# SRIM - Stopping Power Exercise

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**SRIM — Stopping and Range of Ions in Matter** is a software/group of programs, i.e. the Monte Carlo processor TRIM (**"Transport of ions in matter"**) and the **Ion Stopping** & **Range Tables calculator**, to calculate the stopping and range of ions in matter using a full quantum mechanical approach. Ions are "heavy charged particles", e.g. no electrons, neutrons or photons. Asking Wikipedia lets you know that SRIM is a popular and widely used software (at least among nuclear physicists, I would like to add...) as it has got a user-friendly GUI and built-in default parameters for all ions and materials. A nice feature is that the programs can be interrupted at any time, and then resumed later.

## Some tips

- Regarding output files, be careful with the **units**, they may change along the data column. In order to plot them you need to transform them to the same unit.
- In some exercises you must use **energy per nucleon**. The results are different if you just use the energy value.
- Common mistakes:
  1. not using "energy per nucleon" values in the simulations, but simply "energy", which renders rather different results. To get "energy", you multiply "energy per nucleon" with the number of nucleons of the ions.
  2. not making a ΔE-E plot, but rather a range-E plot, which is not the same thing.

## Exercise 1

**Helpful theory: Leo 2.2, especially 2.2.2-2.2.3**
Run the Stopping and range tables calculator for the following ion-target combinations:

1. Proton in silicon
2. Silicon in silicon
3. Lead in silicon

For each combination, use the following ion energy range: 10 eV/nucleon - 5 GeV/nucleon, and use eV/Angstrom as Stopping power units.

a) Make one Log-Log plot of Stopping power (eV/Angstrom) vs Energy (MeV) where you compare all the 3 cases. Plot both the electronic and the nuclear stopping power. Write half a page (A4) where you comment on the results in light of what you have studied about stopping of ions in matter.

b) Make one Log-Log plot of Range ($\mu$m) vs Energy (MeV) (compare the 3 cases).

## Exercise 2

**Helpful theory: Leo 2.2**
Run TRIM for the following ion-target combinations (choose the appropriate input range from the range-energy plot of exercise 1):

1. Lead in silicon, 10 MeV/nucleon
2. Lead in silicon, 10 keV/nucleon
3. Silicon in lead, 10 MeV/nucleon
4. Silicon in lead, 10 keV/nucleon

For each simulation, look at the plots:

- XY longitudinal
- Ionization
- Ion distribution

Comment briefly on the results (approx. half a page). Comment on e.g. particle path, range, straggling and Bragg peak — and what else you see. Compare the two high energy cases with the two low energy cases.

## Exercise 3

**Helpful theory:** http://sympnp.org/proceedings/55/H26.pdf
In this exercise you will need to use the Transmitted Ions/Recoils function in TRIM, which will render a TRANSMIT.txt file. You can find out more about this function by clicking the 'Question mark' next to the tic box.

In a nuclear physics experiment you want to utilize a silicon $\Delta$E-E detector telescope to identify different energetic nuclei by measuring the differences in energy deposited in electronic excitation within the $\Delta$E detector. Your primary interest is to identify protons with energy in the range 0.8–6.0 MeV.

a) Decide what thickness of $\Delta$E and of E detectors you need. Remember that for a good identification you need that the ion penetrates right through the $\Delta$E detector and that it comes to a complete stop within the E detector. Remember also that you want to choose the maximum thickness for $\Delta$E (it is hard to make very thin silicon detectors!) and the minimum thickness for E (you do not want to have a too thick E detector, in case you want to complement your telescope with additional layers in the future).

b) Now that you have defined your telescope, find out the energy range in which you will be able to identify the following nuclei: 2H, 3H, 4He. **Tip:** To simulate deuterons and tritons, change the mass in Ion data.

c) Make one $\Delta$E–E identification plot (use 4-5 points per nuclide).

## Rules and regulations for the exercise

- This is an individual exercise, thus you must present your results individually, in a written report.
- You are encouraged to run the simulations in pairs (as you will probably benefit quite a lot from that, when it comes to the discussion part of the exercise — drawing conclusions etc.) and you (i.e. the two people in the pair) are allowed to present the same graphs in your reports. Please name your simulation partner in the report. However, each individual must present their own written discussion.
- Just to be crystal clear — a report is NOT an email with a random

collection of chunks of text, files and plots ”for the instructor to choose from” and definately not a .zip-file of questionable origin. Any such attempts will be discarded by the instructor. A report is ONE file (.pdf, .docx or .doc, preferably) with a coherent assembly of relevant plots and consise discussion sections in between.

- Any plagiarism (e.g. copy-paste from web-based sources, books or fellow students) will not be tolerated. Please, do not insult the instructor by assuming that she will not find out. She will... Another example of cheating that will not be tolerated: several students each presenting one copy of the same report — this is not the idea of an individual report.

- If you run into trouble when running the simulations, please feel free to let the instuctor know — you can hopefully get reasonably fast and helpful help. The instructor can be reached most easily via email — and can be found in her office on Tuesdays and Thursdays, as well as Friday afternoons.