Research Overview for Prospective Students

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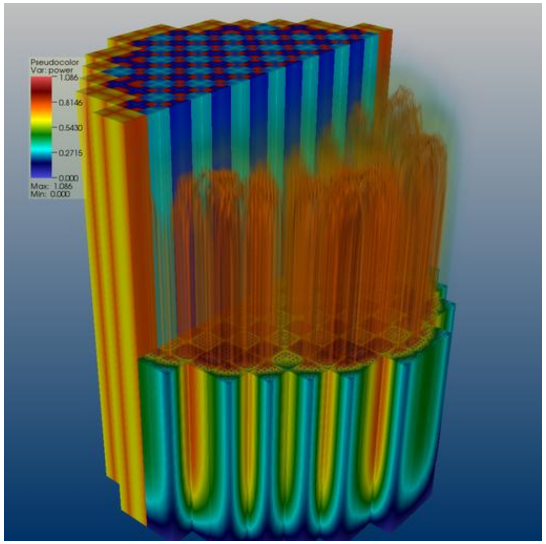
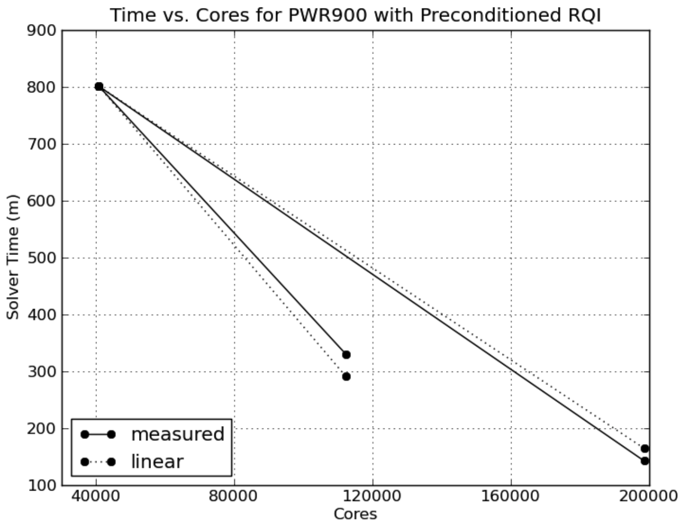
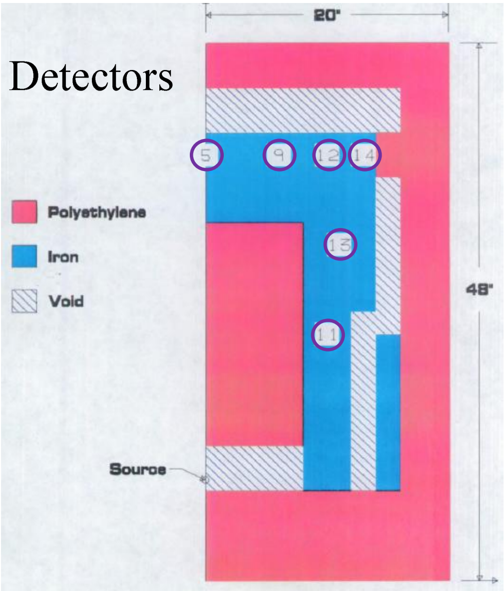
What exactly do you do?

$$[\hat{\Omega} \cdot \nabla + \Sigma(\vec{r}, E)]\psi(\vec{r}, \hat{\Omega}, E) =$$
$$\int dE' \int d\hat{\Omega}' \, \Sigma_s(\vec{r}, E' \to E, \hat{\Omega}' \cdot \hat{\Omega})\psi(\vec{r}, \hat{\Omega}', E')$$
$$+ \frac{\chi(E)}{k} \int dE' \, \nu\Sigma_f(\vec{r}, E') \int d\hat{\Omega}' \, \psi(\vec{r}, \hat{\Omega}', E')$$







How do you do it?

- Deterministic methods require discretization of phase space
  - discretize more finely to improve solution quality
  - use advanced solvers to converge solution more quickly
- Monte Carlo (MC) treats phase space continuously
  - accuracy depends on number of particles simulated
  - often requires variance reduction (VR)
- Hybrid methods: create MC VR parameters using deterministic solutions

Algorithms + Architecture

Applied Math Informed by Physics

Example: use adjoint relationship:

$$\int\int q^{+}(r,E)\phi(r,E)\,dr\,dE = \int\int q(r,E)\phi^{+}(r,E)\,dr\,dE$$

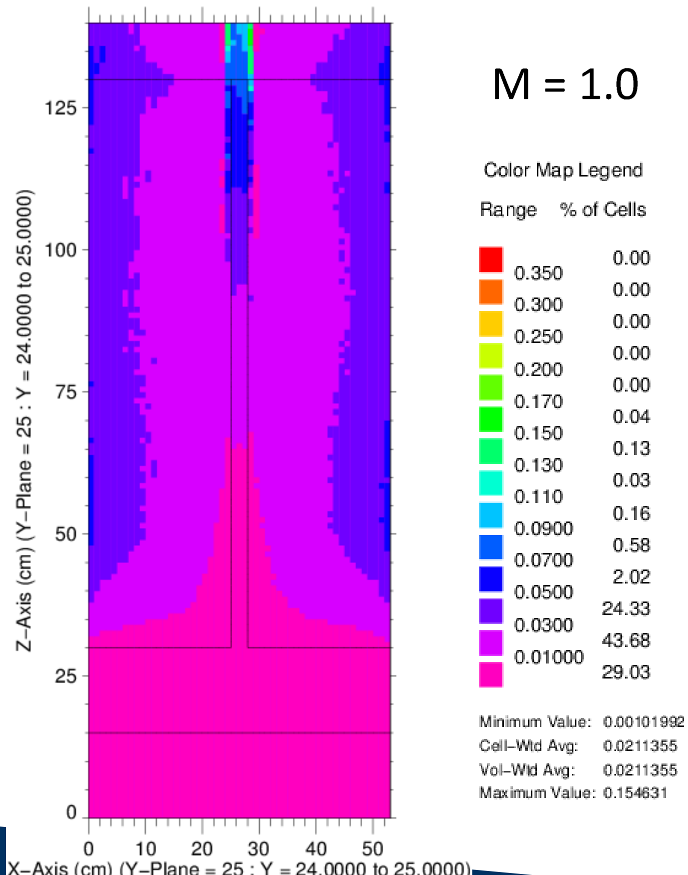
$$\boxed{q^{+}(r,E) = f(r,E)}$$

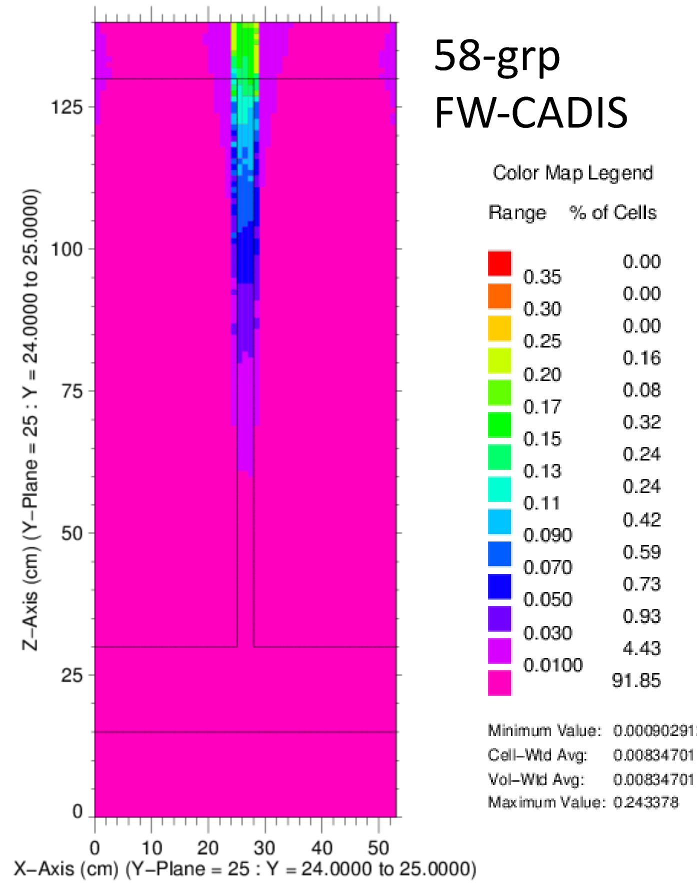
$$R = \int_{E}\int_{V_f} f(r,E)\phi(r,E)\,dr\,dE \longrightarrow R = \int_{E}\int_{V_S} q(r,E)\phi^{+}(r,E)\,dr\,dE$$

Create an importance map augmented by info about physics:

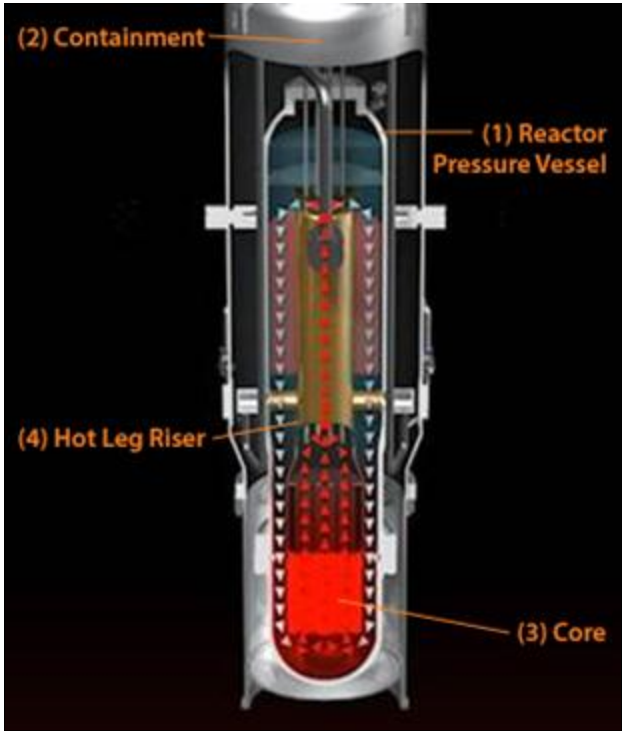
$$q^{\dagger}(\boldsymbol{r},E) = \left(\frac{\phi_{res(\sigma_0)}(\boldsymbol{r},E)}{\phi_{dilute(\sigma_0)}(\boldsymbol{r},E)}\right)^{M} q^{\dagger}_{FWC}, \qquad imp(\boldsymbol{r},E) = \frac{\phi^{\dagger}_{ResFact}(\boldsymbol{r},E)}{R(\boldsymbol{r},E)}$$

Driven By Application





Example Projects



$$\mathbf{L}\psi = \mathbf{MS}\phi + Q$$
$$\phi = \mathbf{D}\psi$$