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The New Deep-underground Direct Measurement of $^{22}Ne(\alpha,\gamma)^{26}Mg$ with EASγ
A feasibility study

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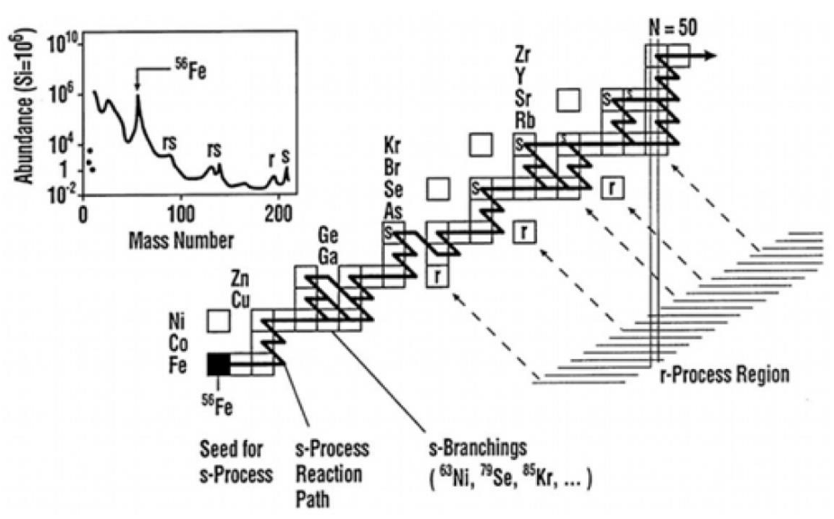
Abstract: The reaction $^{22}Ne(\alpha,\gamma)^{26}Mg$ is associated with several questions in nuclear astrophysics, but its stellar reaction rate remains highly uncertain. This is because all the direct measurements performed so far have been only able to provide upper limits below a strong resonance at 832 keV.
The purpose of EASγ is to perform a direct measurement of $^{22}Ne(\alpha,\gamma)^{26}Mg$ in the range of astrophysical interest (Gamow window) below 600-800 keV and the remeasurement of the well-known 832 keV resonance. The measurement will be performed deep underground at Laboratori Nazionali del Gran Sasso.
In this poster, I will present the current status of the project and the expected sensitivity achieved by EASγ, as predicted by MonteCarlo simulations.

Astrophysical motivation



Kappeler, Mengoni, 2005

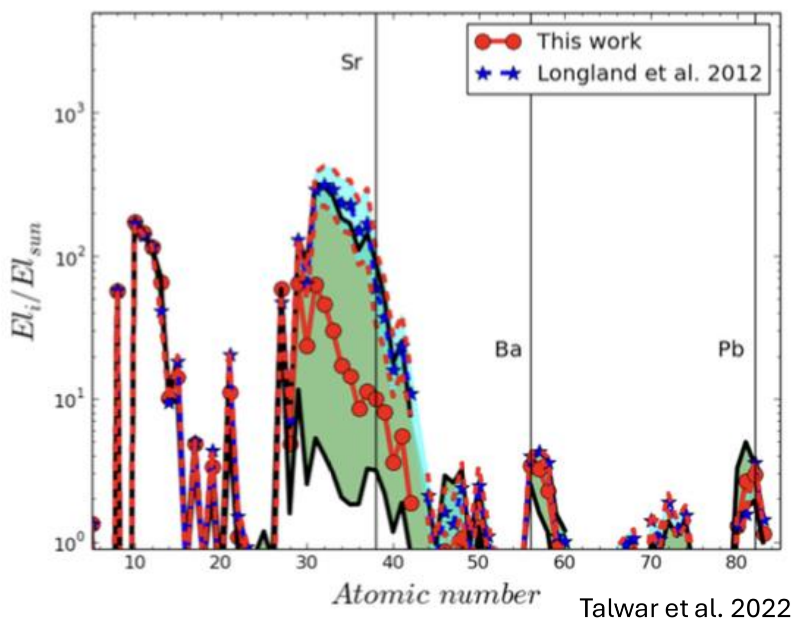
- Isotopic ratios of $^{24,25,26}Mg$ in AGB
- Nucleosynthesis of ^{60}Fe
- Nucleosynthesis beyond Fe through weak component in massive stars
- Abundances of s-only isotopes near branching points in AGB

He burning of ^{22}Ne

$^{22}Ne(\alpha,n)^{25}Mg$ — Q= −478 keV

$^{22}Ne(\alpha,\gamma)^{26}Mg$ — Q= 10614.7 keV

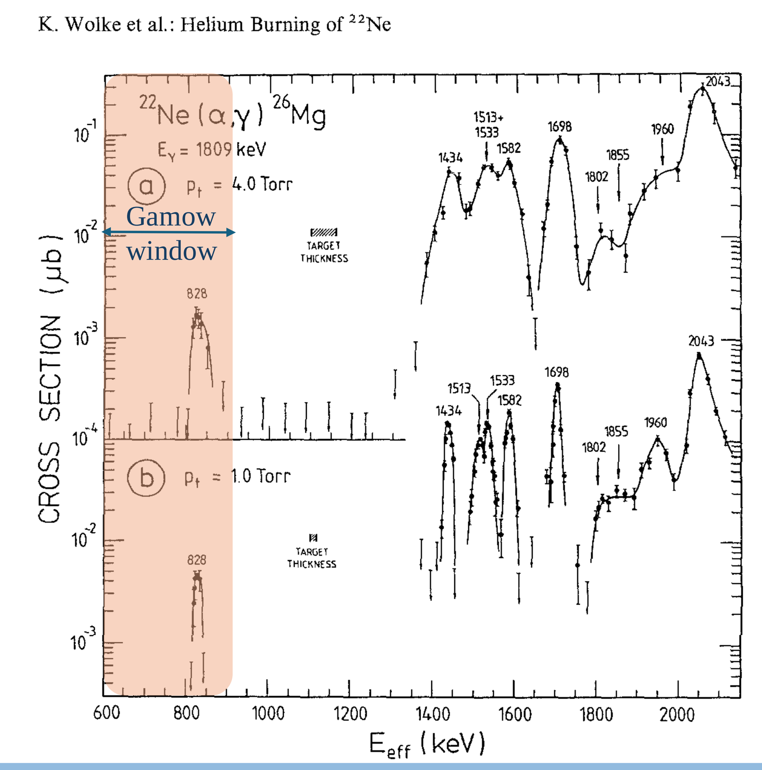
need to determine the reaction rates for both channels



Talwar et al. 2022

State of the art

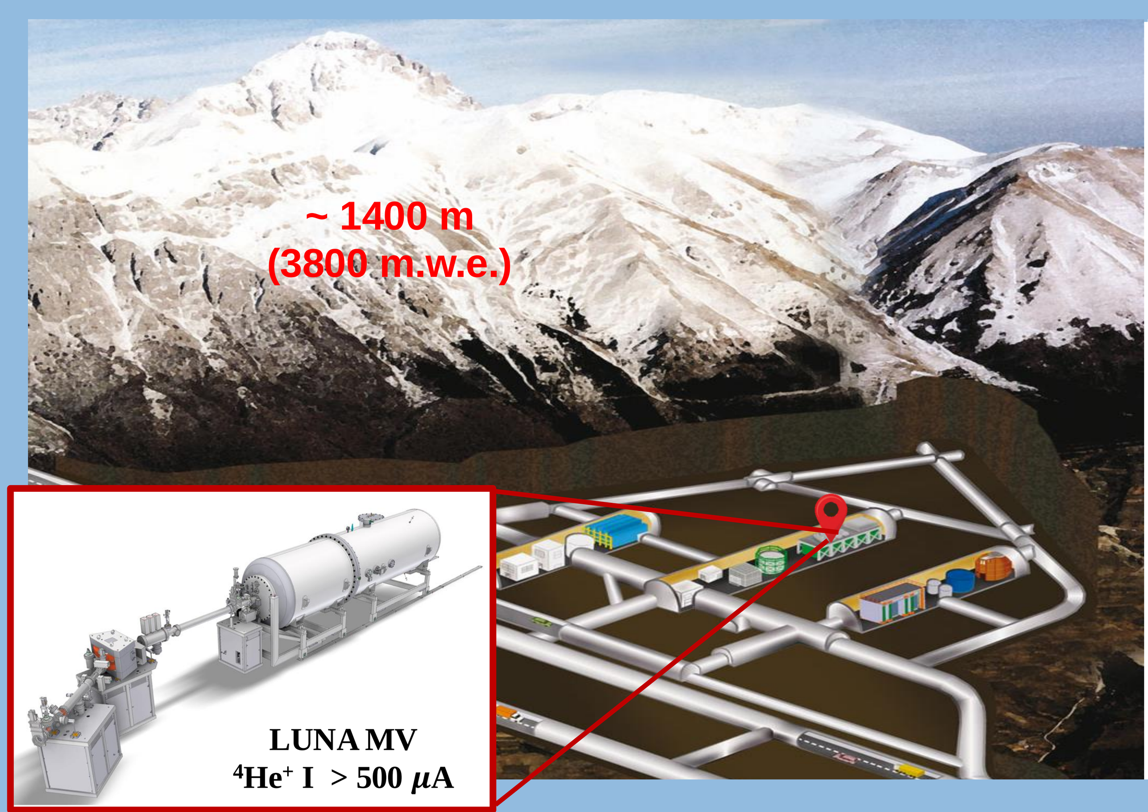
- Low values of energy (hundreds of keV)
- Very low values of X-section (~ pbarn)
- High level density in ^{26}Mg

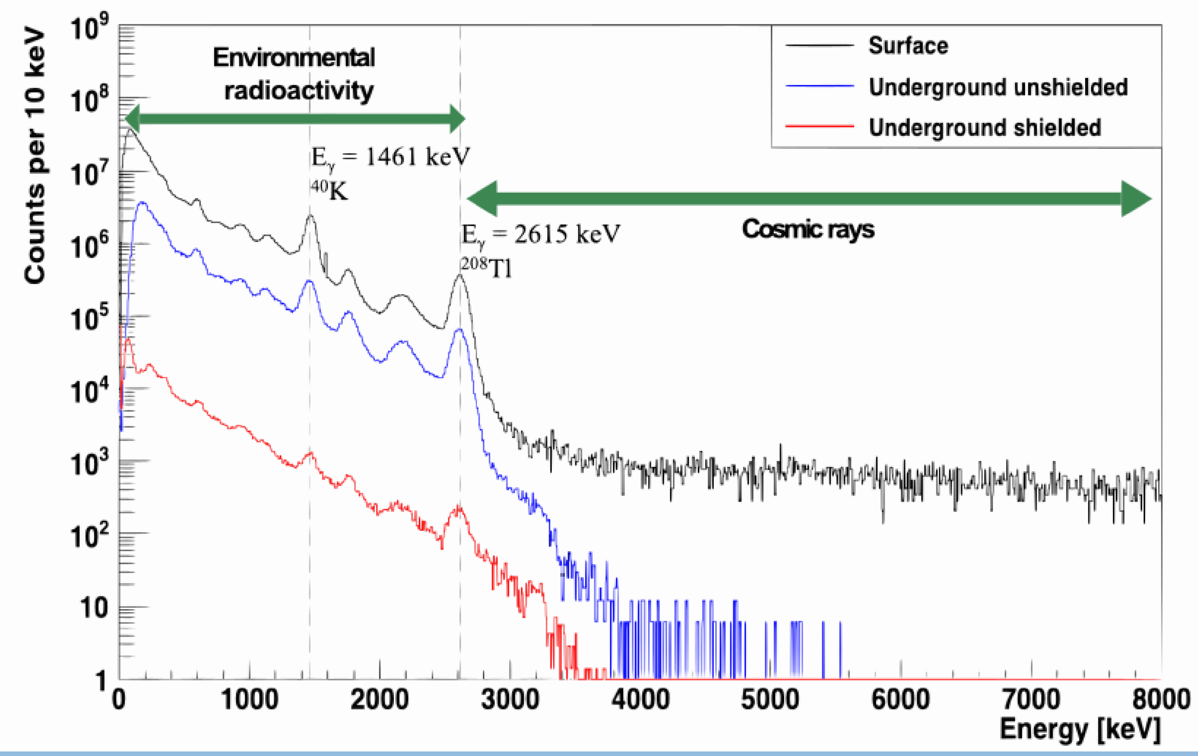


Main Goal of EASγ

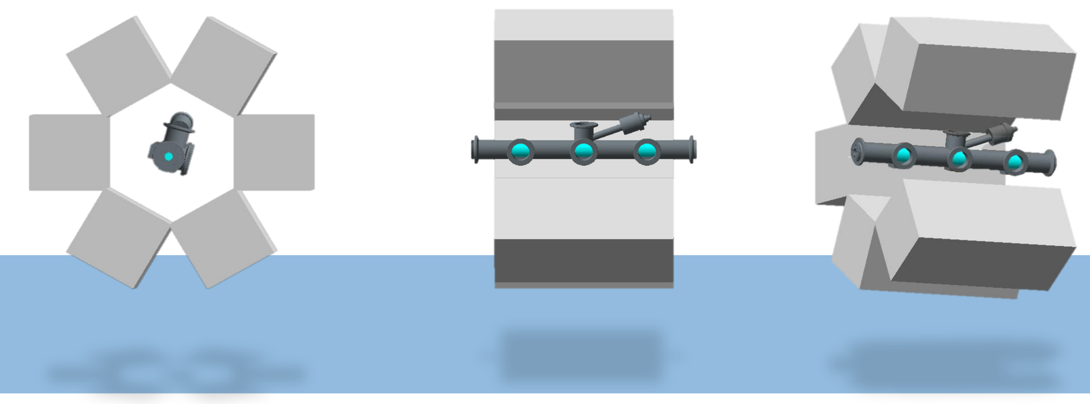
First direct measurement of the $^{22}Ne(\alpha,\gamma)^{26}Mg$ **deep underground** in the range of astrophysical interest below 600-800 keV and the remeasurement of the well-known 832 keV resonance.

EAS$\gamma's$ novel approach





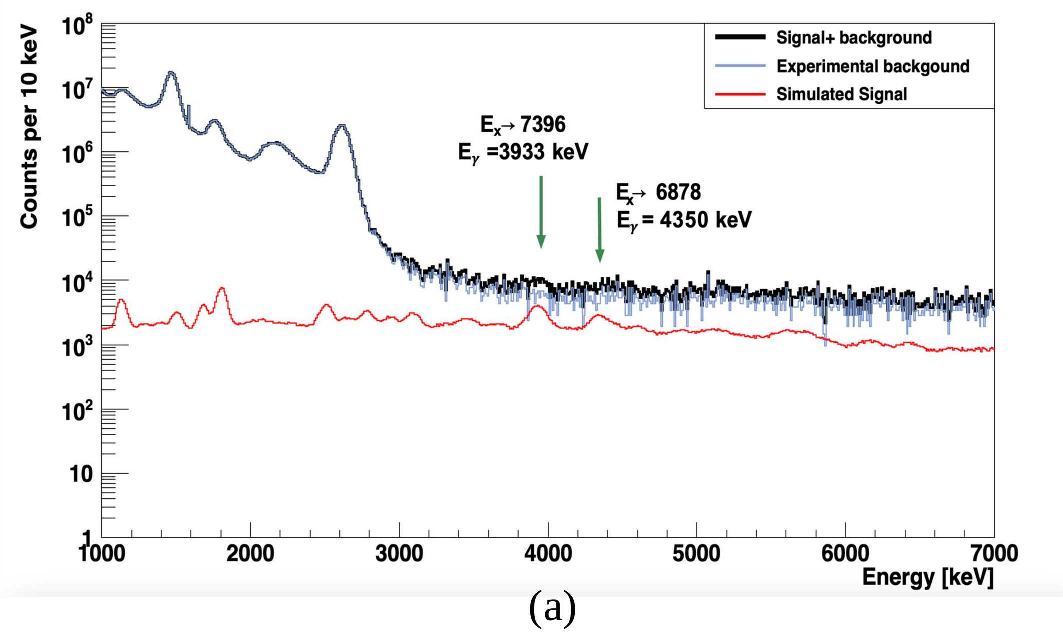
- Quasi free-background environment of LNGS → cosmic-ray background suppression of 5 o.o.m.
- High efficiency γ-ray spectrometer → $\eta_{FEP} \simeq 11$ %
- High and stable α beam provided by LUNA MV
- 99% enriched ^{22}Ne windowless gas target



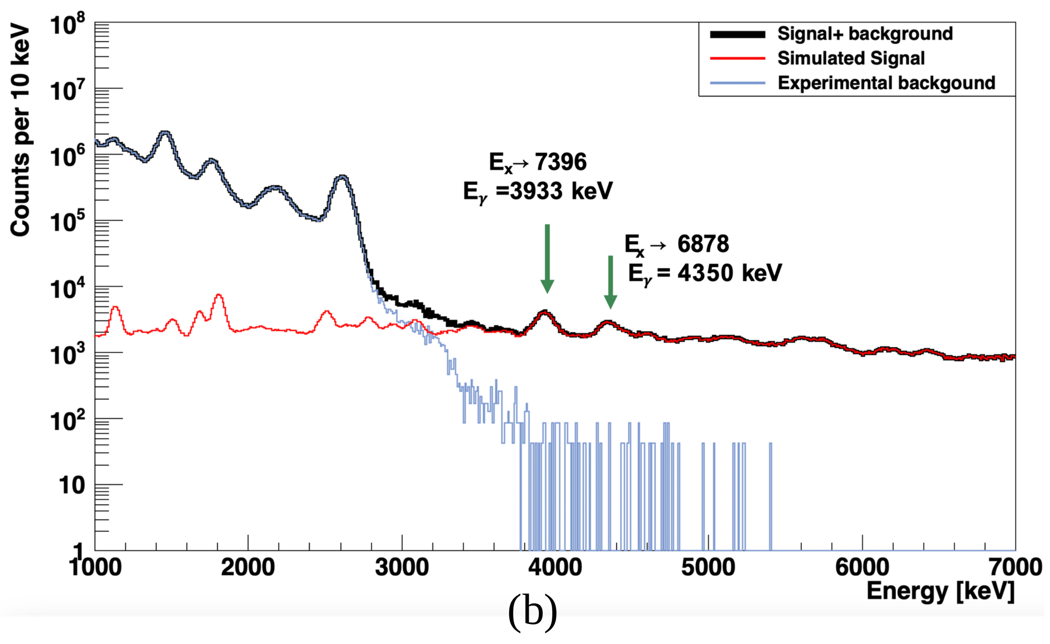
MonteCarlo simulation results

❖ Re-measurement of the well known resonance at 832 keV (E_x = 11329 keV) :

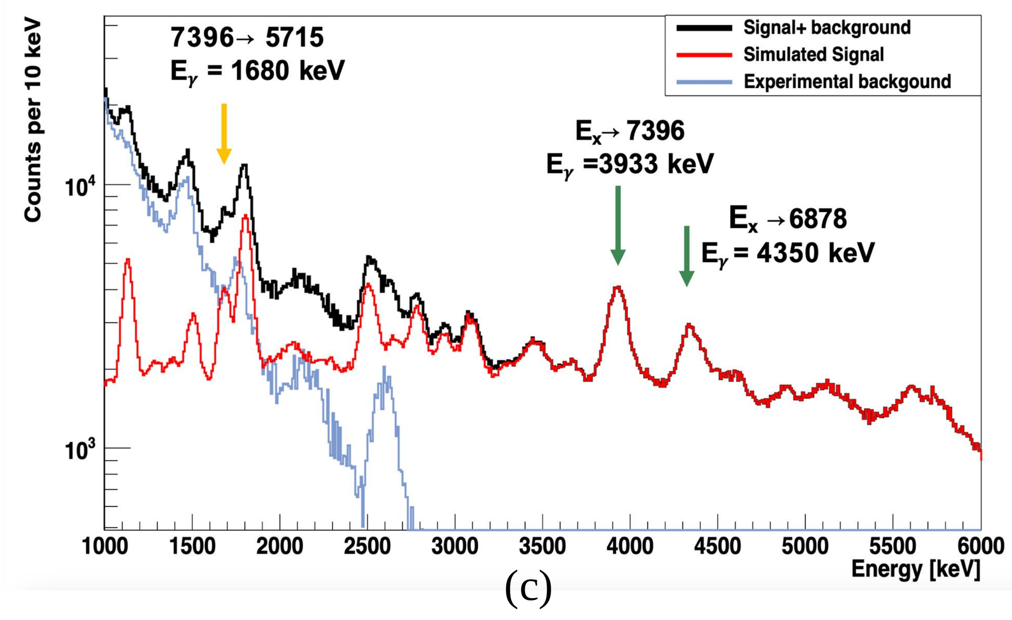
Comparison of the simulated signal (see Table for parameters) with experimental background:



(a)
Array on surface and unshielded



(b)
Array underground and unshielded



(c)
Array underground and with 15 cm of lead shielding

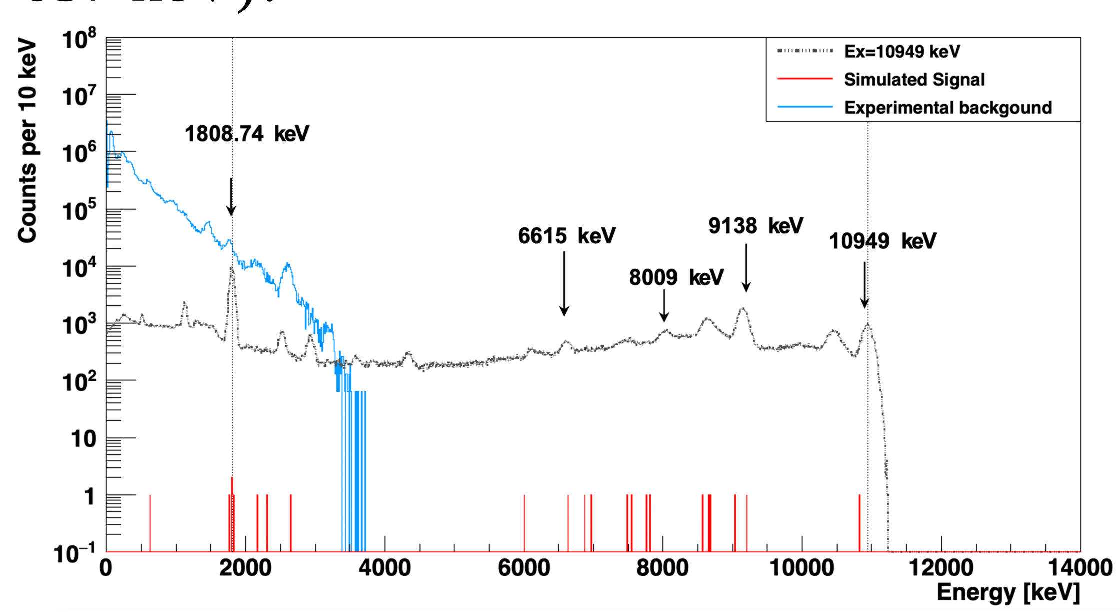
❖ Does an alpha cluster state exist at E_x = 11171 keV (E_r = 657 keV)?

Table 1. Properties of the states of the compound nucleus ^{26}Mg used in the simulation.

E_x	E_r^{cm} (keV)	J^π	$\omega\gamma$ (eV)	events/h
11321	706 ± 1	0^+ or 1^-	$(4.6 \pm 1.2) \times 10^{-5}$	14033
11171	556.33 ± 0.05	$2^+, 1^-$ or ≥ 1	$\sim 10^{-11}$ (UL) [1]	0.034

[1] Calculated using $\Gamma_\alpha, \Gamma_\gamma$ and Γ_n values from Adlsey et al. 2020

I= 500 μA and 40 days of measurement ⟶ only 33 events but some of them fall in the background free region!



Conclusions

The enhancement in sensitivity of EASγ allows to possibly :

- Remeasure the $\omega\gamma$ of the E_r = 832 keV
- Measure or redefine the UL on the $\omega\gamma$ of the E_r = 657 keV

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