A Particle-based Method for Preserving Fluid Sheets

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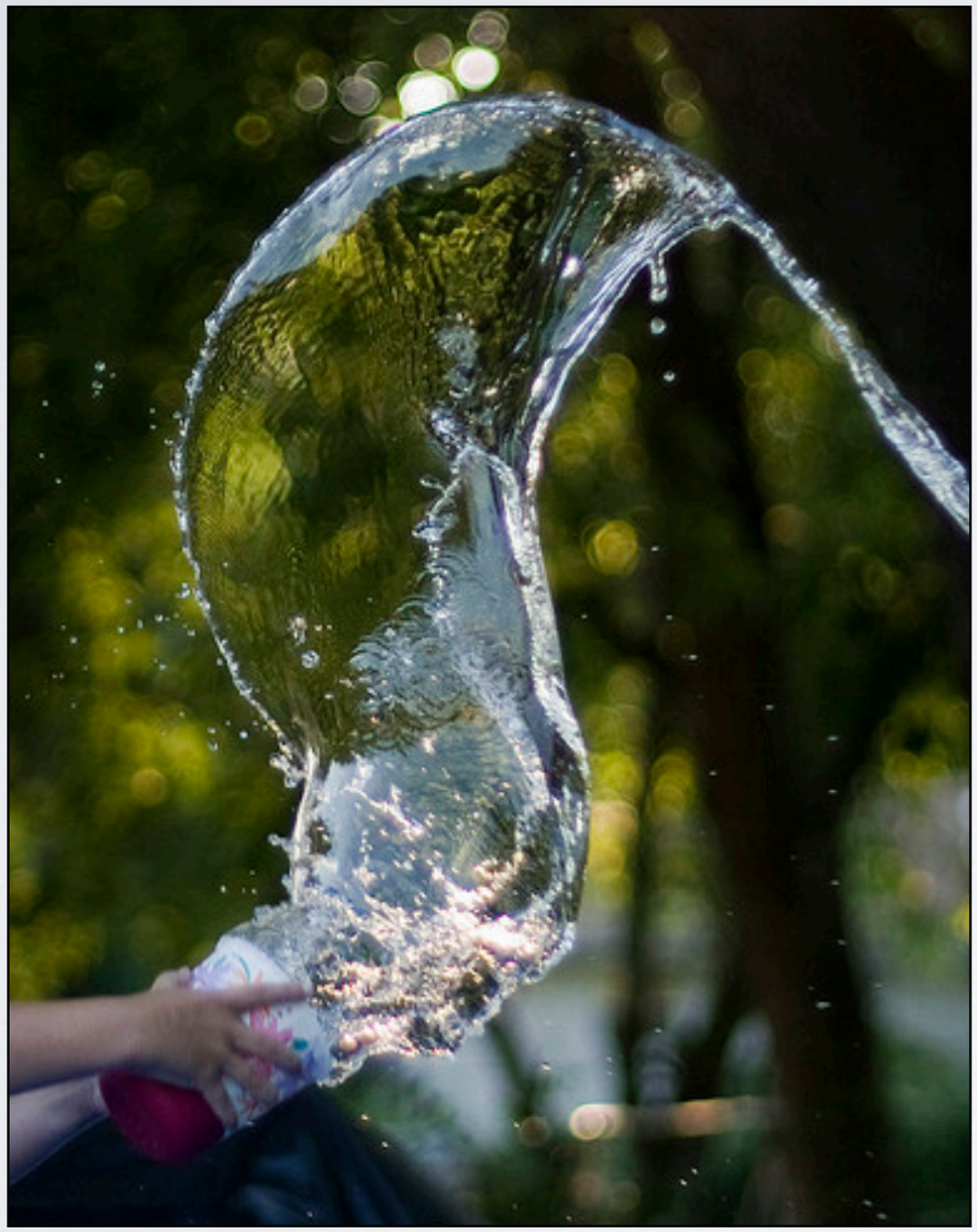
Real Fluid Sheets



http://www.flickr.com/photos/cayusa/2583501396/

http://www.flickr.com/photos/jmarty/124861514

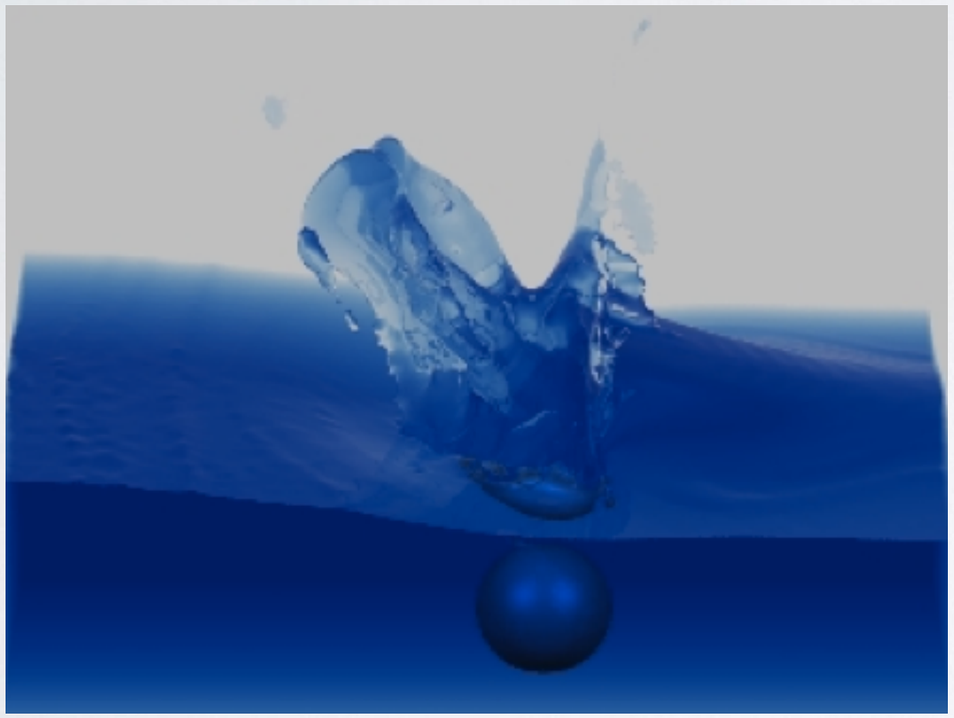
http://www.flickr.com/photos/sanjibm/4543398007/

Traditional Methods

Numerical dissipation (smear)

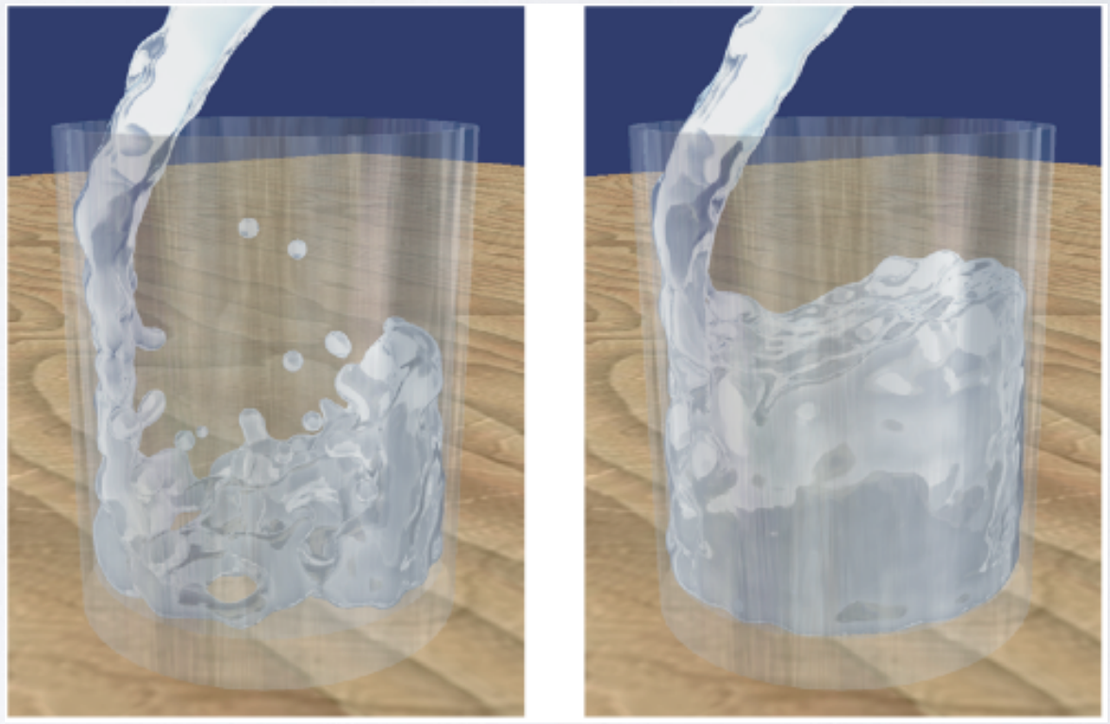
Blobby ruptures

Levelset-based



Foster & Fedkiew [SIG01]

SPH-based

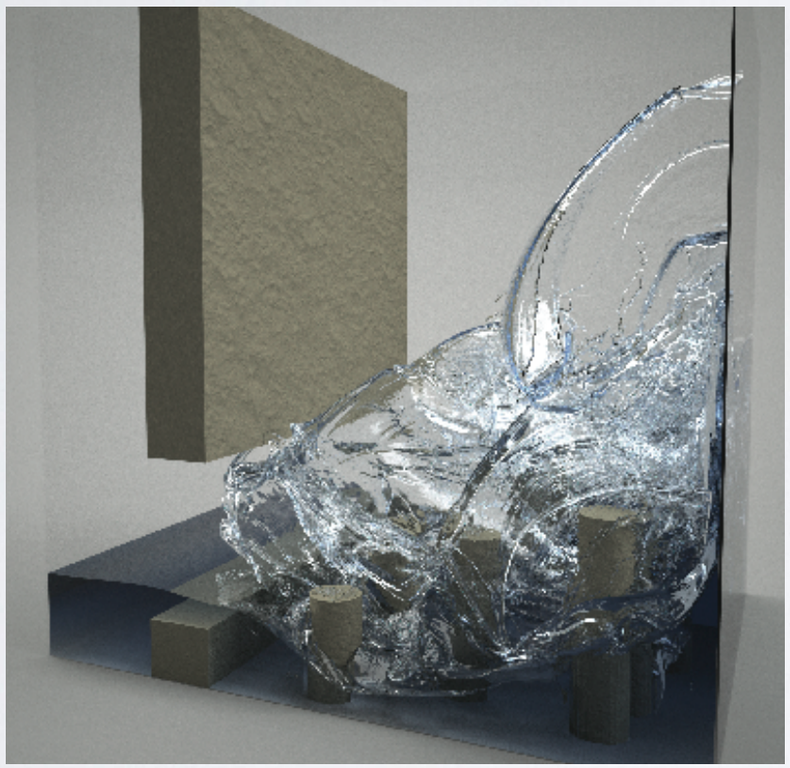


Müller et al. [SCA03]

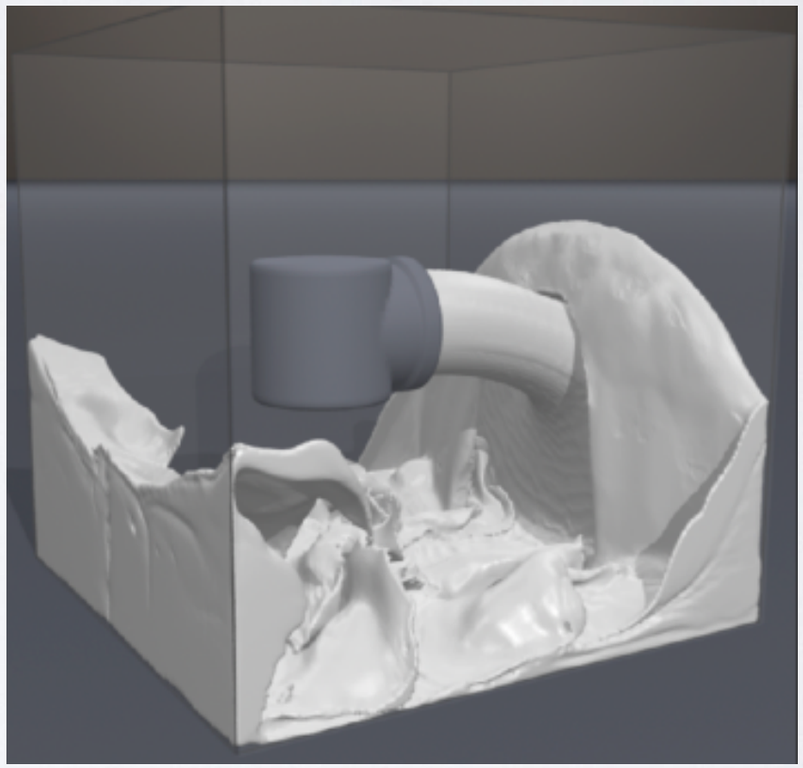
Levelset Extended

Highly accurate tracking & redistancing.

Seed auxiliary particles inside the levelset sheets.

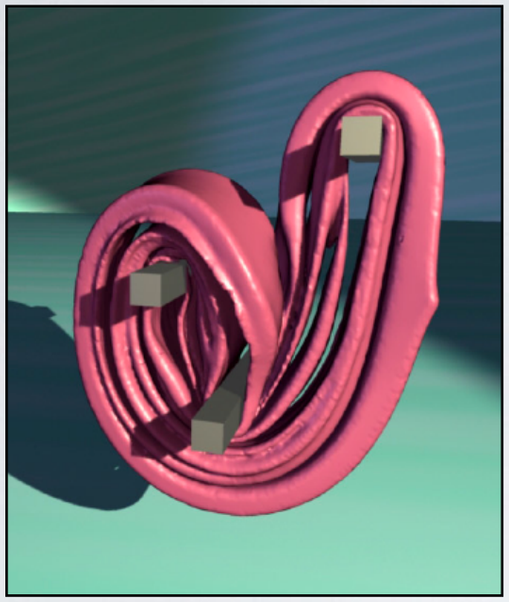


Heo & Ko [SIGA10]



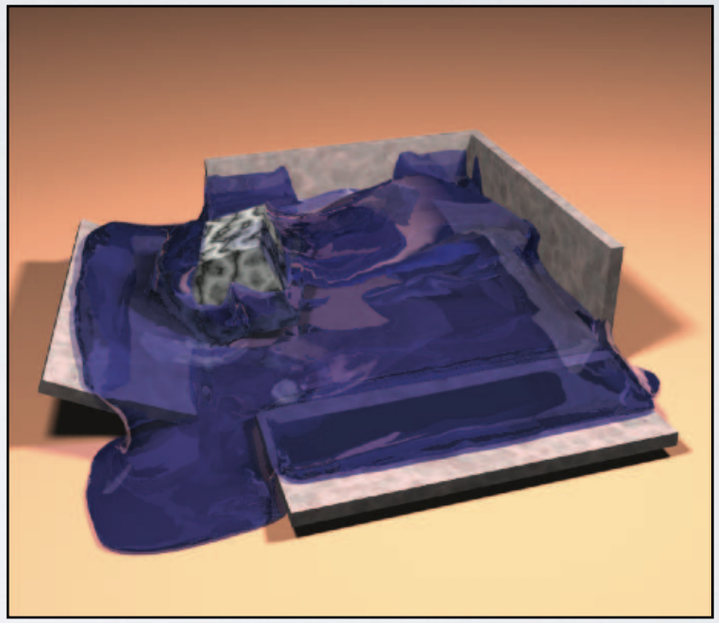
Chentanez et al. [SCA07,SIG11]

Mesh-based Surface Tracking Methods in Fluid

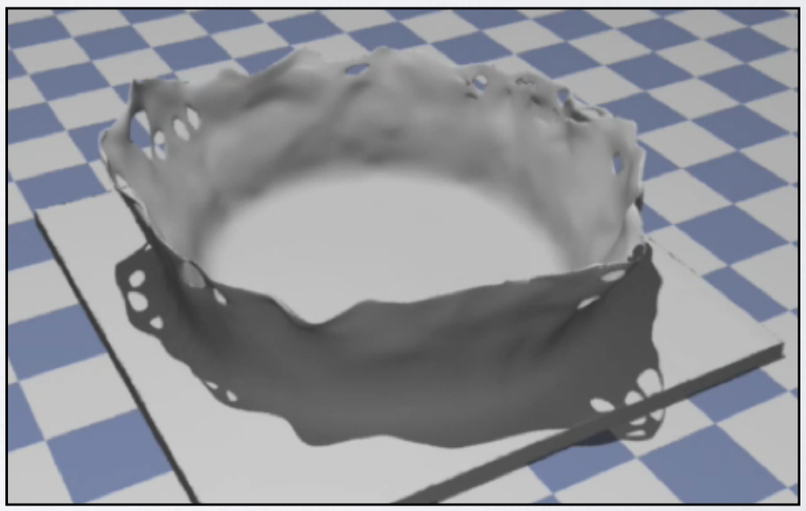


Wojtan et al. [SIG09,SIG10]

Müller [SCA09]



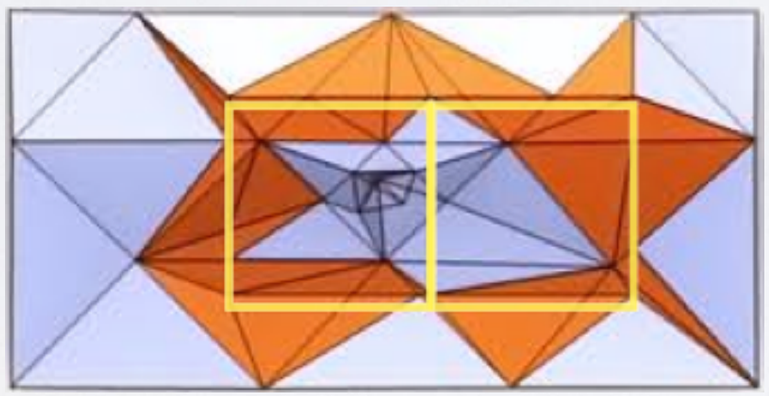
Thürey et al. [SIG10]

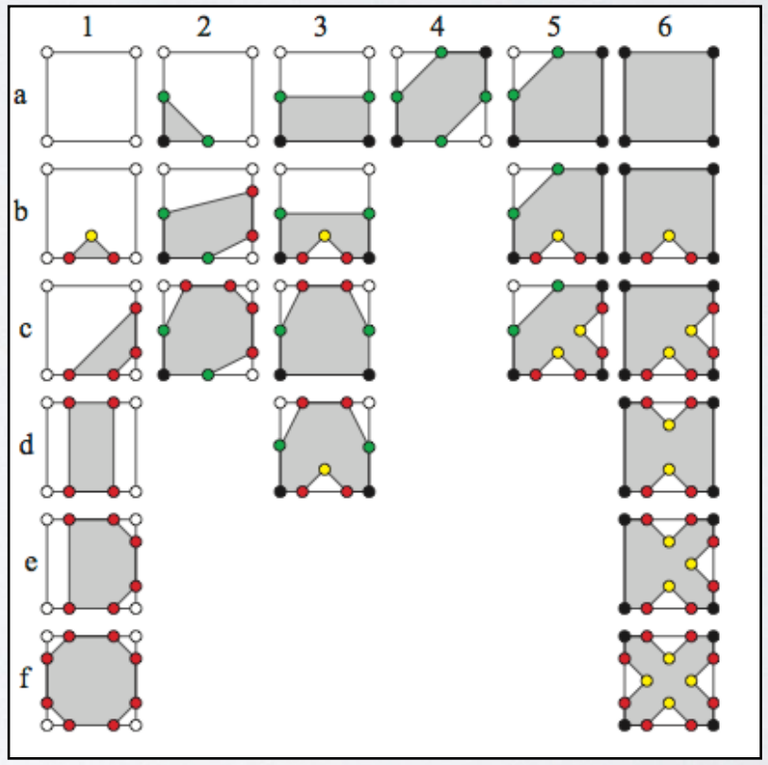


Brochu et al. [SIG10]

Mesh-based Surface Tracking Methods

Difficult topological changes.



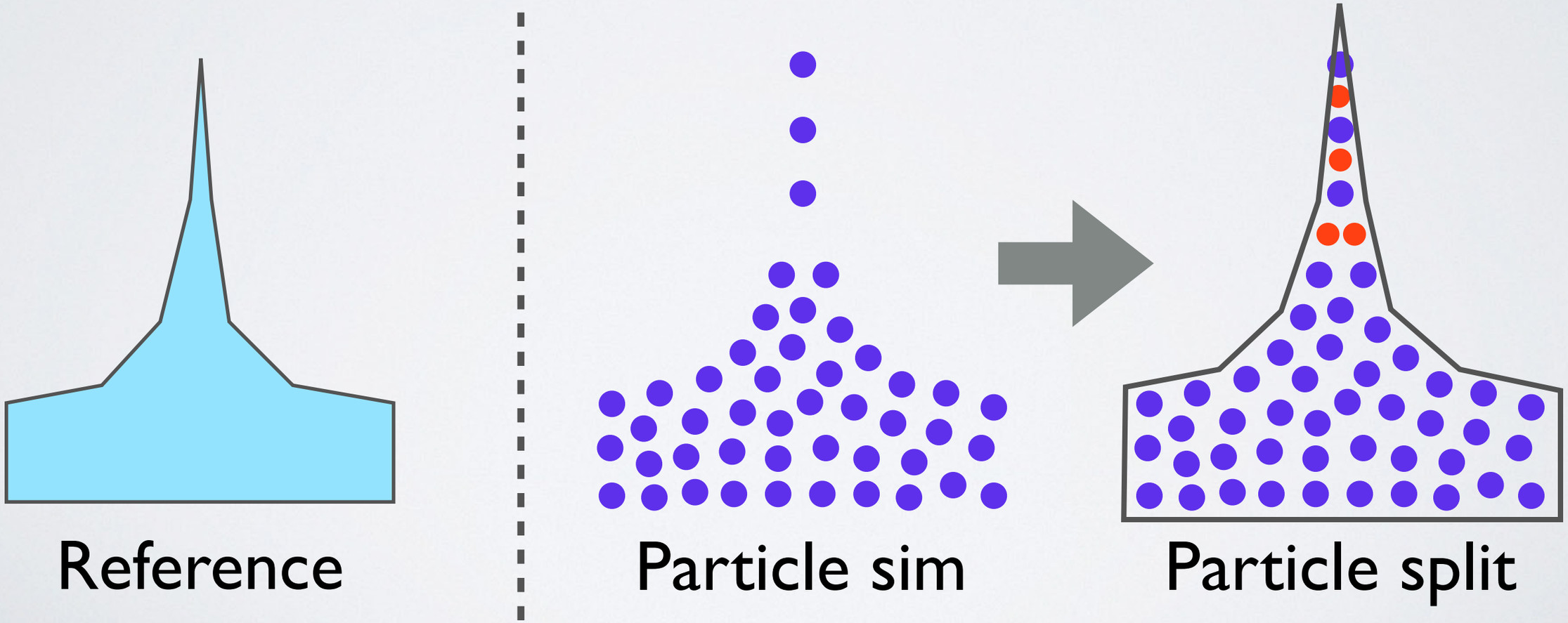


Introducing a Particle-based Alternative.

Fill liquids with particles.

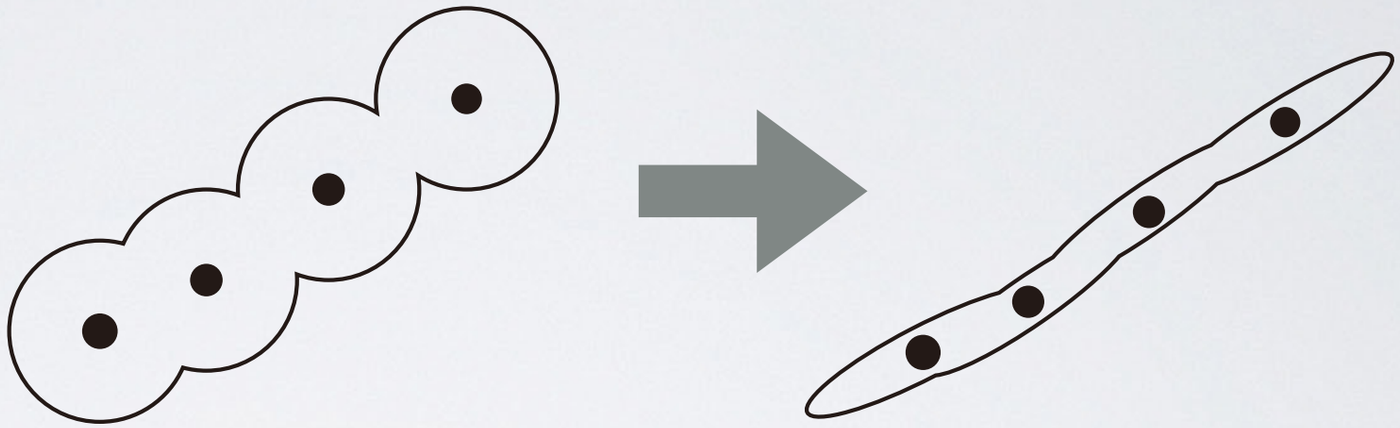
Split particles to prevent the rupture of fluid sheets.

Reconstruct thin smooth meshes.



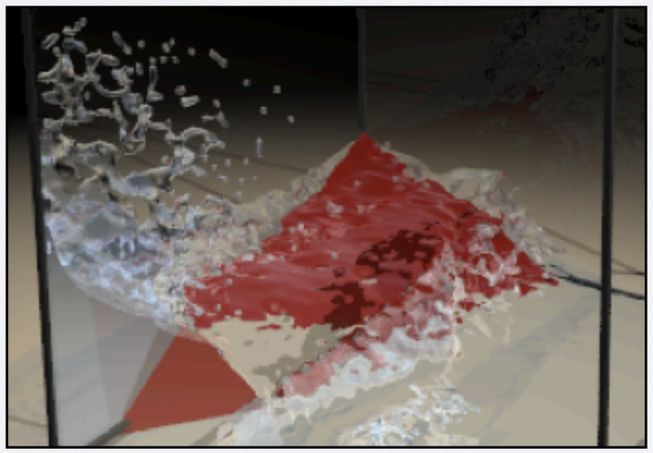
Thin sheets with particles ?
You may doubt this because

Particle surfaces are usually blobby and thick !

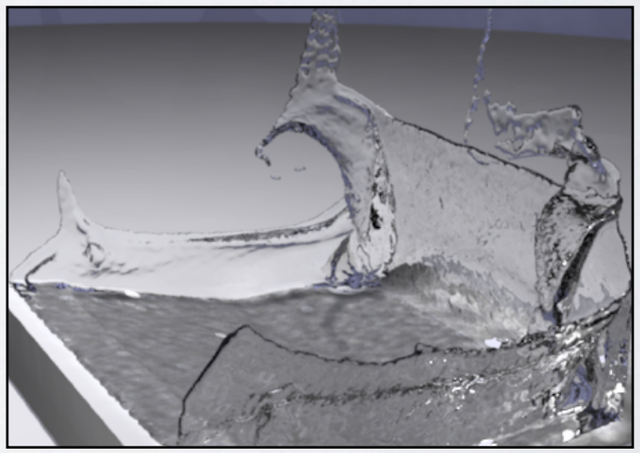


Yu & Turk [SCA10]

Particles are often splashy !



PCISPH



PIC/FLIP

Method

(1) Underlying Fluid

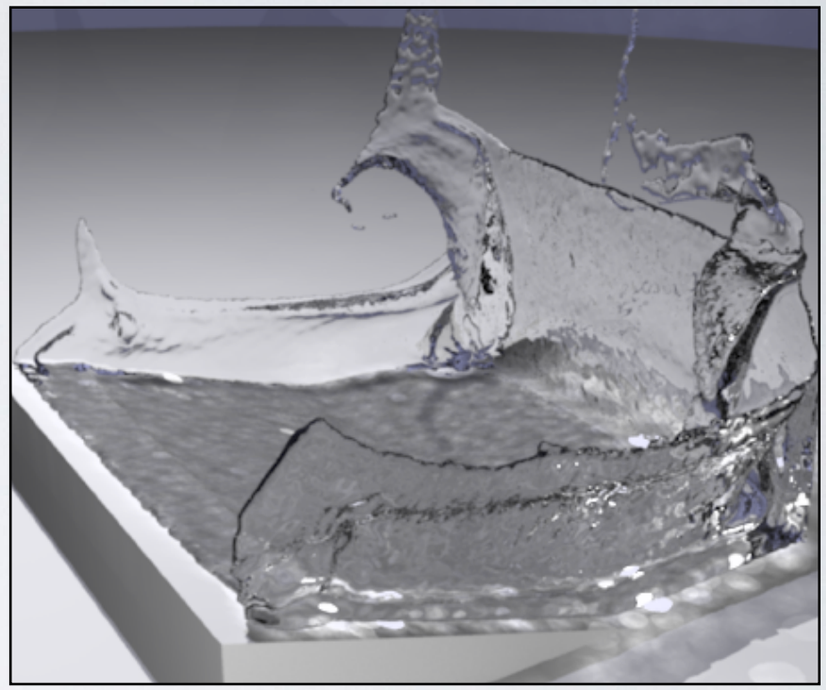
(2) Preserving Sheets

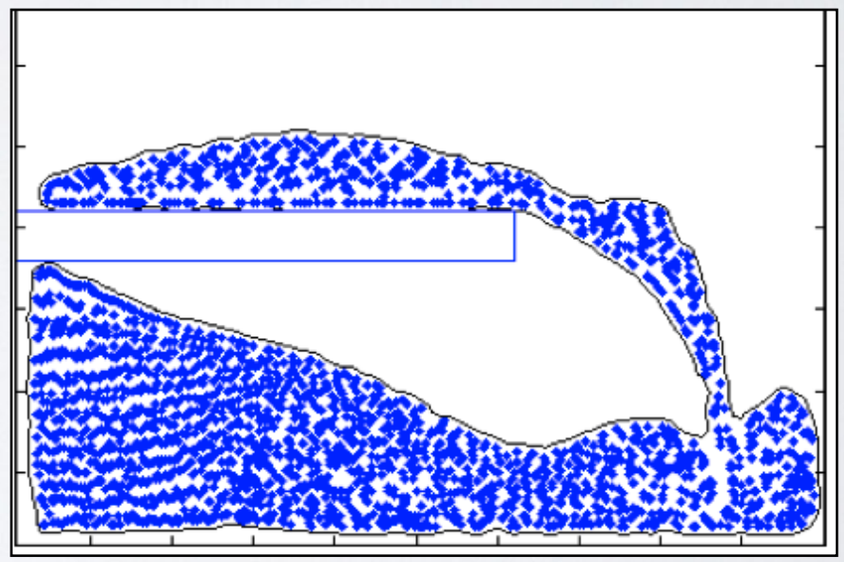
Underlying Fluid

We extend PIC/FLIP method [Zhu&Bridson05]

+ Eulerian-like fluid

+ Stable, fast, and easy to implement.



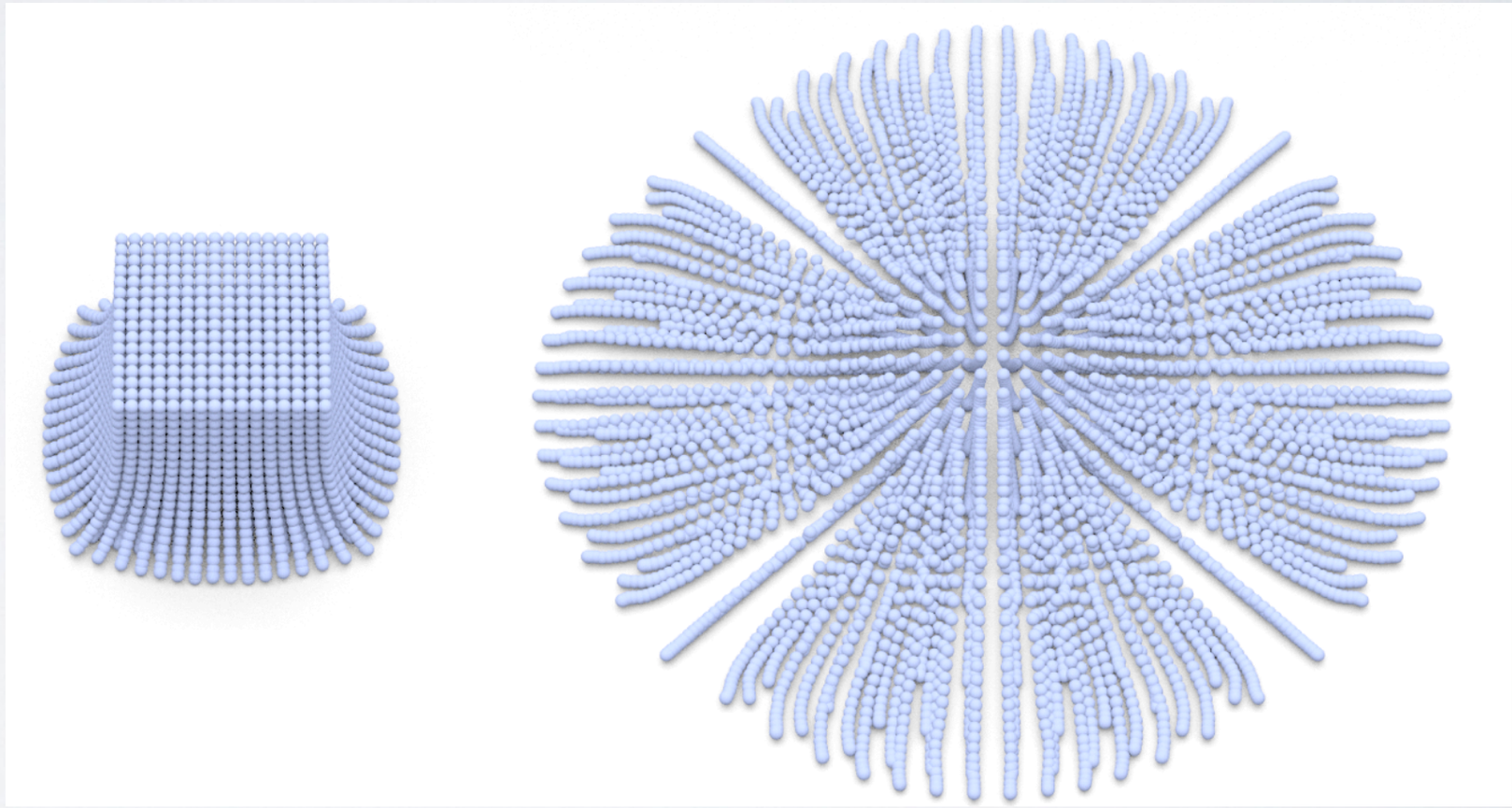


Zhu & Bridson [SIG05]

Underlying Fluid

But uniform particles can easily develop uneven.

Splitting noisy particles is not reliable.

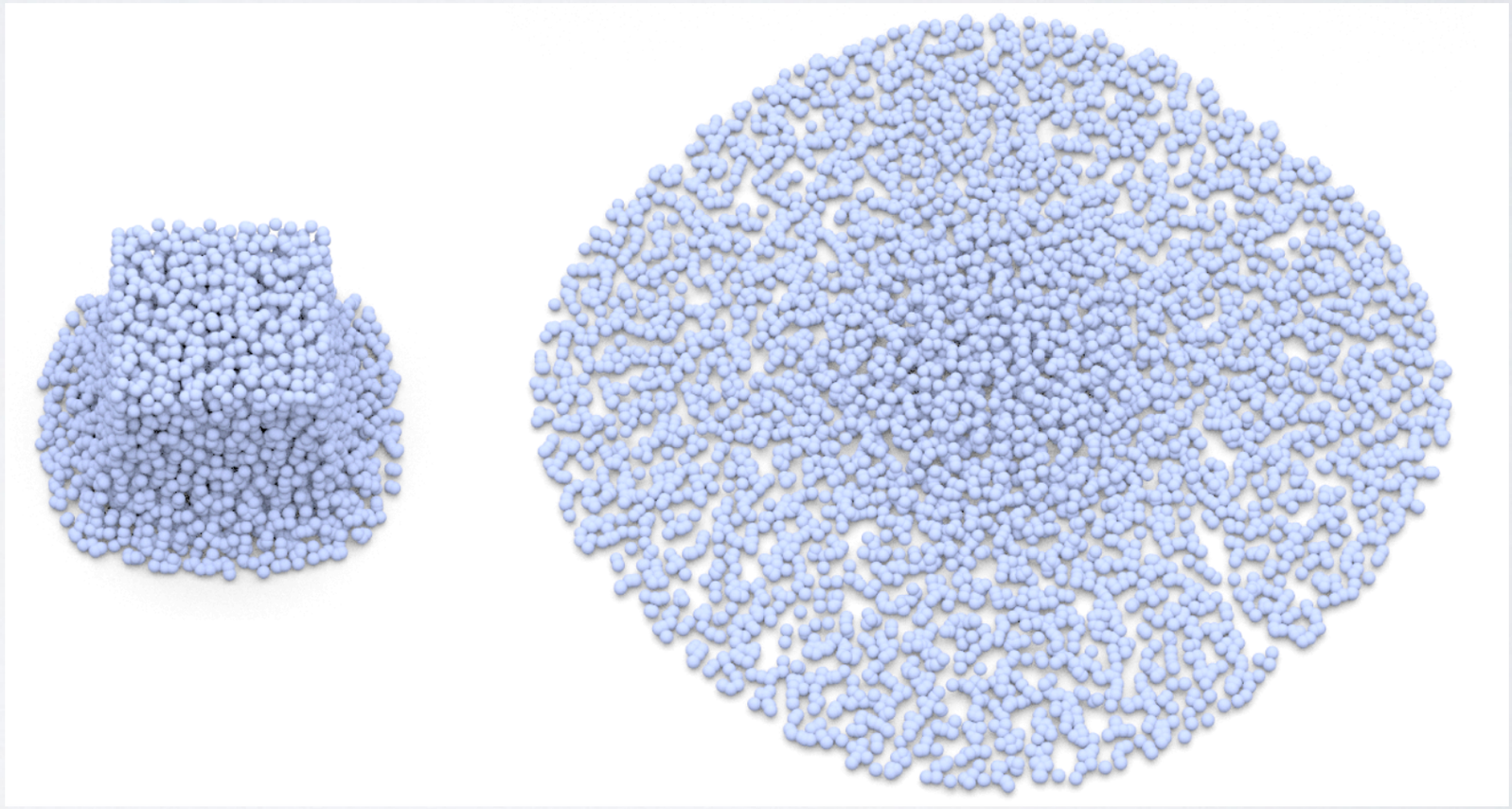


PIC/FLIP alone.

Underlying Fluid

Why not just use jittered particles ? that should do the trick !

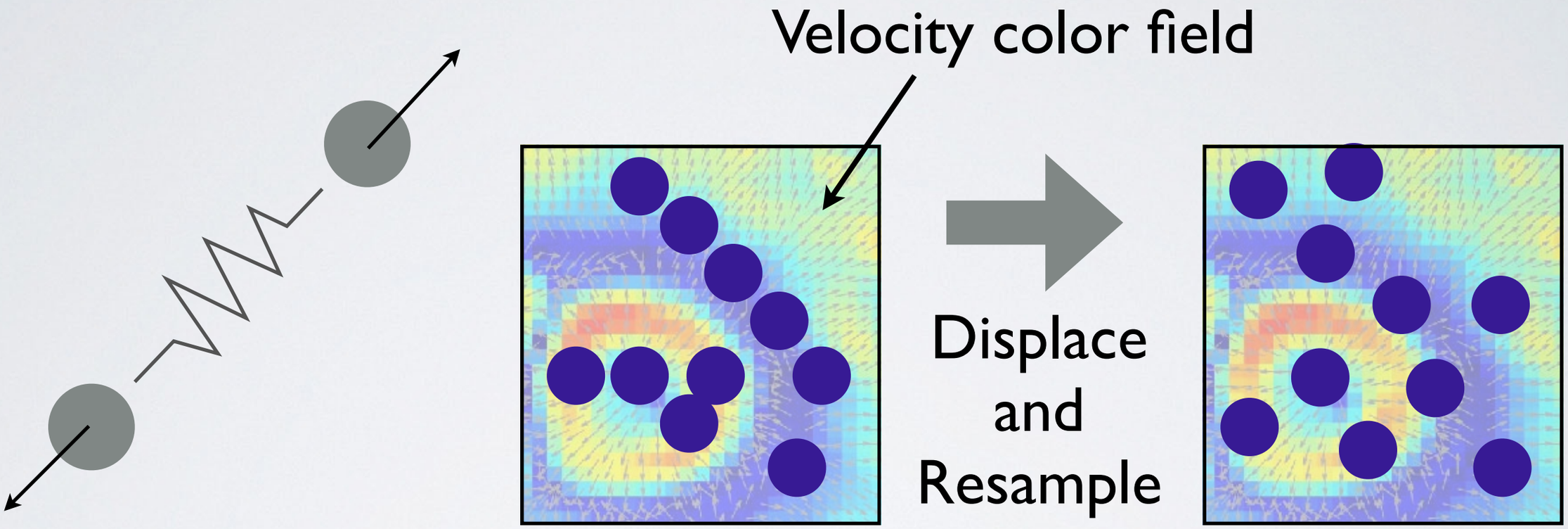
- Yes, it does but only at the beginning. Not a panacea.



Jittered PIC/FLIP.

Underlying Fluid

Displace particles and resample.



Displace particles by SPH-like weak spring force

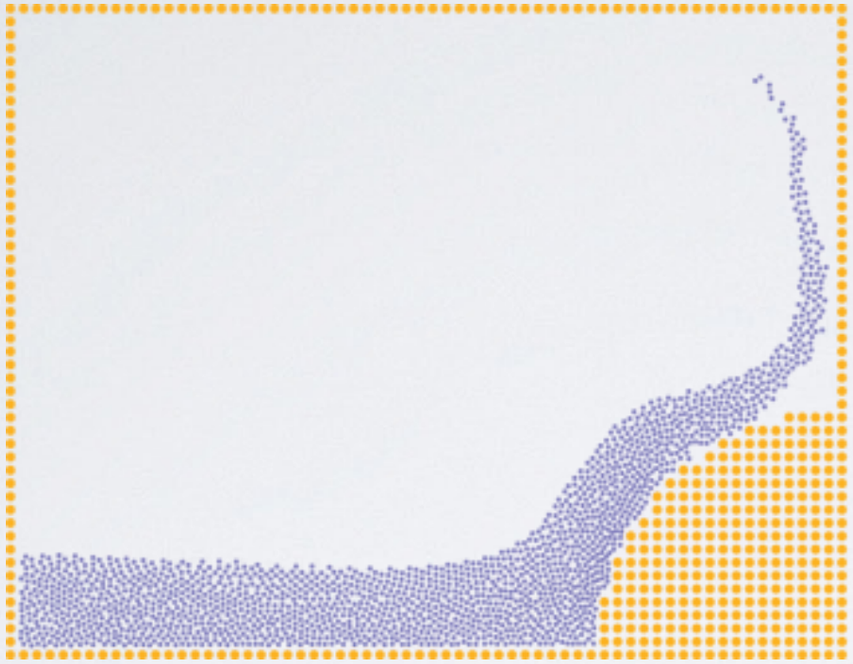
Compute a new particle velocity from the old nearby particles.

(try keep same velocity field)

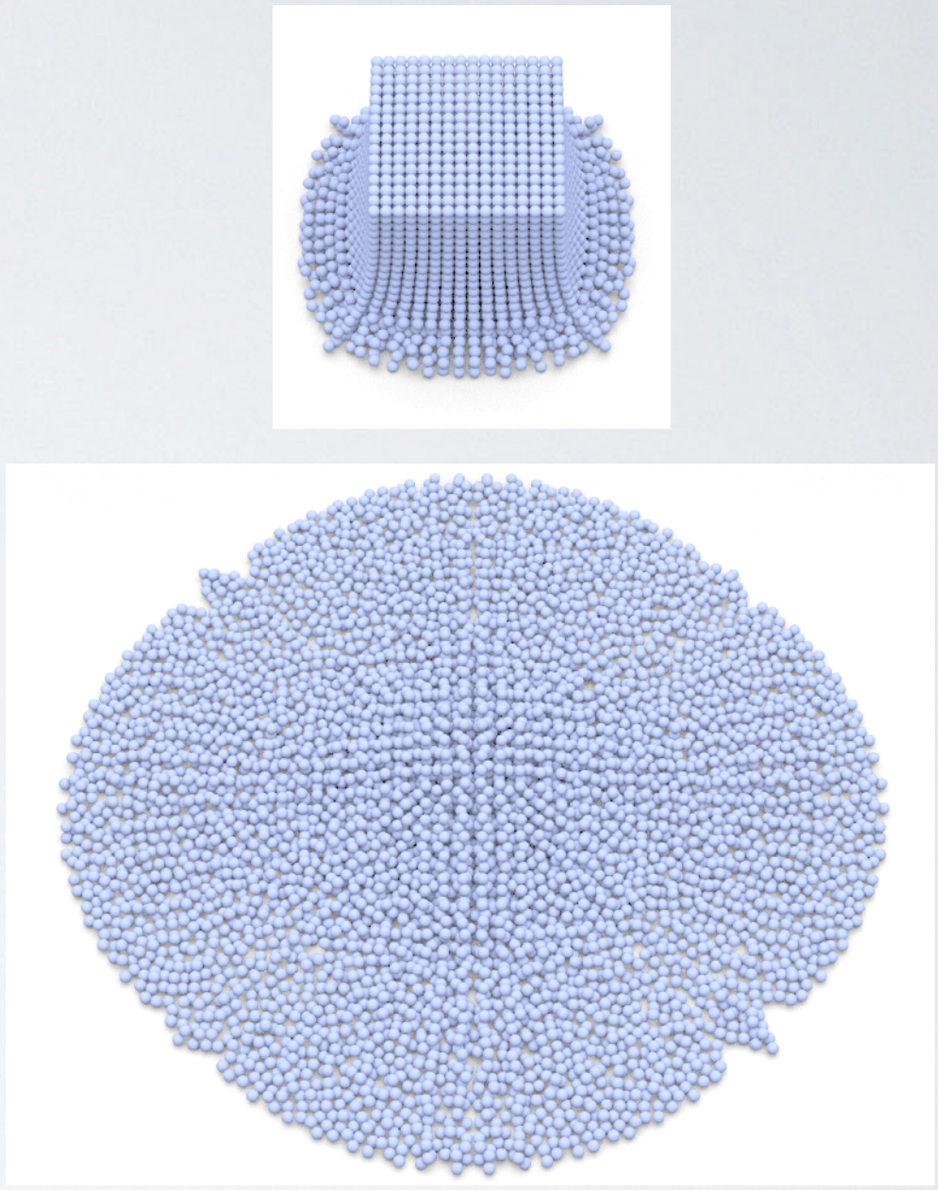
Underlying Fluid

This just works.

Ours



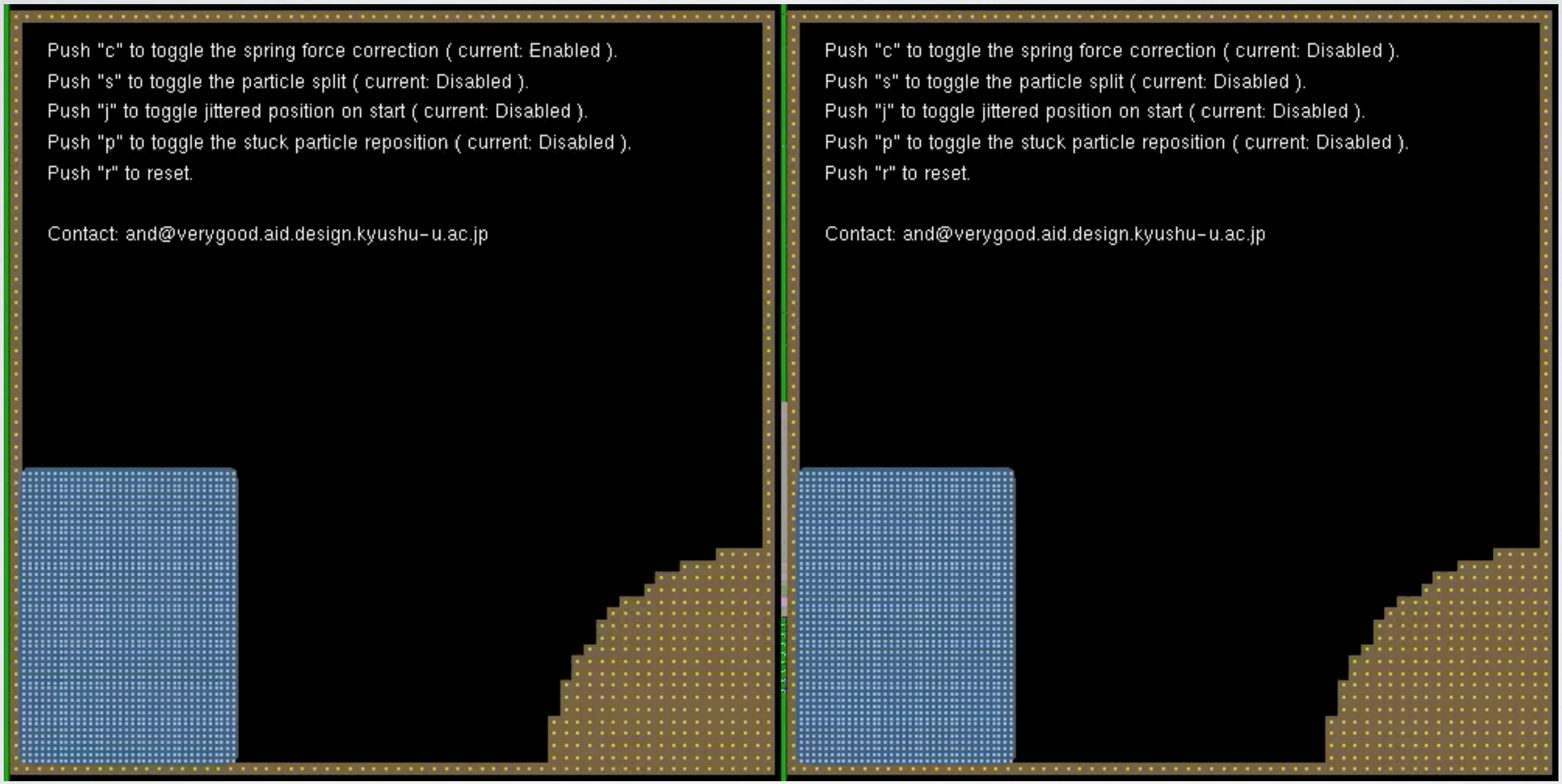
PIC/FLIP alone



PIC/FLIP with weak spring force correction.

Underlying Fluid

2D Comparison



Our liquid solver

PIC/FLIP alone.

Method

(1) Underlying Fluid

(2) Preserving Sheets

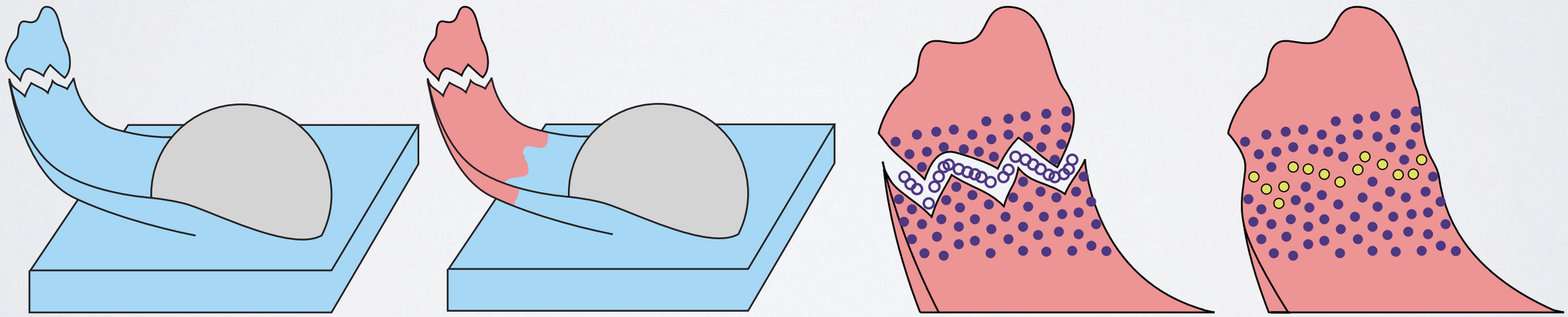
Preserving Sheets: Overview

(a) Given an input simulation

(b) Clip out thin particles

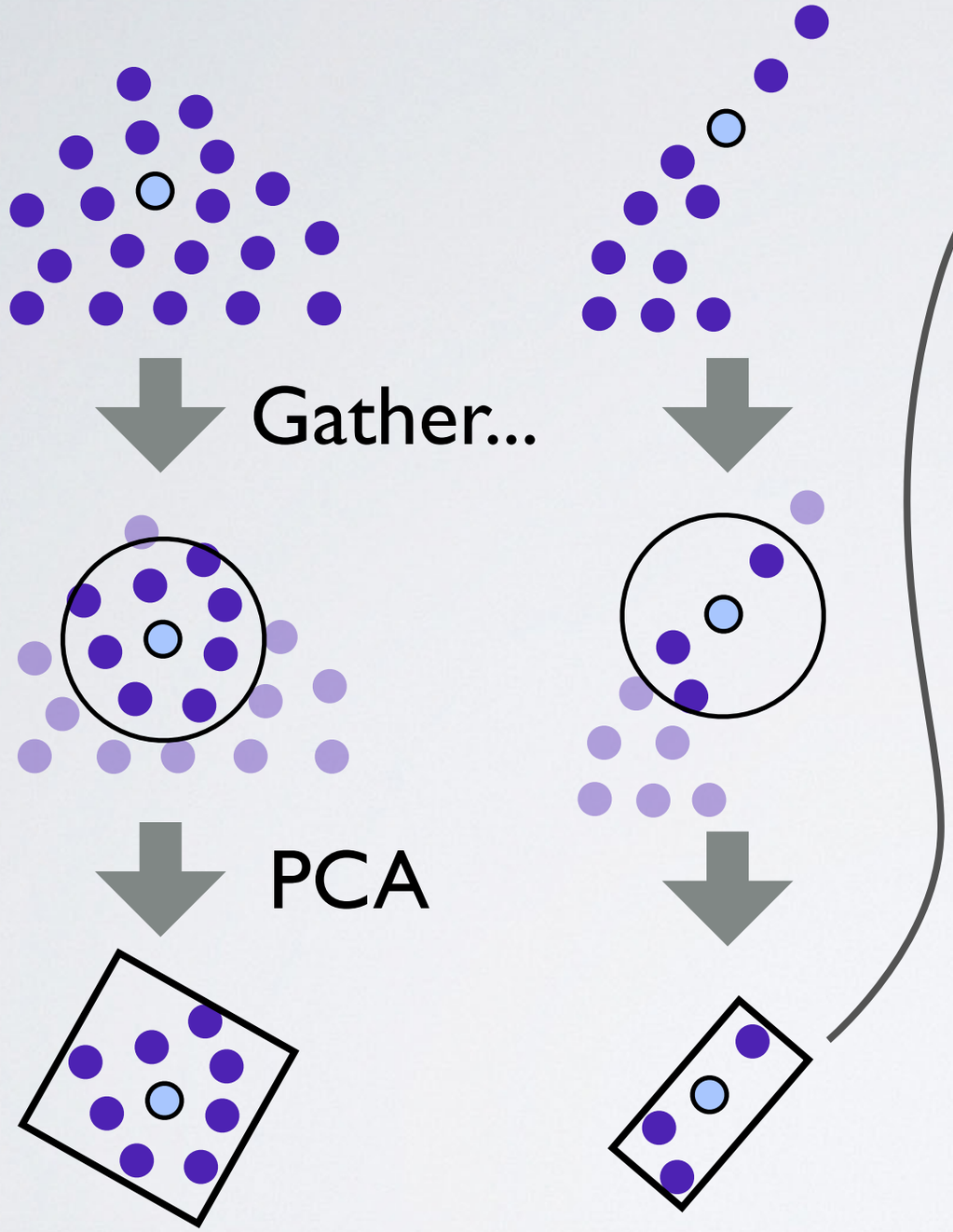
(c) Find candidate split particles

(d) Insert candidates without collision



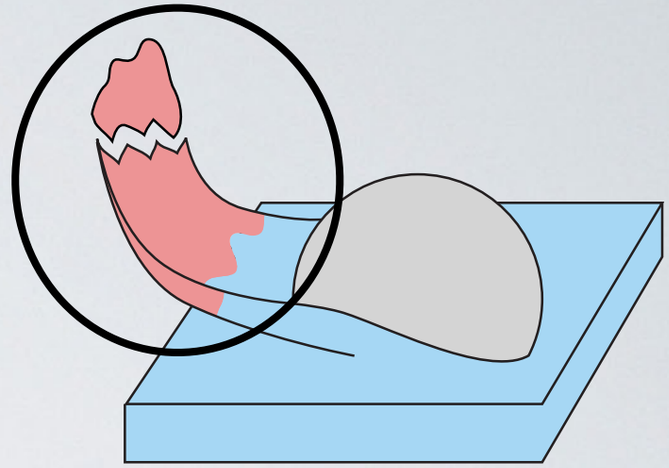
(a) (b) (c) (d)

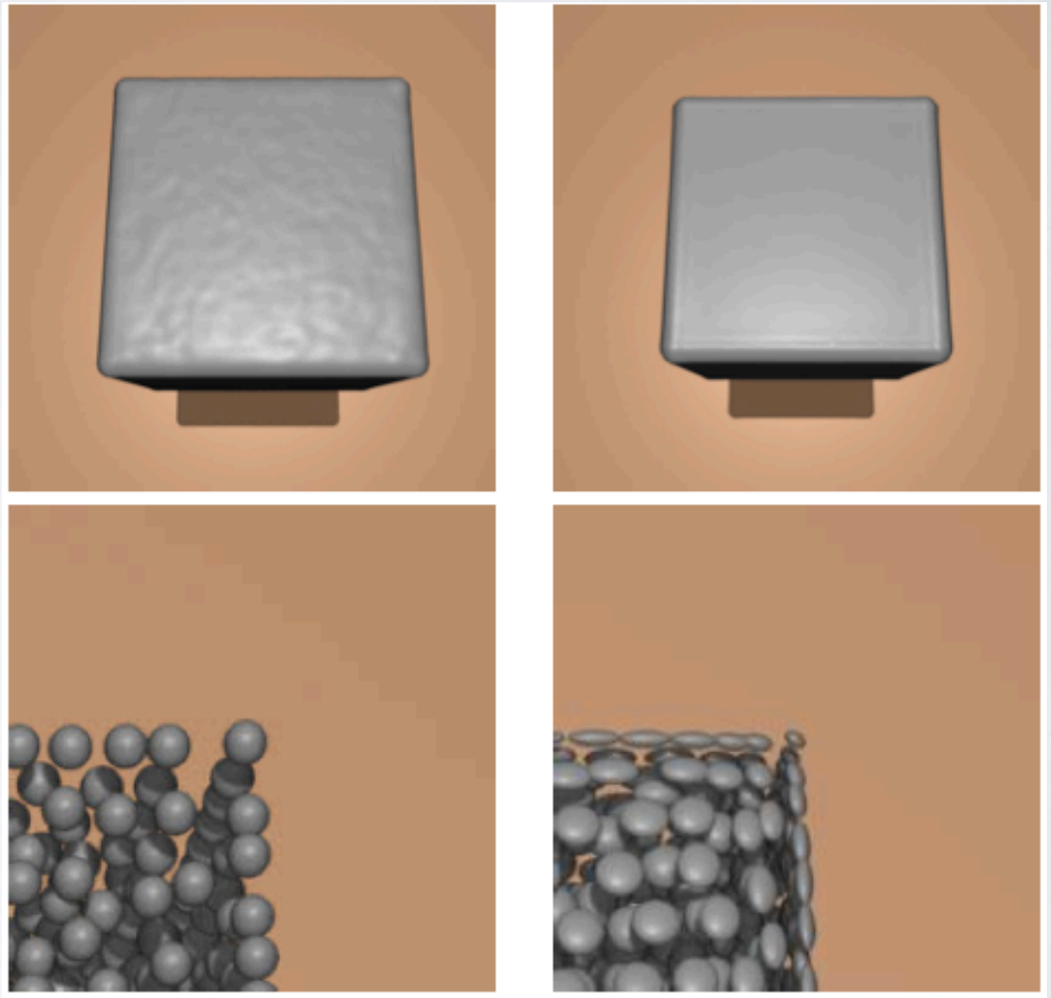
Extracting Thin Particles



Not a thin particle

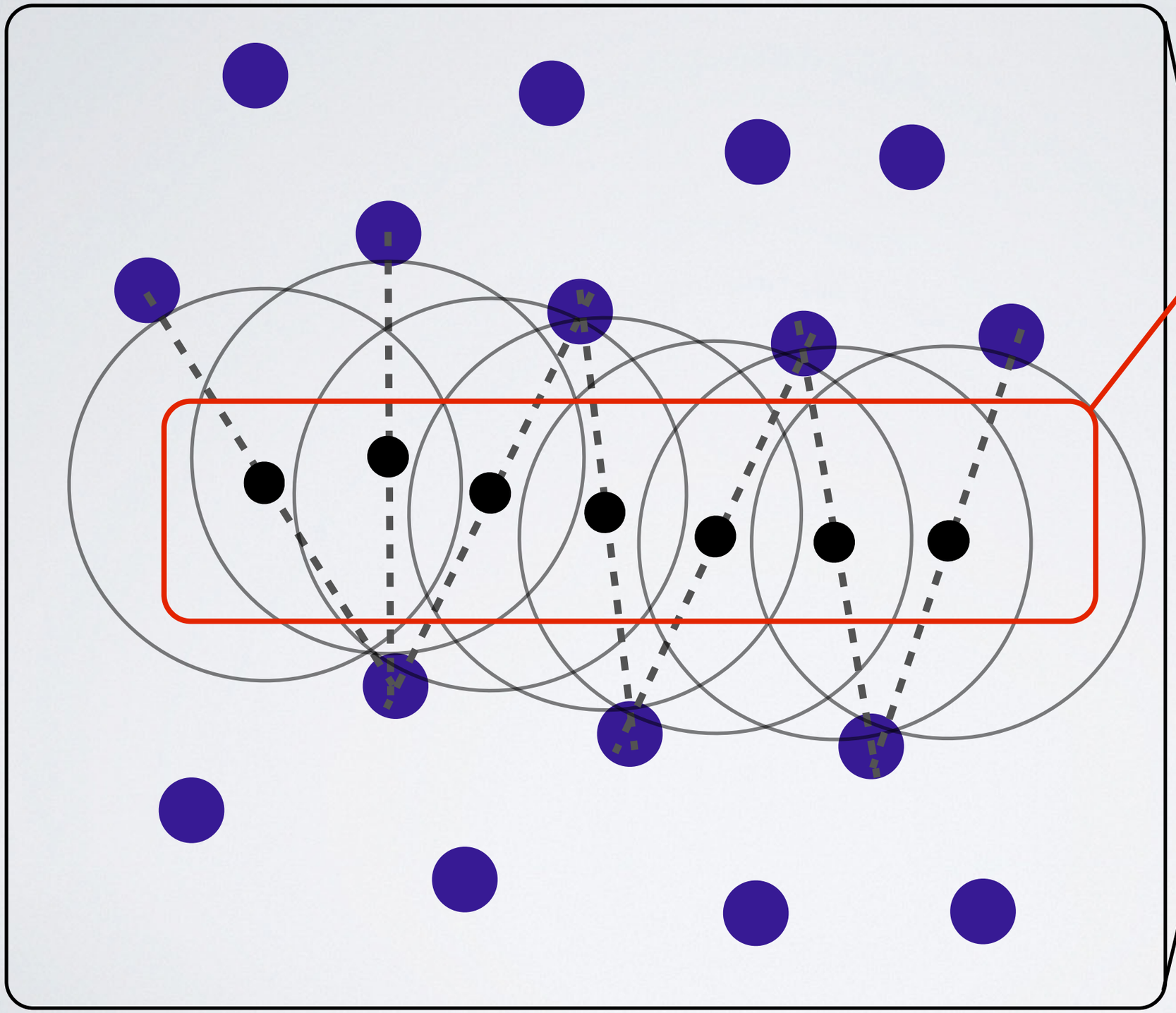
Thin particle !



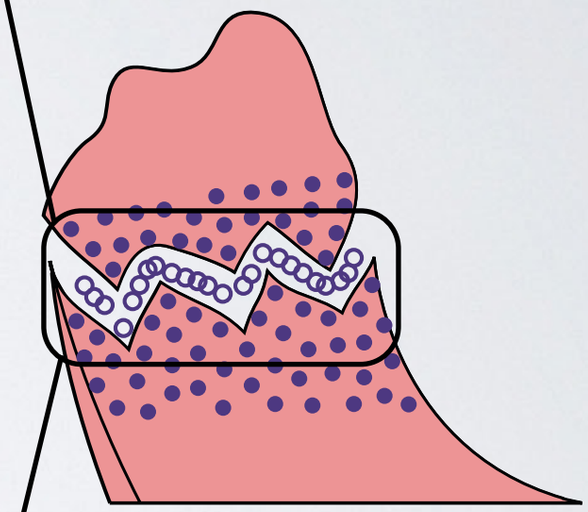


Yu & Turk [SCA10]

Computing Candidate Particles

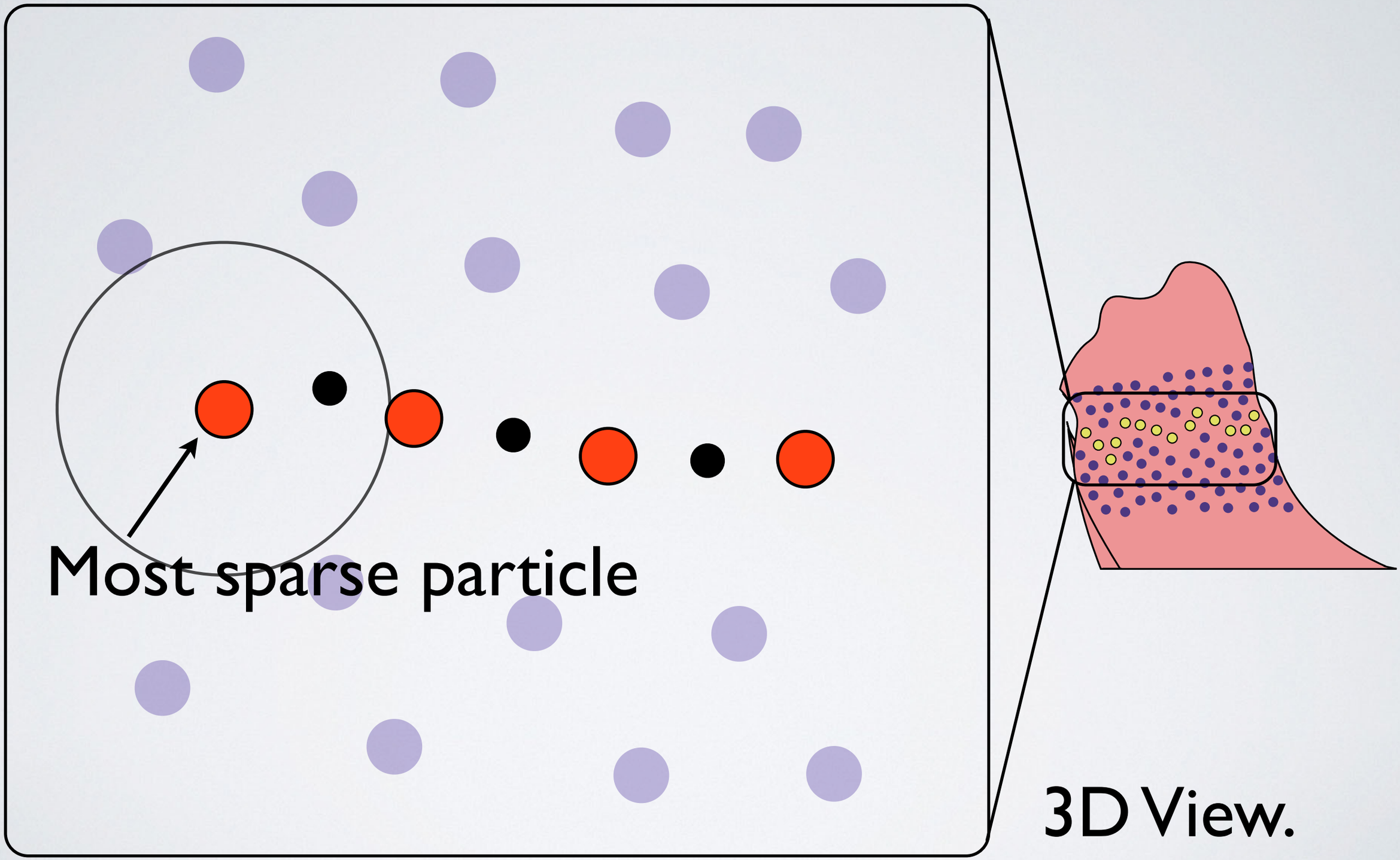


Candidate Particles

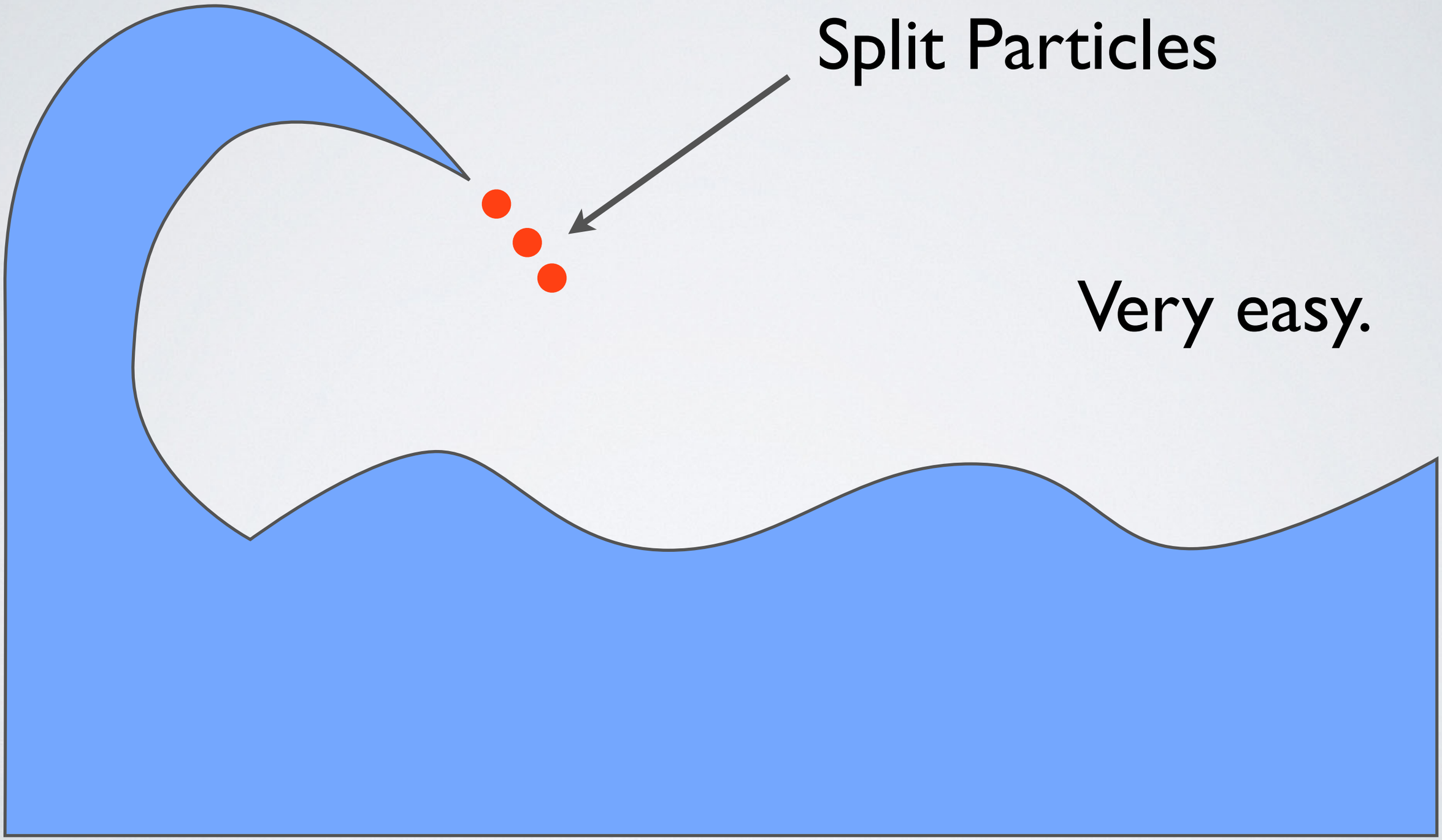


3D View.

Final Particle Insertion (Split)

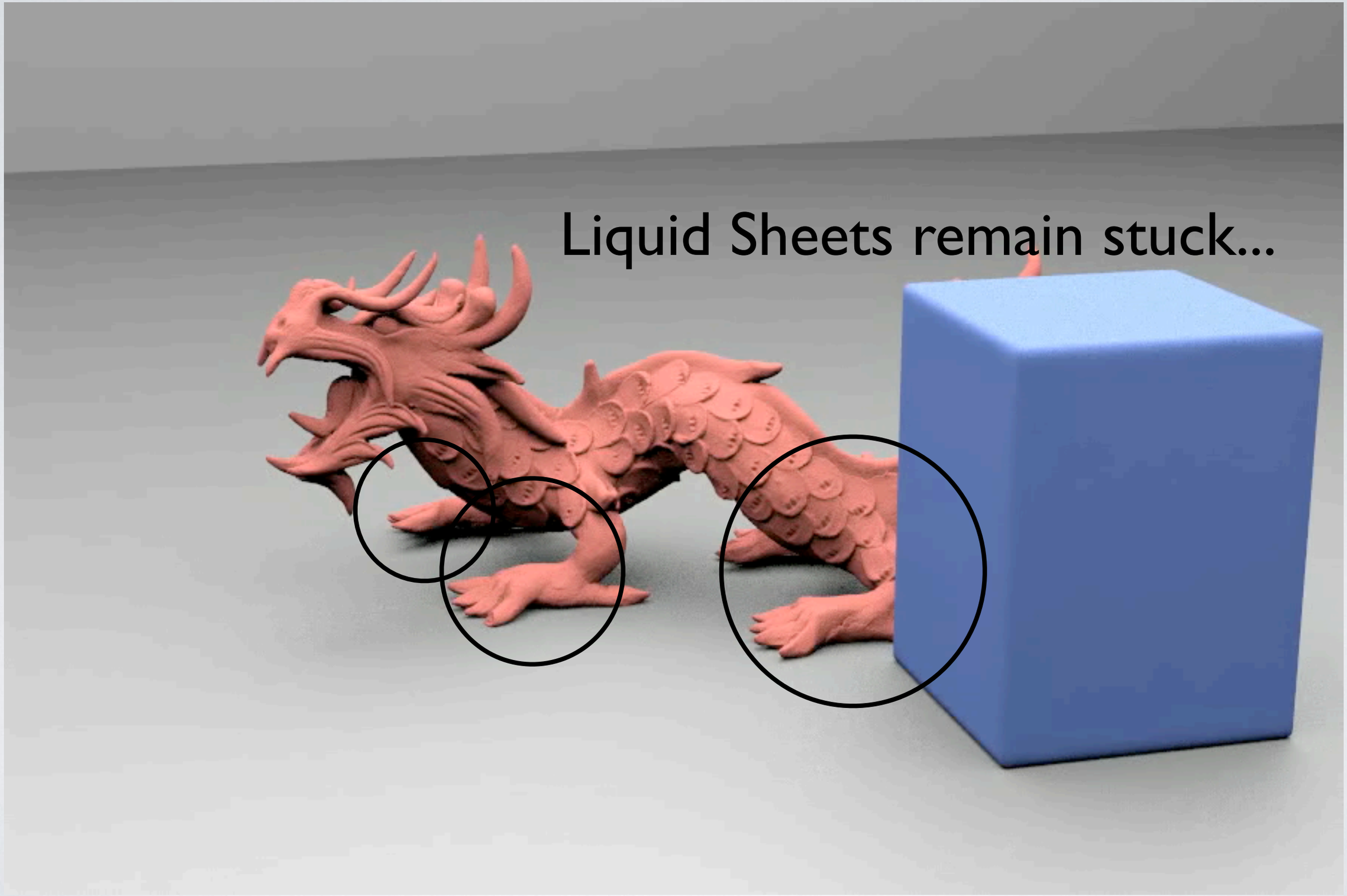


Particle Collapse

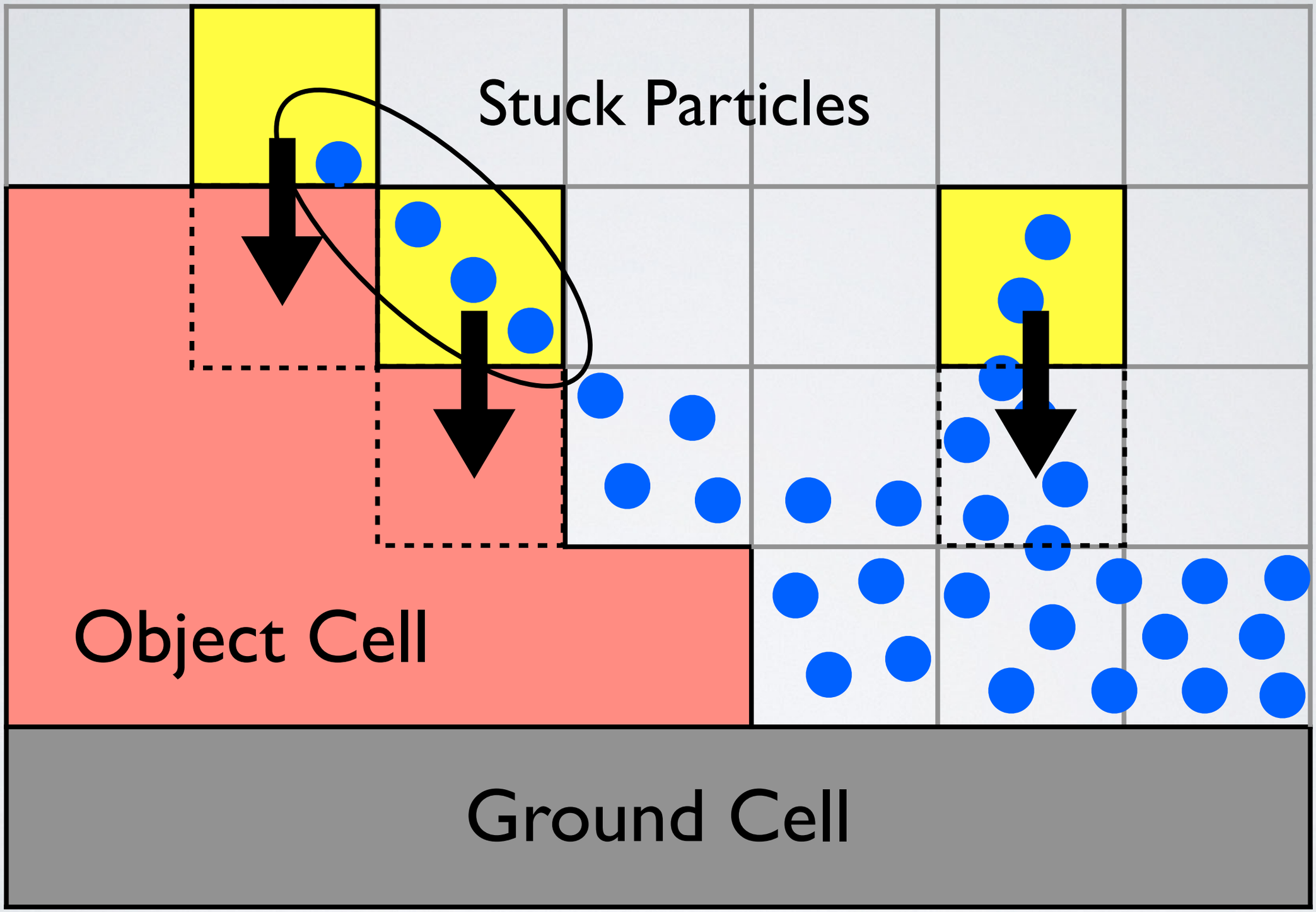


Very easy.

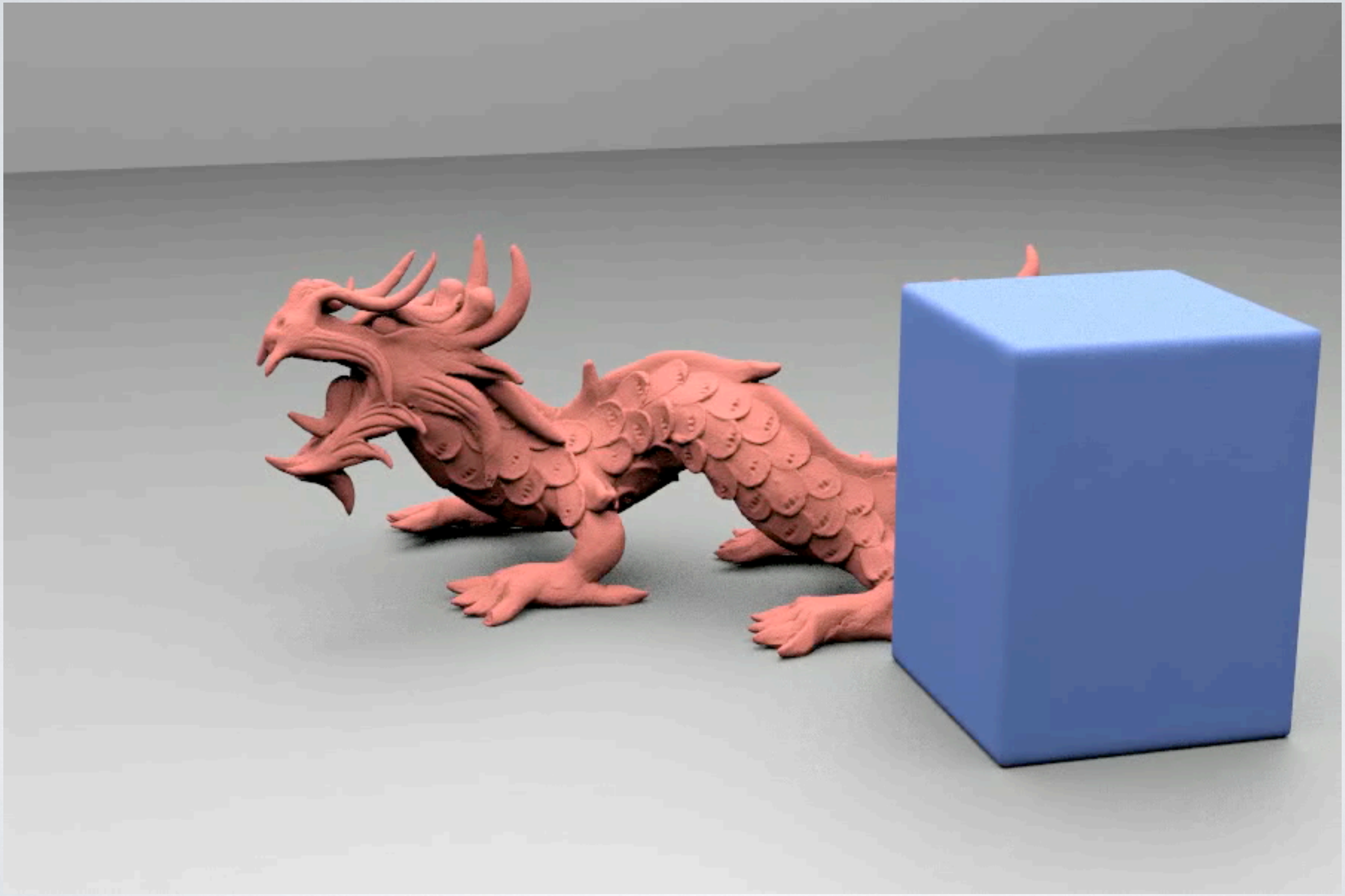
Removing Stuck Sheets on Objects



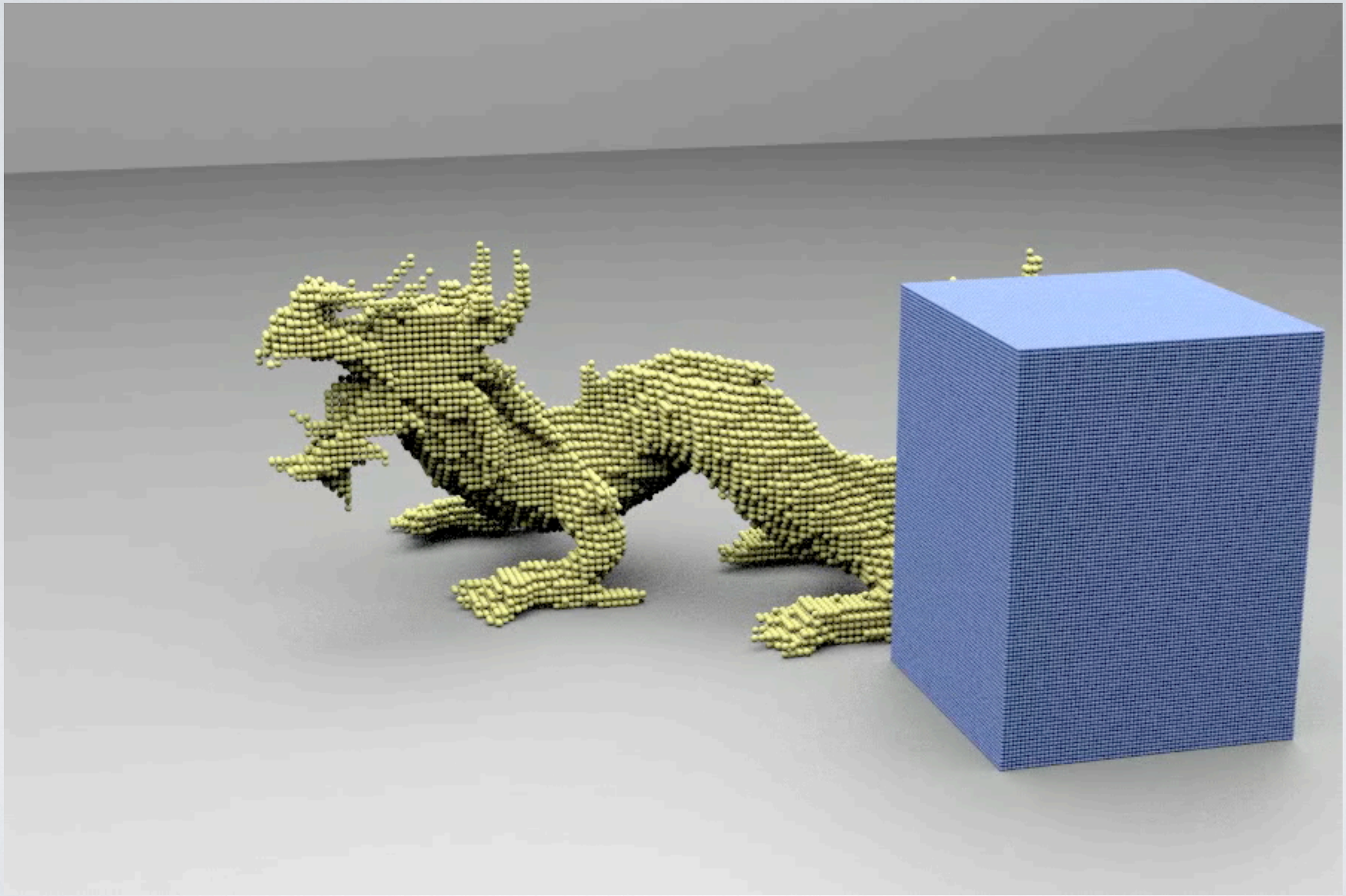
Removing Stuck Sheets on Objects



Removing Stuck Sheets on Objects



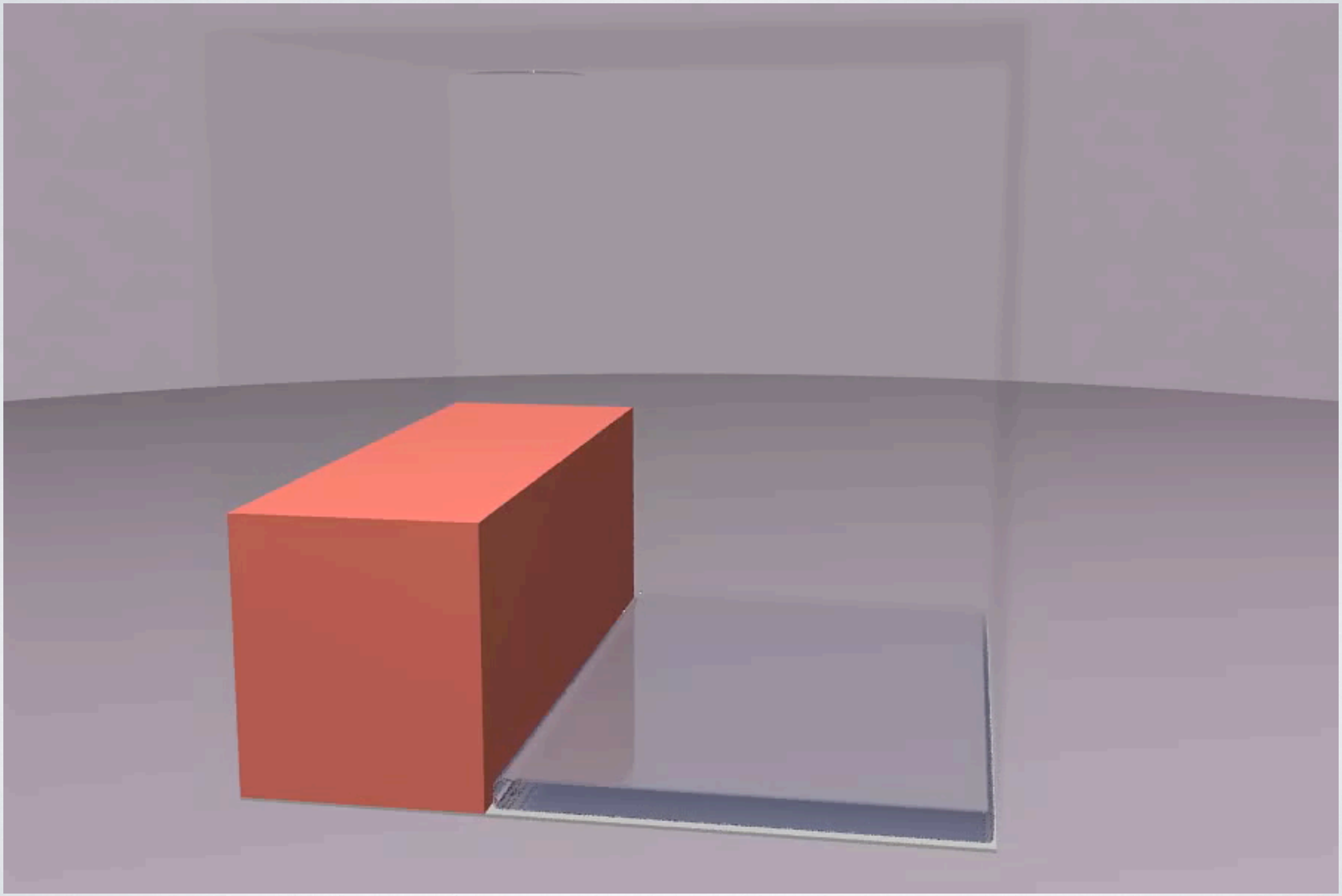
Particle View



Results

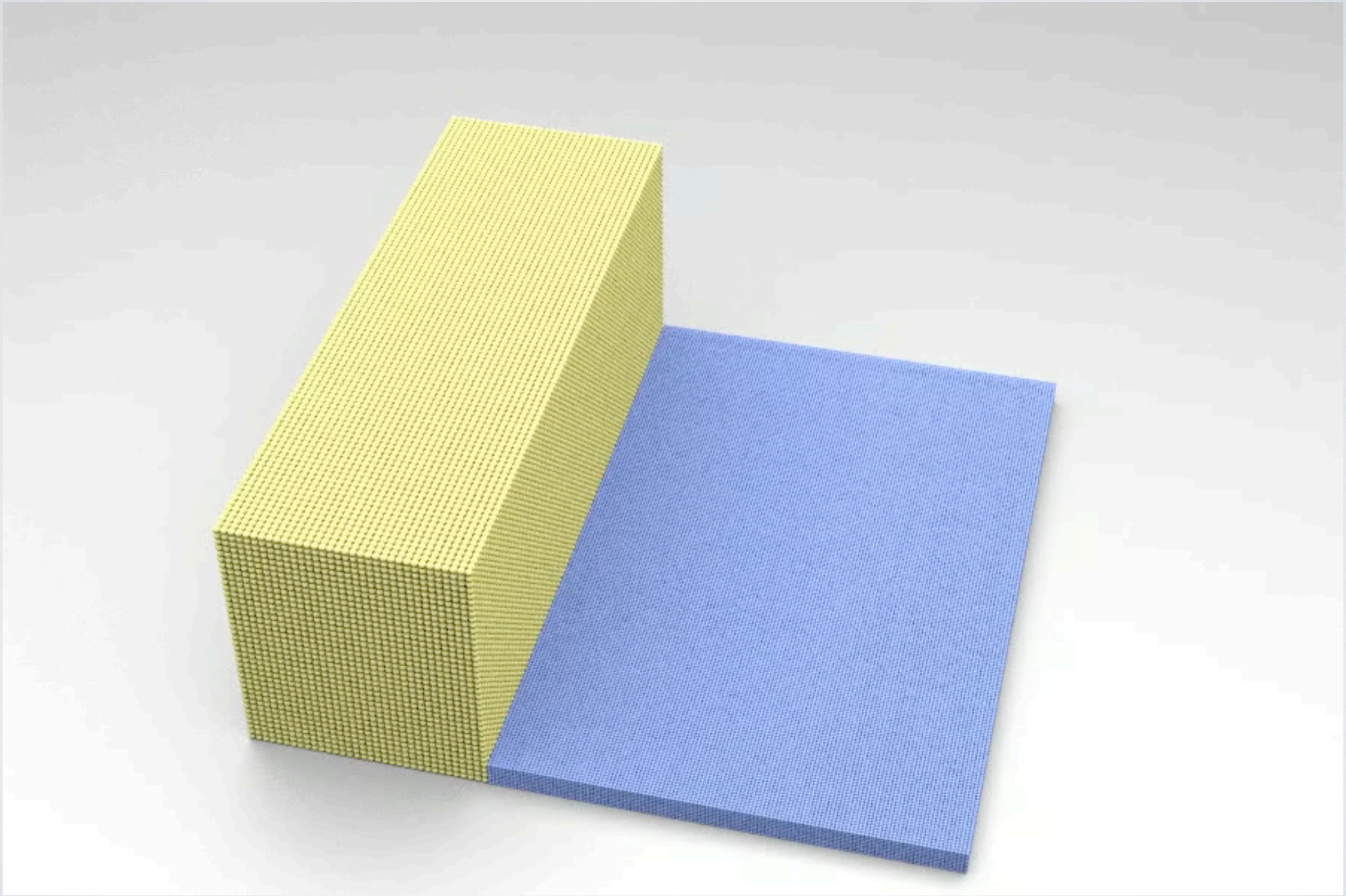
Water Pouring

5~40 sec/timestep



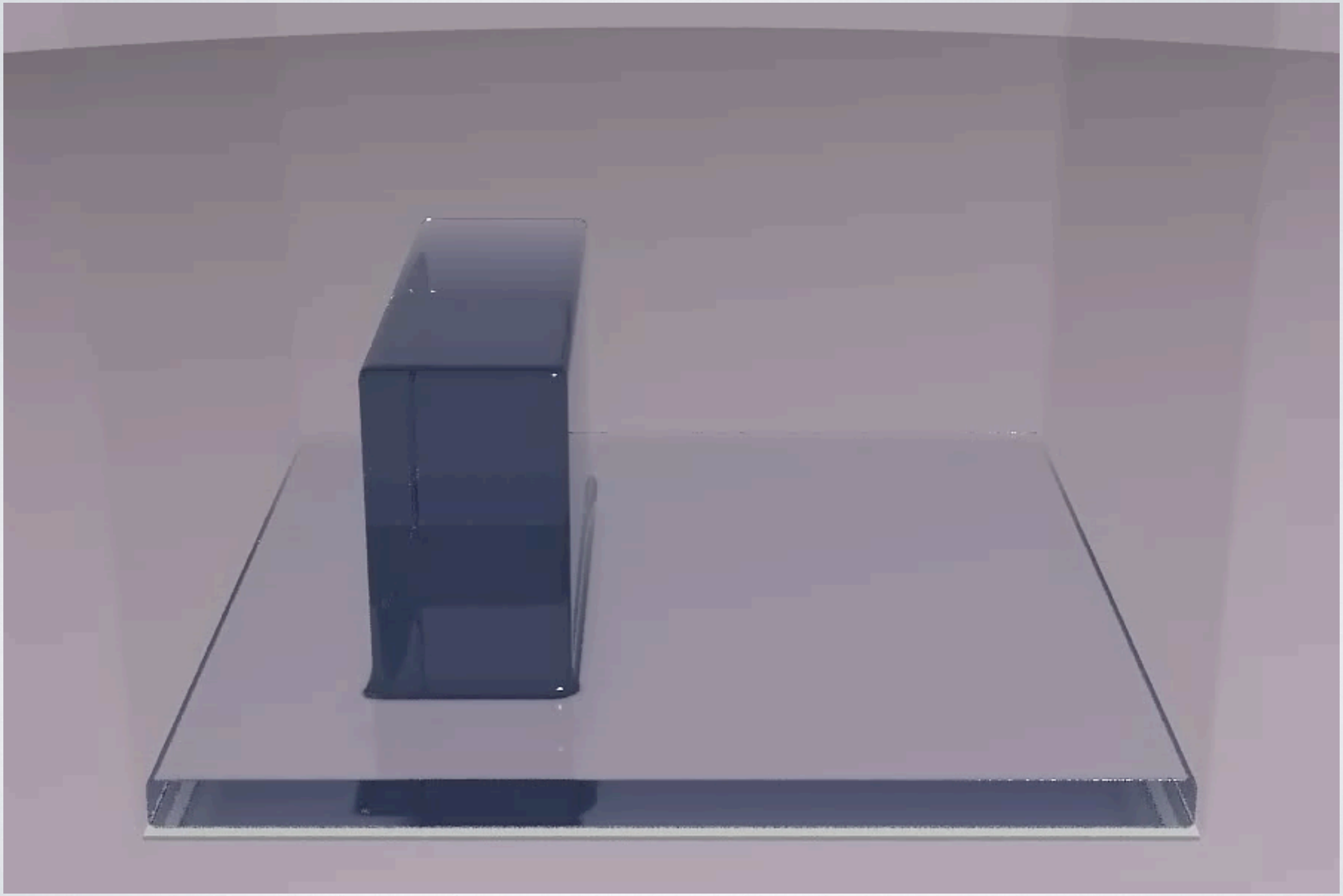
Water Pouring

5~40 sec/timestep



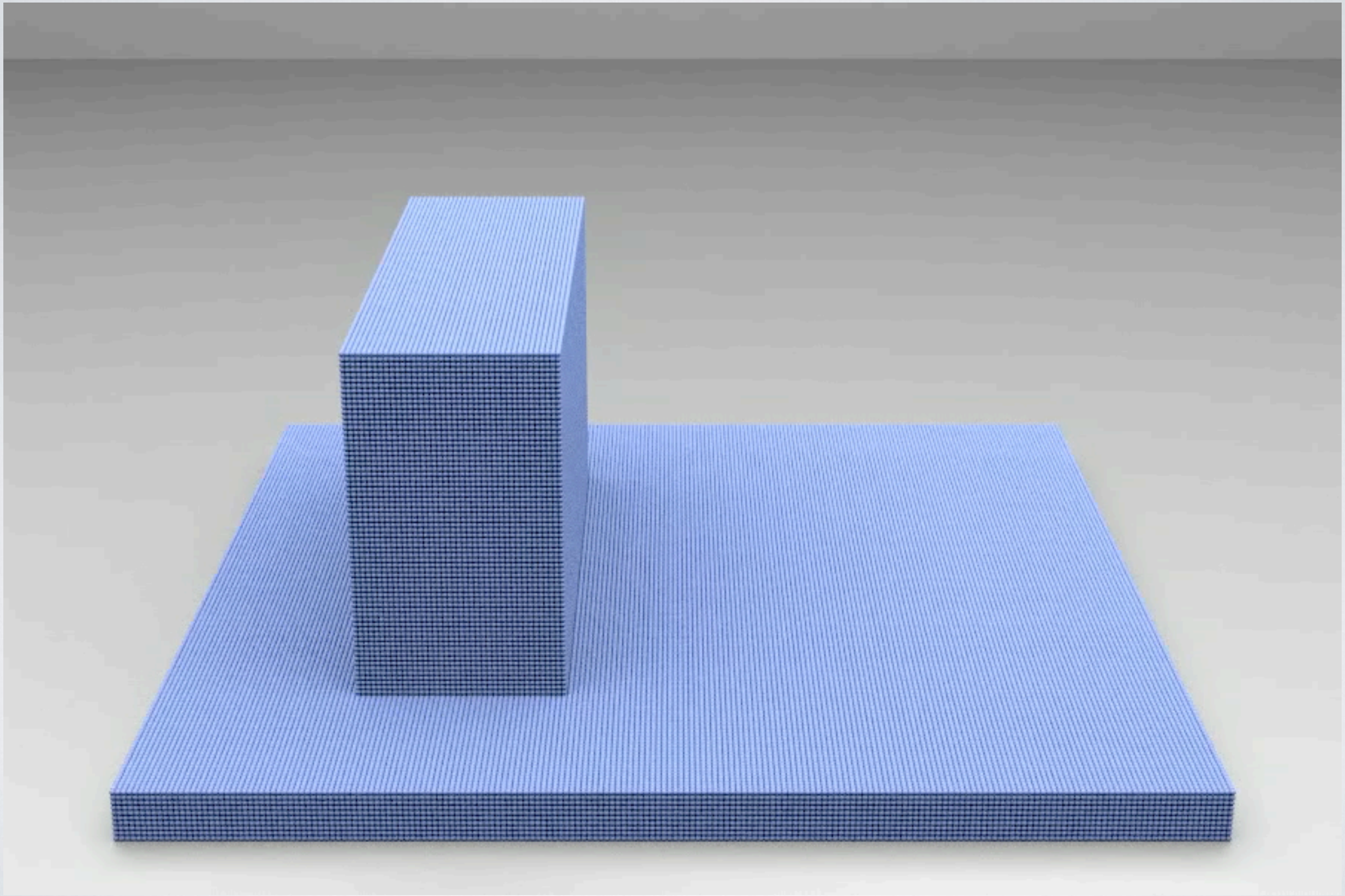
Dambreak Test

12~21 sec/timestep



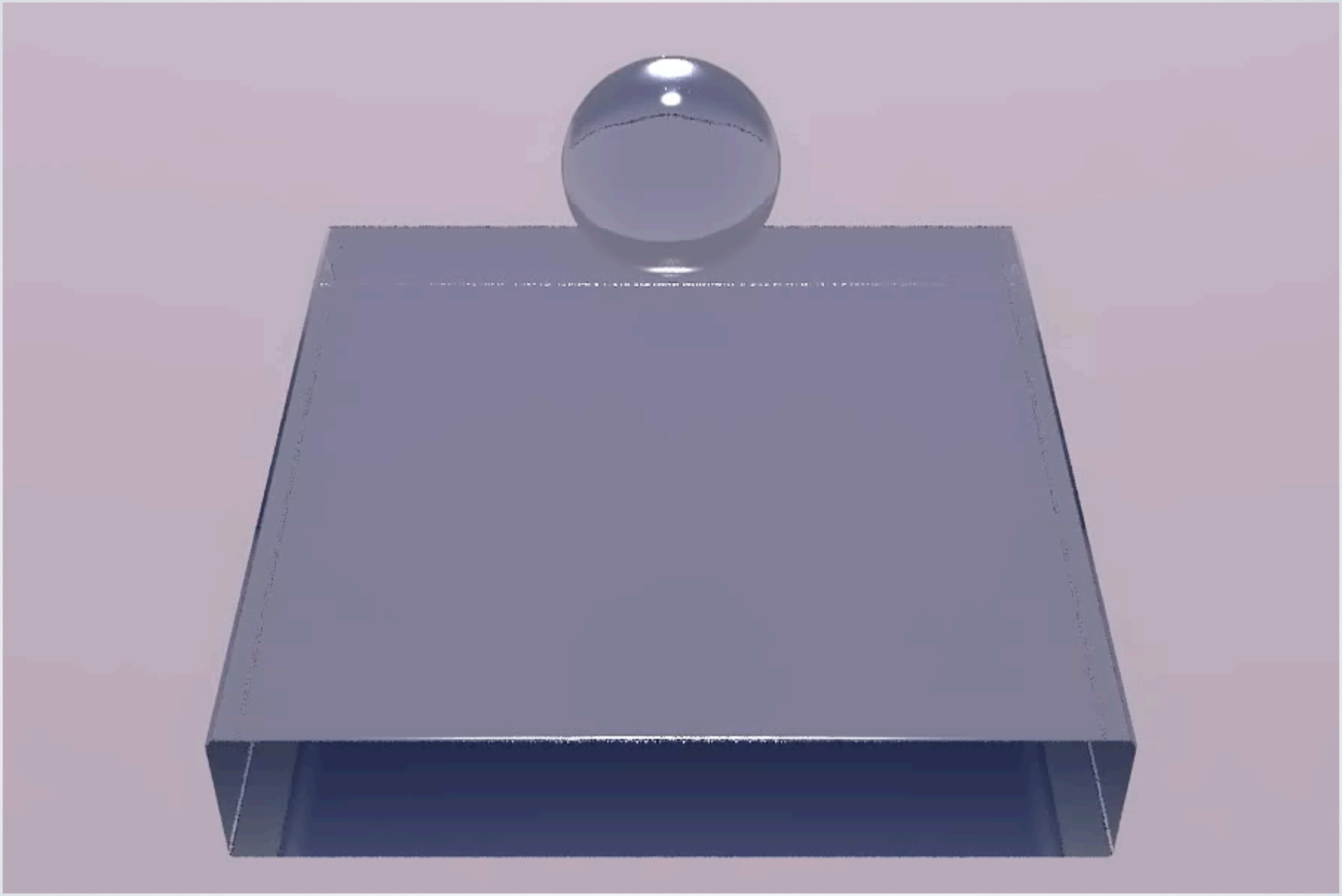
Dambreak Test

12~21 sec/timestep



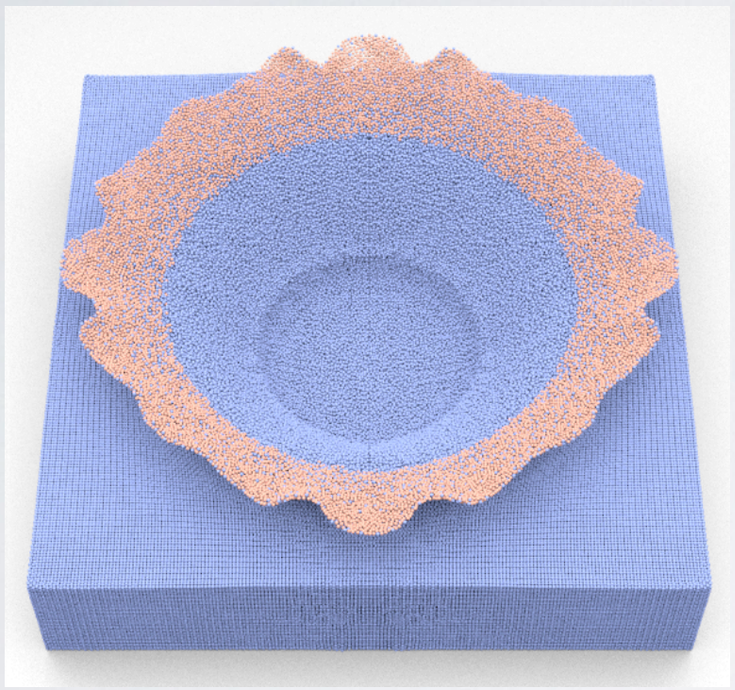
Water Drop Test

21~28 sec/timestep

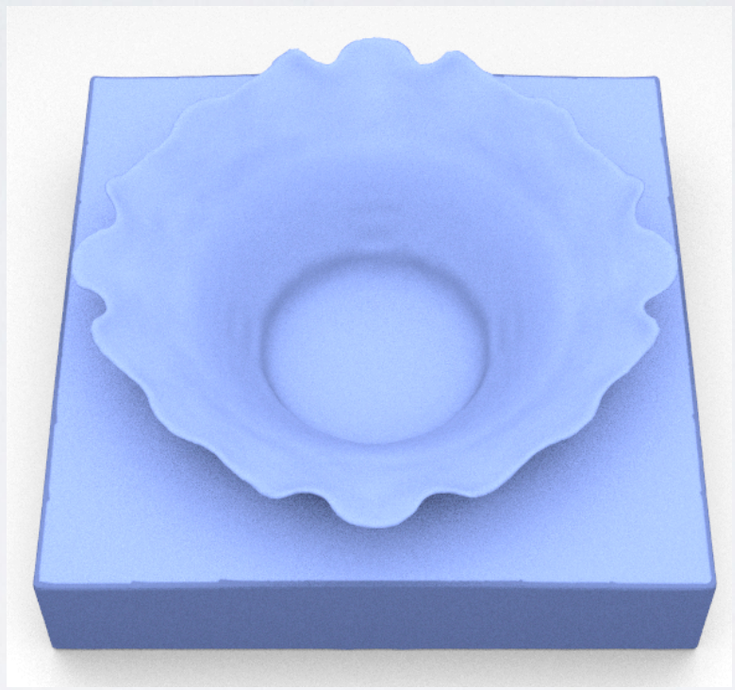


Water Drop Test

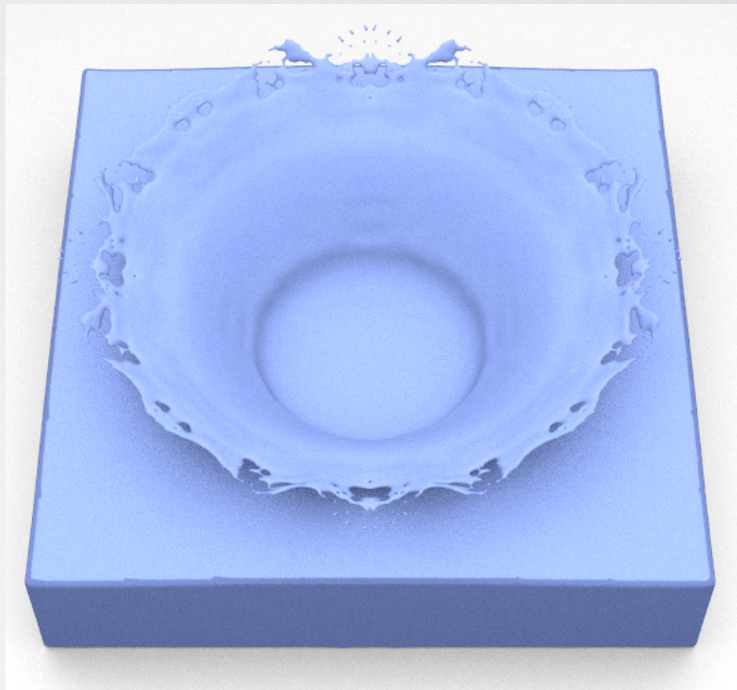
Comparison



Particle visualization with particle splitting (shown in red)



Thin surface generated with anistropic kernels

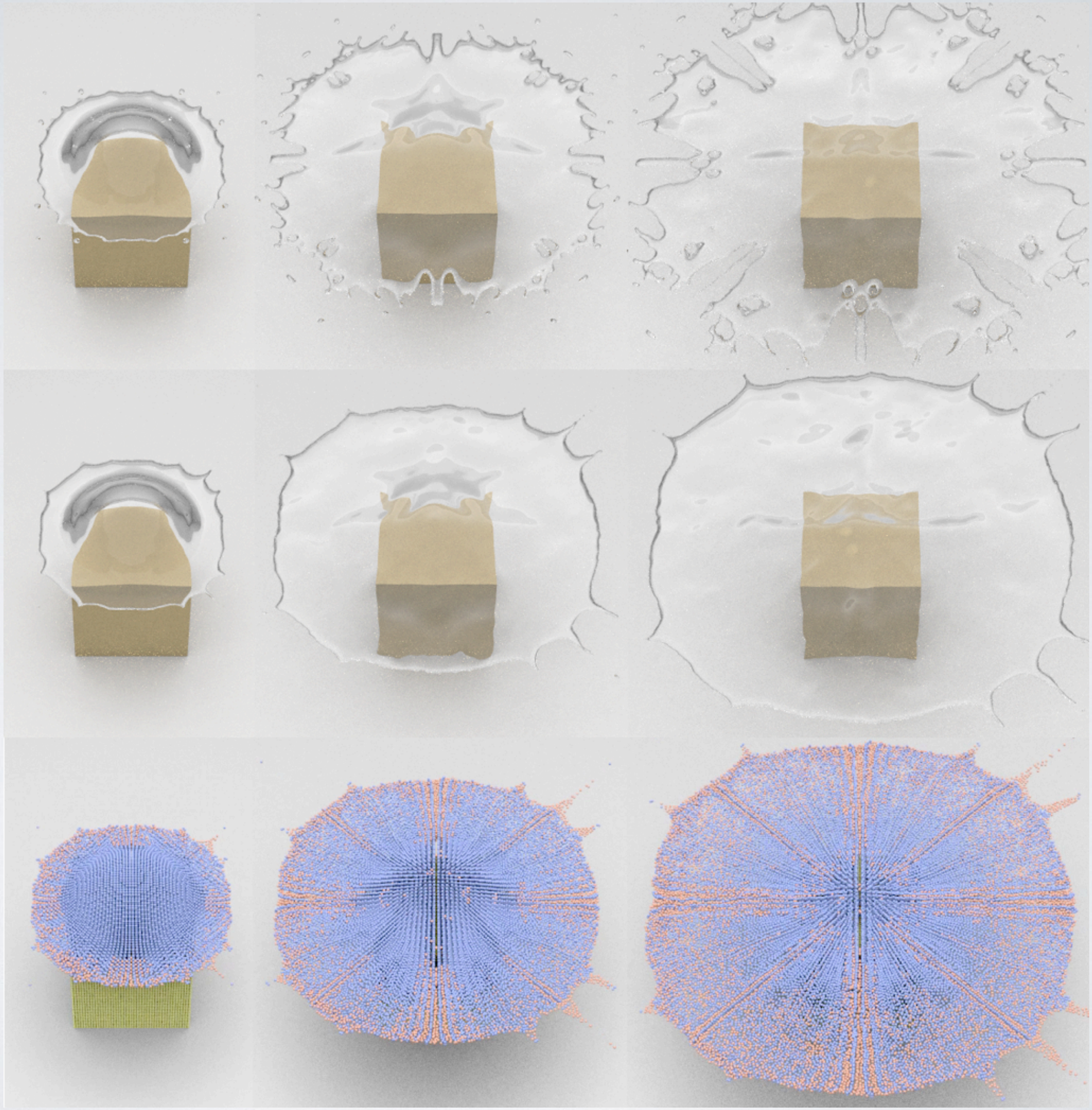


Our method without particle splitting

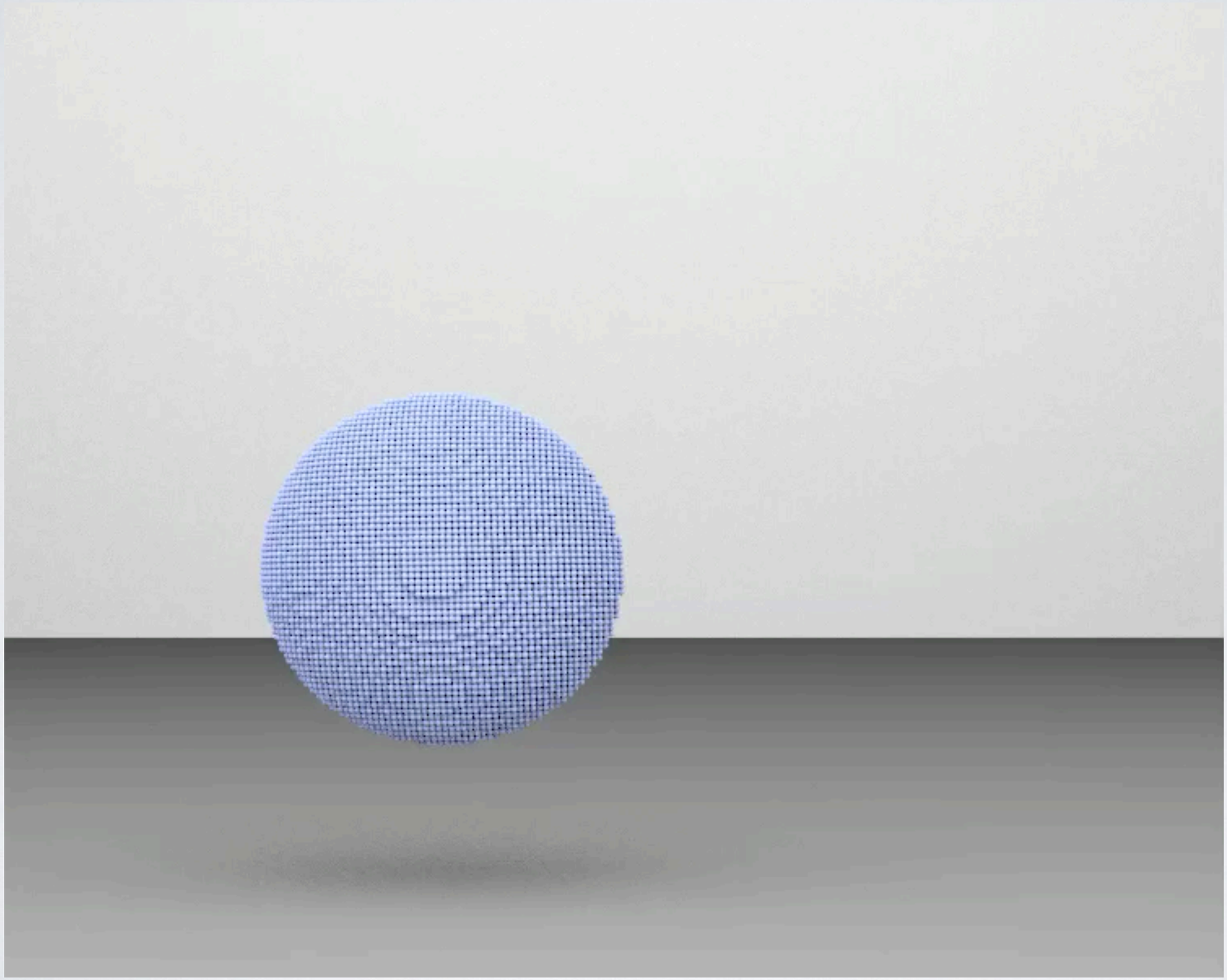
W/o Split

W/ Split

Visualiz

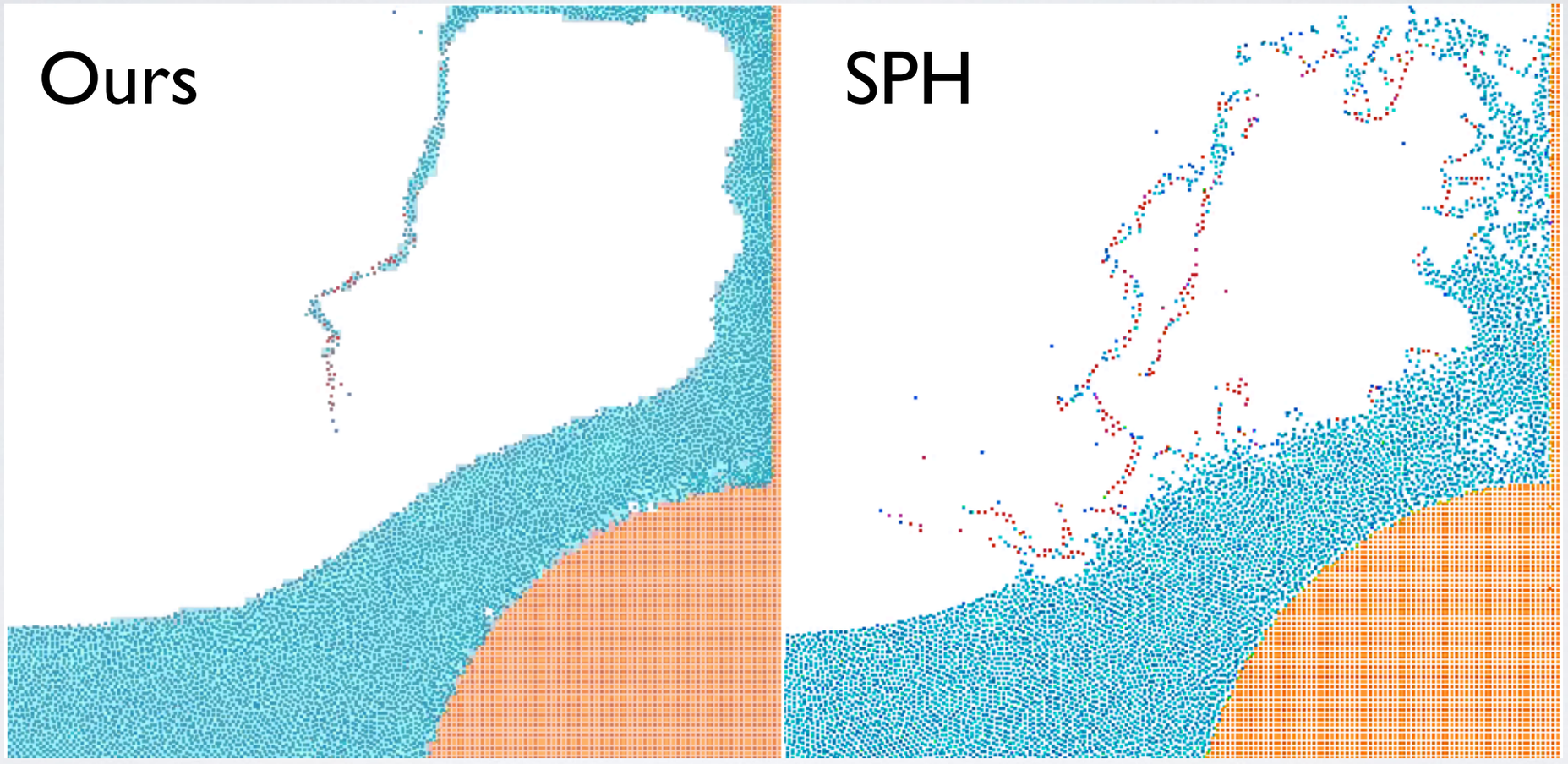


Enright Deformation Test



Why not use SPH method ?

A lot of people want to use it.



We failed with simple SPH method.

Limitations & Future work

Slow. Takes a half minutes for each timestep at 100^3 resolution.

Memory intensive.
Use adaptive methods.

Stuck removal fails in some cases.

Extend to viscoelastic
materials or wispy smokes.

Conclusion

A particle-based framework for preserving fluid sheets.

Easy to implement and robust.

Expensive, slow.

Thank you !

Acknowledgements:

Funding by JSPS fellowship.