Chemical structure of the galactic wind launching zone

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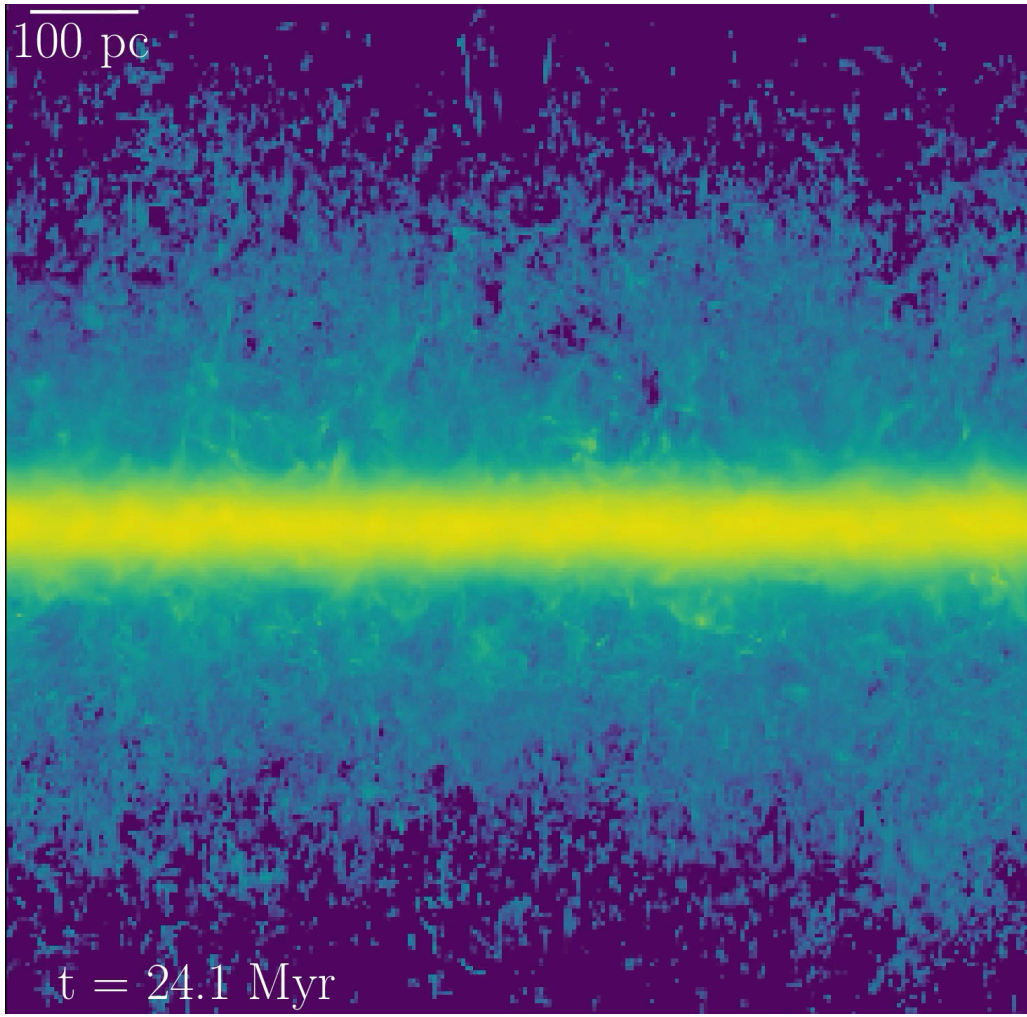

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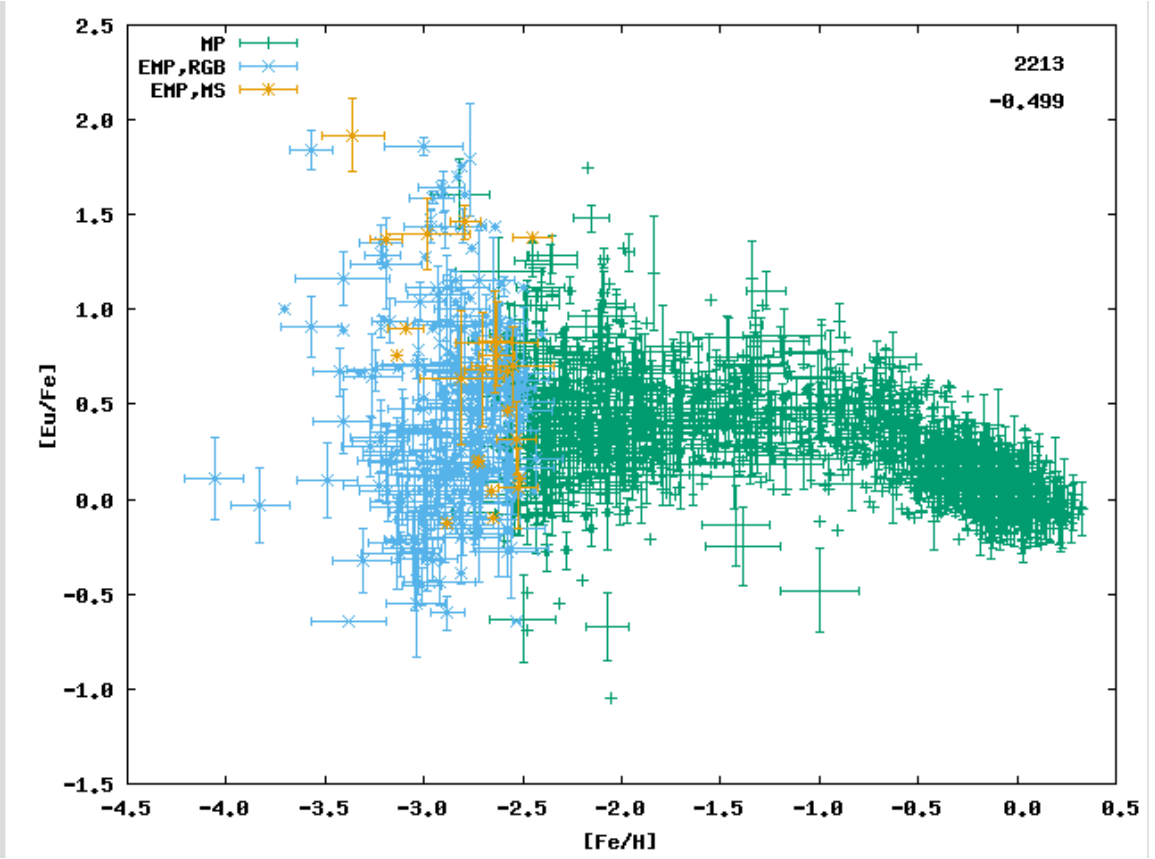
Modelling r-process

- Highly r-process enriched, metal-poor stars in the MW halo are possibly accreted from satellite galaxies
- The mass loss from small galaxy systems could be problematic in this connection.

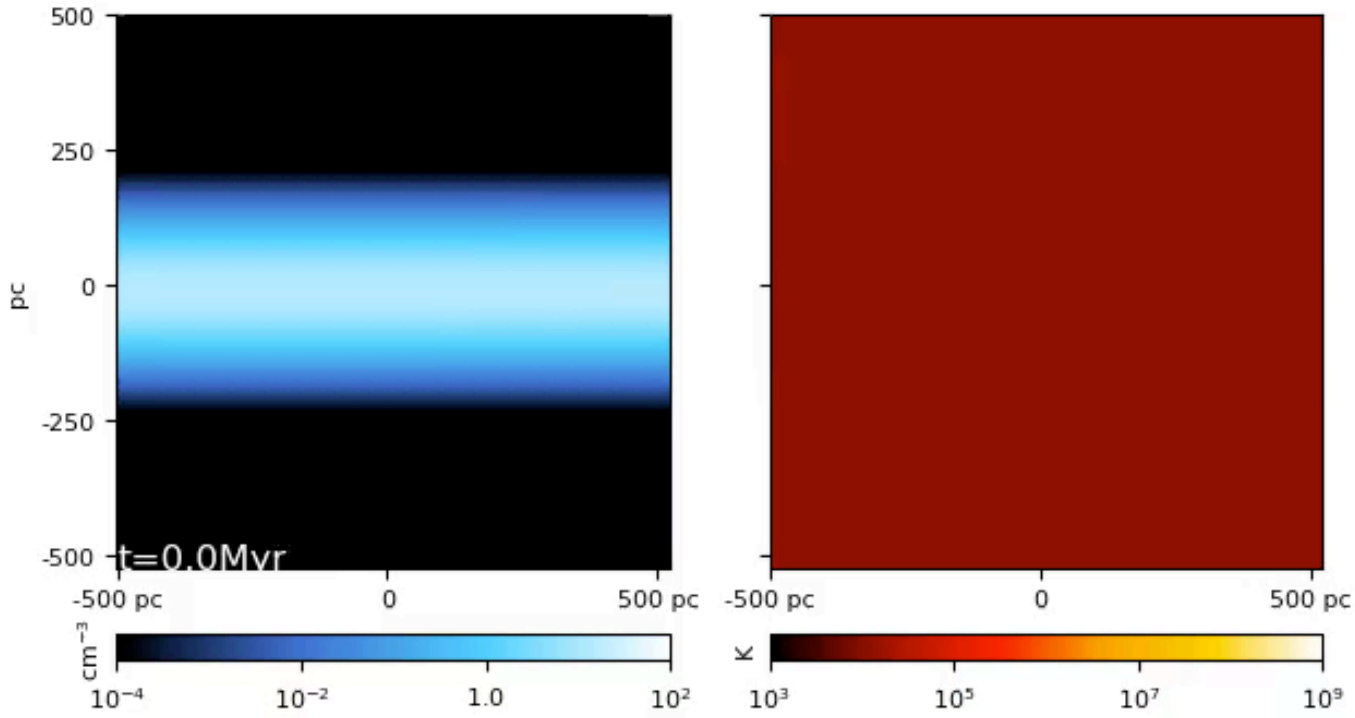
SAGAbase pull on Sep 5th 2023



e.g. Robertson et al 2008, Brauer et al 2019, Naidu et al 2020

The wind launching zone

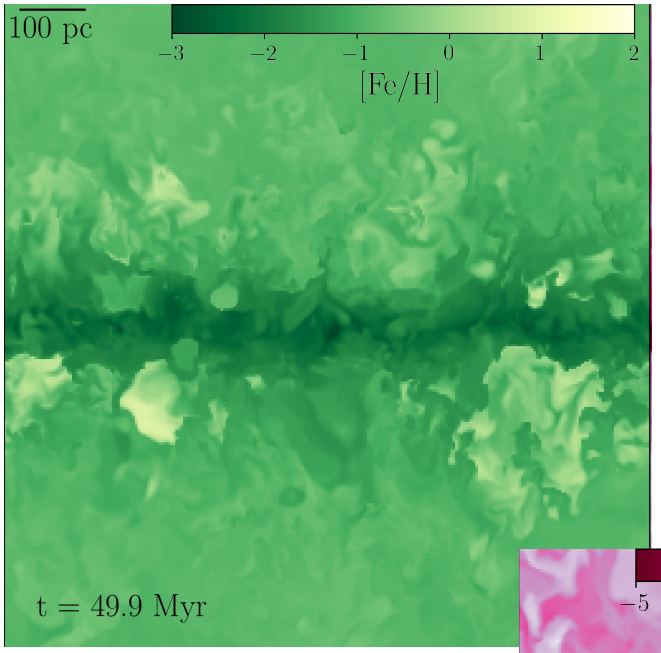
- Studying wind launching by core collapse supernovae
- In patches of galactic disks
- Focused on the chemical structure of the winds as they launch

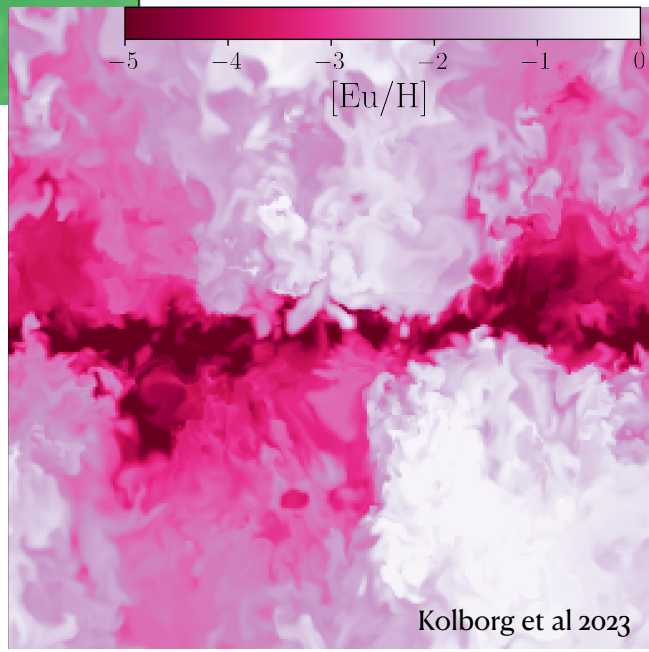


Kolborg et al 2022, Martizzi et al 2016

Chemical structure

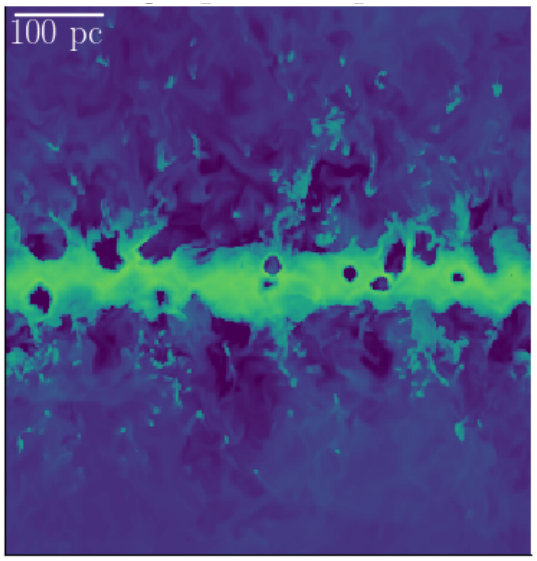
- Metals are tracked on the fly
- Iron group elements from core collapse supernovae
- R-process elements from NSM-like rare events





Galaxy models

Ultra Milky Way



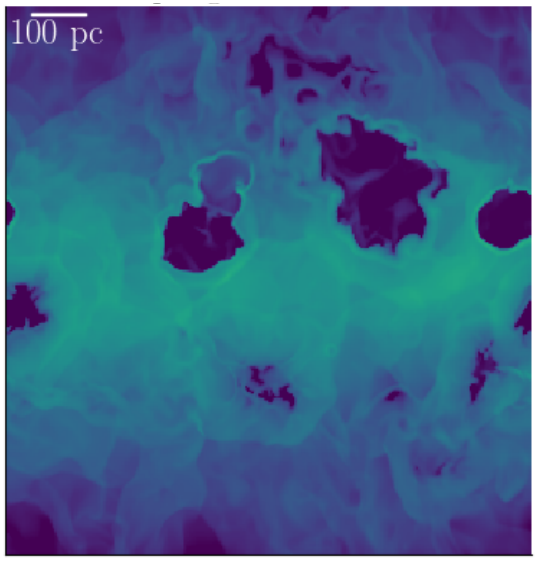
High gas density

$n_{\rm H} \approx 20/{\rm cm}^3$

High SFR

$\Sigma_{\rm SFR} = 30{,}000 M_\odot/{\rm kpc}^2/{\rm Myr}$

Milky Way



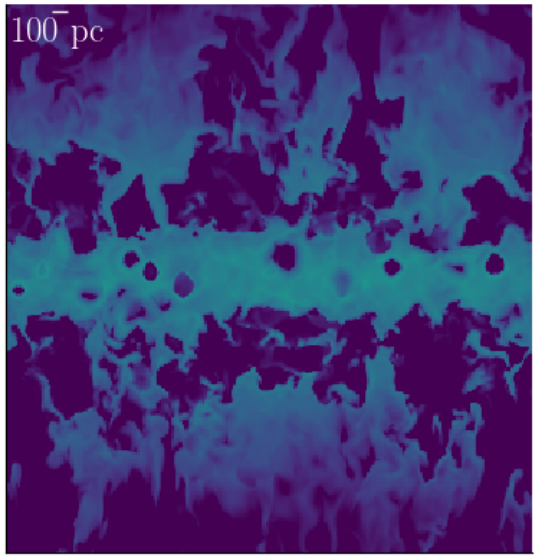
Lower gas density

$n_{\rm H} \approx 1.5/{\rm cm}^3$

Lower SFR

$\Sigma_{\rm SFR} = 1{,}000 M_\odot/{\rm kpc}^2/{\rm Myr}$

Satellite



Low gas density

$n_{\rm H} \approx 0.5/{\rm cm}^3$

Low SFR

$\Sigma_{\rm SFR} = 800 M_\odot/{\rm kpc}^2/{\rm Myr}$

van Dokkum et al 2013, Shen et al 2015, Martizzi et al 2016, Deason et al 2016, Naiman et al 2018, Wang et al 2021

Wind loading factors

$$\eta_M(z) = \frac{\dot{M}_{\rm out}(z)}{\rm SFR}$$

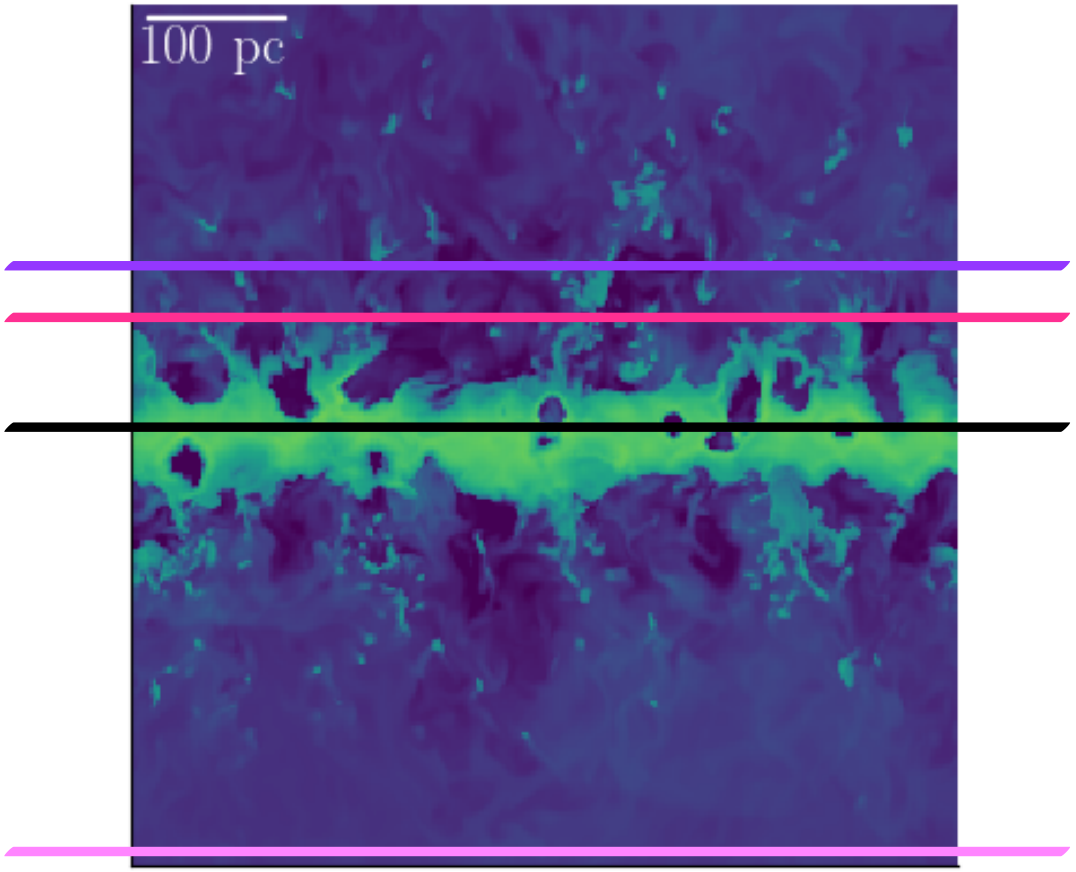
$$\eta_{Z_i} = \frac{\dot{M}_{Z,i}(z)}{\dot{M}_{Z_i,\rm inj}} = \frac{\dot{M}_{Z,i}(z)}{\dot{n}_{\rm SNe} M_{\rm ej} y_{Z_i} f_{p,Z_i}}$$

Flux through:

3 gassous scale heights

2 supernovae scale heights (~4 gaseous scale heights)

1 cell away from the edge of the box

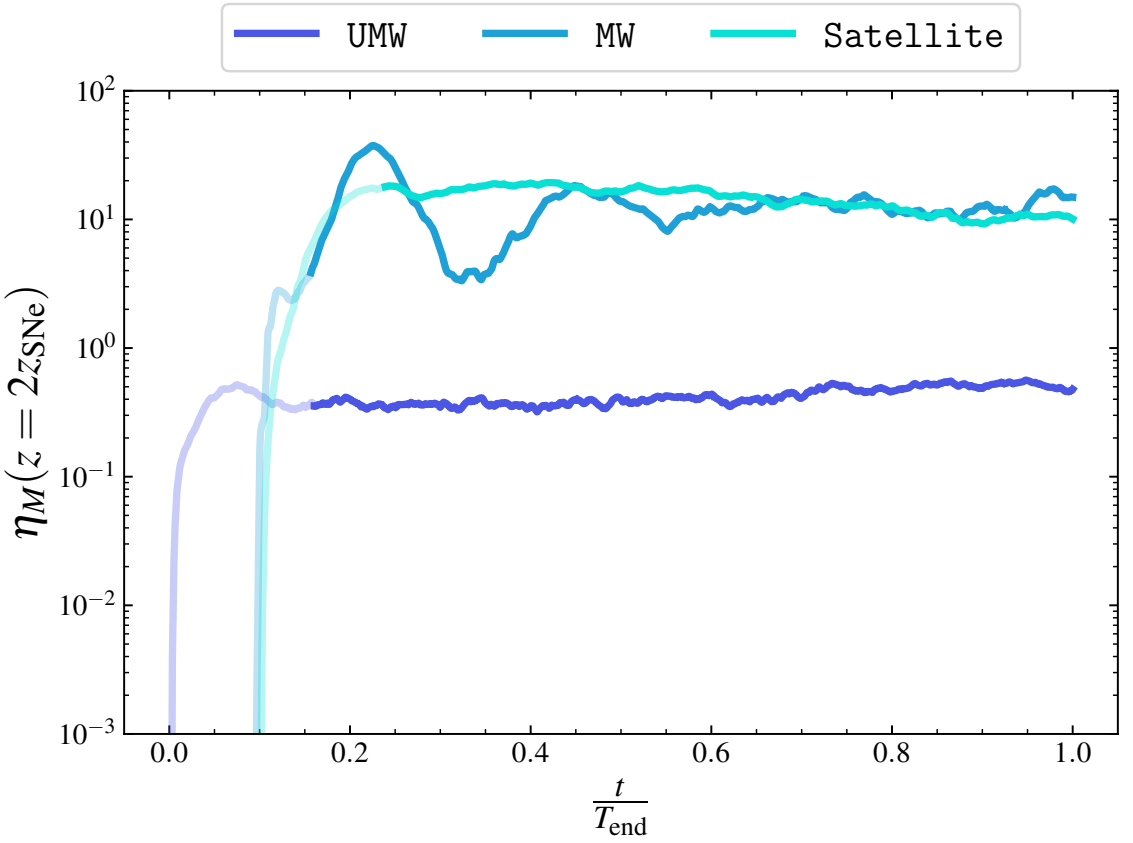


e.g. Li&Bryan 2020

Mass loading factors

$$\eta_M(z) = \frac{\dot{M}_{\rm out}(z)}{\rm SFR}$$

- Weaker gravitational potentials lead to higher mass loading factors
- Loading factors are consistent with numerical studies

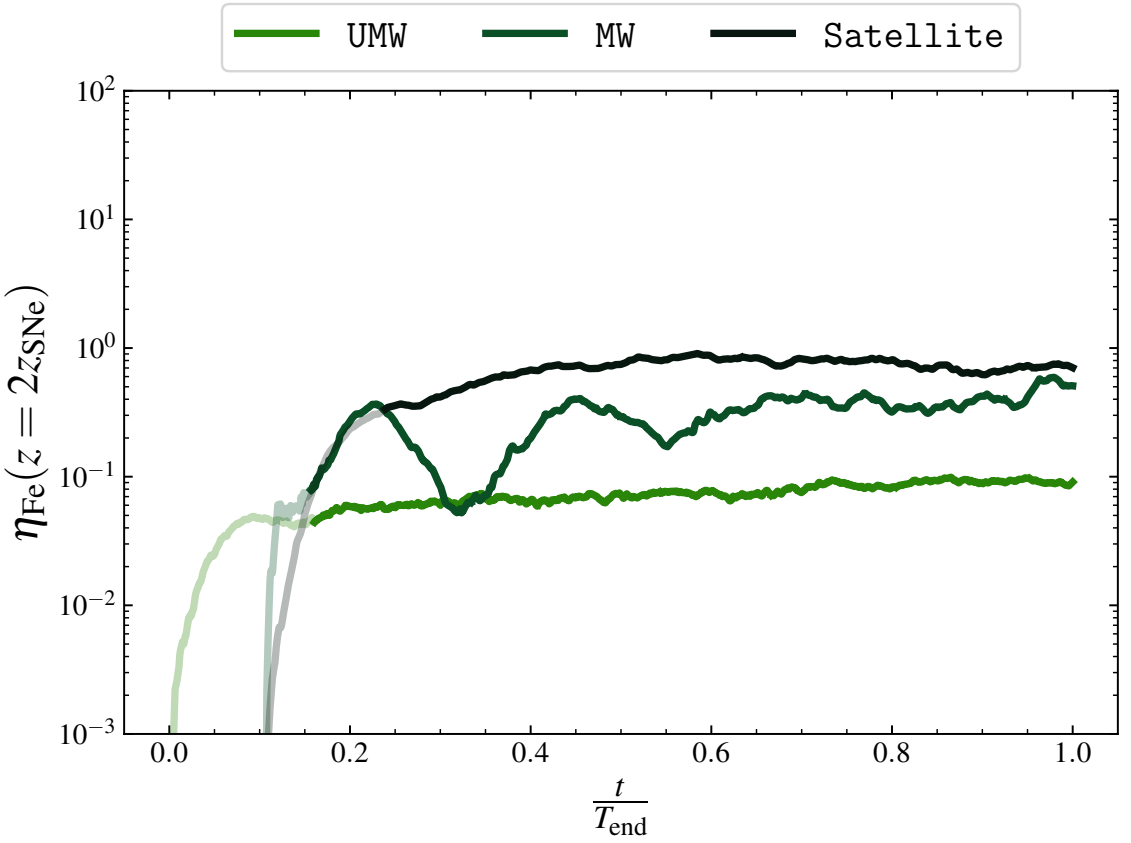


Kolborg et al 2023, Li&Bryan 2020, Martizzi et al 2016

Iron loading factors

$$\eta_{\mathrm{Fe}} = \frac{\dot{M}_{\mathrm{Fe}}(z)}{\dot{n}_{\mathrm{SNe}} 6.8 M_{\odot} \cdot 10^{-2} \cdot 1.0}$$

- Temporal evolution closely tied to η_M
- Weaker potentials loose a greater fraction of their metals

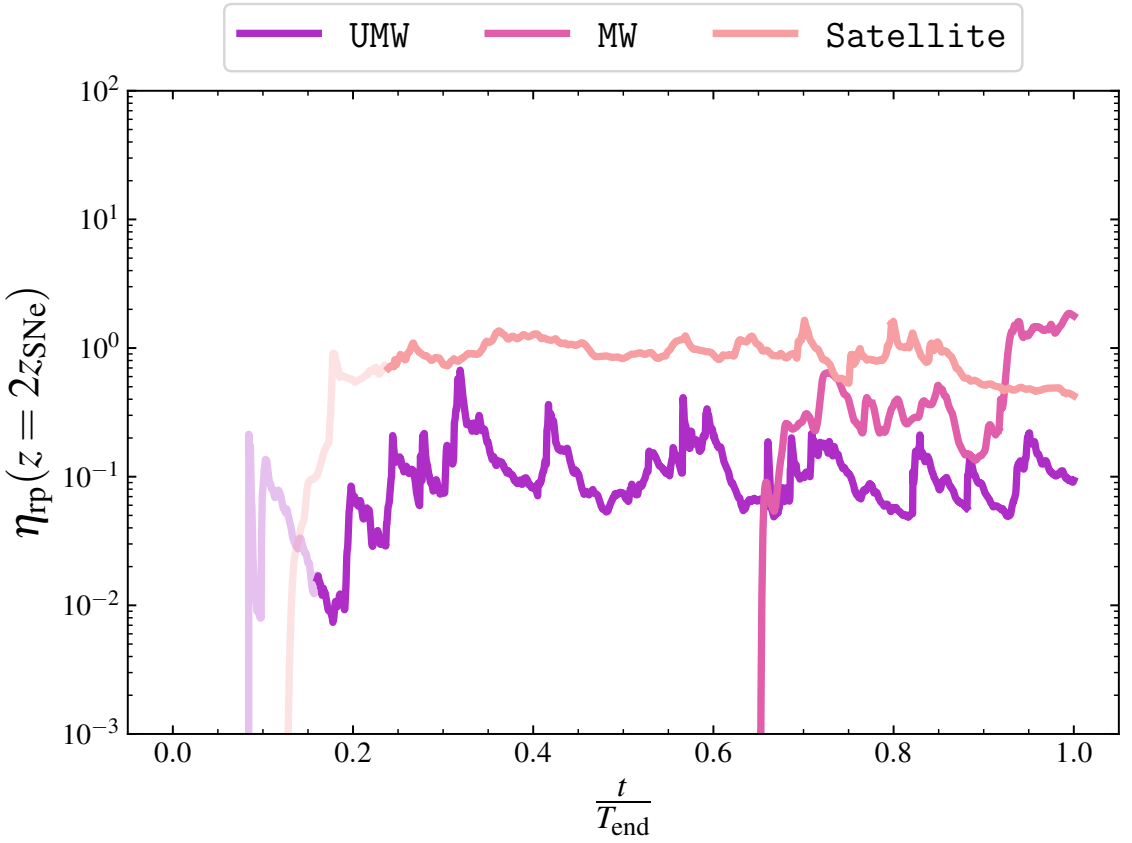


Kolborg et al 2023

r-process loading factors

$$\eta_{\rm rp} = \frac{\dot{M}_{\rm rp}(z)}{\dot{n}_{\rm SNe} \cdot 10^{-2} \cdot 1.0 \cdot 10^{-3}}$$

- Temporal evolution bursty
- Ranking of $\eta_{\rm rp}$ between galaxy potentials follows same patterns as η_M and $\eta_{\rm Fe}$
- $\eta_{\rm rp}$ **within** a galaxy potential is similar to $\eta_{\rm Fe}$



Kolborg et al 2023

r-process loading factors

- Ranking of $\eta_{\rm rp}$ between galaxy potentials follows same patterns as η_M and $\eta_{\rm Fe}$
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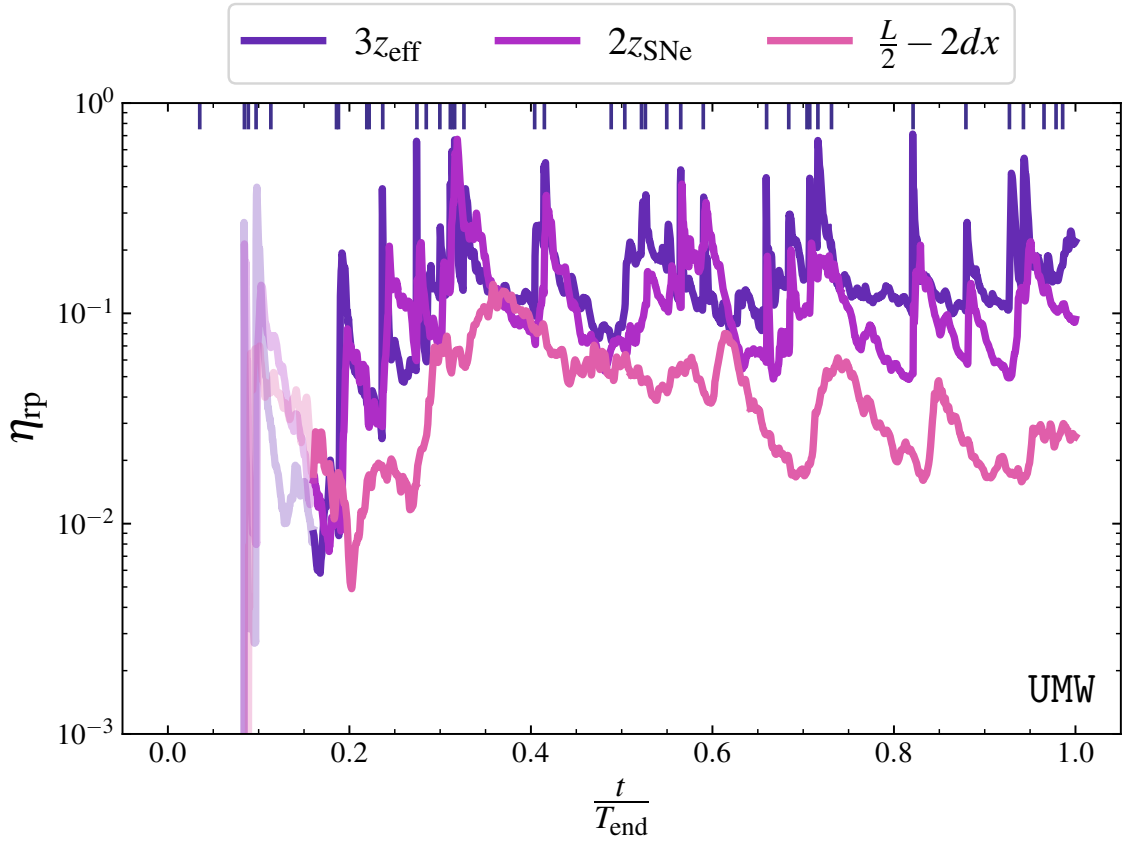
Time averaged loading factors

	UMW	MW	DW
Fe	0.075	0.3	0.7
rp	0.11	0.22*	0.89

Kolborg et al 2023

r-process loading factors

- Temporal evolution bursty
- Loading factor is strongly correlated with fresh injections
- We observe both a time delay and a mixing signature in the wind



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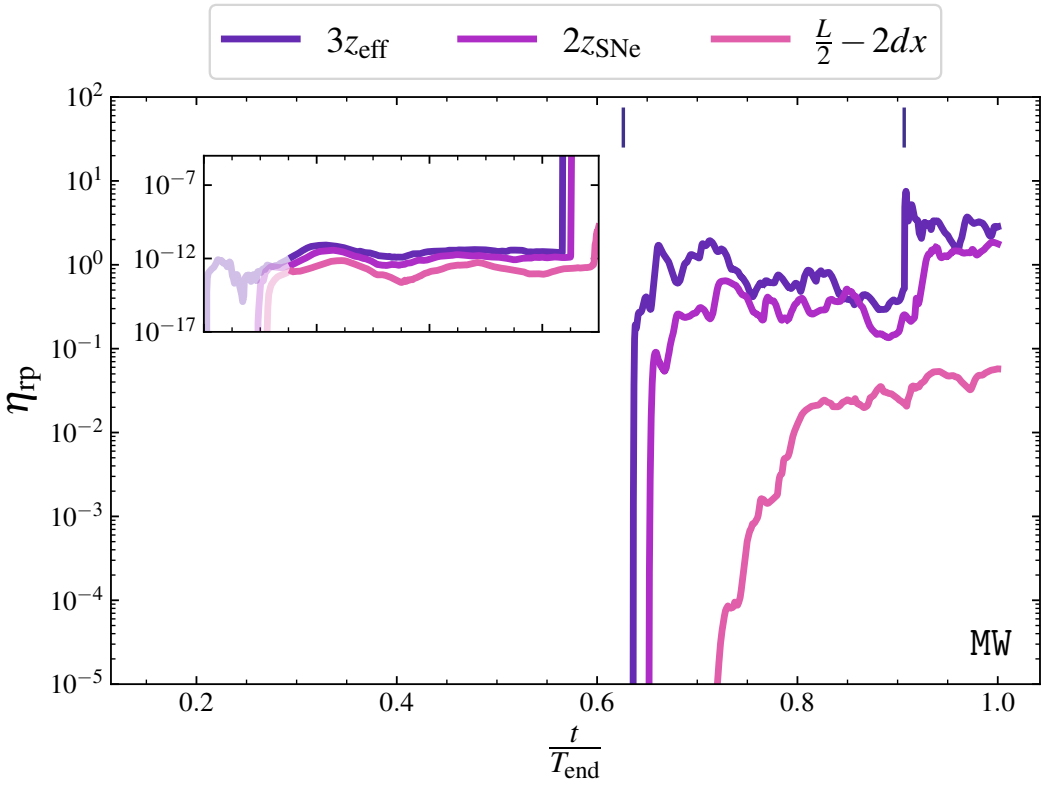
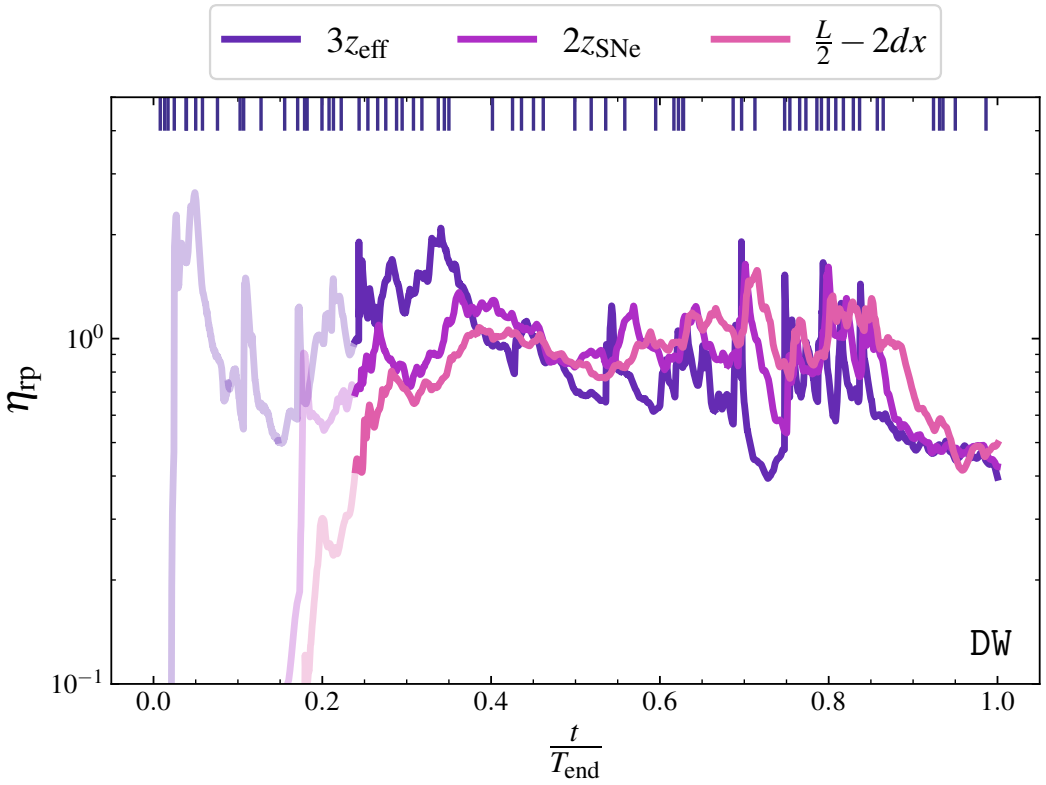
r-process loading factors

Across galaxy models





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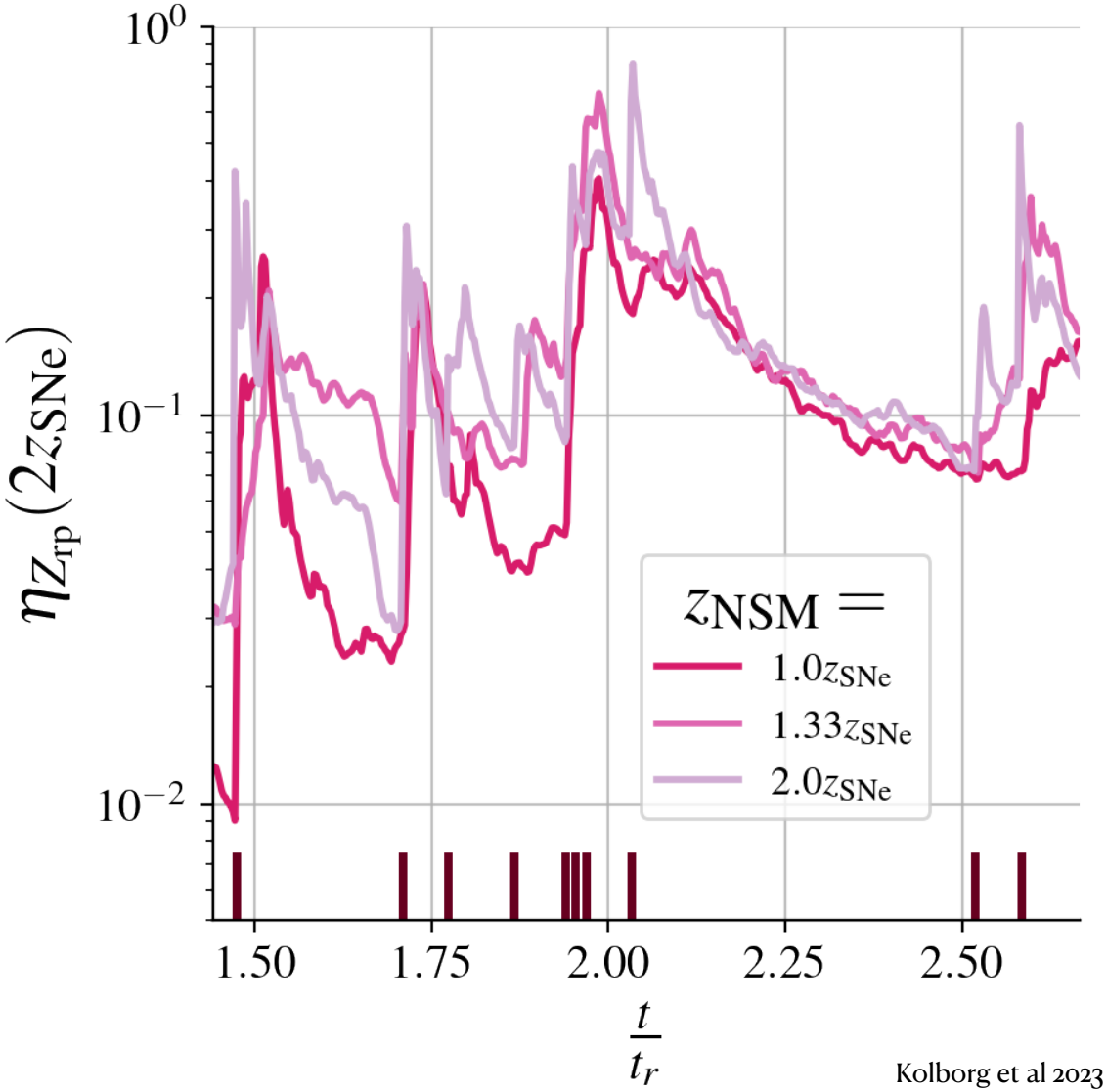
r-process loading factors

Caveat

- Local boxes cannot accommodate large off-sets of r-process events
- On average larger off-sets lead to larger loading factors



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Conclusions

- Local box simulations of SNe driven galactic wind close to the disk
- Mass loading factors consistent with other works
- Wind should be highly enriched in both Fe and r-process elements
- Loading factors are larger in smaller galaxies
- R-process loading factors are generally larger than Fe ones suggesting r-process is not well mixed
- Larger event off-sets are likely to lead to larger $\eta_{\rm rp}$