Traveling-wave electron accelerators – leveraging exascale computing towards scalable laser-plasma accelerators

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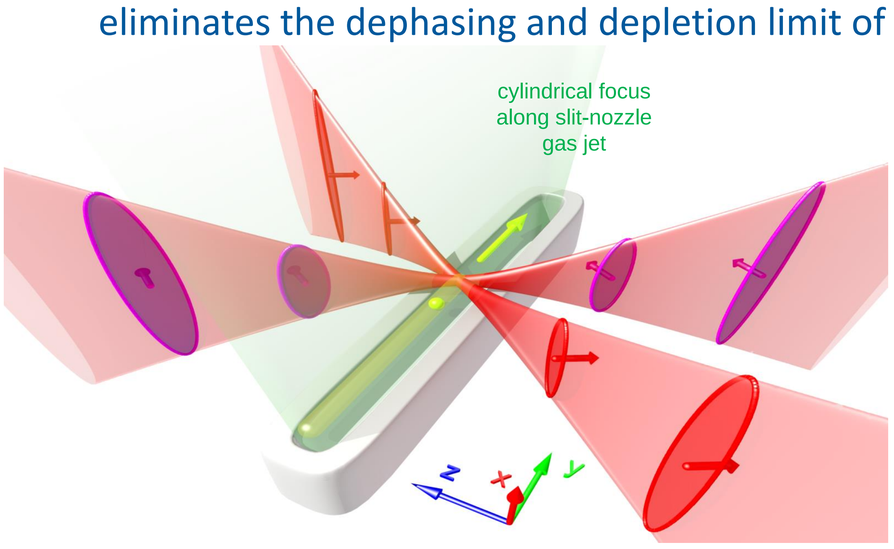
Traveling-Wave Electron acceleration (TWEAC)

eliminates the dephasing and depletion limit of Laser-wakefield acceleration



- Overlap of two obliquely incident laser pulses in cylindrical focus drives plasma cavity for electron acceleration.

→ **Circumvents LWFA dephasing limit**

- Pulse-front tilted laser enforces vacuum speed of light propagation of laser overlap in plasma.

$\alpha = \Phi/2 \rightarrow v_g \equiv c$

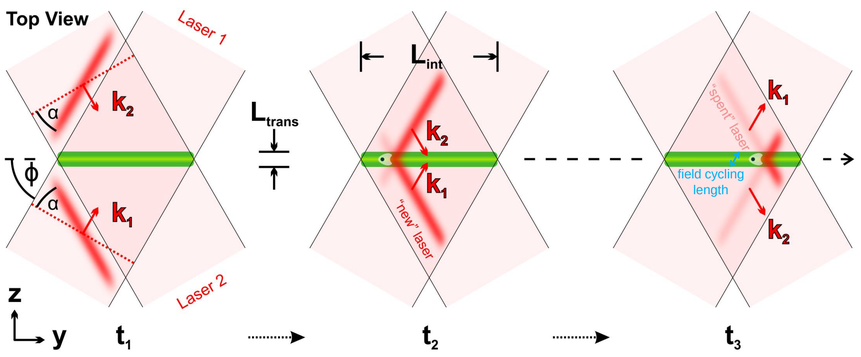
→ **Averts LWFA depletion limit**

- Oblique laser beam geometry continuously feeds a „fresh“ portion of the laser beams into an unperturbed plasma.

L(accelerator**) > L(**depletion length**)**

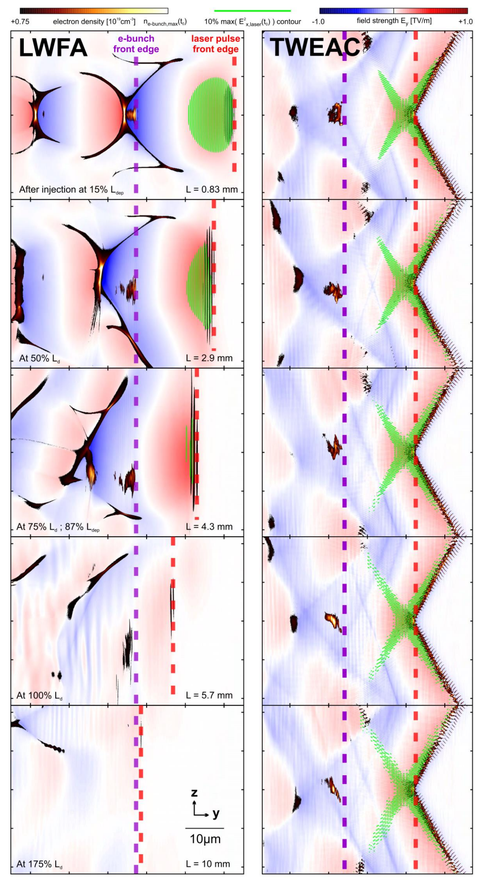
is fine, as long

L(field cycling length**) < L(**depletion length**)**



TWEAC maintains quasi-stationary plasma conditions

- TWEAC accelerator length can be made longer without dephasing or depletion.
- **No need for staging.**
- Quasi-stationary plasma conditions without (parasitic) self-injection.
- No laser self-phase modulation along direction of electron acceleration.
- Does not require guiding of laser pulses.

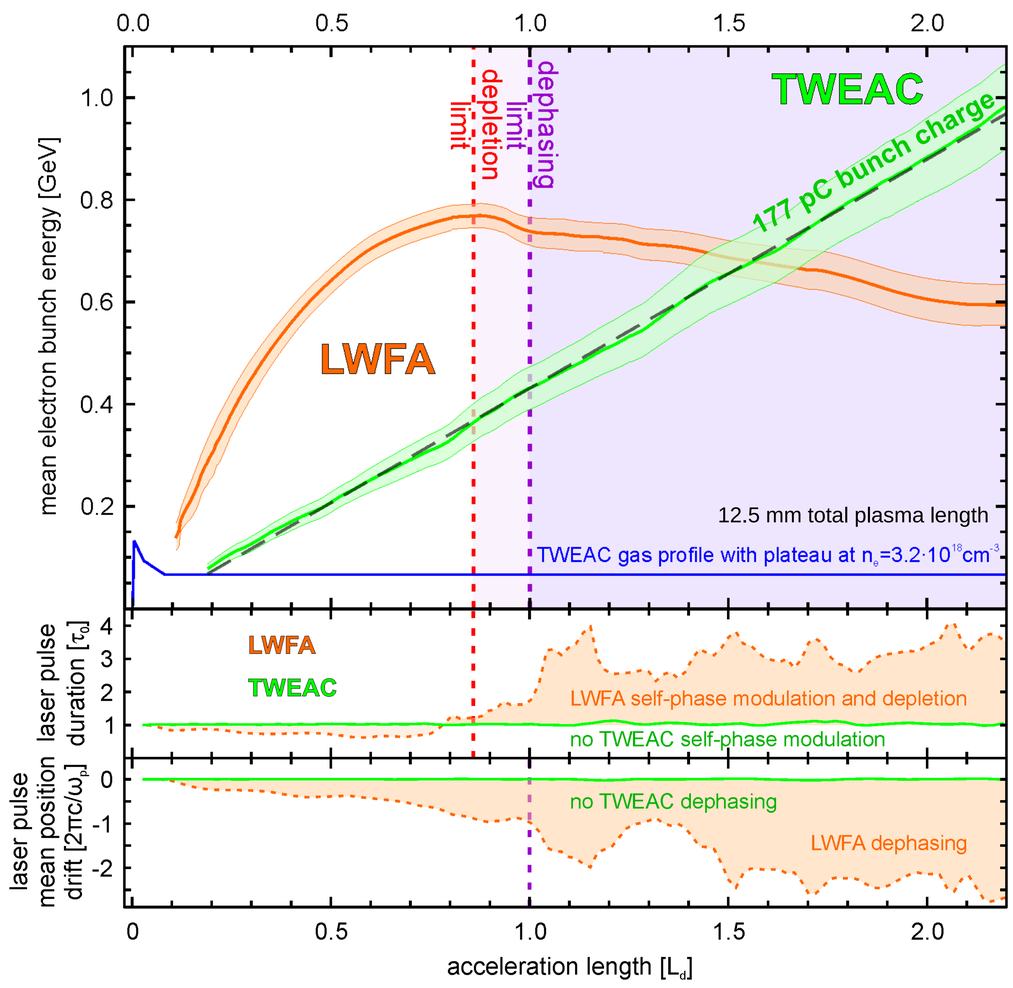


Simulated with

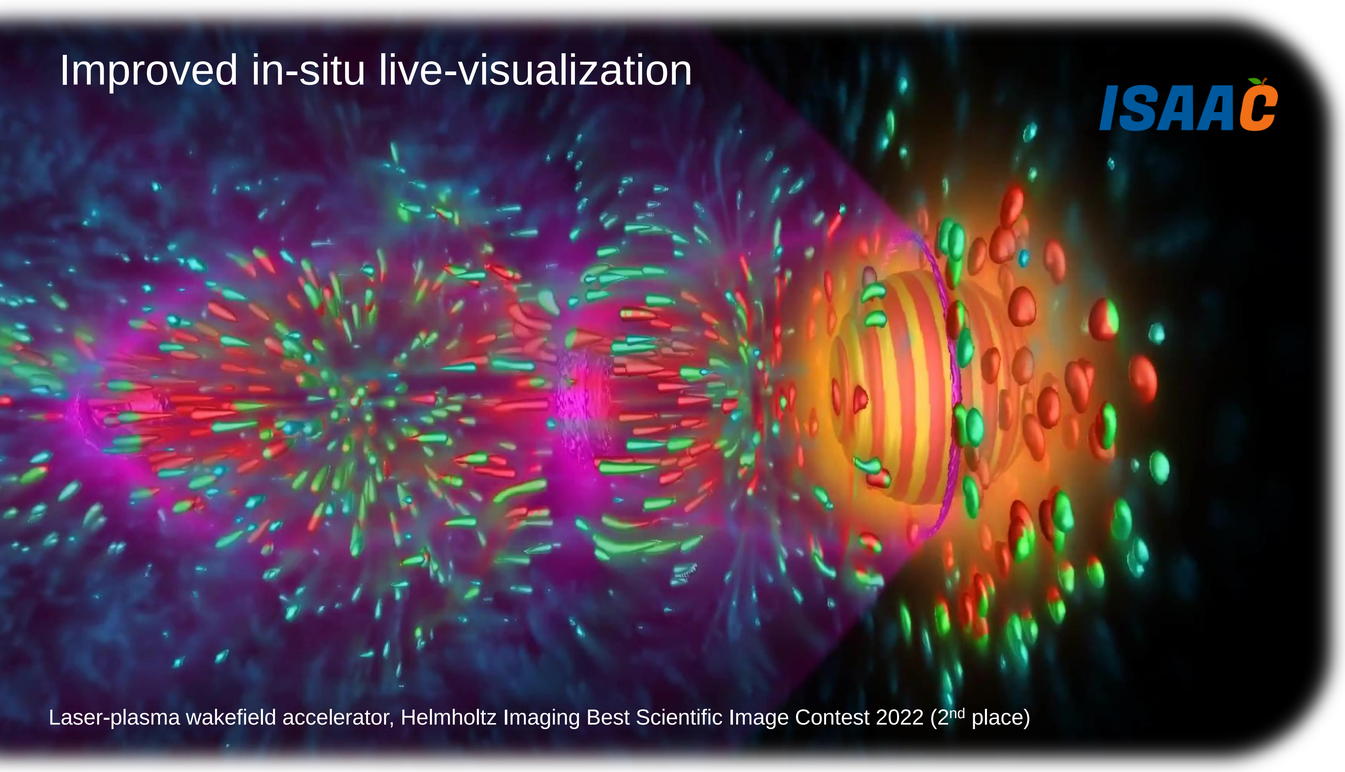
PIConGPU

picongpu.hzdr.de

Performance on GPUs and CPUs



TWEAC scalability with electron density
enables access to novel regimes
without the need for staging



Road to exascale – PIConGPU scales to the largest machines

PIConGPU team is one of 8 teams in early-access project
CAAR for Frontier (Center for Application Readiness) at ORNL

Juwels Booster (Nov 2020),
JSC at FZ Juelich
73 PetaFLOPS (7th Top 500, 3rd Green 500)
936 nodes, 3744 NVIDIA Volta A100s
AMD EPYC Rome CPU

Summit, ORNL (2018)
200 PetaFLOPS
4,608 nodes
27,648 NVIDIA Volta V100s
IBM POWER9 CPU

Frontier, ORNL (2022)
> 1.5 ExaFLOPS
AMD GPU hardware
Cray architecture / compilers

PIConGPU runs on latest AMD GPUs

powered by **alpaka**
github.com/alpaka-group/alpaka

AMD CRAY a Hewlett Packard Enterprise company — OAK RIDGE National Laboratory