High Performance Earthquake Simulations

Alexander Breuer
1992 Landers
Wave Propagation

1992 Landers: Seismic wave propagation coupled to dynamic rupture propagation, 199 Mio. elements
Mesh

1992 Landers: Mesh, 199 Mio. elements
SeisSol

- Dynamic rupture earthquake simulations with ADER-DG FEM
- Full elastic wave equations in 3D and complex heterogeneous media
- Unstructured tetrahedral meshes
- https://github.com/SeisSol/

L’Aquila: Seismic wave propagation
Doctoral Research

- **Single Node:**
  - Kernels
  - OMP
  - Custom memory layout incl. alignment and NUMA-awareness

- **Multi Node:**
  - Asynchronous MPI incl. LTS
  - Prioritization of crucial work
  - Communication “as is”, no additional MPI-buffers

- **Algorithmic:** Clustered Local Time Stepping

Two local time stepping clusters of a 99 Mio. element setup
Results

- **Weak Scaling**
  - 8.6 PFLOPS @ 8,192 Tianhe-2 nodes (~half machine)
  - 1.95 PFLOPS @ SuperMUC-2 (69% of HPL)

- **Production**
  - Dynamic Rupture: 1.4 PFLOPS @ SuperMUC-2 (51% of HPL)
  - LTS Wave Propagation: 1.3 PFLOPS @ SuperMUC-2 (46% of HPL)
  - High order speedup: 5x-10x over “classic” implementation, full machine LTS over GTS +5.6x