Core-Collapse Supernova Yields for Galactic Chemical Evolution

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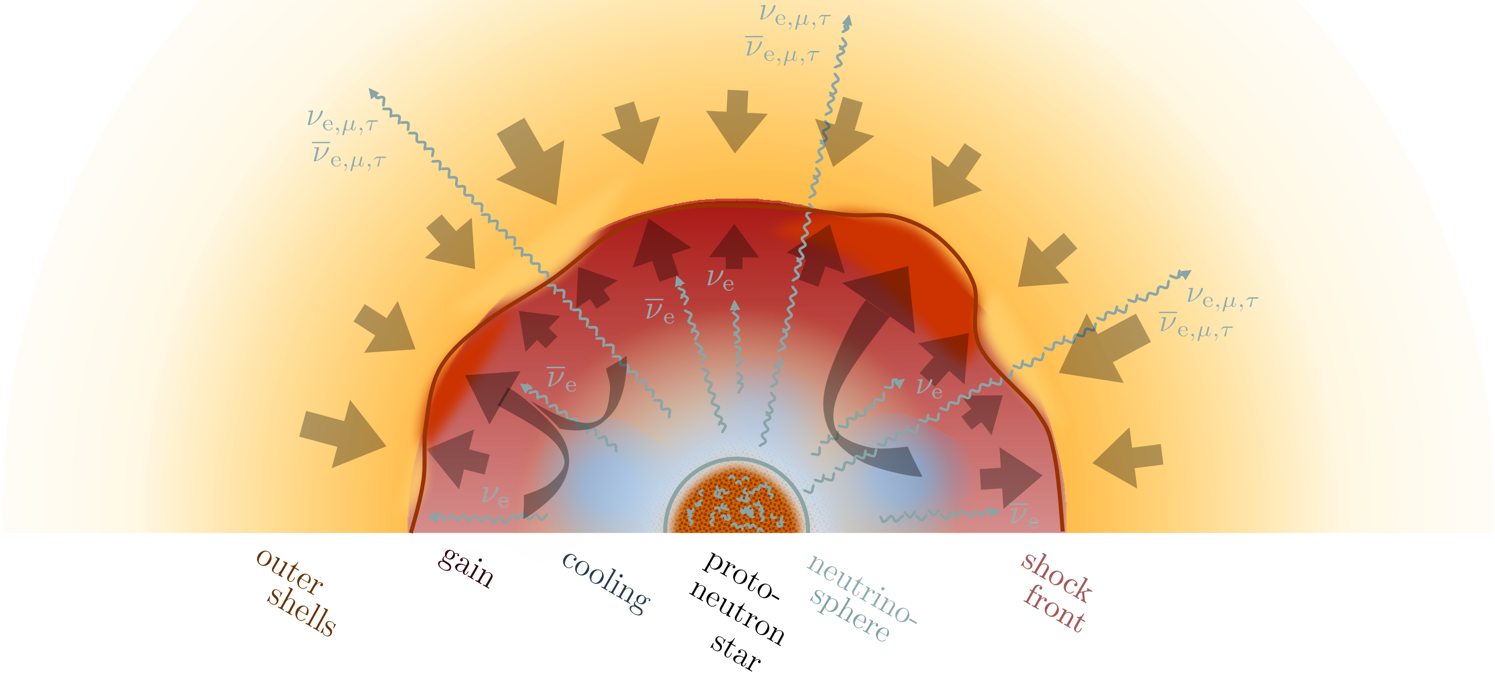
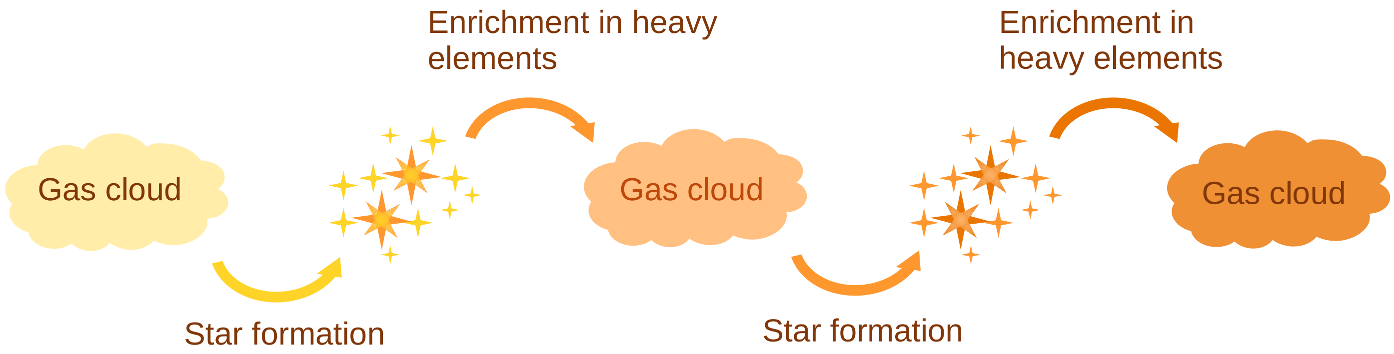
Core-Collapse Supernova

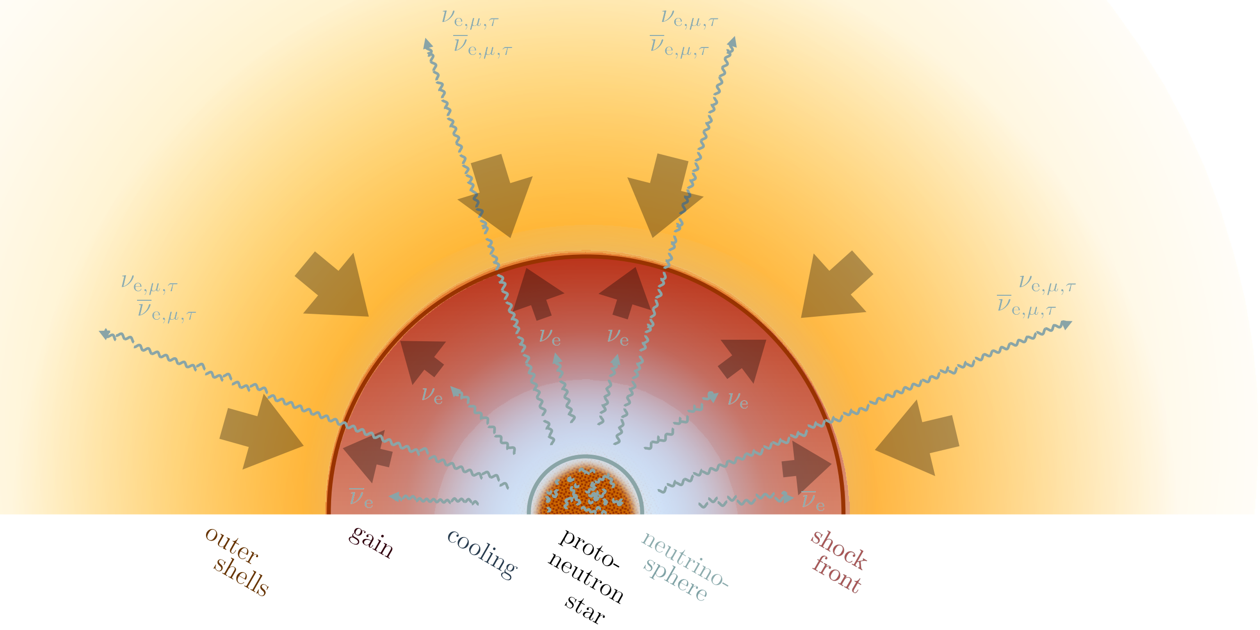


Galactic Chemical Evolution

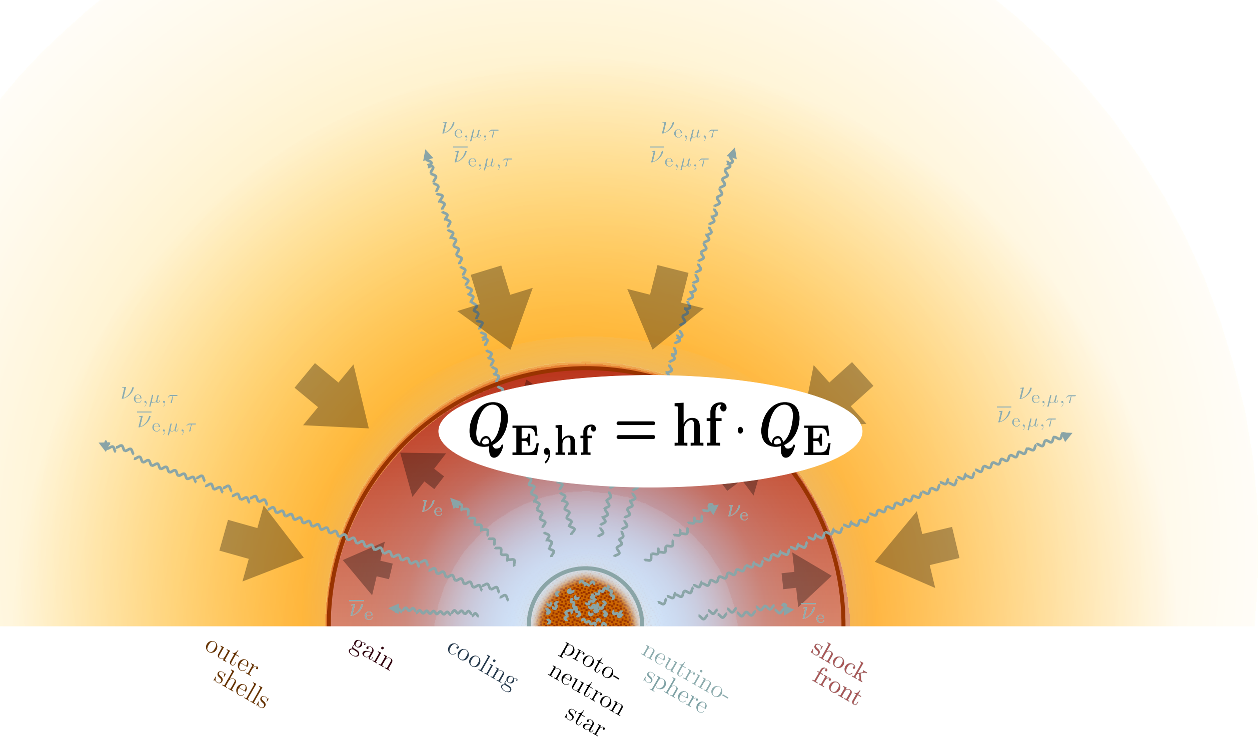


[adapted from B. Côté]

Studies in Spherical Symmetry

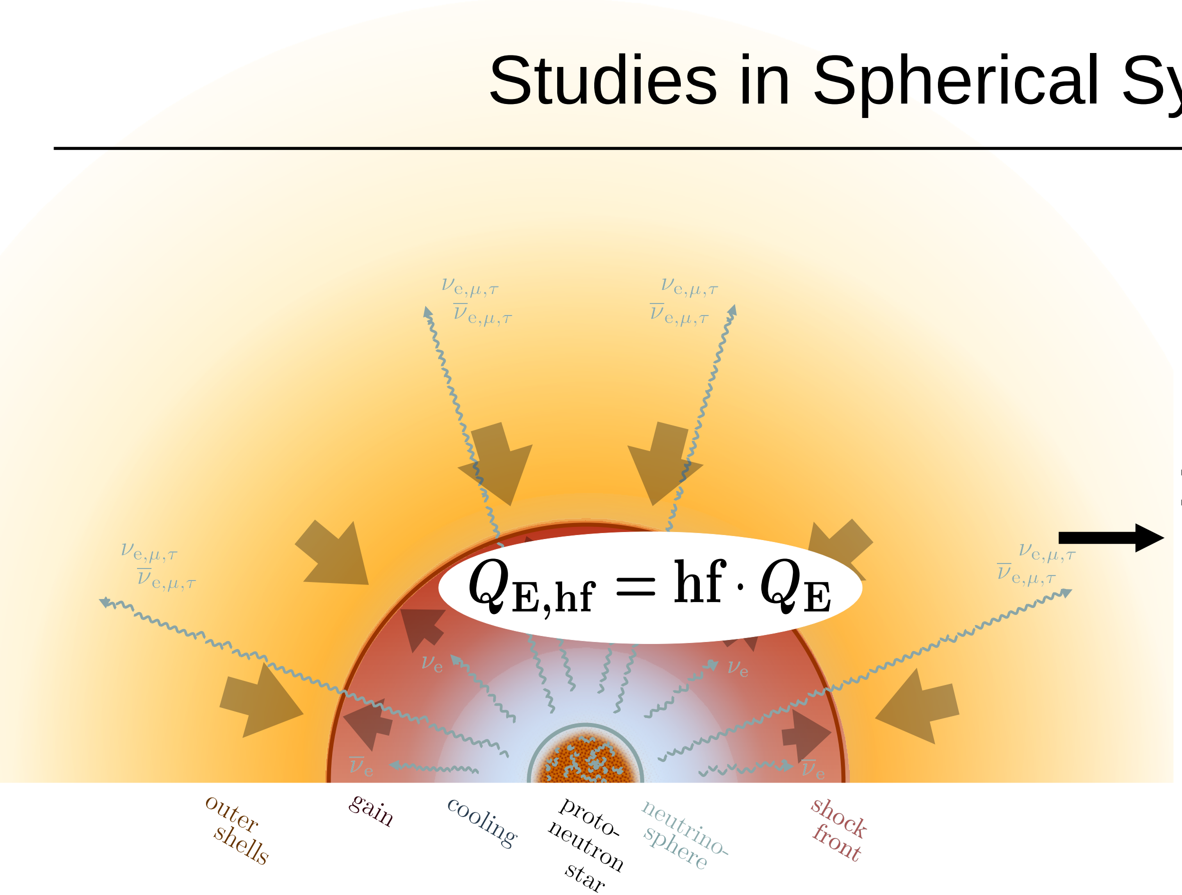


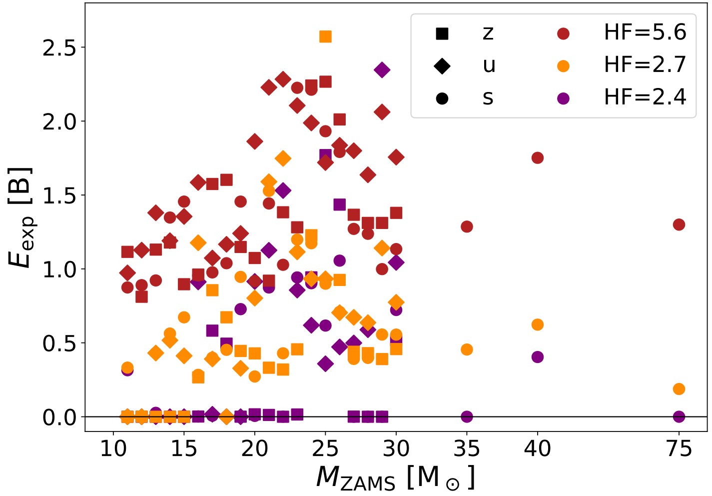
Studies in Spherical Symmetry



$$Q_{\mathrm{E,hf}} = \mathrm{hf} \cdot Q_{\mathrm{E}}$$

Studies in Spherical Symmetry

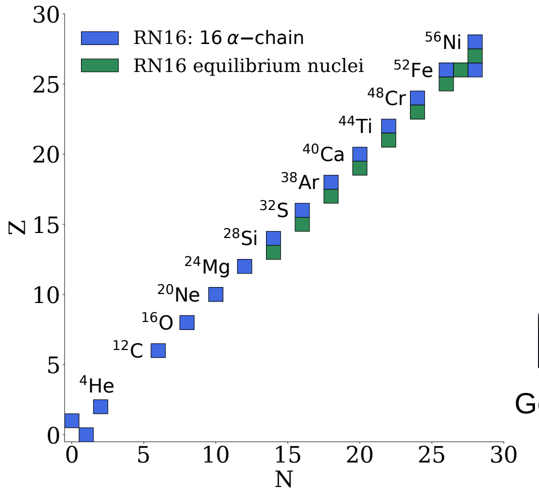




Simulation Setup

- Aenus-Alcar
  (Just et al. 2015, Reichert et al. 2022)
- 189 simulations in 1D
- Two-moment neutrino treatment (M1)
- Nuclear equation of state SFHo
  (Steiner et al. 2013)
- Variation of heating factor to estimate uncertainties

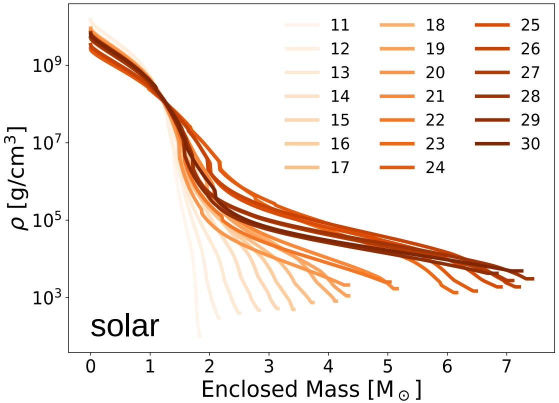
- Reduced nuclear reaction network including 16 alpha-chain isotopes
  (Navó et al. 2023)

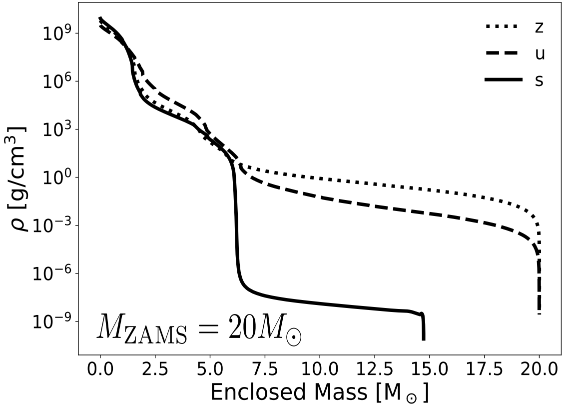


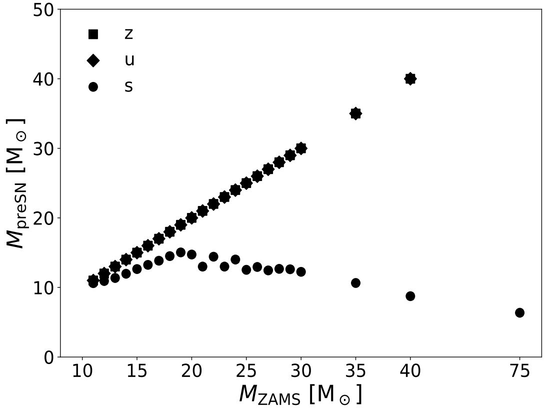
Gerard Navó

Stellar Models

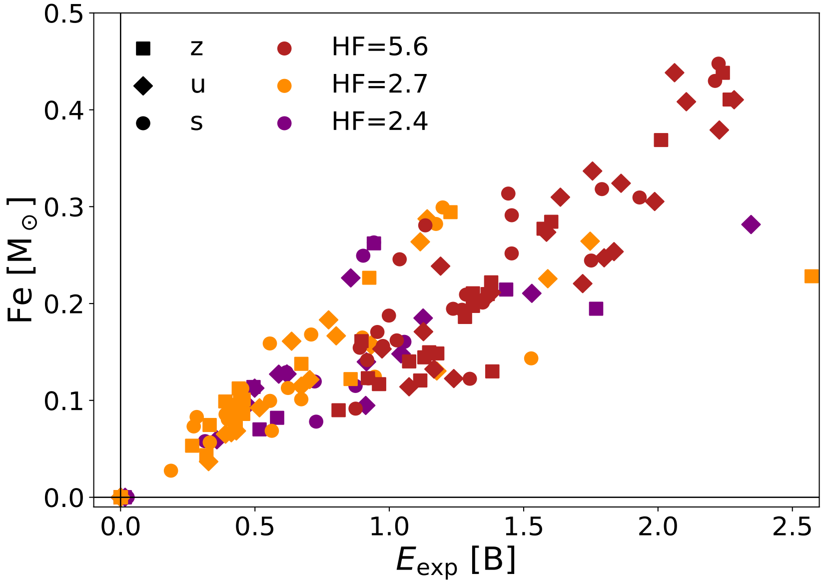
- 63 non-rotating progenitors of Woosley et al. 2002
- Zero-age main sequence (ZAMS) masses of 11−40 $M_\odot$ and 75 $M_\odot$
- Metallicity: primordial (z), 10^{-4} solar (u) and solar (s)



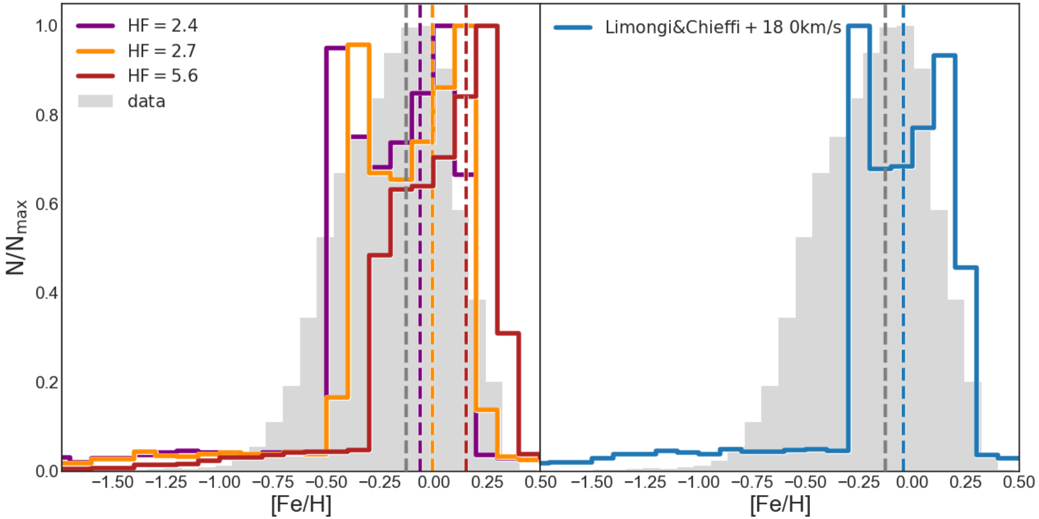




Correlation of Iron Yield with Explosion Energy

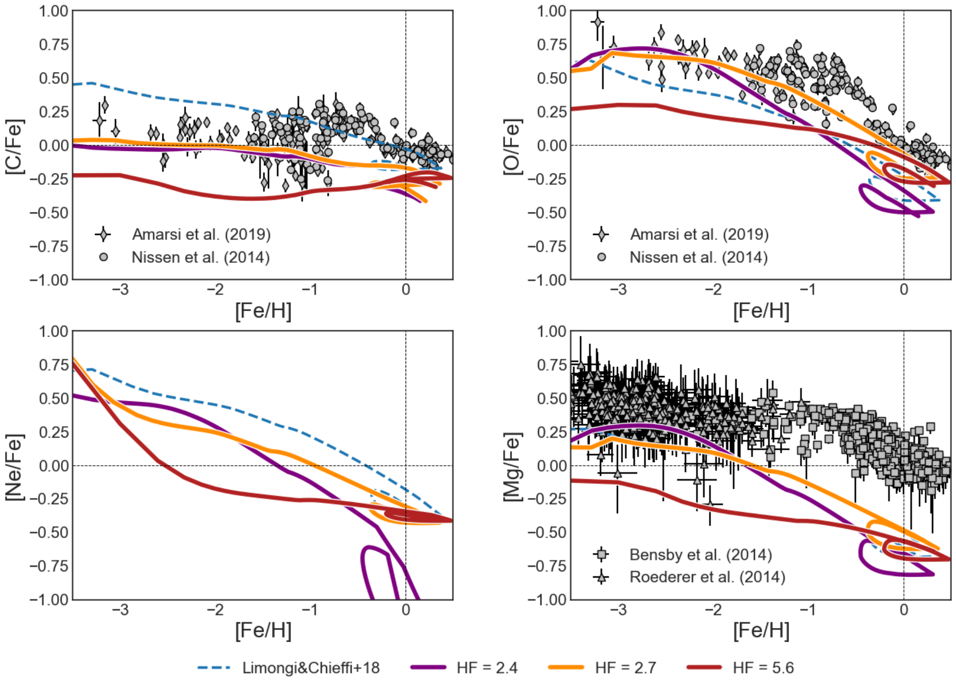


Metallicity distribution function



Bracket notation: $[\mathrm{Fe/H}] = log\left(N_{\mathrm{Fe}}/N_{\mathrm{H}}\right)_{\star} - log\left(N_{\mathrm{Fe}}/N_{\mathrm{H}}\right)_{\odot}$

Carbon, Oxygen, Neon, and Magnesium



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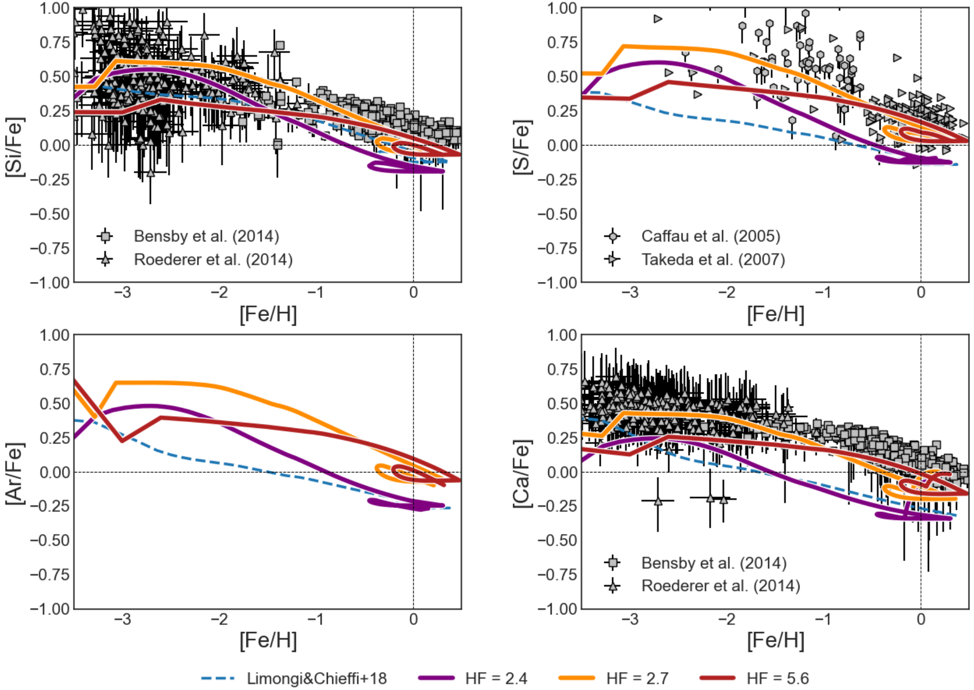
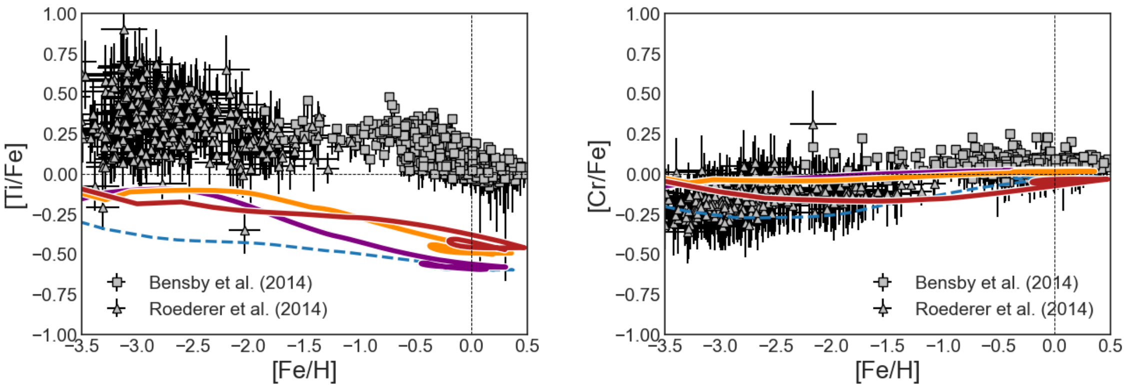
Silicon, Sulfur, Argon, and Calcium



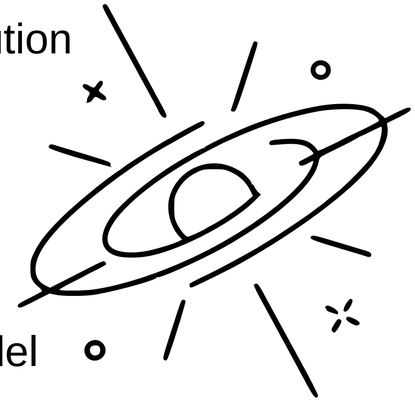
Titanium and Chromium



Summary and Outlook

- Nucleosynthesis from CCSNe is crucial input to galactic chemical evolution
- 189 simulations in spherical symmetry using a heating factor
- Variation of free parameters estimates uncertainties

  $\longrightarrow$ Choice of calibration has a significant impact on GCE
- All studied elements compare well to observations and/or previous model

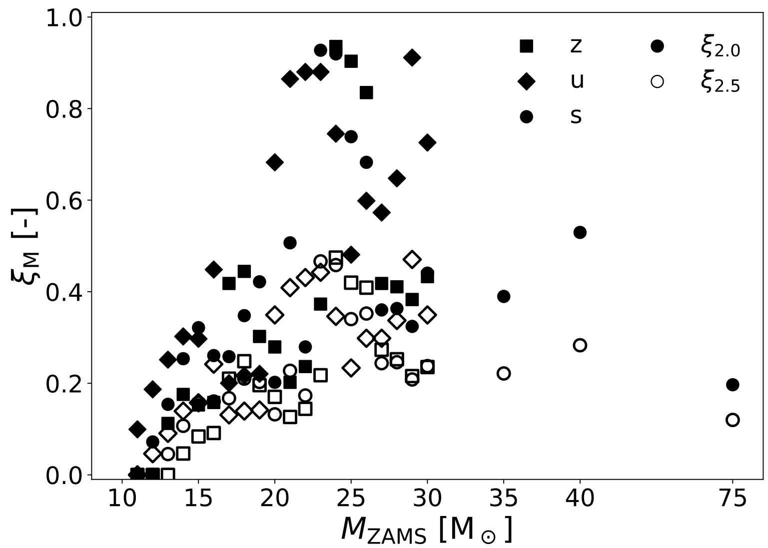


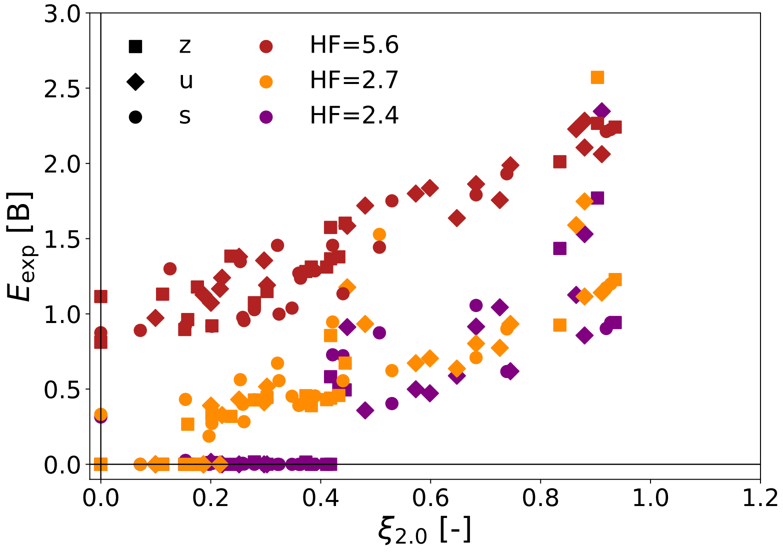
Next step: Create database with stellar yields for GCE using recent advances in stellar evolution and CCSN simulations

paper in preparation

Compactness

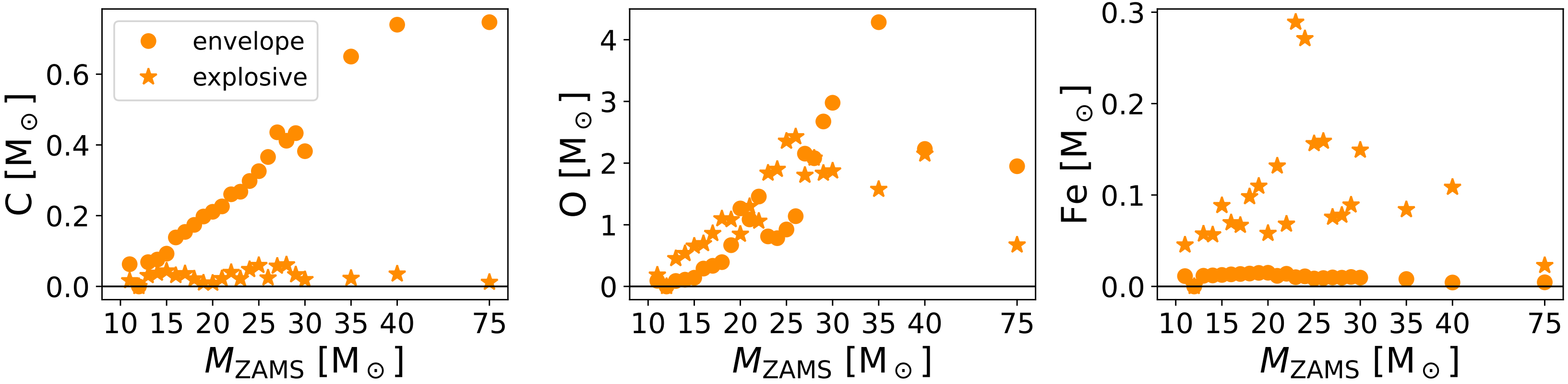
$$\xi_{\mathrm{M}} = \frac{M/M_\odot}{R(M_{\mathrm{bary}} = M)/1000}\Big|_{t=t_{\mathrm{bounce}}}$$ (O'Connor and Ott 2011)





Yields for GCE

$$M_{\mathrm{net},i} = M_{\mathrm{explosive},i} + M_{\mathrm{envelope},i} + M_{\mathrm{wind},i} - M_{\mathrm{ZAMS},i}$$



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Galactic Chemical Evolution Model

star formation rate depends on star formation efficiency and surface gas density

$$\dot{G}_i(R,t) = \dot{G}_{\text{infall},i}(R,t) - \Psi(R,t)X_i(R,t) + R_i(R,t)$$

gas accretion rate has one or two exponentially declining infall episodes

matter is restored to the interstellar medium through stellar winds, supernova explosions, novae and merging neutron stars

Molero et al. 2023