

The composition of  
presolar spinel grain  
OC2: constraining AGB  
models

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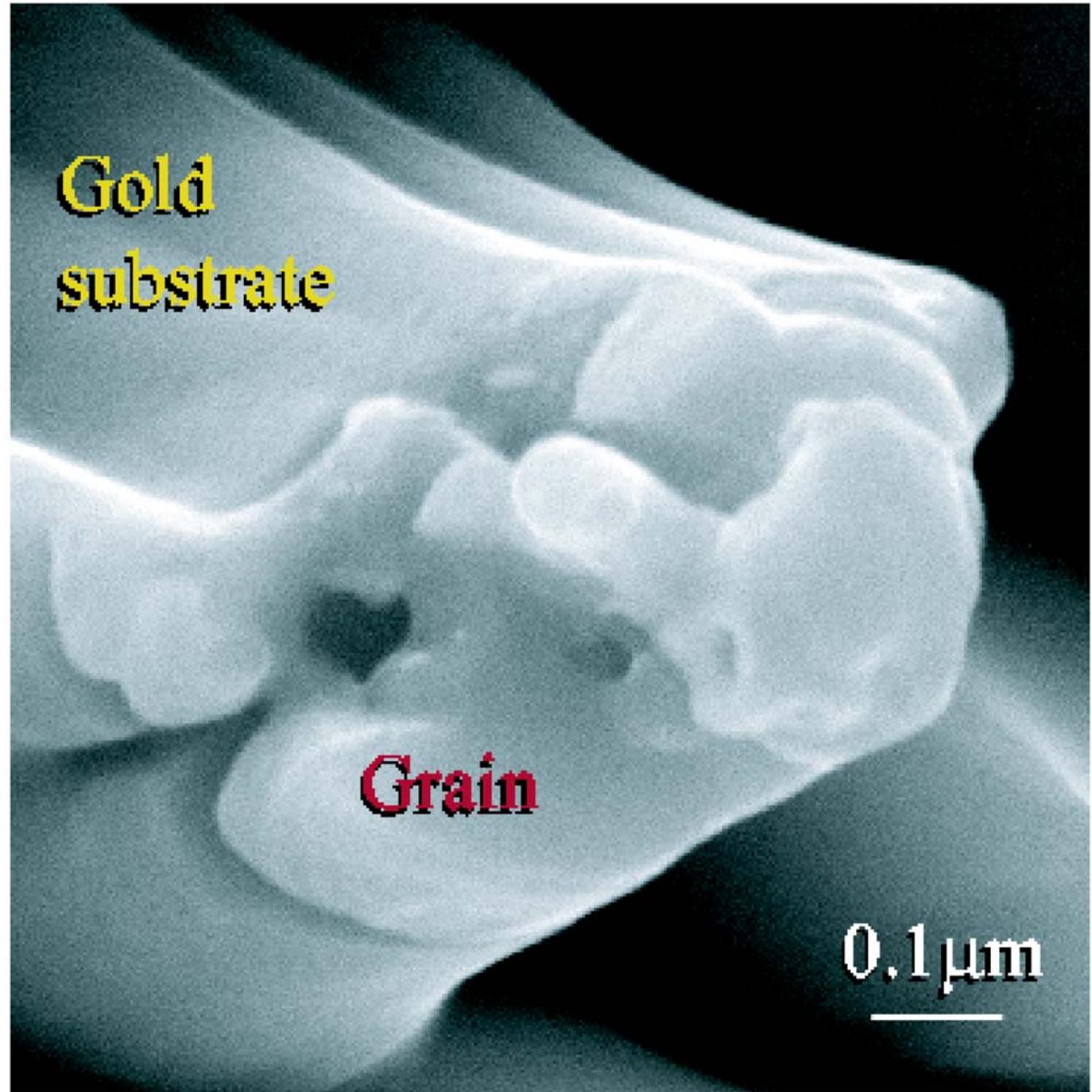
University of North Carolina, USA

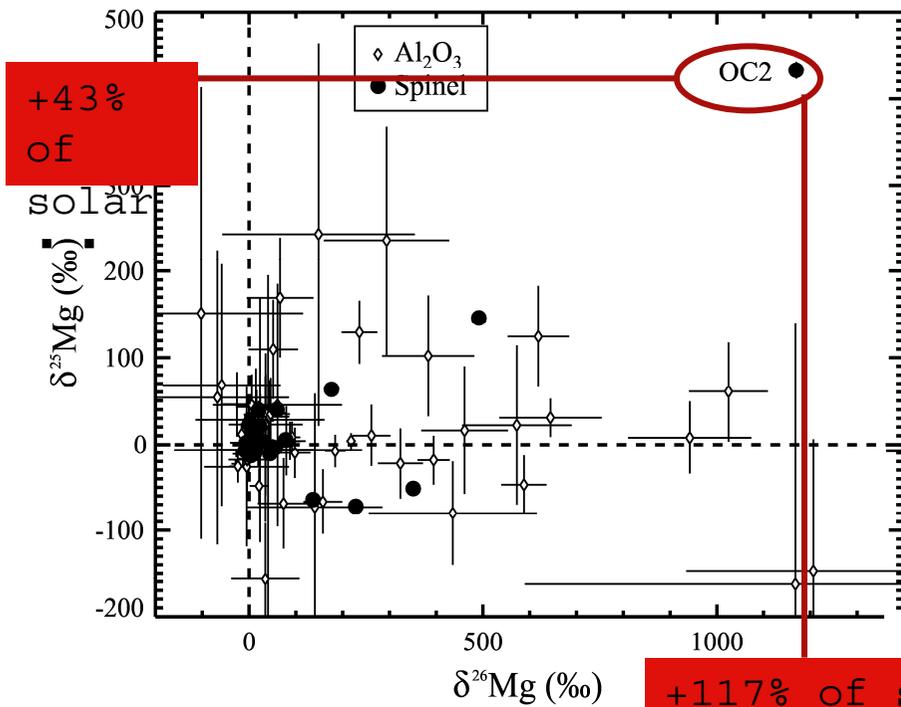
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Scanning  
electron  
microscope  
image of  
presolar  
spinel grain  
OC2.

This 800nm  
ruby-like gem  
is sitting on  
a gold  
pedestal,  
following the  
ion probe  
isotopic  
analysis,  
because the

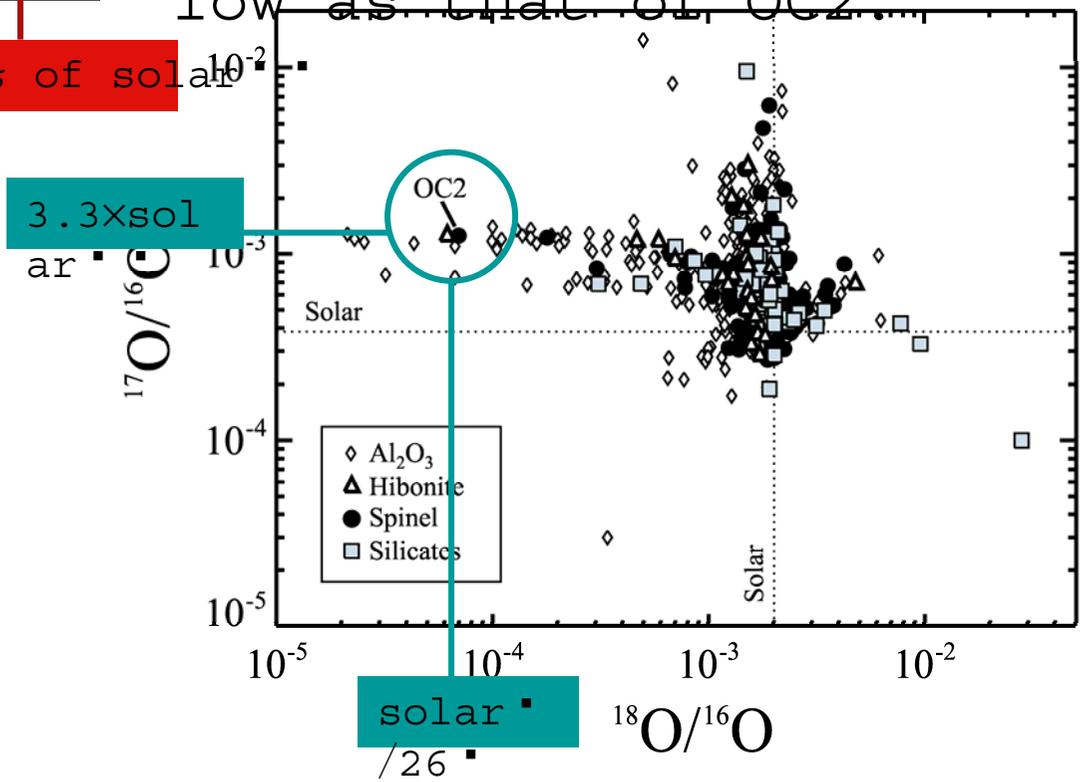




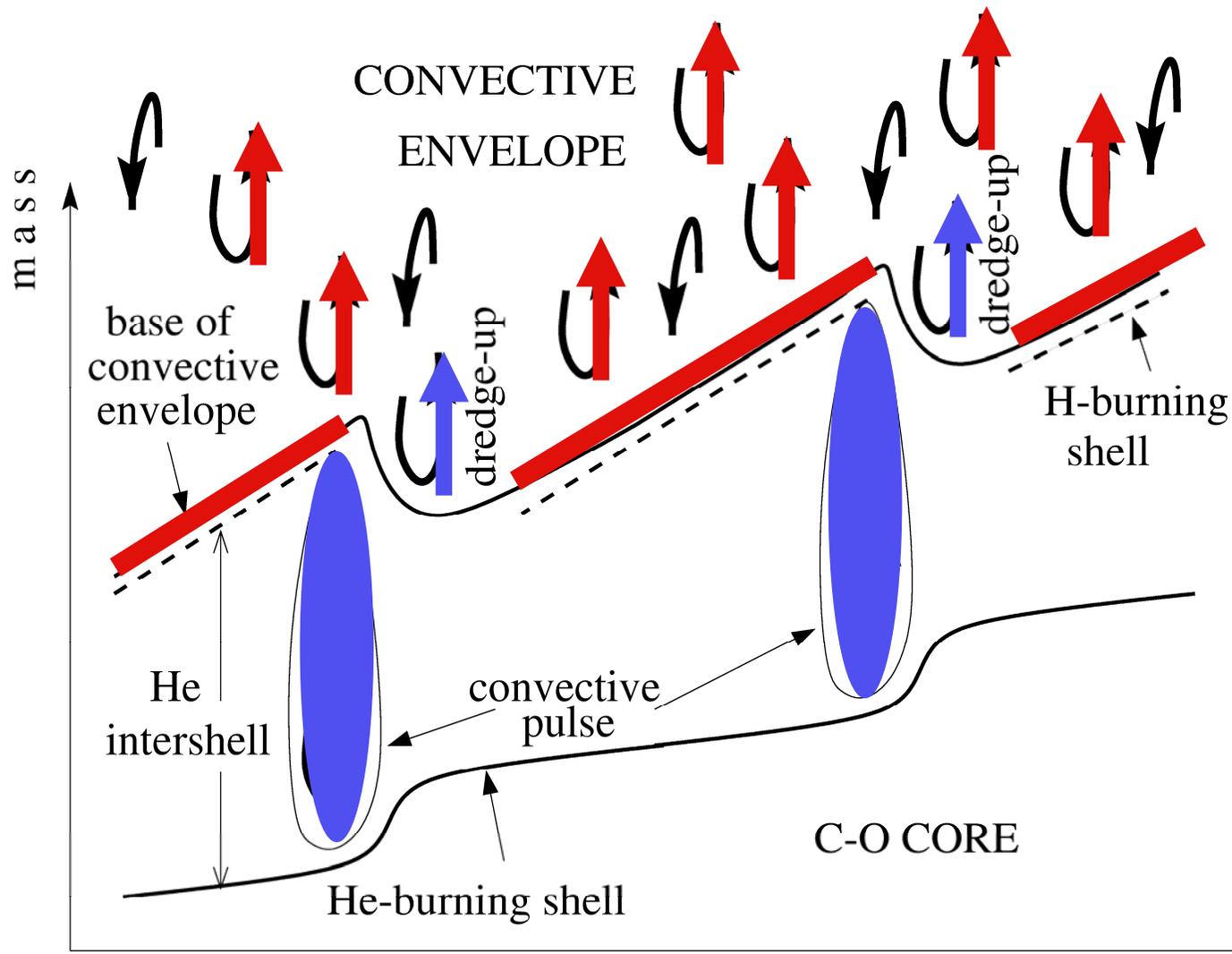
The most remarkable feature of the composition of OC2 is large excesses of the heavy Mg isotopes.

Of  $\approx 600$  known presolar oxide grains, only 10 have  $^{18}\text{O}/^{16}\text{O}$  ratios as low as that of OC2.

The origin of grain OC2 has been tentatively attributed to an intermediate-mass AGB star  $\approx 4 - 7 M_{\odot}$



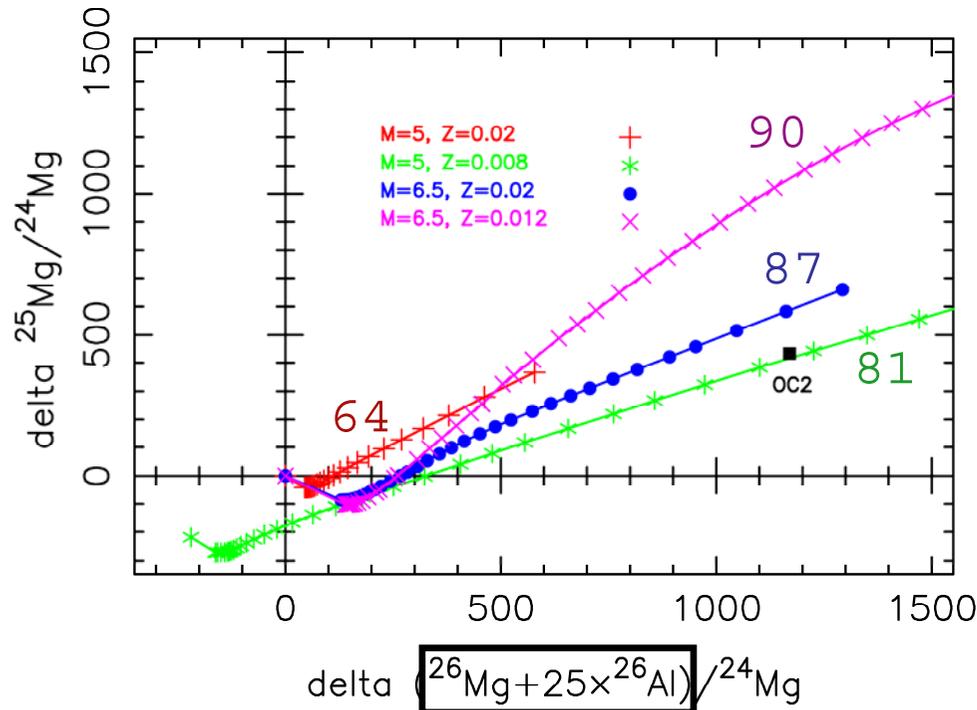
solar / 26



The temperature at the base of the convective envelope exceeds  $\approx 50$  million degrees and hot bottom burning, (HBB) occurs:  $^{17}\text{O}$  is produced,  $^{18}\text{O}$  is destroyed, and  $^{25}\text{Mg}$  can be turned into  $^{26}\text{Al}$

The temperature in the convective pulses exceeds  $\approx 350$  million degrees.  $^{25}\text{Mg}$  and  $^{26}\text{Mg}$  are produced in similar amount by  $^{22}\text{Ne} + \alpha$  and then mixed into the

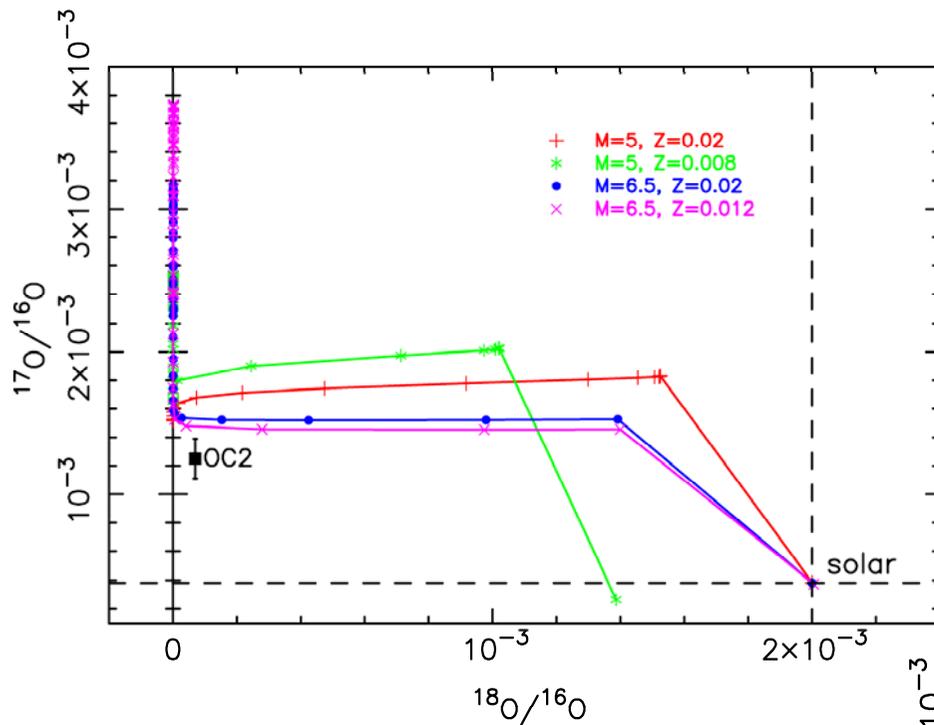
We compare the composition of OC2 to our detailed models of AGB stars



We find the following conditions to match the Mg composition of OC2:

1.  $T$  in the convective pulses > 352 million degrees and/or total mass TDU >  $0.05 M_{\odot}$
2.  $T$  at the base of the convective envelope  $\approx 25$  times more  $\approx 80 -$

Maximum temperatures at  $^{26}\text{Al}$  is incorporated in spinel and decays into the base of the convective envelope in  $0.7$  million years. Aluminium was incorporated in spinel grains preferentially than Mg, given that spinel is

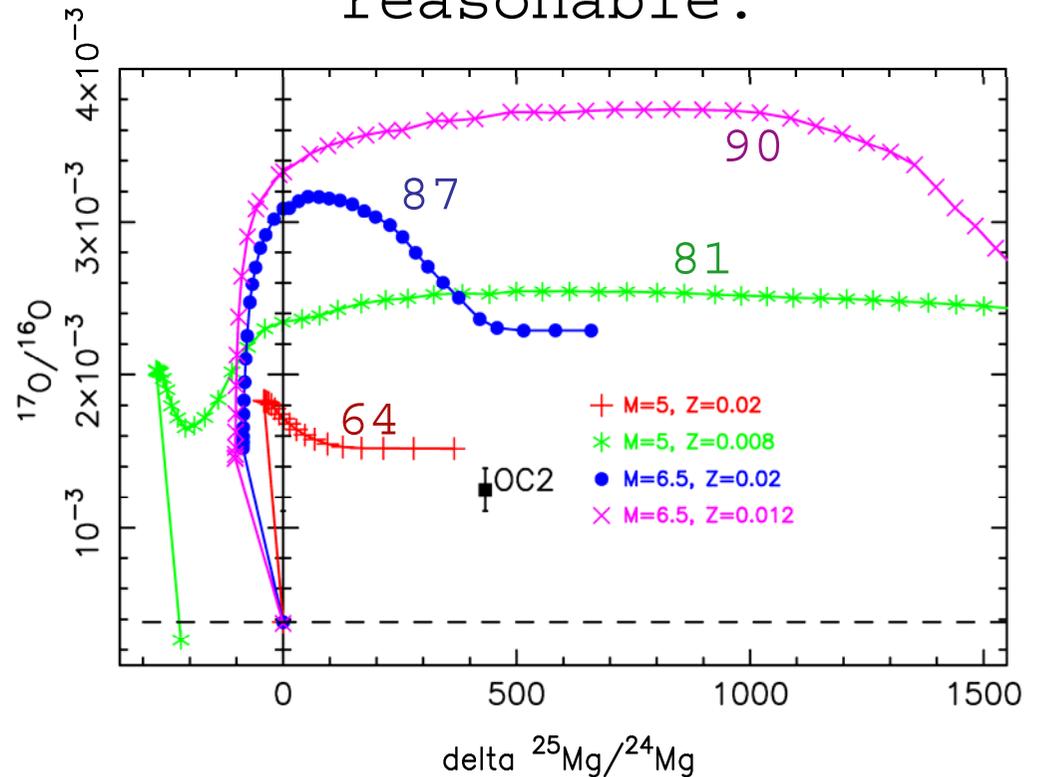


All models deplete  $^{18}\text{O}$  very quickly and cannot match OC2. However, the measured  $^{18}\text{O}/^{16}\text{O}$  ratio can be explained by a 2% level of terrestrial contamination, which is reasonable.

$$^{17}\text{O}/^{16}\text{O} \approx$$

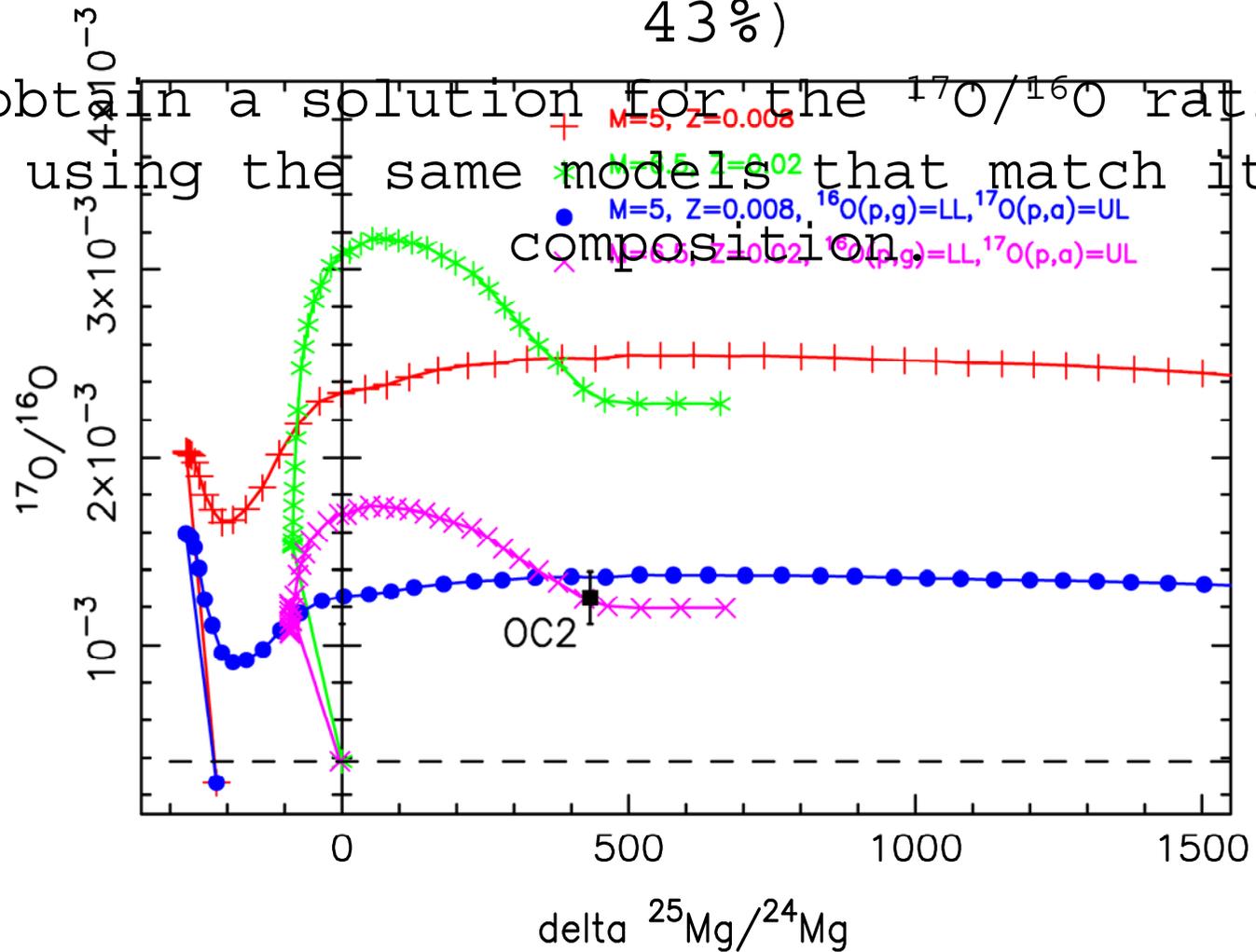
$$^{16}\text{O} (p, \gamma) ^{17}\text{F} / ^{17}\text{O} (p, \alpha) ^{14}\text{N}.$$

This increases with T and is too high in our models to match OC2.



If we take  
the upper limit for the  $^{17}\text{O}(p,\alpha)^{14}\text{N}$  rate  
(+25%) and  
the lower limit for the  $^{16}\text{O}(p,\gamma)^{17}\text{F}$  rate (-  
43%)

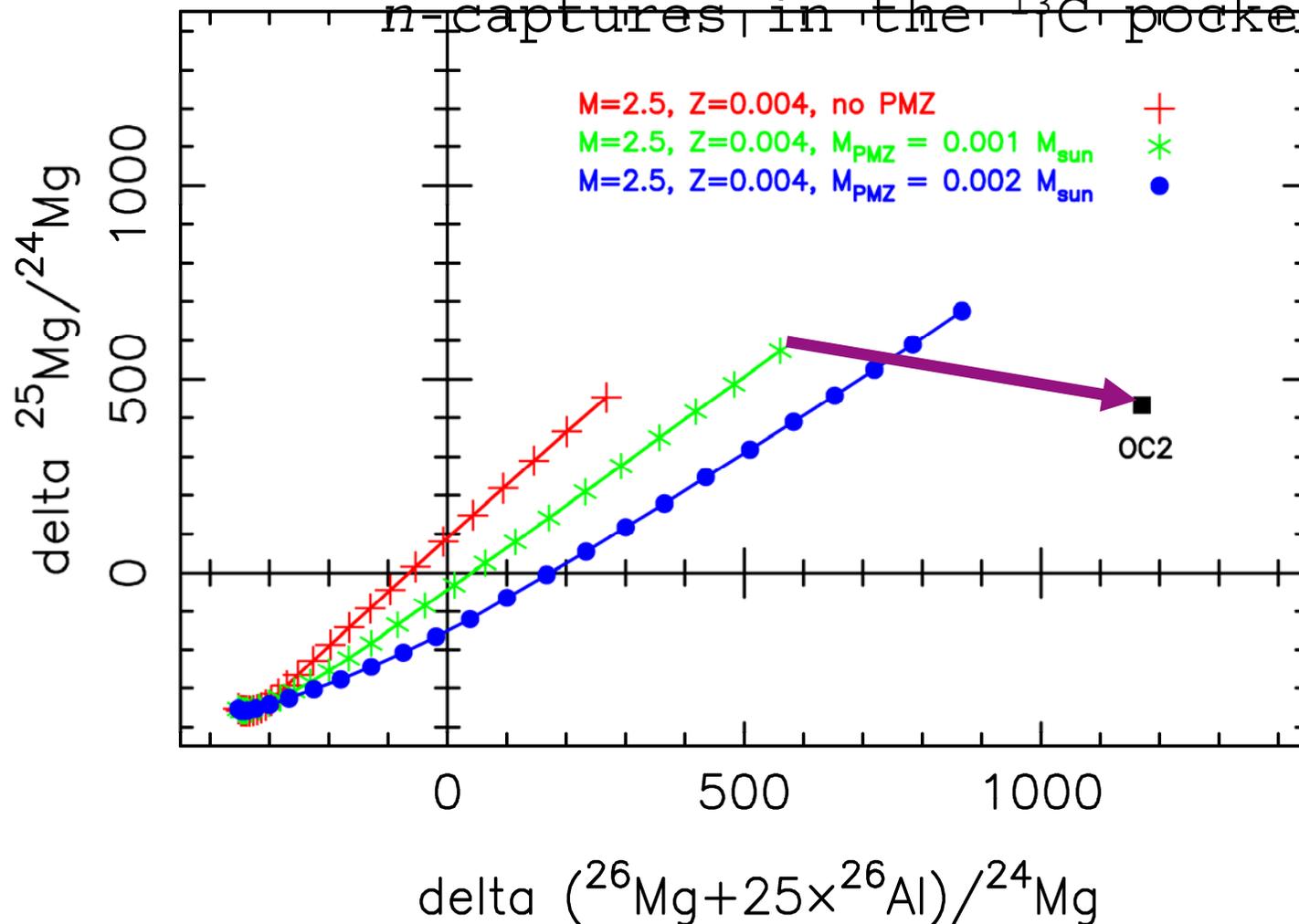
we obtain a solution for the  $^{17}\text{O}/^{16}\text{O}$  ratio of OC2  
using the same models that match its Mg  
composition.



# Alternative solution:

a *low-mass* ( $2.5 - 3.5 M_{\odot}$ ) *low-Z* ( $0.004 - 0.008$ )  
AGB star.

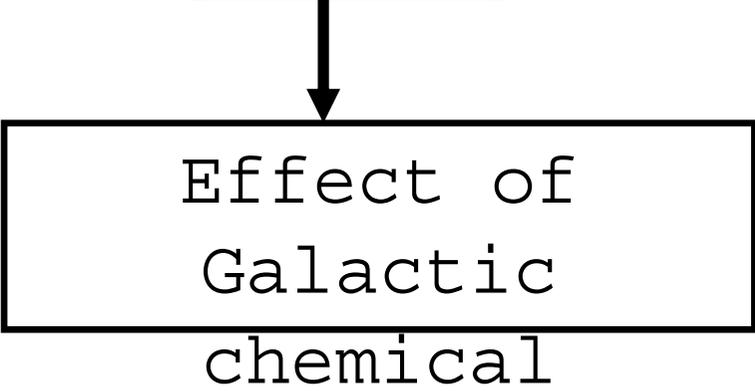
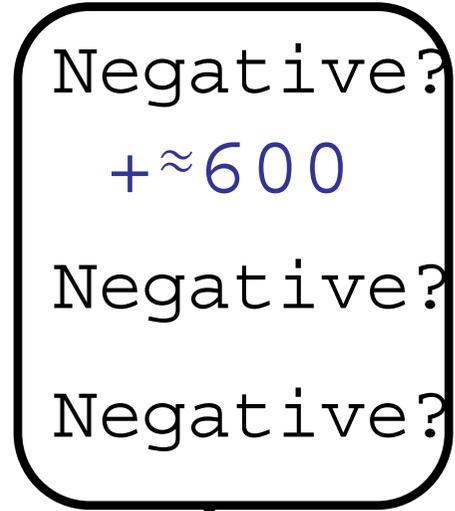
In this case  $^{25}\text{Mg}$  and  $^{26}\text{Mg}$  are also produced by  
 $n$ -captures in the  $^{13}\text{C}$  pocket.



To get the extra needed  $^{26}\text{Al}$  and the right O ratios, one must invoke some **extra mixing - cool bottom**

# The Fe and Cr composition:

	IM AGB $Z \approx Z_{\odot}$	LM AGB $Z \approx 0.3 Z_{\odot}$	OC2
$\delta(^{57}\text{Fe}/^{56}\text{Fe})$	$\approx 80$	$\approx 370$	$170 \pm 191$
$\delta(^{54}\text{Cr}/^{52}\text{Cr})$	$\approx 180$	Negative? $+ \approx 600$	$102 \pm 117$
$\delta(^{50}\text{Cr}/^{52}\text{Cr})$	$\approx 0$	Negative?	$26 \pm 71$
$\delta(^{53}\text{Cr}/^{52}\text{Cr})$	$\approx 0$	Negative?	$-56 \pm 45$



# Summary and conclusions 1

1. The O, Mg and Al composition of OC2 could be produced by an IM-AGB of  $Z \approx Z_{\odot}$ , or by a LM-AGB of  $Z \approx 0.3 Z_{\odot}$  with efficient extra mixing. The large uncertainty in the Fe composition of OC2 does not allow us to determine which model is better, but the Cr composition favors the origin in an IM-AGB star.
2. Using our IM-AGB models it is possible to find a solution. Conditions are: **TDU mass > 0.05  $M_{\odot}$  and/or  $T_{\text{intershell}} > 360$  million degrees,  $T_{\text{mix}} \approx 80 - 85$  million**

# Summary and conclusions

2: *this is just the*

*beginning!*

- We need to compare OC2 to models computed with different physics assumptions to analyse stellar model uncertainties and derive constraints on the choice of the physics in AGB models.
- Further laboratory analysis may also identify additional grains with isotopic compositions similar to OC2 and thus provide *more opportunities* to test the findings of the present work.