

Bound from birth: gas and binaries in young star clusters

MODEST-24, Warsaw

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IC 348
NIRCam

Key Question

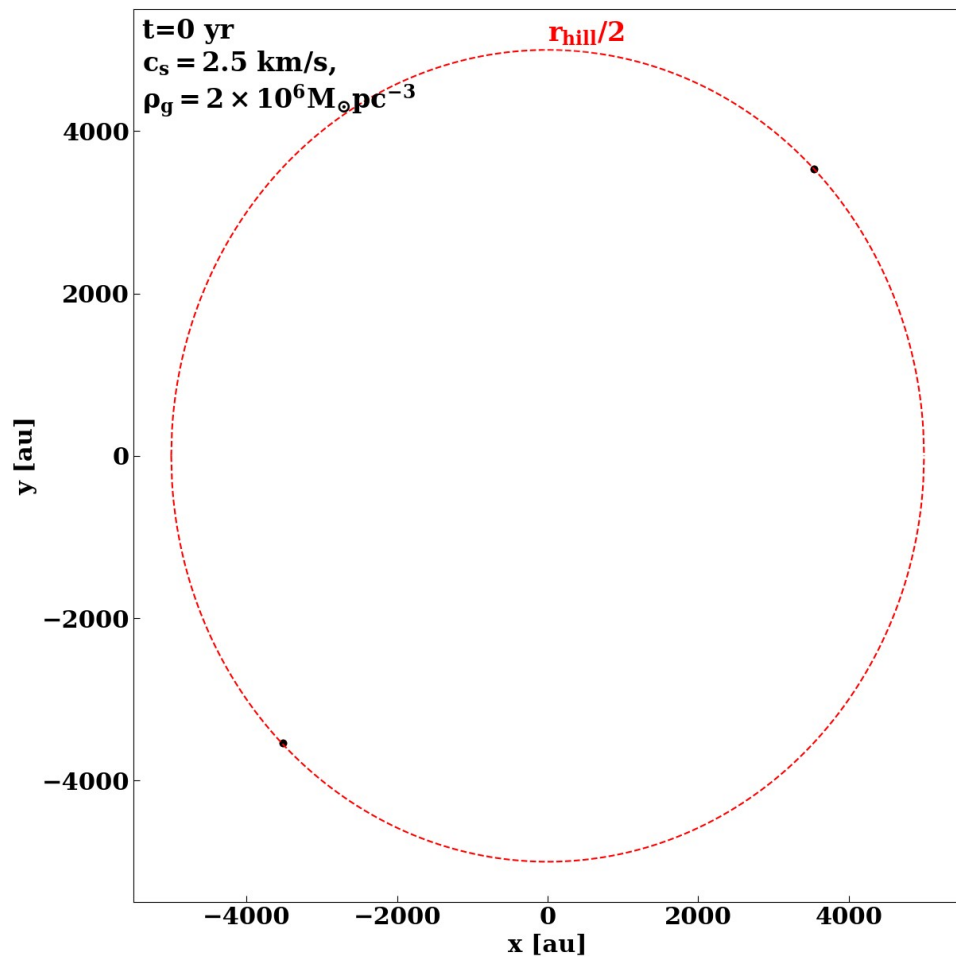
Do binaries in such systems start bound? Or are they captured?

Key Question

Do binaries in such systems start bound? Or are they captured?

**Motivation: Gas dynamical friction assisted binary capture
(Rozner, Generozov, Perets 2023)**

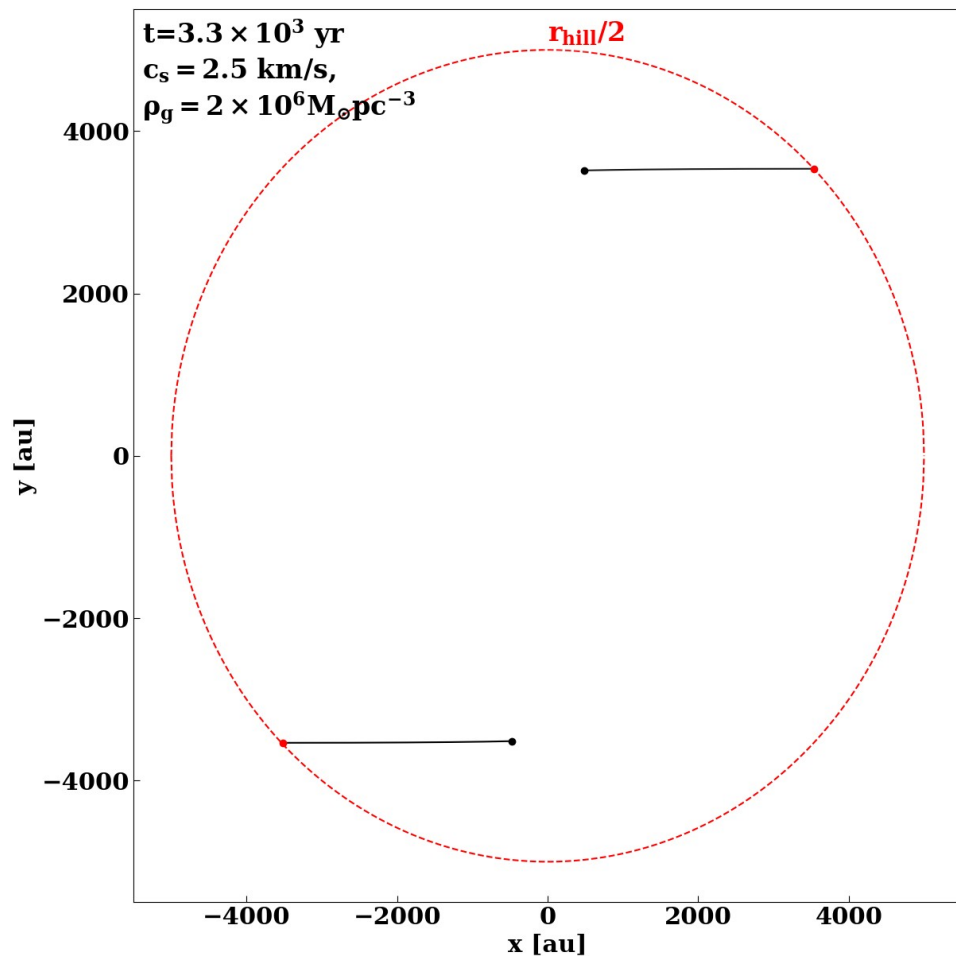
Motivation and previous work



Simulation of capture (with
REBOUNDX)

$10 M_\odot + 10 M_\odot$

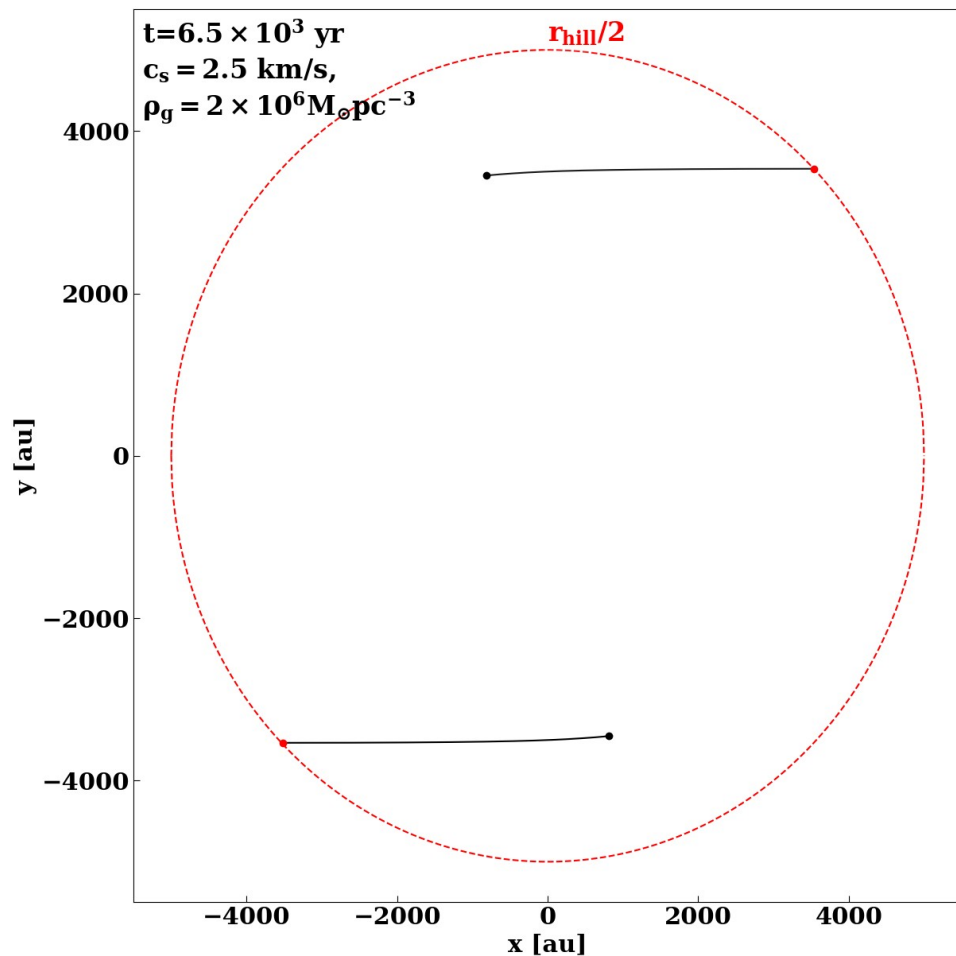
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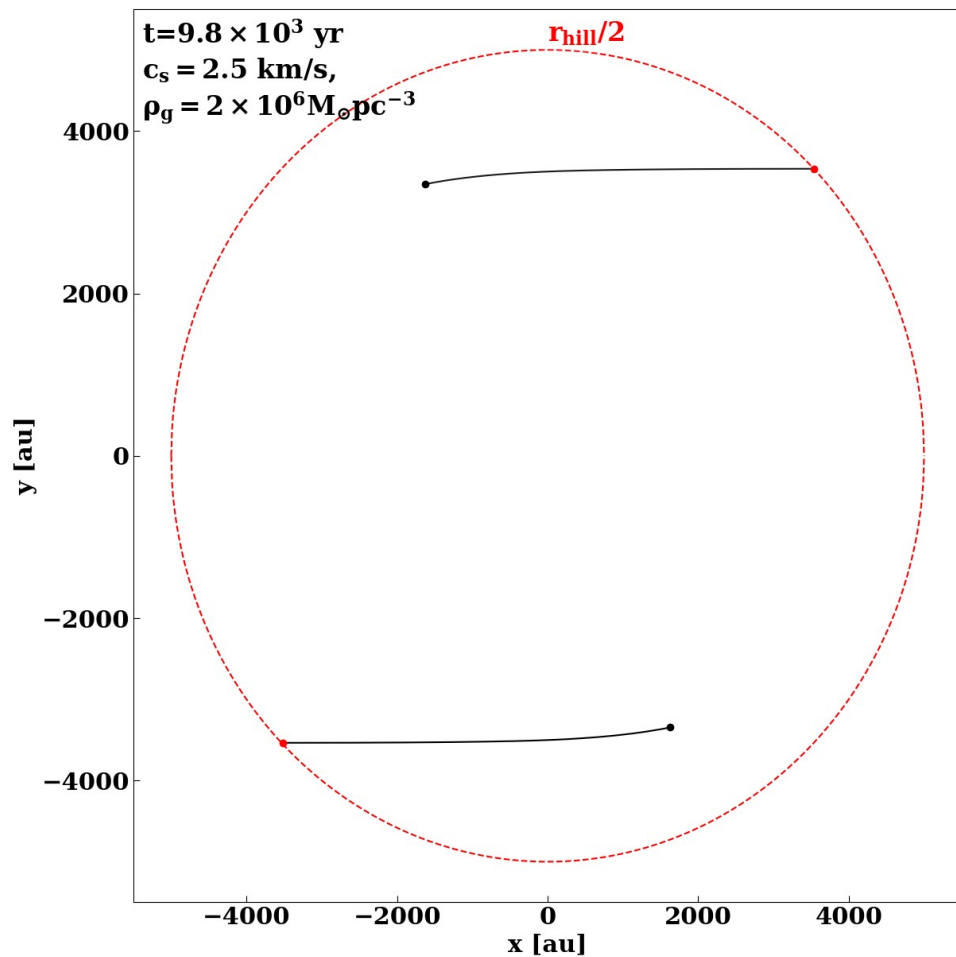
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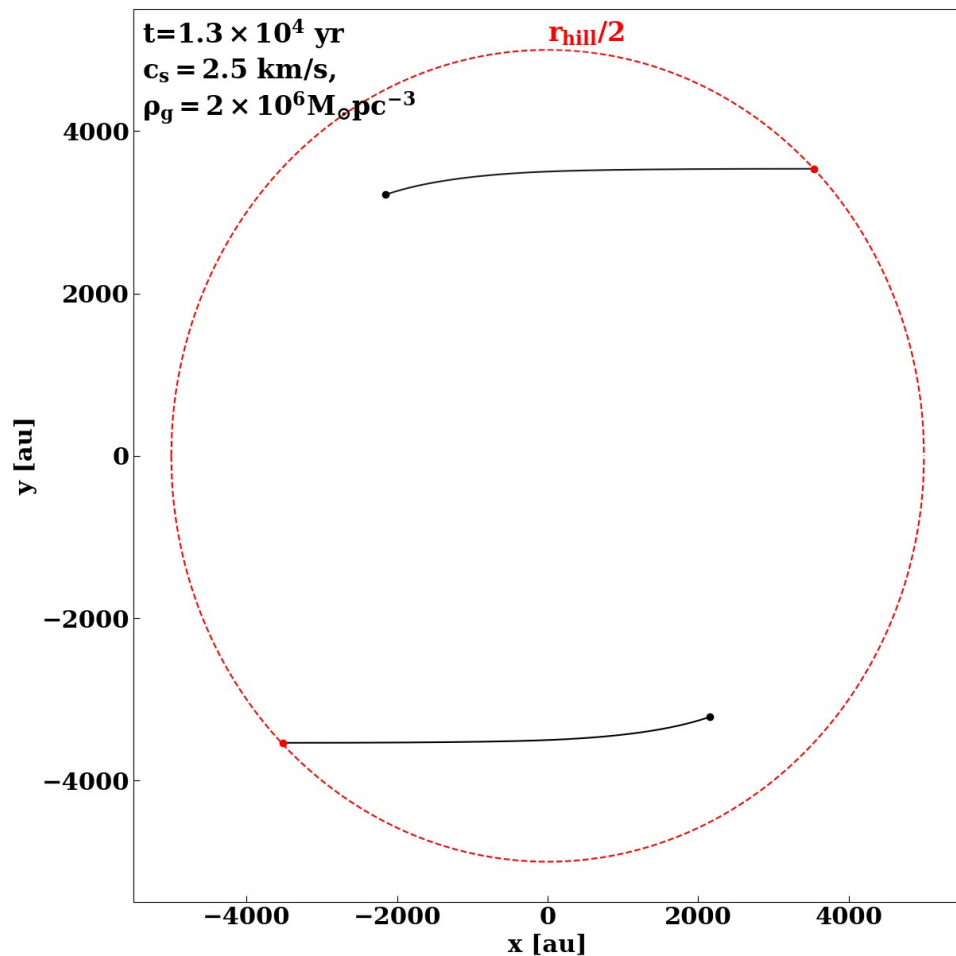
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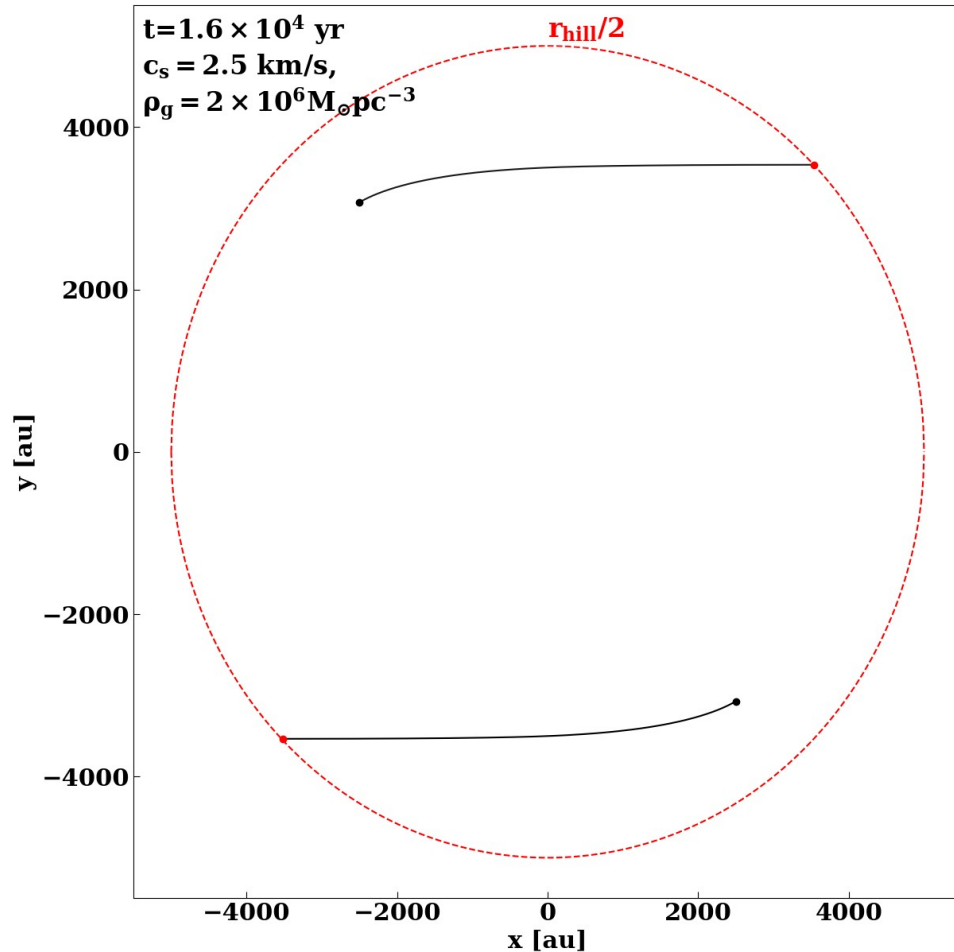
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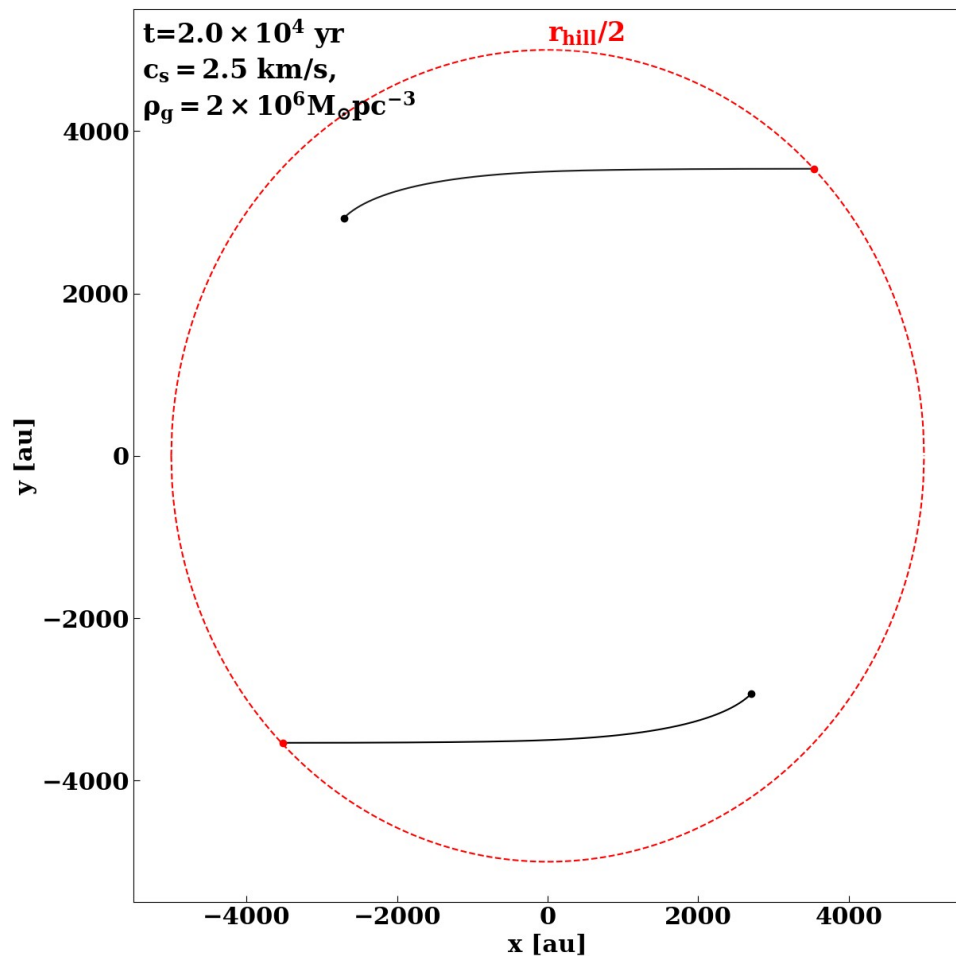
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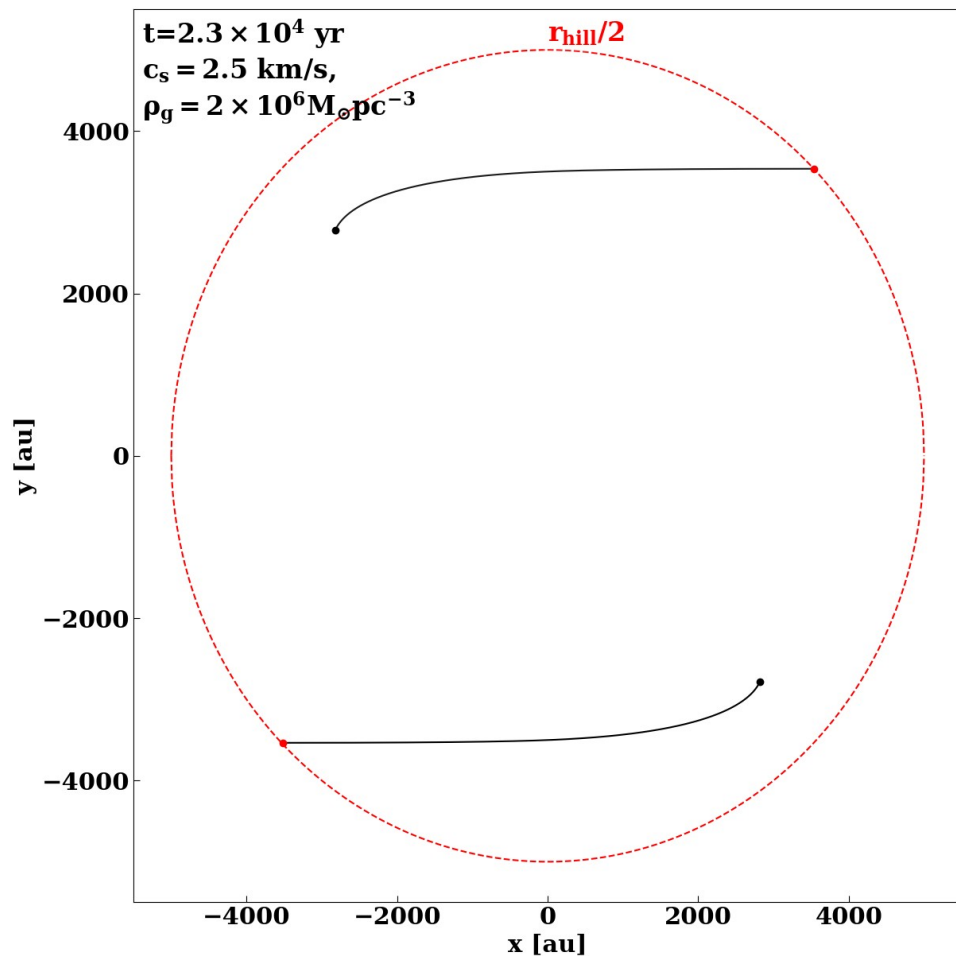
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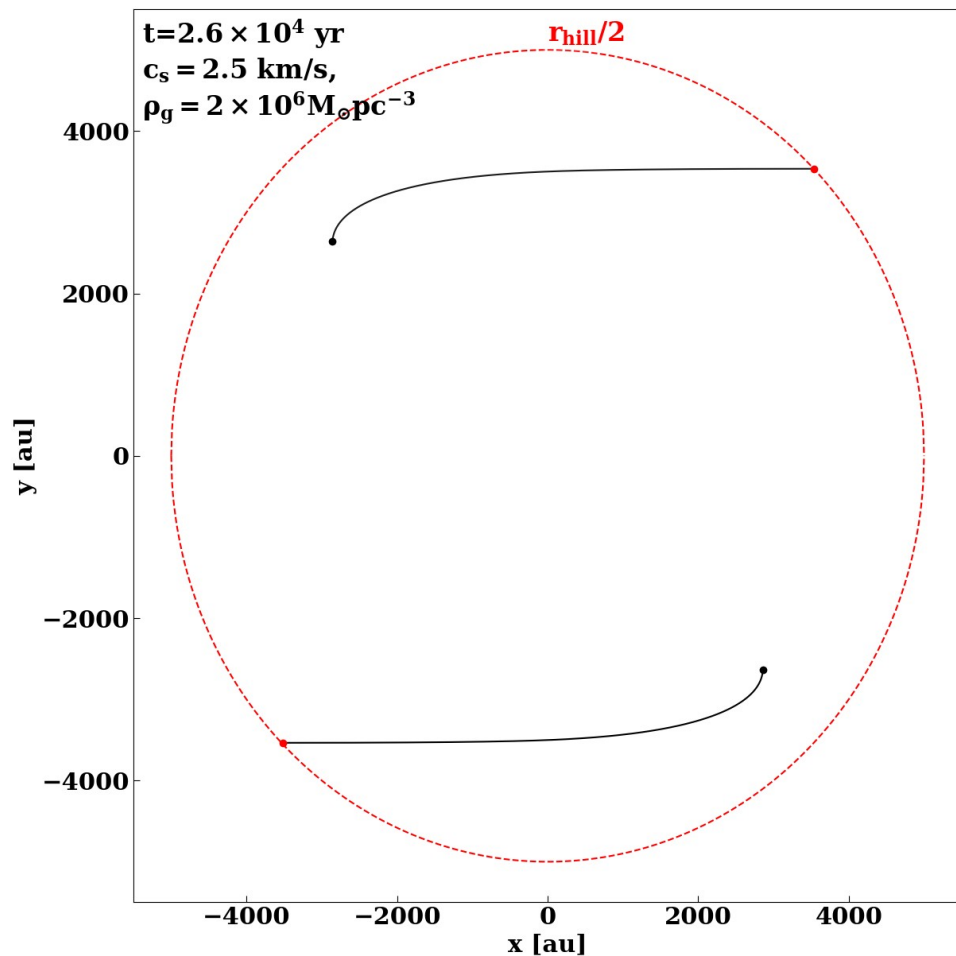
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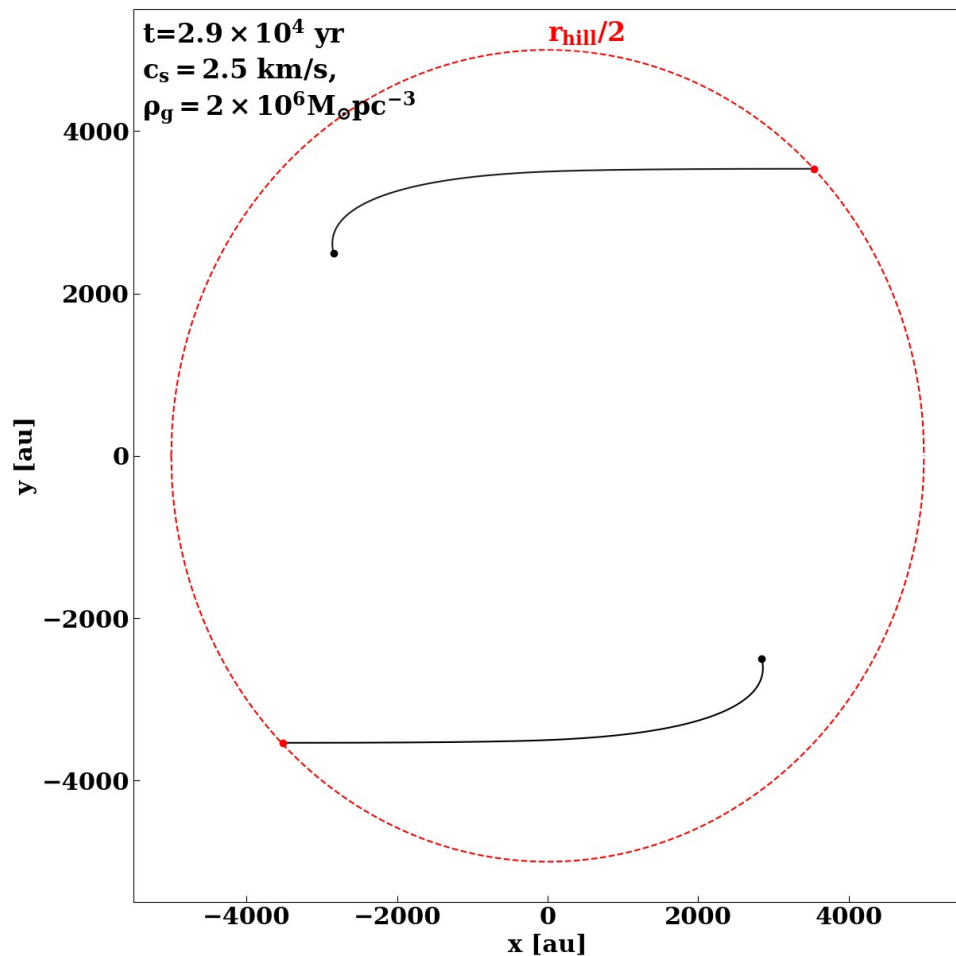
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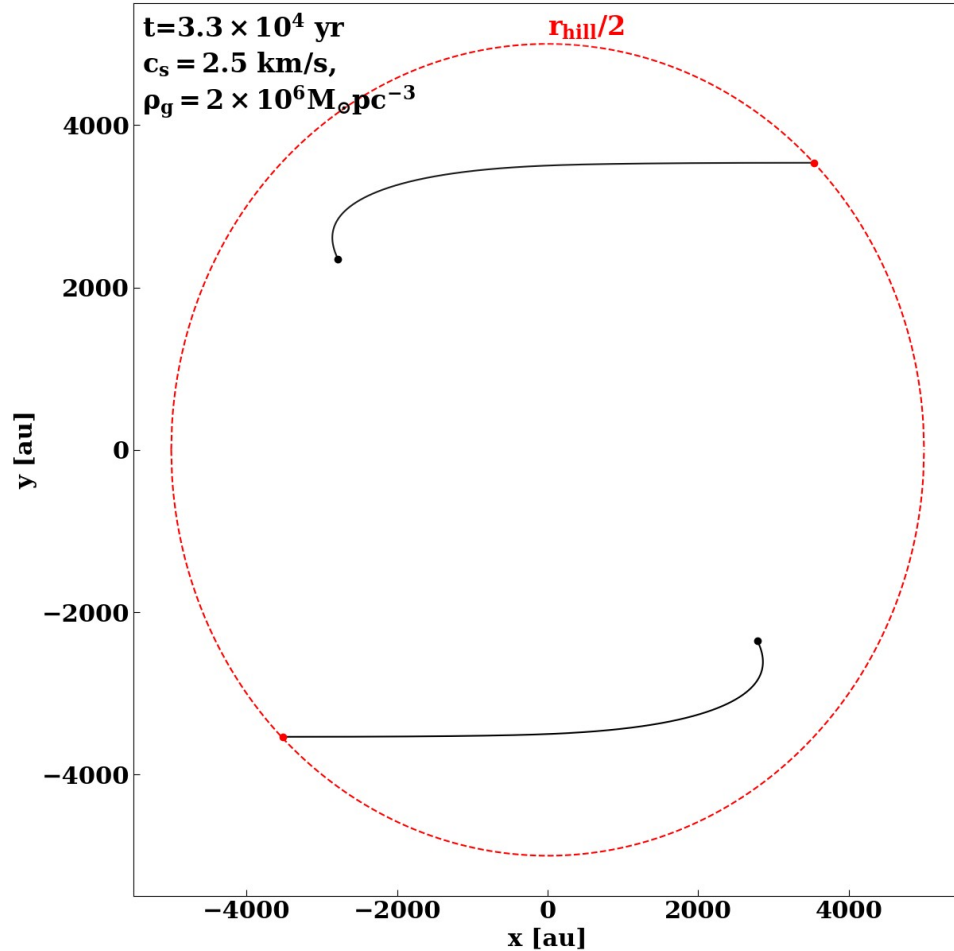
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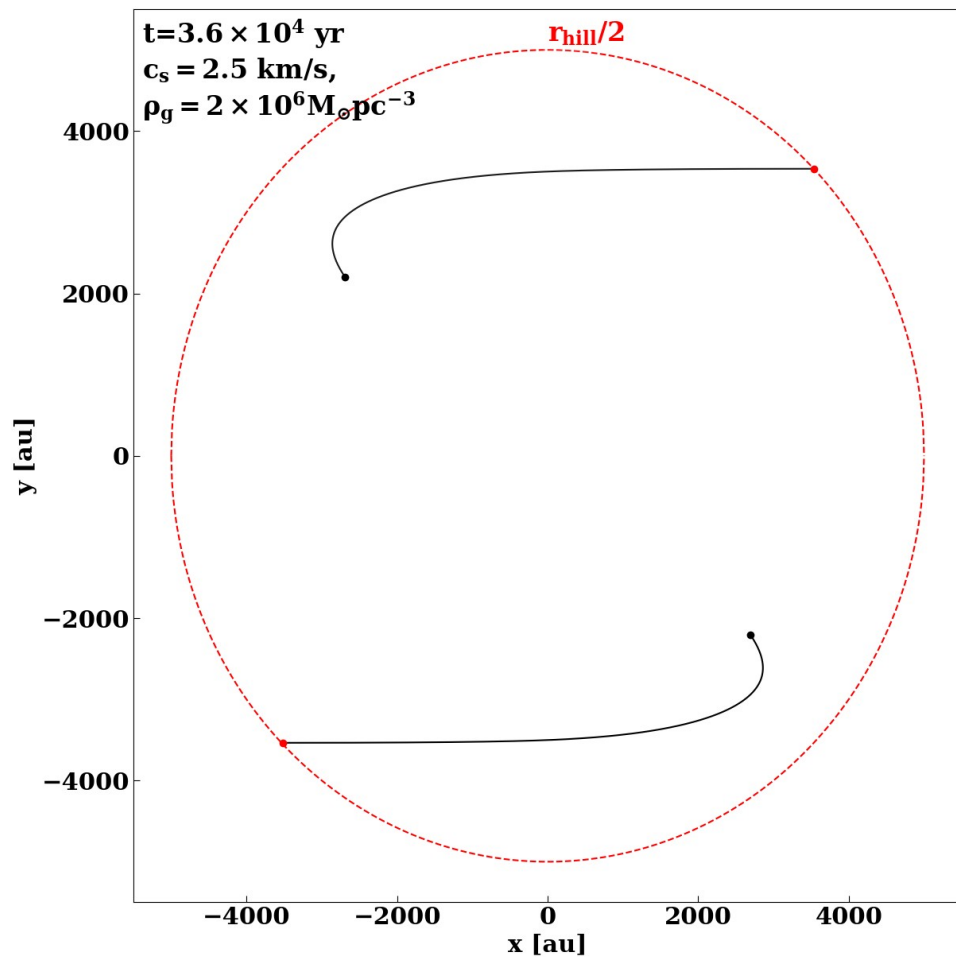
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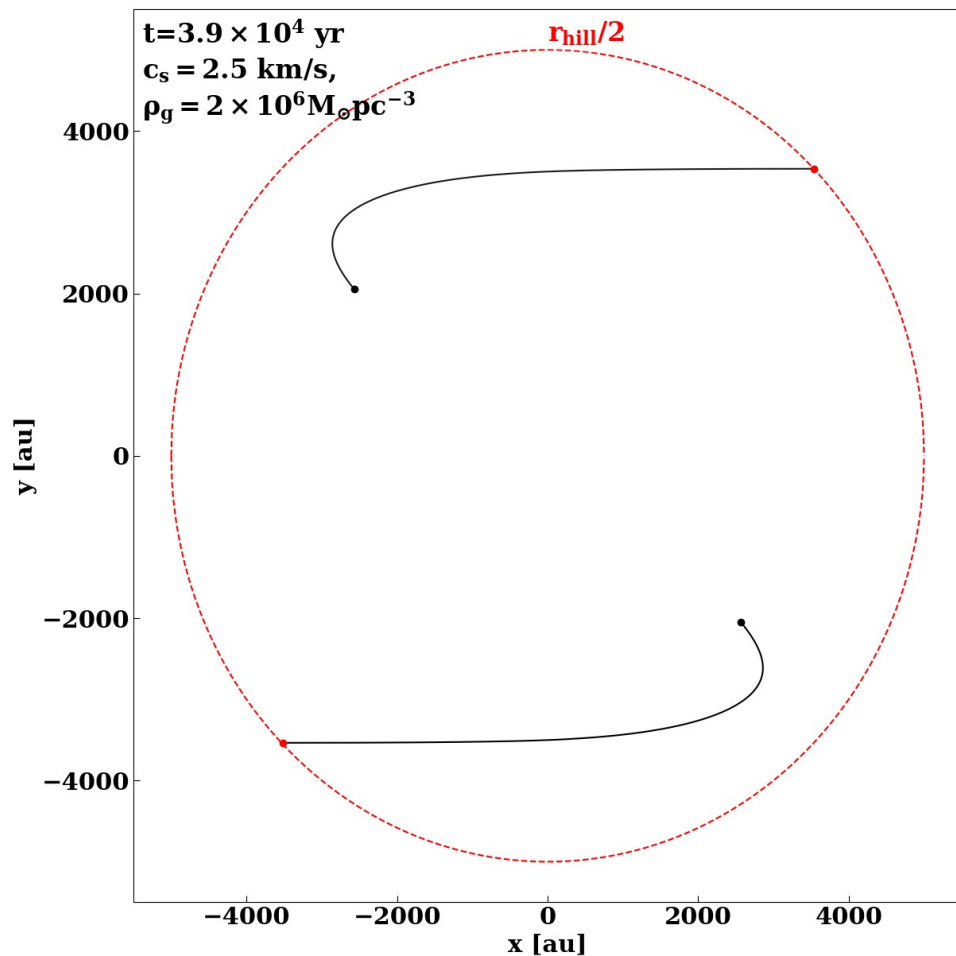
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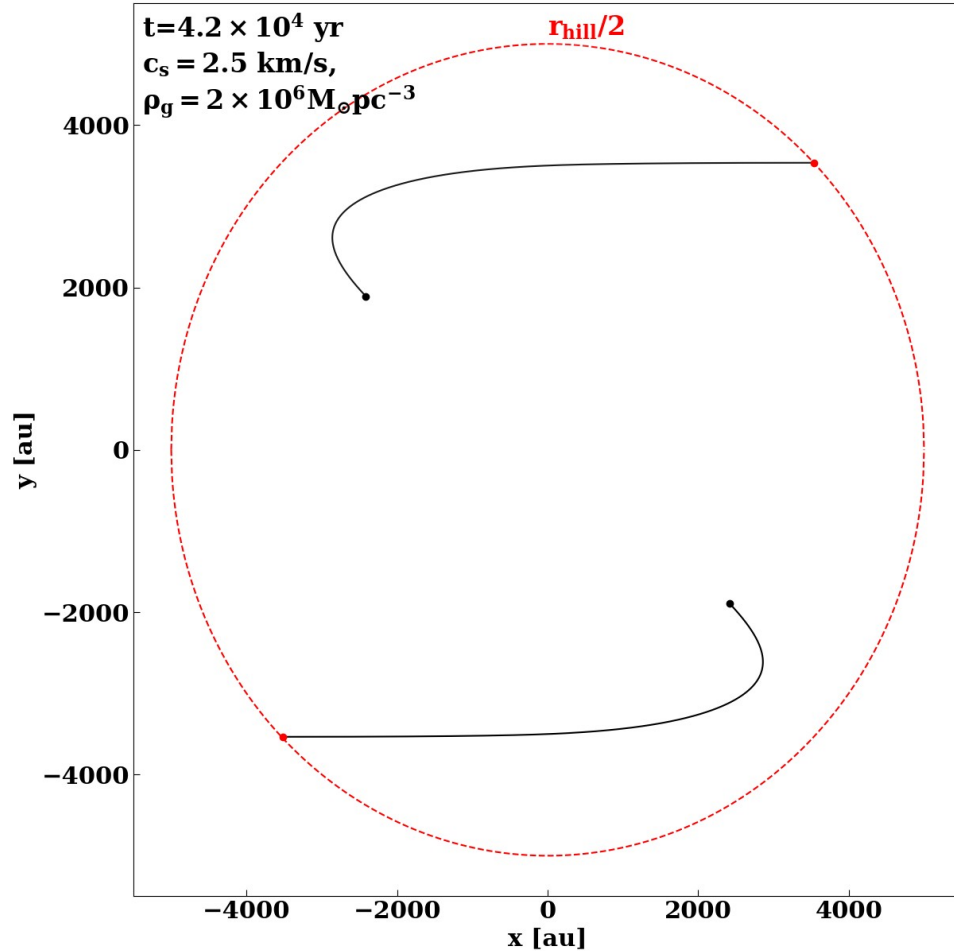
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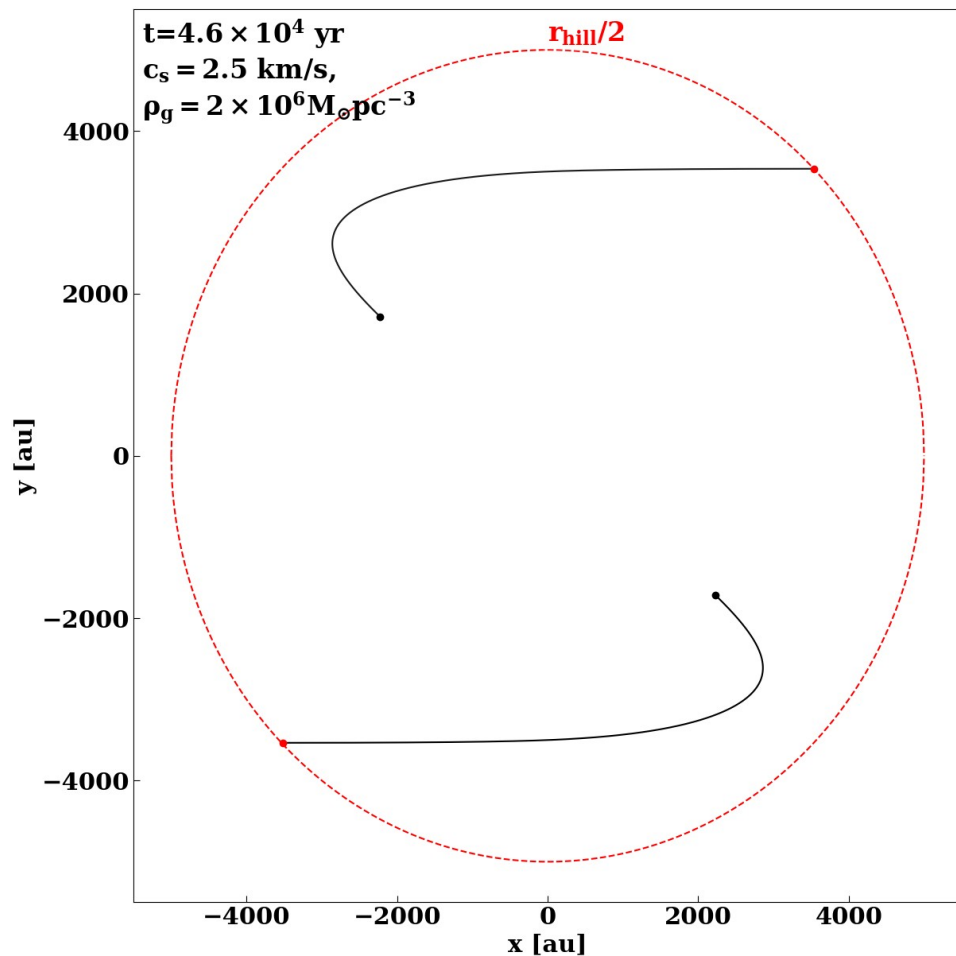
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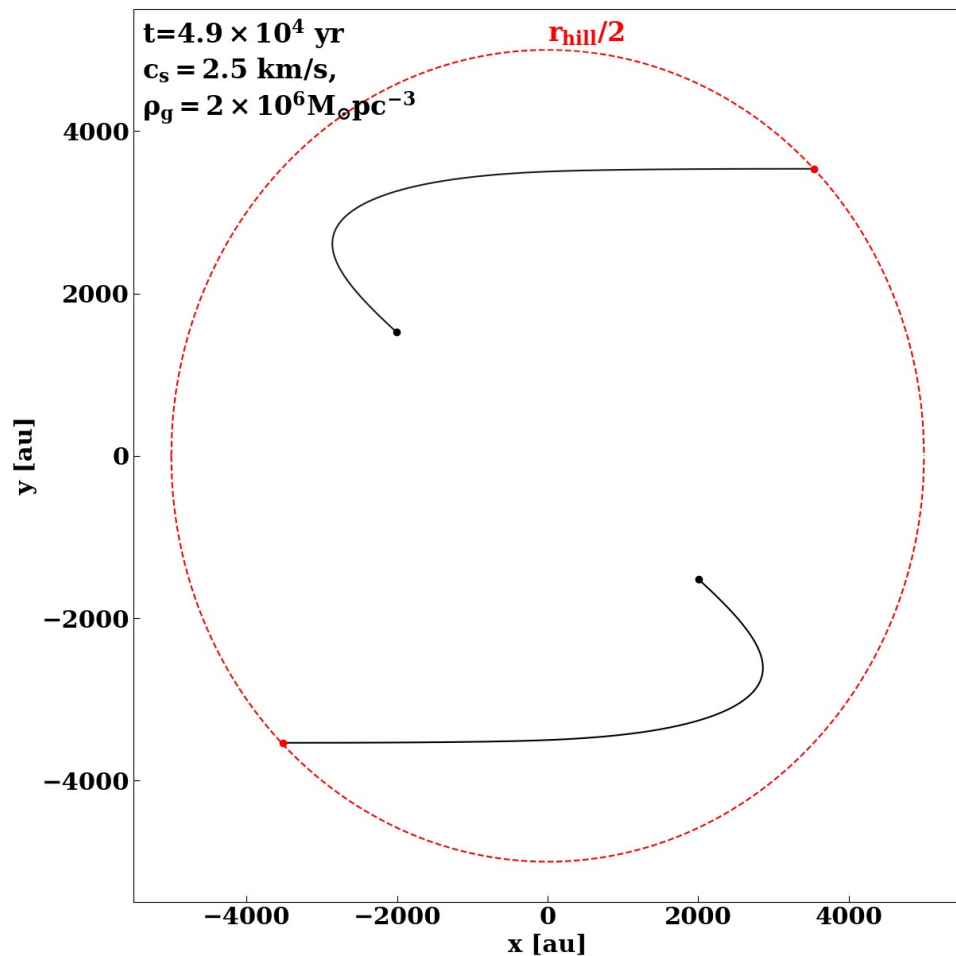
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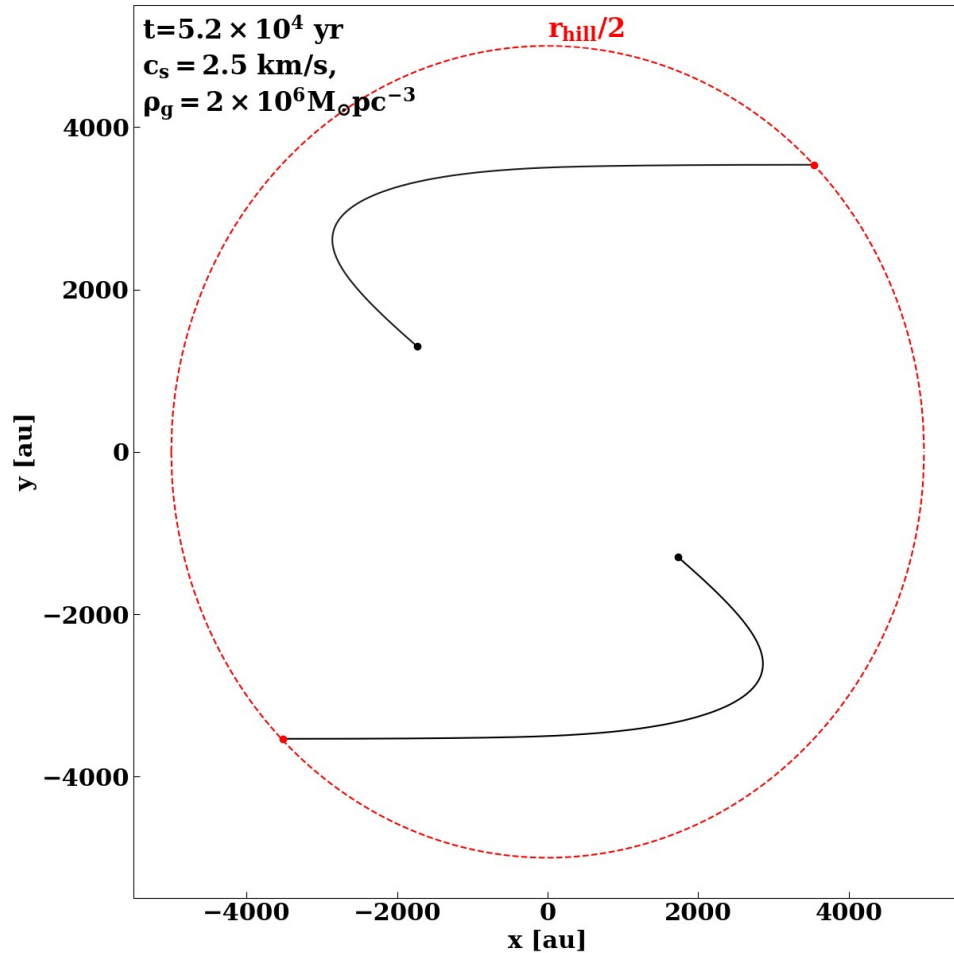
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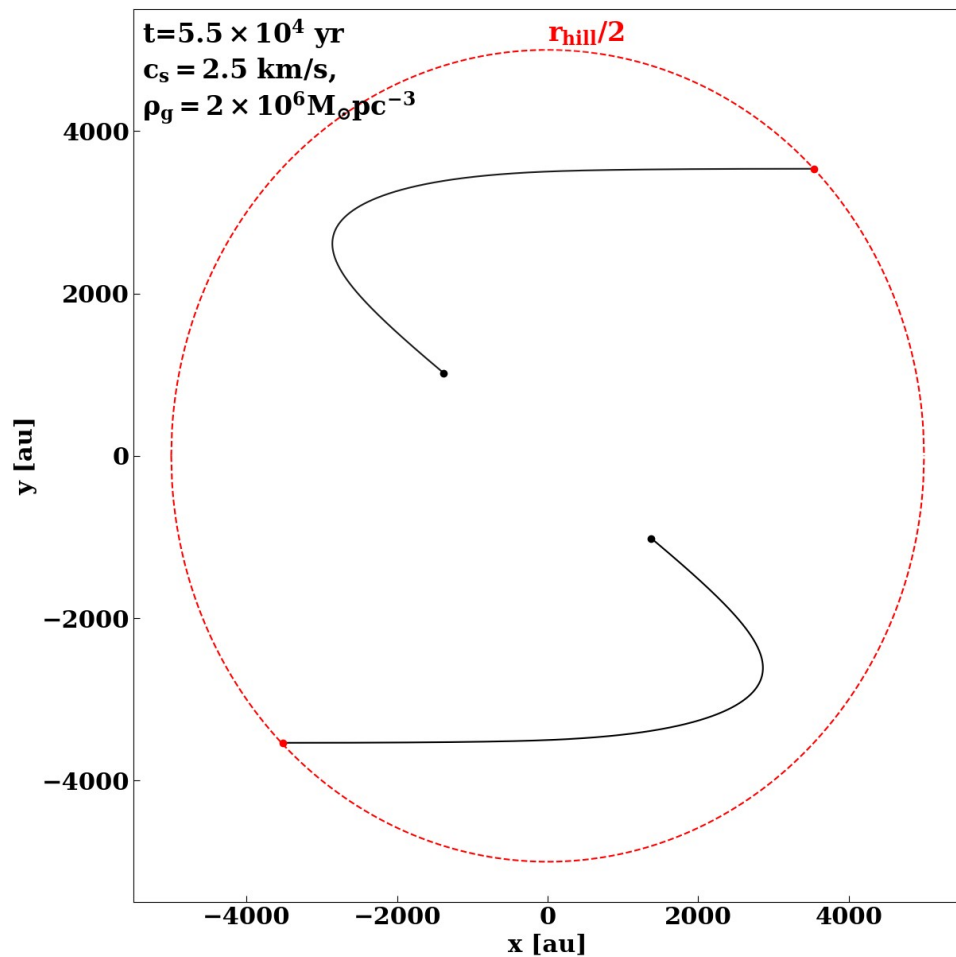
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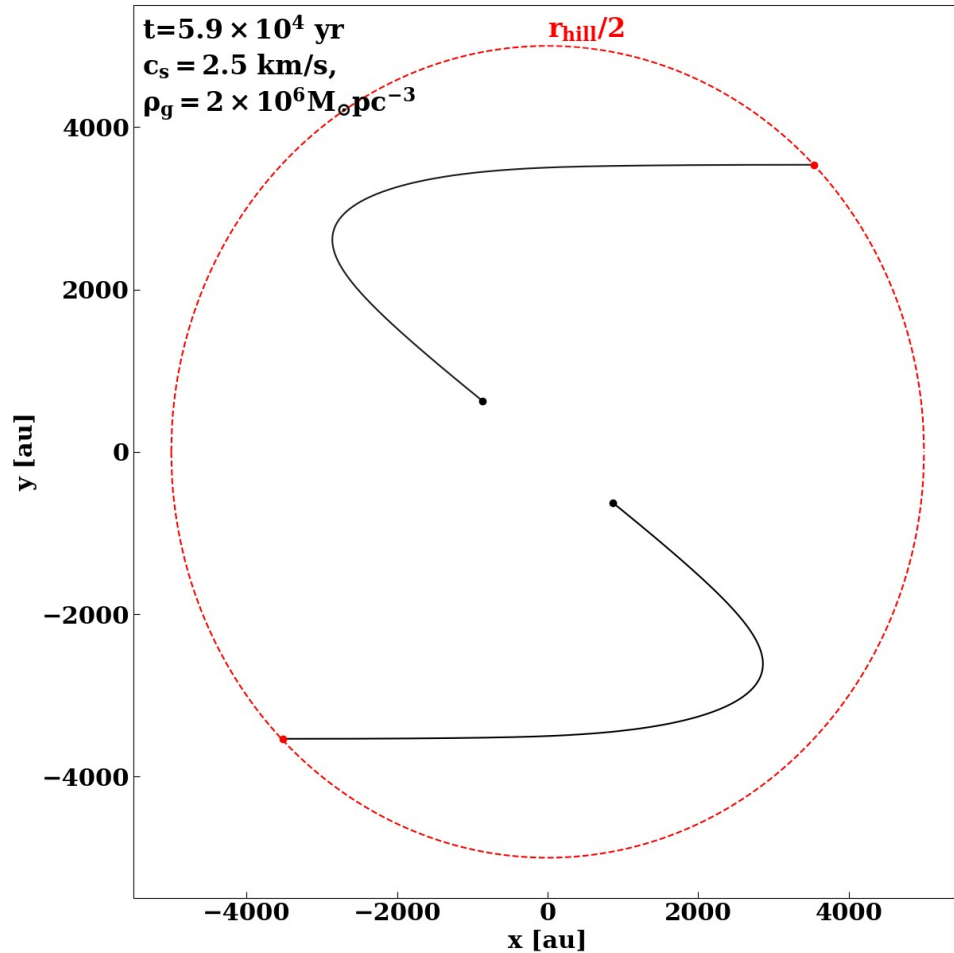
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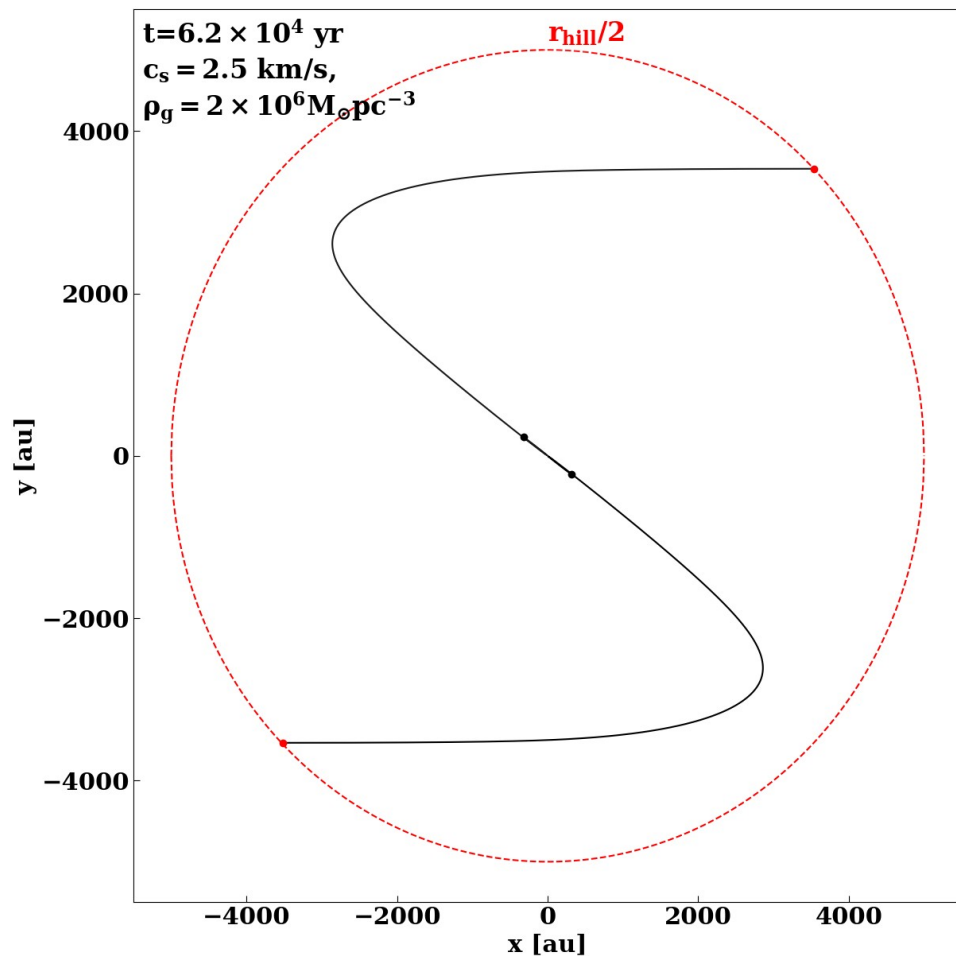
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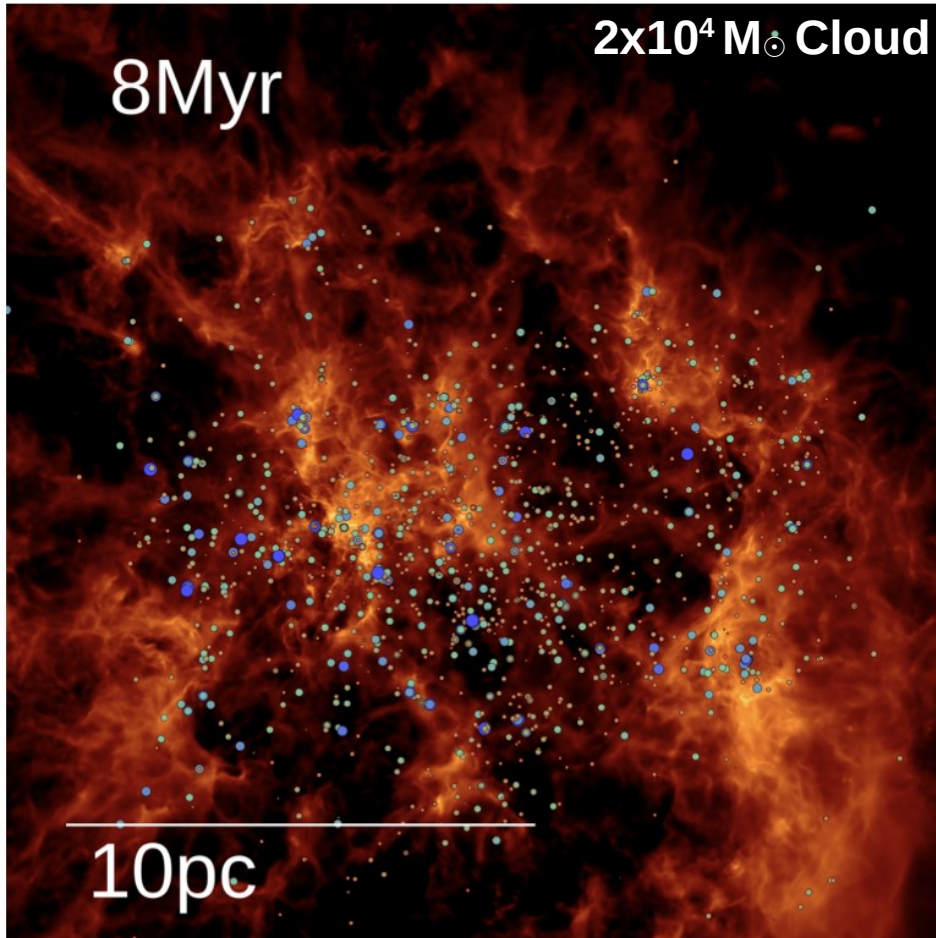
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Starforge simulations



Gravity + MHD +
feedback (winds,
radiation, etc.)

Color/sizes
indicate mass

Binary (and Multiple) ID

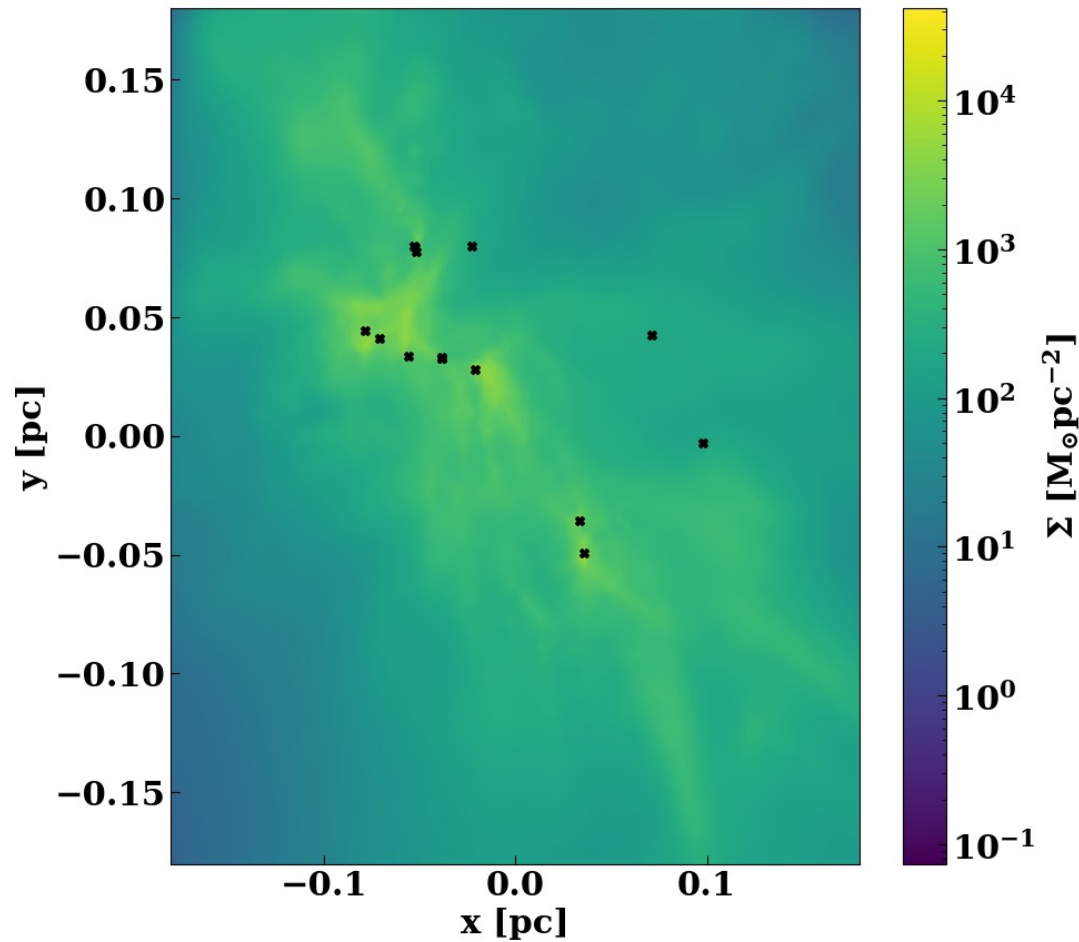
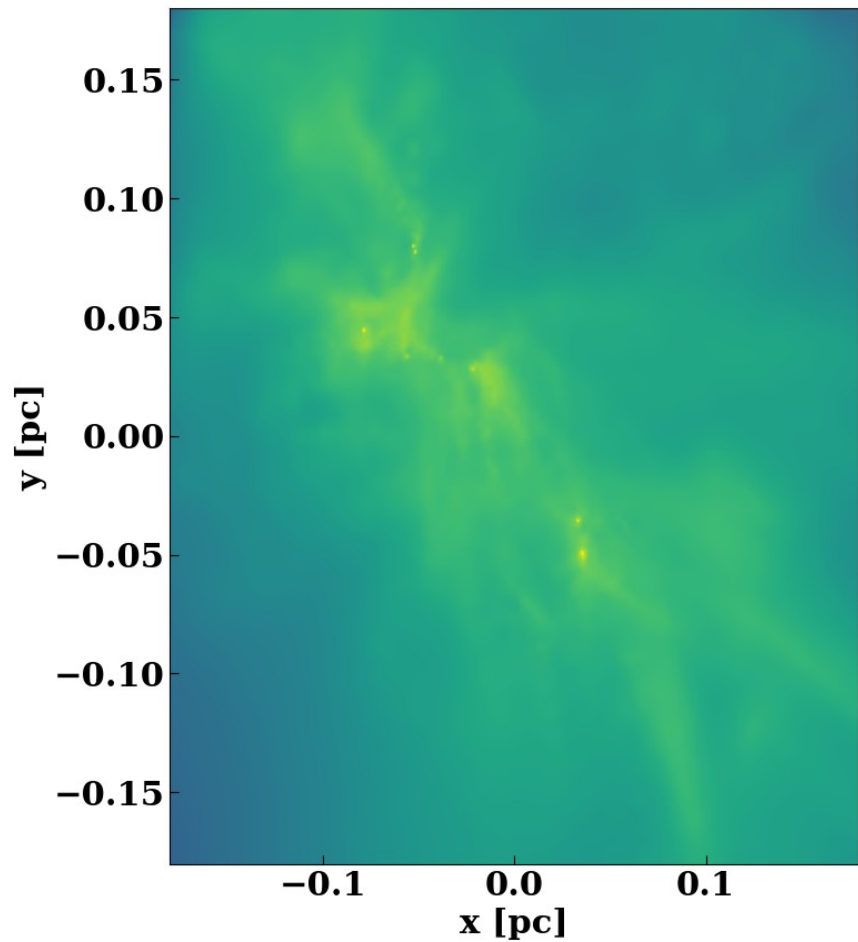
- Assemble pairs hierarchically by binding energy
- Similar to Guszejnov+2023
- Add tidal criterion+halo masses

Binary (and Multiple) ID

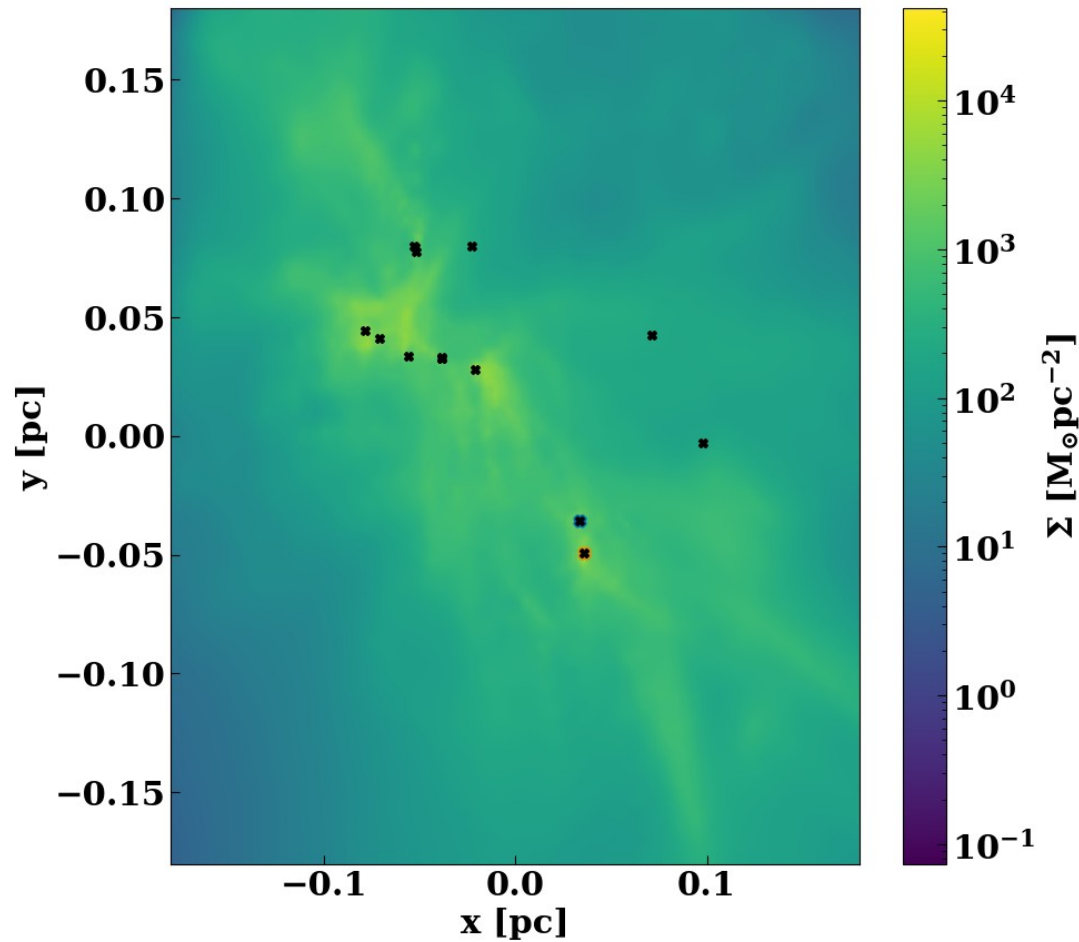
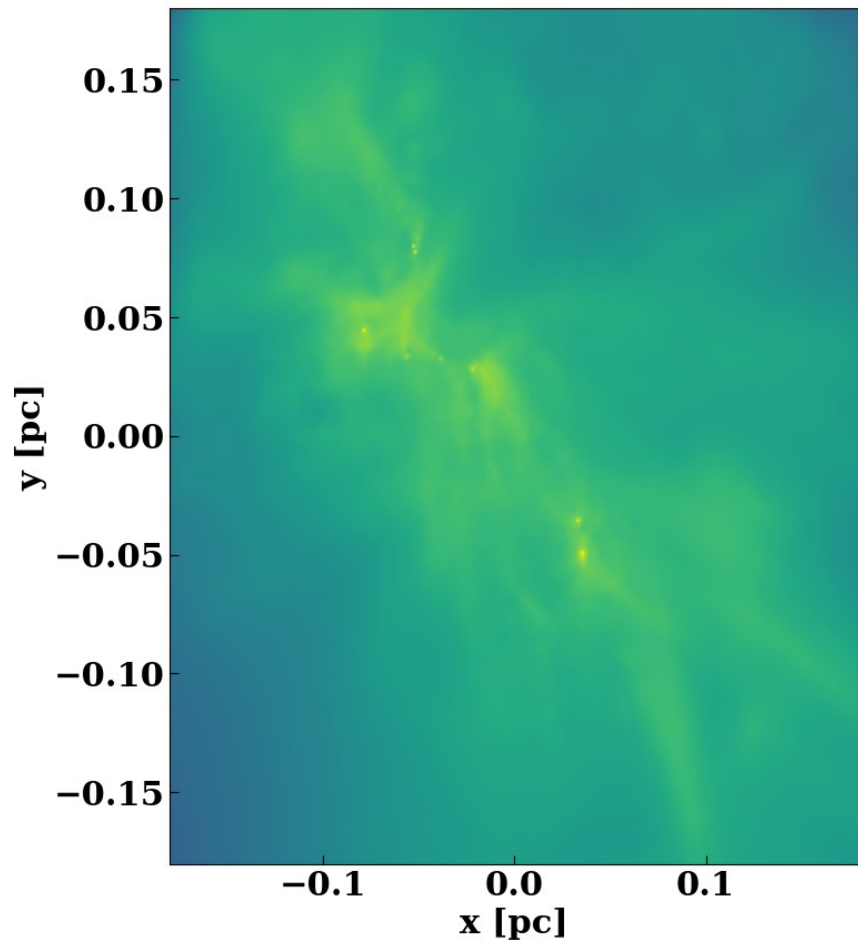
- Assemble pairs hierarchically by binding energy
- Similar to Guszejnov+2023
- Add tidal criterion+halo masses

$$a_{\text{tide}} < f_t a_{\text{int},*} \quad (f_t = 1 \text{ or } 8)$$

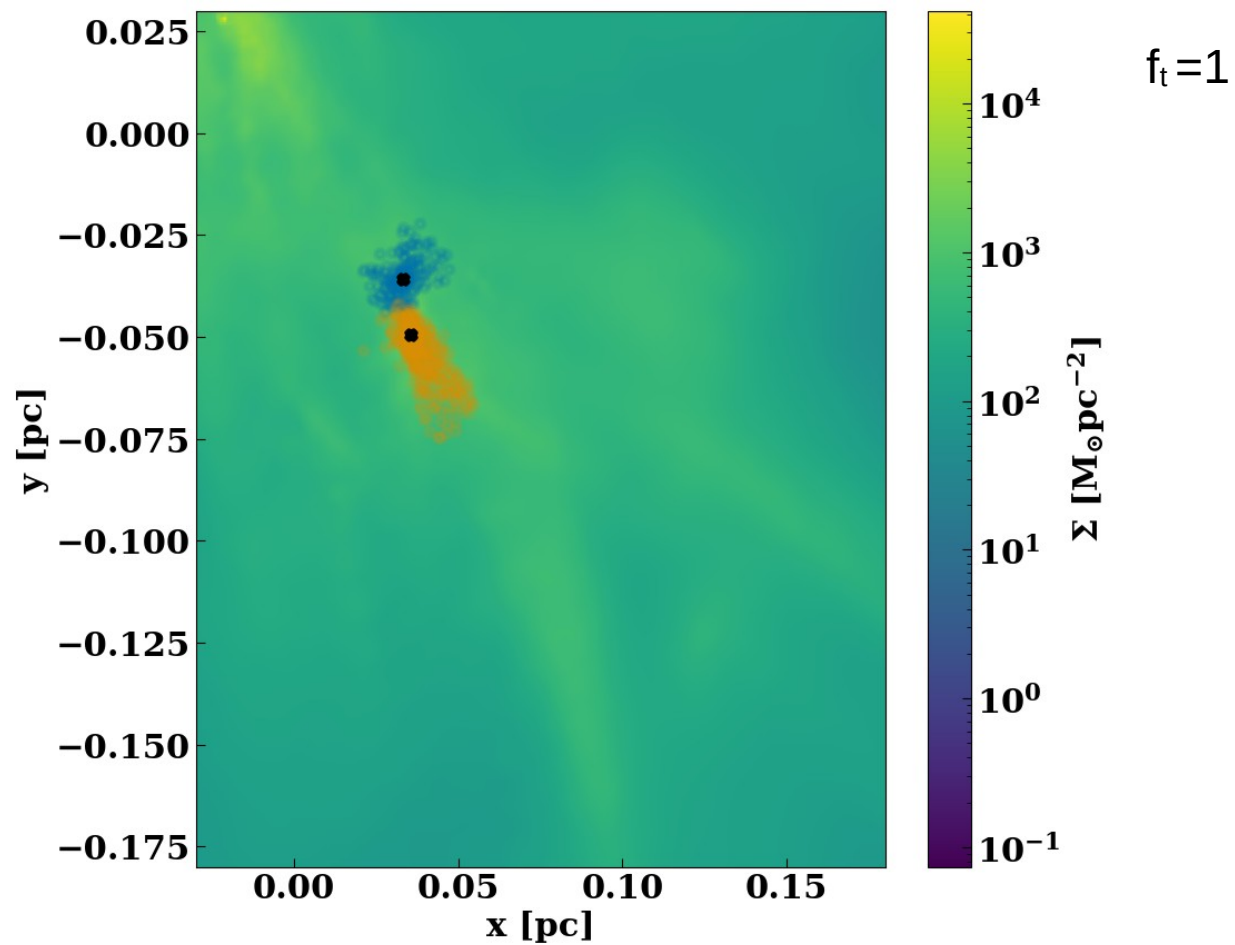
Example binary



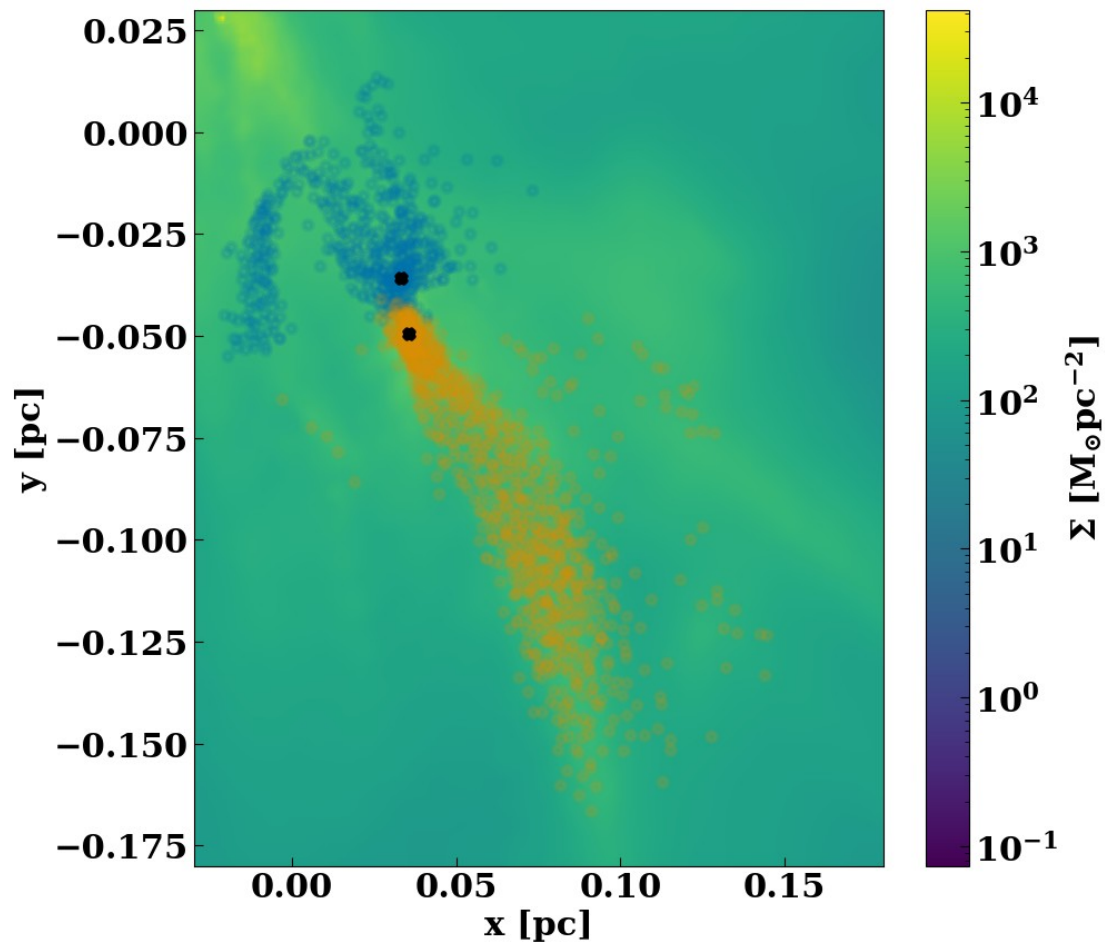
Example binary



Example binary – Gas halos



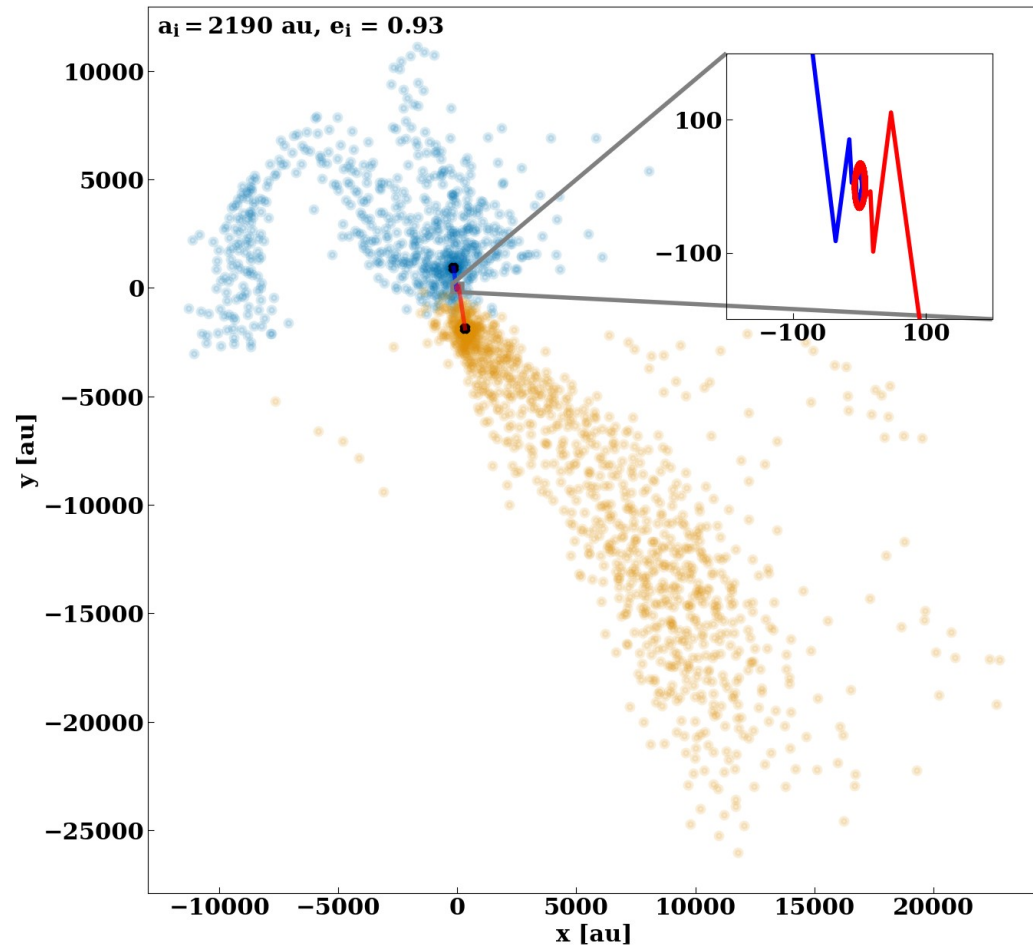
Example binary – Gas halos



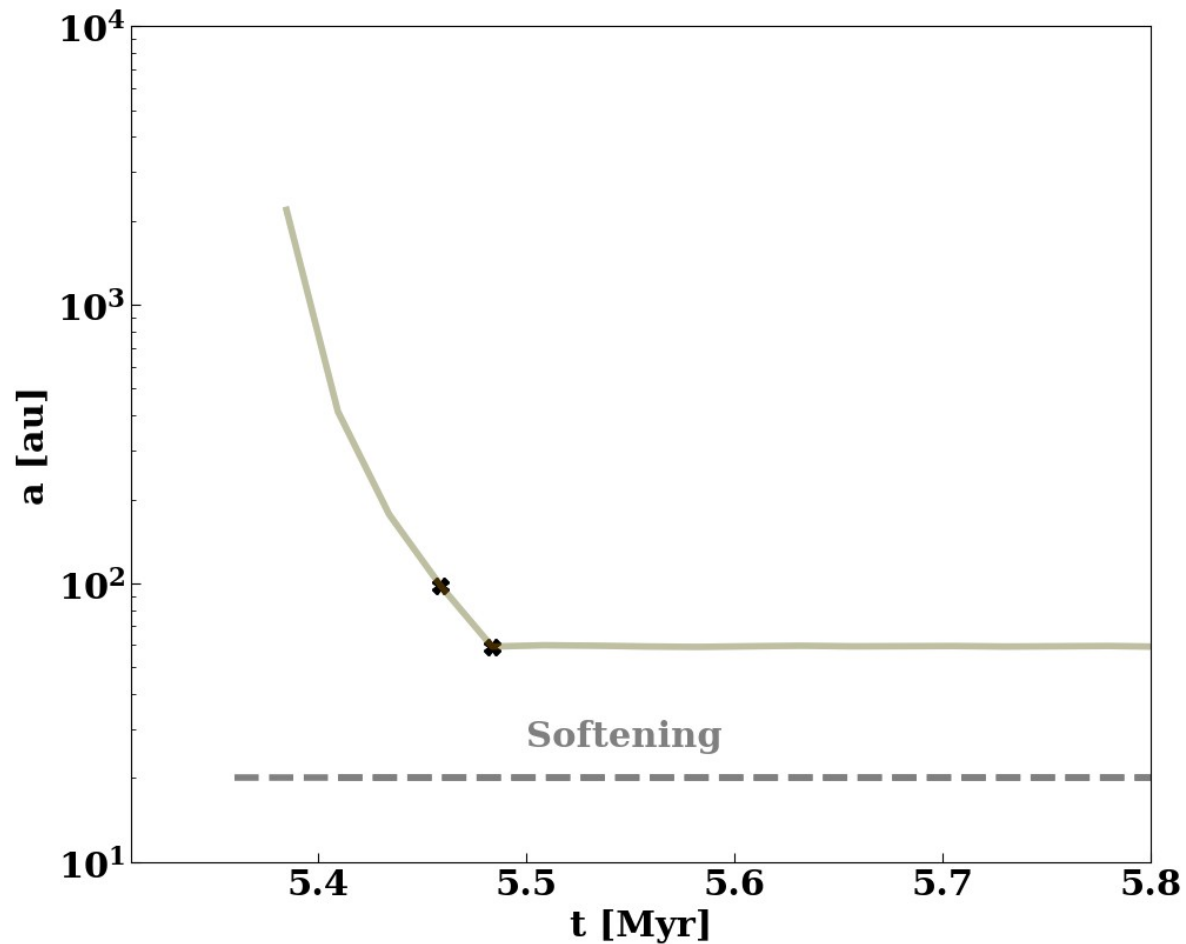
$f_t = 8$

Add halo mass to sink mass
before binary ID

Example binary evolution

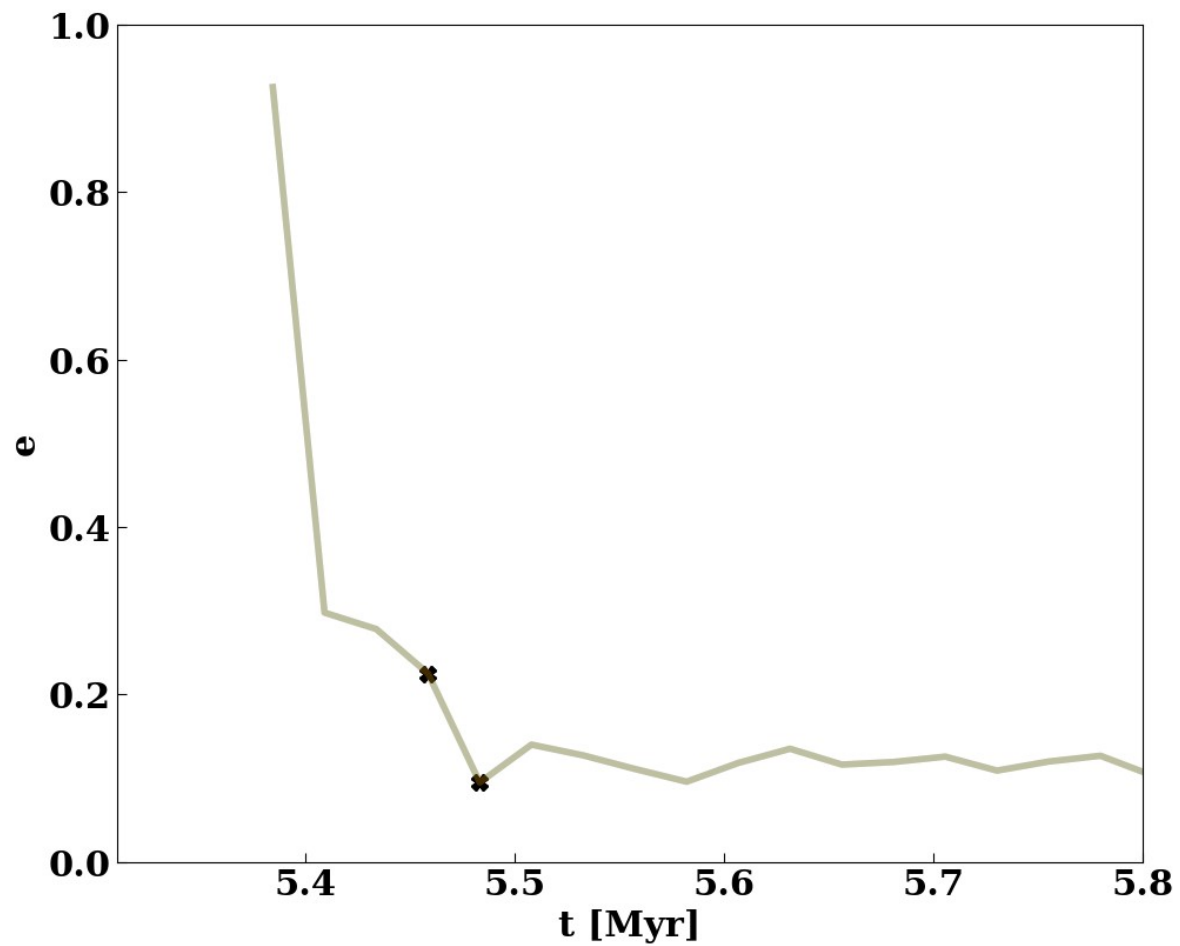


Example binary evolution

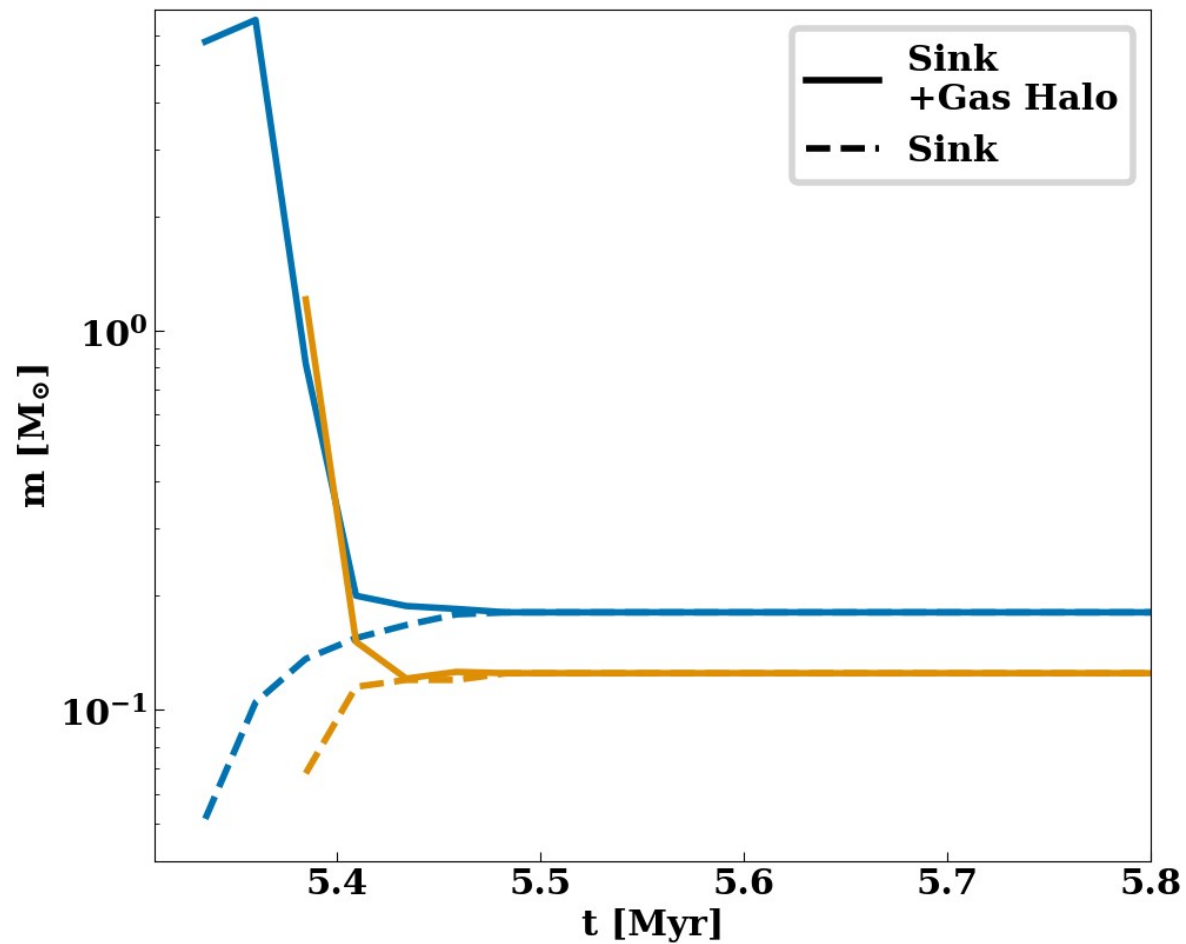


Binary stars inspiral until halos are depleted (Between xs)

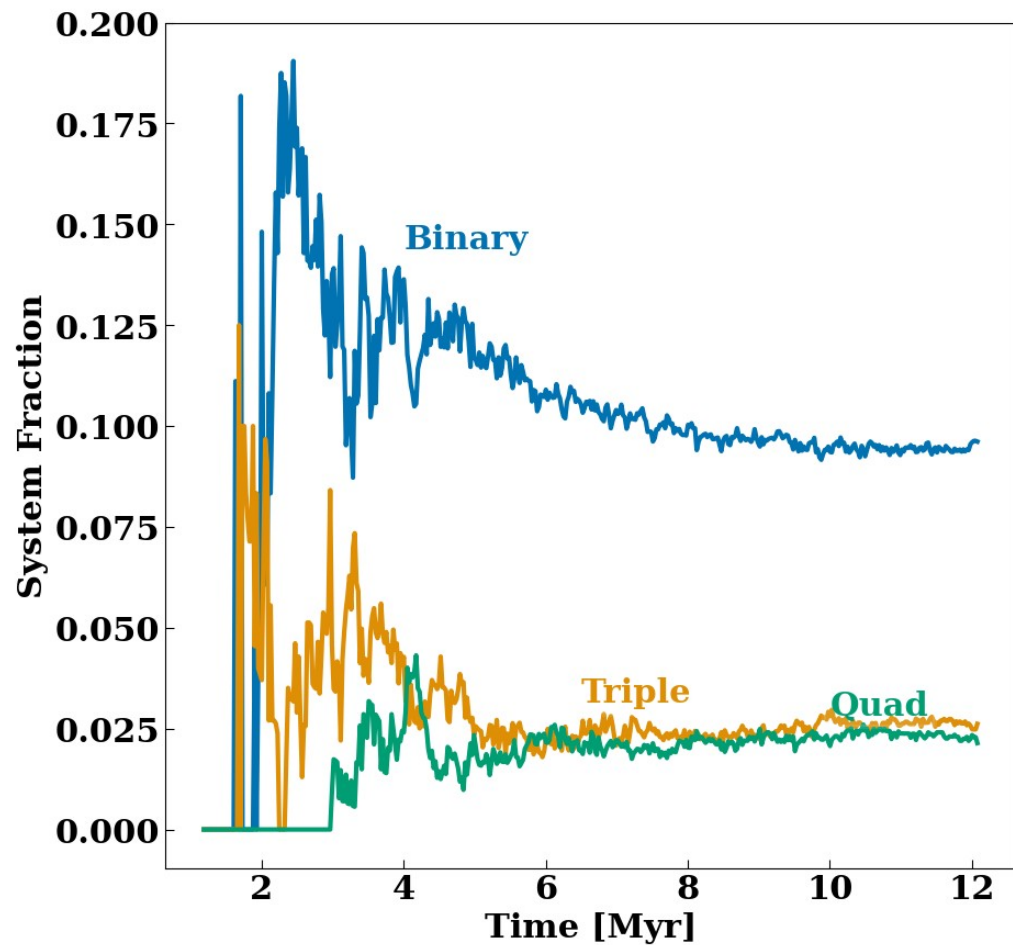
Example binary evolution



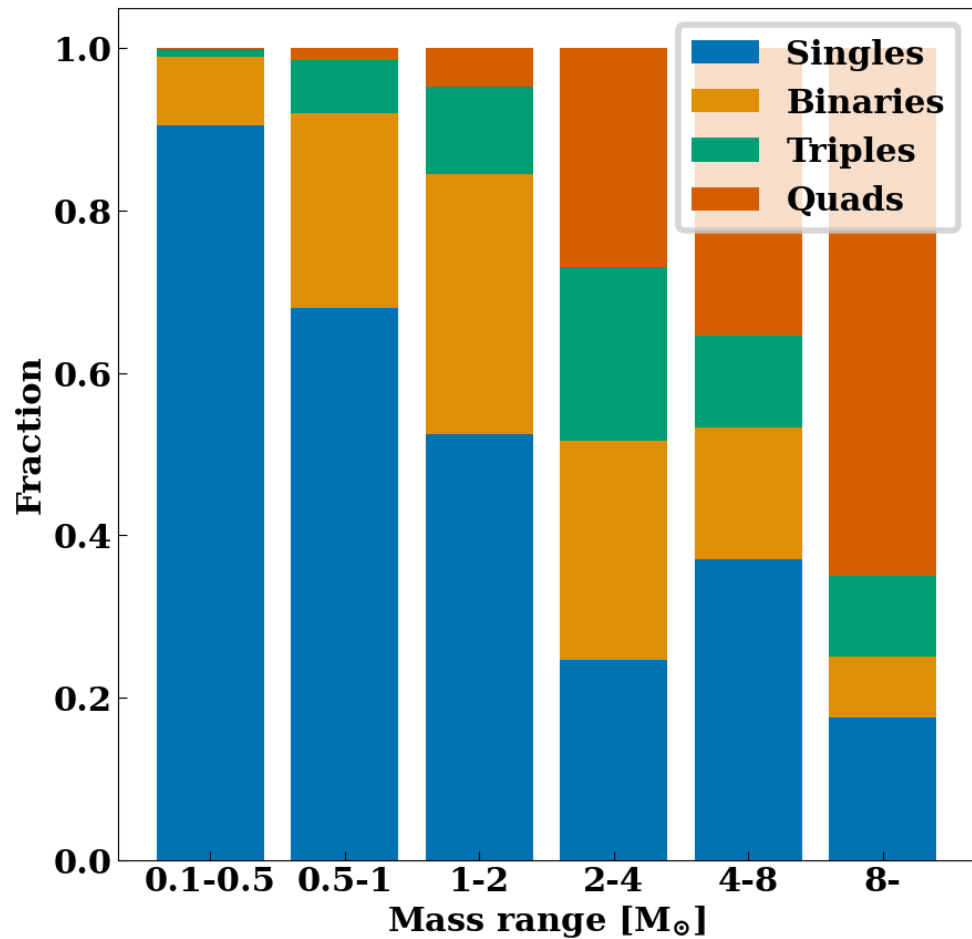
Example binary evolution



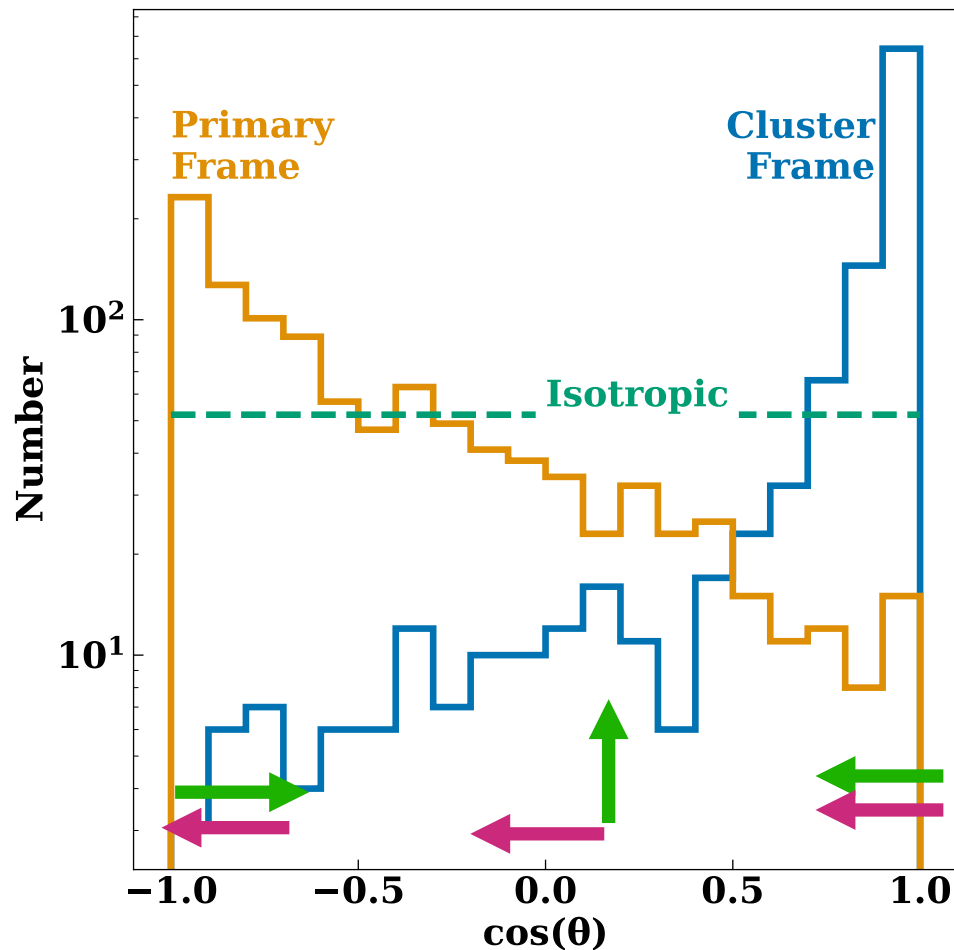
Multiplicity statistics



Multiplicity statistics

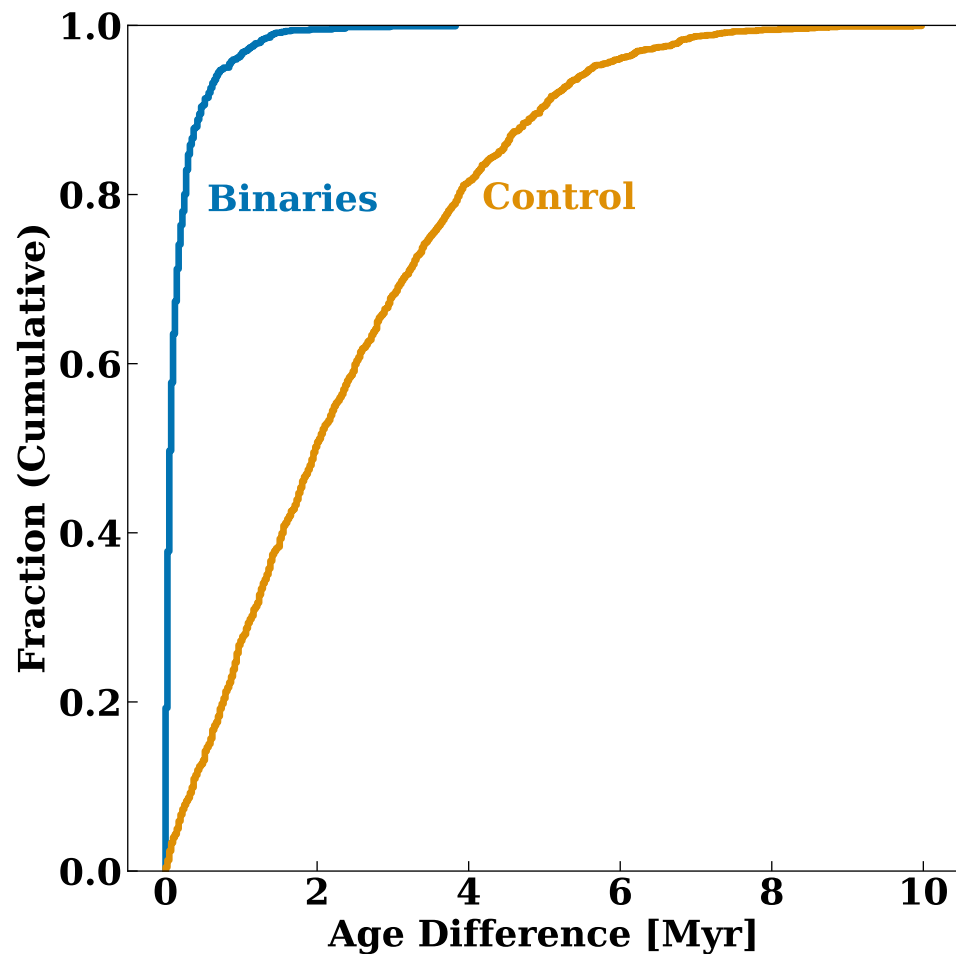


Binary velocities are correlated at birth



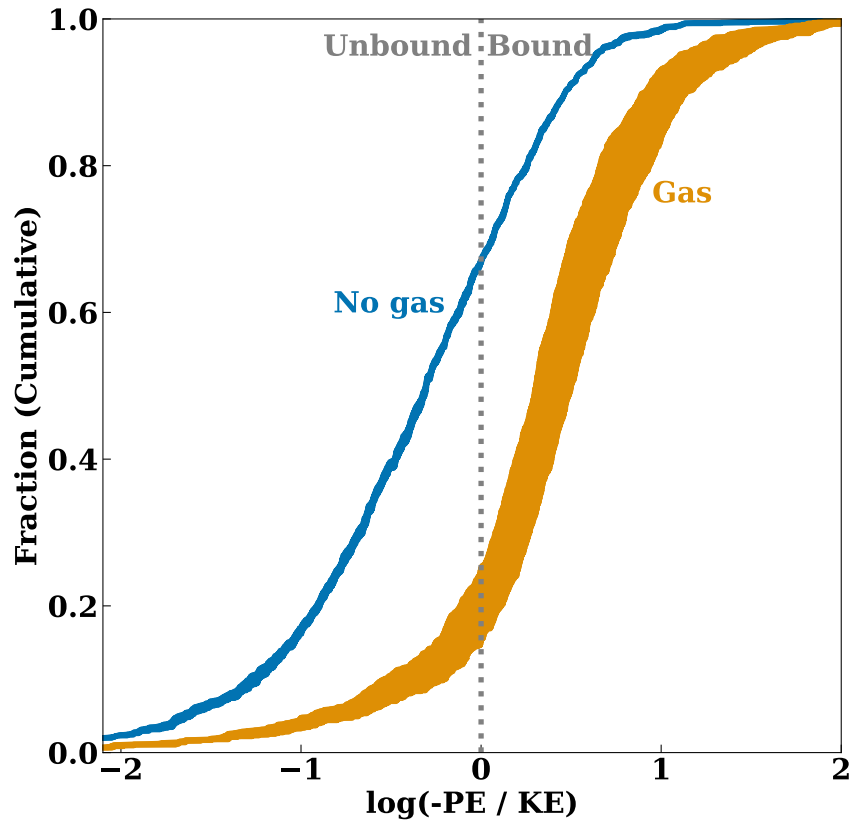
Angle between stars' velocities at "First Snapshot Together" (FST)

Stars have similar ages



Age differences of binaries vs random pairs

Most binary pairs are bound at FST

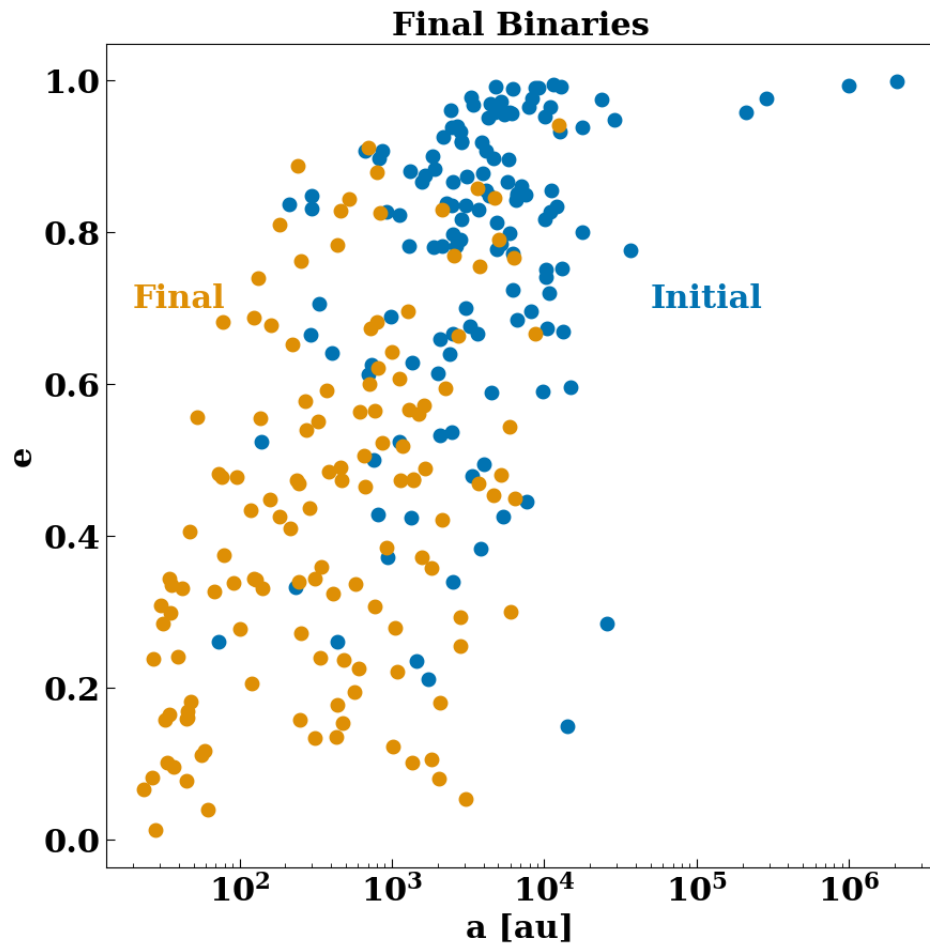


Blue = No gas in PE

Orange = Gas in PE

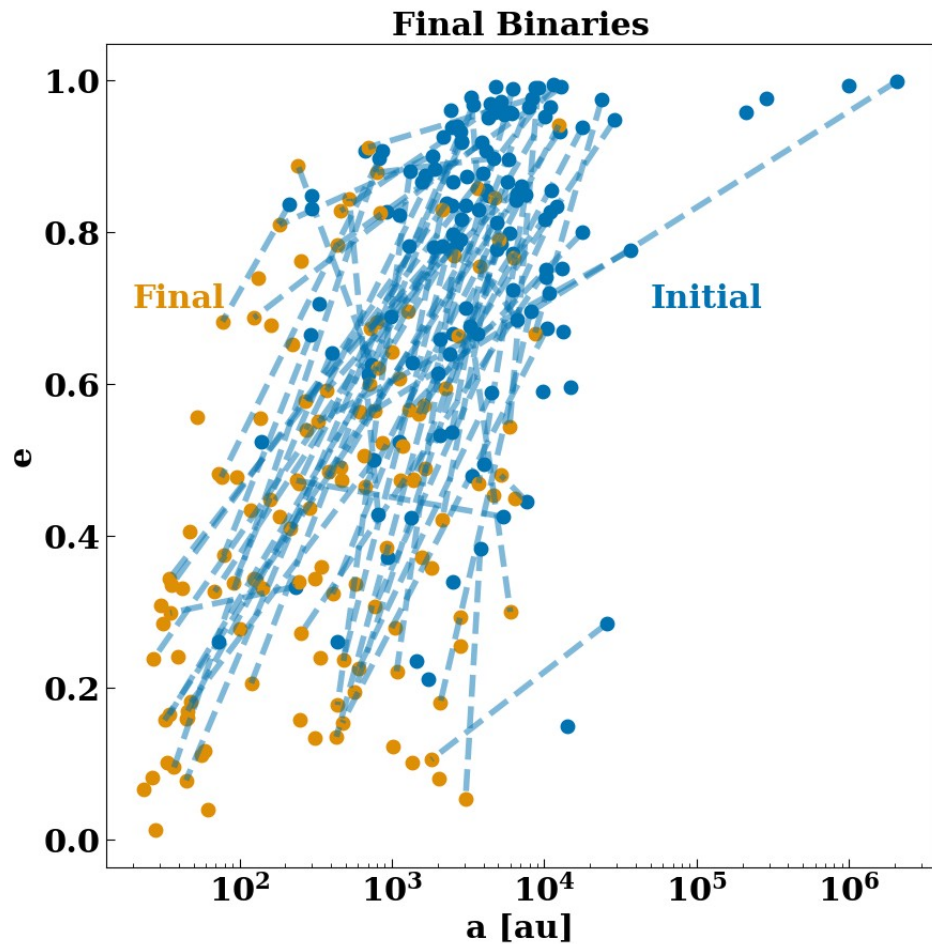
~80% of binaries are bound from birth

Evolution of binary population



Excluding pairs where distance falls below softening length

Evolution of binary population

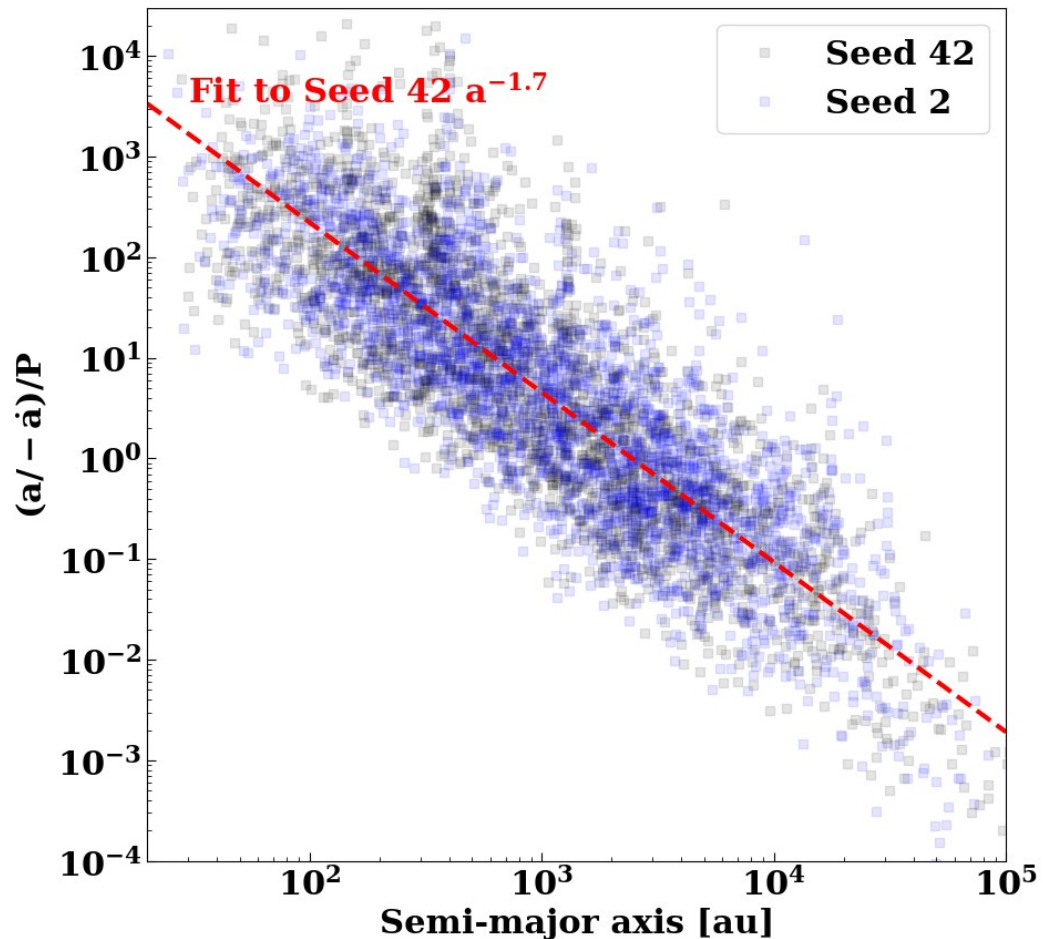


Excluding pairs where distance falls below softening length

Summary and Conclusions

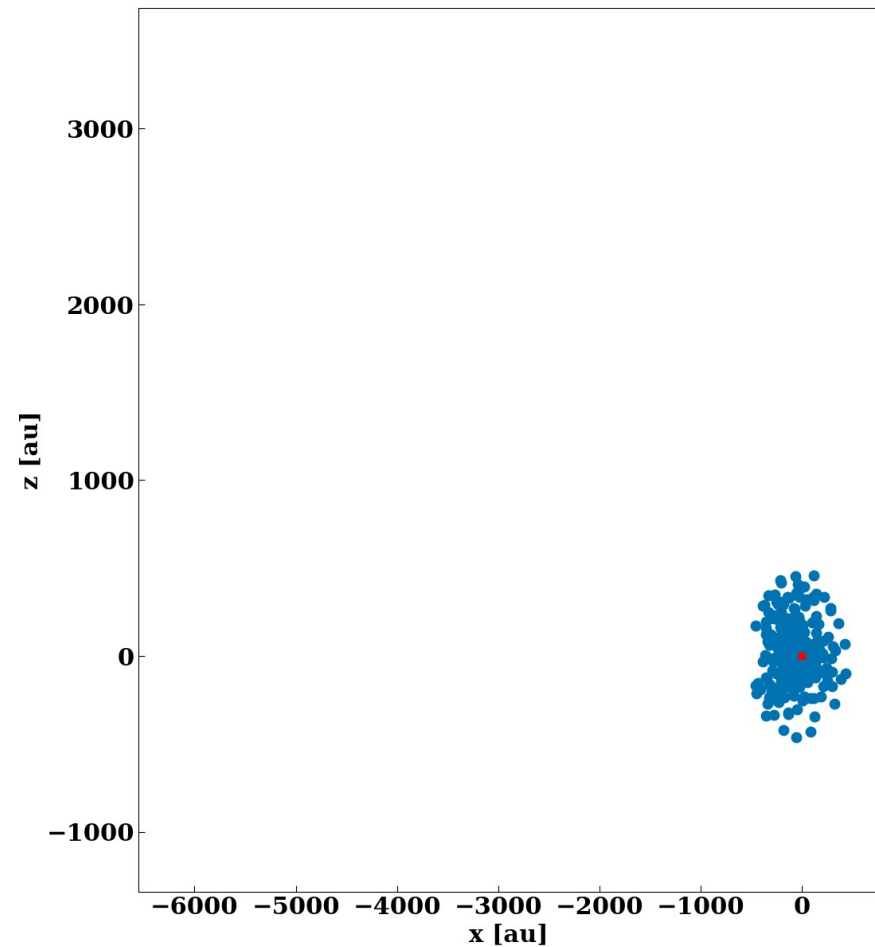
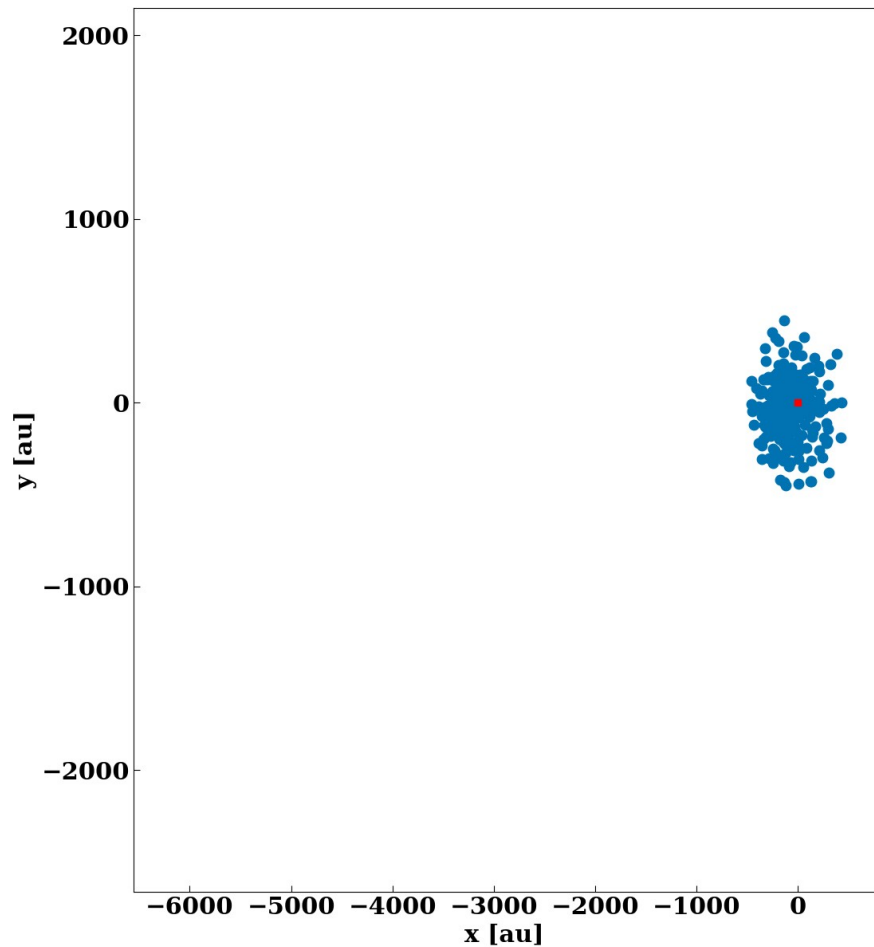
- Most binaries are born bound in detailed simulation of star forming cluster.
- Capture/exchange are sub-dominant.
- Gas dynamical friction shrinks existing binaries.

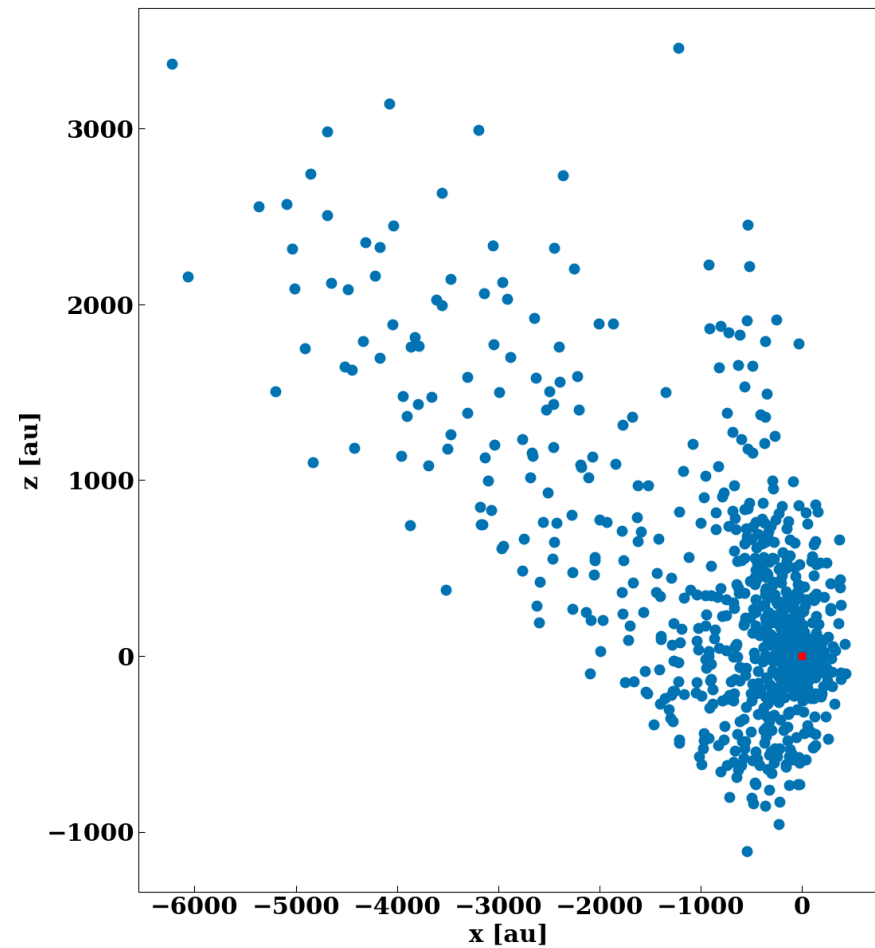
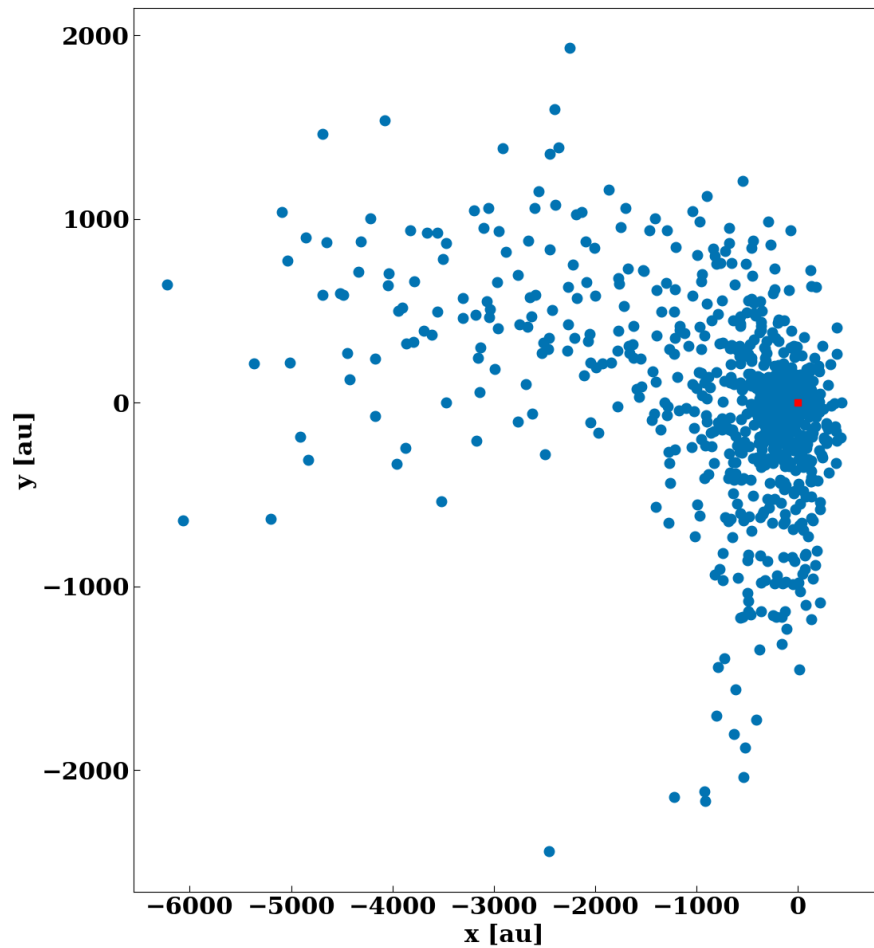
Evolution of binary population



Binaries
inspiral
rapidly due to
GDF.

Gas halo identification

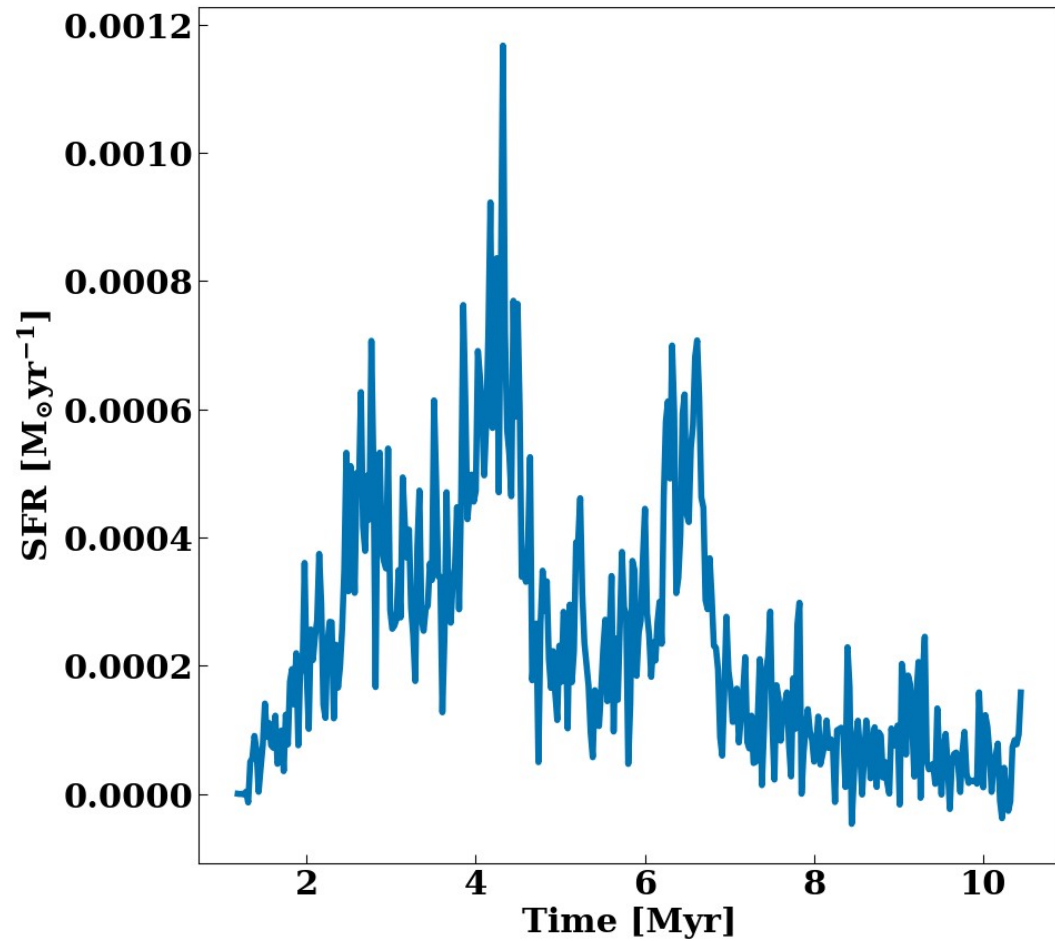




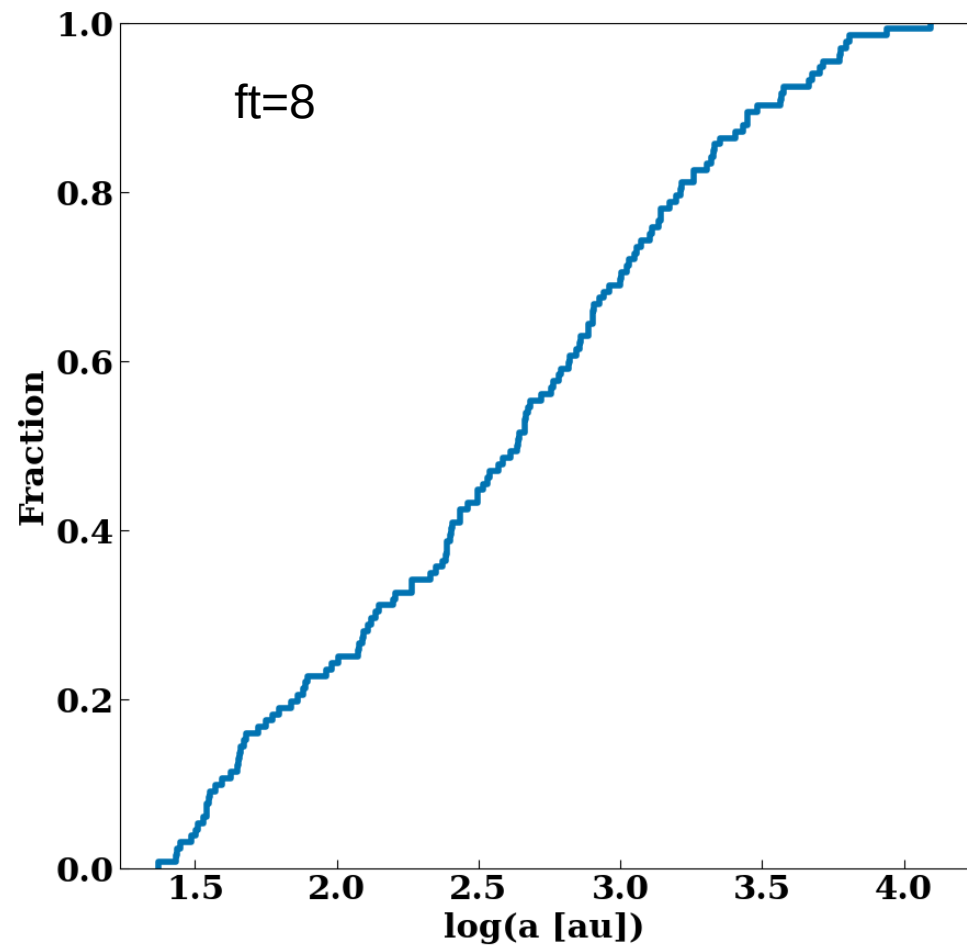
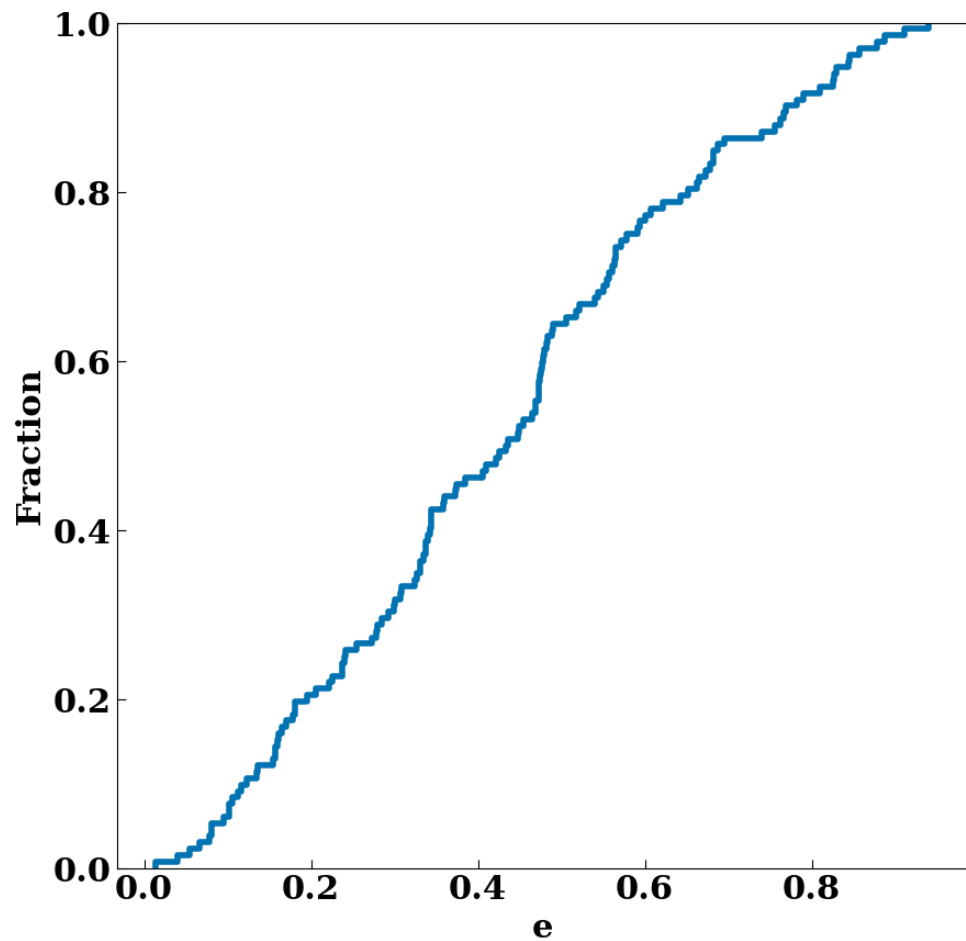
Tidal force definition

$$\mathbf{a}_{\text{tide}} = \mathbf{a}_{\text{ext},*} - \mathbf{a}_{\text{com}} + f_t \mathbf{a}_{\text{int},*} \quad (f_t = 1 \text{ or } 8)$$

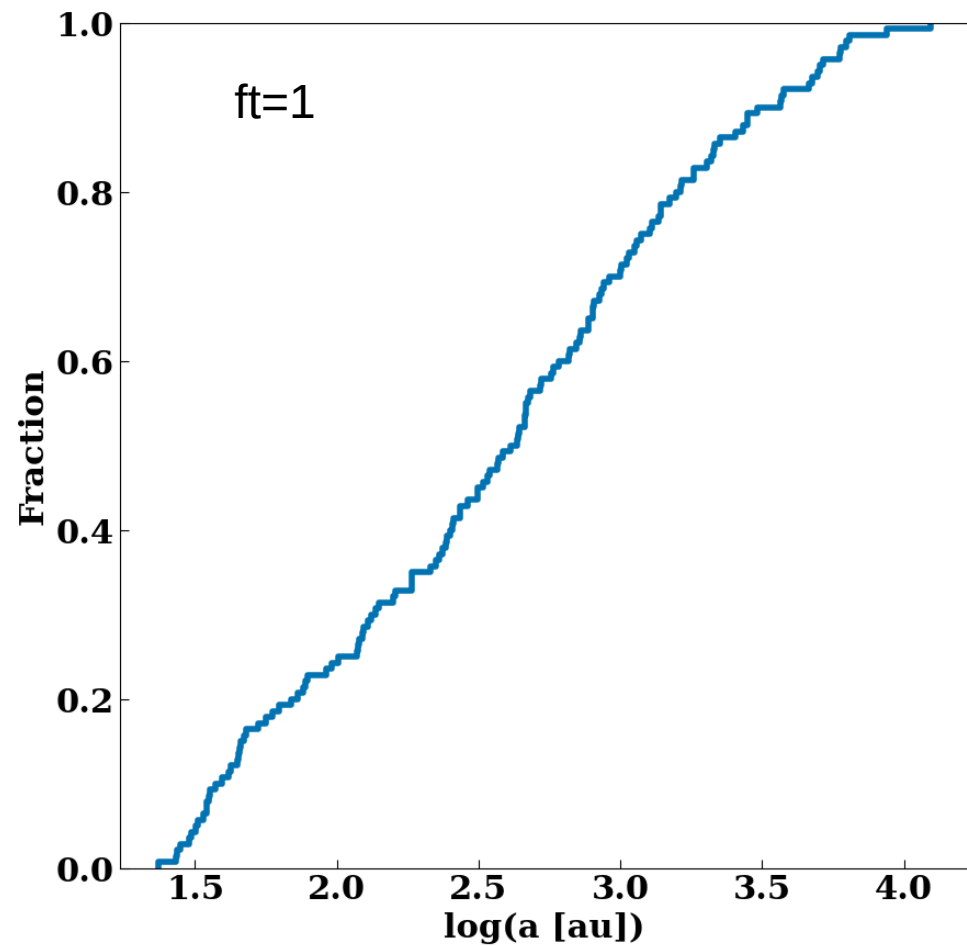
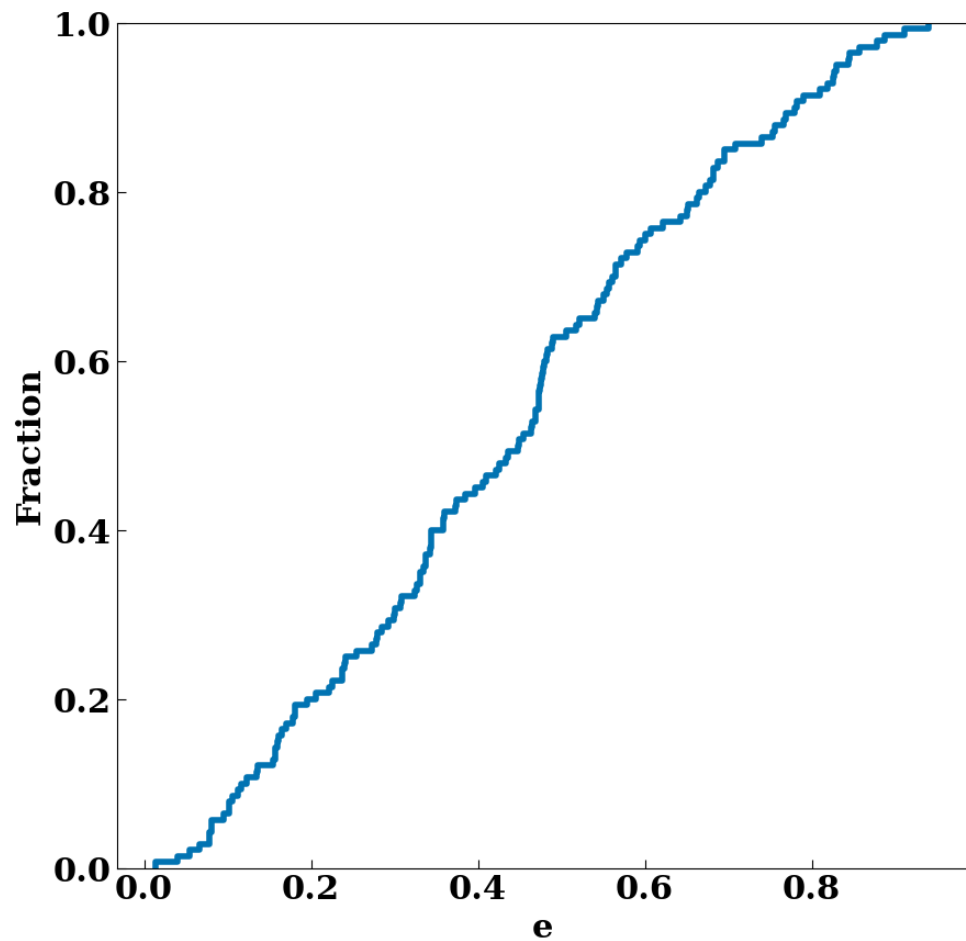
Star formation rate



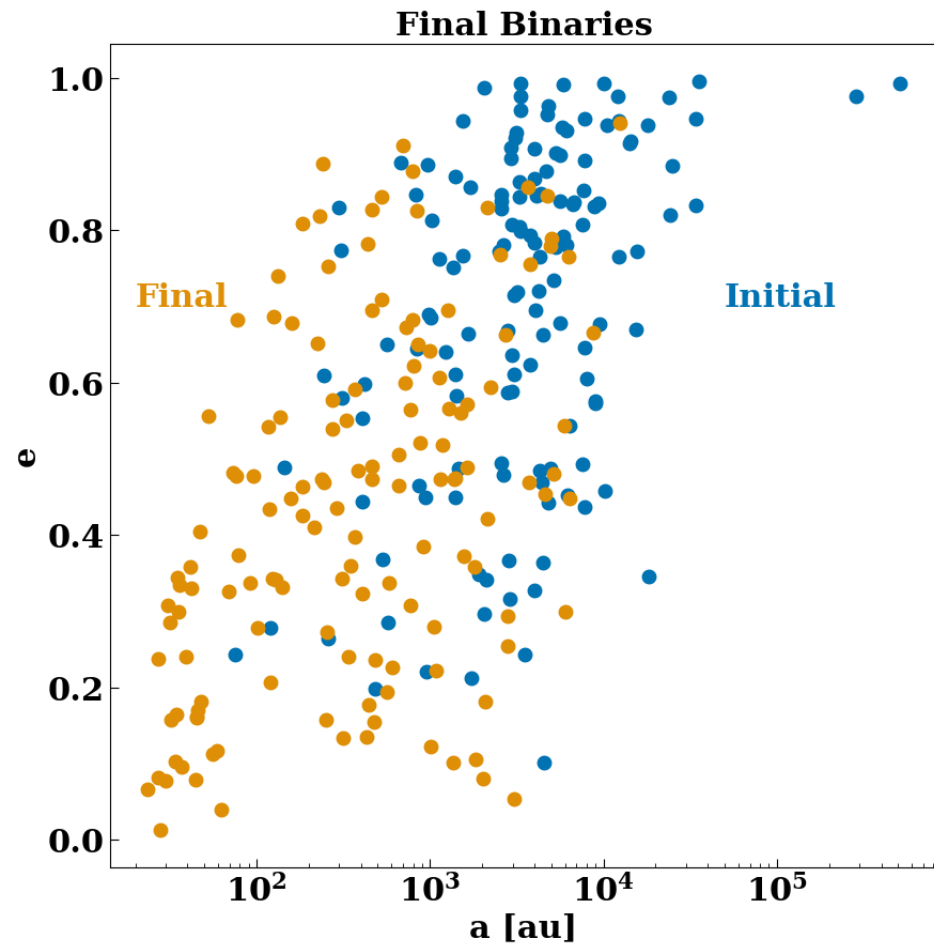
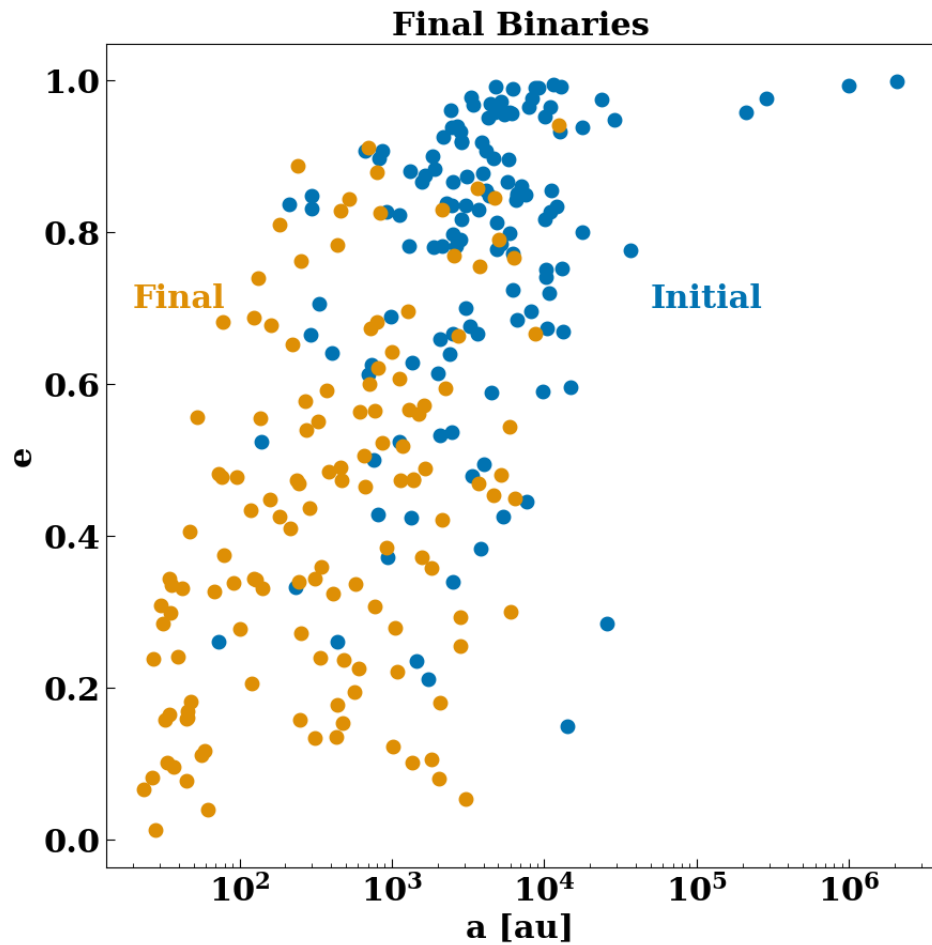
Final 1D Distributions



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Initial versus final orbital elements



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