Post-AGB stars in the Magellanic Clouds as tracers of the s-process nucleosynthesis

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FNRS Contact Group Meeting

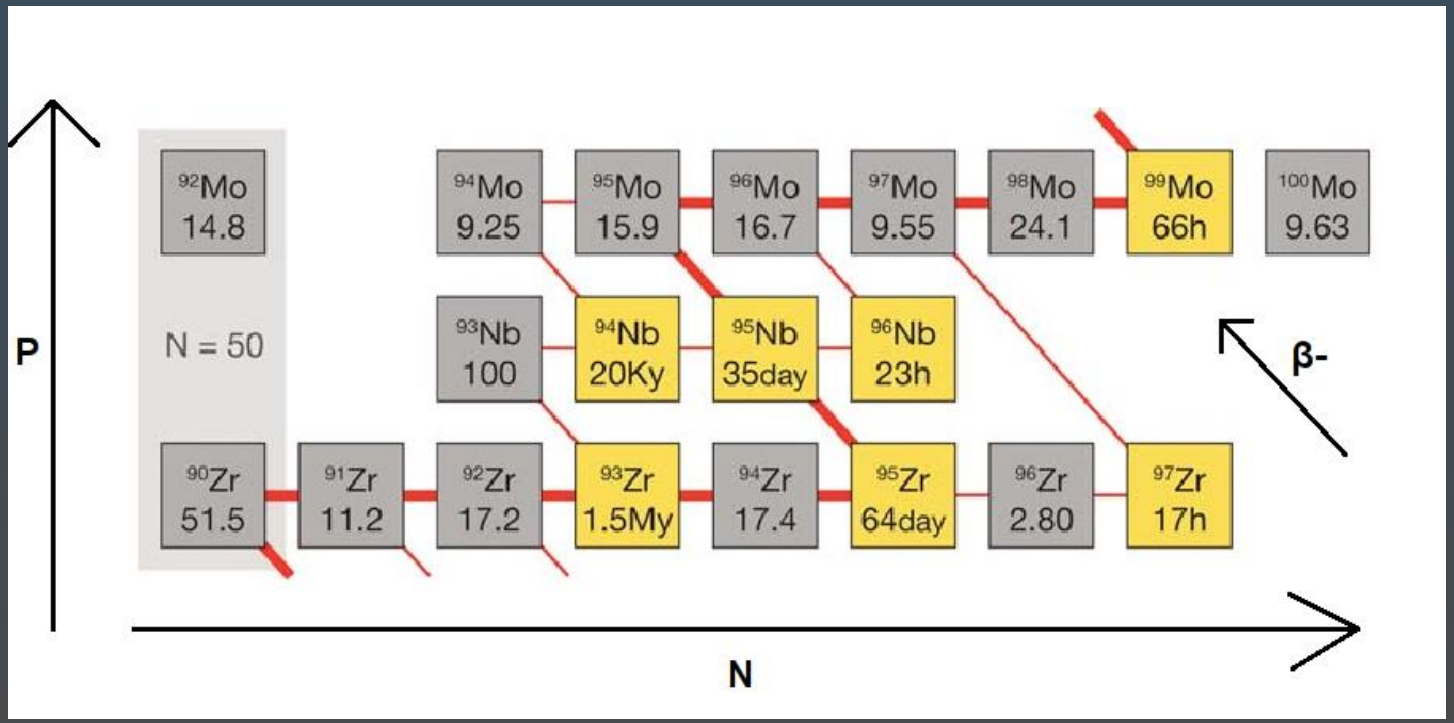
KU LEUVEN

S-process

Origin of approximately half of all elements with Z > 26

Slow neutron capture w.r.t. β^- decay

Creation of elements heavier than Fe: A > 56

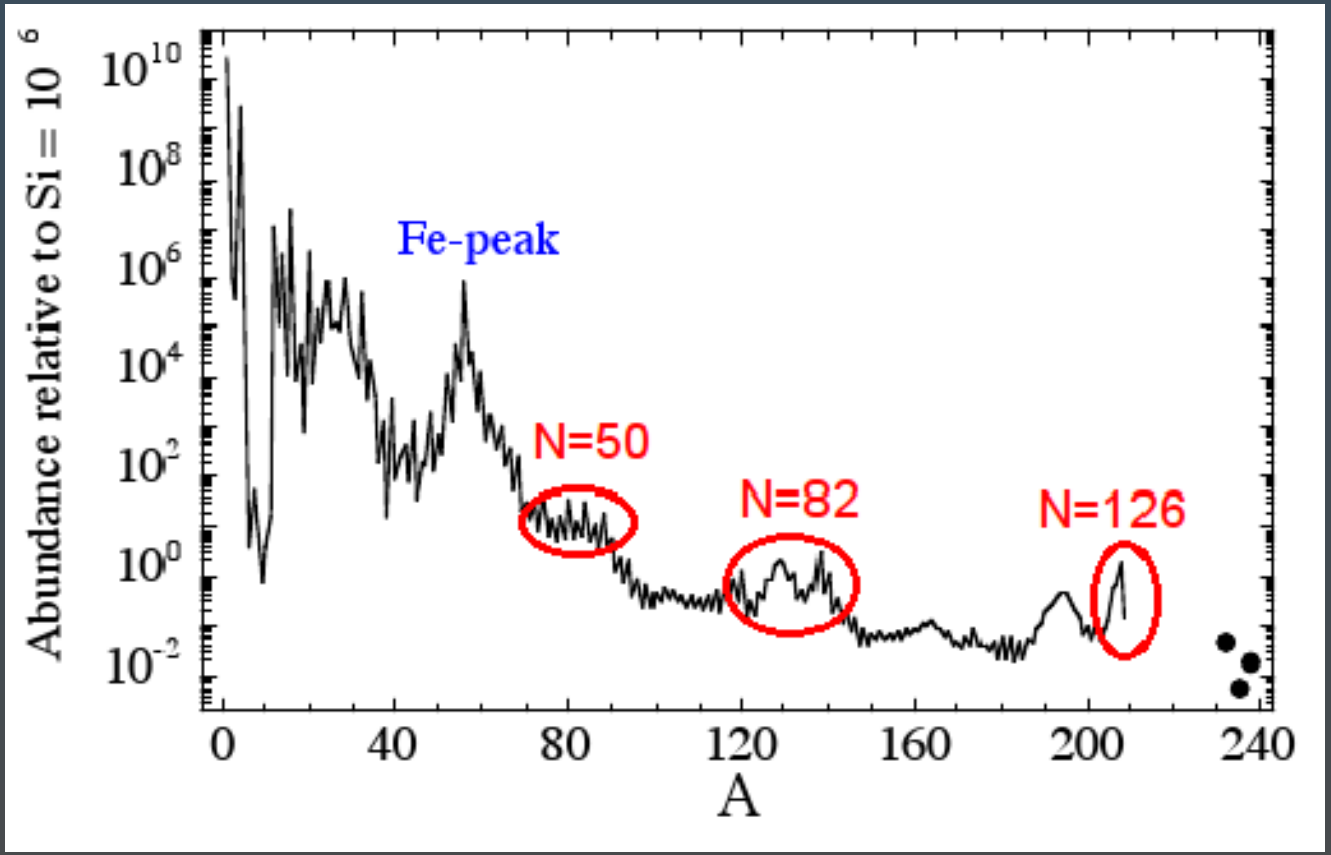


Example of s-process branch

S-process in the solar system

Three s-process peaks at magic neutron numbers

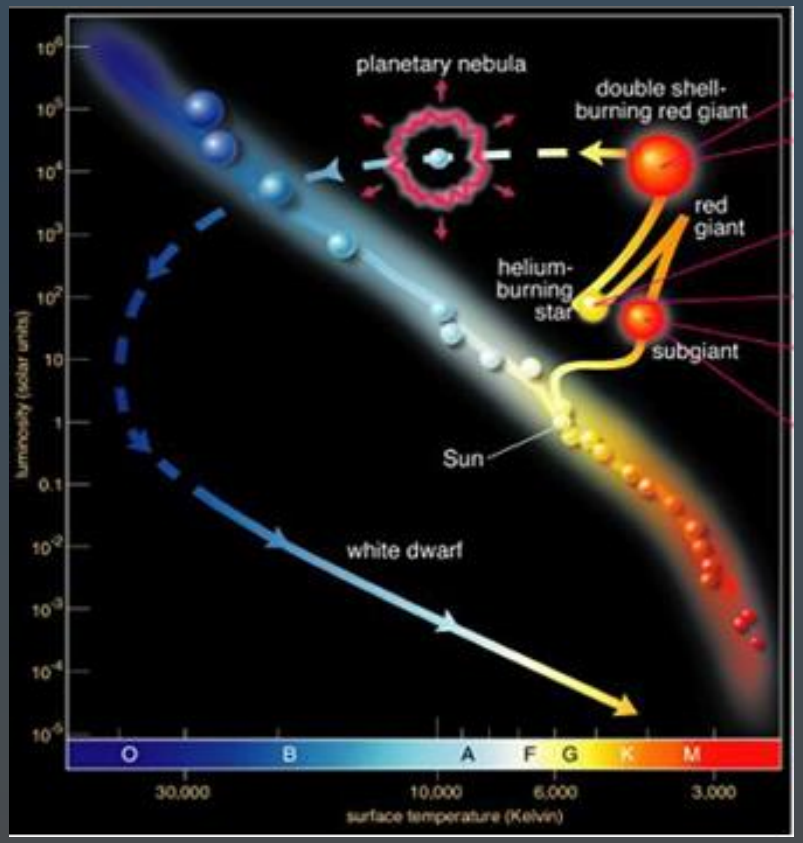
Closed neutron shells (N=50, N=82, N=126)



Solar abundances with s-process peaks

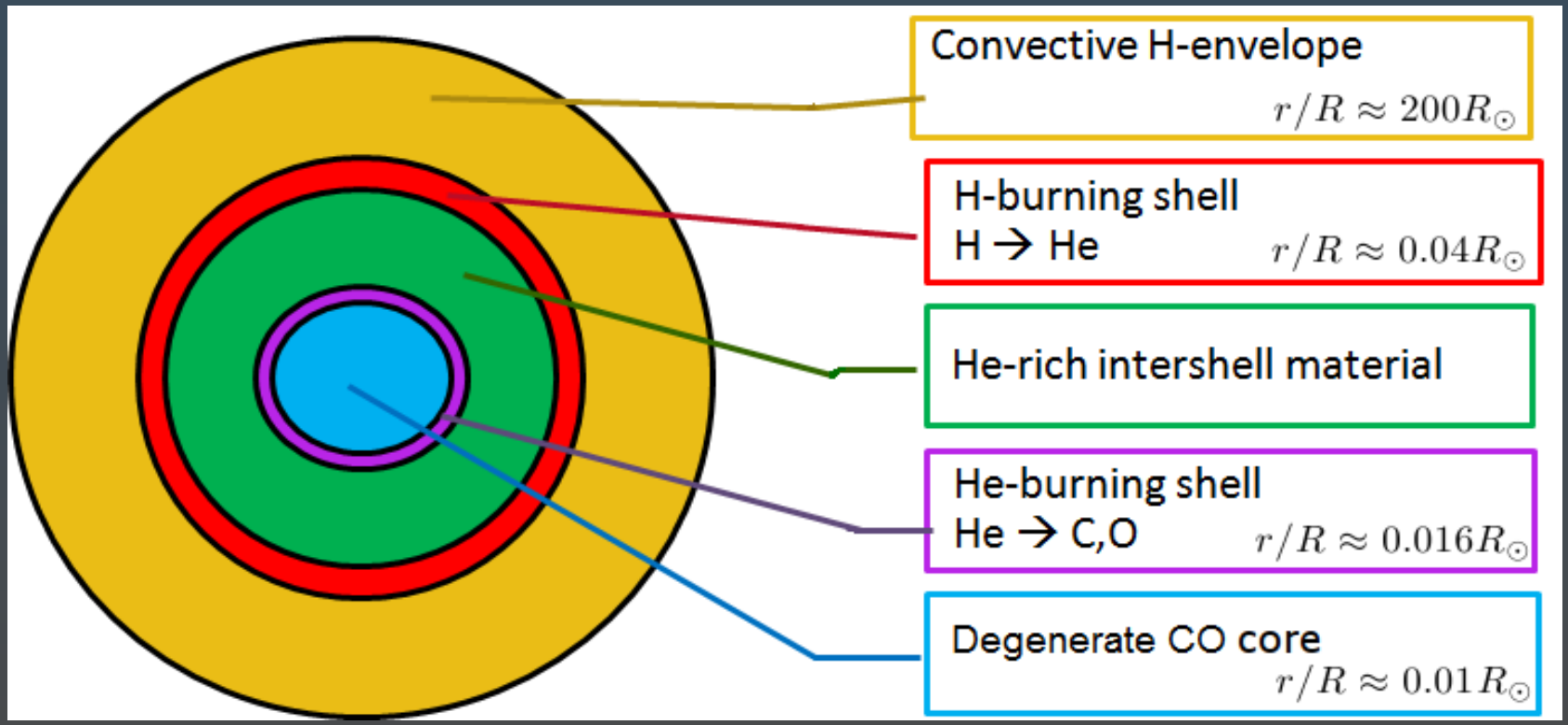
AGB and post-AGB stars

Low and intermediate mass stars ($M_\star \leq 8M_\odot$)



Solar evolution in HR diagram

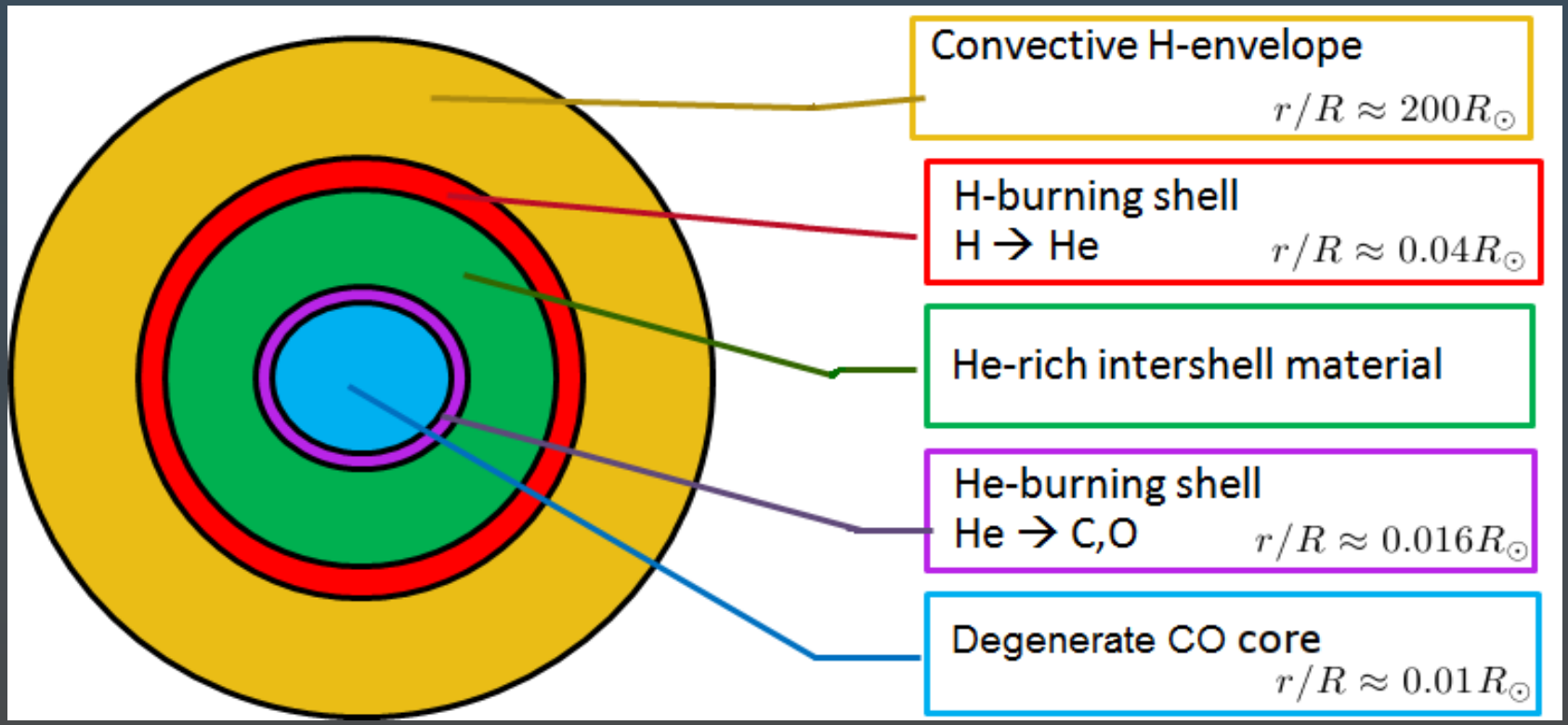
Interior AGB star



Sketch of the interior of an AGB star (not on scale)

AGB nucleosynthesis in a nutshell

- Thermal pulses mix He-burning ashes (^{12}C) in intershell



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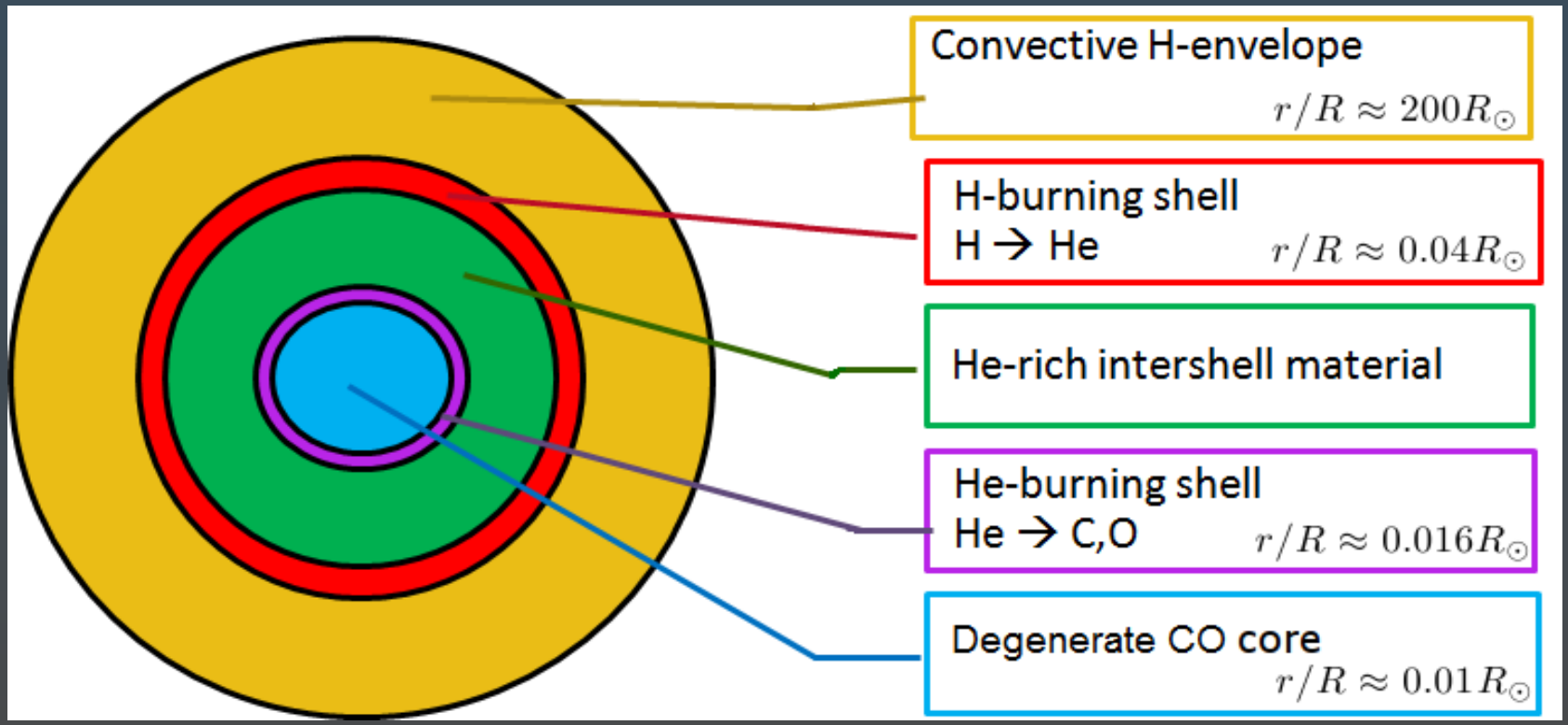

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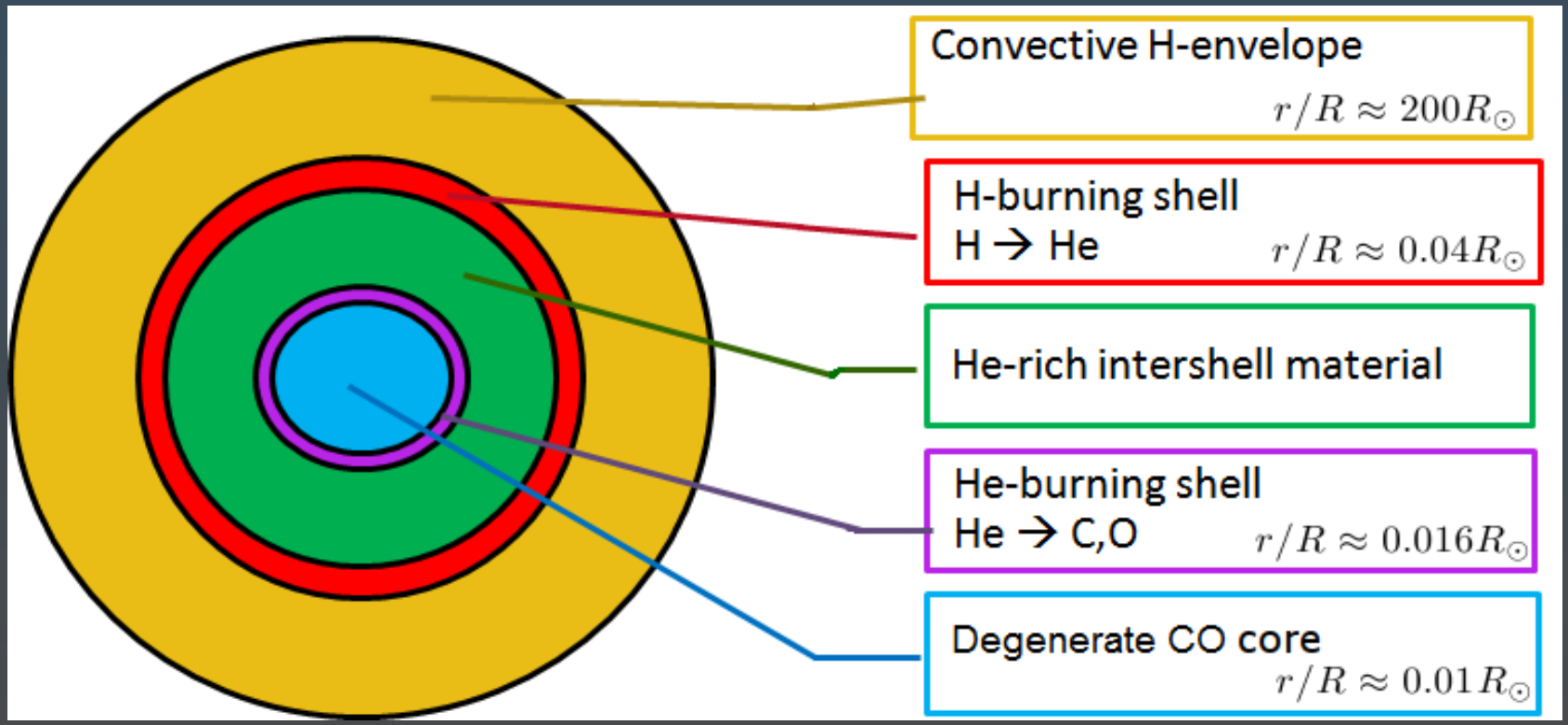

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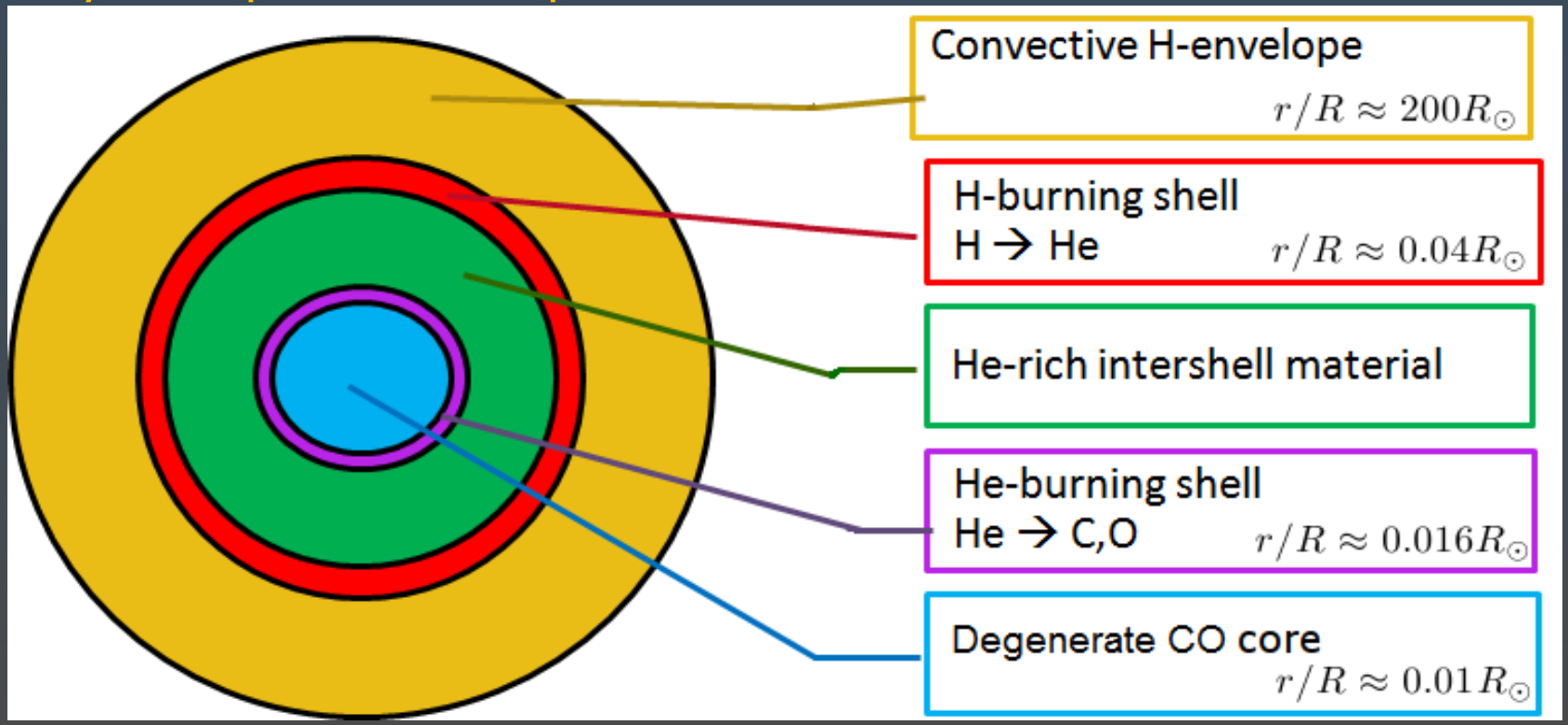
- Cycle repeats: transport of ^{12}C and s-elements



Sketch of the interior of an AGB star (not on scale)

AGB nucleosynthesis models

Systematic observations needed:

- Constrain many assumptions
- Constrain assumed parameters
  - Mixing
  - Rotation
  - Overshooting
  - …

Galactic sample

Large chemical diversity

- Strongly enriched
- Not enriched
- Depleted
- Mildly enriched (very rare)

Unknown distances:

Systematic interpretation difficult

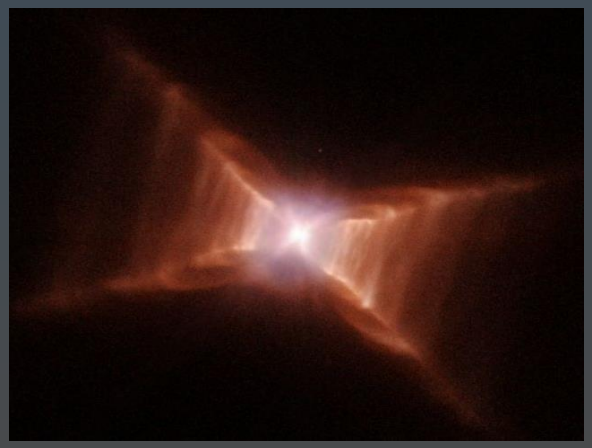
Goal of PhD thesis

Study of the s-process in extra-galactic post-AGB stars in broad metallicity and luminosity range to better constrain s-process and 3rd dredge-up physics

Why post-AGB stars

- Photosphere dominated by atomic transitions
- No more strong mass-loss
- End products s-process and 3rd dredge-up

IRAS 13208-6020

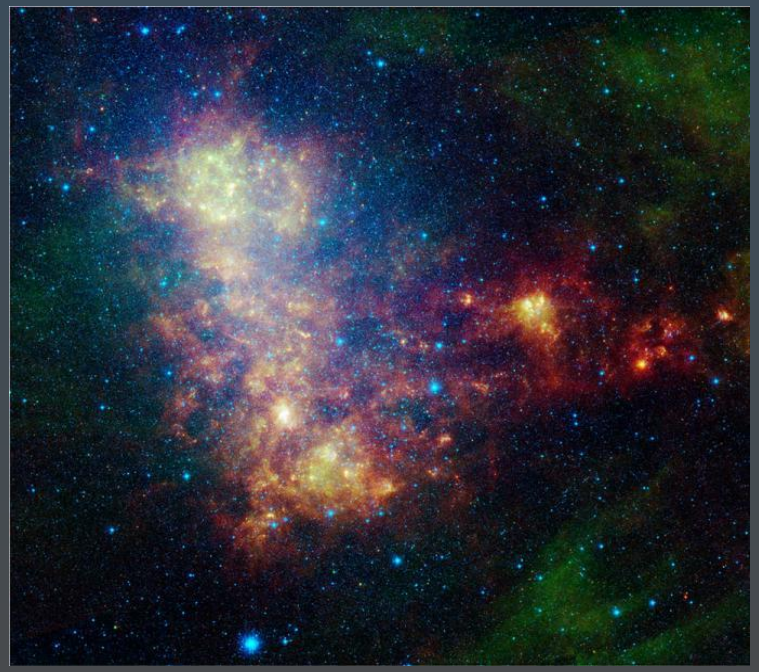


Red Rectangle (HD44179)

Magellanic Clouds

Why extra-galactic?

- Constraint distance to star: luminosity → initial mass
- Range in metallicity



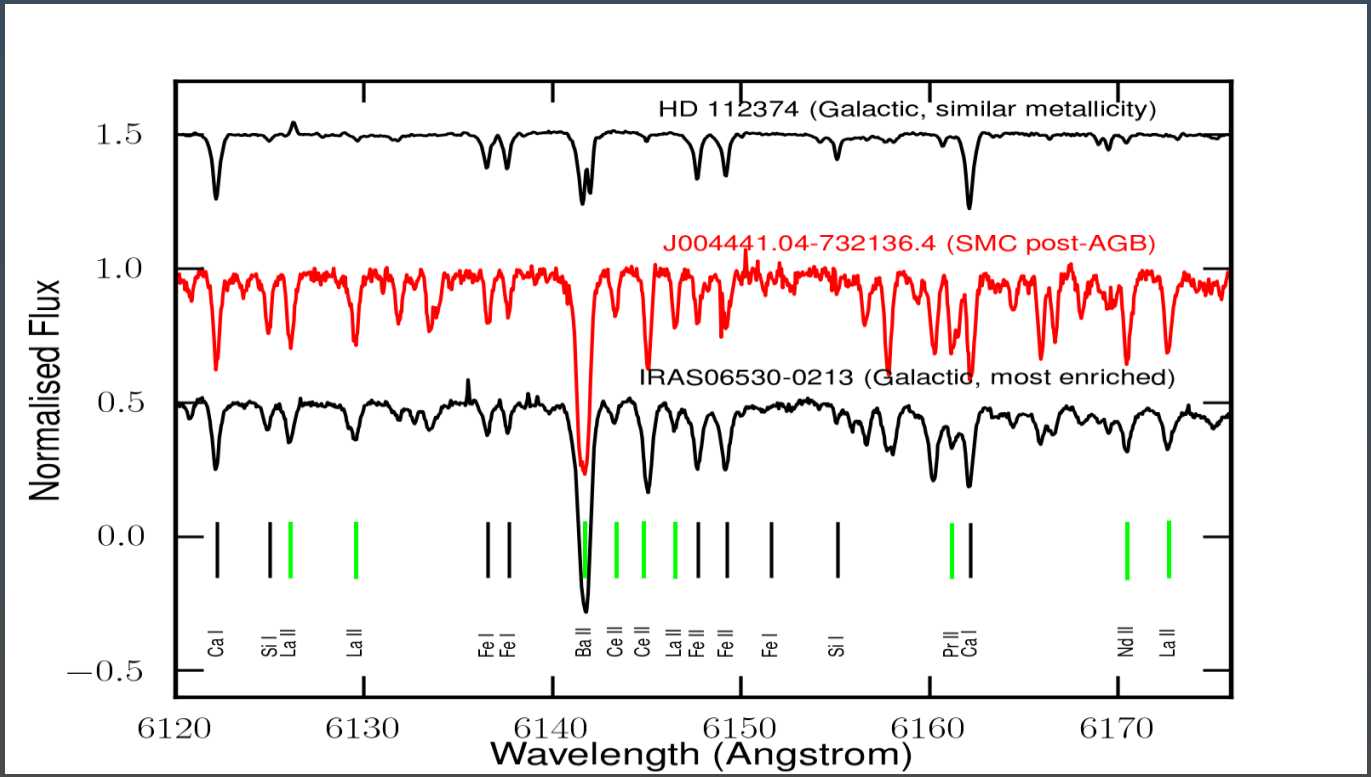
Spitzer image SMC

Spitzer image LMC

Post-AGB spectra

- Enriched vs non-enriched
- Atmospheric parameters
- Abundance determination

Survey
- van Aarle et al., 2011, A&A 554, 106
- Kamath et al., 2014, MNRAS 439, 2211



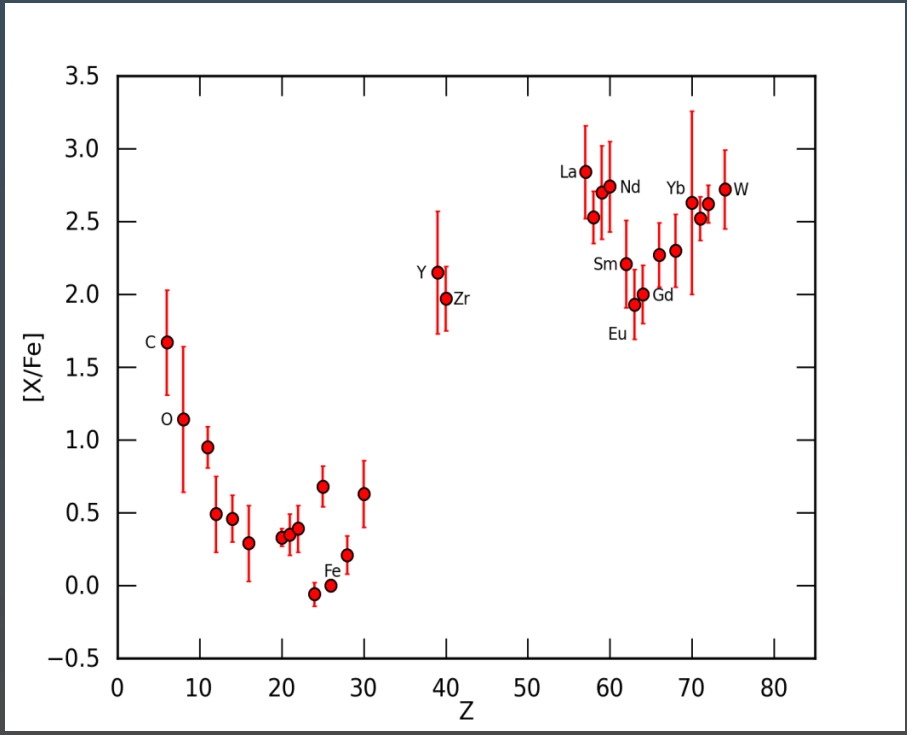
Spectra of 3 post-AGB stars

De Smedt et al, 2012,A&A,541,67

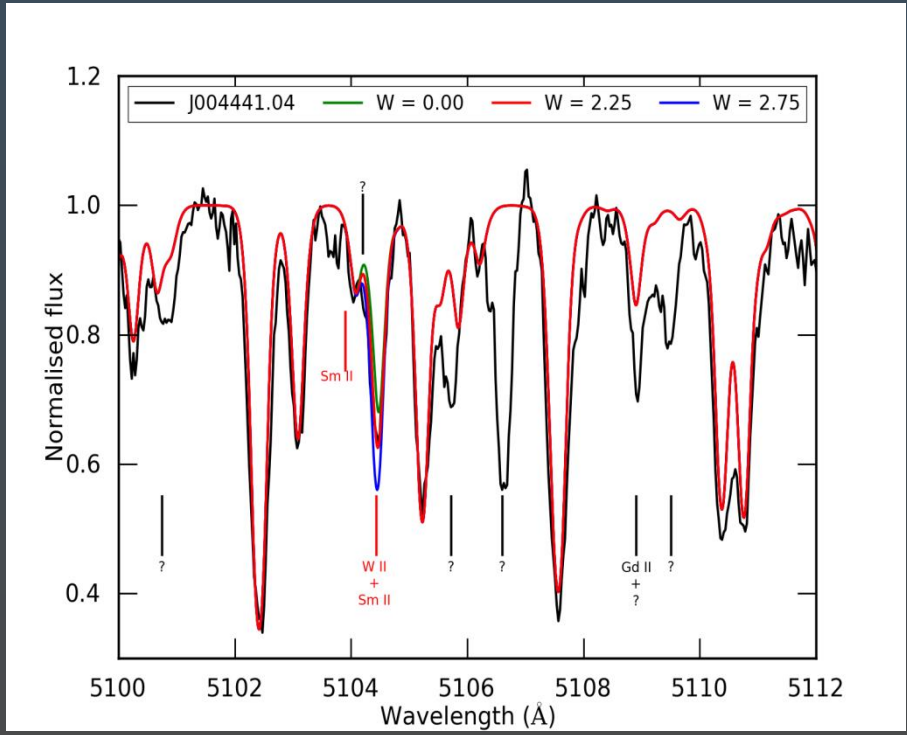
Abundance analysis

- Example star: J004441.04-732136.4
- Via EW calculation (MOOG) and spectral synthesis
- Element over Fe ratio shows enrichment
- Low metallicity

De Smedt et al, 2012,A&A,541,67



Element over Fe ratio

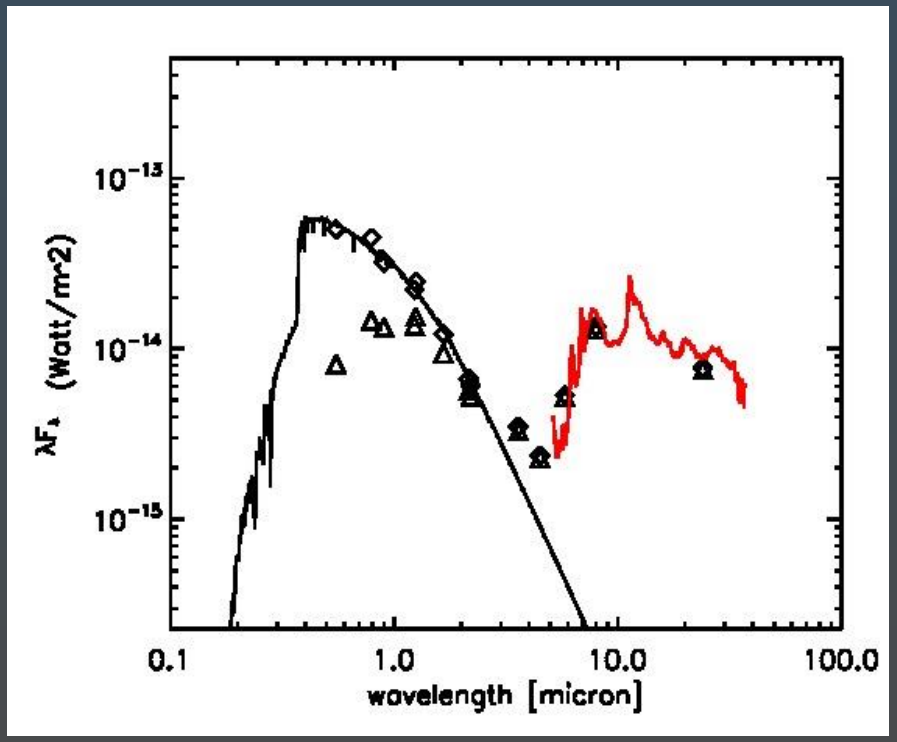


Spectral synthesis

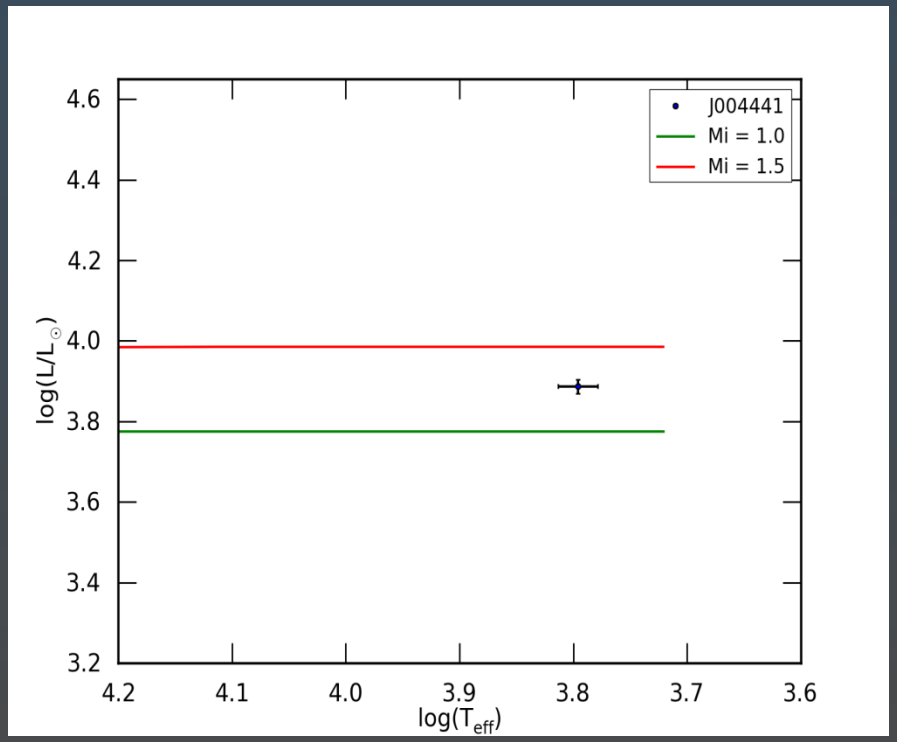
SED and initial mass

- SED gives luminosity
- Initial mass via theoretical post-AGB tracks
- Low mass

De Smedt et al, 2012,A&A,541,67



SED

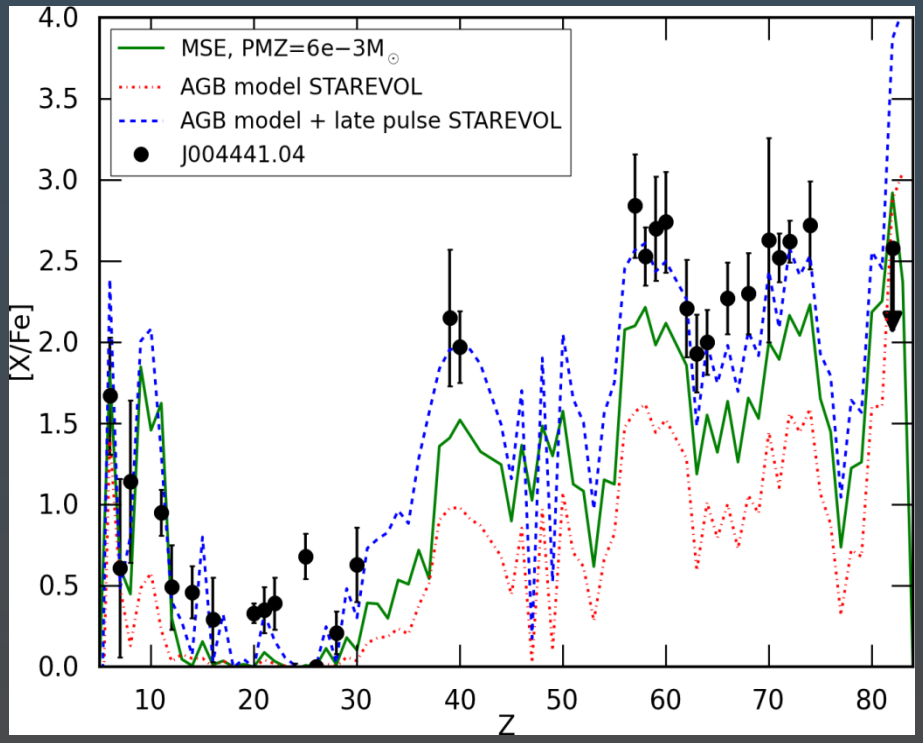


Initial mass determination

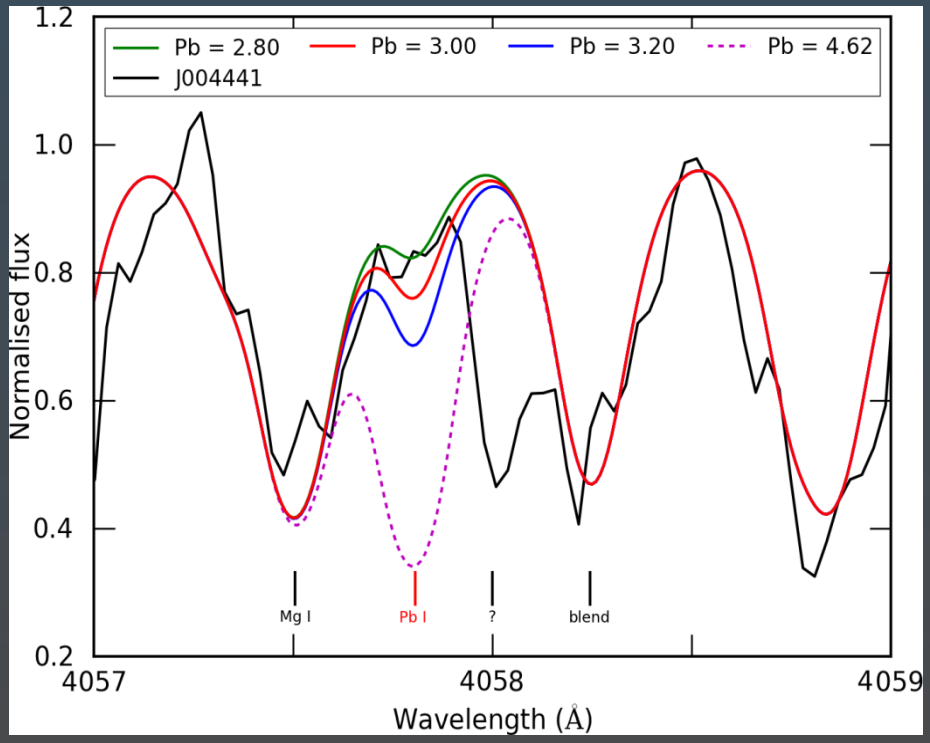
Observations vs models

- Reproduction abundance profile
- No absolute abundance reproduction
- C/O overestimated
- Strong Pb discrepancy

De Smedt et al, 2014,A&A,563,5



Model predictions vs observations



Pb abundance vs model

General conclusions

LMC and SMC post-AGB stars:

- Chemically very diverse (see upcoming papers)

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LMC and SMC post-AGB stars:

- Chemically very diverse (see upcoming papers)
- S-process enriched subsample:
  - ideal test model predictions
  - Conclusions:
    - Models reproduce abundance distribution
    - BUT: absolute abundances poorly fitted
    - O strongly underestimated
    - Pb production strongly overestimated

Thank you for your attention

Questions?