



NUCLEAR PHYSICS DIVISION  
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Computer Tools for Nuclear Physics

# Introduction to SRIM/TRIM

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# Introduction to SRIM / TRIM

**SRIM** is the package aiming to estimate the:

- Losses of energy of a beam of particles passing through an absorber, and the spread after a given length.
- range of ions penetrating the material
- Radiation losses in the material

It consists of:

- Tables of measured and interpolated energy losses: [www.srim.org/SRIM/SRIMPICS/STOPPLOTS.htm](http://www.srim.org/SRIM/SRIMPICS/STOPPLOTS.htm)
- SRIM: calculator of energy losses of a given ion passing through a (thin layer of a) given absorber
- TRIM: simulation of a passage of ions through a given (set of) absorber(s)

## How to install

### Windows

- Create folder SRIM-2013 and go there.
- Download [www.srim.org/SRIM/SRIM-2013-Std.e](http://www.srim.org/SRIM/SRIM-2013-Std.e)
- Add `xe` to the end of the name SRIM-2013-Std.e
- Run the executable to unpack stuff
- In the folder SRIM-Setup run MSVBvm50.exe
- Copy \*.ocx to the main folder SRIM-2013
- Run SRIM.exe

### Linux + Wine

- `mkdir SRIM-2013 ; cd SRIM-2013`
- `wget www.srim.org/SRIM/SRIM-2013-Std.e`
- `mv SRIM-2013-Std.e{,xe}`
- `nice wine SRIM-2013-Std.exe`
- `cd SRIM-Setup ; wine MSVBvm50.exe`
- `cp *.ocx .. ; cd ..`
- `nice wine SRIM.exe`

## Troubleshooting

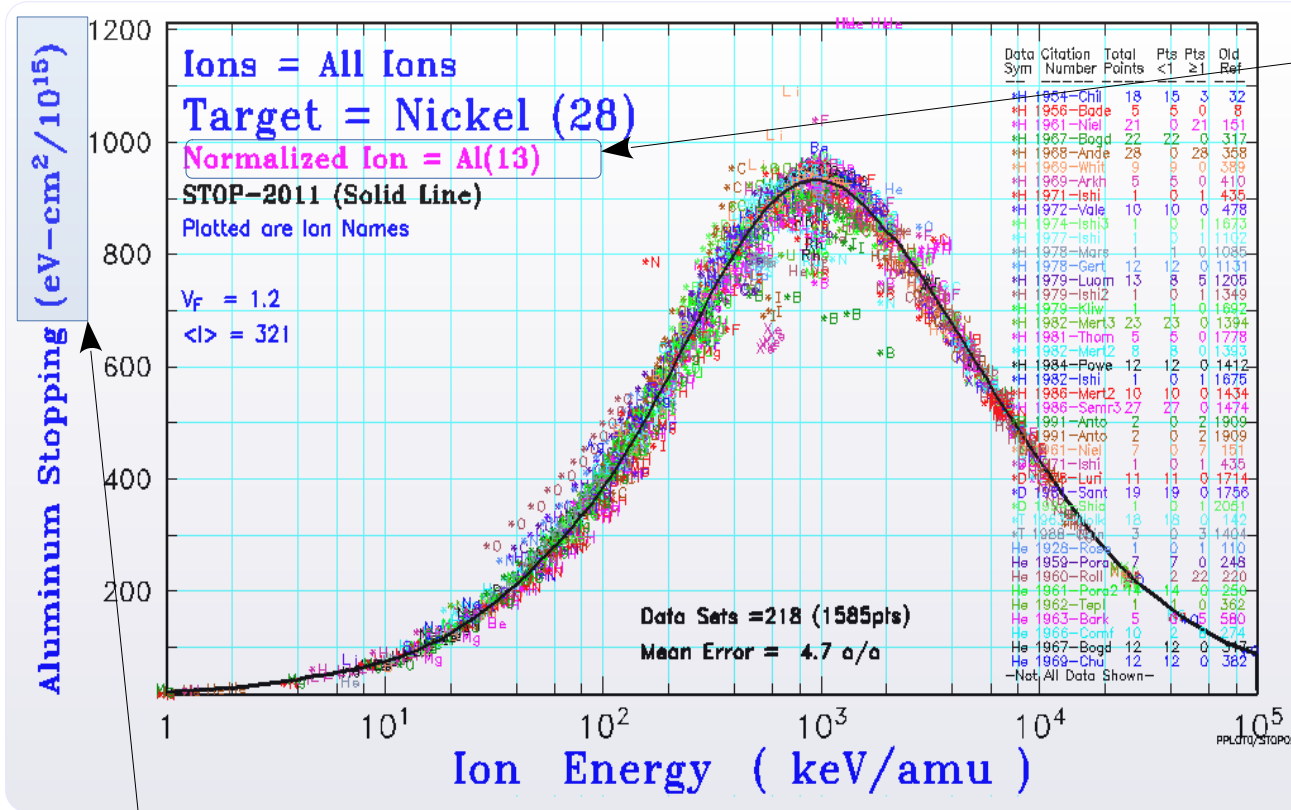
- [Windows] TRIM crashes or freezes → Change date format to "English (US)" and time to dd-MMM-yy ([Win 10 / Win 11](#))
- [Linux] TRIM crashes or freezes → in file `~/.wine/user.reg` change the variable `sDecimal` from `"` to `."`
- Some OCX component not found → find this file in SRIM-Setup folder ⊕ do `cmd` as admin ⊕ [register it](#).
- [Compound Dictionary] unreadable → [add font](#) SRIM-2013/Linedraw.ttf (and activate it)

- Help: SRIM ReadMe (English-2011).rtf file

# Energy loss database on-line

- [www.srim.org/SRIM/SRIMPICS/STOPPLOTS.htm](http://www.srim.org/SRIM/SRIMPICS/STOPPLOTS.htm)

→ shows the plots of *specific energy loss* (= loss of energy per unit path) of [ion X] in [any target] or of [any ion] in [target X].



Values of  $dE/dx$  for every specie of beam ion were normalized to the value for  $^{13}\text{Al}$  beam ion, basing on the **Bethe-Bloch** approximation:

$$-\frac{dE}{dx} \sim \frac{M Z^2}{E_{Kin}} \Bigg|_{Ion} \sim \frac{Z^2}{E_{Kin} / A} \Bigg|_{Ion}$$

In order to retrieve the  $dE/dx$  for your ion specie, you need to rescale:

$$-\frac{dE}{dx} \Bigg|_{Ion X} = -\frac{dE}{dx} \Bigg|_{^{13}\text{Al}} \times \left( \frac{Z_{Ion X}}{Z_{Al}} \right)^2$$

- The unit of  $dE/dx$  is unusual:  $[\text{eV} \cdot \text{cm}^2 / 10^{15}]$ . That's because the value of  $dE/dx$  is given for a target of  $1 \text{ cm}^2$  section which contains 1 atom.
- Let's call  $N_{S_1}$  the number of such atoms in your target. How to calculate  $N_{S_1}$ ?

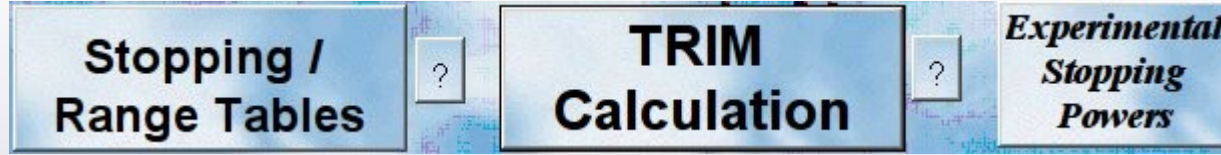
① For a target of given  $A$  and  $\rho$ , the concentration  $n$  is:

$$\frac{n}{N_A} = \frac{\rho}{\mu}$$

② Number  $N_{S_1}$  of atoms in a target of thickness  $x$  and section  $S_1 = 1 \text{ cm}^2$ :  $N_{S_1}(x) = n \cdot x$

## Main menu

SRIM, i.e. energy loss calculator



(database available in the "pro" version only)

## SRIM Menu

To admix a new species of atoms to the absorber

$E_{kin}$  of beam ion [keV]

Caution: not  $E_{kin}/A$   
Limit:  $E_{kin}/A \leq 10 \text{ GeV}$

If the target is gaseous

List of various chemical compounds

Stoichiometric composition, e.g.  $\text{H}_2 \rightarrow \text{Stoich} = 2$

Show results

Choice of units

$$[\rho x] = \text{g/cm}^2$$

$$P_{\text{int}} = \sigma_R \frac{(\rho x)_T}{A_T} N_A$$

$$N(x) = N_0 \exp(-n_T \sigma x_T)$$

For the compound: corrections wrt. Bragg Rule

# SRIM – results

**dE/dx from electromagnetic interactions**

**dE/dx from nuclear interactions**

**Range of beam ion in an absorber**

**Straggling**  
(positional dispersion of beam ions after their stopping)

Stopping Units = eV / (1E15 atoms/cm2)  
See bottom of Table for other Stopping units

Ion Energy	dE/dx Elec.	dE/dx Nuclear	Projected Range	Longitudinal Straggling	Lateral Straggling
10.00 MeV	7.795E+02	4.045E+00	2.42 um	2428 A	3020 A

Factors for conversions between dE/dx units

Multiply Stopping by	for Stopping Units
9.1274E-01	eV / Angstrom
9.1274E+00	keV / micron
9.1274E+00	MeV / mm
1.0261E-02	keV / (ug/cm2)
1.0261E-02	MeV / (mg/cm2)
1.0261E+01	keV / (mg/cm2)
1.0000E+00	eV / (1E15 atoms/cm2)
3.9592E-03	L.S.S. reduced units

# Selection of compounds

[ Link ]

Common Compounds

Categorized | **Alphabetic**

Common Name	Density (g/cm3)	Atomic Stoichiometry (Atoms/Molecule or Percent)
Inconel-600	8.43	Cr-15, Fe-9, Ni-76
Indium nitride (ICRU-488)	6.81	In-1, N-1
Indium oxide (ICRU-490)	7.18	In-2, O-3
Indium Phosphide (ICRU-492)	4.81	In-1, P-1
★ Iso-Butane, (ICRU-493) (gas)		H-10, C-4
★ Iso-octane (ICRU-494)	0.688	C-8, H-18
★ Kapton Polyimide Film (ICRU-179)	1.42	H-10, C-22, N-2, O-5
★ Kapton Polyimide Film (ICRU-179)	1.42	H-2.63, C-69.1, N-7.3, O-20.92
★ Lexan, Makrofol, Polycarbon (ICRU-219)	1.20	H-14, C-16, O-3
★ Lexan, Makrofol, Polycarbonate (ICRU-219)	1.20	H-14, C-16, O-3
LiF Crystal	2.635	Li-1, F-1
Lithium Fluoride Crystal (ICRU-185)	2.635	Li-1, F-1

★ indicates availability of special bond correction \*  
% = Mass % shown instead of Atomic %

Add to Target | Close | Help

Stopping Correction for Target Chemistry and Phase  
\*\*\*\*\* Correction assumes Ion = Al(13) \*\*\*\*\*

Bonding Correction to Stopping = 1.037 = 3.72%

-----  
Assumed Density = 0.00125 g/cm3

Chemical Formula

\* Targets with special bonding corrections to stopping are discussed in "J. F. Ziegler and J. Manoyan, Nucl. Inst. Meth., B35, 215 (1988)."  
This table may be rearranged or added to -- edit the file COMPOUND.DAT.

## List of categories:

- +----- NUCLEAR PHYSICS MATERIALS
- +----- COMMON IMPLANTATION COMPOUNDS
- +----- COMMON TARGET MATERIALS
- +----- PLASTICS / POLYMERS
- +----- METAL ALLOYS
- +----- NUMBERED COMPOUNDS (99-277) from ICRU F
- +----- BIOLOGICAL MATERIALS (Human)
- +----- BIOLOGICAL MATERIALS (Misc.)
- +----- LIQUIDS / GASES

## Bragg Rule:

For a compound made of atoms of type A ⊕ B,

$$\frac{dE}{dx} = \frac{dE}{dx}\bigg|_A + \frac{dE}{dx}\bigg|_B$$

→ It's an approximation that has corrections

[☆] for substances marked in this way, SRIM includes corrections based on CAB model

## Example: Al ion penetrating the Iso-Butane gas

Target Description: Aluminum in Iso-Butane (ICRU-493)

Density (g/cm3): 0.00125

Gas Tgt.

Add Element | Compound Dictionary | Restore Last Target

Delete Element	Symbol	Name	Atomic Number	Weight (amu)	Stoich	Atom %
X	PT H	Hydrogen	1	1.008	10	71.43
X	PT C	Carbon	6	12.011	4	28.57

Density for pressure  $p = 1$  atm.  
If  $p$  is different, the density should be rescaled.

Caution: value for Iso-Butane @  $p = 1$  atm is erroneous. Should be:  $\rho = 0,00251$  g/cm<sup>3</sup>

**Stoichiometry** for C<sub>4</sub>H<sub>10</sub>

# TRIM – Dialog box

**TRIM (Setup Window)**

**Type of TRIM Calculation**  
 DAMAGE: Ion Distribution and Quick Calculation of Damage  
 Basic Plots: Ion Distribution with Recoils projected on Y-Plane

**ION DATA**  
 Symbol: PT, Name of Element: Nickel, Atomic Number: 28, Mass (amu): 57.94, Energy (keV): 10000, Angle of Incidence: 0

**TARGET DATA**  
**Target Layers**  
 Add New Layer: Layer Name: L1, Width: 10 um, Density (g/cm3): 2.702, Compound: 1

**Input Elements to Layer**  
 Add New Element to Layer: Symbol: PT, Name: Aluminum, Atomic Number: 13, Weight (amu): 26.98, Atom Stoich or %: 100.0, Damage (eV) Disp: 25, Latt: 3, Surf: 3.3

**Special Parameters**  
 Name of Calculation: Ni (10000) into L1, Stopping Power Version: SRIM-2008  
 AutoSave at Ion #: 10000, Total Number of Ions: 9999, Random Number Seed: [empty]  
 Plotting Window Depths: Min: 0, Max: 100000

**Output Disk Files**  
 Ion Ranges  
 Backscattered Ions  
 Transmitted Ions/Recoils  
 Sputtered Atoms  
 Collision Details  
 Special "XYZ File" Increment (eV): 0

**Buttons:** Resume saved TRIM calc., Save Input & Run TRIM, Clear All, Calculate Quick Range Table, Main Menu, Problem Solving, Quit

## Simulation type:

1. Neglect damage of target and emission of atoms from target.
2. Full simulation
3. Allow for emission of atoms from the target

Plots to be visualized during the simulation (in-flight)

Selection of compound substances

Go simulate!

If the absorber has more layers

thickness of the absorber

Click if the target is gaseous

No. of ions to propagate

Range of beam axis ("X") on the plot

Choice of output files (that TRIM will generate)

Important option: "Transmitted Ions/Recoils" → file `transmit.txt`

# TRIM – simulation window

The screenshot displays the TRIM simulation interface with the following components:

- Top Bar:** Includes buttons for 'Help', 'Animate', 'Continue', and 'Change TRIM'. It shows '100% ION ENERGY 0%' and 'Now: 134 of 9999 Ions'.
- ION Parameters:** Ion Type: Ni, Ion Energy: 10, Ion Angle: 0. Status: Completed 133 of 9999.
- Plots Window:** Contains a 'PLOT Window' with 'Max Target Depth' set to 100000 and a 'COLLISION PLOT' with checkboxes for 'Ion/Recoils (XY)', 'Ion/Recoils (XZ)', 'Ions (no recoils)', and 'Lateral View (YZ)'. A 'Background color White/Black' option is also present.
- XY Longitudinal Plot:** Titled 'Depth vs. Y-Axis', showing a fan-shaped distribution of ion paths from 0 to 10 um depth.
- ION RANGE Distribution Plot:** Titled 'ION RANGES', showing a histogram of ion ranges. Statistics: Ion Range = 5.24 um, Straggle = 4641 A, Skewness = -1.4163, Kurtosis = 5.3470.
- IONIZATION RECOILS Plot:** Titled 'IONIZATION RECOILS', showing 'Energy Loss (eV/Angstrom)' vs. 'Target Depth'. The red area represents 'IONS' and the blue area represents 'RECOILS'.
- DISTRIBUTION List:** A list of simulation results with checkboxes, including 'Ion Distribution', 'Ion/Recoil Distribution', 'Lateral Range', 'Ionization', 'Phonons', 'Energy to Recoils', 'Damage Events', 'Integral Sputtered', 'Differential Ions', 'Backscattered Ions', 'Transmitted Ions', and 'Collision Details'. A '3-D Plots' section includes 'Ion Distribution 3D', 'Recoil-Dist. 3D', 'Ionization 3D', 'Phonons 3D', and 'Target Damage 3D'.
- Summary Table:**

TOTAL		
Al	0.000000	0.00
- Settings:** 'Save every 10000 ions' checkbox is checked. 'Random Number Counter' is 1044476.

Tracing of passage of the beam ions

Choice of:  
 - plots  
 - output files

Profile of  $\langle dE/dx \rangle$  as function of  $x$   
 It changes along  $x$ , since particle's energy drops during passage

Distribution of ion ranges



# TRIM – beam straggling

**Straggling:** spread of energy and/or position of the beam ions after passage the absorber of a given thickness (e.g. a beam through a target/degrader or through the detector window)

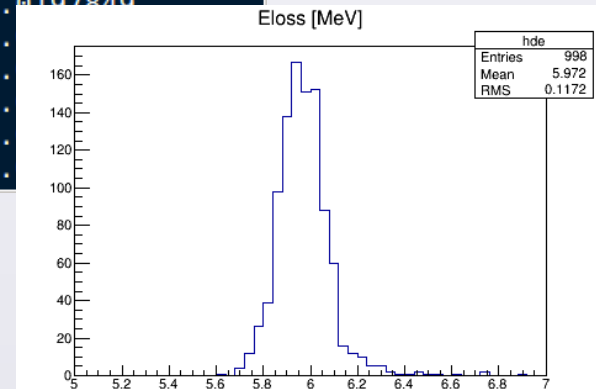
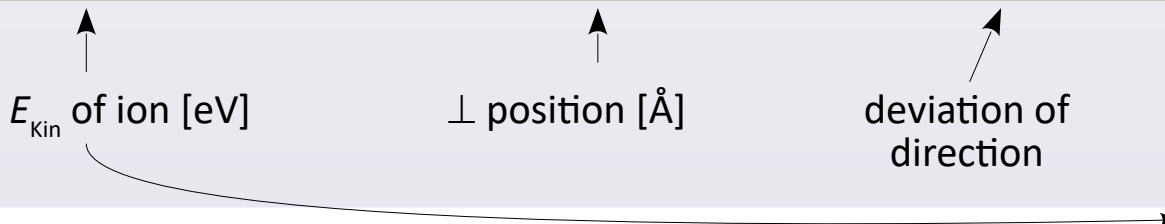
0. We assume here that at least some beam ions would reach the end of the absorber.

In the TRIM dialog box:

1. Switch on [Output Disk Files] → [Transmitted Ions/Recoils] →  , and then select “1”
2. After the simulation: check for the `transmit.txt` file in the SRIM Outputs folder.

```
TRANSMIT.txt x
===== SRIM-2013.00 =====
=====
===== TRANSMIT.txt : File of Transmitted Ions =====
= This file tabulates the kinetics of ions or atoms leaving the target. =
= Column #1: S= Sputtered Atom, B= Backscattered Ion, T= Transmitted Ion. =
= Col.#2: Ion Number, Col.#3: Z of atom leaving, Col.#4: Atom energy (eV). =
= Col.#5-7: Last location: X= Depth into target, Y,Z= Transverse axes. =
= Col.#8-10: Cosines of final trajectory. =
= *** This data file is in the same format as TRIM.DAT (see manual for uses).=
===== TRIM Calc.= Al(10 MeV) ==> Layer 1( 1 um) =====
Ion  Atom  Energy          Depth          Lateral-Position          Atom Direction
Numb Numb   (eV)            X(A)           Y(A)           Z(A)           Cos(X)  Cos(Y)  Cos(Z)
T    1  13   .3983746E+07    1000064E-02    .2971E+03    .4864E+03    .9767120  .1769064  .1213995
T    2  13   .4071823E+07    1000190E-02   -.1117E+03    .3788E+03    .9963755  .0134767  .0839890
T    3  13   .4099861E+07    1000121E-02   -.5497E+01   -.1227E+03    .9991514  -.0411854  .0005086
T    4  13   .4098159E+07    1000217E-02   -.3030E+03    .8463E+02    .9986100  -.0427266  .0308636
T    5  13   .3947297E+07    1000098E-02    .2790E+03   -.7825E+02    .9653103  -.1829261  -.1863174
T    6  13   .3987888E+07    1000197E-02   -.1563E+02   -.8668E+01    .9989632  -.0410004  .0107840
T    7  13   .4131337E+07    1000161E-02    .1038E+03   -.3660E+03    .9990785  .0113496  .
T    8  13   .4141843E+07    1000133E-02    .4241E+02   -.2878E+03    .9992457  .0294721  .
T    9  13   .4048078E+07    1000050E-02   -.1080E+03    .8655E+02    .9978623  -.0515206  .
T   10  13   .3798280E+07    1000108E-02    .1461E+04    .5658E+03    .9552314  .2949221  .
T   11  13   .4052493E+07    1000137E-02    .1921E+03    .4439E+03    .9943126  .0437691  .
```

After passage through the absorber



# TRIM – tracing the energy loss on the way

TRIM can print out all the subsequent acts of interaction in the medium, giving per interaction: position of this interaction, ion energy and the local value of the specific energy loss (loss of  $E$  per unit of path).

In the TRIM dialog box:

1. Switch on [Output Disk Files] → [Collision Details] →
2. After the simulation: check for the `collison.txt` file (typo is intended) in the SRIM Outputs folder.

Example for 1 given ion. Lines reporting the subsequent interactions appear in the raw output like this:

```
...
  Ion   Energy   Depth   Lateral Distance (A)   Se   Atom   Recoil   Target Target Target Target
  Numb  (keV)    (A)     Y Axis   Z Axis  (eV/A) Hit  Energy(eV) DISP.  VAC.  REPLAC INTER
-----
300001319.97E+03337875.E-033-4930.E-063 5782.E-0630772.053  C 333617.E-0330000000001.0003      3      3
300001319.93E+03364043.E-033-2281.E-053 1614.E-0530771.363  0 318512.E-0230000000002.0913      3      3
300001319.90E+03311632.E-023-1204.E-043-1444.E-0530770.633  C 310026.E-0230000000001.1613      3      3
300001319.81E+03322070.E-023-2379.E-043-4559.E-0530768.883  C 313711.E-0230000000001.5683      3      3
300001319.77E+03327281.E-023-3026.E-043-9741.E-0630768.123  C 339293.E-0330000000001.0003      3      3
...

```

The raw output file is misformatted (redundant “3” ‘s appear) .  
After correction, the upper printout should look like much cleaner:

```
...
  Ion   Energy   Depth   Lateral Distance (A)   Se   Atom
  Numb  (keV)    (A)     Y Axis   Z Axis  (eV/A) Hit
-----
  1  19.97E+03  7875.E-03  -4930.E-06  5782.E-06  772.05  C
  1  19.93E+03  64043.E-03  -2281.E-05  1614.E-05  771.36  0
  1  19.90E+03  11632.E-02  -1204.E-04  -1444.E-05  770.63  C
  1  19.81E+03  22070.E-02  -2379.E-04  -4559.E-05  768.88  C
  1  19.77E+03  27281.E-02  -3026.E-04  -9741.E-06  768.12  C
...

```