Evidence for sub-Chandrasekhar Type Ia supernovae from the last major merger

Jason Sanders (UCL)
Vasily Belokurov, Kai Man
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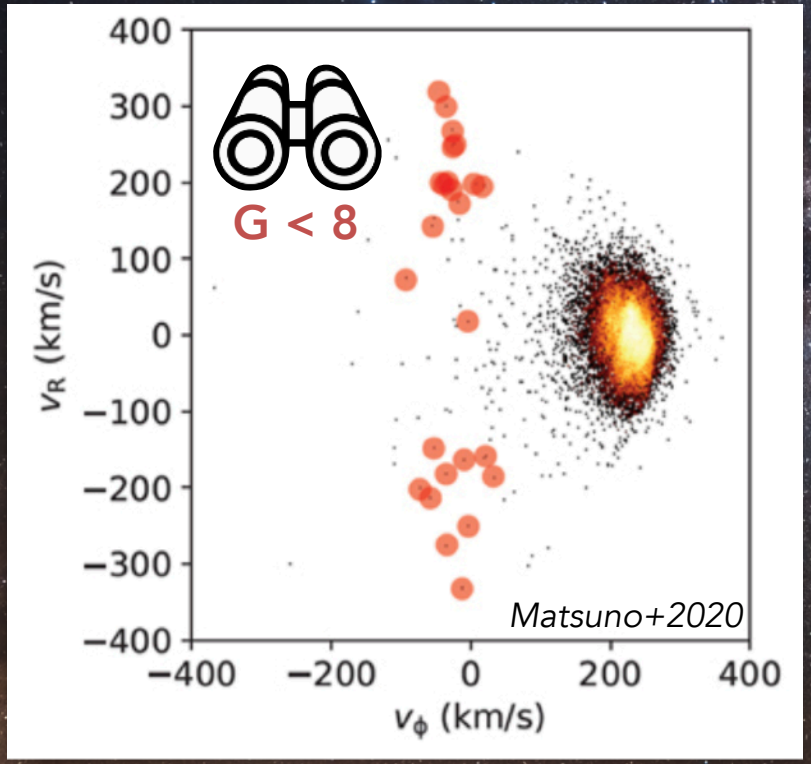
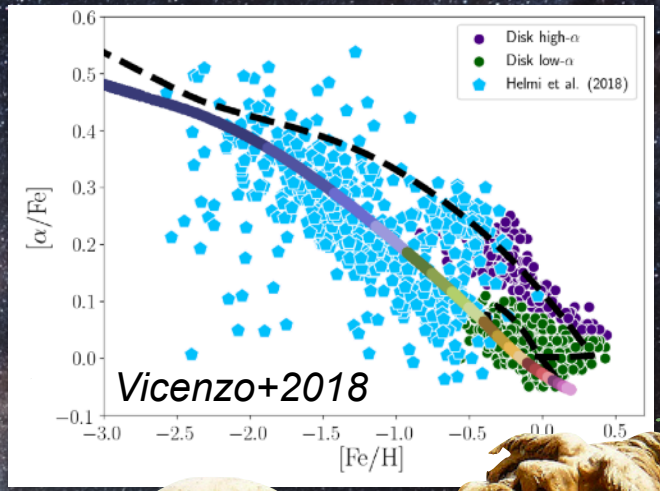
THE ROYAL SOCIETY

A nearby bright low-metallicity 'galaxy'

Belokurov+ (2018), Helmi+ (2018)



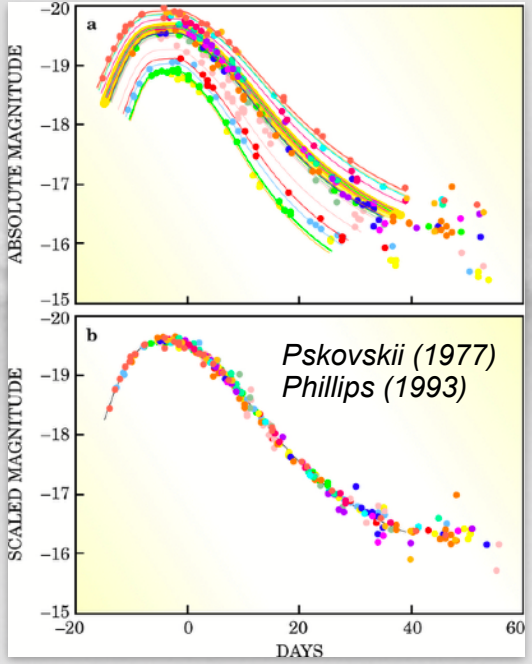


The importance of Type Ia supernovae

Distance ladder

Riess+ (1998)
Perlmutter+ (1999)

Standardizable



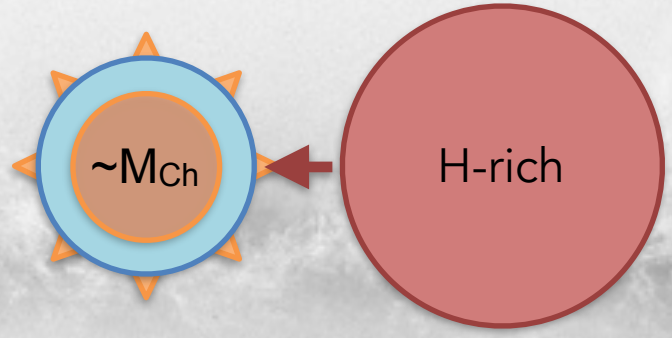
Pskovskii (1977)
Phillips (1993)

C/O white dwarf in a binary

Whelan & Iben 1973
Iben & Tutukov 1984

Type Ia progenitor scenarios *(e.g. Seitenzahl & Townsley 2017, Ruiter 2020)*

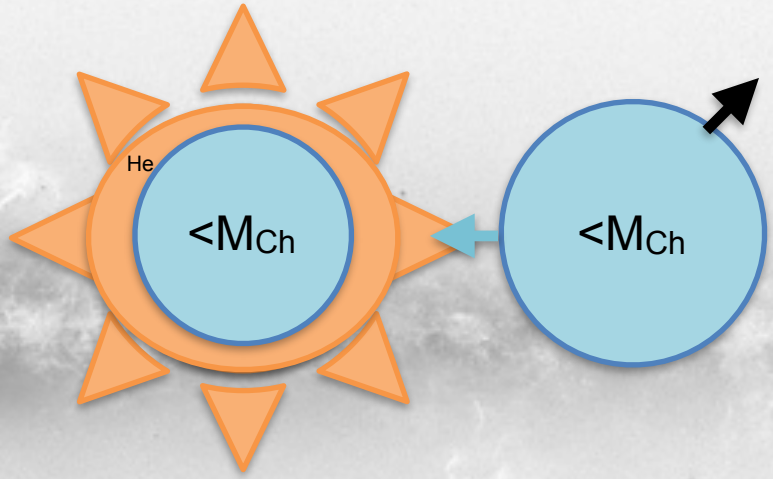
Single-degenerate



Deflagration-to-detonation
Nomoto+ 1984

High density

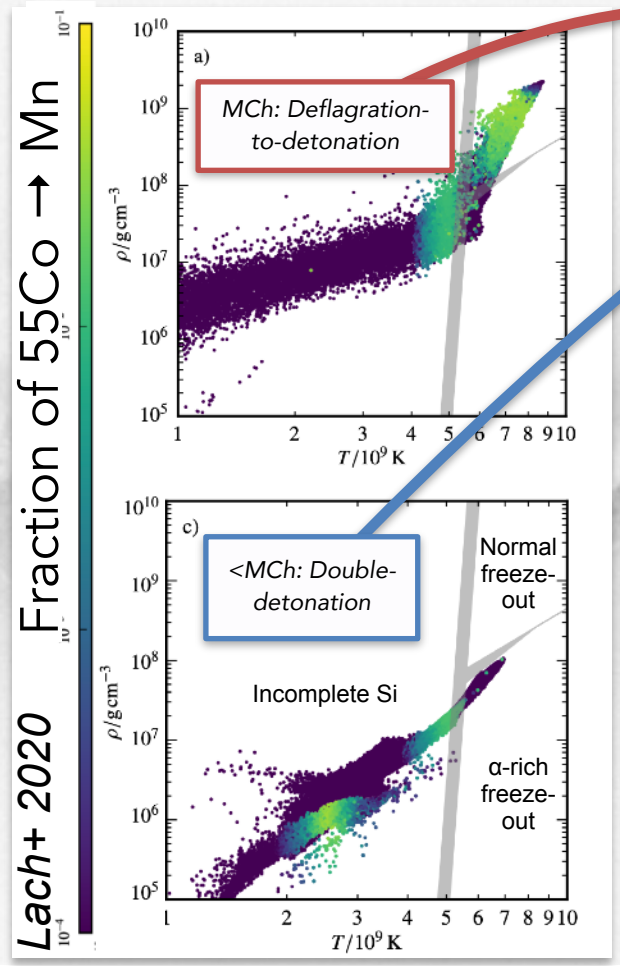
Double-degenerate

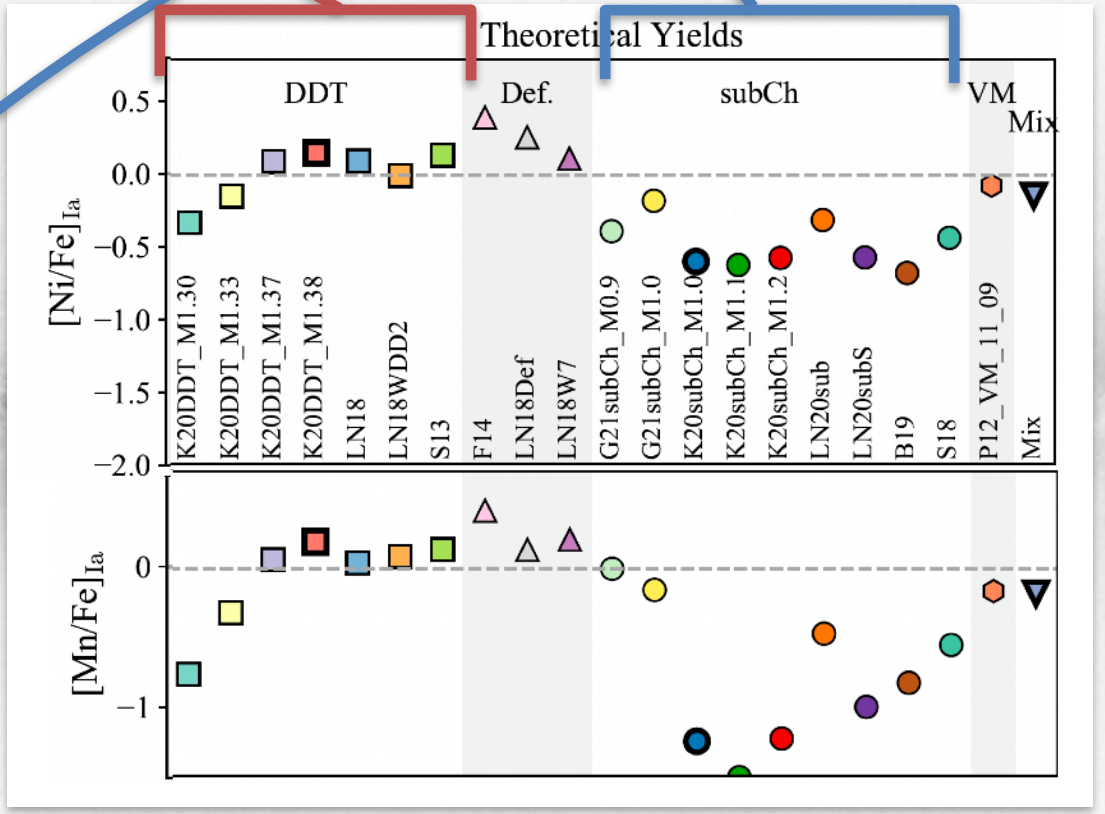


Double-detonation
Woosley & Weaver 1994

Low density

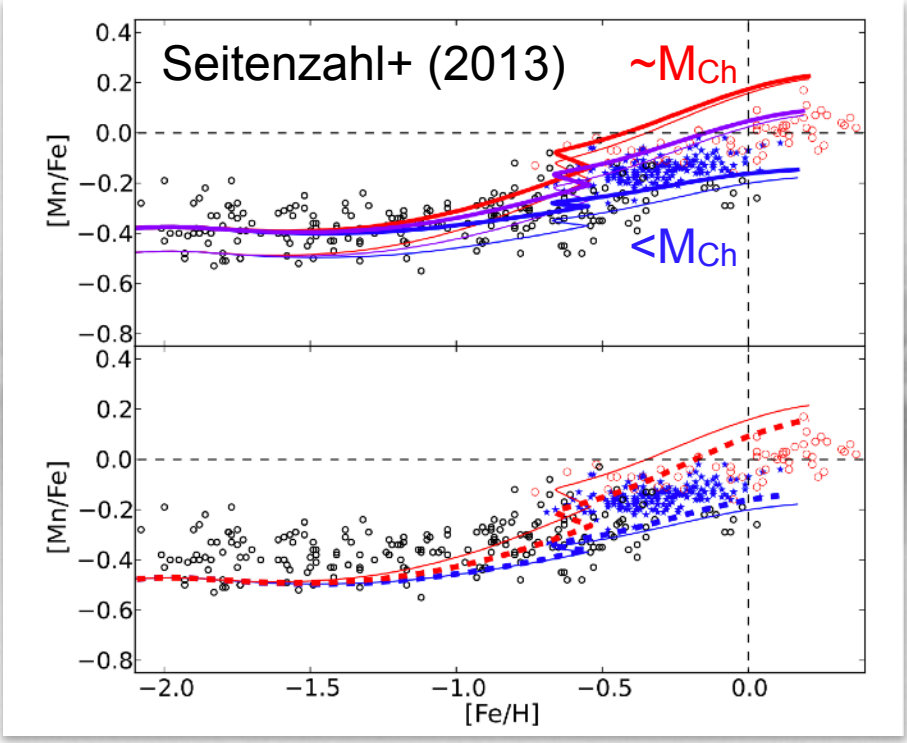
Mn & Ni as discriminators



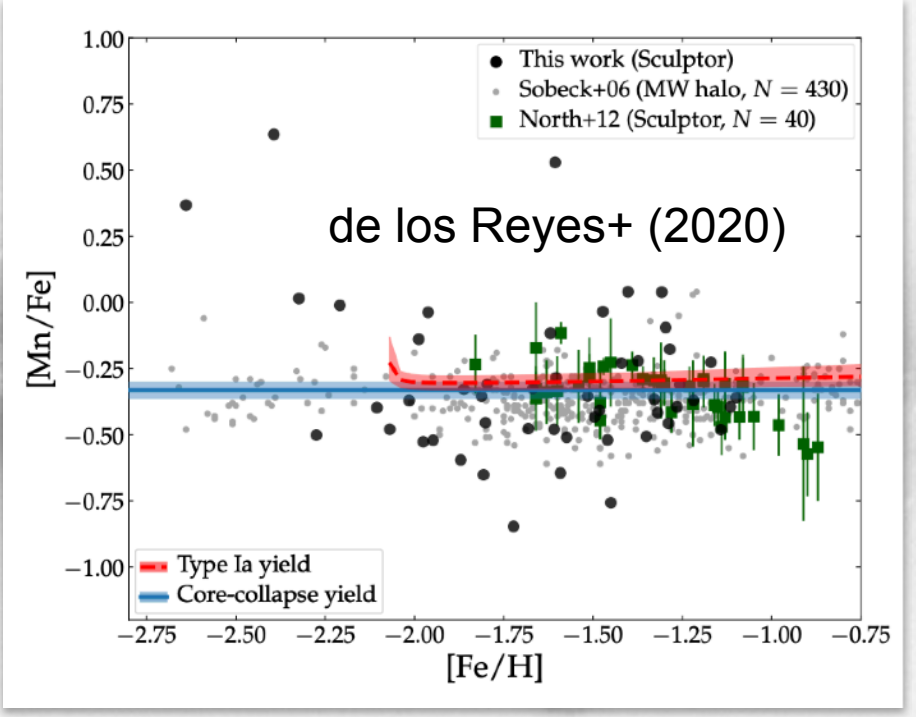


Using stellar abundances to test Type Ia scenario

Milky Way



Sculptor

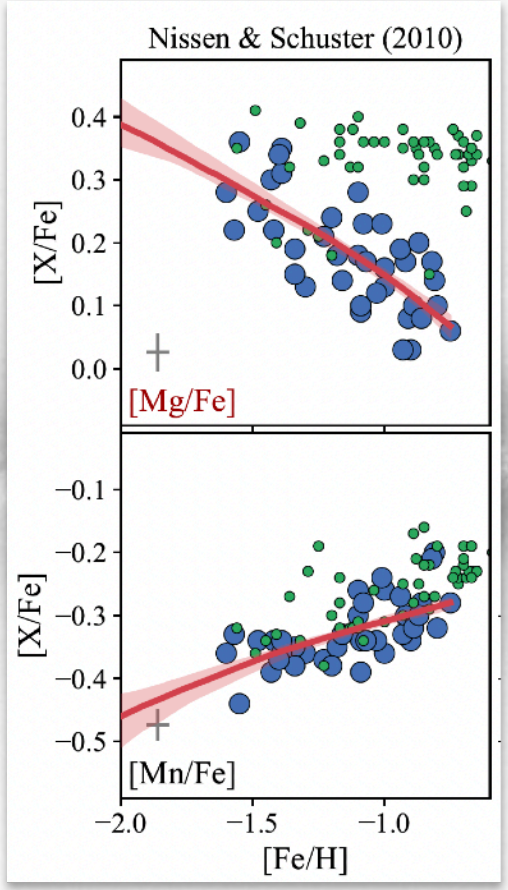


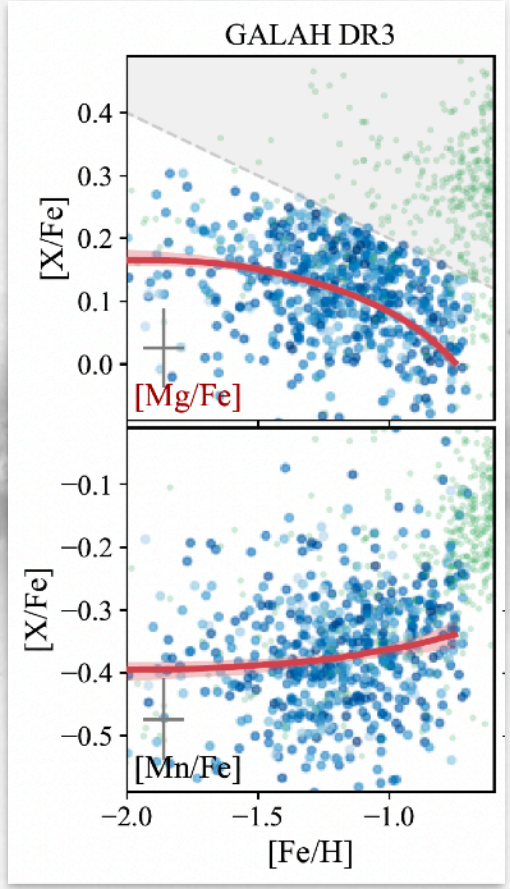
Also Cescutti+ (2008), Kobayashi+ (2020)

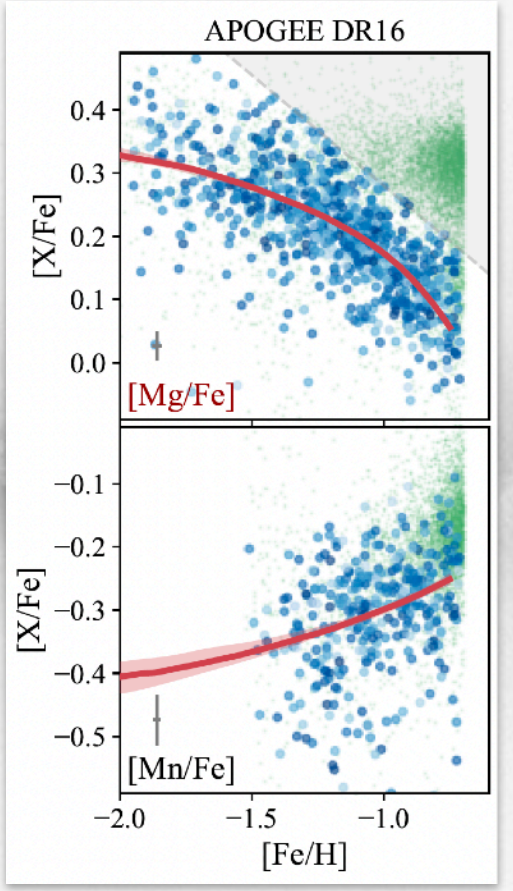
Gaia-Enceladus/Sausage data

Gaia EDR3
+ spectroscopic

- Eccentricity>0.8
- [Fe/H]<-0.7dex
- [Mg/Fe] vs [Fe/H] cut







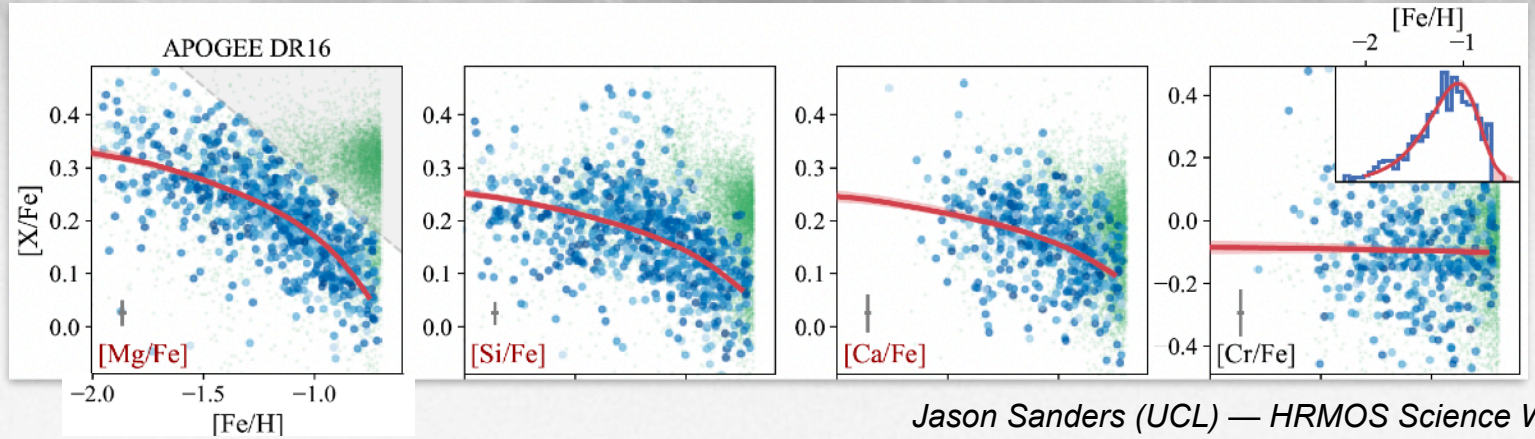
A flexible chemical evolution modelling approach

Flexible fast (analytic) approach (Weinberg+ 2017)

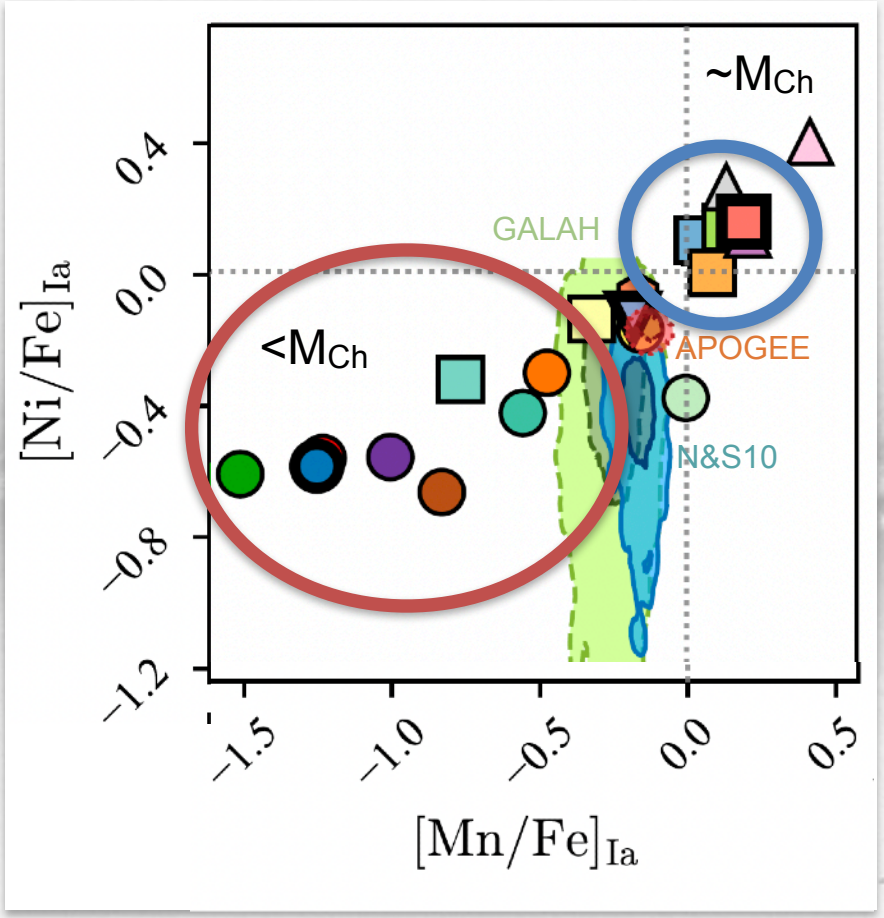
- Single zone
- Star-formation history specified (sum of analytic forms)
- Linear Kennicutt-Schmidt Law
- Type II products returned instantly, Type Ia delay-time distribution, no AGB here
- **Stellar yields independent of metallicity**

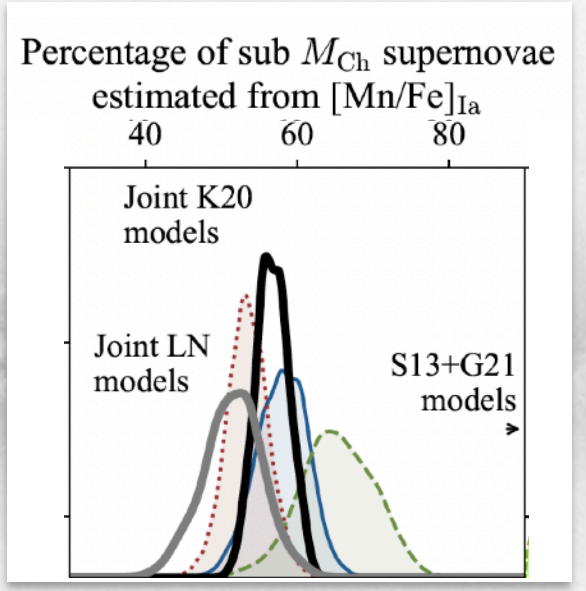
Simultaneously constraining Type II/Ia yields and the chemical evolution parameters

Fitting 9-dimensional data (Fe, Mg, Si, Ca, Cr, Mn, Ni, Cu, Zn)



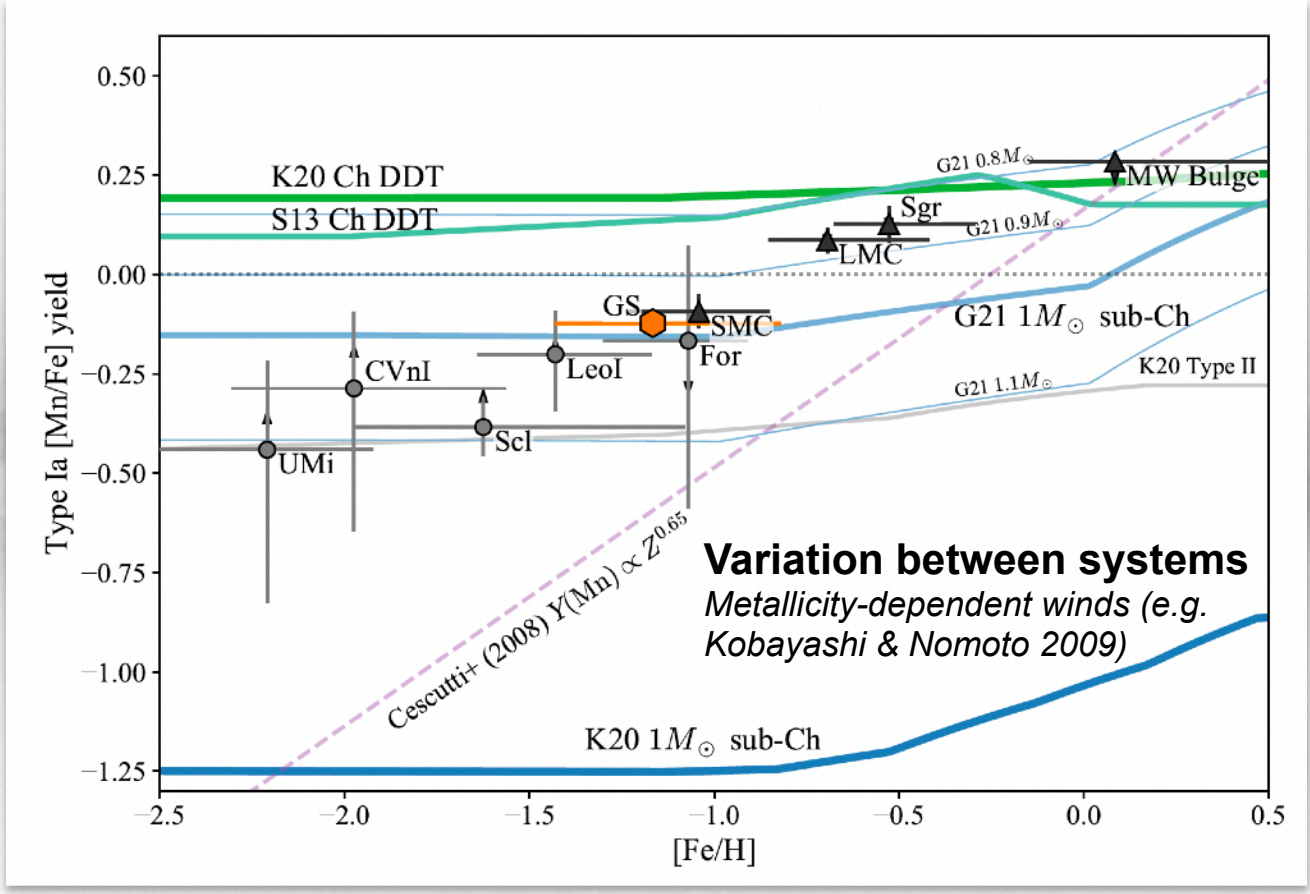
Type Ia Mn & Ni constraints



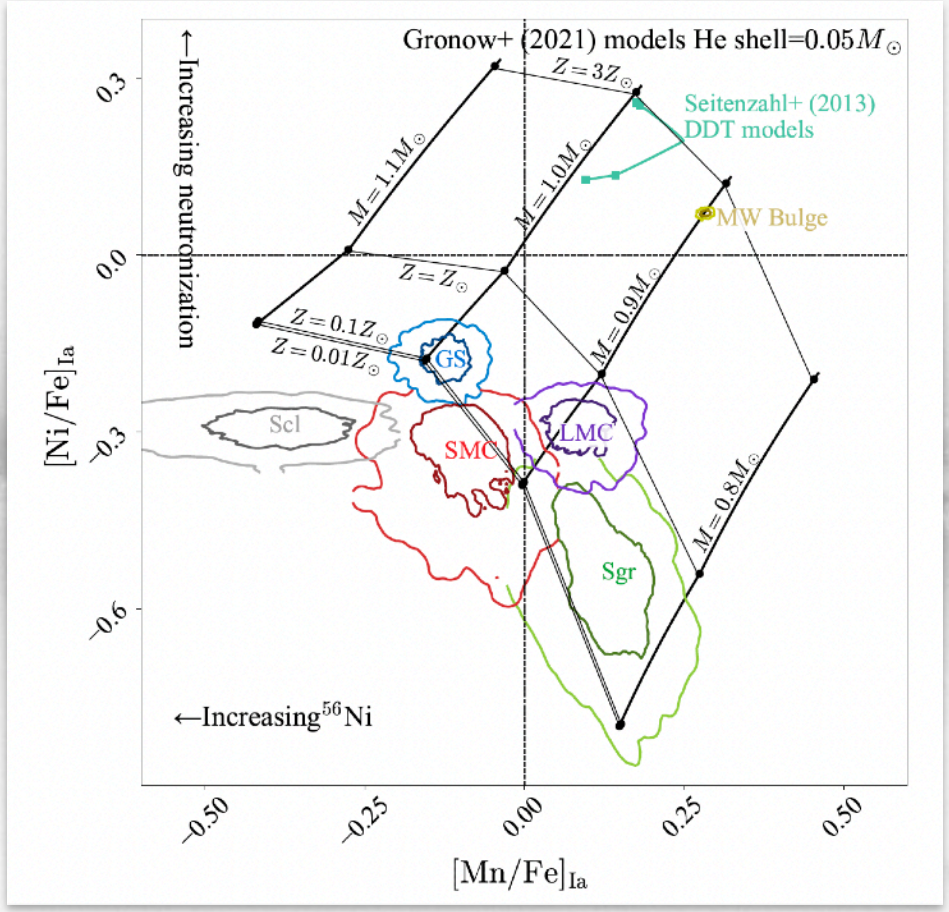


~10% NLTE variation

Evolution across different systems



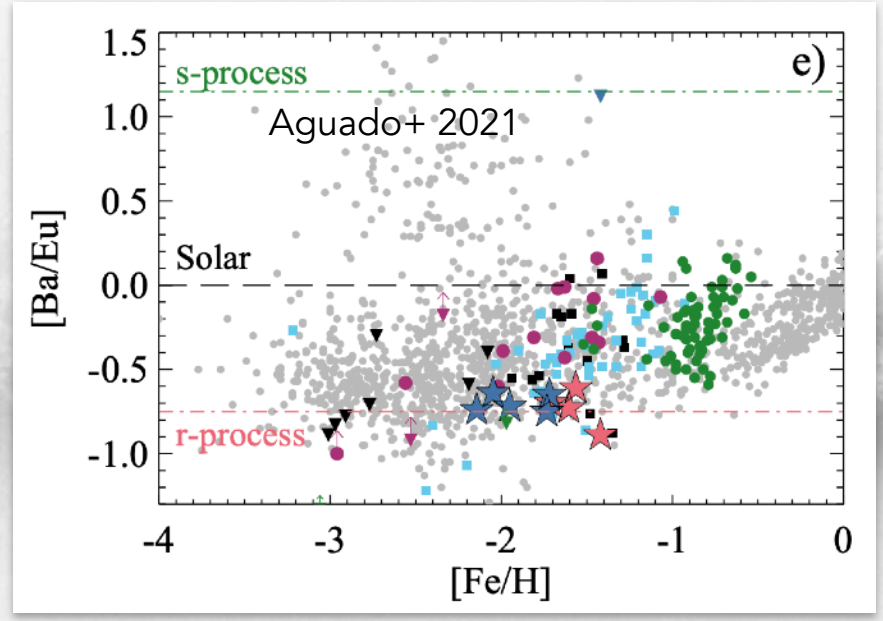
A route to constraining mass-metallicity dependence



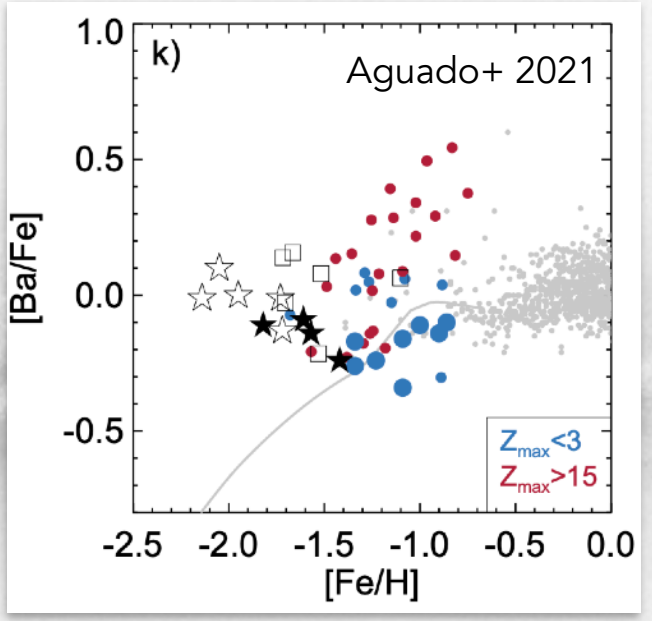
Variation between systems

Mass and metallicity play a role
More extended SFH — lower mass WDs
Similar to extragalactic (Howell+ 2001)

Other channels — r process (e.g. Aguado+ 2021, Matsuno+ 2021)



UVES observations of 9 Sausage & Sequoia members
r-process enhancement



Multi-zone chemical evolution!

Conclusions

- As already realised by Nissen & Schuster (2010), bright stars on halo-like orbits are interesting
- Gaia opens up possibility of reliably kinematically selecting these stars (e.g. Lane+2021)
- An opportunity to study the enrichment channels in a ~low-metallicity early star-forming galaxy!

Thanks