New on BCs: mDBC for floating objects

ALEJANDRO J.C. CRESPO,

CORRADO ALTOMARE, JOSÉ M. DOMÍNGUEZ

MOTIVATION

Have many complex geometries been simulated using SPH?

What boundary conditions are used?

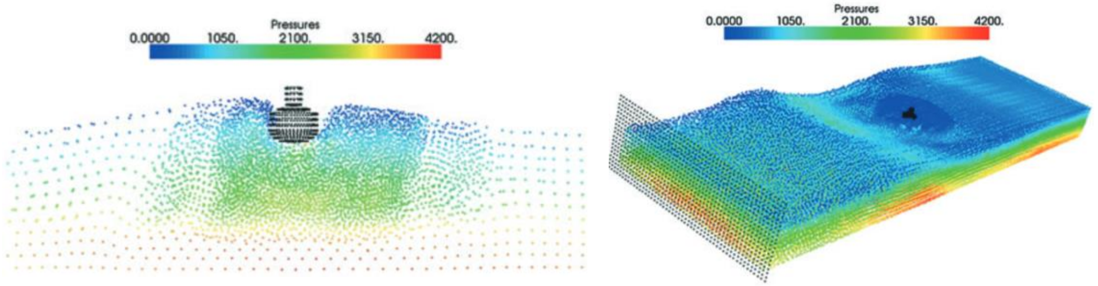
INTERNATIONAL JOURNAL FOR NUMERICAL METHODS IN FLUIDS
Int. J. Numer. Meth. Fluids 2013; **72**:427–452
Published online 7 Nov 2012 in Wiley Online Library (wileyonlinelibrary.com/journal/nmf). DOI: 10.1002/fld.3749

SPH for 3D floating bodies using variable mass particle distribution

Pourya Omidvar[1,*,†], Peter K. Stansby[2] and Benedict D. Rogers[2]

[1]*Department of Mechanical Engineering, The University of Yasouj, Yasouj, Iran*
[2]*School of Mechanical, Aerospace and Civil Engineering, The University of Manchester, Manchester M139PL, UK*

2013: Manchester Boober using repulsive forces



Journal of Fluids and Structures 42 (2013) 112–129

Contents lists available at ScienceDirect

Journal of Fluids and Structures

journal homepage: www.elsevier.com/locate/jfs

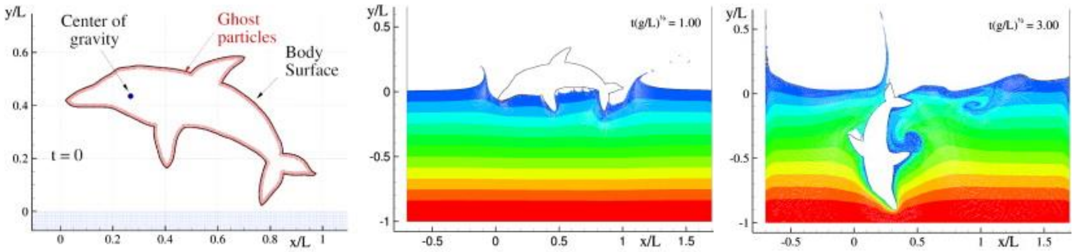
ELSEVIER

Nonlinear water wave interaction with floating bodies in SPH

B. Bouscasse[a,b], A. Colagrossi[a,*], S. Marrone[a], M. Antuono[a]

[a] *CNR-INSEAN, The Italian Ship Model Basin, Rome, Italy*
[b] *Aeronautics Department (ETSIA), Technical University of Madrid (UPM), 28040 Madrid, Spain*

2013: 2-D dolphin shape using ghost particles technique



MOTIVATION

Ocean Engineering 115 (2016) 168–181

Contents lists available at ScienceDirect

Ocean Engineering

journal homepage: www.elsevier.com/locate/oceaneng

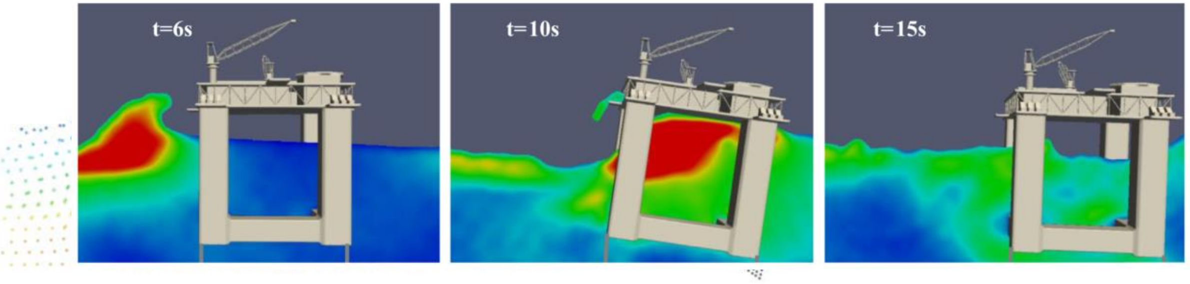
ELSEVIER

The influence of mooring system in rogue wave impact on an offshore platform

Murray Rudman [a,*], Paul W. Cleary [b]

[a] Department of Mechanical and Aerospace Engineering, Monash University, Victoria 3800, Australia
[b] CSIRO Digital Productivity Flagship Private, Bag 10, Clayton South 3169, Victoria, Australia

2016: Offshore platform sing repulsive forces



Aerospace Science and Technology 85 (2019) 277–292

Contents lists available at ScienceDirect

Aerospace Science and Technology

www.elsevier.com/locate/aescte

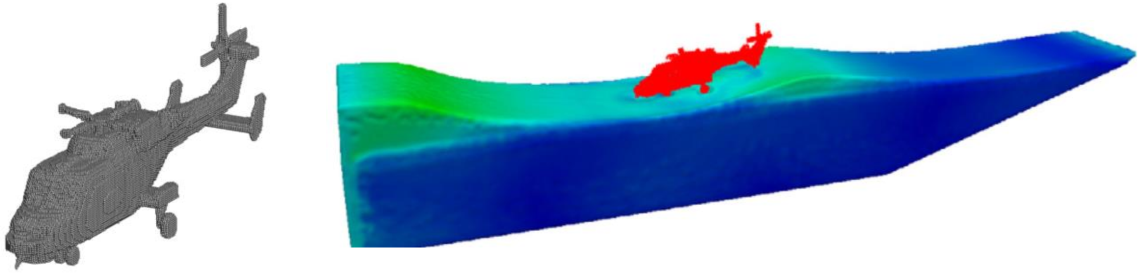
ELSEVIER

Simulation of helicopter ditching using smoothed particle hydrodynamics

Mark A. Woodgate [a], George N. Barakos [a,*], Nigel Scrase [b], Tim Neville [b]

[a] CFD Laboratory, School of Engineering, James Watt South Building, University of Glasgow, Glasgow, G12 8QQ, United Kingdom
[b] Leonardo Helicopters, Yeovil, BA20 2YB, United Kingdom

2019: Impressive ditching helicopter with DBC



ELSEVIER

Available online at www.sciencedirect.com

ScienceDirect

Comput. Methods Appl. Mech. Engrg. 355 (2019) 558–590

Computer methods in applied mechanics and engineering

www.elsevier.com/locate/cma

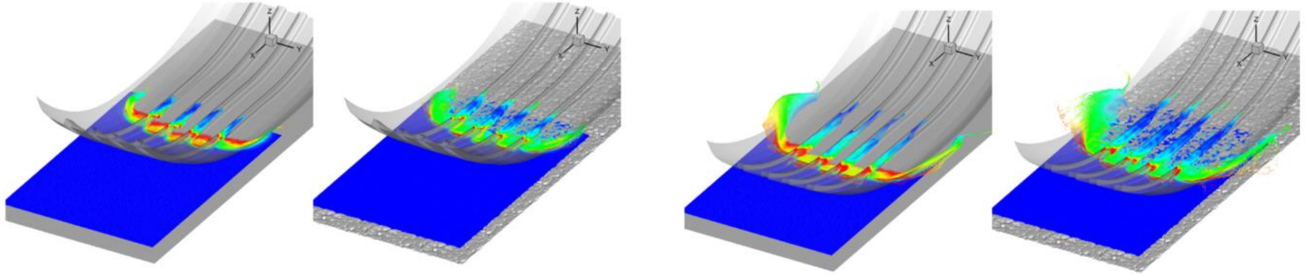
A 3D SPH–FE coupling for FSI problems and its application to tire hydroplaning simulations on rough ground

C. Hermange [a,b], G. Oger [a,*], Y. Le Chenadec [b], D. Le Touzé [a]

[a] École Centrale Nantes, LHEEA res. dept. (ECN and CNRS), Nantes, France
[b] La Manufacture Francaise des Pneumatiques MICHELIN, Clermont-Ferrand, France

Received 13 February 2019; received in revised form 18 June 2019; accepted 20 June 2019
Available online 5 July 2019

2019 Complex tyre model using ghost particles technique



(a) t = 2.5 ms (b) t = 5.0 ms

MOTIVATION

SPHERIC

SPHERIC Grand Challenges
GC#2: Boundary conditions

1) Boundary conditions (BCs) are one of the open problems in SPH

- several approaches with advantages and limitations
- no unanimity about best approach
- it really depends on the problem under study

2) Implementation of BCs is not straightforward

- arduous requirements (mirroring, normal vectors, several layers…)
- how to create a general procedure in an open source code?

3) Users are very demanding people

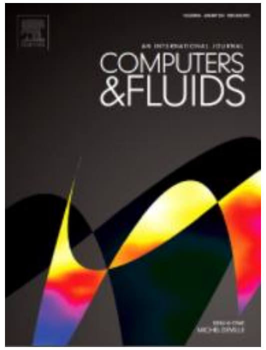
OUR MAIN CHALLENGE: How to deal with complex geometries in a free engineering tool?

BEST OPTION SO FAR: Dynamic Boundary Conditions (DBC)

MOTIVATION

DualSPHysics v5.0:

✓ Density Diffusion Term



G. Fourtakas, J.M. Domínguez, R. Vacondio, B.D. Rogers. 2019. **Local Uniform Stencil (LUST) boundary condition for arbitrary 3-D boundaries in parallel smoothed particle hydrodynamics (SPH) models.** Computers & Fluids, 190: 346-361. doi.org/10.1016/j.compfluid.2019.06.009.

✓ Modified Dynamic Boundary Conditions

A. English, J.M. Domínguez, R. Vacondio, A.J.C. Crespo, P.K. Stansby, S.J. Lind,L. Chiapponi, M. Gómez-Gesteira. 2022. **Modified dynamic boundary conditions (mDBC) for general purpose smoothed particle hydrodynamics (SPH): application to tank sloshing, dam break and fish pass problems.** Computational Particle Mechanics. doi:10.1007/s40571-021-00403-3.

OUTLINE

New boundary conditions: mDBC

DBC drawbacks
Fluid properties from ghost nodes
DBC vs mDBC
Requirements (layers, boundary interface, normals)

mDBC requirements -> XML file

New options in GenCase (*layers*, *freedrawmode*, *variables*)
Example with tank walls (fixed)
Example with piston wavepaddle (moving)
Example with floating box (floating)

mDBC applied to external geometries

New options in GenCase (*advanced drawfilestl*)
Example with simple STL (Cylinder)
Example with complex STL (Duck)

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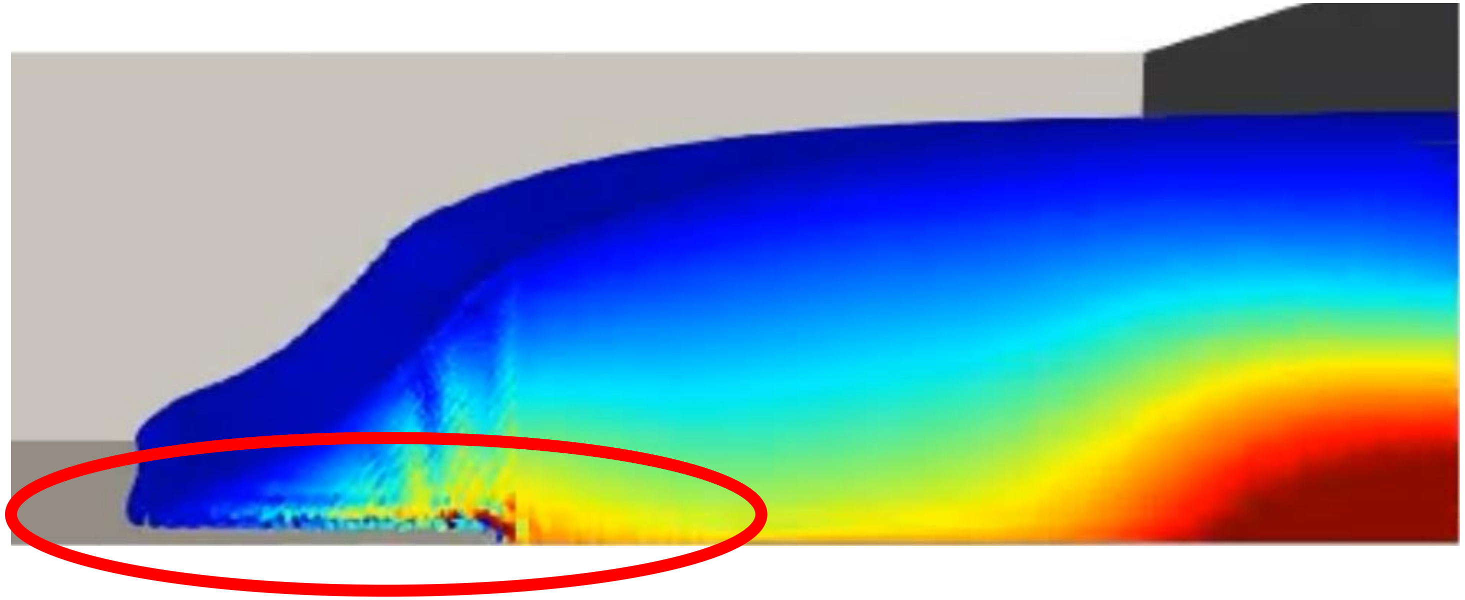
Dynamic Boundary Conditions (DBC)

- DBC are simple, fast, reliable and very versatile.
- Allow very complex geometries in 2-D and 3-D simulations.
- Used in a large number of works.

However…

- **Gap between boundaries and fluid.**



Gap in the advance of a 3-D dam break

Dynamic Boundary Conditions (DBC)

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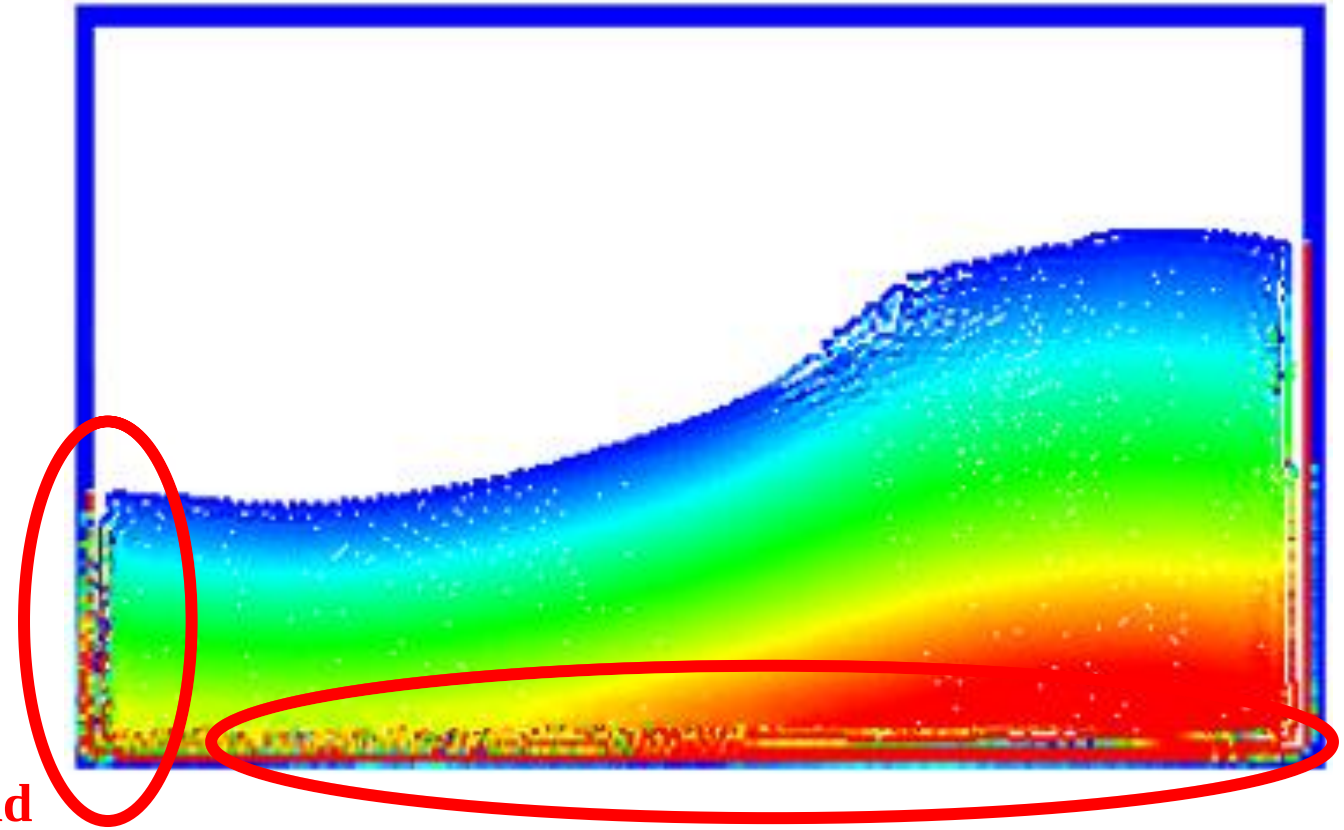
- Used in a large number of works.

However…

- Gap between boundaries and fluid.
- Non-physical density on the boundaries.
- **Pressure measurement is very noisy close to the boundaries.**



Wrong density at the boundaries generates a noisy density field at the fluid

DBC ADVANTAGES

UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

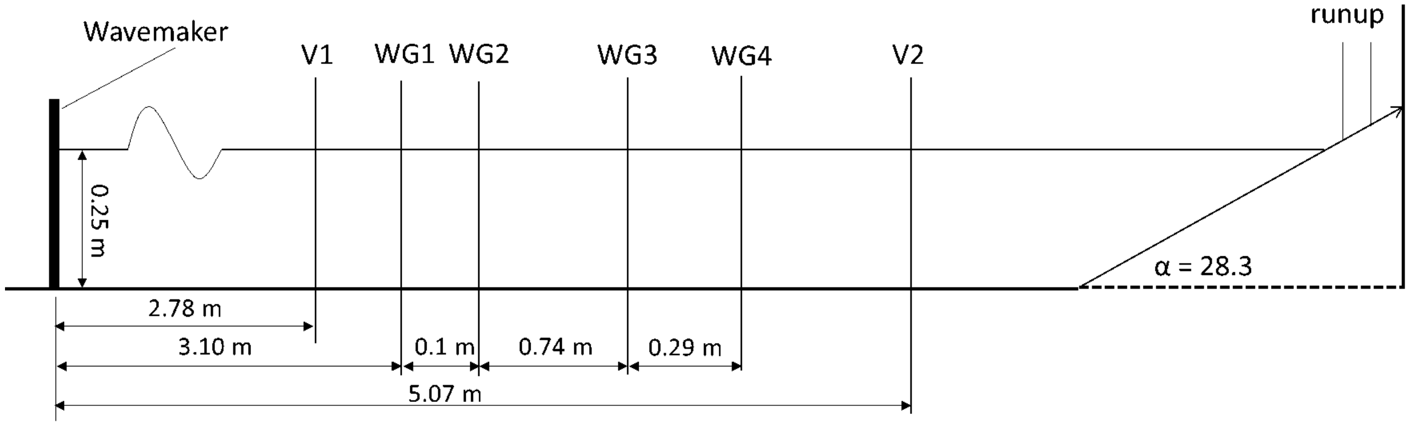
Interaction between waves and fixed structures to measure RUN-UP using DBC

Experiments performed in the CIEMito wave flume at LIM-UPC (Barcelona)

DBC ADVANTAGES

Interaction between waves and fixed structures to measure RUN-UP using DBC

SMOOTH DIKE



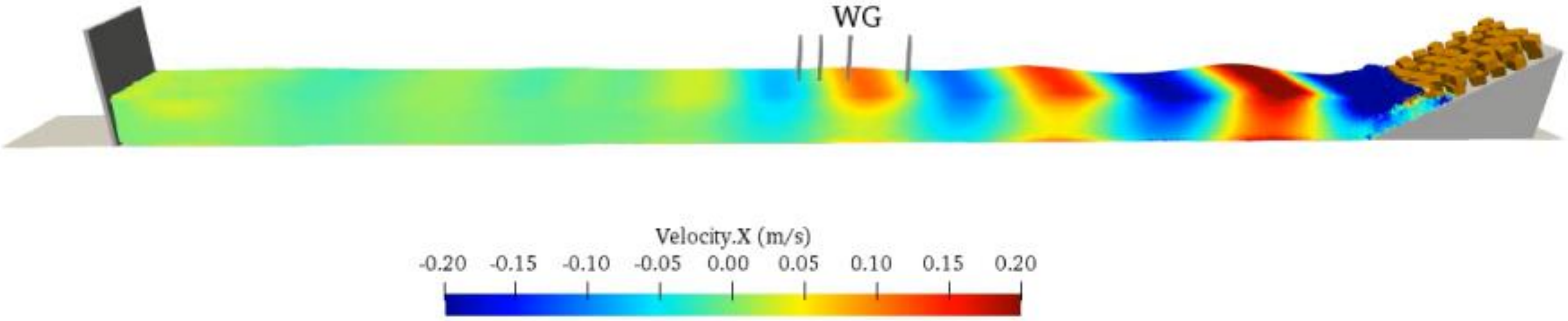
AMOUR BLOCK DIKE

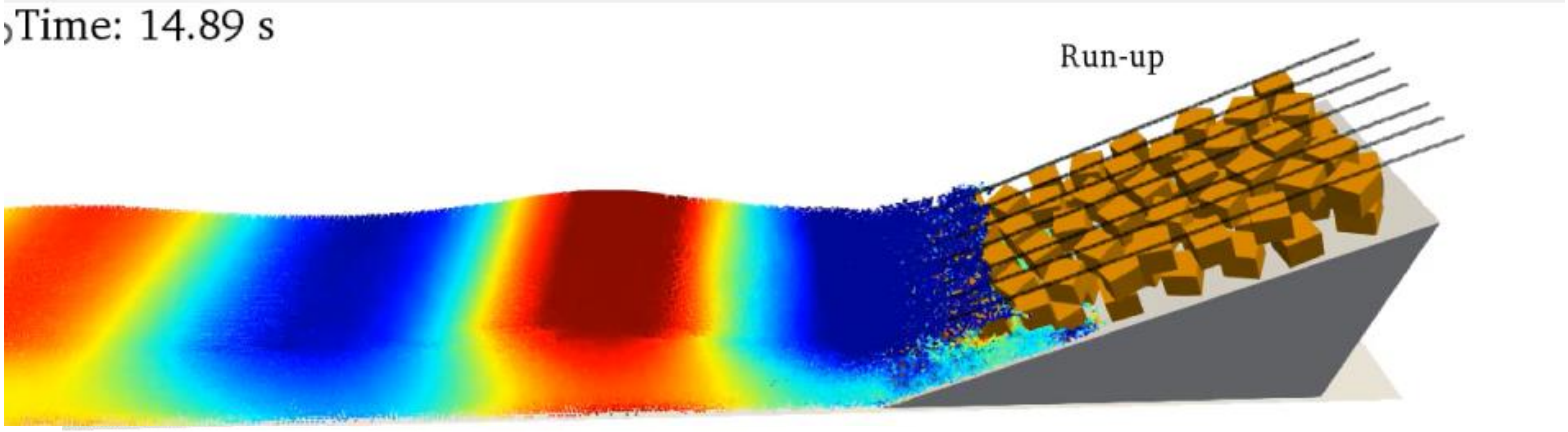
Case#7: H=0.08 m, T=0.87 s, d=0.25 m

DBC ADVANTAGES

Interaction between waves and fixed structures to measure RUN-UP using DBC

Case#7: H=0.08 m, T=0.87 s, d=0.25 m





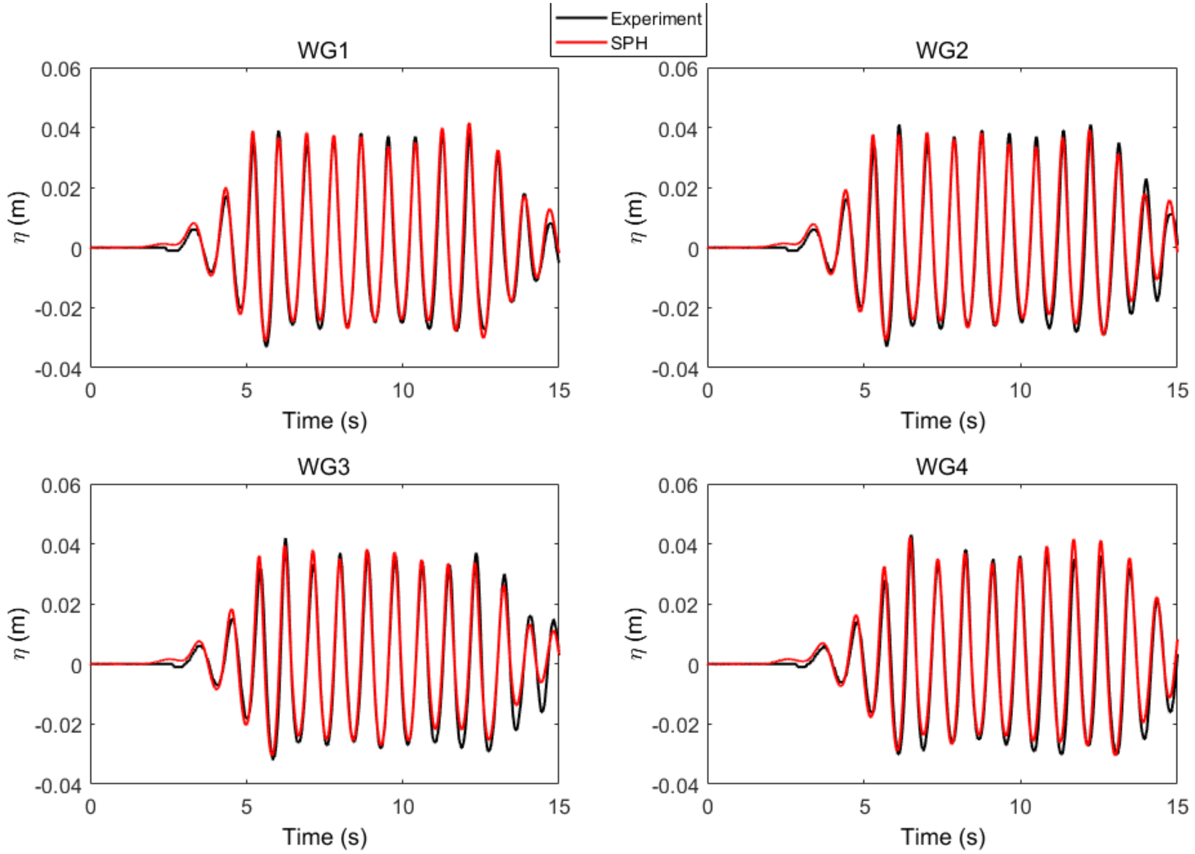
DBC ADVANTAGES

Zhang F, Crespo AJC, Altomare C, Domínguez JM, Marzeddu A, Shang S, Gómez-Gesteira M. 2018. DualSPHysics: a numerical tool to simulate real breakwaters. Journal of Hydrodynamics, 30(1): 99-105. doi:10.1007/s42241-018-0010-0.

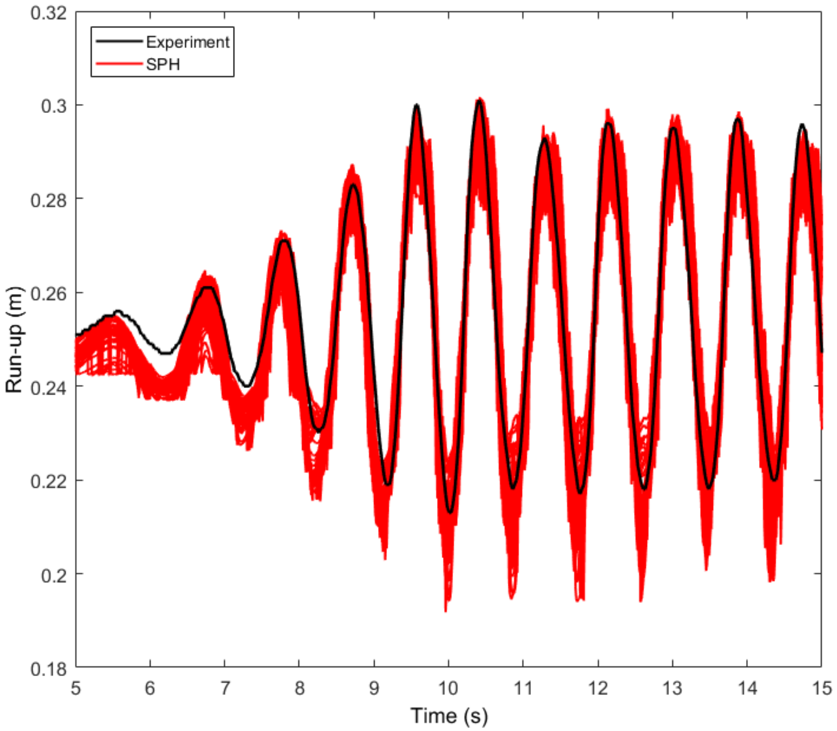
Interaction between waves and fixed structures to measure RUN-UP using DBC

Case#7: H=0.08 m, T=0.87 s, d=0.25 m

Time series of the experimental and numerical surface elevation

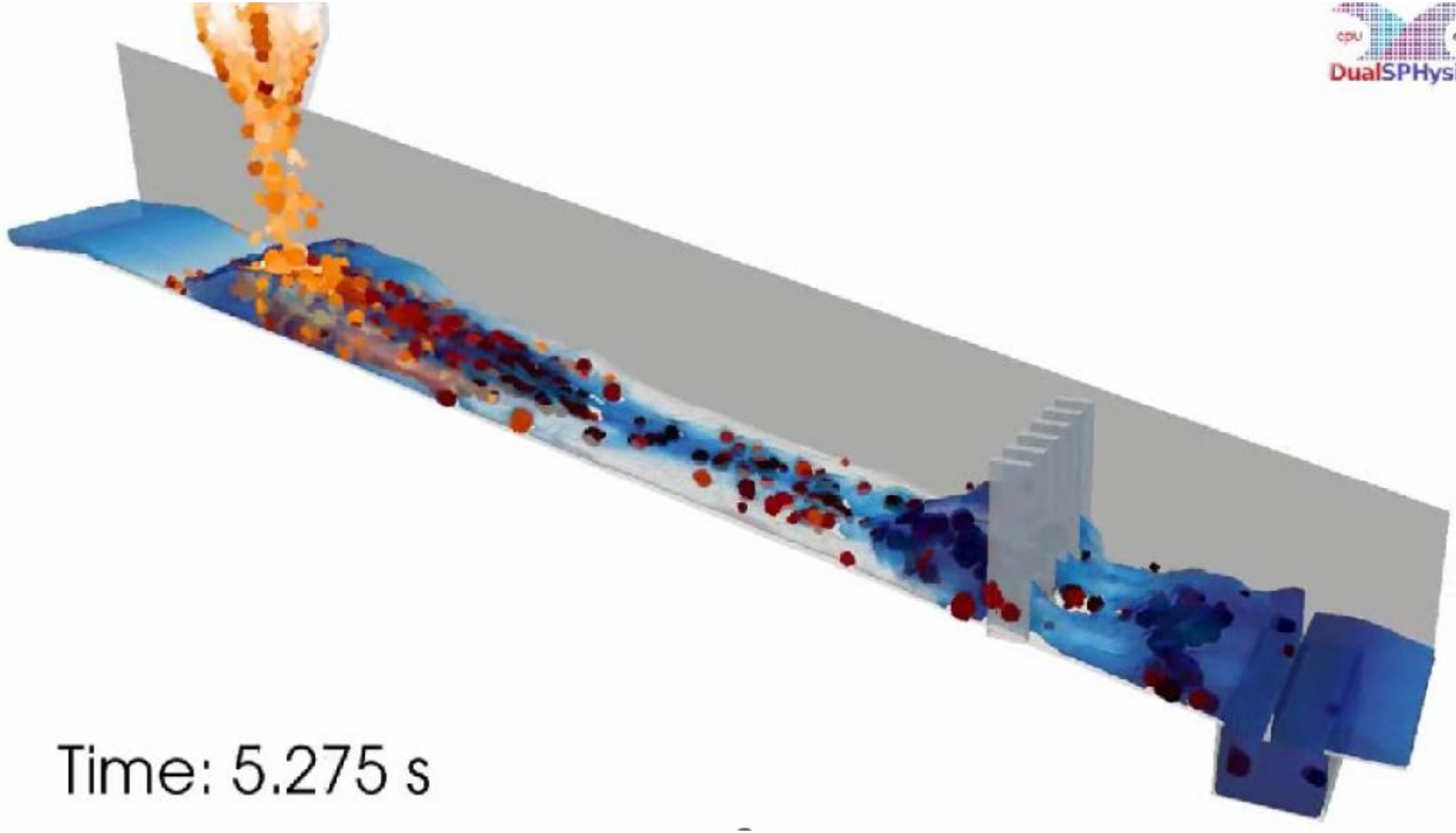


Time series of the experimental and numerical RUNUP



DBC ADVANTAGES

Canelas RB, Domínguez JM, Crespo AJC, Gómez-Gesteira M, Ferreira RML. 2017. Resolved Simulation of a Granular-Fluid Flow with a Coupled SPH-DCDEM Model. Journal of Hydraulic Engineering, 143 (9), art. no.06017012. doi:10.1061/(ASCE)HY.1943-7900.0001331.



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mDBC requirements -> XML file

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- Example with simple STL (Cylinder)
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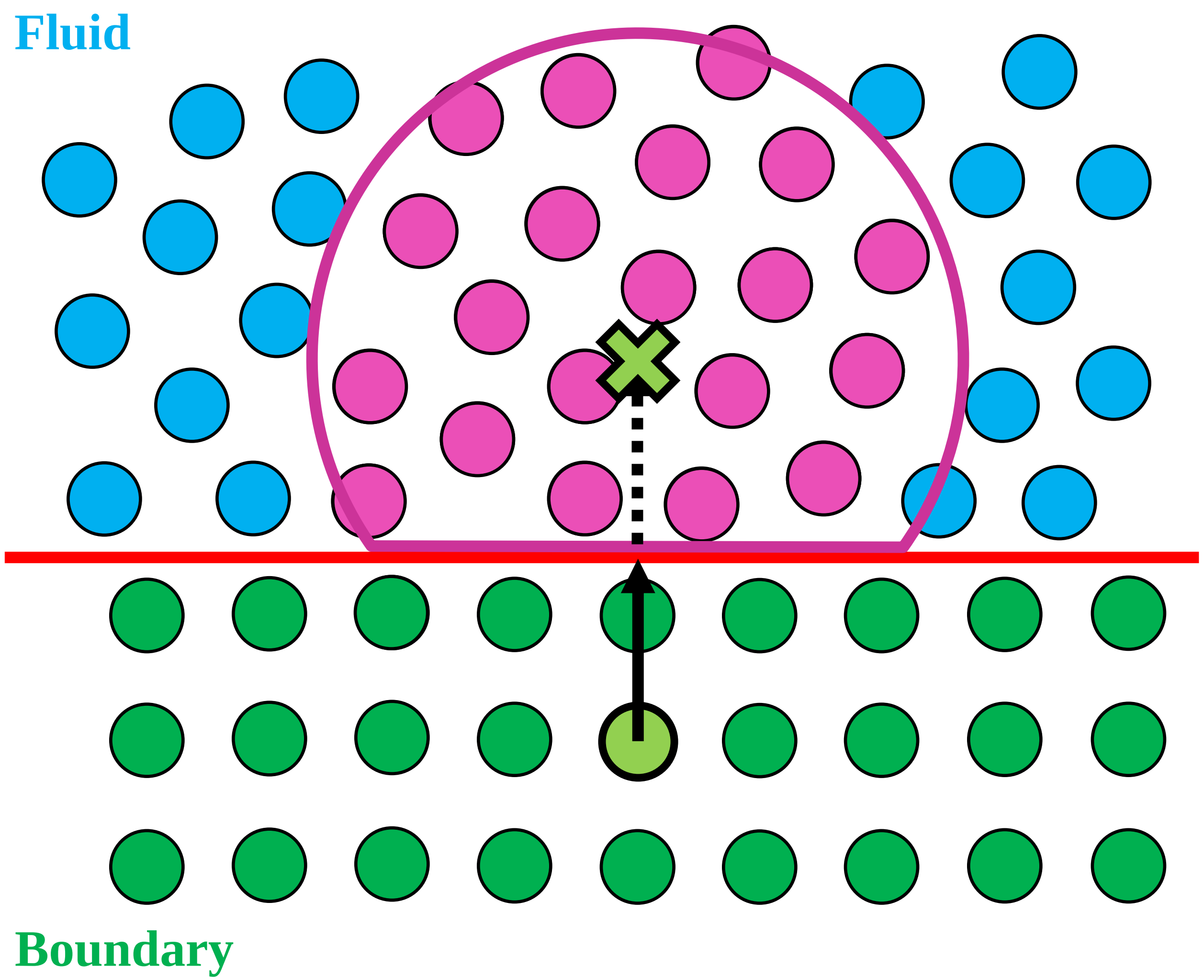
mDBC: FLUID PROPERTIES FROM GHOST NODES



Use a mirroring procedure based on the approach by Marrone et al. (2011) to mirror ghost nodes into the fluid region.

Each **boundary particle** has a **normal vector** to **boundary limit**.

Ghost node (X) is projected into the fluid across a **boundary limit**.

Fluid properties are then computed at the ghost nodes according to the **surrounding fluid** using a corrected SPH approximation proposed by Liu and Liu (2006).

And finally, fluid properties (density and reversed velocity) are mirrored back to **boundary particles**.

mDBC is a correction applied over DBC when boundary particle has a non-zero normal. Thus it is possible to combine DBC with mDBC.

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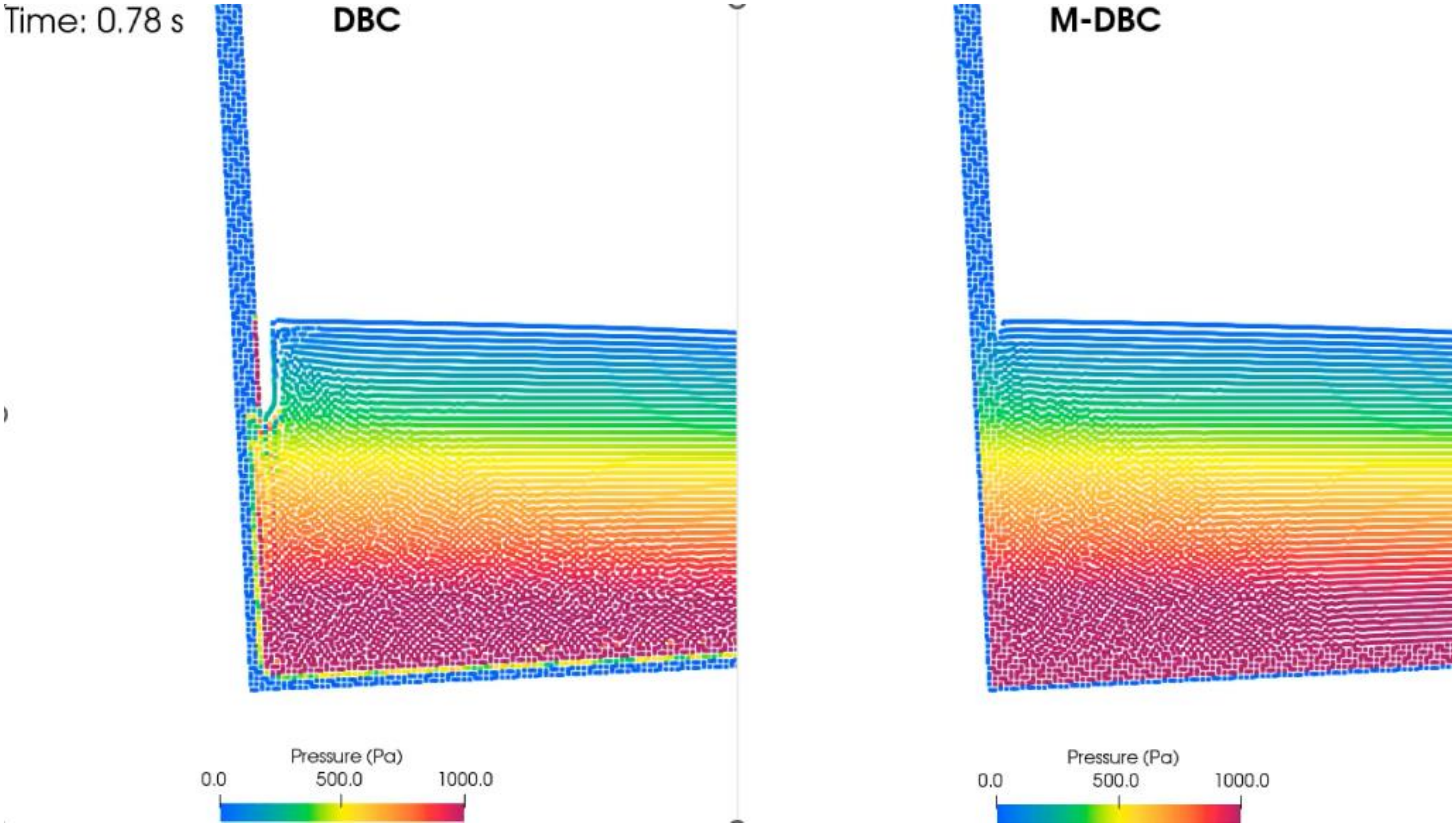
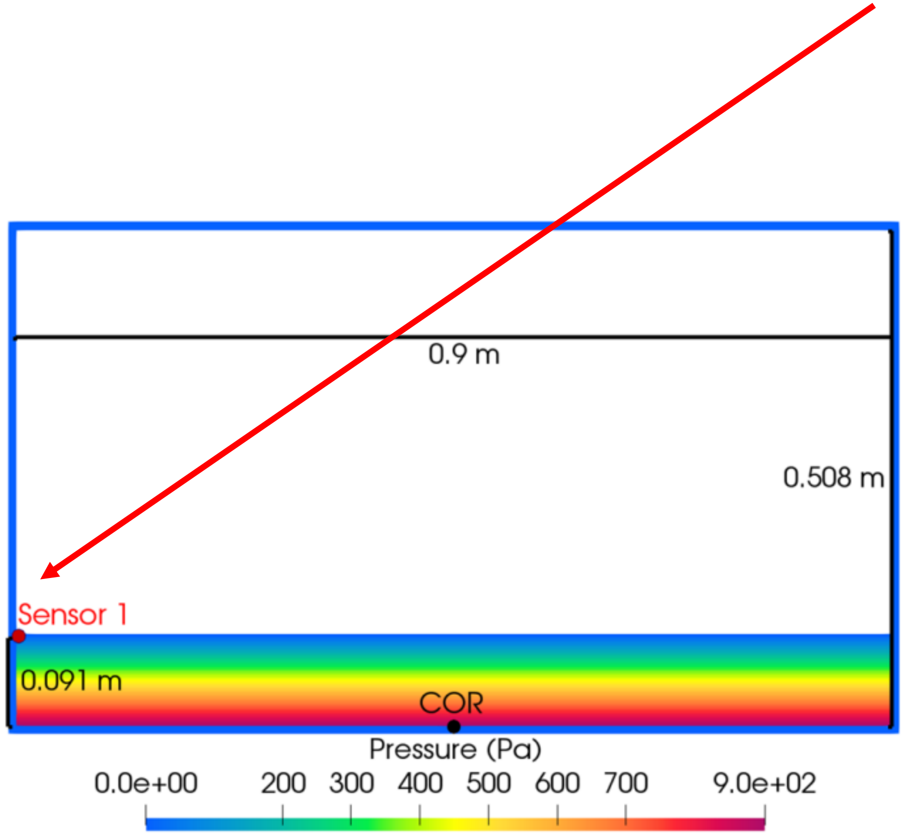
DBC VS MDBC

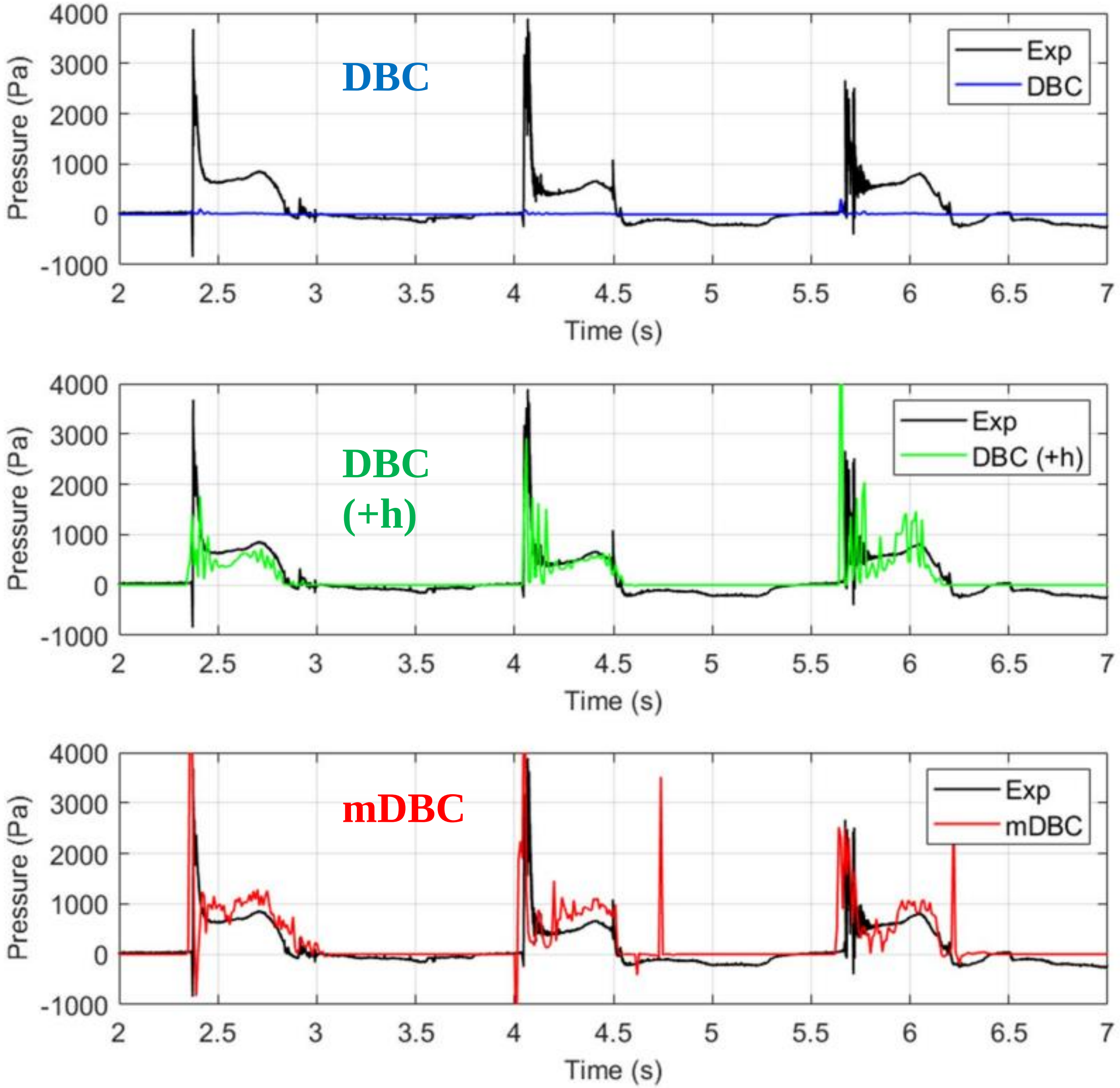
English A, Domínguez JM, Vacondio R, Crespo AJC, Stansby PK, Lind SJ, Chiapponi L, Gómez-Gesteira M. 2022. Modified dynamic boundary conditions (mDBC) for general purpose smoothed particle hydrodynamics (SPH): application to tank sloshing, dam break and fish pass problems. Computational Particle Mechanics, 9(5), 911-925. doi:10.1007/s40571-021-00403-3.



DBC VS MDBC

Comparison of experimental and numerical pressures measured at probe location in SENSOR 1





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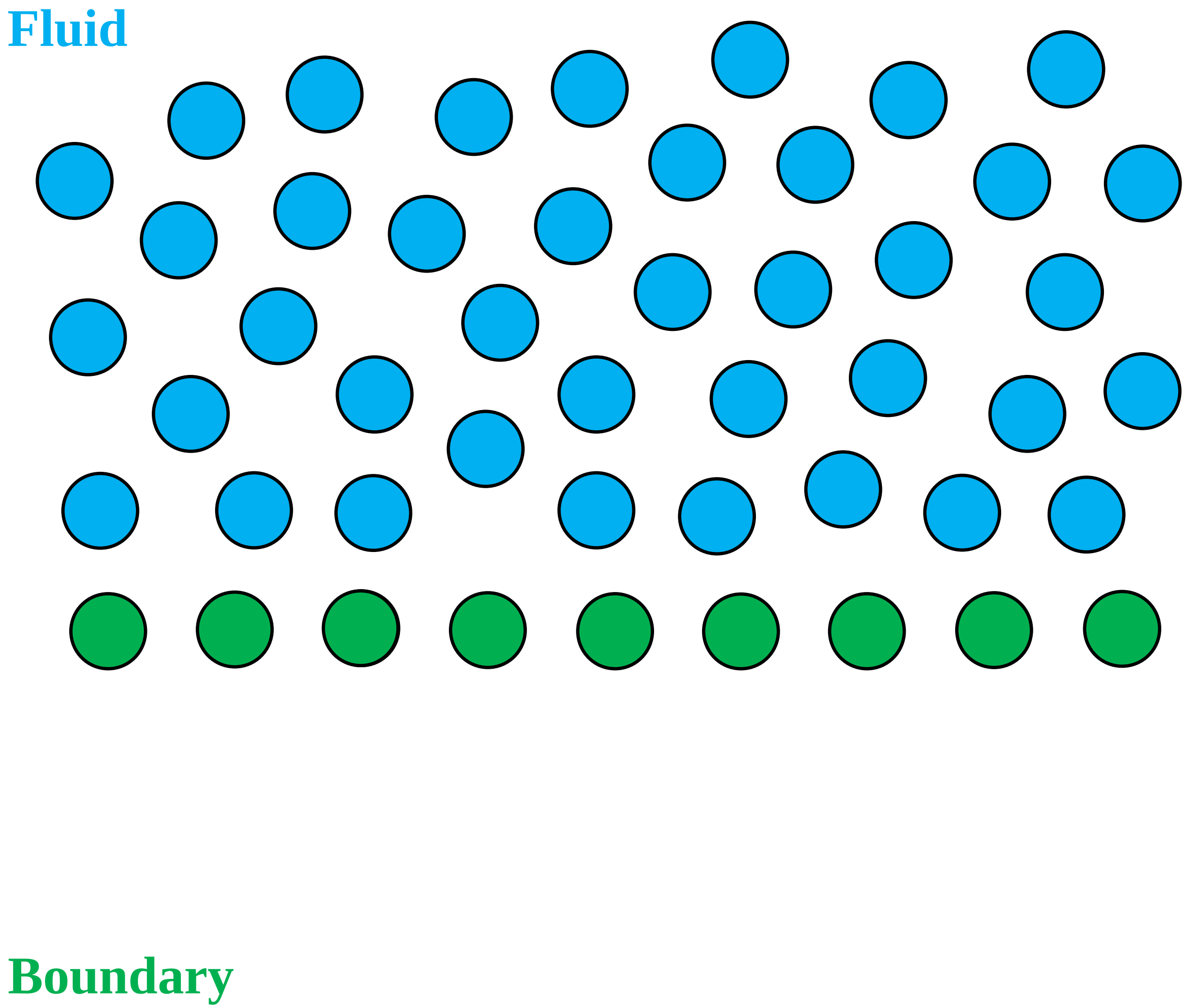
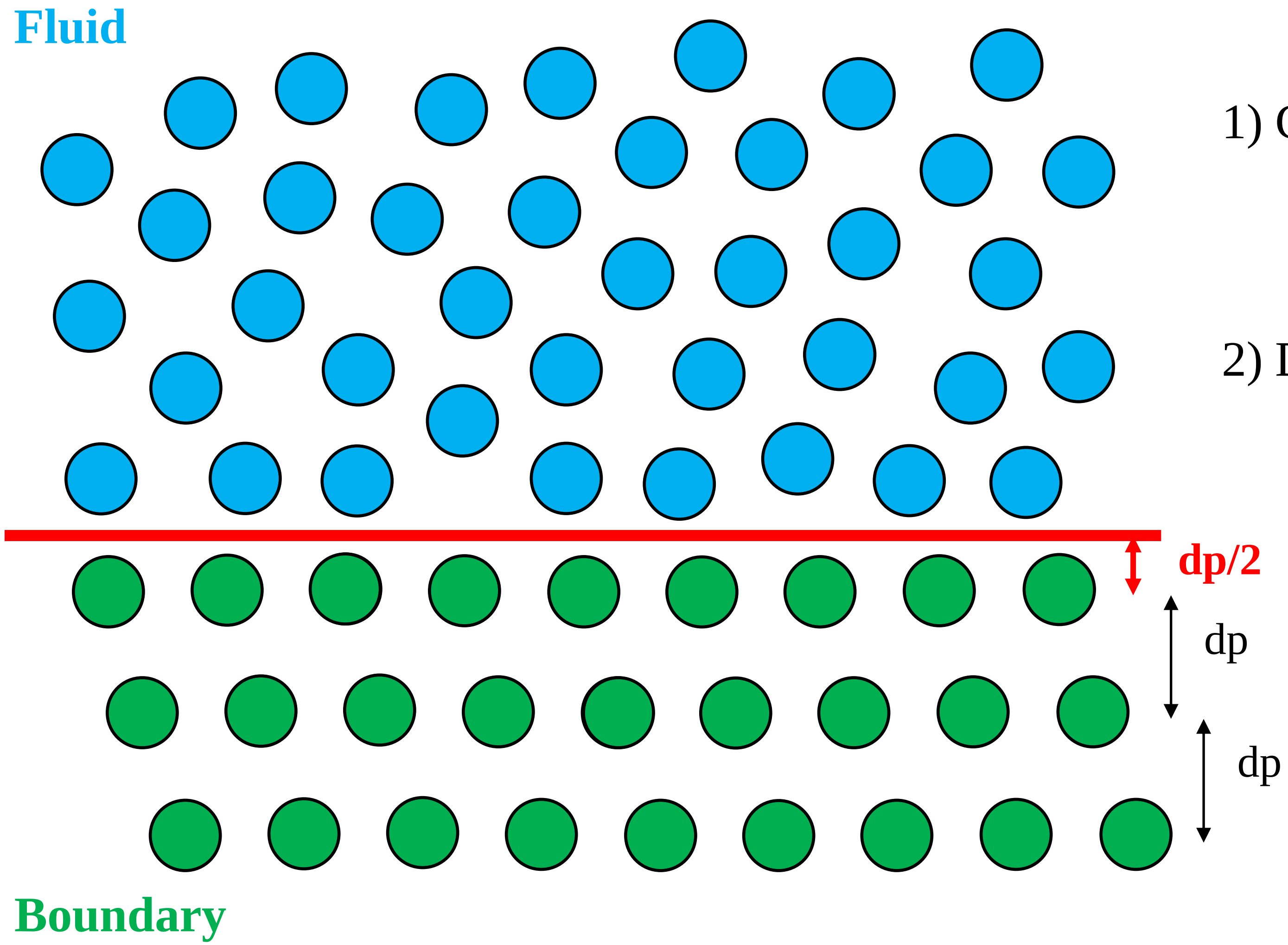
mDBC: Requirements



Requirements to apply mDBC:

mDBC: Requirements

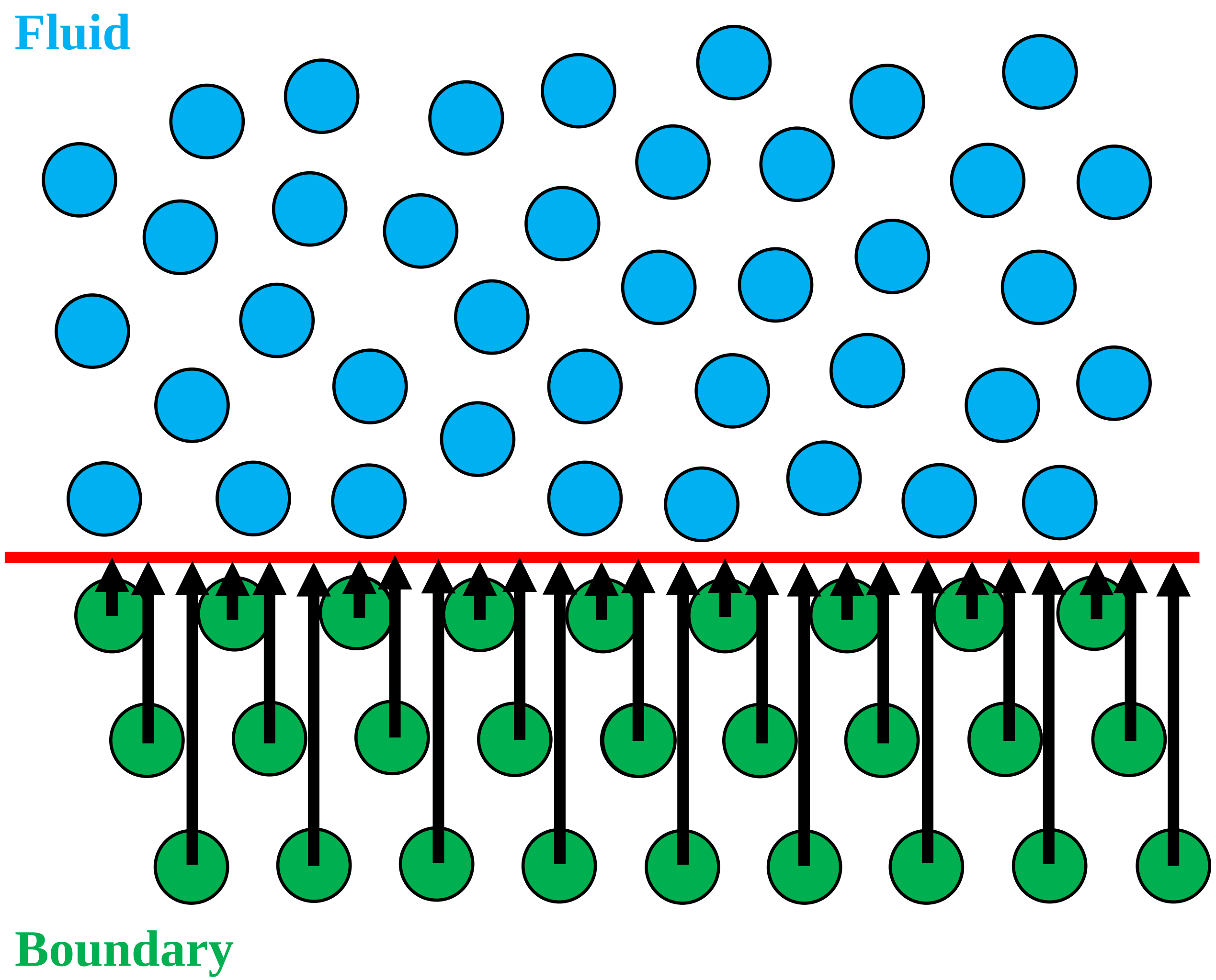


Requirements to apply mDBC:

1) Create several layers of boundary particles
layers>=2h

2) Define where is the boundary limit or the boundary interface (**at dp/2**)

mDBC: Requirements



Requirements to apply mDBC:

1) Create several layers of boundary particles
layers>=2h

2) Define where is the boundary limit or the boundary interface (**at dp/2**)

3) Compute normal vectors for each boundary:

direction towards the fluid
module: distance between particle and boundary limit

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mDBC applied to external geometries

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New options in GenCase

Free drawing mode

Several layers

Numerical variables

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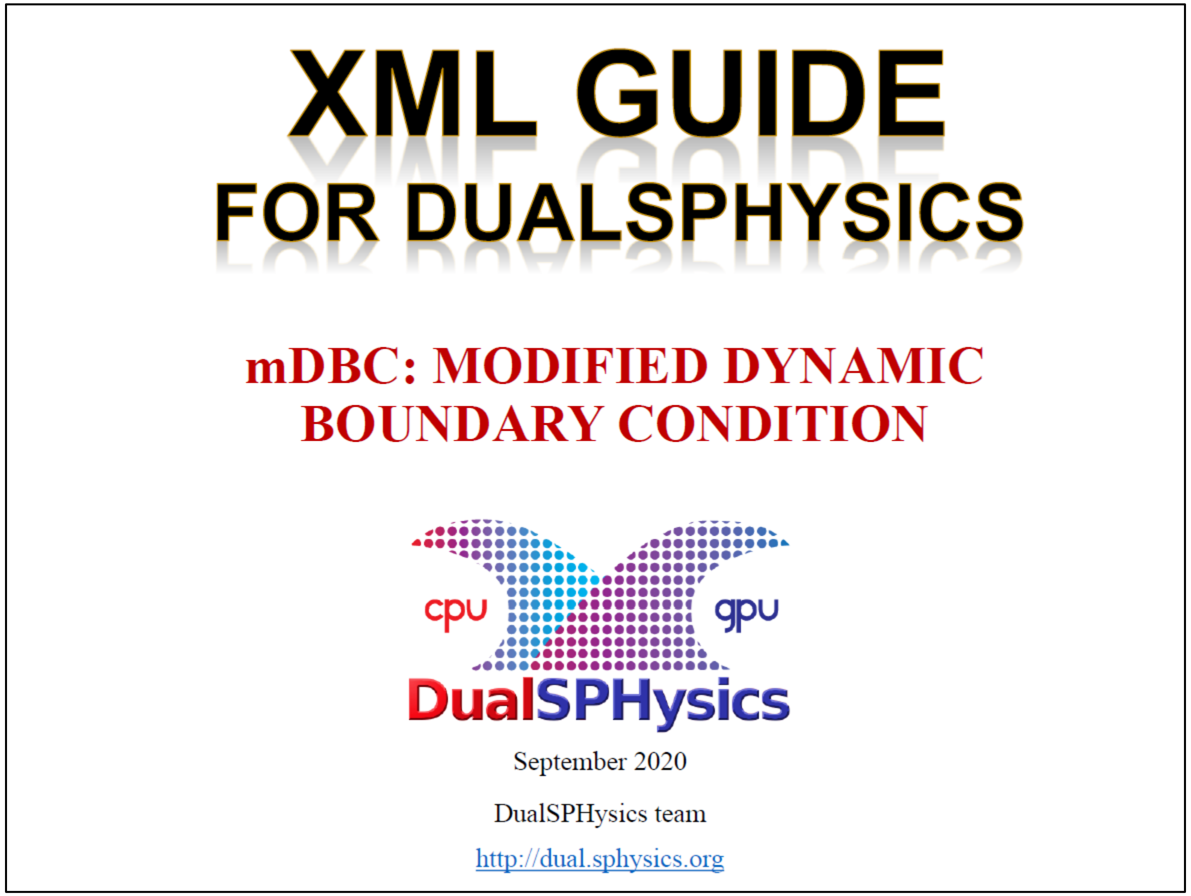
mDBC: Requirements

XML_GUIDE_MDBC.pdf in ***doc\guides***



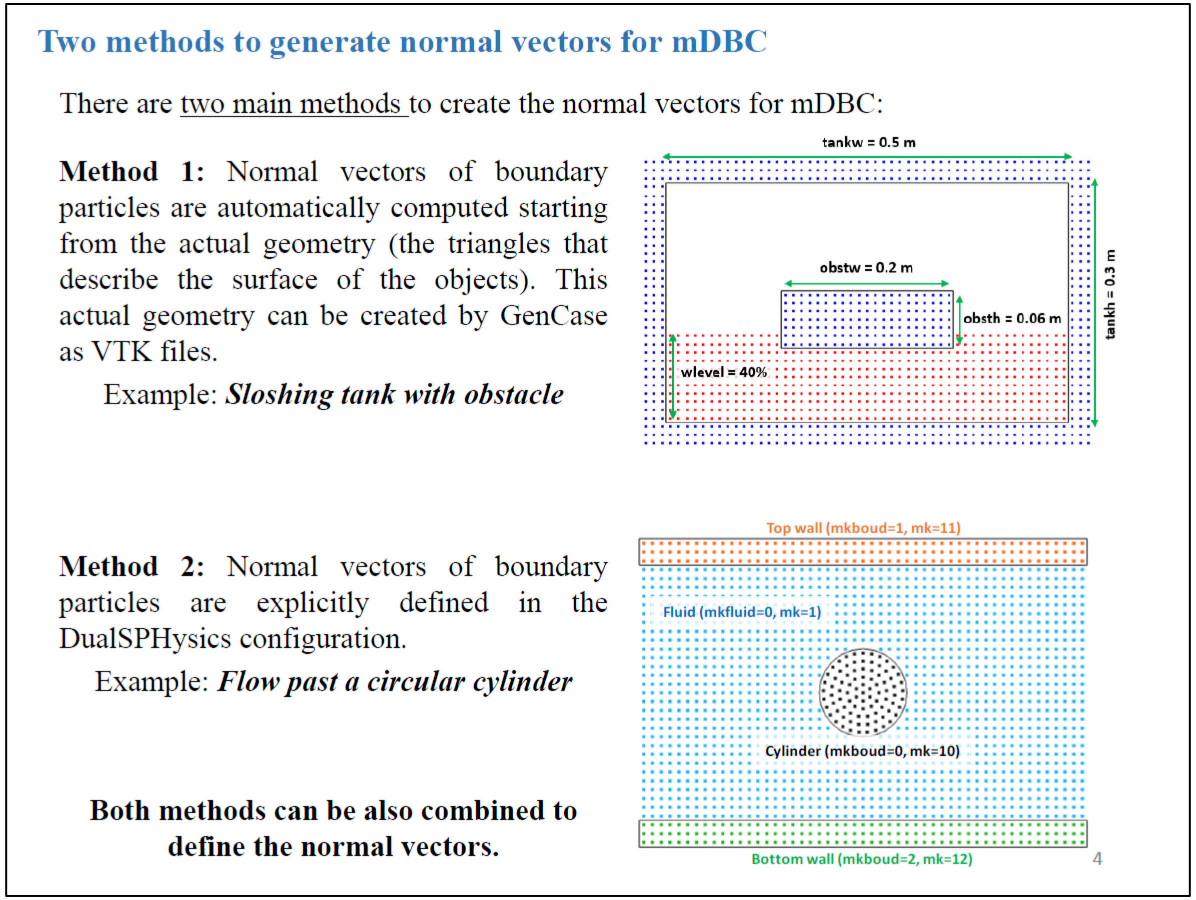
XML GUIDE
FOR DUALSPHYSICS

mDBC: MODIFIED DYNAMIC BOUNDARY CONDITION

September 2020

DualSPHysics team

http://dual.sphysics.org



Two methods to generate normal vectors for mDBC

There are two main methods to create the normal vectors for mDBC:

Method 1: Normal vectors of boundary particles are automatically computed starting from the actual geometry (the triangles that describe the surface of the objects). This actual geometry can be created by GenCase as VTK files.

Example: ***Sloshing tank with obstacle***

Method 2: Normal vectors of boundary particles are explicitly defined in the DualSPHysics configuration.

Example: ***Flow past a circular cylinder***

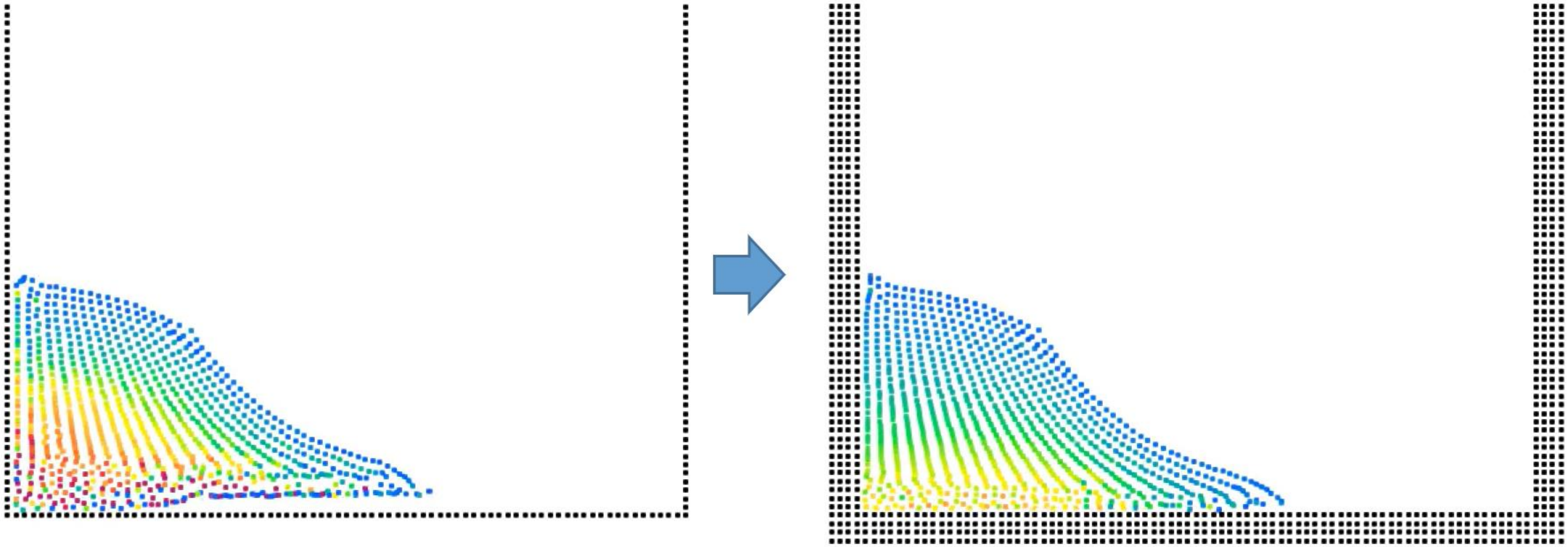
Both methods can be also combined to define the normal vectors.

4

Example with tank walls

DBC

mDBC



Example with tank walls

DBC

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            <hswl value="0" auto="true" comment="Maximum still water level to calculate speedofsound using coefsound" units_comment="metres (m)" />
            <gamma value="7" comment="Polytropic constant for water used in the state equation" />
            <speedsystem value="0" auto="true" comment="Maximum system speed (by default the dam-break propagation is used)" />
            <coefsound value="20" comment="Coefficient to multiply speedsystem" />
            <speedsound value="0" auto="true" comment="Speed of sound to use in the simulation (by default speedofsound=coefsound*speedsystem)" />
            <coefh value="1.2" comment="Coefficient to calculate the smoothing length (h=coefh*sqrt(3*dp^2) in 3D)" />
            <cflnumber value="0.2" comment="Coefficient to multiply dt" />
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                        <size x="1" y="2" z="2" />
                    </drawbox>
                    <setmkbound mk="0" />
                    <drawbox>
                        <boxfill>bottom | left | right | front | back</boxfill>
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                        <size x="4" y="2" z="3" />
                    </drawbox>
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    <execution>
        <parameters>
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            <parameter key="Kernel" value="2" comment="Interaction Kernel 1:Cubic Spline, 2:Wendland (default=2)" />
            <parameter key="ViscoTreatment" value="1" comment="Viscosity formulation 1:Artificial, 2:Laminar+SPS (default=1)" />
            <parameter key="Visco" value="0.02" comment="Viscosity value" />
            <parameter key="ViscoBoundFactor" value="1" comment="Multiply viscosity value with boundary (default=1)" />
            <parameter key="DensityDT" value="2" comment="Density Diffusion Term 0:None, 1:Molteni, 2:Fourtakas, 3:Fourtakas(full) (default=0)" />
            <parameter key="DensityDTvalue" value="0.1" comment="DDT value (default=0.1)" />
            <parameter key="Shifting" value="0" comment="Shifting mode 0:None, 1:Ignore bound, 2:Ignore fixed, 3:Full (default=0)" />
            <parameter key="ShiftCoef" value="-2" comment="Coefficient for shifting computation (default=-2)" />
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            <parameter key="RigidAlgorithm" value="1" comment="Rigid Algorithm 0:collision-free, 1:SPH, 2:DEM, 3:Chrono (default=1)" />
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            <parameter key="DtIni" value="0" comment="Initial time step. Use 0 to defult use (default=h/speedsound)" units_comment="seconds" />
            <parameter key="DtMin" value="0" comment="Minimum time step. Use 0 to defult use (default=coefdtmin*h/speedsound)" units_comment="seconds" />
            <parameter key="DtFixed" value="0" comment="Fixed Dt value. Use 0 to disable (default=disabled)" units_comment="seconds" />
            <parameter key="DtFixedFile" value="NONE" comment="Dt values are loaded from file. Use NONE to disable (default=disabled)" units_comment="milliseconds (ms)" />
            <parameter key="DtAllParticles" value="0" comment="Velocity of particles used to calculate DT. 1:All, 0:Only fluid/floating (default=0)" />
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            <parameter key="TimeOut" value="0.01" comment="Time out data" units_comment="seconds" />
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                <posmin x="default" y="default" z="default" comment="e.g.: x=0.5, y=default-1, z=default-10%" />
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        </parameters>
    </execution>
</case>
```

mDBC

```xml
<case>
    <casedef>
        <constantsdef>
            <gravity x="0" y="0" z="-9.81" comment="Gravitational acceleration" units_comment="m/s^2" />
            <rhop0 value="1000" comment="Reference density of the fluid" units_comment="kg/m^3" />
            <hswl value="0" auto="true" comment="Maximum still water level to calculate speedofsound using coefsound" units_comment="metres (m)" />
            <gamma value="7" comment="Polytropic constant for water used in the state equation" />
            <speedsystem value="0" auto="true" comment="Maximum system speed (by default the dam-break propagation is used)" />
            <coefsound value="20" comment="Coefficient to multiply speedsystem" />
            <speedsound value="0" auto="true" comment="Speed of sound to use in the simulation (by default speedofsound=coefsound*speedsystem)" />
            <coefh value="1.2" comment="Coefficient to calculate the smoothing length (h=coefh*sqrt(3*dp^2) in 3D)" />
            <cflnumber value="0.2" comment="Coefficient to multiply dt" />
        </constantsdef>
        <mkconfig boundcount="240" fluidcount="9" />
        <geometry>
            <definition dp="0.01" units_comment="metres (m)">
                <pointmin x="-1" y="0" z="-1" />
                <pointmax x="4.5" y="0" z="3.5" />
            </definition>
            <commands>
                <list name="GeometryForNormals">
                    <setactive drawpoints="0" drawshapes="1" />
                    <setshapemode>actual | bound</setshapemode>
                    <!-- Tank -->
                    <setnormalinvert invert="true" />
                    <setmkbound mk="0" />
                    <drawbox>
                        <boxfill>bottom | left | right</boxfill>
                        <point x="0" y="-1" z="0" />
                        <size x="4" y="2" z="3" />
                        <layers vdp="-0.5" />
                    </drawbox>
                    <shapeout file="hdp" />
                    <resetdraw />
                </list>
                <mainlist>
                    <!-- Actual geometry at dp/2 -->
                    <runlist name="GeometryForNormals" />
                    <!-- Generation of particles -->
                    <setdrawmode mode="full" />
                    <setmkfluid mk="0" />
                    <drawbox>
                        <boxfill>solid</boxfill>
                        <point x="0" y="-1" z="0" />
                        <size x="1" y="2" z="2" />
                    </drawbox>
                    <setmkbound mk="0" />
                    <drawbox>
                        <boxfill>bottom | left | right | front | back</boxfill>
                        <point x="0" y="-1" z="0" />
                        <size x="4" y="2" z="3" />
                        <layers vdp="0,1,2,3" />
                    </drawbox>
                </mainlist>
            </commands>
        </geometry>
        <normals>
            <distanceh value="3.0" comment="Maximum distance (H*distanceh) to compute normals data (default=2)" />
            <geometryfile file="[CaseName]_hdp_Actual.vtk" comment="File with boundary geometry (VTK format)" />
            <svshapes value="1" comment="Saves VTK with geometry in triangles and quads with its normals for debug (default=0)" />
            <svnormaldata value="0" comment="Saves VTK with normal data for debug (default=0)" />
        </normals>
    </casedef>
    <execution>
        <parameters>
            <parameter key="SavePosDouble" value="0" comment="Saves particle position using double precision (default=0)" />
            <parameter key="Boundary" value="2" comment="Boundary method 1:DBC, 2:mDBC (default=1)" />
            <parameter key="StepAlgorithm" value="1" comment="Step Algorithm 1:Verlet, 2:Symplectic (default=1)" />
            <parameter key="VerletSteps" value="40" comment="Verlet only: Number of steps to apply Euler timestepping (default=40)" />
            <parameter key="Kernel" value="2" comment="Interaction Kernel 1:Cubic Spline, 2:Wendland (default=2)" />
            <parameter key="ViscoTreatment" value="1" comment="Viscosity formulation 1:Artificial, 2:Laminar+SPS (default=1)" />
            <parameter key="Visco" value="0.02" comment="Viscosity value" />
            <parameter key="ViscoBoundFactor" value="1" comment="Multiply viscosity value with boundary (default=1)" />
            <parameter key="DensityDT" value="3" comment="Density Diffusion Term 0:None, 1:Molteni, 2:Fourtakas, 3:Fourtakas(full) (default=0)" />
            <parameter key="DensityDTvalue" value="0.1" comment="DDT value (default=0.1)" />
            <parameter key="Shifting" value="0" comment="Shifting mode 0:None, 1:Ignore bound, 2:Ignore fixed, 3:Full (default=0)" />
            <parameter key="ShiftCoef" value="-2" comment="Coefficient for shifting computation (default=-2)" />
            <parameter key="ShiftTFS" value="0" comment="Threshold to detect free surface. Typically 1.5 for 2D and 2.75 for 3D (default=0)" />
            <parameter key="RigidAlgorithm" value="1" comment="Rigid Algorithm 0:collision-free, 1:SPH, 2:DEM, 3:Chrono (default=1)" />
            <parameter key="FtPause" value="0.0" comment="Time to freeze the floatings at simulation start (warmup) (default=0)" units_comment="seconds" />
            <parameter key="CoefDtMin" value="0.05" comment="Coefficient to calculate minimum time step dtmin=coefdtmin*h/speedsound (default=0.05)" />
            <parameter key="DtIni" value="0" comment="Initial time step. Use 0 to defult use (default=h/speedsound)" units_comment="seconds" />
            <parameter key="DtMin" value="0" comment="Minimum time step. Use 0 to defult use (default=coefdtmin*h/speedsound)" units_comment="seconds" />
            <parameter key="DtFixed" value="0" comment="Fixed Dt value. Use 0 to disable (default=disabled)" units_comment="seconds" />
            <parameter key="DtFixedFile" value="NONE" comment="Dt values are loaded from file. Use NONE to disable (default=disabled)" units_comment="milliseconds (ms)" />
            <parameter key="DtAllParticles" value="0" comment="Velocity of particles used to calculate DT. 1:All, 0:Only fluid/floating (default=0)" />
            <parameter key="TimeMax" value="1.0" comment="Time of simulation" units_comment="seconds" />
            <parameter key="TimeOut" value="0.01" comment="Time out data" units_comment="seconds" />
            <parameter key="PartsOutMax" value="1" comment="%/100 of fluid particles allowed to be excluded from domain (default=1)" units_comment="decimal" />
            <parameter key="RhopOutMin" value="700" comment="Minimum rhop valid (default=700)" units_comment="kg/m^3" />
            <parameter key="RhopOutMax" value="1300" comment="Maximum rhop valid (default=1300)" units_comment="kg/m^3" />
            <simulationdomain comment="Defines domain of simulation (default=Uses minimun and maximum position of the generated particles)">
                <posmin x="default" y="default" z="default" comment="e.g.: x=0.5, y=default-1, z=default-10%" />
                <posmax x="default" y="default" z="default + 50%" />
            </simulationdomain>
        </parameters>
    </execution>
</case>
```

Boundary interface at dp/2

Tank with several layers

Normal vectors

Activates mDBC

Example with tank walls

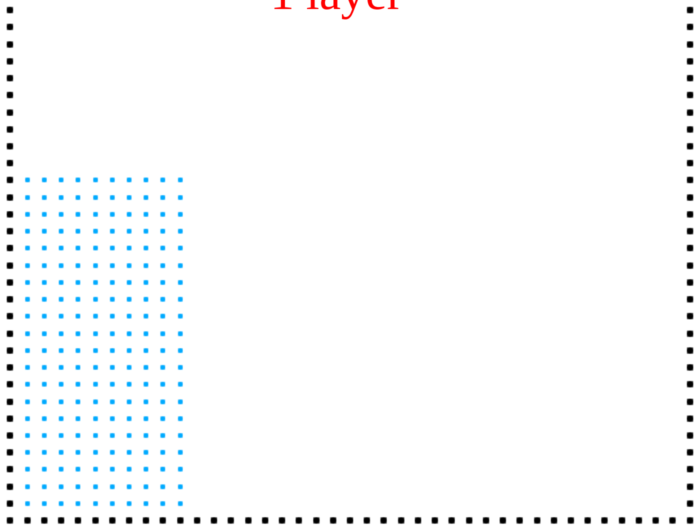
dp	0.1
coefh	1.2
*h=coefh*sqrt(2)*dp*	0.17
*2h=2*h*	0.339
layers=2h/dp	3.394

Tank with several layers

DBC

```
<drawbox>
    <boxfill>bottom | left | right </boxfill>
    <point x="0" y="-1" z="0" />
    <size x="4" y="2" z="3" />
</drawbox>
```

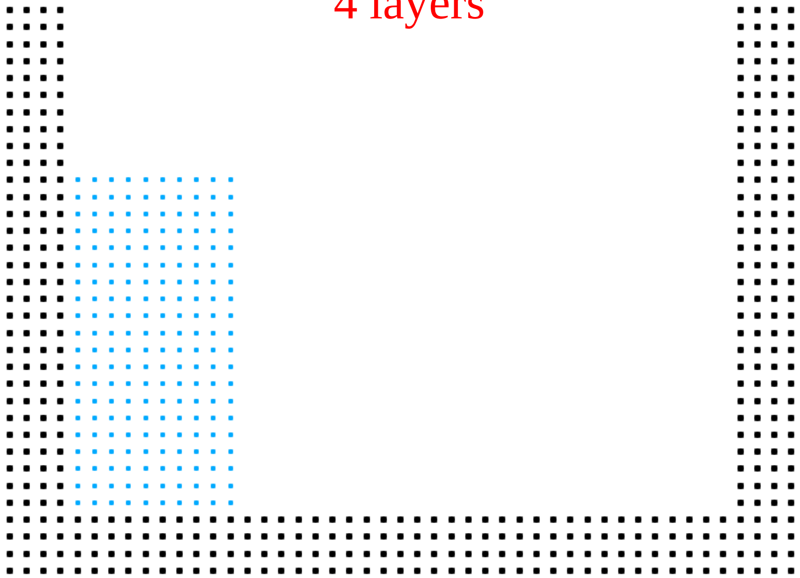
1 layer



mDBC

```
<drawbox>
    <boxfill>bottom | left | right </boxfill>
    <point x="0" y="-1" z="0" />
    <size x="4" y="2" z="3" />
    <layers vdp="0,1,2,3" />
</drawbox>
```

4 layers



Example with tank walls

Boundary interface at dp/2

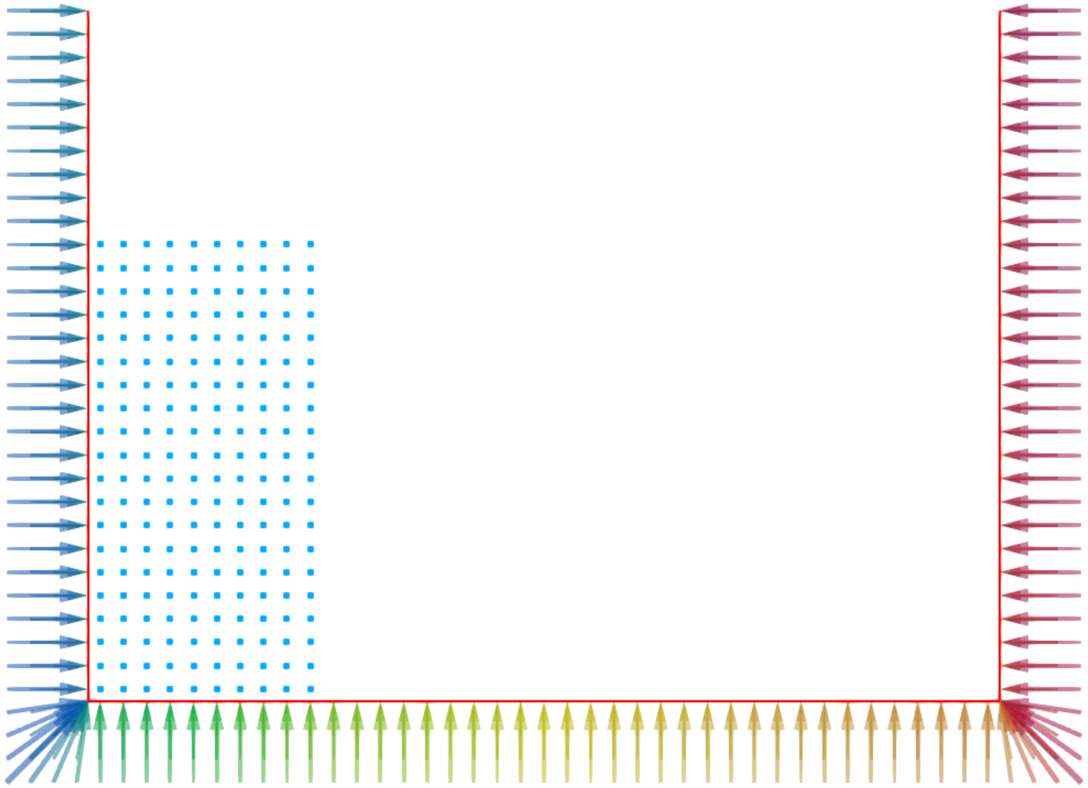
```
<list name="GeometryForNormals">
    <setactive drawpoints="0" drawshapes="1" />
    <setshapemode>actual | bound</setshapemode>
    <!-- Tank -->
    <setnormalinvert invert="true" />
    <setmkbound mk="0" />
    <drawbox>
        <boxfill>bottom | left | right</boxfill>
        <point x="0" y="-1" z="0" />
        <size x="4" y="2" z="3" />
        <layers vdp="-0.5" />
    </drawbox>
    <shapeout file="hdp" />
    <resetdraw />
</list>

<mainlist>
    <!-- Actual geometry at dp/2 -->
    <runlist name="GeometryForNormals" />
    <!-- Generation of particles -->
    (...)

    (...)
</mainlist>
```

Creates boundary interface at 0.5·dp

Example with tank walls

Normal vectors

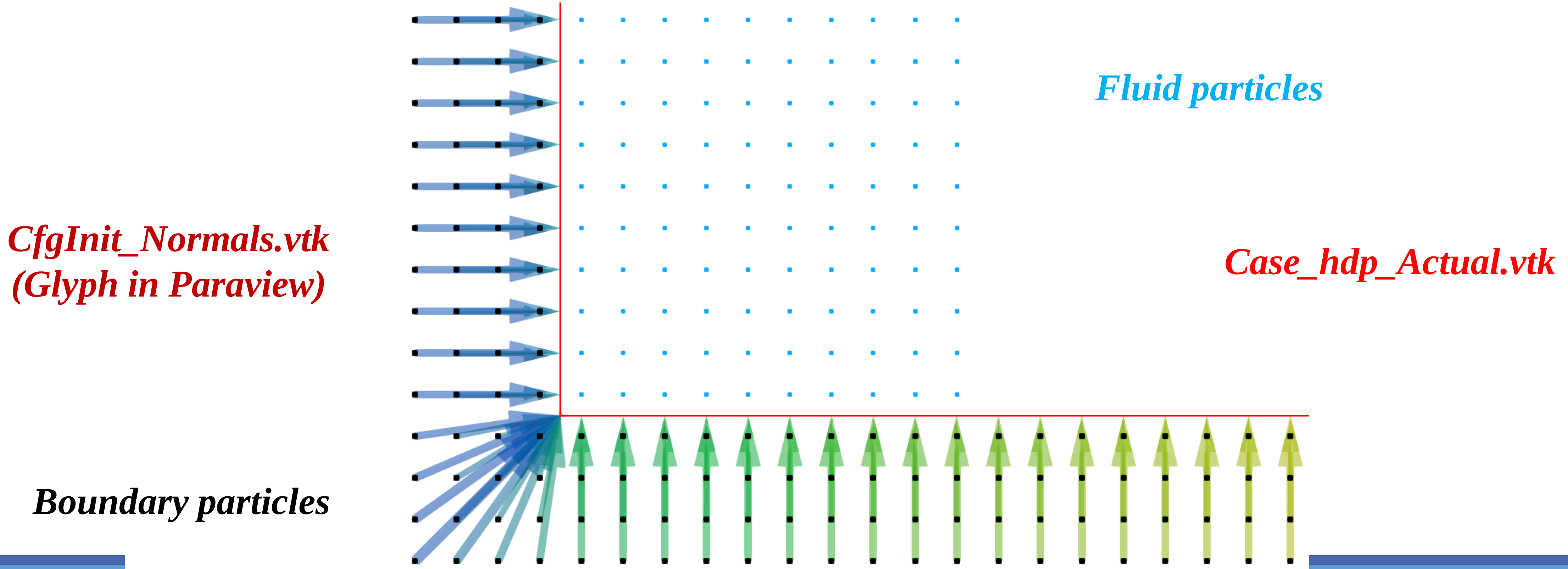
```xml
<normals>
    <distanceh value="3.0" comment="Maximum distance (H*distanceh) to compute normals data (default=2)" />
    <geometryfile file="[CaseName]_hdp_Actual.vtk" comment="File with boundary geometry (VTK format)" />
    <svshapes value="1" comment="Saves VTK with geometry in triangles and quads with its normals for debug (default=0)" />
    <svnormaldata value="0" comment="Saves VTK with normal data for debug (default=0)" />
</normals>
```



Example with tank walls

Normal vectors

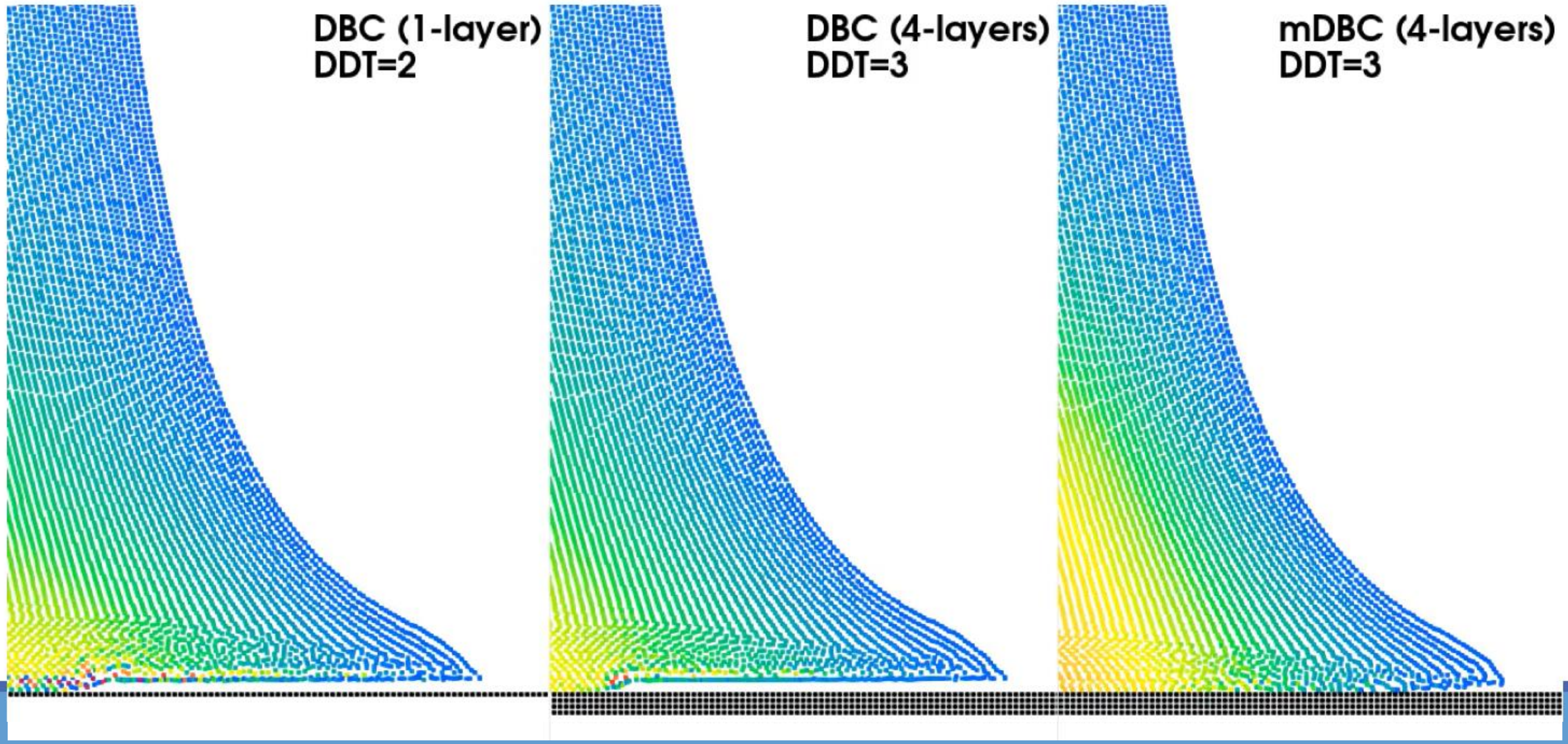
```
<normals>
    <distanceh value="3.0" comment="Maximum distance (H*distanceh) to compute normals data (default=2)" />
    <geometryfile file="[CaseName]_hdp_Actual.vtk" comment="File with boundary geometry (VTK format)" />
    <svshapes value="1" comment="Saves VTK with geometry in triangles and quads with its normals for debug (default=0)" />
    <svnormaldata value="0" comment="Saves VTK with normal data for debug (default=0)" />
</normals>
```



Example with tank walls

Activates mDBC

```
<parameters>
    <parameter key="Boundary" value="2" comment="Boundary method 1:DBC, 2:mDBC " />
    <parameter key="DensityDT" value="3" comment="Density Diffusion Term 0:None, 1:Molteni, 2:Fourtakas, 3:Fourtakas(full)" />
    <parameter key="DensityDTvalue" value="0.1" comment="DDT value (default=0.1)" />
</parameters>
```



OUTLINE

New boundary conditions: mDBC

- DBC drawbacks
- Fluid properties from ghost nodes
- DBC vs mDBC
- Requirements (layers, boundary interface, normals)

mDBC requirements -> XML file

- New options in GenCase (*layers*, *freedrawmode*, *variables*)
- Example with tank walls (fixed)
- Example with piston wavepaddle (moving)
- Example with floating box (floating)

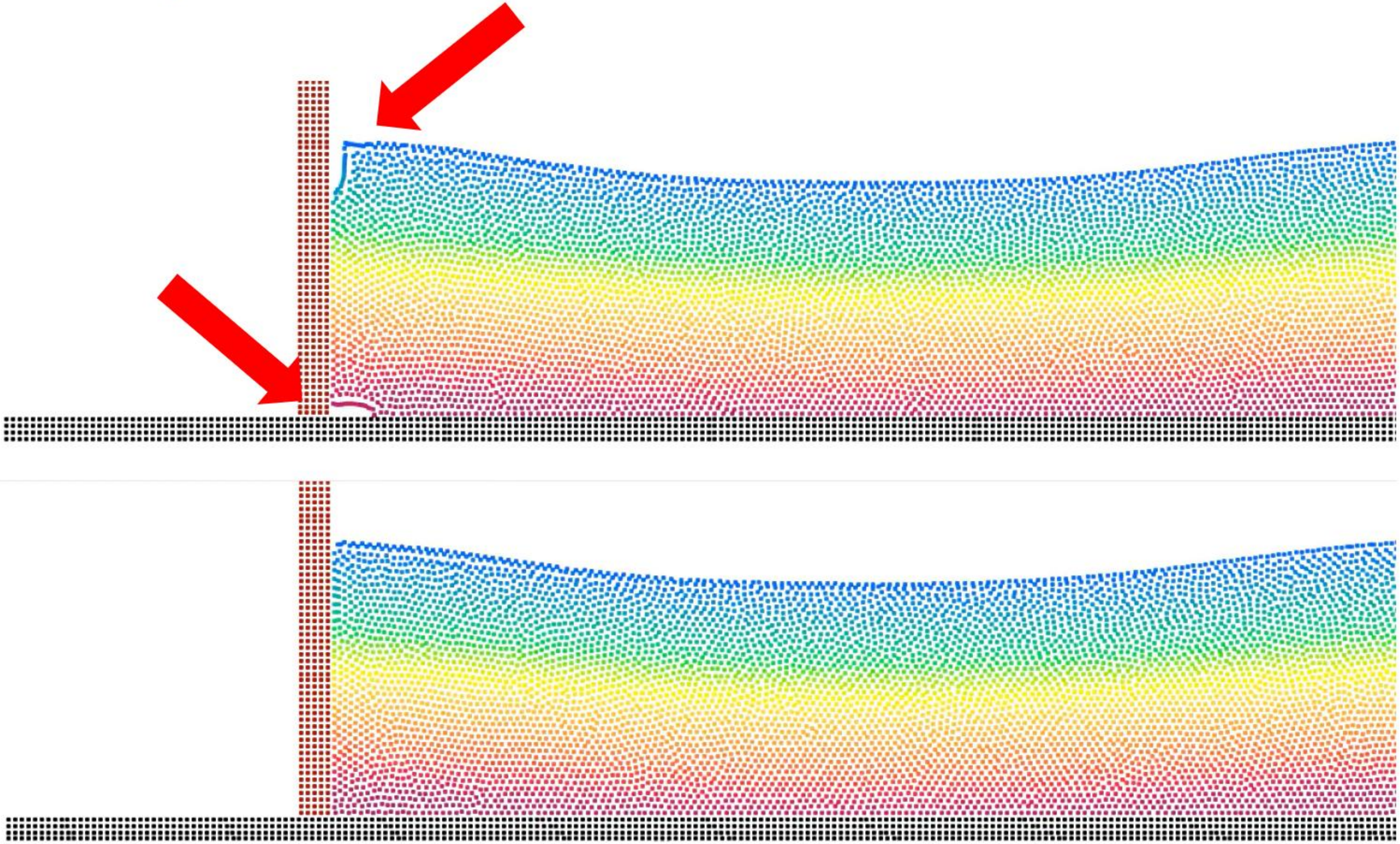
mDBC applied to external geometries

- New options in GenCase (*advanced drawfilestl*)
- Example with simple STL (Cylinder)
- Example with complex STL (Duck)

Example with wave paddle

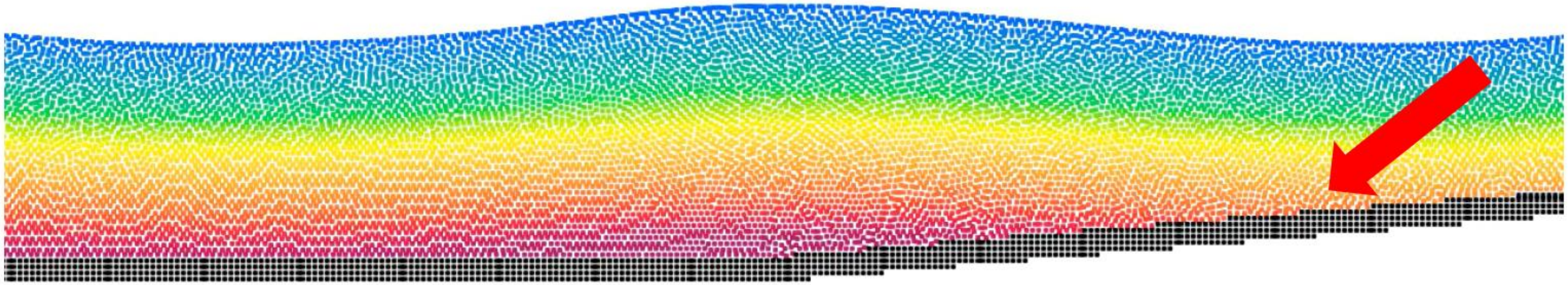
DBC

mDBC

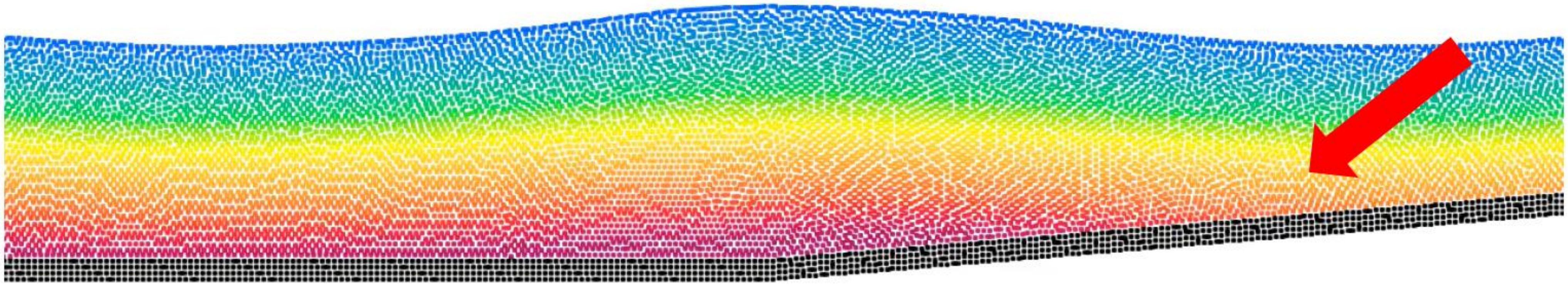


Example with wave paddle

DBC



mDBC



Free drawing mode

Example with wave paddle

Tank with several layers

```
<setmkbound mk="0" />
<setfrdrawmode auto="true" />
<drawextrude closed="false">
    <point x="-0.5" y="-1" z="0" />
    <point x="4" y="-1" z="0" />
    <point x="10.0" y="-1" z="0.5" />
    <extrude x="0" y="2" z="0" />
    <layers vdp="0,-1,-2,-3" />
</drawextrude>
<setfrdrawmode auto="false" />
```

Free drawing mode

4 layers

Boundary interface at dp/2

```
<list name="GeometryForNormals">
    <setactive drawpoints="0" drawshapes="1" />
    <setshapemode>actual | bound</setshapemode>
    <setmkbound mk="0" />
    <setfrdrawmode auto="true" />
    <drawextrude closed="false">
        <point x="-0.5" y="-1" z="0" />
        <point x="4" y="-1" z="0" />
        <point x="10.0" y="-1" z="0.5" />
        <extrude x="0" y="2" z="0" />
        <layers vdp="0.5" />
    </drawextrude>
    <setfrdrawmode auto="false" />
    <shapeout file="hdp" />
    <resetdraw />
</list>
```

Interface at 0.5·dp

Case_hdp_Actual.vtk

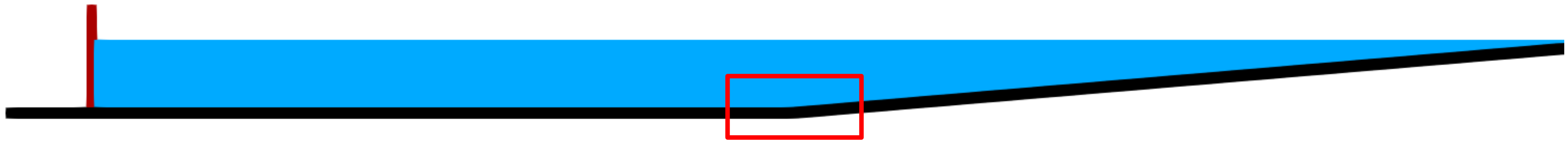
Normal vectors

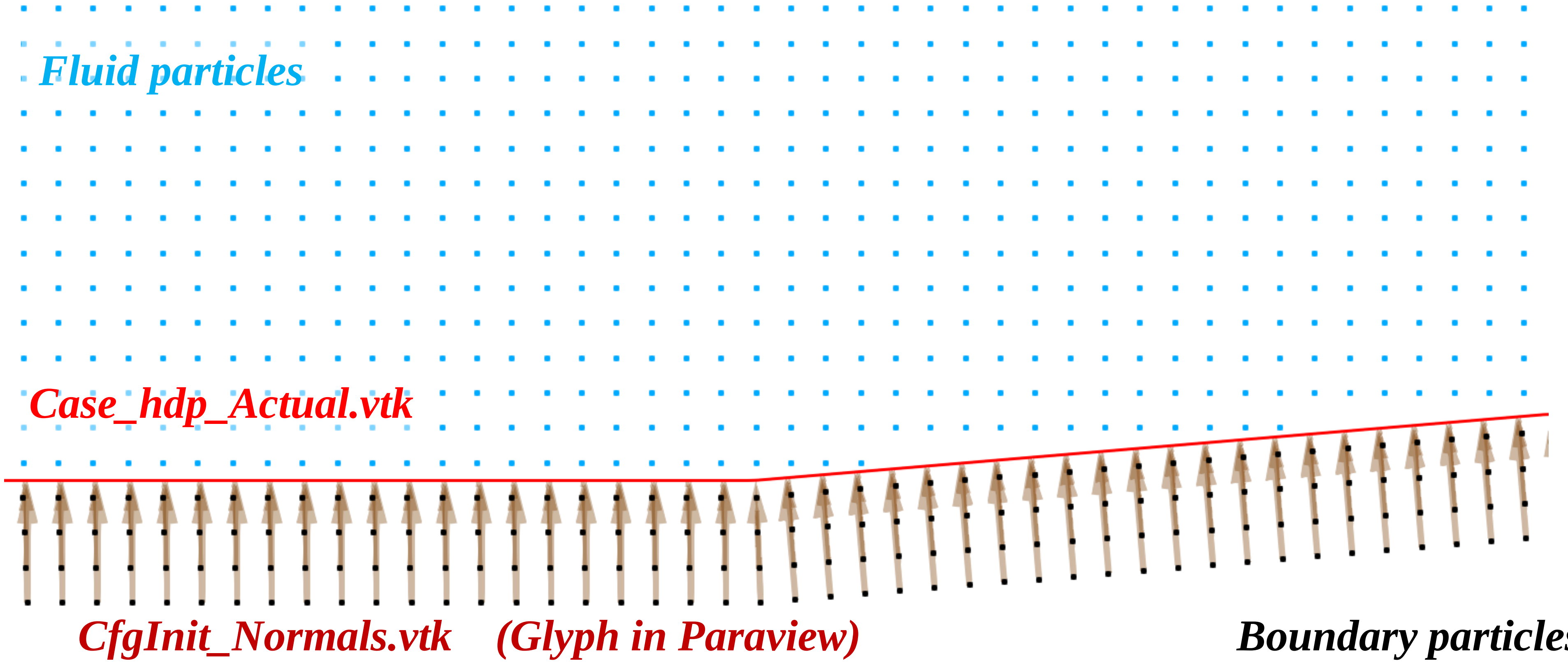
```
<normals>
    <distanceh value="3.0" />
    <geometryfile file="[CaseName]_hdp_Actual.vtk" />
    <svshapes value="1" />
    <svnormaldata value="0" />
</normals>
```

Activates mDBC

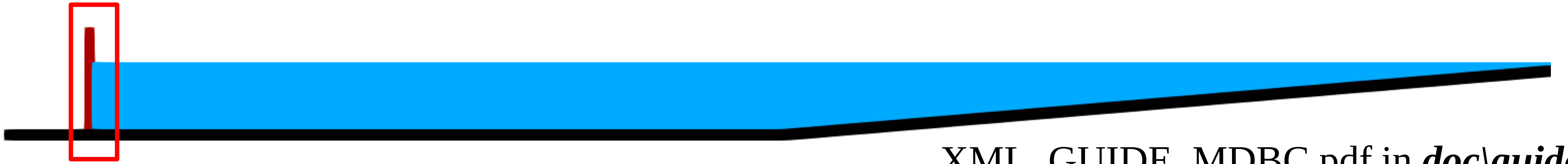
```
<parameters>
    <parameter key="Boundary" value="2" />
    <parameter key="DensityDT" value="3" />
    <parameter key="DensityDTvalue" value="0.1" />
</parameters>
```

Example with wave paddle





Example with wave paddle



XML_GUIDE_MDBC.pdf in ***doc\guides***

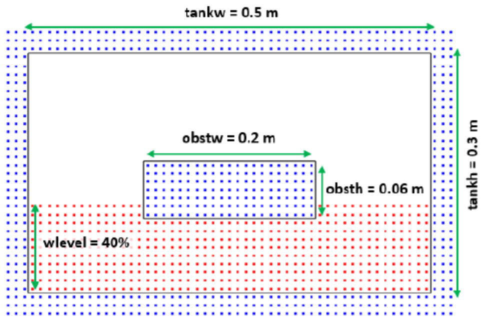
How do we compute normals for the paddle?

Two methods to generate normal vectors for mDBC

There are two main methods to create the normal vectors for mDBC:

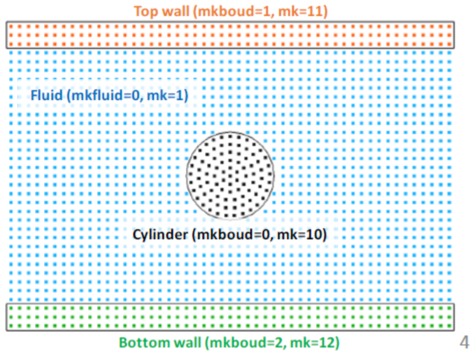
Method 1: Normal vectors of boundary particles are automatically computed starting from the actual geometry (the triangles that describe the surface of the objects). This actual geometry can be created by GenCase as VTK files.

Example: ***Sloshing tank with obstacle***



Method 2: Normal vectors of boundary particles are explicitly defined in the DualSPHysics configuration.

Example: ***Flow past a circular cylinder***



Both methods can be also combined to define the normal vectors.

4

Example with wave paddle

METHOD 1

Tank with several layers

```
<setmkbound mk="10" />
<drawbox>
    <boxfill>solid</boxfill>
    <point x="-0.08" y="-1" z="0" />
    <size x="0.08" y="2" z="0.6" />
</drawbox>
<setmkbound mk="0" />
<setfrdrawmode auto="true" />
<drawextrude closed="false">
    <point x="-0.5" y="-1" z="0" />
    <point x="4" y="-1" z="0" />
    <point x="10.0" y="-1" z="0.5" />
    <extrude x="0" y="2" z="0" />
    <layers vdp="0,-1,-2,-3" />
</drawextrude>
<setfrdrawmode auto="false" />
```

Paddle with 8 columns

Normal vectors

```
<normals>
    <distanceh value="3.0" />
    <geometryfile file="[CaseName]_hdp_Actual.vtk" />
    <svshapes value="1" />
    <svnormaldata value="0" />
</normals>
```

Boundary interface at dp/2

```
<list name="GeometryForNormals">
    <setactive drawpoints="0" drawshapes="1" />
    <setshapemode>actual | bound</setshapemode>
    <setmkbound mk="0" />
    <setfrdrawmode auto="true" />
    <drawextrude closed="false">
        <point x="-0.5" y="-1" z="0" />
        <point x="4" y="-1" z="0" />
        <point x="10.0" y="-1" z="0.5" />
        <extrude x="0" y="2" z="0" />
        <layers vdp="0.5" />
    </drawextrude>
    <setfrdrawmode auto="false" />
    <setmkbound mk="10" />
    <drawbox>
        <boxfill>solid</boxfill>
        <point x="-0.08" y="-1" z="0" />
        <size x="0.08" y="2" z="0.6" />
        <layers vdp="0.5" />
    </drawbox>
    <shapeout file="hdp" />
    <resetdraw />
</list>
```

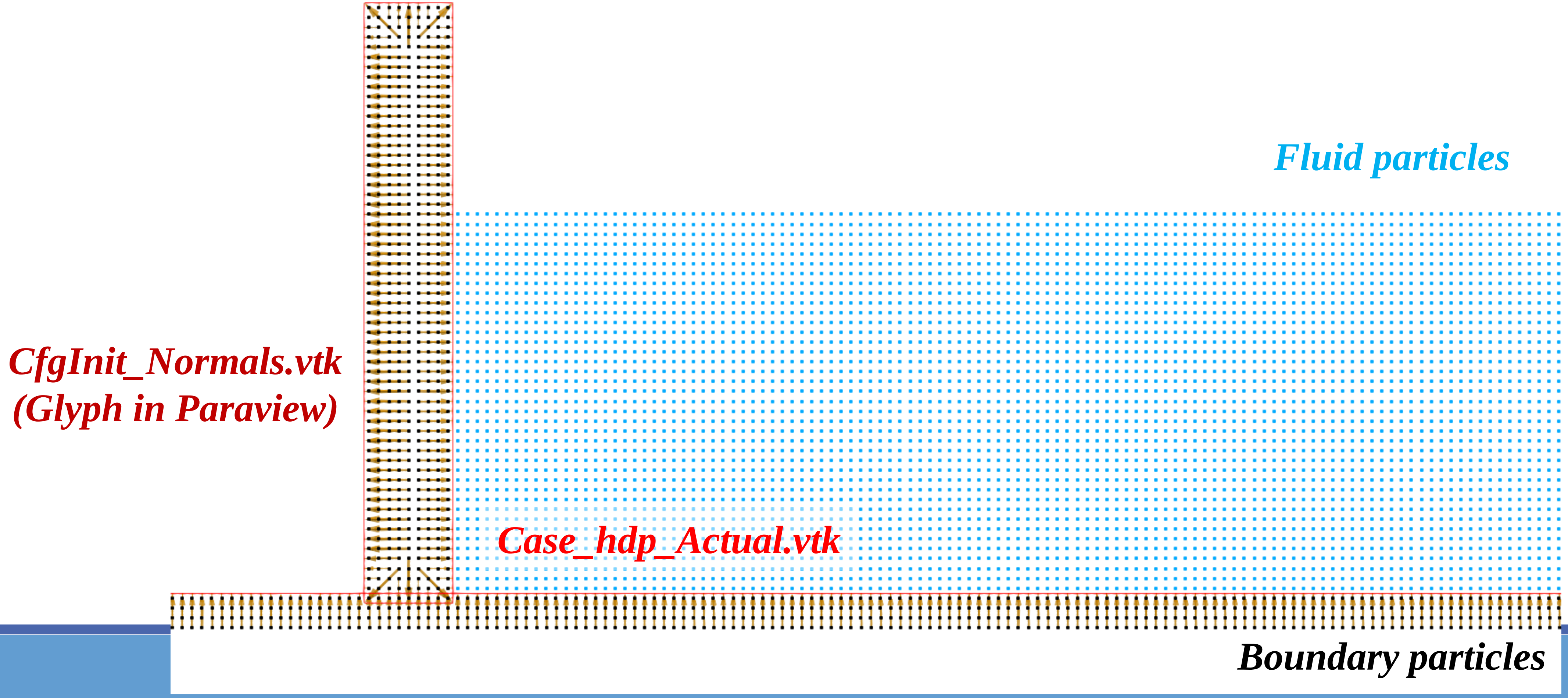
Boundary interface of the paddle at 0.5·dp

Case_hdp_Actual.vtk **includes tank and paddle**

Example with wave paddle

METHOD 1

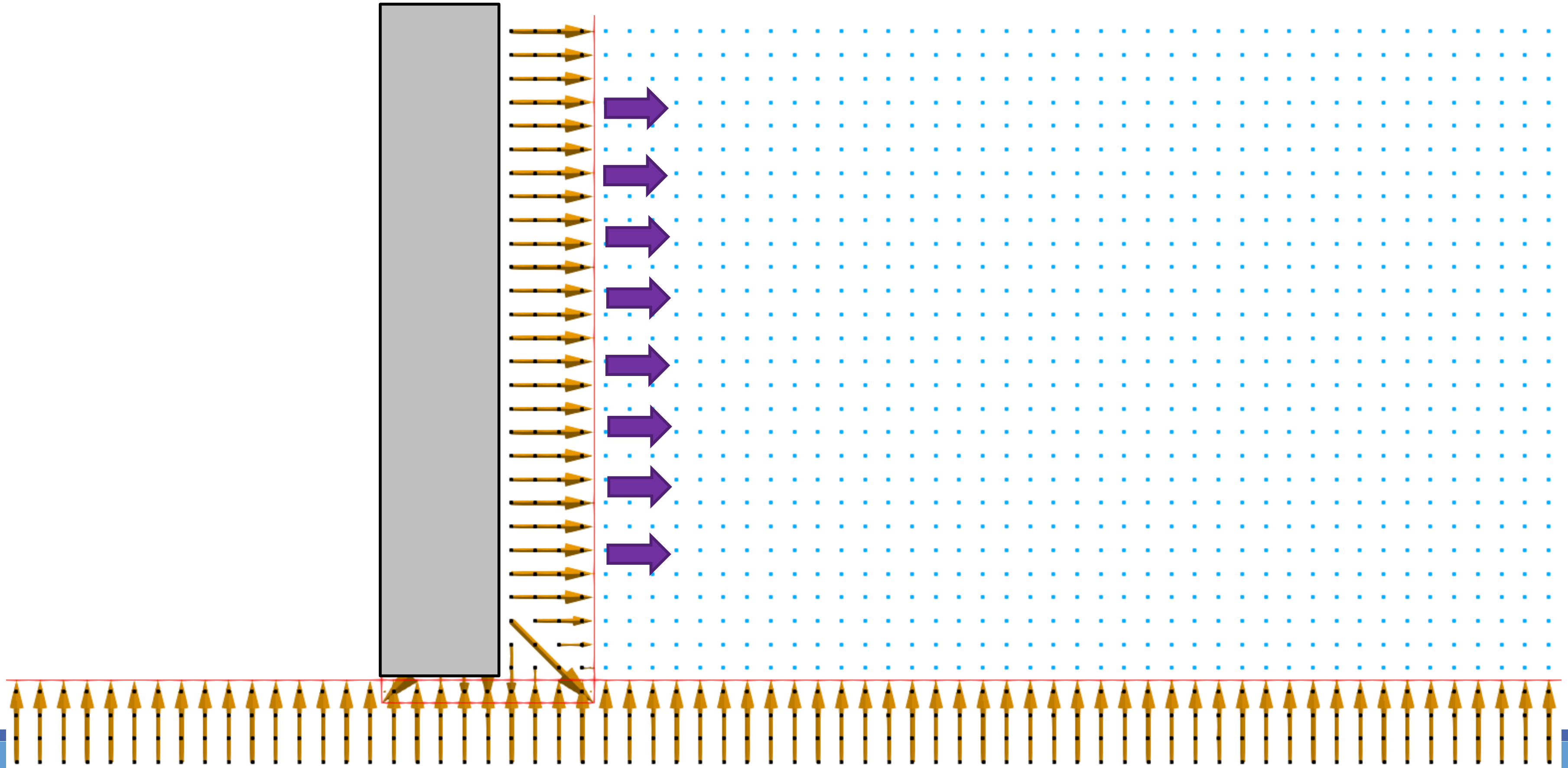
Paddle with 8 columns



Example with wave paddle

METHOD 2

Paddle with 8 columns



Example with wave paddle

METHOD 2

Tank with several layers

```
<setmkbound mk="10" />
<drawbox>
    <boxfill>solid</boxfill>
    <point x="-0.04" y="-1" z="0" />
    <size x="0.04" y="2" z="0.6" />
</drawbox>
<setmkbound mk="0" />
<setfrdrawmode auto="true" />
<drawextrude closed="false">
    <point x="-0.5" y="-1" z="0" />
    <point x="4" y="-1" z="0" />
    <point x="10.0" y="-1" z="0.5" />
    <extrude x="0" y="2" z="0" />
    <layers vdp="0,-1,-2,-3" />
</drawextrude>
<setfrdrawmode auto="false" />
```

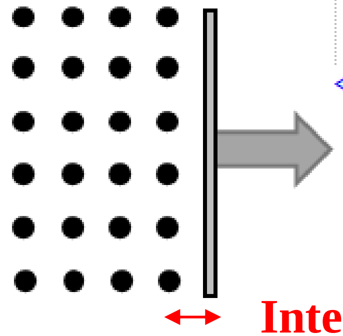
Paddle with 4 columns

Boundary interface at dp/2

```
<list name="GeometryForNormals">
    <setactive drawpoints="0" drawshapes="1" />
    <setshapemode>actual | bound</setshapemode>
    <setmkbound mk="0" />
    <setfrdrawmode auto="true" />
    <drawextrude closed="false">
        <point x="-0.5" y="-1" z="0" />
        <point x="4" y="-1" z="0" />
        <point x="10.0" y="-1" z="0.5" />
        <extrude x="0" y="2" z="0" />
        <layers vdp="0.5" />
    </drawextrude>
    <setfrdrawmode auto="false" />
    <shapeout file="hdp" />
    <resetdraw />
</list>
```

Interface at 0.5·dp

Case_hdp_Actual.vtk
includes only tank



Interface at 0.5·dp

Normal vectors: SPECIAL

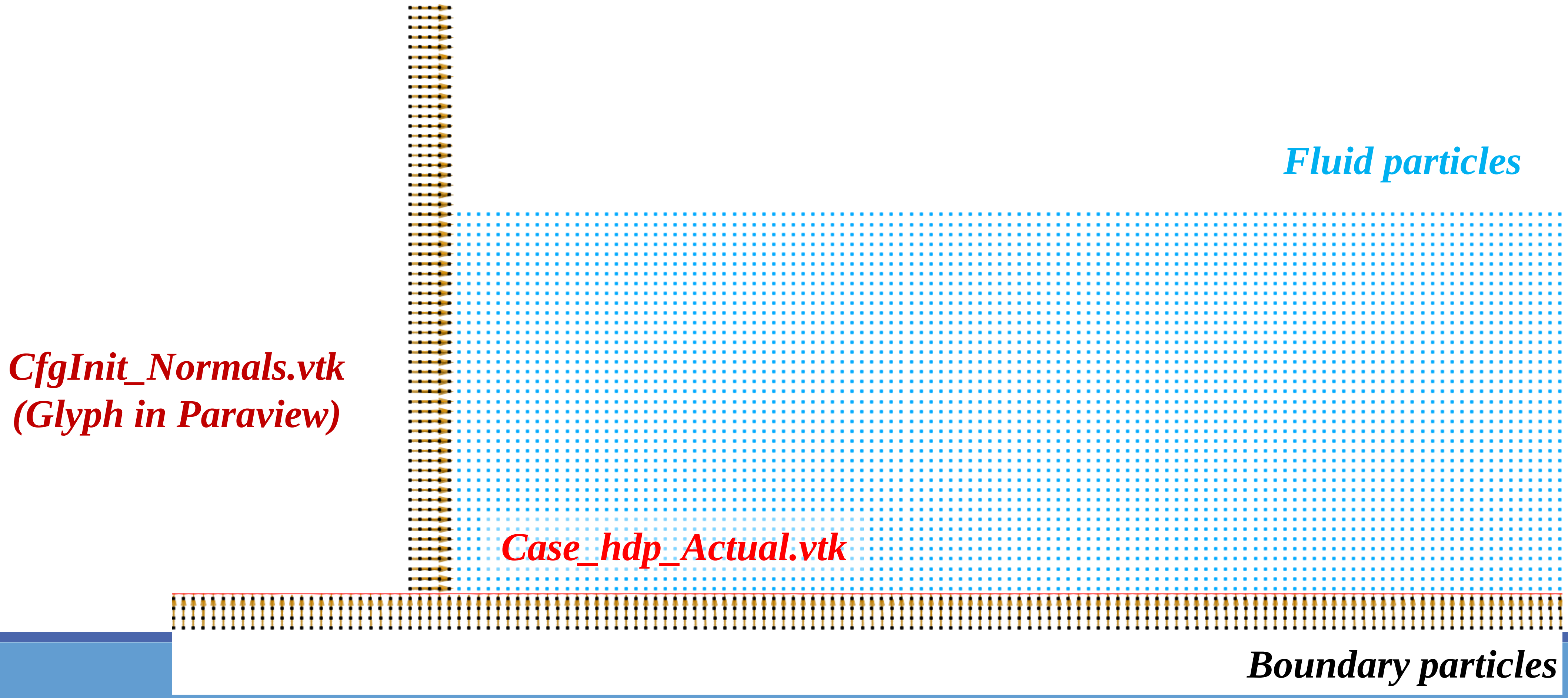
```
<initialize>
    <boundnormal_plane mkbound="10">
        <point auto="true" comment="Point is calculated automatically accoding to normal configuration." />
        <normal x="1" y="0" z="0" />
        <maxdisth v="0" comment="Maximum distance to boundary limit. It uses H*maxdisth (default=2)" />
    </boundnormal_plane>
</initialize>
```

Computes normal vectors of particles of the paddle (all with (1,0,0) direction)

Example with wave paddle

METHOD 2

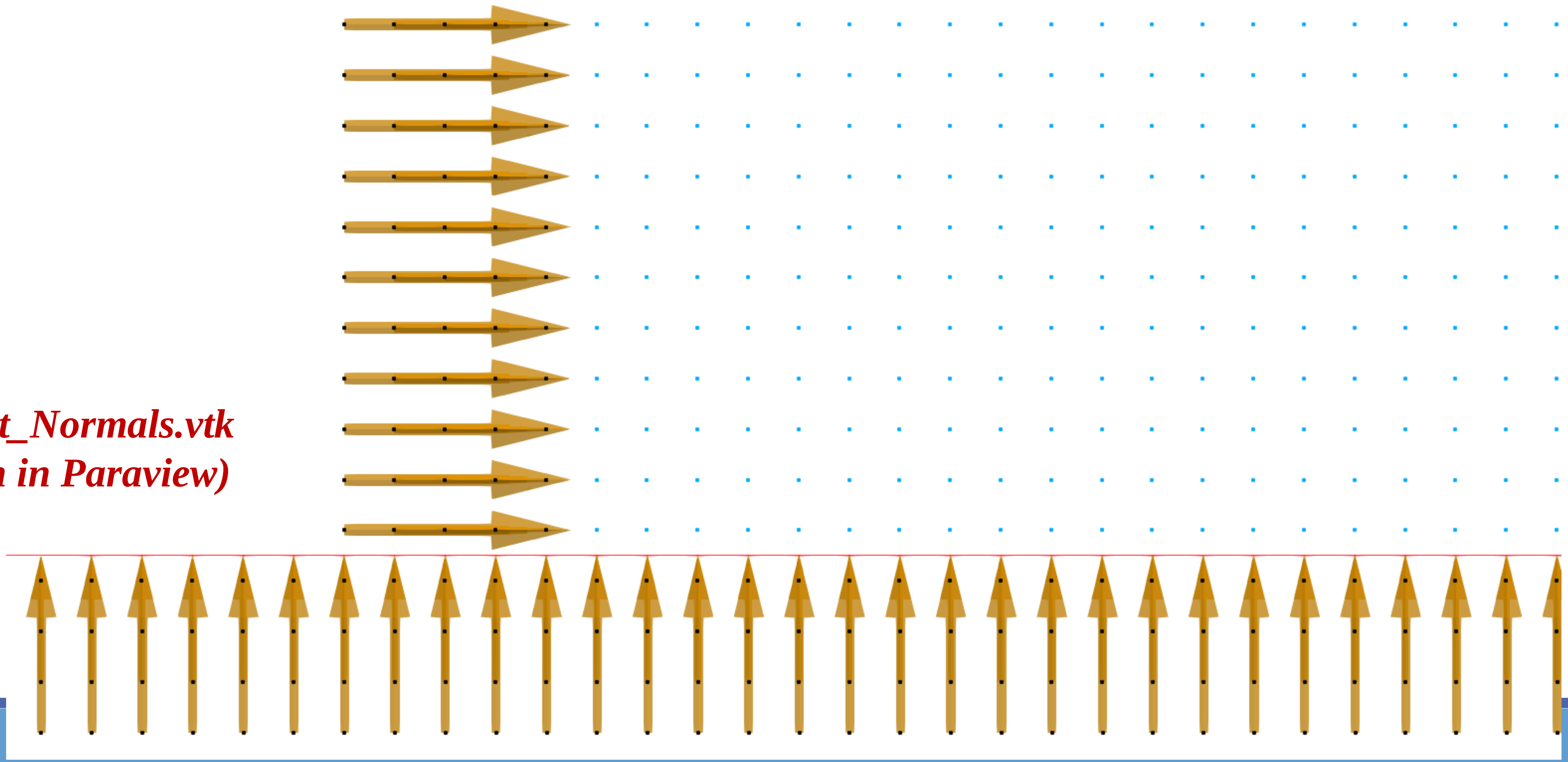
Paddle with 4 columns



Example with wave paddle

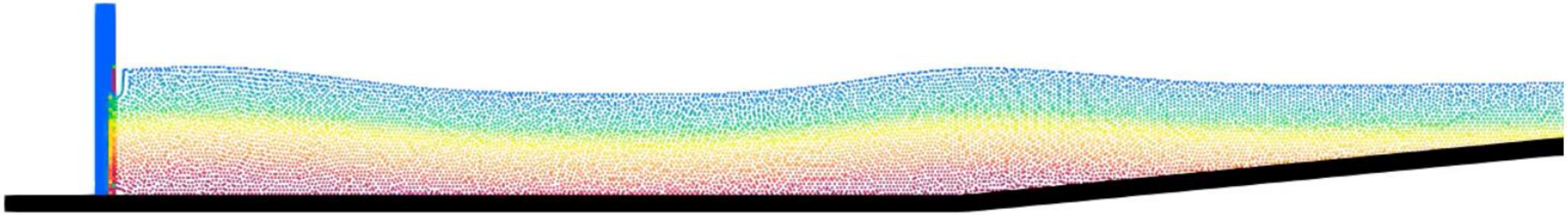
METHOD 2

CfgInit_Normals.vtk
(Glyph in Paraview)

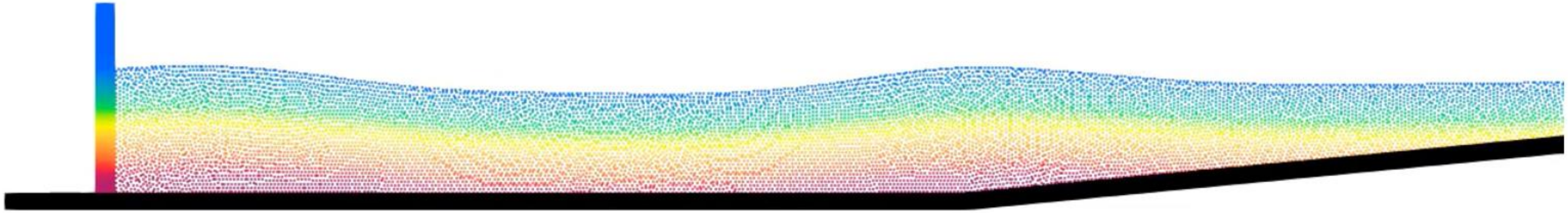


Example with wave paddle

DBC



mDBC



OUTLINE

New boundary conditions: mDBC

- DBC drawbacks
- Fluid properties from ghost nodes
- DBC vs mDBC
- Requirements (layers, boundary interface, normals)

mDBC requirements -> XML file

- New options in GenCase (*layers*, *freedrawmode*, *variables*)
- Example with tank walls (fixed)
- Example with piston wavepaddle (moving)
- Example with floating box (floating)

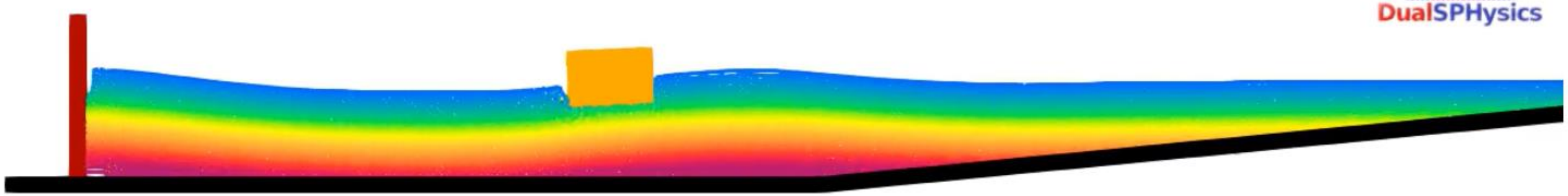
mDBC applied to external geometries

- New options in GenCase (*advanced drawfilestl*)
- Example with simple STL (Cylinder)
- Example with complex STL (Duck)

Example with floating box

DualSPHysics_v5.2_BETA\examples\mdbc\08_FloatingWaves

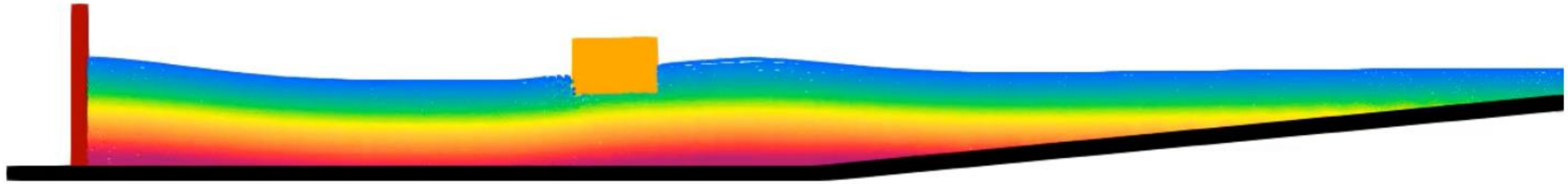
CaseFloatingWaves



Particles: 14,464
Physical time: 20 s
Runtime (RTX 3080 Ti): 177 s

DBC

Time: 3.90 s



Particles: 14,464
Physical time: 20 s
Runtime (RTX 3080 Ti): 208 s

mDBC

Example with floating box

DualSPHysics_v5.2_BETA\examples\mdbc\08_FloatingWaves

Floating box with several layers

```
<setmkbound mk="50" />
<drawbox>
    <boxfill>solid</boxfill>
    <point x="2.8" y="-1" z="0.44" />
    <size x="0.5" y="2" z="0.32" />
</drawbox>
```

Solid BOX

floating

```
<floatings>
    <floating mkbound="50" relativeweight="0.5">
    </floating>
</floatings>
```

Normal vectors

```
<normals>
    <distanceh value="2.0" />
    <geometryfile file="[CaseName]_hdp_Actual.vtk" />
</normals>
```

Boundary interface at dp/2

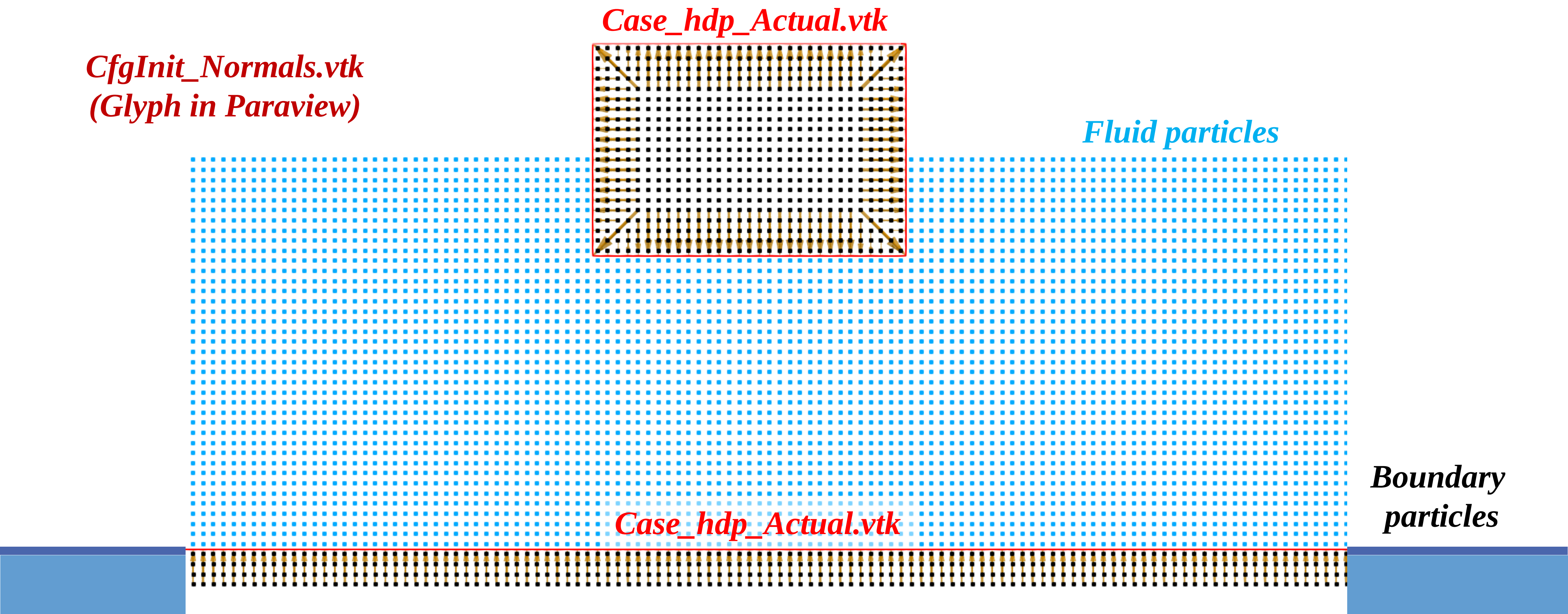
```
<list name="GeometryForNormals">
    <setactive drawpoints="0" drawshapes="1"/>
    <setshapemode>actual | bound</setshapemode>
    <setmkbound mk="0" />
    <drawextrude closed="false">
        <extrude x="0" y="2" z="0" />
        <point x="-0.5" y="-1" z="0" />
        <point x="4.5" y="-1" z="0" />
        <point x="15" y="-1" z="1" />
        <layers vdp="0.5" />
    </drawextrude>
    <setmkbound mk="50" />
    <drawbox>
        <boxfill>solid</boxfill>
        <point x="2.8" y="-1" z="0.44" />
        <size x="0.5" y="2" z="0.32" />
        <layers vdp="0.5" />
    </drawbox>
    <shapeout file="hdp" />
    <resetdraw />
</list>
```

Boundary interface of the BOX at 0.5·dp

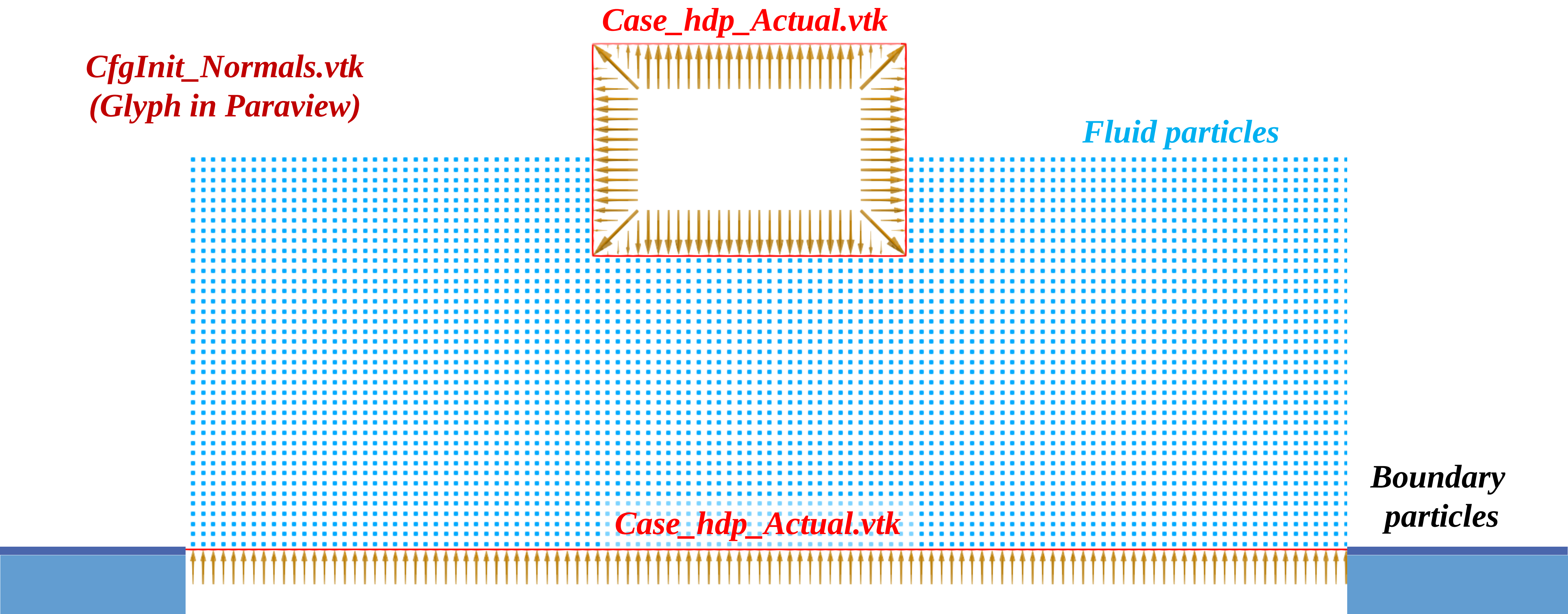
Case_hdp_Actual.vtk **includes tank and BOX**

THIS IS NOT SUPPORTED IN v5.0, ONLY IN v5.2 BETA!!!

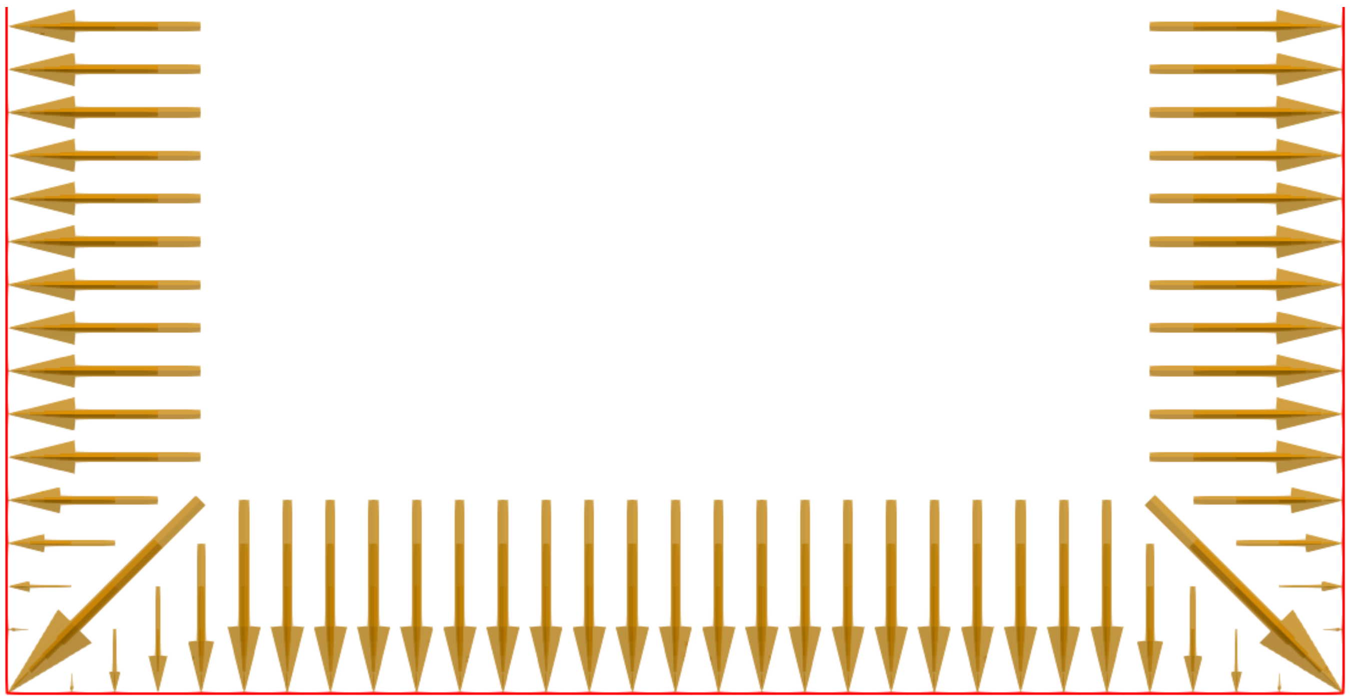
Example with floating box



Example with floating box



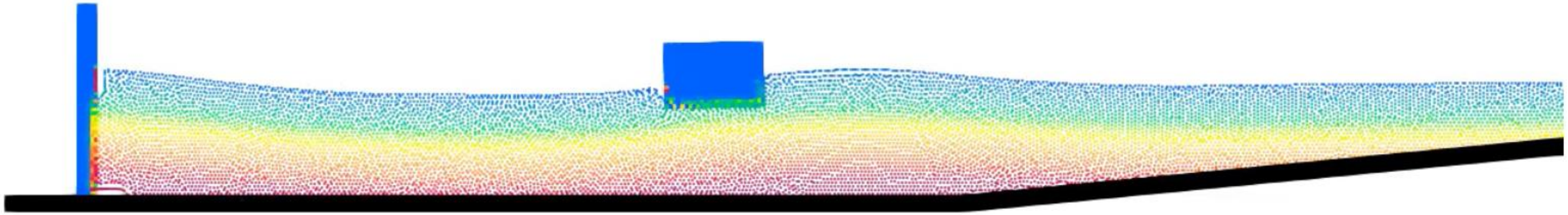
Example with floating box



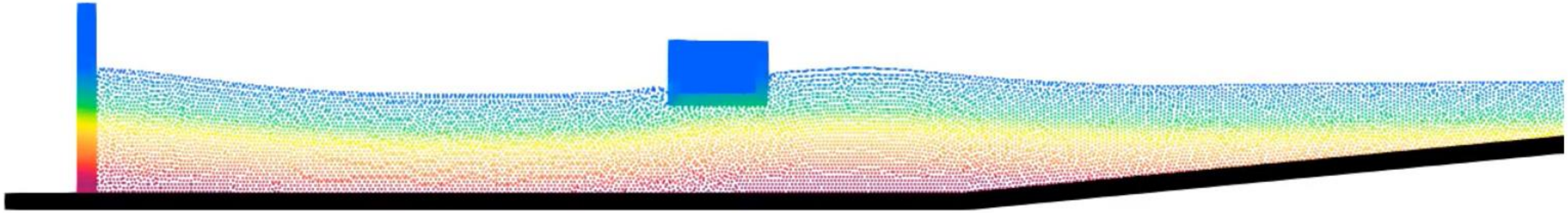
DualSPHysics_v5.0 online does not include this option!!!
BUT NOW YOU HAVE ACCESS TO v5.2 BETA (ONLY YOU)

Example with floating box

DBC

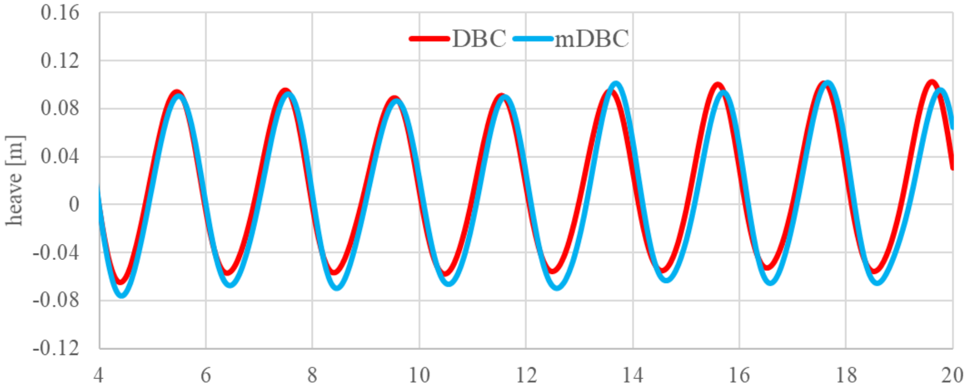


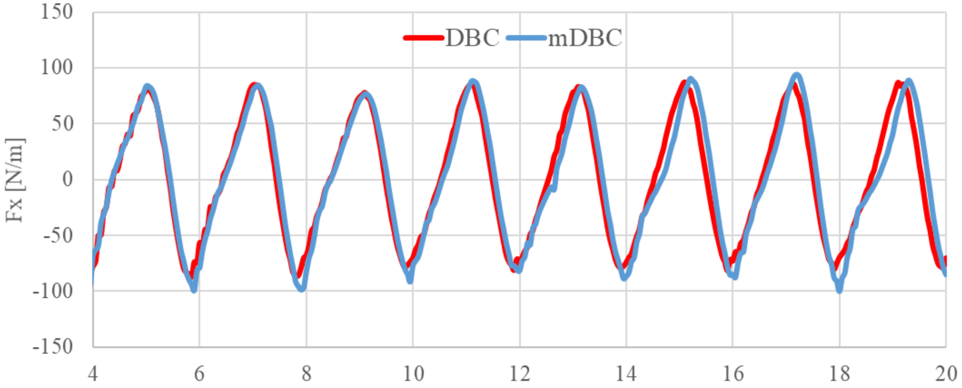
mDBC

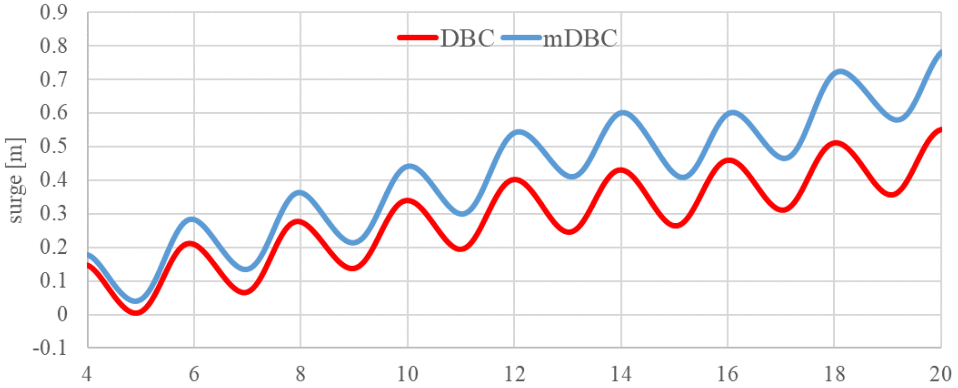


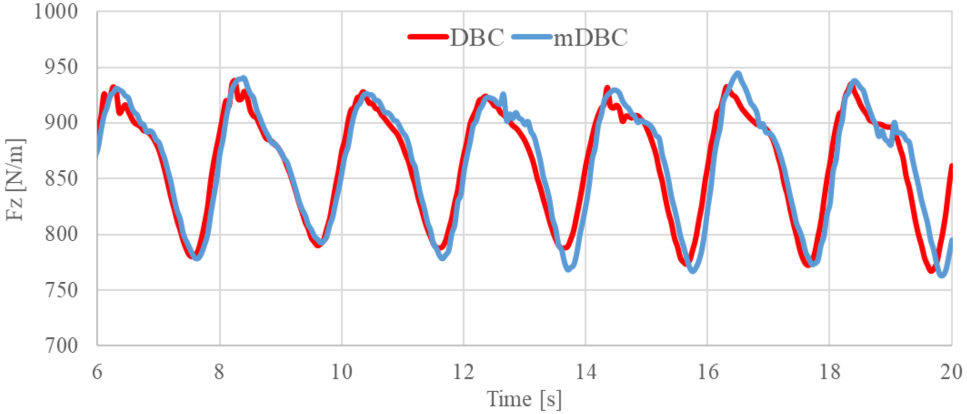
Example with floating box

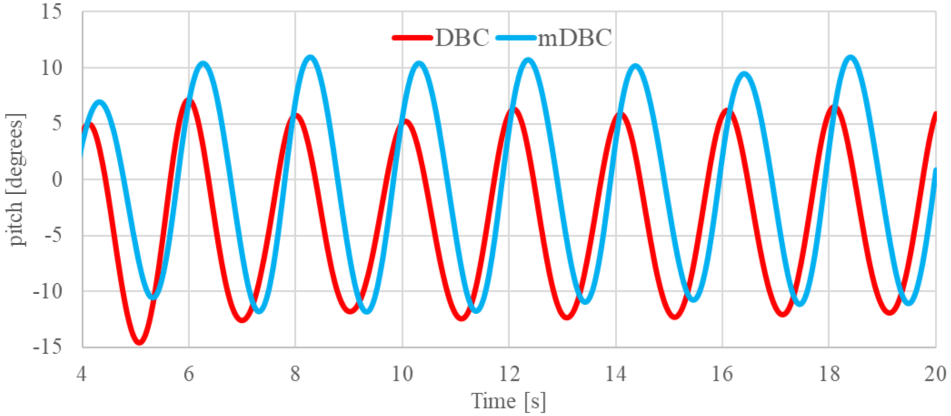
Force signal is less noisy using **mDBC**











OUTLINE

New boundary conditions: mDBC

DBC drawbacks

Fluid properties from ghost nodes

DBC vs mDBC

Requirements (layers, boundary interface, normals)

mDBC requirements -> XML file

New options in GenCase (*layers*, *freedrawmode*, *variables*)

Example with tank walls (fixed)

Example with piston wavepaddle (moving)

Example with floating box (floating)

mDBC applied to external geometries

New options in GenCase (*advanced drawfilestl*)

Example with simple STL (Cylinder)

Example with complex STL (Duck)

New options in GenCase

Free drawing mode

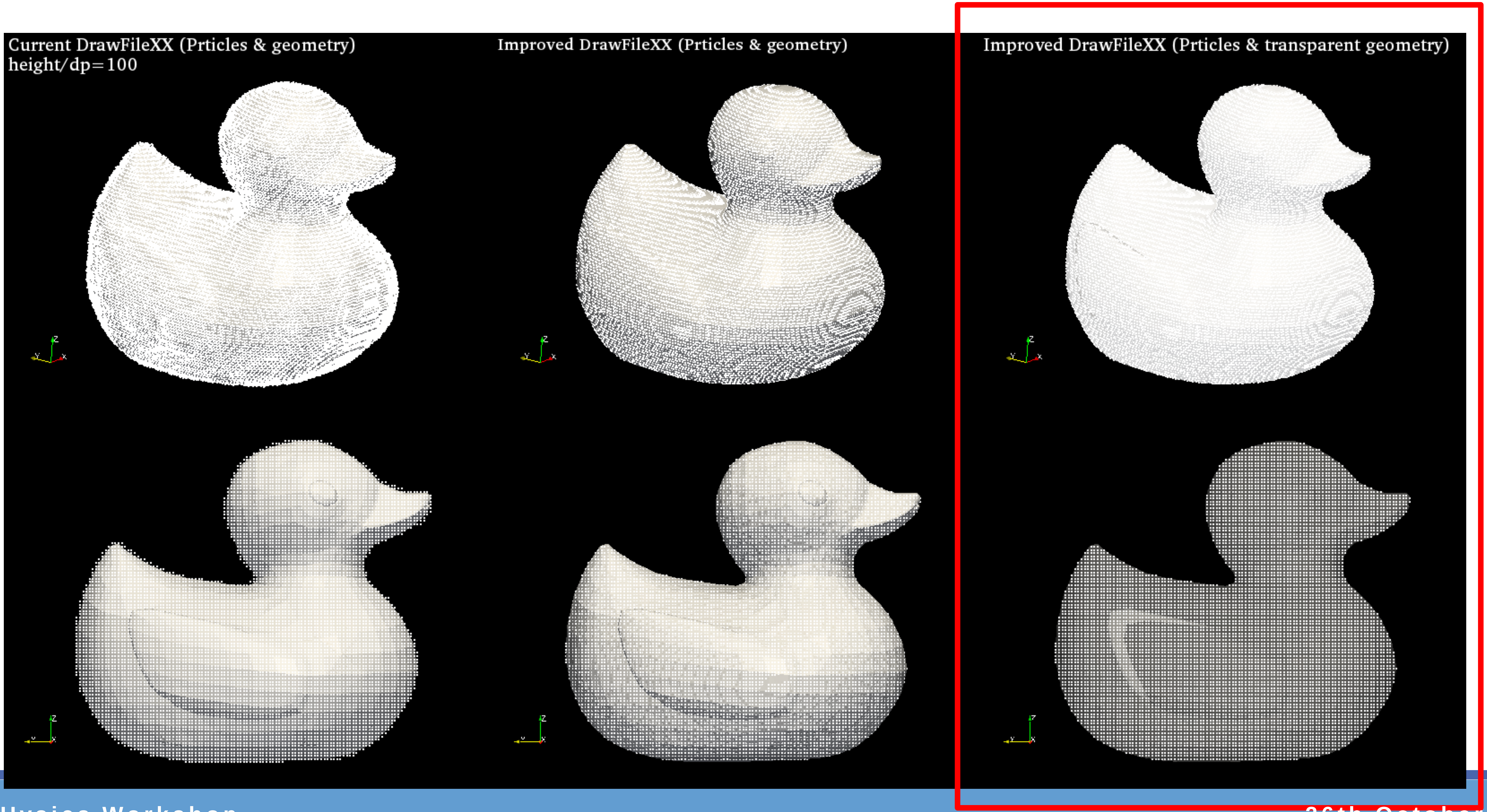
Several layers

Numerical variables

Improved DrawFileXXX

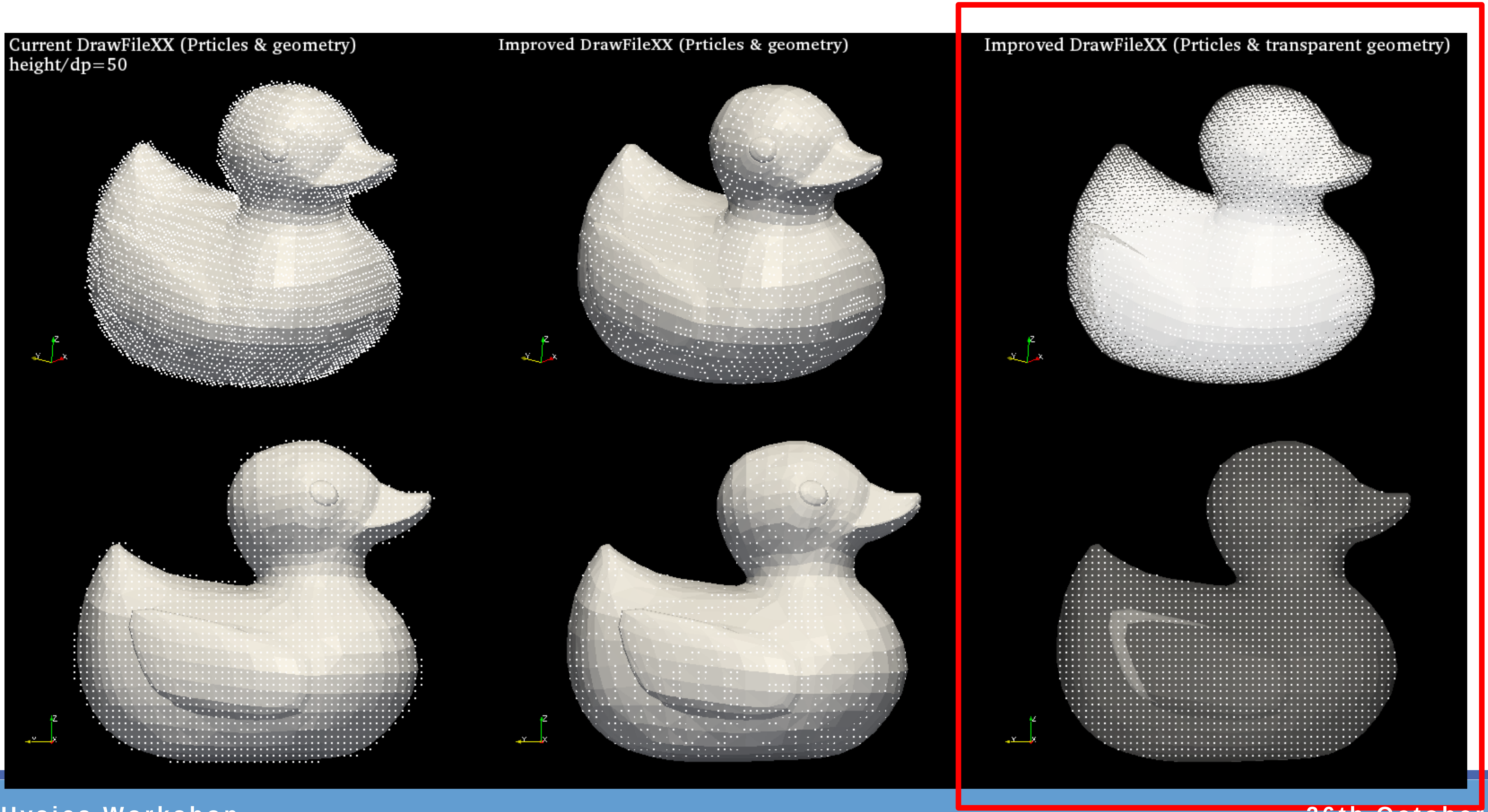
New options in GenCase

New advanced DrawFileSTL (DrawFilePLY, DrawFileVTK)



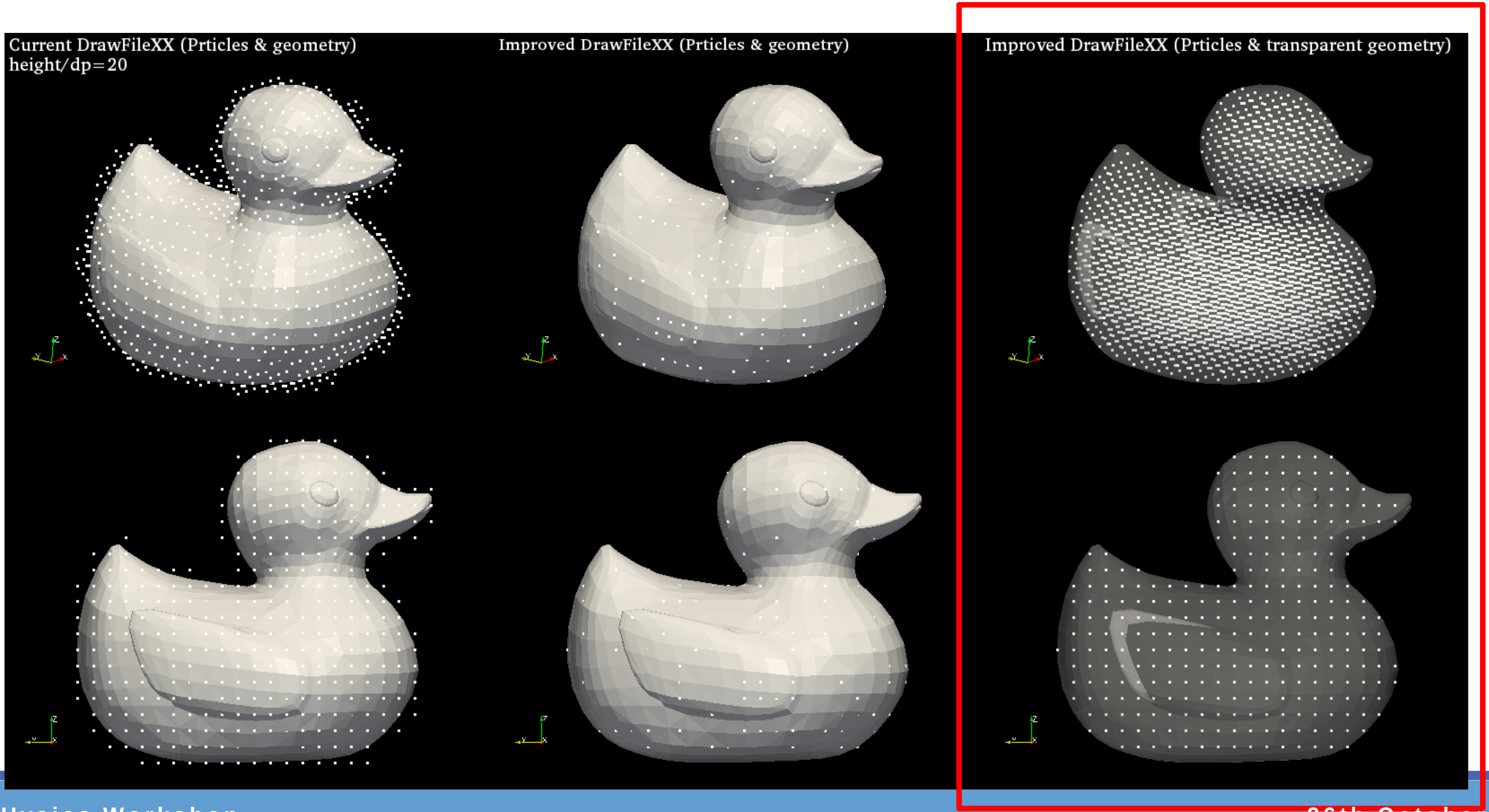
New options in GenCase

New advanced DrawFileSTL (DrawFilePLY, DrawFileVTK)



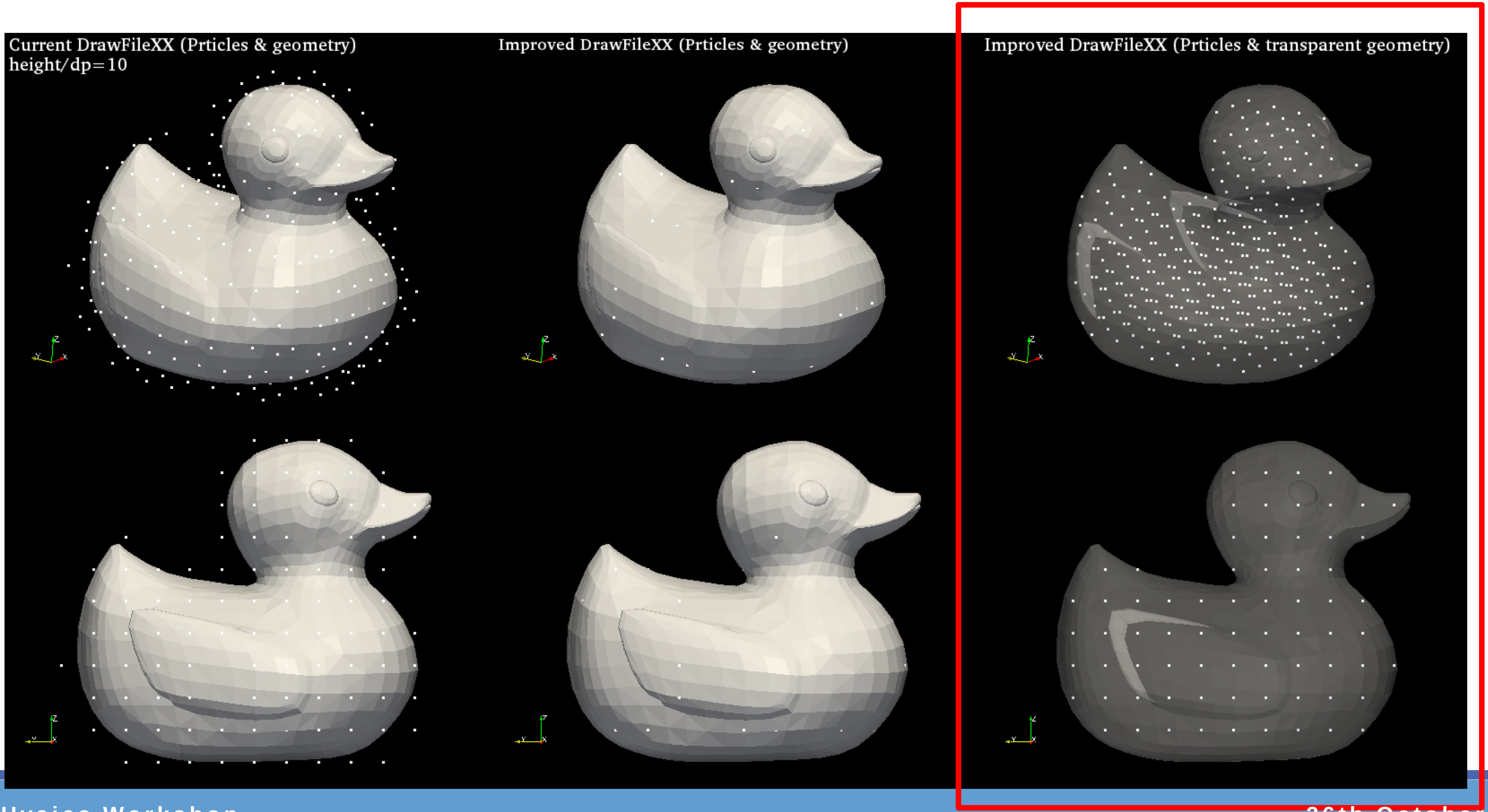
New options in GenCase

New advanced DrawFileSTL (DrawFilePLY, DrawFileVTK)



New options in GenCase

New advanced DrawFileSTL (DrawFilePLY, DrawFileVTK)



OUTLINE

New boundary conditions: mDBC

DBC drawbacks

Fluid properties from ghost nodes

DBC vs mDBC

Requirements (layers, boundary interface, normals)

mDBC requirements -> XML file

New options in GenCase (*layers*, *freedrawmode*, *variables*)

Example with tank walls (fixed)

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Example with floating box (floating)

mDBC applied to external geometries

New options in GenCase (*advanced drawfilestl*)

Example with simple STL (Cylinder)

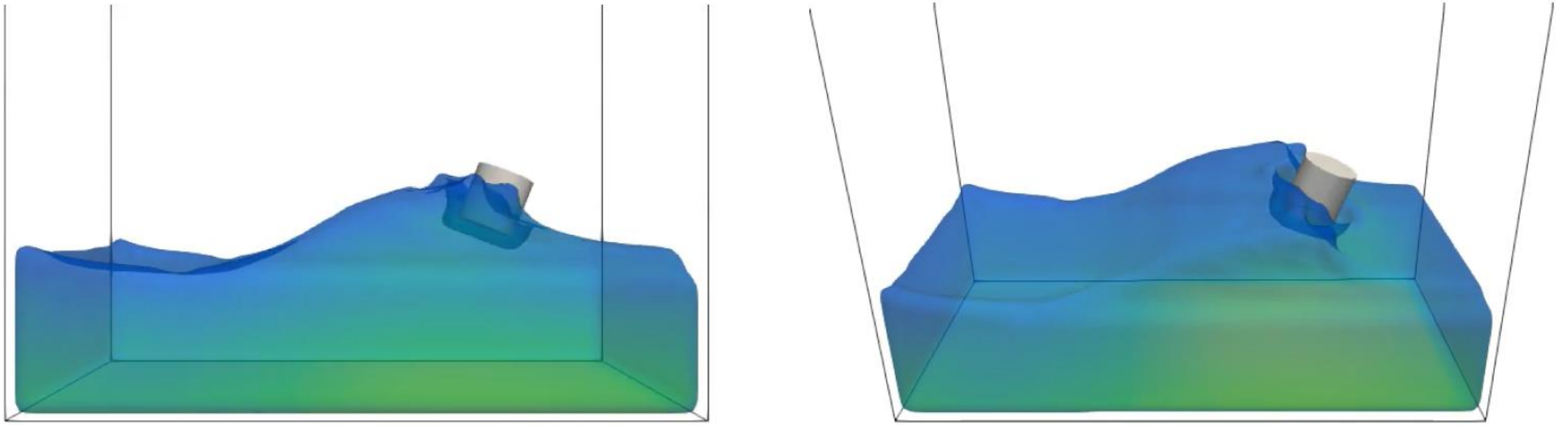
Example with complex STL (Duck)

Example with simple STL

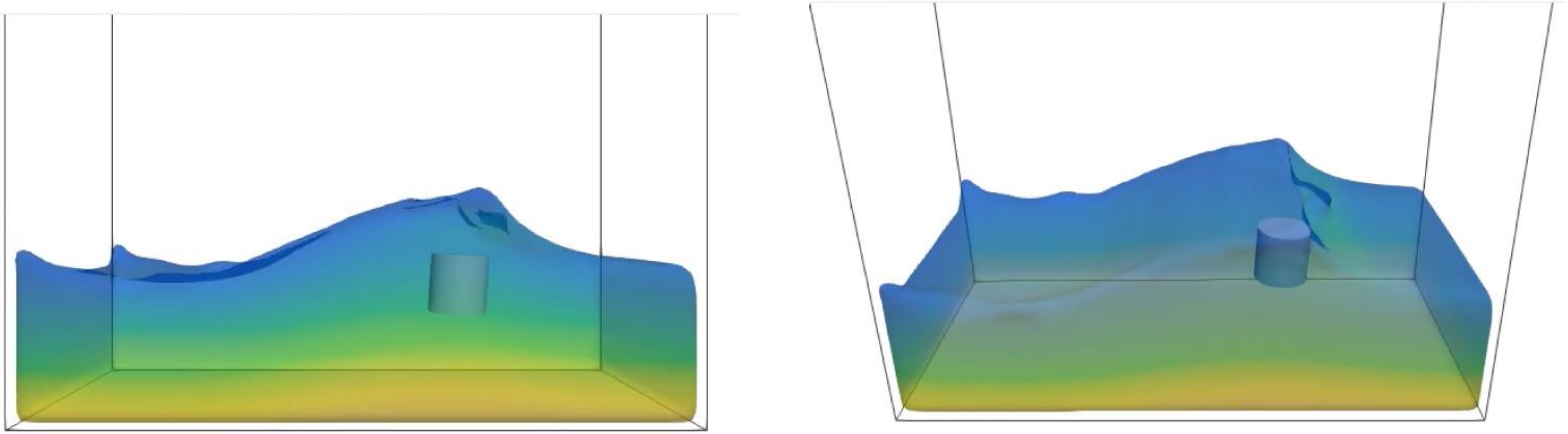
dp=0.01m; nfloat=621
massbody=0.5 kg
volume=0.000621 m^3

DBC

GAP !!!



mDBC



Example with simple STL

Floating STL filled with several layers

```
<drawfilestl file="cylinder.stl" autofill="true" advanced="true">
    <drawmove x="0.6" y="0.25" z="0.3" />
    <drawrotate angx="0" angy="0" angz="270" />
    <drawscale x="0.0025" y="0.0025" z="0.0025" />
    <depth depthmin="#0.001*Dp" />
</drawfilestl>
<shapeout file="" reset="true" />
```

filled

depthmin=0.001·dp

To avoid the creation of particles at the faces

```
<floatings>
    <floating mkbound="50">
        <massbody value="0.5" />
    </floating>
</floatings>
```

floating

Normal vectors

```
<normals>
    <distanceh value="3.0" />
    <geometryfile file="[CaseName]_hdp_Actual.vtk" />
    <svshapes value="1" />
    <svnormaldata value="0" />
</normals>
```

Boundary interface at dp/2??

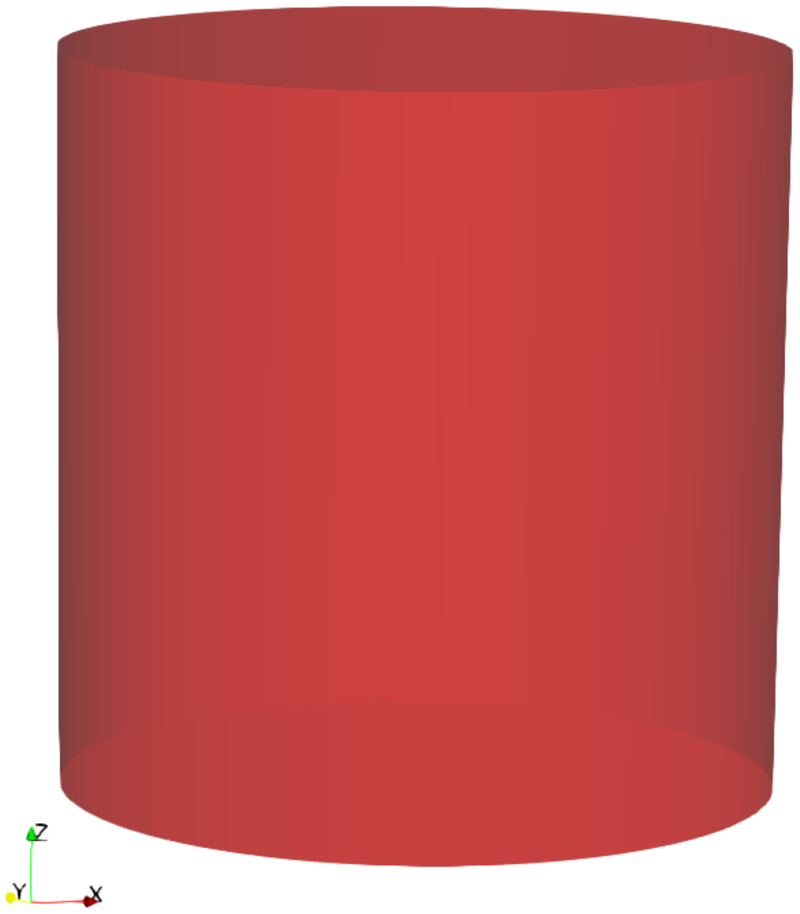
```
<list name="GeometryForNormals">
    <setactive drawpoints="0" drawshapes="1" />
    <setshapemode>actual | bound</setshapemode>
    <!-- Tank -->
    <setnormalinvert invert="true" />
    <setmkbound mk="0" />
    <drawbox>
        <boxfill>bottom | left | right | front | back</boxfill>
        <point x="0" y="0" z="0" />
        <size x="1" y="0.5" z="0.5" />
        <layers vdp="-0.5" />
    </drawbox>
    <setnormalinvert invert="false" />
    <!-- stl -->
    <setmkbound mk="10" />
    <drawfilestl file="cylinder.stl">
        <drawmove x="0.6" y="0.25" z="0.3" />
        <drawrotate angx="0" angy="0" angz="270" />
        <drawscale x="0.0025" y="0.0025" z="0.0025" />
    </drawfilestl>
    <shapeout file="hdp" />
    <resetdraw />
</list>
```

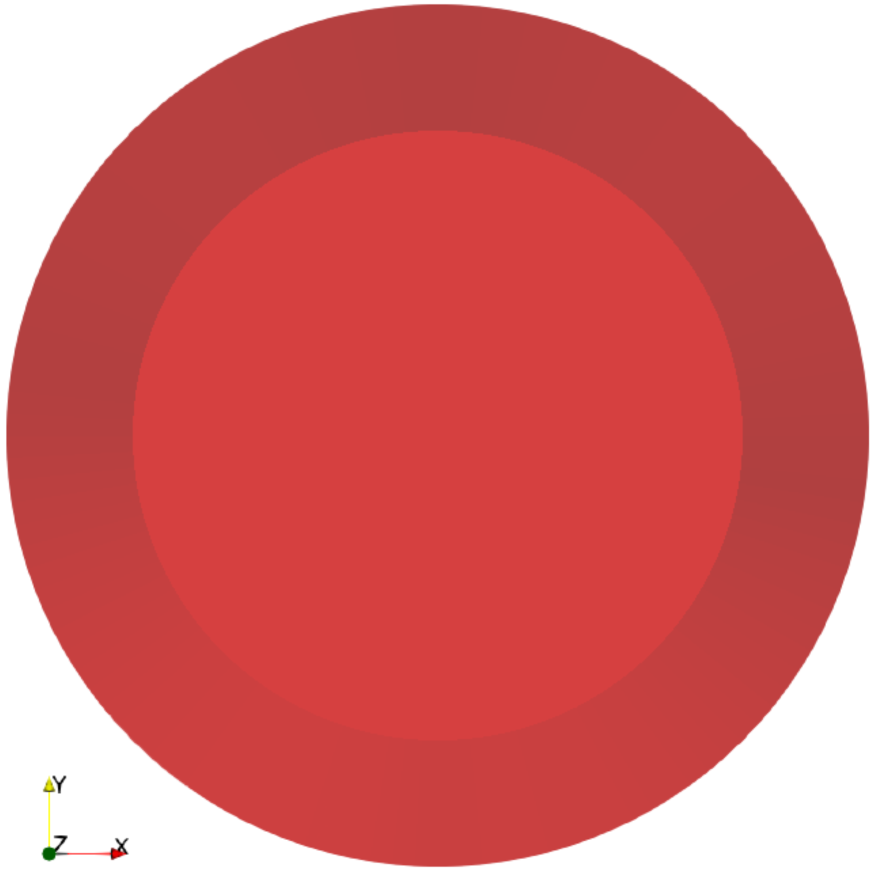
Boundary interface = STL

Case_hdp_Actual.vtk
includes tank and STL

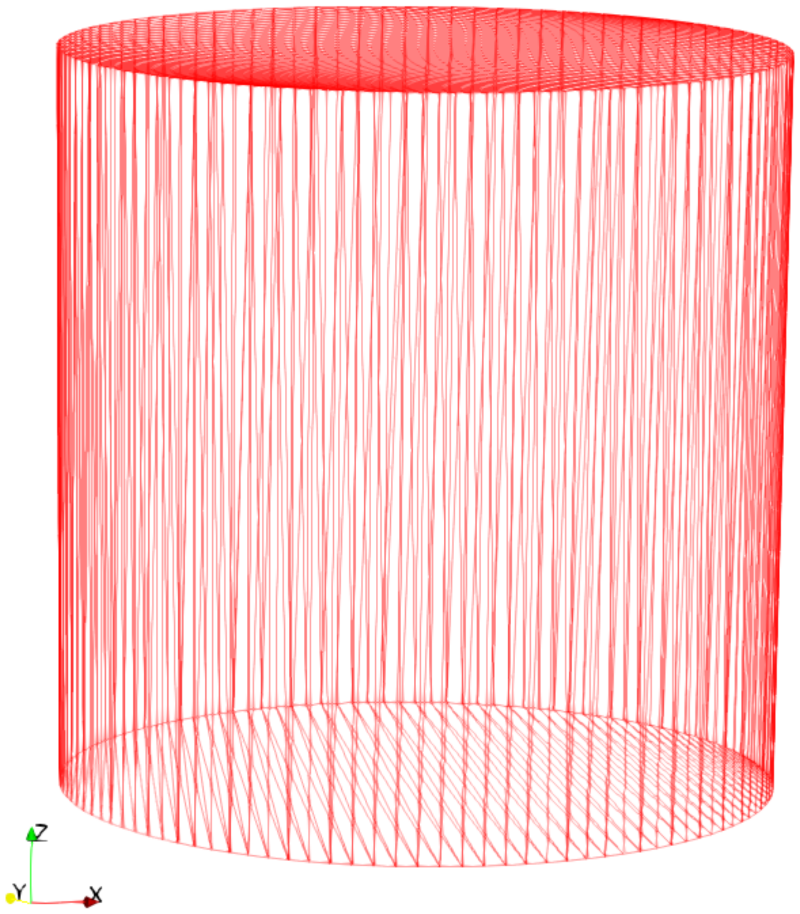
THIS IS NOT SUPPORTED IN v5.0, ONLY IN v5.2 BETA!!!

Example with simple STL





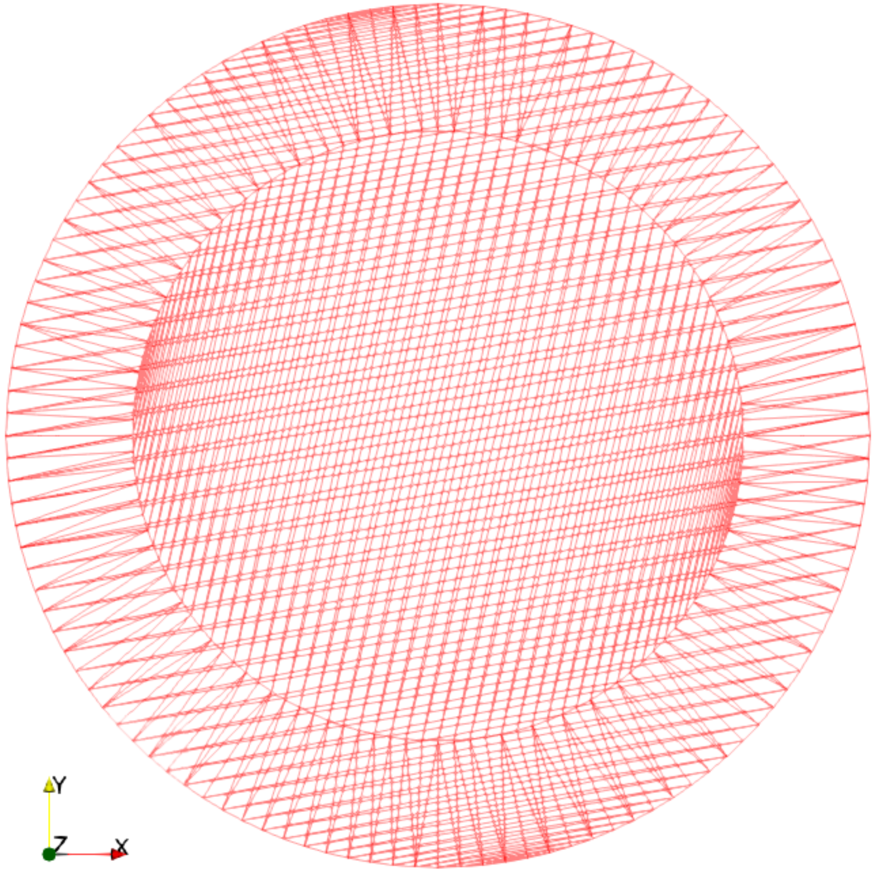
Example with simple STL



Boundary interface = STL

↓

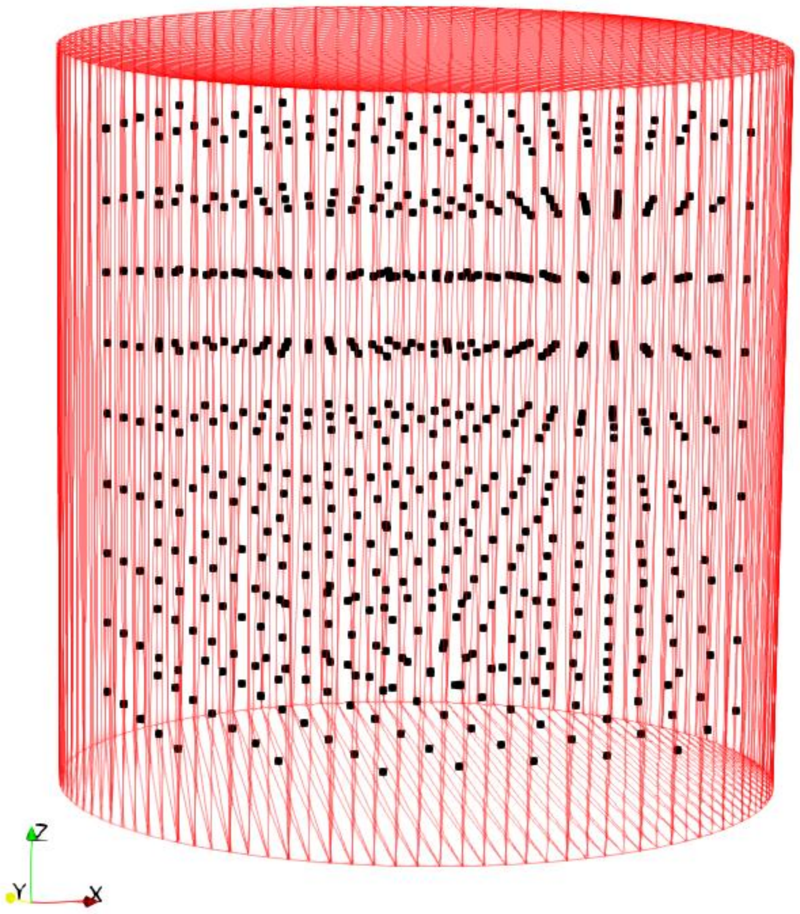
Case_hdp_Actual.vtk

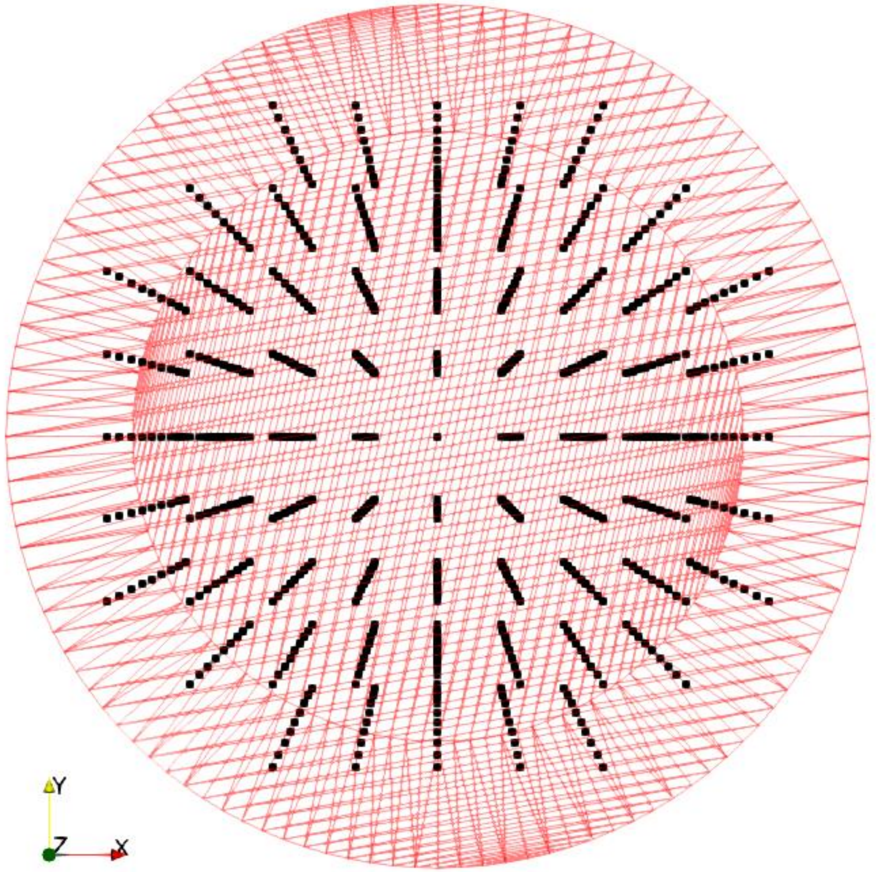


Example with simple STL

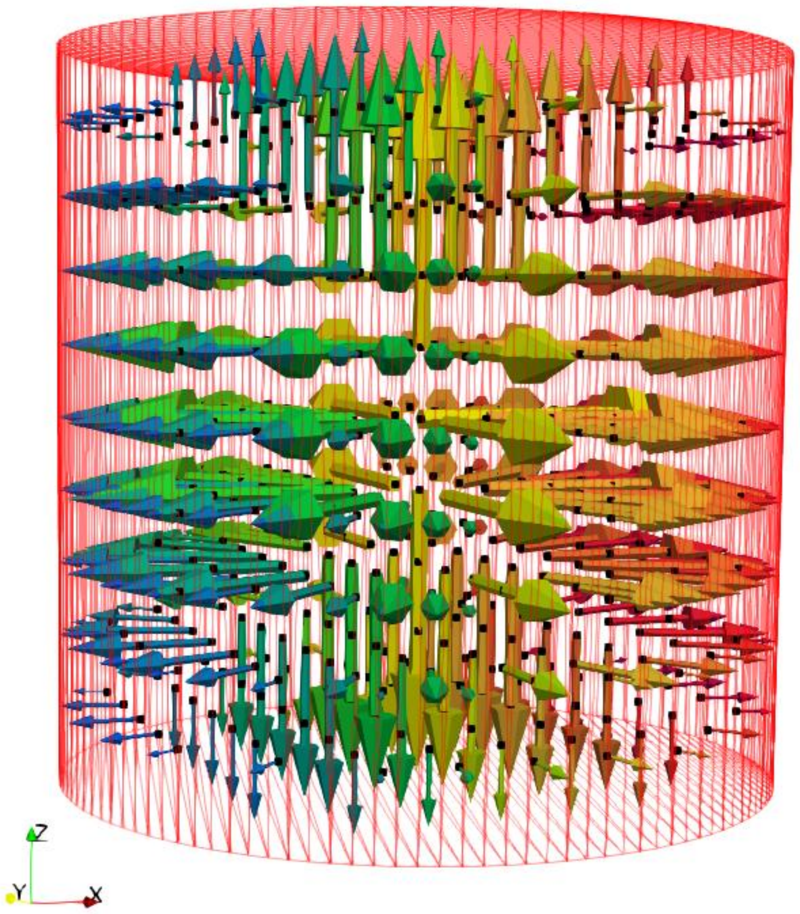
```
<drawfilestl file="cylinder.stl" autofill="true" advanced="true">
    <drawmove x="0.6" y="0.25" z="0.3" />
    <drawrotate angx="0" angy="0" angz="270" />
    <drawscale x="0.0025" y="0.0025" z="0.0025" />
    <depth depthmin="#0.001*Dp" />
</drawfilestl>
<shapeout file="" reset="true" />
```

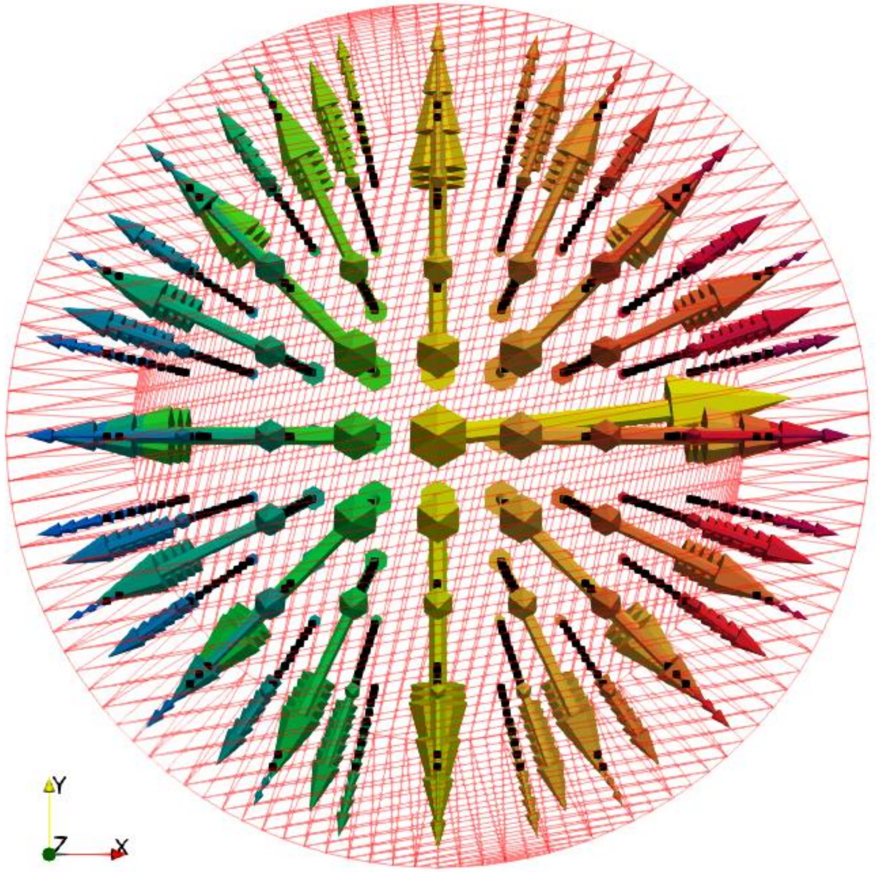
depthmin=0.001·dp





Example with simple STL

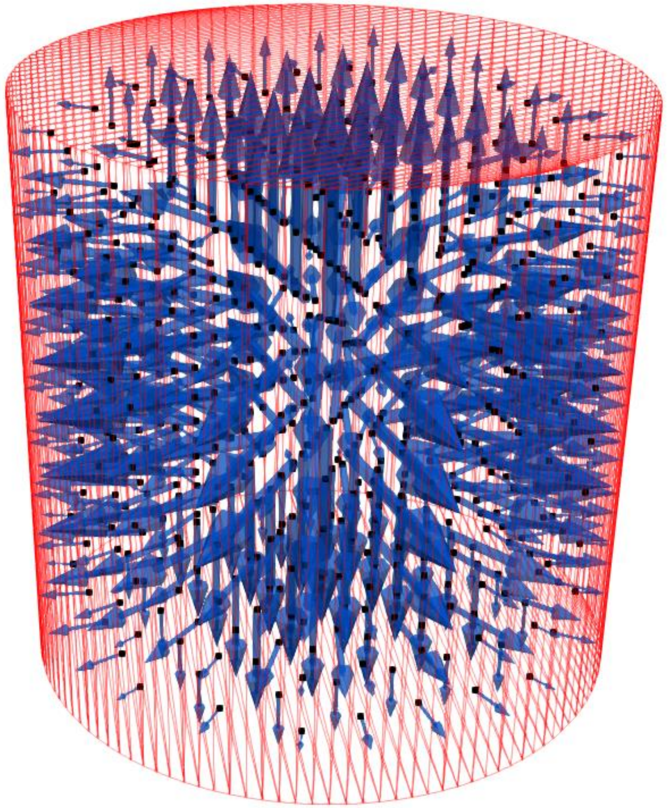




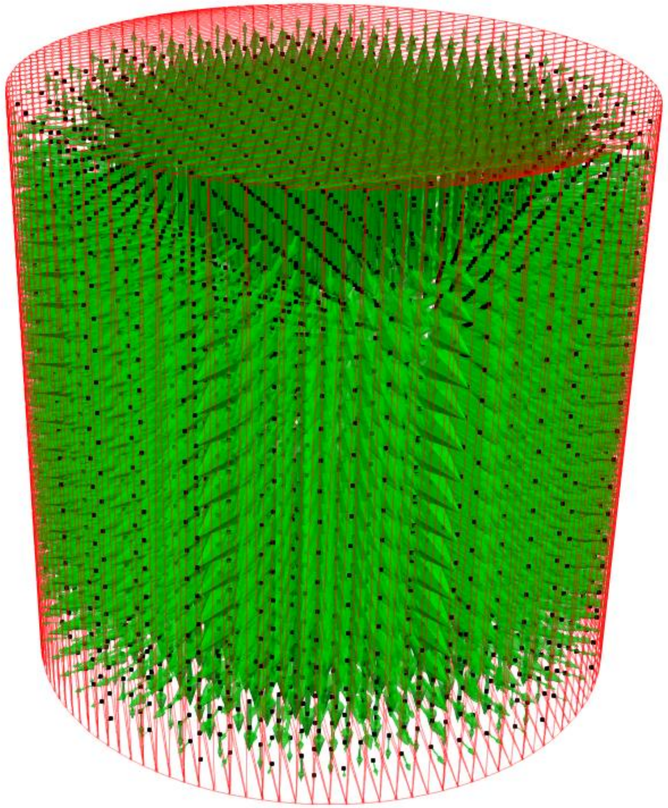
Example with simple STL

Volume of STL=0.000785 m^3

dp=0.01m
nfloat=621
massbody=0.5 kg
volume=0.000621 m^3



dp=0.005m
nfloat=5795
massbody=0.5 kg
volume=0.000724 m^3



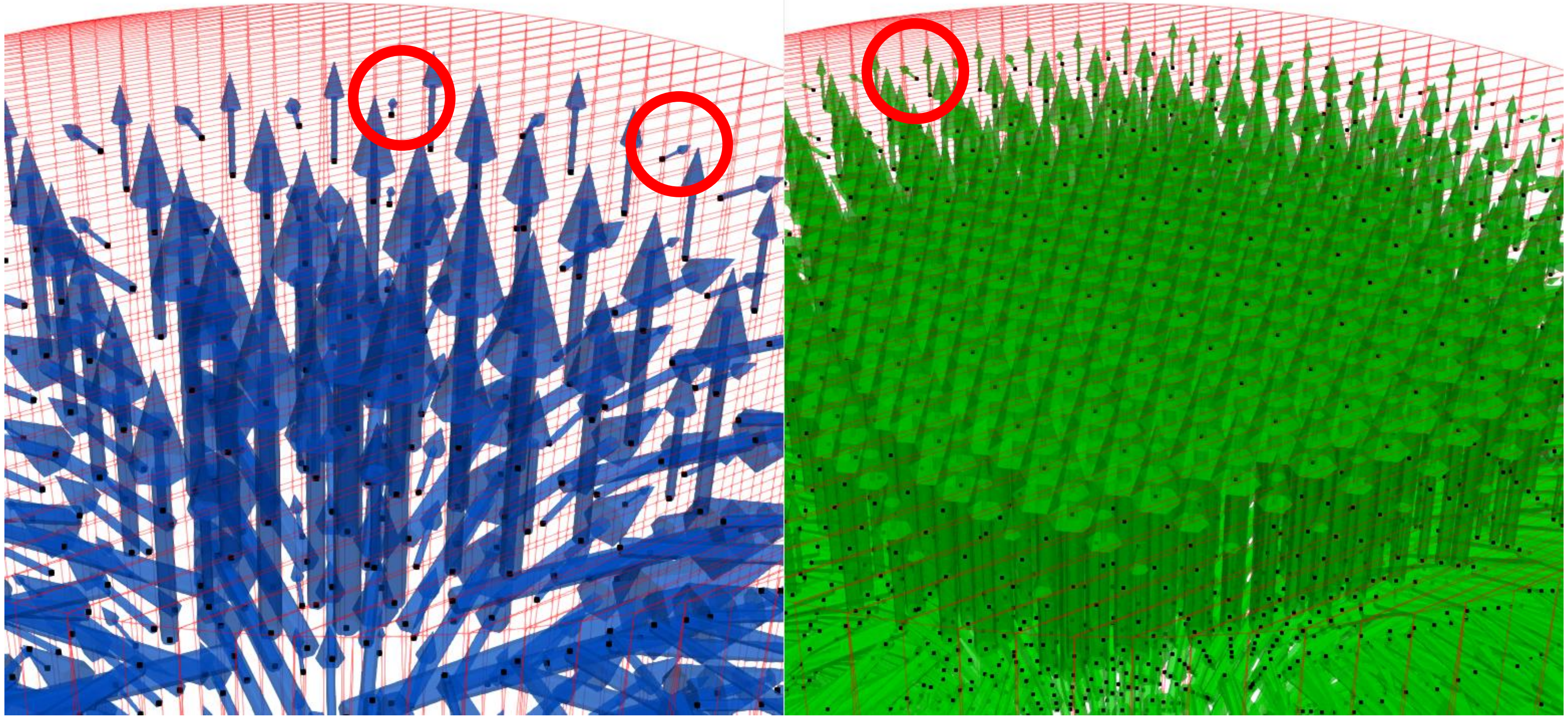
Volume occupied by the particles is important for the bouyant force (force exerted by the fluid)

Example with simple STL

Volume of STL=0.000785 m^3

dp=0.01m
nfloat=621
massbody=0.5 kg
volume=0.000621 m^3

dp=0.005m
nfloat=5795
massbody=0.5 kg
volume=0.000724 m^3



Volume occupied by the particles is important for the bouyant force (force exerted by the fluid)

Example with simple STL

Volume of STL=0.000785 m^3

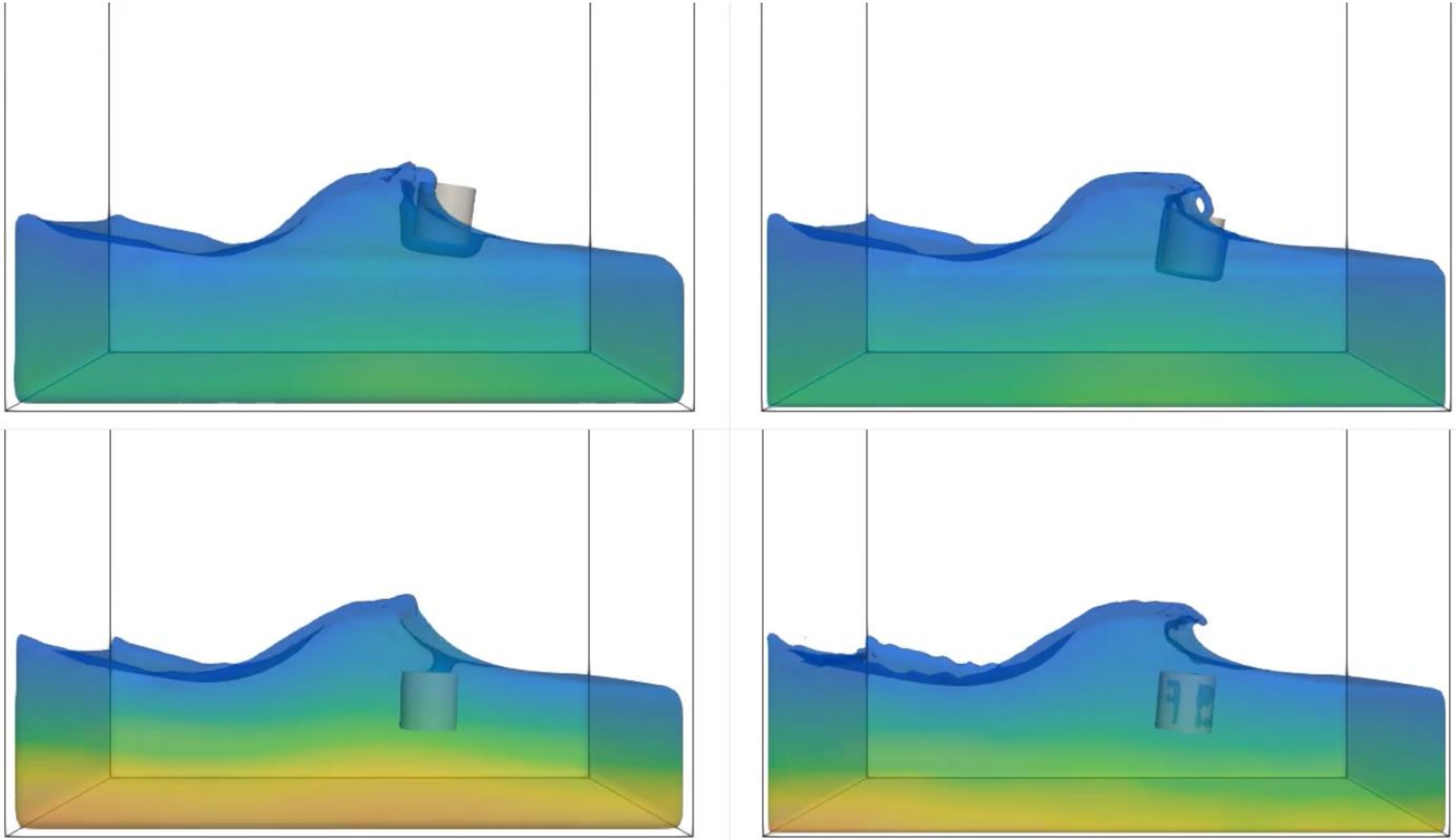
dp=0.01m
volume=0.000621 m^3

dp=0.005m
volume=0.000724 m^3

DBC

GAP !!!

mDBC



OUTLINE

New boundary conditions: mDBC

DBC drawbacks

Fluid properties from ghost nodes

DBC vs mDBC

Requirements (layers, boundary interface, normals)

mDBC requirements -> XML file

New options in GenCase (*layers*, *freedrawmode*, *variables*)

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Example with piston wavepaddle (moving)

Example with floating box (floating)

mDBC applied to external geometries

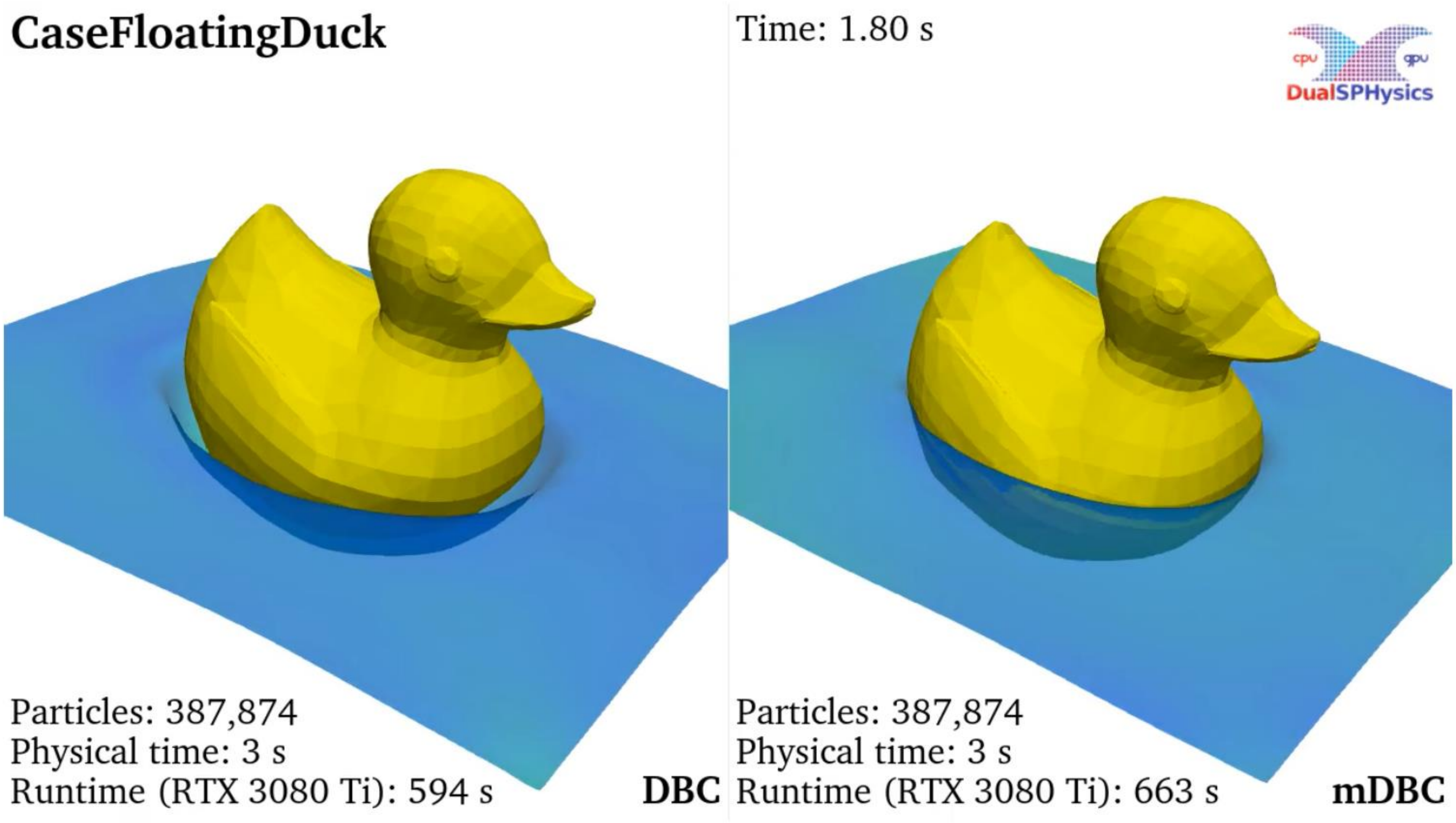
New options in GenCase (*advanced drawfilestl*)

Example with simple STL (Cylinder)

Example with complex STL (Duck)

Example with complex STL

DualSPHysics_v5.2_BETA\examples\mdbc\09_FloatingDuck



Example with complex STL

DualSPHysics_v5.2_BETA\examples\mdbc\09_FloatingDuck

Floating STL filled with several layers

Filled

```
<setmkbound mk="10" />
<drawfilestl file="Duck.stl" autofill="true" advanced="true">
    <drawmove x="#stank/2" y="#stank/2" z="#zpos" />
    <drawscale x="0.2" y="0.2" z="0.2" />
    <drawrotate angx="#xang" angy="0" angz="0" />
    <depth depthmin="#Dp*0.1" />
</drawfilestl>
```

depthmin=0.1·dp

To avoid the creation of particles at the faces

```
<floatings>
    <floating mkbound="10" relativeweight="0.5">
        <translationDOF x="0" y="0" z="1" />
    </floating>
</floatings>
```

floating

Normal vectors

```
<normals>
    <distanceh value="2.0" />
    <geometryfile file="[CaseName]_hdp_Actual.vtk" />
</normals>
```

Boundary interface at dp/2??

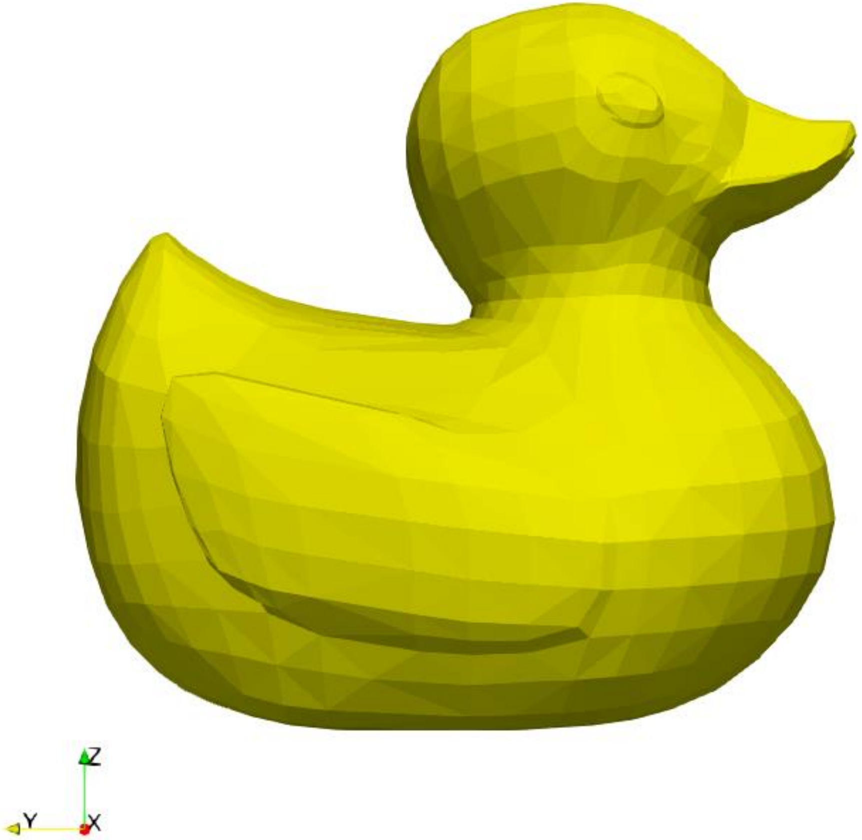
```
<list name="GeometryForNormals">
    <setactive drawpoints="0" drawshapes="1" />
    <setshapemode>actual | bound</setshapemode>
    <setmkbound mk="10" />
    <drawfilestl file="Duck.stl" >
        <drawmove x="#stank/2" y="#stank/2" z="#zpos" />
        <drawscale x="0.2" y="0.2" z="0.2" />
        <drawrotate angx="#xang" angy="0" angz="0" />
    </drawfilestl>
    <shapeout file="hdp" />
    <resetdraw />
</list>
```

Boundary interface = STL

Case_hdp_Actual.vtk **includes STL**

THIS IS NOT SUPPORTED IN v5.0, ONLY IN v5.2 BETA!!!

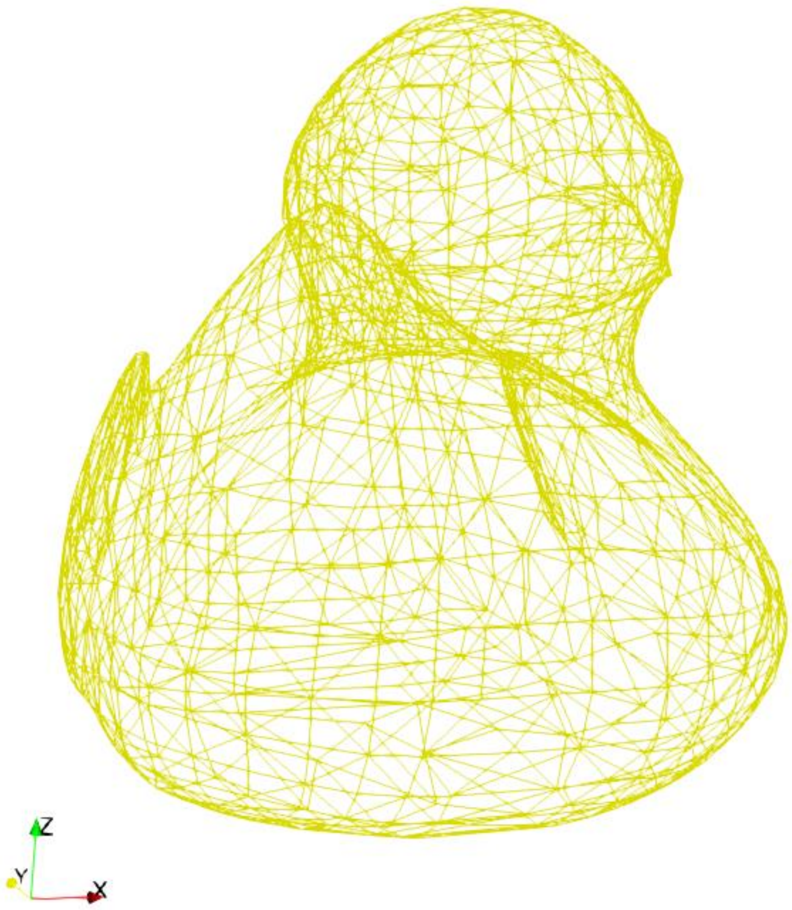
Example with complex STL

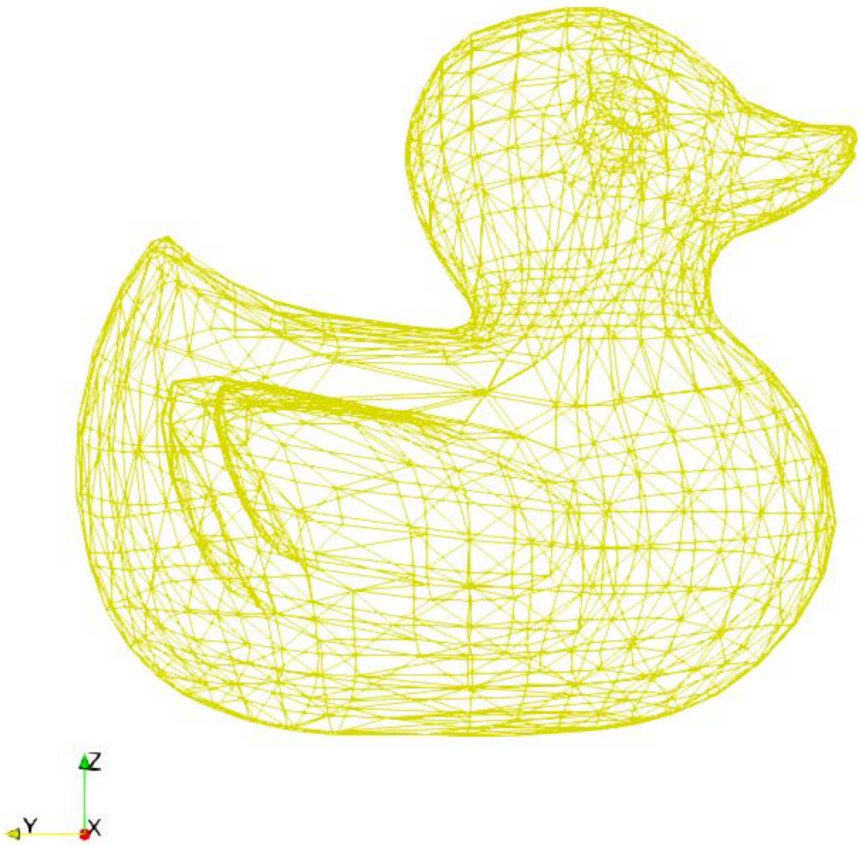


Example with complex STL

Boundary interface = STL

Case_hdp_Actual.vtk

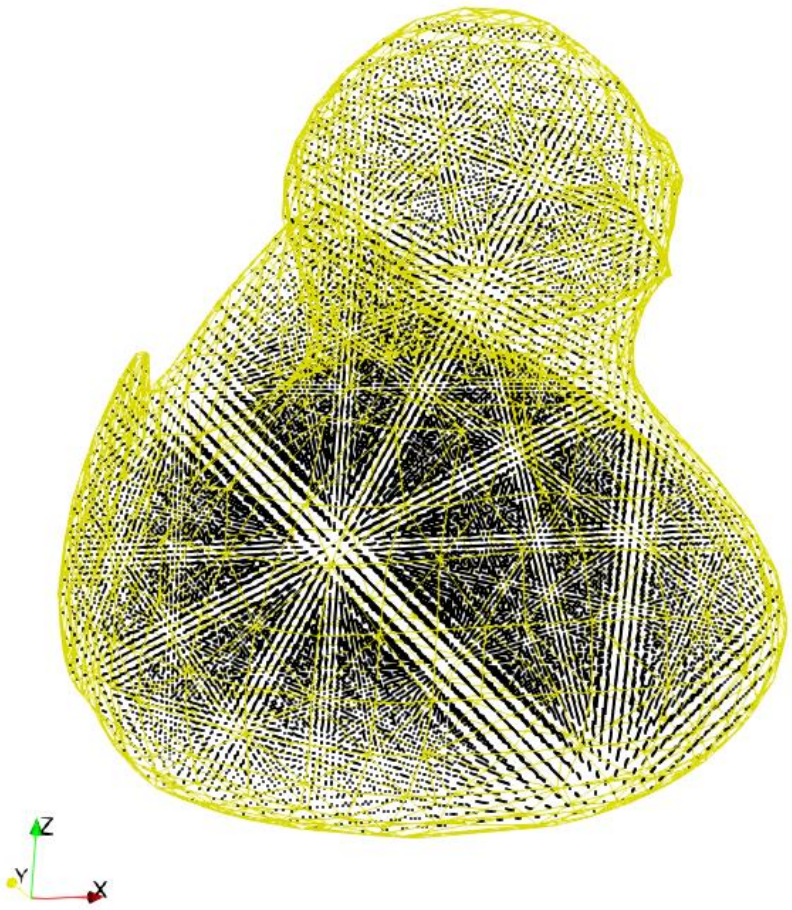


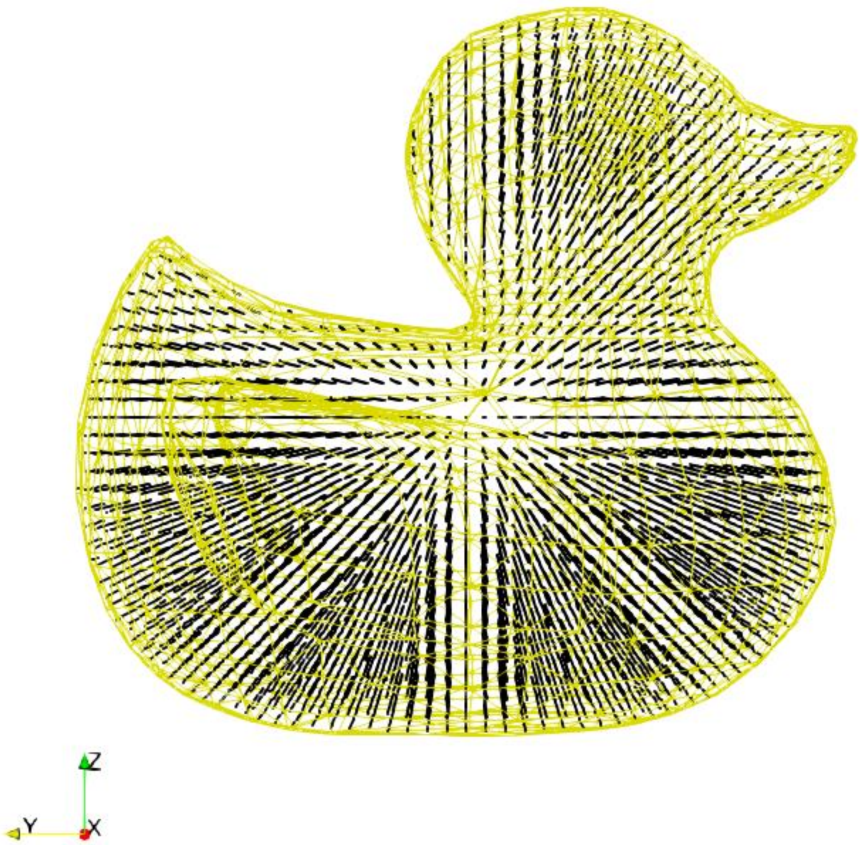


Example with complex STL

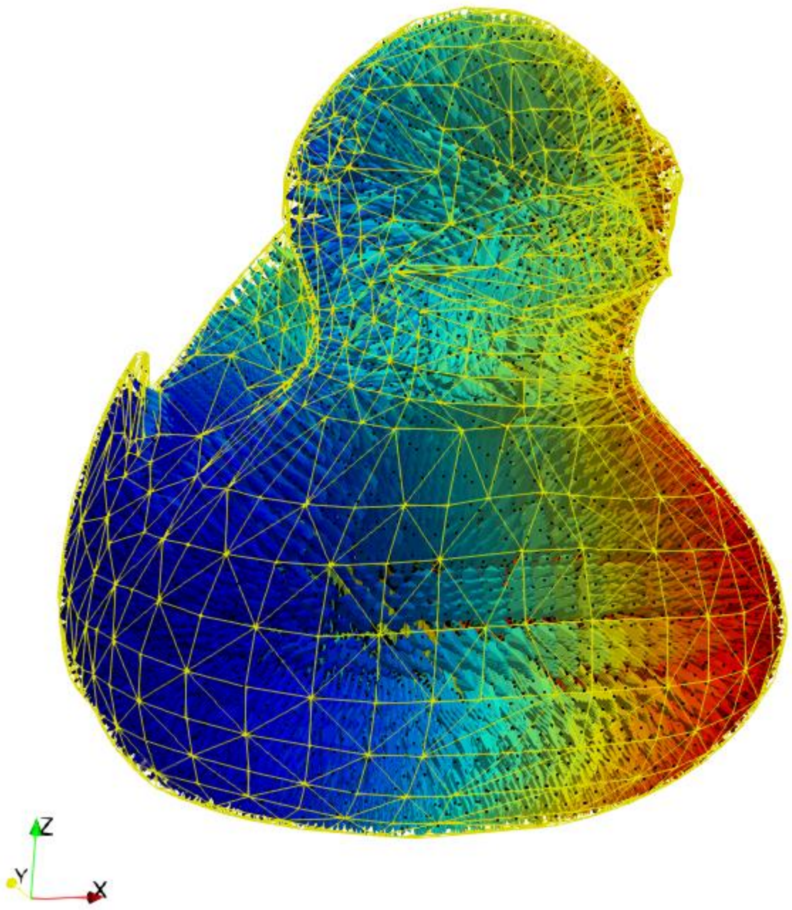
```
<setmkbound mk="10" />
<drawfilestl file="Duck.stl" autofill="true" advanced="true">
    <drawmove x="#stank/2" y="#stank/2" z="#zpos" />
    <drawscale x="0.2" y="0.2" z="0.2" />
    <drawrotate angx="#xang" angy="0" angz="0" />
    <depth depthmin="#Dp*0.1" />
</drawfilestl>
```

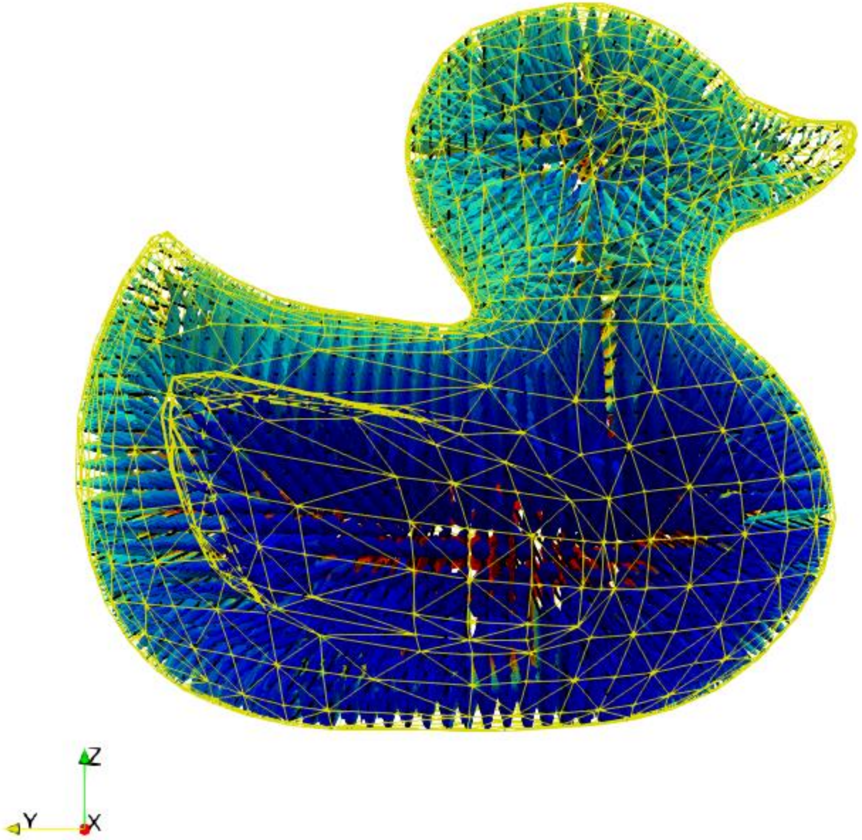
depthmin=0.1·dp



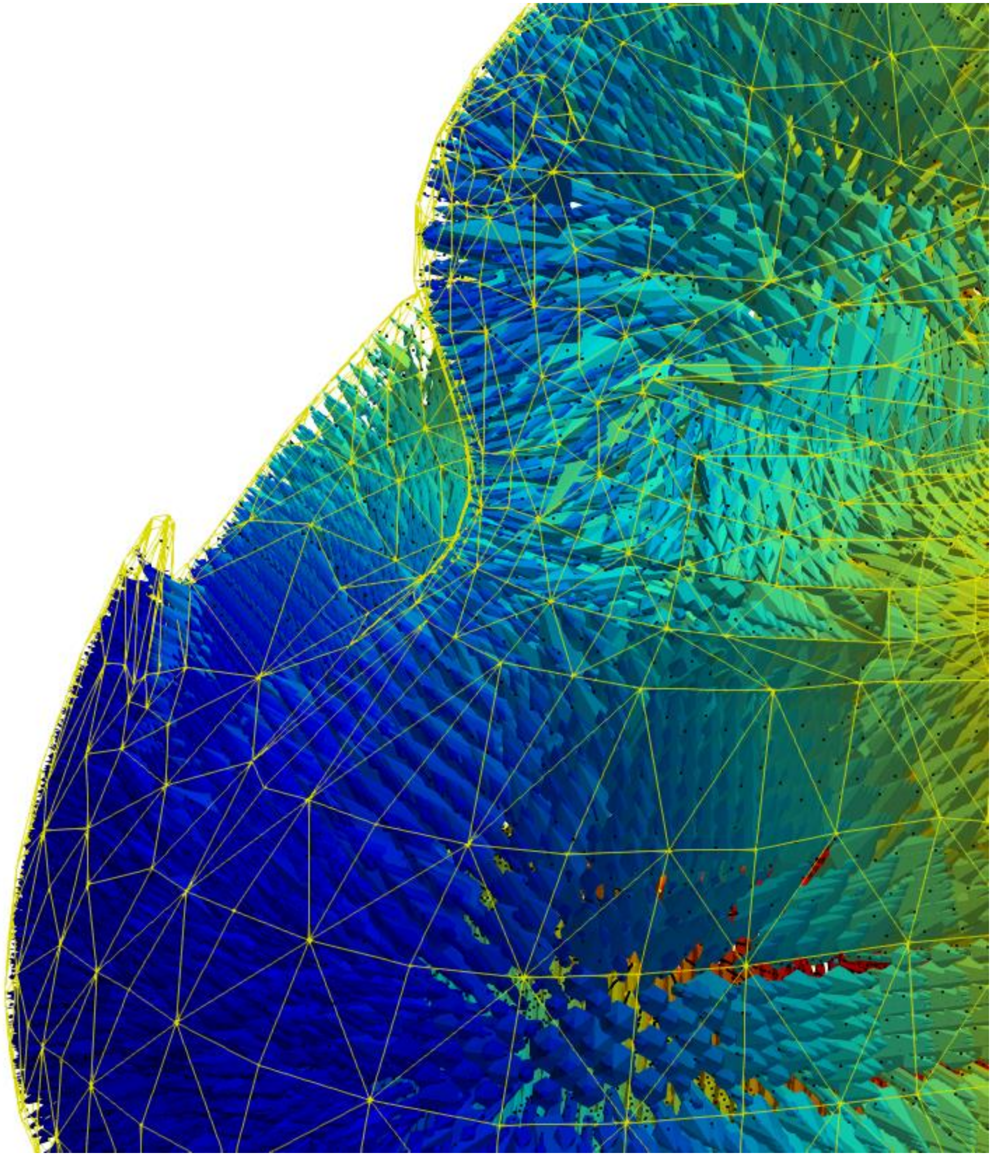


Example with complex STL

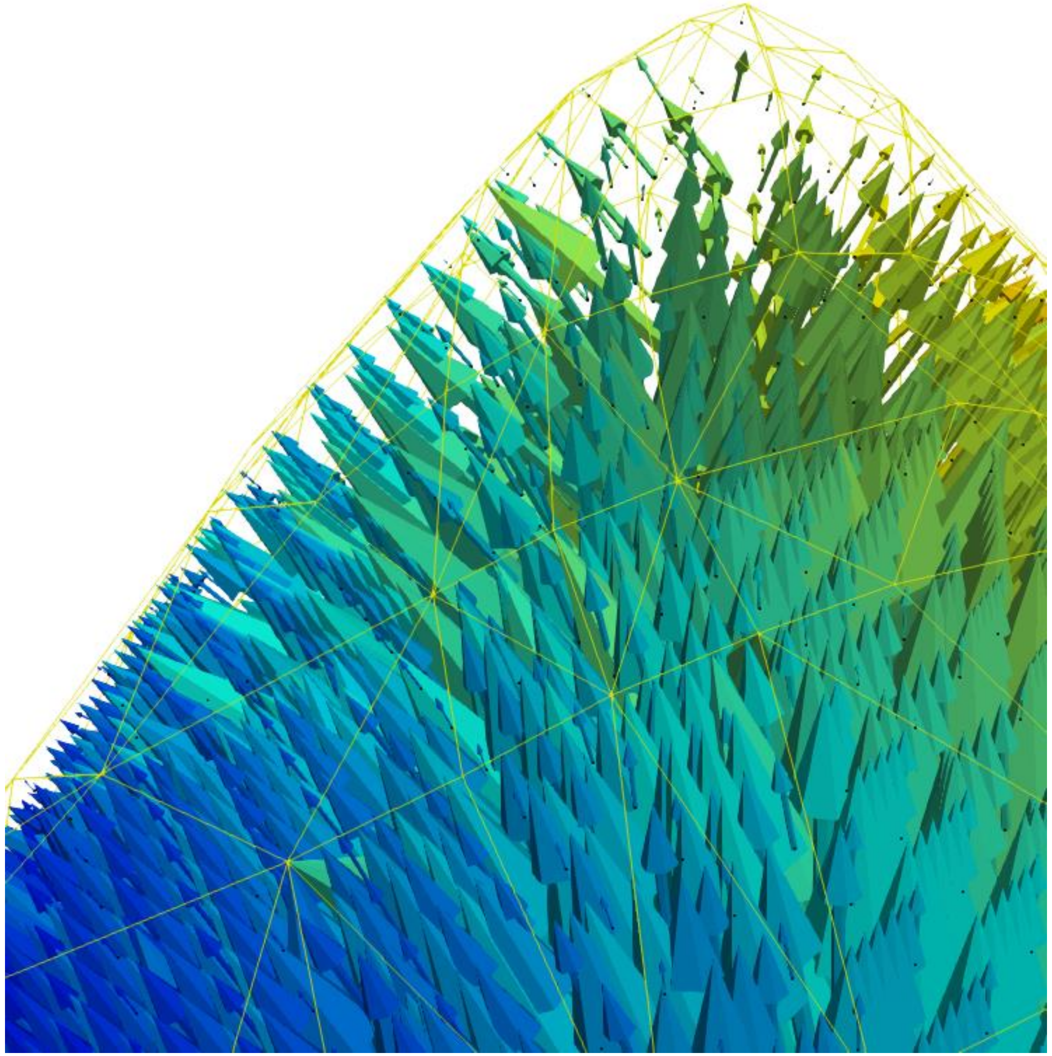




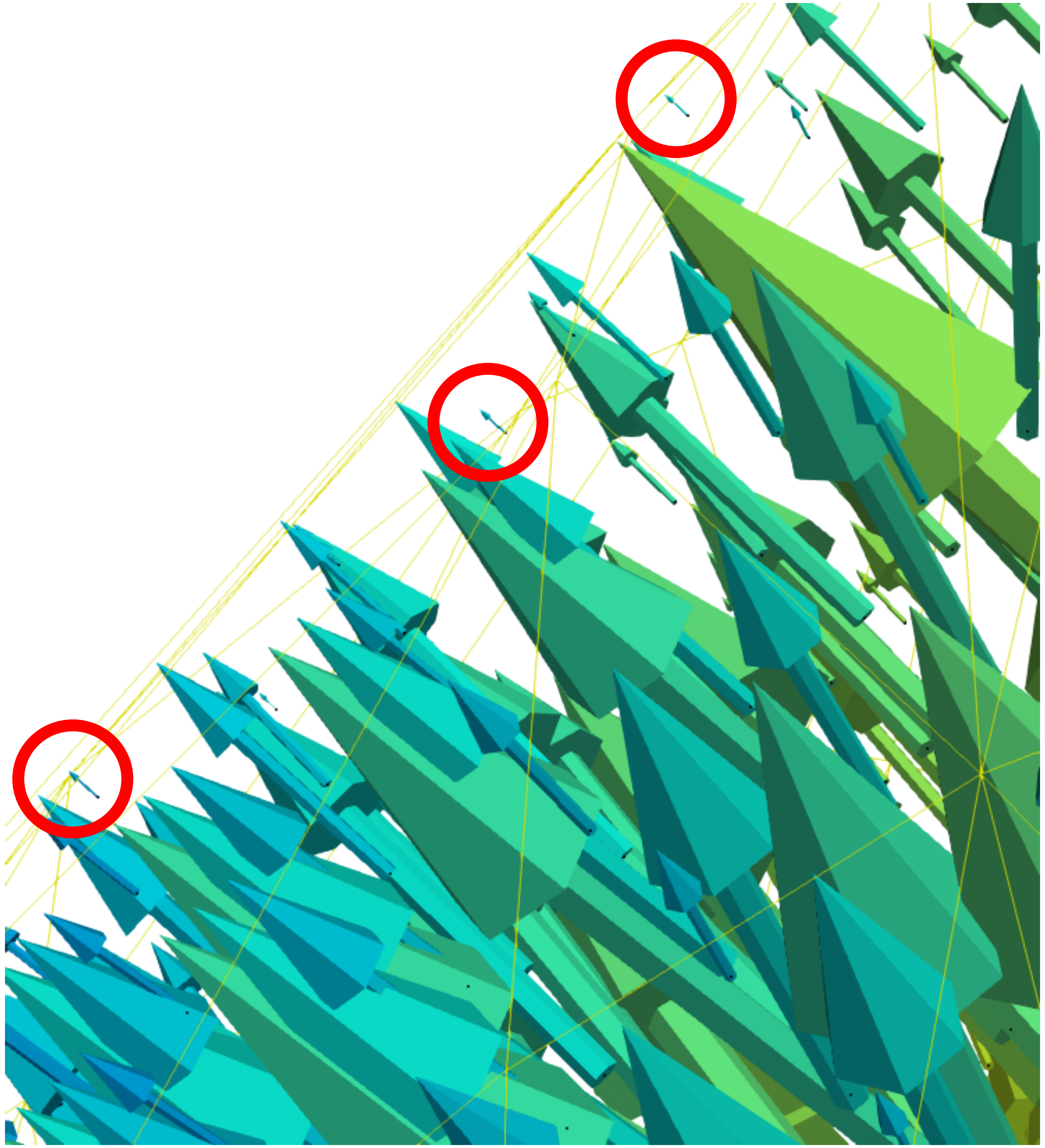
Example with complex STL



Example with complex STL



Example with complex STL



OUTLINE

New boundary conditions: mDBC

DBC drawbacks
Fluid properties from ghost nodes
DBC vs mDBC
Requirements (layers, boundary interface, normals)

mDBC requirements -> XML file

New options in GenCase (*layers*, *freedrawmode*, *variables*)
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Example with piston wavepaddle (moving)
Example with floating box (floating) **examples\mdbc\08_FloatingWaves**

mDBC applied to external geometries

New options in GenCase (*advanced drawfilestl*)
Example with simple STL (Cylinder)
Example with complex STL (Duck) **examples\mdbc\09_FloatingDuck**

TAKE-HOME MESSAGES

To apply mDBC we need: i) several layers, ii) boundary interface, iii) normal vectors for boundary particles

There are useful functionalities to create XML files for cases using mDBC: layers, freedrawmode, advanced STL

Boundary interface defined at dp/2 from boundaries is a general rule (simple geos)

A good practise is to check normal vectors before running the simulation

mDBC for floating objects is now available only in v5.2 BETA

When applying mDBC to floating objects we need to be accurate with the mass of the body and the volume occupied by the boundary particles that form the object

With v5.2 BETA, mDBC can be applied to “appropiate” STL files

New on BCs: mDBC for floating objects

ALEJANDRO J.C. CRESPO,

CORRADO ALTOMARE, JOSÉ M. DOMÍNGUEZ