A Hybrid Model for Stellar Migration and Chemical Evolution in the Milky Way Disk

James W. Johnson

2021 SDSS Collaboration Meeting

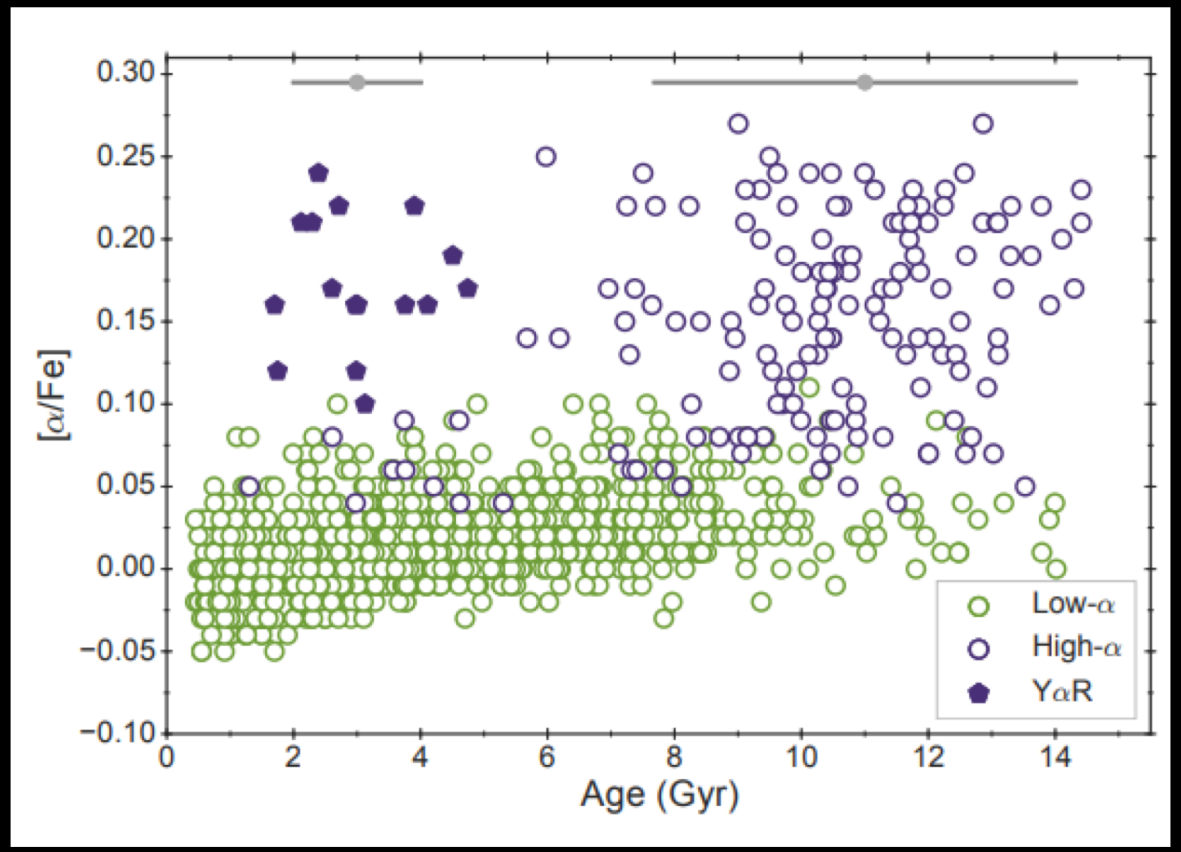
Tuesday, August 17, 2021

THE OHIO STATE UNIVERSITY

@giganano9

arxiv:2103.09838

Context: Age-Metallicity, Age-Alpha Relations

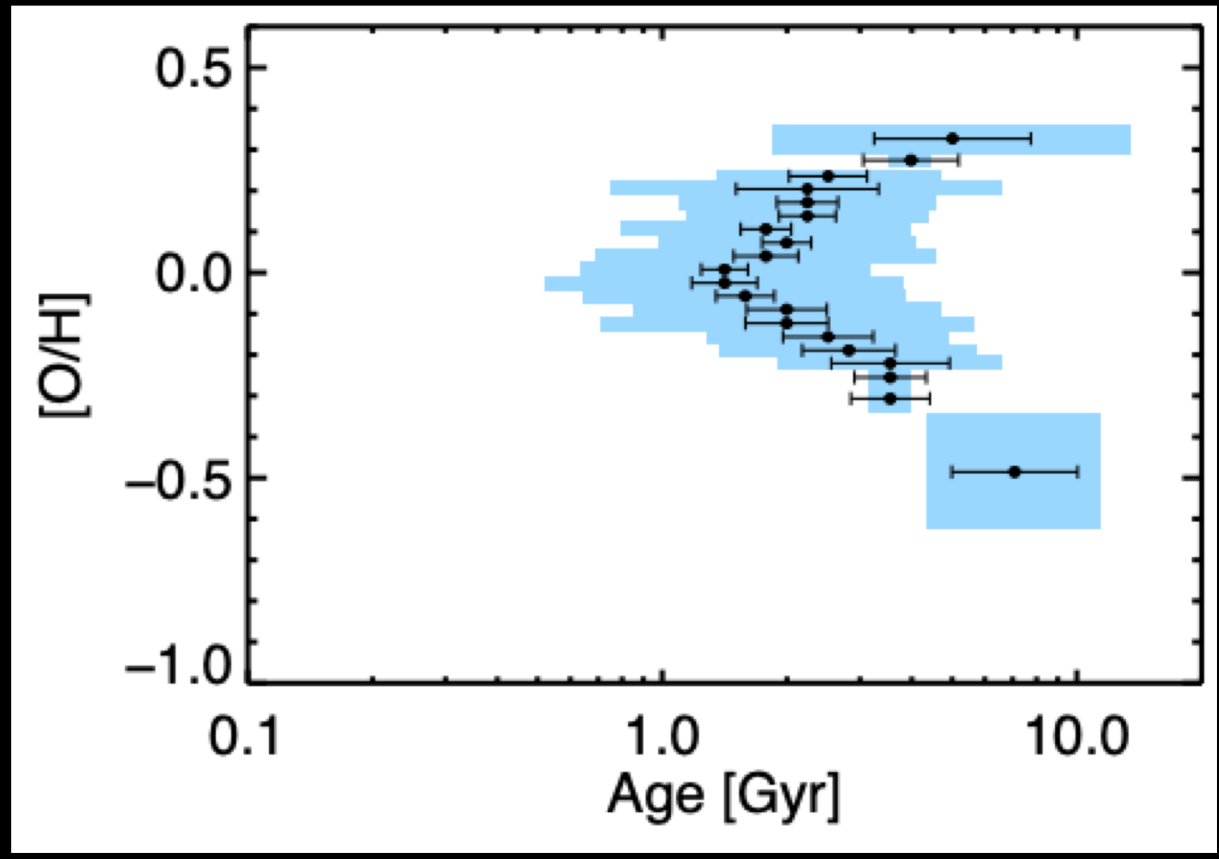


Young, α-rich stars in the solar neighborhood

- "Rejuvenated" old stars? (Jofré++16, Yong++16, Izzard++18, Silva-Aguirre++18, Miglio++21)
- Not all of them (Hekker+Johnson19)

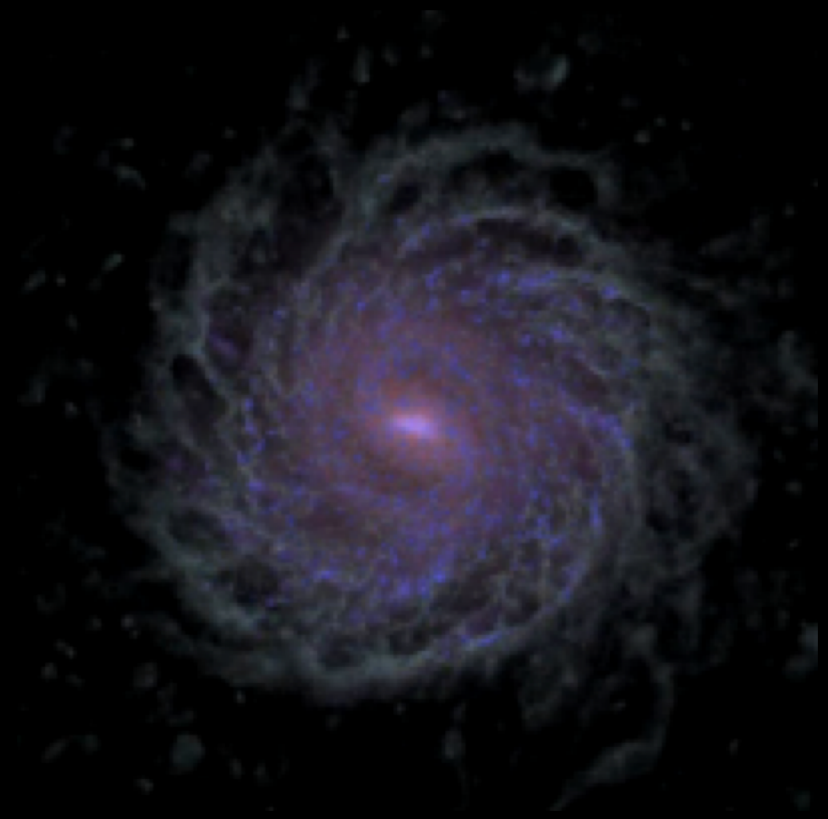
Age-Metallicity Relation non-monotonic (Feuillet++18)

- Migration of old, metal-rich stars born at small R_{gal} (Feuillet++18, Feuillet++19, Lu++21)



Left: Silva-Aguirre++18 Fig. 10; Right: Feuillet++18 Fig. 3

Multi-Zone + Hydro = Hybrid



Stellar Population forms at radius R, time T

1. Find *analog* that formed at similar R, T from *h277* (Christensen++2012 suite, N-body Shop)
2. Assume analog's ΔR and present-day |z|
3. Migrate to final R with $\sqrt{\tau}$-dependence
4. Eject nucleosynthetic products ***as they migrate***

Assume SFH, $\dot{\Sigma}_\star - \Sigma_g$ relation, yields, outflows, then compute abundances

We use dR = 100 pc rings from R = 0 to 20 kpc ran for T = 13.2 Gyr, ~2.1 million stellar populations

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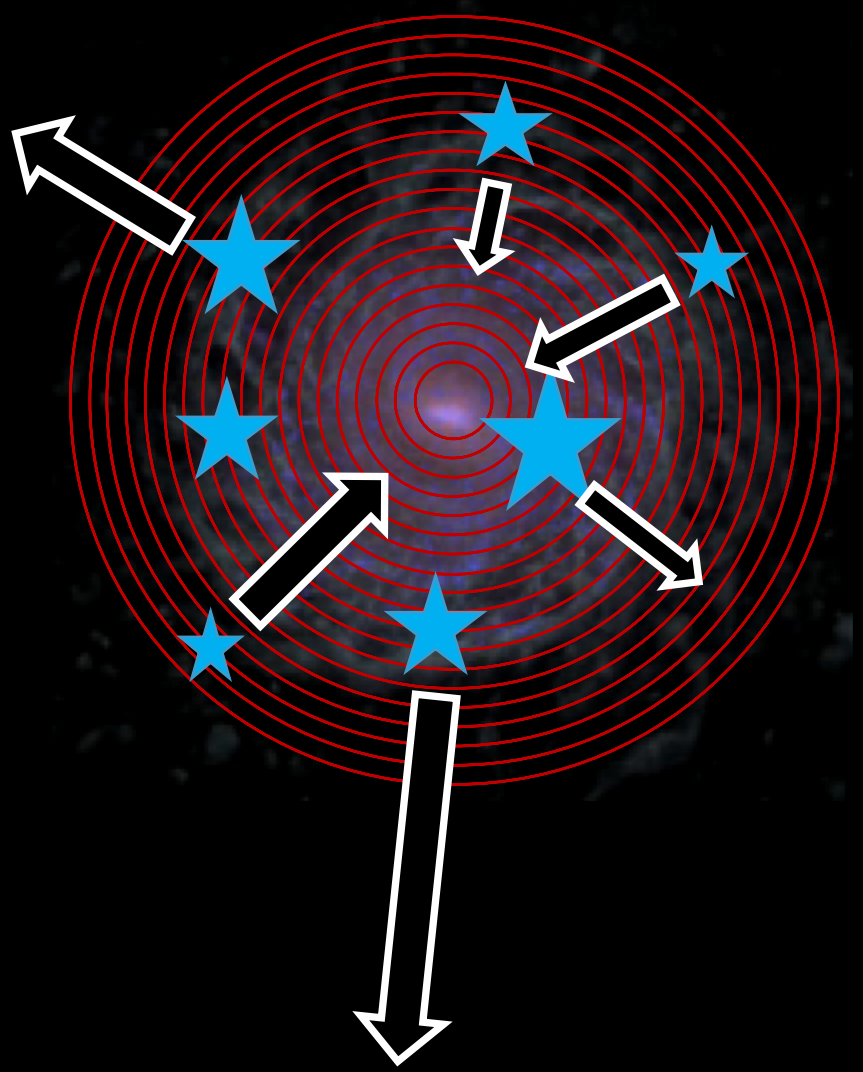

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VICE

Versatile Integrator for Chemical Evolution

vice 1.2.1

```
pip install vice
```

After installing: python3 -m vice [--tutorial] [--docs]

Single Stellar Populations
One-Zone Models
Multi-Zone Models
Calculate Yields

NASA ADS Johnson & Weinberg (2020) | NASA ADS Johnson et al. (2021) | NASA ADS Griffith et al. (2021)

Python 3.6 | 3.7 | 3.8 | 3.9 | PyPI v1.2.1 | License MIT

GitHub CI passing | docs passing | issues 0 open

Join Slack

VICE is a user-friendly python package designed to model chemical enrichment in galaxies.

- 77 elements on the periodic table
- Fast integration of one-zone models
- Enrichment from single stellar populations
- Highly flexible nucleosynthetic yield calculations
- ***User-defined mathematical forms describing:***
  - Nucleosynthetic yields in simulations
  - Mixing processes in multi-zone models
  - Infall and star formation histories
  - The stellar initial mass function
  - The star formation law
  - Element-by-element infall metallicities
  - Type Ia supernova delay-time distributions

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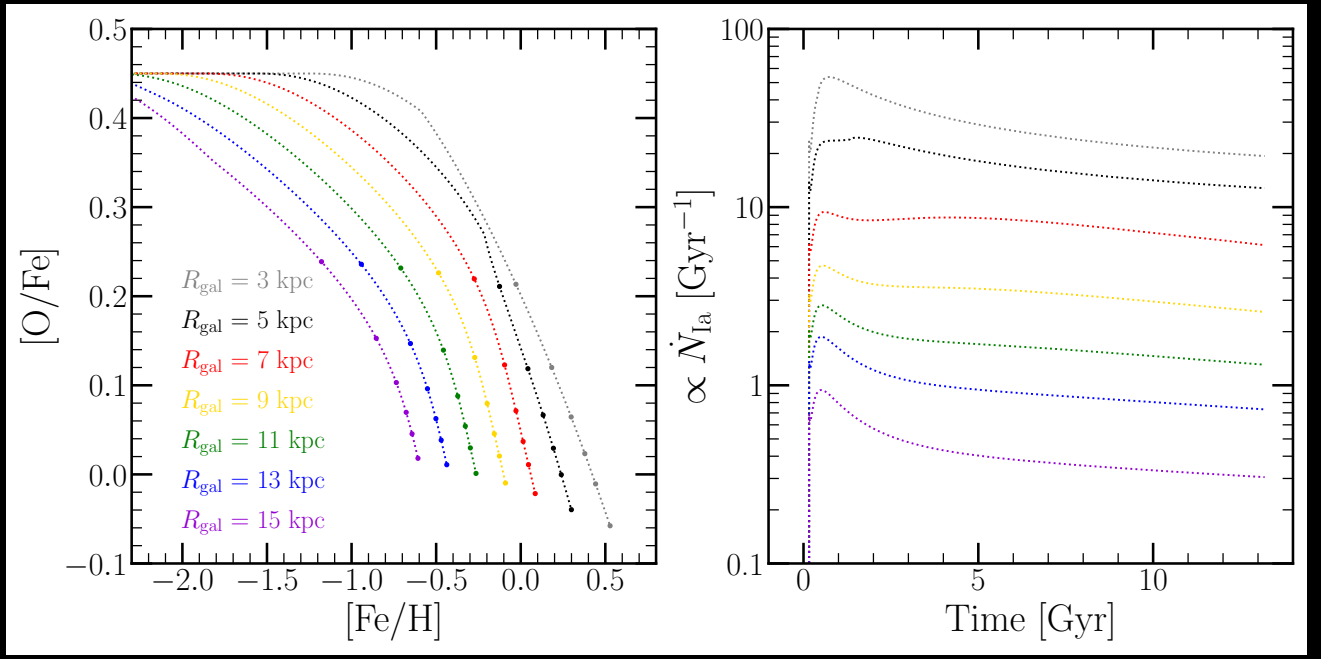
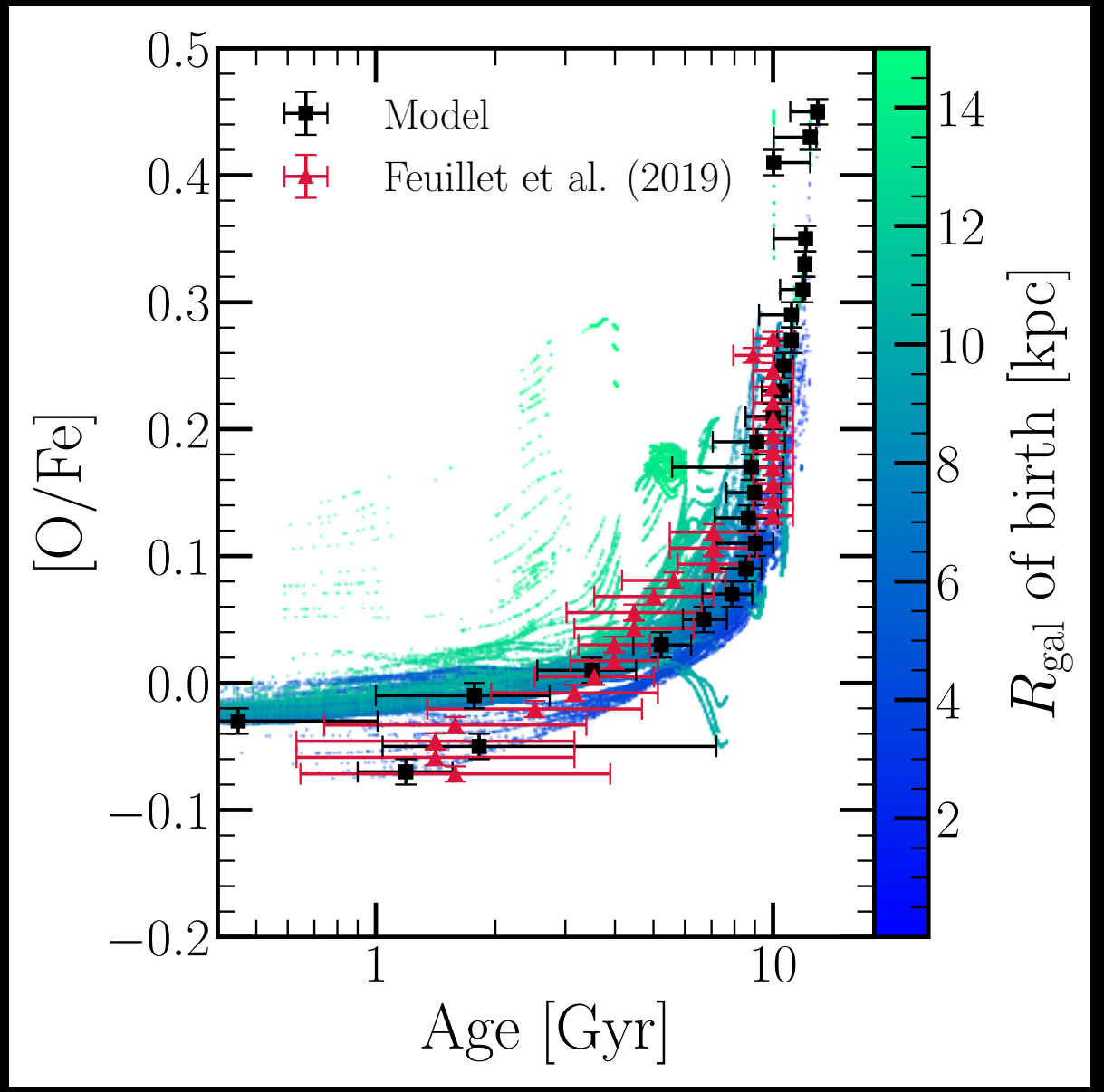
Age-[α/Fe]: The Impact of Stellar Migration

Model predicts young, α-enhanced stars in the solar neighborhood that migrated from large R



Under these models the SN Ia rate fluctuates, causing Fe-poor/rich ISM. Stars inherit these compositions, then migrate to inward



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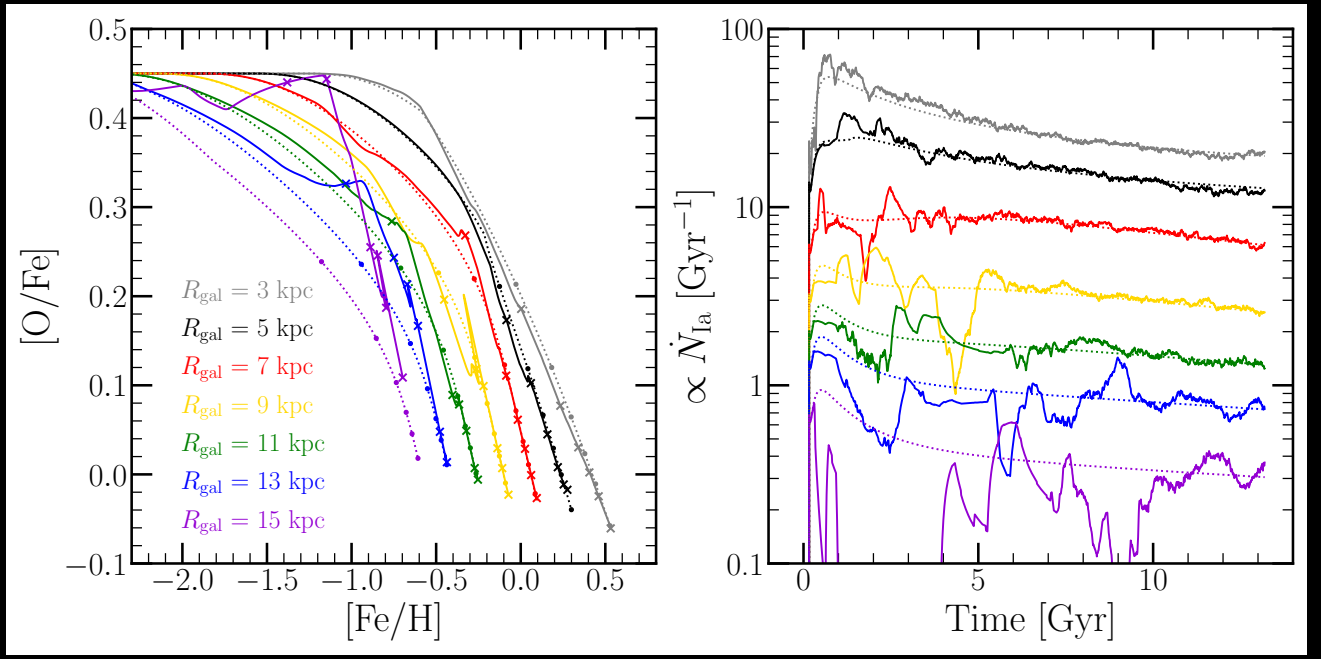

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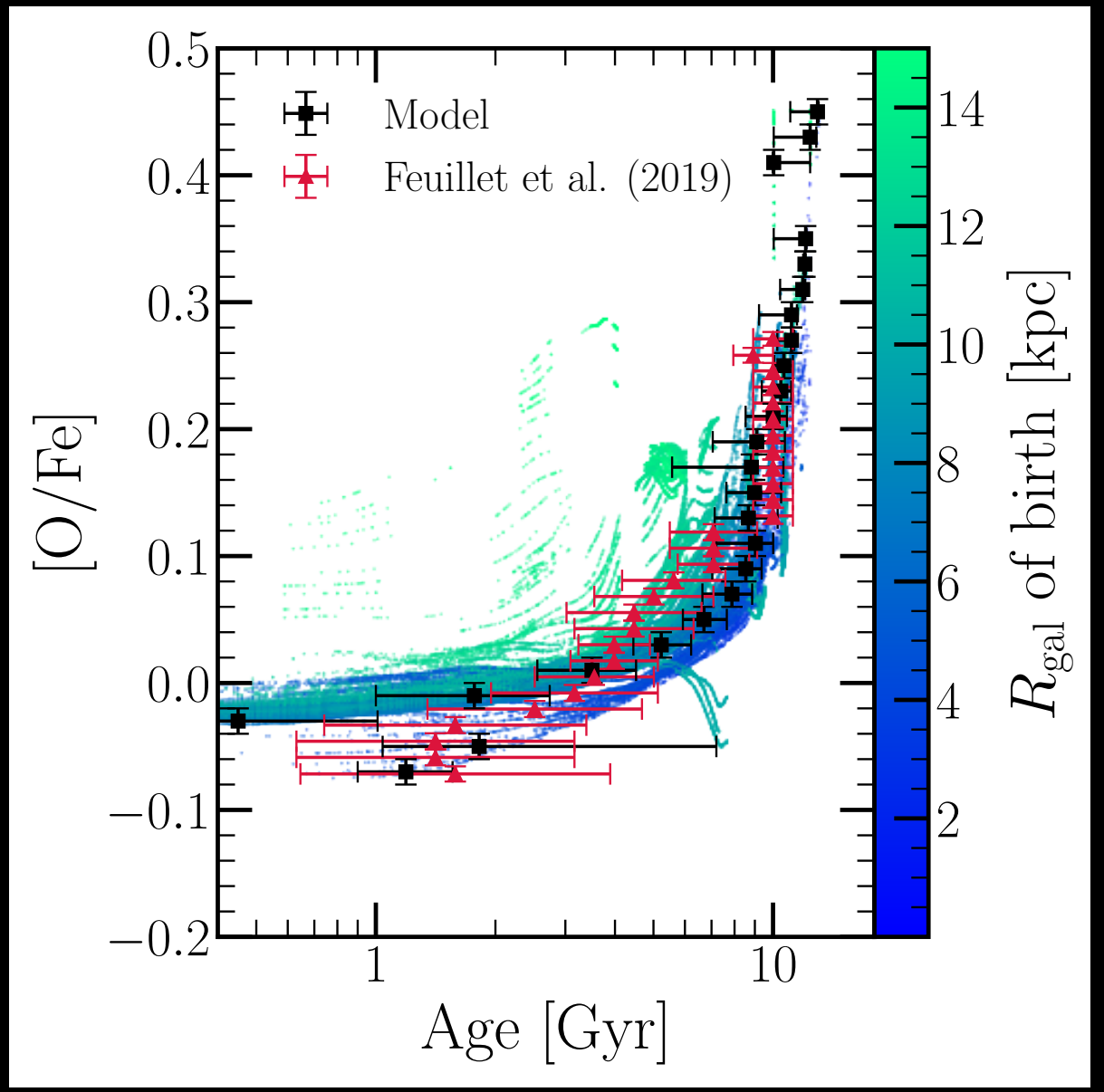
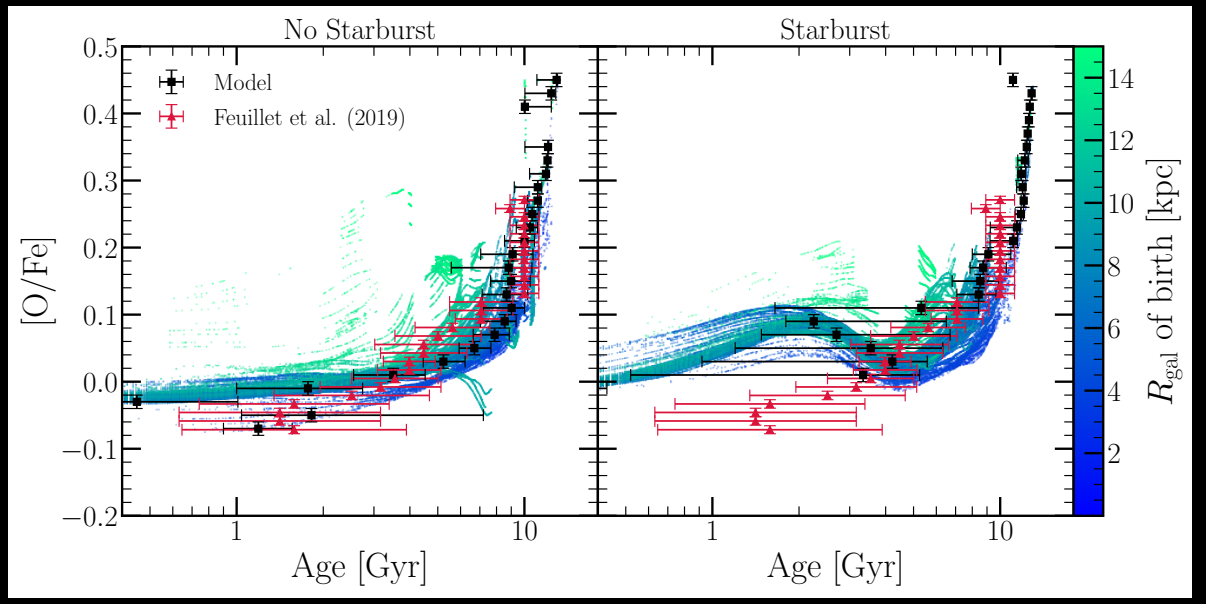


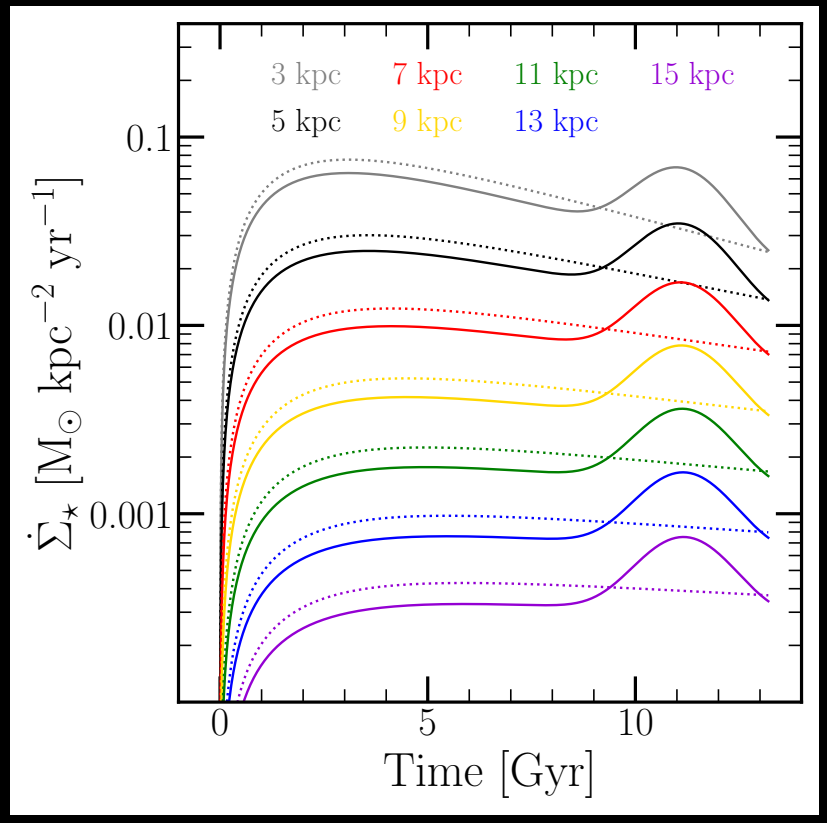
The Impact of the SFH

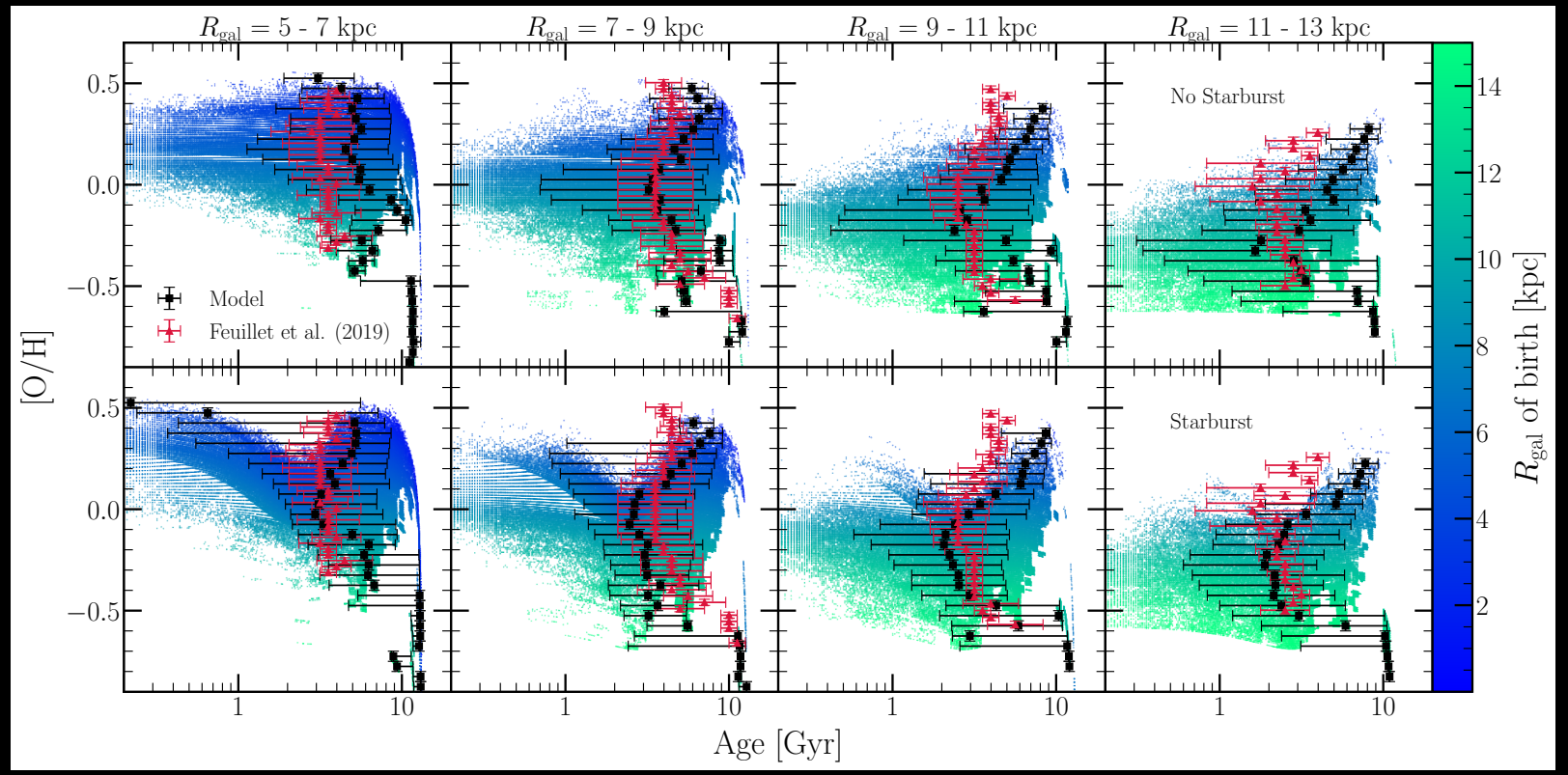
The starburst models:

1. Predict substantial α-enhancement for young stars
2. Better reproduce C-shaped age-[O/H] relation

Different observables favor different models







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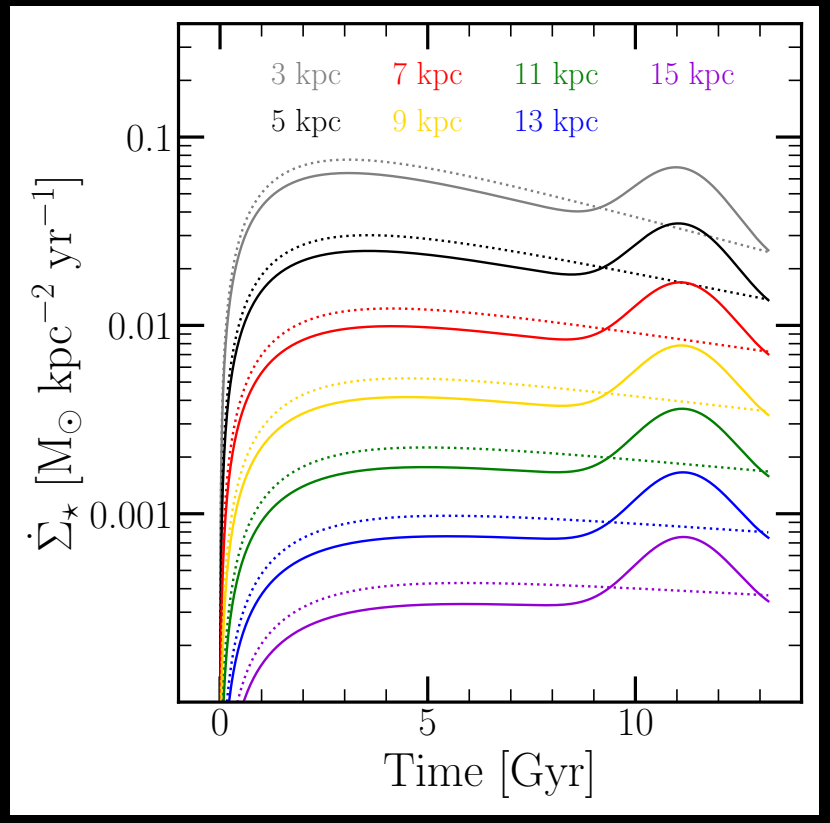

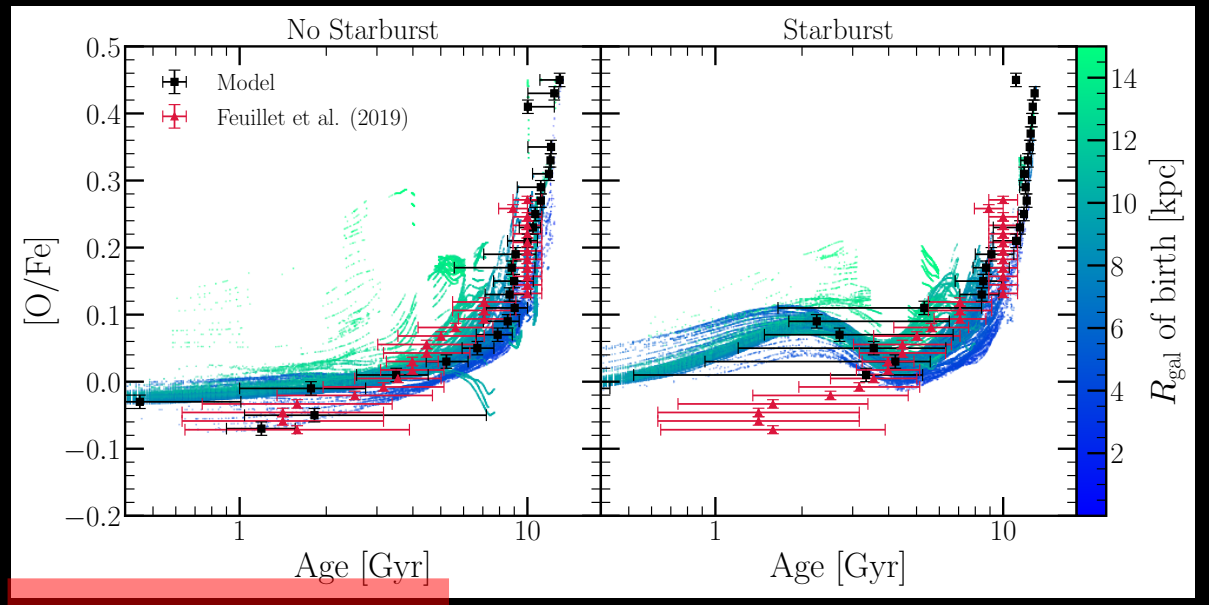

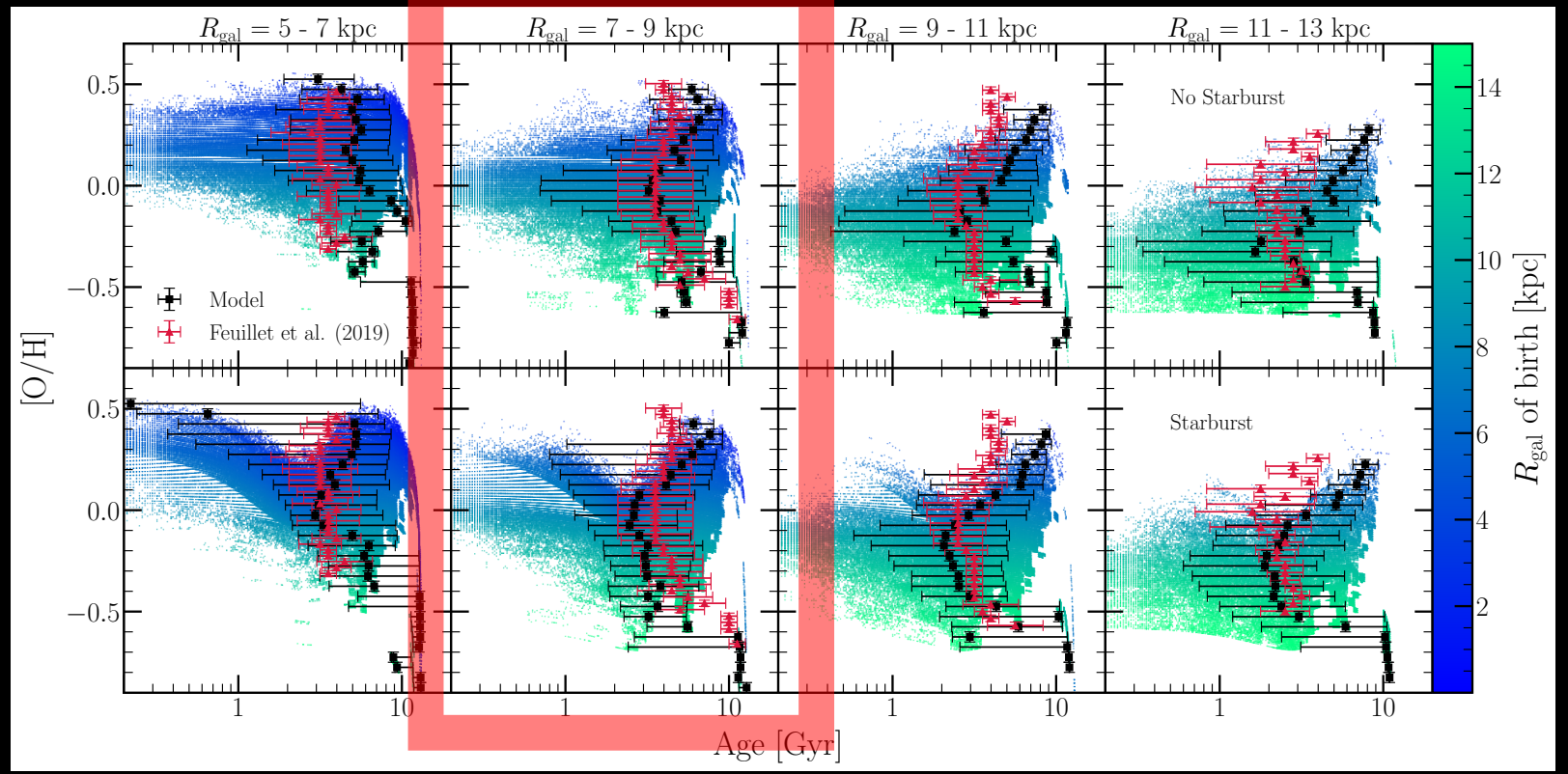

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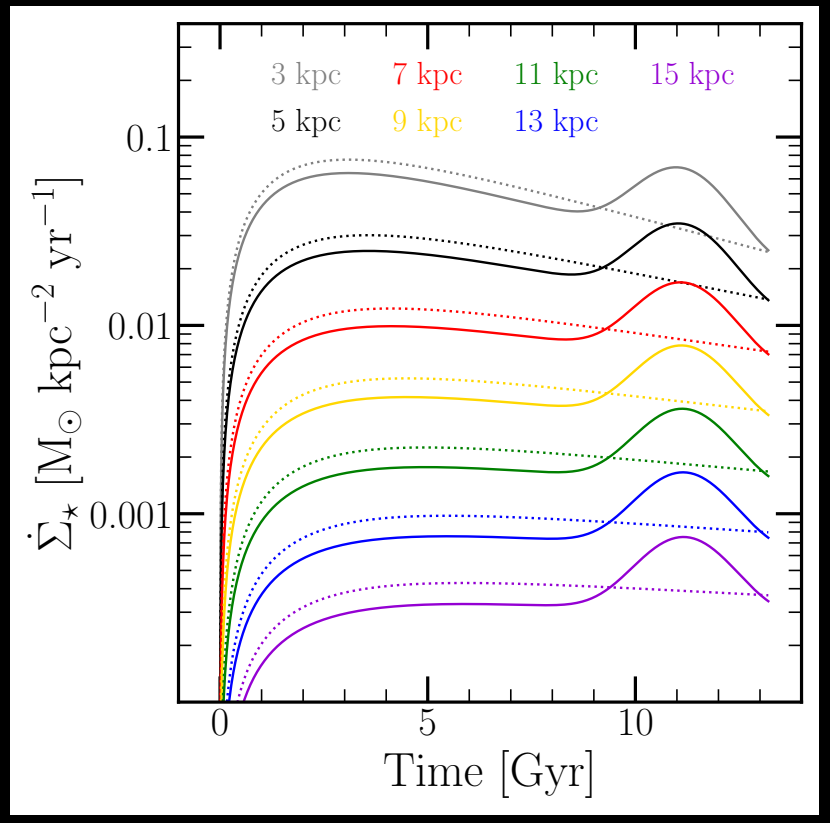

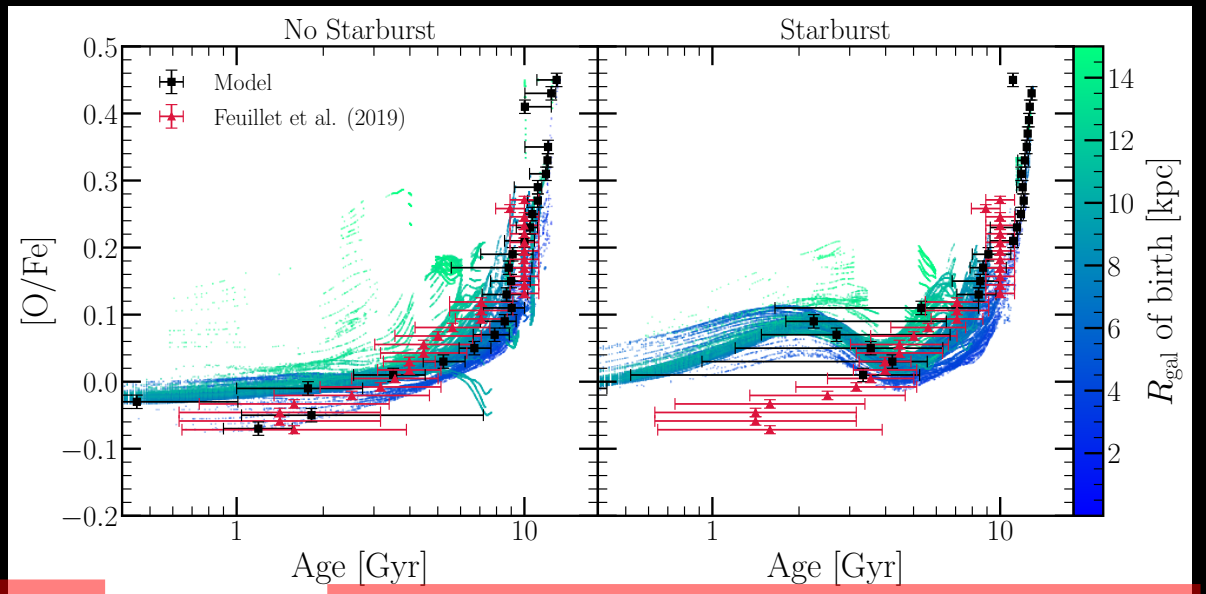

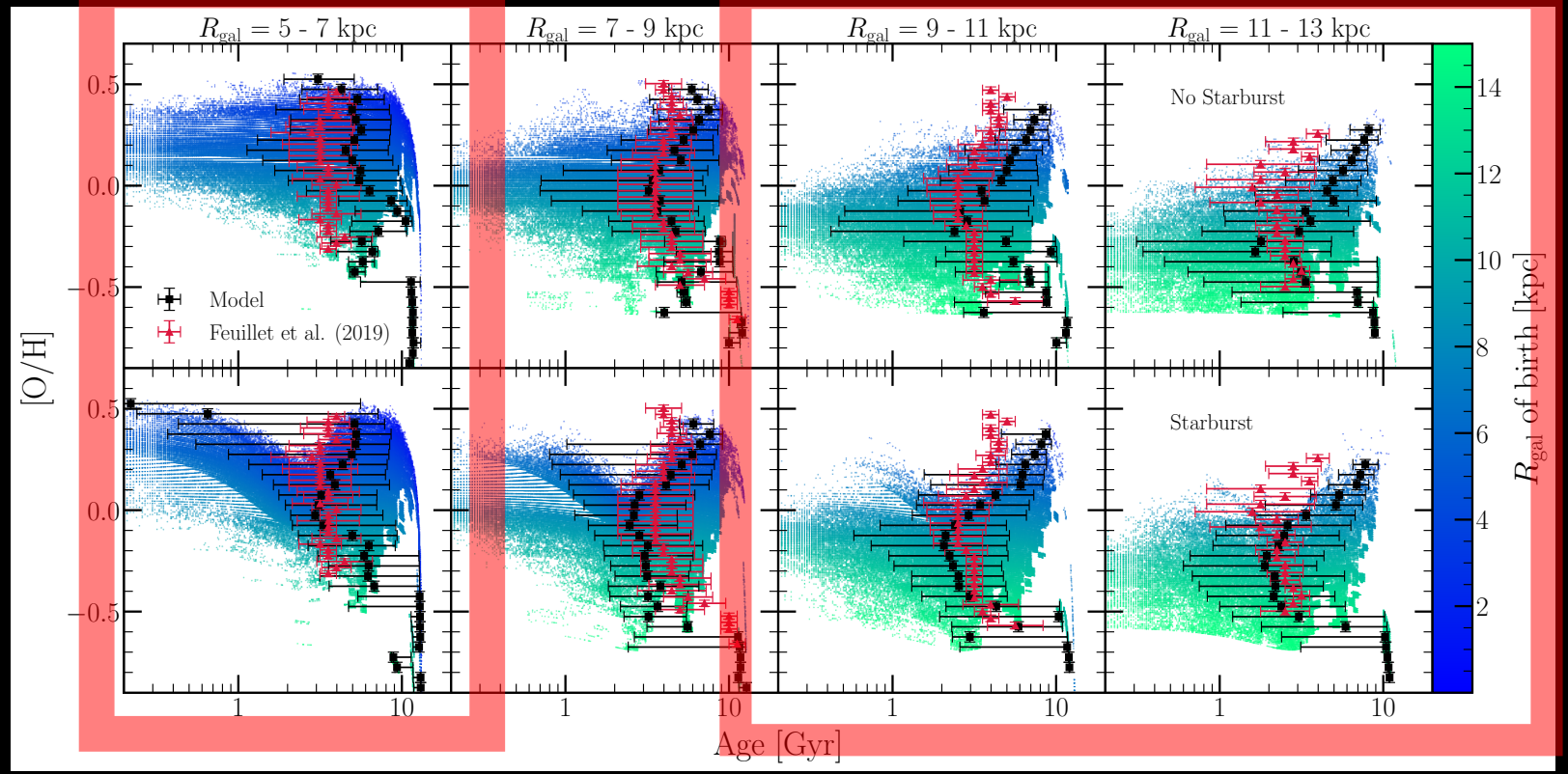

Conclusions

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Young, α-rich stars in solar neighborhood

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Additionally: (arxiv:2103.09838)

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- Intrinsic scatter in age-[O/H], age-[Fe/H], age-[O/Fe] relationships

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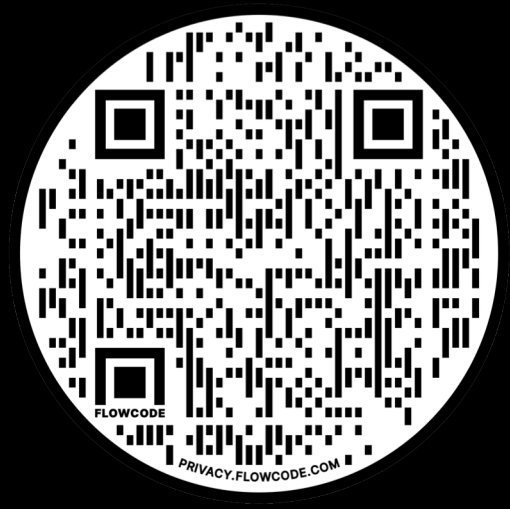
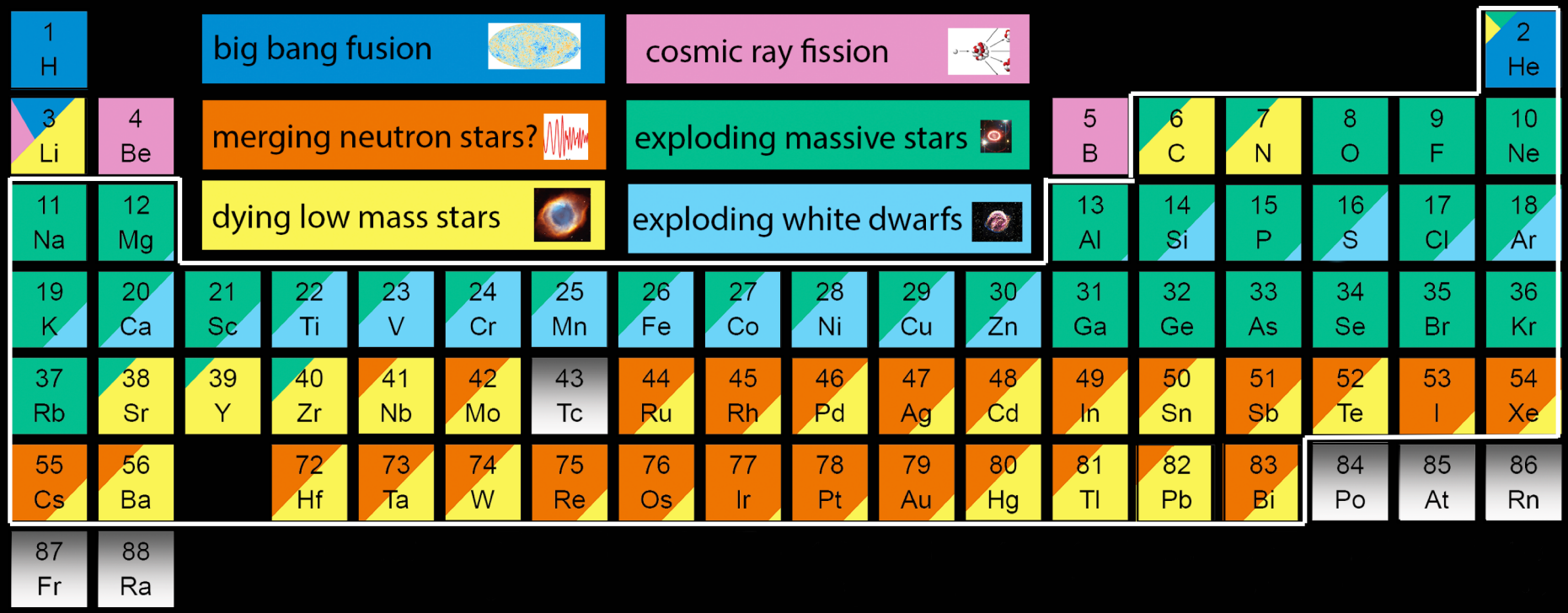
VICE is publicly available! (pip install vice)

- If it can't handle your model, I'm interested in updating it so that it can
- Don't hesitate to ask for help

Join us on Slack!



The Origin of the Solar System Elements



Graphic created by Jennifer Johnson
http://www.astronomy.ohio-state.edu/~jaj/nucleo/

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