Results from Underground Measurement of $^{6}Li(p,\gamma)^{7}Be$

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Astrophysical Motivation

Lithium abundance topic involves the main mucleosynthesis scenarios:

- Big Bang Nucleosynthesis
- Cosmic-ray interaction with interstellar medium
- Stellar Nucleosynthesis, in particular in convective zones of pre-main sequence stars

To improve the understanding of them an accurate determination of the lithium production and depletion channel cross sections is mandatory

State of Art

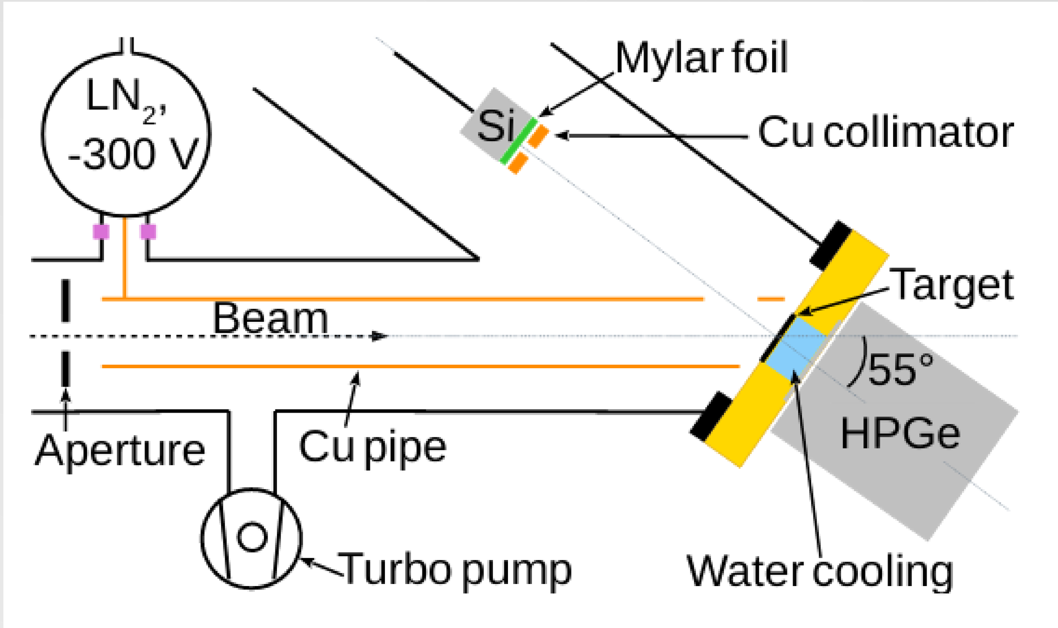
At low energies, E_{cm} < 200 keV, the three main data sets show conflicting results for the S-factor trend of $^{6}Li(p,\gamma)^{7}Be$ [1-3]

A new resonance was claimed in [3] corresponding to a possible excited state at E_x ~ 5800 keV $J^{\pi}=1/2^{+}$ or $3/2^{+}$

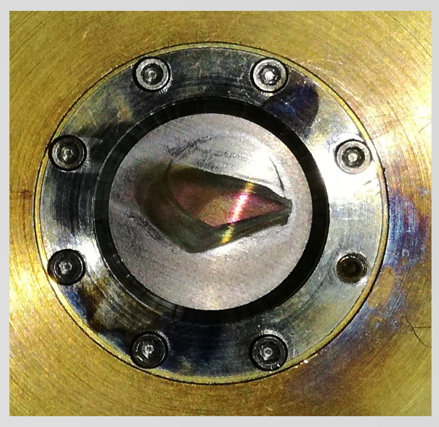
The resonance was neither observed in the recent $^{3}He(^{4}He,\gamma)^{7}Be$ reaction study [4] nor reproduced by theoretical models [5].

Experimental Method

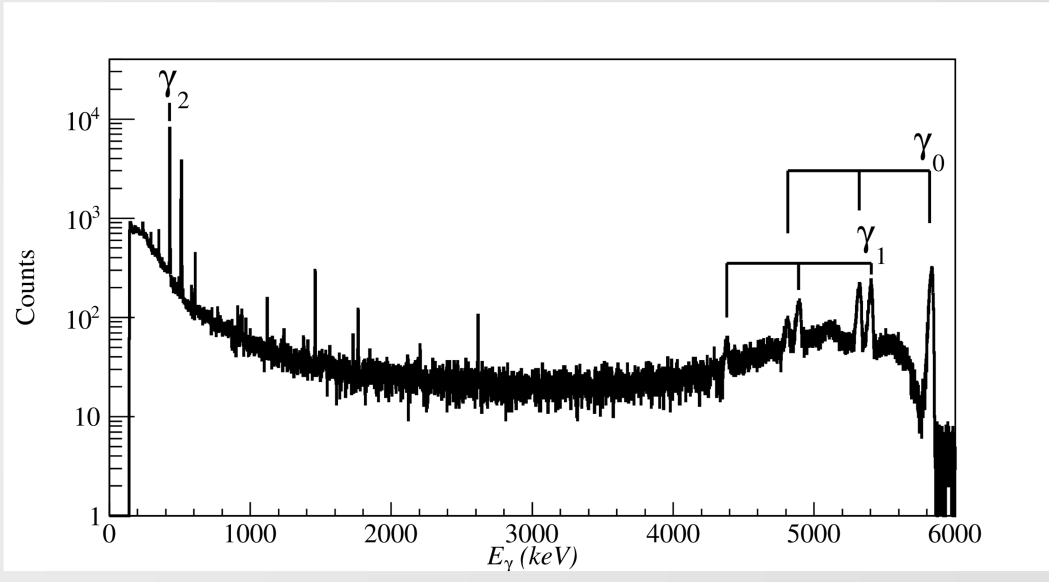
- Laboratory for Underground Nuclear Astrophysics (LUNA) at Gran Sasso Lab., Italy → naturally shielded against cosmic-ray background
- LUNA-400kV Accelerator [6] → typical current of 100 μA
- Energy range investigated E_{cm} = 60 - 350 keV
- Different composition ($^{6}Li_2WO_4$, $^{6}Li_2O$) and thickness (20-200 μg/cm²) ^{6}Li-enriched evaporated targets
- Concurrent detection of α and ^{3}He particles from the $^{6}Li(p,\alpha)^{3}He$ channel using a silicon detector (Si) and γ-rays from $^{6}Li(p,\gamma)^{7}Be$ with an high purity germanium detector (HPGe)
- Efficiency measured with radioactive sources and well known $^{14}N(p,\gamma)^{15}O$ and $^{18}O(p,\alpha)^{15}N$ resonances
- Angular distribution correction from theoretical calculation [5]
- Relative approach to determine the *S*-factor, *S(E)*.



Experimental Setup at LUNA-400kV



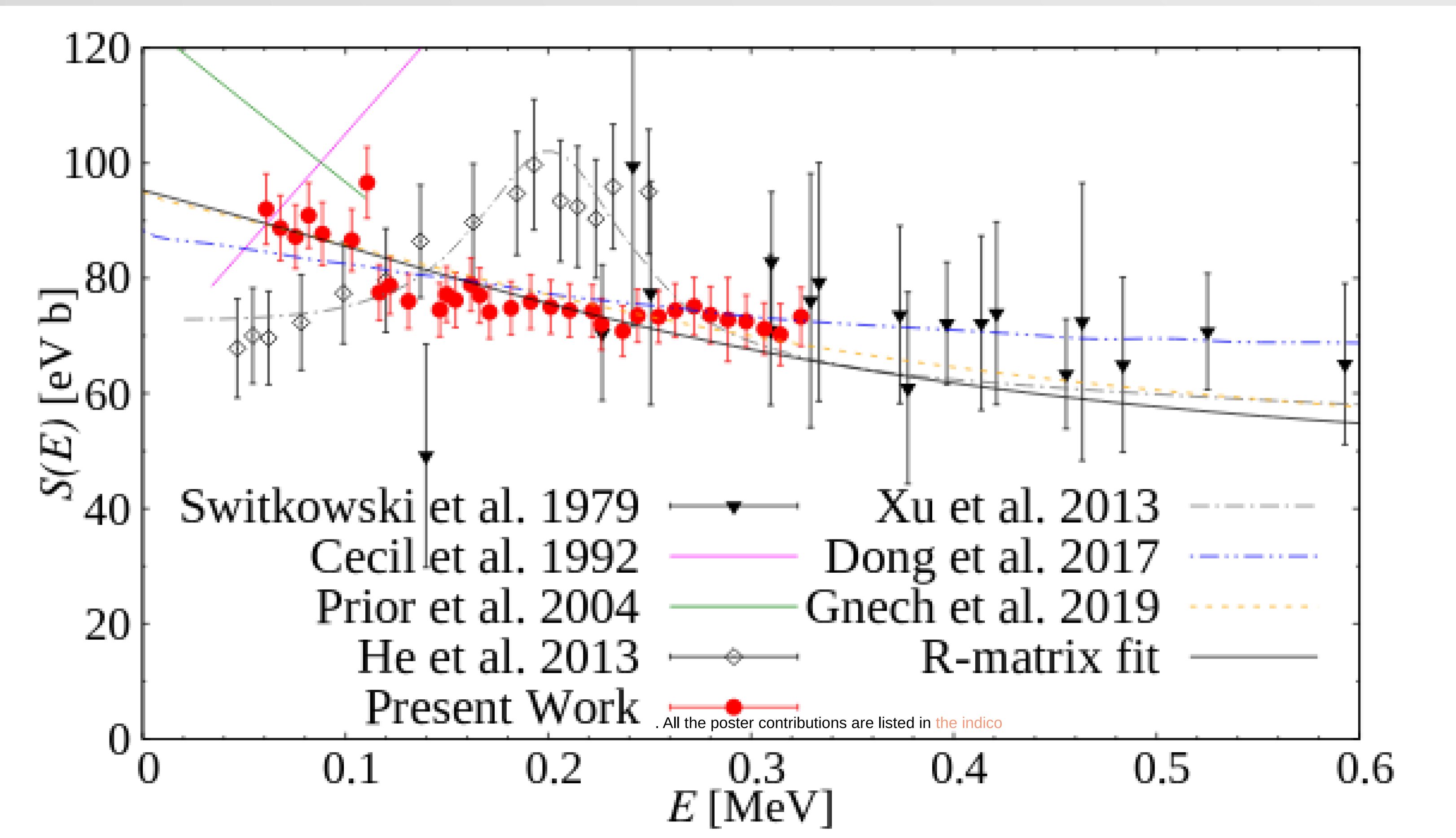
$^{6}Li_2O$ Target after irradiation at LUNA



$\gamma_0 = {}^{6}Li(p,\gamma_0)^{7}Be$
$\gamma_1 = {}^{6}Li(p,\gamma_1)^{7}Be^*$
$\gamma_2 = {}^{7}Be^* \rightarrow {}^{7}Be + \gamma_2$

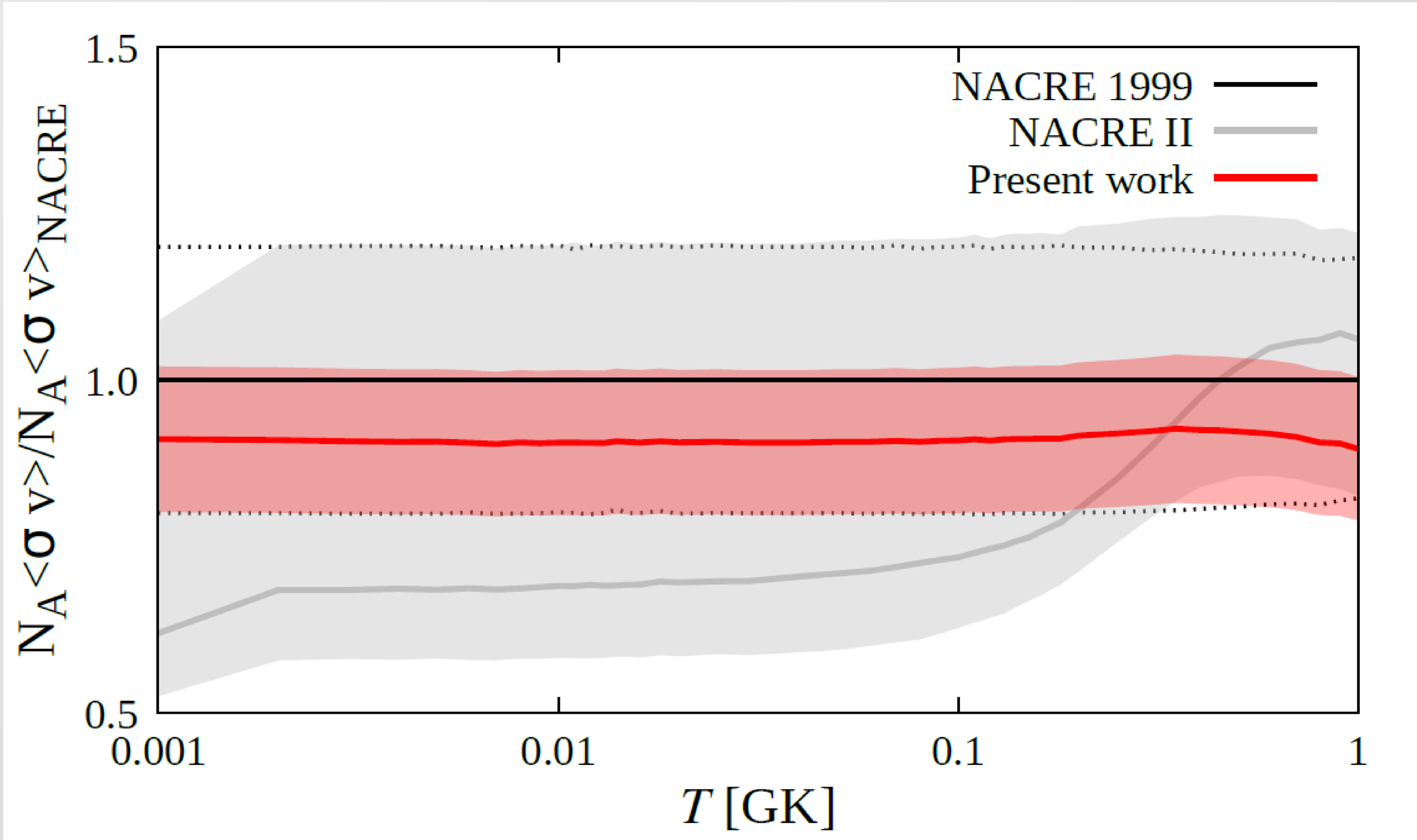
Typical γ-ray spectrum, E_p = 265 keV

Results



Bare *S(E)* from 64 – 338 keV, total uncertainty of 13%

S(E) smoothly varying as a function of *E* with negative slope



Reaction rate in agreement with NACRE [7] but with reduced uncertainty.

Breaking News!

$^{6}Li(p,\gamma)^{7}Be$ studied recently using the asymptotic normalization coefficient (ANC) approach [8].

The ANC derived independently through $^{6}Li(^{3}He,d)^{7}Be$ transfer reaction data and the present work results [9] and excellent agreement was found.

Even more recently a new theoretical calculation was performed and compared with data available and good agreement is found with LUNA results [10].

References

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