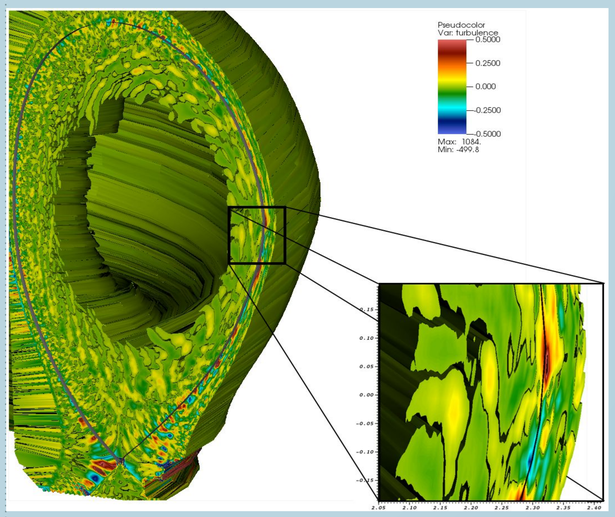
Performance and Scalability of XGC Fusion Code on Summit

XGC CAAR Team



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. 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.

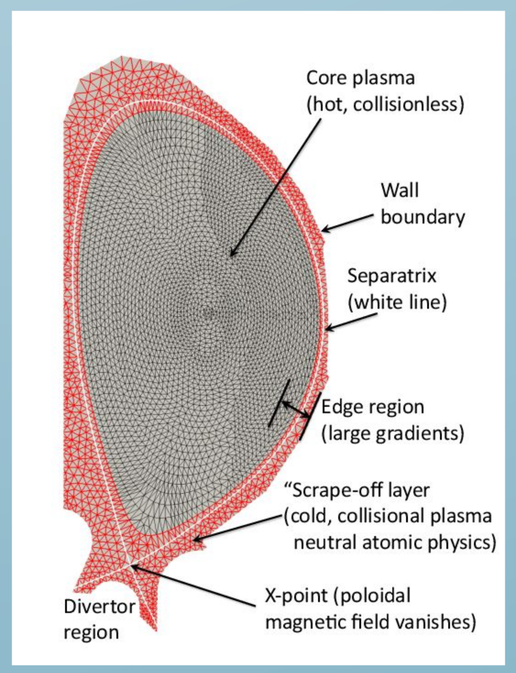


Fig. 1: Unstructured triangular mesh in XGC maps the entire tokamak cross-section, including the divertor separatrix surface and irregular wall structure. Figure used ITER geometry with artificially coarsened mesh for a better visualization.

Performance Results

Compute Nodes	Grid Vertices	Total Electrons	CPU-only (sec)	CPU+GPU (sec)	Speed-up of (CPU+GPU) vs. CPU-only
32	3,751	901M	664.5	75.3	**8.8X**
64	7,495	1,802M	668.9	77.3	**8.7X**
128	15,004	3,604M	677.0	79.3	**8.5X**
256	30,001	7,209M	701.4	83.6	**8.4X**
512	61,078	14,418M	721.4	88.0	**8.2X**
1024	120,432	28,836M	740.7	93.7	**7.9X**

Table 1: XGC weak scaling study on SUMMIT

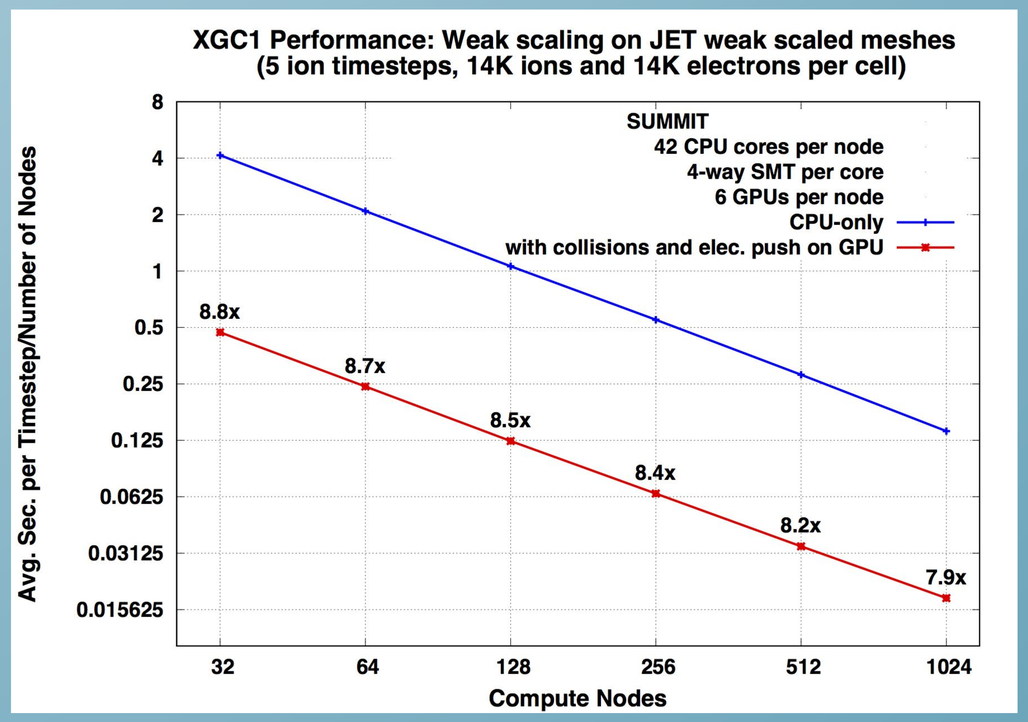
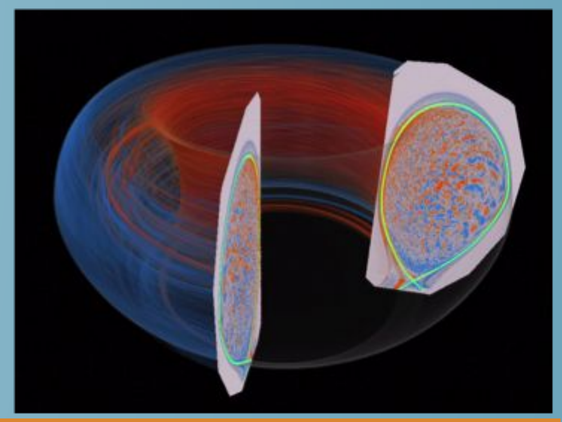


Fig 2: Scaling of XGC on Summit using problem optimized for Titan. A larger problem can show higher speedup factor.



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

- **XGC already scaled to 90% of Titan.**
- **Our initial results suggest XGC has high performance on Summit by effectively using the Volta GPUs.**
- **Further scaling studies will be performed when a larger fraction of Summit will be available.**