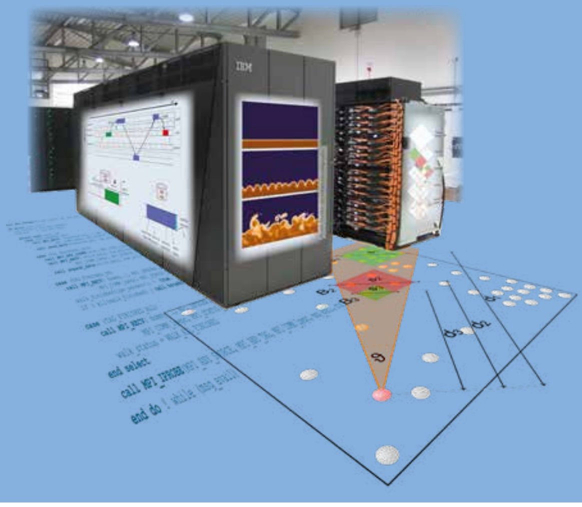
JÜLICH Forschungszentrum | JÜLICH SUPERCOMPUTING CENTRE

SIMULATION AND DATA LABORATORY PLASMA PHYSICS

FROM LASER-BASED X-RAYS TO FUSION DEVICES ON HPC SYSTEMS



- **Exascaling of plasma simulation codes**
- **Fostering expertise in kinetic and fluid algorithms**
- **Research and training in advanced plasma simulation techniques**
- **Transfer of HPC know-how to plasma community**

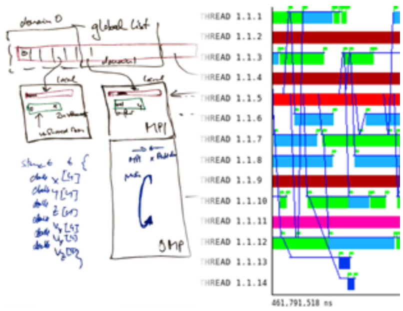
Research & Support Activities

The Plasma Physics Simulation and Data Laboratory specializes in kinetic modelling of nonlinear phenomena in laboratory plasmas, including laser-based particle and radiation sources and magnetic fusion devices. The main numerical tools used are Particle-in-Cell simulation and novel mesh-free kinetic methods based on a parallel tree algorithm with O(N) or O(NlogN) complexity.

Community engagement includes boosting parallel I/O and scaling of user applications, code clinics, porting and tuning and extreme-scaling workshops. We are also actively refactoring in-house codes to exploit prototype exascale architectures.

Projects & Collaborations

Besides long-standing cooperations with the FZJ institutes of Energy and Climate Research (IEK-4) and the experimental JuSPARC team at PGI-6, the group maintains active cooperations with the Helmholtz partners at GSI, HZDR and Garching, the Centre for Mathematical Astrophysics at the KU Leuven, the University of Warwick and ITER.



Algorithm Development & High Level Support

With the advent of many-core architectures and new accellerator units, additional layers of parallelism beyond MPI have to be added to existing scientific codes for making efficient use of the available computing power. For example, adding threaded parallelism to the in-house tree code PEPC increased weak scaling, as demonstrated with up to 1,668,196 parallel threads on the former BlueGene/Q installation at JSC. Here, overlapping communication and computation hides latency, while the hybrid parallelization scheme reduces memory footprint and communication. Other community codes supported in this way include the EPOCH Particle-in-Cell code.

Plasma Simulations

Laser acceleration of electrons and ions is possible with state-of-the-art high-power laser facilities. 3D Particle-in-Cell simulations are essential to provide insight into these nonlinear processes at sub-micron length scales. The example shows an example of laser-driven spin-polarized proton beam at intensities of 10^{23} W/cm^2.

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