The Intrinsic Source Constructor (ISC) and MCNPTools Libraries

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ISC Overview

- ISC is a library for generating intrinsic radiation sources for inputs into radiation transport codes
- ISC is written in C++ and bound to Python (via SWIG)
- ISC uses a CMake build system to build the C++ library and utilities and a Python setuptools setup.py to build the Python extensions
- ISC has with it a single binary utility MISC–the MCNP Intrinsic Source Constructor–that will generate SDEF distributions

ISC Data Files

- ISC has three classes of data files
  1. natural abundance files–contains naturally occurring abundances of isotopes
  2. radioactive decay data files–contains decay mechanisms, branching ratios, and daughter isotopes
  3. particle emission data files–contains the particle emissions from the decay of an isotope
- The data files are C++ Boost Serialized versions of ISC data storage classes
- The data files are typically stored in XML formats that can be interrogated in an editor (if one knows what they are looking for)

To SZAs ... and Beyond

- to adequately capture decay channels, emissions, etc., ZA identifiers are insufficient
- ISC uses SZA identifiers where S is the long-lived isomeric state number (not necessarily the isomer's level number)

$$SZA = S * 1000000 + Z * 1000 + A$$

- For example, Pa-234m1 would be 1091234

Natural Abundance Files

- intended to facilitate usability
- allows a user to specify a natural ZA (i.e., A=000) and automatically expand it to isotopic ZAs
- Currently, the only available data set is the NIST natural abundances

Radioactive Decay Data Files

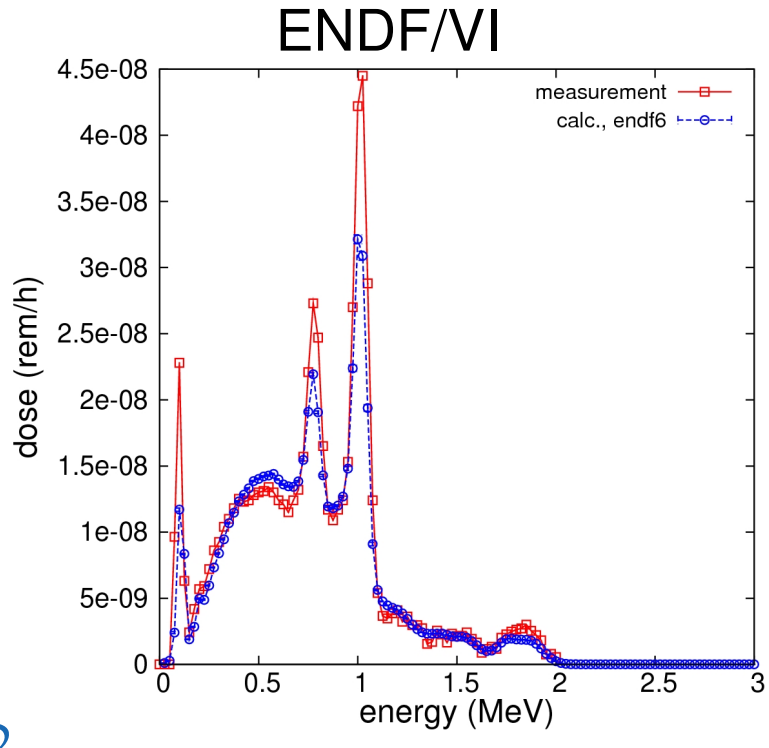
- This file contains information about decay mechanisms, branching ratios, and decay daughters of SZAs
- Currently, these files do not include any information about spontaneous fission products
- Available data sets include data from ENDF/VI (not recommended) and ENDF/VII.1 radioactive decay sublibrary

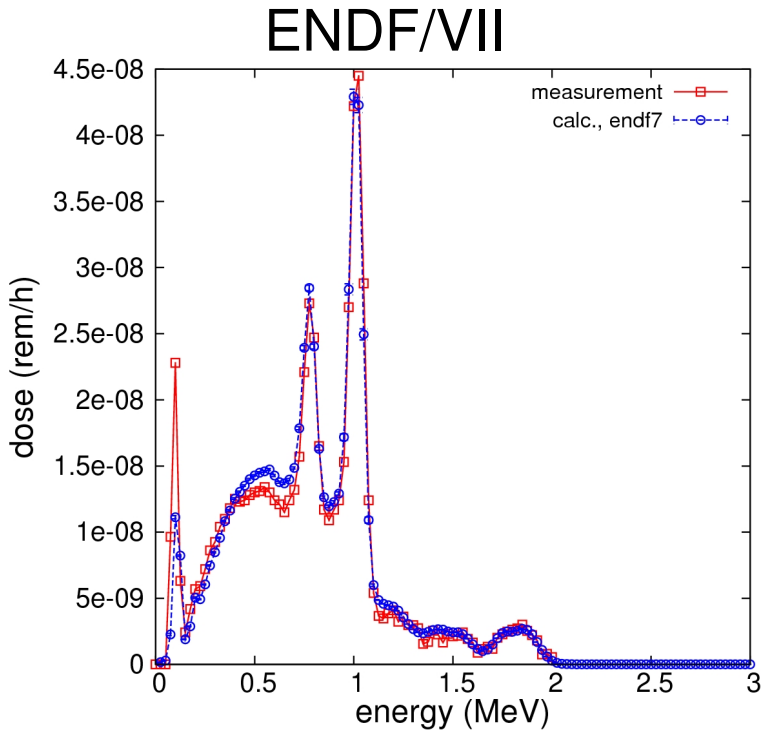
Particle Emission Data Files

- For each SZA, a file exists that has the emissions by particle type
- The emission files do not contain any information about coincident emissions
- Beta-particle spectra are reconstructed based on Fermi theory from end-point energies
- Watt spectrum parameters exist for many/most spontaneously fissioning isotopes (taken from the SOURCES 4C) data set
- The currently available set of particle emission data are from the ENDF/VI (not recommended) and ENDF/VII.1 radioactive decay sublibraries (RDSL)

Why ENDF7.1 and not ENDF6

- vast improvements were made to the ENDF RDSL from ENDF/VI to ENDF/VII.0 and important corrections made in ENDF/VII.1
- below is a comparison of dose measurements to simulation from a DU sphere





Aging Material

- ISC has built into it a Bateman solver
- Materials compositions can be specified, aged, reset, and aged again if desired
- Emission spectra can be generated for either or both the original material composition and the aged composition

MISC Overview

1. MISC is a standalone binary utility that generates SDEF source distributions for MCNP
2. MISC reads and input file with entries generally of the form

$$\langle \text{keyword} \rangle = \langle \text{value} \rangle$$

3. MISC has a User's Manual, but an example input is given herein
4. MISC generates source distributions for a single particle type at a time, but each distribution may have discrete and continuous components
5. MISC outputs two files and output file summarizing the run and a source file that contains the MCNP SDEF distributions

Example MISC Input File (Natural U)

```
# lines beginning with '#' are comments
#
# specify output file
output=test001.out
#
# specify source distribution file
srcout=test001.src
#
# specify the natural abundance file
abundfile=nist.na.xml
#
# specify the decay data file
decayfile=endf7.dk.xml
#
# specify the default particle emission library
pelib=endf7
#
# specify the material isotopic description with
# SZAs (+/-  = atom/mass fracs)
matspec= 92000 -1
#
# specify the material density
density=-18.0
#
# specify the aging of the material in seconds
age = 3.14e7
#
# specify the particle type for the source
particle=p
#
# specify vertical (v) or horizontal (h) formatted
# SDEF distributions
format=v
#
# specify that electron sources should be converted
# to photon sources via a thick-target bremsstrahlung
# approximation
estobrems=y
```

Example MISC Output File

```
USER INPUT MATERIAL SPECIFICATION:

      SZA   Isotope    Mass Frac
    92000     U-Nat  1.00000e+00

Material density: 1.80000e+01 g/cm^3

The material was aged for 3.14000e+07 s  using data from endf7.dk.xml

RESULTING MATERIAL SPECIFICATION:

      SZA   Isotope    Atom Frac    Mass Frac
    80206    Hg-206  1.27980e-33  1.10747e-33
    81205    Tl-205  1.51722e-47  1.30653e-47
    81206    Tl-206  4.29461e-32  3.71630e-32
    81207    Tl-207  2.37491e-23  2.06509e-23
    81210    Tl-210  2.18313e-28  1.92596e-28
    82206    Pb-206  1.79148e-22  1.55023e-22
    82207    Pb-207  5.40613e-19  4.70085e-19
    82209    Pb-209  2.78302e-30  2.44339e-30
    82210    Pb-210  9.45370e-20  8.33986e-20
    82211    Pb-211  1.80241e-22  1.59765e-22
    82214    Pb-214  2.14297e-23  1.92664e-23
    83209    Bi-209  1.69762e-27  1.49045e-27
    83210    Bi-210  5.50424e-23  4.85572e-23
    83211    Bi-211  1.06845e-23  9.47069e-24
    83214    Bi-214  1.59138e-23  1.43072e-23
    83215    Bi-215  3.93728e-29  3.55639e-29
    84210    Po-210  4.90580e-22  4.32777e-22
    84211    Po-211  1.18508e-28  1.05045e-28
    84214    Po-214  2.18935e-30  1.96829e-30
    84215    Po-215  1.48237e-28  1.33895e-28
    84218    Po-218  2.47808e-24  2.26965e-24
    85215    At-215  1.91435e-35  1.72913e-35
    85218    At-218  3.99948e-30  3.66309e-30
    85219    At-219  4.92028e-30  4.52716e-30
    86218    Rn-218  9.33212e-35  8.54709e-35
    86219    Rn-219  3.29601e-25  3.03264e-25
    86222    Rn-222  4.40417e-21  4.10792e-21
    87223    Fr-223  1.93298e-24  1.81109e-24
    88223    Ra-223  8.21964e-20  7.70130e-20
    88226    Ra-226  6.93897e-16  6.58905e-16
    89227    Ac-227  7.29169e-17  6.95469e-17
    90227    Th-227  1.45707e-19  1.38973e-19
    90230    Th-230  1.51702e-10  1.46606e-10
    90231    Th-231  2.97954e-14  2.89201e-14
    90234    Th-234  1.44078e-11  1.41666e-11
    91231    Pa-231  7.02967e-12  6.82315e-12
    91234    Pa-234  2.66978e-16  2.62508e-16
    92234     U-234  5.40000e-05  5.30953e-05
    92235     U-235  7.20400e-03  7.11366e-03
    92238     U-238  9.92742e-01  9.92833e-01
  1091234  Pa-234m1  4.81174e-16  4.73117e-16

Atom density: 4.55401e-02 a/b*cm
Mass density: 1.80000e+01 g/cm^3

TOTAL PARTICLE EMISSION RATES

   Particle   cm^-3 s^-1    g^-1 s^-1   Frac. Rate
          n  2.42704e-01  1.34835e-02  3.80112e-07
          p  1.86172e+05  1.03429e+04  2.91574e-01
          a  4.52334e+05  2.51297e+04  7.08425e-01
      Total  6.38506e+05  3.54726e+04  1.00000e+00
```

Example MISC Source File

- the source emission rate normalization is given per unit volume or mass of the source
- the source is broken into two pieces, the discrete and continuous spectra
- the source can also be output as a function of isotope if desired
- the starting source distribution number can be set in the input file

```
c wgt should equal 1.86172e+05*VOL or 1.03429e+04*MASS
si001 s           2            3
sp001 d 5.89603e-01  4.10397e-01
#          si002        sp002
               l            d
     2.29873e-03  3.35218e-11
     2.29880e-03  3.26936e-21
     2.29892e-03  4.66760e-19
     2.29965e-03  2.08984e-14
     2.37789e-03  7.33374e-14
.
.
.
     3.09400e+00  1.45646e-14
     3.14256e+00  4.59933e-14
     3.14900e+00  3.29619e-15
     3.16050e+00  1.80141e-14
     3.18363e+00  5.09759e-14
#          si003        sp003
               h            d
     0.00000e+00  0.00000e+00
     2.00000e-02  2.89830e-01
     4.00000e-02  1.37373e-01
     6.00000e-02  8.78325e-02
     8.00000e-02  6.35485e-02
     1.00000e-01  4.92536e-02
.
.
.
     4.28000e+00  3.38511e-22
     4.30000e+00  1.56604e-22
     4.32000e+00  5.99534e-23
     4.34000e+00  1.66812e-23
     4.36000e+00  2.36227e-24
```

Interactive MISC example (Co-60)

MISC Co-60 Example

```
# specify output file
output=co60.out
#
# specify source distribution file
srcout=co60.src
#
# specify the natural abundance file
abundfile=nist.na.xml
#
# specify the decay data file
decayfile=endf7.dk.xml
#
# specify the default particle emission library
pelib=endf7
#
# specify the material isotopic description with
# SZAs (+/-  = atom/mass fracs)
matspec= 27060 1.0
#
# specify the material density
# normalize to 1 a/b-cm
density=1.0
#
# specify the aging of the material in seconds
# 1 hl = 5.271 a = 1.663355e+8 s
age=1.663355e+8
#
# specify the particle type for the source
particle=p
# specify vertical (v) or horizontal (h) formatted
# SDEF distributions
#
format=v
```

Examples of Using the ISC Library

- MISC is useful...but the true power of ISC is that YOU can write your own scripts/programs to do whatever you want with decay data
- the ISC library supports C++ with Python bindings
- examples of using the library in Python follow

ISC Example 1a: Loading Data Files

- this example (next slide) demonstrates how to load abundance, decay, and particle emission data files
- the natural abundance and decay data files load information for all SZAs
- the particle emission data is loaded on an SZA basis (loading all the data takes time)

ISC Example 1a: Loading Data Files Continued

```
import os
import isc # import the isc module

# set the path to the ISC data
iscdata = os.getenv("ISCDATA")

# open an abundance data file and convert it to an abundance library
abund_file = isc.AbundanceFile(os.path.join(iscdata,"nist.na.xml"))
abund_lib = isc.AbundanceLib(abund_file)

# open a decay data file and convert it to a decay data library
decay_file = isc.DecayFile(os.path.join(iscdata,"endf7.dk.xml"))
decay_lib = isc.DecayLib(decay_file)

# open an emission file index (contains relative paths to emission data files)
emission_index = isc.EmissionFileIndex(os.path.join(iscdata,"endf7.idx.xml"))
# initialize an empty emission library
emission_lib = isc.EmissionLib()

# loop over all SZAs and import the emission data
# NOTE: one need not load everything, only the things you need
for sza in emission_index.GetSZAs():
  print("loading emission data for isotope {:d}".format(sza))
  emission_file = isc.EmissionFile( os.path.join(iscdata,emission_index.GetPath(sza)) )
  emission_lib.SetFromEmissionFile( emission_file )
```

ISC Example 1b: Loading Binary Data Files

- for convenience and speed, sets of abundance, data, and particle emission data are bundled into binary data files
- these binary data files can be used to load sets of the data
- this is much faster than the previous example, but it loads all the emission data

ISC Example 1b: Loading Binary Data Files Continued

```
import os
import isc # import the isc module

# set the path to the ISC data
iscdata = os.getenv("ISCDATA")

# initialize an empty abundance lib
abund_lib = isc.AbundanceLib()

# initialize an empty decay lib
decay_lib = isc.DecayLib()

# initialize an empty emission library
emission_lib = isc.EmissionLib()

# load the libraries from the prebuilt binary file
isc.loadLibs(abund_lib, decay_lib, emission_lib, os.path.join(iscdata,"endf7.isc.bin"))
```

ISC Example 2: Querying Abundance Data

- this example (next slide) demonstrates how to get mass and natural abundance data out of the abundance library
- First, a set of all U isotopes the library knows about is generated
- Second, a loop is constructed over the set of all U isotopes and the mass and natural abundance is obtained
- Last, if the abundance is greater than zero, the SZA is added to the list of naturally occurring U isotopes

ISC Example 2: Querying Abundance Data Continued

```
import os
import isc # import the isc module

# load the data
iscdata = os.getenv("ISCDATA")
abund_lib = isc.AbundanceLib()
decay_lib = isc.DecayLib()
emission_lib = isc.EmissionLib()
isc.loadLibs(abund_lib, decay_lib, emission_lib, os.path.join(iscdata,"endf7.isc.bin"))

# get all U isotopes with data
u_isos = abund_lib.GetIsosForZ(92)
print(u_isos)

# get mass and abundance for each naturally occuring isotope
nat_u_isos = list()
for iso in u_isos:
    # get mass and abundance for iso
    mass = abund_lib.GetMass(iso)
    abundance = abund_lib.GetAbundance(iso)
    print("{:7d}  {:7.3f}  {:12.5e}".format(iso, mass, abundance))

    # if abundances is non-zero add it to the list of naturally occurring isos
    if( abundance > 0.0 ):
        nat_u_isos.append(iso)
print(nat_u_isos)
```

ISC Example 3: Querying Decay Data

- this example shows how to query the decay data to obtain information such as half life, daughters, and branching ratios
- First, all the daughters of Cs-137 are requested
- Next, a loop over the number of decay pathways is constructed
- Then, for each decay pathway, the daughter and branching ratio is obtained

ISC Example 3: Querying Decay Data Continued

```
import os
import isc # import the isc module

# load the data
iscdata = os.getenv("ISCDATA")
abund_lib = isc.AbundanceLib()
decay_lib = isc.DecayLib()
emission_lib = isc.EmissionLib()
isc.loadLibs(abund_lib, decay_lib, emission_lib, os.path.join(iscdata,"endf7.isc.bin"))

# get all the daughters of Cs-137
cs137_daughters = decay_lib.GetAllDaughters(55137)
print(cs137_daughters)

# get the decay data for Cs-137
cs137_decay_data = decay_lib.GetDecayData(55137)
print("Cs-137 half life = {:12.5e} s".format(cs137_decay_data.GetHalfLife()))

# loop over the number of decay pathways
for i in range(cs137_decay_data.GetNumber()):
   # get daughter SZA is branching ratio
   daughter = cs137_decay_data.GetDaughter(i)
   branching_ratio = cs137_decay_data.GetBranchingRatio(i)
   print("{:7d}  {:12.5e}".format( daughter, branching_ratio ) )
```

ISC Example 4: Querying Emission Data

- This example demonstrates how to get emission spectra of particular particle type out of the emission data
- First, all the spectra from Co-60 are requested
- Second, the gamma emission spectrum is obtained (an emission spectrum can have discrete and continuous pieces)
- Lastly, a loop over the discrete emissions is created and the energy and #/decay are printed

ISC Example 4: Querying Emission Data Continued

```
import os
import isc # import the isc module

# load the data
iscdata = os.getenv("ISCDATA")
abund_lib = isc.AbundanceLib()
decay_lib = isc.DecayLib()
emission_lib = isc.EmissionLib()
isc.loadLibs(abund_lib, decay_lib, emission_lib,\
   os.path.join(iscdata,"endf7.isc.bin"))

# get the emission spectra for Co-60
co60_spectra = emission_lib.GetSpectra(27060)

# get a list of isc particle types for which spectra exist
co60_particle_types = co60_spectra.GetParticleTypes()
print(co60_particle_types)

# loop over the particle types
for ptype in co60_particle_types:
   if ptype == isc.ENDF_DECAY_GAMMA:
      print("Co-60 emits gammas, ptype = {:d}".format(ptype))
   elif ptype == isc.ENDF_DECAY_BETAM:
      print("Co-60 emits beta-, ptype = {:d}".format(ptype))
   elif ptype == isc.ENDF_DECAY_BETAP:
      print("Co-60 emits beta+, ptype = {:d}".format(ptype))
   elif ptype == isc.ENDF_DECAY_IT:
      print("Co-60 has internal transition, ptype = {:d}".format(ptype))
   elif ptype == isc.ENDF_DECAY_ALPHA:
      print("Co-60 emits alphas, ptype = {:d}".format(ptype))
   elif ptype == isc.ENDF_DECAY_ELECTRON:
      print("Co-60 emits electrons, ptype = {:d}".format(ptype))
   elif ptype == isc.ENDF_DECAY_XRAY:
      print("Co-60 emits xrays, ptype = {:d}".format(ptype))

# get the gamma spectrum
co60_gammas = co60_spectra.GetSpectrum(isc.ENDF_DECAY_GAMMA)
print("The number of discrete emissions per decay is {:.3f}".format(\
   co60_gammas.GetDNorm()))

# loop over all the discrete emissions
print("{:12s}  {:12s}".format("energy","#/decay"))
for i in range(co60_gammas.GetDNumber()):
   # get the emission energy and probability/decay
   energy = co60_gammas.GetDEnergy(i)
   intensity = co60_gammas.GetDIntensity(i)
   print("{:12.5e}  {:12.5e}".format(energy,intensity))
```

MCNPTools History and Overview

- MCNPTools was born out the continual need to process MCNP outputs
- MCNPTools is a library that provides object-oriented access to MCNP outputs
  1. MCTAL files
  2. MESHTAL B (MCNP5 style) files
  3. PTRAC files
  4. LNK3DNT files (not herein discussed)
- MCNPTools is is written in C++ and bound to Python and Perl
- MCNPTools also has some binary “widgets”

l3dcoarsen Widget

```
USAGE: l3dcoarsen [--help] [--novoid] [--ifact ifact] [--jfact jfact]
       [--kfact kfact] [--maxmats maxmats] <LNK3DNT> [OUTPUT]

DESCRIPTION:

l3dcoarsen coarsens a LNK3DNT file mesh by specified factors

OPTIONS:

--help, -h        : print usage infomation

--novoid, -n      : Make voids material '0' rather than the assumed material
                    '1' (not recommended)

--ifact, -i       : Factor by which to coarsen in the first mesh dimension

--jfact, -j       : Factor by which to coarsen in the second mesh dimension
                    (if applicable)

--kfact, -k       : Factor by which to coarsen in the third mesh dimension (if
                    applicable)

--maxmats, -m     : Maximum umber of materials to keep include on the
                    coarsened LNK3DNT file (default: same as original)

LNK3DNT           : LNK3DNT file name to coarsen

OUTPUT            : coarsened LNK3DNT output name (Default: lnk3dnt.coarse)

AUTHOR: Clell J. (CJ) Solomon [csolomon@lanl.gov]
```

l3dinfo Widget

```
USAGE: l3dinfo [--full] [--help] <LNK3DNT [LNK3DNT ... ]>

DESCRIPTION:

l3dinfo produces information about LNK3DNT files to stdout

OPTIONS:

--full, -f        : Produce a full listing of the LNK3DNT contents (can
                    greatly increase runtime)

--help, -h        : print usage infomation

LNK3DNT           : LNK3DNT files about which to produce information

AUTHOR: Clell J. (CJ) Solomon [csolomon@lanl.gov]
```

l3dscale Widget

```
USAGE: l3dscale [--help] <LNK3DNT> <FACTOR> [OUTPUT]

DESCRIPTION:

l3dscale scales the dimensions of a LNK3DNT file

OPTIONS:

--help, -h        : print usage infomation

LNK3DNT           : LNK3DNT file to be scaled

FACTOR            : Scaling factor to be applied to the file

OUTPUT            : Output LNK3DNT file name [Default: LNK3DNT.scaled]

AUTHOR: Clell J. (CJ) Solomon [csolomon@lanl.gov]
```

mergemctals Widget

```
USAGE: mergemctals [--help] [--verbose] [--output output] <MCTAL [MCTAL ... ]>

DESCRIPTION:

mergemctals statistically merges multiple MCNP MCTAL files into a single MCTAL
file.

OPTIONS:

--help, -h        : print usage infomation

--verbose, -v     : Increase output verbosity

--output, -o      : Output MCTAL file name [Default: mergemctals.out]

MCTAL             : MCTAL file names to be merged

AUTHOR: Clell J. (CJ) Solomon [csolomon@lanl.gov]
```

Note:

This is an alternative, not yet a replacement for, the Perl script that ships with MCNP. However, this binary can be compiled with MPI (requires C++ Boost Libraries), which speeds up merging.

mergemeshtals Widget

```
USAGE: mergemeshtals [--help] [--verbose] [--output output]
       <MESHTAL [MESHTAL ... ]>

DESCRIPTION:

mergemeshtals statistically merges multiple MCNP MESHTAL files into a single
MESHTAL file.

OPTIONS:

--help, -h        : print usage infomation

--verbose, -v     : Increase output verbosity

--output, -o      : Output MESHTAL file name [Default: mergemeshtals.out]

MESHTAL           : MESHTAL file names to be merged

AUTHOR: Clell J. (CJ) Solomon [csolomon@lanl.gov]
```

Note:

This is an alternative, not yet a replacement for, the Perl script that ships with MCNP. However, this binary can be compiled with MPI (requires C++ Boost Libraries), which speeds up merging.

mctal2rad Widget

```
USAGE: mctal2rad [--direct] [--help] [--log] [--transpose] <MCTAL>
       [TALLY [TALLY ... ]]

DESCRIPTION:

mctal2rad converts an image tally from an MCNP MCTAL file into a TIFF image

OPTIONS:

--direct, -d      : Produce an image of the direct contribution

--help, -h        : print usage infomation

--log, -l         : Produce an image of the log of the MCTAL values

--transpose, -t   : Transpose the image

MCTAL             : MCTAL file containing one or more image tallies

TALLY             : Tally number for which to produce the images

AUTHOR: Clell J. (CJ) Solomon [csolomon@lanl.gov]
```

NOTE:

This utility requires the TIFF libraries be installed.

`mctal` Overview

- The `Mctal` class stores information regarding `mctal` files
- Tally and Kcode data are stored in the `MctalTally` and `MctalKcode` classes, respectively
- Tally and Kcode data are only read into memory when requested via the `getTally` and `getKcode` methods of the `Mctal` class are called

`Mctal` Class Accessors

- general `Mctal` accessors
  - `GetCode()` – return the generating code name
  - `GetVersion()` – return the code version
  - `GetProbid()` – return the problem id number
  - `GetDump()` – return the corresponding runtpe dump number
  - `GetNps()` – return the number of histories
  - `GetRandoms()` – return the number of random numbers
  - `GetTallyList()` – return a list of the tally numbers
  - `SummaryString()` – return a summary string of the `mctal` file
- tally and kcode object accessors
  - `GetTally(NUM)` – return a `MctalTally` object for tally NUM
  - `GetKcode()` – return a `MctalKcode` object

MctalTally Class Accessors I

- general MctalTally accessors
  - ID() – return the tally id (number)
  - SummaryString() – return a summary string of the tally
- MctalTally bin accessors
  - GetFBins() – return the facet bins
  - GetDBins() – return the flagged/direct/collided bins
  - GetUBins() – return the user bins
  - GetSBins() – return the segment bins
  - GetMBins() – return the multiplier bins
  - GetCBins() – return the cosine bins
  - GetEBins() – return the energy bins
  - GetTBins() – return the time bins

MctalTally Class Accessors II

- MctalTally value accessors
  - GetValue(F,D,U,S,M,C,E,T,PERT=NUM) – return the tally value corresponding to the bin specified by the set of indices F, D, U, S, M, C, E, and T for perturbation NUM (defaults to unperturbed) [a negative value for any bin indicates use of the tally fluctuation chart index]
  - GetError(F,D,U,S,M,C,E,T,PERT=NUM) – return the tally **relative** error corresponding to the bin specified by the set of indices F, D, U, S, M, C, E, and T for perturbation NUM (defaults to unperturbed) [a negative value for any bin indicates use of the tally fluctuation chart index]

MctalKcode Class Accessors

- general `MctalKcode` accessors
  - `GetCycles()` – return the number of total kcode cycles
  - `GetSettle()` – return the number of inactive kcode cycles
  - `GetNdat()` – return the number of data elements in a kcode entry
  - `SummaryString()` – return a summary string for the kcode data
- `MctalKcode` data accessor

  GetValue(VAL,CYCLE) – return the kcode value VAL for cycle CYCLE (defaults are averaged combined k_{eff} and last cycle). VAL is an integer between 0 and the number of data elements (see the manual for details)

mctal Examples

1. read tally 4 out of mctal file “my_mctal”, extract the energy bin boundaries, store the tally values for each of the energy bins, and print the tally values for each of the energy bins
2. read the kcode data from mctal file “my_mctal” and print the k_{eff} value and error as a function of active cycle

mctal Example 1 – Python

```
from mcnptools import Mctal, MctalTally

# construct the mctal class from mctal file "my_mctal"
m = Mctal("my_mctal")

tfc = MctalTally.TFC; # alias for -1

# get tally 4 from the mctal file
t4 = m.GetTally(4);

# get the energy bins of tally 4
t4_e = t4.GetEBins();

# loop over energy bin indices to store and print tally bin value
# using the TFC bin for all other bins

# store the tally values with list comprehension
# f d u s m c e t
t4_evals = [ t4.GetValue(tfc,tfc,tfc,tfc,tfc,tfc,i,tfc) for i in range(len(t4_e)) ];

# print the tally values
for i in range(len(t4_evals)):
  print t4_evals[i];
```

mctal Example 2 – Python

```
from mcnptools import Mctal, MctalKcode

# construct the mctal class from the mctal file "my_mctal"
m = Mctal("my_mctal")

# get the kcode data
kc = m.GetKcode()

# alias for average combined keff
keff = MctalKcode.AVG_COMBINED_KEFF
# alias for average combined keff standard deviation
keff_std = MctalKcode.AVG_COMBINED_KEFF_STD

# loop over active cycles and print
for i in range(kc.GetSettle(),kc.GetCycles()):
  print i, "␣␣", kc.GetValue(keff,i), "␣␣", kc.GetValue(keff_std,i)
```

`meshtal` Overview

- The `Meshtal` class stores information about the mesh-tally type B data
- The `MeshtalTally` class stores information about a mesh tally
- The tally data is not read in until the `getTally` method of the `Meshtal` class is called

Meshtal Class Accessors

- general Meshtal accessors
  - `GetCode()` – return the generating code name
  - `GetVersion()` – return the code version
  - `GetProbid()` – return the problem id number
  - `GetComment()` – return the problem comment
  - `GetNps()` – return the number of histories
  - `SummaryString()` – return a summary string
  - `GetTallyList()` – return a list of tallies in the file
- tally object accessor
  - `GetTally(NUM)` – return a tally data object corresponding to tally NUM

MeshtalTally Class Accessors I

- general `MeshtalTally` accessors
  - `ID()` – return the tally id (number)
  - `GetXRBounds()` – return the x/r bin boundaries
  - `GetYZBounds()` – return the y/z bin boundaries
  - `GetZTBounds()` – return the z/theta bin boundaries
  - `GetEBounds()` – return the energy bin boundaries
  - `GetTBounds()` – return the time bin boundaries
  - `GetXRBins()` – return the x/r bin centers
  - `GetYZBins()` – return the y/z bin centers
  - `GetZTBins()` – return the z/theta bin centers
  - `GetEBins()` – return the energy bins
  - `GetTBins()` – return the time bins
  - `GetVolume(I,J,K)` – return the volume of specified element

`MeshtalTally` Class Accessors II

- `MeshtalTally` value accessors
  - `GetValue(I,J,K,E,T)` – return the tally value for (I,J,K)th element for energy bin E and time bin T. E and T default to the totals if left unspecified.
  - `GetError(I,J,K,E,T)` – return the tally **relative** error for the (I,J,K)th element for energy bin E and time bin T. E and T default to the totals if left unspecified.

`meshtal` Examples

1. read in a `meshtal` file, extract tally 4, and print the 2-D slice for the z index of 5

meshtal Example 1 – Python

```
from mcnptools import Meshtal, MeshtalTally
from sys import stdout

# construct the meshtal class from meshtal file "my_meshtal"
m = Meshtal("my_meshtal")

# get tally 4 from the meshtal file
t4 = m.GetTally(4)

# get the x and y bin centers
x = t4.GetXRBins()
y = t4.GetYZBins()

# loop over x and y bins indices and print the tally value for
# z index of 5
for i in range(len(x)):
  for j in range(len(y)):
    stdout.write("{:12.5e}".format(t4.GetValue(i,j,5)))
  stdout.write("\n")
```

Outline

Intrinsic Source Constructor
- Overview
- Using MISC to Generate Source Terms for MCNP
- ISC Library Usage

MCNPTools
- Overview
- Widgets
- MCNPTools Accessor Classes
  - Mctal Class
  - Meshtal (mesh-tally type B) Class
  - Ptrac Class
- Interactive MCNPTools Demo (time permitting)

`ptrac` Overview

- The `Ptrac` class manages data for MCNP's `ptrac` files and can handle BOTH text and binary versions (assumes binary as default)
- The `PtracHistory` class manages data for an individual history
- The `PtracNps` class handles the starting information for a history
- the `PtracEvent` class handles information for particle events

Ptrac Class Accessors

- ReadHistories(NUM) – reads NUM histories and all associated events into memory as a list; allows “chunk” processing of a file without filling memory

PtracHistory Class Accessors

- `GetNPS()` – return a `PtracNps` class to the history (NPS) information
- `GetNumEvents()` – return the number of events recorded for the history
- `GetEvent(NUM)` – return a `PtracEvent` class to the history's NUMth event

PtracNps Class Accessors

- `NPS()` – return the history number
- `Cell()` – return the filtering cell from `CELL` keyword (if present)
- `Surface()` – return the filtering surface from `SURFACE` keyword (if present)
- `Surface()` – return the filtering tally from `TALLY` keyword (if present)
- `Value()` – return the tally score from `TALLY` keyword (if present)

`PtracEvent` Class Accessors

- `Type()` – return the event type
- `Has(DATA)` – return true if the event has data type DATA
- `Get(DATA)` – return the value of the data type DATA

`ptrac` Examples

1. Open a `ptrac` file named “my_ptrac”, read in histories, and print the x, y, and z location and energy of all bank events (this is when particles are pulled from the bank)
2. Open at `ptrac` file named “my_ptrac”, read in histories, and, for all surface crossings, print the x, y, and z location and the angle (in degrees) of the crossing with respect to the surface normal

ptrac Example 1 – Python

```
from mcnptools import Ptrac
from sys import stdout

# explicitly open the file as a binary ptrac
p = Ptrac("my_ptrac", Ptrac.BIN_PTRAC)

# initialize counter
cnt = 0

# read histories in batches of 10000
hists = p.ReadHistories(10000)
while hists:

  # loop over all histories
  for h in hists:
    # loop over all events in the history
    for e in range(h.GetNumEvents()):

      event = h.GetEvent(e)

      if event.Type() == Ptrac.BNK:
        cnt += 1

        stdout.write("{:13d}{:13.5e}{:13.5e}{:13.5e}{:13.5e}\n".format( \
          cnt,
          event.Get(Ptrac.X), \
          event.Get(Ptrac.Y), \
          event.Get(Ptrac.Z), \
          event.Get(Ptrac.ENERGY) \
        ) )

  hists = p.ReadHistories(10000)
```

ptrac Example 2 – Python

```
from mcnptools import Ptrac
from sys import stdout

# explicitly open the file as a binary ptrac
p = Ptrac("my_ptrac", Ptrac.BIN_PTRAC)

# read histories in batches of 10000
hists = p.ReadHistories(10000)

while hists:

  # loop over all histories
  for h in hists:
    # loop over all events in the history
    for e in range(h.GetNumEvents()):

      event = h.GetEvent(e)

      if event.Type() == Ptrac.SUR:
        stdout.write("{:13.5e}{:13.5e}{:13.5e}{:13.5e}\n".format( \
          event.Get(Ptrac.X), \
          event.Get(Ptrac.Y), \
          event.Get(Ptrac.Z), \
          event.Get(Ptrac.ANGLE) \
        ) )

  hists = p.ReadHistories(10000)
```

Interactive MCNPTools Demo