External photoevaporation in models of planet formation

Thomas Haworth — standing in for Gavin Coleman

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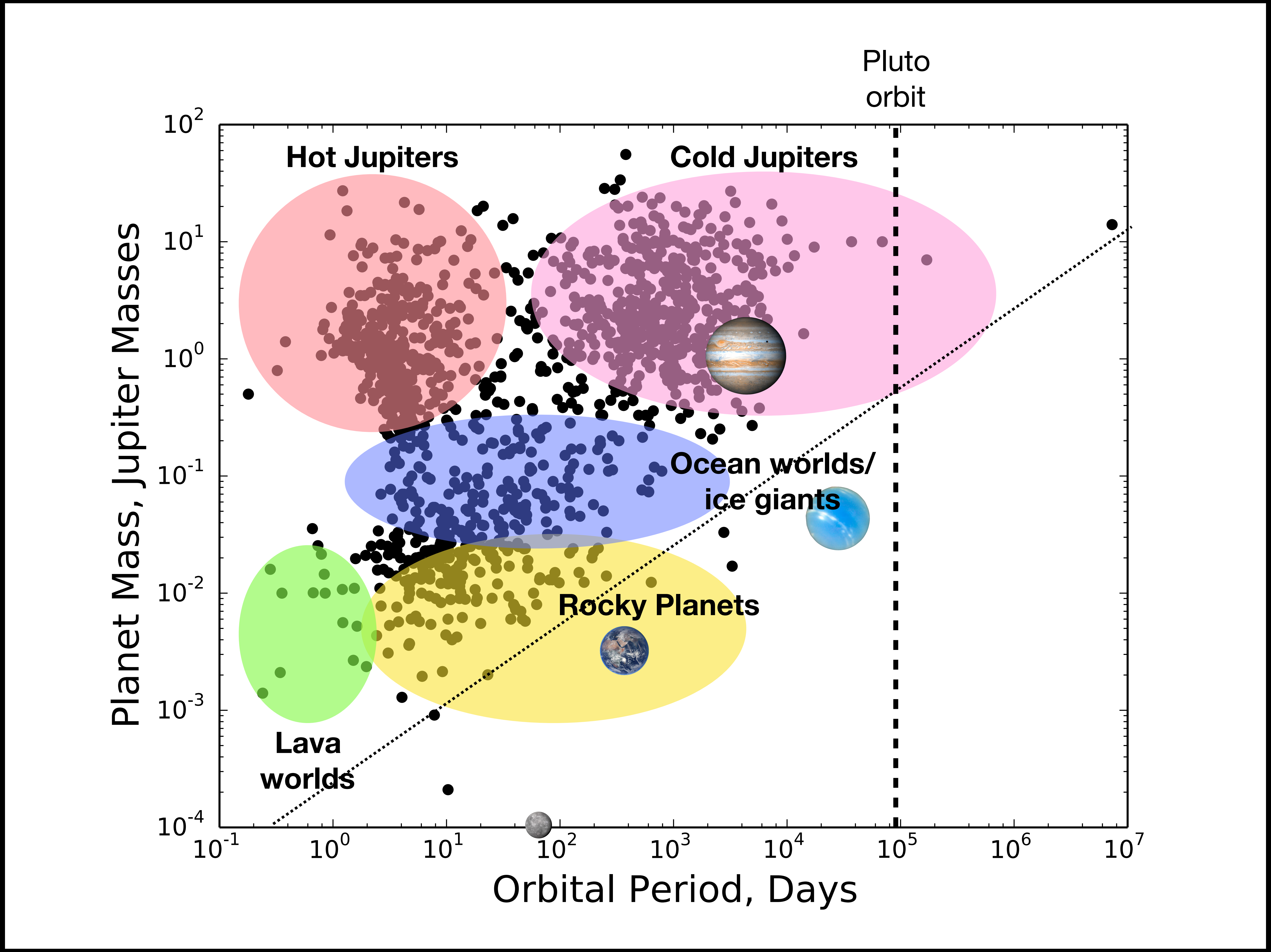
What we wanted from this talk

?



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The standard (e.g. Mordasini + 2012)

External photoevaporation sets the disc lifetime, which affects final mass of giant planets

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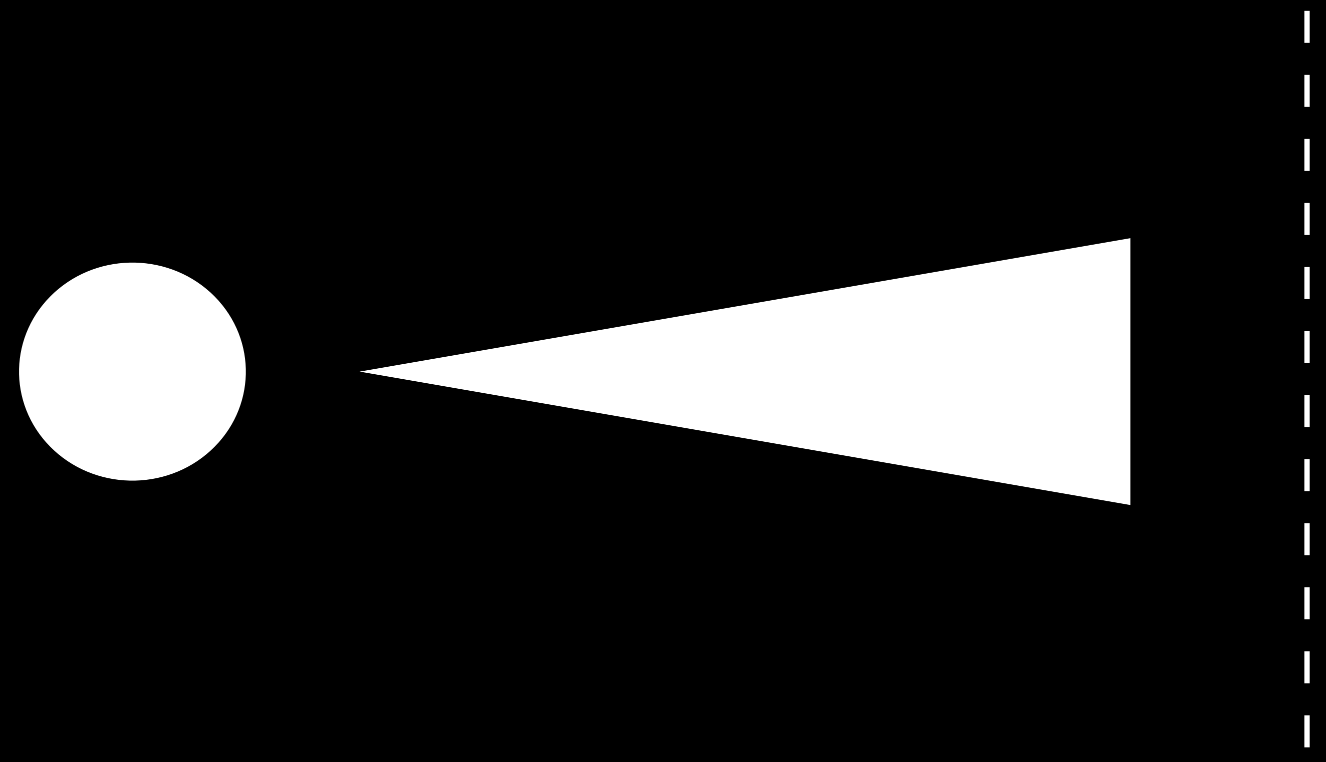
The standard (e.g. Mordasini + 2012)

Follow Matsuyama et al. (2003)

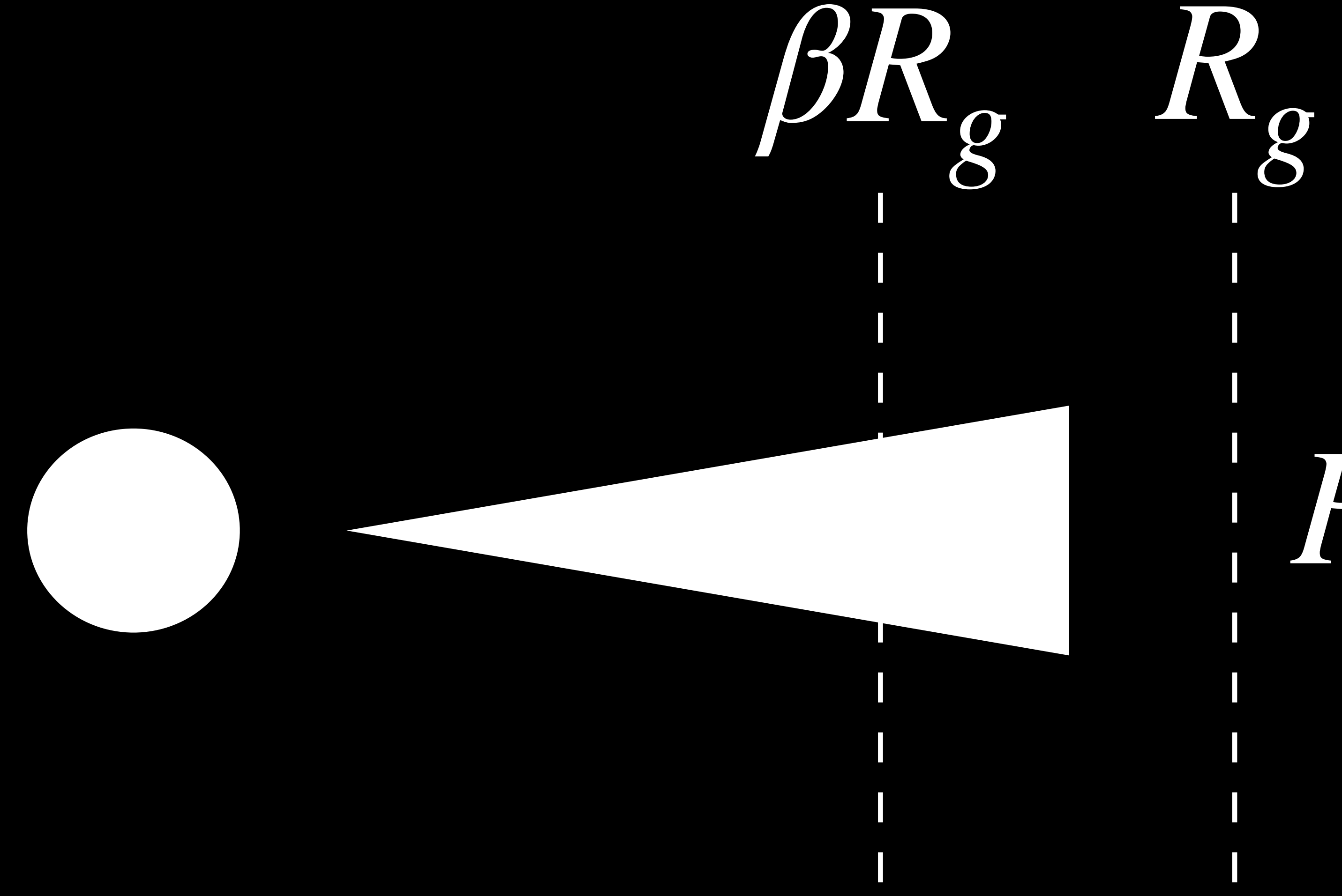


$$R_g = \frac{GM_*}{c_s^2}$$

The standard (e.g. Mordasini + 2012)

Follow Matsuyama et al. (2003)

Lose mass interior to effective gravitational radius (due to pressure gradients) βR_g



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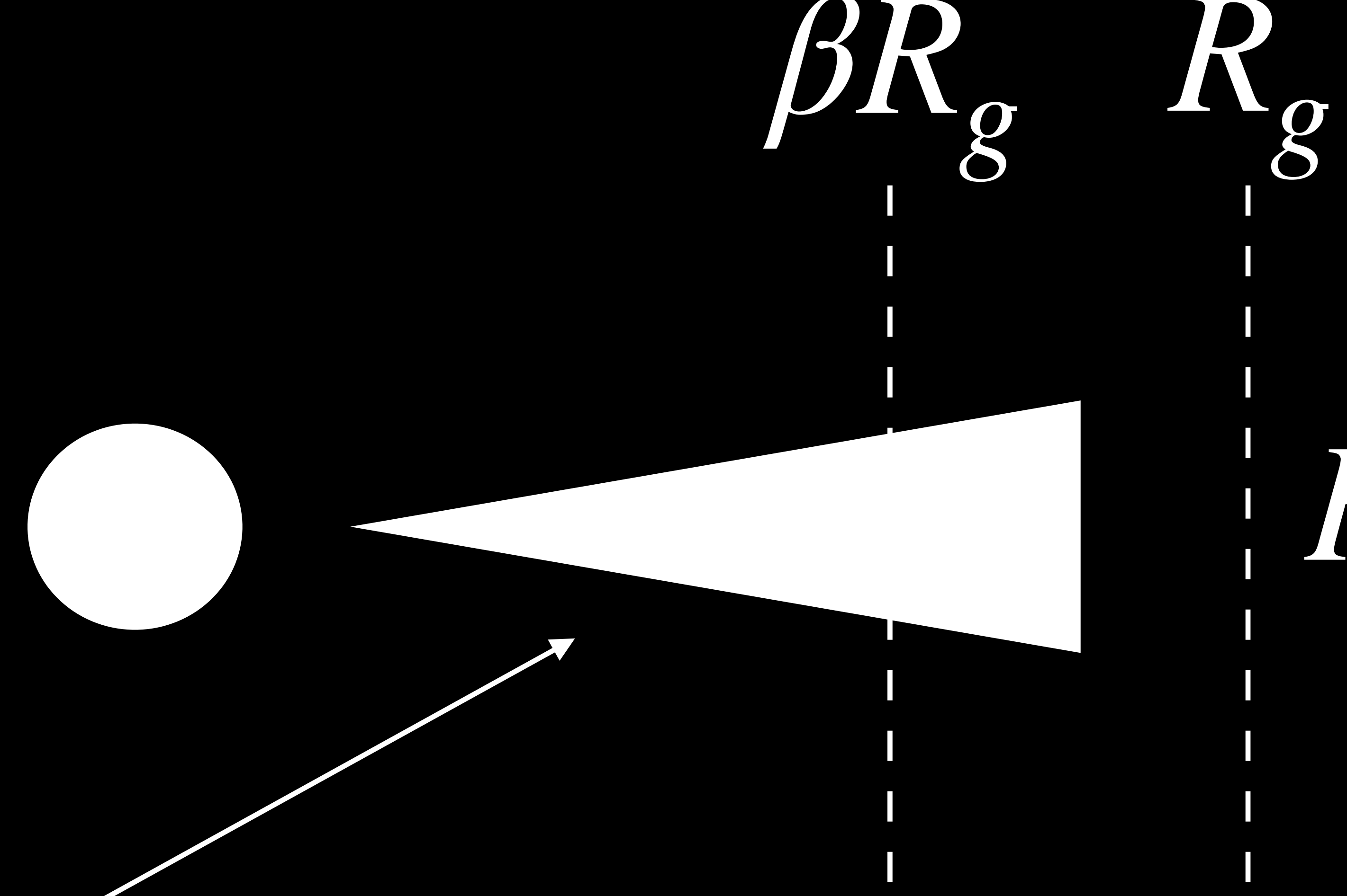


$$R_g = \frac{GM_*}{c_s^2}$$

Mass loss rate is

$$\dot{\Sigma} = 0 \quad (r < \beta R_g)$$

Parameterised mass loss rate

If disc were size $r_{max}(= 1000 au)$

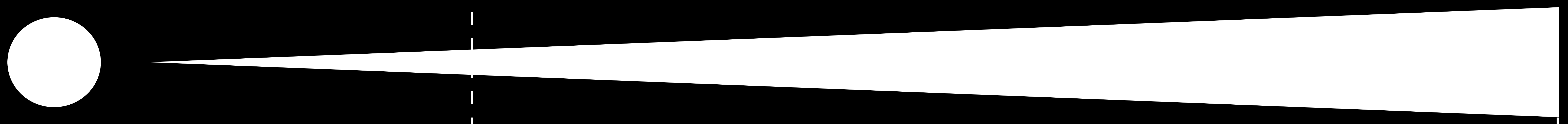
$$\dot{\Sigma}(R) = \frac{\dot{M}_{wind,0}}{\pi(r_{max}^2 - \beta^2 R_g^2)} \quad r \geq \beta R_g$$

The standard (e.g. Mordasini + 2012)

If I’ve understood correctly

βR_g

$r_{max} = 1000au$



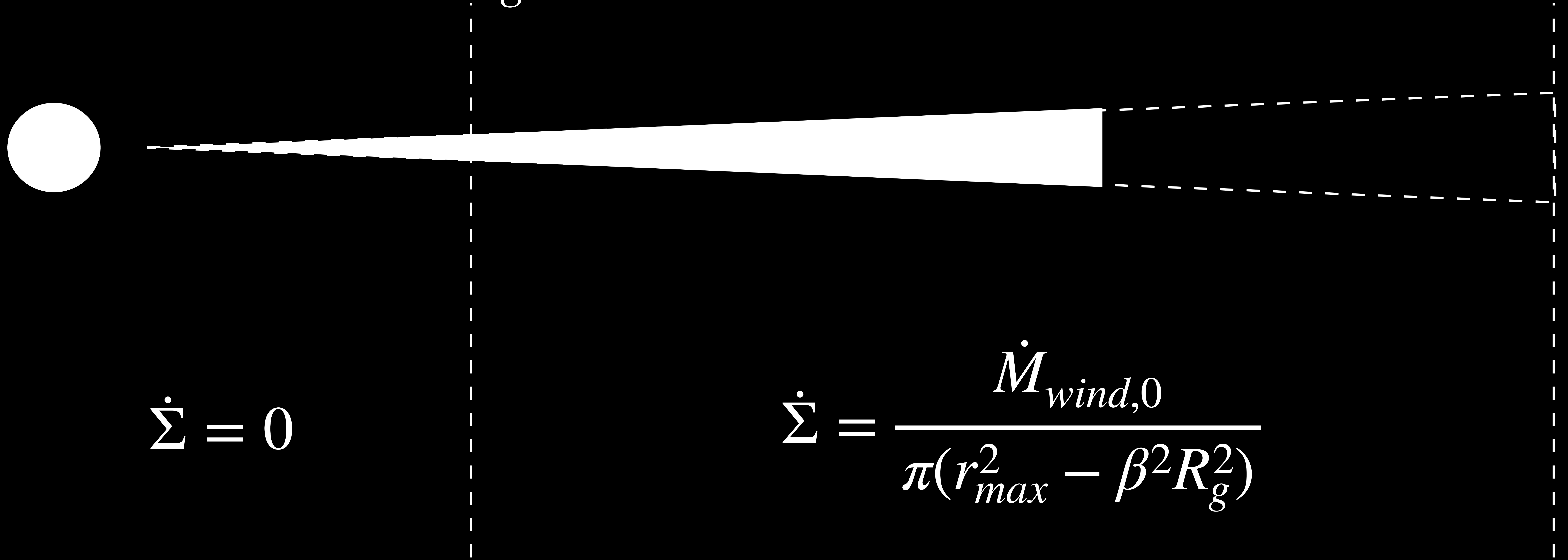
$$\dot{\Sigma} = 0$$

$$\dot{\Sigma} = \frac{\dot{M}_{wind,0}}{\pi(r_{max}^2 - \beta^2 R_g^2)}$$

The standard (e.g. Mordasini + 2012)

If I’ve understood correctly

βR_g $\qquad$ r_d $\qquad$ $r_{max} = 1000au$



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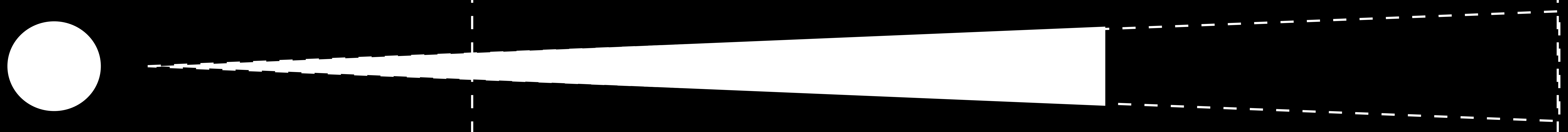
βR_g $\quad$ r_d $\quad$ $r_{max} = 1000 au$

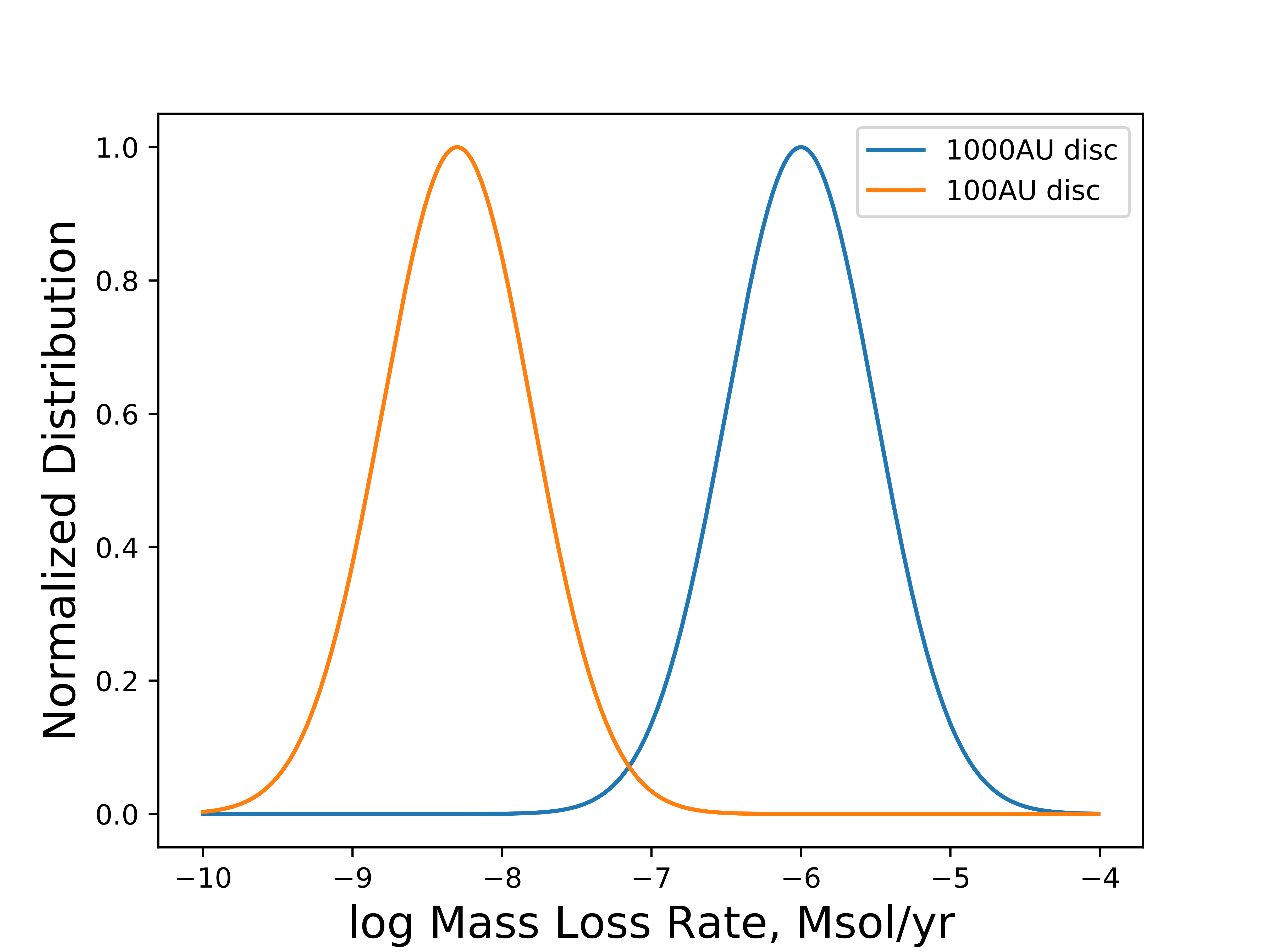


$$\dot{M}_{wind} = \dot{M}_{wind,0}\left(\frac{r_d^2 - \beta^2 R_g^2}{r_{max}^2 - \beta^2 R_g^2}\right)$$

$$\dot{\Sigma} = 0$$

$$\dot{\Sigma} = \frac{\dot{M}_{wind,0}}{\pi(r_{max}^2 - \beta^2 R_g^2)}$$

The standard (e.g. Mordasini + 2012)



Log normal with

$$\mu = -6$$

$$\sigma = 0.5$$

For 1000AU disc

Gives a good distribution of lifetimes

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What might be missing?

e.g. time dependence, accuracy of
sensitivity to star/disc mass?

Based on stuff that works for ONC

Can we do better/is it worth it?

A lot of work on mass loss rates over the years (e.g. Adams+2004,
Facchini + 2016, Haworth + 2018)

e.g. FRIED — Haworth et al. (2018)

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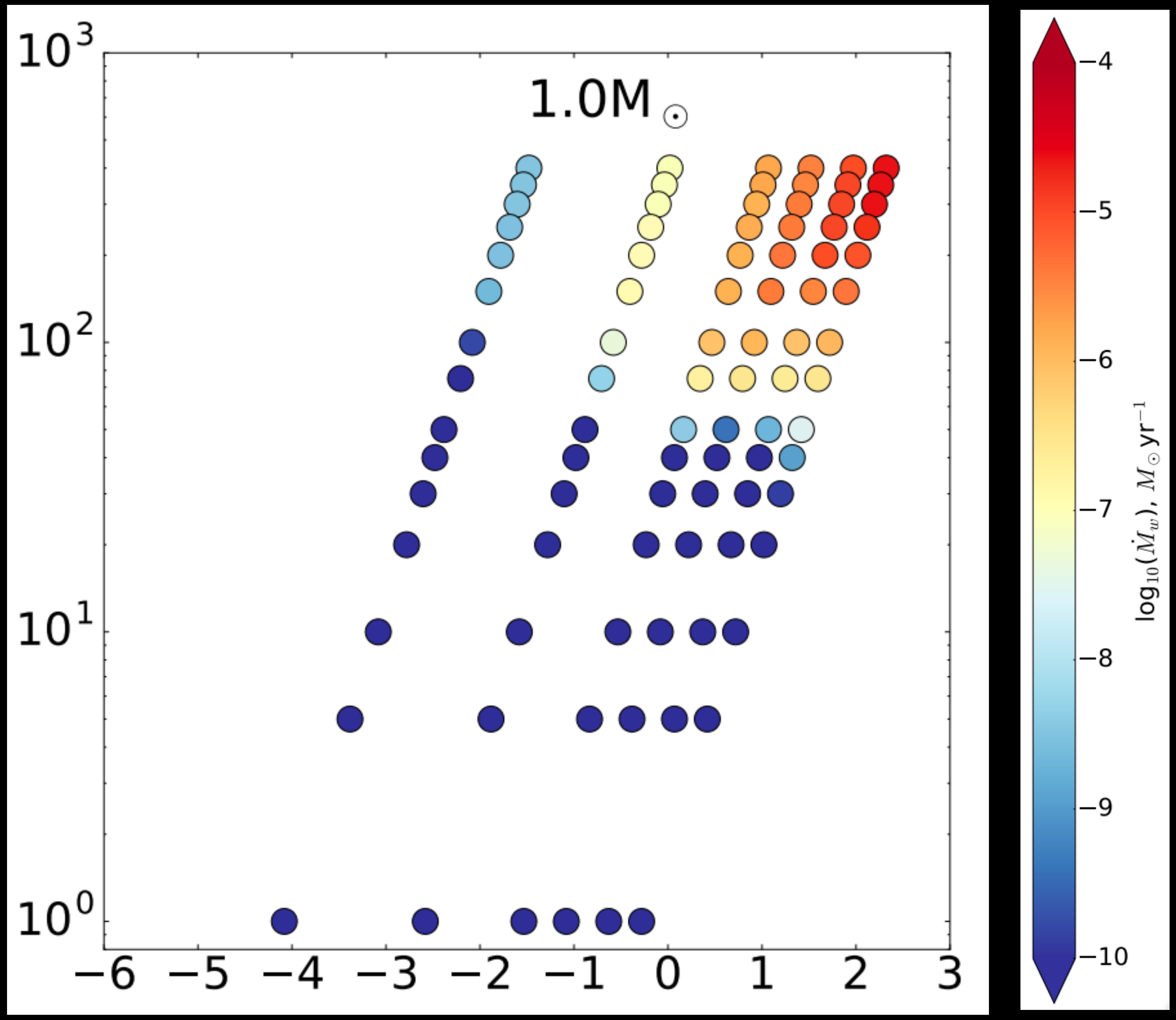
Quick comparison with FRIED

Disc radius, AU



Log disc mass, Jupiter Masses

Haworth et al. (2018), MNRAS, 481,452

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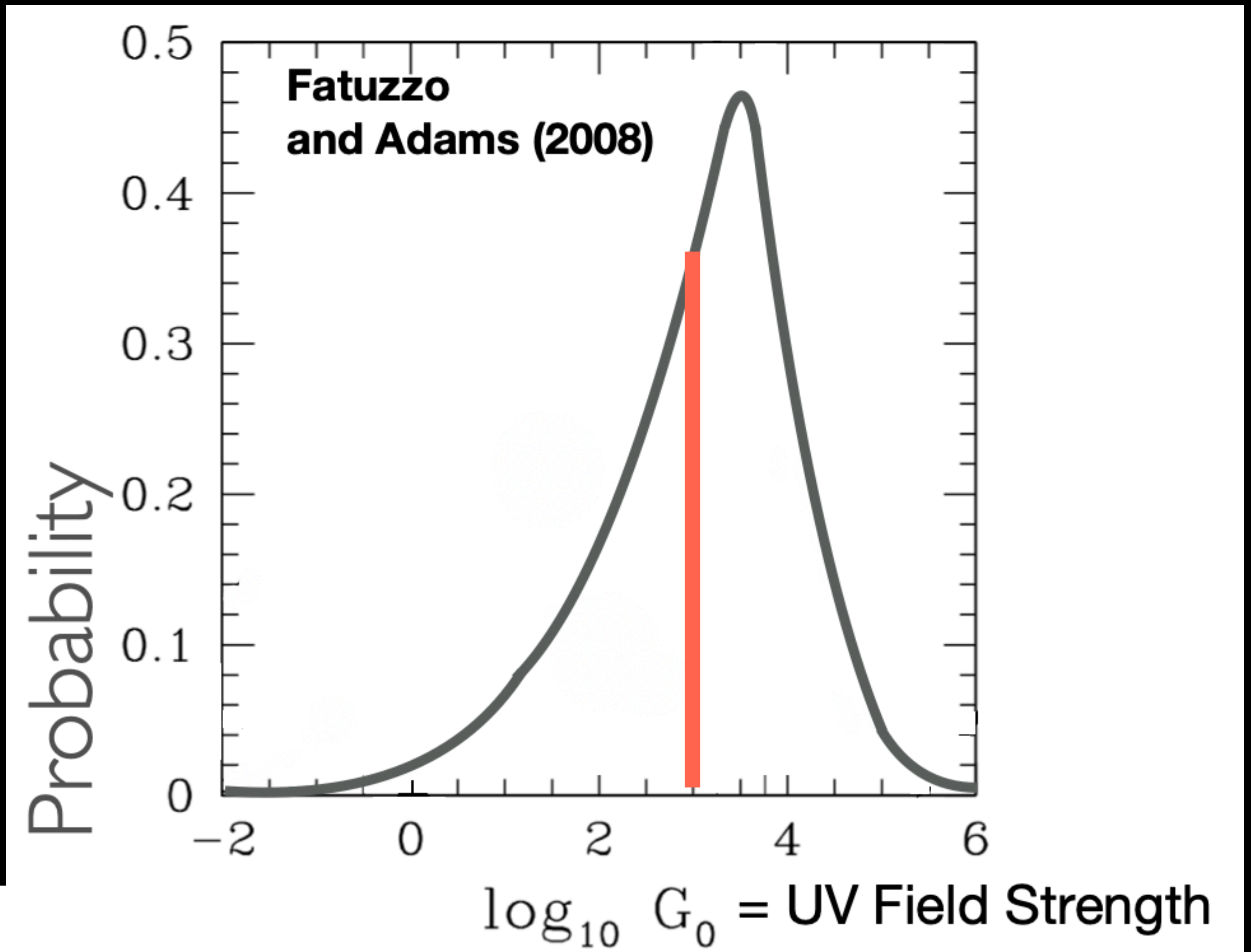
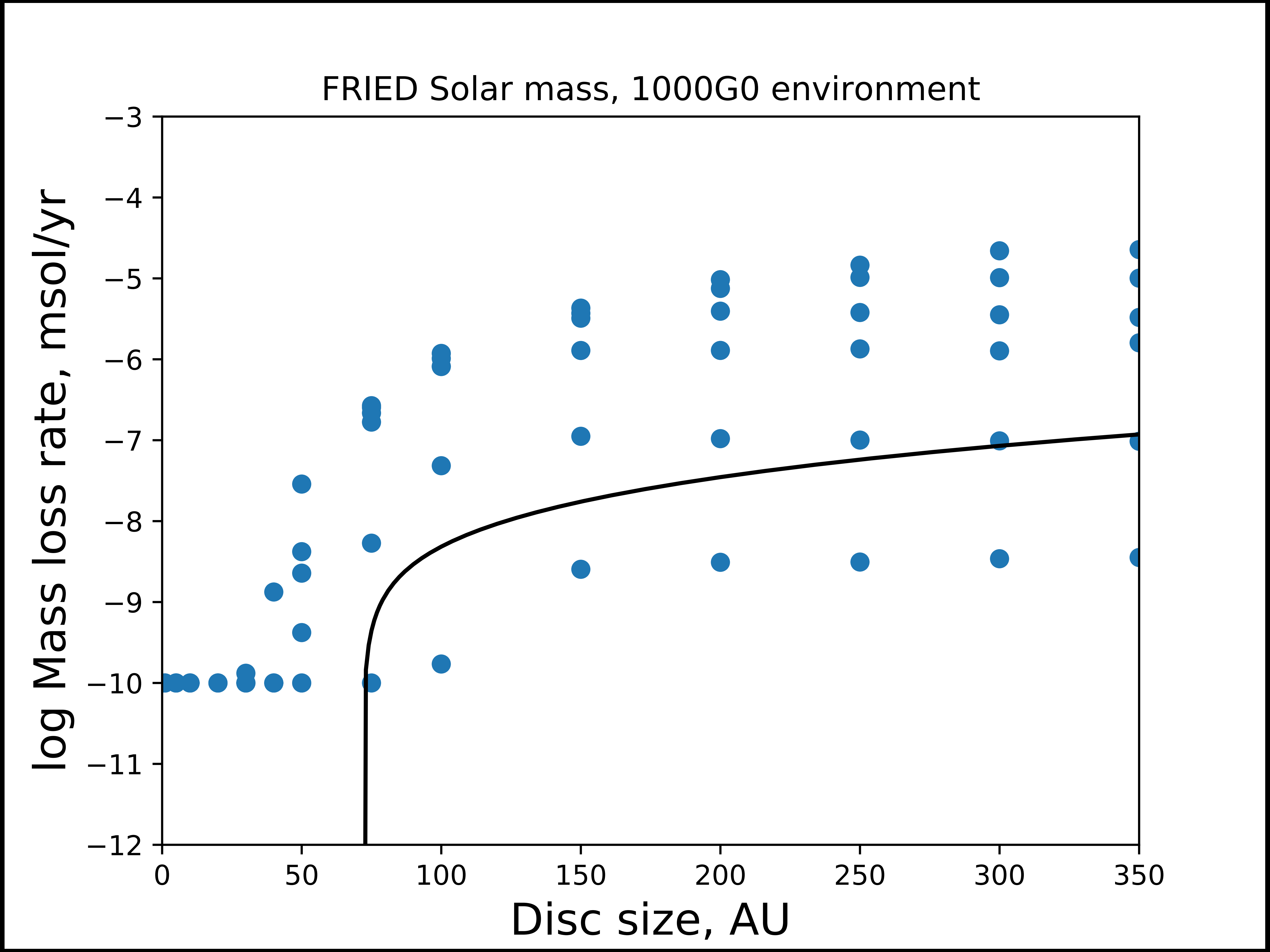
Quick comparison with FRIED

Line is peak of Bern $\dot{M}_{wind,0}$ distribution

Points are FRIED for 1Msol star in 1000G0 environment with different disc masses/sizes





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Quick comparison with FRIED

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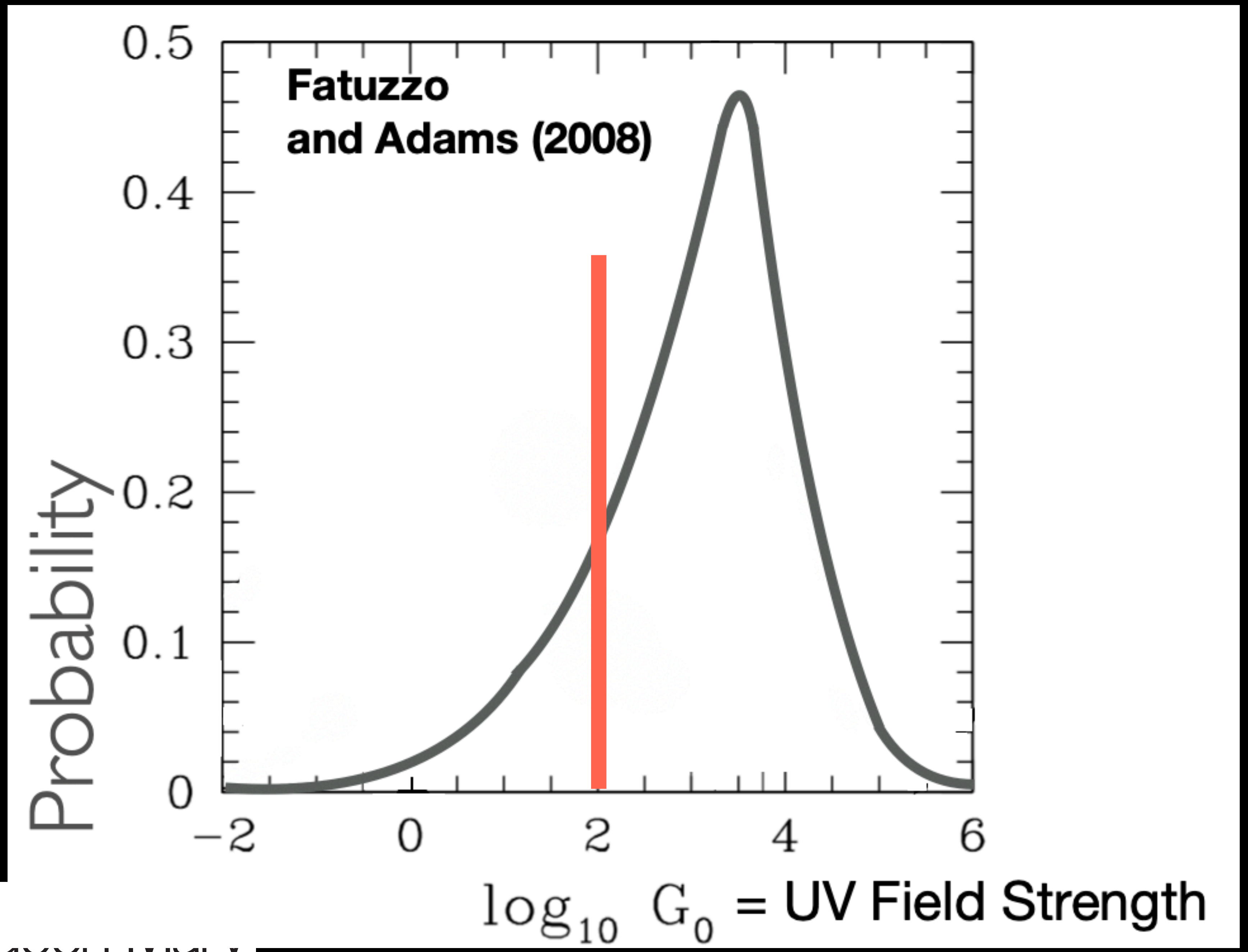

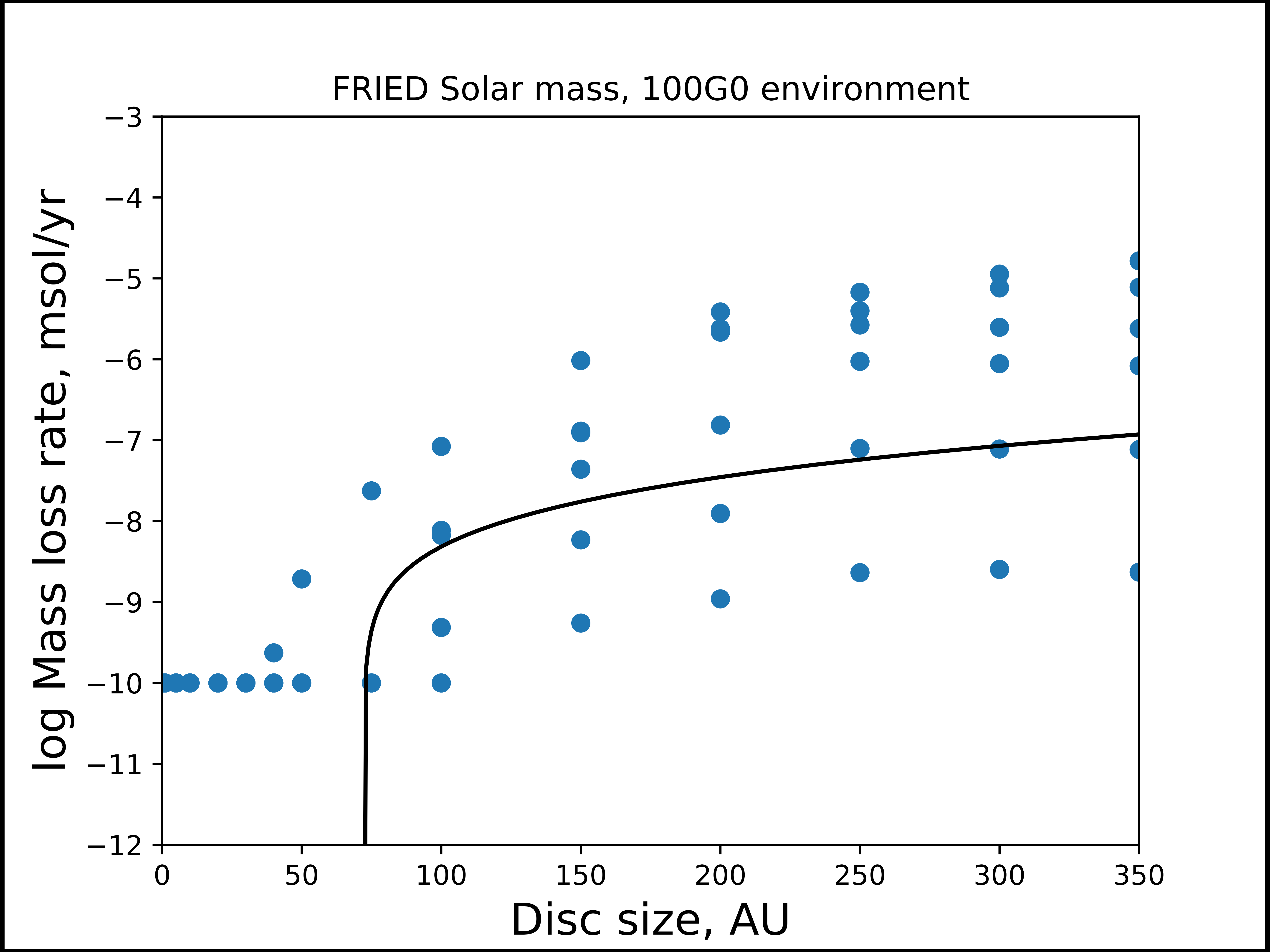

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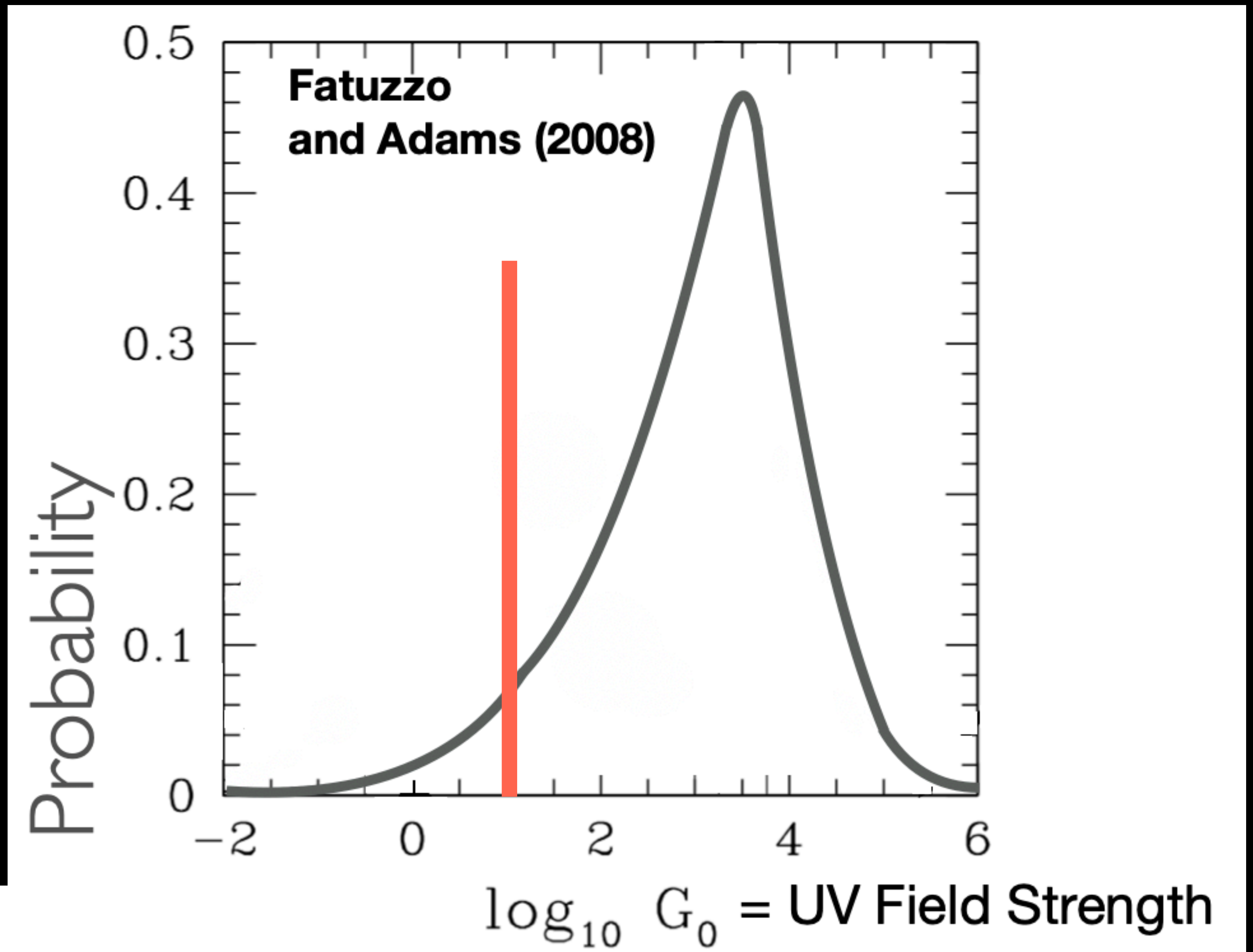
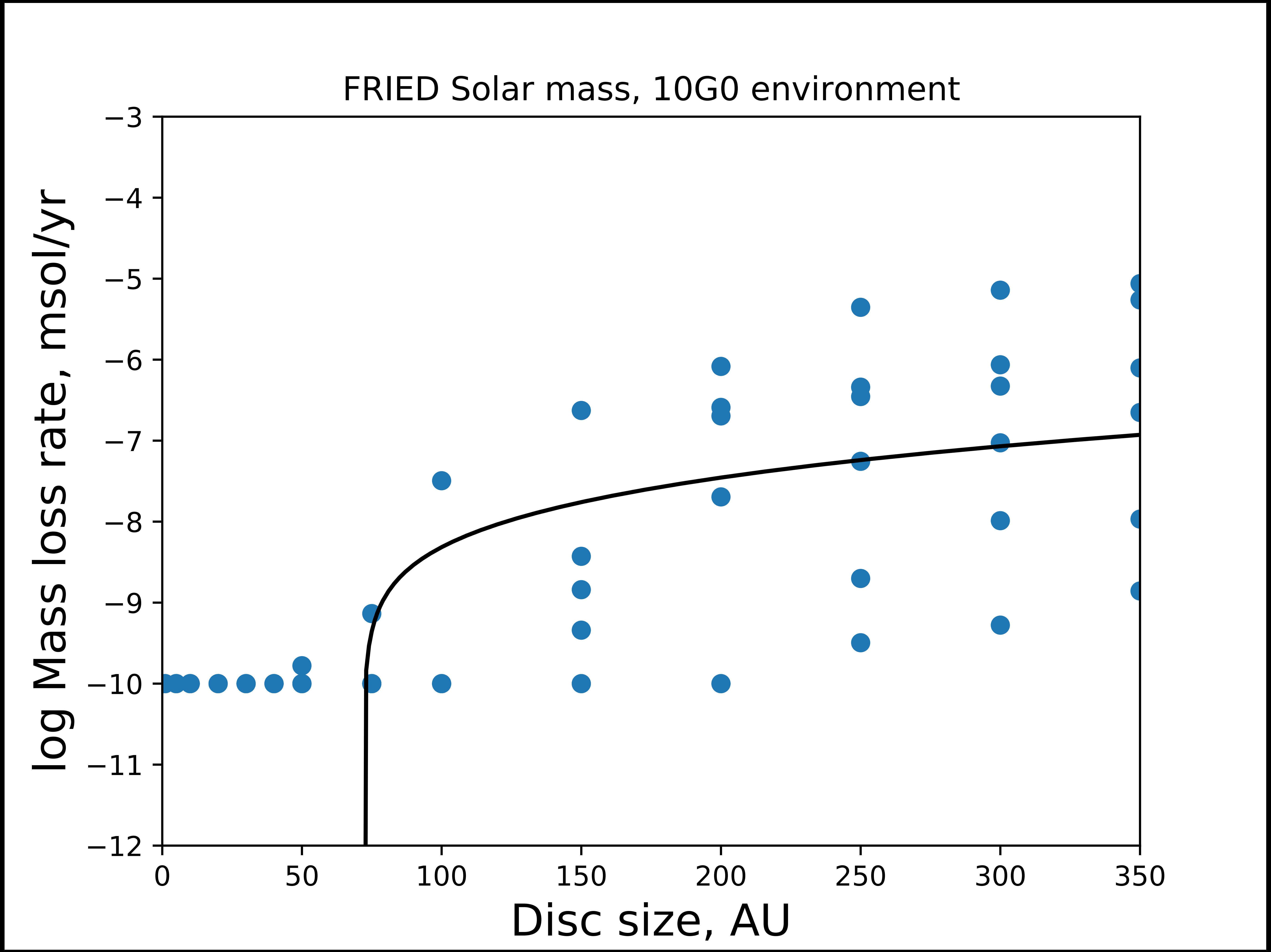
Points are FRIED for 1Msol star in 10G0 environment with different disc masses/sizes





A quick idea is to flip the question:

How big does the external photoevaporative mass loss rate $\dot{M}_{wind}$ have to be for it to become directly important for planet formation (e.g. in the inner disc).

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Abrupt Summary

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