Sharing of Good Industry Practices and/or Lessons Learned in Nuclear Criticality Safety

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A Review of Best Practices for Monte Carlo NCS Calculations

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NUCLEAR ENGINEERING

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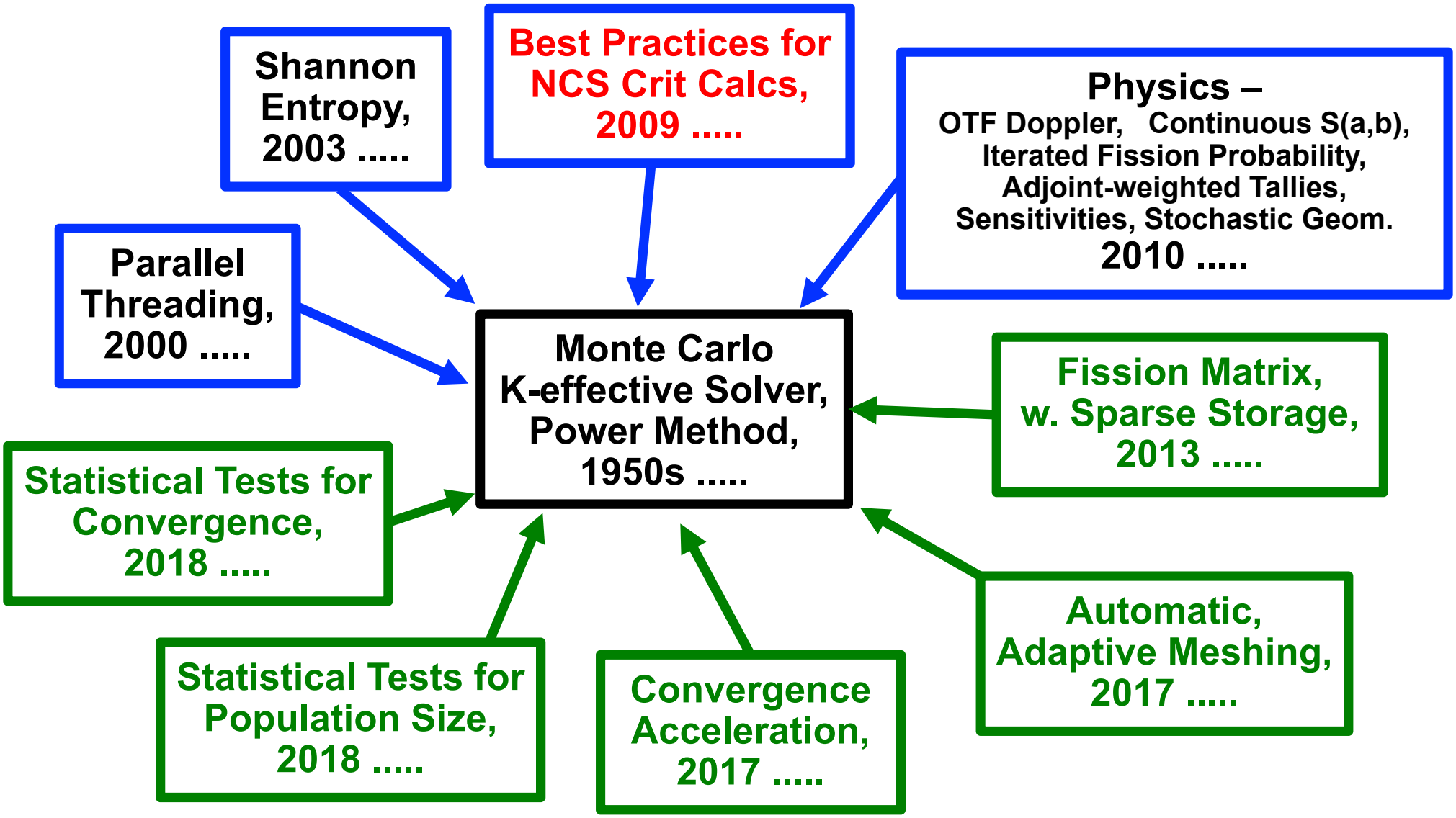
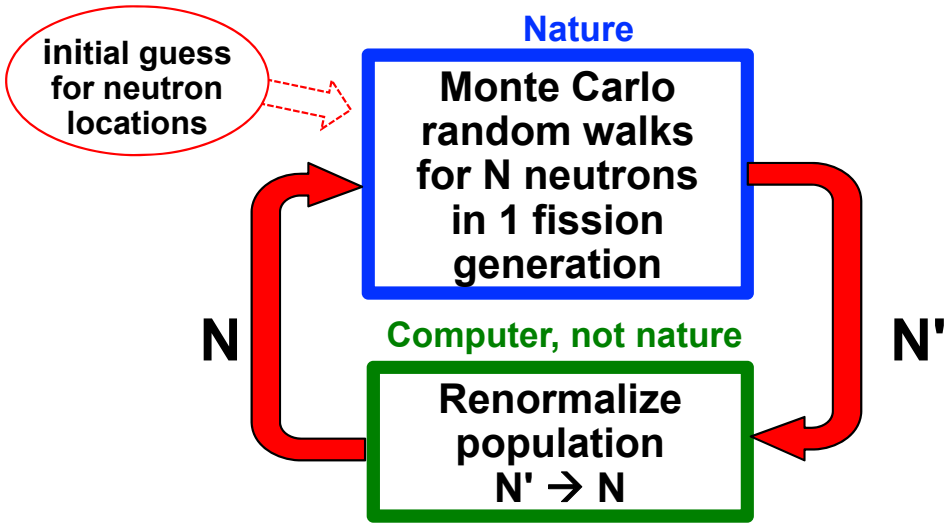
LANL R&D for MC Criticality Calculations

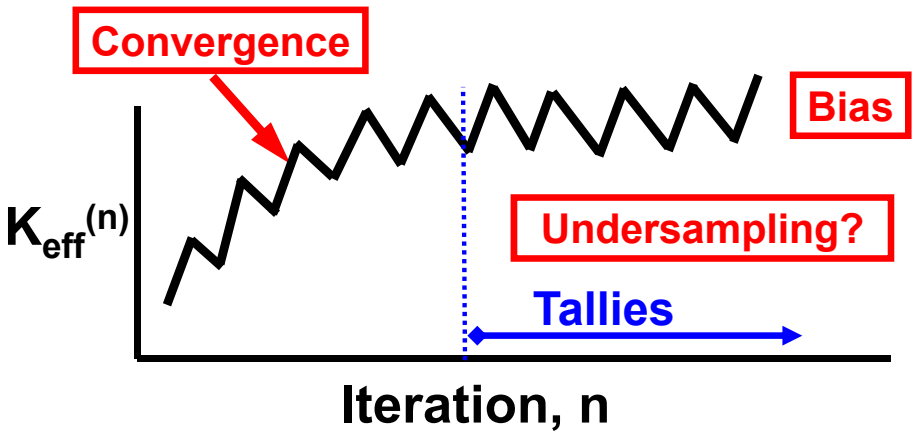


Green boxes – NCSP TPR 2019, ICNC 2019, & ANS 2019 Winter

MC Criticality Calculations - Concerns



Renormalization introduces bias



- **Bias in Keff**
  - ~ -1 / (neutrons/cycle)
  - – nonconservative
- **Bias in source shape**
  - Too low in high-importance regions,
  - Too high in low-importance regions
- **Undersampling/clustering**
  - Not enough neutrons/cycle to cover space
- **Convergence**
  - source shape takes longer than keff
- **Loosely-coupled problems**
  - weak interactions, may miss things
- **Best Practices**
  - Source in all fissile regions.
  - Examine H_{src} plot for convergence.
  - >10k neuts/cycle (>100k big probs).
  - A few 100 active cycles.

MC NCS Calculations - Workflow

- **Set up problem, particular attention to fission source guess**
  - for discrete pieces of fissile material:
    Put KSRC points in each fissile region
  - if lattice, reactor, storage vault, solution tanks:
    Use SDEF to sample source guess uniformly in volume of system

- **Make a trial run**
  - A few 1000 neuts/cycle, 50-100 cycles

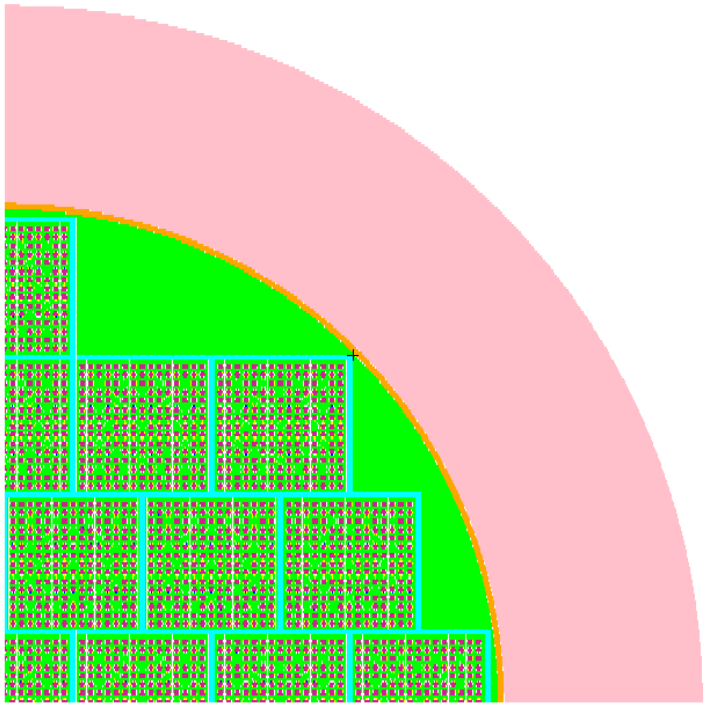
- **Examine Keff & Shannon entropy plots vs cycle**
  - determine cycle where K_{eff} & H_{src} Shannon entropy have BOTH reached asymptotic behavior
  - Parameter studies - make a few trial runs, set conservative discard cycles

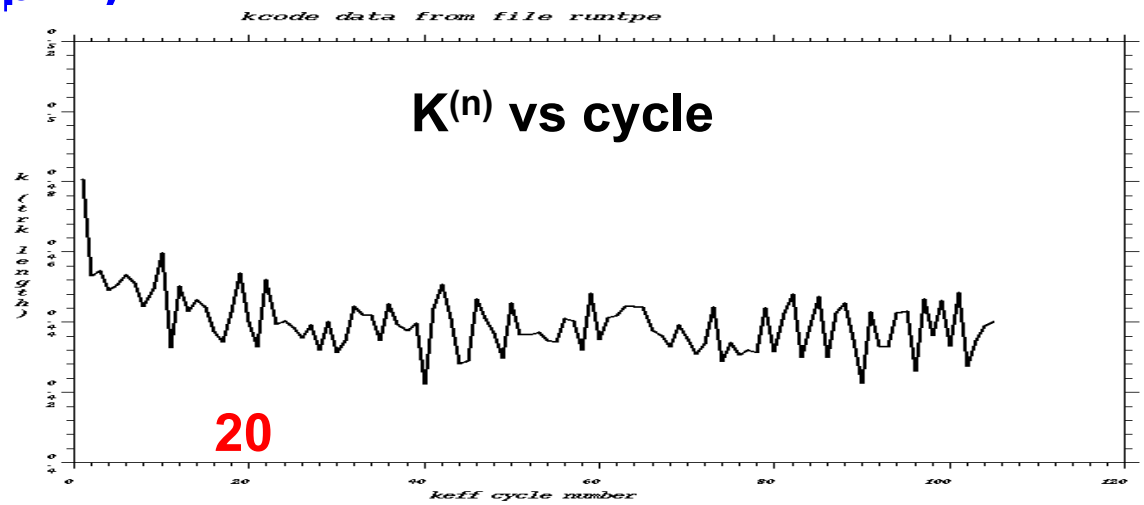
- **Fix parameters on KCODE card**
  - Ordinary problems - 10,000 neuts/cycle or more
  - Reactors, storage vaults, loosely-coupled – 100k neuts/cycle or more
  - set number of cycles to discard (from previous step)
  - set 100 or more active cycles

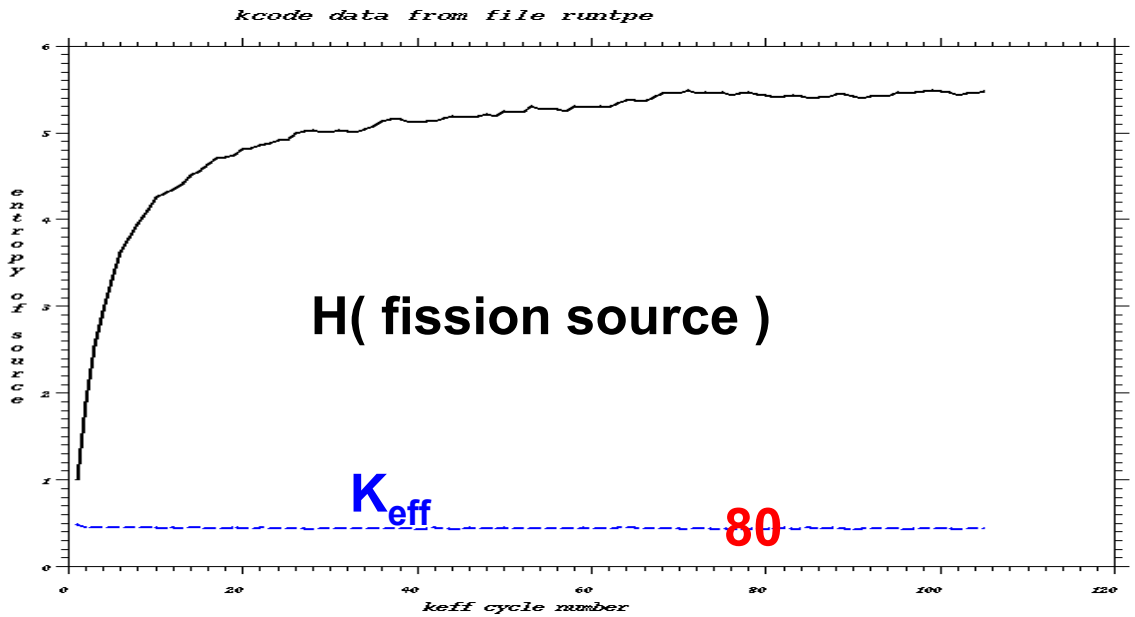
- **Make final run for results (make "continue" runs if σ_{keff} too large)**

Criticality Calculations - Convergence

- **Reactor core (Problem inp24)**







DR = .98

References

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- F.B. Brown, "Advanced Computational Methods for Monte Carlo Calculations, LANL report LA-UR-18-20247 (2018)
- F.B. Brown, “Investigation of Clustering in MCNP6 Monte Carlo Criticality Calculations”, Int. Conf. on Transport Theory, Monterey CA, Oct 2017, LA-UR-17-29261 (2017).

- F.B. Brown, “A Review of Best Practices for Monte Carlo Criticality Calculations”, ANS NCSD 2009, Hanford WA, LA-UR-09-03136 (2009).