

6-way coupling of DEM+CFD+FEM with preCICE

preCICE workshop 2020

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Outline

Our goal

- Multi-physics coupling
- Coupling of 3 solvers

DEM+CFD+FEM Coupling

- deal.II
- OpenFOAM
- XDEM

Results

- 6-way coupling on testcase

Conclusion

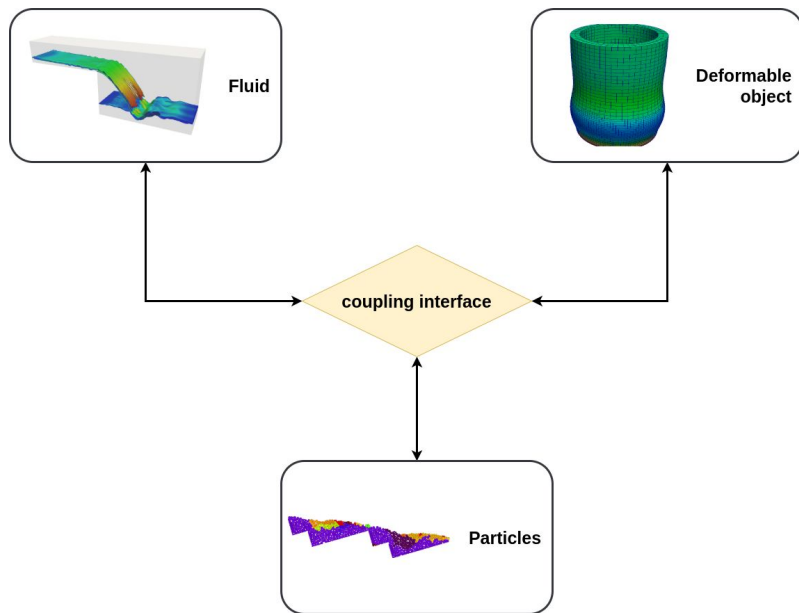
- Future Work

Multi-physics coupling

GOAL

Our goal

- 6-way coupling DEM+CFD+FEM (with volume coupling)
 - *Fluid* \leftrightarrow *Deformable object*
 - *Particles* \leftrightarrow *Fluid*
 - *Deformable object* \leftrightarrow *Particles*

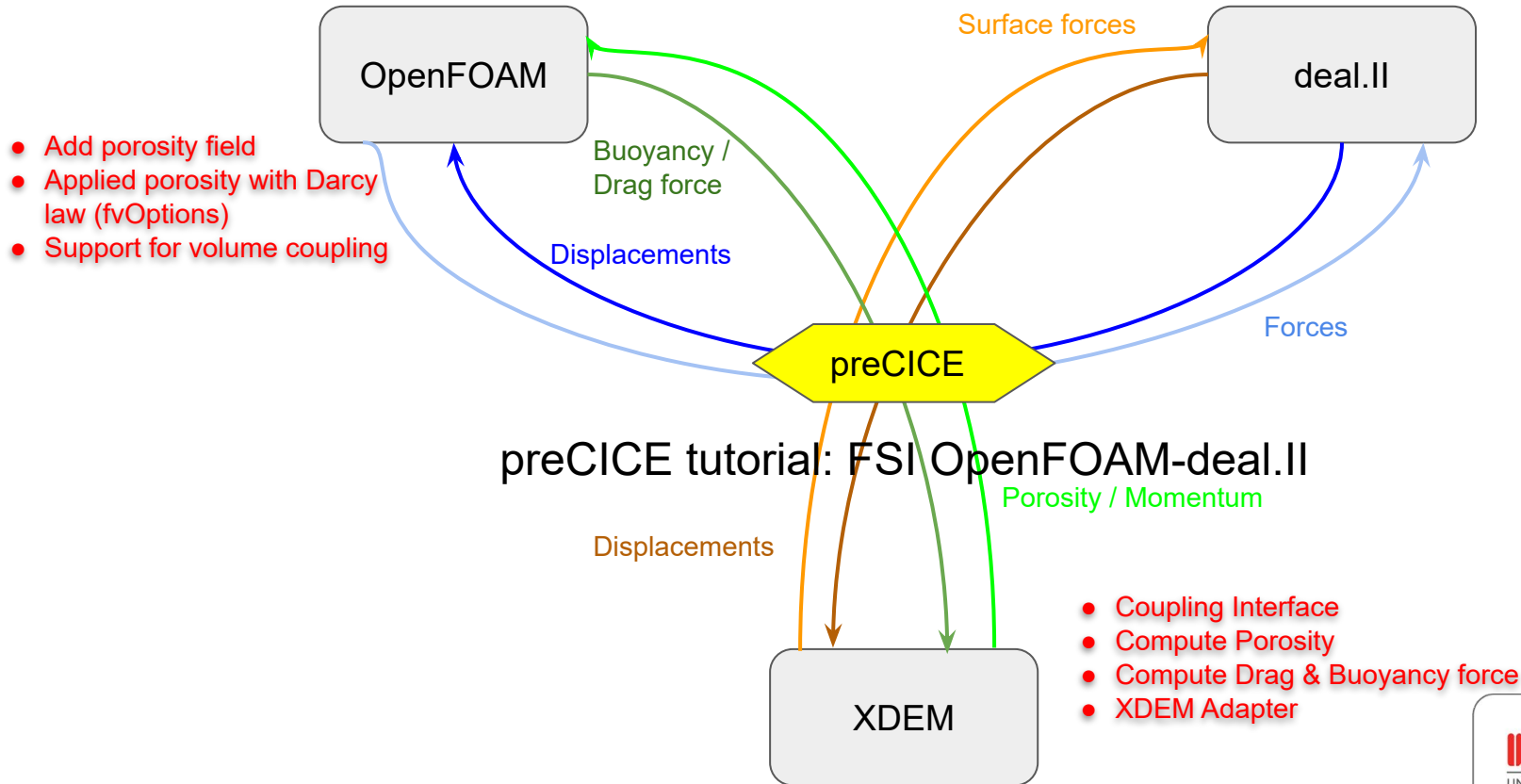


Coupling of 3 solvers

- CFD: OpenFOAM
- FEM: deal.II
- DEM: XDEM

DEM+CFD+FEM coupling

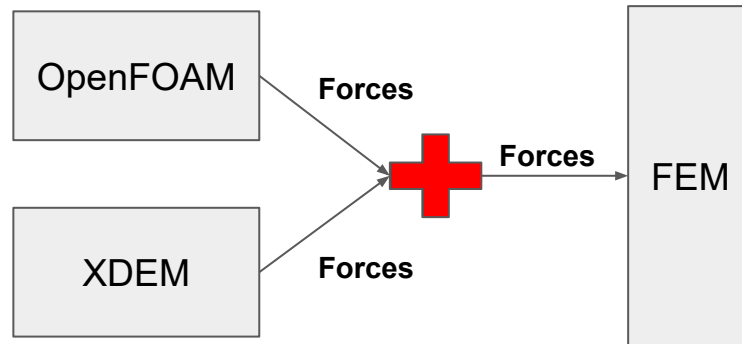
- Sum of forces from DEM & CFD



deal.II

Modifications for deal.II

- Computation of a sum of forces (from CFD / DEM to FEM)
 - Forces from particles + Forces from Fluid



Open questions

- Operations over data without modifying adapters?

OpenFOAM

Modifications for OpenFOAM

Solver: PorousPimpleFoam

- Add **porosity** field
- Applied porosity with **Darcy law** (fvOptions)

Adapter

- Support for **volume coupling** (thanks to PR#97 OF adapter <https://precice.discourse.group/t/can-precice-be-used-for-volume-coupling/27/3>)

Open questions

- Add porosity in the solver equation as a semi-implicit source

XDEM

What is XDEM?

eXtended Discrete Element Method

Dynamics

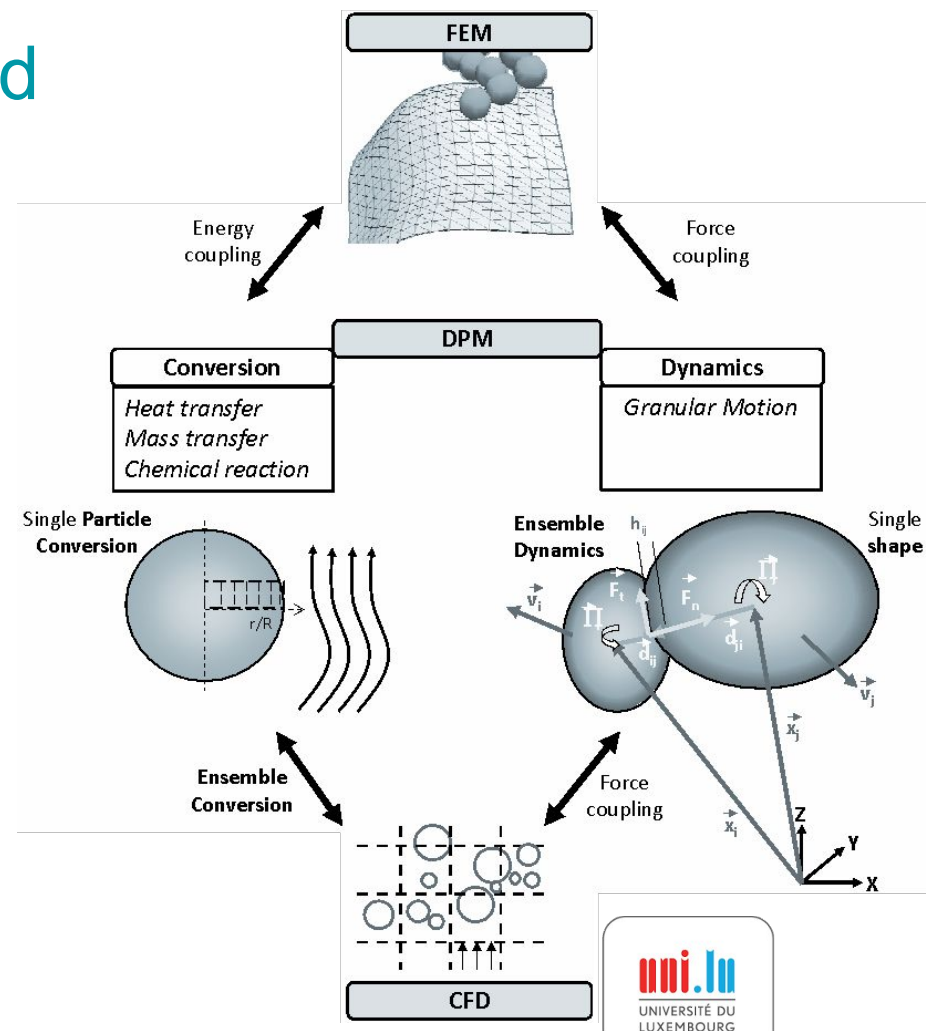
- Force and torques
- Particle motion

Conversion

- Heat and mass transfer
- Chemical reactions

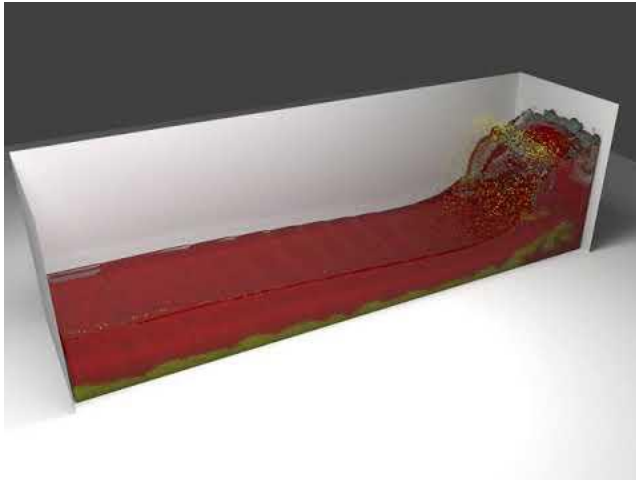
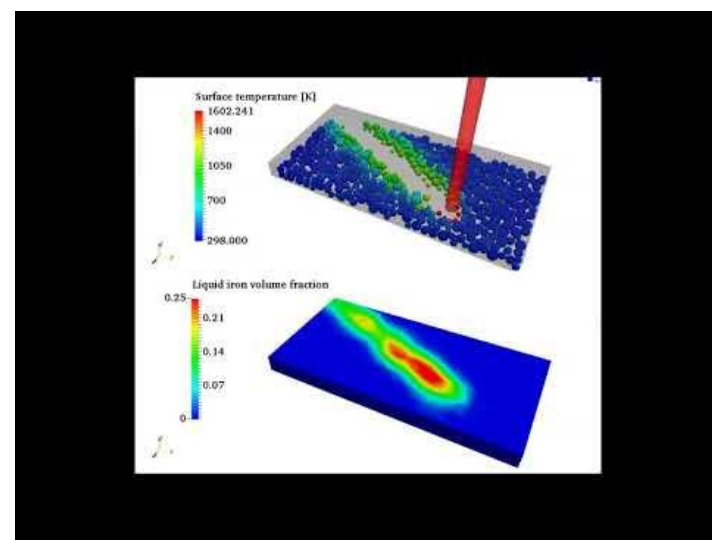
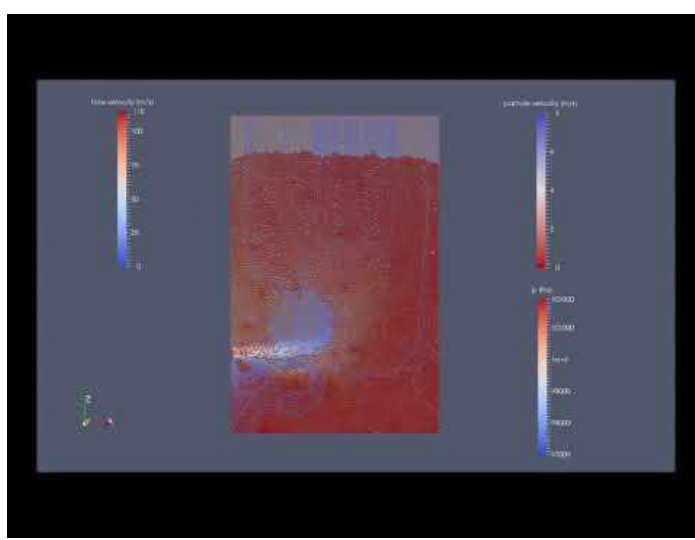
AD-Hoc Coupling with

- CFD: Foam-extend / OpenFOAM
- FEM: Diffpack

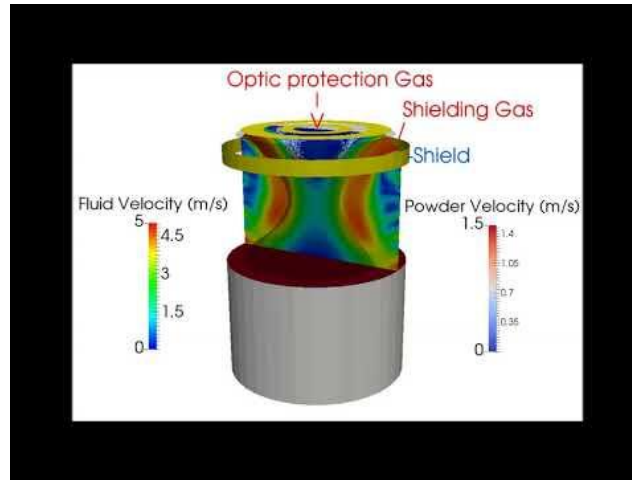


Examples

Formation of a Raceway in a Blast Furnace



Dam Break



Selective Laser Melting

Selective Laser Melting Powder dynamics

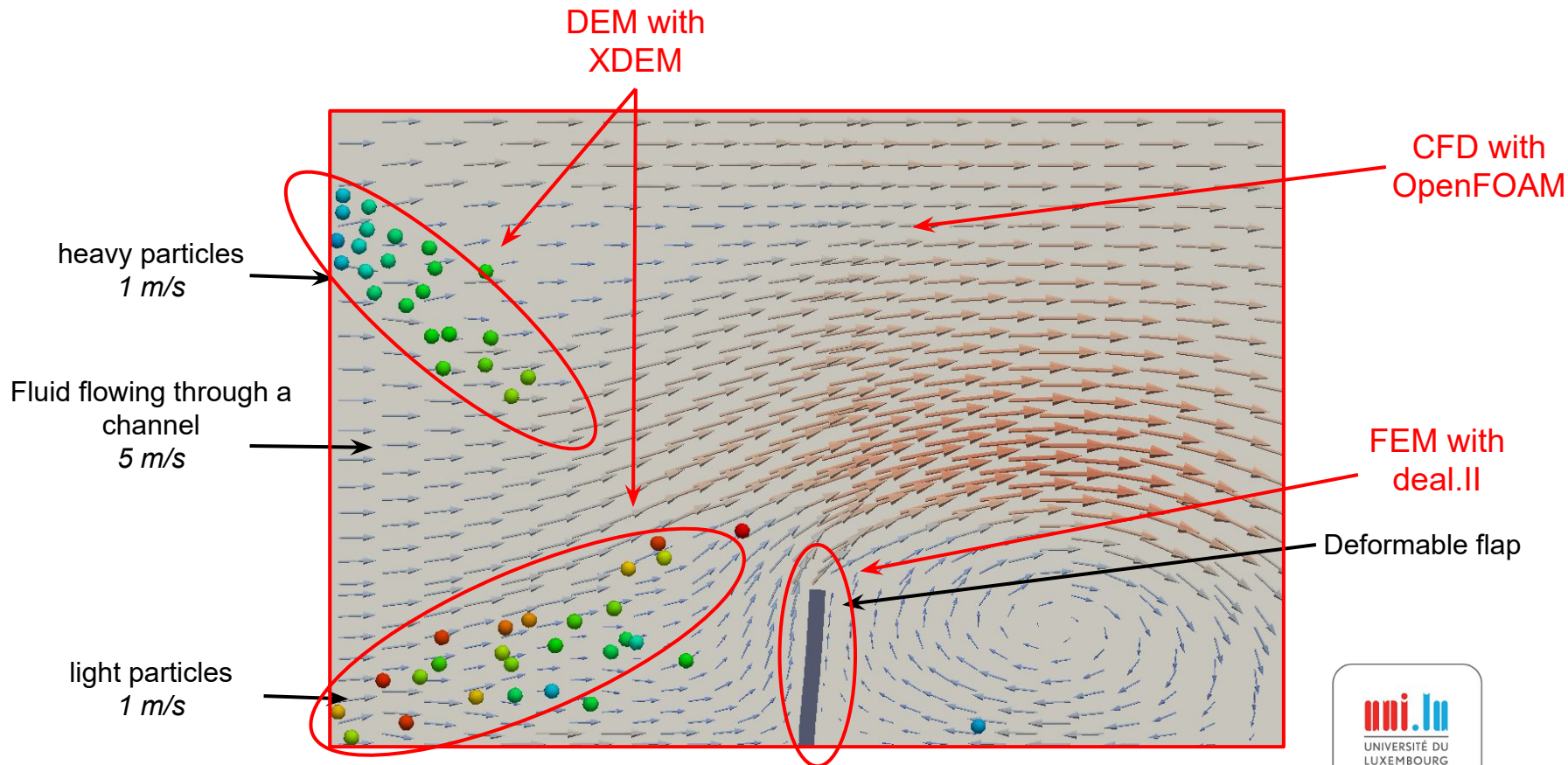


Creation of XDEM Adapter and interface coupling

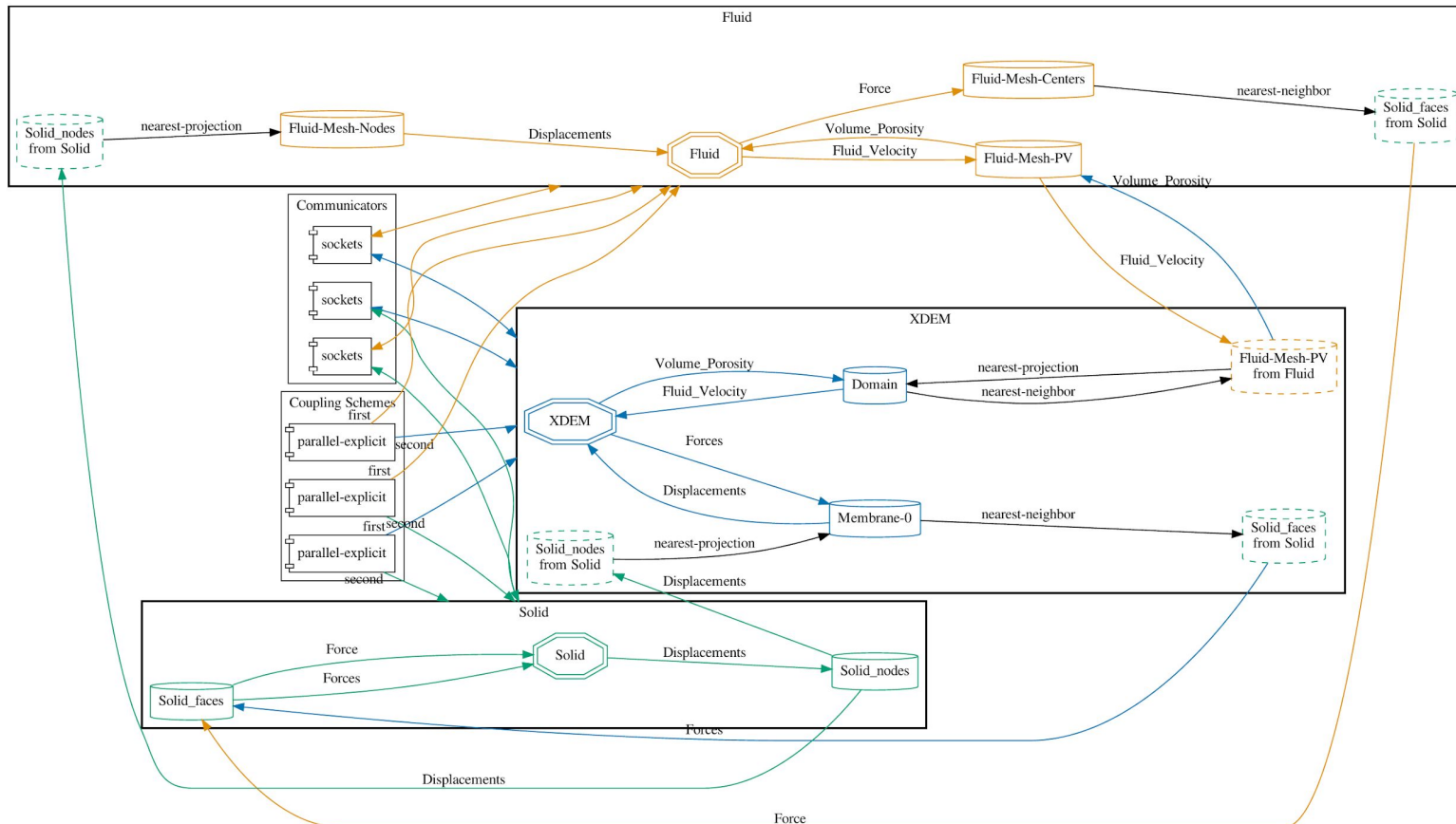
Re-organize coupling functionalities into a coupling interface

- CFD Coupling interface for XDEM
 - Computation of **porosity**
 - Computation of **drag** and **buoyancy forces** (from fluid velocity)
- FEM Coupling interface for XDEM
 - Integration of **displacements** (from solid forces)
- Creation of **XDEM adapter** for preCICE

Testcase

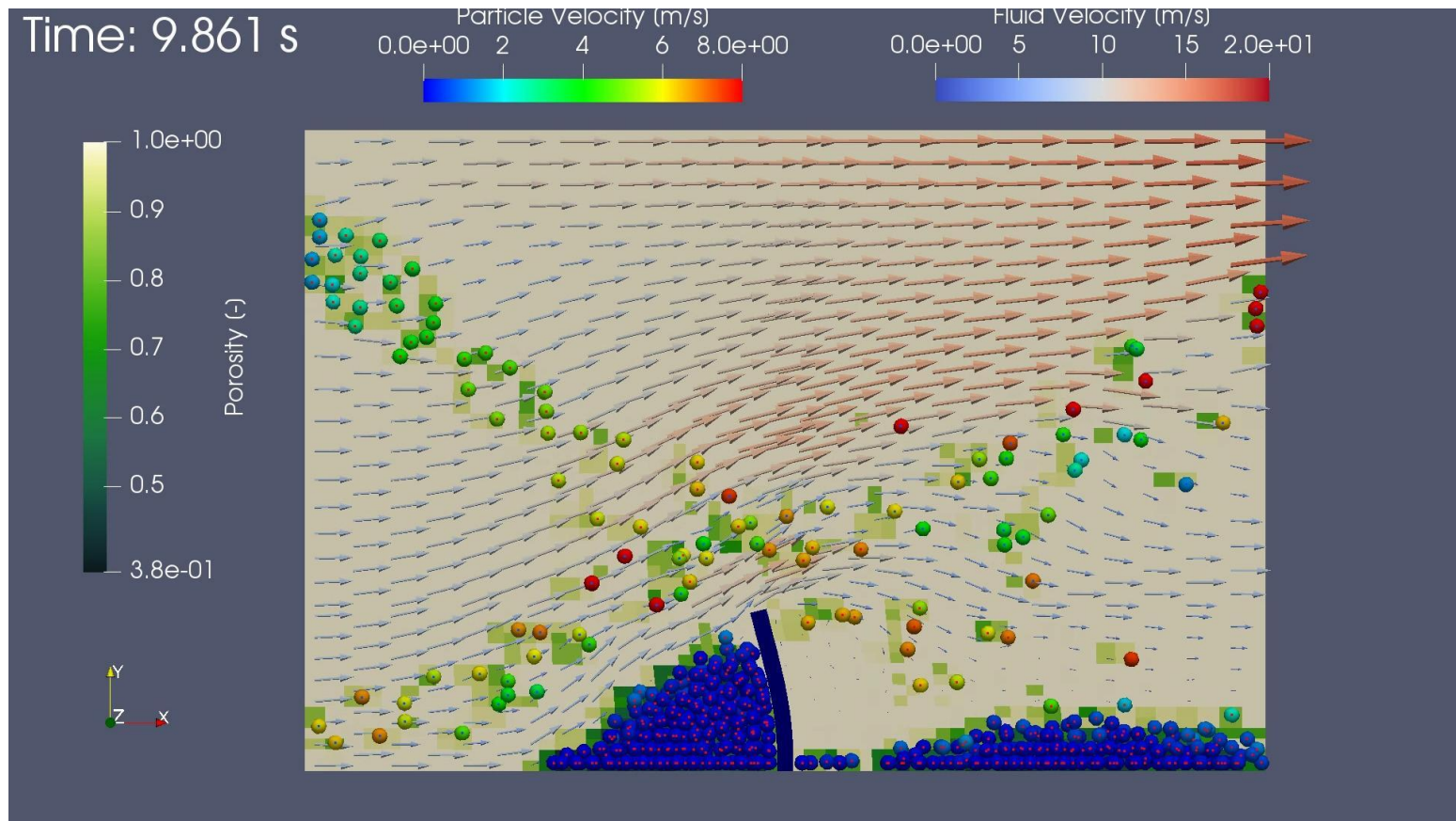


preCICE config

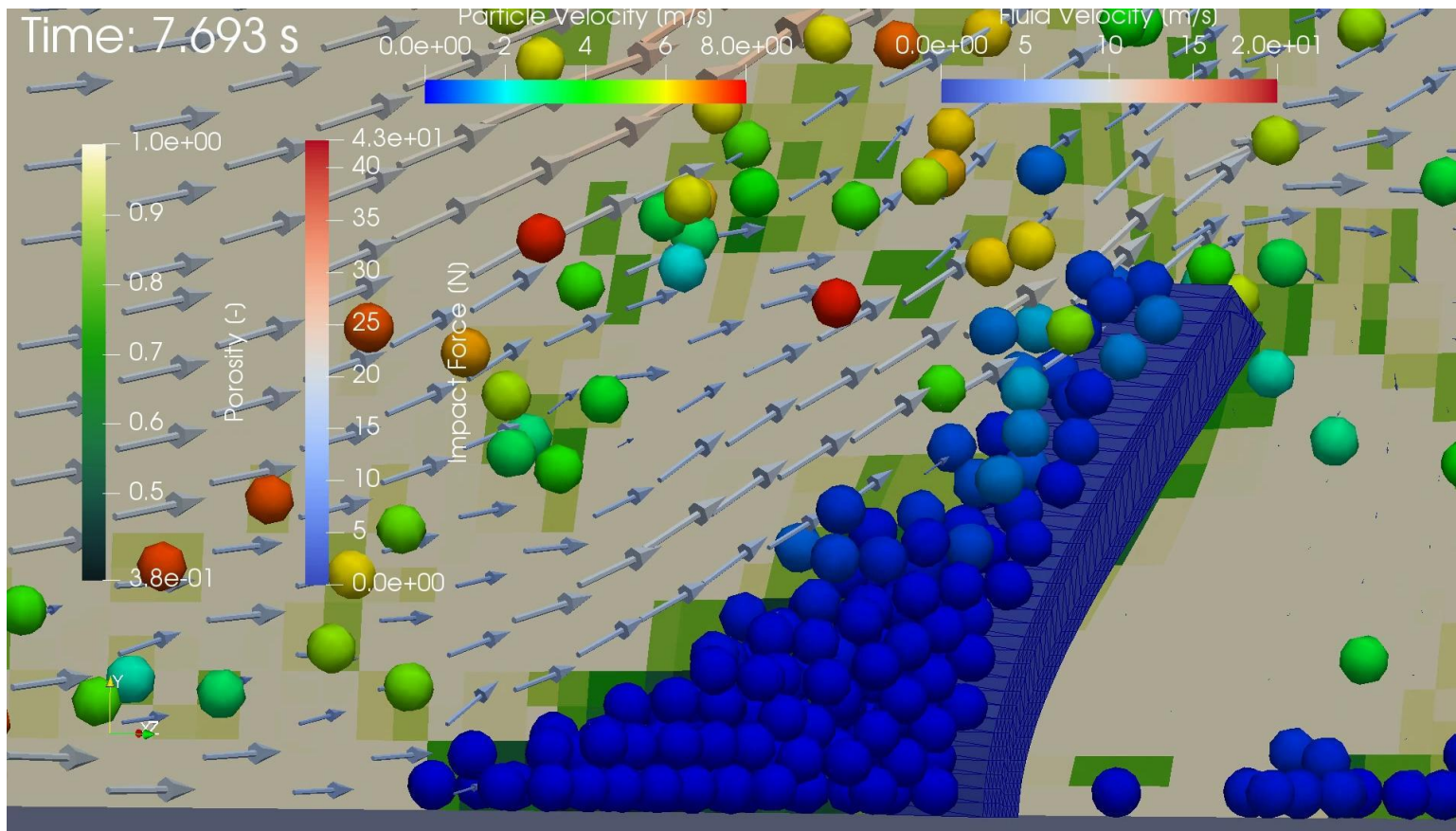


Results

Results: 6-way coupling DEM+CFD+FEM



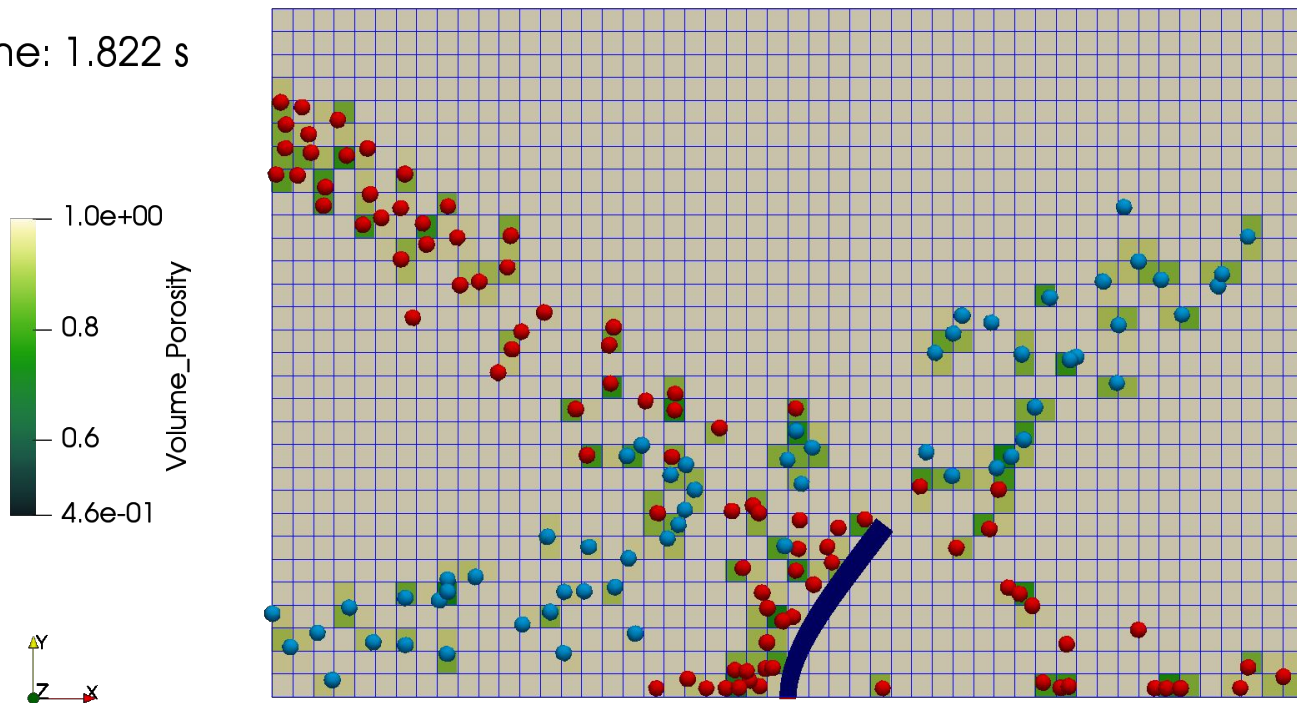
Results: 6-way coupling DEM+CFD+FEM



Porosity field and mesh displacement

Porosity field after mesh displacement in OpenFOAM

Time: 1.822 s



Conclusion

Preliminary results: 6-way coupling

OpenFOAM Adapter

- Volume coupling (PR#97)

Coupling interface in XDEM

- DEM + CFD
- First step into preCICE coupling

Future work / Other issues

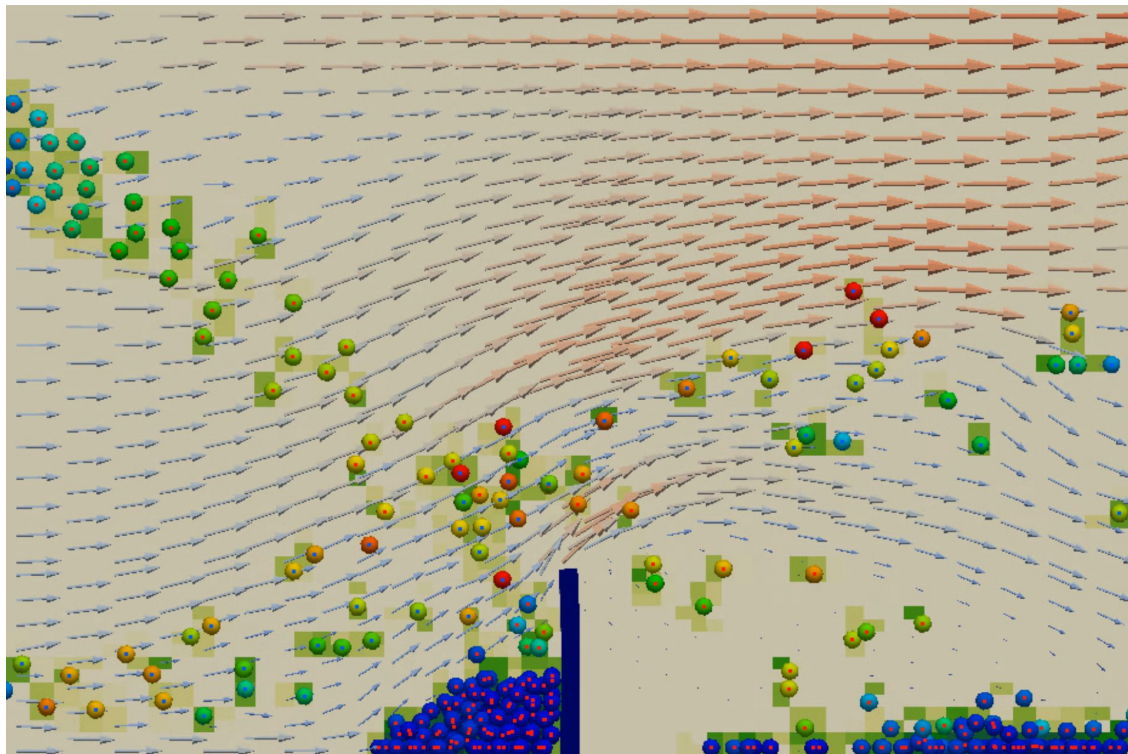
- Porosity field and mesh displacements
- Heat and mass transfer (DEM-CFD)
- Use realistic test cases (dam break)
- Run each solver in parallel

Thank you for your attention!



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