The exam

It will be a written exam – an essay. You will have two choices:

- You can write an essay about one or two of the **general topics** listed below.
- You can also choose **your own topic** for your essay (medical applications, nuclear energy production, radiation detectors, etc.) not included in the list but still you are required to be familiar with the general topics. Before you start working on your own topic, you should communicate with me to make sure that you **get my approval**.

You can use whatever source you want not only "Bantu", but please, use online sources so that the rest of us can check it easily, because **I will make your work public *in the class* for other students to learn from it and possibly criticize it**.

You need not consult with each other about your choices – for all I care all of you can select the same topic. After all I expect original thinking and work from you, and if you use copy/paste technique, you'd feel uneasy if I yellowed the identical sentences in your essays (except for quotations, clearly "marked as such"). You are expected to understand what you write, so you can explain it to the rest of the class if needed.

- Add a **list of references** to the essay.
- The **title** is up to you.
- The **length** should be 2-10 pages, no more.
- Delivery: email attachment (address: **nagy.elte** at **gmail.com**)
- Document form: **PDF**

Deadline: January 15, 2015

Before you make your choice

It is only a suggestion that should help you to get a reasonable overview of the material before you actually start working on your essay.

1. Read the general topics *leisurely*
2. Read the "**Introduction to Nuclear Science:** Bantu_e.pdf " *leisurely* **Forget Chapter 1 and the Appendix.** This leaves you 130 pages to read. **Never mind the tables**, unless you are very much interested and cannot help. You can **skip most of the equations** if not all. But **try to understand the figures**. If, however, a figure slows you down, but you understand the text, skip that too. In general the figures are meant to help understand the text and not the other way around.

3. Read the general topics *carefully*
   If you find that you understand all the *underlined items*, you are ready to choose your topic(s) and you can start collecting material to your essay. If not, you may want to reread some parts of "Bantu".

General topics

The *terms in italic* can serve as keywords if you want to search the topic by Google. Also, they are important technical terms that you are supposed to be familiar with if you want to read nuclear literature.

1. Properties of *fundamental* & *composite particles* most relevant to the *nucleus* and *nuclear decay* (*electron*, *positron*, *neutrinos* & *nucleons*).
   Fundamental & *residual* forces.
2. Composition of the atomic nucleus – *nuclide* vs. *isotope* (*isobar*, *isotone* & *nuclear isomer*) – the *chart of nuclides* – location of *stable nuclides* as well as the different *decay modes* on the chart
3. *Nuclear radius* (formula), *mass density* of nuclei. *Nuclear spin*, *magnetic moments* of *electron*, *nucleons* and *nuclei*. *Bohr magneton*, *nuclear magneton*
4. *The Q value*. How can you use it to judge *nuclear stability* against different kinds of nuclear decay (alpha, beta). How can you calculate *Q* for *nuclear reactions* from the (rest) masses of or, alternatively, from the kinetic energies of the participants. *Binding energy per nucleon*, *separation energy* of nucleons.
5. Nuclear *shell model*, *magic numbers*, *double/doubly magic* nuclides, various examples showing that *pairing of like nucleons* is favorable (*even-odd systematics*)
6. *Liquid drop model* and *Weizsäcker equation* (semi-empirical mass formula: *volume* term, *surface* term, *Coulomb* term, *asymmetry* term, *pairing* term), *mass parabolas* and *β-stability*.
7. *Decay modes* and their typical occurrence on the *N*–*Z* diagram (*chart of nuclides*): α, β, β^+, EC, p, n, f, 2β, γ, IT, IC. Conceptual difference between *X rays* and *γ rays*. *Bremsstrahlung*. Explanation of the difference between the *energy distribution* of *α particles* (*discrete*) and *β particles* (*continuous*)
8. *Aftereffects* of decay: *recoil*, *internal conversion*, *Auger effect*
9. The *activity* and its SI unit (Bq). The *exponential law of decay*; λ, τ and $T_{1/2}$ (*decay constant*, *mean life*, *half-life*), *branching* and *series of decay*; *radioactive equilibrium*, the 4 major *naturally occurring decay series* (the reason of why 4 such series exist and not 5 or 6).
10. Comparing the *interactions of* α and β *radiations with matter*. *Absorption curves*. The *Bragg curve*. *Linear energy transfer* (LET) and *stopping power* (*S*) expressed by the same formula ($-dE/dx$). *Cherenkov radiation*. Interaction of *positrons* with matter (*positronium* formation, *annihilation*). *Slowing* down *neutrons*.
11. Interaction of γ rays with matter: *Compton effect/scattering*, *photoelectric effect* and *pair production*. *Attenuation coefficient*. *γ spectra*
12. Basics of *nuclear reactions*. *Reaction cross section*. Understanding of how and why the energy dependence of the reaction cross sections differ for *neutrons* and *charged particles*. The *Coulomb barrier*. *Nuclear chain reaction*. *Neutron activation analysis* (NAA).

The schedule of this school year in Hungarian

- http://www.elte.hu/kozerdeku/tanev1415