Disclaimer:
Los Alamos National Laboratory, an affirmative action/equal opportunity employer, is operated by Triad National Security, LLC for the National Nuclear Security Administration of U.S. Department of Energy under contract 89233218CNA000001. By approving this article, the publisher recognizes that the U.S. Government retains nonexclusive, royalty-free license to publish or reproduce the published form of this contribution, or to allow others to do so, for U.S. Government purposes. Los Alamos National Laboratory requests that the publisher identify this article as work performed under the auspices of the U.S. Department of Energy. Los Alamos National Laboratory strongly supports academic freedom and a researcher's right to publish; as an institution, however, the Laboratory does not endorse the viewpoint of a publication or guarantee its technical correctness.
Parallelism in MCNP® 6.2

Jeffery Bull
XCP-3 (Monte Carlo Codes)

Roundtable on MCNP Parallelism Performance
2021 MCNP® User Symposium

July 16, 2021
MCNP uses two methods to run in parallel

Message Passing Interface (MPI)

- Manager
  - Sends workers a set of histories to run
  - Collects results
- Worker A
  - Performs particle transport
  - Returns results
- Worker B
  - Interchange data via messages

Shared memory multiprocessing (OpenMP)

- Master Thread
  - Holds shared data
  - Only copy of fixed data: (geometry, cross sections)
- Thread 1
  - Performs particle transport
  - Only executes the transport subroutine and dependences.
- Thread 2
  - Interchange data via shared memory
Trade Offs

• **MPI**
  - Pros
    - Easier to implement
    - Can be use with (almost) all features of MCNP6
    - Only way to run on multi-node clusters.
  - Cons
    - Implementation on Linux and MacOS systems require user to compile MCNP

• **OpenMP**
  - Pros
    - Included in the distributed executables.
    - Limited to a subset of MCNP6 capabilities
  - Cons
    - Difficult to implement
      - Some sections in the parallel region must be run serially – requires thread locks
      - Insure individual threads don’t overwrite critical data
    - Limited to a subset of MCNP6 capabilities
    - Speedup depends on computer architecture (NUMA memory)
Hand off to Avery
OpenMP Performance Of The Test Problem

Snow cluster
• 128 GB per node
• 2 sockets/node
• 18 CPUs/socket
• No hyperthreading
• Non-uniform memory access (NUMA)

Compare results for 9 and 36 threads.
Fraction Of Time Thread Is Waiting For Work

9 threads: 55% CPU time spent in spin/overhead state

36 threads: 90% CPU time spent in spin/overhead state