CGYRO performance on Slingshot-connected Perlmutter GPU nodes

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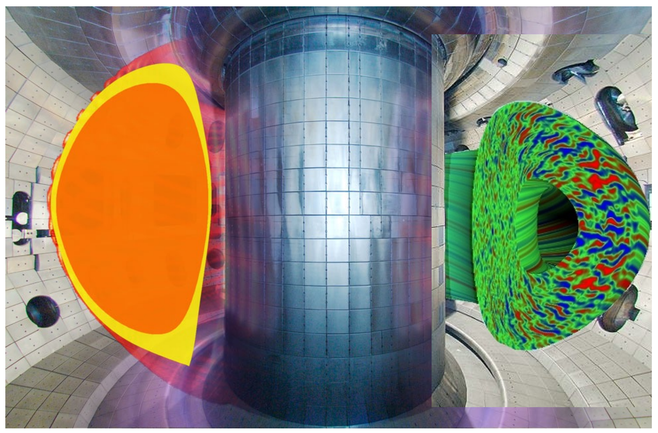
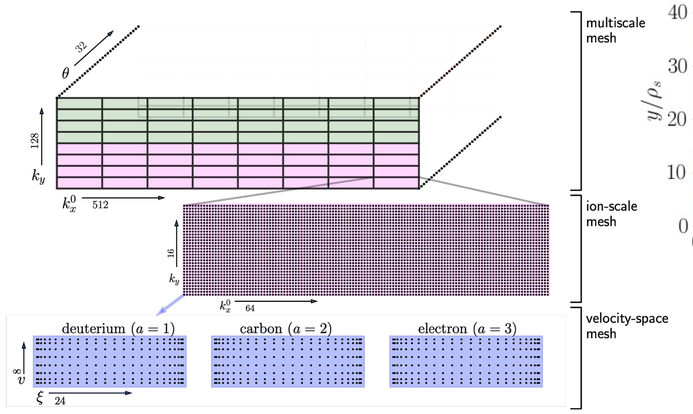
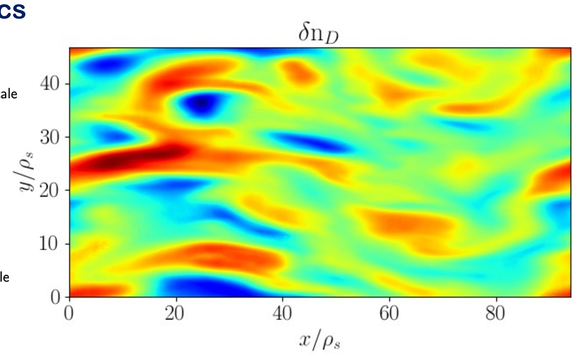


Experimental methods are essential for gathering new operational modes. But **simulations** are used to validate basic theory, plan experiments, interpret results on present devices, and ultimately to design future devices.

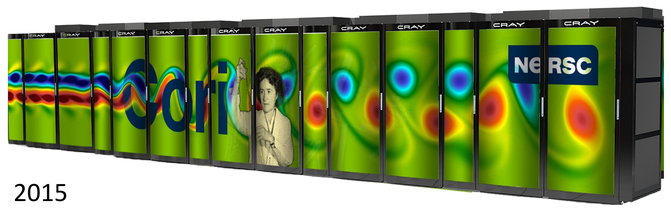
CGYRO is a premier tool for multi-scale fusion plasma turbulence simulation and has been in use by the fusion community for several years.

https://gafusion.github.io/doc/cgyro.html





Another result with time evolution available at:
https://www.ga.com/images/BlogFeaturedImages/ga-scientists-leverage-DOE-belli-alcc.gif



2015

Most simulations need a HPC system.

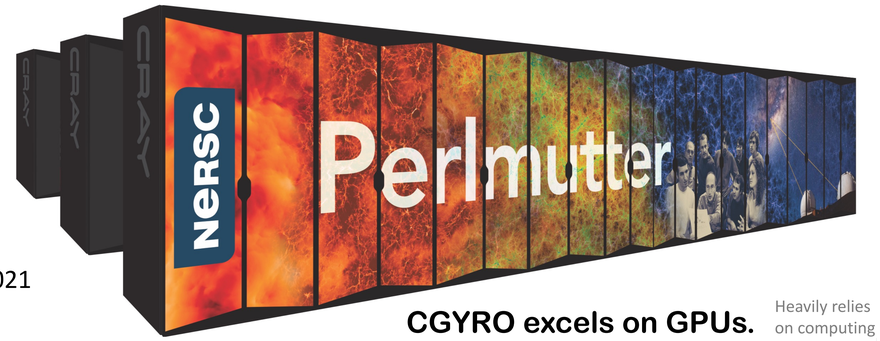
Memory footprint of cutting-edge simulations too big to fit into a single node.

NERSC National Energy Research Scientific Computing Center

Benchmark sh04 case represents the current cutting-edge multi-scale fusion turbulence simulations, having a 5+1-dimensional grid of (128 x 1152 x 24 x 18 x 8) x 3 species.

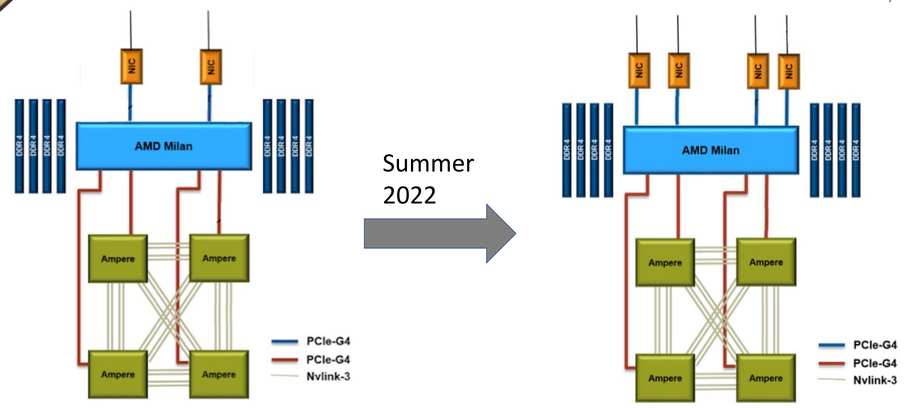
https://github.com/scidac/atom-open-doc/blob/master/CGYRO_inputs/sh04/input.cgyro

2021

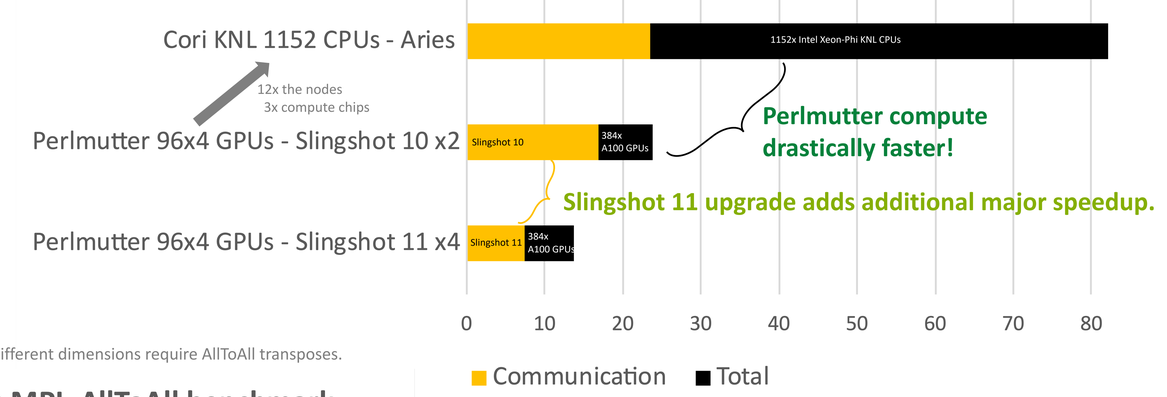


CGYRO excels on GPUs.

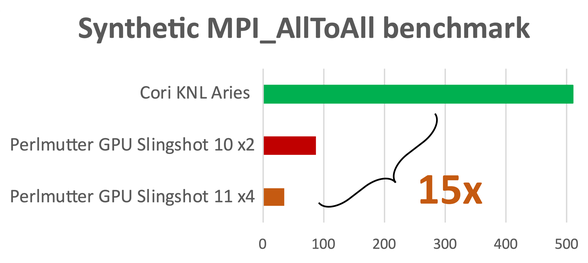
Heavily relies on computing many 2D FFTs.



Perlmutter benchmarks were run in early Aug 2022.



Couplings in different dimensions require AllToAll transposes.



64 MPI ranks on 16 nodes

Mostly MPI_AllToAll, with some token compute

https://github.com/scidac/atom-open-doc/blob/master/2022.11-SC22/cgyro_test_alltoall.F90

The CGYRO problem decomposition makes it very communication-heavy. Recent interconnect upgrade from Slingshot 10 to 11 provides major speedup.

That said, the fraction spent on communication is still higher on Perlmutter when compared to Cori.

The fusion research community is heavily relying on NERSC HPC systems for its simulation needs. The Perlmutter system provides a significant additional capability, especially after the upgrade to Slingshot 11.

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