Characterizing Exoplanetary Rocks Using Polluted White Dwarfs

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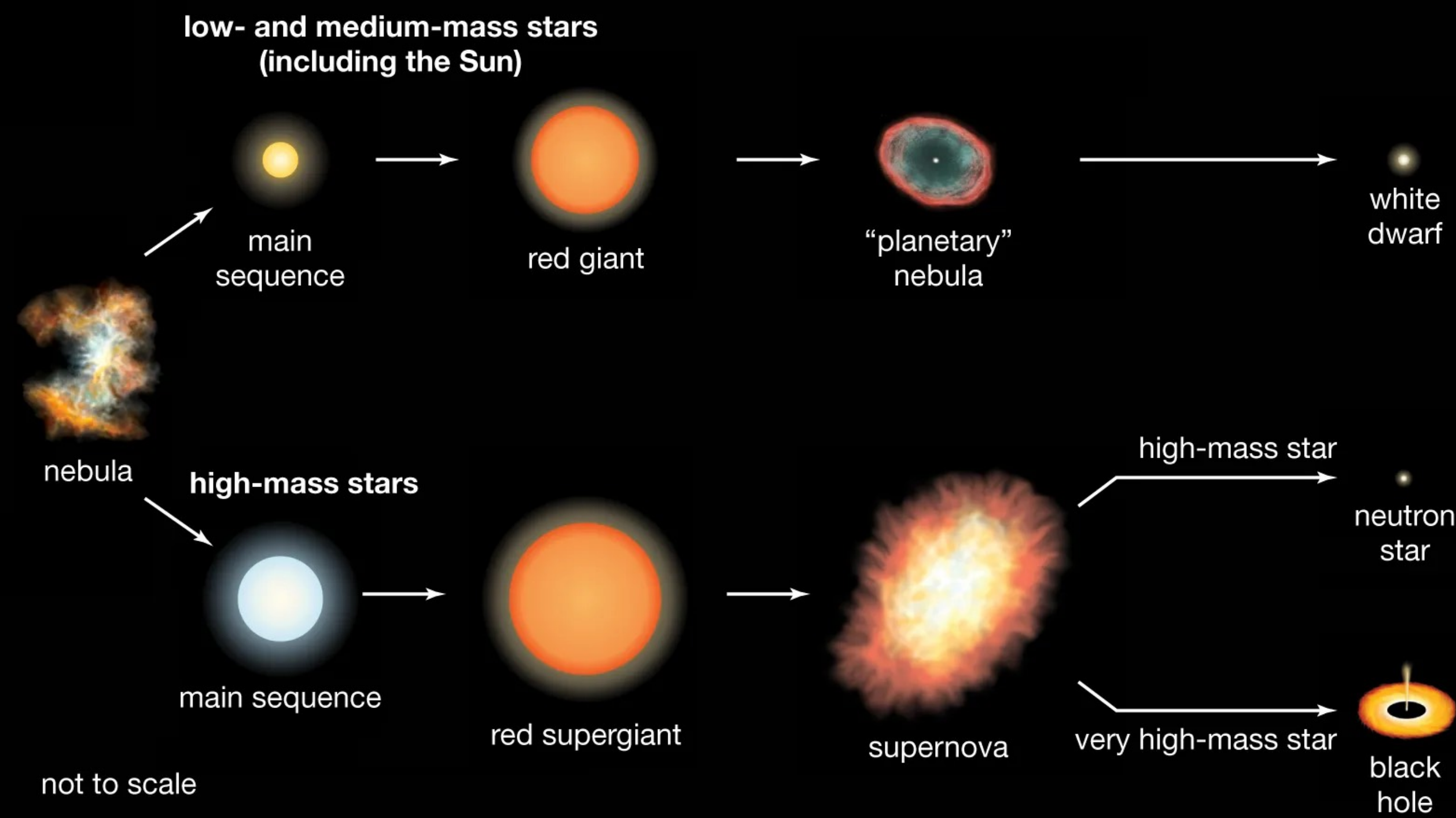
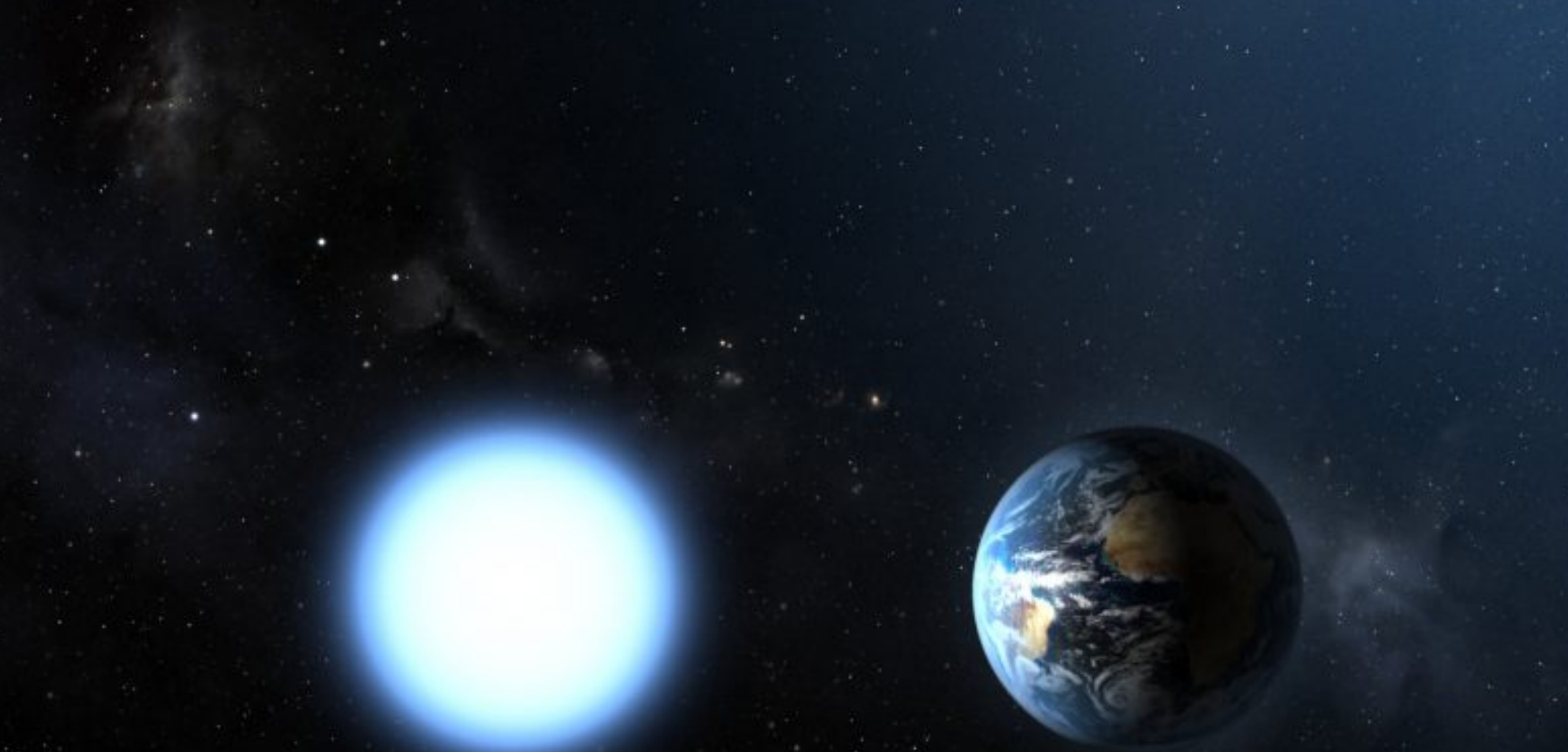
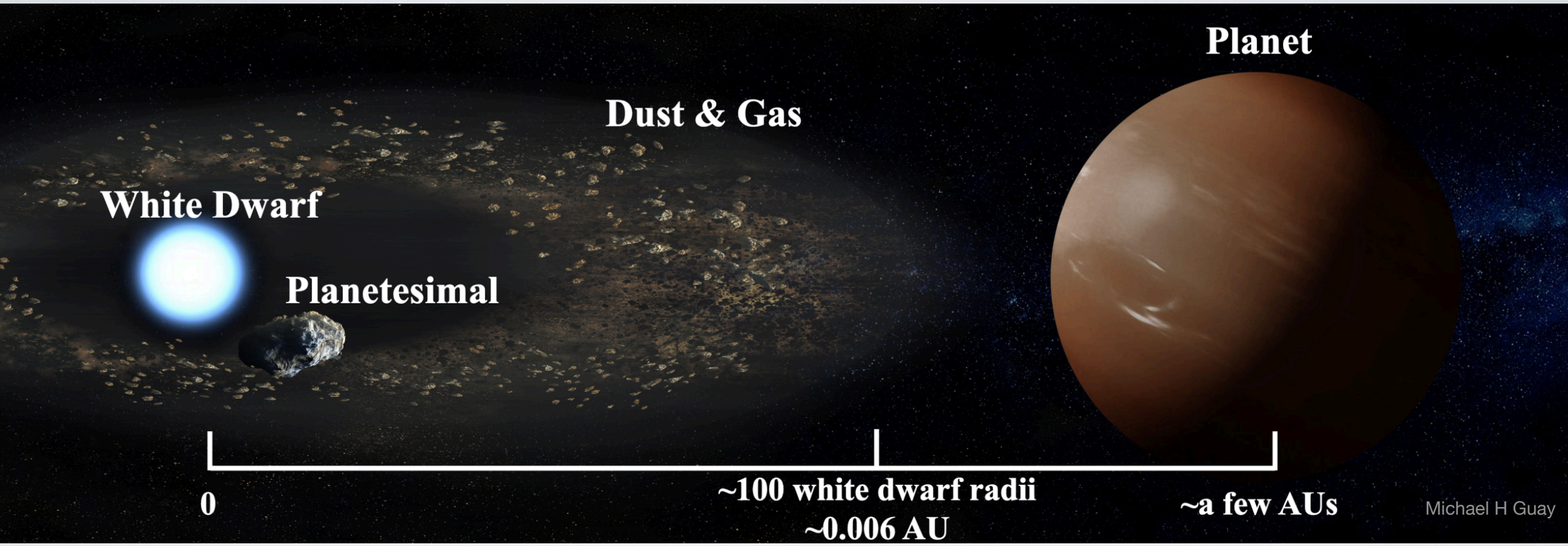
Stellar evolution





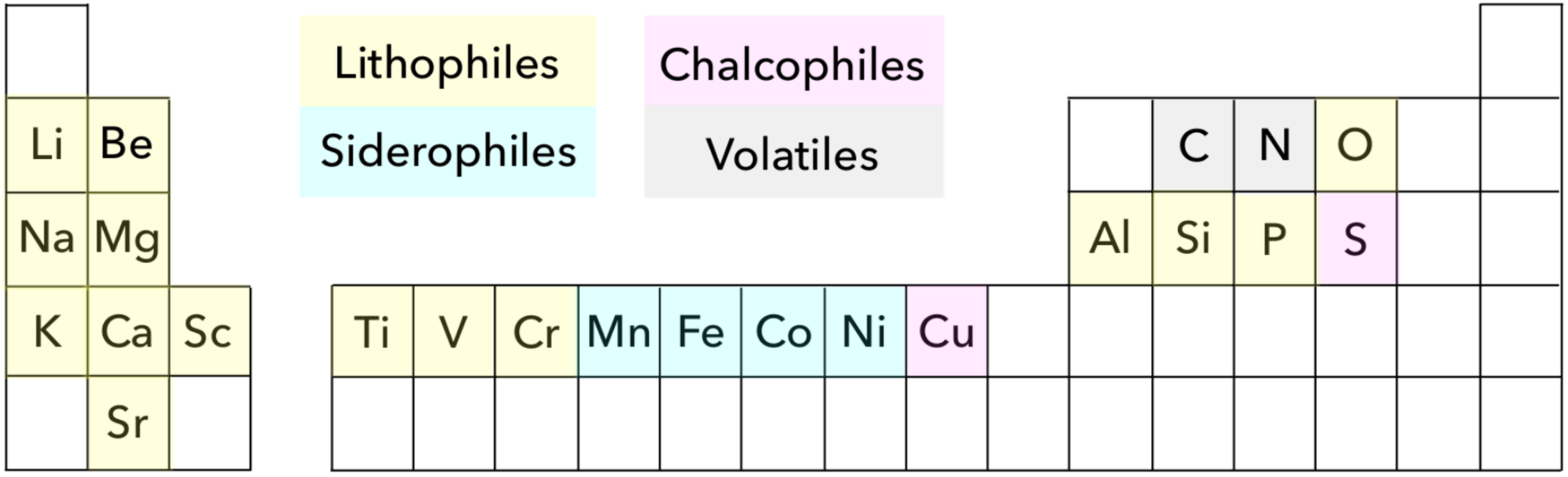
~1/3 of white dwarfs are polluted by heavy elements

WHITE DWARF SYSTEMS ARE ACTIVE



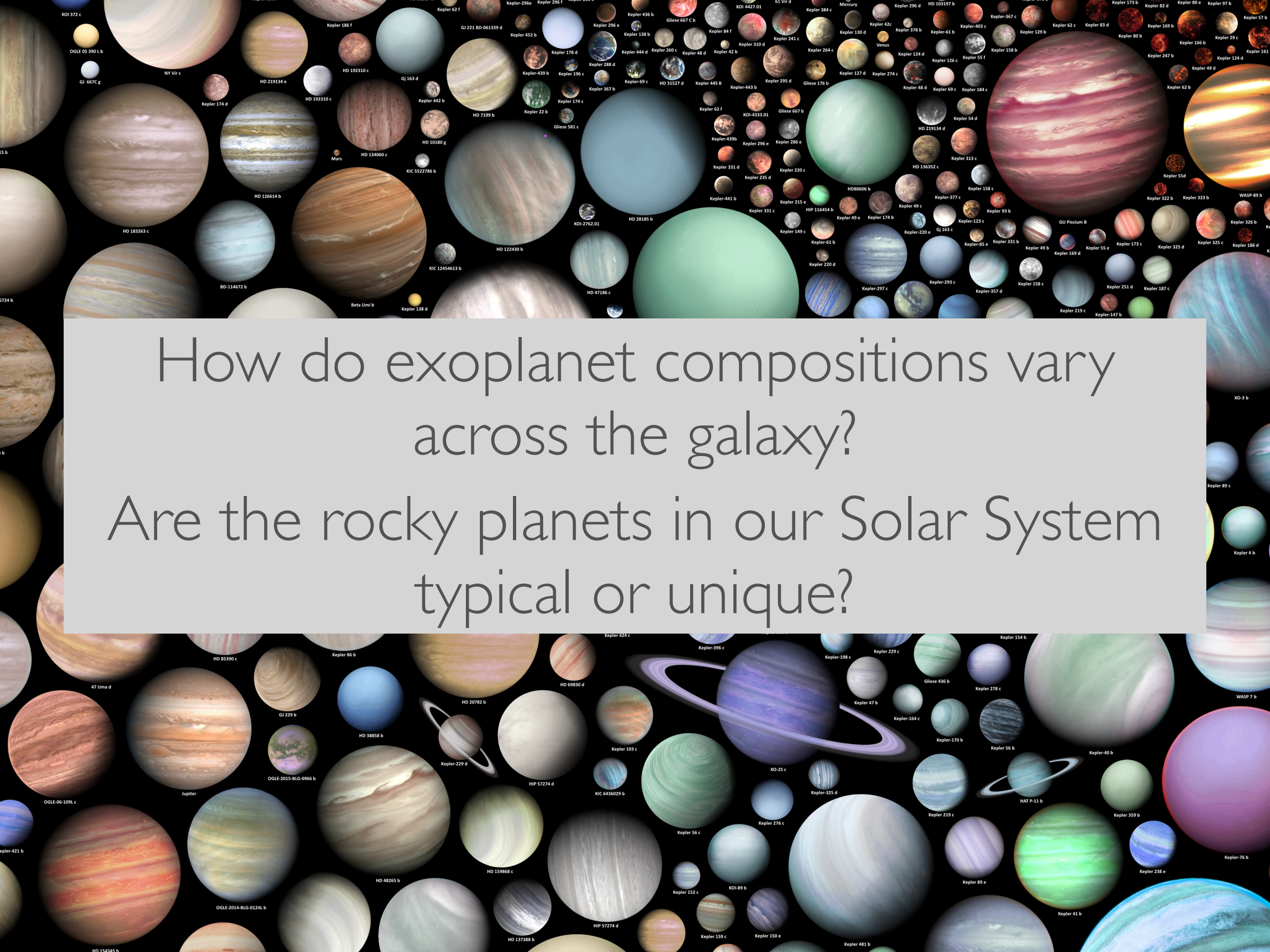
Gas, dust, major and minor planets have been detected around white dwarfs in a variety of orbits and states of decay

Planetary metals observed in white dwarf photospheres



Veras 2021

- Pollution is mostly rocky and sometimes icy
- >1000 polluted white dwarfs, ~50 highly polluted
- Pollution candidates include asteroids, comets, KBOs, exomoons

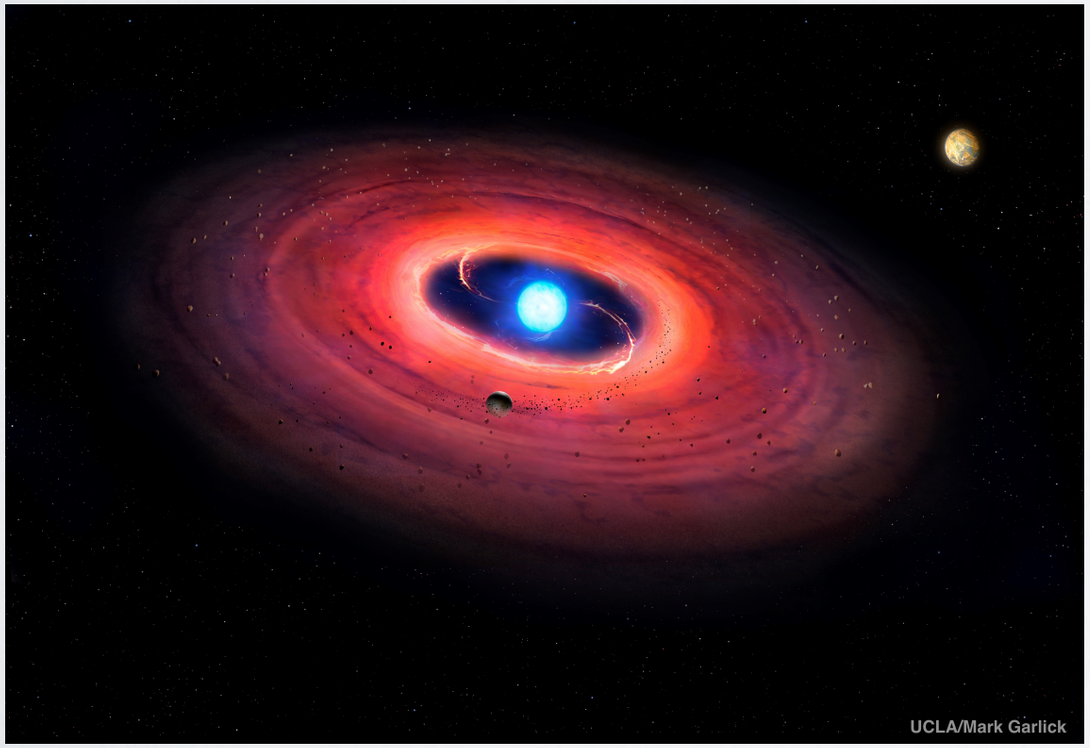


How do exoplanet compositions vary across the galaxy?

Are the rocky planets in our Solar System typical or unique?

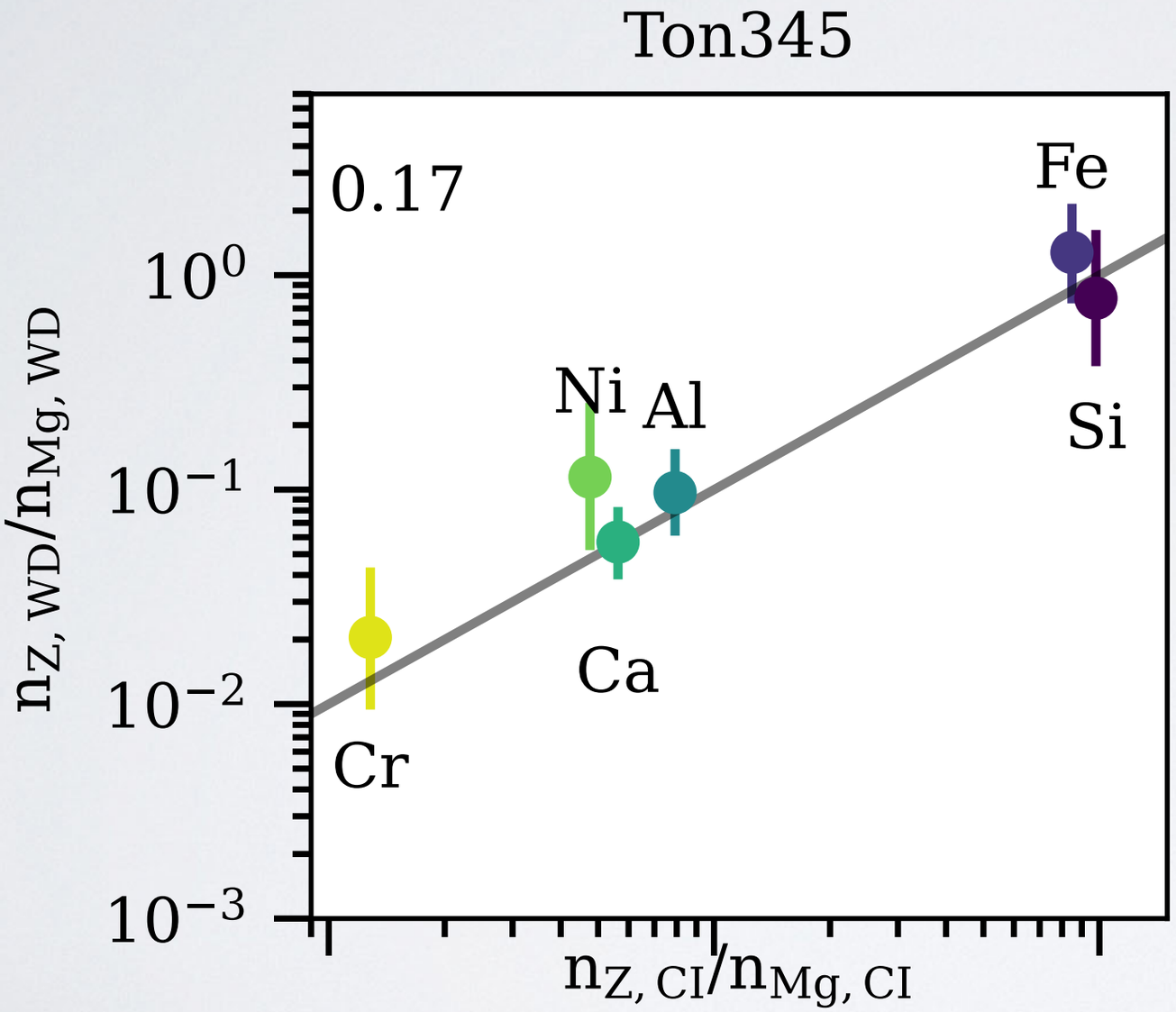
HOW DO EXOPLANET COMPOSITIONS VARY ACROSS THE GALAXY?

- White dwarf pollution provides samples of exoplanetary rocks in the solar neighborhood
- We test local exoplanet compositions by comparing polluted white dwarfs to solar system rocks and benchmark against local stellar abundances

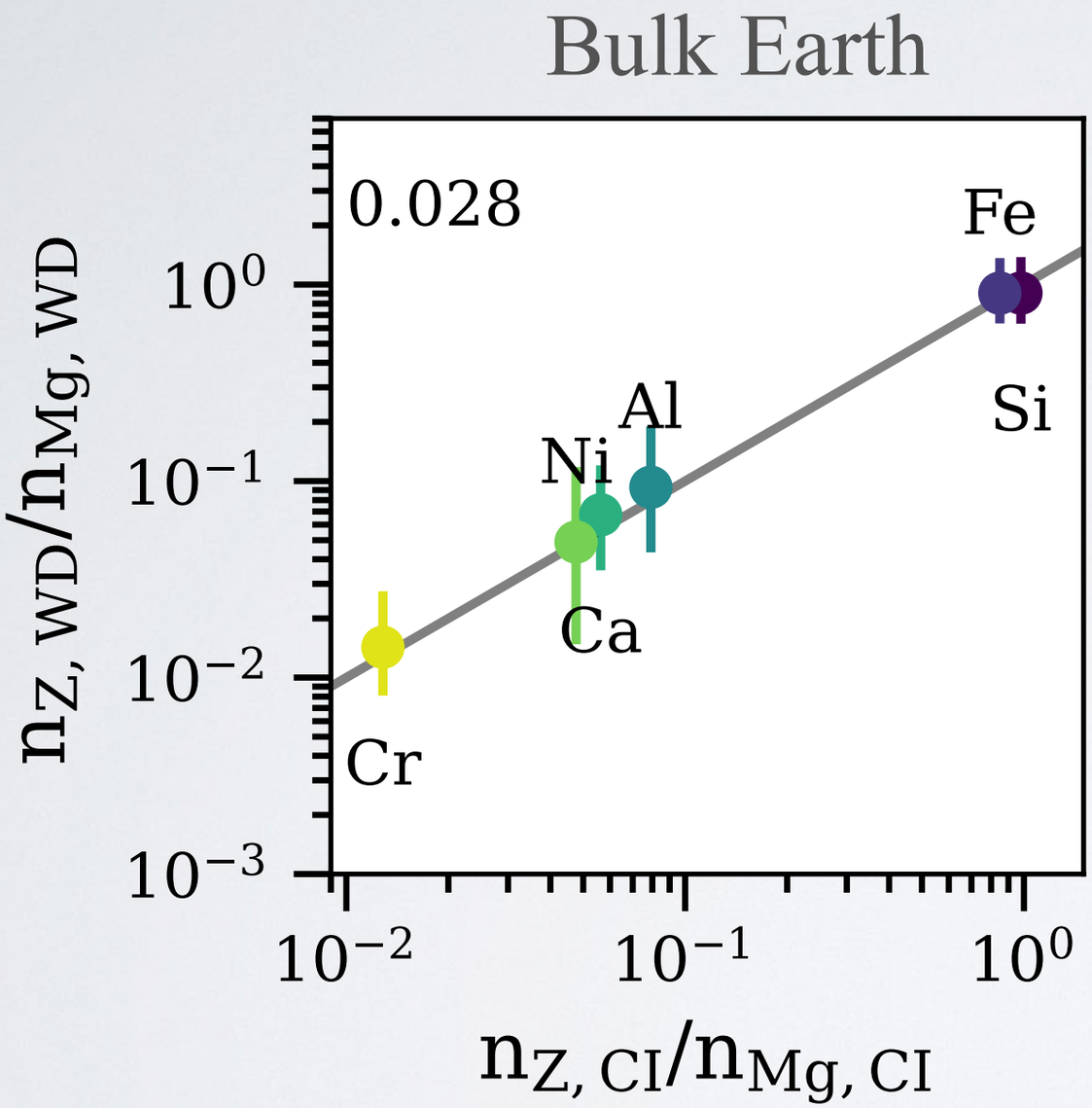


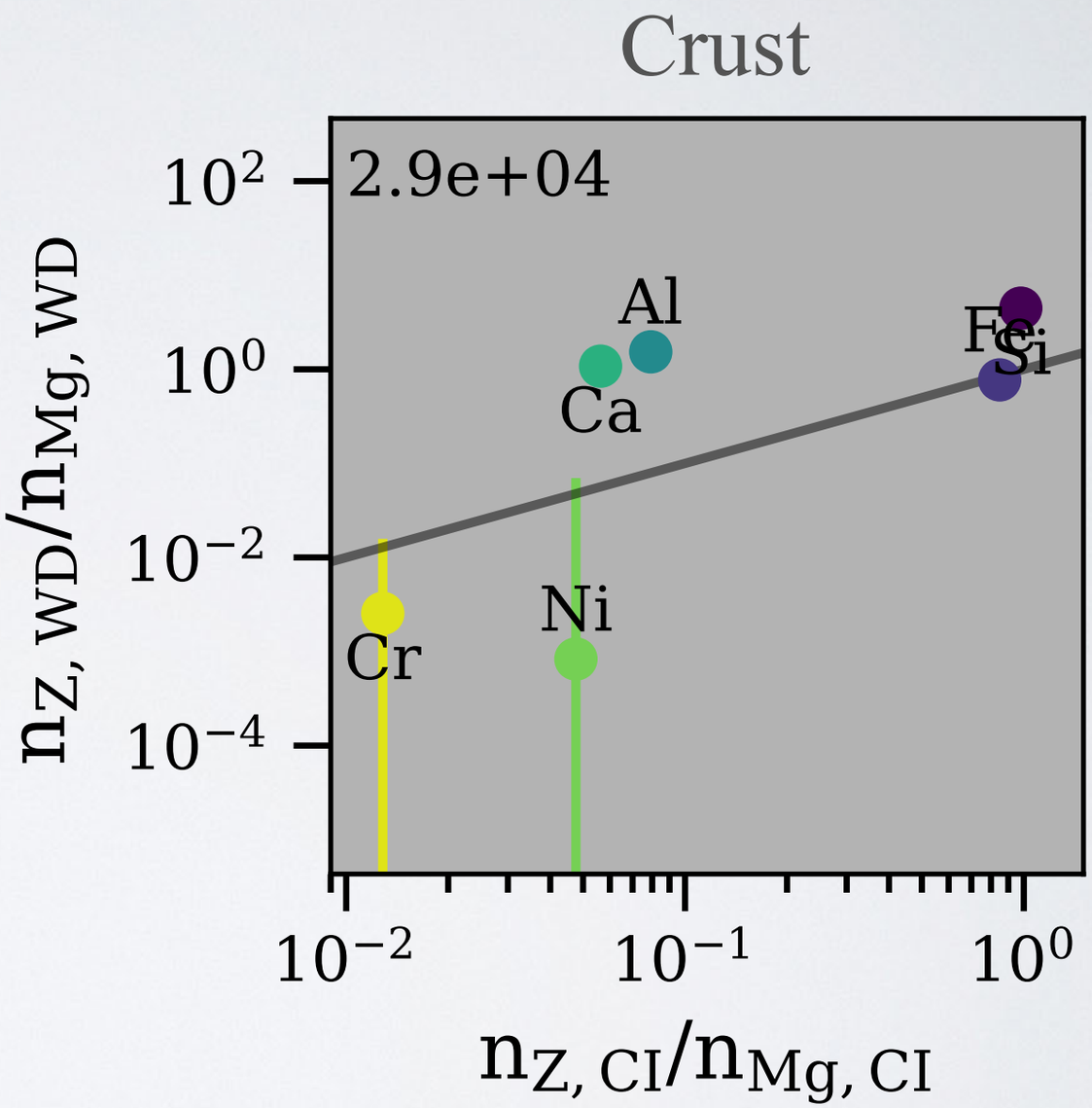
COMPARING EXO-ROCKS TO SOLAR SYSTEM CHONDRITES

Chondrites are best representation of Solar System compositions

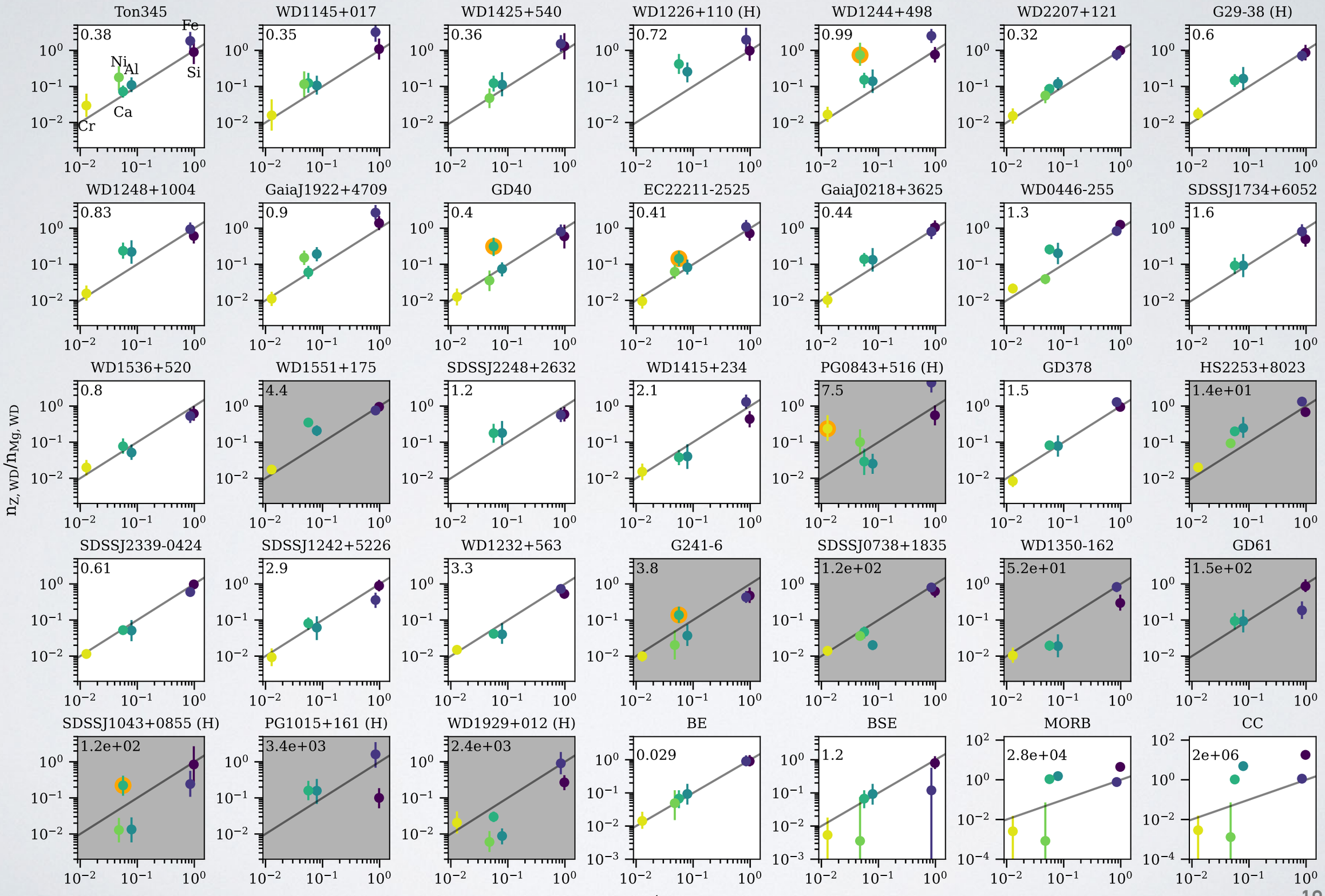


STATISTICALLY DISTINGUISH BETWEEN CHONDRITE AND CRUST





WHITE DWARFS ABUNDANCES



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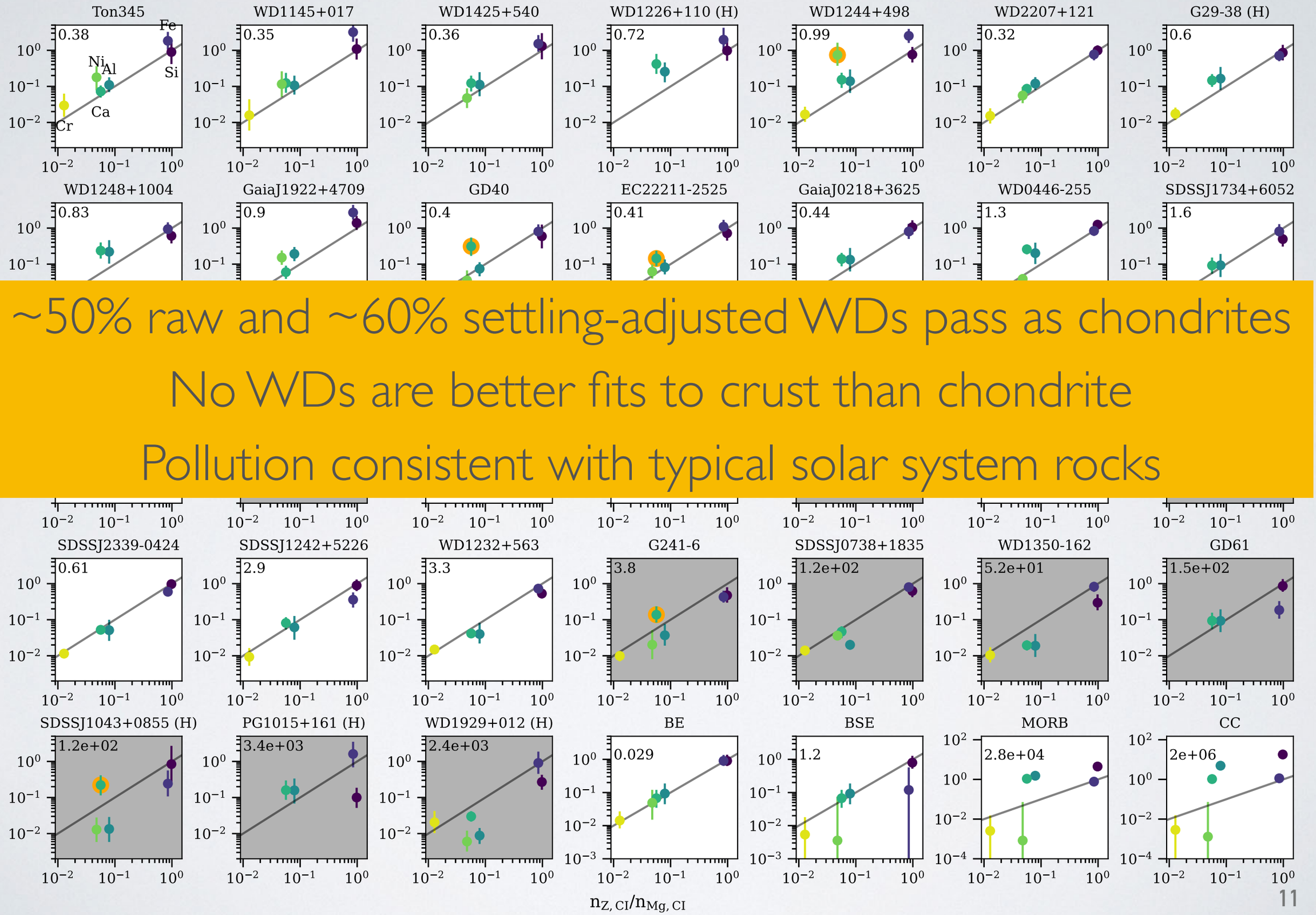


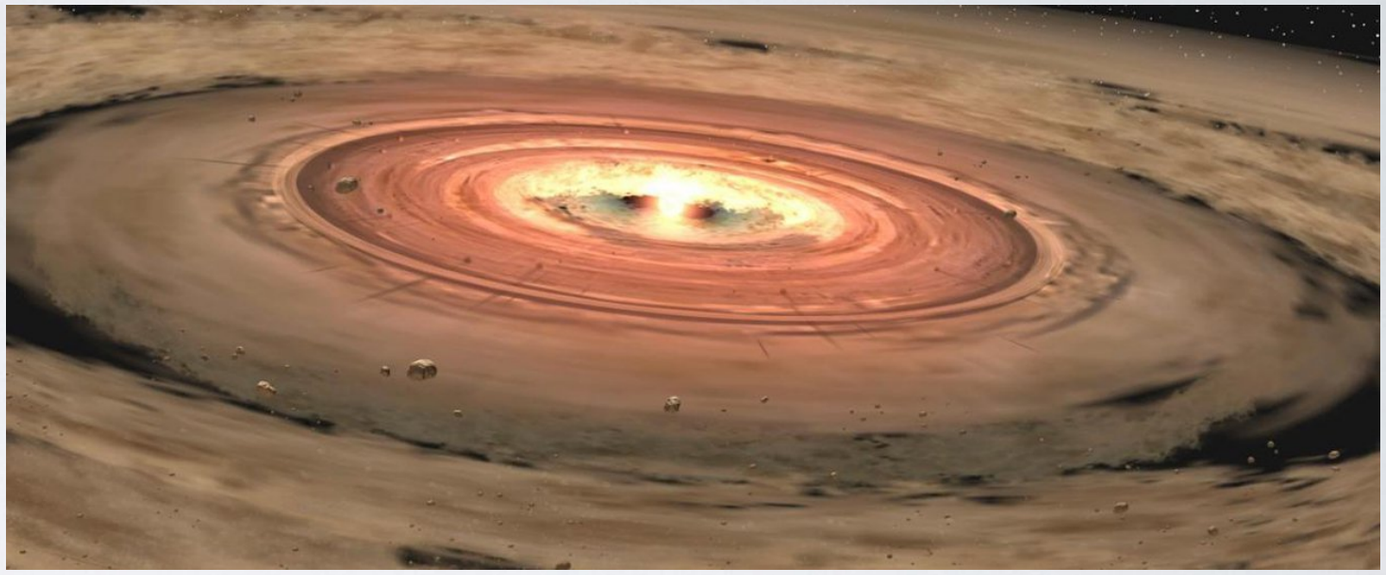
~50% raw and ~60% settling-adjusted WDs pass as chondrites

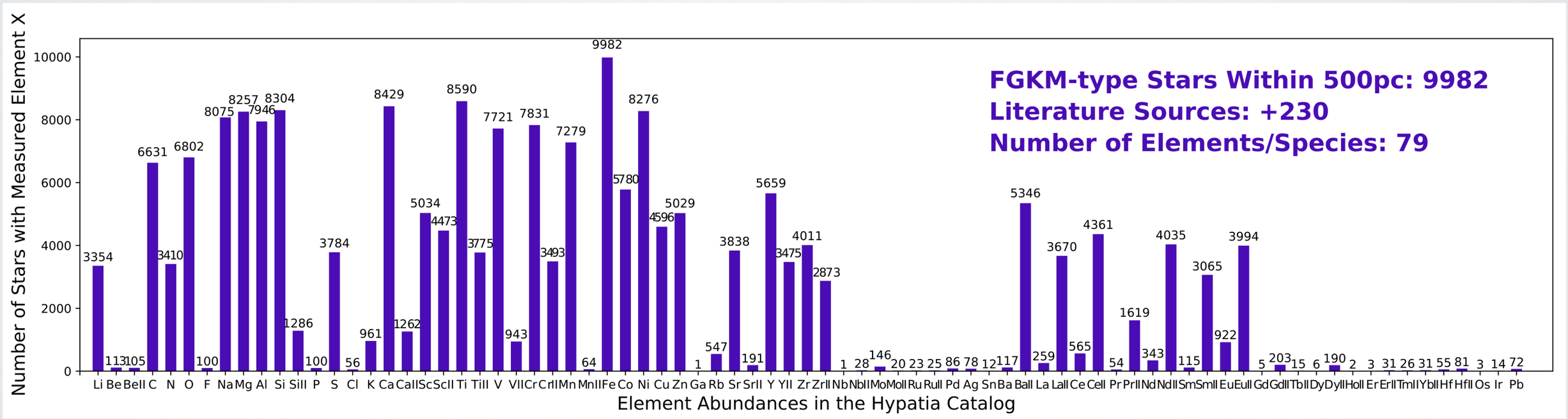
No WDs are better fits to crust than chondrite

Pollution consistent with typical solar system rocks

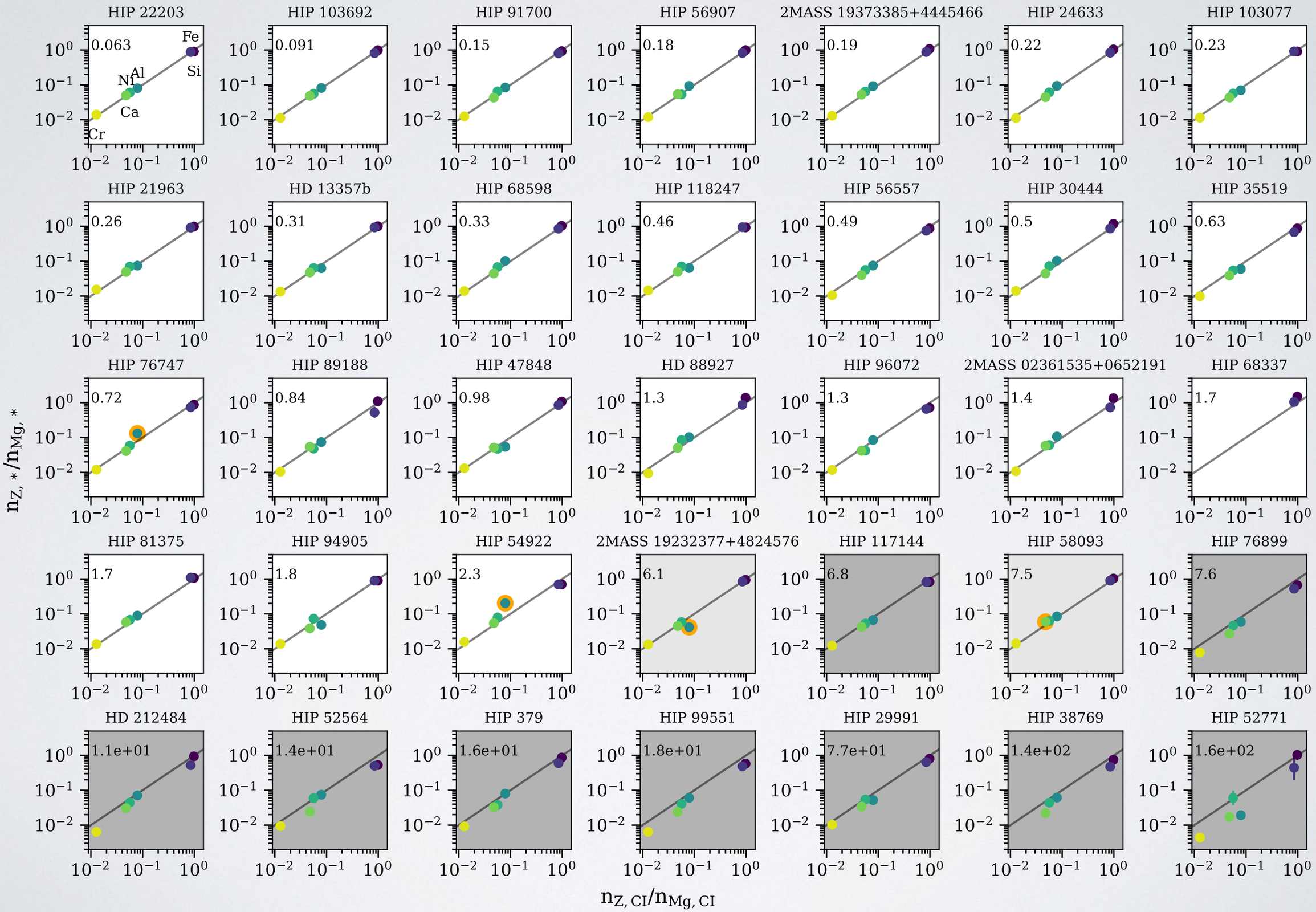
HYPATIA CATALOGUE STARS

Stellar abundances represent protoplanetary disk environments and correlate with planet compositions
(Thiabaud+ 2015, Bonsor+ 2021)



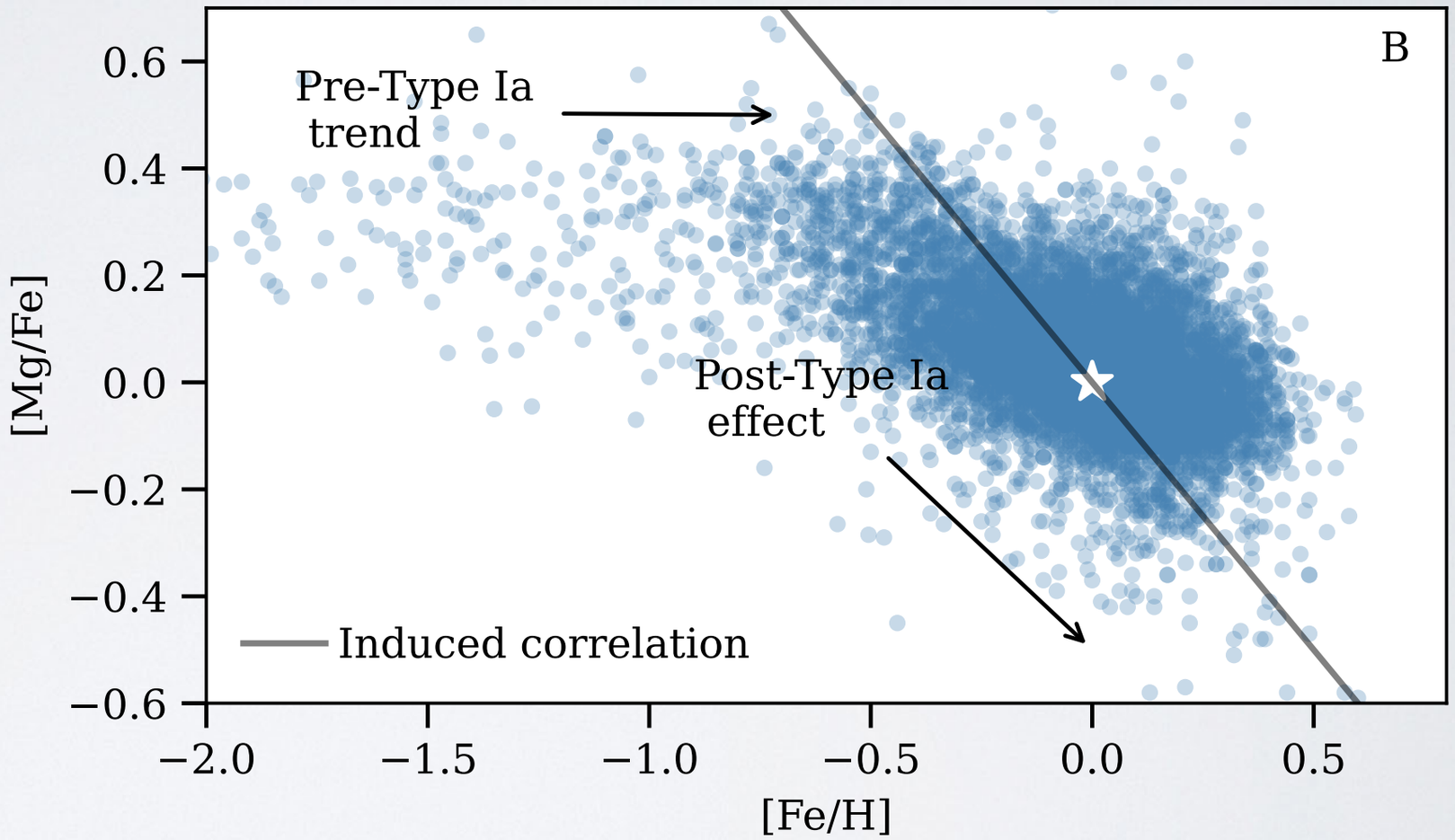


HYPATIA CATALOGUE STARS

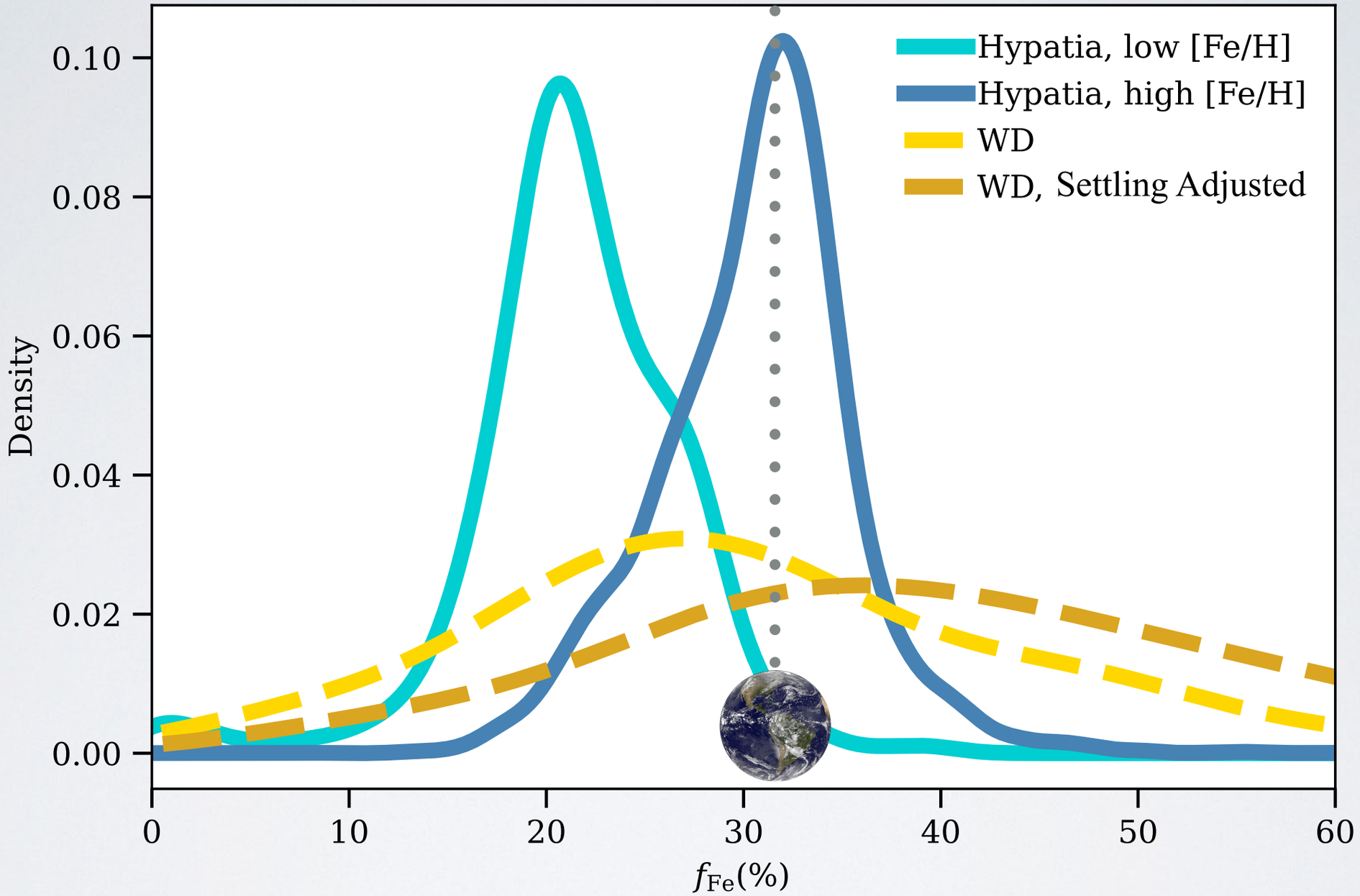


CONSIDERING EFFECTS OF GALACTIC CHEMICAL EVOLUTION

- Metallicity [Fe/H] increases with time
- Change in lithophile/ siderophile ratios due to late effects from Type Ia supernovae



EFFECTS OF GALACTIC CHEMICAL EVOLUTION – SMALLER CORES?

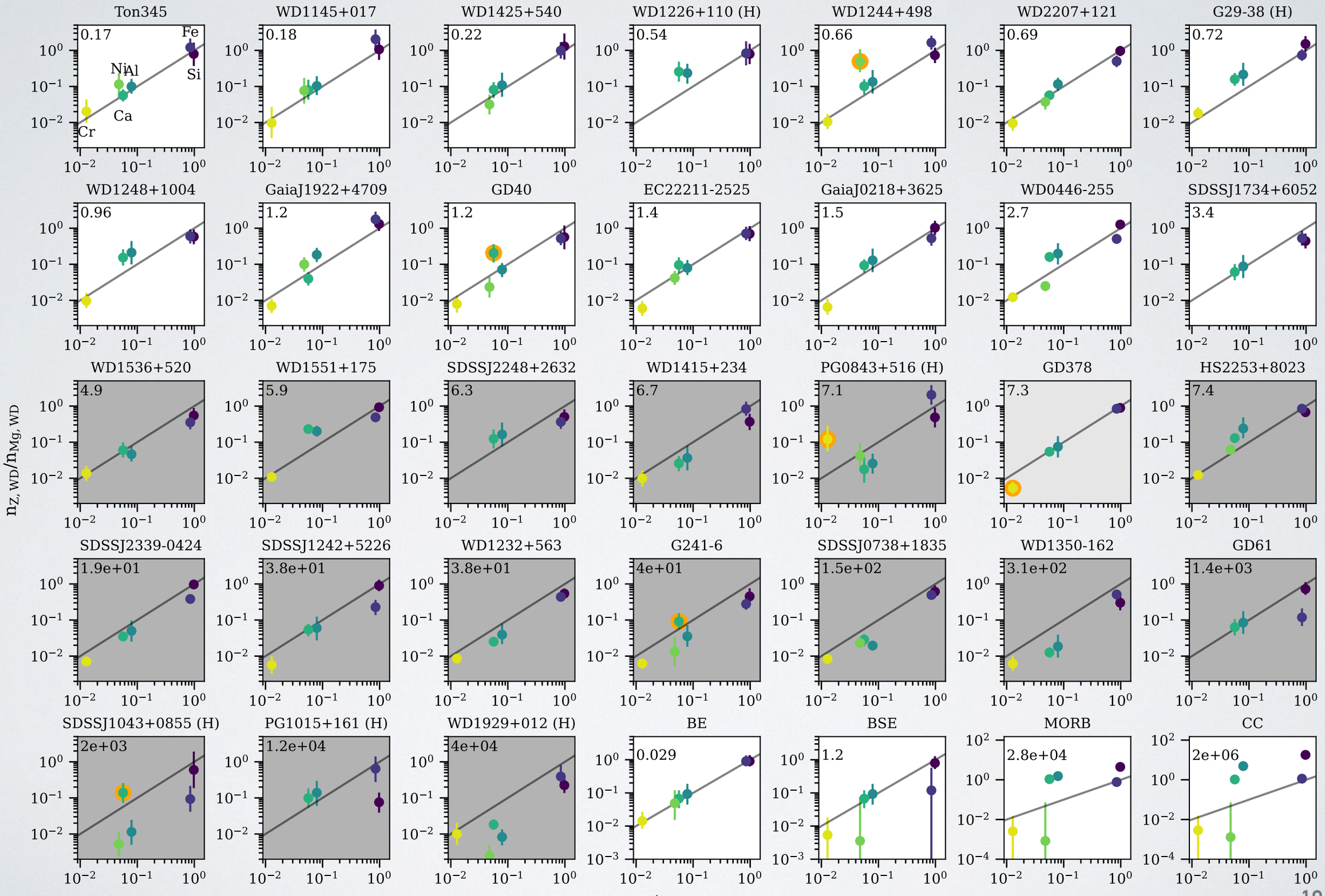


Expect smaller cores at early times or in very low metallicity regions of the galaxy

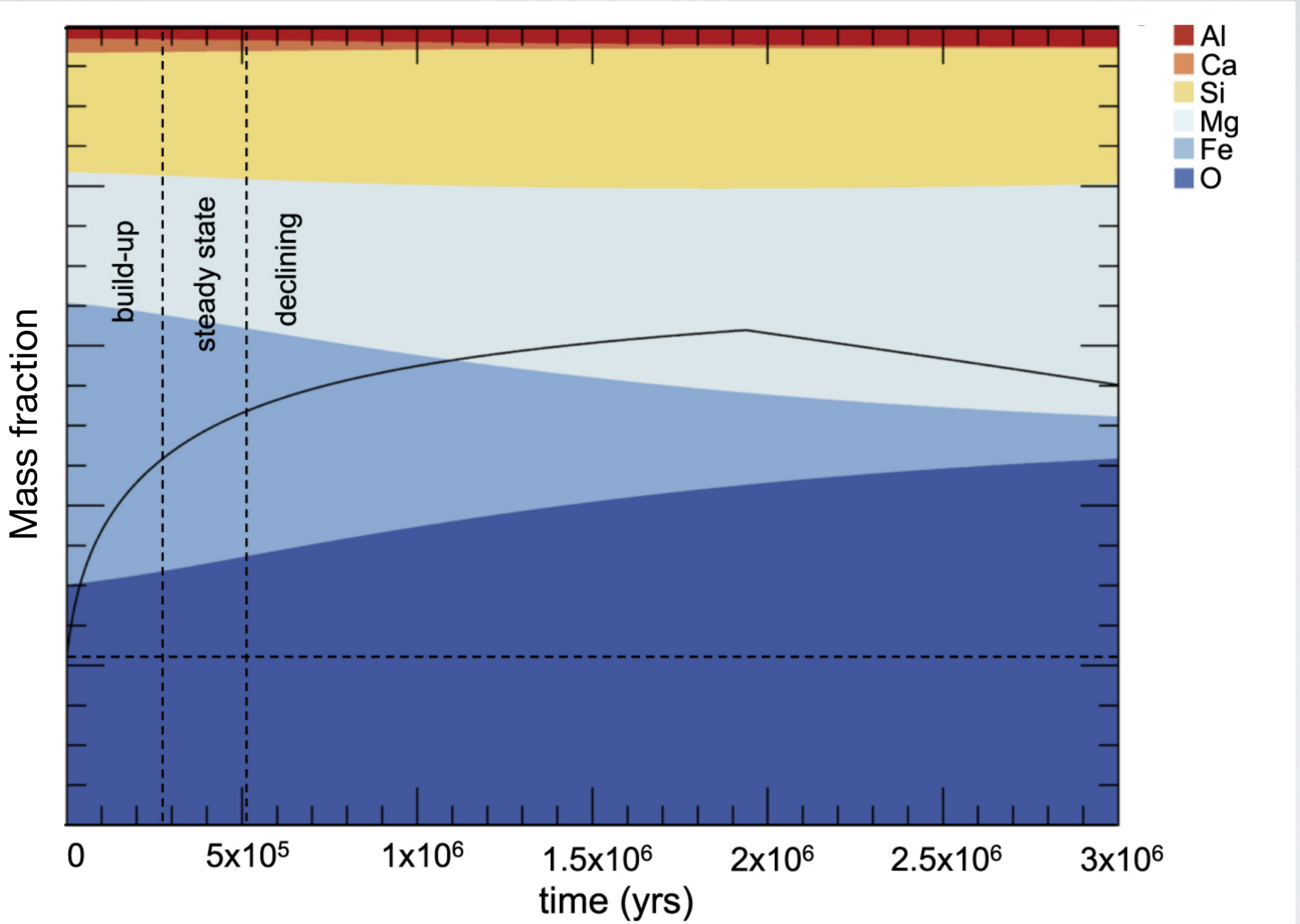
SUMMARY

- Solar system rocks are typical in the solar neighborhood
  - >50% of exo-rocks sampled by polluted WDs are consistent with chondritic material
  - ~75% of local stars sample by Hypatia Catalog are consistent with chondrites
    - No evidence for accretion of crust by WDs
- On galactic scales, chemical evolution may lead to systematically smaller iron cores in planets at early times, but galactic effects are likely not impacting the current sample of polluted WD compositions

WHITE DWARFS – RAW DATA



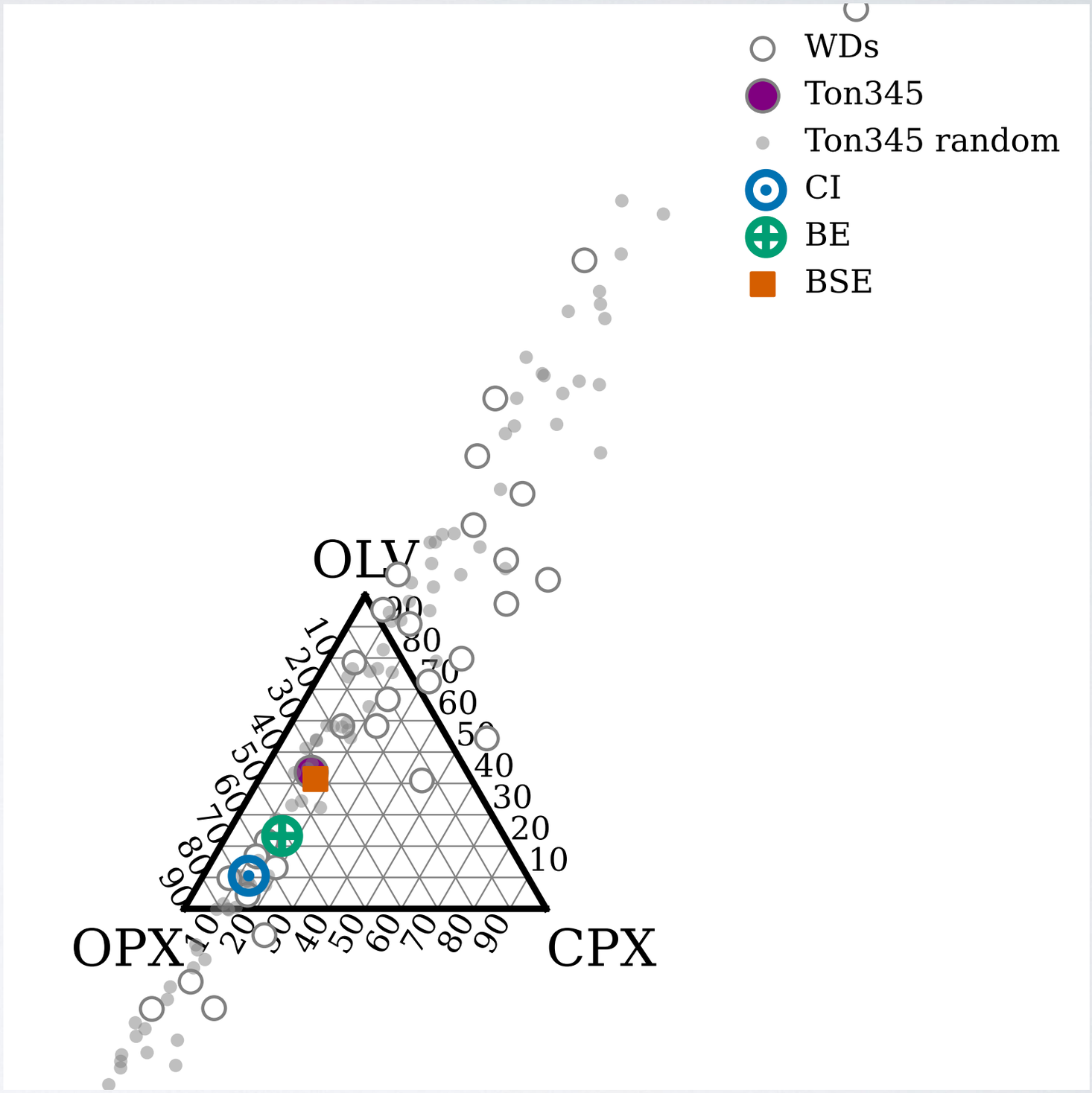
DIFFERENTIAL SETTLING INFLUENCES MEASURED COMPOSITION



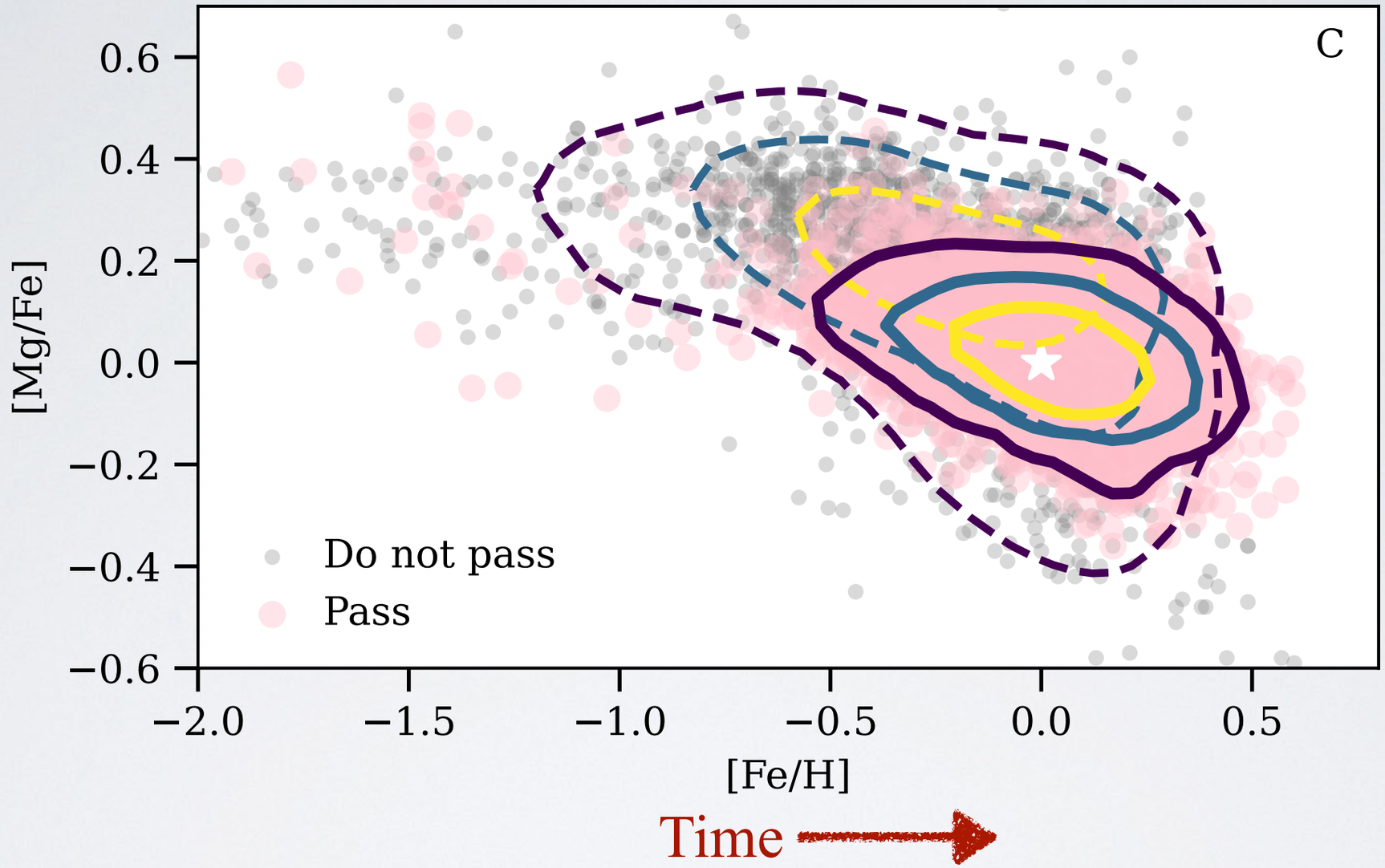
Doyle et al. 2020

CLASSIFYING WHITE DWARF POLLUTION BY MINERALOGY

Uncertainties in Mg, Si, Ca abundances too large to constrain mineralogy

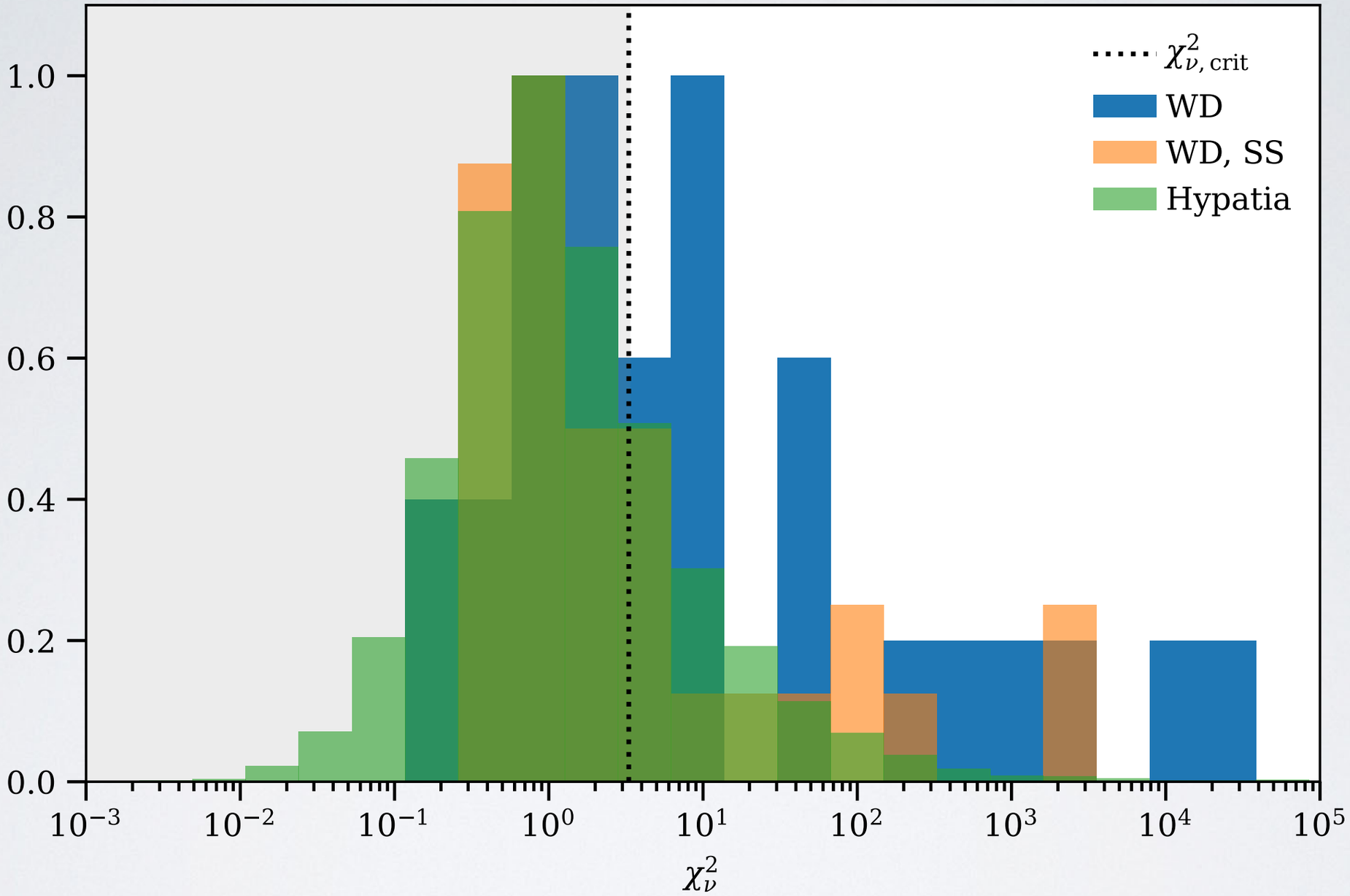


CONSIDERING EFFECTS OF GALACTIC CHEMICAL EVOLUTION



- Lithophile/siderophile ratio (Mg/Fe) changes with time
- Lower metallicity stars (forming at earlier times) tend to be less consistent with chondrites

HYPATIA CATALOGUE STARS ARE CHONDRITIC



~75% of Hypatia Catalogue stars pass as chondritic