# SuperNEMO - Geant4 Validation

# 1 Introduction

This repository holds a configuration to study Geant4 simulation and to plot relevant physical quantities in order to check Geant4 reliability.

The current version is hosted at https://github.com/xgarrido/snemo_simulation_modules/geant4_validation under git version control. You can clone this repository by doing

```
git clone https://github.com/xgarrido/snemo_simulation_modules/geant4_validation geant4_validation
```

This will create a directory geant4_validation in the working directory containing all the source files needed to configure and to setup SN@ilWare programs.

# 2 Content

The code is organised as follow :

`README.org` This file holds the pipeline configuration + the documentation on how to use the `geant4_validation` module.

`Makefile` The `Makefile` allows to generate the pipeline configuration by parsing and tangling this file *i.e.* `README.org` (see below).

`source` This directory holds the source code of the `geant4_validation` module. It also has a `CMakeLists.txt` file in order to compile, build and install all the software pieces through `cmake` rules.

The `README.org` file is organised using org-babel and its ability to execute source code. It requires then a recent installation of emacs[a] which bundles `org`. Without entering into too much details regarding `org-babel` abilities, the basic idea is to give a "literate" way to navigate through the different sections, each of them representing a part of the pipeline configuration. Moreover, using `org` folding/unfolding capability, item can be hide and the user can focus on relevant parts.

To export the different configuration files, you can run `org-babel-tangle` which will tangle each code block into the given file[b] or use the associated `Makefile`. The author recommends to use the `Makefile` since the tangling process is asynchronous and thus, does not freeze your emacs (`org-babel-tangle` "occupies" emacs during its execution).

# 3 Geometry setup

## 3.1 Manager configuration

### Setup label, description and version

```
#@description Setup label
setup_label : string = "geant4_validation"
```

[a] http://gdml.web.cern.ch/GDML
[b] Emacs lisp function can be run using ALT-x command and typing the function name.

```
#@description Setup description
setup_description : string = "A minimal geometry setup to test Geant4"

#@description Setup version
setup_version : string = "1.0"
```

### Logging priority

```
#@description Logging priority
logging.priority : string = "warning"
```

### Geometry factory

The geometry factory holds all the files needed for the geometry construction.

- Logging priority

  ```
  #@description Logging priority of the embedded geometry model factory
  factory.logging.priority : string = "warning"
  ```

- Geometry files

  ```
  #@description List of files describing the geometry models
  factory.geom_files : string[3] as path =                          \
    "@GEANT4_VALIDATION_DIR@/config/geometry/optical_module.geom" \
    "@GEANT4_VALIDATION_DIR@/config/geometry/source.geom"         \
    "@GEANT4_VALIDATION_DIR@/config/geometry/lab_world.geom"
  ```

### ID manager

- Logging priority

  ```
  #@description Logging flag of the embedded ID manager
  id_mgr.logging.priority : string = "warning"
  ```

- Category list Categories are used to assign a unique id number (integer) to a geometrical volume.

  ```
  #@description Source file of the geometry categories used by the ID manager
  id_mgr.categories_list : string as path = \
    "@GEANT4_VALIDATION_DIR@/config/geometry/categories.lis"
  ```

### Mapping configuration

```
#@description Build the embedded default mapping dictionnary
build_mapping : boolean = 1

#@description Max depth of the mapping
mapping.max_depth : integer = 100
```

### Plugins configuration

```
#@description Plugins factory preload from system registration (default=0)
plugins.factory_no_preload : boolean = 0

#@description Plugins initialization at load (default=0)
plugins.force_initialization_at_load : boolean = 0
```

```
#@description Configuration files for geometry manager's plugins
plugins.configuration_files : string[2] as path =                  \
    "@GEANT4_VALIDATION_DIR@/config/geometry/materials_plugin.conf" \
    "@GEANT4_VALIDATION_DIR@/config/geometry/magnetic_field_plugin.conf"
```

## 3.2 Geometry models

### Optical module

- Preamble

```
#@description List of geometry models
#@key_label   "name"
#@meta_label  "type"
```

- Wrapping model
  - z-position (front) wrapping

```
[name="zpos_wrapping.model" type="geomtools::simple_shaped_model"]

#@config The configuration parameters for the wrapping in front of the scintillator block

#@description The name of the 3D shape
shape_type : string =  "box"

#@description The X dimension
x : real as length  = 100.0 mm

#@description The Y dimension
y : real as length  = 100.0 mm

#@description The Z dimension
z : real as length  = 12 um

#@description The name of the material
material.ref : string  = "mylar"
```

  - x-sides wrapping
    * Model

```
[name="x_sides_wrapping.model" type="geomtools::simple_shaped_model"]

#@config The configuration parameters for the wrapping on X sides of the scintillator block

#@description The name of the 3D shape
shape_type : string = "box"

#@description The X dimension
x : real as length = 40.0 mm

#@description The Y dimension
y : real as length = 100.0 mm

#@description The Z dimension
z : real as length = 12 um
```

```
#@description The name of the material
material.ref      : string  = "mylar"
```

* Positionning

```
[name="xpos_wrapping.model" type="geomtools::rotated_boxed_model"]

#@config The configuration parameters for the rotated wrapping film

#@description Rotation geometry model
rotated.model : string = "x_sides_wrapping.model"

#@description Rotated geometry model label
rotated.label : string = "side_wrapping"

#@description Rotation axis
rotated.axis  : string = "y"

#@description Rotation special angle
rotated.special_angle : string  = "90"

#@description The name of the material
material.ref      : string  = "lab_medium"
```

```
[name="xneg_wrapping.model" type="geomtools::rotated_boxed_model"]

#@config The configuration parameters for the rotated wrapping film

#@description Rotation axis
rotated.axis  : string = "y"

#@description Rotation special angle
rotated.special_angle : string  = "270"

#@description Rotation geometry model
rotated.model : string = "x_sides_wrapping.model"

#@description Rotated geometry model label
rotated.label : string = "side_wrapping"

#@description The name of the material
material.ref      : string  = "lab_medium"
```

– y-sides wrapping

* Model

```
[name="y_sides_wrapping.model" type="geomtools::simple_shaped_model"]

#@config The configuration parameters for the wrapping on Y sides of the scintillator block

#@description The name of the 3D shape
shape_type : string = "box"

#@description The X dimension
x : real as length = 100.0 mm

#@description The Y dimension
y : real as length = 40.0 mm
```

```
#@description The Z dimension
z : real as length = 12 um

#@description The name of the material
material.ref : string = "mylar"
```

* Positionning

```
[name="ypos_wrapping.model" type="geomtools::rotated_boxed_model"]

#@config The configuration parameters for the rotated wrapping film

#@description Rotation axis
rotated.axis  : string = "x"

#@description Rotation special angle
rotated.special_angle : string  = "90"

#@description Rotation geometry model
rotated.model : string = "y_sides_wrapping.model"

#@description Rotated geometry model label
rotated.label : string = "side_wrapping"

#@description The name of the material
material.ref      : string  = "lab_medium"
```

```
[name="yneg_wrapping.model" type="geomtools::rotated_boxed_model"]

#@config The configuration parameters for the rotated wrapping film

#@description Rotation axis
rotated.axis  : string = "x"

#@description Rotation special angle
rotated.special_angle : string  = "270"

#@description Rotation geometry model
rotated.model : string = "y_sides_wrapping.model"

#@description Rotated geometry model label
rotated.label : string = "side_wrapping"

#@description The name of the material
material.ref      : string  = "lab_medium"
```

- Scintillator model
  - Block model We first design the shape and the dimensions of the block

```
[name="scintillator_block.model" type="geomtools::simple_shaped_model"]

#@config The configuration parameters for the scintillator block

#@description The name of the 3D shape
shape_type : string =  "box"

#@description The X dimension
```

```
x : real as length = 100.0 mm

#@description The Y dimension
y : real as length = 100.0 mm

#@description The Z dimension
z : real as length = 40.0 mm
```

Then we define a material

```
#@description The name of the material
# material.ref      : string = "polystyrene"
material.ref      : string = "std::NaI"
```

Finally, we attach to it a sensitive category to ease the interface between `mctools` and Geant4 digitization[c]

```
#@description The 'sensitive' category attached to this detector volume
sensitive.category : string  = "scin_SD"
```

– Wrapped block model The wrapped model consists of wrapping with mylar the previous "nude" block. We then use a `surrounded_bowed_model` to place mylar on each scintillator faces.

```
[name="wrapped_scintillator_block.model" type="geomtools::surrounded_boxed_model"]

#@config The configuration parameters for the wrapped scintillatorblock

#@description The name of the surrounded geometry model
surrounded.model         : string = "scintillator_block.model"

#@description The label associated to the surrounded geometry model
surrounded.label         : string = "scintillator_block"

#@description The name of the (z>0) side surrounding geometry model
surrounded.top_model     : string = "zpos_wrapping.model"

#@description The name of a  (x>0) side surrounding geometry model
surrounded.front_model   : string = "xpos_wrapping.model"

#@description The name of a  (x<0) side surrounding geometry model
surrounded.back_model    : string = "xneg_wrapping.model"

#@description The name of a  (y>0) side surrounding geometry model
surrounded.right_model   : string = "ypos_wrapping.model"

#@description The name of a  (y<0) side surrounding geometry model
surrounded.left_model    : string = "yneg_wrapping.model"

#@description The label of the (z>0) side surrounding geometry model
surrounded.top_label     : string = "top_wrapping"

#@description The label of a  (x>0) side surrounding geometry model
surrounded.front_label   : string = "front_wrapping"
```

[c] We recommend that you name any sensitive category with the `_SD` suffix. This is to ease the reading of other configuration files at the simulation level (step hit processors). Also note that if you prefix the sensitive category name with two underscores (example: `__test_SD`), then the sensitive category is considered as "private" (non official) and may be processed in some special way by the simulation engine.

```
#@description The label of a  (x<0) side surrounding geometry model
surrounded.back_label    : string = "back_wrapping"

#@description The label of a  (y>0) side surrounding geometry model
surrounded.right_label   : string = "right_wrapping"

#@description The label of a  (y<0) side surrounding geometry model
surrounded.left_label    : string = "left_wrapping"

#@description The name of the material
material.ref      : string  = "lab_medium"
```

Finally, we attach mapping id to the mother volume as well as its daughter *i.e.* mylar elements.

```
#@description The mapping directive for the "scintillator_block" daughter volume
mapping.daughter_id.scintillator_block : string  = "[scin_block.gc]"

#@description The mapping directive for the "left_wrapping" daughter volume
mapping.daughter_id.front_wrapping     : string  = "[scin_block_wrapping.gc:side=0]"

#@description The mapping directive for the "right_wrapping" daughter volume
mapping.daughter_id.back_wrapping      : string  = "[scin_block_wrapping.gc:side=1]"

#@description The mapping directive for the "left_wrapping" daughter volume
mapping.daughter_id.left_wrapping      : string  = "[scin_block_wrapping.gc:side=2]"

#@description The mapping directive for the "right_wrapping" daughter volume
mapping.daughter_id.right_wrapping     : string  = "[scin_block_wrapping.gc:side=3]"

#@description The mapping directive for the "top_wrapping" daughter volume
mapping.daughter_id.top_wrapping       : string  = "[scin_block_wrapping.gc:side=5]"
```

- Light guide model
  - Basic light guide

```
[name="light_guide.model" type="geomtools::simple_shaped_model"]

#@config The configuration parameters for the light guide

#@description The default implicit length unit
length_unit  : string = "mm"

#@description The name of the 3D shape
shape_type   : string = "polyhedra"

#@description The polyhedra build mode
build_mode   : string = "points"

#@description The polyhedra number of sides
sides        : integer = 4

#@description The list of Z coordinates for the shape
list_of_z    : real [3] =  -40.     +30.     +40.

#@description The list of inner radius coordinates for the shape
```

```
list_of_rmin : real [3] =    0.      0.       0.

#@description The list of outer radius coordinates for the shape
list_of_rmax : real [3] =    20.    50.     50.

#@description The name of the material
material.ref : string  = "plexiglass"
```

– Rotated light guide

```
###########################################################################
[name="rotated_light_guide.model" type="geomtools::rotated_boxed_model"]

#@config The configuration parameters for the rotated light guide

#@description The rotation axis
rotated.axis  : string = "z"

#@description The rotation angle
rotated.angle : real as angle = 45.0 degree

#@description The X dimension
x             : real as length = 100.0 mm

#@description The Y dimension
y             : real as length = 100.0 mm

#@description The name of the model to be rotated
rotated.model : string = "light_guide.model"

#@description The label associated to the rotated daughter model
rotated.label : string = "light_guide"

#@description The name of the material around the light guide to be rotated
material.ref  : string  = "lab_medium"
```

- PMT model

```
[name="pmt.model" type="geomtools::simple_shaped_model"]

#@config The configuration parameters for the photomultiplier tube

#@description The default implicit length unit
length_unit  : string   = "mm"

#@description The name of the 3D shape
shape_type   : string   = "polycone"

#@description The polycone build mode
build_mode   : string   = "points"

#@description The list of Z coordinates for the shape
list_of_z    : real [6] =  -50.0   -49.0  -48.99  +48.99  +49.0 +50.0

#@description The list of inner radius coordinates for the shape
list_of_rmin : real [6] =    0.      0.    19.     19.      0.    0.

#@description The list of outer radius coordinates for the shape
```

```
list_of_rmax : real [6] =    20.    20.    20.     20.     20.   20.

#@description The name of the material
material.ref : string  = "glass"
```

- Optical module Given the previous model, we stack them to get a full optical module from PMT → light guide → scintillator block → the last layer of mylar

```
[name="optical_module.model" type="geomtools::stacked_model"]

#@config The configuration parameters for the optical module

#@description The stacking axis
stacked.axis            : string = "z"

#@description The number of stacked volumes
stacked.number_of_items : integer = 3

#@description The model of the stacked volume #2
stacked.model_2   : string  = "wrapped_scintillator_block.model"

#@description The label of the stacked volume #2
stacked.label_2   : string  = "scintillator_block"

#@description The model of the stacked volume #1
stacked.model_1   : string   = "rotated_light_guide.model"

#@description The label of the stacked volume #1
stacked.label_1   : string  = "light_guide"

#@description The model of the stacked volume #0
stacked.model_0   : string   = "pmt.model"

#@description The label of the stacked volume #0
stacked.label_0   : string  = "pmt"

#@description The name of the material
material.ref      : string    = "lab_medium"

#@description The mapping directive for the "light_guide" daughter volume
mapping.daughter_id.light_guide : string  = "[light_guide.gc]"
```

## Source

- Preamble

```
#@description List of geometry models
#@key_label   "name"
#@meta_label  "type"
```

- Film model

```
[name="source_film.model" type="geomtools::simple_shaped_model"]

#@config The configuration parameters for the source film

#@description The name of the 3D shape of the source film
shape_type  : string = "cylinder"
```

```
#@description The R dimension (radius) of the cylinder source film
r : real as length = 9.5 mm

#@description The Z dimension (thickness) of the cylinder source film
z : real as length = 5 um

#@description The name of the material of the source film
material.ref : string = "mylar"
```

- Source support model

```
[name="source_support.model" type="geomtools::simple_shaped_model"]

#@config The configuration parameters for the source support

#@description The name of the 3D shape of the source support ring
shape_type  : string = "tube"

#@description The inner R dimension (inner radius) of the source support ring
inner_r     : real as length = 10.0 mm

#@description The outer R dimension (inner radius) of the source support ring
outer_r     : real as length = 12.0 mm

#@description The Z dimension (thickness) of the source support ring
z           : real as length = 5.0 mm

#@description The name of the material of the source support ring
material.ref : string = "aluminium"
```

- Source model The source model will used the two previous models by placing them "internally" to a larger cylinder. We first declare the holding volume

```
[name="source.model" type="geomtools::simple_shaped_model"]

#@description The name of the 3D shape of the source cylindric envelope
shape_type  : string = "cylinder"

#@description The R dimension (radius) of the source cylindric envelope
r : real as length = 12.0 mm

#@description The Z dimension (thickness) of the source cylindric envelope
z : real as length = 5.0 mm

#@description The name of the material
material.ref : string  = "lab_medium"
```

and then place inside, the "support" and "film" models

```
#@description The list of daughter volumes by label
internal_item.labels : string[2] = "support" "film"

#@description The model of the "support" daughter volume
internal_item.model.support : string  = "source_support.model"

#@description The placement of the "support" daughter volume
internal_item.placement.support : string  = "0 0 0 (mm)"
```

```
#@description The model of the "film" daughter volume
internal_item.model.film : string  = "source_film.model"

#@description The placement of the "film" daughter volume
internal_item.placement.film : string  = "0 0 0 (mm)"
```

We finally define mapping ids

```
#@description The mapping directives for the "film" daughter volume
mapping.daughter_id.film : string  = "[source_film.gc]"

#@description The mapping directives for the "support" daughter volume
mapping.daughter_id.support : string  = "[source_support.gc]"
```

## Laboratory & world volume

- Preamble

```
#@description List of geometry models
#@key_label   "name"
#@meta_label  "type"
```

- Absorber

```
[name="thin_absorber.model" type="geomtools::simple_shaped_model"]

#@config The configuration parameters for the thin_absorber front of the detector

#@description The name of the 3D shape
shape_type :   string =  "box"

#@description The X dimension
x   : real as length = 100.0 mm

#@description The Y dimension
y   : real as length = 100.0 mm

#@description The Z dimension
z   : real as length = 50 um

#@description The name of the material
material.ref      : string  = "copper"
```

- Black box

```
[name="black_box.model" type="geomtools::simple_shaped_model"]

#@config The configuration parameters for the light guide

#@description The default implicit length unit
length_unit : string = "mm"

#@description The name of the 3D shape
shape_type : string = "polyhedra"

#@description The polyhedra build mode
build_mode : string = "points"
```

```
#@description The polyhedra number of sides
sides        : integer = 4

#@description The list of Z coordinates for the shape
list_of_z    : real [2] =   -125.     +125.

#@description The list of inner radius coordinates for the shape
list_of_rmin : real [2] =    51.      51.

#@description The list of outer radius coordinates for the shape
list_of_rmax : real [2] =    53.      53.

#@description The name of the material
material.ref : string  = "inox"
```

- Lab. model

```
[name="lab.model" type="geomtools::simple_shaped_model"]

#@config The configuration parameters for the laboratory experimental area

#@description The name of the 3D shape of the lab area
shape_type  : string = "box"

#@description The X dimension of the box
x           : real as length = 900.0 mm

#@description The Y dimension of the box
y           : real as length = 450.0 mm

#@description The Z dimension of the box
z           : real as length = 450.0 mm

#@description The name of the material that fills the lab atmosphere
material.ref : string = "lab_medium"

#@description The list of daughter volumes by labels
internal_item.labels : string[4] = "source" "detector" "box" "absorber0"

#@description The model of the "source" daughter volume
internal_item.model.source        : string  = "source.model"

#@description The placement of the "source" daughter volume
internal_item.placement.source    : string  = "20 0 0 (cm) / y +90 (degree)"

#@description The model of the "detector" daughter volume
internal_item.model.detector      : string  = "optical_module.model"

#@description The placement of the "detector" daughter volume
internal_item.placement.detector  : string  = "-20 0 0 (cm) / y +90 (degree) "

#@description The model of the "box" daughter volume
internal_item.model.box           : string  = "black_box.model"

#@description The placement of the "box" daughter volume
internal_item.placement.box       : string  = "-24 0 0 (cm) @  0 90 45 (degree) "
```

```
#@description The model of the "absorber0" daughter volume
internal_item.model.absorber0     : string  = "thin_absorber.model"

#@description The placement of the "absorber0" daughter volume
internal_item.placement.absorber0 : string  = "0 0 0 (cm) @  0 90 0 (degree) "

#@description The mapping directives for the "source" daughter volume
mapping.daughter_id.source   : string  = "[source.gc:position=0]"

#@description The mapping directives for the "detector" daughter volume
mapping.daughter_id.detector : string  = "[optical_module.gc:detector=0]"
```

- World volume

```
[name="world" type="geomtools::simple_world_model"]

#@config configuration parameters for the world logical volume

#@description The world volume X dimension (box)
world.x         : real as length  = 1000.0 mm

#@description The world volume Y dimension (box)
world.y         : real as length = 500.0 mm

#@description The world volume Z dimension (box)
world.z         : real as length = 500.0 mm

#@description The name of the model that represents the experimental setup daughter volume
setup.model     : string = "lab.model"

#@description The setup placement phi angle
setup.phi       : real as angle = 0.0 degree

#@description The setup placement theta angle
setup.theta     : real as angle = 0.0 degree

#@description The setup placement X coordinate
setup.x         : real as length = 0.0 mm

#@description The setup placement Y coordinate
setup.y         : real as length = 0.0 mm

#@description The setup placement Z coordinate
setup.z         : real as length = 0.0 mm

#@description The name of the material that fills the world volume
material.ref    : string = "vacuum"

#@description The mapping directives for the 'setup' daughter volume
mapping.daughter_id.setup : string  = "[lab.gc:area=0]"
```

## 3.3 Mapping categories

```
#@description A list of geometry ID categories/types
#@key_label   "category"
#@meta_label  "type"
```

```
#################################################################
# This is the mandatory top-level geometry category.
# One should always provide it :
[category="world" type="0"]

#@config The geometry category of the top-level world volume

#@description The world's GID address is characterized by its 'world' number
addresses : string[1] = "world"


#################################################################
# This geometry category addresses an experimental area volume :
[category="lab.gc"  type="100"]

#@config The geometry category of the experimental area volume (lab)

#@description A lab's GID address is charaterized by its 'area' number
addresses : string[1] = "area"


#################################################################
# This geometry category addresses a calibration source object :
[category="source.gc" type="1000"]

#@config The geometry category of a calibration source

#@description The GID address of a calibration source is defined by its 'position' number
addresses : string[1] = "position"


#########################################################################
# This geometry category addresses the support frame of a calibration source :
[category="source_support.gc" type="1010"]

#@config The geometry category of a calibration source support

#@description The GID address of a source support inherits the GID address of the source
inherits : string = "source.gc"


#################################################################
# This geometry category addresses of a calibration source film :
[category="source_film.gc" type="1020"]

#@config The geometry category of a calibration source film

#@description The GID address of a source film inherits the GID address of the source
inherits : string = "source.gc"


#######################################################
# This geometry category addresses an optical module :
[category="optical_module.gc" type="2020"]
```

```
#@config The geometry category of a calibration source film

#@description The GID address of a column is defined by its 'detector' number
addresses : string[1] = "detector"


################################################################################
#  This geometry category addresses the scintillator block of an optical module :
[category="scin_block.gc" type="2030"]

#@config The geometry category of the scintillator block of an optical module

#@description The GID address of a scin block inherits the GID address of the optical module
inherits : string = "optical_module.gc"


################################################
[category="scin_block_wrapping.gc" type="2031"]

#@config The geometry category of a wrapping film around a scintillator block

#@description The GID address of a wrapping film extends GID address of the scintillator block
extends : string[1] = "scin_block.gc"

#@description The 'side' number extend the mother scintillator block GID address
by      : string[1] = "side"


#######################################
[category="light_guide.gc" type="2032"]

#@config The geometry category of the light guide

#@description The GID address of a light guide inherits the GID address of the optical module
inherits : string[1] = "optical_module.gc"
```

## 3.4 Materials plugin

We use the definitions of isotopes, elements and materials from the installed materials library. Here the `materials_aliases` definition are locally defined to change the source foil isotope.

### Plugin declaration

```
#@description The geometry manager plugin for materials

#@key_label  "name"
#@meta_label "type"

[name="materials_driver" type="geomtools::materials_plugin"]
```

### Logging priority

```
#@description Logging priority
logging.priority : string = "warning"
```

## Files

```
#@description List of files describing the materials
materials.configuration_files : string[4] as path = \
    "@materials:data/std_isotopes.def"              \
    "@materials:data/std_elements.def"              \
    "@materials:data/std_materials.def"             \
    "@GEANT4_VALIDATION_DIR@/config/geometry/materials_aliases.def"
```

## Material aliases

```
#@description A sample list of aliases for standard materials
#@key_label   "name"
#@meta_label  "type"

[name="air" type="alias"]
#@description The alias for air
material : string = "std::air"

[name="aluminium" type="alias"]
#@description The alias for aluminium
material : string = "std::aluminium"

[name="inox" type="alias"]
#@description The alias for inox
material : string = "std::inox"

[name="copper" type="alias"]
#@description The alias for copper
material : string = "std::copper"

[name="mylar" type="alias"]
#@description The alias for mylar
material : string = "std::mylar"

[name="plexiglass" type="alias"]
#@description The alias for plexiglass
material : string = "std::plexiglass"

[name="polystyrene" type="alias"]
#@description The alias for polystyrene
material : string = "std::polystyrene"

[name="glass" type="alias"]
#@description The alias for pyrex
material : string = "std::pyrex"

[name="vacuum" type="alias"]
#@description The alias for vacuum
material : string = "std::vacuum"

[name="lab_medium" type="alias"]
#@description The alias for air
material : string = "std::air"
#material : string = "std::vacuum"
```

## 3.5 Magnetic field plugin

### Plugin declaration

```
#@description The geometry manager plugin for emfield

#@key_label  "name"
#@meta_label "type"

[name="fields_driver" type="emfield::emfield_geom_plugin"]
```

### Logging priority

```
#@description Logging priority
logging.priority : string = "warning"
```

### EM field manager configuration

```
#@description Manager logging priority
manager.logging.priority : string = "warning"

#@description The name of the geometry service
manager.services.geometry : string = "Geo"

#@description List of EM fields definitions files
manager.field_definitions_filenames : string[1] as path = \
    "@GEANT4_VALIDATION_DIR@/config/geometry/magnetic_field_drivers.conf"
```

EM field defined within `manager.field_definitions_filenames` file can be set independently and at the same time for different G4 volumes. This association between volumes and field is done by the `geom_map` object of `emfield` component.

```
#@description Flag to activate the geometry volume/field associations map
manager.build_geom_map : boolean = 1

#@description Manager logging priority
manager.geom_map.logging.priority : string = "warning"

#@description The list of EM fields associated to some logical volumes
manager.geom_map.associations.labels : string[1] = "lab"

#@description The logical model associated for the label 'tracker'
manager.geom_map.associations.lab.volume : string = "lab.model.log"

#@description The EM field associated for the label "tracker"
manager.geom_map.associations.lab.field_name : string = "B0"
```

### Magnetic fields

- Preamble

  ```
  #@description Definition parameters for some electro-magnetic fields
  #@key_label   "name"
  #@meta_label  "type"
  ```

- Constant magnetic field

```
[name="B0" type="emfield::uniform_magnetic_field"]

#@config Configuration parameters for the magnetic field generated by a coil

#@description Default implicit magnetic field unit
magnetic_field.unit        : string  = "gauss"

#@description Coordinates of the static magnetic field (Bx, By, Bz)
magnetic_field.coordinates : real[3] = 0.0 0.0 25.0
```

## 3.6 Visualization settings

### Browser settings

```
[name="browser_settings"]

#@description Setup label.
setup_label : string = "geant4_validation"

#@description Tab to view at startup.
# 0: 3D Display 1: Raw Data 2: Options, 3: Selection
startup_tab : integer = 0

# 0: Top view 1: Front view 2: Side view
startup_2d_view : integer = 0

#@description Background color of displays.
background_color : integer[3] =   0   0   0
```

### Geometry settings

```
[name="geometry_settings"]

#@description List of volumes to take care.
volume_category_list : string[8] =                          \
^^I^^I^^I^^I   "lab.gc"                \
^^I^^I^^I^^I   "light_guide.gc"        \
^^I^^I^^I^^I   "optical_module.gc"     \
^^I^^I^^I^^I   "scin_block.gc"         \
^^I^^I^^I^^I   "scin_block_wrapping.gc" \
^^I^^I^^I^^I   "source.gc"             \
^^I^^I^^I^^I   "source_film.gc"        \
^^I^^I^^I^^I   "source_support.gc"

#@description Volume visibility (visible/invisible/disable)
lab.gc.visibility                : string = "invisible"
light_guide.gc.visibility        : string = "invisible"
optical_module.gc.visibility     : string = "invisible"
scin_block.gc.visibility         : string = "visible"
scin_block_wrapping.gc.visibility : string = "invisible"
source.gc.visibility             : string = "visible"
source_film.gc.visibility        : string = "visible"
source_support.gc.visibility     : string = "visible"

#@description Volume color
lab.gc.color                : integer[3] = 228 123 220
```

```
light_guide.gc.color         : integer[3] = 158 246 222
optical_module.gc.color      : integer[3] = 141  17  79
scin_block.gc.color          : integer[3] = 144  17 179
scin_block_wrapping.gc.color : integer[3] =  86 111 124
source.gc.color              : integer[3] = 236  33 141
source_film.gc.color         : integer[3] = 163  44  34
source_support.gc.color      : integer[3] =  90 156 254
```

#### Particle settings

```
[name="particle_settings"]

#@description MC particle color
gamma.color    : string = "#FFD700"
electron.color : string = "#87CEEB"
```

#### Misc.

```
[name="miscellaneous"]

#@description MC line style
mc_line_style : integer = 1
mc_line_width : integer = 0

#@description Figure save options
save.directory : string = "."
save.extension : string = ".eps"
save.prefix    : string = "event_"
```

# 4 Simulation setup

## 4.1 Geant4 configuration

#### Manager setup

```
[name="manager"]

#@description Logging priority
logging.priority      : string = "warning"
```

#### Event generator

The following code holds the genbb manager to give access to several primary generators.

```
[name="event_generator"]

#@description Configuration file for the embedded '::genbb::manager'
manager.config : string as path = \
    "@GEANT4_VALIDATION_DIR@/config/pipeline/genbb_manager.conf"
```

#### Vertex generator

This part basically provides the location of vertex generator implemented by genvtx.

```
[name="vertex_generator"]

#@description Main configuration file for the vertex generator manager
manager.config : string as path = \
    "@GEANT4_VALIDATION_DIR@/config/pipeline/genvertex_manager.conf"
```

### Detector construction

```
[name="detector_construction"]
```

- Logging priority

  ```
  #@description Logging priority
  logging.priority : string = "warning"
  ```

- GDML scheme and options The Geometry Description Markup Language is an application-indepedent geometry description format based on XML[a]. It is used as Geant4 toolkit bindings through `gemotools` converters.

  ```
  #@description Temporary directory for GDML file generation:
  gdml.tmp_dir         : string as path = "/tmp/${USER}/geant4_validation_g4.d"

  #@description Access mode to the GDML schema ("local" or "remote")
  gdml.schema_location : string = "local" # "remote"

  #@description Flag to skip GDML validation
  gdml.no_validation   : boolean = 0
  ```

- Step hit processors Step hit processors are used to convert Geant4 steps into detector hits for SuperNEMO physics.

  ```
  #@description Logging support for step hit processor factory
  hit_processor_factory.logging.priority : string = "warning"

  #@description Configuration file for the step hit processor factory:
  hit_processor_factory.config : string as path = \
      "@GEANT4_VALIDATION_DIR@/config/pipeline/step_hit_processor_factory.conf"
  ```

- Sensitive detectors This category defines sensitive detectors where special treatments of Geant4 steps must be applied. This can be in direct relation with step hit processors defined above.

  ```
  #@description Parameters for the generation of 'sensitive hits' through 'sensitive detectors' :
  sensitive.detectors : string[1] = "scin_SD"

  #@description Logging priority
  sensitive.scin_SD.logging.priority               : string  = "warning"

  #@description Buffer capacity for hits
  sensitive.scin_SD.hits_buffer_capacity           : integer = 200

  #@description Flag to activate the recording of alpha particle quenching
  sensitive.scin_SD.record_alpha_quenching         : boolean = 1

  #@description Flag to activate the recording of any track ID
  sensitive.scin_SD.record_track_id                : boolean = 1

  #@description Flag to activate the recording of any primary particle flag
  ```

```
sensitive.scin_SD.record_primary_particle        : boolean = 1

#@description Flag to drop hits with zero energy deposit
sensitive.scin_SD.drop_zero_energy_deposit_steps  : boolean = 0

#@description Flag to track gamma particles
sensitive.scin_SD.track_gamma                     : boolean = 1
```

- Geant4 step hit limits The following code defines geometry models where Geant4 steps are size limited.

```
#@description List of geometry logical volumes with max steps:
limits.list_of_volumes : string[3] = \
^^I^^I       "source_film.model.log" \
^^I^^I       "scintillator_block.model.log" \
^^I^^I       "lab.model.log"

#@description Max step length inside source pad:
limits.max_step.source_film.model.log        : real as length = 5 um

#@description Max step length inside scintillator block:
limits.max_step.scintillator_block.model.log : real as length = 100 um

#@description Max step length inside lab volume:
limits.max_step.lab.model.log                : real as length = 1 cm
```

- Geant4 regions Definition of Geant4 regions.

```
#@description List of regions
regions : string[3] = "scintillator" "lab" "source"

#@description List of attached volumes/models for region "scintillator"
regions.scintillator.volumes : string[1] = "scintillator_block.model.log"

#@description List of attached volumes/models for region "lab"
regions.lab.volumes          : string[2] = "lab.model.log" "source.model.log"

#@description List of attached volumes/models for region "source"
regions.source.volumes       : string[1] = "source_film.model.log"
```

- Magnetic field

```
#@description Flag to use magnetic field
using_magnetic_field             : boolean = 0

#@description Logging priority threshold of the embedded Geant4 magnetic fields
magnetic_field.logging.priority   : string = "warning"

#@description Name of the magnetic field geometry plugin
magnetic_field.plugin_name        : string = "fields_driver"

#@description Name of the associated fields
magnetic_field.associations       : string[1] = "module"

#@description SetDeltaChord miss distance (mm):
magnetic_field.miss_distance : real as length = 0.5 mm
```

### Physics list

In the development of a Geant4-based application, it is the user's responsibility to decide which physics processes are required, and then to include them in the physics list. The next lines are just aliases to relevant phycical processes for SuperNEMO.

```
[name="physics_list"]
```

- Logging priority

```
#@description Logging priority
logging.priority : string = "warning"
```

- Plugins

```
#@description List of physics constructors
physics_constructors.names : string[2] = "particles" "em"

#@description Class ID of the physics constructors named 'particles'
physics_constructors.particles.id     : string = "mctools::g4::particles_physics_constructor"

#@description Configuration file of the physics constructors named 'particles'
physics_constructors.particles.config : string as path = \
    "@GEANT4_VALIDATION_DIR@/config/pipeline/particles.conf"

#@description Class ID of the physics constructors named 'em'
physics_constructors.em.id            : string = "mctools::g4::em_physics_constructor"

#@description Configuration file of the physics constructors named 'em'
physics_constructors.em.config        : string as path = \
    "@GEANT4_VALIDATION_DIR@/config/pipeline/em_processes.conf"
```

  - Particle physics constructor Quite experimental try to set particles used within this "framework".

```
#@config Configuration parameters for the particles Geant4 physics constructor

#@description The activation flag for geantinos (neutral and charged, default: 0)
#use_geantinos               : boolean = 0

#@description The activation flag for optical photons (default: 0)
#use_optical_photons         : boolean = 0

#@description The activation flag for muon leptons (default: 0)
#use_muon_leptons          : boolean = 0

#@description The activation flag for tau leptons (default: 0)
#use_tau_leptons           : boolean = 0

#@description The activation flag for light mesons (default: 0)
#use_light_mesons          : boolean = 0

#@description The activation flag for charm mesons (default: 0)
#use_charm_mesons          : boolean = 0

#@description The activation flag for bottom mesons (default: 0)
#use_bottom_mesons         : boolean = 0
```

```
#@description The activation flag for nucleons (default: 1)
use_nucleons             : boolean = 1

#@description The activation flag for strange baryons (default: 0)
#use_strange_baryons      : boolean = 0

#@description The activation flag for charm baryons (default: 0)
#use_charm_baryons        : boolean = 0

#@description The activation flag for bottom baryons (default: 0)
#use_bottom_baryons       : boolean = 0

#@description The activation flag for light nuclei (default: 1)
use_light_nuclei         : boolean = 1

#@description The activation flag for light anti-nuclei (default: 0)
#use_light_anti_nuclei    : boolean = 0

#@description The activation flag for generic ion (default: 0)
use_generic_ion          : boolean = 1
```

- EM physics process
  - General settings

```
#@config Configuration parameters for the electro-magnetic Geant4 physics constructor

#@description Electro-magntox interaction model (value in: "standard", "low_energy", "penelope")
em.model : string = "standard"
```

  - Electrons/positrons

```
#@description The activation flag for electron/positron ionisation (energy loss/delta ray production)
em.electron.ionisation           : boolean = 1

#@description The activation flag for electron/positron multiple scatterring process
em.electron.multiple_scatterring : boolean = 1

#@description The activation flag for electron/positron multiple scatterring process
em.electron.multiple_scatterring.use_distance_to_boundary: boolean = 1

#@description The range factor for electron/positron multiple scatterring process
em.electron.multiple_scatterring.range_factor: real = 0.005

#@description The activation flag for electron/positron bremsstrahlung process
em.electron.bremsstrahlung       : boolean = 1

#@description The activation flag for electron/positron step limiter process
em.electron.step_limiter         : boolean = 1

#@description The activation flag for positron pannihilation
em.positron.annihilation         : boolean = 1
```

  - Gammas

```
#@description The activation flag for Rayleigh scattering
em.gamma.rayleigh_scattering  : boolean = 0

#@description The activation flag for photoelectric effect
em.gamma.photo_electric       : boolean = 1
```

```
#@description The activation flag for Compton scattering
em.gamma.compton_scattering   : boolean = 1

#@description The activation flag for gamma conversion
em.gamma.conversion           : boolean = 1

#@description The activation flag for gamma conversion to muons
em.gamma.conversion_to_muons  : boolean = 0
```

* Muons

```
#@description The activation flag for muon ionisation
em.muon.ionisation           : boolean = 0

#@description The activation flag for muon multiple scatterring process
em.muon.multiple_scatterring : boolean = 0

#@description The activation flag for muon pair production
em.muon.pair_production      : boolean = 0

#@description The activation flag for muon bremsstrahlung process
em.muon.bremsstrahlung       : boolean = 0

#@description The activation flag for muon step limiter process
em.muon.step_limiter         : boolean = 0
```

* Ions

```
#@description The activation flag for ion ionisation
em.ion.ionisation           : boolean = 1

#@description The activation flag for ion multiple scatterring process
em.ion.multiple_scatterring : boolean = 1

#@description The activation flag for ion step limiter process
em.ion.step_limiter         : boolean = 1
```

* Deexcitation

```
#@description The activation flag for deexcitation fluorescence process
#em.deexcitation.fluo         : boolean = 0

#@description The activation flag for Auger process
#em.deexcitation.auger        : boolean = 0

#@description The activation flag for PIXE
#em.deexcitation.pixe         : boolean = 0

#@description The activation model for PIXE cross-sections
#em.deexcitation.pixe.model   : string = "Empirical"

#@description The regions where to apply some deexcitation process
#em.deexcitation.regions : string[2] = "A" "B"

#@description The activation flag for deexcitation fluorescence process in region "A"
#em.deexcitation.regions.A.fluo  : boolean = 1

#@description The activation flag for Auger process in region "A"
```

```
#em.deexcitation.regions.A.auger : boolean = 1

#@description The activation flag for PIXE in region "A"
#em.deexcitation.regions.A.pixe  : boolean = 1

#@description The activation flag for deexcitation fluorescence process in region "B"
#em.deexcitation.regions.B.fluo  : boolean = 1

#@description The activation flag for Auger process in region "B"
#em.deexcitation.regions.B.auger : boolean = 1

#@description The activation flag for PIXE in region "B"
#em.deexcitation.regions.B.pixe  : boolean = 1
```

- Using Geant4 region cuts These cuts are related to some production processes and then, define some minimal step hit size given the detector region.

```
#@description Activate the use of specific cuts
using_production_cuts : boolean = 1

#@description The energy low edge for cuts
production_cuts.low_energy    : real as energy  = 1 keV

#@description The energy high edge for cuts
production_cuts.high_energy   : real as energy = 100 MeV

#@description The production cut default value
production_cuts.default_value : real as length = 1.0 mm

#@description The production cut for gamma
production_cuts.gamma : real as length = 1.0 mm

#@description The production cut for electron
production_cuts.electron : real as length = 1.0 mm

#@description The production cut for positron
production_cuts.positron : real as length = 1.0 mm

#@description The production cut for proton
production_cuts.proton : real as length = 1.0 mm

#@description List of region with production cut
production_cuts.regions : string[3] = "scintillator" "lab" "source"

#@description Production cut value for region "calorimeter"
production_cuts.regions.scintillator.gamma : real as length = 1.0 mm

#@description Production cut value for region "calorimeter"
production_cuts.regions.scintillator.electron : real as length = 1.0 mm

#@description Production cut value for region "tracker"
production_cuts.regions.lab.gamma : real as length = 0.5 mm

#@description Production cut value for region "tracker"
production_cuts.regions.lab.electron : real as length = 0.5 mm

#@description Production cut value for region "source"
```

```
production_cuts.regions.source.gamma : real as length = 0.05 mm

#@description Production cut value for region "source"
production_cuts.regions.source.electron : real as length = 0.05 mm
```

### Geant4 related action

The last part of the configuration concerned Geant4 actions but do not hold a lot of options.

- Run action

```
[name="run_action"]

#@description Logging priority :
logging.priority : string = "warning"

#@description Run action event number print modulo :
#number_events_modulo : integer = 100

#@description If set, this flag forbids the generation of output files :
file.no_save : boolean = 1
```

- Event action

```
[name="event_action"]

#@description Logging priority :
logging.priority : string = "warning"
```

- Primary generator action

```
[name="primary_generator_action"]

#@config Configuration of the primary generator action

#@description Primary generator action logging priority
logging.priority : string = "warning"
```

- Tracking action

```
[name="tracking_action"]

#@description Logging priority :
logging.priority : string = "warning"
```

- Stepping action

```
[name="stepping_action"]

#@description Logging priority :
logging.priority : string = "warning"
```

- Stacking action

```
[name="stacking_action"]

#@description Logging priority :
logging.priority : string = "warning"
```

```
#@description Kill secondary particles within some volumes :
# kill_particles : boolean = 0

#@description Kill secondary particles within some volumes :
#kill_particles.volumes : string[1] = "drift_cell_core"

#@description Kill secondary particles within some materials :
#kill_particles.materials : string[1] = "tracking_gas"
```

## 4.2 Genbb configuration

The genbb package is dedicated to the generation of double beta decay and/or radioactive background primary events as input for a simulation program.

More details concerning the use of genbb can be found in LPC wiki.

```
#@config Main configuration parameters for the genbb manager

#@description Logging priority
logging.priority : string = "warning"

#@description List of files containing particle generator definition rules
generators.configuration_files : string[2] as path = \
    "@GEANT4_VALIDATION_DIR@/config/pipeline/calibrations.conf" \
    "@GEANT4_VALIDATION_DIR@/config/pipeline/guns.conf"
```

### Calibration configuration

- Insert preamble

  ```
  #@description A sample list of setups
  #@key_label   "name"
  #@meta_label  "type"
  ```

- Bi207

  ```
  [name="Bi207" type="genbb::wdecay0"]
  #@config Bi-207 decay
  logging.priority : string = "warning"
  decay_type       : string = "background"
  decay_isotope    : string = "Bi207+Pb207m"
  ```

- Co60

  ```
  [name="Co60" type="genbb::wdecay0"]
  #@config Co-60 decay
  logging.priority : string = "warning"
  decay_type       : string = "background"
  decay_isotope    : string = "Co60"
  ```

### Guns configuration

- Insert preamble

  ```
  #@description A sample list of setups
  #@key_label   "name"
  #@meta_label  "type"
  ```

- 1 MeV electron

```
[name="electron_1MeV" type="genbb::single_particle_generator"]
#@config Electron with monokinetic energy @ 1 MeV [miscellaneous]

#@description Seed for the embedded random number generator:
#seed          : integer = 314159

#@description Generated particle ("electron", "positron", "gamma", "alpha"):
particle_name : string = "electron"

#@description Mode ("energy_range", "gaussian_energy", "monokinetic", "spectrum"):
mode          : string = "monokinetic"

#@description Direction of the emitted particle
emission_direction : string = "randomized"

#@description The kinetic energy of the generated particle
energy        : real as energy  = 1000 keV
```

- 1 MeV cone electron

```
[name="electron_1MeV_cone" type="genbb::single_particle_generator"]
#@config Electron with monokinetic energy @ 1 MeV [miscellaneous]

#@description Generated particle ("electron", "positron", "gamma", "alpha"):
particle_name : string = "electron"

#@description Mode ("energy_range", "gaussian_energy", "monokinetic", "spectrum"):
mode          : string = "monokinetic"

#@description Direction of the emitted particle
emission_direction : string = "cone"

#@description The emission cone axis (values: "+x", "-x", "+y", "-y", "+z", "-z", "30.0 45.0 degree")
cone.axis : string = "-x"

#@description The default implicit angle unit
angle_unit : string = "degree"

#@description The minimum emission angle (cone)
cone.min_angle : real as angle = 0 degree

#@description The maximum emission angle (cone)
cone.max_angle : real as angle = 10 degree

#@description The kinetic energy of the generated particle
energy        : real as energy = 1000 keV
```

- 1 MeV cone gamma

```
[name="gamma_1MeV_cone" type="genbb::single_particle_generator"]
#@config Gamma with monokinetic energy @ 1 MeV [miscellaneous]

#@description Generated particle ("electron", "positron", "gamma", "alpha"):
particle_name : string = "gamma"

#@description Mode ("energy_range", "gaussian_energy", "monokinetic", "spectrum"):
mode          : string = "monokinetic"
```

```
#@description Direction of the emitted particle
emission_direction : string = "cone"

#@description The emission cone axis (values: "+x", "-x", "+y", "-y", "+z", "-z", "30.0 45.0 degree")
cone.axis : string = "-x"

#@description The default implicit angle unit
angle_unit : string = "degree"

#@description The minimum emission angle (cone)
cone.min_angle : real as angle = 0 degree

#@description The maximum emission angle (cone)
cone.max_angle : real as angle = 10 degree

#@description The kinetic energy of the generated particle
energy        : real as energy = 1000 keV
```

## 4.3 Vertex configuration

```
#@config Main configuration parameters for the genvertex manager

#@description Logging priority
logging.priority : string = "warning"

#@description List of files containing particle generator definition rules
vg_list : string[1] as path = \
    "@GEANT4_VALIDATION_DIR@/config/pipeline/vgs.conf"
```

### Generators configuration

- Insert preamble

  ```
  #@description A sample list of setups
  #@key_label   "name"
  #@meta_label  "type"
  ```

- From the source bulk

  ```
  [name="source_bulk.vg" type="genvtx::cylinder_model_vg"]

  #@config Vertex generation from the source bulk

  #@description Debug flag
  debug  : boolean = 0

  #@description The rule that describes the geometry origin of vertex in term of geometry category and addresses (geom
  origin : string  = "category='source_film.gc' position={*}"

  #@description The mode used for vertex generator from the underlying box model associated to the target logical volum
  mode   : string  = "bulk"
  ```

- From the source surface

  ```
  [name="source_surface.vg" type="genvtx::cylinder_model_vg"]

  #@config Vertex generation from the source surface
  ```

```
#@description Debug flag
debug  : boolean = 0

#@description The rule that describes the geometry origin of vertex in term of geometry category and addresses (geom
origin : string  = "category='source_film.gc' position={*}"

#@description The mode used for vertex generator from the underlying box model associated to the target logical volum
mode   : string  = "surface"

#@description Surface mode cylinder inner face activation
mode.surface.side   : boolean = 0

#@description Surface mode cylinder top face activation
mode.surface.top    : boolean = 1

#@description Surface mode cylinder bottom face activation
mode.surface.bottom : boolean = 1
```

## 4.4 Step hit processor configuration

### Insert preamble

```
#@description A list of simulated step hit processors
#@key_label   "name"
#@meta_label  "type"
```

### Scintillator/calorimeter hits

```
[name="scin.hit_processor" type="mctools::calorimeter_step_hit_processor"]

#@config The step hit processor for the scintillator blocks

#@description Debug flag
logging.priority      : string = "warning"

#@description The name of the category of MC hits output by this processor
hit.category          : string = "scin.hit"

#@description The name of the sensitive MC hits the processor must process to fill the output hit category
sensitive.category    : string = "scin_SD"

#@description Flag to activate a preallocated buffer/pool of MC hits to optimize memory management
use_private_pool      : boolean  = 1

#@description Initial capacity of the buffer/pool of MC hits
private_pool_capacity : integer  = 10

#@description The time spread of primary MC step hits to apply the clusterization
cluster.time_range    : real as time  = 1.0 ns

#@description The spacial spread of primary MC step hits to apply the clusterization
cluster.space_range   : real as length = 10.0 mm

#@description The name of the geometry category to be attached to the output MC hits
mapping.category      : string = "scin_block.gc"
```

```
#@description The name of the geometry category to be attached to the output MC hits
##mapping.category.any_addresses :  string[1] = "part"

[name="scin.visu.hit_processor" type="mctools::push_all_step_hit_processor"]

#@config The step hit processor for collecting all scintillator hits in the scintillator volume for visualization

#@description Debug flag
logging.priority   : string = "warning"

#@description The name of the target collection of MC hits
hit.category       : string  = "__visu.tracks"

#@description The sensitive category
sensitive.category : string  = "scin_SD"
```

### Enabling all volumes

```
[name="all.volumes.visu.hit_processor" type="mctools::push_all_step_hit_processor"]

#@config The step hit processor for collecting all the visu hits

#@description Logging flag
logging.priority     : string  = "warning"

#@description The category of output hit associated to this processor
hit.category         : string  = "__visu.tracks"

#@description The name of the sensitive MC hits that must be processed to fill the output hit category
sensitive.category   : string  = "__all.volumes.SD"

#@description Activating all volumes
geometry.volumes.all : boolean = 1
```

# 5 Pipeline general configuration

SN@ilWare implements the concept of data processing pipeline. An event record object is passed through a chain of data processing modules, each of them being responsible for a given task. Modules and services are declared in Section `Modules` and Section 7. For more details on running SuperNEMO simulations and the concept behind modules/services see these mandatory presentations given by F. Mauger.

The `@GEANT4_VALIDATION_DIR@` corresponds to the directory where configuration files are going to be stored. This variable which varies from one installation to the other, is automatically change when the tangle process occurs. This is done *via* the `Makefile` which parse and replace this variable.

## 5.1 Module manager

This file is the main and central piece of code for loading all modules/services needed by `dpp_processing` binary. It provides links to module files and service files.

### Logging priority

```
#@description Module manager logging priority
logging.priority : string = "warning"

#@description Embedded module factory debug flag
factory.debug : boolean = 0

#@description Embedded module factory 'no preload' flag
factory.no_preload : boolean = 0
```

### Service manager configuration

```
#@description The configuration file of the embedded service manager
service_manager.configuration : string[1] as path = \
    "@GEANT4_VALIDATION_DIR@/config/pipeline/service_manager.conf"
```

### Configuration files for modules

```
#@description The configuration files for modules
modules.configuration_files : string[2] as path =                          \
    "@GEANT4_VALIDATION_DIR@/config/pipeline/geant4_simulation_module.conf" \
    "@GEANT4_VALIDATION_DIR@/config/pipeline/geant4_validation_module.conf"
```

## 5.2 Service manager

### Logging priority

```
#@description Service manager logging priority
logging.priority : string = "warning"
```

### Name & description

```
#@description The name of the service manager
name : string = "sn_service_manager"

#@description The description of the service manager
description : string = "A SuperNEMO service manager"
```

### List of service files

```
#@description The list of files that describe services
services.configuration_files : string[1] as path = \
    "@GEANT4_VALIDATION_DIR@/config/pipeline/services.conf"
```

## 5.3 DLL loader

### Code generator

This skeleton code ease the declaration of dll loader since it receives a table list and builds the corresponding `dlls.conf` file.

```
echo '#@description A sample list of setups'
echo '#@key_label   "name"'
echo '#@meta_label  "filename"'
arr_name=(${name})
```

```
arr_filename=($filename)
for ((i=0; i < ${#arr_name[@]}; i++))
do
    dll=${arr_name[$i]}
    dllpath=${arr_filename[$i]}
    if [ "$dllpath" != "none" ]; then
^^Iecho '[name="'$dll'" filename="'$dllpath'"]'
    else
^^Iecho '[name="'$dll'" filename=""]'
    fi
    echo '#config The '$dll' library'
    echo 'autoload : boolean = 1'
    echo
done
```

### Libraries

This part set the different libraries to be loaded at runtime. This is needed since event data models are defined in other libraries than the one currently named `geant4_validation`. The following table sets the libraries

| | |
|---|---|
| Bayeux_mctools_geant4 | $SNAILWARE_PRO_DIR/bayeux/install/lib64/libBayeux_mctools_geant4.so |

**Table 1** – Libraries to be used by `geant4_validation` modules

```
#@description A sample list of setups
#@key_label   "name"
#@meta_label  "filename"
[name="Bayeux_mctools_geant4" filename="$SNAILWARE_PRO_DIR/bayeux/install/lib64/libBayeux_mctools_geant4.so"]
#config The Bayeux_mctools_geant4 library
autoload : boolean = 1
```

# 6 Modules configuration

## 6.1 Simulation module

### Module preamble

```
#@description A sample list of setups
#@key_label   "name"
#@meta_label  "type"
```

### Declaration & description

```
[name="geant4_simulation_module" type="mctools::g4::simulation_module"]

#@description A threaded Geant4 simulation module
```

### Logging priority

```
#@description Logging priority
logging.priority : string = "warning"
```

### Bank & service labels

```
#@description The Geometry Service label
Geo_label : string = "Geo"

#@description The 'Simulated data' bank label in the event record
SD_label  : string = "SD"

#@description Flag to allow cleaning of some former simulated data bank if any (default: 0)
erase_former_SD_bank : boolean = 0
```

### Seed values

```
#@description The simulation manager PRNG seed
manager.seed                  : integer = 1

#@description The vertex generator PRNG seed
manager.vertex_generator_seed : integer = 4

#@description The event generator PRNG seed
manager.event_generator_seed  : integer = 5

#@description The SHPF PRNG seed
manager.shpf_seed             : integer = 6

#@description The saving of PRNG seeds
manager.output_prng_seeds_file  : string as path = "/tmp/${USER}/snemo.d/prng_seeds.save"

#@description The saving of PRNG states
manager.output_prng_states_file : string as path = "/tmp/${USER}/snemo.d/prng_states.save"

#@description The modulo for PRNG states backup
manager.prng_states_save_modulo : integer = 10
```

### Vertex generator

```
#@description The vertex generator PRNG label
manager.vertex_generator_name : string  = "source_bulk.vg"
```

### Event generator

```
#@description The event generator PRNG label
manager.event_generator_name  : string  = "Bi207"
```

### Simulation manager

```
#@description The simulation manager configuration file
manager.configuration_filename : string as path = \
    "@GEANT4_VALIDATION_DIR@/config/pipeline/g4_manager.conf"
```

## 6.2 Validation module

The next item holds the configuration for validating Geant4 setup. The second item is related to histogram declarations.

Here, we just set up the module declaration.

### Module preamble

```
#@description A sample list of setups
#@key_label   "name"
#@meta_label  "type"
```

### Declaration & description

```
[name="geant4_validation_module" type="analysis::geant4_validation_module"]

#@description A module to study and to validate Geant4 setup
```

### Logging priority

```
#@description Logging priority
logging.priority : string = "notice"
```

### Histogram service label

Set the same histogram service label as defined here

```
#@description The Histogram Service label
Histo_label : string = "Histo"
```

- Histogram declarations The histogram declarations *i.e.* name, boundaries, binning… are set in this section which is organized by data bank related plots. There are two kinds of histograms:
  - *template* histogram which may be used by several data bank.
  - Mandatory preamble

    ```
    #@description A sample list of setups
    #@key_label   "name"
    #@meta_label  "type"
    ```

  - Energy template

    ```
    [name="energy_template" type="mygsl::histogram_1d"]
    #@description The title of the histogram (optional)
    title : string = ""

    #@description The group of the histogram (optional)
    group : string = "__template"

    #@description The build mode (default : "regular", "table", "mimic");
    mode : string = "regular"

    #@description The linear mode (default)
    linear : boolean = 1

    #@description The X axis label
    display.xaxis.label : string = "\Upsigma_\text{\tiny 1,2}$E$_\text{calibrated}"

    #@description The X axis unit for display (a standard unit, typically SI or CLHEP)
    display.xaxis.unit : string = "keV"

    #@description The Y axis label
    display.yaxis.label : string = "dN/dE [A.U.]"
    ```

```
#@description The number of bins
number_of_bins : integer = 25

#@description The unit of the bins' bounds (a standard unit, typically SI or CLHEP)
unit : string = "keV"

#@description The lower bound of the histogram
min : real = 2000.0

#@description The upper bound of the histogram
max : real = 3200.0
```

# 7 Services

A service generally hosts a specific resource that can be shared by many other software components, including other services or data processing modules (see SN@ilWare FAQ).

## 7.1 Preamble

```
#@description A sample list of setups
#@key_label   "name"
#@meta_label  "type"
```

## 7.2 Context service

```
[name="Ctx" type="dpp::context_service"]

#@description Logging priority
logging.priority : string = "warning"

#@description File from which the context is to be loaded at program start
load.file : string as path  = "/tmp/${USER}/snemo.d/snemo_context.conf"

#@description File to store the context at program termination
store.file : string as path = "/tmp/${USER}/snemo.d/snemo_context_end.conf"

#@description Flag to backup the former context load file
backup.file : string as path = "/tmp/${USER}/snemo.d/snemo_context_bak.conf"
```

## 7.3 Geometry service

The following code block declares the geometry service to properly load all the geometry and material construction of the detector. This service, only declared here, can be used by several operations like calibration, particle track reconstruction … but all of them will use the same geometry.

```
[name="Geo" type="geomtools::geometry_service"]

#@description Logging priority
logging.priority : string = "warning"

#@description Embedded SuperNEMO geometry manager main configuration file
manager.configuration_file : string as path = \
    "@GEANT4_VALIDATION_DIR@/config/geometry/manager.conf"
```

```
#@description Embedded SuperNEMO geometry manager must build its mapping lookup table
manager.build_mapping : boolean = 1

#@description Embedded geometry manager's mapping lookup table does not exclude any geometry category
manager.no_excluded_categories : boolean = 1
```

### 7.4 Histogram service

The histogram service provides an esay way to handle histogram plot from different modules (mainly plot modules). It provides a service where 1D or 2D histograms can be added to a histogram dictionnary.

```
[name="Histo" type="dpp::histogram_service"]

#@description Logging priority
logging.priority : string = "warning"

#@description The description string of the embedded pool of histograms
pool.description : string = "Geant4 histograms"

#@description The main configuration file for the embedded histogram manager
pool.histo.setups : string[1] as path = \
    "@GEANT4_VALIDATION_DIR@/config/pipeline/histogram_templates.conf"
```

Finally, all histograms created can be stored inside ROOT files or XML archives.

```
#@description The ouput file where to store the histograms
output_files : string[2] as path =                          \
    "/tmp/${USER}/snemo.d/geant4_validation_histos.root" \
    "/tmp/${USER}/snemo.d/geant4_vlaidation_histos.xml"
```

## 8 Running SN@ilWare processing chain

### 8.1 Tangling configuration

First, you need to tangle this file. As explained in the Content section, you may use the dedicated `Makefile` to generate the pipeline configuration. Just run `make` within this working directory.

### 8.2 Source code compilation

Second, you need to compile the `geant4_validation` module files. The build system used is `cmake` and a `CMakeLists.txt` file is provided to correctly setup the dependences. Nevertheless, this implies that you have already and correctly installed Cadfael, Bayeux and Falaise. Then, you can configure, build and install the `geant4_validation` module by doing

```
mkdir {build,install} && cd build
cmake                                           \
    -DCMAKE_PREFIX_PATH="<path to Falaise install>" \
    -DCMAKE_INSTALL_PREFIX=../install           \
    ../source
make install
cd ..
```

## 8.3 Use and execute `geant4_validation` module

After a successful build, you will get an `install` directory holding the `libgeant4_validation.so` file. Assuming you are under `bash` shell, you will need to add it to your `LD_LIBRARY_PATH` by doing

```
export LD_LIBRARY_PATH=${PWD}/install/lib:${LD_LIBRARY_PATH}
```

Another approach, maybe less intrusive, will be to set the `LD_LIBRARY_PATH` when running the `dpp_processing` binary. You can for example write something like

```
LD_LIBRARY_PATH=${PWD}/install/lib:${LD_LIBRARY_PATH} dpp_processing ...
```

Running processing pipeline is done by the `dpp_processing` program provided by `dpp` library. Its call is pretty simple and only implies to have a module manager file and the name of the module to be run *i.e.* `geant4_validation_module`. Nevertheless, you need to dynamically load the library(ies) which holds the needed modules.

```
dpp_processing                                                  \
    --module-manager-config $PWD/config/pipeline/module_manager.conf \
    --module geant4_validation_module                           \
    --load-dll geant4_validation                                \
    --load-dll <library>_bio
```

`<library>_bio` represents libraries which holds event data models such as `mctools_bio`. You can use the `dlls.conf` file built in section 5.3 by writing

```
dpp_processing                                                  \
    --module-manager-config $PWD/config/pipeline/module_manager.conf \
    --module geant4_validation_module                           \
    --load-dll geant4_validation                                \
    --dll-config $PWD/config/pipeline/dlls.conf
```

It will run the `geant4_validation_module` and it will generate a ROOT file containing several histograms. This file is located by default, in `/tmp/${USER}/snemo.d` directory under the `geant4_validation_histos.root` name. You can change the output directory and output file name in this section.