FUSION FOR ENERGY

Memorandum

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Subject: **iMCNP_Source**

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To: **Everybody interested**

The manual definition of complex SDEF sources composed by numerous cylinders may be very tedious, cumbersome and inefficient. Therefore, the iMCNP_Source 3.6 python routine can be used to automatize the source definition process. Indeed, it converts a MCNP input file composed only by a collection of cylindrical cells representing the pipes in a suitable SDEF MCNP syntax. The resulting source can adopt different shapes (as line, superficial and volumetric) and it can be biased in function of user-defined tags present in the in-line comments (e.g. pipe_activated). Moreover, iMCNP_Source computes the total source activity.

What iMCNP_Source does

The iMCNP_Source is a python 3.6 routine that writes MCNP SDEF sources from a collection of cylinders with the associated tags info if present. The collection of cylinders has the MCNP cell format and therefore can be obtained from CAD models with the use of codes like SuperMC or MCCAD.

This routine is especially useful when automatizing the source definition of activated water flowing through pipes. The pipes are represented as cylinders in the CAD models and they need to be translated in a proper SDEF definition. This python tool automatizes most of the process requiring from the user little preparation and parameter specification.

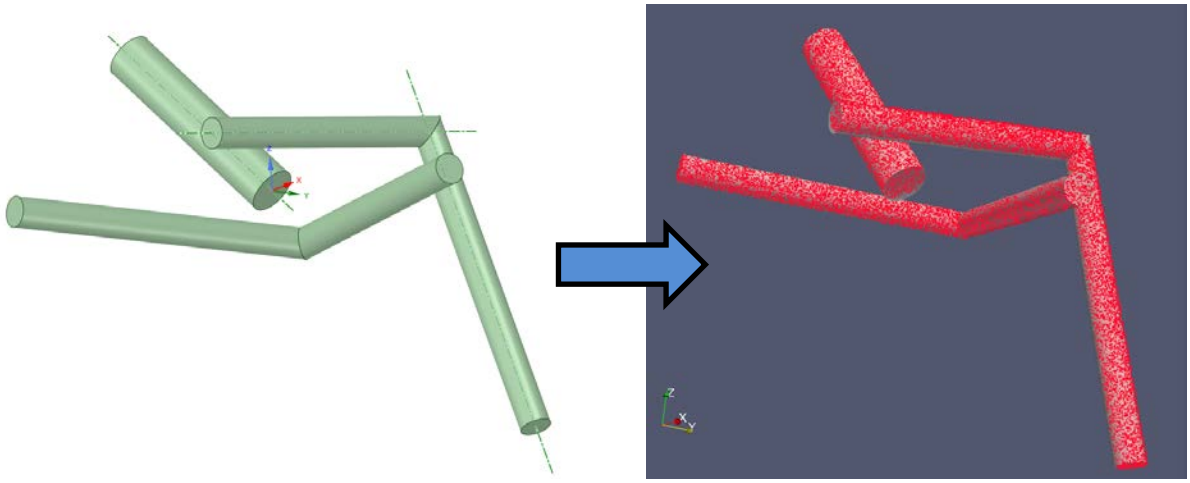

Figure 1 - Particles being generated inside a given collection of pipes

Indeed, every pipe source can be biased according to the keys and values of the “actDict” dictionary found in the iMCNP_Source.py file. The biasing can be deactivated by setting the “isTagged” variable to False. In that case the default biasing obtained from “defaultActivity” and “gammaPerDis” will be used. “ergSpectrum” defines the distributions relating to the energy spectrum of the source particles while the “source” variable can have the form “cyl”, “line” or “acp” for a volumetric, linear or cylindrically superficial source.

When defining a source in MCNP several distributions cards may need to be applied. There is a limit to the amount of distributions present in a MCNP input currently set as 999. The routine helps avoiding reaching the limit by identifying employ the same distributions for pipes with the same features (e.g. radius, length …).

How to use it

Three sequential steps are needed:

1. Parameters specification
2. Preparation of the MCNP SDEF input
3. Run the iMCNP_Source python routine

Parameters specification

The following user parameters are detailed and modifiable in the iMCNP_source.py file:

- defaultActivity: activity in Bq/cm3, Bq/cm2, Bq/cm depending on the source type
- startDISTR: number of the initial distribution
- gammaPerDis: gammas produced per atom disintegration
- isTagged flag [True, False]:
    - True: the activity of each cell is biased according to the tag present in the cell in-line comment and the value of the “actDict” dictionary.
    - False: the activity of each cell is constant and equal to the defaultActivity parameter.
- ergSpectrum: MCNP energy spectra definition
- source: to set the type of geometrical source
    - cyl: cylinders
    - line: line source located in the cylinder center
    - acp: distribution on the surface

```
# ==================     USER PARAMETERS ========================================
#

startDISTR       = 10      # Number of the initial distribution
defaultActivity  = 8.30e9  # Bq/cm3
gammaPerDis      = 0.749578
isTagged = True
actDict  = { 'y_pos_water_top':7.5679e9, 'y_pos_water_bottom':0., \
             'y_neg_water_top':7.5679e9, 'y_neg_water_bottom':0., \
             'c_pos_water_top':7.5679e9, 'c_pos_water_bottom':0., \
             'c_neg_water_top':7.5679e9, 'c_neg_water_bottom':0. }
# Energy spectrum of emitted radiation (MCNP format for SI6 ending in EOL)
ergSpectrum='C . . Spectrum for N-16\n' +
            'si'+str(4+startDISTR) +' L 0.9865 1.755 1.9548 2.7415 2.8225 6.0482 6.1292 6.9
            'sp'+str(4+startDISTR) +'   0.0035 0.14 0.04 0.84 0.0013 0.013 68.8 0.04 5.0 0.

# Definition of the type of source:
# cyl  --> cylinders
# line --> line
# acp  --> distribution on the surface to simulate activate corrosion product deposits.
source = 'acp'
#
# ======================  END OF USER PARAMETERS ================================


# ====================    PROGRAM PARAMETERS   ==================================
# Program parameters
# MCNP comment marks
commStr = 'Cc'
# Number of parameters in surface definition
nparDict={'P':4,'GQ':10,'PX':1,'PY':1,'PZ':1,'C/X':3,'C/Y':3,'C/Z':3,'CX':1,'CY':1,'CZ':1}
# Initial distribution number
ndis0   = 10 + startDISTR
# ======================  END OF PROGRAM PARAMETERS ==============================
```

Figure 2 - User Parameters

Preparation of the MCNP SDEF input

The iMCNP_source requires as input a file containing the information of the pipes in a specific format. The format is that of a MCNP input file with some special considerations. The MCNP input file should be only composed by the source cylinders cells, defined as follows:

- The first line of each cell should contain the single cylinder definition.
- The second line of the cell is not read by the script and should preferably contain the importance cards. If the “isTagged” flag is set to True there will be a third line in every cell with a comment beginning with a “$”. That comment should be one of the keys found in “actDict” and will relate that cell to a specific activity.
- Third line, if present, is devoted to an in-line comment (e.g. “$ Comment Here”).

```
1     0   ( -5 13 -12)
          IMP:N=1.0  IMP:P=1.0  IMP:E=0.0 TMP=2.53005e-008
          $c_neg_water_top
2     0   ( -1 19 -18)
          IMP:N=1.0  IMP:P=1.0  IMP:E=0.0 TMP=2.53005e-008
          $c_neg_water_top
3     0   ( -3 -14 16)
          IMP:N=1.0  IMP:P=1.0  IMP:E=0.0 TMP=2.53005e-008
          $c_neg_water_top
```

Figure 3 - MCNP input detail

Run the iMCNP_Source python routine

Once the parameters and MCNP input geometry are prepared, iMCNP_Source can be executed as follows:

python iMNCP_source.py <input file name>

A new text file, named as *InputFile + [SDEF-typeOfSource],* will be generated containing the source definition in the MCNP syntax. The user may then copy and paste that source definition whenever is needed.

Example of SDEF generated

```
C . . Total gamma source:  5.79196e+16 g/s
sdef par=p pos=d11 axs=fpos=d12 ext=fpos=d13 erg=d14 rad=fpos=d15
si11 L
C actflag@c_neg_water_top
       700.0      0.0  1000.0    700.0   200.0  1000.0
C actflag@c_pos_water_bottom
       500.0   200.0  1000.0
C actflag@c_neg_water_top
       500.0   200.0  1000.0
sp11
C actflag@c_neg_water_top
      1.78314e+16  1.78314e+16
C actflag@c_pos_water_bottom
      2.97191e+16
C actflag@c_neg_water_top
      1.18876e+16
ds12 L
C actflag@c_neg_water_top
      1.0000  0.0000  0.0000   1.0000  0.0000  0.0000
C actflag@c_pos_water_bottom
      1.0000  0.0000  0.0000
C actflag@c_neg_water_top
      1.0000  0.0000  0.0000
ds13 s 21 21 22 20
ds15 s 23 23 23 23
C . . Spectrum for N-16
si14 L 0.9865 1.755 1.9548 2.7415 2.8225 6.0482 6.1292 6.9155 7.1151 8.8692
sp14   0.0035 0.14 0.04 0.84 0.0013 0.013 68.8 0.04 5.0 0.08
C . . Distributions EXT
si20 h 0 200.00
si21 h 0 300.00
si22 h 0 500.00
C . . Distribuciones RAD
si23 h 0 49.90  50.00
sp23   0 1.0e-06  1
```

Figure 4 – Example of typical SDEF generated

Warning and limitations

- Due to the routine source definition implementation, the resulted SDEF has an inherent limitation in the corners between pipes. Indeed, as the source is defined by a series of cylinders limited at both ends by planes perpendicular to the axes, an over and under-sampled might be present in the corners zones. This problem affects all the types of sources (cyl, line,acp).

  An example of this phenomena is illustrated in Fig.4, in which the elbow area has an over-sampling in the inner part but an under sampling (indeed no sampling at all) in the outer one.

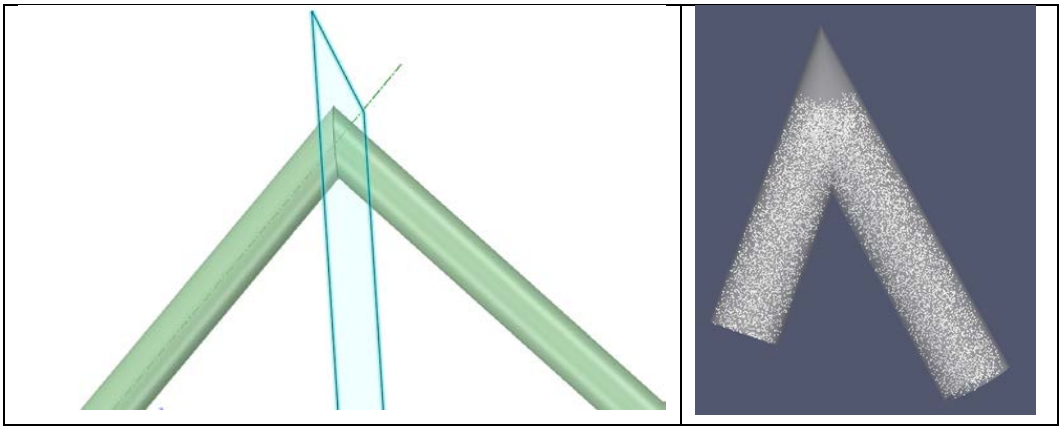

Figure 5 – Under-over sampling in the SDEF particle generation

  Nevertheless, the iMCNP SDEF definition is considered a good approximation of the reality, the user might consider to compile MCNP with an external source subroutine to improve even more the accuracy of the simulation.

- The iMCNP_Source python routine can parse only cylinders cell with:
  - 3 surfaces: a cylinder with two planes
  - 4 surfaces: a hollow pipe defined by two planes and two concentric cylinders. In this case the inner cylindrical surface is assumed for the SDEF construction
- Please remember that MCNP5v1.60 cannot cope with more than 999 sdef distributions
- Although, the generated SDEF definitions are suited for gamma particle, another type of particle may be easily implemented by manual modification.

Further developments

- The cell cookie-cutter may be introduced as flag option to avoid the over/under-sampled regions.
- The capability to produce parallelepiped sources representing water deposits could be added.