VARSKIN+ v1.3
Software Release Note

July 2024

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Revision History

Revision	Description
0	Initial release.

Table of Contents

1.0 Introduction

This document outlines in detail the modifications, additions, and/or removal of features from VARSKIN+ v1.2 to VARSKIN+ v1.3.

All modifications are based on items entered in the RCD software issue tracker as a source for the basis of a change.

2.0 Abbreviations and Definitions

Table 2-1. Abbreviations and definitions.

Term	Definition
CP	change package number (gitlab version identifier)
DLL	dynamic-link library
GUI	graphical user interface

3.0 Base Line Code

The changes identified here have been incorporated into the baseline of VARSKIN+ v1.3. Table 3-1 and Table 3-1 document the attributes of the software product with project dependencies as identified in Table 3-3.

Table 3-1. GIT attributes.

Git Location	Revision ID (Commit SHA)
https://gitlab.com/RCD-1/varskin/-/tags/varskin+v1.1	d2f7c94e0b144f9830f151307078c27f68d63a6e
https://gitlab.com/RCD-1/varskin/-/tags/varskin+v1.2	2295b4ef6963f161fdfa91868ded5419ff602121
https://gitlab.com/RCD-1/varskin/-/tags/varskin+v1.3	137adac8cb4c6ade81d4eb9c70018eeaa7c69fe2

Table 3-2. Executable attributes.

Executable Name	VARSKIN+1.3.exe
MD5sum	b79669c73a794c9c1d92d6e954a87c6c
SHA256	832b22a523c9e83889b1f001937e8b0c327ad29b4cadd7e98173045435decd2f
SHA512	4dac6e4bcb6b95c0679ec2d001aa61ad0400fe7626b6c8f106fd1cb031eb82721c8dde34f36933b0226e569fd7e1e98a6ea97fd453c2d3cafacfb62c7a59af2e

Table 3-3. Dependency attributes.

Software	Version	Git Location	Revision ID (Commit SHA)
NRC-Graphing	1.0	https://gitlab.com/RCD-1/nrc-graphing	575af944ddf229c6ba033b4117f90d84117c9f49
RadToolbox	3.0.1	https://gitlab.com/RCD-1/radtoolbox	e9e97bc4b43f14e885afde8ebebd226d8bf6e92d

Software	Version	Git Location	Revision ID (Commit SHA)
Intel® Fortran Compiler Classic	2021.11.0	n/a	n/a
JDK	21	n/a	n/a

4.0 Changes

The following sub-sections outline the changes made from VARSKIN+ version 1.2 to VARSKIN+ version 1.3. A summary of changes is provided in Table 4-1.

Table 4-1. Summary of versions and resolved issues.

Version	Issue #	Description	Section(s)
1.2 (CP29)	-	Major Release.	-
1.2.1 (CP31)	48	Correction to Wound Dose calculation of shallow dose displayed results.	4.1
1.2.2 (CP33)	44	Consolidation of variable type definitions within source code. No impact to results.	4.2
1.2.3 (CP30)	46	Adding loading of covers from the scenario file for Skin Dose.	4.3
1.2.4 (CP36)	57	Corrected issue where nuclides with daughters cannot be moved from "Available in Data Base" to "Selected for Analysis".	4.4
1.2.5 (CP39)	60	Addition of RadToolbox to VARSKIN+.	4.5
1.2.6 (CP37)	59	When a parent nuclide that had daughters was deleted the files associated with the daughters were not deleted.	4.6
1.2.7 (CP40)	70	Show dose detail window for shallow dose in Wound Dose. Adjusted 'No Decay' results to account for biological removal.	4.7
1.2.8 (CP41)	71	Correction to WoundDose line source axial nodalization.	4.8

Version	Issue #	Description	Section(s)
1.2.9 (CP42)	78	Correction to electron local dose within WoundDose.	4.9
1.2.10 (CP43)	79	Correction to average electron and Beta energy calculation.	4.10
1.2.11 (CP44)	61, 77	Corrections to use of a custom nuclide (XX-MeV) as a source that appeared previously 'disconnected'. Allowed user to enter the half-life for a custom nuclide.	4.11
1.2.12 (CP46)	75	Correction to permissions required for running RadToolbox.	4.5
1.2.13 (CP45)	74	On the dose results table for SkinDose and WoundDose "-" is displayed when there are no particles present to distinguish from a zero dose when particles are present.	4.12
1.2.14 (CP47)	82	For SkinDose and WoundDose updated the tissue density for alpha dose calculations.	4.13
1.2.15 (CP48)	80	Updated to use the term Photon (instead of Gamma) when talking related to parameters that consider more than just gammas (e.g., x-rays).	4.14
1.2.16 (CP34)	53	Added German, Korean, and Akan languages.	4.15

Version	Issue #	Description	Section(s)
1.2.17 (CP49)	85	Correction to SkinDose dose report text file error where progeny doses are greater than total dose.	4.16
1.2.18 (CP38)	58	Allowed Saving Scenario Prior to Running Scenario.	4.17
1.3 (CP51)	-	Major Release.	-

4.1. Issue 48: Over-correction for Decay in WoundDose

It was noted that a hand-calculated wound local dose estimate matched the value returned in the "No Decay Correction" section of the Dose Detail window, and not the value displayed in the Results table. The value reported in the Results table was noted to be about 60% low, consistently and regardless of nuclide.

This was found to be because the wound dose calculation already accounts for effective half-life (calculated from both radiological and biological half-life, See Section 4.2 of NUREG-6918) within the dose rate calculation. Retrieving the already decay-corrected dose resulted in the radiological half-life being accounted for again, improperly reducing the dose result. This reduction is equal to 0.632 for cases where the radiological half-life is much shorter than the biological half-life.

This has been rectified by using the non-decay-corrected dose for wound model results, in both the results table and the text report creation function.

4.2. Issue 44: Consolidation of Internal Fortran Type Variables.

Both the ‘intertypemod’ and ‘constants’ modules had definitions for the integer (SIK) and real (SDK) type definitions. These define precision of integers and reals (respectively) in Fortran. The various other modules then use a combination of the two modules to consistently define precision for all variables. ‘intertypemod’ was eliminated and all other uses point to the constants module.

There is no impact on code results.

4.3. Issue 46: Covers Not Being Saved

It was found that the covers were not being loaded from saved scenario files. This has been corrected and SkinDose will now load covers from scenario files.

4.4. Issue 57: Moving Between Available and Selected for Parents with Daughters

An error was found where nuclides from 107D and 38D would not move between "Available in Database" and "Selected for Analysis". This was causing the user to have to reload daughters for every new instance of SkinDose.

This has been corrected.

4.5. Issue 60 and 75: Incorporation of RadToolbox into Varskin+

Adds RadToolbox to be accessible through VARSKIN+. No changes made to RadToolbox source itself.

Initially when selecting RadToolbox button from that VARSKIN+ main launcher window, RadToolbox did not open properly. It is noted that a modification to adjust the Rtoolbox.exe manifest to perform a soft redirect of oleaut32.dll was required. This was done by adjusting the 'name' to include the local path. This results in the program favoring the system version (SysWOW64) over the local version (VB6).

4.6. Issue 59: Nuclide Library Cleanup when Deleting Nuclides

When a nuclide with daughters is deleted from SkinDose, the daughters were not being deleted from the library directory.

This occurrence is invisible to the user, but the issue has been resolved by removing daughters if they are not part of other decay chains.

4.7. Issue 70: Show Dose Detail Window for Shallow Dose and Define "No Decay Dose"

For Shallow Dose calculation within WoundDose, it is requested to allow users to view the Dose Detail window. It is requested that the following be displayed: (1) the initial dose rate; and (2) the dose rate with no decay where the time applied is to account for the biological loss only. The Dose Detail window should not be available for local or systemic dose.

The following items were modified to resolve Issue 70:

1. Allowed access to Dose Detail window only if Shallow Dose within Wound Dose is select.
2. When switching between the local, systemic, and shallow dose tables in WoundDose, the calculation button is not put into an out-of-date state (red) as inputs have not changed by simply switching tables.
3. Updated results table such that moving the window between screens does not put the calculation button into an out-of-date state (red) as inputs have not changed. Moving the window was causing a property change of the table.
4. Made available the calculation of a "No Decay Dose" which is only based on the biological removal rate with no allowance of nuclide decay.

5. Updated WoundDose report to use updated Decay Dose and editorial cleanup to Report class.

4.8. Issue 71: Correction to WoundDose Line Source Axial Nodalization

A user was examining the difference in shallow dose rate for a line-source injury and noted the dose rate results using a constant linear activity per unit injury length did not approach the expected limit with changes in injury length (depth). For example, the dose to the averaging disk kept increasing as the line source kept increasing in depth beyond the range of alphas.

The issue was identified as a result of an error in the number of calculated axial intervals of which to perform the various dose calculations along the line source. This is now corrected. Figure 4-1 demonstrates that the alpha dose now plateaus just after the approximate range of a 6 MeV electron.

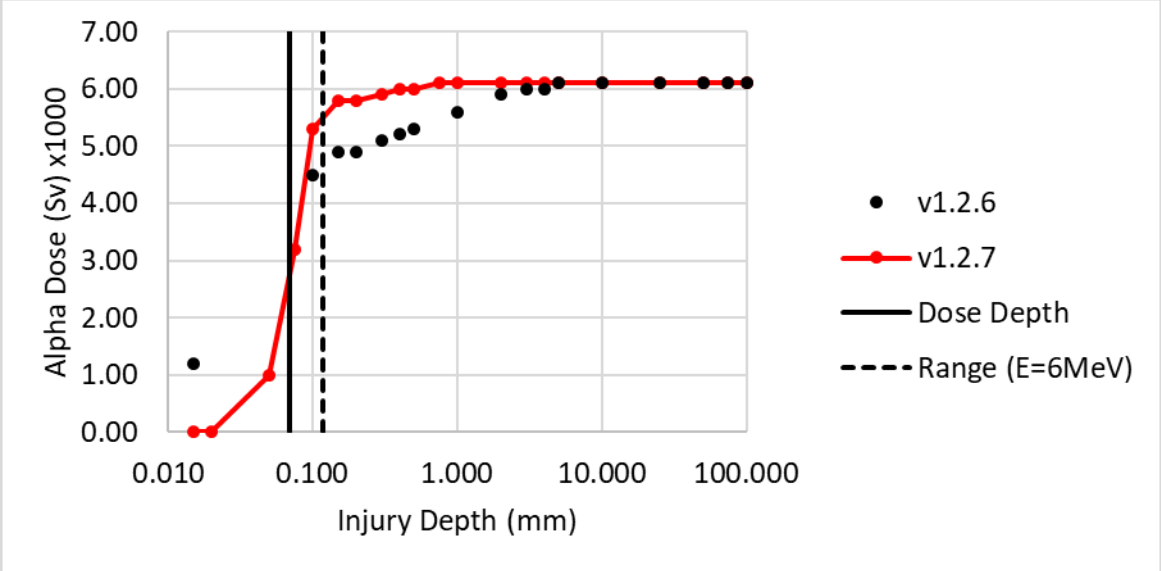

Figure 4-1. Alpha dose as function of injury depth.

4.9. Issue 78: Correction to Electron Local Dose within WoundDose

In WoundDose, the local dose calculation for beta particles (specifically) is incorrect. The local electron dose was calculated by integrating the beta spectrum to obtain the dose of the entire spectrum followed by dividing by the integrated yield. This does not result in the total dose from all energies but rather the average dose per beta emission. The division by the integrated yield is removed so that the

integration of Y*E over all dE energy bins is consistent with the first integral term in brackets in the following equation:

$$D_e = c\frac{Q\ \tau\ w_{r_e}}{\rho\ V_P}\left[\int Y_\beta E_\beta dE + \sum_i Y_i\ E_i\right] \qquad \text{Equation 4-1}$$

Testing was performed for various nuclides that have a mixture of electrons and betas. Hand calculated values were compared to that reported by WoundDose and all results are within +/-0.5%

Table 4-2. Test input conditions for Issue-78.

Parameter	Value	Units
Source	Point	(-)
Retention Class	4	days
Activity	1	Bq
Nuclide Effective Z	7.42	(-)

Table 4-3. Average electron energy verification for Issue-78.

Nuclide	Database	Reference (mSV)	WoundDose (mSV)	Relative Error (mSV)
P-32	ICRP-107	4.316E-02	4.328E-02	0.29%
Tc-99m	ICRP-38	6.293E-05	6.294E-05	0.02%
Tc-99m	ICRP-107	6.238E-05	6.231E-05	-0.11%
Ba-137m	ICRP-38	2.249E-06	2.251E-06	0.08%
Ba-137m	ICRP-107	2.264E-06	2.266E-06	0.11%
Co-60	ICRP-107	7.656E-03	7.656E-03	0.00%

4.10. Issue 79: Correction to Average Electron and Beta Energy Calculation

The average electron plus beta energy returned in SkinDose or WoundDose for Tc-99m is inconsistent between the use of ICRP-38 (0.0132 MeV) and ICRP-107 (0.127 MeV). The expected answer is about 0.0132 MeV per transition.

This is confirmed to be an error where the average electron and beta energies are directly added as eav = eavbeta + eavelec. The units on eavelec are average energy per nuclear transition whereas the units on eavbeta are average energy of all beta particles normalized to the spectrum. eavbeta should be eavbeta*y1 to

obtain average energy of the beta spectrum per nuclear transition. The ICRP databases provide the energy and yield of each branch per transition. The average energy pertransition including betas is then described by Equation 4-2. This was corrected in SadCalc.

$$\bar{E} = \sum \underbrace{(E_i \cdot \gamma_i)}_{Electrons} + \underbrace{\underbrace{\frac{\int Y_\beta E_\beta dE}{\int Y_\beta dE}}_{Avg.\ Beta\ Energy} \cdot \int Y_\beta dE}_{Avg.\ Beta\ Energy\ per\ Transition} \qquad \text{Equation 4-2}$$

Testing was performed for nuclides with various combinations with and without a beta spectrum. Testing results confirm that the average electron (electron + beta) energy per transition is consistent (Table 4-4).

Table 4-4. Average electron energy verification for Issue-79.

Nuclide	Database	Reference Value (MeV)	SkinDose (MeV)	Relative Error (%)
P-32	ICRP-107	6.948E-01	6.94E-01	-0.11%
Tc-99m	ICRP-38	1.342E-02	1.34E-02	-0.12%
Tc-99m	ICRP-107	1.330E-02	1.33E-02	0.01%
Ba-137m	ICRP-38	6.395E-02	6.39E-02	-0.07%
Ba-137m	ICRP-107	6.435E-02	6.44E-02	0.07%
Co-60	ICRP-107	9.652E-02	9.65E-02	-0.02%
1 MeV Electron	N/A	1.000E+00	1.00E+00	0.00%
Bi-212	ICRP-38	4.680E-01	4.68E-01	0.00%
Bi-212	ICRP-107	5.012E-01	5.01E-01	-0.04%

4.11. Issue 61, 77: Corrections to the Use of Custom Nuclide (XX-MeV) as a Source

Running with a custom nuclide specifying alpha, electron, and photon energies, a zero dose for all particle types was obtained. Additionally, the code requires the user to delete the XX-MeV nuclide before changing energy. It was requested that whenever the XX-MeV nuclide is "Selected for Analysis", that the energy input window shows up and displays whatever energies are currently on file (zero if no

XX-MeV nuclide is in the User library, or whatever energies are in the library if the nuclide is present).

The following changes were made:

1. Coding connections for the definition of custom nuclide were corrected. When a custom nuclide with a single electron was specified, there was no underlying beta spectrum to add the yield information to. This is now corrected and the energy vs yield array is generated.
2. Limits on the decay factor calculation to properly handle very small and large time constants (i.e., half-lives) were implemented. This prevents a zero dose result due to exponential operator over-flow (resolving numbers beyond the allowable precision).
3. Added an option to XX-MeV custom nuclide input to allow user to specify the half-life (Figure 4-2).

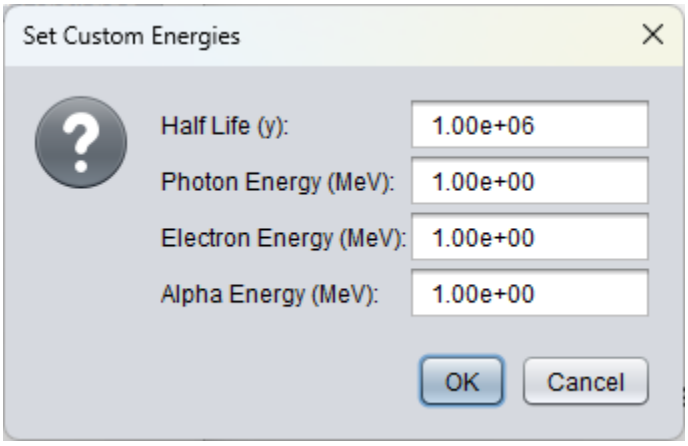

Figure 4-2. User input of half life for a custom nuclide (XX-MeV).

4. When modifying/replacing the custom nuclide the previous entered values are displayed for the user to edit.
5. General cleanup and simplification to SadCalc (Fortran electron energy distribution processing routine).

4.12. Issue 74: Distinguish Zero Dose Results from when No Particles are Present

SkinDose and the shallow dose calculation in WoundDose are intended to have the dose output display as zero when the dose is calculated to be zero (i.e., when particles are emitted but not reaching the averaging area/volume). Conversely,

when no particle of a given type is emitted, the intention is to display a hyphen ('-') as the dose result for that particle type.

When treatment of progenies was modified in v1.2 this feature was lost.

This was resolved by updating the internal HashMaps which are used to track progeny information to default to -0.0 as opposed to 0.0. Minus zero (-0.0) is a special flag to indicate that no particles of that type are emitted.

4.13. Issue 82: Tissue Density Adjustment

When alpha dose is calculated in SkinDose and WoundDose (Shallow Dose), the density of tissue used in the calculation was assumed to be 1.0 g/cm^3 for version 1.2 and previous releases. This value was accurate enough for gamma and electron dose calculations, but its accuracy becomes more critical in alpha dose calculations.

This issue was resolved in version 1.3 by adjusting the density parameter from 1.0 to 1.1 g/cm^3.

Testing was performed using Po-214 and Po-218 with varying tissue depths, showing that with the adjustment, the alpha dose approaches zero closer to the theoretical alpha particle range (Figure 4-3 and Figure 4-4).

The dose values for version 1.3 using a density of 1.1 g/cm^3 are consistent with dose values of version 1.2 using a density of 1.0 g/cm^3 with a 1.1 multiplication factor applied to the dose depth in units of mg/cm^2.

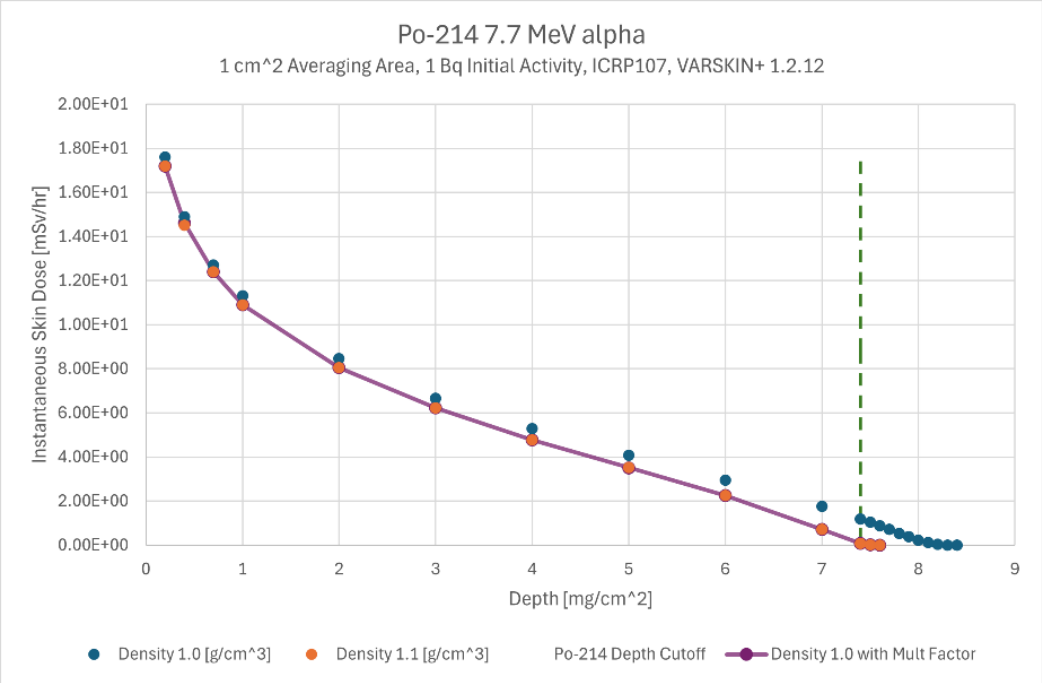

Figure 4-3. Comparison of original model, current model, original model with multiplication factor applied to dose depth, and the theoretical alpha particle range for Po-214 (noted as the dash vertical line).

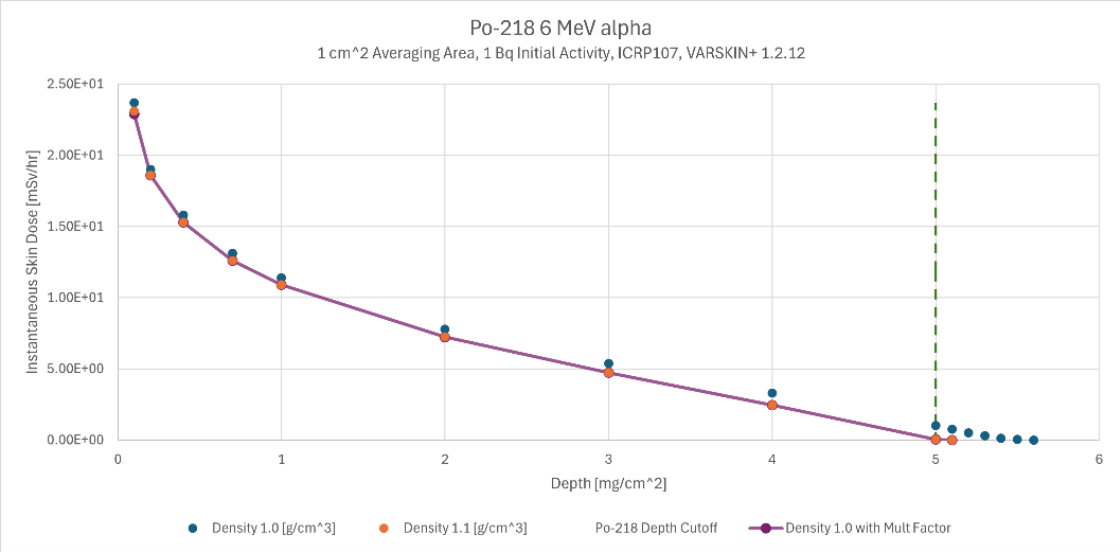

Figure 4-4. Comparison of original model, current model, original model with multiplication factor applied to dose depth, and the theoretical alpha particle range for Po-218 (noted as the dashed vertical line).

4.14. Issue 80: Use of the Term "Photon"

The terminology used within the Dose Detail window did not reflect that both gamma particles and X-rays contribute to the initial dose rate and final dose.

This was resolved by changing the language of labelling parameters in the Dose Detail window from "Gamma" to the more general term "Photon".

4.15. Issue 53: Addition of Languages

Three new languages were added to VARSKIN:

- German,
- Korean, and
- Akan.

This required a reworking of some of the images and better sizing of the application to account for the different lengths of the various translations.

4.16. Issue 85: Correction to SkinDose Dose Report for Printed Progeny Doses

Using SkinDose to analyze nuclides with progeny (e.g., Cs-137 using the ICRP-107D database), a dose report is created that provides the dose (e.g., mSv) for each progeny nuclide followed by the total dose (e.g., mSv). However, the total dose result is smaller than the sum of the progeny.

This was an error in the printing of the report only. The units on the individual progeny doses were as listed in the report section (e.g., mSv); however, the parent nuclide dose units being printed were actually in rem/hr and were not properly being converted to dose. This is corrected such that progeny doses reported are consistent with the units requested by the user for total dose.

4.17. Issue 58: Allowed Saving Scenario Prior to Running Scenario

Previously, a scenario saved before calculating the dose would not be able to be reloaded properly.. This issue occurred with both the "Save" and the "Save As" options.

This issue is now resolved.