



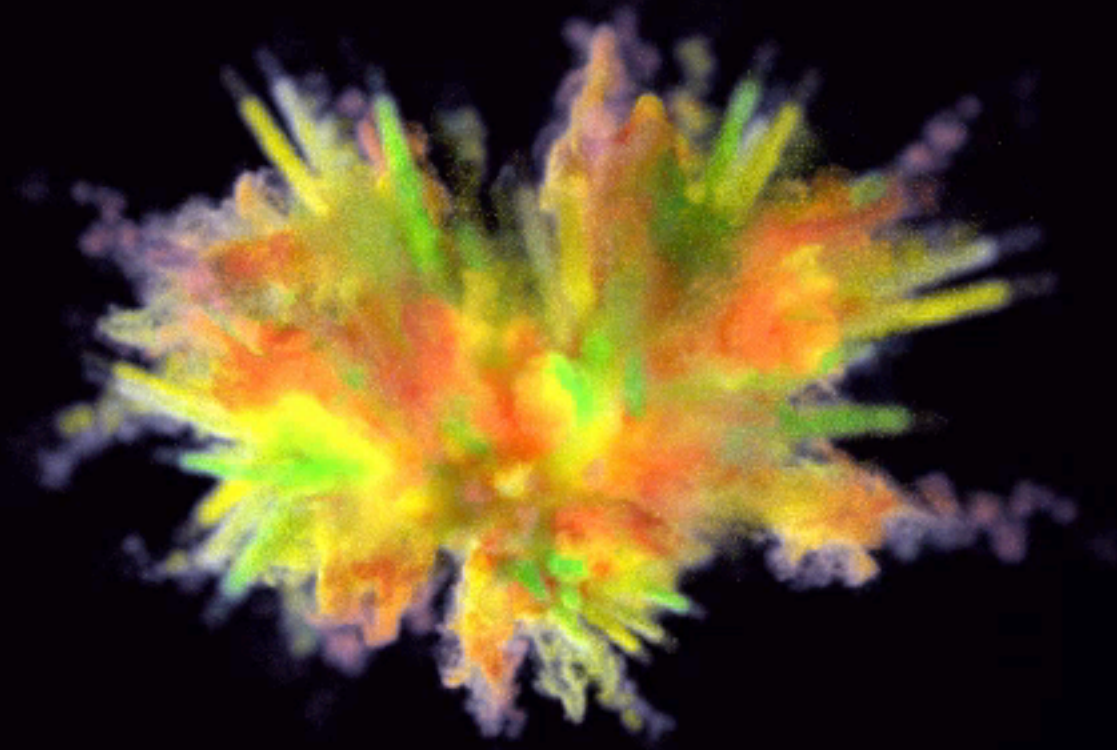
WALT DISNEY

ANIMATION STUDIOS

Spectral and Decomposition Tracking for Rendering Heterogeneous Volumes

authored by **Peter Kutz, Ralf Habel, Karl Li, and Jan Novák**
and presented by **Peter Kutz**

Chromatic Heterogeneous



Delta Tracking

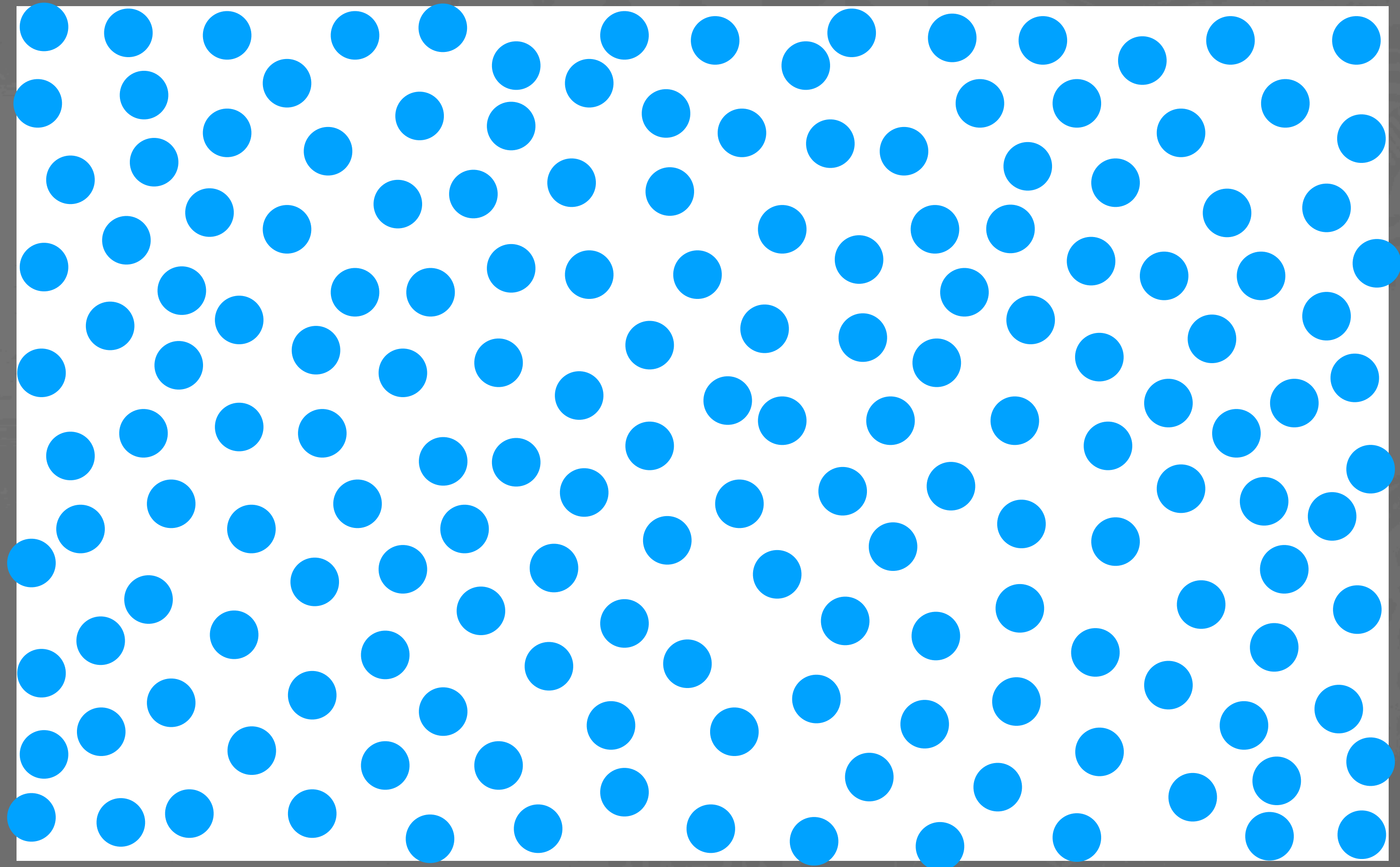
Decomposition Tracking for Increased Speed

Integral Formulation of Null-Collision Algorithms

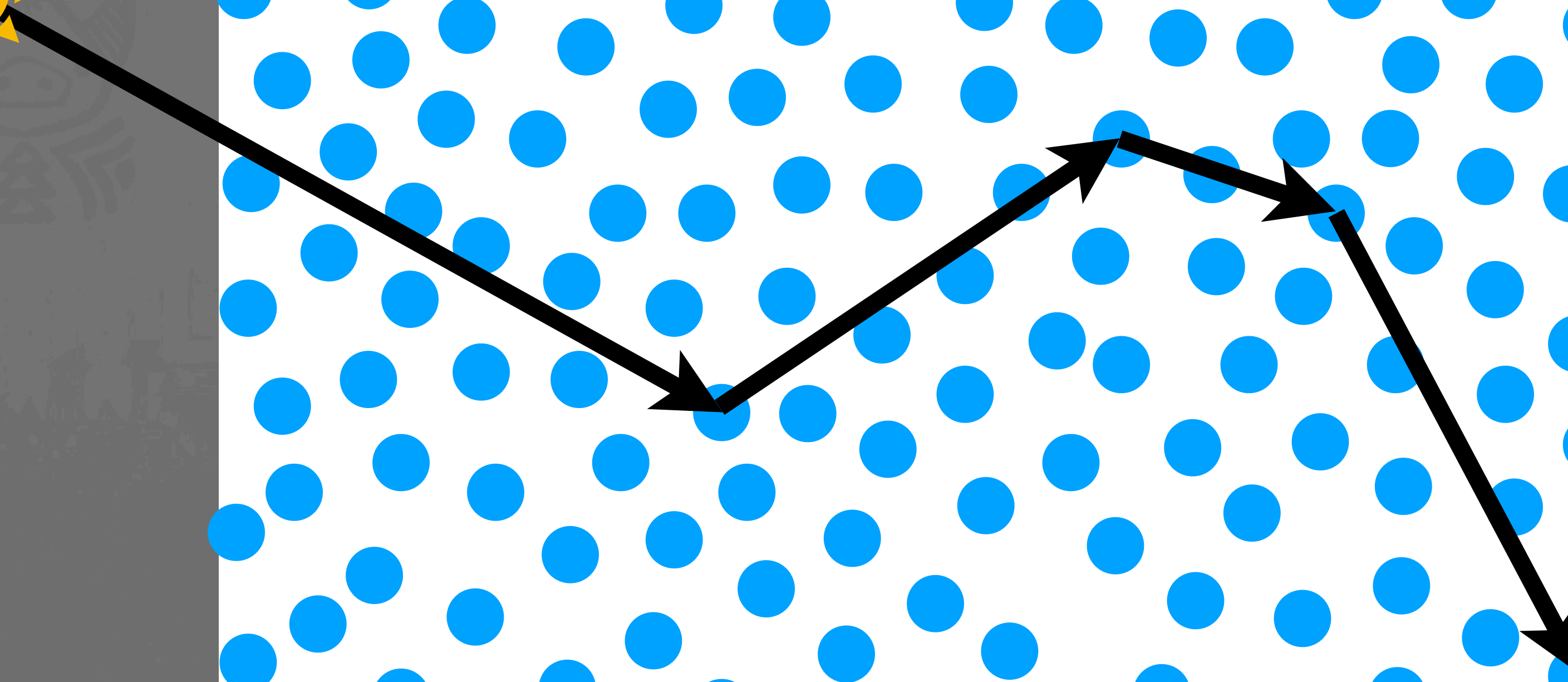
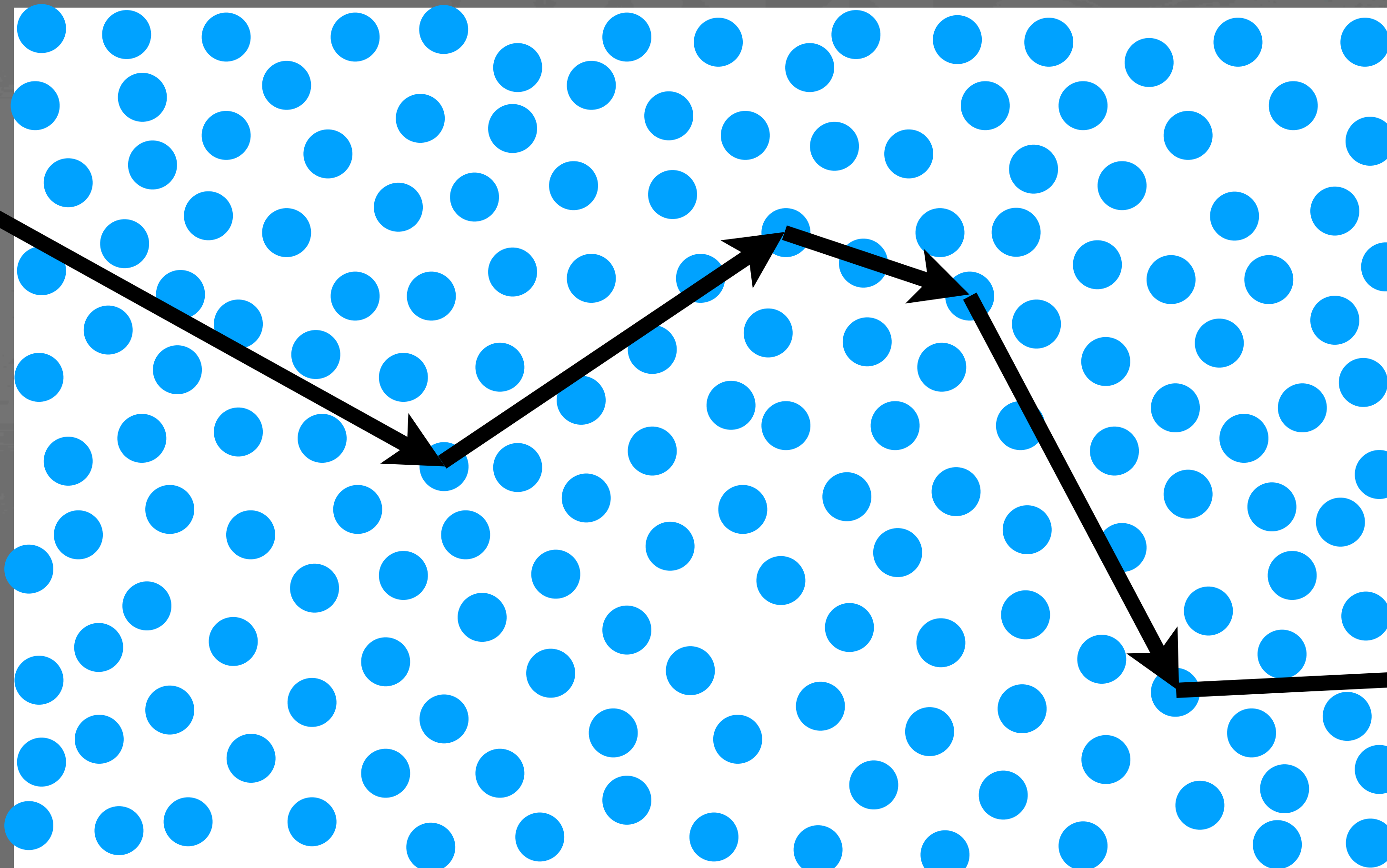
Spectral Tracking for Reduced Variance

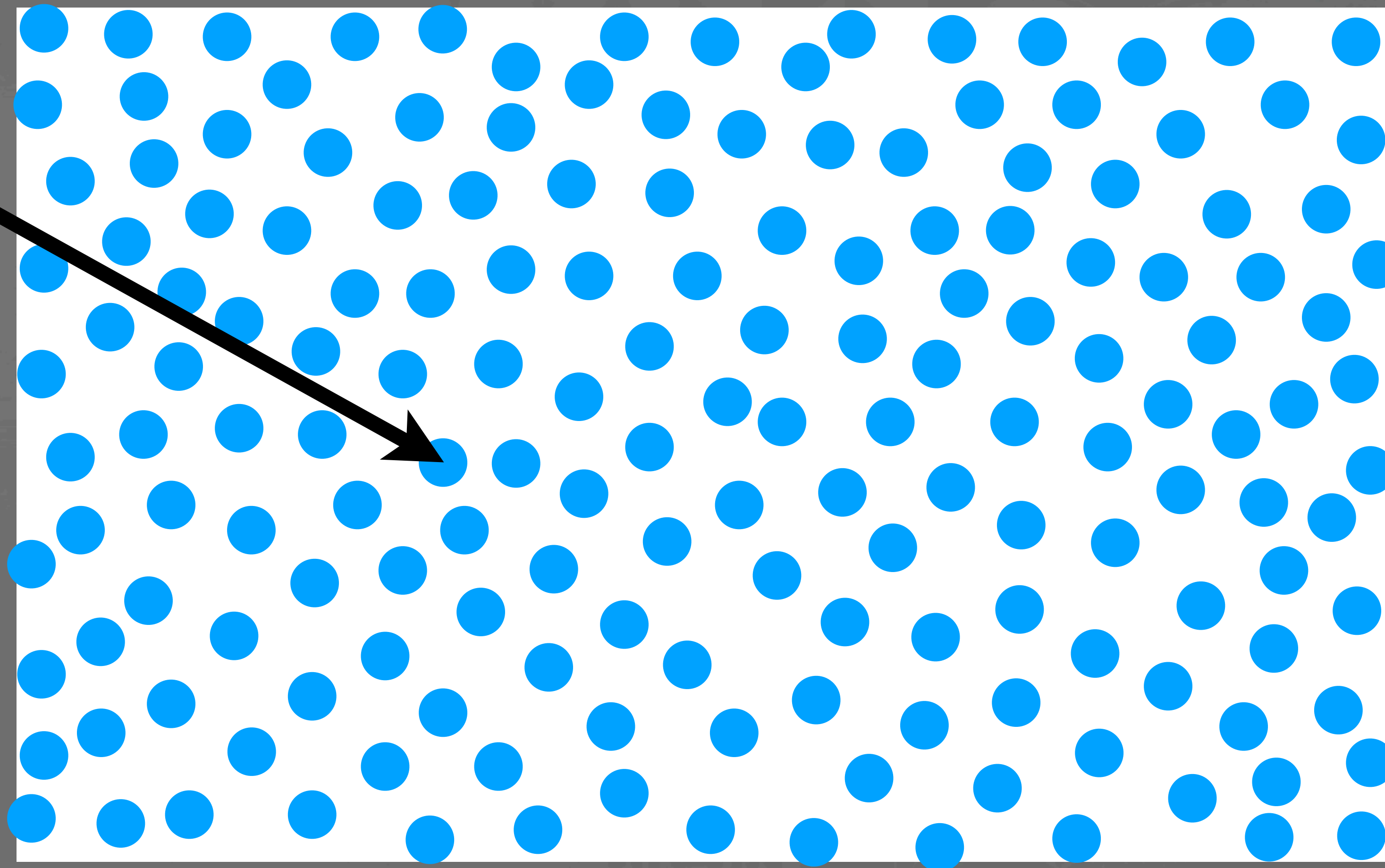
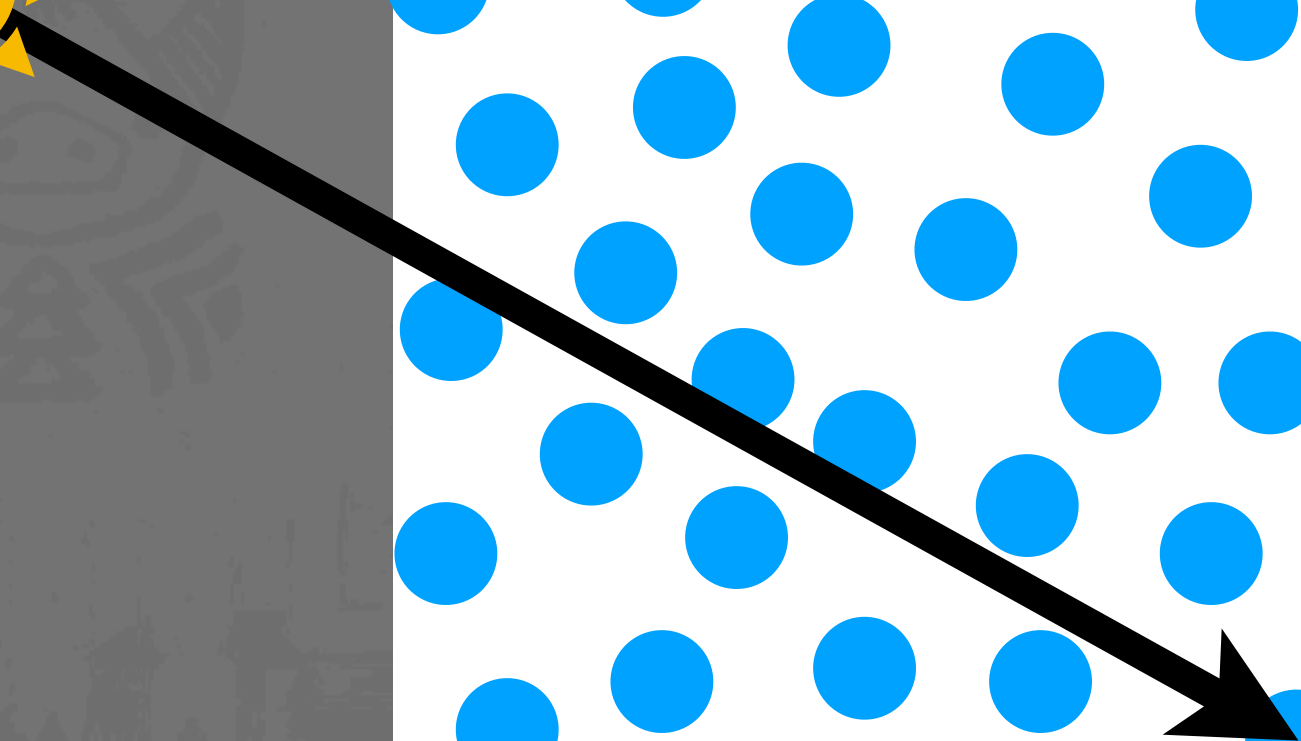
Putting It All Together

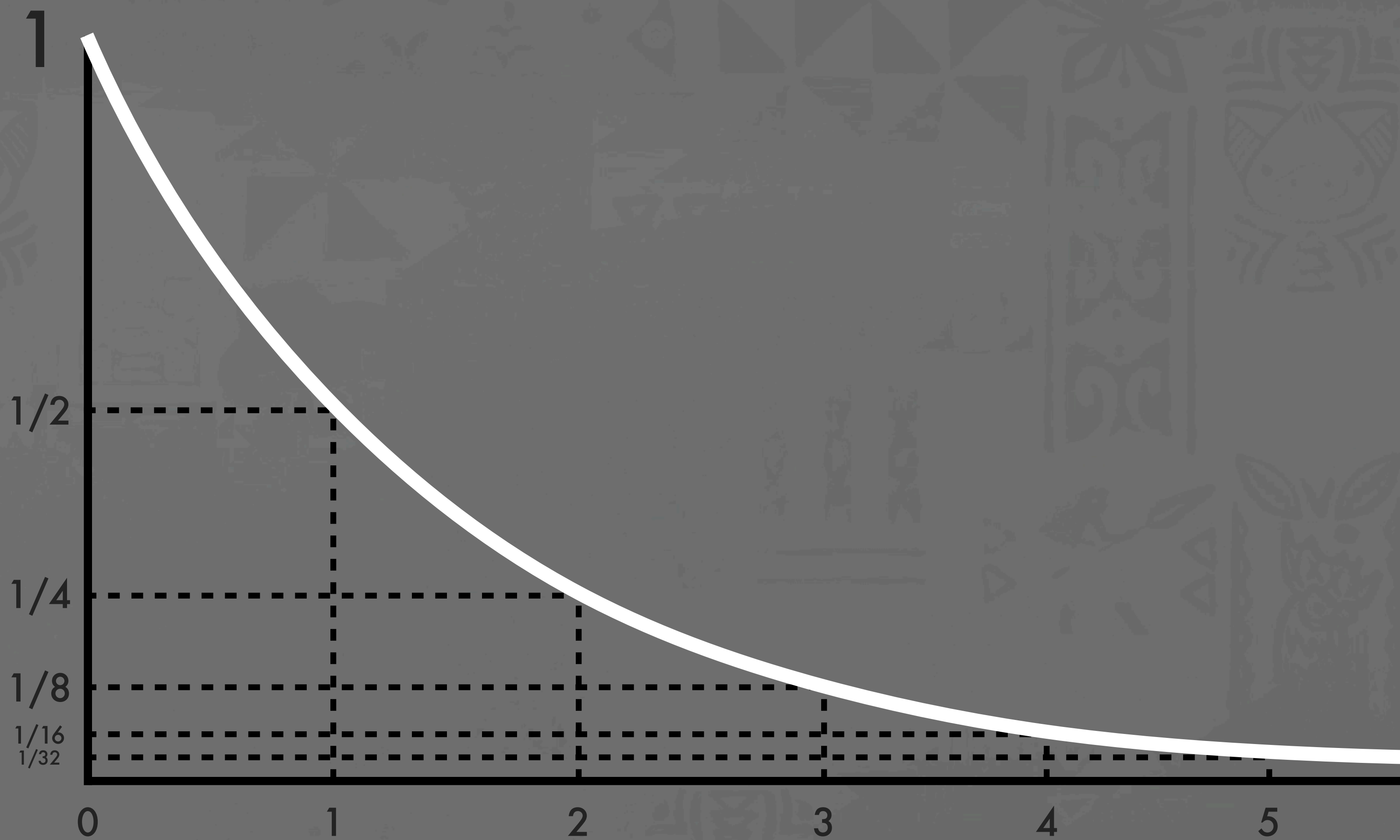
Delta Tracking



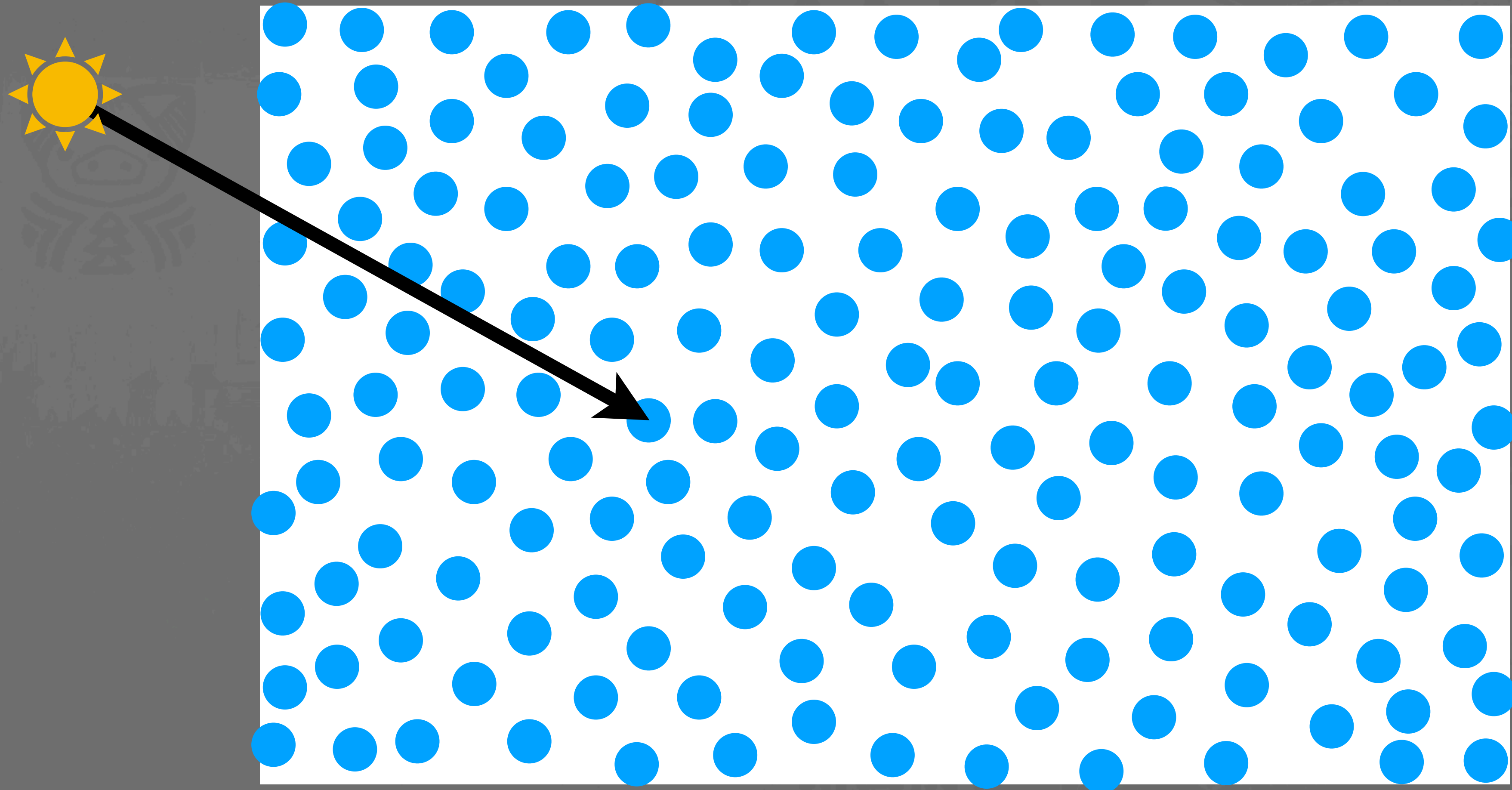
(homogeneous volume)





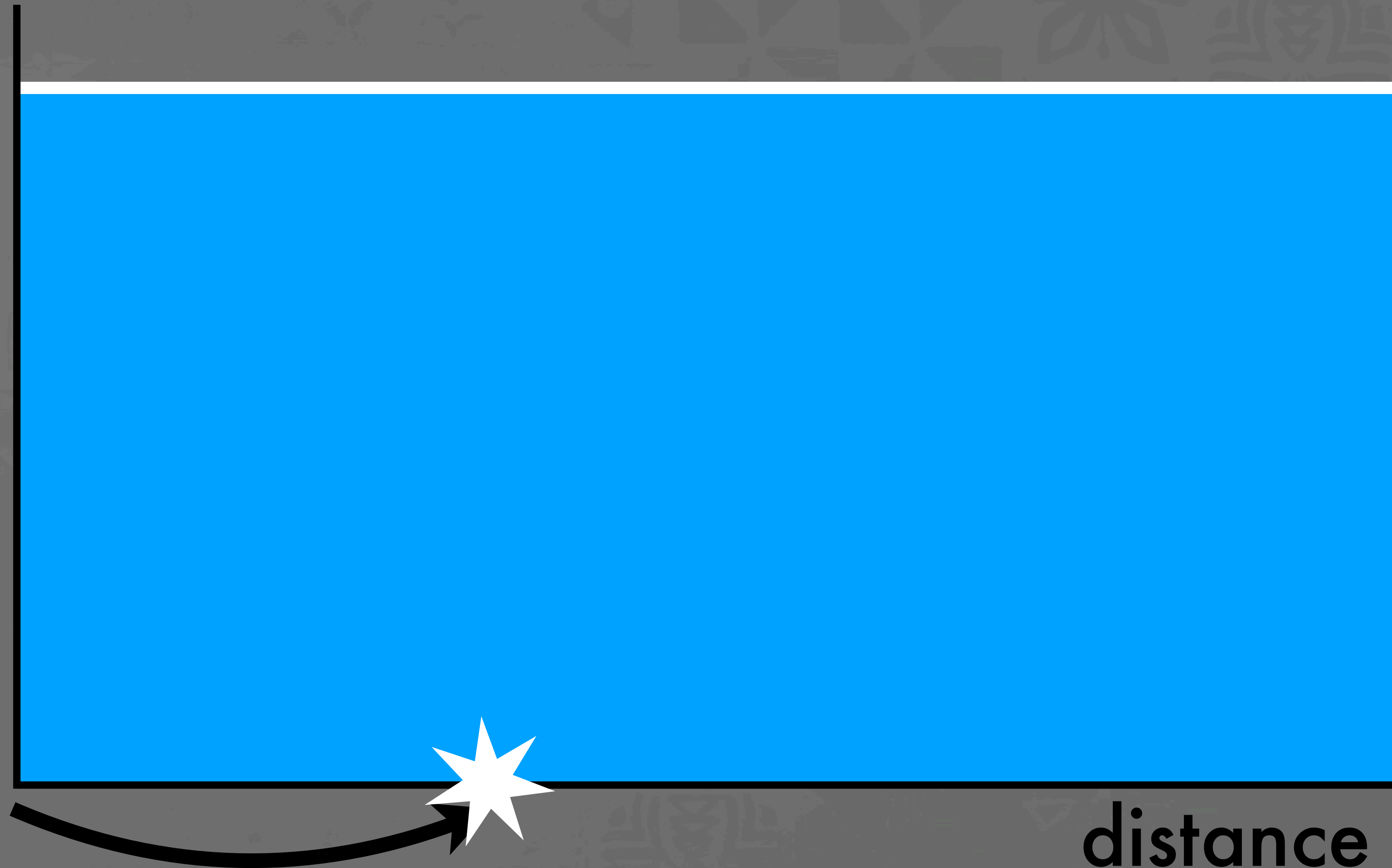


Closed-Form Tracking

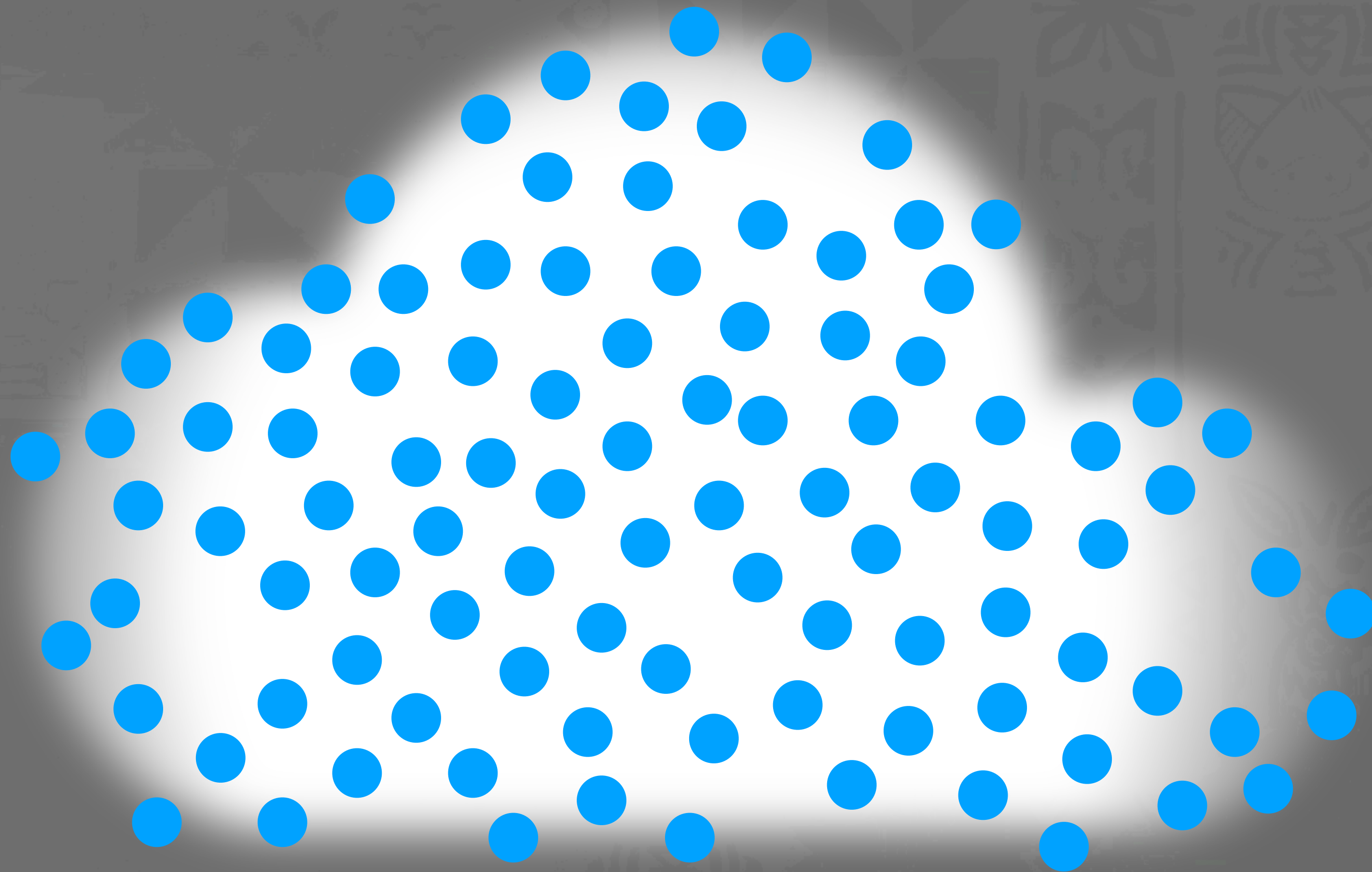


Closed-Form Tracking

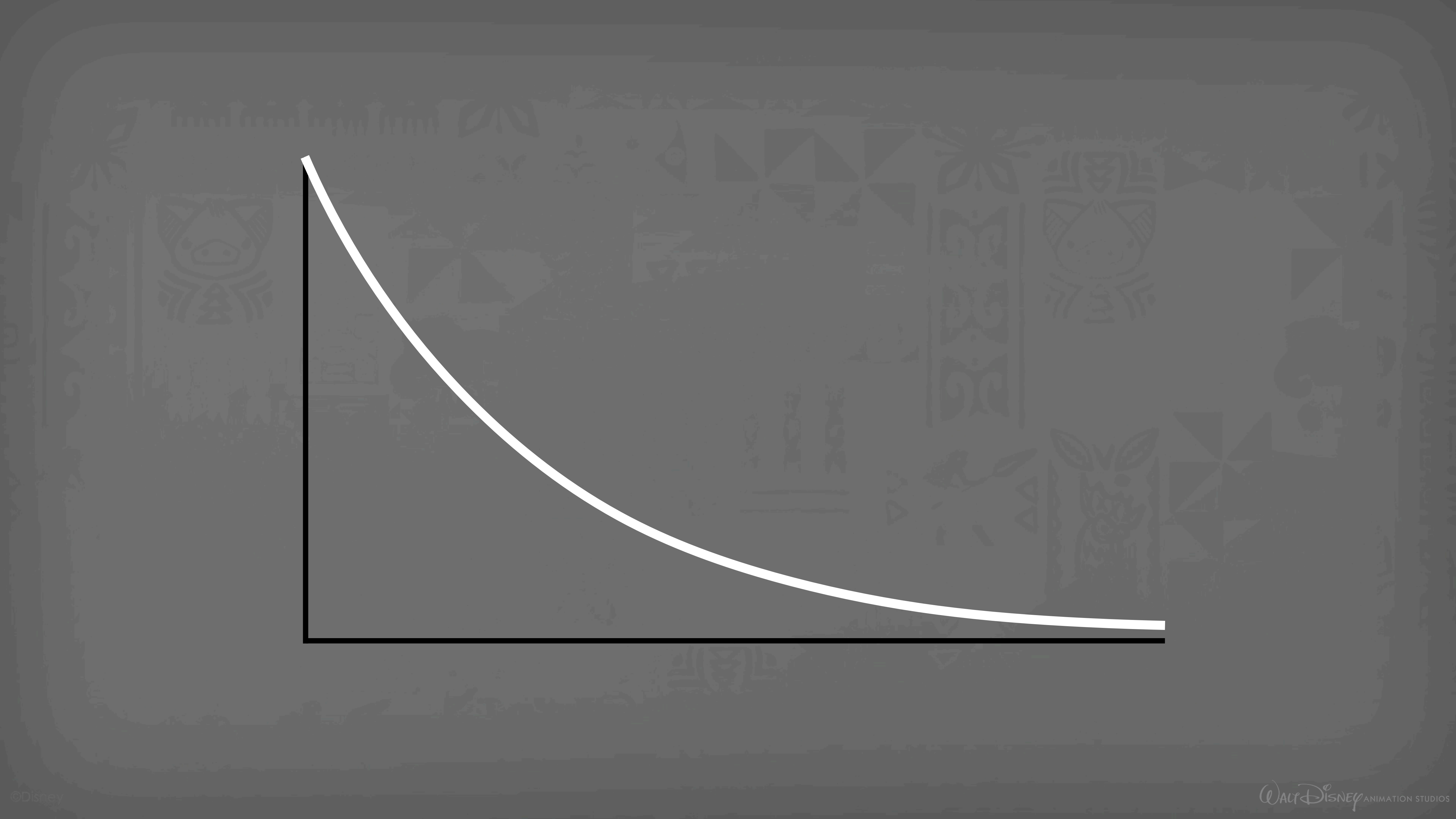
extinction

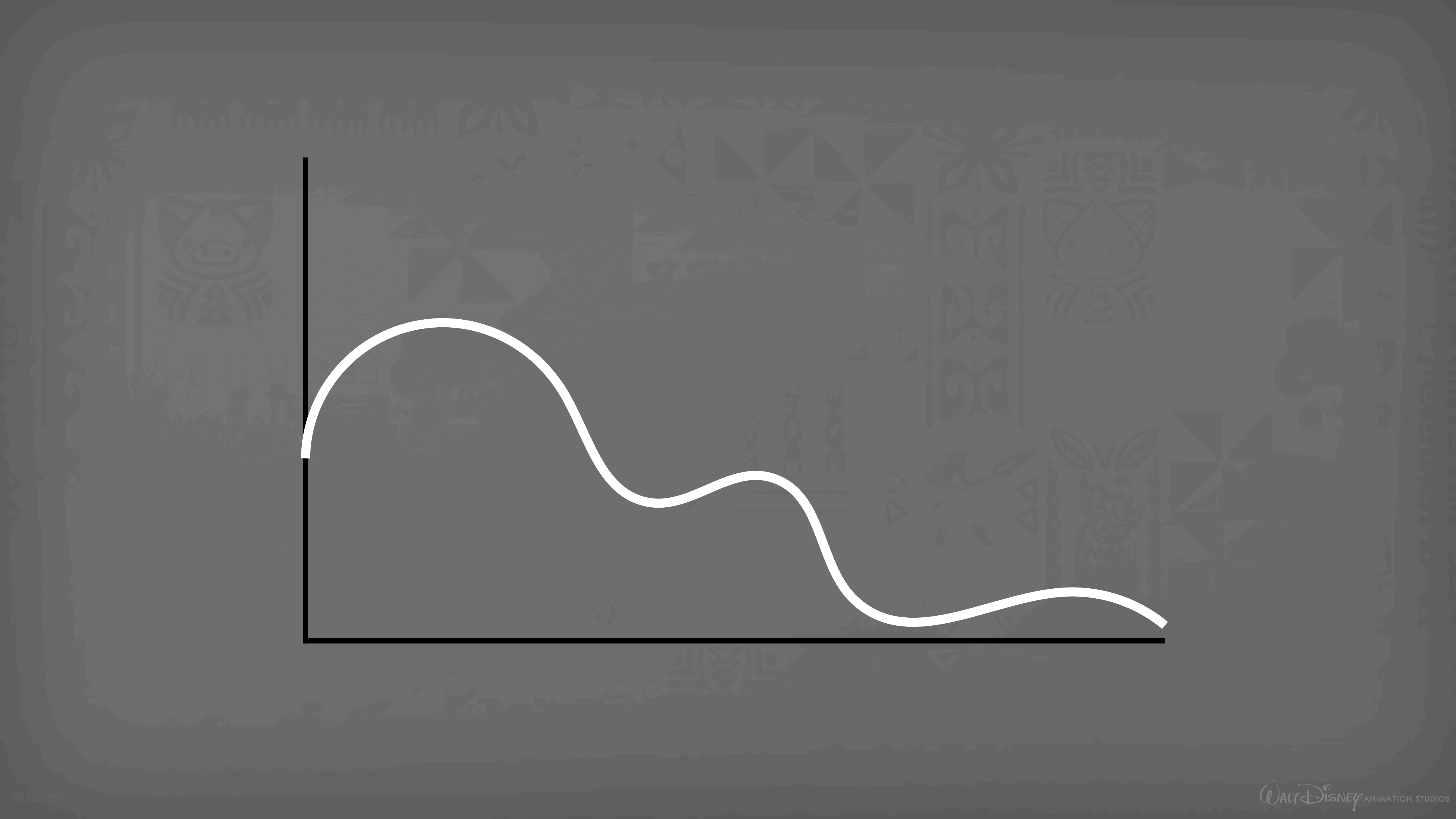


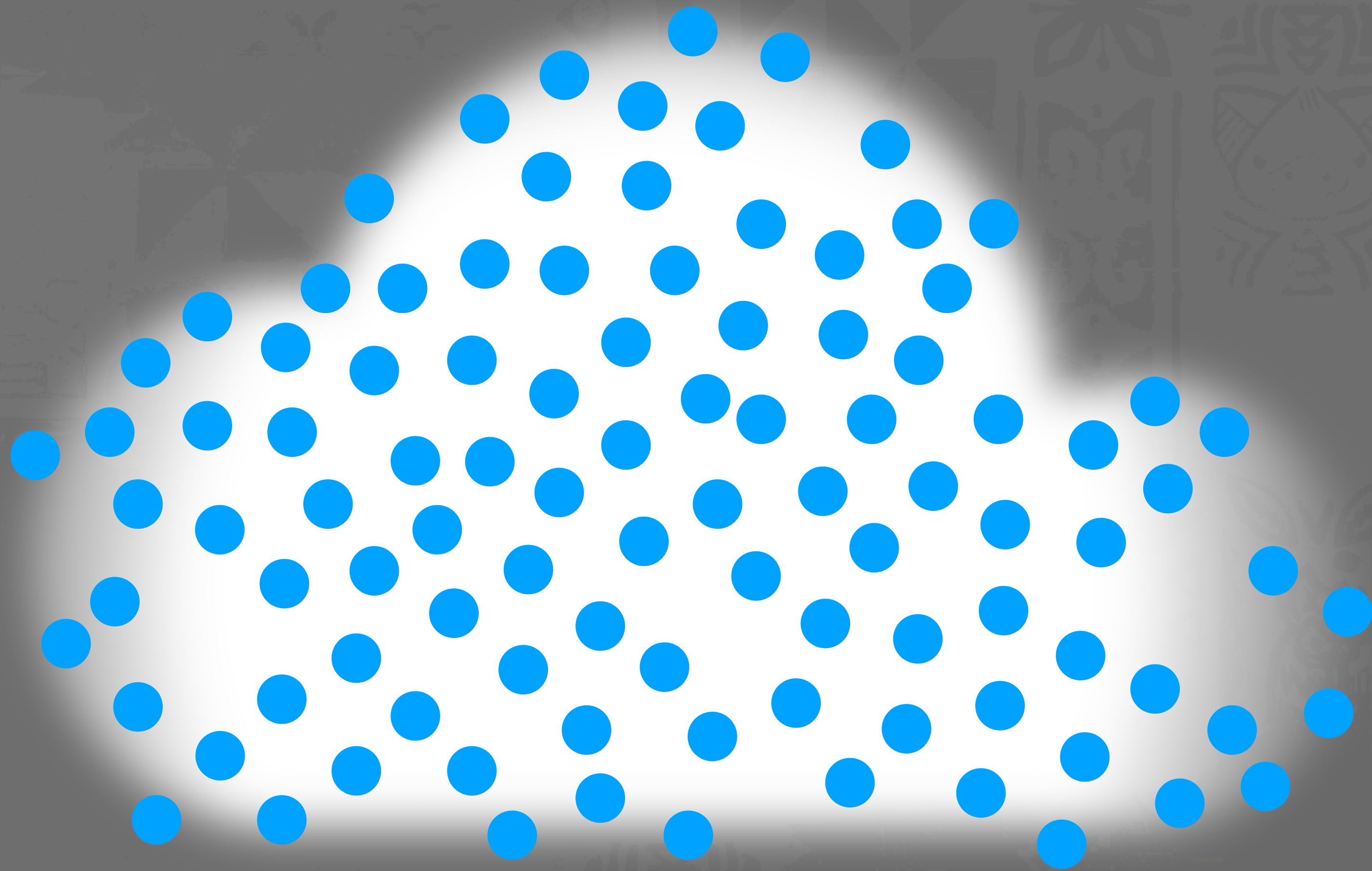
distance

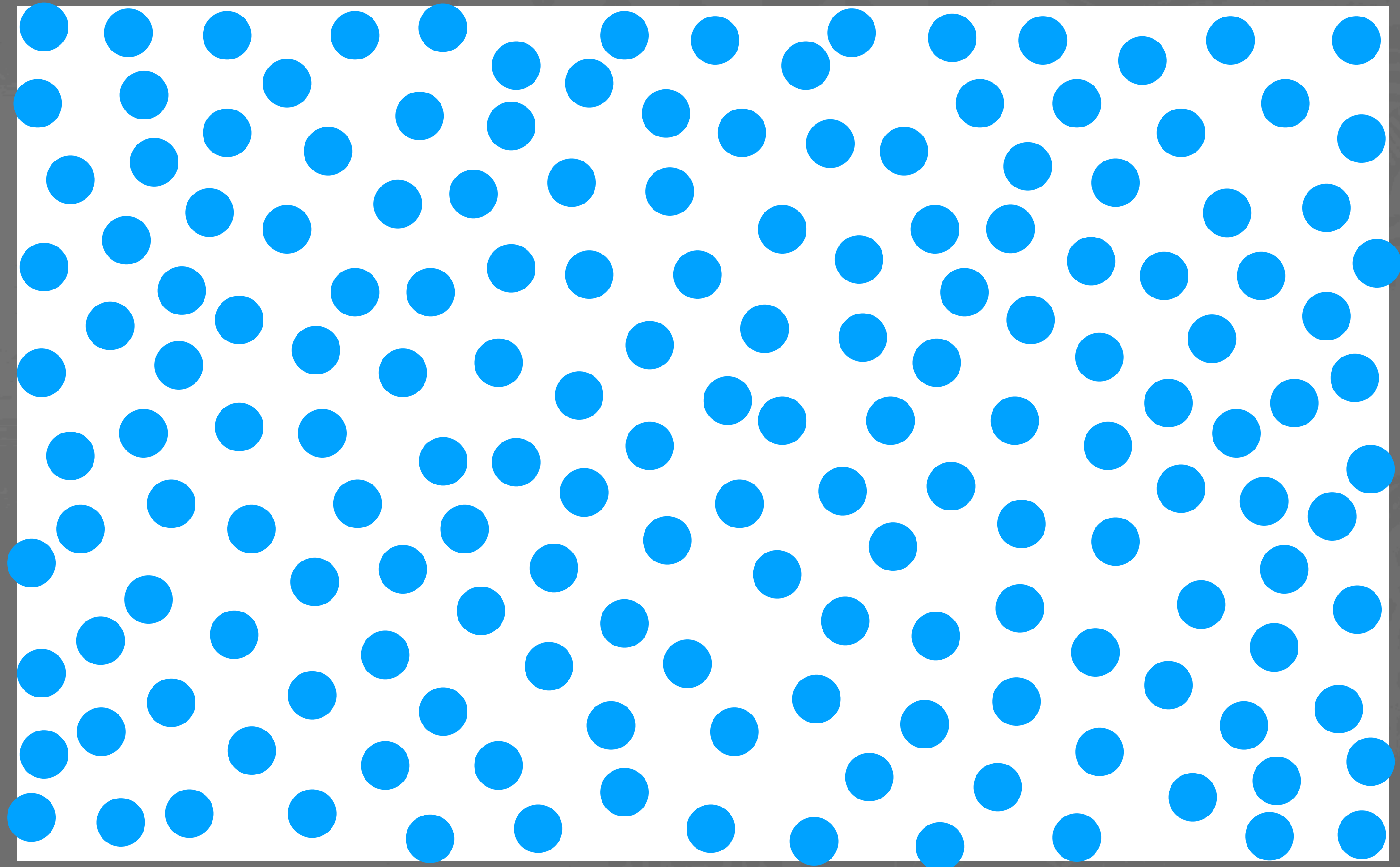


(heterogeneous volume)



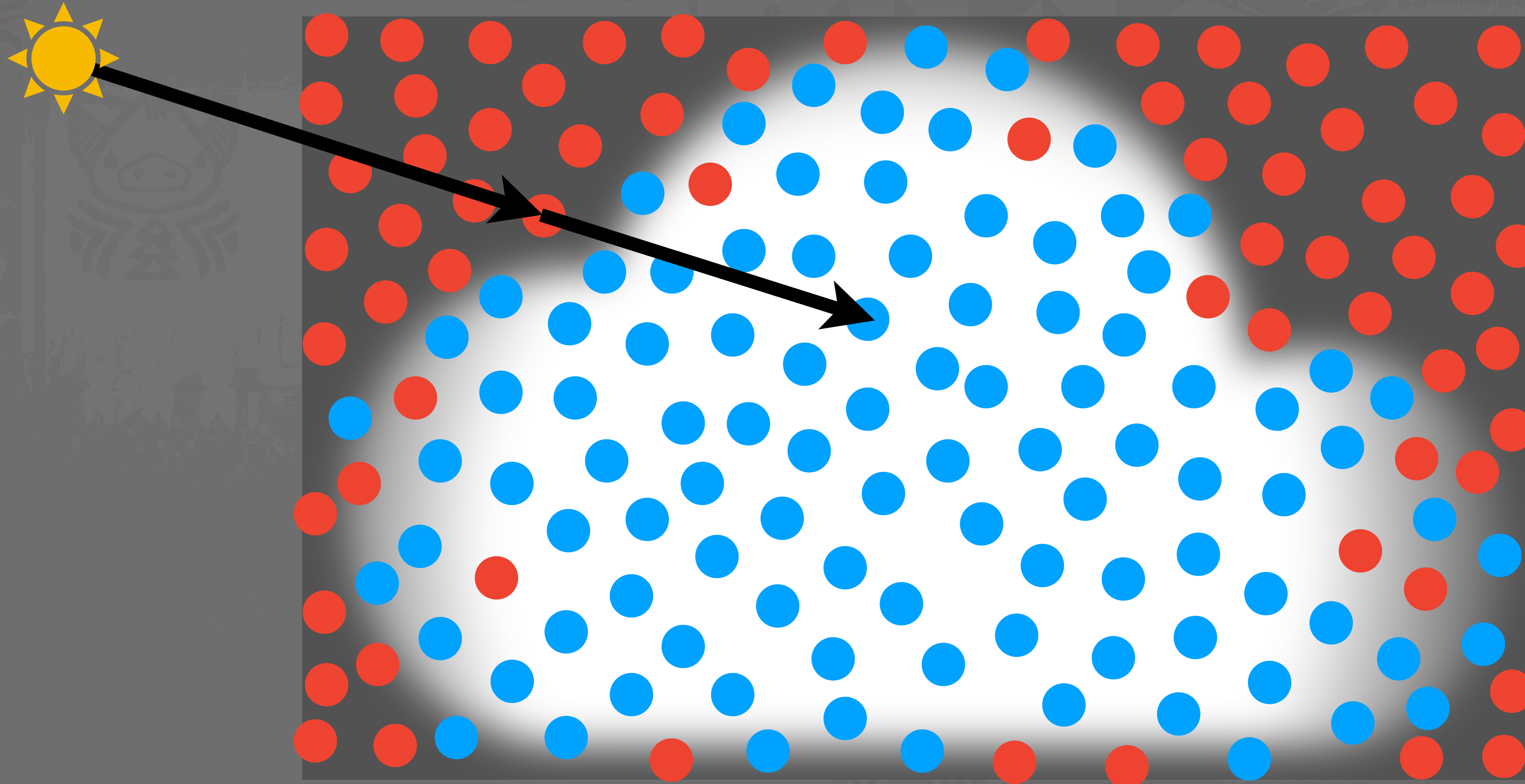






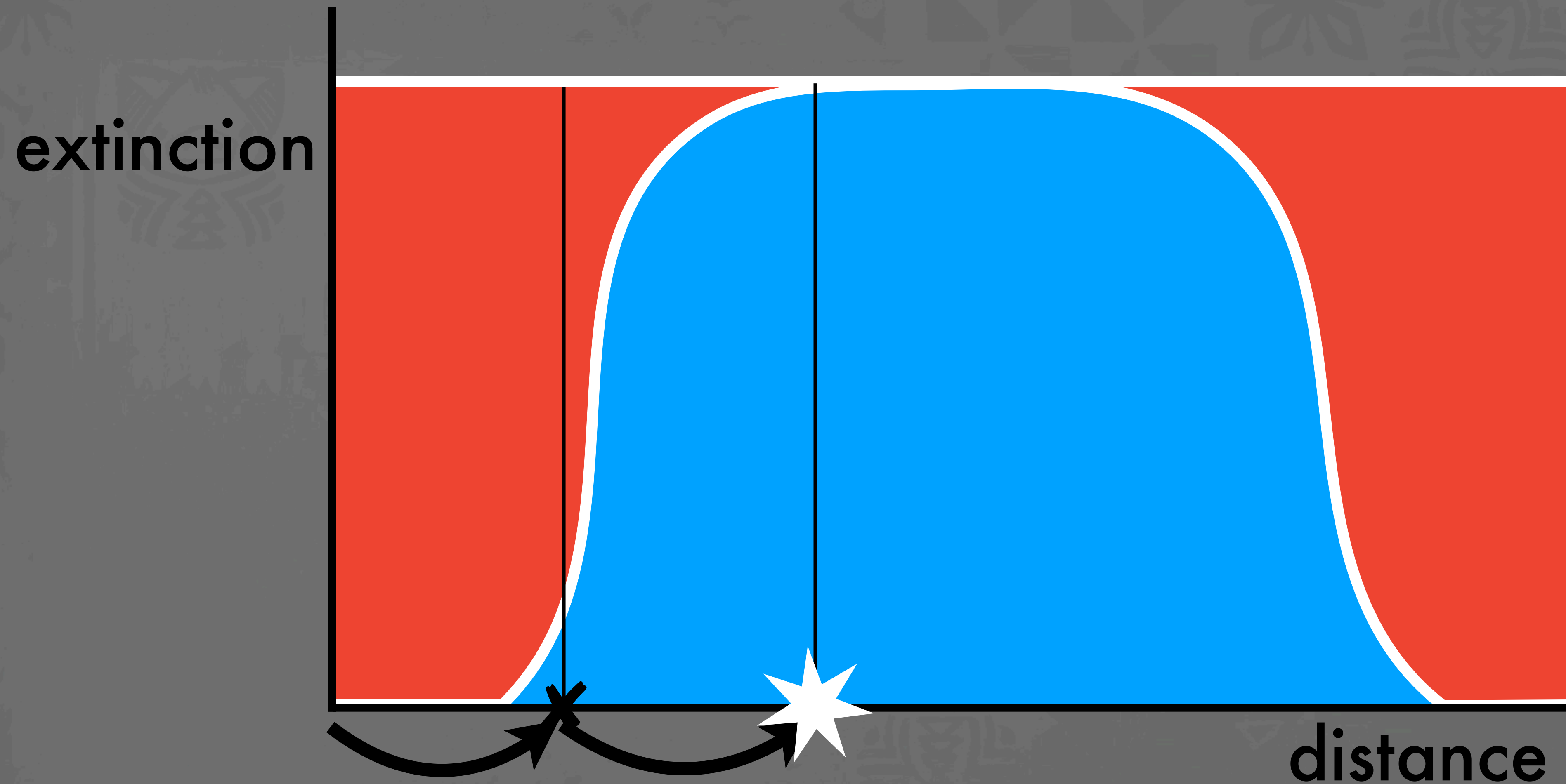
Delta Tracking

● = real
● = fictitious



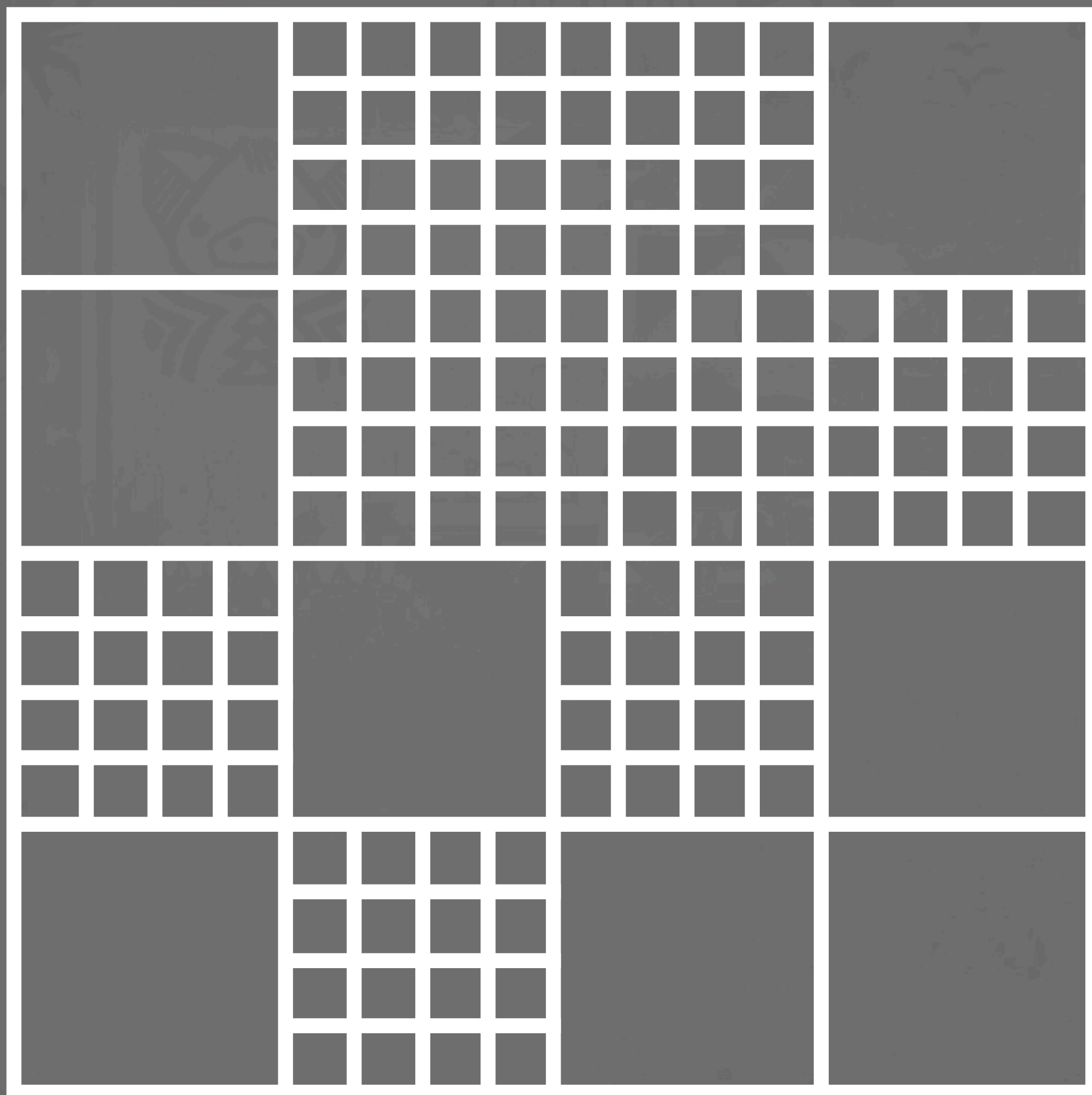
Delta Tracking

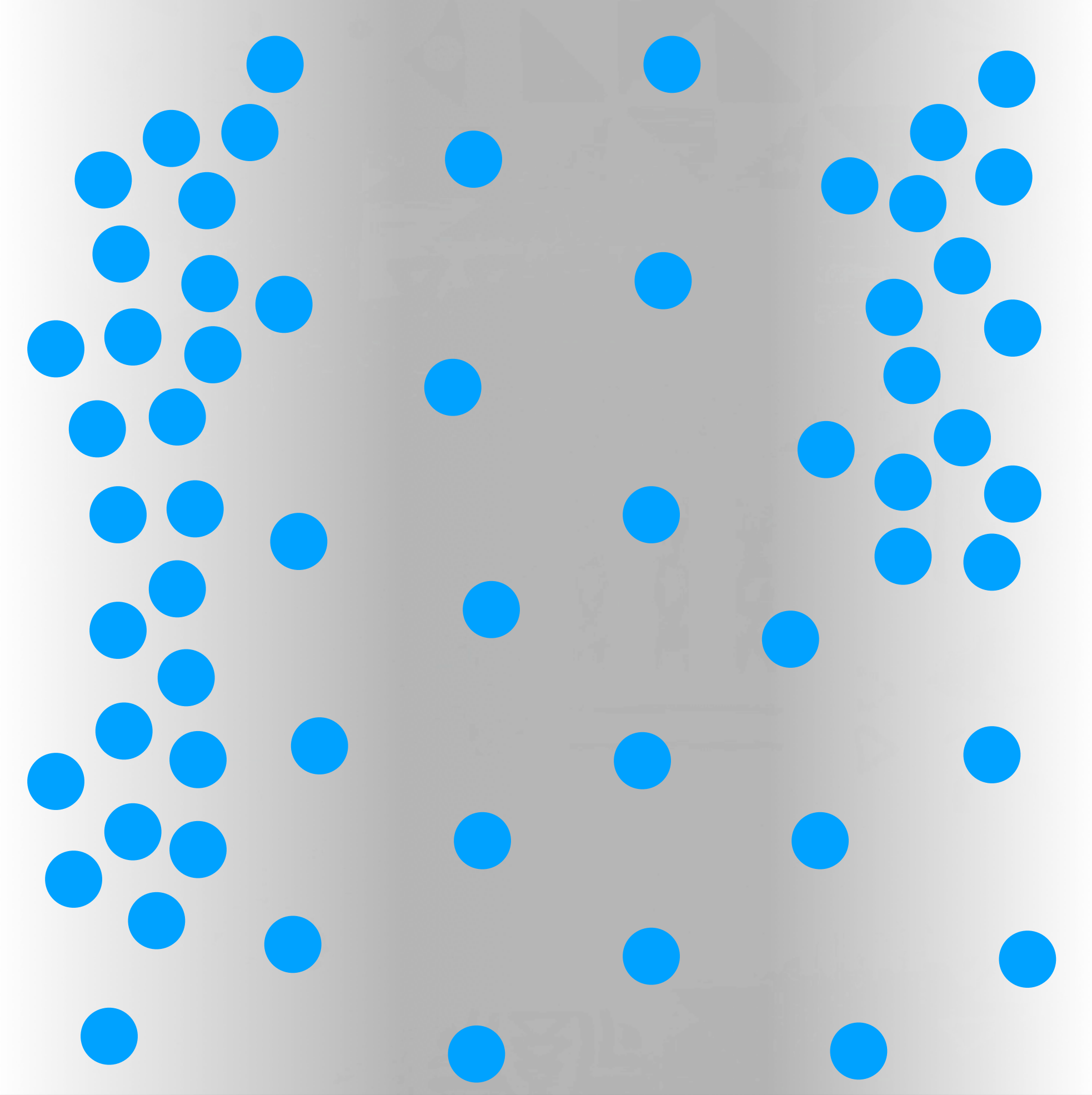
● = real
● = fictitious



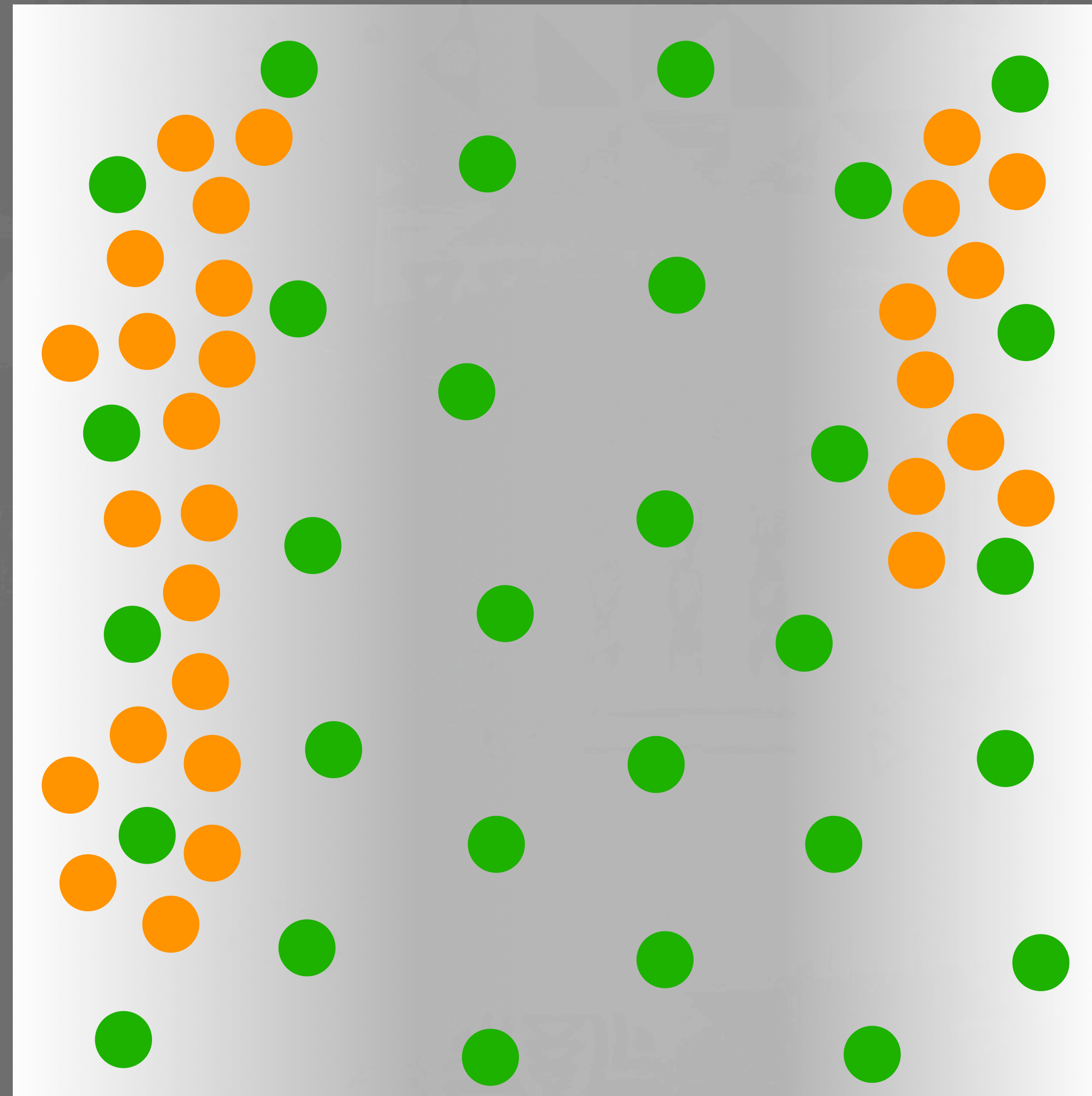
Decomposition Tracking

memory accesses

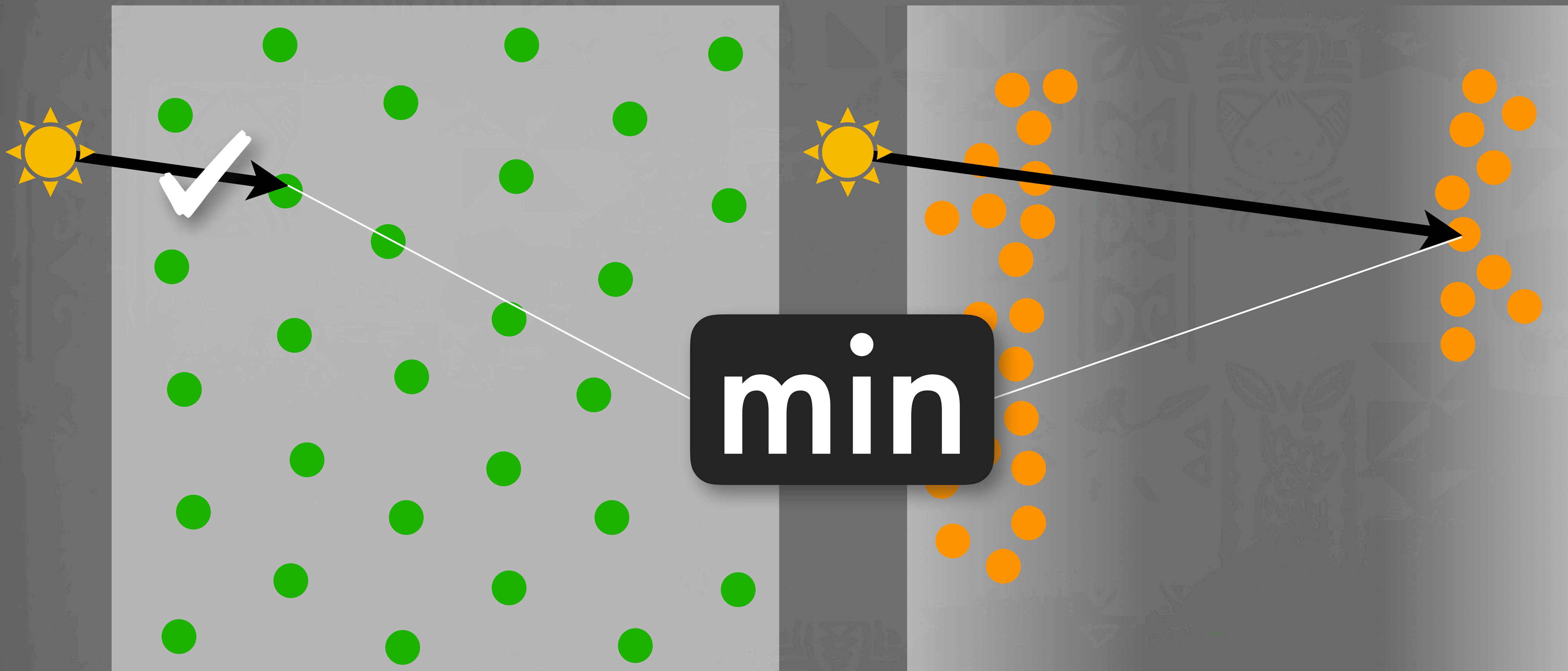




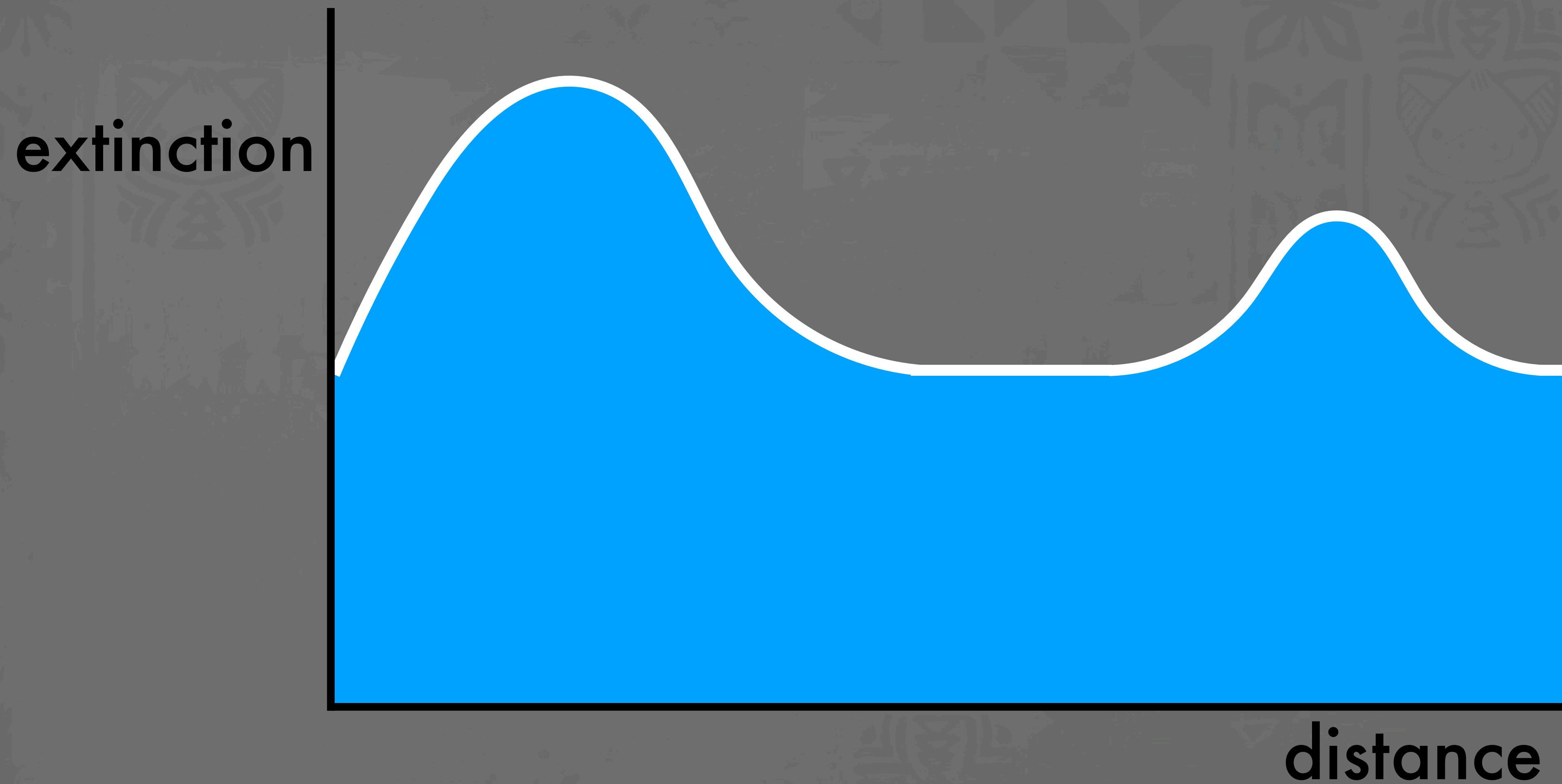
- = homogeneous control
- = heterogeneous residual



Decomposition Tracking



Decomposition Tracking



Decomposition Tracking

● = residual
● = control

extinction

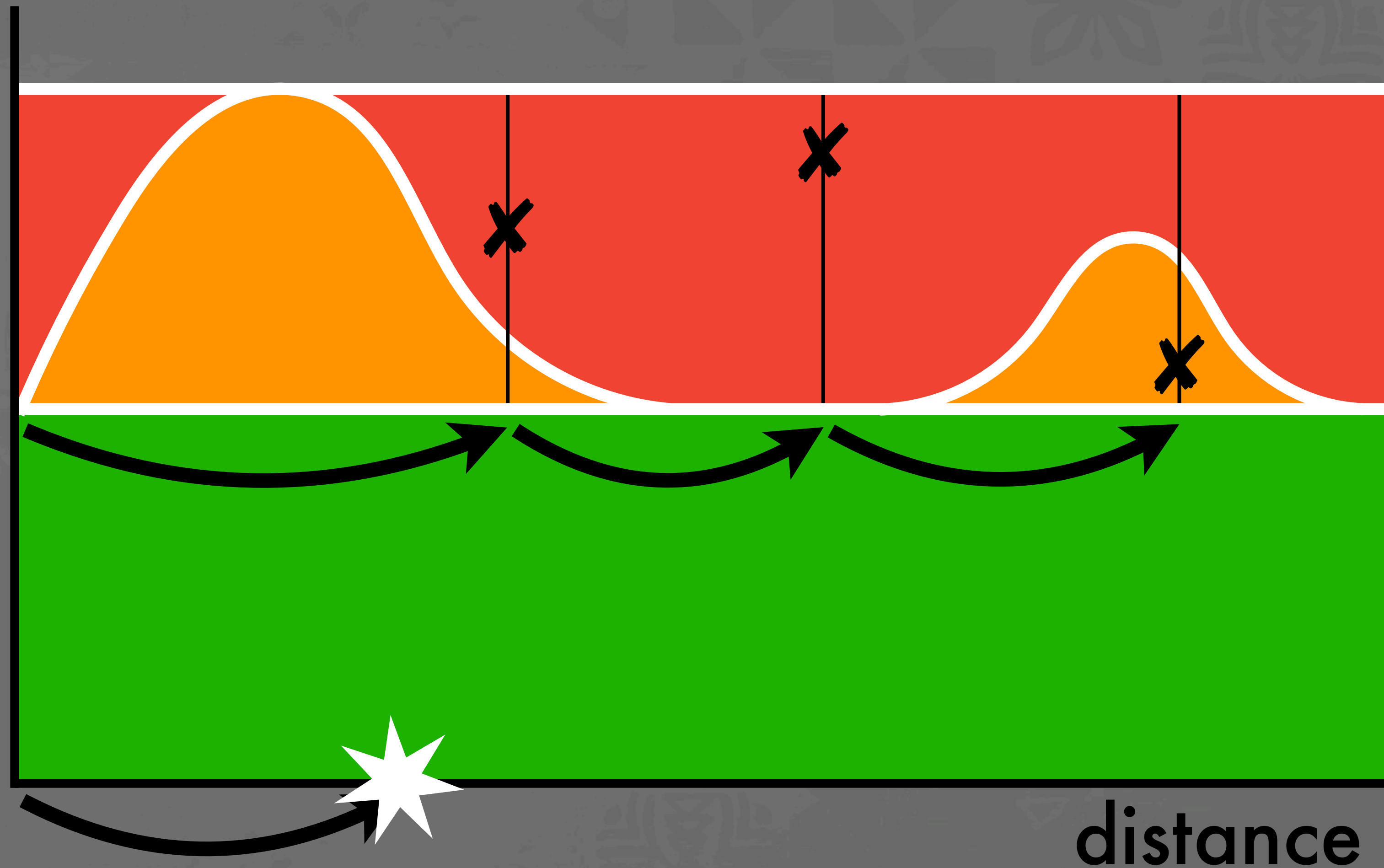


distance

Decomposition Tracking

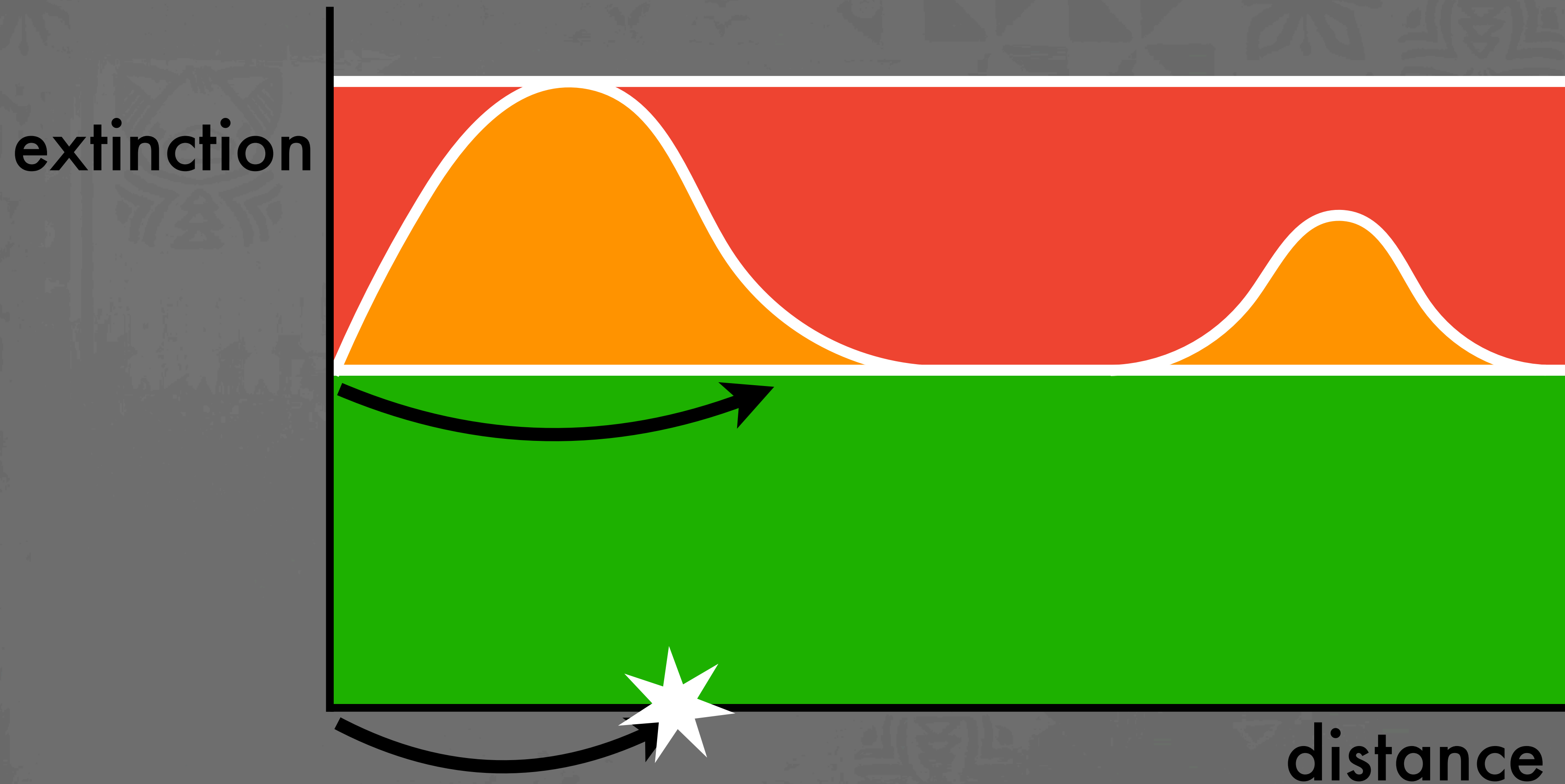
- = fictitious
- = residual
- = control

extinction



Decomposition Tracking

- = fictitious
- = residual
- = control



delta tracking



decomposition tracking



18% faster

Integral Formulation of Null-Collision Algorithms

The Integral Formulation of Null-Collision Algorithms

arbitrary free-path-sampling coefficient

$$\begin{aligned}
 L(\mathbf{x}, \omega) = & \int_0^\infty \boxed{\bar{\mu}(\mathbf{x} - t\omega)} \exp \left(- \int_0^t \underbrace{\bar{\mu}(\mathbf{x} - s\omega)}_{\text{weights}} ds \right) \\
 & \times \left[\int_0^1 \mathcal{H}[\xi_e < \boxed{P_a(\mathbf{x} - t\omega)}] \underbrace{\frac{\mu_a(\mathbf{x} - t\omega)}{\bar{\mu}(\mathbf{x} - t\omega) P_a(\mathbf{x} - t\omega)}}_{\text{weights}} L_e(\mathbf{x} - t\omega, \omega) d\xi_e \right. \\
 & + \int_0^1 \mathcal{H}[\xi_s < \boxed{P_s(\mathbf{x} - t\omega)}] \underbrace{\frac{\mu_s(\mathbf{x} - t\omega)}{\bar{\mu}(\mathbf{x} - t\omega) P_s(\mathbf{x} - t\omega)}}_{\text{weights}} \left[\int_{S^2} f_p(\omega, \bar{\omega}) L(\mathbf{x} - t\omega, \bar{\omega}) d\bar{\omega} \right] d\xi_s \\
 & \left. + \int_0^1 \mathcal{H}[\xi_n < \boxed{P_n(\mathbf{x} - t\omega)}] \underbrace{\frac{\mu_n(\mathbf{x} - t\omega)}{\bar{\mu}(\mathbf{x} - t\omega) P_n(\mathbf{x} - t\omega)}}_{\text{weights}} L(\mathbf{x} - t\omega, \omega) d\xi_n \right] dt
 \end{aligned}$$

arbitrary interaction probabilities

Weighted Delta Tracking

Repeat:

Step forward using **free-path-sampling coefficient**.

If choose scattering using **scattering probability**:

Apply **weight**.

Change direction.

Else if choose null collision using **null probability**:

Apply **weight**.

Else:

Terminate path.



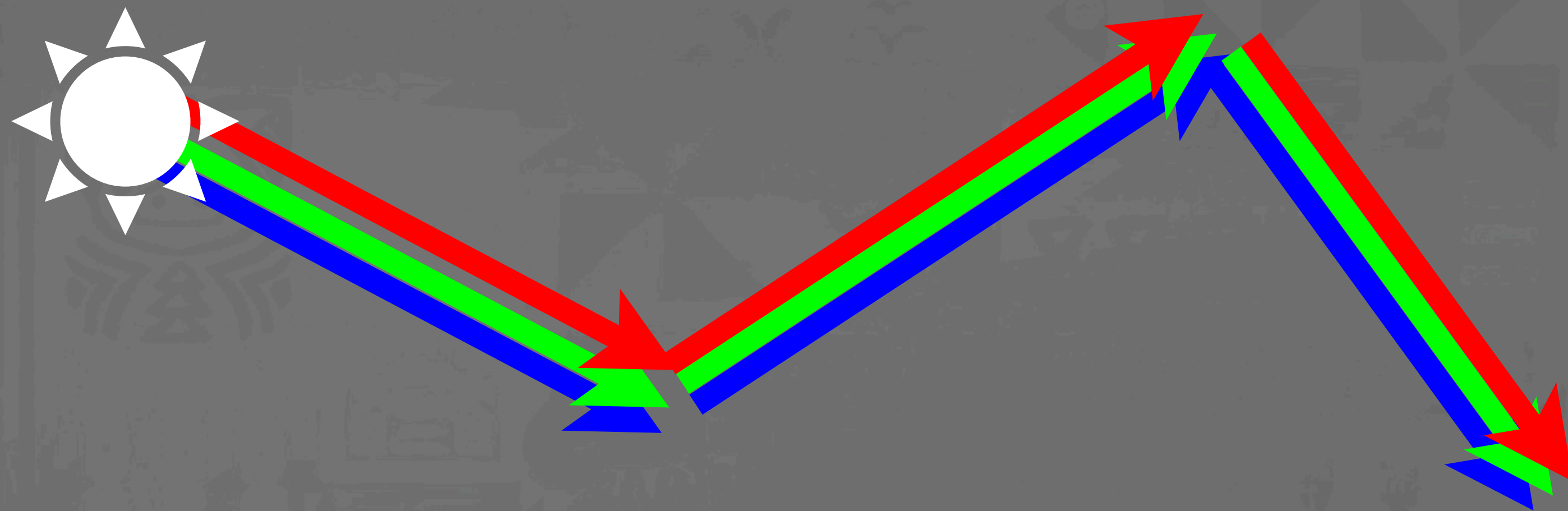
Spectral Tracking

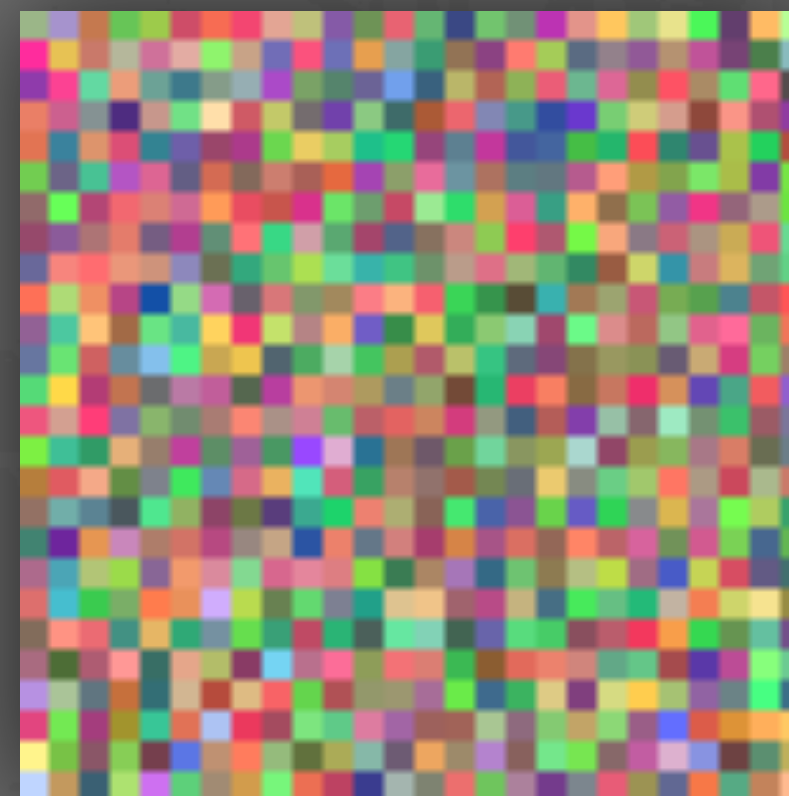
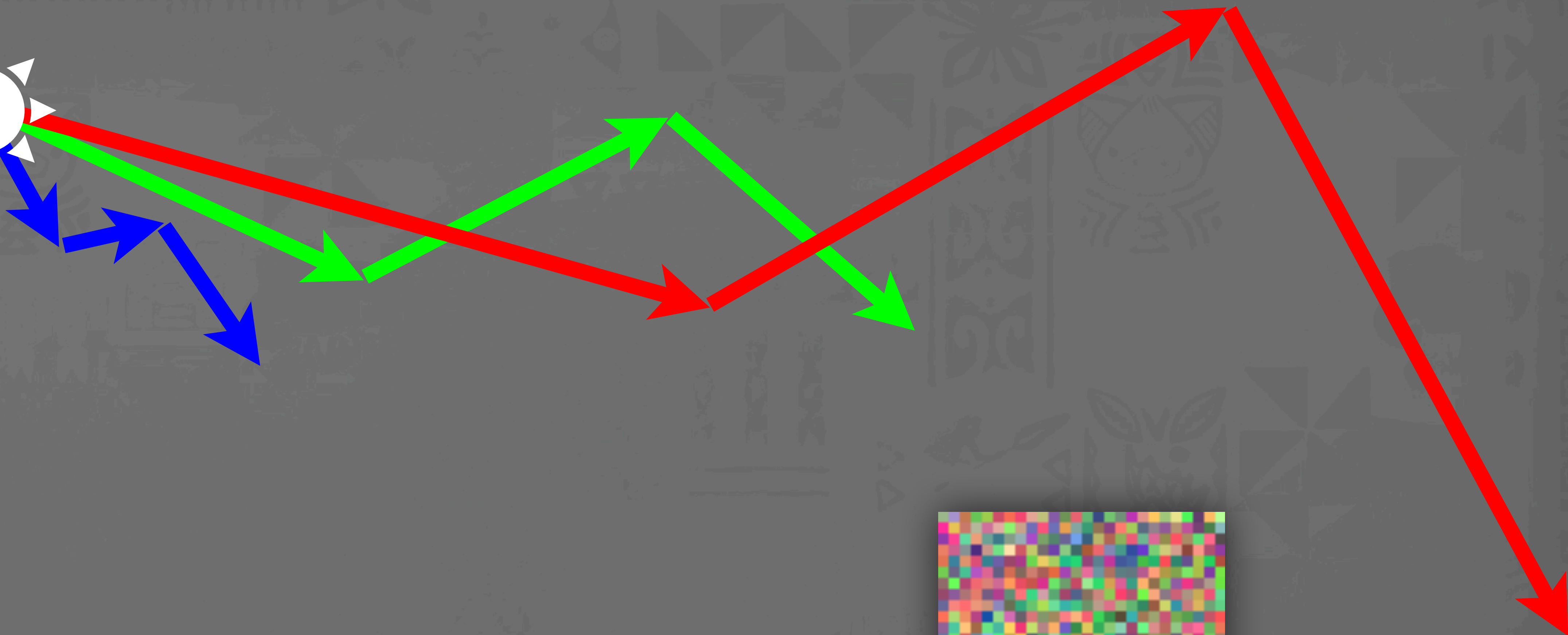
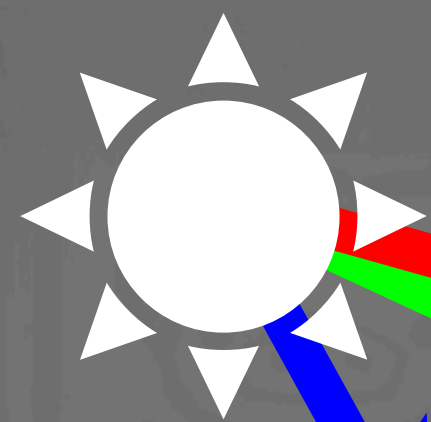
650 nm

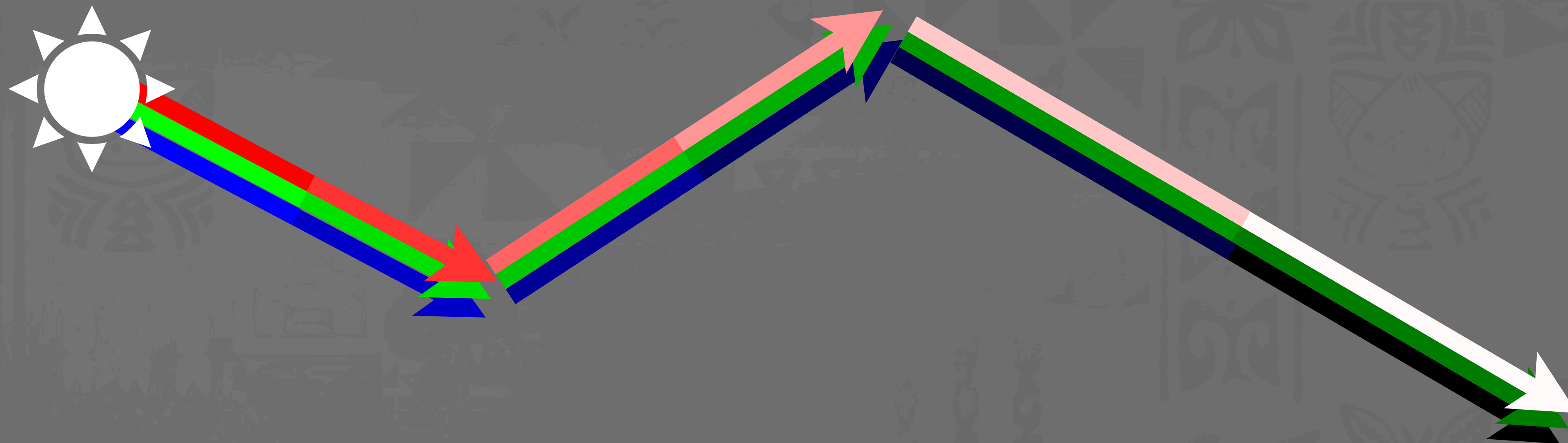
550 nm

450 nm









Repeat:

Step forward using fpsc.

If scat using scat prob:

Apply weight.

Change direction.

Else if null using null prob:

Apply weight.

Repeat:

Step forward using `fp`.

If `scat` using `scat` `prob`:

Apply `weight`.

Change direction.

Else if `null` using `null` `prob`:

Apply `weight`.

Repeat:

Step forward using **fp**sc.

If scat using **scat** prob:

Apply **weight**.

Change direction.

Else if null using **null** prob:

Apply **weight**.

Repeat:

Step forward using **fp**sc.

If scat using **scat** prob:

Apply **weight**.

Change direction.

Else if null using **null** prob:

Apply **weight**.

Repeat:

Step forward using **fp**sc.

If scat using **scat** prob:

Apply **weight**.

Change direction.

Else if null using **null** prob:

Apply **weight**.

Repeat:

Step forward using **fp**sc.

If scat using **scat** prob:

Apply **weight**.

Change direction.

Else if null using **null** prob:

Apply **weight**.

Repeat:

Step forward using **fp**sc.

If scat using **scat** prob:

Apply **weight**.

Change direction.

Else if null using **null** prob:

Apply **weight**.

Repeat:

Step forward using **fp**sc.

If scat using **scat** prob:

Apply **weight**.

Change direction.

Else if null using **null** prob:

Apply **weight**.

Repeat:

Step forward using fpssc.

If scat using scat prob:

Apply **weight**.

Change direction.

Else if null using null prob:

Apply **weight**.

Repeat:

Step forward using fpssc.

If scat using scat prob:

Apply **weight**.

Change direction.

Else if null using null prob:

Apply **weight**.

Repeat:

Step forward using fpssc.

If scat using scat prob:

Apply **weight**.

Change direction.

Else if null using null prob:

Apply **weight**.

(weight_r , weight_g , weight_b)

Repeat:

Step forward using fpsc.

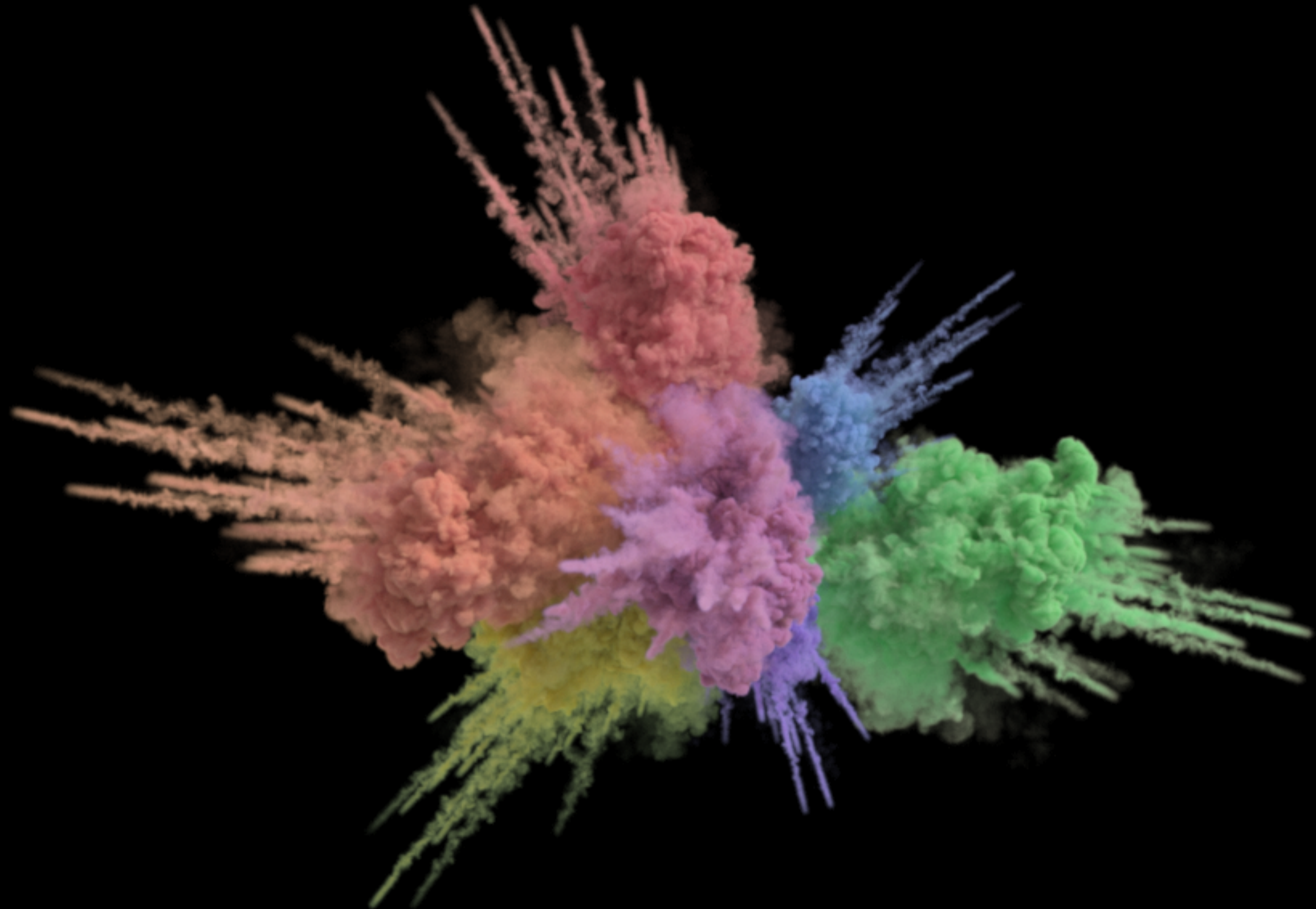
If scat using scat prob:

Apply (weight, weight, weight).

Change direction.

Else if null using null prob:

Apply (weight, weight, weight).



delta tracking

spectral tracking

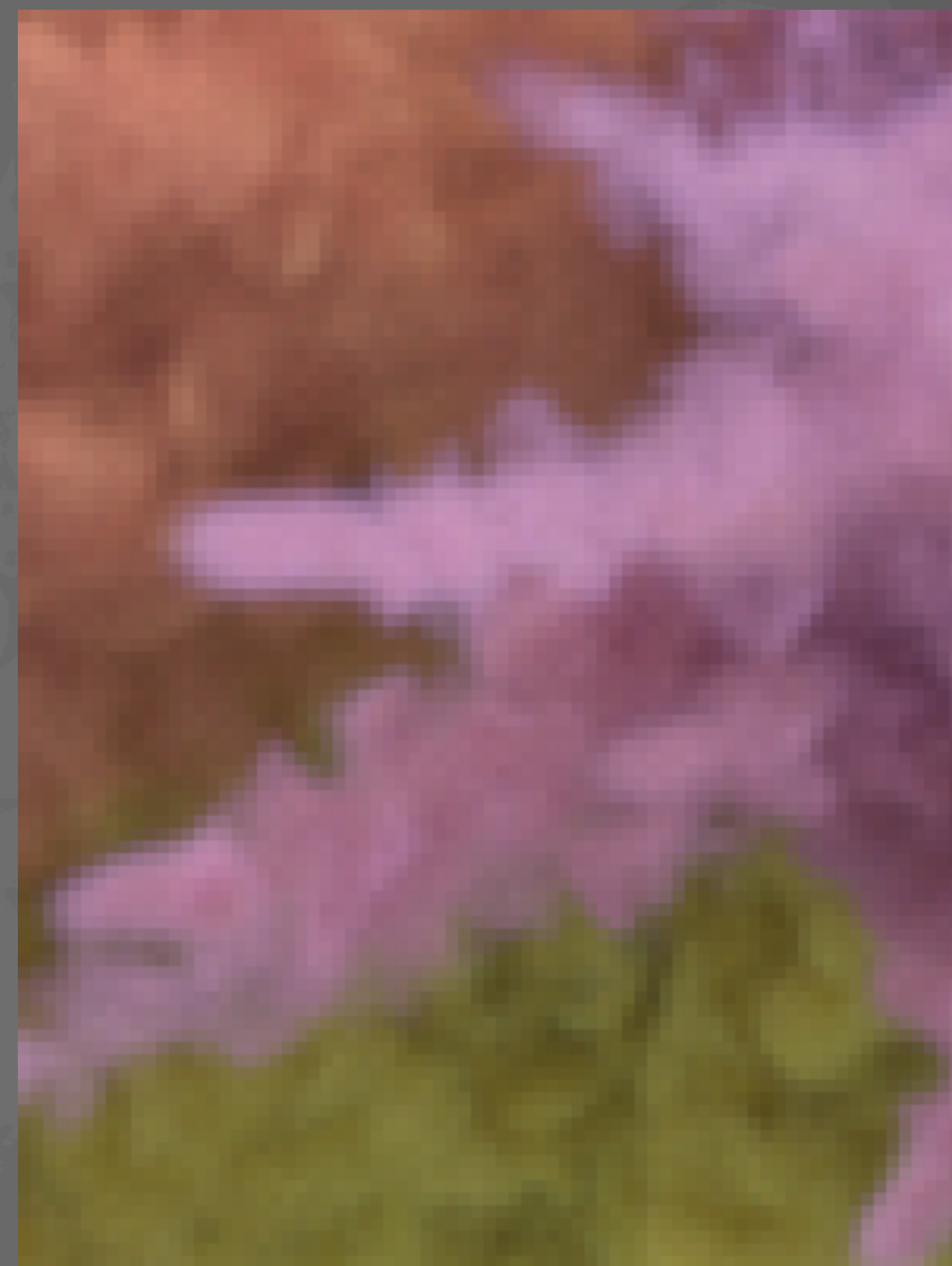
reference



1x



2.7x

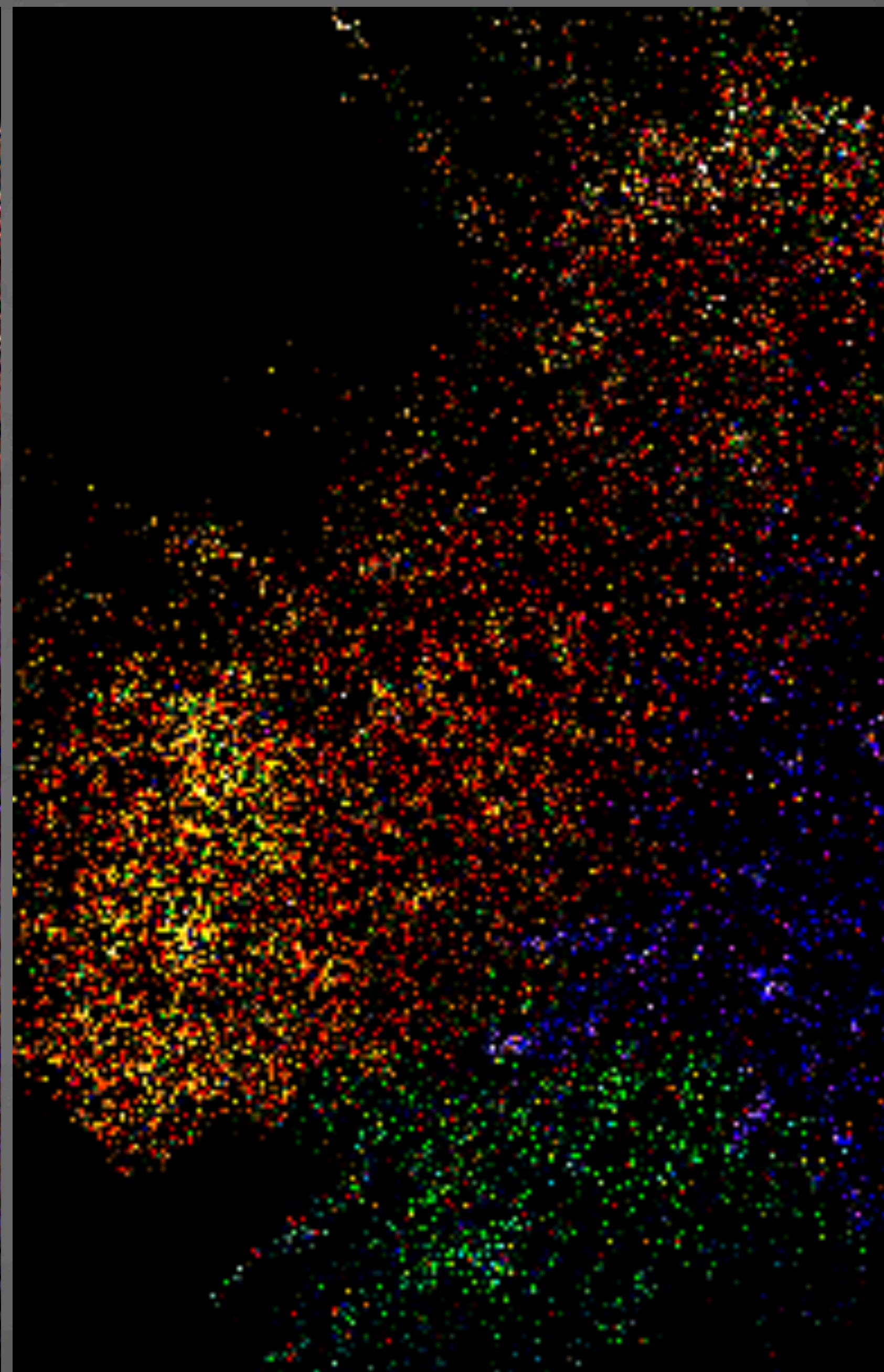
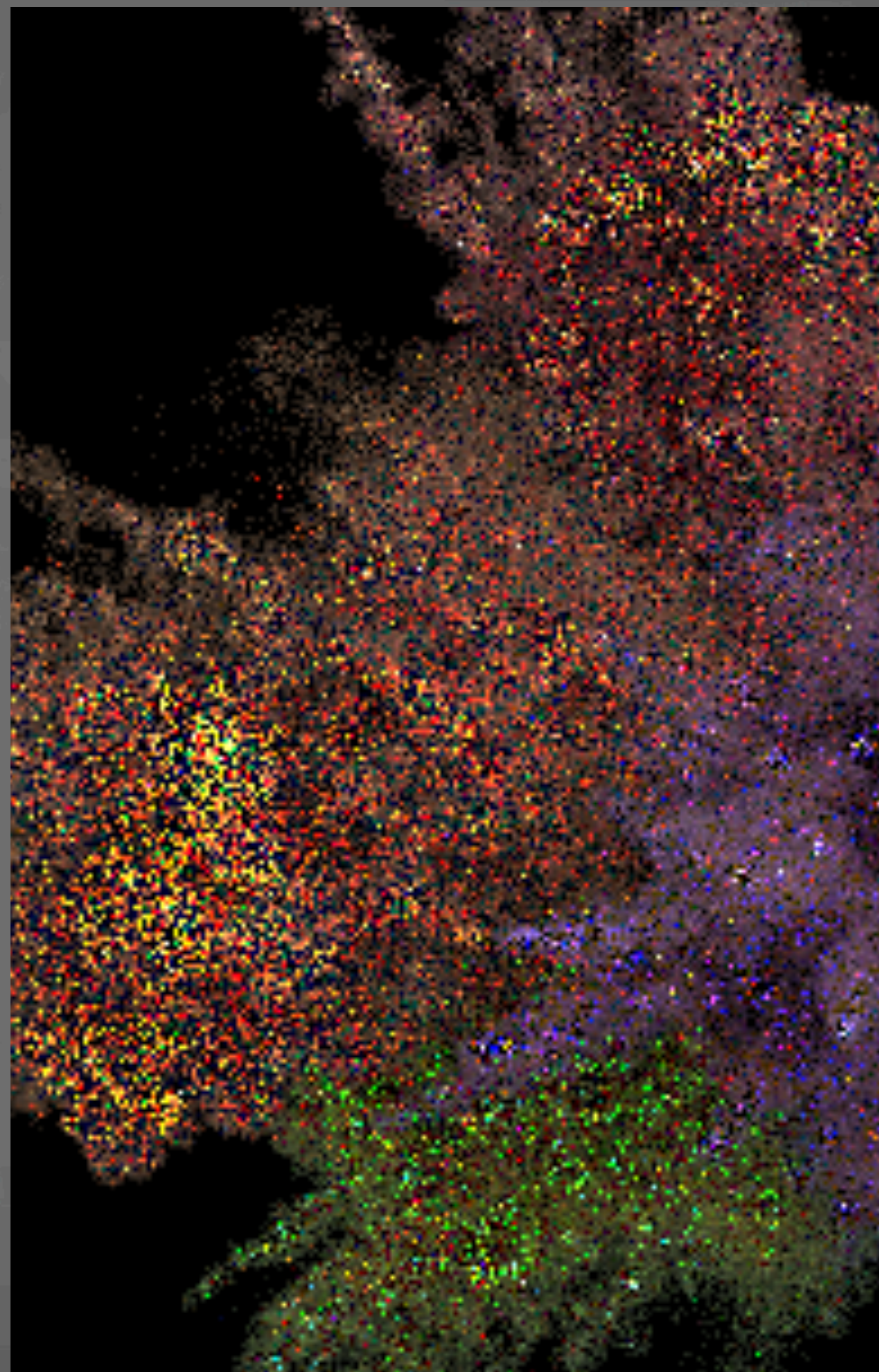
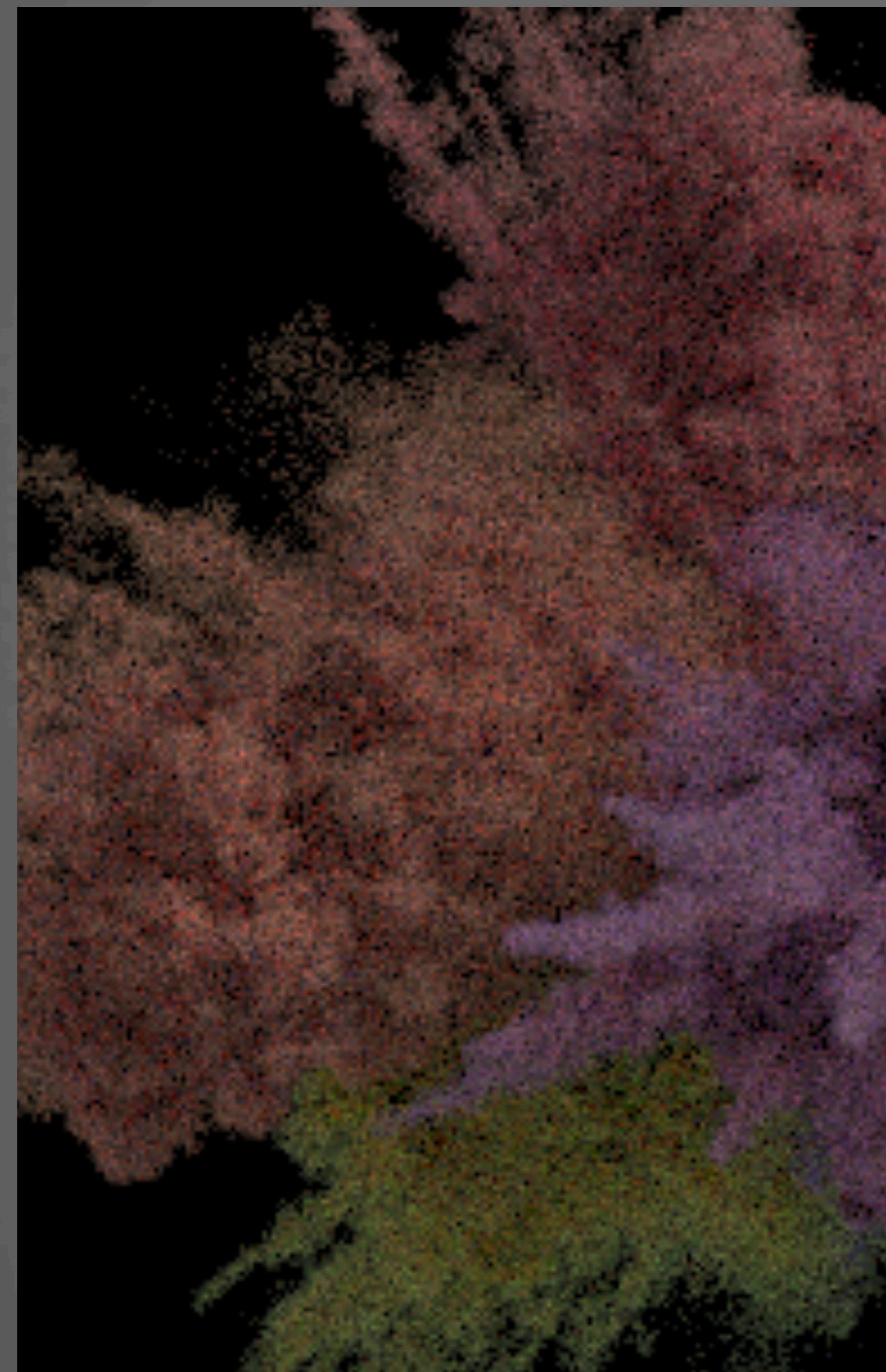


free-path-sampling coefficient
absorption/emission probability
scattering probability
null probability

bounding

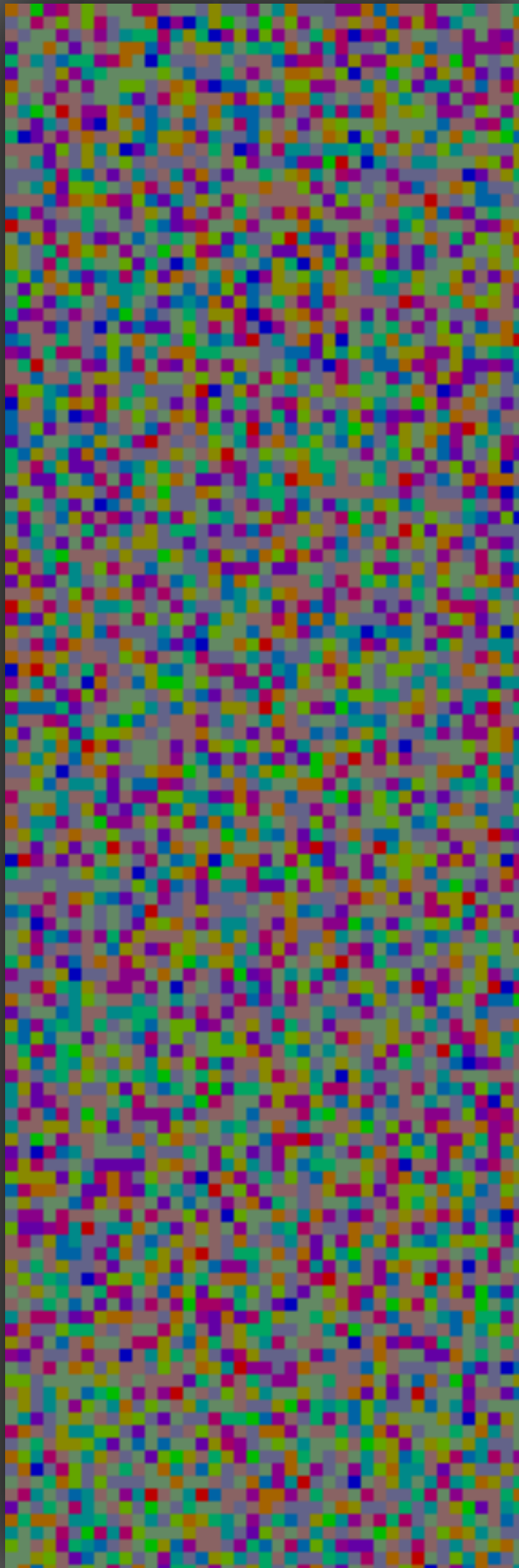
non-bounding

non-bounding negated

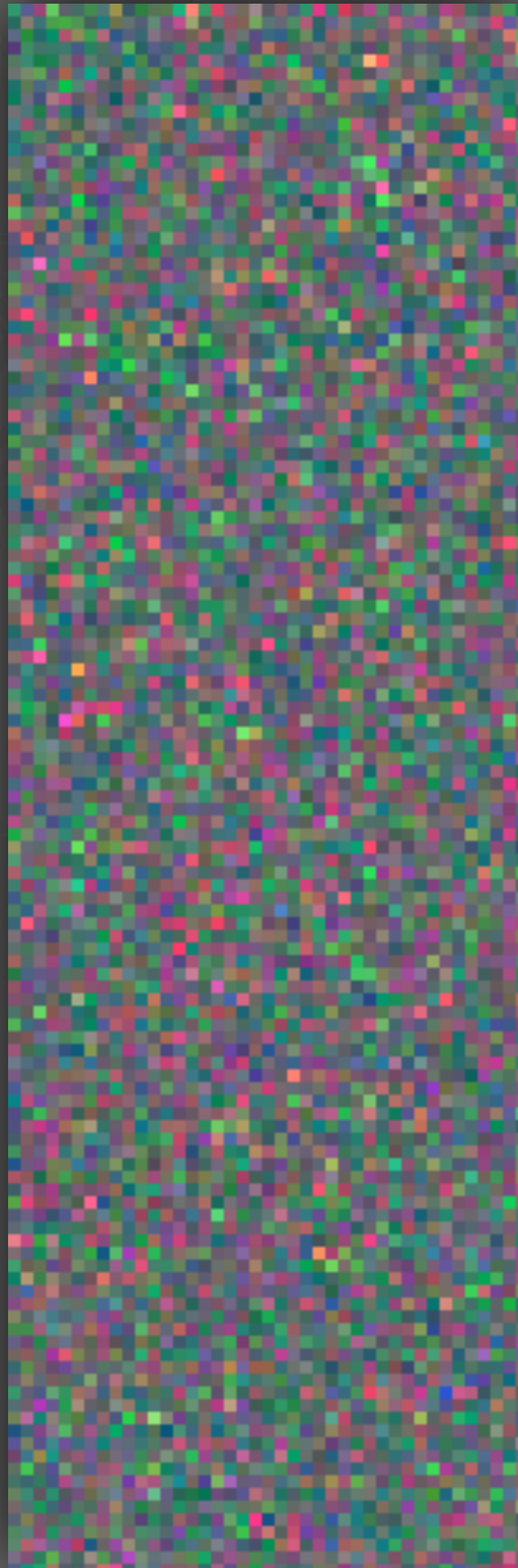


free-path-sampling coefficient
absorption/emission probability
scattering probability
null probability

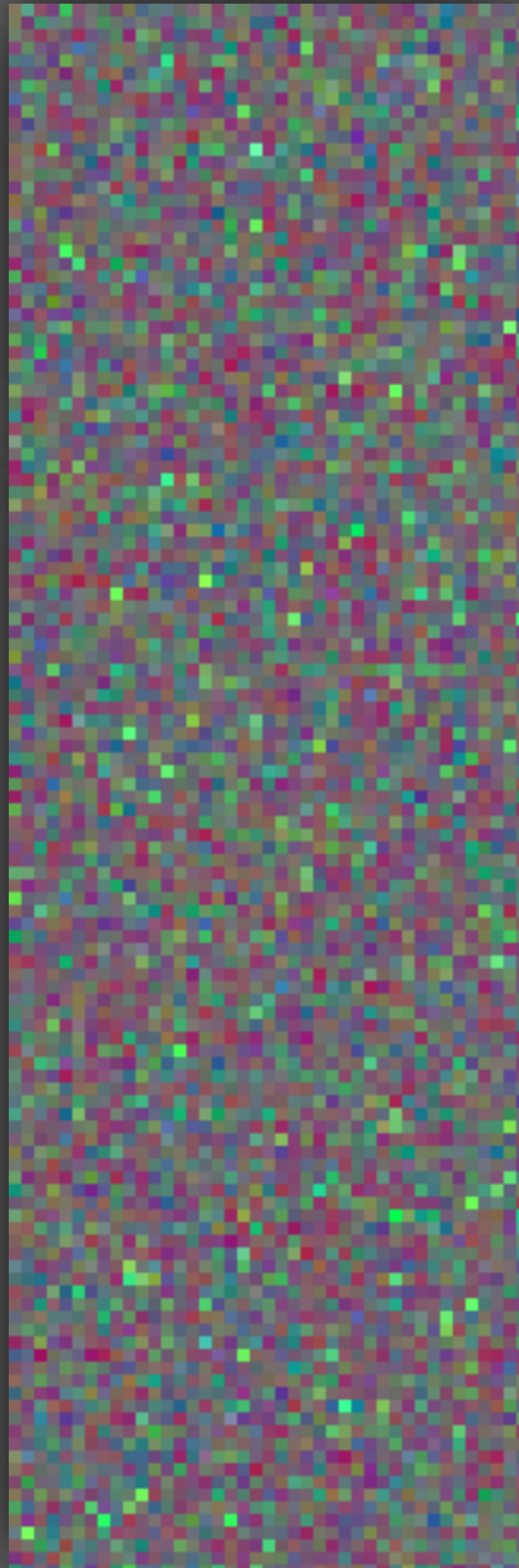
delta



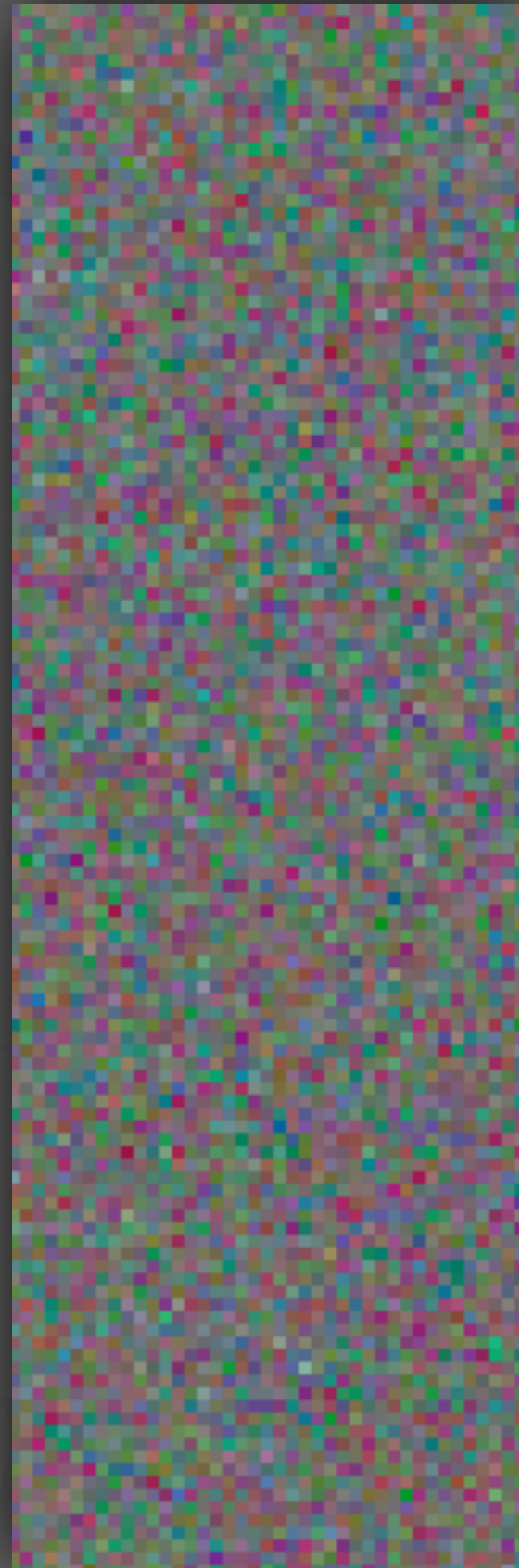
max



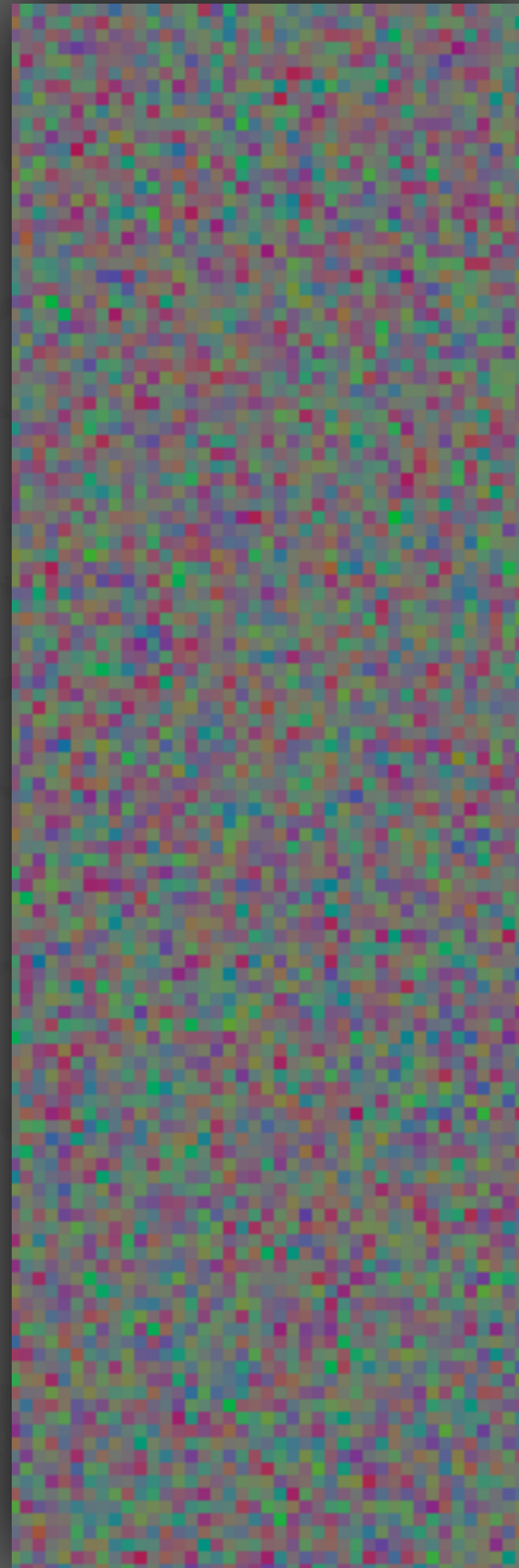
average



history-aware
max



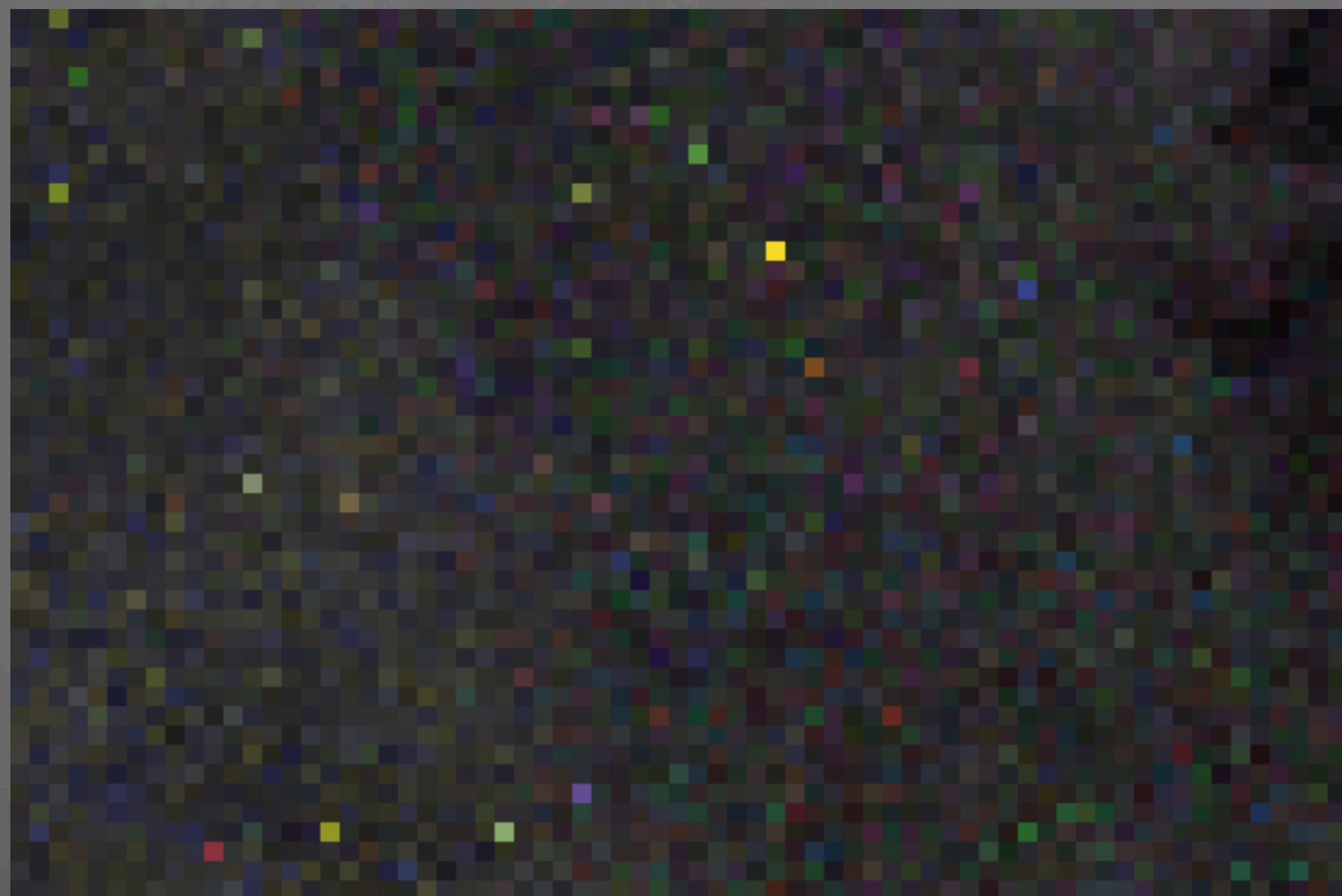
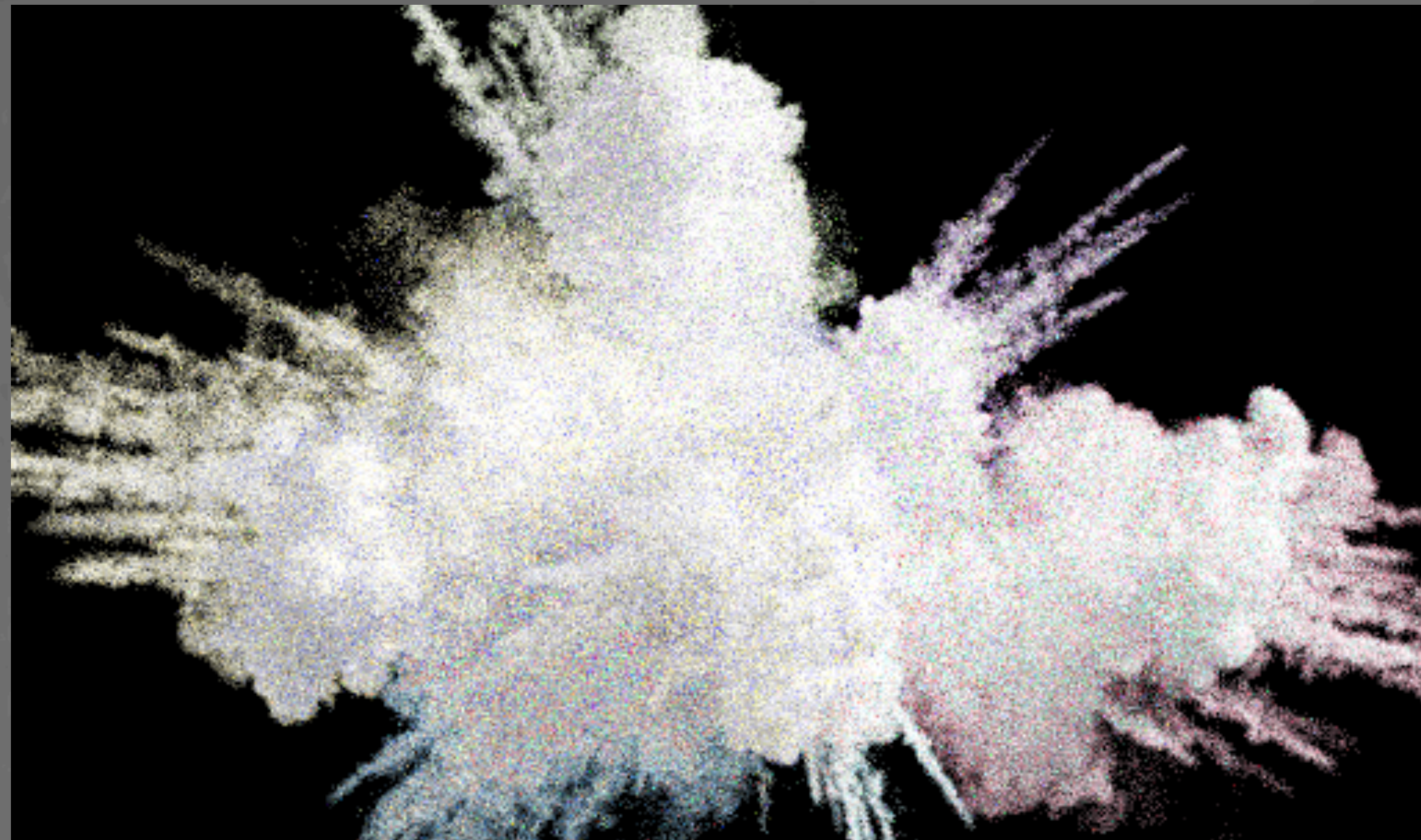
history-aware
average



reference



history-aware max



history-aware average



weight

1

distance

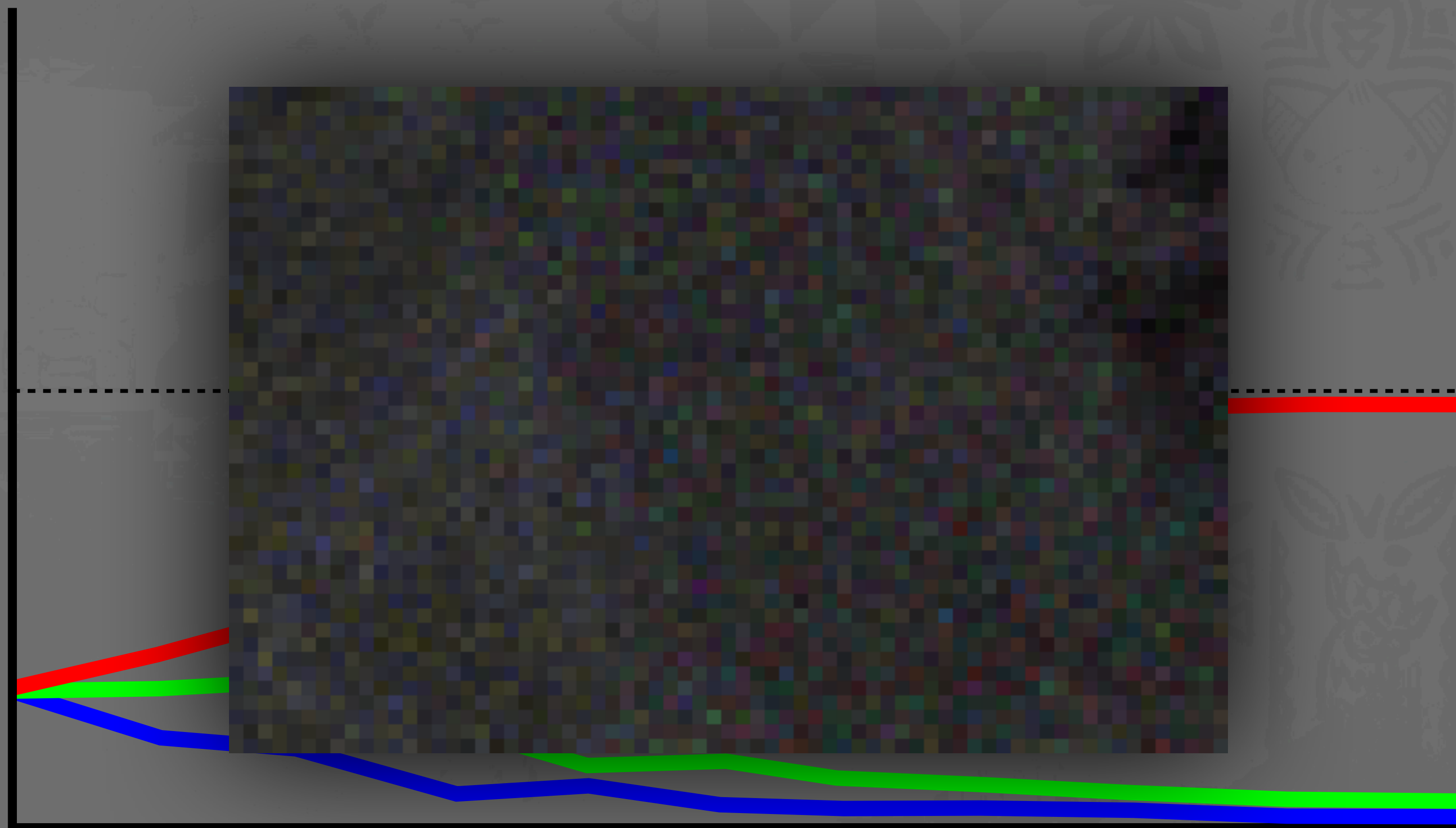


weight

3

1

distance

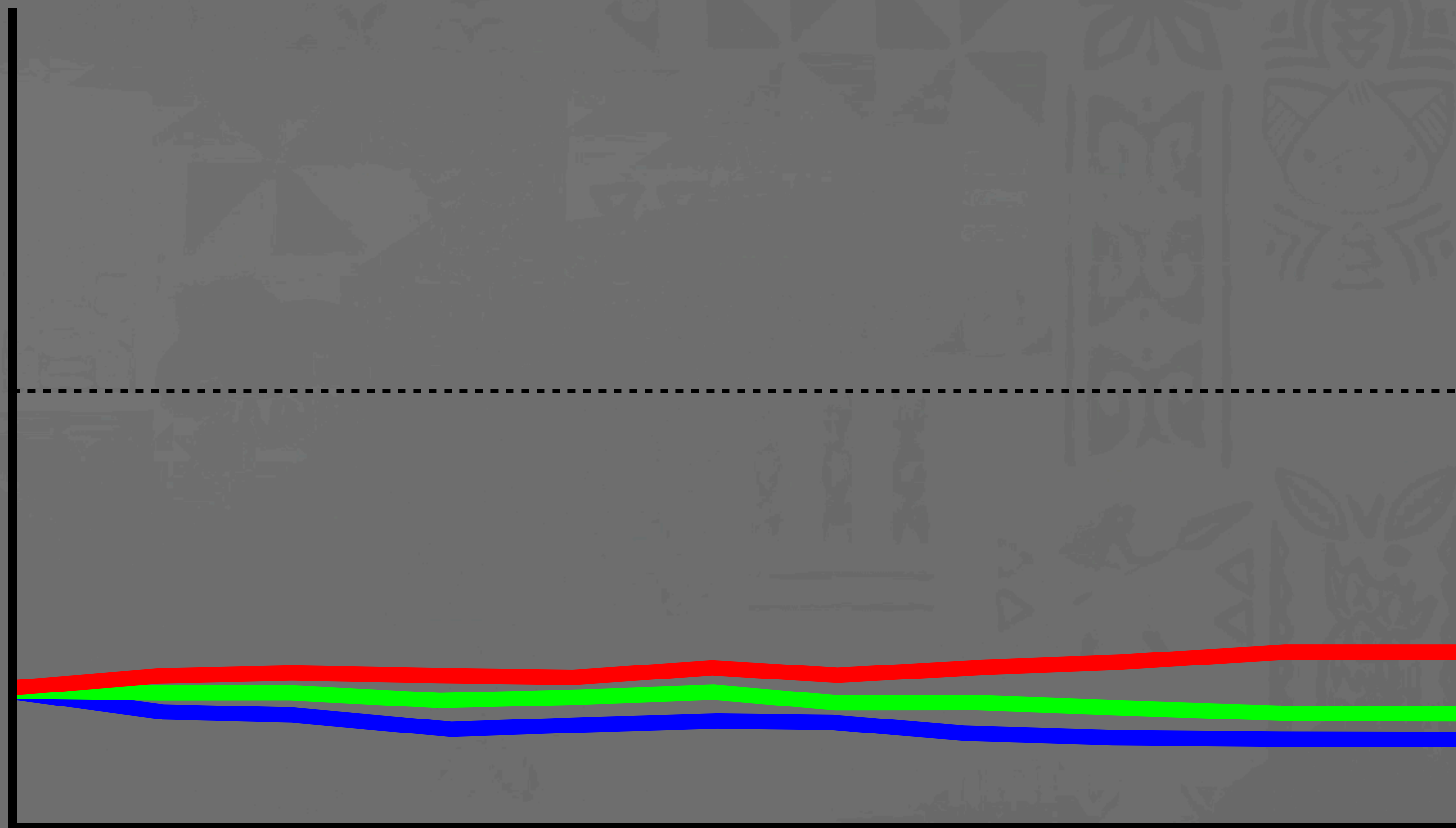


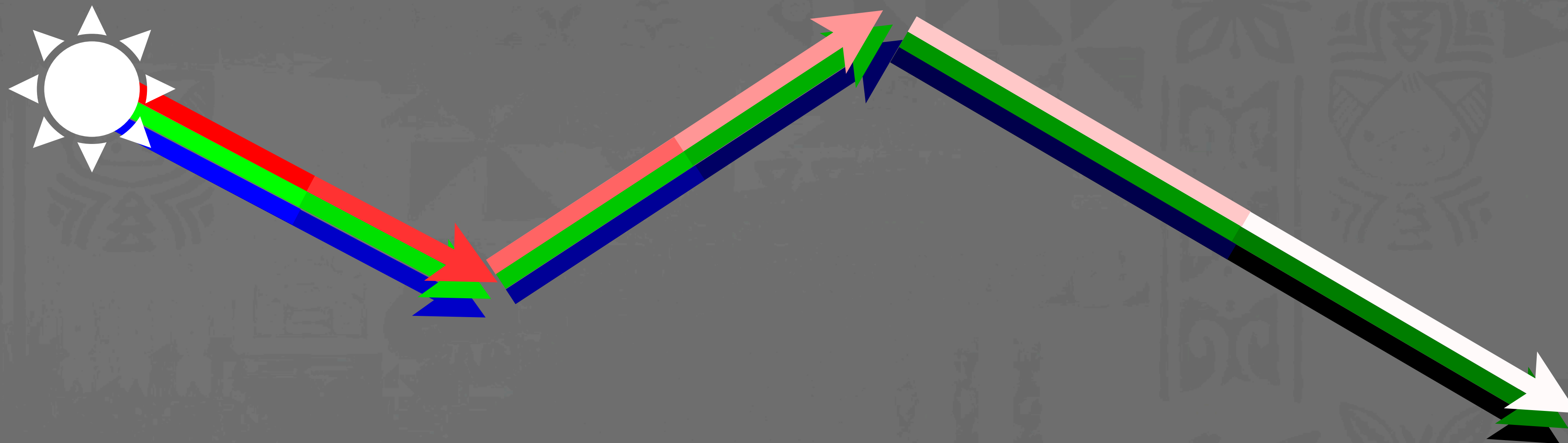
weight

3

1

distance





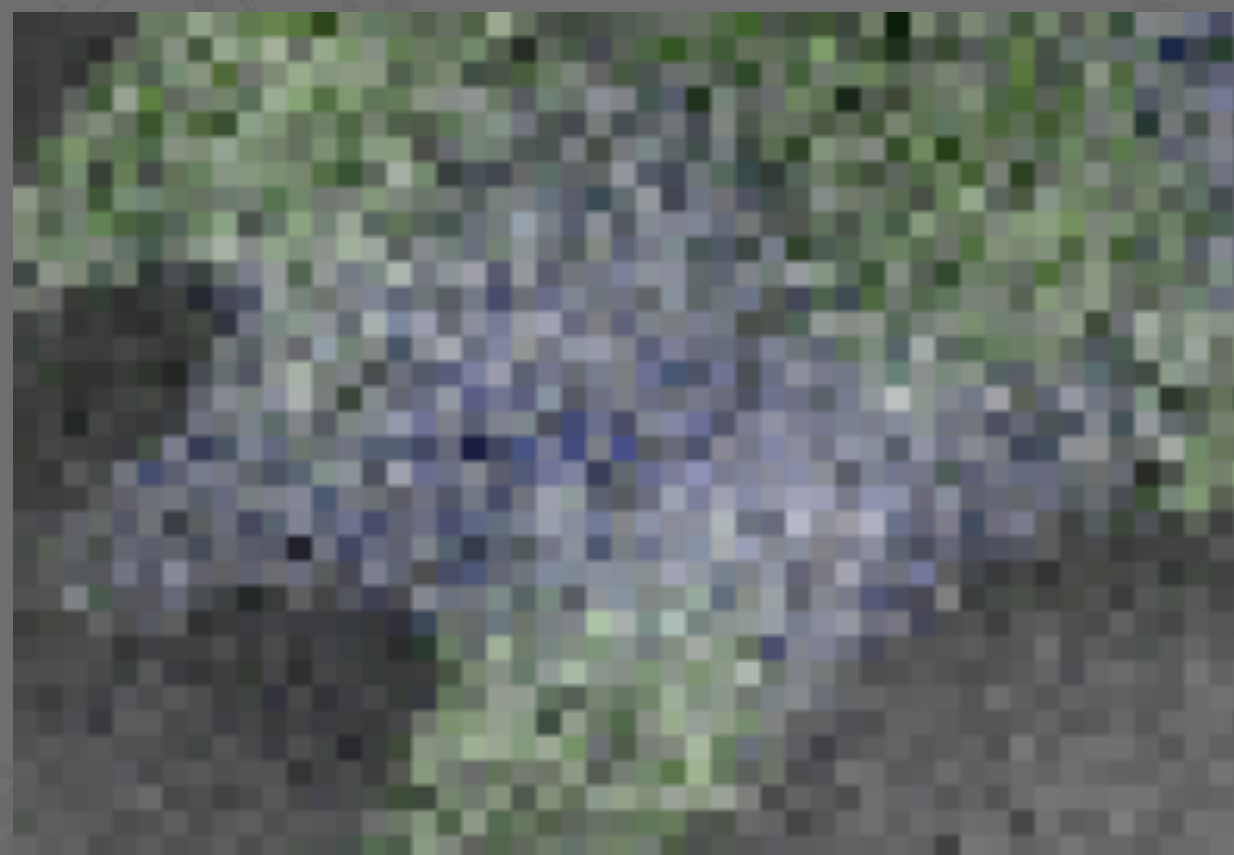
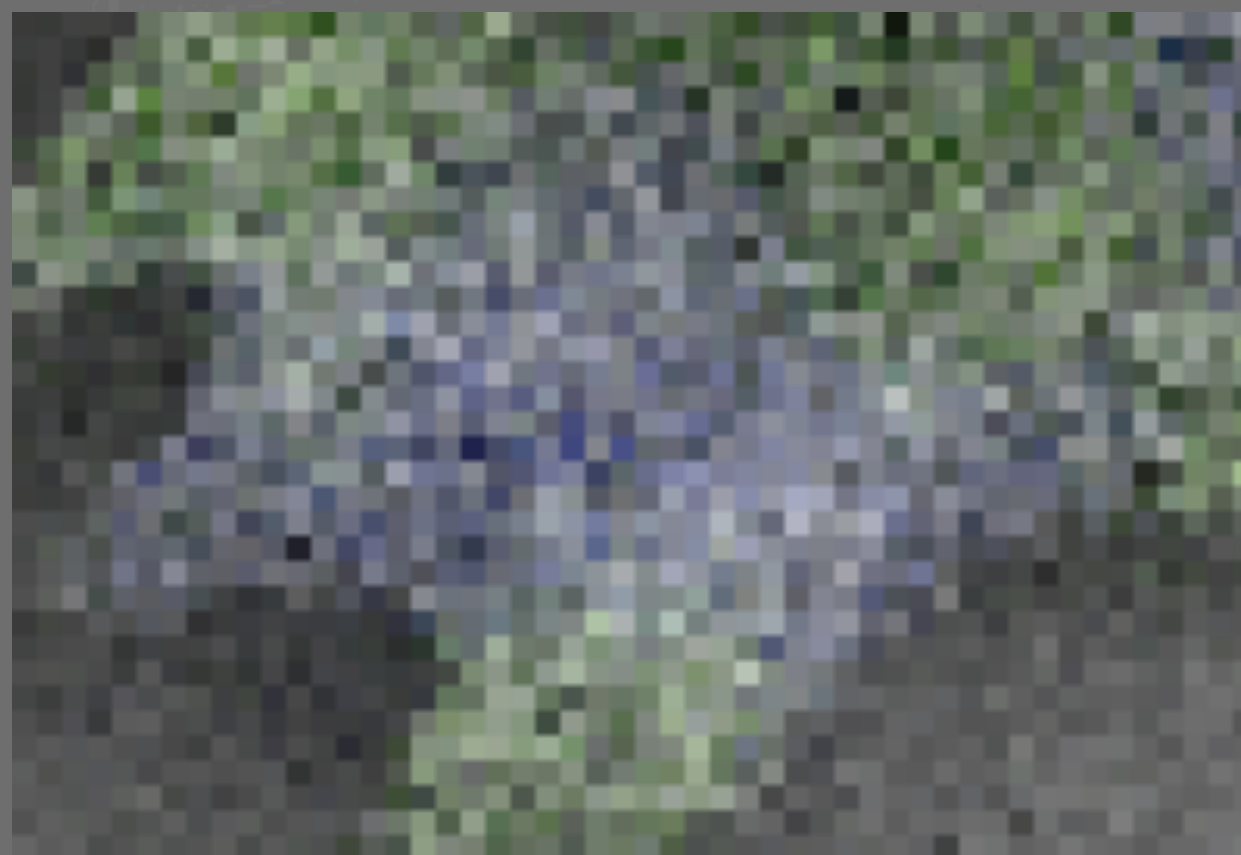
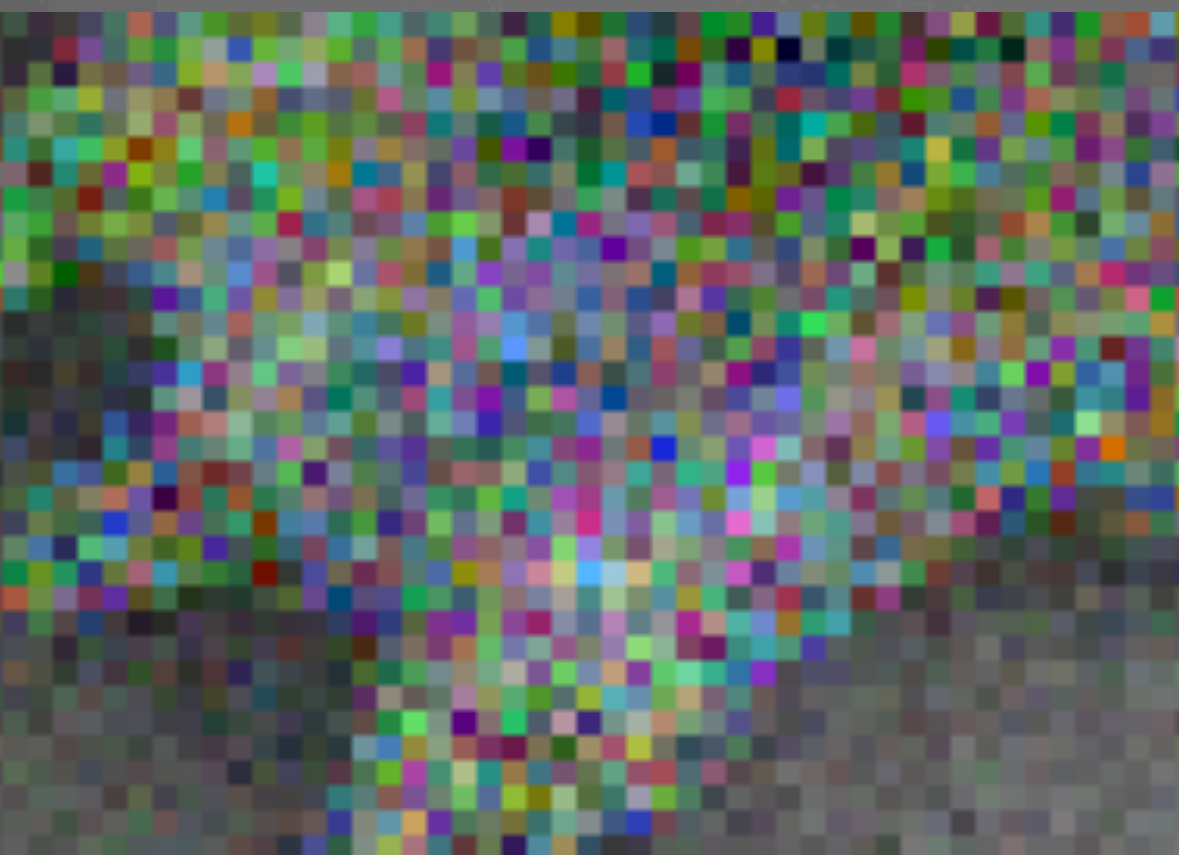
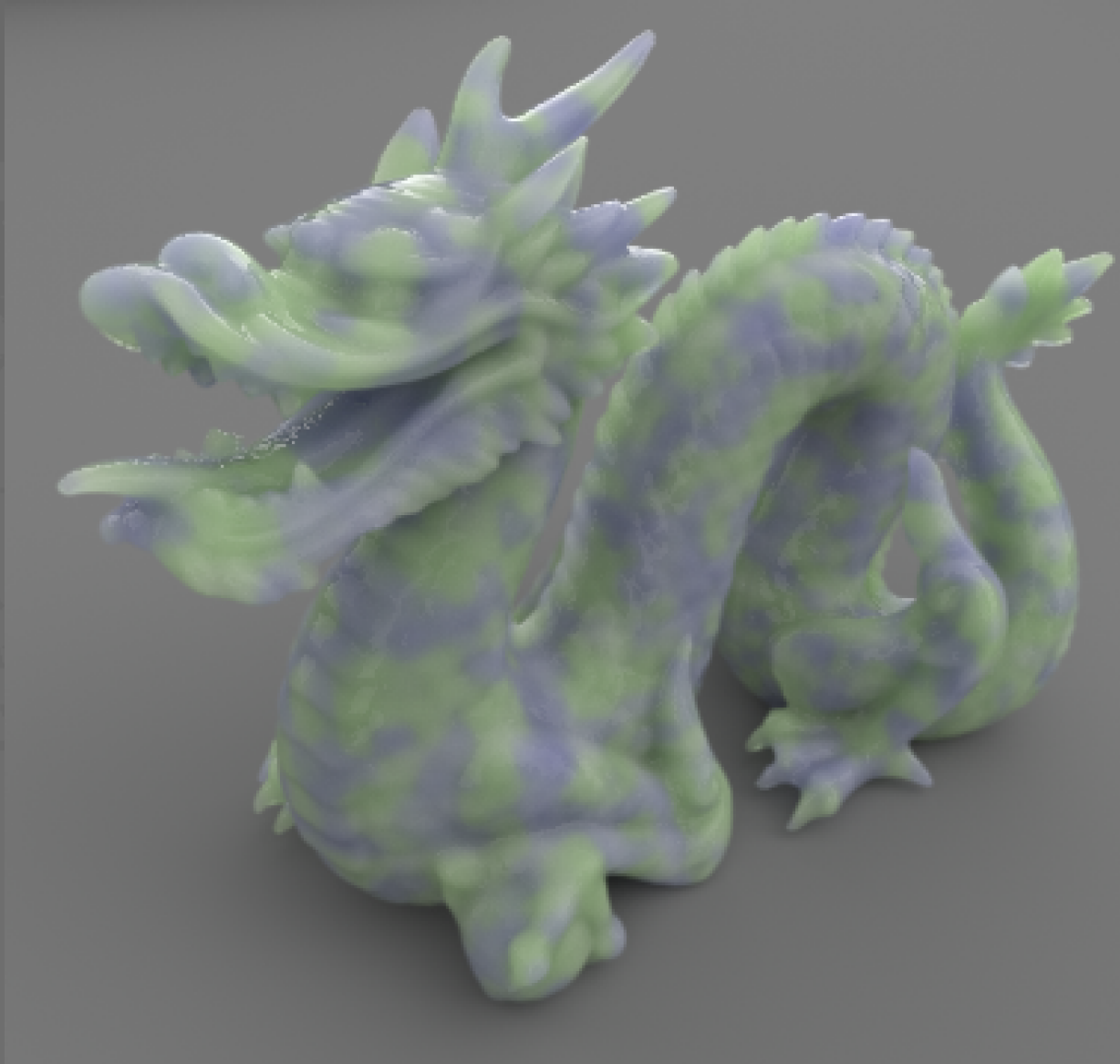
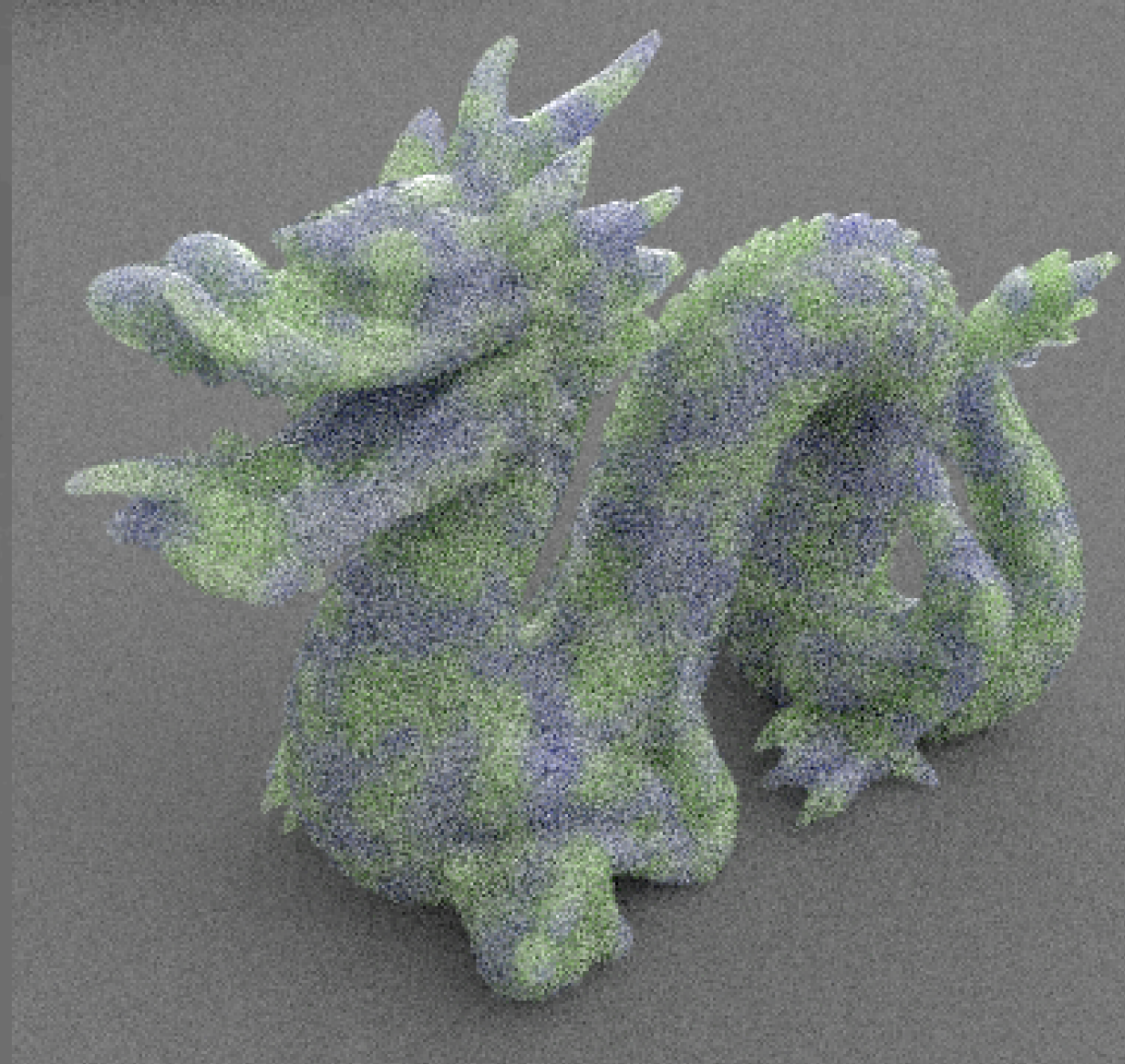
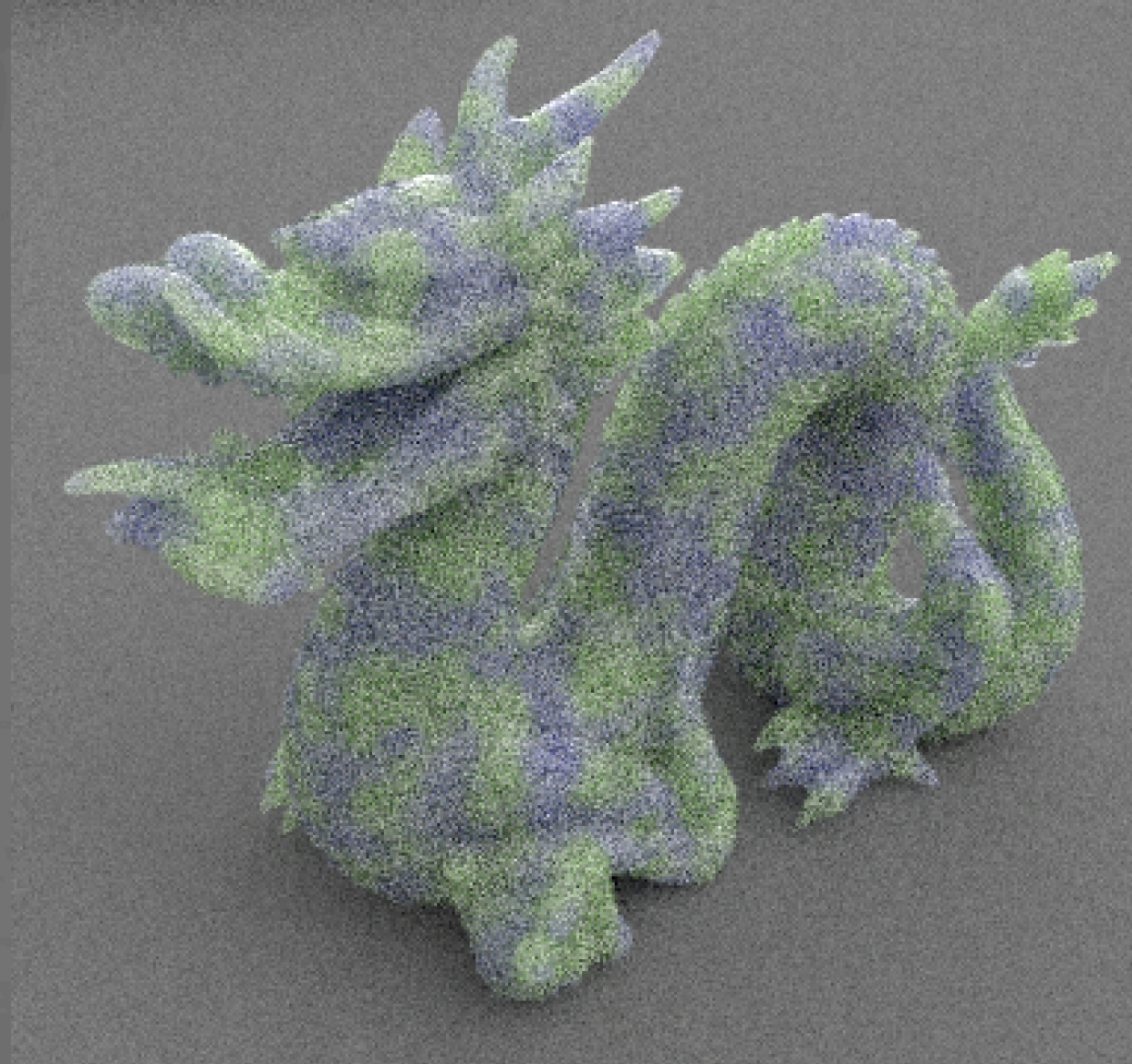
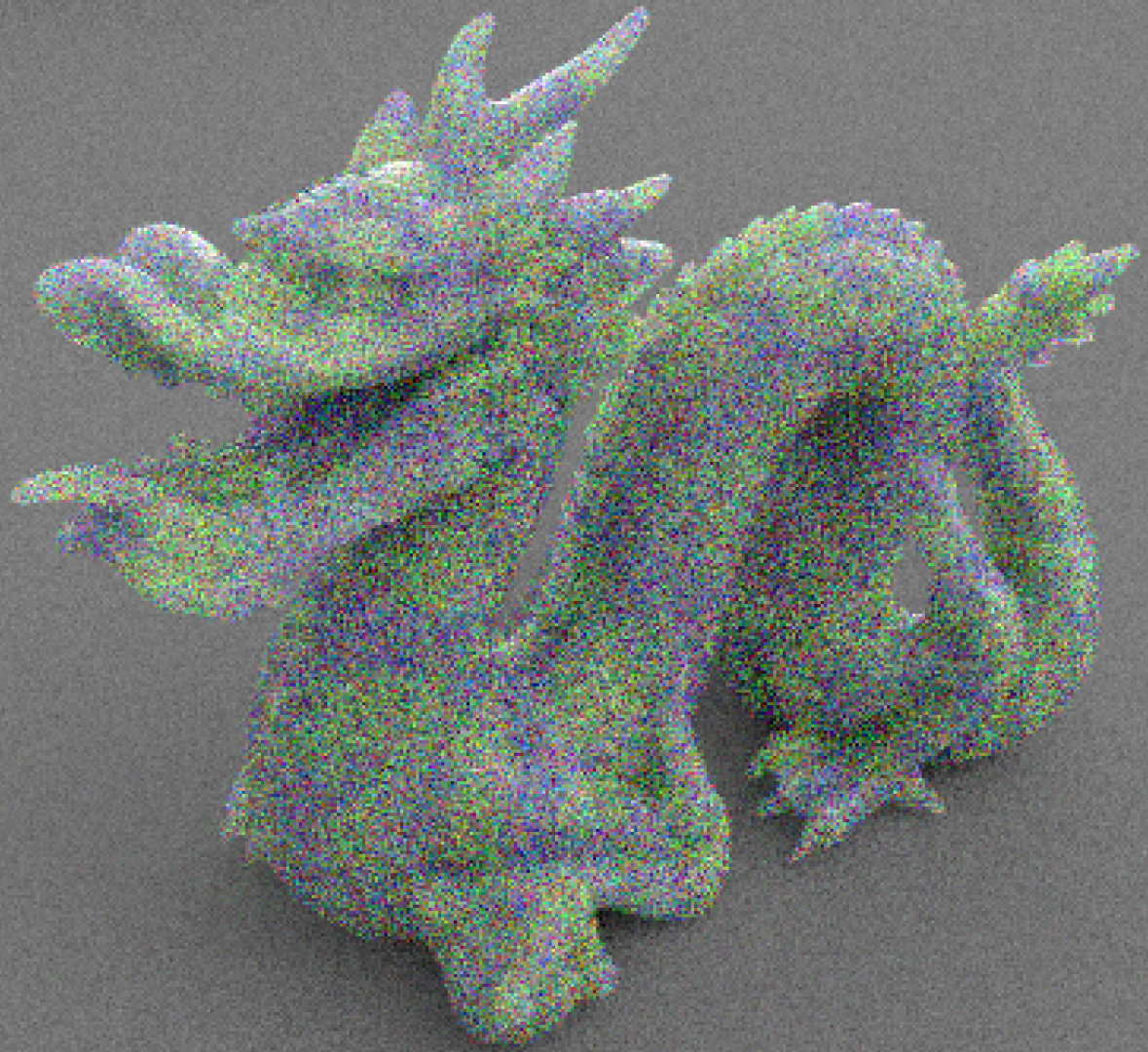
Putting It All Together

delta

spectral

spectral+decomp

reference



1x

3.3x

4.2x

Thank you for your attention!



WALT DISNEY

ANIMATION STUDIOS