ThiMeT: Thickness Measurement Tools for SRIM

v1.0

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ThiMeT is a code for thickness calculation using SRIM (www.srim.org) stopping power values. ThiMeT code also can be used for the determination of the required thickness for energy degraders which are needed for nuclear reactions. ThiMeT calculation is very easy and quick compared to the TRIM code calculation. ThiMeT code also contains TTEC Module for calculation of the average transmission energy from the TRIM output file "transmit.txt".

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Introduction

ThiMeT is a code for thickness calculation using SRIM [1] stopping power values. ThiMeT code also can be used for the determination of the required thickness for energy degraders which are needed for nuclear reactions. ThiMeT calculations are very easy and quick compared to the TRIM code calculations.

Thickness of a material can be calculated by measure energy loss through matter if the stopping power of the material is well known [2]. This method widely uses to measure energy degrader, backing and target thickness for nuclear reactions [3,4]. But the ions continuously loss their energies moving through matter and also stopping power is change because of the energy dependent nature of stopping power. For this reason, when the thickness calculates, one must take in to account this effect, especially for the thick material. ThiMeT code takes into account stopping power changes through matter and calculate accurate thickness by using SRIM [1]. ThiMeT code also can be used for the determination of the required thickness for energy degraders. This is often use for light ions, such as protons, to obtain lower energies quickly [5,6,7,8]. Please note that ThiMeT code actually use SR Module in the SRIM and the nuclear stopping powers of SR Module are **slightly different** from those in the full tables since these are improved values which will later be incorporated into SRIM [1].

Installation of ThiMeT

Because of the ThiMeT code uses SRIM code, first you should install it. SRIM code can be download from www.srim.org.

After the installation of the SRIM, download the ThiMeT code (www.thimet.org) for appropriate platform which you use. Extract the zip file and copy the ThiMeT code folder wherever you want. This folder includes **"Docs", "OUT_ThiMeT"** and **"OUT_TTEC"** sub-folders and also **"ThiMeT.exe"**, **"TTEC.exe"** and "**SRIM_Path.txt"** files. Open the **"SRIM_Path.txt"** file and change your own path of the SRIM code and save it. Now you ready to use ThiMeT code.

Running ThiMeT Code

Because of the ThiMeT code uses SRIM parameters first you should adjust SRIM code for calculation. For this follow these steps;

1. Run the SRIM code and chose the **"Stopping / Range Tables",**
2. Chose projectile from **"ion"** section,
3. Add the material which is correspond your target or degrader from **"Add element"** or **"Compound Dictionary",**
4. Change the **"Stopping Power Unit"** to **"keV / micron",**
5. If **"Density"** and **"Compound Correction"** are correct, and there is no need to change them, then click to **"Calculate Table"** and click to **"OK" ,**
6. Then click to **"Close"** to close calculated results,
7. Close the SRIM.

Now you are ready to use ThiMeT. For the same material and ion you don't need to do same steps given above but if you want to calculate for new material or for new projectile, you should follow again steps 1 to 7.

In order to run ThiMeT code just double clicks to **"ThiMeT.exe"** file or in command mode type **"ThiMeT.exe".** Code will ask you just two parameter, **"Projectile energy"** and **"Exit energy"** from the material. Please give energies as **integer** and in **"keV"** unit. Code will calculate thickness in a few seconds, according to energy difference between incident ions and exit ions may be it takes longer. Thickness results are in two units; **µm** (micron) and **µg/cm²** or **mm** and **mg/cm²** according to its value.

Verification

Here you can find some example calculation and result for common degrader materials in order to verify your results. SRIM-2013 stopping power (SR Module) values were used for these calculations.

Table 1. ThiMeT thickness calculation for common degrader materials.

Projectile	Target / Degrader Material	Incident ion energy (keV)	Exit ion energy (keV)	ThiMeT Thickness
H	Be	100 000	88 488	9.9953 mm
H	C	100 000	84 344	9.9921 mm
H	Al	100 000	83 628	9.9950 mm
H	Plexiglas	158 600	30 000	144.8785 mm
He	Be	100 000	86 002	999.418 µm
He	C	100 000	80 947	999.382 µm
He	Al	100 000	80 947	999.632 µm
He	Al	10 000	8 000	17.899 µm
He	Al	3 183	1 000	8.377 µm

Limitations

Some SRIM stopping power and experimental one, not in a good agreement for all energy ranges, ions and targets. Please check related energy range from SRIM web site (www.srim.org)

You can use 1 keV to 1 GeV energy range, but please consider that for low energies, deviation on SRIM stopping power is too high. You can check stopping power deviation for related energy range from SRIM web site. It is better to double check your results with TRIM (the Transport of Ions in Matter) simulation. It means, enter your thickness result from ThiMeT to TRIM, and check energy loss calculated from TRIM (www.srim.org). For average energy loss calculation you can use TTEC code.

For more information of reliability of stopping power codes and tables, see these references; [9-26].

Measurement of Thickness

Thickness of a material can be calculated by measure energy loss through matter if the stopping power of the material is well known. Generally ^{241}Am and ^{148}Gd source uses for the thickness measurement. Energy loss of alpha particles through matter determine with a particle detector in vacuum chamber. First, just collimated source measured and then material placed between source and detector, and measurement repeat with this setup (Figure 1). Projectile and exit energies determined from these two measurements (or spectra) and these energies give as input to ThiMeT code. Because of the energy calibration of detector is crucial; also with a pulser energy calibration should be checked. Detailed information can be found at reference [27] for alpha-particle spectrometry.

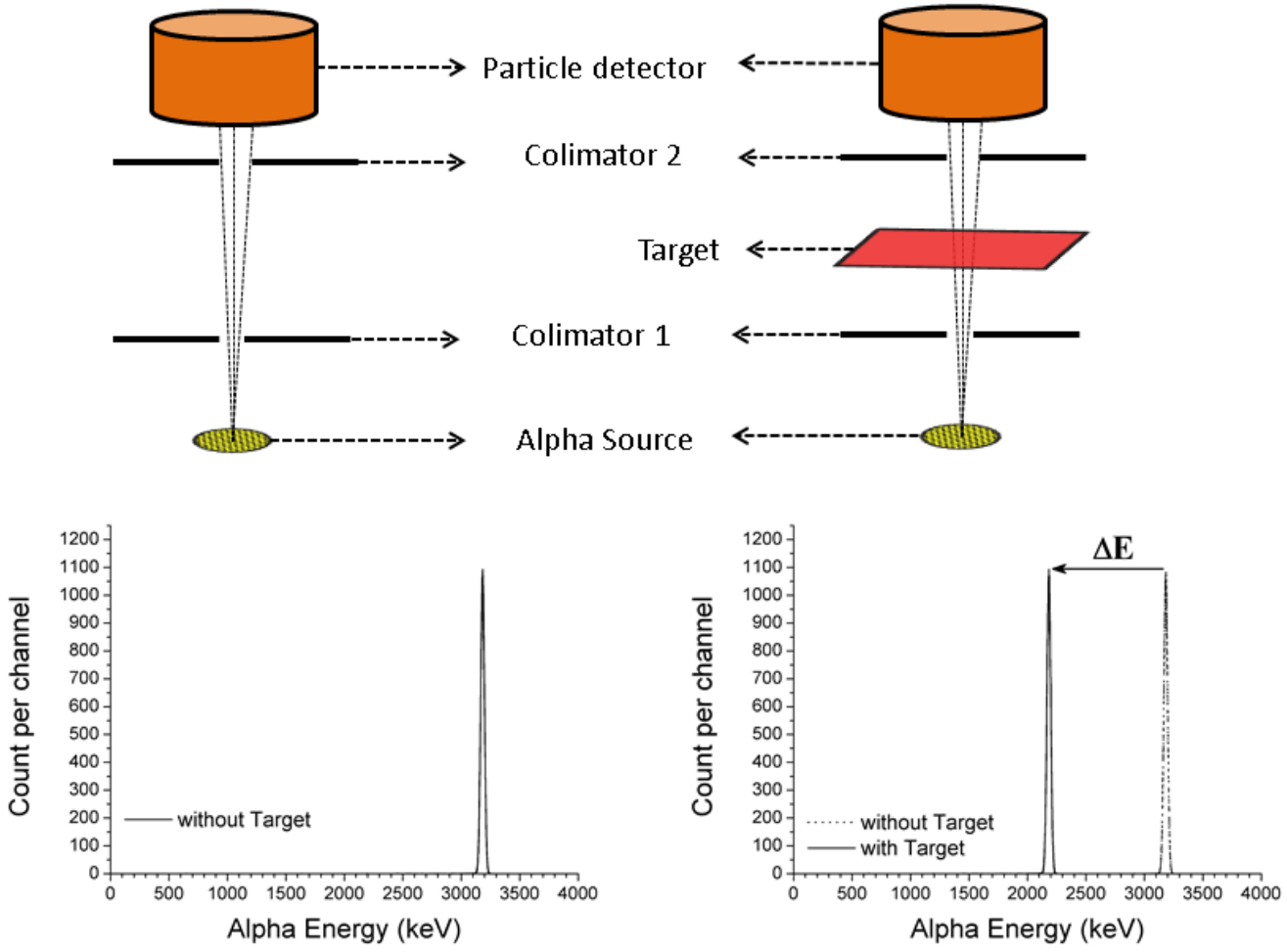

Figure 1. The experimental setup and obtained spectra for thickness measurement using alpha spectroscopy.

Required Degrader Thickness Calculations; In order to determine required thickness for energy degrader, you should enter beam energy of the accelerator as "Projectile energy" and desired energy as "Exit Energy" in the ThiMeT code. If the energy loss is too high, please consider that calculation takes a few minute according to your computer performance.

Comparison with TRIM

Here is the some example of the thickness calculation with ThiMeT and TRIM code. For the high energy loss, difference between ThiMeT and TRIM calculation less than 0.1 percent. For the comparison these steps followed;

1. The certain thickness for Be (10mm), projectile ion (H) and its energy (100 MeV) entered to the TRIM, and run for 10000 ions (in order to fastest calculation "No graphical" and "No auto save" modes set for TRIM)
2. Run TTEC code to get average energy of transmitted ions from "Transmit.txt" file
3. Run ThiMeT code and enter projectile energy (100MeV), and average energy calculated from TTEC as exit energy. Results will be : 9.995269 mm
4. Difference between calculated thickness from ThiMeT (9.995269 mm) and entered thickness in TRIM (10 mm) calculated as percent (**%** 0.05).

Table 2. Calculated ThiMeT thickness and comparison with TRIM code for common degrader materials.

Parameters				**TRIM Calculation**		**ThiMeT Calculation**		
Projectile	**Target / Degrader Material**	**Incident ion energy (keV)**	**Exit ion energy (keV)**	**Thickness (µm)**	**Calc. Time***	**Thickness (µm)**	**Calc. Time***	**Diff. (%)**
H	Be	100 000	88 488	10 000	2m 7s	9 995.3	~3 s	0.05
H	C	100 000	84 344	10 000	3m 7s	9 992.1	~3 s	0.08
H	Al	100 000	83 628	10 000	3m 26s	9 995.0	~3 s	0.05
H	Be	100 000	52419	35 000	7m 34s	34 986.5	7 s	0.04
H	C	100 000	24 890	35 000	14m 10s	35 034.5	12 s	0.10
H	Al	100 000	18644	35 000	15m 37s	35050.4	13 s	0.14
He	Be	100 000	17213	4 000	21m 21s	3 998.221	25 s	0.04
He	C	100 000	18105	3 000	29m 16s	2 998.922	28 s	0.04
He	Al	100 000	16866	3 000	36m10	3 000.003	25 s	0.00
He	Be	100 000	86 002	1 000	3m 34s	999.418	~4 s	0.06
He	C	100 000	80 947	1 000	3m 25s	999.382	~4 s	0.06
He	Al	100 000	80 606	1 000	4m 2s	999.632	~3 s	0.04
He	Al	10 000	8 000	17.95	54 s	17.899	~1 s	0.28
He	Al	3 183	1 000	8.415	58 s	8.377	~1 s	0.45

* In order to fastest calculation "No graphical" and "No auto save" modes set for TRIM and incident ion number is 10000.
Computer specifications : Windows 7 (64 bit), CPU: Intel Core i5 M450 2.4GHz, RAM: 4GB

If you want to calculate required Plexiglas thickness of 158.6 MeV protons to 30 MeV with TRIM code, there is a method in the TRIM user manual or in the TRIM follow these menus: Help, FAQ and Scientific Explanations / Special Applications of TRIM / Ion Energy Reducer (Energy Degraders). According to this method you need to run TRIM a few times, and for the calculation you need more than 3 hours for every run for the 100 000 ions (with same computer in Table 2). Also for the precise calculation you need to run TRIM more times to determine the thickness but same calculation with ThiMeT code will take less than half minute.

TTEC Code

TTEC is a code for calculation of average transmission energy using "Transmit.txt" output file of TRIM Code. This code needed for comparison with TRIM. Result and energy distribution of the transmitted ions (energy spectrum) can be found in **"OUT_TTEC"** folder. Spectrum format is the **".spe"** file format which is Ortec text spectrum file. For the energy calibration, assumed that calibration equation is linear and the max energy is the last channel energy in the spectrum.

Contact

For the suggestions, comments and questions please send an email to info@thimet.org or support@thimet.org .

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