Heating of planetesimals from ^{60}Fe & ^{26}Al

Hunting the source of short-lived radioisotopes and simulating desiccation in planetesimals

Dr. Joseph Eatson - University of Sheffield
Supervisor: Dr. Richard Parker - University of Sheffield

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Contents & questions

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How do disks survive this enrichment?

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What are SLRs?

Short-lived radioisotopes

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- Half-lives on the order of 1 Myr.

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Short-lived radioisotopes

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- ^{26}Al and ^{60}Fe primarily discussed.
- Primary heating source in the early solar system **[1]**.
- Homogenous throughout solar system.
- Wolf-Rayet (WR) winds and supernovae are sources of SLRs.

[1] Fu & Elkins-Tanton 2014

Planetesimal desiccation

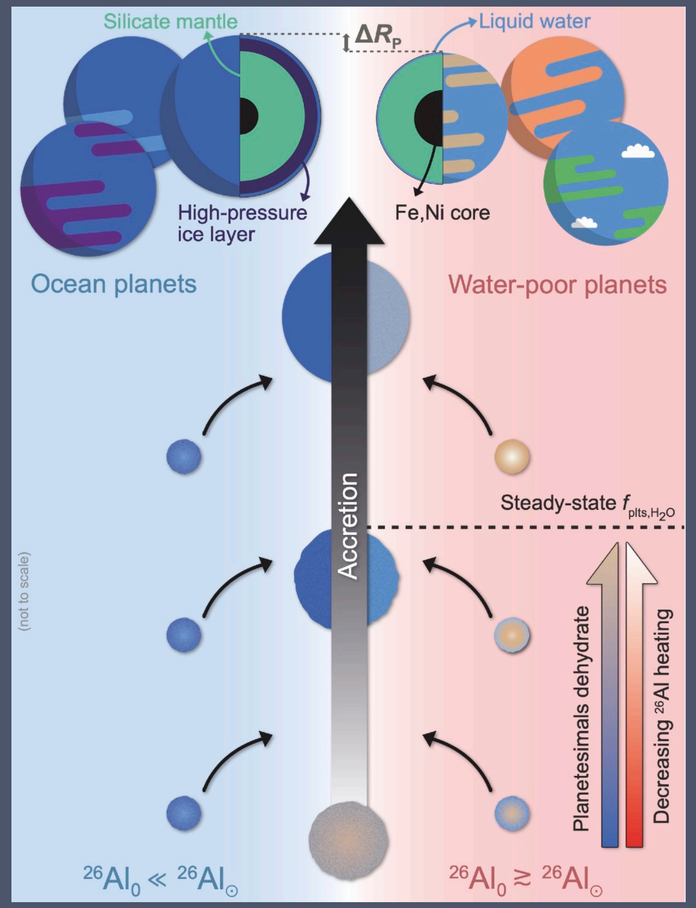
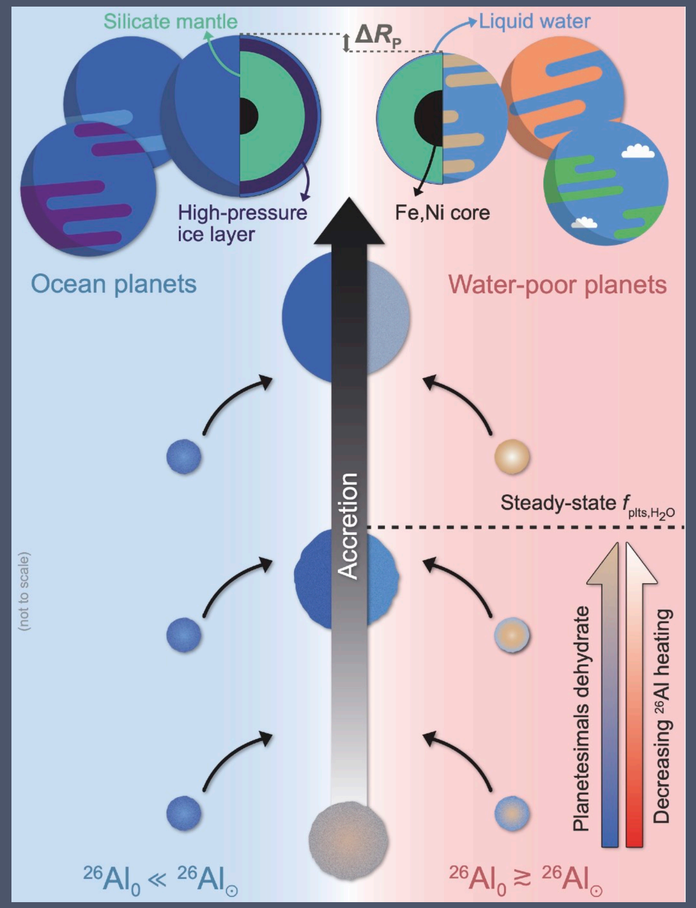


Fig. Lichtenberg+ 2019, [1] Lichtenberg+ 2019

Planetesimal desiccation

- Heating = vaporisation and outgassing **[1]**.



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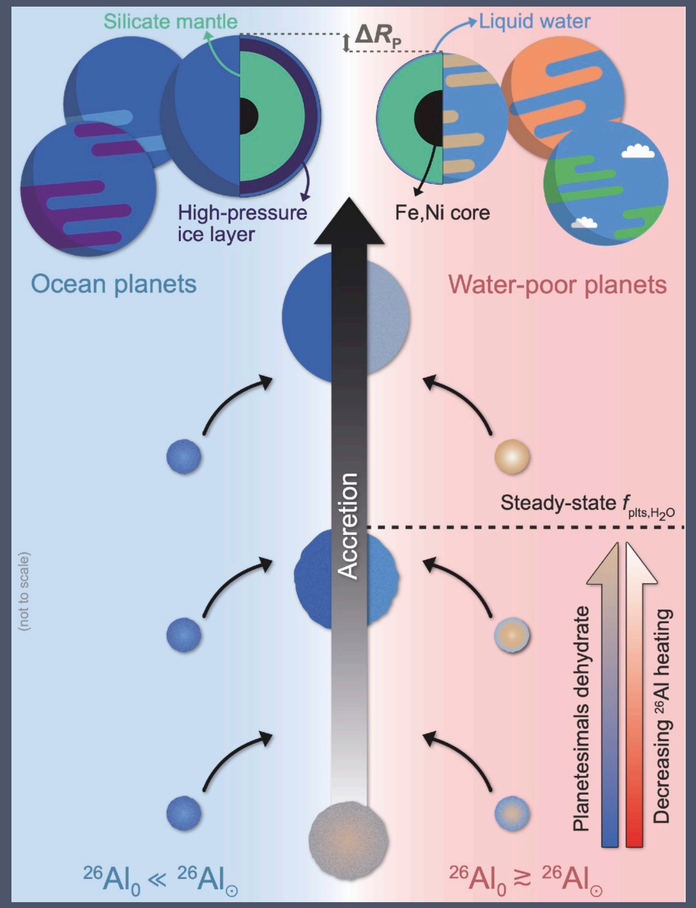

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Planetesimal desiccation

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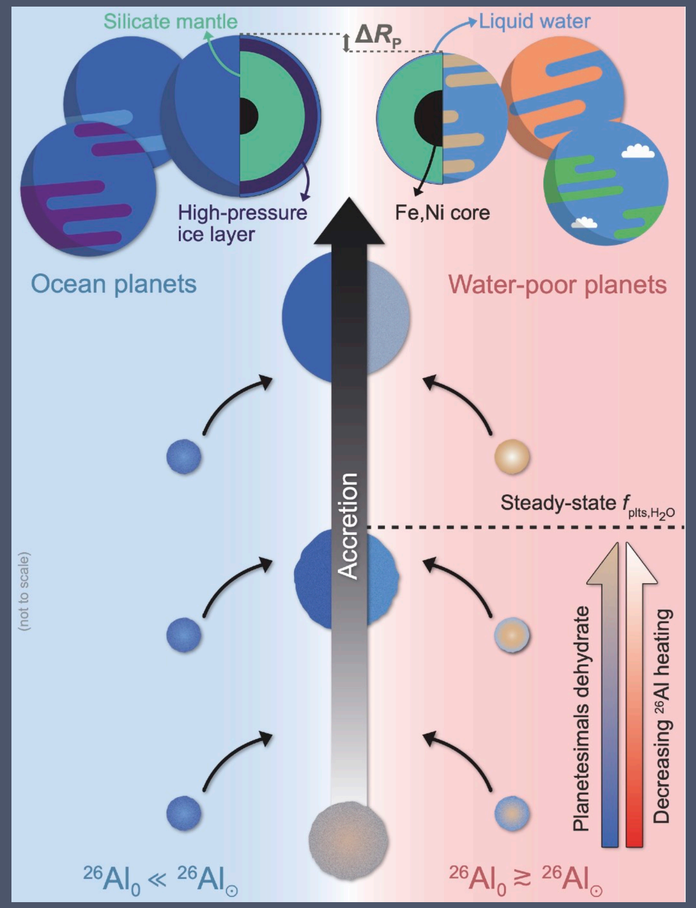

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Planetesimal heating by SLRs

Motivations

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How much does the SLR ^{60}Fe influence heating and desiccation?

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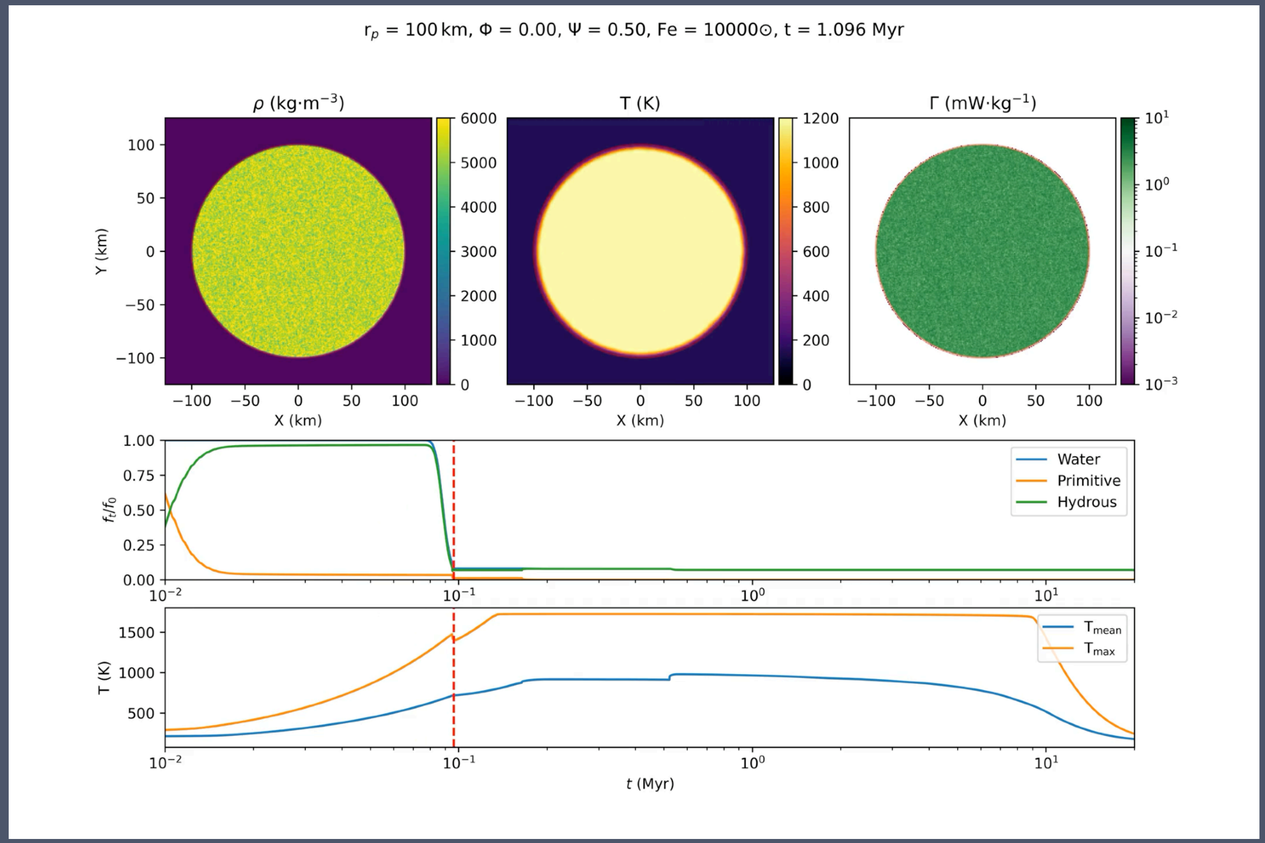
How much ^{60}Fe needed to get desiccation?

Melting rocks

Eatson, Parker, Lichtenberg & Gerya 2024



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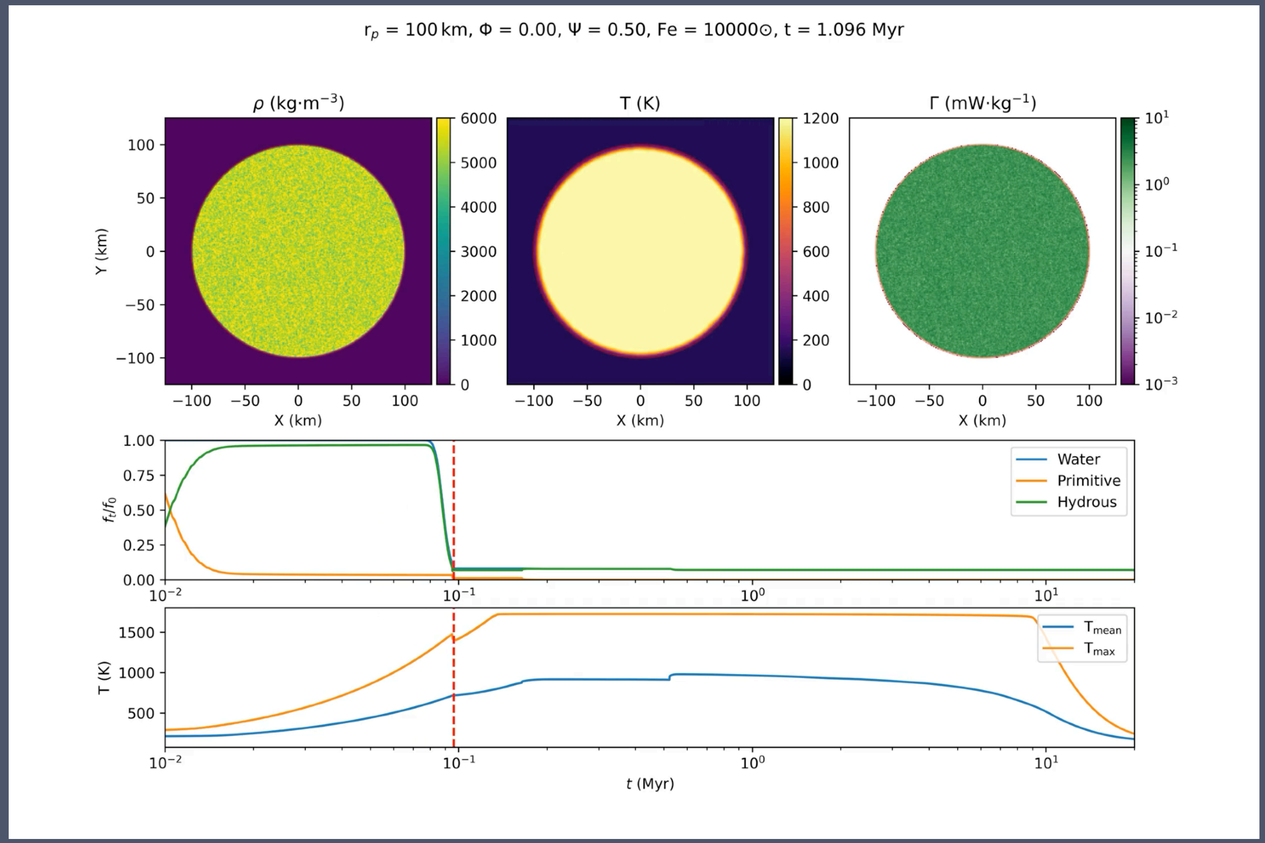

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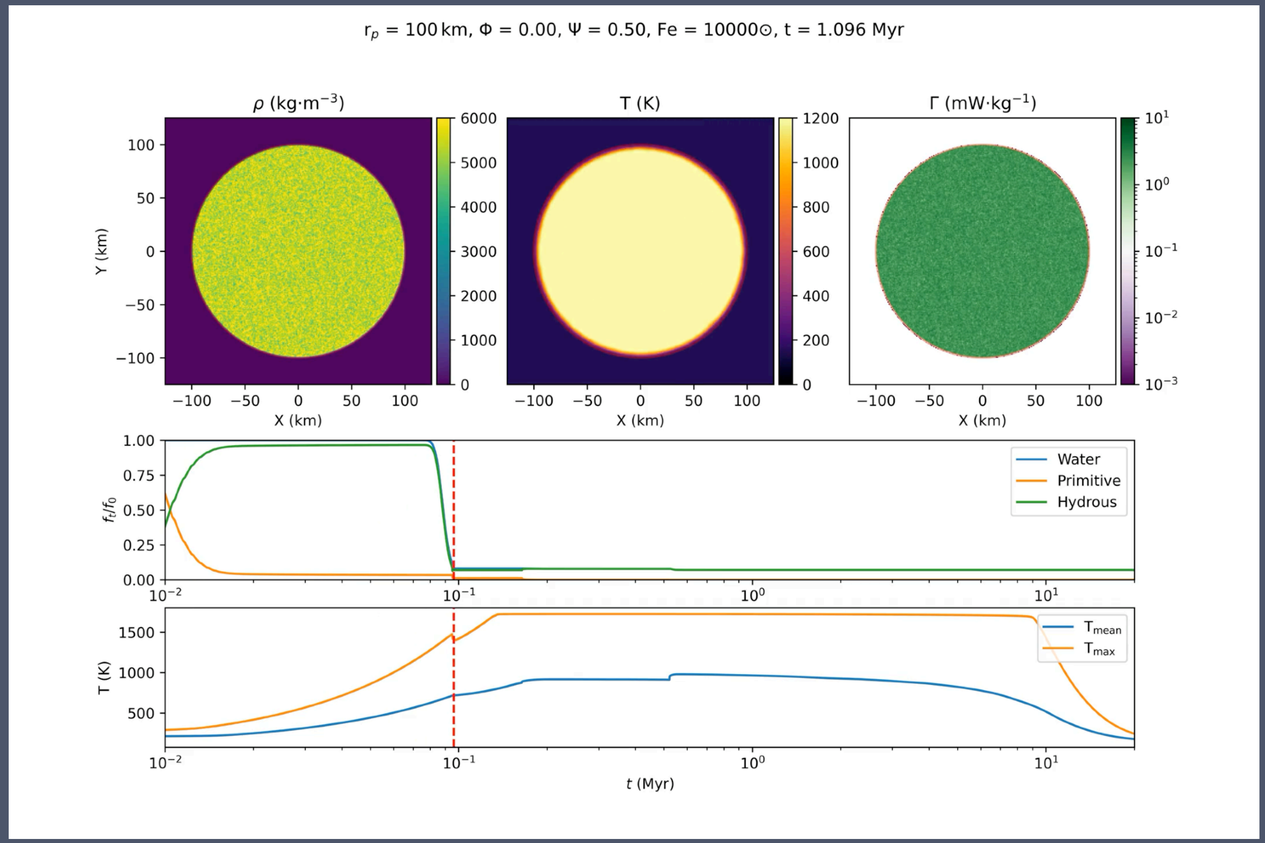

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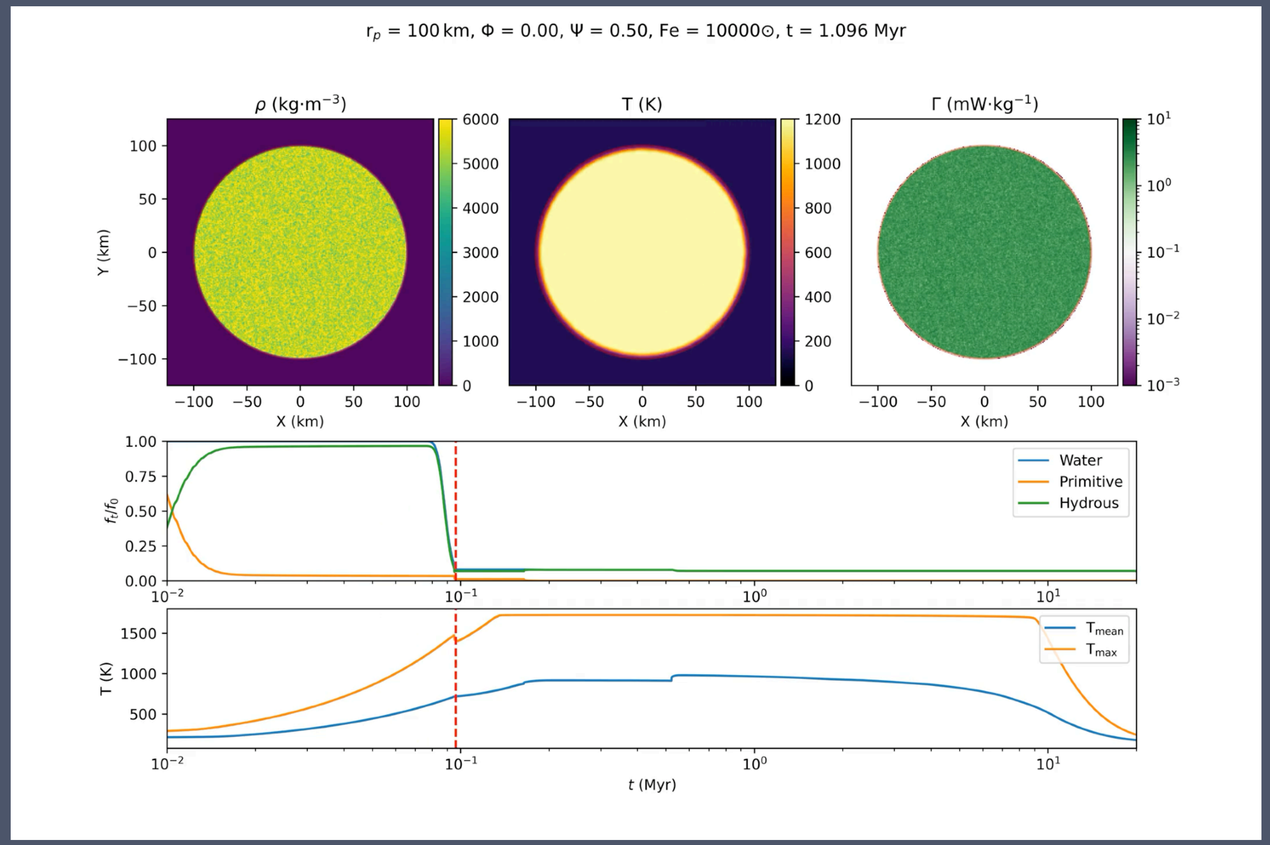

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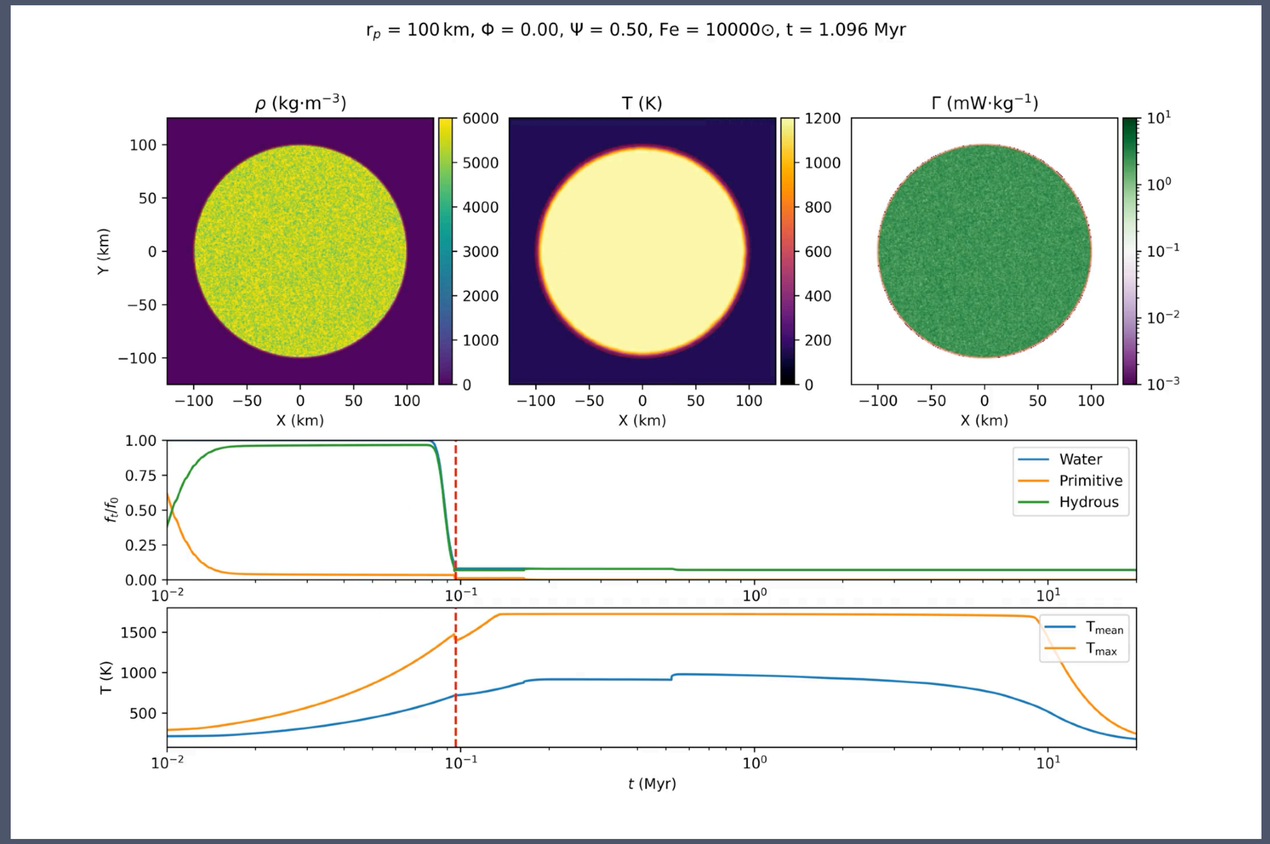
- Simulations using I2ELVIS **[1]**.
- Parameter space explored varying enrichment and Fe content.
- Measuring water retention fraction.



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Drying out rocks

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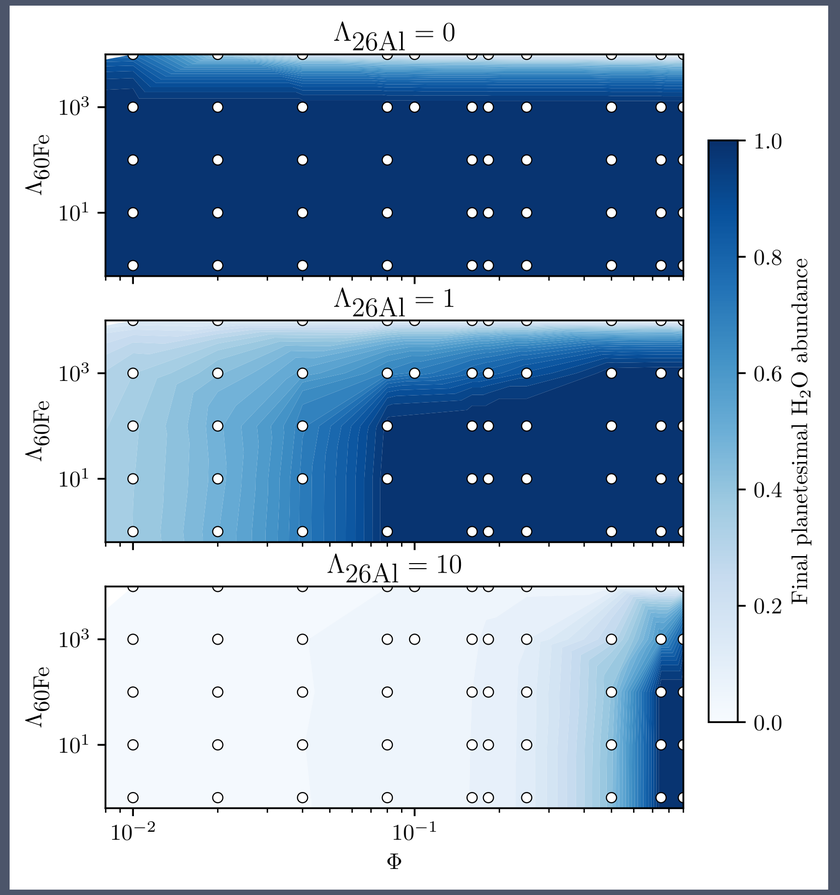

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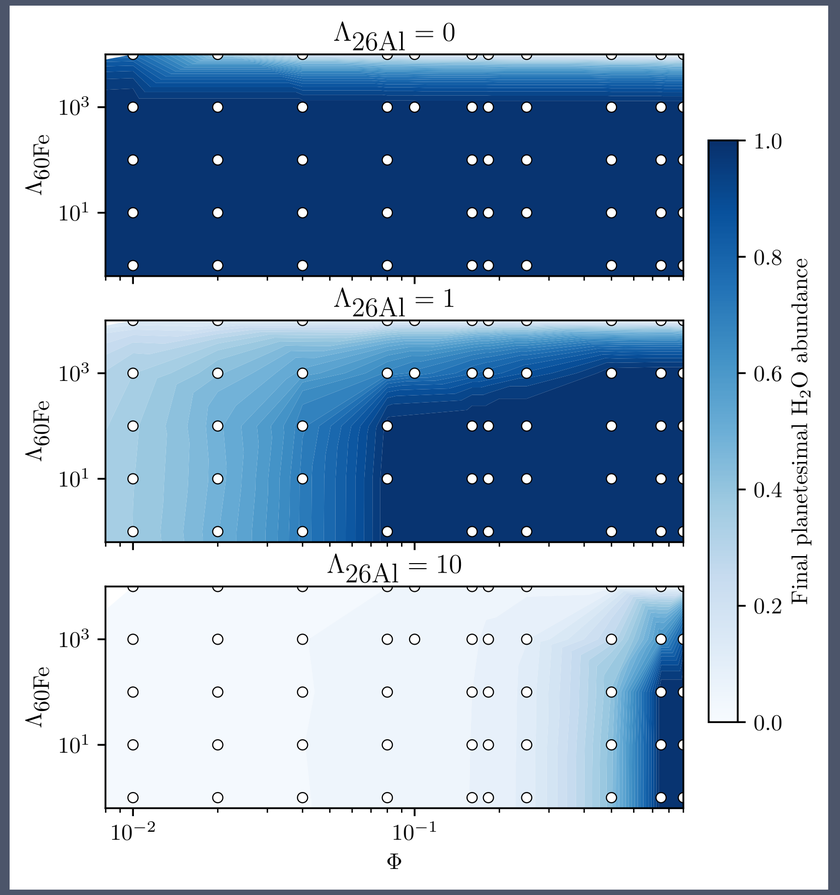
- ^{60}Fe ~200x solar for any desiccation!



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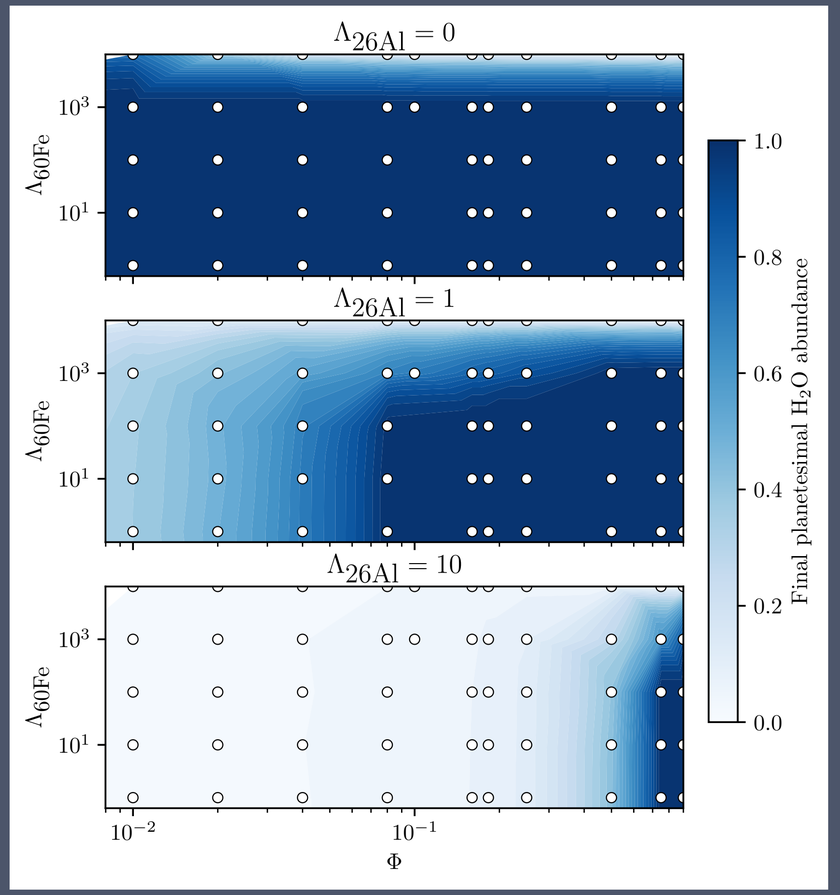

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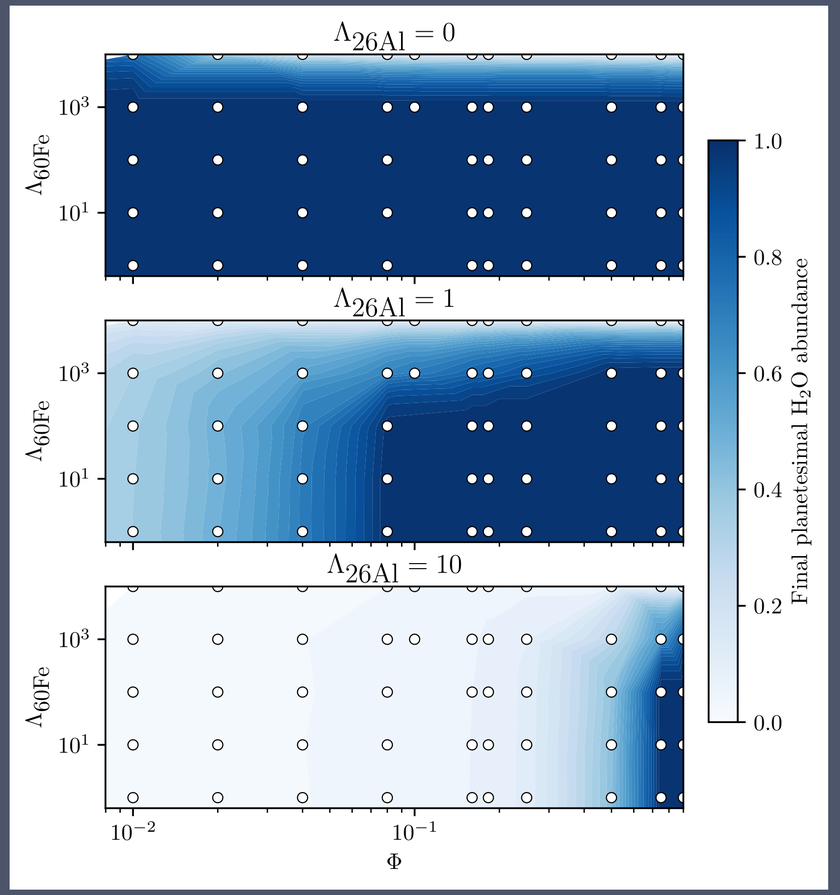
- ^{60}Fe ~200x solar for any desiccation!
- 1/10th solar needed for ^{26}Al equivalent **[1]**.
- ^{26}Al a far more effective SLR for heating & desiccation.



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SLR enrichment of disks

More motivations

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How common are highly enriched ^{26}Al and ^{60}Fe disks?

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How common are highly enriched ^{26}Al and ^{60}Fe disks?

How dependent is enrichment on star forming region density?

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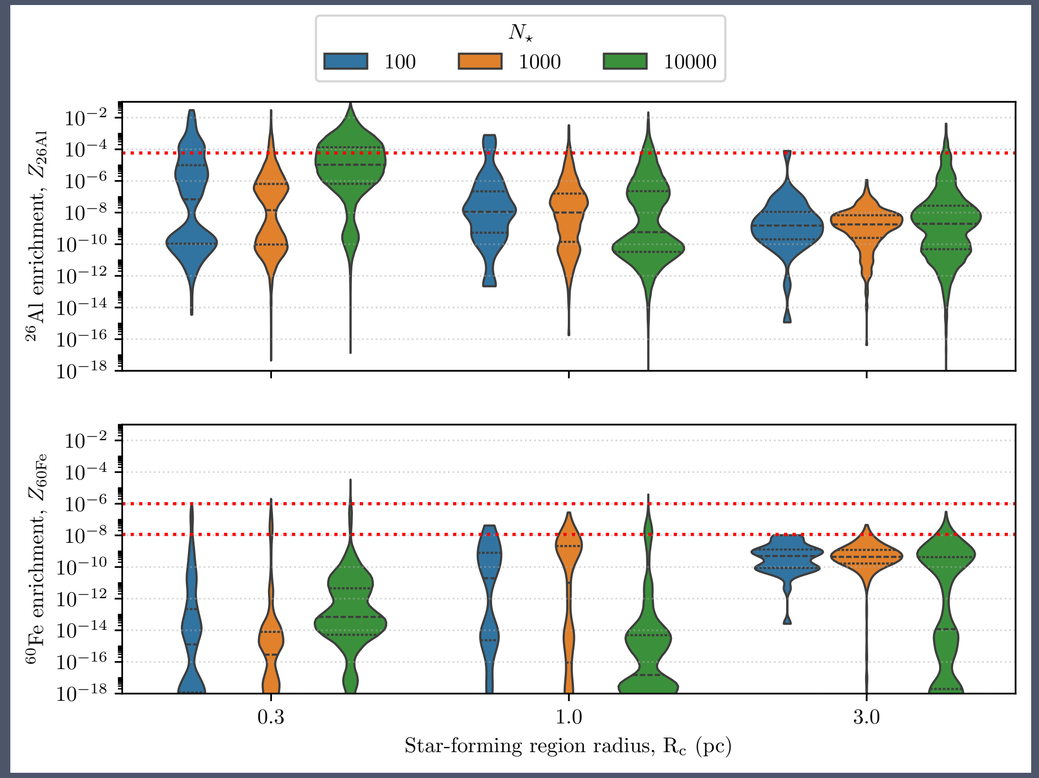
Is there another pre-formation mechanism?

Enriching disks

Eatson, Parker & Lichtenberg 2024



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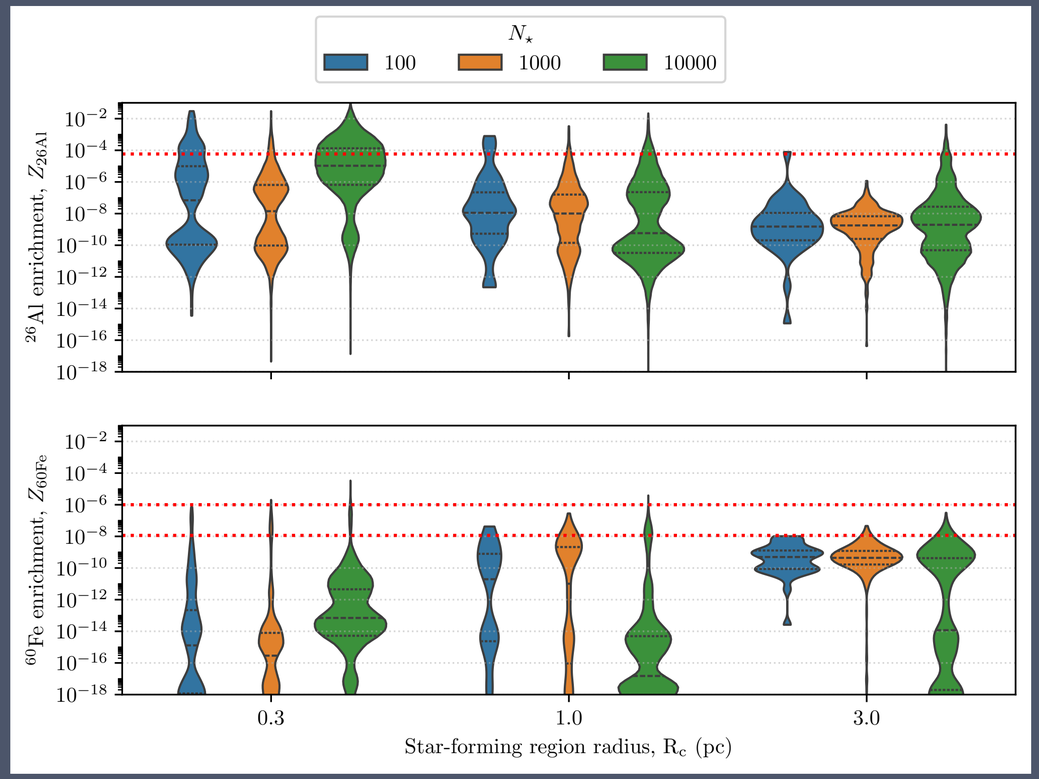

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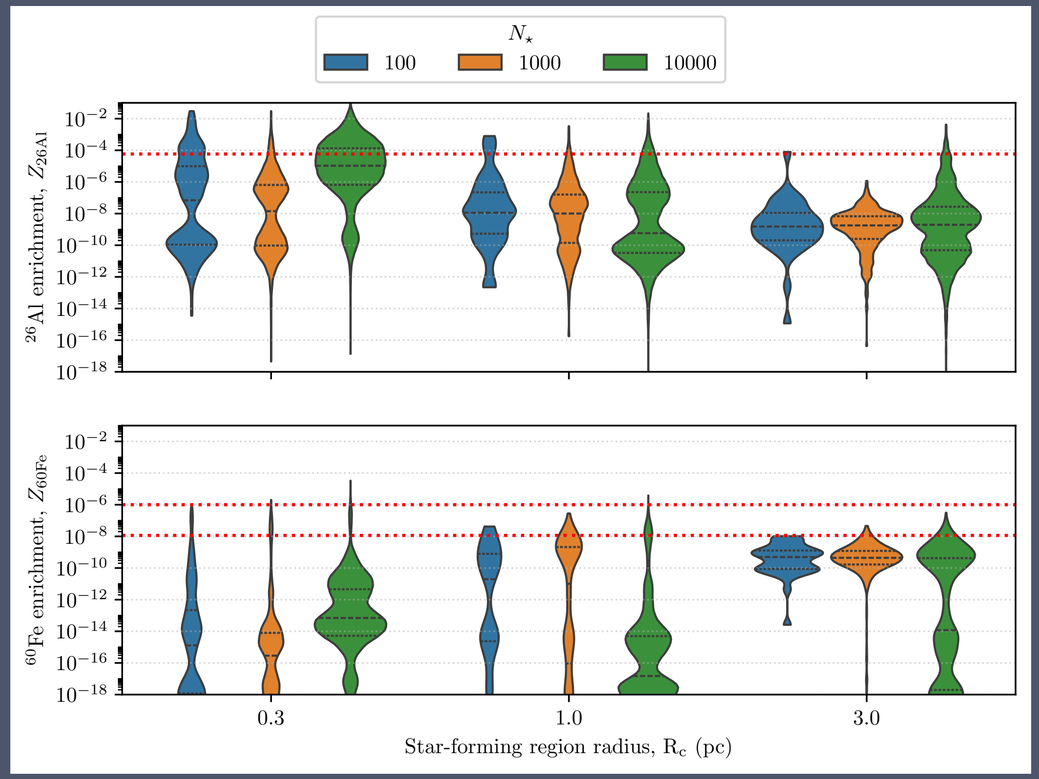

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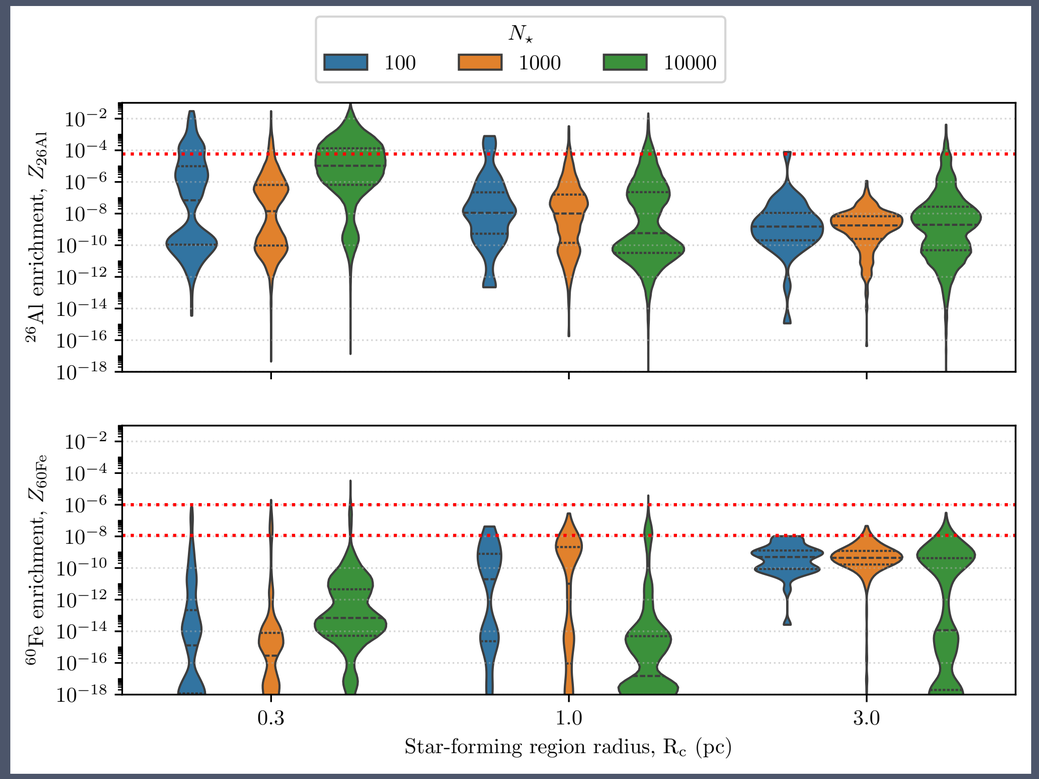

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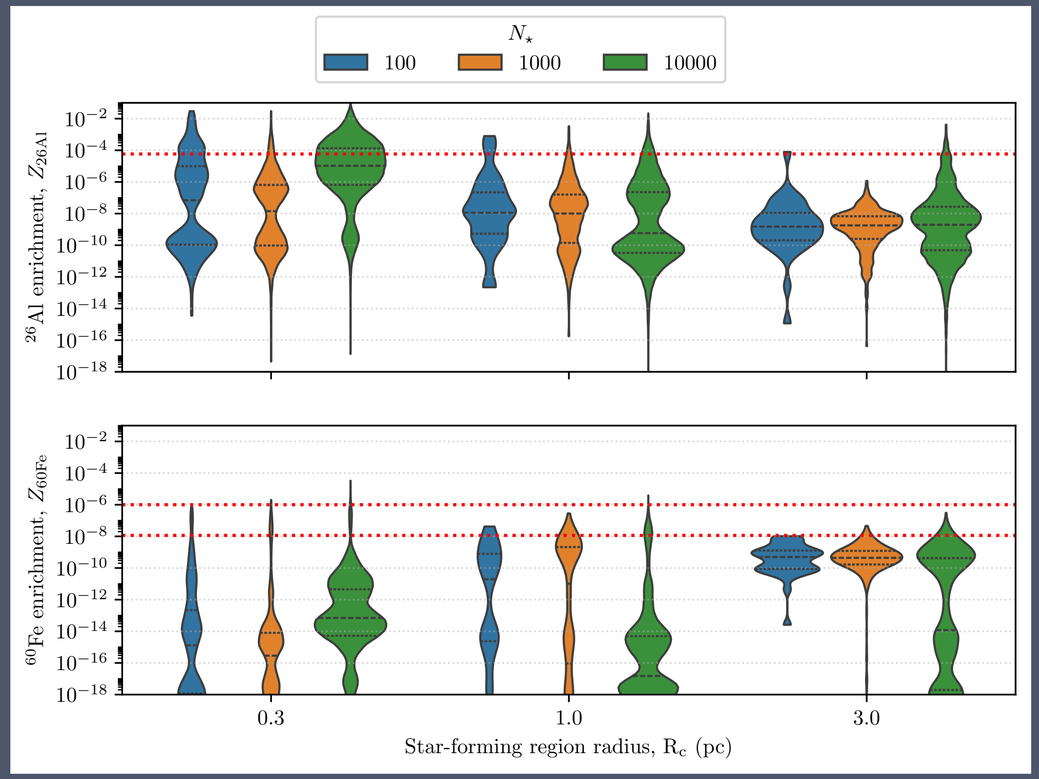

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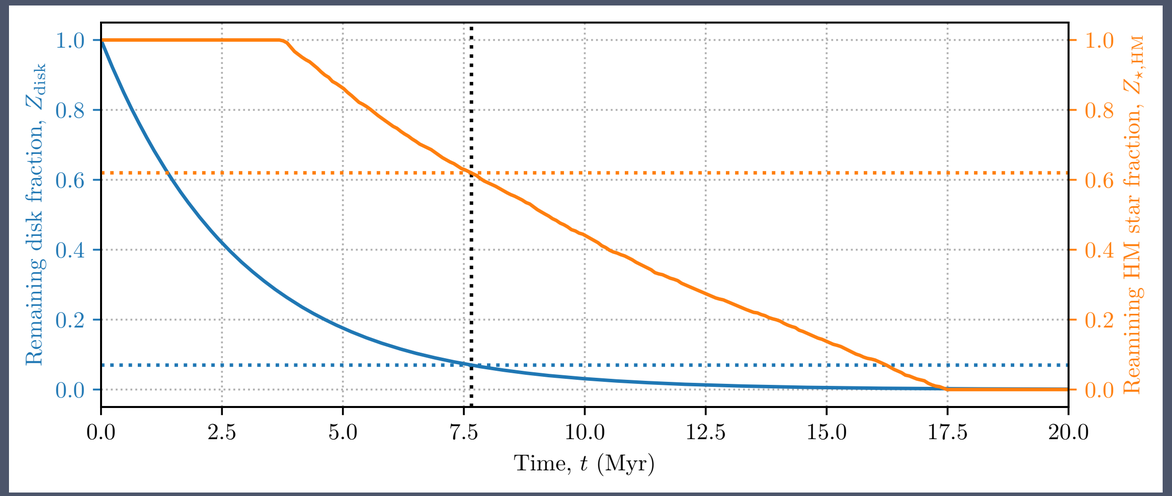
The hitch with winds and SNe



X-axis: time
Y-axis left/blue: Remaining disks
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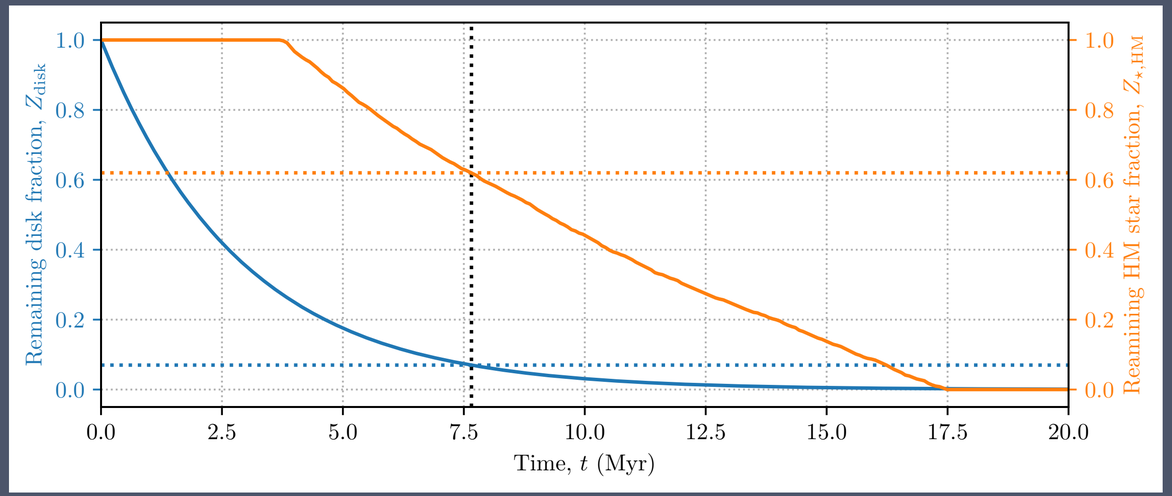
- ^{60}Fe not produced by WR winds **[1]**.



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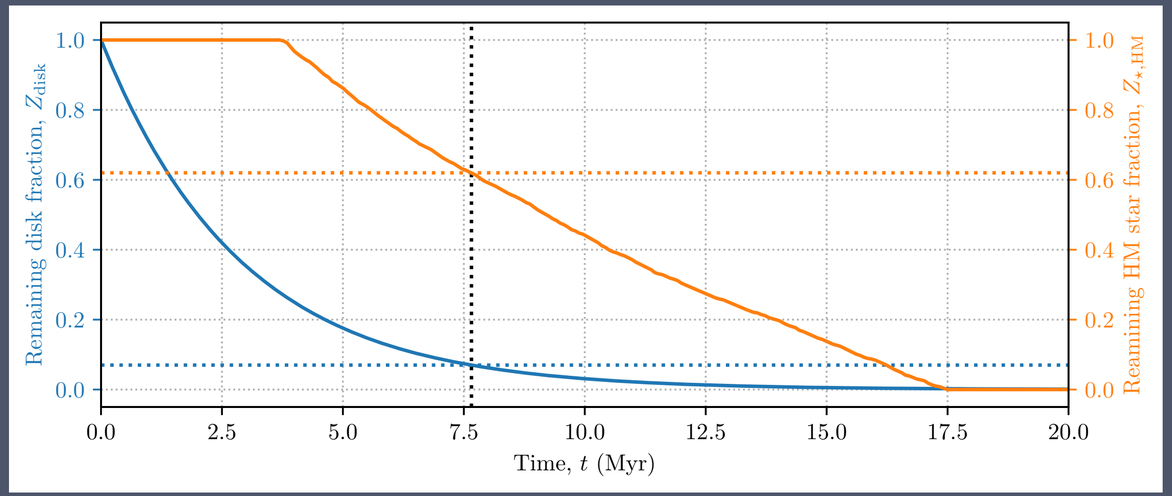

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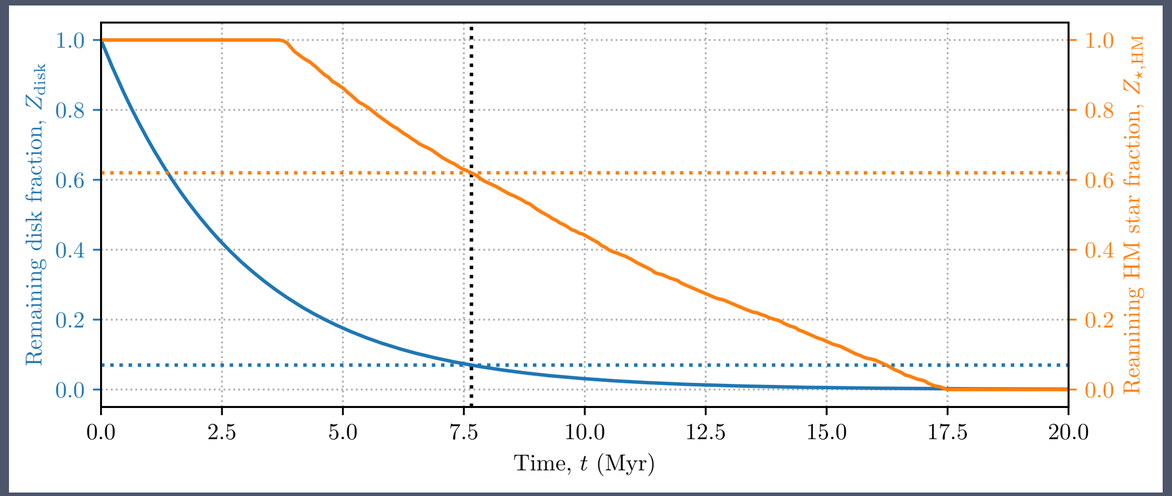

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The hitch with winds and SNe

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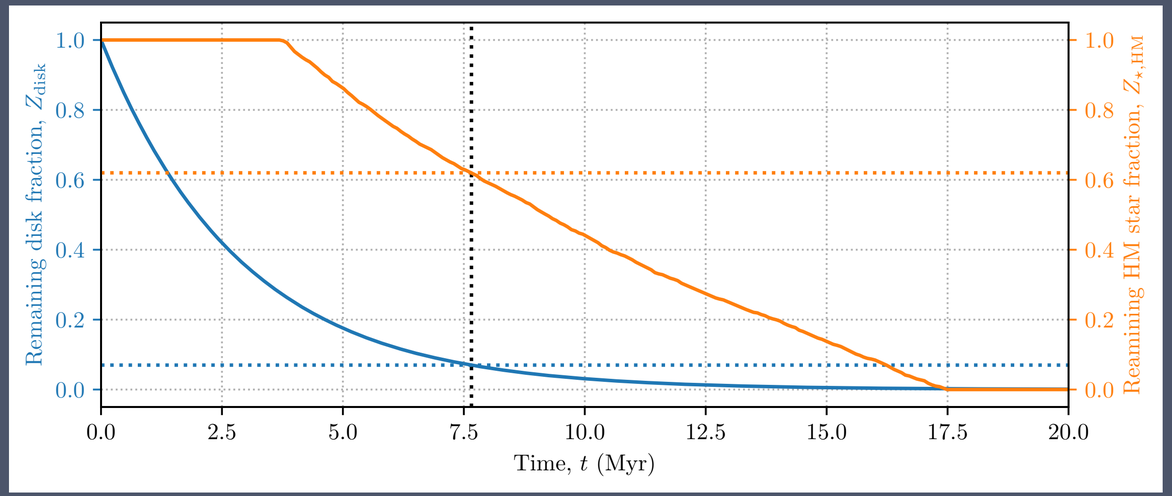
- Photoevaporation and shocks **[2]**.
- Other enrichment methods?



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Interlopers?

[1] Parker & Schoettler, 2023

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- AGB star observed to pass through cluster [1].

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- AGB star observed to pass through cluster **[1]**.
- AGBIs inject ^{26}Al *and* ^{60}Fe.
- Gentler winds, less UV flux.

[1] Parker & Schoettler, 2023

AGBI sensitivity to...

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Interloper evolution?

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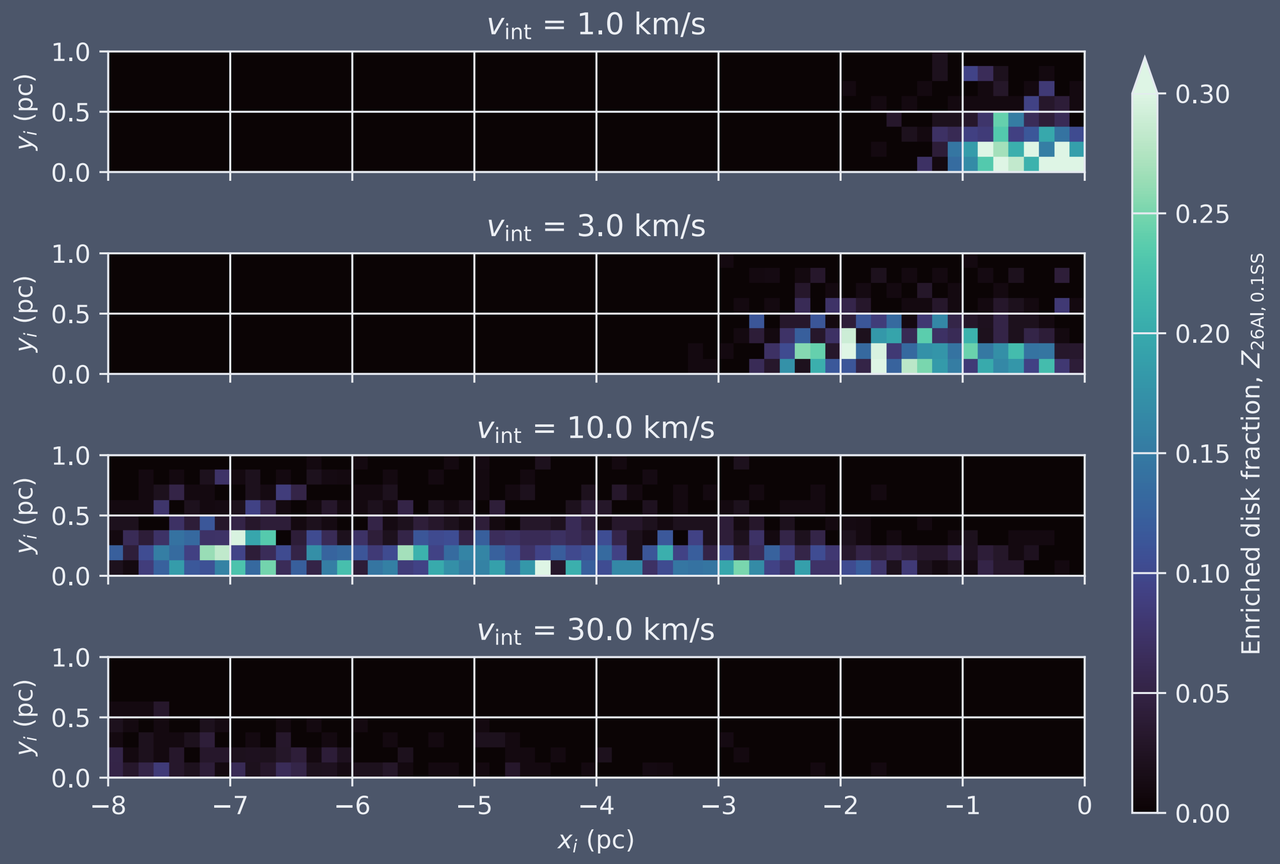
Interloper evolution?

Encounter velocity?

Interlopers!

Eatson & Parker
In prep.
QR code for poster!



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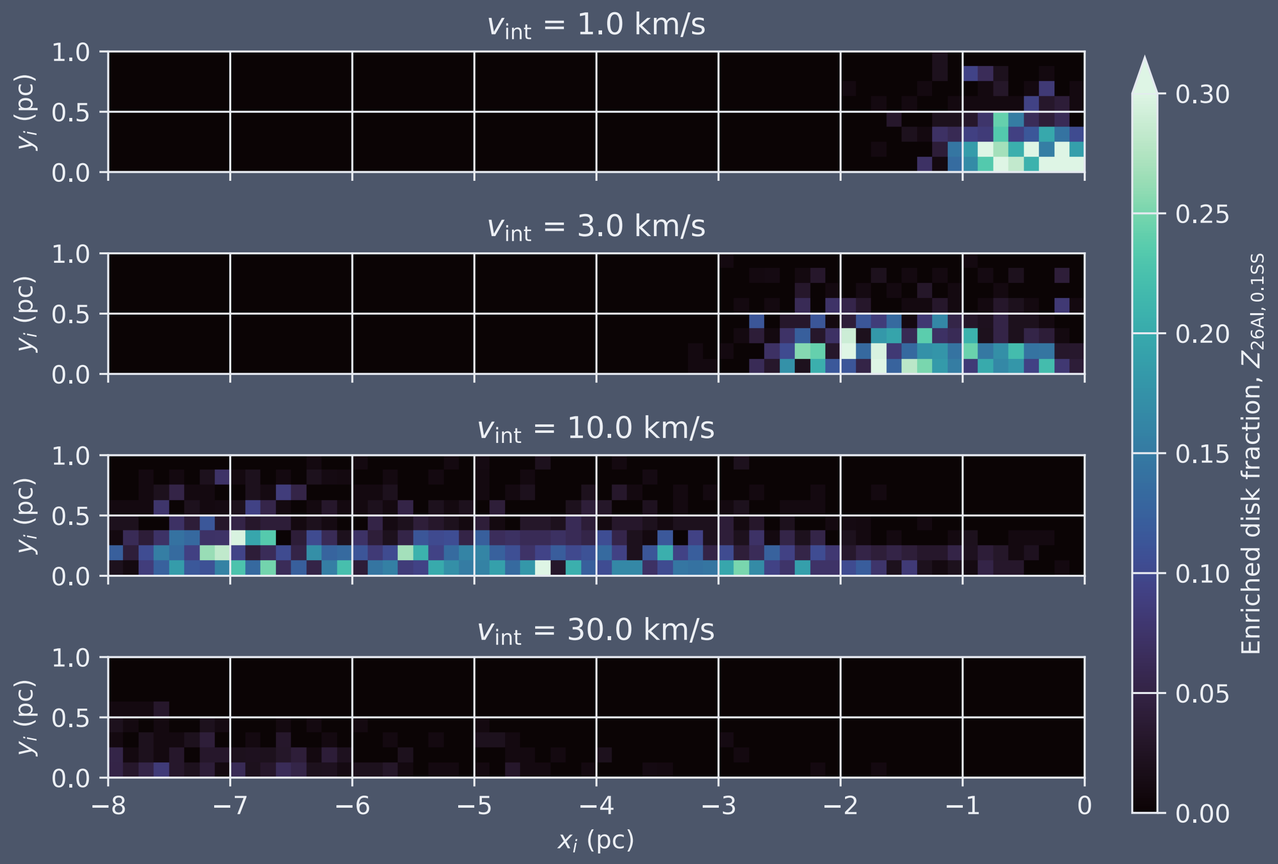

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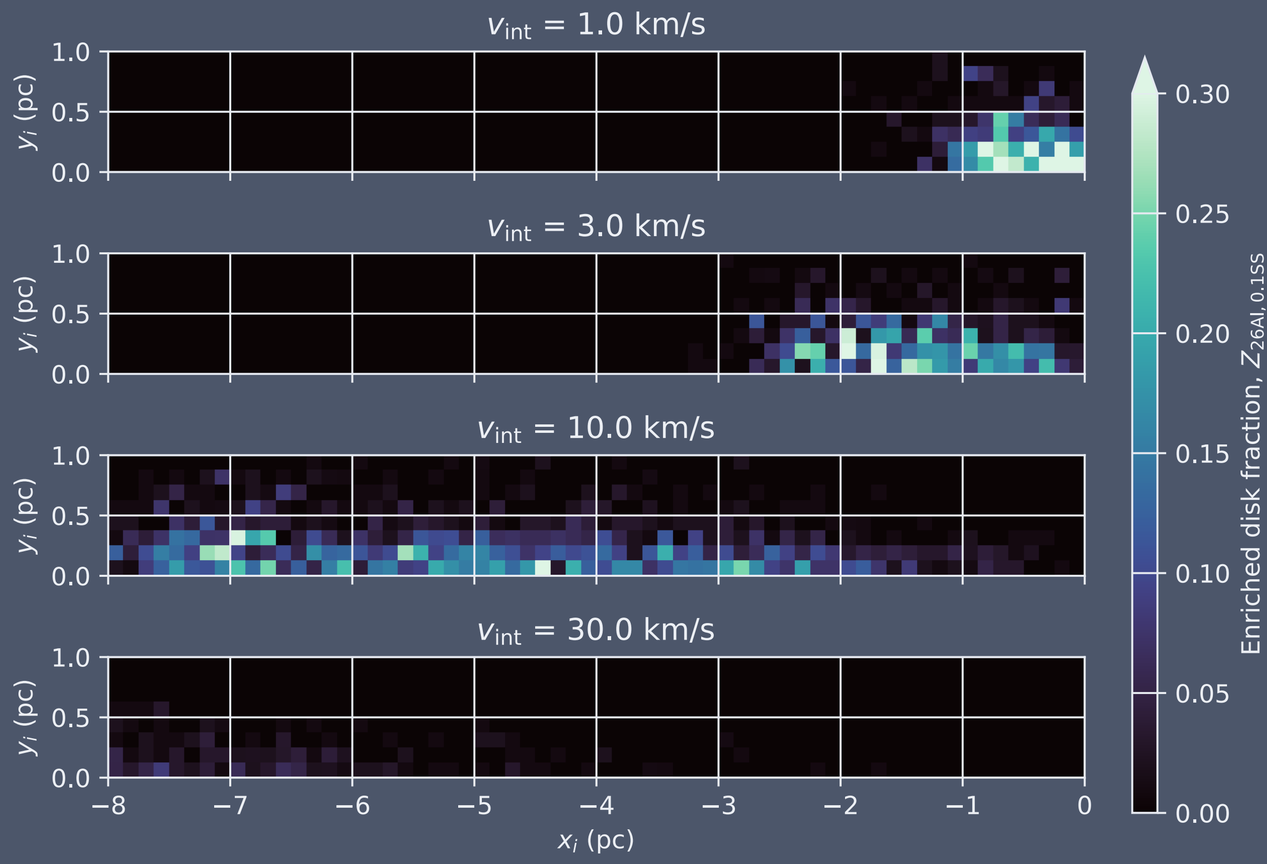

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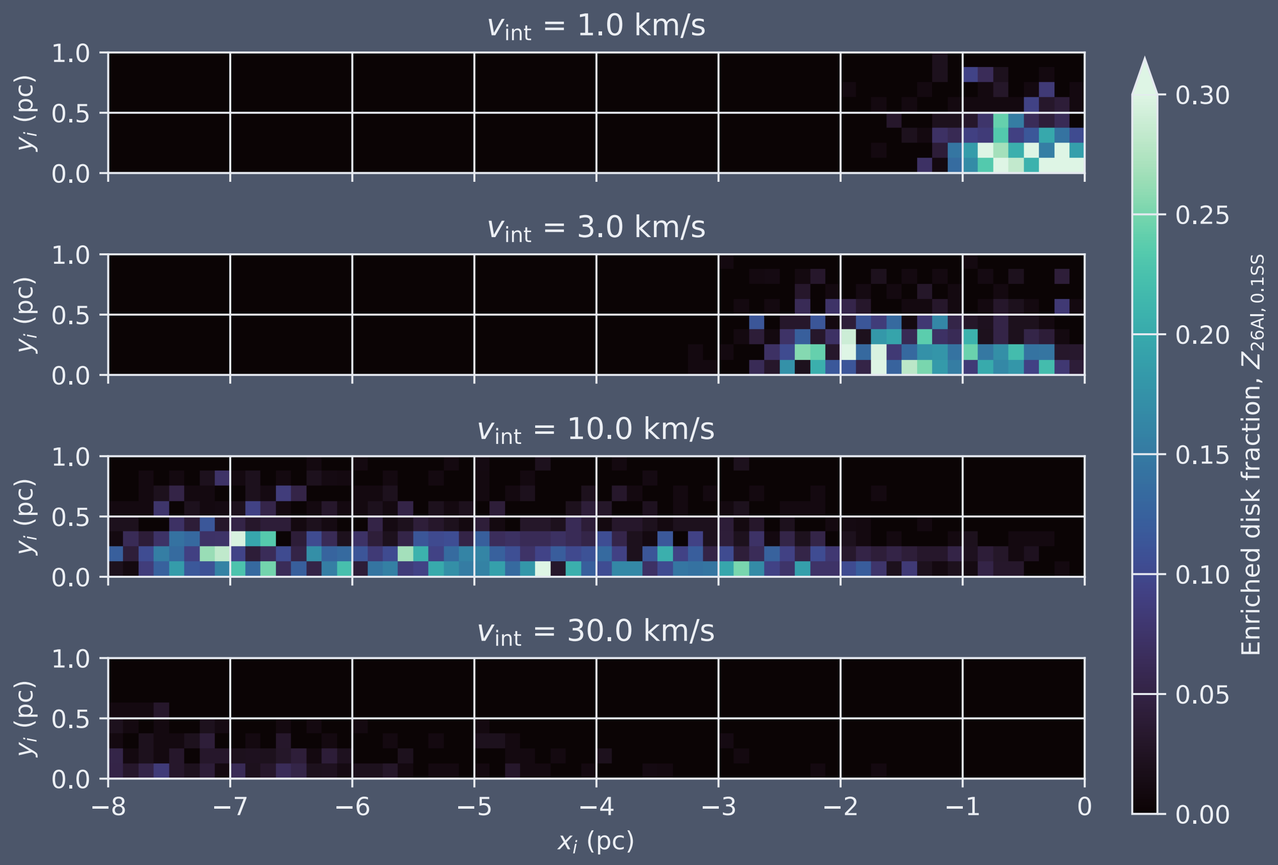

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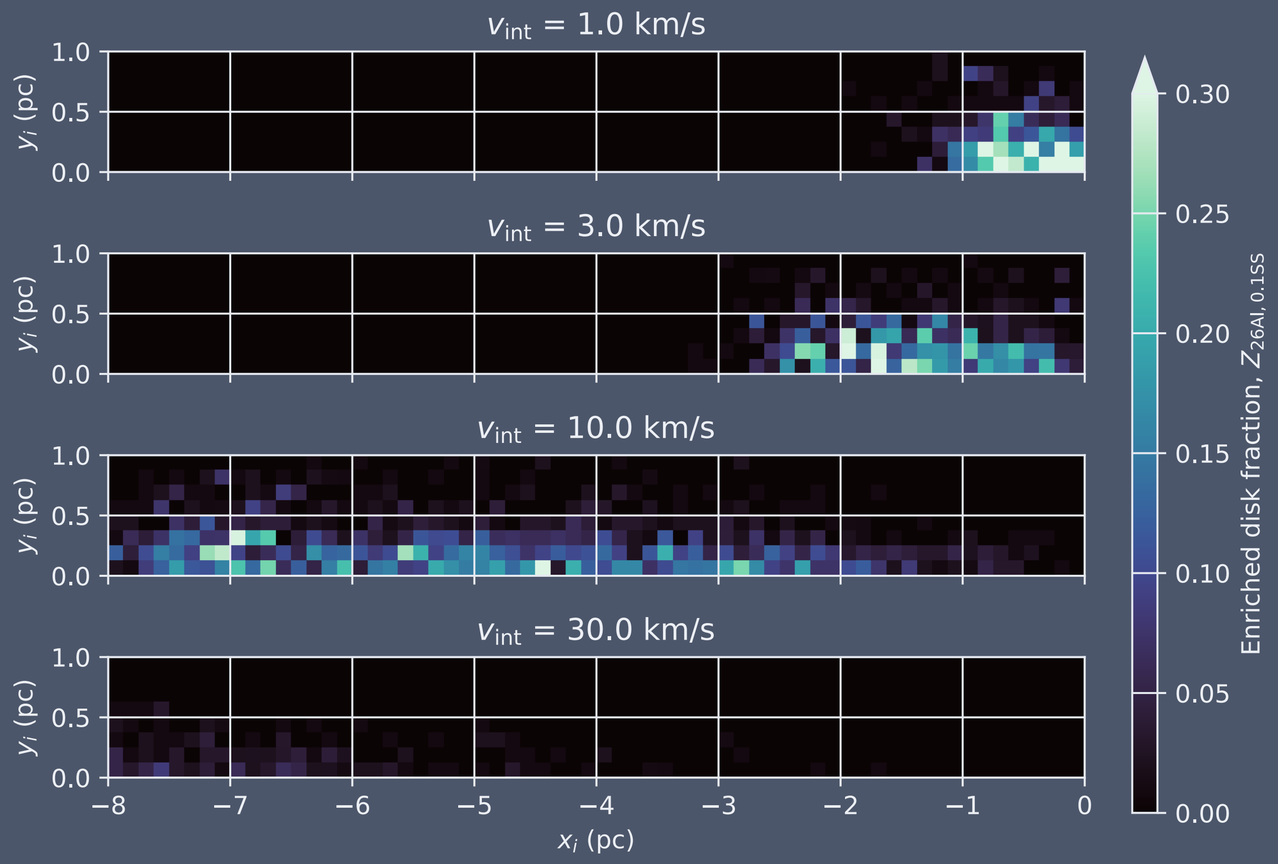

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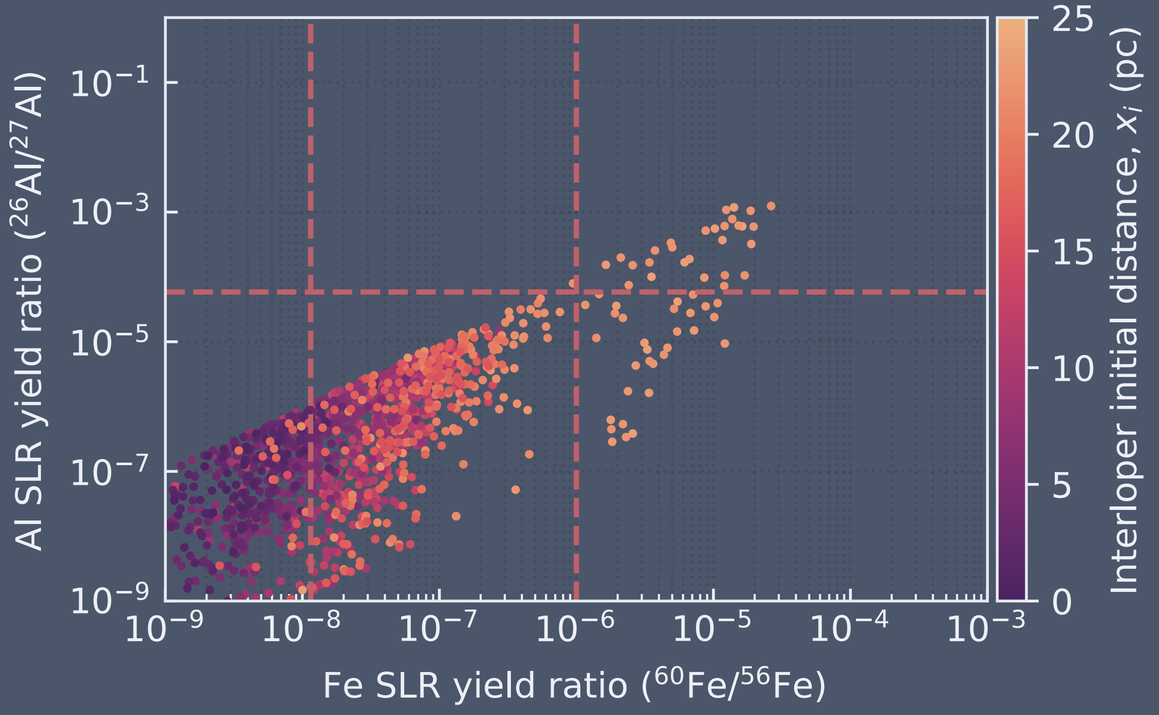
- High enrichment even at 30 km/s.



Probably gone on too long

Wrap it up!

Conclusions

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- Decay heating mainly through ^{26}Al, sims show ^{60}Fe needs high enrichment. ^{60}Fe a useful tracer for formation mechanism.
- *N*-body sims show that massive star ^{60}Fe enrichment is not sufficient for this level of enrichment.
- Enrichment through AGB interlopers provides an alternate, gentler route to disk enrichment for ^{26}Al and ^{60}Fe.

Questions?

⇦ *Slide deck and poster here!*

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