#+title: Exam notes
#+DESCRIPTION: Notes for the statistics exam a.a. 2022-2023
#+AUTHOR: Riccardo Maria Gesuè
#+EMAIL: gesue.riccardo@gssi.it
#+FILETAGS: :exam:statistics:
#+PROPERTY: header-args :noweb yes :tangle no :results silent
#+HTML_MATHJAX: align: left indent: 5em tagside: left

- Introduction...
- Assignment...
- Article notes

**◈ Article: Csedreki et al..

****○ Introduction...

****○ The neutron detector array...

****○ Background contributions...

****○ Efficiency measurement

******▷ The $^{51}V(p,n)^{51}Cr$ reaction

Measurements performed at Atomki.
The $^{51}V(p,n)^{51}Cr$ reaction ($Q = -1534.8\,keV$) was used to produce mono-energetic neutrons in the energy range below $1\,MeV$. This reaction is characterized by slow variations of the neutron intensity and energy with angle. Moreover the target preparation and utilization is well-known.
However its application is limited by the opening of additional neutron channels above $E_{p,lab} = 2330\,keV$, which corresponds to the first excited state of ^{51}Cr at $E_x = 749\,keV$.
Above this energy, neutrons of different energies might be mixed in the emitted neutron spectrum of the reaction. This contribution is negligible up to $E_{p,lab} = 2600\,keV$.
Therefore measurements were performed at $E_{p,lab} = 1700, 2000, 2300, 2600\,keV$ assuming mononergetic n_0 neutrons emitted at 130, 420, 710 and 990 keV energy, respectively.
The determination of the total number of emitted neutrons was based on the activation technique.
The number of reactions that take place during the ... t ... can be obtained as:

$$N_R = \frac{N_\gamma}{B\eta_{320}}\frac{e^{\lambda t_w}}{1-e^{-\lambda t_c}}\frac{\lambda t_i}{1-e^{-\lambda t_i}}$$

```
\[
N_{R} = \frac{N_{\gamma}}{B\eta_{320}}\frac{e^{\lambda t_{w}}}{1-e^{-\lambda t_{c}}} \frac{\lambda t_{i}}{1-e^{-\lambda t_{i}}}
\]
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where N_γ is the number of detected 320 keV γ rays, t_c is the counting time, t_w is the waiting time elapsed between the end of the irradiation and the start of the counting, and λ is the decay constant.

**◈ Compute cross section with constant s-factor

The total reaction cross-section can be expressed in terms of the astrophysical s-factor as

$$\sigma(E) = \frac{S(E)e^{-2\pi\eta}}{E} \qquad (1)$$

Where $\eta = \frac{Z_1 Z_2 e^2}{4\pi\epsilon_0 \hbar v}$ is the Sommerfeld parameter.
With energy in the center of mass system in units of keV and the reduced mass μ given in atomic mass units:

$$2\pi\eta = 31.29 \times Z_1 Z_2 \sqrt{\frac{\mu}{E}}.$$

****○ Code

******▷ Penetrability

Define a function.

```
#+name:F_penetrability
#+begin_src python
def CalculateTwopieta(z1:int, z2:int, m1:float, m2:float, E:float)→float:
    k: float = 31.29
    mu: float = m1*m2/(m1+m2)
    twopieta: float = k * z1 * z2 * np.sqrt(mu / E)
    return twopieta
def CalculatePenetrability(z1:int, z2:int, m1:float, m2:float, E:float)→float:
    twopieta: float = CalculateTwopieta(z1, z2, m1, m2, E)
    penetrability: float = np.exp(-twopieta)
    return penetrability
#+end_src
```

In addition the moderator was surrounded with 25.3 mm (vertical config) and 50.8 mm (horizontal config) thick layer of 5% borated polyethylene to further reduce the environmental neutron background.
In both setups, a cooling loop running deionised water at 5°C is integrated in the target holders for beam power dissipation (~100 W).

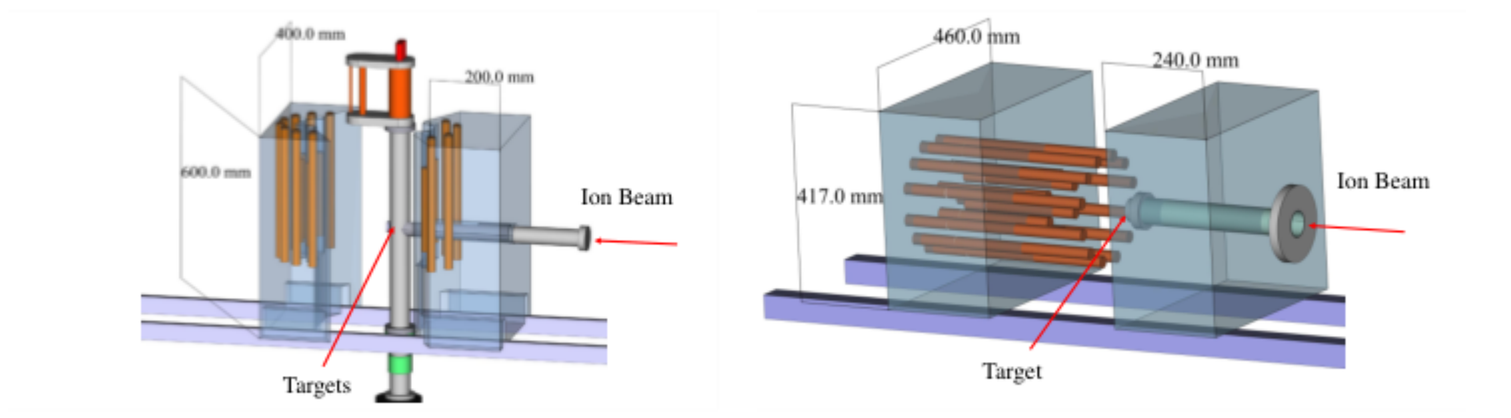

Figure 1: Vertical (left panel) and horizontal (right panel) setup of the LUNA neutron detector array. Dimensions of the moderators, target positions and beam direction are also indicated (see text for more details).

The vertical setup was used to measure the reaction cross section in the energy range $E_{\alpha,lab} = 360 - 400\,keV$, while the horizontal setup was used for the low energy measurements $E_{\alpha,lab} = 300 - 360\,keV$.