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.

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

**CGYRO excels on GPUs.** Heavily relies on computing many 2D FFTs. Couplings in different dimensions require AllToAll transposes.

**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.**

- Perlmutter 64 GPUs - Slingshot 10 x 2
- Perlmutter 64 GPUs - Slingshot 11 x 4
- Slingshot 11 upgrade adds additional major speedup.

Synthetic MPI_AllToAll benchmark

64 MPI ranks on 16 nodes
Mostly _MPI_AllToAll_, with some token compute

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.