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Title: Semi-Analytic Benchmarks for MCNP6

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Semi - Analytic Benchmarks for MCNP6

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LANL

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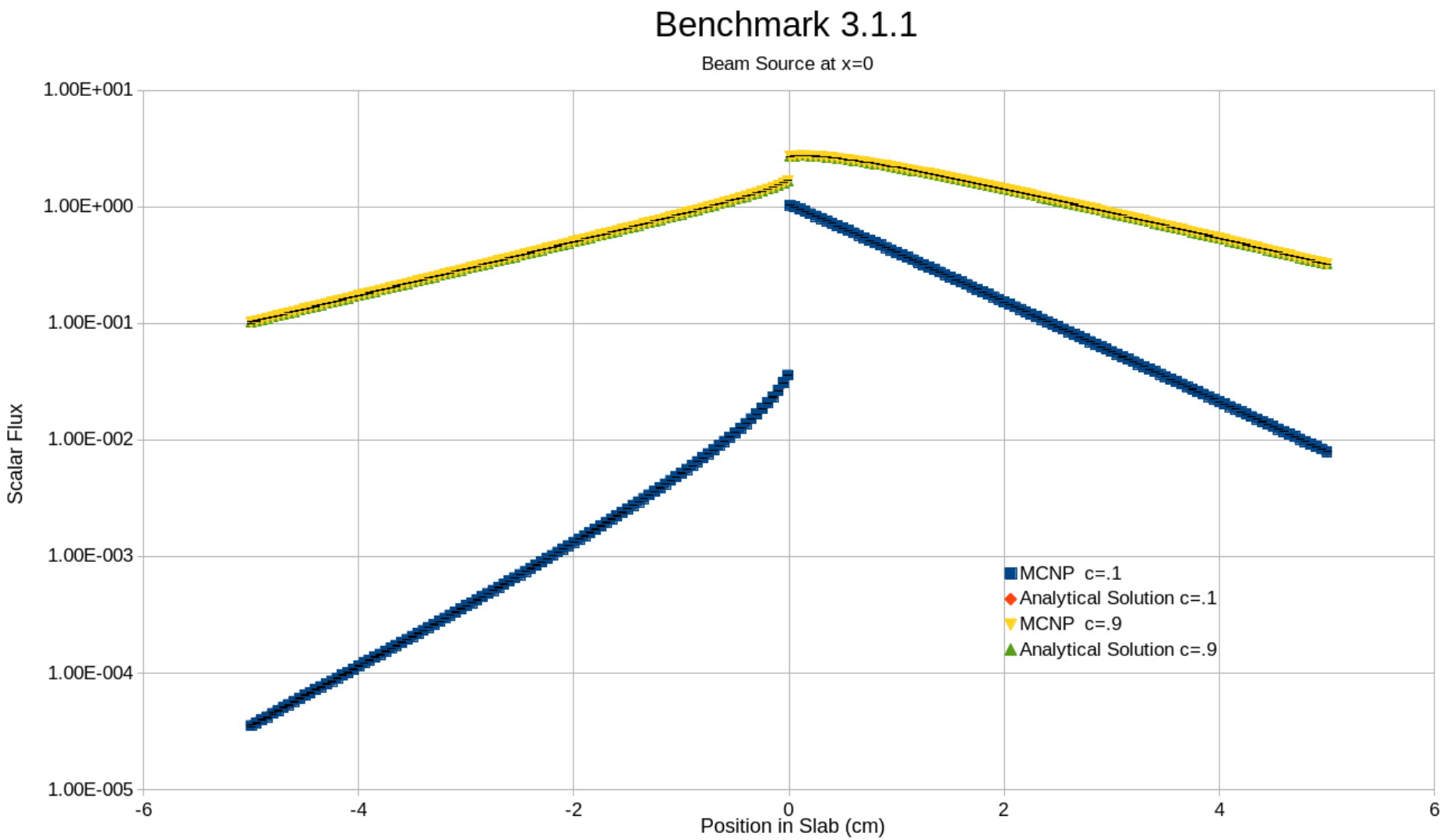
Introduction

- Created an automated fixed source benchmark suite for code verification in MCNP6 (18 individual problems).
- Benchmarks come from Barry Ganapol's book, *Analytical Benchmarks for Nuclear Engineering Applications.*
- Compared analytical results with MCNP6 using Python.

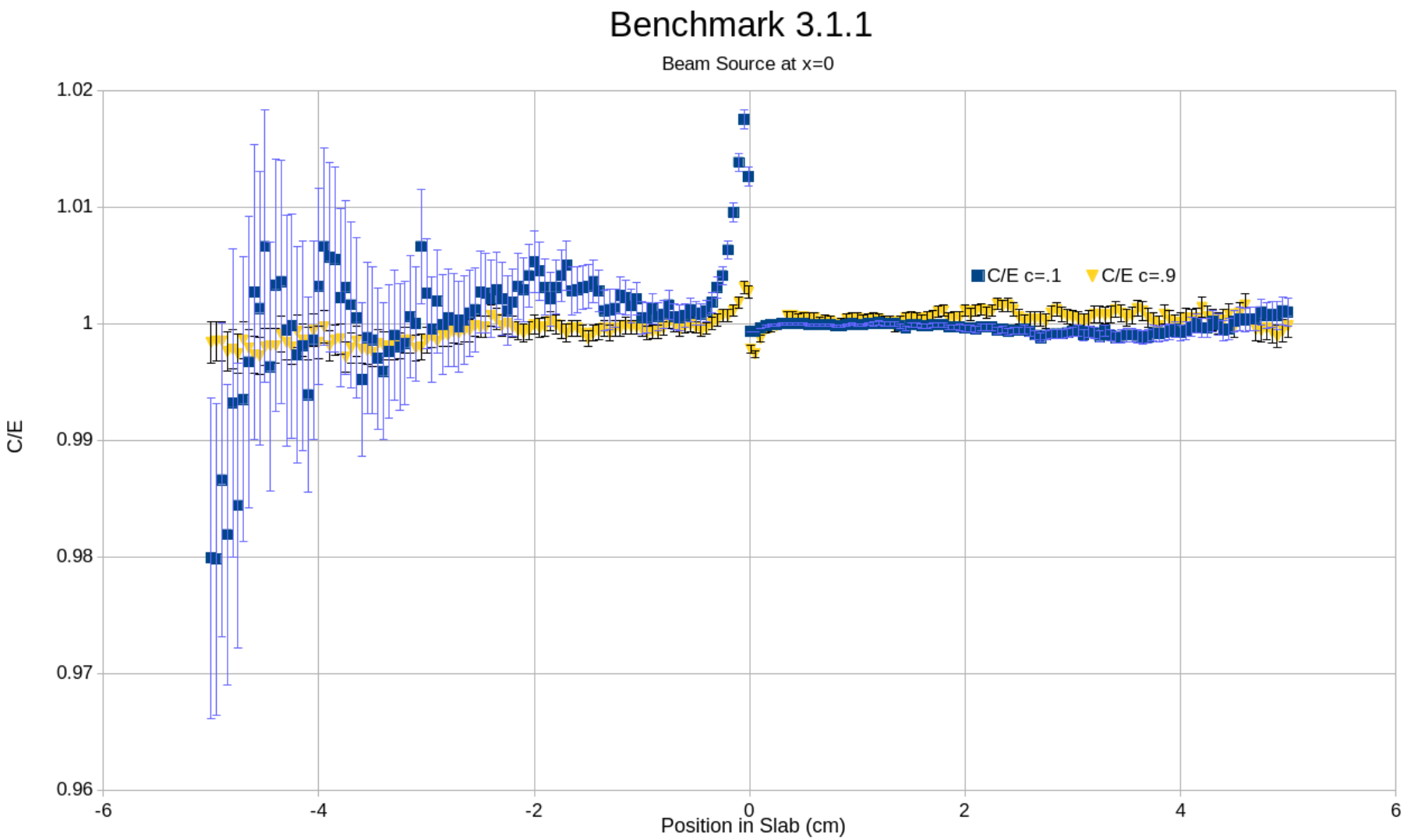
Benchmark	Geometry	Source	Varied
3.1	Infinite Medium	Beam/Isotropic	Source/Beam Angle
3.2	Half Space	Beam/Isotropic	Source
3.3	Finite Slab	Beam	Slab Thickness
3.4*	Infinite Cylinder	Volume Source	Radius

*Fixed Source & Criticallity Problems

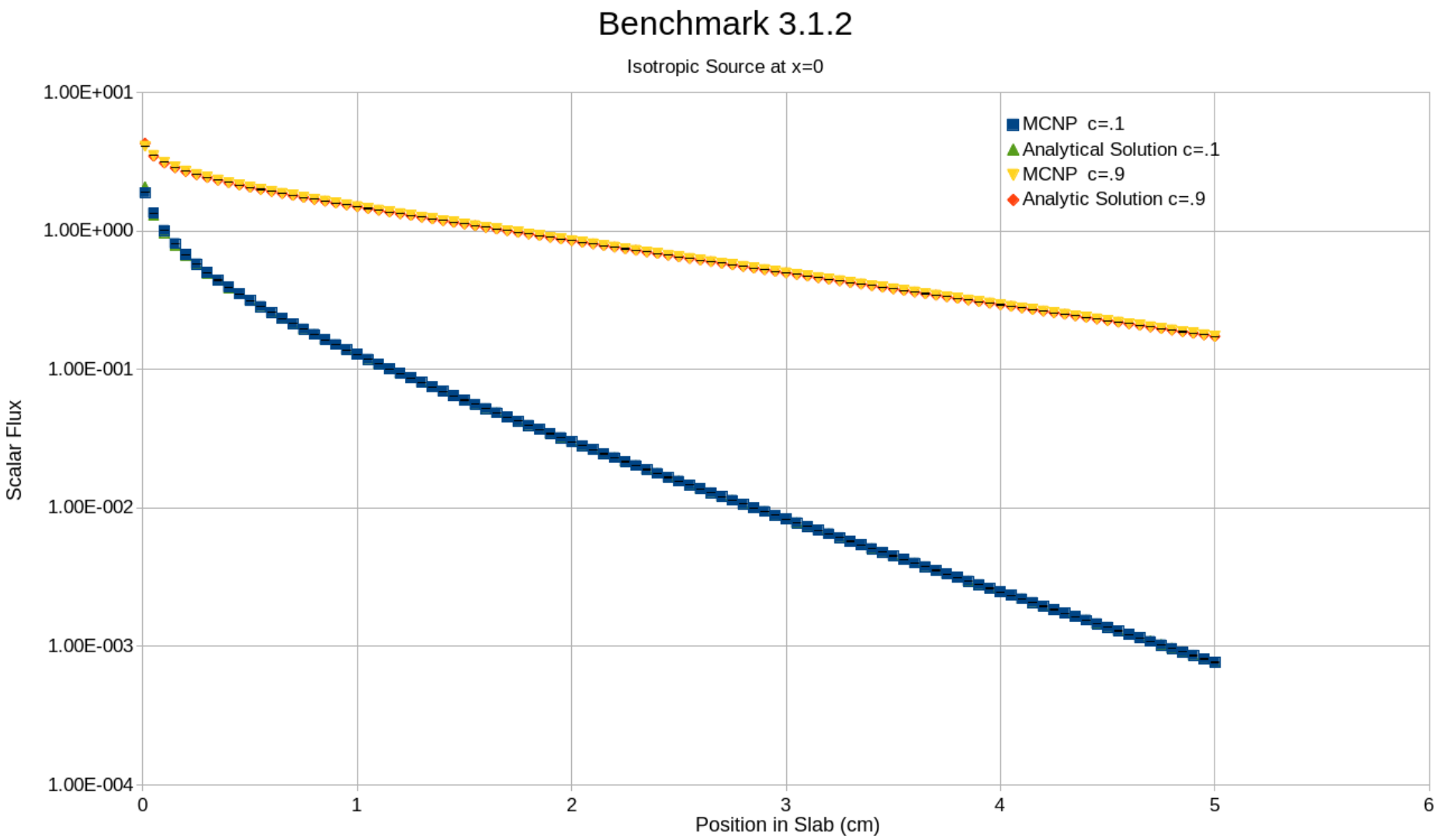
3.1 Beam Source in Infinite Medium



3.1 Beam Source in Infinite Medium



3.1 Isotropic Source in Infinite Medium



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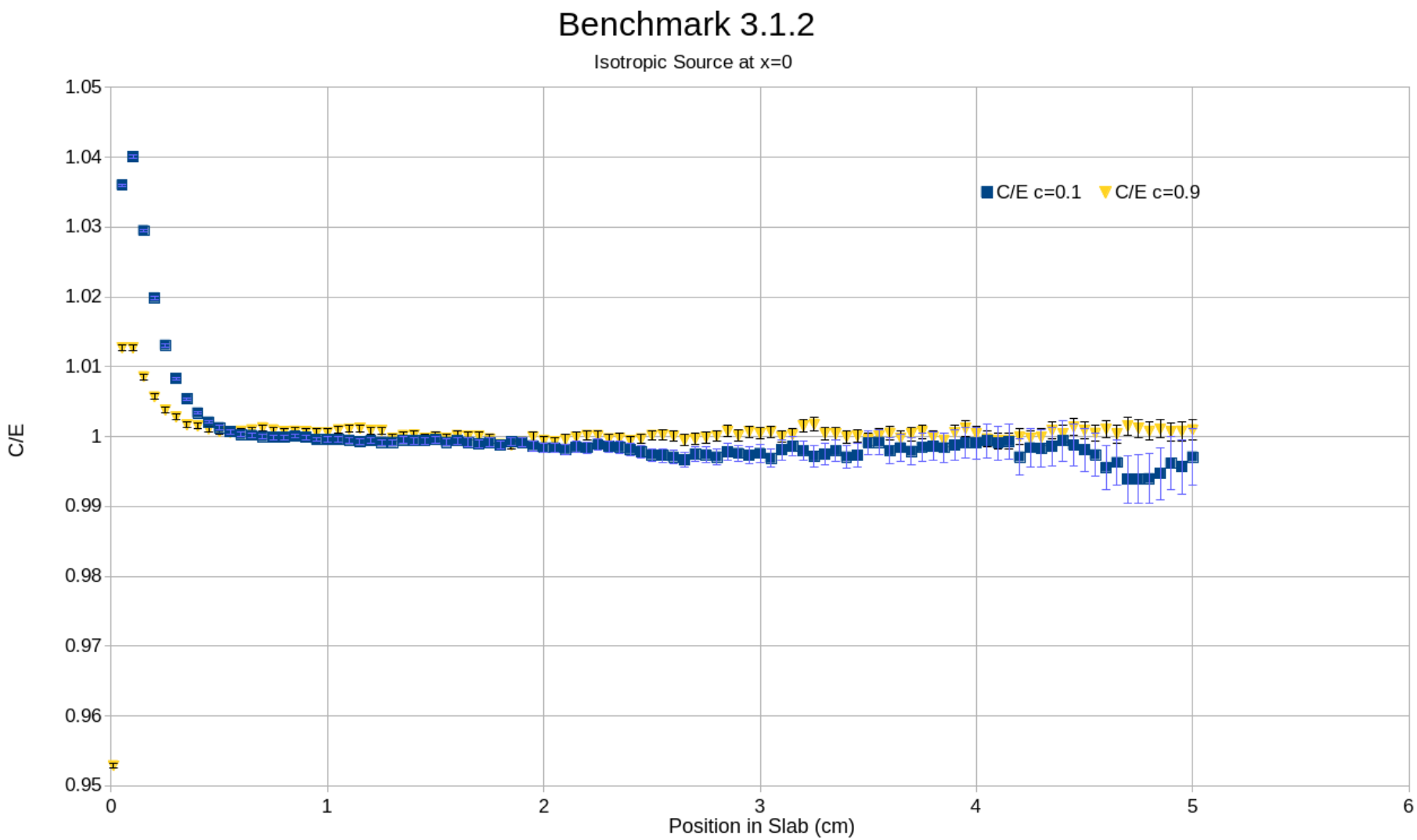
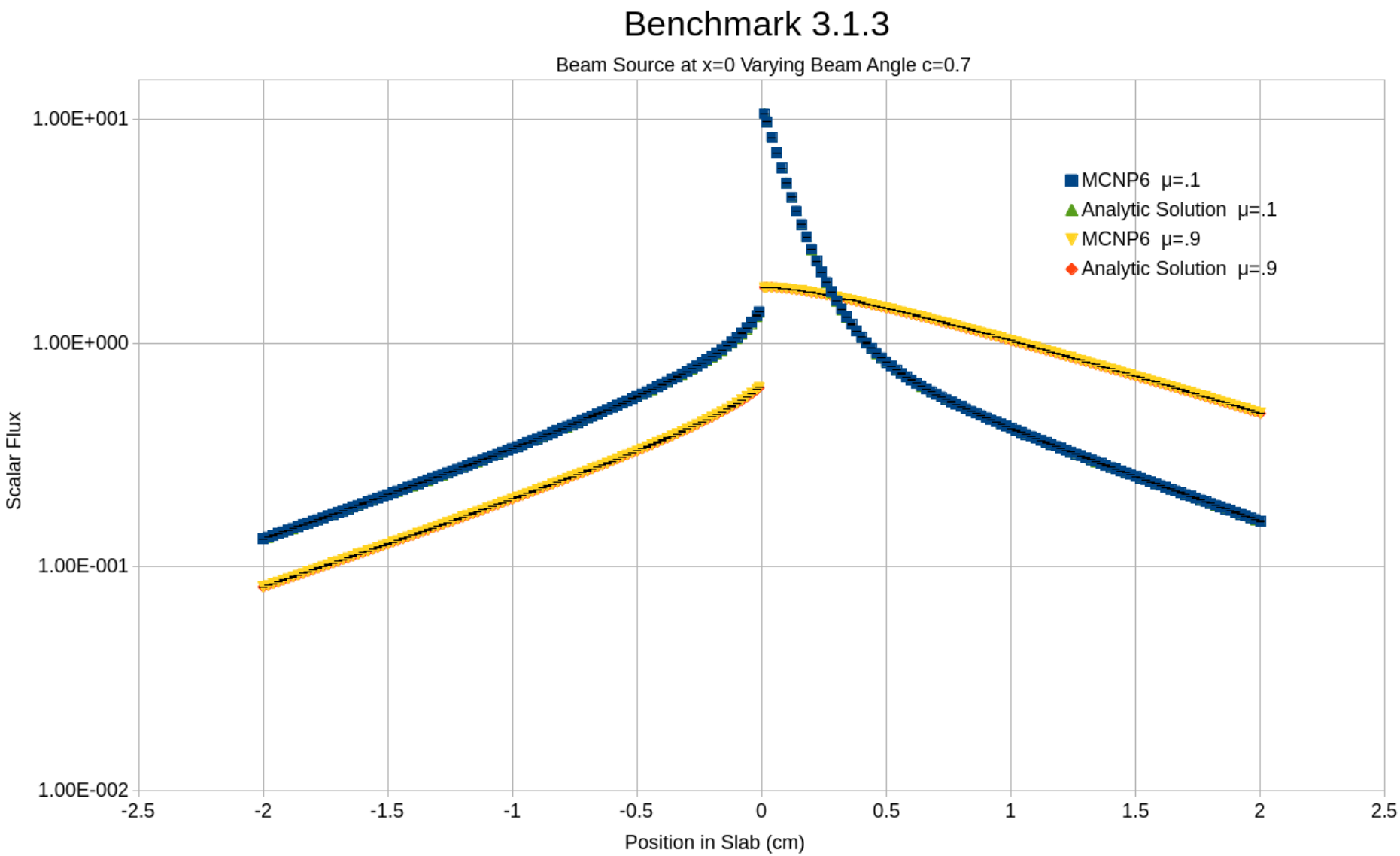


3.1 Varying Beam Angle in Infinite Medium



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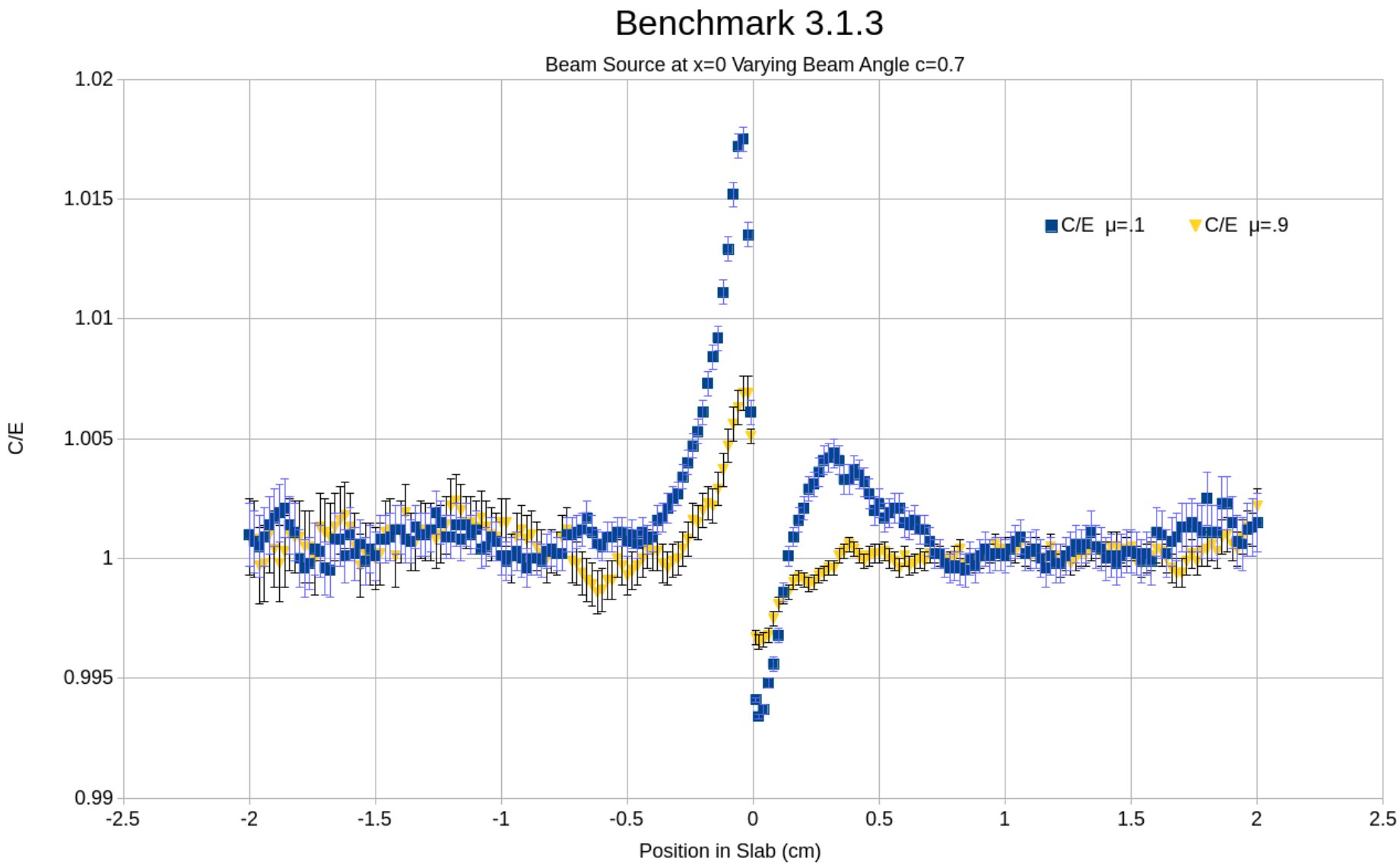
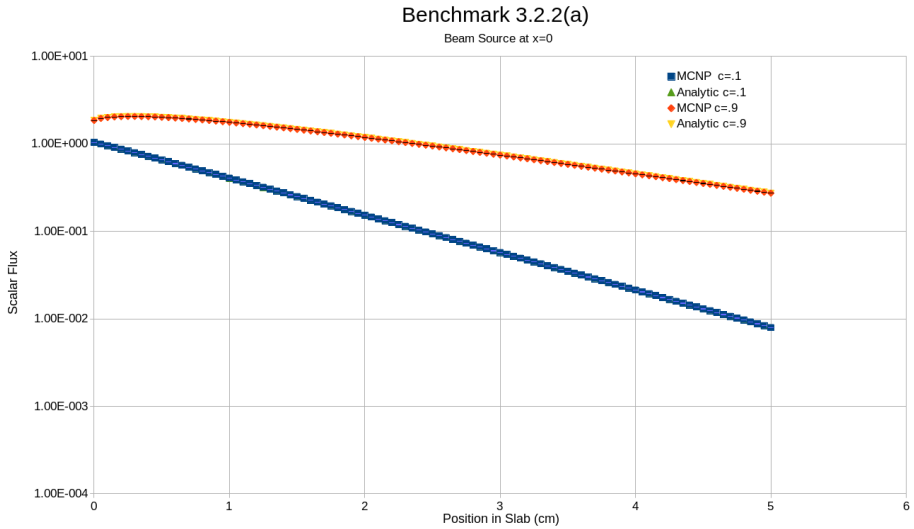
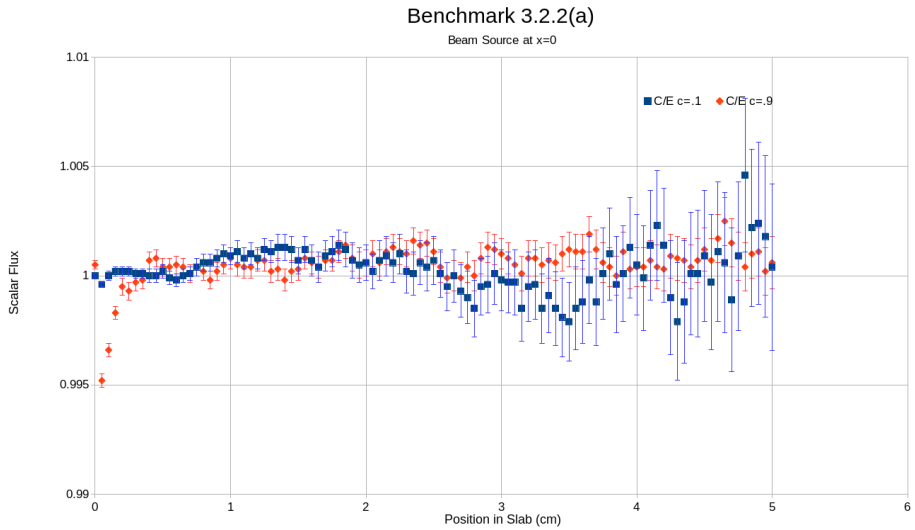


3.2 Beam in Half Space

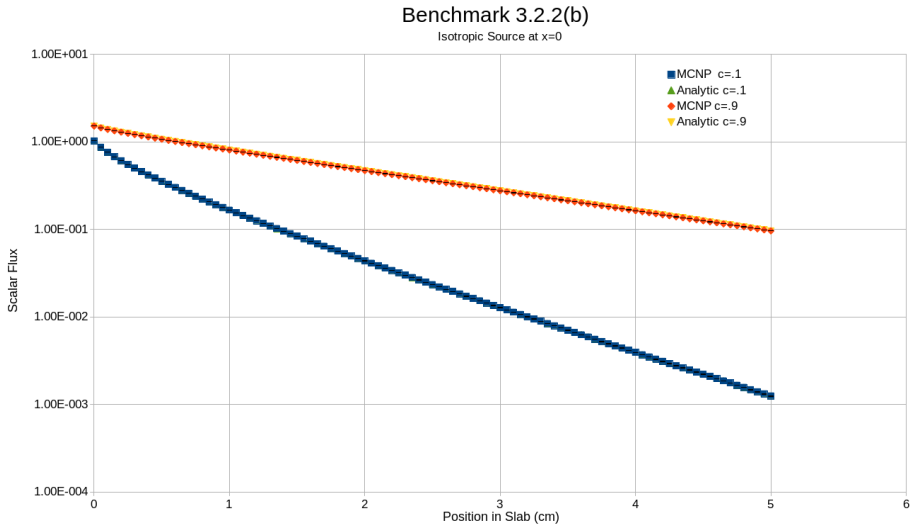


Flux Shapes



MCNP6 Divided by Analytic Solution

3.2 Isotropic Source in Half Space



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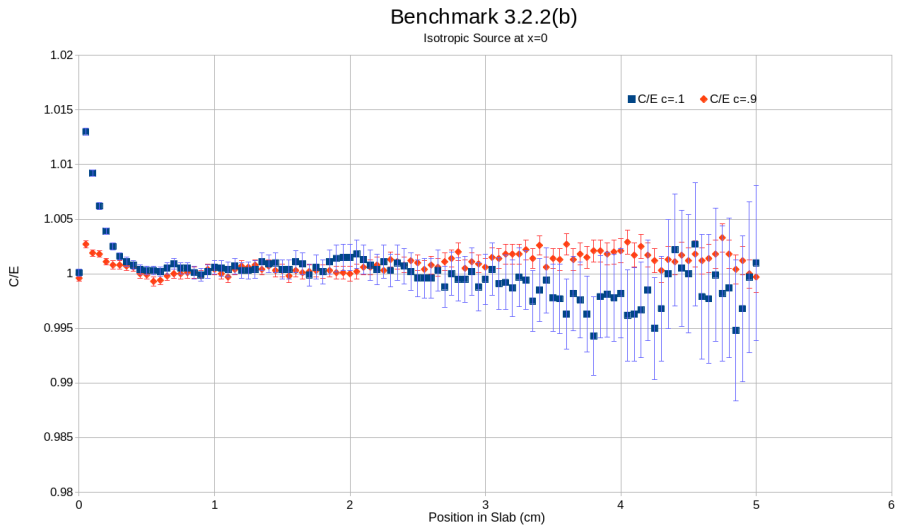


MCNP6 Divided by Analytic Solution

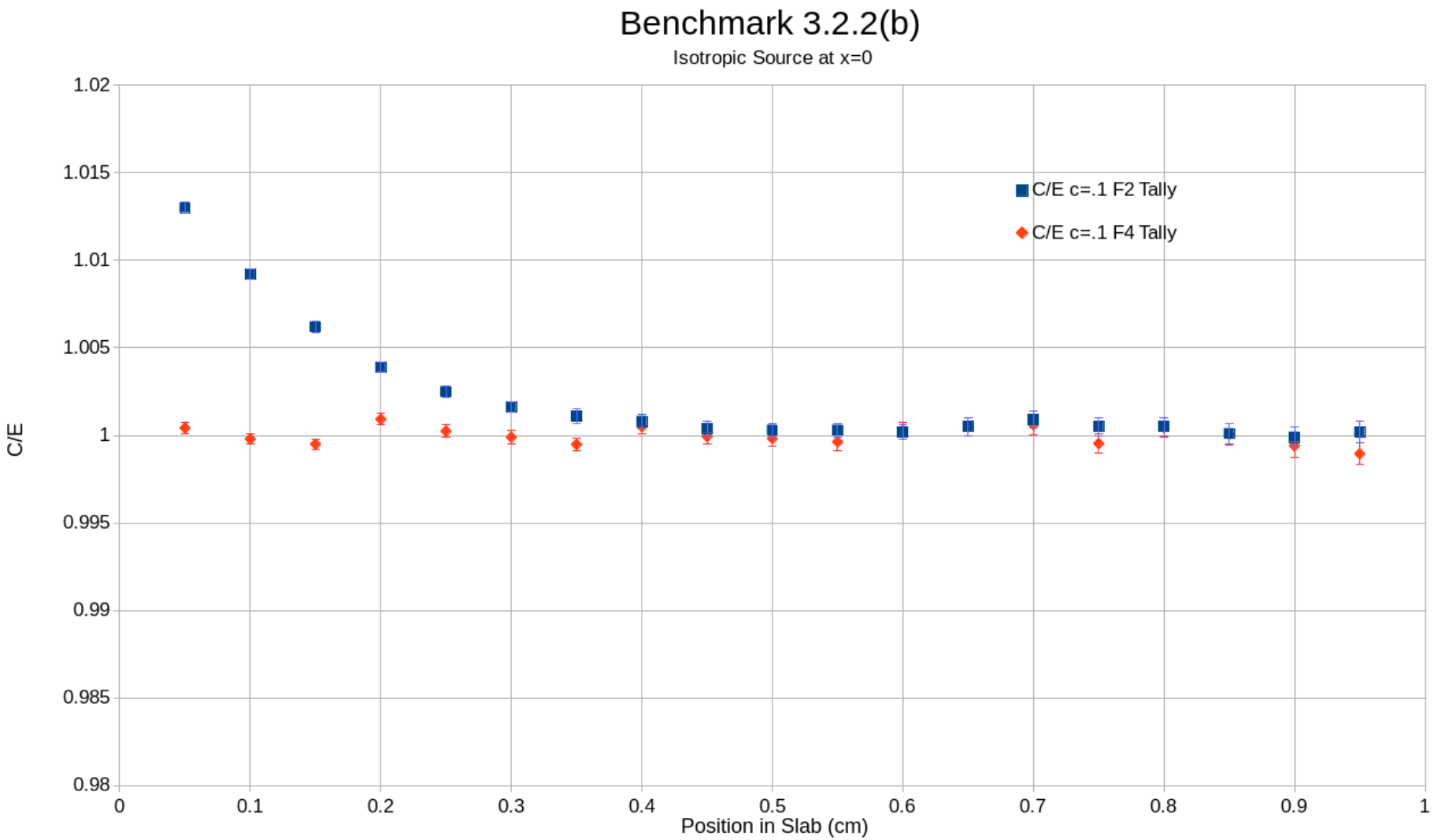
F2 Surface Flux Tally

Below $|\mu| < .1$ MCNP6 makes a constant contribution of $|\mu| = .05$ to the F2 tally (isotropic flux is assumed), in order to ensure that the variance is finite and to maintain good statistics.

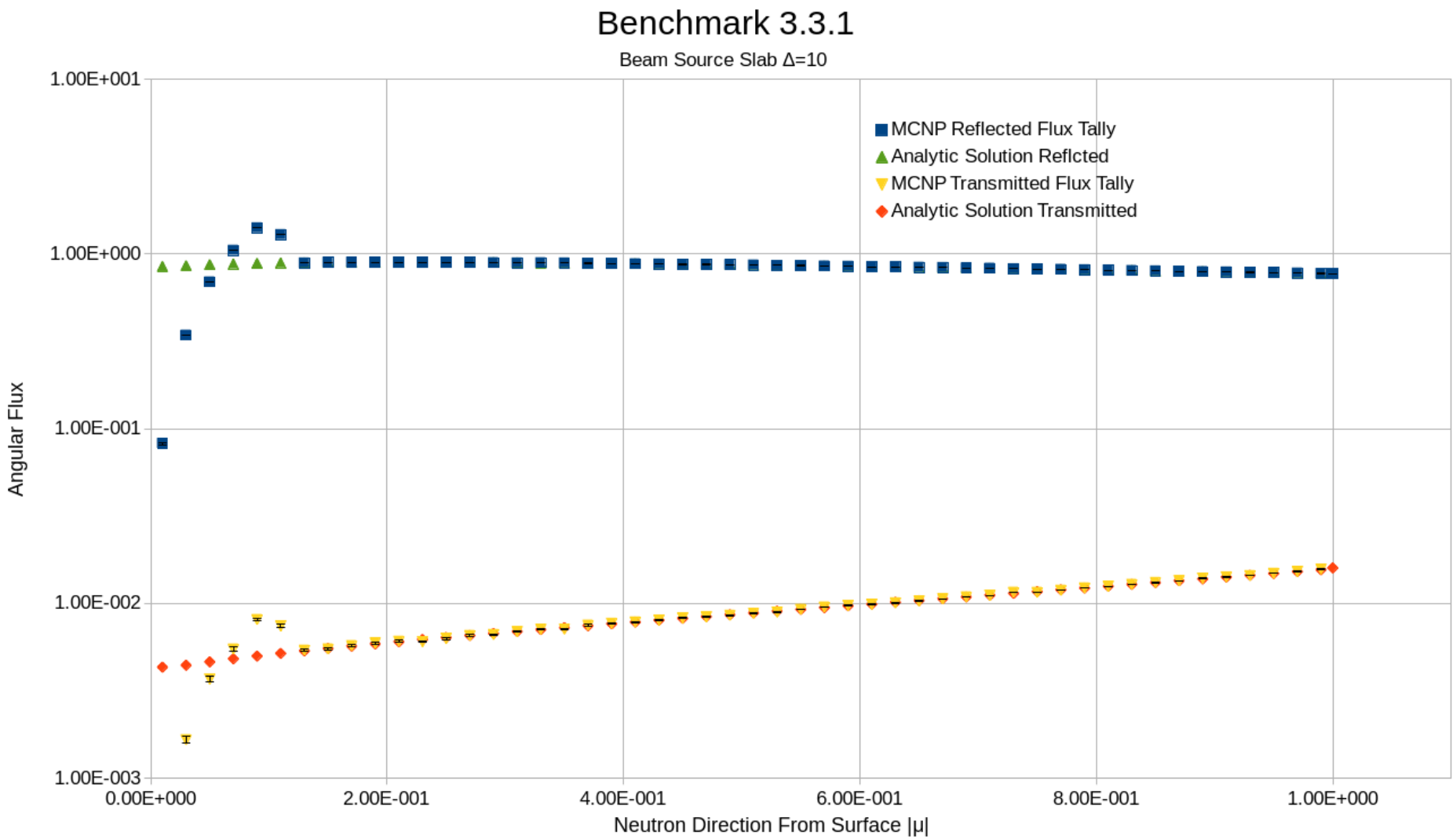
$$\phi = \frac{1}{A * W} \sum \frac{wgt}{|\mu|} \tag{1}$$

To be sure that the F2 tally is the cause for the difference in values, some problems were reworked with different tallies.

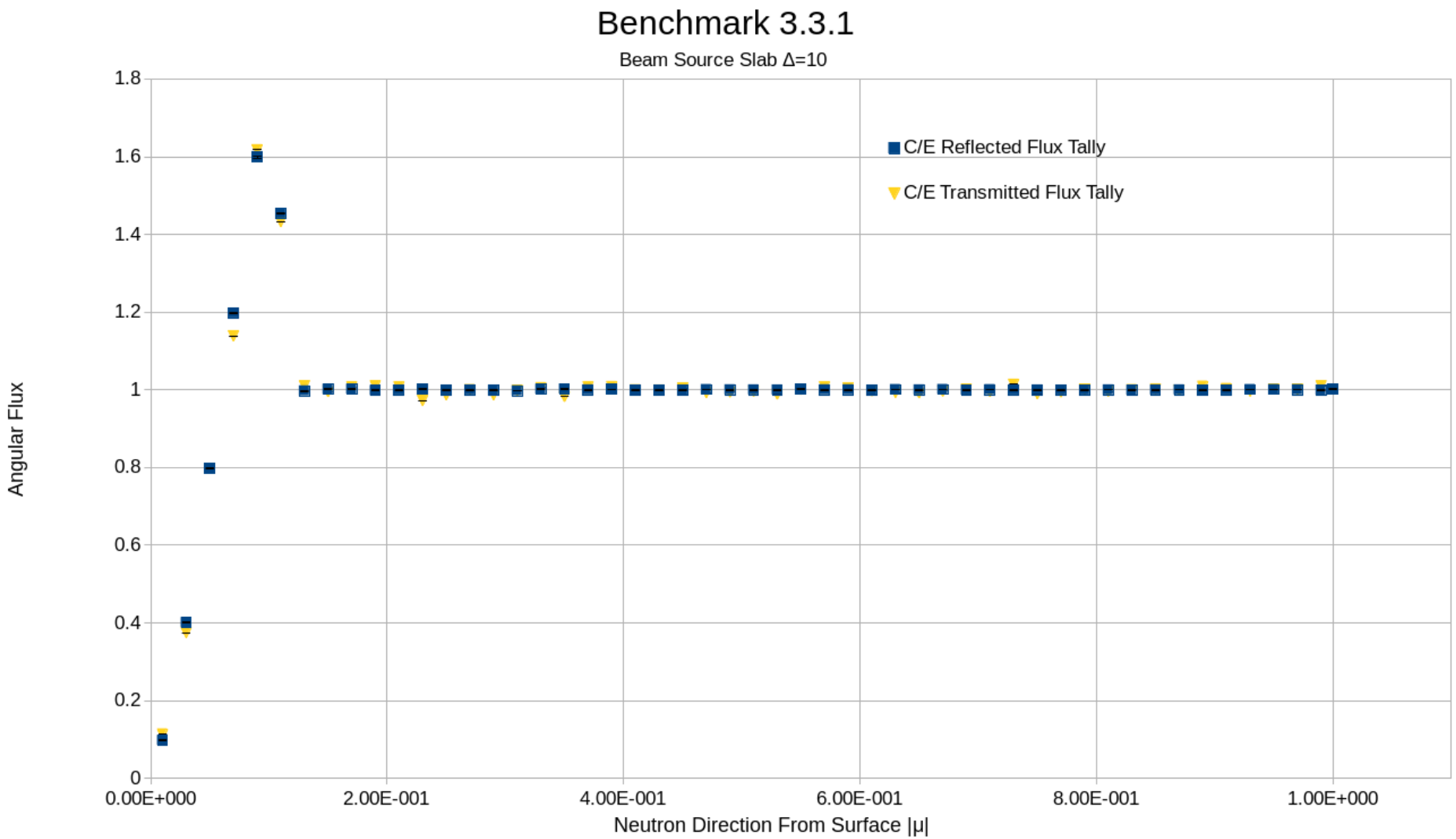
3.2 Isotropic Source in Half Space with F4 Tally



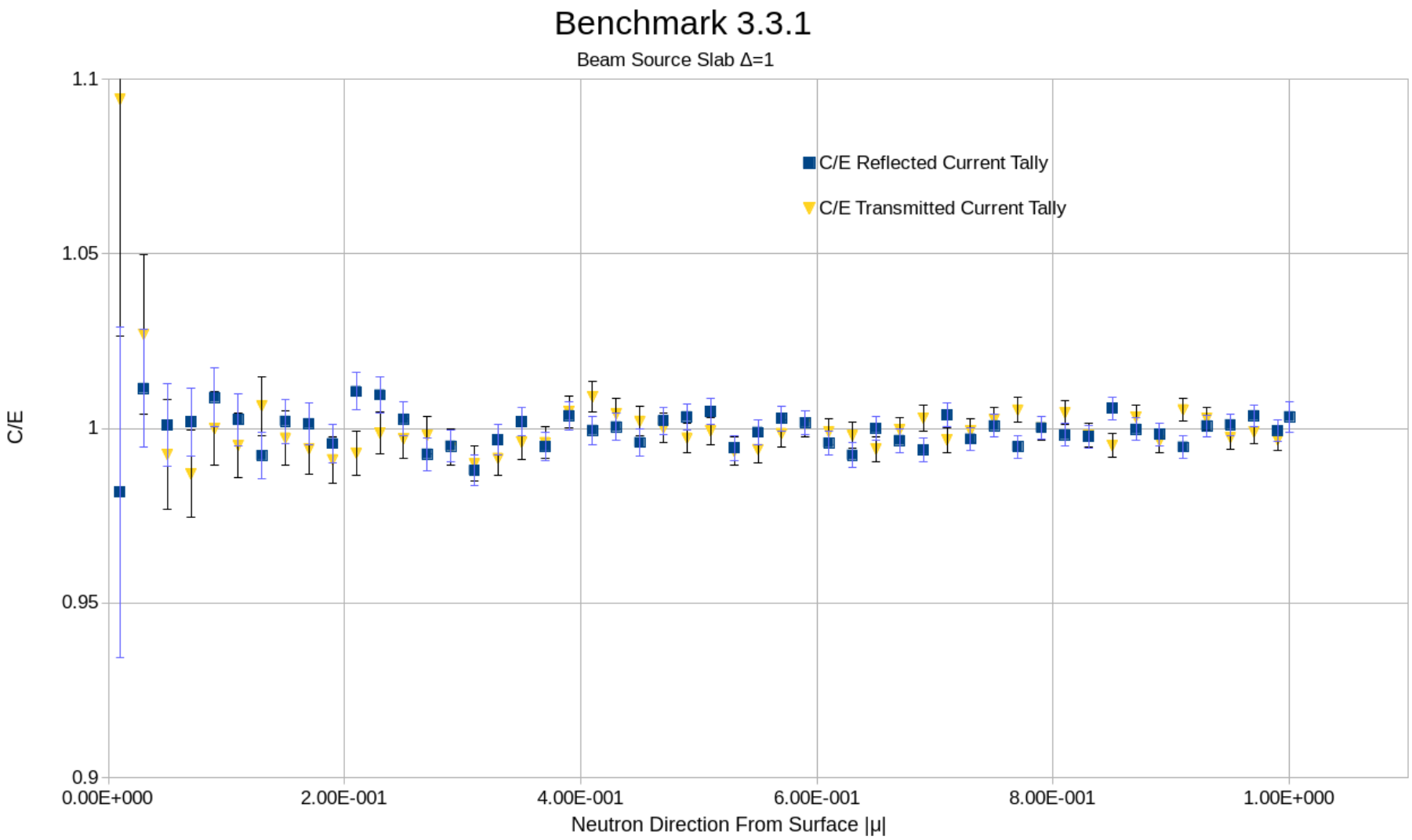
3.3 Beam Through Finite Slab



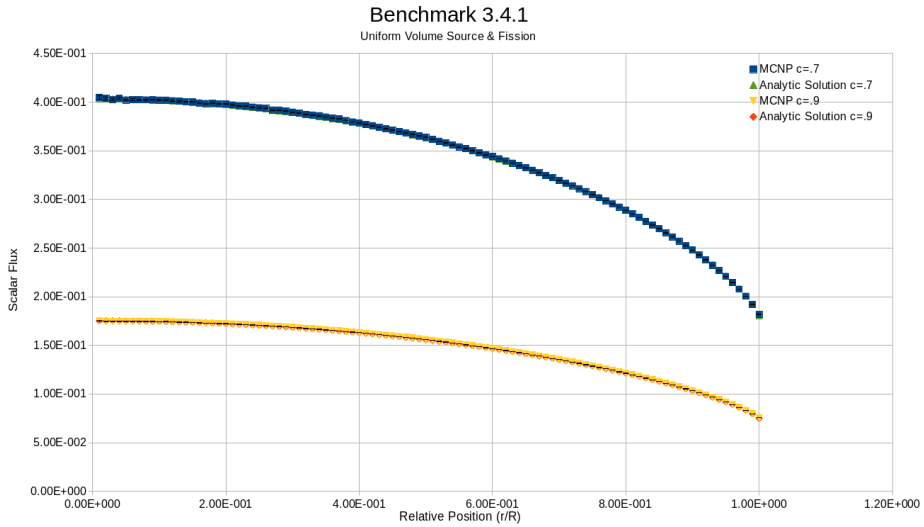
3.3 Beam Through Finite Slab



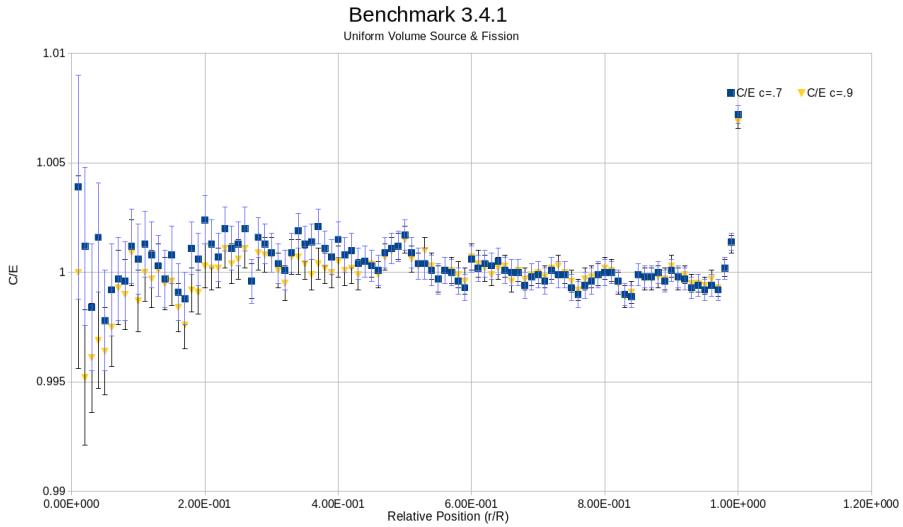
3.3 Beam Through Finite Slab with F1 Tally



3.4 Infinite Cylinder

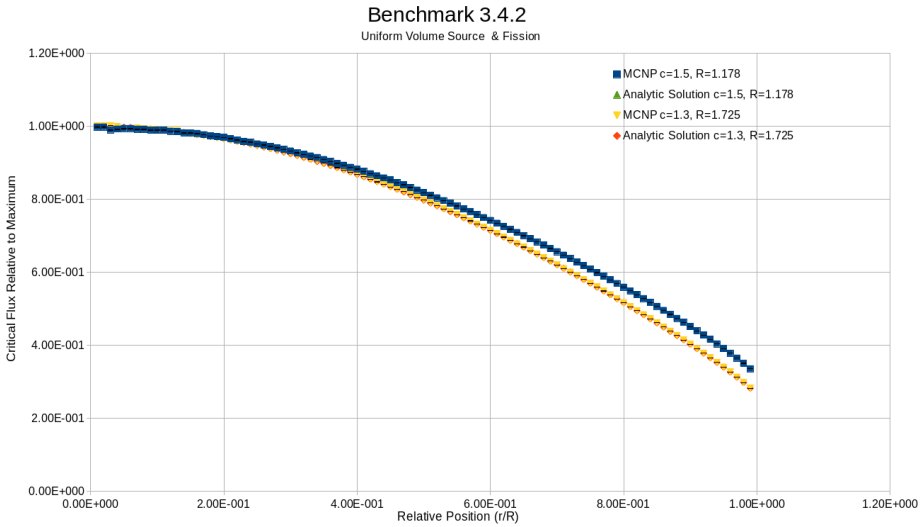


Radial Flux Shape

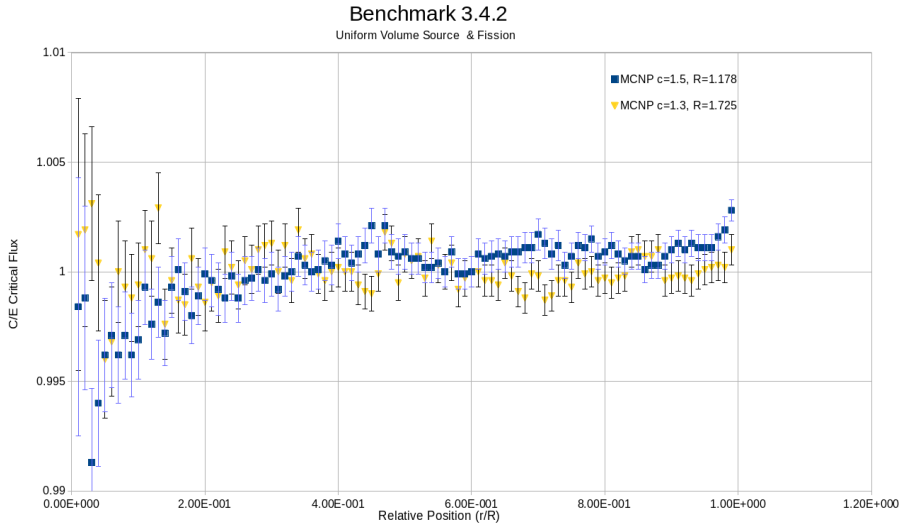


MCNP6 Divided by Analytic Solution

3.4 Critical Infinite Cylinder



Critical Flux Profile $\frac{\phi(r)}{\phi(max)}$

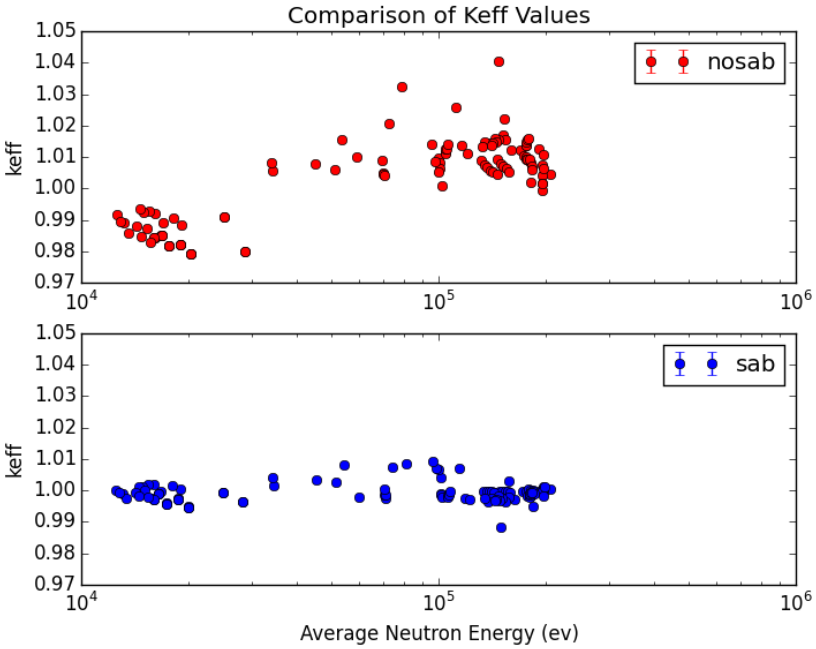


MCNP6 Divided by Analytic Solution

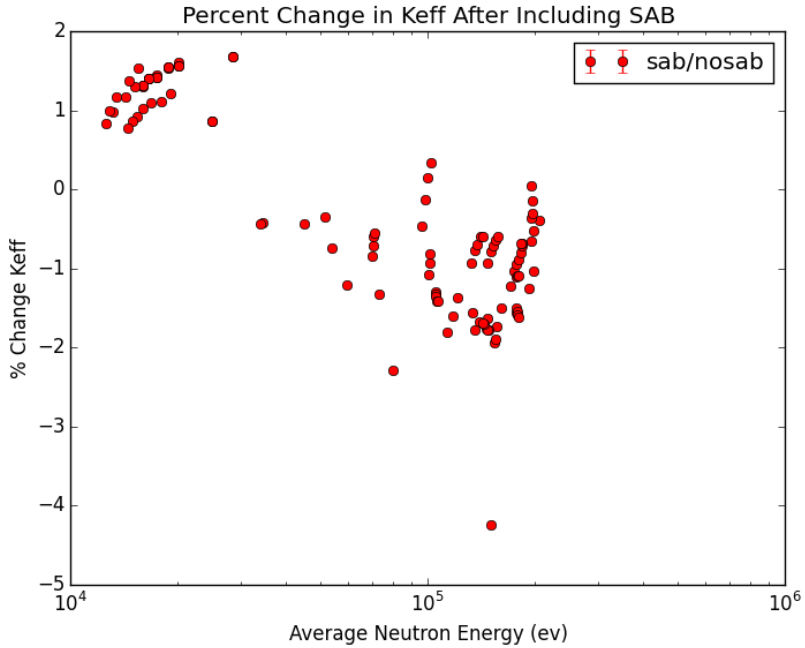
Discussion

- The F2 tally can cause issues in high scattering systems and near sources.
- To mitigate this effect the F4 tally should be used for scalar flux measurements, and the F1 tally should be used for angular flux measurements.
- For the most part MCNP6 results match the analytical solution within statistics.

Other Work



Efffect of $S(\alpha, \beta)$ of keff



Percent Change in k_{eff}

Future Work

- Add slowing down (chapter 2) or multidimensional (chapter 4) benchmarks from Barry Ganapol's book.
- Rework problems using the F4 tally.
- Compare continuous cross-sections and multigroup cross-sections.
- Add more systems to document effect of $S(\alpha, \beta)$ on k_{eff}.

Acknowledgements

- Thank you to Michael Rising, Forrest Brown, and the XCP-3 group at LANL for the support with this project.
- This work was supported by the DOE Nuclear Criticality Safety Program.

Questions