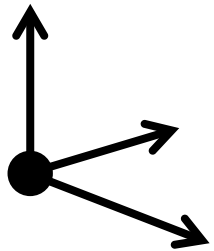
Live, Interactive, In-Situ, In-GPU Visualization of Plasma Simulations Running on GPU Supercomputers

Live, Interactive, In-Situ, In-GPU Visualization of Plasma Simulations Running on GPU Supercomputers

Letting physicists play with their simulation while it‘s running

Benjamin Schneider, Richard Pausch, Damian Hettmanczyk, Heiko Burau, Axel Huebl, Felix Schmitt, René Widera, Sebastian Grottel, Stefan Gumhold, Michael Bussmann

The current state of the art visualization



Position x
Position y
Position z

Dimensions: 3

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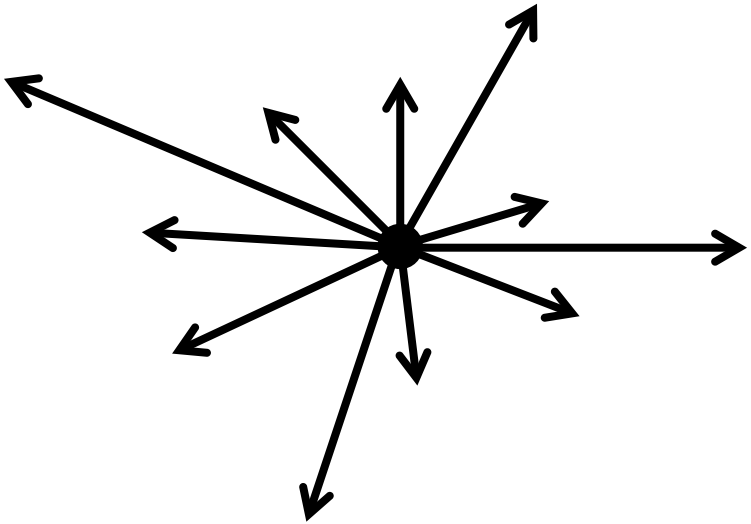
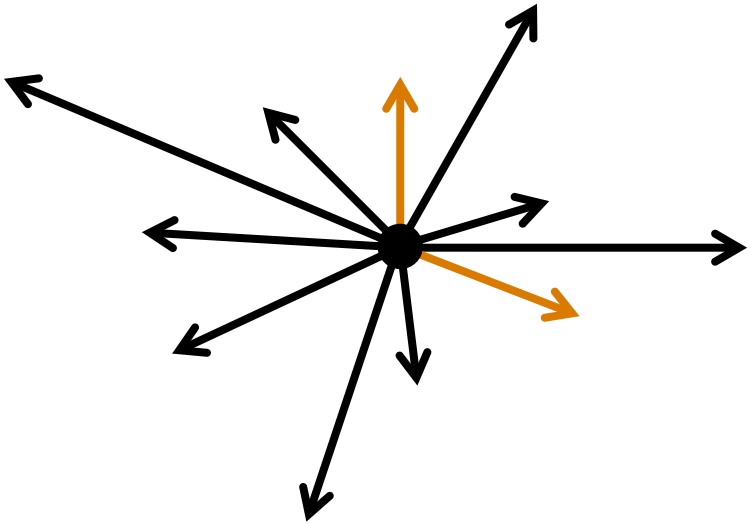
Problems with state of the art visualization



Dimensions: many

Position x
Position y
Position z
Speed x
Speed y
Speed z
Energy
Electric Field x
Electric Field y
Electric Field z
Magnetic Field x
...

Problems with state of the art visualization



Dimensions: many
Reduced to: 2

Position x
Position y
Position z
Speed x
Speed y
Speed z
Energy
Electric Field x
Electric Field y
Electric Field z
Magnetic Field x
...

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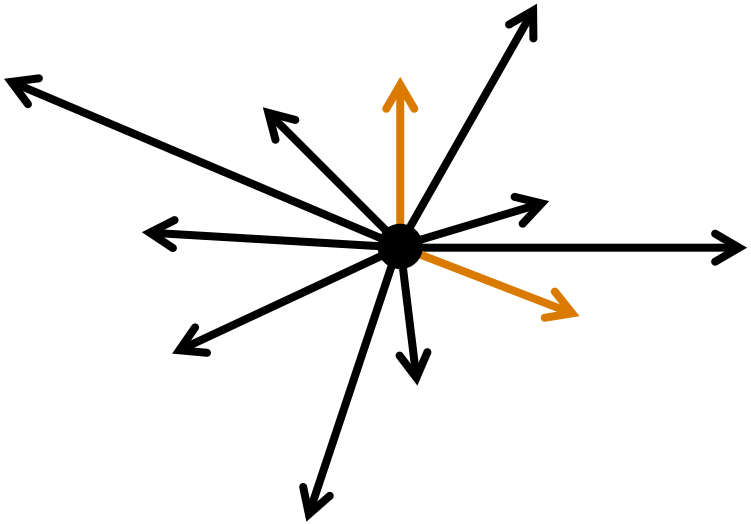
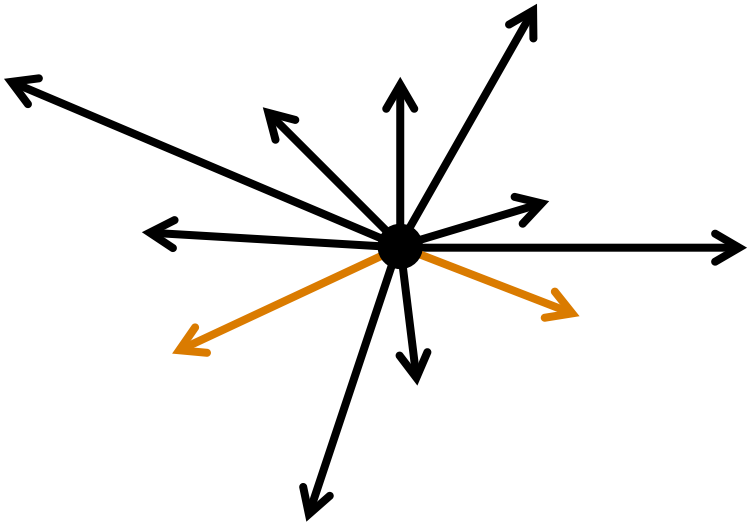
Problems with state of the art visualization



Dimensions: many
Reduced to: what you need

Position x
Position y
Position z
Speed x
Speed y
Speed z
Energy
Electric Field x
Electric Field y
Electric Field z
Magnetic Field x
...

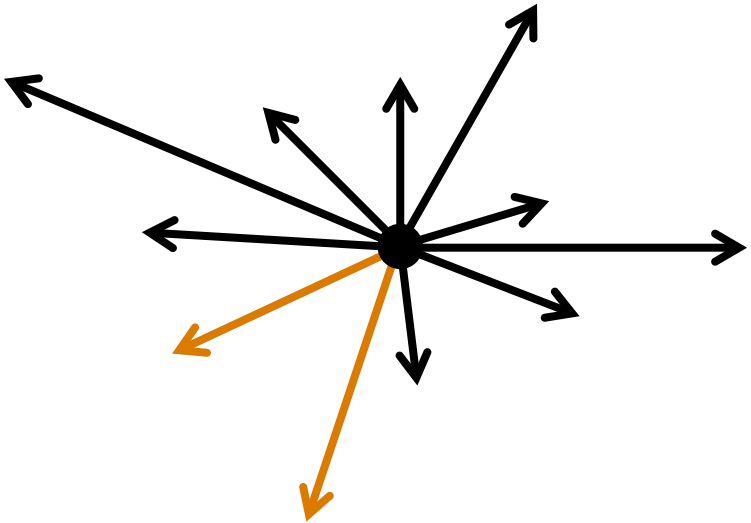
Problems with state of the art visualization



Dimensions: many
Reduced to: what you need

Position x
Position y
Position z
Speed x
Speed y
Speed z
Energy
Electric Field x
Electric Field y
Electric Field z
Magnetic Field x
...

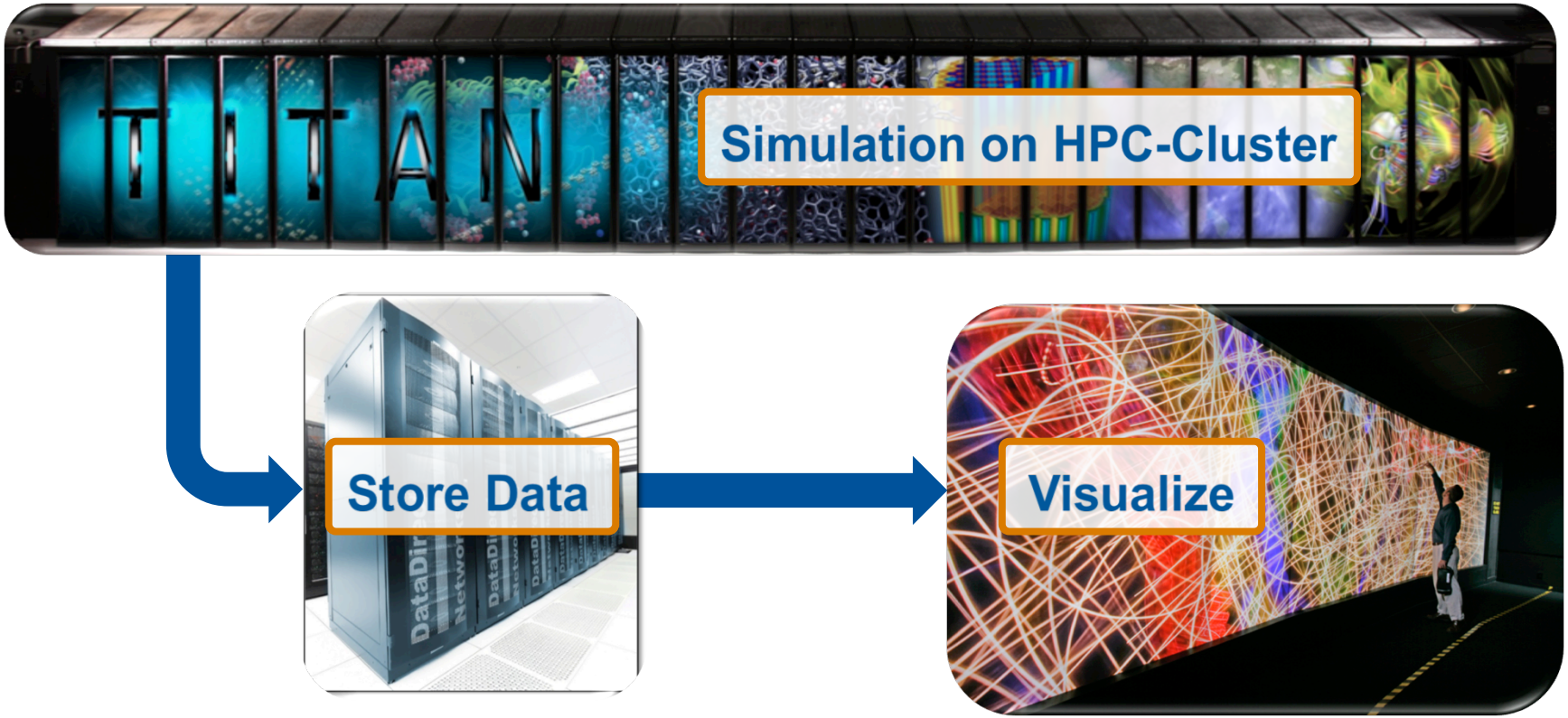
Problems with state of the art visualization



Dimensions: many
Reduced to: what you need

Position x
Position y
Position z
Speed x
Speed y
Speed z
Energy
Electric Field x
Electric Field y
Electric Field z
Magnetic Field x
...

Classical visualization chain



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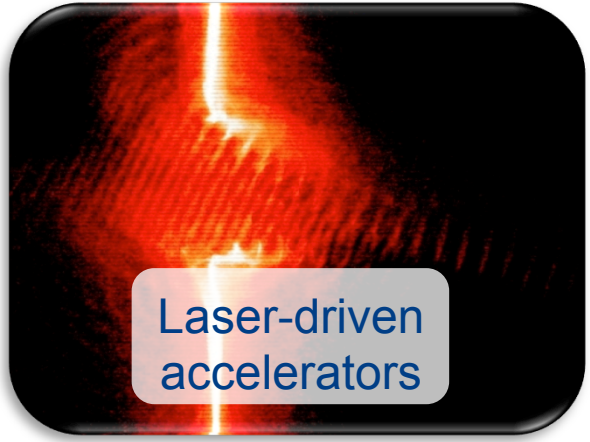
PIConGPU – a many GPGPU plasma simulation



PIConGPU

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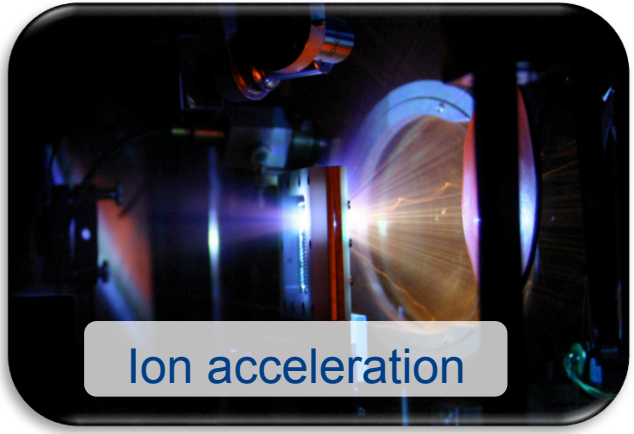
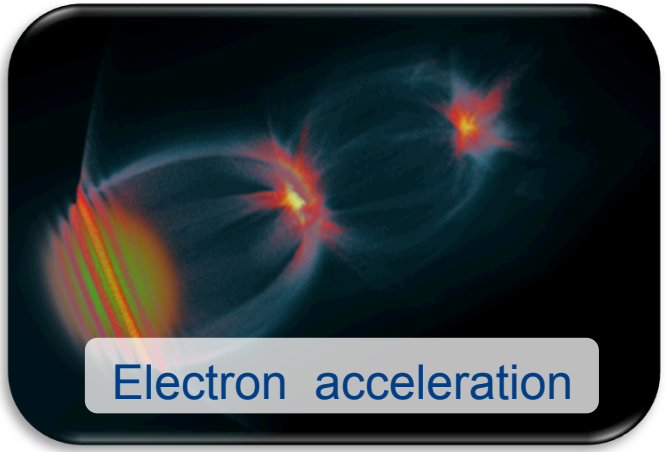
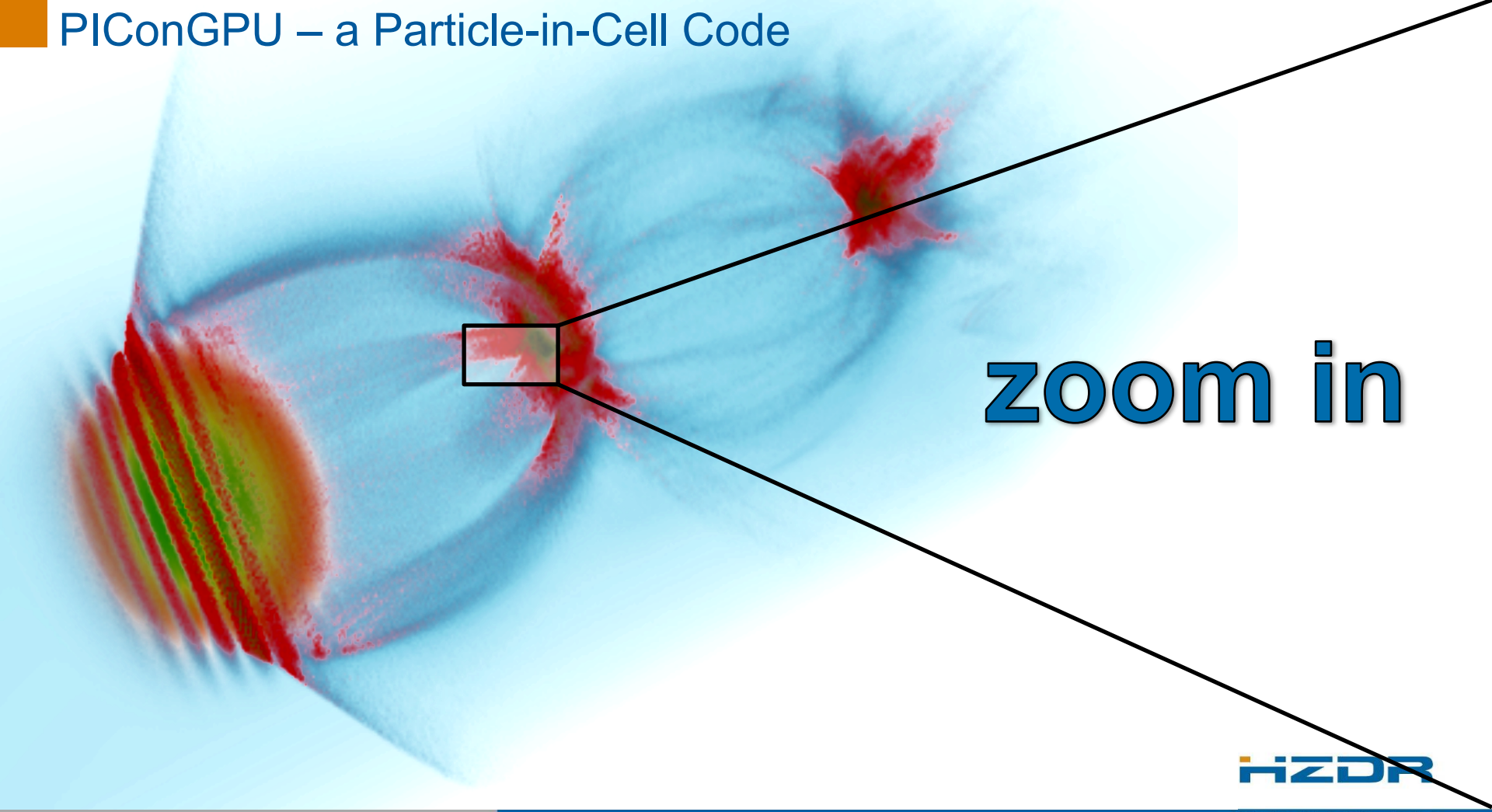
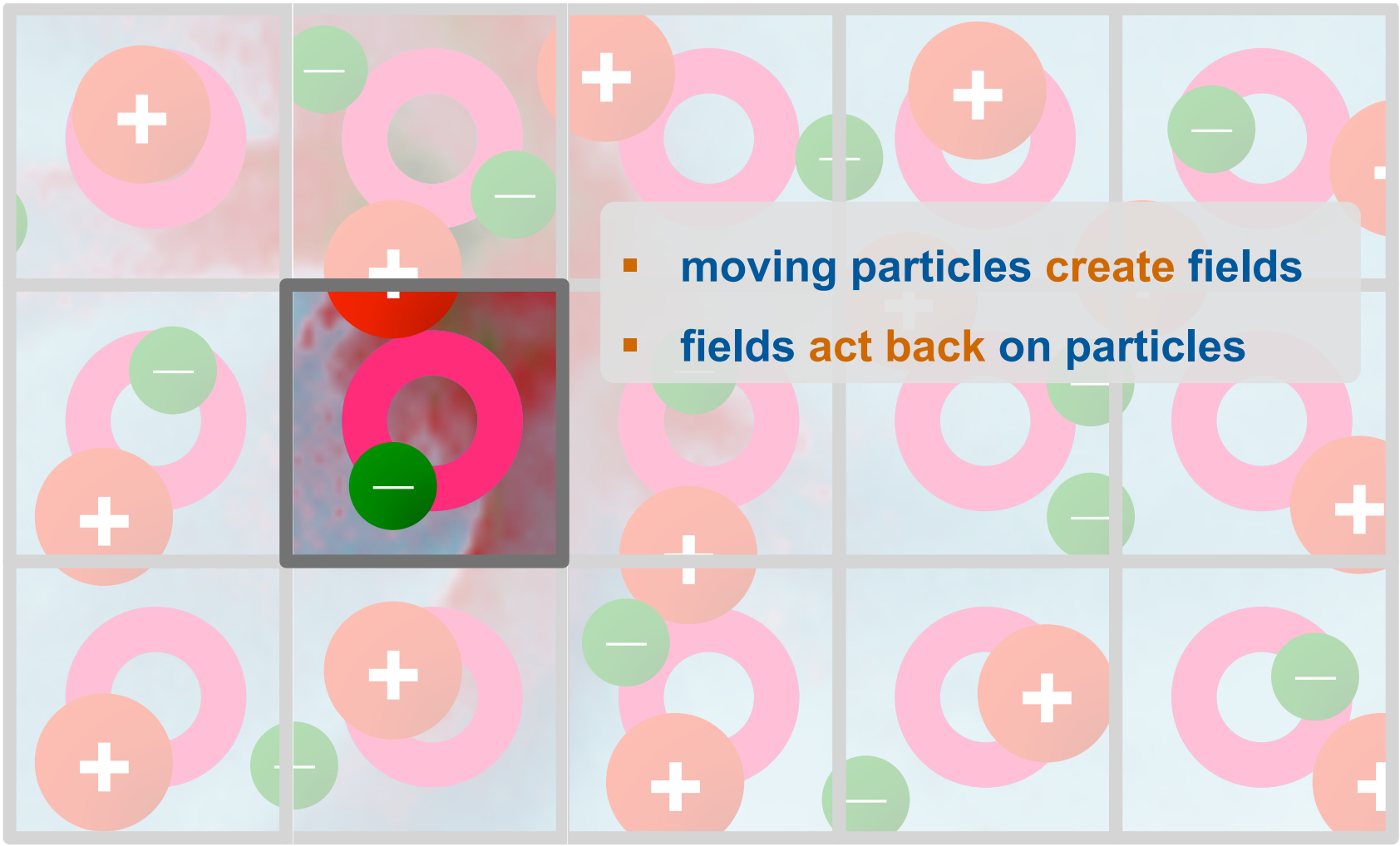
ROSSENDORF



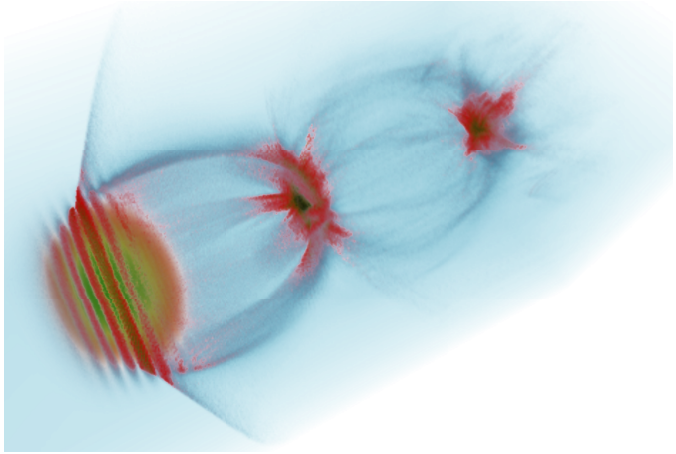


PIConGPU – a Particle-in-Cell Code




moving particles create fields
fields act back on particles

Domain decomposition



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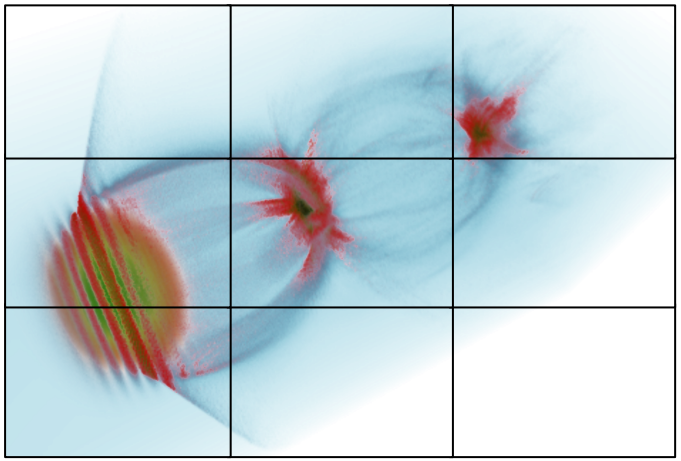
Domain decomposition



PIConGPU

HPC Compute Node | HPC Compute Node | HPC Compute Node
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HPC Compute Node | HPC Compute Node | HPC Compute Node

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Classical Visualization Chain

PIConGPU

Simulation on HPC-Cluster

1 billion particles

512x4096x512 cells

60.000 time steps

in 100 minutes

Store Data

170 GByte / time step

1.7 TByte / second

10.2 PByte disk space

Visualize

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Frames-per-second simulation codes

10-30 frames-per-second

Transporting data for visualization

copy simulation data

- bandwidth too low
- latency too high

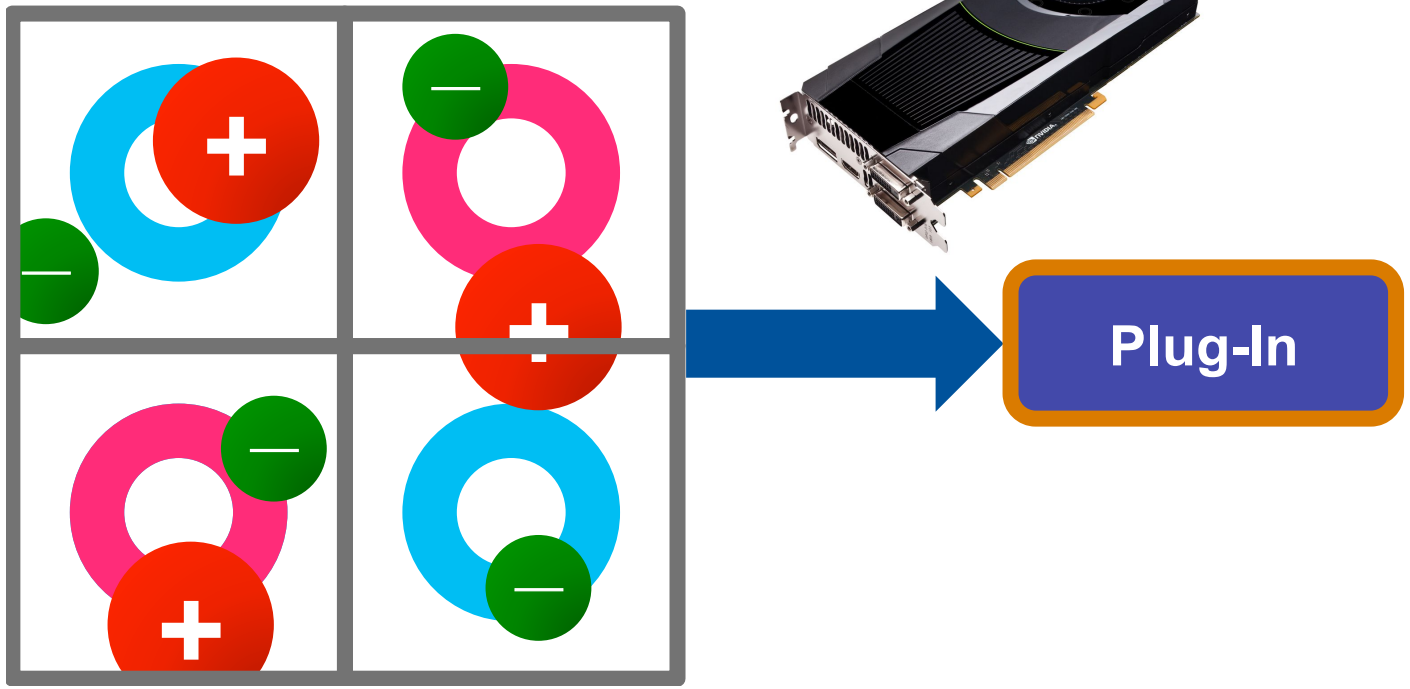
HPC Compute Node

Using the GPU for visualization

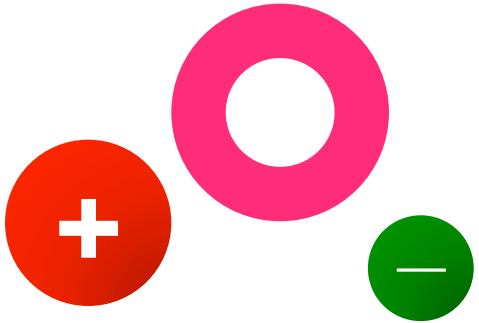
Stay on the GPU?
It's great for graphics, right?

- **no X-server**
  can be activated, but is usually not
  limits execution time to 13 sec
- **no direct OpenGL support**
  data structure not compatible with
  OpenGL data structure
- **requires writing own renderer**

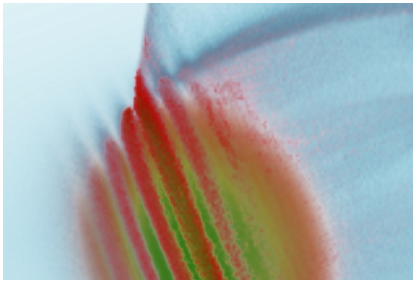
Plug-Ins – the fast way to your data



Exploring simulations with in-situ visualization



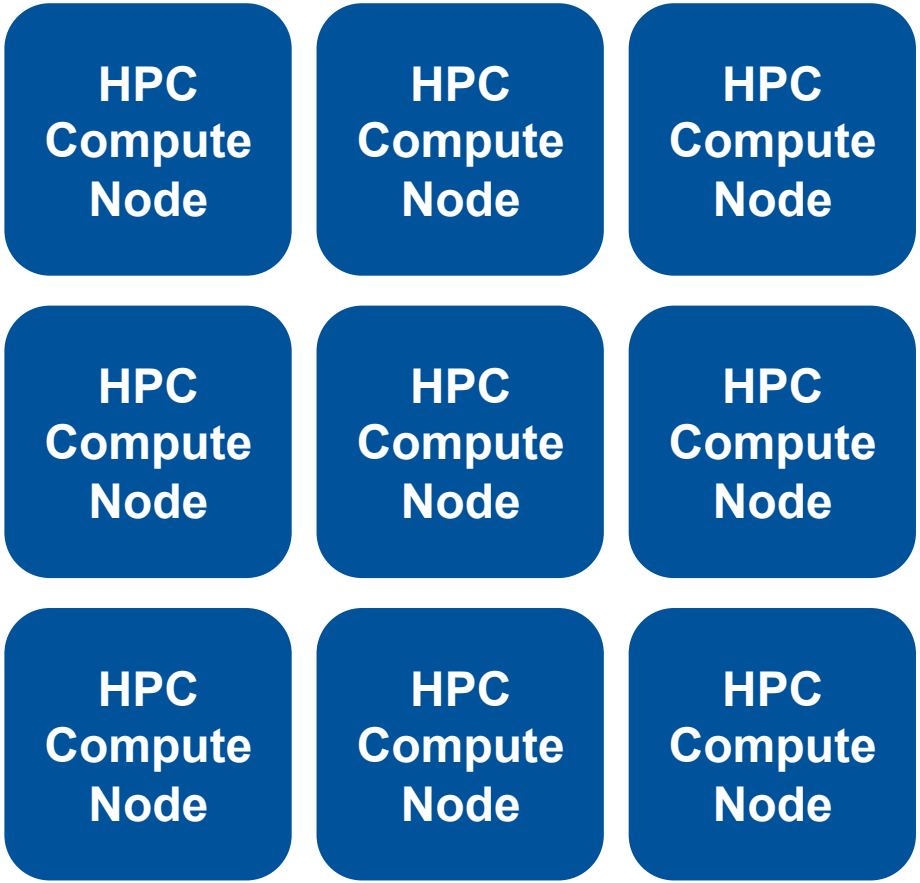
HPC Compute Node



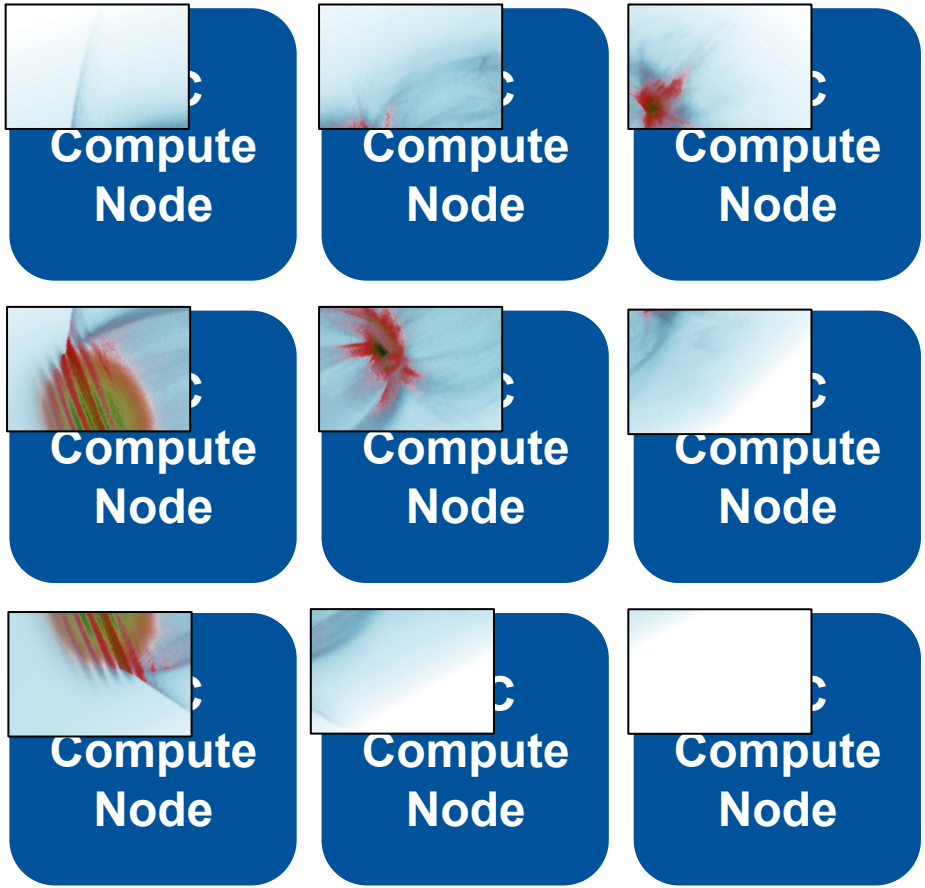
PIConGPU

Plug-In

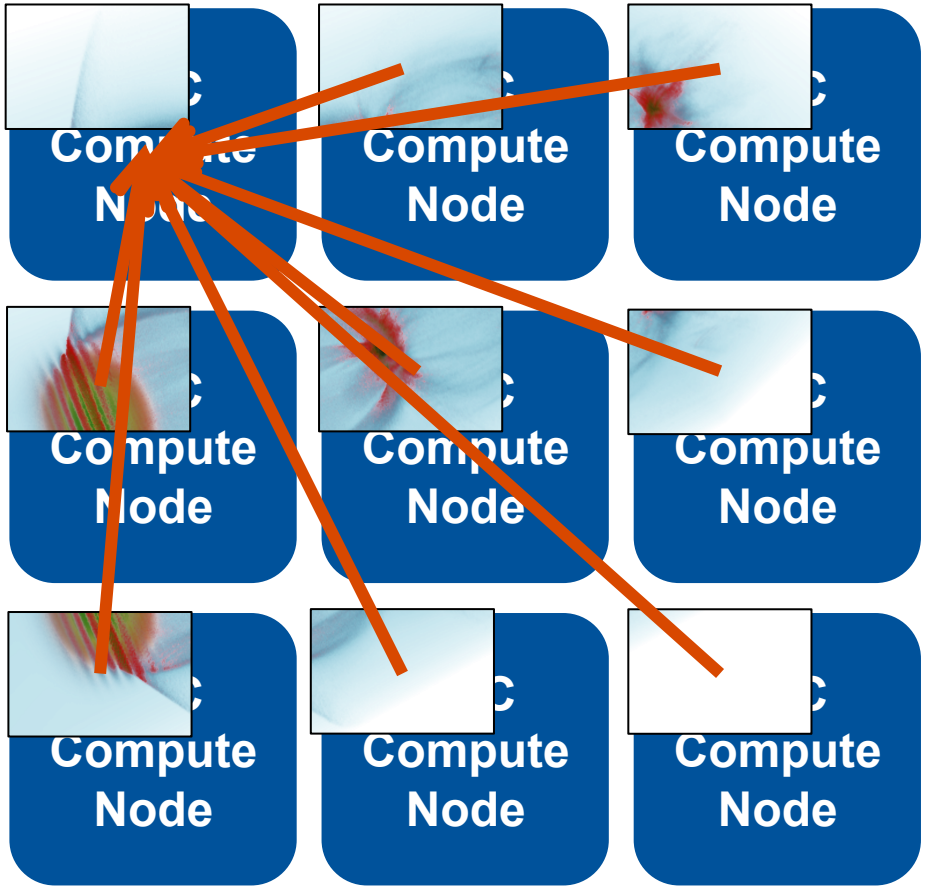
The Setup


HPC Compute Node
HPC Compute Node
HPC Compute Node
HPC Compute Node
HPC Compute Node
HPC Compute Node
HPC Compute Node
HPC Compute Node
HPC Compute Node

1. Parallel in-situ rendering



2. Gather partial pictures



3. Compose picture (sort last)

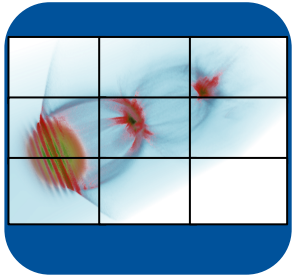


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Image composition on the cluster

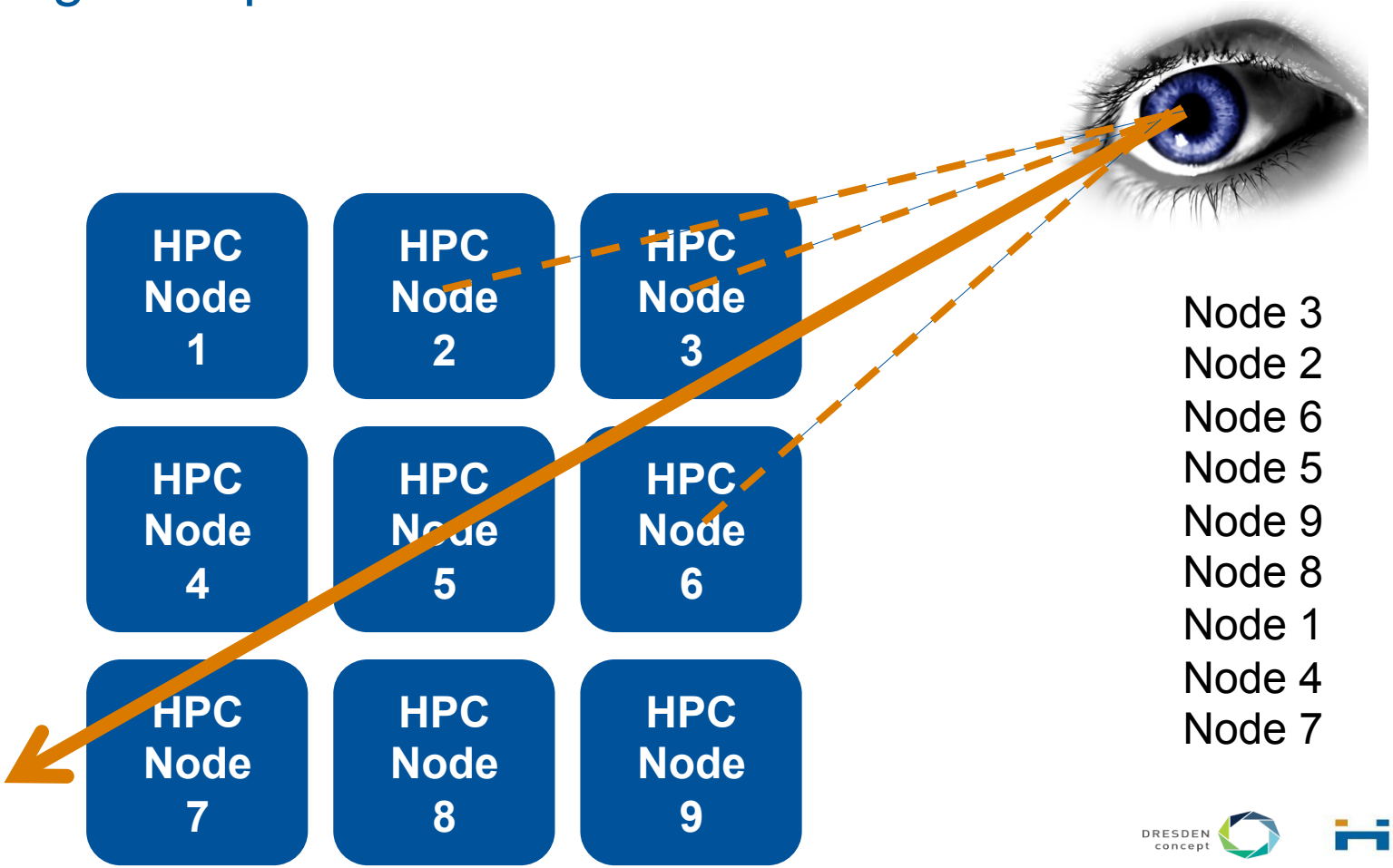

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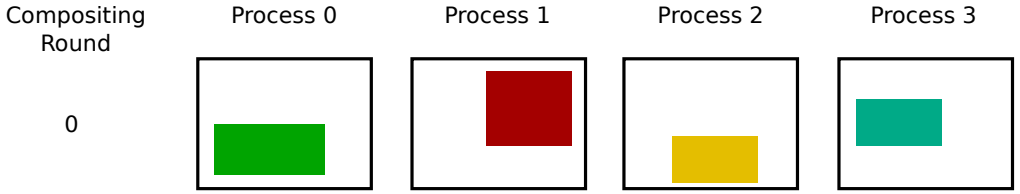
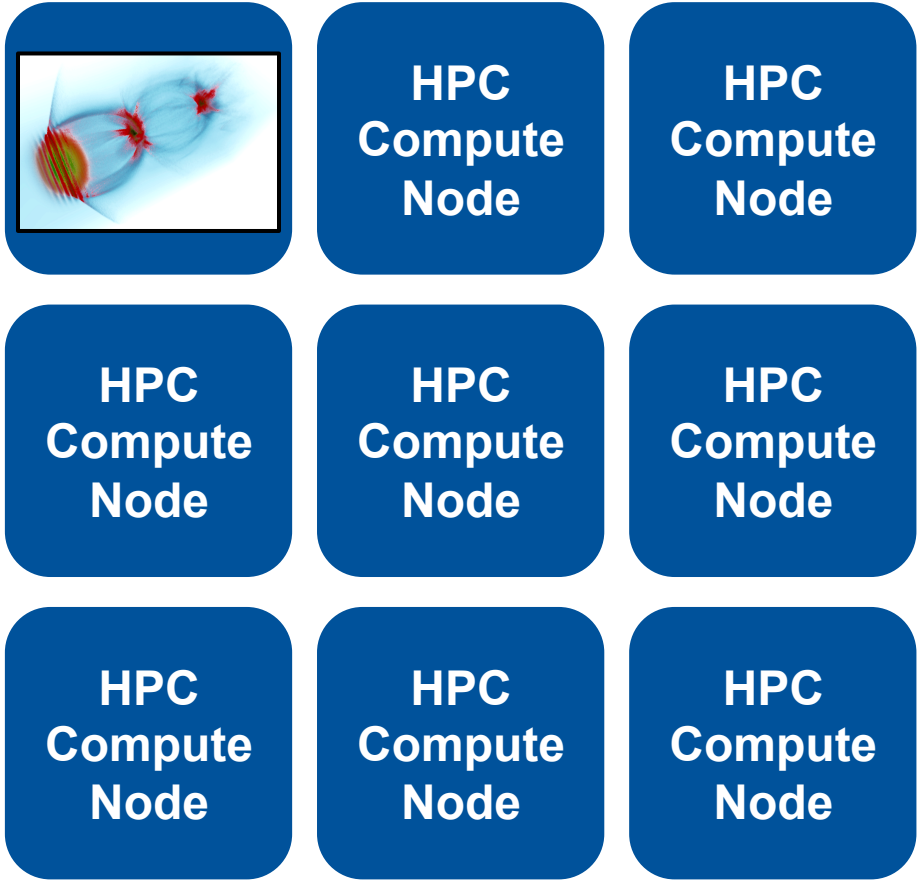
Image composition on the cluster



4. Send picture to client



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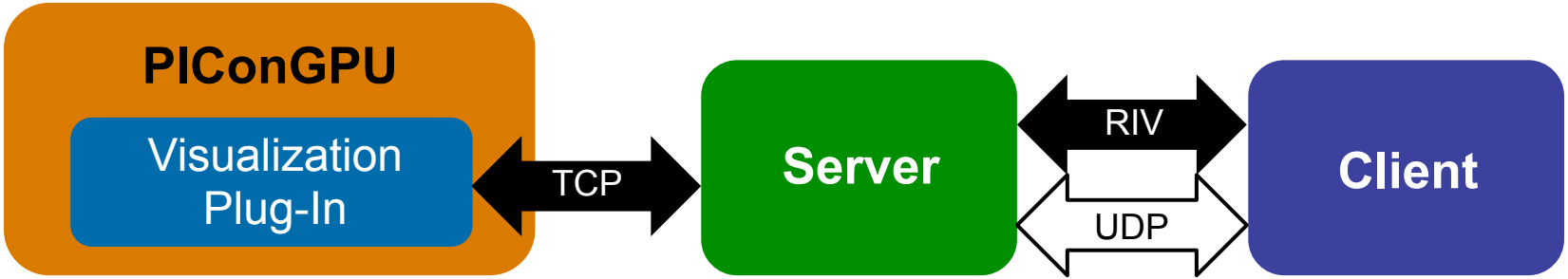
Connection is everything – how to get your data

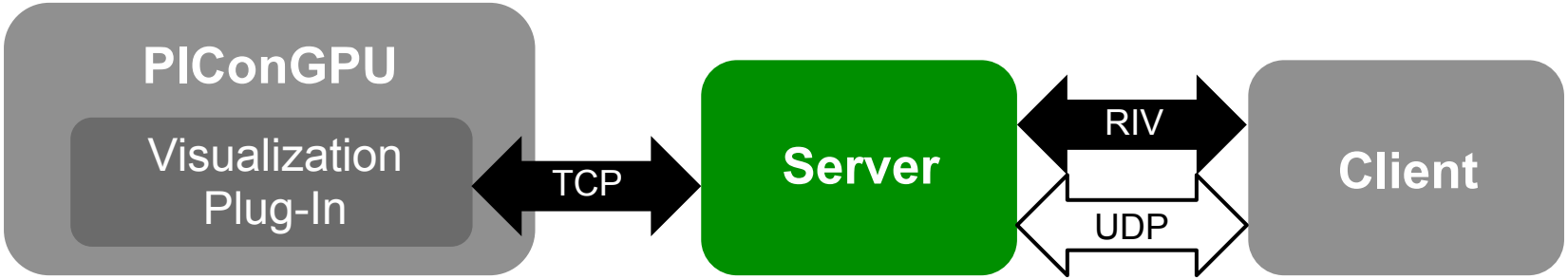


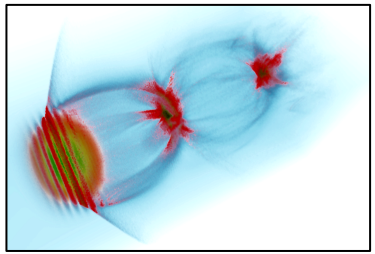
Simulate and Visualize

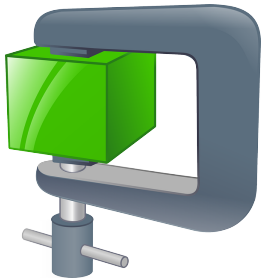
Transport Images

View

Making the connection – the visualization server







http://pixabay.com/de/kompression-archiver-komprimieren-149782/

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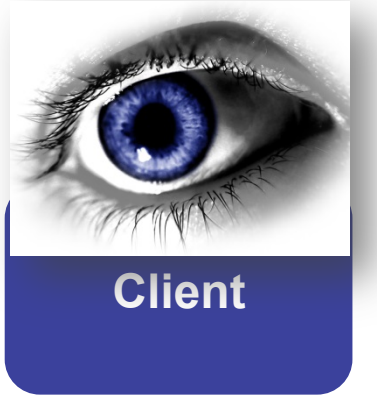
5. Change view, etc.



HPC Login Node

HPC Compute Node

HPC Compute Node

HPC Compute Node

HPC Compute Node

HPC Compute Node

HPC Compute Node

HPC Compute Node

HPC Compute Node

HPC Compute Node

Visualization Client

Visualization Server

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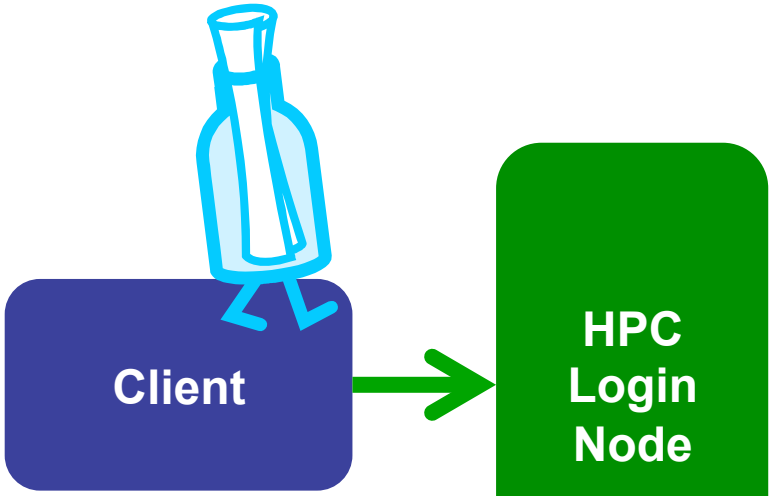
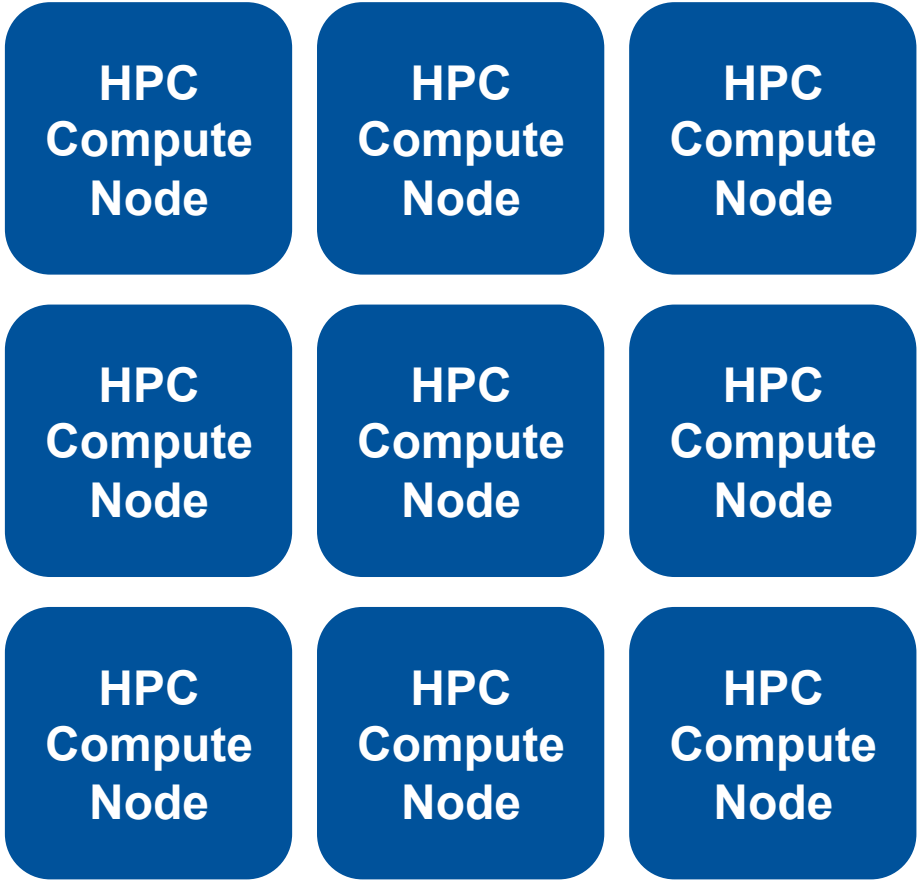
6. Message can be anything!



Visualization Client

Visualization Server



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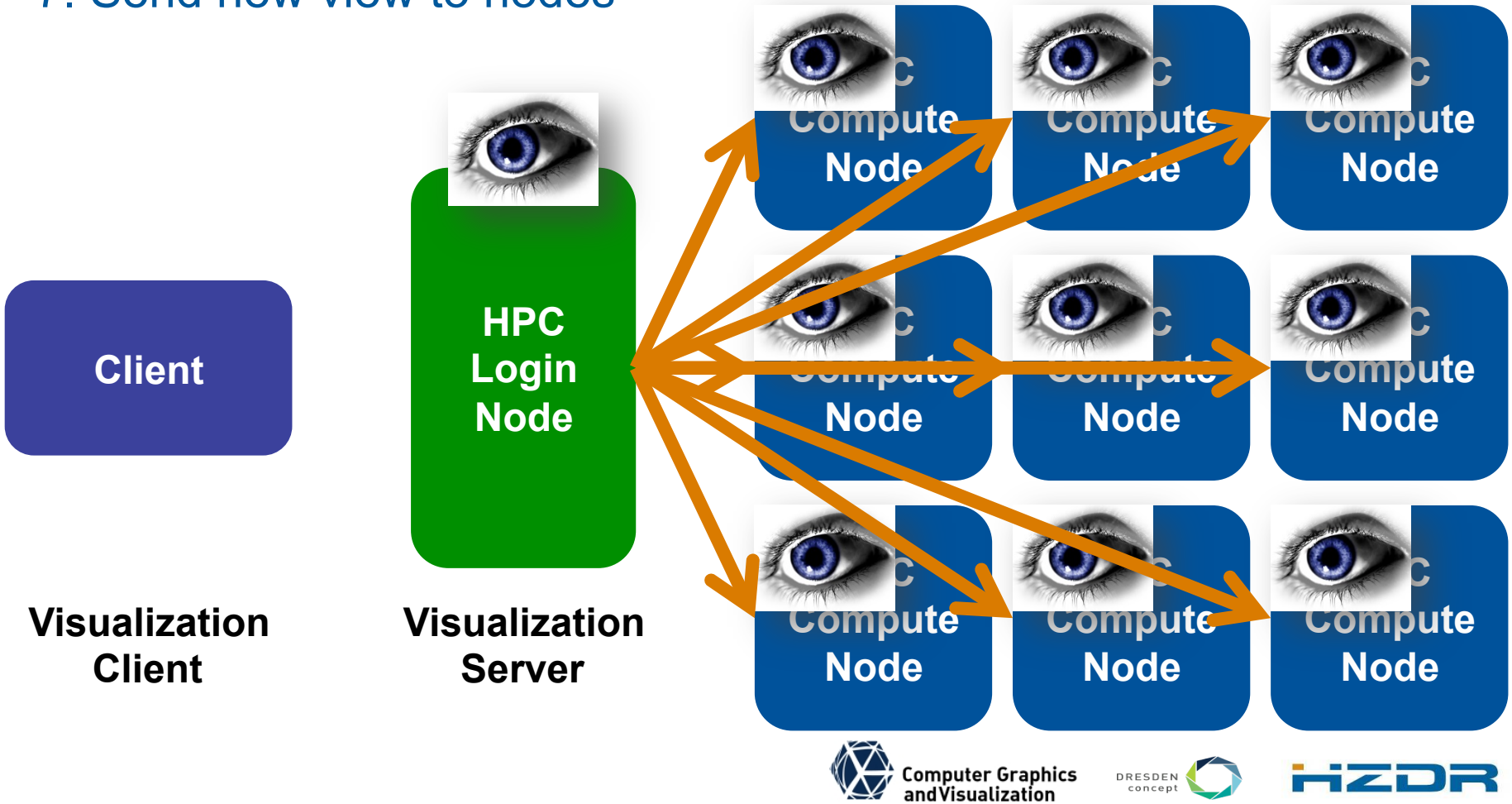
7. Send new view to nodes



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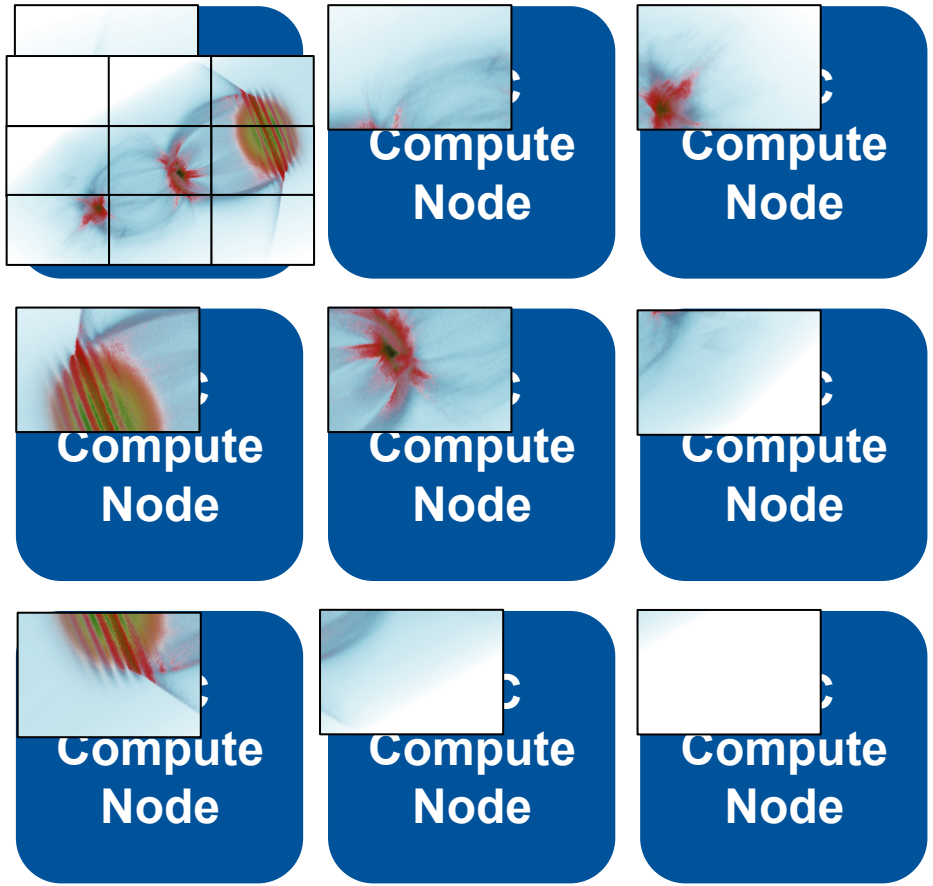
8. Render new view locally

Client

HPC Login Node

Visualization Client

Visualization Server



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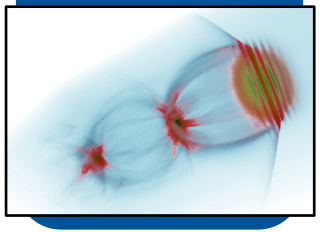
9. Send new image to client



HPC Compute Node

HPC Compute Node

HPC Compute Node

HPC Compute Node

HPC Compute Node

HPC Compute Node

HPC Compute Node

HPC Compute Node

HPC Compute Node

Client

HPC Login Node

Visualization Client

Visualization Server

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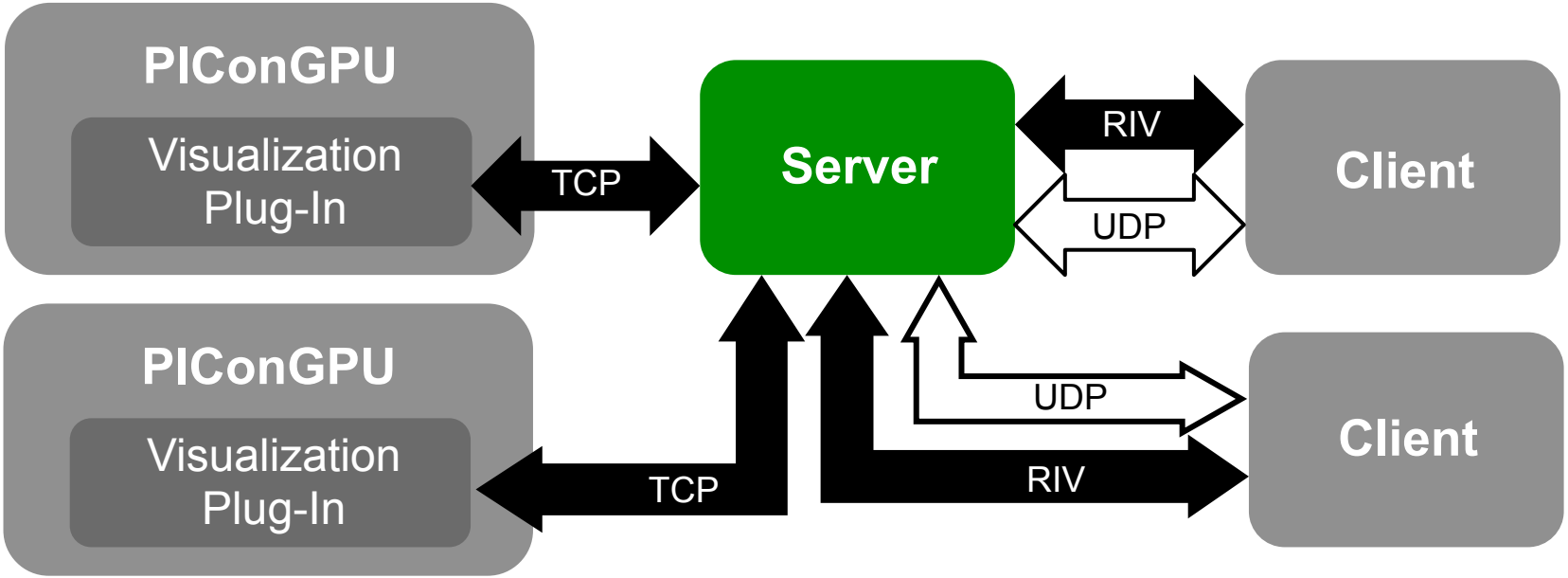
Making multiple connection – the visualization server



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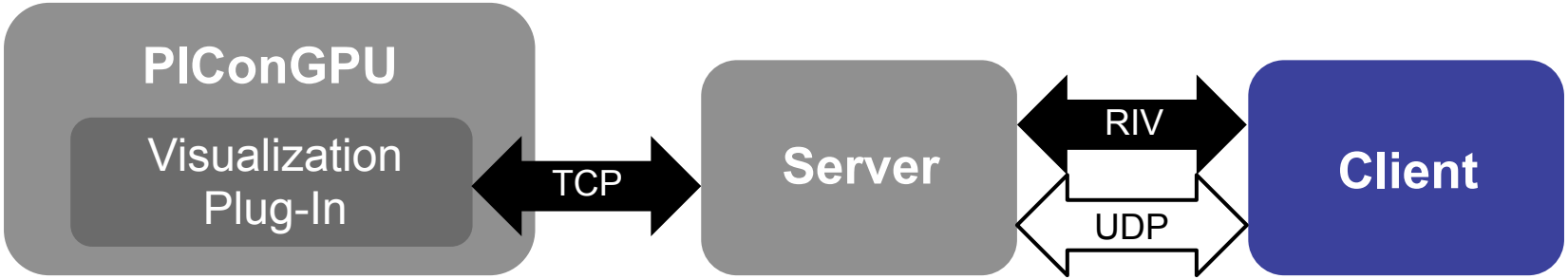
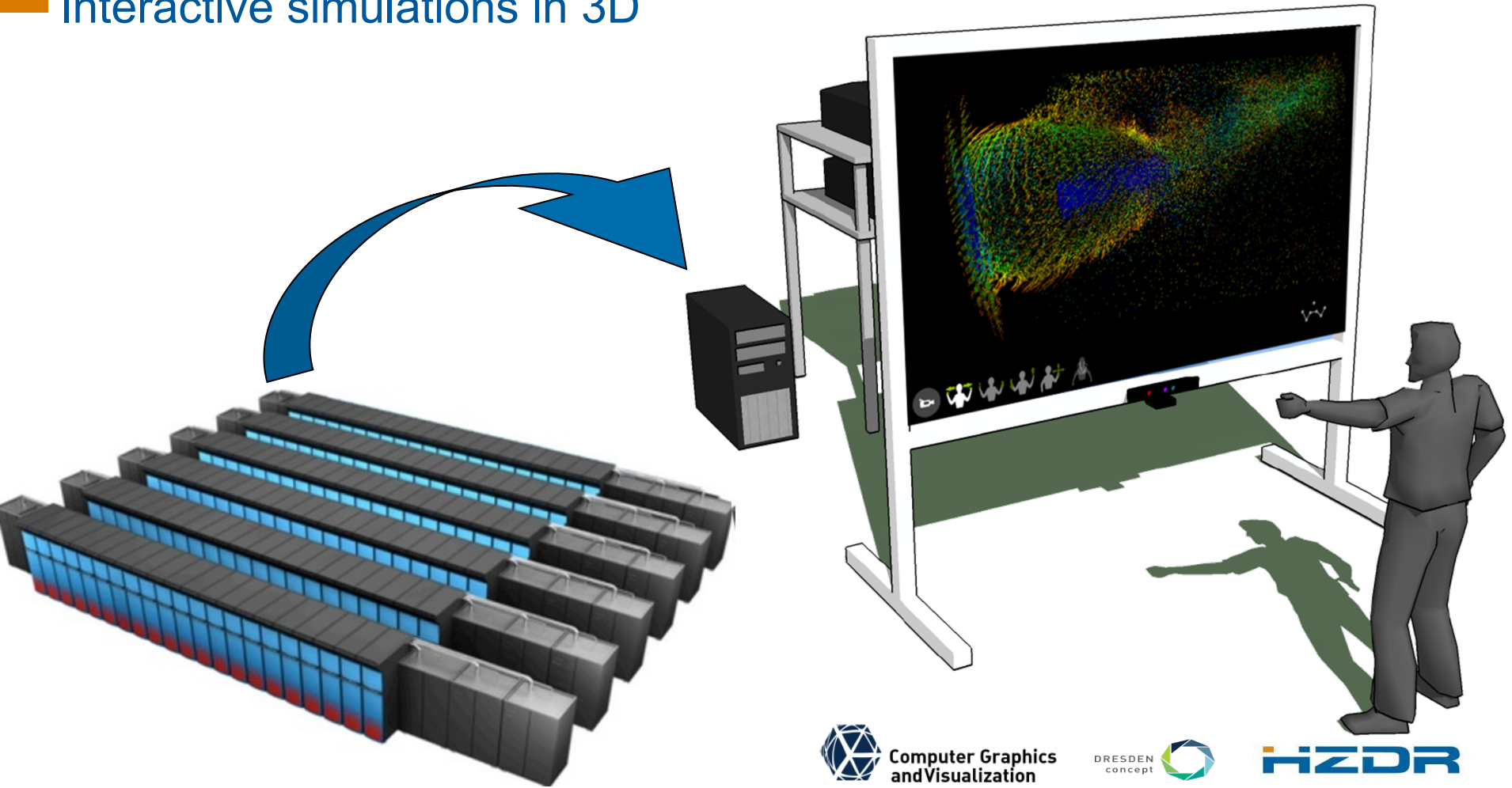
r.pausch@hzdr.de

Letting you play with your simulation – the client



provides user interface to interact with the simulation

Interactive simulations in 3D



Computer Graphics and Visualization

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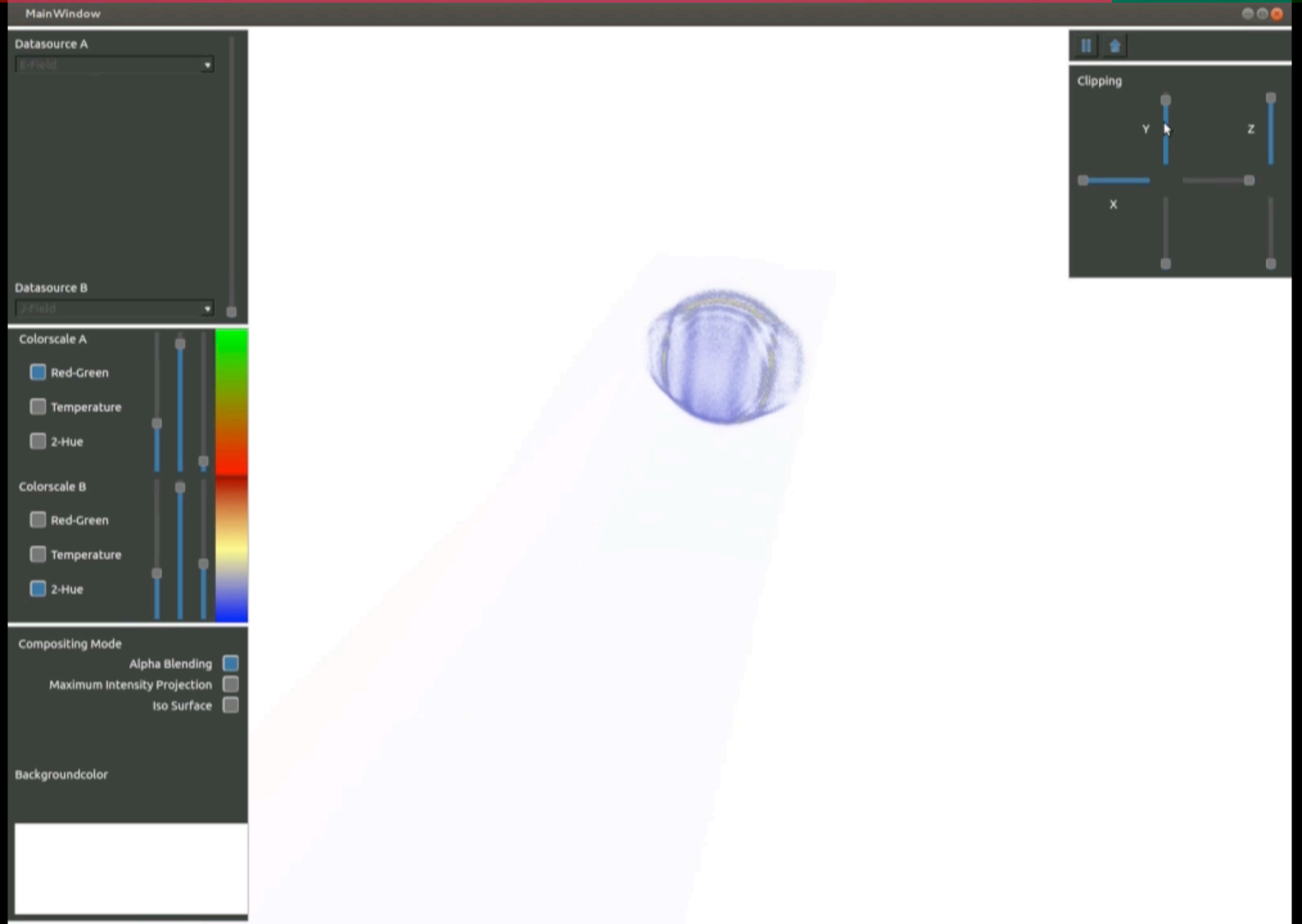
r.pausch@hzdr.de

Now, we have a live and interactive in-situ plasma simulation!

Video
or
Live Visualization


MainWindow
Datasource A
E-Field
Datasource B
B-Field
Colorscale A
Red-Green
Temperature
2-Hue
Colorscale B
Red-Green
Temperature
2-Hue
Compositing Mode
Alpha Blending
Maximum Intensity Projection
Iso Surface
Backgroundcolor
Clipping
Y
Z
X

Visualization for today and future simulations

- **Codes with frames-per-second performance are available right now.**
- **Many more will come.**
- **The old visualization becomes impractical.**
- **Avoid transferring data. Go in-situ.**

The Developers

Heiko Burau
Wolfgang Hönig
Axel Hübl
Richard Pausch
Felix Schmitt
Rene Widera

Benjamin Schneider
Damian Hettmanczyk
Sebastian Grottel
Stefan Gumhold

picongpu.hzdr.de