Novelties on DualSPHysics: solver, pre-processing and post-processing

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OUTLINE

Novelties on v4.2
Novelties on pre-processing
Novelties on post-processing

Novelties on v4.3
How to download beta v4.3

BEFORE

How to prepare a release of an open-source code?

1. Source code (debugging, comments, previous ok)
2. Working examples (easy for users, many options)
3. Many files of help (XML templates)
4. User guides (PDFs, WIKI):
   - SPH formulation
   - Details of the implementation
   - How to compile the code (linux and windows)
   - Details of the working examples
   - How to generate new cases
5. Upload files in the website and GitHub
6. Check that everything works ok

Novelties on v4.2

SPH FORMULATION

GITHUB

WIKI

NEW STRUCTURE

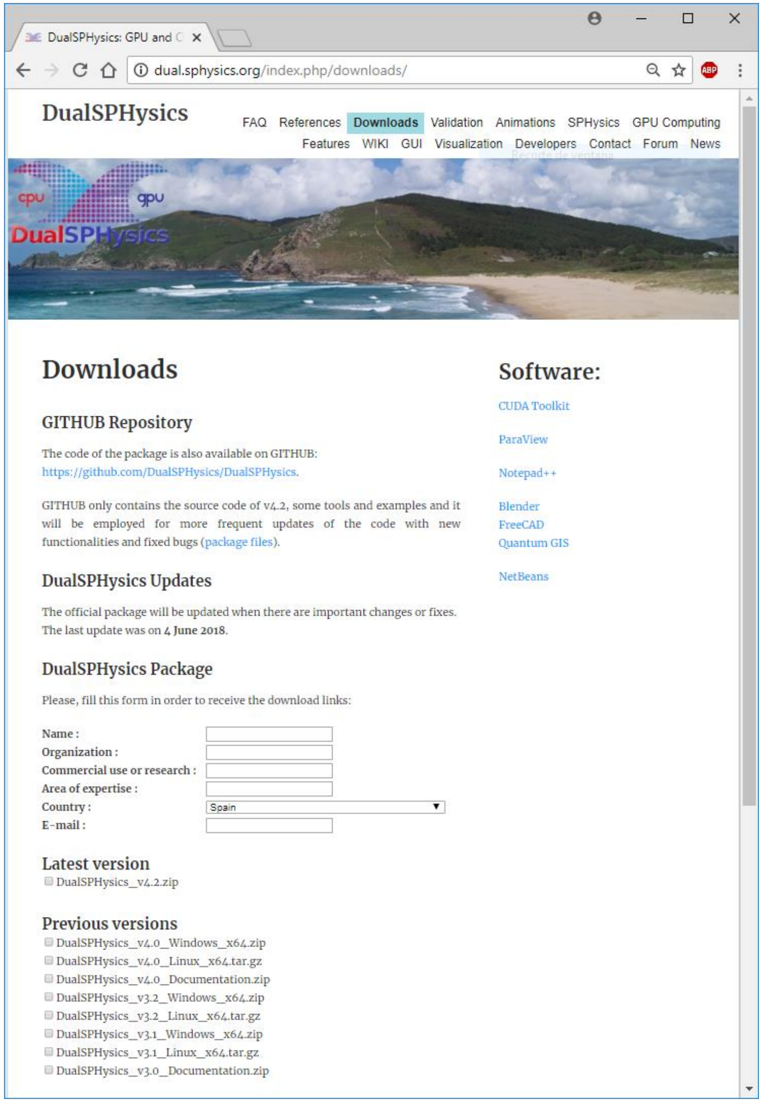
NEW LICENSE LGPL

Novelties on v4.2 – SPH Formulation

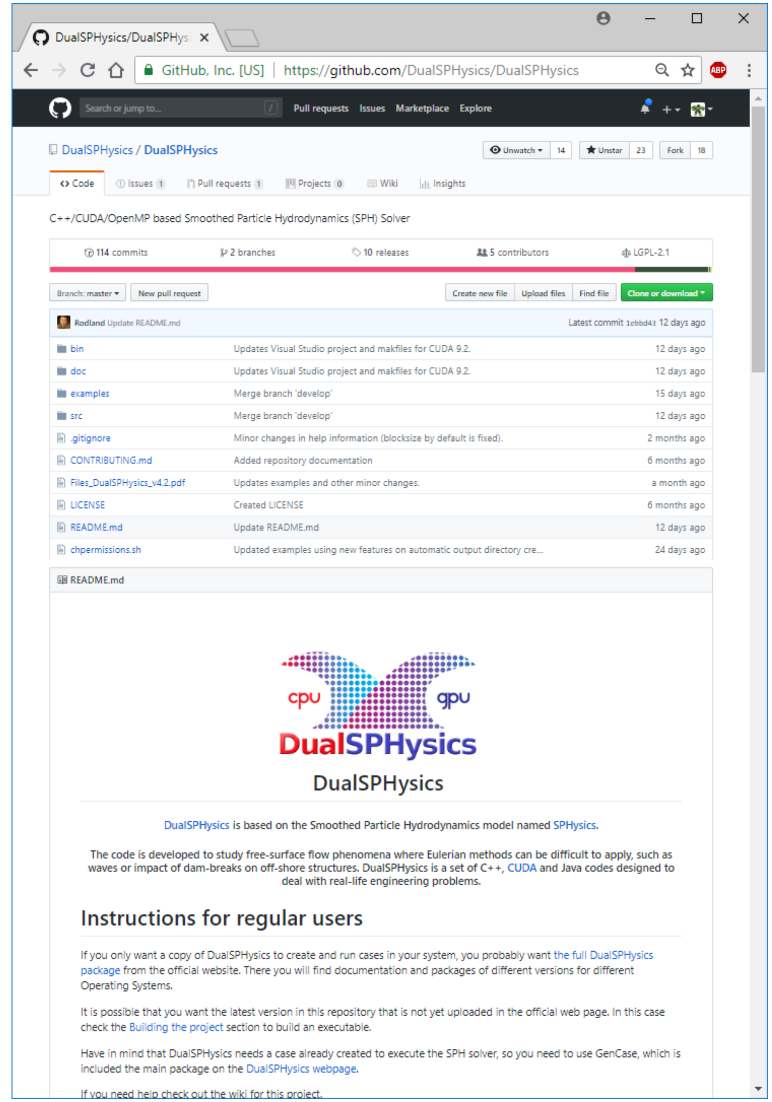
- •Parallelisation with OpenMP and CUDA (one GPU card) (Domínguez et al., 2013)
- •Time integration scheme: Verlet (Verlet, 1967) & Symplectic (Leimkhuler, 1996)
- •Variable time step (Monaghan and Kos, 1999)
- •Kernel functions: Cubic Spline (Monaghan and Lattanzio, 1985) & Quintic Wendland (Wendland, 1995)
- •Density treatment: Delta-SPH formulation (Molteni and Colagrossi, 2009)
- •Viscosity: Artificial (Monaghan, 1992) & Laminar + SPS turbulence model (Dalrymple and Rogers, 2006)
- •Weakly compressible approach using Tait's equation of state (Batchelor, 1974)
- •Shifting algorithm (Lind et al., 2012)
- •Dynamic boundary conditions (Crespo et al., 2007)
- •Floating objects (Monaghan et al., 2003)
- •Periodic open boundaries (Gómez-Gesteira et al., 2012)
- •Coupling with Discrete Element Method (Canelas et al., 2016)
- •External body forces (Longshaw and Rogers, 2015)
- •Double precision (Domínguez et al., 2013)
- •Multi-phase (soil-water) (Fourtakas and Rogers, 2016)
- •Multi-phase (gas-liquid) (Mokos et al., 2015)
- •Piston- and flap-type long-crested second-order wave generation (Altomare et al., 2017)
- •Passive and Active Wave Absorption System (Altomare et al., 2017)

Novelties on v4.2 - GITHUB

DualSPHysics Package
http://dual.sphysics.org



DualSPHysics Code on GitHub (since v4.2)
https://github.com/DualSPHysics/DualSPHysics



Novelties on v4.2 - WIKI

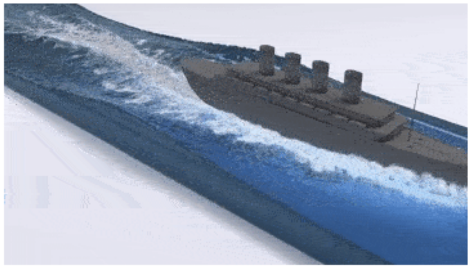
The users guide has been moved to a WIKI:
https://github.com/DualSPHysics/DualSPHysics/wiki

DualSPHysics

DualSPHysics

DualSPHysics is based on the Smoothed Particle Hydrodynamics model named SPHysics.

The code is developed to study free-surface flow phenomena where Eulerian methods can be difficult to apply, such as waves or impact of dam-breaks on off-shore structures. DualSPHysics is a set of C++, CUDA and Java codes designed to deal with real-life engineering problems.



Welcome to the DualSPHysics Wiki. Here you will find documentation and information about the DualSPHysics project: codes, structure, workflow, compilation, working examples, etc.

Suggestions and errors in the Wiki

If you have suggestions (a new section, corrections or contributions) please notify it using the ISSUES section of the repository. Please include something like [WIKI] into the title to help us to prioritize the work.

Novelties on v4.2 – New structure

http://dual.sphysics.org/index.php/downloads/

```
DualSPHysics_v4.2
├── bin
│   ├── linux
│   └── windows
├── doc
│   ├── guides
│   ├── help
│   └── xml_format
├── examples
│   ├── main
│   │   ├── 01_DamBreak
│   │   ├── 02_Periodicity
│   │   ├── 03_MovingSquare
│   │   ├── 04_ExternalForces
│   │   ├── 05_SloshingTank
│   │   ├── 06_Wavemaker
│   │   ├── 07_WavemakerFile
│   │   ├── 08_WavesFlap
│   │   ├── 09_WavesPiston
│   │   ├── 10_WavesPistonAWAS
│   │   ├── 11_Floating
│   │   ├── 12_FloatingWaves
│   │   ├── 13_Pump
│   │   ├── 14_DEM
│   │   └── 15_Poiseuille
│   ├── twophases
│   │   ├── DSPH_v3.4_LiquidSediment
│   │   │   └── 01_DamBreak
│   │   └── DSPH_v4.0_LiquidGas
│   │       ├── 01_DamBreak
│   │       ├── 02_ObstacleImpact
│   │       ├── 03_WetDamBreak
│   │       ├── 04_SloshingTank
│   │       ├── 05_DEM
│   │       └── 06_SurfaceTension
│   ├── motion
│   └── others
│       ├── ExternalDt
│       ├── ExternalViscoFile
│       ├── GaugeSystem
│       ├── PosDouble
│       ├── RedrawGenCase
│       ├── Restart
│       ├── RotatedBox
│       ├── SaveDt
│       └── TimeOut
├── src
│   ├── lib
│   ├── source
│   └── VS
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│       ├── lib
│       ├── source
│       └── VS
└── src_ extra
    └── ToVTK_v4
        ├── bin
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https://github.com/DualSPHysics/DualSPHysics

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Novelties on v4.2 – New structure

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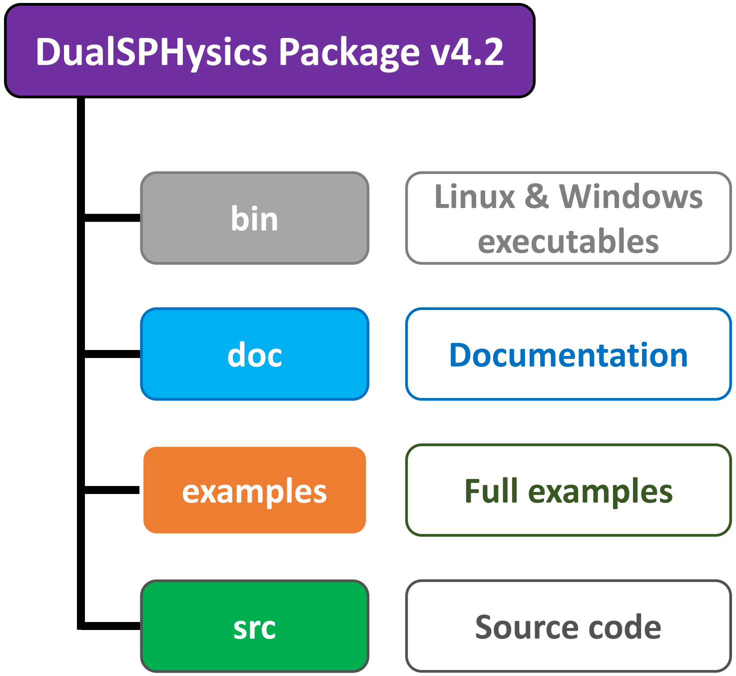

Linux & Windows executables:

Pre-processing:
- GenCase4

SPH solver:
- DualSPHysics4.2
- DualSPHysics4.0_LiquidGas
- DualSPHysics3.4_LiquidSediment

Post-processing (visualization):
- PartVTK4
- PartVTKOut4
- IsoSurface4

Post-processing (calculations):
- BoundaryVTK4
- ComputeForces4
- FloatingInfo4
- FlowTool4
- MeasureTool4

LINUX & WINDOWS in the same package

Novelties on v4.2 – New structure

DualSPHysics Package v4.2

- **bin** — Linux & Windows executables
- **doc** — Documentation
- **examples** — Full examples
- **src** — Source code

Documentation (guides and other help files) :

Pre-processing:
- XML_v4.0_GUIDE.pdf
- ExternalModelsConversion.pdf

SPH solver:
- DualSPHysics_v4.2_GUIDE.pdf
- DualSPHysics_v4.0_LiquidGas_GUIDE.pdf

Post-processing:
- PostprocessingCalculations_v4.2.pdf

Help of executables
XML Templates for configuration

DualSPHysics_v4.2_GUIDE.pdf -> WIKI

Novelties on v4.2 – New structure

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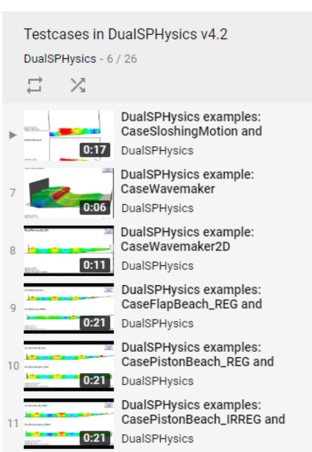


Playlist in YouTube

Full examples (also pre-processing & post-processing):

DamBreak	WaveMaker	Floating
Periodicity	WavesFlap	FloatingWaves
MovingSquare	WavesPiston	Pump
ExternalForces	WavesPistonAWAS	DEM
SloshingTank	WaveMakerFile	Pouseuille

Full examples - LiquidSediment & LiquidGas:

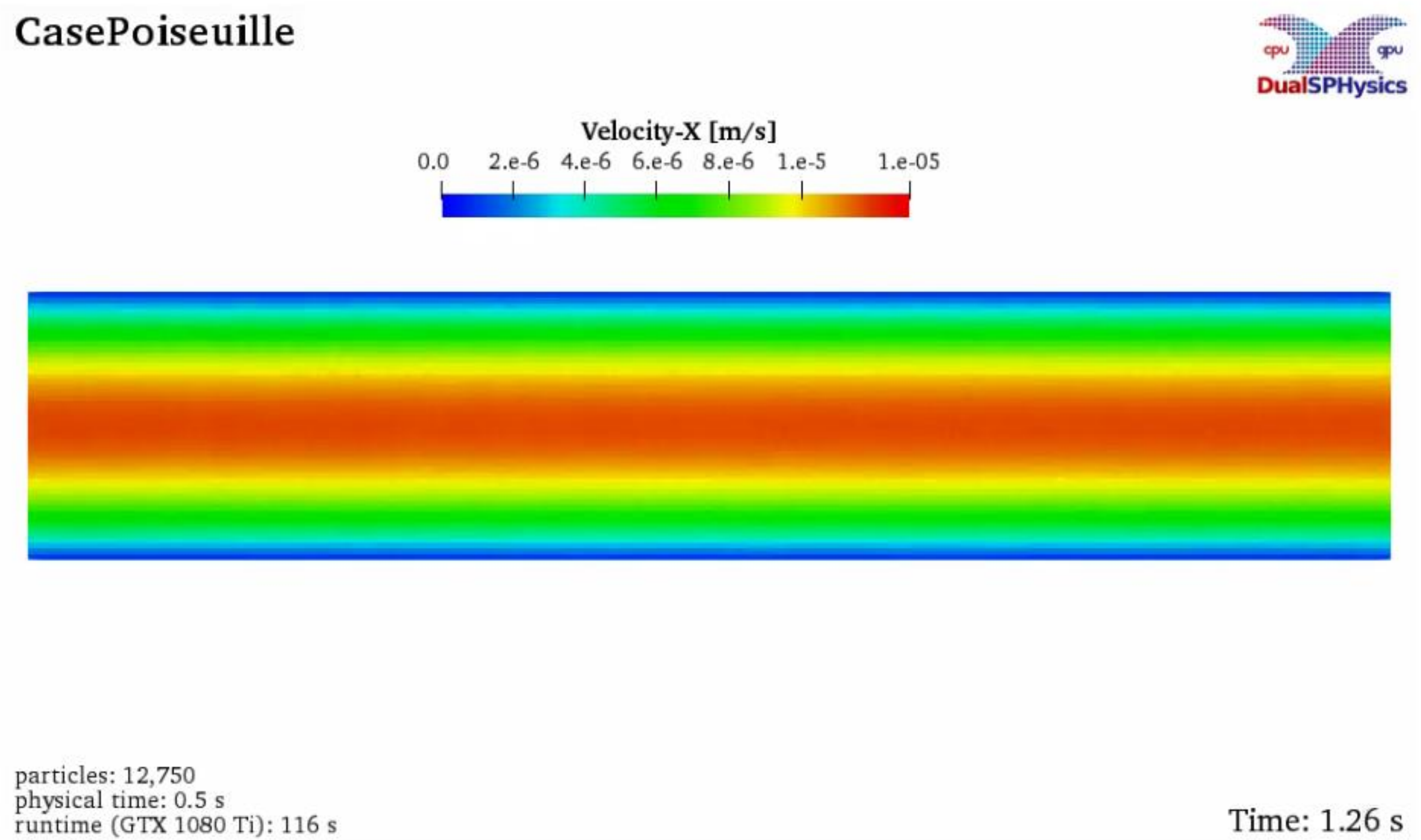
LiquidSediment:
- Dambreak

LiquidGas:
- ObstacleImpact
- DamBreak
- SloshingTank
- WetDambreak
- SurfaceTension
- DEM

Novelties on v4.2 – New structure

New test cases

- Poiseuille flow
- Many floatings
- Flap and piston wavemakers
- Dike with AWAS where overtopping is computed



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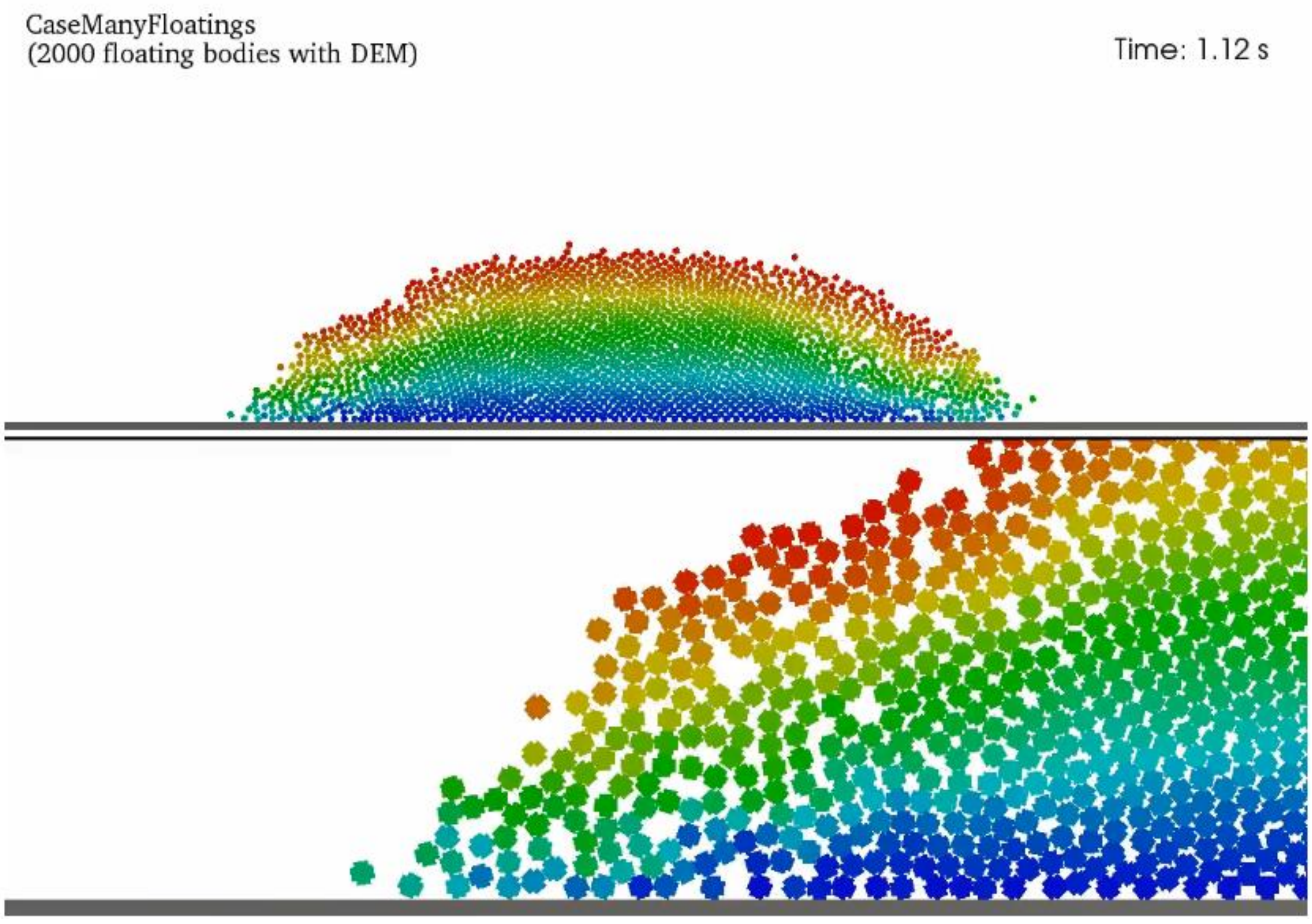

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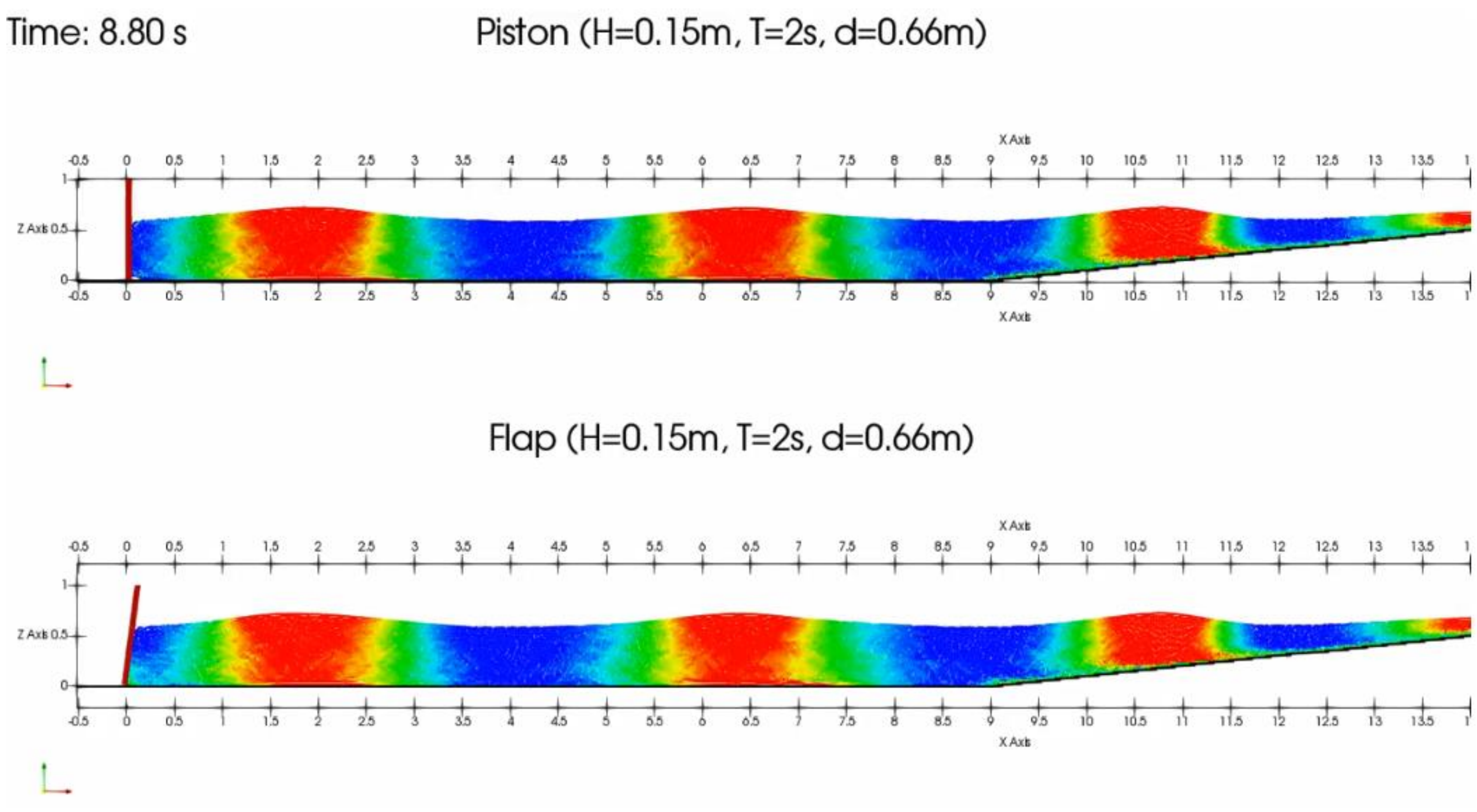

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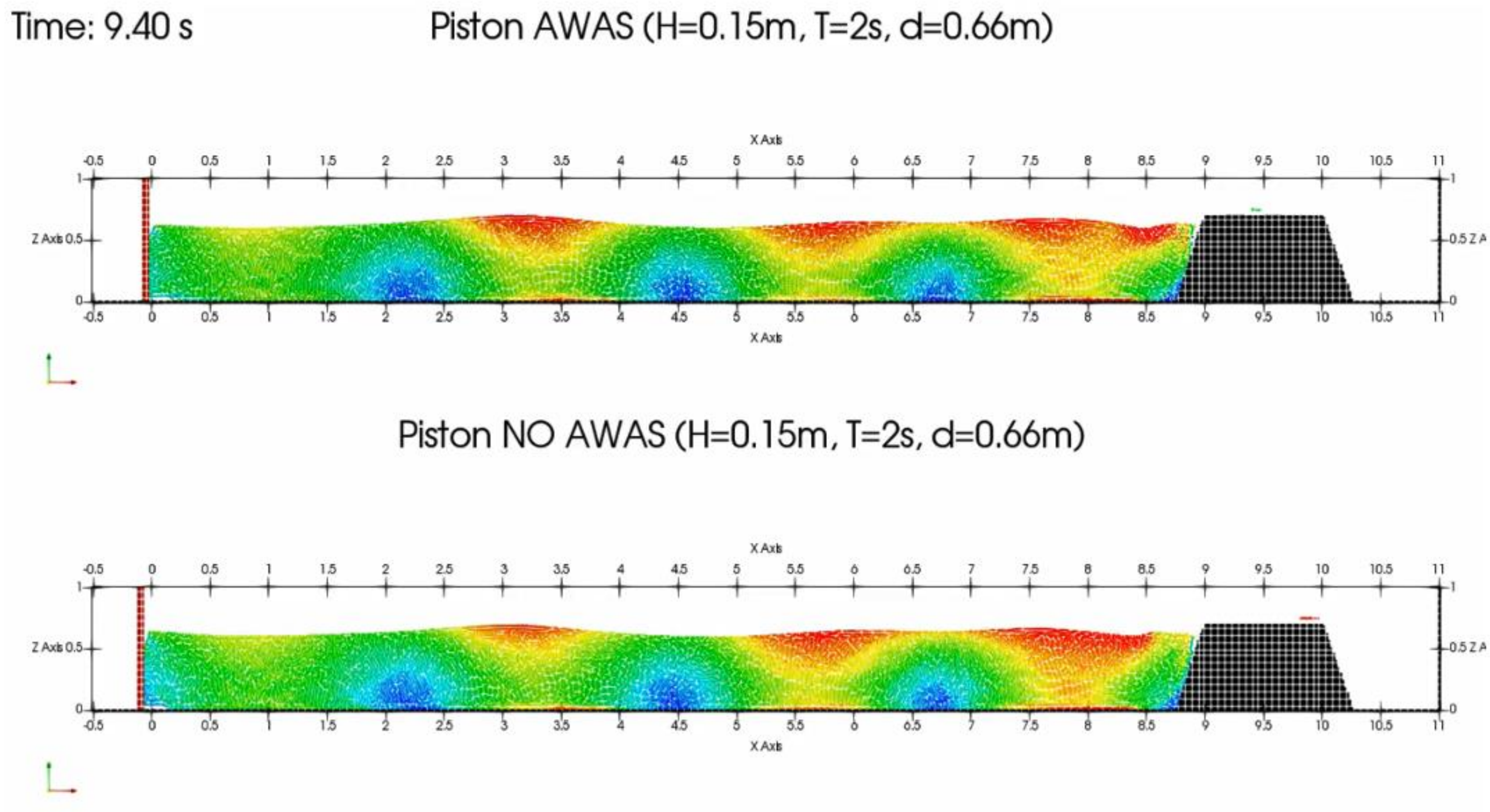


Novelties on v4.2 – New structure

New test cases

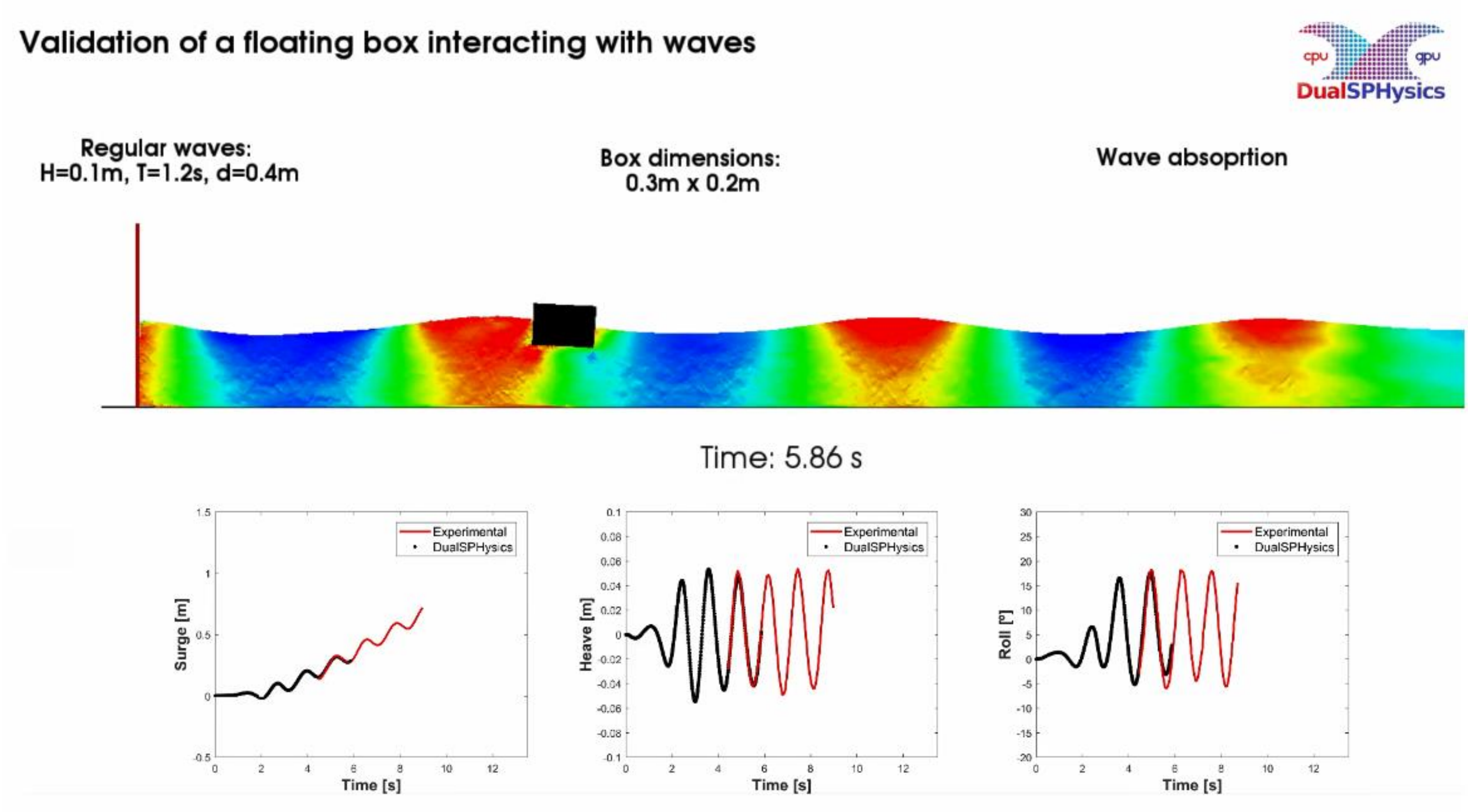
- More information for validations:

- CaseDambreakVal2D:	experimental data
- CaseSloshing:	experimental data
- CaseWavemaker2D:	experimental data
- CaseFlap:	theoretical solution
- CasePiston:	theoretical solution
- CaseFloatingSphereVal2D:	other numerical solution
- CaseFloatingWavesVal:	experimental data
- CaseFloatingWavesVal2:	experimental data
- CasePoiseuille:	theoretical solution

Novelties on v4.2 – New structure

New test cases

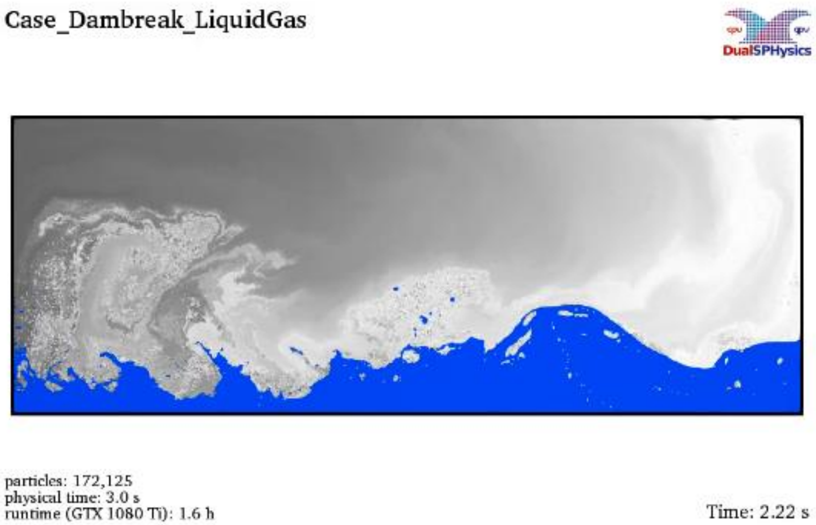
- More information for validations:
  - CaseFloatingWavesVal2: experimental data

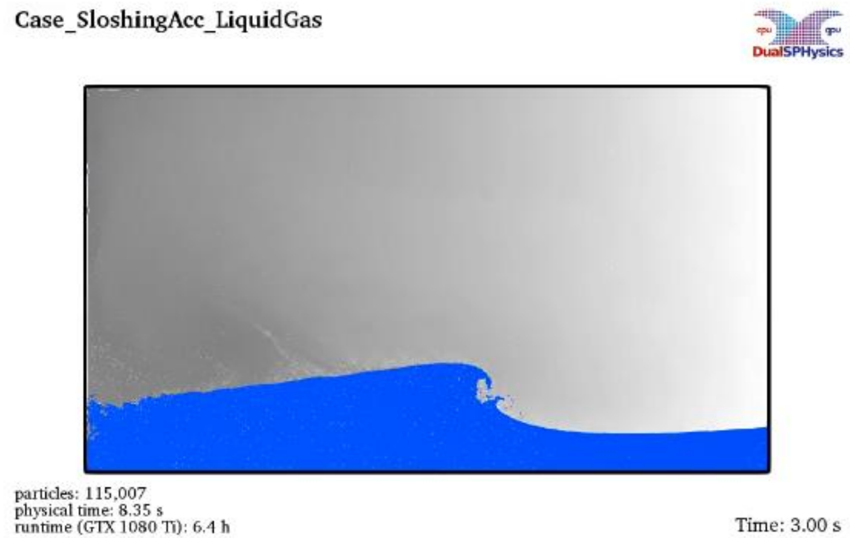


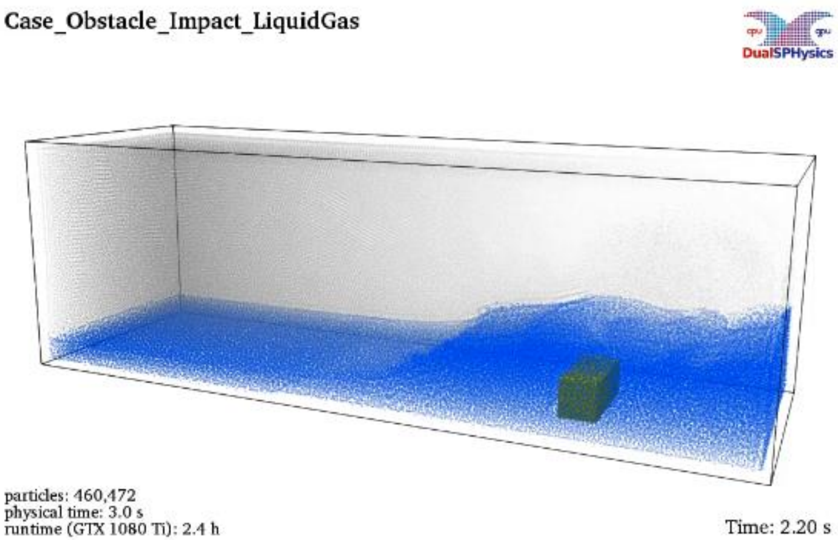
Novelties on v4.2 – New structure

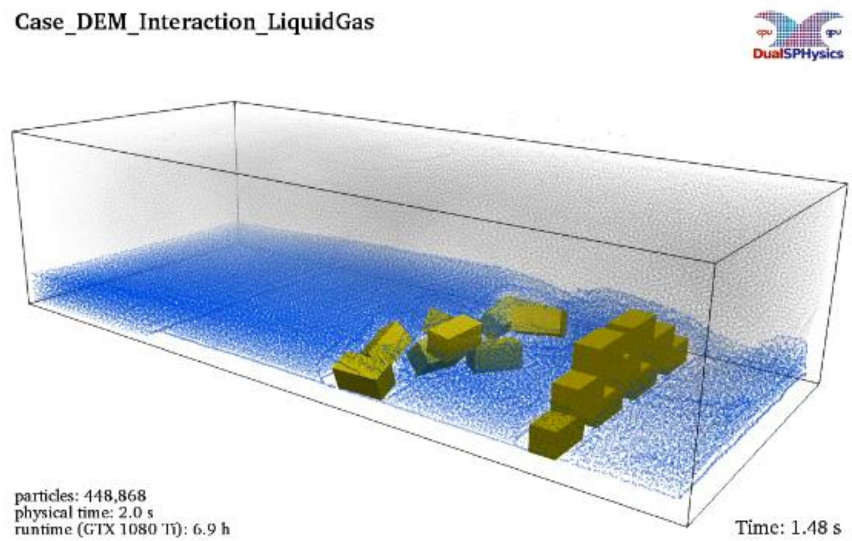
Multiphase code: LiquidGas

•Source code and examples

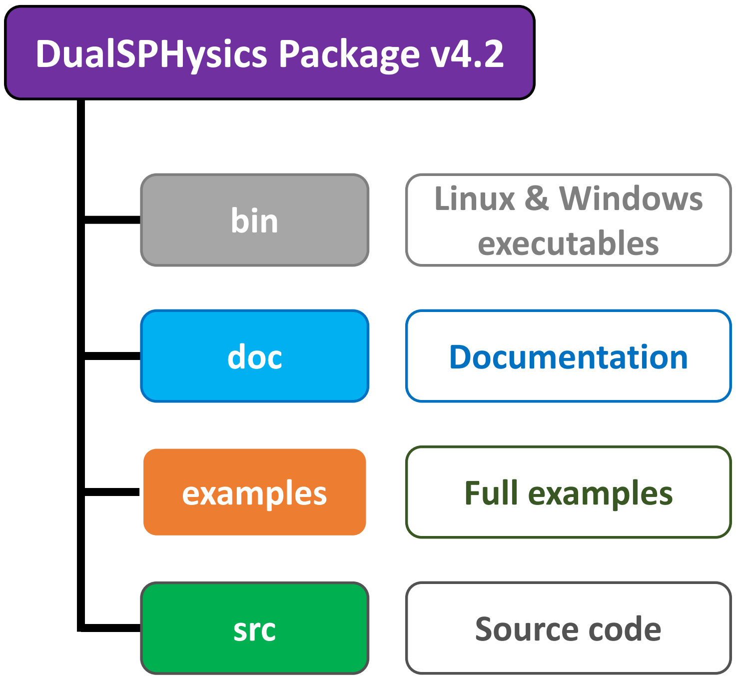








Novelties on v4.2 – New structure



Source code ready to compile:

Codes:
- DualSPHysics v4.2
- DualSPHysics v4.0 LiquidGas
- ToVTK (data usage example)

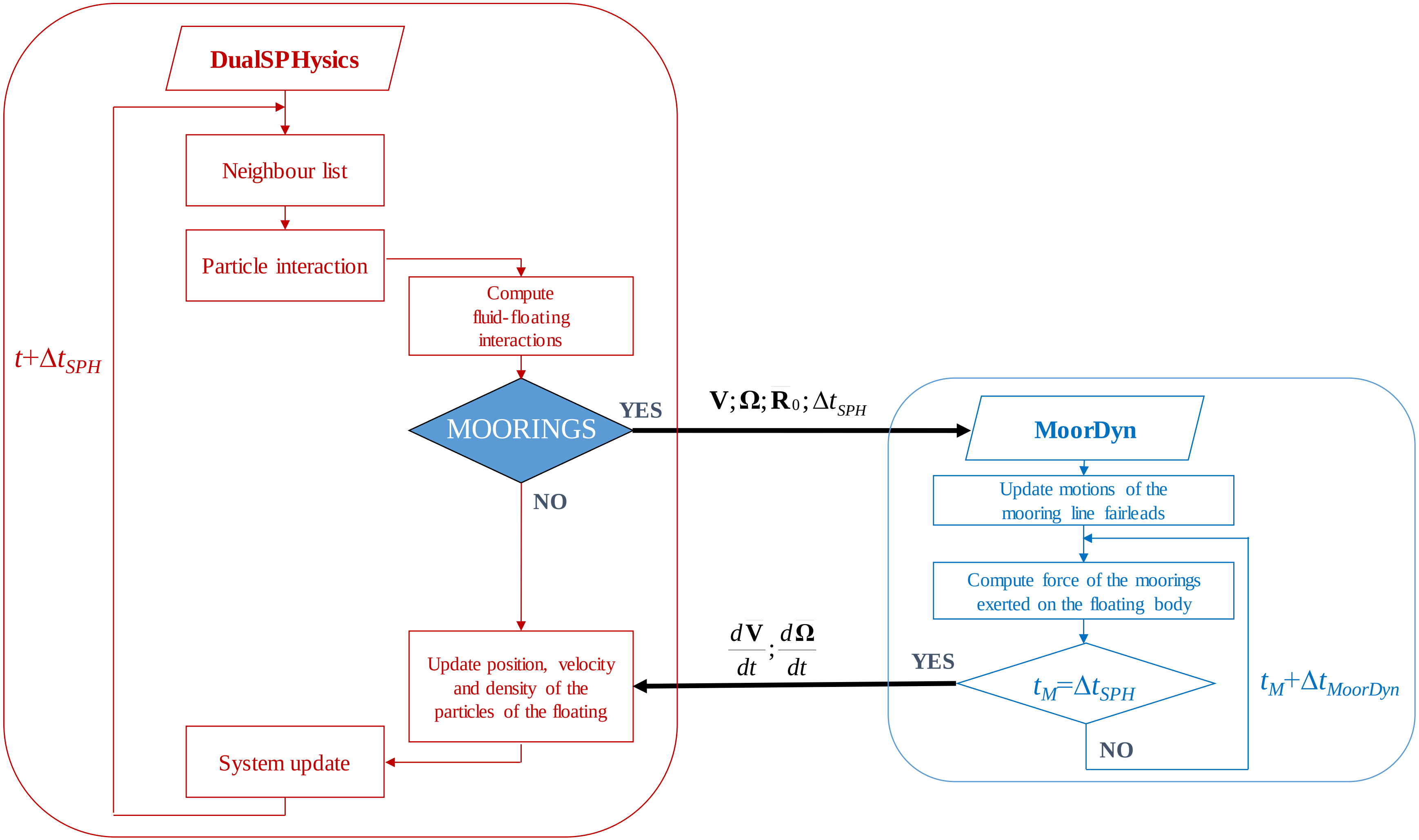
Precompiled libraries:
- Linux (gcc4 & gcc5)
- Windows (Visual Studio 2015)

Compiling:
- Makefiles for Linux
- Project for Visual Studio 2015
- CMake file

CUDA 9.2
Linux (gcc4 & gcc5)
Visual Studio Community 2015 (free)
Cmake

Novelties on v4.2 – New structure

Improved implementation of floating objects to facilitate coupling with other models



Novelties on v4.2 – New structure

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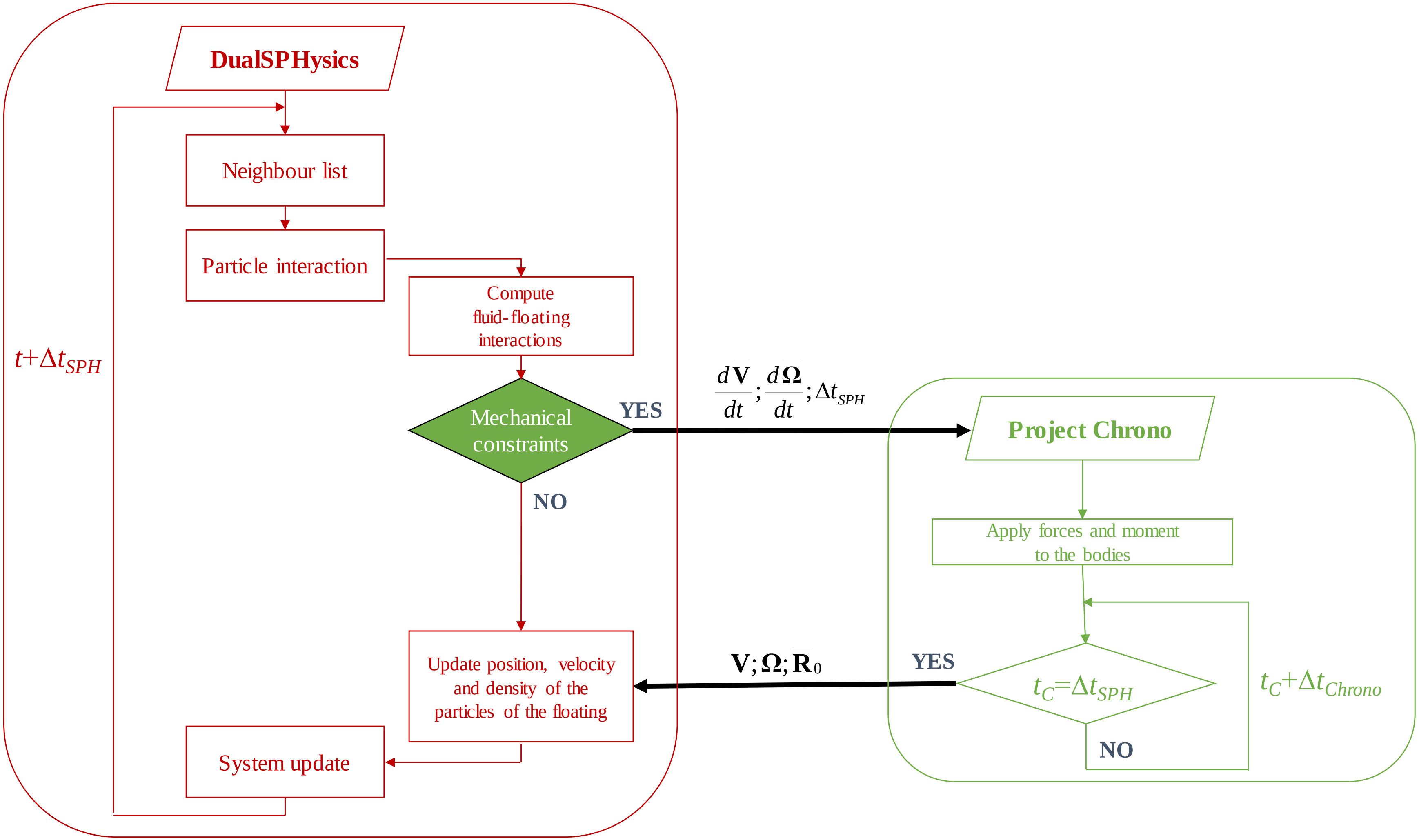


Novelties on v4.2 – New LICENSE

LGPL v2.1- GNU Lesser General Public License (LGPL)

- Software can be incorporated into both free software and proprietary software
- Developers and companies can integrate LGPL software into their software without being required to release the source code of their own software-parts
- Libraries linked to DualSPHysics can be closed source
- LGPL can be used in commercial applications

Novelties on v4.2

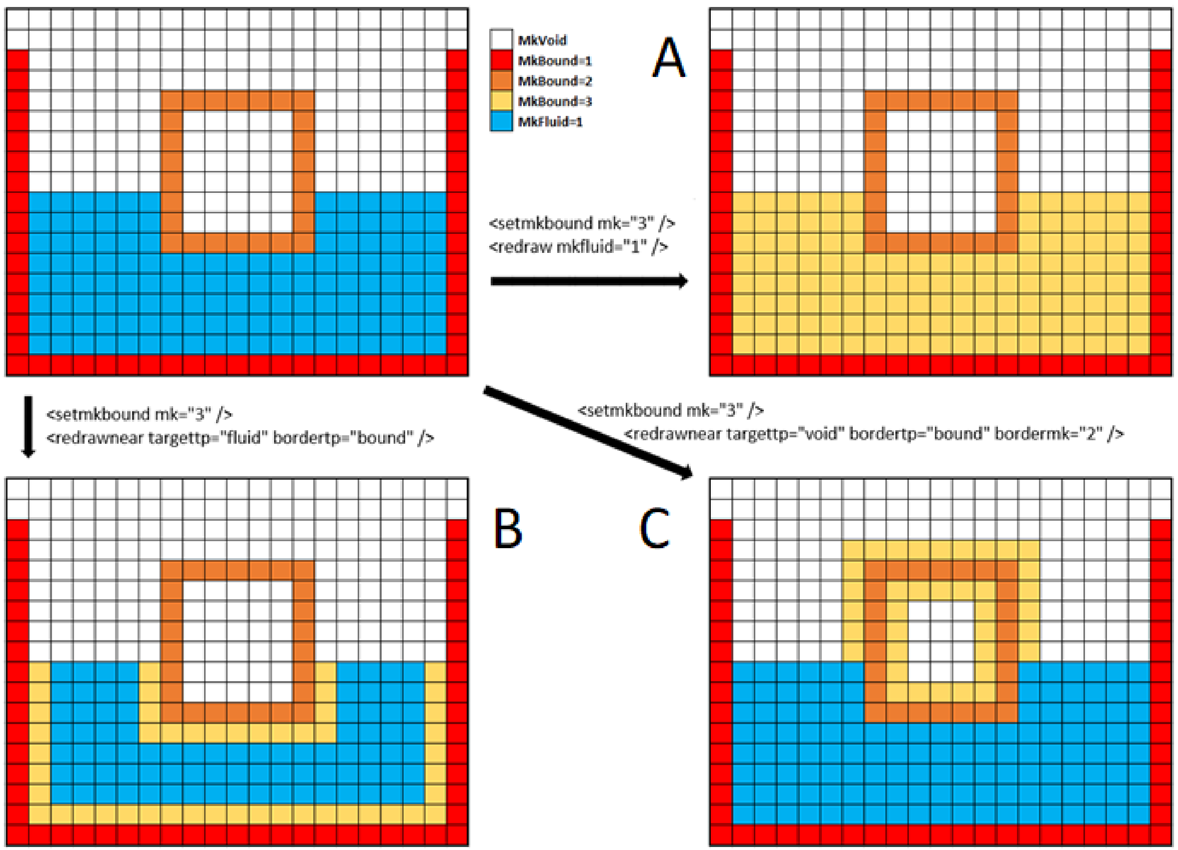
Novelties on pre-processing

Novelties on post-processing

Novelties on v4.2 – Pre-processing

RedrawGenCase examples\others\RedrawGenCase

- The <redraw> command assigns the “mk” defined by the last <setmkvoid>, <setmkbound> or <setmkfluid> to all nodes that follow a given condition.
- The <redrawnear> command allows to indicate the nodes that will be modified if there is a neighbouring node that follows some given condition



Novelties on v4.2 – Pre-processing

RedrawGenCase

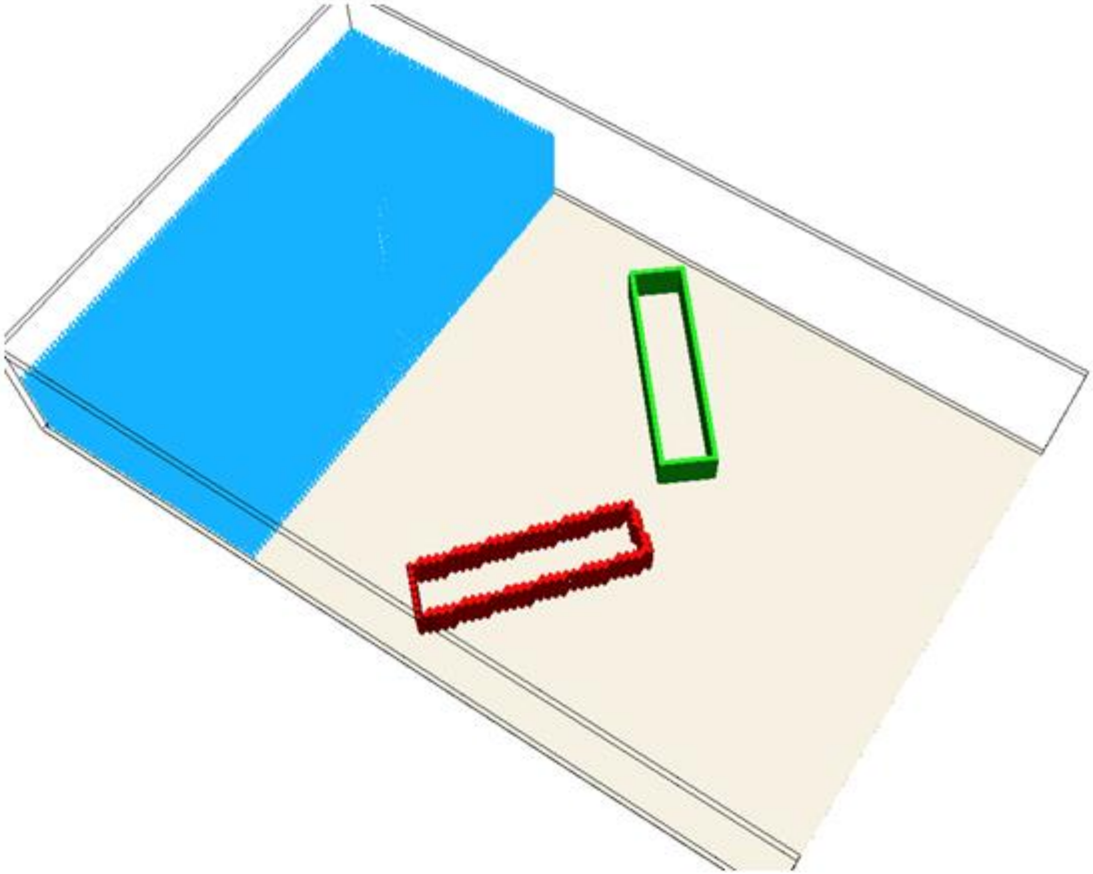
RedrawSimple.xml

Novelties on v4.2 – Pre-processing

RotatedBox

examples\others\RotatedBox

i) one box is created based on the 3-D Cartesian lattice used by GenCase

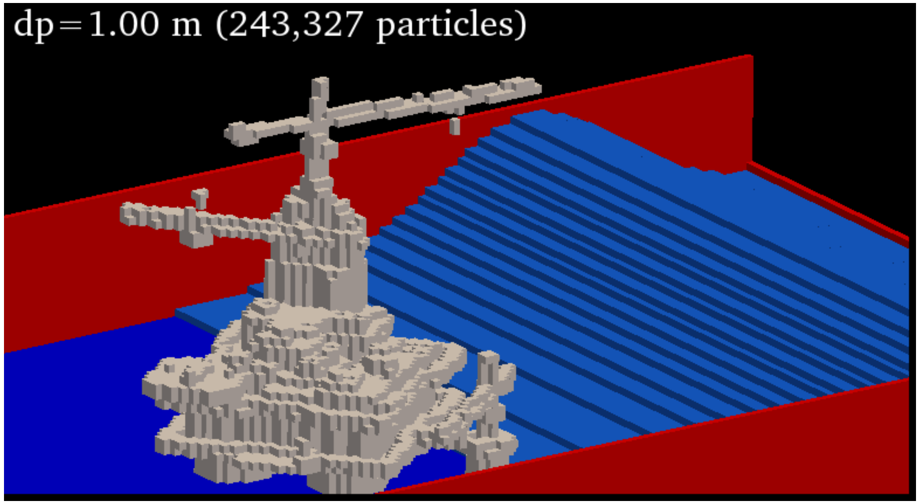


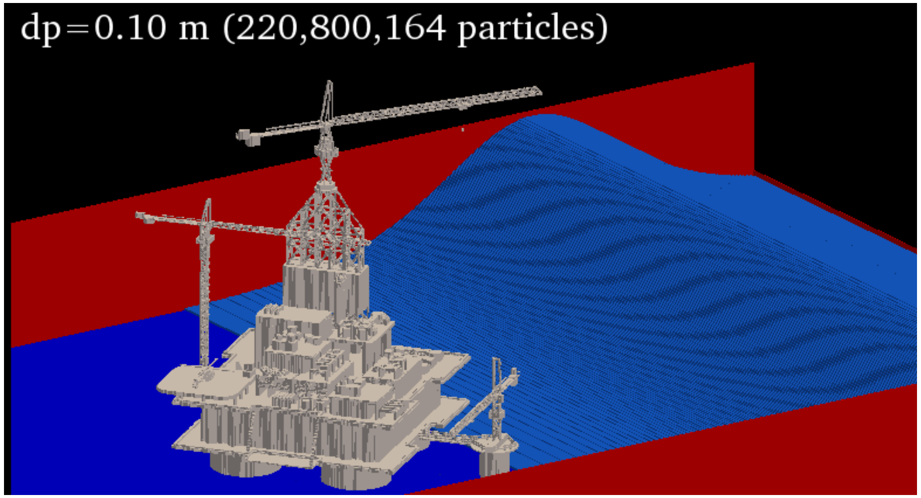
ii) the second box, is initially created using <drawbox> and later uses <rotateaxis> to apply a matrix that rotates the position of the particles of the box**, so that, particles are finally created in global positions that are not linked to the nodes of the 3-D lattice**

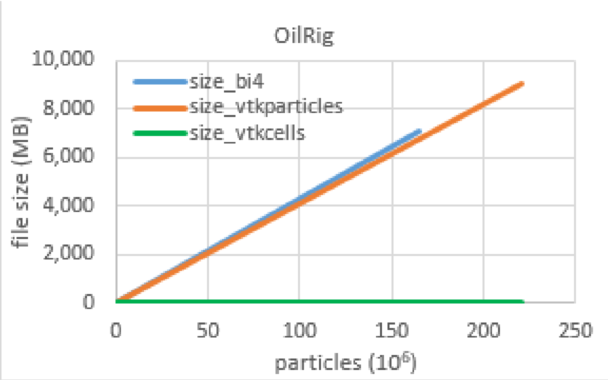
Novelties on v4.2 – Pre-processing

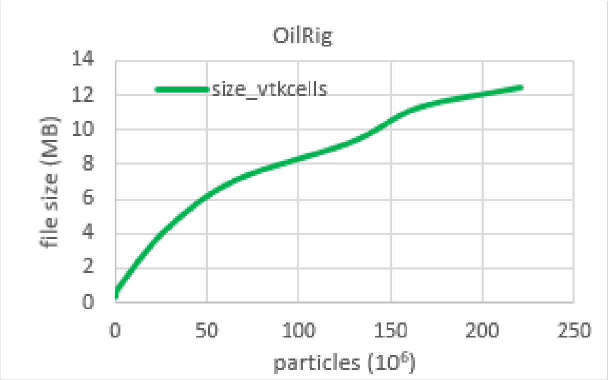
New output VTK file one thousand times less heavy to easily visualise huge cases

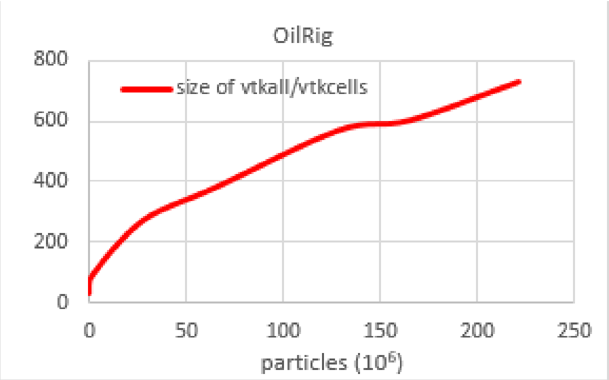
Case_MkCells.vtk











Novelties on v4.2 – Post-processing

FlowTool

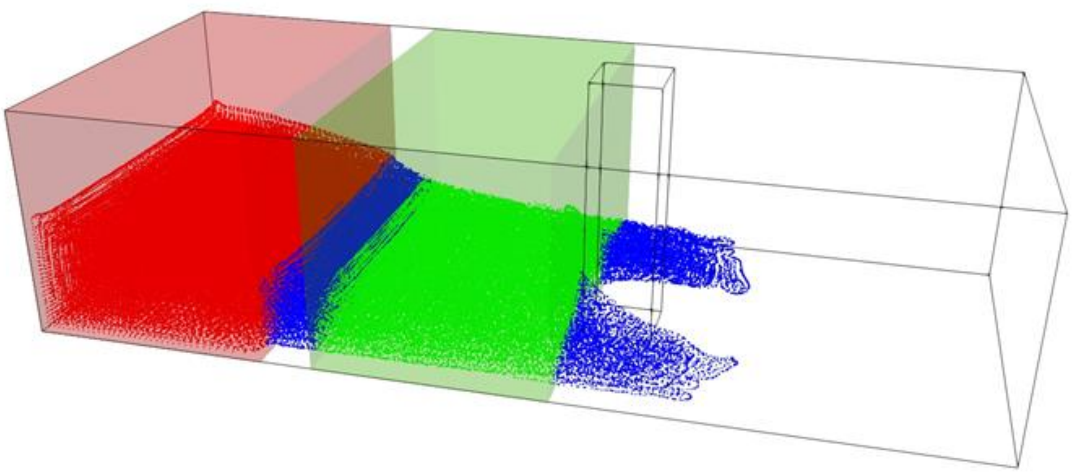
<u>Calculates:</u>

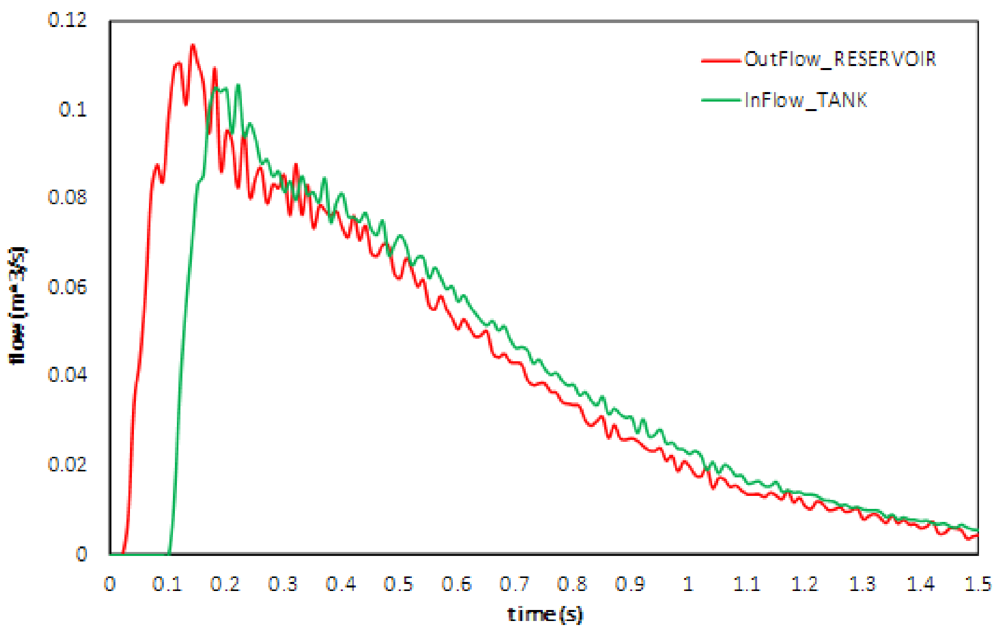
- number of fluid particles that enters or leaves domains defined by the user
- average velocity of the particles that enters that domain since last output time
- volume calculated by multiplying the volume of one particle by the number of particles
- inflow and outflow by dividing volume with the interval time (output time)

This post-processing tool is therefore very useful to compute discharges or overtopping in the case of coastal protection

Novelties on v4.2 – Post-processing

FlowTool: to compute inflow, outflow… overtopping





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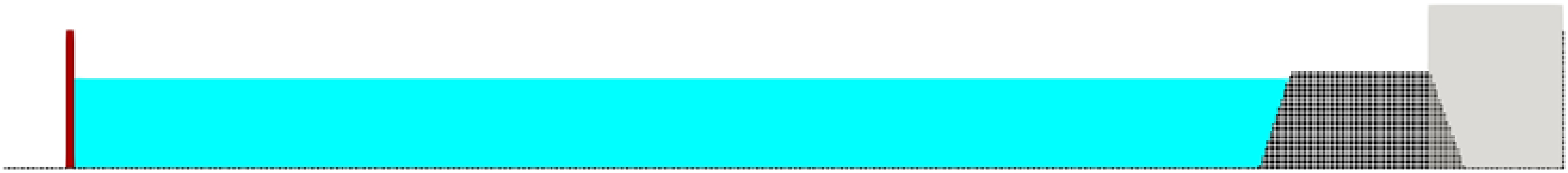

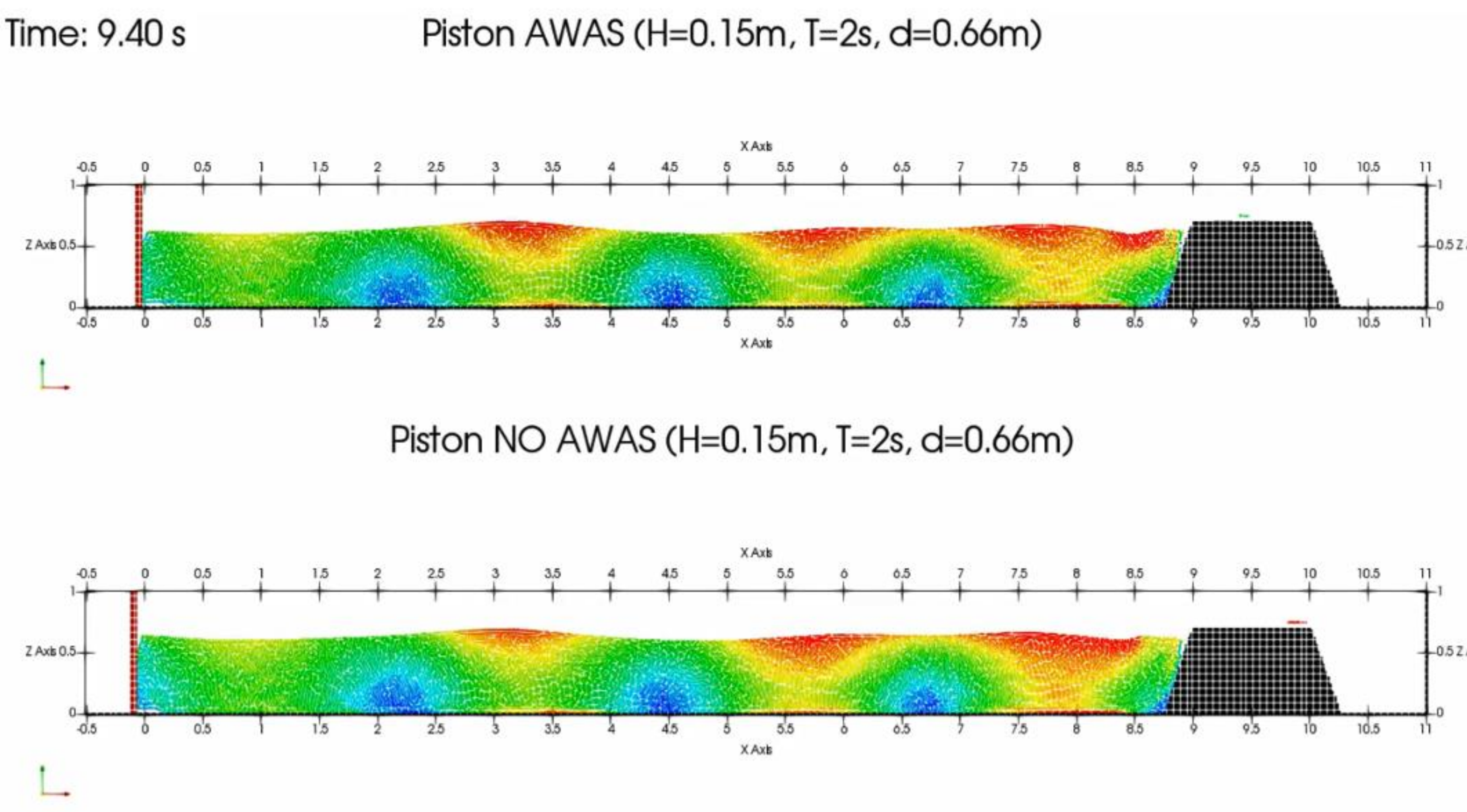

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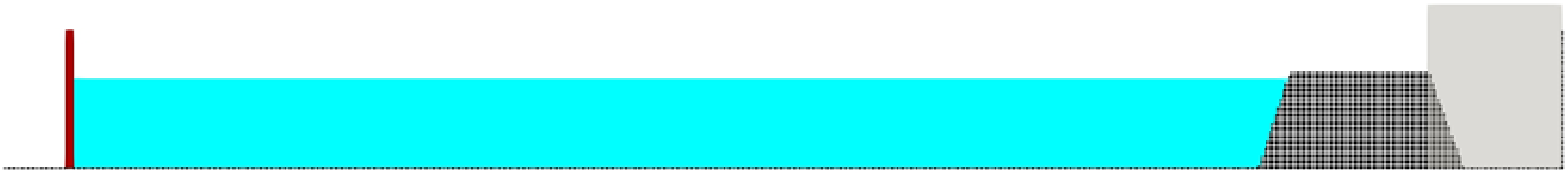
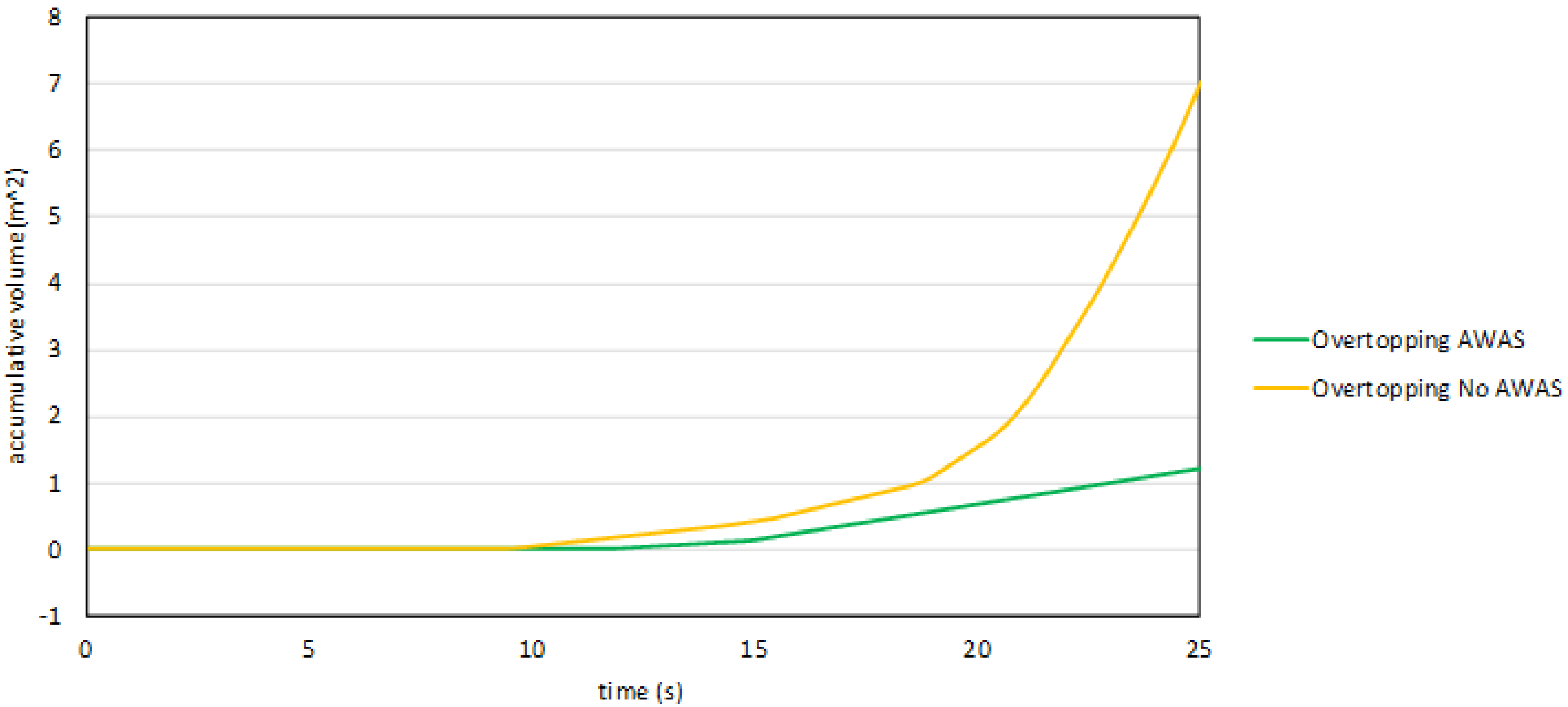
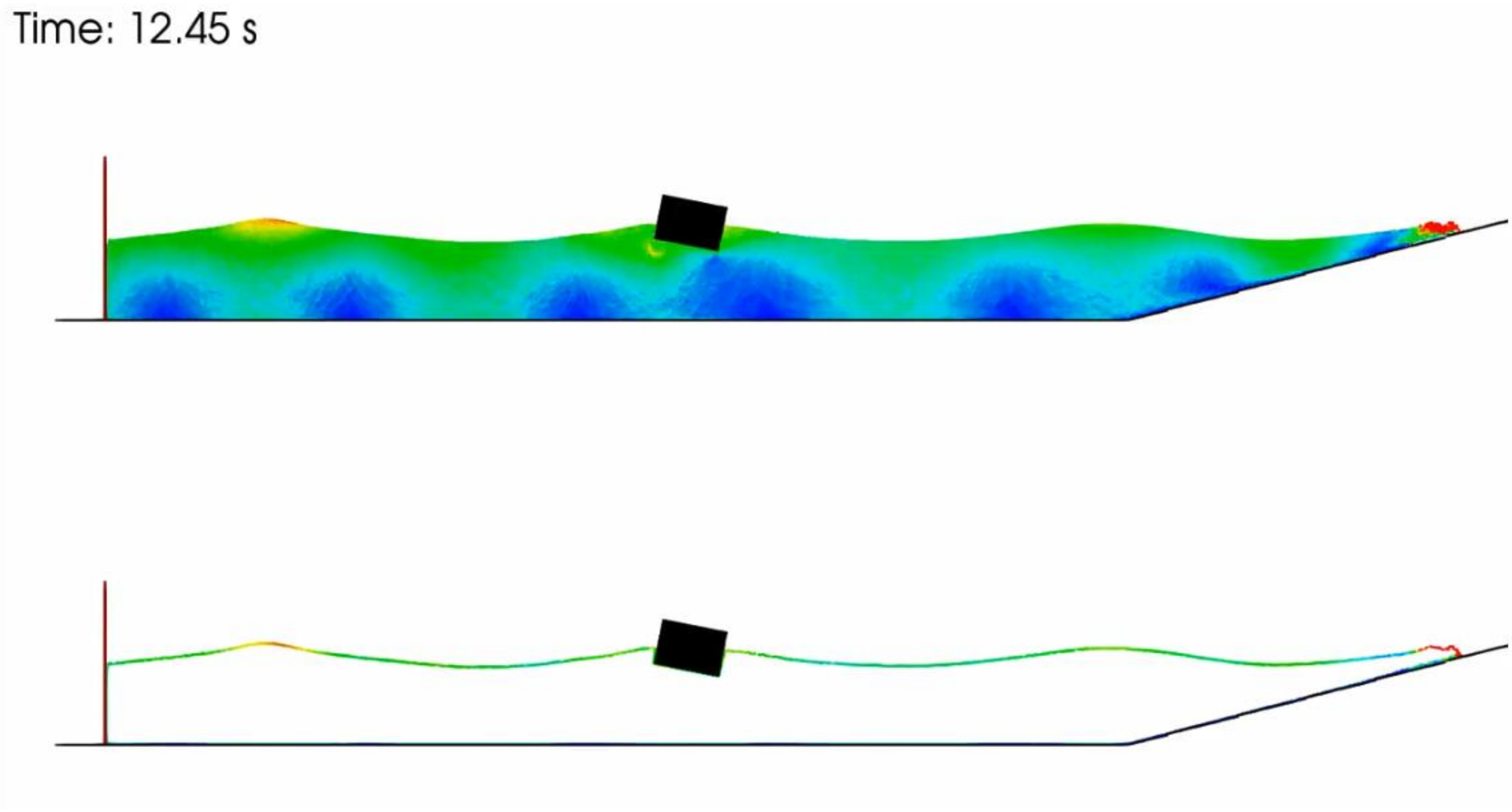




Novelties on v4.2 – Post-processing

IsoSurface.exe: now also creates slices



Novelties on v4.2 – Post-processing

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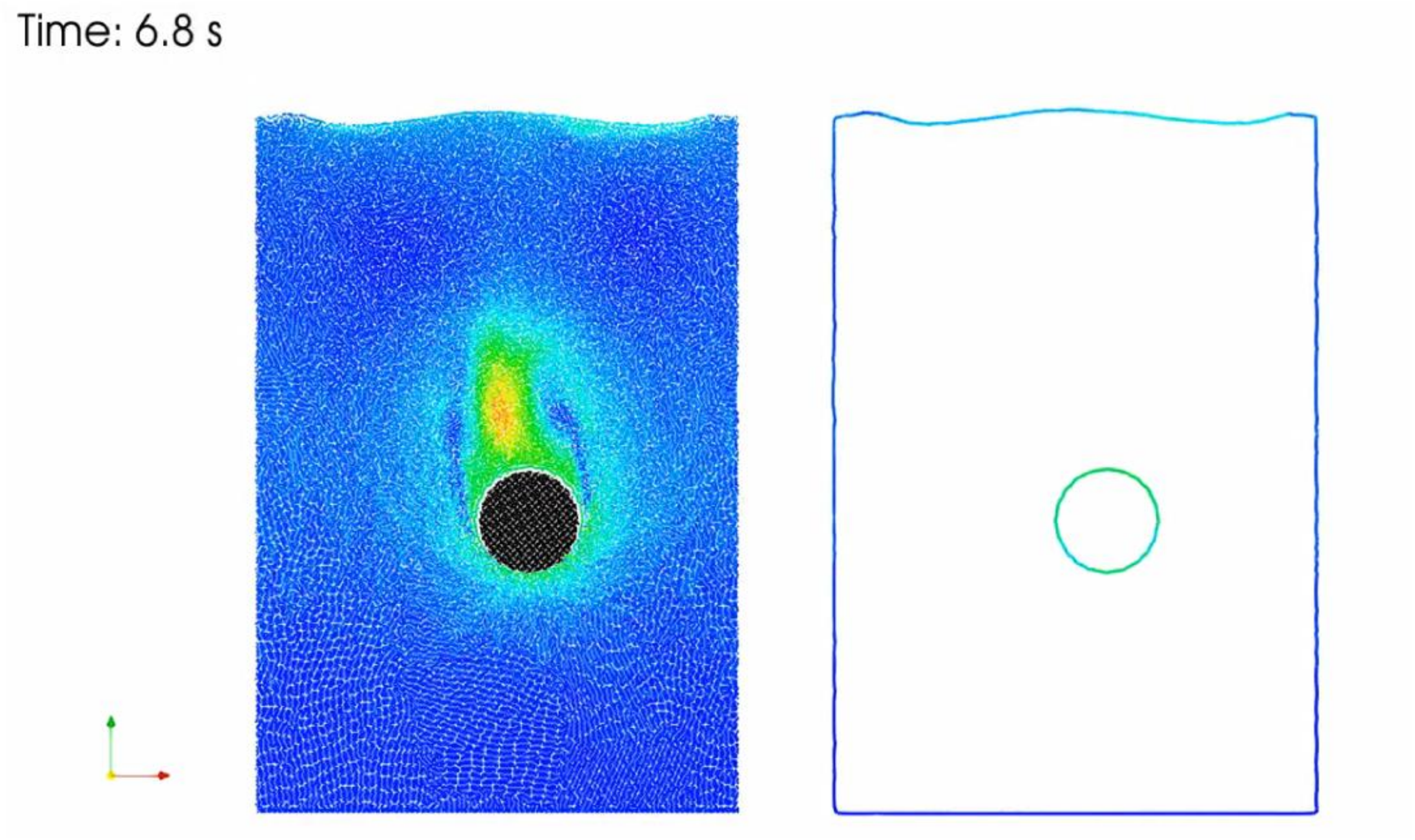
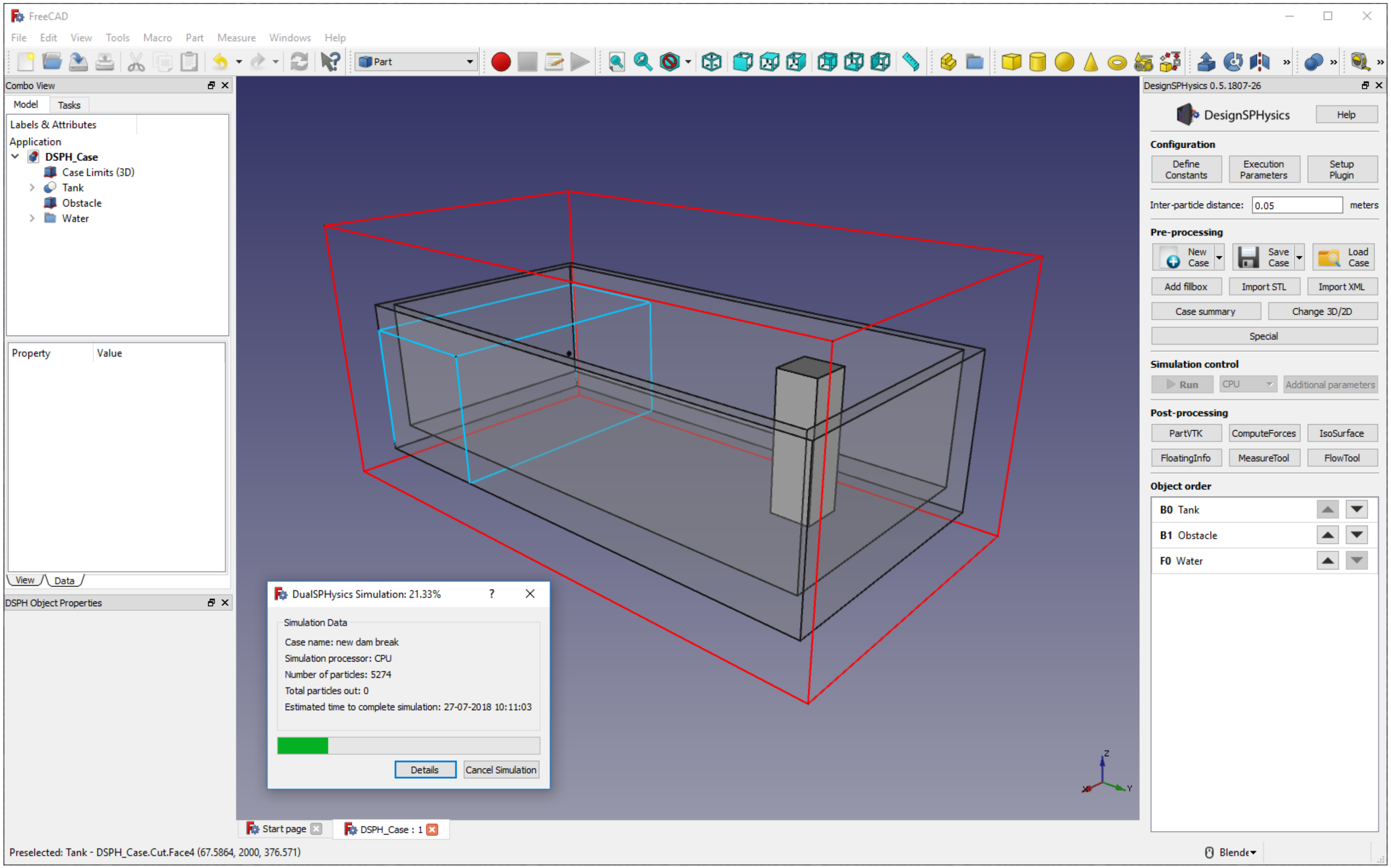


Novelties on v4.2 – Graphical User Interface

Graphical User Interface using FreeCAD with **DesignSPHysics**: http://design.sphysics.org/

Source code available at https://github.com/DualSPHysics/DesignSPHysics



Novelties on v4.2 – Graphical User Interface

22 October 2018
4th DualSPHysics Users Workshop, Instituto Superior Tecnico, Lisbon, Portugal

27 September 2018
Short Course on “Computational Fluid Dynamics for Free Surface Flows by Smoothed Particle Hydrodynamics”, University of Florence, Italy

25 June 2018
13th SPHERIC Workshop, National University of Ireland, Galway, Ireland

19 June 2018
Course: “DualSPHysics: Numerical tool in coastal engineering and marine energy”, Centro de Estudios de Técnicas Aplicadas del CEDEX, Madrid, Spain

10 April 2018
SPH 2-day CPD Course, University of Manchester, UK

13 November 2017
3rd DualSPHysics Users Workshop, University of Parma, Italy

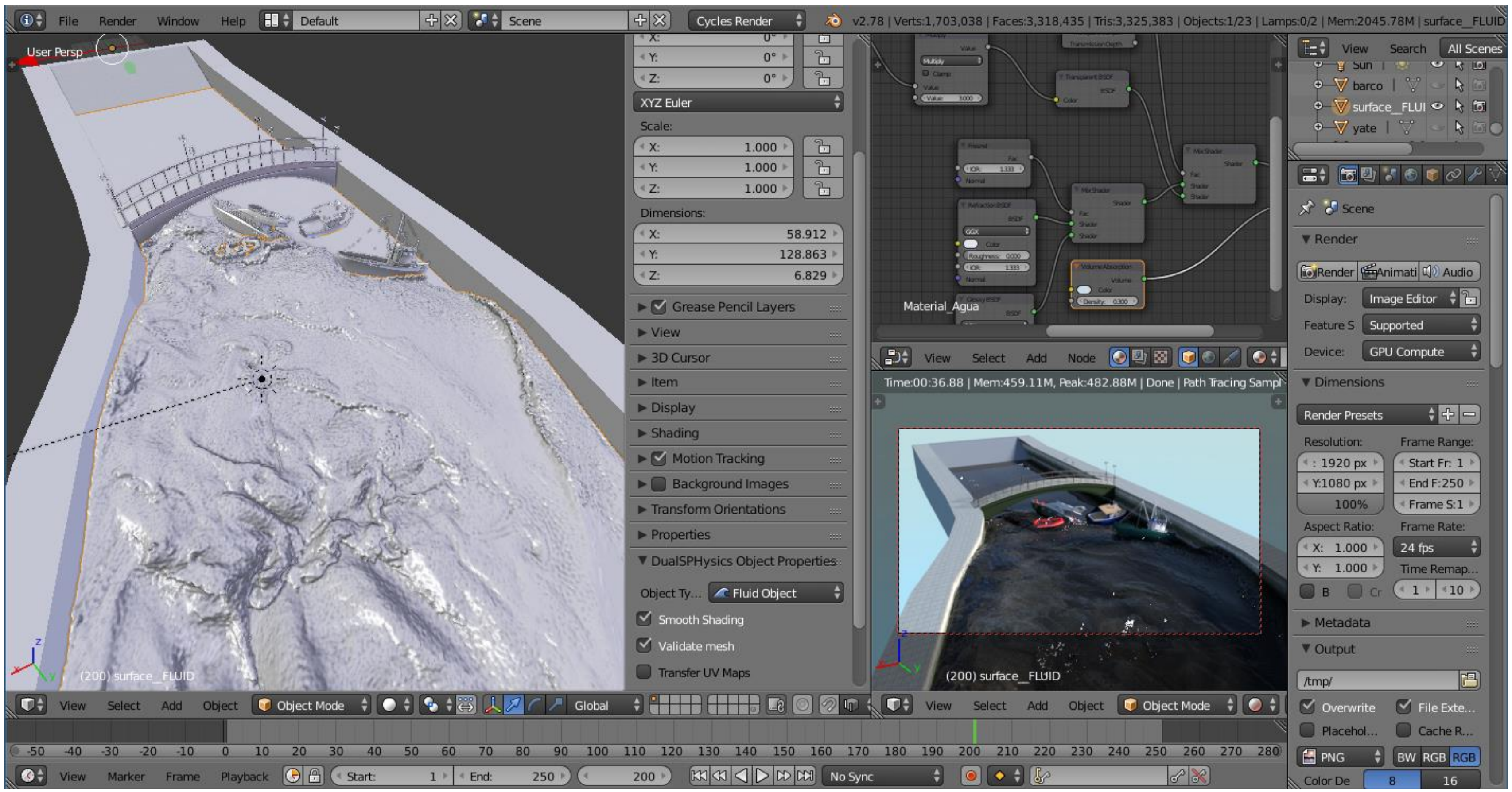
17 October 2017
SPHERIC Beijing International Workshop, Peking University (PKU), China

12 June 2017
12th SPHERIC Workshop, Universidade de Vigo, Ourense, Spain

Novelties on v4.2 – Advanced visualisation

Advanced visualisation using Blender with **VisualSPHysics**: http://visual.sphysics.org/

Source code available at https://github.com/EPhysLab-UVigo/VisualSPHysics



Novelties on v4.2 – Advanced visualisation

Advanced visualisation using Blender with **VisualSPHysics**: http://visual.sphysics.org/

Source code available at https://github.com/EPhysLab-UVigo/VisualSPHysics

Novelties on v4.3

i) Coupling with wave propagation models
(SWASH, Relaxation zone, etc)

ii) Coupling with Project Chrono
(Multi-physics)

iii) Open boundaries
(Inlet & Outlet)

iv) Correction for Dynamic Boundary Conditions

Novelties on v4.3

Day 3 (24/10/2018)		
09:00 - 09:40	DualSPHysics modelling sea waves. New developments, capabilities and practical examples.	Dr Corrado Altomare, Ghent University
09:40 - 10:20	Multiphase simulations in DSPH. New developments, capabilities and practical examples.	Dr Georgios Fourtakas, University of Manchester
10:20 - 10:50	Coffee Break	
10:50 - 11:30	Open Inlet/Outlet boundary conditions. New developments, capabilities and practical examples.	Dr Angelo Tafuni, New Jersey Institute of Technology
11:30 - 12:10	Presenting DualSPHysics with a Chrono Project implementation. New developments, capabilities and practical examples.	Dr Ricardo Canelas, University of Lisbon
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PPTs will include detailed information and explanation of the examples
They will be converted into PDF and uploaded at the website

Novelties on v4.3

STRUCTURE:

doc

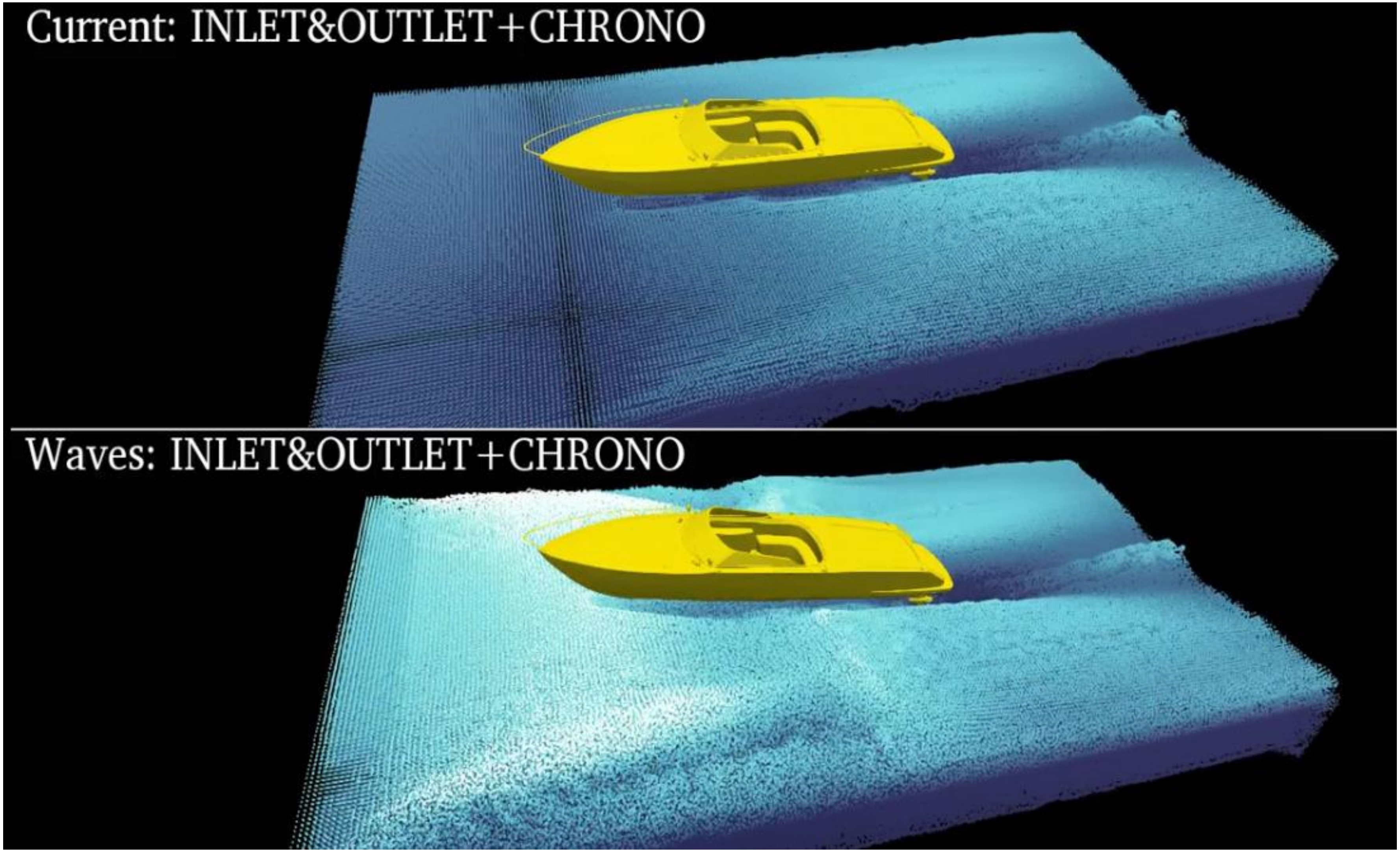
- **xml_format**
  - **_FmtXML_MLPistons.xml**
  - **_FmtXML_RelaxationZones.xml**
  - **_FmtXML_Chrono.xml**
  - **_FmtXML_BoundCorr.xml**
  - **_FmtXML_InOut.xml**

examples

- **main**
- **twophases**
- **others**
- **wavecoupling**
- **chrono**
- **inletoutlet**
- **boundcorrection**

Novelties on v4.3

Planning HULL: CHRONO + INLET&OUTLET



Novelties on v4.3

Correction for Dynamic Boundary Conditions

- It has been obtained as a special case of Open boundary conditions

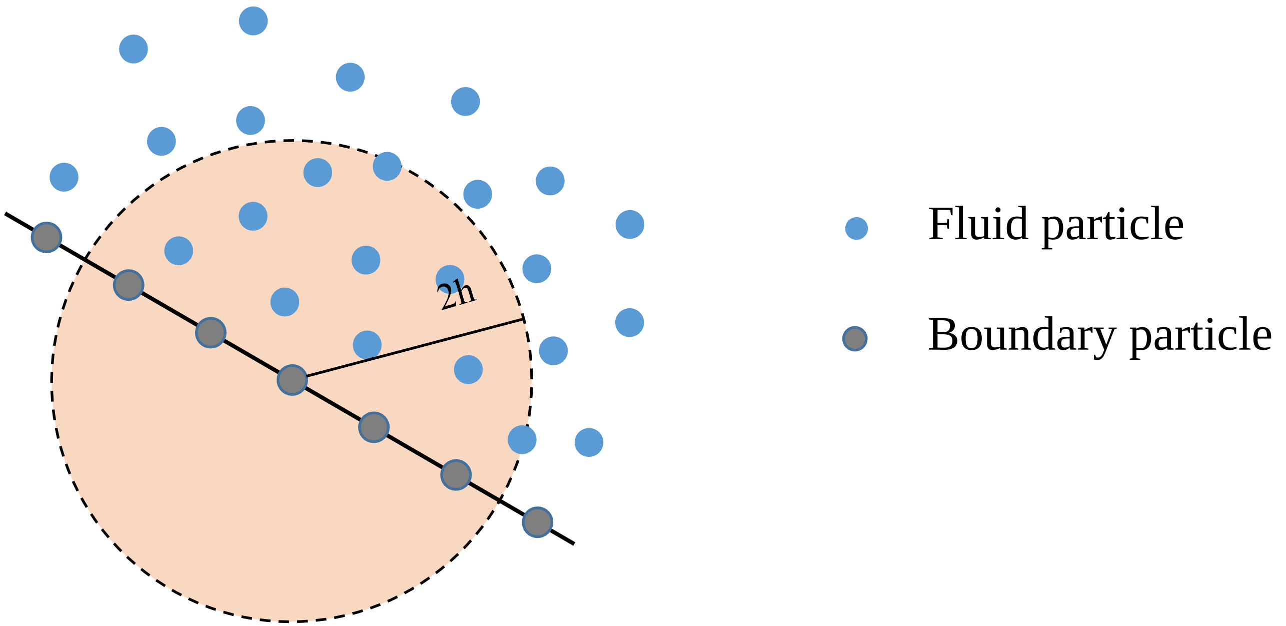
  (see presentation of Dr. Tafuni)

- The aim is to fix some issues of Dynamic BC

- Similar to “Fixed Ghost Particles” of Marrone et al. (2011)

Novelties on v4.3

Dynamic boundary condition



Dynamic boundaries updated with continuity equation

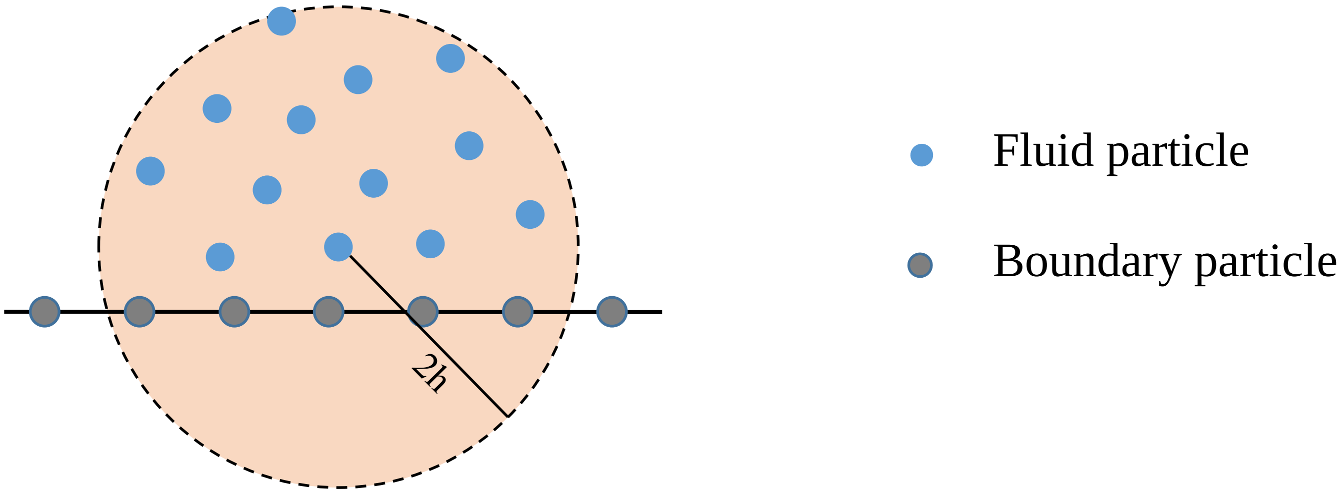
$$\frac{d\rho_a}{dt} = \sum_b (\mathbf{v}_a - \mathbf{v}_b) \cdot \nabla W_{ab}$$

No momentum Equation

$$\mathbf{v}_a = 0$$

Novelties on v4.3

Fluid – Boundary Interaction



Fluid – Boundary interaction:

$$\frac{d\rho_a}{dt} = \sum_b m_b (\mathbf{v}_a - \mathbf{v}_b) \cdot \nabla W_{ab}$$

$$\frac{d\mathbf{v}_a}{dt} = \sum_b m_b \frac{p_a + p_b}{\rho_a \rho_b} \cdot \nabla W_{ab}$$

Novelties on v4.3

DYNAMIC BOUNDARY CONDITIONS

ADVANTAGES

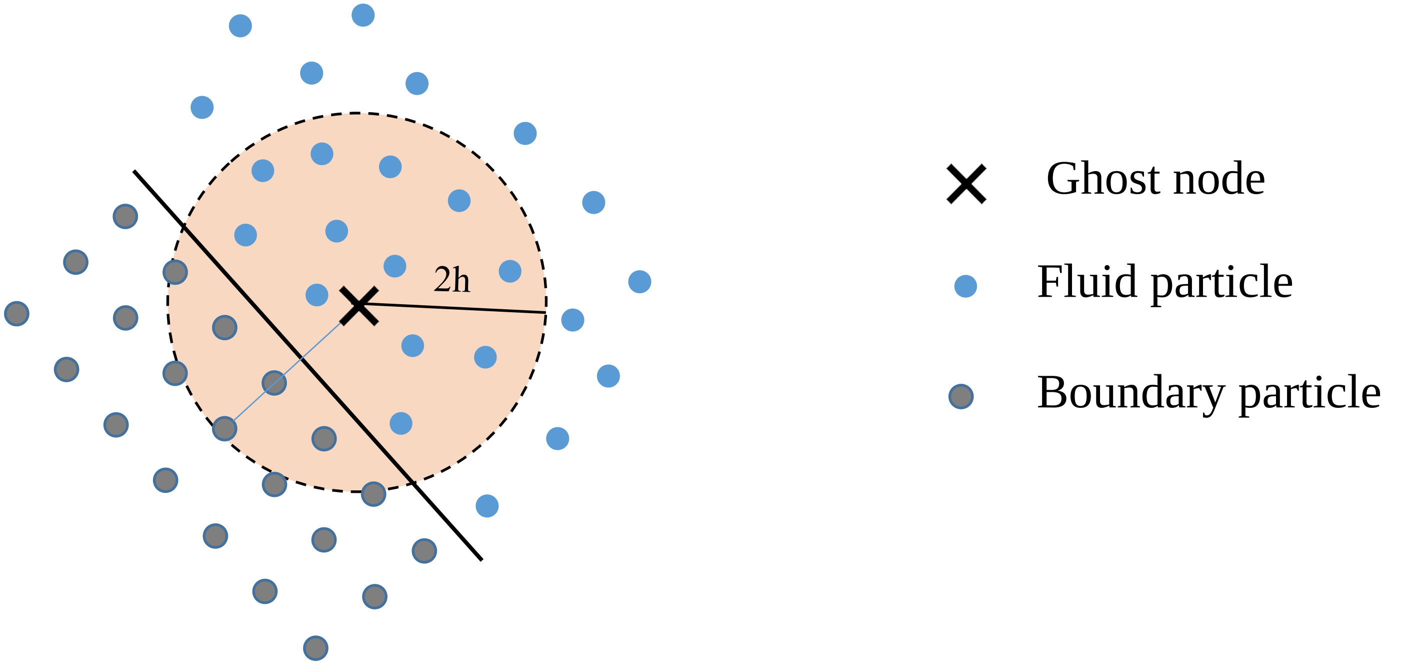
DBC can be applied to arbitrary 2-D and 3-D geometries
provide good validation in many engineering problems

DISADVANTAGES

unphysical density/pressure values of the boundary particles
high repulsive force resulting in a separation distance (GAP)

Novelties on v4.3

Correction for DBC



Corrected SPH sum at ghost point:

$$\rho_g = \sum_b m_b \overline{W}_{gb} \qquad \nabla\rho_g = \sum_b m_b \bar{\nabla} W_{gb}$$

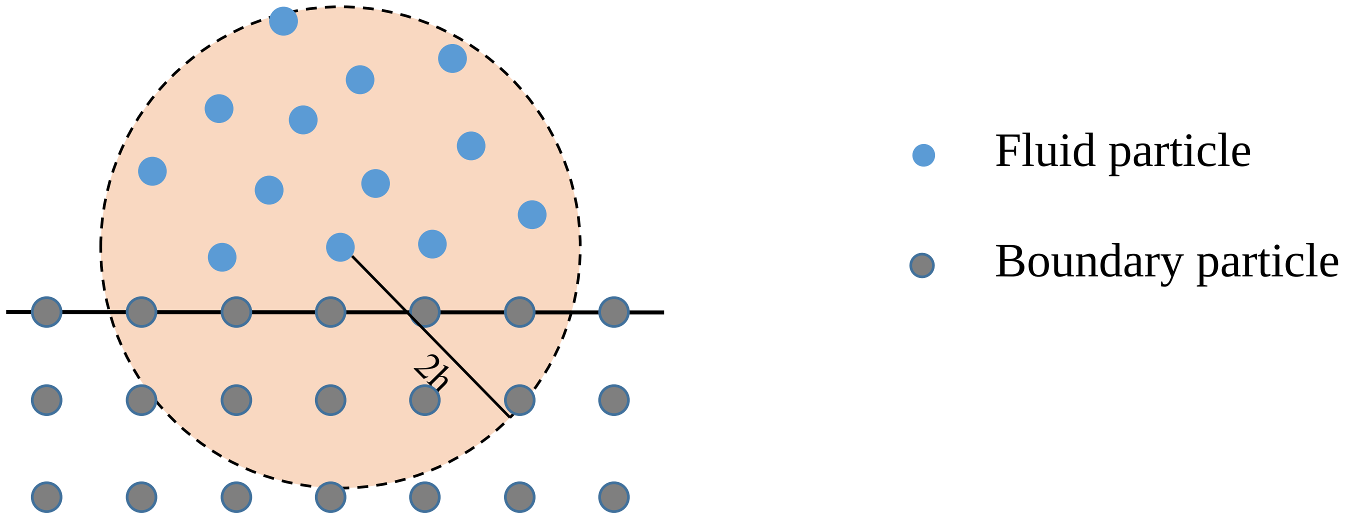
$$\rho_a = \rho_g + (\mathbf{r}_a - \mathbf{r}_g) \cdot \nabla\rho_g$$

$$\mathbf{v}_a = 0$$

Novelties on v4.3

Correction for DBC

Fluid – Boundary Interaction



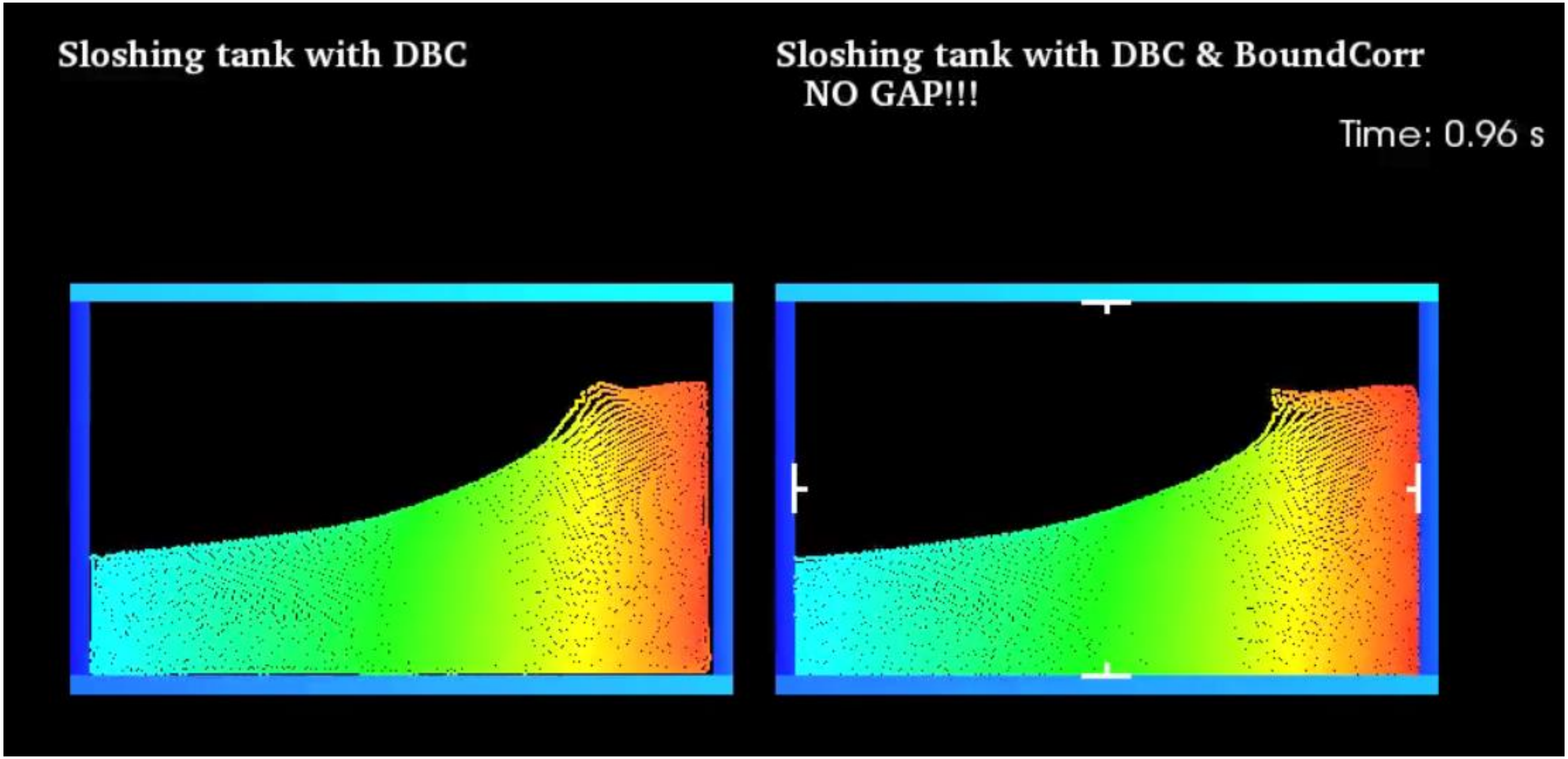
Fluid – Boundary interaction:

$$\frac{d\rho_a}{dt} = \sum_b m_b (\mathbf{v}_a - \mathbf{v}_b) \cdot \nabla W_{ab}$$

$$\frac{d\mathbf{v}_a}{dt} = \sum_b m_b \frac{p_a + p_b}{\rho_a \rho_b} \cdot \nabla W_{ab}$$

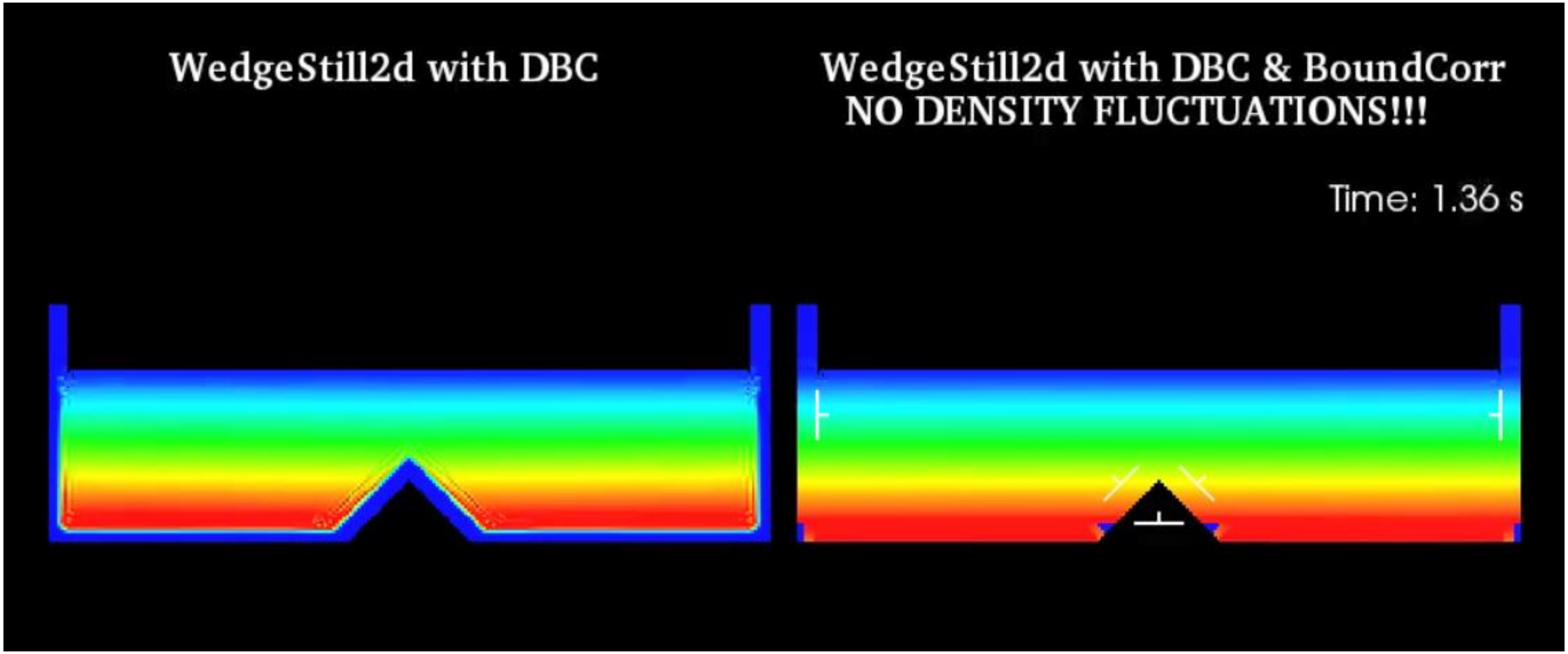
Novelties on v4.3

Correction for DBC: NO GAP



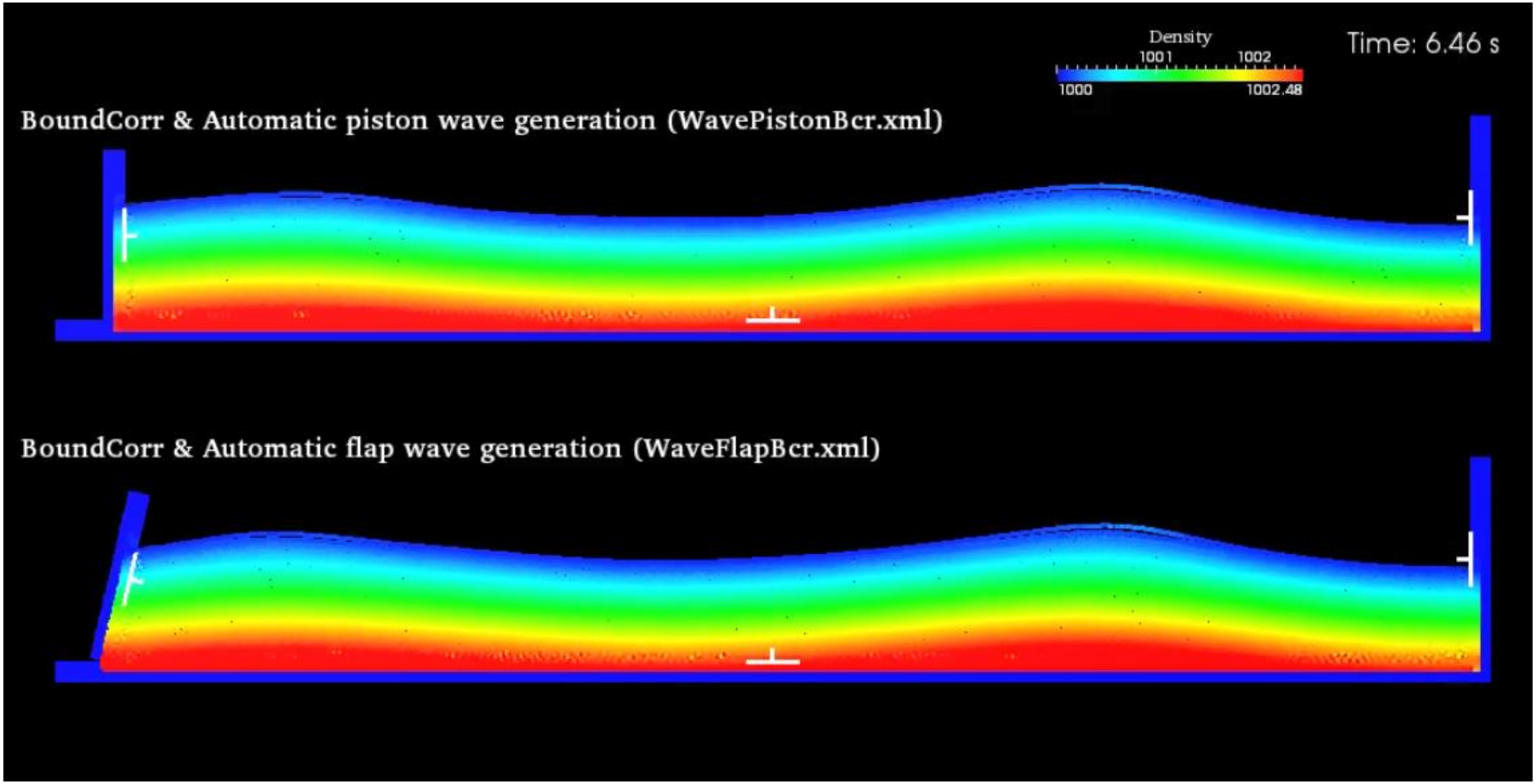
Novelties on v4.3

Correction for DBC: NO DENSITY FLUCTUATIONS



Novelties on v4.3

Correction for DBC:
NO GAP & NO DENSITY FLUCTUATIONS



Novelties on v4.3

Correction for DBC

- No unphysical gap between fluid and boundary
- Less oscillation in the pressure field
- More computationally expensive
- Unit vector for each boundary particle has to be calculated
- At the moment only available **v**=0, but it can be generalized for slip and no slip.

Novelties on v4.3

i) Coupling with wave propagation models
(SWASH, Relaxation zone, etc)

ii) Coupling with Project Chrono
(Multi-physics)

iii) Open boundaries
(Inlet & Outlet)

iv) Correction for DBC

Future novelties

Beta v4.3 → **Release of v4.4**

NEXT VERSIONS

- Coupling with MoorDyn library
- Other BCs
- Incompressible SPH
- Variable particle resolution
- **Multi-GPU implementation**