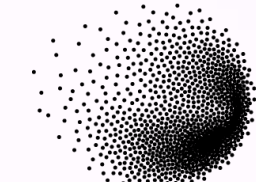


ORB5X

A performance-portable global electromagnetic gyrokinetic PIC code in C++/Kokkos built using Agentic AI

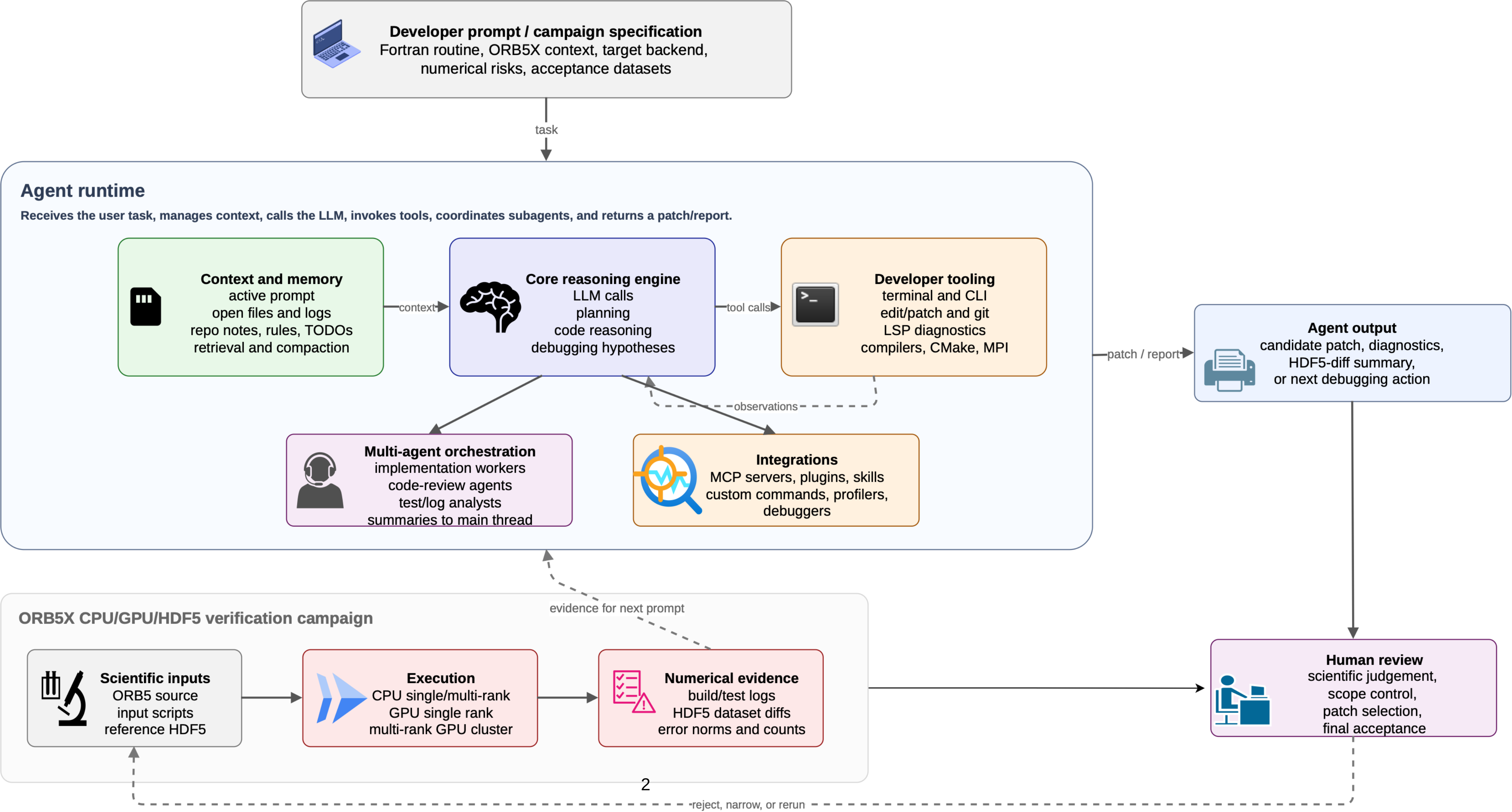
Mohsen Sadr,
July 9, 2026



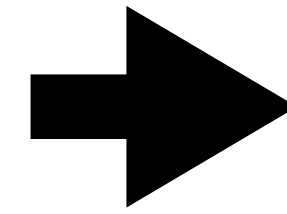
PSI



Agentic AI workflow



ORB5



ORB5X

5 months

Fortran

C++17

MPI and OpenACC

MPI and Kokkos (**portable**)

Needs Special Nvidia Fortran Compiler

CUDA (NVIDIA) and ROC (AMD)

Complicated Makefile

Modern and simple CMake

HDF5/FFTW/LAPACK has to be installed on system

Builds HDF5/FFTW/LAPACK from scratch if needed

No unit tests

Built-in unit tests

Runs on multiple CPUs and GPUs

Runs on multiple CPUs and GPUs

e.g. cmake commands

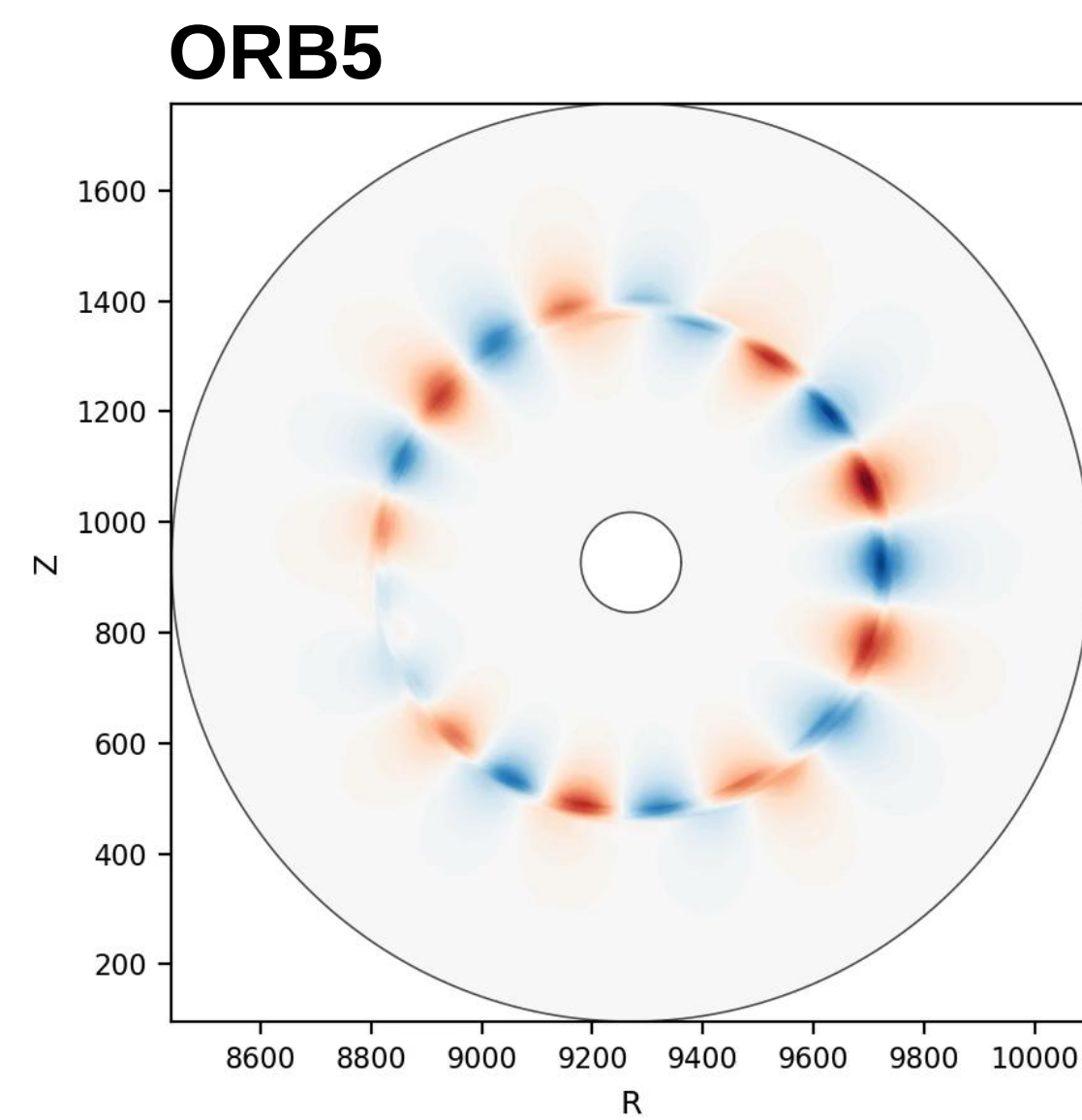
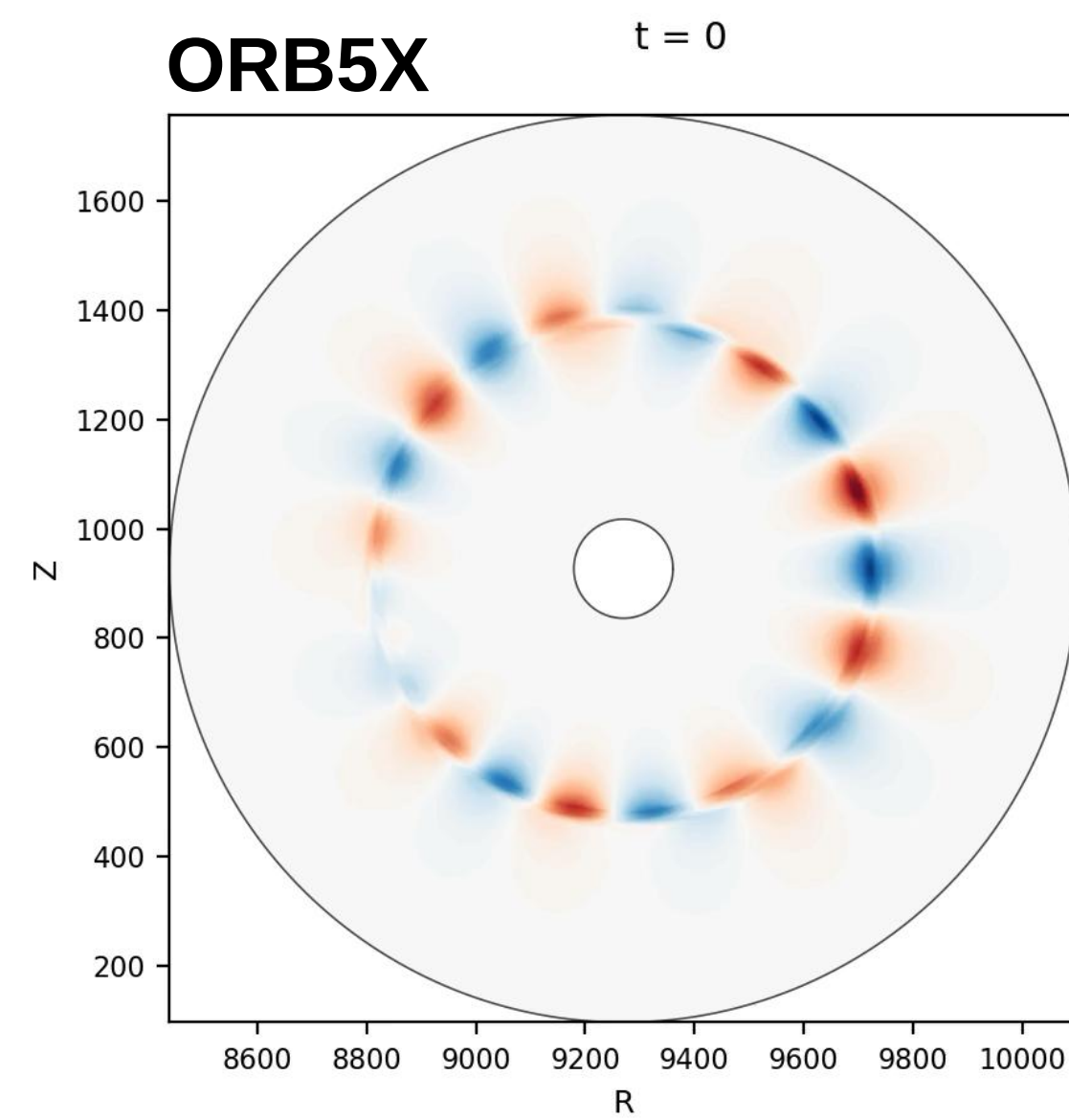
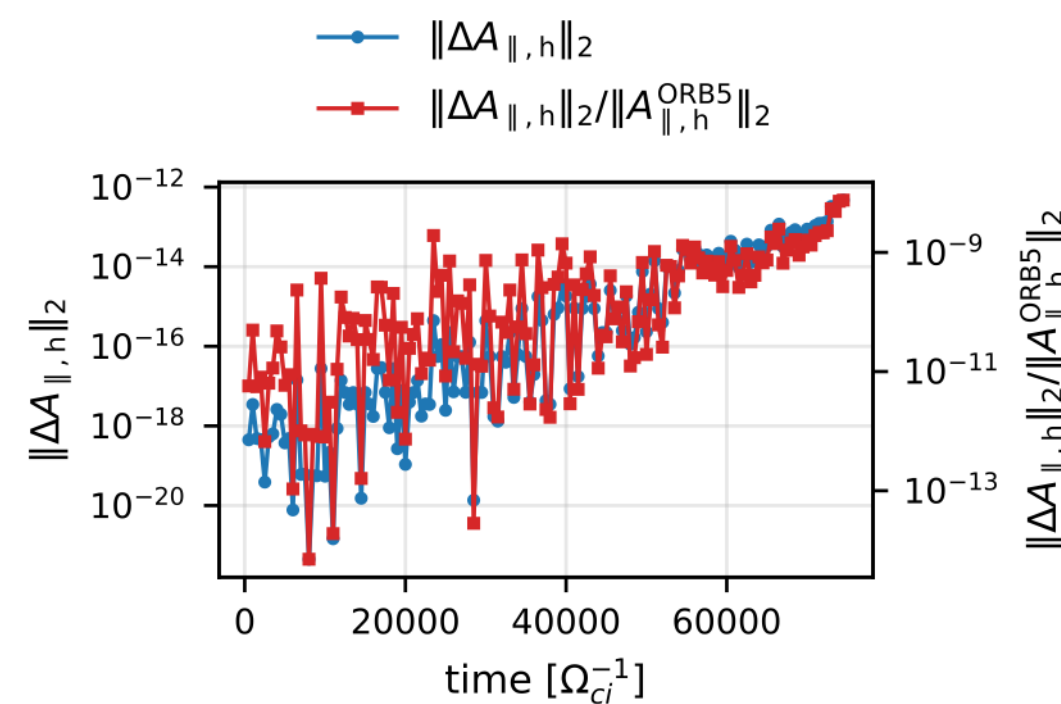
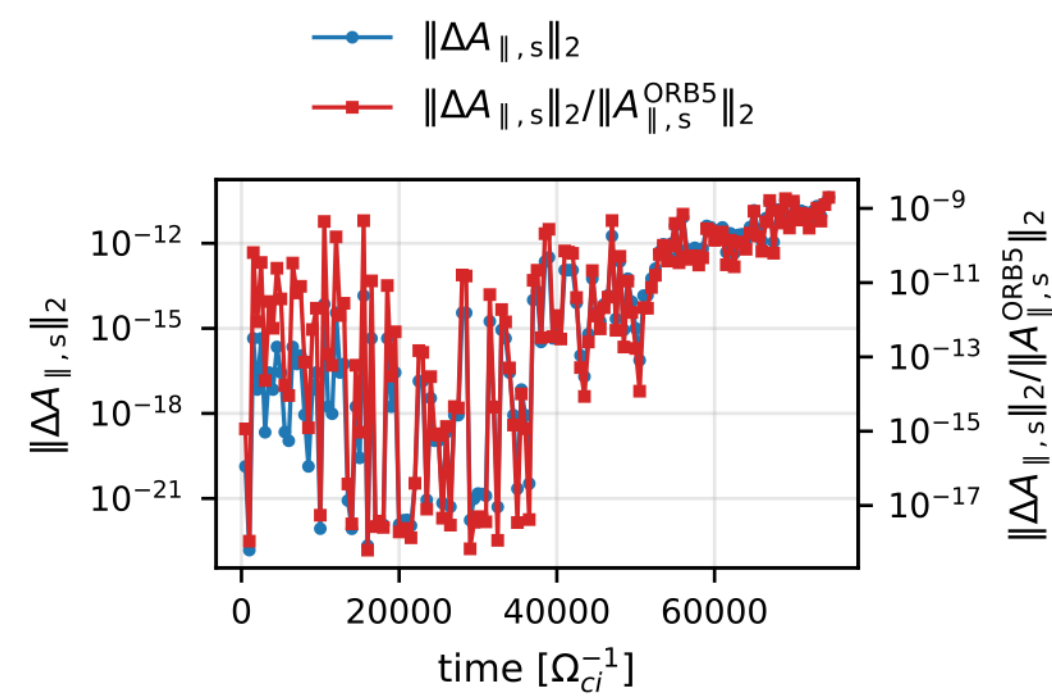
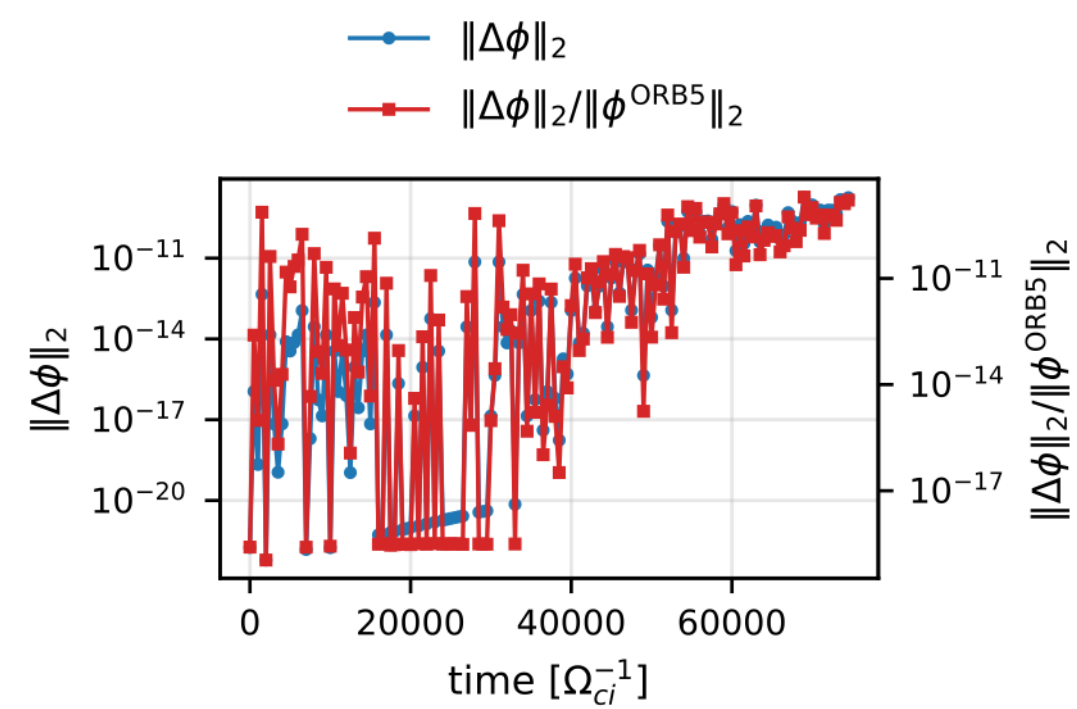
CPU/MPI configuration with dependencies built by ORB5X

```
1 cmake -B <build dir> \  
2   -DORB5X_BUILD_KOKKOS_FROM_SOURCE=ON \  
3   -DORB5X_BUILD_HDF5_FROM_SOURCE=ON \  
4   -DORB5X_BUILD_FFTW3_FROM_SOURCE=ON \  
5   -DORB5X_BUILD_LAPACK_FROM_SOURCE=ON  
6 cmake --build <build dir>
```

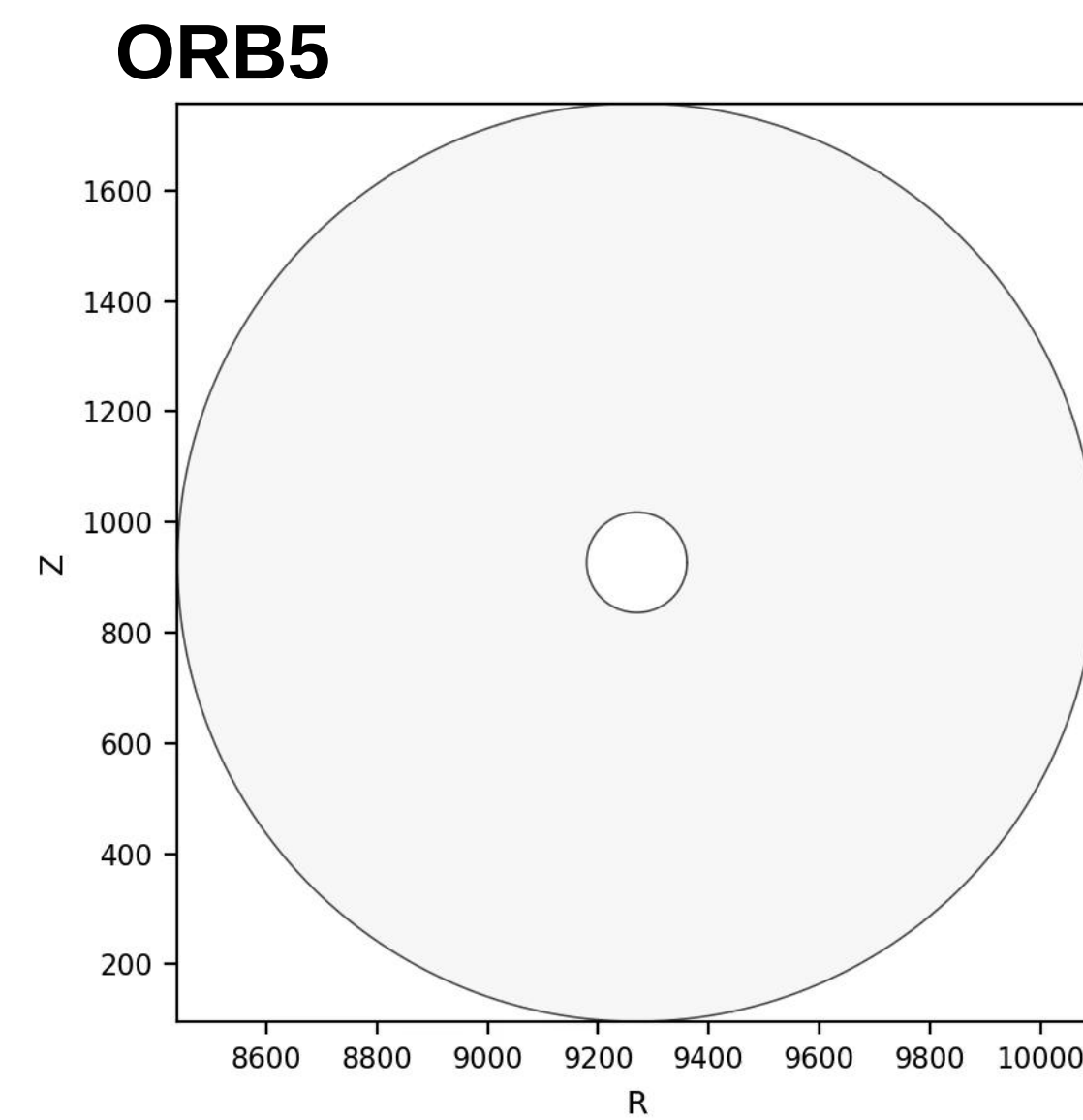
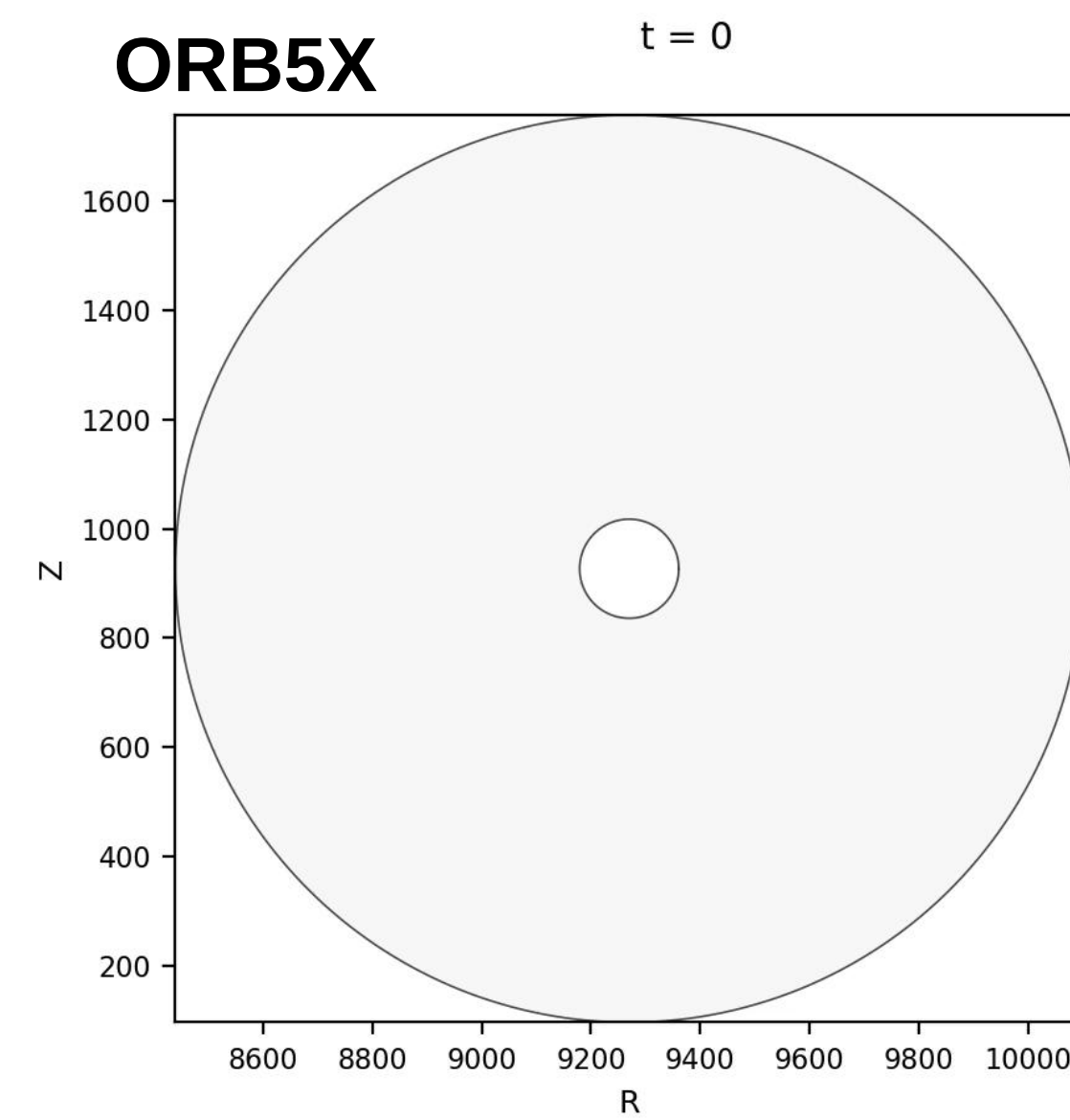
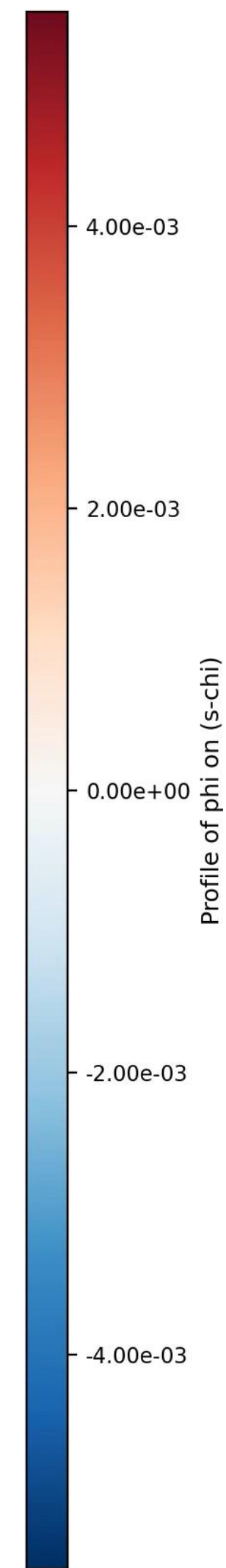
NVIDIA A100 GPU configuration through Kokkos CUDA

```
1 cmake -B <build dir> \  
2   -DORB5X_BUILD_KOKKOS_FROM_SOURCE=ON \  
3   -DKokkos_ENABLE_CUDA=ON \  
4   -DKokkos_ARCH_AMPERE80=ON \  
5   -DORB5X_BUILD_HDF5_FROM_SOURCE=ON \  
6   -DORB5X_BUILD_FFTW3_FROM_SOURCE=ON \  
7   -DORB5X_BUILD_LAPACK_FROM_SOURCE=ON  
8 cmake --build <build dir>
```

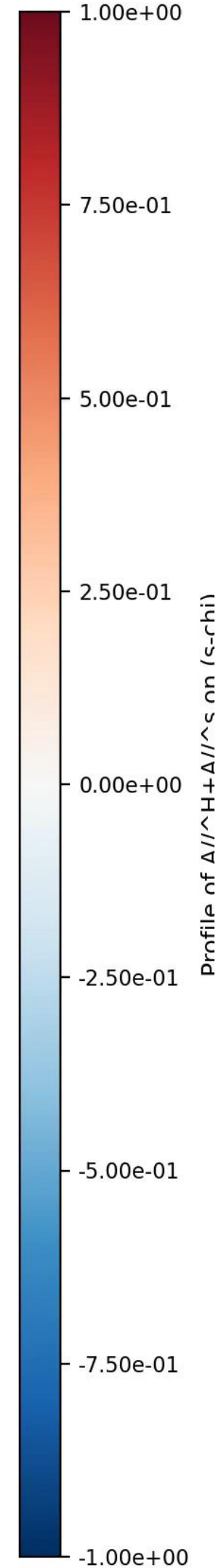
ITPA-TAE



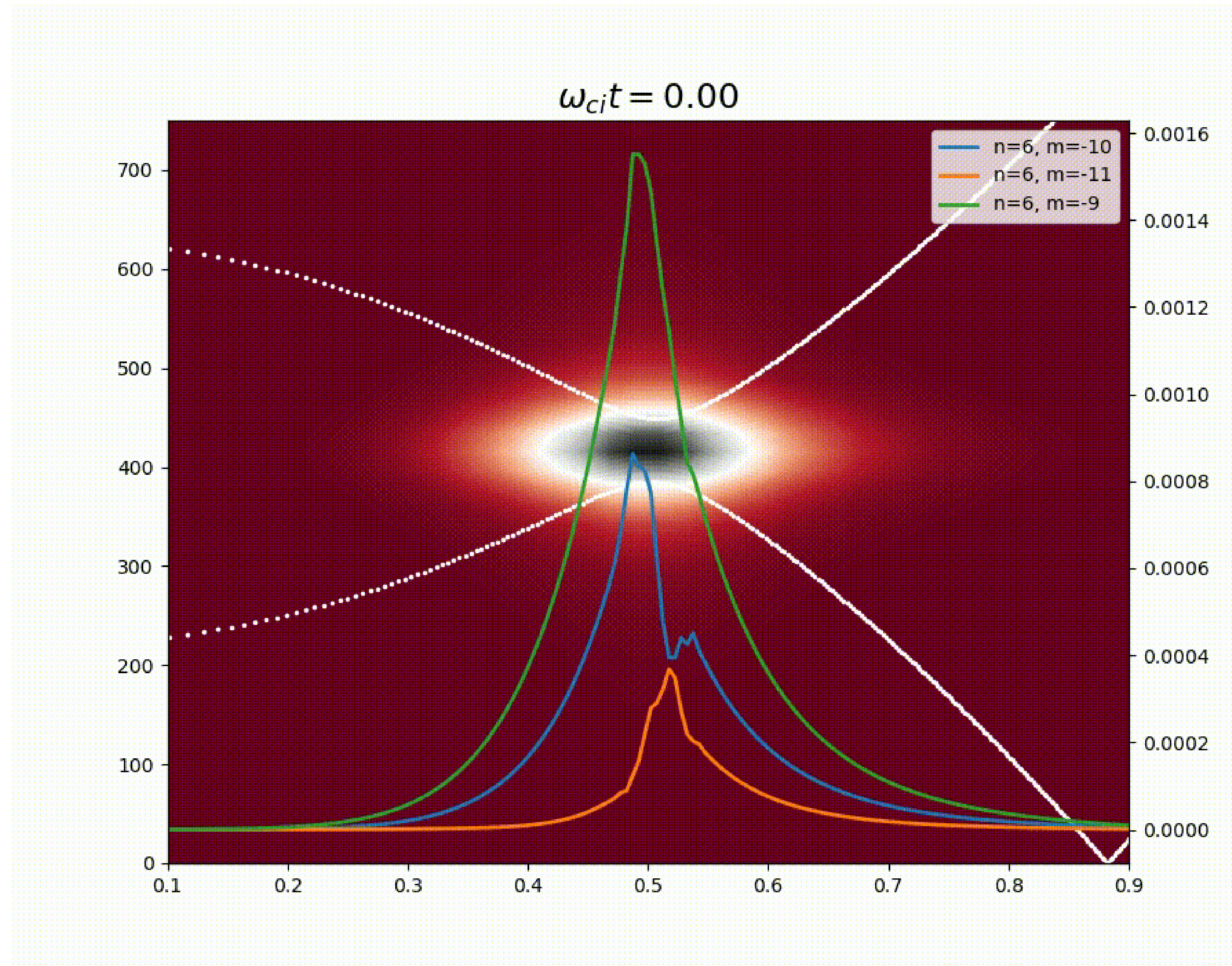
ϕ 5



$A_{\parallel}$

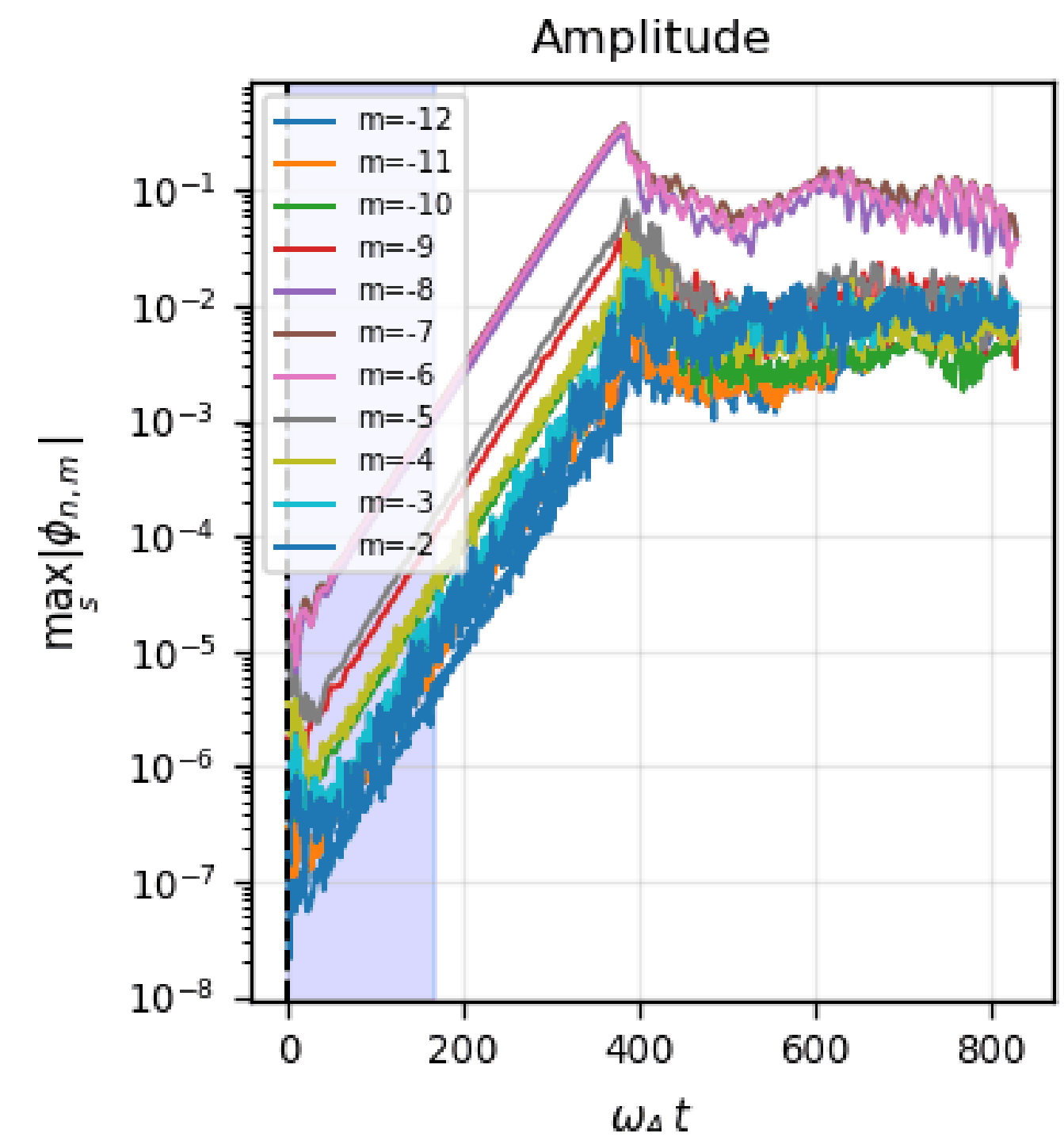
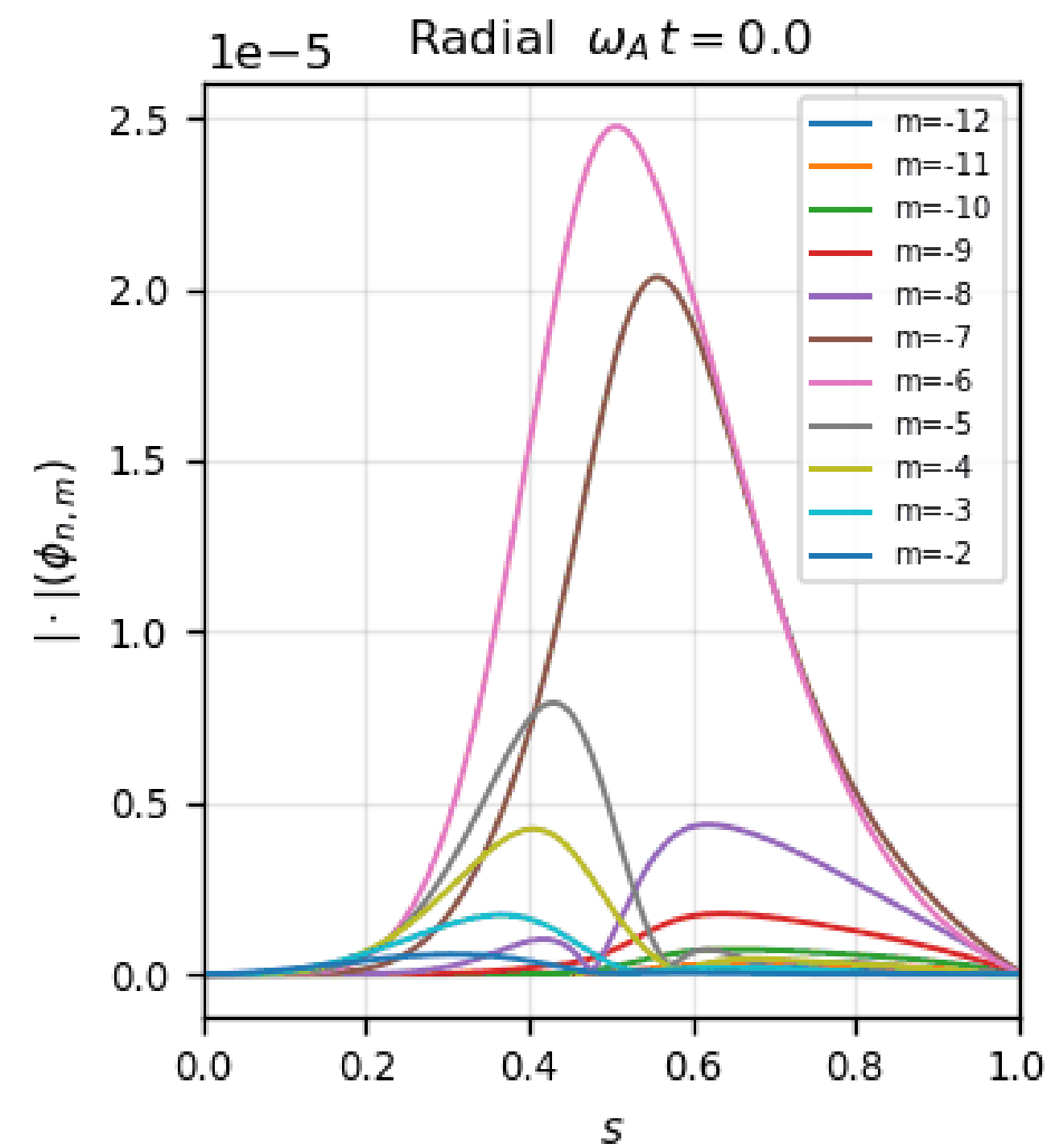
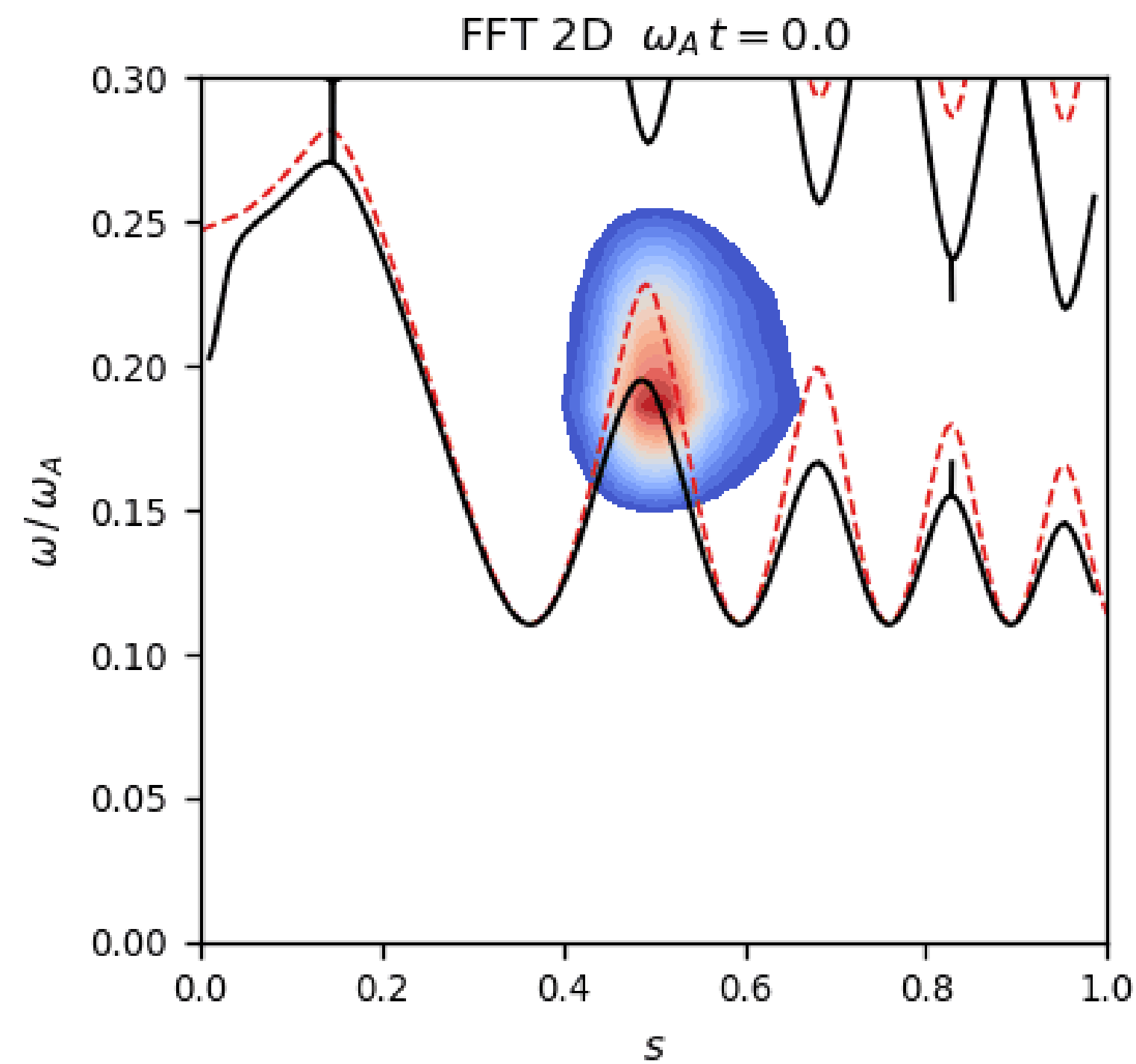


ITPA-TAE



Result by Alexey Mishchenko @IPP

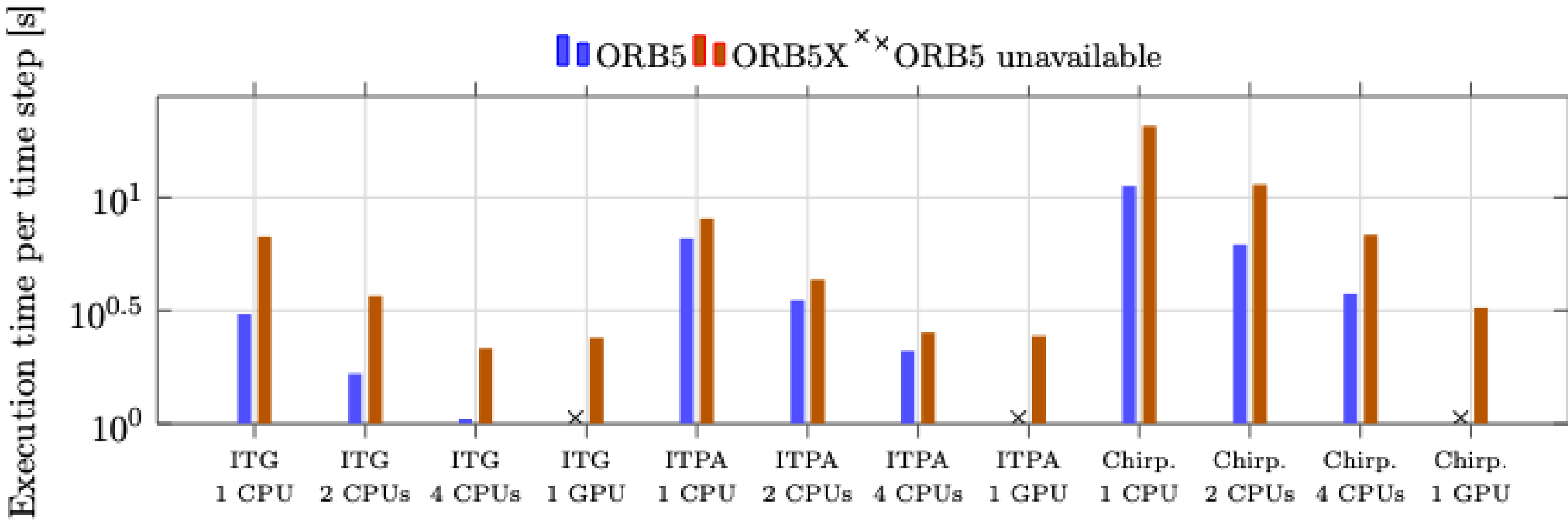
Chirping



Result by Alexey Mishchenko and Xin Wang @IPP

Performance & Portability

Lenovo Laptop
Legion Pro 5i



Tested Machines

Mac Book Air - M4 chip

Lenovo Legion Pro 5i

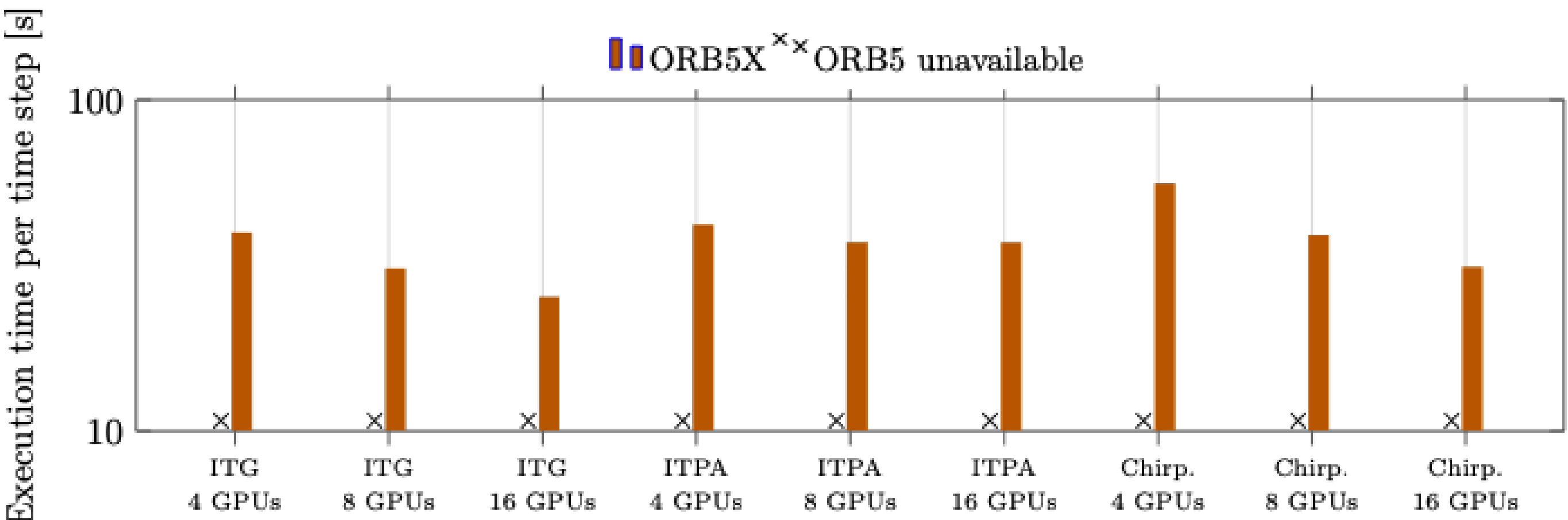
ALPS-Daint GH200

ALPS-Merlin7 A100

Cineca-Pitagora H100

Viper AMD MI300A

NVIDIA GH200
ALPS-Daint



Planned Benchmarking



Leonardo BOOSTER

Nvidia A100

LUMI-G

AMD MI250x GPUs

MareNostrum 5 ACC

Nvidia Hopper GPUs

Karolina GPU

Nvidia A100

DISCOVERER +

Nvidia DGX H200

Outlook

- Submit the first draft of ORB5X end of July
- Improve performance
- Create a documentation website for users
- Interface with VMEC++, DESC, Stella, or other MHD solvers for Stellarators
- Differentiable Programming with Enzyme for confinement optimization
- Physics-aware coding agent - in production

PAldynamics.ch

WE PROVIDE PHYSICS-AWARE AGENTIC INTELLIGENCE

From Fusion Energy to Space Travel

Partner with us

