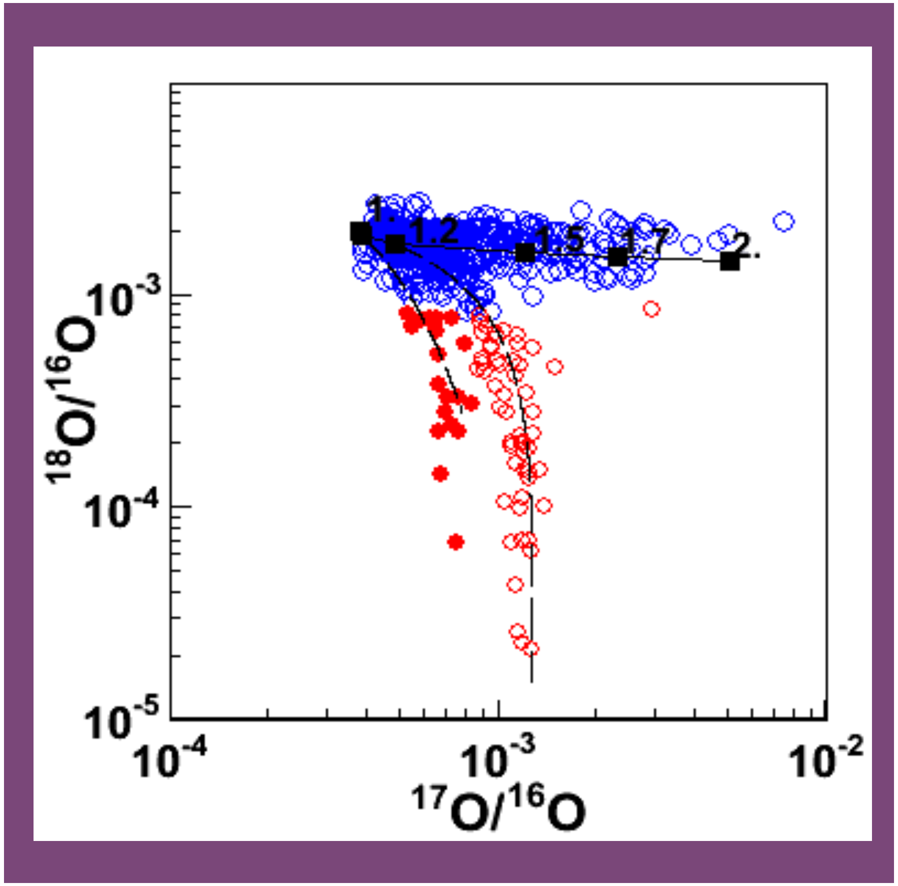
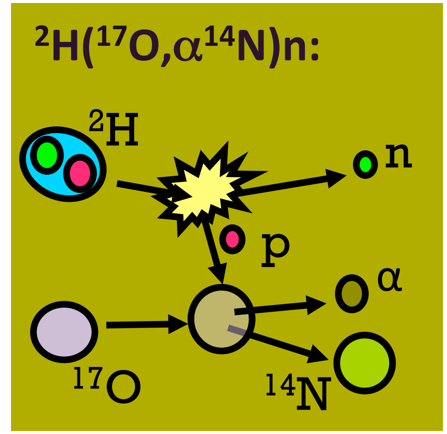
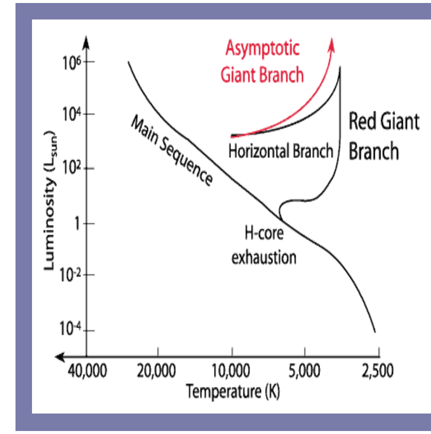
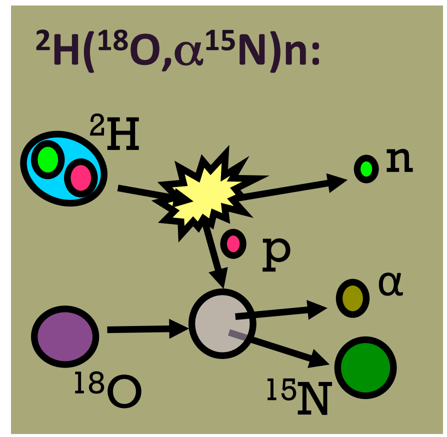
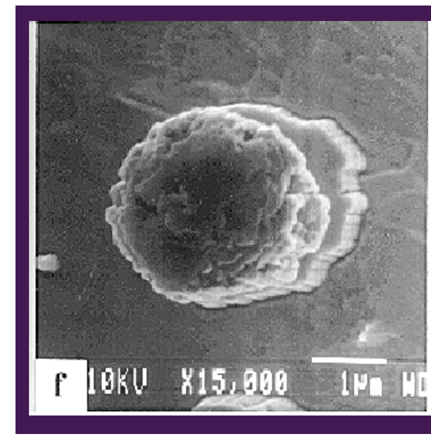








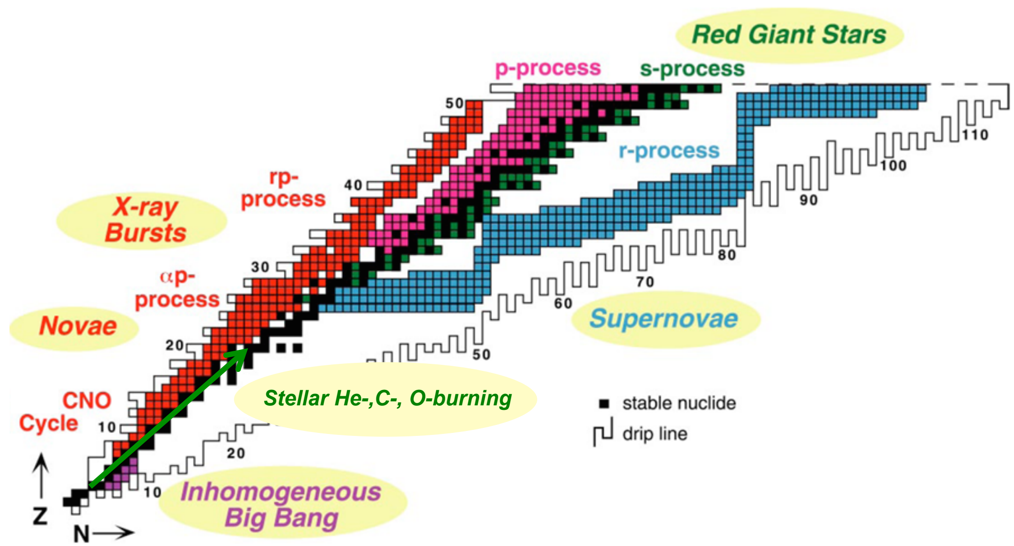


AGB star nucleosynthesis: when new data from nuclear physics help to solve puzzles

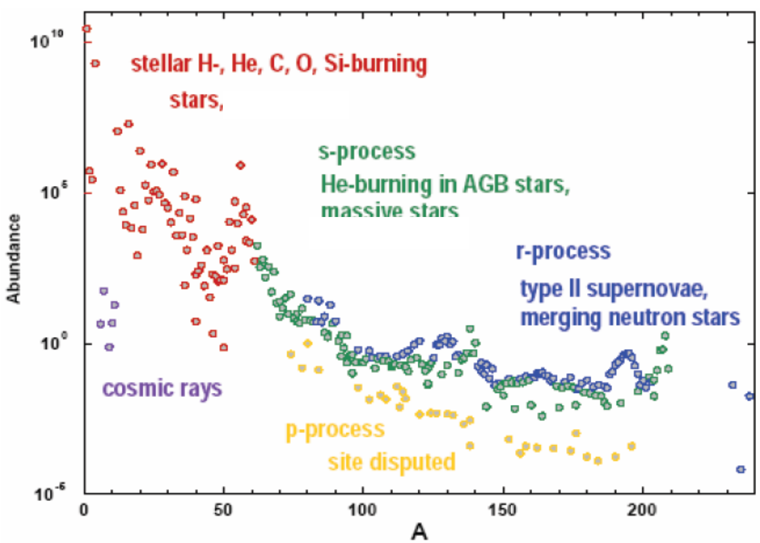
Sara Palmerini
LNS – INFN, Catania, Italy

+ Low mass star contribution to the chemical evolution of galaxies

- ~~Supernovae stars produce the most part of nuclei in the galaxies~~
- 50% of nuclei are produce by low mass stars.



Burbidge, Burbidge, Fowler & Hoyle (B²FH): Rev. Mod. Phys. 29 (1957) 547

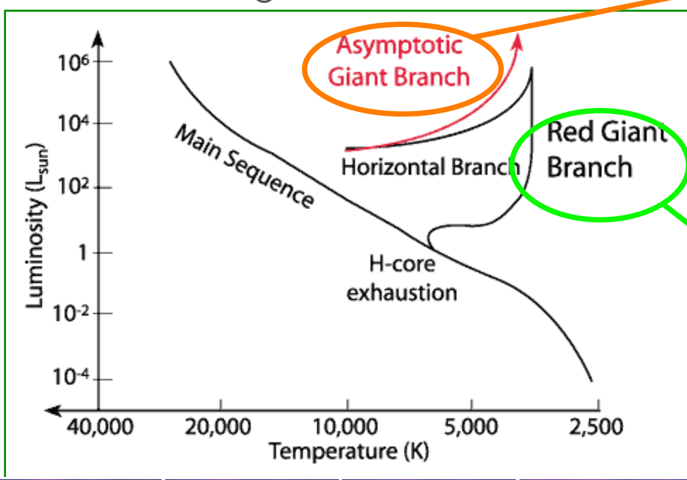


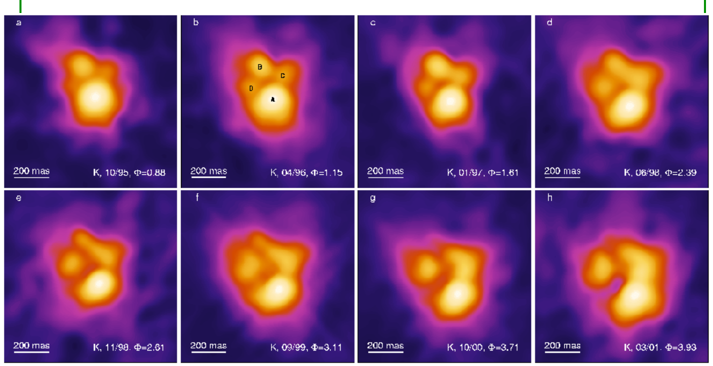
from: M. Wiescher, JINA lectures on Nuclear Astrophysics

- The lower is the mass, the larger is the number of stars

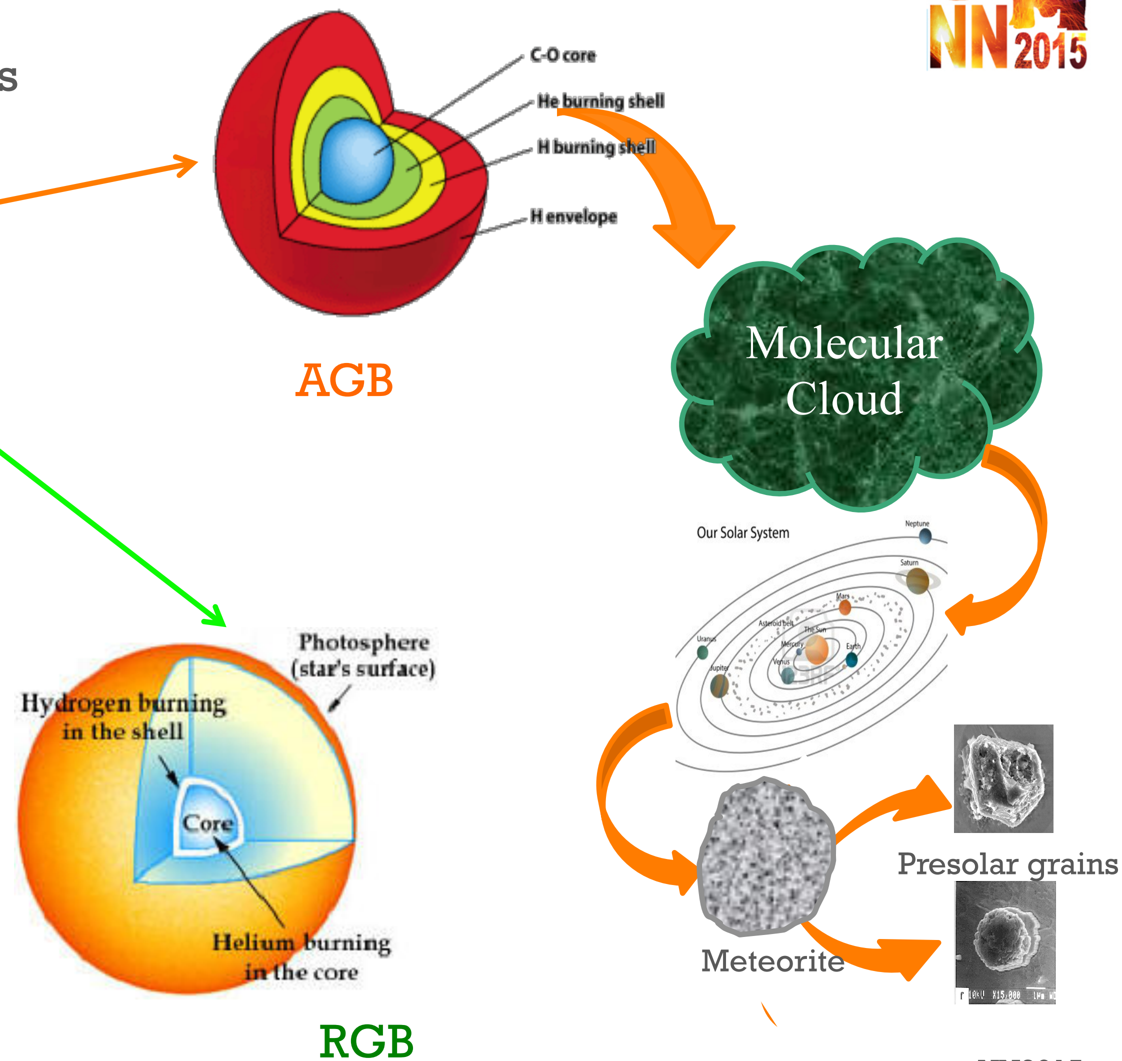
+ Low mass star contribution to the chemical evolution of galaxies

- The lower is the mass, the larger is the number of stars
- $M<3M_{\odot}$



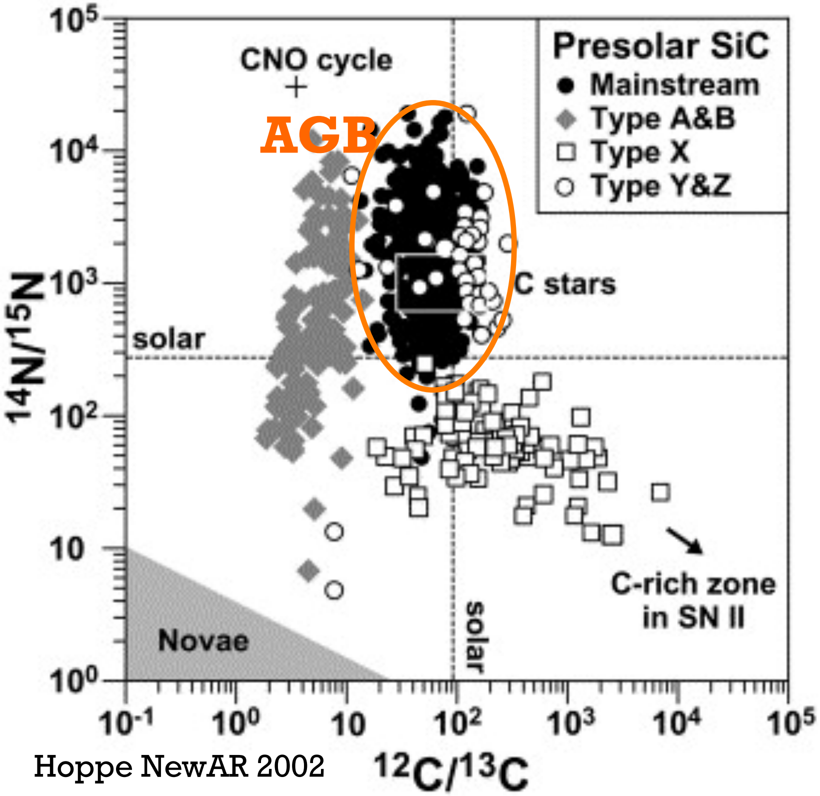


IRC+10216 C-star is the brightest object on the sky at at mid infrared

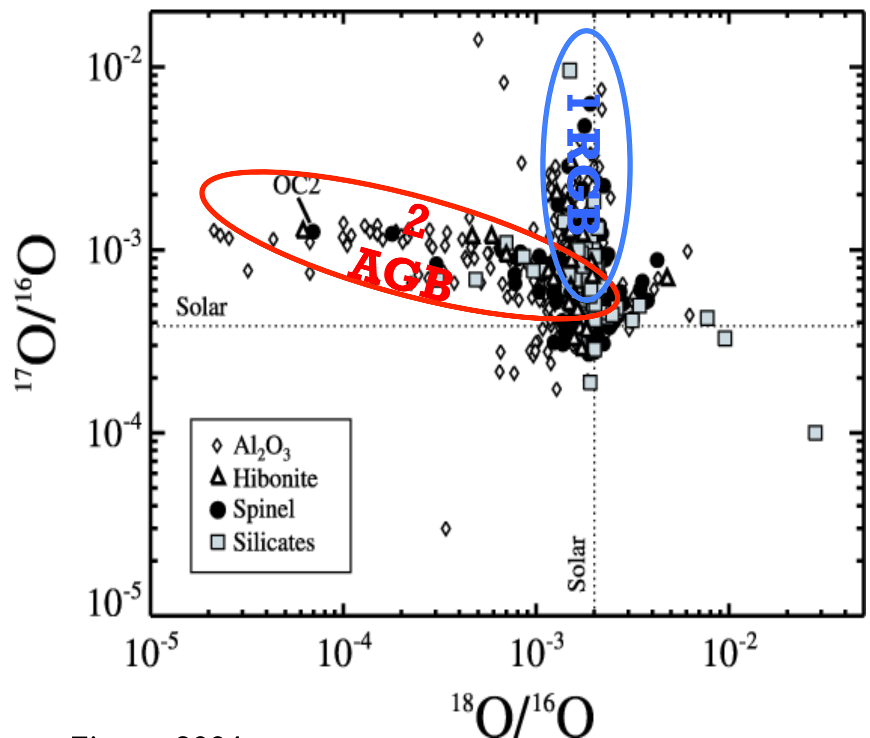


Grains & challenges from RGB & AGB stars

C/O≥1 SiC grains	C/O<1 Oxide grains



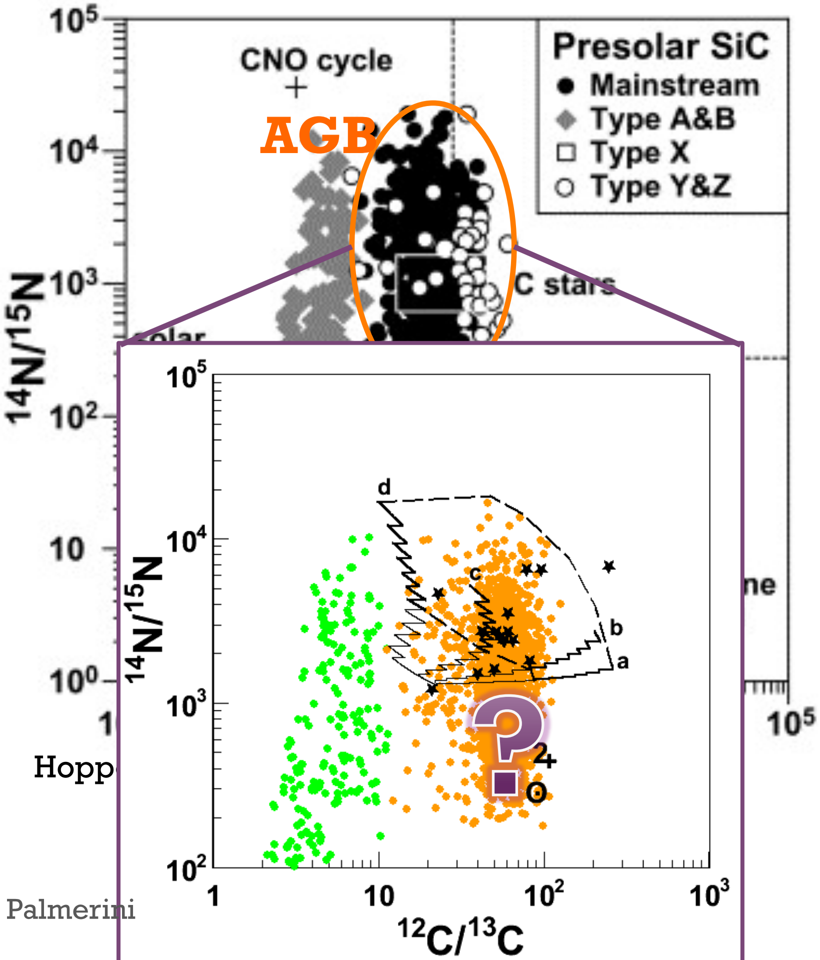
Hoppe NewAR 2002



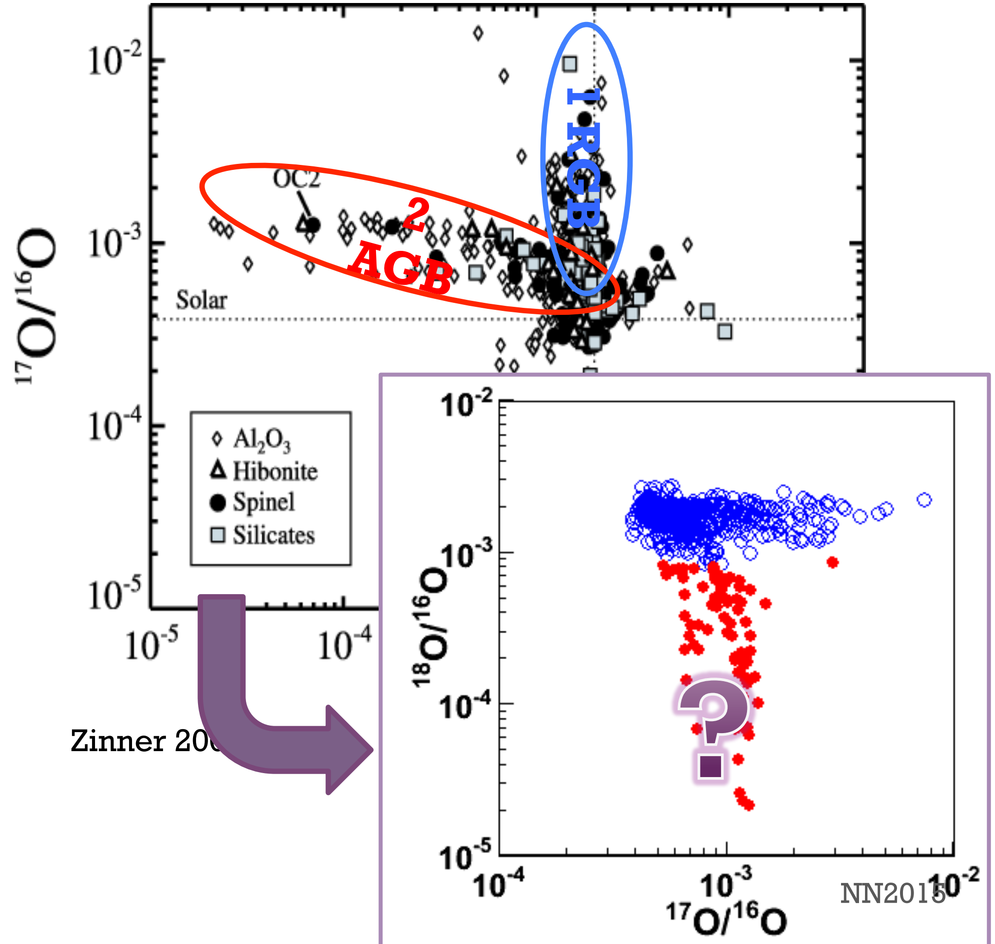
Zinner 2004

+ # Grains & challenges from RGB & AGB stars

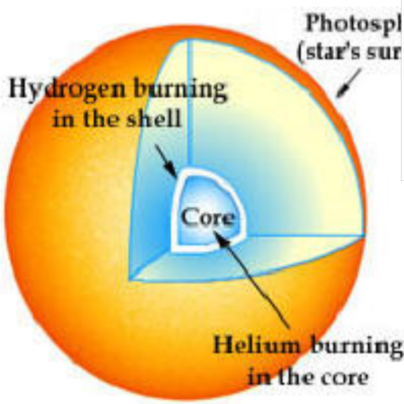
C/O≥1 SiC grains

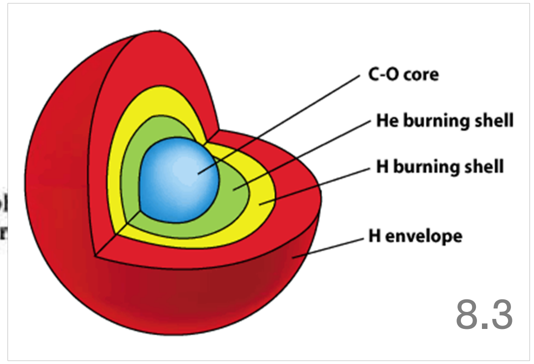


C/O<1 Oxide grains



+ Energy range of the H-burning shell





Temperature:

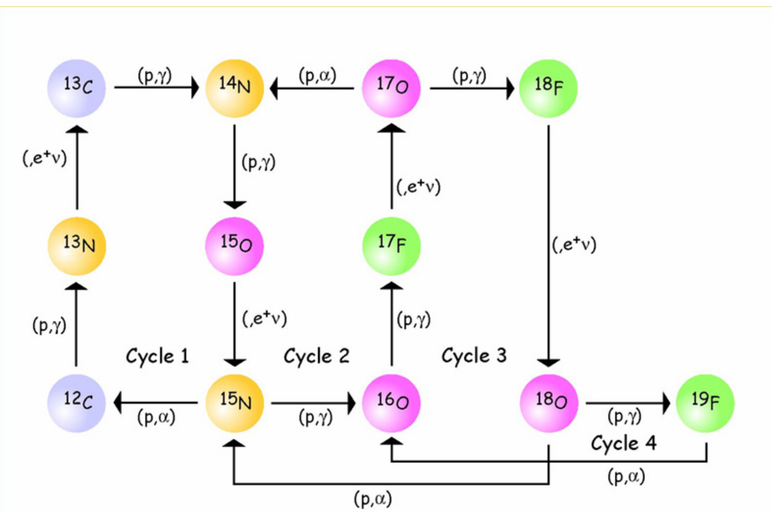
$8.3\ 10^7$ K ⟷ $3\ 10^6$K

~~Conversion Factors Between Units of Energy~~

~~3.45 kev ⟷ 0.25 keV~~

Most effective energy (^{17}O +p reactions)

125 keV ⟷ 36.5 keV



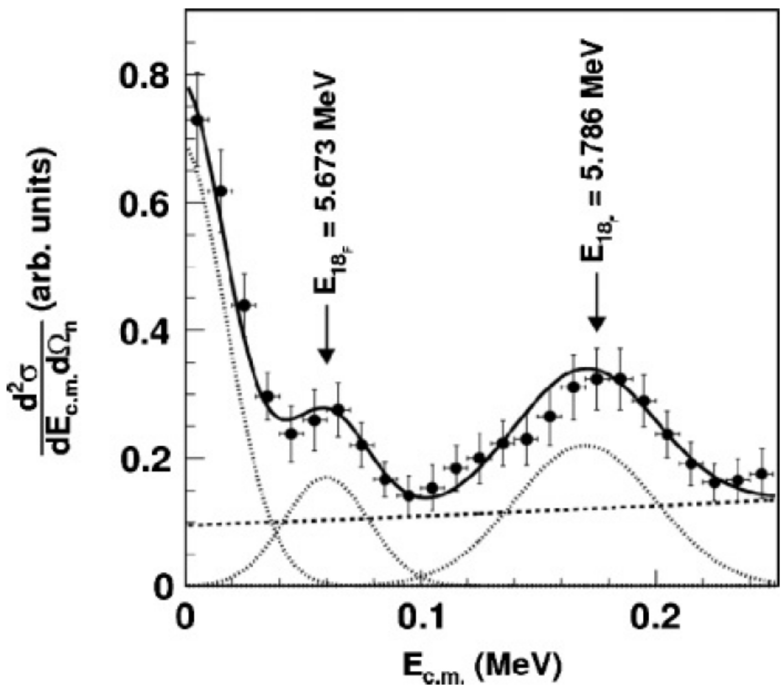
$$N_A\langle\sigma v\rangle = N_A \frac{(8/\pi)^{1/2}}{\mu^{1/2}(k_B T)^{3/2}} \int_0^\infty \sigma E \exp(-E/k_B T)\, dE,$$

$$E_0 = \left(\frac{\mu}{2}\right)^{1/3} \left(\frac{\pi e^2 Z_1 Z_2 k_B T}{\hbar}\right)^{2/3} = 0.1220 (Z_1^2 Z_2^2 A)^{1/3} T_9^{2/3}\ \text{MeV}$$

+ Reaction rates from determined by THM

$^{17}O(p,\alpha)^{14}N$

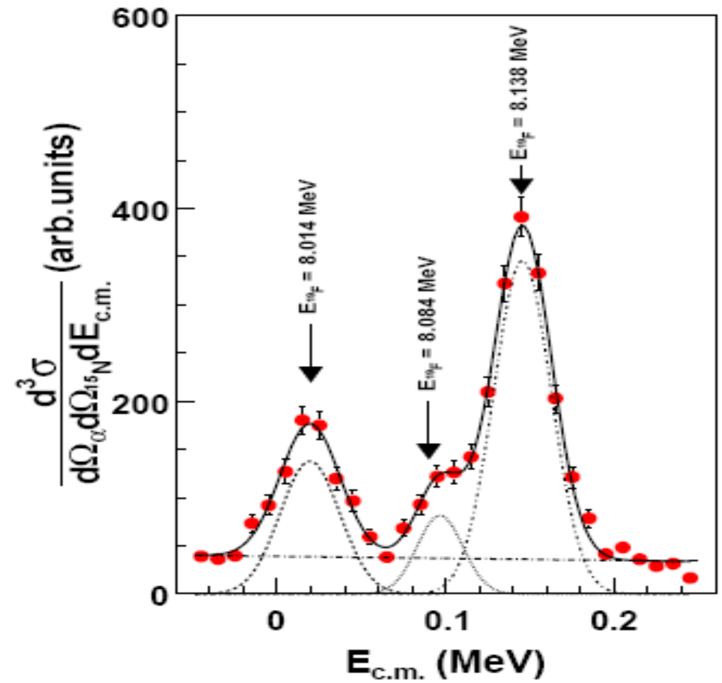
Sergi et al. 2015 PRC in press
POSTER n.37



ωγ (eV)	THM	Chafa et al. 2007	NACRE
65 keV	3.4 ± 0.6 10^{-6}	4.7±0.8·10^{-9}	$5.5^{+1.8}_{-1.0}\cdot 10^{-9}$
183 keV	1.16 ± 0.1 10^{-3}	1.66 ± 0.1 10^{-3}	$5.8^{+5.2}_{-5.8}\cdot 10^{-5}$

$^{18}O(p,\alpha)^{15}N$

La Cognata et al. 2010 152501
ApJ, 708 811

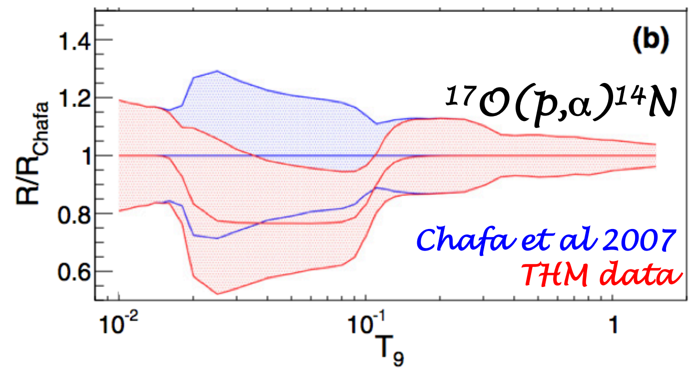


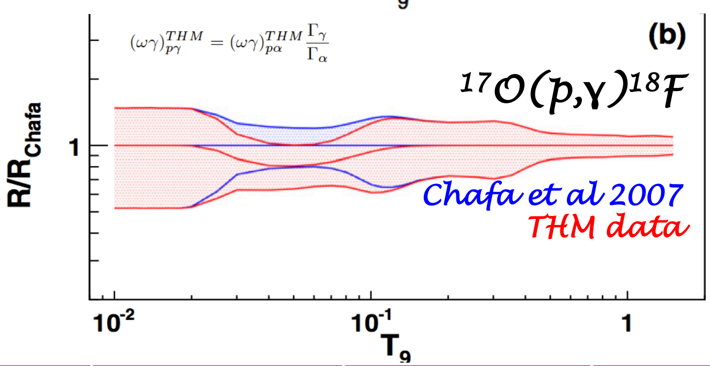
ωγ (eV)	THM	NACRE
20 keV	$8.3^{+3.8}_{-2.6}$ 10^{-19}	6^{+17}_{-5} 10^{-19}
90 keV	1.8 ± 0.3 10^{-7}	1.6 ± 0.5 10^{-7}

+ Reaction rate from determined by THM

$^{17}O(p,\alpha)^{14}N$

Sergi et al. 2015 PRC in press
POSTER n.37





ωγ (eV)	THM	Chafa et al. 2007	NACRE
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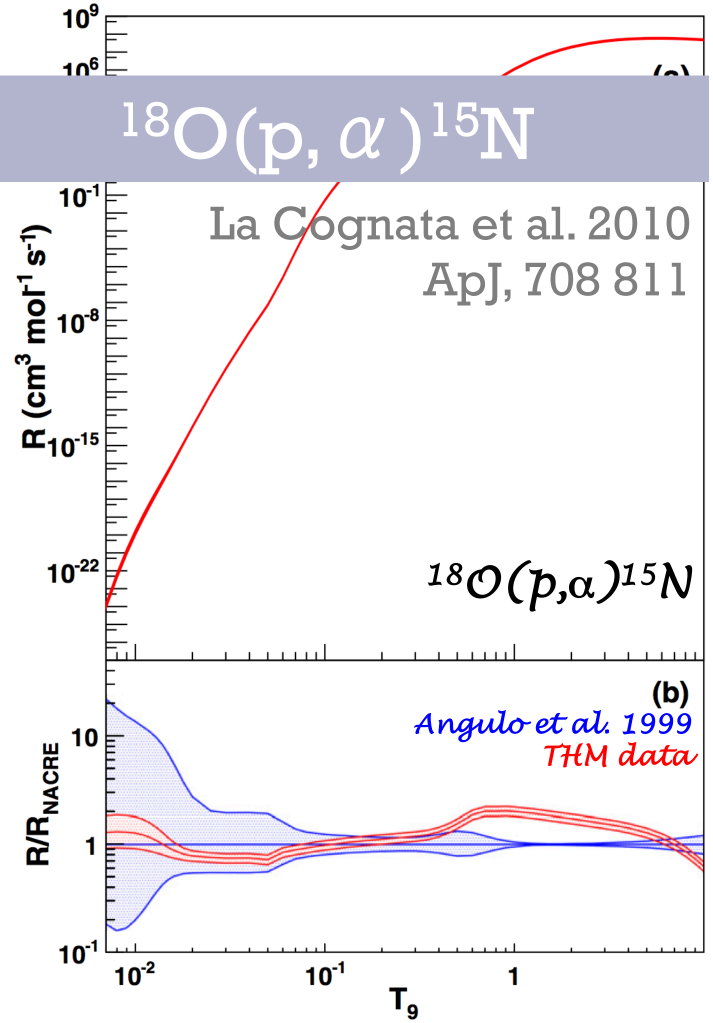

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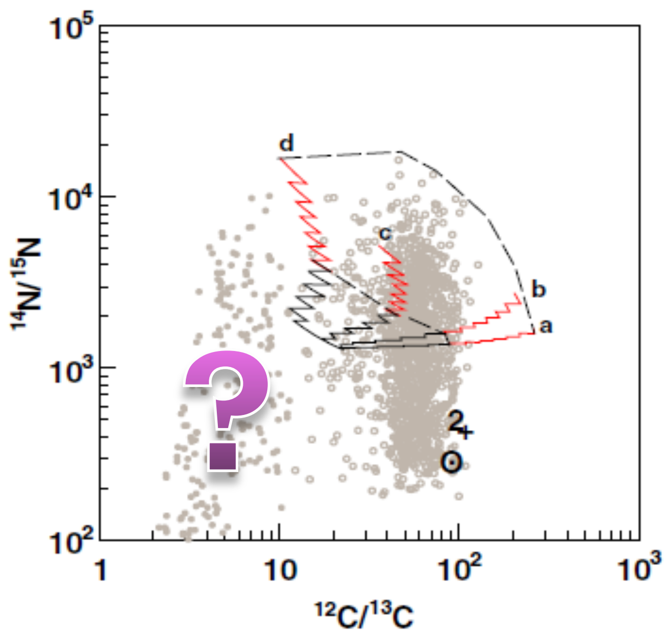
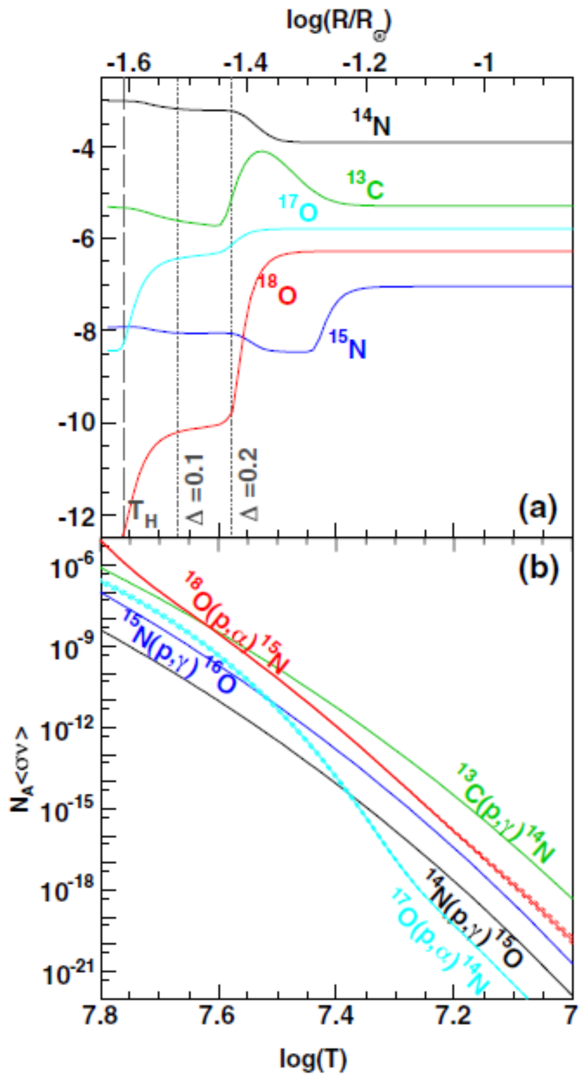
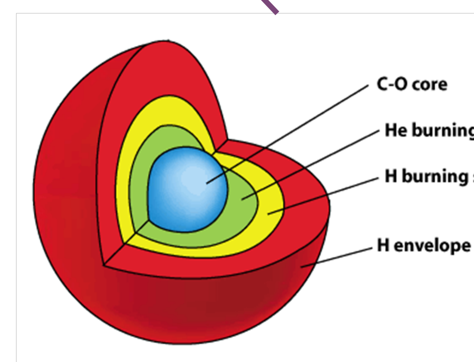
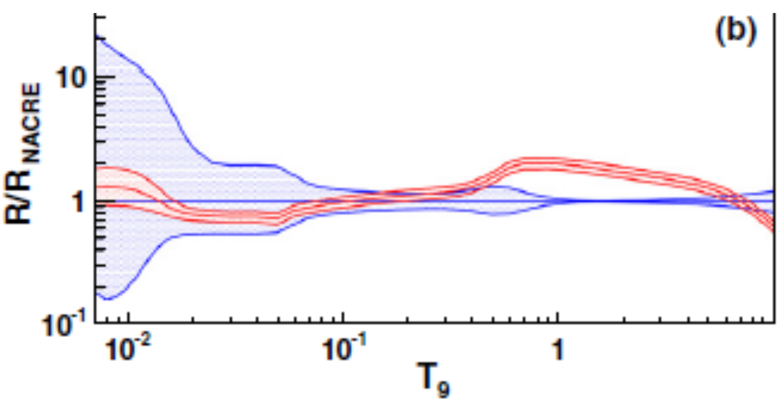
$^{18}O(p,\alpha)^{15}N$ and the challenging Nitrogen isotopic ratio in SiC grains

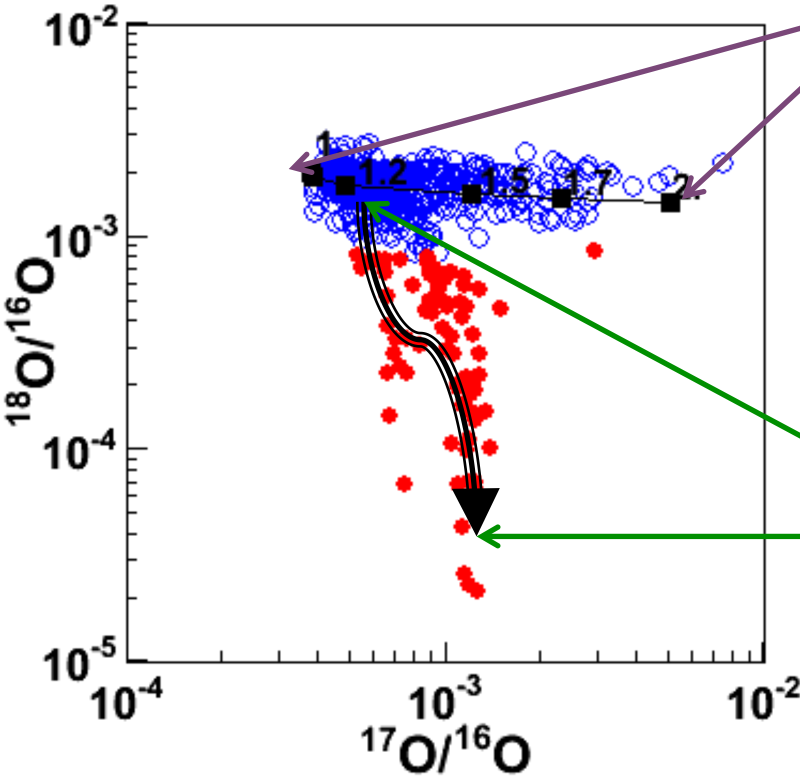


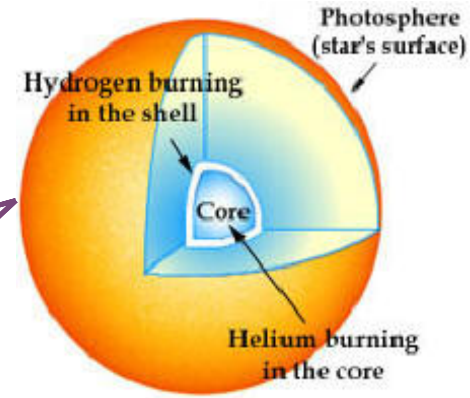




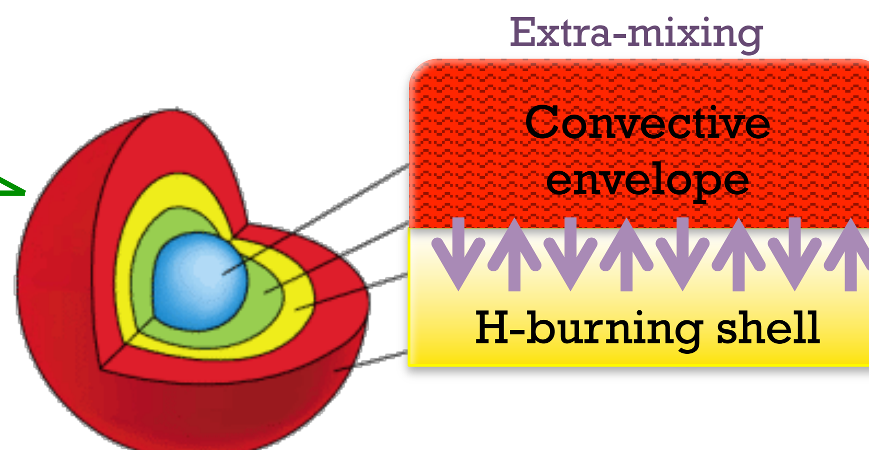


^{17}O+p reaction rates and Oxide grains



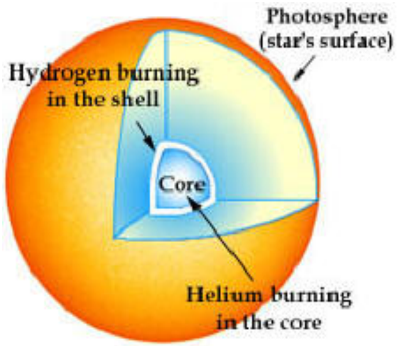


- RGB stars with $1M_{\odot}<M_{\star}<2M_{\odot}$ and solar composition

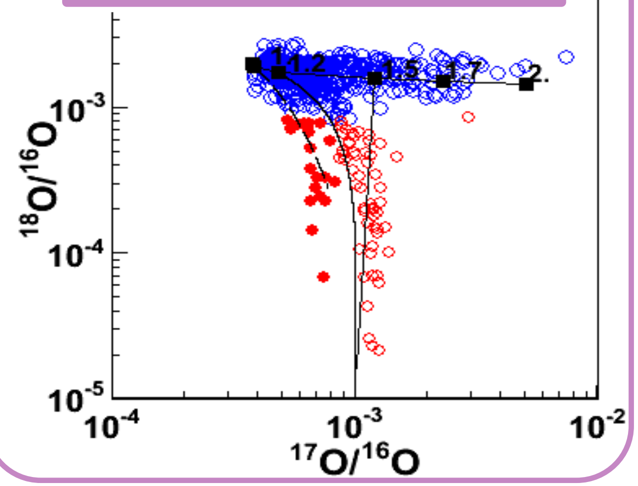


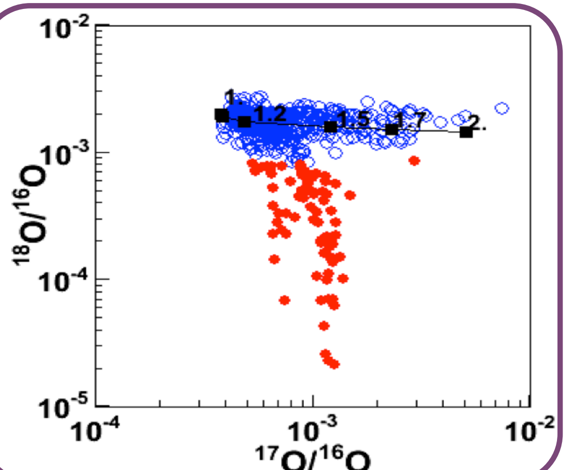
- AGB stars with $M_{\star}<2M_{\odot}$ and solar composition

+ $^{17}O+p$ reaction rates and Oxide grains



Palmerini et al. 2011

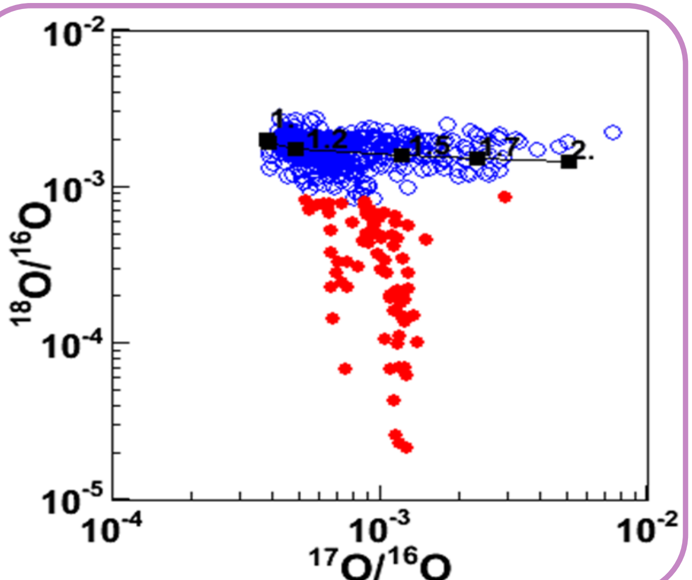


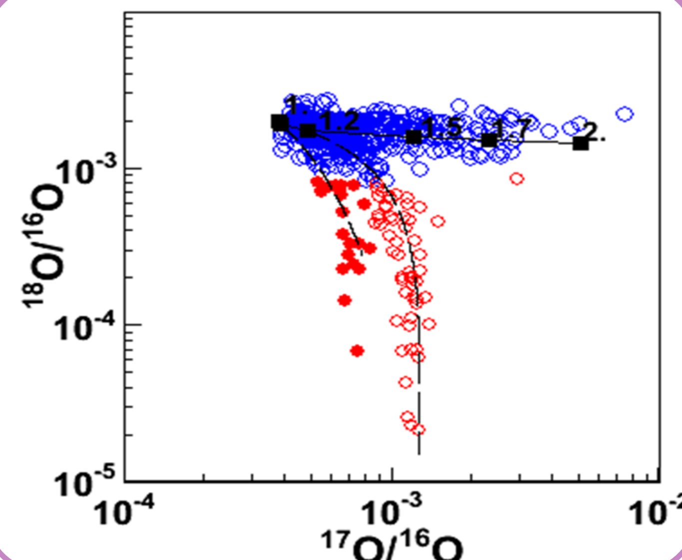


$^{17}O+p$ from
Chafa et al. 2007

- Low mass RGB stars ($M_\star<2M_\odot$) are progenitor of group 1 grains
- Extra-mixing in AGB stars account for isotopic composition of Group 2 oxide grains

$^{17}O+p$ reaction rates and Oxide grains

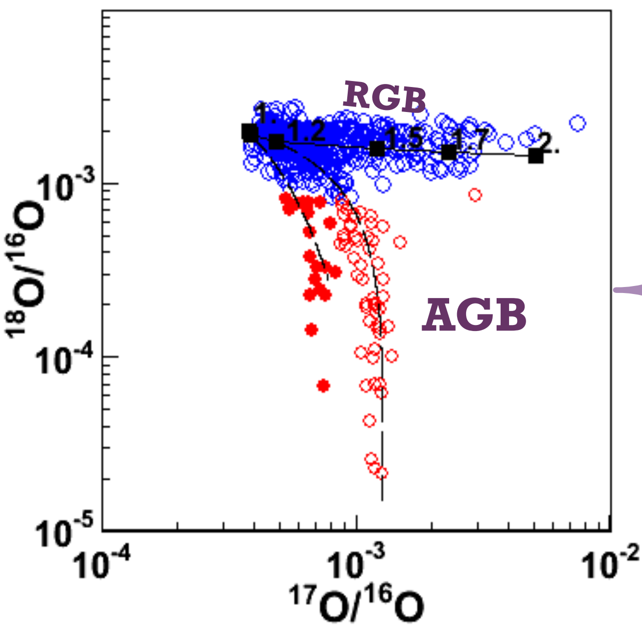


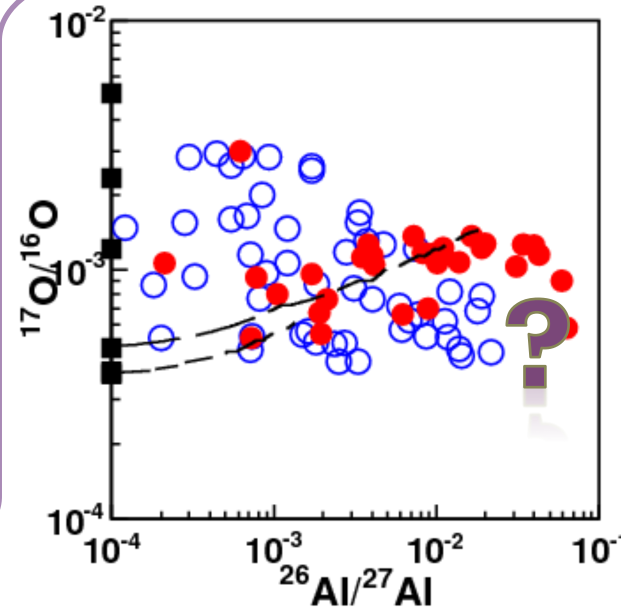


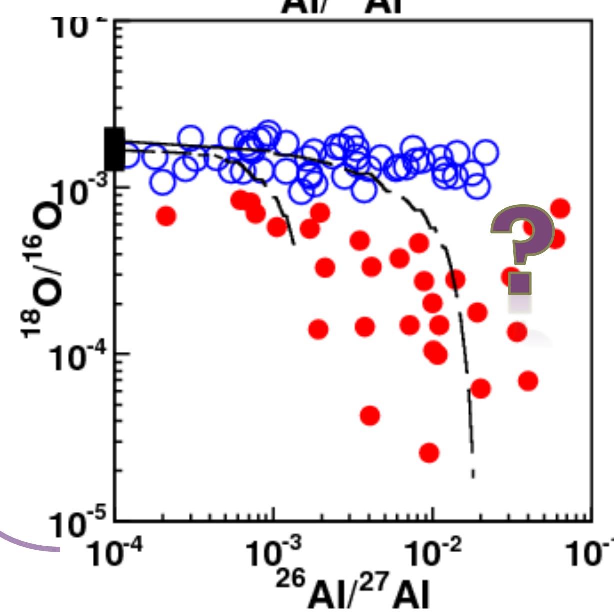
THM data

- Mass range of stellar progenitors of group 2 oxide grains is $1M_\odot < M_\star < 1.2M_\odot$
- Group 2 grains might be divided in 2 subgroups because of the progenitor mass

+ Aluminum isotopic ratio: a possible solution from nuclear physics?



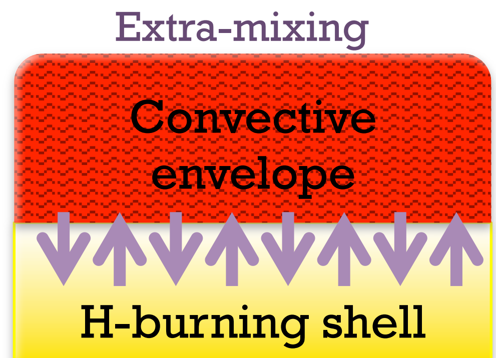




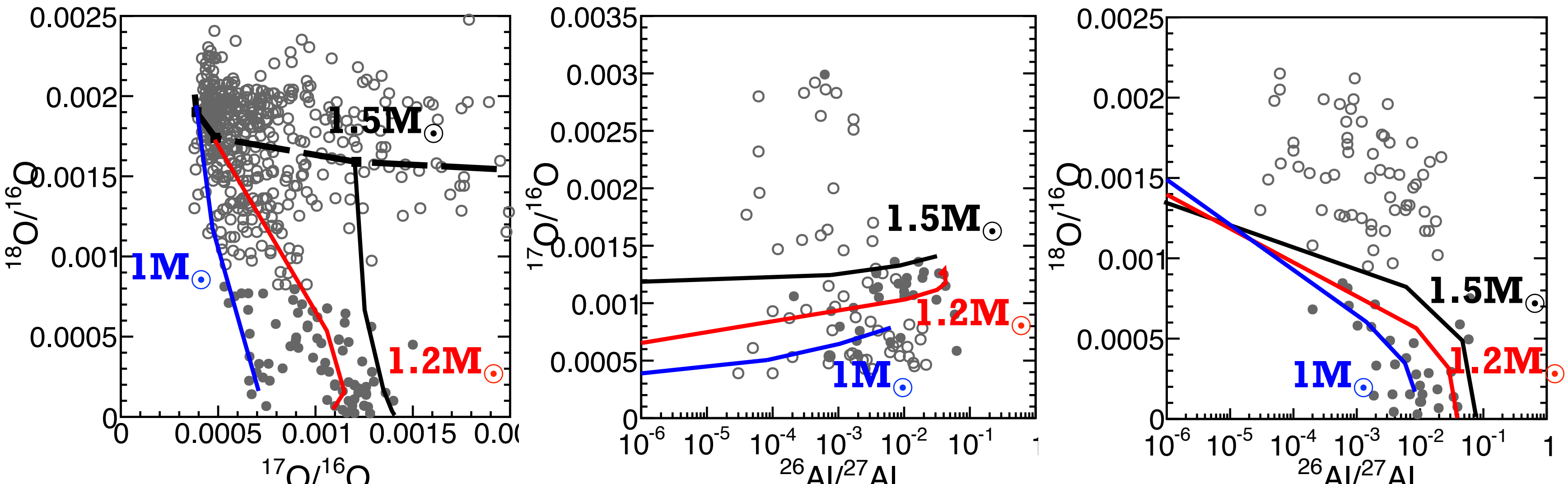
How to reach $^{26}Al/^{27}Al>0.02$ shown by part of group 2 grains?

Aluminum isotopic ratio: a possible solution from stellar ~~nuclear~~ physics

- The measurement of $^{25}Mg(p, \gamma)^{26}Al$ excludes that a solution coming from nuclear data (Strieder et al. 2012)

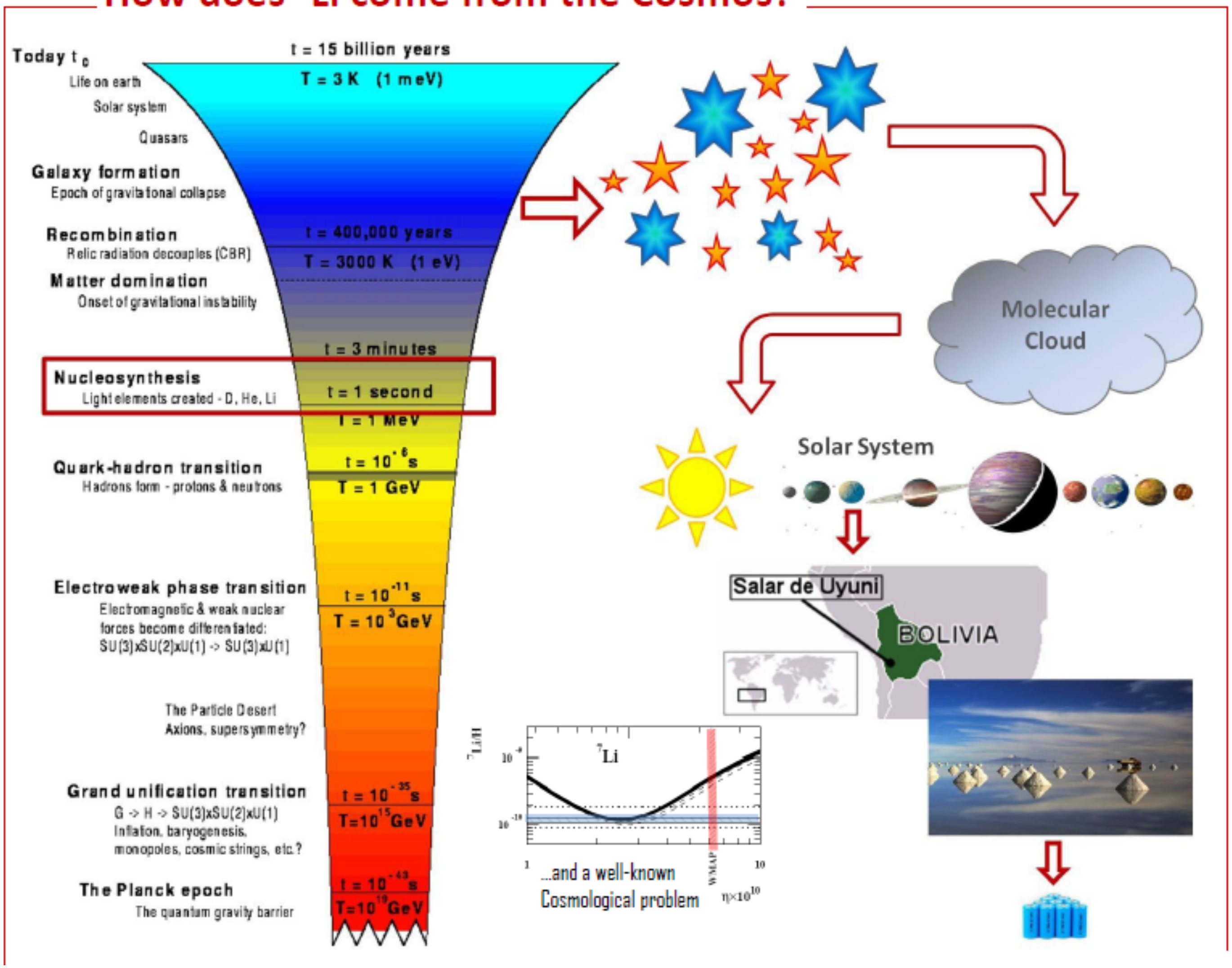


- What about the mixing profile?



Palmerini et al. in prep

How does ^{7}Li come from the Cosmos?



A new estimation of ^{7}Be life-time in Stellar Conditions Li

Sun:
T= 1.57×10^{7} K
ρ =160 g/cm^{3}

PHYSICAL REVIEW VOLUME 128, NUMBER 3 NOVEMBER 1, 1962

Electron Capture and Nuclear Matrix Elements of Be^{7}†

JOHN N. BAHCALL*
Indiana University, Bloomington, Indiana
(Received June 28, 1962)

$$\tau_{\text{star}}^{-1} \equiv \lambda_{\text{star}}/\ln 2 = 1.02 n_e T_6^{-1/2} \times 10^{-32}\ \text{sec}^{-1},$$

REVIEW OF MODERN PHYSICS, VOLUME 83, JANUARY–MARCH 2011

Solar fusion cross sections. II. The pp chain and CNO cycles

E. G. Adelberger, A. García, R. G. Hamish Robertson, and K. A. Snover

$$R(^{7}\mathrm{Be} + e^{-}) = 5.60(1 \pm 0.02) \times 10^{-9}(\rho/\mu_e) \times T_6^{-1/2}[1 + 0.004(T_6 - 16)]\,\mathrm{s}^{-1}, \qquad (40)$$

valid for $10 < T_6 < 16$, is identical to Eq. (26) of Solar Fusion I. Here ρ is the density in units of g/cm^{3}, T_6 is the

RGB & AGB:
T= 5 ×10^{7} -2 ×10^{6} K
ρ=0.01 – 100 g/cm^{3}

The Poisson–Boltzmann approach (the other "classical" one) <u>does not hold outside the conditions of the solar nucleus</u>. In particular, <u>at lower temperatures and densities</u>, where a large part of the Li production occurs (because the competing proton captures on ^{7}Be become ineffective)

THE ASTROPHYSICAL JOURNAL, 764:118 (12pp), 2013 February 20 doi:10.1088/0004-637X/764/2/118

THEORETICAL ESTIMATES OF STELLAR e^{-} CAPTURES. I. THE HALF-LIFE OF ^{7}Be IN EVOLVED STARS

S. SIMONUCCI[1,2], S. TAIOLI[2,3,4,5], S. PALMERINI[6], AND M. BUSSO[2,7]
[1] Department of Physics, University of Camerino, Camerino, Italy
[2] Istituto Nazionale di Fisica Nucleare, Sezione di Perugia, Perugia, Italy; stefano.simonucci@unicam.it
[3] Interdisciplinary Laboratory for Computational Science, FBK-CMM and University of Trento, Trento, Italy; taioli@fbk.eu

+ Li in AGBs and the ‘new’ ^{7}Be life time

^{3}He → (α,γ) ^{7}Be ; (^{3}He,2p) ^{4}He

^{7}Be → (e-,ν) ^{7}Li ; (p,γ) ^{8}Be → 2α

^{7}Li → (p,α) ^{4}He ; (p,γ) ^{8}B(β) ^{8}Be → 2α

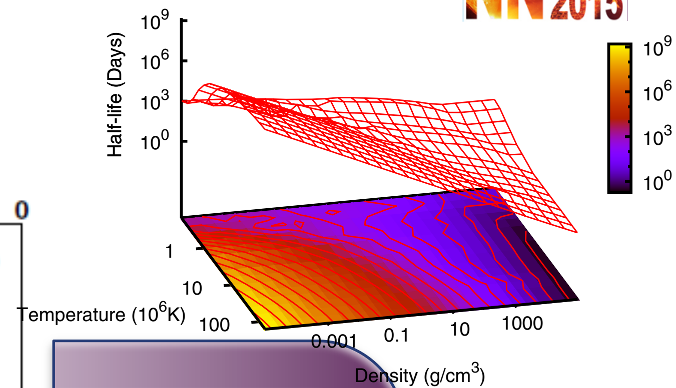
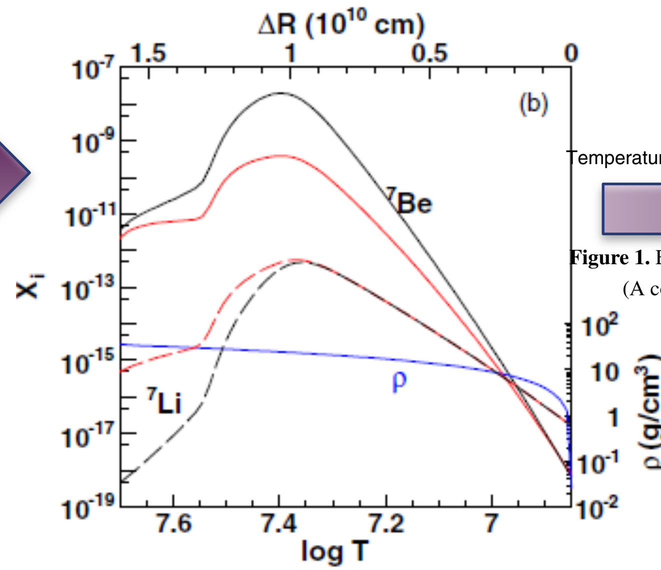
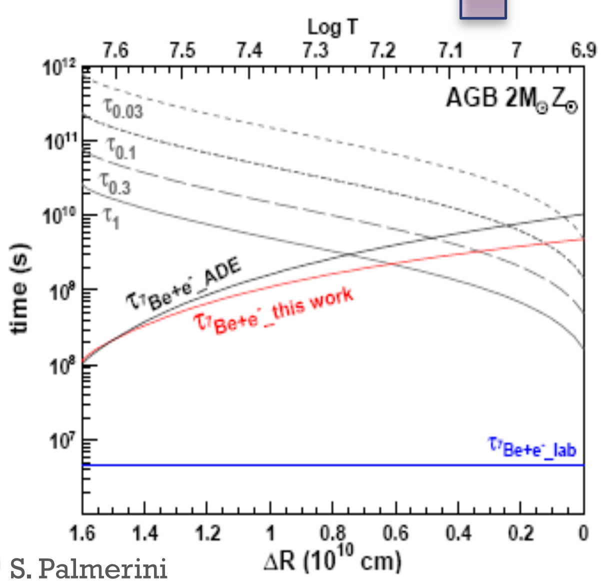
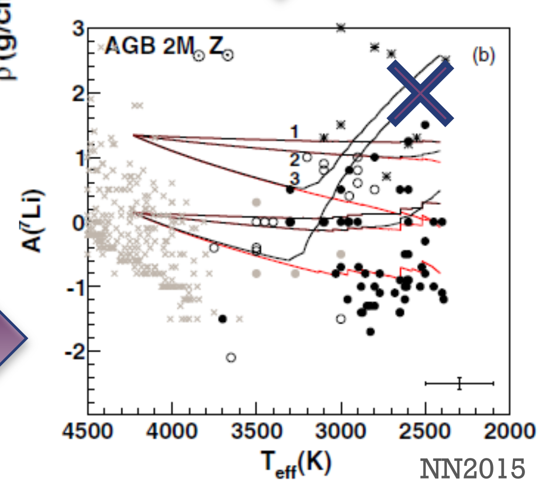


Figure 1. Electron-capture half-life in days for ^{7}Be as a function of ρ and T. (A color version of this figure is available in the online journal.)







In nuclear astrophysics

- Sometimes solutions come from nuclei ($^{17}O/^{16}O$ in grains)
- Sometimes solutions come from stars ($^{26}Al/^{27}Al$ in grains)
- Other times we do not know yet ($^{14}N/^{15}N$ in grains and the Li problem)
- In any case it is necessary to collaborate

GRAZIE!

THANK YOU!