



The past lives of metal polluted white dwarfs

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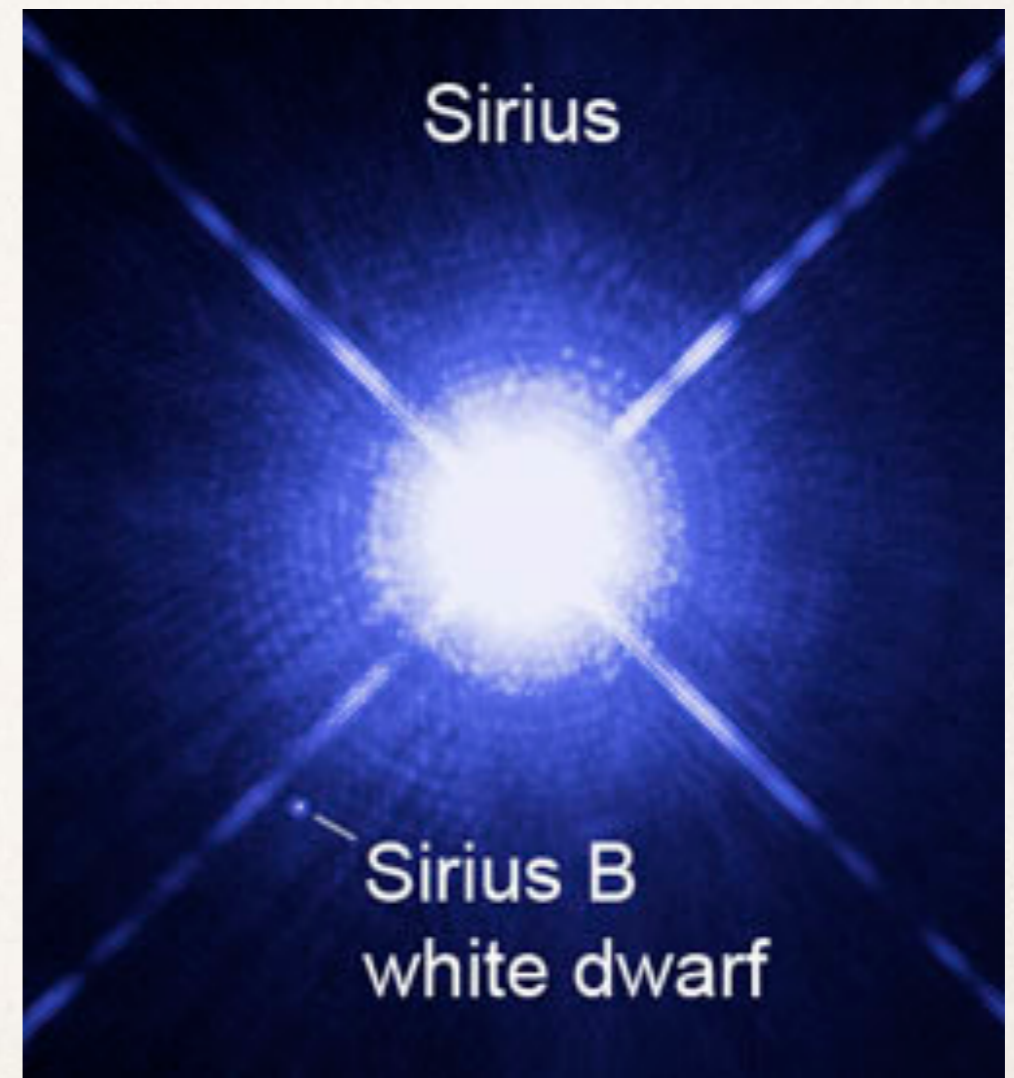
Universidad Autónoma de Madrid, España

March 7th, 2017

Planetary Systems Beyond Main Sequence II

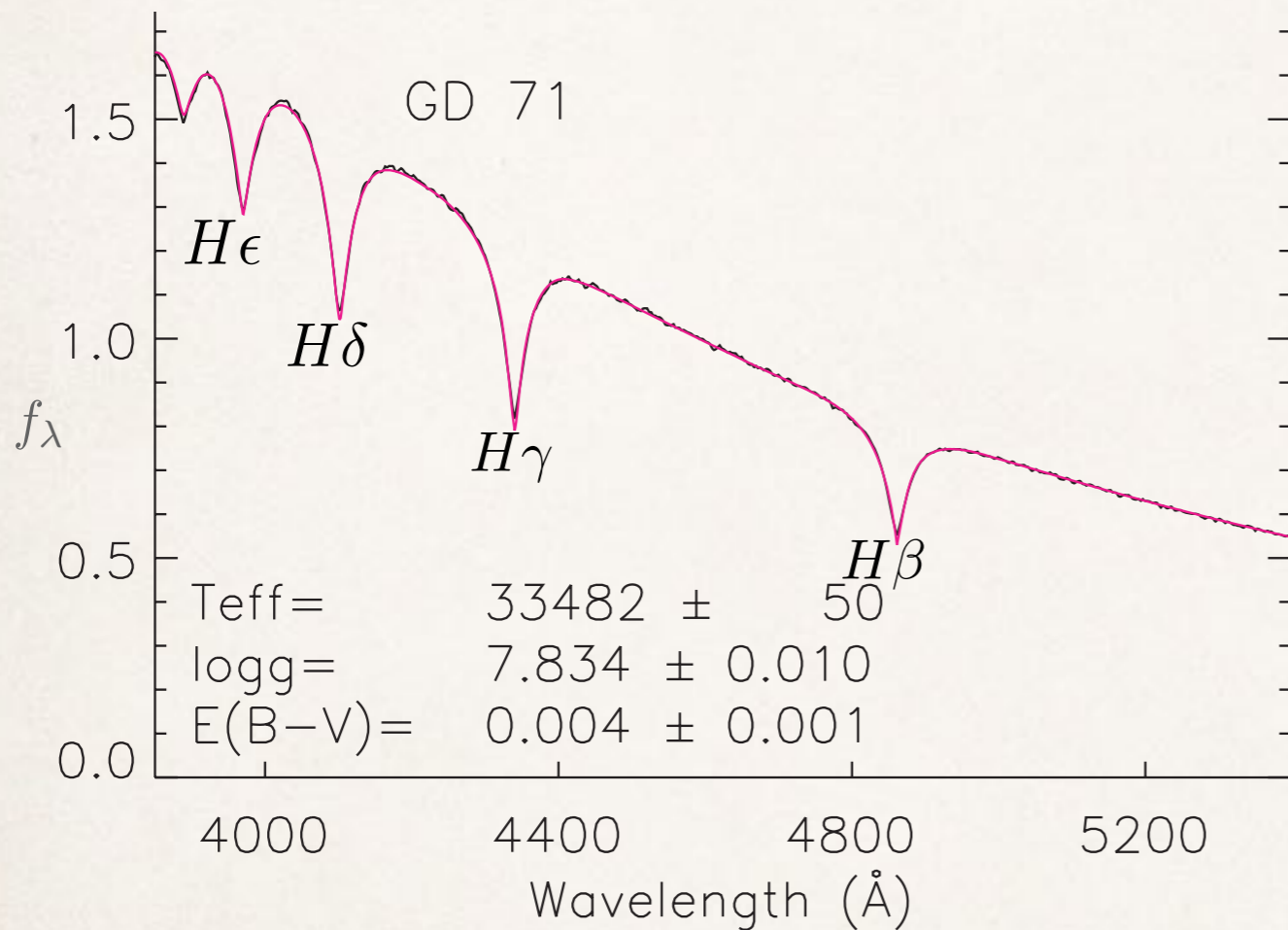
Outline

- ❖ White Dwarf Pollution
- ❖ Mechanisms of pollution
- ❖ Our approach
- ❖ Preliminary results



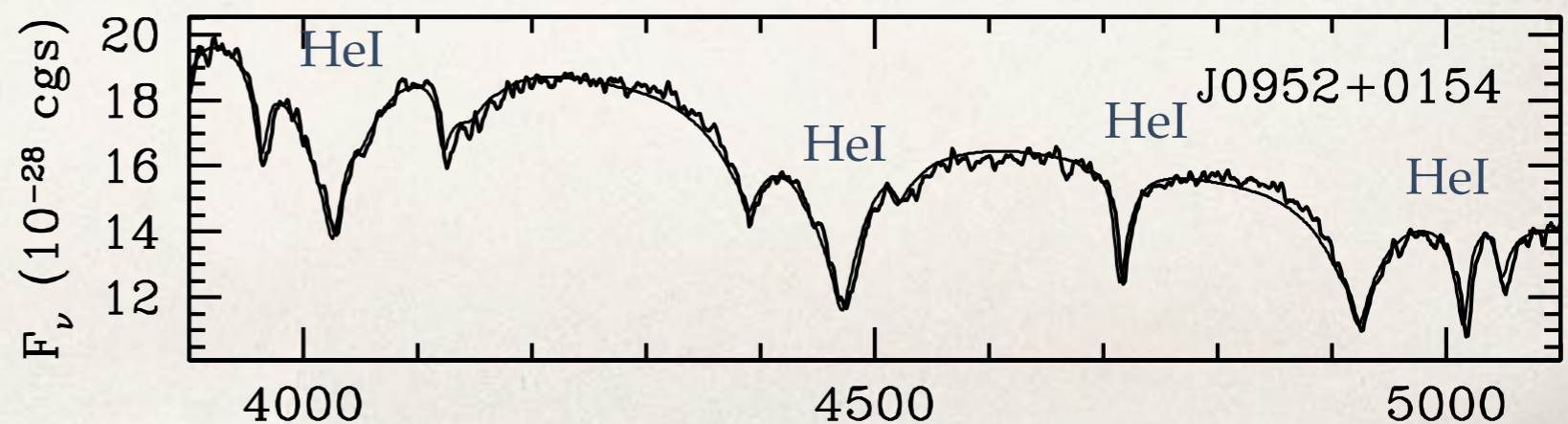
NASA/ESA

White Dwarfs: DA and DB



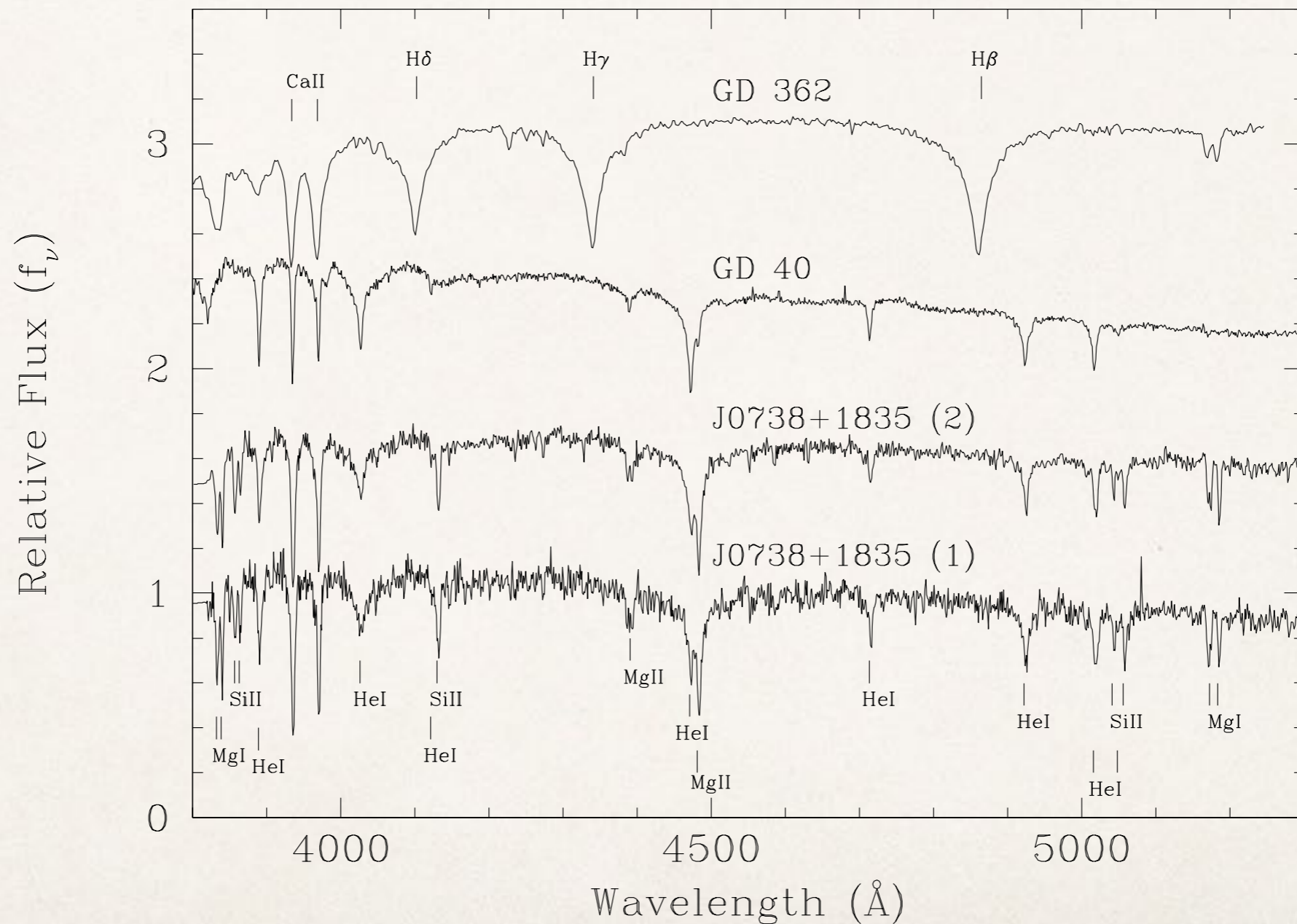
DA WD GD 71 spectrum
(Allende Prieto et al. 2009).

DB WD J0952+0154 spectrum
(Eisenstein et al. 2006).

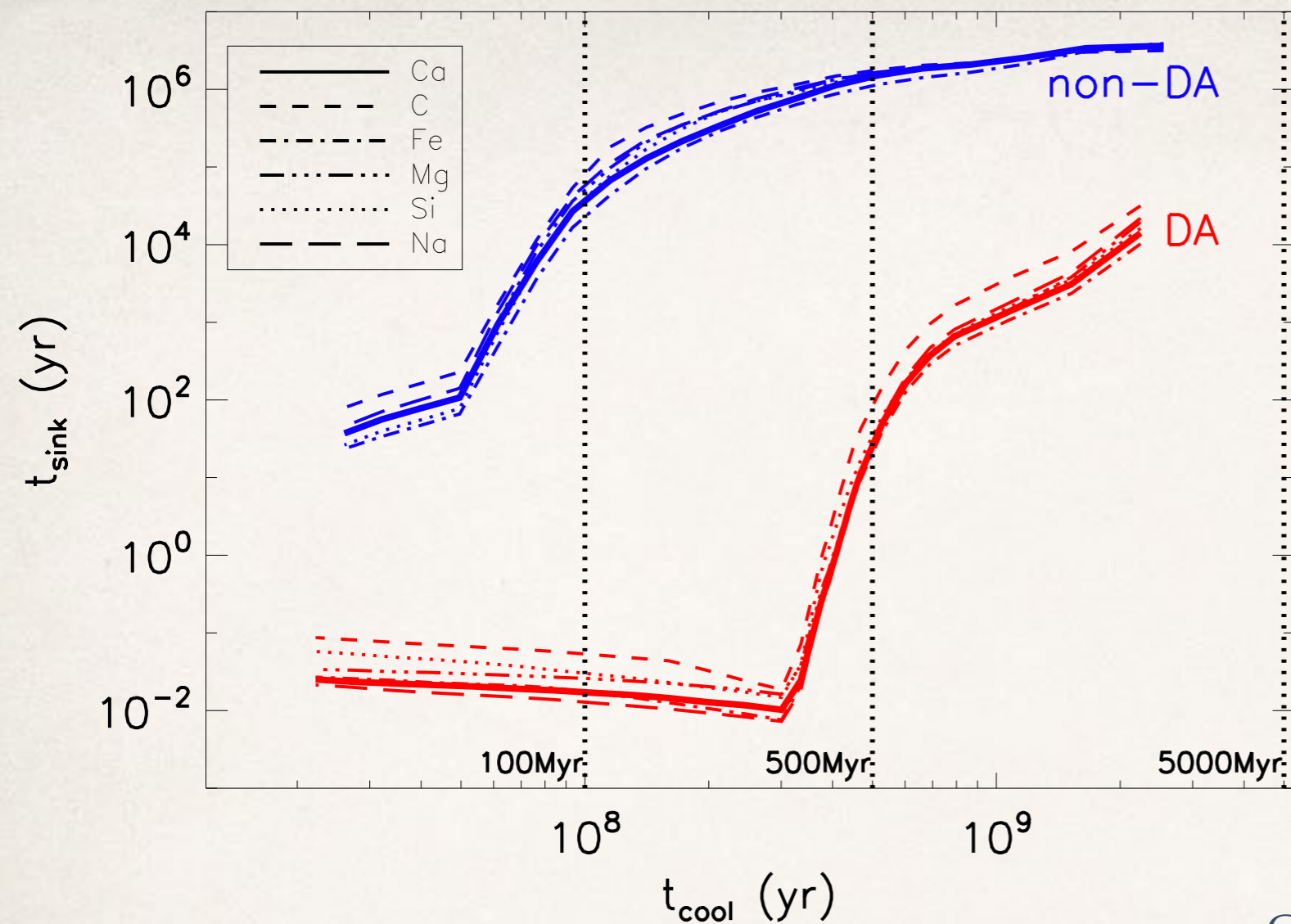


White Dwarf Pollution

First White Dwarf with atmospheric pollution (Van Maanen 1917).



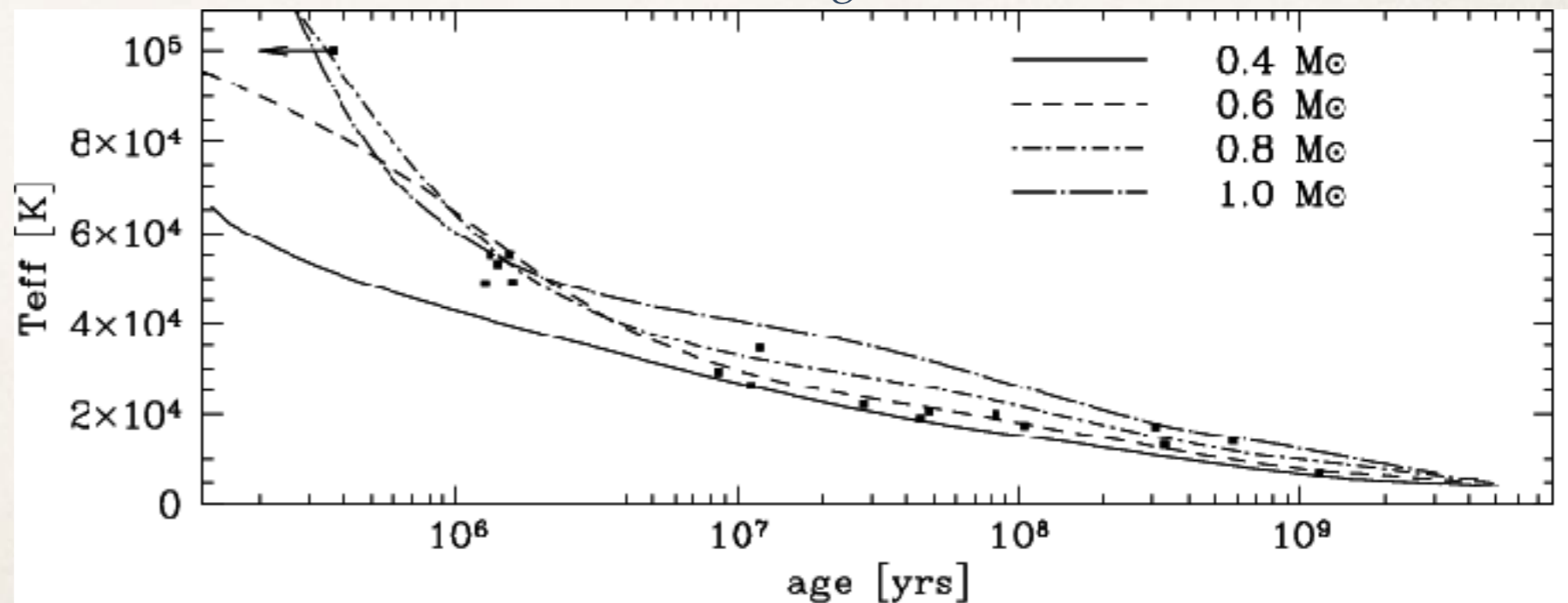
WD SDSS spectra (Dufour et al. 2010)



Wyatt, 2014

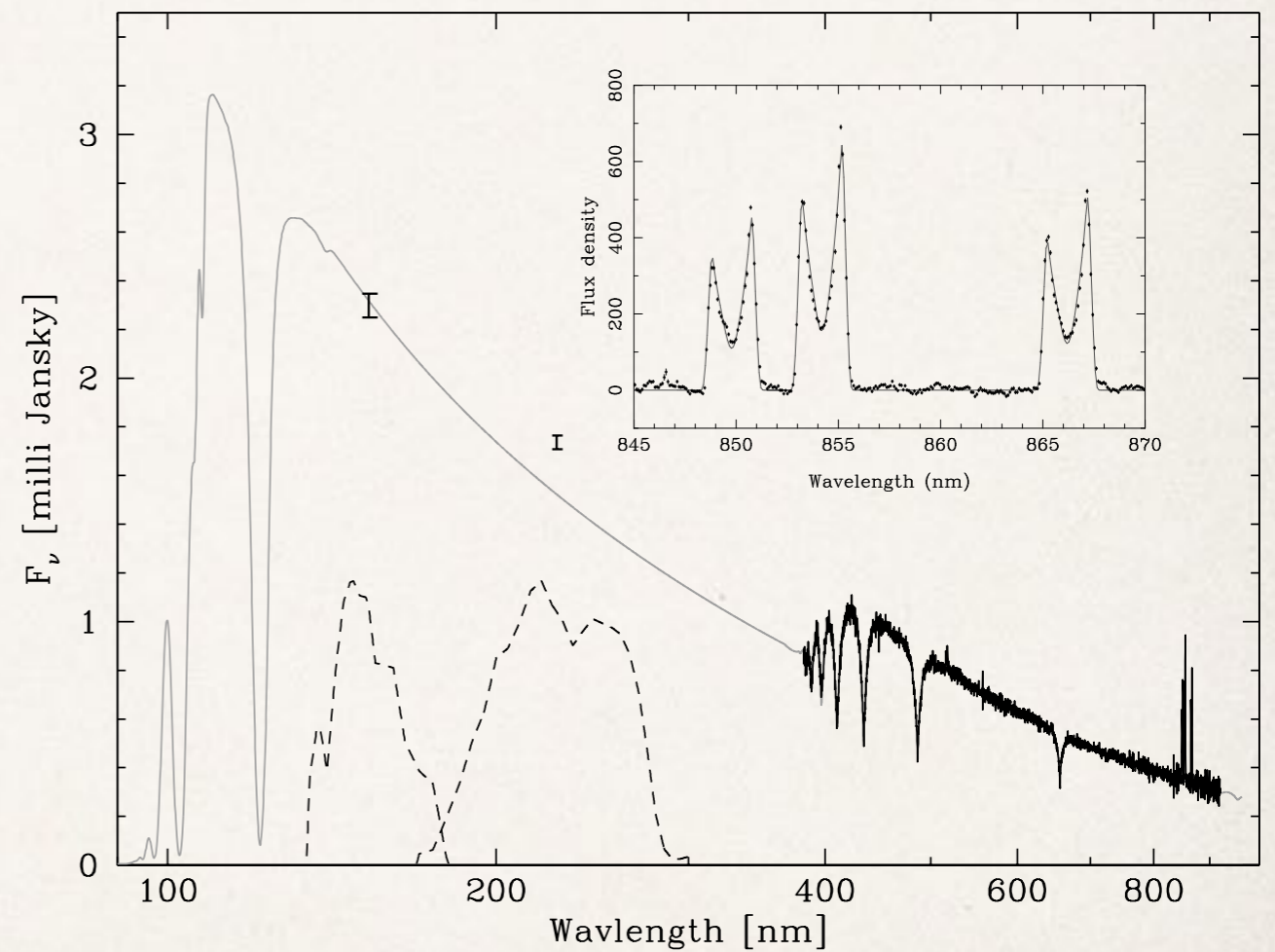
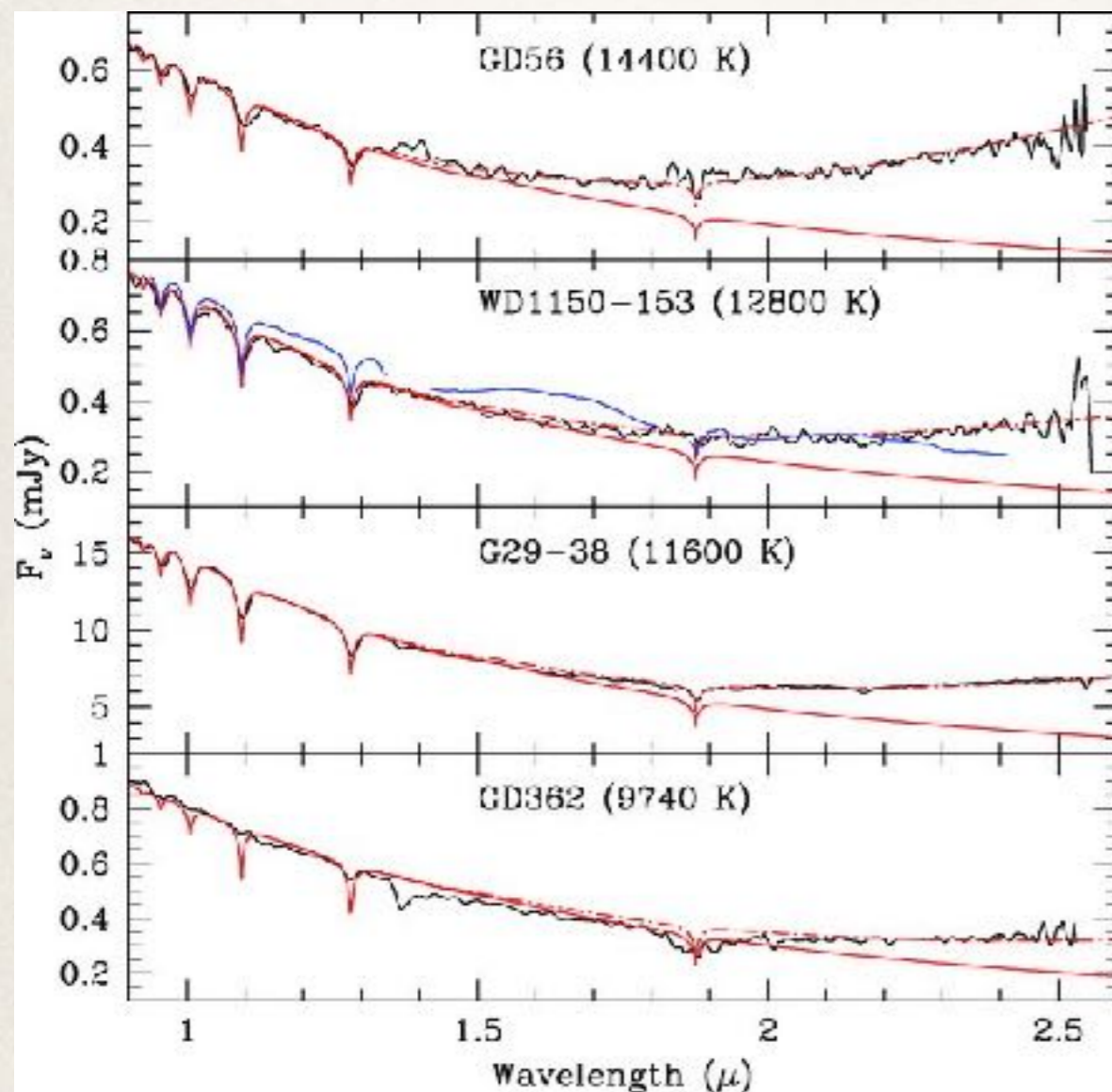
Polluted cool white dwarfs should accrete material from the exterior.

Cooling Time (Schreiber & Gänsicke, 2003)

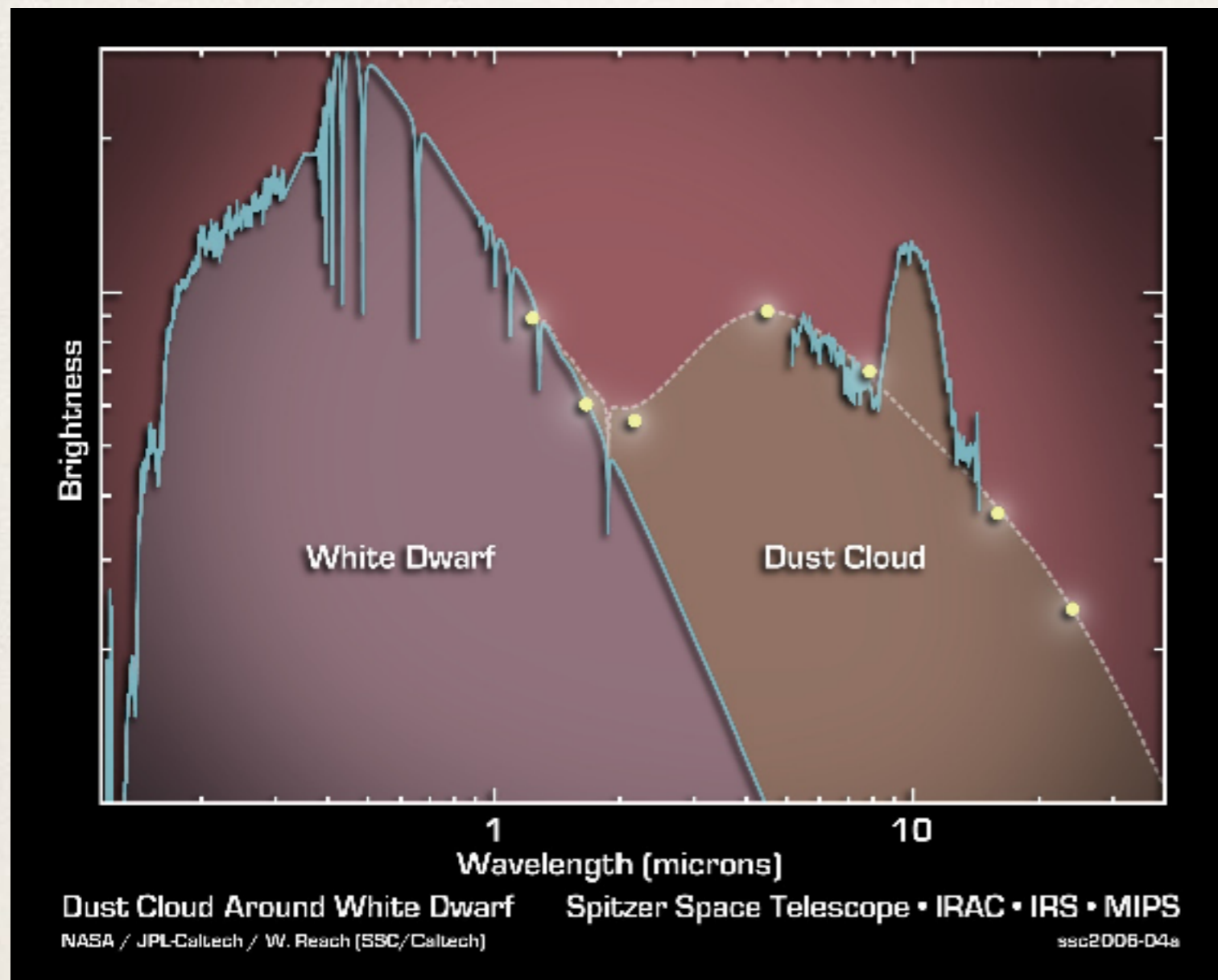


Mechanism of external pollution

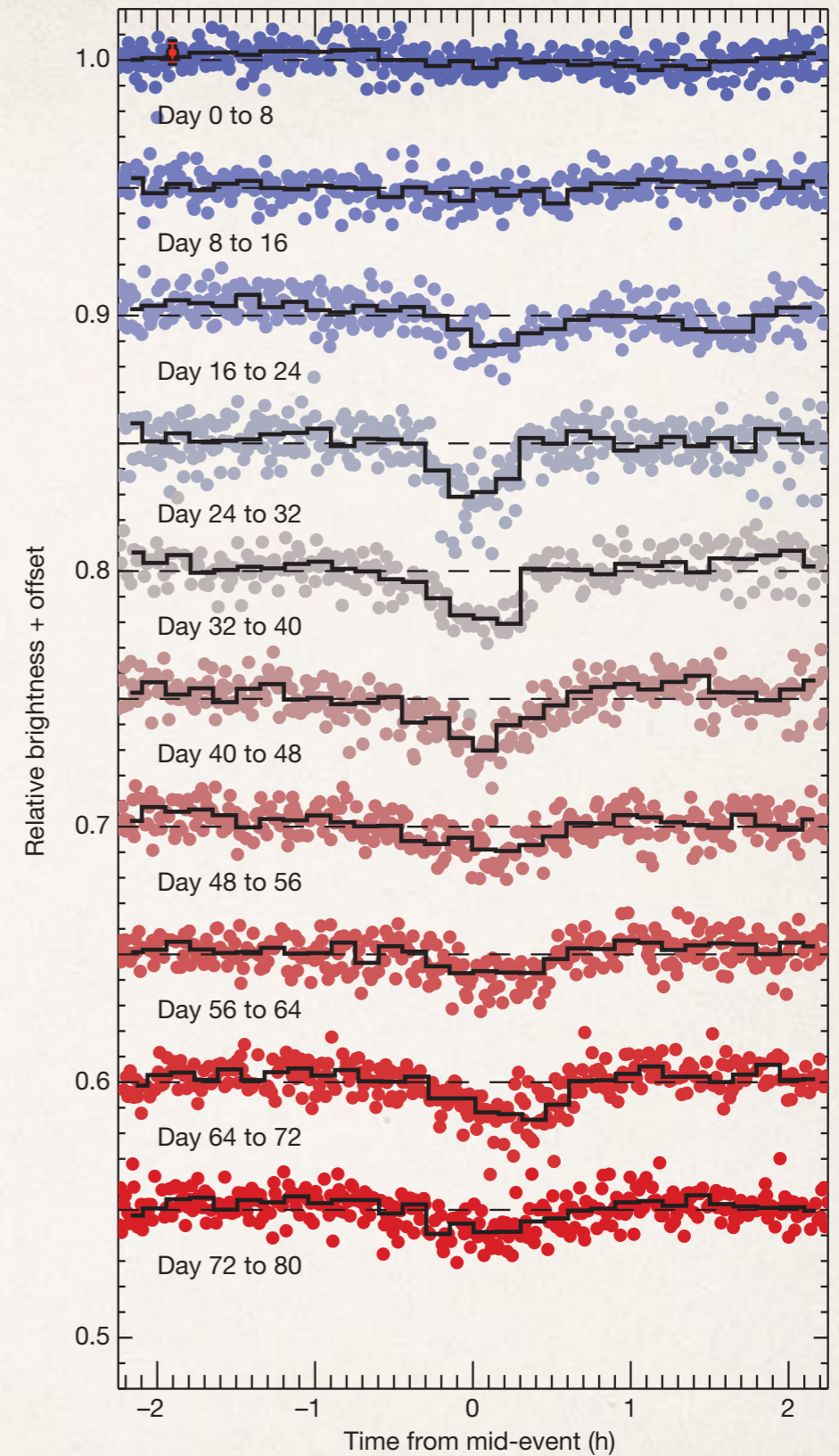
Kilic & Redfield, 2007



SDSS 1228+1040 spectrum (Gänsicke et al. 2006)



Planetesimals Accretion



- ❖ Planetesimal transits around WD1145+017 (Vanderburg et al. 2015).

Proposed Mechanisms for planetesimals accretion

Unstable Planetary Systems
(Debes & Sigurdsson, 2002)

Two / Three widely
separated planets
(Veras & Mustill, 2013,
Mustill, Veras & Villaver 2014)

Wide Binary Companion
(Bonsor & Veras, 2015)



CfA / Mark A. Garlik

Asteroid belt and interaction with
Planet

(Bonsor, Mustill & Wyatt, 2011; Debes, Walsh
& Stark, 2012; Frewen & Hansen, 2014)

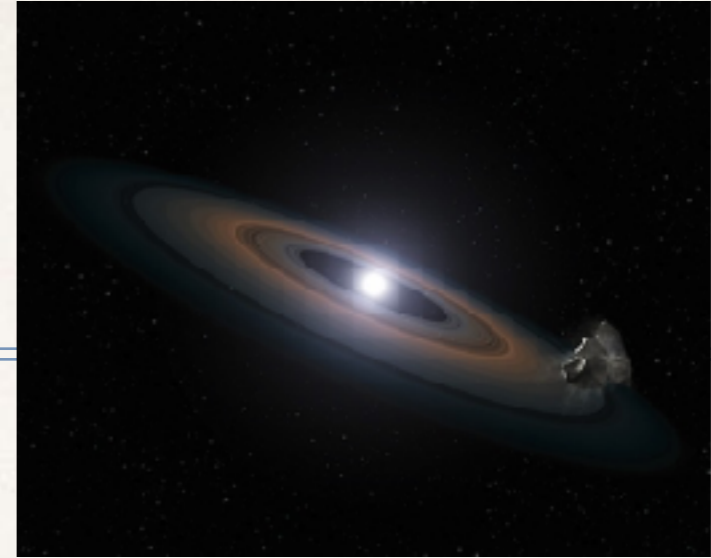
Remnant Exo-Oort Cloud Comets
(Veras, Shannon & Gänsicke, 2014;
Caiazzo & Heyl, 2017).

Our method:

To compare the properties (mass, kinematics, ...) of the polluted white dwarf sample with respect to non-polluted sample to find the mechanism(s) causing pollution.

Sample Selection

NASA/ESA



Polluted sample

Revisited literature for white dwarfs with calculated **accretion rates** and stellar parameters as **distance**, **mass**, cooling time, etc.

104 polluted white dwarfs with accretion

Stellar parameters found in Farihi et al. (2009), Holberg et al. (2016), Girven et al. (2011), Koester & Willen (2006), Zuckerman et al. (2010), Xu & Jura (2014) among others.

Non-Polluted sample

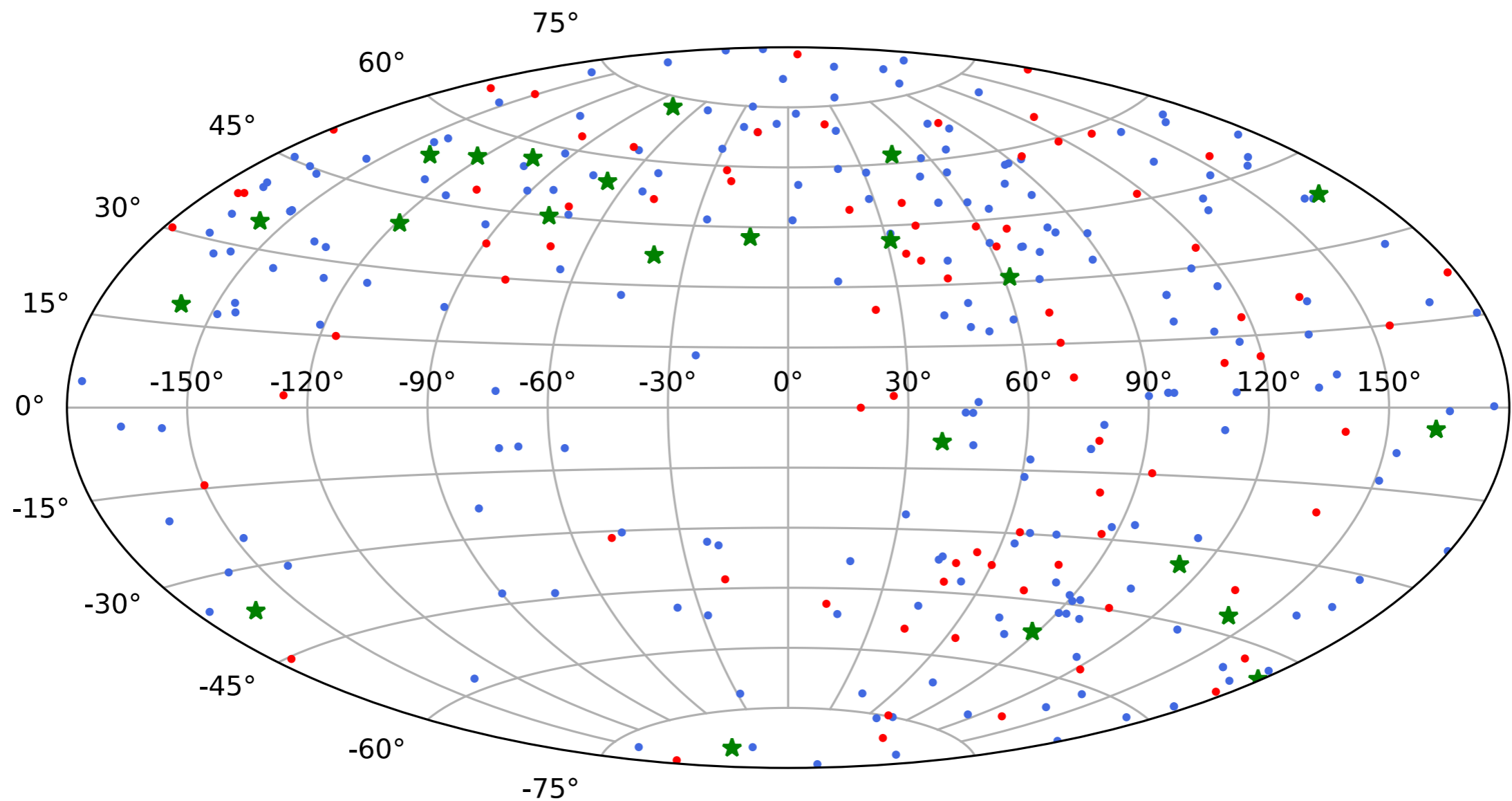
Spectroscopic identification from different surveys and catalogs: SDSS, PG Survey, SUPERBLINK survey, Villanova WD Catalog, etc.

Gianninas et al. (2011), Girven et al. (2011), Hu et al. (2007), Kawka & Vennes (2012), Liebert et al. (2005), Limoges & Bergeron (2010), Limoges et al. (2013, 2015), Bergeron (2011) and Holberg et al. (2016).

The comparison sample was randomly selected from the non-polluted sample of 4540 objects.

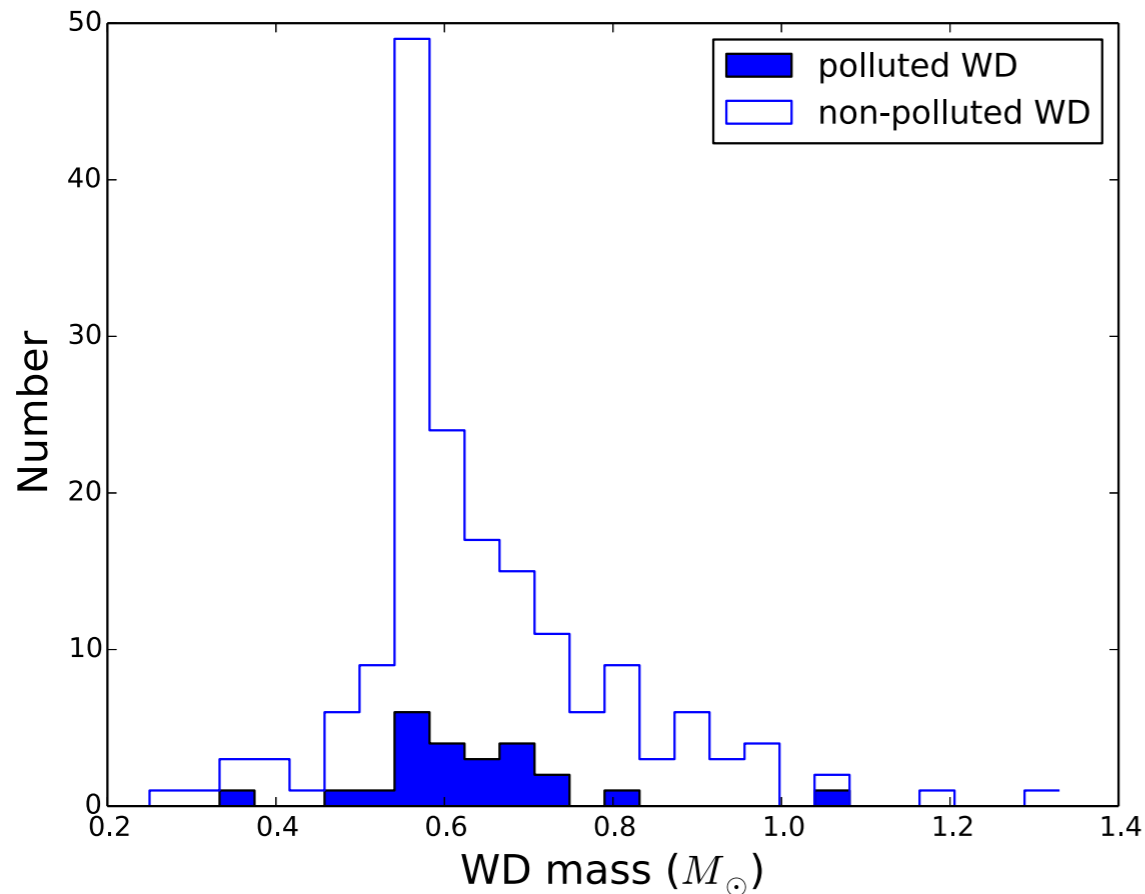
Spatial distribution

Selected sample in Galactic Coordinates



Red: accretion sample Blue: comparison sample *: Polluted WD IR excesses

Mass distribution up to 25 pc from the Sun



Polluted sample

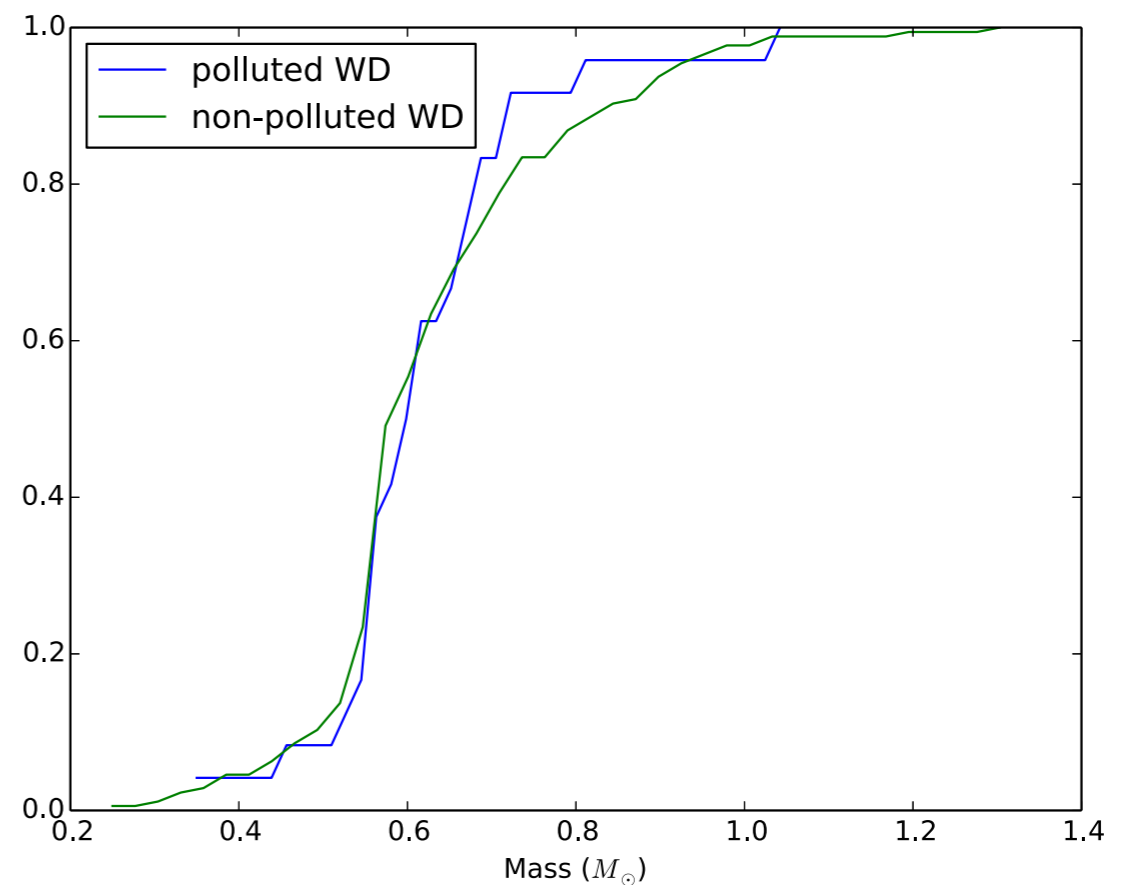
Mean Mass: $0.64 M_{\odot}$

Median Mass: $0.62 M_{\odot}$

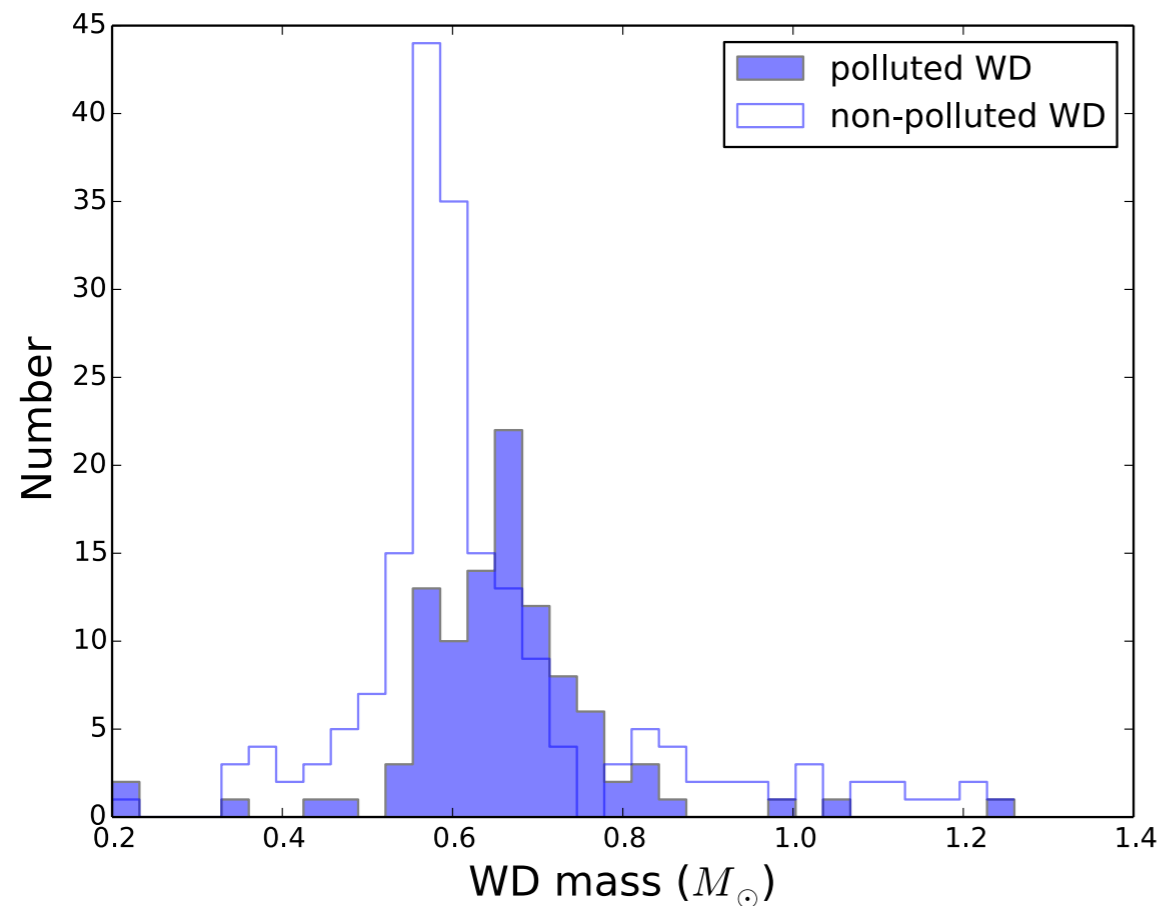
Non-polluted sample

Mean Mass: $0.65 M_{\odot}$

Median Mass: $0.61 M_{\odot}$



Mass distribution up to 200 pc from the Sun



Polluted sample

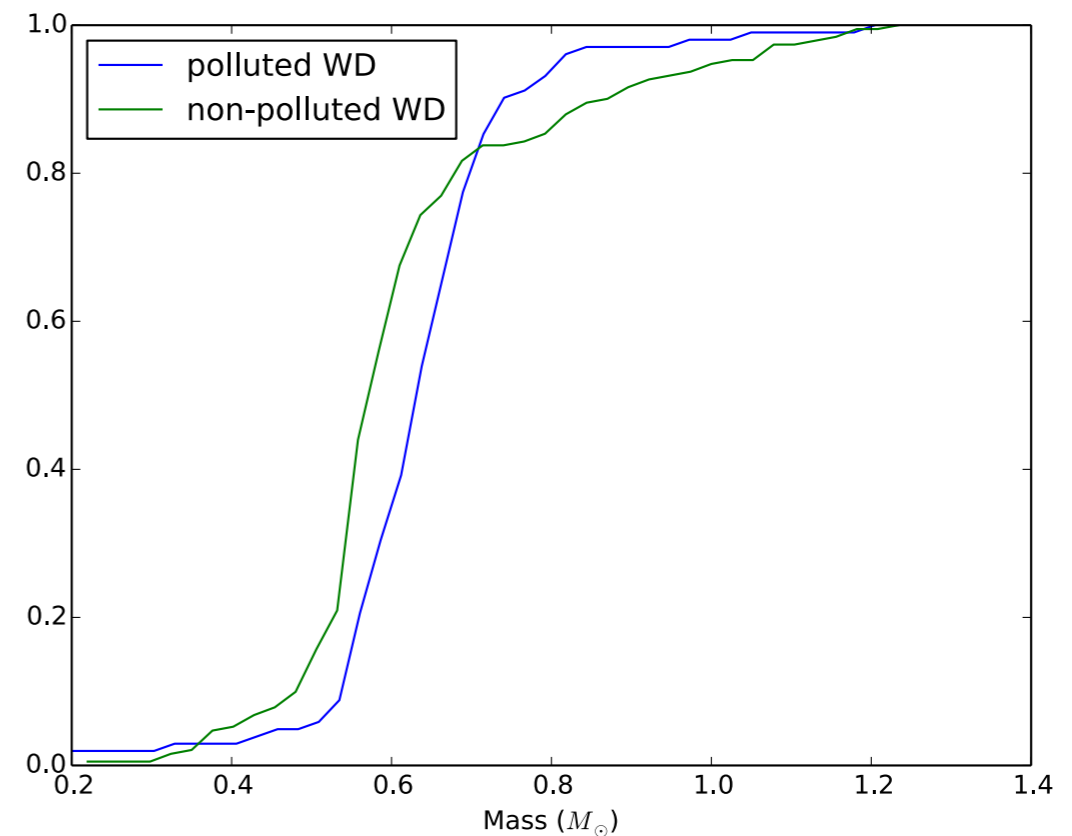
Mean Mass: $0.66 M_{\odot}$

Median Mass: $0.65 M_{\odot}$

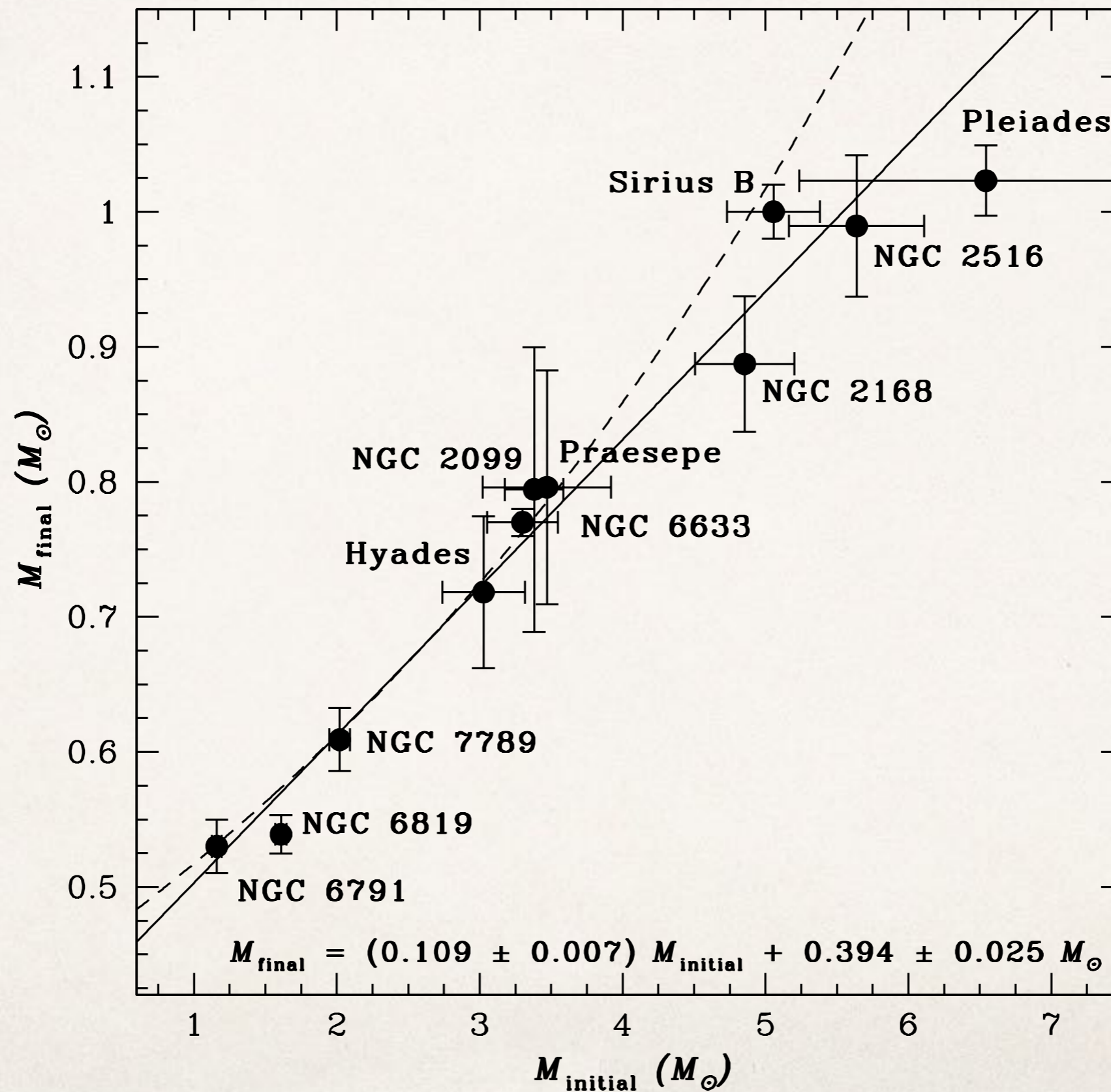
Non-polluted sample

Mean Mass: $0.64 M_{\odot}$

Median Mass: $0.59 M_{\odot}$



Initial-final mass relation (Kalirai et al. 2008)

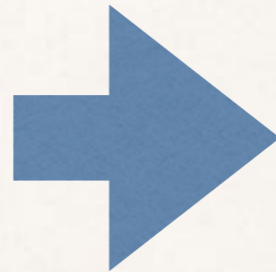


Progenitor mass of the WD samples

Polluted sample

Mean Mass: $0.66 M_{\odot}$

Median Mass: $0.65 M_{\odot}$



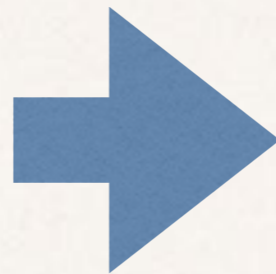
Mean initial mass: $2.43 M_{\odot}$

Median initial mass: $2.39 M_{\odot}$

Non-polluted sample

Mean Mass: $0.65 M_{\odot}$

Median Mass: $0.59 M_{\odot}$



Mean initial mass: $2.30 M_{\odot}$

Median initial mass: $1.84 M_{\odot}$

Koester et al. 2014 found a mean mass for progenitors of DA stars of $\sim 2 M_{\odot}$ which corresponds to A type stars in main sequence.

Connection to debris disks in the main sequence phase

Is circumstellar material of white dwarfs a remnant of the
main sequence phase?

Detection rates of debris disk for A stars:

- ❖ 33% at 70 μm (Su et al. 2006)
- ❖ 25% at 100 μm (Thureau et al. 2013)

+

Exo-cometary activity in A stars (Rebollido et al. in prep.)

We are still analyzing: $\langle z \rangle$, accretion rates, kinematics, ISM conditions...to guide our theoretical efforts.

Work in progress...

Thank you