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# Advanced Techniques for Monte Carlo simulations:

## Ex-core responses supporting safety analysis

(1) ENEA (2) IRSN

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# Monte Carlo Simulations supporting Safety Analyses

Complex nuclear systems:

Modelling irradiation field, related responses

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Modelling Multiplicative Systems to get "far" targets
(ex-core detectors, fuel storage sites…)

Relevant for safety-security issues

## Monte Carlo: Simulation Strategies

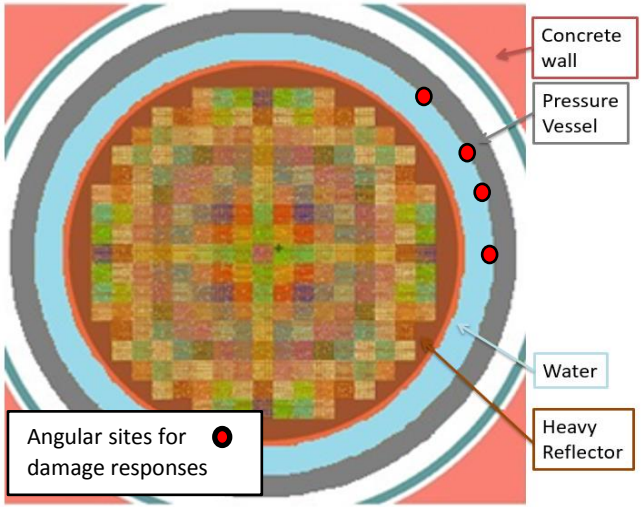
| Determine system parameters | Determine detector response |
| --- | --- |
| sampling "according to nature" | biasing / forcing natural sampling |

Standard Approach to Multiplicative Systems

Analog simulation gets neutron field Source is fission reaction rate

Non-analog simulation gets "distant" responses Variance Reduction Techniques

# Standard vs. Proposed Approach: Decoupled vs. Single




Model of the core: MCNP(5-1.4 & 6.1)

Reactor system: Gen-III/III$^+$ core

Objective: dpa damage to vessel

Responses of interest:

- Neutron flux (E > 1 MeV)
- Neutron flux (E > 100 keV)
- (Neutron dpa response function)
- Gamma flux (E > 700 keV)

Evaluated at: core mid-plane, 4 angular positions

## Standard Approach

| | | |
|---|---|---|
| 1 | Source Created | Fission tallies in pin-by-pin pattern (axial bins) |
| 2 | Source Utilized | DPA/Flux responses requested (e.g. DSA) |

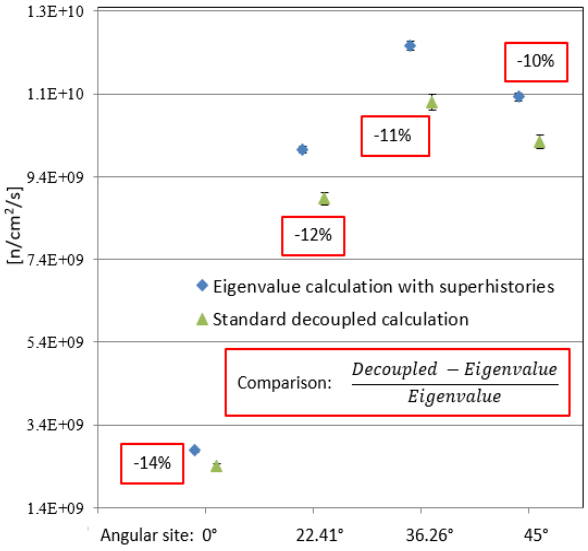
## Proposed Approach

| | | |
|---|---|---|
| 1 | No Need for Source | Eigenvalue and tallies evaluated in same problem (DSA) |

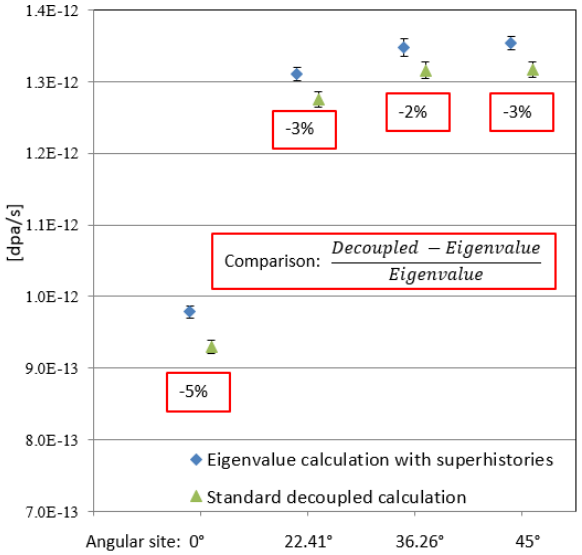
Variance Reduction Technique: DSA with multi-response capability

# Standard vs. Proposed Approach: Decoupled vs. Single

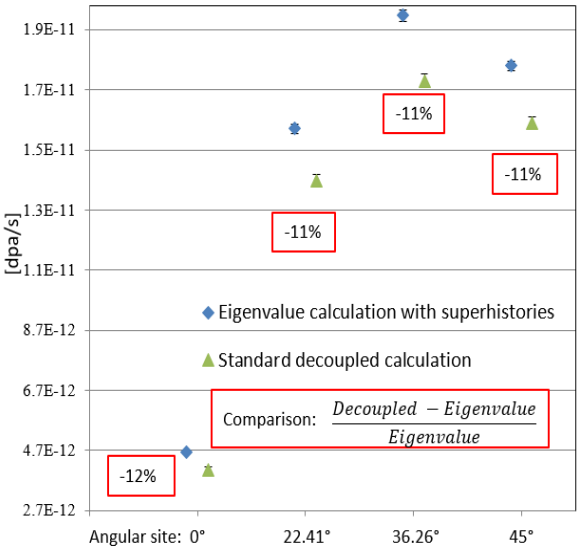
Reactor system: Gen-III core  Objective: n/g dpa damage to vessel




Neutron flux (E>1 MeV)




Gamma DPA




Neutron DPA

## Conclusions and Perspectives

- Aim of the study: approximations introduced in decoupling process
- Interesting underestimation for single eigenvalue simulation
- Impact of fixed source spectrum for decoupled methodology
- Variance Reduction: Direct Statistical Approach (DSA) also for k-simulations

Thanks for your attention