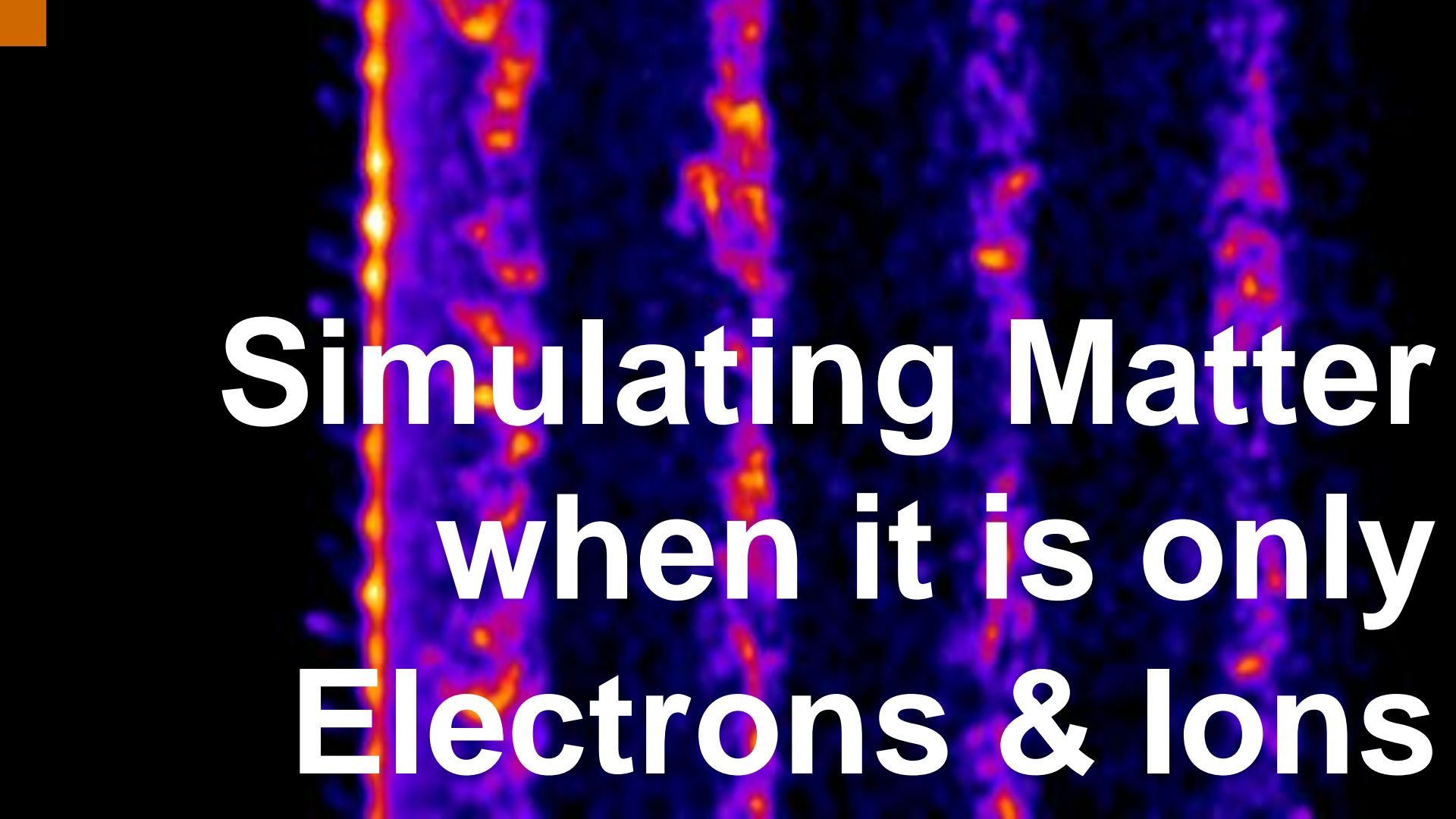


# Simulating What is Measured – Closing the Loop between Experiment and Simulation

Michael Bussmann, Axel Huebl

Computational Radiation Physics  
Helmholtz-Center Dresden Rossendorf

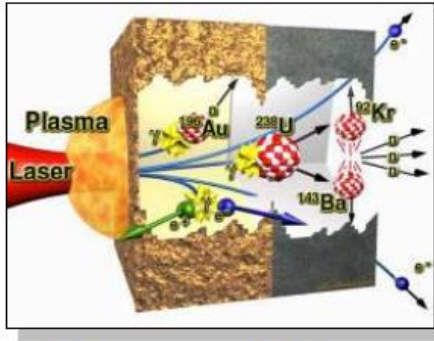
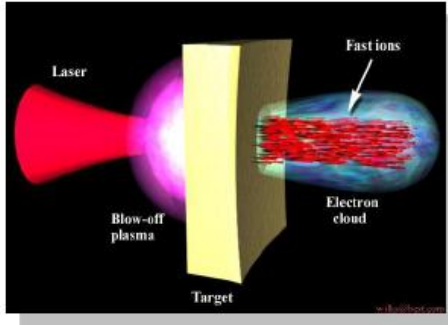


The background of the slide is a vertical strip of a simulation, likely a plasma simulation, showing a turbulent structure. The color scale ranges from blue (low intensity) to red (high intensity), with a prominent vertical red and orange structure on the left side. The text is overlaid on this background.

# **Simulating Matter when it is only Electrons & Ions**

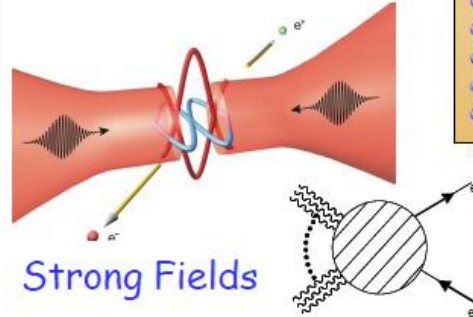
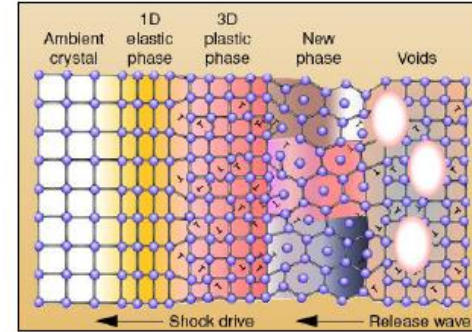
# Matter under Extreme Conditions

## Extreme particle beams



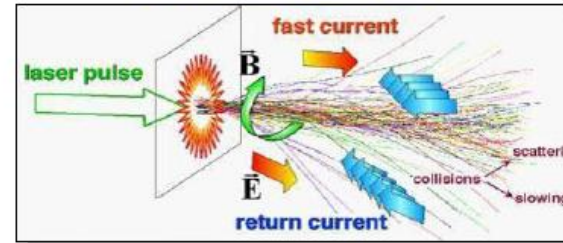
## Extreme radiations

## Extreme pressures

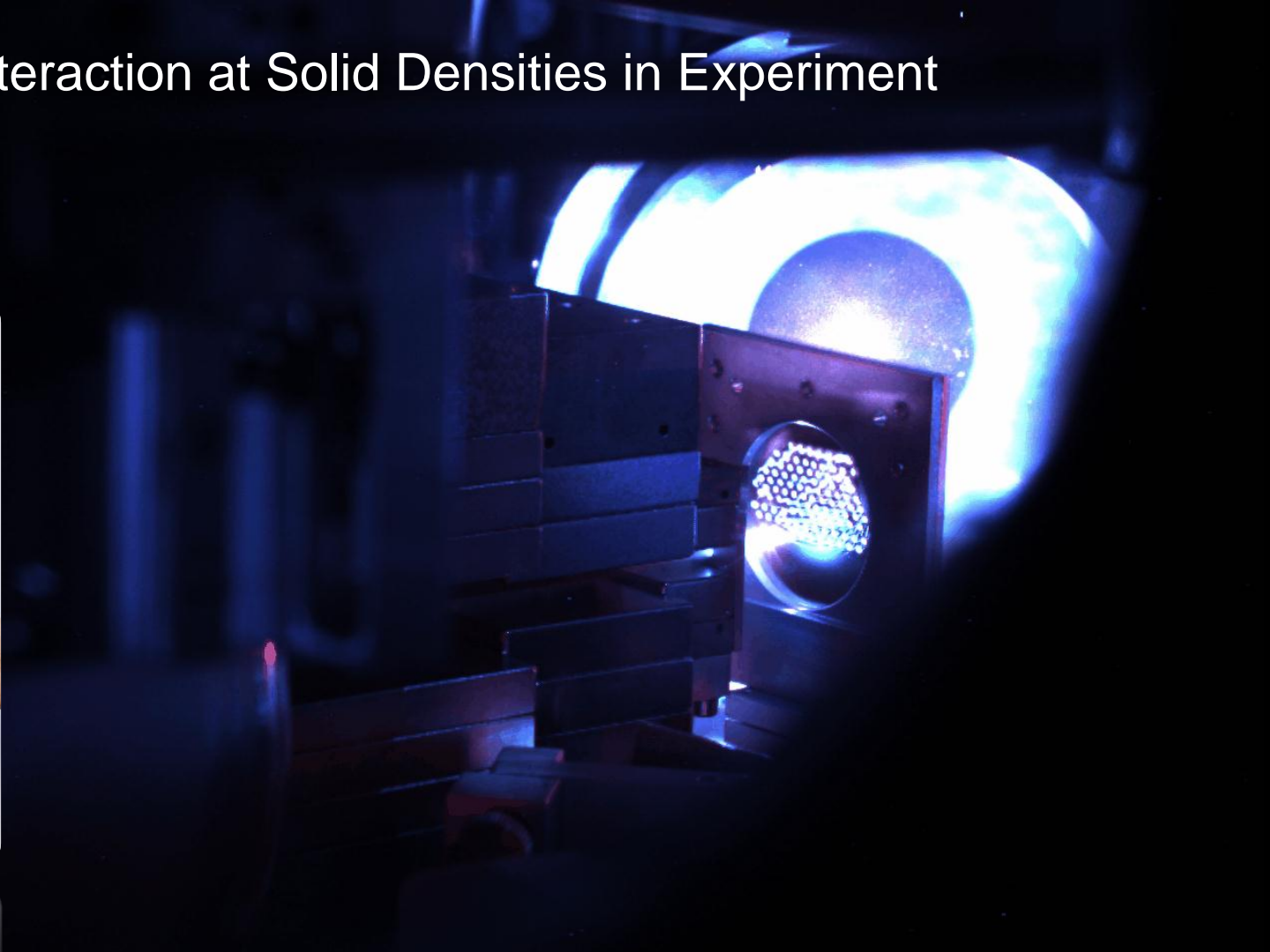


## Strong Fields

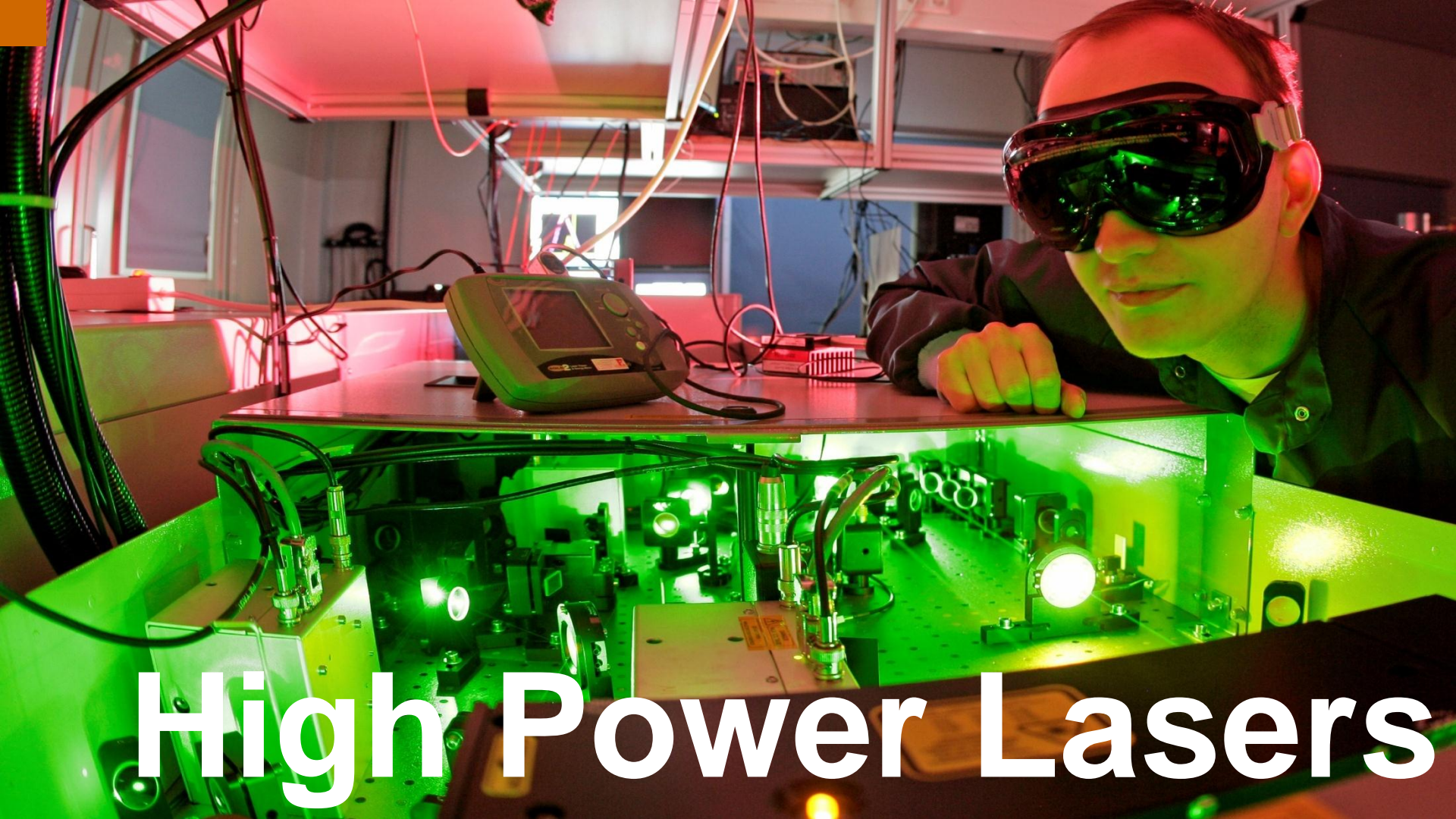
## Extreme currents



# Laser-Matter Interaction at Solid Densities in Experiment

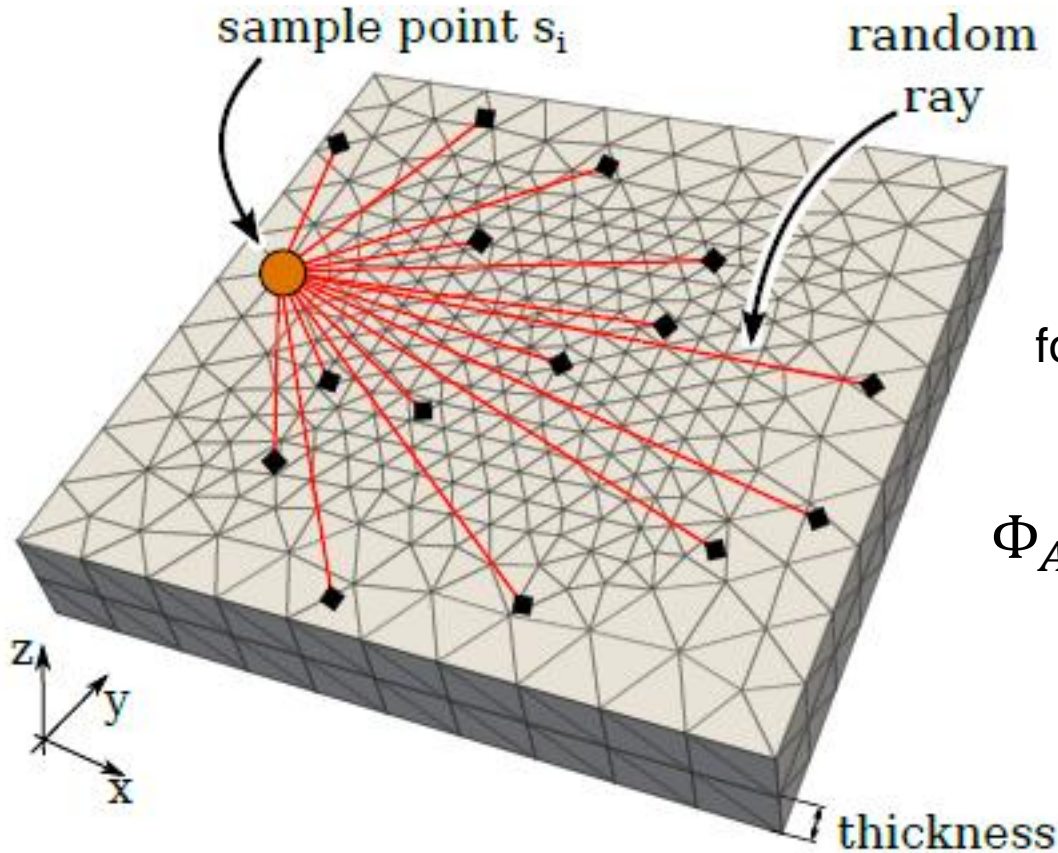






# High Power Lasers

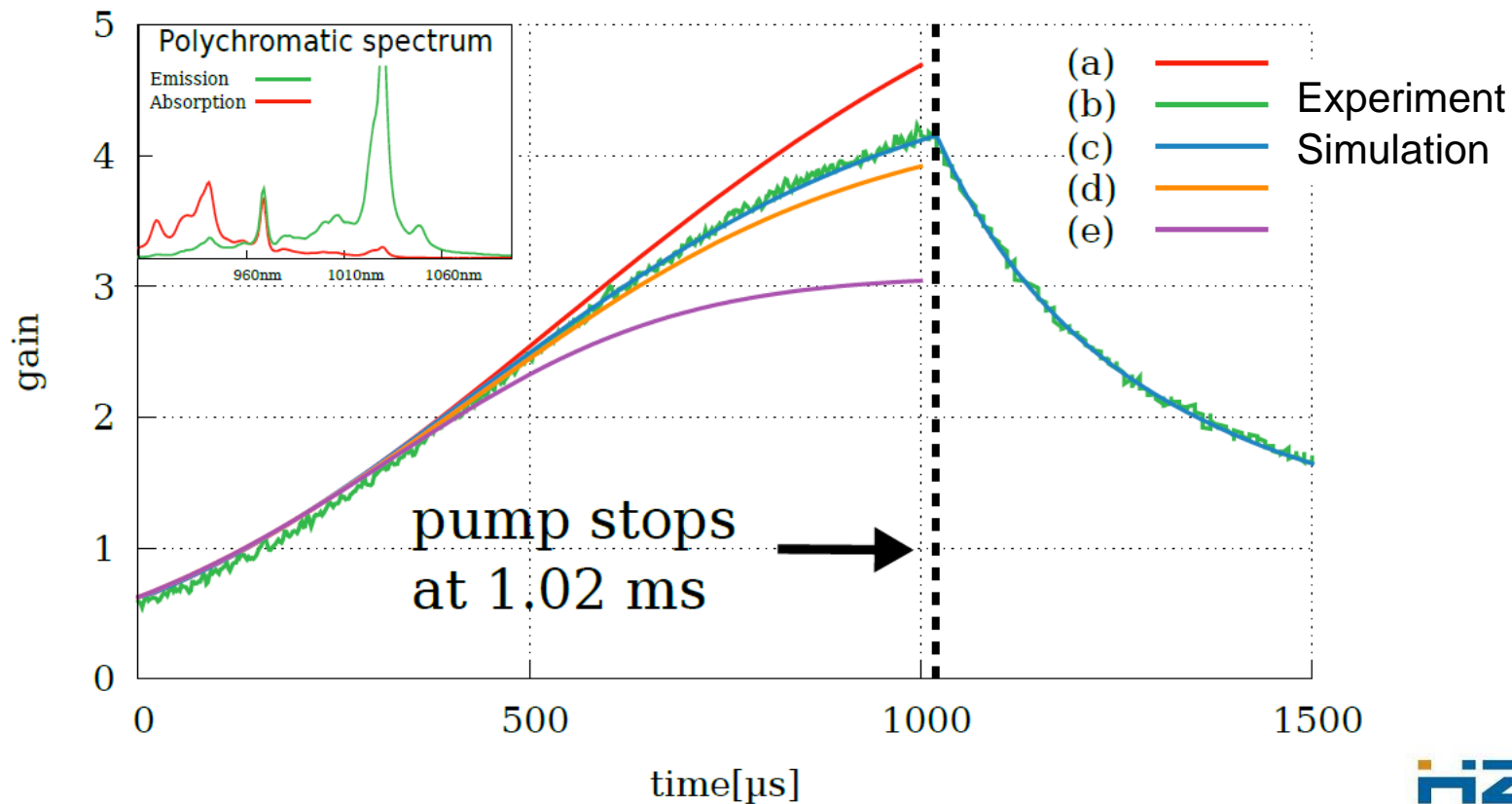
# Modelling Amplified Spontaneous Emission (ASE) with GPUs



Monte-Carlo Raytracing  
+ Sampling  
for directly solving the ASE Integral

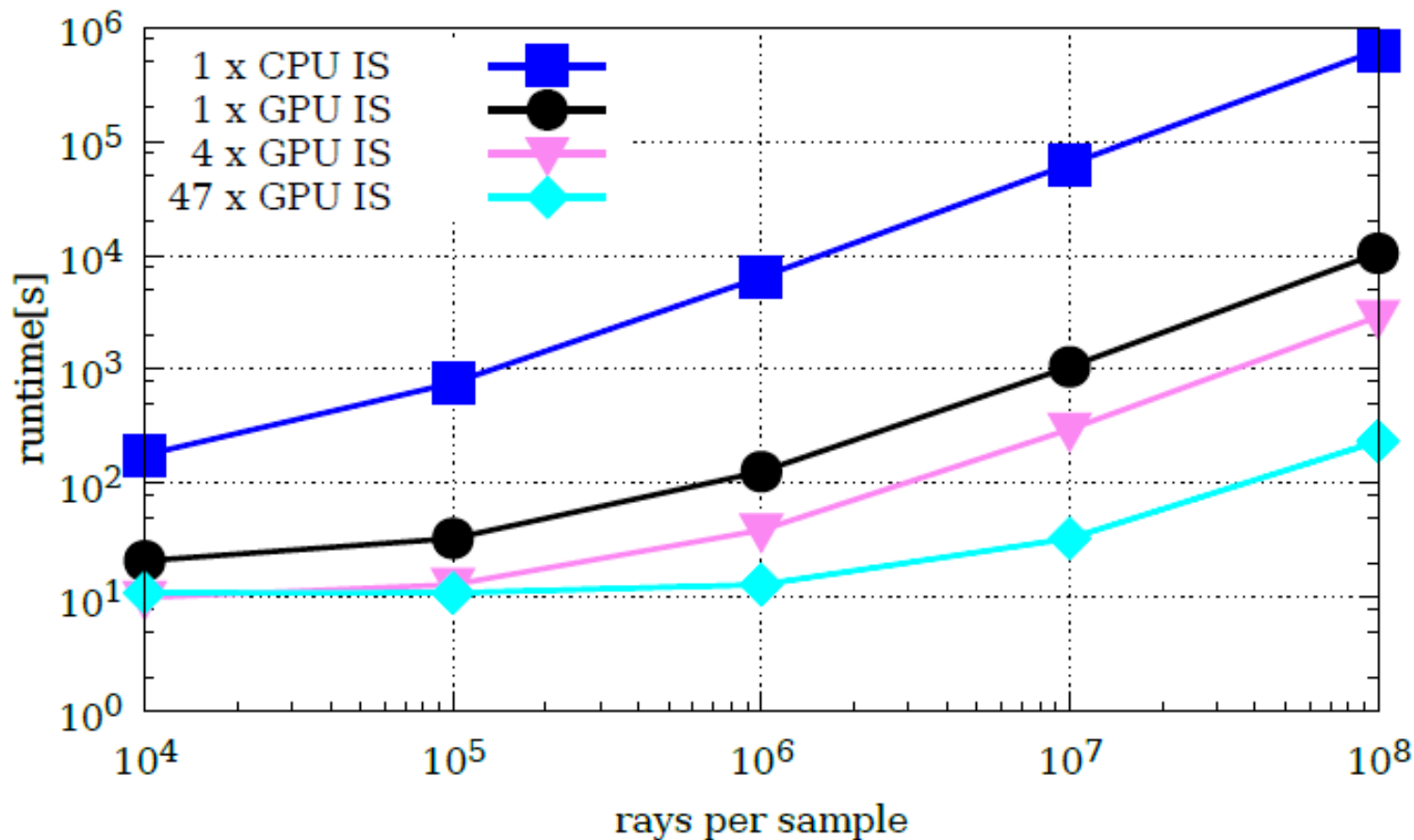
$$\Phi_{ASE} \propto \sum_{u=0}^{N-1} \hat{n}(r_{i,u}) \cdot G(\overline{r_{i,u} \vec{s}})$$

# Simulation agrees perfectly with Measurement



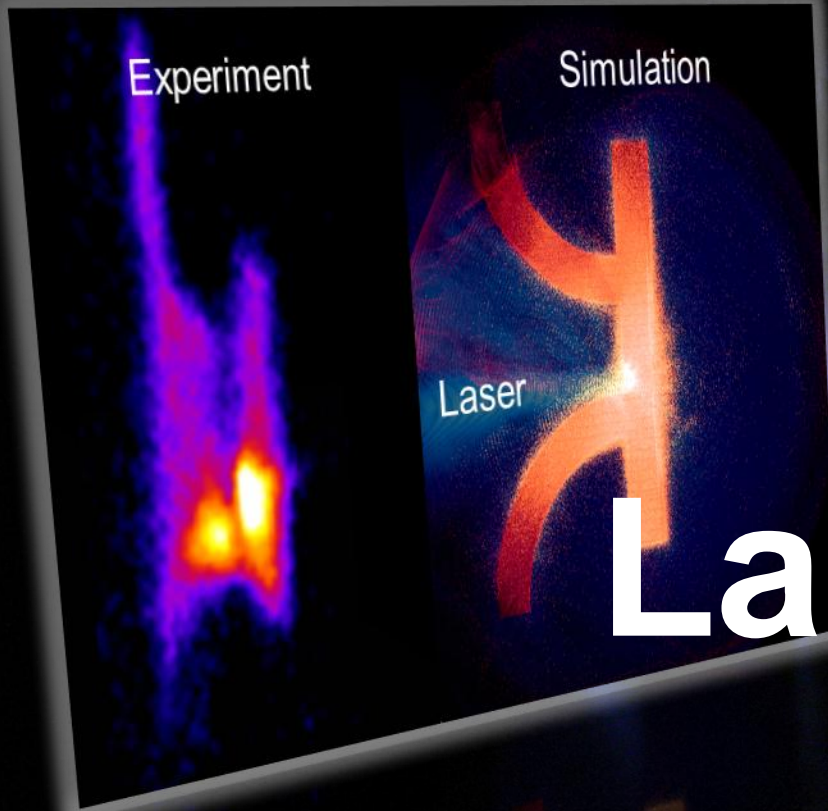


# With GPUs, ASE can now be computed in Minutes instead of Weeks

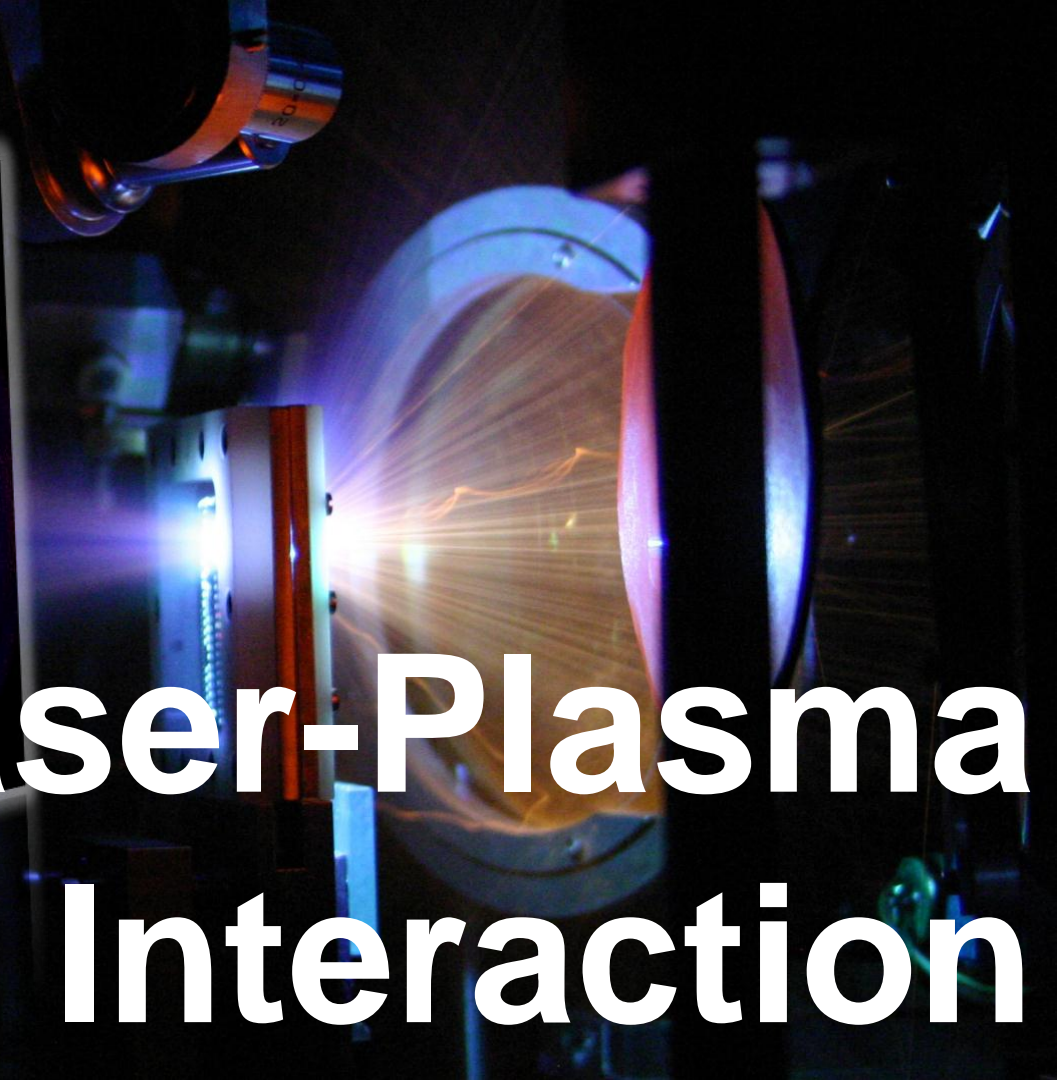




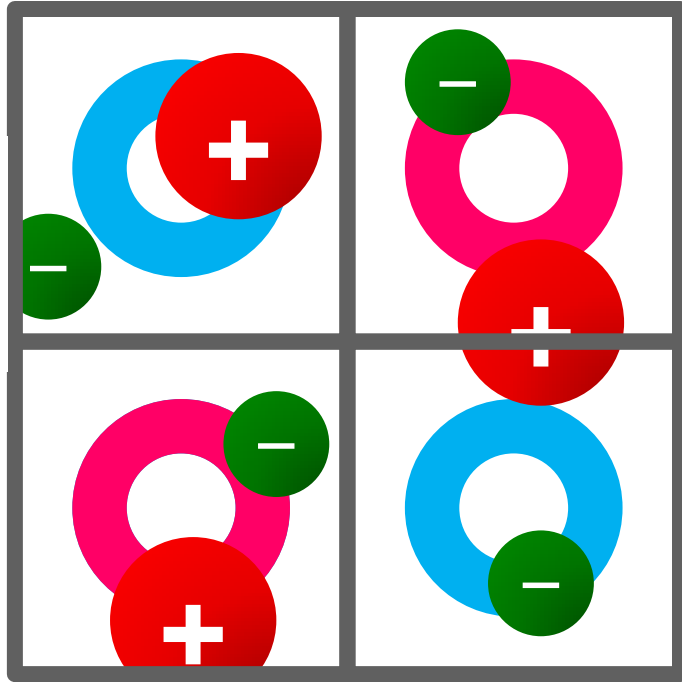
**See Poster P5122  
on HASEonGPU  
by Axel Huebl**



# Laser-Plasma Interaction



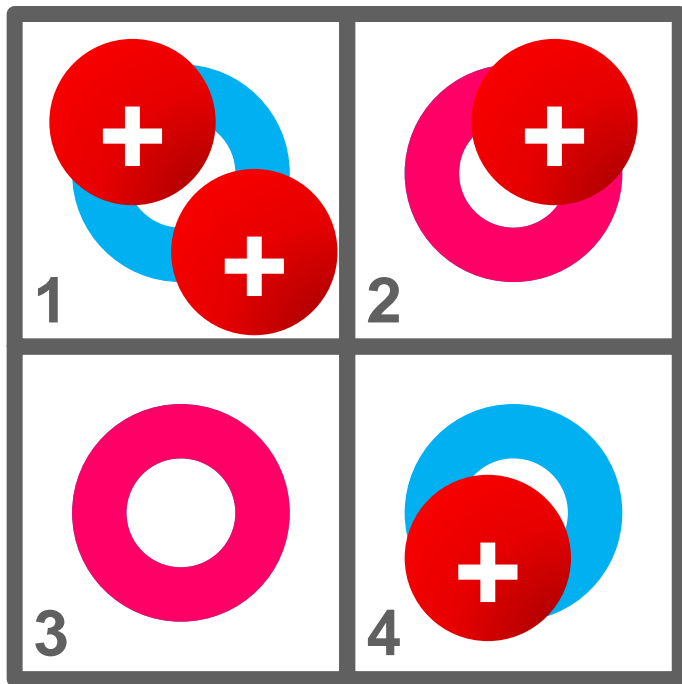
# Plasma Simulation using the Particle-in-Cell Technique



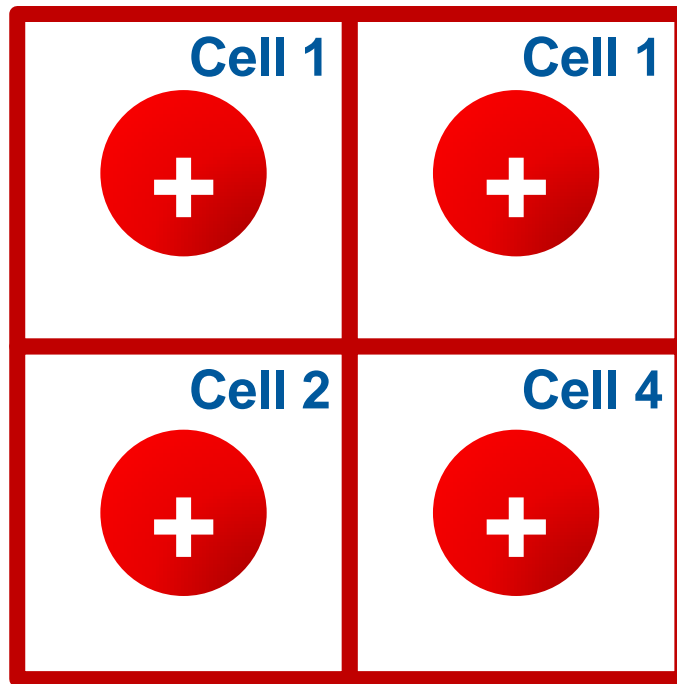
**Field Domain**

**Particle Domain**

# Creating vectorized Data Structures for Particles and Fields



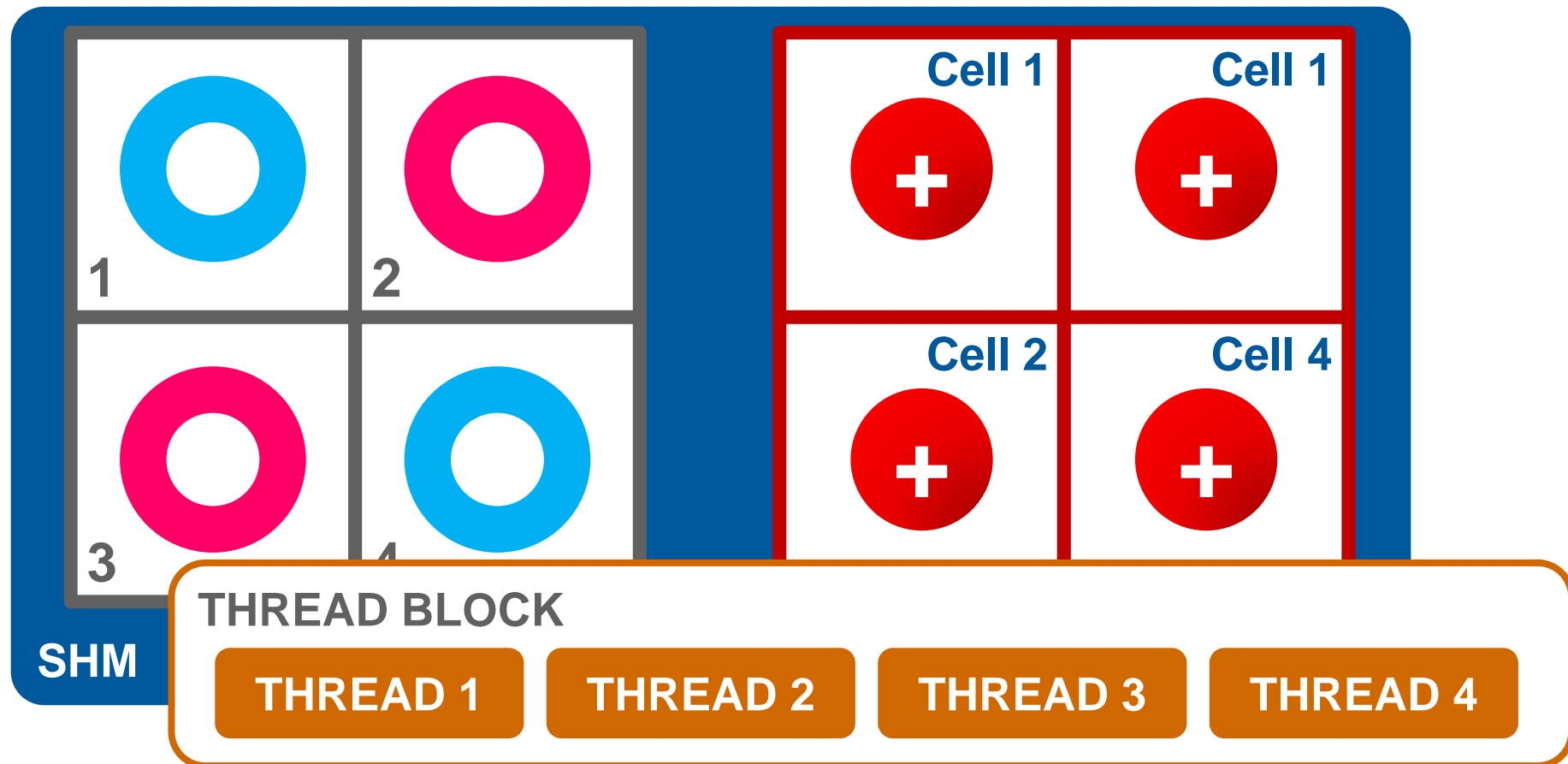
**Field Domain**



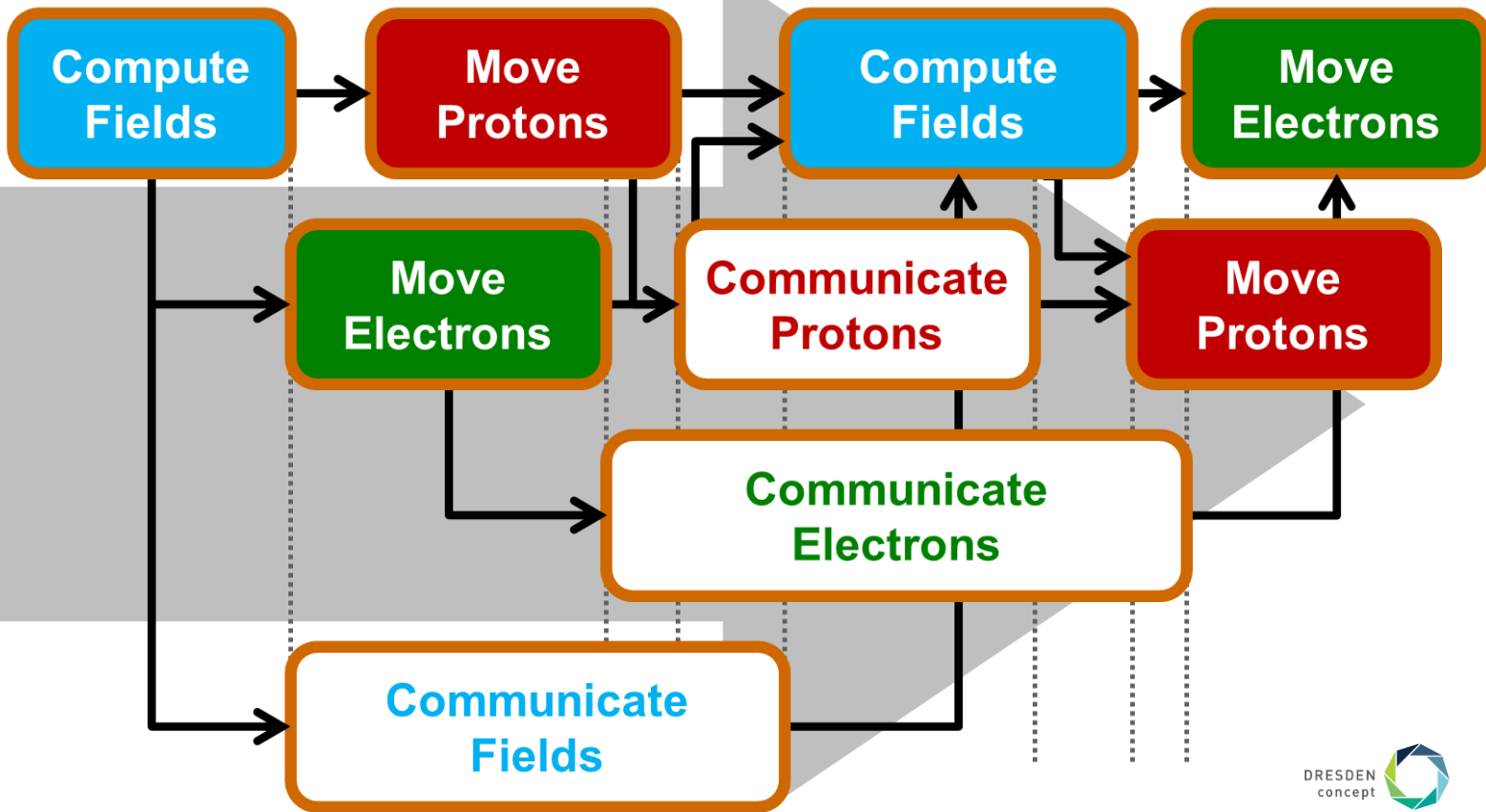
**Particle Domain**



# Thread-wise Operations on Fields and Particles in Shared Memory



# Task-Parallel Execution of Kernels + Asynchronous Communication

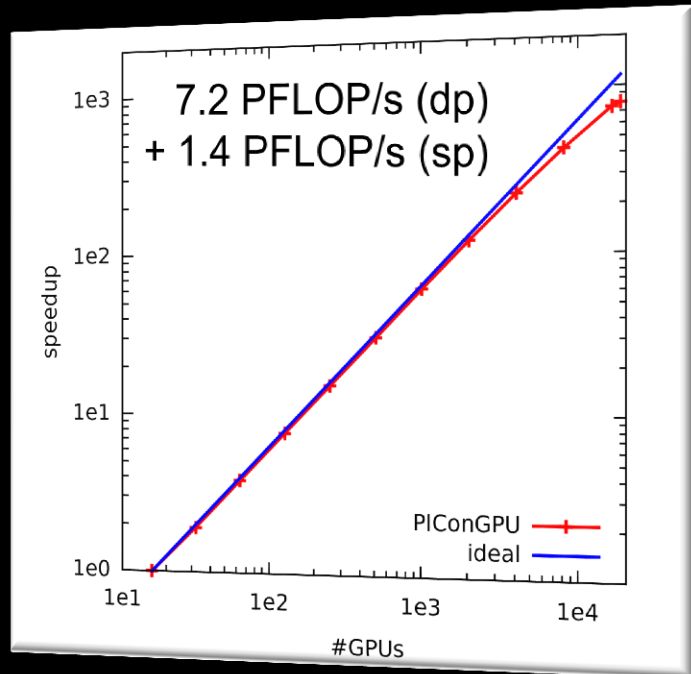


PIConGPU

# PICon GPU

- 3D3V Particle-in-Cell Code
- Fully GPU-accelerated C++
- Open Source
- See [picongpu.hzdr.de](http://picongpu.hzdr.de)

See S5193  
at 2:30 pm today

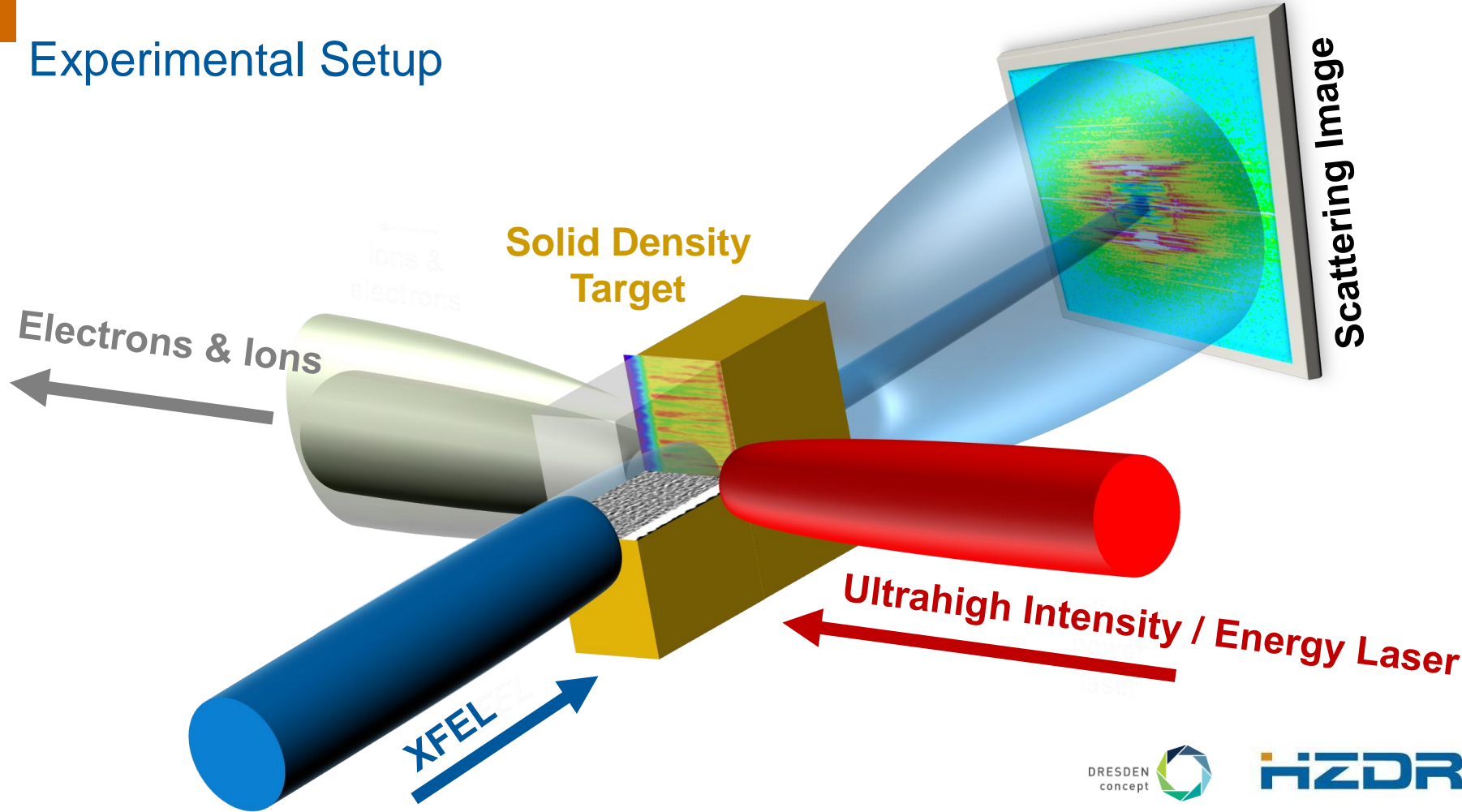




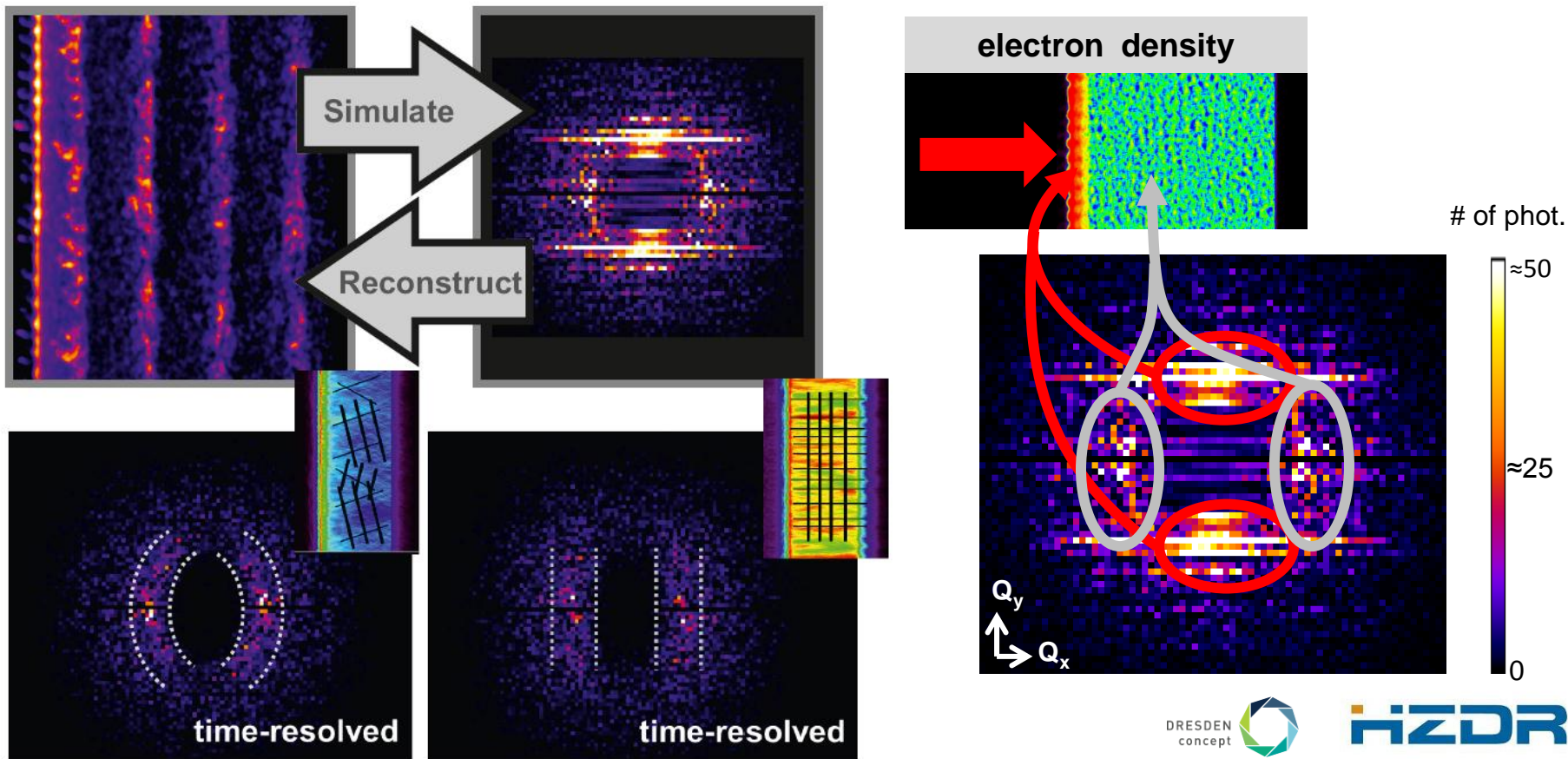
# Probing Plasmas with X-ray Lasers



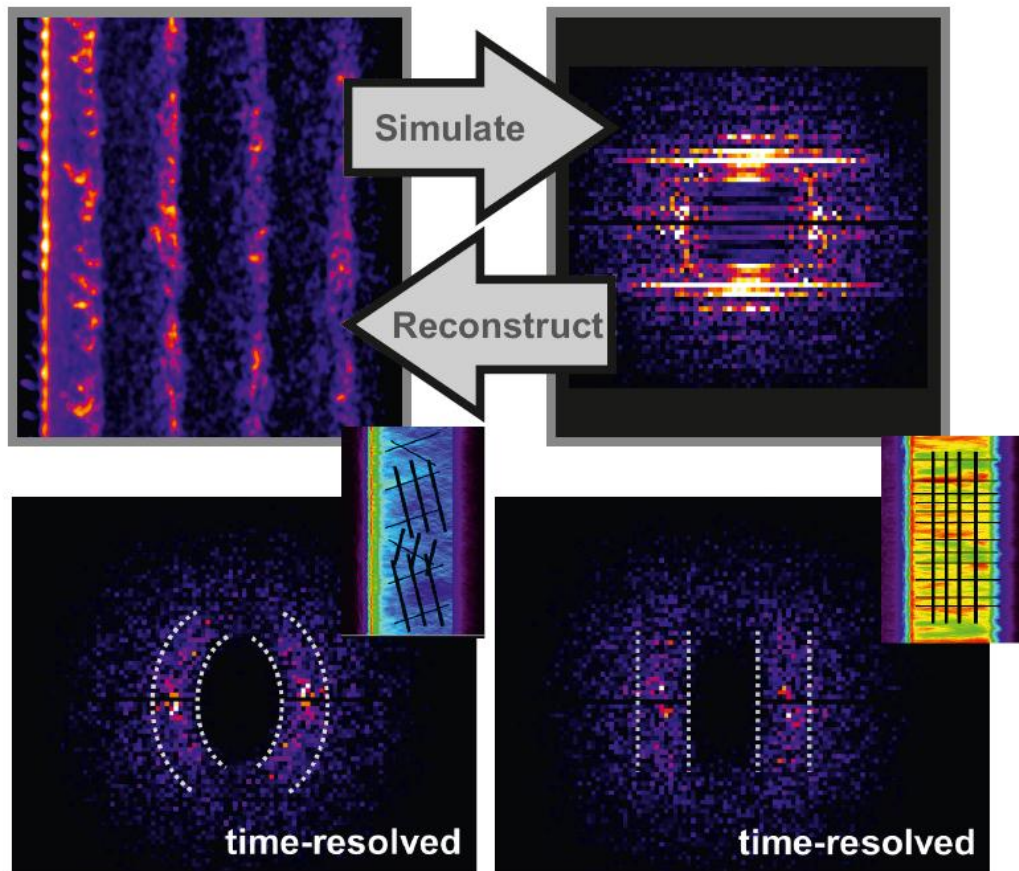
# Experimental Setup



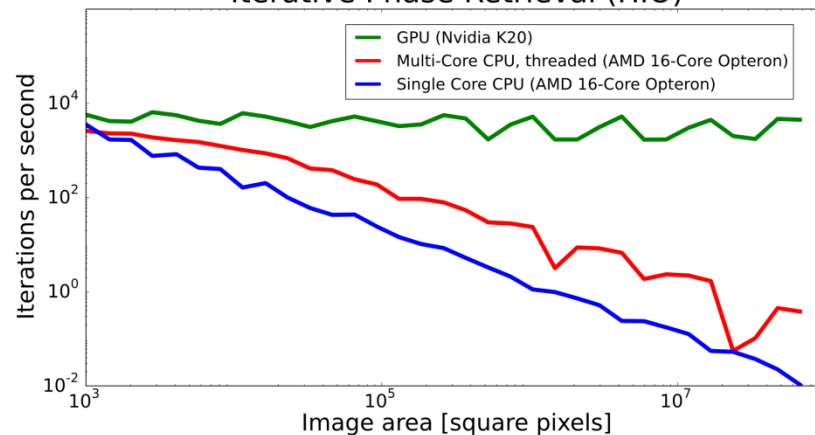
# Synthetic X-Ray Scattering Images from Simulations



# Accelerate the Reconstruction with GPUs



## Iterative Phase Retrieval (HIO)



# We need to include all relevant Atomic Physics Processes

**FLYCHK**

Total number of FLYCHK users: 676

FLYCHK provides a capability to generate atomic level populations and charge state distributions for low-Z to mid-Z elements under NLTE conditions.

User ID:  
Password:

to be fully integrated into

**PICon GPU**

Reference: [High Energy Density Physics v.1, 2005](#)

Manual: [1995\(PDF\)](#) [2008\(PDF\)](#)

[README](#) [EXAMPLES](#) [Q&A](#)

[FLYCHK at IAEA](#)

[FLYCHK User Forum](#)



[Latest news](#)

[Contact us](#)

(userid request etc.)



[Rate our products and services](#)

**HZDR**



# The Loop

**X-Ray Laser  
Simulation**  
(work in progress)

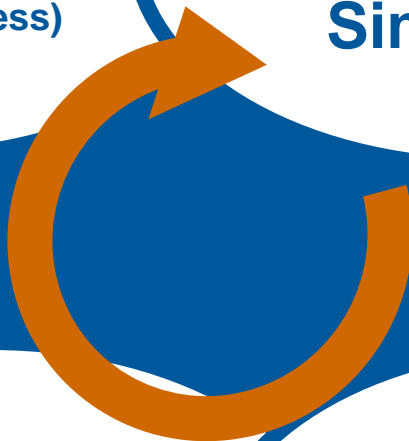
**High Power  
Laser  
Simulation**

**Atomic  
Physics  
Simulation**  
(work in progress)

**Phase  
retrieval**

**Plasma  
Simulation**

**Synthetic  
Diagnostics**





**Won't this take  
AGES?**