Abstract

The software verification and validation process is described for the General purpose Source Particle Module (GSPM) based on the CERN Geant4 code. The objective is to conduct a comprehensive set of tests to verify functionality in response to user commands.
Record of changes

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<table>
<thead>
<tr>
<th>Issue</th>
<th>Date</th>
<th>Detail of changes</th>
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</thead>
<tbody>
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</tr>
</tbody>
</table>
# Table of contents

1 INTRODUCTION ......................................................................................................................... 7
   1.1 Contractual ............................................................................................................................. 7
   1.2 Purpose of the Document ....................................................................................................... 7
   1.3 Scope of the Software ............................................................................................................. 7
   1.4 Definitions, acronyms and abbreviations ............................................................................... 7
   1.5 References ............................................................................................................................... 7
   1.6 Overview of the document ..................................................................................................... 8

2 REVIEW ........................................................................................................................................... 9

3 UNIT AND INTEGRATION TESTS ............................................................................................... 10
   3.1 Test plan #1 ........................................................................................................................... 10
      3.1.1 Test items ........................................................................................................................ 10
      3.1.2 Features to be tested ....................................................................................................... 10
      3.1.3 Test deliverables ............................................................................................................. 10
      3.1.4 Test pass/fail criteria ..................................................................................................... 10
      3.1.5 Test ................................................................................................................................. 10
   3.2 Test Plan #2 .......................................................................................................................... 11
      3.2.1 Test Items ....................................................................................................................... 11
      3.2.2 Features to be tested ..................................................................................................... 11
      3.2.3 Test deliverables ............................................................................................................ 11
      3.2.4 Test pass/fail criteria ................................................................................................... 11
      3.2.5 Test ............................................................................................................................... 10
   3.3 Test plan #3 .......................................................................................................................... 11
      3.3.1 Test Items ....................................................................................................................... 11
      3.3.2 Features to be tested ..................................................................................................... 12
      3.3.3 Test deliverables ............................................................................................................ 12
      3.3.4 Test pass/fail criteria ................................................................................................... 12
      3.3.5 Test ............................................................................................................................... 11
   3.4 Test Plan #4 .......................................................................................................................... 12
      3.4.1 Test Items ....................................................................................................................... 12
      3.4.2 Features to be tested ..................................................................................................... 12
      3.4.3 Test deliverables ............................................................................................................ 13
      3.4.4 Test pass/fail criteria ................................................................................................... 13
   3.5 Test Plan #5 .......................................................................................................................... 13
      3.5.1 Test Items ....................................................................................................................... 13
      3.5.2 Features to be tested ..................................................................................................... 13
      3.5.3 Test deliverables ............................................................................................................ 13
      3.5.4 Test pass/fail criteria ................................................................................................... 13
   3.6 Test Plan #6 .......................................................................................................................... 14
      3.6.1 Test Items ....................................................................................................................... 14
      3.6.2 Features to be tested ..................................................................................................... 14
3.7 Test Plan #7 ................................................................................................................................................14
  3.7.1 Test Items ...........................................................................................................................................14
  3.7.2 Features to be tested ............................................................................................................................14
  3.7.3 Test deliverables ..................................................................................................................................15
  3.7.4 Test pass/fail criteria ...........................................................................................................................15

3.8 Test Plan #8 ................................................................................................................................................15
  3.8.1 Test Items ...........................................................................................................................................15
  3.8.2 Features to be tested ............................................................................................................................15
  3.8.3 Test deliverables ..................................................................................................................................15
  3.8.4 Test pass/fail criteria ...........................................................................................................................15

3.9 Test Plan #9 ................................................................................................................................................16
  3.9.1 Test Items ...........................................................................................................................................16
  3.9.2 Features to be tested ............................................................................................................................16
  3.9.3 Test deliverables ..................................................................................................................................16
  3.9.4 Test pass/fail criteria ...........................................................................................................................16

3.10 Test Plan #10 ...........................................................................................................................................16
  3.10.1 Test Items ...........................................................................................................................................16
  3.10.2 Features to be tested ............................................................................................................................17
  3.10.3 Test deliverables ..................................................................................................................................17
  3.10.4 Test pass/fail criteria ...........................................................................................................................17

3.11 Test Plan #11 ...........................................................................................................................................17
  3.11.1 Test Items ...........................................................................................................................................17
  3.11.2 Features to be tested ............................................................................................................................17
  3.11.3 Test deliverables ..................................................................................................................................17
  3.11.4 Test pass/fail criteria ...........................................................................................................................18

3.12 Test Plan #12 ...........................................................................................................................................18
  3.12.1 Test Items ...........................................................................................................................................18
  3.12.2 Features to be tested ............................................................................................................................18
  3.12.3 Test deliverables ..................................................................................................................................18
  3.12.4 Test pass/fail criteria ...........................................................................................................................18

3.13 Test Plan #13 ...........................................................................................................................................18
  3.13.1 Test Items ...........................................................................................................................................18
  3.13.2 Features to be tested ............................................................................................................................19
  3.13.3 Test deliverables ..................................................................................................................................19
  3.13.4 Test pass/fail criteria ...........................................................................................................................19

3.14 Test Plan #14 ...........................................................................................................................................19
  3.14.1 Test Items ...........................................................................................................................................19
  3.14.2 Features to be tested ............................................................................................................................19
  3.14.3 Test deliverables ..................................................................................................................................20
  3.14.4 Test pass/fail criteria ...........................................................................................................................20

3.15 Test Plan #15 ...........................................................................................................................................20
  3.15.1 Test Items ...........................................................................................................................................20
  3.15.2 Features to be tested ............................................................................................................................20
  3.15.3 Test deliverables ..................................................................................................................................20
  3.15.4 Test pass/fail criteria ...........................................................................................................................20

3.16 Test Plan #16 ...........................................................................................................................................21
  3.16.1 Test Items ...........................................................................................................................................21
  3.16.2 Features to be tested ............................................................................................................................21
3.17 Test Plan #17

3.17.1 Test Items

3.17.2 Features to be tested

3.17.3 Test deliverables

3.17.4 Test pass/fail criteria

3.18 Test Plan #18

3.18.1 Test Items

3.18.2 Features to be tested

3.18.3 Test deliverables

3.18.4 Test pass/fail criteria

3.19 Test Plan #19

3.19.1 Test Items

3.19.2 Features to be tested

3.19.3 Test deliverables

3.19.4 Test pass/fail criteria

3.20 Test Plan #20

3.20.1 Test Items

3.20.2 Features to be tested

3.20.3 Test deliverables

3.20.4 Test pass/fail criteria

3.21 Test Plan #21

3.21.1 Test Items

3.21.2 Features to be tested

3.21.3 Test deliverables

3.21.4 Test pass/fail criteria

3.22 Test Plan #22

3.22.1 Test Items

3.22.2 Features to be tested

3.22.3 Test deliverables

3.22.4 Test pass/fail criteria

3.23 Test Plan #23

3.23.1 Test Items

3.23.2 Features to be tested

3.23.3 Test deliverables

3.23.4 Test pass/fail criteria

3.24 Test Plan #24

3.24.1 Test Items

3.24.2 Features to be tested

3.24.3 Test deliverables

3.24.4 Test pass/fail criteria

3.25 Test Plan #25

3.25.1 Test Items

3.25.2 Features to be tested

3.25.3 Test deliverables

3.25.4 Test pass/fail criteria

3.26 Test Plan #26

3.26.1 Test Items

3.26.2 Features to be tested
3.26.3 Test deliverables .................................................................................................................................29
3.26.4 Test pass/fail criteria ............................................................................................................................29

3.27 Test Plan #27 ..........................................................................................................................................29
3.27.1 Test Items ............................................................................................................................................29
3.27.2 Features to be tested ............................................................................................................................29
3.27.3 Test deliverables ................................................................................................................................29
3.27.4 Test pass/fail criteria ...........................................................................................................................30

4 UNIT AND INTEGRATION TEST REPORT TEMPLATES AND RESULTS .......... 31
4.1 Unit/Integration Test ..................................................................................................................................31

5 ACCEPTANCE TEST PROCEDURES ................................................................................................. 32
5.1 Description of the test .................................................................................................................................32
5.2 Test deliverables ........................................................................................................................................32
5.3 Test case pass/fail criteria..........................................................................................................................32

6 SOFTWARE REQUIREMENTS VERSUS TEST TRACEABILITY MATRIX .......... 33
1 Introduction

1.1 Contractual

This document has been issued by the University of Southampton for ESA/ESTEC under contract 12115/96/NL/JG, Work Order No. 3 (ESA Technology Research Programme, Space Environment and Effects Major Axis). This report describes work undertaken in Work Package 6.2 – “Radiation transport Physics modelled – implementation”.

1.2 Purpose of the Document

This document is intended as a plan and record for the technical reviews and tests carried out on the GSPM. It shall be used to assess that the coding is of sufficient quality, contains sufficient internal documentation, responds correctly to commands provided by the user, carries out the mathematical calculations to the required accuracy, and meets the performance requirements.

1.3 Scope of the Software

This code is intended for use with the CERN Geant4 code for Monte-Carlo, high-energy particle transport. This code was developed with Geant4.1.0.

1.4 Definitions, acronyms and abbreviations

CERN Conseil Europeen pour la Recherche Nucleaire

DERA Defence Evaluation and Research Agency

ESA European Space Agency

Geant4 version 4 of the CERN GEANT code for Monte Carlo simulation of high-energy, fundamental particle transport

GSPM General purpose Source Particle Module

OO Object-Oriented

SPARSET Spacecraft Radiation Shielding and Effects Toolkit

URD User Requirements Document

TIMM The INTEGRAL Mass Model

MGEANT Multi-purpose GEANT

1.5 References


From this Web page, access can be obtained to User Documentation:
1.6 Overview of the document

This document describes the verification and validation plan for the GSPM and satisfies the requirement in the SSD to record and deliver test results.
2 Review

Only two new classes have to be tested, the G4GSPMGun class and the G4GSPMGunMessenger class. Testing will be carried out using a series of macros that can be run one after the other. These will present the GSPM with all of the different inputs expected from users and the outputs can be assessed to determine the correctness of the code. The G4GSPMGunMessenger will capture the user input and run the appropriate G4GSPMGun methods. This means the macros can test both classes together.

The GSPM code has been written by C Ferguson who shall also carry out the tests described in this document. The document shall be updated according to the results of the Unit/Integration Tests. The source code and documentation shall be passed to Dr P Nieminen for inspection and technical review.
3 Unit and Integration tests

3.1 Test plan #1

3.1.1 Test items

SetPosDisType, SetCentreCoords, SetAngDisType, SetEnergyDisType, SetMonoEnergy, GeneratePointSource, GenerateIsotropicFlux, GenerateMonoEnergetic, GenRandTheta, GenRandPhi and GenRandEnergy.

3.1.2 Features to be tested

- Specification of a point source.
- Specification of the co-ordinates of the point source.
- Specification of an isotropic distribution.
- Specification of a mono-energetic source.
- Specification of the energy of the mono-energetic particles.
- Generation of particles at the position defined the point source.
- Generation of particles with momentum vectors distributed according to isotropic function.
- Generation of particles with energy given by the mono-energetic source specified.

3.1.3 Test deliverables

The test deliverables shall be a completed Test Sheet.

3.1.4 Test pass/fail criteria

If the commands in the macro are entered without any errors, and the particles generated fit the above expectation, then the GSPM is considered to have passed this test.

3.1.5 Test

1) Type : <path_to_your_gspm>gspm test1.g4mac >! <your_log_file>

2) When this has finished running you can view your_log_file and look at the starting position, the momentum vectors and the energy of the particles created to check these are as expected.

3) The user can also look at the last 300 lines of output to assess the general statistical correctness of the GSPM. In the macro the verbosity is set to 2, which is the most verbose, and this means the destructor prints out information for the entire run. This can be plotted in the form of graphs to check the overall distribution of starting positions, momentum vectors and energies.
3.2 Test Plan #2

3.2.1 Test Items

The macro test2.g4mac is used to test the following methods: SetPosDisType, SetPosDisShape, SetCentreCoords, SetHalfX, SetHalfY, SetAngDisType, SetEnergyDisType, SetEmin, SetEmax, SetGradient, SetInterCept, GeneratePointsInPlane, GenerateCosineLawFlux, GenerateLinearEnergies, GenRandX, GenRandY, GenRandTheta, GenRandPhi and GenRandEnergy.

3.2.2 Features to be tested

- Specification of a plane type source that is square in shape.
- Specification of a cosine-law angular distribution.
- Specification of a linear energy spectrum with positive gradient and intercept.
- Generation of starting positions confined to the specified square distribution.
- Generation of momentum vectors according to a cosine-law distribution.
- Generation of particle energies according to specified spectrum.

3.2.3 Test deliverables

The test deliverables shall be a completed Test Sheet.

3.2.4 Test pass/fail criteria

The GSPM will be considered to have passed this test if the commands in the macro can be entered without error, and the positions, momentum vectors and energies are distributed according to the above specifications.

3.2.5 Test

1) Type: `<path_to_your_gspm>gspm test2.g4mac >! <your_log_file>`

2) When this has finished running you can view `your_log_file` and look at the starting position, the momentum vectors and the energy of the particles created to check these are as expected.

3) The last 300 lines of output can be used to assess the general statistical correctness of the GSPM.

3.3 Test plan #3

3.3.1 Test Items

The macro test3.g4mac tests the following methods: SetPosDisType, SetPosDisShape, SetCentreCoords, SetHalfX, SetHalfY, SetAngDisType, SetEnergyDisType, SetEmin, SetEmax, SetAlpha, GeneratePointsInPlane, GenerateIsotropicFlux, GeneratePowEnergies, GenRandX, GenRandY, GenRandTheta, GenRandPhi and GenRandEnergy.
3.3.2 Features to be tested

- Specification of plane source rectangular in shape.
- Specification of isotropic angular distribution.
- Specification of power-law with a positive index.
- Generation of starting positions confined to a rectangular plane.
- Generation of momentum vectors distributed according to an isotropic distribution.
- Generation of particles with energies distributed according the specified power-law.

3.3.3 Test deliverables

The test deliverables shall be a completed Test Sheet.

3.3.4 Test pass/fail criteria

If visual inspection of the output of the GSPM confirms that the particles positions, momentum vectors and energies are distributed according to the specifications above then the GSPM is considered to have passed.

3.3.5 Test

1) Type: `<path_to_your_gspm>gspm test3.g4mac >! <your_log_file>

2) When this has finished running you can view `your_log_file` and look at the starting position, the momentum vectors and the energy of the particles created to check these are as expected.

3) The last 300 lines of output can be used to assess the general statistical correctness of the GSPM.

3.4 Test Plan #4

3.4.1 Test Items

The macro test4.g4mac is used to test the following methods: SetPosDisType, SetPosDisShape, SetCentreCoords, SetRadius, SetAngDisType, SetEnergyDisType, SetEmin, SetEmax, SetEzero, GeneratePointsInPlane, GenerateCosineLawFlux, GenerateExpEnergies, GenRandX, GenRandY, GenRandTheta, GenRandPhi and GenRandEnergy.

3.4.2 Features to be tested

- Specification of a circular plane source.
- Specification of a cosine-law angular distribution.
- Specification of an exponential energy spectrum.
- Generation of particles with starting positions confined to a circular plane.
• Generation of particles with momentum vectors distributed according to a cosine-law distribution.

• Generation of particles with energies distributed according to an exponential.

### 3.4.3 Test deliverables

The test deliverables shall be a completed Test Sheet.

### 3.4.4 Test pass/fail criteria

1) Type: `<path_to_your_gspm>gspm test4.g4mac >! <your_log_file>`

2) When this has finished running you can view `your_log_file` and look at the starting position, the momentum vectors and the energy of the particles created to check these are as expected.

3) The last 300 lines of output can be used to assess the general statistical correctness of the GSPM.

### 3.5 Test Plan #5

#### 3.5.1 Test Items

The macro `test5.g4mac` is used to test the following methods: SetPosDisType, SetPosDisShape, SetCentreCoords, SetHalfX, SetHalfY, SetAngDisType, SetEnergyDisType, SetEmin, SetEmax, SetTemp, GeneratePointsInPlane, GenerateIsotropicFlux, GenerateBremEnergies, GenRandX, GenRandY, GenRandTheta, GenRandPhi and GenRandEnergy.

#### 3.5.2 Features to be tested

- Specification of an ellipsoidal plane source.
- Specification of an isotropic angular distribution.
- Specification of a bremsstrahlung energy spectrum.
- Generation of particles with starting positions confined to an ellipsoidal plane.
- Generation of particles with momentum vectors distributed according to an isotropic distribution.
- Generation of particles with energies distributed according to a bremsstrahlung function.

#### 3.5.3 Test deliverables

The test deliverables shall be a completed Test Sheet.

#### 3.5.4 Test pass/fail criteria

1) Type: `<path_to_your_gspm>gspm test5.g4mac >! <your_log_file>`

2) When this has finished running you can view `your_log_file` and look at the starting position, the momentum vectors and the energy of the particles created to check these are as expected.

3) The last 300 lines of output can be used to assess the general statistical correctness of the GSPM.
3.6 Test Plan #6

3.6.1 Test Items

The macro test6.g4mac is used to test the following methods: SetPosDisType, SetPosDisShape, SetCentreCoords, SetRadius, SetAngDisType, SetEnergyDisType, SetEmin, SetEmax, SetTemp, GeneratePointsOnSurface, GenerateIsotropicFlux, GenerateBbodyEnergies, GenRandX, GenRandY, GenRandPhi and GenRandEnergy.

3.6.2 Features to be tested

- Specification of a spherical surface source.
- Specification of an isotropic angular distribution.
- Specification of a black body energy spectrum.
- Generation of particles with starting positions confined to the surface of a sphere.
- Generation of particles with momentum vectors distributed according to an isotropic distribution.
- Generation of particles with energies distributed according to a black body spectrum.

3.6.3 Test deliverables

The test deliverables shall be a completed Test Sheet.

3.6.4 Test pass/fail criteria

1) Type: `<path_to_your_gspm>gspm test6.g4mac >! <your_log_file>

2) When this has finished running you can view `your_log_file` and look at the starting position, the momentum vectors and the energy of the particles created to check these are as expected.

3) The last 300 lines of output can be used to assess the general statistical correctness of the GSPM.

3.7 Test Plan #7

3.7.1 Test Items

The macro test7.g4mac is used to test the following methods: SetPosDisType, SetPosDisShape, SetCentreCoords, SetRadius, SetHalfZ, SetAngDisType, SetEnergyDisType, SetEmin, SetEmax, GeneratePointsOnSurface, GenerateCosineLawFlux, Calculate, CalculateCdgSpectrum, GenerateCdgEnergies, GenRandZ, GenRandTheta, GenRandPhi and GenRandEnergy.

3.7.2 Features to be tested

- Specification of a cylindrical surface source.
- Specification of a cosine-law angular distribution.
- Specification of a cosmic diffuse gamma ray spectrum.
• Generation of particles with starting positions confined to the surface of a cylinder.

• Generation of particles with momentum vectors distributed according to a cosine-law distribution.

• Generation of particles with energies distributed according to the cosmic diffuse gamma ray spectrum.

3.7.3 Test deliverables

The test deliverables shall be a completed Test Sheet.

3.7.4 Test pass/fail criteria

1) Type : <path_to_your_gspm>gspm test7.g4mac >! <your_log_file>

2) When this has finished running you can view your_log_file and look at the starting position, the momentum vectors and the energy of the particles created to check these are as expected.

3) The last 300 lines of output can be used to assess the general statistical correctness of the GSPM.

3.8 Test Plan #8

3.8.1 Test Items

The macro test8.g4mac is used to test the following methods: SetPosDisType, SetPosDisShape, SetCentreCoords, SetHalfX, SetHalfY, SetHalfZ, SetAngDisType, SetEnergyDisType, SetEmin, SetEmax, SetGradient, SetInterCept, GeneratePointsOnSurface, GenerateIsotropicFlux, GenerateLinearEnergies, GenRandX, GenRandY, GenRandZ, GenRandTheta, GenRandPhi and GenRandEnergy.

3.8.2 Features to be tested

• Specification of an ellipsoidal surface source.

• Specification of an isotropic angular distribution.

• Specification of a linear energy spectrum with gradient equal to zero.

• Generation of particles with starting positions confined to the surface of an ellipsoid.

• Generation of particles with momentum vectors distributed according to an isotropic distribution.

• Generation of particles with energies distributed according to a linear spectrum.

3.8.3 Test deliverables

The test deliverables shall be a completed Test Sheet.

3.8.4 Test pass/fail criteria

1) Type : <path_to_your_gspm>gspm test8.g4mac >! <your_log_file>
2) When this has finished running you can view your_log_file and look at the starting position, the momentum vectors and the energy of the particles created to check these are as expected.

3) The last 300 lines of output can be used to assess the general statistical correctness of the GSPM.

3.9 Test Plan #9

3.9.1 Test Items

The macro test9.g4mac is used to test the following methods: SetPosDisType, SetPosDisShape, SetCentreCoords, SetHalfX, SetHalfY, SetHalfZ, SetParAlpha, SetParTheta, SetParPhi, SetAngDisType, SetEnergyDisType, SetEmin, SetEmax, SetGradient, SetInterCept, GeneratePointsOnSurface, GenerateIsotropicFlux, GenerateLinearEnergies, GenRandX, GenRandY, GenRandZ, GenRandTheta, GenRandPhi and GenRandEnergy.

3.9.2 Features to be tested

• Specification of a parallelepiped surface source.
• Specification of an isotropic angular distribution.
• Specification of a linear energy spectrum with a negative gradient.
• Generation of particles with starting positions confined to the surface of a parallelepiped.
• Generation of particles with momentum vectors distributed according to an isotropic distribution.
• Generation of particles with energies distributed according to a linear spectrum.

3.9.3 Test deliverables

The test deliverables shall be a completed Test Sheet.

3.9.4 Test pass/fail criteria

1) Type : <path_to_your_gspm>gspm test9.g4mac >! <your_log_file>

2) When this has finished running you can view your_log_file and look at the starting position, the momentum vectors and the energy of the particles created to check these are as expected.

3) The last 300 lines of output can be used to assess the general statistical correctness of the GSPM.

3.10 Test Plan #10

3.10.1 Test Items

The macro test10.g4mac is used to test the following methods: SetPosDisType, SetPosDisShape, SetCentreCoords, SetRadius, SetAngDisType, SetEnergyDisType, SetEmin, SetEmax, SetGradient, SetInterCept, GeneratePointsInVolume, GenerateIsotropicFlux, GenerateLinearEnergies, GenRandX, GenRandY, GenRandZ, GenRandTheta, GenRandPhi and GenRandEnergy.
3.10.2 Features to be tested

- Specification of a spherical volume source.
- Specification of an isotropic angular distribution.
- Specification of a linear energy spectrum with an intercept equal to zero.
- Generation of particles with starting positions confined to the volume of a sphere.
- Generation of particles with momentum vectors distributed according to an isotropic distribution.
- Generation of particles with energies distributed according to a linear function.

3.10.3 Test deliverables

The test deliverables shall be a completed Test Sheet.

3.10.4 Test pass/fail criteria

1) Type: `<path_to_your_gspm>gspm test10.g4mac >! <your_log_file>`

2) When this has finished running you can view `your_log_file` and look at the starting position, the momentum vectors and the energy of the particles created to check these are as expected.

3) The last 300 lines of output can be used to assess the general statistical correctness of the GSPM.

3.11 Test Plan #11

3.11.1 Test Items

The macro `test11.g4mac` is used to test the following methods: `SetPosDisType`, `SetPosDisShape`, `SetCentreCoords`, `SetRadius`, `SetHalfZ`, `SetAngDisType`, `SetEnergyDisType`, `SetEmin`, `SetEmax`, `SetAlpha`, `GeneratePointsInVolume`, `GenerateIsotropicFlux`, `GeneratePowEnergies`, `GenRandX`, `GenRandY`, `GenRandZ`, `GenRandTheta`, `GenRandPhi` and `GenRandEnergy`.

3.11.2 Features to be tested

- Specification of a cylindrical volume source.
- Specification of an isotropic angular distribution.
- Specification of a power-law energy spectrum with a negative index.
- Generation of particles with starting positions confined to the volume of a cylinder.
- Generation of particles with momentum vectors distributed according to an isotropic distribution.
- Generation of particles with energies distributed according to a power-law function.

3.11.3 Test deliverables

The test deliverables shall be a completed Test Sheet.
3.11.4 Test pass/fail criteria

1) Type: `<path_to_your_gspm>gspm  test11.g4mac >! <your_log_file>`

2) When this has finished running you can view `your_log_file` and look at the starting position, the momentum vectors and the energy of the particles created to check these are as expected.

3) The last 300 lines of output can be used to assess the general statistical correctness of the GSPM.

### 3.12 Test Plan #12

#### 3.12.1 Test Items

The macro `test12.g4mac` is used to test the following methods: `SetPosDisType`, `SetPosDisShape`, `SetCentreCoords`, `SetHalfX`, `SetHalfY`, `SetHalfZ`, `SetAngDisType`, `SetEnergyDisType`, `SetEmin`, `SetEmax`, `SetAlpha`, `GeneratePointsInVolume`, `GenerateIsotropicFlux`, `GeneratePowEnergies`, `GenRandX`, `GenRandY`, `GenRandZ`, `GenRandTheta`, `GenRandPhi` and `GenRandEnergy`.

#### 3.12.2 Features to be tested

- Specification of an ellipsoidal volume source.
- Specification of an isotropic angular distribution.
- Specification of a power-law energy spectrum with index equal to zero.
- Generation of particles with starting positions confined to the volume of an ellipsoid.
- Generation of particles with momentum vectors distributed according to an isotropic distribution.
- Generation of particles with energies distributed according to a power-law function.

#### 3.12.3 Test deliverables

The test deliverables shall be a completed Test Sheet.

#### 3.12.4 Test pass/fail criteria

1) Type: `<path_to_your_gspm>gspm  test12.g4mac >! <your_log_file>`

2) When this has finished running you can view `your_log_file` and look at the starting position, the momentum vectors and the energy of the particles created to check these are as expected.

3) The last 300 lines of output can be used to assess the general statistical correctness of the GSPM.

### 3.13 Test Plan #13

#### 3.13.1 Test Items

The macro `test13.g4mac` is used to test the following methods: `SetPosDisType`, `SetPosDisShape`, `SetCentreCoords`, `SetHalfX`, `SetHalfY`, `SetHalfZ`, `SetParAlpha`, `SetParTheta`, `SetParPhi`, `SetAngDisType`, `SetEnergyDisType`, `SetEmin`, `SetEmax`, `SetEzero`, `GeneratePointsInVolume`, `GenRandX`, `GenRandY`, `GenRandZ`, `GenRandTheta`, `GenRandPhi` and `GenRandEnergy`.

3.13.2 Features to be tested

- Specification of a parallelepiped volume source.
- Specification of a cosine-law angular distribution.
- Specification of an exponential energy spectrum.
- Generation of particles with starting positions confined to the volume of a parallelepiped.
- Generation of particles with momentum vectors distributed according to a cosine-law distribution.
- Generation of particles with energies distributed according to an exponential function.

3.13.3 Test deliverables

The test deliverables shall be a completed Test Sheet.

3.13.4 Test pass/fail criteria

1) Type : `<path_to_your_gspm>gspm test13.g4mac >! <your_log_file>`

2) When this has finished running you can view `your_log_file` and look at the starting position, the momentum vectors and the energy of the particles created to check these are as expected.

3) The last 300 lines of output can be used to assess the general statistical correctness of the GSPM.

3.14 Test Plan #14

3.14.1 Test Items

The macro test14.g4mac is used to test the following methods: SetPosDisType, SetPosDisShape, SetCentreCoords, SetRadius, SetPosRot1, GenerateRotationMatrices, SetAngDisType, SetEnergyDisType, SetEmin, SetEmax, SetEzero, GeneratePointsInPlane, GenerateIsotropicFlux, GenerateExpEnergies, GenRandX, GenRandY, GenRandTheta, GenRandPhi and GenRandEnergy.

3.14.2 Features to be tested

- Specification of a circular plane source with a rotation matrix.
- Specification of an isotropic angular distribution.
- Specification of an exponential energy spectrum with $E_0$ equal to 1.
- Generation of particles with starting positions confined to a rotated circular plane source.
- Generation of particles with momentum vectors distributed according to an isotropic distribution.
• Generation of particles with energies distributed according to an exponential function.

3.14.3 Test deliverables

The test deliverables shall be a completed Test Sheet.

3.14.4 Test pass/fail criteria

1) Type: `<path_to_your_gspm>gspm test14.g4mac >! <your_log_file>`

2) When this has finished running you can view `your_log_file` and look at the starting position, the momentum vectors and the energy of the particles created to check these are as expected.

3) The last 300 lines of output can be used to assess the general statistical correctness of the GSPM.

3.15 Test Plan #15

3.15.1 Test Items

The macro test15.g4mac is used to test the following methods: SetPosDisType, SetPosDisShape, SetCentreCoords, SetRadius, SetHalfZ, SetPosRot2, GenerateRotationMatrices, SetAngDisType, SetEnergyDisType, SetEmin, SetEmax, SetTemp, GeneratePointsOnSurface, GenerateIsotropicFlux, GenerateBremEnergies, GenRandX, GenRandY, GenRandZ, GenRandTheta, GenRandPhi and GenRandEnergy.

3.15.2 Features to be tested

• Specification of a cylindrical surface source with a rotation applied.

• Specification of an isotropic angular distribution.

• Specification of a bremsstrahlung energy spectrum.

• Generation of particles with starting positions confined to the surface of a cylinder.

• Generation of particles with momentum vectors distributed according to an isotropic distribution.

• Generation of particles with energies distributed according to a bremsstrahlung function.

3.15.3 Test deliverables

The test deliverables shall be a completed Test Sheet.

3.15.4 Test pass/fail criteria

1) Type: `<path_to_your_gspm>gspm test15.g4mac >! <your_log_file>`

2) When this has finished running you can view `your_log_file` and look at the starting position, the momentum vectors and the energy of the particles created to check these are as expected.

3) The last 300 lines of output can be used to assess the general statistical correctness of the GSPM.
3.16 Test Plan #16

3.16.1 Test Items

The macro test16.g4mac is used to test the following methods: SetPosDisType, SetPosDisShape, SetCentreCoords, SetHalIX, SetHalIY, SetHalIZ, SetPosRot1, SetPosRot2, GenerateRotationMatrices, SetAngDisType, SetEnergyDisType, SetEmin, SetEmax, SetTemp, GeneratePointsInVolume, GenerateIsotropicFlux, GenerateBremEnergies, GenRandX, GenRandY, GenRandZ, GenRandTheta, GenRandPhi and GenRandEnergy.

3.16.2 Features to be tested

- Specification of a parallelepiped volume source with rotation applied.
- Specification of an isotropic angular distribution.
- Specification of a bremsstrahlung energy spectrum.
- Generation of particles with starting positions confined to the volume of a parallelepiped.
- Generation of particles with momentum vectors distributed according to an isotropic distribution.
- Generation of particles with energies distributed according to a bremsstrahlung function.

3.16.3 Test deliverables

The test deliverables shall be a completed Test Sheet.

3.16.4 Test pass/fail criteria

1) Type: `<path_to_your_gspm>gspm test16.g4mac` >! `<your_log_file>`

2) When this has finished running you can view `your_log_file` and look at the starting position, the momentum vectors and the energy of the particles created to check these are as expected.

3) The last 300 lines of output can be used to assess the general statistical correctness of the GSPM.

3.17 Test Plan #17

3.17.1 Test Items

The macro test17.g4mac is used to test the following methods: SetPosDisType, SetPosDisShape, SetCentreCoords, SetRadius, ConfinSourceToVolume, SetAngDisType, SetEnergyDisType, SetEmin, SetEmax, SetEzero, GeneratePointsInVolume, IsSourceConfined, GenerateIsotropicFlux, GenerateExpEnergies, GenRandX, GenRandY, GenRandZ, GenRandTheta, GenRandPhi and GenRandEnergy.

3.17.2 Features to be tested

- Specification of a spherical volume source, with points confined to be inside v2_sol.
- Specification of an isotropic angular distribution.
• Specification of an exponential energy spectrum.

• Generation of particles with starting positions confined to the volume of a sphere.

• Generation of particles with momentum vectors distributed according to an isotropic distribution.

• Generation of particles with energies distributed according to an exponential function.

3.17.3 Test deliverables

The test deliverables shall be a completed Test Sheet.

3.17.4 Test pass/fail criteria

1) Type: `<path_to_your_gspm>gspm test17.g4mac>`! `<your_log_file>`

2) When this has finished running you can view `your_log_file` and look at the starting position, the momentum vectors and the energy of the particles created to check these are as expected.

3) The last 300 lines of output can be used to assess the general statistical correctness of the GSPM.

3.18 Test Plan #18

3.18.1 Test Items

The macro test18.g4mac is used to test the following methods: SetPosDisType, SetPosDisShape, SetCentreCoords, SetHalflX, SetHalflY, SetAngDisType, SetEnergyDisType, UserEnergyHisto, GenUserHistEnergies, GeneratePointsInPlane, GenerateCosineLawFlux, GenRandX, GenRandY, GenRandTheta, GenRandPhi and GenRandEnergy.

3.18.2 Features to be tested

• Specification of a square plane source.

• Specification of a cosine-law angular distribution.

• Specification of a user-defined energy histogram.

• Generation of particles with starting positions confined to a square plane.

• Generation of particles with momentum vectors distributed according to a cosine-law distribution.

• Generation of particles with energies distributed according to a user-defined histogram.

3.18.3 Test deliverables

The test deliverables shall be a completed Test Sheet.

3.18.4 Test pass/fail criteria

1) Type: `<path_to_your_gspm>gspm test18.g4mac>`! `<your_log_file>`
2) When this has finished running you can view your_log_file and look at the starting position, the momentum vectors and the energy of the particles created to check these are as expected.

3) The last 300 lines of output can be used to assess the general statistical correctness of the GSPM.

3.19 Test Plan #19

3.19.1 Test Items

The macro test19.g4mac is used to test the following methods: SetPosDisType, SetPosDisShape, SetCentreCoords, SetHalfX, SetHalfY, SetAngDisType, SetEnergyDisType, ArbEnergyHisto, ArbInterpolate, LinearInterpolation, GeneratePointsInPlane, GenerateCosineLawFlux, GenArbPointEnergies, GenerateLinearEnergies, GenRandX, GenRandY, GenRandTheta, GenRandPhi and GenRandEnergy.

3.19.2 Features to be tested

- Specification of a square plane source.
- Specification of a cosine-law angular distribution.
- Specification of an arbitrary point-wise spectrum and linear interpolation.
- Generation of particles with starting positions confined to a square plane.
- Generation of particles with momentum vectors distributed according to a cosine-law distribution.
- Generation of particles with energies distributed according to an arbitrary point-wise function which has then been interpolated with linear functions.

3.19.3 Test deliverables

The test deliverables shall be a completed Test Sheet.

3.19.4 Test pass/fail criteria

1) Type: `<path_to_your_gspm>gspm_test19.g4mac`! `<your_log_file>`

2) When this has finished running you can view your_log_file and look at the starting position, the momentum vectors and the energy of the particles created to check these are as expected.

3) The last 300 lines of output can be used to assess the general statistical correctness of the GSPM.

3.20 Test Plan #20

3.20.1 Test Items

The macro test20.g4mac is used to test the following methods: SetPosDisType, SetPosDisShape, SetCentreCoords, SetHalfX, SetHalfY, SetAngDisType, SetEnergyDisType, ArbEnergyHisto, ArbInterpolate, LogInterpolation, GeneratePointsInPlane, GenerateCosineLawFlux,

3.20.2 Features to be tested

- Specification of a square plane source.
- Specification of a cosine-law angular distribution.
- Specification of an arbitrary point-wise spectrum an use of logarithmic interpolation.
- Generation of particles with starting positions confined to a square plane.
- Generation of particles with momentum vectors distributed according to a cosine-law distribution.
- Generation of particles with energies distributed according to logarithmic interpolation of an arbitrary point-wise energy spectrum.

3.20.3 Test deliverables

The test deliverables shall be a completed Test Sheet.

3.20.4 Test pass/fail criteria

1) Type: `<path_to_your_gspm>gspm test20.g4mac`! `<your_log_file>`

2) When this has finished running you can view `your_log_file` and look at the starting position, the momentum vectors and the energy of the particles created to check these are as expected.

3) The last 300 lines of output can be used to assess the general statistical correctness of the GSPM.

3.21 Test Plan #21

3.21.1 Test Items

The macro test21.g4mac is used to test the following methods: SetPosDisType, SetPosDisShape, SetCentreCoords, SetHalfX, SetHalfY, SetAngDisType, SetEnergyDisType, ArbEnergyHisto, ArbInterpolate, ExpInterpolation, GeneratePointsInPlane, GenerateCosineLawFlux, GenArbPointEnergies, GenerateExpEnergies, GenRandX, GenRandY, GenRandTheta, GenRandPhi and GenRandEnergy.

3.21.2 Features to be tested

- Specification of a square plane source.
- Specification of a cosine-law angular distribution.
- Specification of an arbitrary point-wise energy spectrum and exponential interpolation.
- Generation of particles with starting positions confined to a square plane.
• Generation of particles with momentum vectors distributed according to a cosine-law distribution.

• Generation of particles with energies distributed according to the exponential interpolation of an arbitrary point-wise energy spectrum.

3.21.3 Test deliverables

The test deliverables shall be a completed Test Sheet.

3.21.4 Test pass/fail criteria

1) Type: `<path_to_your_gspm>gspm test21.g4mac >! <your_log_file>`

2) When this has finished running you can view `your_log_file` and look at the starting position, the momentum vectors and the energy of the particles created to check these are as expected.

3) The last 300 lines of output can be used to assess the general statistical correctness of the GSPM.

3.22 Test Plan #22

3.22.1 Test Items

The macro test22.g4mac is used to test the following methods: SetPosDisType, SetPosDisShape, SetCentreCoords, SetHalfX, SetHalfY, SetAngDisType, SetEnergyDisType, ArbEnergyHisto, ArbInterpolate, SplineInterpolation, GeneratePointsInPlane, GenerateCosineLawFlux, GenArbPointEnergies, GenRandX, GenRandY, GenRandTheta, GenRandPhi and GenRandEnergy.

3.22.2 Features to be tested

• Specification of a square plane source.

• Specification of a cosine-law angular distribution.

• Specification of an arbitrary point-wise energy spectrum and spline interpolation.

• Generation of particles with starting positions confined to a square plane.

• Generation of particles with momentum vectors distributed according to a cosine-law distribution.

• Generation of particles with energies distributed according to spline interpolation of an arbitrary point-wise energy spectrum.

3.22.3 Test deliverables

The test deliverables shall be a completed Test Sheet.

3.22.4 Test pass/fail criteria

1) Type: `<path_to_your_gspm>gspm test22.g4mac >! <your_log_file>`
2) When this has finished running you can view your_log_file and look at the starting position, the momentum vectors and the energy of the particles created to check these are as expected.

3) The last 300 lines of output can be used to assess the general statistical correctness of the GSPM.

### 3.23 Test Plan #23

#### 3.23.1 Test Items

The macro test23.g4mac is used to test the following methods: SetPosDisType, SetPosDisShape, SetCentreCoords, SetHalfX, SetHalfY, SetAngDisType, UserDefAngTheta, UserDefAngPhi, SetEnergyDisType, EpnEnergyHisto, GeneratePointsInVolume, GenerateUserDefFlux, GenerateUserDefTheta, GenerateUserDefPhi, ConvertEPNToEnergy, GenEpnHistEnergies and SetXBias, SetYBias, GenRandX, GenRandY, GenRandTheta, GenRandPhi and GenRandEnergy. This macro uses alpha particles to test the energy per nucleon spectra.

#### 3.23.2 Features to be tested

- Specification of a square plane source.
- Specification of a user-defined angular distribution in both theta and phi.
- Specification of a user-defined energy per nucleon spectrum.
- Biasing of the x and y distributions.
- Generation of particles with starting positions confined to a square plane.
- Generation of particles with momentum vectors distributed according to a user-defined distribution.
- Generation of particles with energies distributed according to a user-defined function.

#### 3.23.3 Test deliverables

The test deliverables shall be a completed Test Sheet.

#### 3.23.4 Test pass/fail criteria

1) Type: `<path_to_your_gspm>gspm test23.g4mac >! <your_log_file>`

2) When this has finished running you can view your_log_file and look at the starting position, the momentum vectors and the energy of the particles created to check these are as expected.

3) The last 300 lines of output can be used to assess the general statistical correctness of the GSPM.
3.24 Test Plan #24

3.24.1 Test Items

The macro test24.g4mac is used to test the following methods: SetPosDisType, SetPosDisShape, SetCentreCoords, SetRadius, SetAngDisType, SetEnergyDisType, ArbEnergyHisto, ArbInterpolate, LinearInterpolation, InputDifferentialSpectra, GeneratePointsInVolume, GenerateIsotropicFlux, GenArbPointEnergies, GenerateLinearEnergies, SetZBias, SetThetaBias, SetPhiBias, GenRandZ, GenRandX, GenRandY, GenRandTheta, GenRandPhi and GenRandEnergy.

3.24.2 Features to be tested

- Specification of a spherical volume source.
- Specification of an isotropic angular distribution.
- Specification of an integral point-wise spectrum and linear interpolation.
- Biasing of the z, theta and phi distributions.
- Generation of particles with starting positions confined to the volume of a sphere.
- Generation of particles with momentum vectors distributed according to an isotropic distribution.
- Generation of particles with energies distributed according to linear interpolation of an integral point-wise spectrum.

3.24.3 Test deliverables

The test deliverables shall be a completed Test Sheet.

3.24.4 Test pass/fail criteria

1) Type : `<path_to_your_gspm>gspm test24.g4mac >! <your_log_file>`

2) When this has finished running you can view `your_log_file` and look at the starting position, the momentum vectors and the energy of the particles created to check these are as expected.

3) The last 300 lines of output can be used to assess the general statistical correctness of the GSPM.

3.25 Test Plan #25

3.25.1 Test Items

The macro test25.g4mac is used to test the following methods: SetPosDisType, SetPosDisShape, SetCentreCoords, SetRadius, SetAngDisType, SetEnergyDisType, UserEnergyHisto, InputEnergySpectra, GeneratePointsInVolume, GenerateIsotropicFlux, GenUserHistEnergies, SetThetaBias, SetPhiBias, GenRandX, GenRandY, GenRandZ, GenRandEnergy, GenRandTheta and GenRandPhi.
3.25.2 Features to be tested

- Specification of a spherical volume source.
- Specification of an isotropic angular distribution.
- Specification of a momentum user-defined histogram.
- Bias theta and phi distributions.
- Generation of particles with starting positions confined to the volume of a sphere.
- Generation of particles with momentum vectors distributed according to an isotropic distribution.
- Generation of particles with energies distributed according to a user-defined histogram.

3.25.3 Test deliverables

The test deliverables shall be a completed Test Sheet.

3.25.4 Test pass/fail criteria

1) Type : `<path_to_your_gspm>gspm test25.g4mac >! <your_log_file>`

2) When this has finished running you can view `your_log_file` and look at the starting position, the momentum vectors and the energy of the particles created to check these are as expected.

3) The last 300 lines of output can be used to assess the general statistical correctness of the GSPM.

3.26 Test Plan #26

3.26.1 Test Items

The macro test26.g4mac is used to test the following methods: SetPosDisType, SetPosDisShape, SetCentreCoords, SetHalfX, SetHalfY, SetAngDisType, SetEnergyDisType, SetEmin, SetEmax, SetGradient, SetInterCept, GeneratePointsInPlane, GenerateCosineLawFlux, GenerateLinearEnergies, SetEnergyBias, GenRandX, GenRandY, GenRandTheta, GenRandPhi, GenRandEnergy, SetMinTheta, SetMaxTheta, SetMinPhi and SetMaxPhi. This macro also sets the particle type to be electron.

3.26.2 Features to be tested

- Specification of a square plane source.
- Specification of a cosine-law angular distribution.
- Specification of a linear energy spectrum.
- Biasing of the energy distribution.
- Generation of particles with starting positions confined to a square plane.
• Generation of particles with momentum vectors distributed according to a cosine-law distribution.

• Generation of particles with energies distributed according to a linear function and allowing for biasing of the energy distribution.

3.26.3 Test deliverables

The test deliverables shall be a completed Test Sheet.

3.26.4 Test pass/fail criteria

1) Type : `<path_to_your_gspm>gspm  test26.g4mac >! <your_log_file>`

2) When this has finished running you can view `your_log_file` and look at the starting position, the momentum vectors and the energy of the particles created to check these are as expected.

3) The last 300 lines of output can be used to assess the general statistical correctness of the GSPM.

3.27 Test Plan #27

3.27.1 Test Items

The macro test27.g4mac is used to test the following methods: SetPosDisType, SetPosDisShape, SetCentreCoords, SetHalfX, SetHalfY, SetAngDisType, UserDefAngTheta, SetUserWRTSurface, GenerateUserDefFlux, GenerateUserDefTheta, SetEnergyDisType, ArbEnergyHisto, ArbInterpolate, LinearInterpolation, InputEnergySpectra, GeneratePointsInPlane, GenArbPointEnergies, GenerateLinearEnergies, GenRandX, GenRandY, GenRandTheta, GenRandPhi and GenRandEnergy. This macro defines the particle type to be electron.

3.27.2 Features to be tested

• Specification of a square plane source.

• Specification of a user-defined angular distribution.

• Specification of an arbitrary point-wise momentum spectrum with linear interpolation.

• Generation of particles with starting positions confined to a square plane.

• Generation of particles with momentum vectors distributed according to a user-defined distribution.

• Generation of particles with energies distributed according to linear interpolation of a point-wise momentum spectrum.

3.27.3 Test deliverables

The test deliverables shall be a completed Test Sheet.
3.27.4 Test pass/fail criteria

1) Type: `<path_to_your_gspm>gspm test27.g4mac >! <your_log_file>`

2) When this has finished running you can view `your_log_file` and look at the starting position, the momentum vectors and the energy of the particles created to check these are as expected.

3) The last 300 lines of output can be used to assess the general statistical correctness of the GSPM.
# 4 Unit and Integration Test report templates and results

The following form shall be completed for the Unit/Integration test phase.

## 4.1 Unit/Integration Test

<table>
<thead>
<tr>
<th>Test</th>
<th>Module</th>
<th>Pass/Fail</th>
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<td>#1</td>
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</table>

Signature ____________________________
5 Acceptance test procedures

5.1 Description of the test

The acceptance tests shall comprise the Unit/Integration Test results performed on a computer identified by the customer.

5.2 Test deliverables

The test deliverables shall be the Unit/Integration Test deliverables and the results generated at acceptance. The results of the acceptance tests shall be held in the Software Transfer Document.

5.3 Test case pass/fail criteria

The GSPM is considered to have passed the acceptance tests if it passes all the Unit/Integration Tests.
6 Software requirements versus test traceability matrix

Table 6.1 shows a cross-reference of the software requirements and Unit/Integration Tests. This shows that the software requirements can be met with the proposed test plan.

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<thead>
<tr>
<th>SR</th>
<th>UIT1</th>
<th>UIT2</th>
<th>UIT3</th>
<th>UIT4</th>
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