

# Time-resolving Hot Jupiter System Evolution with Population-level Stellar Age Inferences

**Stephen Schmidt**

Johns Hopkins University

Know Thy Star, Know Thy Planet II

February 4, 2025



Collaborator: Kevin Schlaufman

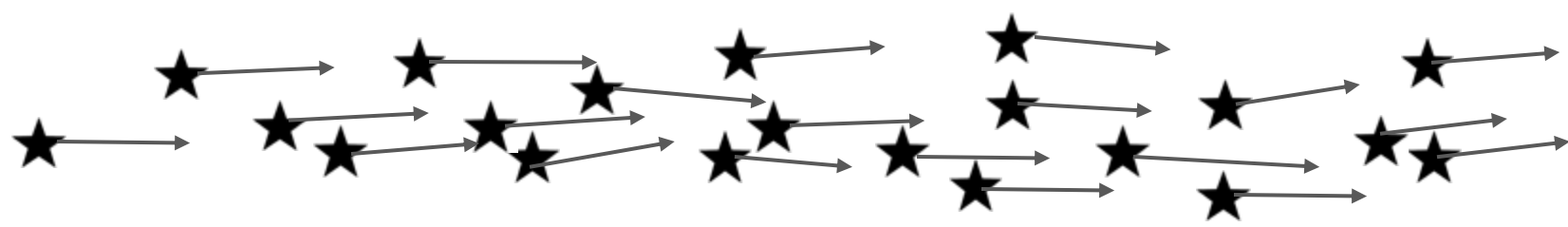
1-10 Myr: Formation, Disk-driven migration

10-100 Myr: Atmospheric mass loss, Planet-planet scattering

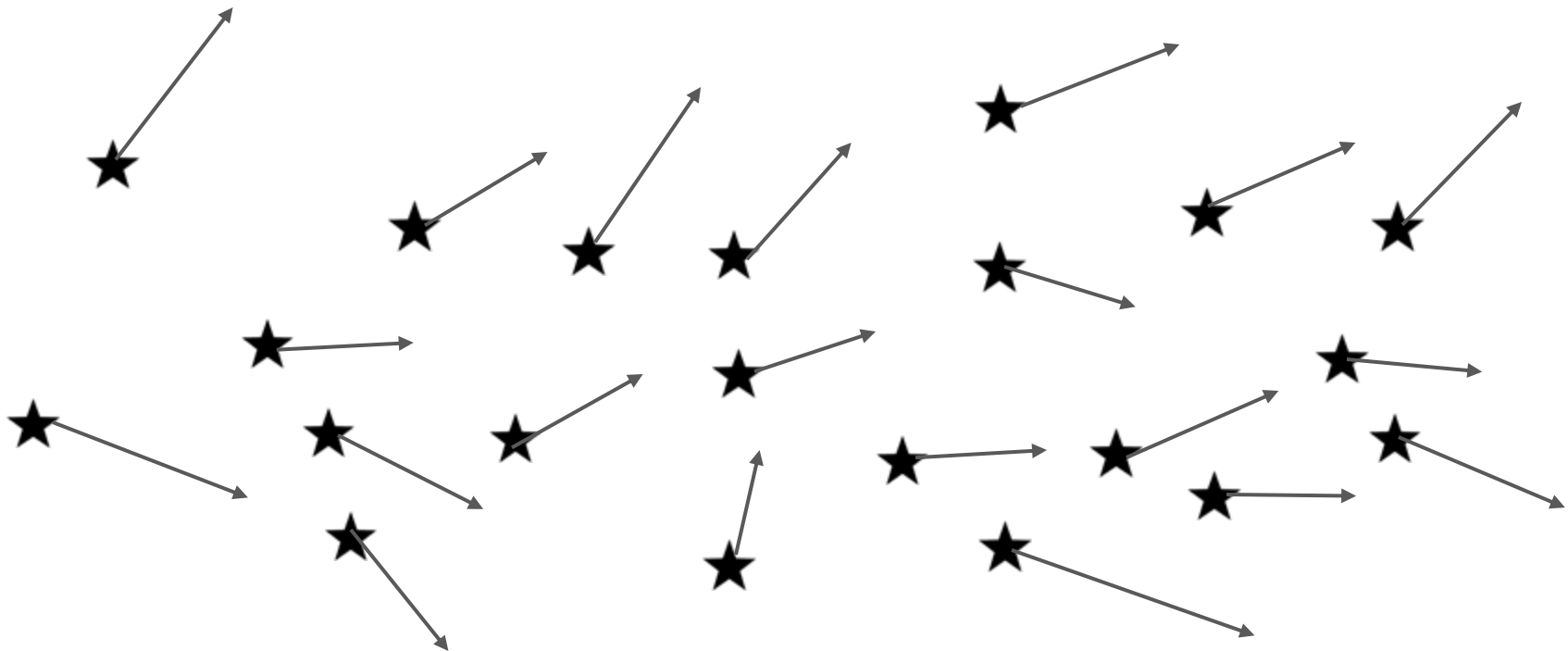
100 Myr-1 Gyr: Tidal Circularization

1-10 Gyr: Secular orbit evolution, tidal decay, obliquity excitation/damping

- (1) Lithium depletion – young stars
- (2) Activity Indicators – young stars
- (3) Gyrochronology – young-ish stars
- (4) Asteroseismology – unavailable for most planet hosts
- (5) Isochrones – uncertainties too big (or requires JWST)

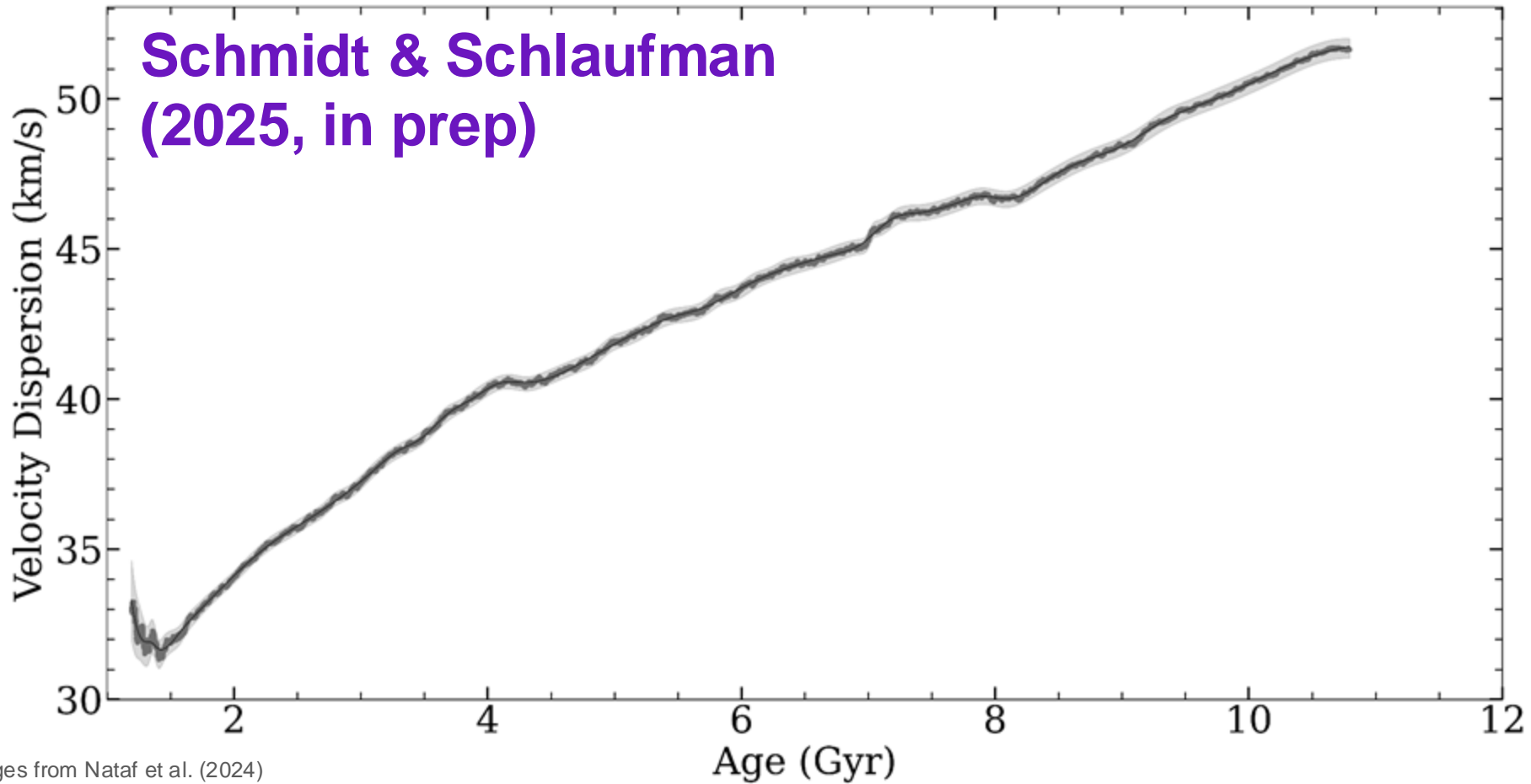


Time since formation: < 1  
Gyr



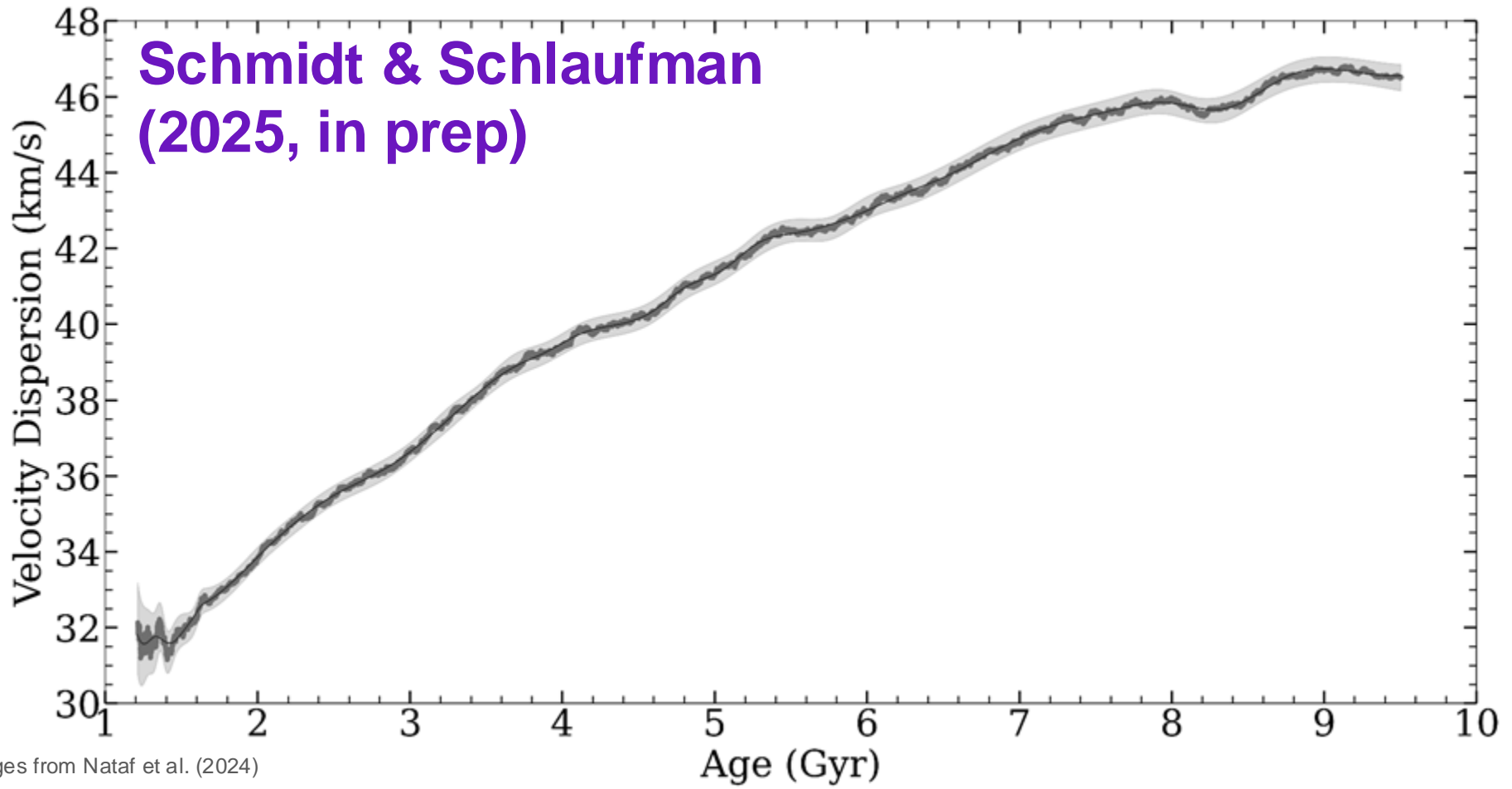
Time since formation: 6 Gyr

**Schmidt & Schlaufman  
(2025, in prep)**



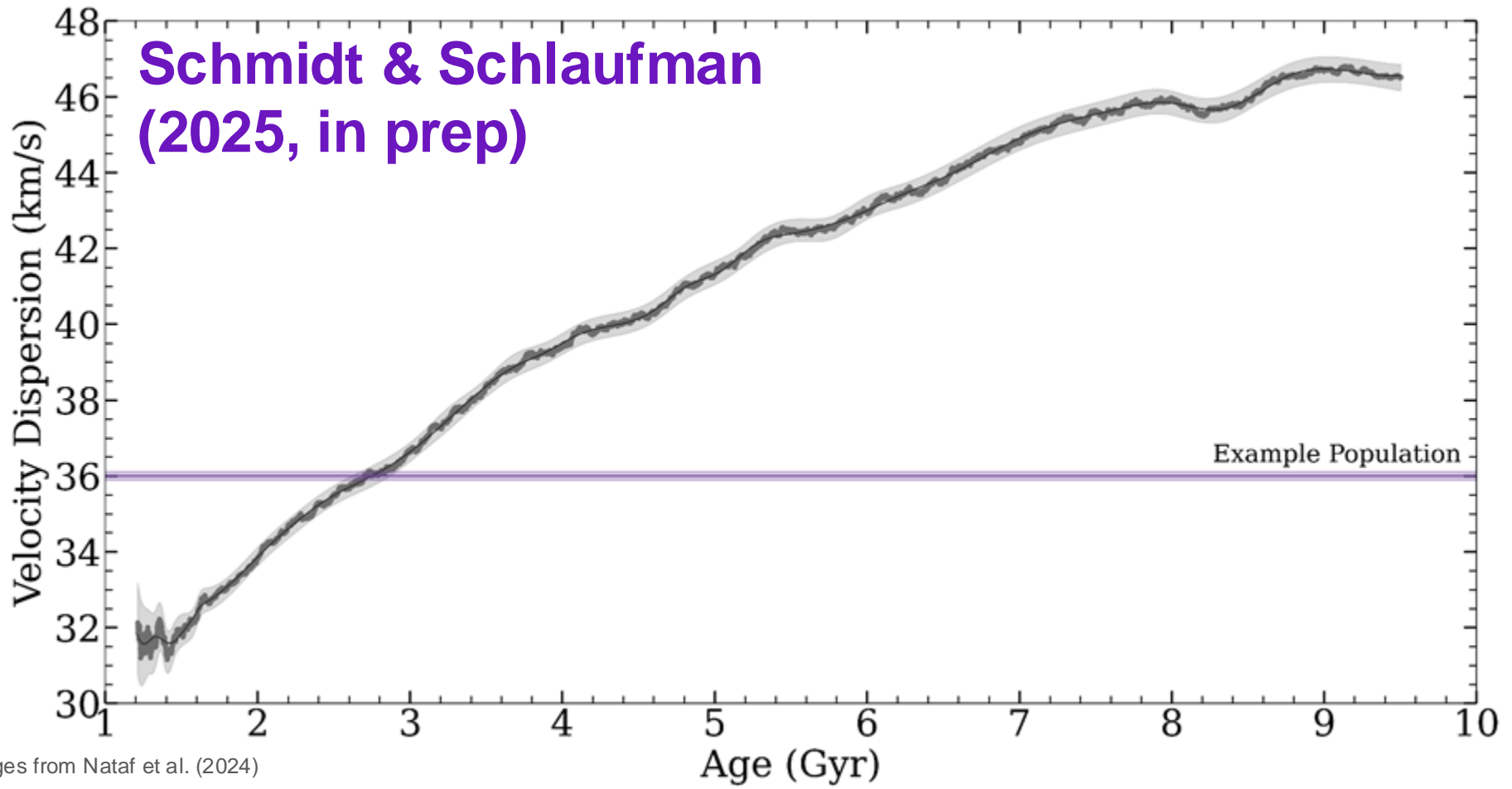
Ages from Nataf et al. (2024)

**Schmidt & Schlaufman  
(2025, in prep)**



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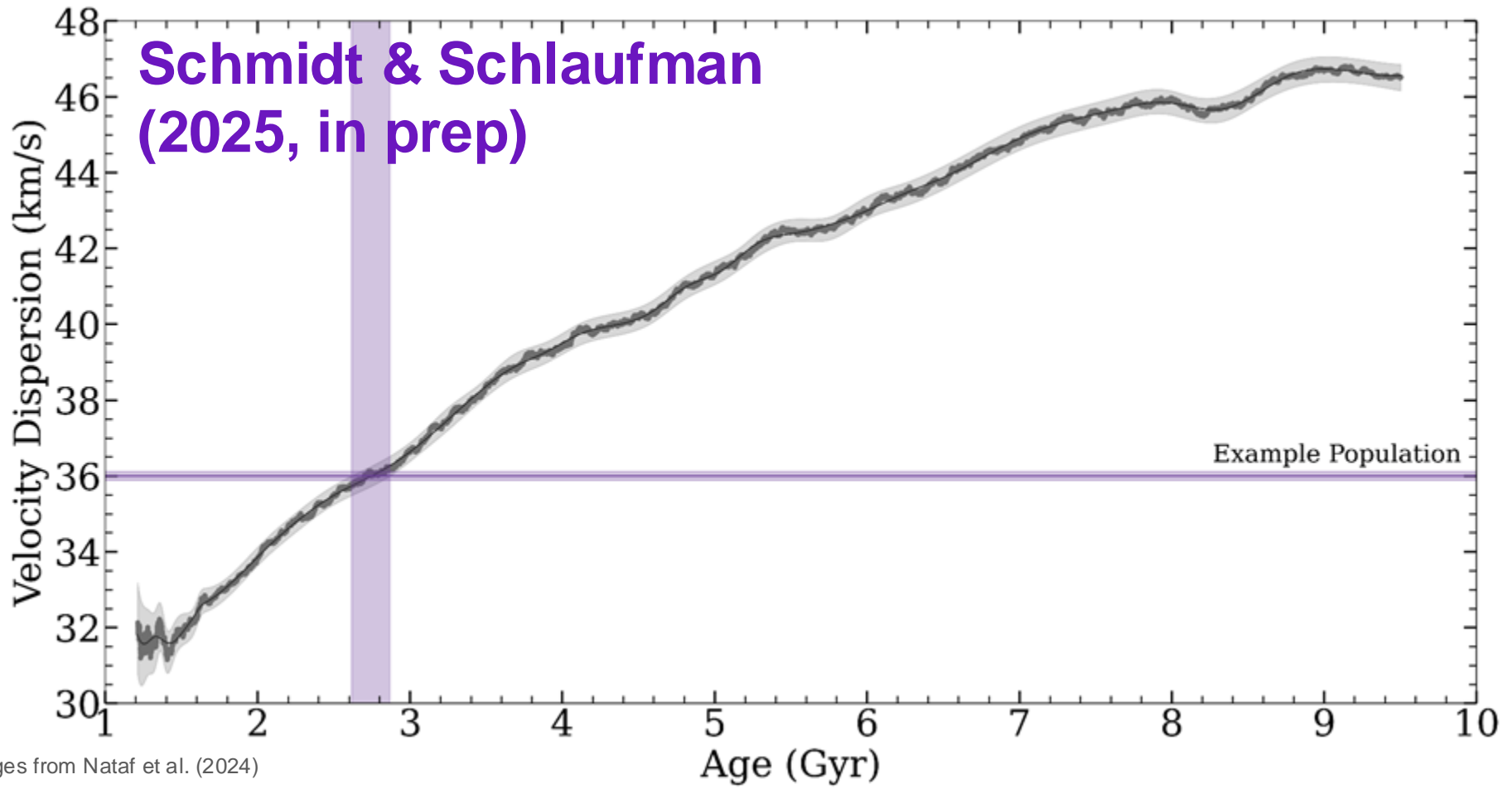
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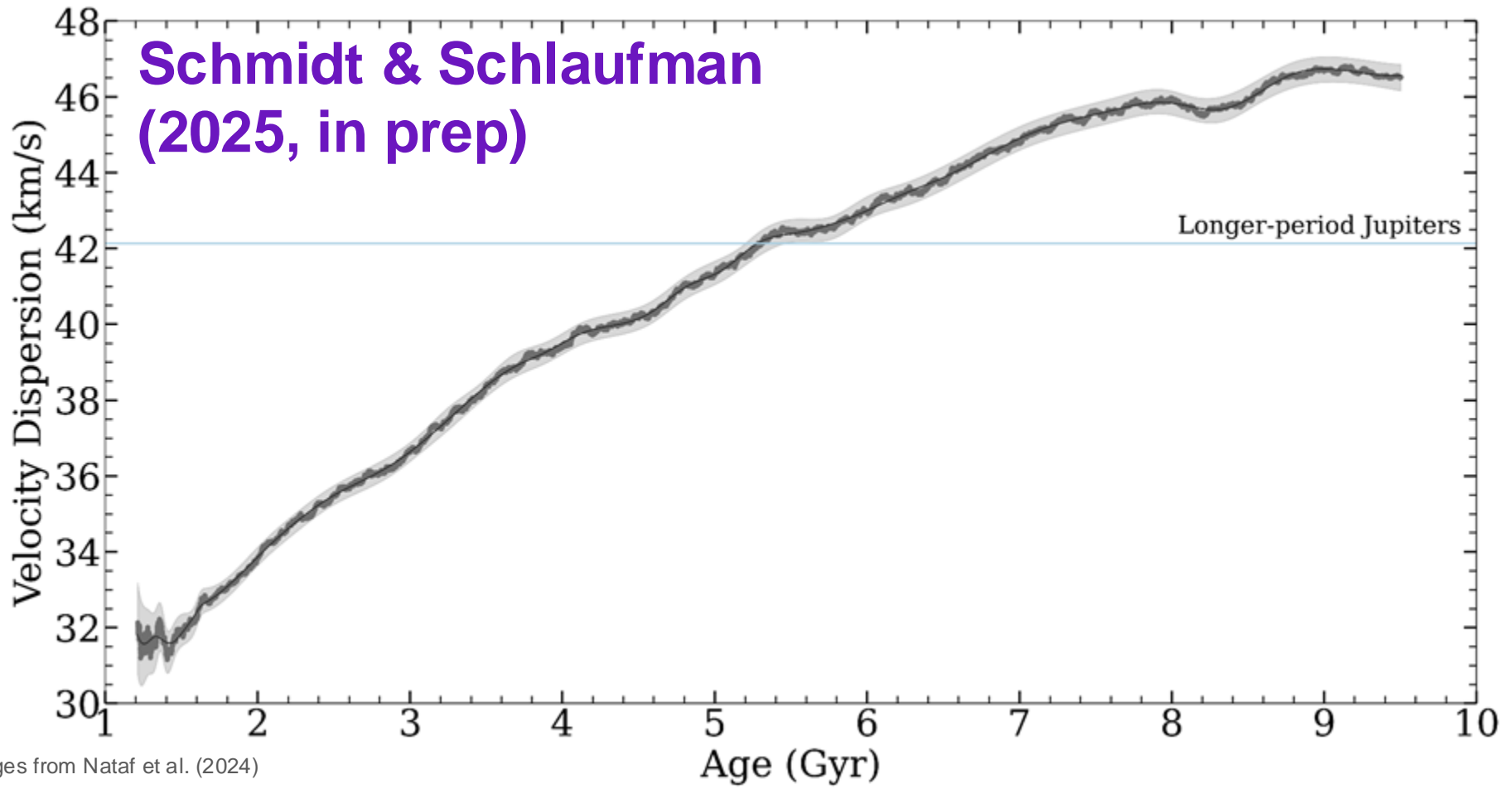


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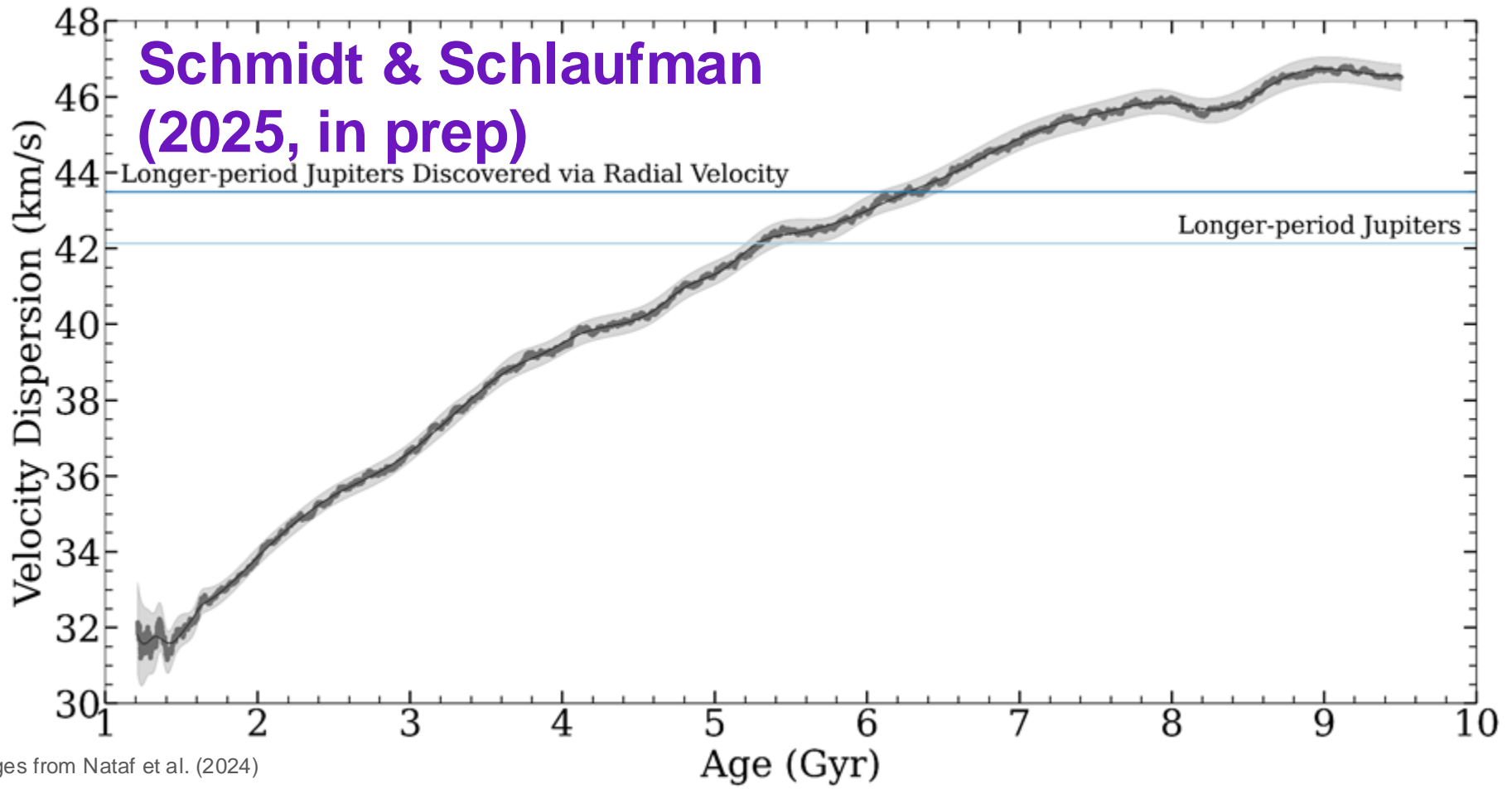
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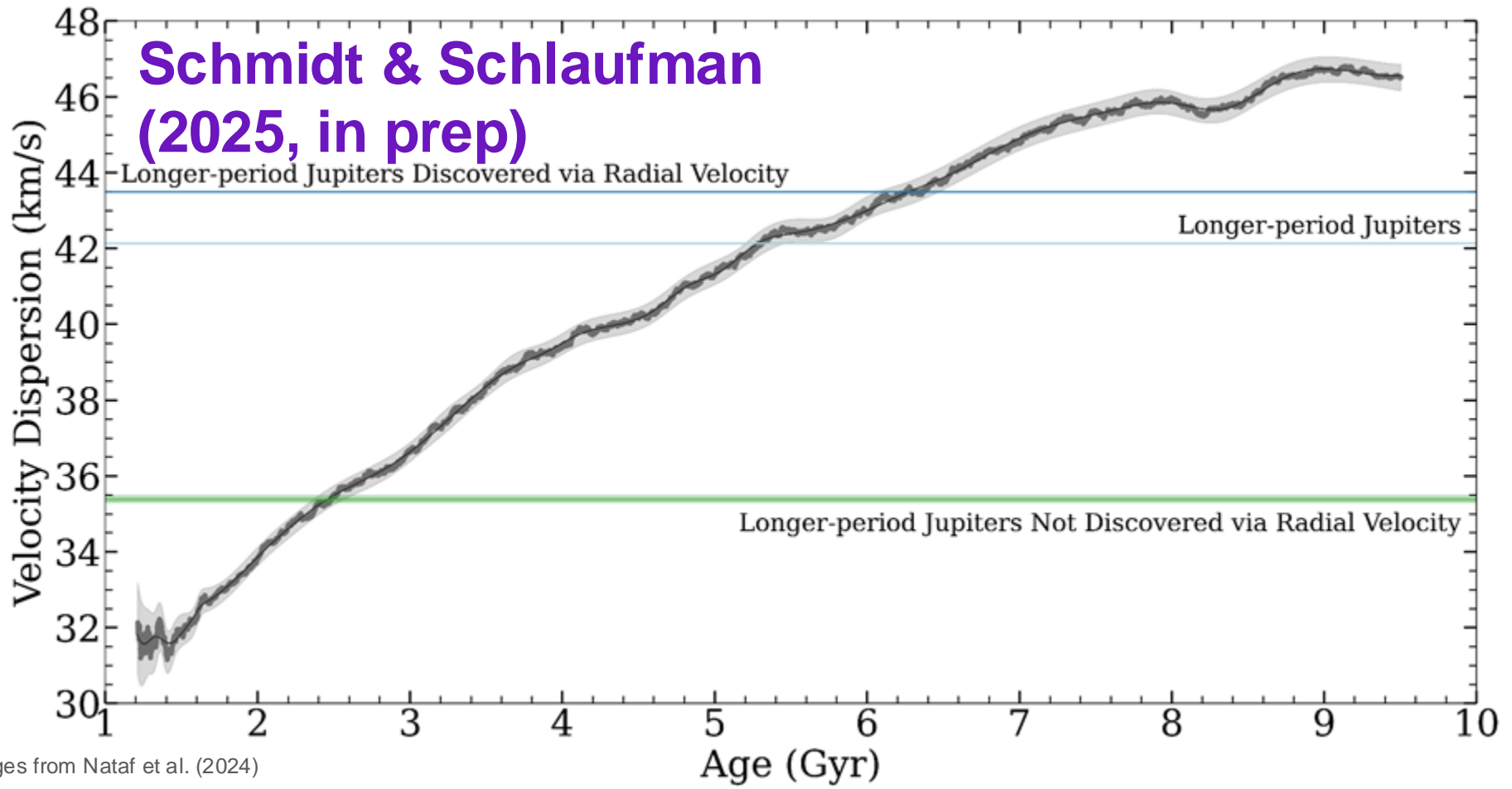
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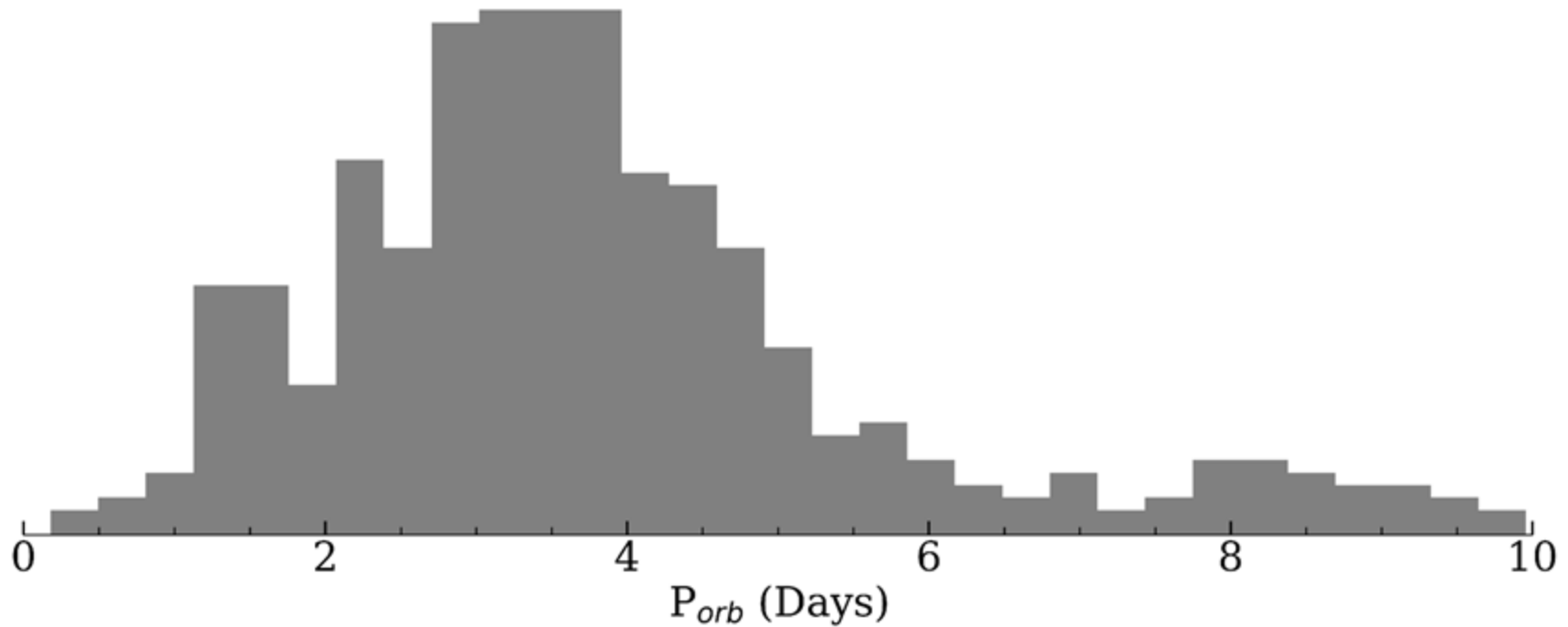


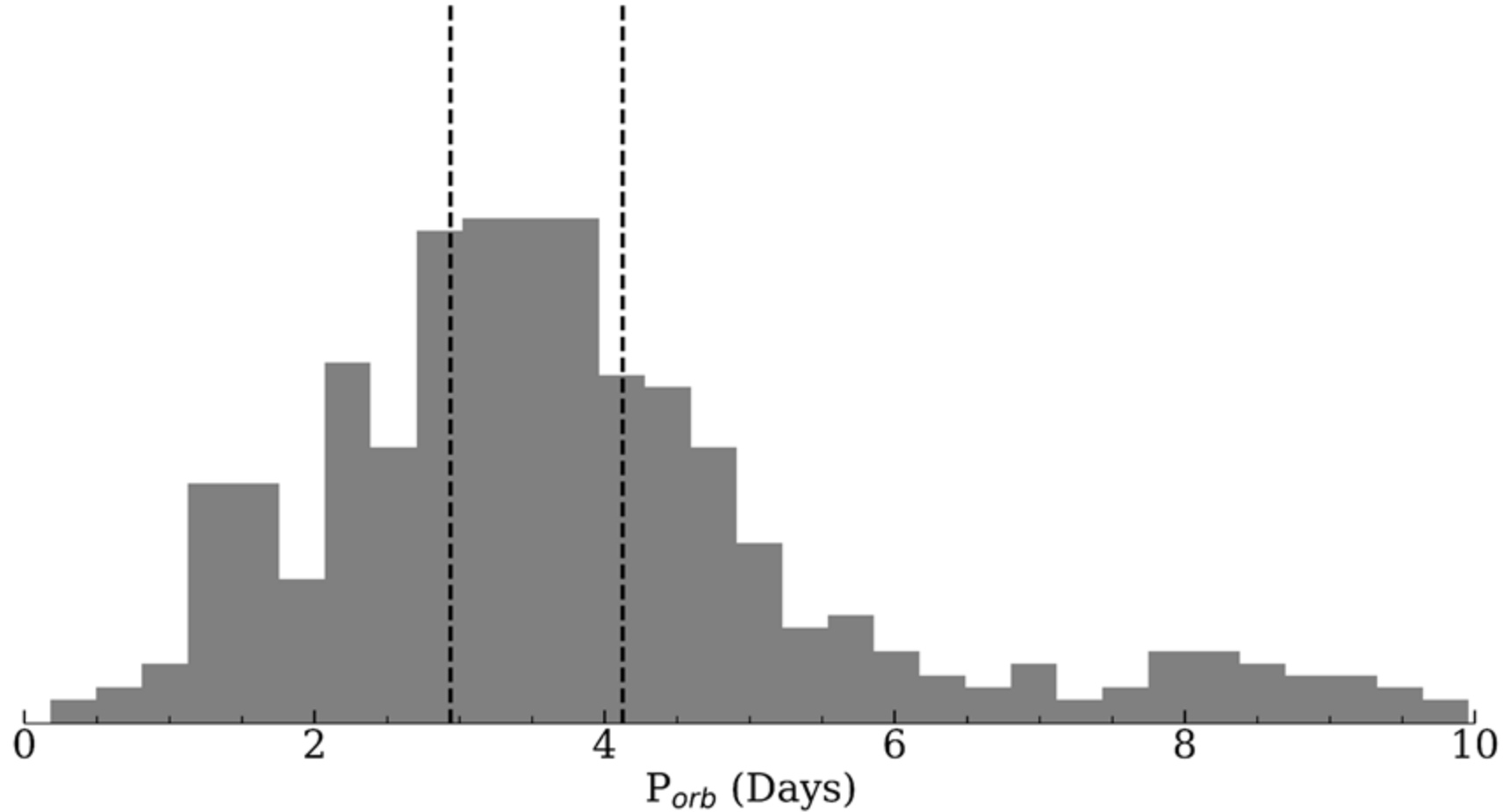
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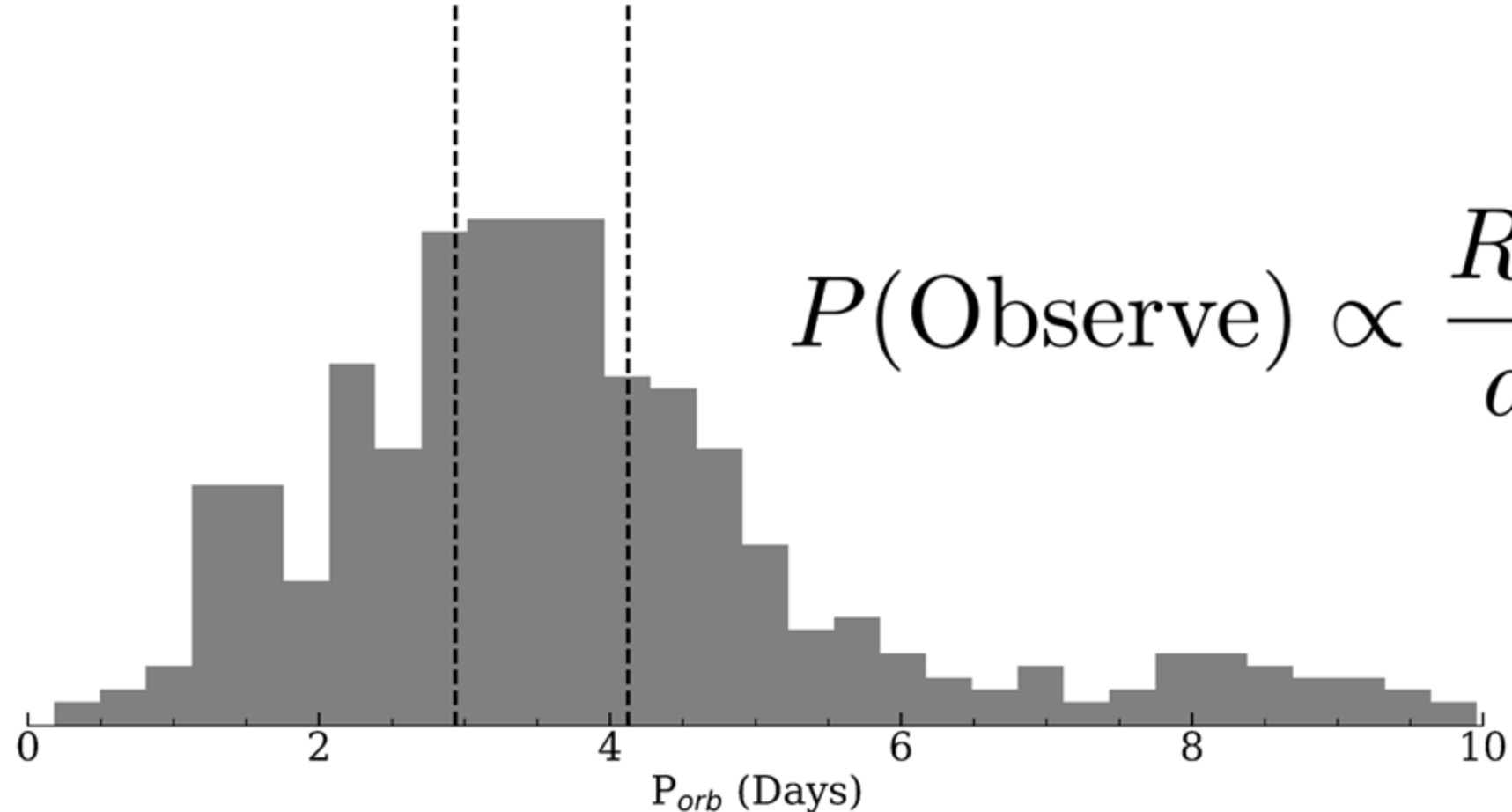
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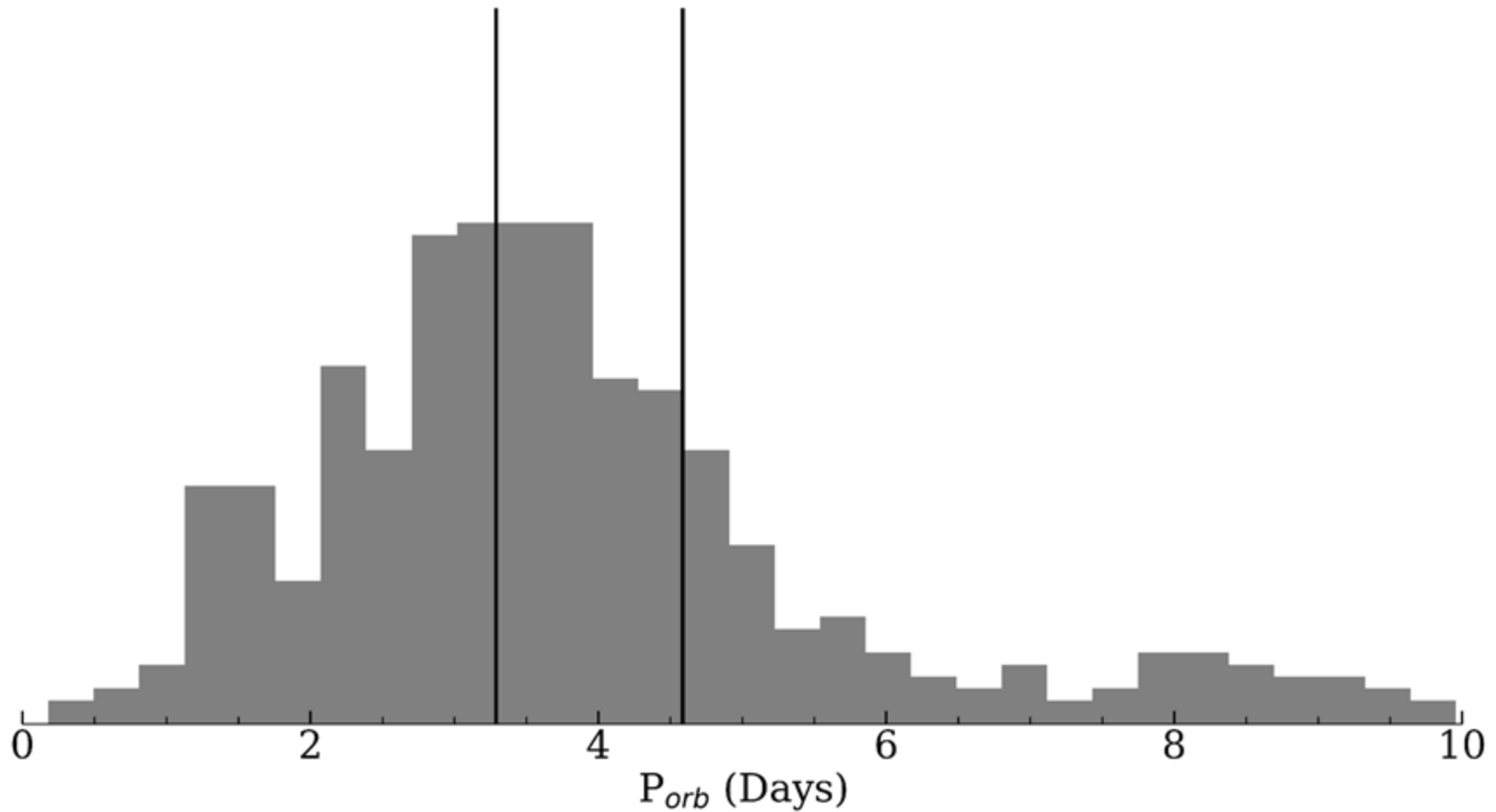


Ages from Nataf et al. (2024)

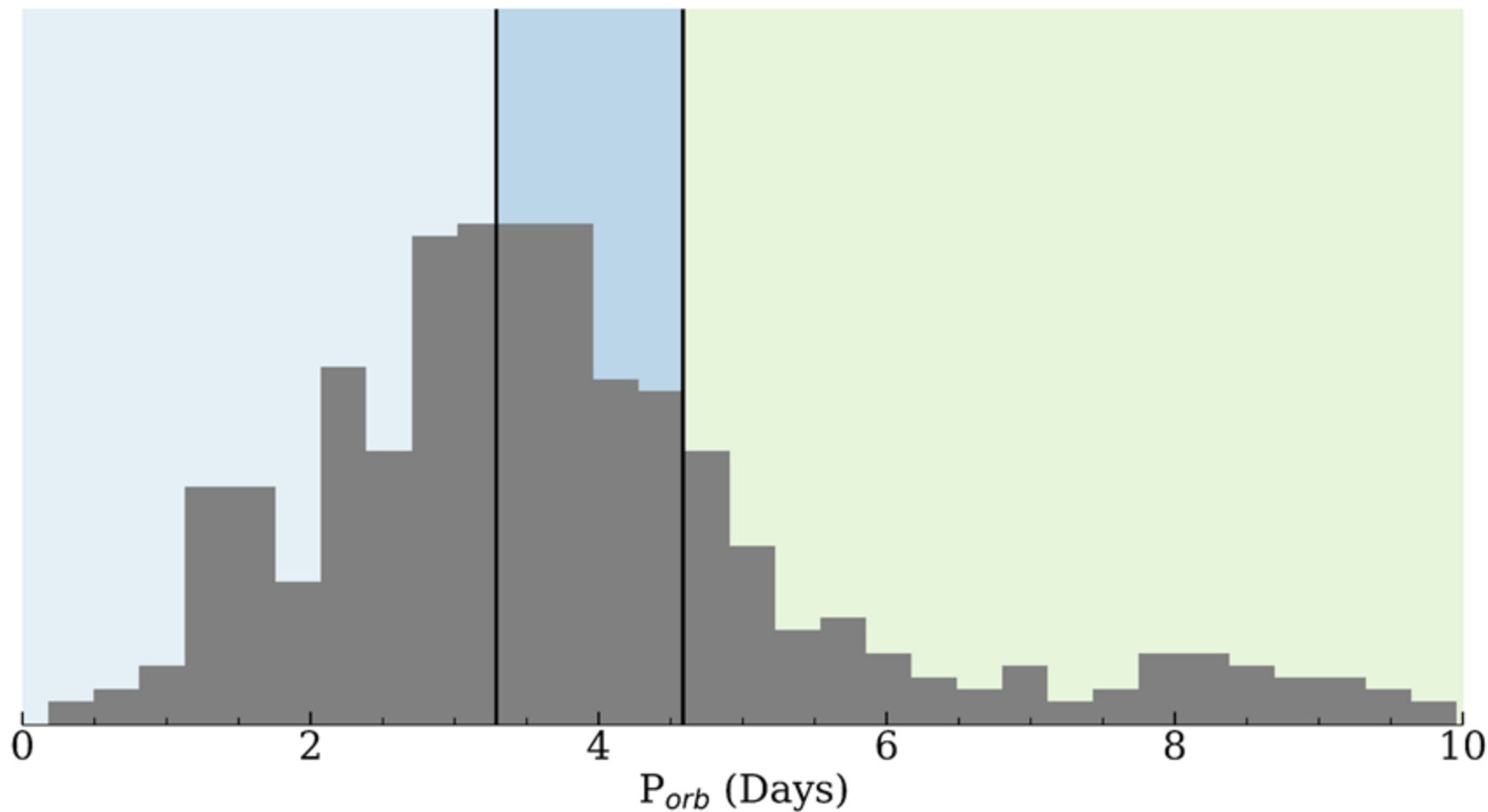








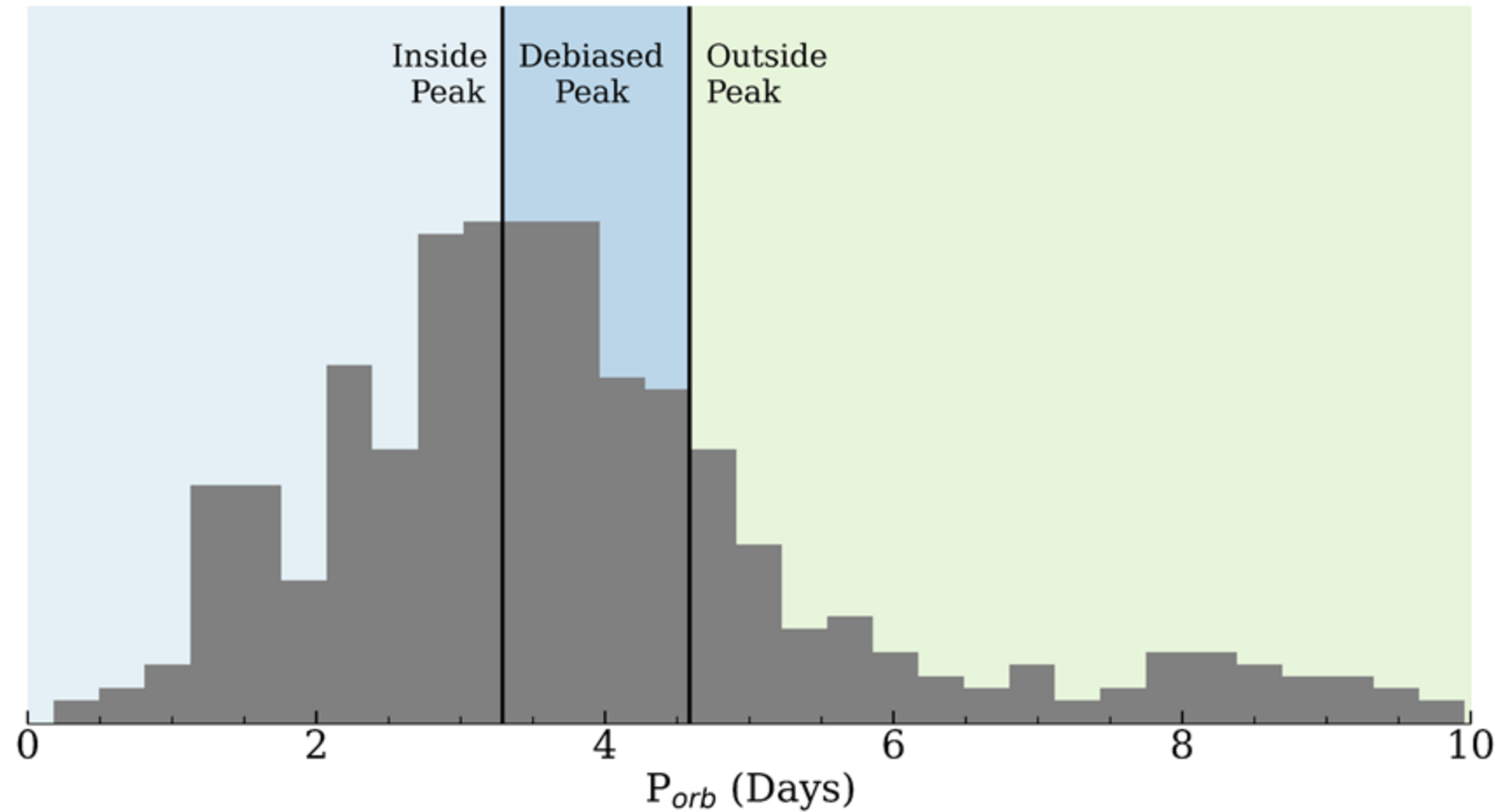




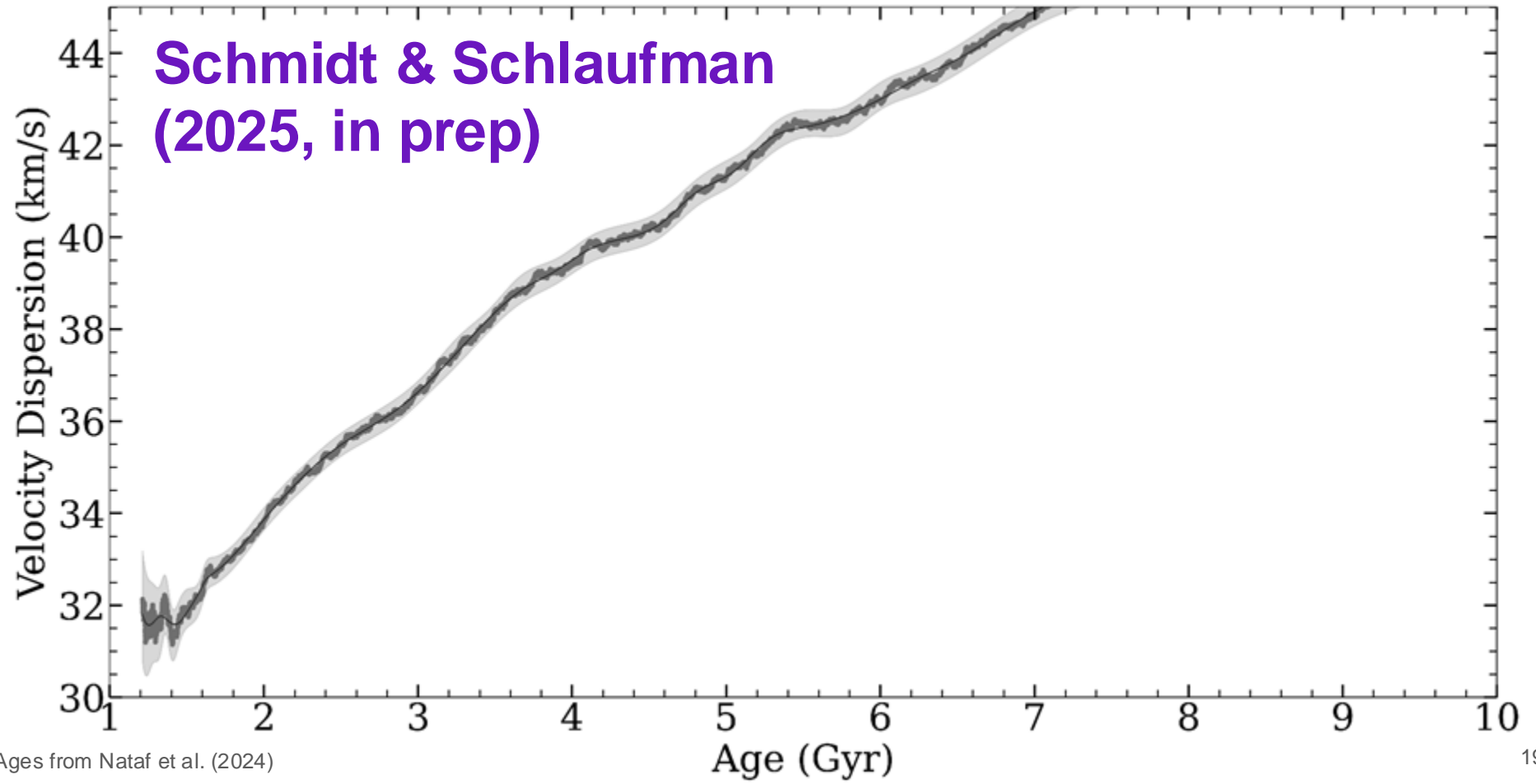
# The Debiased Peak of the Period Distribution

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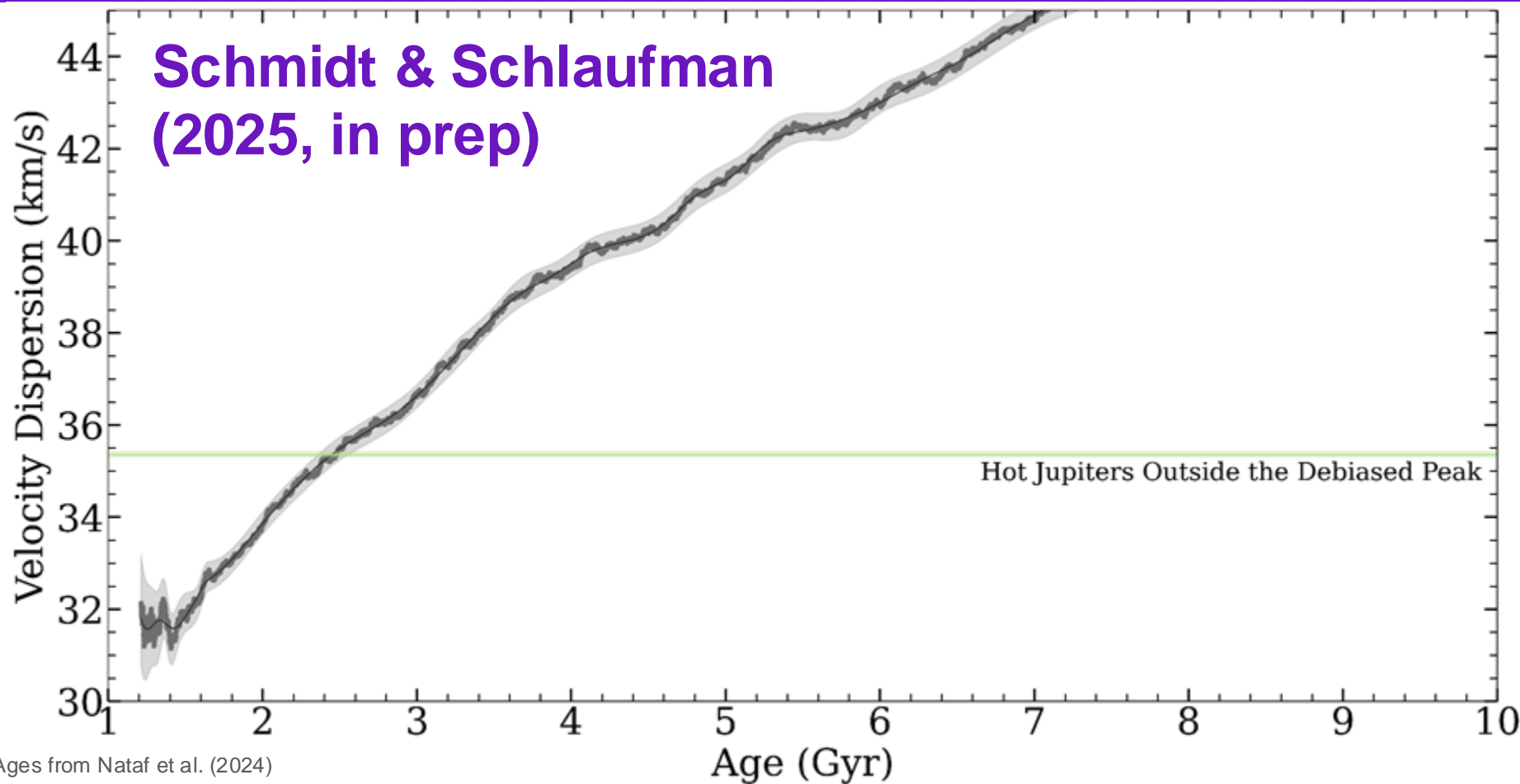


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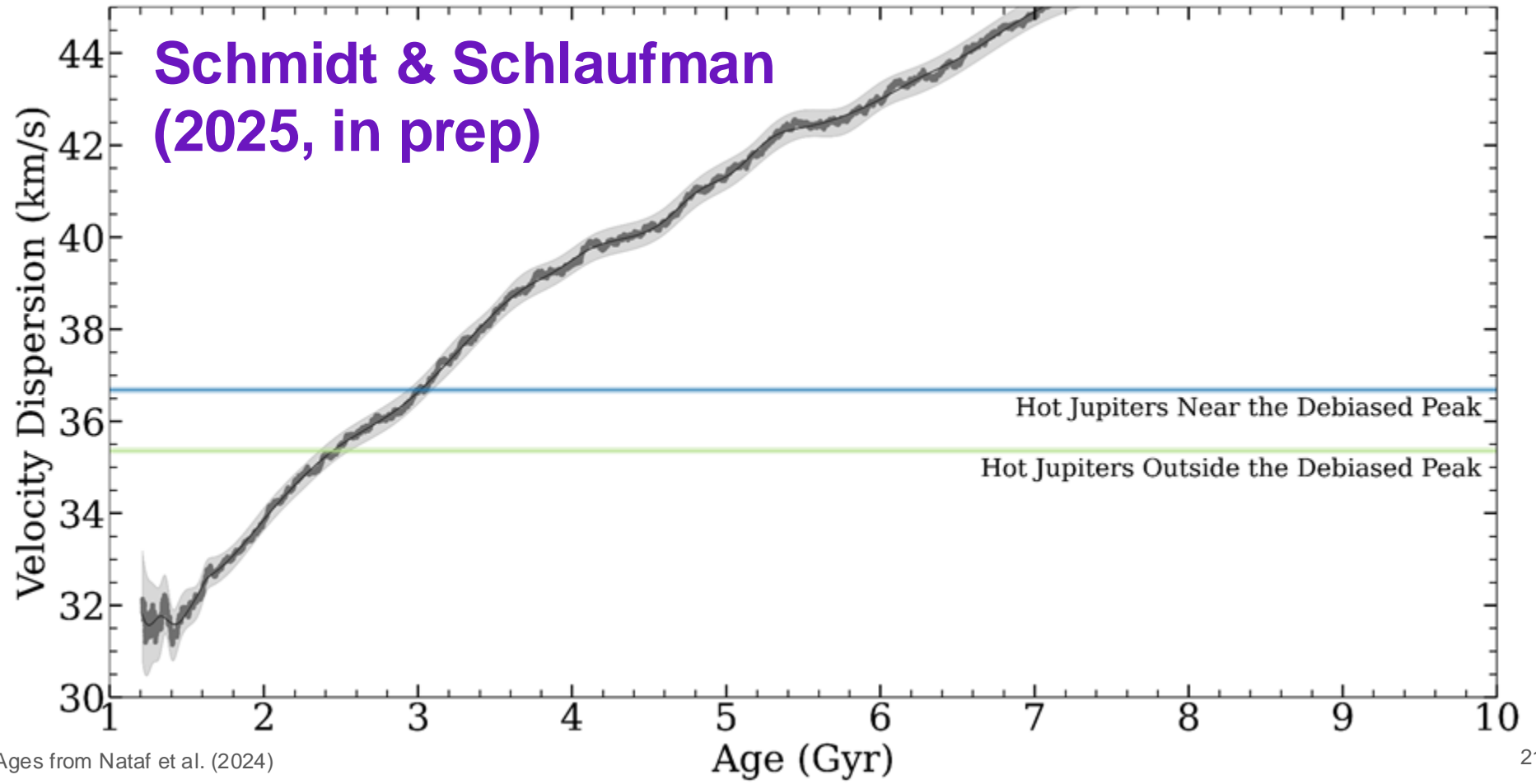


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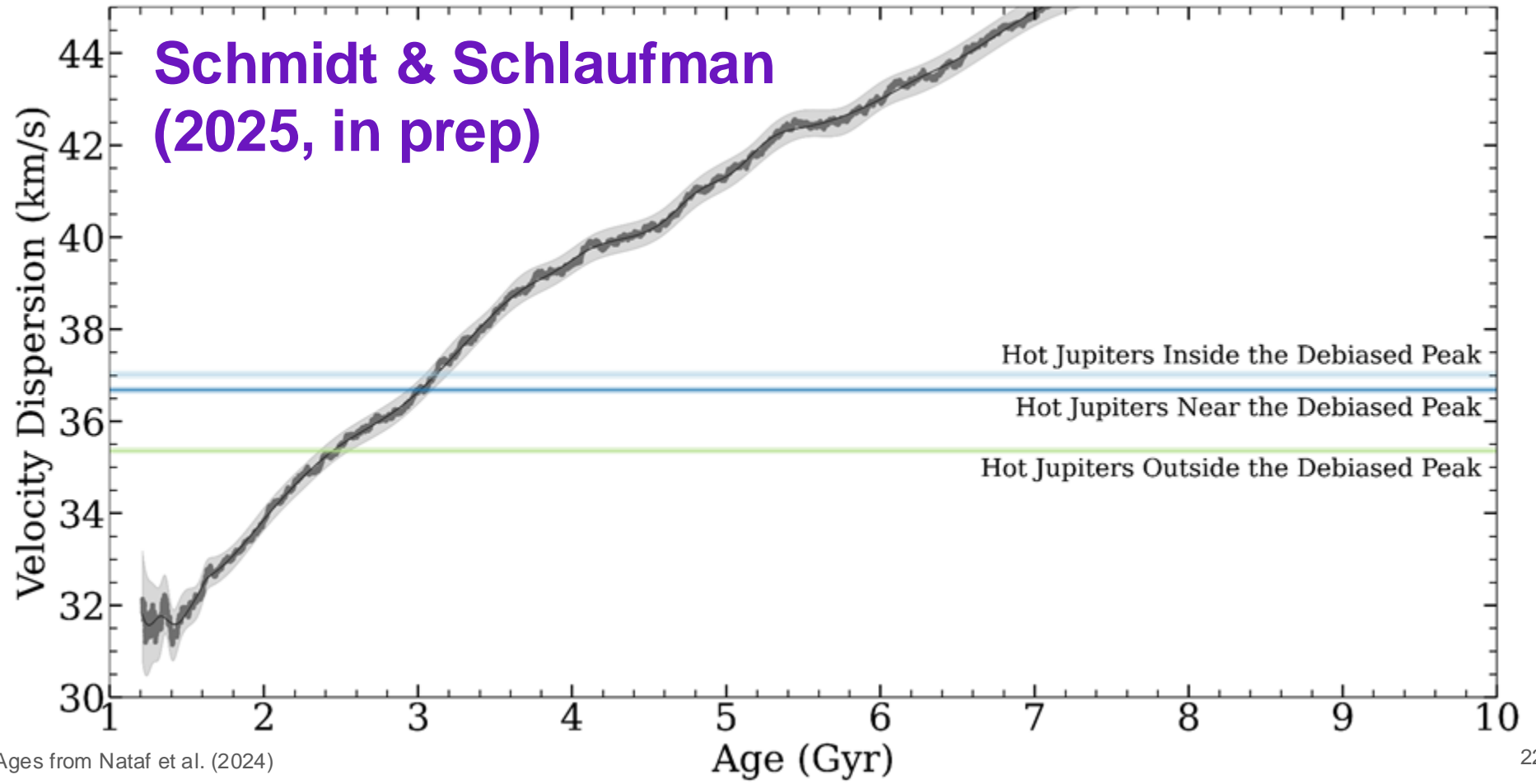


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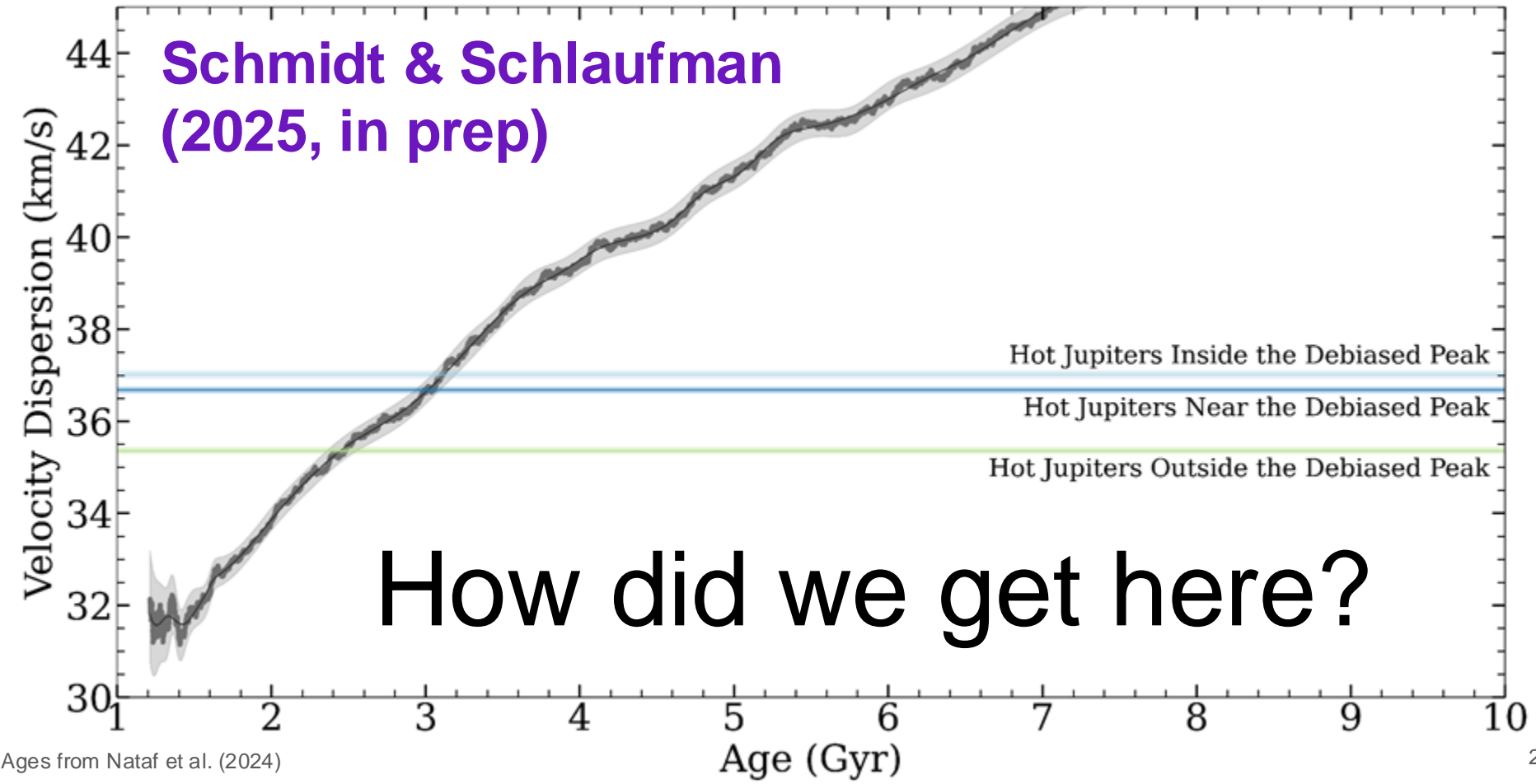


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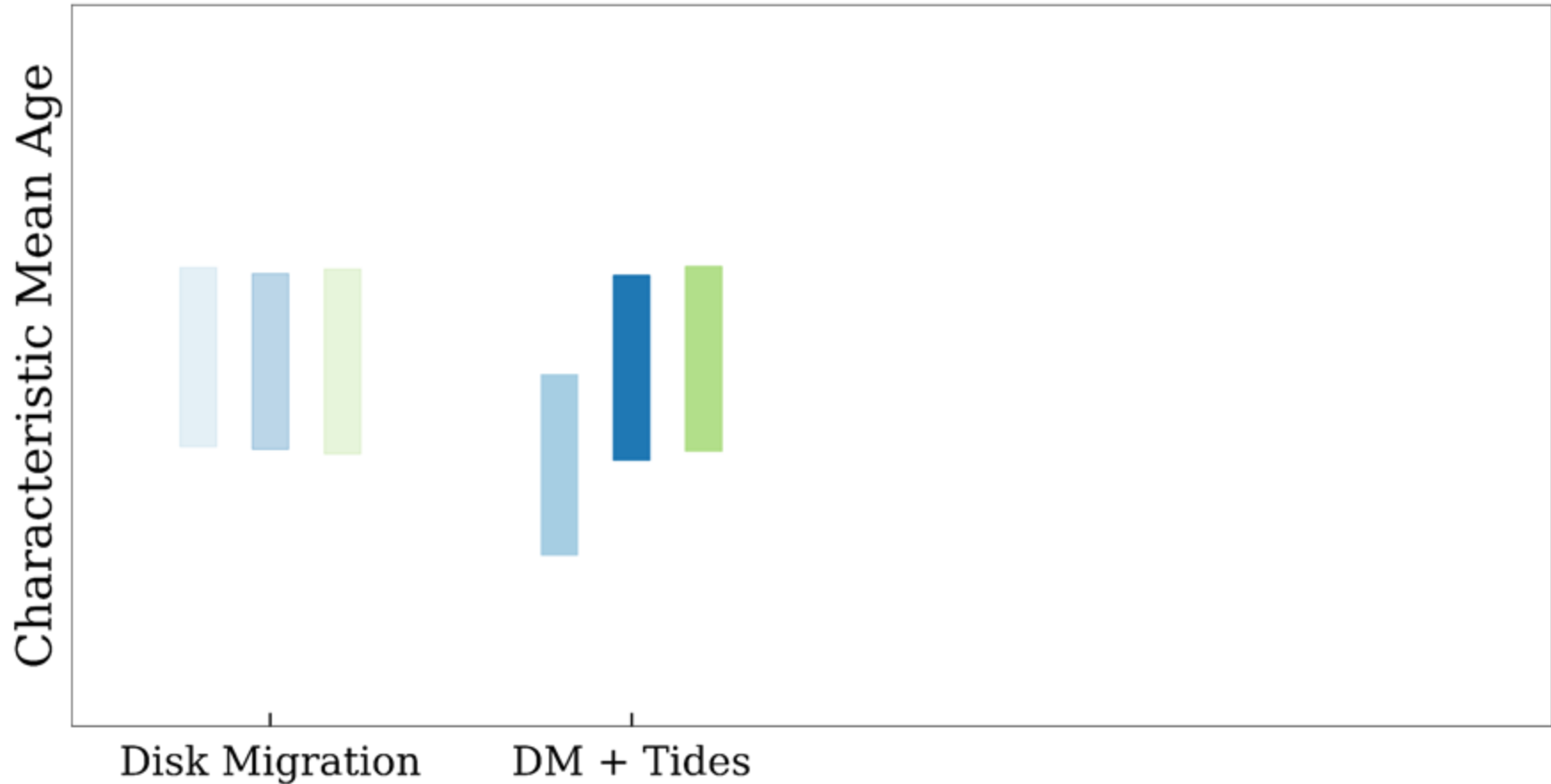
- (1) Early-time disk migration
- (2) A late-time migration mechanism
- (3) Tidal inspiral

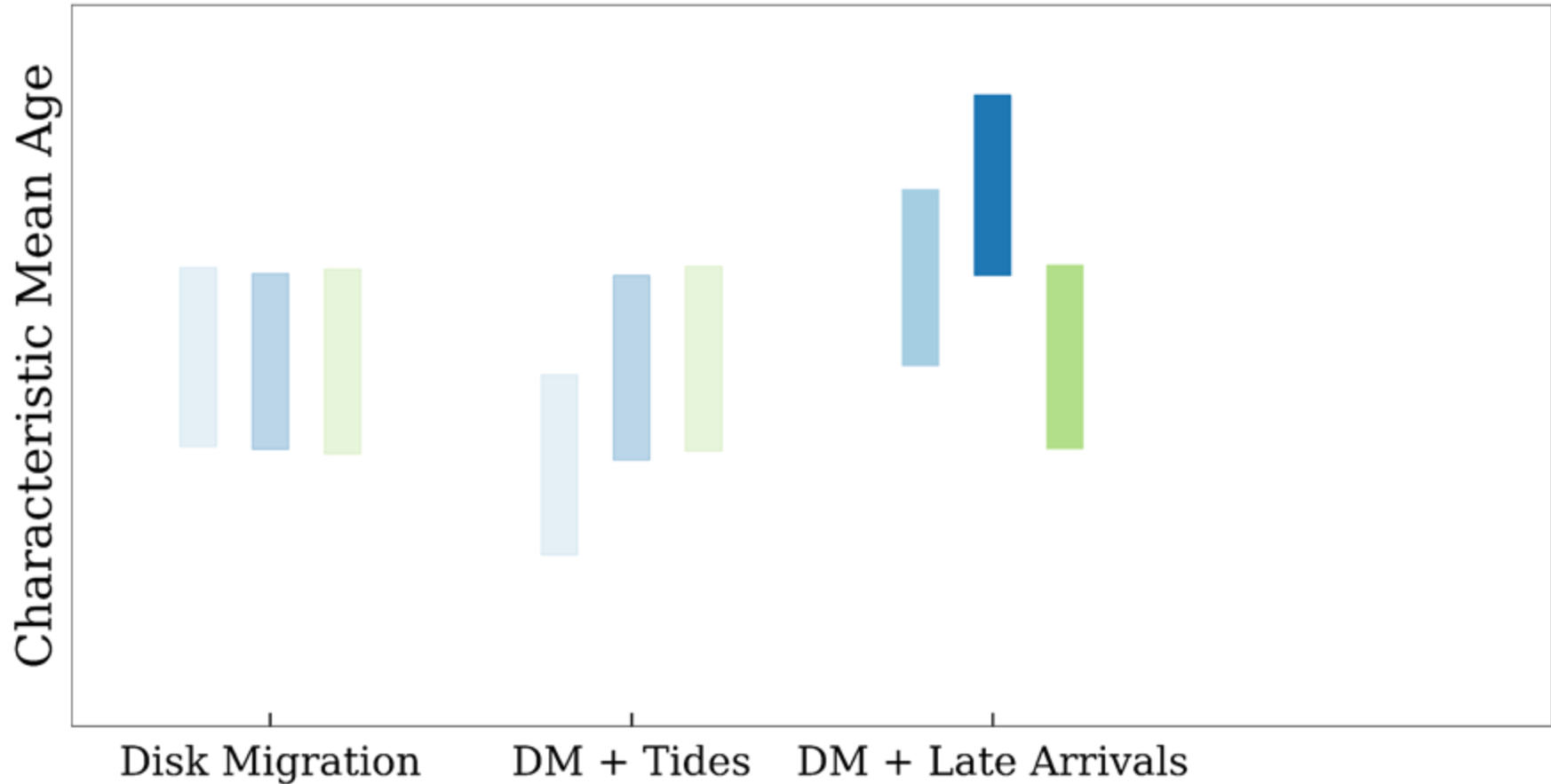


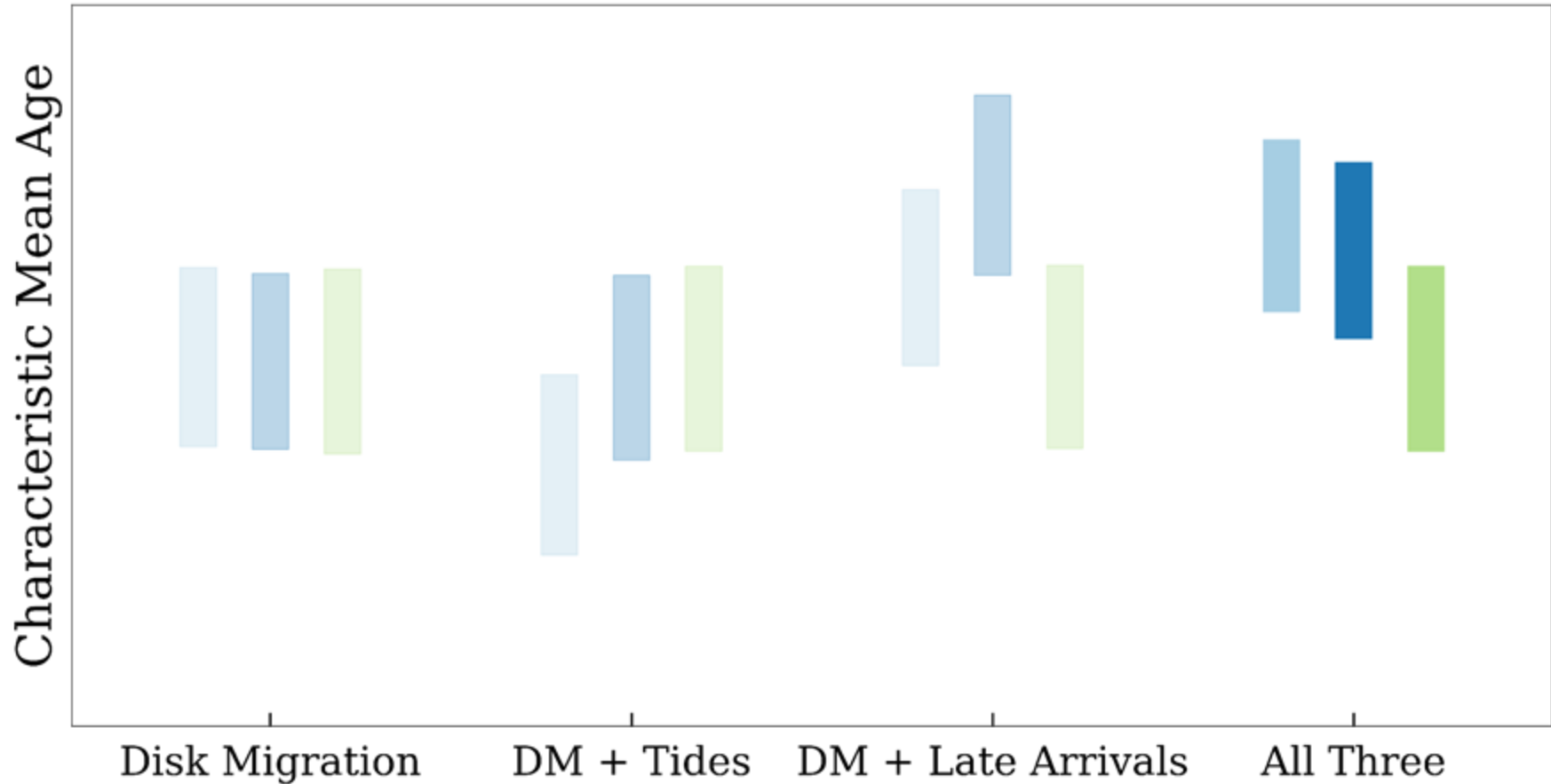
Characteristic Mean Age

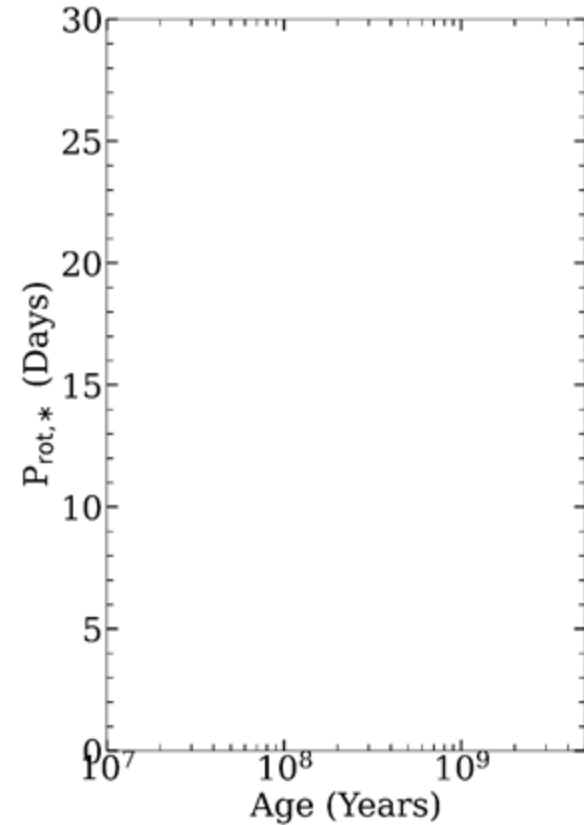
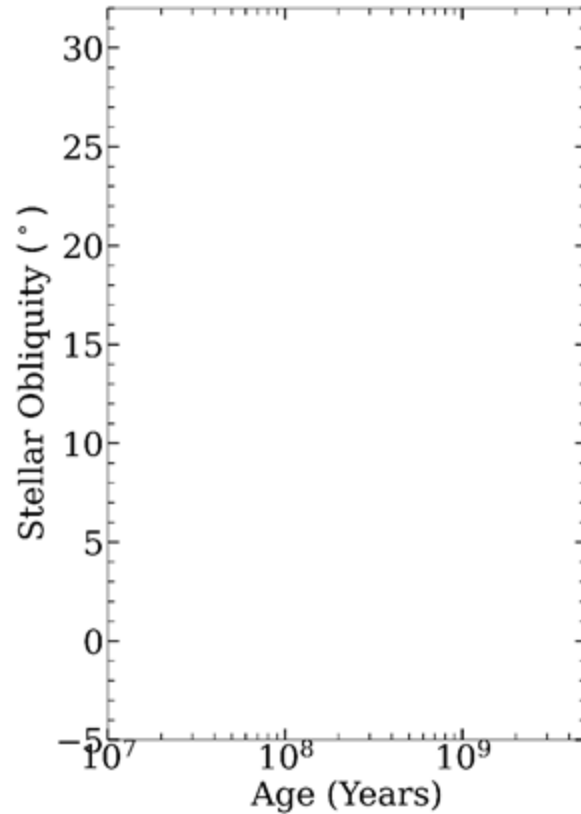
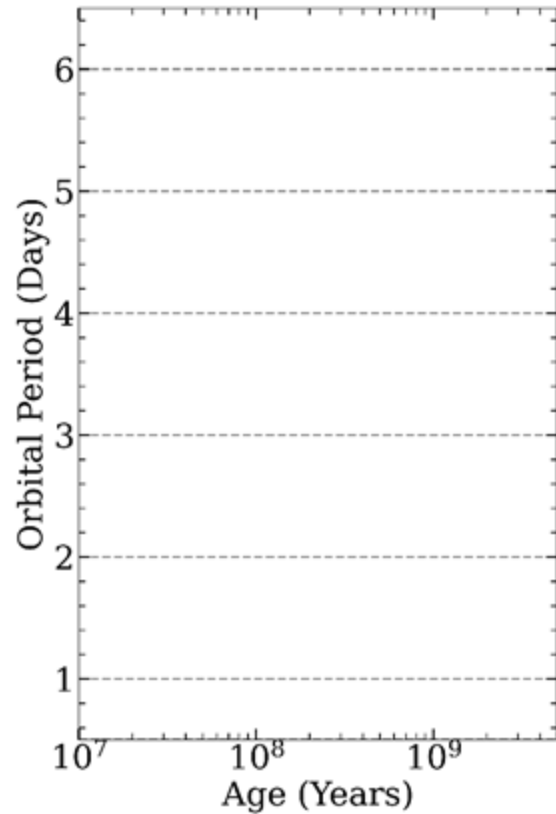


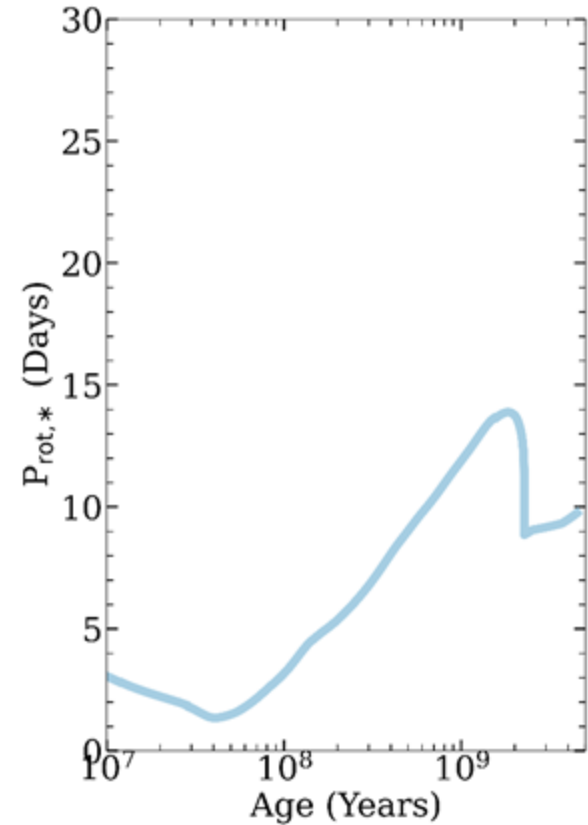
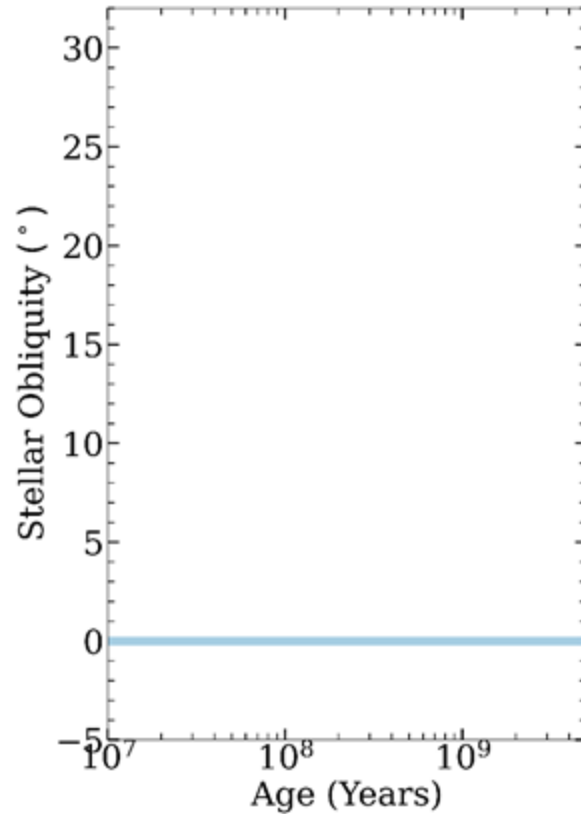
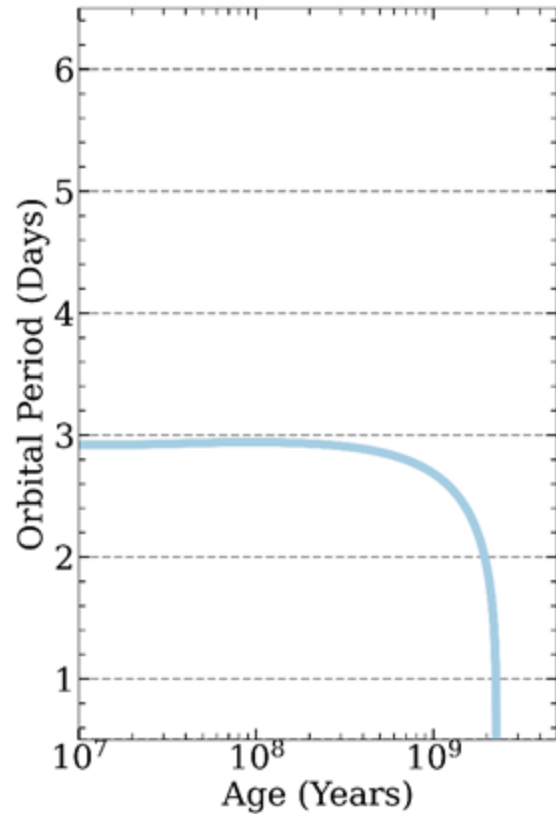


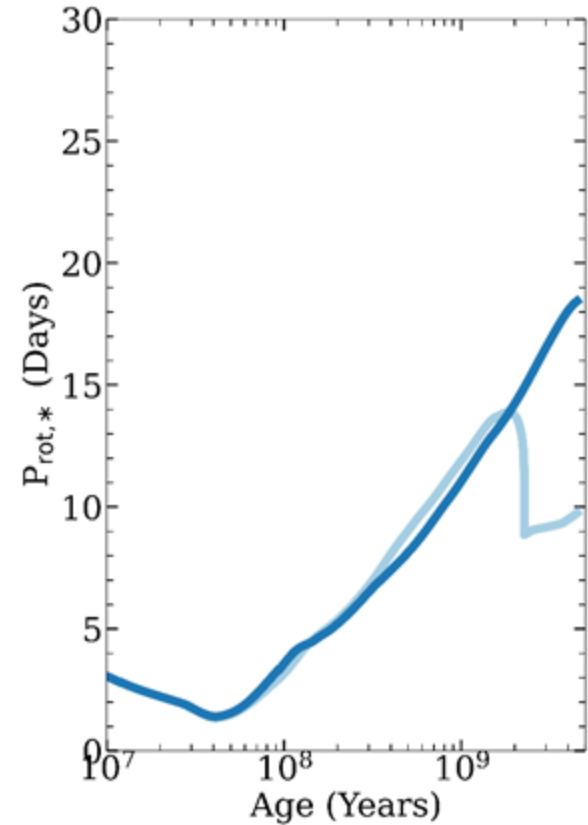
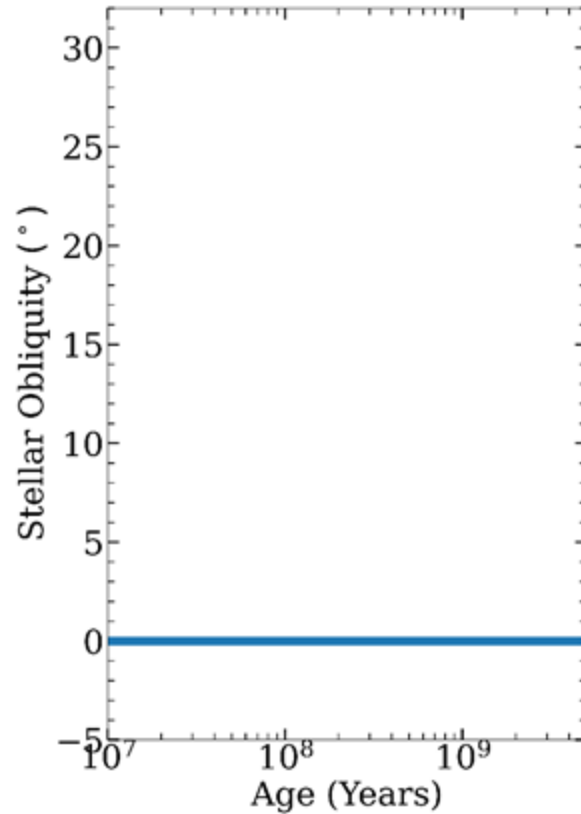
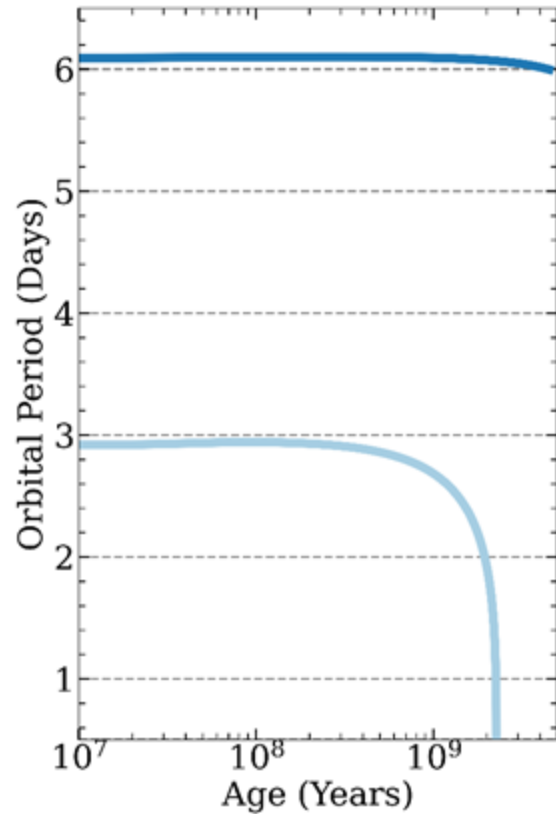




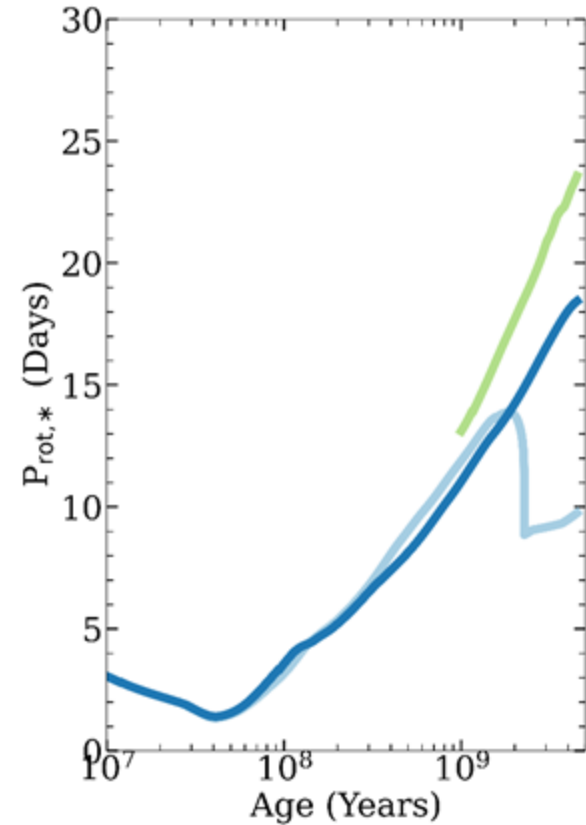
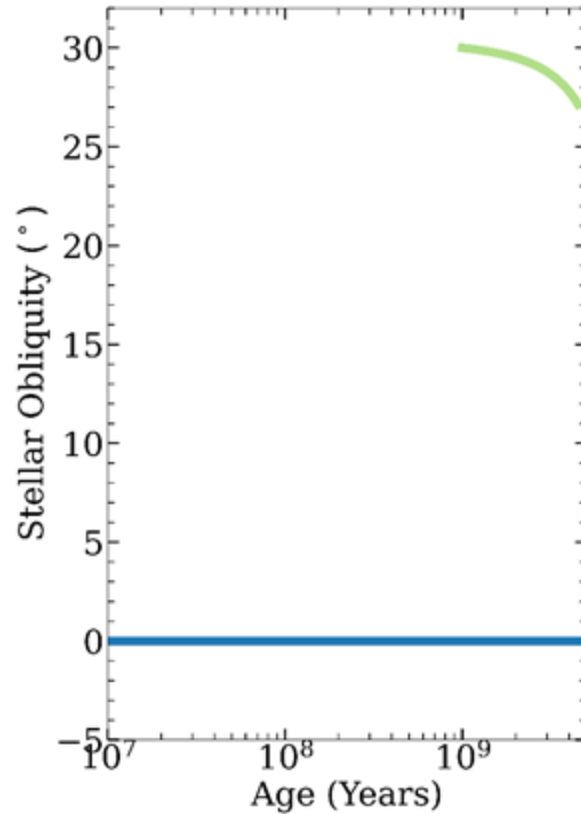
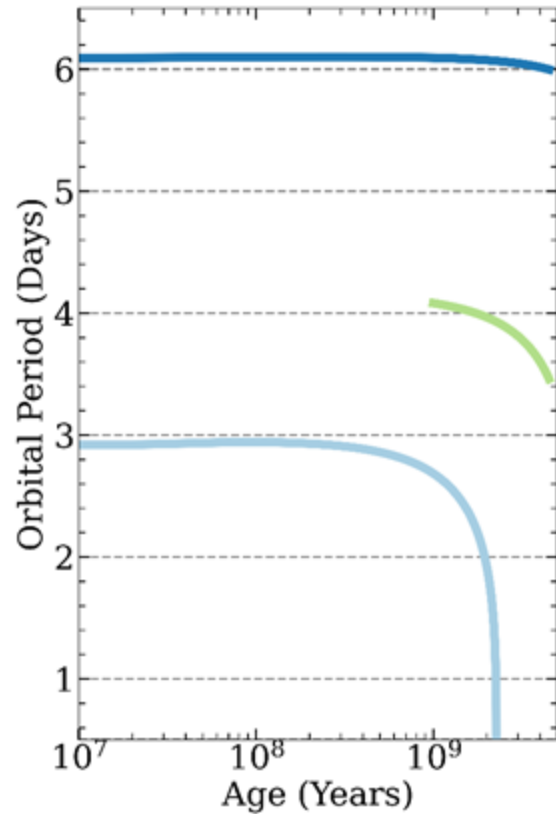


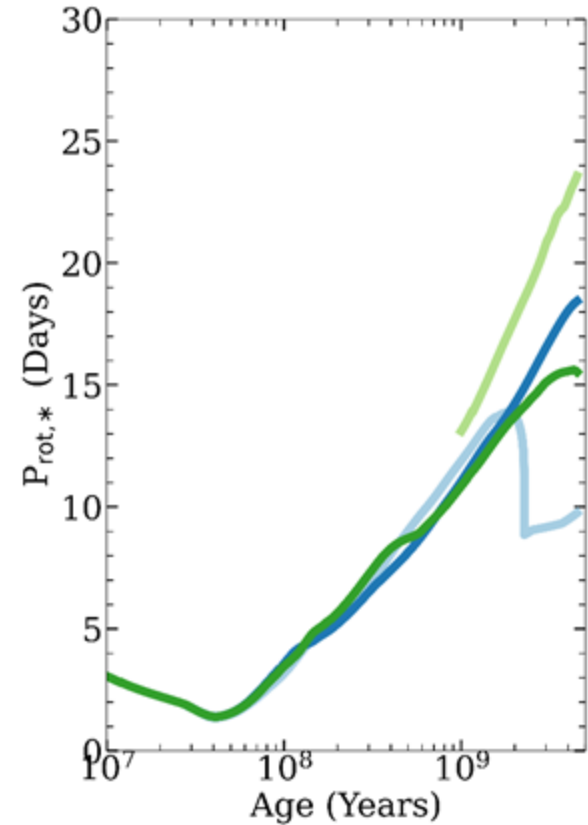
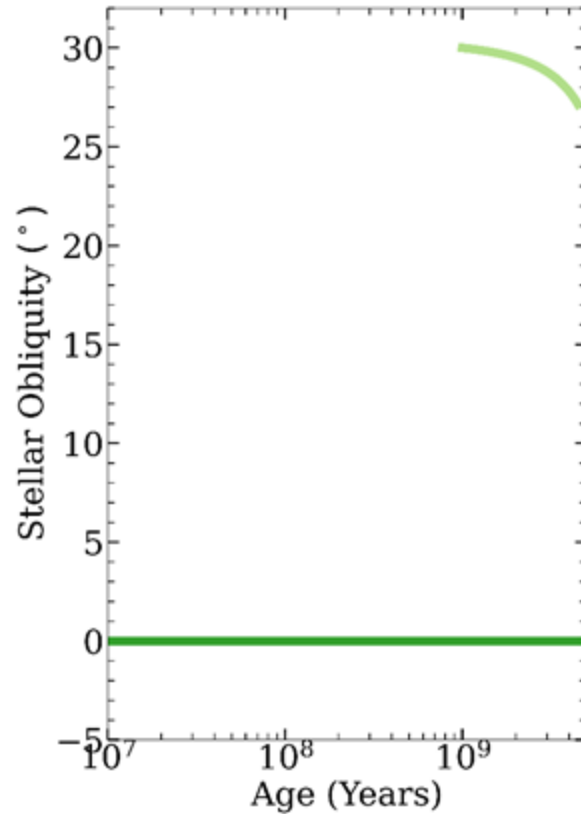
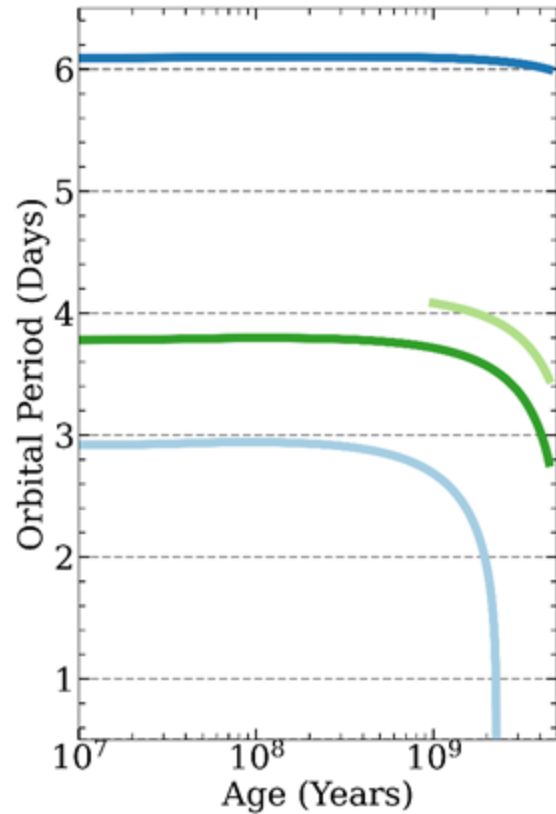








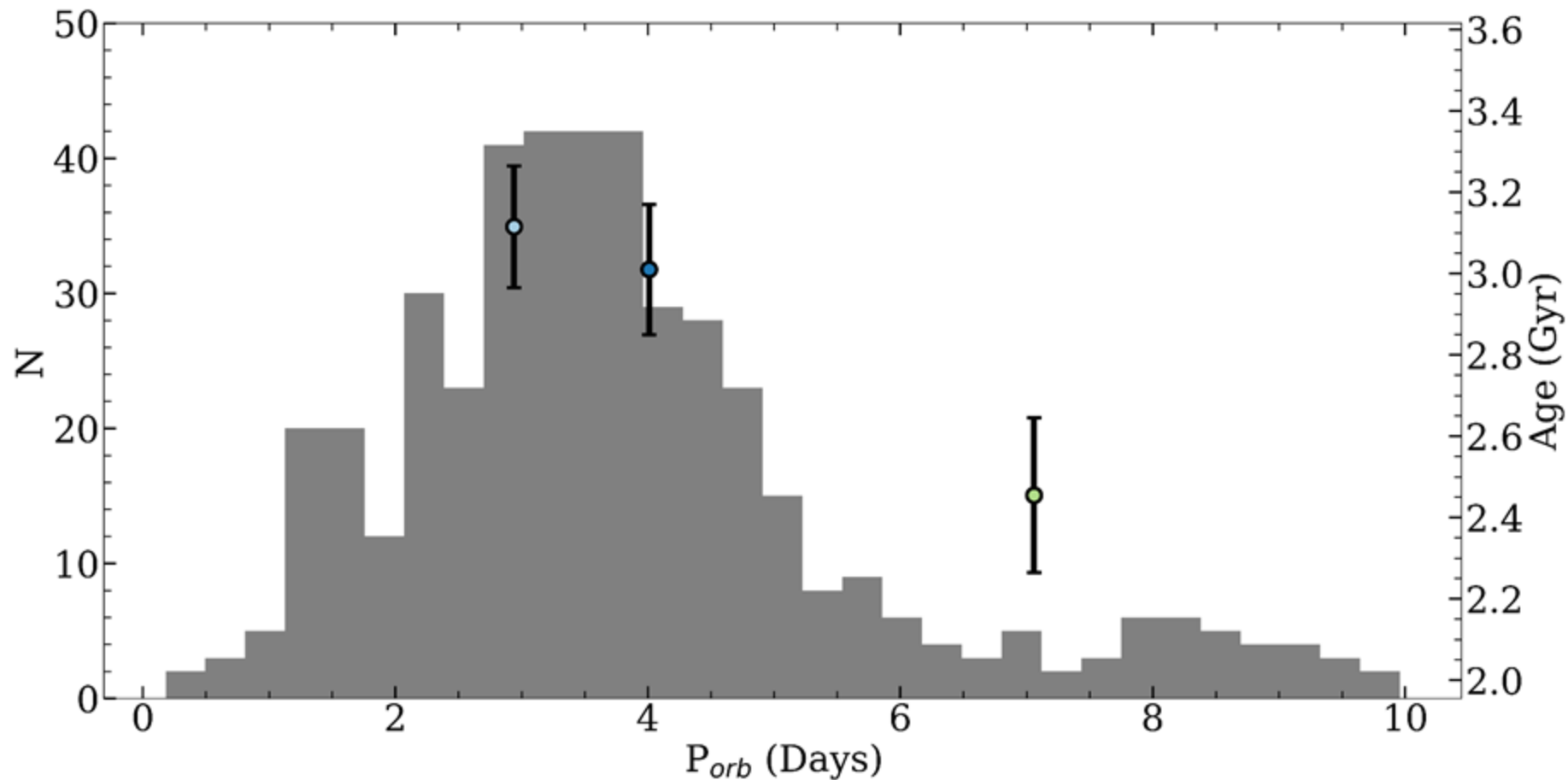




# Parametric Model Can Reproduce Our Observations

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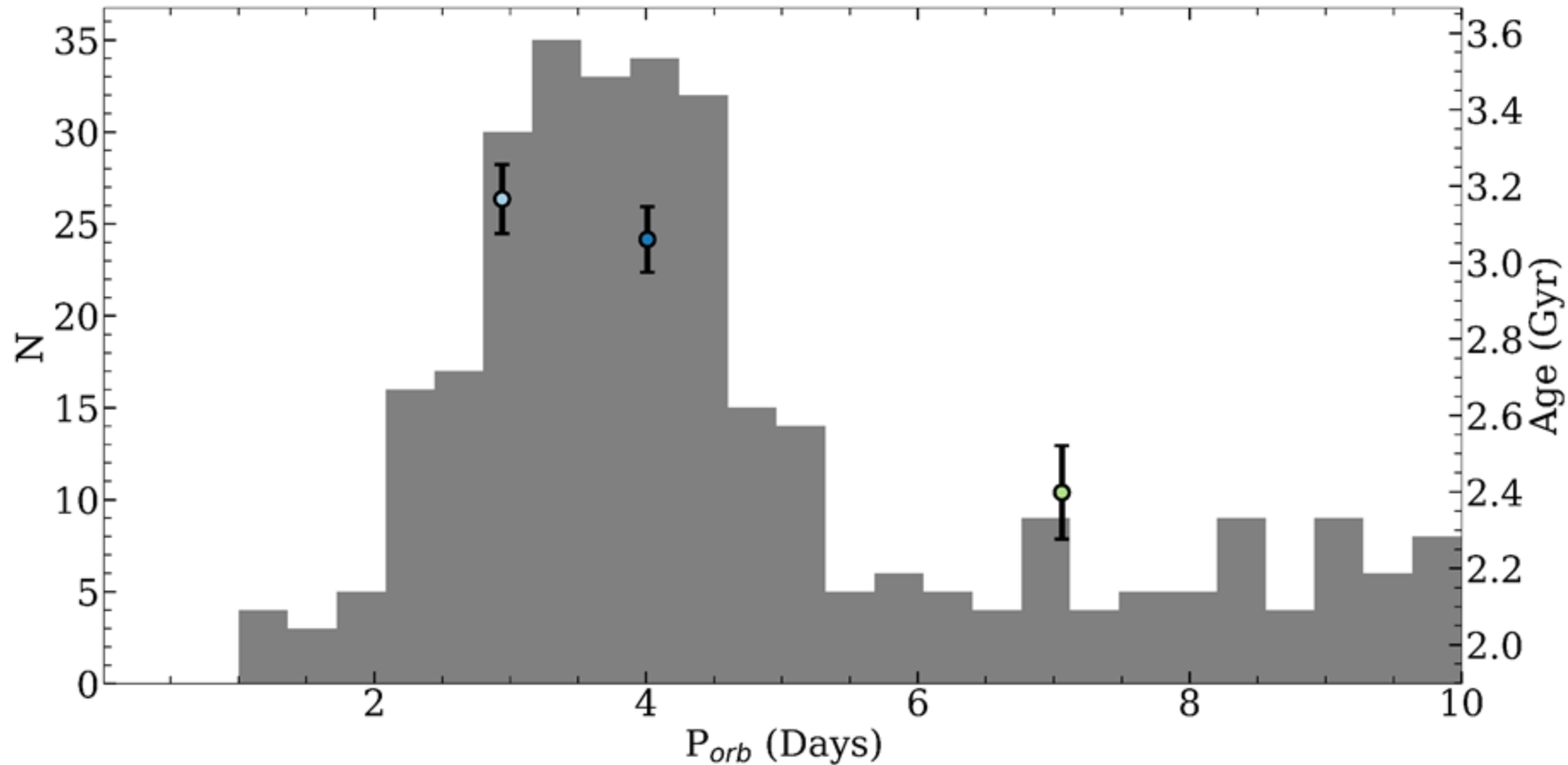
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# Parametric Model Can Reproduce Our Observations

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- (1) New method for absolute ages via velocity dispersion extended to the solar neighborhood
- (2) Hot Jupiters near & inside the debiased orbital period peak are older than those outside it, and the population inside is slightly older than the peak (is it unrelated to observational bias)
- (3) The combination of an early, uniformly-distributed & late-time, peak-populating migration mechanism can replicate the subpopulation ages we infer

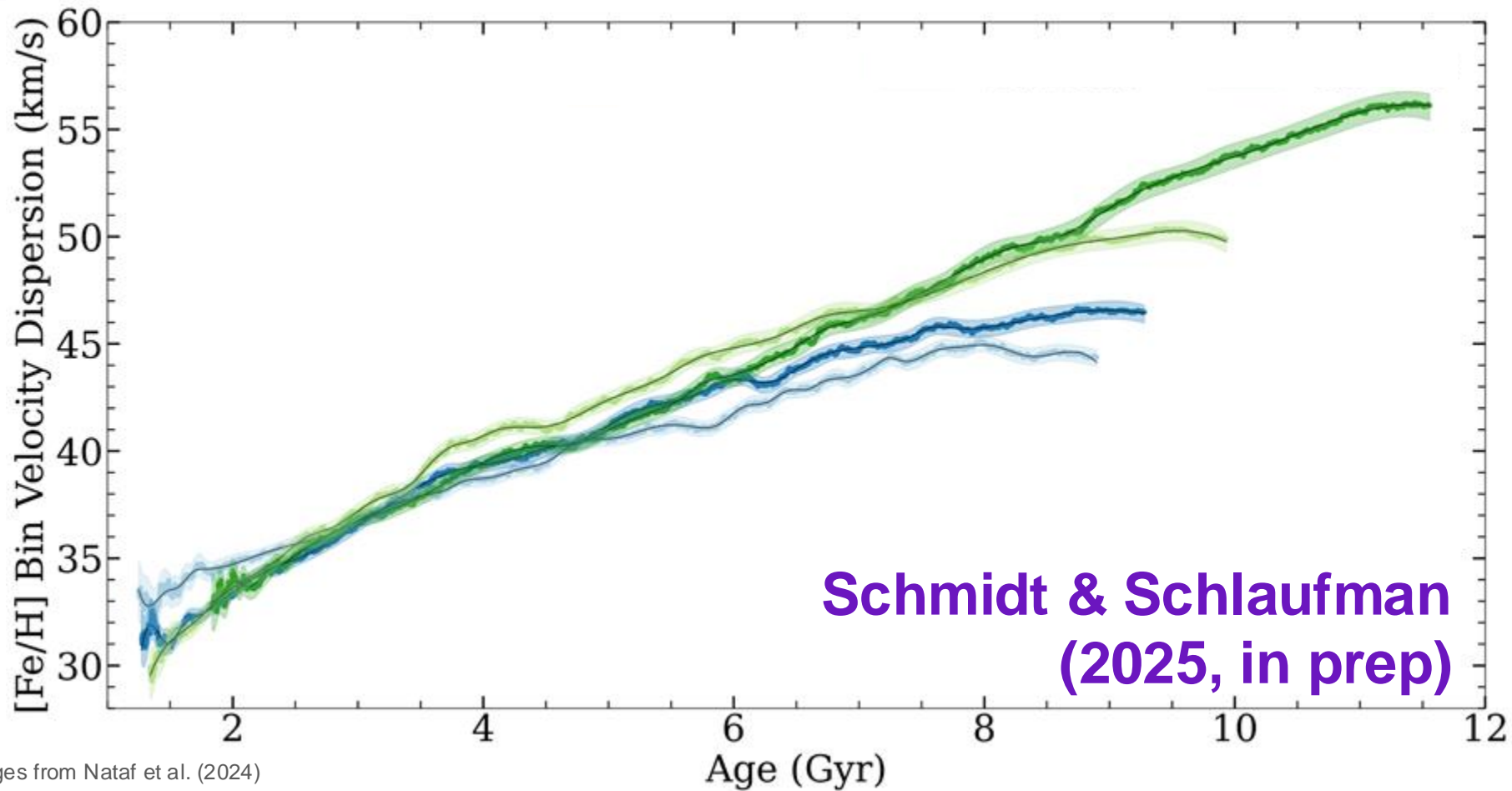
**Check out my poster on the internal heating of hot Jupiters! (4.15)**

# Backup Slides

# Stellar Metallicity Not A Concern At HJ Ages

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**Schmidt & Schlaufman  
(2025, in prep)**

## Disk Migration only, $Q_* \sim 10^7$

- Brings HJs to ~uniform period distribution (?)
- Little tidal dissipation; HJs remain mostly close to post-migration separations
- Resulting ages should be similar/consistent

## DM & Late-time mechanism, $Q_* \sim 10^7$

- Combination of uniform & peak-populating mechanisms
- Little tidal dissipation; HJs remain mostly close to post-migration separations, but ones near peak would be older
- Peak population would be oldest

## Disk Migration only, $Q_* \sim 10^5$

- Brings HJs to ~uniform period distribution (?)
- Much tidal dissipation; Close-in HJs destroyed; mid-range HJs move in
- Inner population should be young, followed by middle & outer

## DM & Late-time mechanism, $Q_* \sim 10^5$

- Combination of uniform & peak-populating mechanisms
- Much tidal dissipation; Close-in HJs destroyed; mid-range HJs move in, but ones near peak would be older
- Inside & Peak should be similar, but non-populated outer should be younger



