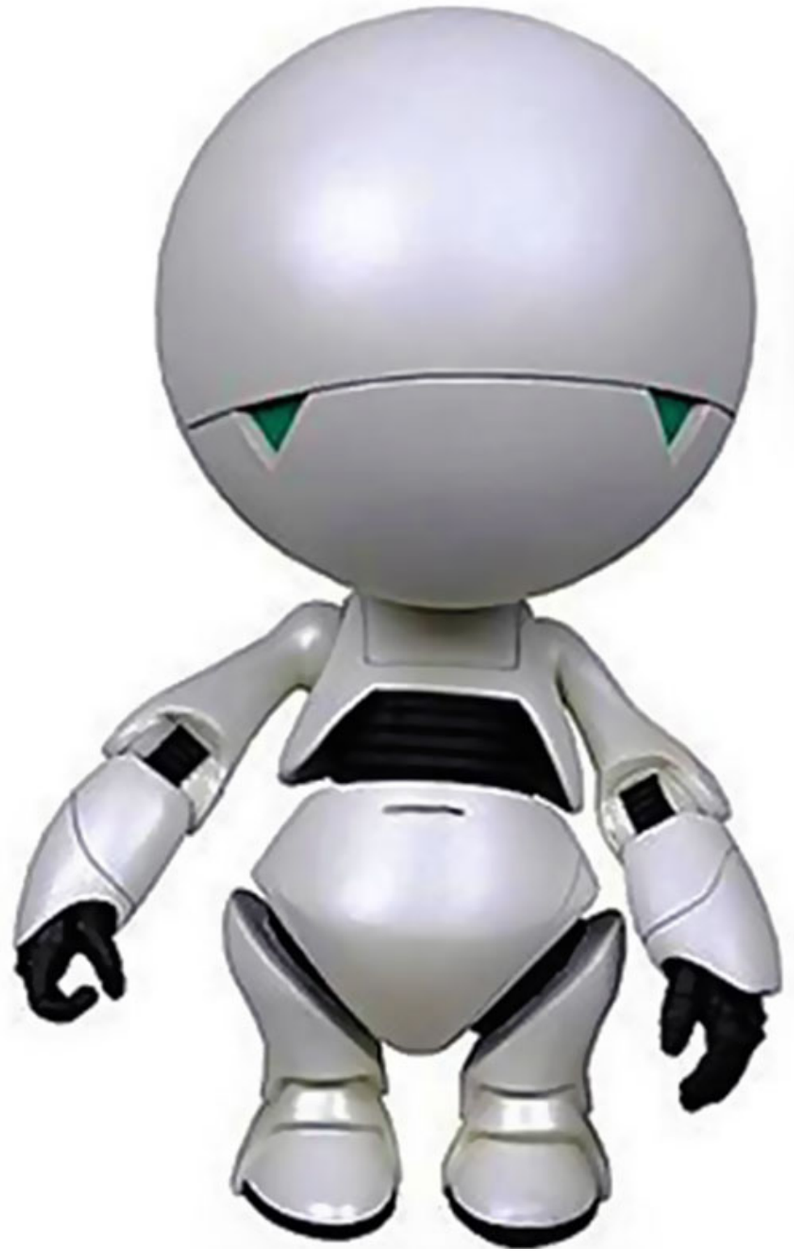
WISE colors


1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00
−1
0
1
2
3
4
5
[3.6] - [4.6]
[4.6] - [12]
nucleus
Foreground star
90% AGN (Assef+, 2018)
75% AGN (Assef+, 2018)

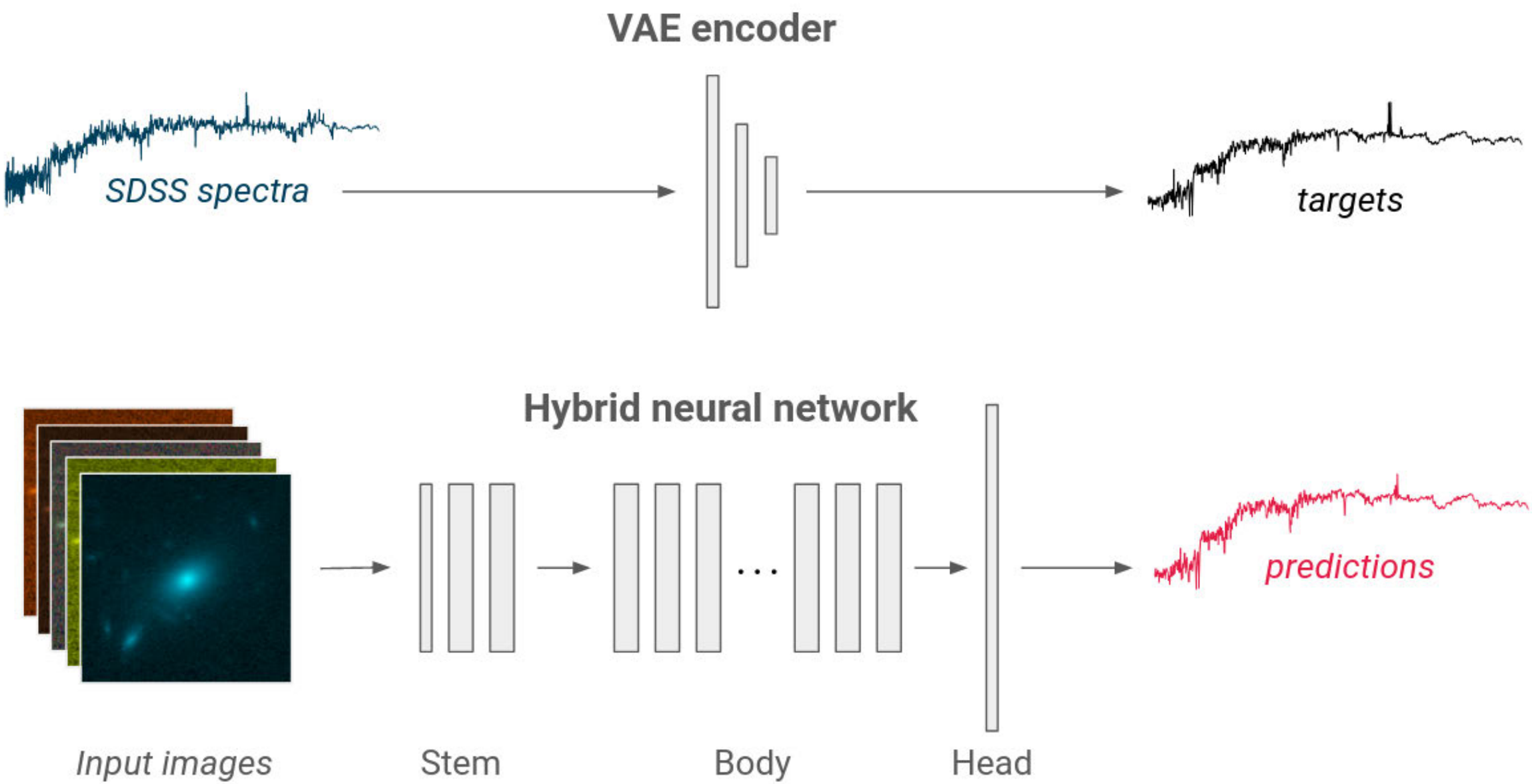
Machine Learning to the rescue!

- If we do not have a spectrum, maybe we can predict one? Using just images we have already.

- And based on machine learning, can we say if we expect a supermassive black hole in the center?



Two ML Applications



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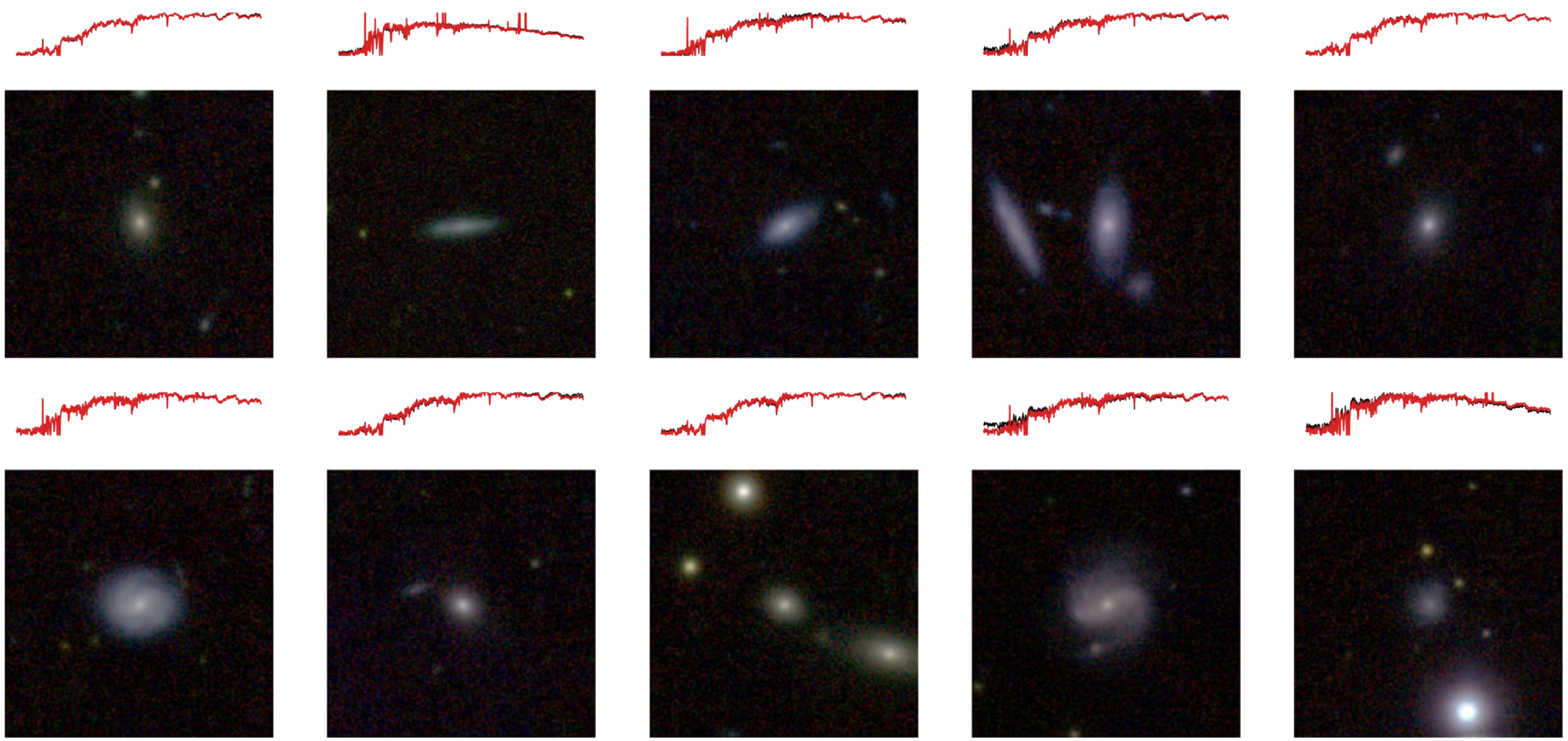
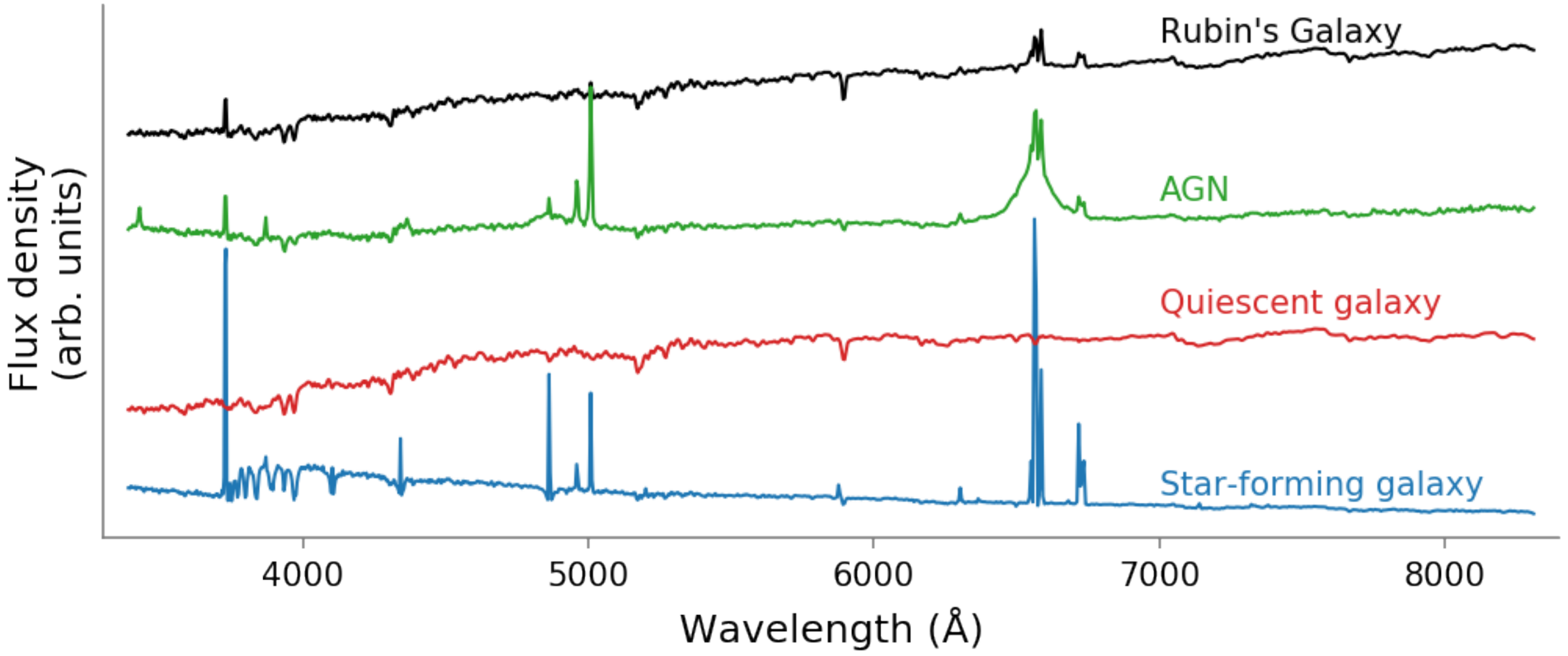
Training Set of Sloan Digital Sky Survey



Wu & Peek, 2021, arXiv:2009.12318

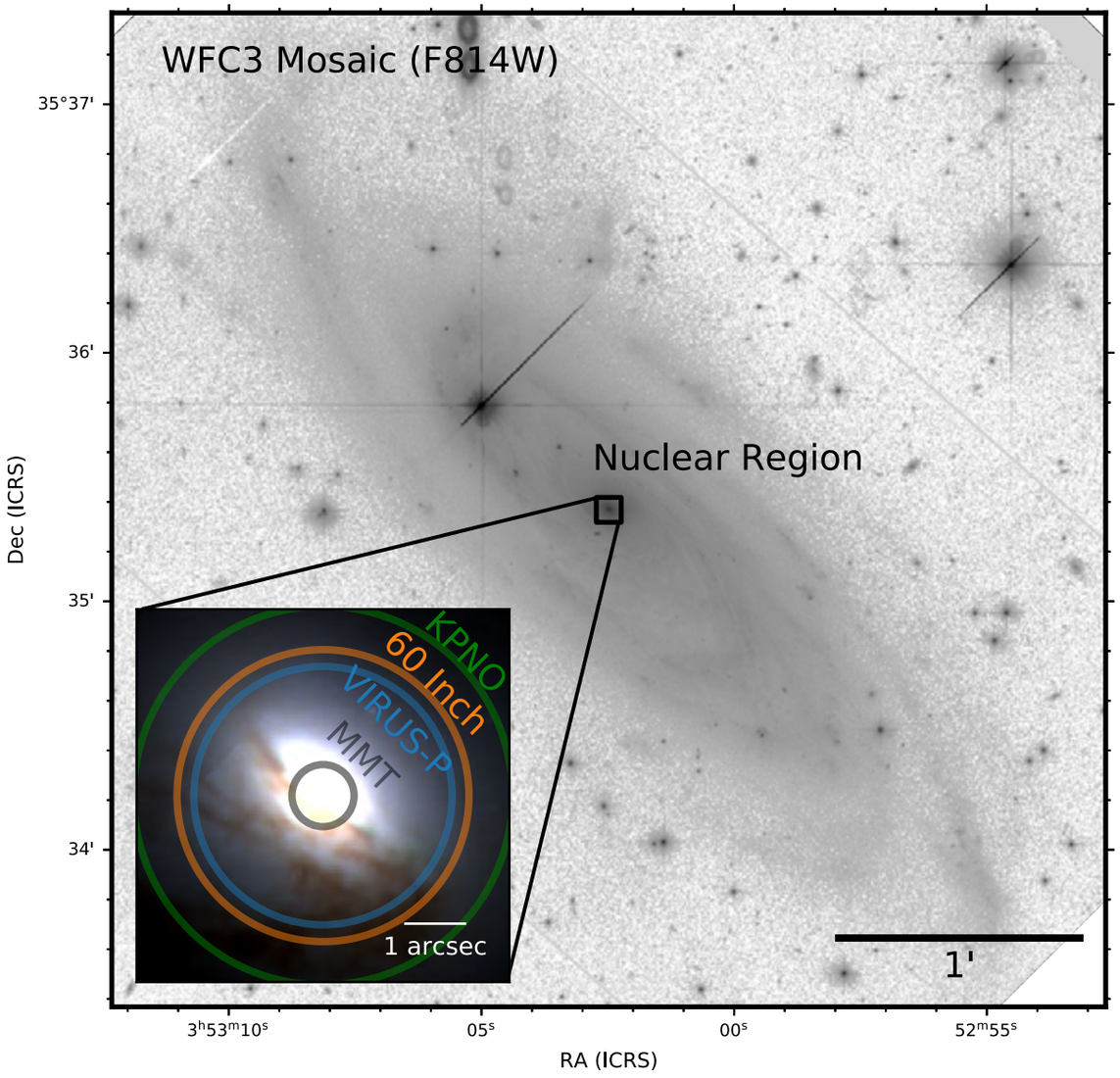
Result for Rubin's Galaxy



Let's check!

- Dig out spectra from 1983 (thanks Bill Keel!)

- New observations with MMT (asked Joannah Hinz and Tim Pickering nicely).



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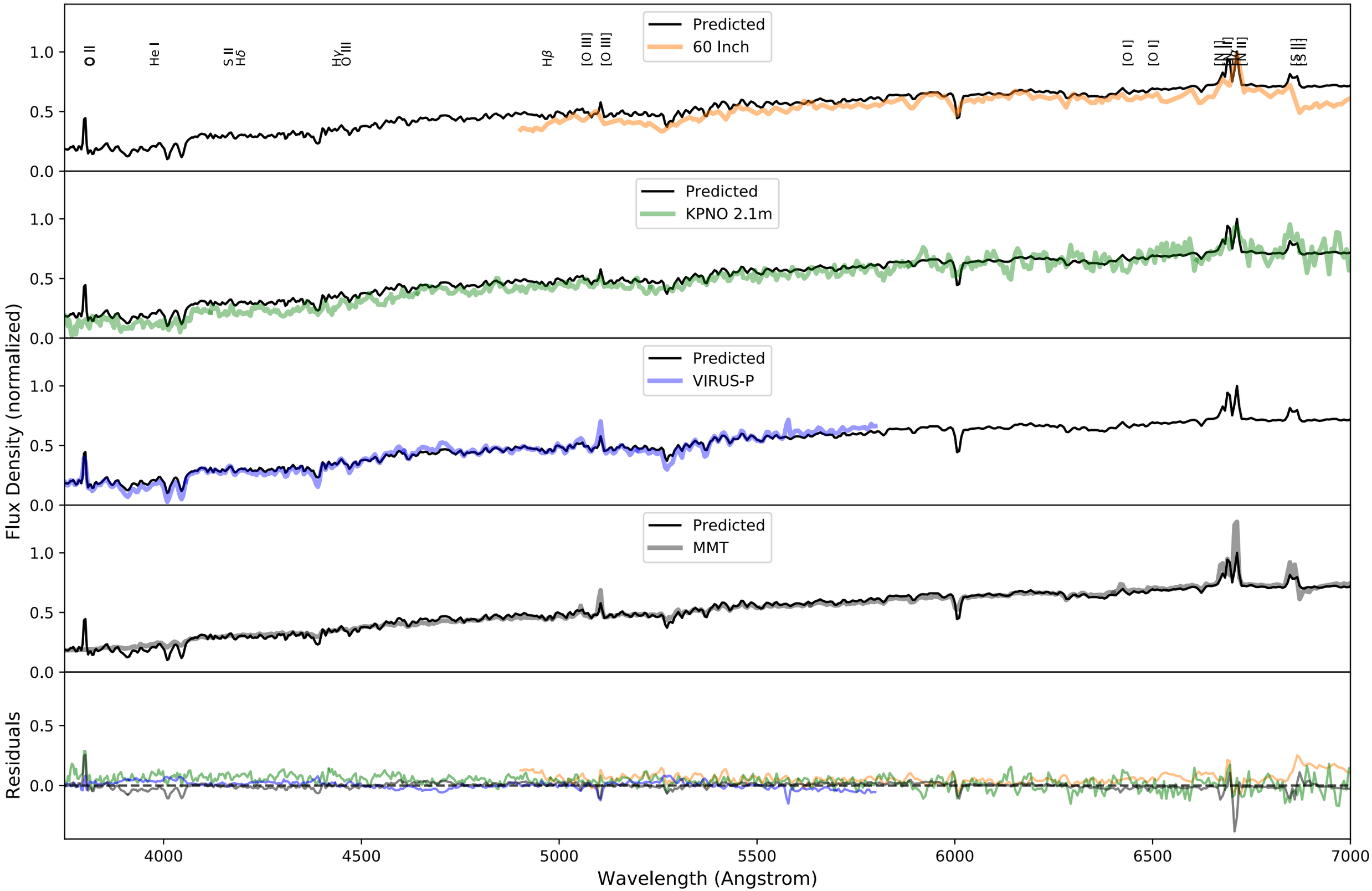
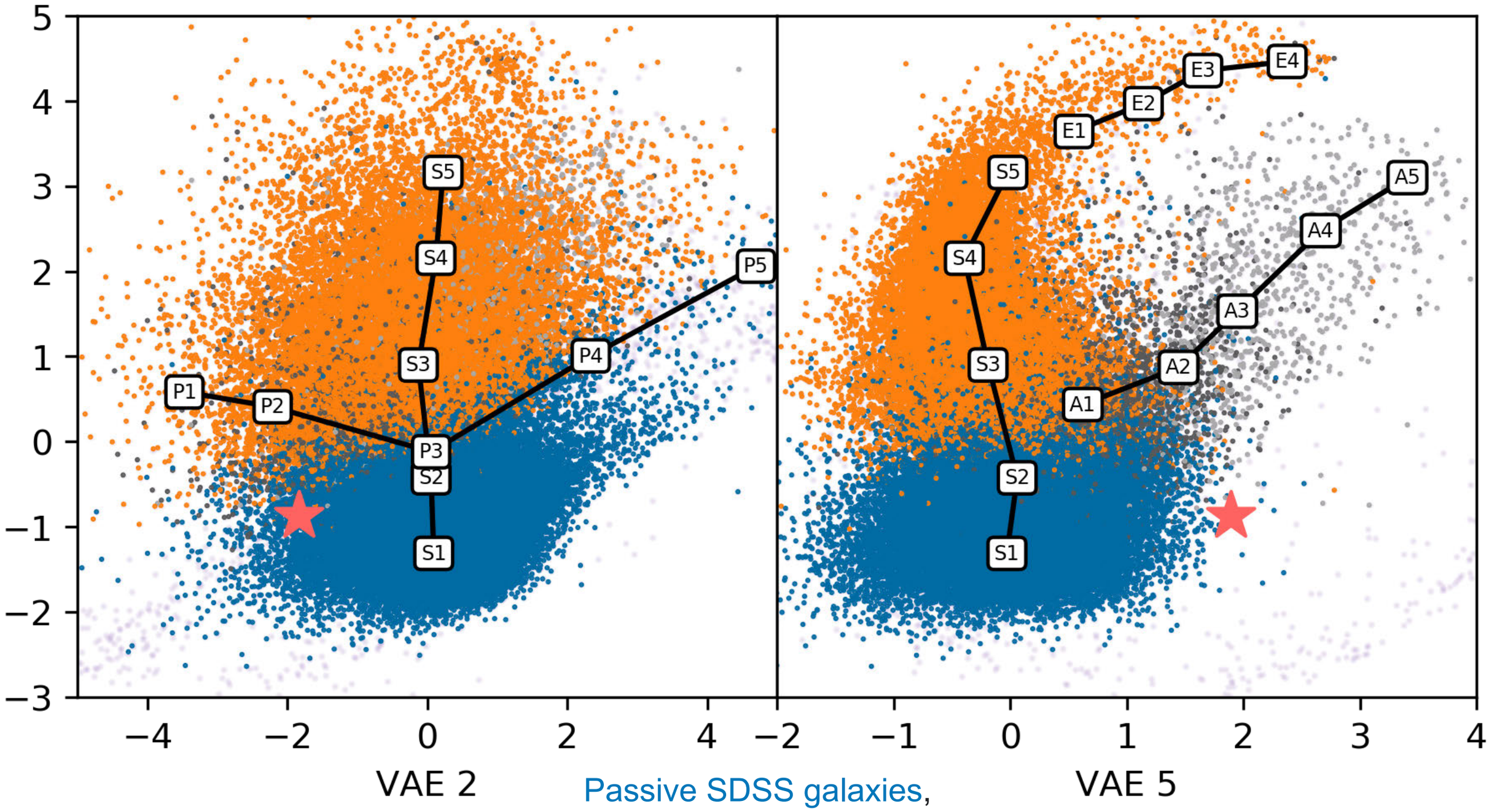


Holwerda+ (2021, *submitted*)

B.W. Holwerda - PALS - March 2, 2021

That's really good!



Passive SDSS galaxies,
star-forming galaxies,
AGN.

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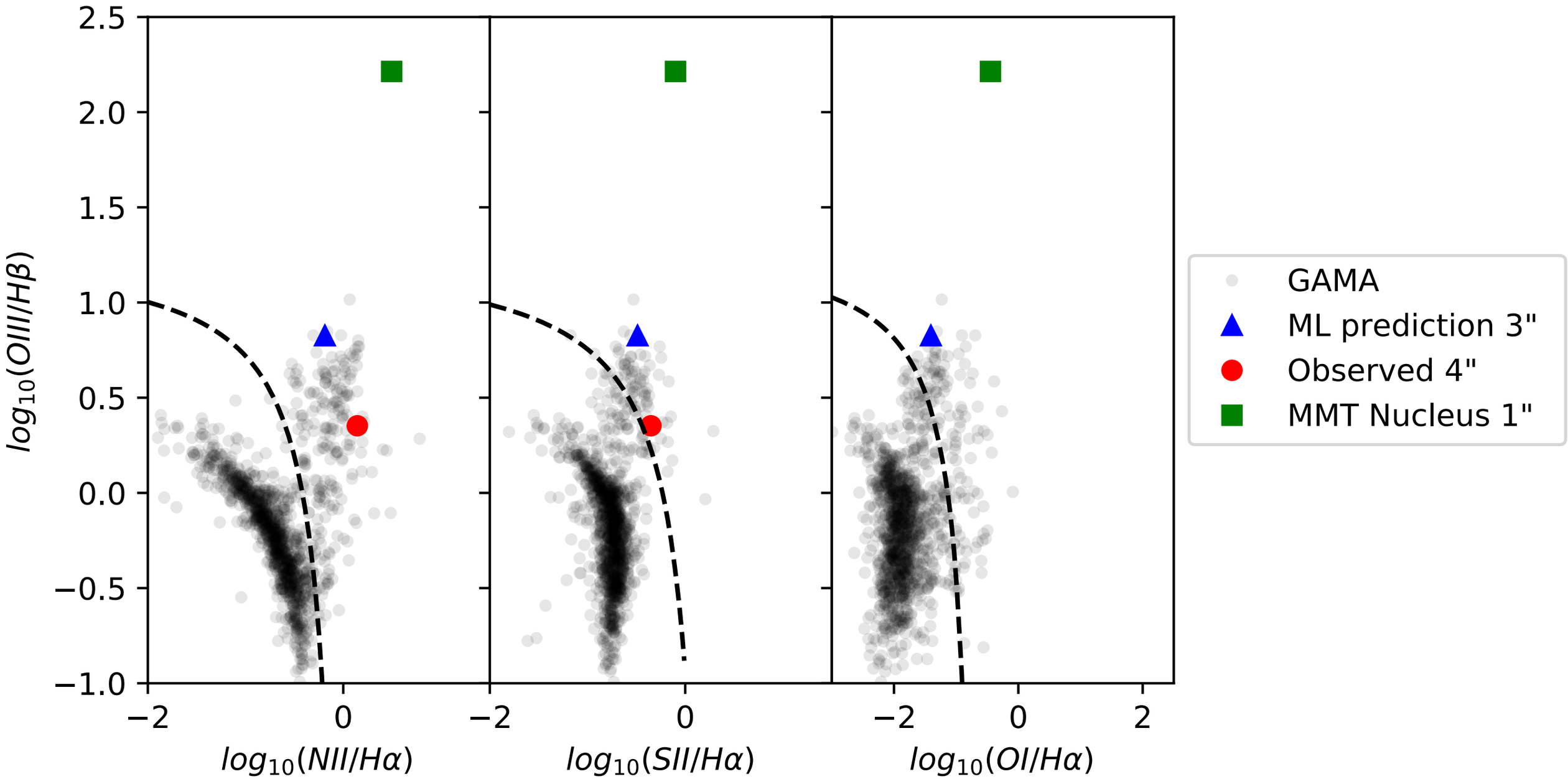
BPT Diagram



Holwerda+ (2021, submitted)

Rubin's Galaxy

- A massive spiral galaxy ($M* = 10^{12.5} M_{\odot}$)

- Current star formation low: $log(\dot{M}_{*}) \sim 0.4 M_{\odot}/yr$ (Hunter+ 2013). How to build it at this rate?

- Stellar cluster population similar to that of much smaller/ lower-mass star-forming disk galaxies.

- Specific frequency of globular clusters and color range suggest a slow built-up of this massive disk with only very minor mergers.

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Rubin's Galaxy's Nucleus

- The nucleus holds an AGN.
- This is remarkably well predicted by a Machine Learning algorithm (Wy & Peek) using just the PAN-STARRS images.
- Big disks like this are relatively rare, encouraging to see the ML algorithm getting it right anyway.
- Just secular processes feeding the AGN?

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Follow-up observations