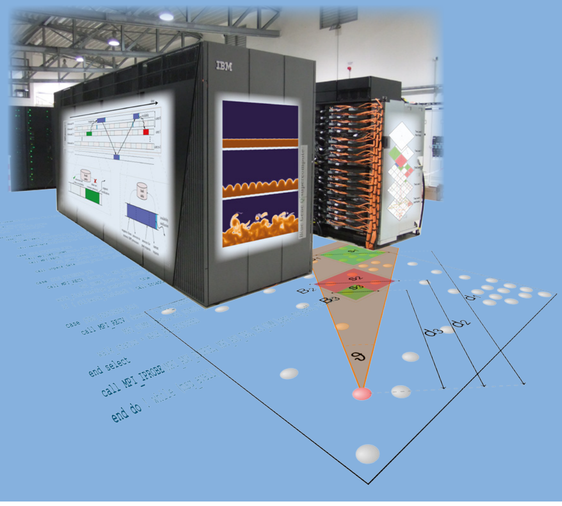
SIMULATION LABORATORY PLASMA PHYSICS

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

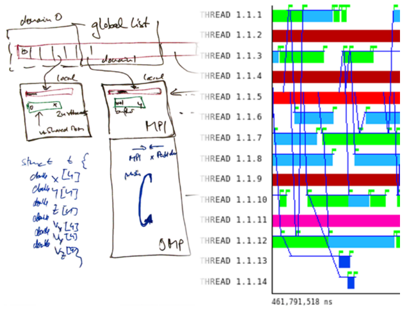


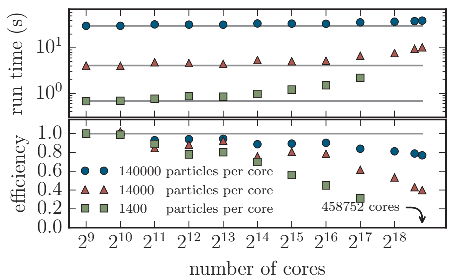
- **Exascaling of plasma simulation codes**
- **Fostering expertise in kinetic and fluid algorithms**
- **Research and training in advanced plasma simulation techniques**
- **Transfer of HPC know-how to plasma community**

Research & Support Activities

The Plasma Physics SimLab 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.

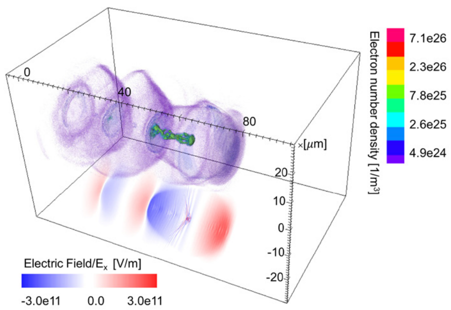
Community engagement includes boosting parallel I/O and scaling of user applications, code clinics, porting and tuning and extreme-scaling workshops. We are also actively refactoring in-house codes to exploit prototype exascale architectures.





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 JSC Exascale Labs ExaCluster Laboratory (ECL) and the POWER Acceleration and Design Center (PADC). External partners include KU Leuven, U. Alberta and ITER.



Algorithm Development

With the recent 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.

High-Level Support

Weak scaling of the tree code PEPC with up to 1,668,196 parallel threads on the BlueGene/Q installation at JSC. Overlapping communication and computation hides latency, while a hybrid parallelization scheme reduces memory footprint and communication.

Plasma Simulations

Cavity regime of electron acceleration using a 20 fs laser pulse with intensity of 10^{20} W/cm^2 sent through a helium gas target. 3D Particle-in-Cell simulations show that electrons can be accelerated to 80 MeV over 260 micrometers propagation length, giving an average electric field gradient of 300 GV/m.

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