



Introducing the Rhea simulations: Star Formation in Galactic Spiral Arms

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Overview

- We present the Rhea simulations, a set of detailed isolated MW simulations to model the Galaxy as good as possible.
- How does a detailed galactic potential affect the star formation of the simulated galaxy?
- Does a prevalent spiral potential has an impact?

Included physics

Our simulations include

- a potential fitted to the MW
- chemical network tracking hydrogen, heating & cooling
- star formation & stellar feedback
- magnetic fields (see Kjellgren et al., in prep)
- cosmic rays (see Girichidis & Kjellgren et al., in prep.)

Star Formation and Stellar Feedback

- We use star particles.
- Their formation is controlled by the Jeans mass and follows a probabilistic approach

$$\rho = \frac{M_{\text{cell}}}{M_{\text{starP}}} (1 - \exp(-\text{SFR} \frac{t}{M_{\text{cell}}})) \quad (1)$$

- Star particles are populated with individual stars according to a Kroupa IMF.
- Supernovae inject energy or momentum, depending on if the Sedov-Taylor-phase is resolved.

The simulations

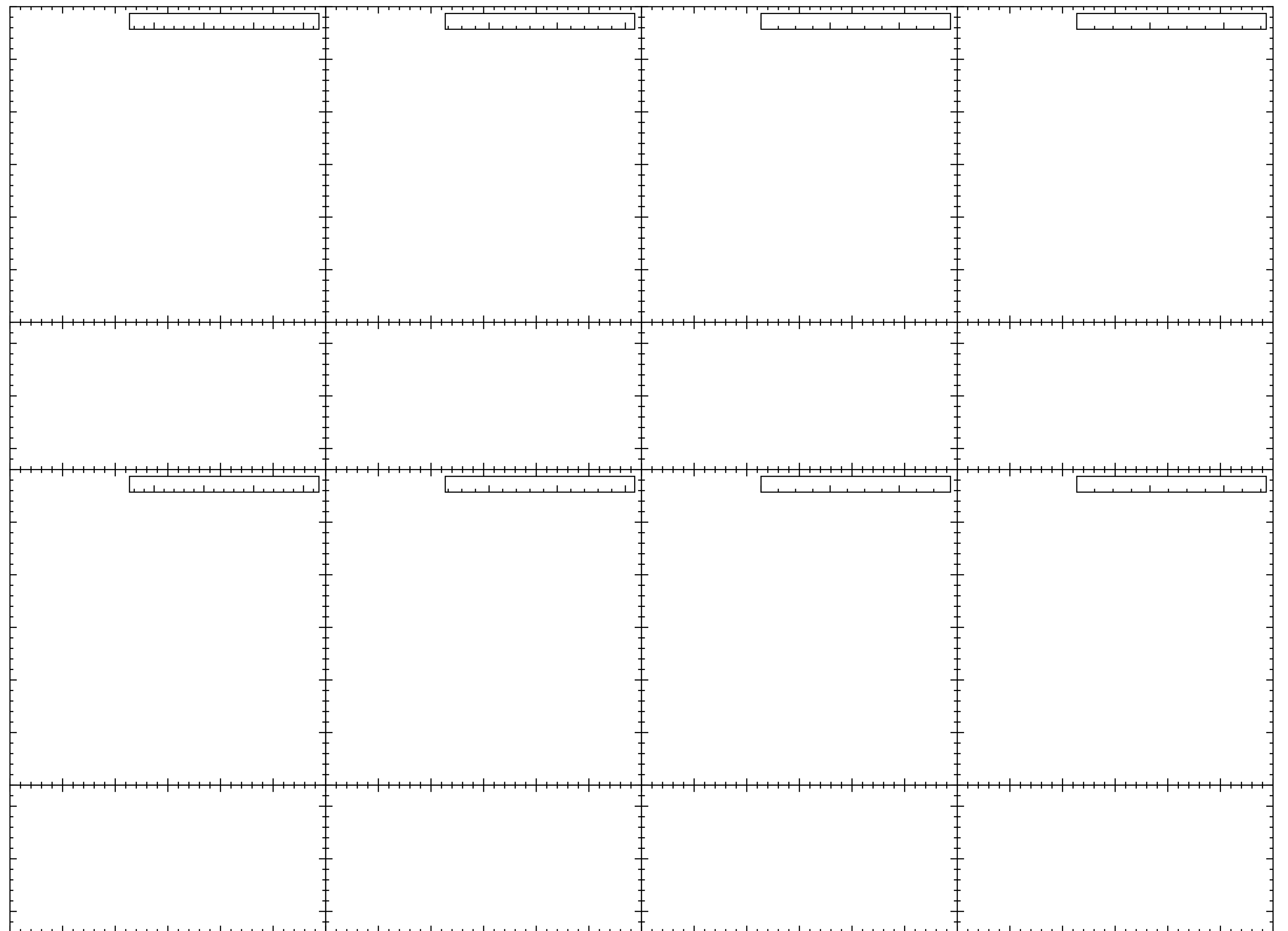
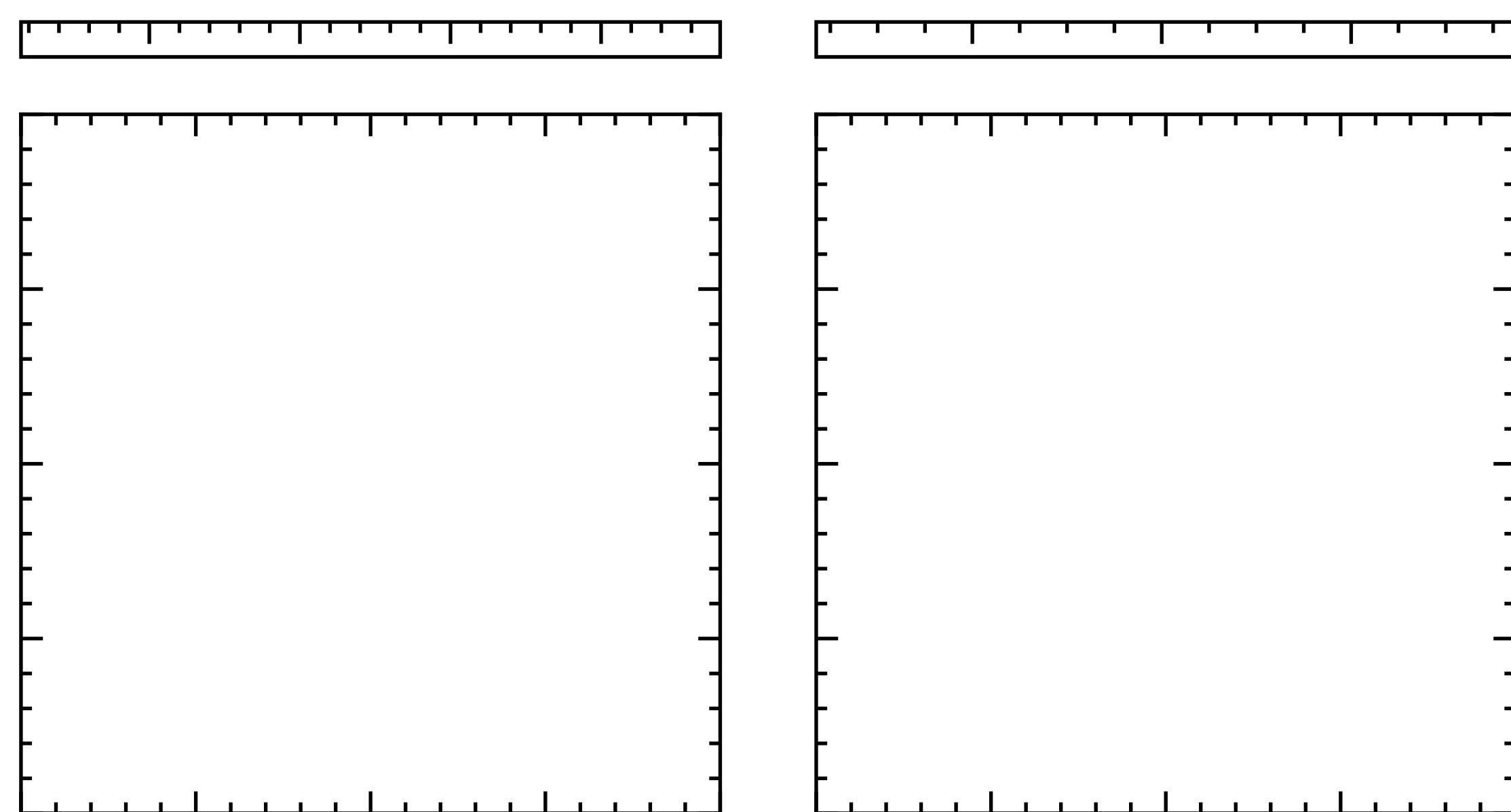


Figure: Gas surface density, H⁺ surface density, stellar surface density and temperature for the Rhea simulation (upper row) and a comparison simulation with a flat potential (lower row).

The Milky Way Potential



The potential includes

- Sagittarius A*
- Nuclear stellar cluster
- Nuclear stellar disk
- Galactic bar (right)
- Galactic disk (axisymmetric & spiral component (left))
- Dark matter halo

and is written in AGAMA (Hunter et al, 2024, arXiv:2403.18000).

Basic Properties

- Initial density distribution:

$$\rho_{\text{gal}}(R_{\text{gal}}, z) = \frac{\rho_0}{4z_d} \exp\left(-\frac{R_m}{R_{\text{gal}}} - \frac{R_{\text{gal}}}{R_d}\right) \text{sech}^2\left(\frac{z}{2z_d}\right) \quad (2)$$

- Mass of the barionic disk: $1.2 \times 10^{10} M_{\odot}$
- Disk radius: 30 kpc
- Stars-to-gas-ratio: 16%

The Flat Potential

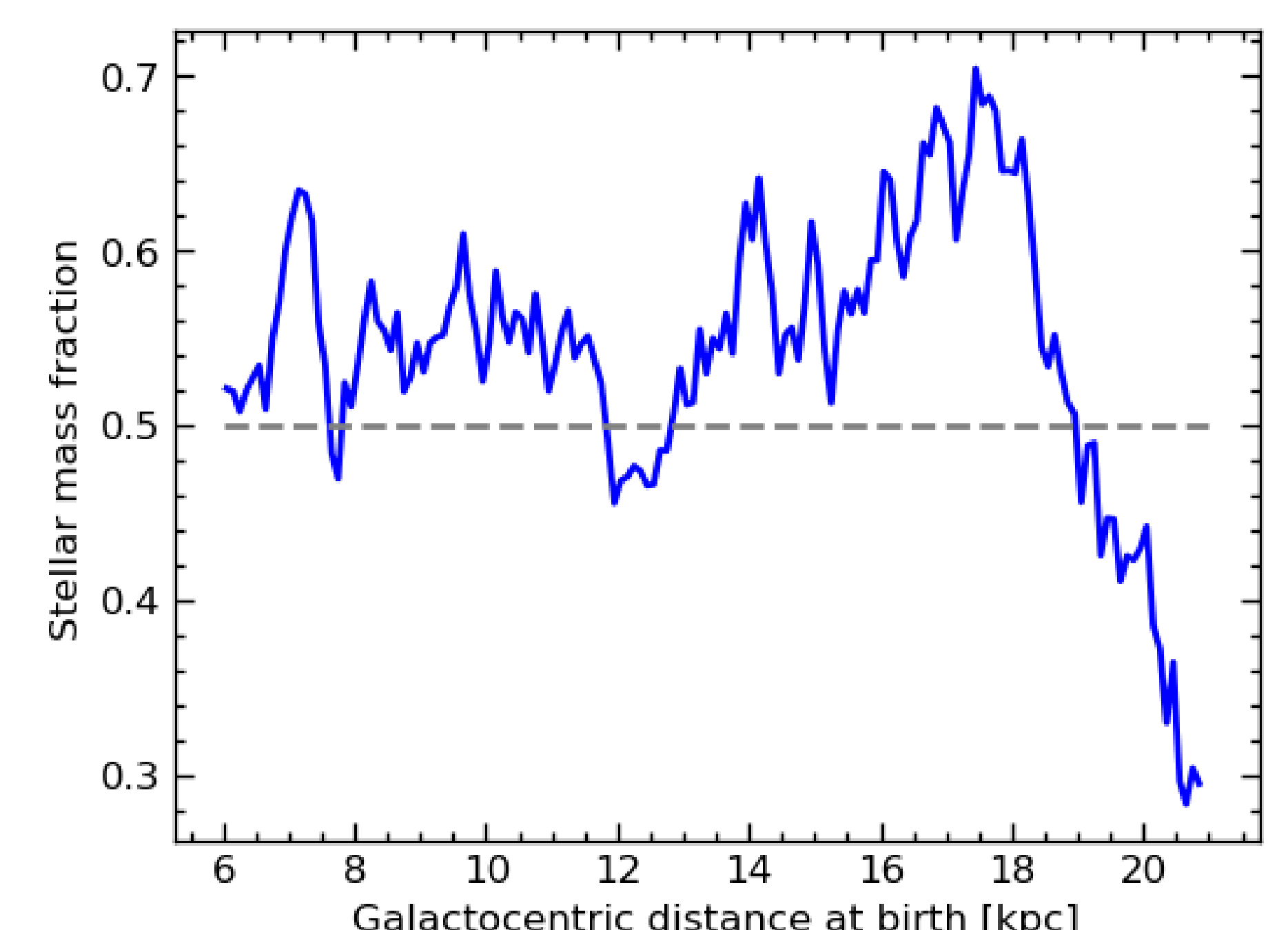
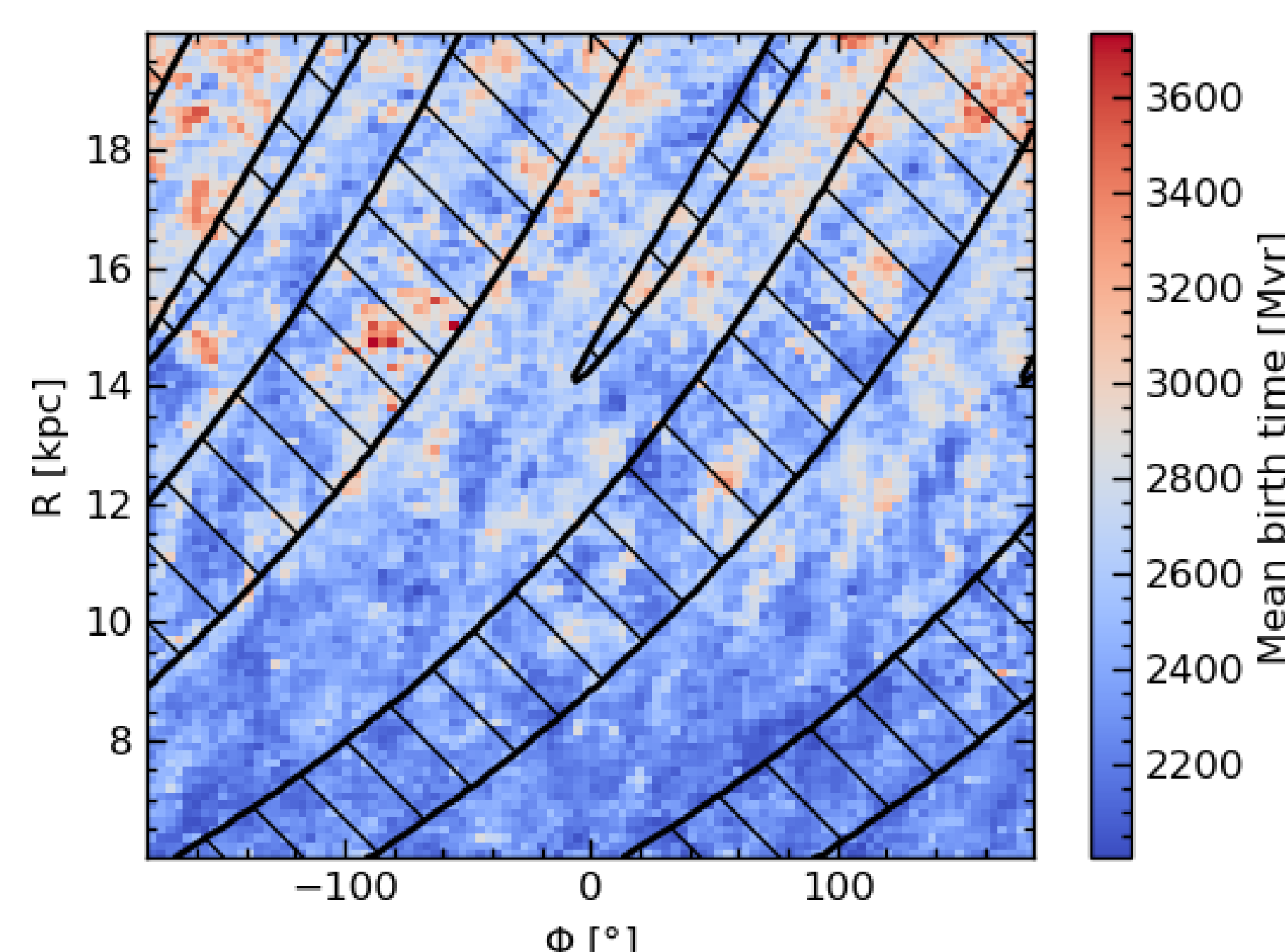
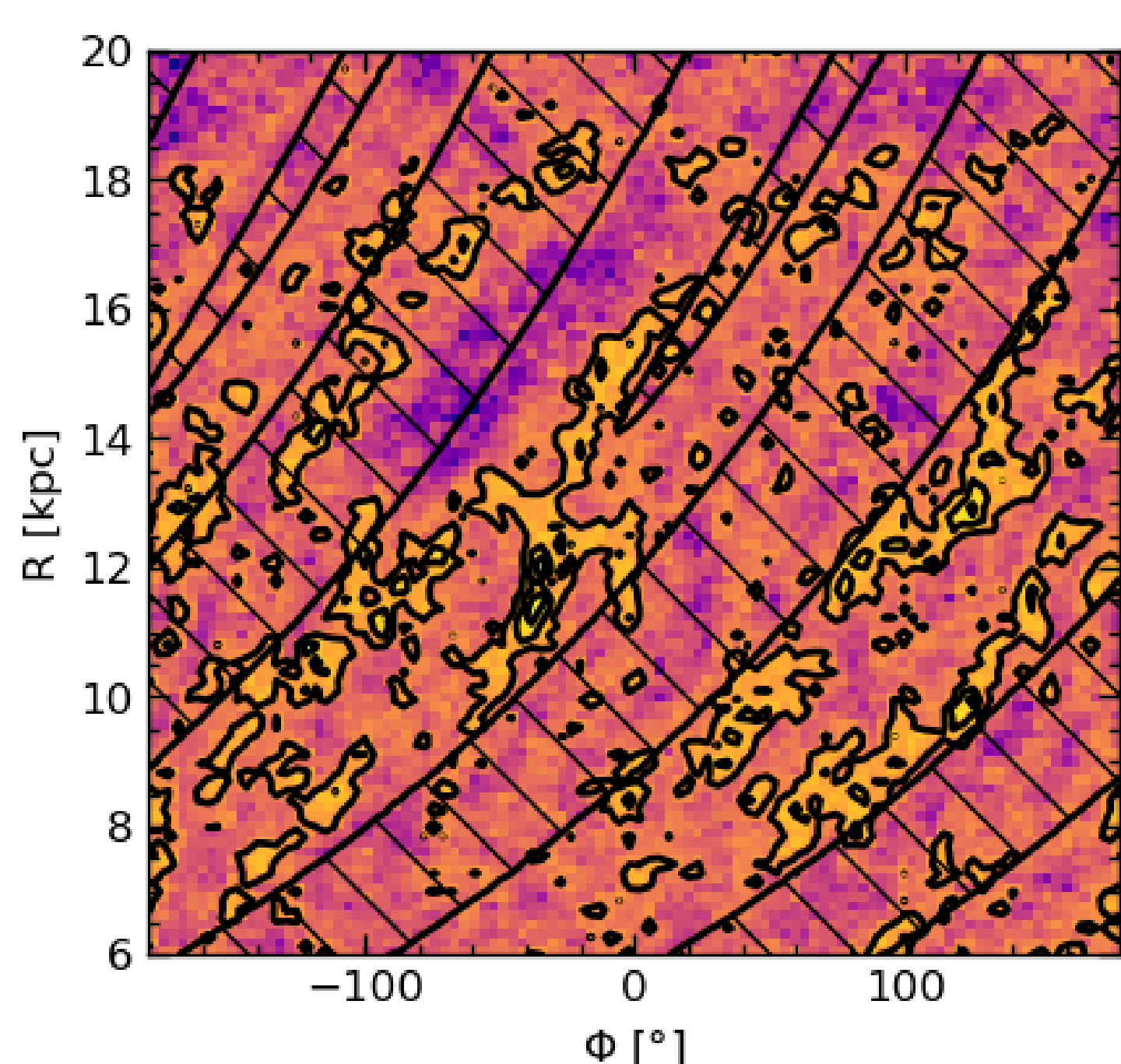
- Ensures a flat rotation curve of $v_{\text{circ}} = 220 \text{ km s}^{-1}$
- Logarithmic potential of the form

$$\Phi = \frac{1}{2} v_0^2 \ln(R_c^2 + R_{\text{gal}}^2) + \frac{z^2}{q^2} + \text{const.} \quad (3)$$

Important Results

- The global SFR is unaltered by the introduction of a detailed potential.
- However, the bar potential prevents the galactic center from being quenched.
- Only with a spiral arm potential stable spiral arms form. In a flat potential spiral arms are short-lived.
- With a stable spiral arm potential, 56 % of the stars form within their potential well.

Star formation in Spiral Arms of the Milky Way Potential



In general, in the Milky Way potential, SF follows the spiral arm potential (uncrossed region). In the Flat potential, no stable star-forming arms form.

The mean stellar formation time indicates inside-out SF in the Galaxy, but no longer-lasting star formation in spiral arms.

Up to 18 kpc, > 50 % of stars form in the spiral arms.