And now from the top:
A decade of evolution in our understanding of the super-Earth/Jupiter connection

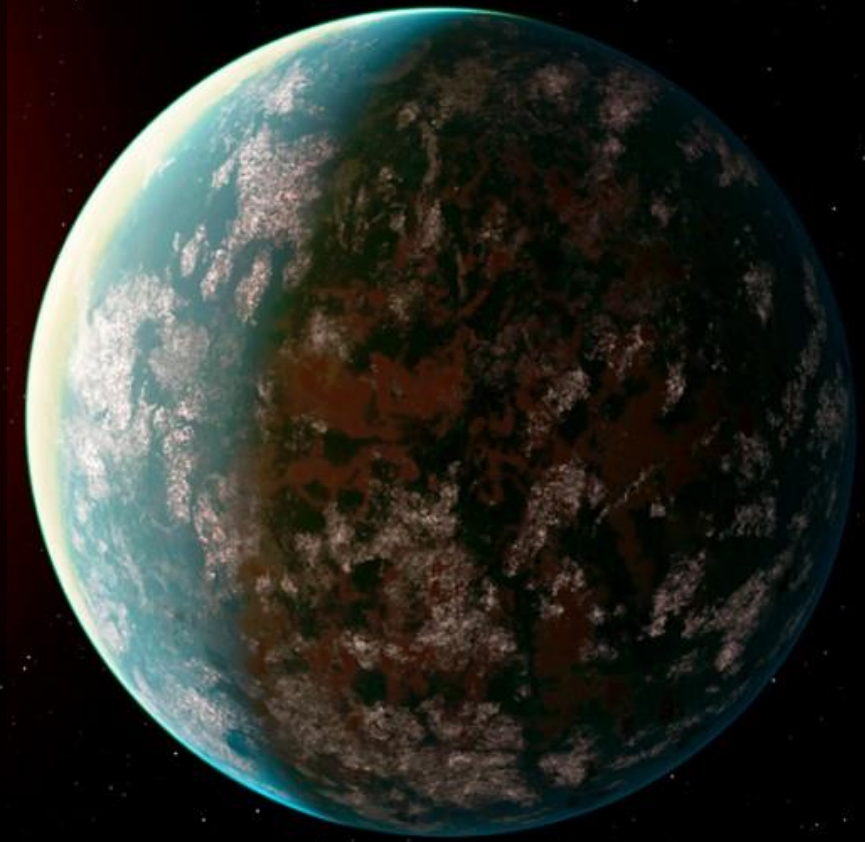
Marta L. Bryan
Assistant Professor
Penn State University

On the Shoulders of Giants Workshop

Thursday March 26, 2026

2018/2019

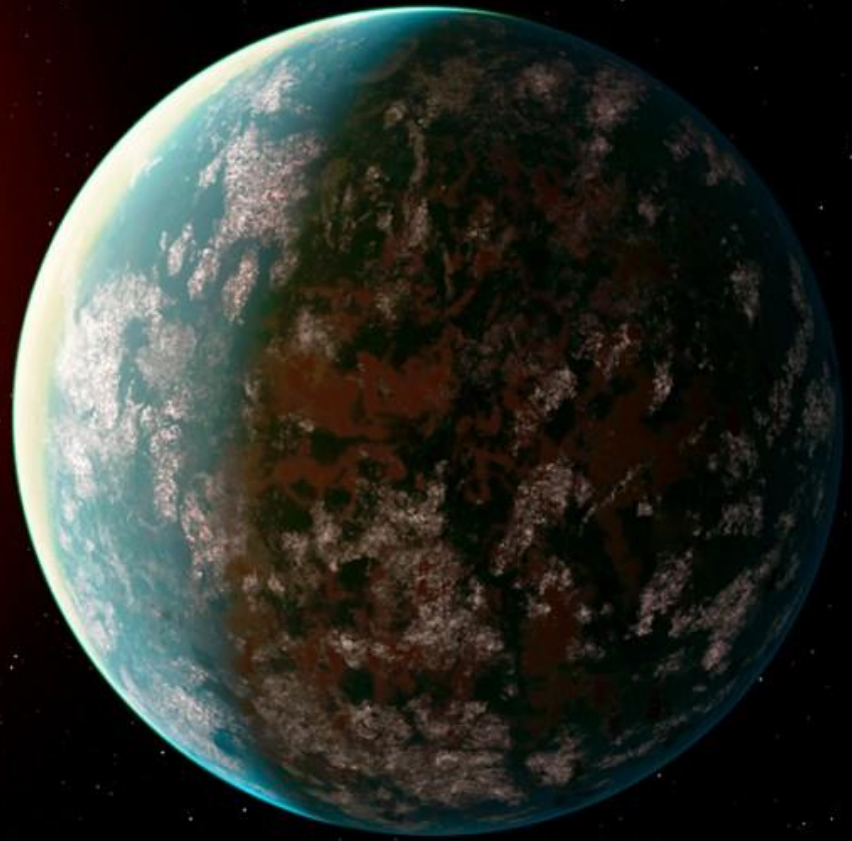
Are outer gas giants common or rare in super-Earth systems?



2018/2019

Are outer gas giants common or rare in super-Earth systems?

Do gas giants help or hurt super-Earth formation?



2018/2019

Are outer gas giants common or rare in super-Earth systems?

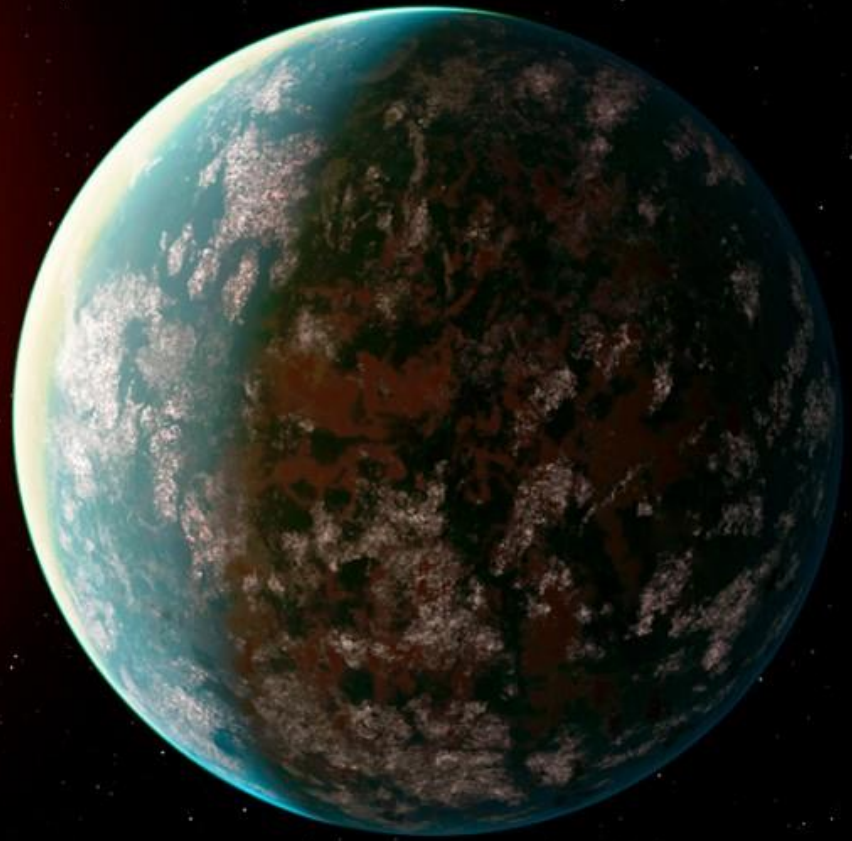
P(LPG|SE)

Bryan+2019

60 SE systems

P(LPG)

Wittenmyer+2016

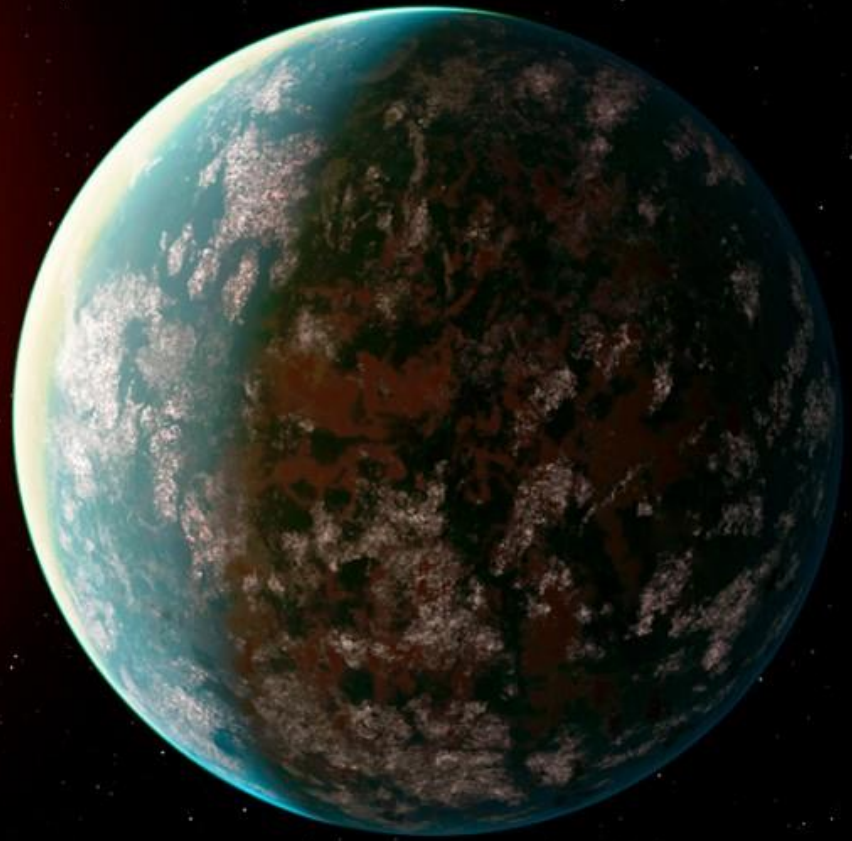


2018/2019

1/3 stars host a super-Earth

1/10 stars host a Jupiter analog

No correlation → 1/10 super-Earth systems host a Jupiter analog



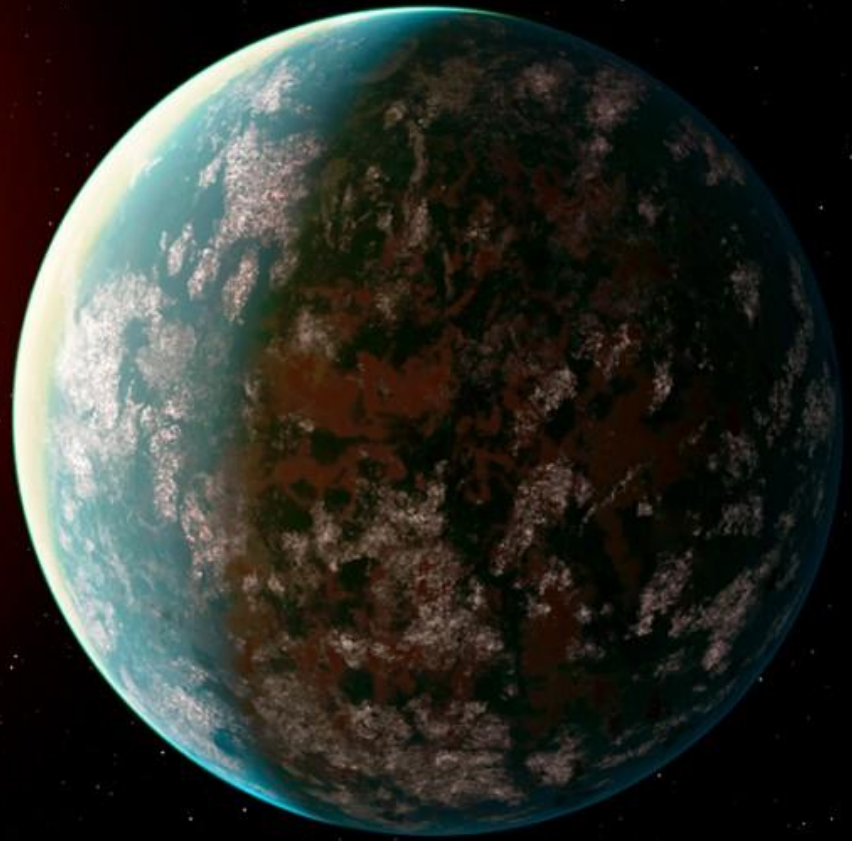
2018/2019

1/3 stars host a super-Earth

1/10 stars host a Jupiter analog

No correlation → 1/10 super-Earth systems host a Jupiter analog

What we found → 4/10 super-Earth systems host a Jupiter analog

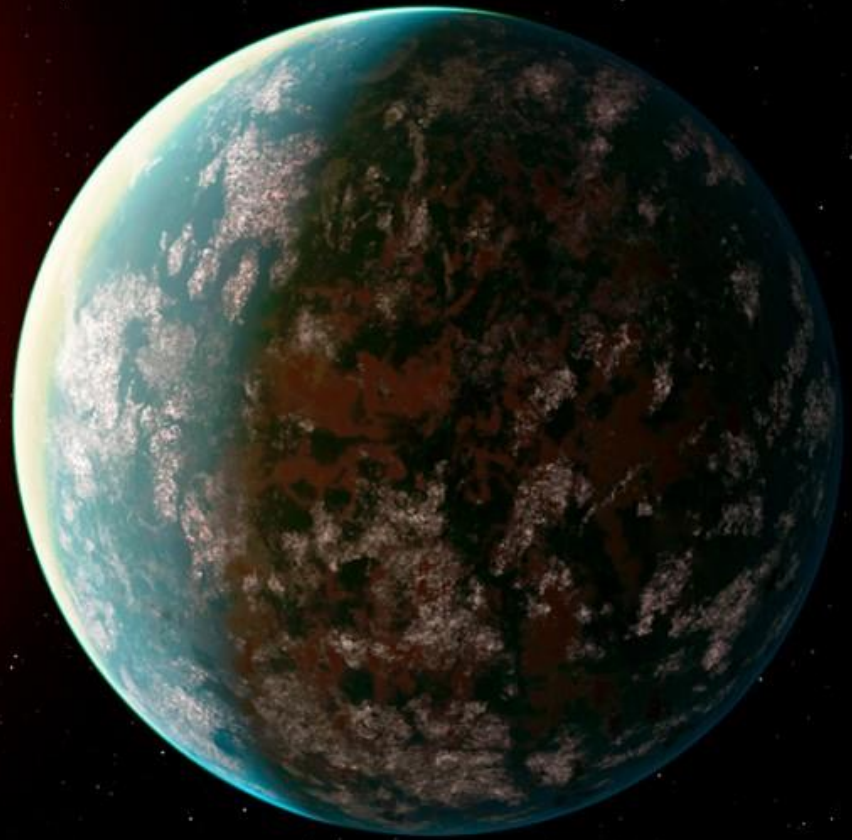


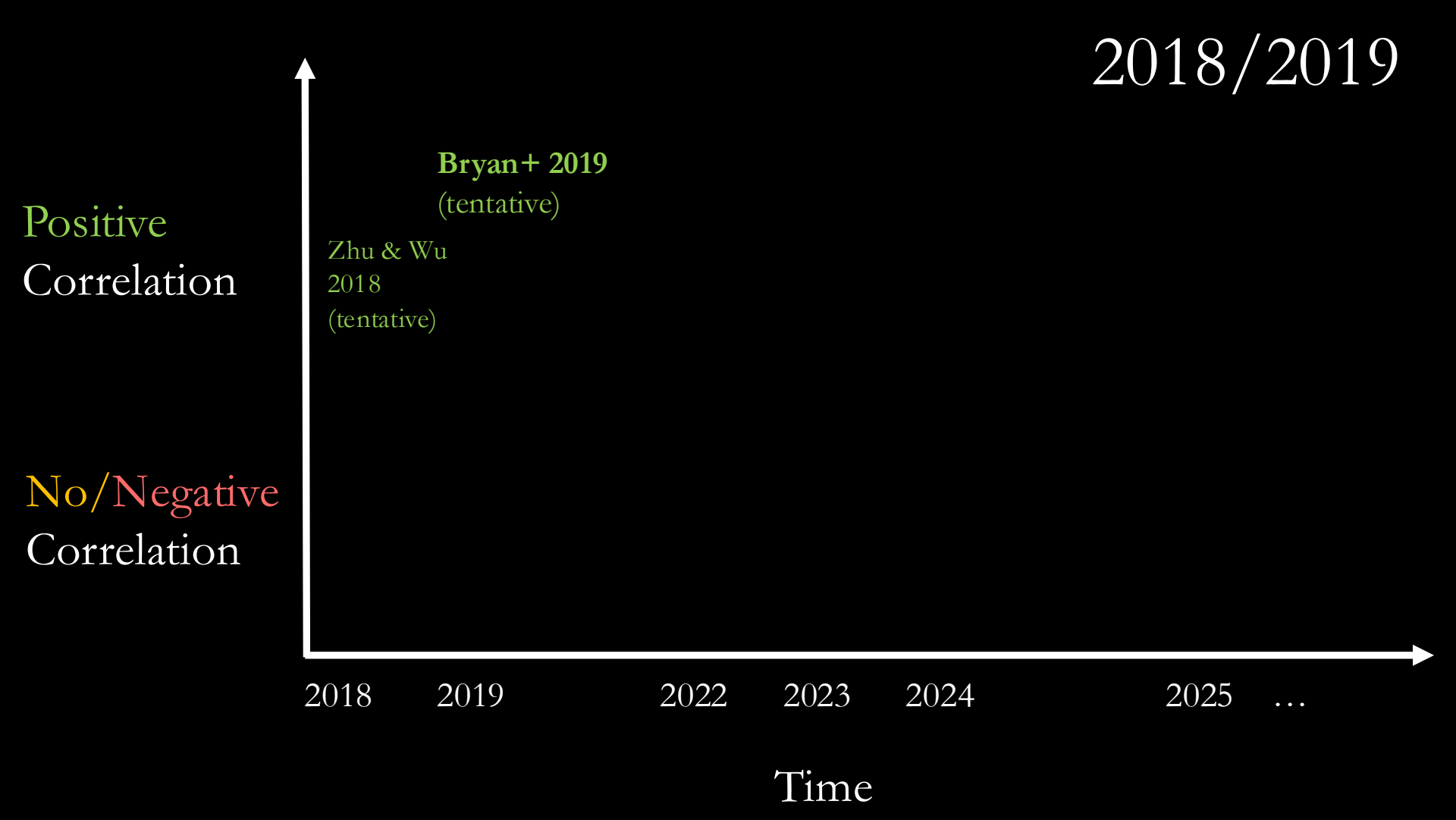
2018/2019

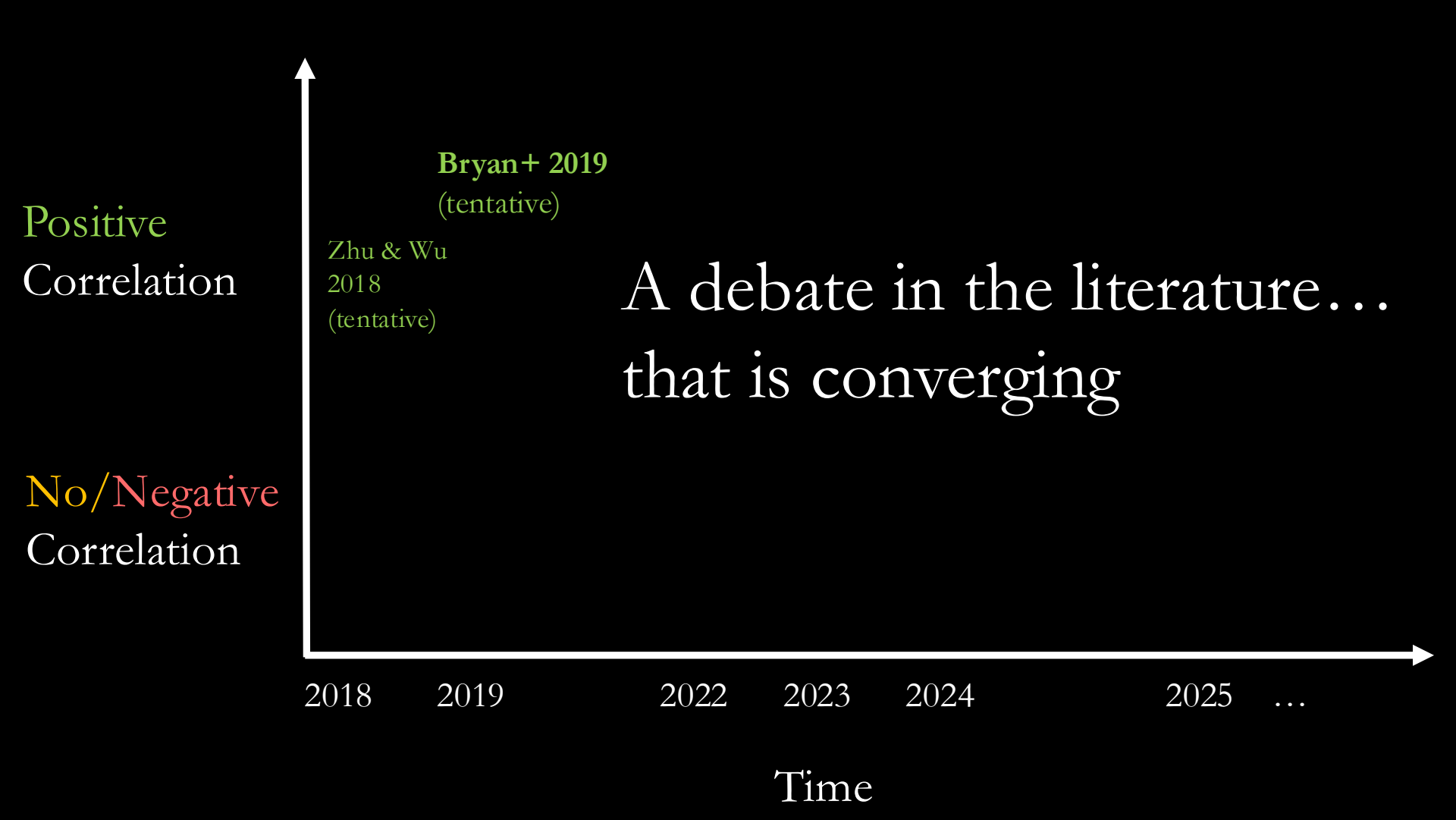
Are outer gas giants common or rare in super-Earth systems?

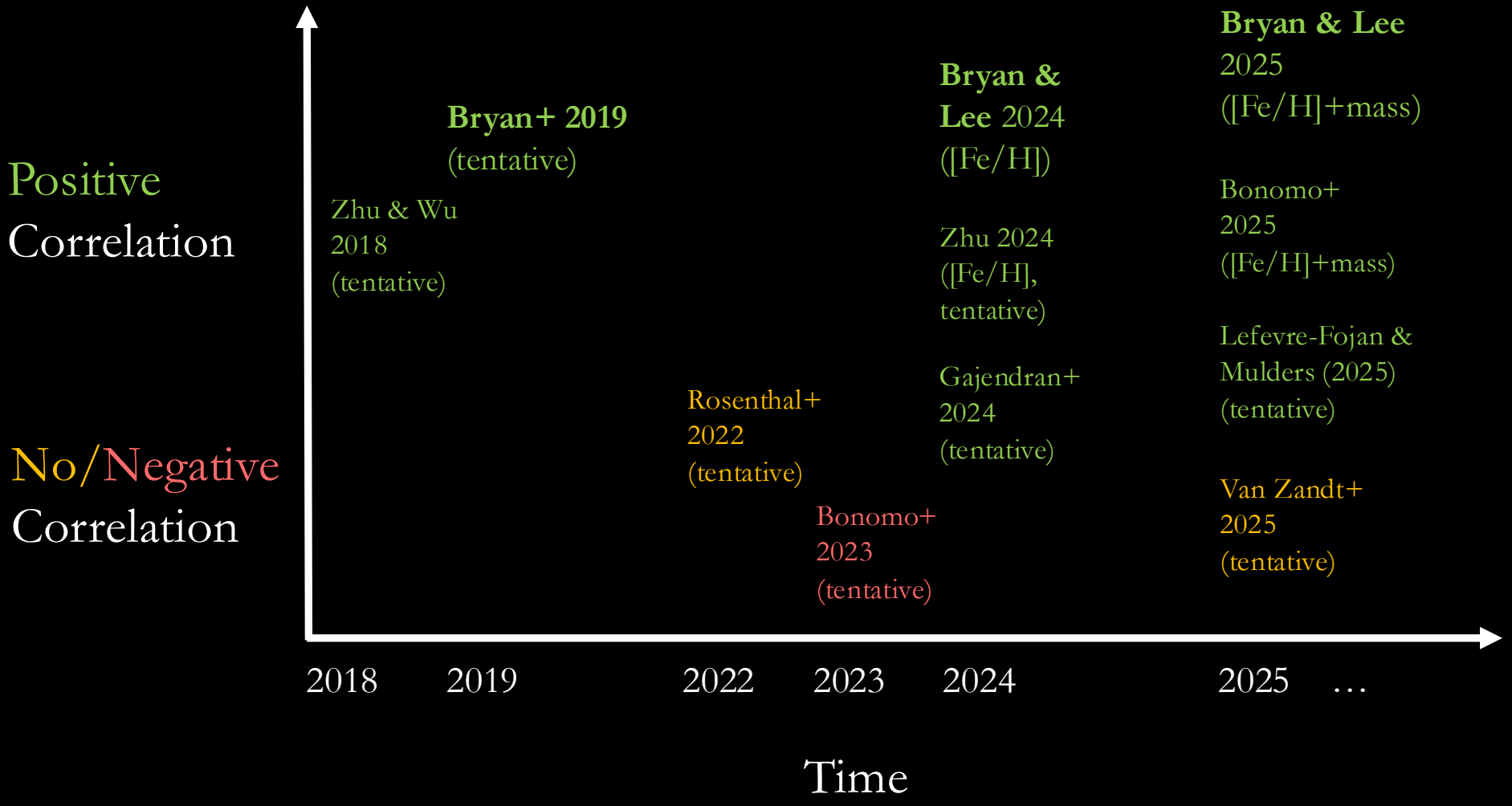
↓

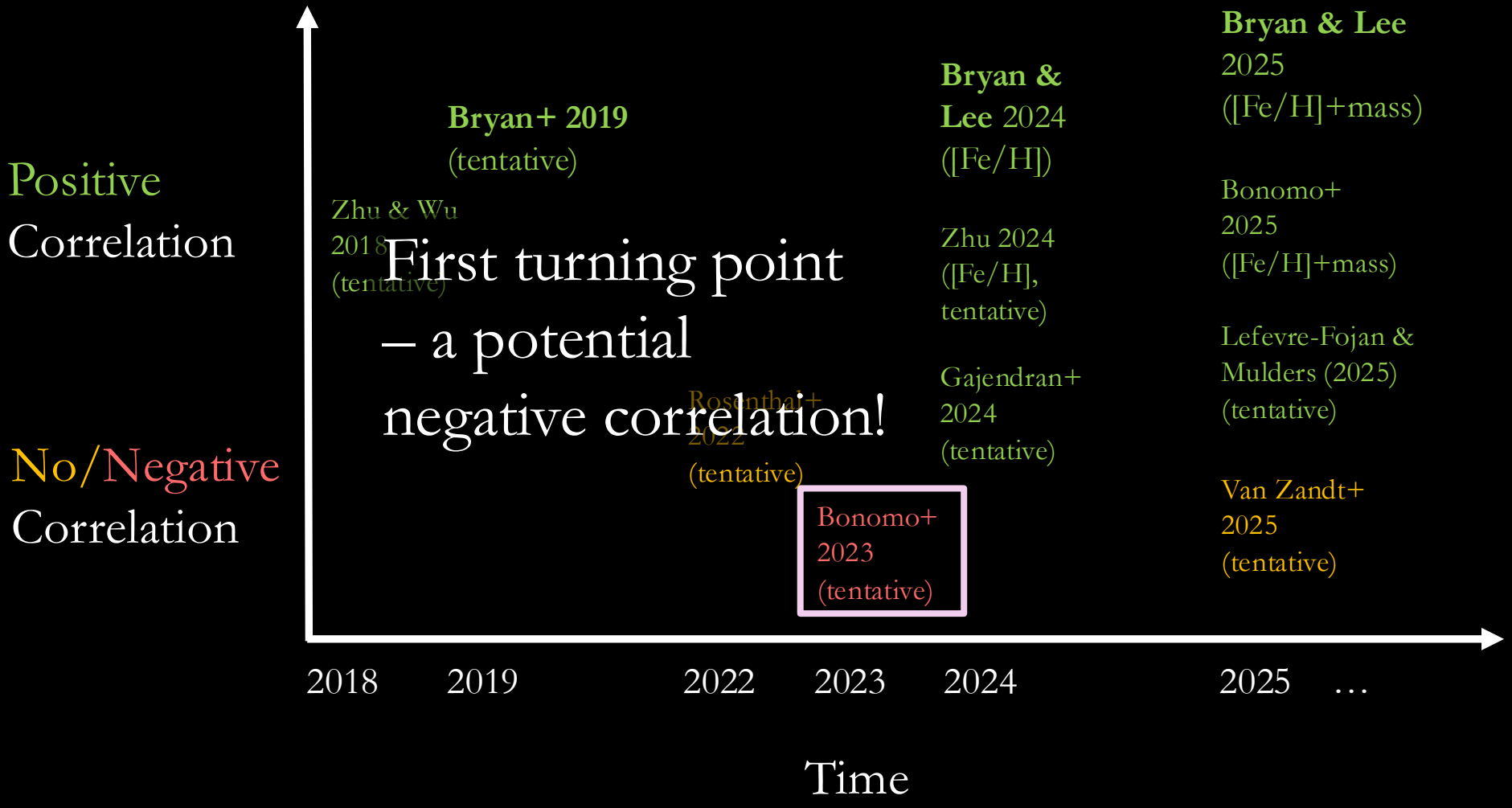
Tentative positive correlation




2018/2019
Positive
Correlation
No/Negative
Correlation
Bryan+ 2019
(tentative)
Zhu & Wu
2018
(tentative)
2018
2019
2022
2023
2024
2025
…
Time


Positive
Correlation
No/Negative
Correlation
Bryan+ 2019
(tentative)
Zhu & Wu
2018
(tentative)
A debate in the literature…
that is converging
2018
2019
2022
2023
2024
2025
…
Time


Positive Correlation
No/Negative Correlation
Zhu & Wu 2018 (tentative)
Bryan+ 2019 (tentative)
Rosenthal+ 2022 (tentative)
Bonomo+ 2023 (tentative)
Bryan & Lee 2024 ([Fe/H])
Zhu 2024 ([Fe/H], tentative)
Gajendran+ 2024 (tentative)
Bryan & Lee 2025 ([Fe/H]+mass)
Bonomo+ 2025 ([Fe/H]+mass)
Lefevre-Fojan & Mulders (2025) (tentative)
Van Zandt+ 2025 (tentative)
2018
2019
2022
2023
2024
2025
…
Time


Positive Correlation
No/Negative Correlation
Zhu & Wu 2018 (tentative)
Bryan+ 2019 (tentative)
First turning point – a potential negative correlation!
Rosenthal+ 2022 (tentative)
Bonomo+ 2023 (tentative)
Bryan & Lee 2024 ([Fe/H])
Zhu 2024 ([Fe/H], tentative)
Gajendran+ 2024 (tentative)
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2018
2019
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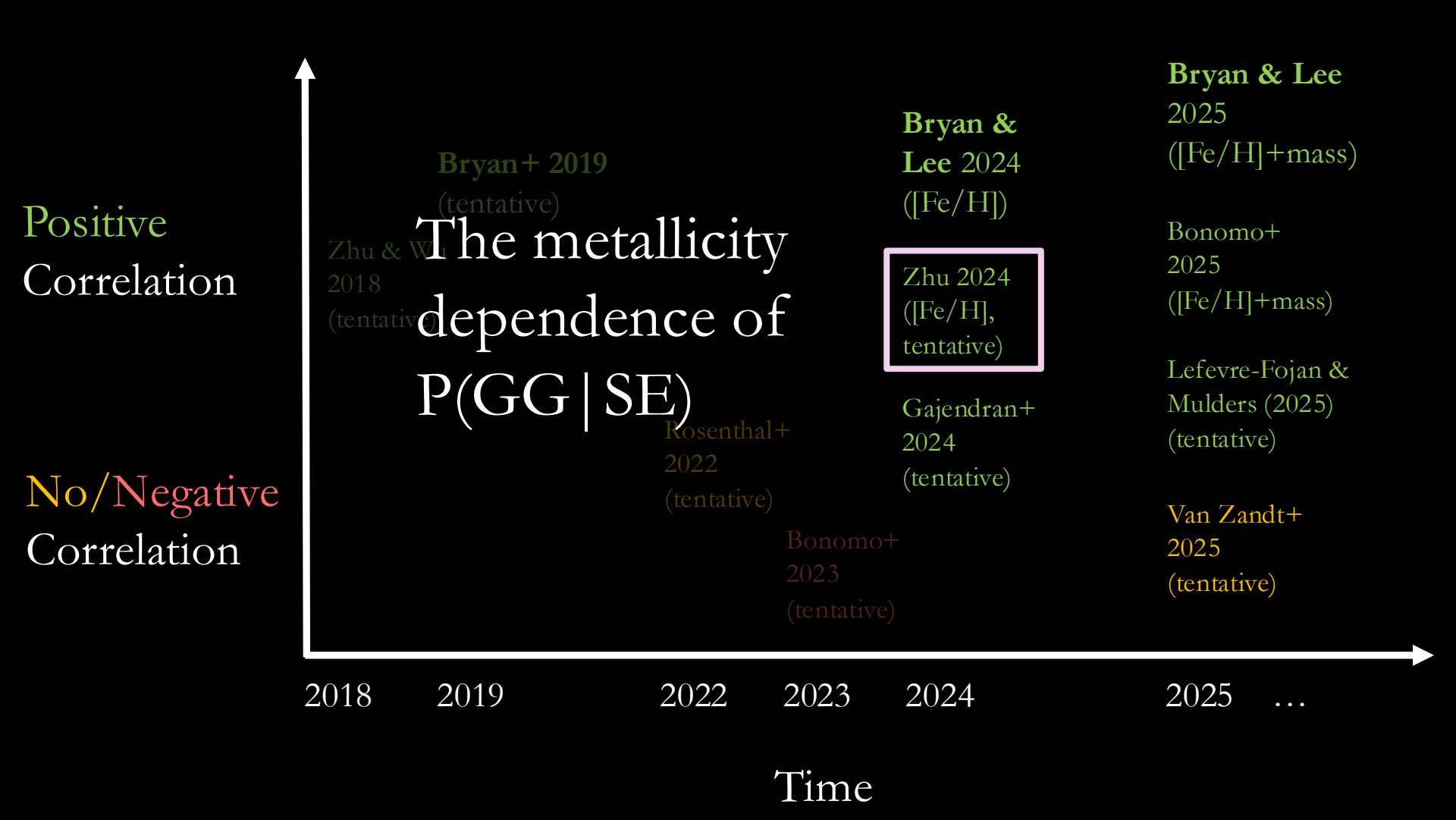
2025
…
Time


Positive Correlation
No/Negative Correlation
The metallicity dependence of P(GG|SE)
Zhu & Wu 2018 (tentative)
Bryan+ 2019 (tentative)
Rosenthal+ 2022 (tentative)
Bonomo+ 2023 (tentative)
Bryan & Lee 2024 ([Fe/H])
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Gajendran+ 2024 (tentative)
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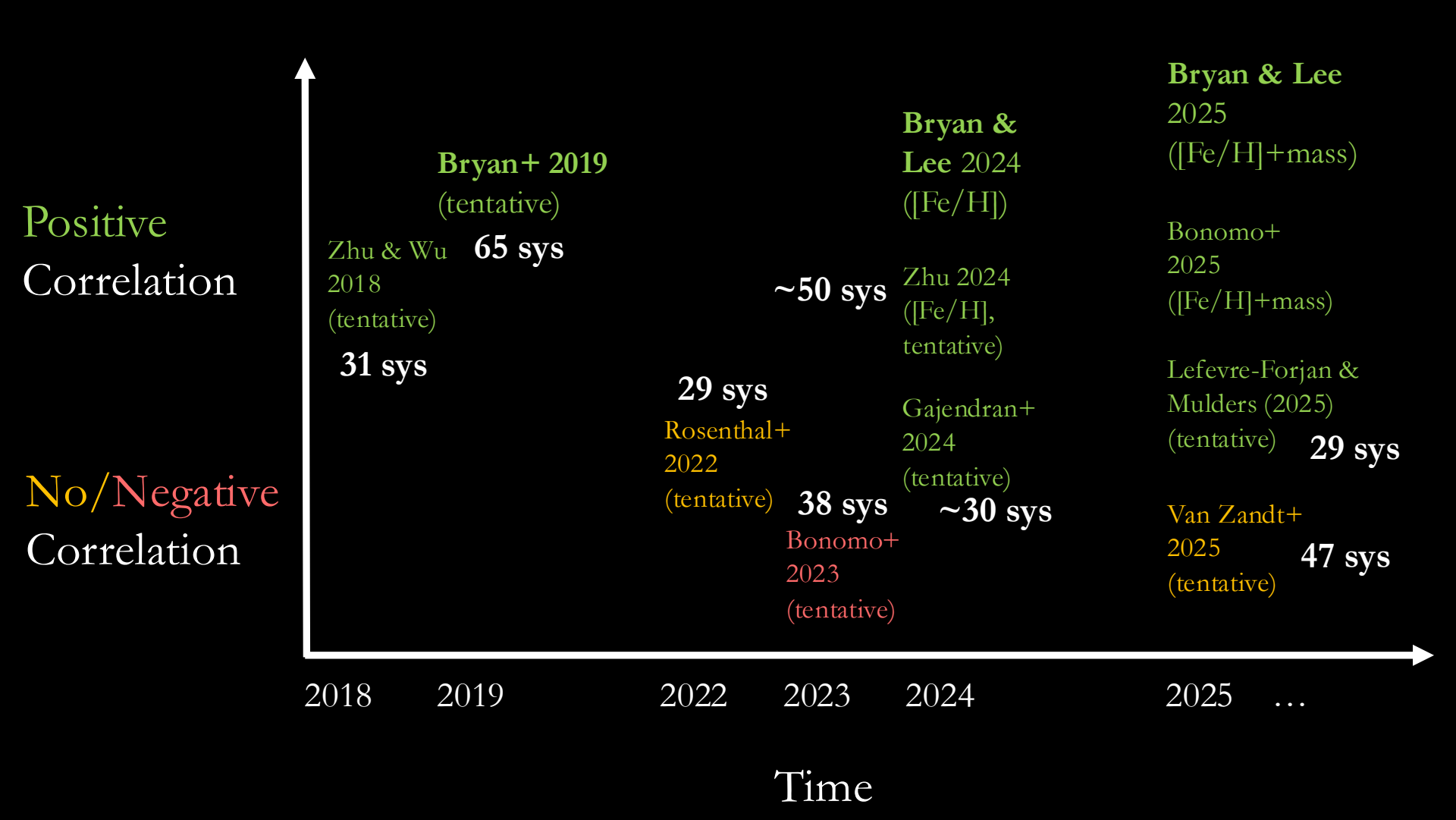
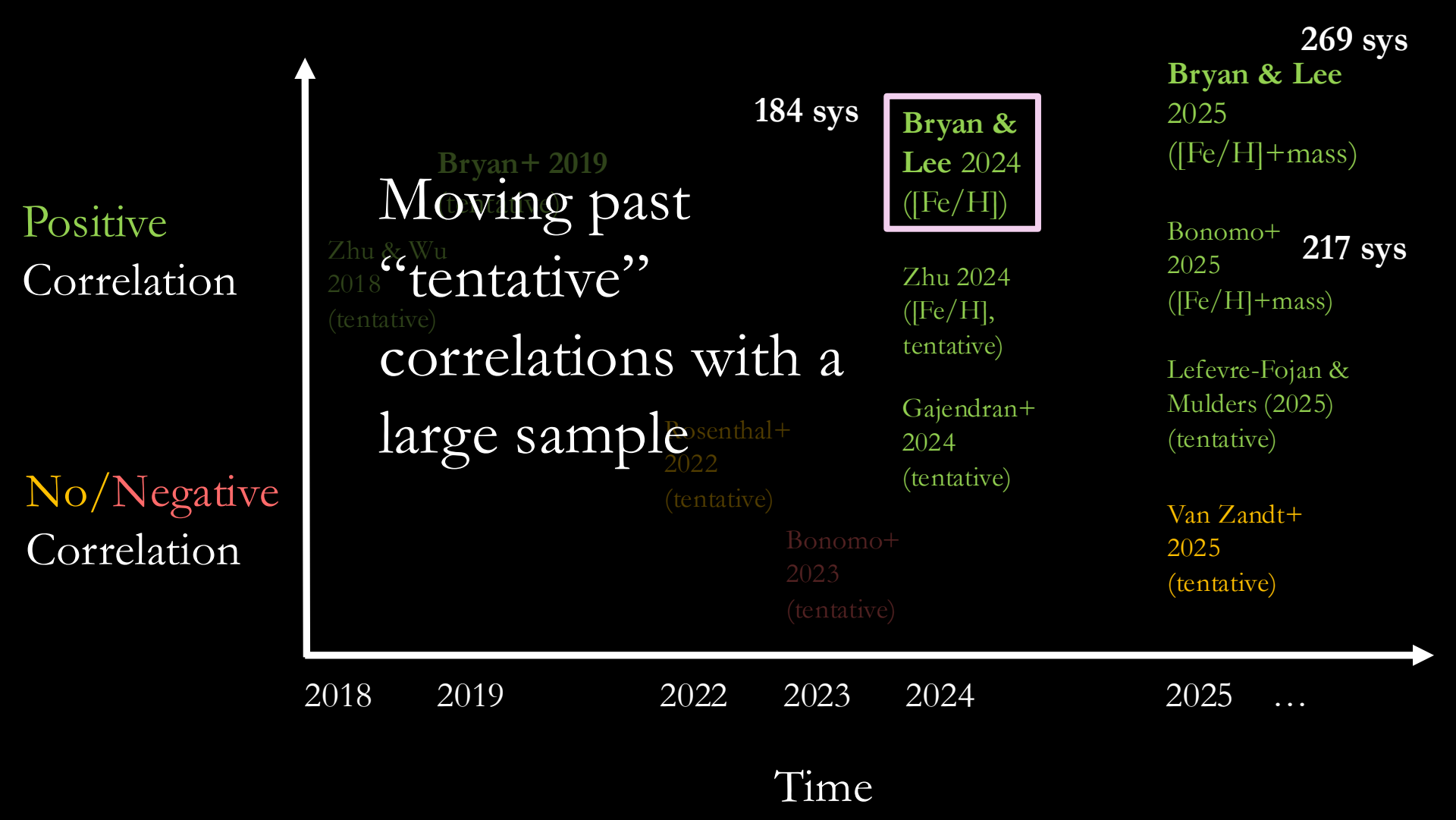
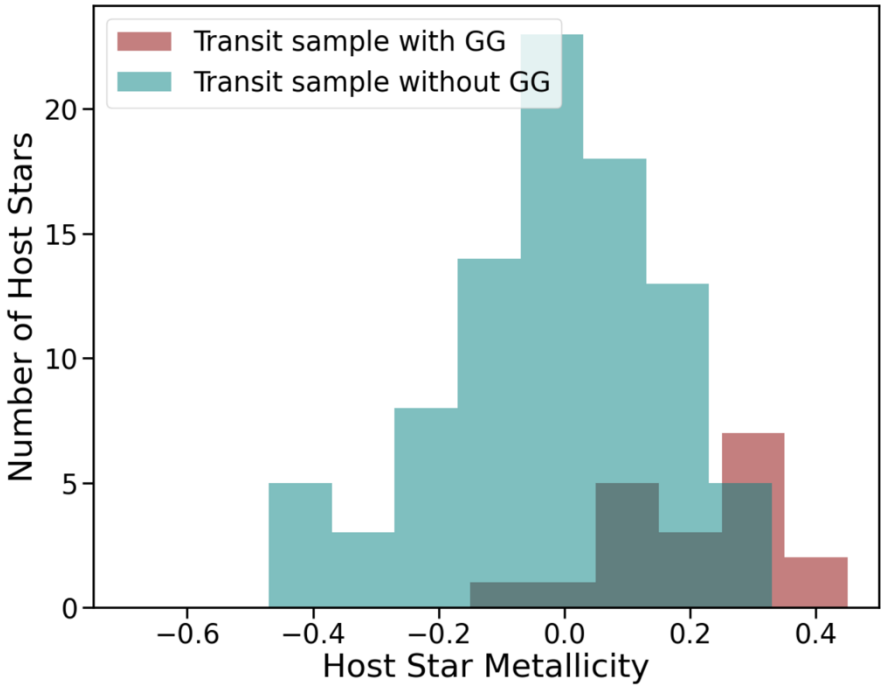
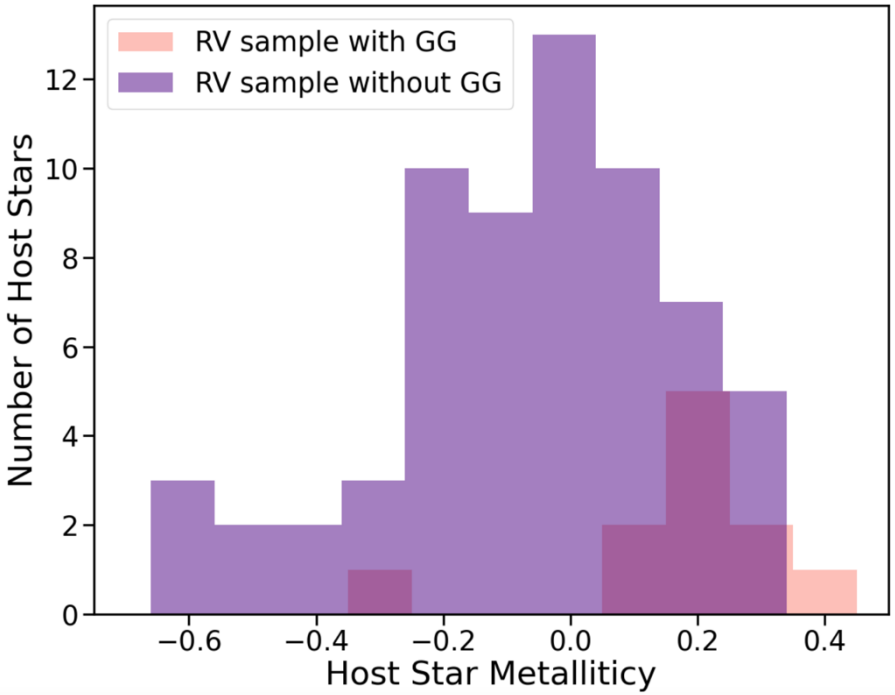
Bonomo+ 2025 ([Fe/H]+mass)
Lefevre-Fojan & Mulders (2025) (tentative)
Van Zandt+ 2025 (tentative)
2018
2019
2022
2023
2024
2025
…
Time


Positive Correlation
No/Negative Correlation
Zhu & Wu 2018 (tentative)
31 sys
Bryan+ 2019 (tentative)
65 sys
29 sys
Rosenthal+ 2022 (tentative)
~50 sys
38 sys
Bonomo+ 2023 (tentative)
Bryan & Lee 2024 ([Fe/H])
Zhu 2024 ([Fe/H], tentative)
Gajendran+ 2024 (tentative)
~30 sys
Bryan & Lee 2025 ([Fe/H]+mass)
Bonomo+ 2025 ([Fe/H]+mass)
Lefevre-Forjan & Mulders (2025) (tentative)
29 sys
Van Zandt+ 2025 (tentative)
47 sys
2018
2019
2022
2023
2024
2025
…
Time


Positive Correlation
No/Negative Correlation
Moving past "tentative" correlations with a large sample
Zhu & Wu 2018 (tentative)
Bryan+ 2019 (tentative)
Rosenthal+ 2022 (tentative)
Bonomo+ 2023 (tentative)
184 sys
Bryan & Lee 2024 ([Fe/H])
Zhu 2024 ([Fe/H], tentative)
Gajendran+ 2024 (tentative)
269 sys
Bryan & Lee 2025 ([Fe/H]+mass)
Bonomo+ 2025 ([Fe/H]+mass)
217 sys
Lefevre-Fojan & Mulders (2025) (tentative)
Van Zandt+ 2025 (tentative)
2018
2019
2022
2023
2024
2025
…
Time

2024: New sample! 184 super-Earth systems





Bryan & Lee 2024

Maximizing sample sizes…

with a heterogeneous sample

Broad selection criteria – inner SE, public RV dataset, min time baseline/# datapoints

Maximizing sample sizes…

with a heterogeneous sample

Broad selection criteria – inner SE, public RV dataset, min time baseline/# datapoints

184 systems with a wide range of baselines, observing cadences, number of datapoints, measurement precision

Maximizing sample sizes…

with a heterogeneous sample

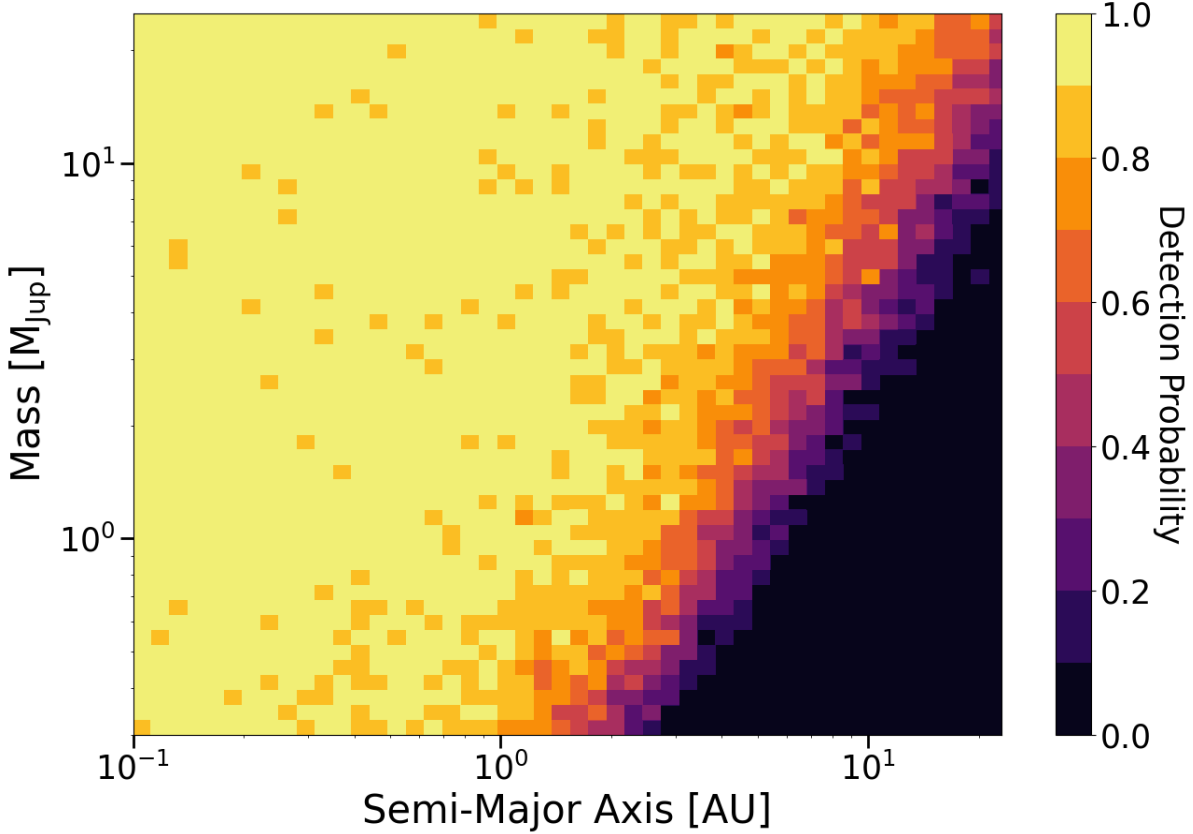
Broad selection criteria – inner SE, public RV dataset, min time baseline/# datapoints

184 systems with a wide range of baselines, observing cadences, number of datapoints, measurement precision

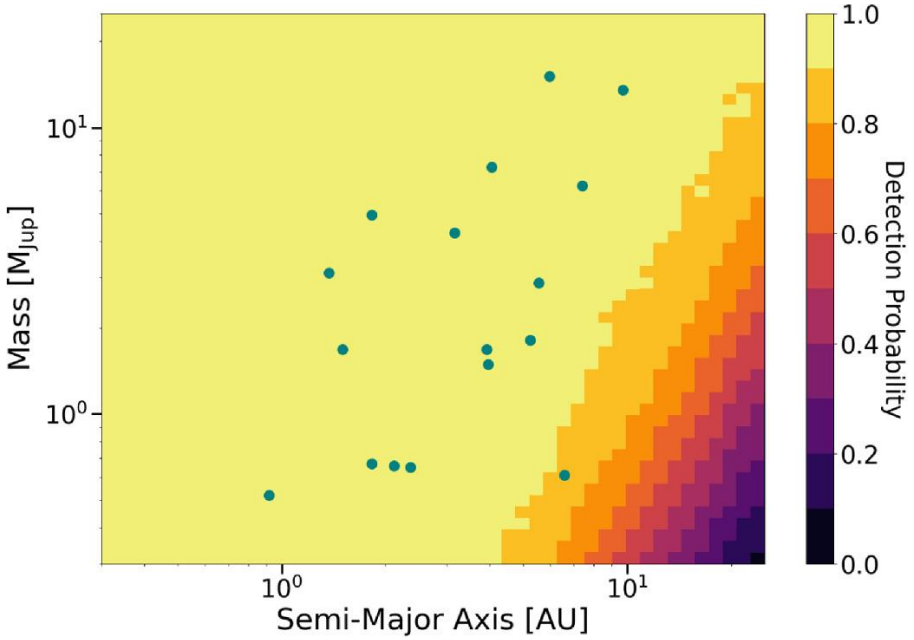
Individual system sensitivities to outer GG can vary significantly!

Correcting differences in sensitivity on a system-by-system basis

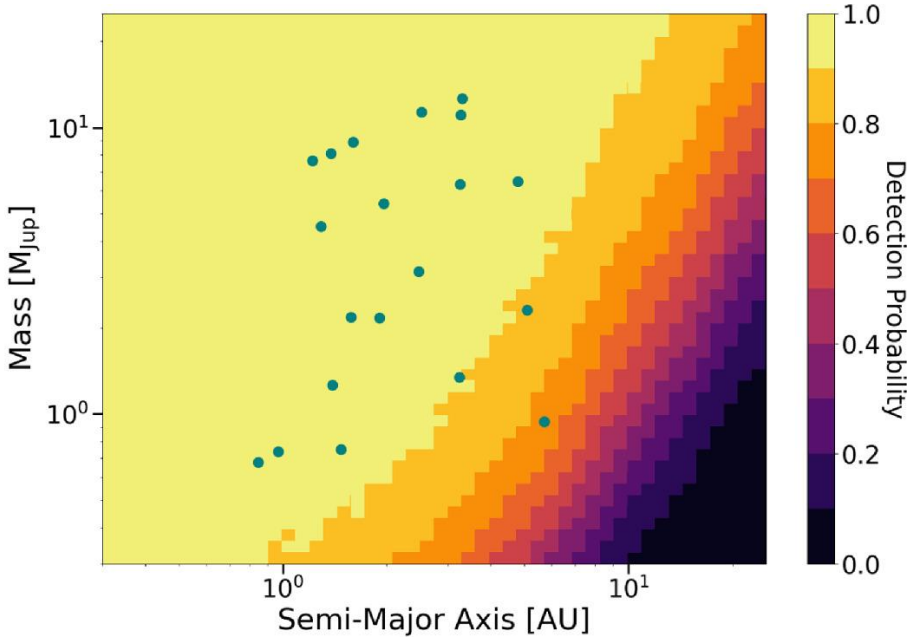
For each injected planet, calculate simulated RVs at each observational epoch
→ would this planet have been "detected" or "not detected"?



Median completeness maps for our sample

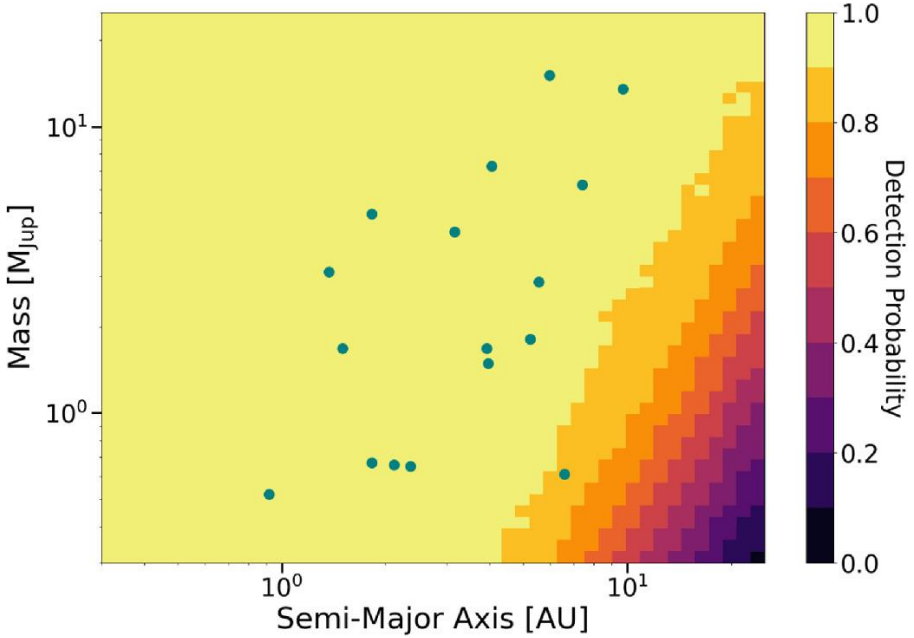


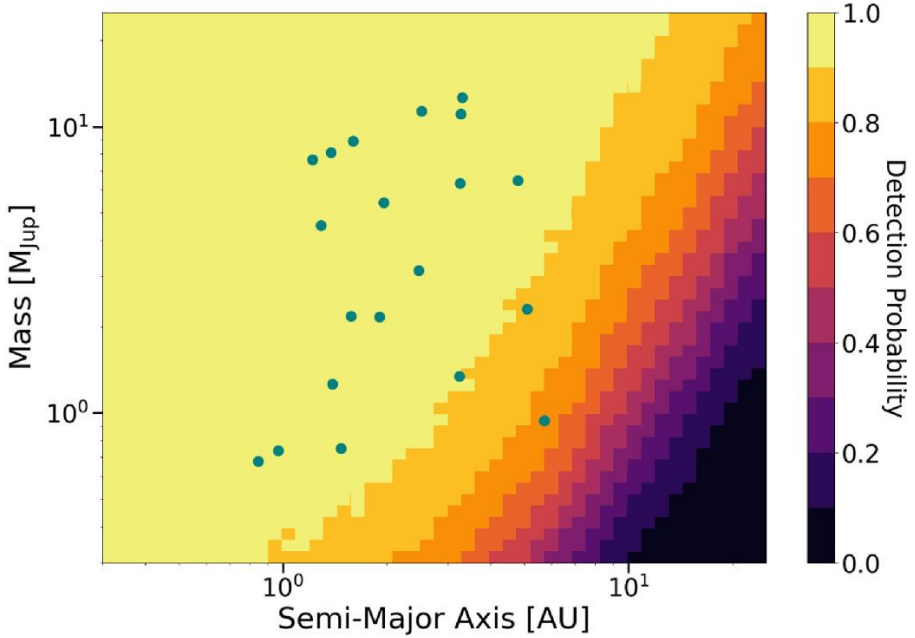
SE discovered with RV



SE discovered with transits

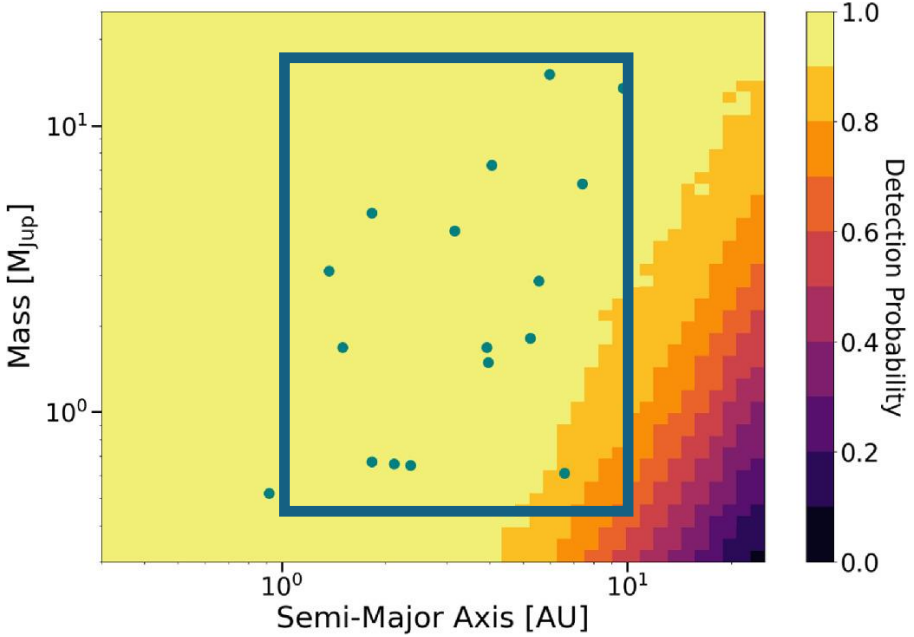
Median completeness maps for our sample

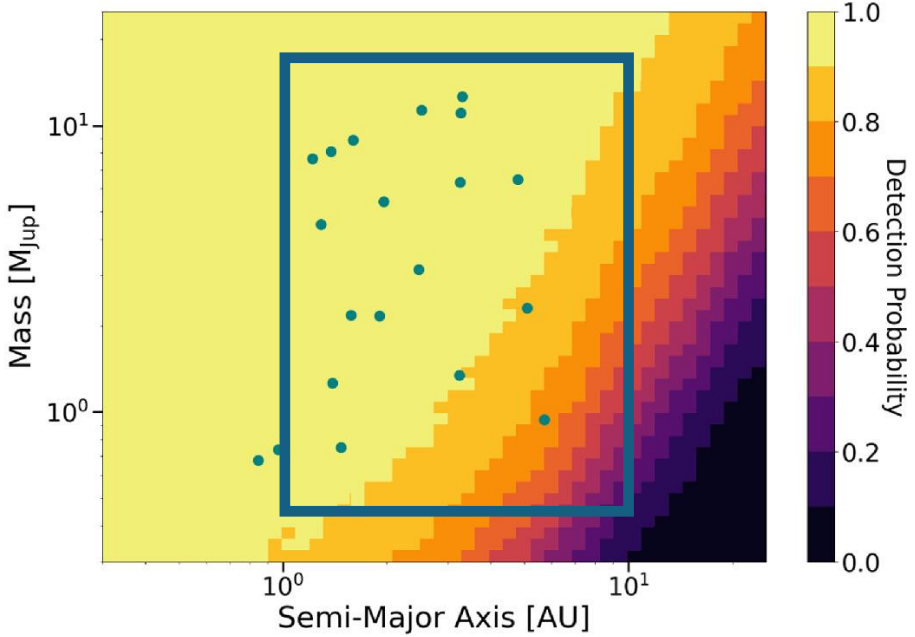




Confirmed gas giants are in regions of parameter space where both transit and RV samples are on average close to, if not at, 100% completeness.

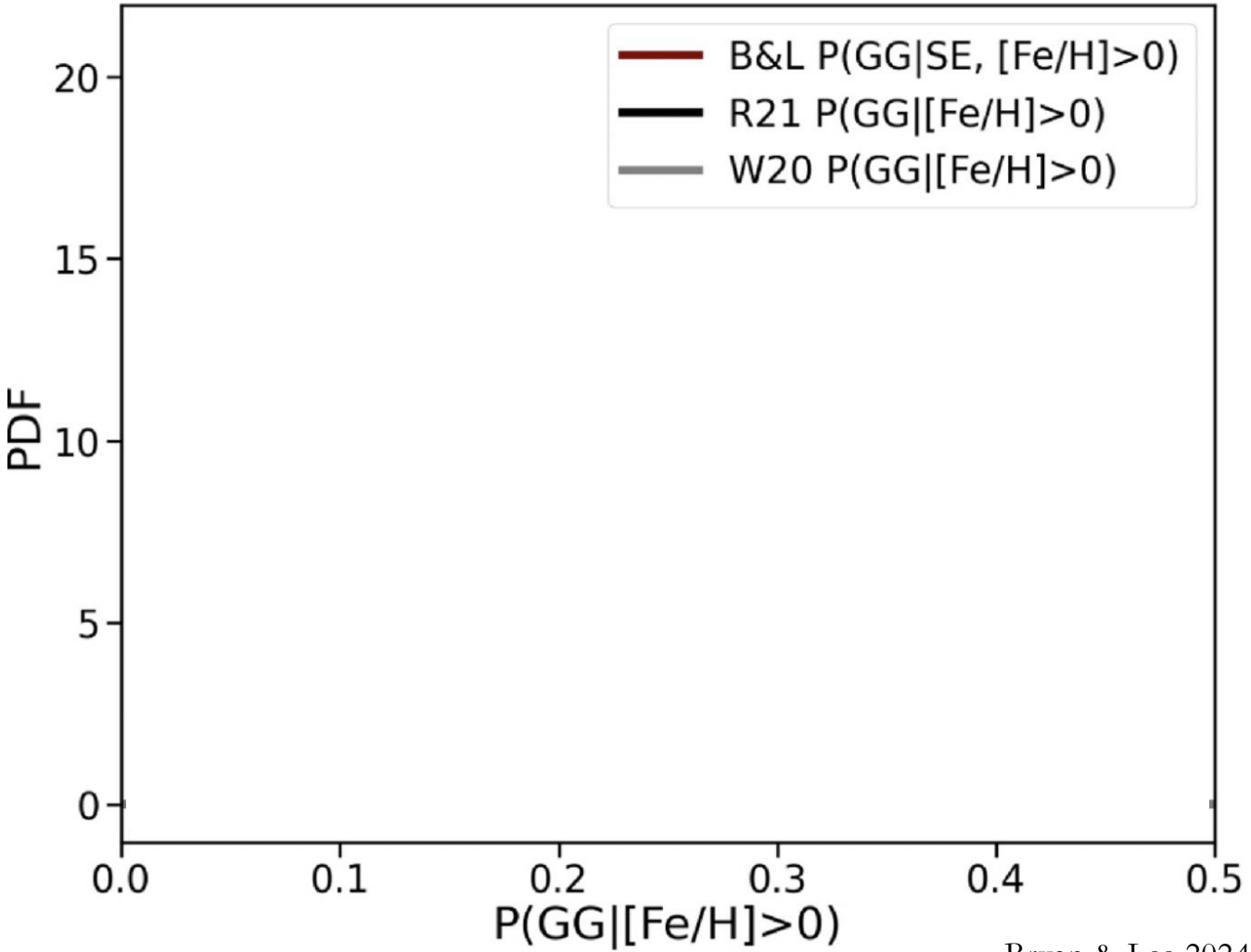
Median completeness maps for our sample





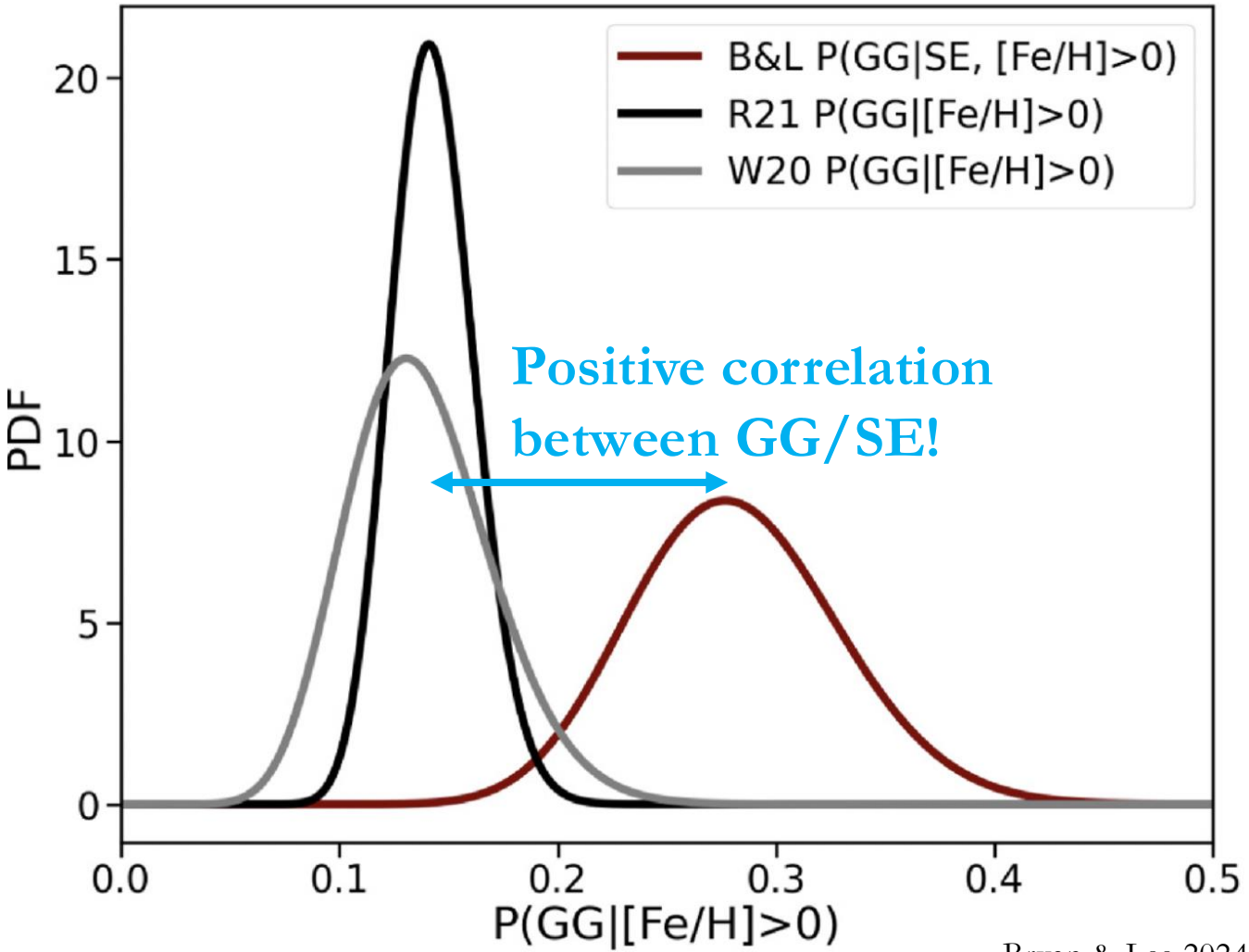
Motivation for our outer gas giant definition: 0.5-20 M_{jup}, 1-10 AU

Positive, negative, or no correlation between SE and GG?



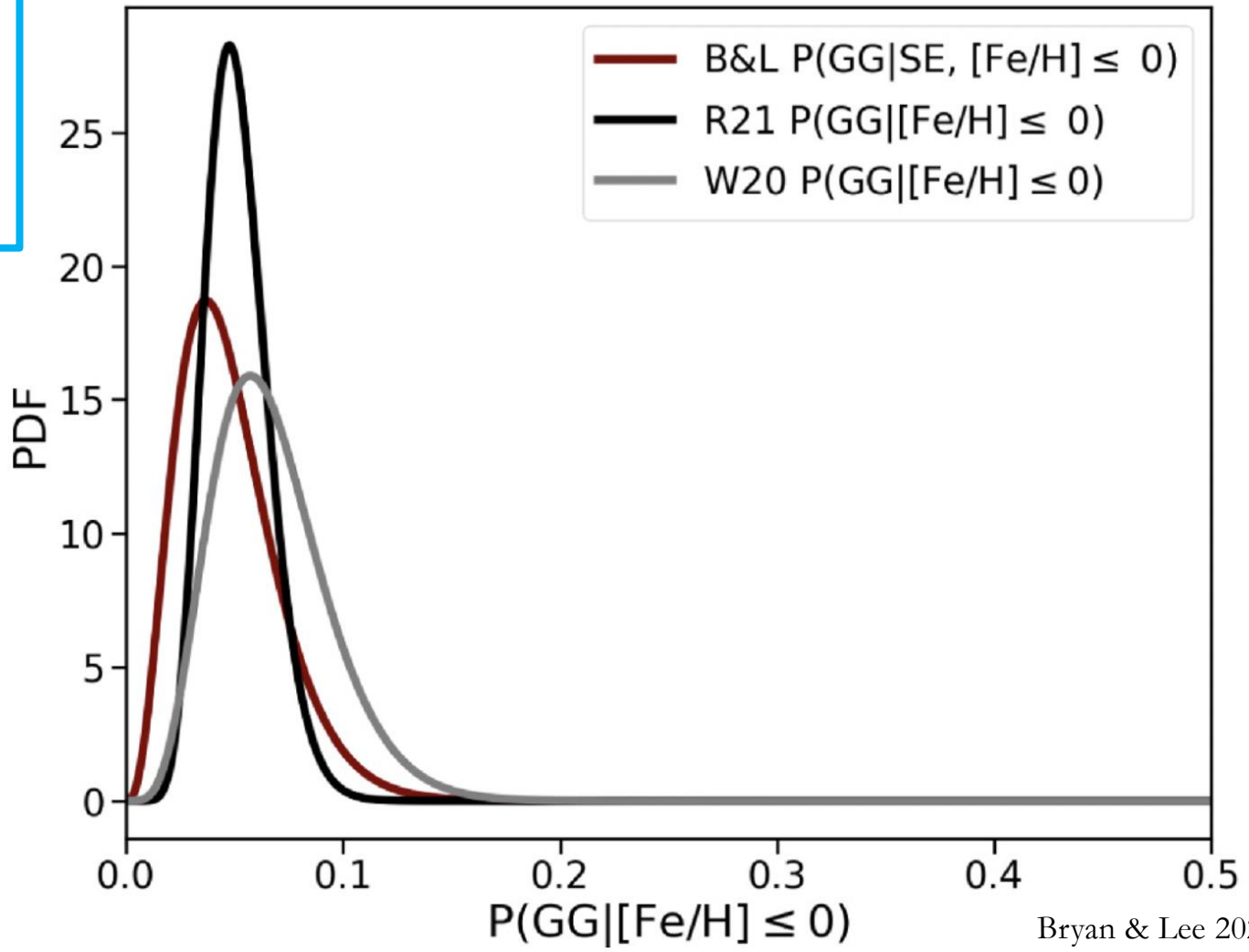
Bryan & Lee 2024

A striking positive correlation for metal-rich systems!



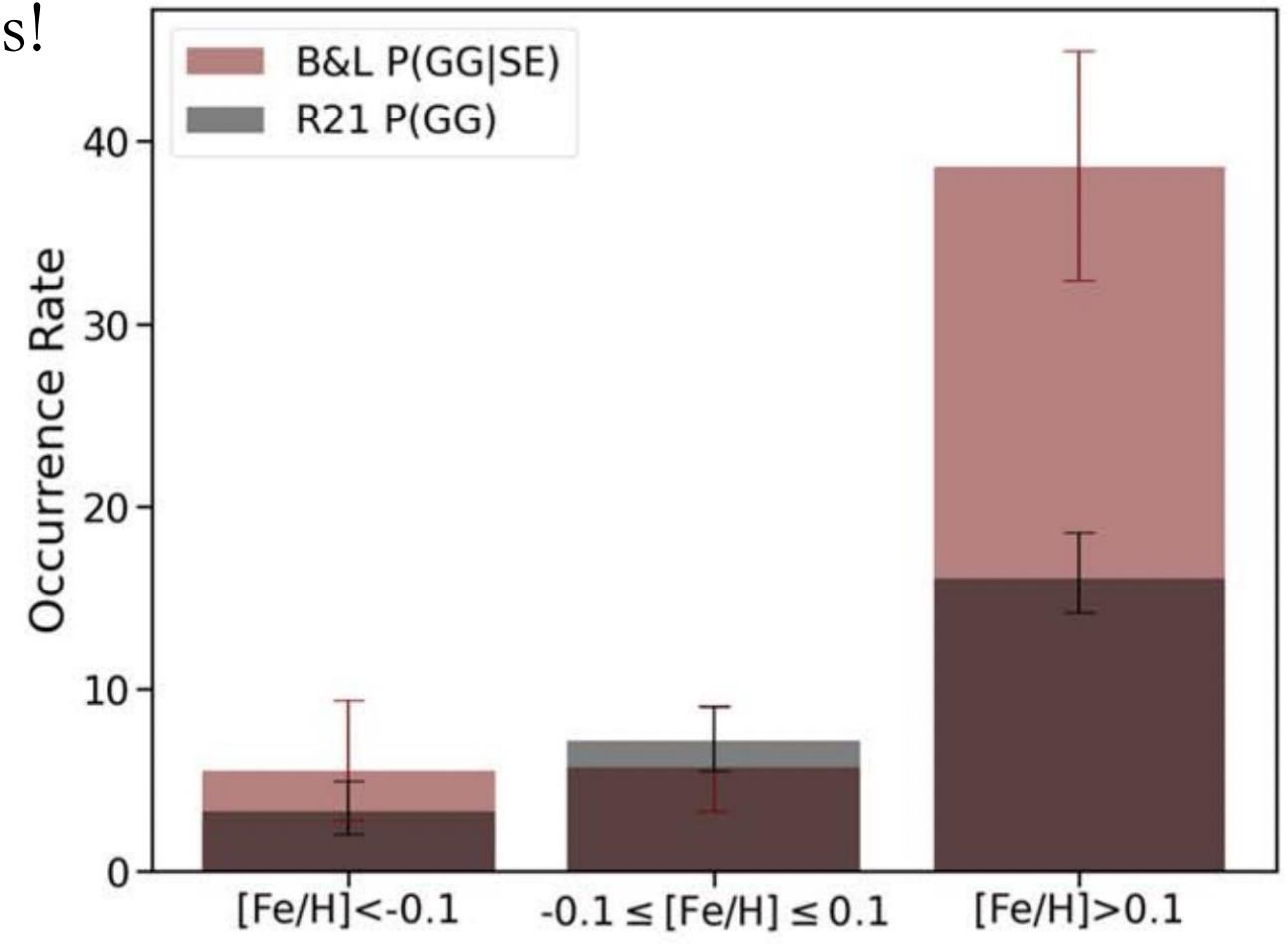
Bryan & Lee 2024

No correlation for metal-poor systems



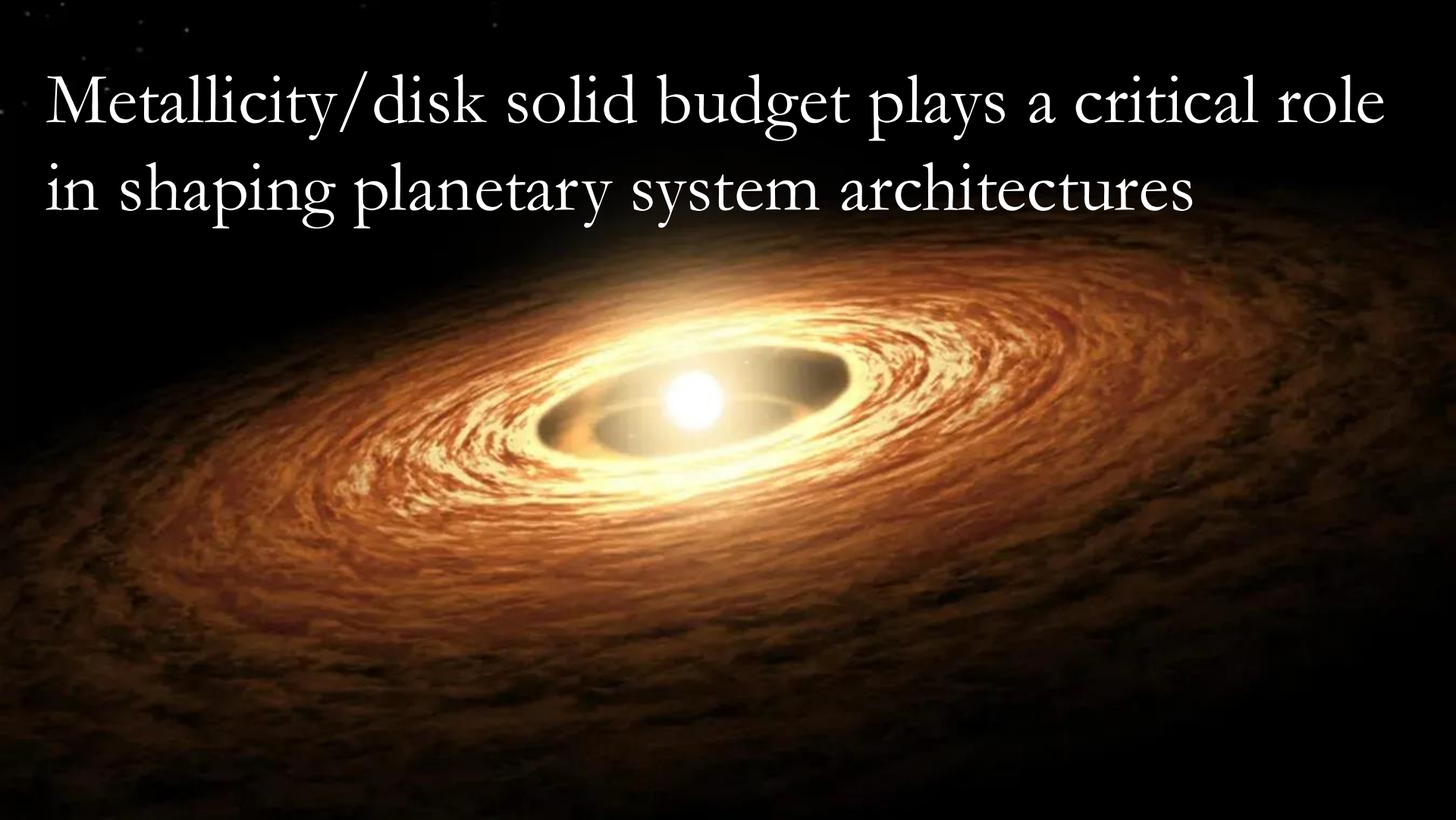
Bryan & Lee 2024

An even stronger positive correlation around the most metal-rich stars!



Bryan & Lee 2024

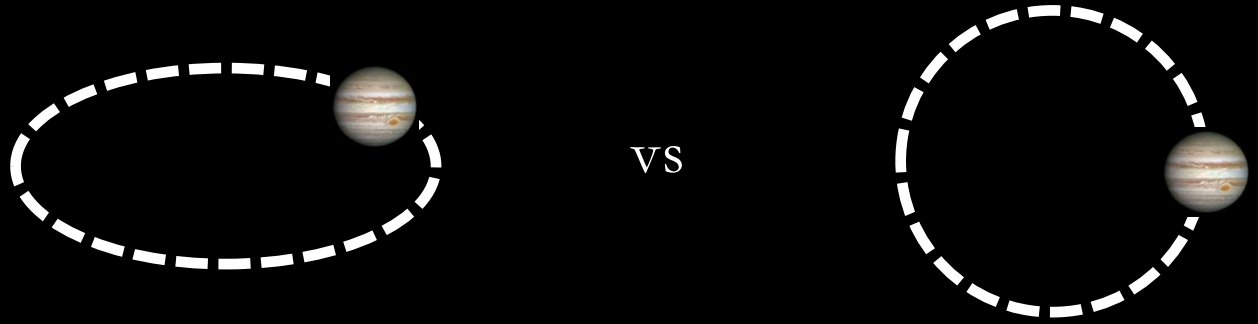
Metallicity/disk solid budget plays a critical role in shaping planetary system architectures



Do outer gas giant properties impact this SE/GG connection?

Proximity of GG

Dynamically hot/cold GG



Multiplicity of GG

Do outer gas giant properties impact this SE/GG connection?

Proximity of GG

vs

Short answer: ?????

Hard to say, nothing statistically significant…

Multiplicity of GG

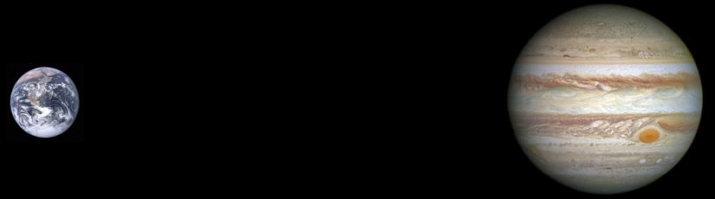
vs

Do outer gas giant properties impact this SE/GG connection?

Proximity of GG

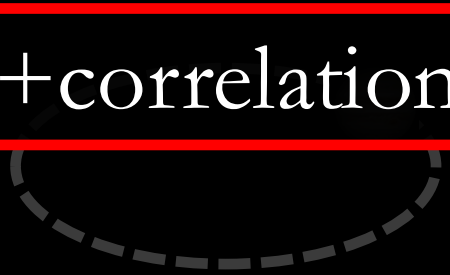
+correlation

vs



++correlation

Dynamically hot/cold GG



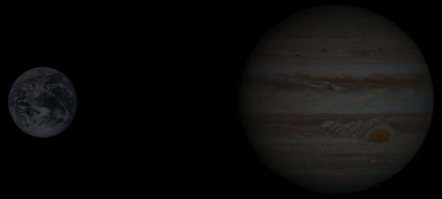
vs

Multiplicity of GG

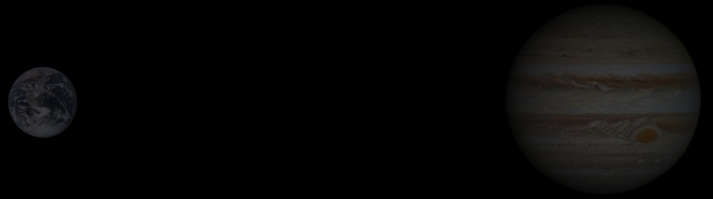
vs

Do outer gas giant properties impact this SE/GG connection?

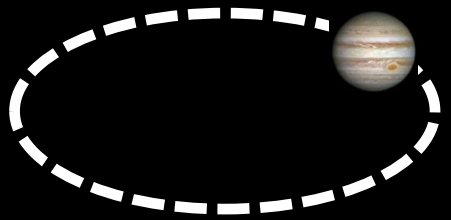
Proximity of GG



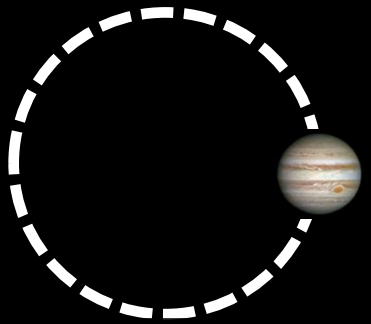
vs



Dynamically hot/cold GG



vs



Multiplicity of GG

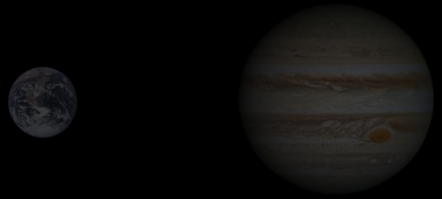
++correlation

vs

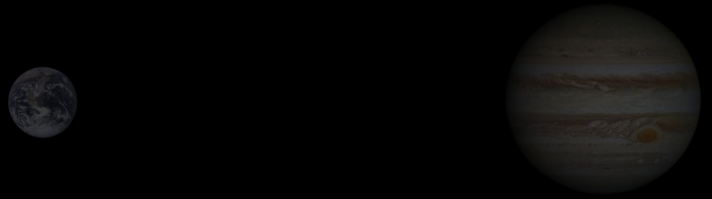
+correlation

Do outer gas giant properties impact this SE/GG connection?

Proximity of GG



vs



Dynamically hot/cold GG

+correlation

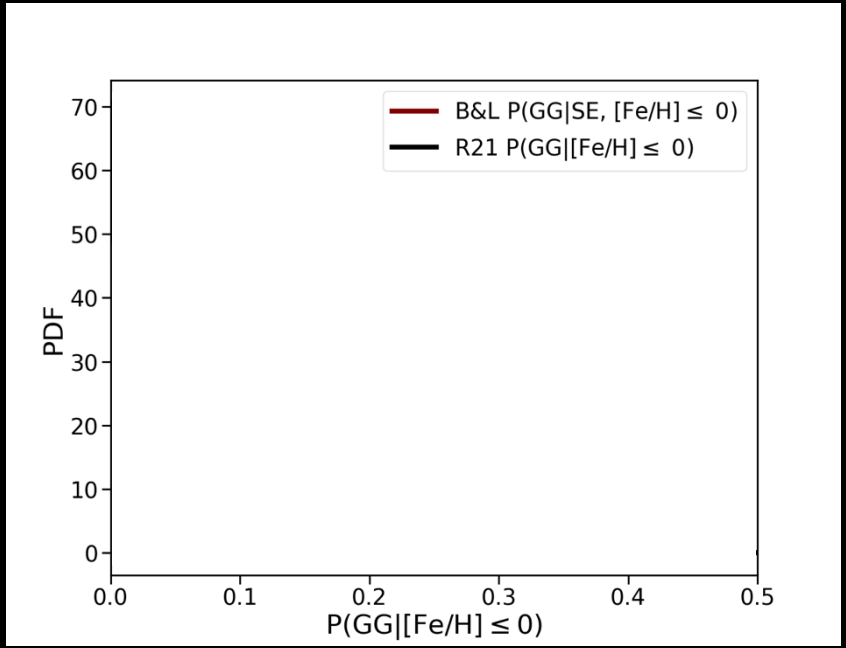
vs

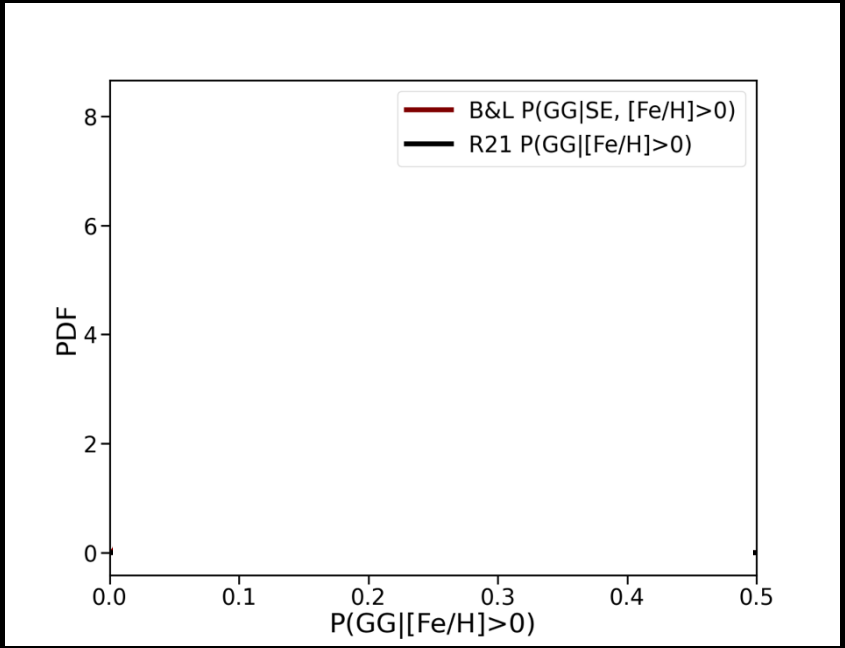
++correlation

Multiplicity of GG

vs

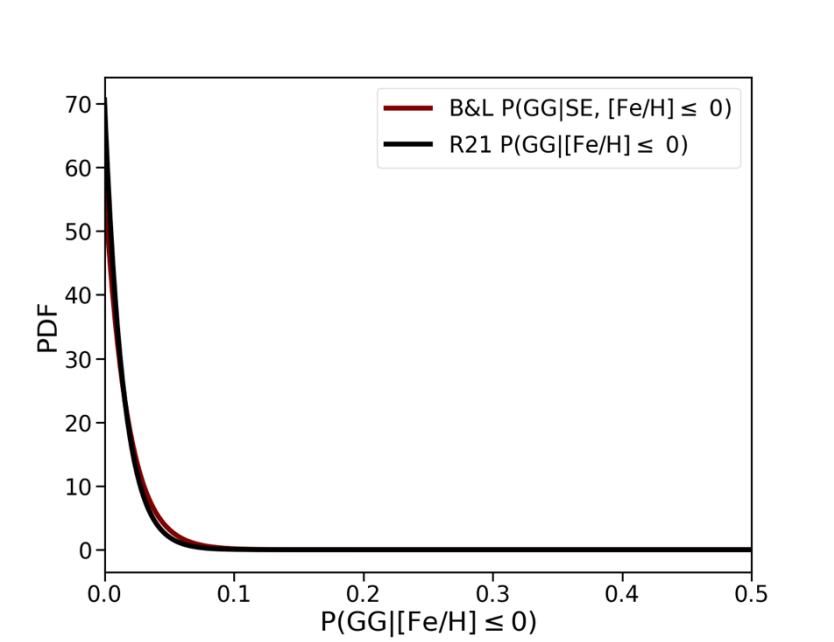
2025: What is the SE/GG connection around M-dwarfs?



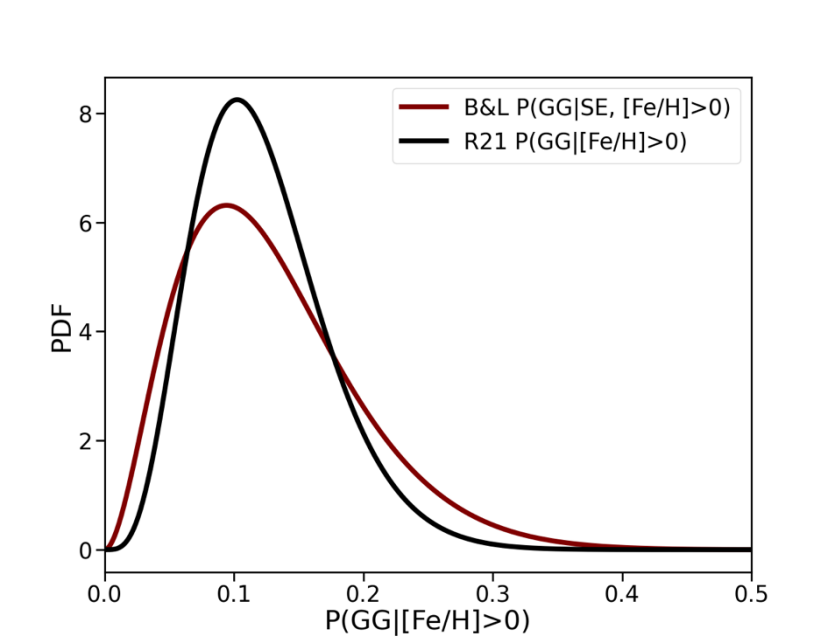


Bryan & Lee 2025

No correlation in metal-poor M-dwarf systems!

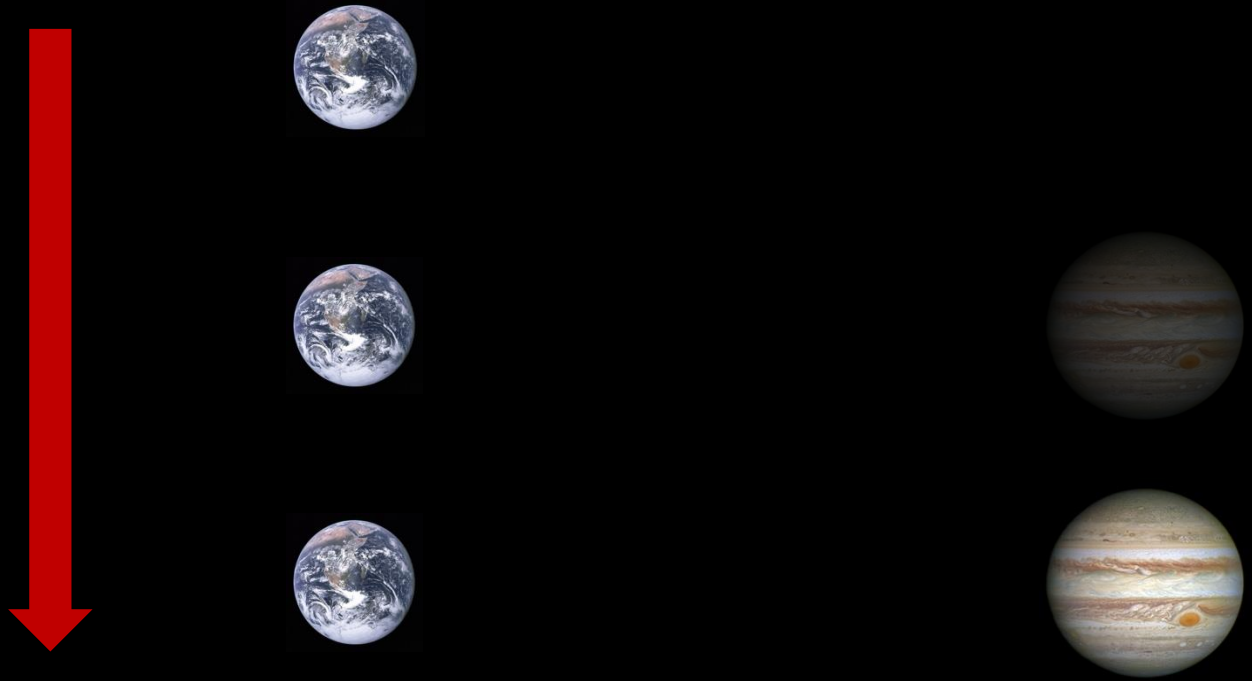


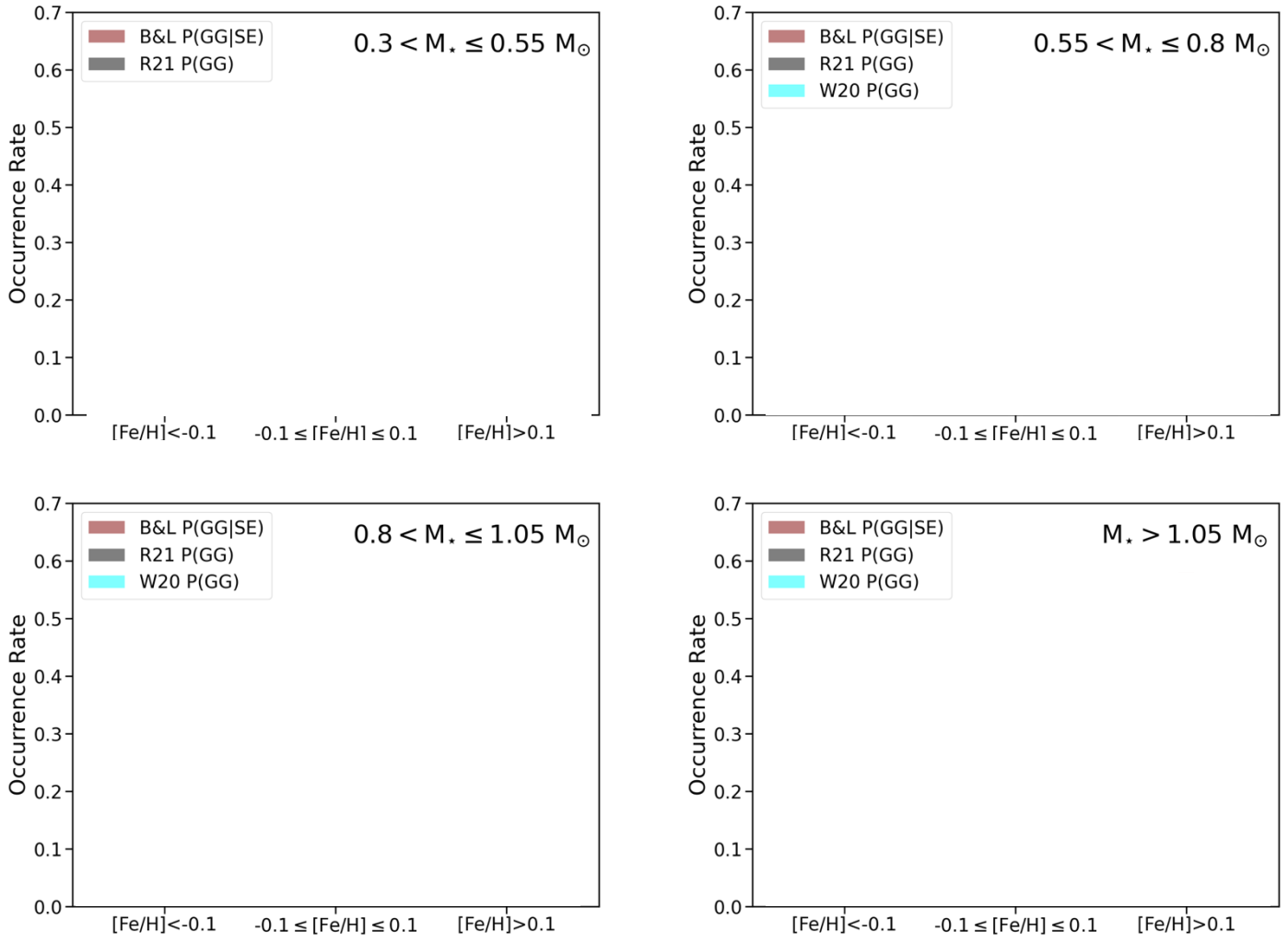
No correlation in metal-rich M-dwarf systems!



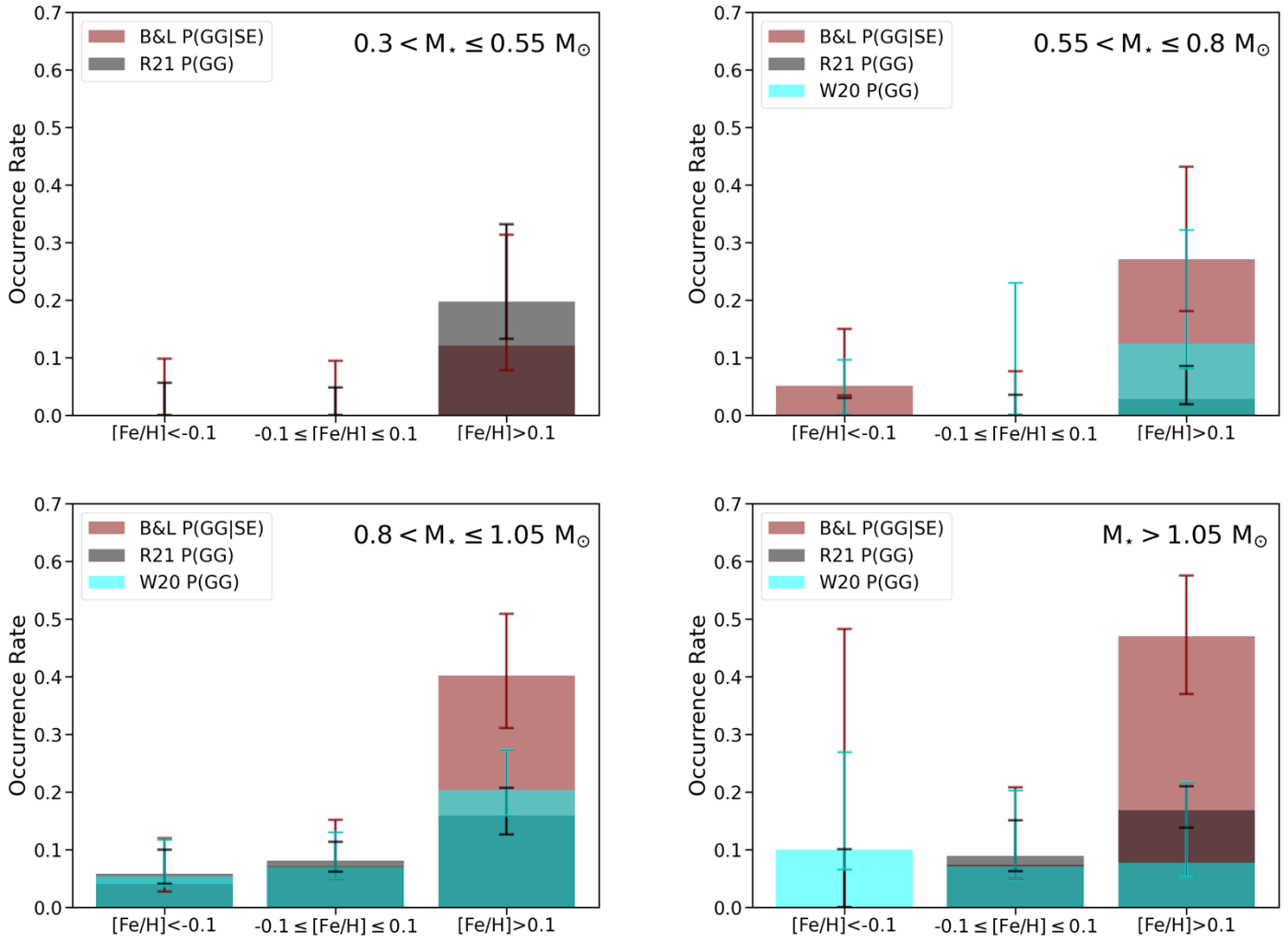
Bryan & Lee 2025

A stellar mass/metallicity transition to a positive SE/GG correlation





Bryan & Lee 2025



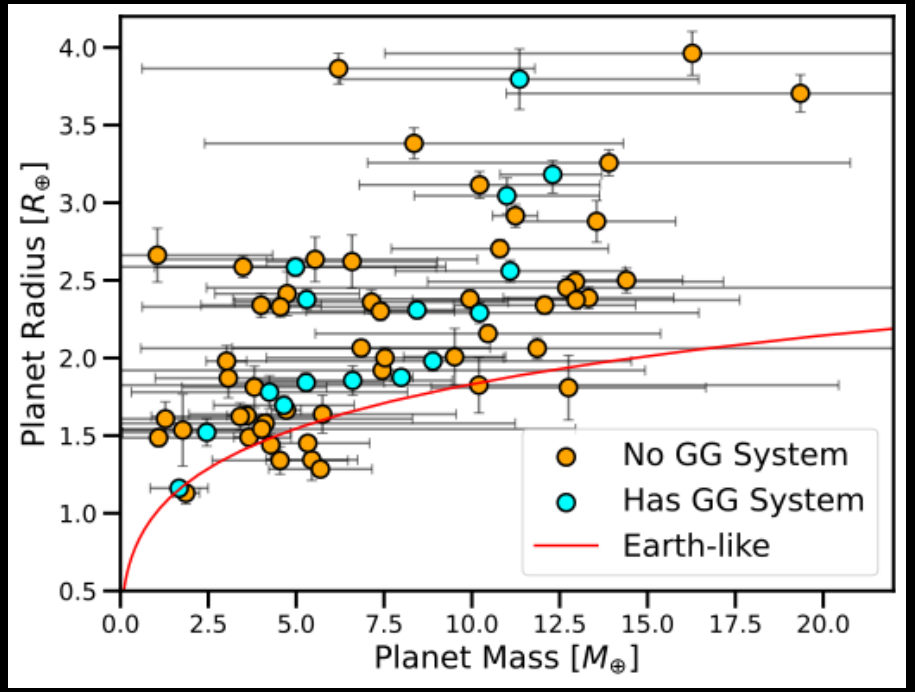
Bryan & Lee 2025

A positive SE/GG correlation emerges, driven by disk solid content

Chachan & Lee 2023
Bitsch & Izidoro 2023
Chachan et al 2022

Going forward: How do gas giants shape the properties of inner systems?

Coming soon – An early look at how gas giants shape small planet bulk compositions



Joseph Tang
UofT → Columbia
1st year grad

Tang, Bryan, & Lee in prep