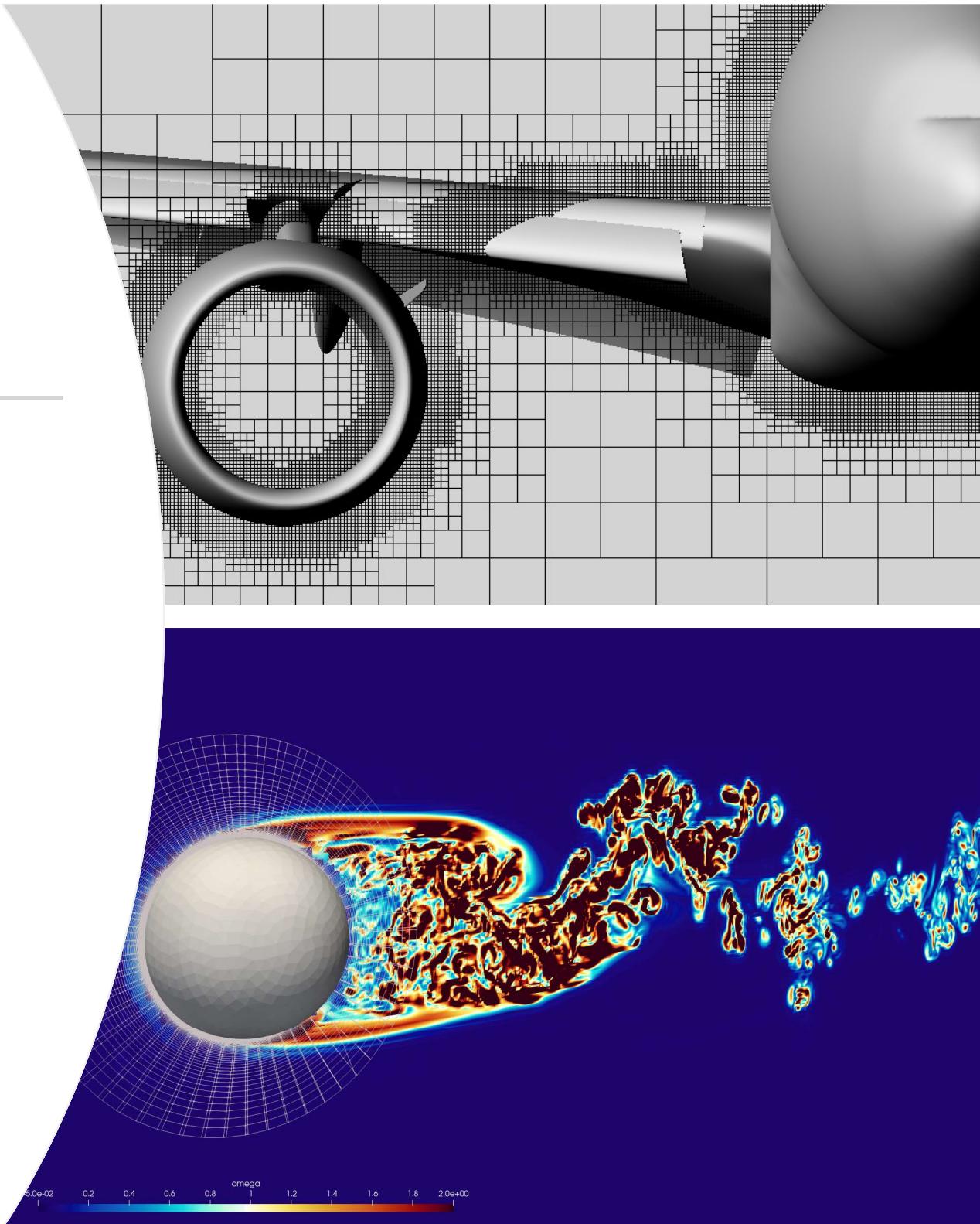
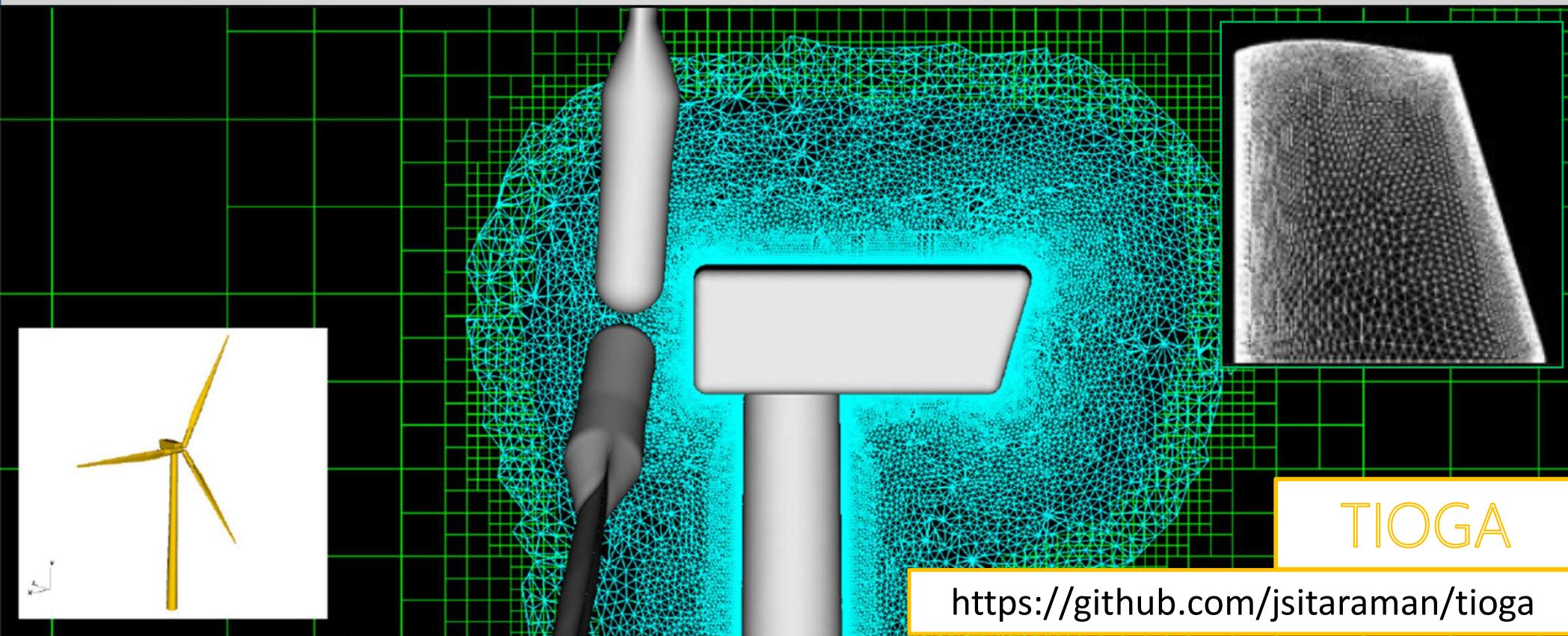


Unstructured Mesh Applications

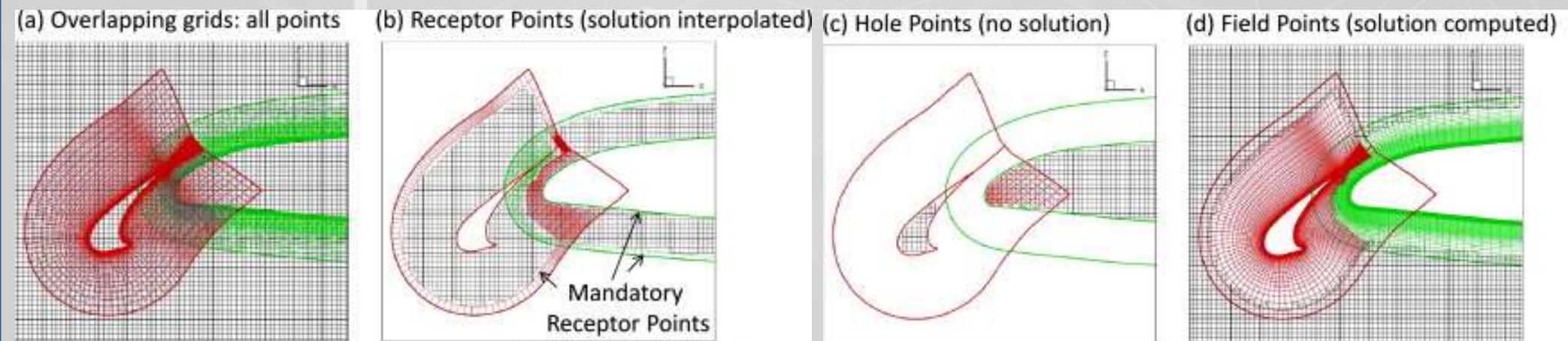


Nonuniform Meshes

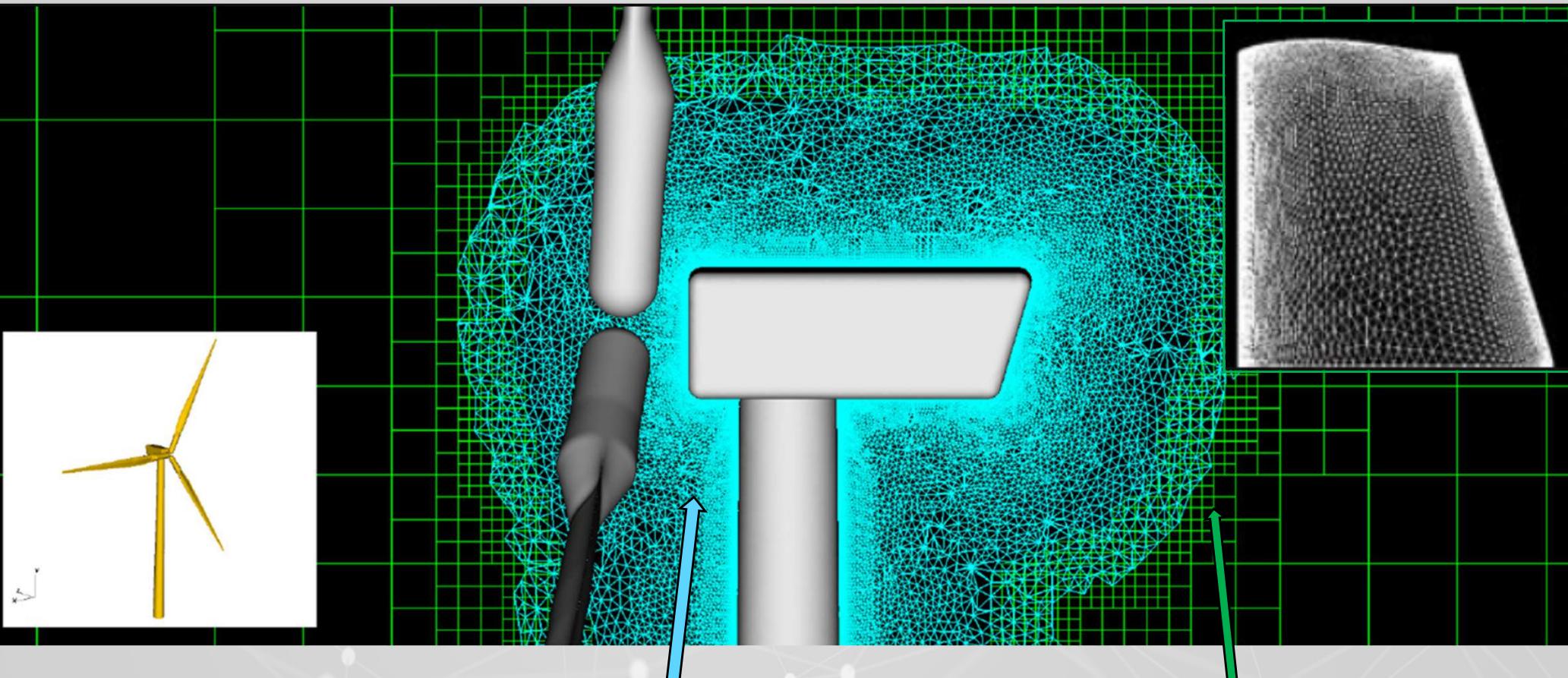
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<https://github.com/jsitaraman/tioga>



MPI Groups



Unstructured Mixed Element Meshes
Vertex-centered Finite Volume Method
Implicit Time Stepping

Structured/Unstructured Hex Meshes
Dynamic Adaptive Mesh Refinement
Discontinuous Galerkin Method
Explicit Time Stepping

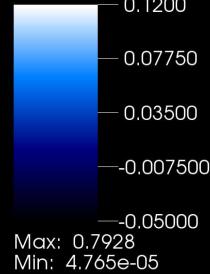
S-76 Rotor Wake

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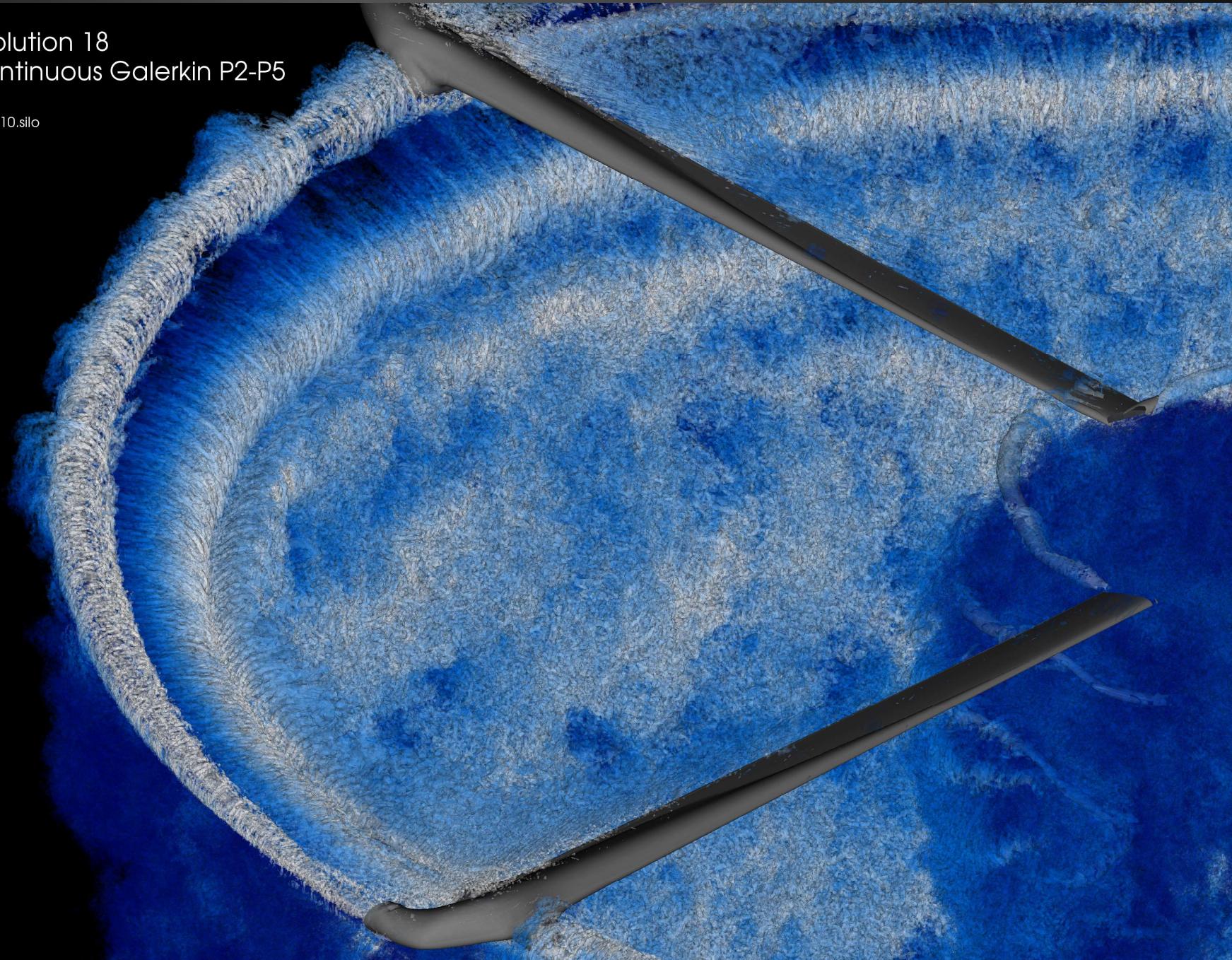
S-76 Rotor-Revolution 18
Wake3D: Discontinuous Galerkin P2-P5

Pseudocolor
DB: iso_qcriterion=0.001_0010.silo
Cycle: 10 Time: 10

Var: vm



Max: 0.7928
Min: 4.765e-05



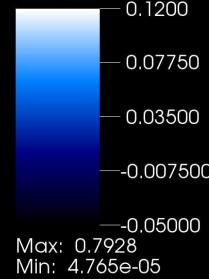
S-76 Rotor Wake

UNIVERSITY
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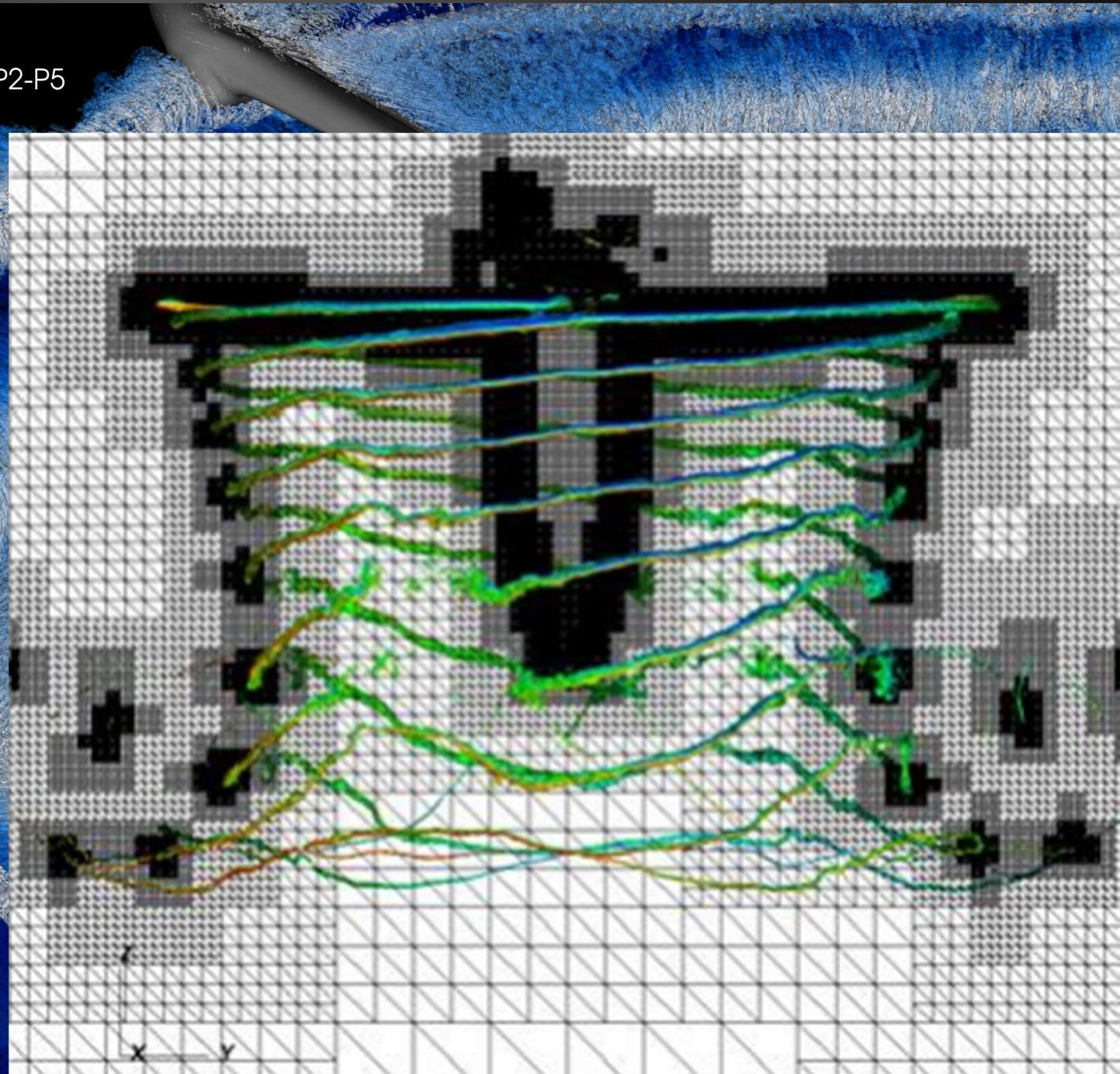
S-76 Rotor-Revolution 18
Wake3D: Discontinuous Galerkin P2-P5

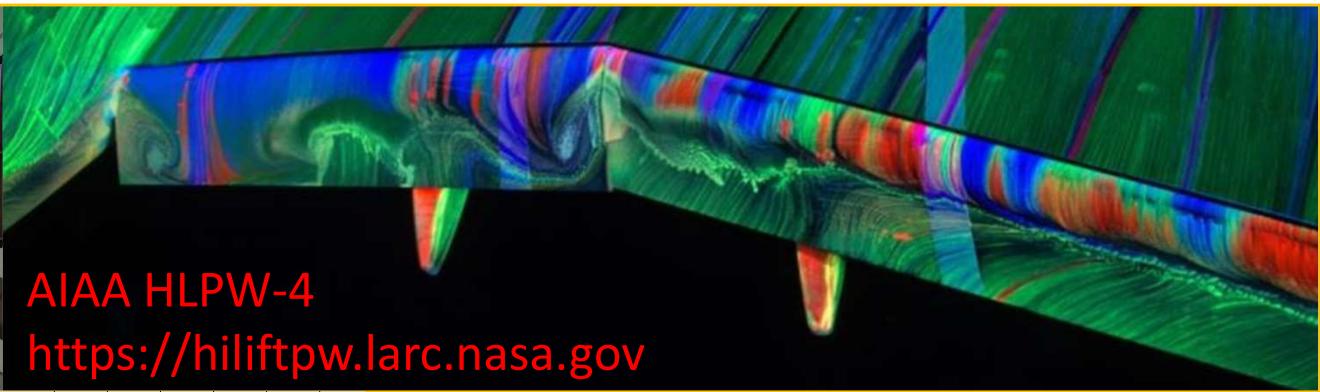
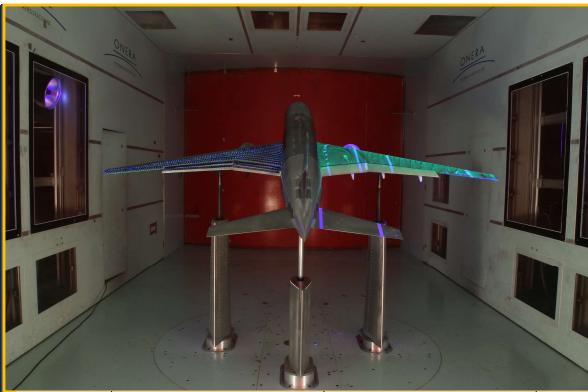
Pseudocolor
DB: iso_qcriterion=0.001_0010.silo
Cycle: 10 Time: 10

Var: vm

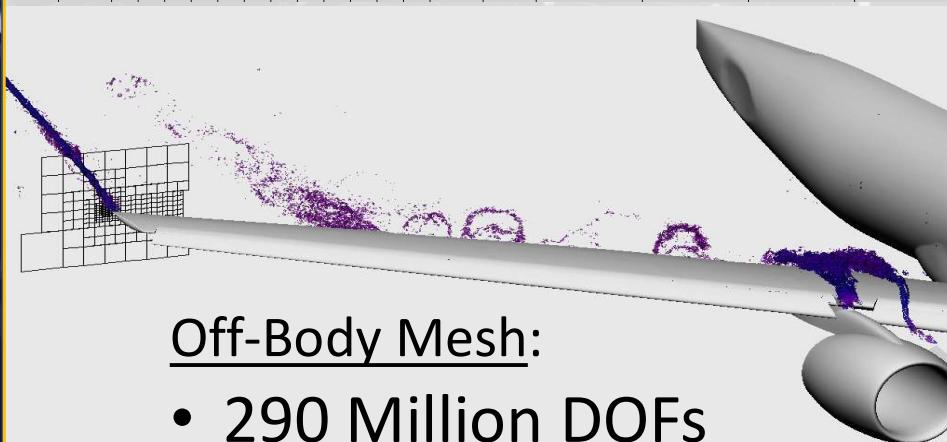
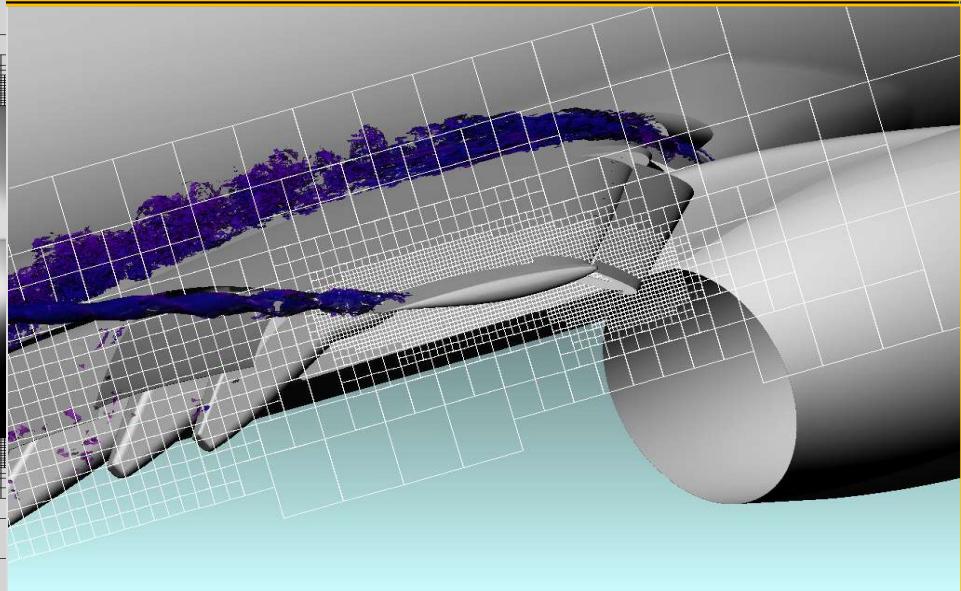
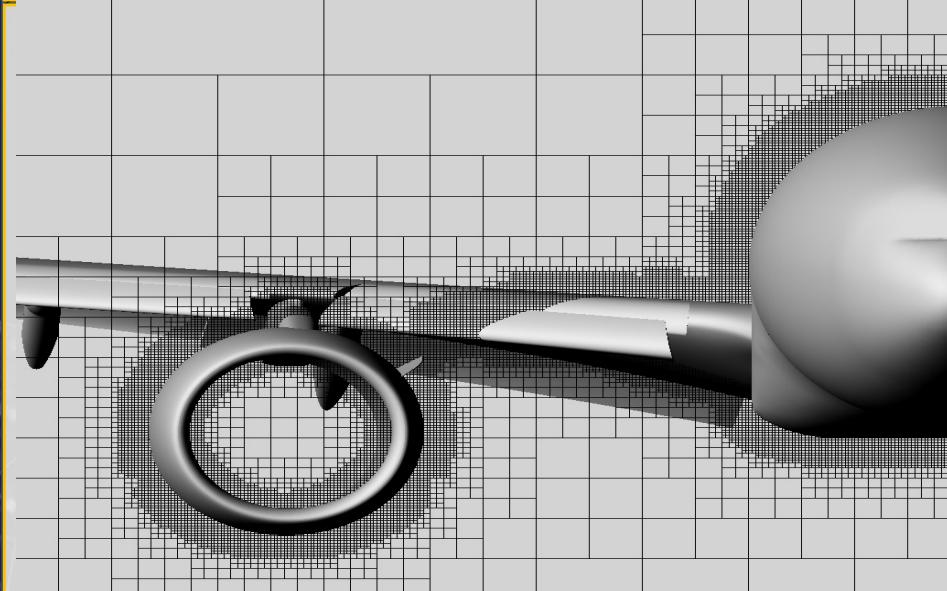


Z
X
Y



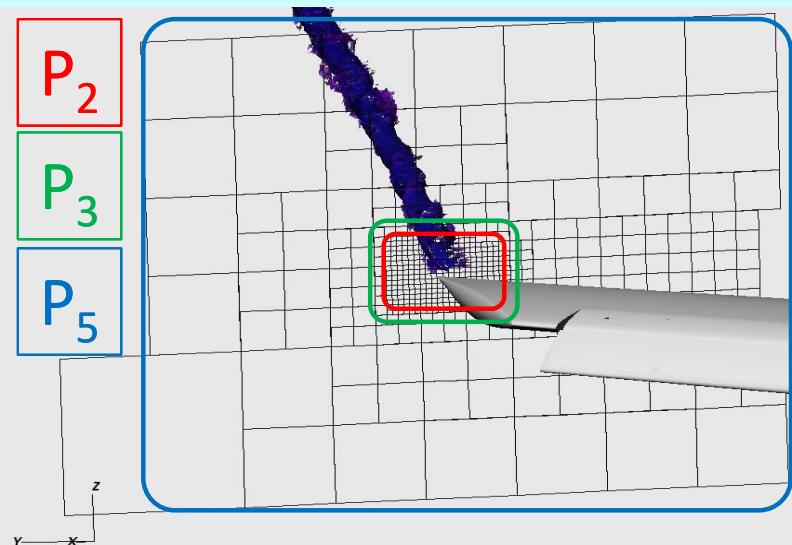


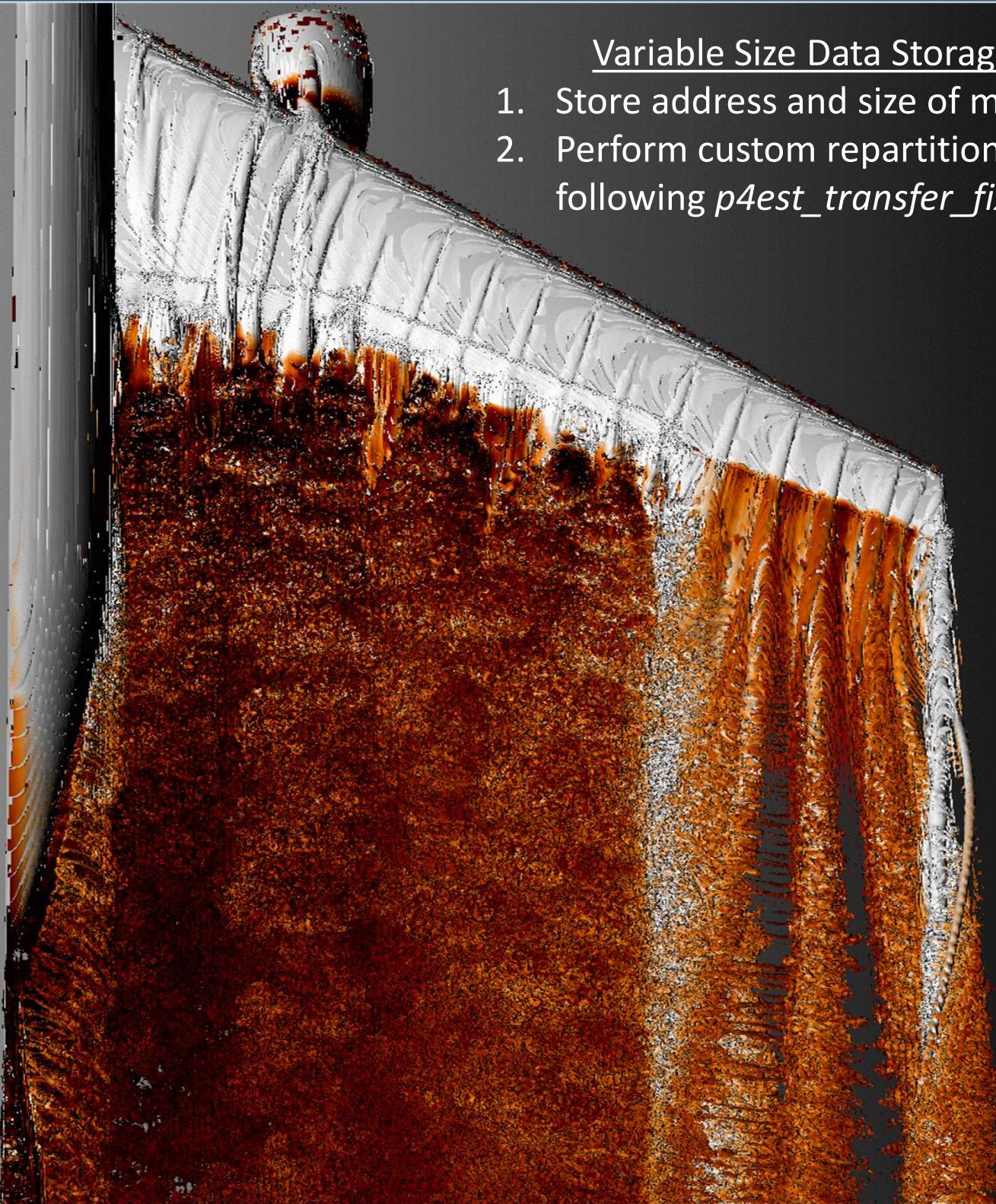
AIAA HLPW-4
<https://hiliftpw.larc.nasa.gov>



Off-Body Mesh:

- 290 Million DOFs
- 3rd-, 4th-, 6th-order elements

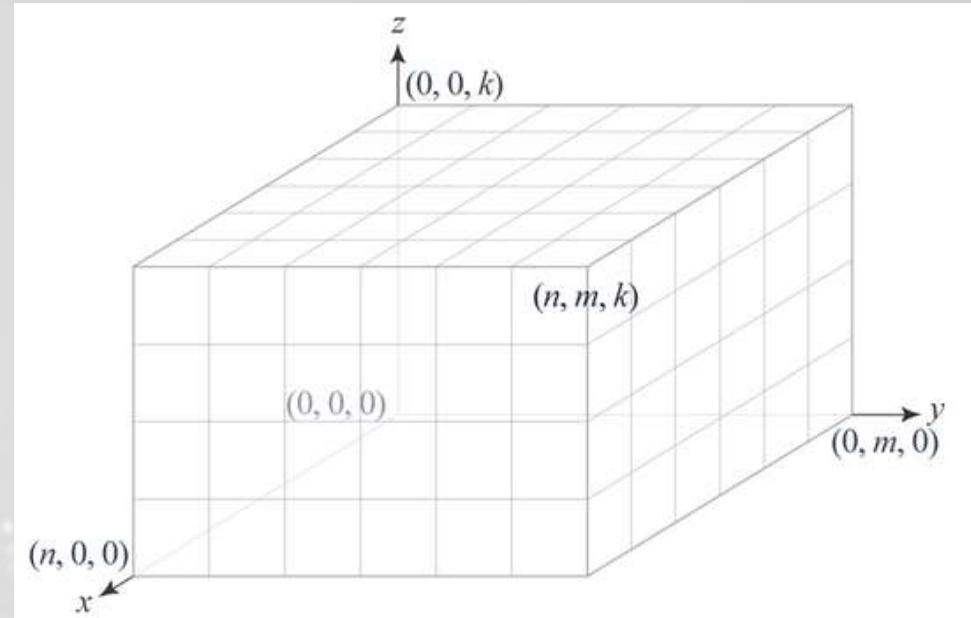
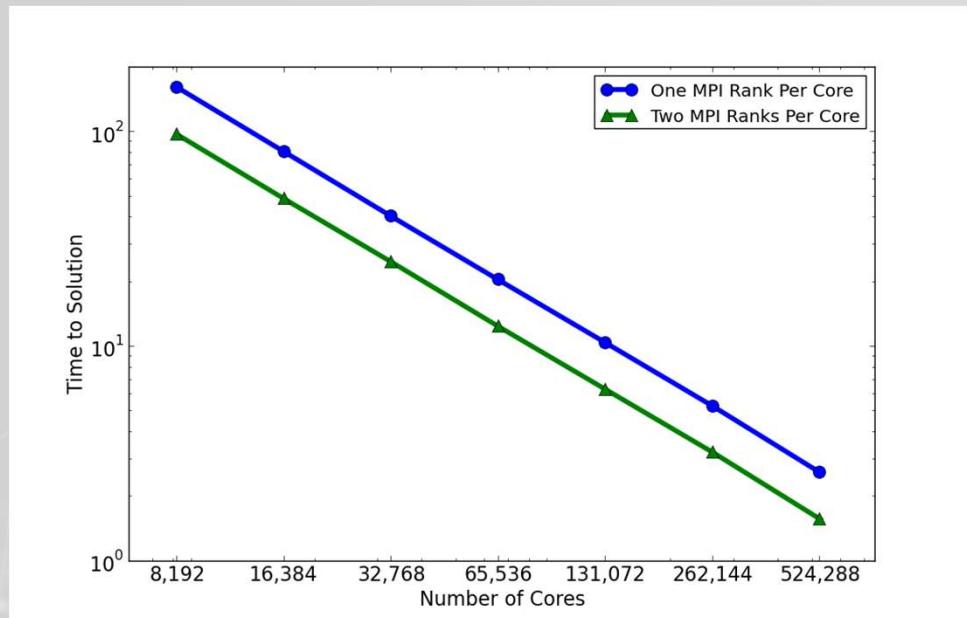




Variable Size Data Storage in p4est

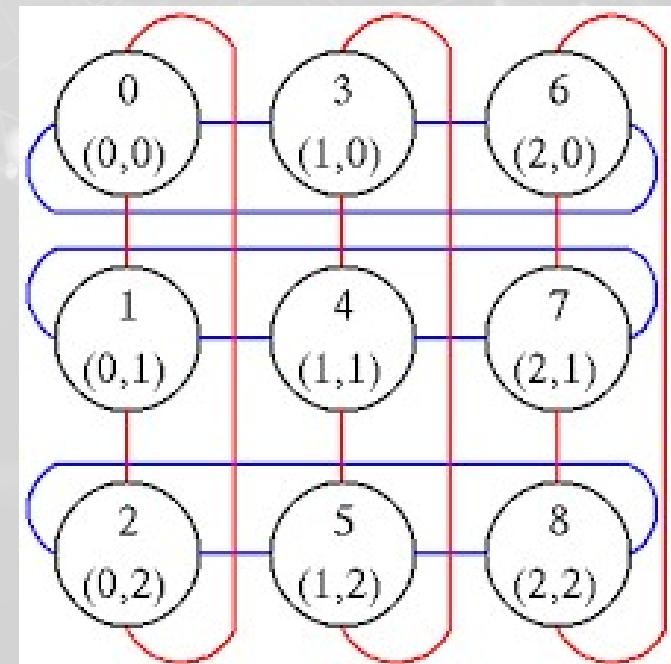
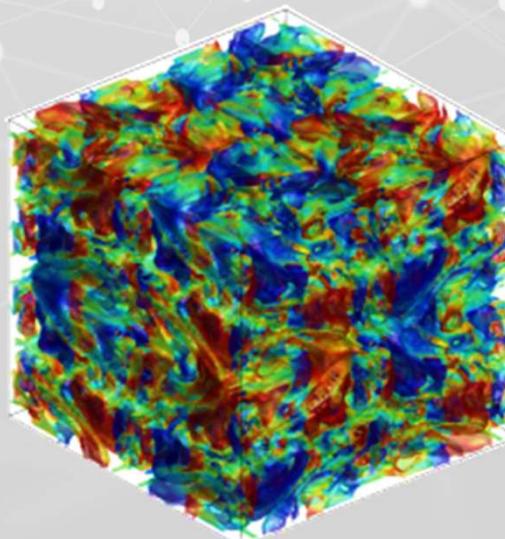
1. Store address and size of mem buffer
2. Perform custom repartitioning transfer following *p4est_transfer_fixed* algorithm

MPI_Cart_shift: CPU Scaling



Strong Scaling on ALCF Mira

- Taylor-Green Vortex
- Fully periodic
- Mesh: 512 x 512 x 512
- Fifth order: $p = 4$
- 16.8 Billion DOFs
- 83.9 Billion unknowns
- 2 MPI ranks per core
- 64% faster



Hands On Exercise #1: MPI_Cart_shift

1. Copy Problem Code

```
>> /jet/home/akirby/IHPCSS2023-mpi
```

```
>> cd IHPCSS2023-mpi/stencil
```

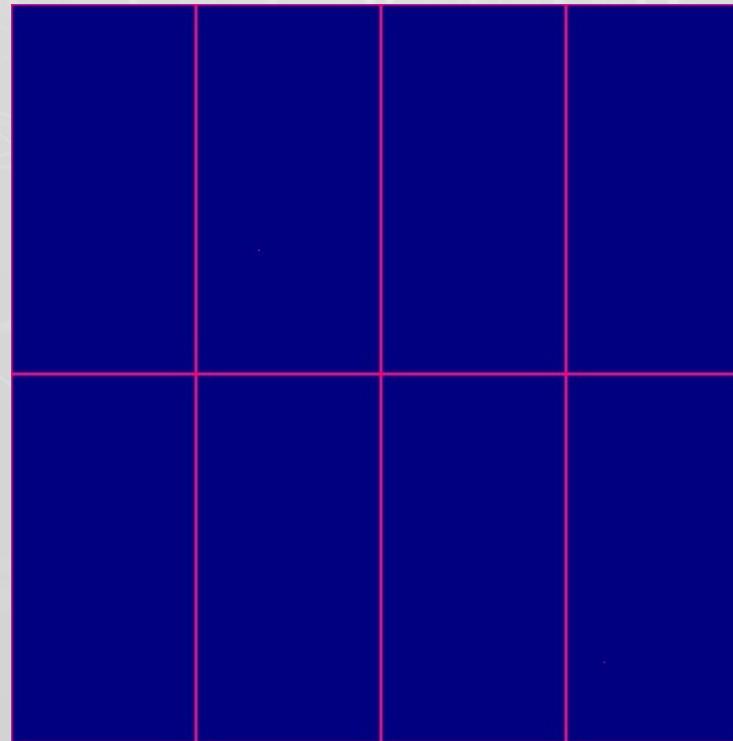
2. Compiling

```
>> ./interactive.sh
```

```
>> make
```

3. Executing

```
>> ./run8.sh
```



0 (0,0)	1 (0,1)	2 (0,2)	3 (0,3)
4 (1,0)	5 (1,1)	6 (1,2)	7 (1,3)
8 (2,0)	9 (2,1)	10 (2,2)	11 (2,3)
12 (3,0)	13 (3,1)	14 (3,2)	15 (3,3)

display WRK/8/output-0.bmp

Hands On Exercise #1: MPI_Cart_shift

1. Copy Problem Code

```
>> /jet/home/akirby/IHPCSS2023-mpi
```

```
>> cd IHPCSS2023-mpi/stencil
```

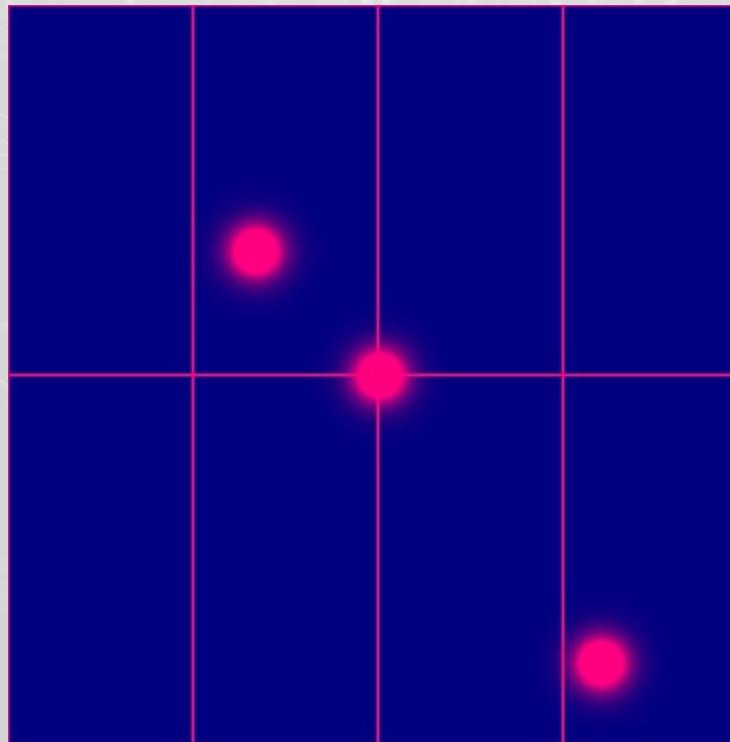
2. Compiling

```
>> ./interactive.sh
```

```
>> make
```

3. Executing

```
>> ./run8.sh
```



0 (0,0)	1 (0,1)	2 (0,2)	3 (0,3)
4 (1,0)	5 (1,1)	6 (1,2)	7 (1,3)
8 (2,0)	9 (2,1)	10 (2,2)	11 (2,3)
12 (3,0)	13 (3,1)	14 (3,2)	15 (3,3)

display output-2000.bmp

Hands On Exercise #1: MPI_Cart_shift

1. Copy Problem Code

```
>> /jet/home/akirby/IHPCSS2023-mpi
```

```
>> cd IHPCSS2023-mpi/stencil
```

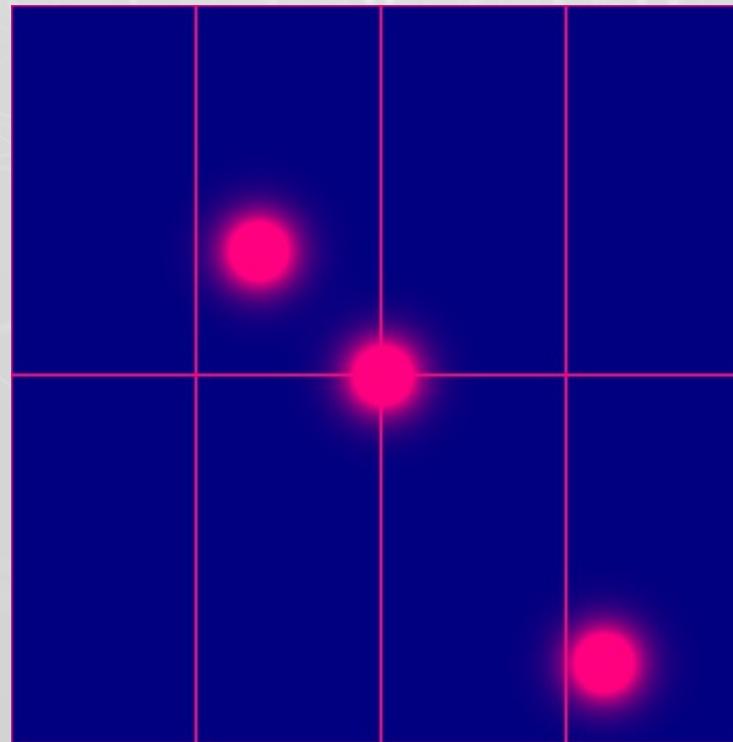
2. Compiling

```
>> ./interactive.sh
```

```
>> make
```

3. Executing

```
>> ./run8.sh
```



0 (0,0)	1 (0,1)	2 (0,2)	3 (0,3)
4 (1,0)	5 (1,1)	6 (1,2)	7 (1,3)
8 (2,0)	9 (2,1)	10 (2,2)	11 (2,3)
12 (3,0)	13 (3,1)	14 (3,2)	15 (3,3)

display output-4000.bmp

Hands On Exercise #1: MPI_Cart_shift

1. Copy Problem Code

```
>> /jet/home/akirby/IHPCSS2023-mpi
```

```
>> cd IHPCSS2023-mpi/stencil
```

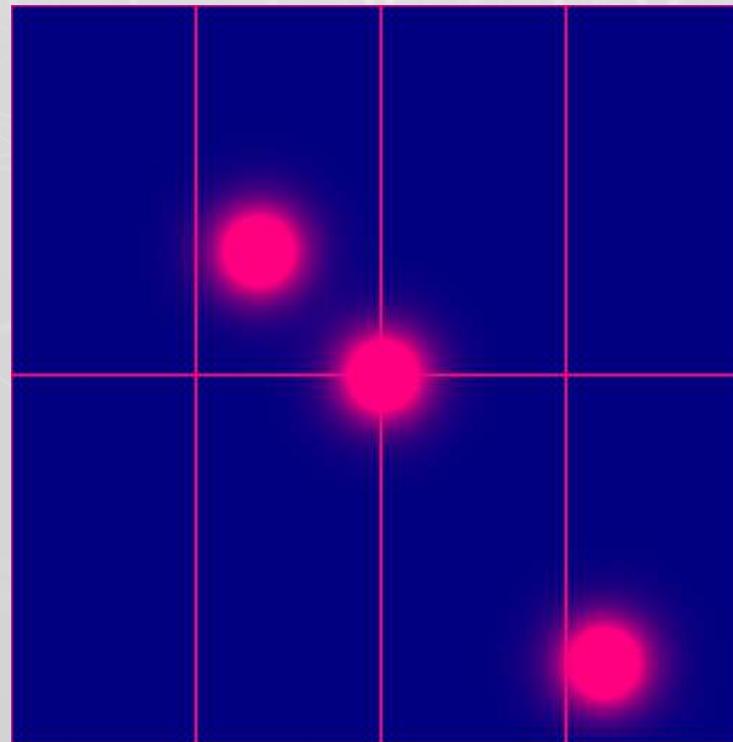
2. Compiling

```
>> ./interactive.sh
```

```
>> make
```

3. Executing

```
>> ./run8.sh
```



0 (0,0)	1 (0,1)	2 (0,2)	3 (0,3)
4 (1,0)	5 (1,1)	6 (1,2)	7 (1,3)
8 (2,0)	9 (2,1)	10 (2,2)	11 (2,3)
12 (3,0)	13 (3,1)	14 (3,2)	15 (3,3)

display output-6000.bmp

Hands On Exercise #1: MPI_Cart_shift

1. Copy Problem Code

```
>> /jet/home/akirby/IHPCSS2023-mpi
```

```
>> cd IHPCSS2023-mpi/stencil
```

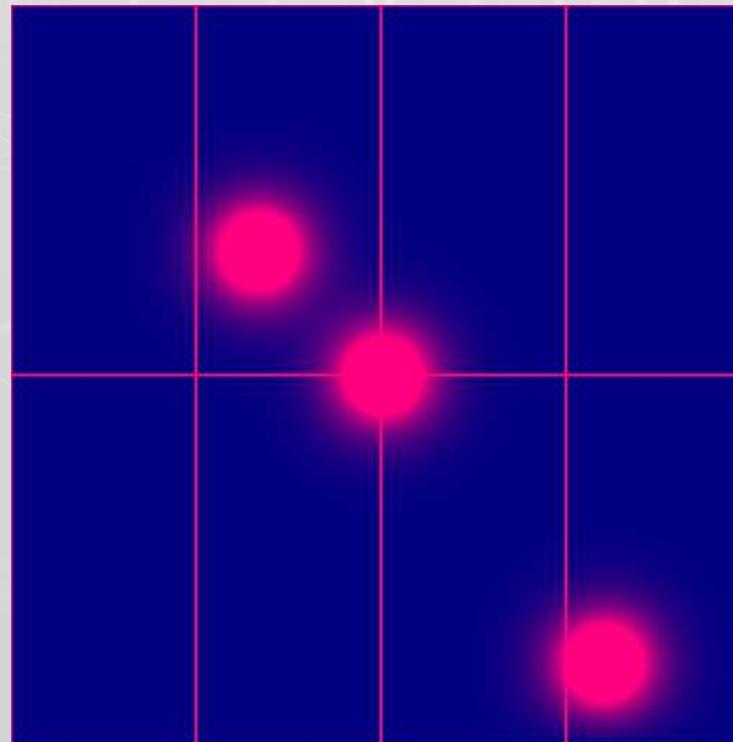
2. Compiling

```
>> ./interactive.sh
```

```
>> make
```

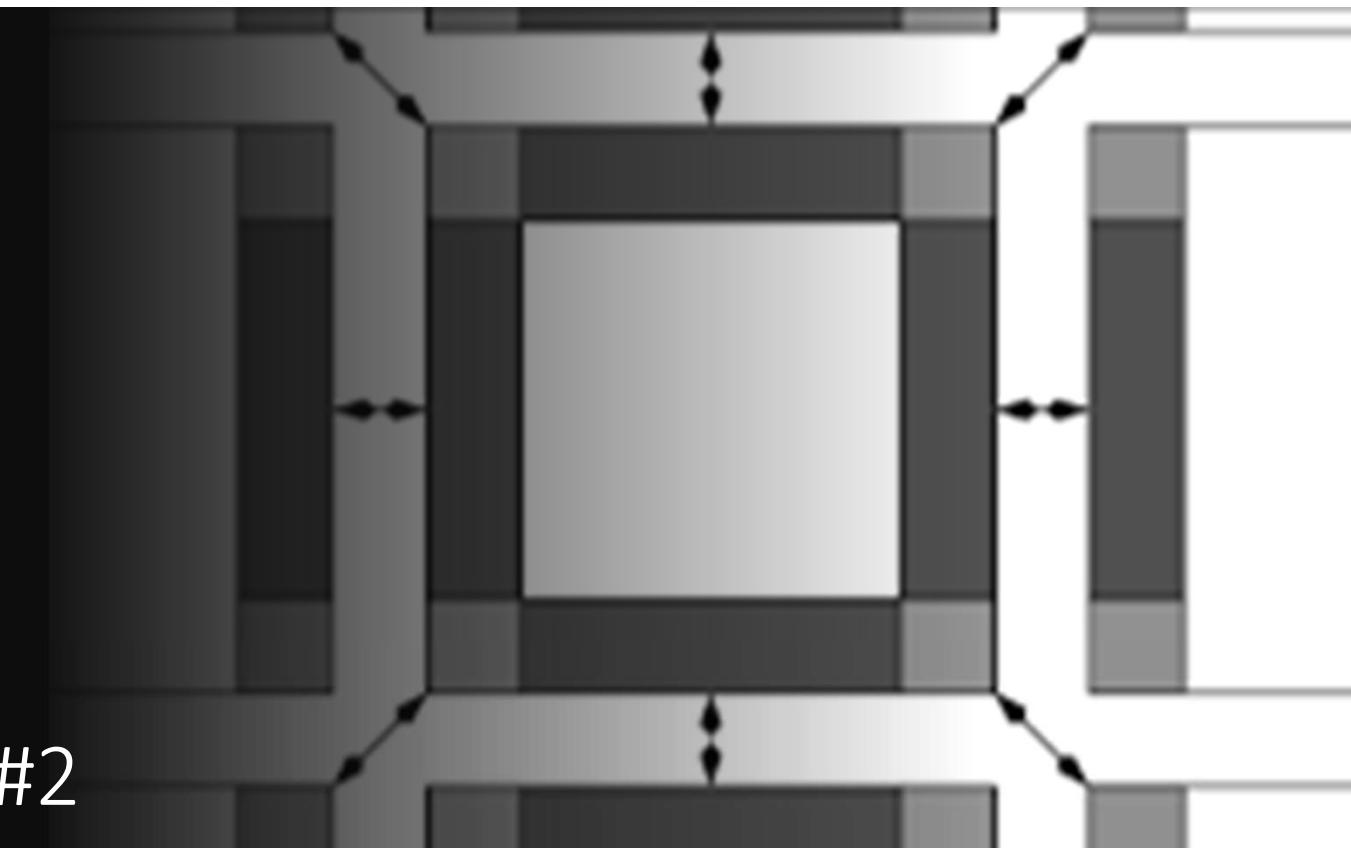
3. Executing

```
>> ./run8.sh
```



0 (0,0)	1 (0,1)	2 (0,2)	3 (0,3)
4 (1,0)	5 (1,1)	6 (1,2)	7 (1,3)
8 (2,0)	9 (2,1)	10 (2,2)	11 (2,3)
12 (3,0)	13 (3,1)	14 (3,2)	15 (3,3)

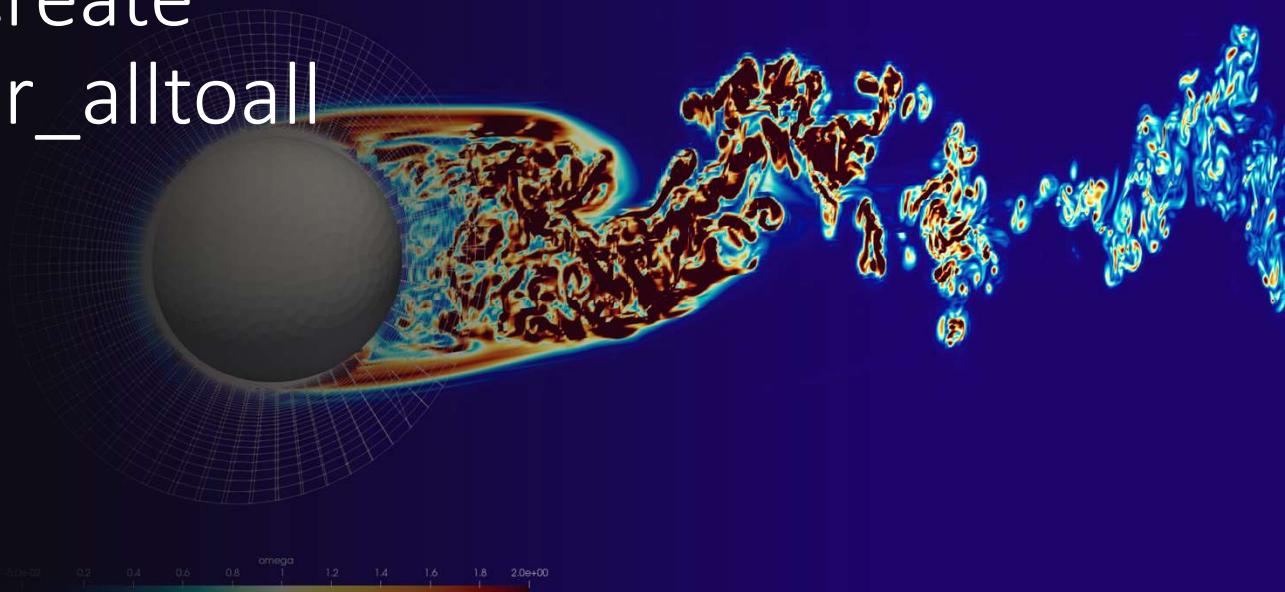
display output-8000.bmp



Hands on Exercise #2

Part 1 - MPI_Graph_create

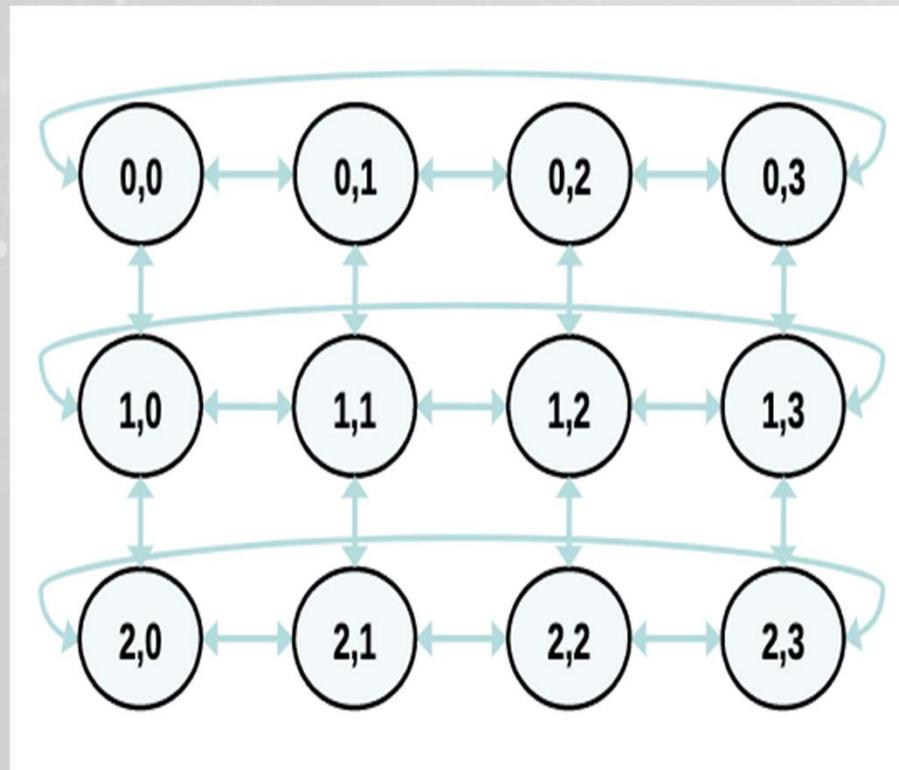
Part 2 - MPI_Neighbor_alltoall



Hands on Exercise #2: MPI_Graph_create

Goal: Replace MPI_Cart_shift
- MPI_Graph_create

Part 1: Build the graph!



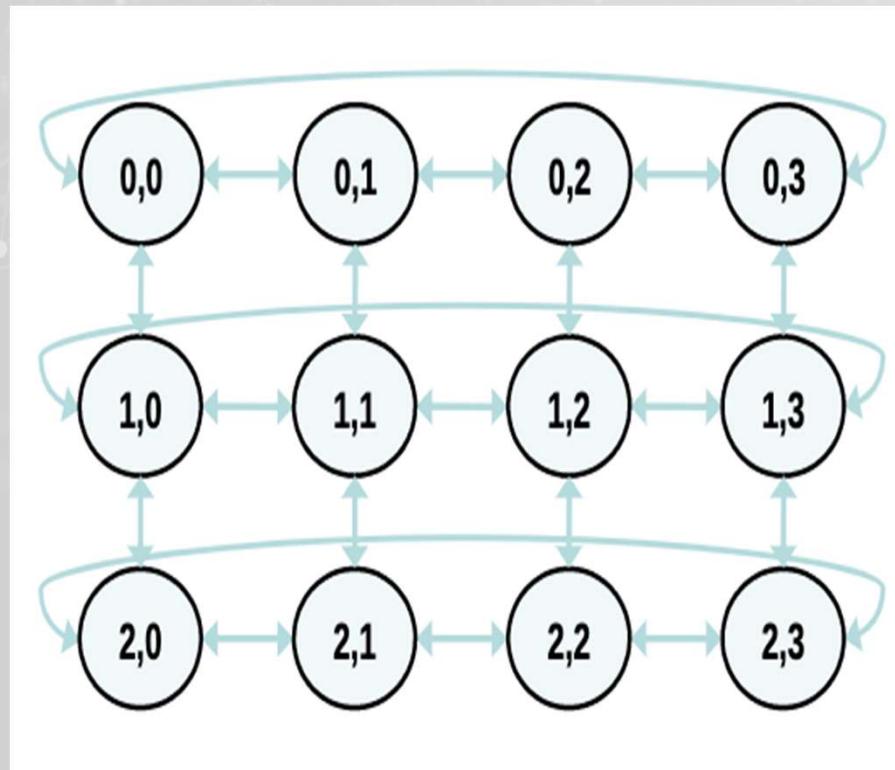
0 (0,0)	1 (0,1)	2 (0,2)	3 (0,3)
4 (1,0)	5 (1,1)	6 (1,2)	7 (1,3)
8 (2,0)	9 (2,1)	10 (2,2)	11 (2,3)
12 (3,0)	13 (3,1)	14 (3,2)	15 (3,3)

See example graph code in
directory:
stencil/graph-neighbor/graph-
examples

Hands on Exercise #3: MPI_Neighbor_alltoall

Goal: Replace MPI_Isend/Irecv
- MPI_Neighbor_alltoall

Part 2: Replace the communication!



0 (0,0)	1 (0,1)	2 (0,2)	3 (0,3)
4 (1,0)	5 (1,1)	6 (1,2)	7 (1,3)
8 (2,0)	9 (2,1)	10 (2,2)	11 (2,3)
12 (3,0)	13 (3,1)	14 (3,2)	15 (3,3)

See example graph code in
directory:
stencil/graph-neighbor/graph-
examples