HASEonGPU

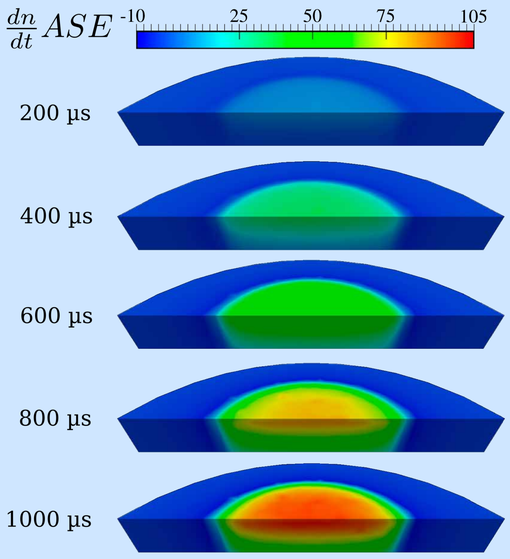
An Open-Source ASE code for calculating the gain in high power laser media on GPU clusters

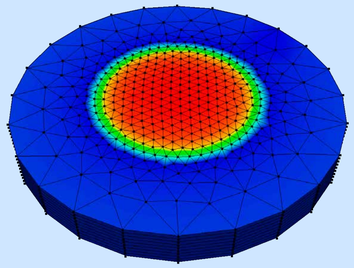
A. Huebl, E. Zenker, C. Eckert, D. Albach, M. Bussmann

HZDR
TECHNISCHE UNIVERSITÄT DRESDEN
HELMHOLTZ ZENTRUM DRESDEN ROSSENDORF

What took one week so far is now computable within minutes

The fundamental process in high spatial resolution





- Dimensions of laser gain medium ⌀ 6cm x 0.7cm
- Heterogenous geometry increases resolution in areas of interest

- Pumped energy is reduced by radiation and ASE

$$\frac{dn}{dt} = \left.\frac{dn}{dt}\right|_{p} - \left.\frac{dn}{dt}\right|_{Rad} - \left.\frac{dn}{dt}\right|_{ASE}$$

with $$\left.\frac{dn}{dt}\right|_{ASE} = \int_{\lambda} g_0 \cdot \Phi_{ASE}\, d\lambda$$

- Amplified spontaneous emission flux as line integral

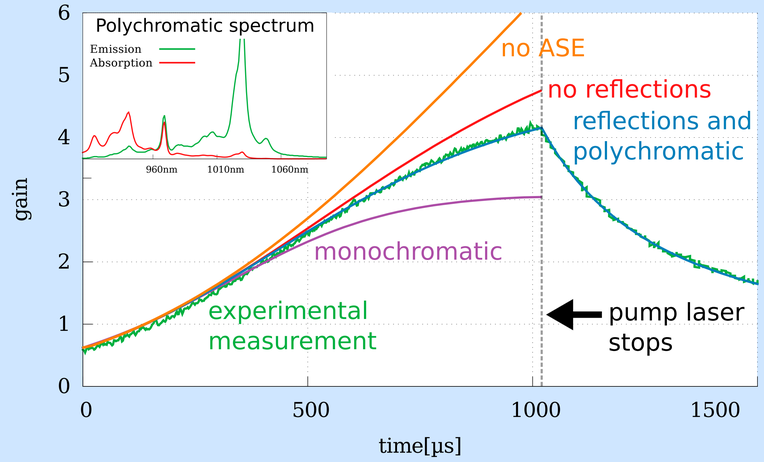
$$\Phi_{ASE}(s_i) = \frac{1}{4\pi} \iint_{V\lambda} \frac{\hat{n}(r)}{\tau_f |\rho(r, s_i)|^2}\, g(\lambda)\, G_{r \to s_i}\, dV\, d\lambda$$

- Equation rewritten as Monte Carlo integration

$$\Phi_{ASE}(s_i) = \frac{1}{4\pi N \tau_f} \sum_{u=0}^{N-1} \hat{n}(r_{i,u}) \cdot gain(\overrightarrow{r_{i,u} s_i})$$

Extended with reflections and polychromatic spectrum

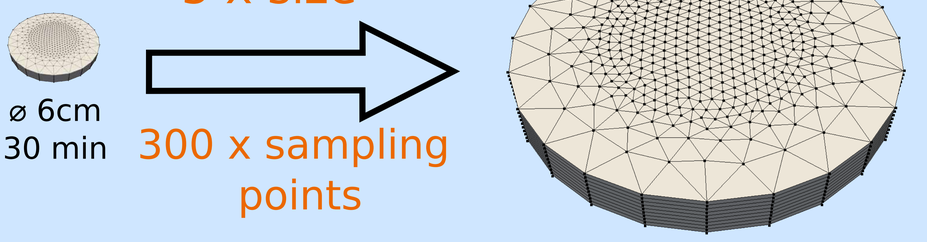
Full simulation fits experiment perfectly



- Gain for 150 timesteps in about 30 minutes

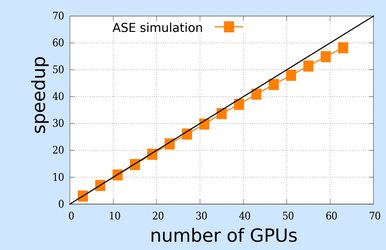
Imagine ASE flux simulations for massive laser gain media

Increase size and spatial resolution

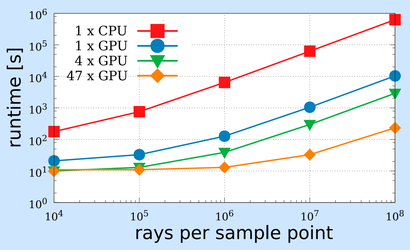


- Fast Monte Carlo algorithm on GPUs extends the borders of ASE flux calculations
- Computations of ASE flux for the upcoming generation of high-power laser systems

Exploiting the scalability of Monte Carlo algorithms



Close to perfect strong scaling

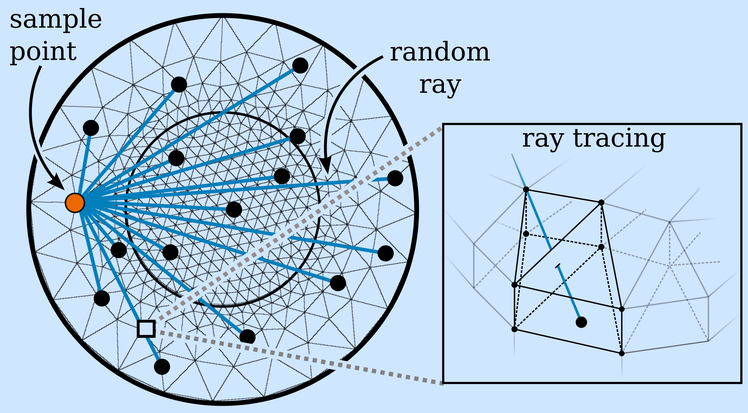


Large speedup

- There is no reason to use only *one* GPU!

The method

Ray tracing through the gain medium by millions of rays in parallel



to be published in Comput. Phys. Commun., Open-Source: https://github.com/ComputationalRadiationPhysics/HASEonGPU

NVIDIA CUDA CENTER OF EXCELLENCE