Low Mass Galaxy Interactions Trigger Black Hole Accretion

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Dodge Family Postdoctoral Fellow

In collaboration with: J. Irwin (Alabama), P. Nair (Alabama), B. Wells (Duke), O. Holmes (Purdue), J. Eames (Alabama)

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MOTIVATION

Growth and emergence of first supermassive black holes

Introduction

- Discoveries of SMBHs in the young Universe

  1) 8×10^8 M_{sol} at z=7.5 (Banados+2018)

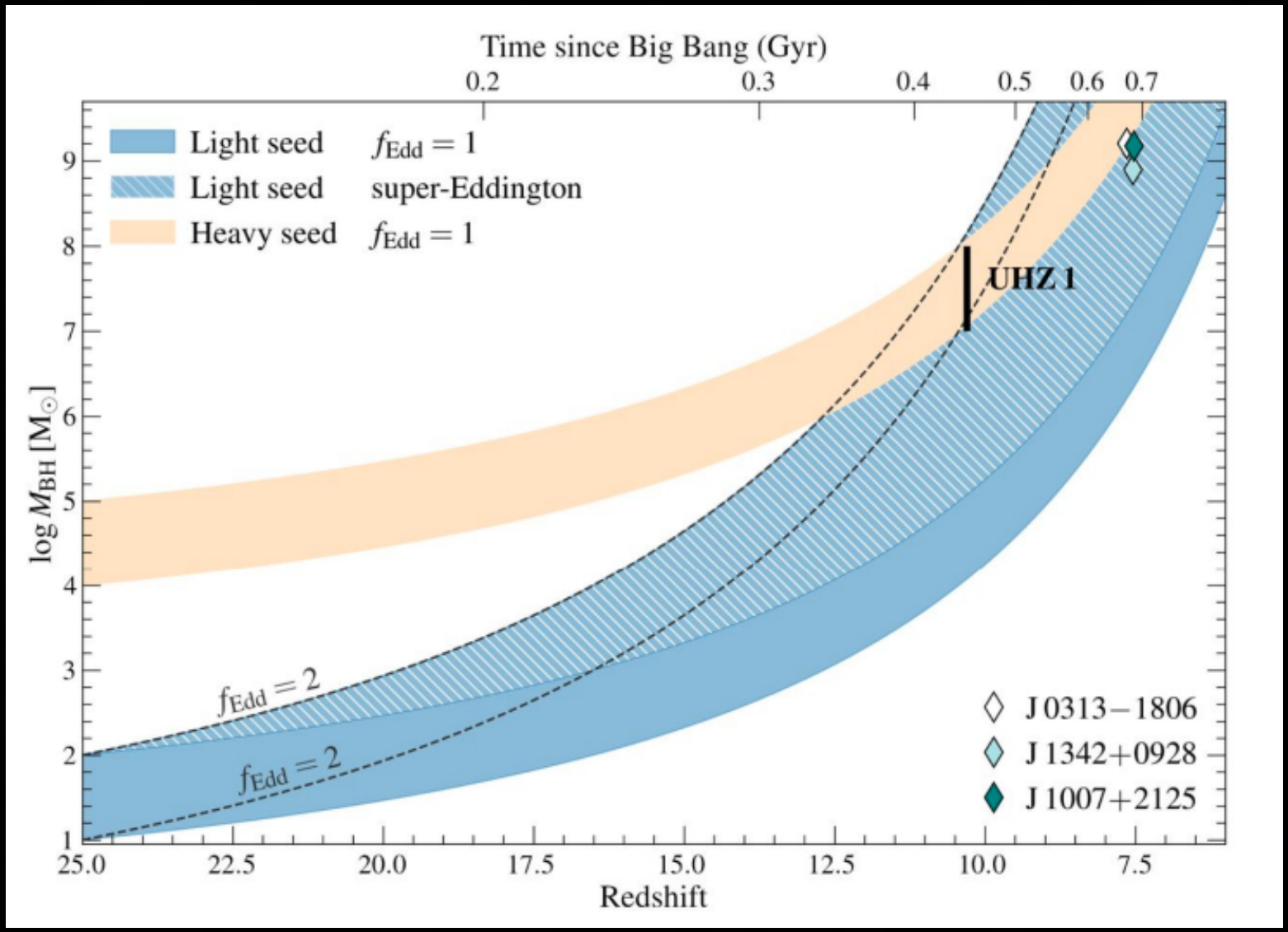
  2) 1×10^9 M_{sol} at z=7.5 (Yang+2020)

  3) 2×10^9 M_{sol} at z=7.6 (Wang+2021)

  4) 10^7-10^8 M_{sol} at z=10.3 (Bogdan+2024)

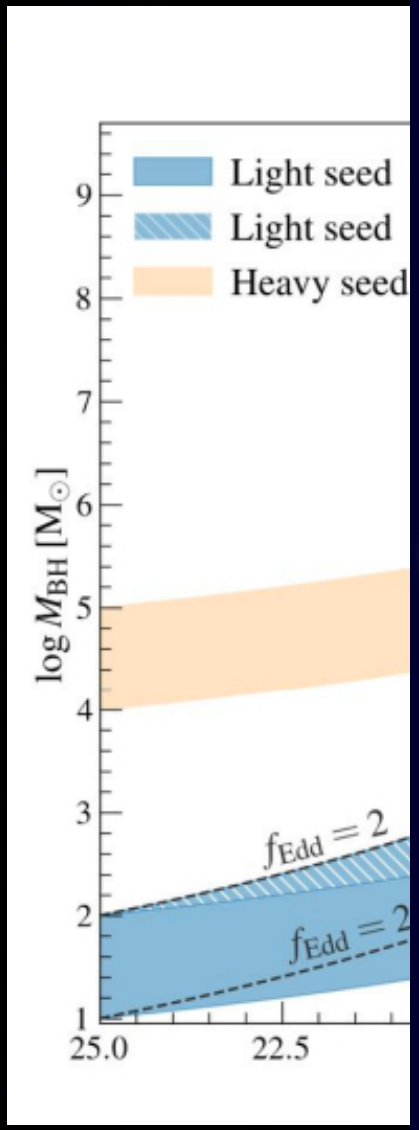
  ...and many more

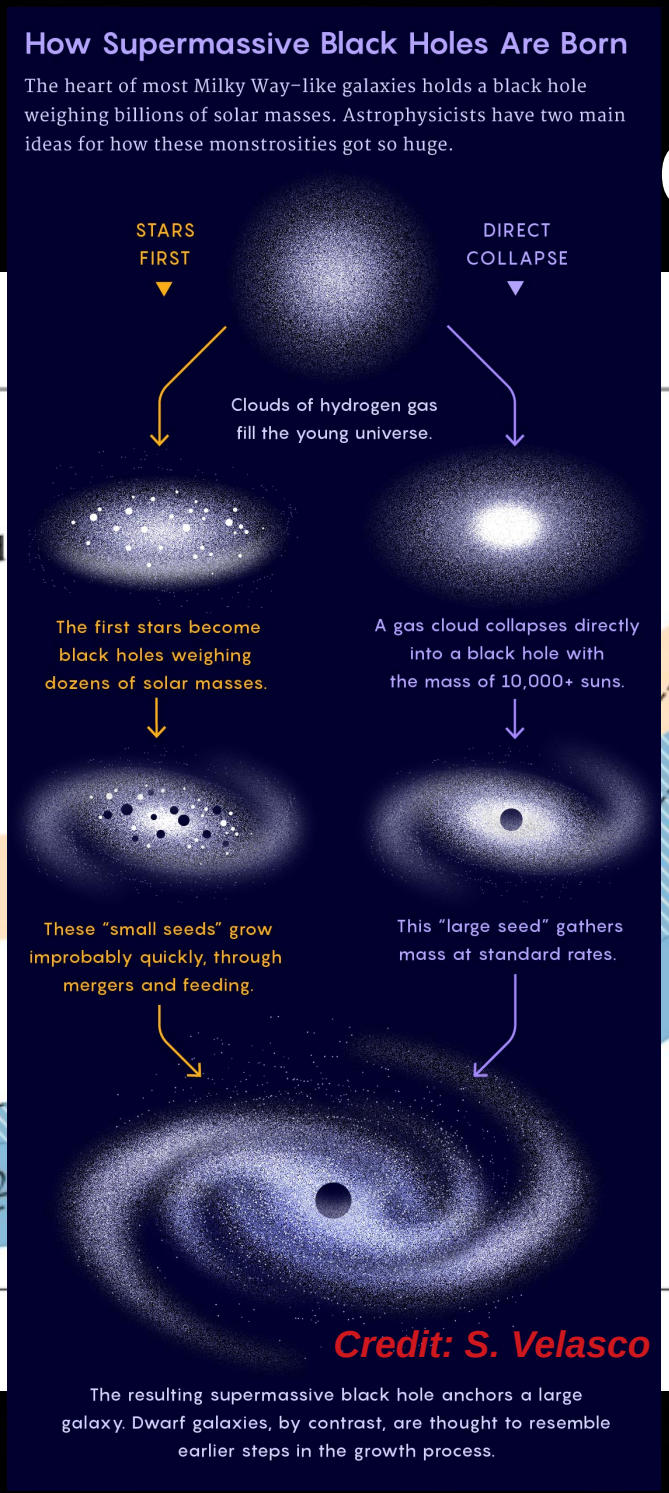
SMBH Formation Scenarios

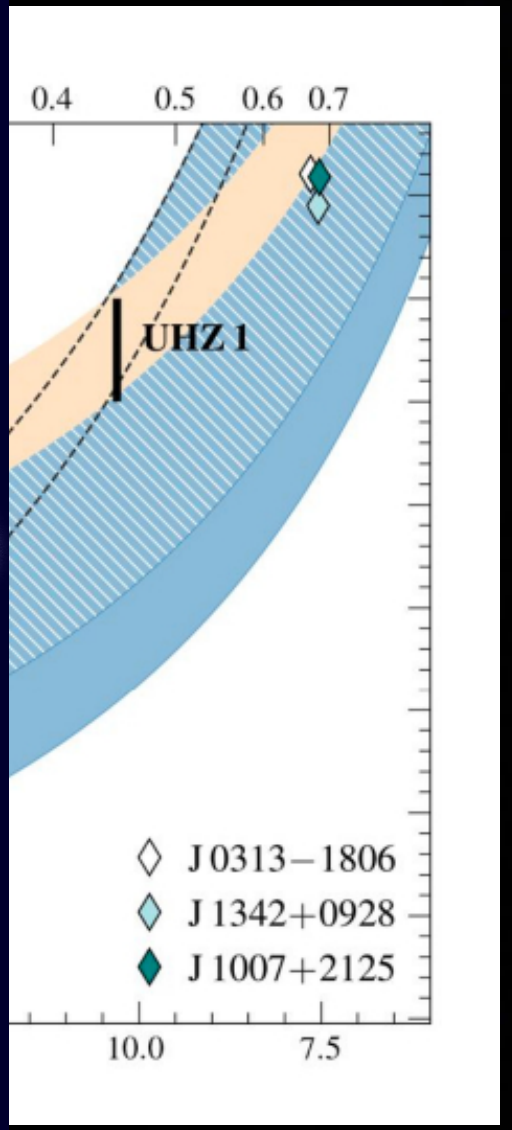


Bogdan+2024

SMBH scenarios







Bogdan+2024

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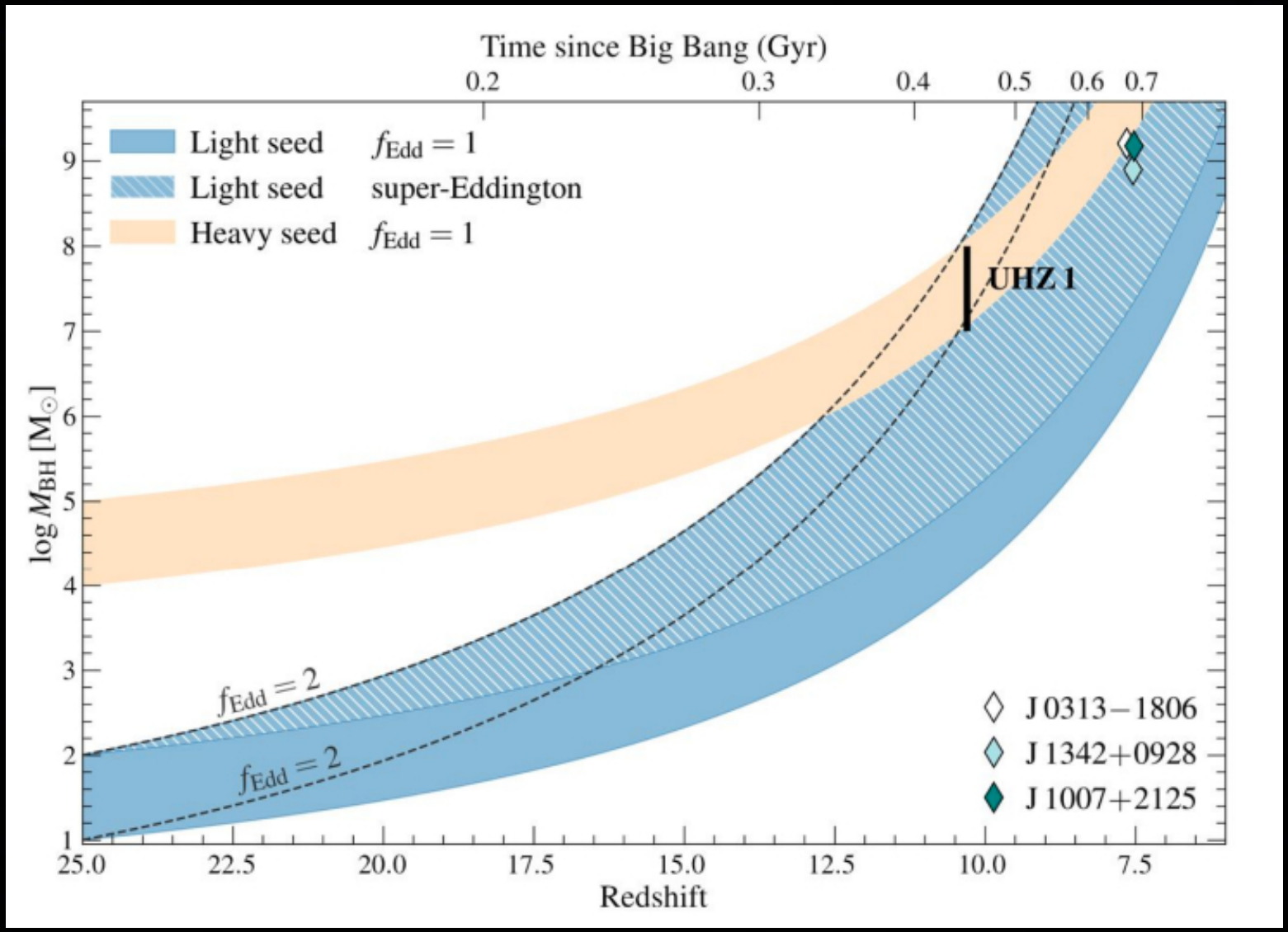

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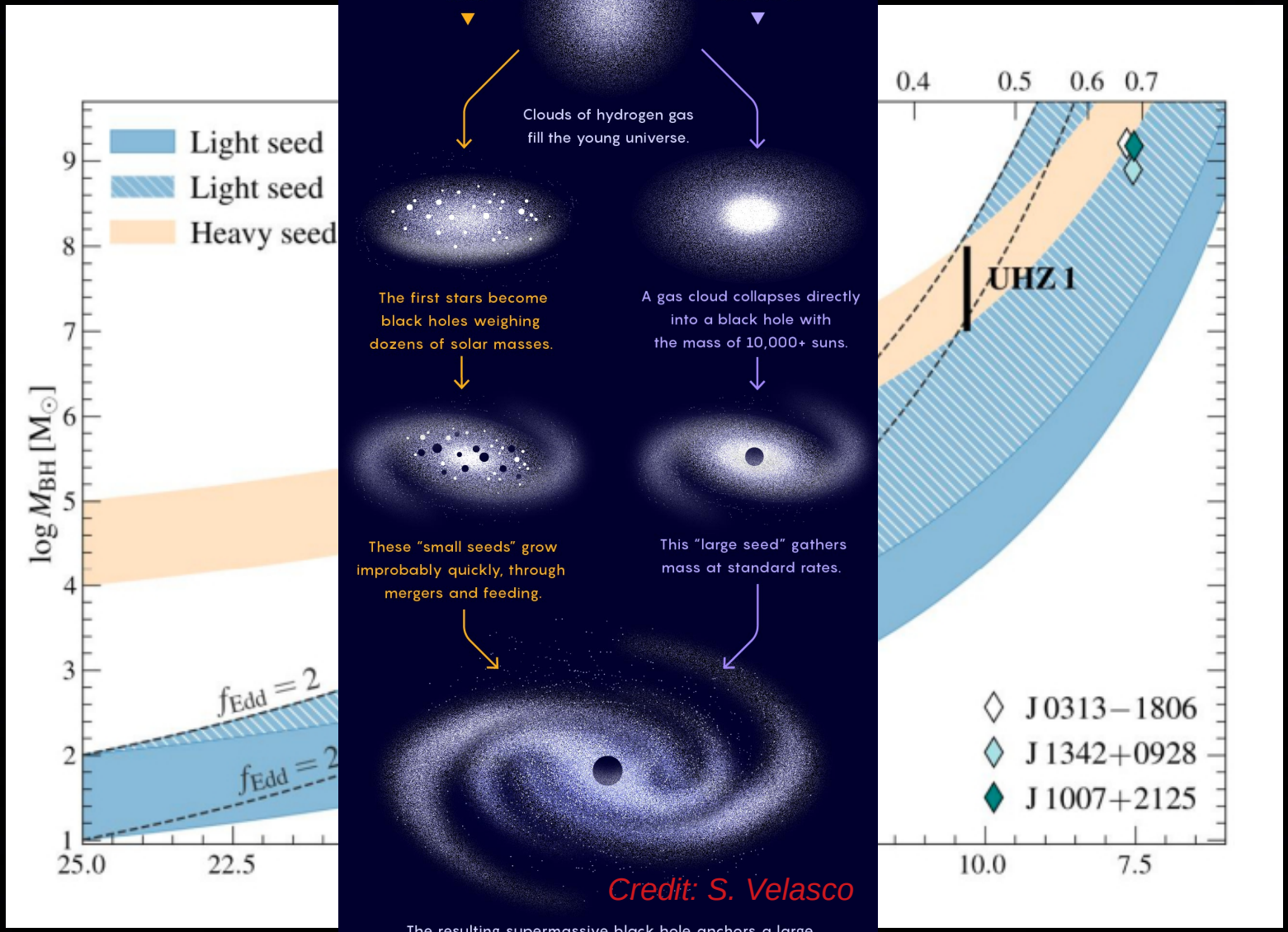

How Supermassive Black Holes Are Born

The heart of most Milky Way–like galaxies holds a black hole weighing billions of solar masses. Astrophysicists have two main ideas for how these monstrosities got so huge.

STARS FIRST

DIRECT COLLAPSE

Clouds of hydrogen gas fill the young universe.

The first stars become black holes weighing dozens of solar masses.

A gas cloud collapses directly into a black hole with the mass of 10,000+ suns.

These "small seeds" grow improbably quickly, through mergers and feeding.

This "large seed" gathers mass at standard rates.

Credit: S. Velasco

The resulting supermassive black hole anchors a large galaxy. Dwarf galaxies, by contrast, are thought to resemble earlier steps in the growth process.

Bogdan+2024

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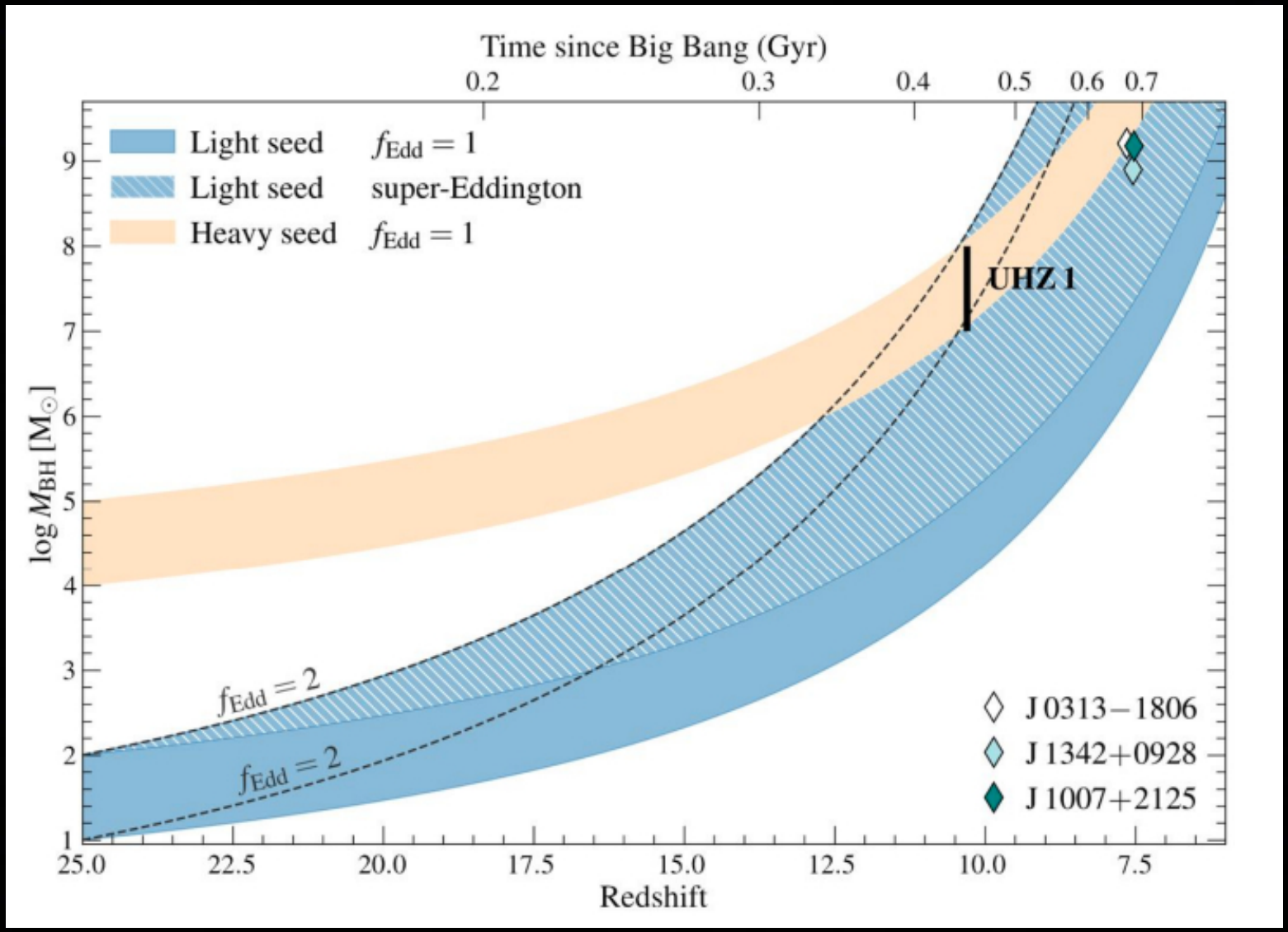


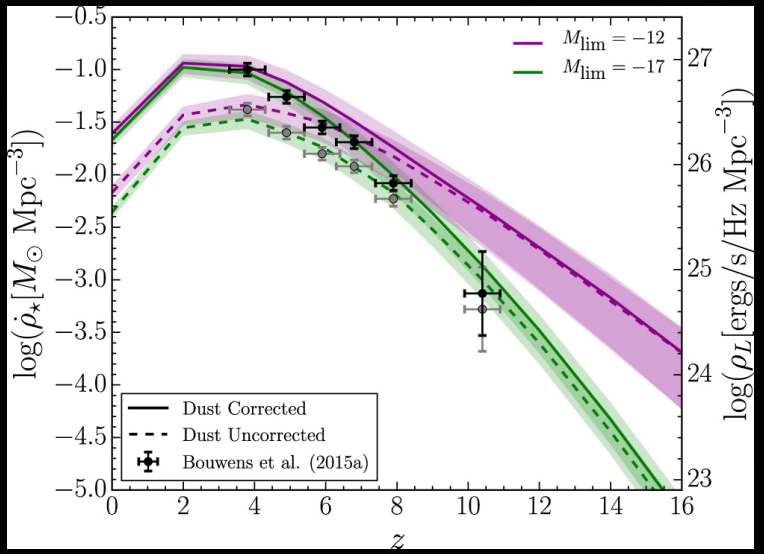
Bogdan+2024

QUESTION

Could have early Universe environmental conditions acted as evolutionary mechanisms for accelerated black hole growth?

Galaxy Demographics in the Early Universe

- From UV LF, unseen faint dwarfs dominate galaxy population beyond z=7 (Mason+2015)



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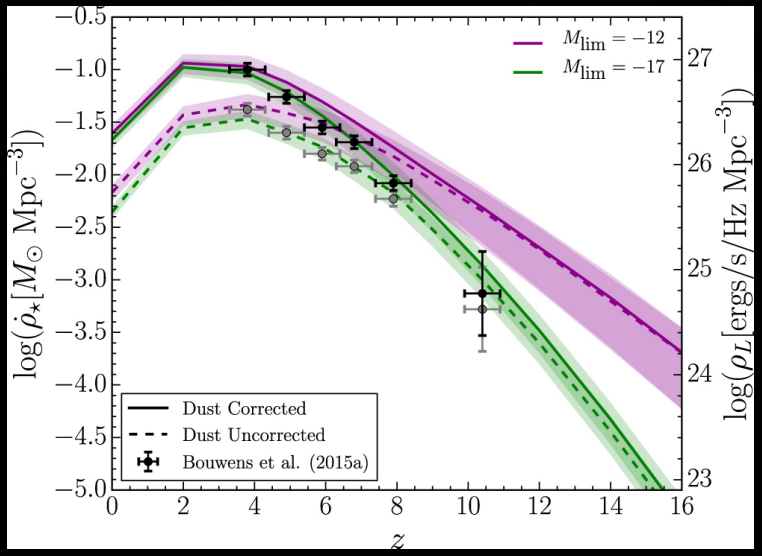
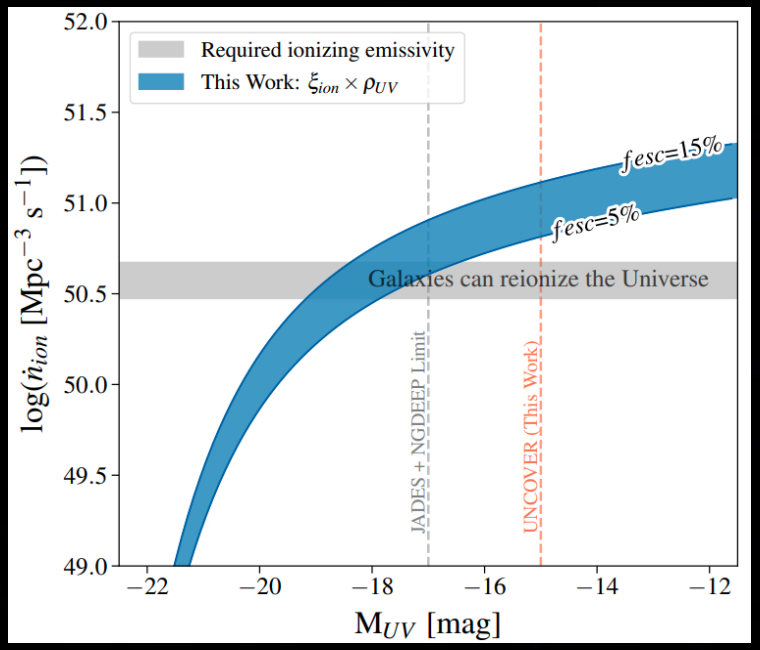
- From UV LF, unseen faint dwarfs dominate galaxy population beyond z=7 (Mason+2015)
- JWST data suggests that faint galaxies reionized the Universe (Atek+2024)





Galaxy Interactions as AGN Triggers

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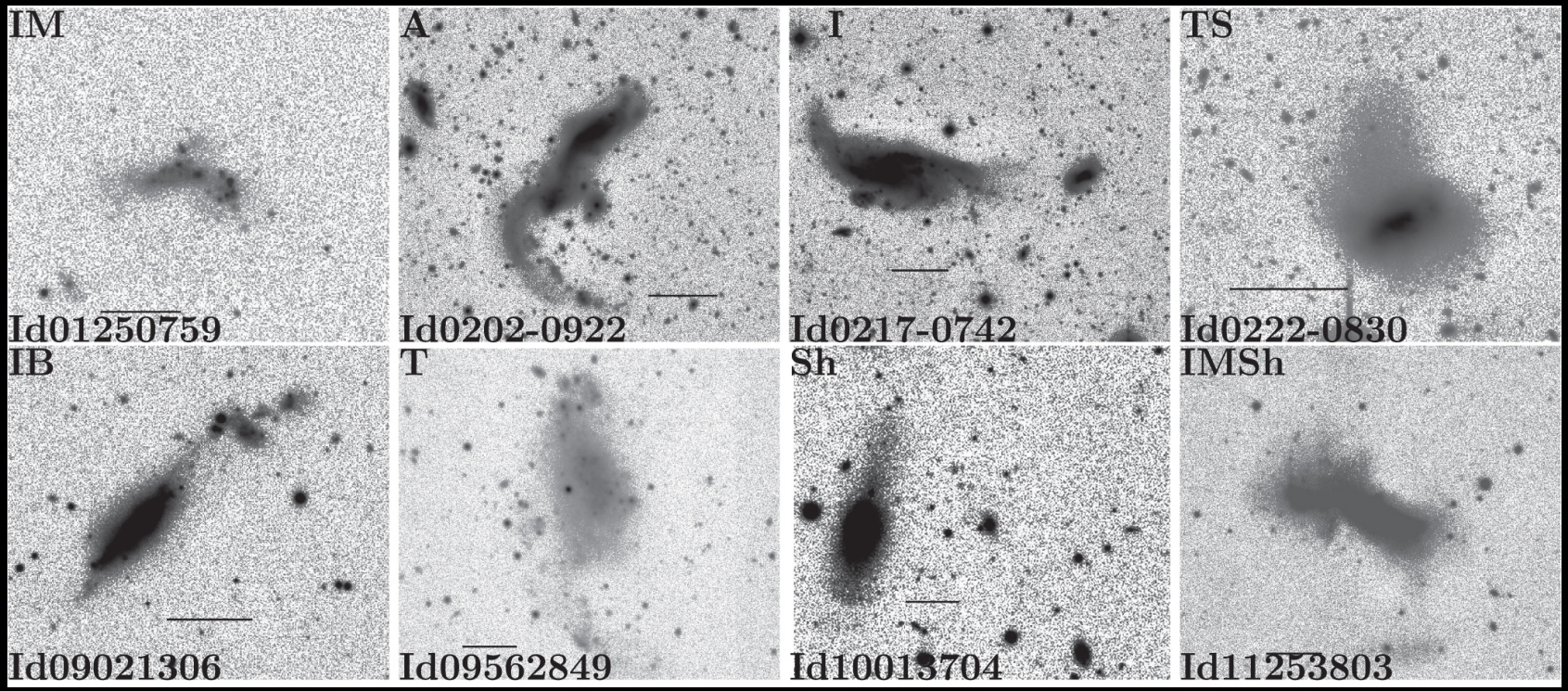
- Theory, simulations, observations
- Some claim no relationship (Alonso+2007, Li+2008, Silva+2019)
- Some claim strong relationship (Gao+2020, Li+2023, Comerford+2024)
- Various stages of interactions
- Various mass scales

Dwarf-dwarf Galaxy Pairs

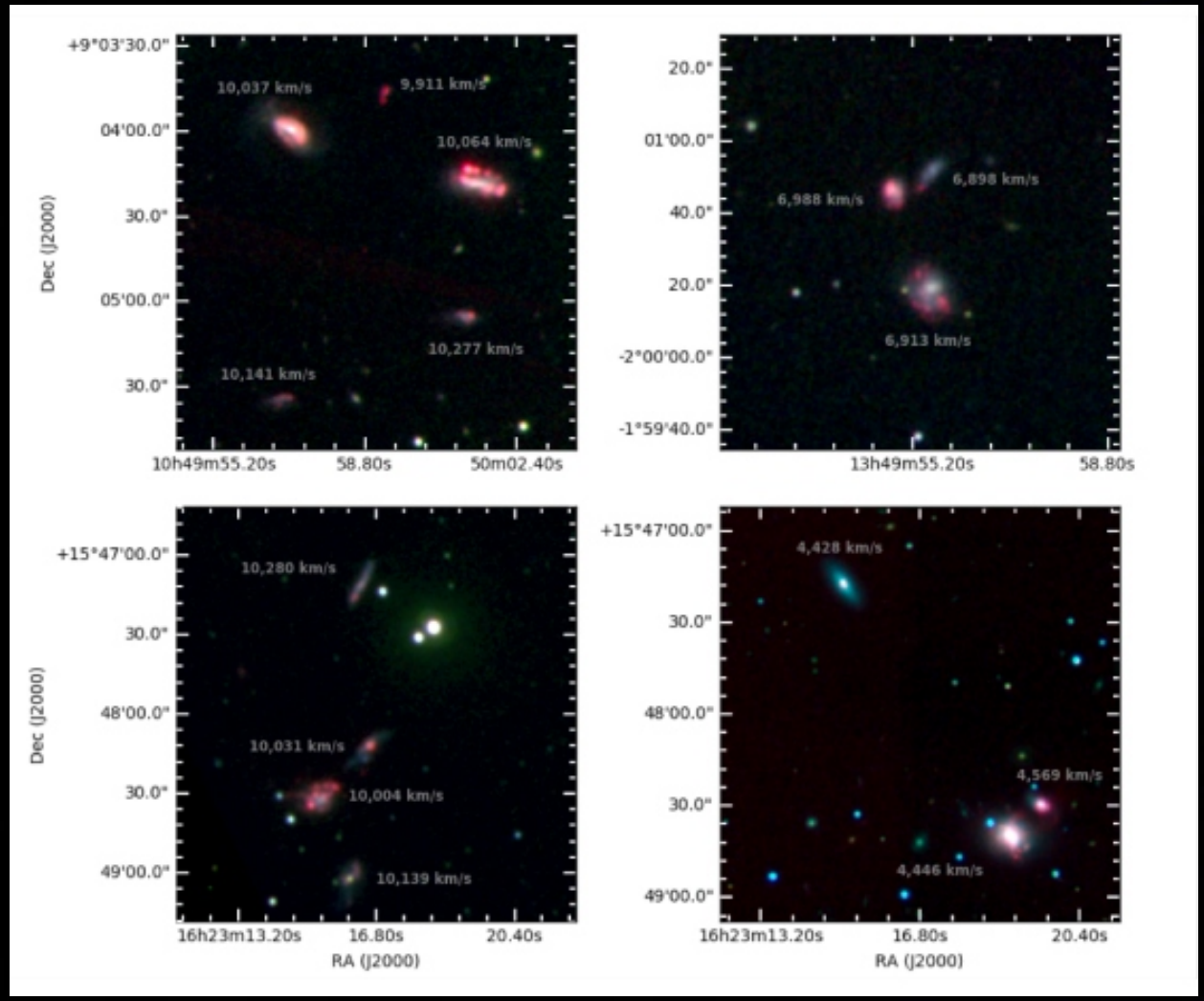
- The Tiny Titans (Stierwalt+2015)
- Sample of dwarf-dwarf pairs from SDSS (Paudel+2018)



Paudel+2018

Dwarf Galaxy Groups

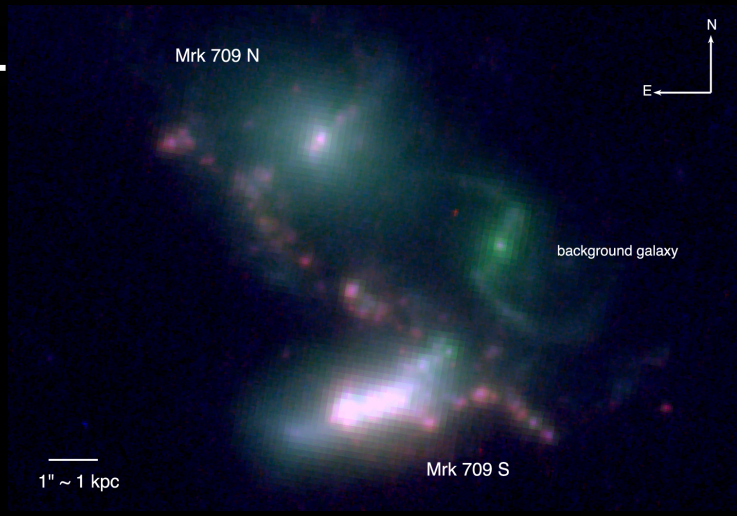
- Small sample of dwarf galaxy groups (Stierwalt+2017)



Stierwalt+2017

AGN in Dwarf-dwarf Interactions

- Markarian709 (Reines+2014 Kimbro+2021)



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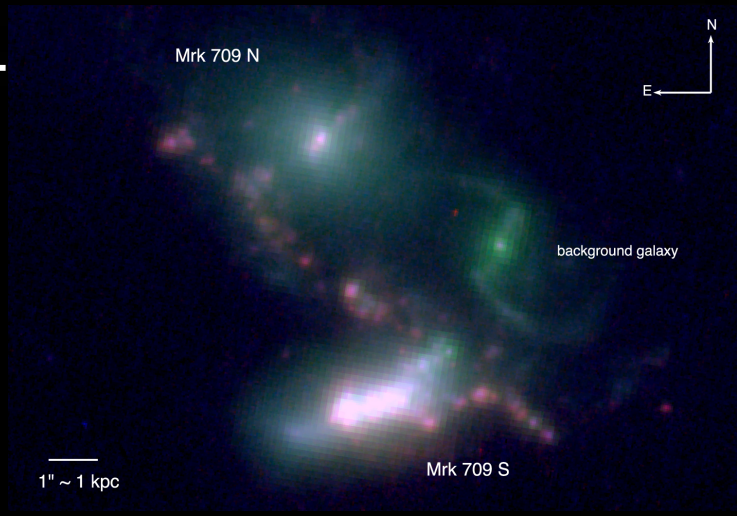
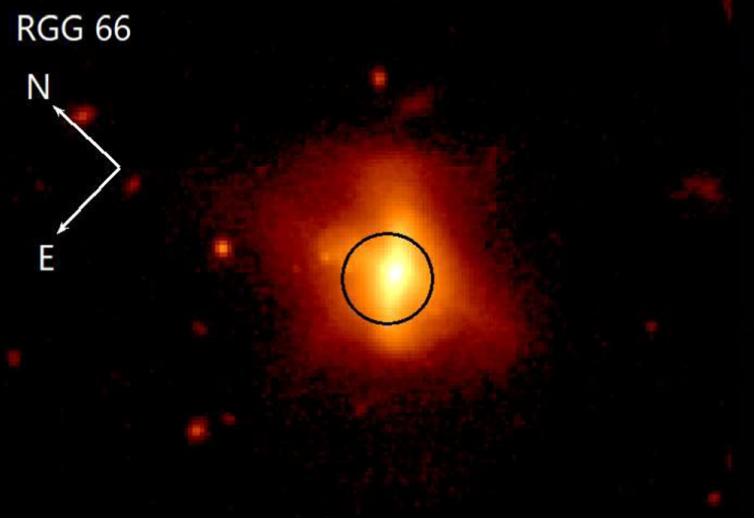
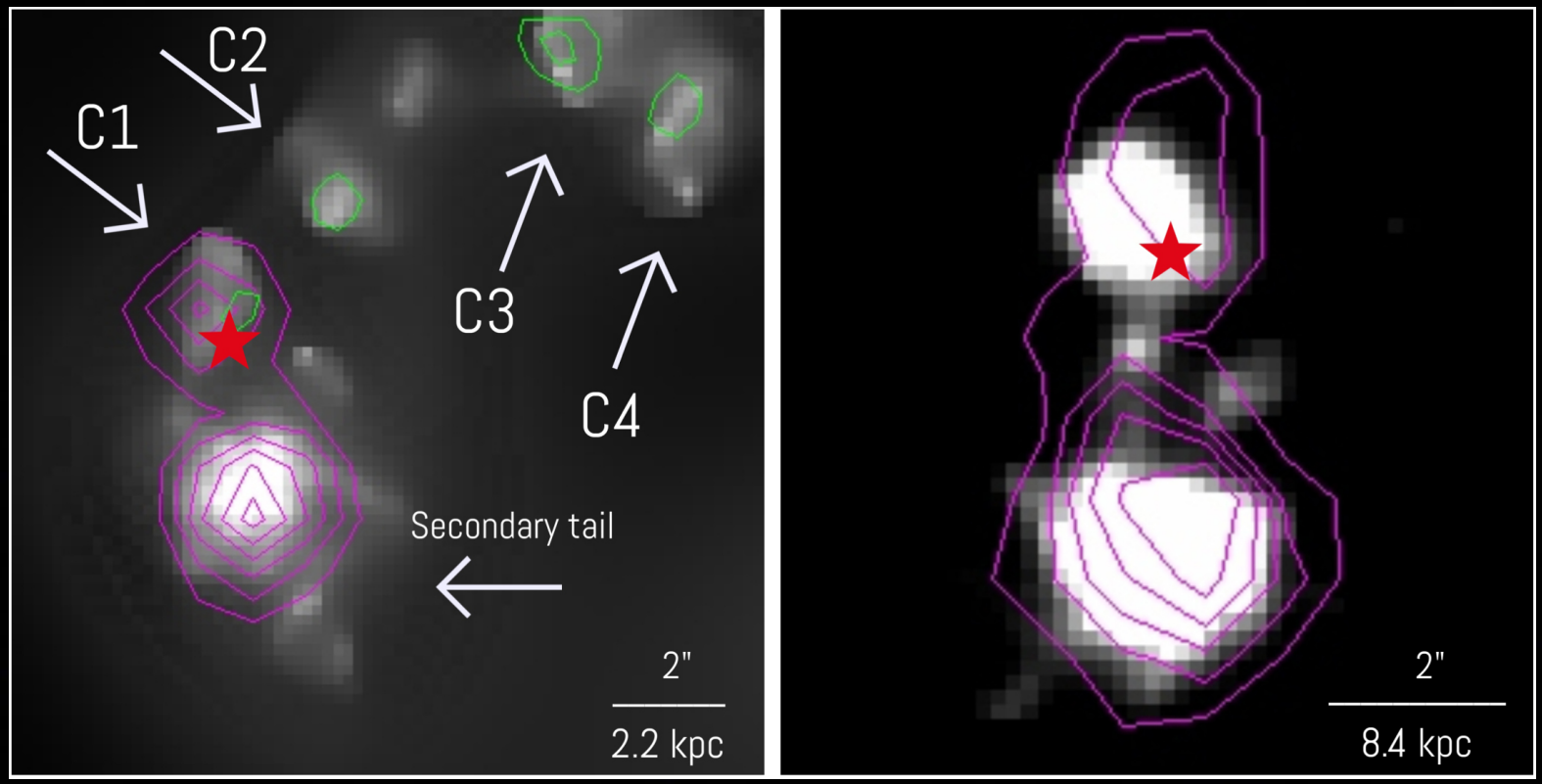


- RGG66 (Kimbrell&Reines 2024)



Candidates for Dual AGN

- Two more candidates for dual AGN (Mićić+2023)



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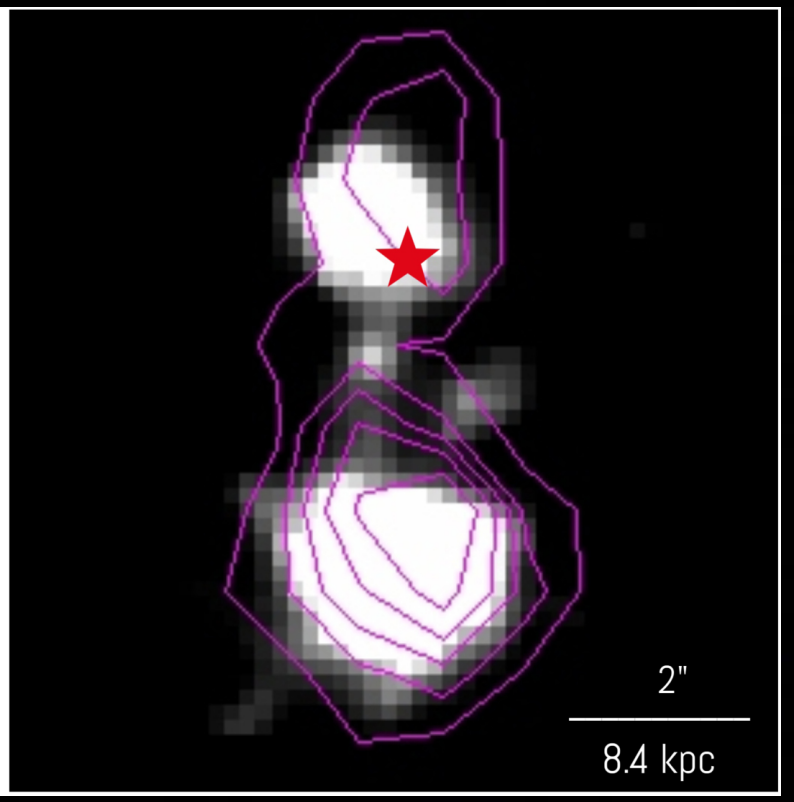
- T dual AGN
  (N



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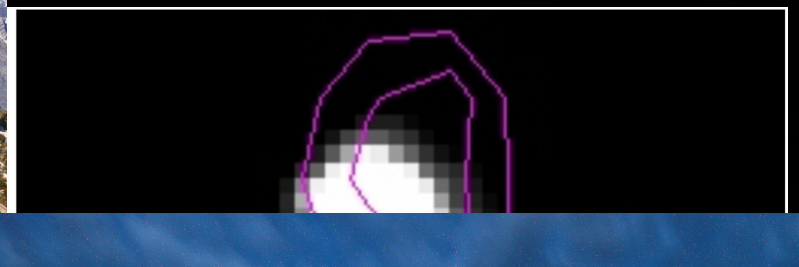
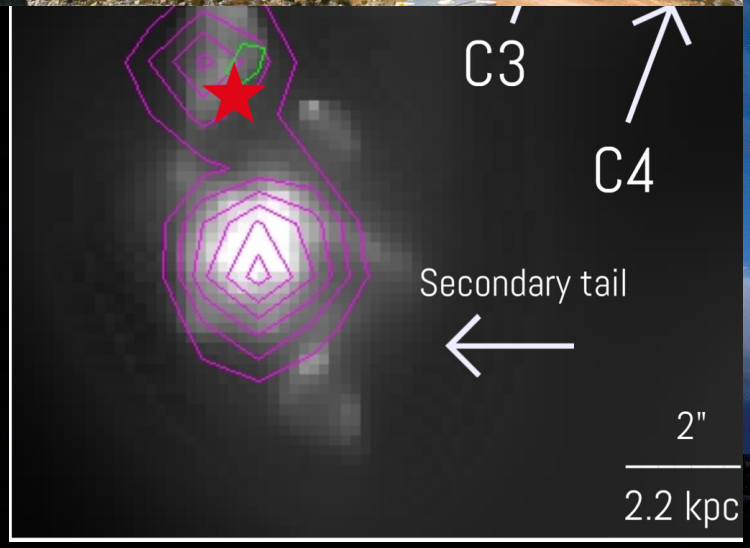
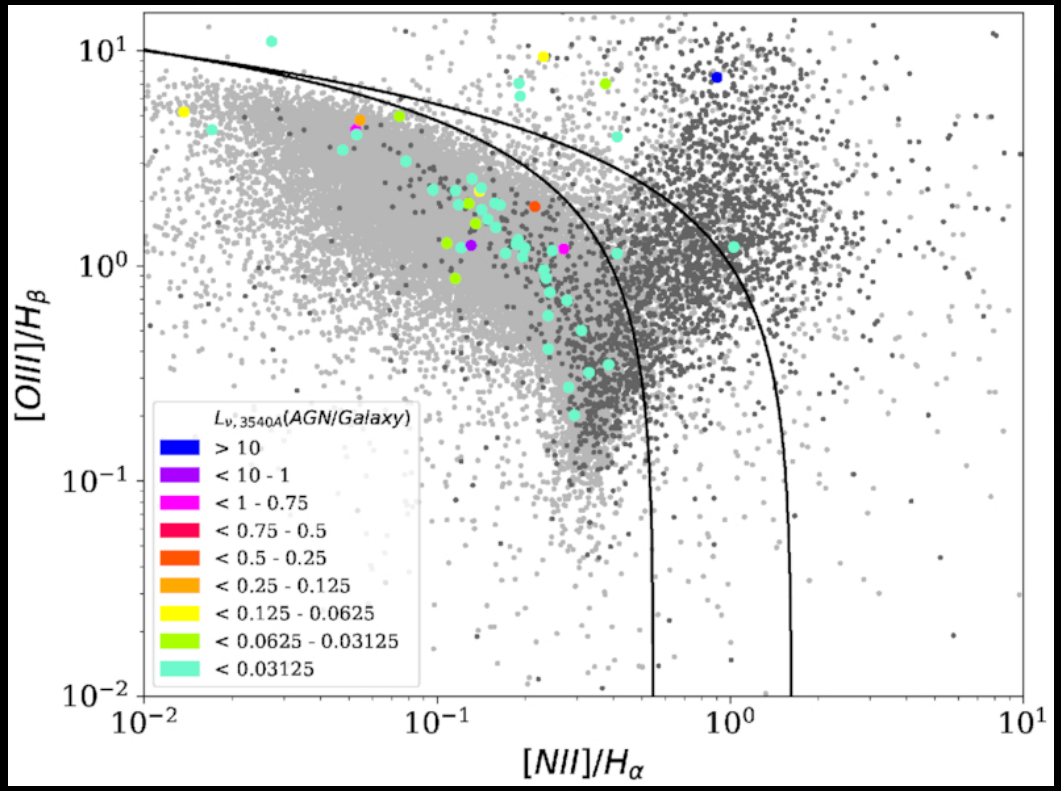




Detectability of AGN in Dwarf Galaxies

- BPT diagrams inaccurate (Birchall+2020)



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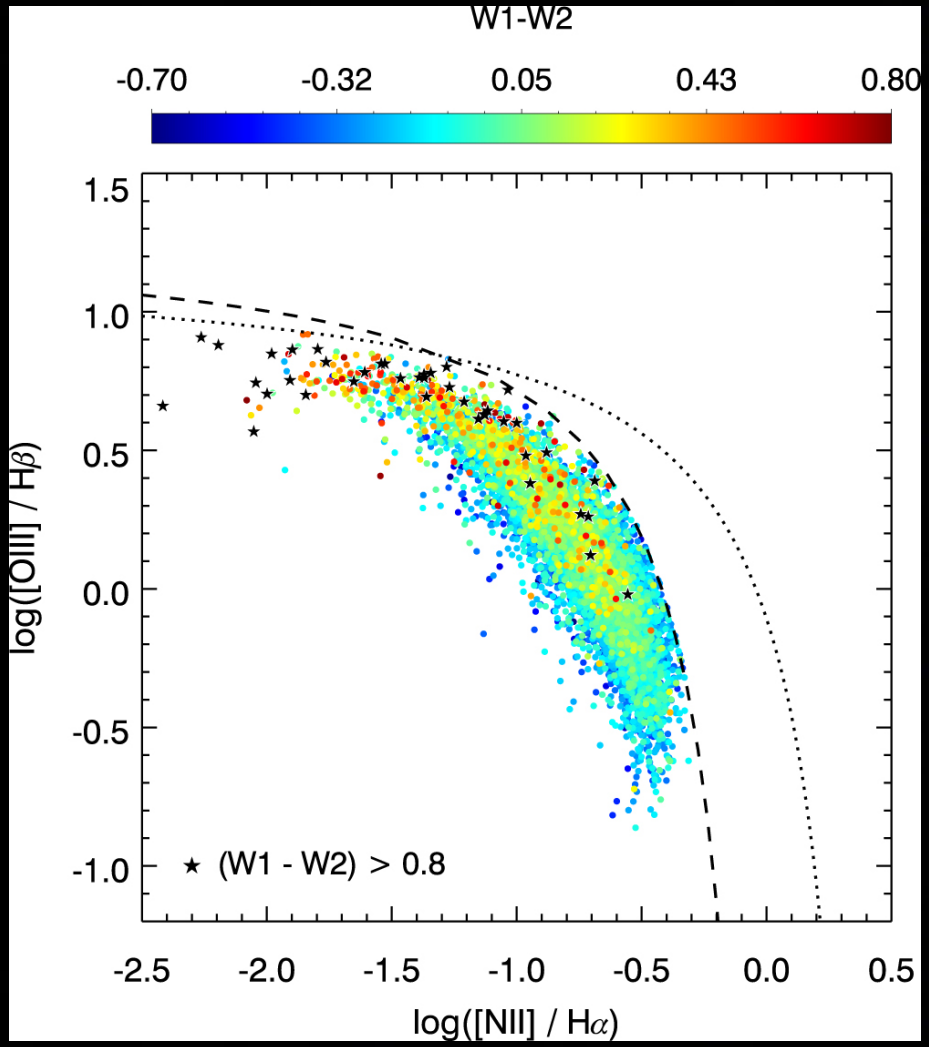
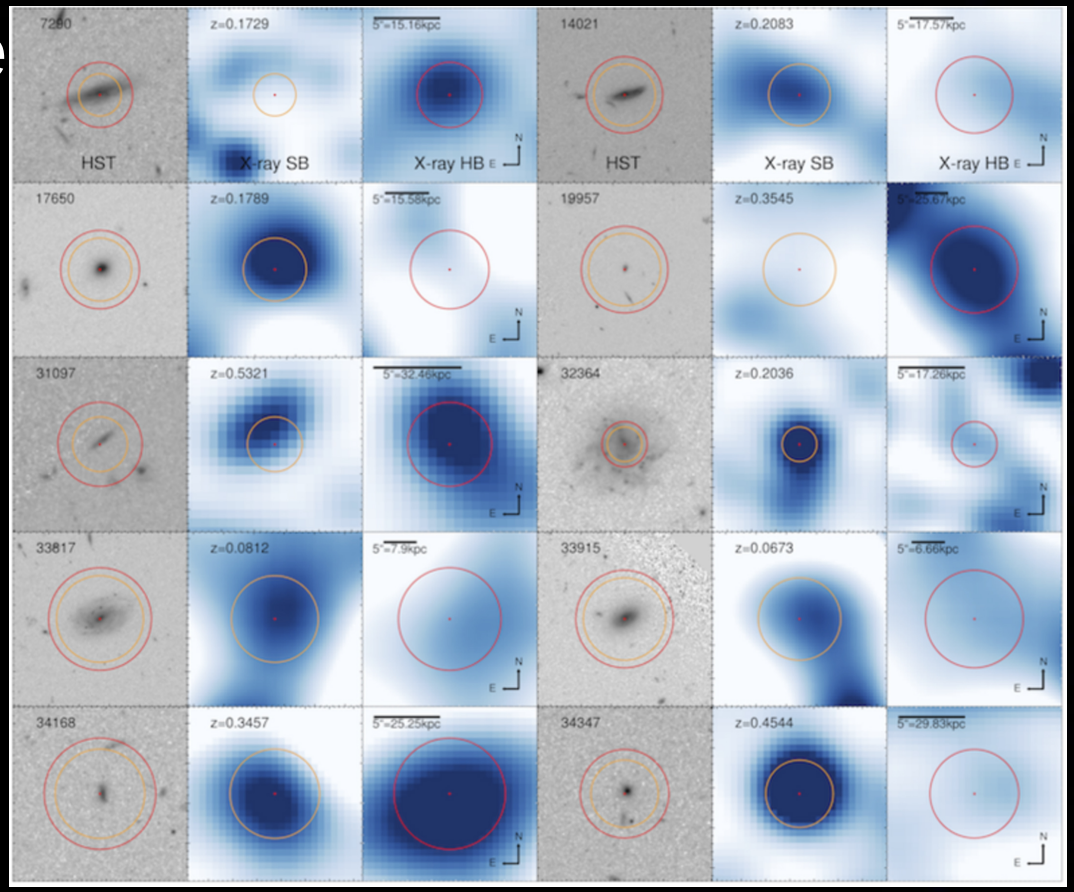


Detectability of AGN in Dwarf Galaxies

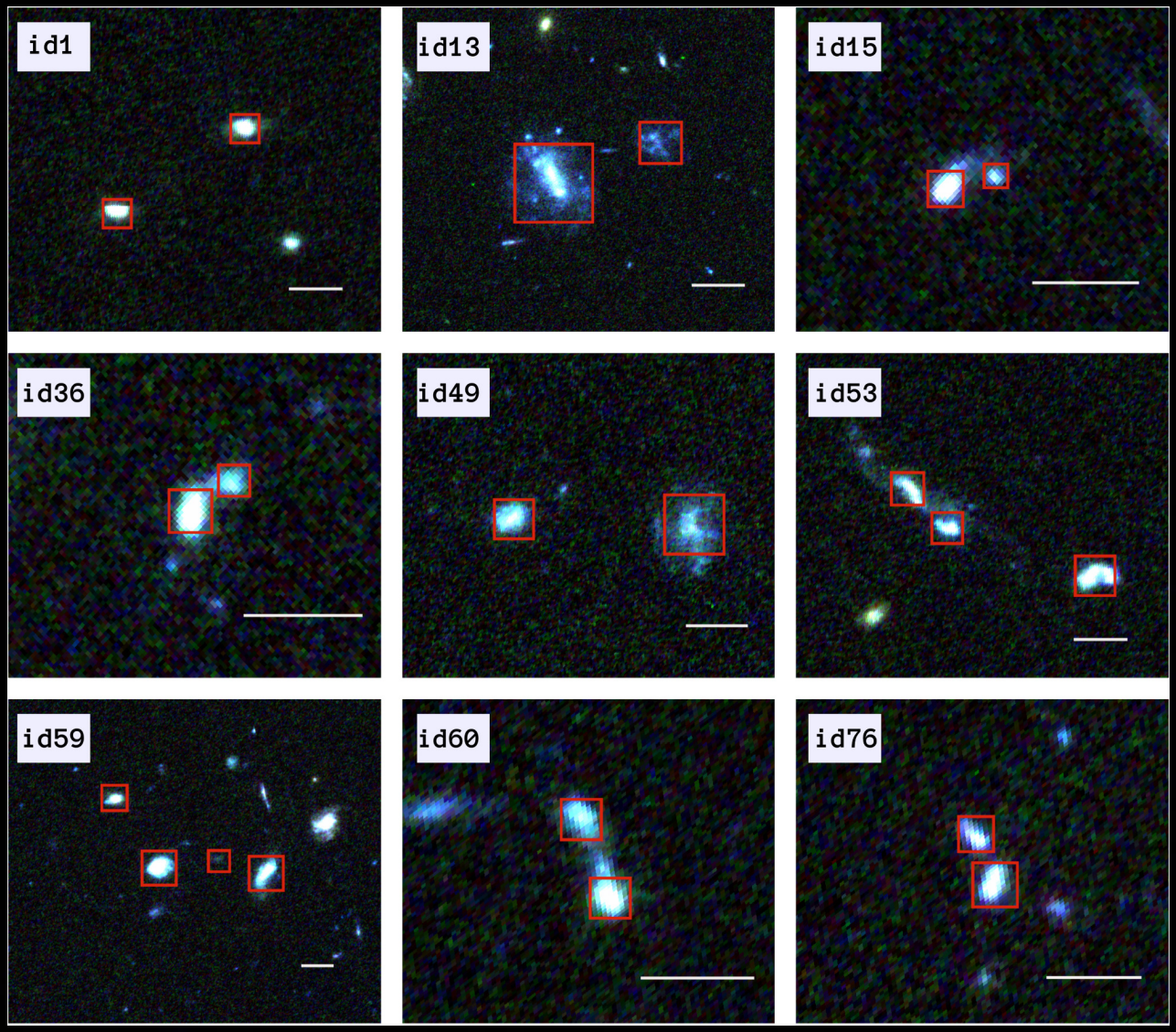
- BPT diagrams inaccurate (Birchall+2020)
- Mid-infrared colors confuse with star formation (Hainline+2016)
- X-ray most promissing but many problems (Pardo+2016, Lemons+ 2018, Mezcua+2020)



Pardo+2016

A New Sample of Dwarf Systems

- CANDELS fields
- 3D-HST survey
- 82 dwarf pairs
- 11 dwarf groups



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- GOODS-S, t_{exp}=7Msec

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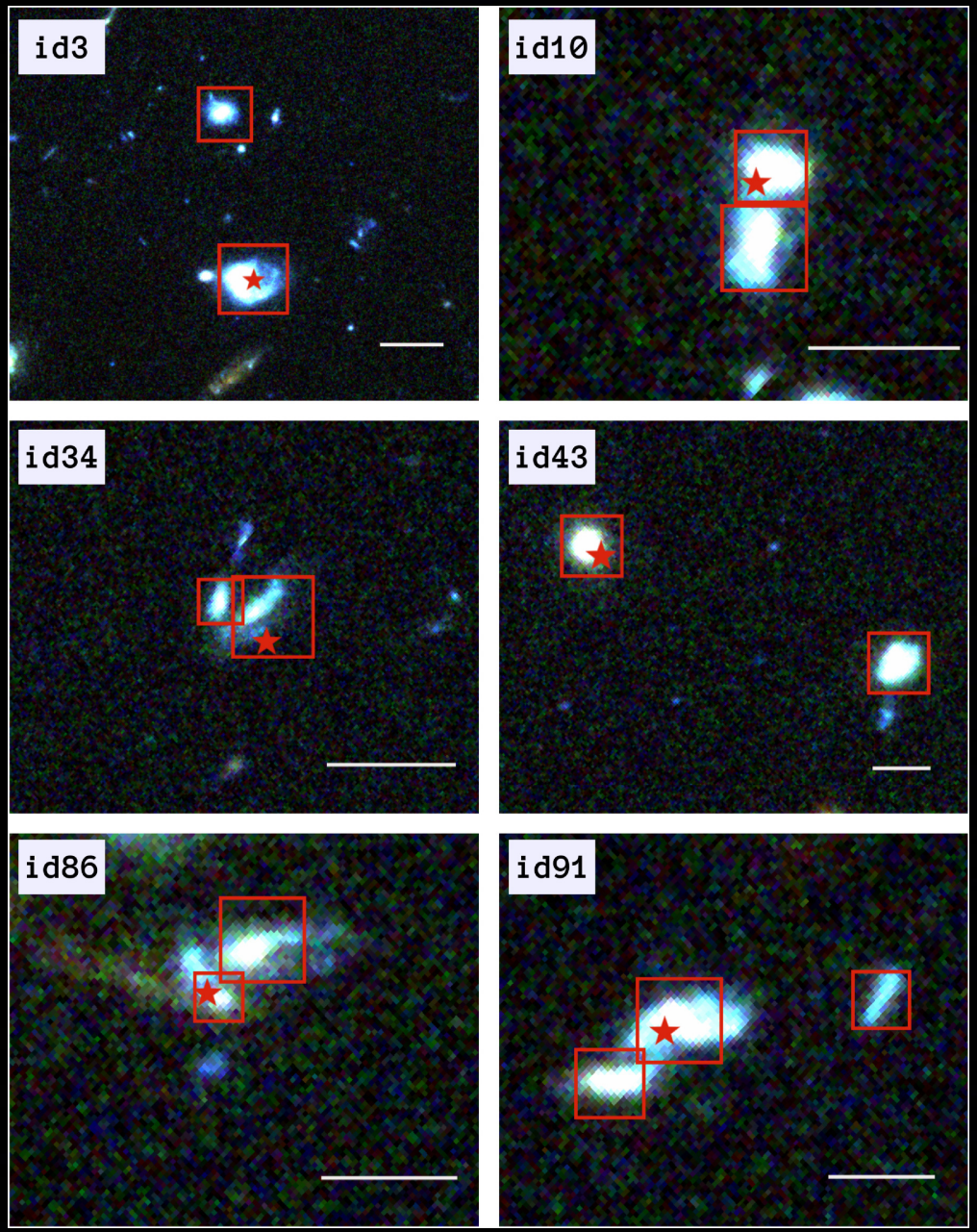
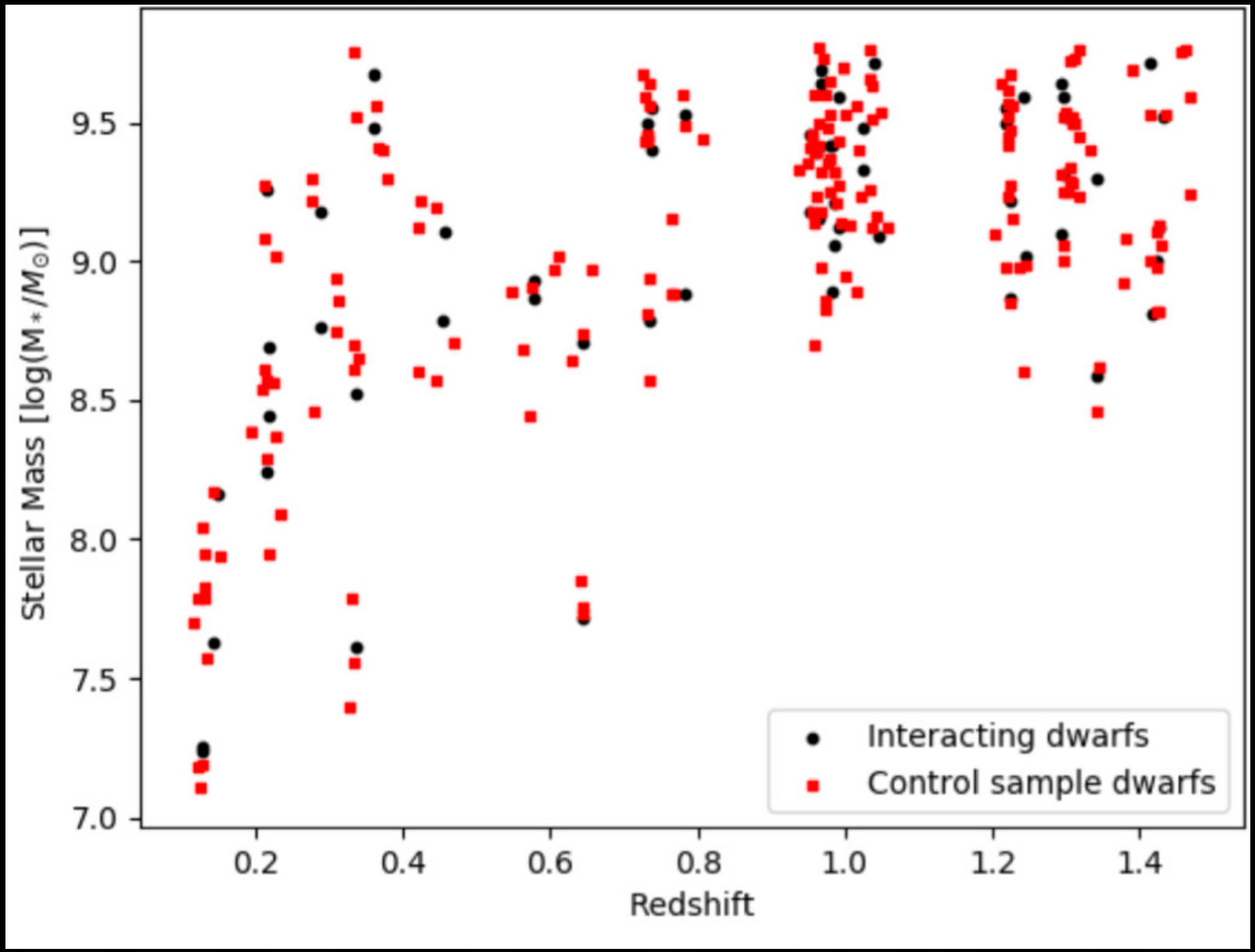
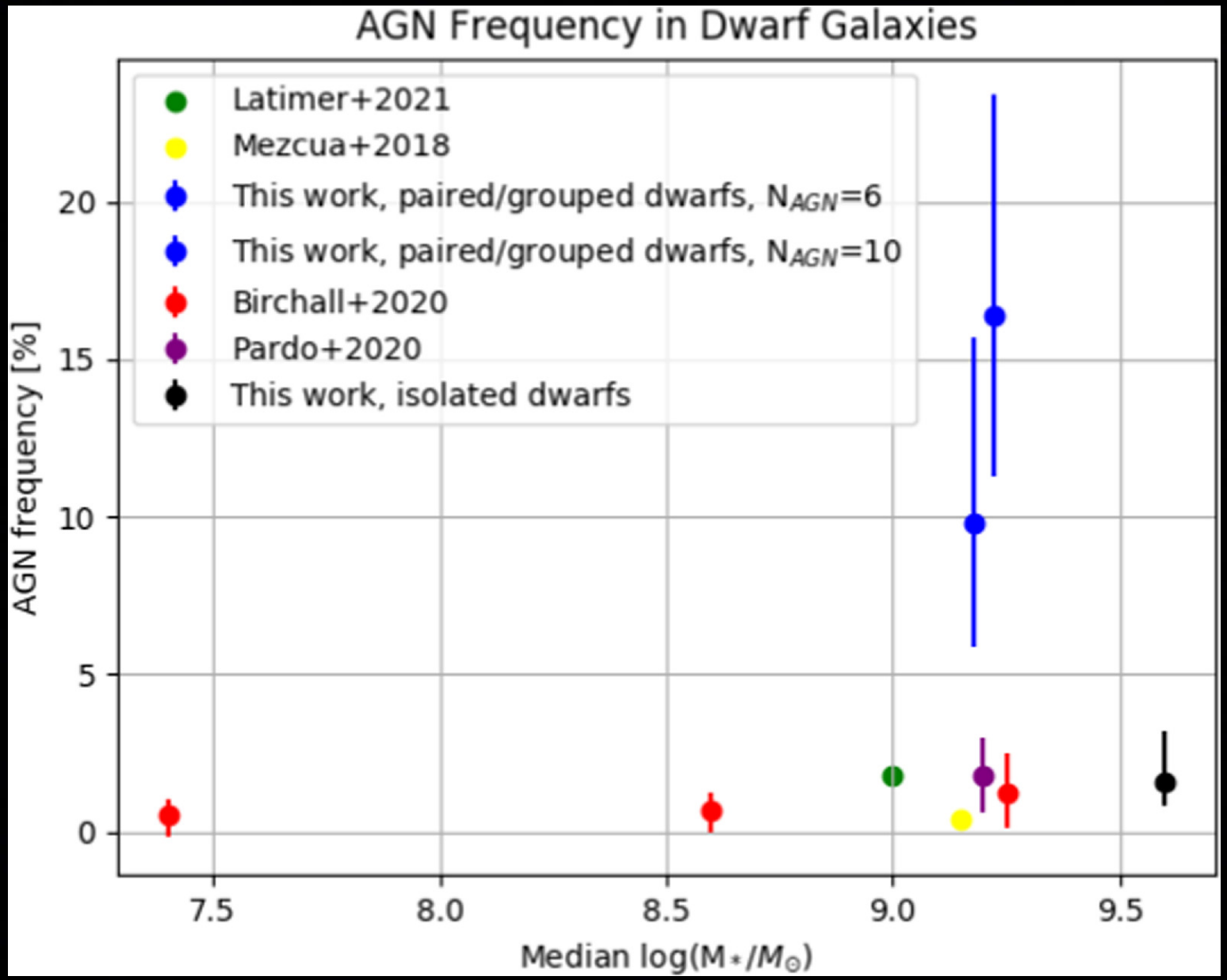
- Importance of LLAGN
- Corrected for non-AGN contributions
- 6-10 new AGN
- 10-15% frequency



Control Sample

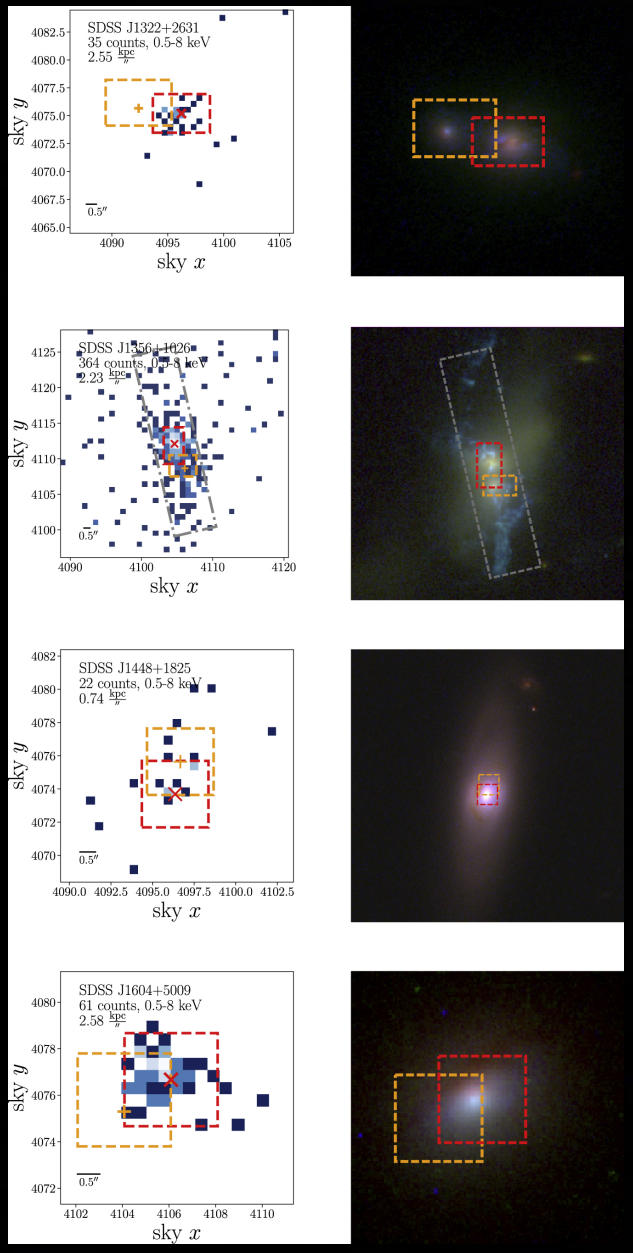


AGN in Interacting vs. Isolated Dwarfs



Current Work

- Bayesian Analysis of AGNs in X-rays-BAYMAX (Foord+2020)



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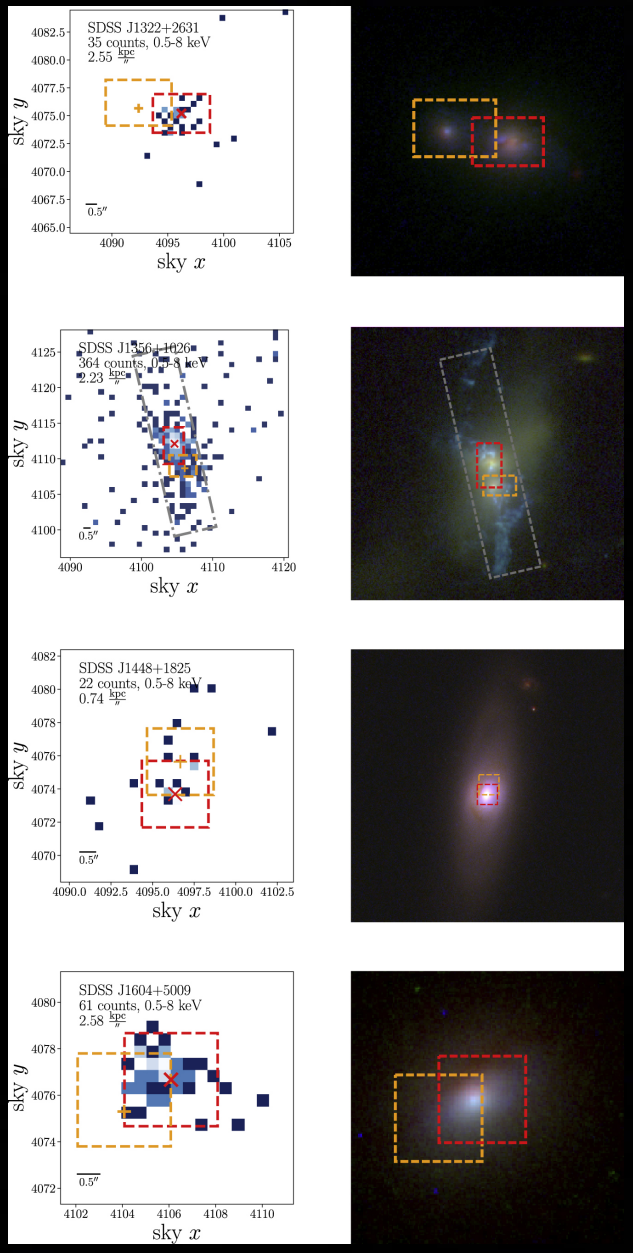
- SED fitting with CIGALE – a step forward towards black hole masses



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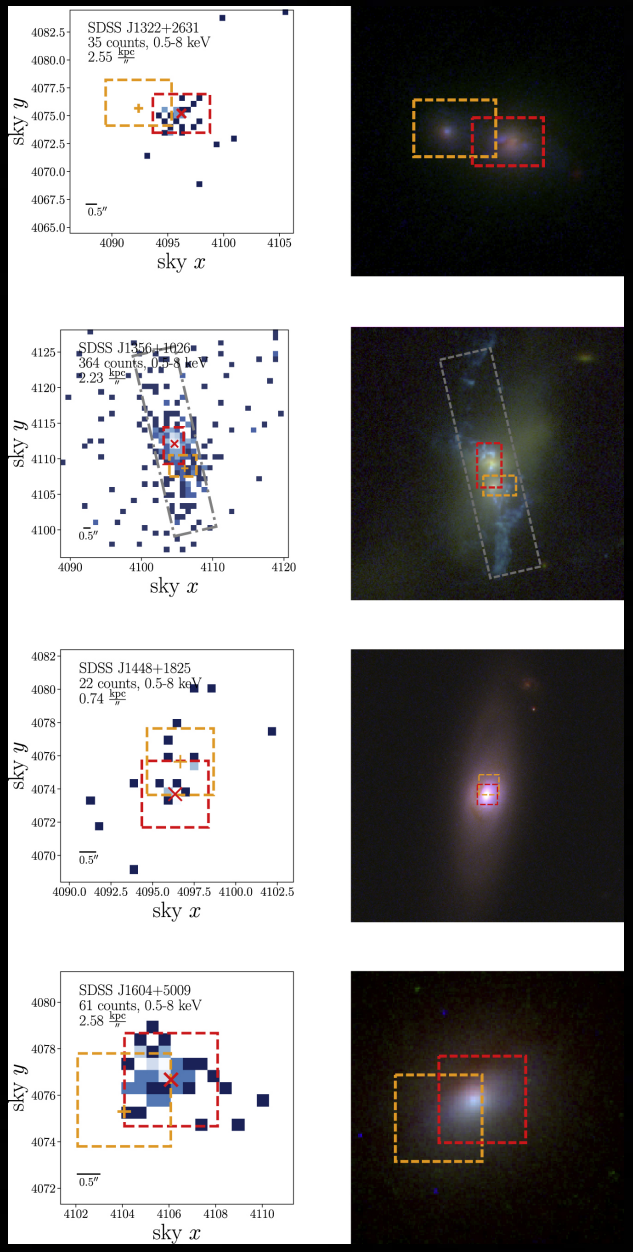

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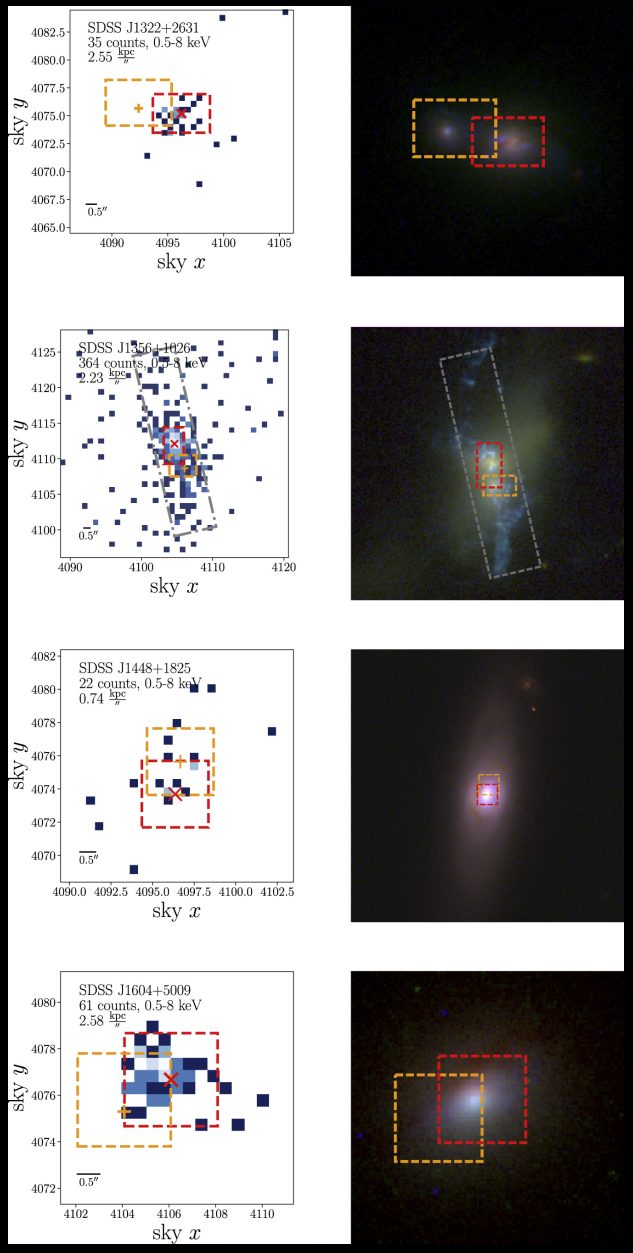
- Stacking analysis
- Minor mergers – investigating rapid black hole growth mechanisms



Foord+(2020)

THANK YOU!

Demographics of Dwarf Systems