

Quick Look: Variance Reduction at Scale

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Background & Interests

Education, Work, and Research

- Gonzaga Univ., Spokane WA
 - Physics & Math-Computer Science
- Consultant for GroGuru Inc.
 - Established an async. RS-485 serial communication protocol variant for two indep. µCs via near field magnetic induction antennae
- GSRP 2018 Summer Intern
 - Designed a cosmic ray muon detector advancing upon the MIT Cosmic Watch project
 - Capable of particle energy approx. and air-shower coincidence detection
 - AJP publication in review
- Electrical Impedance Tomography
 - Cont. Fall 2019; Numerical Methods for PDE approx. for medical imaging technologies

My History and Interests



Background & Overview of Research

Variance Reduction for Implicit Monte Carlo (IMC)

- IMC is stochastic – there is inherent uncertainty in the solution
- Variance reduction methods are implemented to improve simulation efficiency while producing equivalent unbiased results

Response Functions and Research Objective

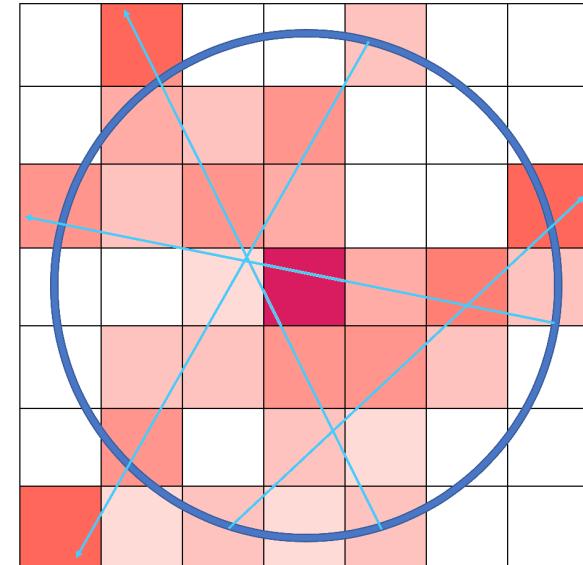
- A response function VRM is designed to reduce variance by increasing the number of particles that contribute to solution tallies
- Explore use in modeling astrophysical events such as multi-dimensional supernova transients

Method

1. Run the backwards approx. to calculate response opacities

$$\text{Contribution} = E_{\text{particle}} * e^{-(\sigma_r + \frac{1}{c\Delta t})d_{\text{tally}}}$$

2. Run the forward simulation using the response opacity to contribute to the tally at particle birth and every scattering event

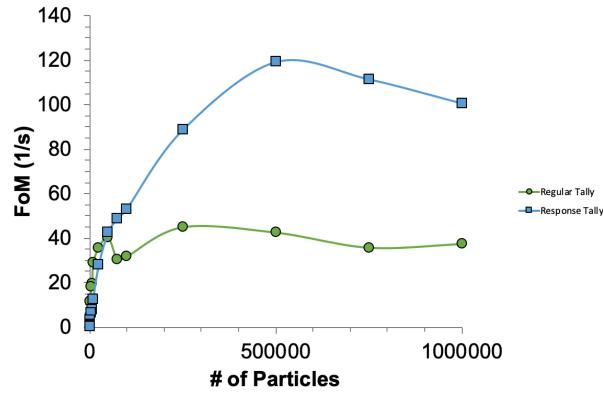


The Backwards Approx:

Particles are traced from the tally (blue) towards the source (purple). As they pass through the mesh, a 'response value' is calculated from a weighted average based on the distance traveled and opacity from all cells it has passed through

Results & Conclusions

Figure of Merit of Regular and Response Methods



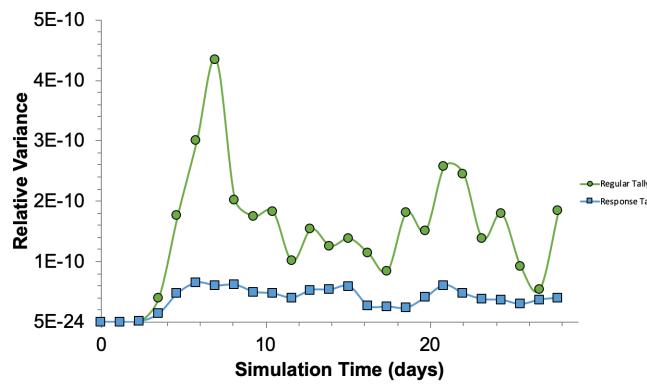
Left Top:

Figure of Merit of the response function against a standard method. This shows that >50k particles, our method has far lower variance.

Left Bottom:

Rel. variance vs time of a supernova simulation. This also demonstrates our method results in a smaller variance.

Variance of 'Cubanova' Simulation Flux Calculation



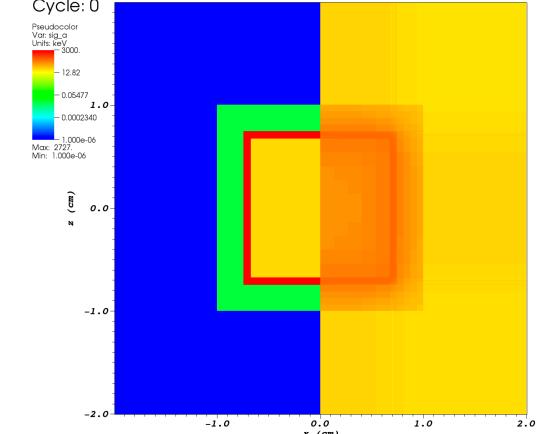
Right Top:

Side by side of the true opacity vs the response value/opacity.

Right Bottom:

The electron temperature of the supernova at the end of simulation. Overheated regions likely result from small corner cells.

DB: output_1.silo



DB: output_242.silo

