Measurement of the neutron capture cross section of ^{30}Si at n_TOF

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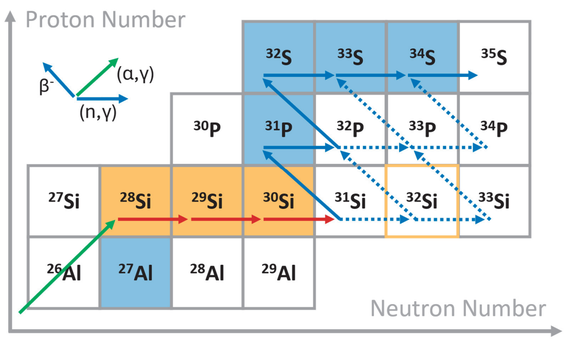
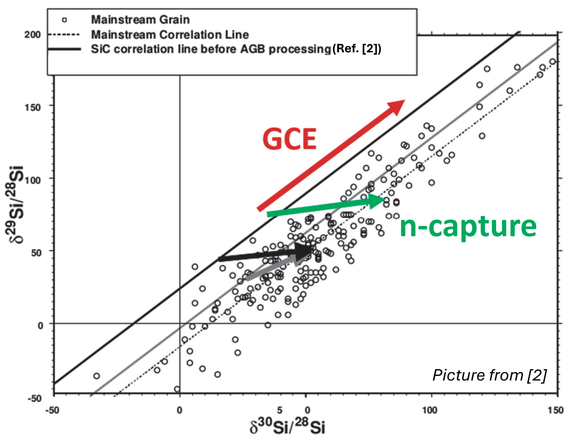
Motivations



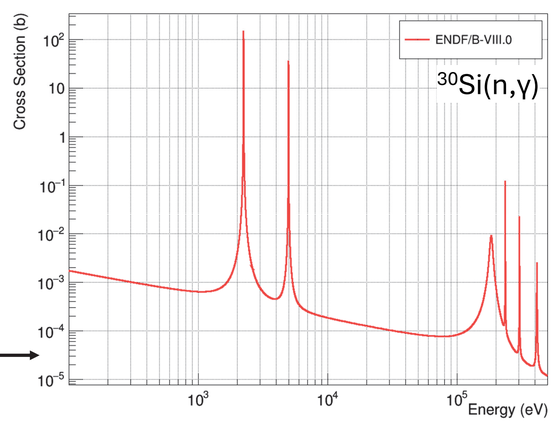
The bulk of the ^{29}Si and ^{30}Si present today in our Solar System is mostly made via neutron capture reactions in the convective carbon-shell of **massive stars** at temperatures about 1 GK.
In these stellar conditions, the ^{28,29,30}Si neutron capture cross sections are crucial to simulate and predict the final yields and the relative abundances of silicon isotopes.



^{28,29,30}Si neutron capture cross section are also important to understand the silicon isotopic abundances measured in **pre-solar SiC grains** formed around AGB stars.
In particular, they are crucial to disentangle the contribution of the internal neutron-capture nucleosynthesis from the contribution of the galactical chemical evolution, that models the composition of the pre-stellar gas.

Previous measurements

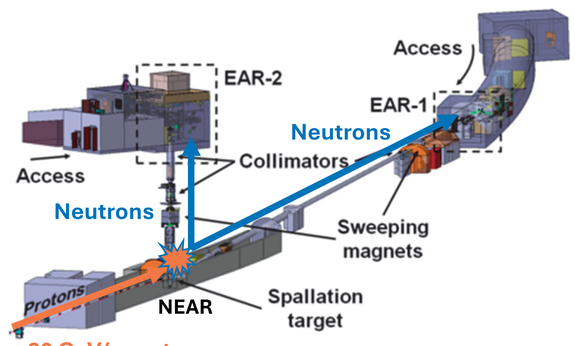
The most recent measurements of ^{30}Si neutron capture cross were performed by Guber et al. (2003) [2] and Beer et al. (2002) [3], but the resulting Maxwellian Averaged Cross Sections were found to **differ by almost a factor 2**. MACS from nuclear data libraries are even more discrepant.



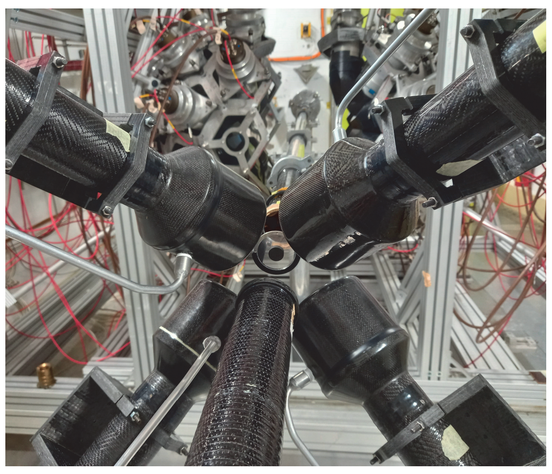
The n_TOF facility

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



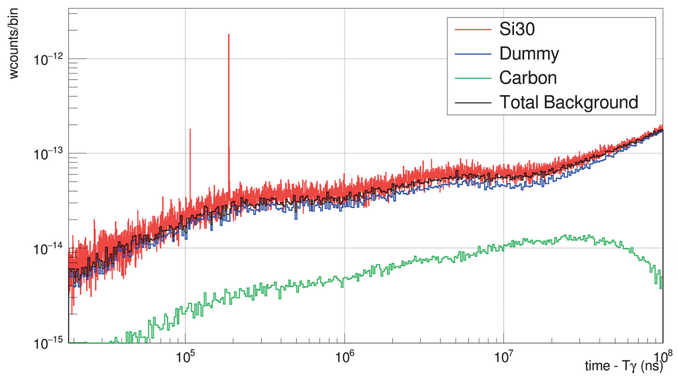
Measurement and Data Analysis



A new **time-of-flight measurement** was performed at both the experimental areas of the n_TOF facility using:

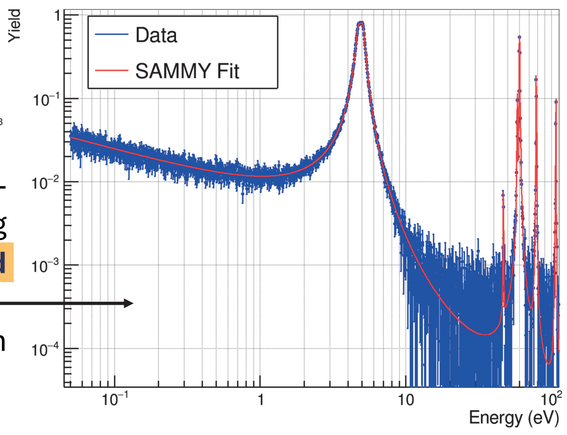
- ❑ State-of-the-art **C_6D_6 liquid scintillators**, optimized to reduce the neutron sensitivity (EAR1)
- ❑ ^{30}Si enriched sintered sample (99.6% enrichment)
- ❑ ^{Nat}Si sample for mass normalization

Data have been analyzed using the **Total Energy Detection** principle, combined with the **Pulse Height Weighting Technique**.



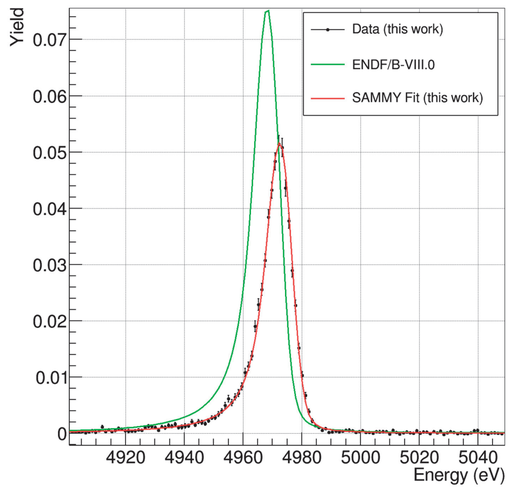
The background has been estimated via dedicated measurements with empty and carbon samples.

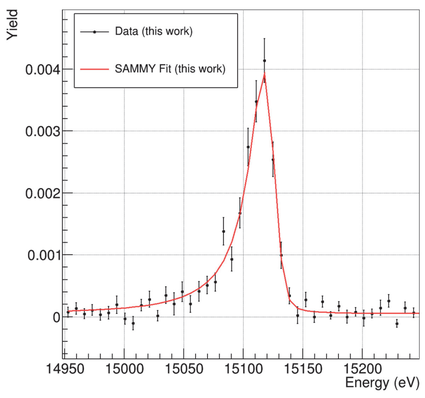
The capture yield and the neutron flight-path have been normalized performing additional measurements with a **Gold sample**.
The R-Matrix-based code SAMMY has been used for resonance analysis.



Preliminary Results

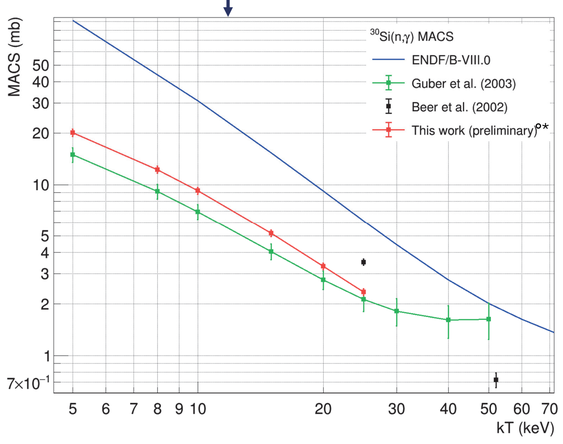
- ❑ No resonance at 2.235 keV
- ❑ Resonance at 15.14 keV (not in libraries, but already observed) is confirmed
- ❑ **Resonance kernels** from this work seem to **disagree** with nuclear data libraries and previous measurements

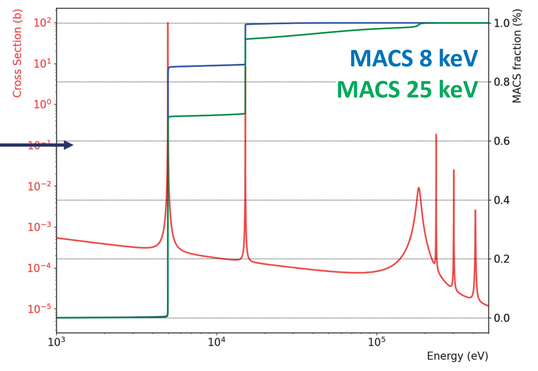




Energy (eV)	Kernel = $g\Gamma_n\Gamma_\gamma/\Gamma$ (meV)			
	This work (preliminary)*	*Guber [2] †*	*Beer [3]*	*ENDF/B-VIII.0*
4981.18	**263 ± 14**	190	410	391
15144.1	**146 ± 11**	94	120	---

- ❑ **Preliminary MACS** calculated with the estimated resonance parameters° (dominant contribution at low energy) also **disagree** with the values from data libraries and previous measurements





👉 **Resonance Analysis to be completed at higher energies**

👉 **Analysis of EAR2 to be completed** for thermal cross section evaluation and cross-check of resonance parameters

** Systematic uncertainty not yet fully evaluated* *† Unpublished data, reported in [3]* *° Direct capture contribution is not yet included*

References:

[1] C. Lederer-Woods et al., CERN-INTC-2023-009/INTC-P-653 (2023)
[2] K. Guber et al., Physical Review C 67, 062802(R) (2003)
[3] H. Beer et al., Nuclear Physics A 709, 453-466 (2002)