

jh190004-MDJ

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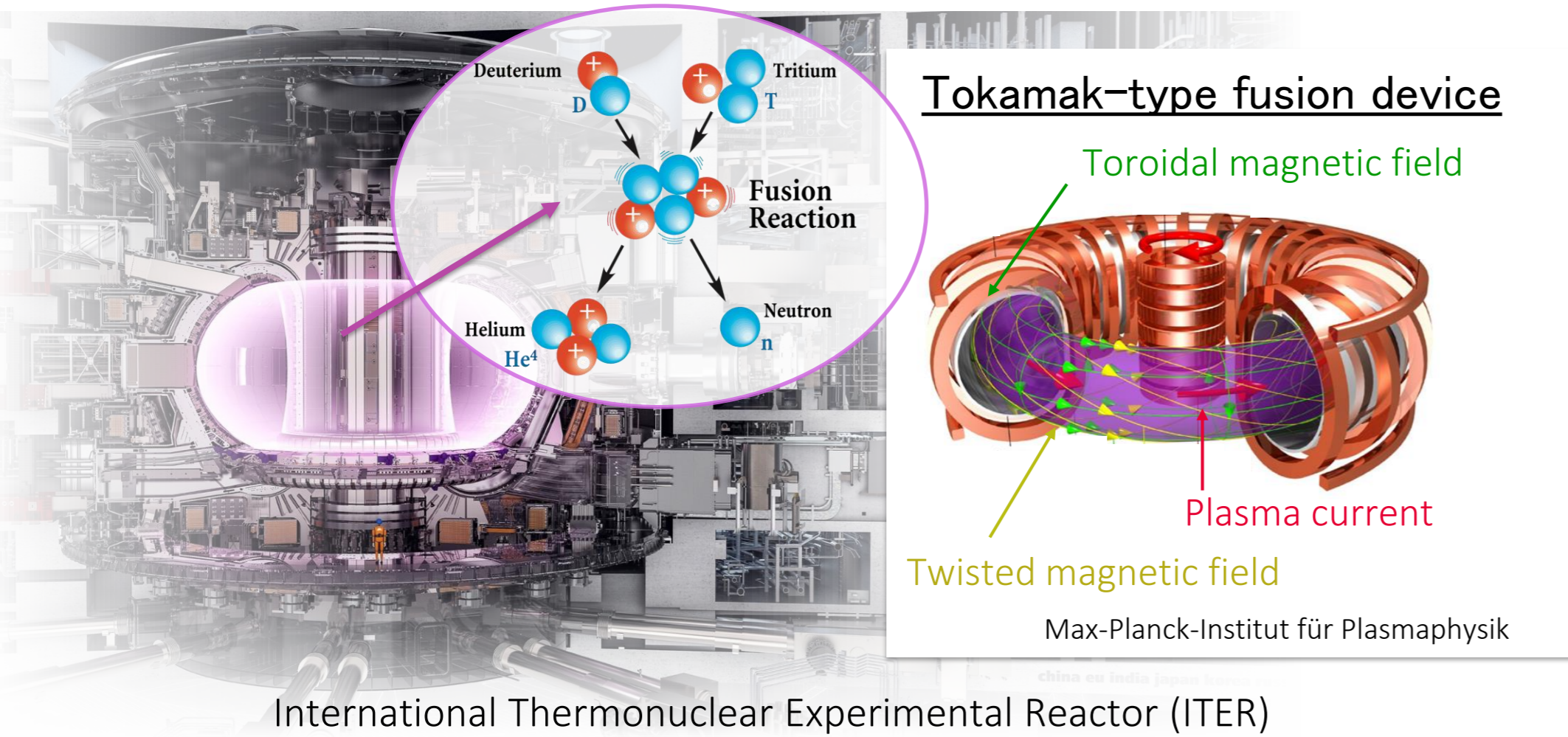
# Whole-volume gyrokinetic simulation of magnetic fusion plasmas with in-situ data processing



## Collaborating Researchers

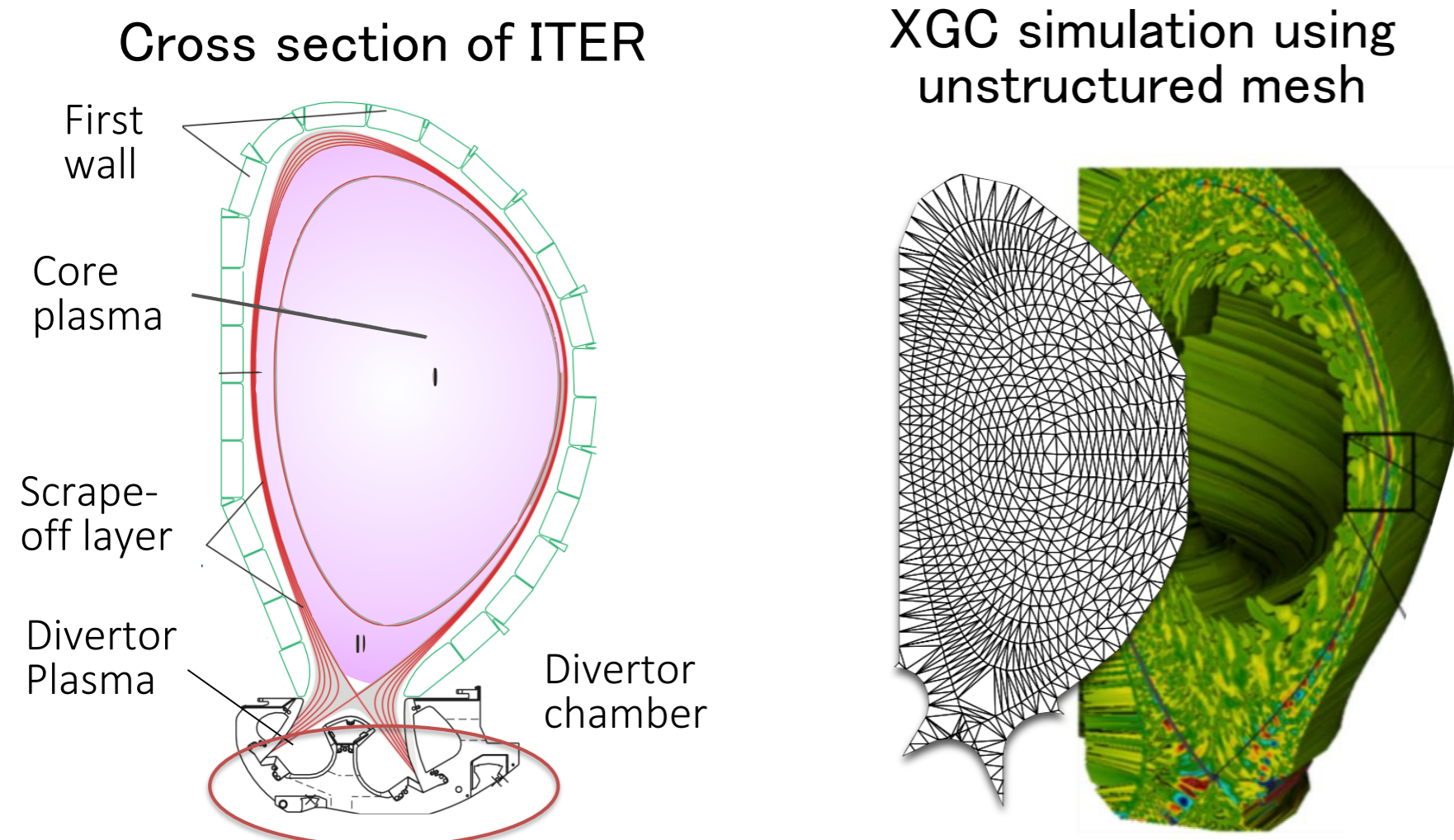
- T. Aoki (GSIC, Tokyo Institute of Technology)
- C-S. Chang, S. Ethier (PPPL)
- S. Klasky, J. Choi and E. D' Azevedo (ORNL)
- Y. Idomura (JAEA) S. Ishiguro (NIFS)

## Magnetic fusion device



- Nuclear fusion reactions, e.g., D-T reaction, can be a sustainable energy source to meet world-wide energy demands.
- To produce net power from the reactions, we have to confine the fuels with high temperature ( $> 10^8$  °C) in the reactor.
- Torus-type magnetic configurations with twisting field lines have been proposed to confine the fuels.

## Whole-volume modeling of fusion device



- Precise prediction of device heat load by whole device kinetic modeling has a critical importance in ITER operation and future reactor designs.
- Robust computational model and large computational resources are required for multi-physics simulation including core and edge regions.
- X-point Gyrokinetic Code (XGC)**
  - Field solver using finite element method on unstructured mesh
  - Hybrid use of Lagrange (PIC) and Euler (5D mesh) descriptions for kinetic plasma dynamics

<https://hbps.pppl.gov/computing/xgc-1>



- Adaptive I/O System (ADIOS)**
  - Middleware for high performance parallel I/O
  - Optimal "on-the-fly" data aggregation, relocation and reduction among massive parallel computational, staging and I/O nodes

<https://www.olcf.ornl.gov/center-projects/adios/>

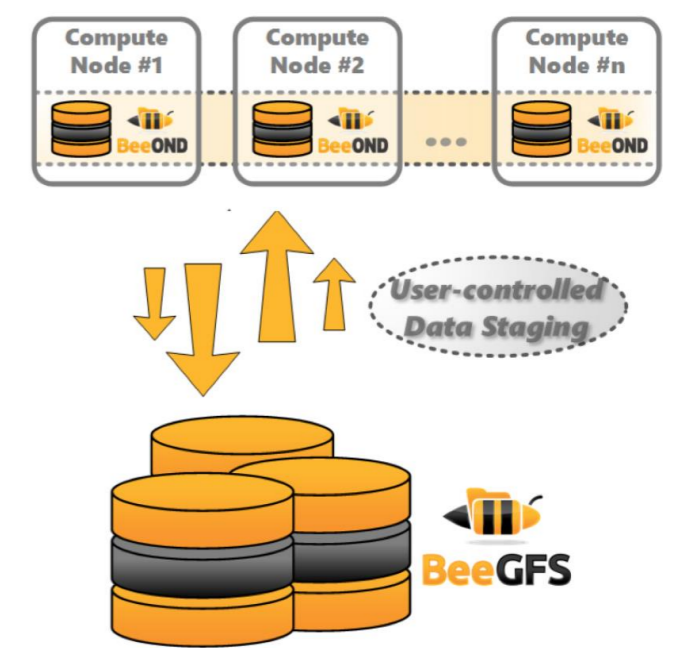
## Motivation

### US-side

S. Klasky and J. Choi, US-Japan JIFT Workshop @ PPPL

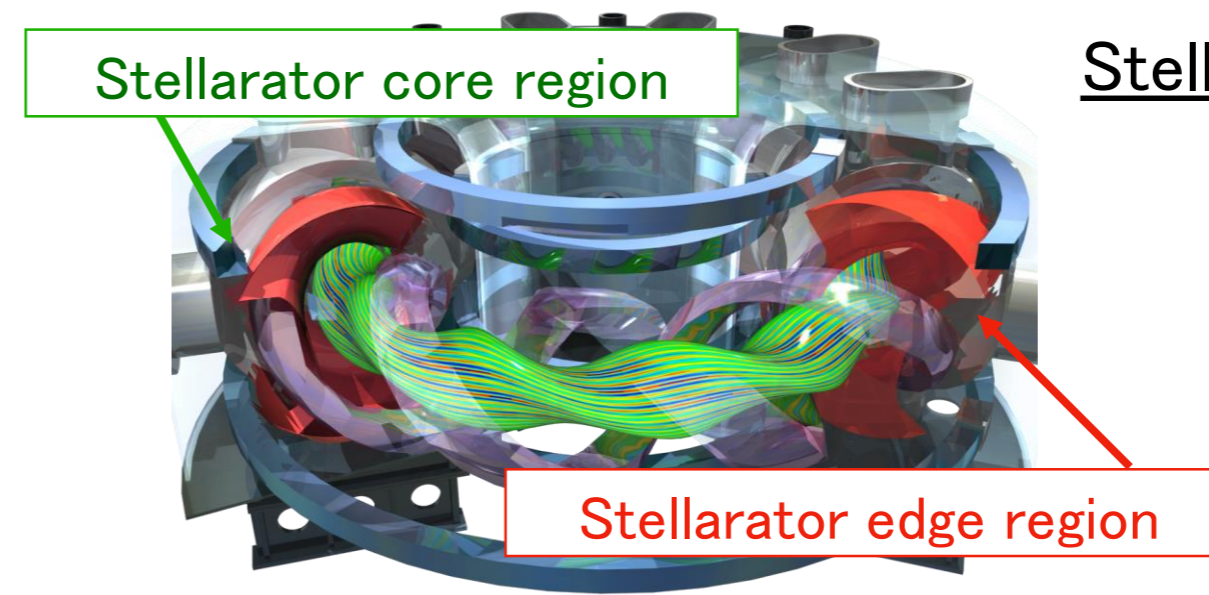
- Comparative study on ADIOS + XGC performance between US DOE machines and TSUBAME 3
- Impact of heterogeneous filesystems in TSUBAME 3 (BeeGFS On Demand)
- Application to code - code coupling for multi-scale plasma simulations in the core and edge regions

	Summit ORNL	Theta ANL	Tsubame3 Tokyo Tech
Locality	Node local	Node local	Node Local
System	Local filesystem	XFS filesystem	BeeGFS On Demand
Capacity	800 GB per node	128 GB per node	2 TB per node
Parallel Filesystem	GPFS Lustre	Lustre	Lustre



### Japan-side

- Extension of XGC to non-axisymmetric three dimensional geometries - from Tokamaks to Stellarators
- Porting to Tsubame 3 to combine with the latest ADIOS technology and XGC features used on DOE machines



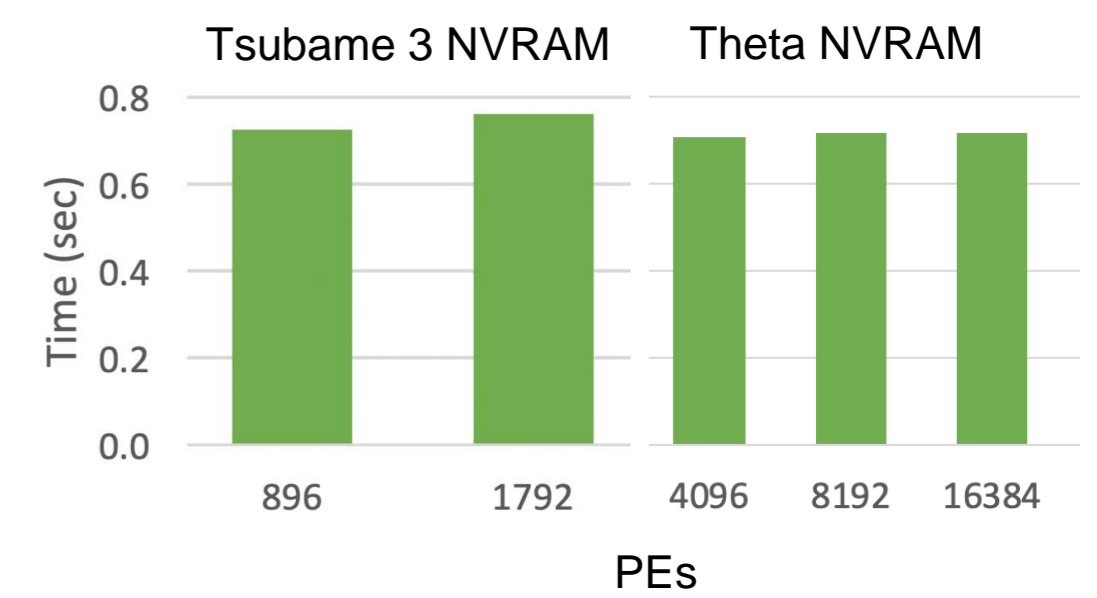
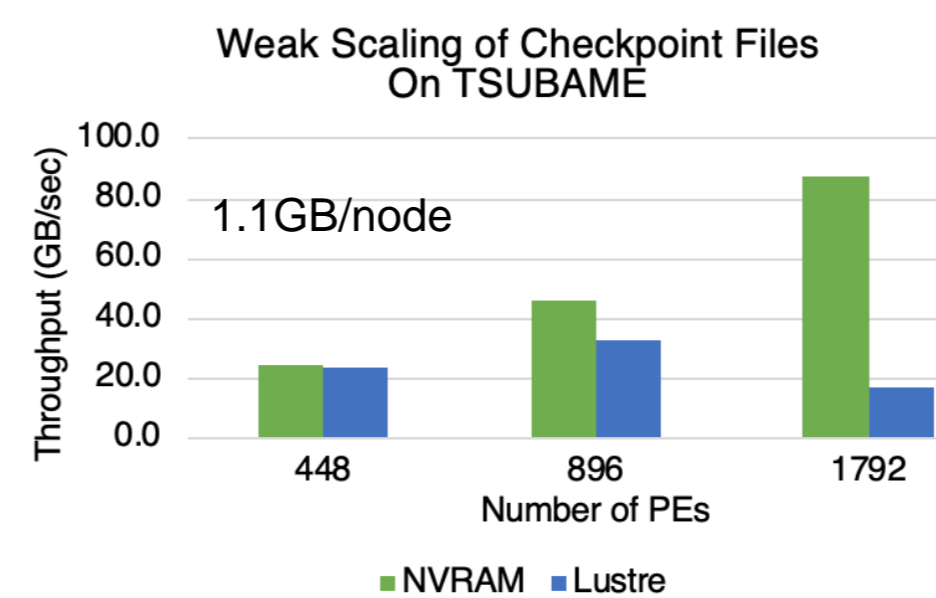
"Large Helical Device" in NIFS

### Stellarator-type fusion device

- Another candidate of magnetic fusion device
- Stable but complicated 3D magnetic field created by twisted external coils

## Results in FY 2018

- As the first step, XGC1+ADIOS has been successfully ported and basic performance experiments are conducted.



- Construction of field-aligned unstructured mesh in 3D geometry for finite-element Poisson solver.
- Benchmark tests on core plasma transport and high-energy particle confinement in the entire region.

