The impact of n_TOF data on s-process nucleosynthesis

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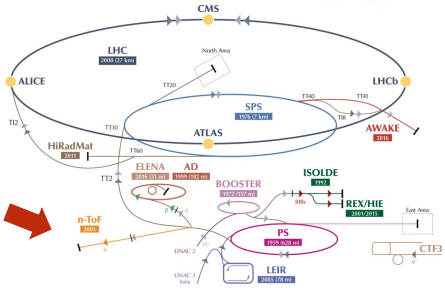
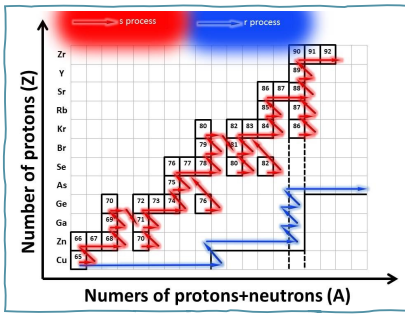
n_TOF @ CERN

Since 2001, neutron-induced cross section measurements have been performed at the neutron time-of-flight facility n_TOF at CERN. So far, (n,γ) data have been collected for ^{24,25,26}Mg, ^{54,57}Fe, ^{58,59,62,63}Ni, ^{70,72,73}Ge, ^{90,91,92,93,94,96}Zr, ^{139}La, ^{140}Ce, ^{147}Pm, ^{151}Sm, ^{154,155,157}Gd, ^{171}Tm, ^{186,187,188}Os, ^{197}Au, ^{203,204}Tl, ^{204,206,207}Pb and ^{209}Bi isotopes, while others (^{78,79}Se, ^{94,95,96}Mo, ^{94}Nb, ^{160}Gd, ^{176}Yb) are being studied.



The CERN accelerator complex

Stellar nucleosynthesis

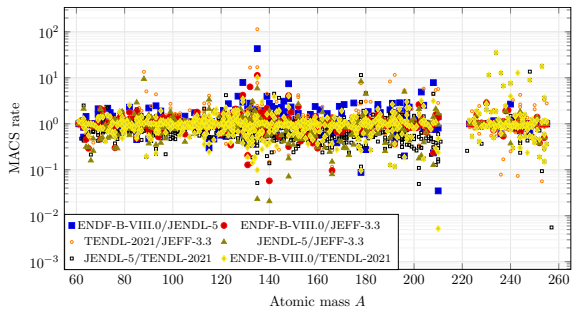


- Neutron radiative capture (n,γ) reactions and beta decays account for the production of elements heavier that iron in stellar interiors;
- Based on different time scale, two processes can be recognised:
  - s (= slow) process, and
  - r (= rapid) process;
- About half of the elements are produced by the *r process* (in explosive scenarios like supernovae, neutron star mergers, …);
- The other half is produced by the *s process* in Red Giant Stars during helium burning phases (the neutron capture chain moves along the valley of b stability).

MACS

The main nuclear physics input for the study of the s-process nucleosynthesis is the complete network of (n,g) cross sections averaged over the stellar neutron energy spectrum, the so-called Maxwellian Averaged Capture cross Section (MACS).

We have developed an automated procedure to derive pointwise MACS for temperatures between 10 and 1000 MK, using the data from evaluated nuclear data files (ENDF format), in the format required by FUNS [1]. Then, we have repeated stellar model calculations while varying the nuclear data input.

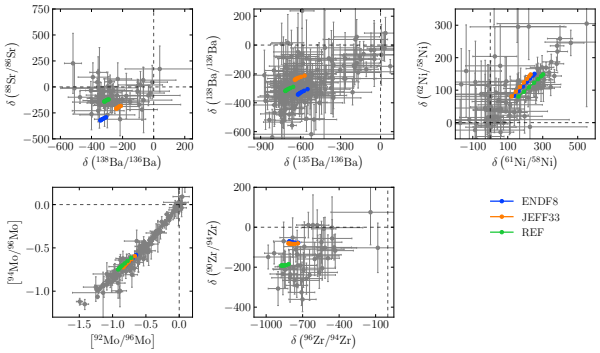


Ratios of MACS at kT = 8 keV from main evaluations

1. C. Cristallo, et al., ApJ S **197** (2011) 17

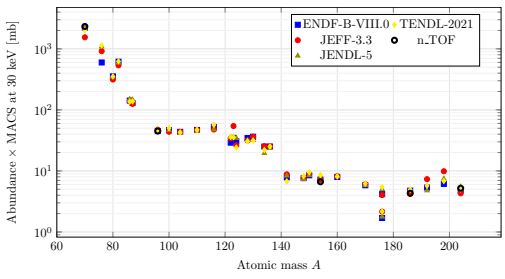
Nucleosynthesis in AGB stars

Refined stellar models for a $2M_{sun}$ asymptotic giant branch (AGB) star with metallicity Z = 0.01 were used to derive s-process abundances. Different (n,g) cross sections from different international evaluations were given as input to the stellar model. The obtained information was then used to interpret pre-solar grain isotopic abundances.



Comparison between AGB model calculations using different nuclear data input and isotopic abundances in pre-solar grains.

The same MACS were also used to compute the sN_s distribution as a function of the atomic mass.



The product cross section times s-process abundances for s-only isotopes

Conclusion

- Improved s_g from n_TOF were used to derive s-process abundances
- Detailed stellar model calculations show that new accurate experimental data are required

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