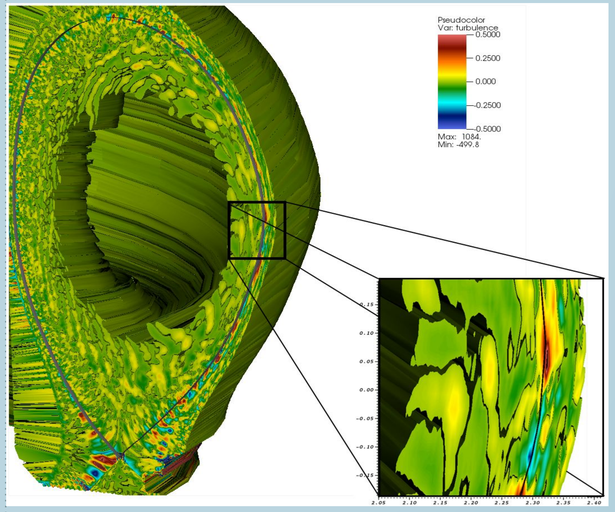
Performance and Scalability of XGC Fusion Code on Summit

Stephen Abbot[1], Patrick Worley[2], Seung-Hoe Ku[3], Stephane Ethier[3], Robert Hager[3], C. S. Chang[3], Mark Adams[4], Ed D'Azevedo[5]
[1]Nvidia, [2]PHW Consult, [3]PPPL, [4]LBNL, [5]ORNL

HBPS
High-fidelity Boundary Plasma Simulation



XGC Fusion Code

XGC is a modern first-principles gyrokinetic code using particle-in-cell (PIC) technology for modeling the plasma in a tokamak fusion device, emphasizing the boundary region. XGC can handle complex geometry including the X-point and the scrape-off edge region. A field-following unstructured mesh is used in each poloidal plane.

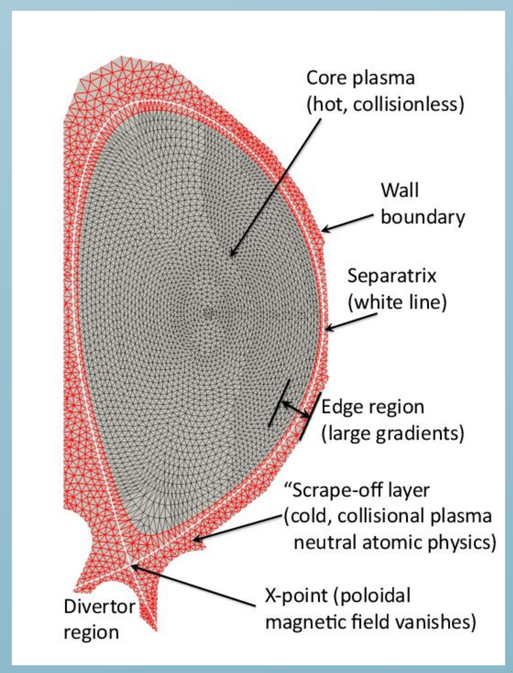


Fig. 1: Unstructured triangular mesh in XGC maps the entire tokamak cross-section, including the divertor separatrix surface and irregular wall structure. Figure used ITER geometry with artificially coarsened mesh for a better visualization.

Performance Results

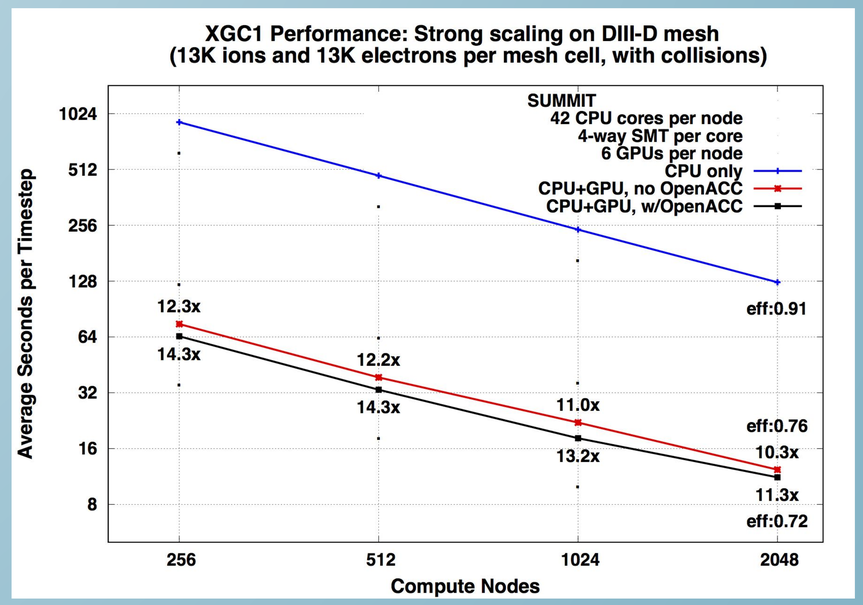


Figure 1: XGC strong scaling study on SUMMIT

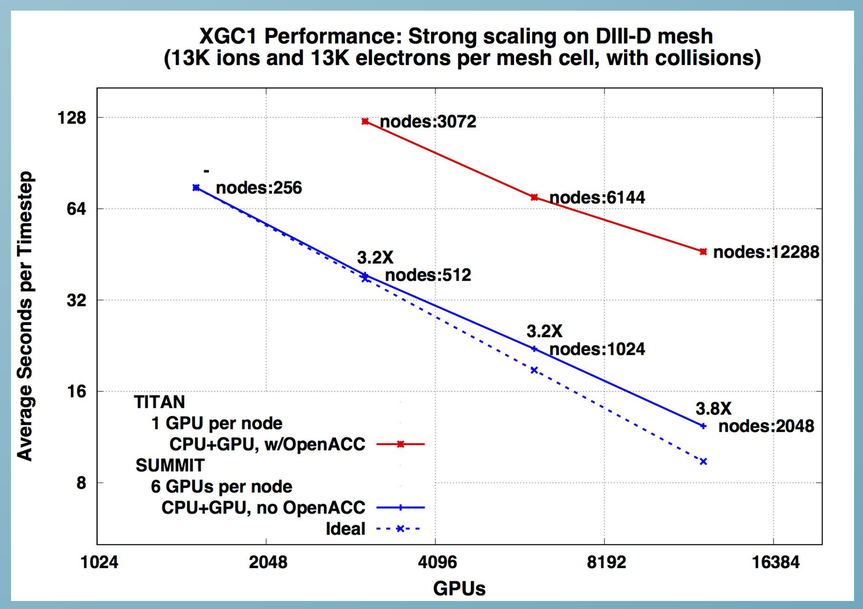


Figure 2: GPU-to-GPU comparison of Summit vs Titan

Details

- Electron push is the most expensive computational kernel and optimized for GPU using CUDA Fortran to take advantage of texture memory.
- Multi-species collision is another expensive kernel and optimized using OpenACC for GPU.
- XGC uses ADIOS to achieve high performance in parallel I/O to NVRAM and parallel file system (300 GB/s on 32 nodes).
- XGC uses OpenMP over multiple cores and uses 1 MPI rank per GPU

CONCLUSIONS

- Near linear strong scaling to 2048 nodes (over 40%) of Summit
- Weak scaling is also near linear
- About 11X speedup at 2,048 nodes using GPU (and CPU simultaneously) acceleration over CPU-only version
- 2048 nodes on Summit is about 3.8X faster over 12288 nodes on Titan
- Further scaling studies will be performed when a larger fraction of Summit will be available.

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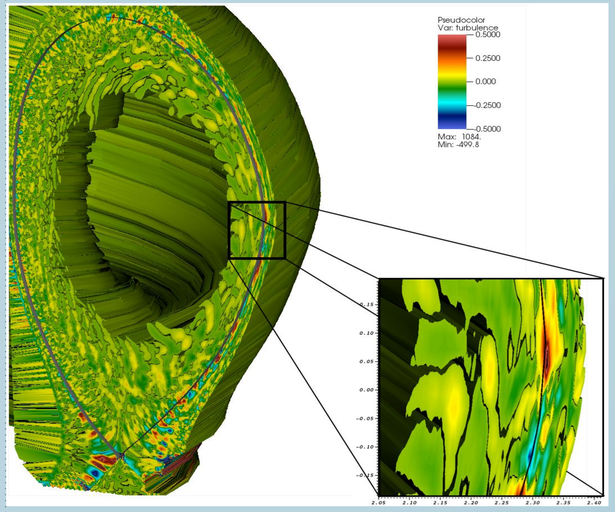

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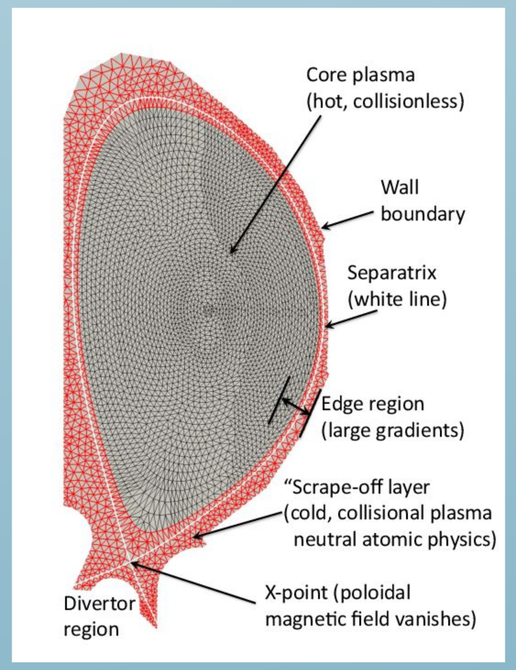

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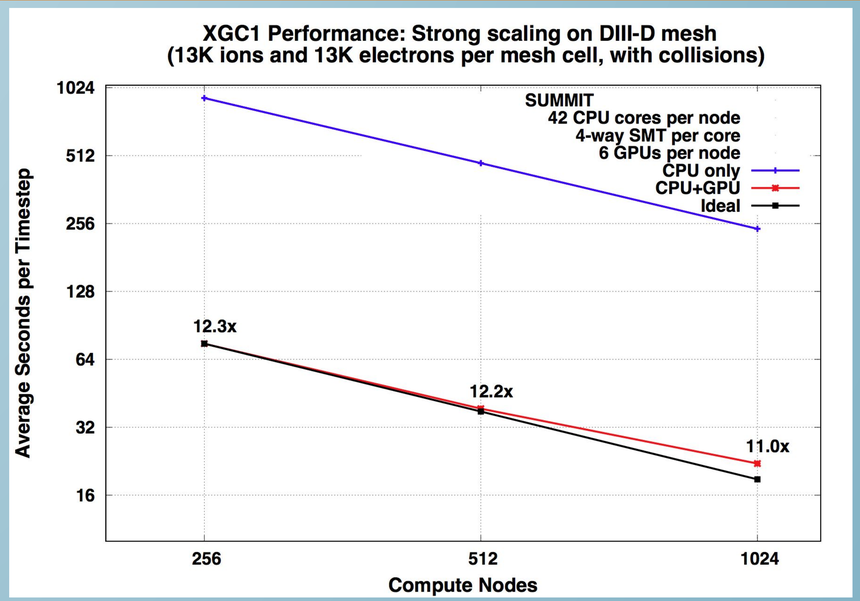

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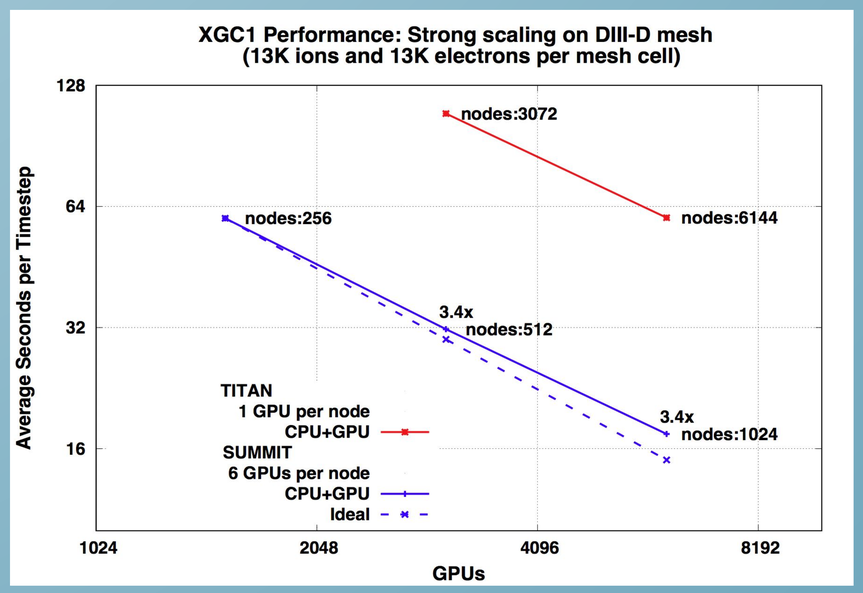

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CONCLUSIONS

- Near linear strong scaling to 1024 nodes (over 20%) of Summit
- About 11X speedup using GPU acceleration over CPU-only version
- 1024 nodes on Summit is about 3.4X faster over 6144 nodes on Titan
- Further scaling studies will be performed when a larger fraction of Summit will be available.

Acknowledgments: This material is based upon work supported by the U.S. Department of Energy, Office of Science, Office of Fusion Energy Sciences, Advanced Scientific Computing Research. This research used resources of the Oak Ridge Leadership Computing Facility, which is a DOE Office of Science User Facility.

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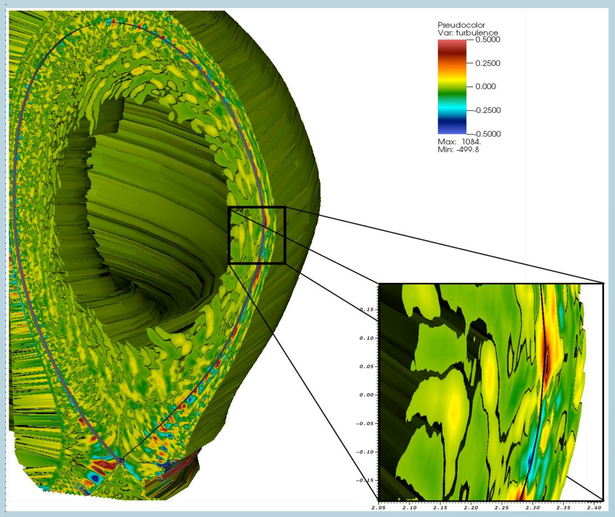

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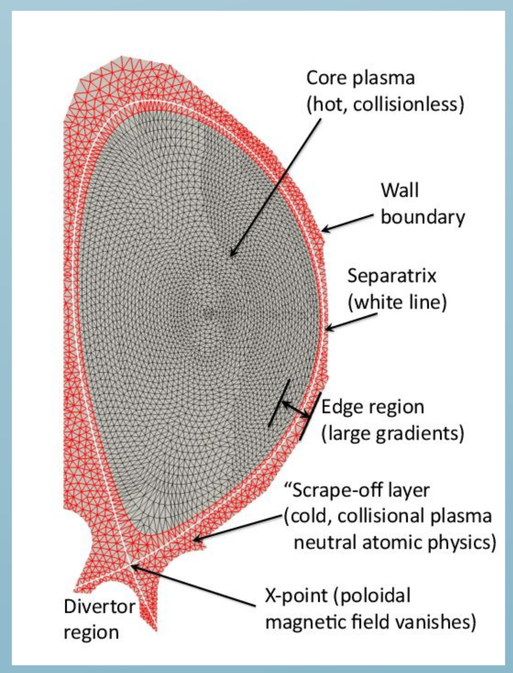

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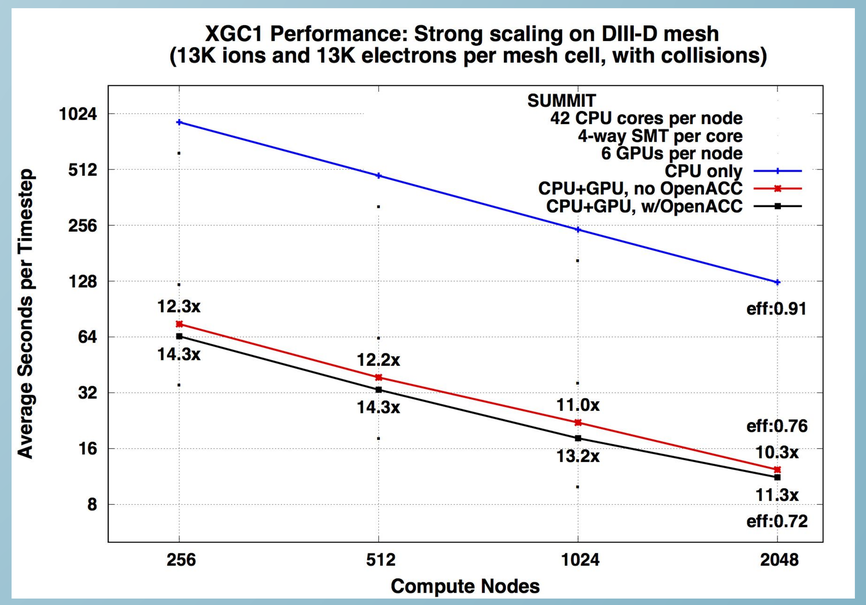

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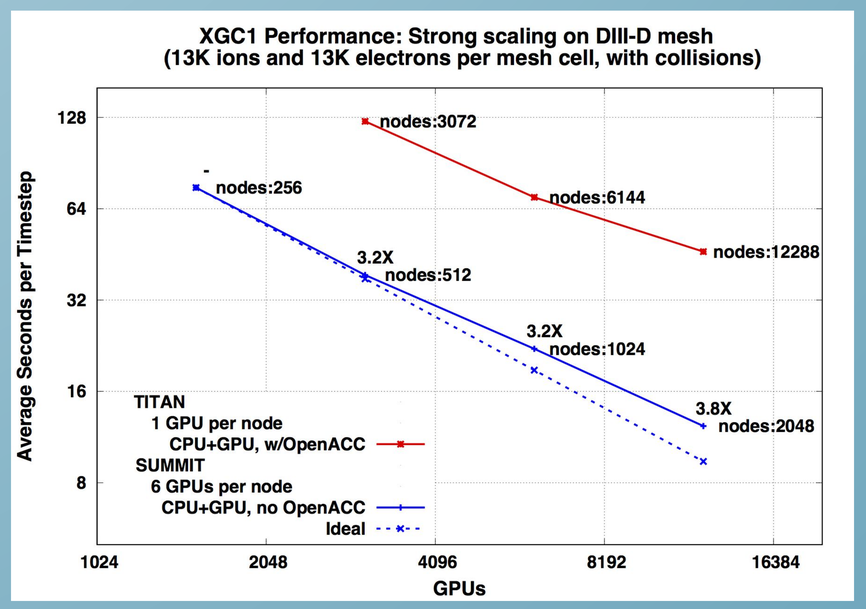

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