Beam Window Optimization

Caltech

First, a quick summary of the first half of the simulation chain, and where the beam window comes in.

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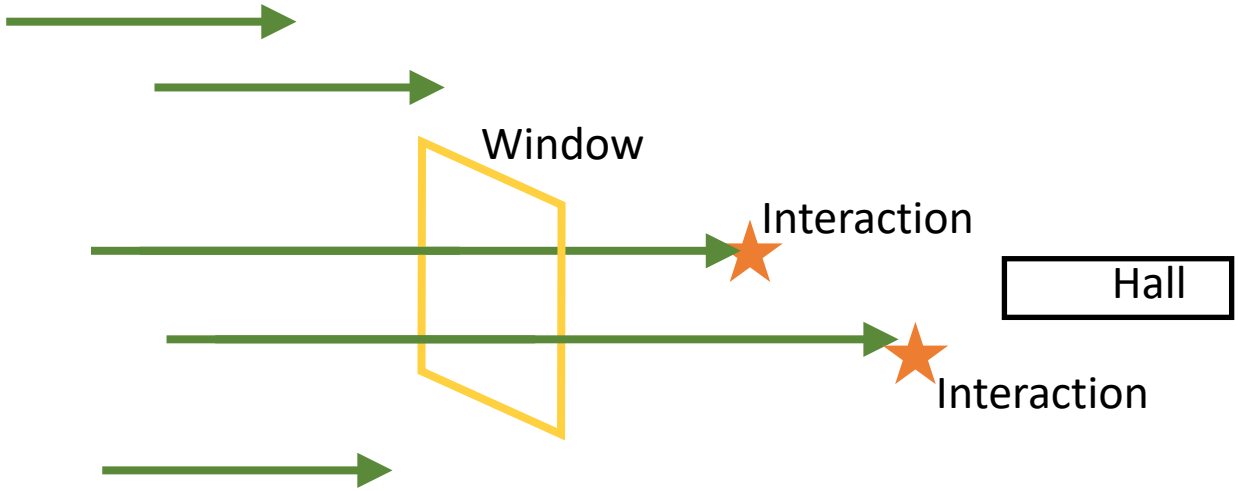
Step 1: Generate events with Genie



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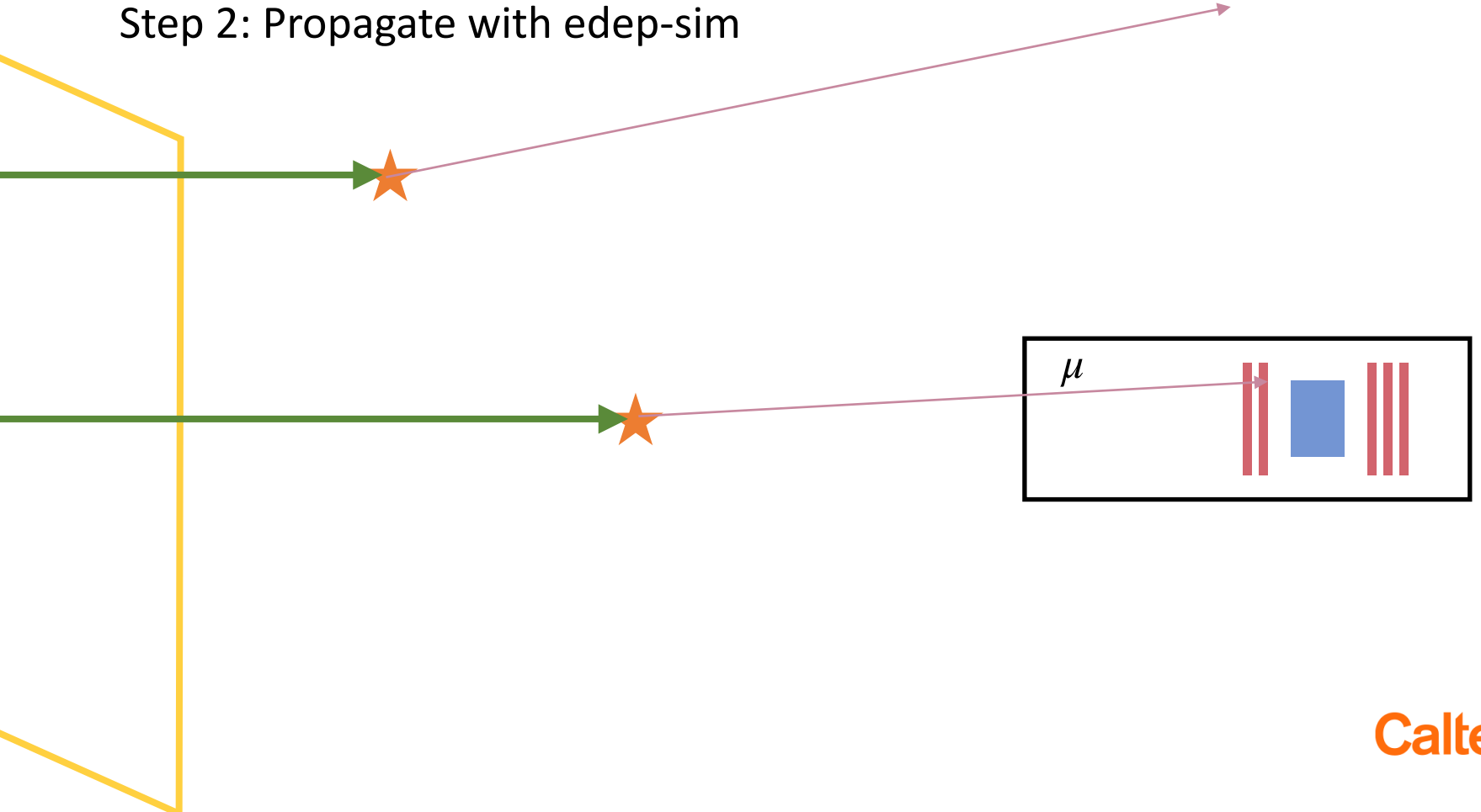
Step 2: Propagate with edep-sim



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Problem:

A large fraction of computation time is spent propagating events that never deposit any energy in the detector volume.

Can we change the beam window to reduce the number of these wasted events?

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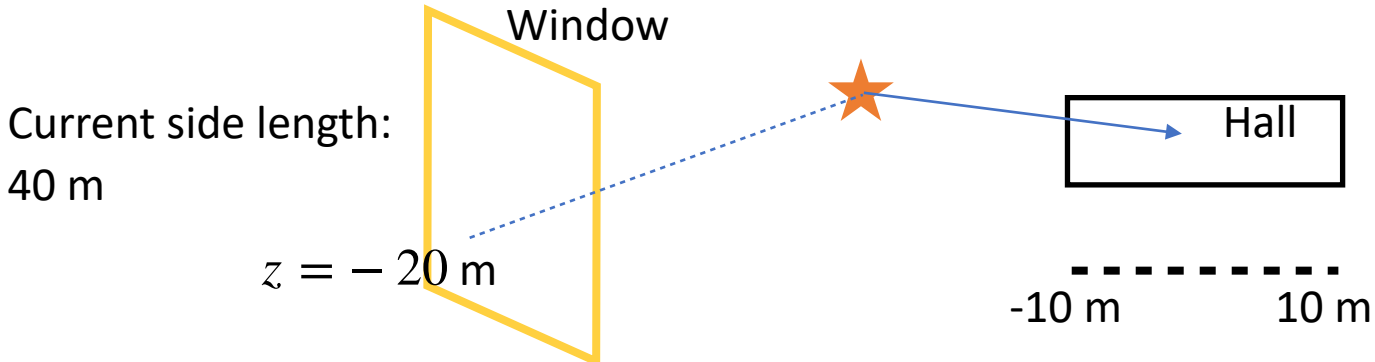
First, only look at edep-sim outputs. These only include events that traverse the sensitive detector volume.

Instead of creating several simulations with different beam windows, we can look at the existing simulation and see what events would be eliminated by shrinking the window.

Using interaction vertex position and neutrino momentum, you can backtrack the x-y position of the neutrino at the beam window position.



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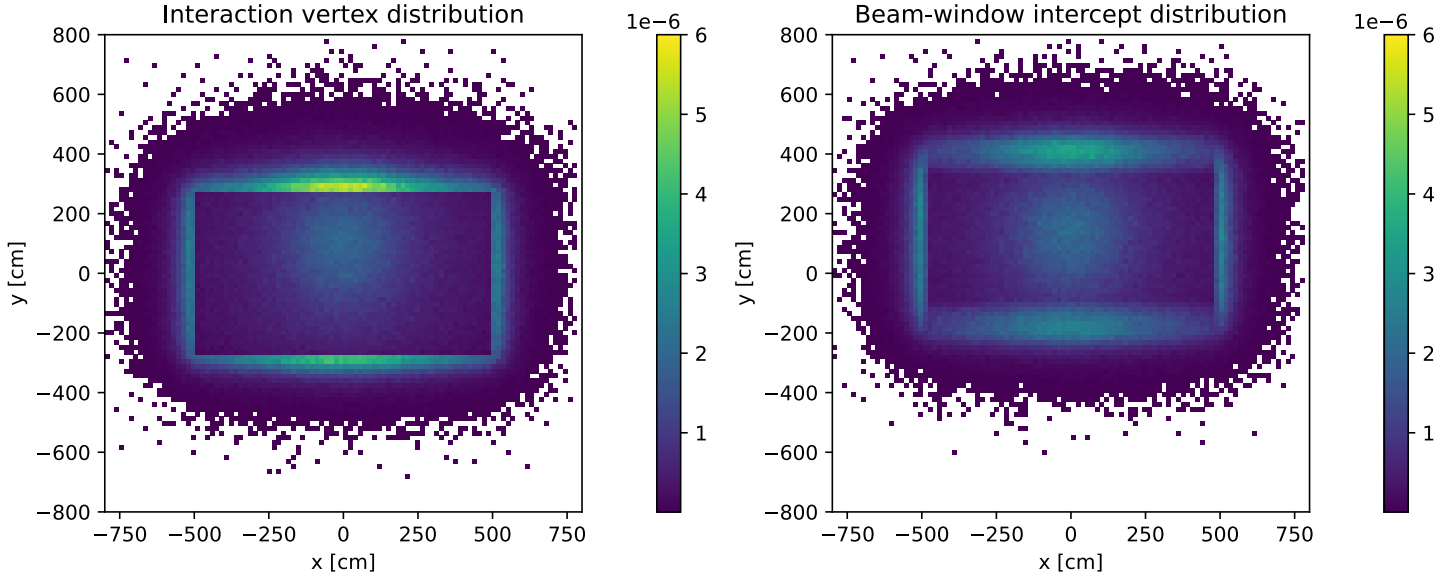
Looking at first 100 files in

`/global/cfs/cdirs/dune/users/mkramer/mywork/2x2_sim/run-convert2h5/output/MiniRun3_1E19_RHC.convert2h5.withMinerva/EDEPSIM_H5/`

And look only at events that are produced inside the rock.



White means zero events

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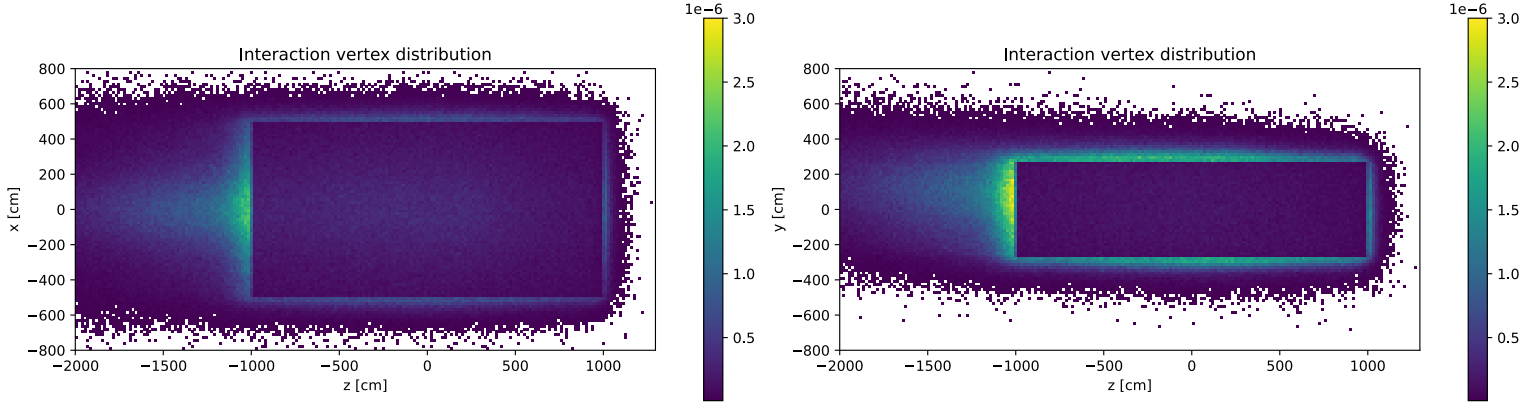
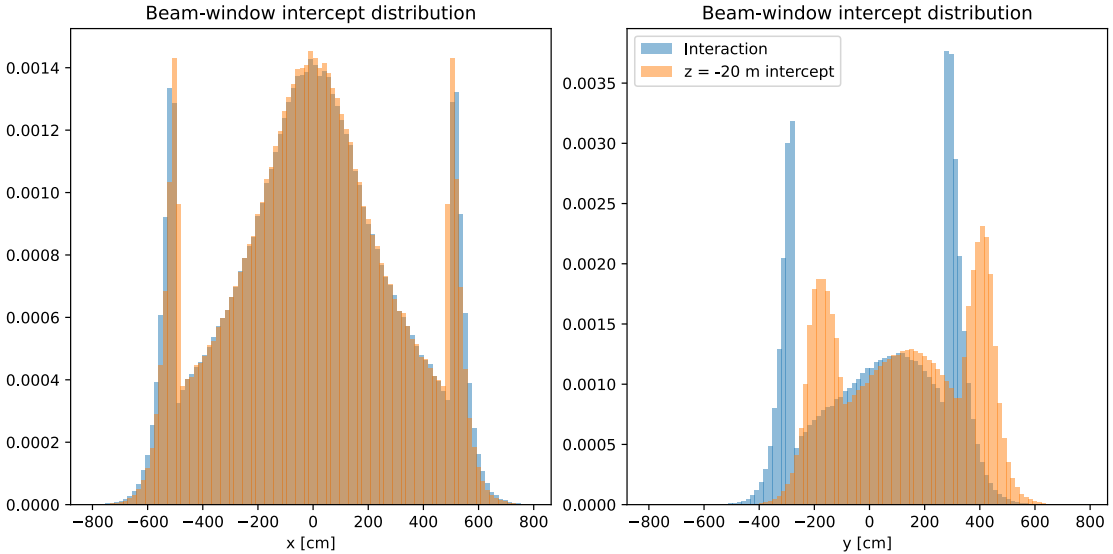

Interaction vertex distribution
x [cm]
z [cm]
1e−6
Interaction vertex distribution
y [cm]
z [cm]
1e−6


Beam-window intercept distribution
x [cm]
Beam-window intercept distribution
Interaction
z = -20 m intercept
y [cm]

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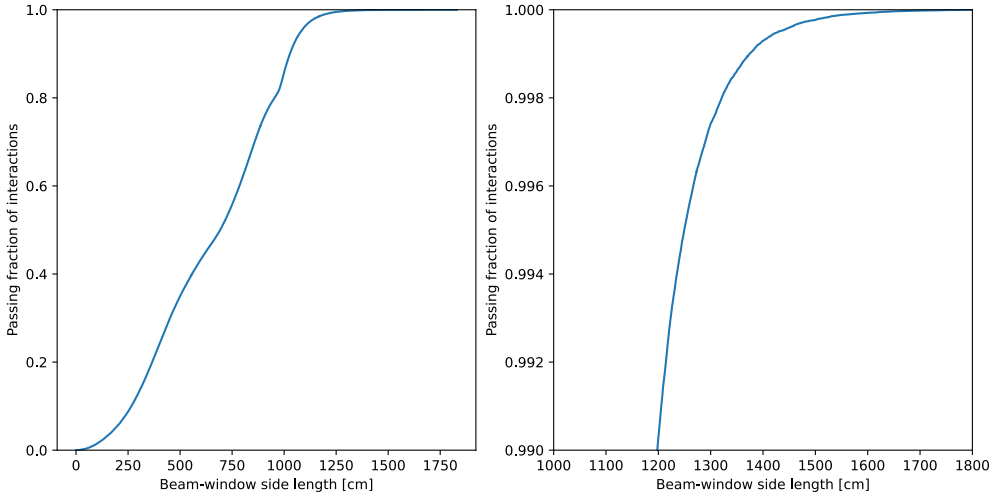
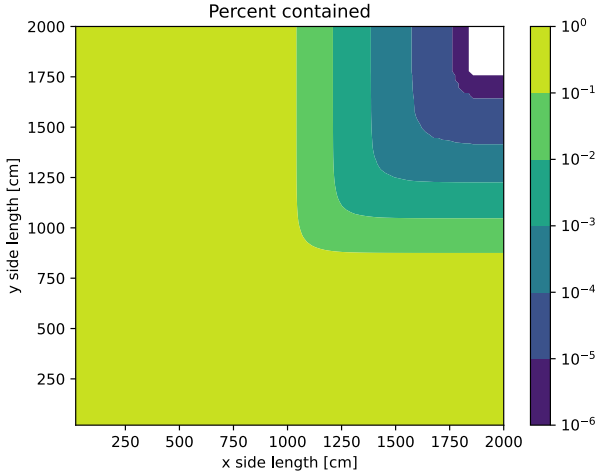
Square window



Max intercept at side length of 17.5 m

Rectangular window



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Conclusion 1:

We can safely reduce the beam window from side length from 40 m to 18 m. This corresponds to a 20% of volume.

To see what this means in terms of computational improvement, we need to look at Genie files.

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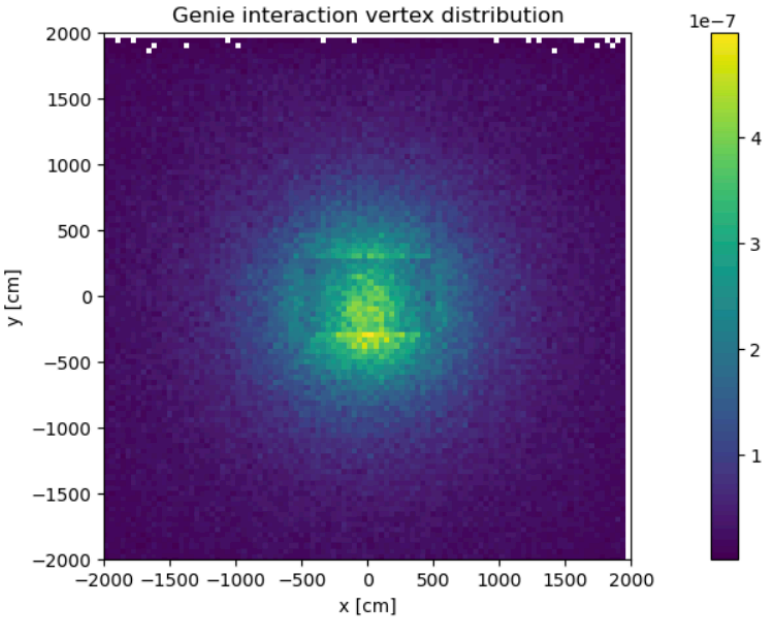
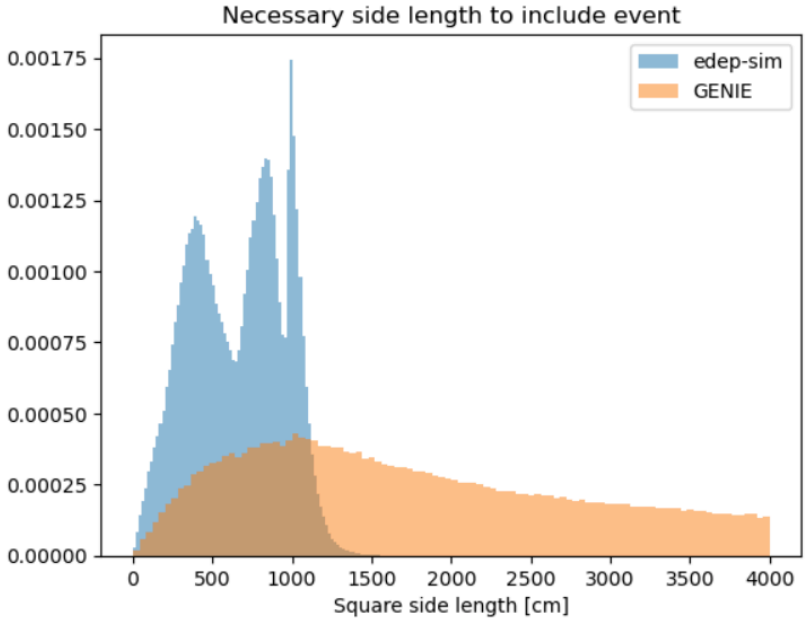

Genie interaction vertex distribution
2000
1500
1000
500
0
−500
−1000
−1500
−2000
y [cm]
−2000 −1500 −1000 −500 0 500 1000 1500 2000
x [cm]
1e−7
4
3
2
1


Necessary side length to include event
edep-sim
GENIE
0.00175
0.00150
0.00125
0.00100
0.00075
0.00050
0.00025
0.00000
0 500 1000 1500 2000 2500 3000 3500 4000
Square side length [cm]

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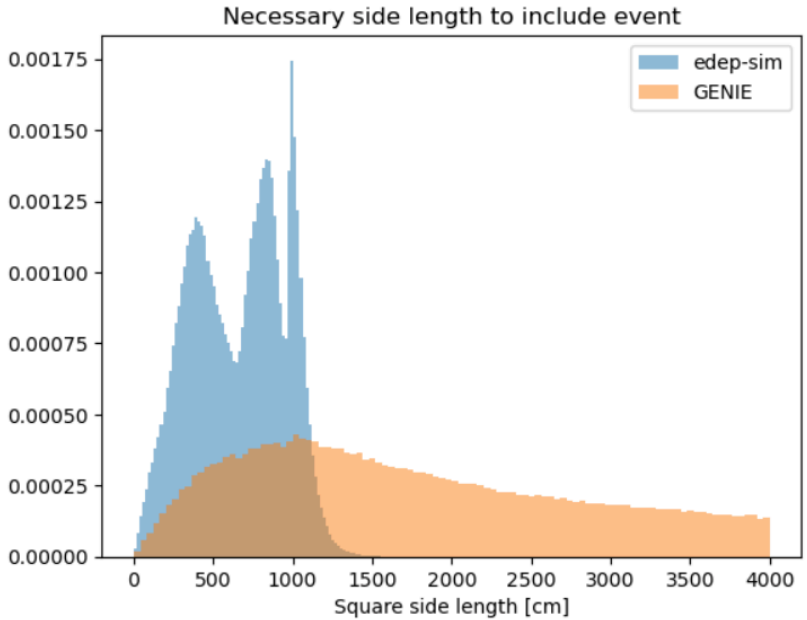
Conclusion 2: A box beam-window with side length 18 m will reduce rock computation time to 56% of the original amount.

Unfortunately, detector-sensitive events rapidly rise as you go lower in beam window size.



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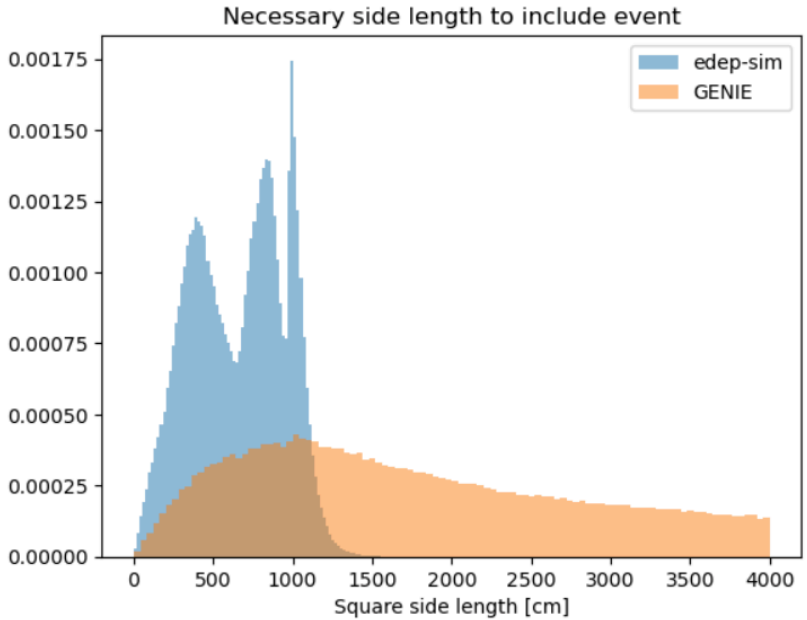

Buuuuut, we have another dimension…

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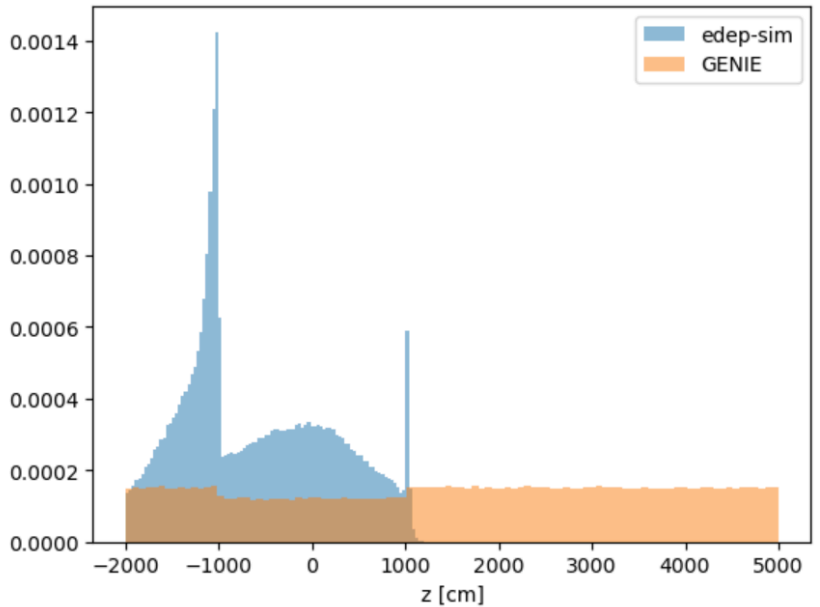
Can we get rid of points in the z-axis?

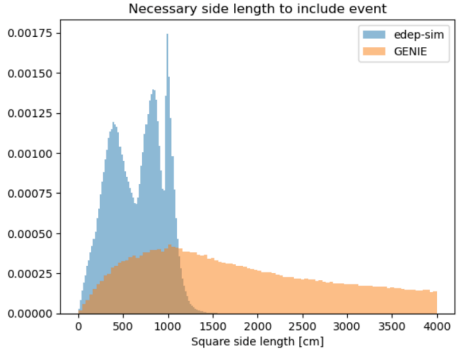
Events are being simulated out to 50 m past the 2x2, but the furthest event detected had a vertex at ~13 m.

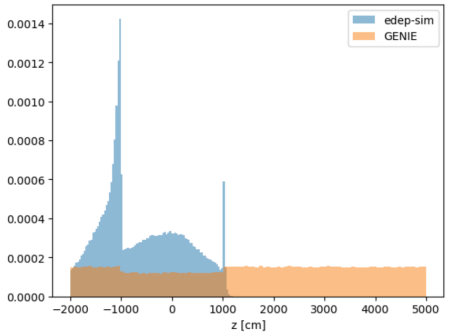
This gives another factor of ~2 that we can cut out.



With the combination of reducing the beam window to a side length of 18 m, and limit interaction vertices to z < 13 m, we can reduce rock computation time to 23% of the current time.

My thoughts: The above boundaries lie close to peaks of detector-sensitive events. Therefore, I think this is close to limit that box-cuts in the interaction vertices can provide. Further improvements would require more complex cuts (e.g. outgoing muon energy or angle dependent)





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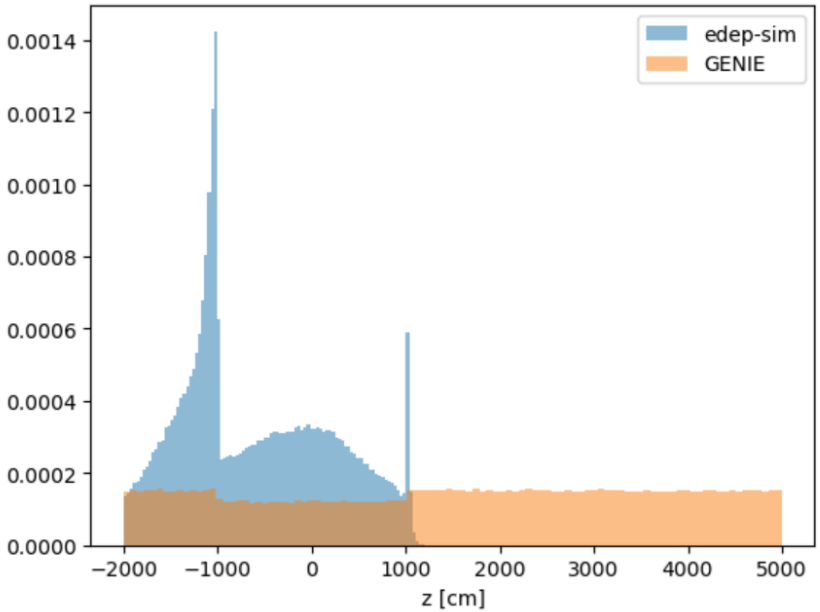
Also, the sudden cutoff of events at z=-20 m tells us that the beam-window is not upstream enough.



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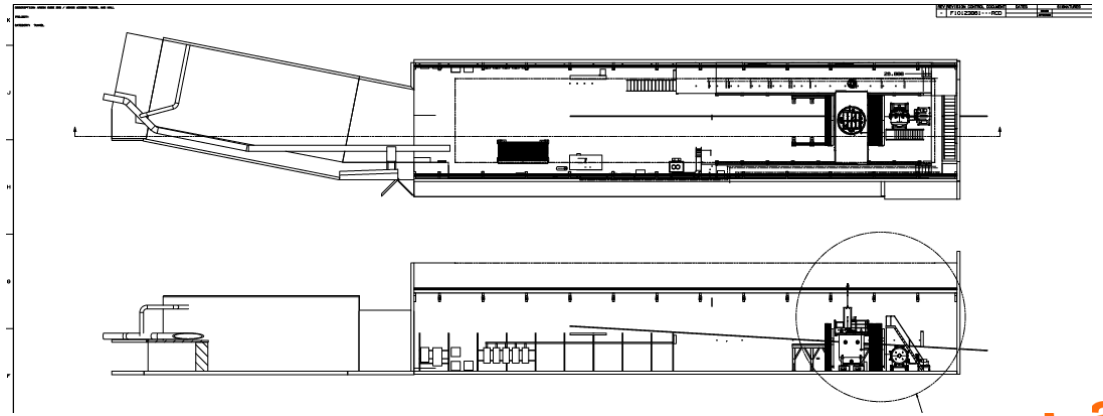
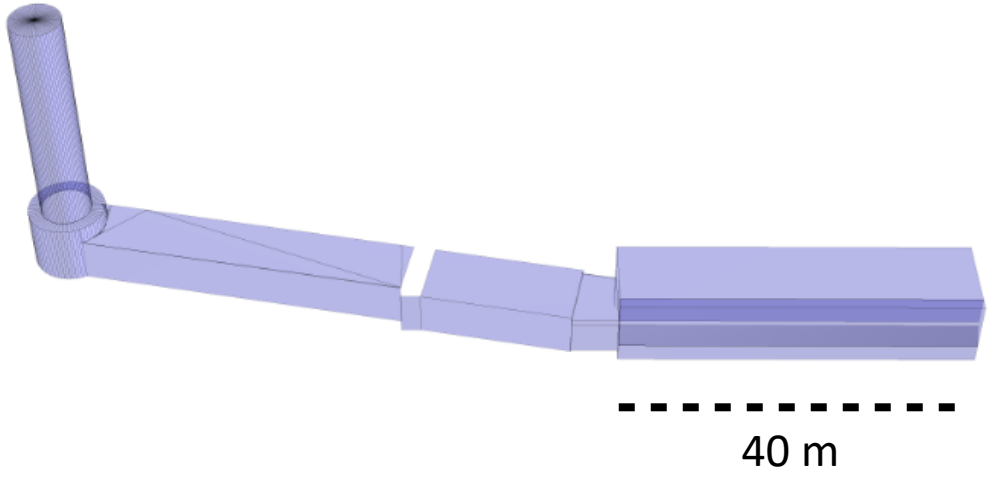
Above simulations were made with a simplified hall geometry. Zach is nearing completion on a more accurate model, and simulations will be redone once updated hall geometry is inputted.



For test with new geometry, we plan to place the window significantly upstream.

Matt, please teach me to run the simulations



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