Witnessing the Emergence of a Carbon Star

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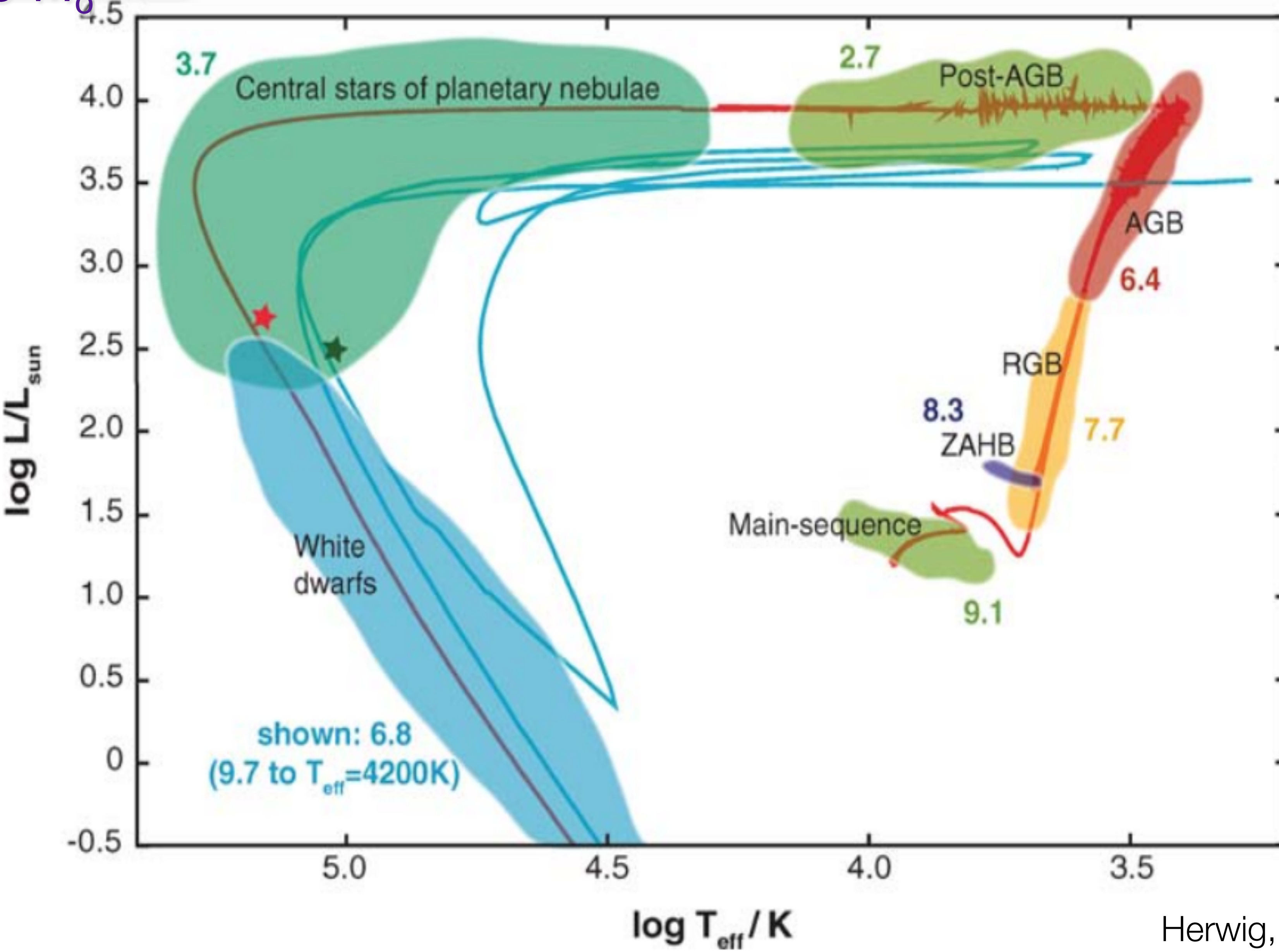
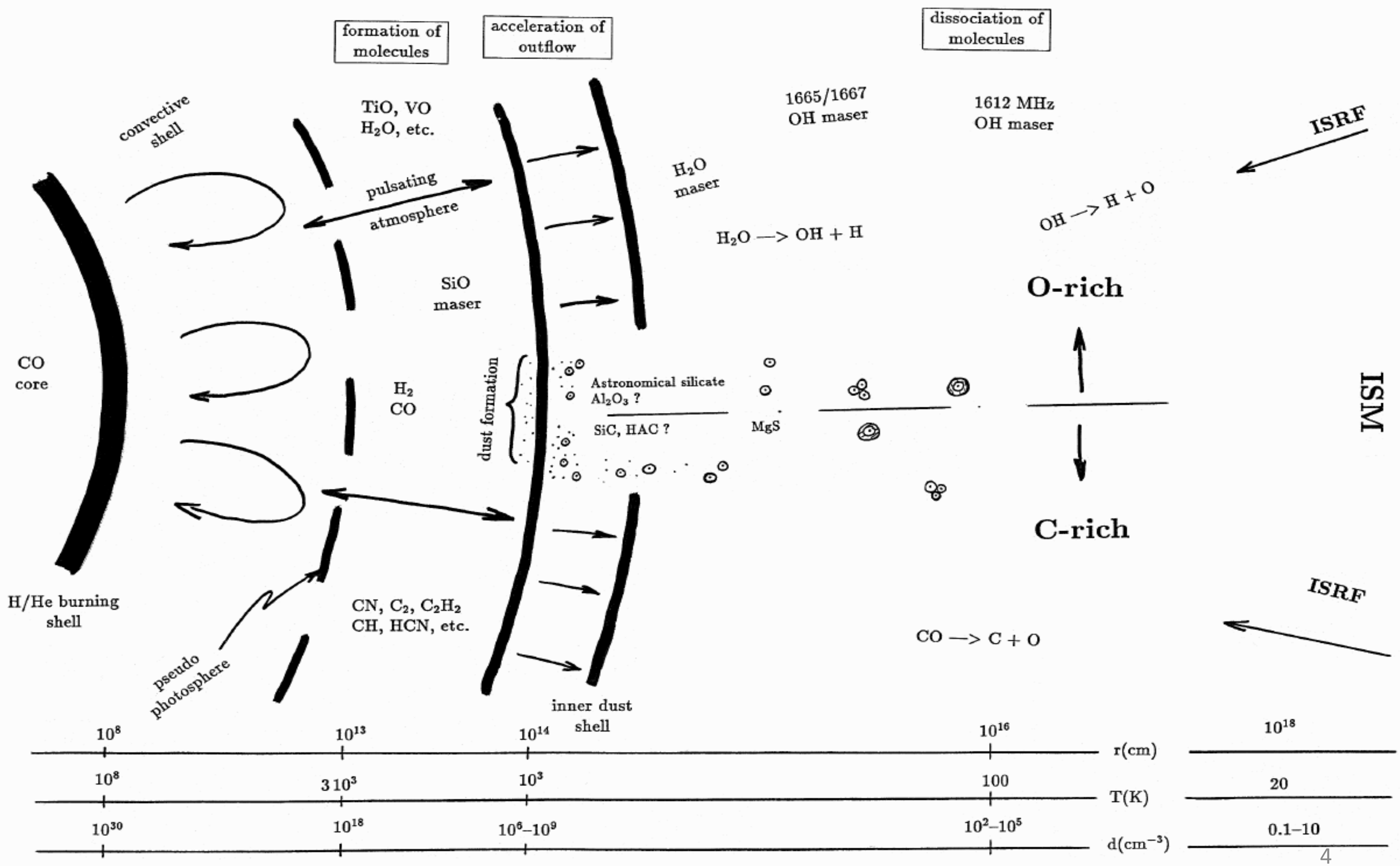
Planetary Nebulae with progenitor stars masses from 0.8 – 8 $M_{\odot}$



Herwig, 2005

Planetary Nebulae Chemistry



Chemistry depends on the mass of the progenitor. Mass division inside the low mass stars: O-rich vs C-rich.

C-rich

$2 < M < 5$

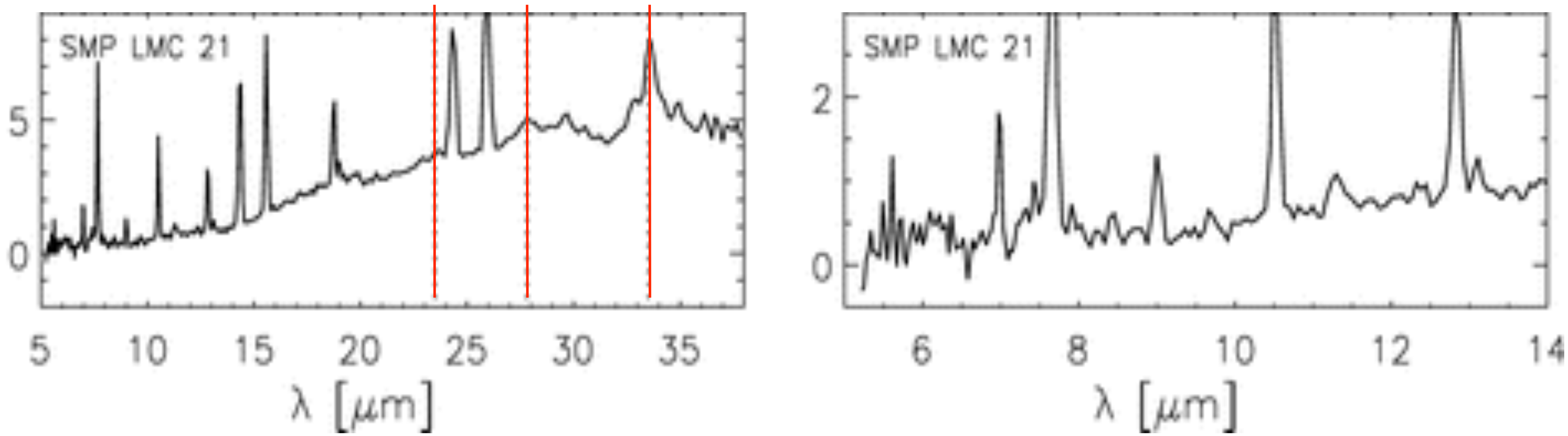
O-rich

$0.8 < M < 2$

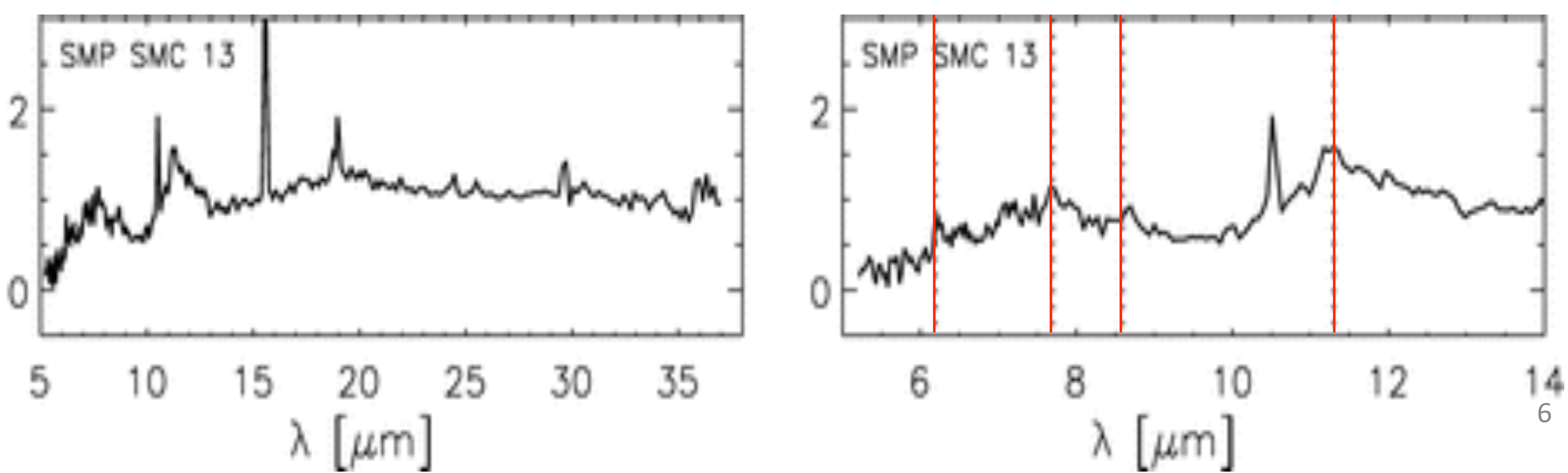
$5 < M < 8$

This chemistry difference is reflected in the nebula, the molecular zone and the dust formation zone.

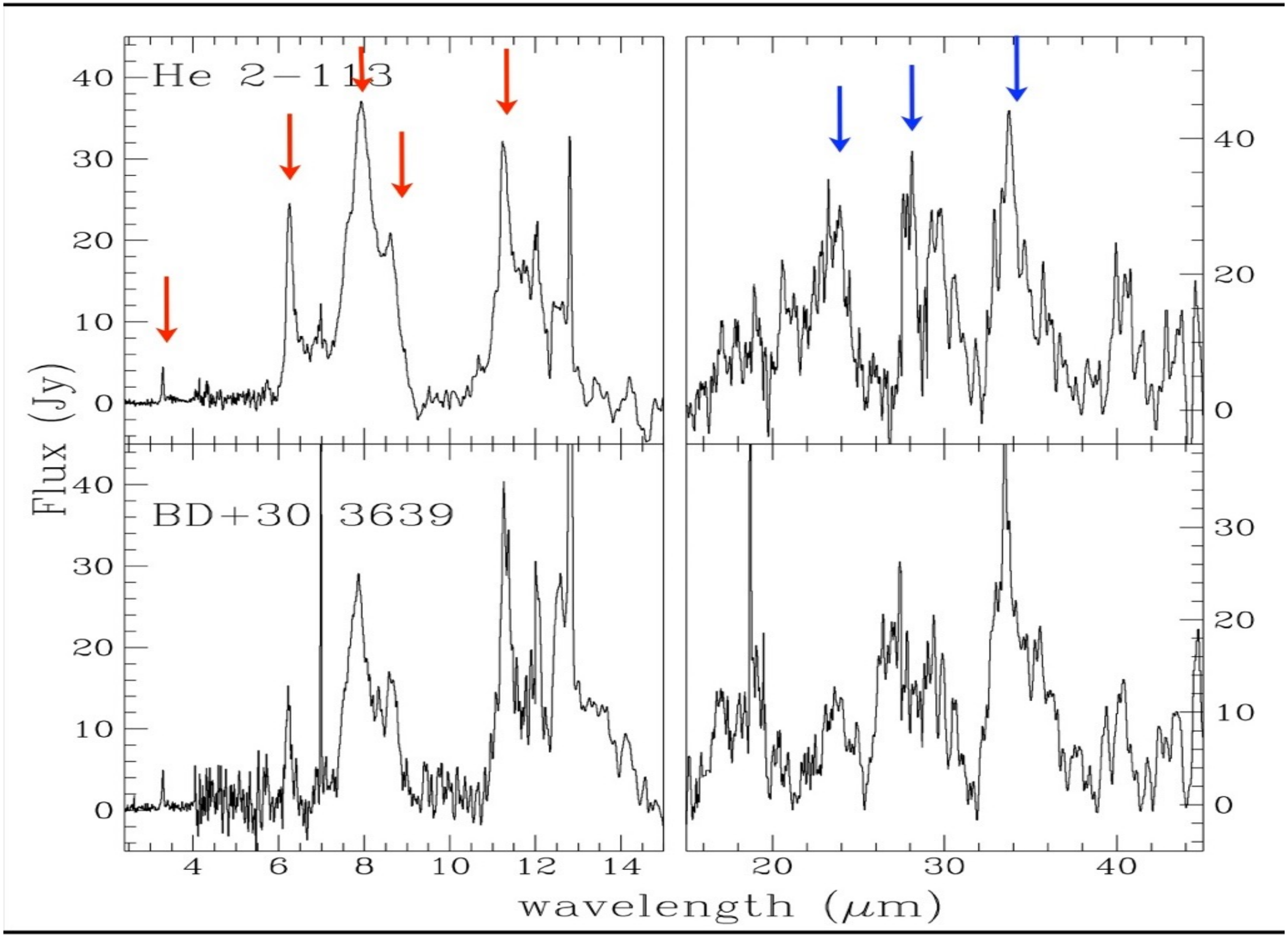
O-rich PNe – silicate features – 23.5, 27.5 and 33.8 μm



C-rich PNe – PAH bands – 6.2, 7.7, 8.6 and 11.3 μm

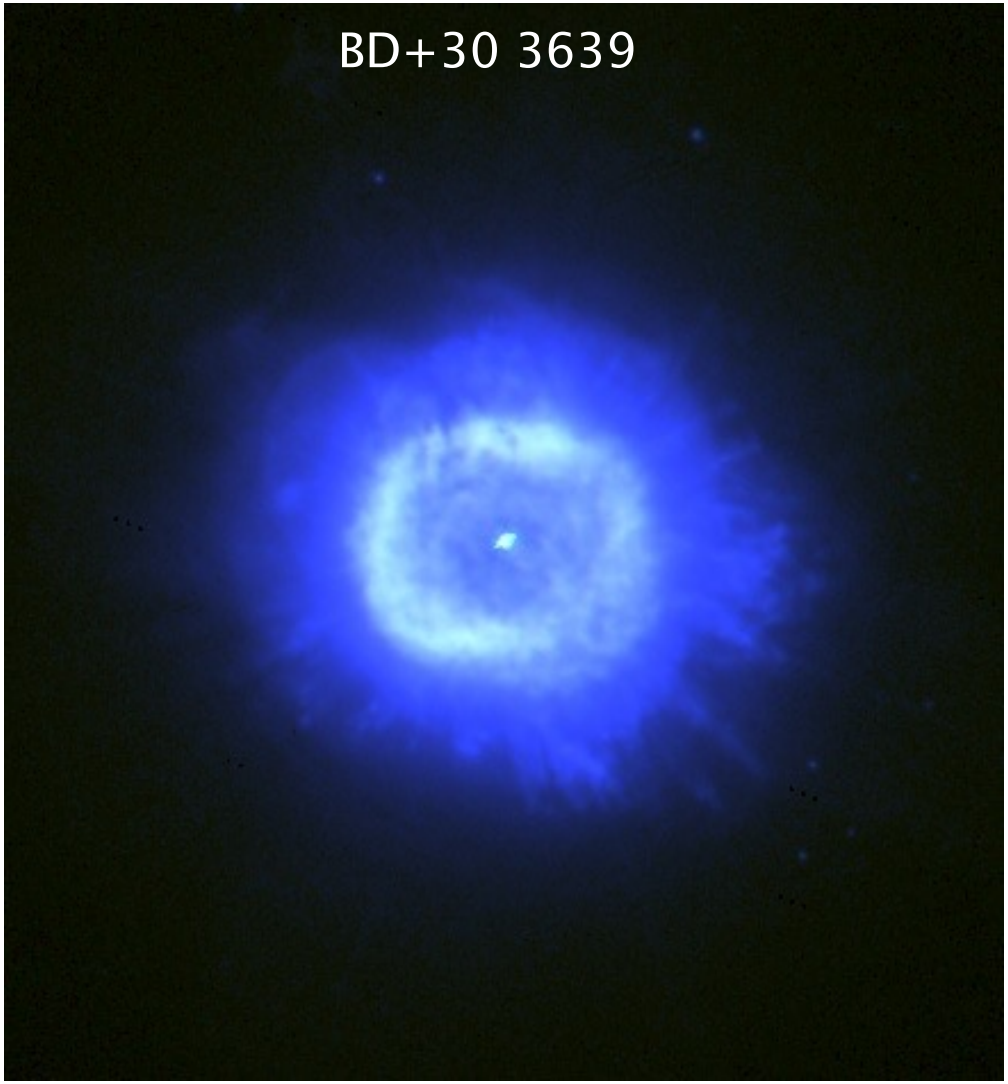


The mixed chemistry problem:
O-rich and C-rich molecules and dust in the same PN



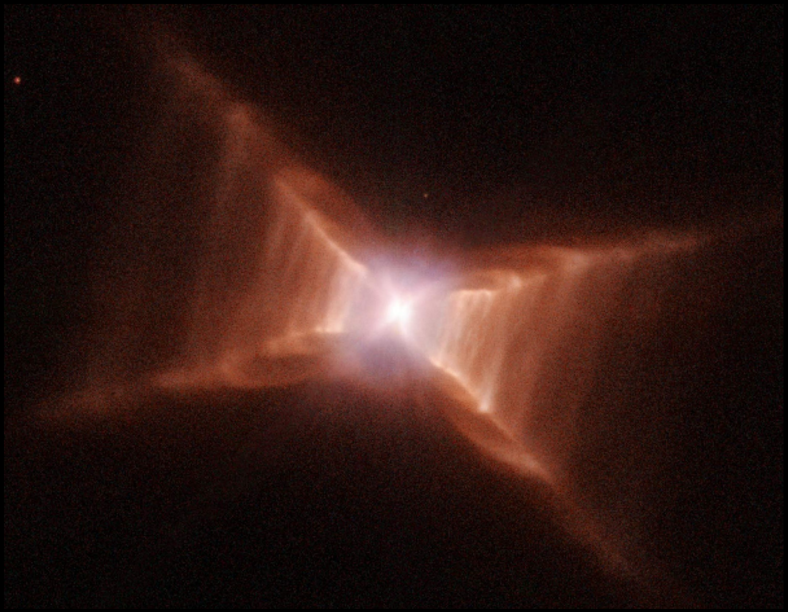
Zijlstra et al. 1991, Waters et al. 1998

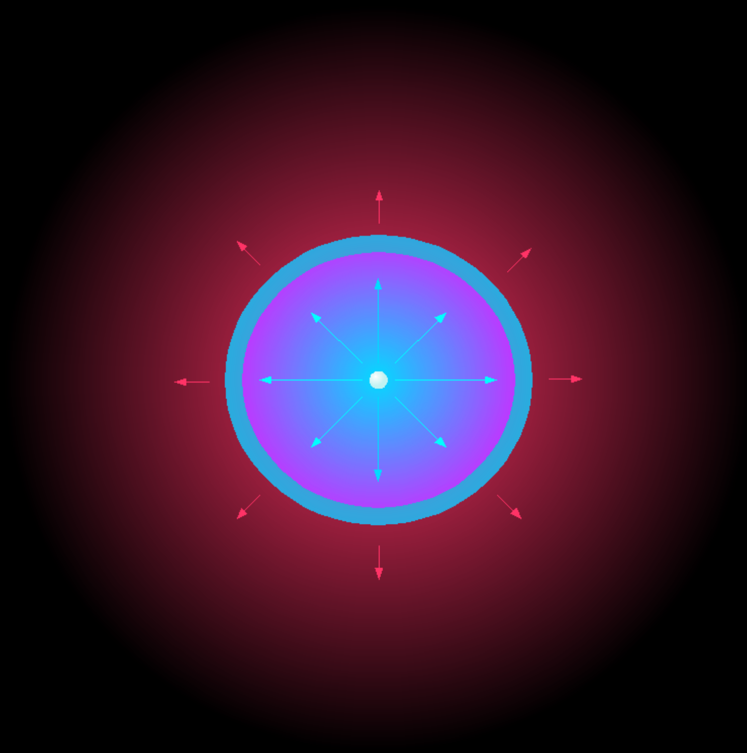
Mixed chemistry problem in PNe from the Galactic Disk.



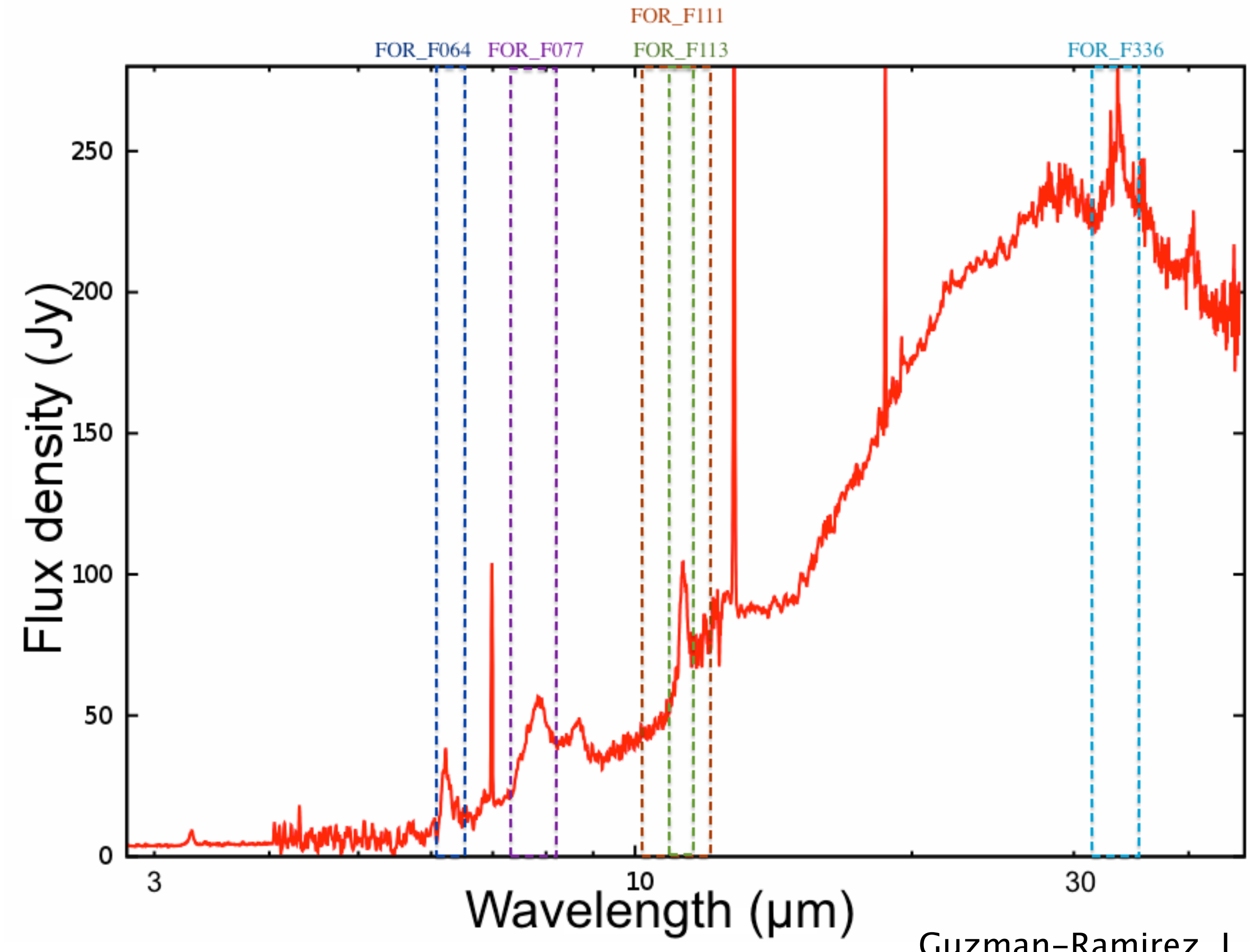
Waters et al., 1998 attributed it to an AGB fatal thermal pulse (AFTP)

Two scenarios can produce mixed chemistry in PNe from the Galactic Disk after a AFTP.





Testing the two scenarios that can produce mixed chemistry in PNe from the Galactic Disk after a AFTP.



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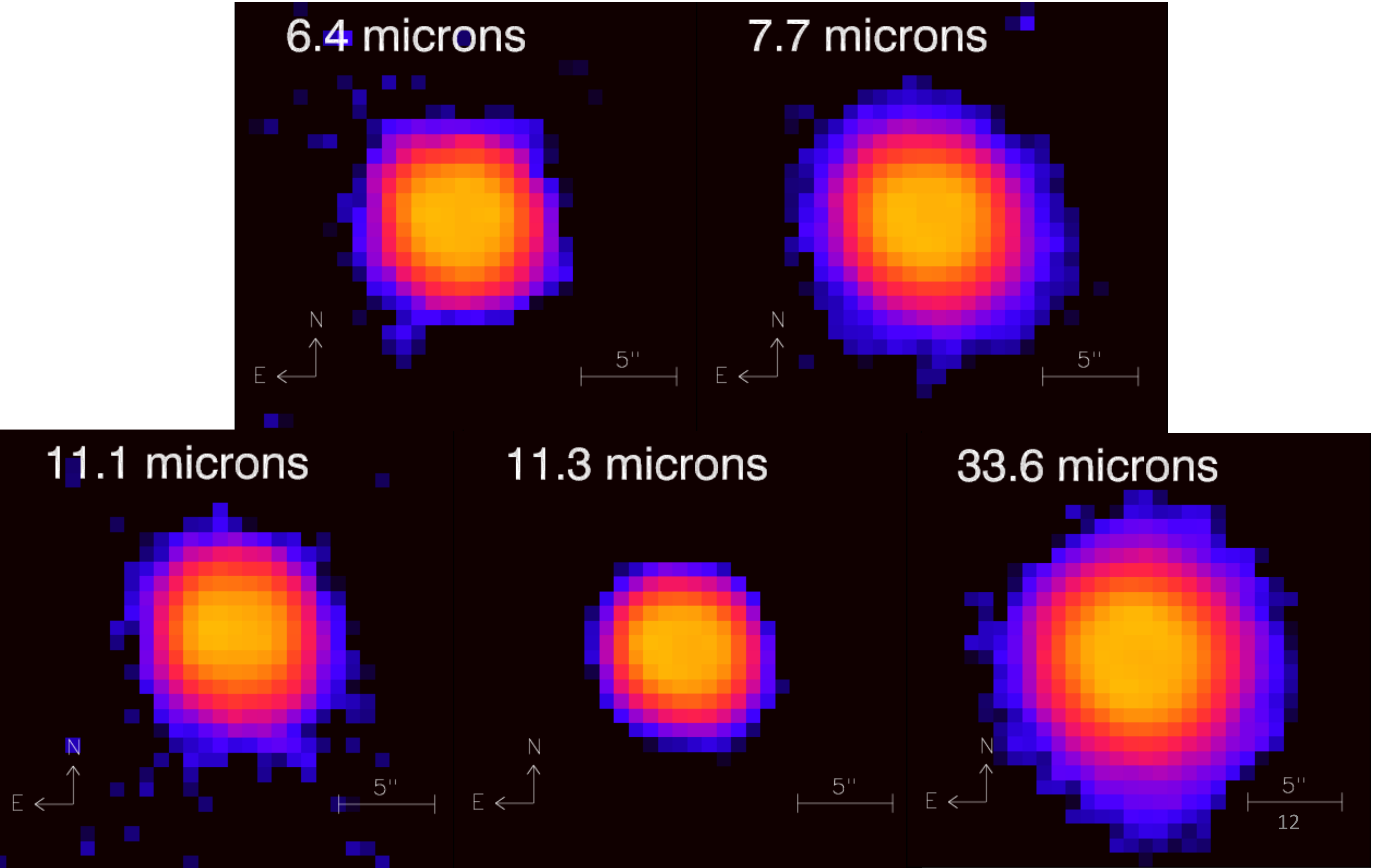
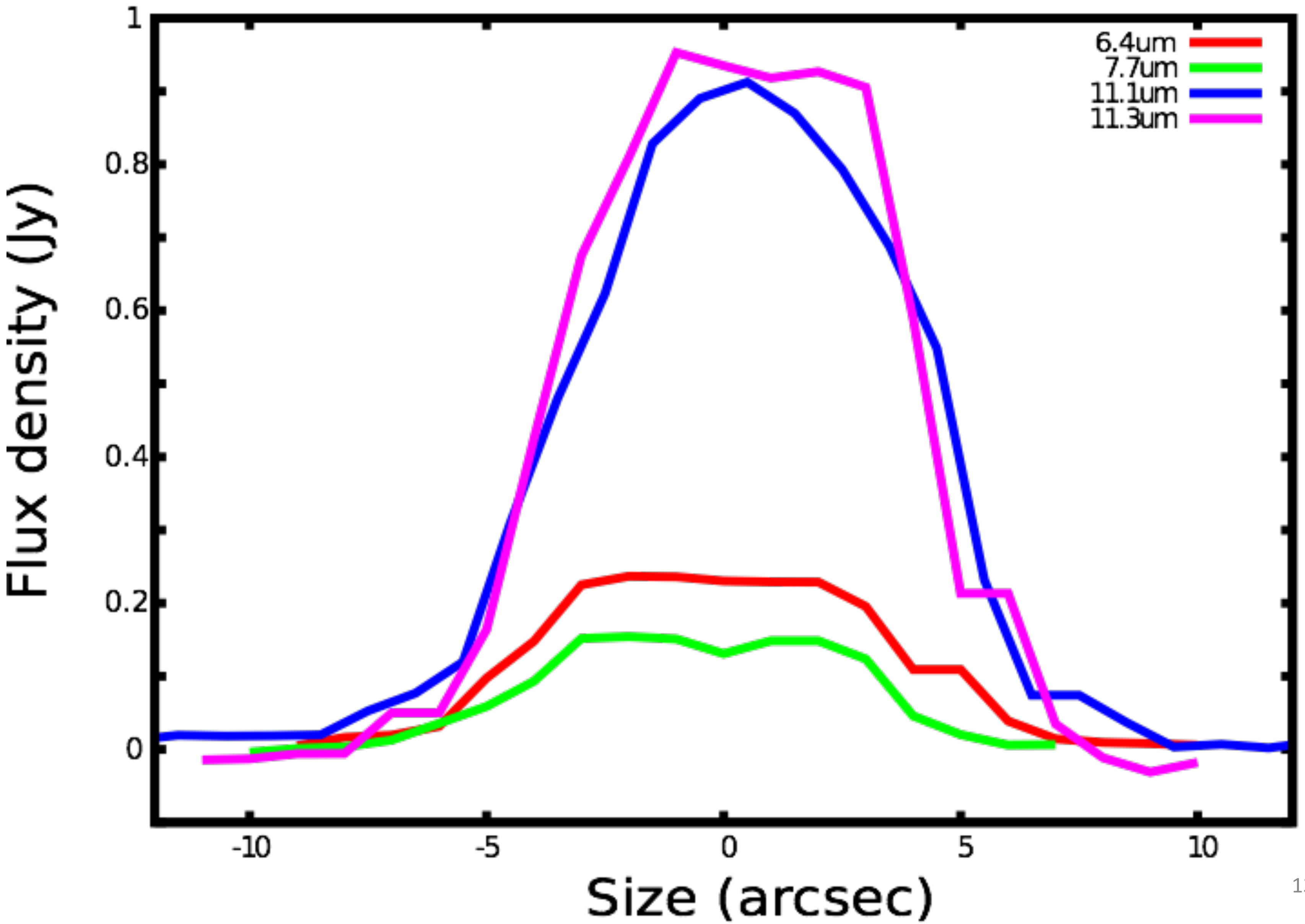
Testing the two scenarios that can produce mixed chemistry
in PNe from the Galactic Disk after a AFTR

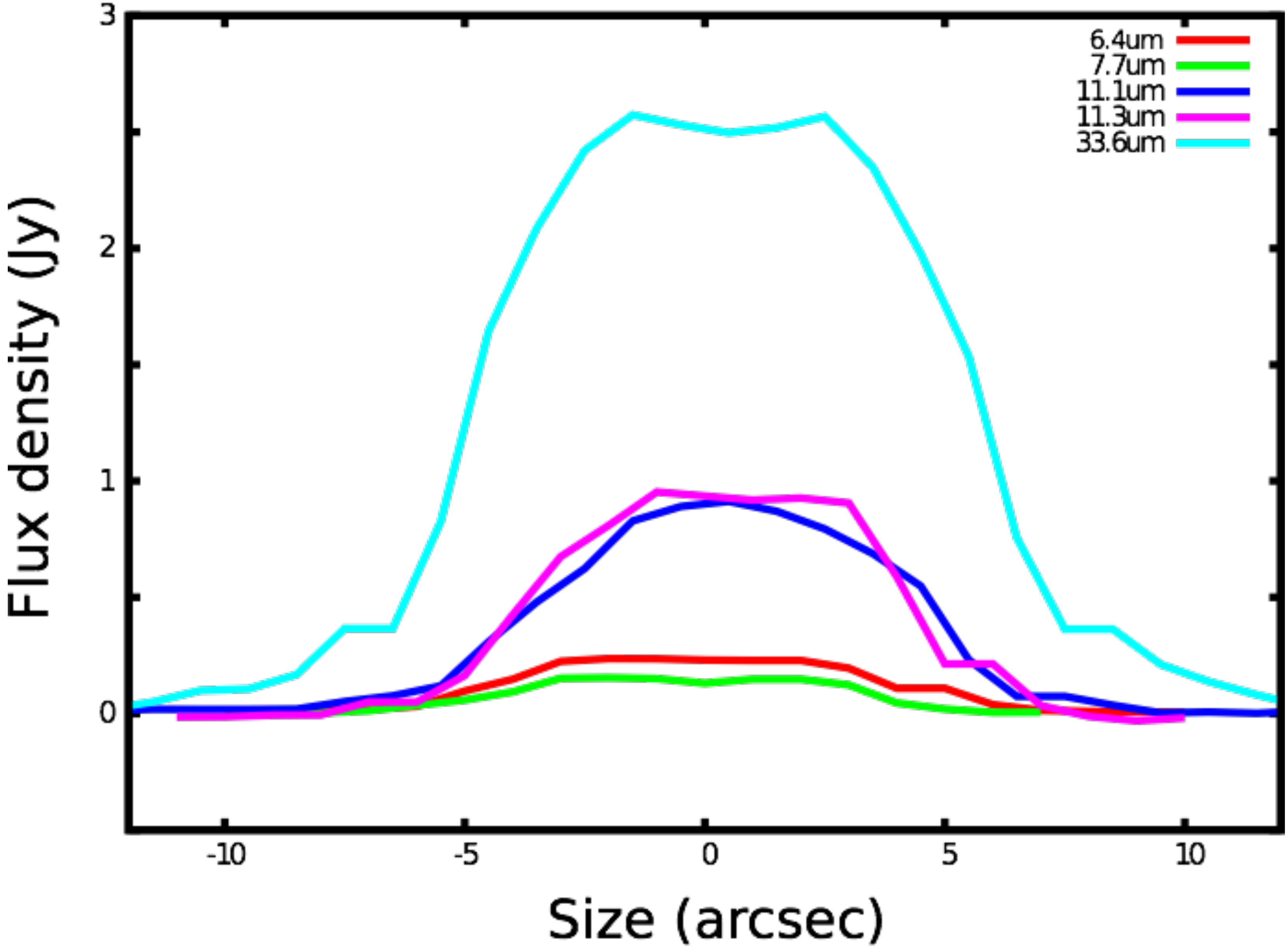
BD+30 3639 observations using FORCAST instrument on board of SOFIA



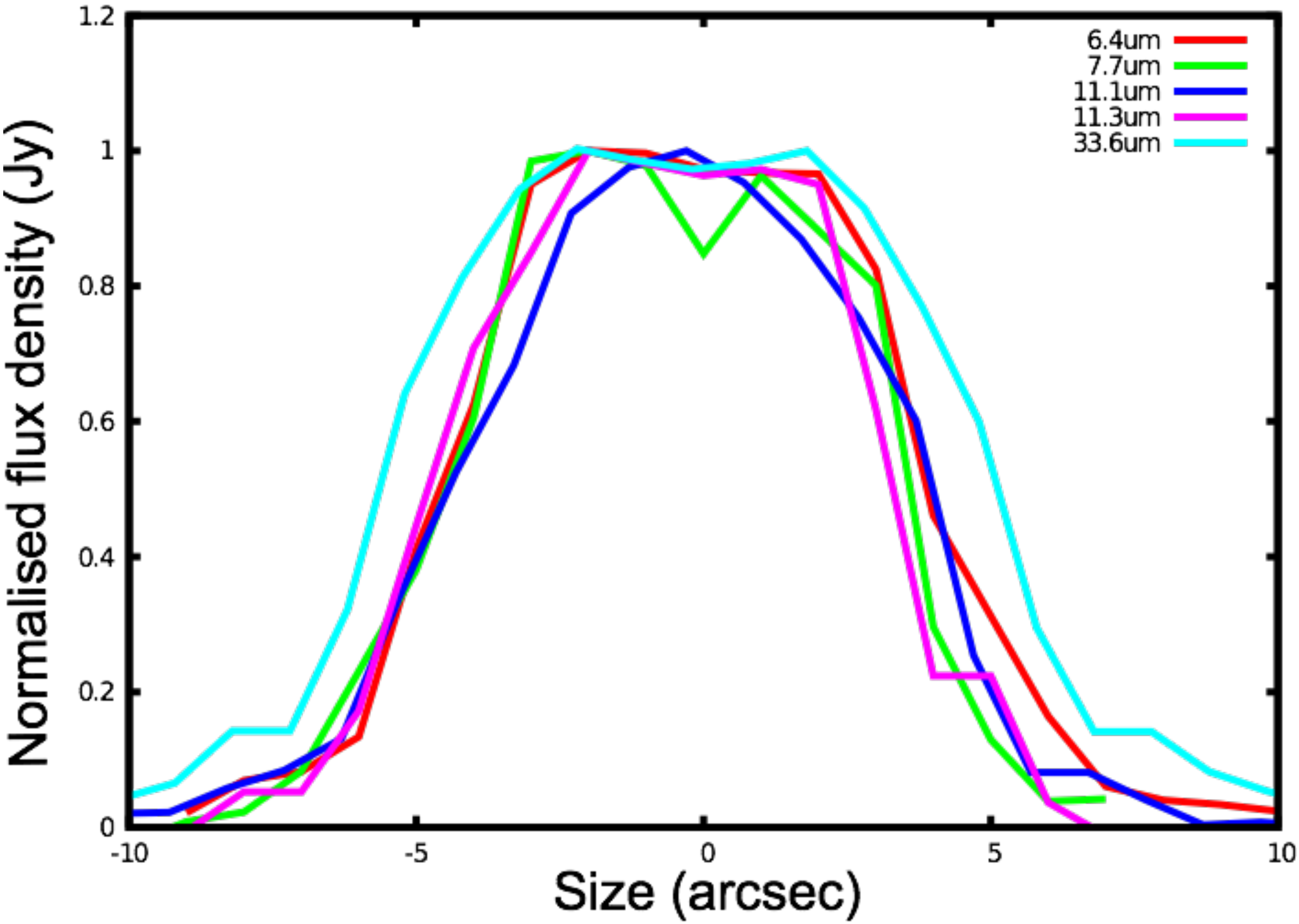
BD+30 3639 observations using FORCAST instrument on board of SOFIA



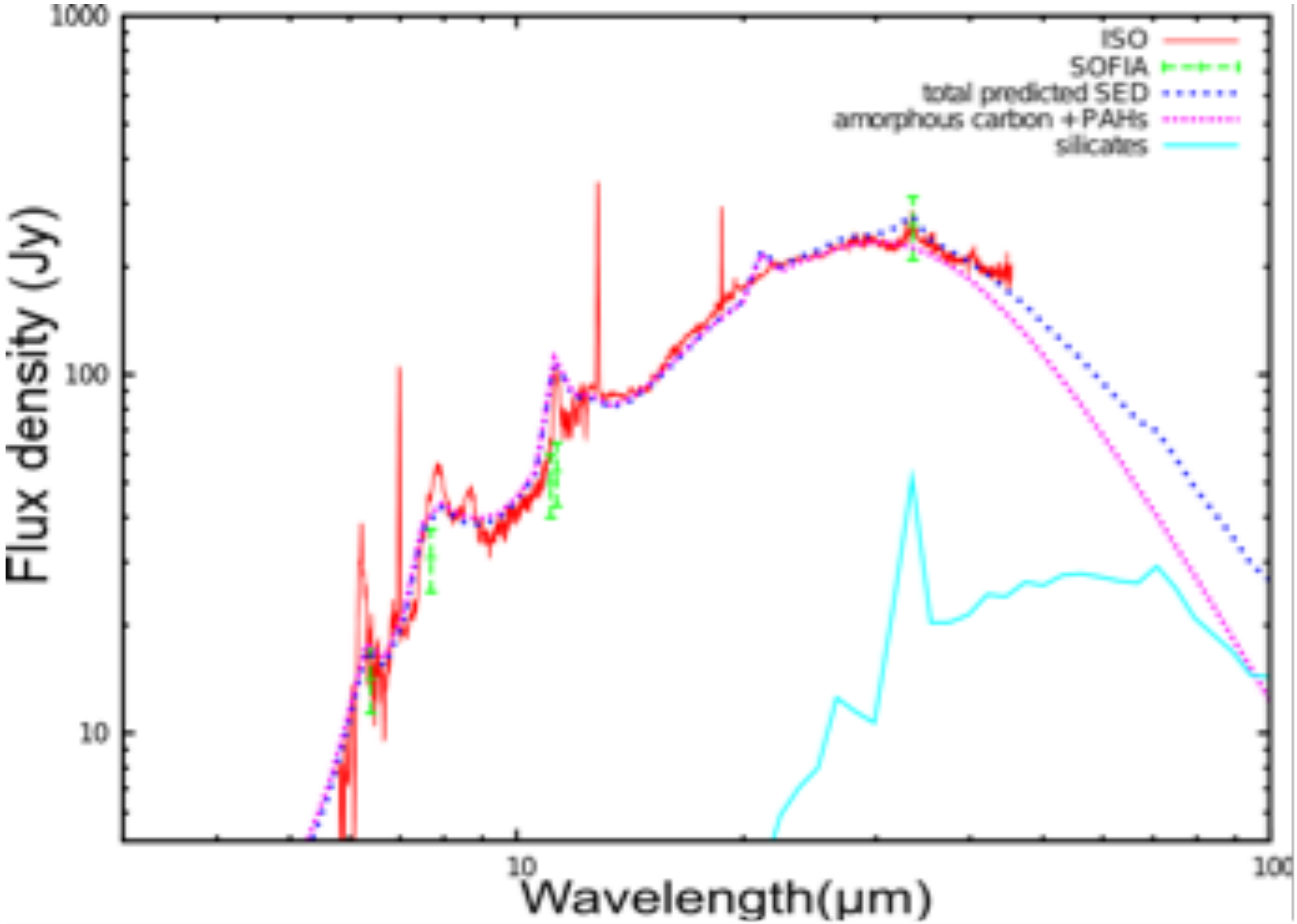
BD+30 3639 observations using FORCAST instrument on board of SOFIA



BD+30 3639 observations using FORCAST instrument on board of SOFIA



BD+30 3639 MOCASIN dust model



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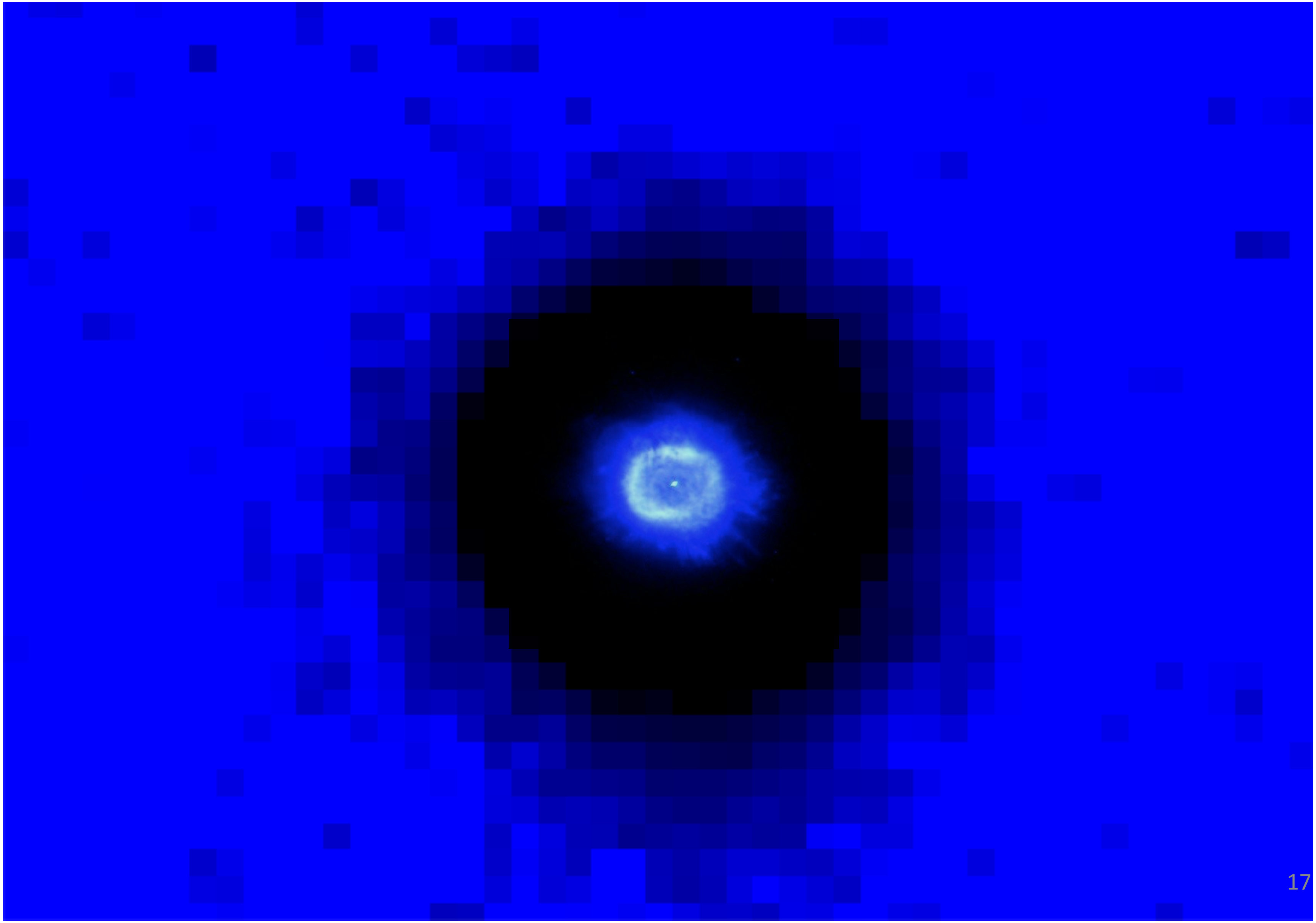
BD+30 3639 became a C-rich star only a few thousands of years ago



Conclusions

An AFTP can lead to both a considerable enrichment with carbon and oxygen and to the dilution of hydrogen.

BD+30 3639 provides a rare glimpse into a phase of stellar evolution which is crucial to the origin of carbon in the Universe.

Thank you!