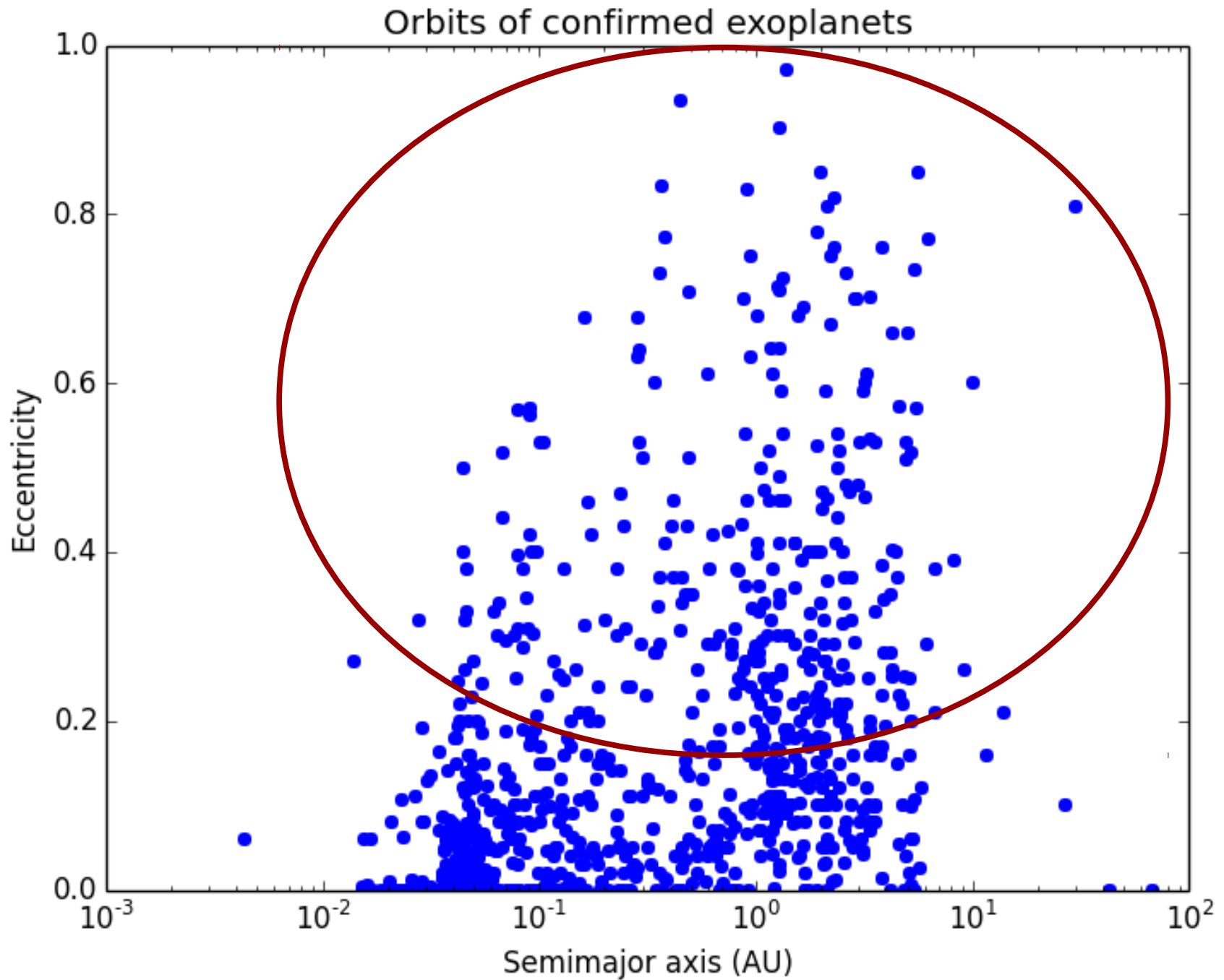


Survival of habitable planets in unstable planetary systems

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Carrera, Davies, Johansen, 2016, in prep



DYNAMICAL INSTABILITY

EVERY planet system with more than one planet is UNSTABLE.
This means that one day,

- a planet will be ejected
- OR - a planet will collide with the Sun
- OR - a planet will collide with another planet

After an instability, the remaining planet is often left in an ECCENTRIC orbit.

The solar system is stable for longer than the lifetime of the Sun.

OTHER planet systems can be stable for much shorter periods.

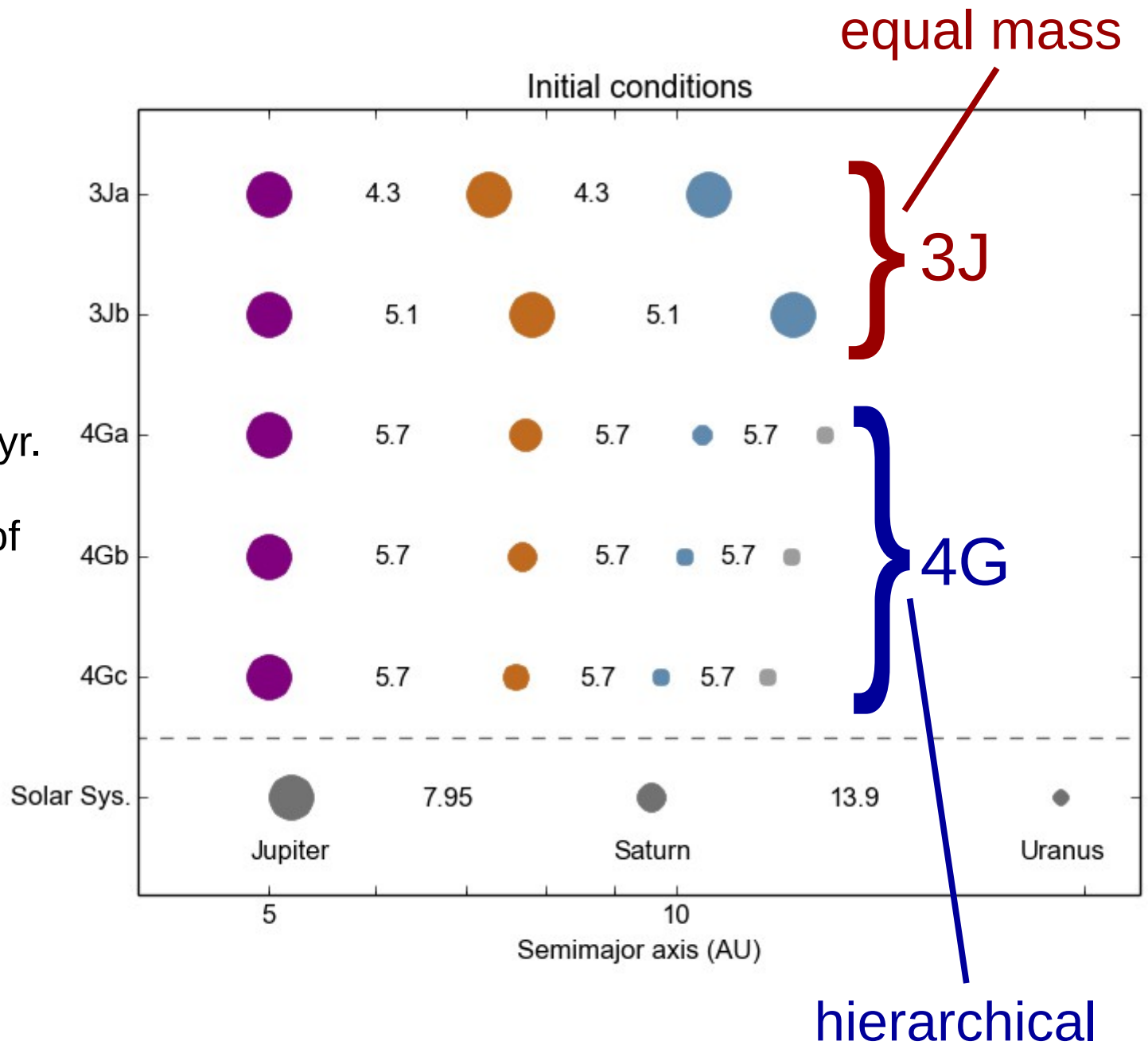
What happens to **habitable** planets
when the **giant** planets have an instability?

Which of the **observed** giant planet systems
are most likely to **also** have a habitable planet?

METHODS

- N-body simulations.
- 3-4 giant planets
- 100 test particles.
- Unstable in a few Myr.
- Mutual inclinations of ~3 deg.

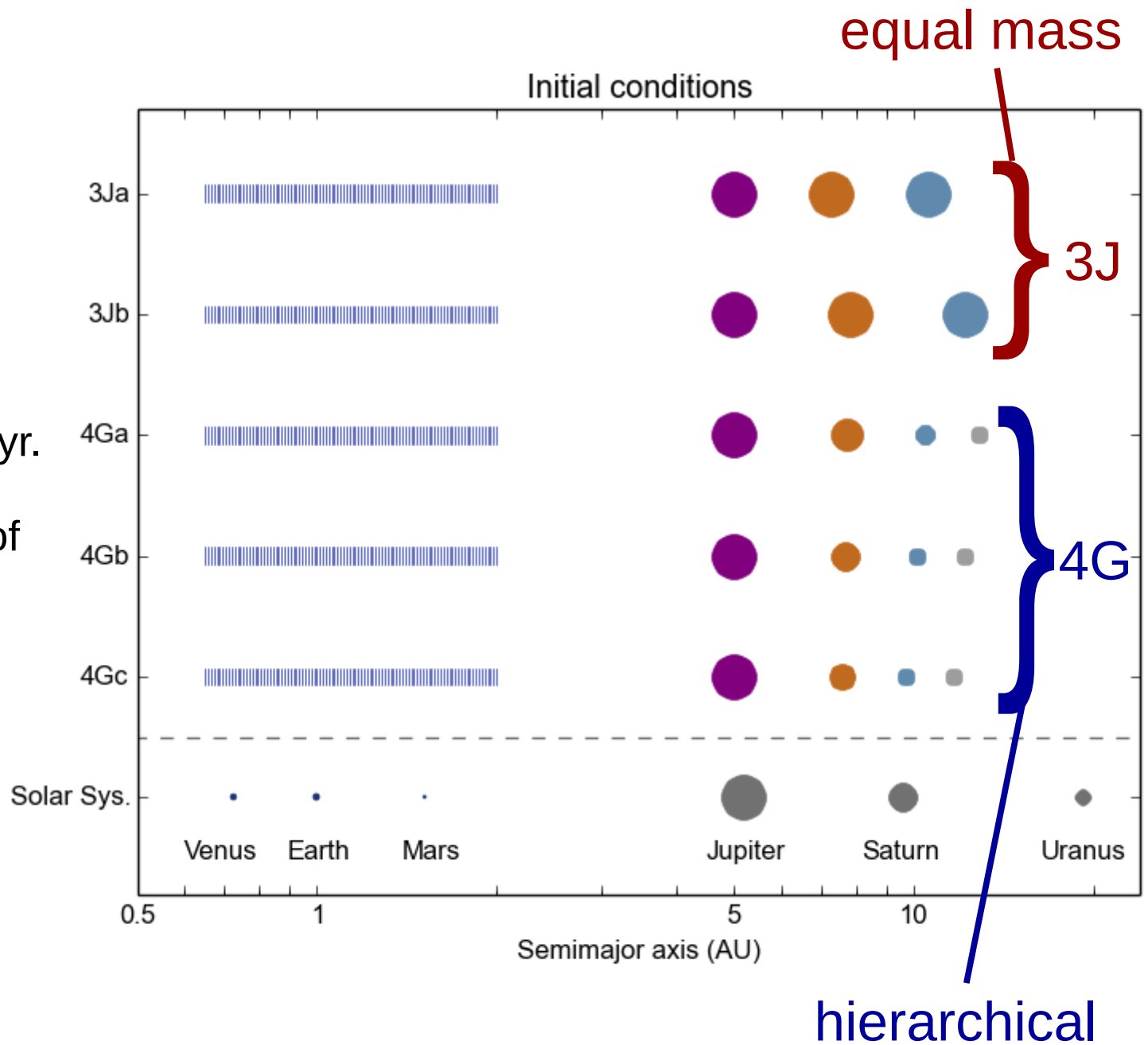
3J = 3 Jupiters
 4G = 4 giant planets



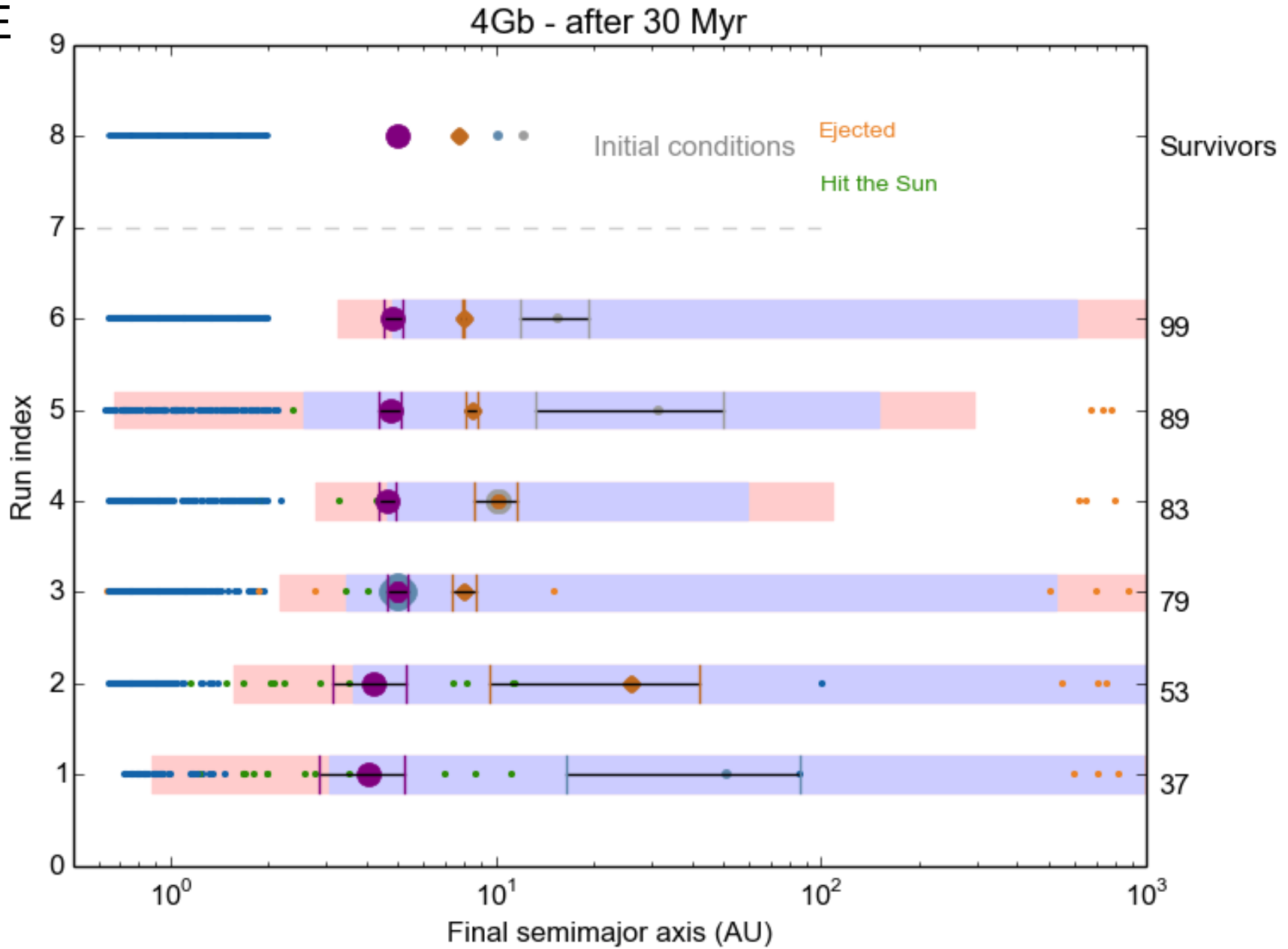
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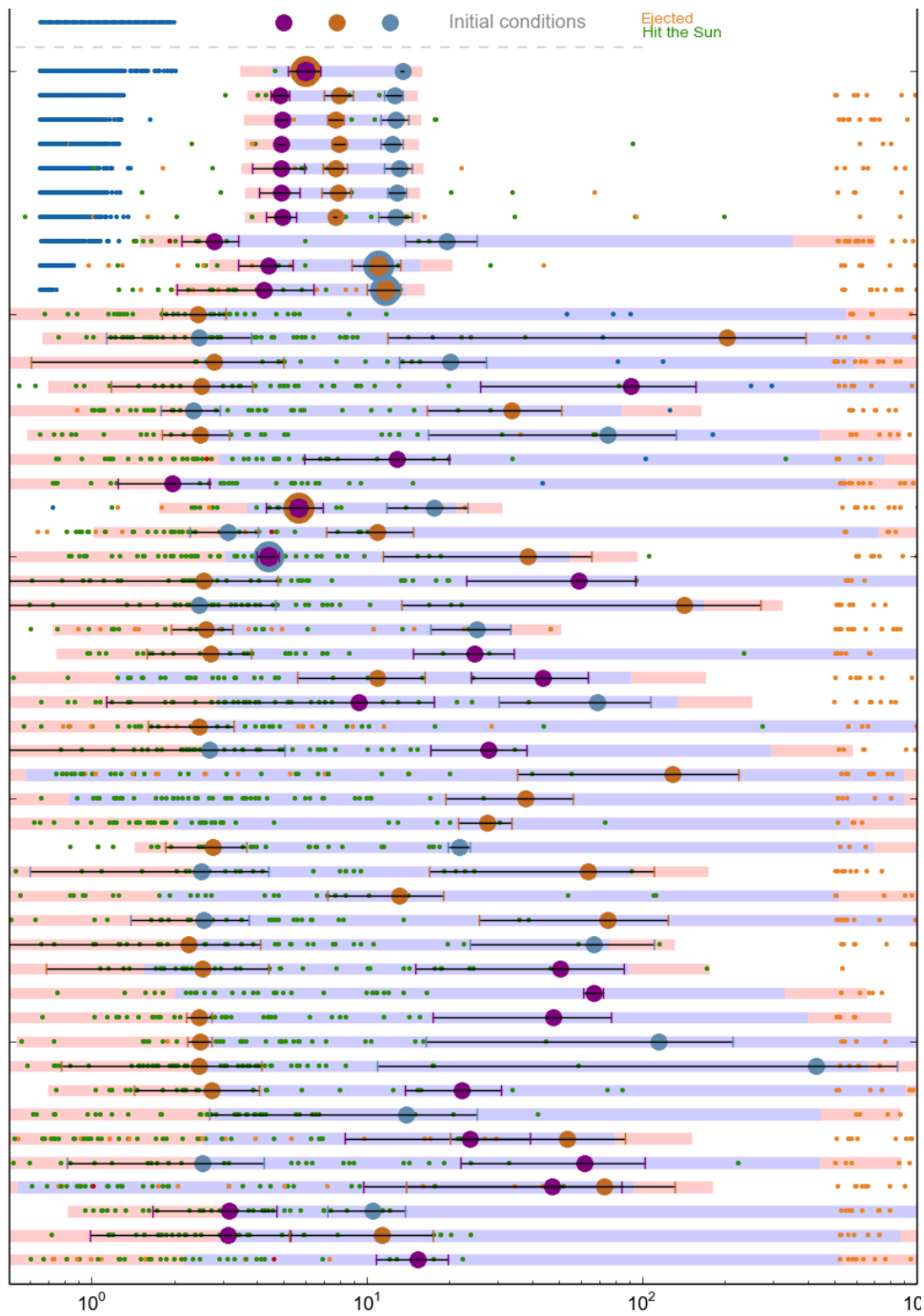
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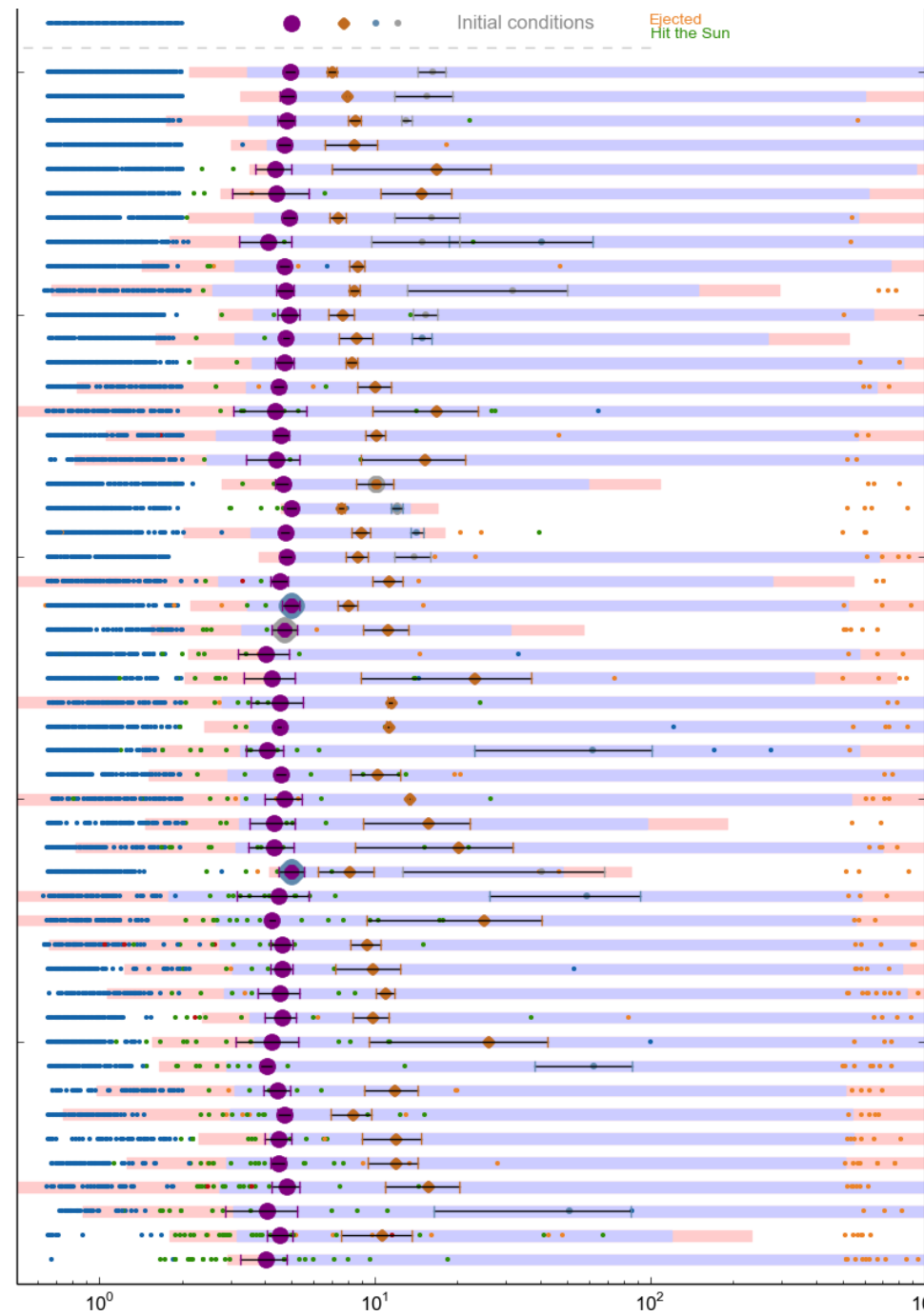
EXAMPLE



3Jb



4Gb

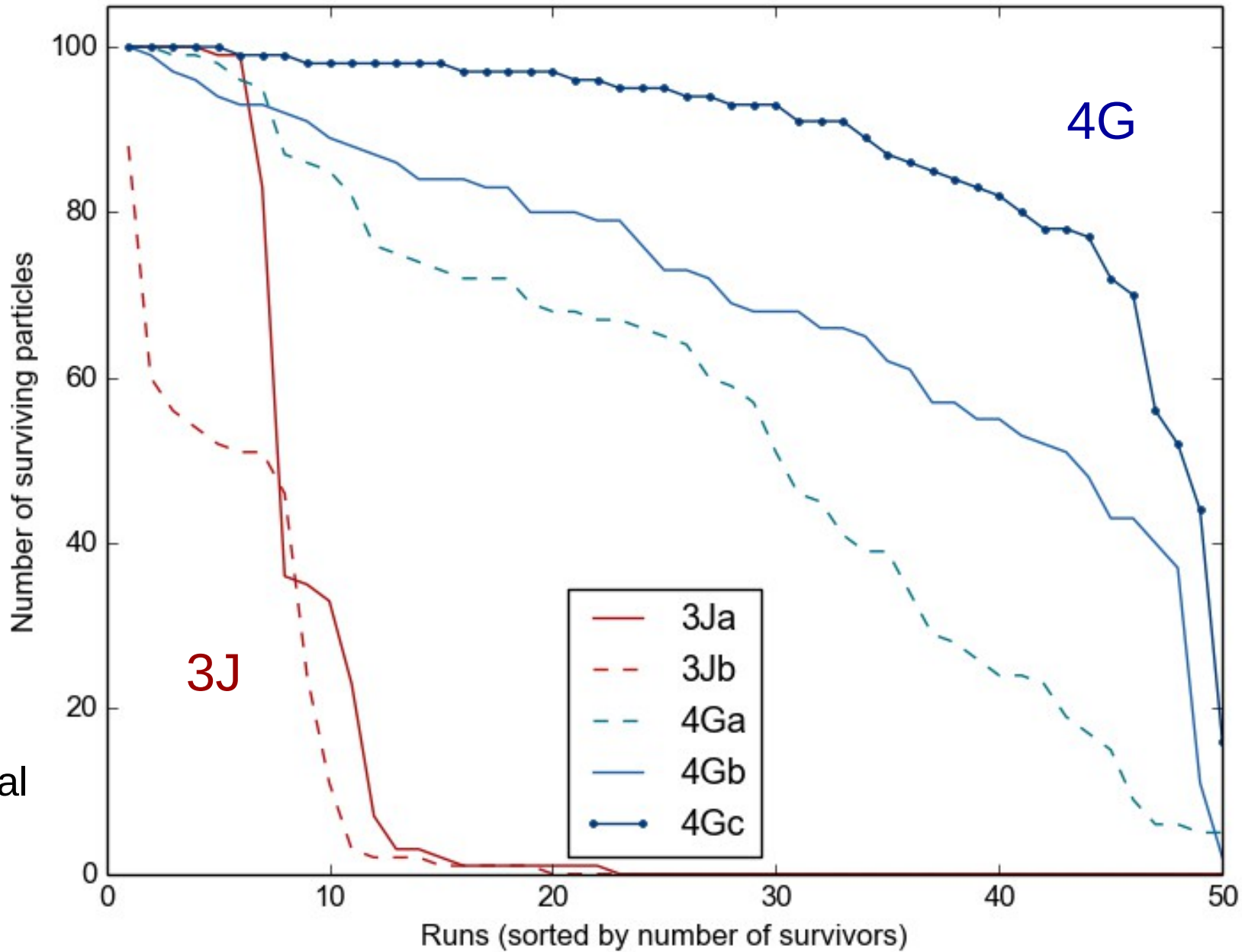


RESULTS

Hierarchical (4G) systems are a lot less damaging.

3J systems are extremely destructive.

more hierarchical
=
less damaging

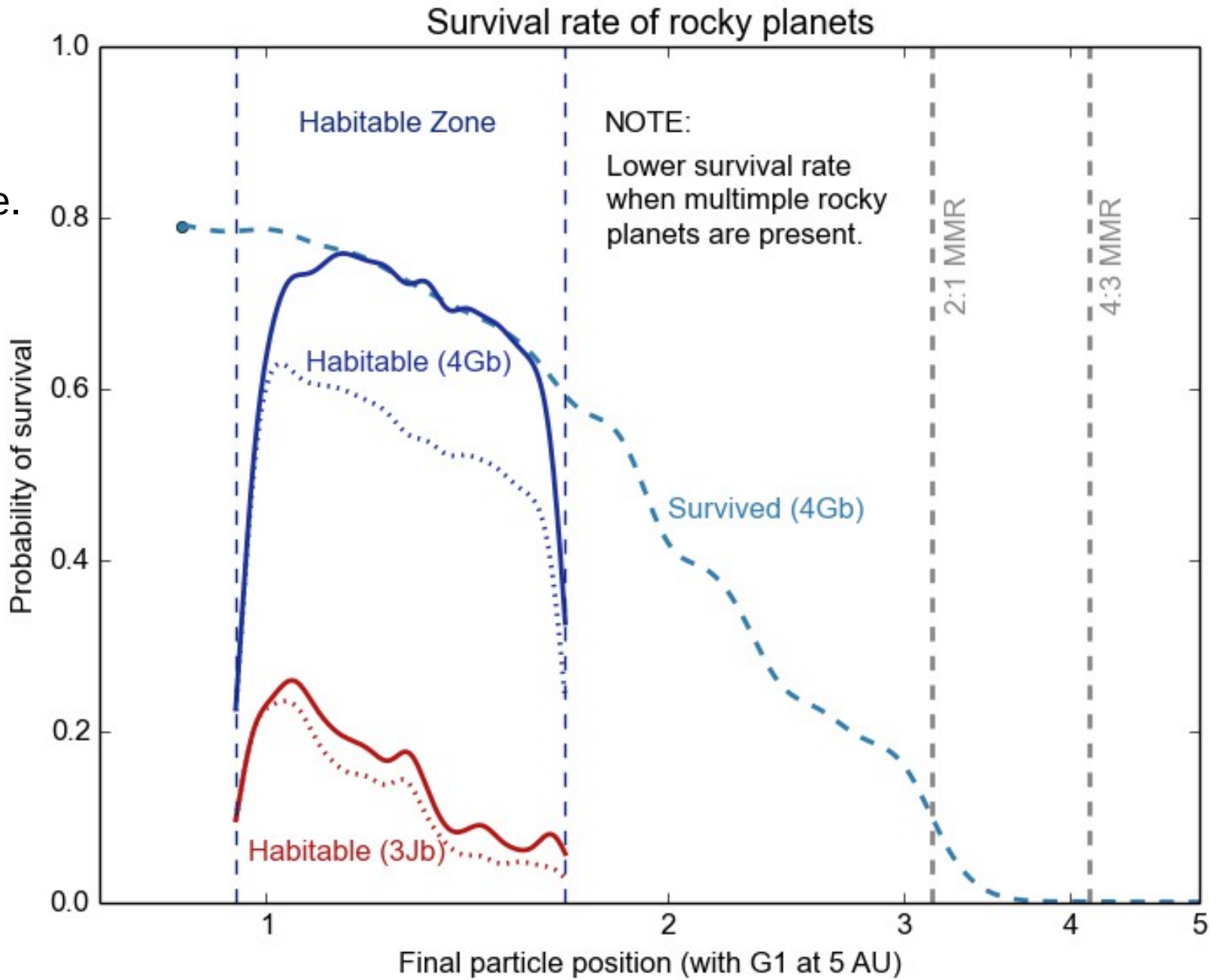


RESULTS

In 4G, habitable planets usually remain habitable.

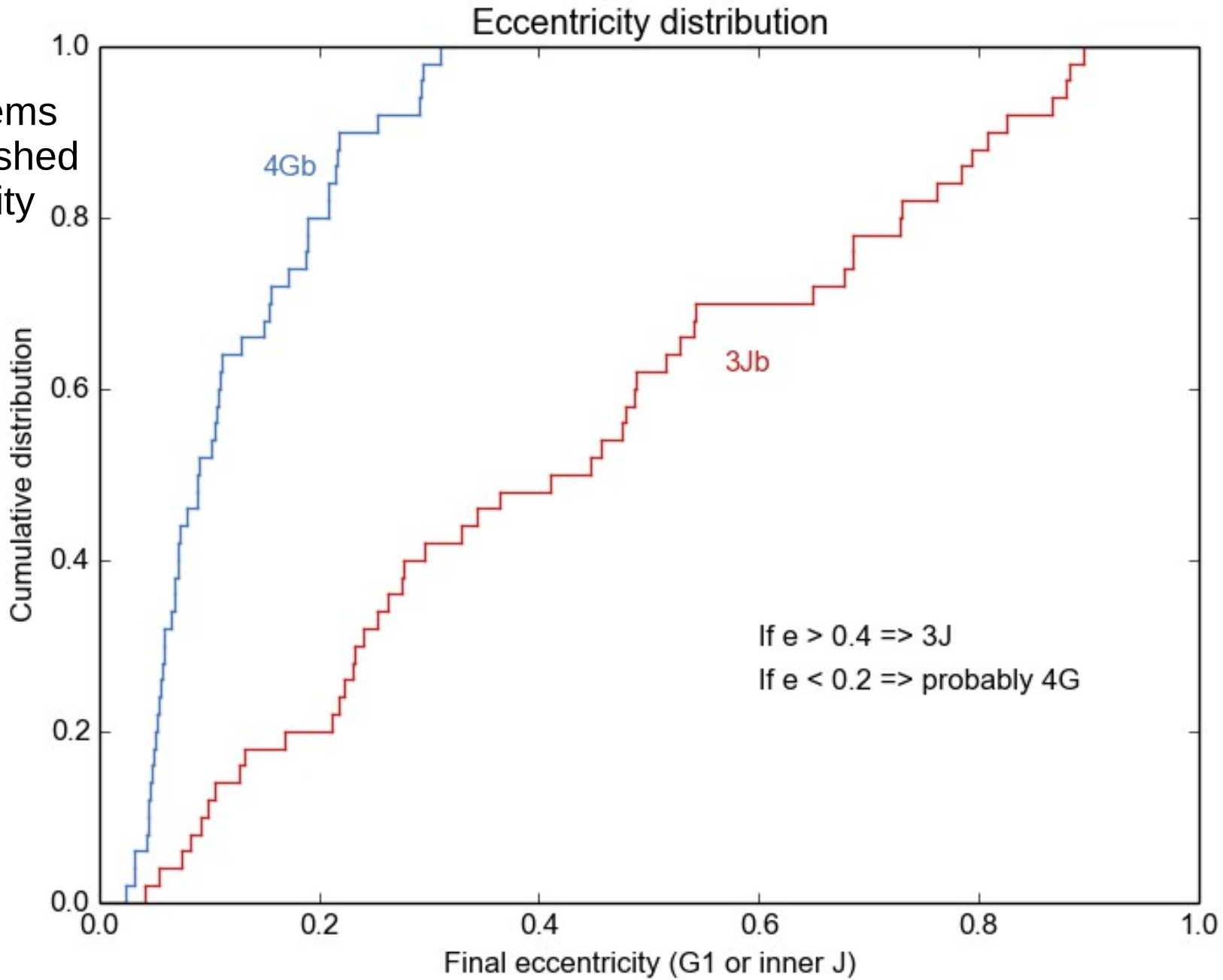


except near the inner edge of the HZ.



RESULTS

3J and 4G systems can be distinguished by the eccentricity of the remaining giant planet.



CONCLUSIONS

- Dynamical instabilities between giant planets can affect the orbits of habitable planets.
- More hierarchical (4G) giant planet systems are less damaging to terrestrial planets. Habitable worlds usually survive and remain habitable.
- If the final (i.e. observed) eccentricity is less than 0.2, there is a good chance that a habitable planet survived.