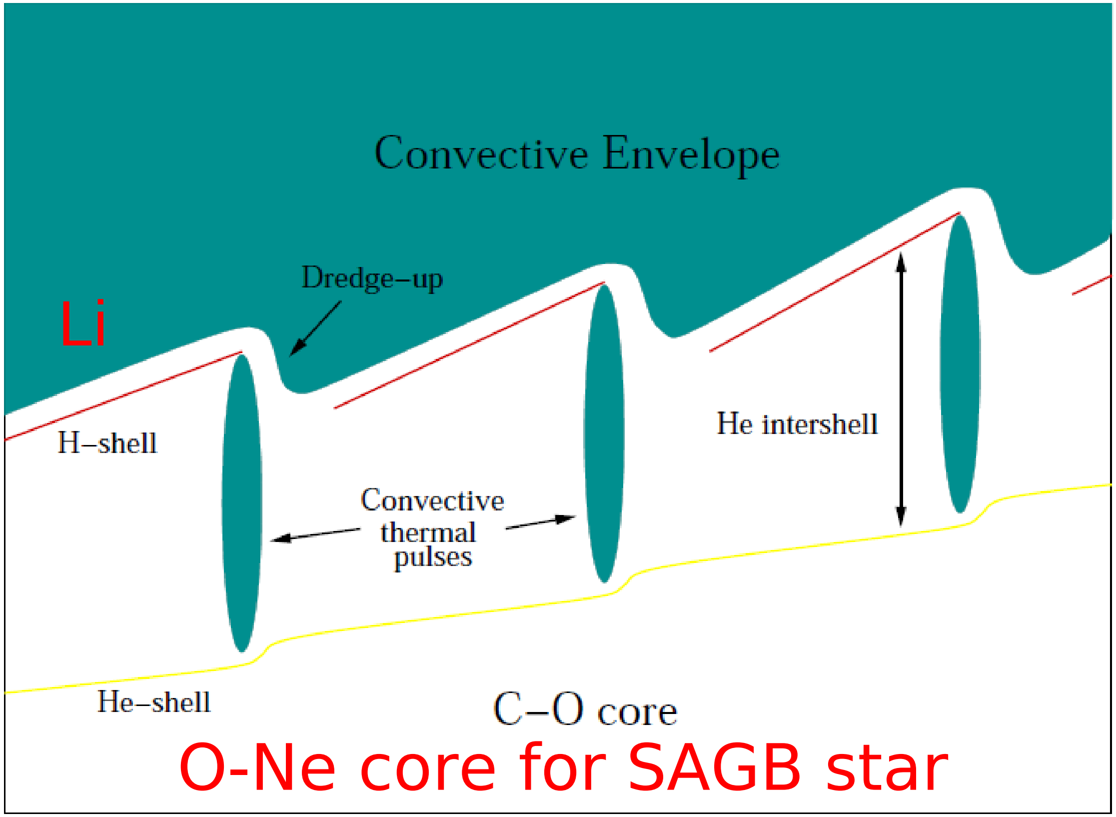
Lithium production in SAGB stars



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Outline

- SAGB stars and Li production
- Codes and input physics
- Exploration of effects
  - Initial mass and metallicity
  - Mass loss rates
  - Mixing length parameter
- Conclusions

SAGB stars & Li production

- SAGB stars:
  - hot enough to ignite carbon at the early AGB phase.
  - mass range: ~7 to ~10 M_{sun}
- Hot bottom burning:
  Bottom of convective envelope > 60 million K.
- Li is created during HBB via Cameron & Fowler (1971) mechanism. He3+He4->Be7, Be7+e-> Li7
- There is only a short period of time in which Li is enhanced in the surface.
- Li abundances then go down due to depletion of ^{3}He
- Previous work for $Z=10^{-3}$ by Ventura and D'Antona (2010)

Our codes & input physics

- Monash version of the Mount Stromlo stellar evolution program (MONSTAR), -see Doherty et al. (2010) for published model of SAGB stars.
- The nucleosynthesis was performed using a post processing code with a 77 species network.
- Standard mass loss rate is Vassiliadis & Wood (1993). Other mass loss rates: Bloecker (1995), van Loon et al (2005) & Reimers (1975) are also considered.

Our codes & input physics

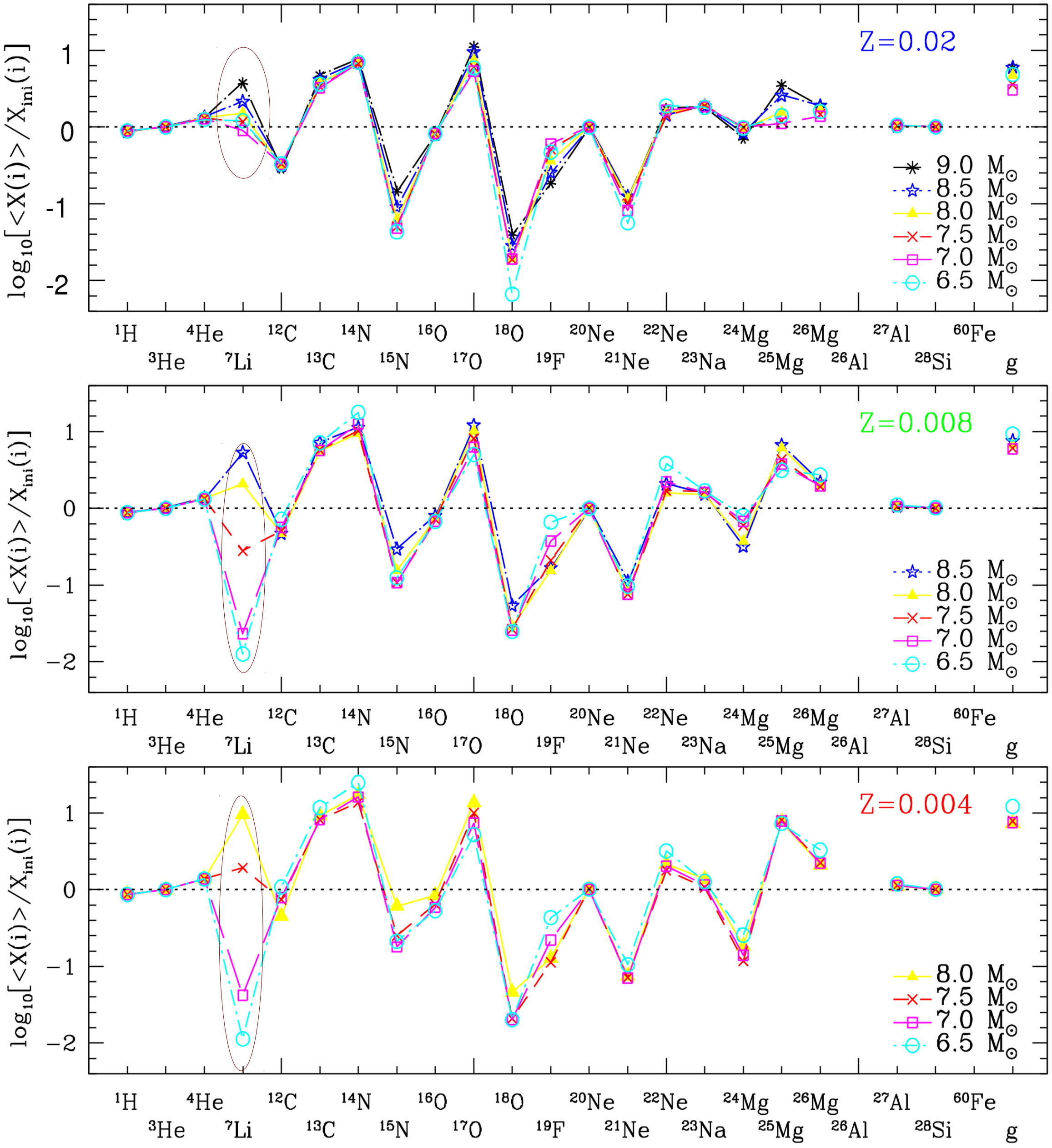
- Mixing length parameter α is set to 1.75
  Other mixing length parameters are also investigated
- No extra mixing / cool bottom process used
- Initial Li is set to be [Li/Fe]=0 for solar, LMC, SMC
  log $\boldsymbol{\varepsilon}_{\mathbf{Li}}$=2.176 for lower metallicity.
- Yield for isotope X are calculated by:

$$M_i = \int_0^{\tau} [X(i) - X_0(i)] \frac{dM}{dt} dt,$$

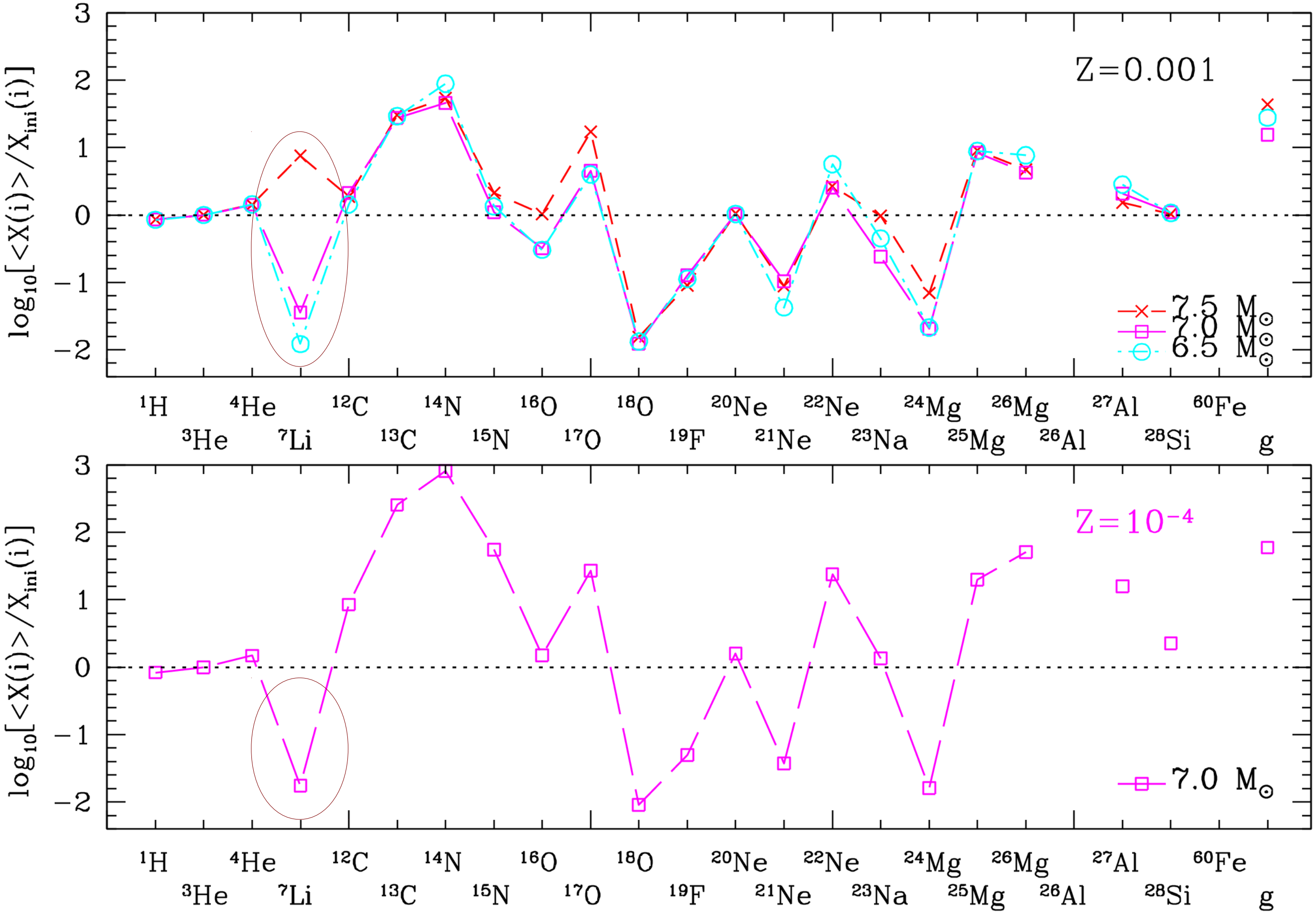
(surface abundance of X – initial abundance of X)

x mass loss rate, throughout the evolution

Production factor for solar, LMC, SMC compositions



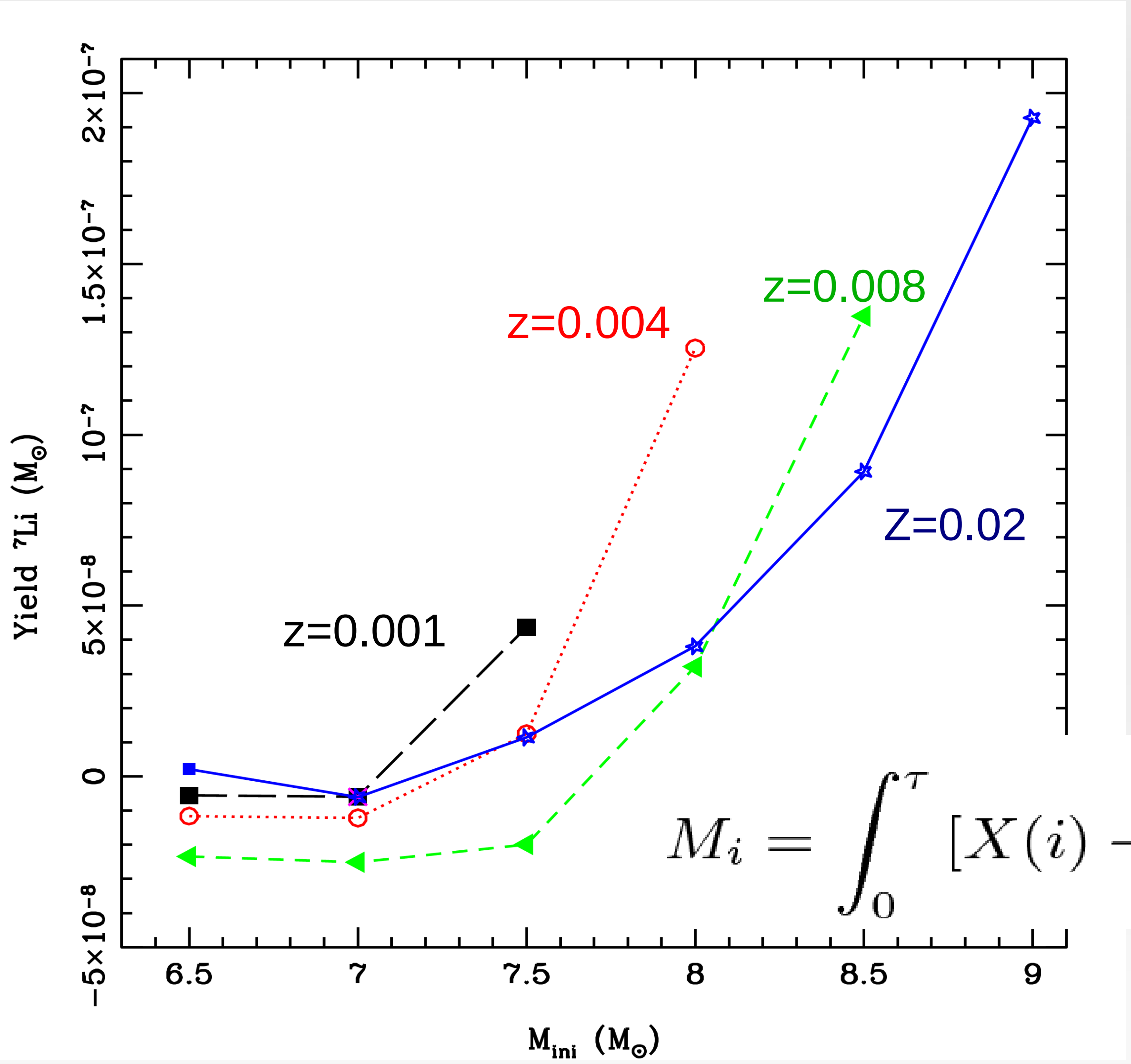
Production factor for Z=10^{-3}, Z=10^{-4}



Analysis of results

- General trend with initial **mass and metallicity**
- Effects of the **mass loss rates**
- Effects of the **mixing length parameter** α

Trend of Li yields with Z, M_0



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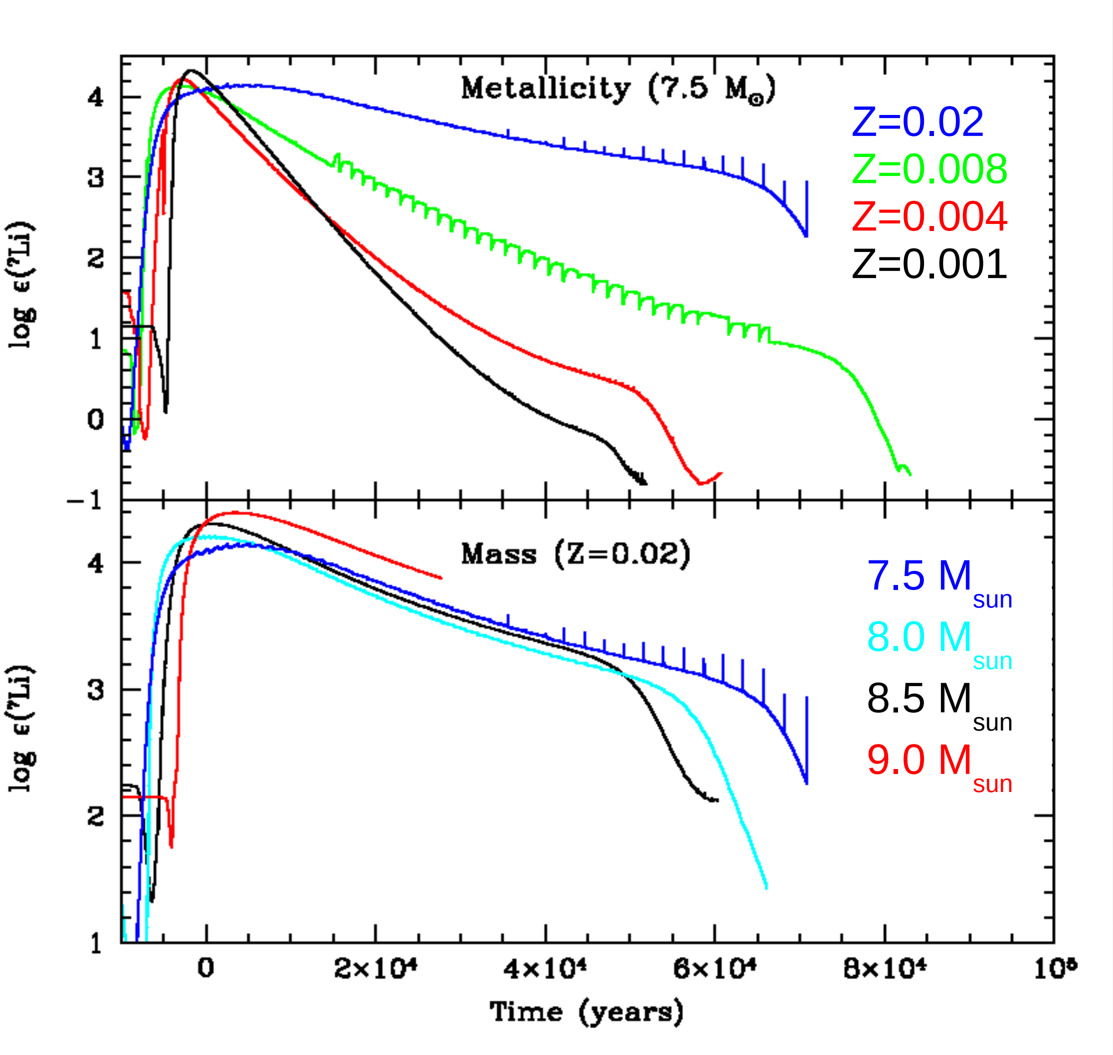
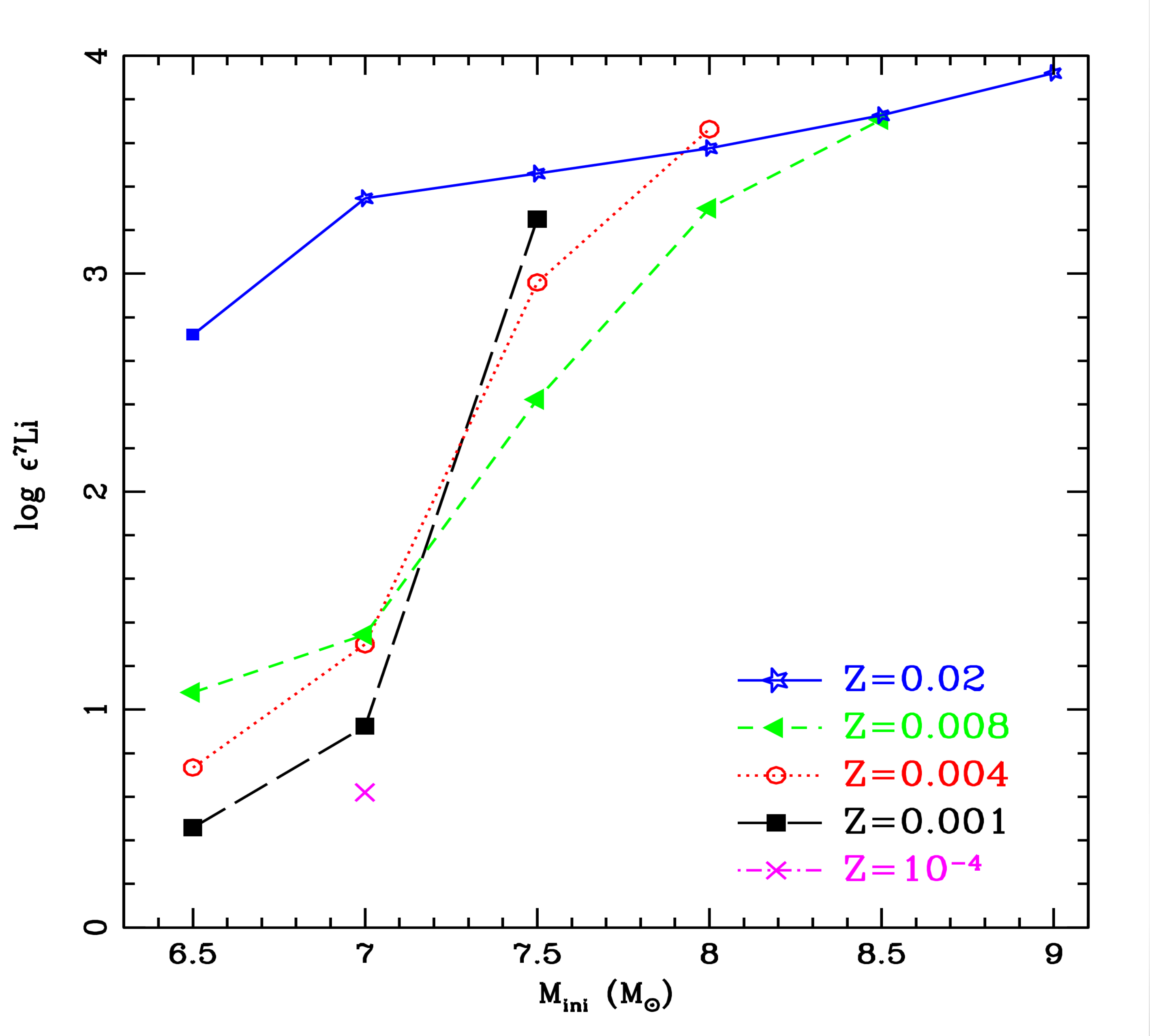
Trend of Li yields with Z, M_0



Average abundance in the ejecta



Mass trend

- **More massive SAGB stars produce more Li** because the early TP-SAGB temperatures in the base of their convective envelopes are higher (more efficient HBB).
- This leads to a **higher peak of Li abundances**. Although the high Li phase is shorter, **the early mass loss rates are higher**.
- The less massive AGB stars (<7M) don't have positive yield, although some of them have a small period that Li is enhanced in the surface.

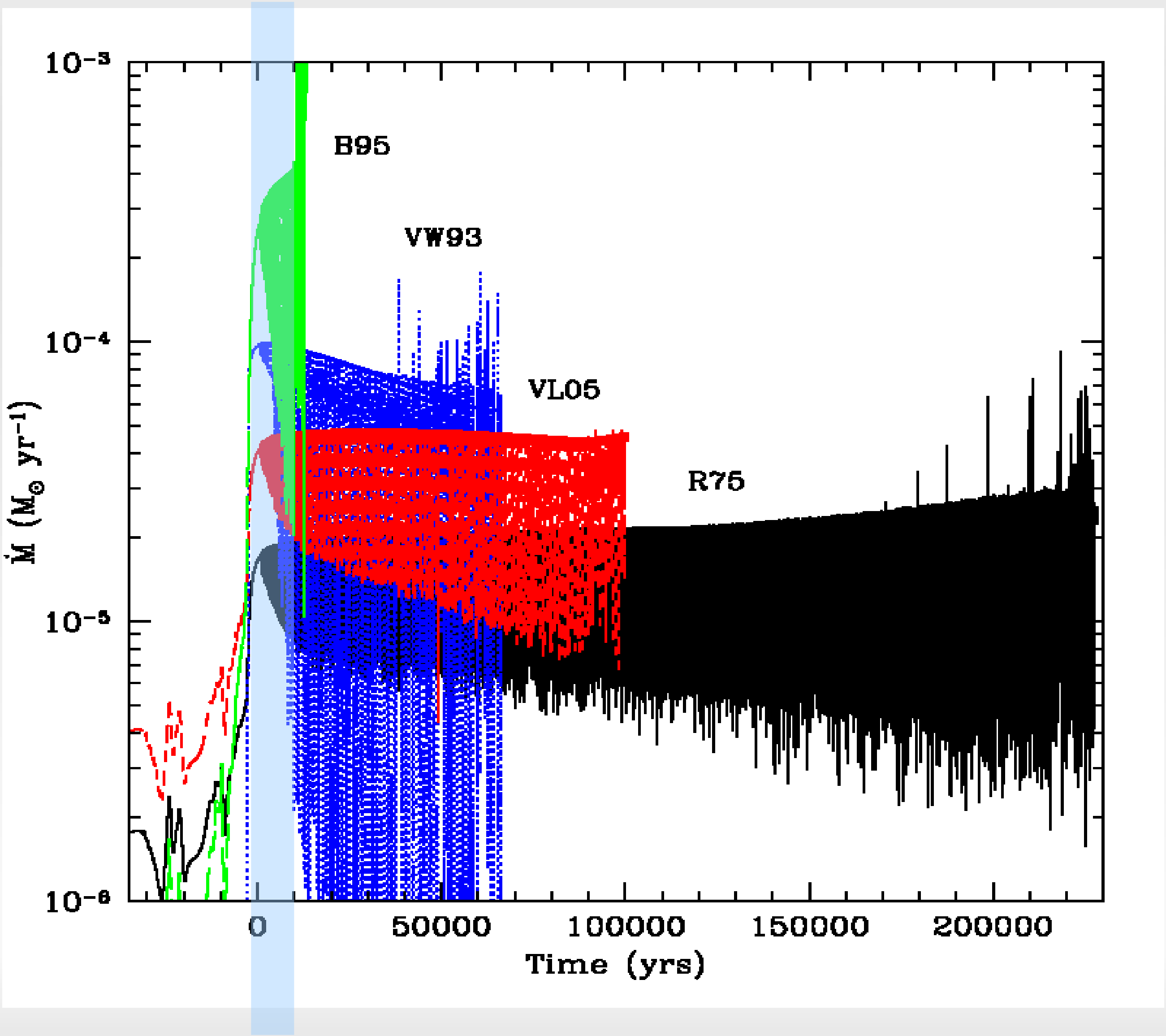
Metallicity trend

- Two competing effects:
  - The temperatures at the base of the convective envelopes are higher for lower metallicity stars, so less massive AGB stars also produce Li at low Z.
  - At the same time the early mass-loss rate at lower metallicity is lower, so it is harder to extract Li before depletion.

  => For the same initial masses Li yields increase with decreasing Z

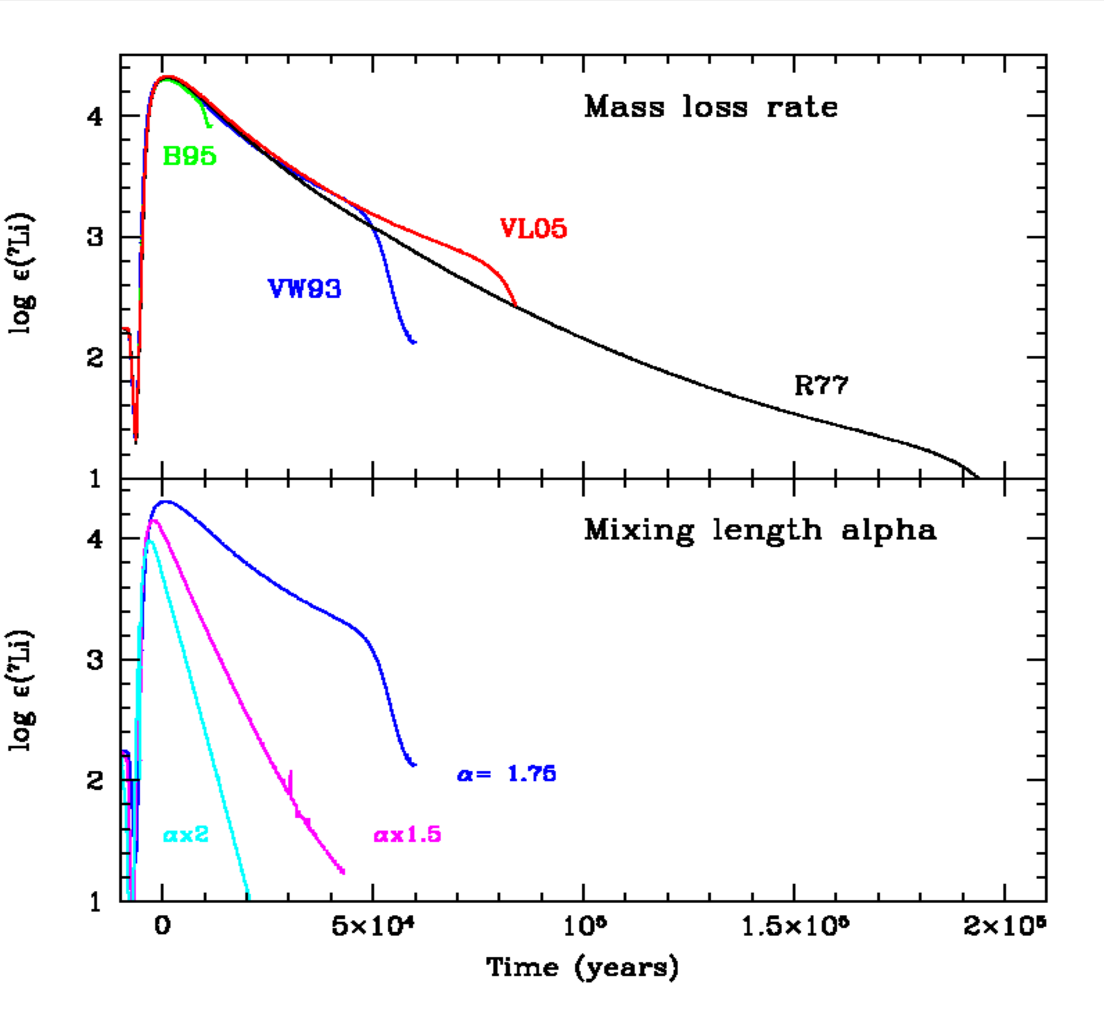
  => Higher Z stars make more Li overall

Effects of the mass loss rates



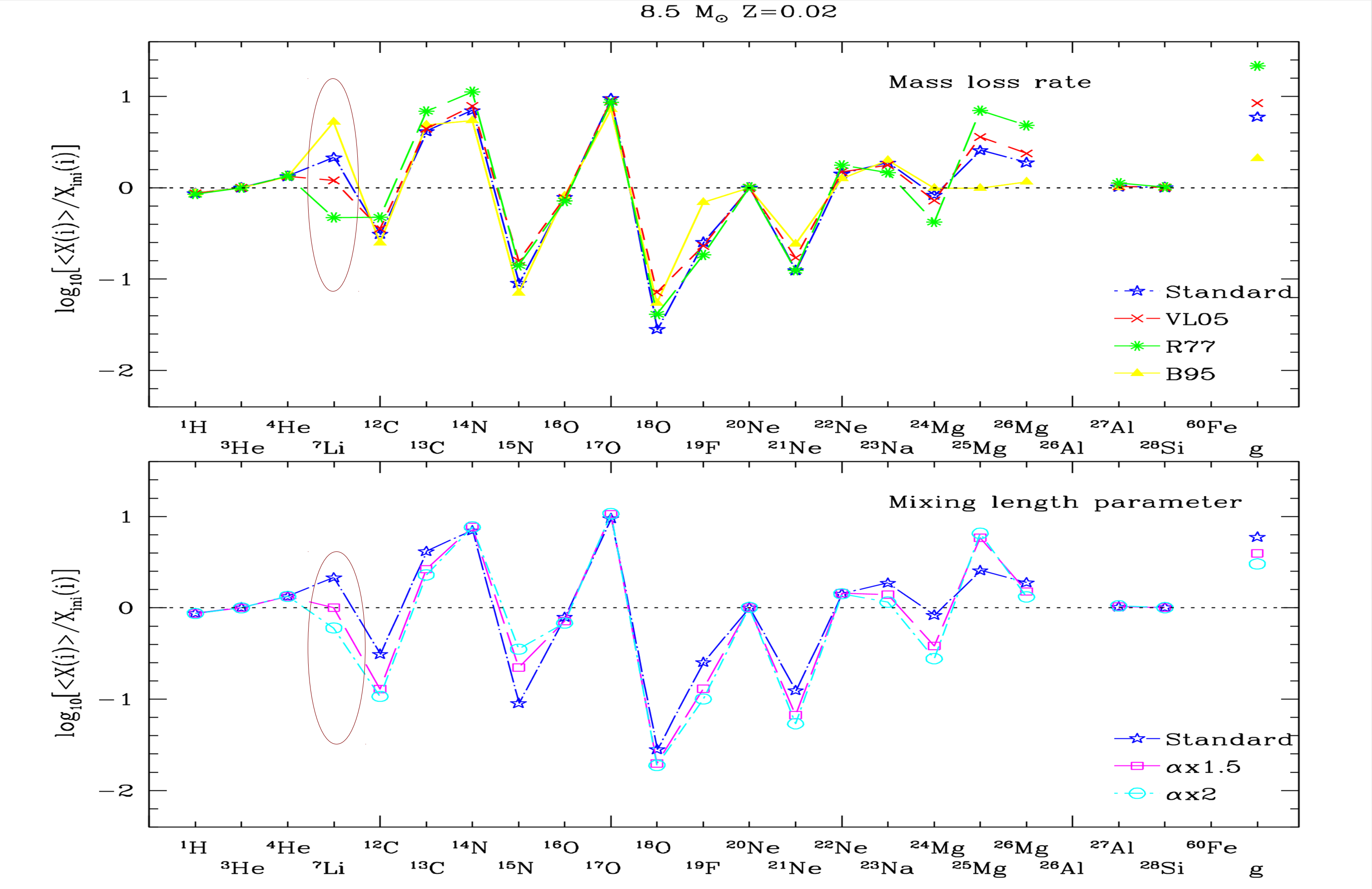
Effects of mass loss rates and α

8.5 M Z=0.02. Evolution of surface abundances.
Effects of the mass loss rate & mixing length parameter.



Effects of mass loss rates and α

8.5 M Z=0.02. Yields.
Effects of the mass loss rate & mixing length parameter.



Effects of mass loss rates and α

- **Peak log ε_{Li} can be as high as 4.3**.
- **For the same initial masses Li yields increase with decreasing Z**
- Li is enriched at the surface for a brief period of time in the early TP-SAGB. Therefore **higher mass loss rate at this phase can extract much more Li.**
  - If mass is tranferred to a companion star at this time, the surface of this companion star would be significantly enhanced in Li.
- **Increasing the mixing length parameter actually decreases the Li yields** because the Li peaks for a shorter time, even when the temperature at base of convective envelope is higher.

Conclusions

- Li yields are highly dependent on the mass loss rates.
  - Rapid mass loss rates lead to significant enhancement of Li.
  - The presence of a close companion might strip off the envelope at the early AGB and lead to the enrichment in Li of the accreting star.
- The scatter of Li yields for different initial masses tends to increase with decreasing Z.
- For the same initial masses Li yields increase with decreasing Z.
- Higher Z stars make more Li in total.