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MCNPX GRAPHICS AND ARITHMETIC TALLY UPGRADES

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ABSTRACT

MCNPX tallies and cross-sections are plotted using the MCPLOT package. We report on an assortment of upgrades to MCPLOT that are intended to improve the appearance of two-dimensional tally and cross-section plots. We have also expanded the content and versatility of the MCPLOT "help" command. Finally, we describe the initial phase of capability implementation to post-process tally data using arithmetic operations. These improvements will enable users to better display and manipulate simulation results.

Key Words: MCNPX, MCPLOT, graphics, arithmetic, tally.

1. INTRODUCTION

Los Alamos National Laboratory (LANL) develops and maintains the MCNPX^{TM}[1] Monte Carlo N-Particle eXtended general-purpose radiation transport code. MCNPX accommodates intricate three-dimensional geometrical models, continuous-energy transport of 34 different particle types plus heavy-ion transport[2], fuel burnup[3], and high-fidelity delayed-gamma emission[4]. MCNPX is written in Fortran 90, has been parallelized, and works on platforms including single-processor personal computers (PCs), Sun workstations, Linux clusters, and supercomputers. MCNPX has approximately 2000 users throughout the world working on endeavors that include radiation therapy, reactor design, and homeland security.

Visualization of model geometry and of calculated results ("tallies") is an important component of the simulation process, particularly when complex models involving multi-particle transport are being analyzed. MCNPX contains the interactive "PLOT" package to plot model geometry. Since its creation three decades ago, the "MCPLOT" package has been used to make two-dimensional (2-D) plots of tally information (i.e., calculated fluxes, currents, etc.) and of nuclear cross-section data. We have made many upgrades to improve appearance of plots produced using MCPLOT. In addition, we have added content from the MCNPX manual to MCPLOT's "help" command so as to alleviate the need to refer to the manual.

At times, the ability to post-process tallies using arithmetic operations is desired by analysts. For example, a user might wish to study the difference between tallies for a pair of simulations that were conducted using models that differed only in source particle type. Until now this study

could not be done using MCNPX. We report here on a new capability that is being developed to enable the post-processing of tallies using arithmetic operations.

2. MCPLOT 2-D-PLOT GRAPHICS UPGRADES

Figures 1 and 2 contain pre- and post-upgrade plots of the same tally data. The MCPLOT graphics improvements include (1) log-axis numbering that is reasonably dense, (2) differentiated major and minor tick lengths on log axes, (3) use of "e" format for exponents, (4) horizontal display of ordinate numbers (to decrease crowding), (5) the use of upper-case fonts for labels where appropriate, (6) maximum legend curve-identifier length increased from ten to 23 characters, (7) maximum title length increased from 40 to 70 characters, (8) maximum number of log-axes decades increased from 17 to 34, and (9) improved clarity in legend block.

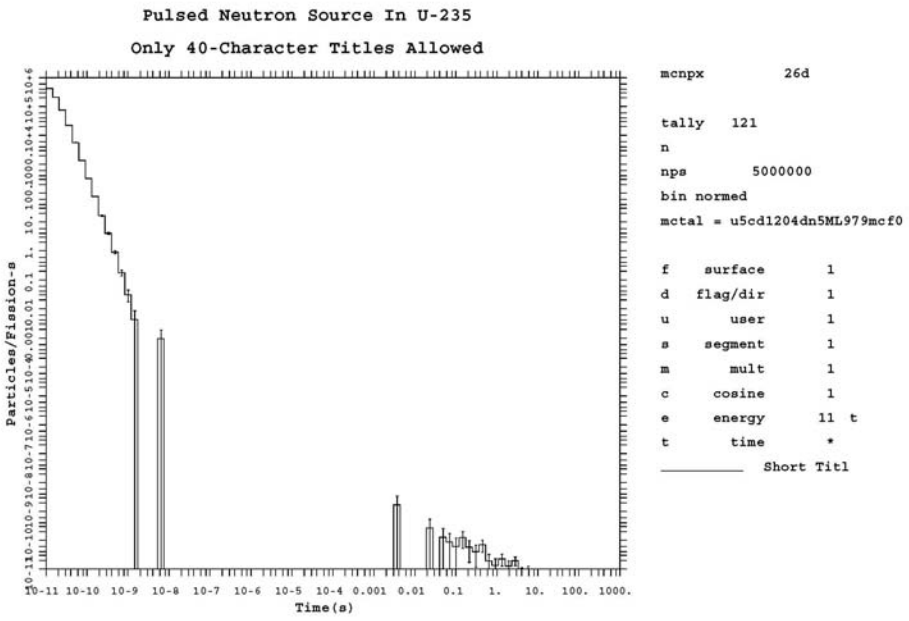

Figure 1. Legacy MCPLOT 2-D tally plot. PDF image.

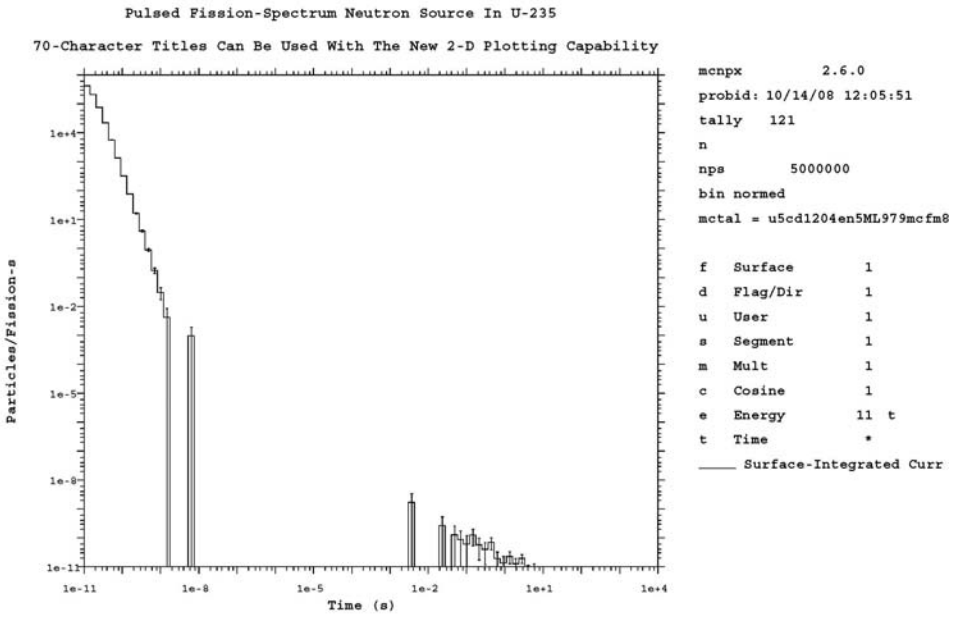

Figure 2. Improved MCPLOT 2-D tally plot. PDF image.

3. MCPLOT "HELP" COMMAND UPGRADES

The legacy MCNPX MCPLOT "help" command capability was exceedingly limited—it only provided a three-column un-alphabetized list of commands. The "help" command has been improved in two ways. First, the basic "help" command now produces an alphabetized command listing. Second, syntax and content is now provided for individual commands. Figure 3 illustrates the revamped "help" command output for the "coplot" command.

```
mcplot>
help coplot
  coplot  > Syntax: coplot
            Plot multiple curves on one plot. COPLOT is
            effective for 2-D plots only. If COPLOT is
            the last command on a line, it functions as
            if it were followed by an &.
 mcplot>
```

Figure 3. New MCPLOT "help" command capability illustrating content for the "coplot" command, including invocation syntax and purpose.

4. POST-PROCESSING ARITHMETIC OPERATIONS FOR TALLIES

Previous versions of MCNPX did not allow post-processing of tally data using arithmetic operations. We have begun development of post-processing capability to enable addition, subtraction, multiplication, and division operations for tally data produced by one or more MCNPX calculations.

To illustrate, the following command sequence calculates and plots the difference between the surface-integrated currents for simulations involving point sources of 20-MeV photons and neutrons positioned at the center of a 100-cm radius sphere of water.

```
rmctal=pcpp4m          ←Read photon tally mctal file
tal 0 = tal 1          ←Create a saved arithmetic tally (photons)
rmctal=pcpp6m          ←Read neutron tally mctal file
tal 10 = tal 1         ←Create another saved arithmetic tally (neutrons)
tal 20 = tal 10 - tal 0 ←Save the difference
tal 0 label "tal 0: 20-MeV photons " cop
tal 10 label "tal 10: 20-MeV neutrons" cop
tal 20 label "dif=photons-neutrons"      ←Plot the tallies
```

Figure 4 contains the tallies for the respective calculations as well as their difference.

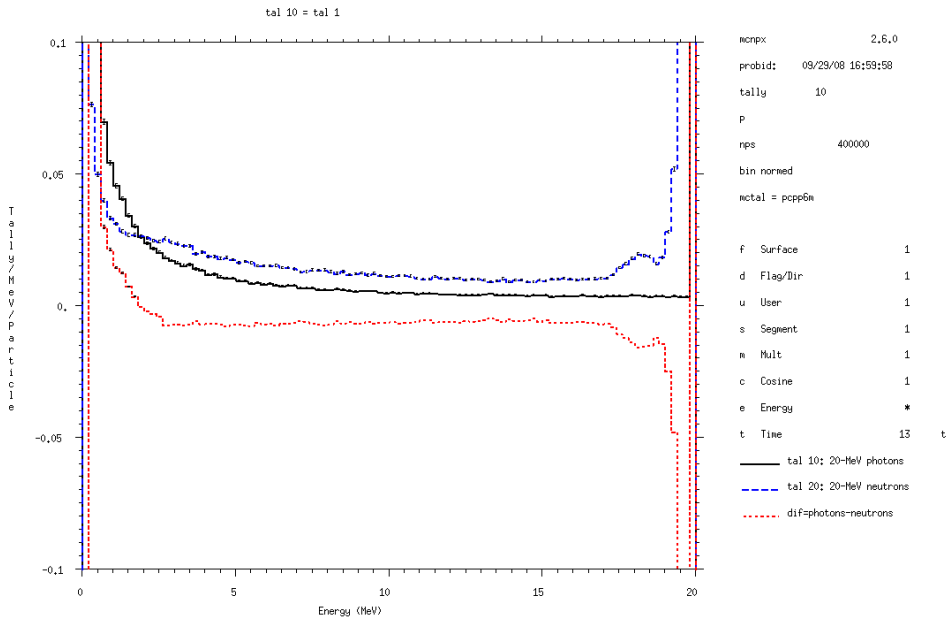

Figure 4. New MCPLOT arithmetic-tally capability. tal 0 and tal 10 are the saved arithmetic tallies for the photon and neutron sources, respectively, while "dif" is their difference.

5. CONCLUSIONS

The MCNPX MCPLOT graphics package has been upgraded to provide enhanced quality for 2-D tally and cross-section plots. The MCPLOT "help" command has been extended to (1) provide an alphabetized list of commands and (2) include syntax and content for each MCPLOT command.

A new MCNPX feature is being developed that provides the capability to post-process tally data using arithmetic operations ("arithmetic tallies"). The initial upgrades include addition, subtraction, multiplication, and division operations on tally data generated for one or more MCNPX calculations. The user has the choice of creating and plotting arithmetic tallies with or without saving them for further use.

The MCPLOT graphics and "help" upgrades appear in MCNPX versions 27a and 27b, while the capability to post-process tallies using arithmetic operations will appear subsequently once development and alpha testing has matured.

REFERENCES

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