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| *Title:* | A Tutorial on Merging Tallies from Separate MCNP5 Runs |
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# A Tutorial on Merging Tallies From Separate MCNP5 Runs

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**Monte Carlo Codes**
**X-3-MCC, LANL**

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# Abstract

## A Tutorial on Merging Tallies from Separate MCNP5 Runs

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**The MCNP5 Monte Carlo code will save the results from a particle transport calculation in several files: The output file (outp) contains many details of the calculation, including a description of the problem, summary tables of problem execution, and results from the problem tallies. Ordinary tallies (F1, F2, F4, F5, F6, F7, F8) are also saved separately in a text file called "mctal", while mesh tallies (FMESHn) are saved separately in a text file called "meshtal".**

**If an MCNP5 calculation is run several times, using a different random number seed for each run, then several copies of the "mctal" and "meshtal" file are created. The tally results in these separate files are statistically independent and could be combined to produce overall averages and relative errors.**

**Two utility programs are available to combine independent tally files:**

- **merge_mctal can be used to merge the mctal files from independent runs**
- **merge_meshtal can be used to merge the meshtal files from independent runs**

**This tutorial provides information on using the merge_mctal & merge_meshtal utilities.**

# MCNP Tallies



- **Ordinary tallies**
  - F1, F2, F4, F5, F6, F7, F8
  - These tallies are printed in the output file
  - If the 3rd entry on the PRDMP card is >0,
    then the results of these tallies are written to the MCTAL file
  - Note: If there is no PRDMP card in the input or if the 3rd entry is 0,
    then an MCTAL file is not created
  - The MCTAL file format is given in the MCNP5 Manual, Vol II, Appendix B, pp. B-24 - B-27

- **Mesh tallies**
  - FMESHn
  - These tallies are written to the MESHTAL file
  - Many different formats are available, depending on the choice of GEOM= and OUT= entries on the FMESHn card.
  - See FMESHn, MCNP5 Manual, Vol II, pp. 3-114 - 3-116

# Merging Ordinary Tallies



- **merge_mctal**
  - A utility program that will merge 2 or more MCTAL files
  - Usage:

    **merge_mctal [-o mctalmrg] mctal1 mctal2 [...]**

    mctalmrg = optional name of final merged MCTAL file (output), default = MCTALMRG

    mctal1 = name of first MCTAL file to merge

    mctal2 = name of second MCTAL file to merge

    ... = names of other MCTAL files to merge
  - Example

    merge_mctal mctal mctam mctan

    Combines 3 files (mctal, mctam, mctan) into one merged file (MCTALMRG)

# Merging Mesh Tallies

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- **merge_meshtal**
  - A utility program that will merge 2 or more MESHTAL files
  - Usage:

**merge_meshtal -i meshtal1 meshtal2 [...] -o meshtalout**

meshtal1 = name of first MESHTAL file to merge
meshtal2 = name of second MESHTAL file to merge
[…] = names of additional MESHTAL files to merge
meshtalout = name of final merged MESHTAL file (output),
default= MESHTALMRG

(If the input files have different formats, then the format of the first input file will be used for the merged output)

  - Example

merge_meshtal -i meshtal meshtam meshtan -o prob1_meshtal

Combines 3 files (meshtal, meshtam, meshtan) into one merged file (prob1_meshtal)

# Some Details on Merging Tally Files



- merge_mctal & merge_meshtal both produce the correct combined tallies (mean result & relative error), within the precision used in writing the MCTAL & MESHTAL files.

- Be very careful & keep track of what files get merged -- there is no way to prevent merging a file twice (which is not what you want to do!)

- Information concerning Tally Fluctuation Charts (TFC data) cannot be preserved when combining tallies. Instead, the TFC data from the first MCTAL file is simply copied to the output file.

- The following pages provide details on how the mean results and relative errors are obtained when combining separate files

# Standard MCNP tallies



**Define:** $x_k =$ **the quantity tallied for the k-th history**

$N =$ **number of histories**

**Then, MCNP computes the mean from**

$$\bar{x} = \frac{1}{N} \cdot \sum_{k=1}^{N} x_k$$

**The population variance is then**

$$\sigma_x^2 = \frac{1}{N} \cdot \sum_{k=1}^{N} x_k^2 - \bar{x}^2$$

**(MCNP divides by N, rather than N-1)**

**The variance of the mean ($\bar{x}$) is:**

$$\sigma_{\bar{x}}^2 = \frac{\sigma_x^2}{N} = \frac{1}{N} \cdot \left[ \frac{1}{N} \cdot \sum_{k=1}^{N} x_k^2 - \bar{x}^2 \right]$$

**The Relative Error in $\bar{x}$ is:**

$$RE_{\bar{x}} = \frac{\sigma_{\bar{x}}}{\bar{x}}$$

# Combining Tallies from Independent Runs



- **Must have**
  - identical geometry, cross-sections, code options, etc.
  - different random number seeds
  - (perhaps) different numbers of histories
  - no duplication/overlap of histories

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| | **Run #1 produces:** | $N_1,\ \bar{x}_1,\ RE_{\bar{x}1}$ |
| | **Run #2 produces:** | $N_2,\ \bar{x}_2,\ RE_{\bar{x}2}$ |
| **Problem:** | **Produce combined** | $N,\ \bar{x},\ RE_{\bar{x}}$ |

# Combined Mean



**Define**

$$N = N_1 + N_2$$

$$S_1 = N_1 \cdot \bar{x}_1 = \sum_{k=1}^{N_1} x_{1,k} \qquad S_2 = N_2 \cdot \bar{x}_2 = \sum_{k=1}^{N_2} x_{2,k}$$

**Then**

$$\bar{x} = \frac{1}{N} \cdot \left[ \sum_{k=1}^{N_1} x_{1,k} + \sum_{k=1}^{N_2} x_{2,k} \right] = \frac{1}{N} \cdot \left[ S_1 + S_2 \right] = \frac{N_1 \cdot \bar{x}_1 + N_2 \cdot \bar{x}_2}{N_1 + N_2}$$

# Combined Relative Error



**Define** $N = N_1 + N_2$, $S_1$, $S_2$ **as before, and**

$$T_1 = \sum_{k=1}^{N_1} x_{1,k}^2 \qquad T_2 = \sum_{k=1}^{N_2} x_{2,k}^2$$

**Note that**

$$\sigma_{\bar{x}_1}^2 = \bar{x}_1^2 \cdot RE_{\bar{x}1}^2 = \frac{1}{N_1} \cdot \left[ \frac{1}{N_1} \cdot \sum_{k=1}^{N_1} x_{1,k}^2 - \bar{x}_1^2 \right] = \frac{1}{N_1} \cdot \left[ \frac{T_1}{N_1} - \bar{x}_1^2 \right]$$

**so that**

$$T_1 = N_1 \cdot \left( N_1 \cdot \bar{x}_1^2 \cdot RE_{\bar{x}1}^2 + \bar{x}_1^2 \right) = N_1 \cdot \bar{x}_1^2 \cdot \left( N_1 \cdot RE_{\bar{x}1}^2 + 1 \right)$$

$$T_2 = N_2 \cdot \left( N_2 \cdot \bar{x}_2^2 \cdot RE_{\bar{x}2}^2 + \bar{x}_2^2 \right) = N_2 \cdot \bar{x}_2^2 \cdot \left( N_2 \cdot RE_{\bar{x}2}^2 + 1 \right)$$

**Then**

$$\sigma_{\bar{x}}^2 = \frac{1}{N} \cdot \left[ \frac{1}{N} \cdot \left( \sum_{k=1}^{N_1} x_{1,k}^2 + \sum_{k=1}^{N_2} x_k^{(2)} \right) - \bar{x}^2 \right] = \frac{1}{N} \cdot \left[ \frac{T_1 + T_2}{N} - \bar{x}^2 \right]$$

$$RE_{\bar{x}} = \frac{\sigma_{\bar{x}}}{\bar{x}}$$