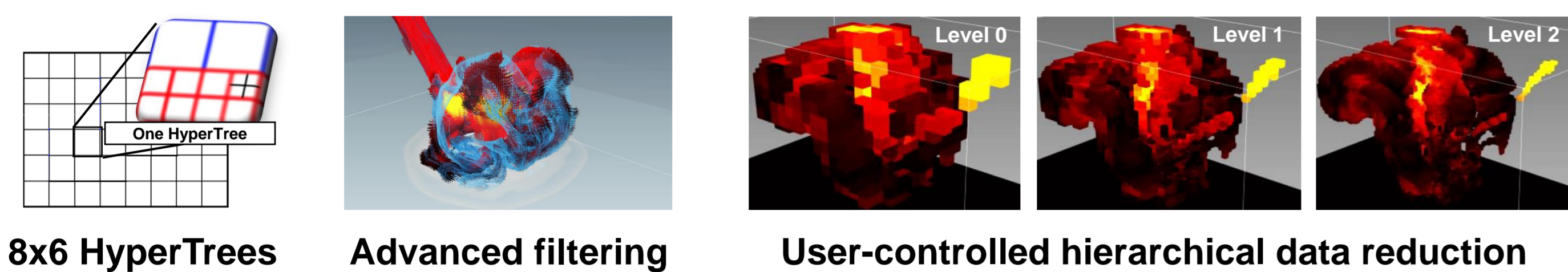


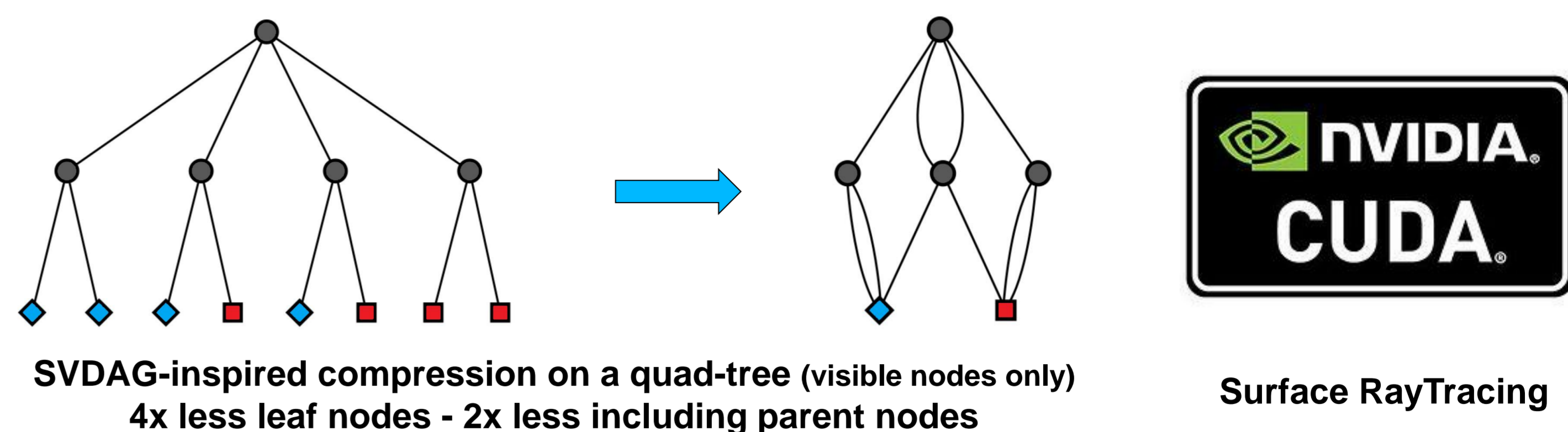
## Scientific Visualization - VTK HyperTreeGrid [1,2]

- ✓ **Efficient memory-wise** for sparse simulation data representation
- ✓ **Advanced filtering** available in ParaView / VTK
- ✓ **User-controlled hierarchical data reduction** in Paraview / VTK to accelerate analyses [3,4]
- ✓ **Generally efficient surface rendering** as an unstructured mesh:  $N^3$  volume data -  $N^2$  surface data
- ✓ **Distributed parallel computations** through whole trees dispatch



## Computer Graphics – Compressed Octree (SVDAG) [5]

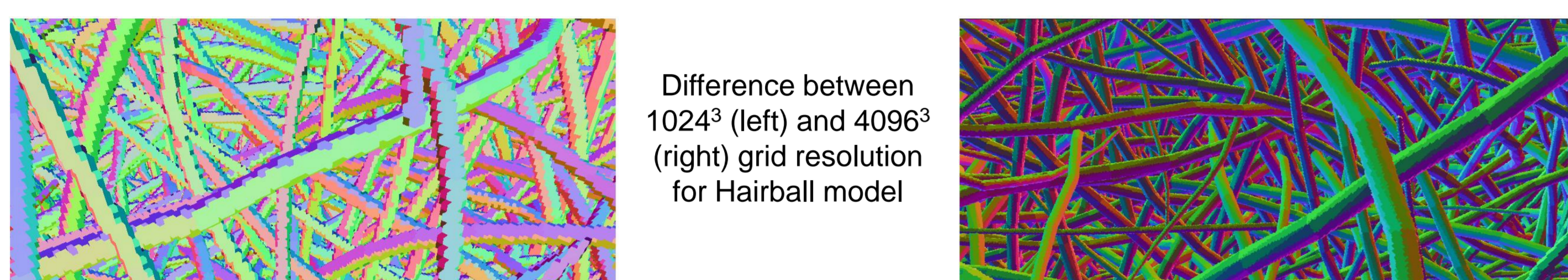
- ✓ **High compression ratios** of octree on surface Computer Graphics scenes
- ✓ **Very efficient surface RayTracing** on Nvidia GPUs using CUDA



## Problem

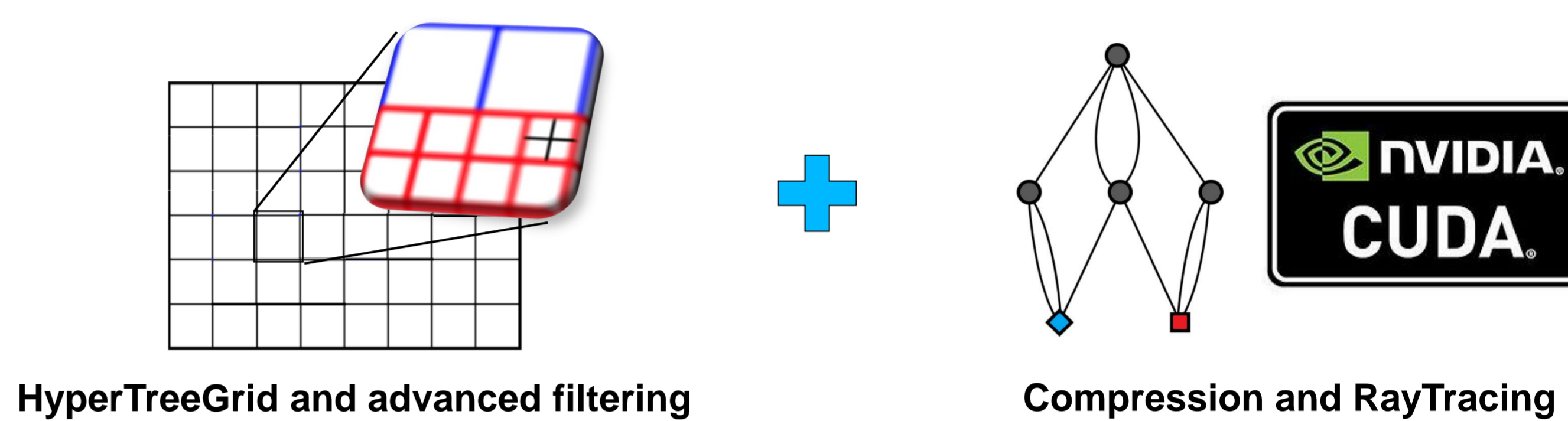
- Rendering for the Visualization Toolkit (VTK) HyperTreeGrid: **memory consumption can be very large**
- ✗ Generation of an unstructured mesh with as much **surface data as volume data** for extreme cases
  - ✗ For some mesh, surface representation is on average 10x more costly in memory than HyperTreeGrid
  - ✗ In extreme cases, **surface representation does not fit on a GPU**

Voxel Grid	32 <sup>3</sup>	64 <sup>3</sup>	128 <sup>3</sup>	256 <sup>3</sup>	512 <sup>3</sup>	1024 <sup>3</sup>	2048 <sup>3</sup>	4096 <sup>3</sup>
GPU memory (MB, Max 8192)	2	2,5	49	252	1005	4774	Out of Memory	Out of Memory



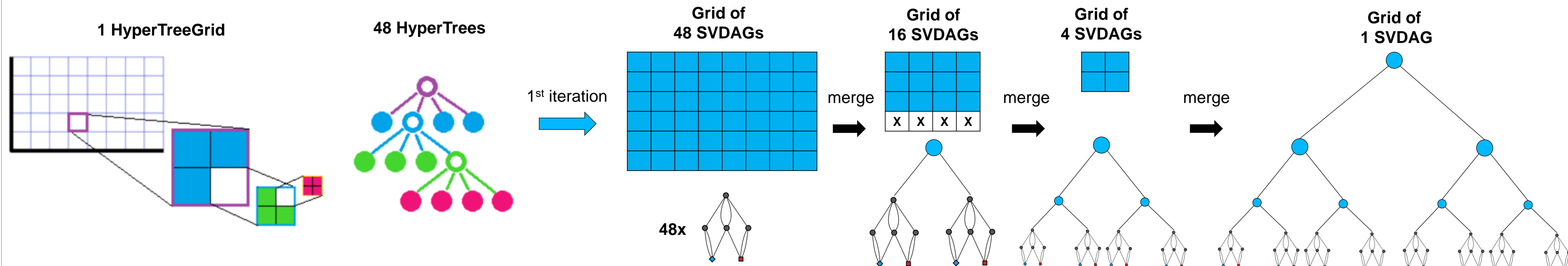
## Proposal

- Evaluation of SVDAG-inspired compression and rendering, applied to VTK HyperTreeGrid:
- **Compression** of scientific volume data
  - **Surface RayTracing** of HyperTreeGrid on Nvidia GPUs
  - **Reduction of the memory footprint** for surface rendering of HyperTreeGrid



## Contributions

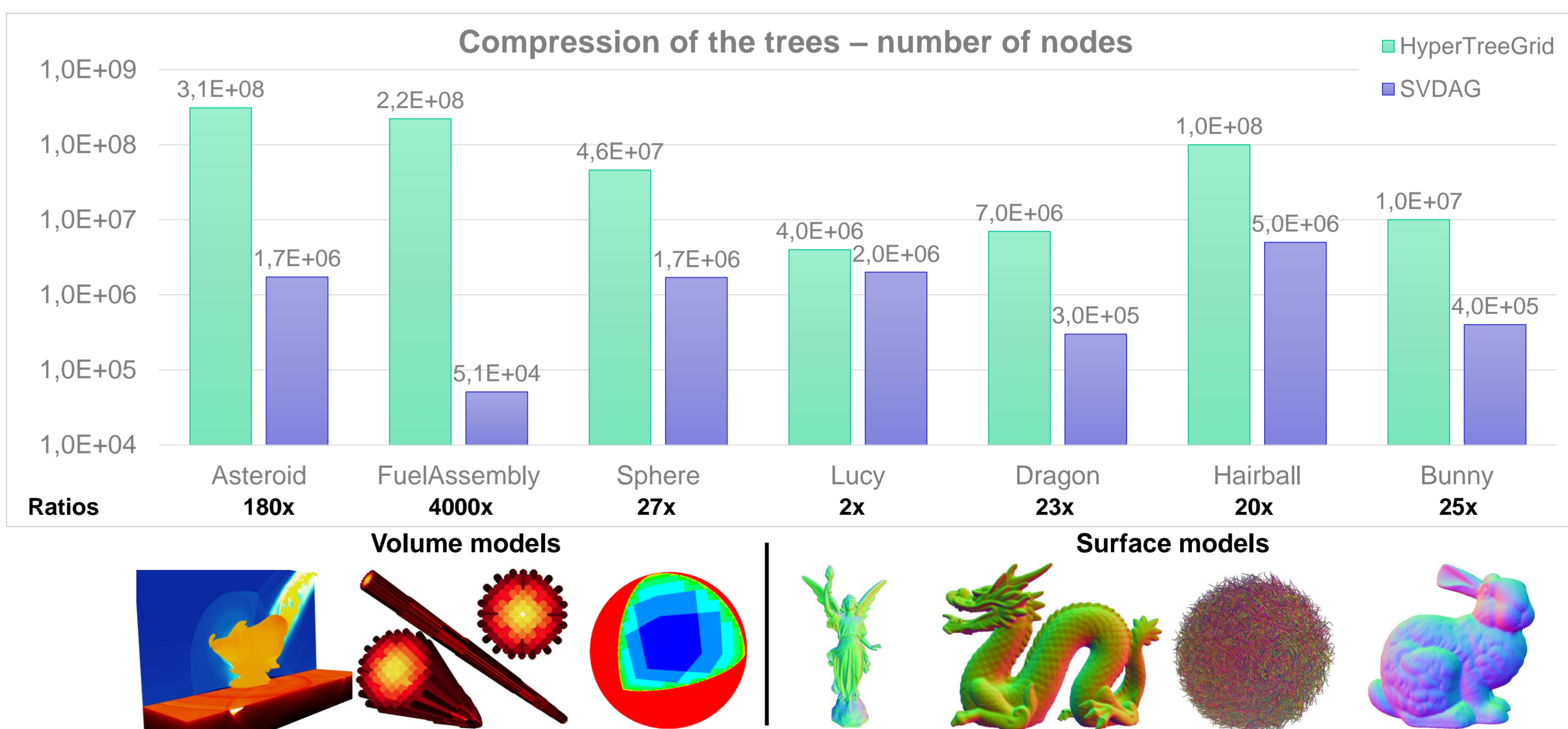
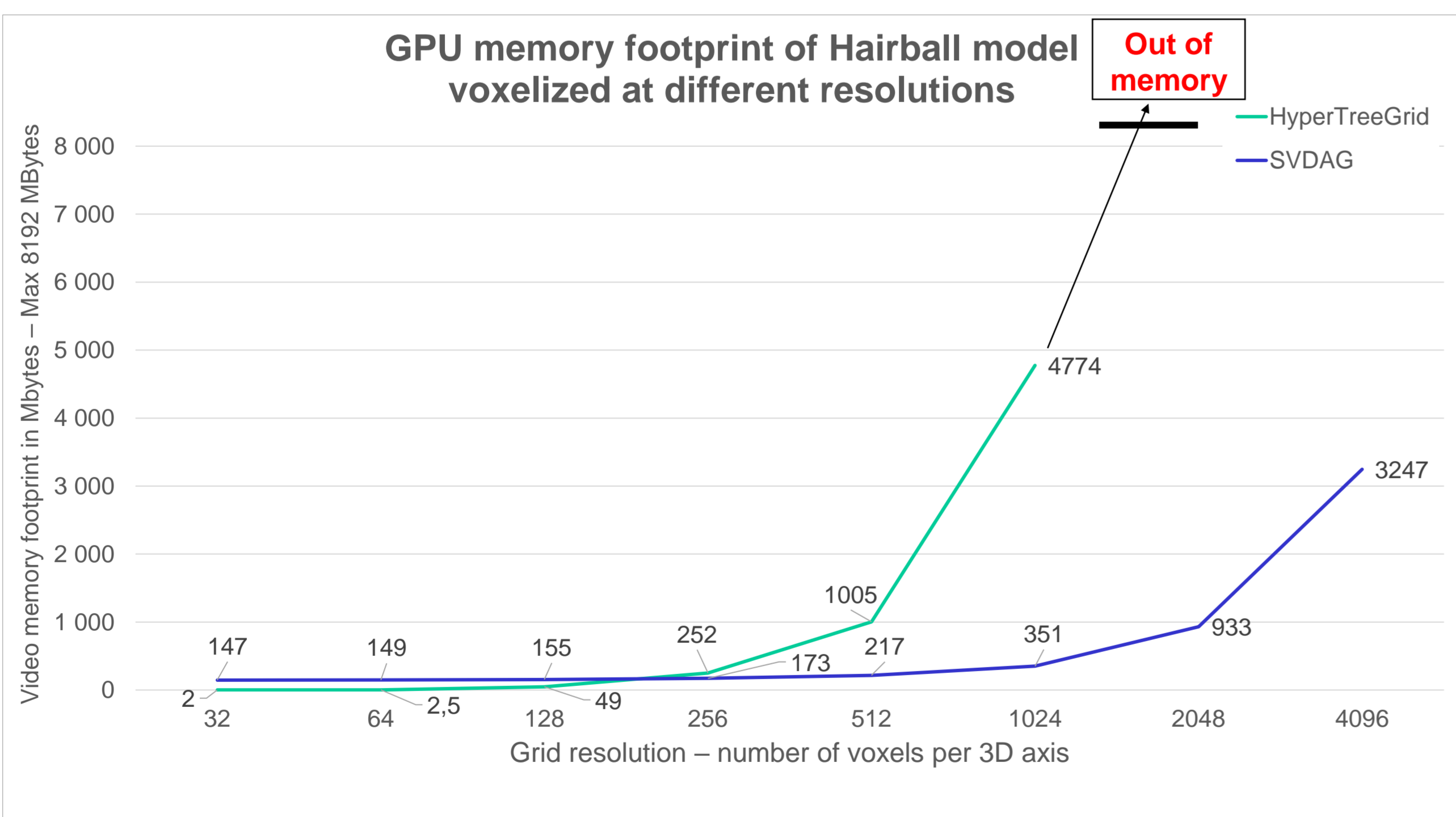
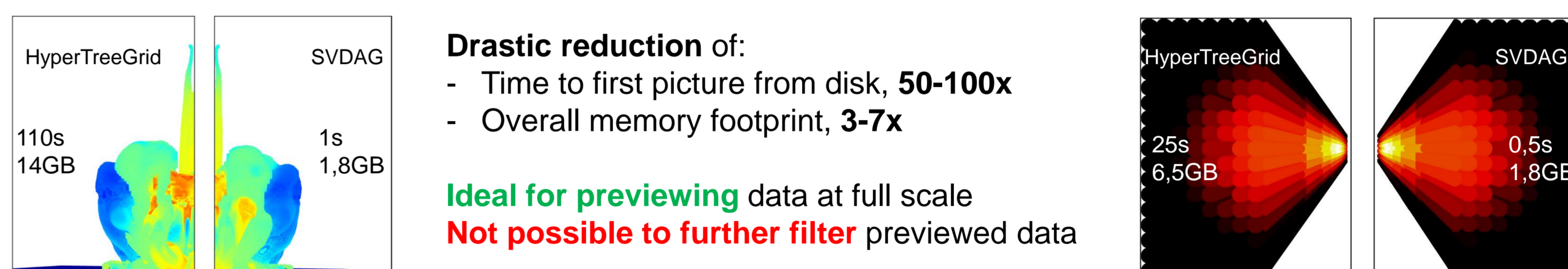
- ✓ **Implementation of a HyperTreeGrid to SVDAG conversion**



- ✓ **Evaluation of compression and rendering** of HyperTreeGrid surface and volume models as SVDAG
- ✓ **Benchmark** of an export of HyperTreeGrid as SVDAG to storage for **preview purposes**

## Results - Combined Data Reduction

- ✓ **Extreme compression:** number of octrees nodes for scientific visualization volume data
- ✓ **Enables the interactive surface rendering** for some HyperTreeGrid models on the GPU, otherwise **not possible with current native VTK rendering**
- ✓ **Almost instant preview** of data at **full simulation resolution** instead of **dozens of seconds**



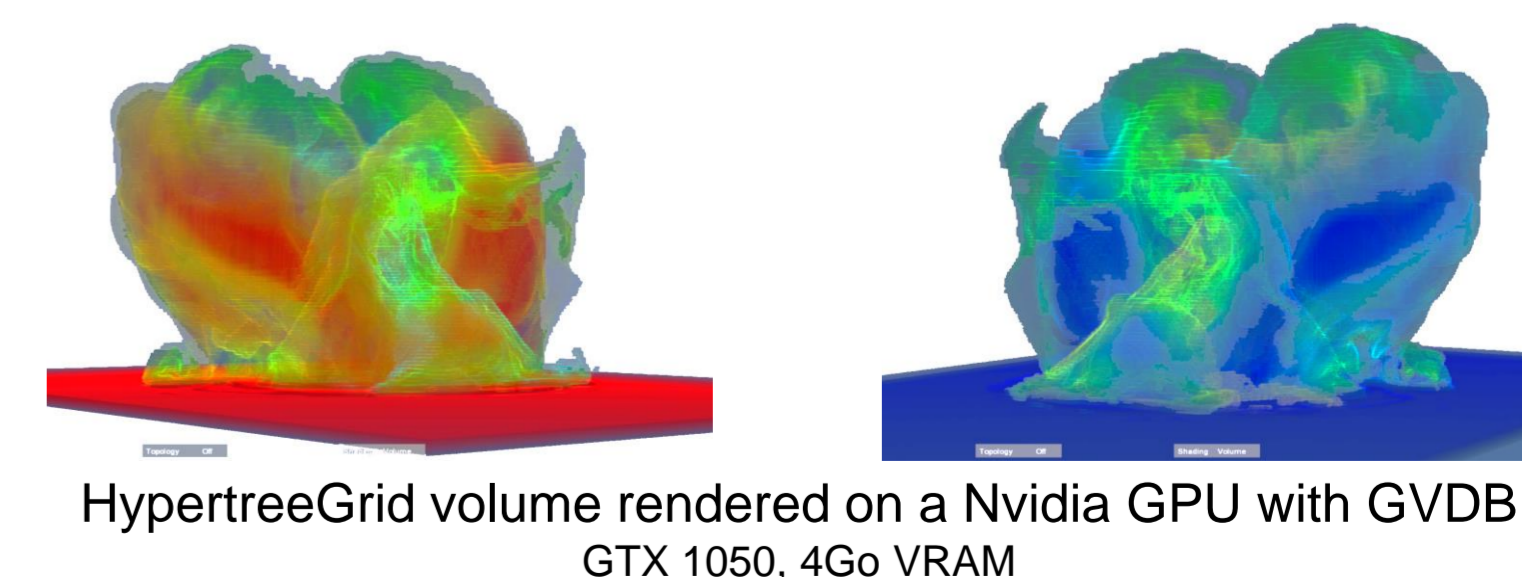
## Conclusion

In this work, we evaluated AMR mesh compression for the rendering of SciVis volume data.

- We achieved great improvements over native HTG rendering scheme :
- **Reduction of memory footprint** by ratios of 3-7x
  - Load data for **preview at full scale** 50-100x faster
  - Make it possible to render data on GPU, originally impossible

## Future Work

- In future work, we plan to:
- investigate **attribute compression** [6], for HyperTreeGrid volume data
  - Explore **other AMR representations** such as VDB [7]
  - Evaluate **volume rendering** of HyperTreeGrid data on
    - Nvidia GPUs with GVDB [8]
    - x86 CPUs with Intel OSPRay [9].



## References

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