
**C**ollaborative **R**esearch into **E**xascale **S**ystemware,
**T**ools and **A**pplications

# Exascale Pre and Post Processing

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# CRESTA Work Package 5: User Tools

- Objectives: development of pre  and post processing as well as remote hybrid rendering tools to support exascale applications and users including:
  - Mesh manipulation and partitioning tools
  - Visualisation tools
  - Data management tools

# Survey

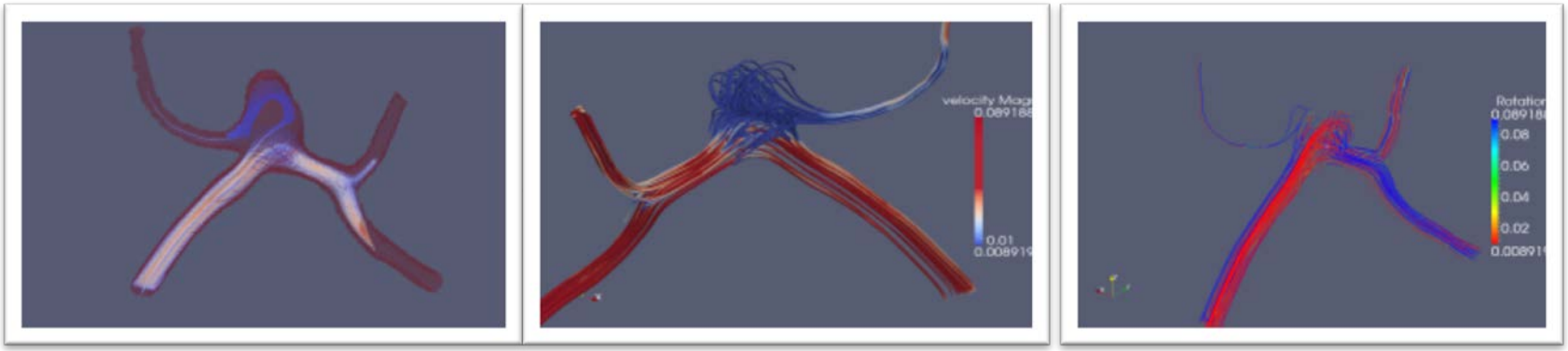
- Post Processing
- Remote Hybrid Rendering
- Pre processing interface PPSTee

# Challenges in Exascale Post Processing

- Huge amount of data to be processed and visualised
- Not possible to store data on disk
- Moving data is costly
- Memory issue
- Efficiency of parallelisation with respect to visualisation techniques
- Latency

# Post Processing

- Blood flow simulation for aneurysm study
- Flow visualisation
  - Volumes
  - Lines
  - Particles



# Approaches

- In-situ visualisation
  - Visualise on-going simulation result, without pausing simulation
  - Visualise coarse data
- Interactive visualisation
  - Interactive frame rates (no latency to human eyes)
  - Finding suitable visualisation techniques
  - Finding suitable parallelisation for chosen visualisation techniques
  - Exploring rendering with GPU
- Multi-resolution data visualisation
  - Define level of details.
  - Provide visualisation on different levels of details.
  - Enable first result on a much coarser mesh.

# In-Situ Visualisation

- Test result with HemeLB

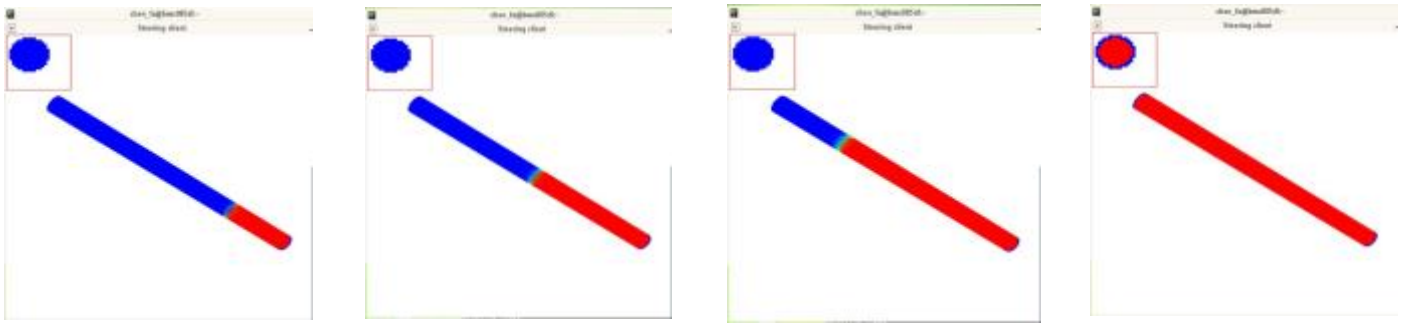
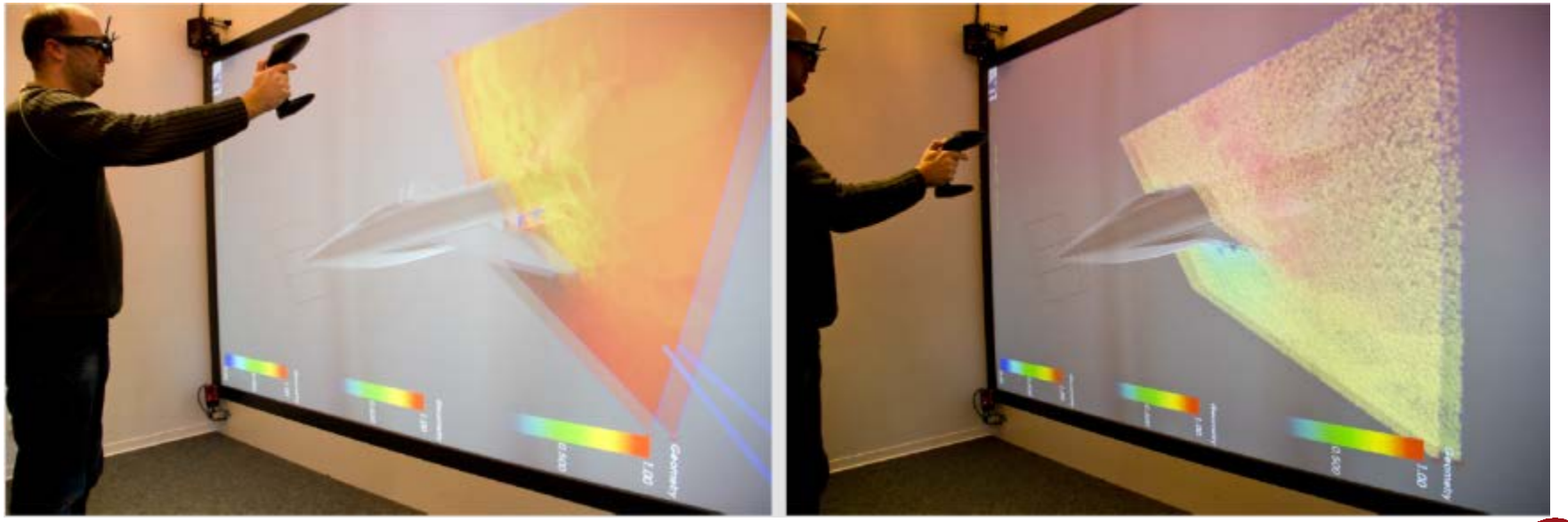


Fig: An example of cut plane in-situ visualisation of a testing simulation. This visualisation is provided at run time, i.e., while simulation is running.

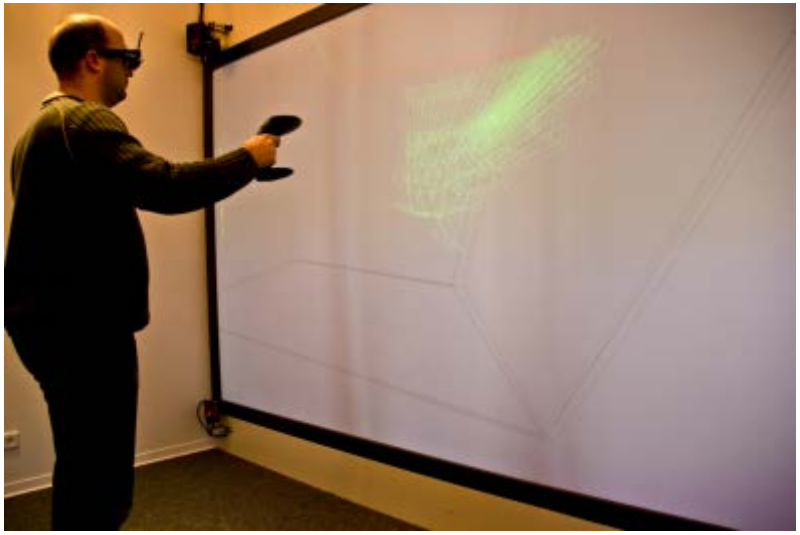
- Visualisation is done on the same node where simulation is performed.

# Using Virtual Reality

- Power-wall, display-wall systems
- Immersive visualisation
- Provide great details
- Enhanced depth perception in VR
- Enable user to explore their data in a natural way



# Computational Steering



- Steer mesh or simulation parameters
- Based on provided in-situ visualisation
- Carry out steering during simulation is running
- Prevent failure
- Achieve better convergence for the solver
- Saving time

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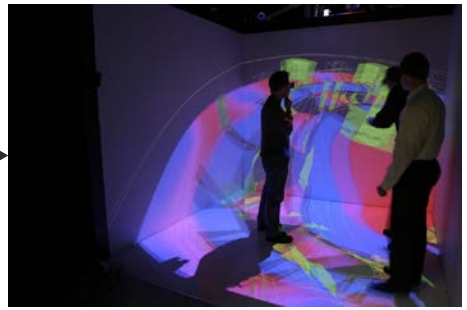
# Remote Hybrid Rendering

- Goal: Access simulations on exascale resources from desktops and immersive virtual environments.


Remote Desktops
(Zuffenhausen,
RWTH Aachen)

Remote Tiled Displays / Powerwalls
(HLRS, IHS)



Remote Virtual Reality
(Stuttgart, Sindelfingen)

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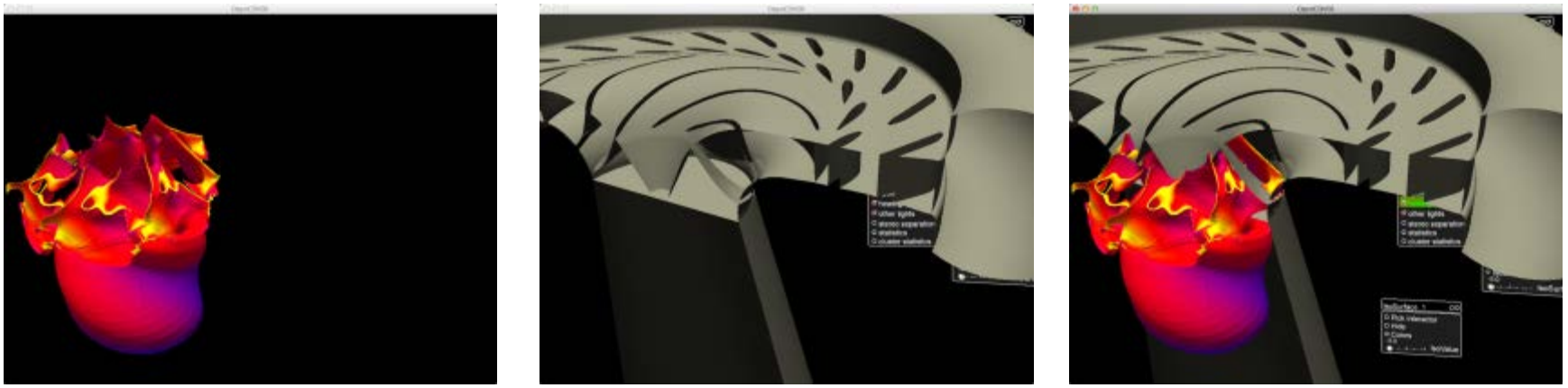
# Remote Hybrid Rendering: Advantage



Remote + Local = Display

- Simulation data is rendered on or near the exascale system using scalable methods
- Static context information is overlayed locally
- Better interactivity because of some decoupling of interaction from remote rendering

# PPSTEE

A Pre-Processing Interface for Steering Exascale Simulations by Intermediate Result Analysis through In-Situ Post-Processing

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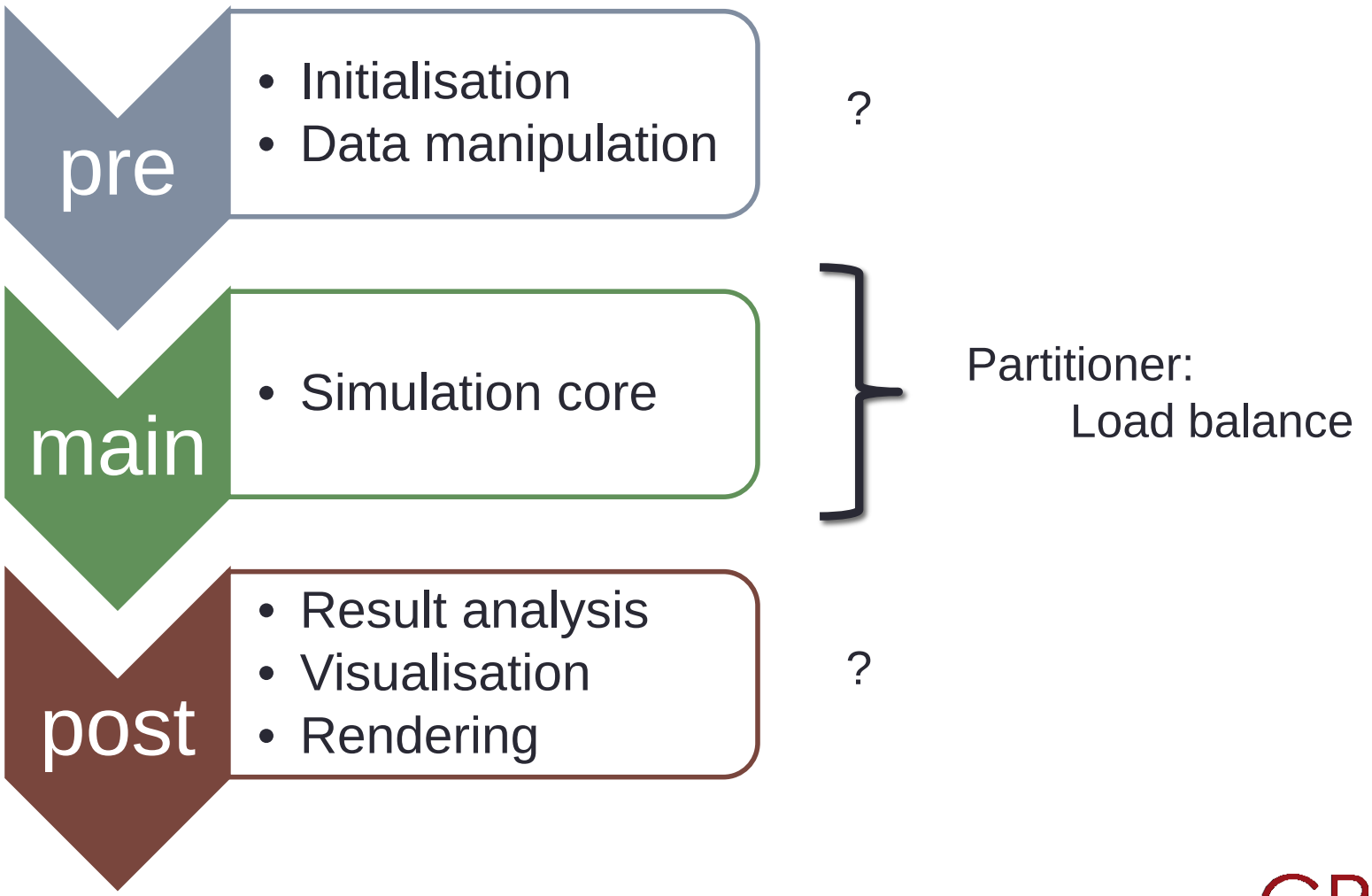
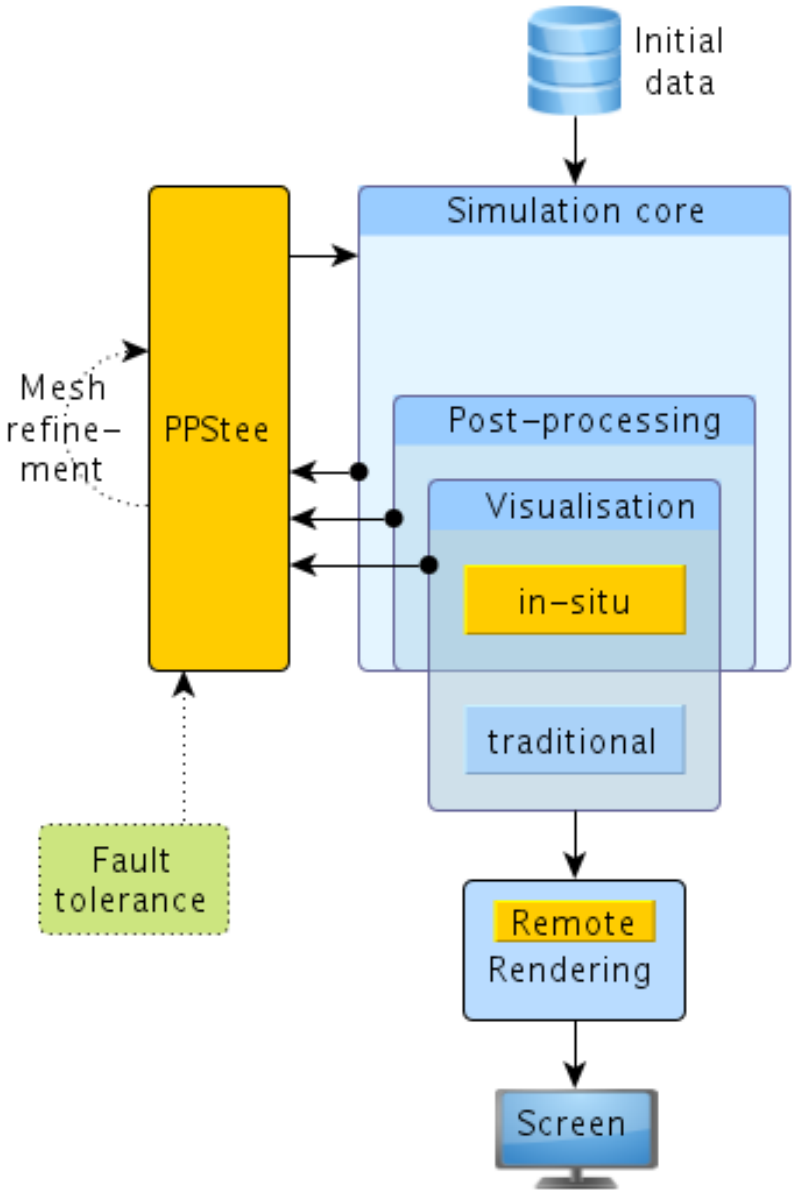
# Motivation

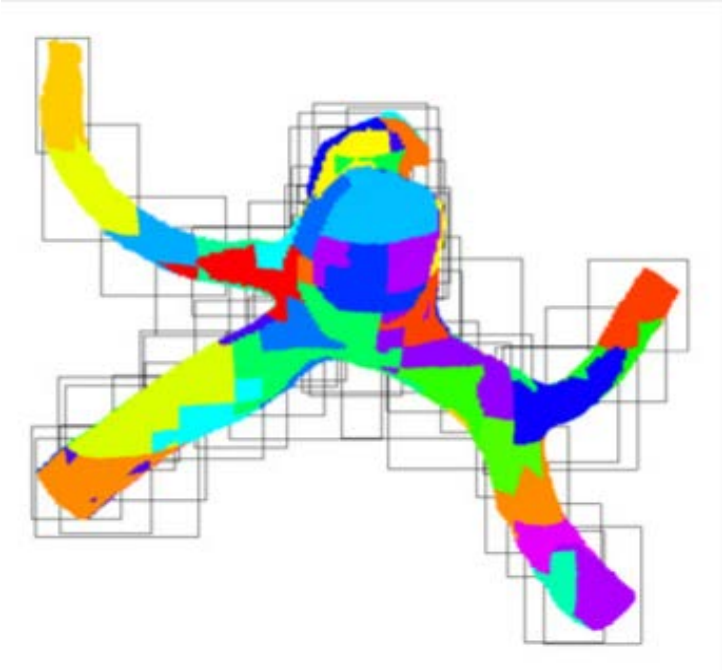

pre
• Initialisation
• Data manipulation
?
main
• Simulation core
Partitioner:
Load balance
post
• Result analysis
• Visualisation
• Rendering
?

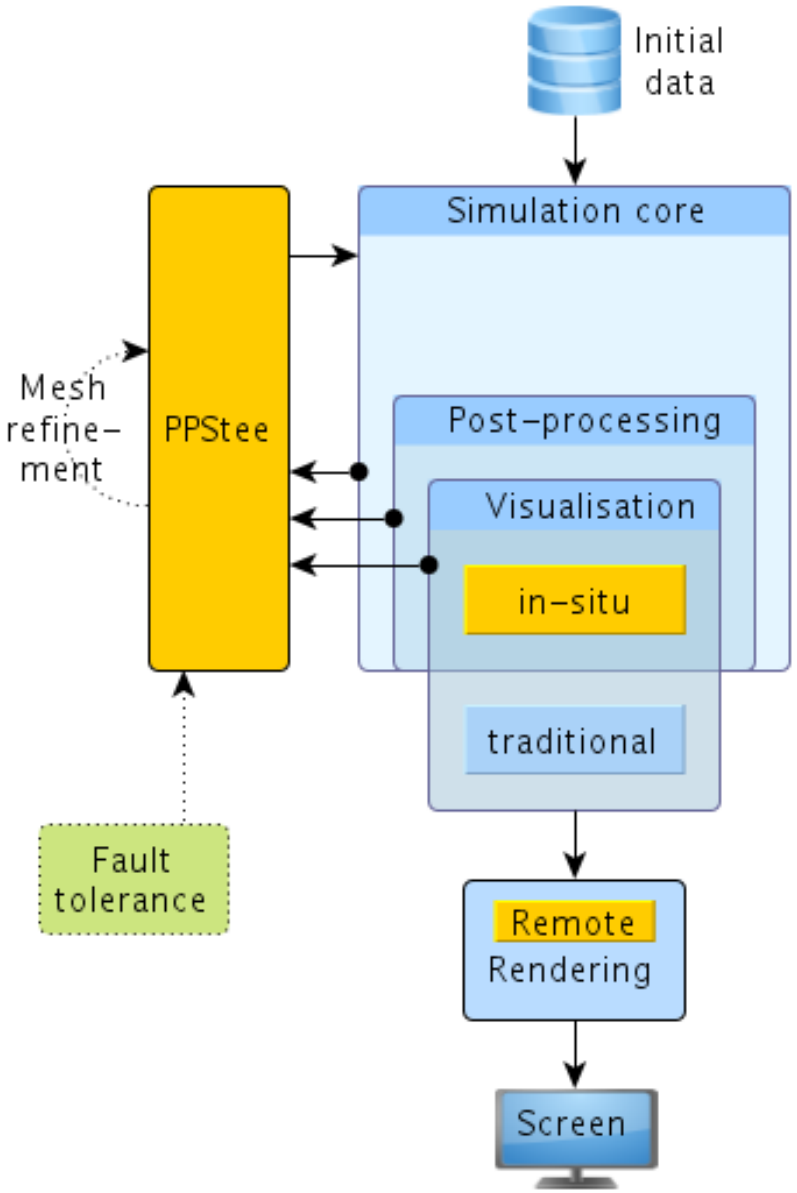
# PPStee data flow: overview



# Assumptions

- The simulation uses a partitioner
  - There is some sort of mesh
  - The mesh is there (= in memory): an initial (=bad) read-in happens
- The simulation has more than one stage
  - E.g.: an in-situ data analysis or visualisation is integrated






# Properties

- Swappable external partitioning tool
- Flexible data format
- Incorporates different simulation stages like computation and visualisation
- Easily adjustable to
  - new partitioning tools
  - different kinds of stages
  - fault tolerance
  - (more/any) mesh refinement

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# Advantages

- Offers standardised partitioner access
- Relies on established external partitioning tools
  (however own ones can be integrated as well)
- Little overhead: if partitioning is already implemented required interface input is present in some (similar) form
- Small memory requirements

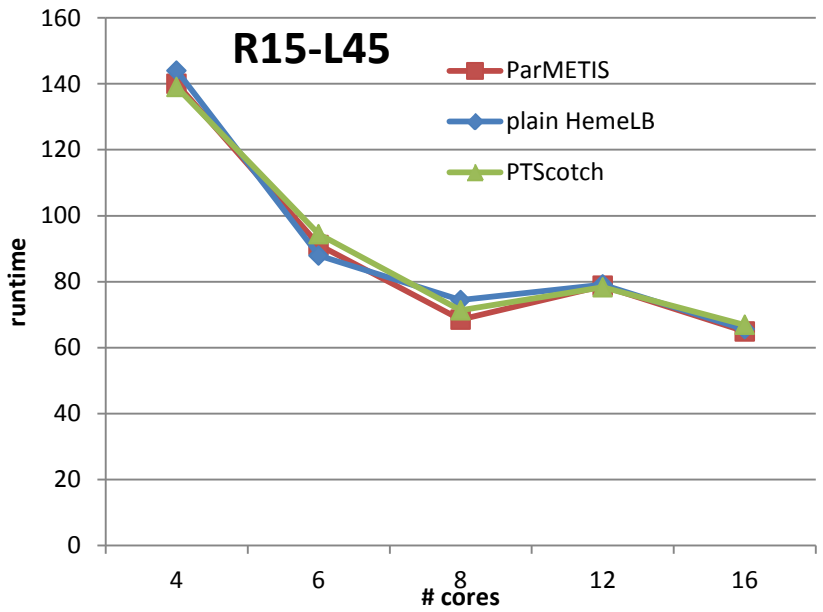
# Disadvantages

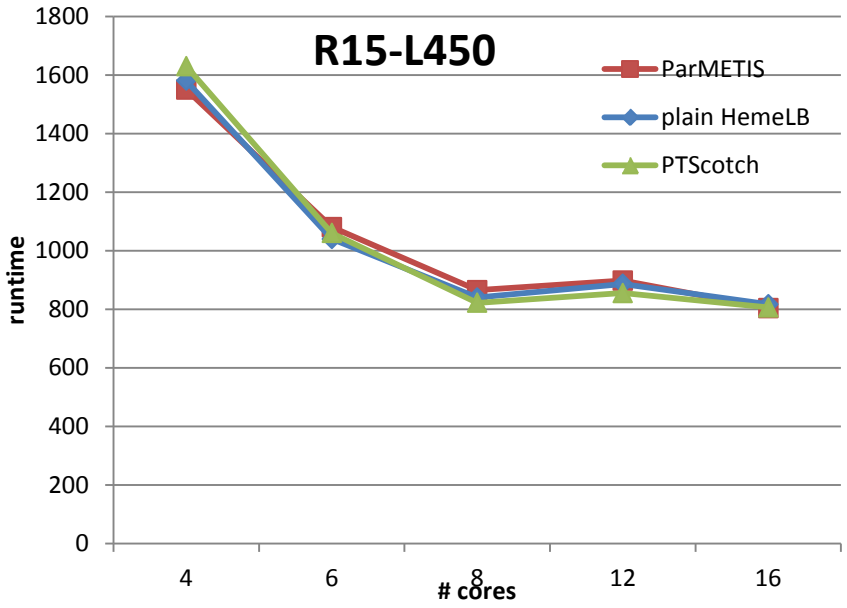
- Individual routines of external partitioning tools covering special functionalities have to be implemented separately (yet this is possible)
- Another software layer

# Preliminary results

HemeLB test runs on HemeLB test data sets (R15-L45 and R15-L450)

PPStee using ParMETIS vs. PPStee using PTScotch
vs. plain HemeLB code (ParMETIS)

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# Conclusions

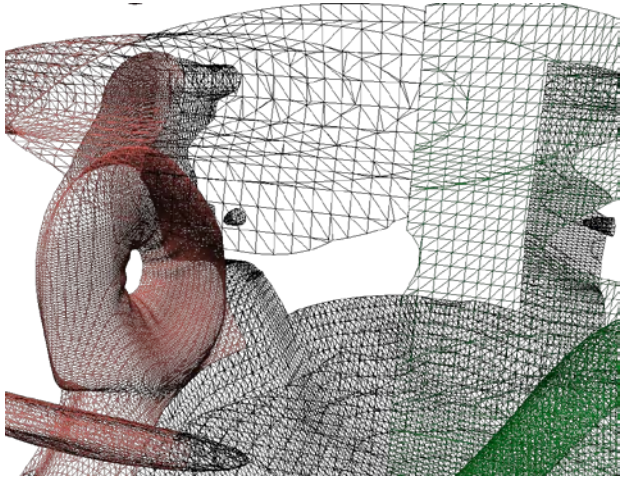
- Pre-processing data structures and algorithms suitable for exascale systems identified
- Prototype pre-processing interface for exascale systems defined and tested with HemeLB
- Concepts for data structures and algorithms suitable for exascale interactive post-processing including remote hybrid rendering developed
- Tests of prototype post-processing tools with HemeLB and OpenFOAM data sets successful

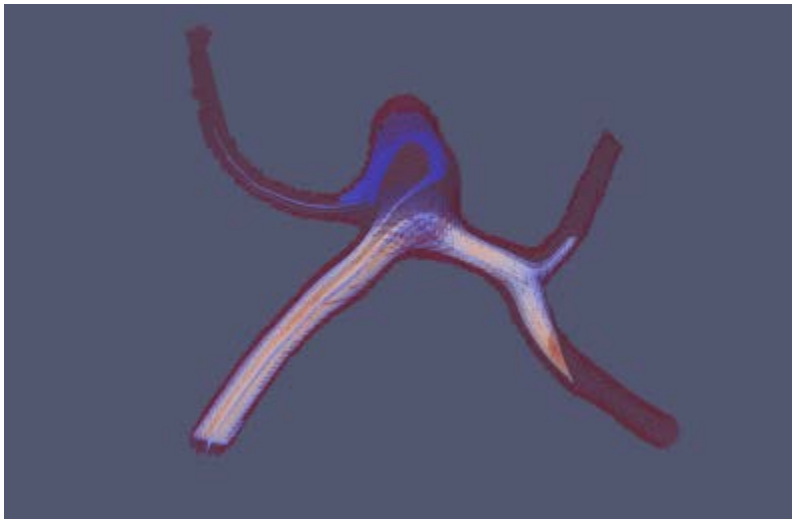
# Future work

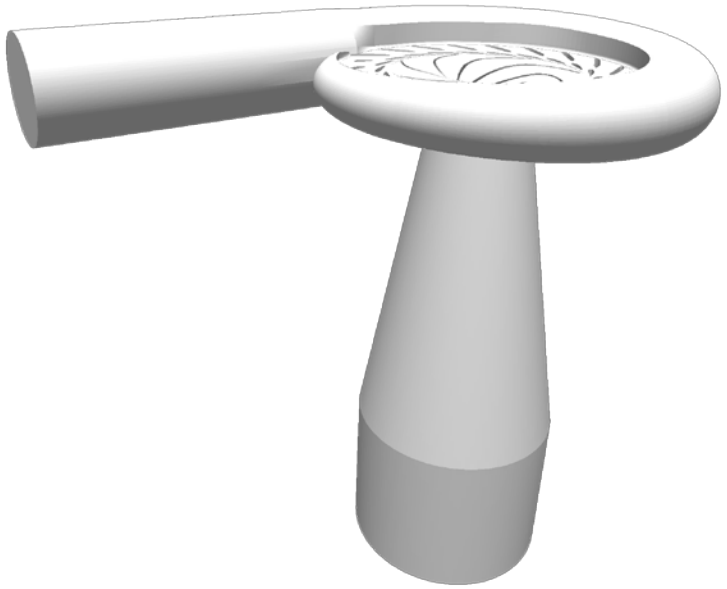
- Integration of PPStee into HemeLB production version
- Performance measurements with HemeLB (also using Zoltan)
- Further tests with other applications (OpenFOAM)
- Revision of architecture
- Comparison with other frameworks
  (some of them cover features of PPStee, e.g. ITAPS)

- Further development of the exascale post processing and remote hybrid rendering techniques

- Further co-design with CRESTA applications







**Thank you**

**for your attention!**

# Basic usage: example

Old call to ParMETIS:

```
ParMETIS_V3_PartKway(
        vtxdist, xadj, adjncy,
        vwgt, adjwgt,
        wgtflag, numflag, ncon, nparts,
        tpwgts, ubvec, options, edgecut,
        part,
        comm);
```

# Basic usage: example

Call to PPStee:

```
// get interface
PPStee ppstee;
// submit graph
ppstee.submitGraph(pgraph);
// submit weights
ppstee.submitNewStage(wgtCmp, PPSTEE_STAGE_COMPUTATION);
ppstee.submitNewStage(wgtVis, PPSTEE_STAGE_VISUALISATION);
// calculate partitioning
PPSteePart* ppart;
ppstee.getPartitioning(&ppart);
```

# Basic usage: example

Build graph:

```
// get graph (as ParMETIS type)
PPSteeGraph pgraph = PPSteeGraphParmetis(MPI_COMM_WORLD,
                                         vtxdist, xadj, adjncy);
```

Build weights:

```
// construct and set weights for computation
PPSteeWeights wgtCmp(&pgraph);
wgtCmp.setWeightsData(vwgt_c, adjwgt_c);
// construct and set weights for visualisation
PPSteeWeights wgtVis(&pgraph);
wgtVis.setWeightsData(vwgt_v, adjwgt_v);
```