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# CONSTRAINTS ON REMNANT PLANETARY SYSTEMS AS A FUNCTION OF MAIN-SEQUENCE MASS WITH HST/COS

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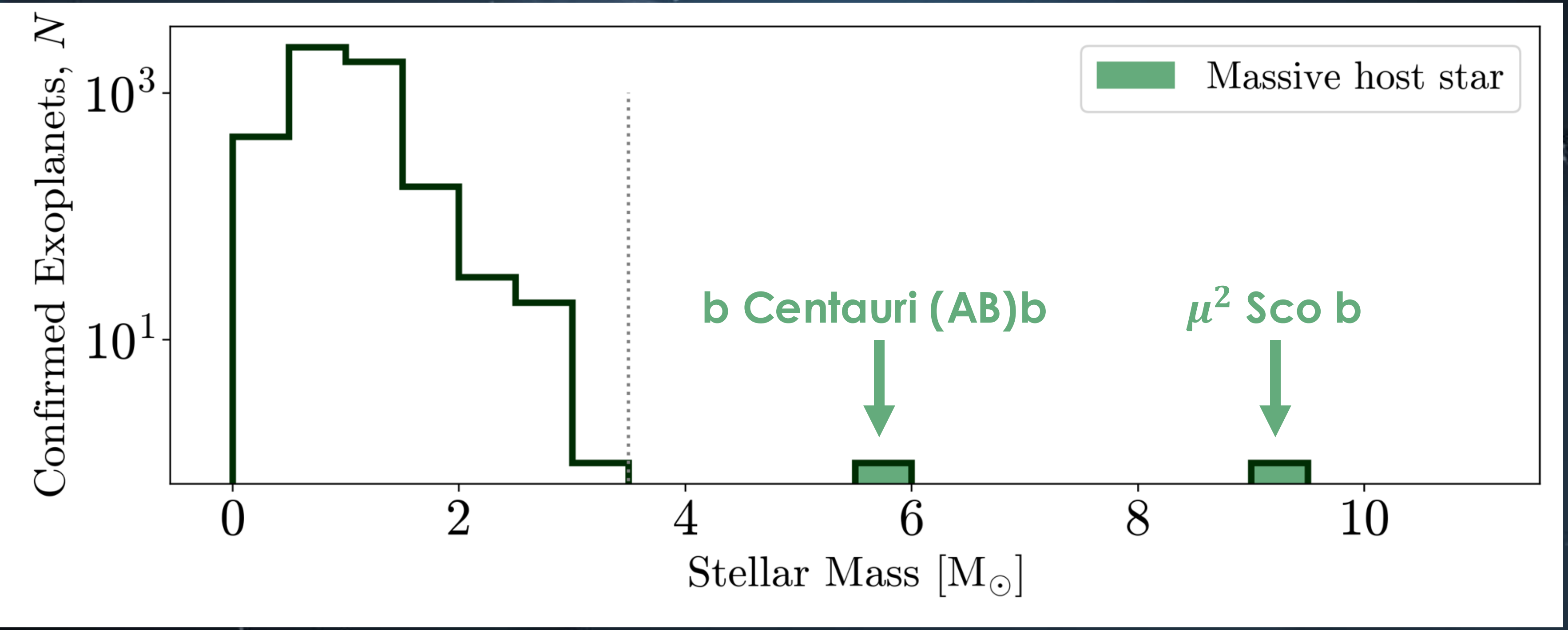
Illustration by NASA/JPL-Caltech

# Our Galaxy is full of exoplanets

More than 5,800 confirmed planets as of 2025

**Yet only 2 confirmed planets with host star mass $M_{host} > 3.5\ M_\odot$**

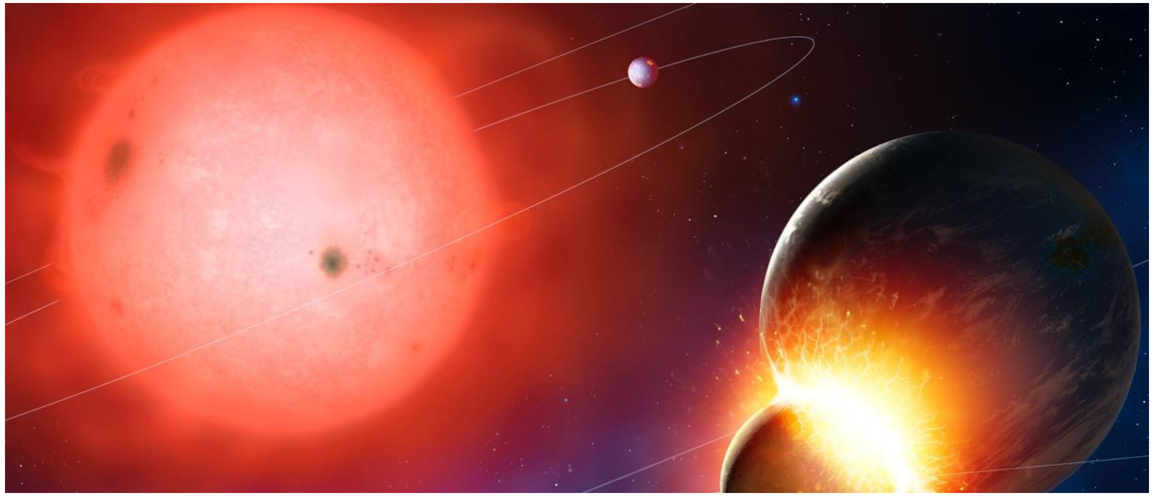



Adapted from NASA Exoplanet Archive

Illustration by NASA/JPL-Caltech

# Planets at wide orbits can survive stellar evolution

As the star radius increases, the closest planets are engulfed, some collide or escape, and some planets survive



**Remnant planetary systems around white dwarfs can be inferred from metal pollution detection**

Illustrations by Mark Garlick

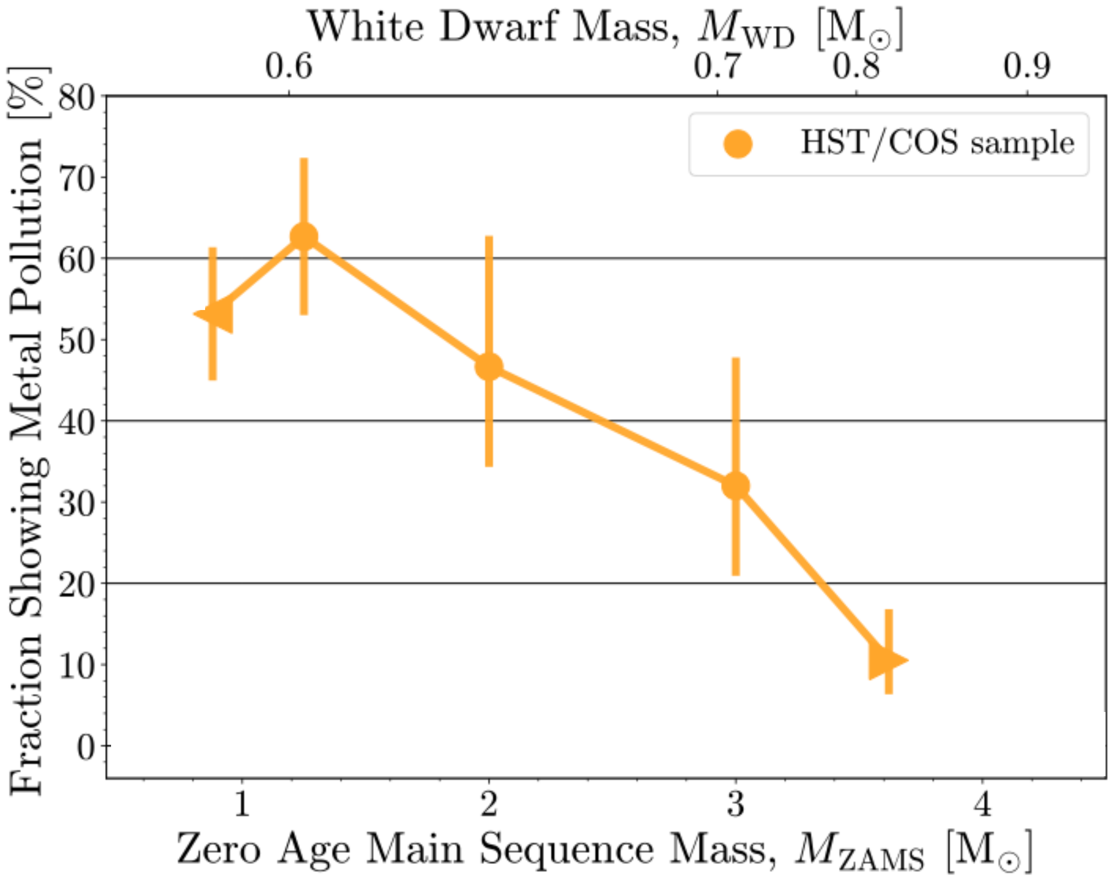
# White dwarfs give insight on remnant planetary systems

**43% ± 4% of white dwarfs show photospheric metals**

11% $^{+6}_{-4}$% of **massive*** white dwarfs show photospheric metals

*descending from stars with mass $M_{ZAMS} > 3.5\ M_{\odot}$

**Planetary remnants around white dwarfs are common**



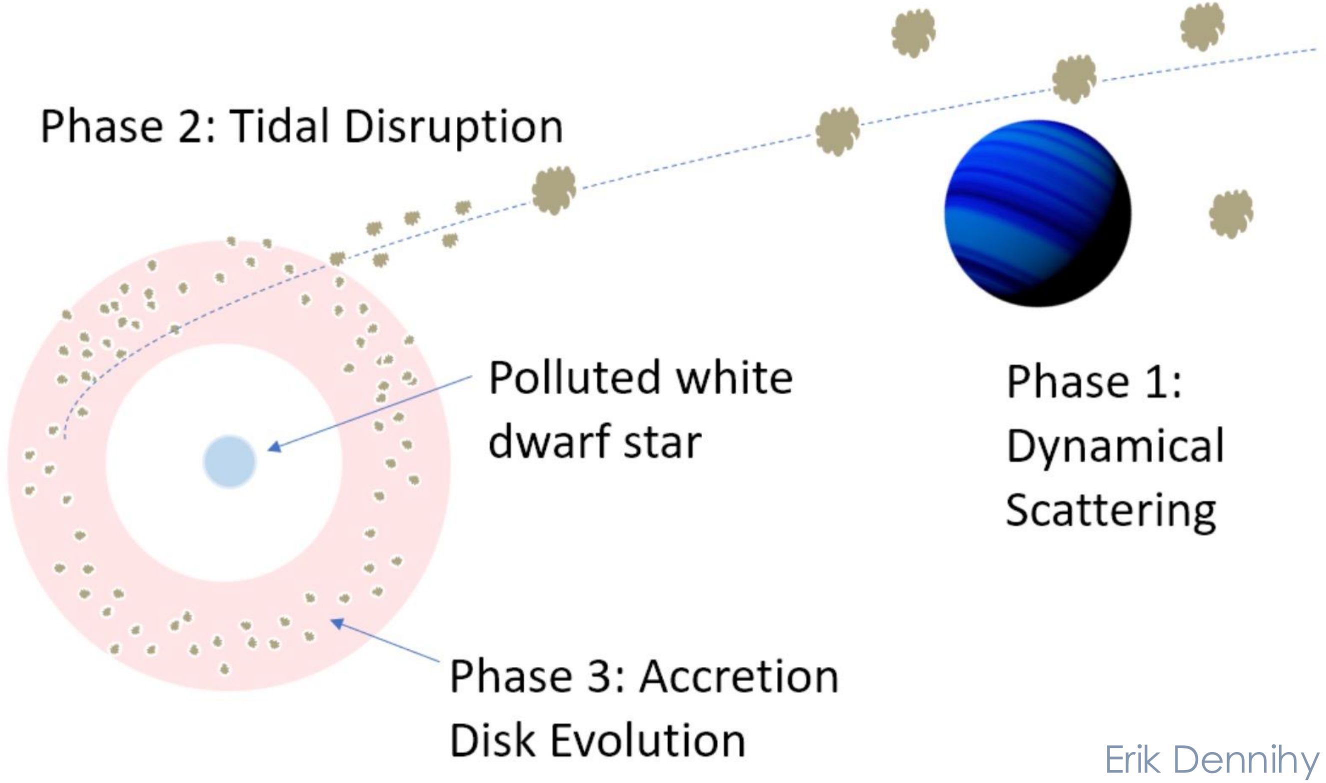

Adapted from Ould Rouis et al. 2024

# Metal pollution as proxy for remnant planetary systems

Accretion of scattered, tidally disrupted planetesimals onto the white dwarf

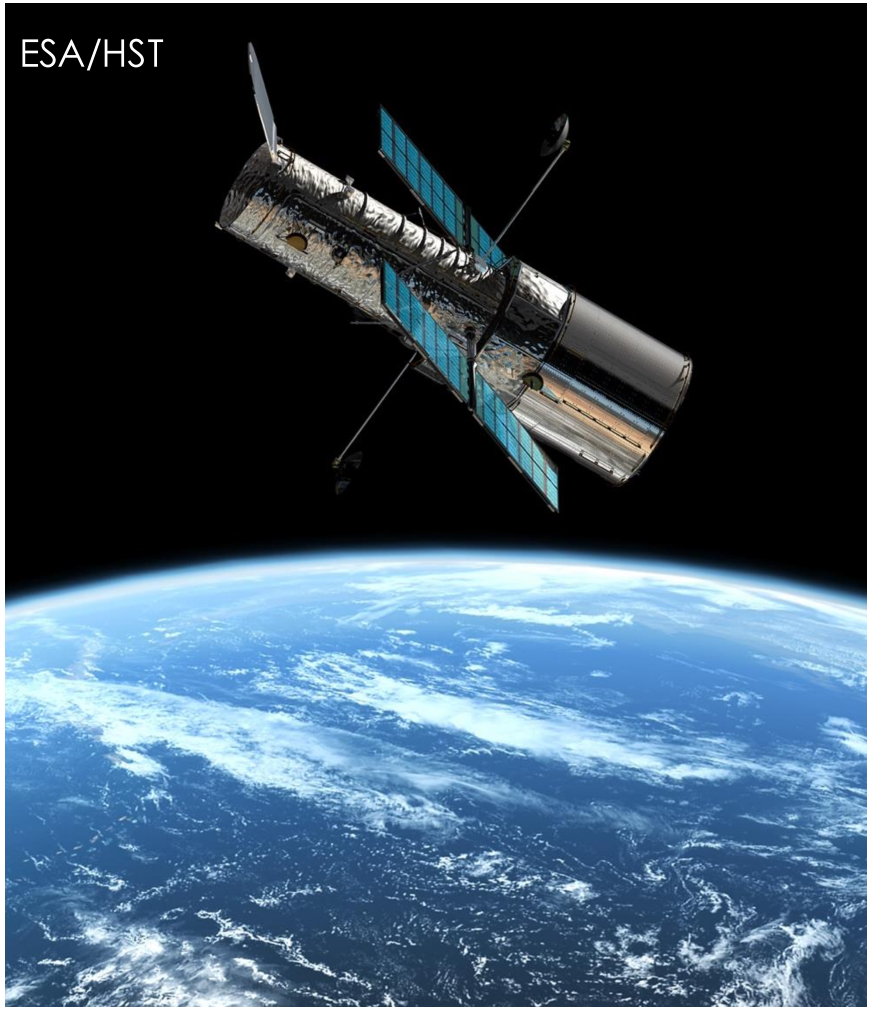
Implies at least 1 surviving planet and a reservoir of planetesimals
*(Farihi 2016)*

Abundances are alike Bulk Earth with elements Fe, O, Mg, or Si
*(Xu et al. 2014)*

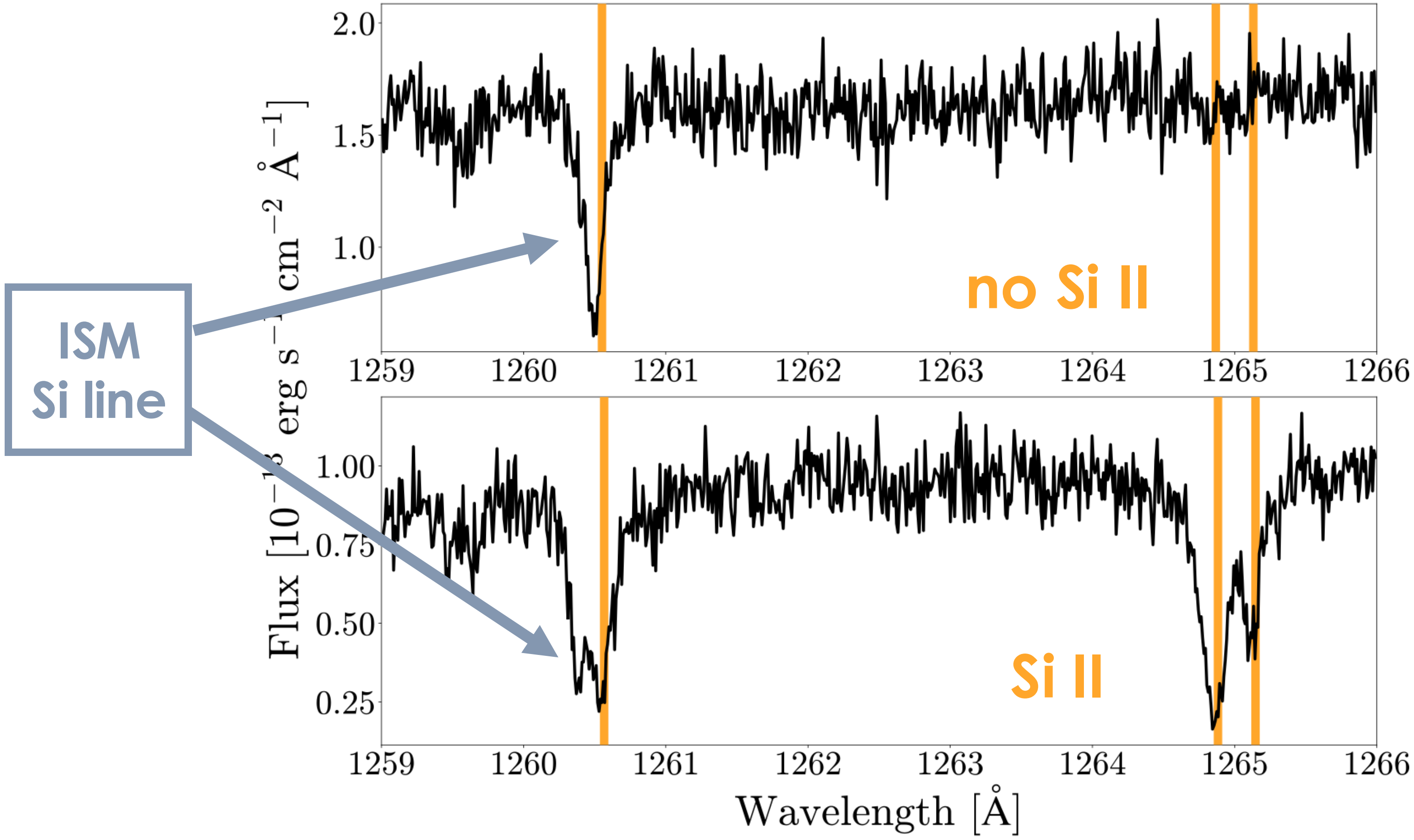



Erik Dennihy

# Metal pollution in Hubble Space Telescope COS Spectra



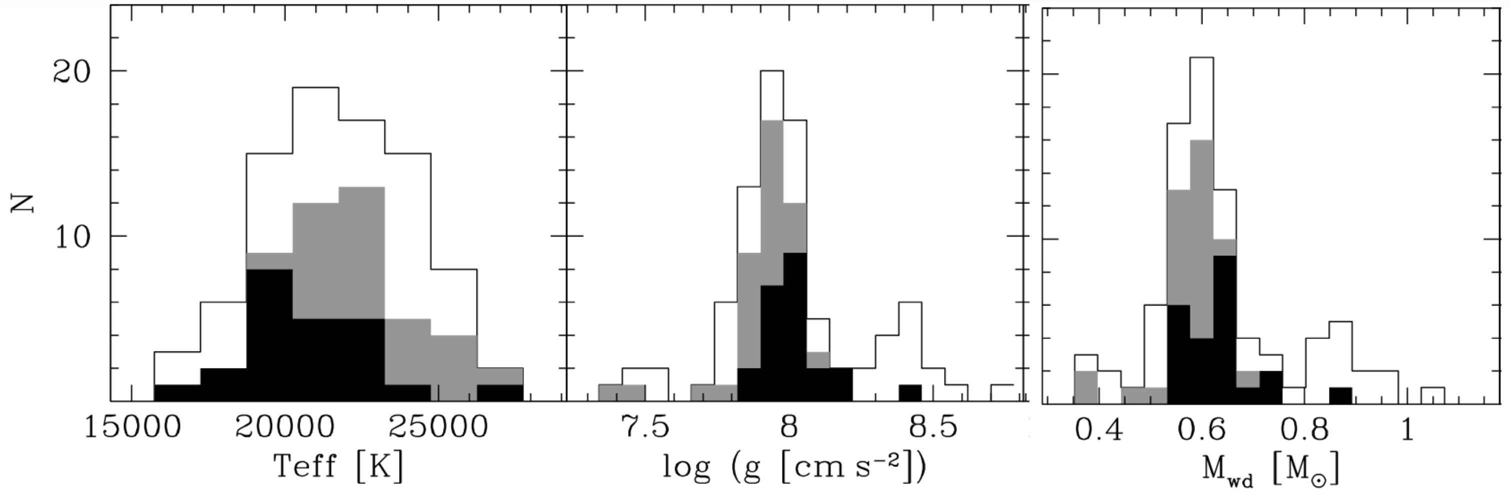

Metals detected to a limit of log(Si/H) ~ -8 or $10^5$ g/s



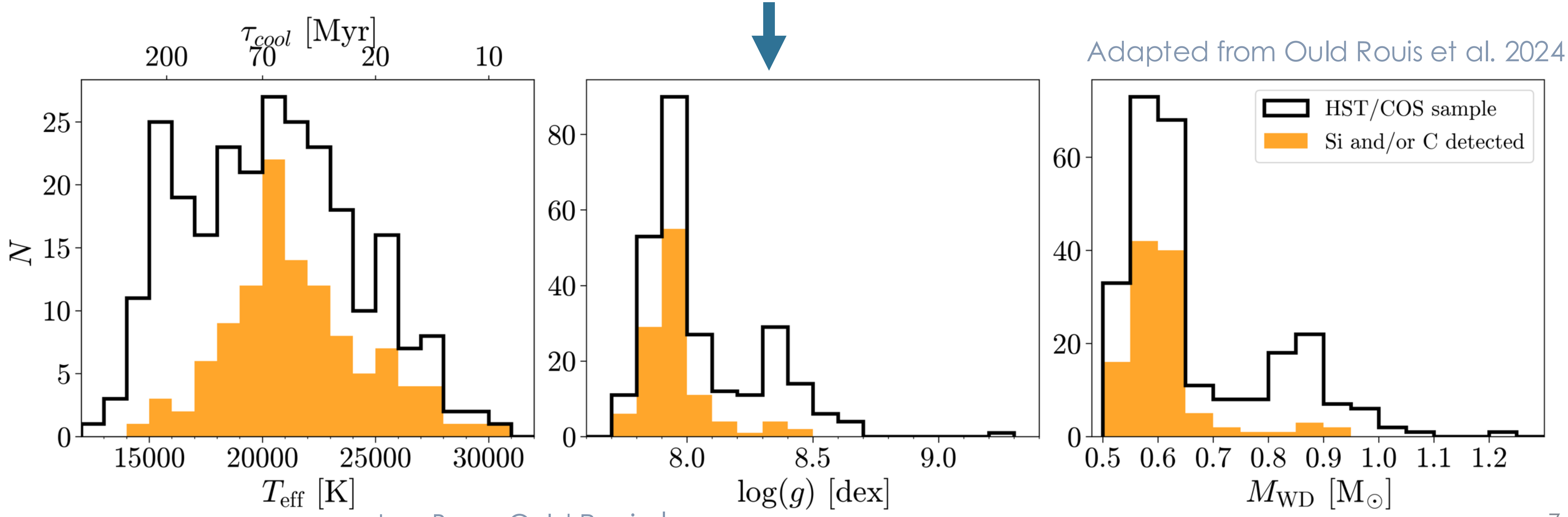

Ould Rouis et al. 2024

# HST/COS Sample

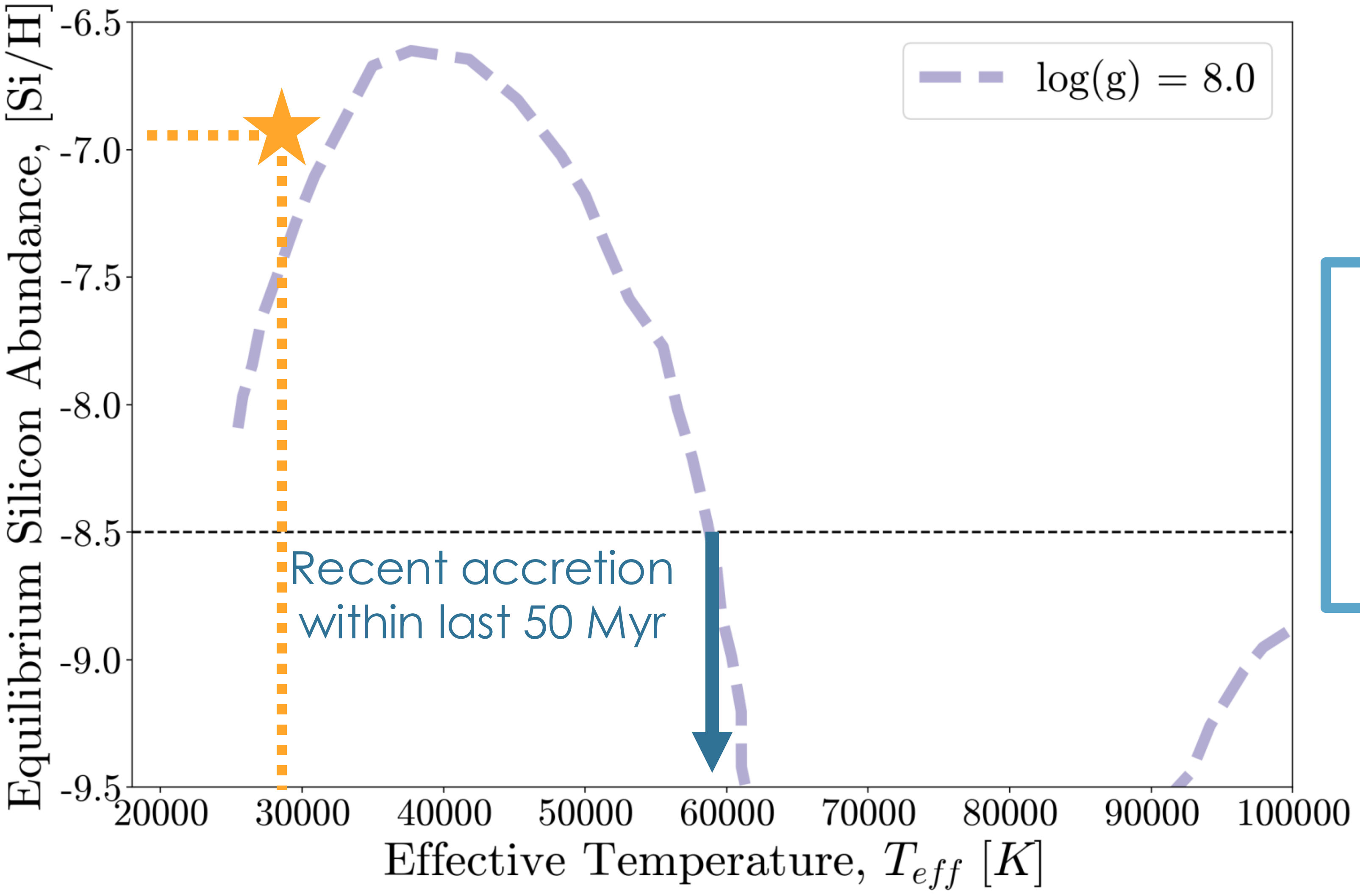
Koester et al. 2014




Adapted from Ould Rouis et al. 2024



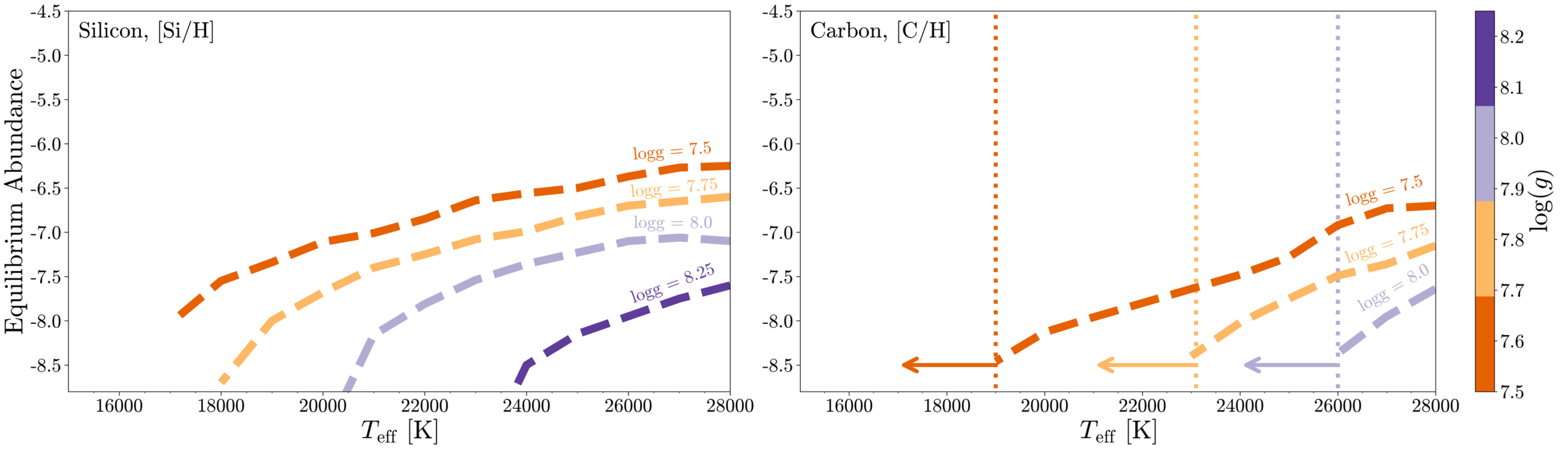
# Metals sink out of photosphere on the order of days to years, unless radiative levitation support metals against gravitational settling



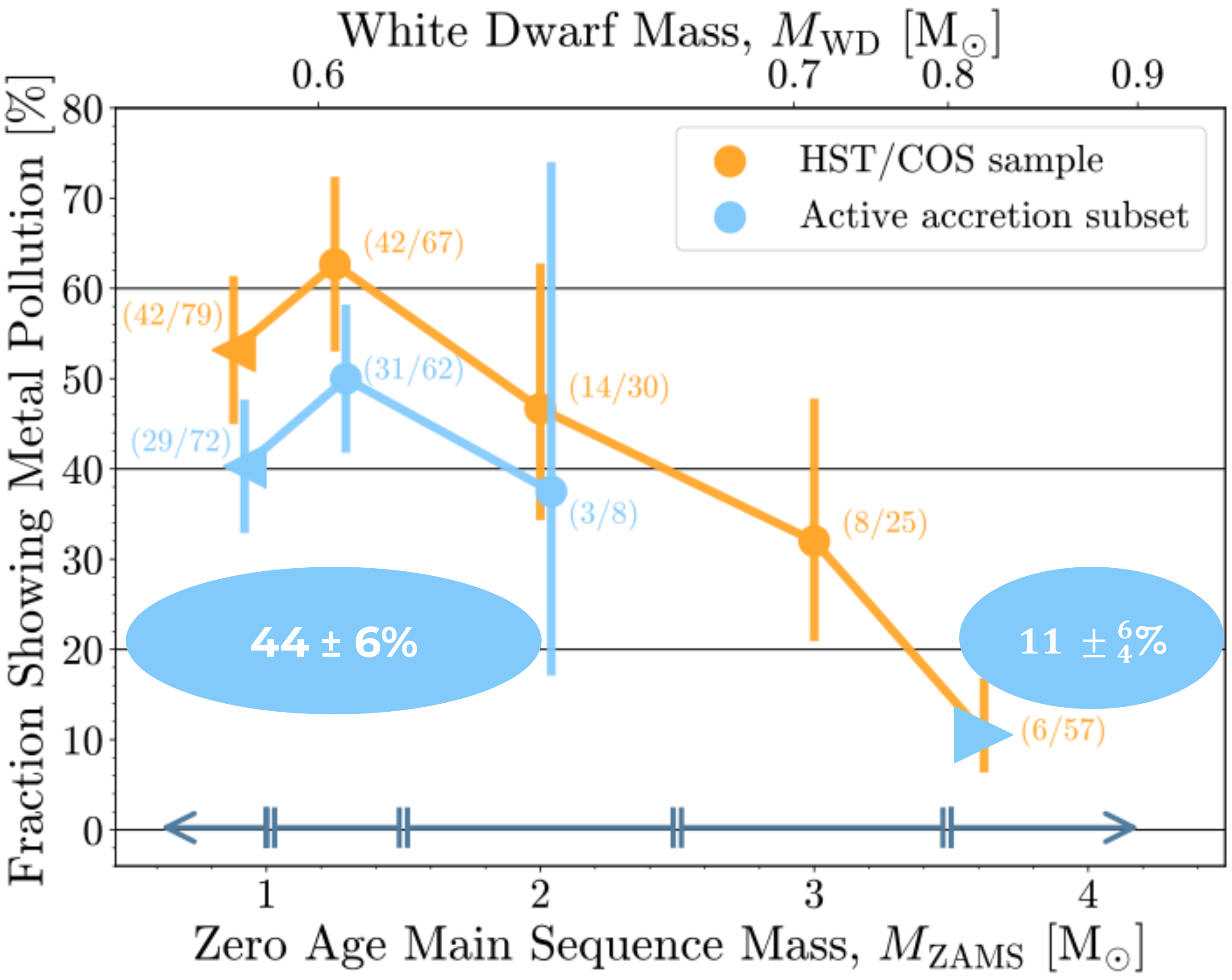

**Observational bias prevents the distinction between active and recent accretion**

Adapted from Chayer et al. 1995

# Carbon is less affected by radiative levitation and defines active accretion subset




Models from Koester et al. 2014




- **$M_{ZAMS} < 2.5\ M_\odot$ : 44% ± 6%** show active accretion of remnant planetary systems

- **$M_{ZAMS} > 3.5\ M_\odot$ : 11% $^{+6}_{-4}$%** show active accretion of remnant planetary systems

**4σ difference!**

Ould Rouis et al. 2024

# Are mergers to blame for missing signs of planets around massive white dwarfs?

~40% of massive white dwarfs are expected to originate from stellar mergers (Temmink et al. 2020)

Identified with strong magnetism, rapid rotation, or atypical kinematics (Kilic et al. 2023, Jewett et al. 2024)

# Merger byproduct contamination among the massive white dwarfs of HST/COS sample

## STRONG MAGNETISM

No Zeeman splitting, detectable for magnetic fields > 2 MG

## RAPID ROTATIONS

No variable candidates at short periods detected to a significance threshold of median amplitude 0.25% in TESS

## ATYPICAL KINEMATICS

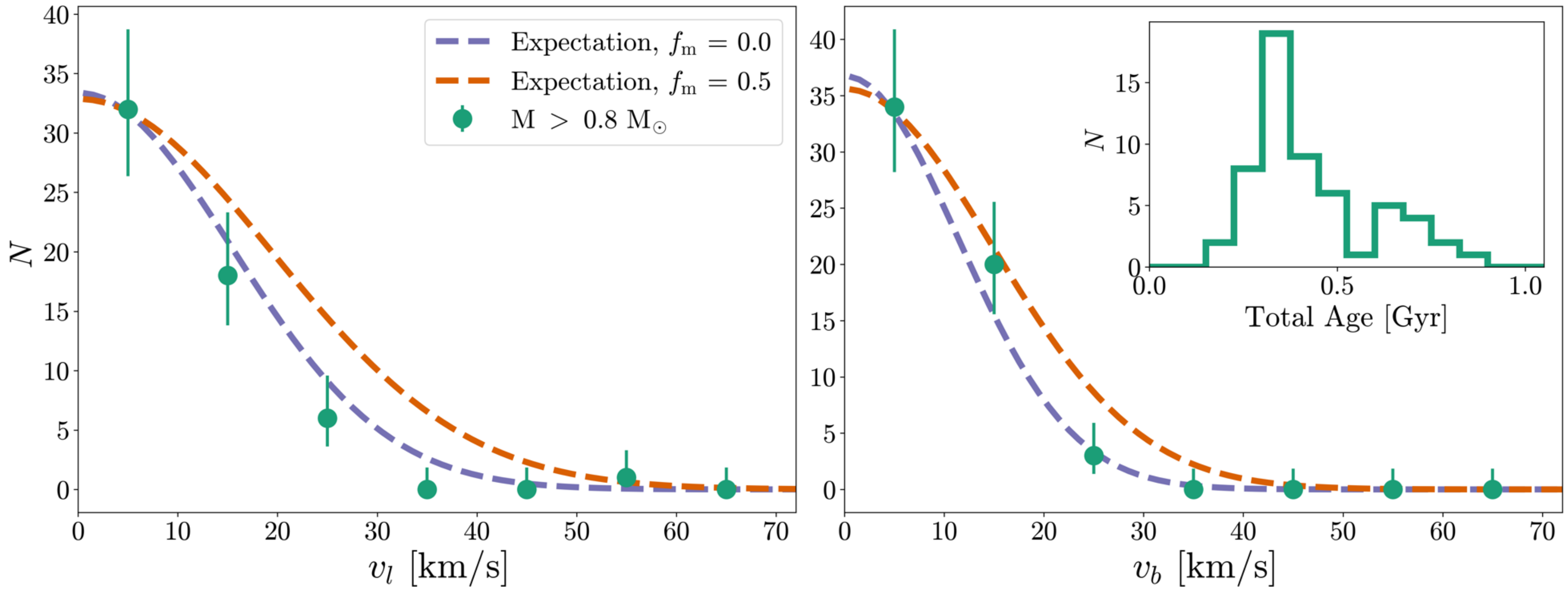
Young white dwarfs are expected to have slow transverse velocities (Holmberg et al. 2009)

# Merger byproduct contamination among the massive white dwarfs of HST/COS sample

## STRONG MAGNETISM

## RAPID ROTATIONS

## ATYPICAL KINEMATICS




Young white dwarfs are expected to have slow transverse velocities
(Holmberg et al. 2009)

No significant fraction of kinematic outliers

Ould Rouis et al. 2024

# Are different planetary formation, architecture, and survival to blame for missing signs of planets around massive white dwarfs?

## FORMATION

There may be a smaller reservoir of debris reaching the white dwarf stage

## ARCHITECTURE

Surviving planets at wide orbits may scatter debris on a less frequent timescale

## SURVIVAL

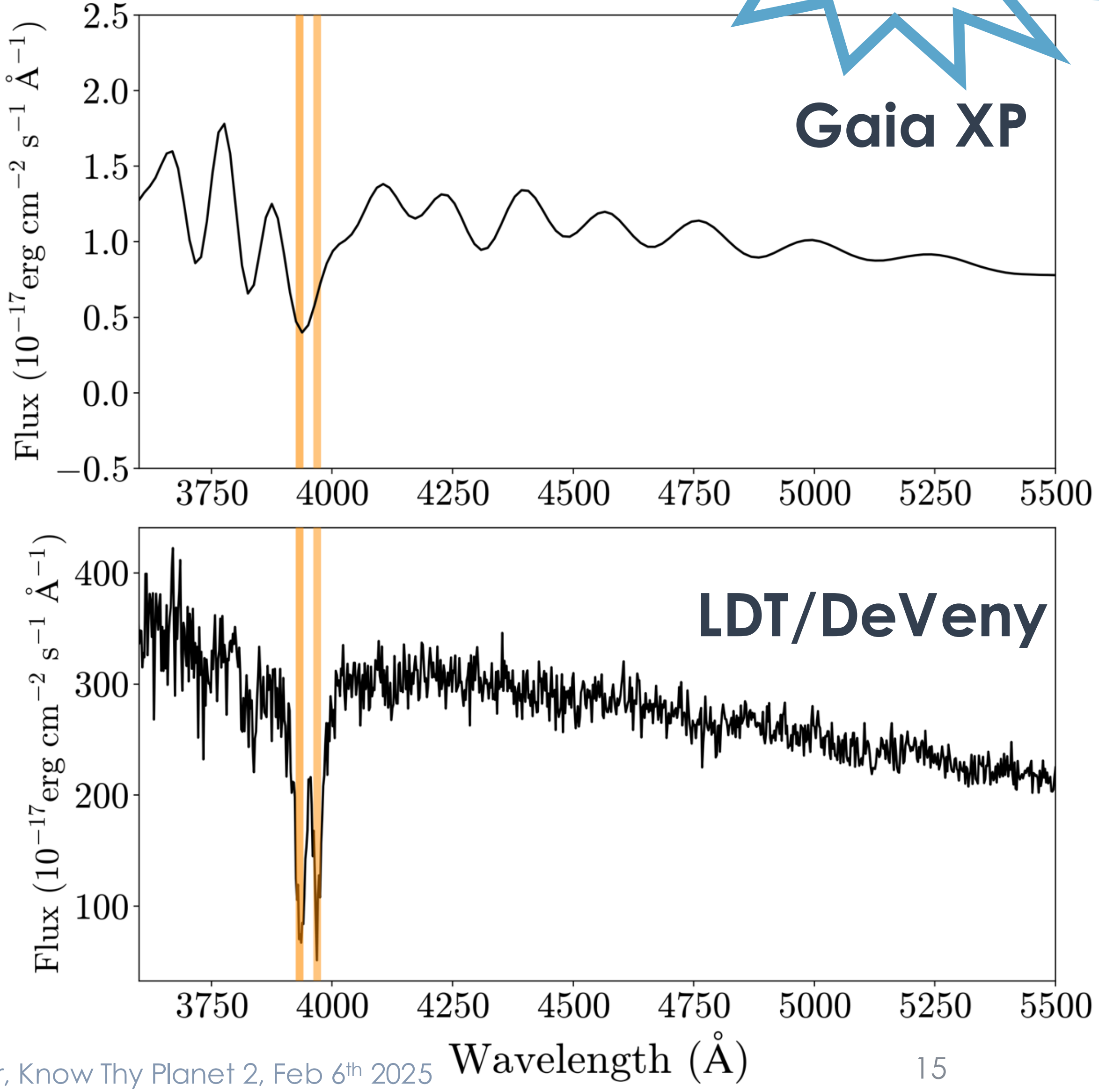
There may be a narrower orbital parameter space for stable surviving planets

# Gaia low-resolution spectroscopy offers insights on order of magnitude larger samples of massive metal polluted white dwarfs

NEXT STEPS

**Most massive white dwarfs with a probability of being metal polluted $P_{DZ}$ > 50% show photospheric Ca**

(52/61)



# CONSTRAINTS ON REMNANT PLANETARY SYSTEMS AS A FUNCTION OF MAIN-SEQUENCE MASS WITH HST/COS

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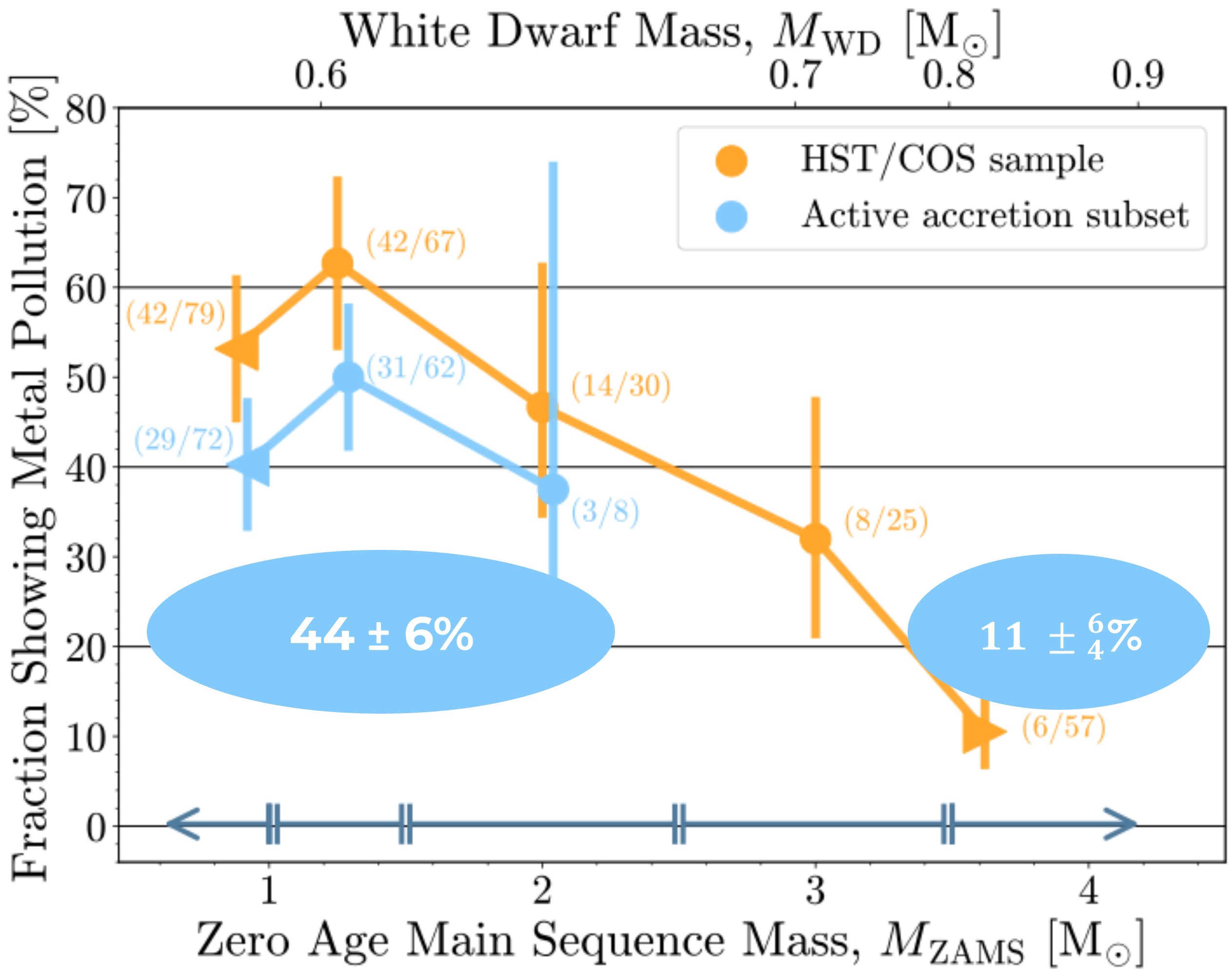
- **More than 40% of white dwarfs** observed with HST/COS **host remnant planetary systems**
- **Massive white dwarfs** (with progenitors $M_{ZAMS} > 3.5\ M_{\odot}$) have a **metal pollution fraction of 11%** $\pm^{6}_{4}$**%**
- We find a **4σ statistically significant decrease in active accretion** of metals onto massive white dwarfs
- We see no evidence that stellar mergers broadly affect our sample

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