Measurement of the neutron capture cross section of ^{64}Ni at n_TOF

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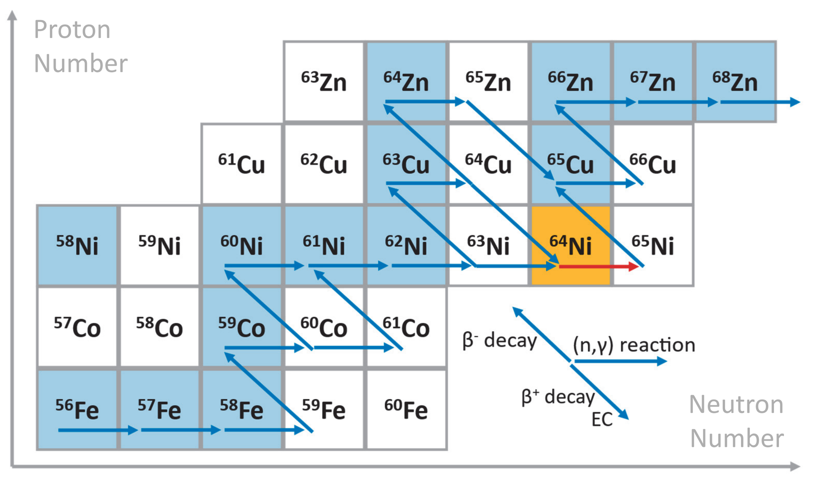
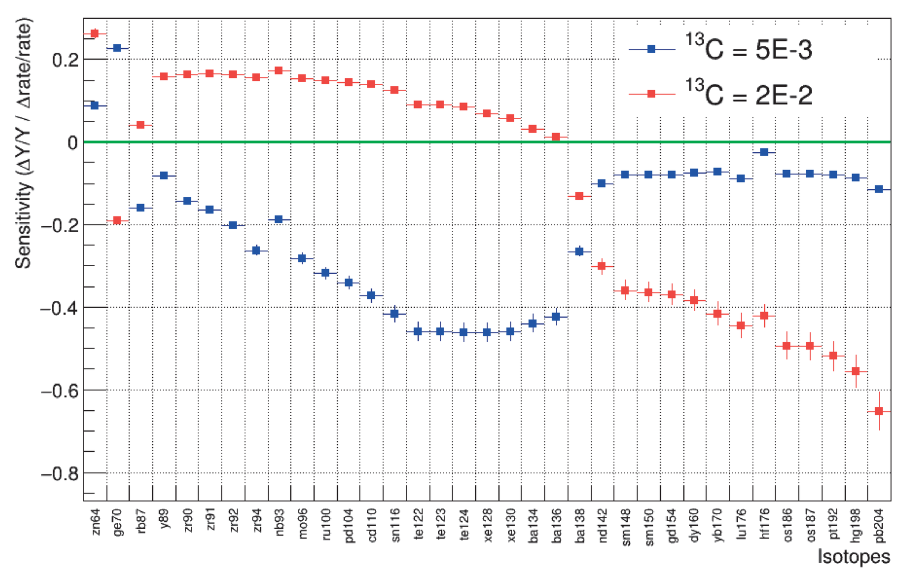
Motivations

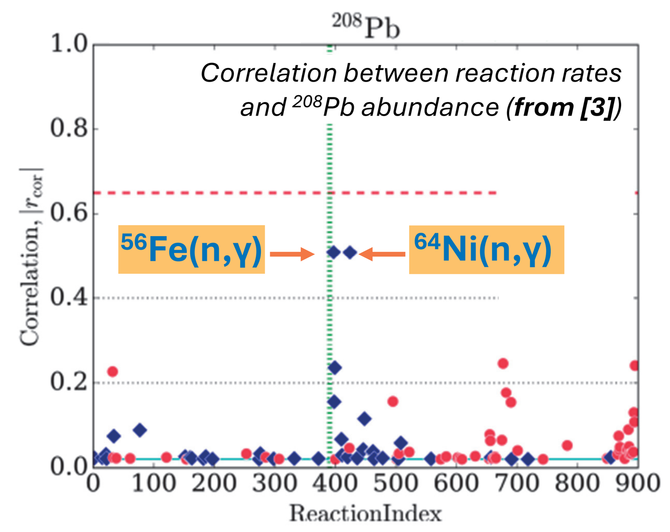
^{64}Ni is one of seeds of the astrophysical **s-process**, a series of neutron capture reactions and beta decays responsible for the nucleosynthesis of half of the nuclei heavier than Iron. Its neutron capture cross section is therefore crucial:



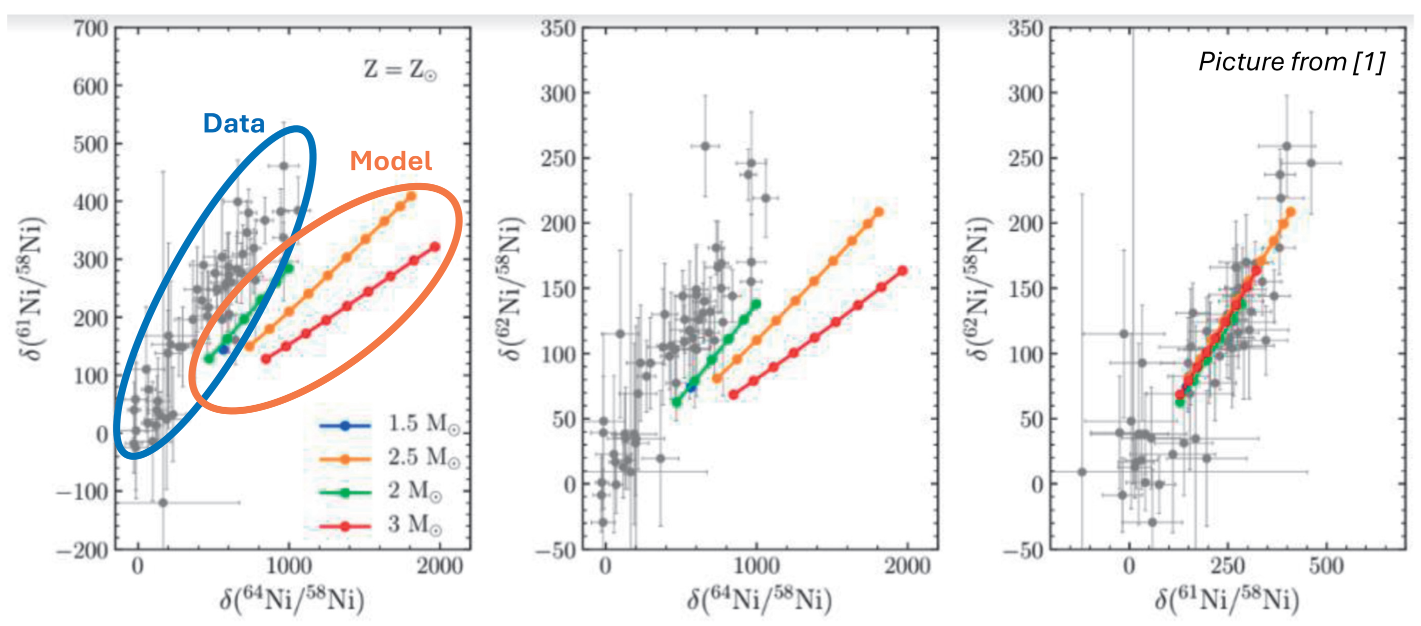
- **to accurately simulate the weak s-process in massive stars** (A < 90), where uncertainties on a cross section are known to propagate on the uncertainties of the abundances of all the heavier nuclei [2]

- **to accurately simulate the main s-process in AGB stars** (A > 90), where the neutron capture rate of ^{64}Ni has been found to importantly affect the abundances of many isotopes later synthesized in the process [3]





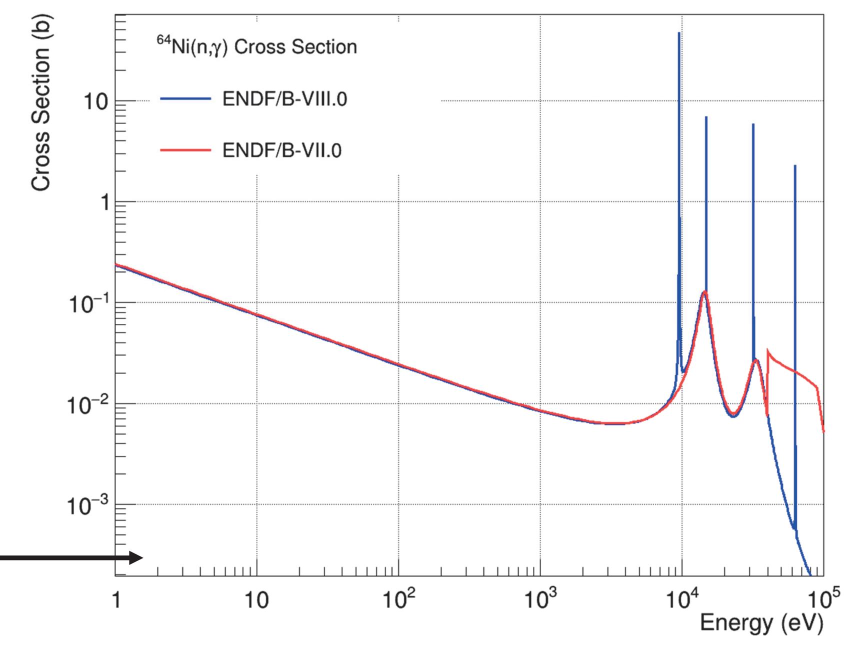
- **to possibly explain the discrepancy observed in presolar SiC grains** between the measured abundance of ^{64}Ni and the predictions from a recently introduced model for AGB stars [4]. Since the model is working for most of the isotopes, the discrepancy could be due to an incorrectness of the input neutron capture rate of ^{64}Ni rather than an incompleteness of the model.

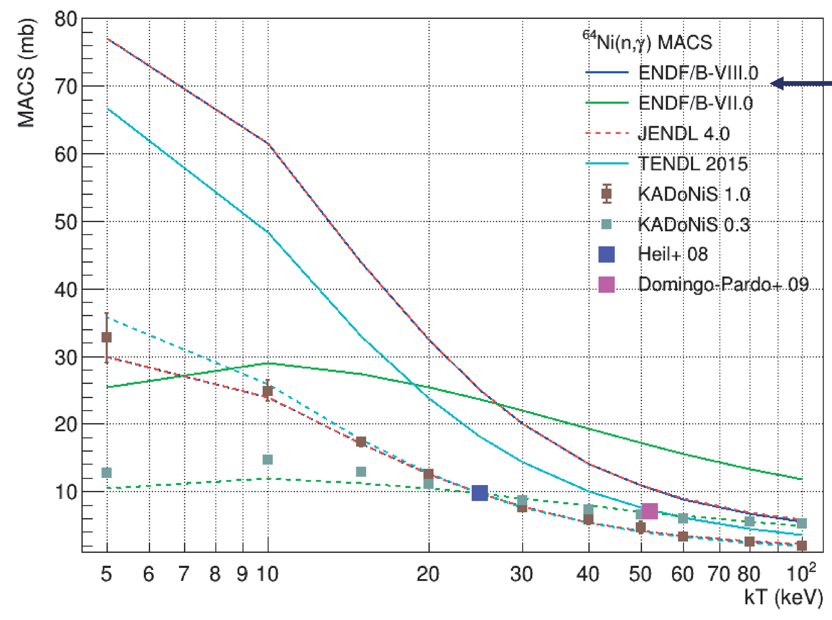


Previous measurements

Time-of-flight measurements of the ^{64}Ni capture cross section reported in literature are **few, discrepant and incomplete**.

The most recent measurement [5] was performed in the **'80s** and it found important discrepancies with respect to previous measurements [6], but without reporting p-wave resonances. Different nuclear data libraries also show huge discrepancies.





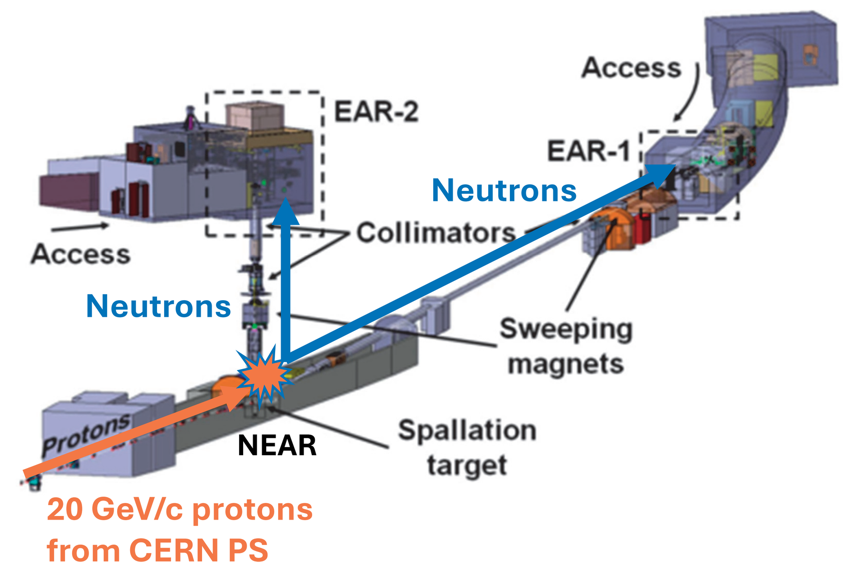
Maxwellian Averaged Cross Sections from activation measurements [7, 8] disagree with values computed from nuclear data libraries.

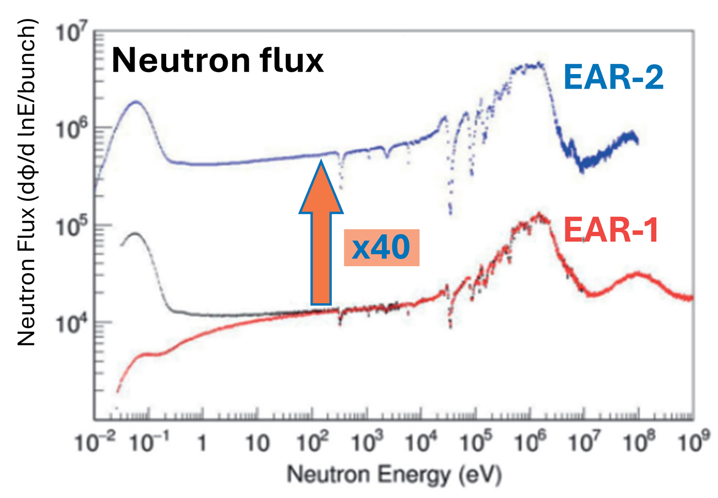
However, their energy extrapolation relies on the discrepant time-of-flight measurements that currently lead to discrepancies larger than a factor 2 at low energy.

The n_TOF facility

The **n_TOF facility** is a pulsed white neutron spallation source at CERN for time-of-flight measurements of neutron-induced reaction cross sections. It is characterized by:

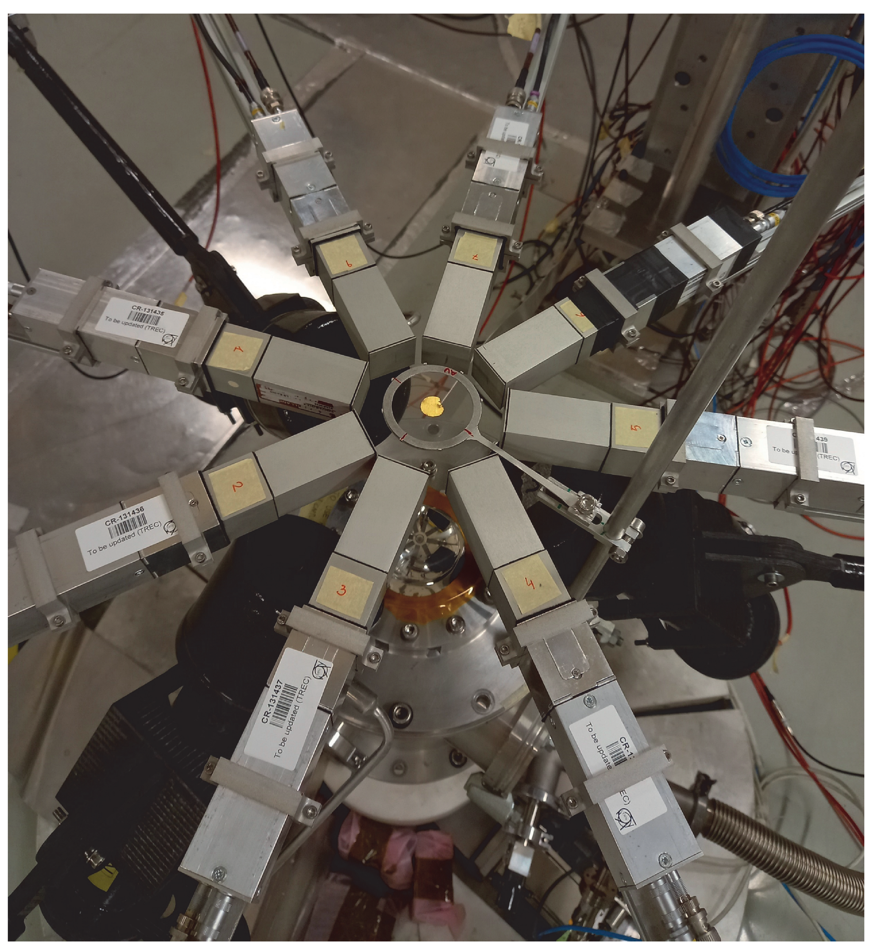
- High neutron flux
- Wide neutron energy range
- Excellent energy resolution





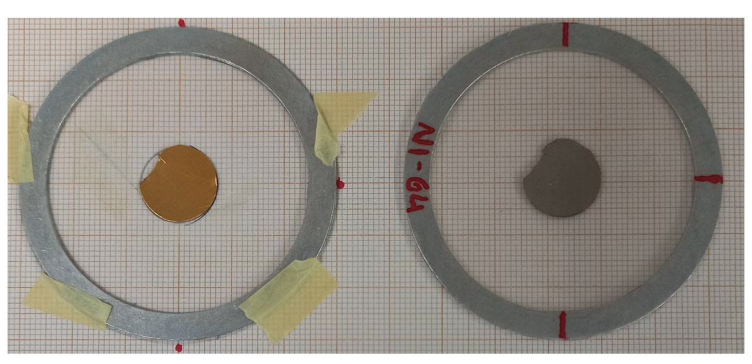
The construction of **EAR-2**, closer to the spallation target and characterized by a higher neutron flux, has enabled the measurement of samples with high radioactivity and/or small mass (down to μg). As a result, the costly ^{64}Ni could also be studied.

Measurement and Data Analysis



The new time-of-flight measurement was performed at n_TOF EAR-2 in 2023 using:

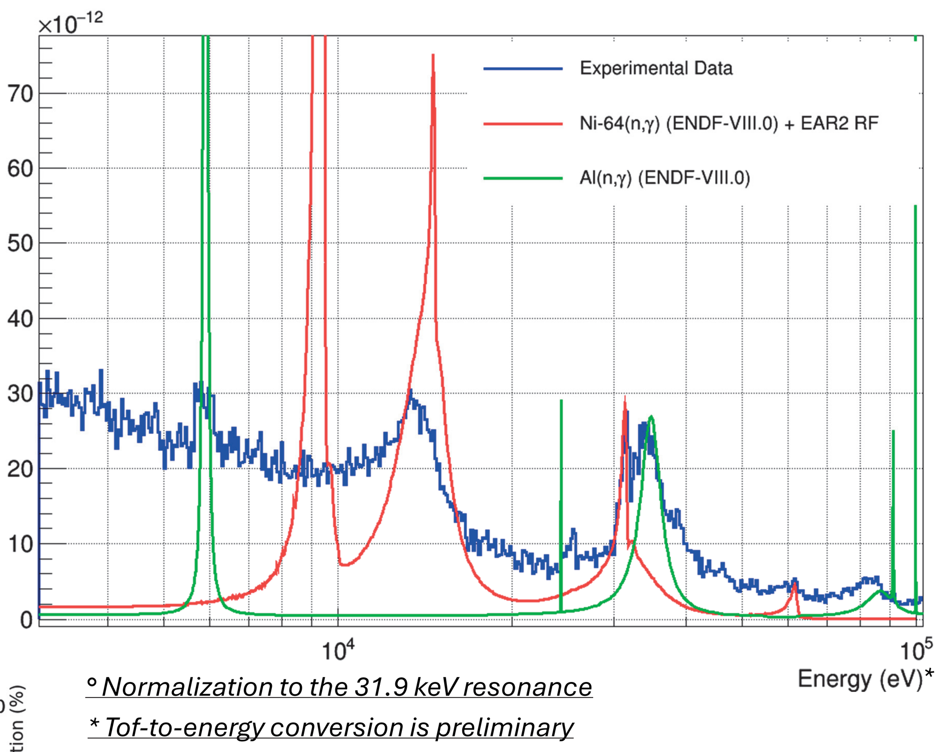
- State-of-the-art **C_6D_6 segmented liquid scintillators (sTED)**, optimized for the higher counting rate of EAR-2
- ^{64}Ni enriched sintered sample (99.5% enrichment)



Data will be analyzed using the **Total Energy Detection** principle combined with the **Pulse Height Weighting Technique** and will be normalized with respect to the 4.9 eV **Gold** resonance.

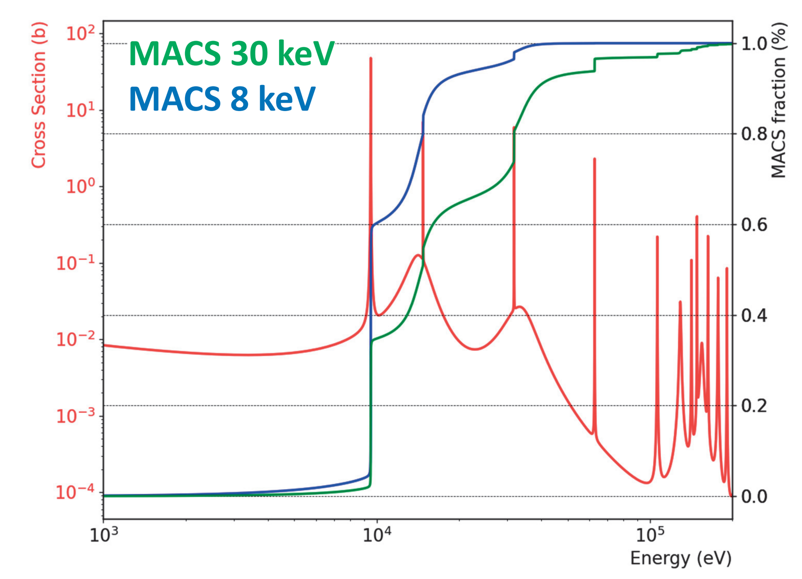
Preliminary Results

- **No resonance at 9.52 keV**
- Evidence for only some of the expected p-wave resonances (31.9 keV, 62.8 keV*)
- Effects due to neutron-capture reactions on **Aluminum** (contamination or neutron-scattering effect)



° Normalization to the 31.9 keV resonance

** Tof-to-energy conversion is preliminary*



MACS at low energy is expected to be smaller than the value reported in the latest nuclear data library releases

Analysis is currently ongoing...

References:

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