Credit:NASA/JPL Caltech

Stellar Archeology using Wind Properties

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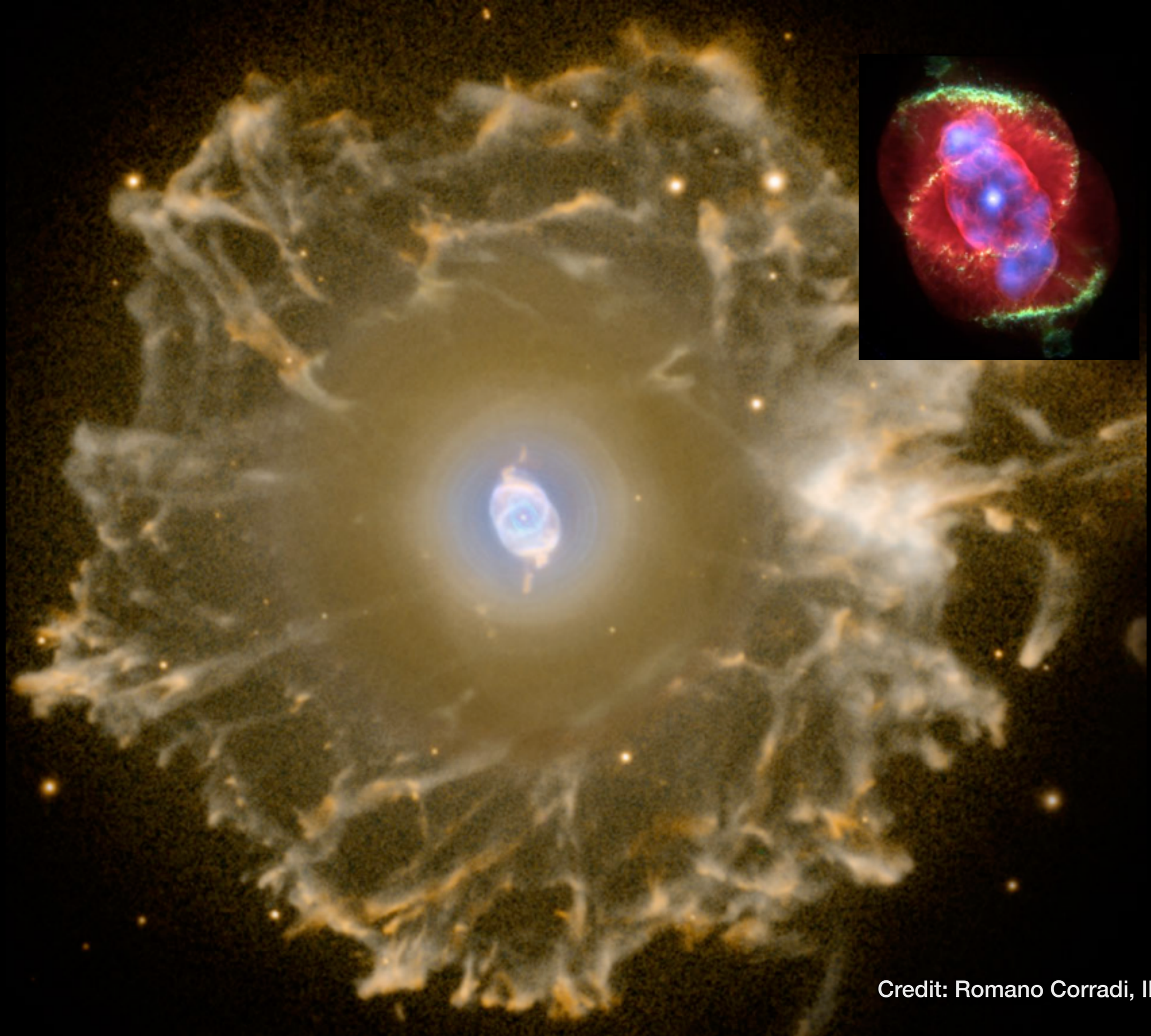


Credit: Romano Corradi, ING, NOT

M 2-9

Hubble Legacy Archive, NASA, ESA

The Ingredients:

- To understand the mass-loss return from low and intermediate mass stars we need to evolve the star.

- AGB PN (single) stars progenitors range from 1 up to 8 $M_{\odot}$

- Stellar dynamics, where to find the mass-loss? Systemic velocities in the Galaxy: 0- 150 km/s

- Collimation mechanisms

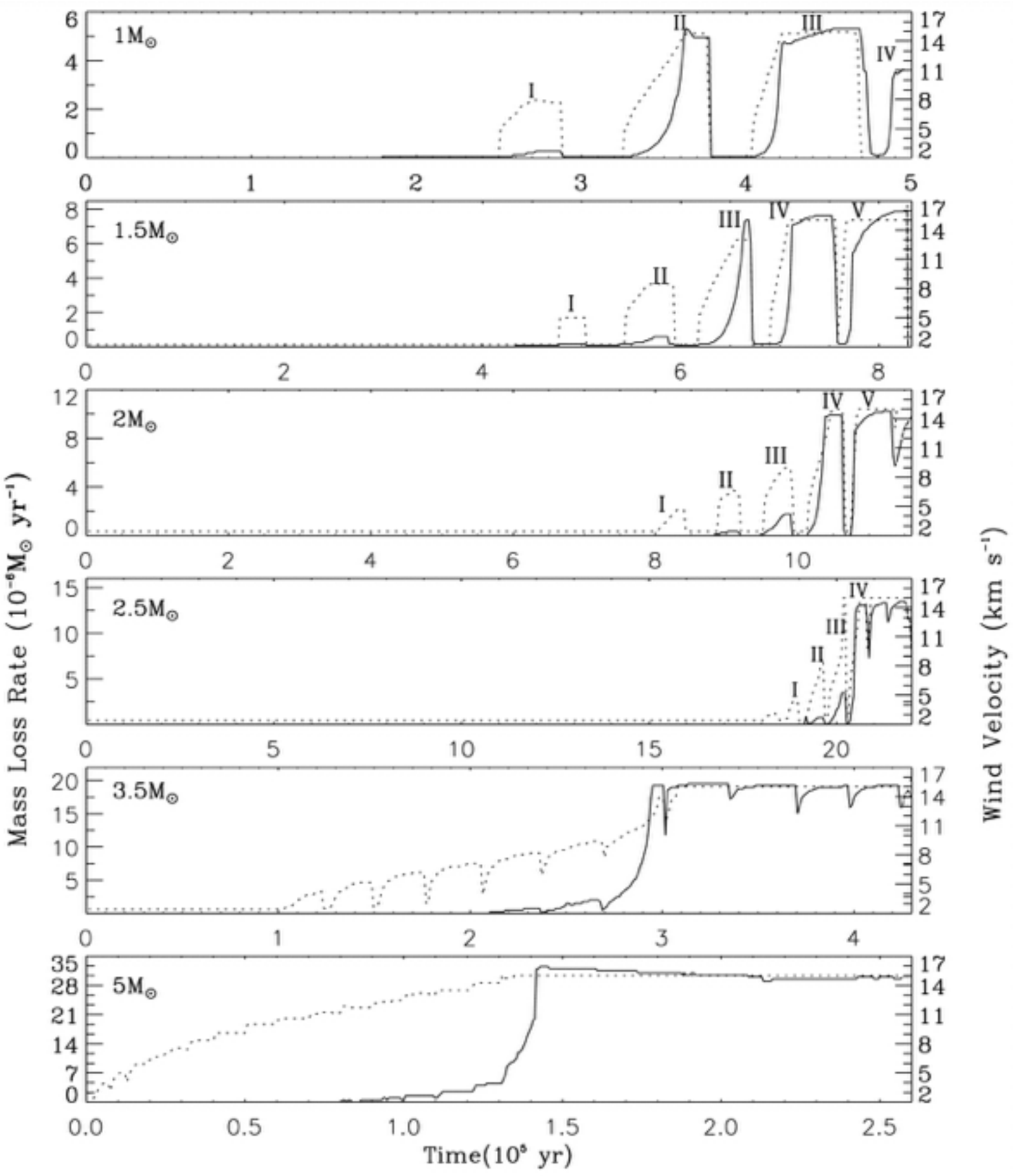
THE STAR

Mass-loss is the signature of the TP-AGB evolution. At uncertain rates it removes up to 7 M_{sun} of material on timescales of 10^5-10^6 yr

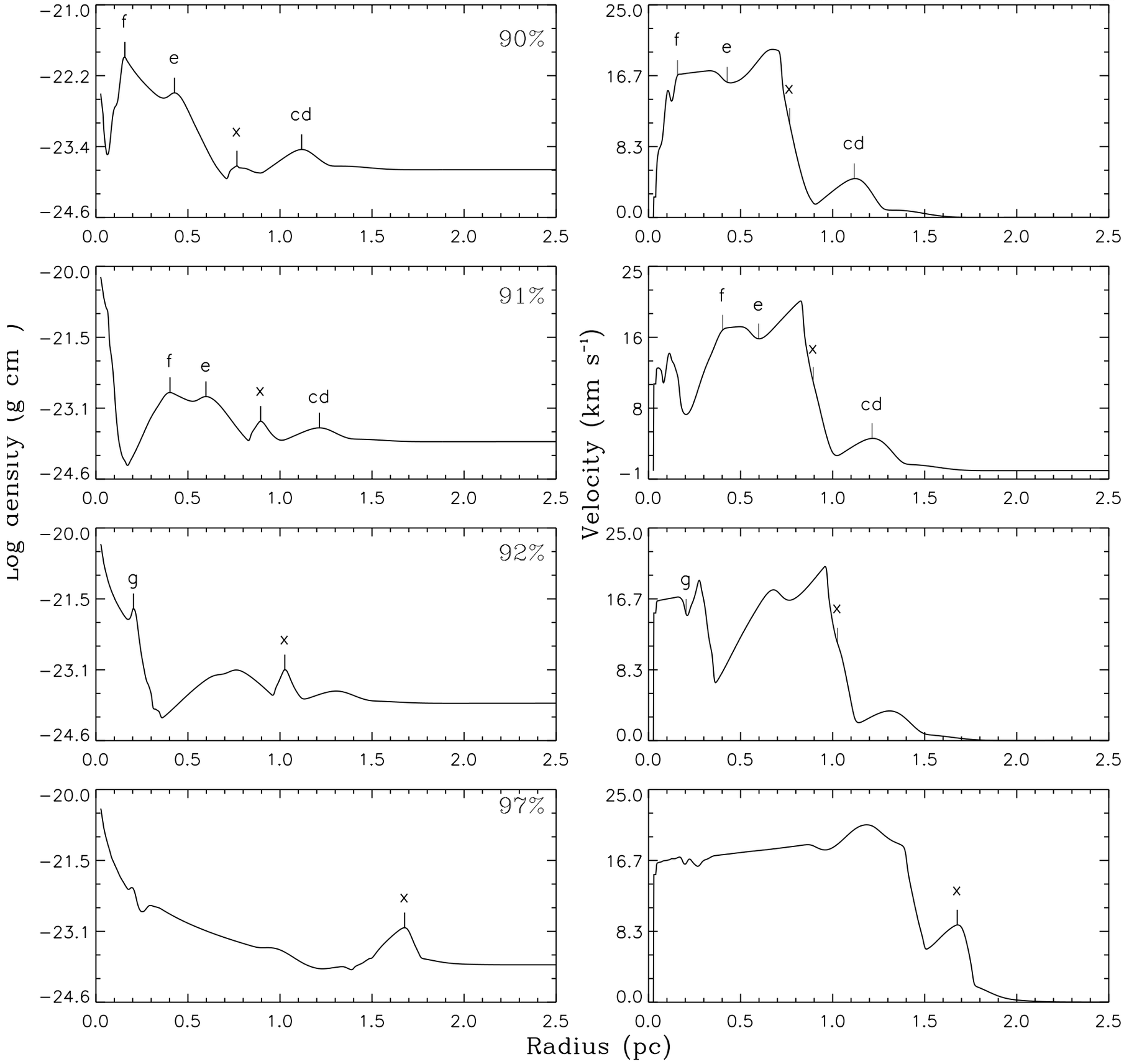
(Vassiliadis & Wood 1993, Blocker 1995, Herwig 2005, Schroder et al. 1999).

Initial-to final mass fixed, then higher mass-loss rates imply shorter evolutionary timescales.

AGB Wind

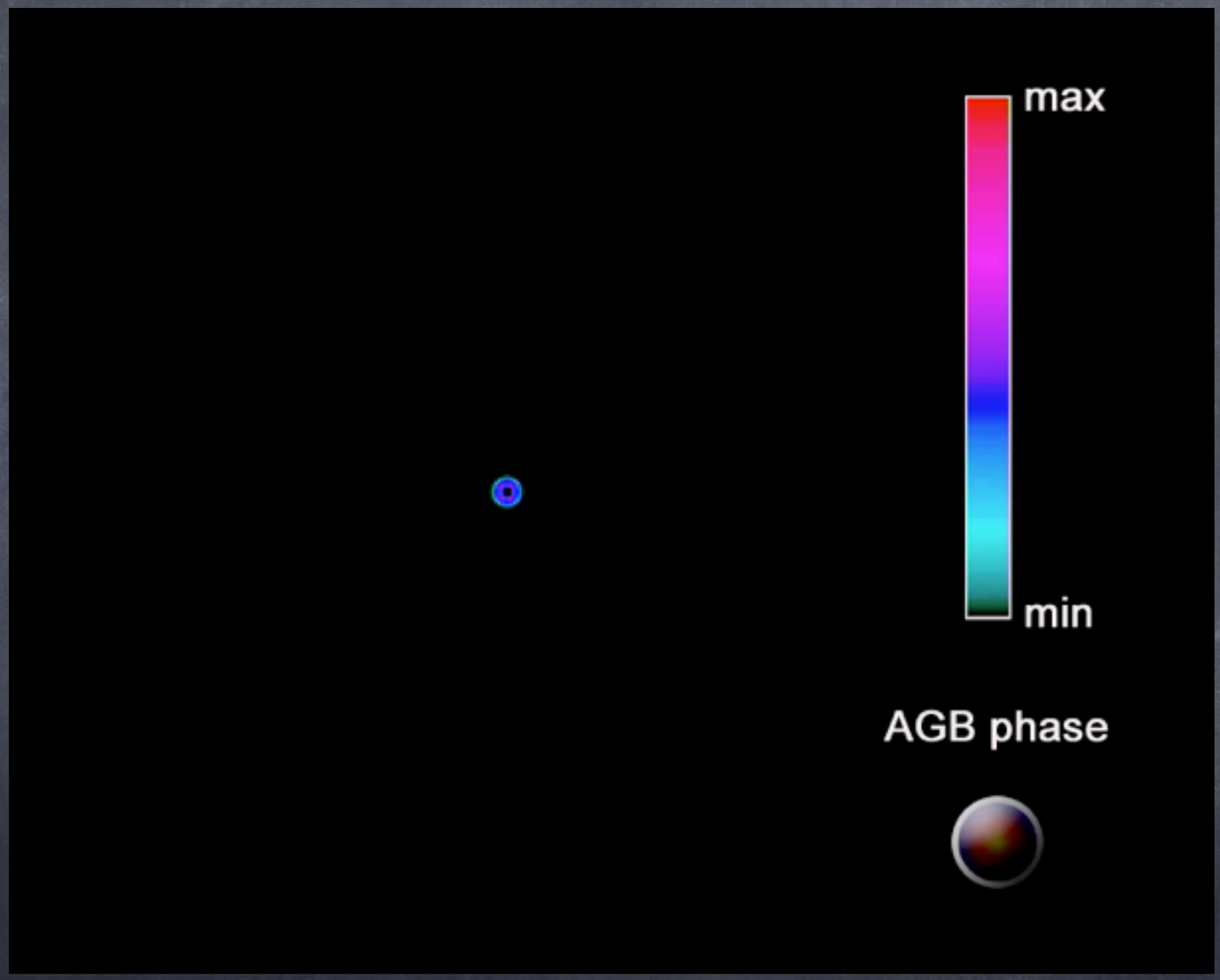

1M⊙
1.5M⊙
2M⊙
2.5M⊙
3.5M⊙
5M⊙
I
II
III
IV
V
Mass Loss Rate (10⁻⁶M⊙ yr⁻¹)
Wind Velocity (km s⁻¹)
Time(10⁵ yr)

Gas Kinematics



Villaver et al. (2002a)

AGB+PN



Villaver et al. (2002)

ENVIRONMENT

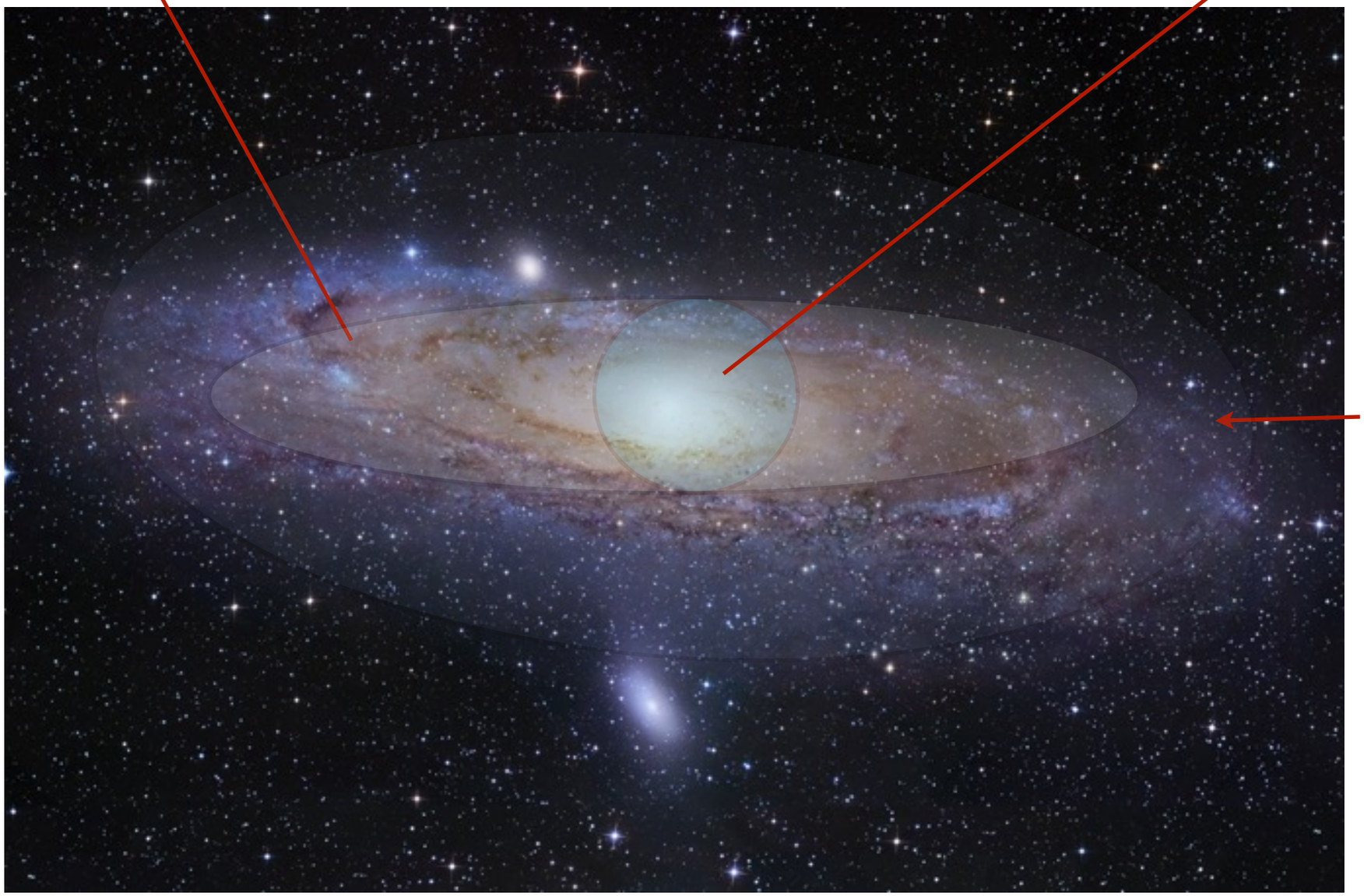
Disk

Circular orbits

v~10-40 kms^{-1}

Bulge

*v > 100 km s^{-1}

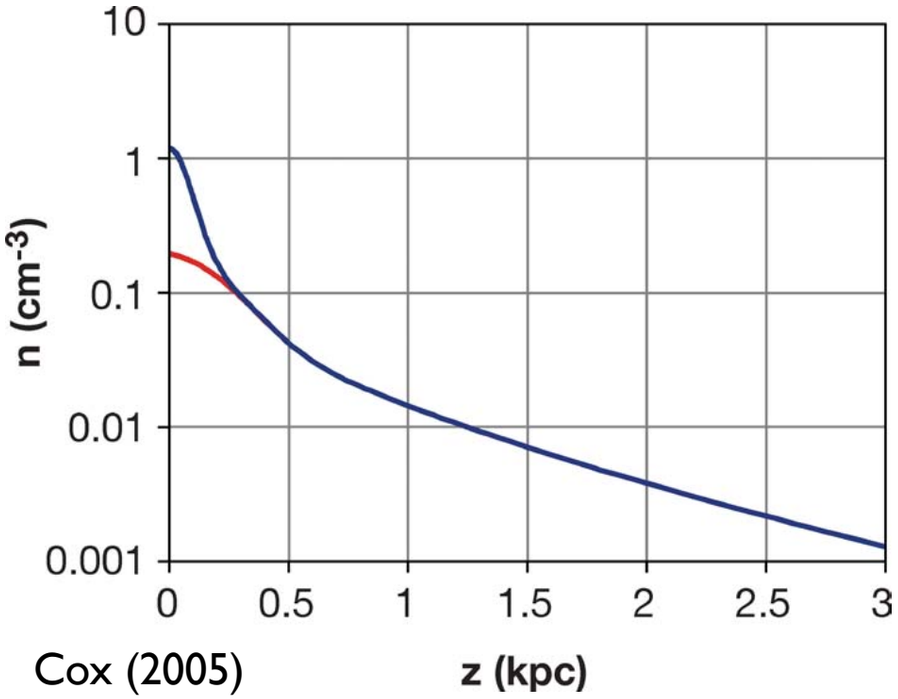


Halo

*Random orbits in 3D

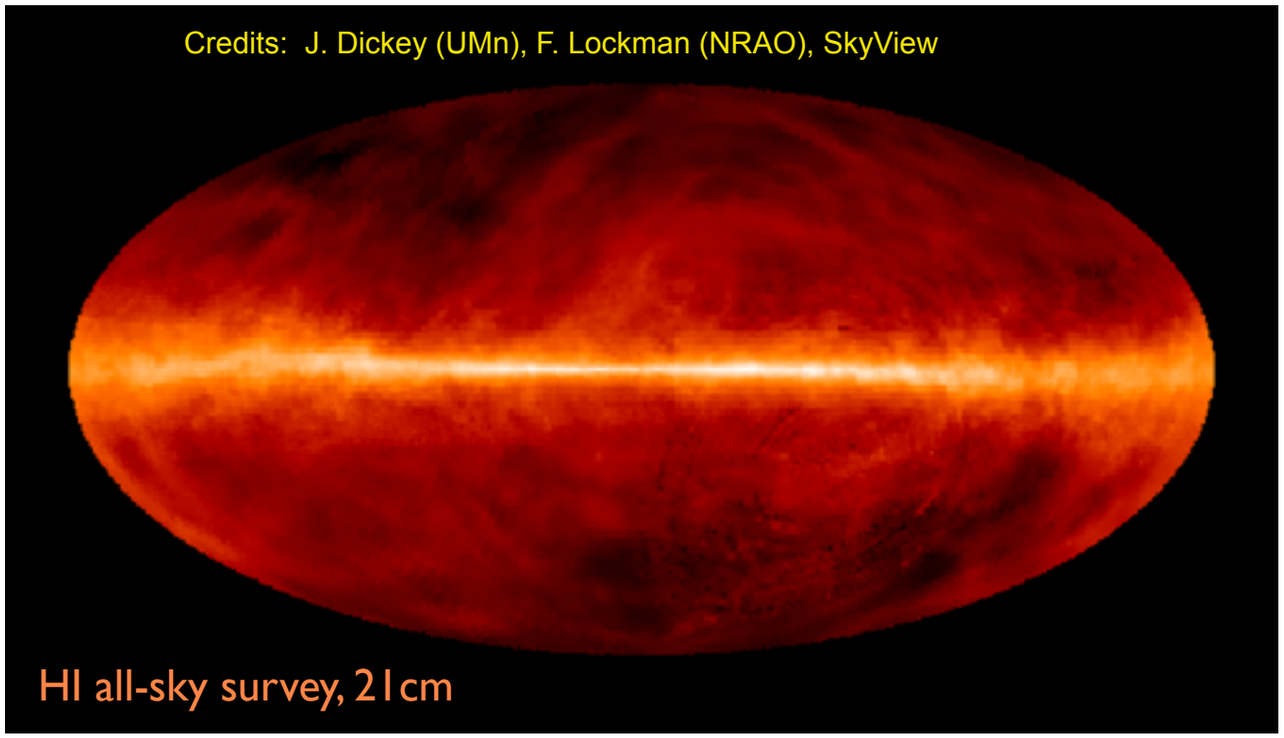
*v~85-100 km s^{-1}

THE ISM CONDITIONS



Cox (2005)

Figure 1 The distribution of interstellar hydrogen density above the Galactic Plane. The total is shown in *blue*, the warm diffuse component in *red*.

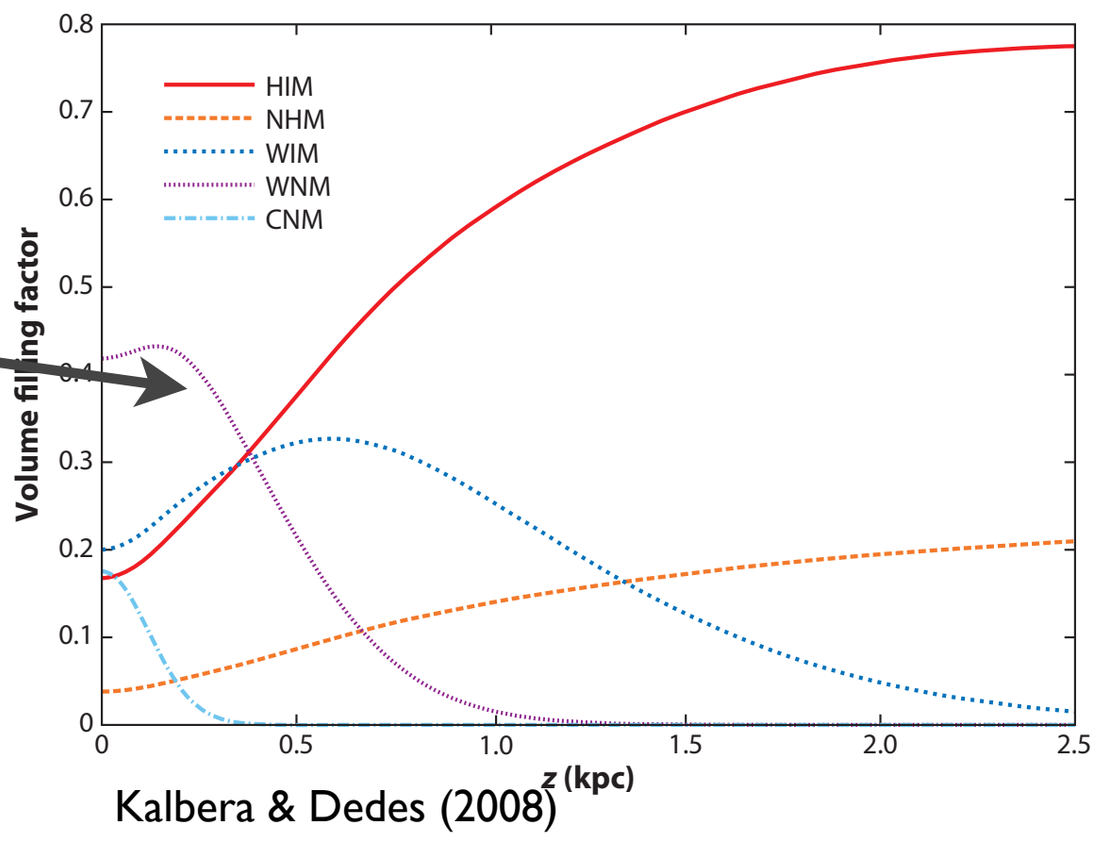


cold HI: $0.57 * 0.7 \exp[-(z/127\,\mathrm{pc})^2]$

warm HIa: $0.57 * 0.18 \exp[-(z/318\,\mathrm{pc})^2]$

warm HIb: $0.57 * 0.11 \exp(-|z|/403\,\mathrm{pc})$

diffuse HII: $0.025 \exp(-|z|/1000\,\mathrm{pc})$.

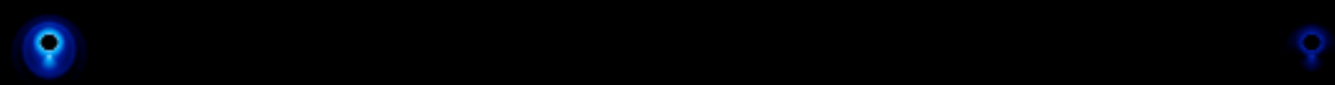


Kalbera & Dedes (2008)

Low Velocity Interaction: V = 10 km/s

$n = 0.1\ cm^{-3}$

$n = 1\ cm^{-3}$



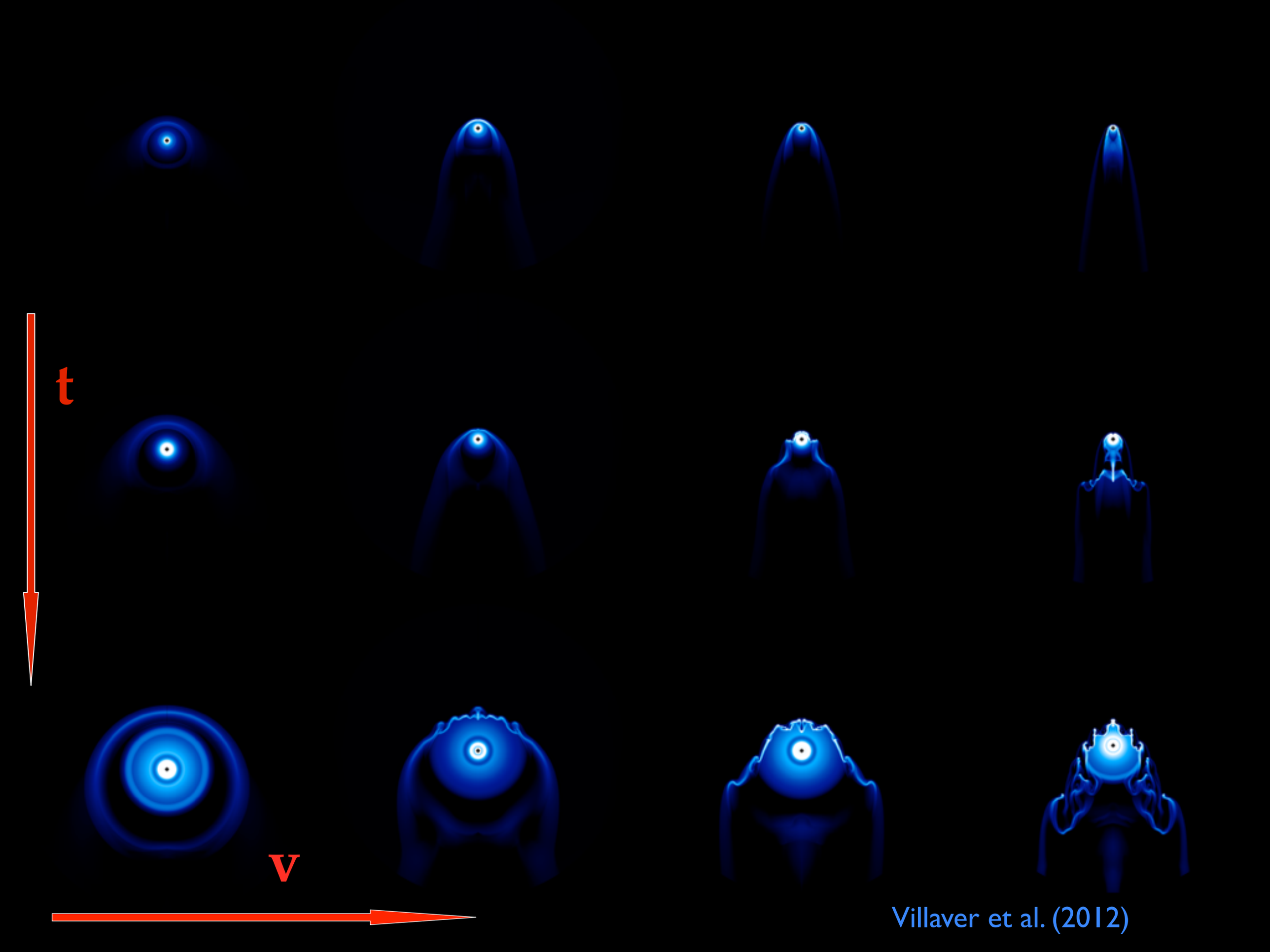
Villaver et al. (2012)

High Velocity Interaction $V = 100$ km s^{-1}

$n = 0.01$ cm^{-3}

$n = 0.1$ cm^{-3}

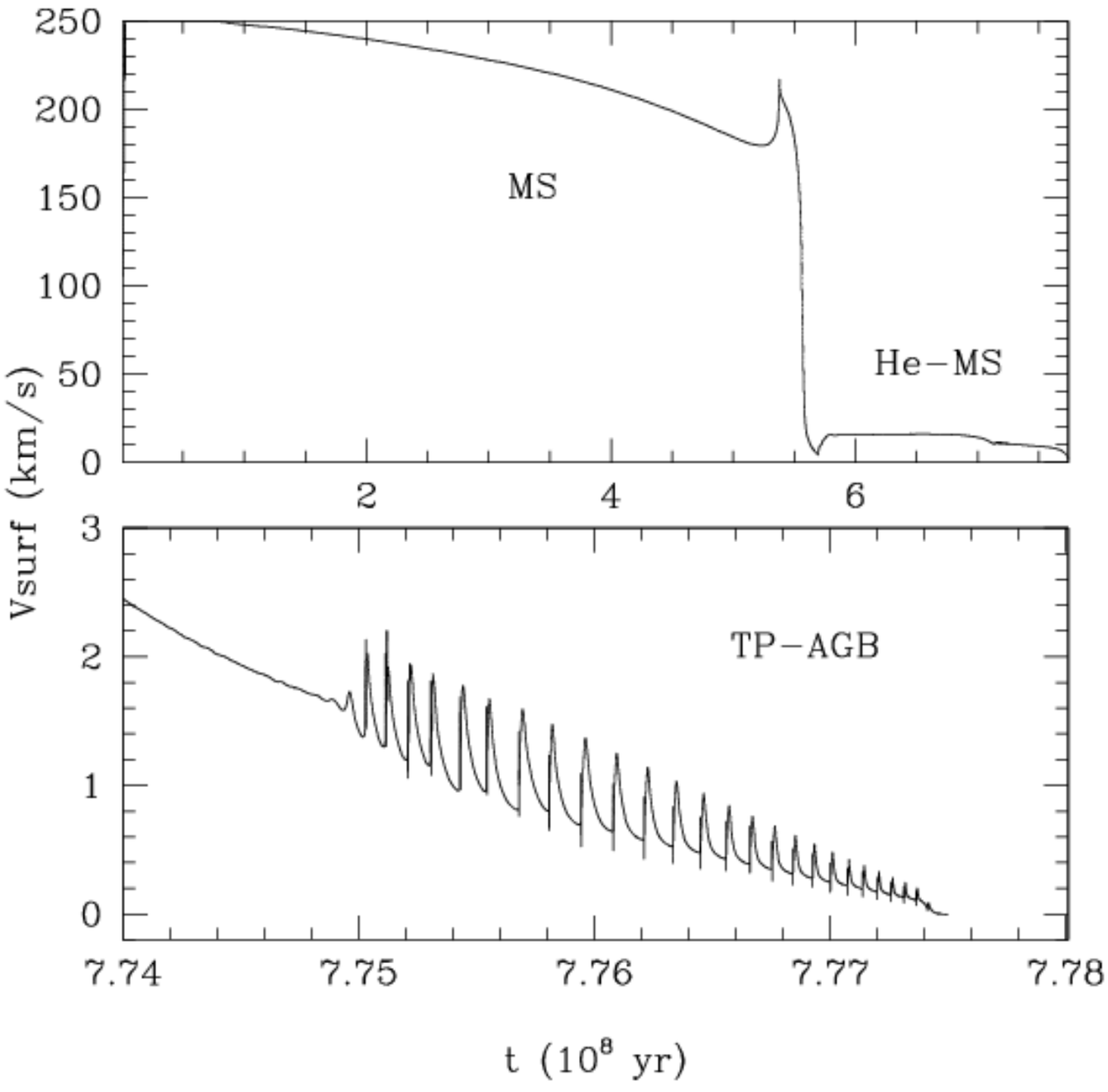
Villaver et al. (2012)



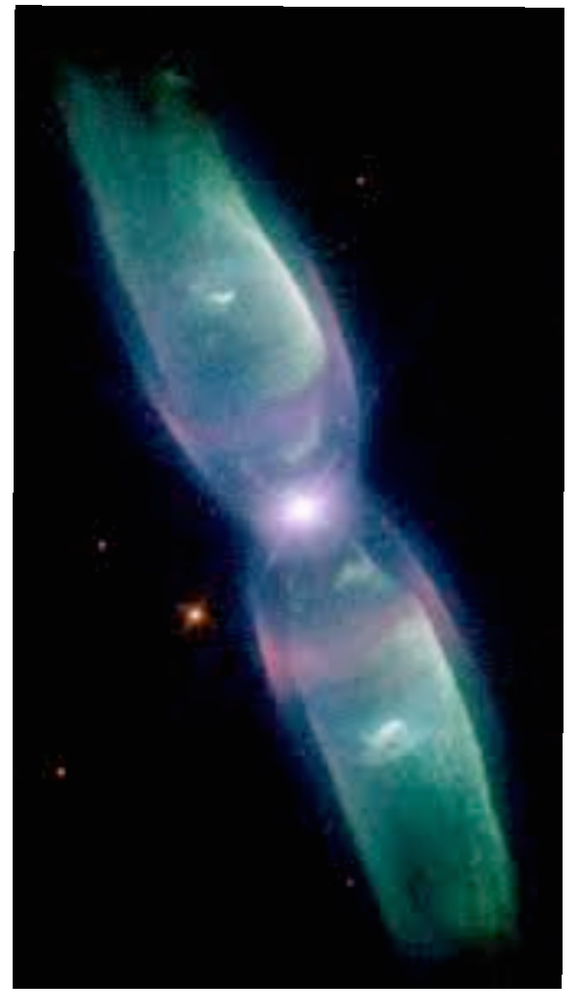
Villaver et al. (2012)

The star: collimation mechanism

STELLAR ROTATION

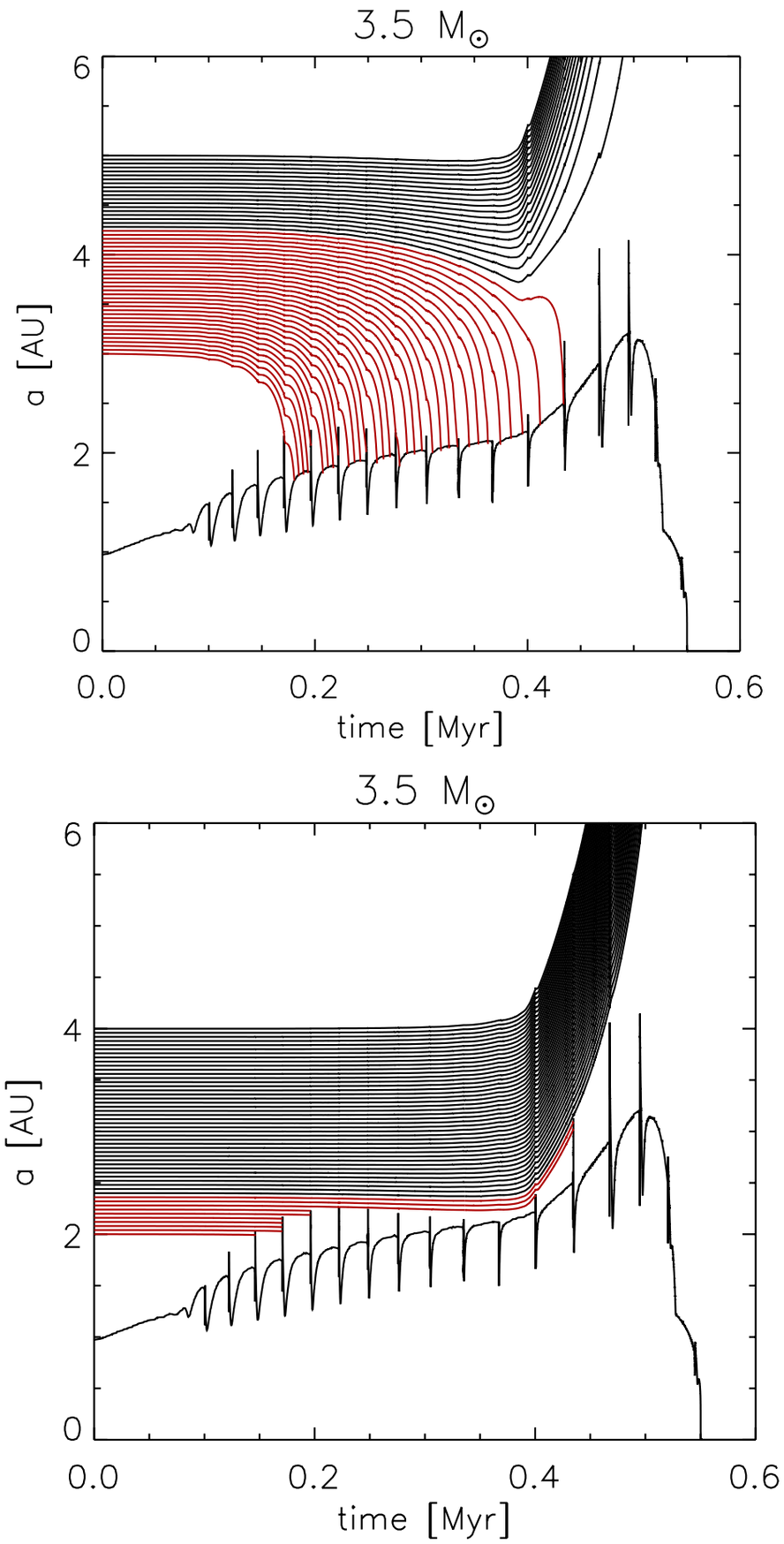


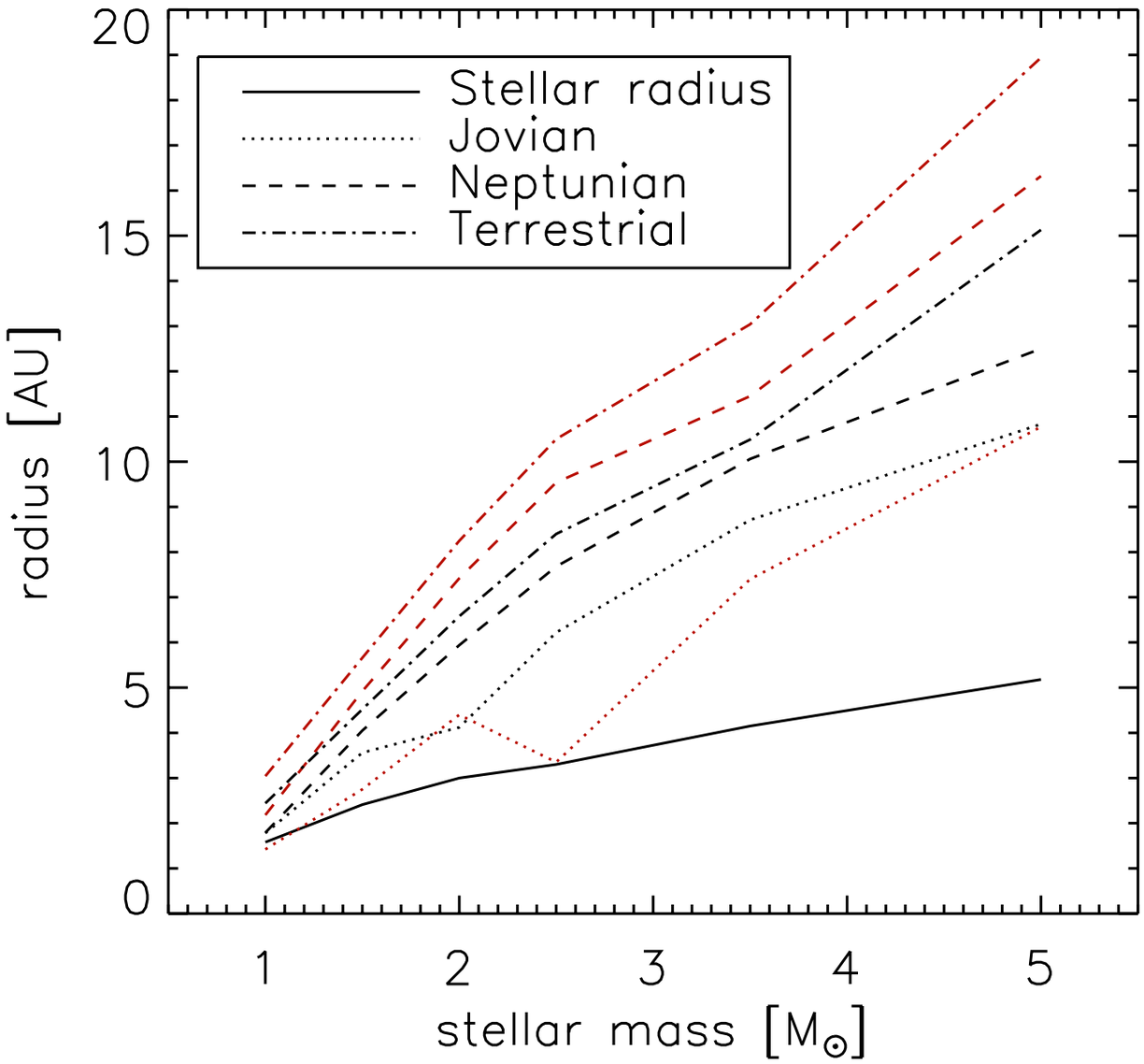
García-Segura, Villaver et al. (2014, 2016)



Need a companion!

AGB evolution





Mustill & Villaver (2012; Villaver et al. (2014)

Summary

- Shells up to 2.5 pc around AGB stars
- Most observations can only recover the brightest last episode of mass-loss
- ISM interaction + cometary tails result of the interaction with the ISM at small velocities
- Ram pressure striping reduces the mass of the envelopes. We cannot see the contribution of AGB stars to the ISM
- Single stars cannot make highly collimated PNe objets