Github

Wednesday, March 12, 2025 11:39 PM

https://github.com/bradenpecora/ME388F/tree/main/HW5

Getting x value at which average occurs

Thursday, March 6, 2025 5:07 PM

The x value of a cell average is not the middle.

$$\frac{\psi}{\psi^0} = e^{-\frac{\varepsilon_t x}{\mu}}$$

$$\text{avg value} = \frac{1}{x_R - x_L}\int_{x_L}^{x_R} e^{-\frac{\varepsilon_t z}{\mu}}\,dz$$

$$\frac{1}{x_R - x_L}\left[-\frac{\mu}{\varepsilon_t} e^{-\frac{\varepsilon_t z}{\mu}}\right]_{x_L}^{x_R}$$

$$\frac{1}{\Delta x}\,\frac{-\mu}{\varepsilon_t}\left(e^{-\frac{\varepsilon_t}{\mu} x+\Delta x} - e^{-\frac{\varepsilon_t}{\mu} x}\right)$$

At what x does the the analytic solution equal the average value across a delta x

$$\frac{1}{\Delta x}\,\frac{-\mu}{\varepsilon_t}\left(e^{-\frac{\varepsilon_t(x+\Delta x)}{\mu}} - e^{-\frac{\varepsilon_t}{\mu} x}\right) = e^{\frac{-\varepsilon_t}{\mu}(x+\delta)}$$

$$\frac{1}{\Delta x}\,\frac{-\mu}{\varepsilon_t}\left(e^{\frac{-\varepsilon_t}{\mu} x} e^{\frac{-\varepsilon_t \Delta x}{\mu}} - e^{-\frac{\varepsilon_t}{\mu} x}\right) = e^{\frac{-\varepsilon_t}{\mu} x}\, e^{\frac{-\varepsilon_t}{\mu}\delta}$$

$$\frac{-\mu}{\Delta x\,\varepsilon_t}\left(e^{-\frac{\varepsilon_t \Delta x}{\mu}}-1\right)=e^{-\frac{\varepsilon_t}{\mu}\delta}$$

$$\ln\left(-\frac{\mu}{\Delta x\,\varepsilon_t}\left(e^{-\frac{\varepsilon_t \Delta x}{\mu}}-1\right)\right)=-\frac{\varepsilon_t}{\mu}\delta$$

$$\delta=-\frac{\mu}{\varepsilon_t}\ln\left(\frac{-\mu}{\Delta x\,\varepsilon_t}\left(e^{-\frac{\varepsilon_t \Delta x}{\mu}}-1\right)\right)$$

1a

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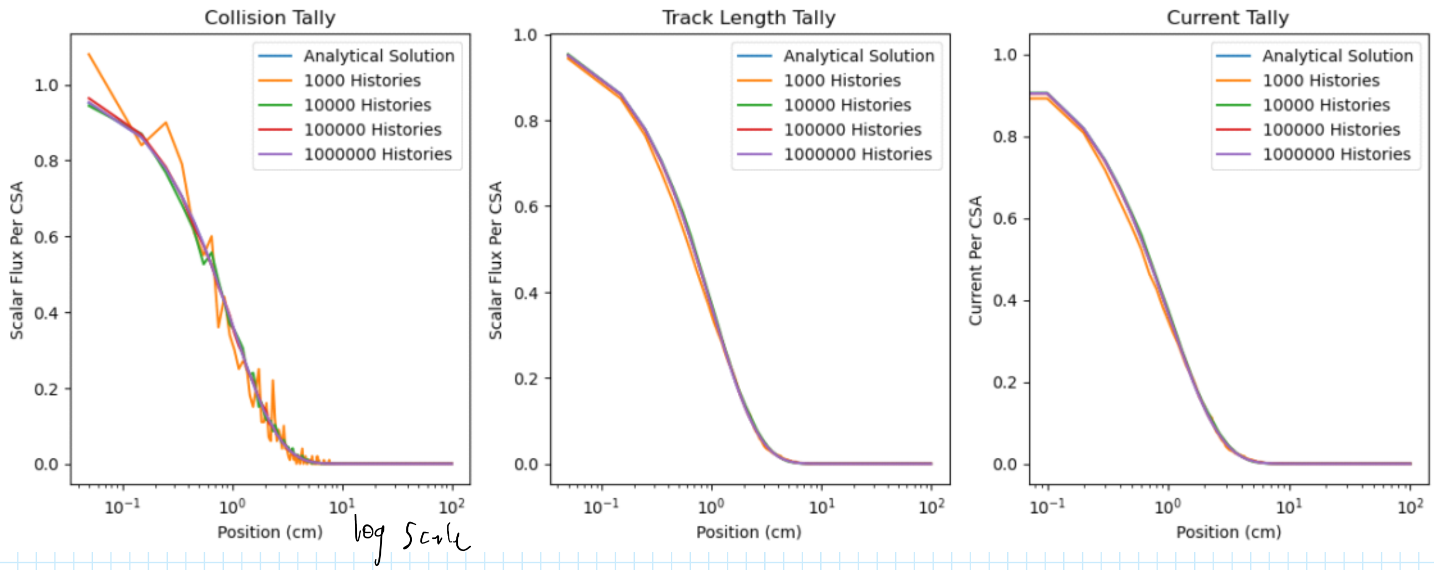
1. Simplified Monte Carlo: This is a progression of problems that you can compare with analytic (and deterministic) solutions to evaluate the accuracy of the Monte Carlo:
   (a) One random number per particle history.
      i. Right-traveling ($\mu = 1$) particles on the left face of a purely absorbing material should have a $\frac{\psi(x)}{\psi(0)} = e^{-\frac{\Sigma_t x}{\mu}}$ using all three tallies; there is only one random number chosen per particle.
         A. As you increase the number of histories, does the solution converge towards the analytic?
         B. If you increase the number of particles by a factor of 4, does the error decrease by a factor of 2?
         C. What should the current, $_x(x)$, be? Does it converge to that with the same rate of convergence?
      ii. Do the same for the left-traveling version.
      iii. Do the same for the $\mu = \frac{1}{\sqrt{3}}$ and $\frac{-1}{\sqrt{3}}$ version.

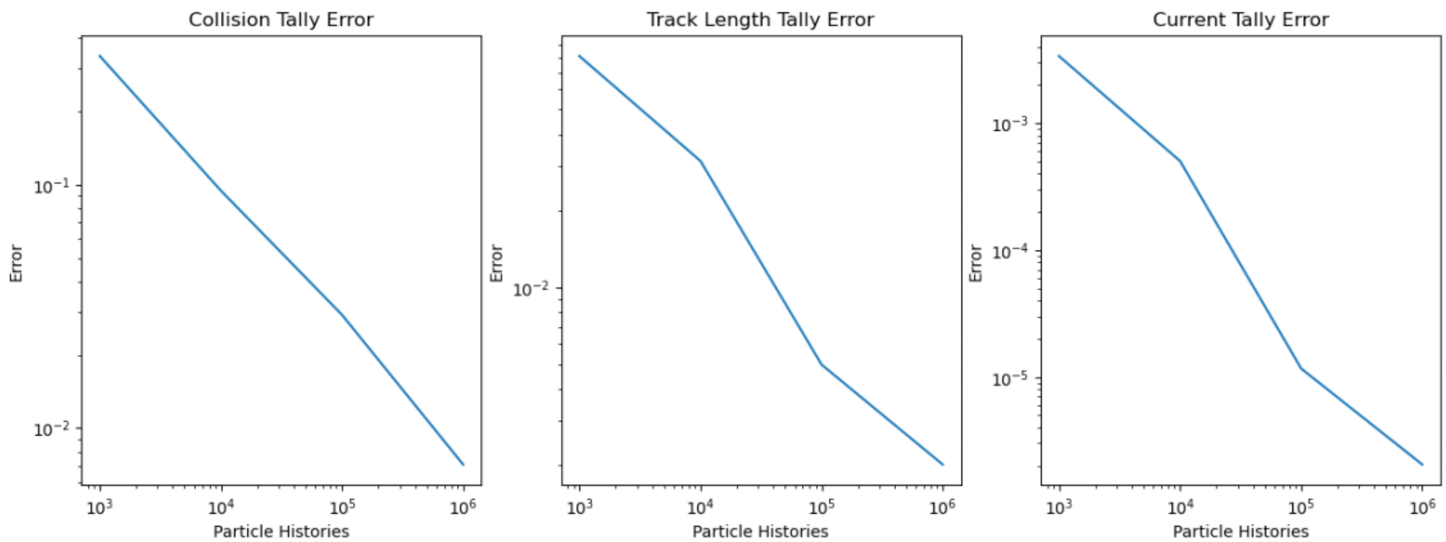
My monte carlo tally returns a flux with $\psi_0 = \mu$ for some reason, so $\frac{\psi}{\psi_0} = \frac{\text{tally}}{\mu}$ and $J = \text{tally}$

since $\frac{J}{\psi_0} = \mu \frac{\psi}{\psi_0} = \text{tally}$

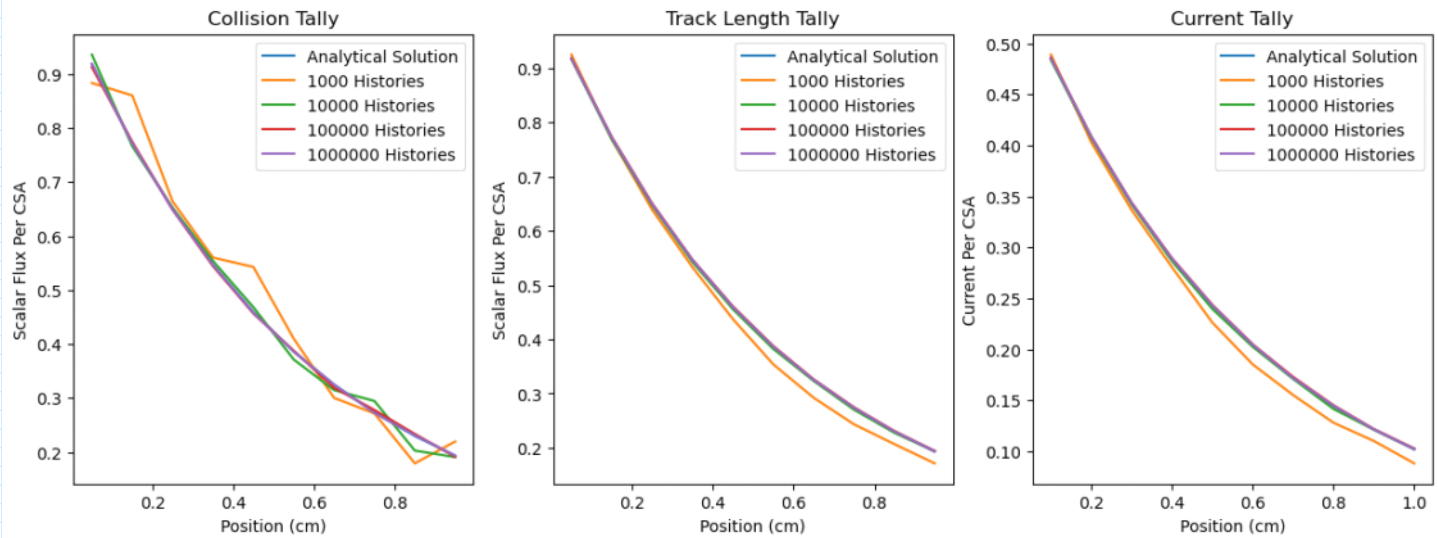
Mu = 1

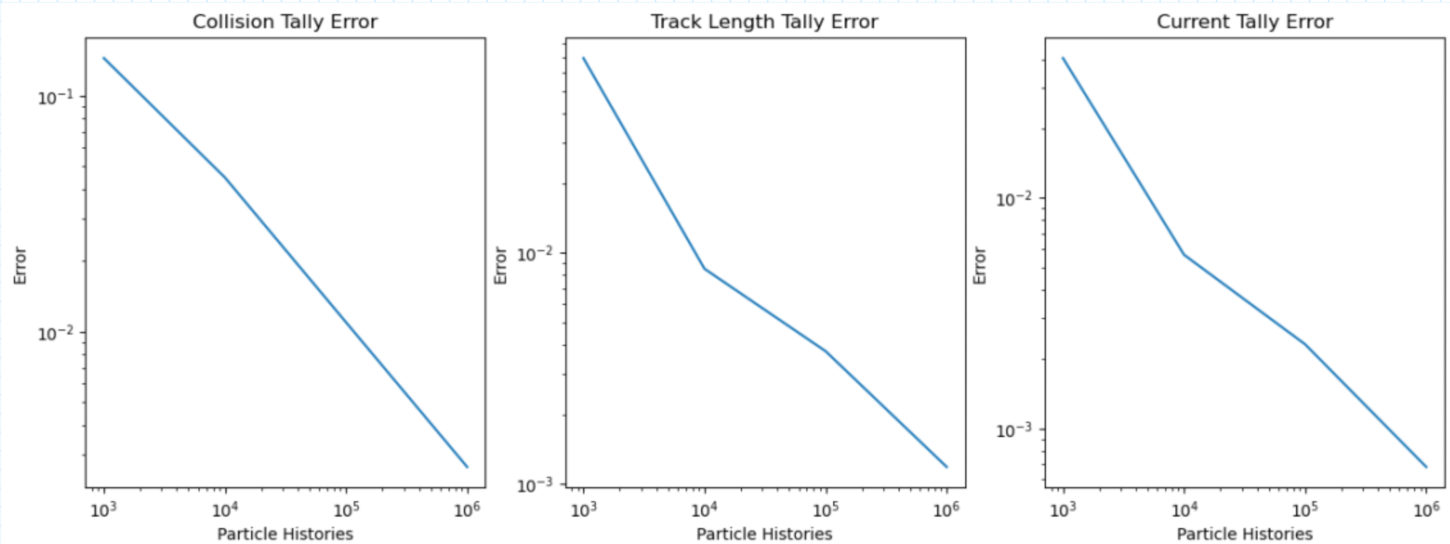


log scale

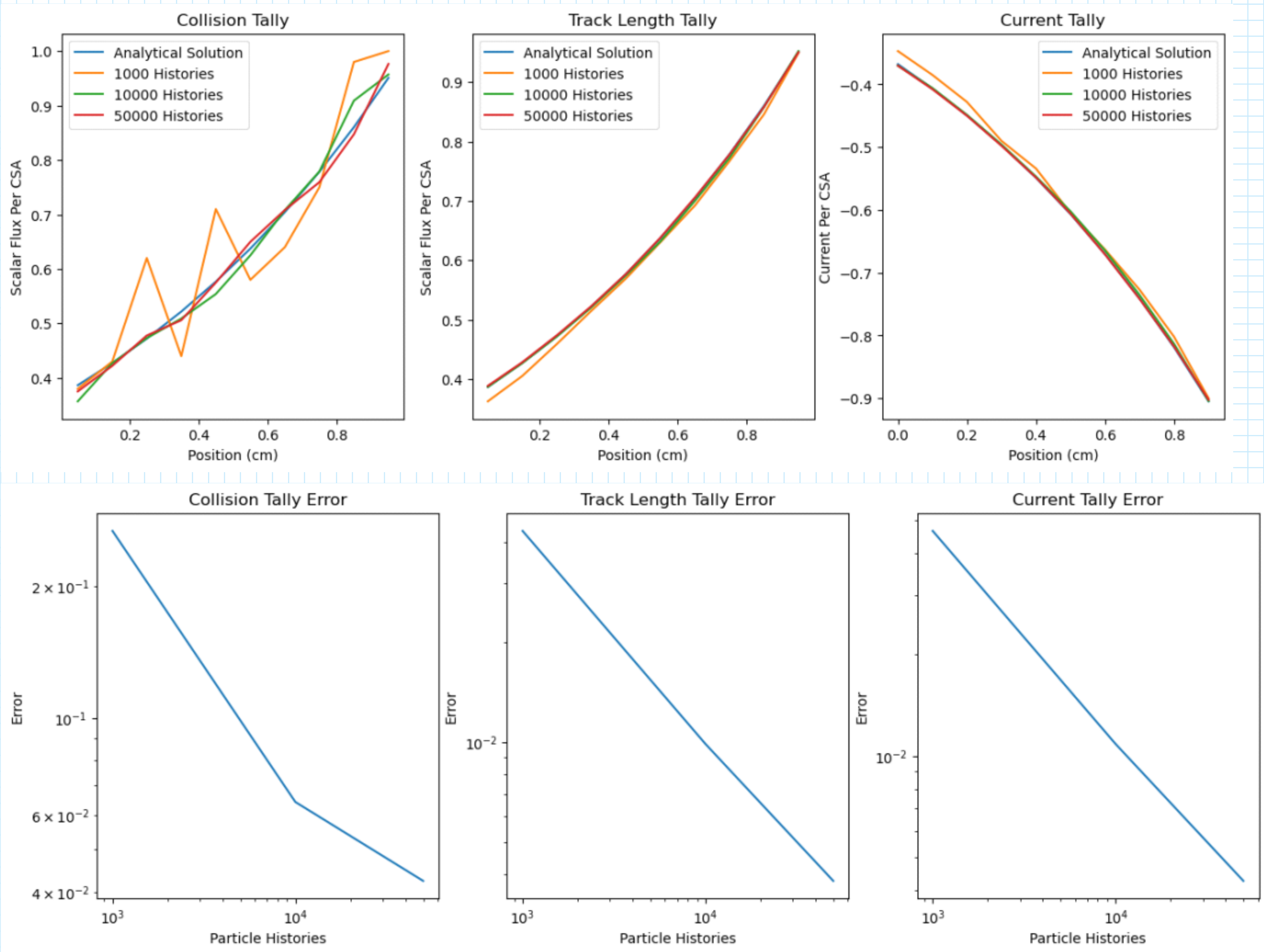


$\mu = \frac{1}{\sqrt{3}}$ $x = [0, 1]$

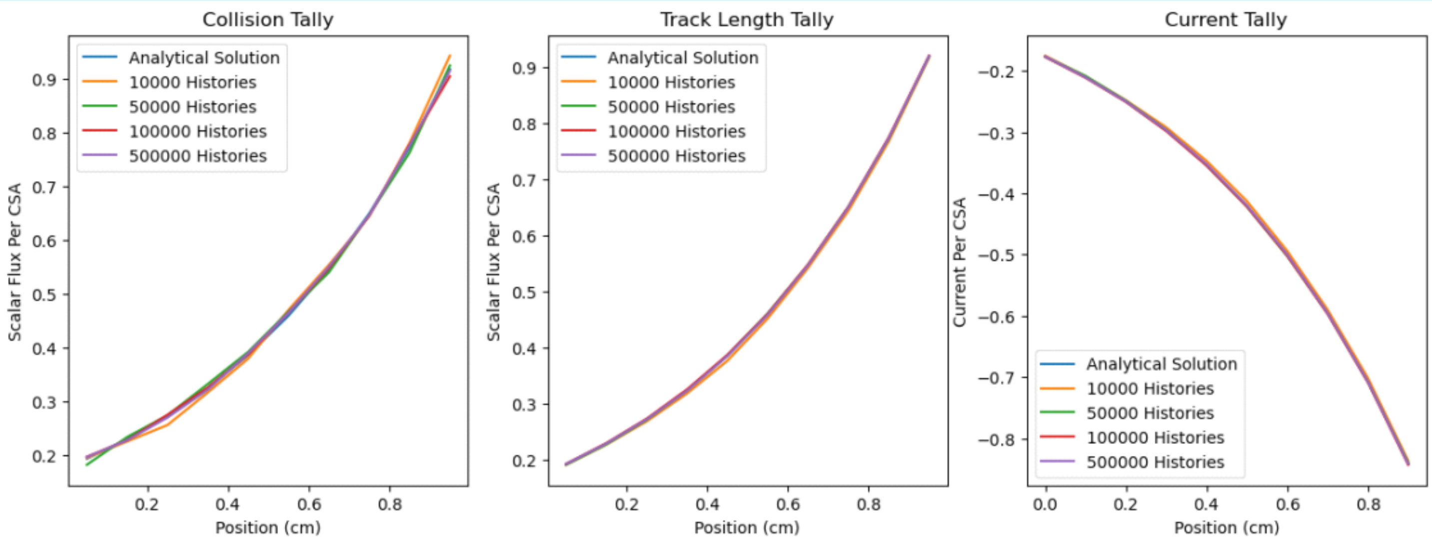


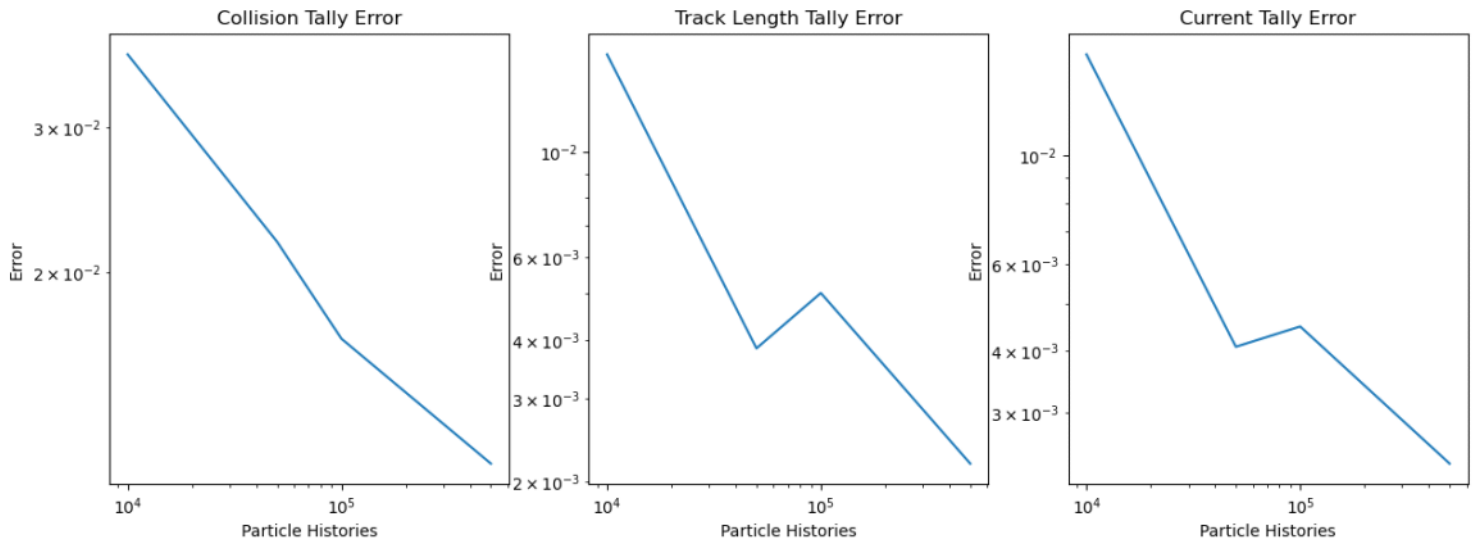


$\mu = -1$



$\mu = -\frac{1}{\sqrt{3}}$





Yes, the solution does converge towards the analytic
Yes, increasing the particles by x4 decreases error by x2
Current converges

1b

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(b) Two random numbers per particle.

i. Fixed isotropic source with reflecting boundaries: sample location (x) and direction (μ) in a pure absorber.

A. Does the solution approach the analytic as the number of histories increase?

B. At the expected rate?

C. Is the solution flat?

D. Is the current zero?

ii. Change the magnitude of the source and the total cross section to see if all tallies are as expected.

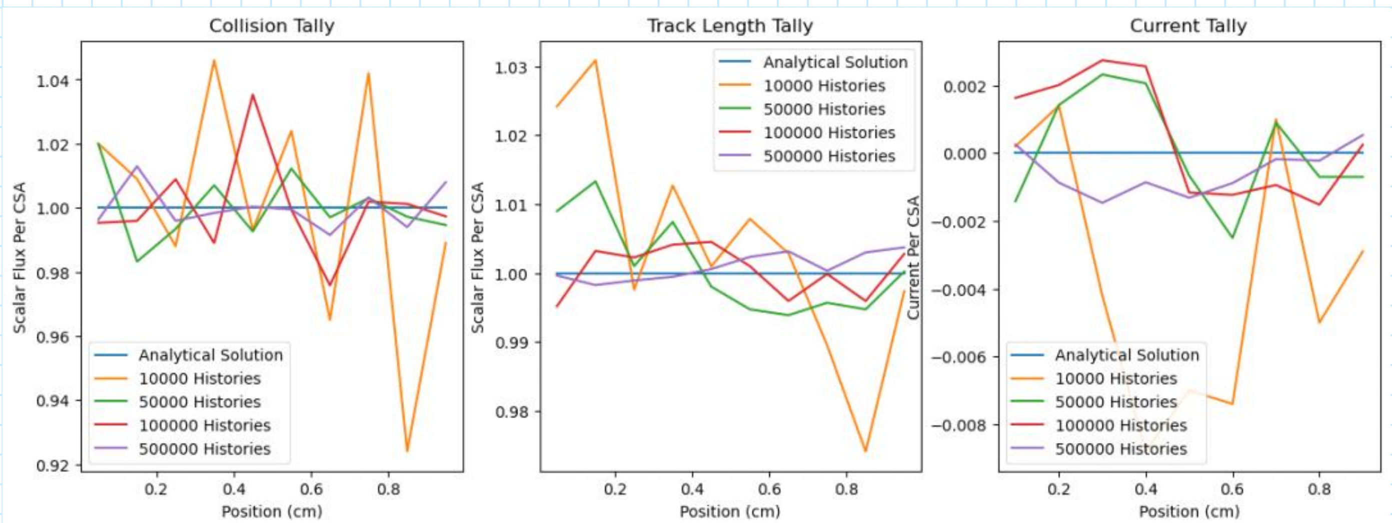
$\phi = \frac{Q}{\Sigma_a}$ is the analytic

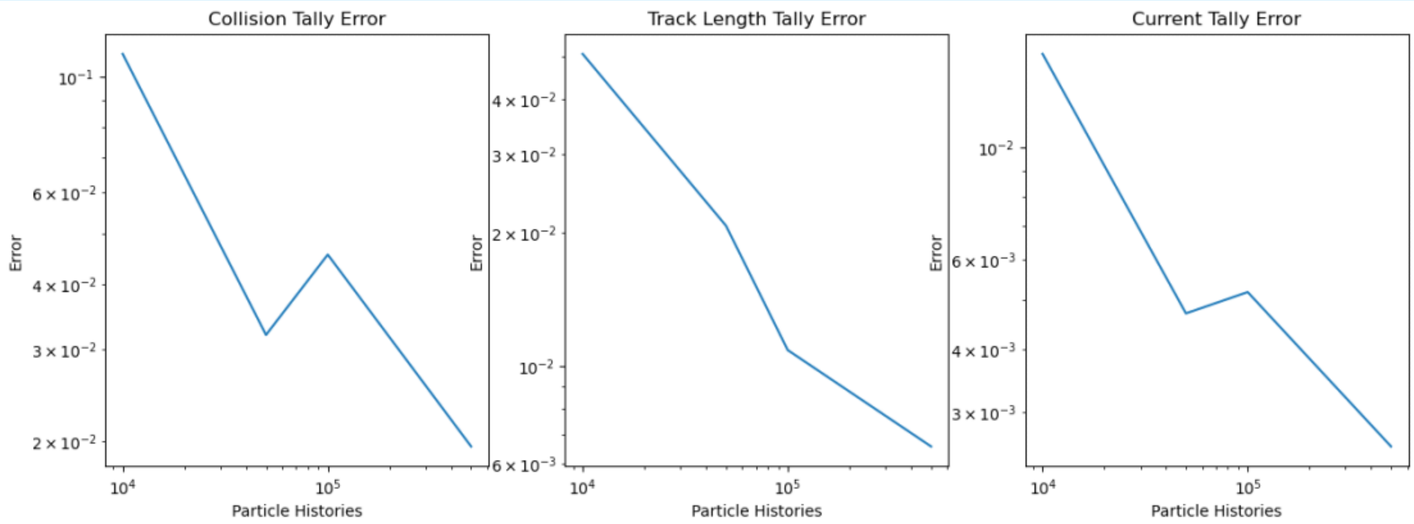
Solution should be flat

Current should be zero

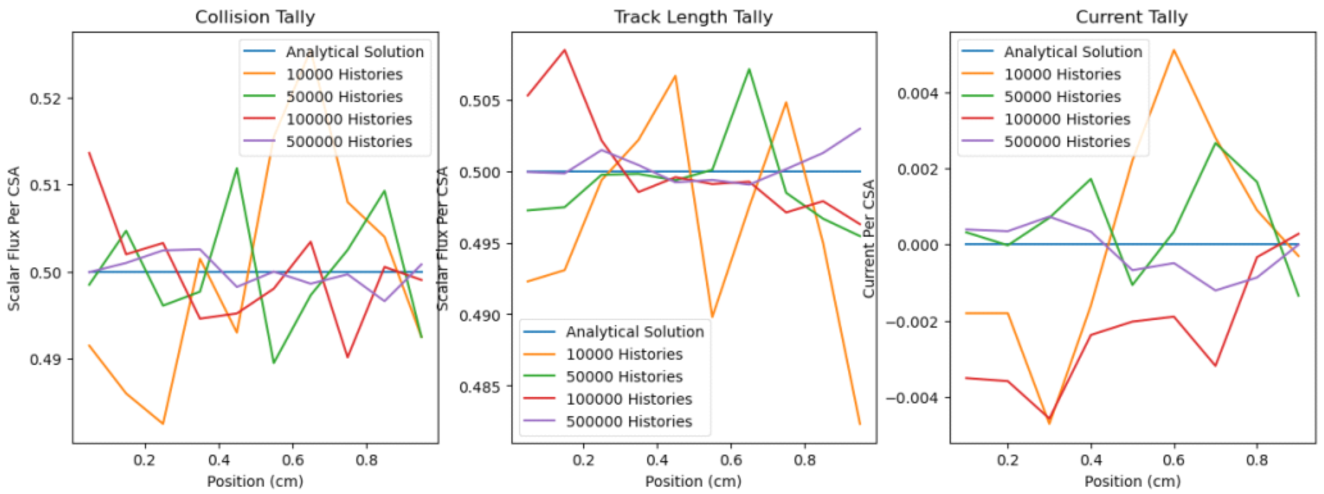
The solution converges at the same rate

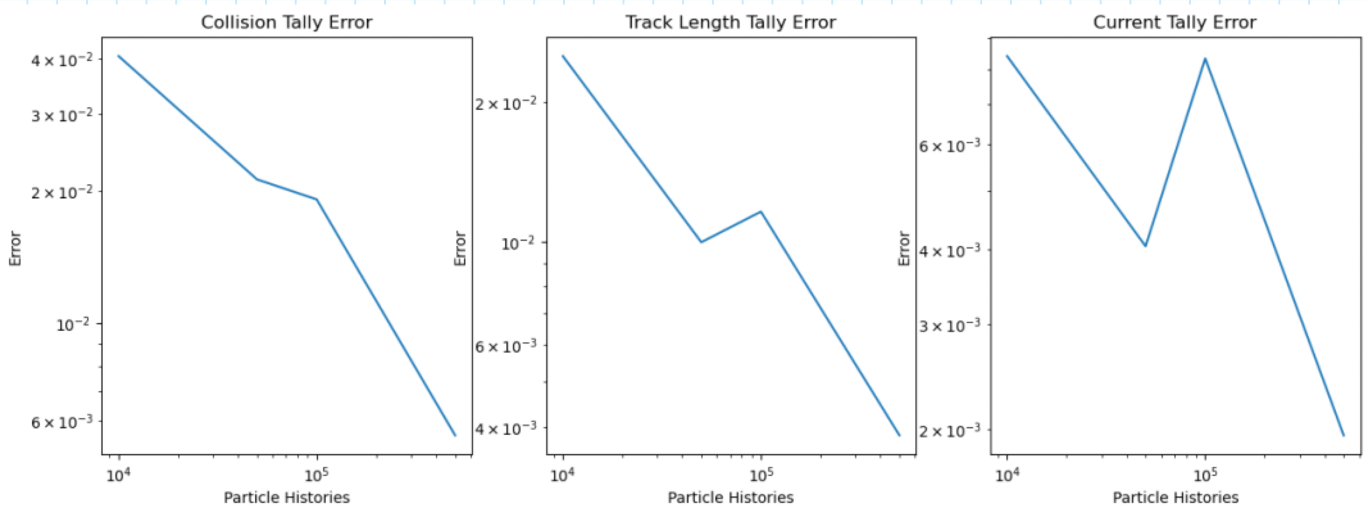
4x particles $\Rightarrow$ 2x error decrease




Collision Tally Error
Error
Particle Histories
Track Length Tally Error
Error
Particle Histories
Current Tally Error
Error
Particle Histories

$\Sigma_t = 2$


Collision Tally
Analytical Solution
10000 Histories
50000 Histories
100000 Histories
500000 Histories
Scalar Flux Per CSA
Position (cm)
Track Length Tally
Analytical Solution
10000 Histories
50000 Histories
100000 Histories
500000 Histories
Scalar Flux Per CSA
Position (cm)
Current Tally
Analytical Solution
10000 Histories
50000 Histories
100000 Histories
500000 Histories
Current Per CSA
Position (cm)


Collision Tally Error
Error
Particle Histories
Track Length Tally Error
Error
Particle Histories
Current Tally Error
Error
Particle Histories

1c

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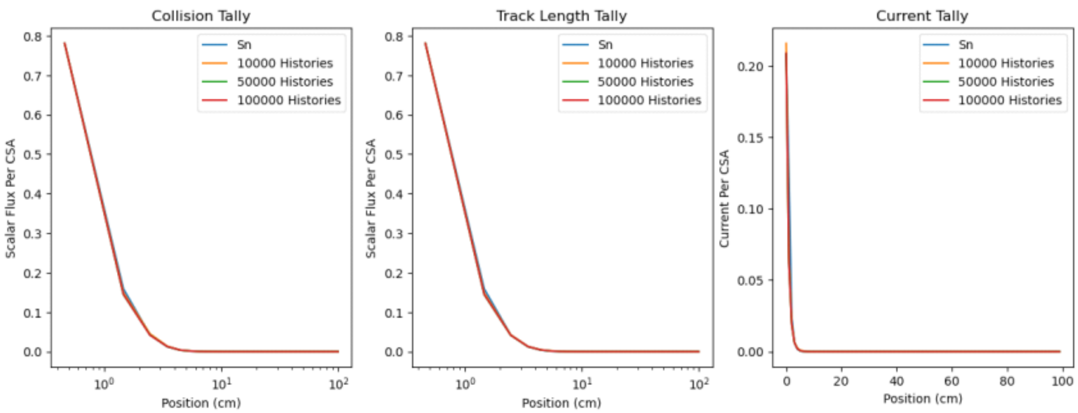
iii. Fixed incident angular flux on the left surface of a pure absorbing material: sample direction (θ) and distance ($\Sigma_t x$)

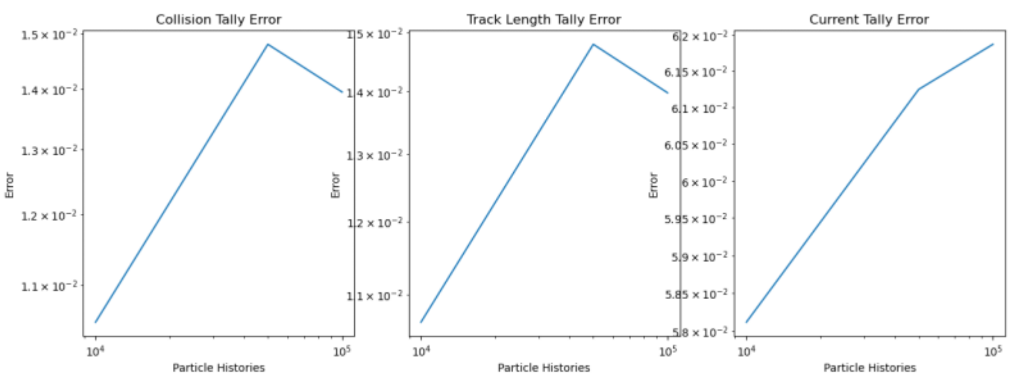
A. Does the spatial distribution of the scalar flux agree with the S_n?

B. Does it converge correctly?

I divided ϕ_{MC} by $\phi_{MC}(x=0)$ and multiplied by $\phi_{Sn}(x=0)$ to normalize



Monte carlo converges to something



I calculated error with S64 as the "truth" solution". Monte Carlo seems to be getting farther and farther away from Sn, which makes sense, as Monte Carlo should technically be more accurate

This could be because there is an enforced vacuum boundary condition at x = 100 for Sn and particles can still leak out in Monte Carlo, especially as the number of particles grows.

2

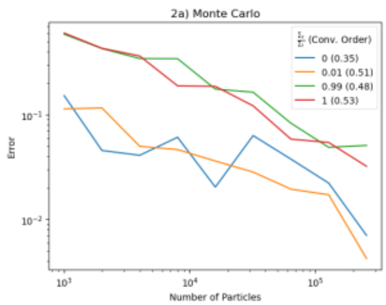
Monday, March 10, 2025 1:31 PM

2. Order of convergence study: Using the three codes (S_n, diffusion, Monte Carlo), run a series of problems where the size of the spatial mesh (or number of monte carlo histories) progressively decreases (e.g. factors of 2 until your computer struggles).
    - For each code, what is the solution for a highly-refined case?
    - As the mesh gets coarser from that, how quickly does it get bad? use this to estimate the order of convergence.
    - For problems that are analytic, does the solution for each method converge to the analytic solution?

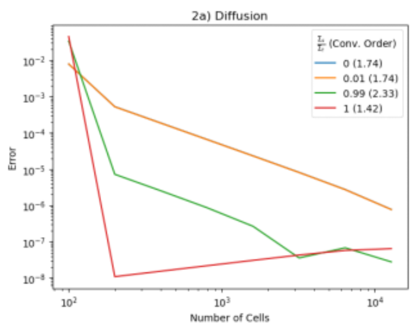
    What is the order of convergence for each code to ITS most refined solution?

    (a) Isotropic incident on one surface; $\frac{\Sigma_s}{\Sigma_t} = [1, 0.99, 0.01, 0]$
    (b) Isotropic source in the middle; vacuum BCs; $\frac{\Sigma_s}{\Sigma_t} = [1, 0.99, 0.01, 0]$
    (c) Two different materials (pick a BC and source): what happens near the interface?
        i. Reflector/scatterer
        ii. Reflector/air
        iii. Reflector/source
        iv. Reflector/absorber
        v. Absorber/source
        vi. Absorber/air
        vii. Source/air

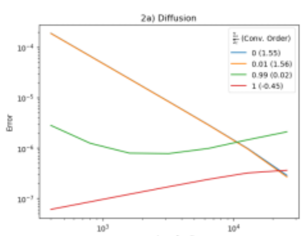
I only did a 5cm for problem A since it just decays to zero and makes it hard to calculate errors



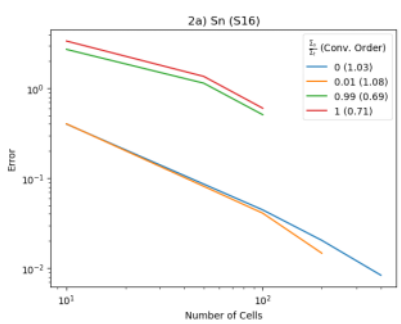
Order of convergence is about 0.5 w/ number of particles



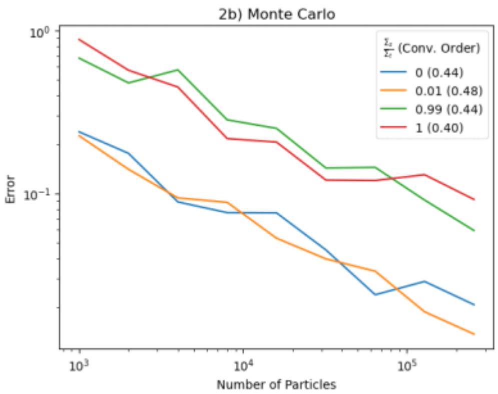
Order of convergence is about 2 with number of cells



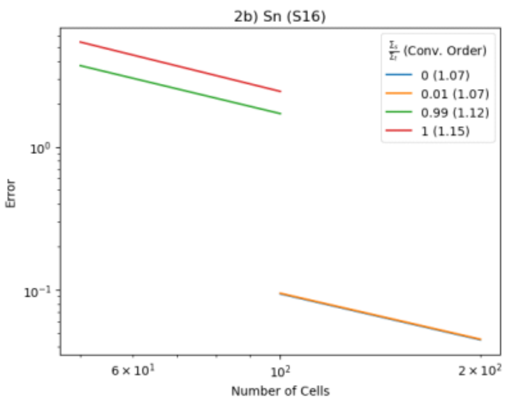
Here's another plot
Things get kind of weird for convergence as Sigma_s approaches Sigma_total
The flux becomes approximately a straight line with a negative slope
The solution is already pretty accurate at low number of cells, but as we get past a certain point,
The error increases, probably due to something related to numerical percision



Order of convergence is about 1

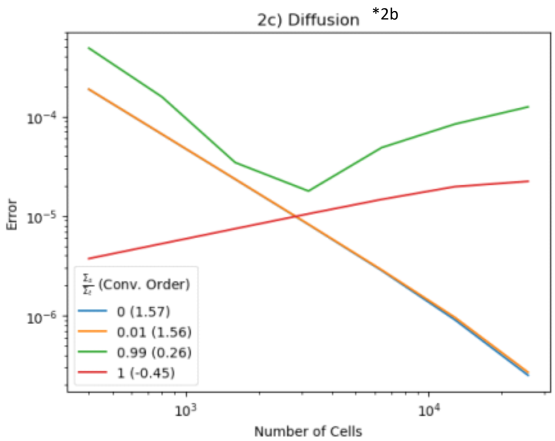


Order of convergence is still about 0.5



Order of convergence is strongly 1

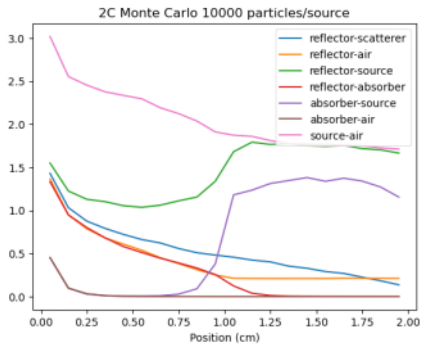
*2b

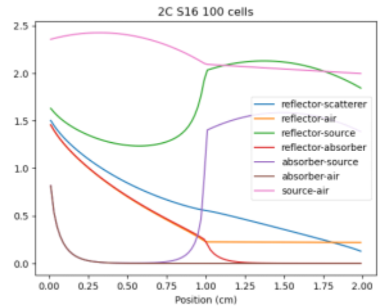


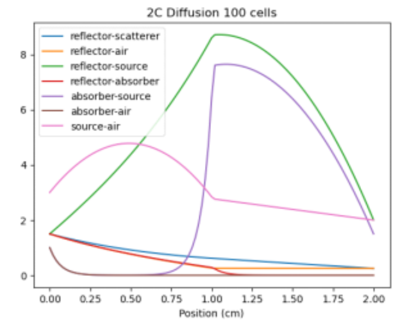
I think the same thing as before is happening with the high scattering

Order of convergence is 1.5 ish

For 2c I am doing an isotropic source on the left, 1cm of material A 1 cm of material b

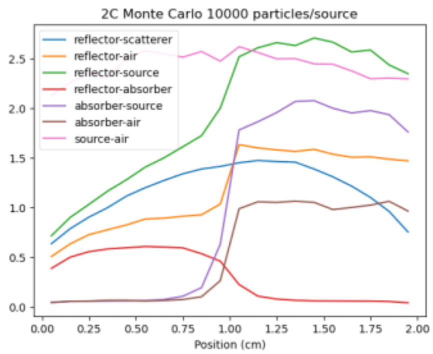


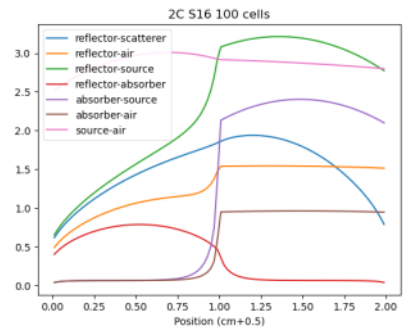


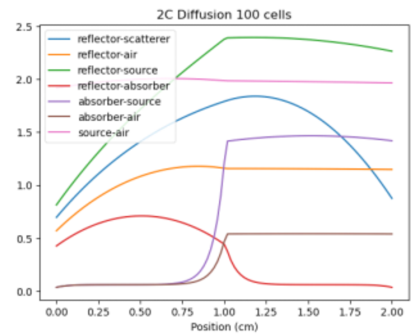


For diffusion I kind of had to guess at the left and right boundary conditions
Diffusion is terrible at the boundary

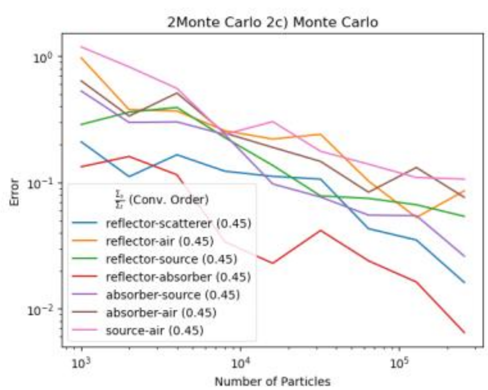
Here is vacuum boundary conditions with a full volumetric source (+ the normal source from "source")
(That is, I don't need to specify a left and right flux boundary for diffusion)

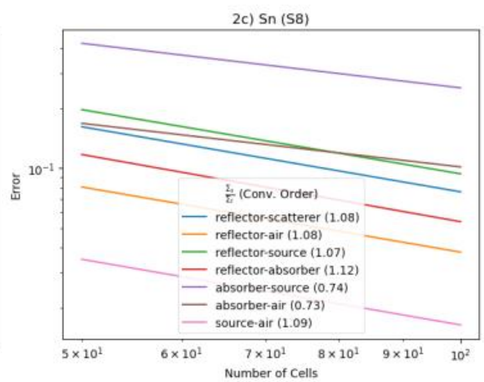


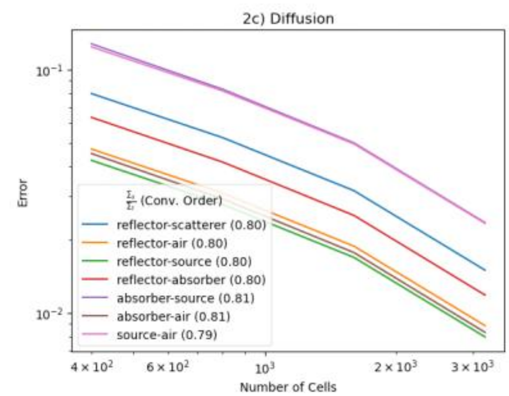




Order of convergence on the above problem







0.5 order of convergence still

Order of convergence is 1

Order of convergence is about 0.8