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

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XXV GIORNATE DI STUDIO SUI RIVELATORI
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MAIN STEPS

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

NUCLEOSYNTHESIS PROCESS

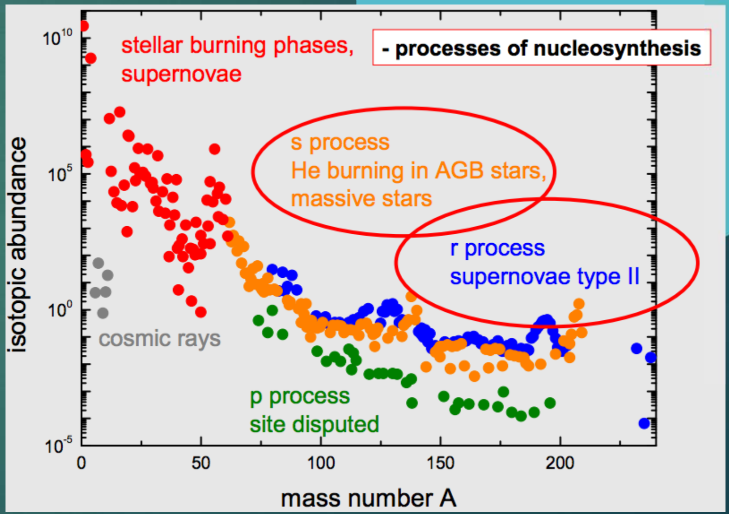
- Big Bang Nucleosynthesis (BBN) for lighest nuclei (H^2 - Be^7)
- A<56: Nuclear fusion (PP, CNO, NeNa, He-Burning…)
- A>56: neutron capture (*r o s process) or proton capture(p process)*

- Neutrons captured in *s processes* are mainly produced in the reaction*

$^{13}C(\alpha,n)^{16}O$ (Q=2.216 MeV)

In low mass stars (3 $M_\odot$) in the Asymptotic Giant Branch (AGB)

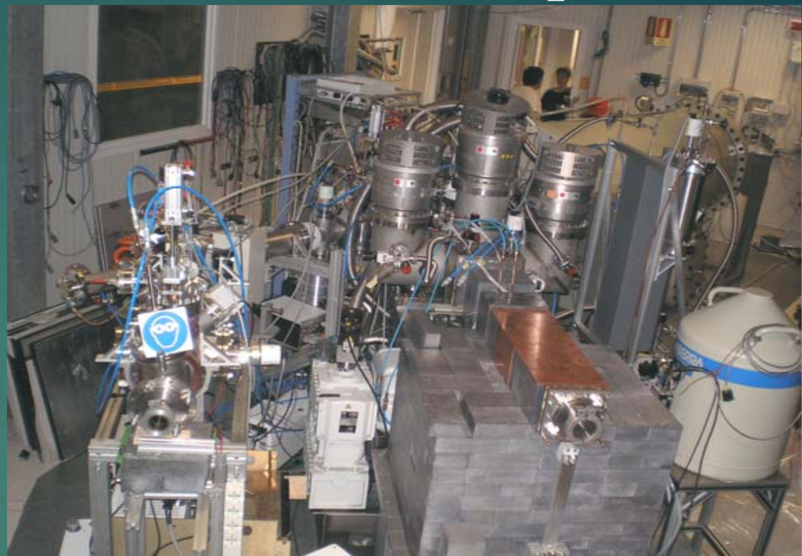
- In this reaction fast neutrons ($E_n \approx 2$ MeV) are produced,



*Burbidge, Burbidge, Fowler, Hoyle, Rew. Mod. Phys. Vol 29 (1957), 547-650

THE MEASUREMENT @ LUNA (LNGS)

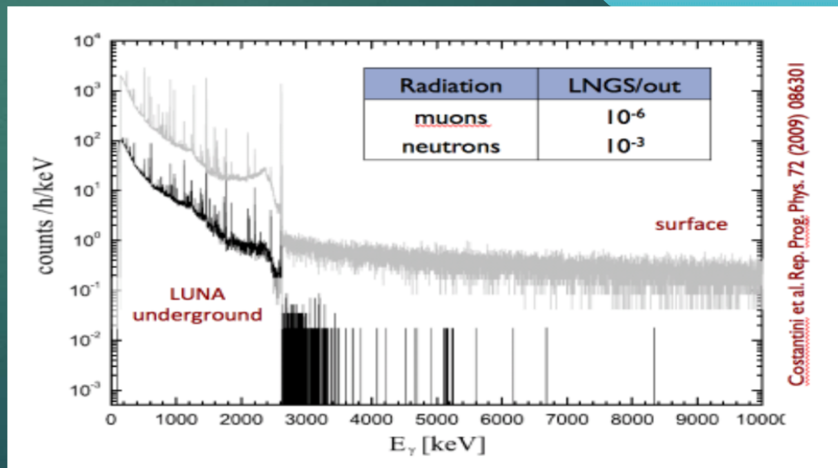
- Direct kinematic
- Alpha beam (400-200 KeV)
- Enriched ^{13}C solid target (10^{18} atoms/cm^{2})



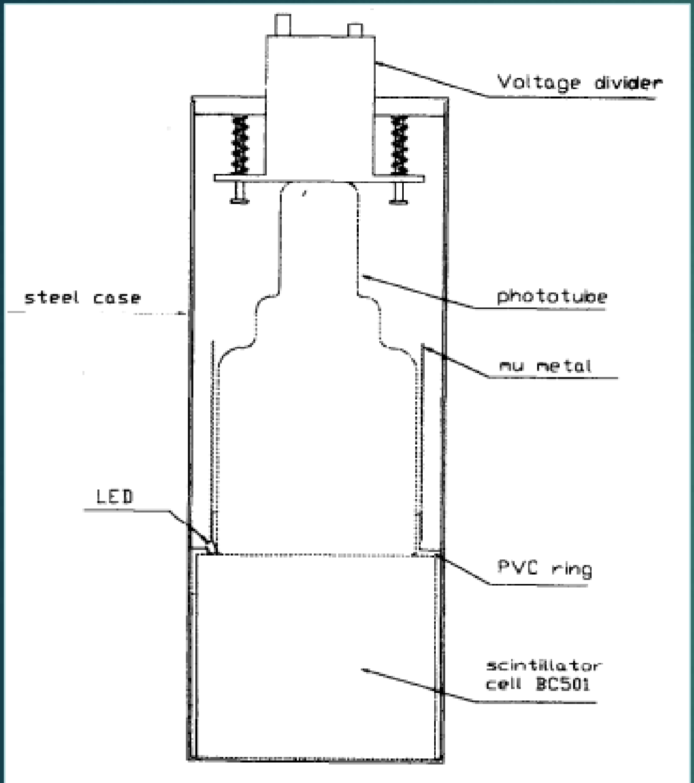
Reaction rate expected at E_{beam}=200keV

10^{-4} counts/h!!!!
(assuming:
<I> =200 μA
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)

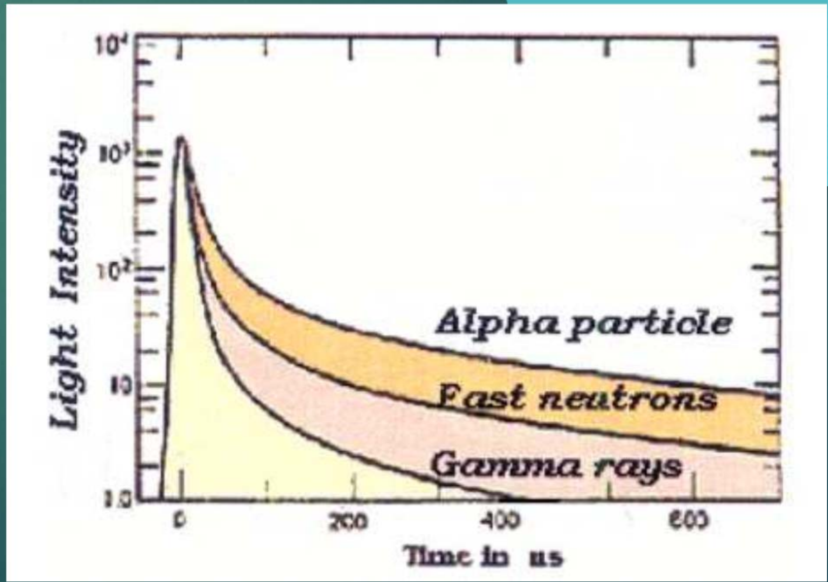


LIQUID ORGANIC SCINTILLATORS & PULSE SHAPE DISCRIMINATION TECHNIQUES

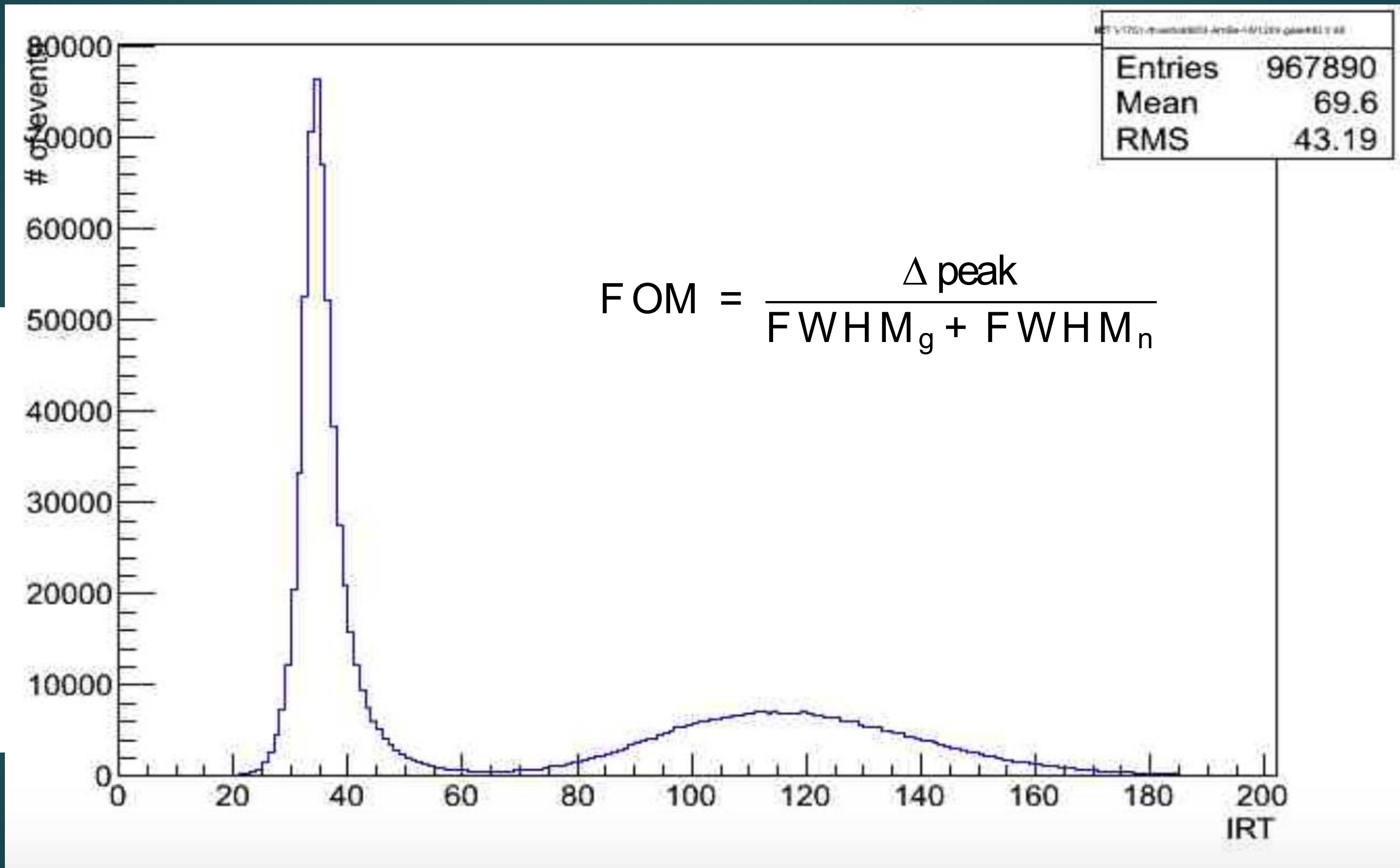


- Liquid organic scintillators are sensible to both fast neutrons (elastic scattering np) and electrons (Compton scattering)
- A Pulse Shape Discrimination (PSD) process is needed, in order to select events of our interest.

$$N(t) = C_s \cdot e^{-(t/\tau_s)} + C_f \cdot e^{-(t/\tau_f)}$$

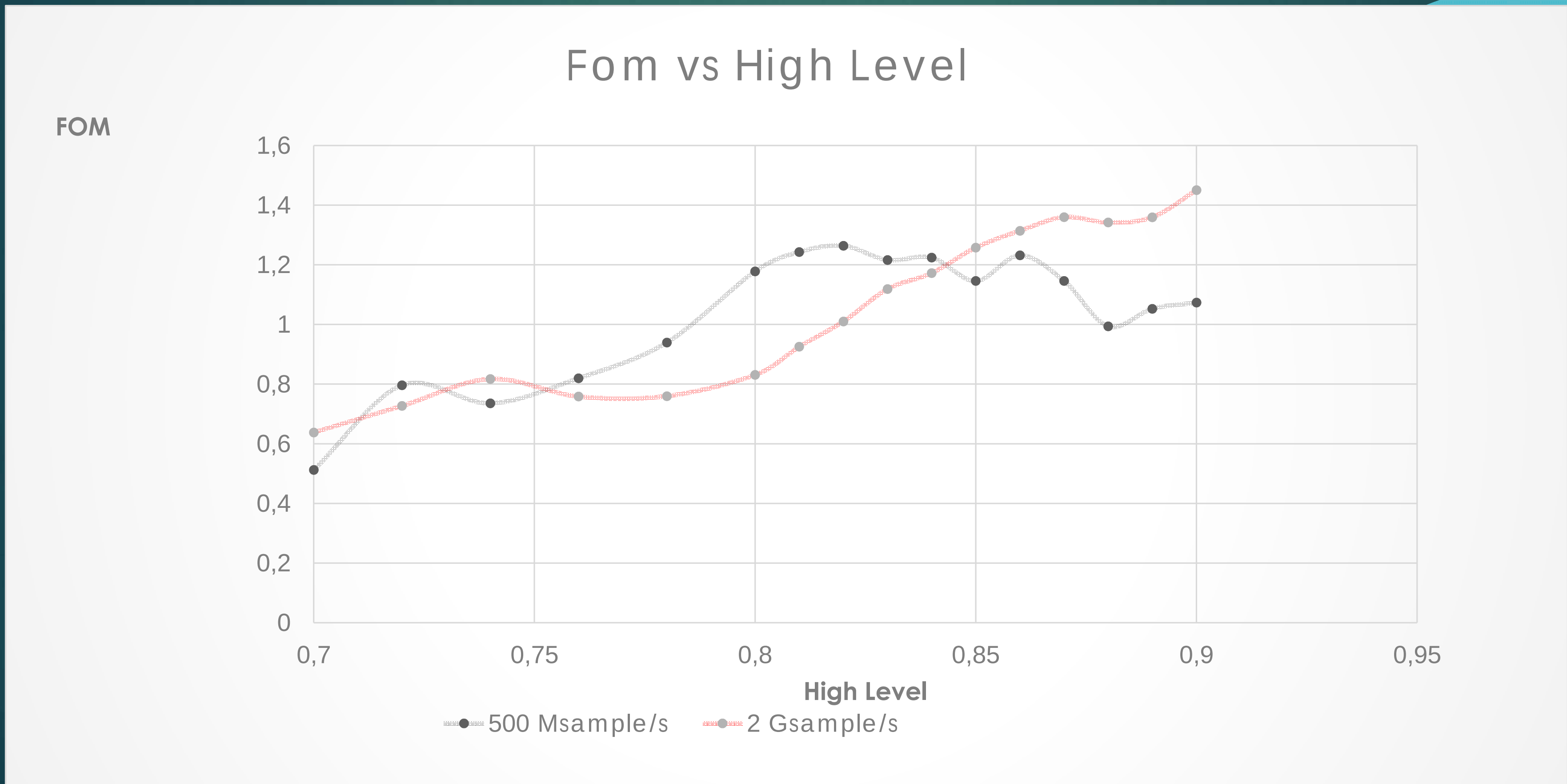


INTEGRATION RISE TIME (IRT)

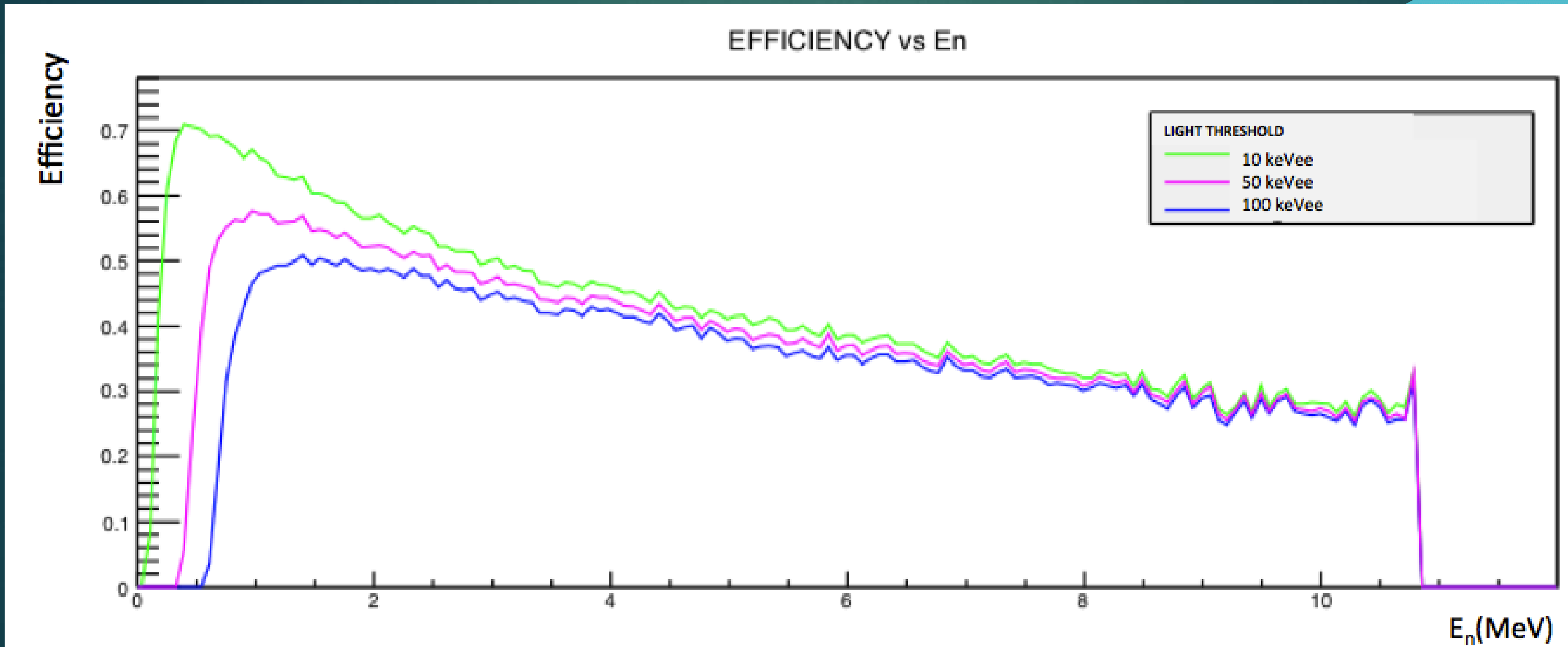


$$FOM = \frac{\Delta\, peak}{FWHM_g + FWHM_n}$$

HIGH THRESHOLD VARIATION



GEANT4 SIMULATION EFFICIENCY



COMING SOON

- Underground background neutron measurements
- Study for slow neutrons detection