

STUDY OF THE DC COMPONENT OF $^{20}\text{Ne}(p, \gamma)^{21}\text{Na}$ REACTION AT LUNA

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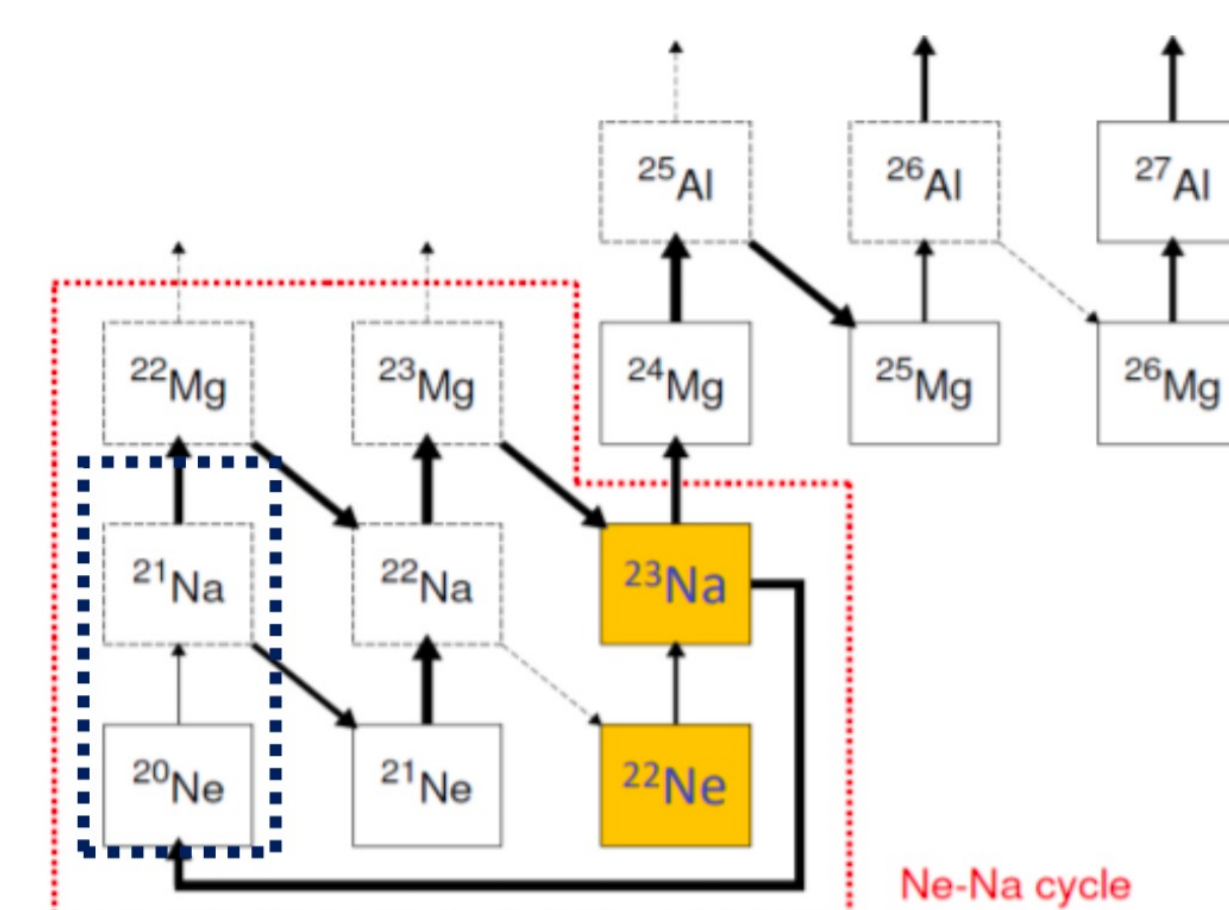
Astrophysical motivation

The **NeNa-MgAl cycles** are involved in the synthesis of Ne, Na, Mg and Al isotopes. The $^{20}\text{Ne}(p, \gamma)^{21}\text{Na}$ is the **first** and **slowest** reaction of the NeNa cycle, thus constituting a **bottleneck** for the production of the other isotopes.

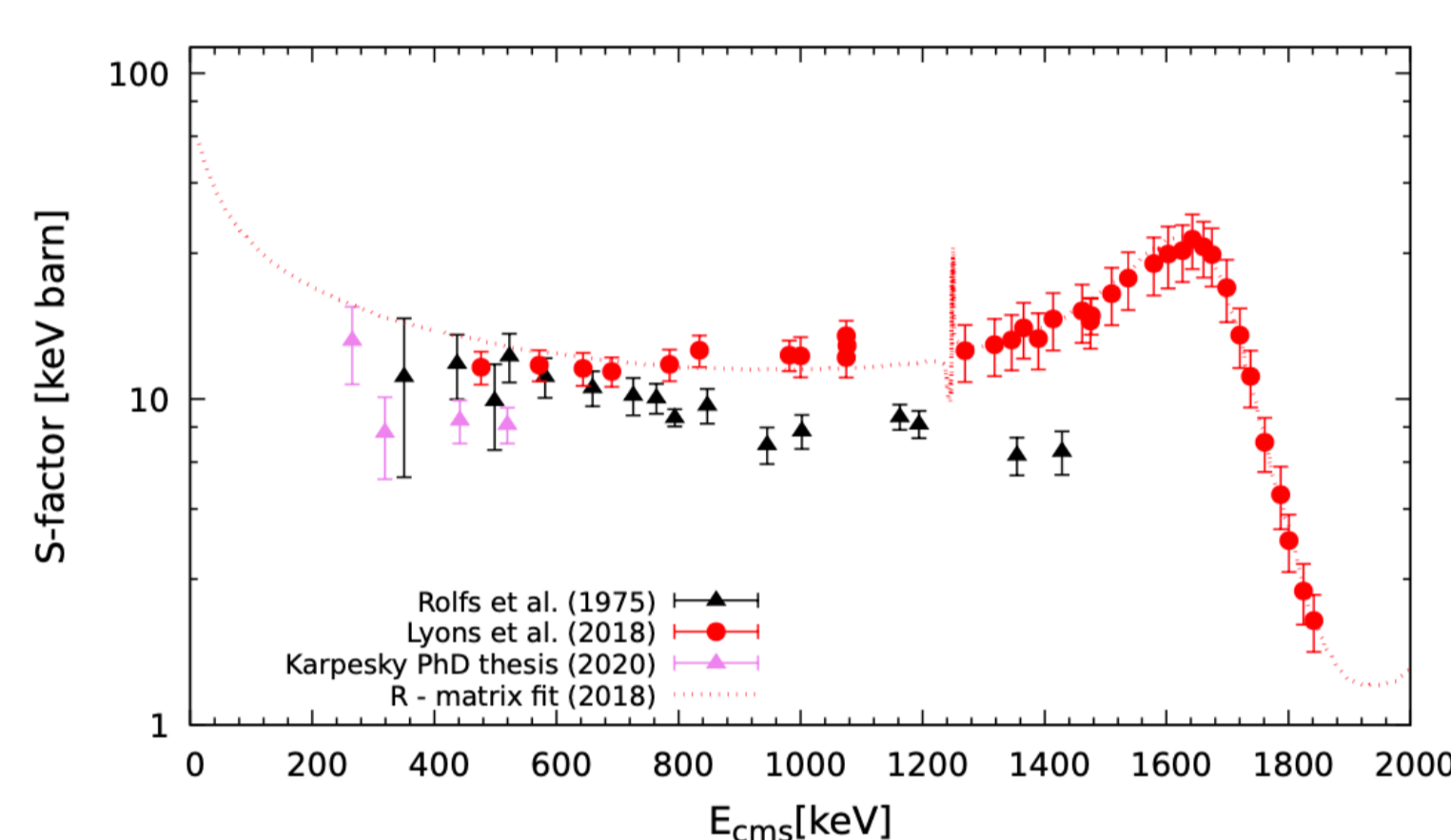
This reaction is important in different stellar scenarios where a temperature of **T=0.1-1 GK** is achieved, such as :

- red giants stars (during H shell-burning)
- asymptotic giant branch stars,
- classical ONe novae
- massive stars

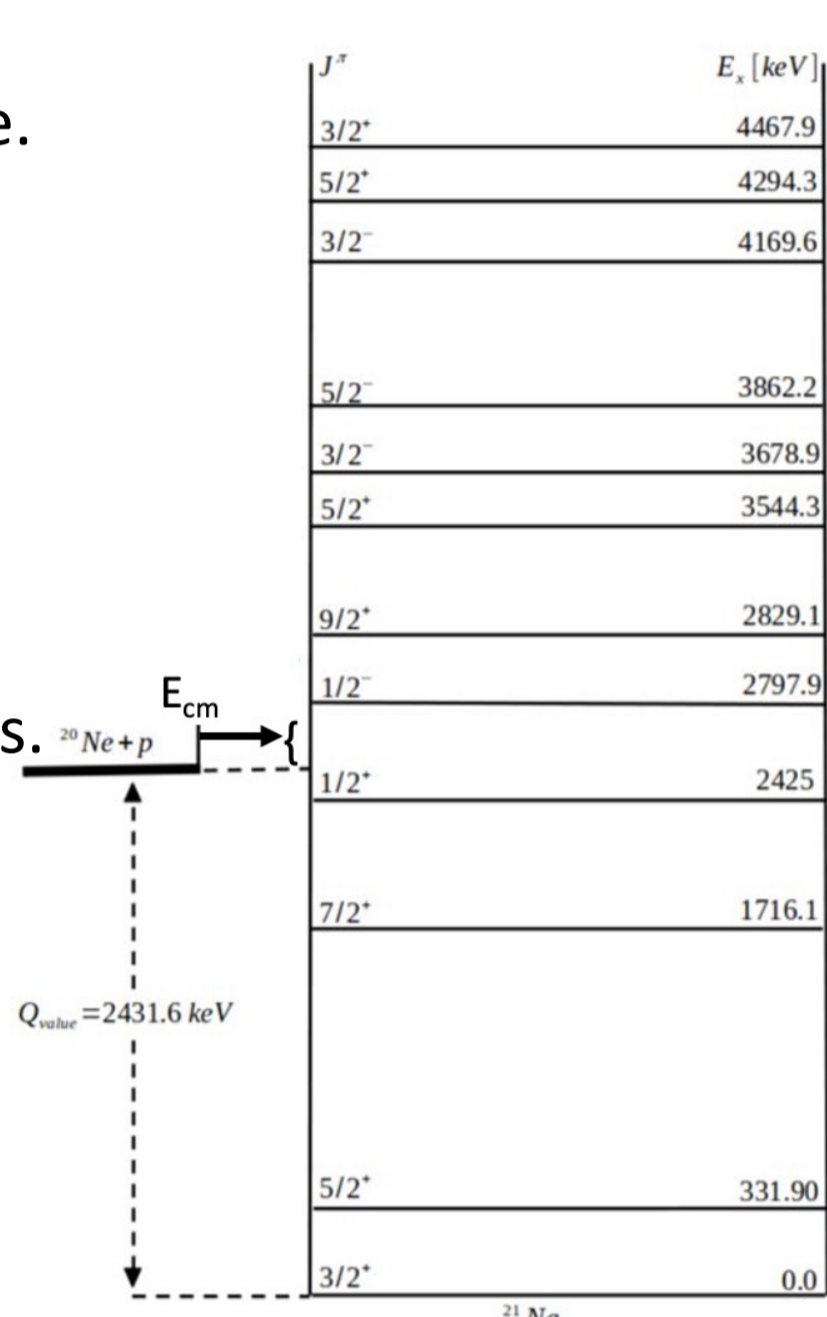
At the state of the art, existing uncertainties on the $^{20}\text{Ne}(p, \gamma)^{21}\text{Na}$ reaction rate are the ones that most severely affect the estimated elements abundances produced in the NeNa cycle. In particular, such uncertainties affect the amount of produced ^{22}Na , a stellar γ -ray signature, and ^{22}Ne , an important neutron source for the s-process, via the $^{22}\text{Ne}(\alpha, n)^{25}\text{Mg}$ reaction.



State of the art



^{21}Na level scheme. The direct capture primaries can populate the excited levels, which then de-excite emitting secondary gammas. In our spectra, we can clearly see a **peak from the de-excitation of the 2425 keV state to the ground state**



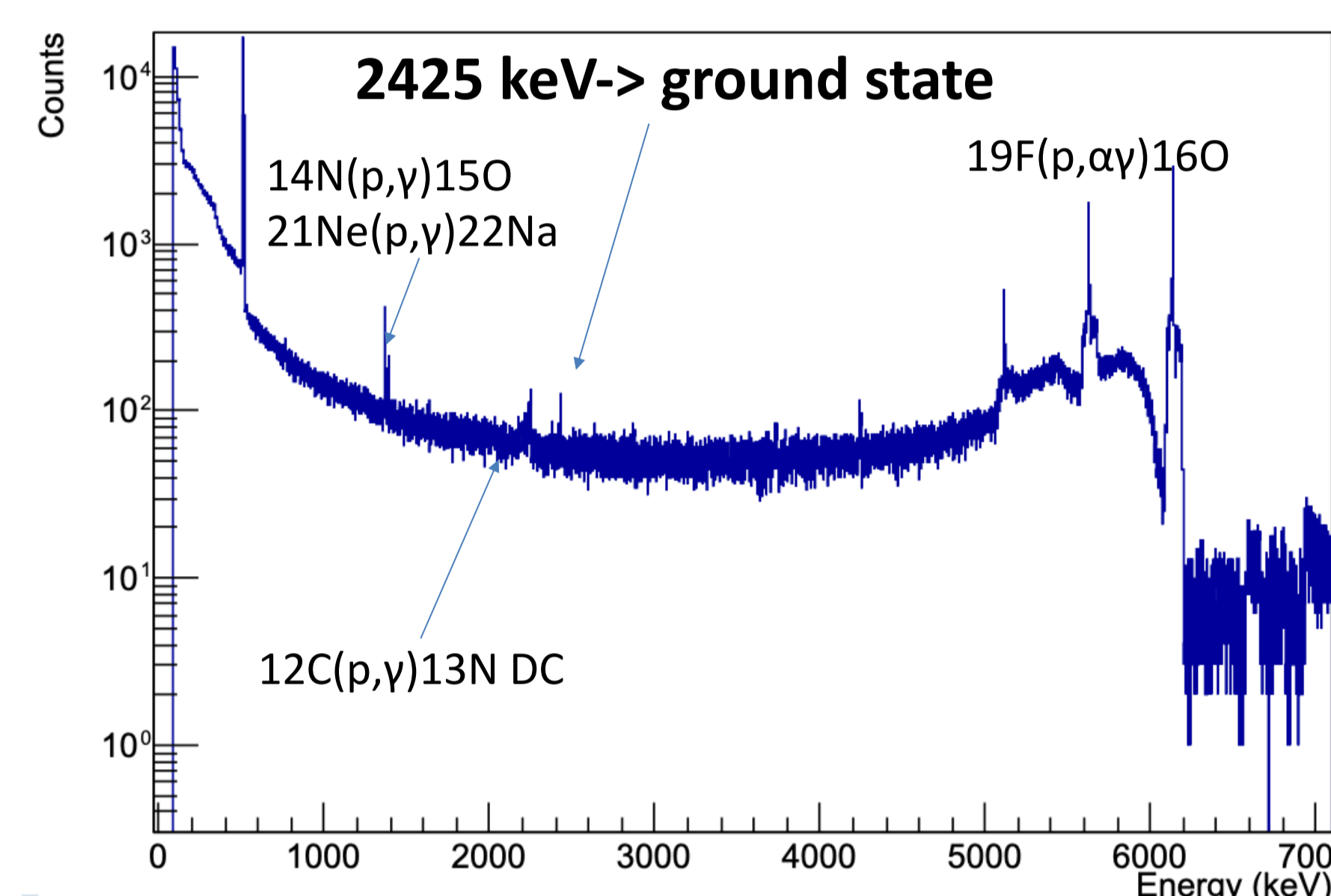
S-factor for the $^{20}\text{Ne}(p, \gamma)^{21}\text{Na}$ reaction using literature data referring to the DC \rightarrow 2425 keV (Source: E.Masha PhD thesis, 2022)

Campaign details and example of acquired spectrum

We have performed 10 long runs:

- at 2 mbar gas pressure: $E_{\text{beam}} = 260, 300, 310, 320, 330, 380$ keV
- at 0.5 mbar gas pressure: $E_{\text{beam}} = 400$ keV

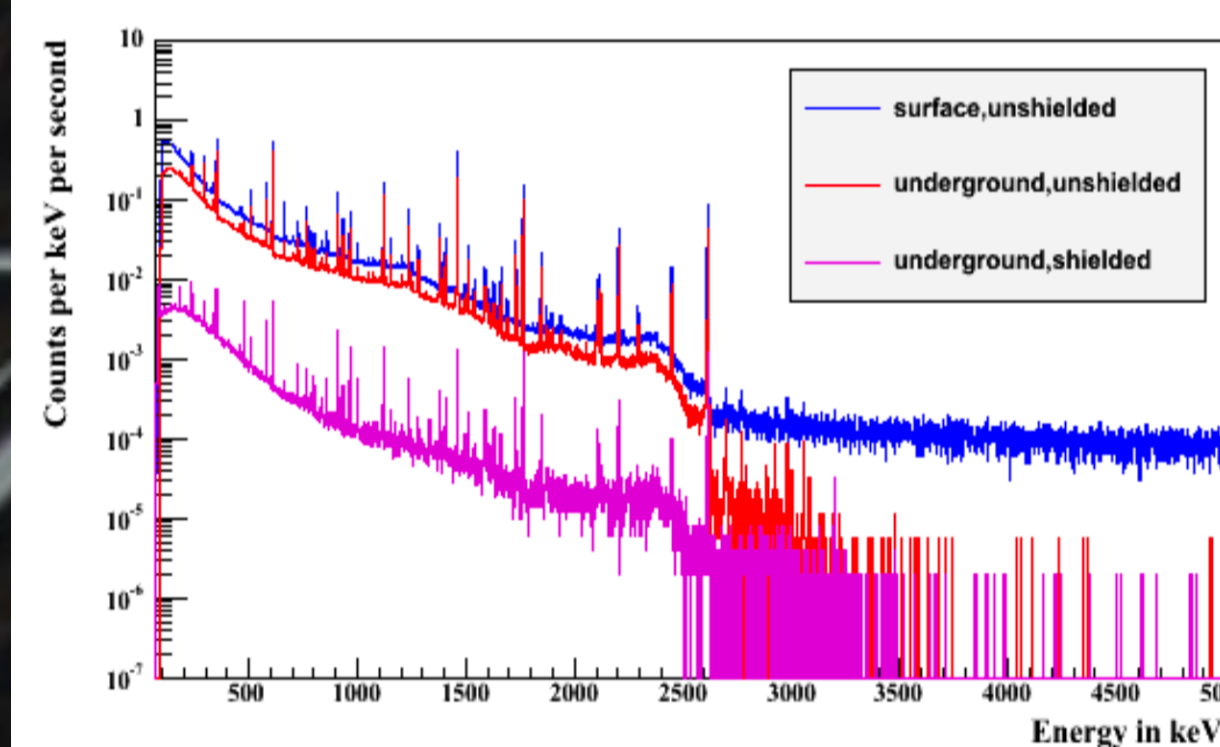
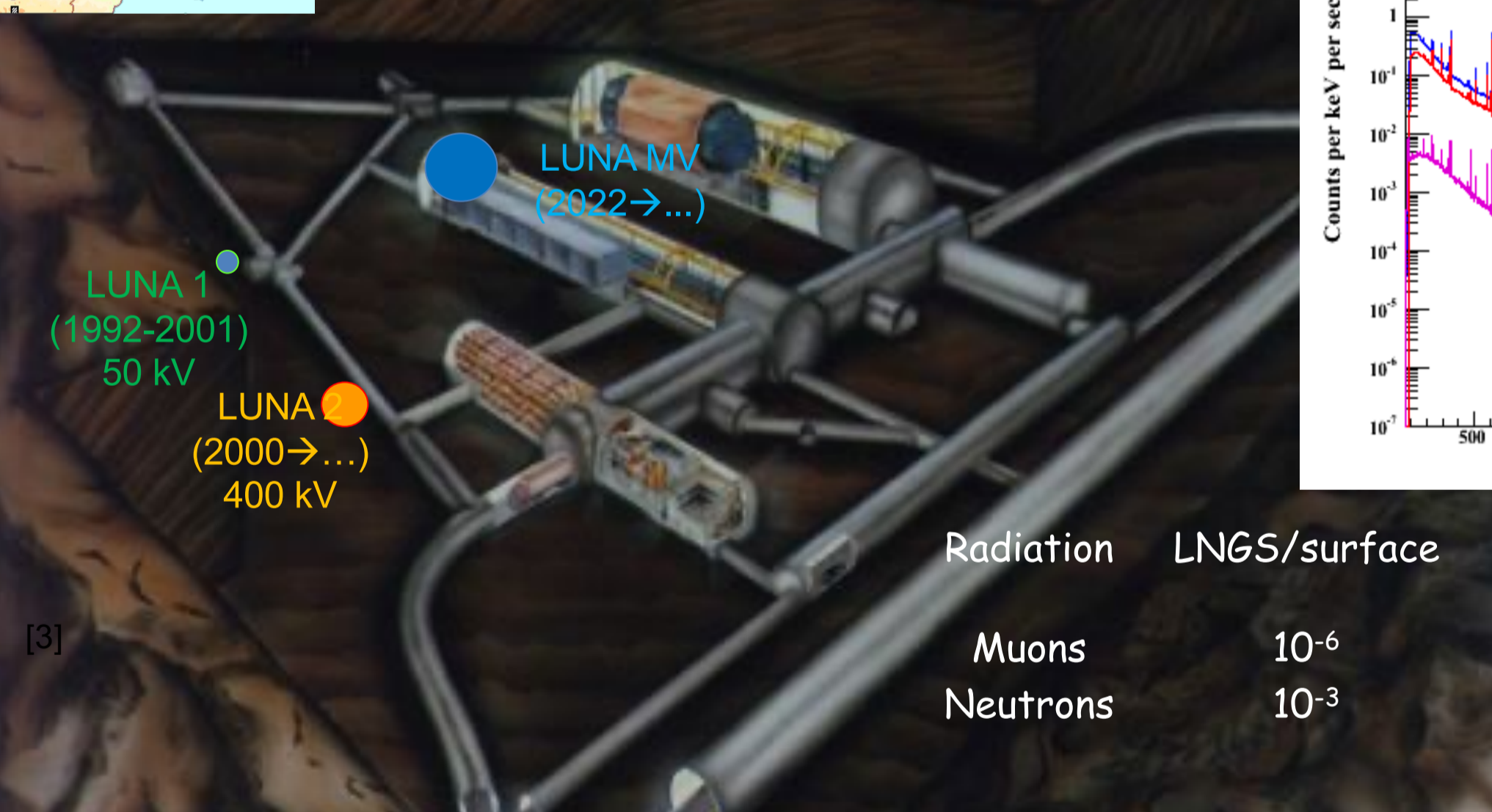
$E_b = 330$ keV spectrum



Experimental setup

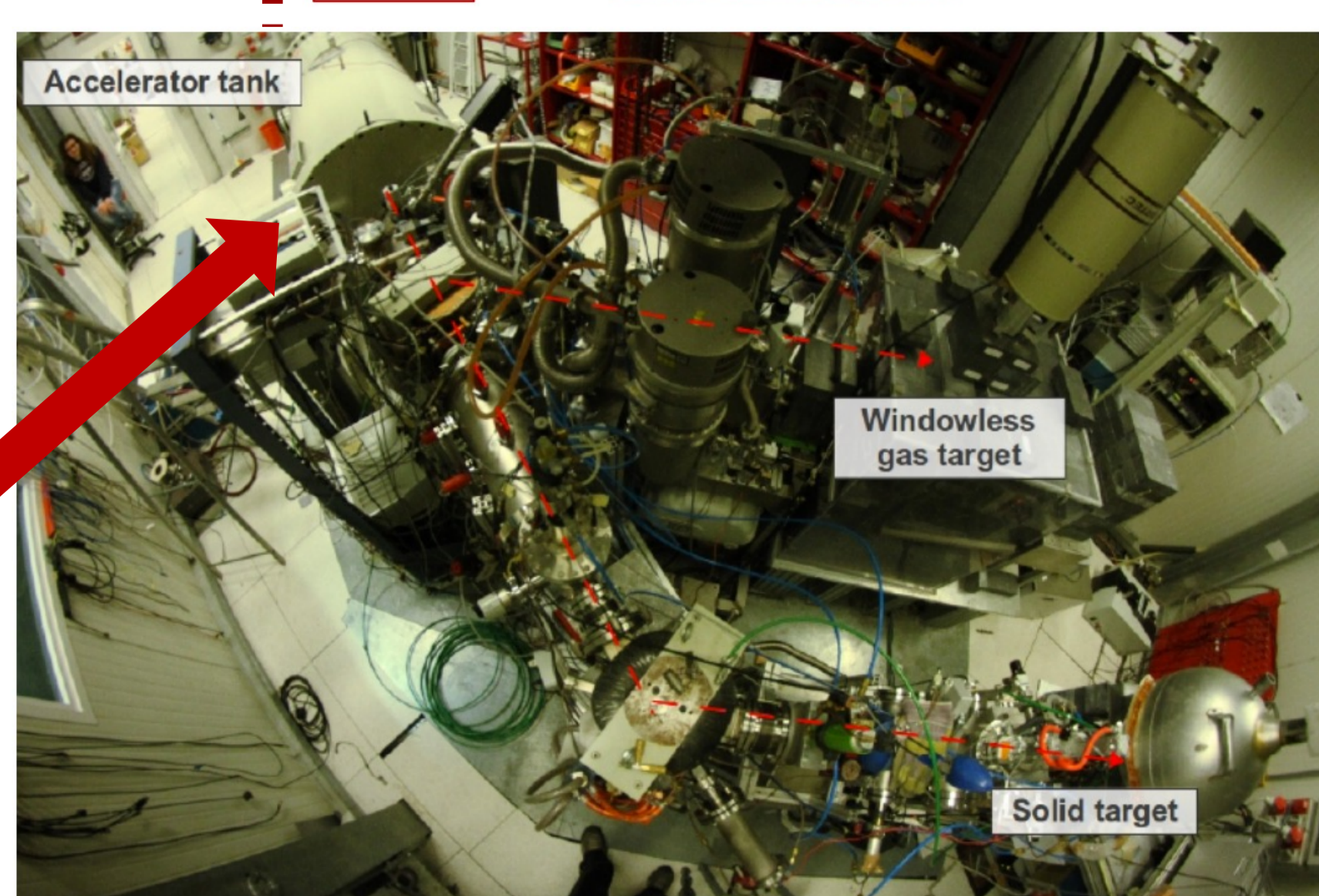
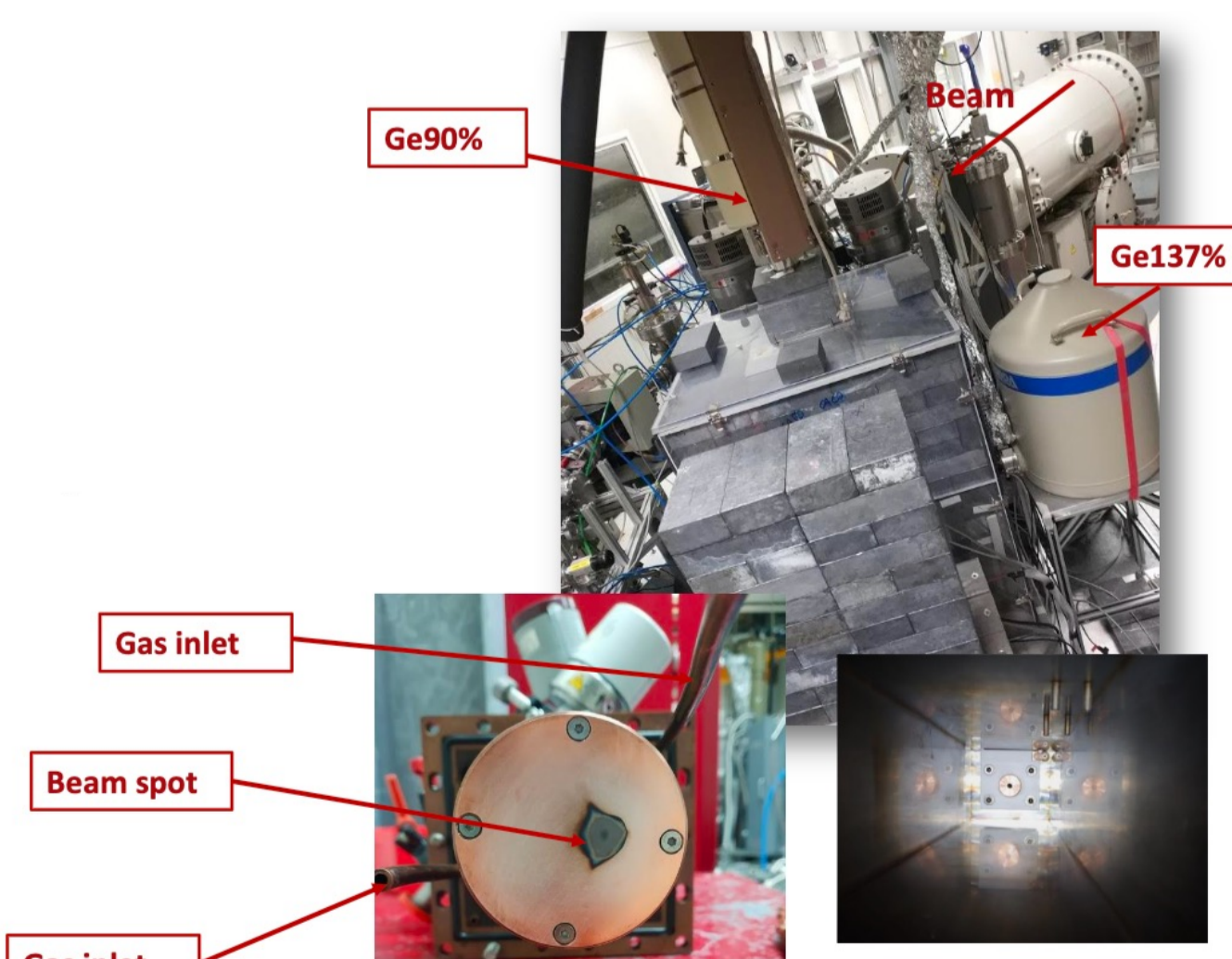
Laboratory for Underground Nuclear Astrophysics

LNGS (1400 m rock shielding \equiv 4000 m w.e.)



HPGe detectors and gas target

- Natural neon gas (90.48% ^{20}Ne)
- 2 HPGe detectors fully shielded
- Windowless gas target with pressure control feedback system (no target deterioration over run time and reduced energy loss and energy straggling effect)
- Shielding with copper and lead to reduce residual background from radioactive isotopes dominating the gamma spectrum below 3 MeV



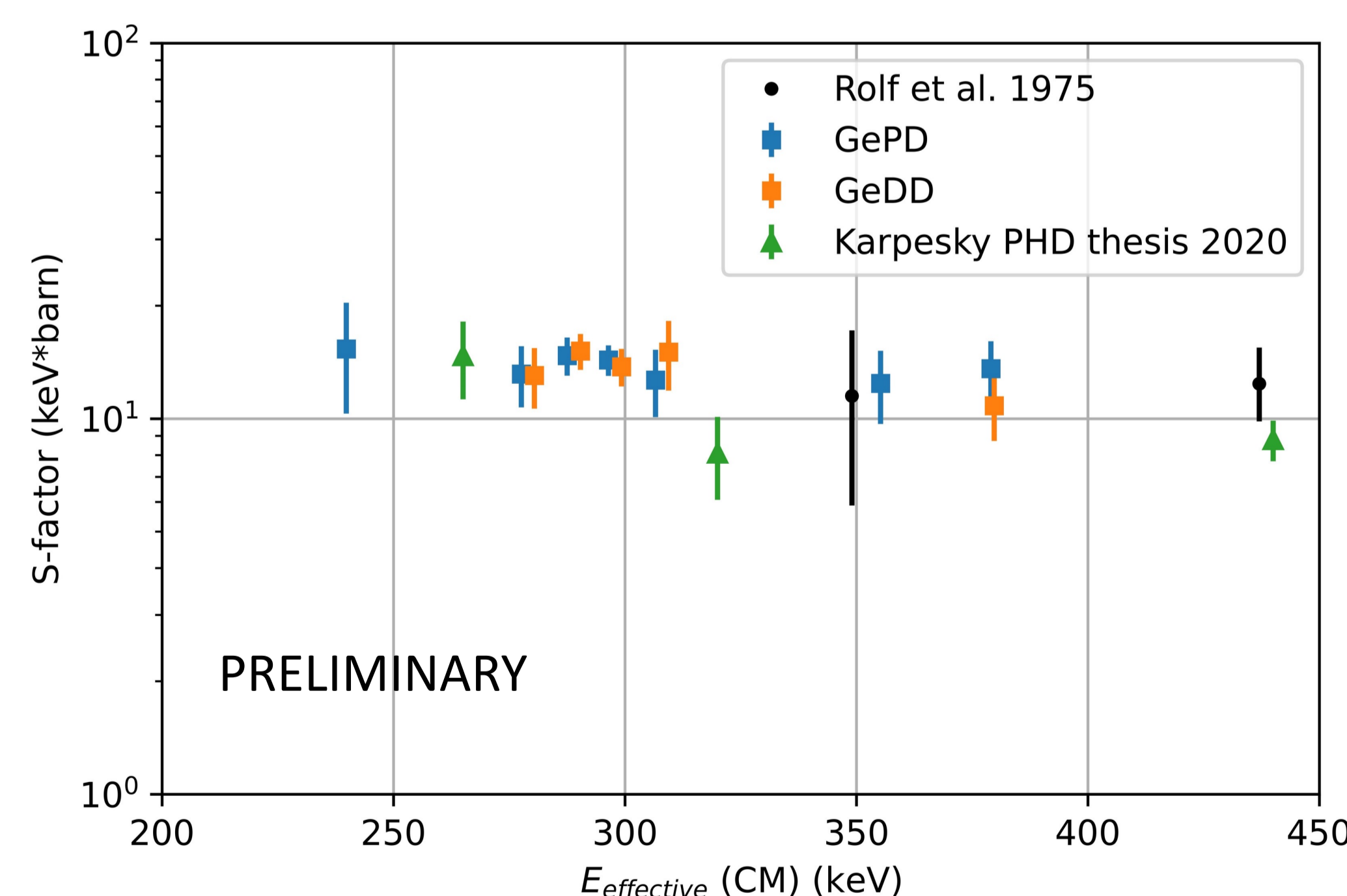
LUNA 400 keV electrostatic accelerator

Preliminary results

Preliminary results for the **S-factor** relative to the DC \rightarrow 2425 keV state are here shown. More refined analysis is still ongoing.

Obtained values take into account:

- **Beam heating effect** on gas target density
- **Efficiency** of the HPGe crystals (GePD and GeDD) in detecting 2425 keV radiation at the different positions in the target chamber
- **Beam energy loss** within the gas (for 2mbar pressure $\Delta E \approx 20$ keV)



Since the direct capture takes place **throughout the whole chamber**, where different proton beam energies are achieved, we have associated to our S-factor values an effective energy. $E_{\text{effective}}$ represents the beam energy in the center of mass at the position where **half of the experimental yield** is obtained.

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