Cross section study of the $^{13}\text{C}(\alpha,\text{n})^{16}\text{O}$ reaction at low energy (LUNA collaboration)

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MAIN STEPS

- Physical motivation
- Why underground?
- Study of a possible detector
NUCLEOSYNTHESIS PROCESS

- Big Bang Nucleosynthesis (BBN) for lighest nuclei (H\(^2\) - Be\(^7\))
- A<56: Nuclear fusion (PP, CNO, NeNa, He-Burning…)
- A>56: neutron capture (r o s process) or proton capture (p process)

Neutrons captured in s processes are mainly produced in the reaction*
\[ ^{13}\text{C} (\alpha, n)^{16}\text{O} \quad (Q=2.216 \text{ MeV}) \]
In low mass stars (3 M\(_{\odot}\)) in the Asymptotic Giant Branch (AGB)

In this reaction fast neutrons (\(E_n \approx 2 \text{ MeV}\)) are produced,

*Burbidge, Burbidge, Fowler, Hoyle, Rev. Mod. Phys. Vol 29 (1957), 547-650
THE MEASUREMENT @ LUNA (LNGS)

- Direct kinematic
- Alpha beam (400-200 KeV)
- Enriched $^{13}$C solid target ($10^{18}$ atoms/cm$^2$)

Reaction rate expected at $E_{\text{beam}} = 200$keV

$10^{-4}$ counts/h!!!!

(assuming:
$\langle I \rangle = 200$ $\mu$A
detection efficiency of 100%)

Underground measurements are needed in order to screen the measurement from natural background (cosmic rays, natural radioactivity)
(At LNGS $10^{-6}$ flux of muons, $10^{-3}$ flux of neutrons respect to the surface)
Liquid organic scintillators are sensitive to both fast neutrons (elastic scattering np) and electrons (Compton scattering).

A Pulse Shape Discrimination (PSD) process is needed, in order to select events of our interest.

\[ N(t) = C_s \cdot e^{-(t/\tau_s)} + C_f \cdot e^{-(t/\tau_f)} \]
INTEGRATION RISE TIME (IRT)

\[ FOM = \frac{\Delta \text{peak}}{FWHM_g + FWHM_n} \]
HIGH THRESHOLD VARIATION

FOM vs High Level

- 500 Msample/s
- 2 Gsample/s
GEANT4 SIMULATION EFFICIENCY
COMING SOON

- Underground background neutron measurements
- Study for slow neutrons detection