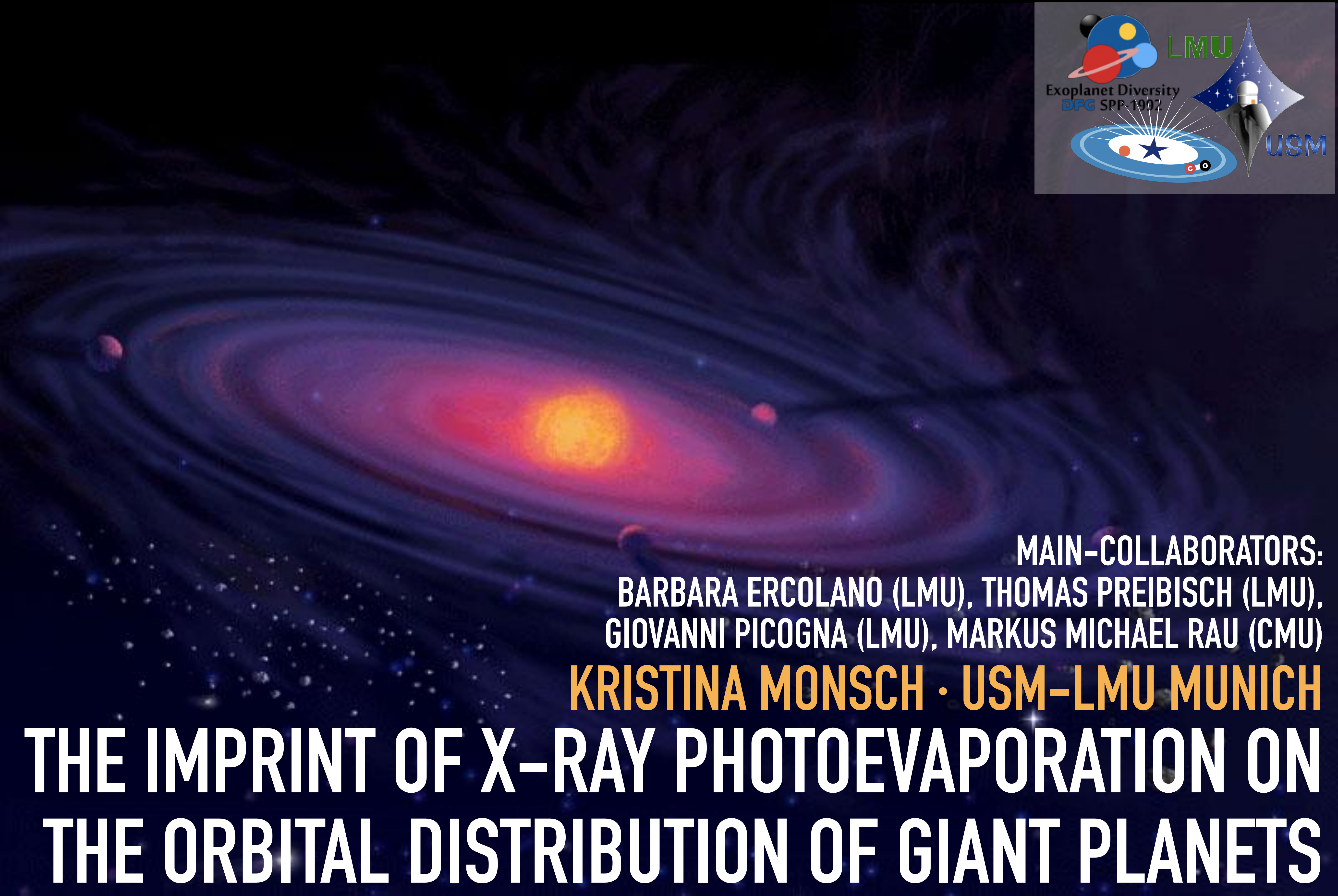

Credit: NASA/Brian Brondel (lic. under Creative Commons)

SUPPORTED BY DFG SPP-1992, RU-TD & LMU

MAIN-COLLABORATORS:
BARBARA ERCOLANO (LMU), THOMAS PREIBISCH (LMU),
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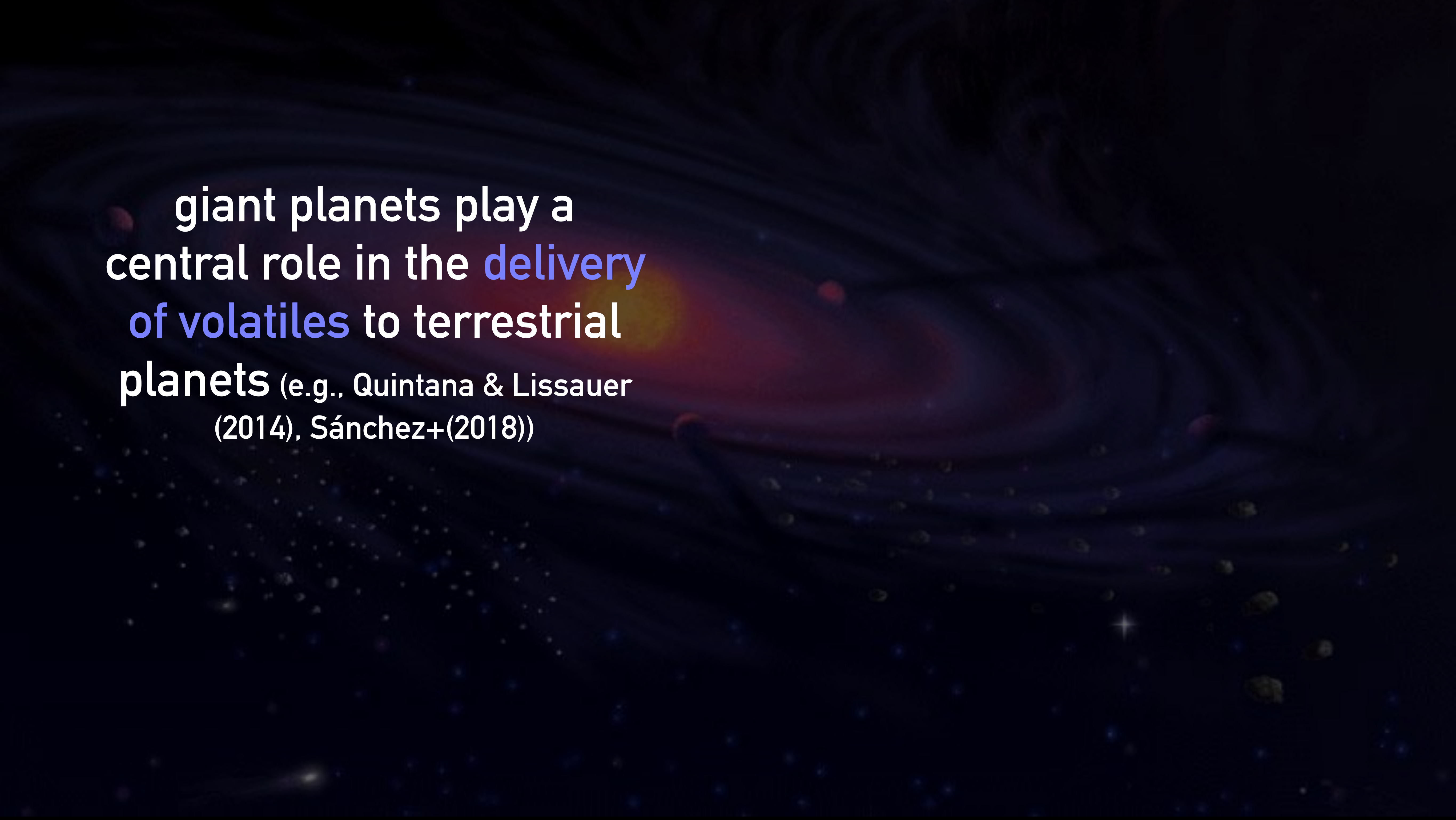
KRISTINA MONSCH · USM-LMU MUNICH

THE IMPRINT OF X-RAY PHOTOEVAPORATION ON THE ORBITAL DISTRIBUTION OF GIANT PLANETS

How do giant planets affect the habitability of a (terrestrial) planet?



giant planets play a central role in the delivery of volatiles to terrestrial planets (e.g., Quintana & Lissauer (2014), Sánchez+(2018))

Credit: NASA/Brian Brondel (lic. under Creative Commons)

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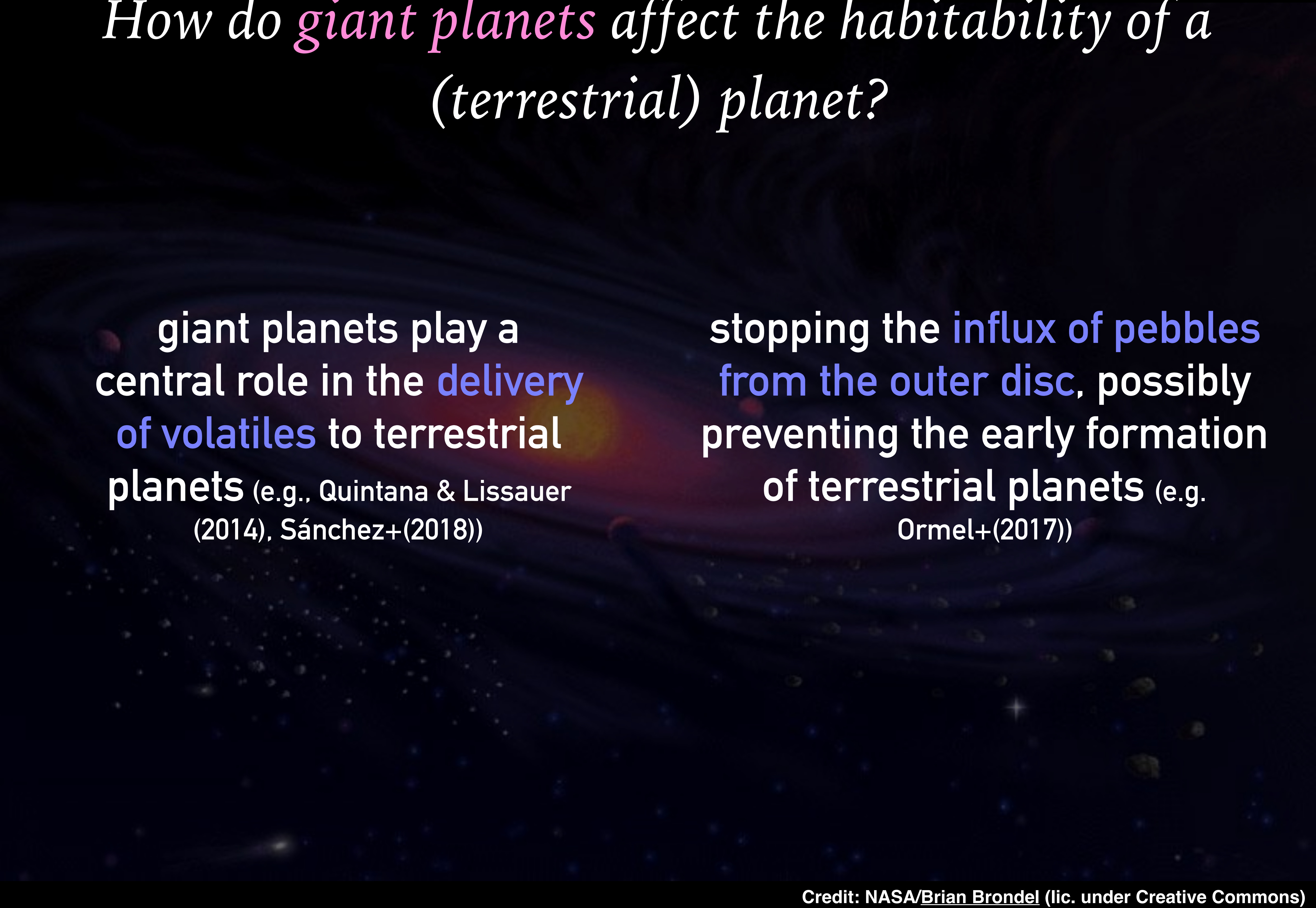

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stopping the influx of pebbles from the outer disc, possibly preventing the early formation of terrestrial planets (e.g. Ormel+(2017))

Credit: NASA/Brian Brondel (lic. under Creative Commons)

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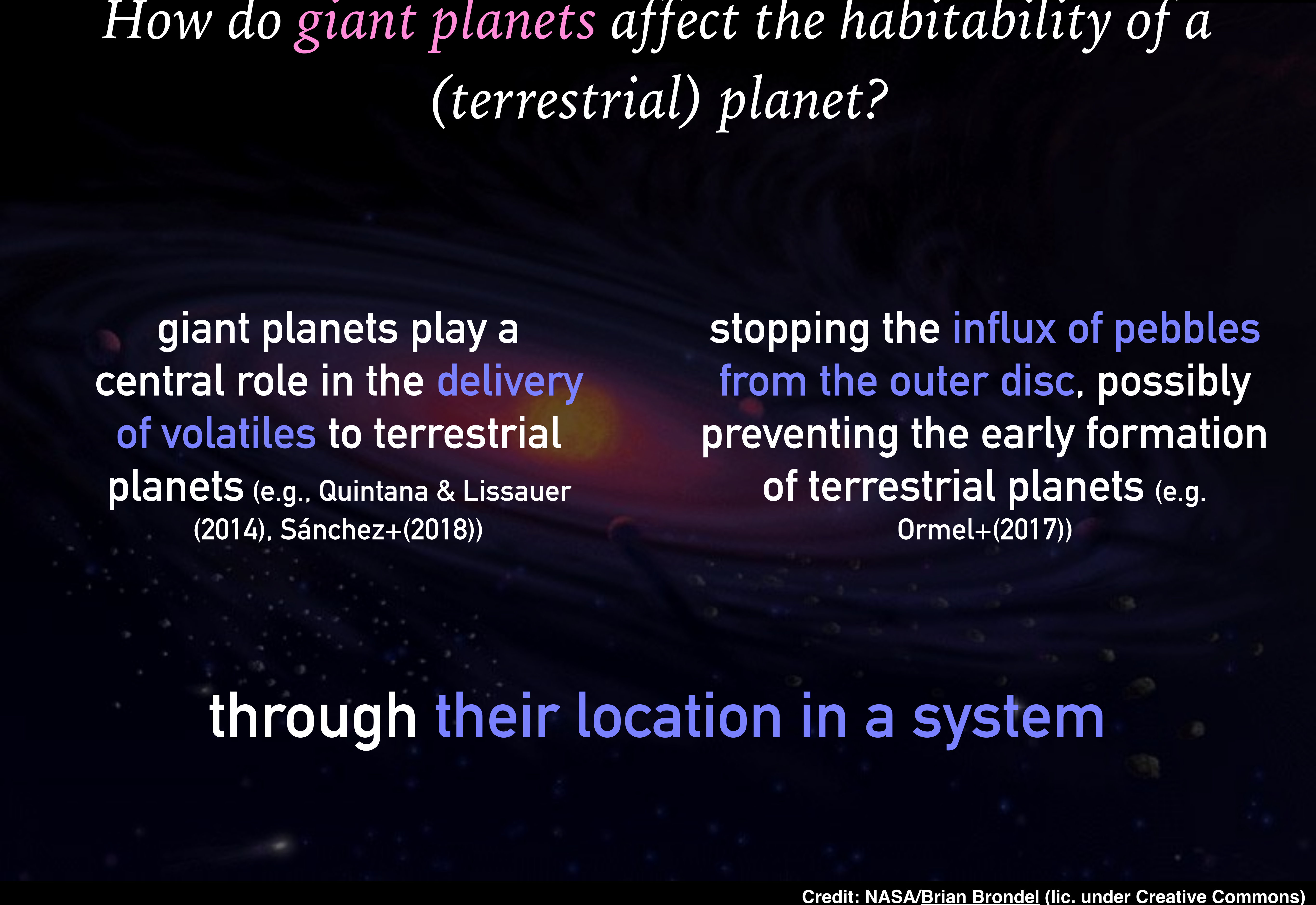


giant planets play a central role in the delivery of volatiles to terrestrial planets (e.g., Quintana & Lissauer (2014), Sánchez+(2018))

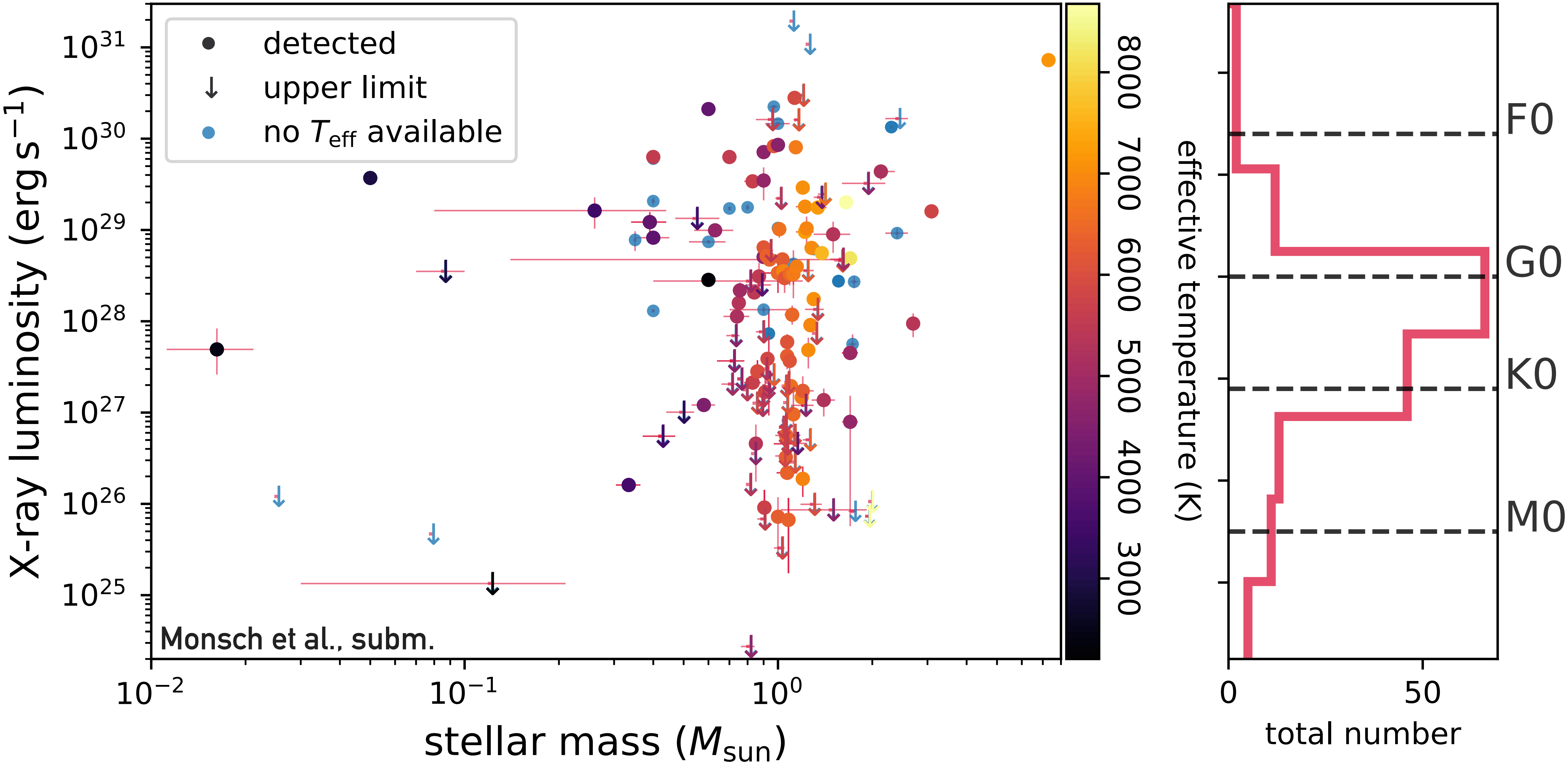
stopping the influx of pebbles from the outer disc, possibly preventing the early formation of terrestrial planets (e.g. Ormel+(2017))

through their location in a system

Credit: NASA/Brian Brondel (lic. under Creative Commons)

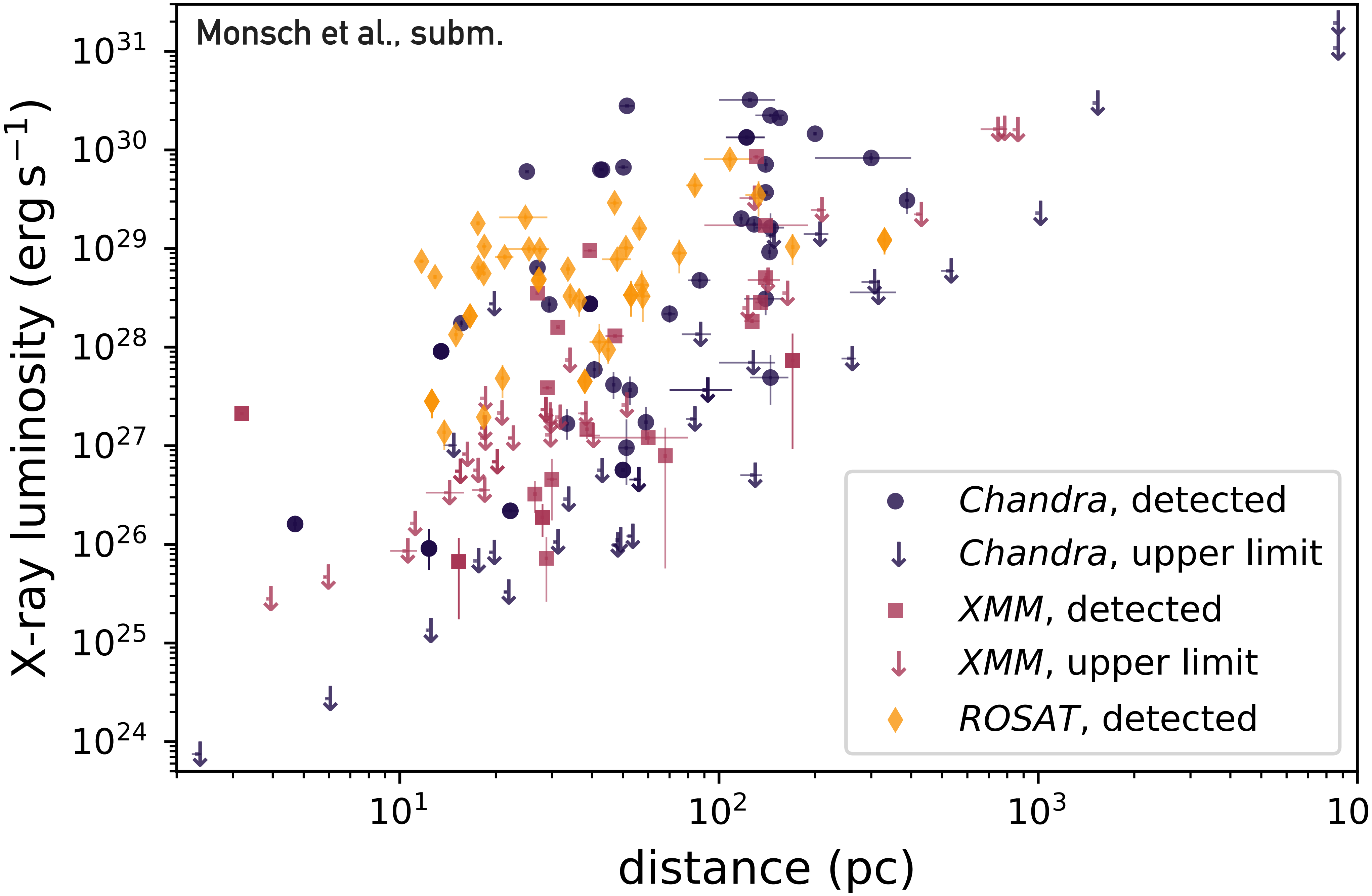
X-RAY OBSERVATIONS OF GIANT PLANET-HOSTING STARS

We constructed a catalog containing the X-ray luminosities as well as basic properties of more than 200 giant planets and their host stars, being the most extensive of its kind currently available.

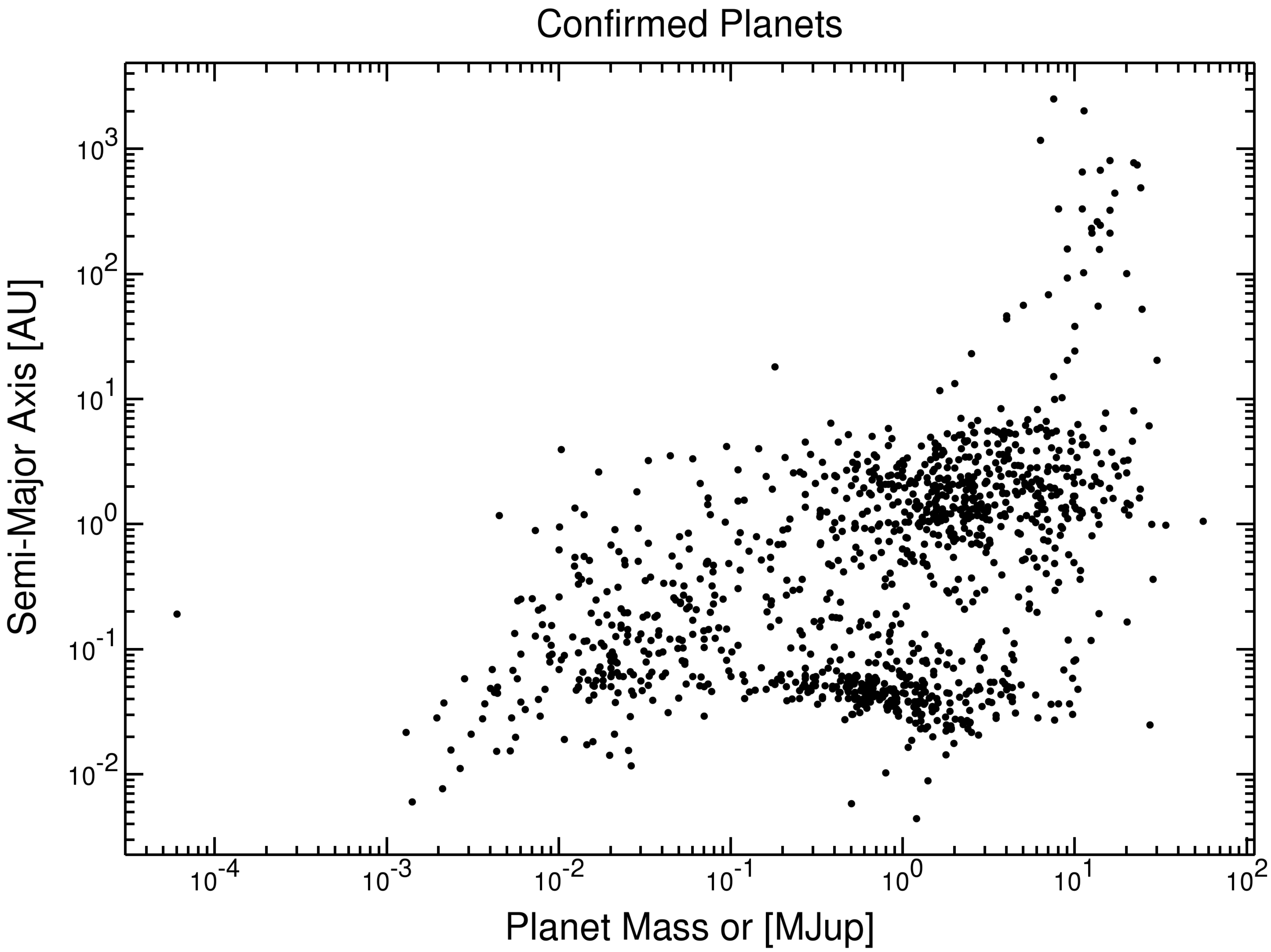


X-RAY OBSERVATIONS OF GIANT PLANET-HOSTING STARS

For this purpose we have used archival Chandra, XMM-Newton and ROSAT data to calculate source fluxes and luminosities.



THE DEMOGRAPHICS OF GIANTS



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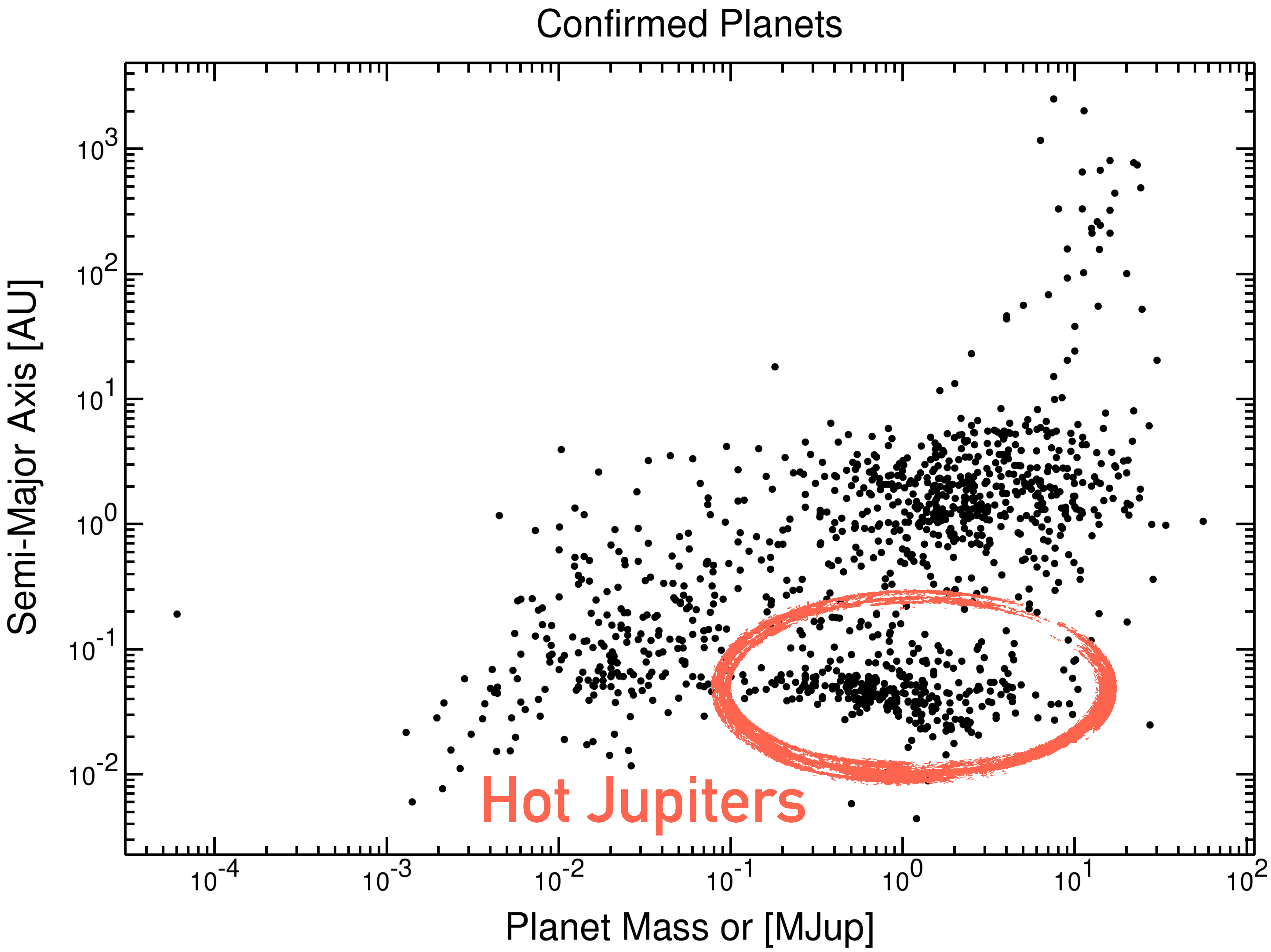

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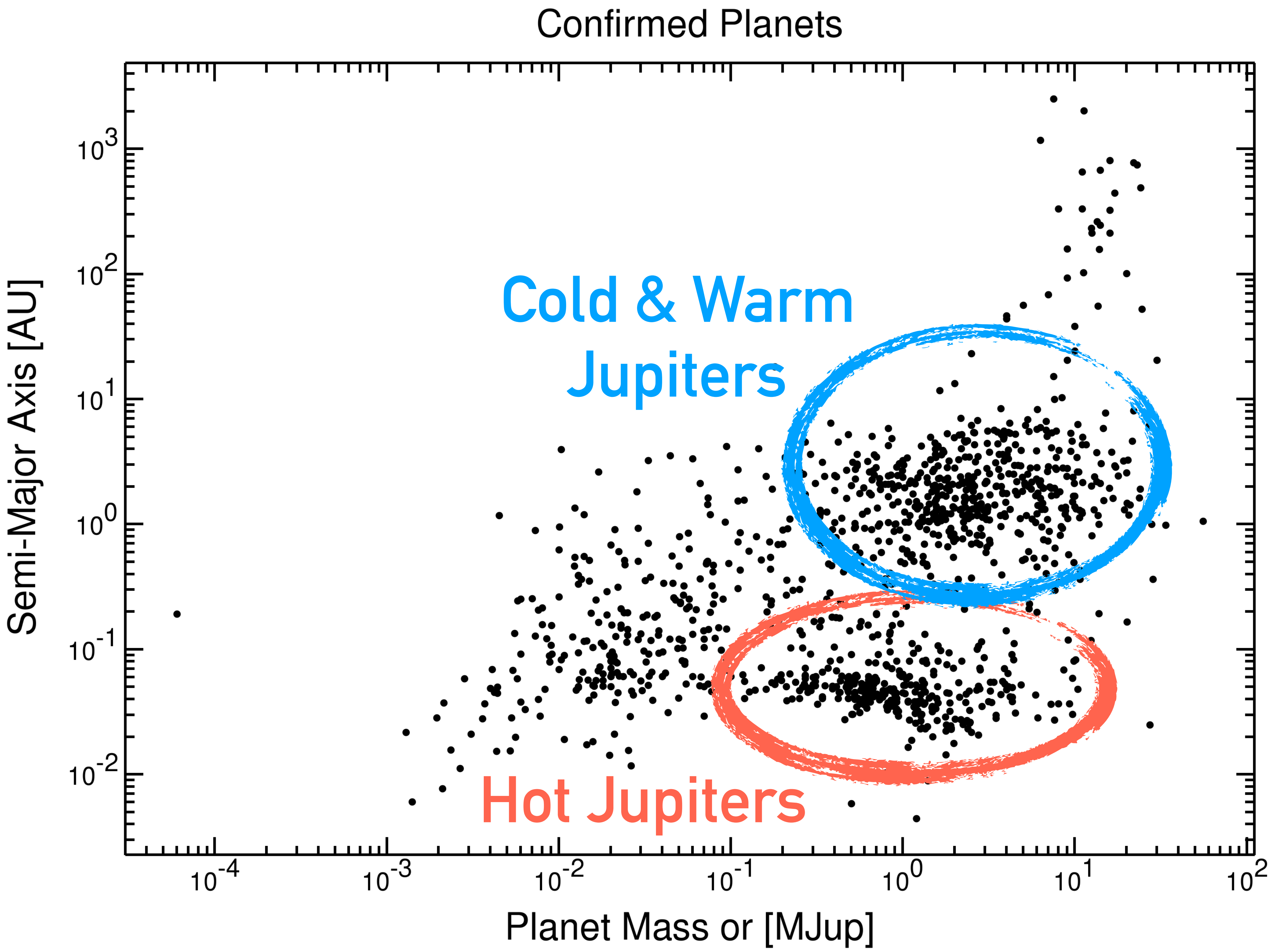

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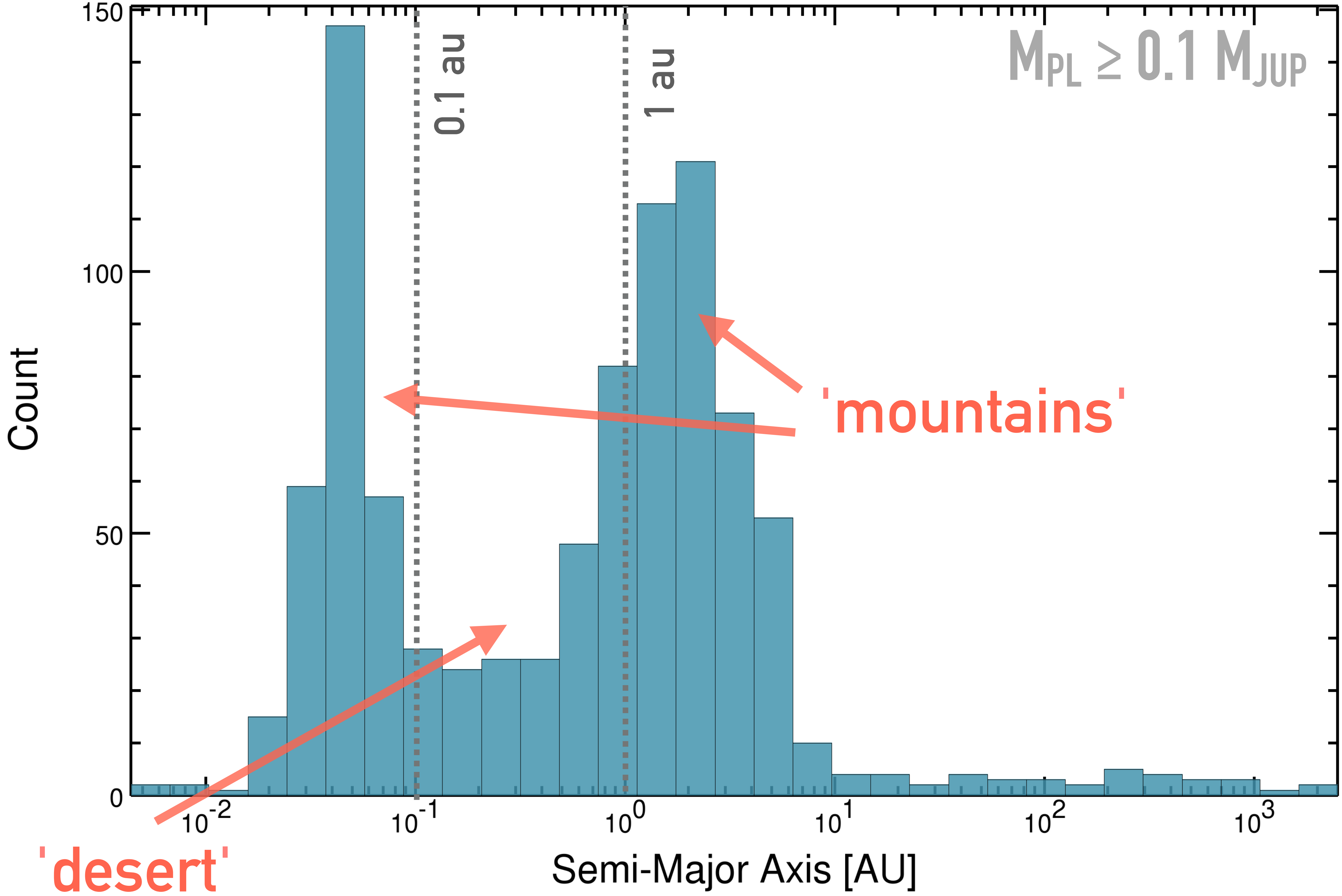

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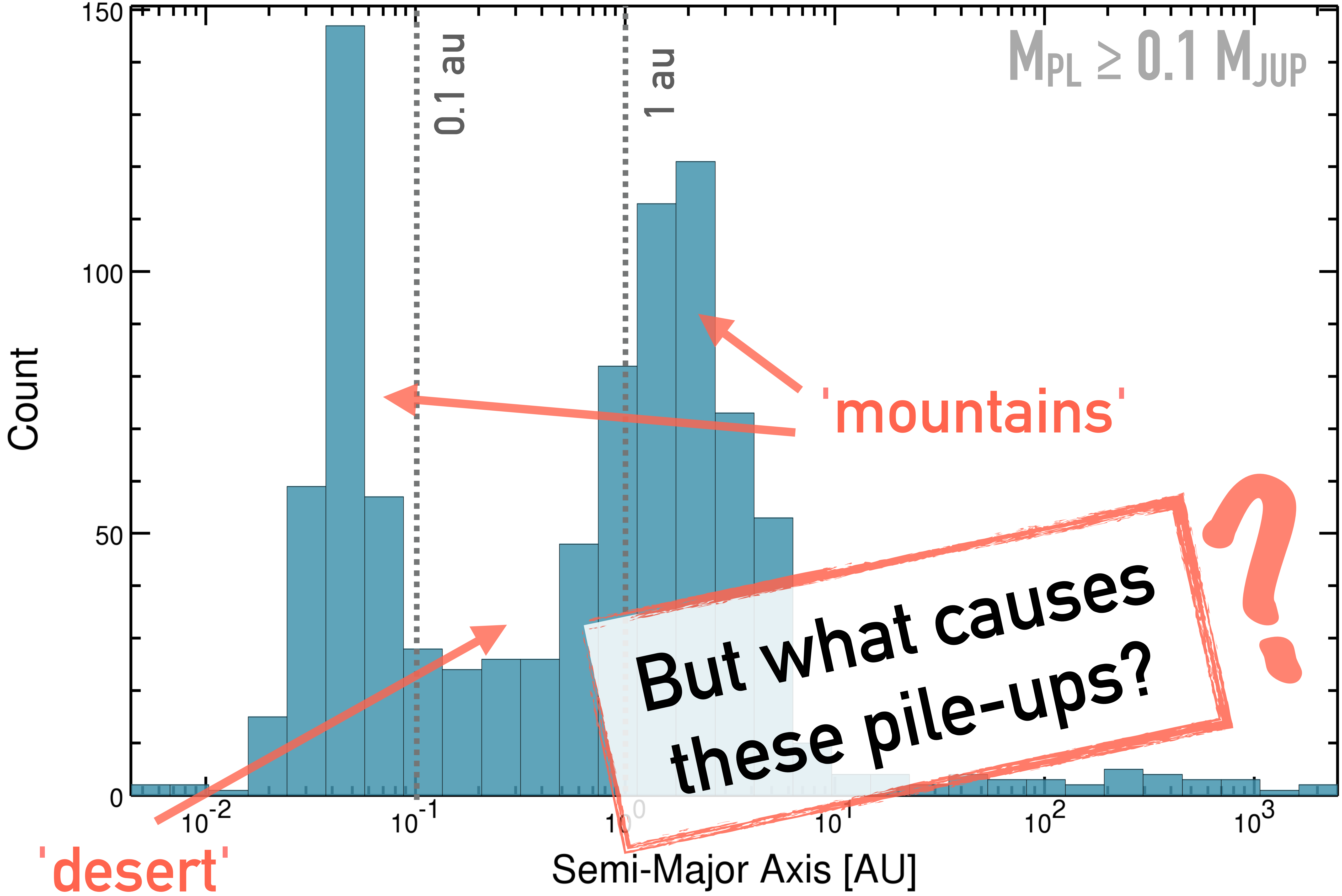
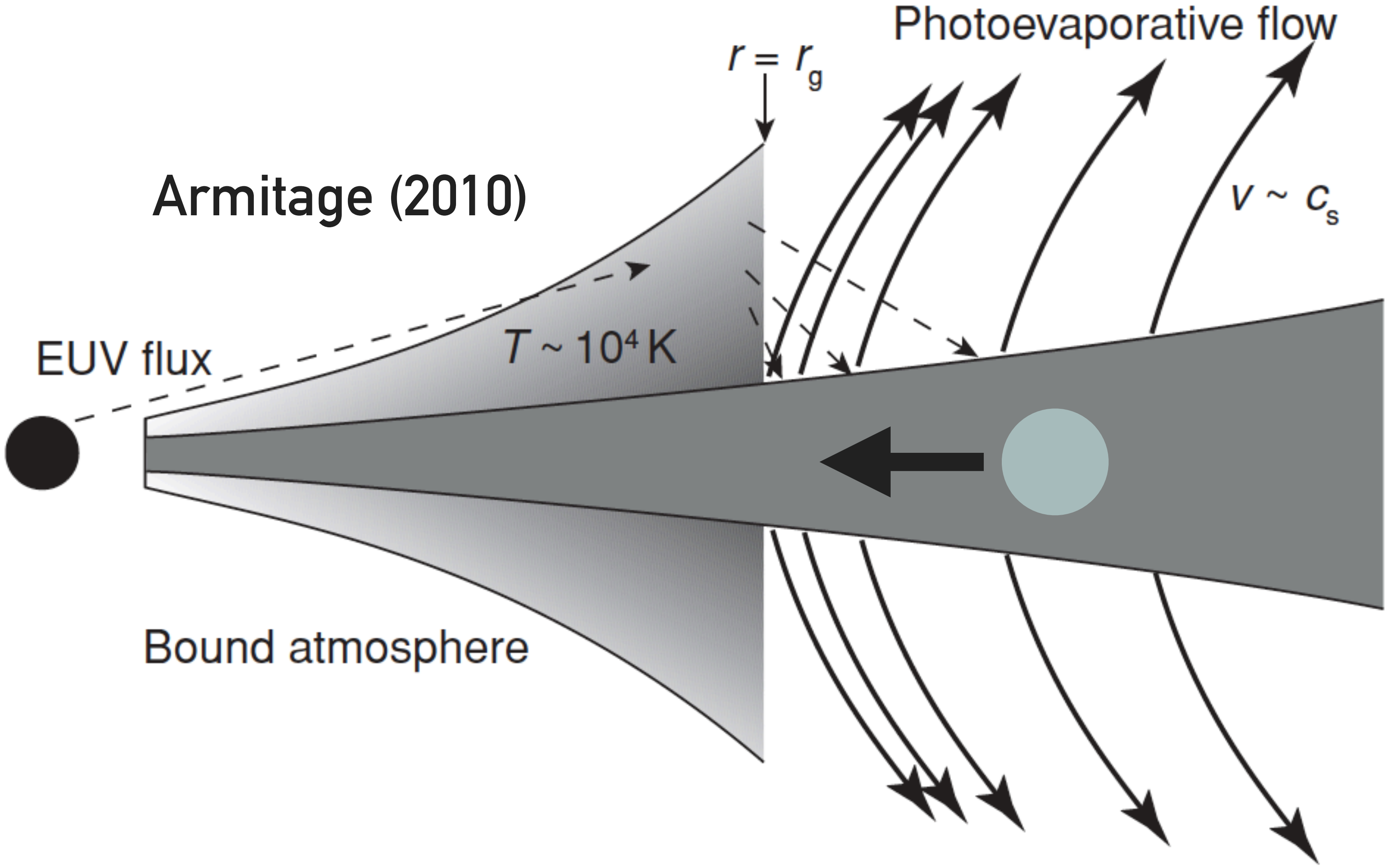


But what causes these pile-ups?

PHOTOEVAPORATION

photoevaporation opens a gap near the gravitational radius

$$r_\mathrm{g} = \frac{GM_\star}{c^2}$$



Armitage (2010)

PHOTOEVAPORATION

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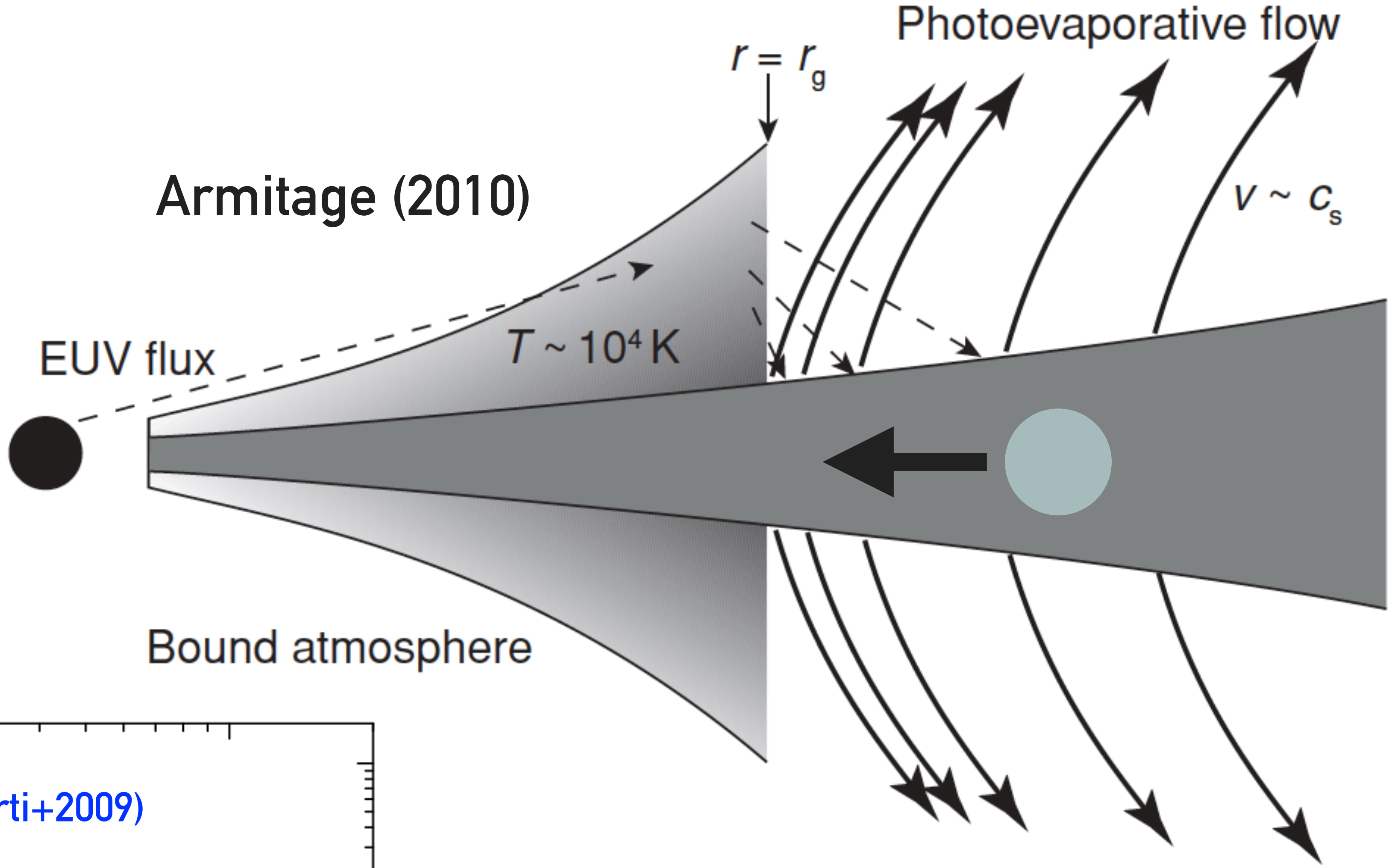
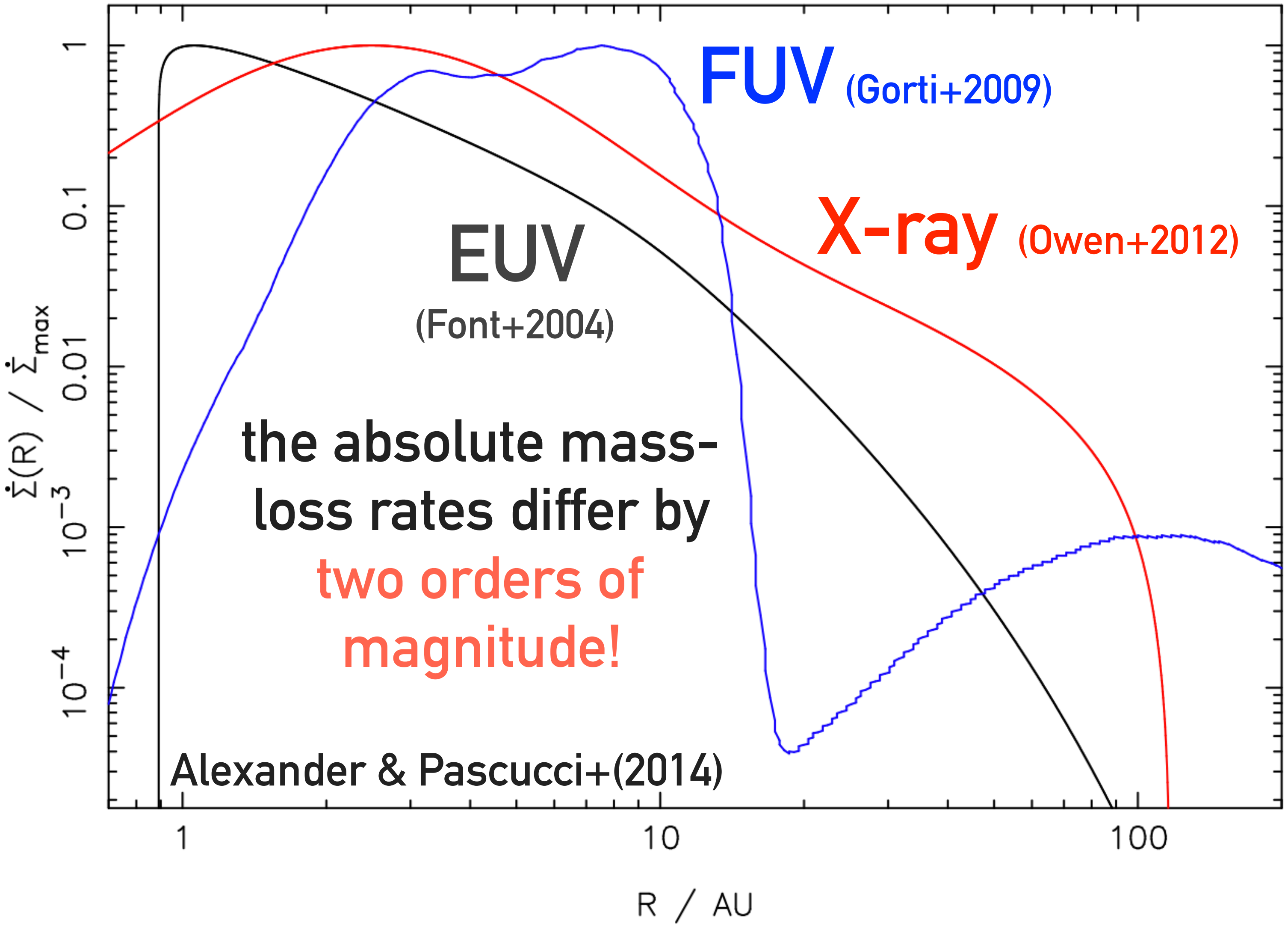




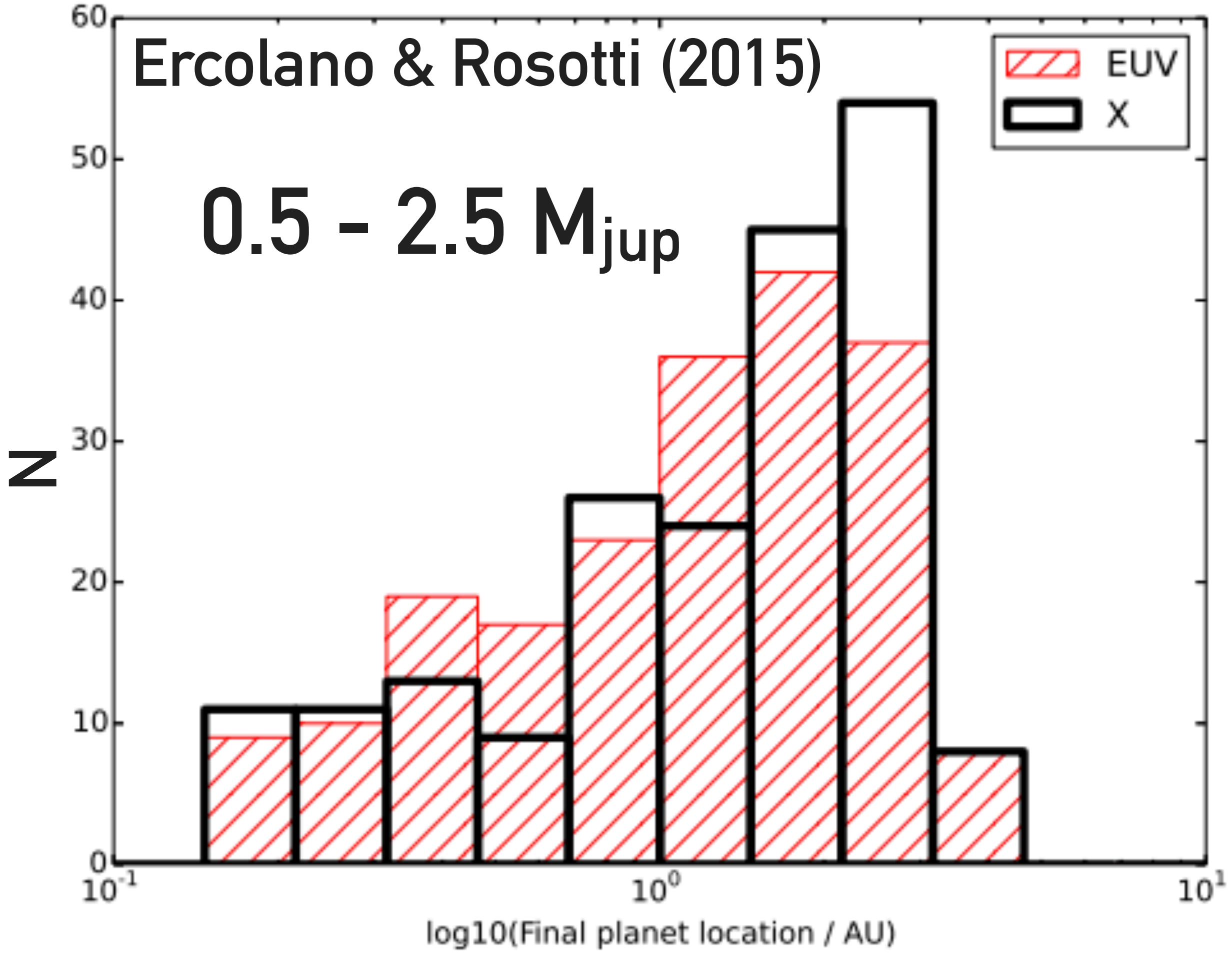
the absolute mass-loss rates differ by two orders of magnitude!

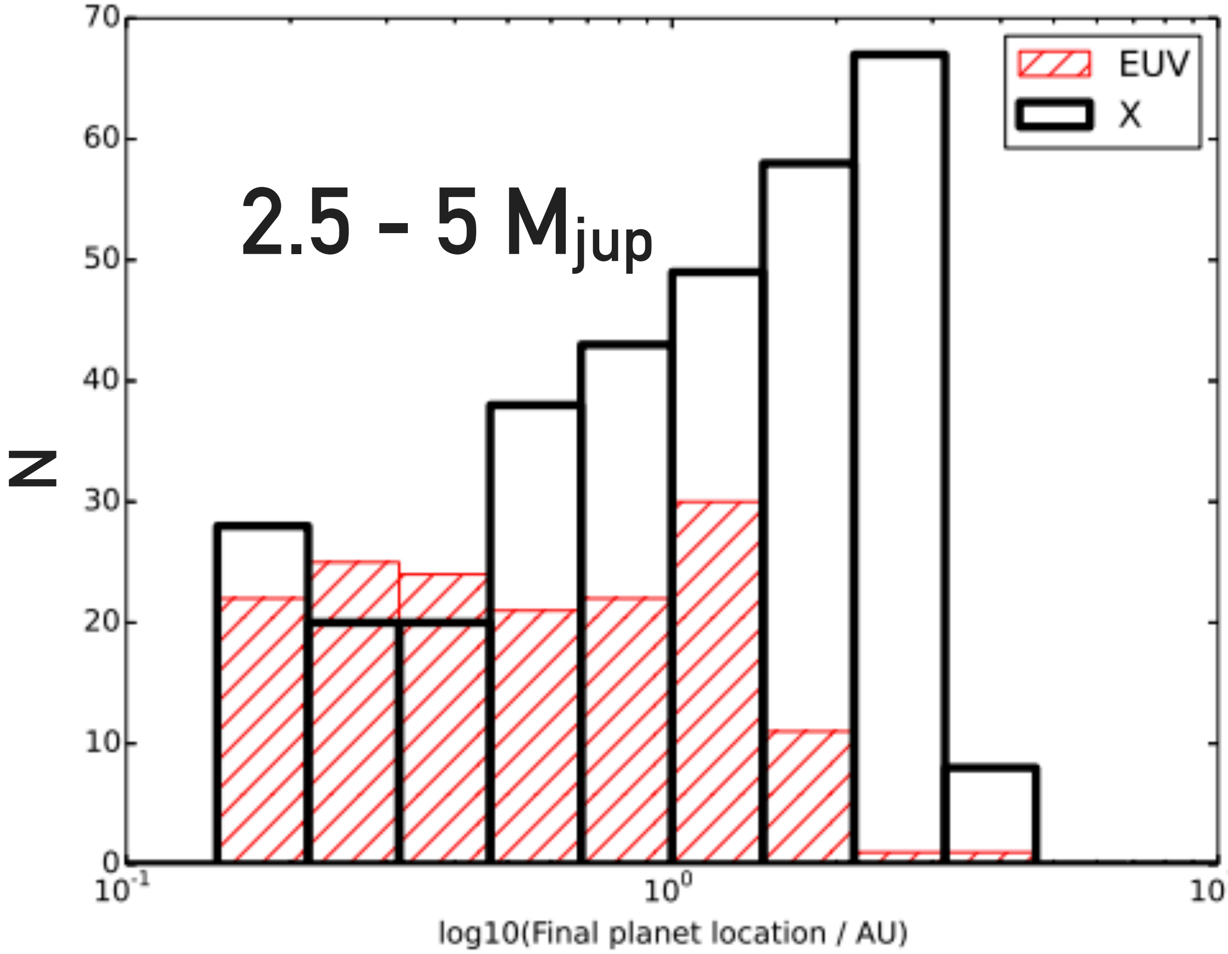
Alexander & Pascucci+(2014)

The mass-loss rate and the location of r_g change drastically for different photoevaporation profiles!

DISC DISPERSAL & GIANT PLANET MIGRATION

Different photoevaporation profiles lead to completely **distinct orbital configurations** of giant planets!





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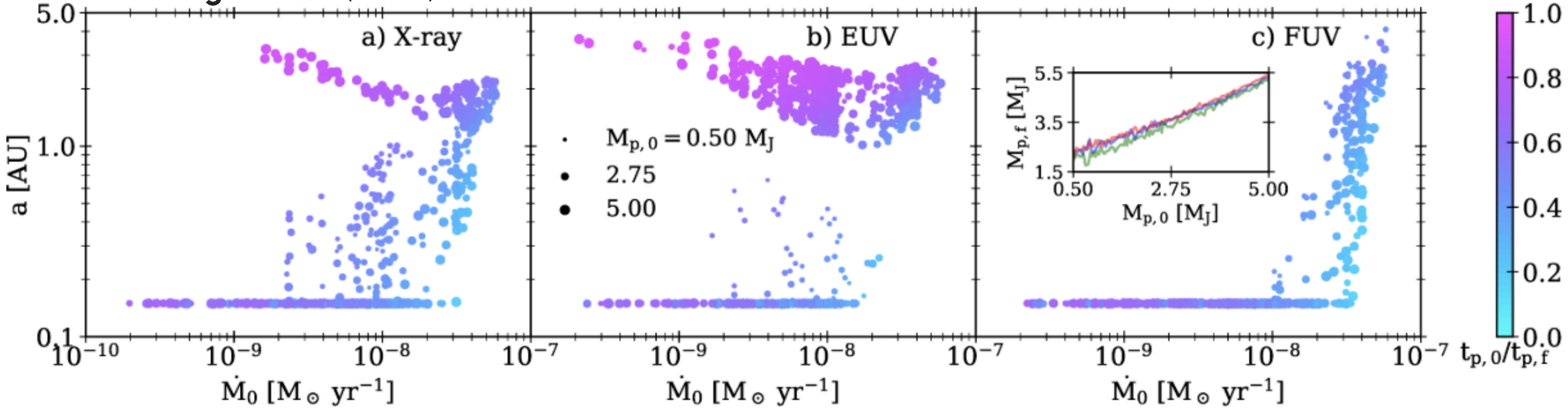

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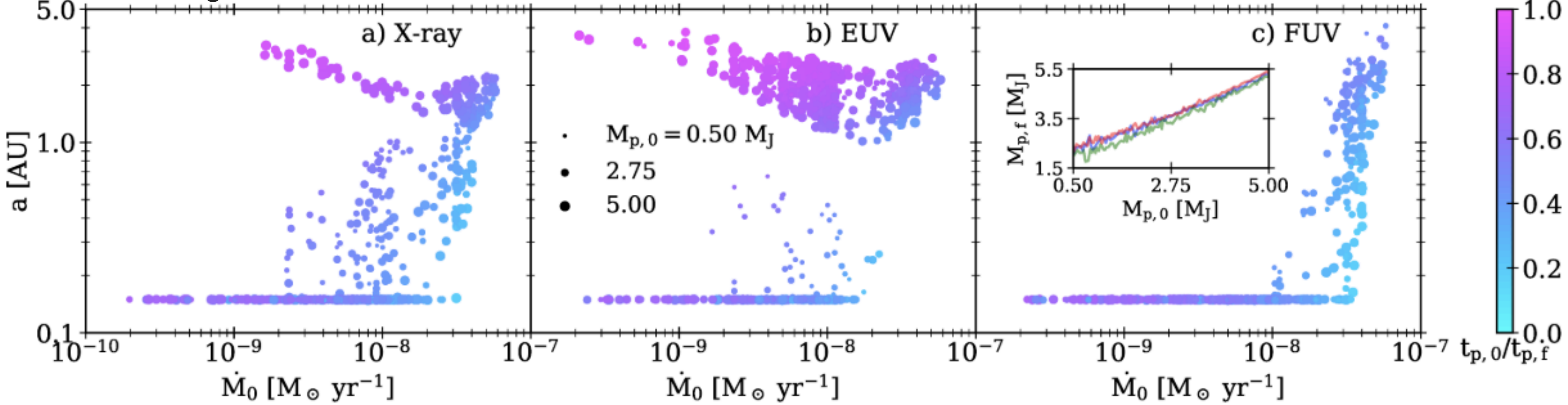
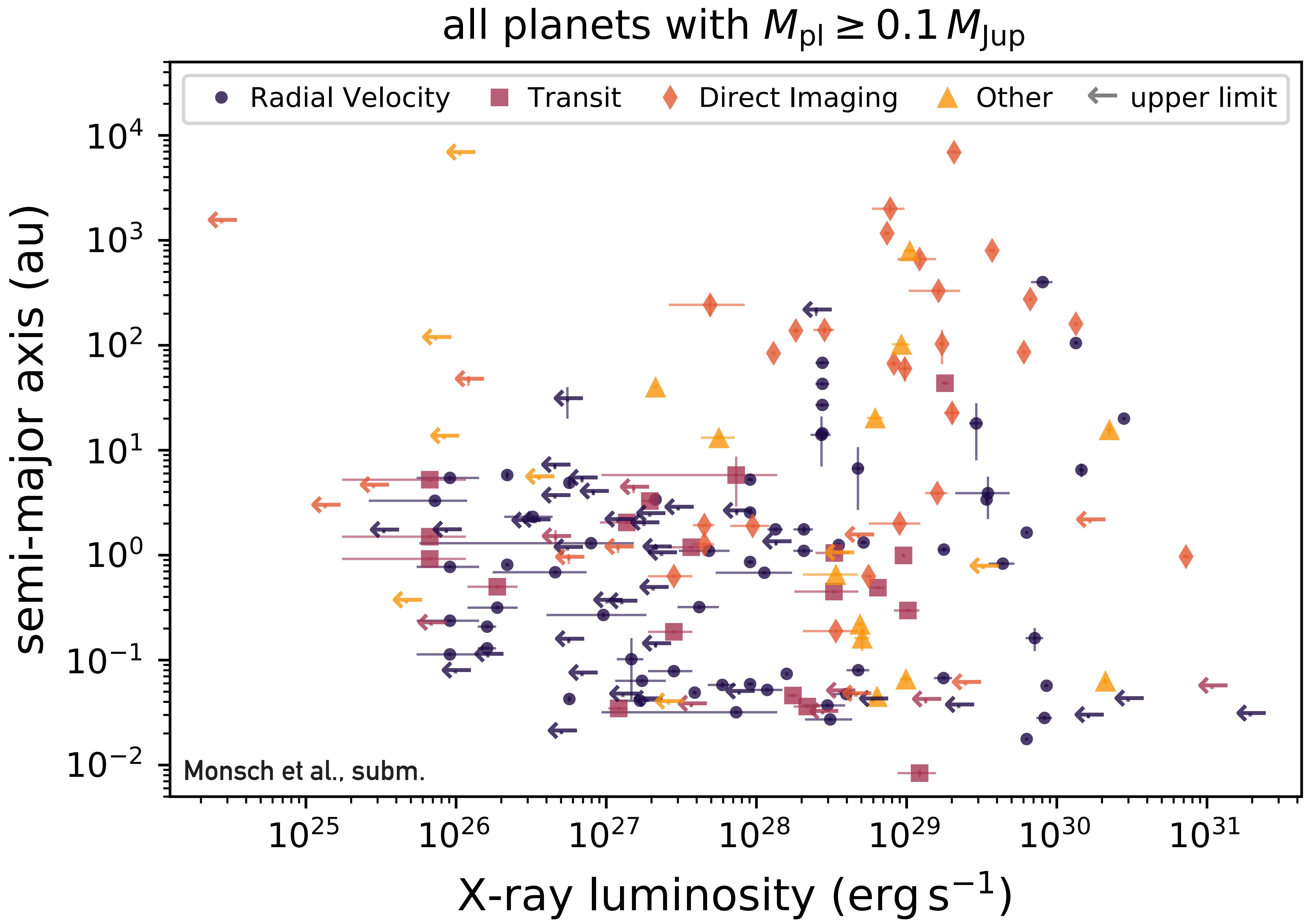

Jennings et al. (2018)

Can we find signatures of X-ray driven photoevaporation in today's giant planet distribution?

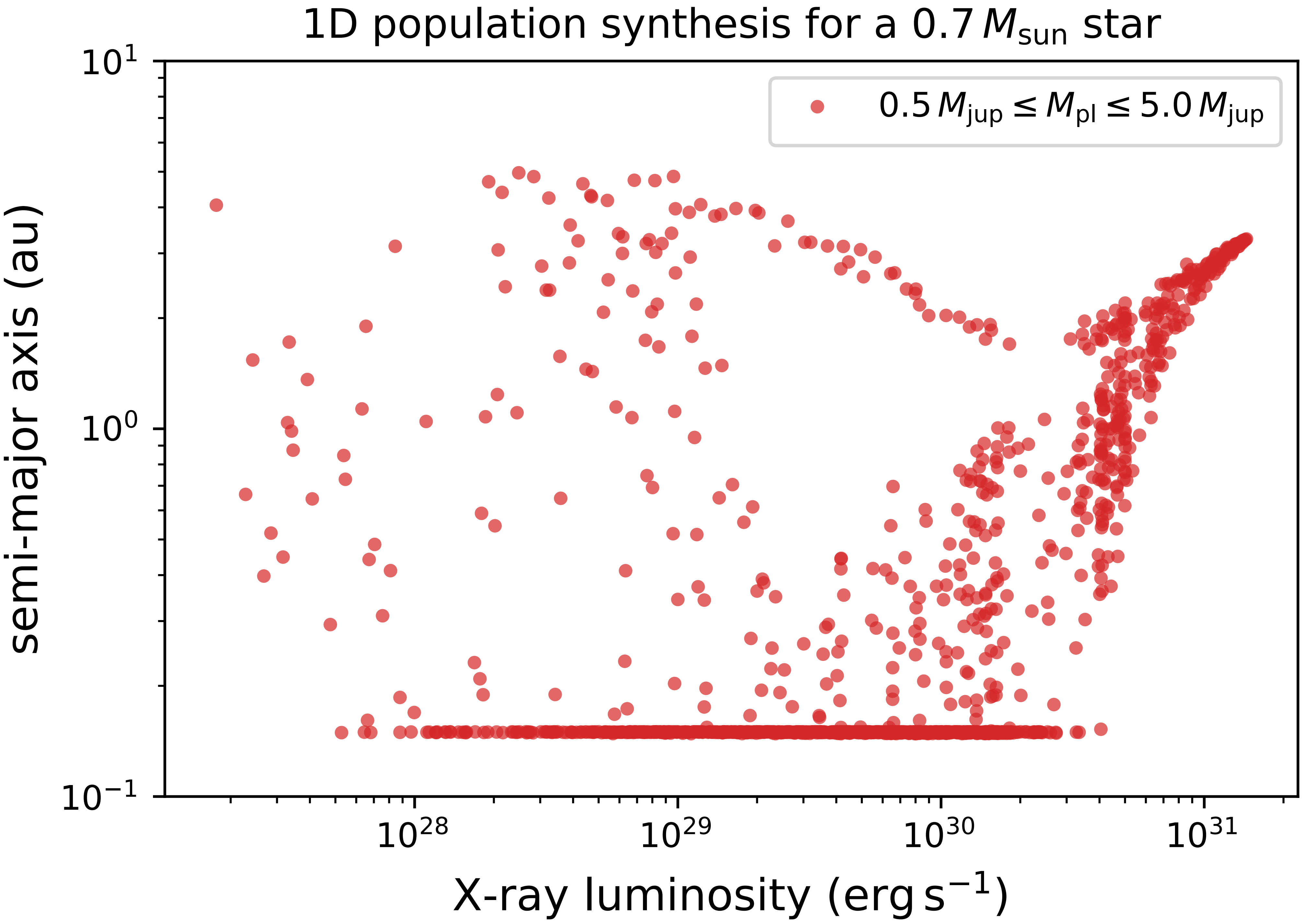
X-RAY OBSERVATIONS OF GIANT PLANET-HOSTING STARS



PRELIMINARY NUMERICAL RESULTS

1D planet population synthesis using the viscous evolution code SPOCK (Ercolano & Rosotti, 2015)

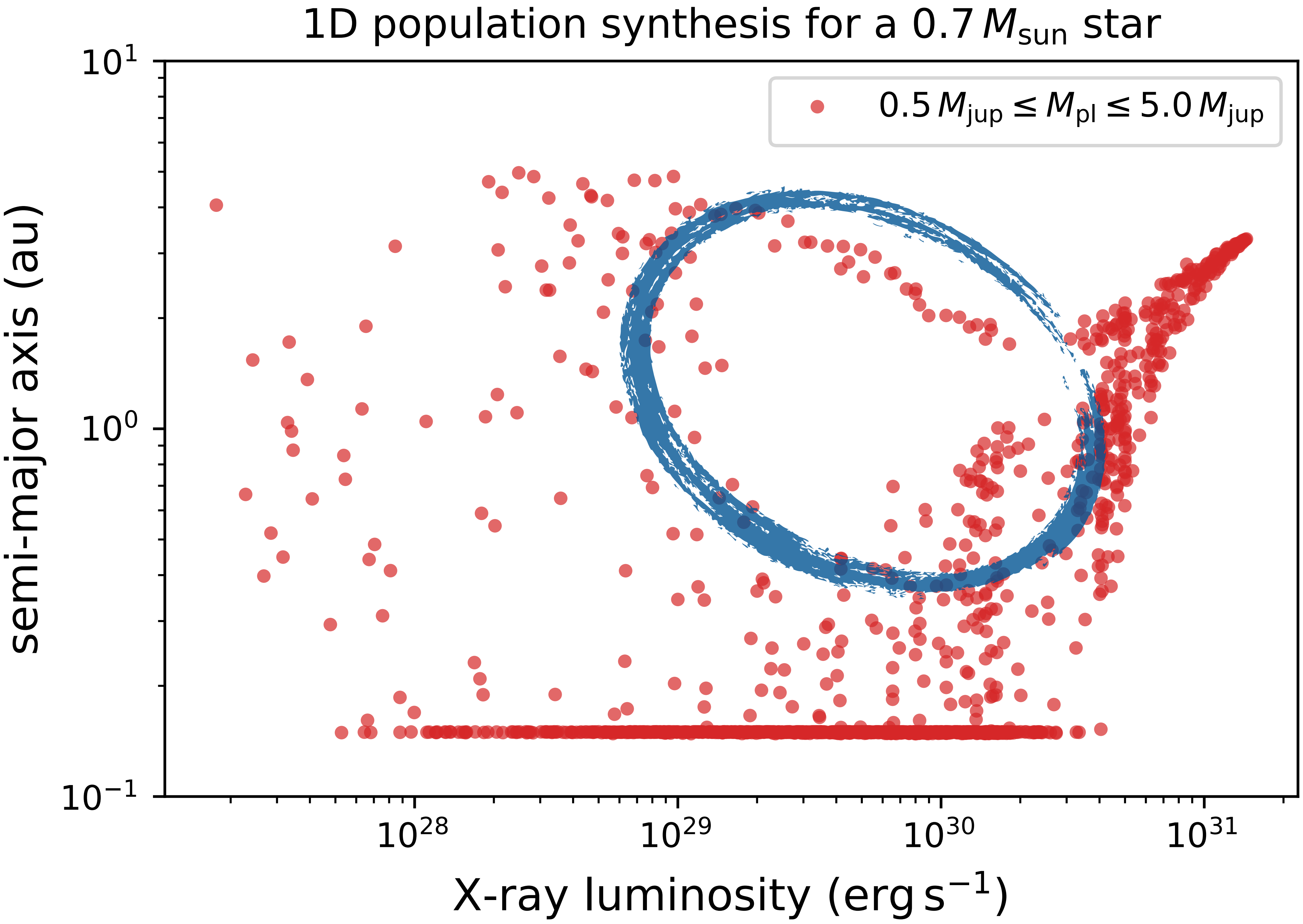
numerical setup:
$M_\star = 0.7\ M_\odot$
$M_{disc} = 0.07\ M_\odot$
$M_{pl} = 0.5 - 5\ M_{jup}$
$a_{initial} = 5$ au
$H/R = 0.1$
XEUV-PE



PRELIMINARY NUMERICAL RESULTS

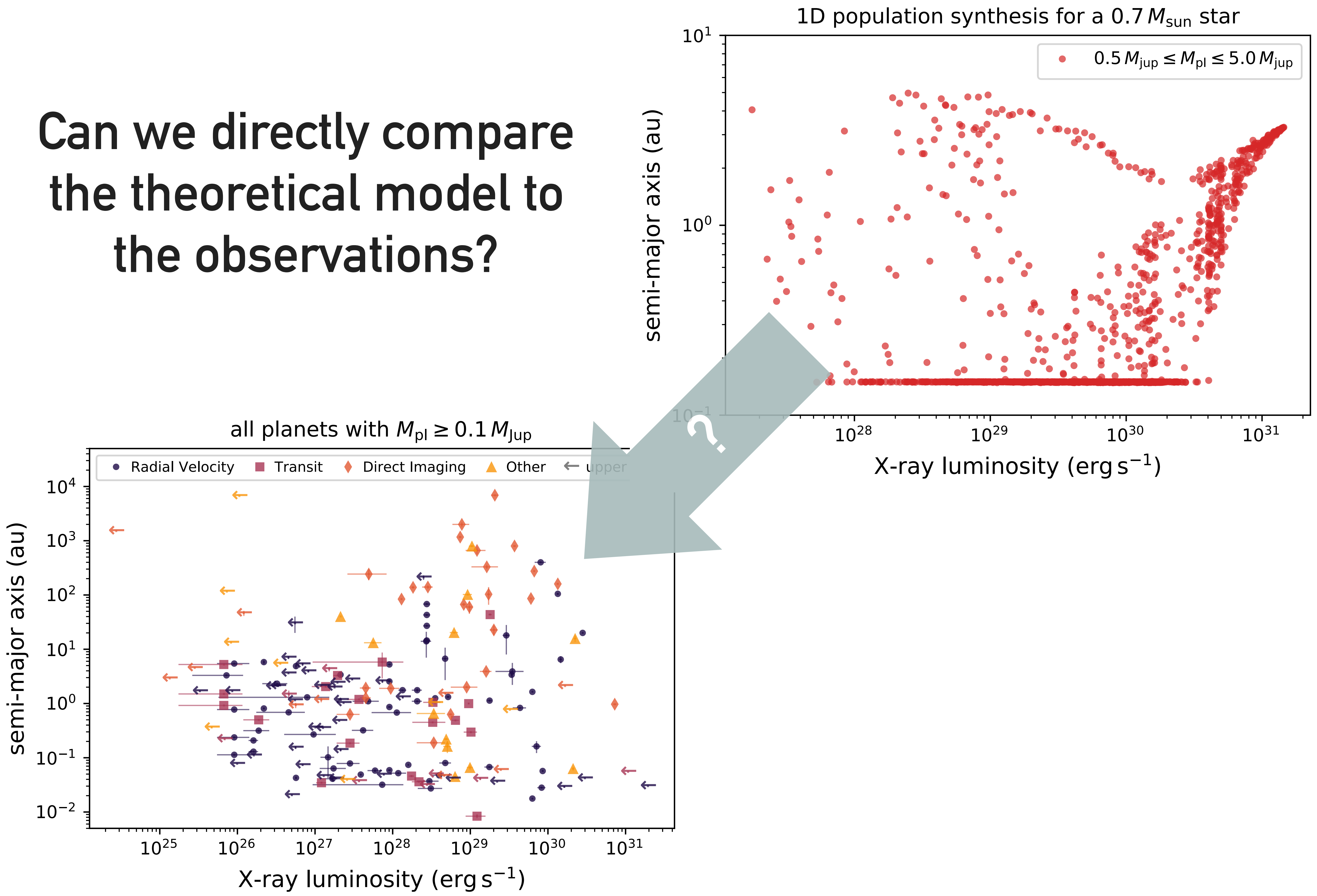
1D planet population synthesis using the viscous evolution code SPOCK (Ercolano & Rosotti, 2015)

X-ray PE opens a gap in the disc at ~1 au and creates a natural parking radius



THEORY VS OBSERVATIONS

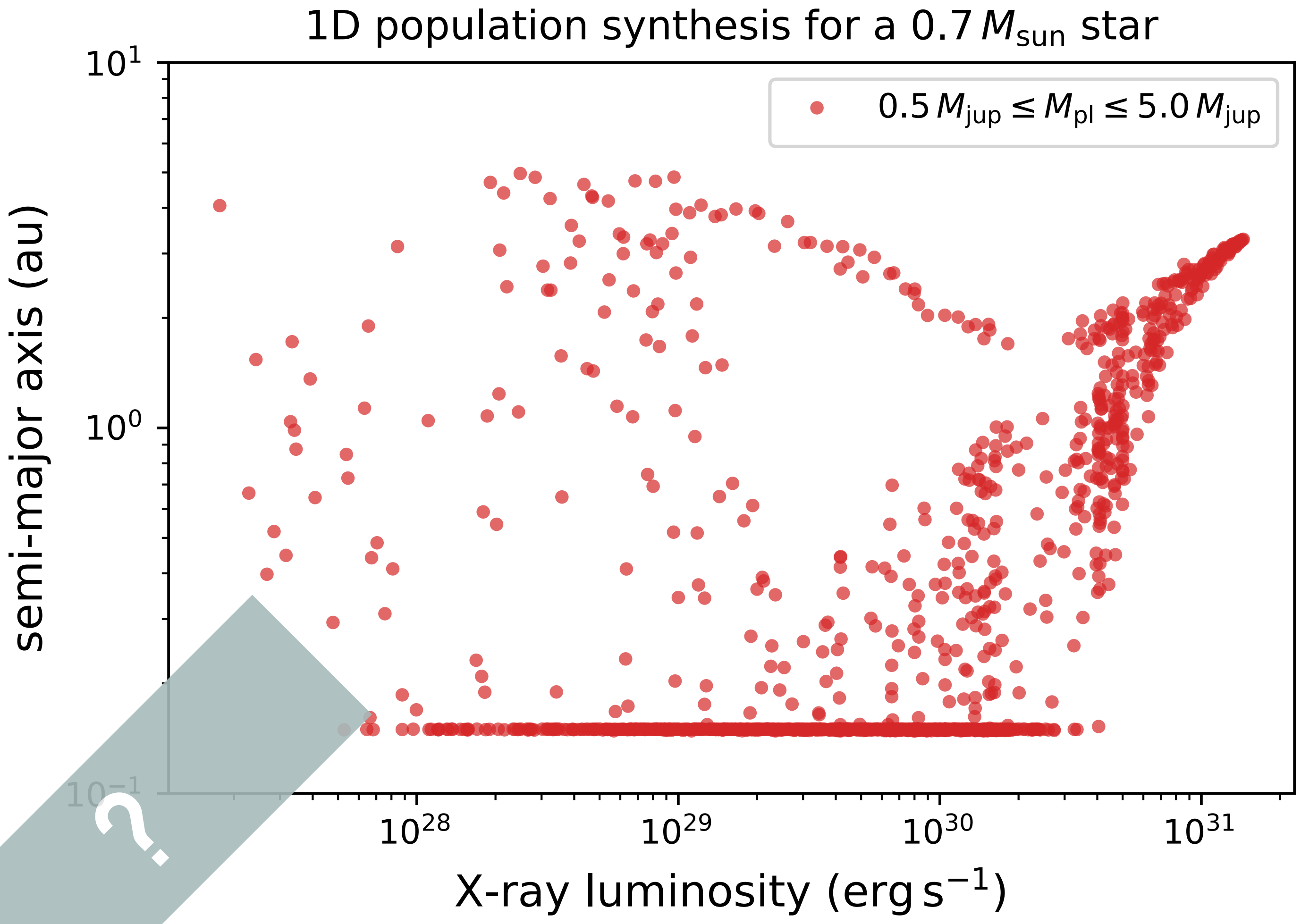
Can we directly compare the theoretical model to the observations?

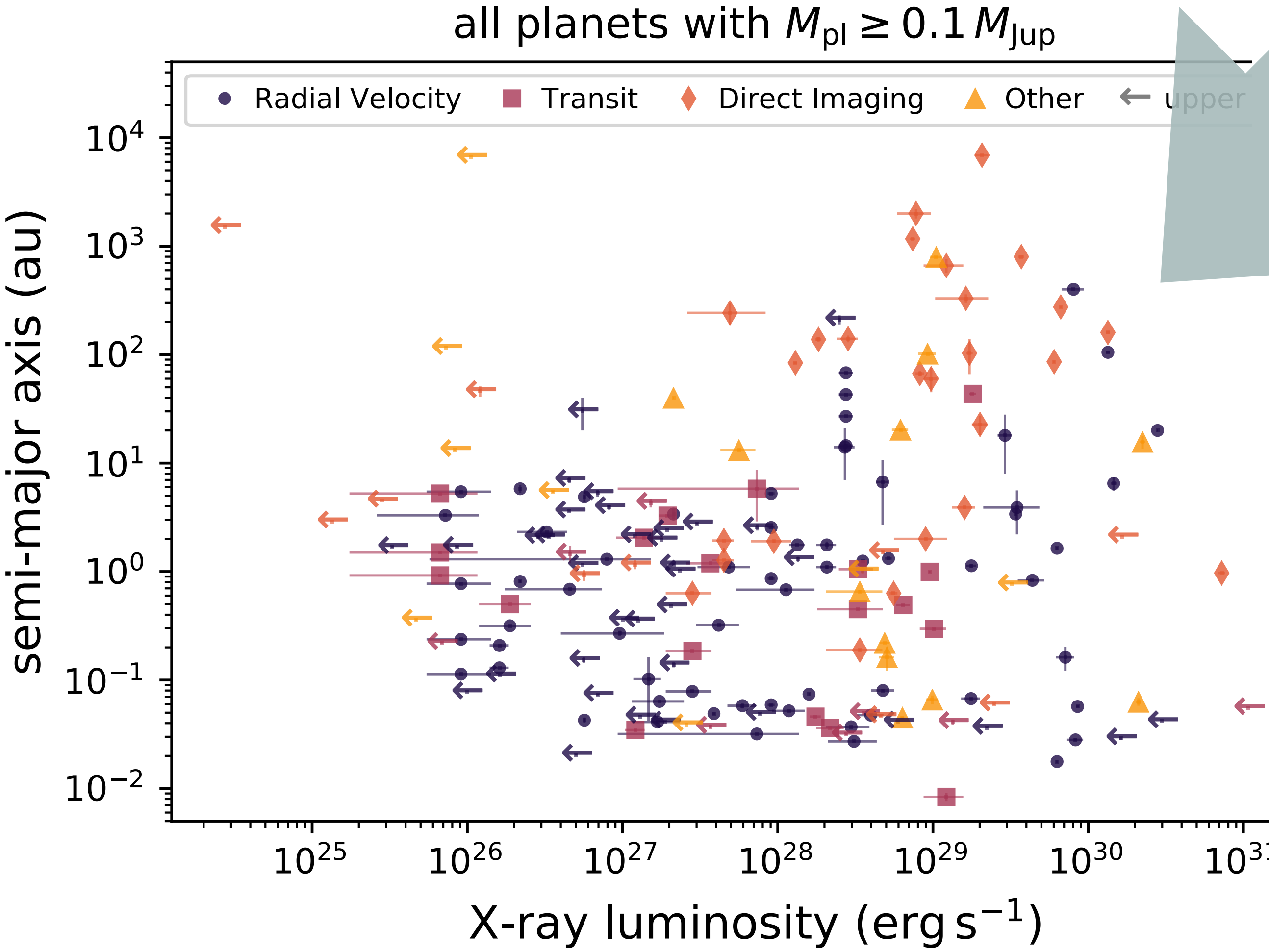


THEORY VS OBSERVATIONS

Can we directly compare the theoretical model to the observations?

NO! But…





… we can make rough predictions about the location and extent of the expected features in the observations!

PRELIMINARY NUMERICAL RESULTS

1D planet population synthesis using the viscous evolution code **SPOCK** (Ercolano & Rosotti, 2015)

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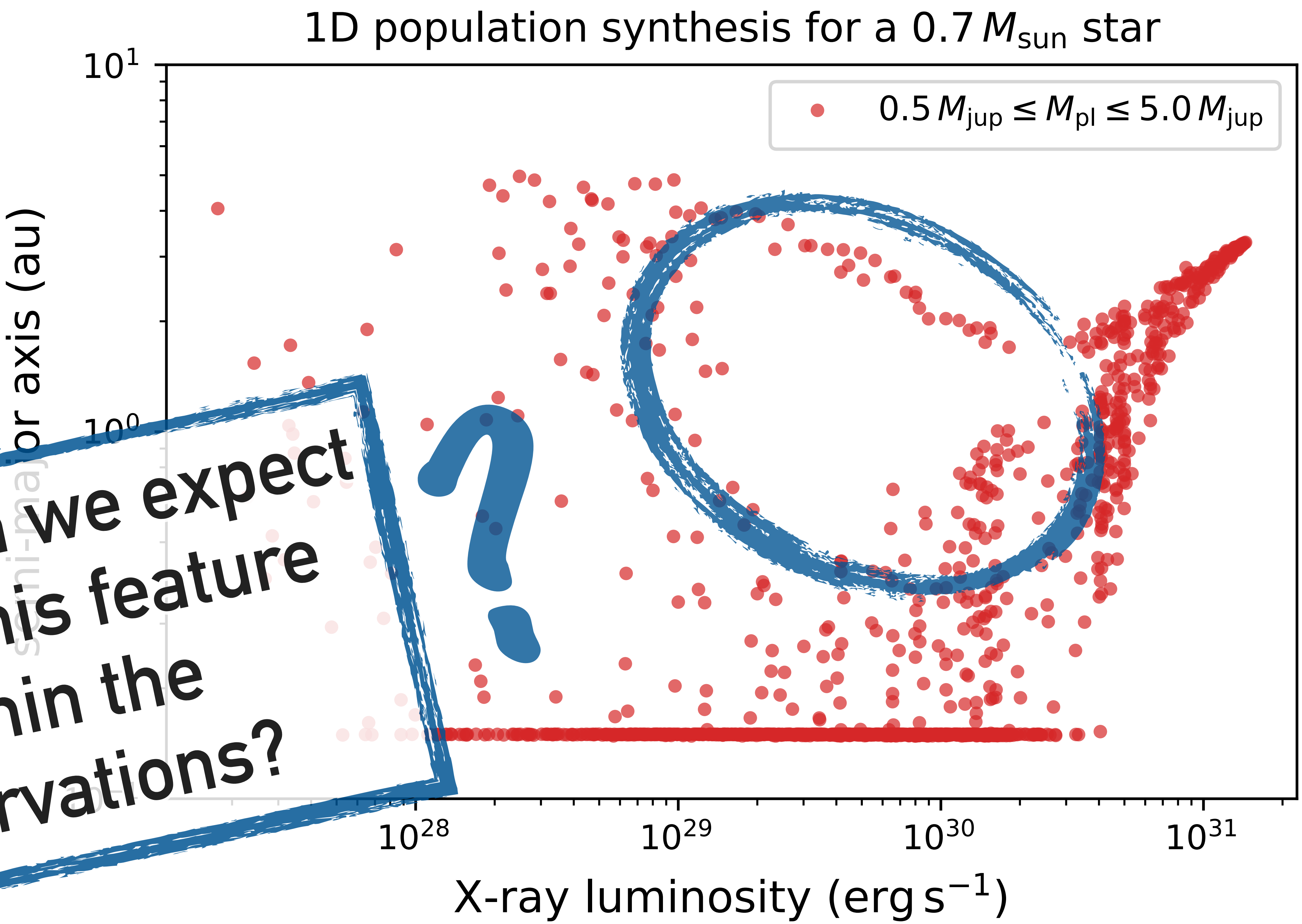
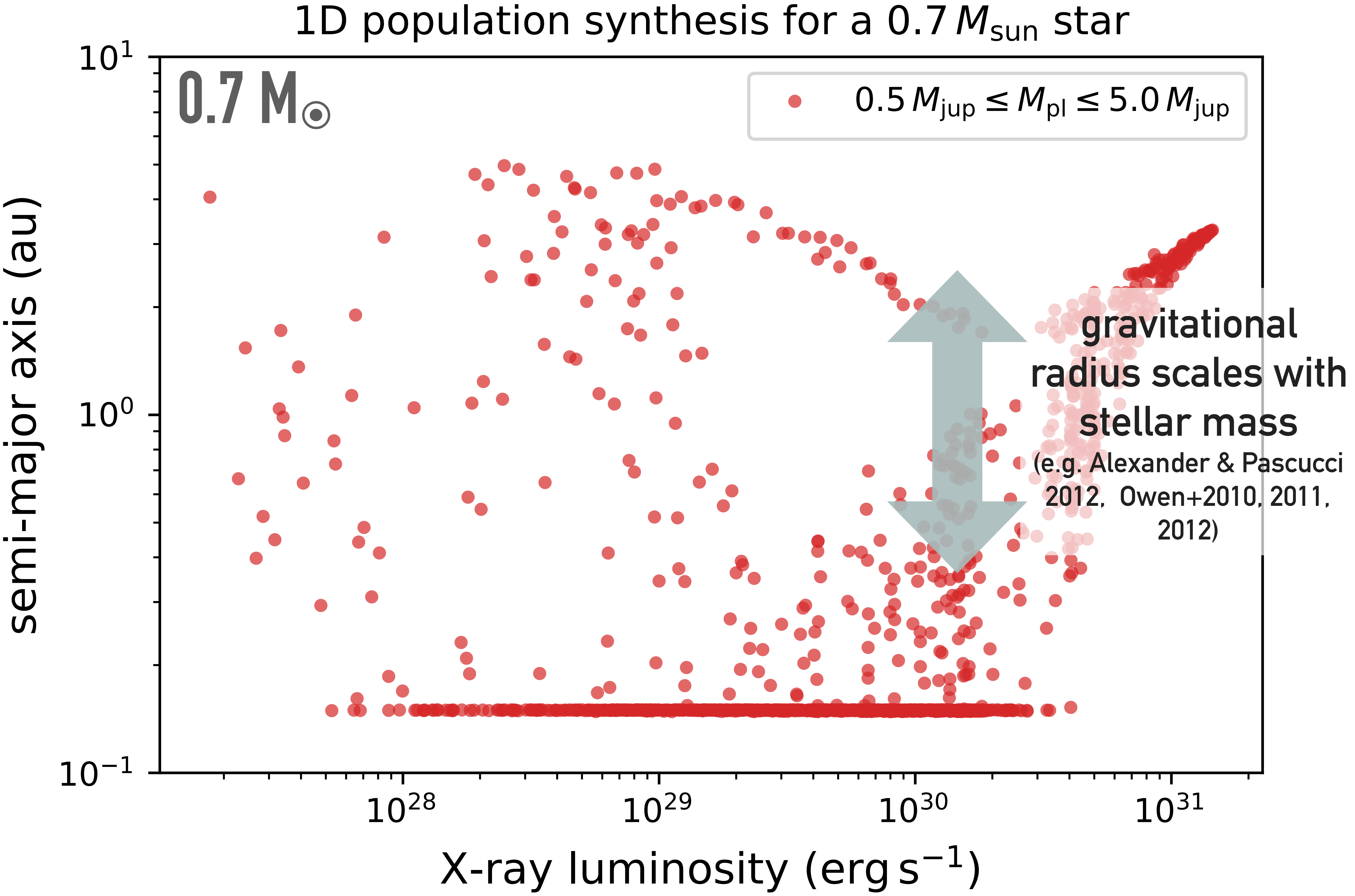


Where can we expect to find this feature within the observations?

THEORETICAL PREDICTIONS OF OBSERVATIONAL FEATURES

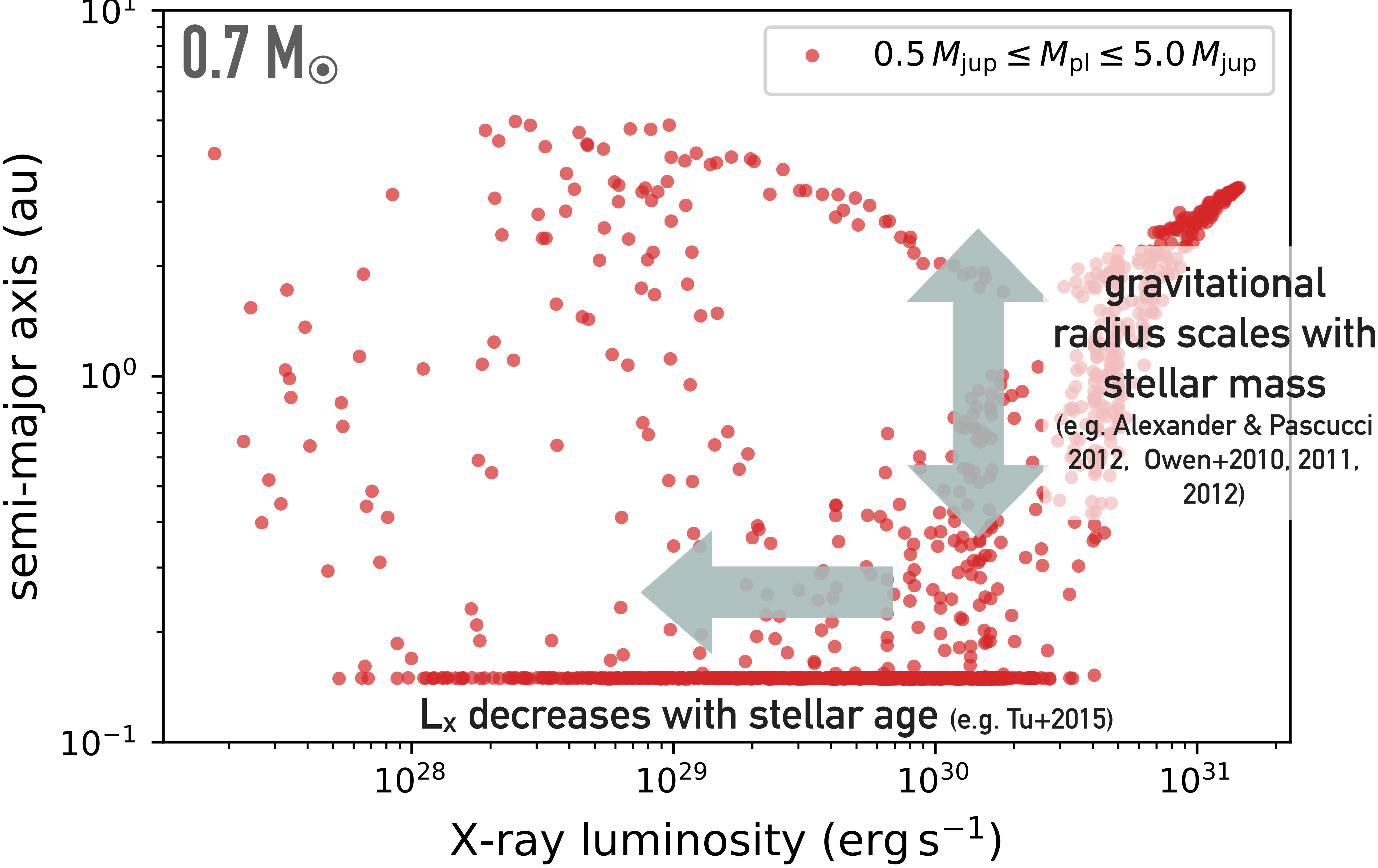


gravitational radius scales with stellar mass

(e.g. Alexander & Pascucci 2012, Owen+2010, 2011, 2012)

THEORETICAL PREDICTIONS OF OBSERVATIONAL FEATURES

1D population synthesis for a $0.7\,M_{\rm sun}$ star



gravitational radius scales with stellar mass

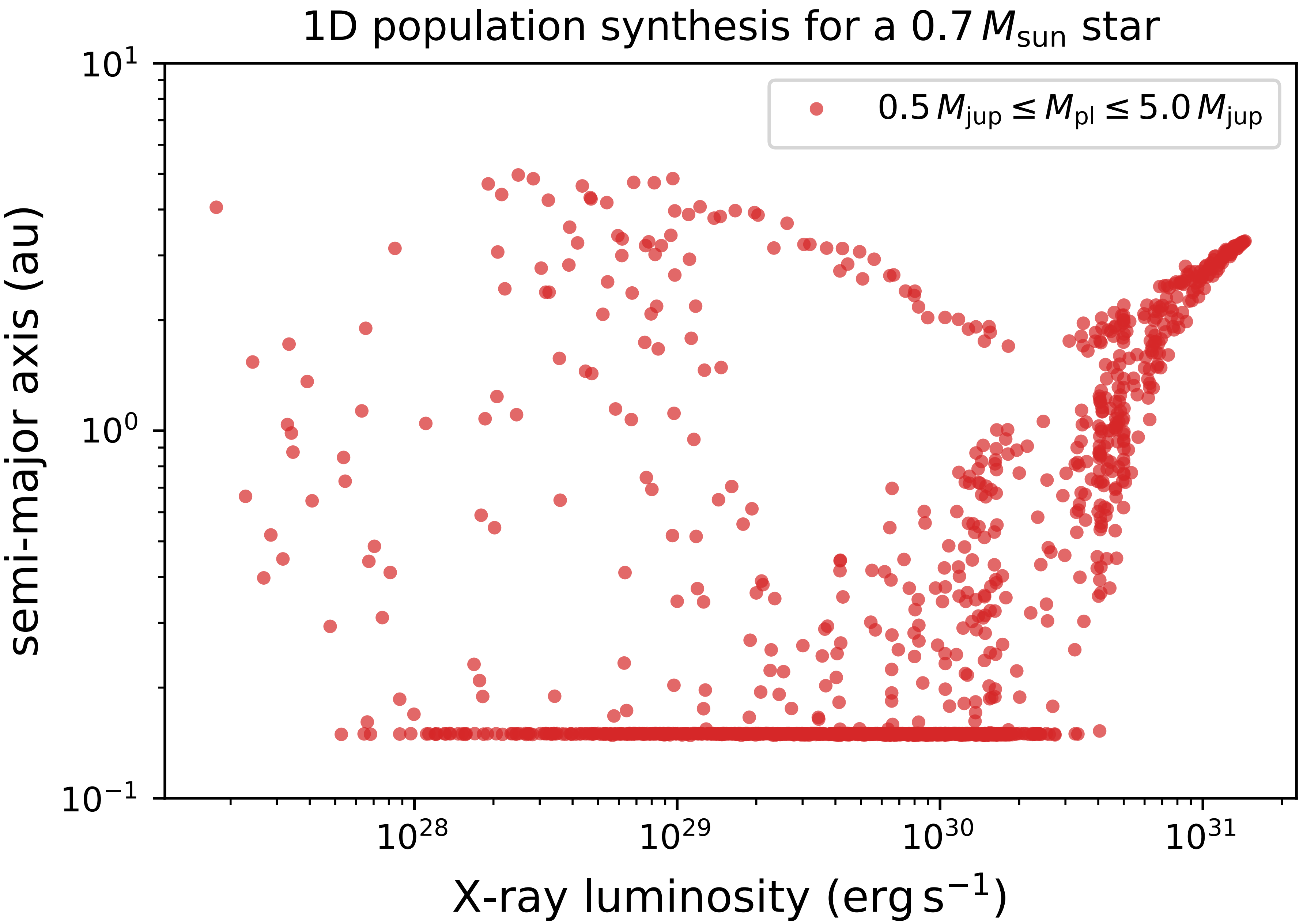
(e.g. Alexander & Pascucci 2012, Owen+2010, 2011, 2012)

L_X decreases with stellar age (e.g. Tu+2015)

Caution!

This plot is the result of very specific initial conditions!

Little changes in the initial setup can have drastic effects on the outcome!



such as:

- ➤ leakage
- ➤ planet insertion time
- ➤ planet insertion location
- ➤ stopping conditions
- ➤ stellar mass
- ➤ …

SUMMARY

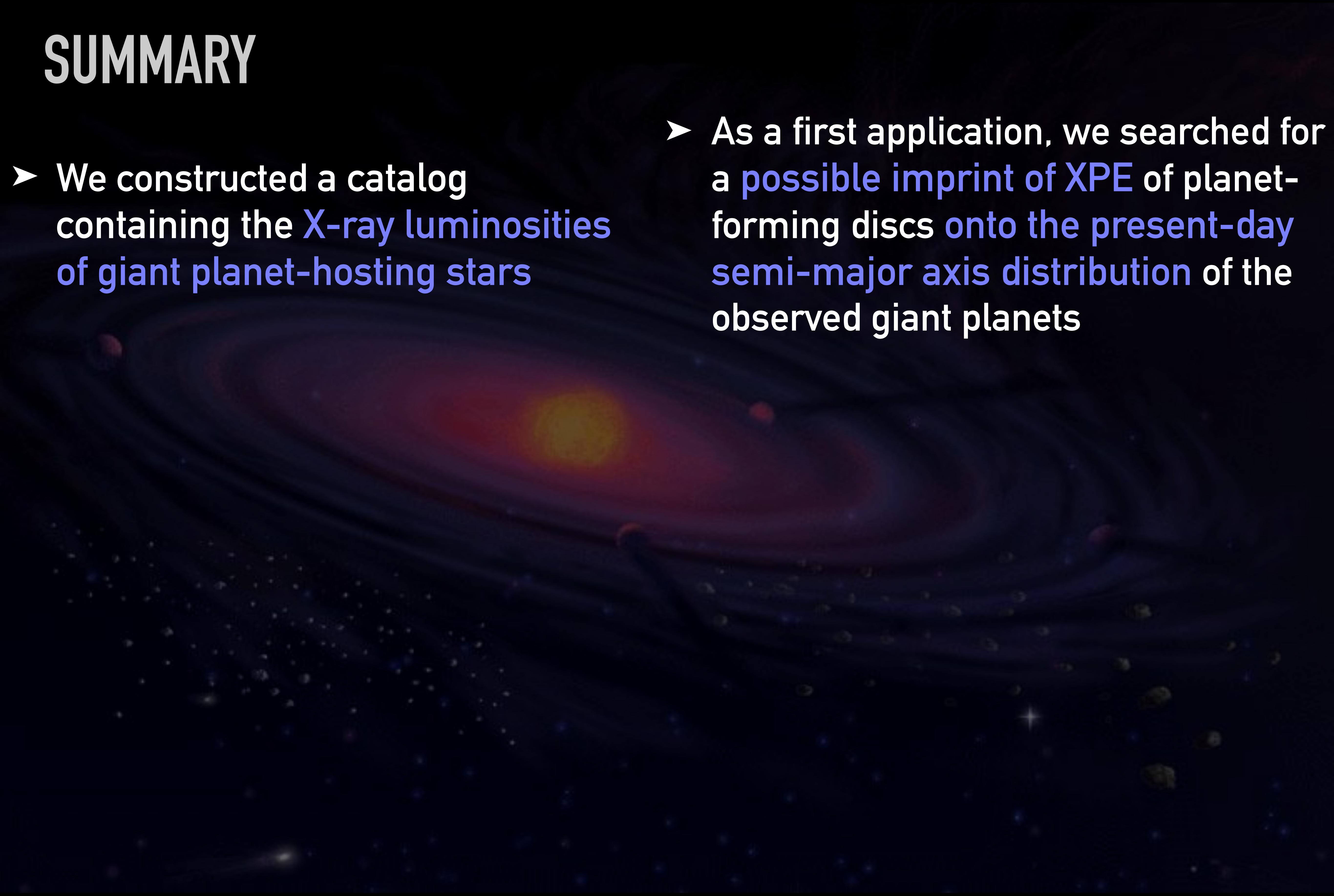
Credit: NASA/Brian Brondel (lic. under Creative Commons)

SUMMARY

- We constructed a catalog containing the X-ray luminosities of giant planet-hosting stars

Credit: NASA/Brian Brondel (lic. under Creative Commons)

SUMMARY



- We constructed a catalog containing the X-ray luminosities of giant planet-hosting stars
- As a first application, we searched for a possible imprint of XPE of planet-forming discs onto the present-day semi-major axis distribution of the observed giant planets

Credit: NASA/Brian Brondel (lic. under Creative Commons)

SUMMARY

- We constructed a catalog containing the X-ray luminosities of giant planet-hosting stars
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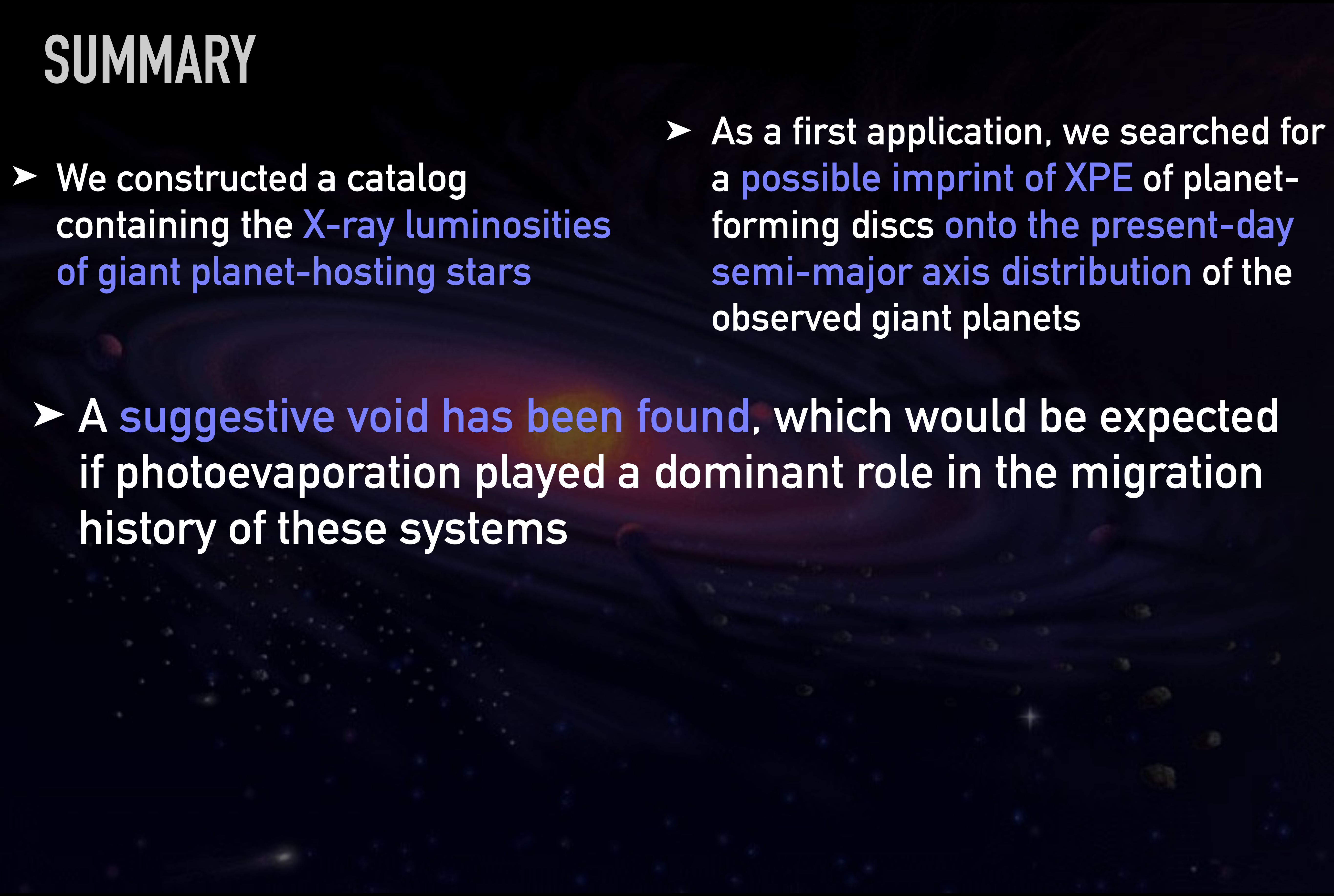
- A suggestive void has been found, which would be expected if photoevaporation played a dominant role in the migration history of these systems



Credit: NASA/Brian Brondel (lic. under Creative Commons)

SUMMARY

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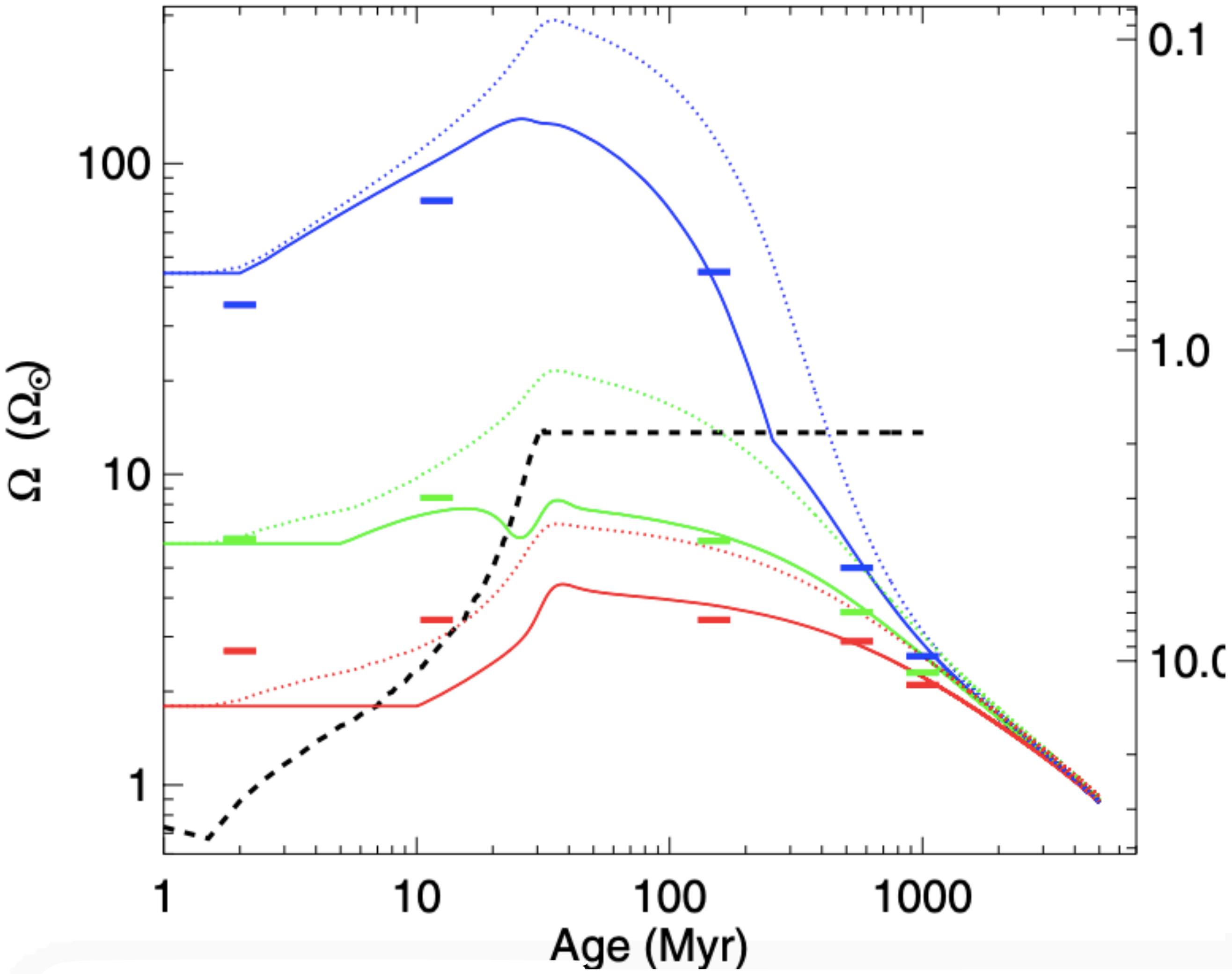
OUTLOOK

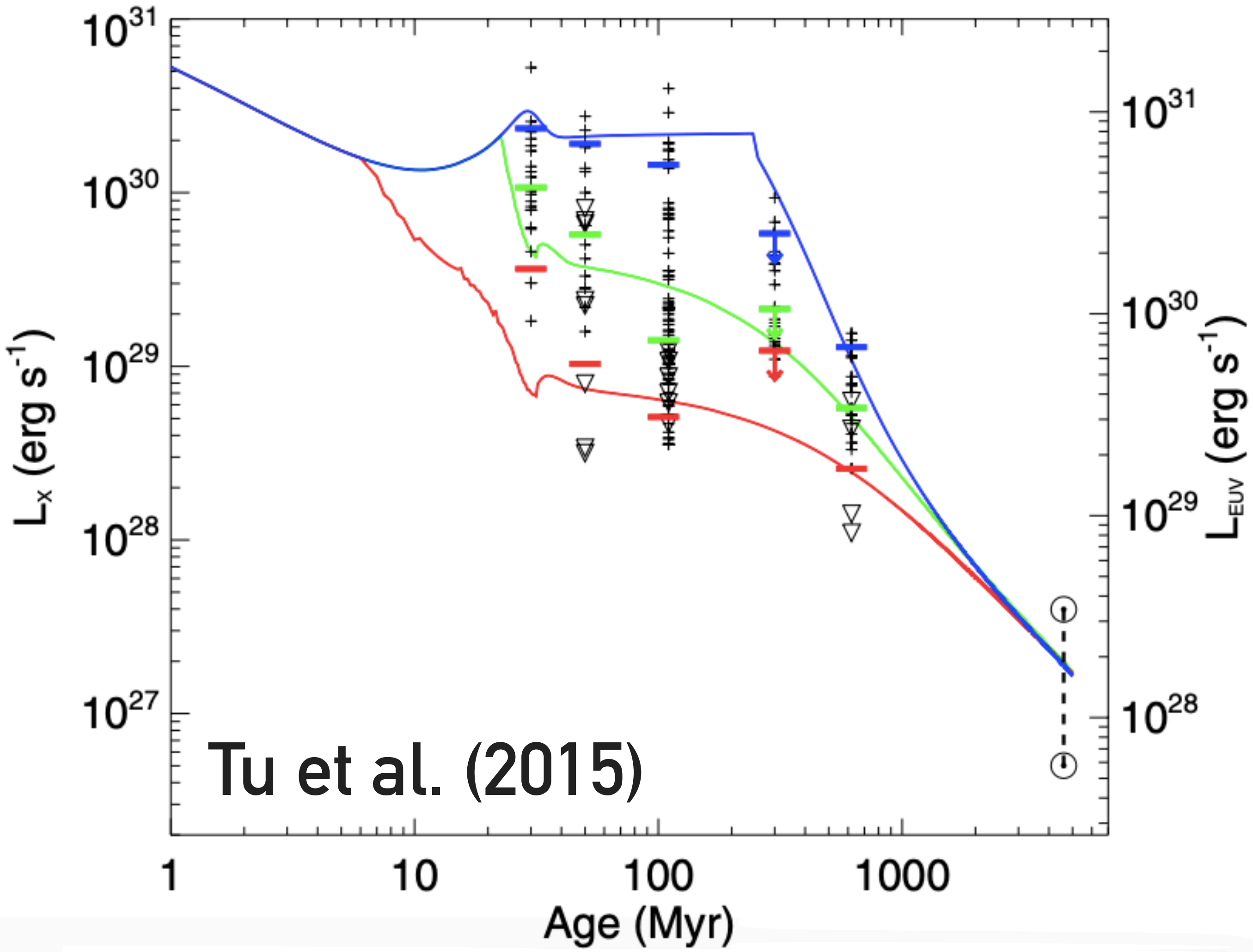
More detailed 1D AND 2D simulations are required to fully explore the underlying mechanisms. Future work will therefore include an adequate parameter-space investigation constrained by the observations.

Credit: NASA/Brian Brondel (lic. under Creative Commons)

TIME EVOLUTION OF THE STELLAR X-RAY EMISSION

Tu et al. (2015): The order of different evolutionary tracks for Lx remains the same for t ~ 5-1000 Myr





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