Tutorial for MANTIS

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I. Introduction

MANTIS is an efficient and flexible simulation tool for R&D and optimization of radiation imaging systems that use x-ray, γ, $e^{\pm}$ and optical photons. The physics models in MANTIS are described in Ref. [1]. This tutorial describes the contents of the Monte Carlo code MANTIS distribution (version 1.0) and guides first-time users through the demonstration examples. Please read the entire document before starting to use the package[1]. Since MANTIS is an extension to PENELOPE [2], familiarity with the PENELOPE2005 package is needed.

II. Distribution package

The files included in this distribution of MANTIS are listed below.

- `\.` FORTRAN source:
  `MANTIS.F`
  `DETECT2.F90`
  `PENELOPE.F`
  `PENAUX.F`
  `PENGEOM.F`
  `PENVARED.F`
  `SOURCEBOXISOTROPICGAUSSSPECTRUM.F`
  `SOURCEPHASESPACEFILE.F`
  `TALLYDETECT2.F`
  `TALLYENERGYDEPOSITION ...`
  `...PULSEHEIGHTSPECTRUM.F`
  `TALLYPARTICLECURRENTSPECTRUM.F`
  `TALLYPHASESPACEFILE.F`
  `TALLYSPATIALDOSEDISTRIB.F`
  `TALLYSPATIALDOSEDISTRIB_C1.F`
  `TALLYSPATIALDOSEDISTRIB_C2.F`
  `TALLYSPATIALDOSEDISTRIB_C3.F`
  `TIMING.F`
  This directory also includes a workspace and project file associated with `Visual Studio`:
  `MANTIS.DSW`
  `MANTIS.DSP`
  not needed if you don't use that software package.
- `\demo` Files needed to run the demo example described in Section V. More information about the input files can be found in the file header.
  Optical transport material properties:
  `abs-vacuum.dm2`
  `backing.dm2`
  `csi.dm2`
  `diode.dm2`
  `gas.dm2`
  `pseudo-vacuum.dm2`
  `substrate.dm2`
  Configuration for demonstration examples with wild character `?` stands for `R` or `L` (see Section V for details):
  `mantis_demo_CsI_H?.d2c` contains general optical Monte Carlo configuration parameters
  `mantis_demo_CsI_H?.d2d` contains detector spectral sensitivity
  `mantis_demo_CsI_H?.d2m` contains material list
  `mantis_demo_CsI_H?.d2s` contains surface definitions
  `mantis_demo_CsI_H?.d2x` contains emission spectrum for scintillator
  `mantis_demo_CsI_H?.pen` contains general Monte Carlo configuration parameters for ionizing radiation transport (see PENELOPE documentation)
  Material file (for particle transport): `dixid.mat`
  Geometry file: `dixid00.level4.geo`
  Jobname file: `mantis.job`
  Output files (you can generate the same output files by running the example cases; useful to compare results): `*.out`, `*.dat`.

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- `\doc` This tutorial, `TUTORIAL_mantis.pdf`.
- `\gnuplot_scripts` A few `Gnuplot` scripts for MANTIS output.
- `\release` Intermediate compilation files obtained with `Visual Fortran`. File list not included. The executable in this directory `mantis.exe` should run in any Windows-based computer with no compilation required.

III. Additional Software

- To compile MANTIS, the user needs a current FORTRAN compiler with support for F90.[2]
- For plotting MANTIS results, the distribution includes example scripts for GNUPLOT, a command-driven plotting program.[3] Useful but not required.

IV. Compilation

If you are not using the executable provided with the distribution, compile MANTIS using the provided Make file in the root directory of the distribution (`\.`), or using

```
F mantis.f detect2.f90 -o mantis.exe
```

where `F` is the `FORTRAN` compiler command in your system.

V. Demonstration Example

- Copy the executable `mantis.exe` to the `\demo` directory and run the program.
- There are two demonstration examples included in version 1.0. Both are for a columnar 100-μm-thick CsI detector. Case `*_HR.*` is for a high resolution screen with absorptive backing, and case `*_HL.*` is a high light output screen with reflective backing. The x-ray primaries are from a 70.5-keV pencil beam perpendicular to the detector plane. The user selects the case to run by changing the name of the job in the jobname file `mantis.job`. Run one case after the other and you'll generate output files for both cases named appropriately.
- Description of output files:

  `*xray_events.out` contains initial ionizing particle paths

  `*optical_events.out` contains initial optical photon paths

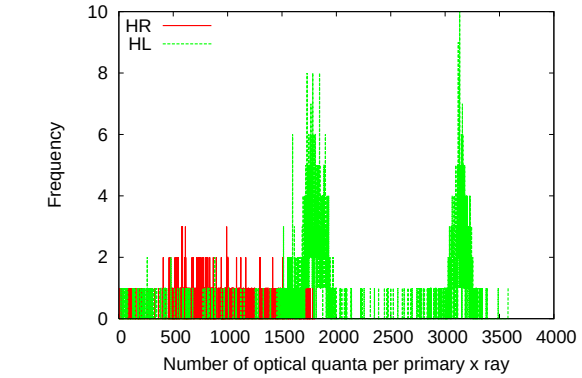
  `*1det.out` contains line-spread function

  `*3det.out` contains 3D point-response function

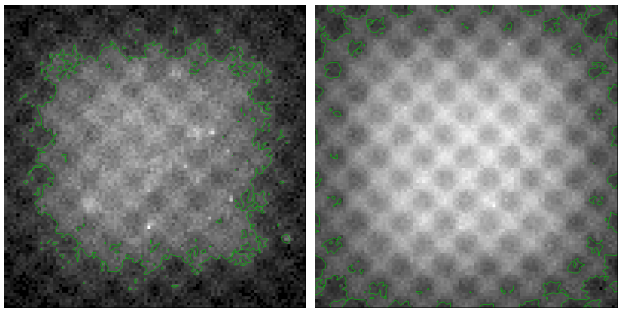
  `*case.out` contains statistics of the optical transport

  `*collect.out` contains statistics of the light output (pulse-height spectrum)

  `*.dat` contains output of ionizing radiation transport
- For the purpose of this demonstration example, `Gnuplot` scripts are provided to plot the 3D point-response function and the pulse-height spectrum of both screen models. Run the file `mantis_plots.gnu` to generate the corresponding plots seen in Fig. 1.



(a) Pulse-height spectra results.



(b) Point-response for HR. (c) Point-response for HL.

Fig. 1: Outputs of MANTIS example. The strong structure seen in the response function comes from the idealized, highly regular columnar scintillator geometry.

References

[1] Aldo Badano and Josep Sempau. Mantis: combined x-ray, electron and optical monte carlo simulations of indirect radiation imaging systems. *Phys Med Biol*, 51(6):1545–1561, Mar 2006.

[2] F. Salvat, J. M. Fernández-Varea, and J. Sempau. *PENELOPE, A Code System for Monte Carlo Simulation of Electron and Photon Transport*. OECD Nuclear Energy Agency, Issy-les-Moulineaux, France, 2003. Available in pdf format at `http://www.nea.fr`.

[2] A free compiler successfully used for MANTIS is G95 (`http://www.g95.org`). Intel offers a free Linux compiler for non-commercial development (`http://www.intel.com`).

[3] Available for multiple platforms from `http://www.gnuplot.info`.