Abstract

I present a computational investigation of single-particle dynamics in a double-slit geometry that deliberately avoids any measurement-induced perturbation. Using a straightforward trajectory-simulation program, I model the motion of individual particles emitted from a point source ("the gun") toward a detection screen, allowing them to interact elastically with the interior surfaces of the slits. By systematically varying wall thickness, slit height, inter-slit gap, particle speed, size, and incident angle, I generate a series of impact distributions ranging from uniform spreads to highly structured multi-cluster patterns. Notably, when the wall thickness allows the particle to bounce several times inside the slit, the emergent patterns evolve into configurations that closely resemble the classic interference fringes of quantum double-slit experiments.

My analysis reveals that these wave-like imprints arise from the superposition of numerous classical trajectories produced by successive bounces off the slit walls, rather than from an intrinsic wave property of the particles. Consequently, the study suggests that apparent interference phenomena can be reproduced within a purely classical framework, highlighting the pivotal role of mechanical interactions between particles and slit boundaries in shaping observed detection pattern.

Simulating Single-Particle Trajectories in a Double-Slit Setup

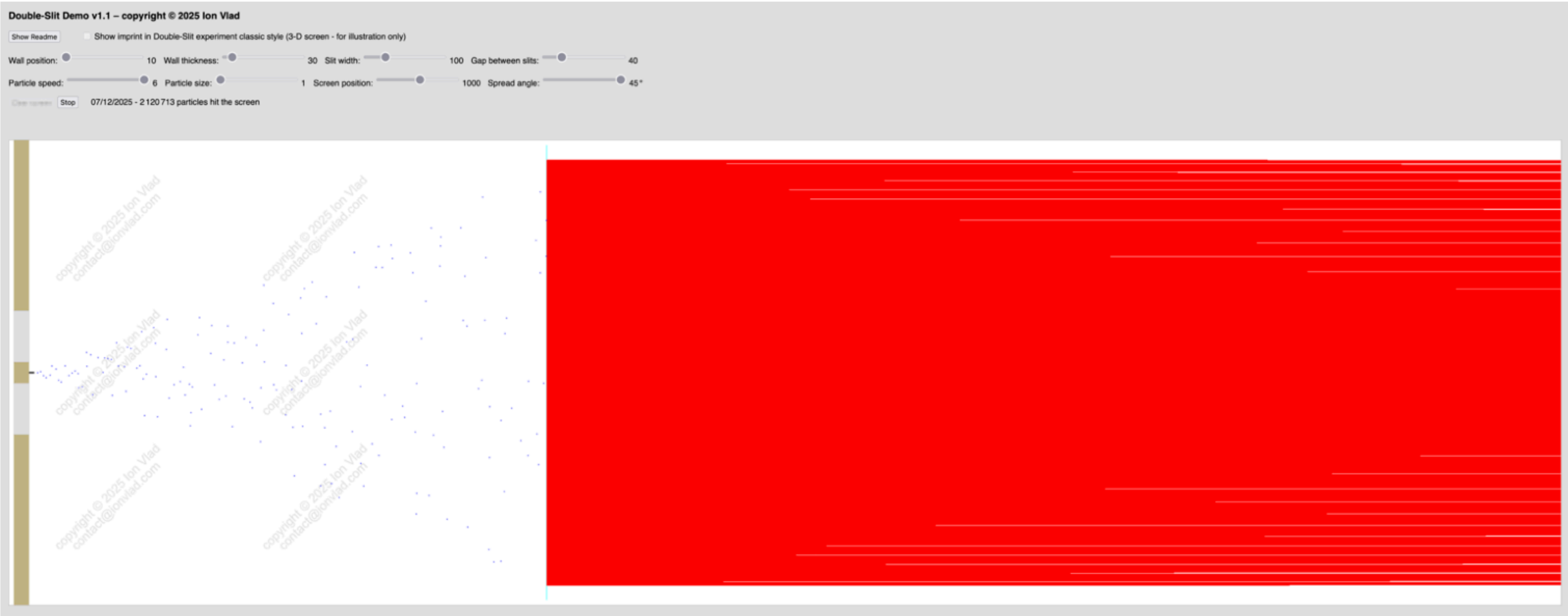
The double-slit experiment performed with individual particles has been reproduced many times, yet a universally accepted description of how a single particle can exhibit wave-like behaviour remains elusive. In quantum mechanics we learn that any attempt to detect, observe, or measure a particle inevitably perturbs its trajectory, leading to conclusions that may not reflect the particle's intrinsic dynamics.

To explore the motion of a solitary particle without invoking measurement, I wrote a simple program that simulates its trajectory from a source ("the gun") to a detection screen. The results are illustrated in the screenshots below.

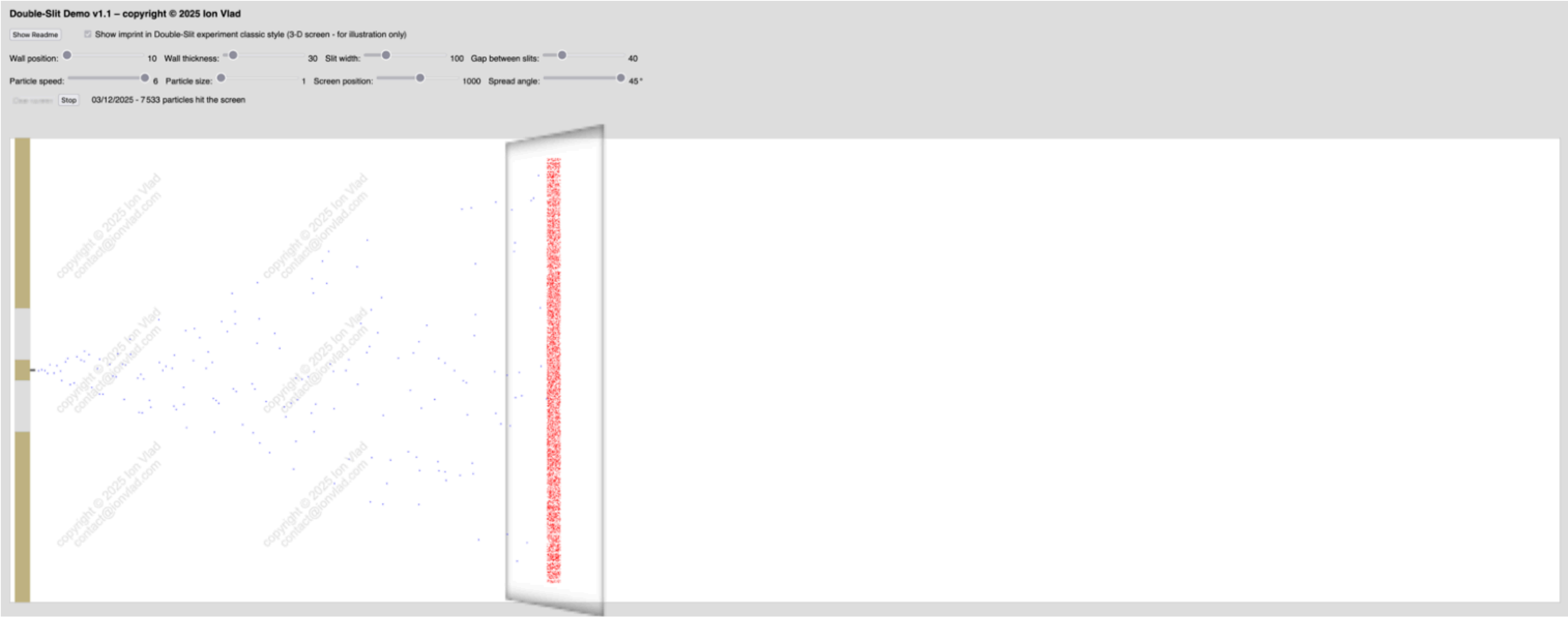
Because it’s a computer simulation, I used pixels as the measurement unit, but any unit works as long as the proportions are preserved. Also, because the particle’s mass is assumed to be negligible, the simulation treats each bounce off the wall or slit as perfectly elastic—so the particle’s speed remains unchanged after every collision.

1. No Obstacle Between Source and Screen

When there is no wall separating the gun from the screen, the impact pattern on the detector is essentially uniform—a flat spread of hits. This can be seen on Screenshot 1 2D and Screenshot 1 3D.



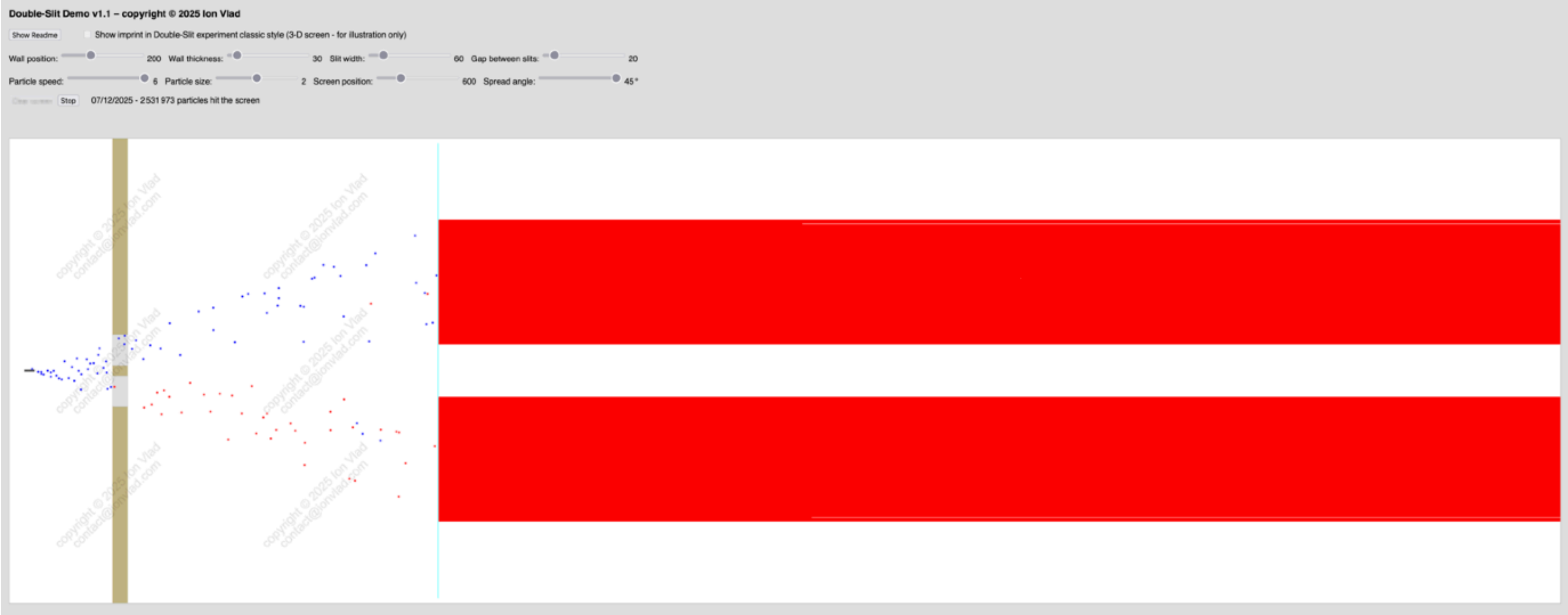
Screenshot 1 2D



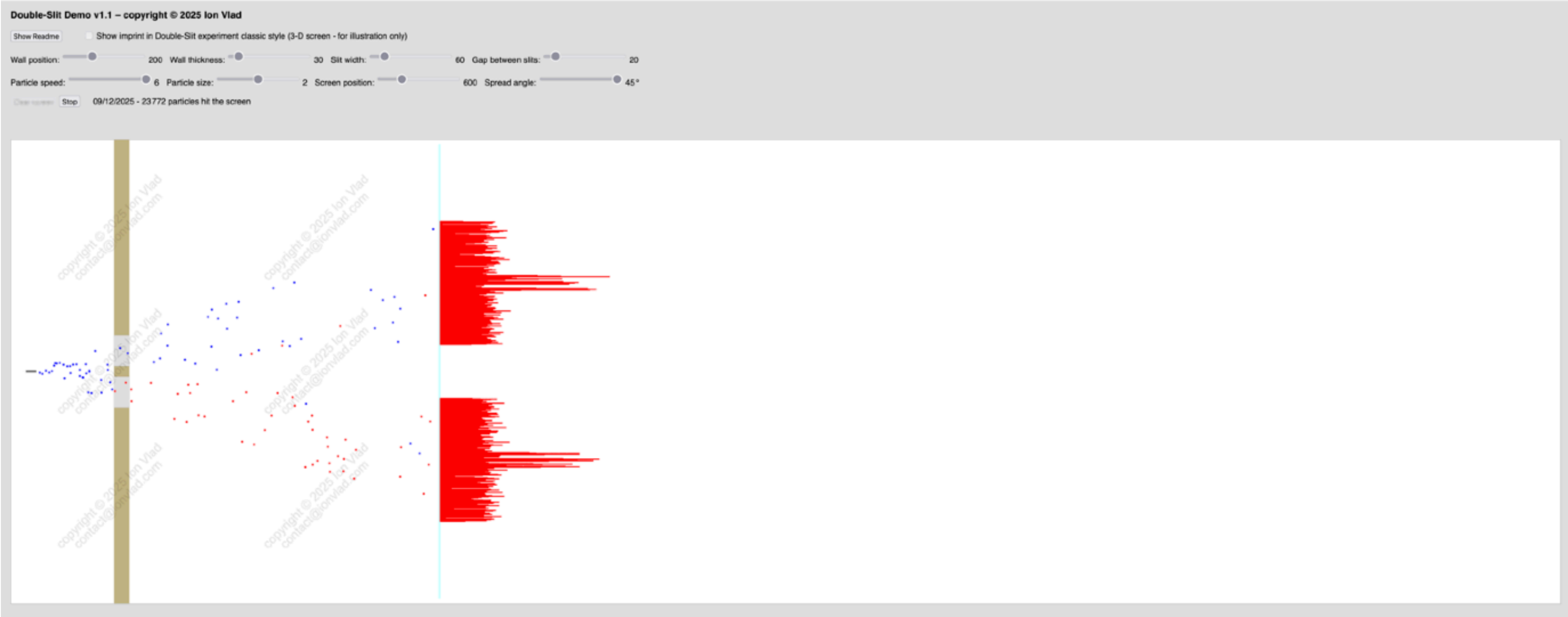
Screenshot 1 3D

2. Introducing a Wall with Two Slits

Adding a barrier that contains two narrow openings produces a markedly different pattern. The screen now shows two distinct clusters of impacts, corresponding to particles that passed through each slit.



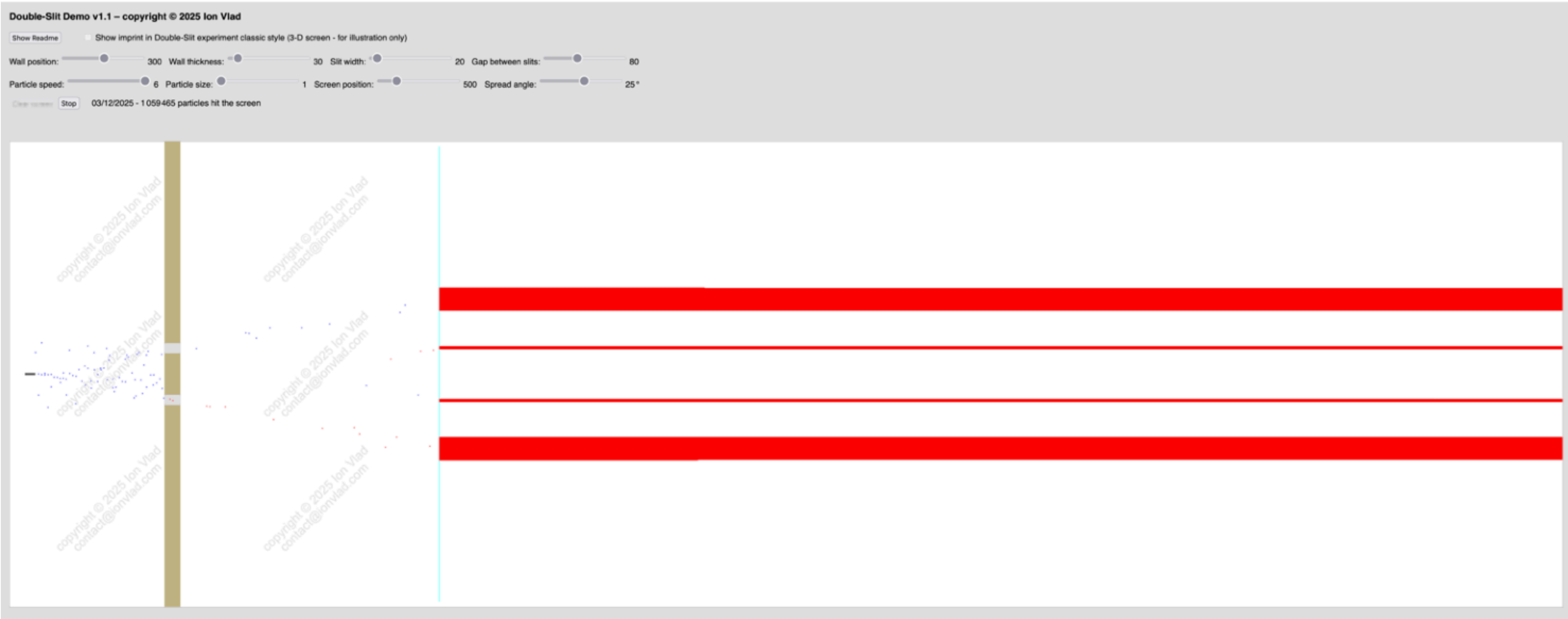
Screenshot 2 2D



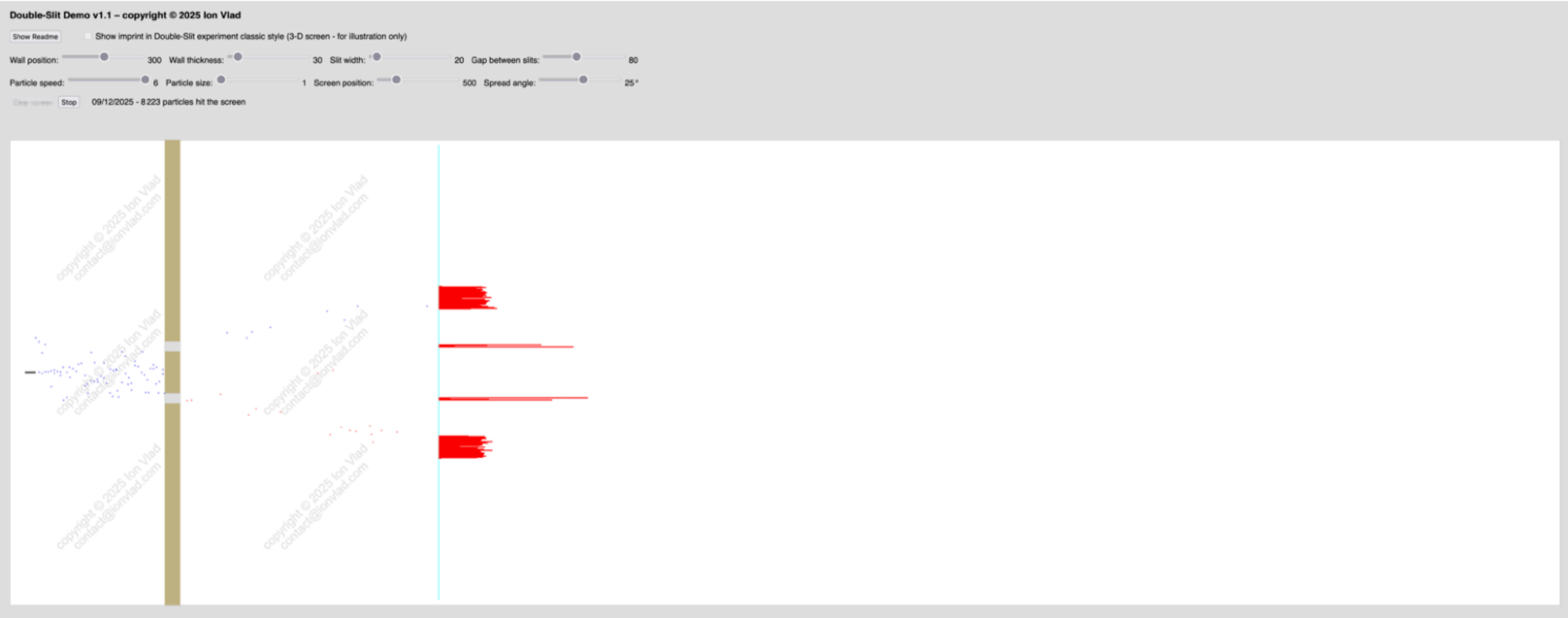
Screenshot 2 2D intermediate

3. Varying Wall Thickness, Slit Height, and Gap

Increasing the wall’s thickness, adjusting the slit height, or widening the separation between the slits yields a more intricate distribution. In Screenshot 3 2D and Screenshot 3 2D *intermediate, the* imprint resolves into four separate bundles, even though only two slits are present. This occurs because particles can bounce off any of the four interior surfaces of the slits.



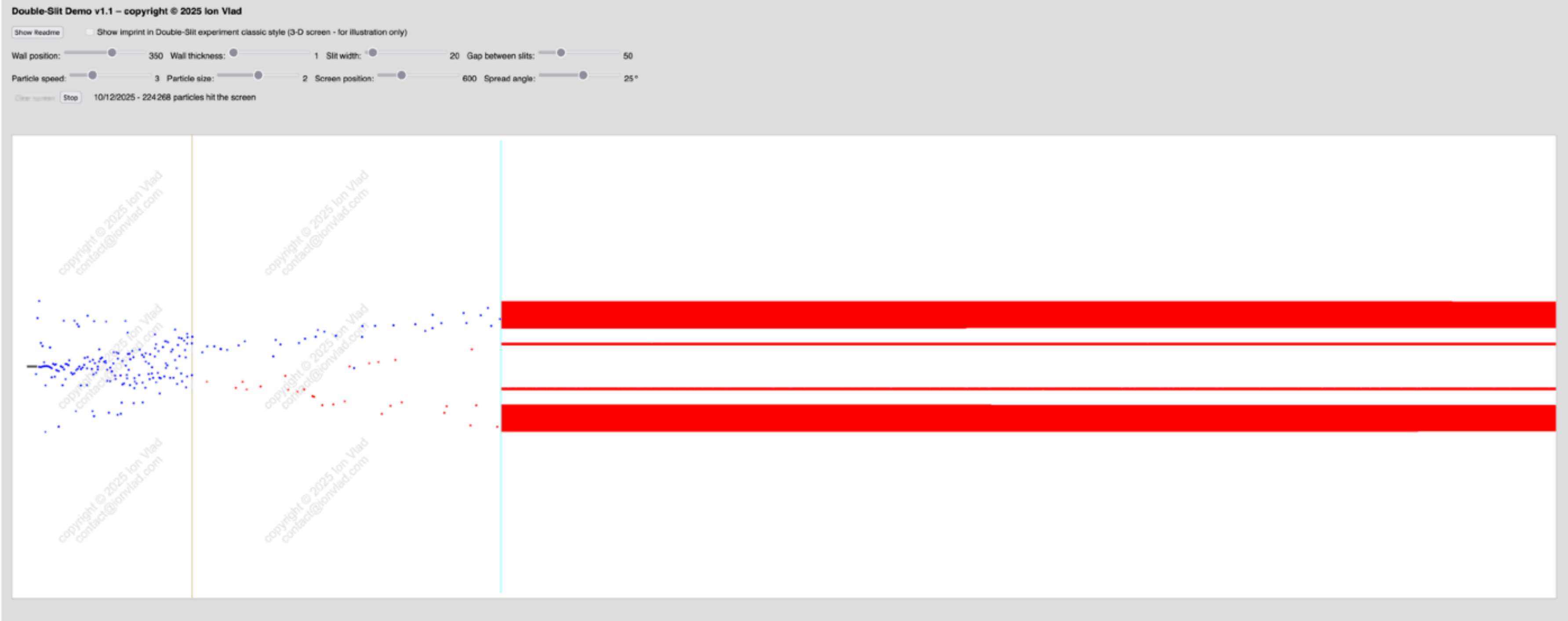
Screenshot 3 2D



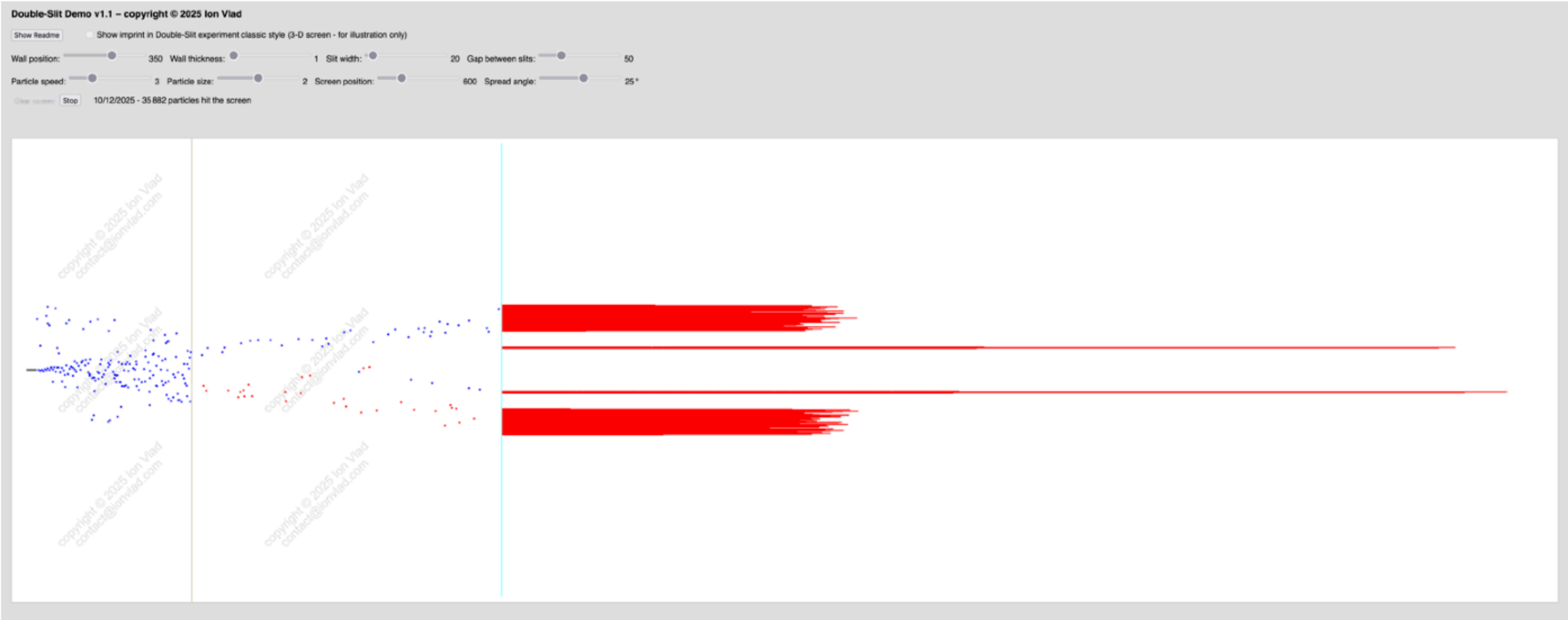
Screenshot 3 2D intermediate

4. Thin Walls Relative to Particle Size

Surprisingly, the same multi-bundle pattern emerges when the wall's thickness is reduced to less than the particle's diameter, as shown in Screenshot 4.2 2D and in Screenshot 4.2 2D intermediate.



Screenshot 4.2 2D



Screenshot 4.2 2D intermediate

5. Further Parameter Tuning

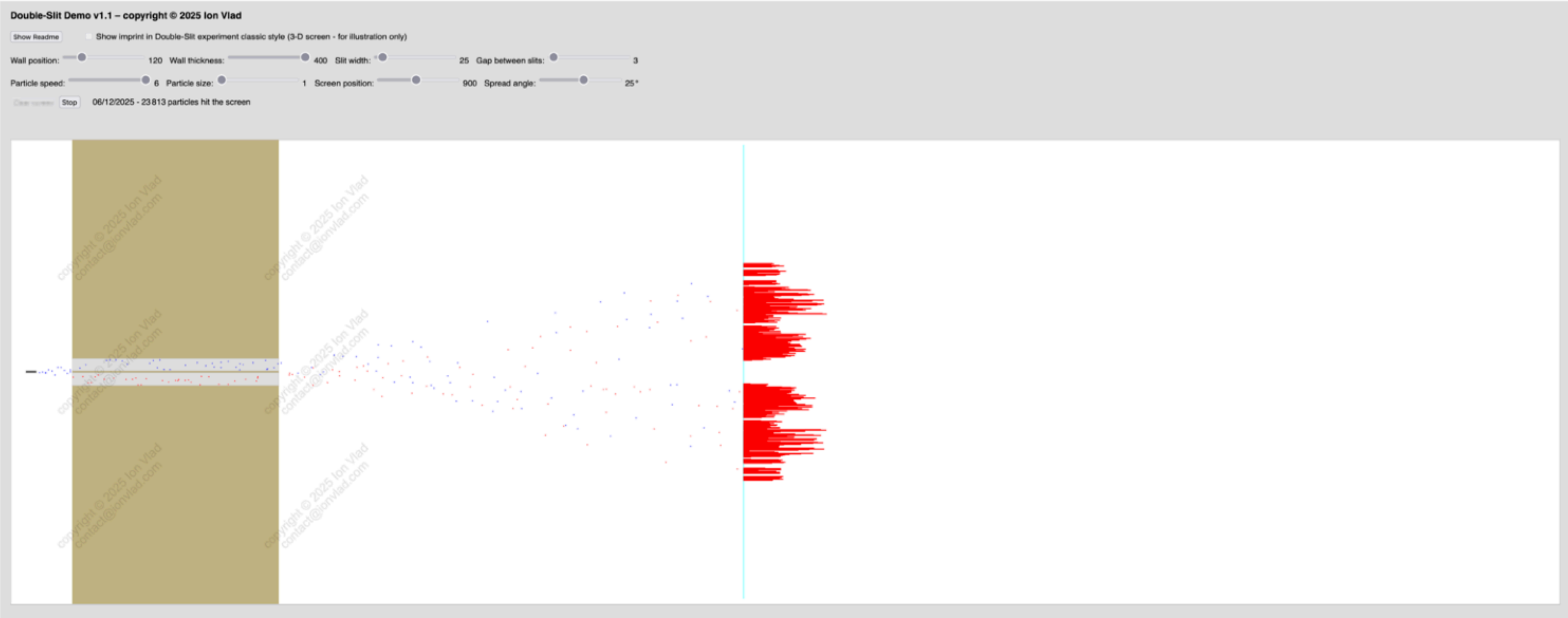
By fine-tuning additional parameters—such as particle size, speed, incident angle, slit dimensions, and the distances between gun, wall, and screen—the impact pattern becomes increasingly complex. Screenshot 5 2D displays an even larger number of distinct bundles.

Screenshot 5 2D

6. Emergence of a Wave-Like Distribution

When the system is configured appropriately, the resulting imprint begins to resemble a classic interference pattern, with alternating high- and low-intensity regions reminiscent of a wave. This effect is evident in Screenshot 6 3D and Screenshot 6 2D intermediate.

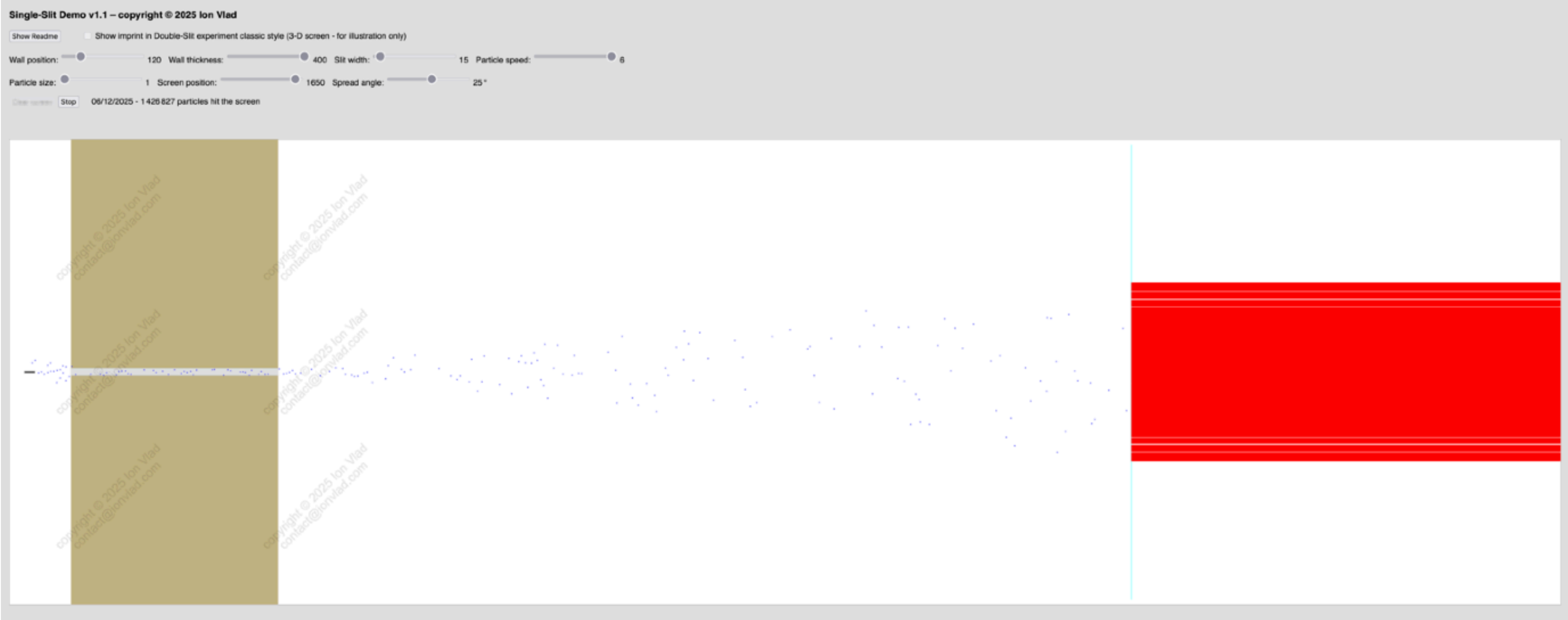
Screenshot 6 3D



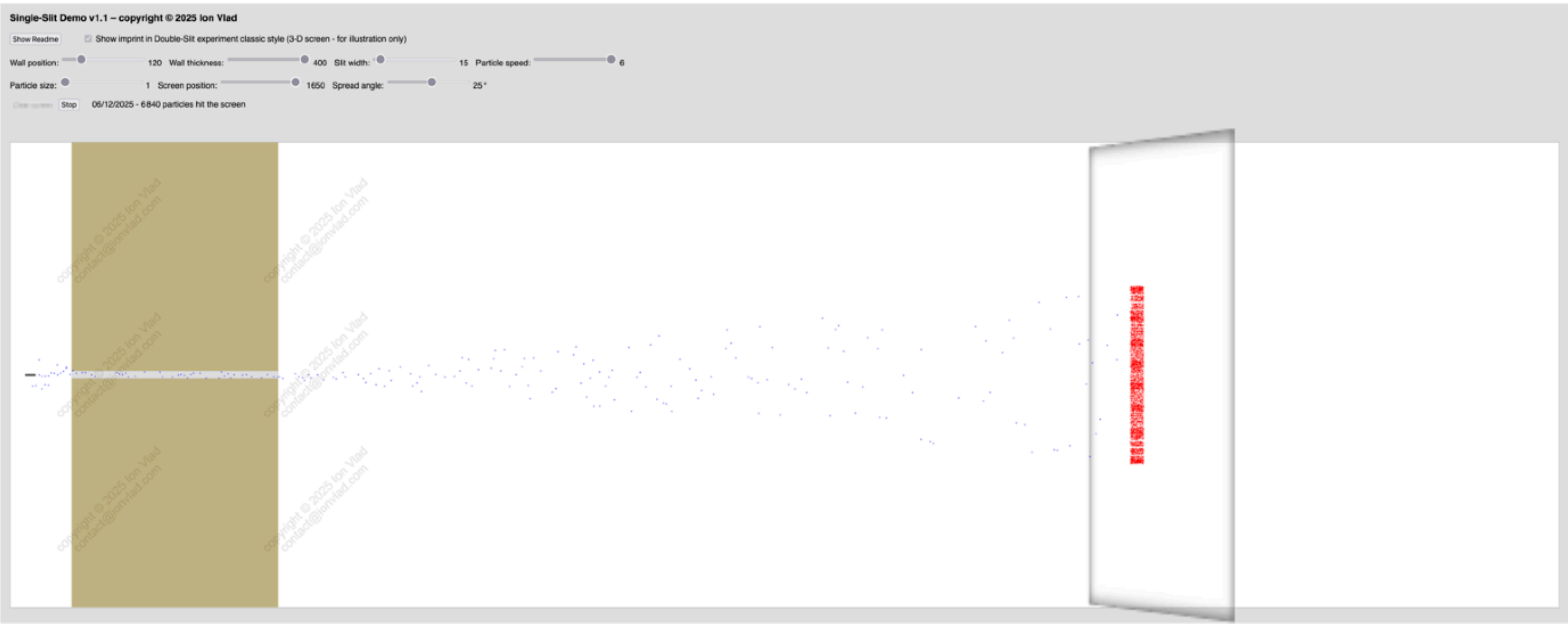
Screenshot 6 2D intermediate

7. Single slit wall

Surprisingly, the same multi-bundle pattern emerges even when the wall has only a single slit, as shown in Screenshot 7 2D and in Screenshot 7 3D.



Screenshot 7 2D



Screenshot 7 3D

Discussion

The observed “wave-like” imprint appears to arise from the particle’s propensity to bounce off the interior surfaces of the slits. Each collision can alter the particle’s direction and speed, allowing it to emerge from the slit at a variety of angles. Consequently, the final distribution on the screen reflects a superposition of many possible trajectories rather than a true wave phenomenon.

From this perspective, any detector, beam splitter, or deflector that interacts with the particle inevitably modifies its path, potentially leading to misleading interpretations of the underlying physics.

Conclusion

The simulations suggest that the interference-like patterns commonly attributed to wave behaviour can be reproduced by classical bouncing dynamics alone. In other words, the “wave-like” imprint may stem from the mechanical interactions of a single particle with the slit walls, rather than from an intrinsic wave nature of the particle itself. Reproducing the pattern does not falsify quantum mechanics, but highlights the importance of boundary interactions. While a single particle doesn’t exhibit wave-like behaviour, a collection of particles can. Conversely, a wave can be described in terms of particle behaviour—such as a photon in light or a water molecule in a ripple.

As we can see, the “wave-like” imprint occurs when the thickness of the wall is far greater than the particle diameter, which in previous experiments was kind of default since the chosen particle was an electron.

If we are to reproduce this experiment with macro particles, in order to get the same results, we have to keep the proportions right (particle diameter - wall thickness - particle mass - speed). However, there are some limitations since a greater mass would cause the particle to lose momentum inside the slit.

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All the documents, the program and even more screenshots, can be found here: https://github.com/Ion-Vlad/Simulating-Single-Particle-Trajectories-in-a-Double-Slit-Setup and here: https://drive.proton.me/urls/XG5ZKT94A8#ijnqZsisCgjv

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