# The Galactic habitable zone with detailed chemical evolution models

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# Outline

- The Galactic habitable zone
- The GHZ model of Spitoni et al. (2014)
- The GHZ using chemical evolution models
- Results
- Summary

# The Galactic habitable zone

THE GALACTIC HABITABLE ZONE is defined as the region with sufficiently high metallicity to form planetary systems in which Earth-like planets could be born and might be capable of sustaining life, after surviving to close supernova explosion events (Gonzalez et al. 2001).

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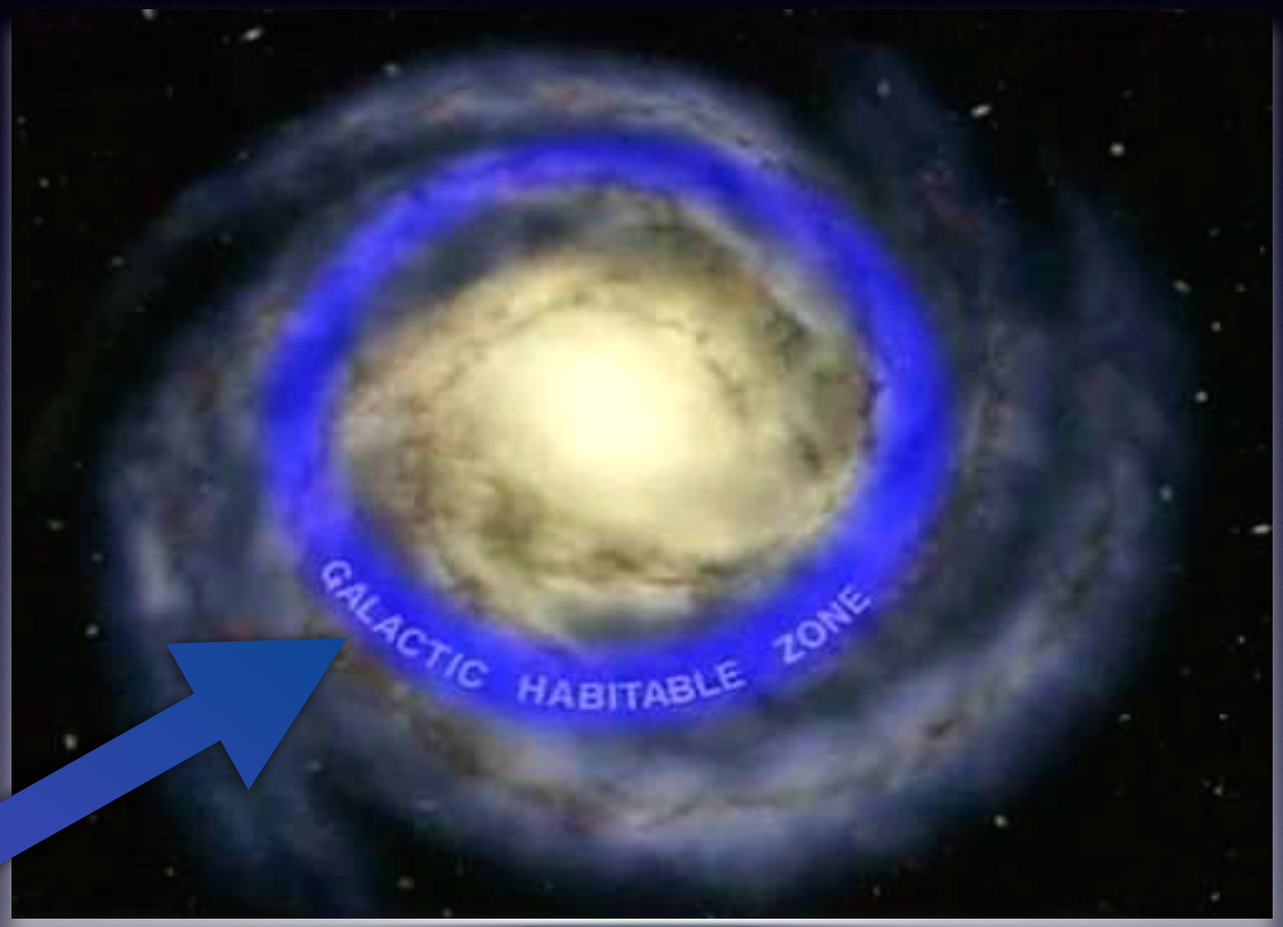
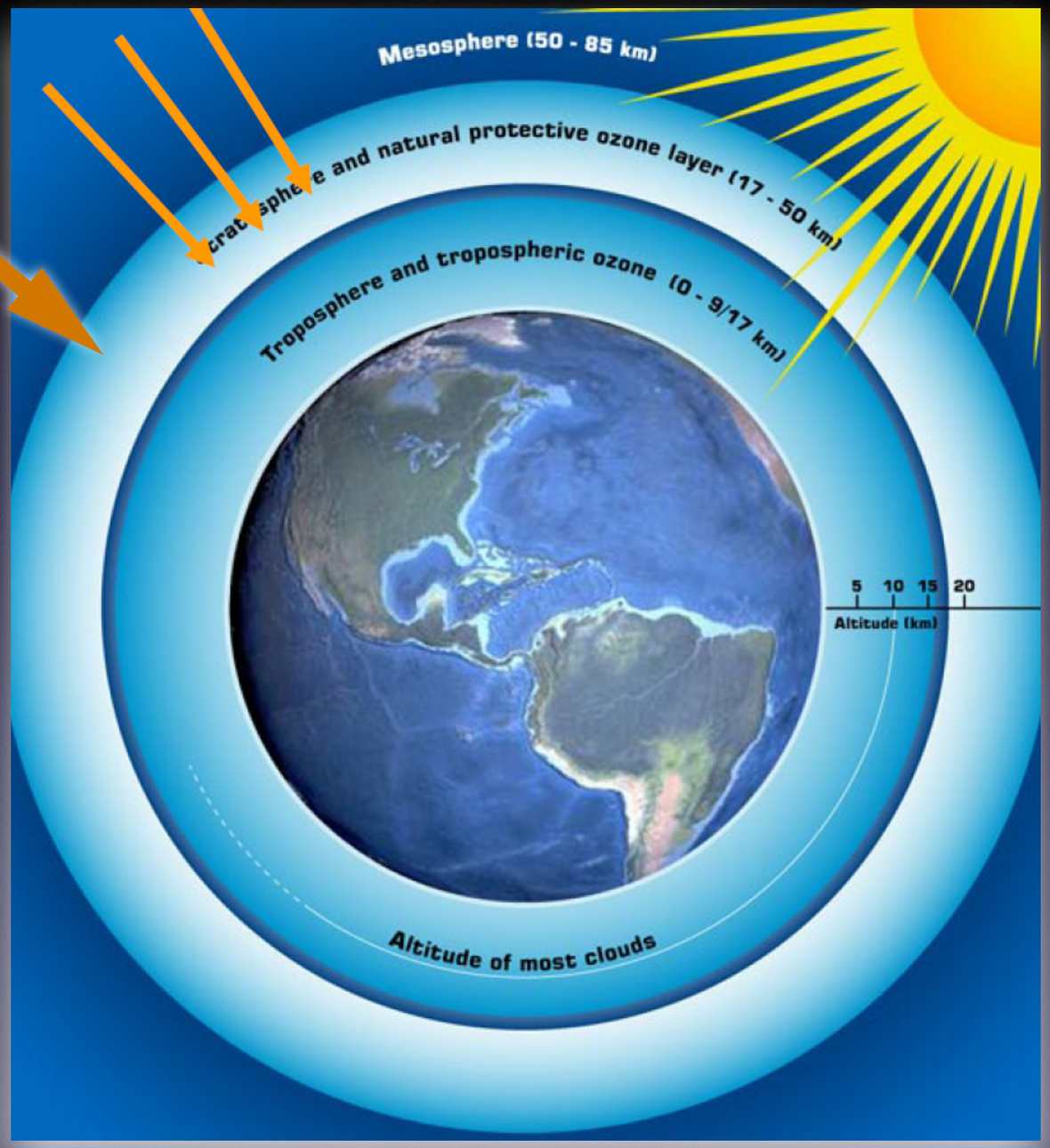



Lineweaver at al. (2004) identified the GHZ as an annular region between 7 and 9 kpc

When a SN explodes, it emits STRONG RADIATION that may ionize the planets atmosphere, causing stratospheric ozone depletion.

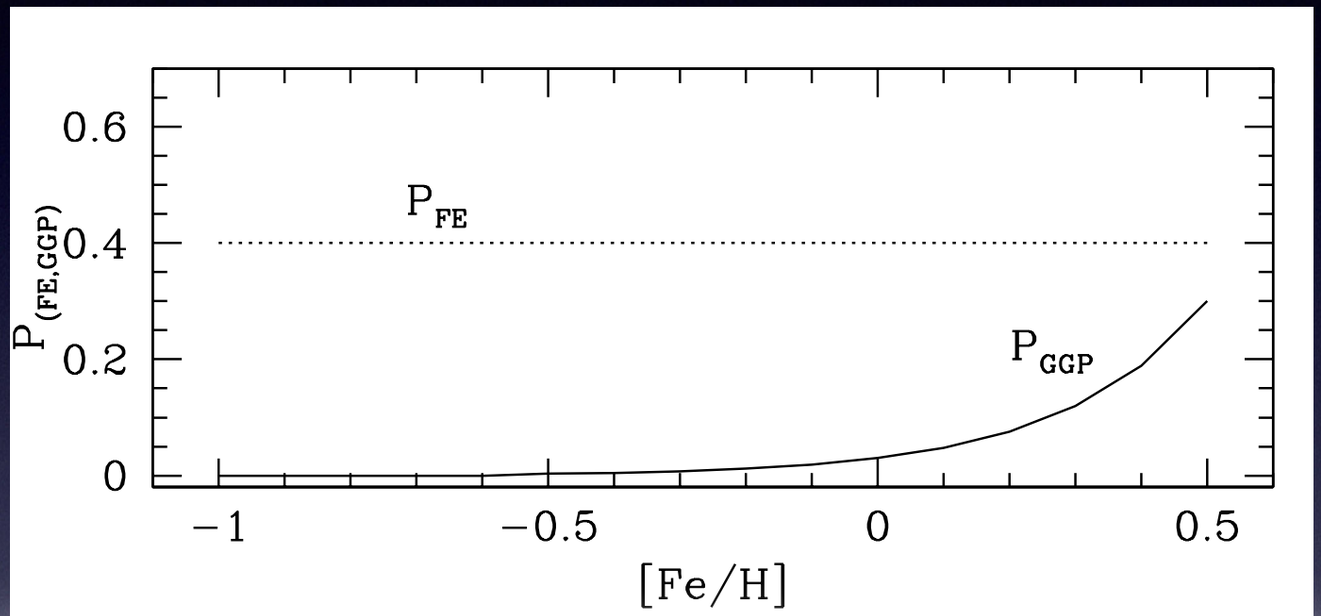
Then ULTRAVIOLET FLUX from the planets host star reaches the surface and oceans, originating damage to genetic material DNA, which could induce mutation or cell death, and consequently the planet sterilization (Gehrels et al. 2003).



# The Galactic habitable zone model in Spitoni et al. (2014)

# The probability of forming Earth-like planets

(following Prantzos 2008 prescriptions)




$P_{FE}$: Earth-like planets

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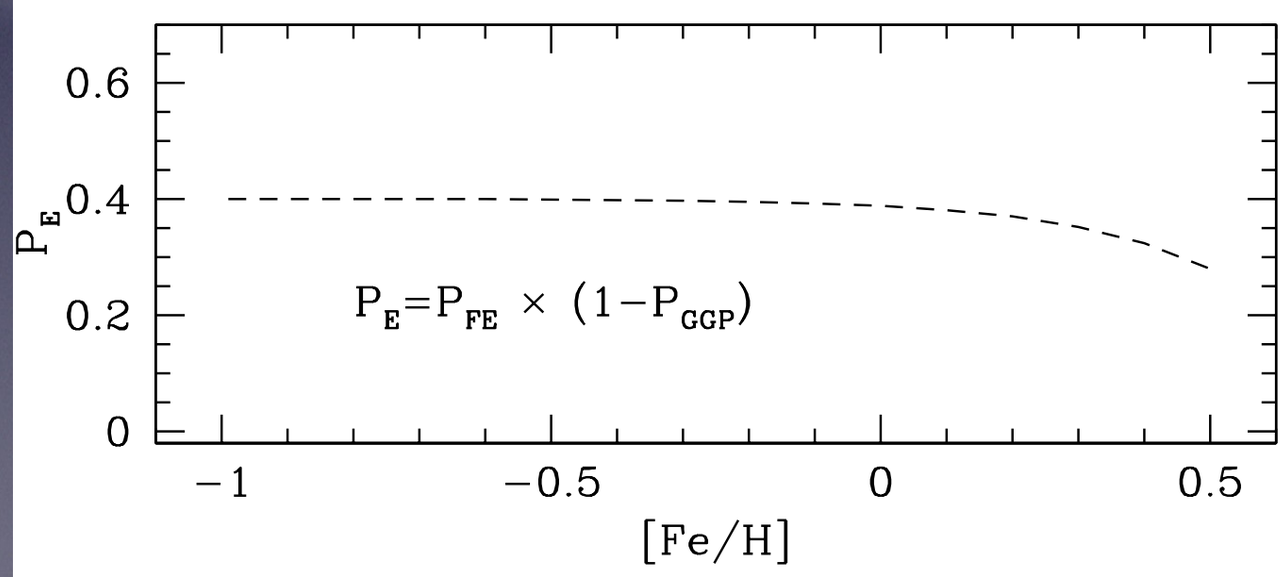

The fraction of all stars having Earths (but no gas giant planets) which survived supernova explosions as a function of the galactic radius is defined as following (Prantzos 2008):

$$P_{GHZ}(R,t) = \frac{\int_0^t SFR(R,t')P_E(R,t')P_{SN}(R,t')dt'}{\int_0^t SFR(R,t')dt'}$$

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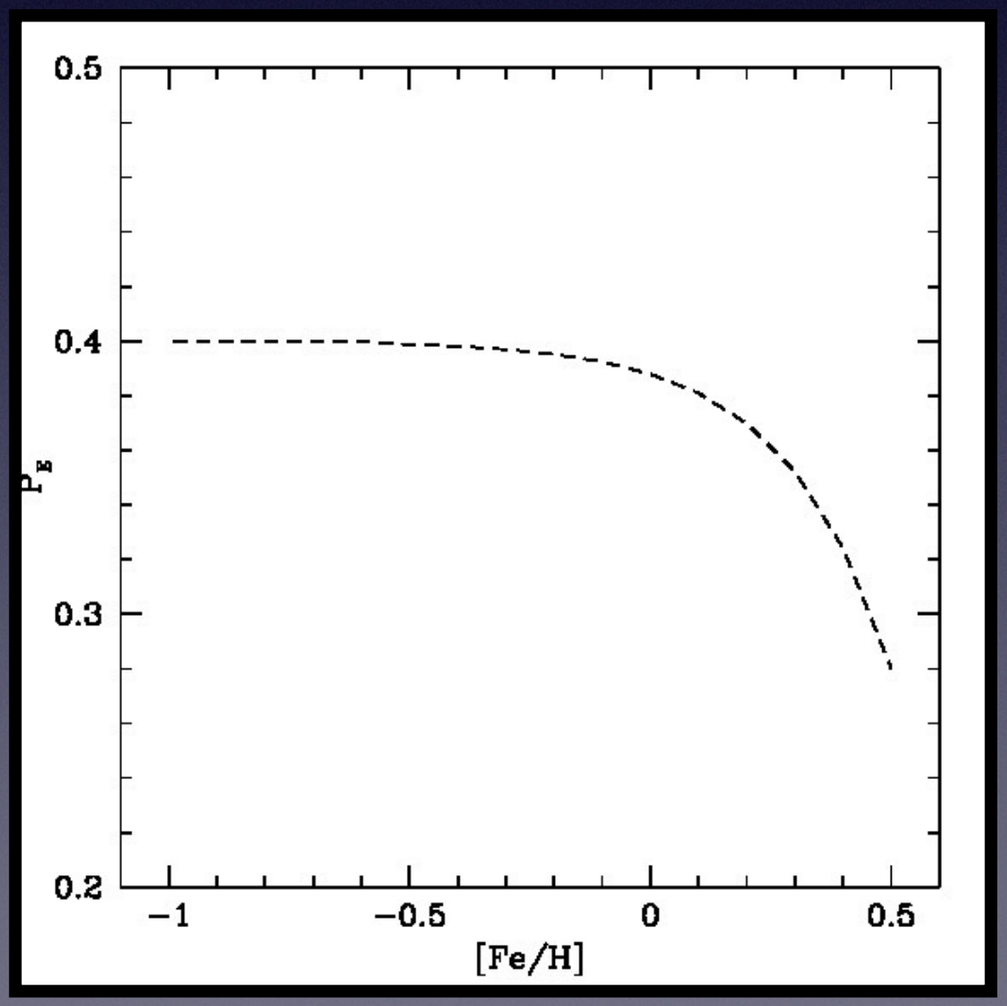

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# The probability $P_{SN}(R', t')$ of surviving SN explosions

We define <RSN*> as the average SN rate in the solar neighbourhood during the last 4.5 Gyr of the Milky Way's life (Carigi et al. 2013).

$$< RSN^* >= 0.013 \ \mathrm{Gyr}^{-1} \ \mathrm{pc}^{-2}$$ (ES & Matteucci 2011)

if SNR > 2 <RSN*>
then
$P_{SN}$ = 0 else
$P_{SN}$ = 1

# The Chemical evolution models

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[Fe/H]

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# CHEMICAL EVOLUTION MODELS FOR THE MW DISK

- Two Infall model $A(r,t) = a(r)e^{-t/\tau_H(r)} + b(r)e^{-(t-t_{max})/\tau_D(r)}$
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## I) MODEL WITHOUT RADIAL GAS FLOWS

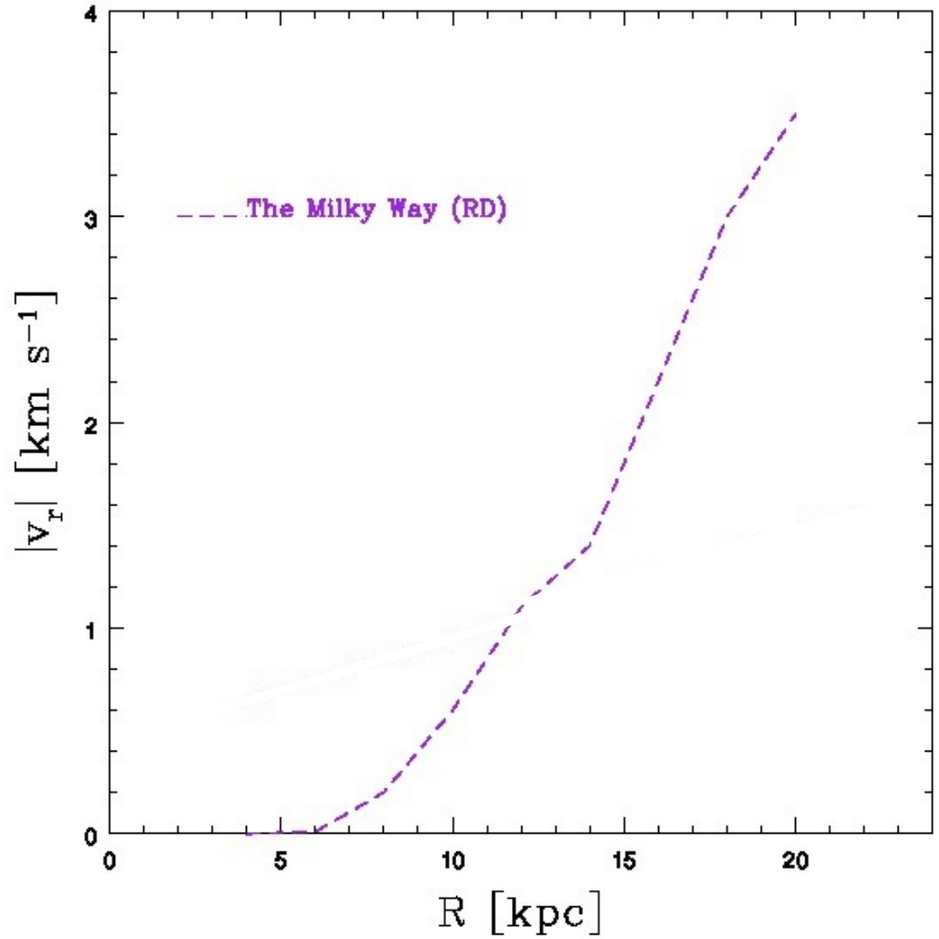
Spitoni & Matteucci (2011)

- Threshold in gas density for the SF

# CHEMICAL EVOLUTION MODELS FOR THE MW DISK

- $nax)/\tau_D(r)$
- yr
- II)
- • No threshold in gas density for the SF

## MODEL WITH RADIAL GAS FLOWS (Mott et al. 2013)




- **Radial inflow of gas,** with velocity pattern in agreement with theoretical works of Lacey & Fall (1985), Schoenrich & Binney (2009).

# GHZ RESULTS I)

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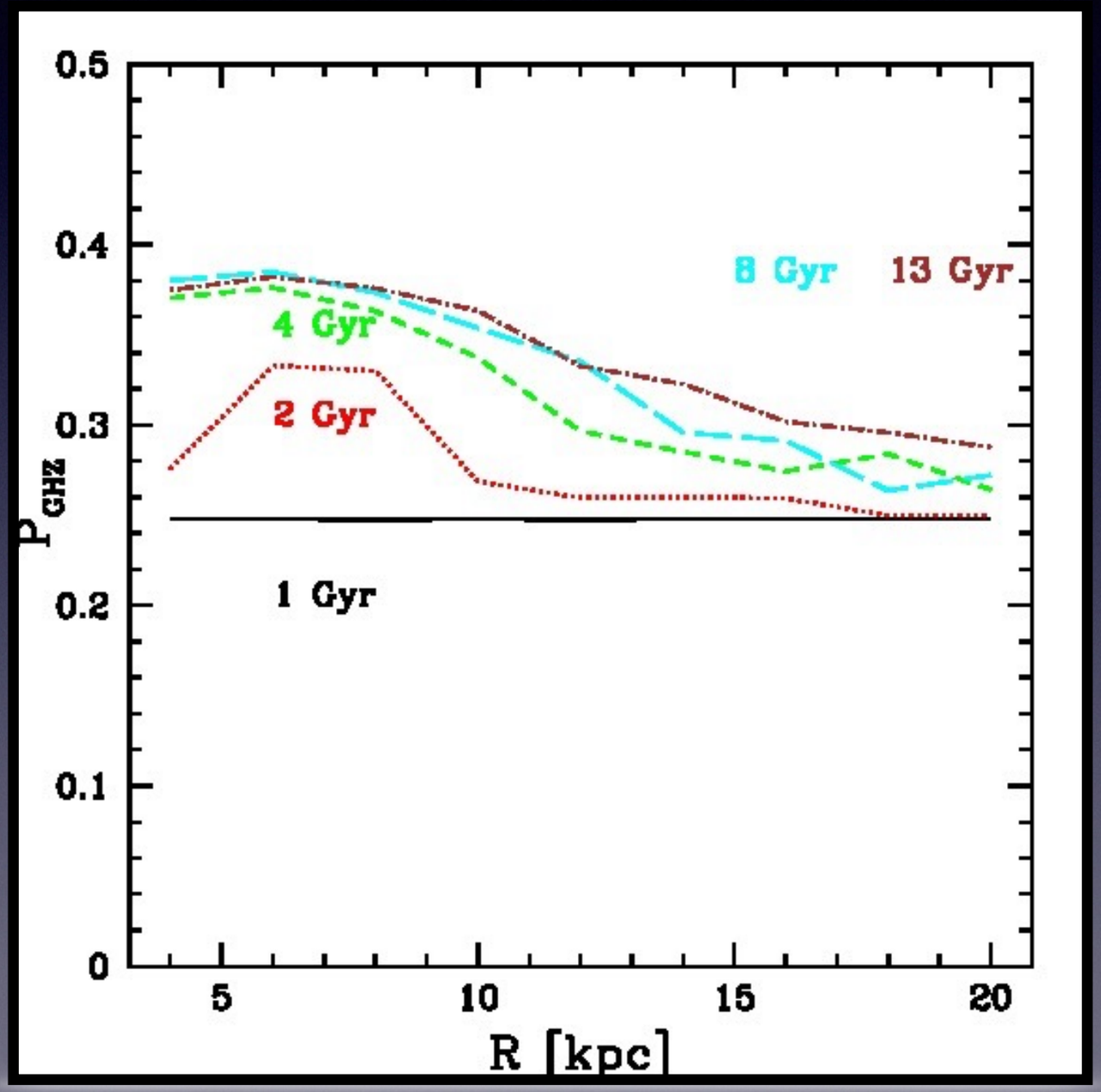
Chemical evolution models without radial gas flows

# The $P_{GHZ}$ quantity for the model without radial gas flows




Model without SN destruction effects

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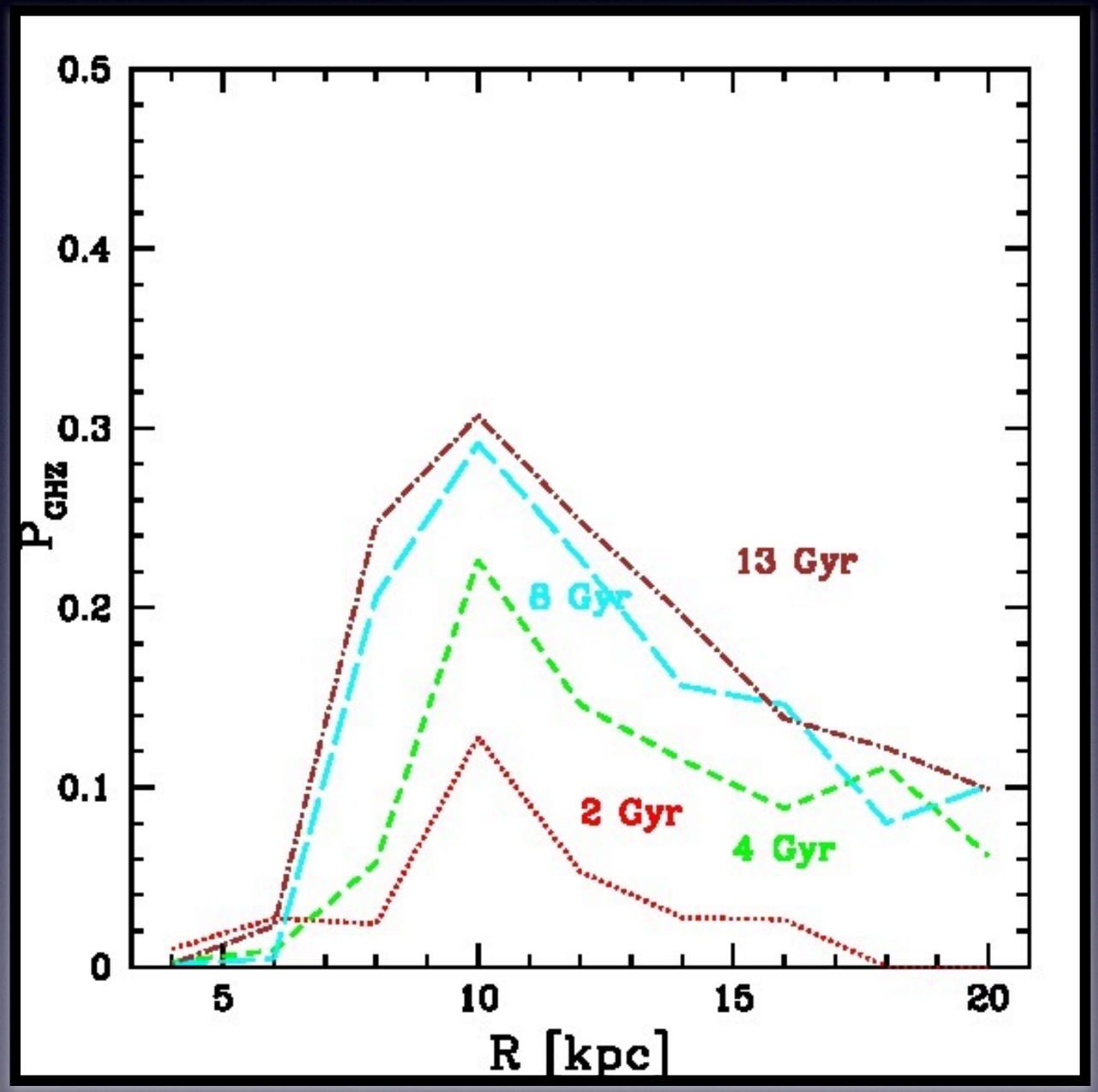


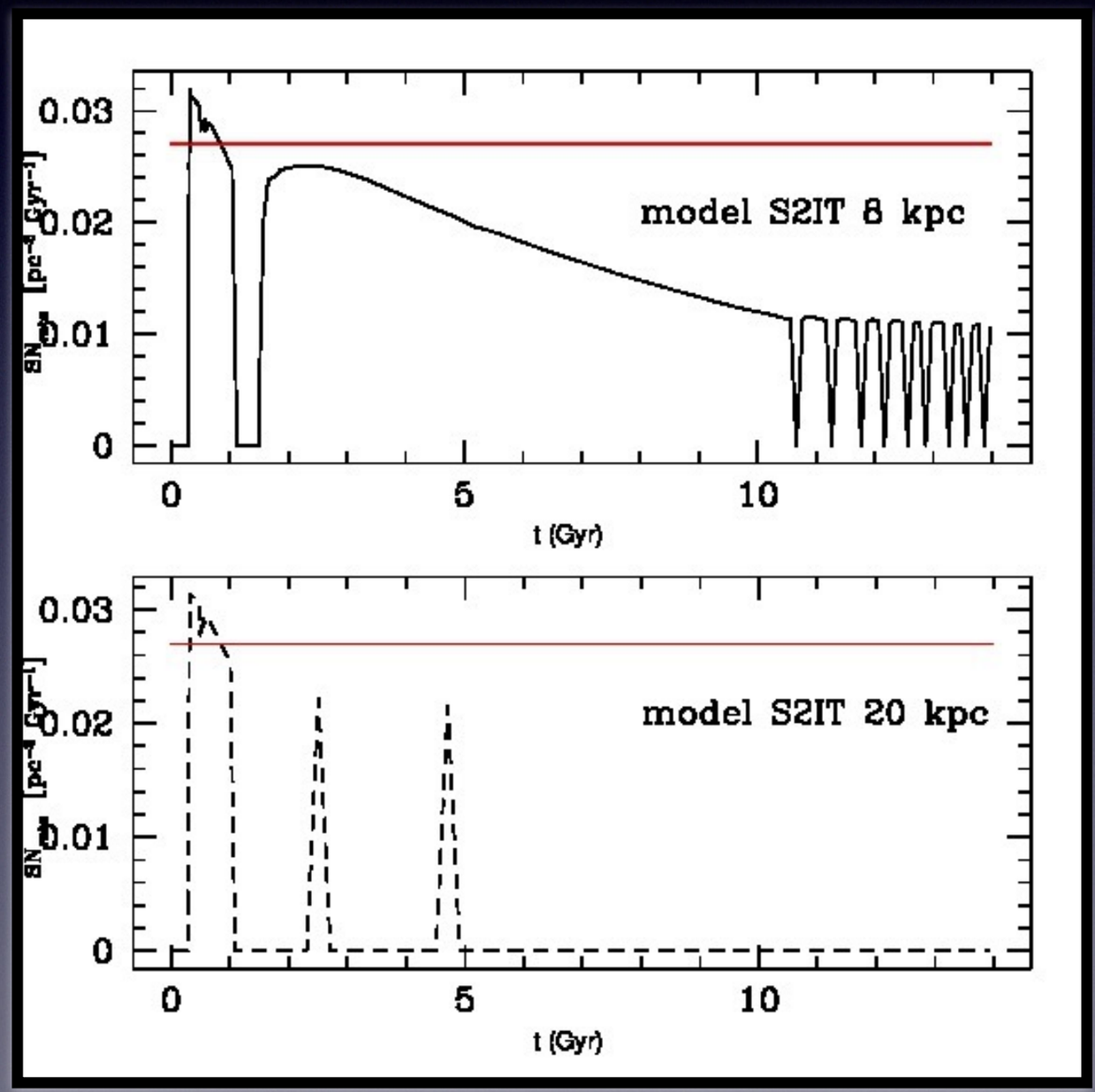

The total number of stars with habitable Earth-size planets

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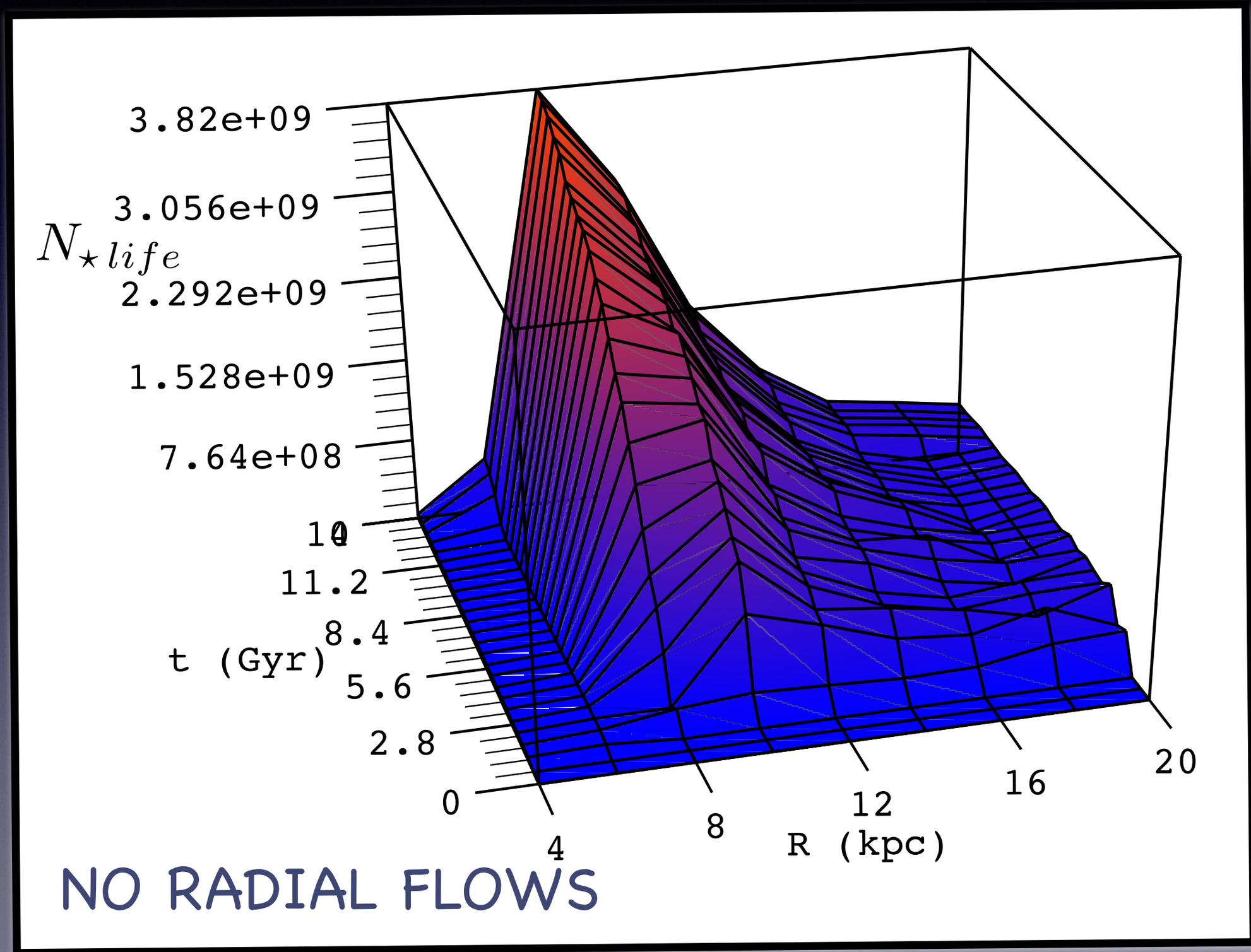
$$N_{\star life}(R,t) = P_{GHZ}(R,t) \times N_{\star tot}(R,t)$$

# The number of stars hosting habitable Earth-like planets in the Milky Way (with SN destruction effects)




NO RADIAL FLOWS

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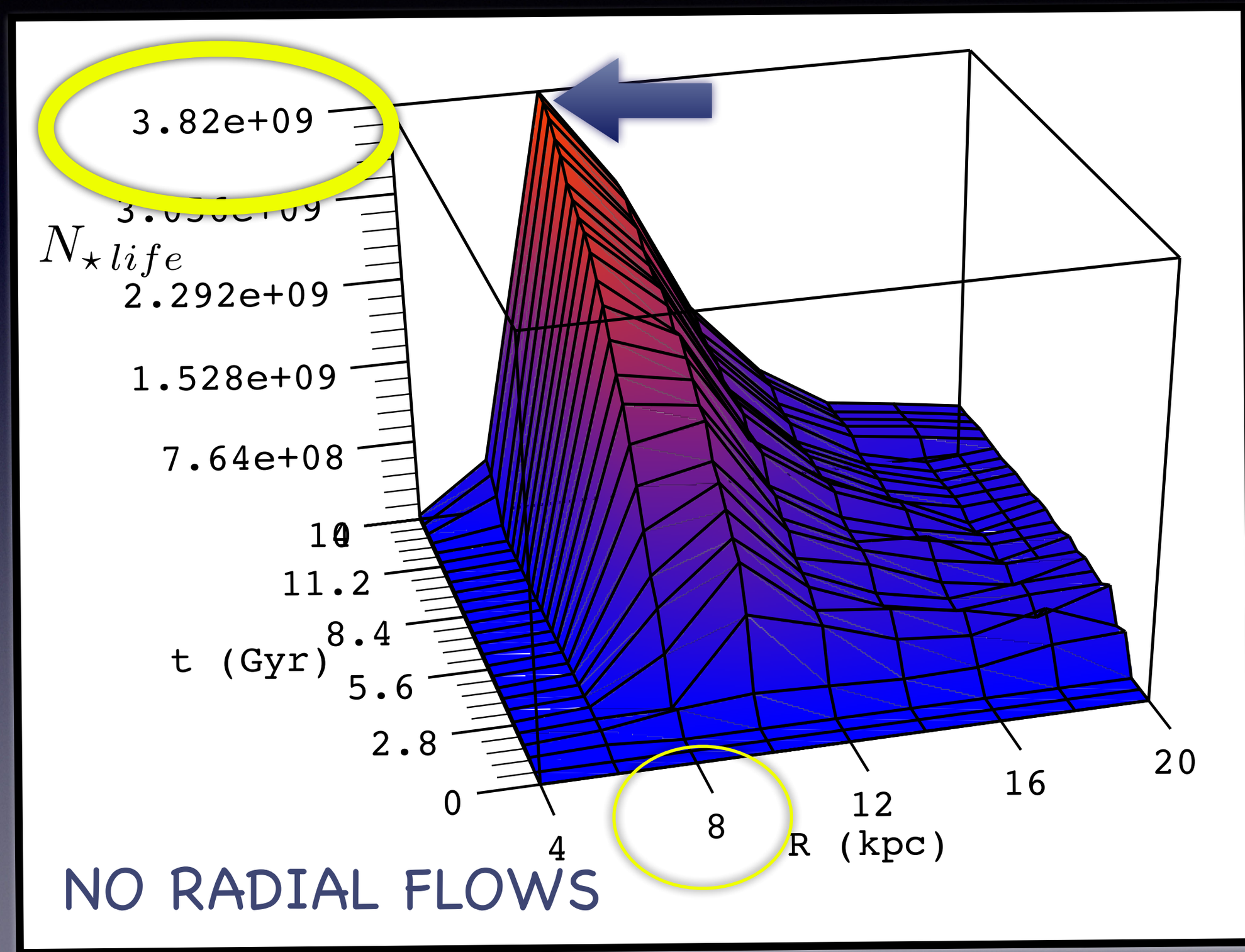

# GHZ RESULTS II)

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Chemical evolution models with radial gas flows

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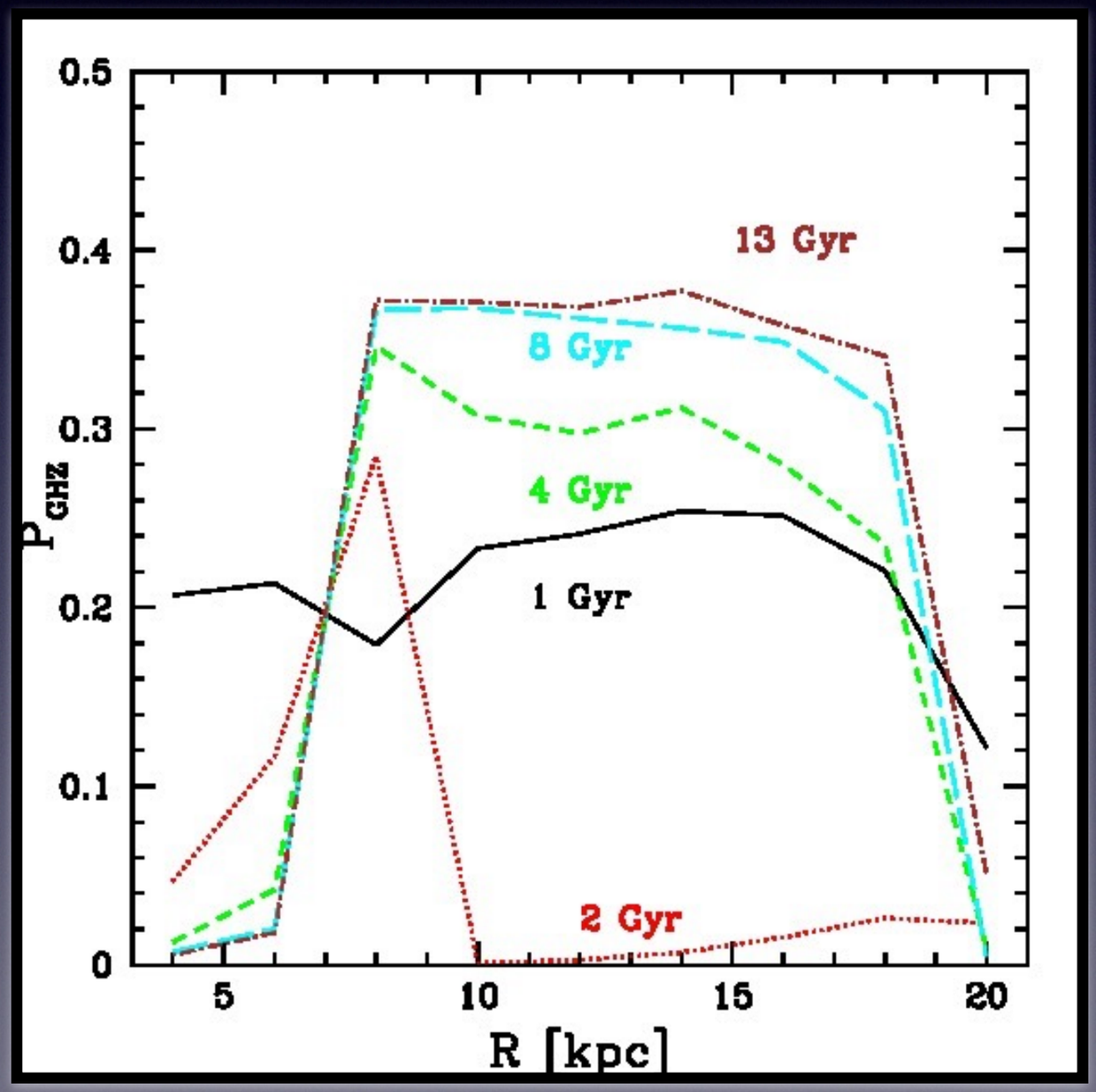
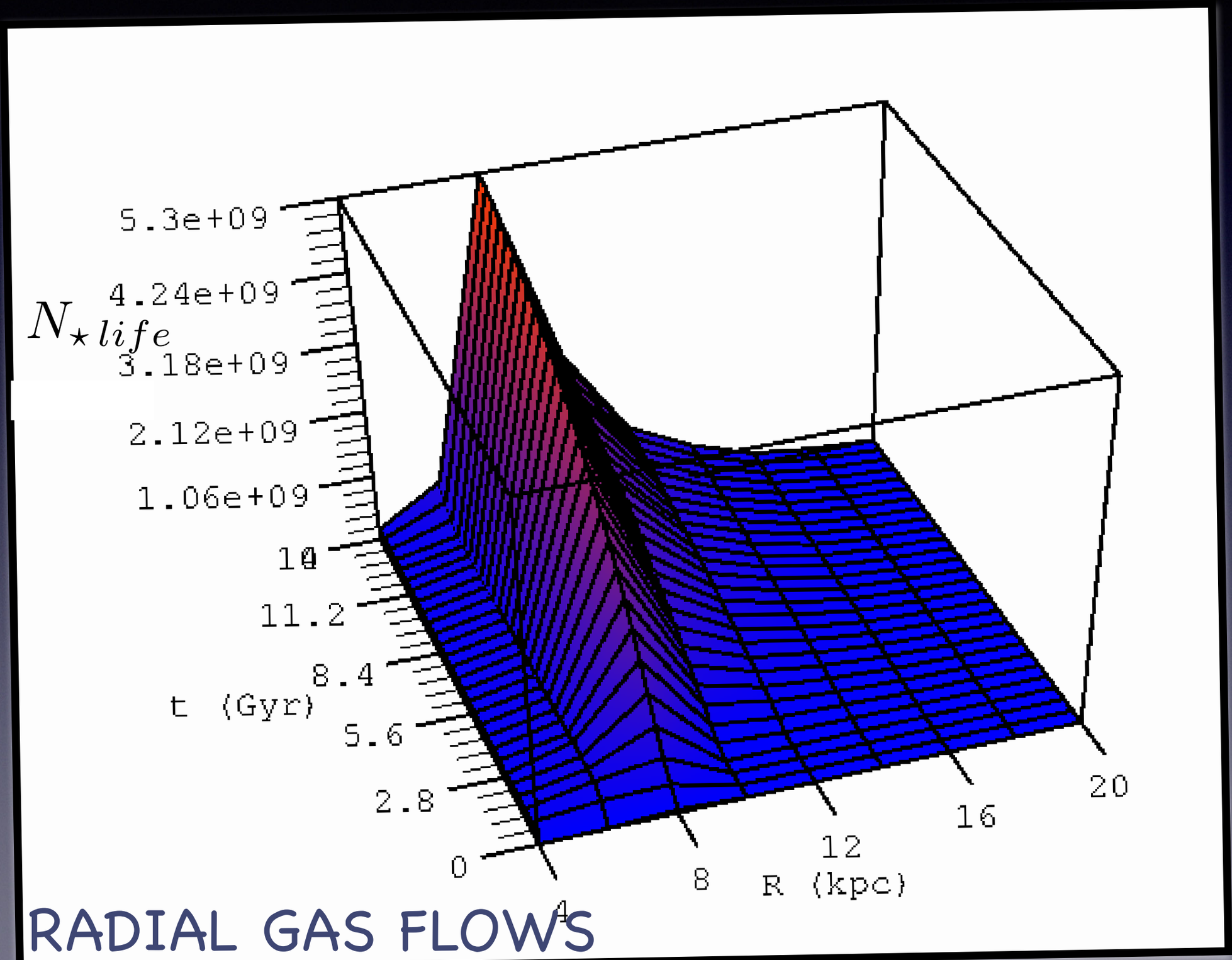



Model with SN destruction effects

At the present time at 8 kpc the number of stars hosting habitable planets is increased by 38 % compared to the "classical" model

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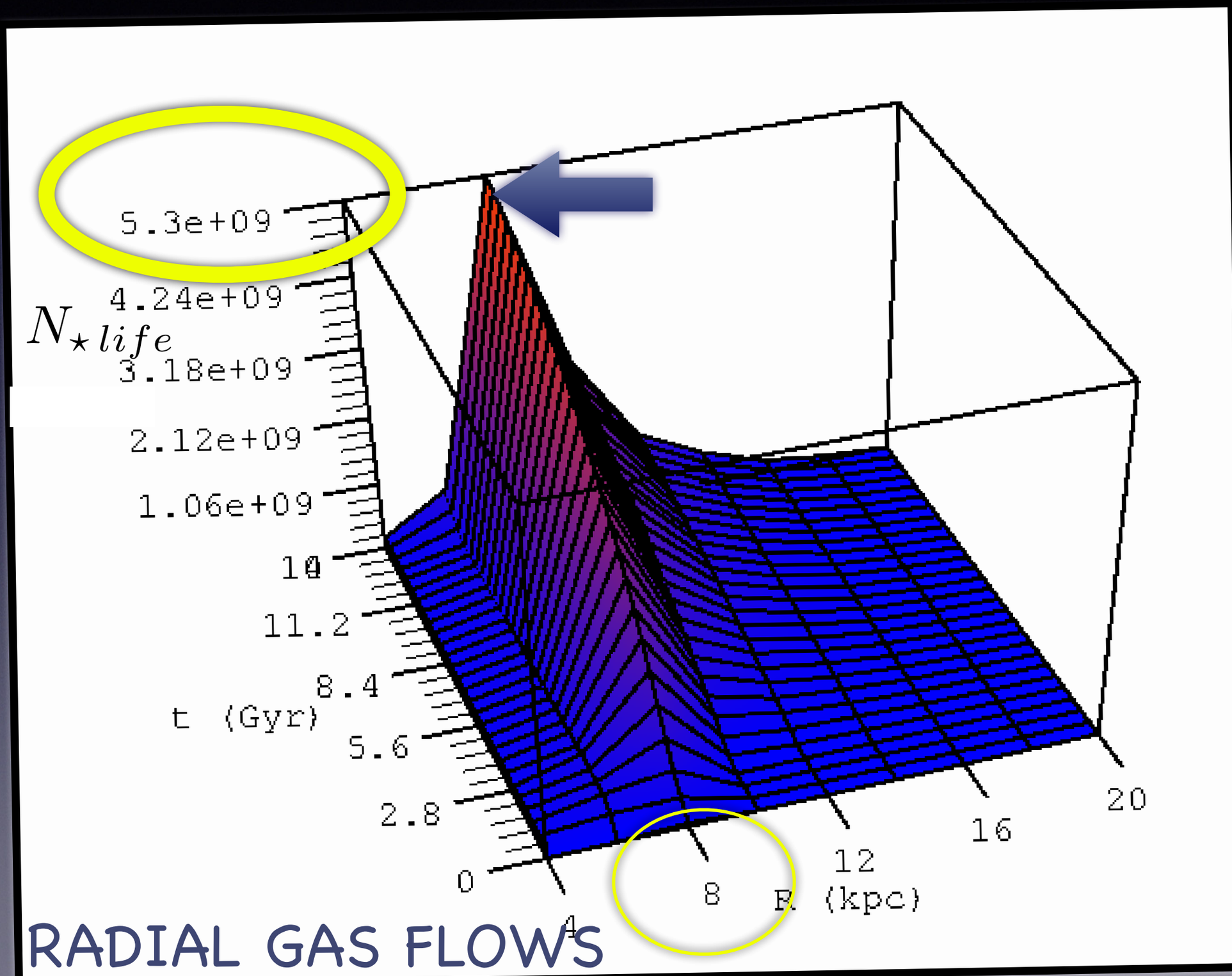


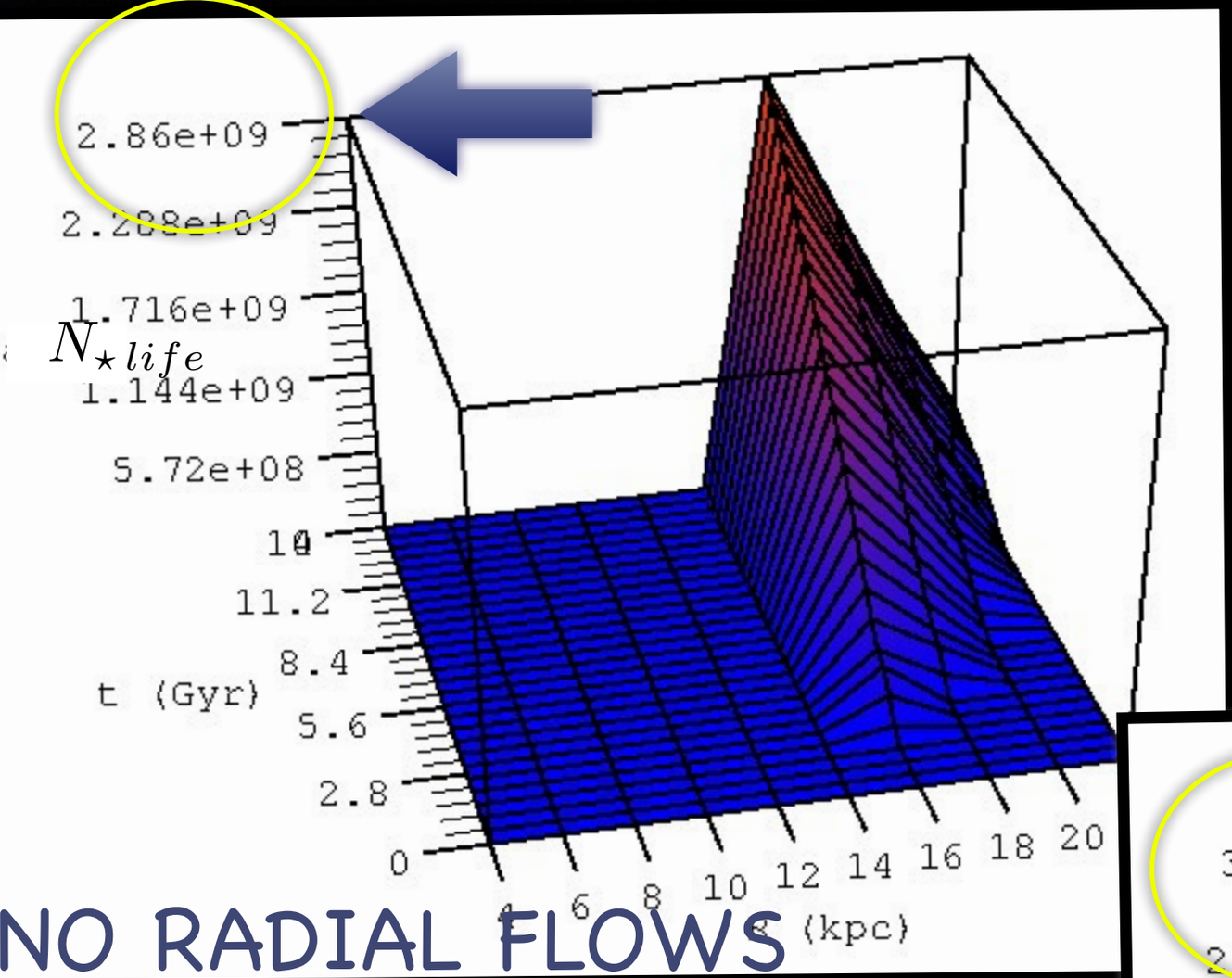

RADIAL GAS FLOWS

# Conclusions

- The effect of the gas radial inflows is to enhance the number of stars hosting a habitable planet with respect to the "classical" model results in the region of maximum probability for this occurrence.

- At the present time, the maximum number of host stars is centered at 8 kpc, and the total number of host stars is increased by 38 % compared to the "classical" model results.

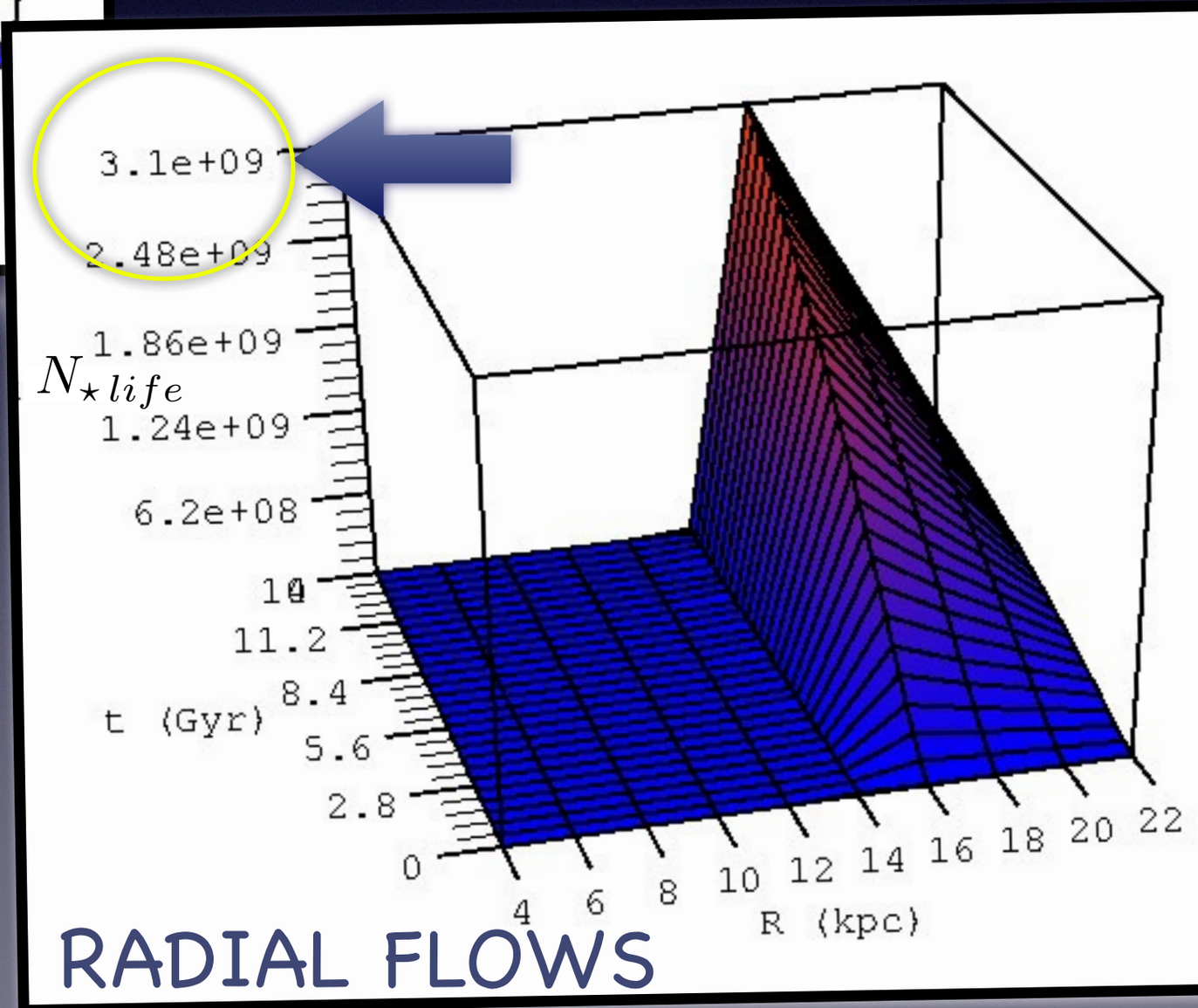
# GHZ RESULTS..... M31




NO RADIAL FLOWS

The number of stars hosting habitable Earth-like planets in Andromeda

At the present time at 8 kpc $N_{\star life}$ is increased by 10 % compared to the "classical" model




RADIAL FLOWS