Most Hot Jupiters Were Cool Giant Planets For Over a Gyr

Stephen Schmidt
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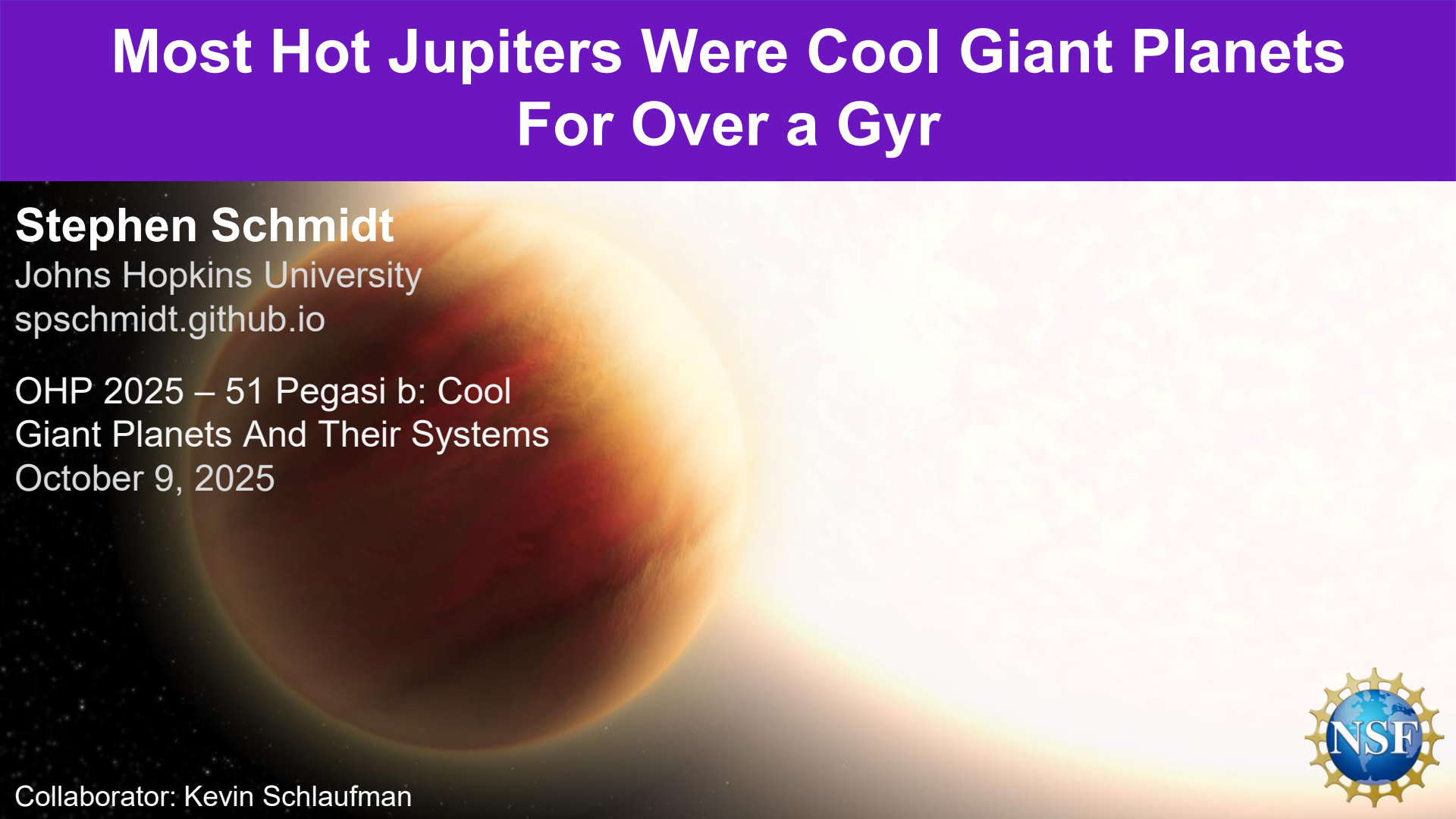
OHP 2025 – 51 Pegasi b: Cool Giant Planets And Their Systems
October 9, 2025



Collaborator: Kevin Schlaufman

The Solar System's Cool Giant Planets

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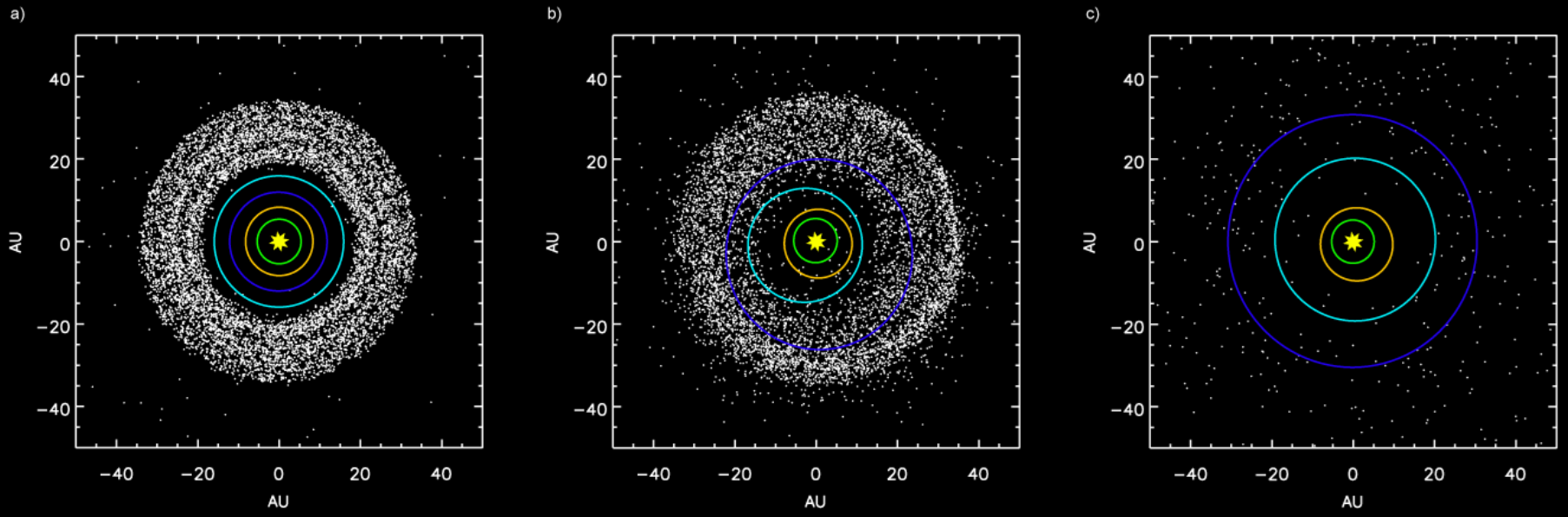

Hot Jupiters are Different

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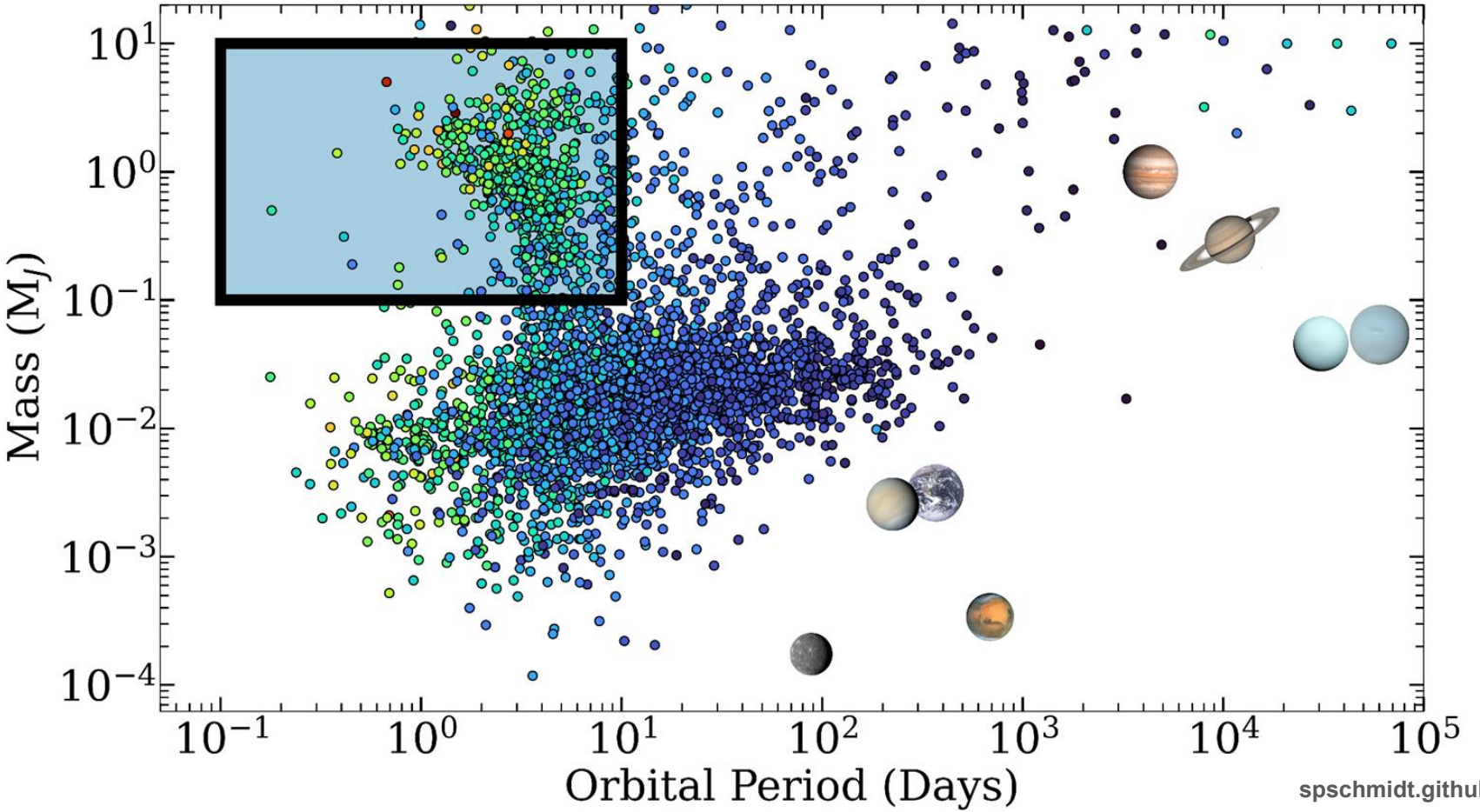

(1) Disk migration/in situ formation

(2) High-eccentricity migration

(3) Tidal inspiral

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(1) Disk migration/in situ formation:

Early Times,

(2) High-eccentricity migration:

Early and/or Late Times?,

(3) Tidal inspiral:

Late Times,

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(1) Disk migration/in situ formation:

Early Times, Mostly Uniform

(2) High-eccentricity migration:

Early and/or Late Times?, Highly Peaked

(3) Tidal inspiral:

Late Times, Destroys Closest-in Planets

The Hot Jupiter Orbital Period Distribution

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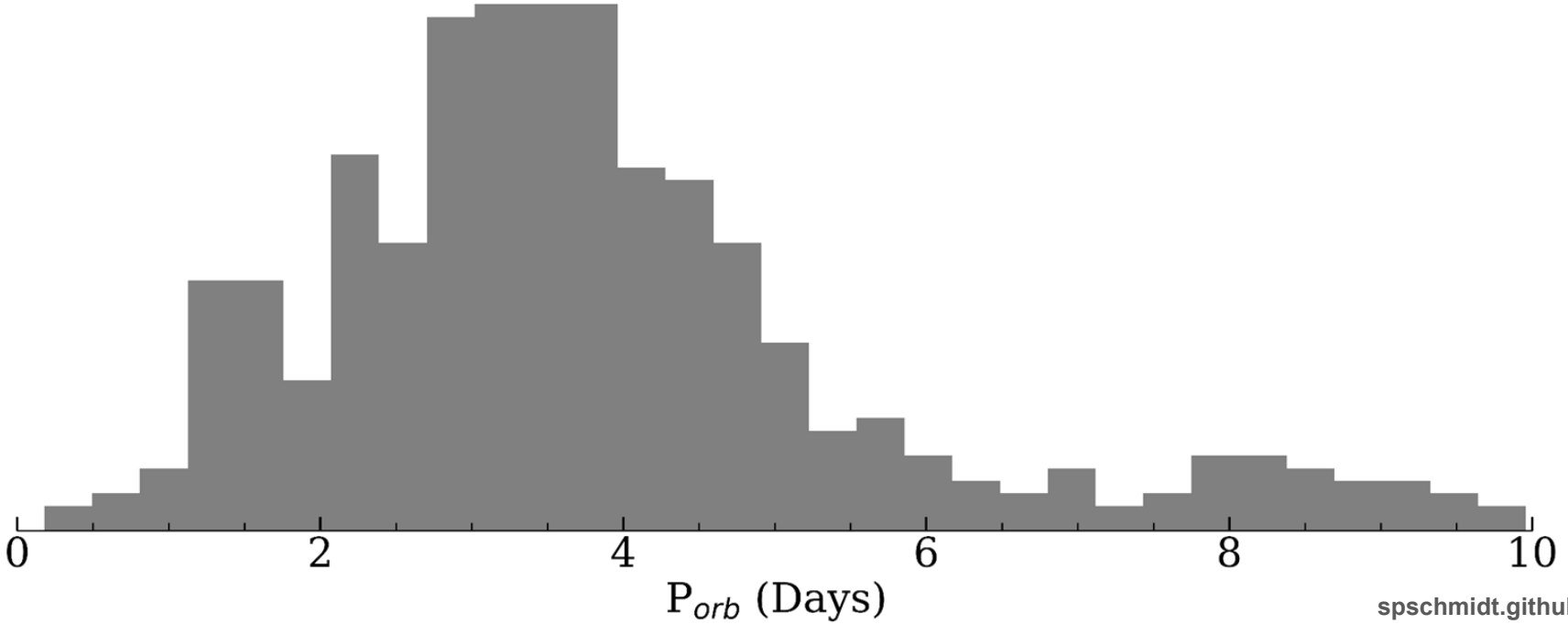

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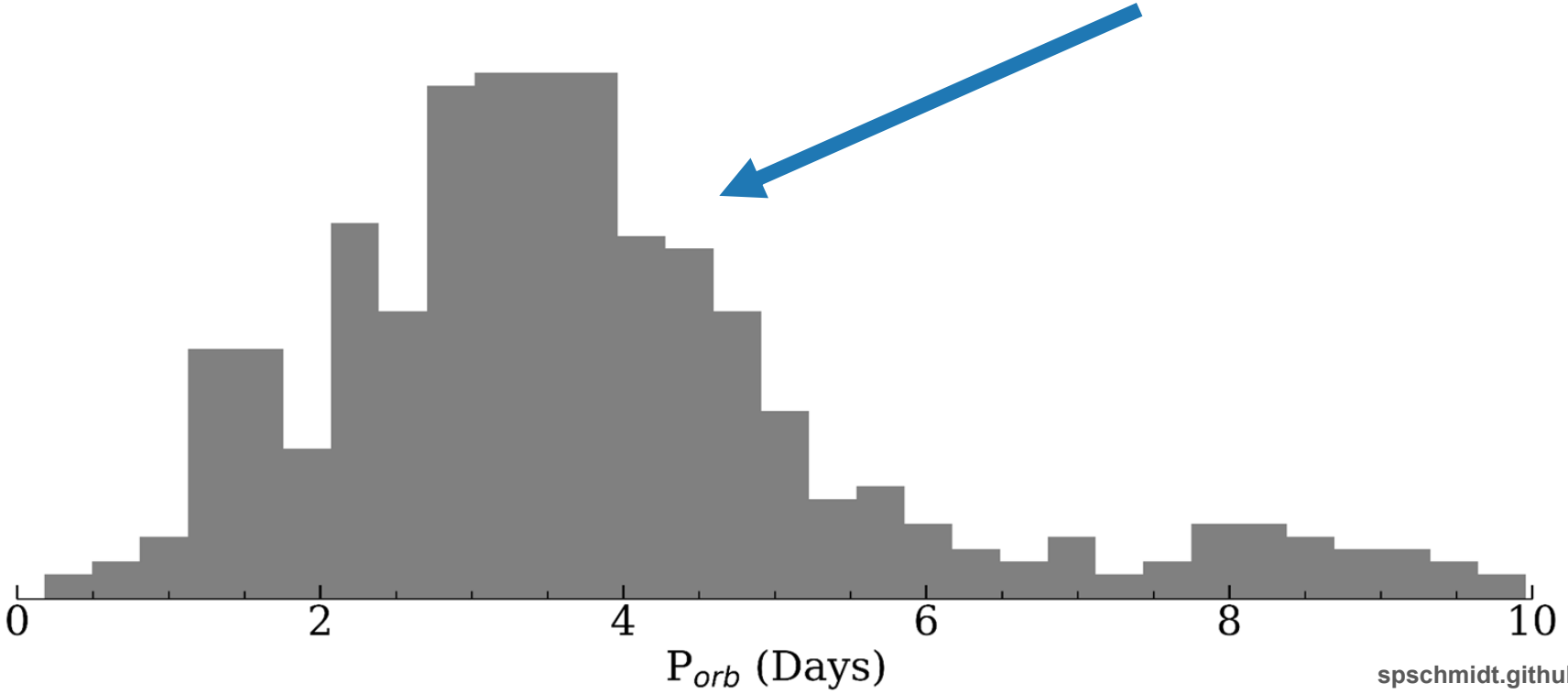

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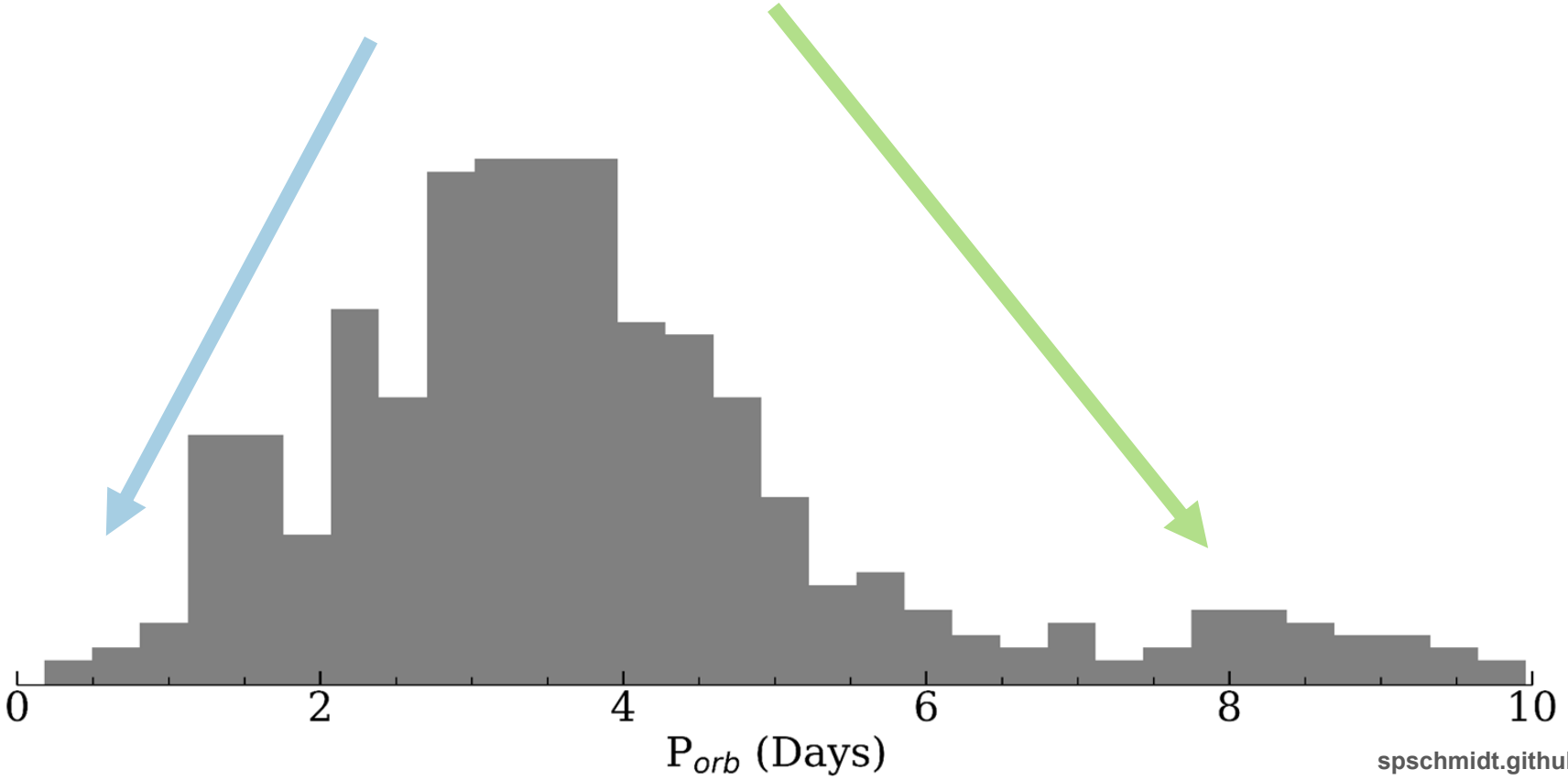

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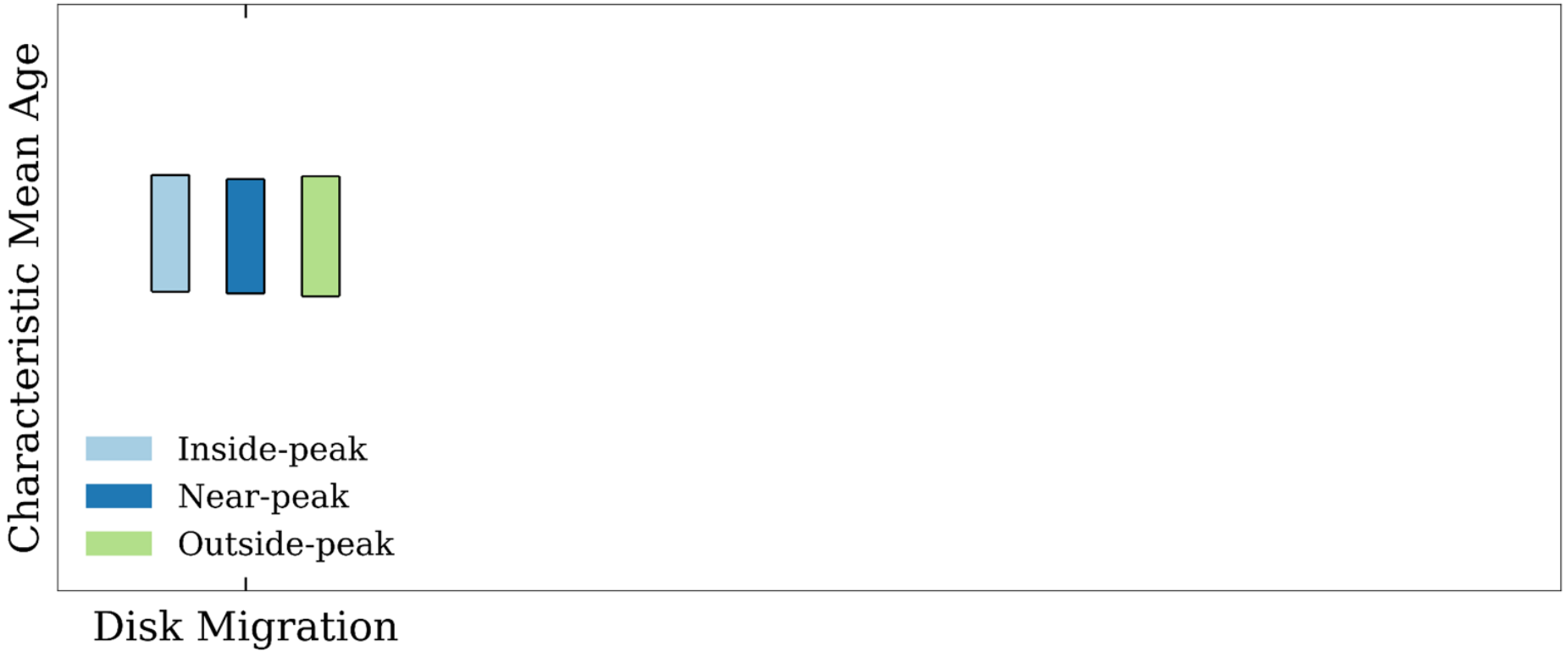

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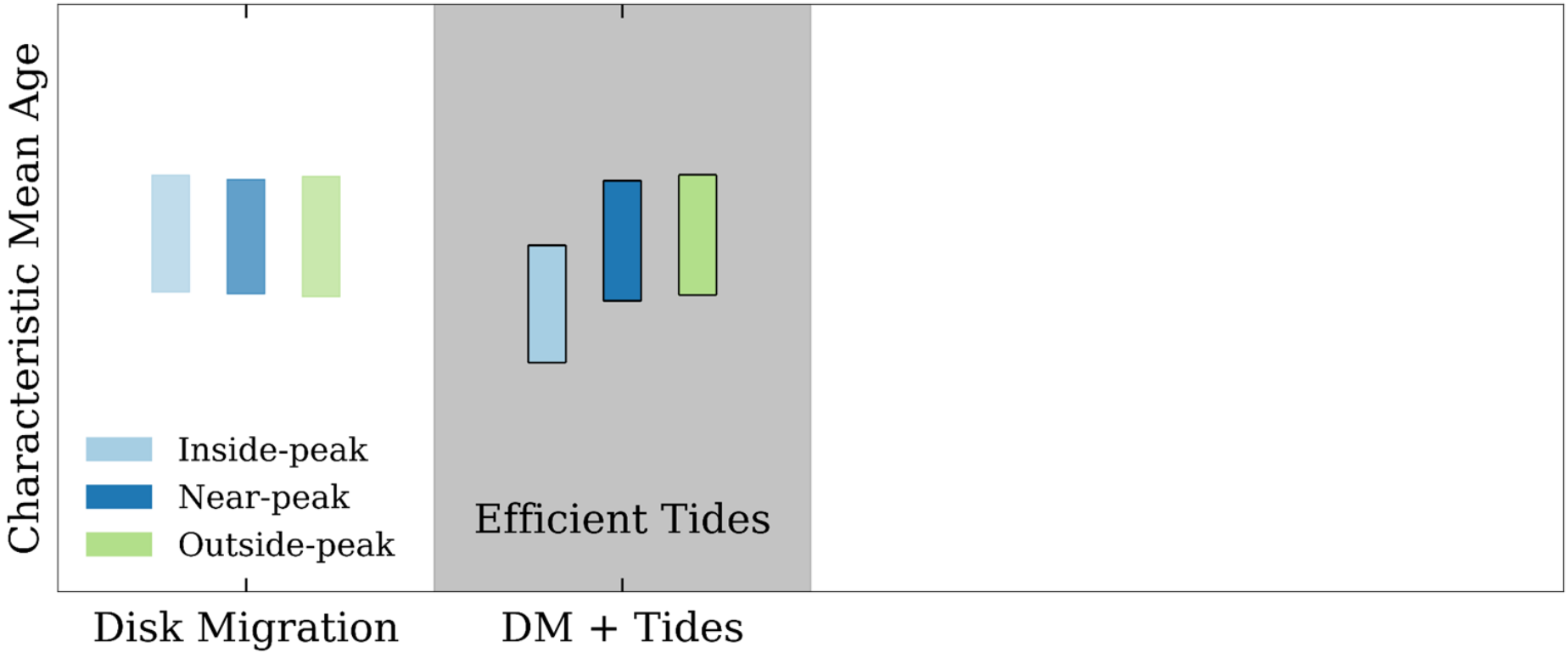

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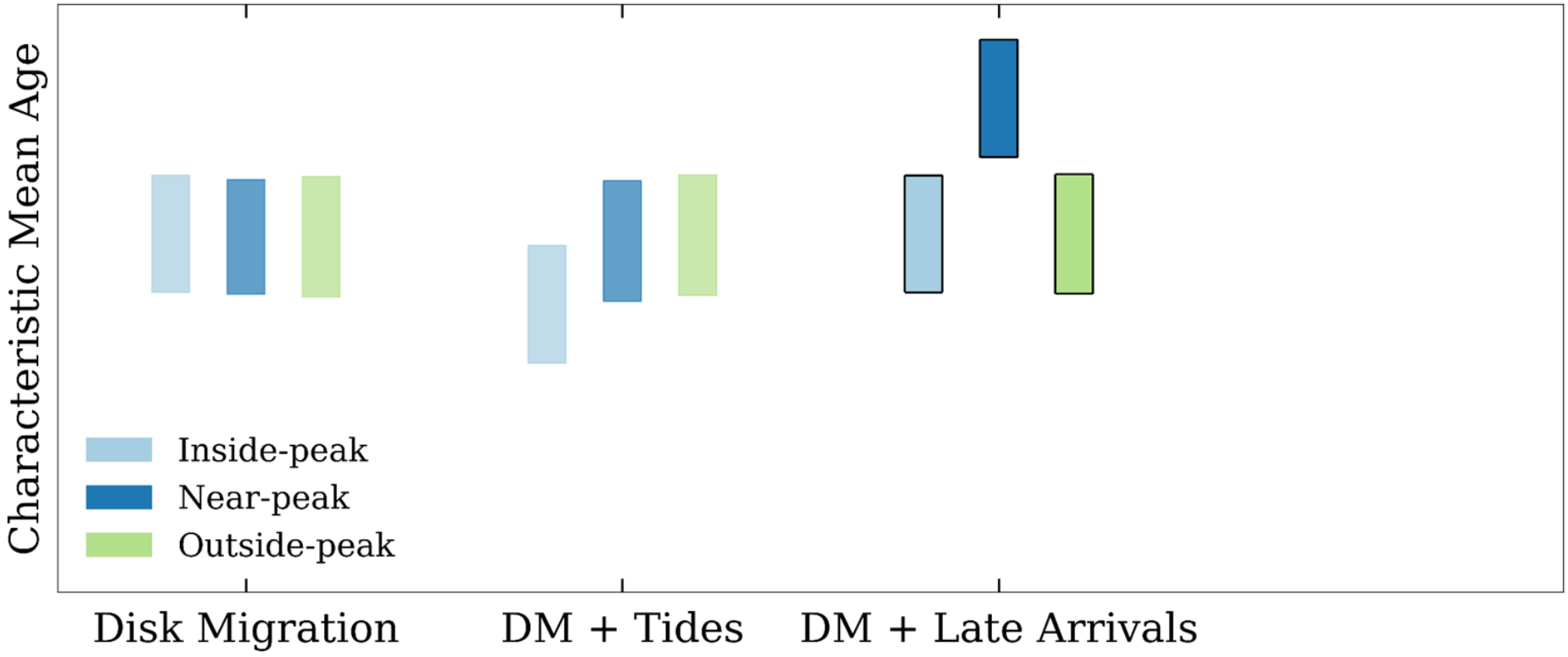

Formation Scenarios

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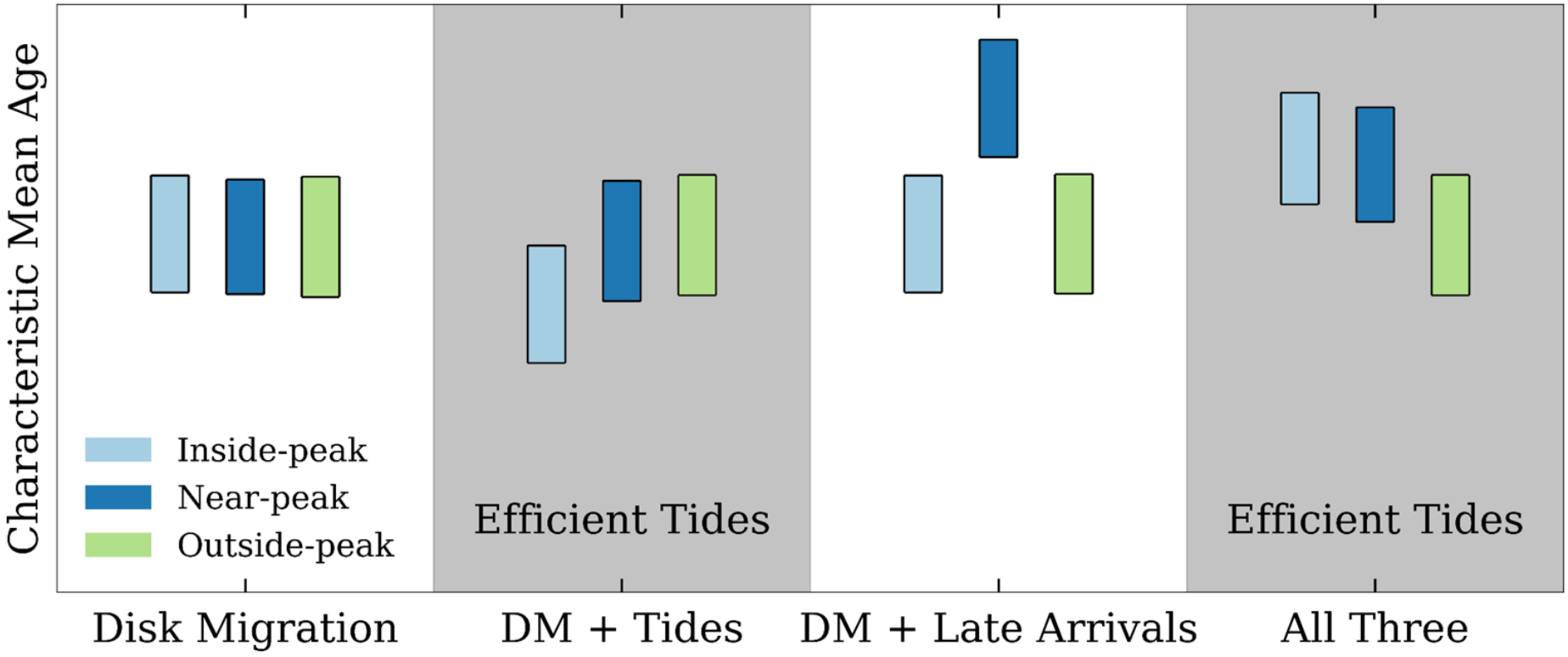

The Peak of the Period Distribution

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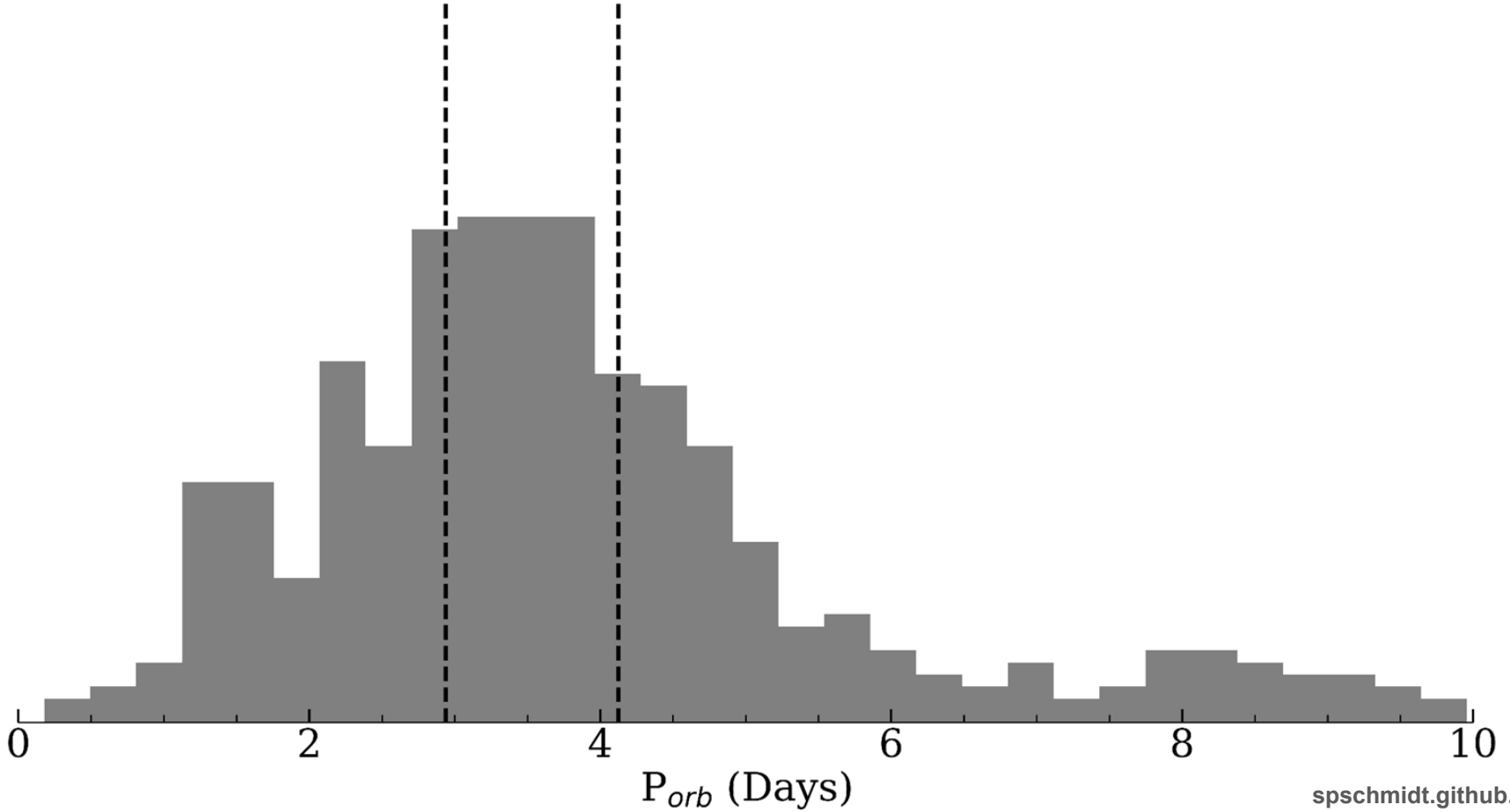

The Peak of the Period Distribution (Bias)

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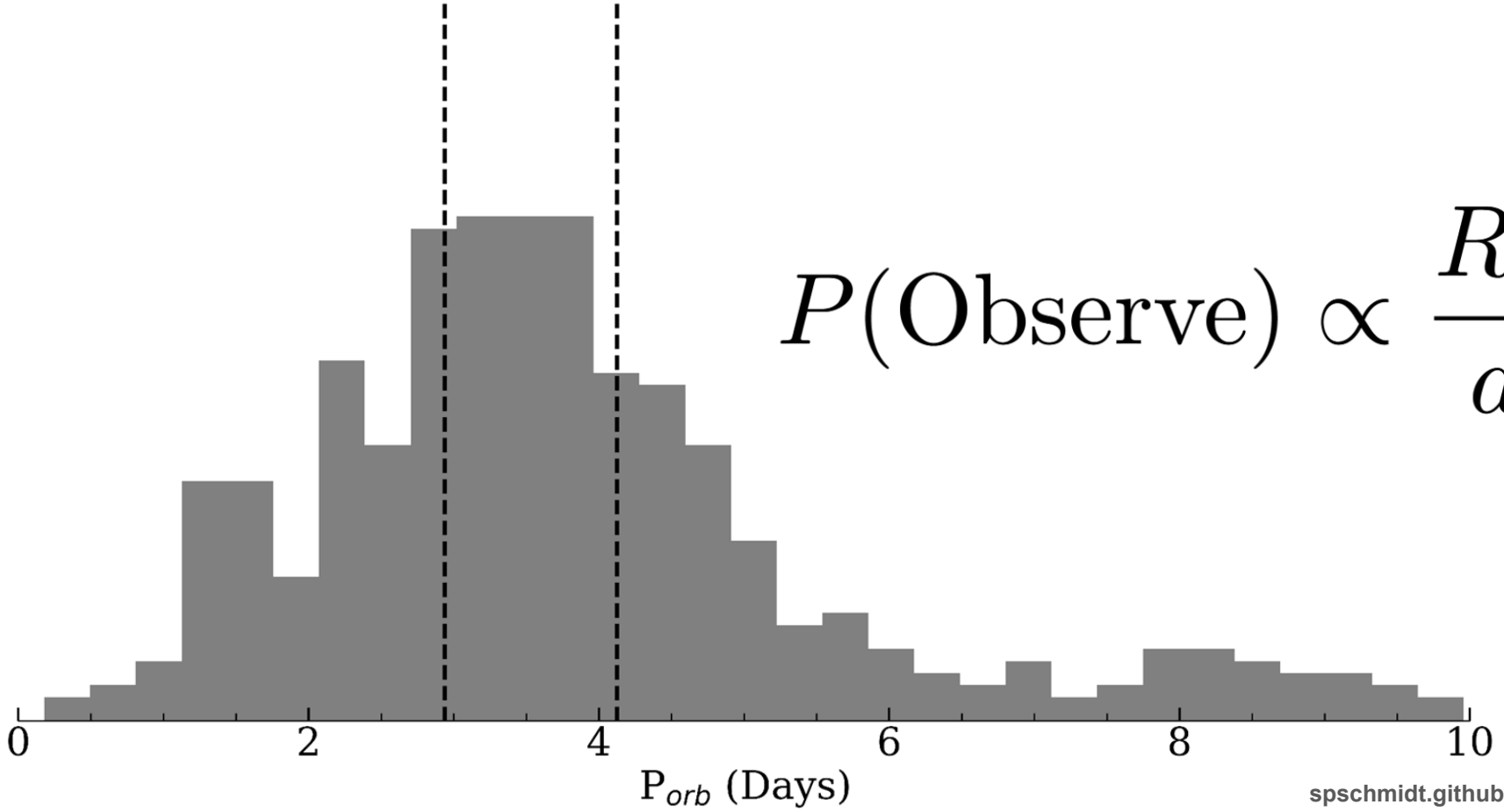

$$P(\text{Observe}) \propto \frac{R_*}{a}$$

The Debiased Peak of the Period Distribution

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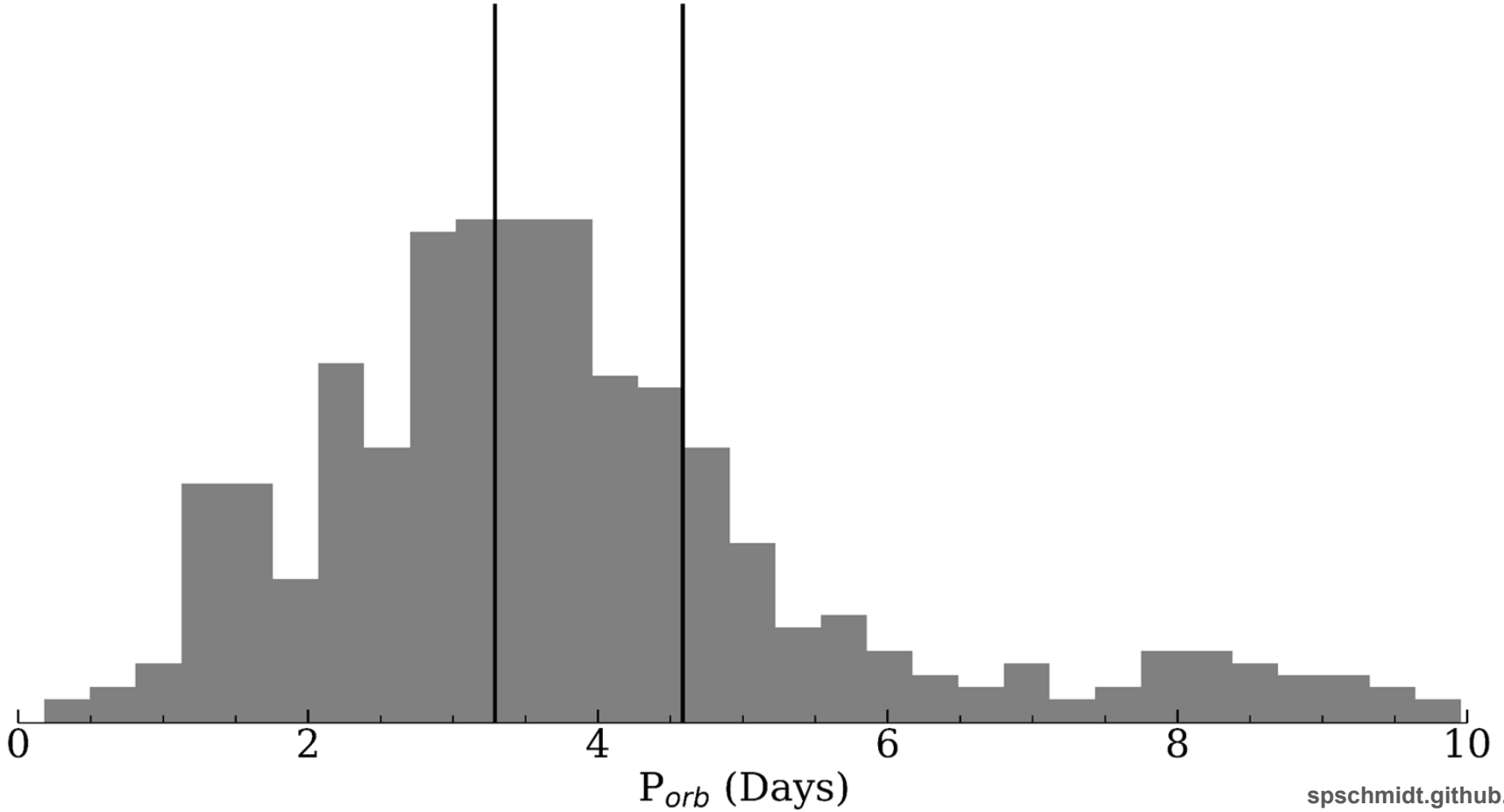

The Debiased Peak of the Period Distribution

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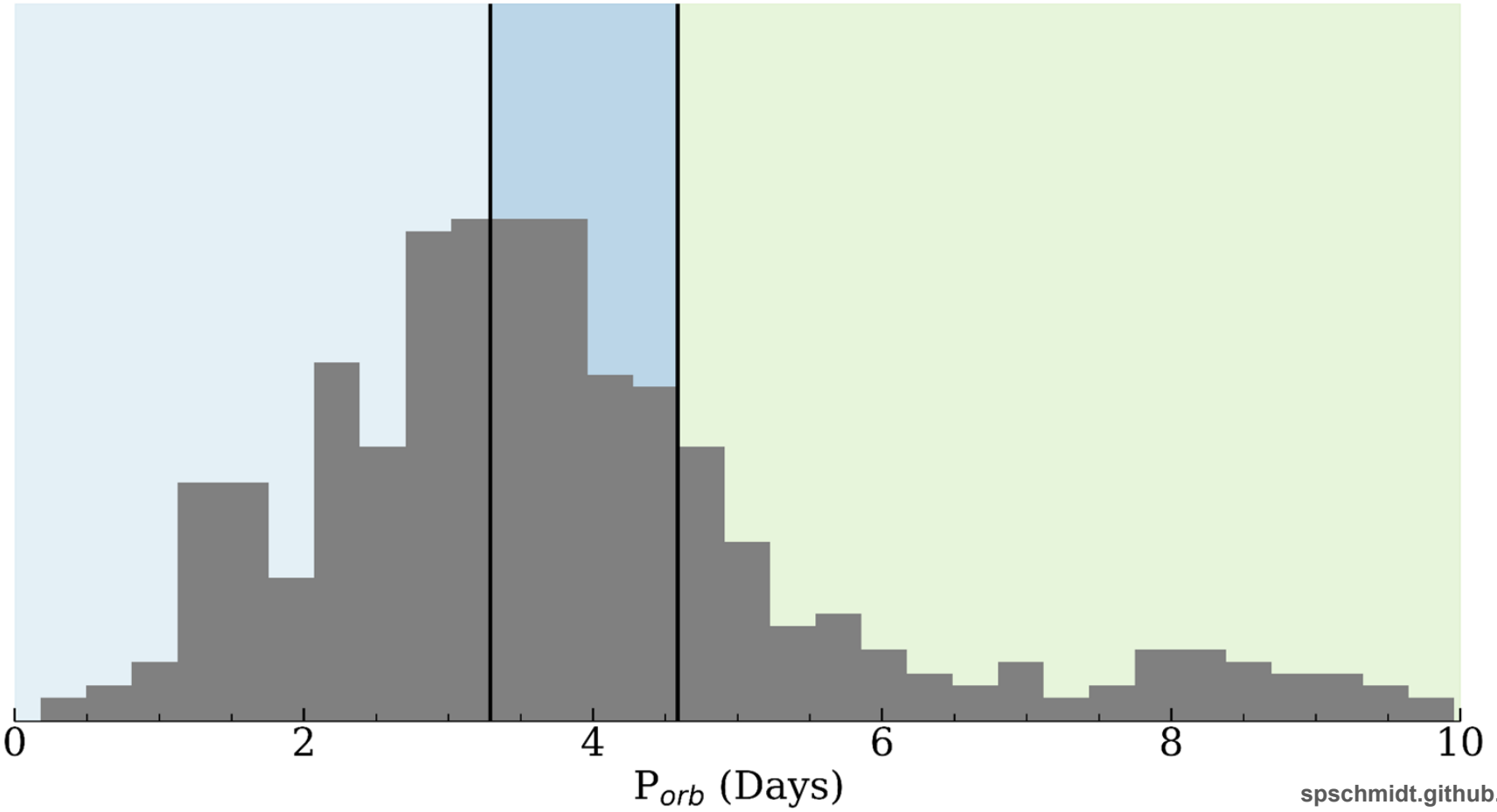

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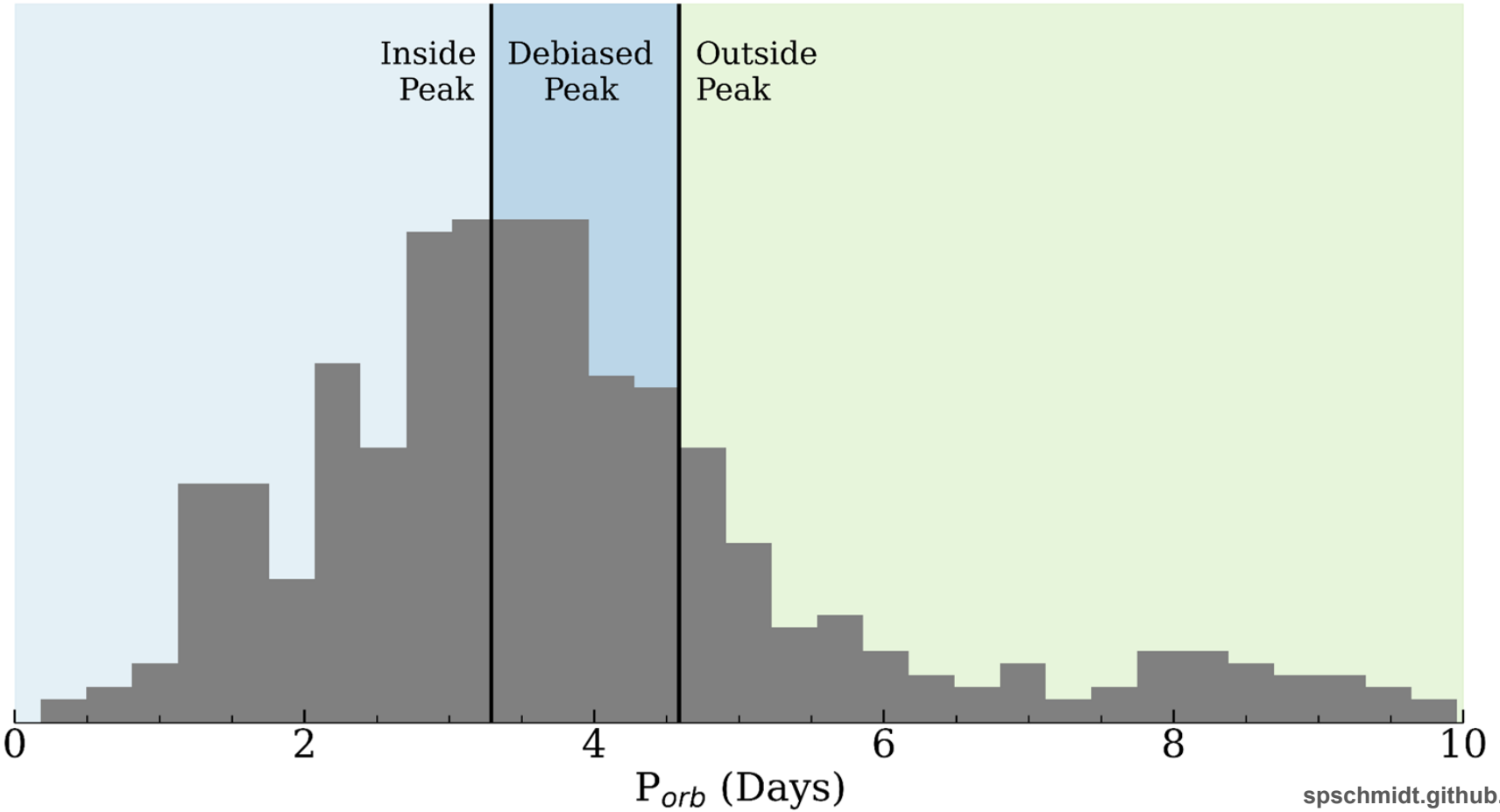

Velocity Dispersion: Stars Form Close to Mid-plane

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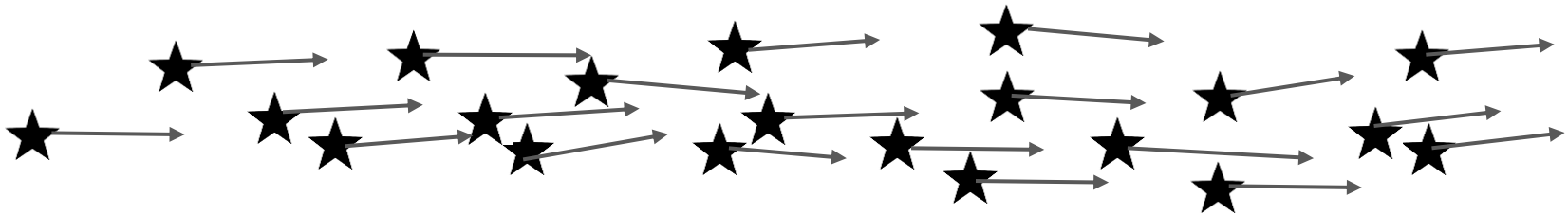

Time since formation: < 1 Gyr

Velocity Dispersion: Random Kicks Over Time

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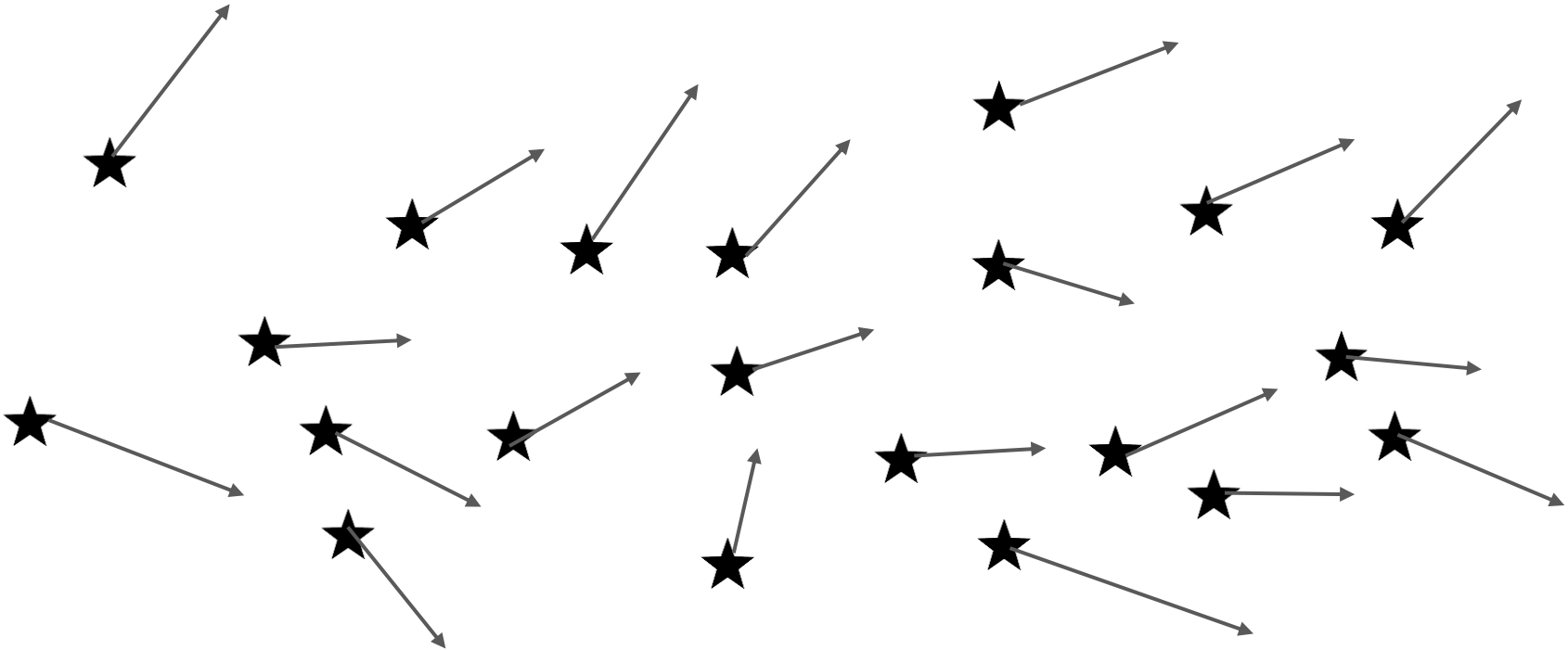

Time since formation: 6 Gyr

Solar Neighborhood Age-VD Relation

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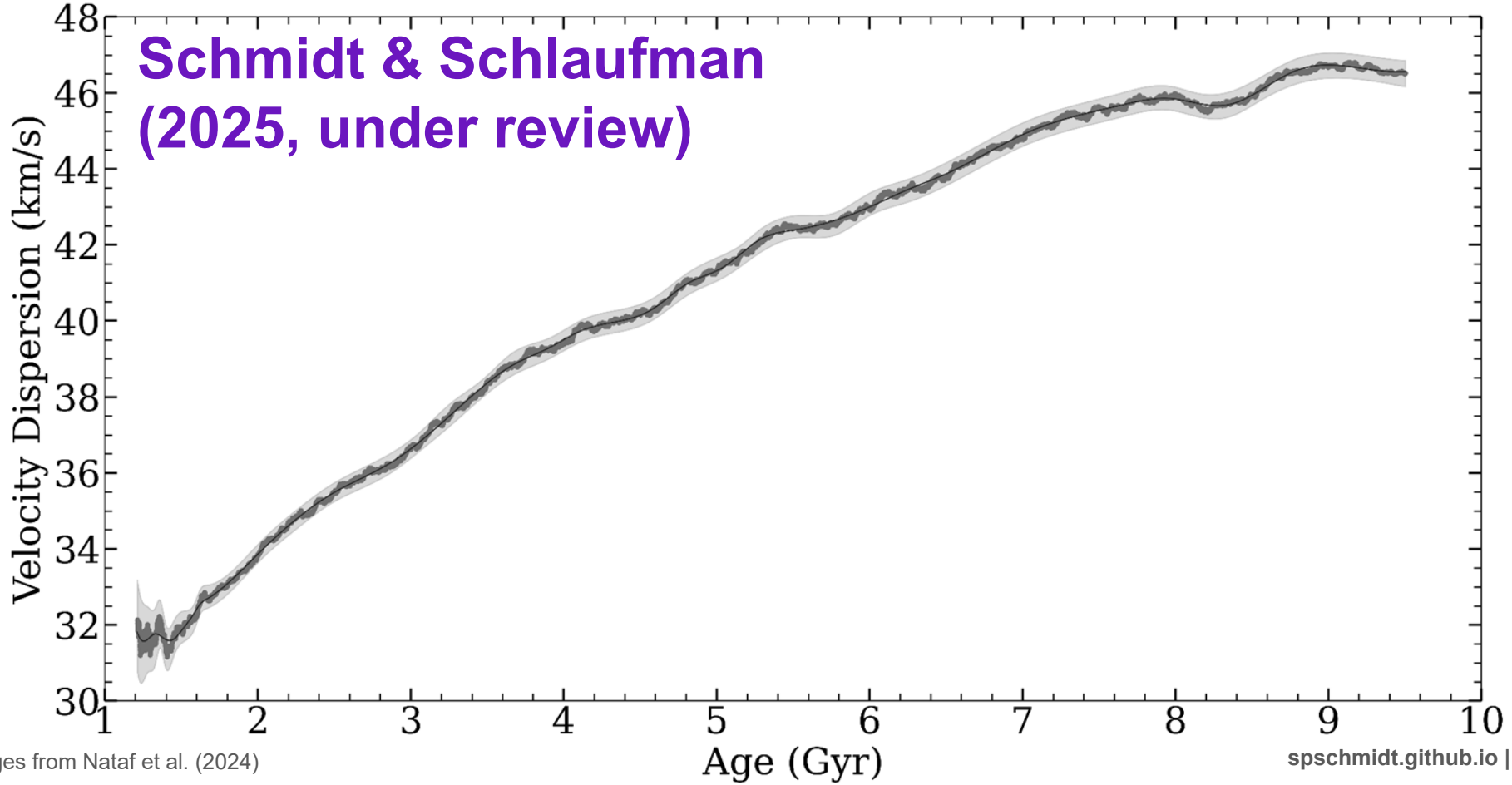

Ages from Nataf et al. (2024)

Population Comparisons to the Age-VD Relation

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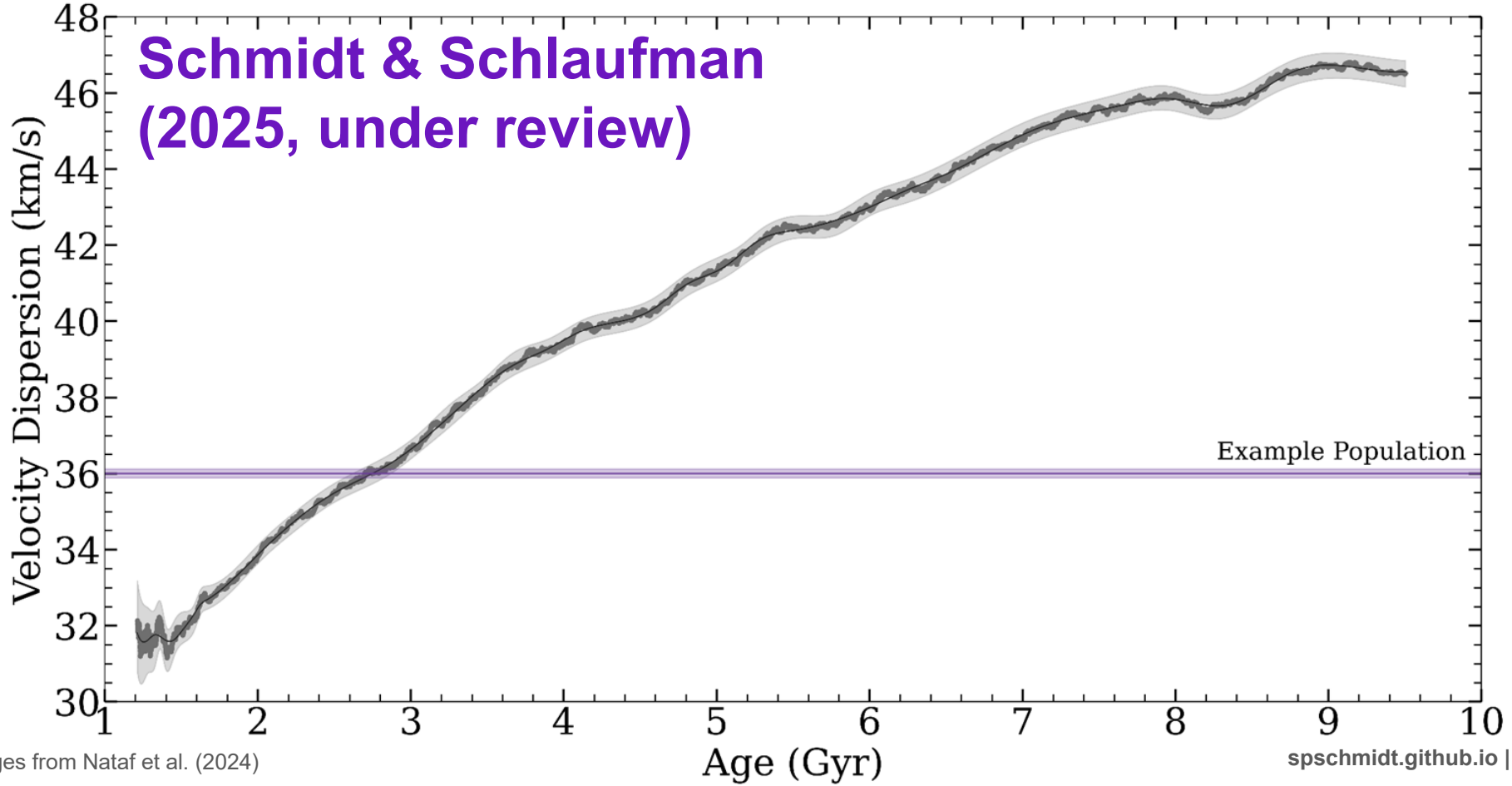

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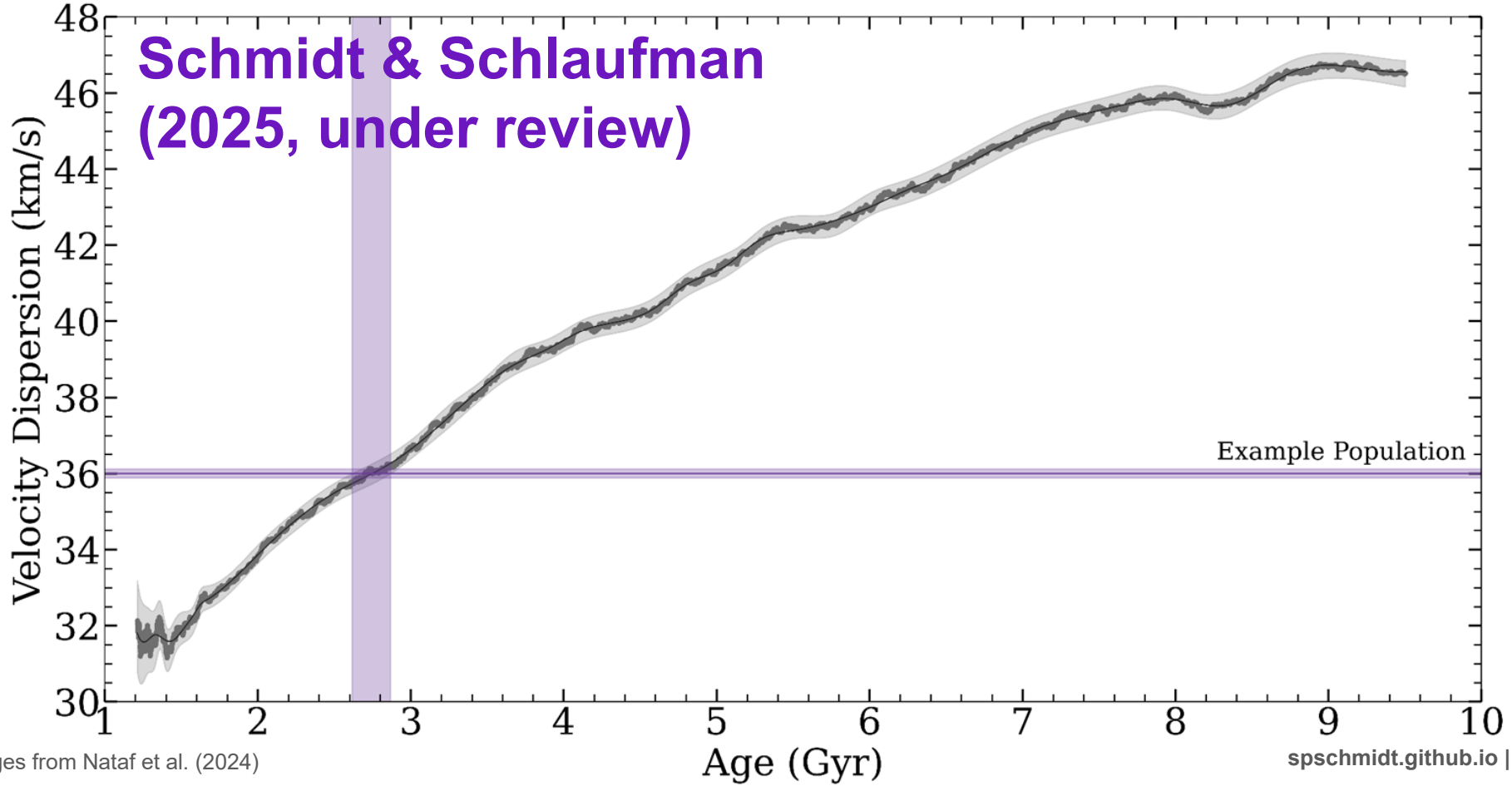

Ages from Nataf et al. (2024)

Detection Method Selection Biases

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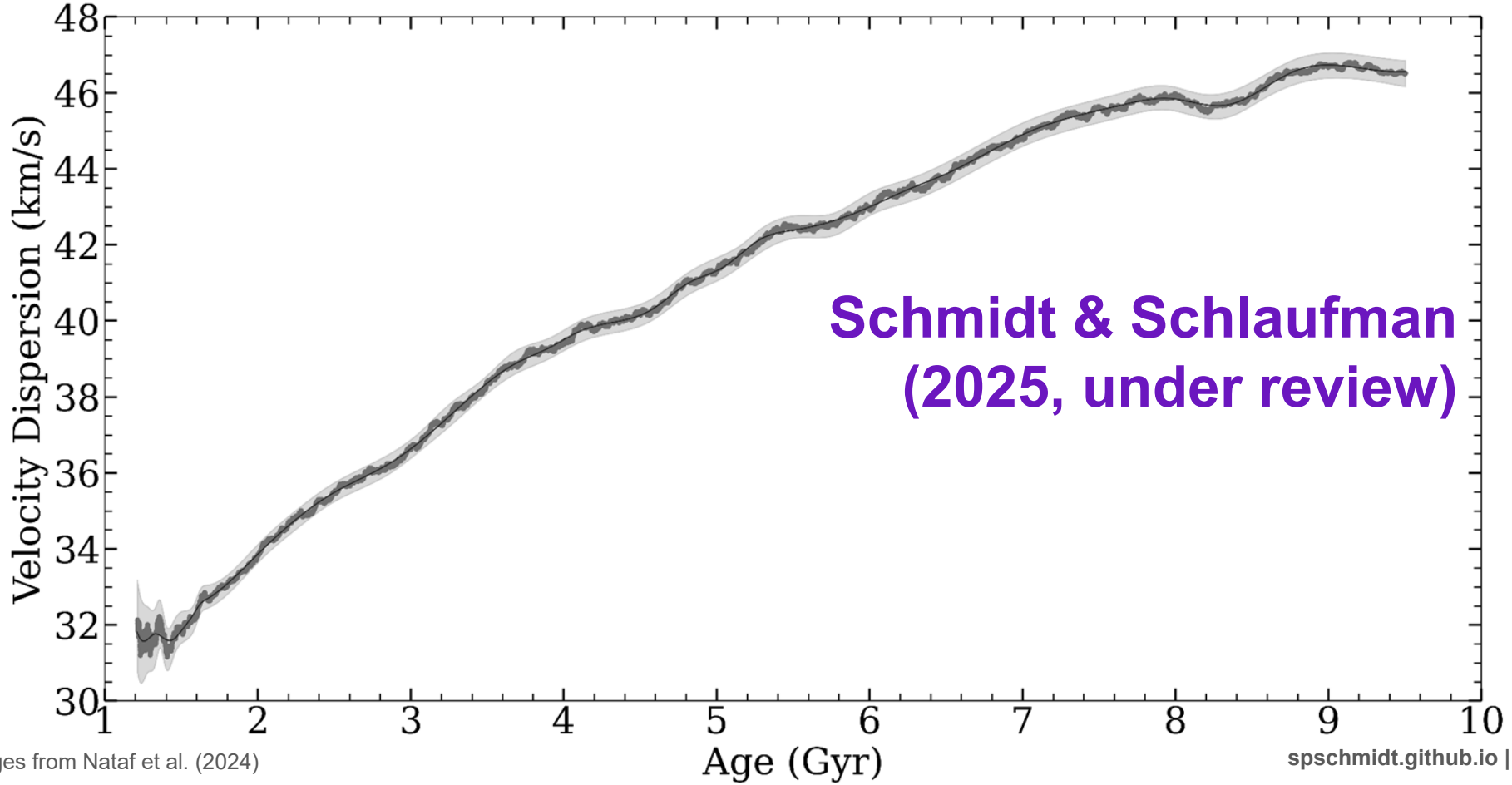

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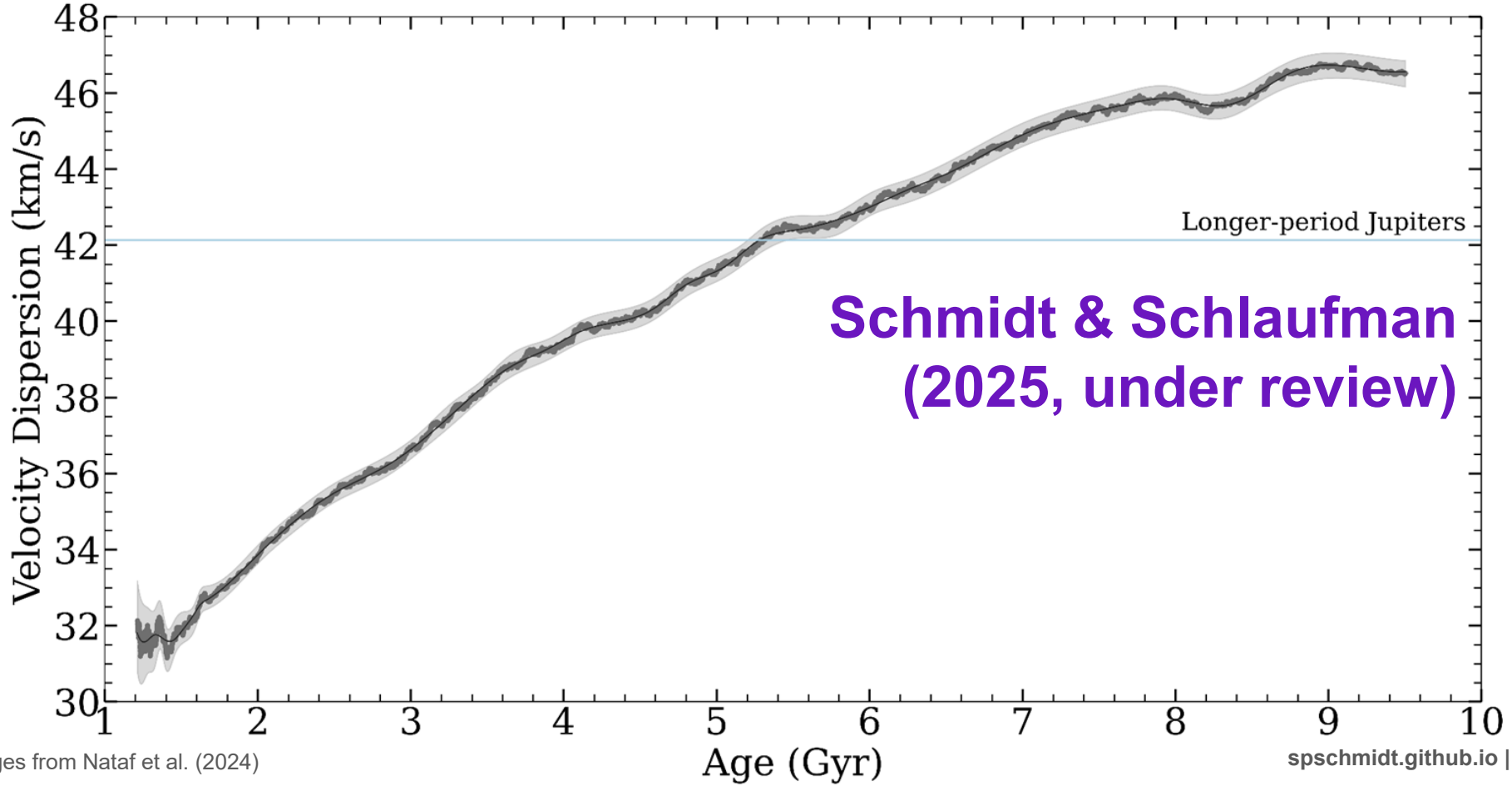

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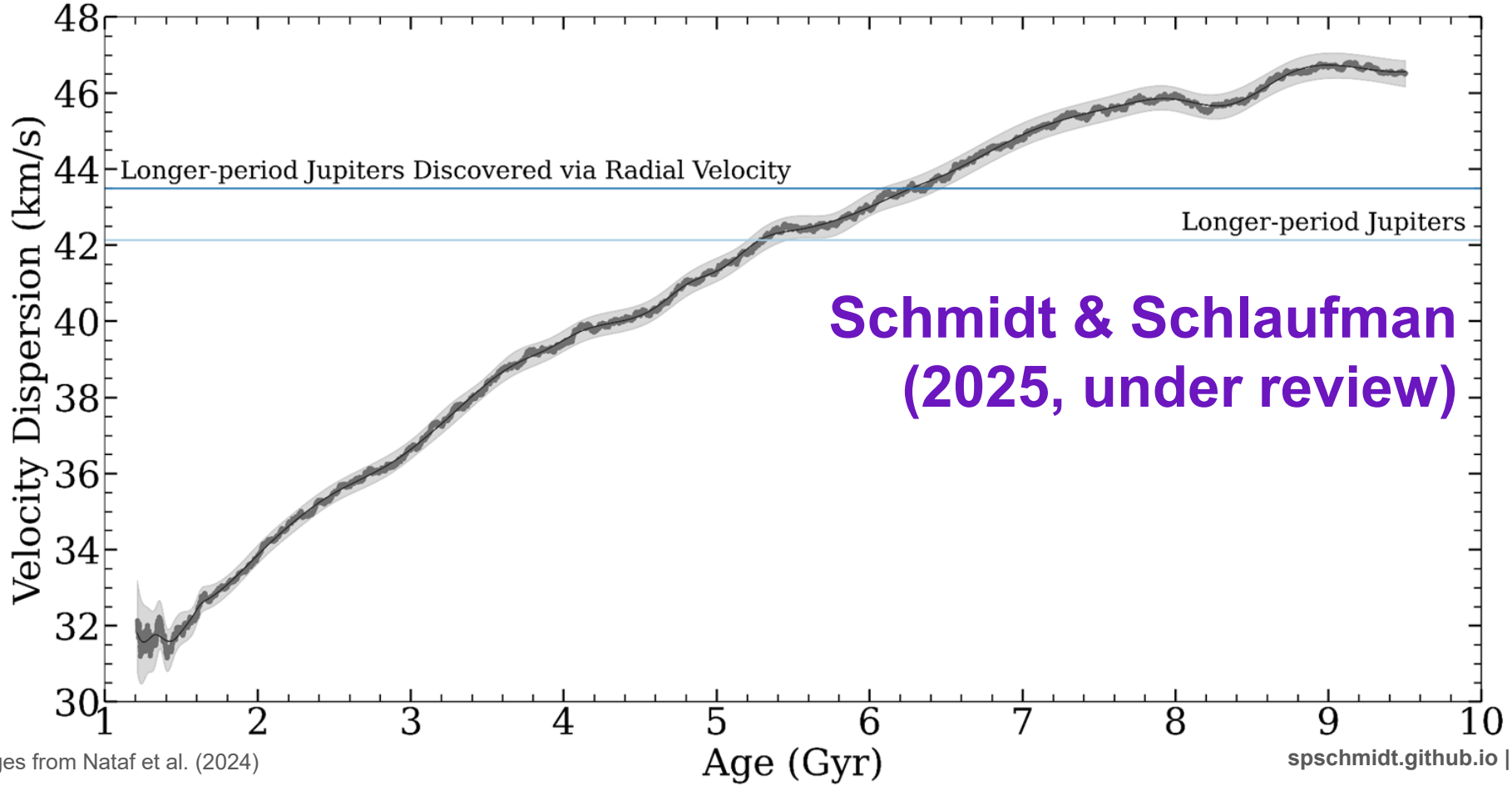

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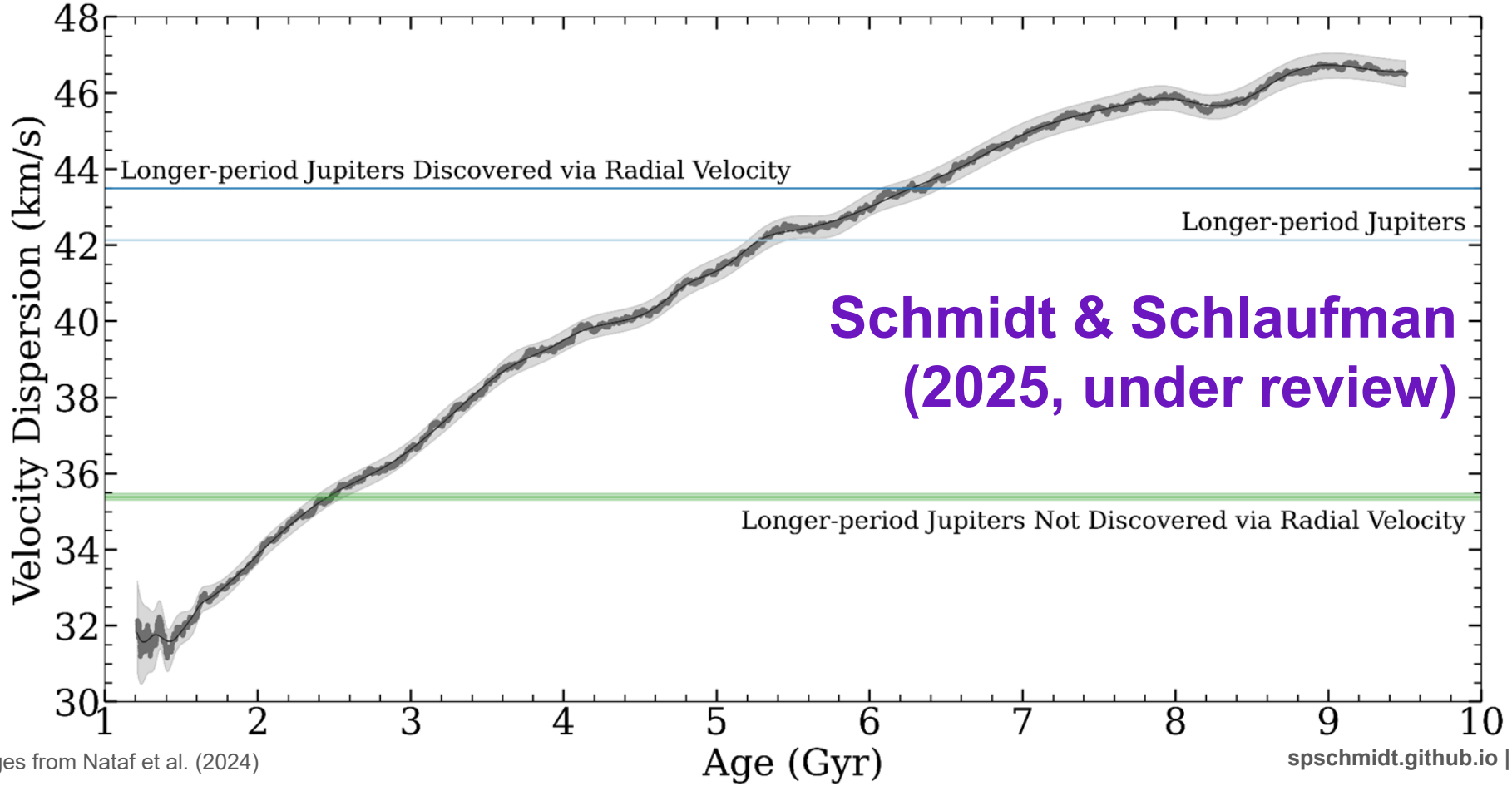

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Hot Jupiter Subpopulation Ages

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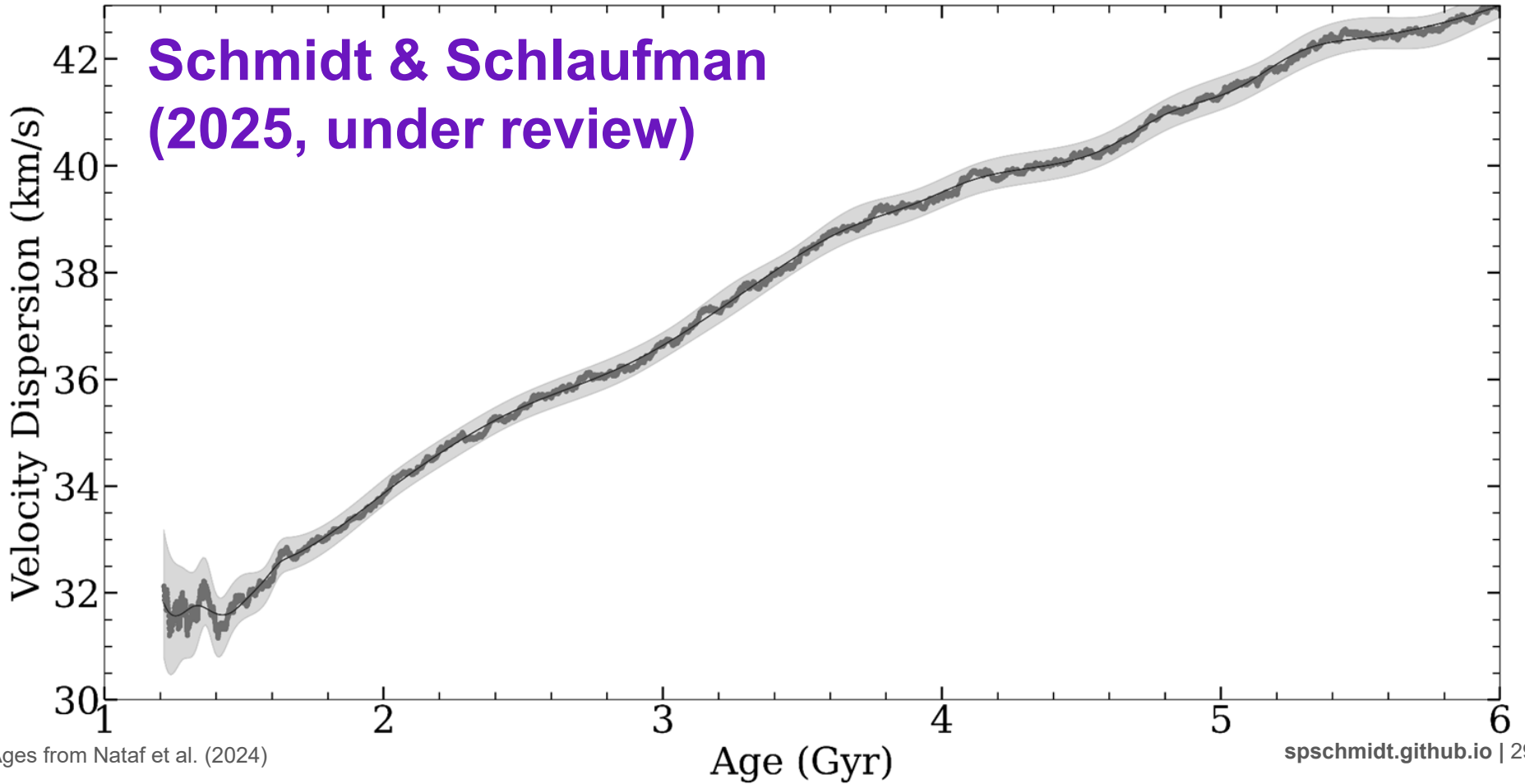

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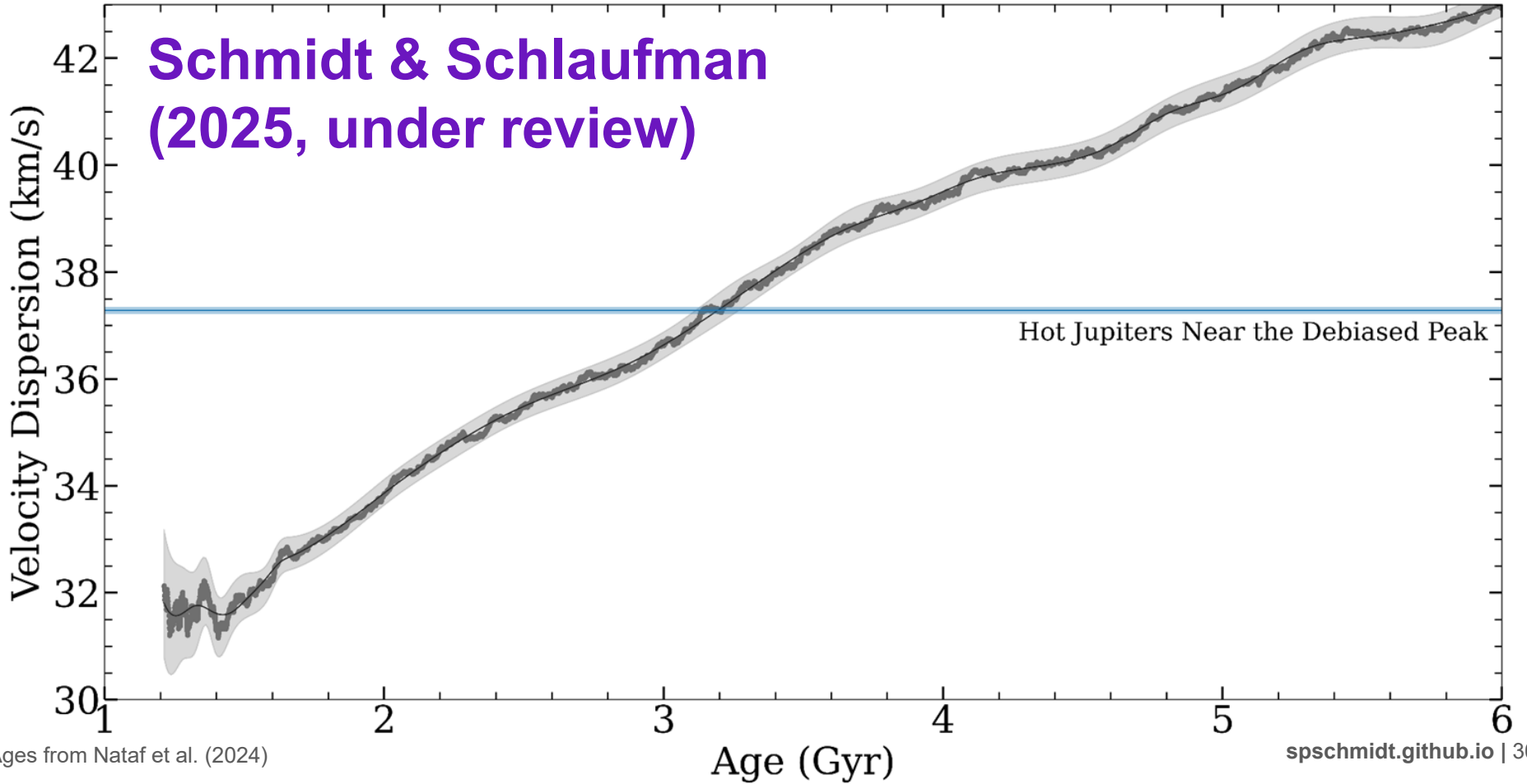

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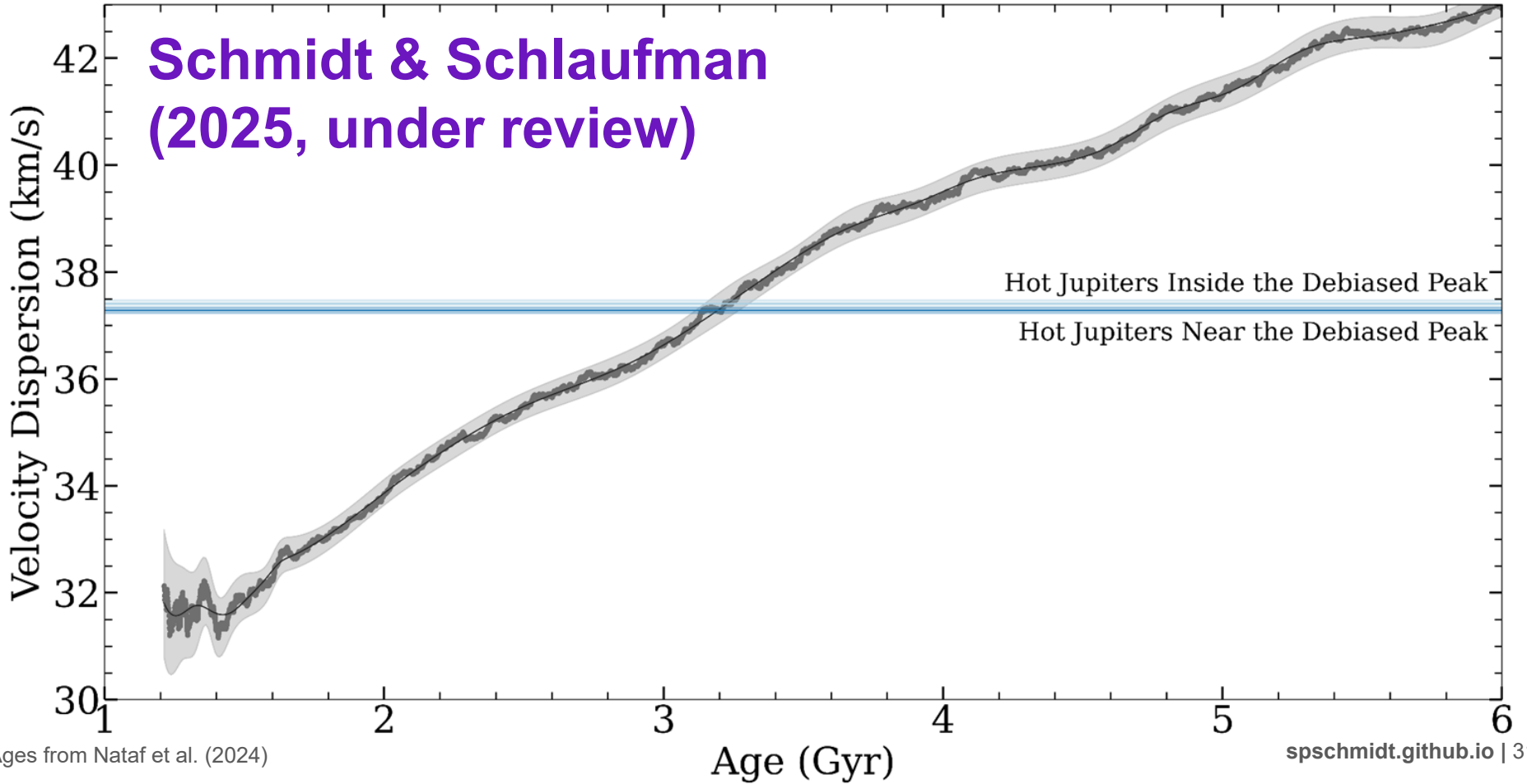

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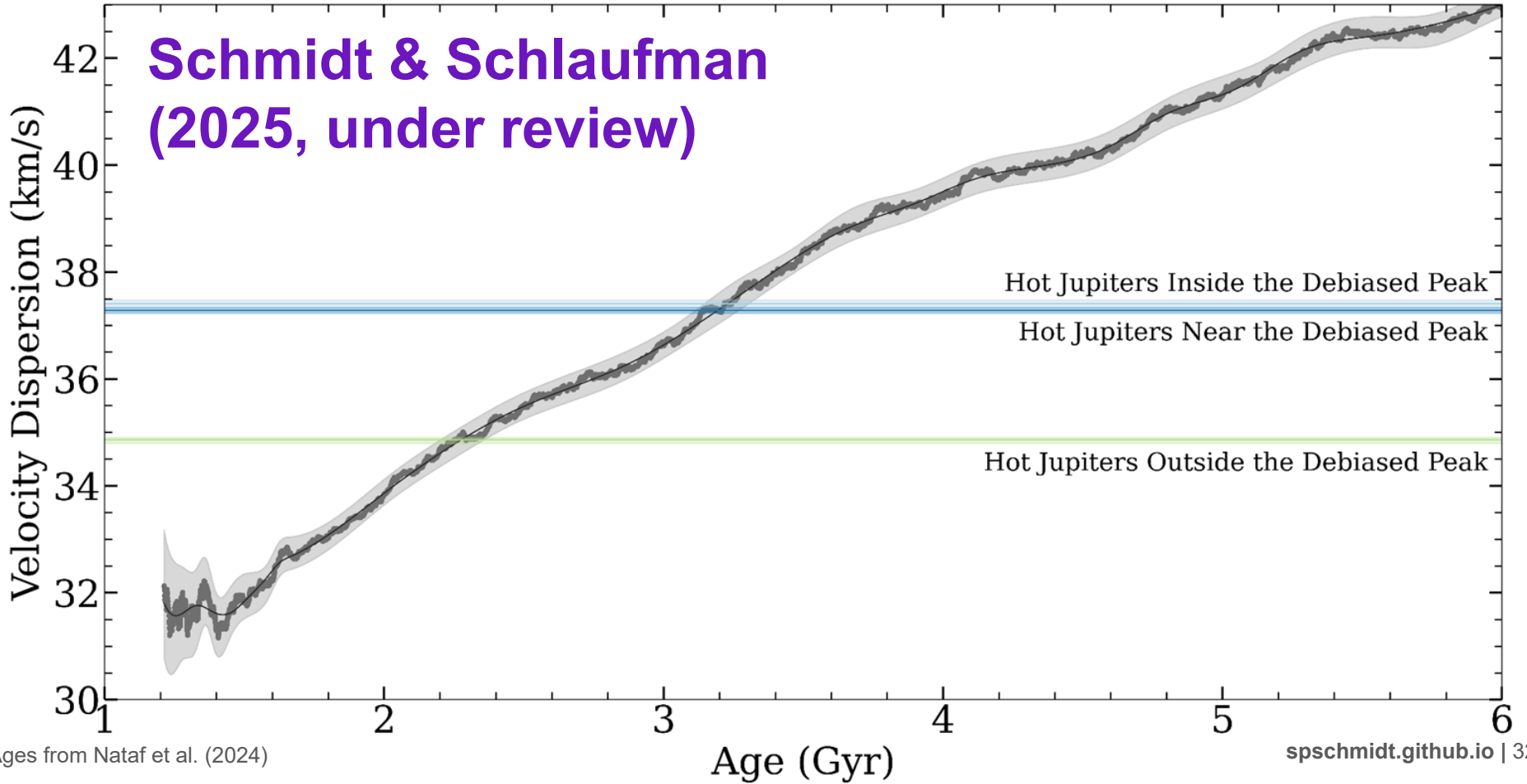

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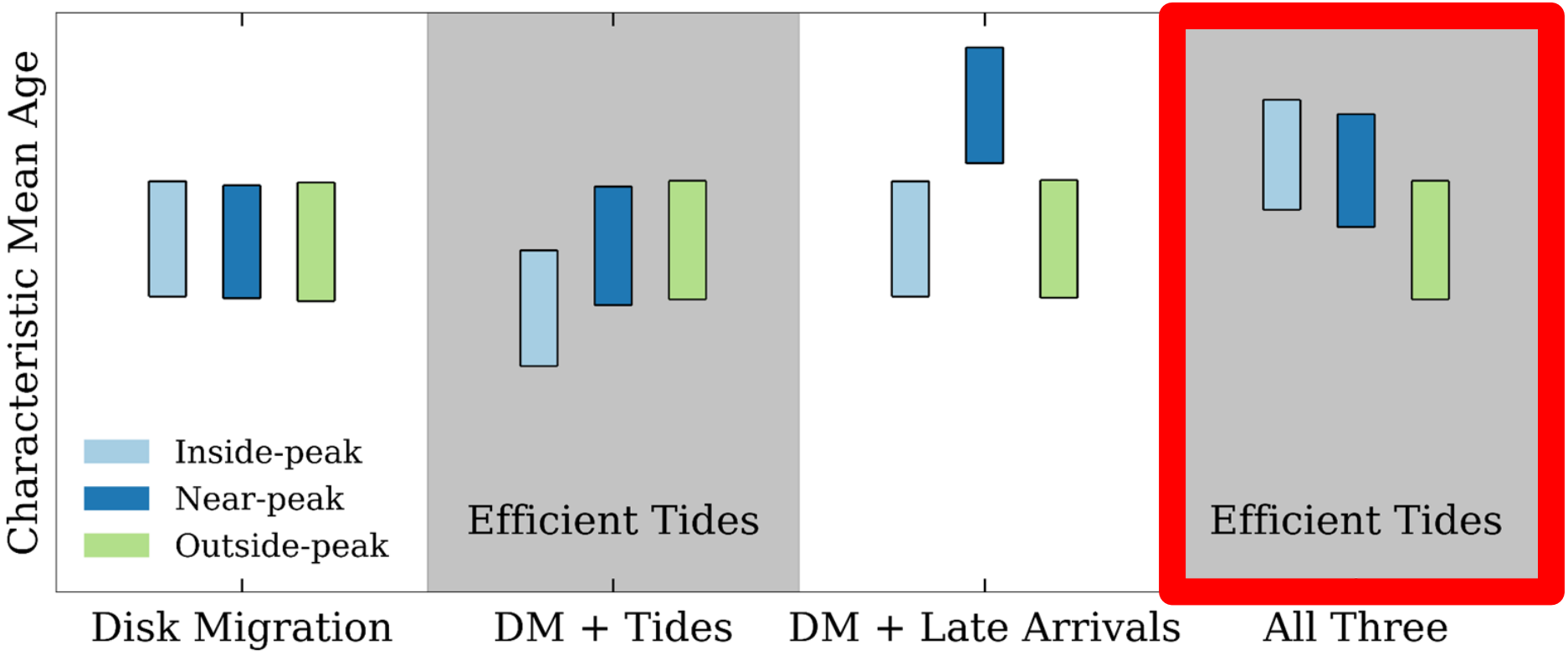

Parametric Forward Model vs. Ground Truth

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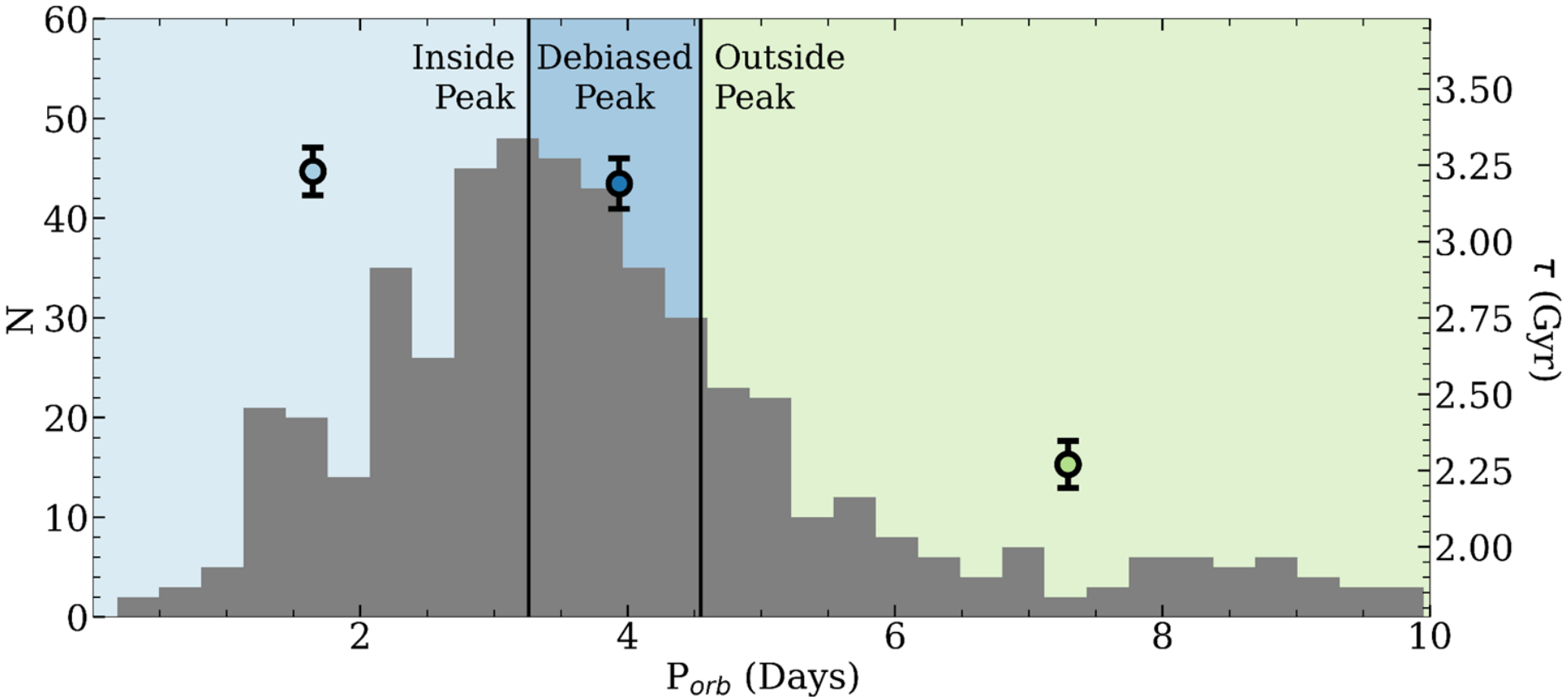

Forward Model Tuning Parameters

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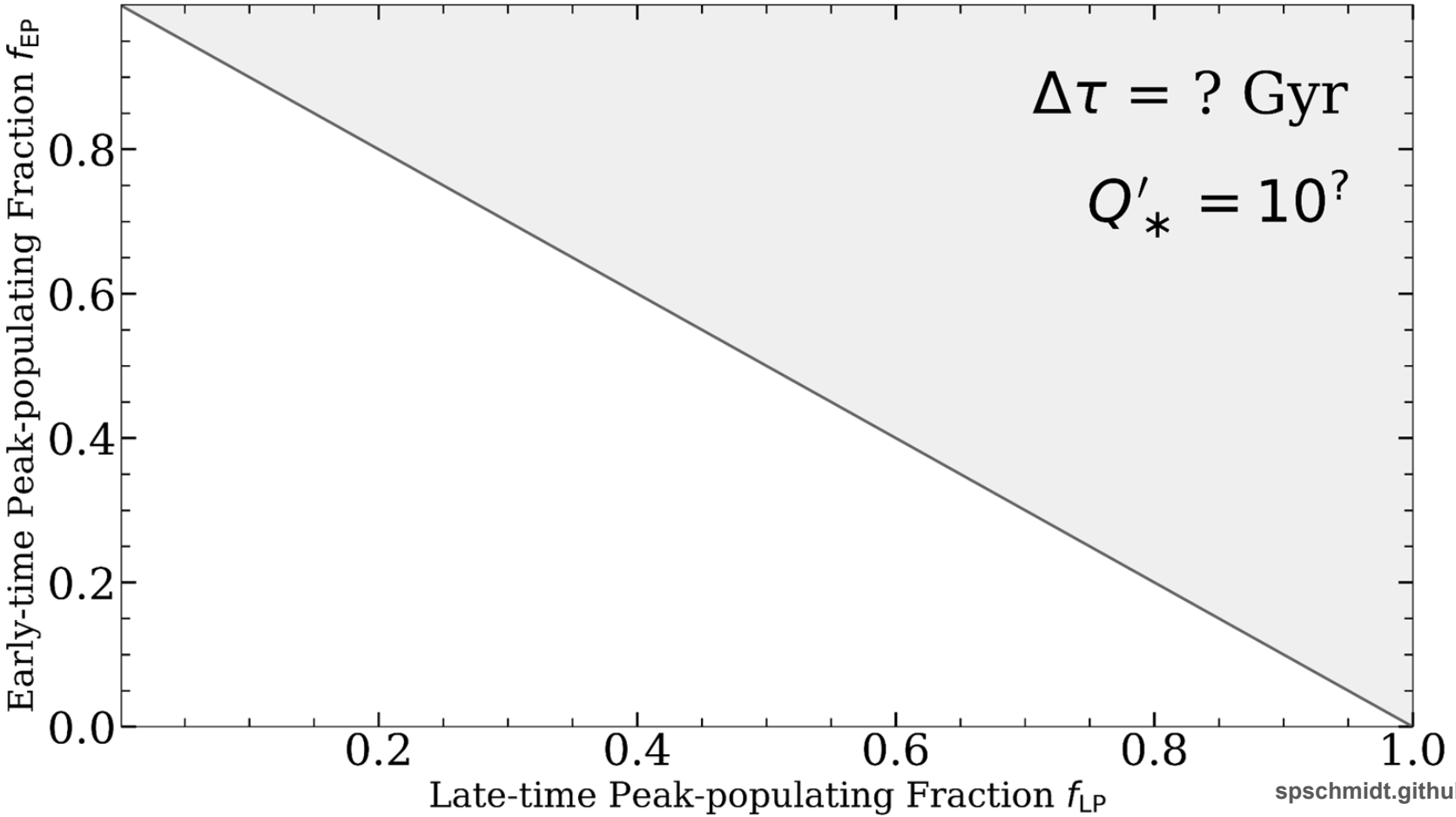

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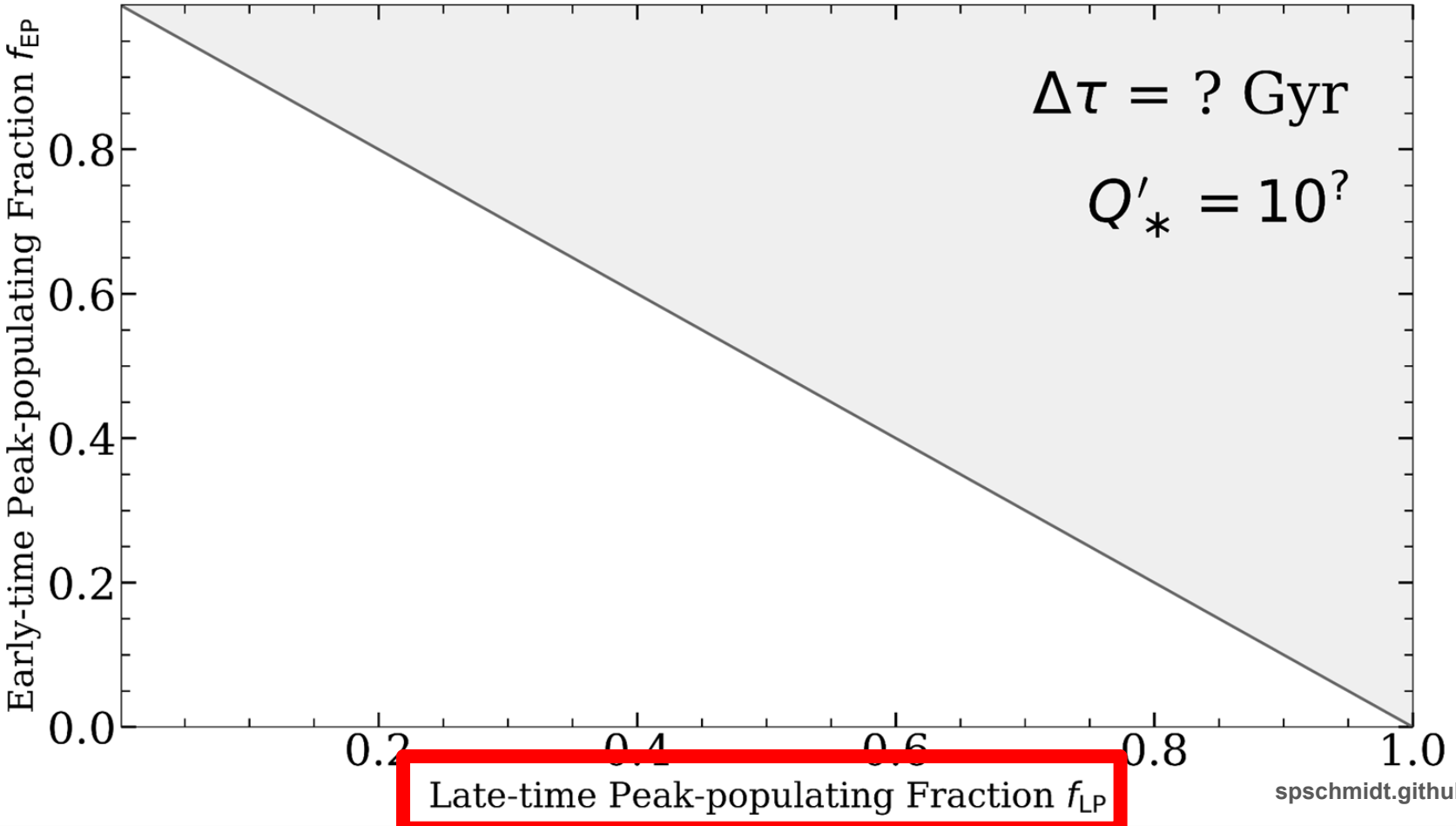

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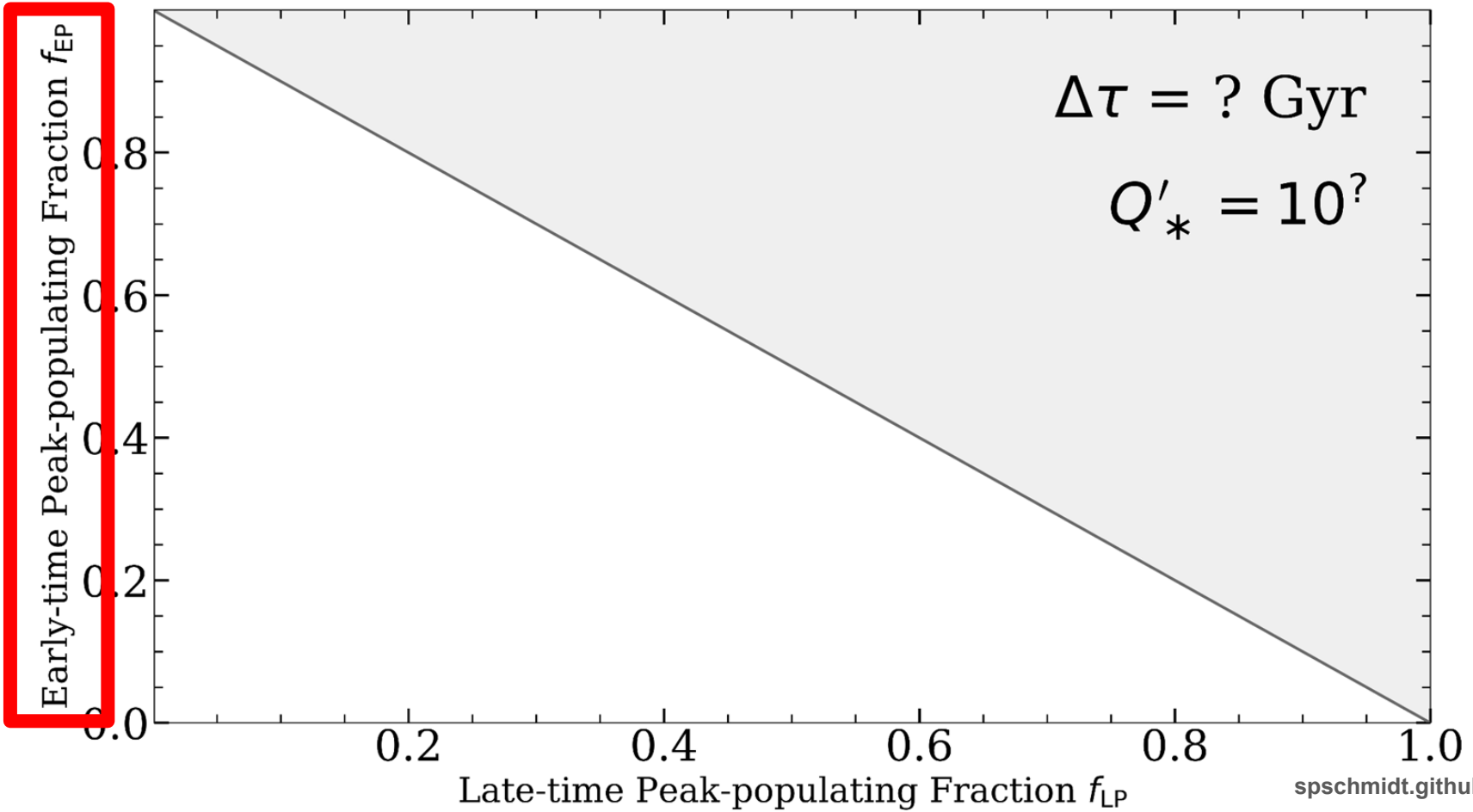

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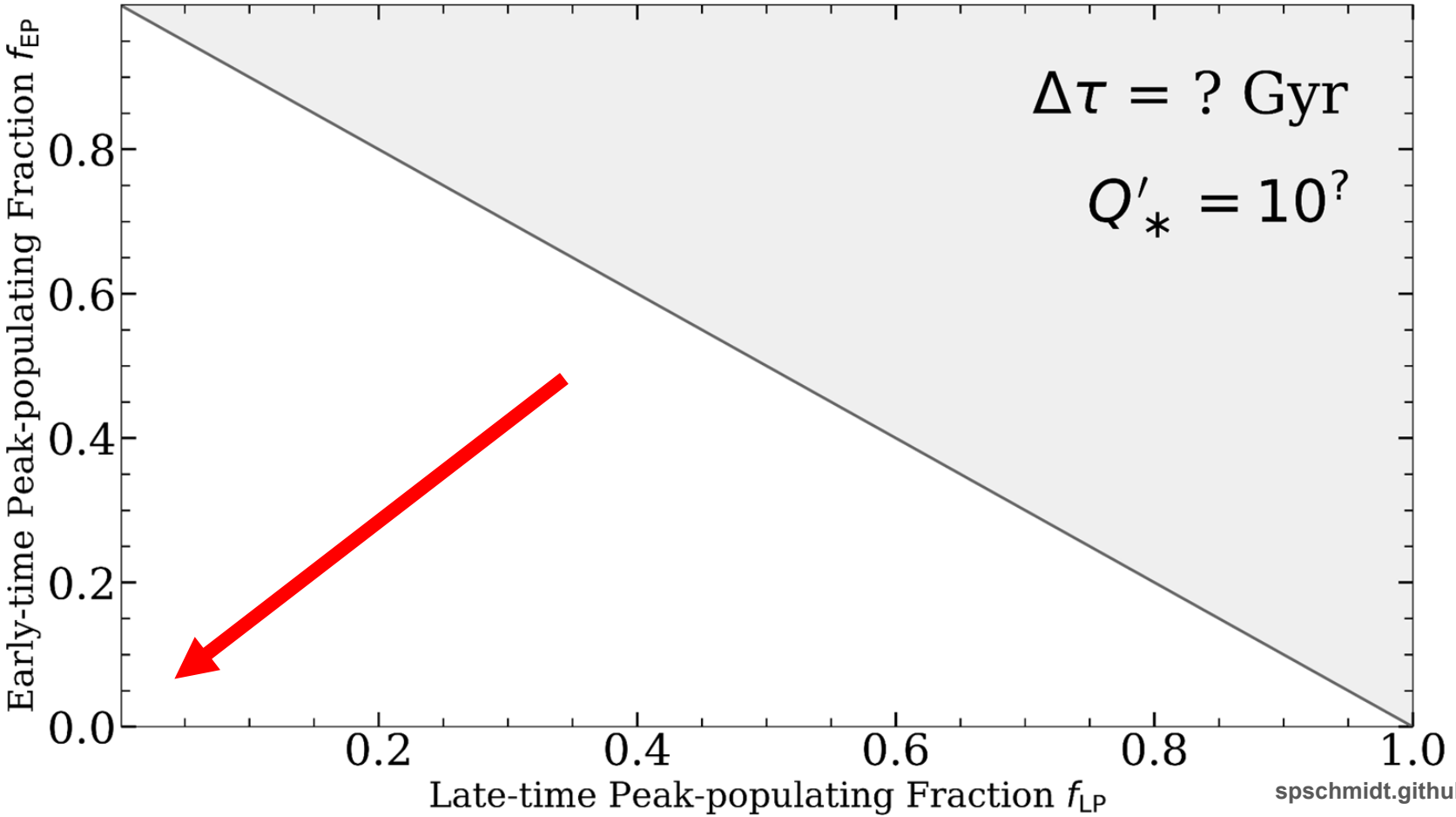

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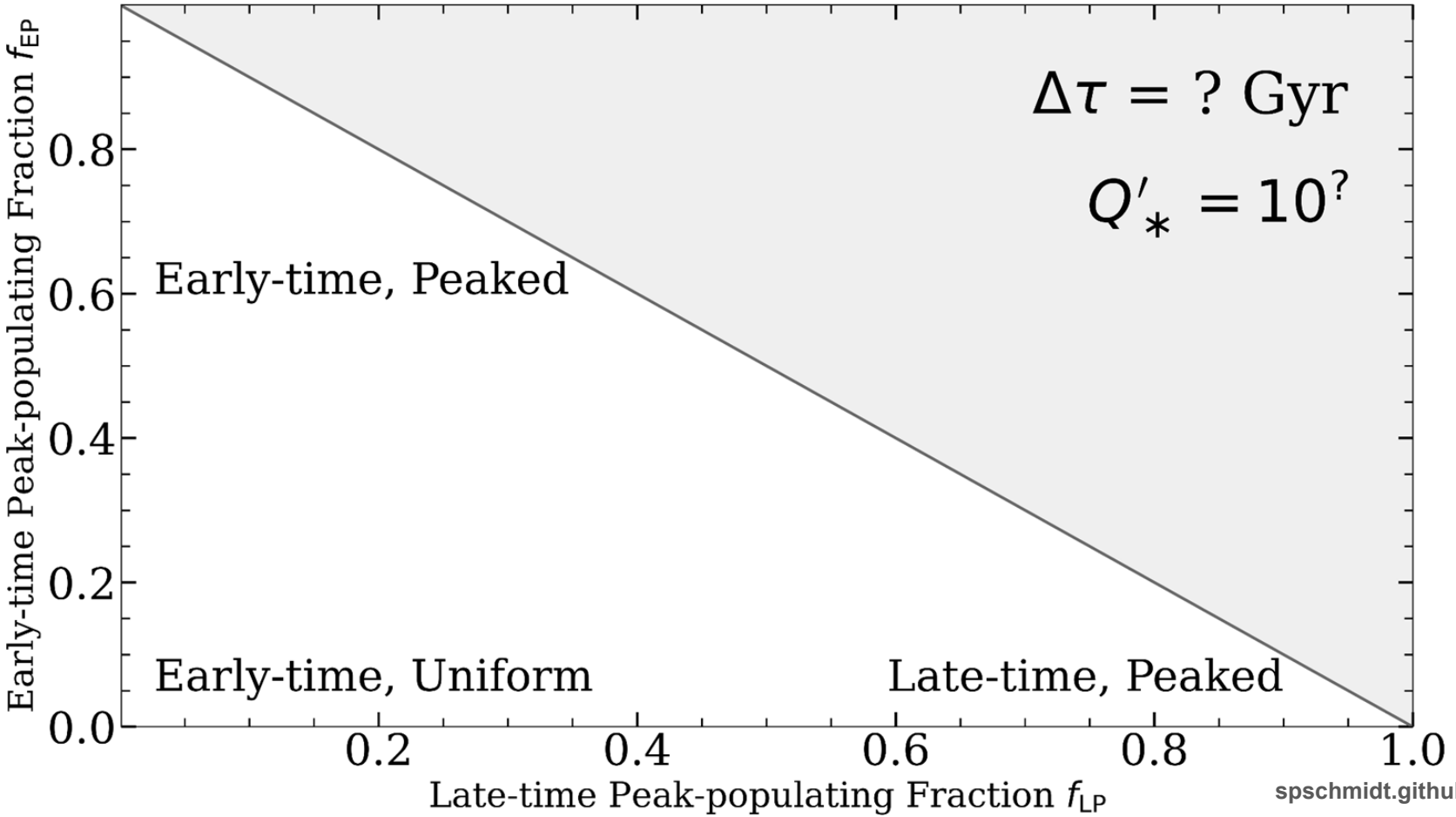

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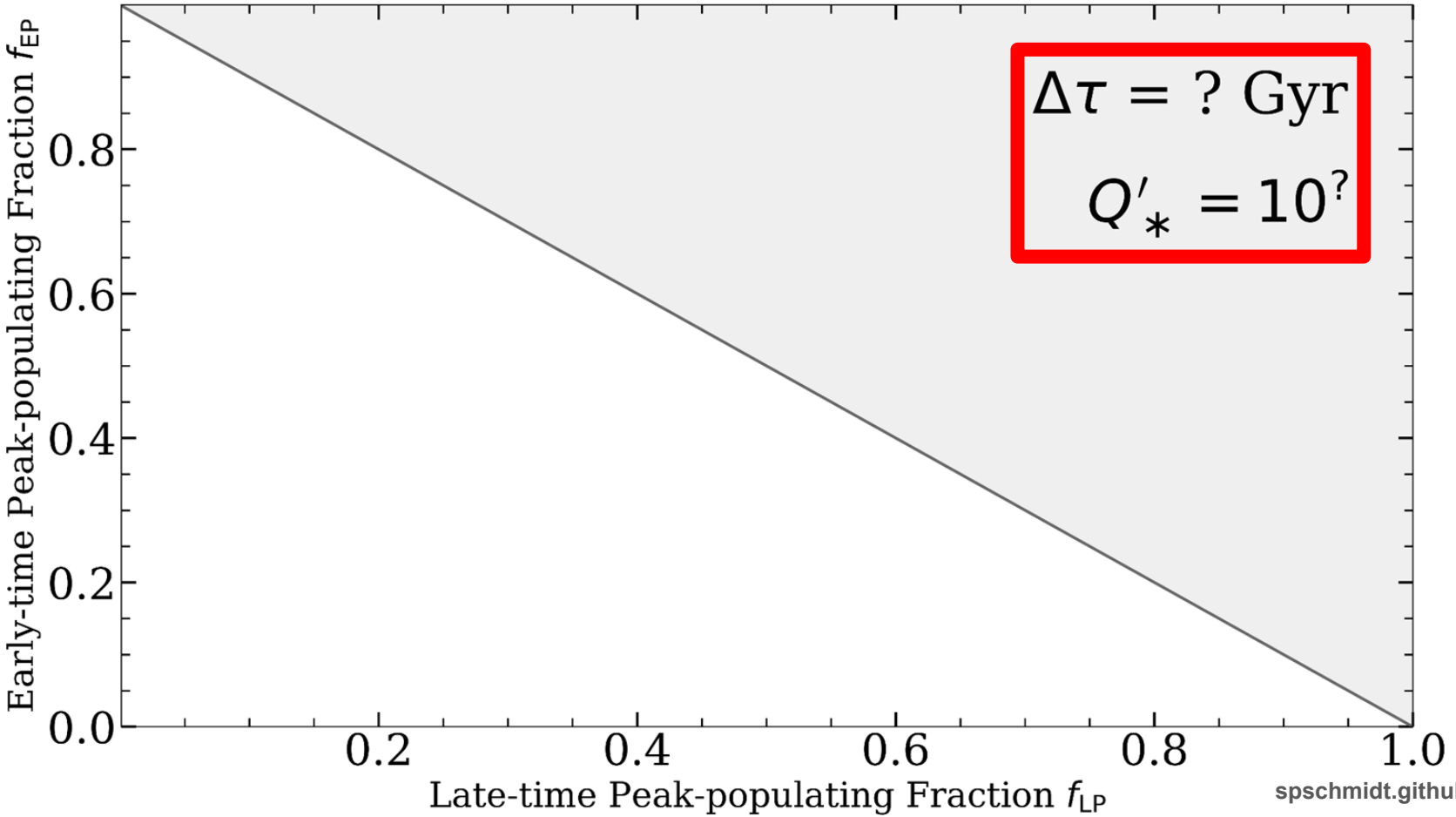

Forward Model Results Explanation

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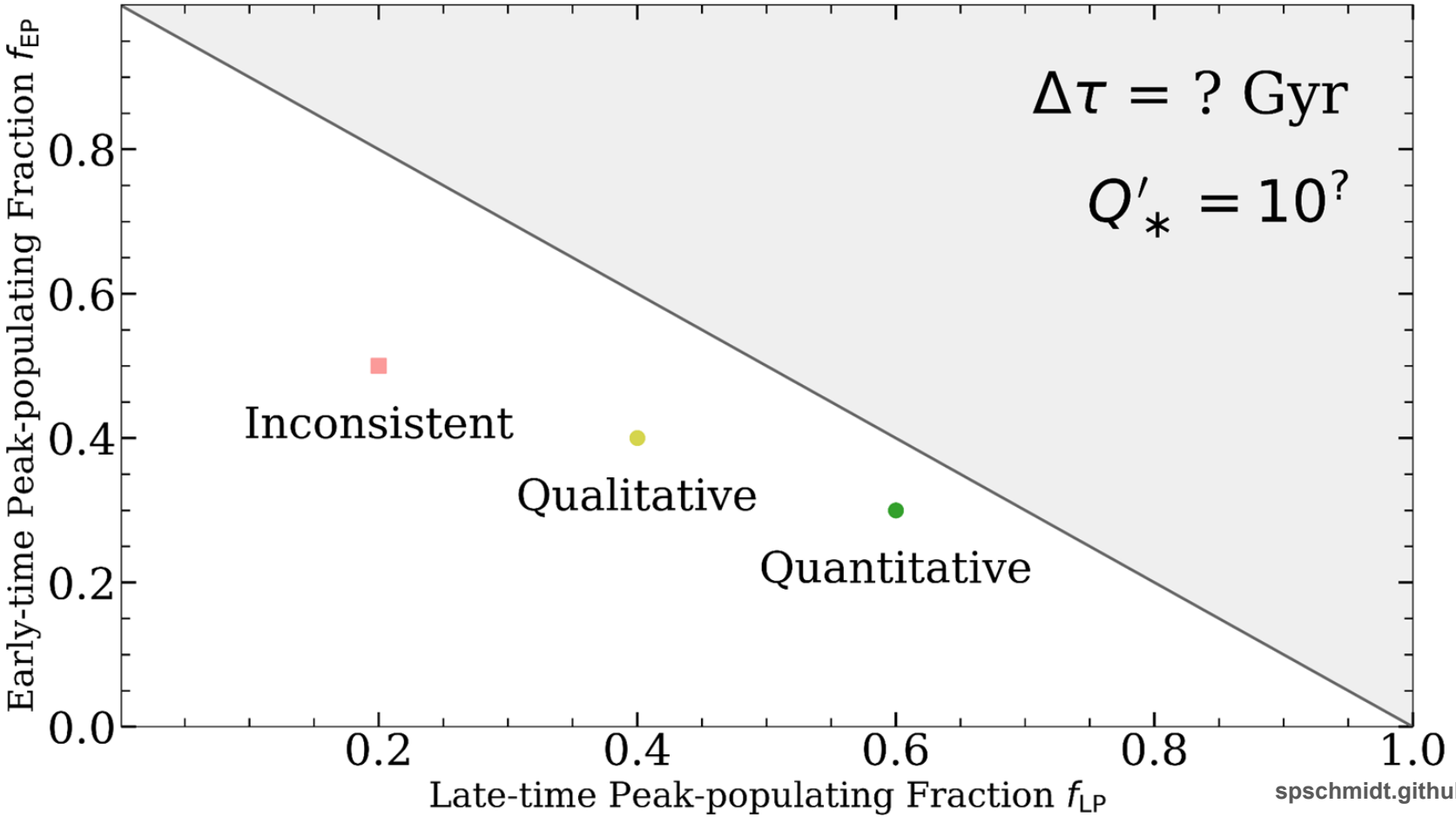

We Need Some Tidal Dissipation

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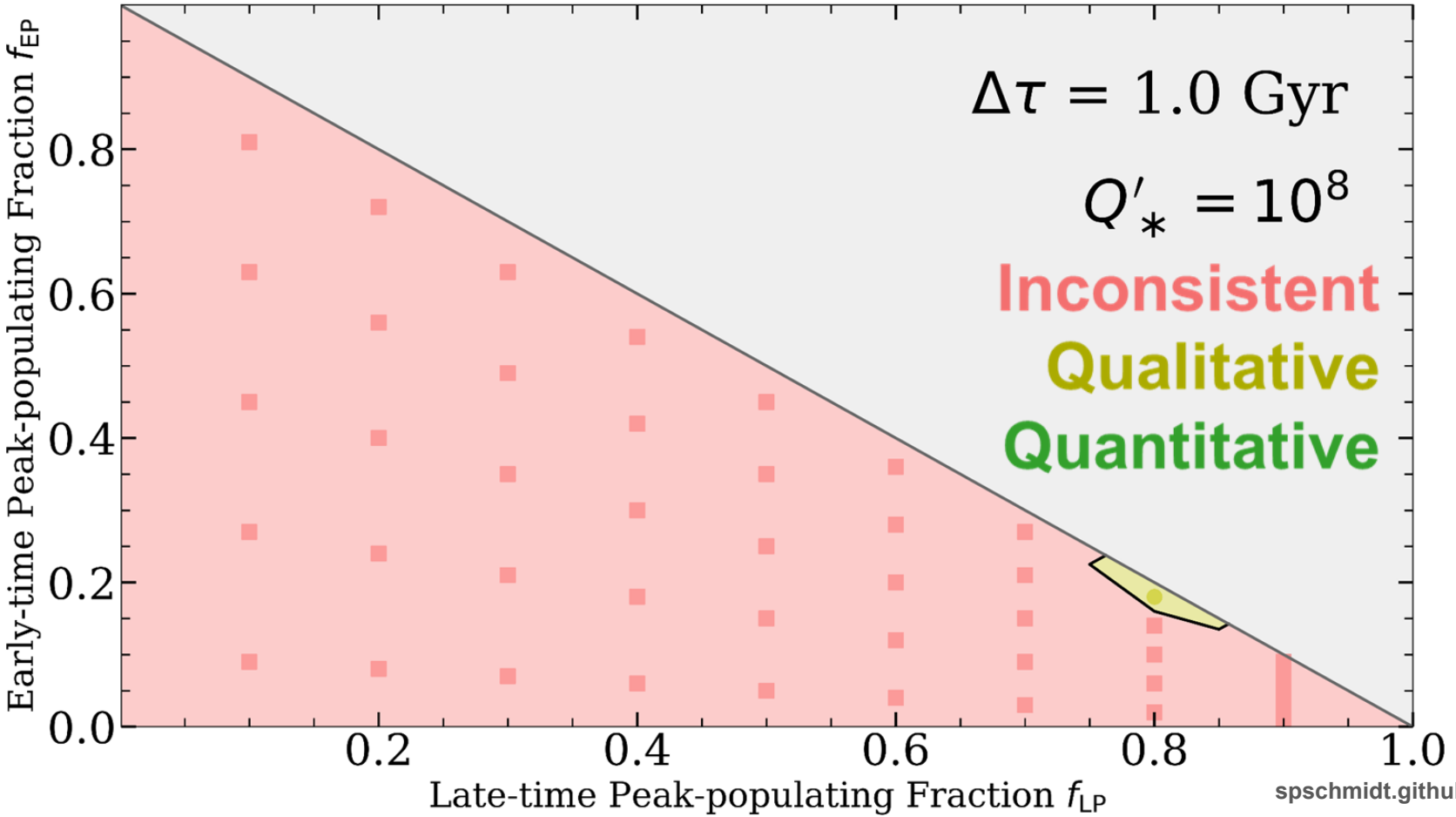

But Not Too Much

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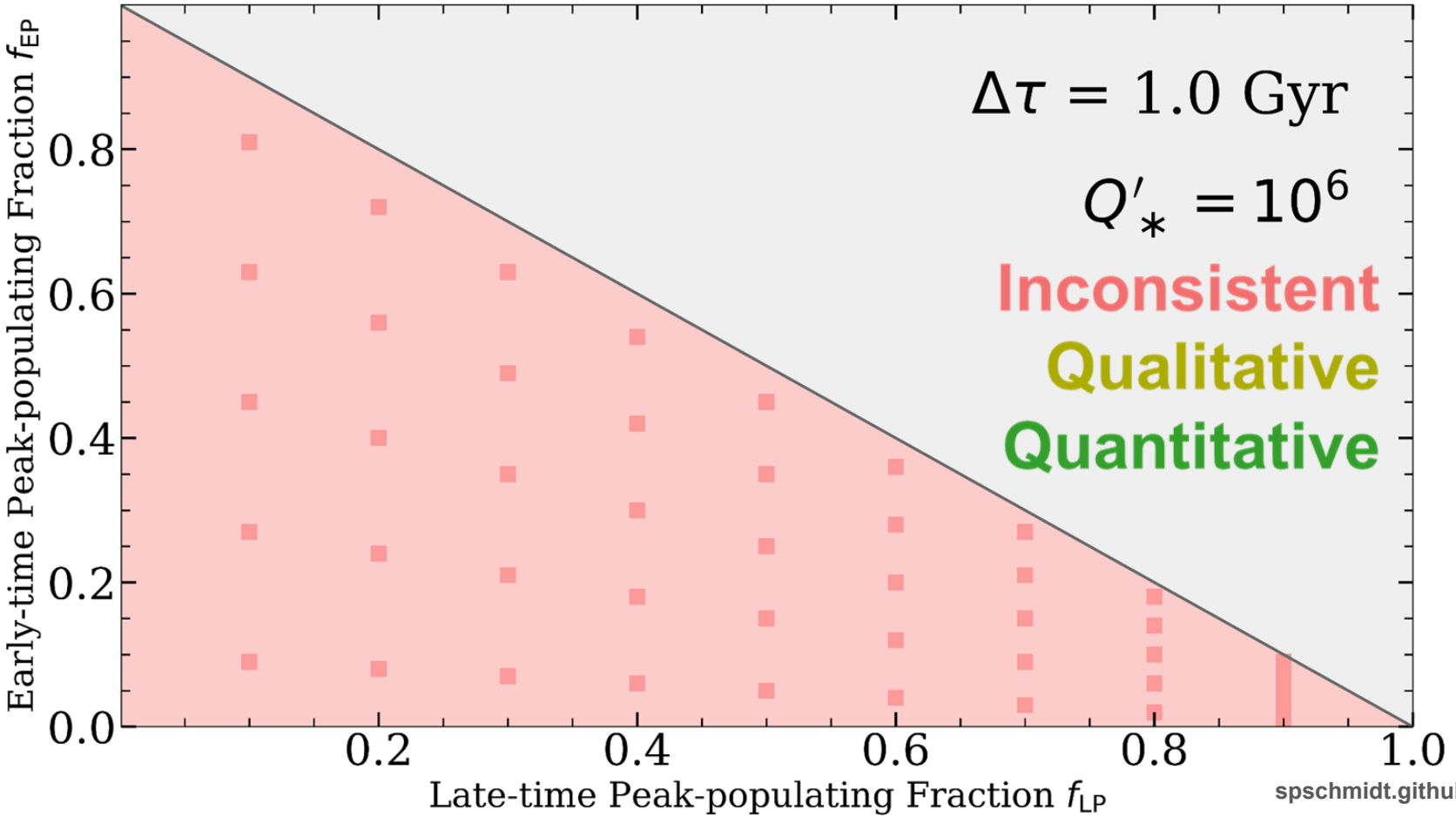

Qualitative Results at Low Time Lags

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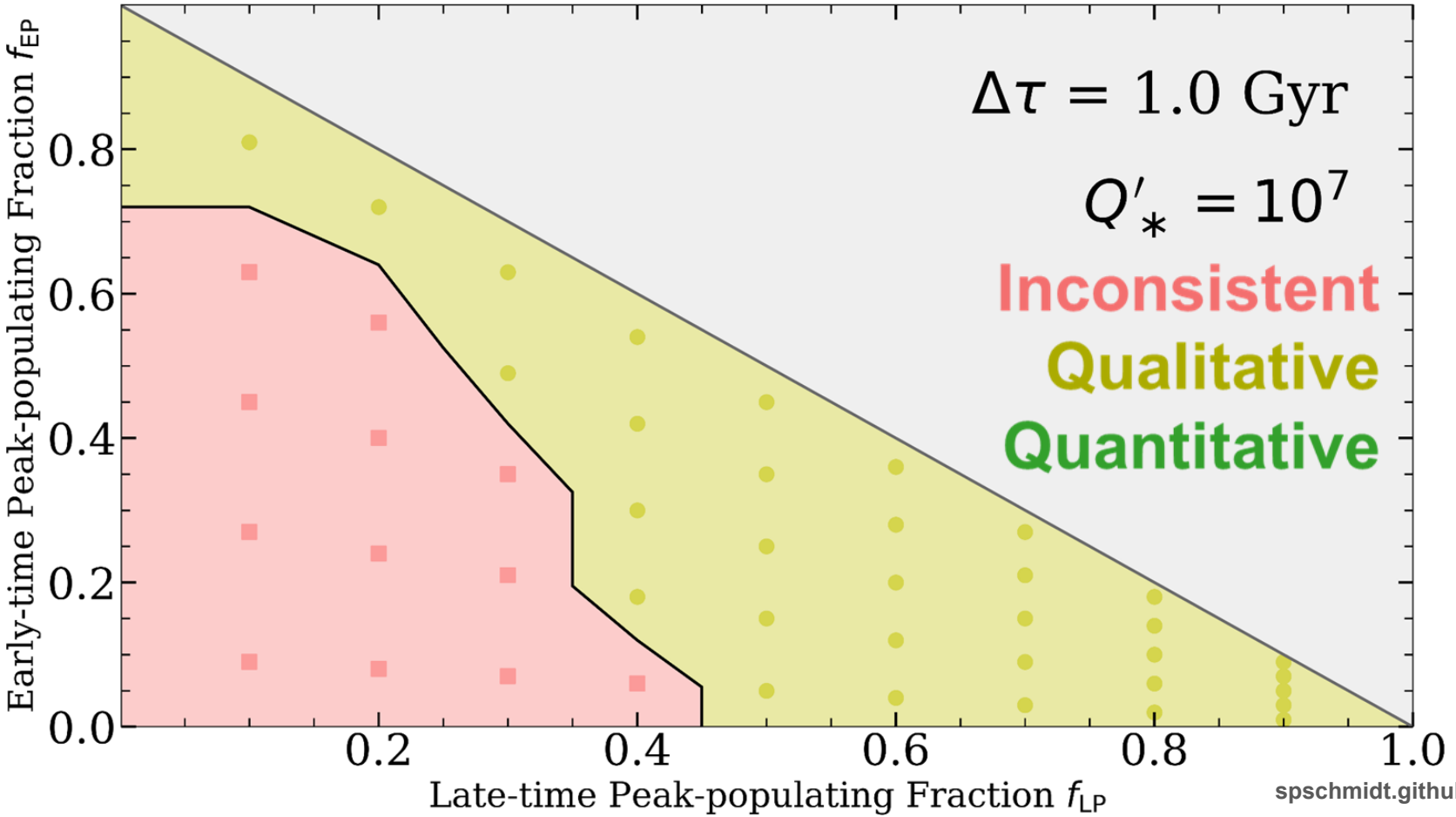

Quantitatively Consistent Results at >1.5 Gyr

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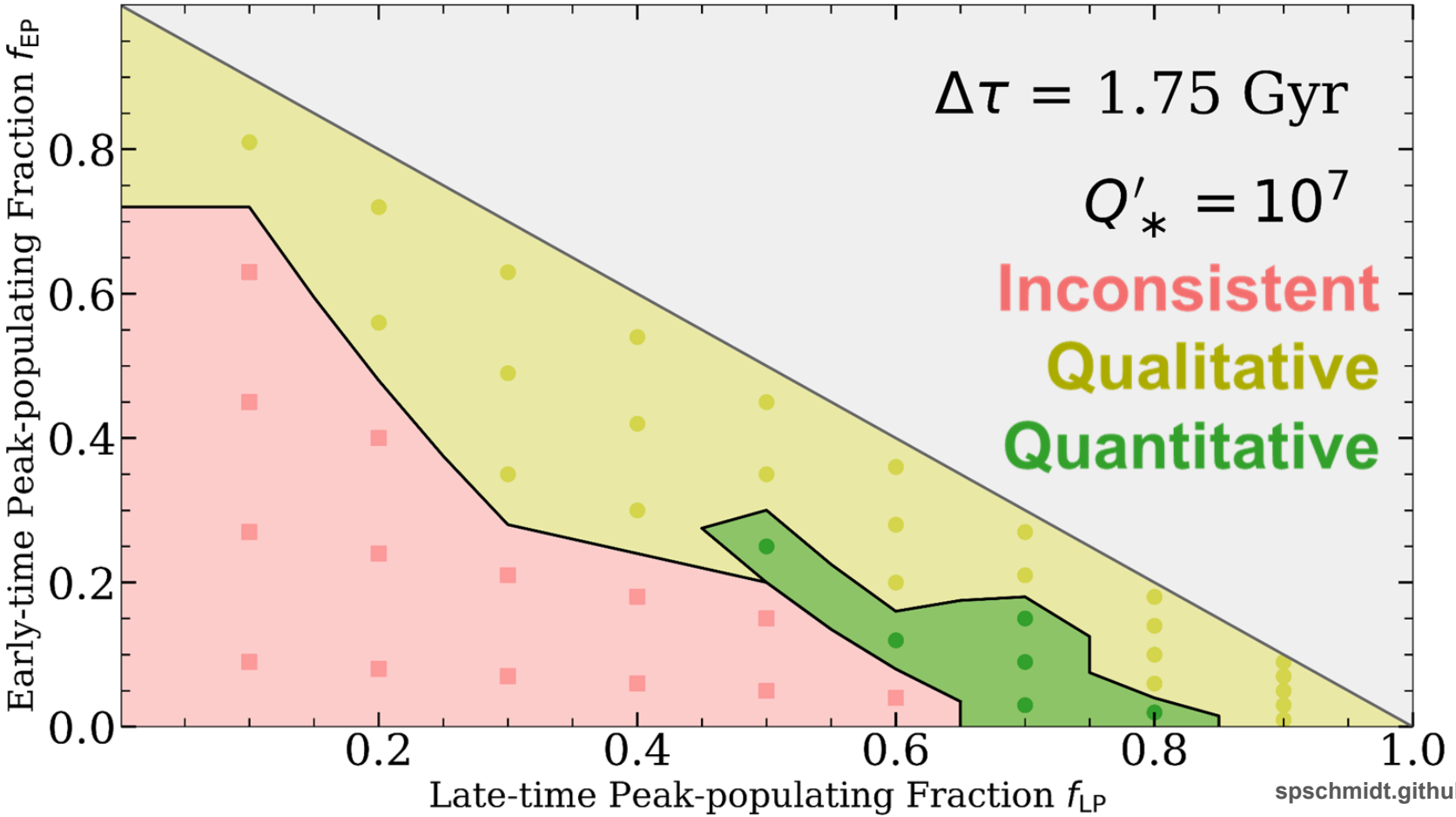

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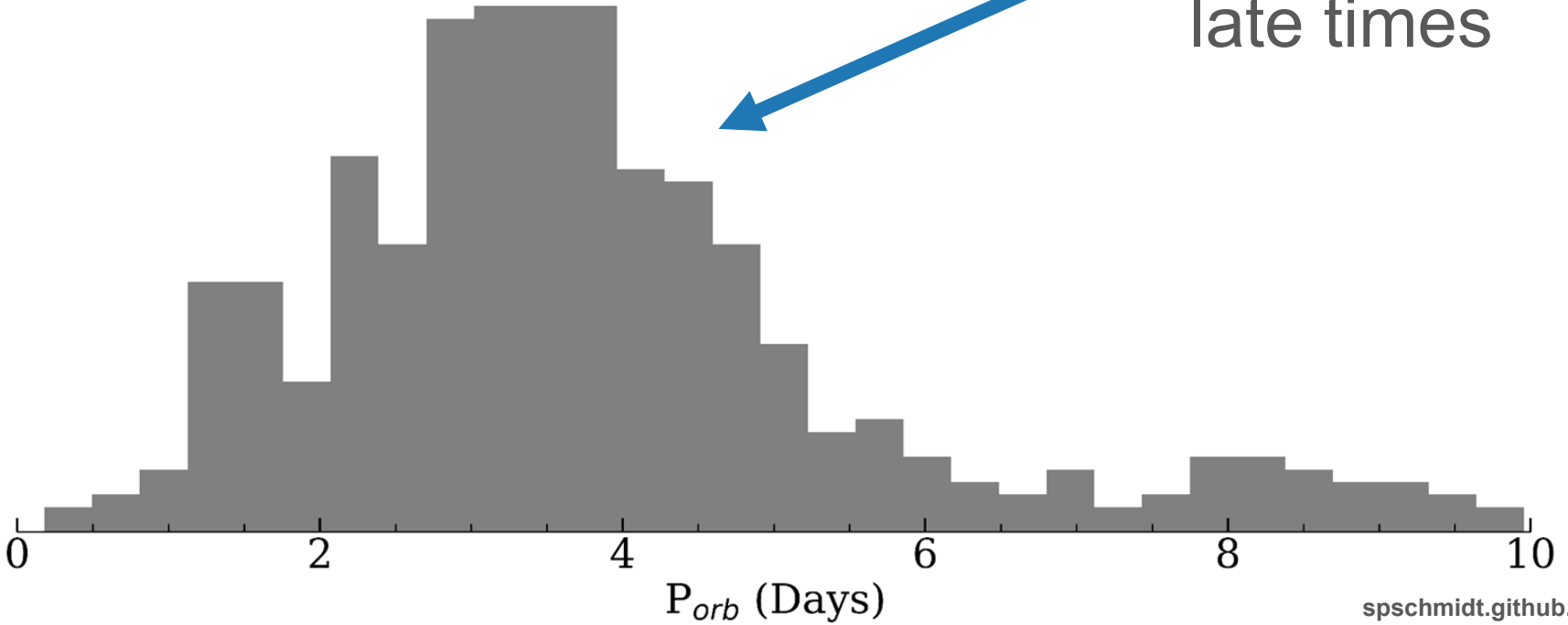
Mostly high-e migration at late times



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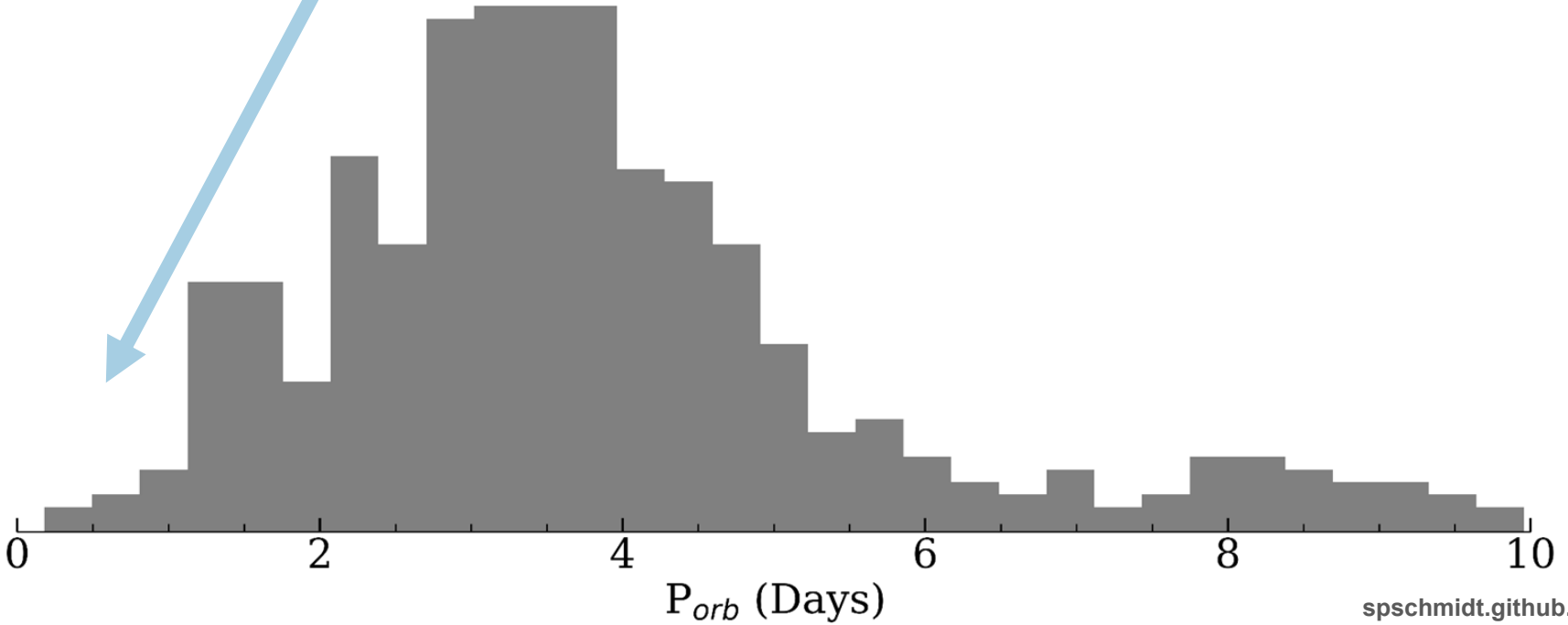
Combination of mechanisms
+ tidal evolution



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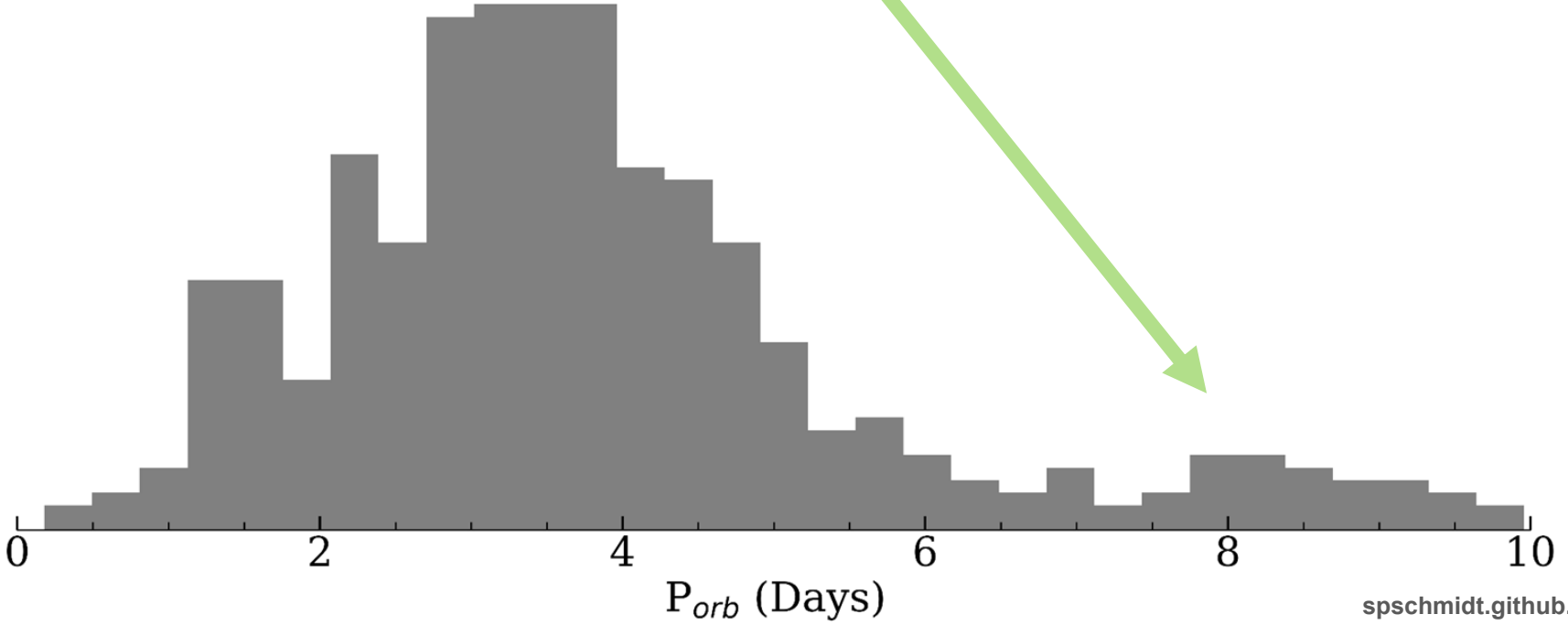
Mostly disk migration / in situ formation?



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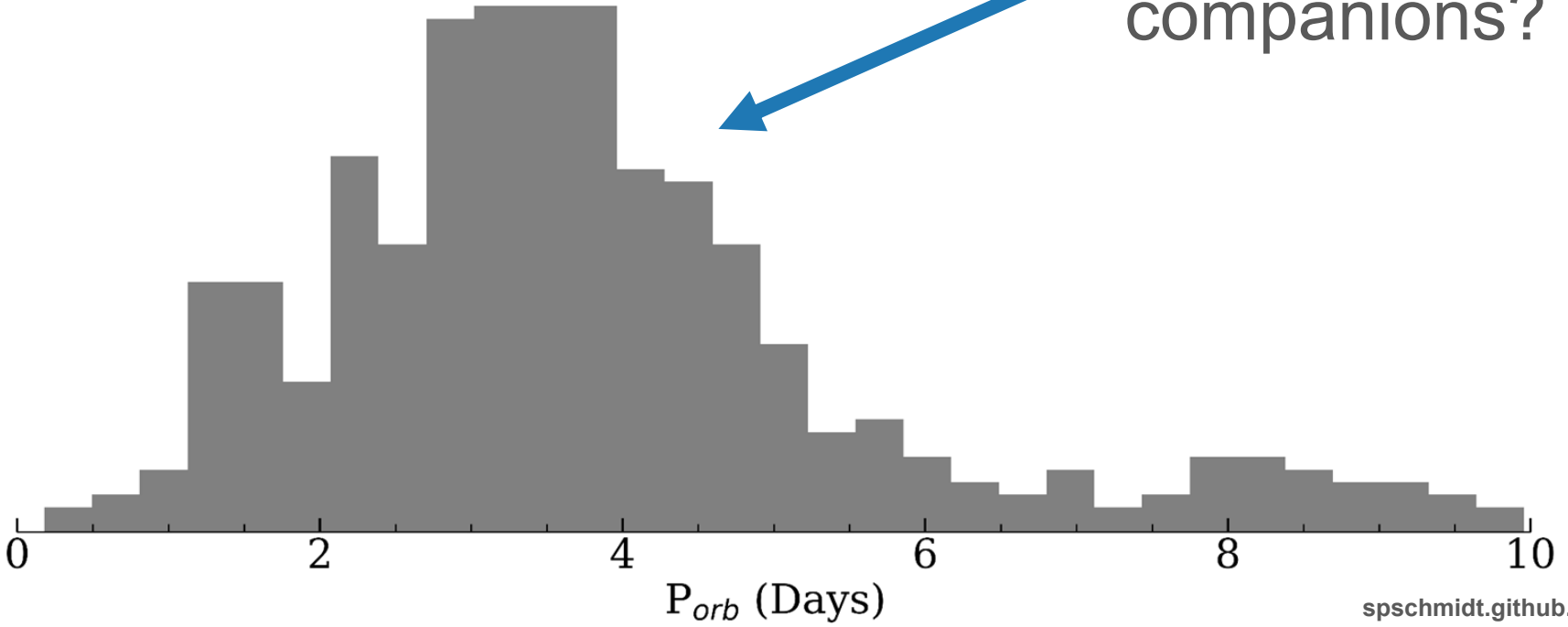
More likely to have outer companions?



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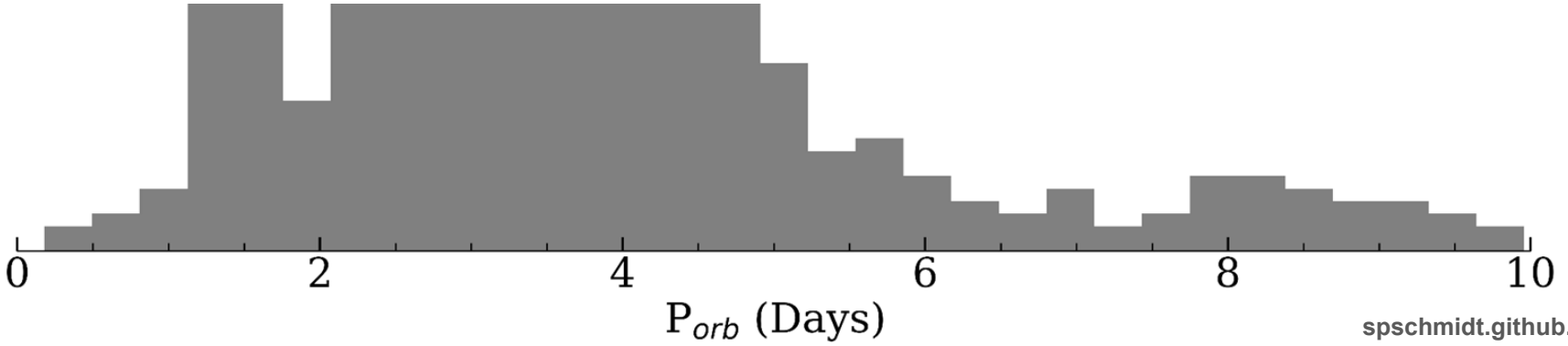
The younger hot Jupiter population would be less peaked?



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(1) We have time resolved giant planet formation outside the solar system for the first time!

(2) **Most hot Jupiters are late arrivals**, typically taking 1.5 Gyr or more to arrive at their observed locations.

(3) Hot Jupiters with P_{orbit} > 5 days may have formed in a different manner than those near/inside the peak, (e.g., disk migration or in situ formation)