Effects of Varying the FIRE Feedback Model on the ISM in a Self-regulating Disk Galaxy

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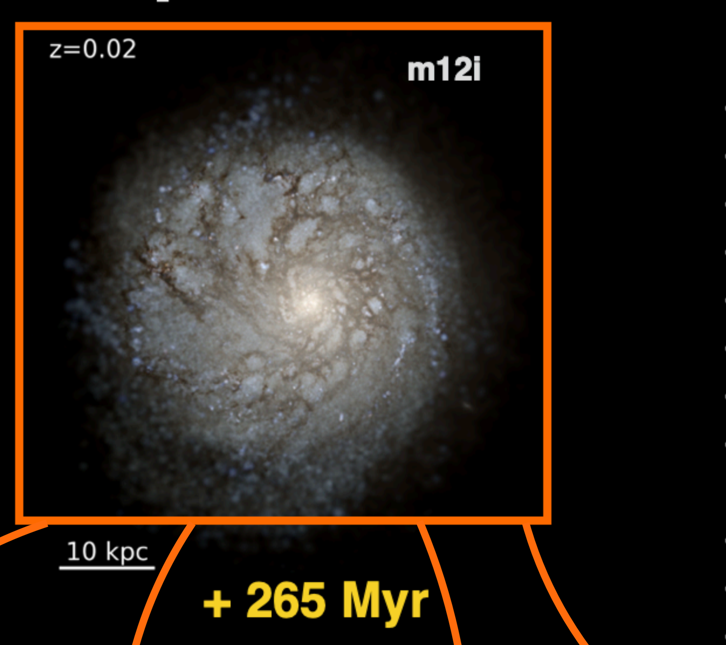
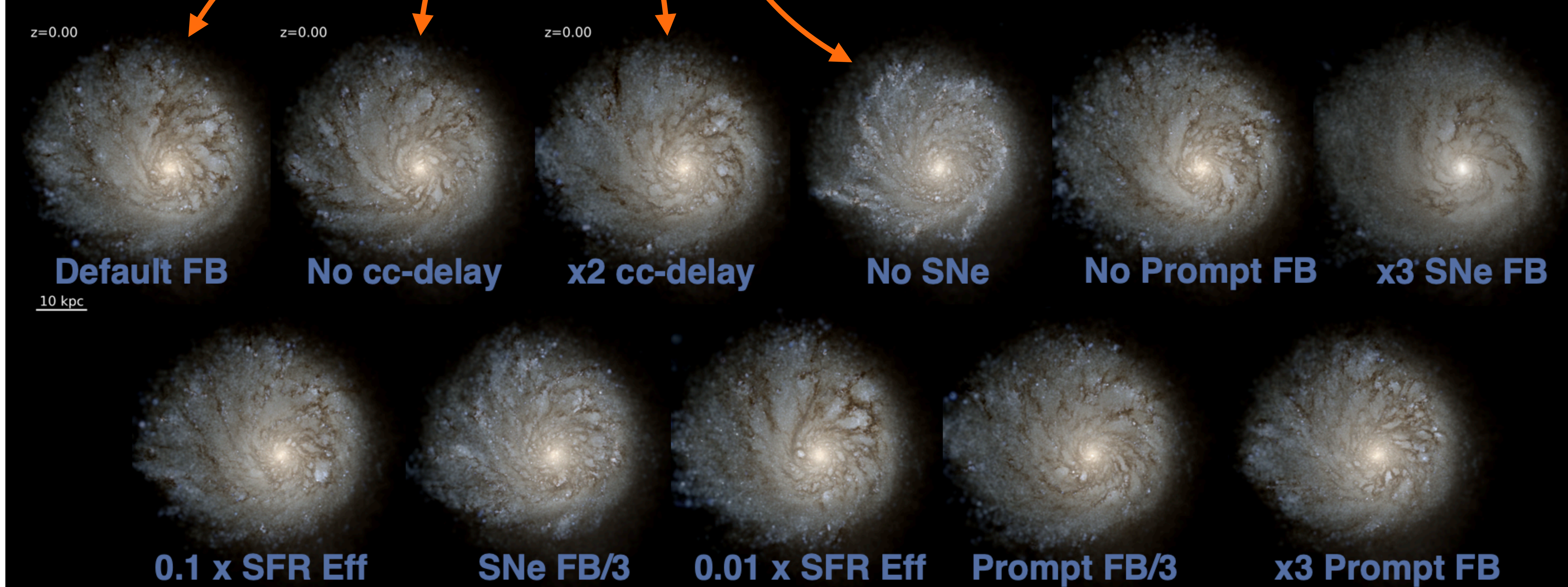
Simulation Experiment Set-up

Take z ~ 0.02 snapshot of FIRE-2 m12i, at 7100 M$_\odot$ resolution with a fairly quiescent, star-forming disk, and evolve it for ~250 Myr with variations on the standard FIRE-2 feedback prescriptions



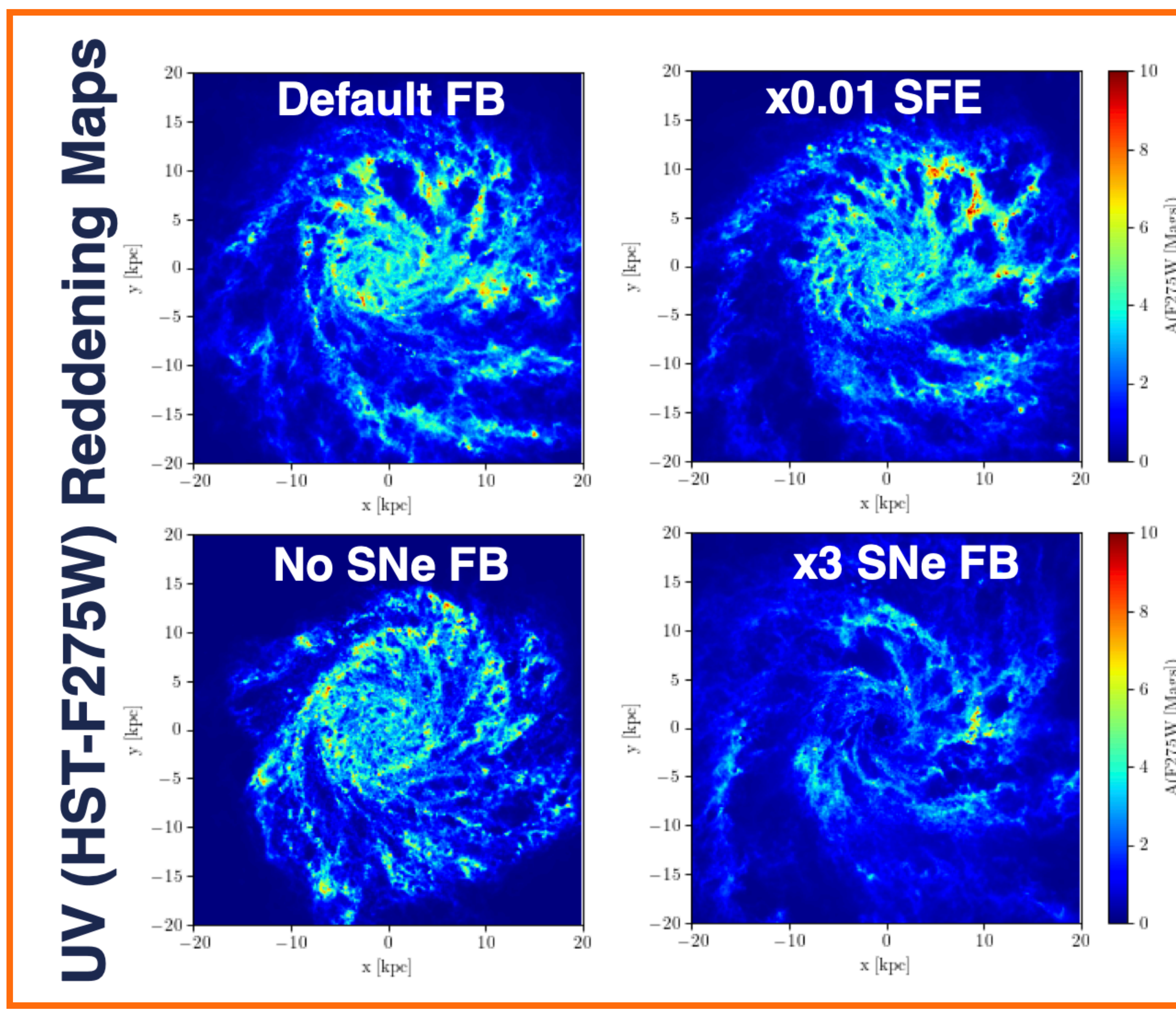
Variations include:

- Default FIRE-2 Feedback Physics
- No core-collapse SN delay time
- Double core-collapse SN delay time (6.8 Myr)
- No core-collapse SN Feedback
- 3 x Initial SN Energy
- 1/3 x Initial SN Energy
- Only core-collapse SN Feedback
- 3 x Photoionization + Radiation Pressure + Winds ("Prompt Feedback") Strength
- 1/3 x "Prompt Feedback" Strength
- 0.1 x Grid-scale Star formation Efficiency
- 0.01 x Grid-scale Star formation Efficiency

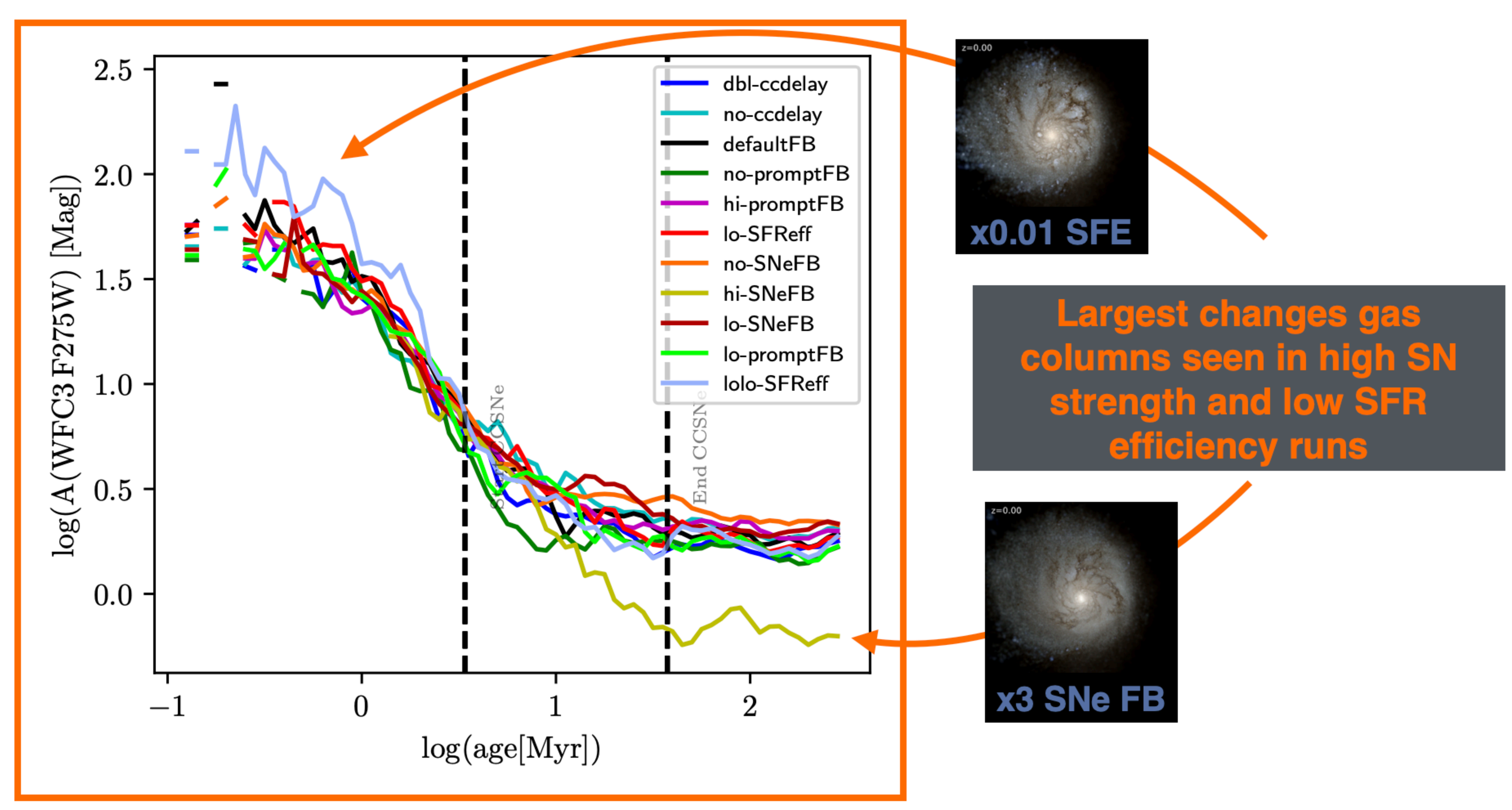


At a glance, only the *no-supernovae* run looks strongly visually distinct.

Most variations on the feedback model do not produce marked changes to the appearance of the galaxy, *unless they strongly affect the global ISM energetics.* Increasing or decreasing the strength of supernovae (or eliminating them from the simulation) does alter the galaxy's appearance, mostly by changing the star formation rate. Note that eliminating supernova feedback (No SNe) causes the galaxy to radially contract, as more gas orbital energy is converted into stabilizing turbulence.

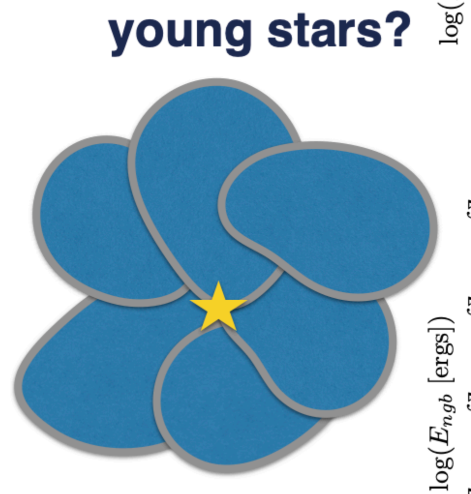


Changes to Stellar UV Reddening

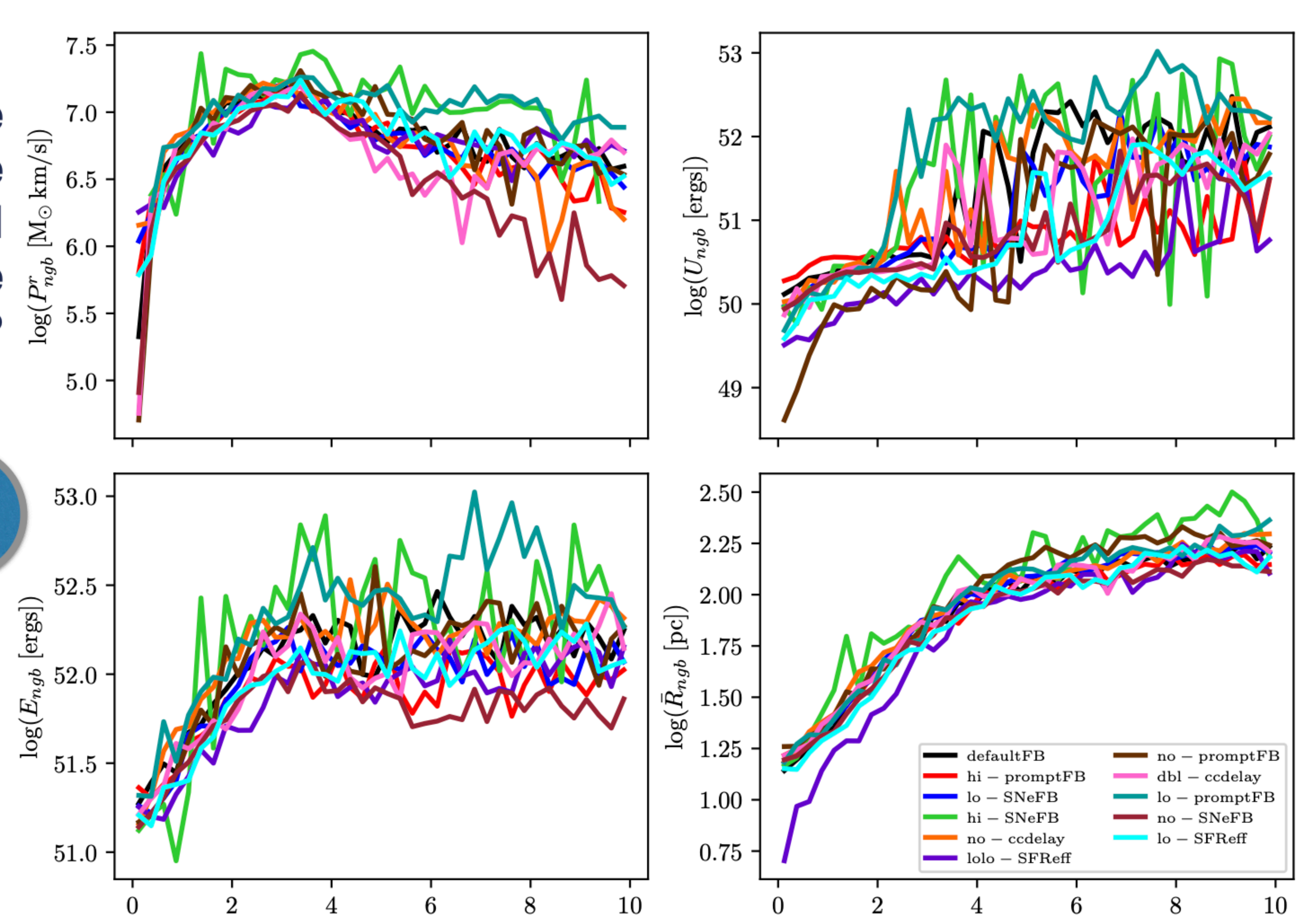


Variations to the feedback and star formation model by and large do not affect the average reddening of stars in the galaxy unless the changes either affect the density in which stars form (e.g., reducing the grid-scale star formation efficiency parameter to the point at which gas collapses to significantly higher densities to reduce the local free fall time in order to achieve similar SFRs) or causes changes in the large-scale gas surface density.

What about the immediate dynamical environment to the young stars?



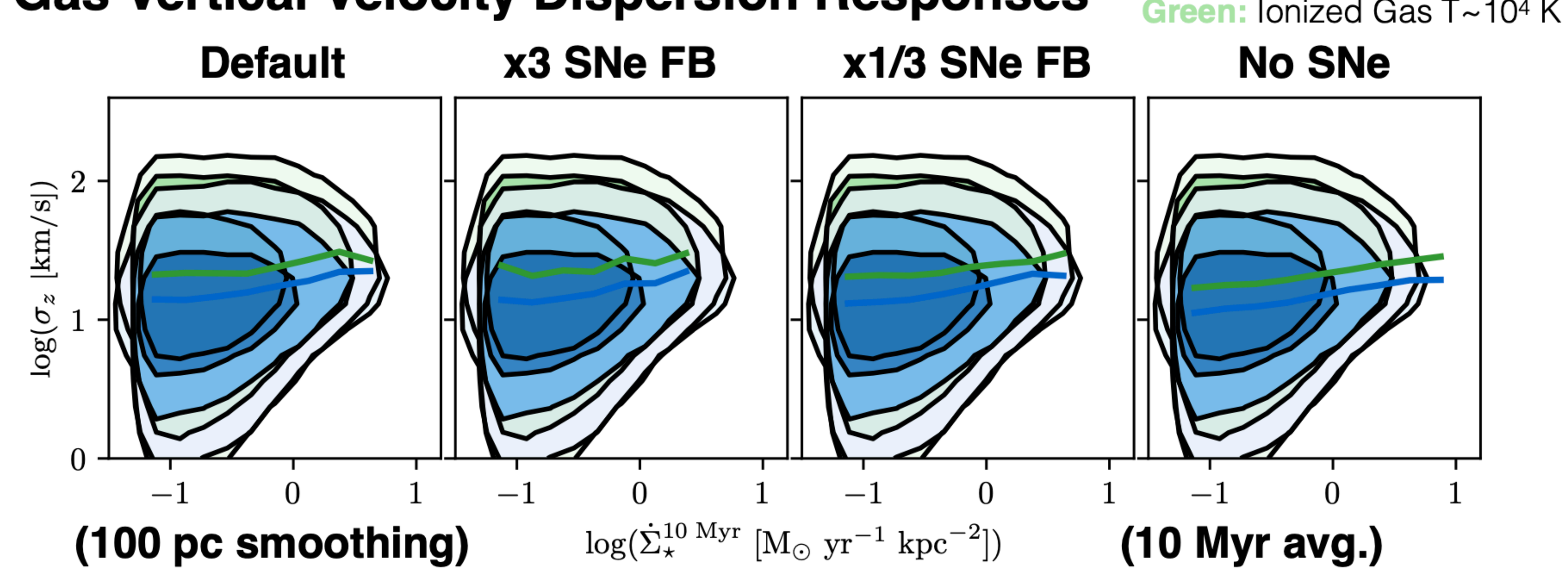
Measured with the 64 nearest neighbor gas elements to each young star particle



When considering the immediate gas dynamical environment around young star particles, there are surprisingly few large changes between model variants. *Clockwise from top-left:* the radial momentum in gas is only largely shifted at late times by either eliminating or dramatically strengthening SNe feedback, the internal energy of the gas measures if some form of feedback has formed an ionized bubble, the 'bubble' as formed by expanding gas follows nearly the same scaling with time between all runs except for the 1% SFE run where gas collapses to higher initial densities (its late time evolution is similar to the other runs), and the kinetic energy follows roughly the same for shifts as the gas radial momentum. These are all consistent with maintaining Larson's Laws scalings.

Gas Vertical Velocity Dispersion Responses

Blue: Cold & Dense gas
Green: Ionized Gas T~10⁴ K



The vertical velocity dispersions, on 100 pc scales, do not respond to almost *any* variation in the star formation or feedback models. The galaxy itself is self-regulating, finding a way to achieve roughly an equilibrium in the ISM to maintain marginal stability against fragmentation and collapse (Toomre's Q of order unity). Only the case where supernovae are entirely eliminated do the velocity dispersions fall (only slightly, ~0.1-0.2 dex), but other modes of feedback can still convert in-plane motions to out-of-plane motions from the increased radially inward gas motion to maintain rough marginal stability.

Marginal gas stability is paramount in disk galaxies.

Key Takeaways

- Changing the delay time of cc-SNe, the strength of prompt feedback or small-scale SFE (to a point) has little effect on gas velocity dispersions, or star-forming region properties
- Strong SNe do affect inter-arm gas, sweeping out diffuse gas effectively
- Most dramatic effects appear when SN FB is culled *entirely*: vertical velocity dispersions fall, gas is dense *on-average*
- *Self-regulating disks are hard to affect in most 'observable' parameters!*

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