Post-main sequence evolution of debris discs

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Observations of dusty discs

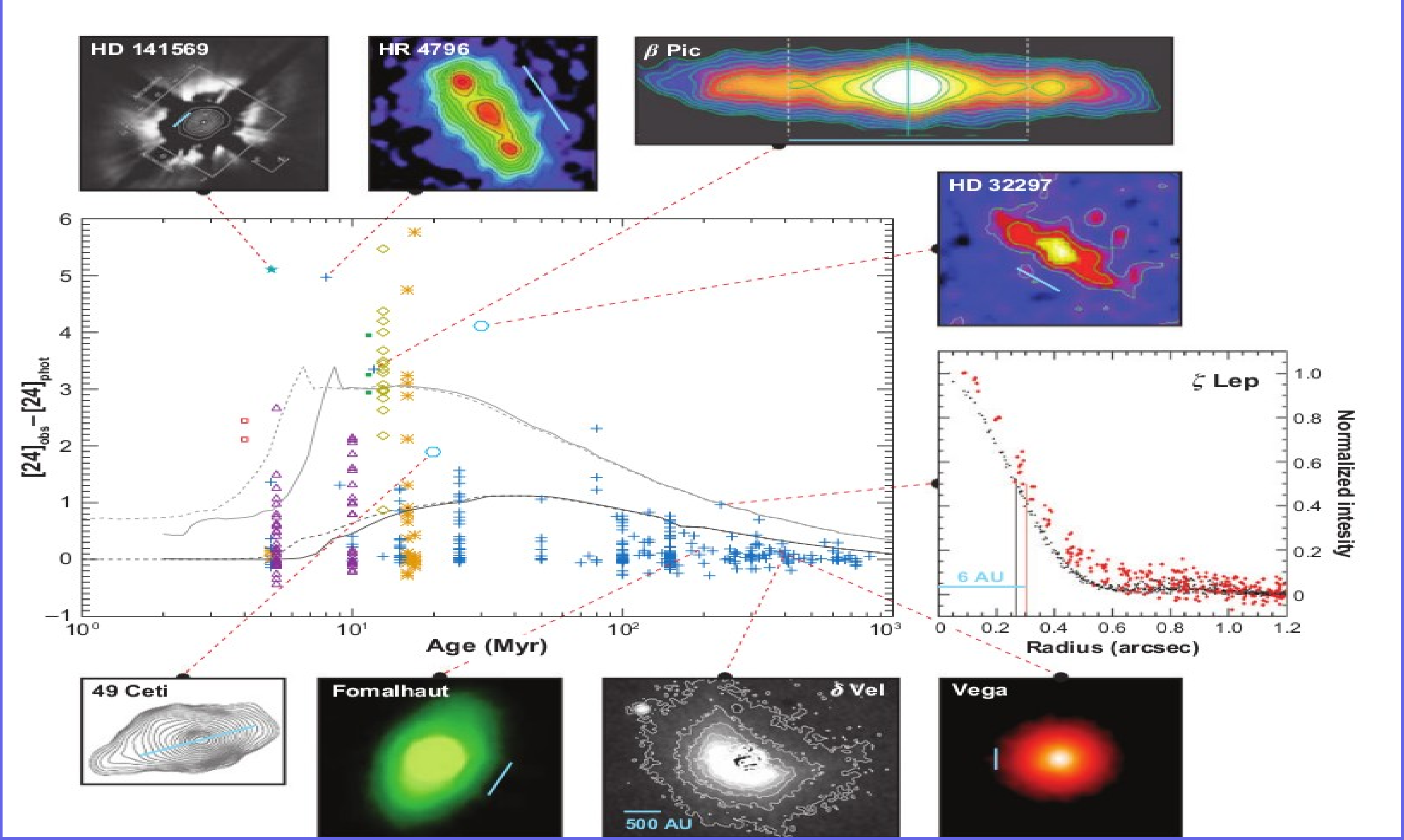
Models to evolve debris discs from main sequence to white dwarf phase

Bonsor, Wyatt et al 2010 (in prep)

Debris discs around white dwarfs and giant stars

Discs on the Main Sequence

There are lots of observations....



Discs around giant stars

G & K giants observed with IRAS @ 60µm:

3-14 % (Jura et al 1990, Plets et all 1999)

These could be:

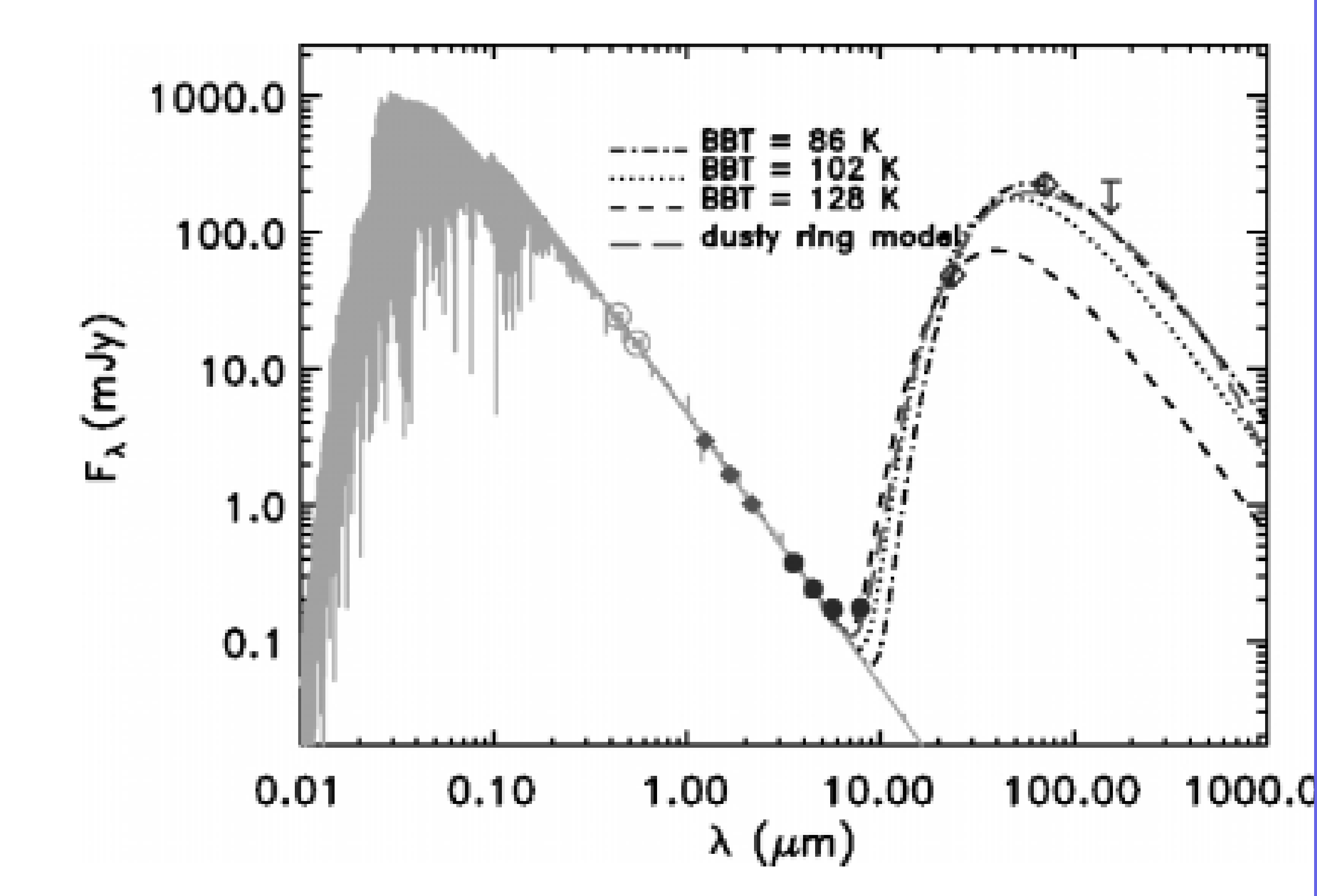
- dusty discs, like MS debris discs
- cirrus hot spots
- sporadic mass loss

Kim, Zuckerman and Silverstone 2001

Discs around white dwarfs

Helix Nebula : a young white dwarf, surrounded by a planetary nebula.

Infrared excess observed with Spitzer at 24 and 70um, an upper limit at 160um



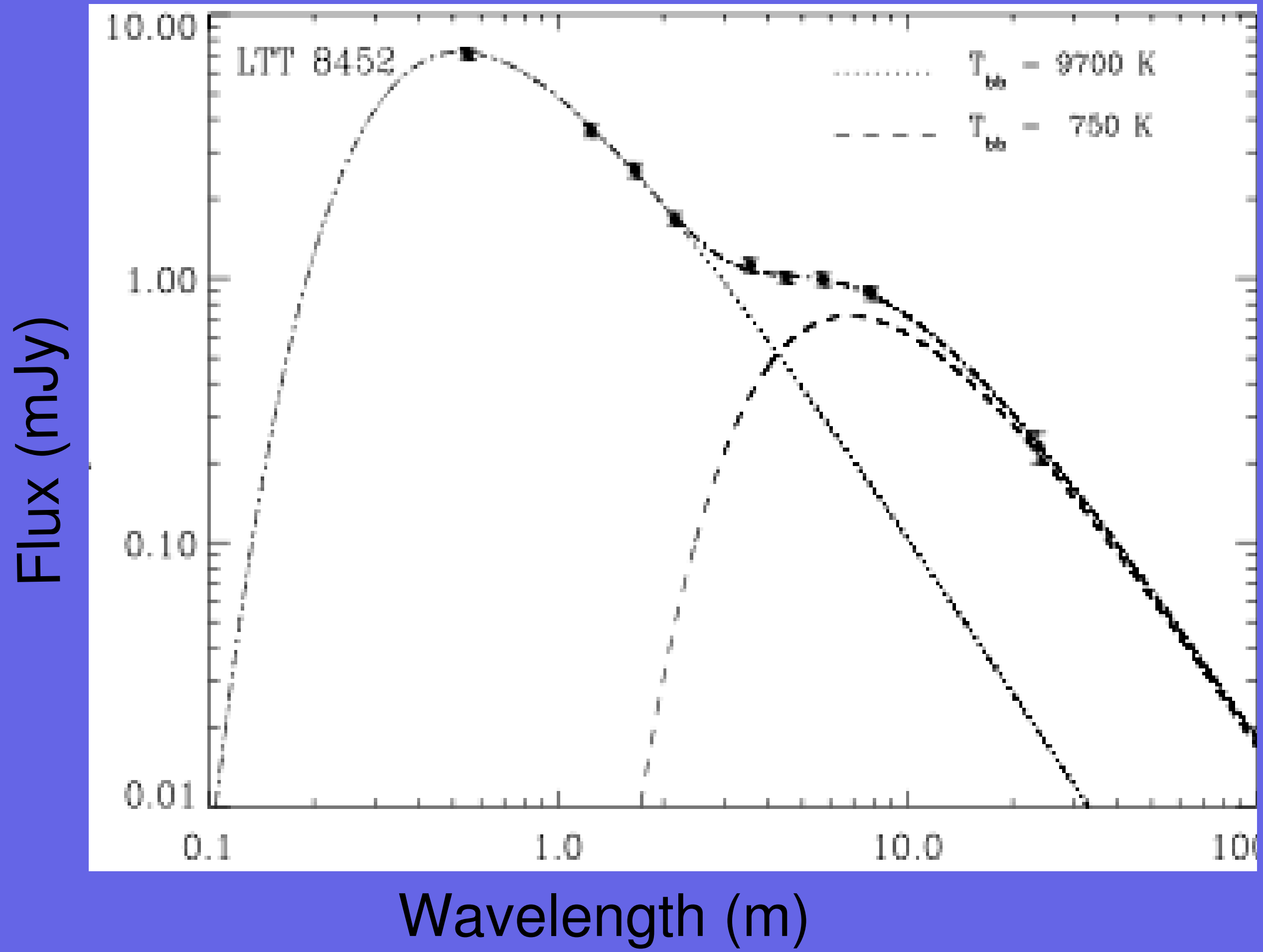
A dusty disc similar to MS debris discs?

Su et al 2007

Hot, dusty discs around white dwarfs

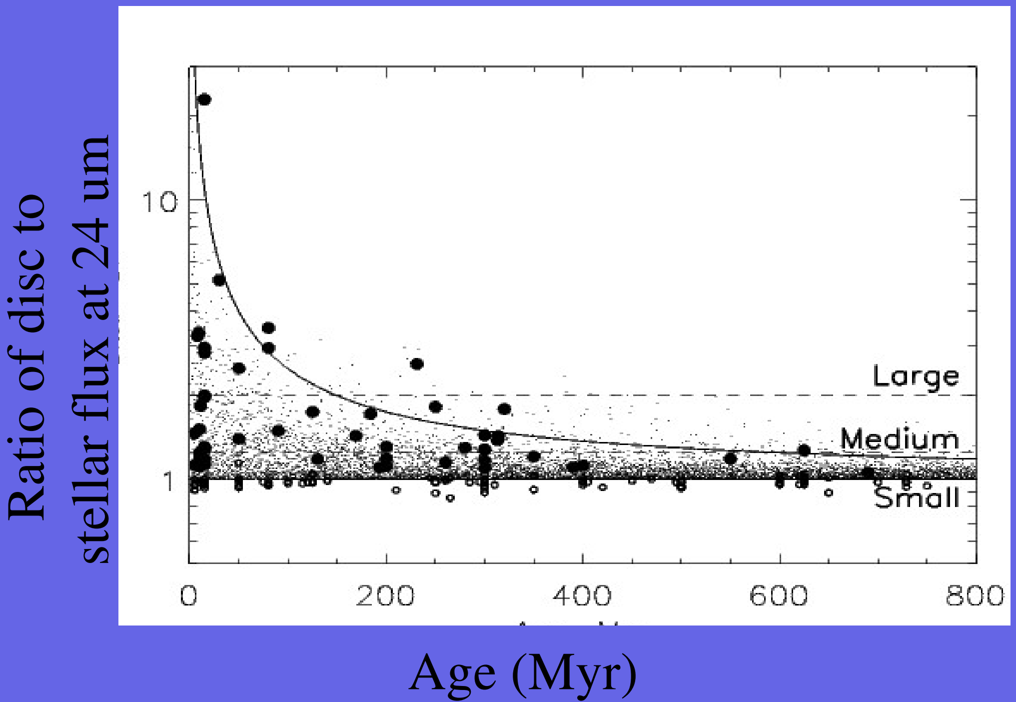
e.g Farihi et al 2009, von Hippel et al 2007, etc.....

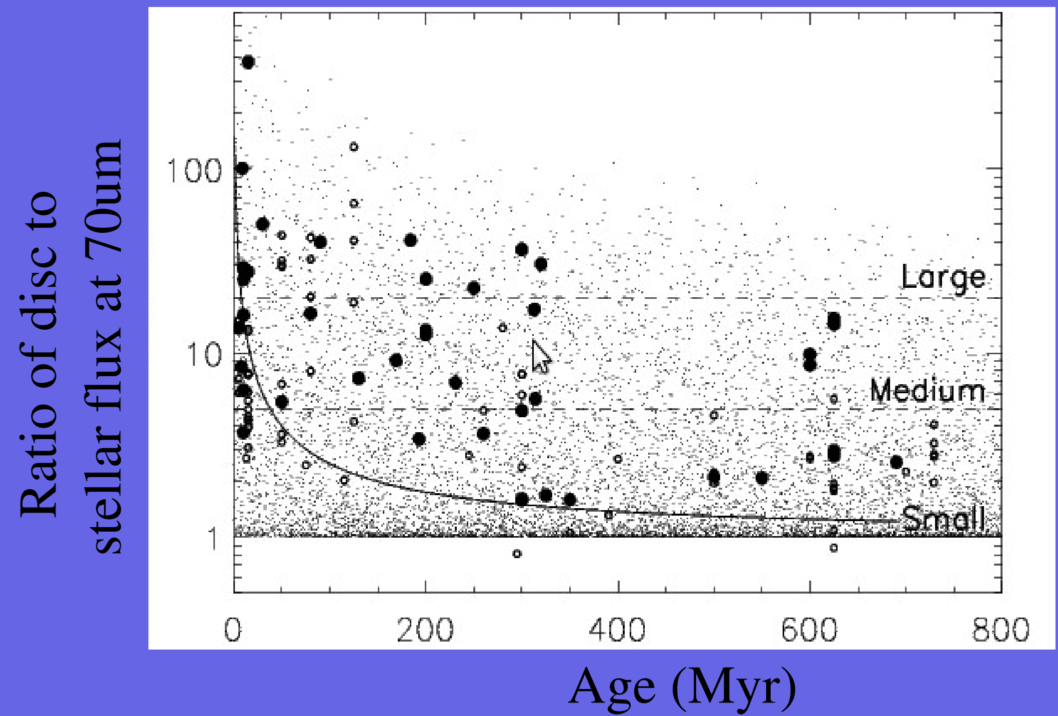
Radii ~ Rsolar



Tidally disrupted asteroids or comets

Population of debris discs on the main sequence





- Observed discs
- Model pop^{n}

Constrain population of debris discs around **main sequence A stars** using the **steady state collisional models of Wyatt et al 2007** and **Spitzer** observations at **24um** and **70um**.

Population of debris discs around main sequence A stars

↓ Wyatt et al 2007

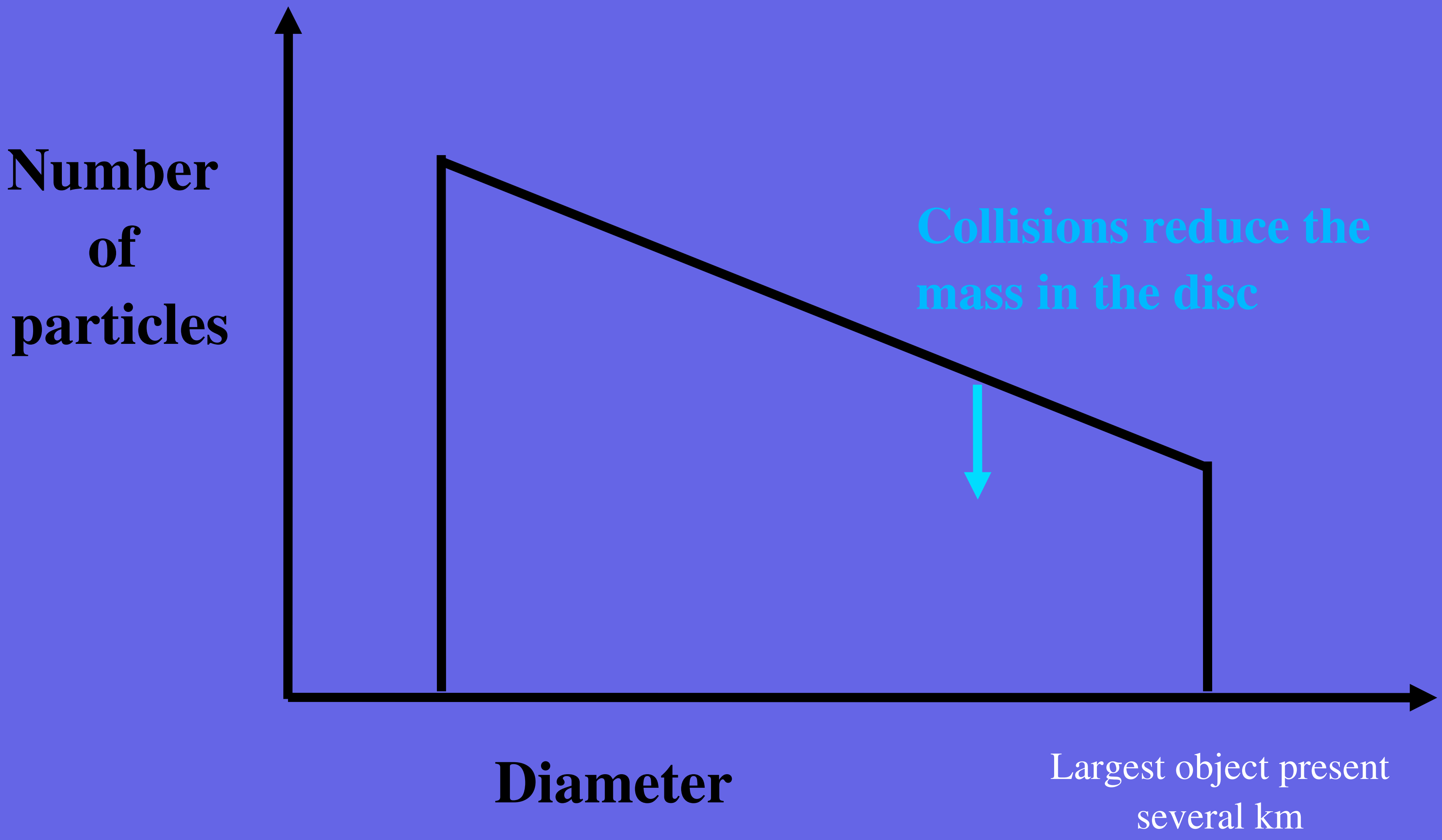
Stellar evolution

↓ Hurley et al 2000

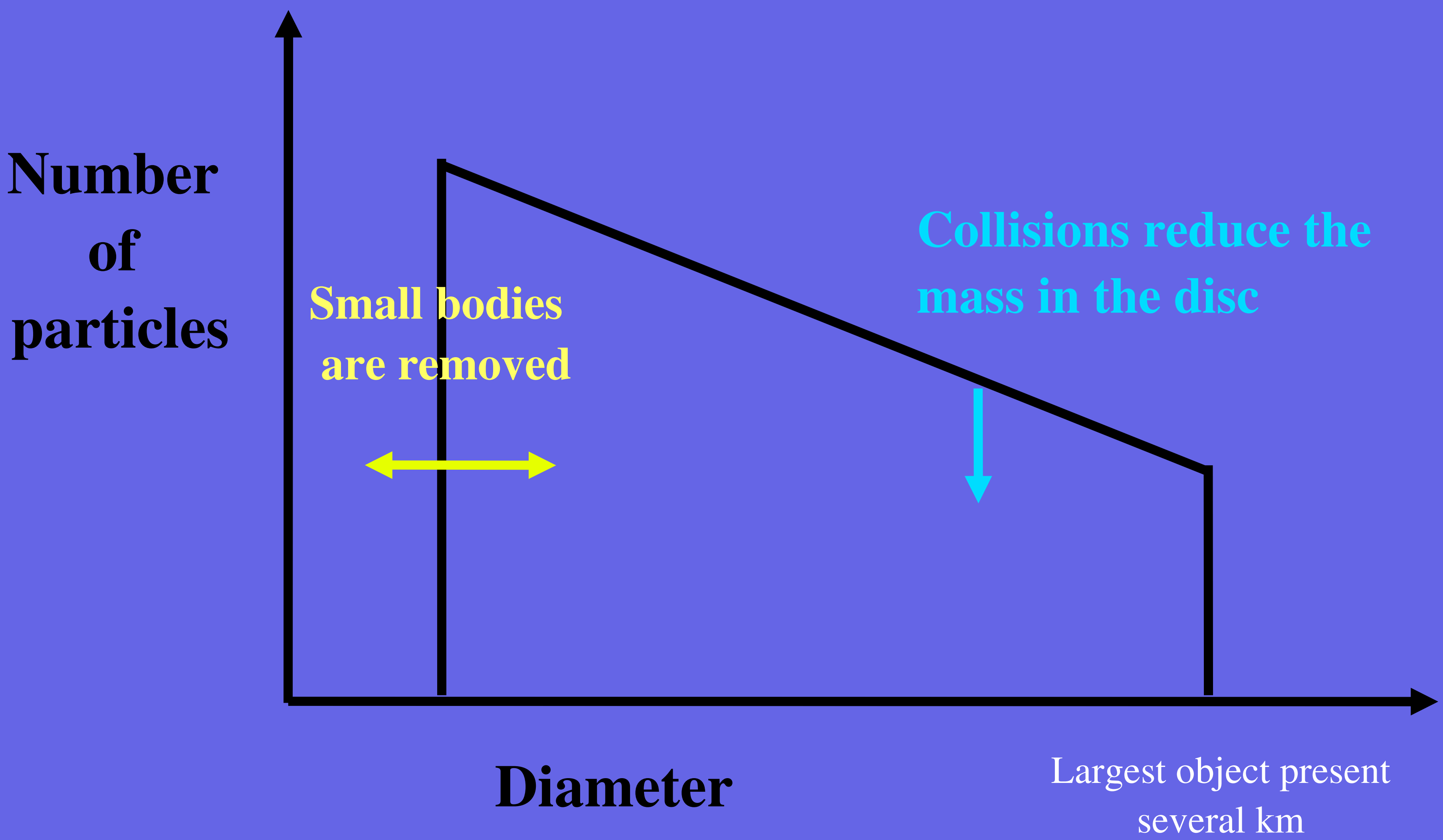
Population of debris discs around evolved stars

Provide a theoretical framework that investigates all of the processes affecting a disc during its evolution

Collisional Evolution



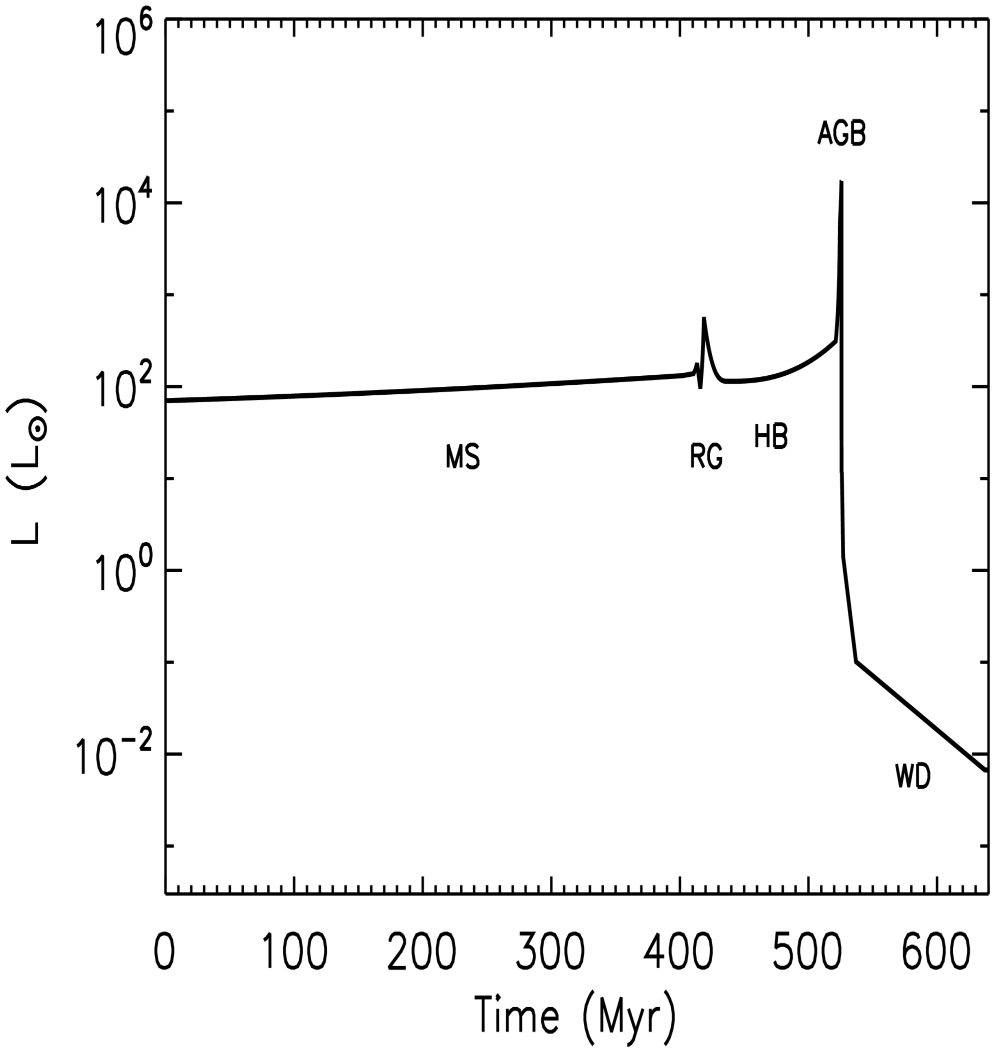
Collisional Evolution

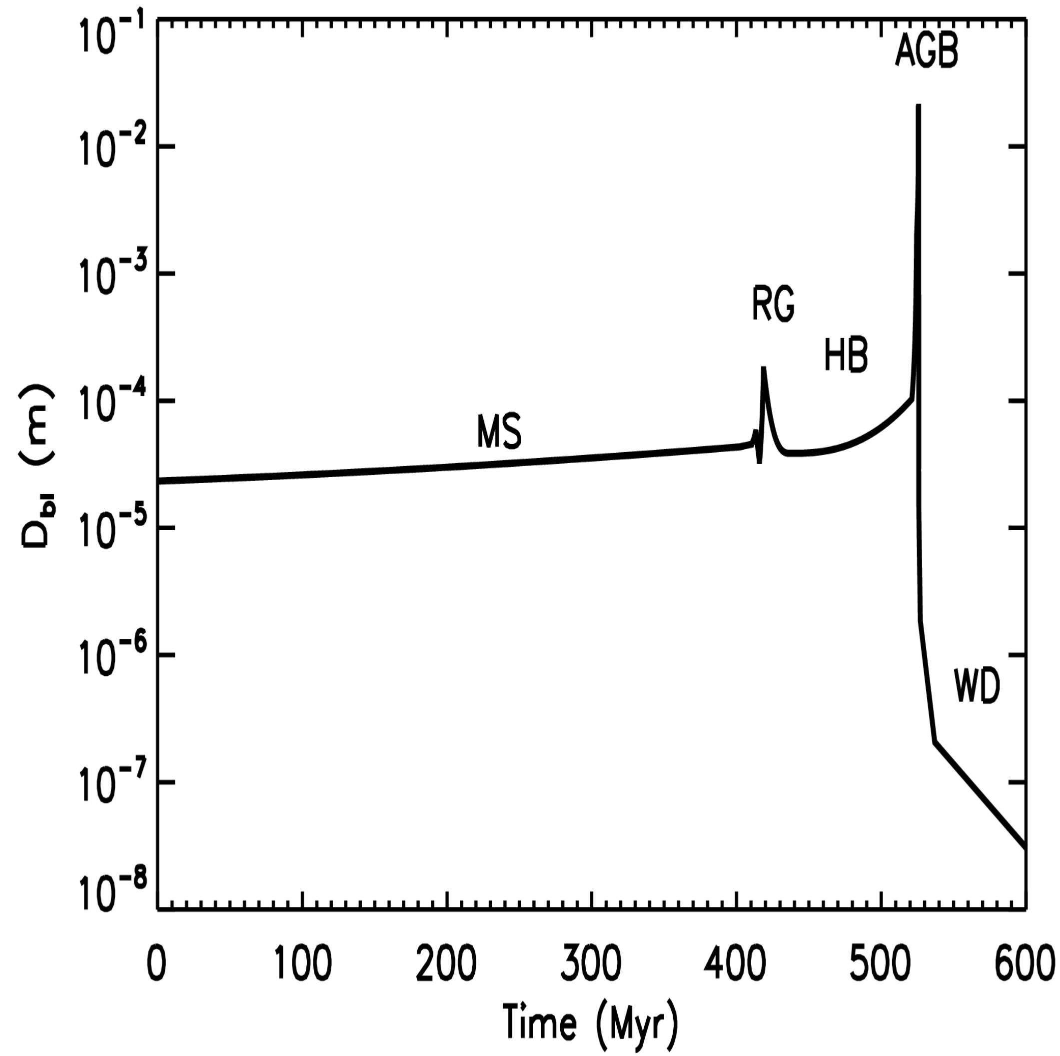


Small bodies removed by?

Process	When is it important?
Radiation pressure	throughout evolution
Poynting-Robertson drag	x
Stellar wind pressure	x
Stellar wind drag	AGB
Sublimation	RG and AGB ?

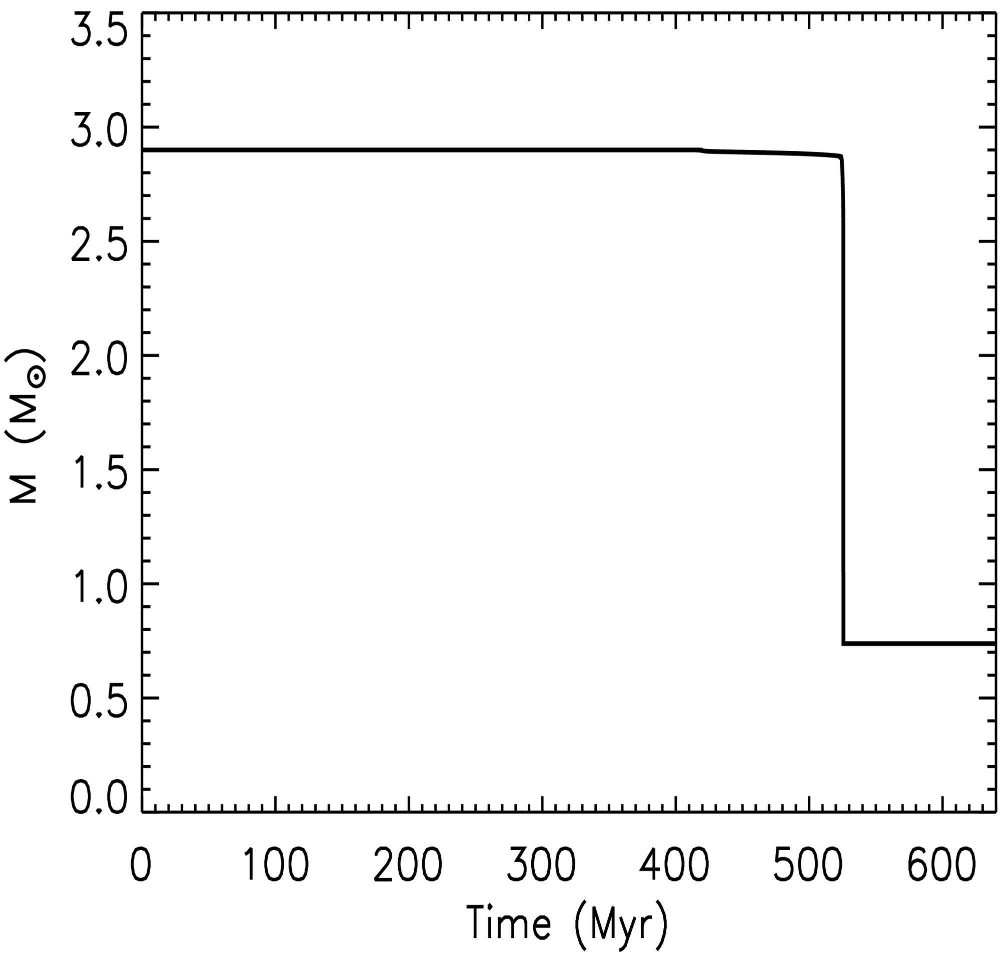
Effect of radiation pressure blow-out

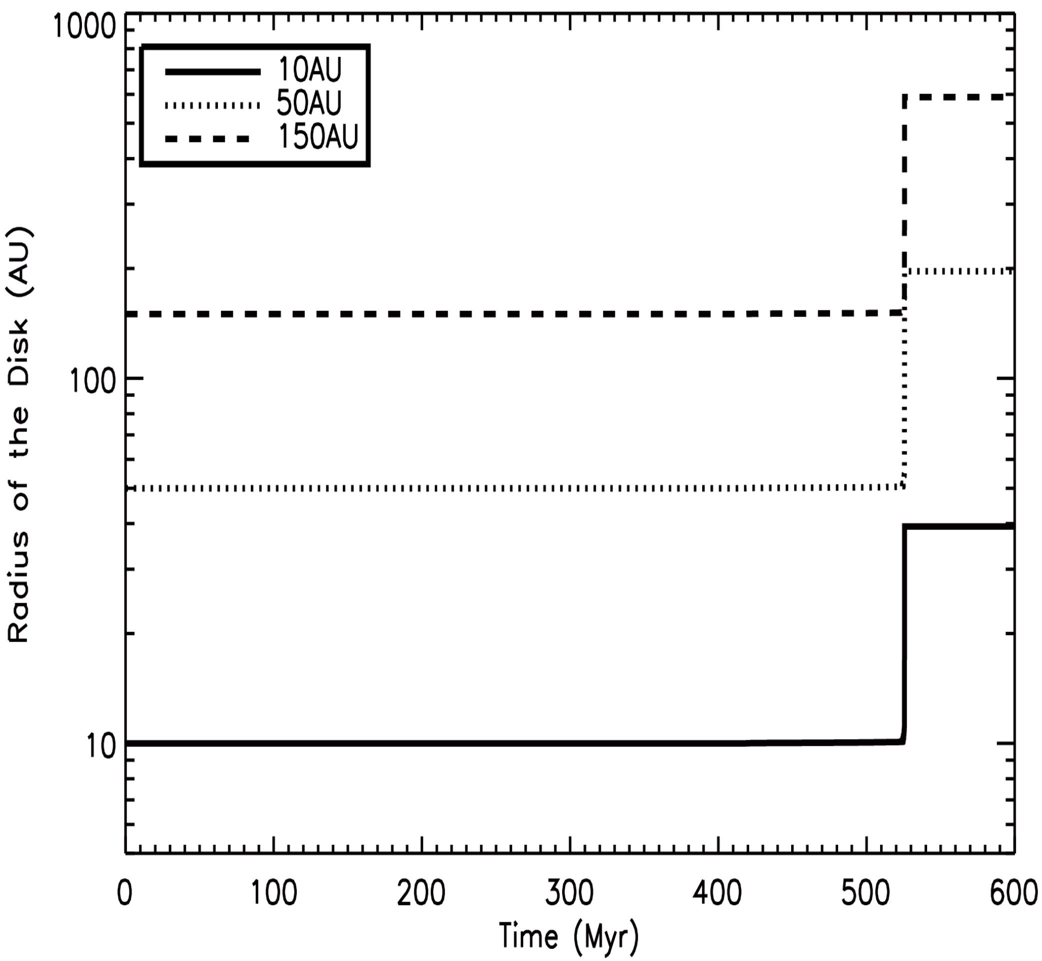




2.9 $M_\odot$

Disc radius evolution

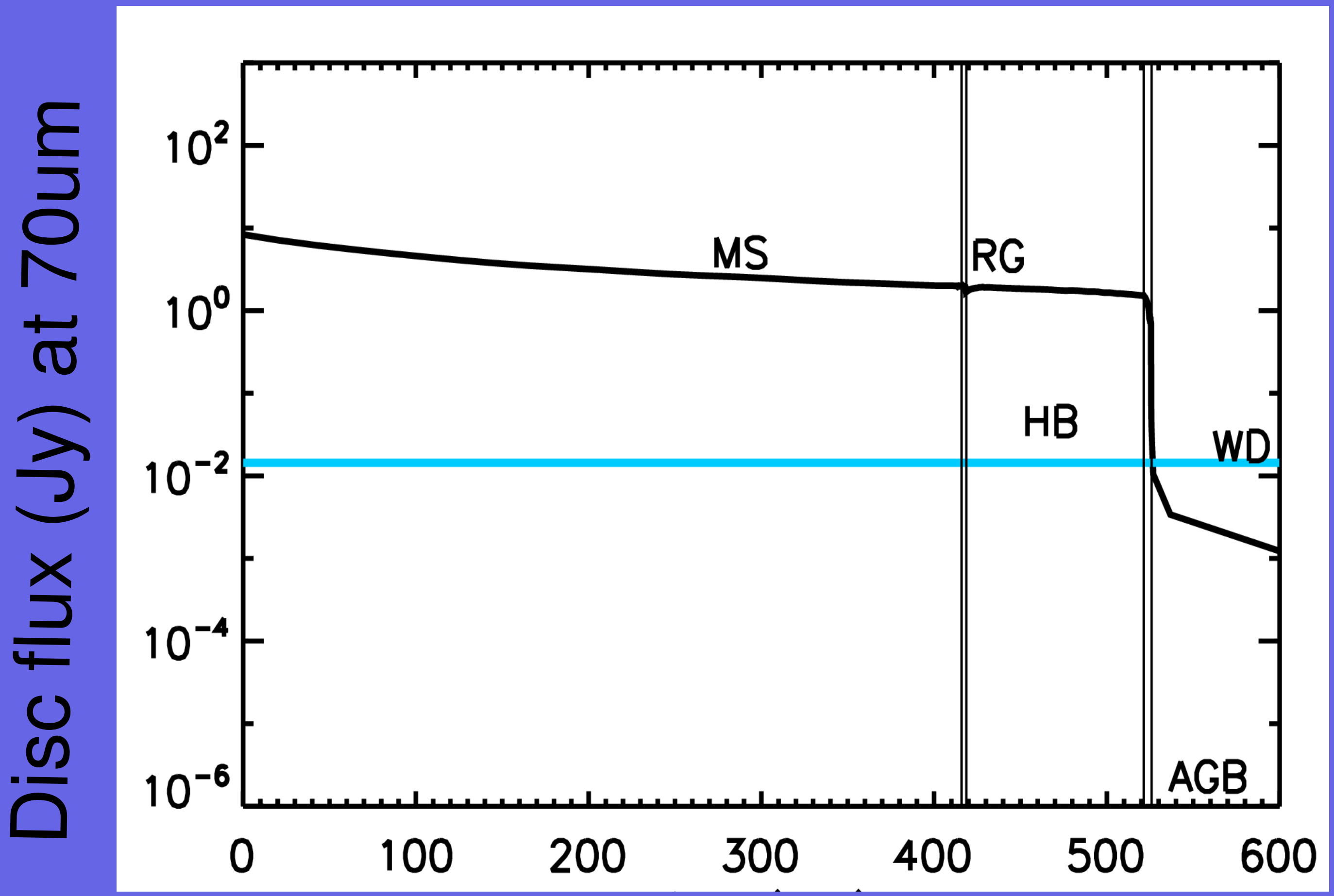




Disc radii increase around white dwarfs

2.9 $M_\odot$

Disc luminosity



Time (Myr)

Initial radius: 100AU

Initial mass $30M_\oplus$

Star: 2.9 $M_\odot$

Distance: 10pc

Spitzer at 70um

Bonsor et al 2010 in prep

To detect a disc we require:

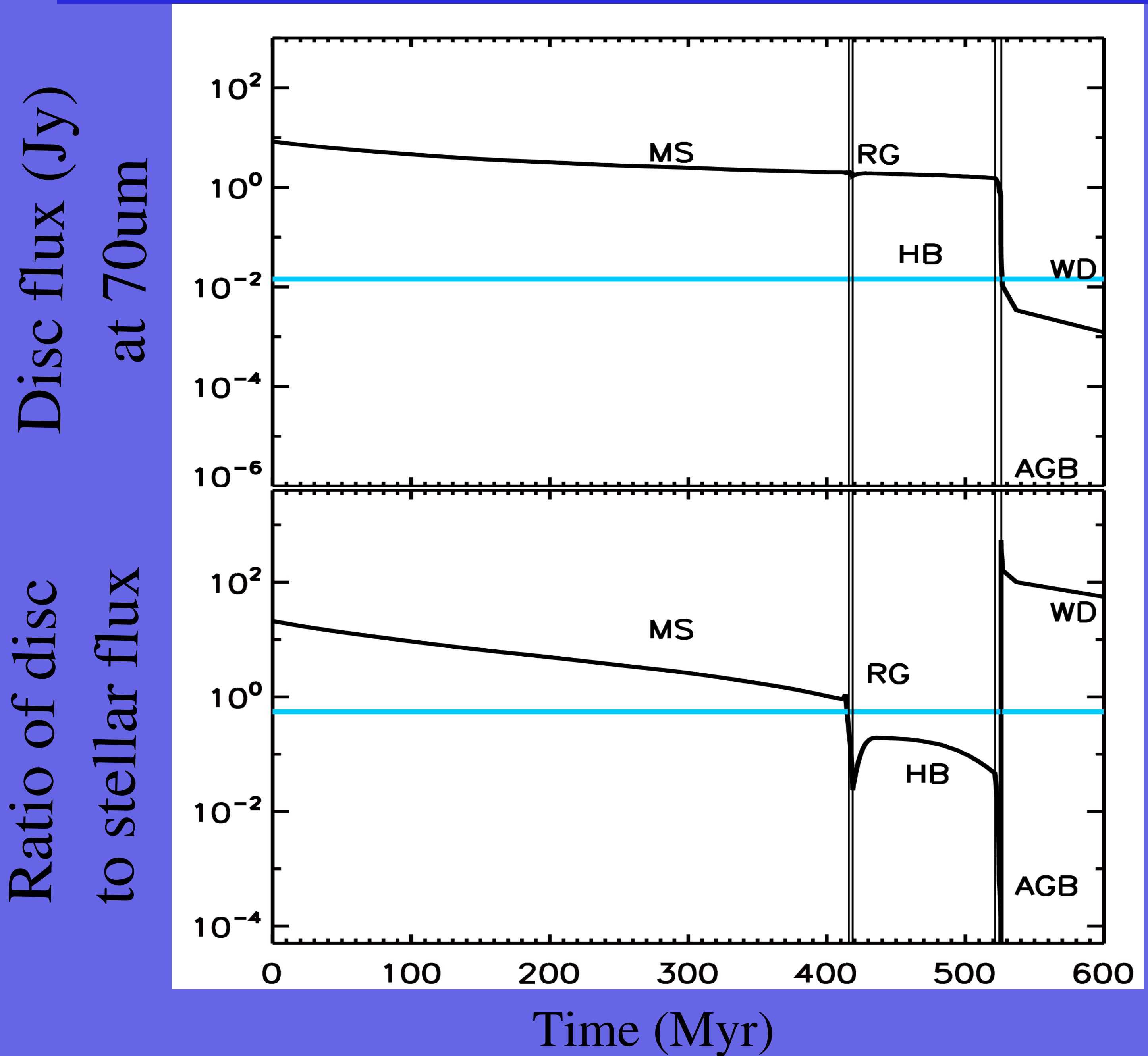
Disc is bright:

Disc flux > Sensitivity

Disc is brighter than star:

$$\frac{\text{Disc flux}}{\text{Stellar flux}} > \text{Calibration limit}$$

When are discs detectable?



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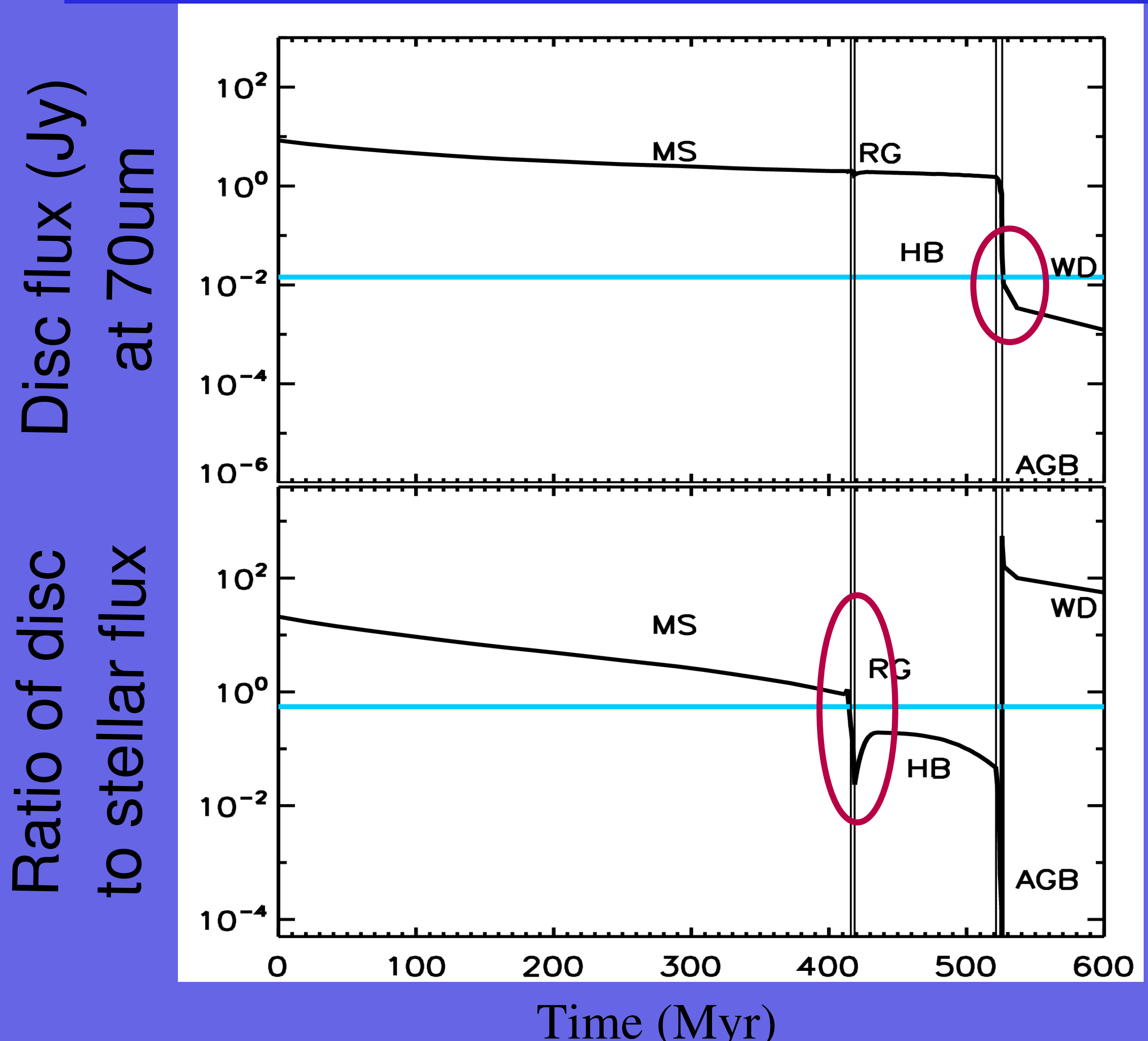
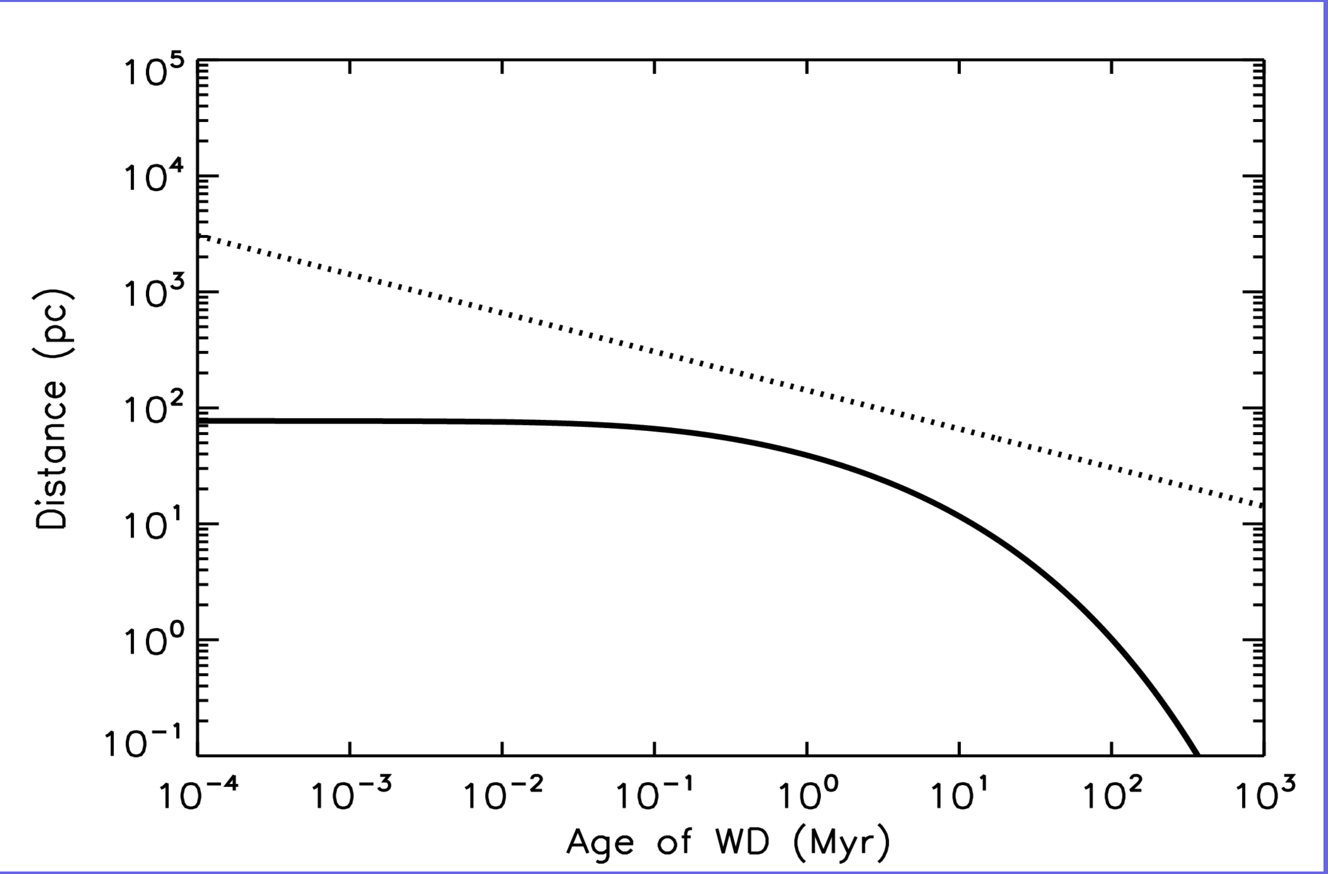


Around hot, young, nearby white dwarfs

Around giant branch stars

Dust around young white dwarfs



······ Distance within which there is expected to be one WD with t< tcool

— Max. distance at which a disc around a 0.5 $M_\odot$ WD with a disc mass of 10^{-2} $M_\oplus$ and a disc radius of 100AU is detectable with Spitzer at 70um.

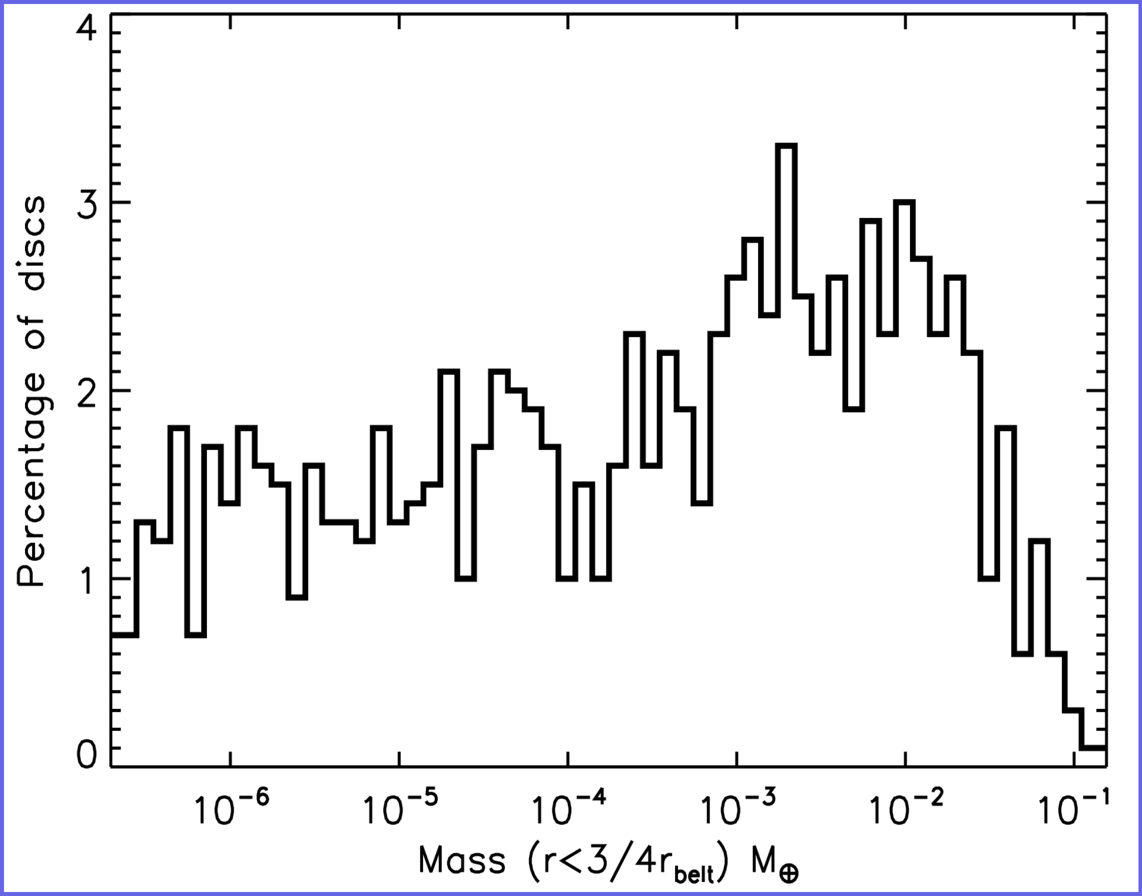
Optimum age for detection ~ 1Myr @ ~200pc

Helix Nebula

Explaining the hot, dusty white dwarf discs

Radii ~ $R_{\odot}$ rather than 10AU smallest disc in pop^{n} evolved from MS

Disc material spirals inwards due to stellar wind drag such that a significant proportion of the disc mass is found inside of the belt at the end of the AGB.



Compare to hot WD discs with masses 10^{-10} – 10^{-2} $M_{\oplus}$

Detecting discs around giants

Percentage of population of discs observed around MS A stars Wyatt et al 2007 with detectable excess, within 150pc

Spitzer at 70um	24%
Herschel PACs at 70um	25%
Herschel PACS at 160um	21%

But we havn't included sublimation...

Sublimation could:

- decrease no. of detectable discs by sublimating all small grains
- increase no. of detectable discs by releasing a population of small silicate grains, as in the models of Jura 90(?)

Future observations of giant stars could constrain the effects of sublimation on debris discs

Also…

- **Detailed modelling required to determine if observed excess results from debris discs rather than cirrus hot spots or stars undergoing mass loss**
- **Include population of debris discs around FGK stars**
- **Include large radii discs**

Conclusions

- Bonsor, Wyatt et al 2010 (in prep)
  Models to investigate the effects of stellar evolution on debris discs and to find the population of discs around evolved stars.

- Debris discs are detectable around young white dwarfs, but these are rare close to the sun- fits with observation of disc around the helix nebula

- Stellar wind drag provides a plausible reservoir of material to explain hot white dwarf discs

- Future observations of discs around giant stars could constrain the effects of sublimation on the disc