Making Runaways: The Ejection of Stars from Clusters due to Dynamical Evolution

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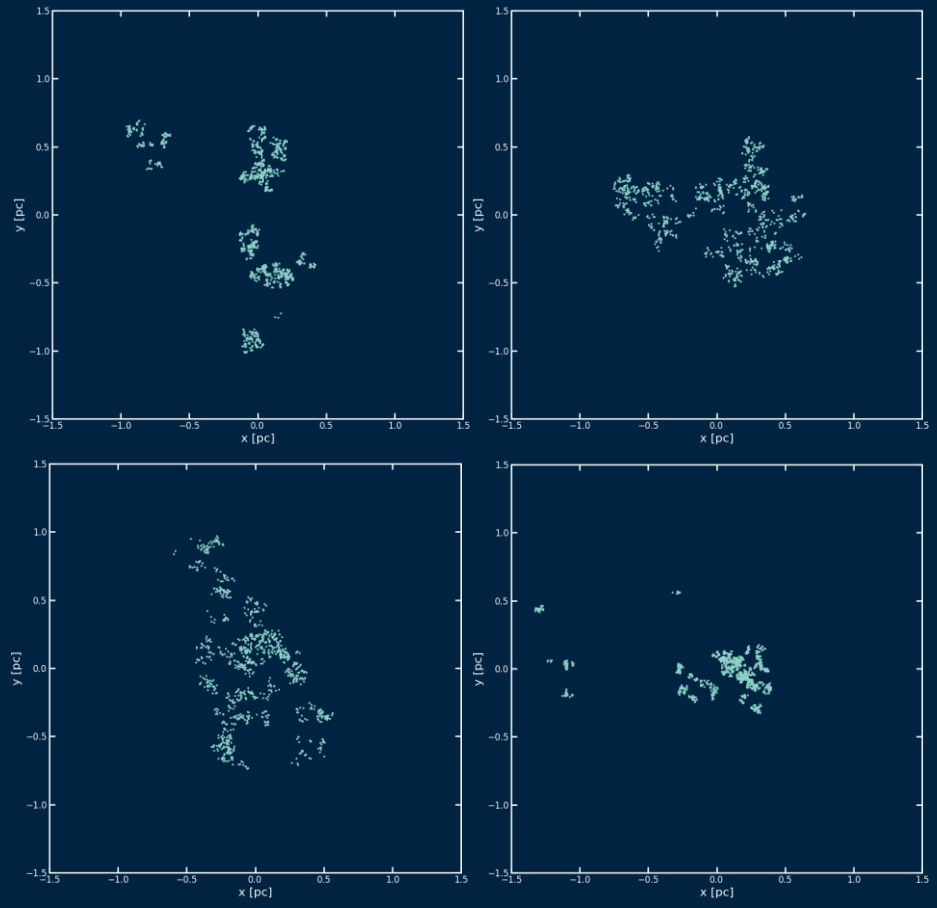
Science & Technology Facilities Council

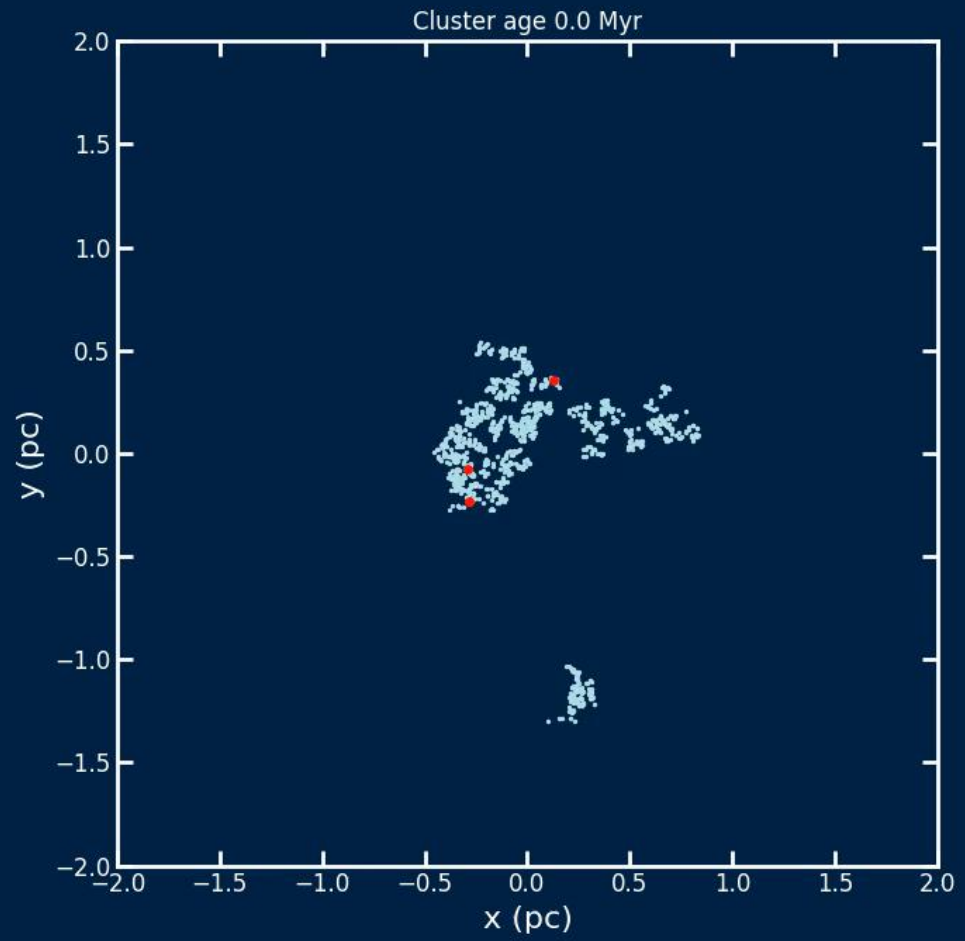
1. N-body Simulations: Initial conditions

1. Initial substructure + virial ratio

Highly substructured



Subvirial (‘cool’)



1. The initial conditions summarised

- Initially subvirial and highly substructured
  (box fractal method: Goodwin & Whitworth 2004)
- **3 scenarios:**

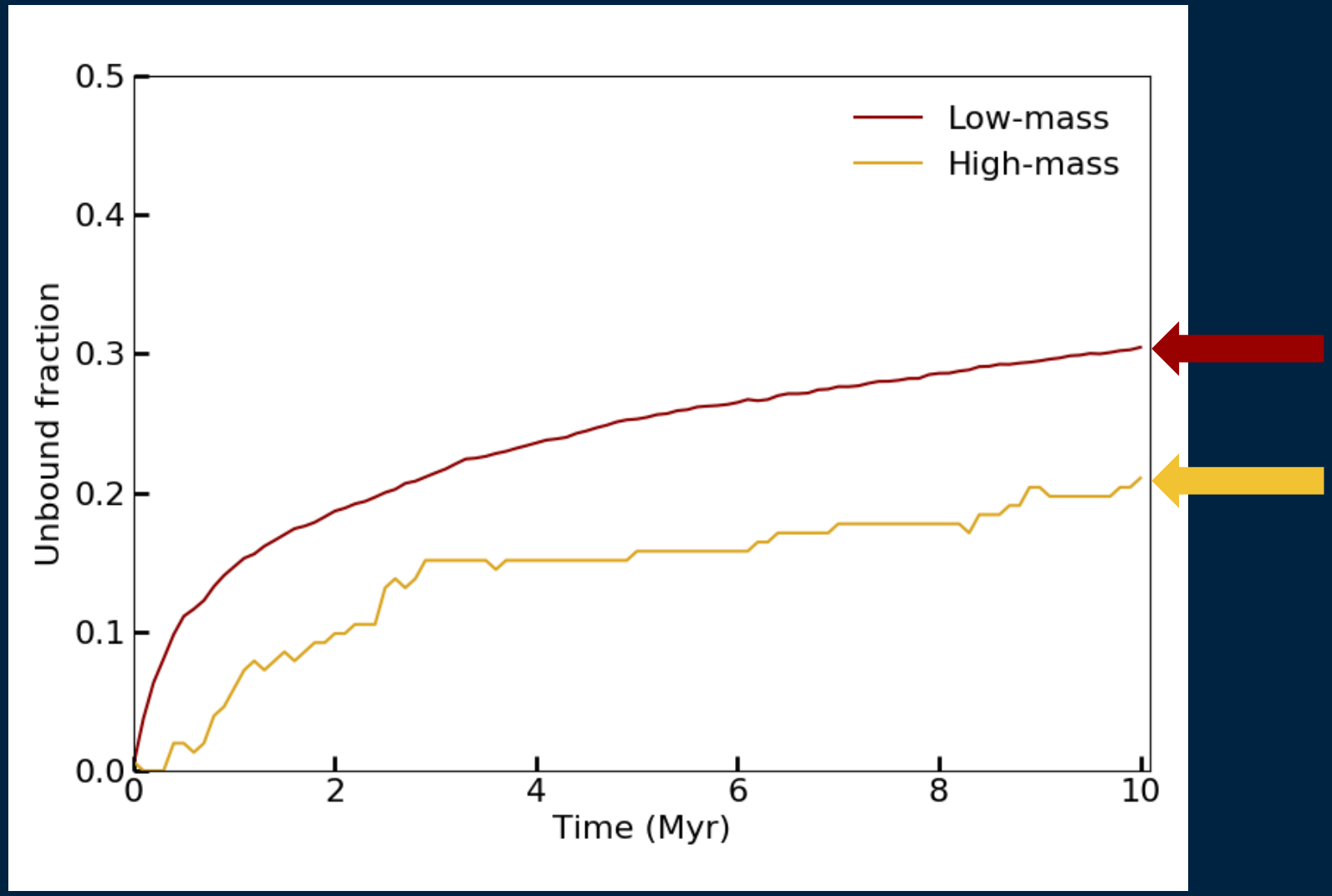
  no PB, no SE **Stellar evolution (SE)** **Primordial binaries (PB)**

- 20 simulations each with 1000 stars per cluster evolved over 10 Myr
- Maschberger IMF (Maschberger 2013)
- Initial radius = 1 pc
- Starlab N-body integrator *kira* (Portegies Zwart et al. 2001)

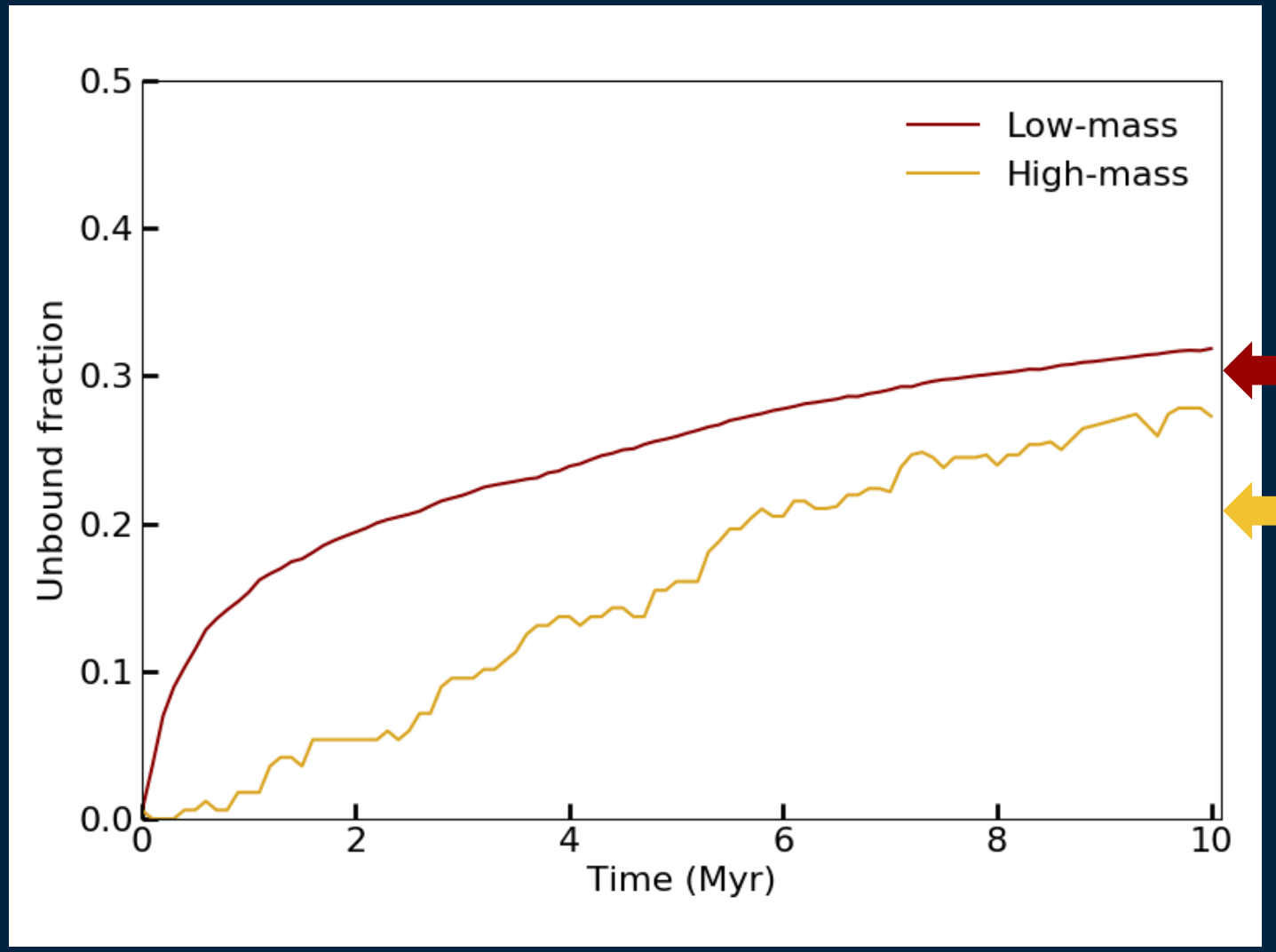
  (for dynamical evolution, see also Parker et al. 2014, Parker & Wright 2016)

2. Unbound fraction by mass class

2. No PB, no SE


0.5
0.4
0.3
0.2
0.1
0.0
Unbound fraction
0
2
4
6
8
10
Time (Myr)
Low-mass
High-mass

2. With SE, no PB



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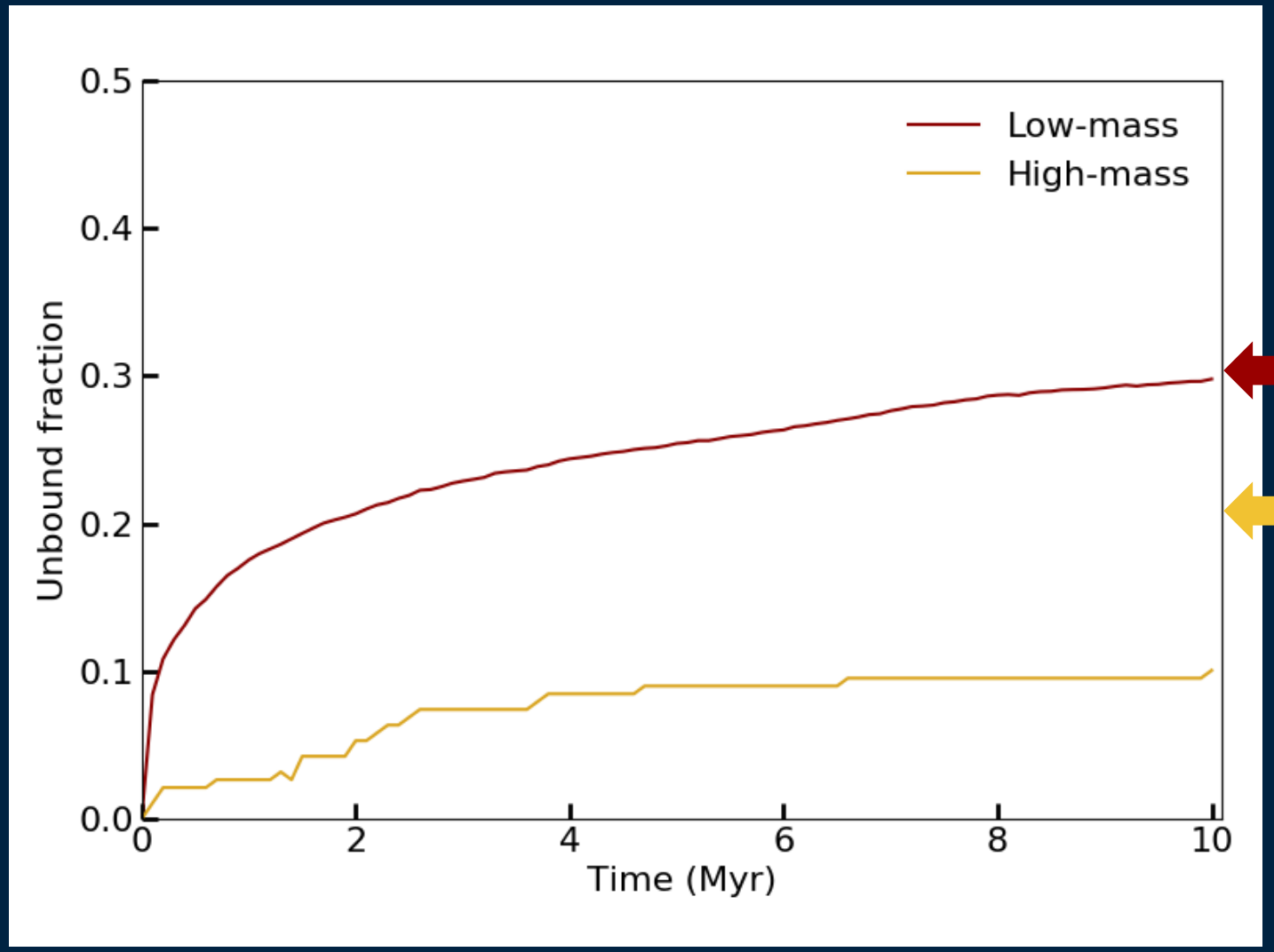

3. Proper motion of unbound stars at 5 Myr

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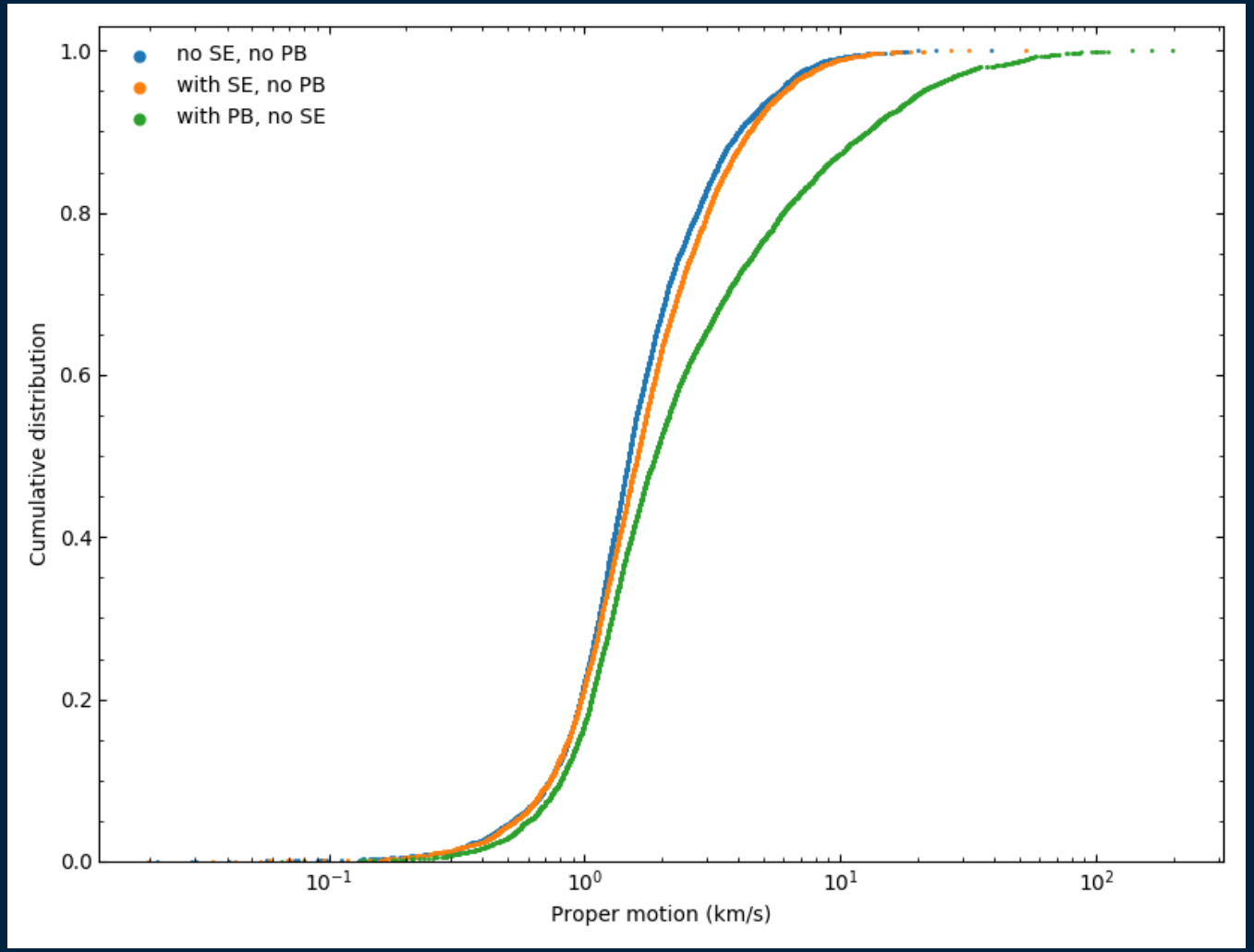

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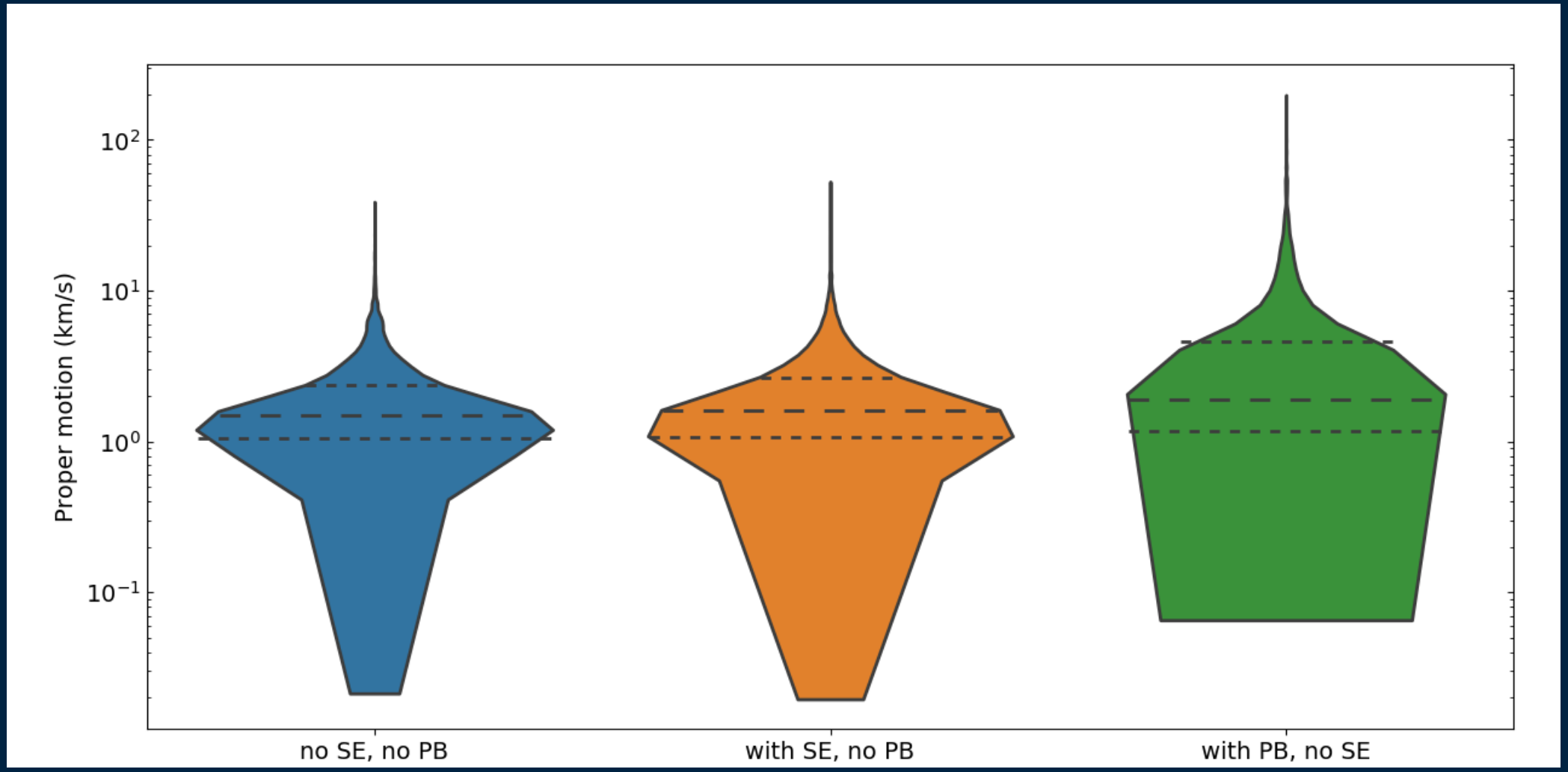

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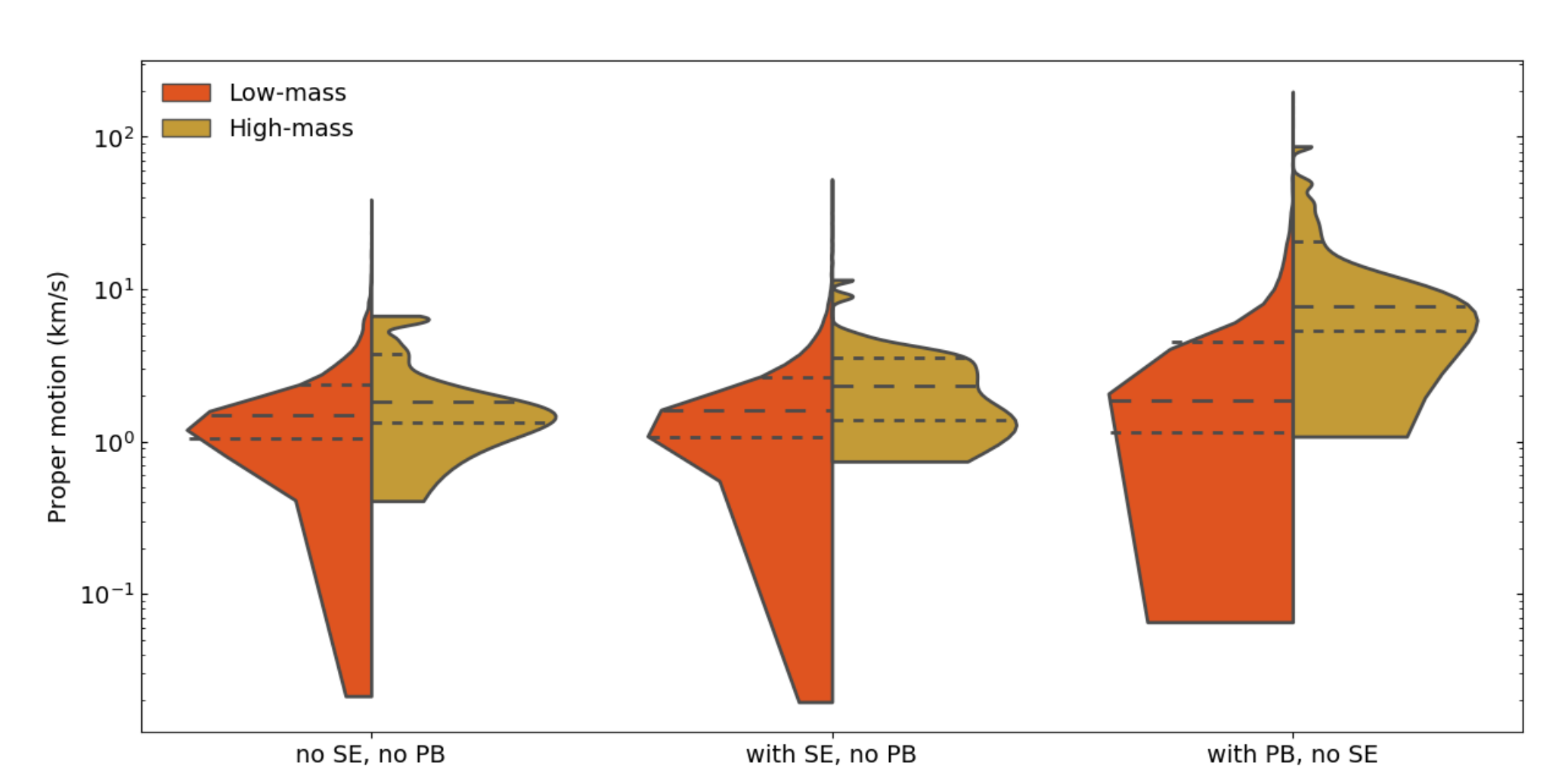
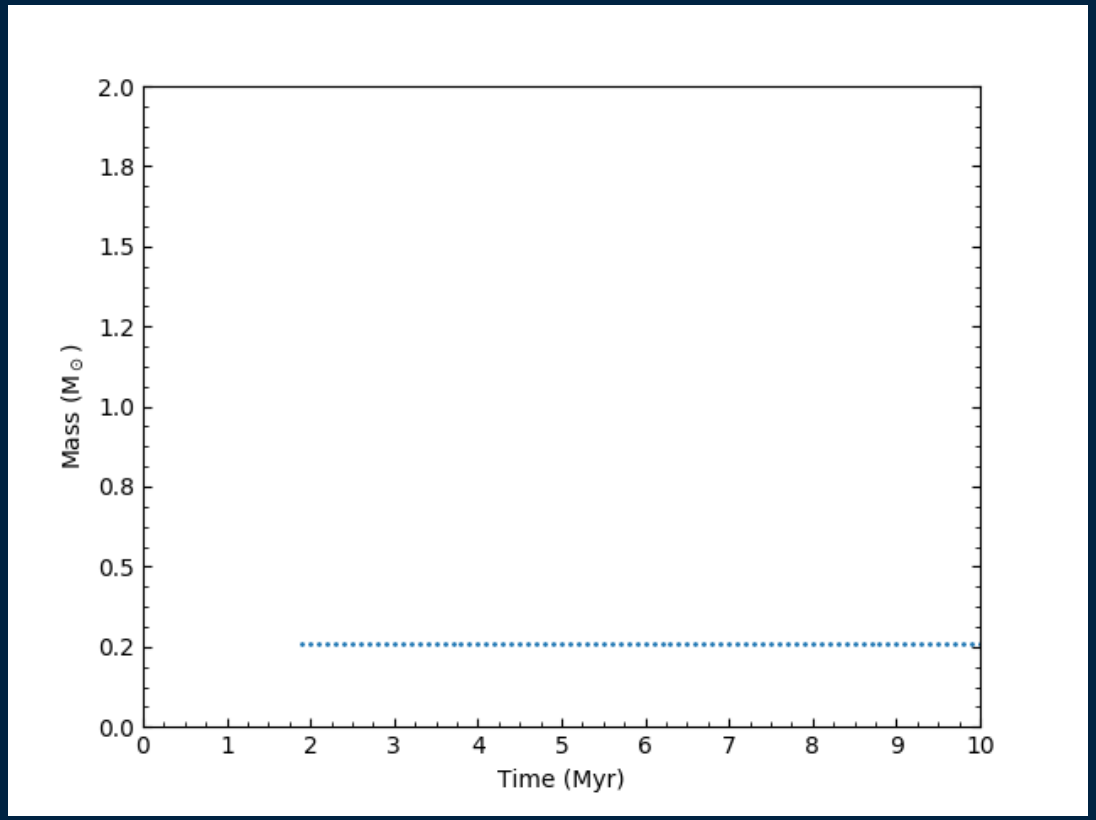


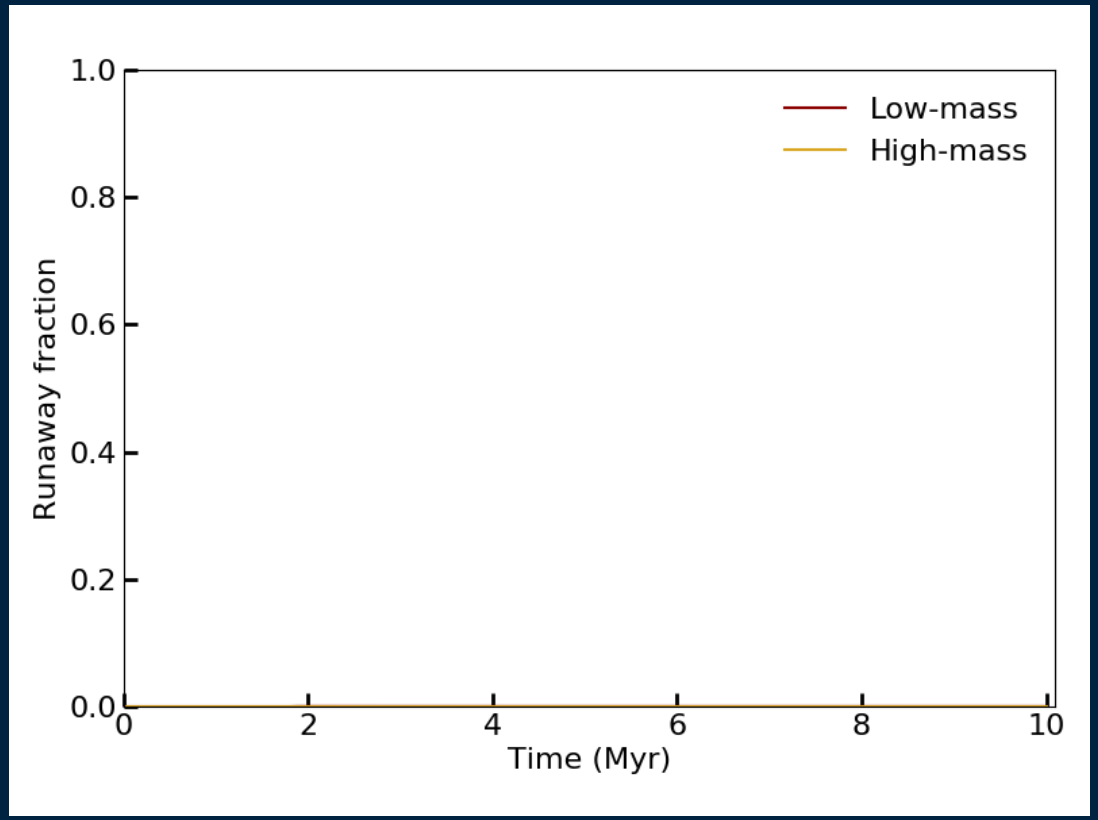
4.Making Runaways & Walkaways

4. Runaways from clusters w/o PB, SE

Runaways (> 30 km/s)

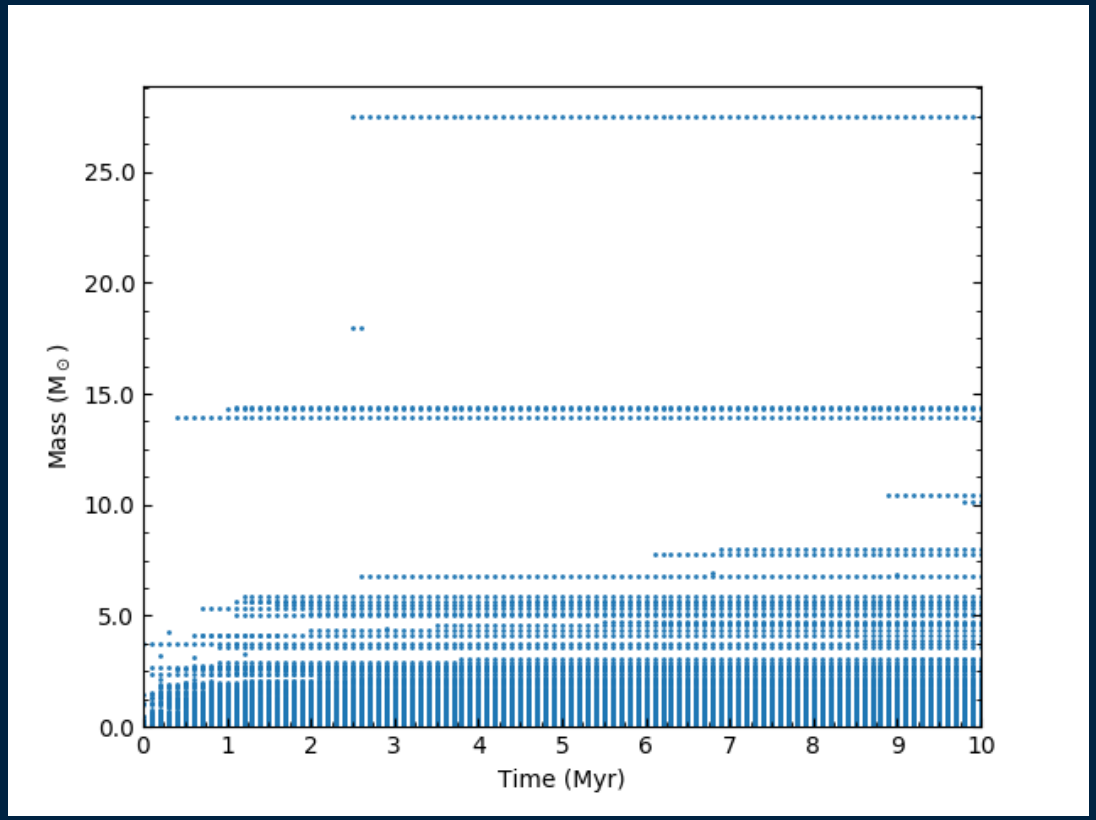


Runaway fraction by mass class

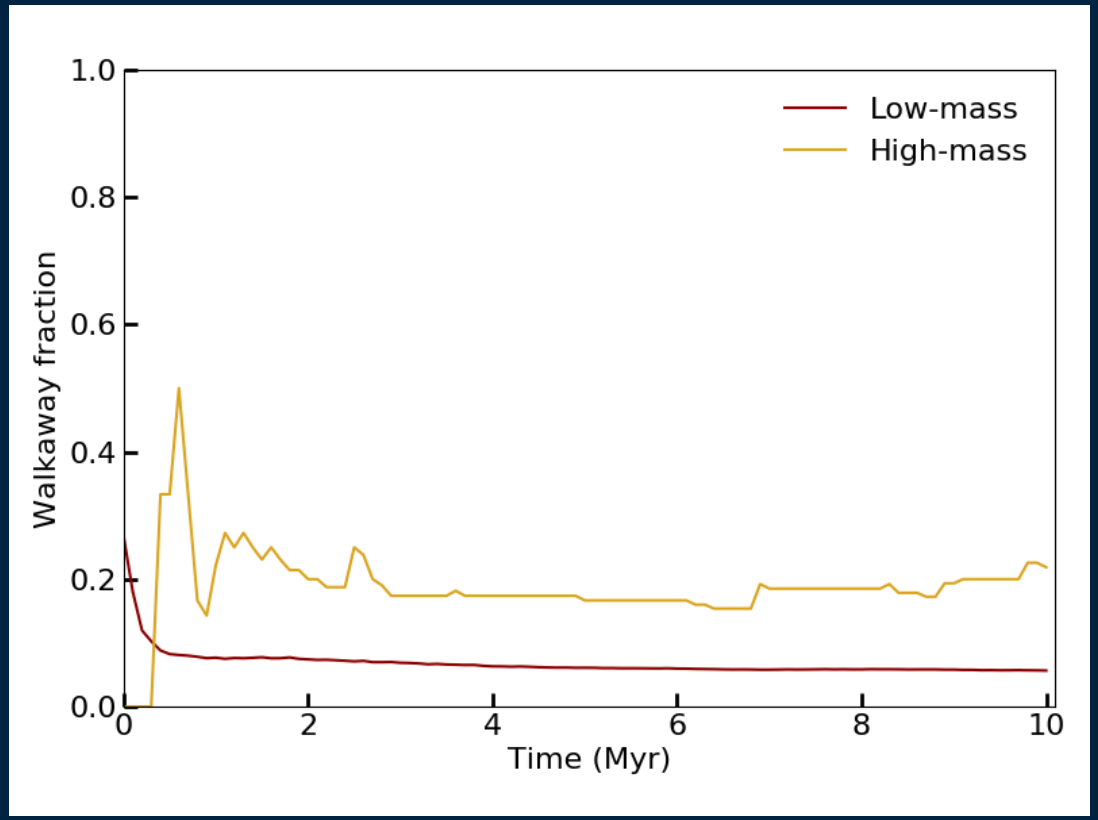


4. Walkaways from clusters w/o PB, SE

Walkaways (5 -30 km/s)

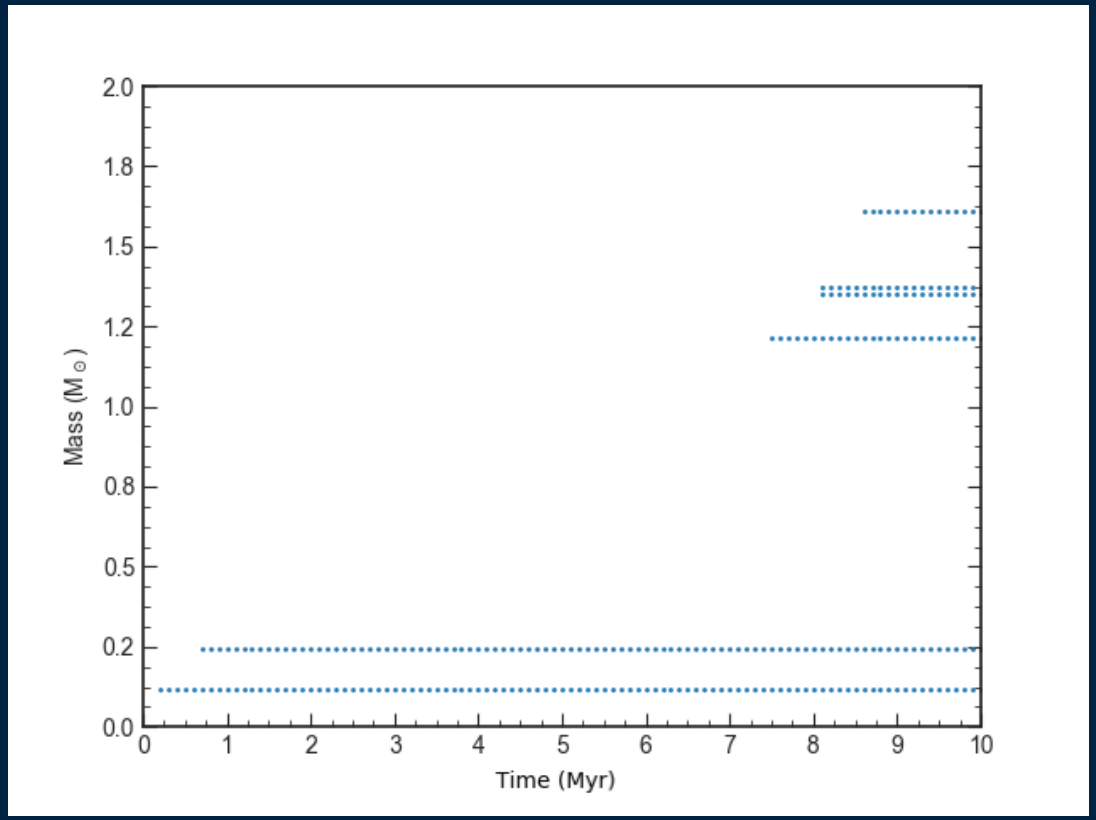


Walkaway fraction by mass class



4. Runaways from clusters with SE, but no PB

Runaways (> 30 km/s)



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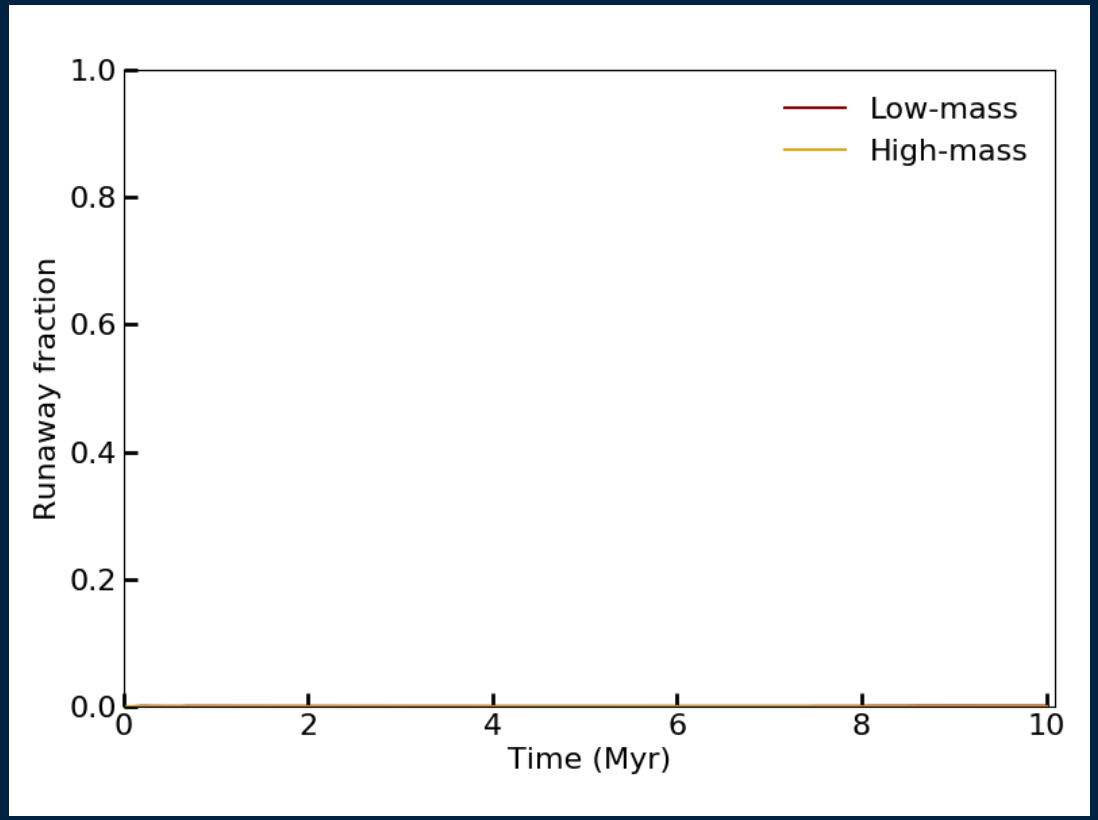

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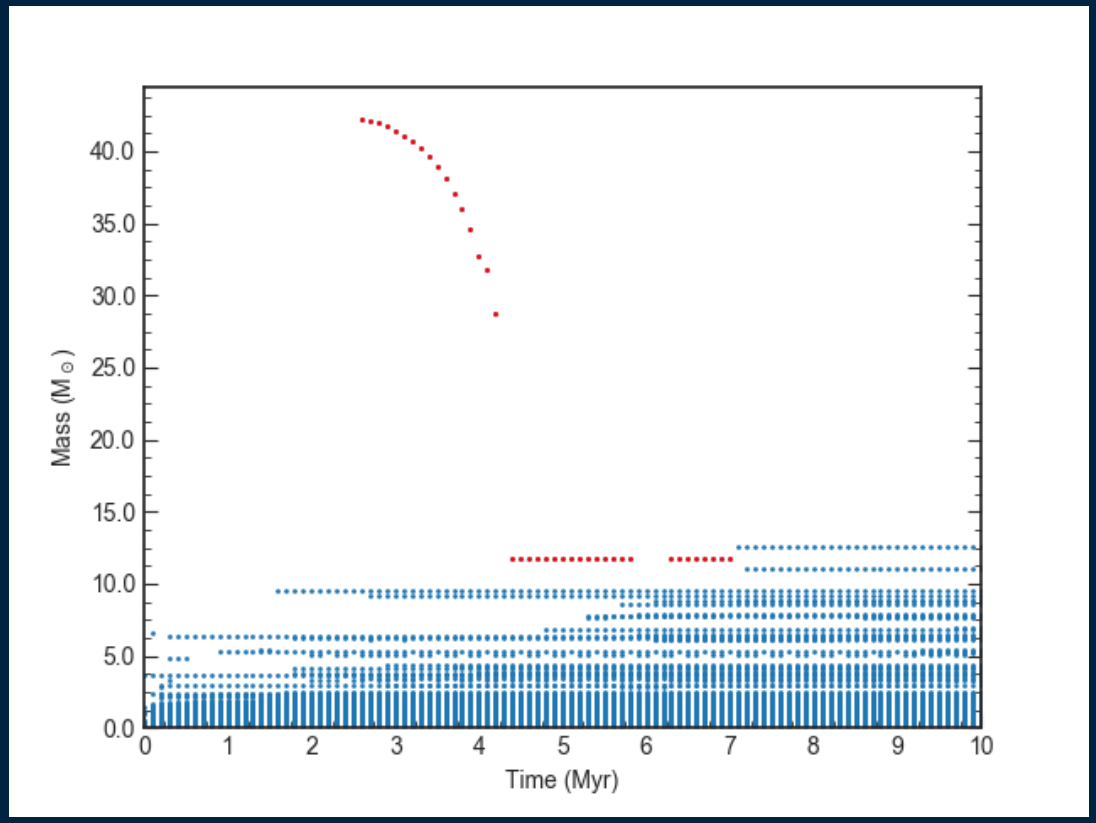

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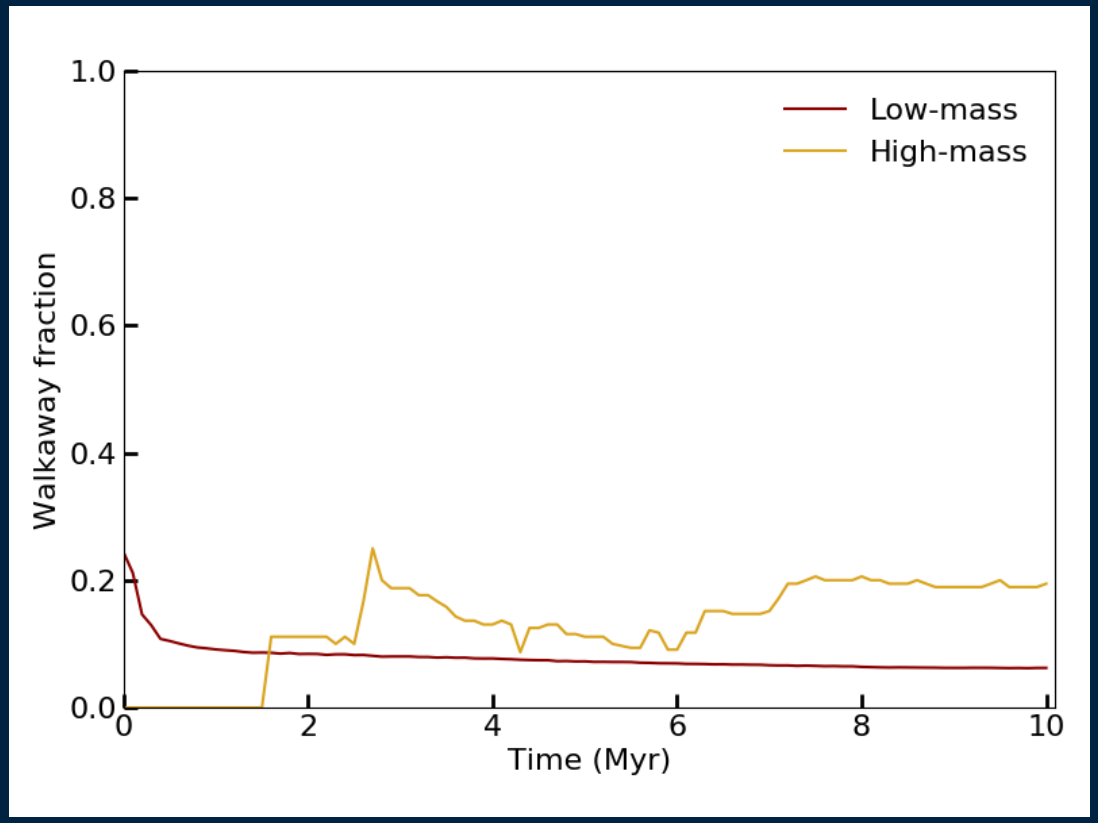

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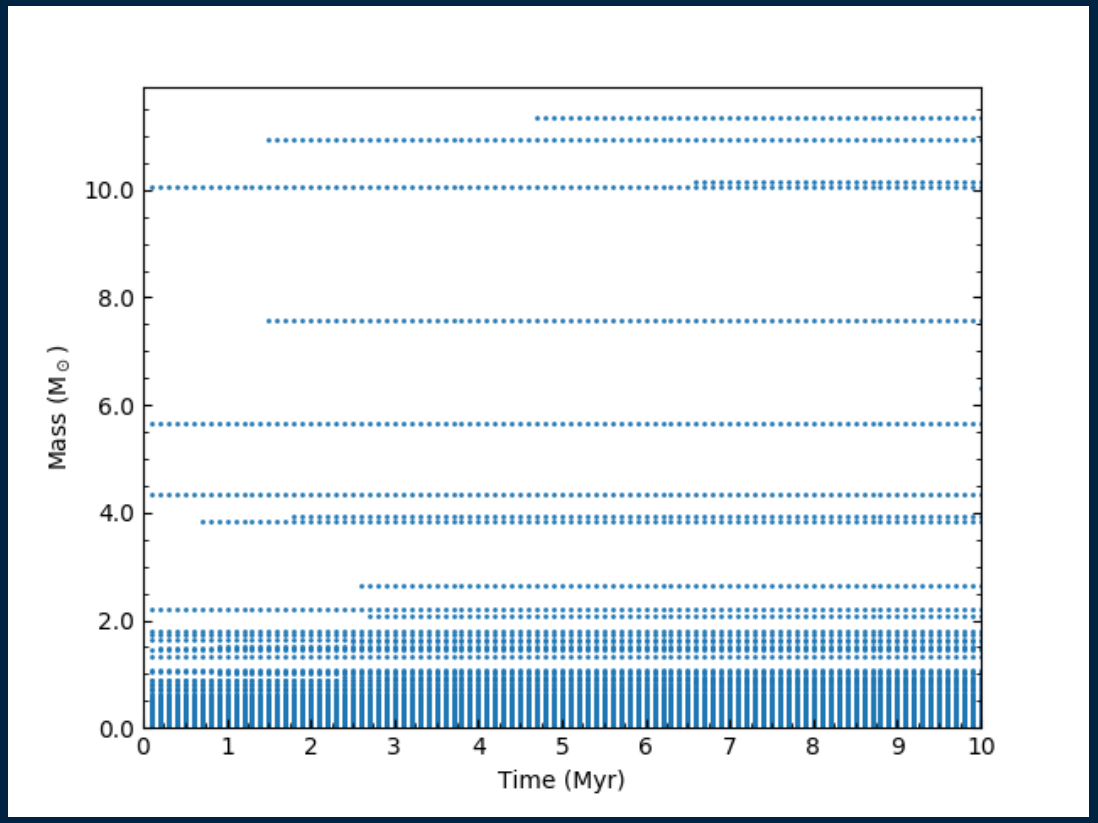
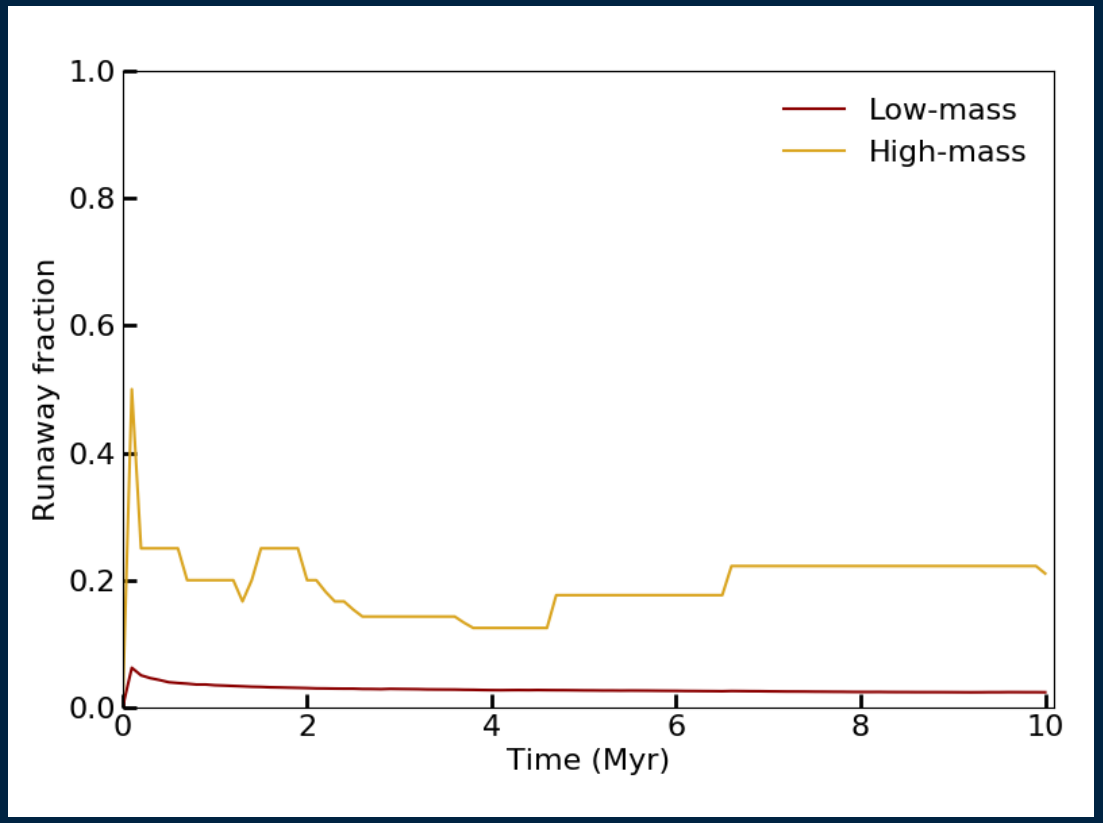


Runaway fraction by mass class



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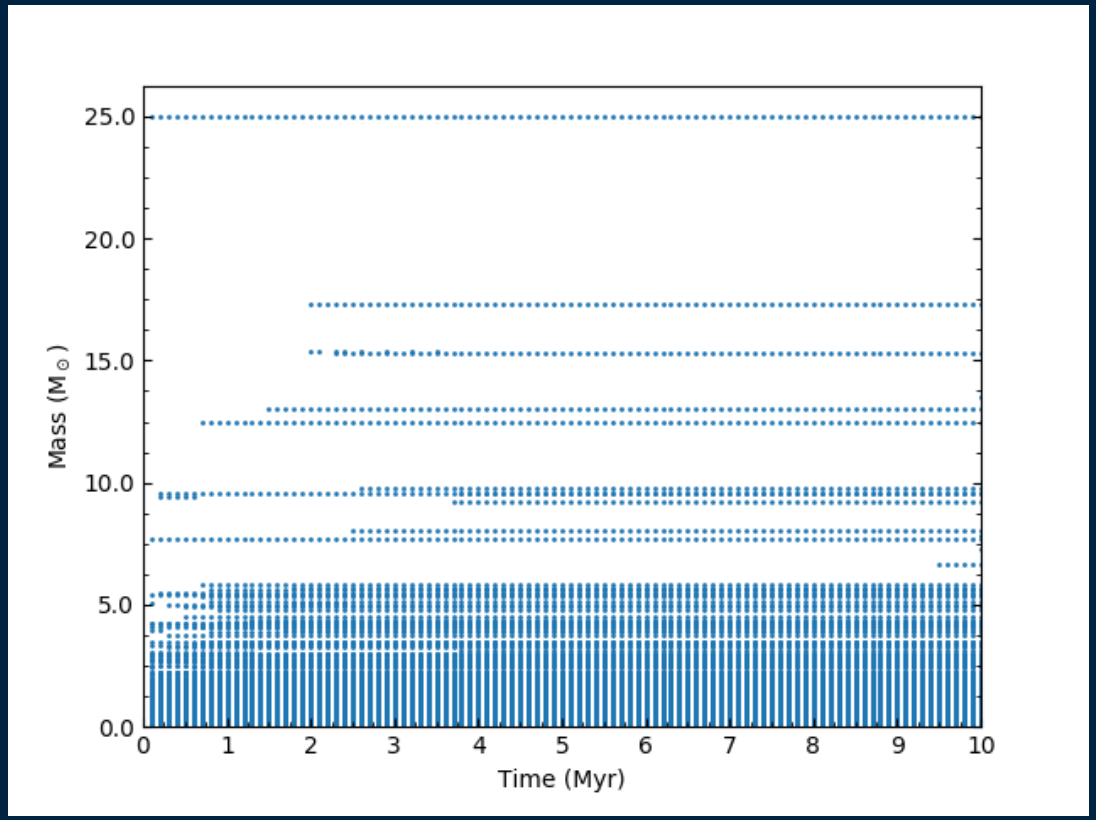
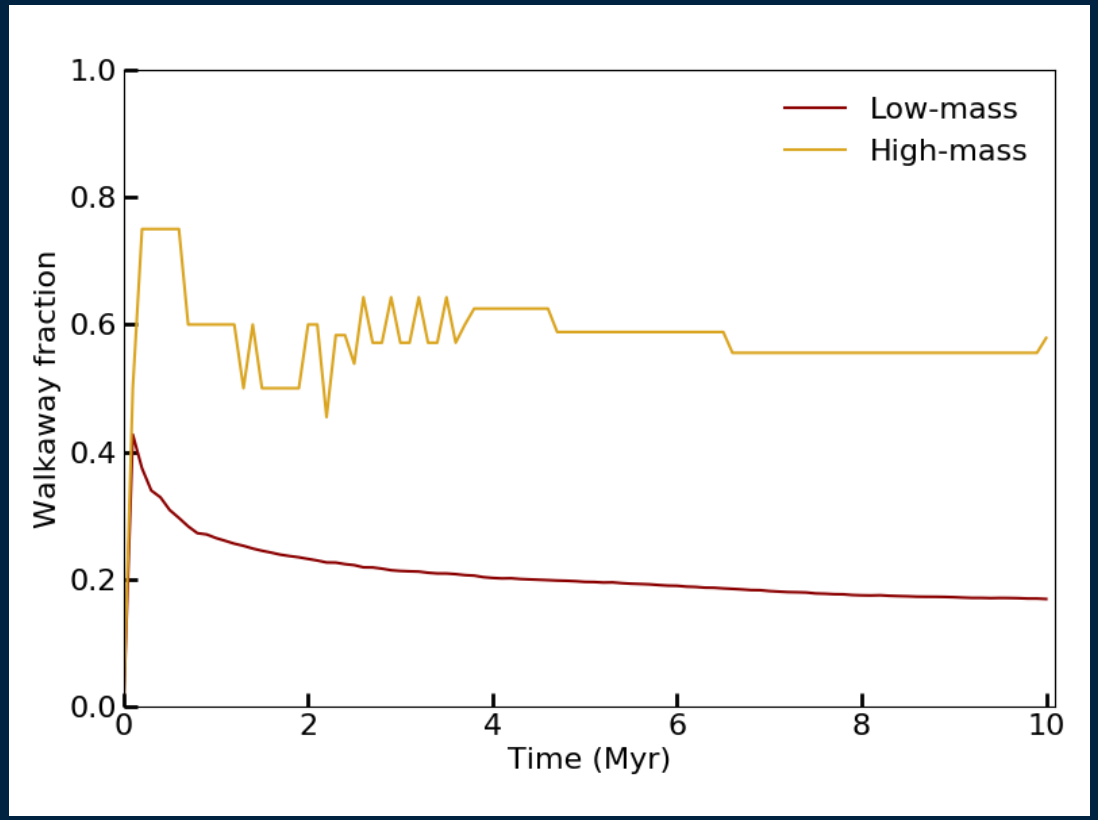


Walkaway fraction by mass class



Conclusions

Presence of **stellar evolution** in clusters...

- slightly increases velocity and overall fraction of unbound stars in both mass classes
- has no effect on runaway fractions (0% for both mass classes), but increases number of low-mass runaways
- ejects large absolute number of low-mass walkway stars
- decreases walkaway fraction of high-mass stars

Presence of **primordial binaries** in clusters...

- increases median and maximum velocity of unbound stars
- increases unbound fraction of low-mass stars at early times, however significantly decreases fraction of high-mass unbound stars (about ½ compared to cluster w/o PB)
- ejects most high-mass stars at least at walkaway velocities and ~25% at runaway velocities