High average gradient in multistage plasma wakefield accelerators

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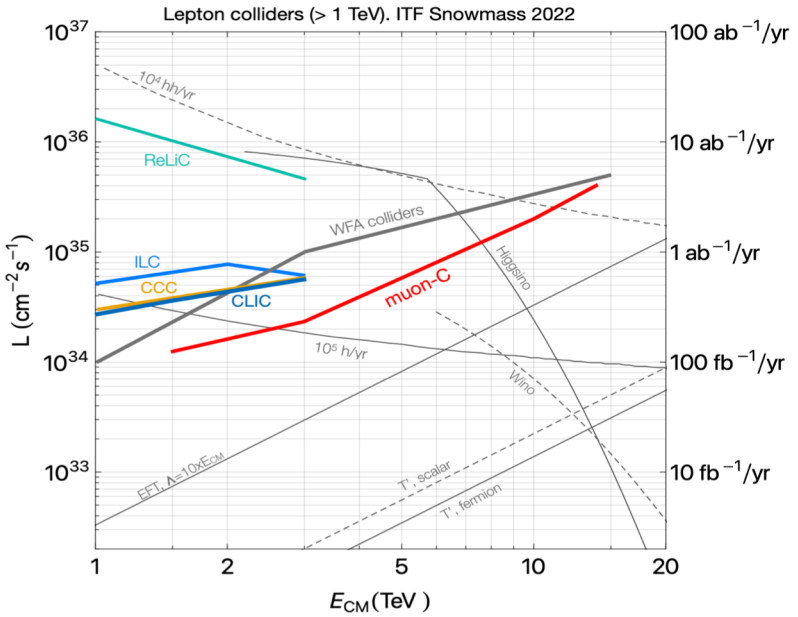
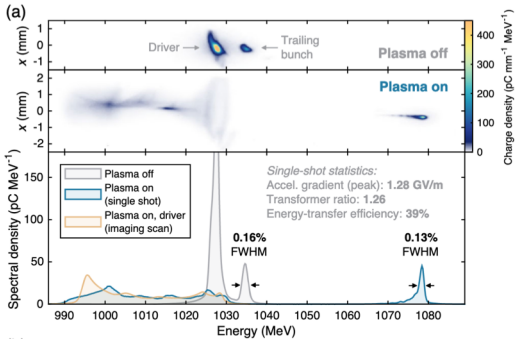
* Starting 06/23: SLAC National Accelerator Laboratory

How do we reach beyond 10 TeV c.o.m. with PWFAs ?



Source: T. Roser, et al. "Report of the Snowmass 2021 Collider Implementation Task Force." *arXiv:2208.06030* (2022).

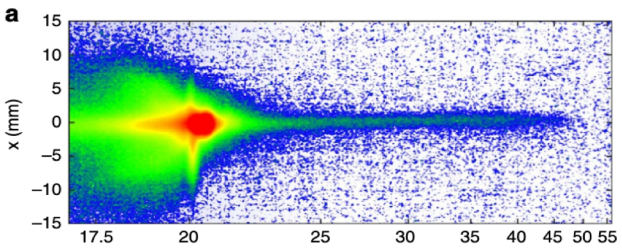
1.28 GV/m



FLASHForward: optimized for high efficiency and energy-spread conservation

Source: CA Lindstrøm, et al. *Phys. Rev. Lett.* (2021)

130 GV/m

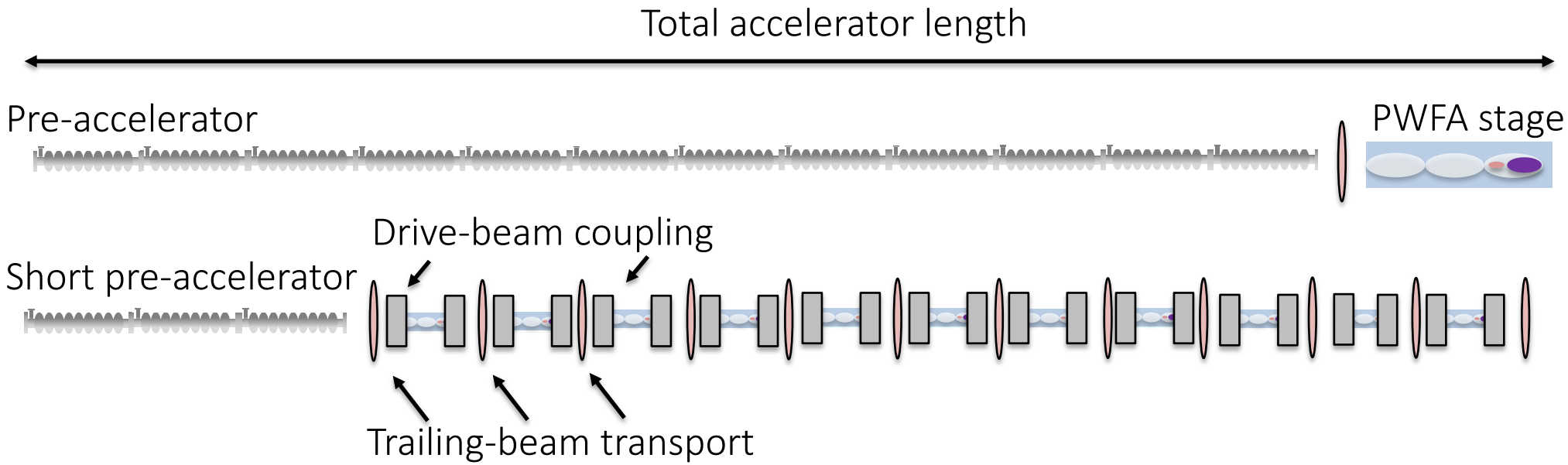


FACET-I: Measurement of high accelerating gradient in Ar

Source: S. Corde, et al. *Nature Comm.* (2015)

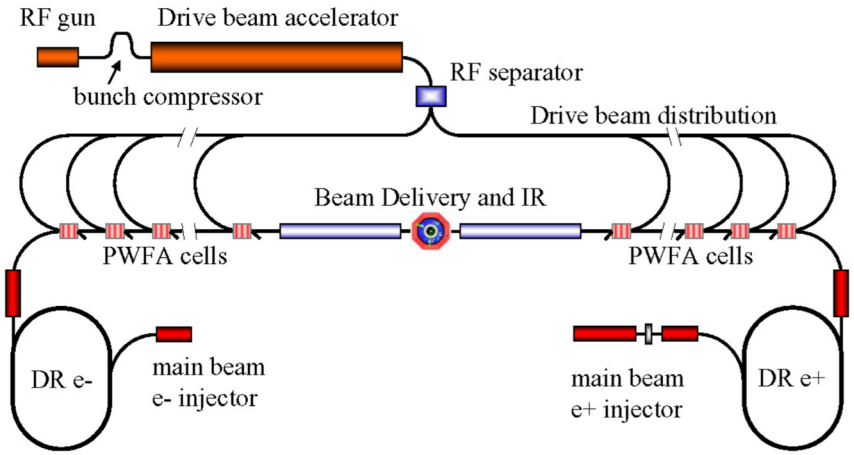
- High fields in beam-driven plasma wakefield accelerators renders it an interesting technology
- Very good progress on single-stage PWFA quality
- Community is working on testable strategies that scale PWFAs to TeV energies

Multiple plasma stages are required to significantly shrink the accelerator

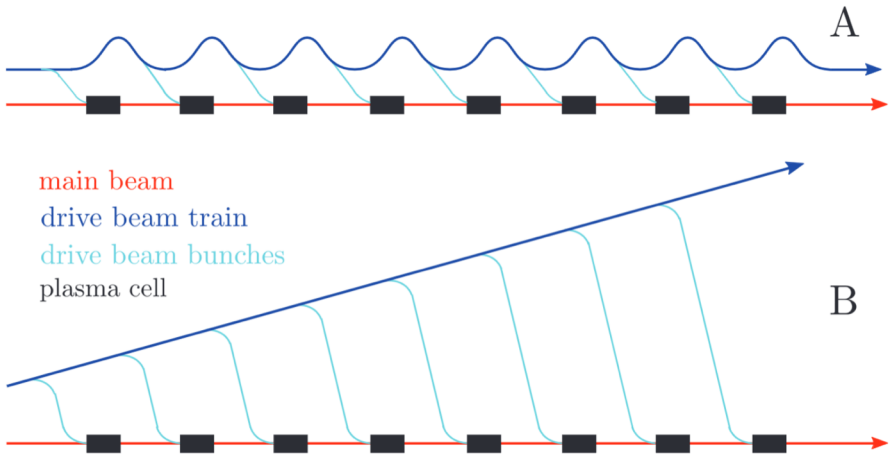


- PWFAs transfer energy from a driver to a trailing beam.
- Energy gain per stage limited by drive-beam energy
- Multiple consecutive stages allow for much higher **average gradients**

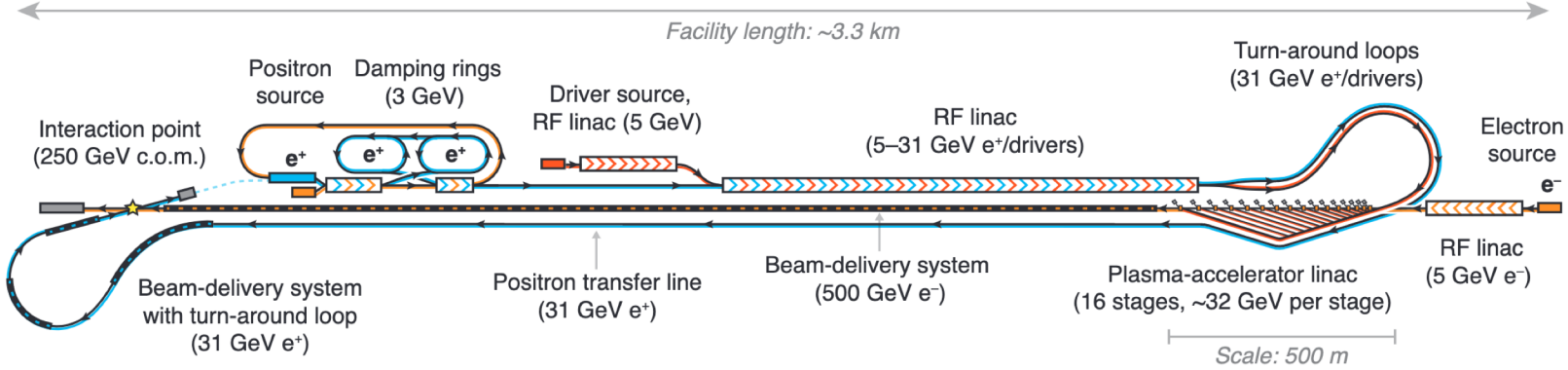
Several staging designs for PWFAs available



Source: A. Seryi, et al. *PAC09, Vancouver, BC* (2009)



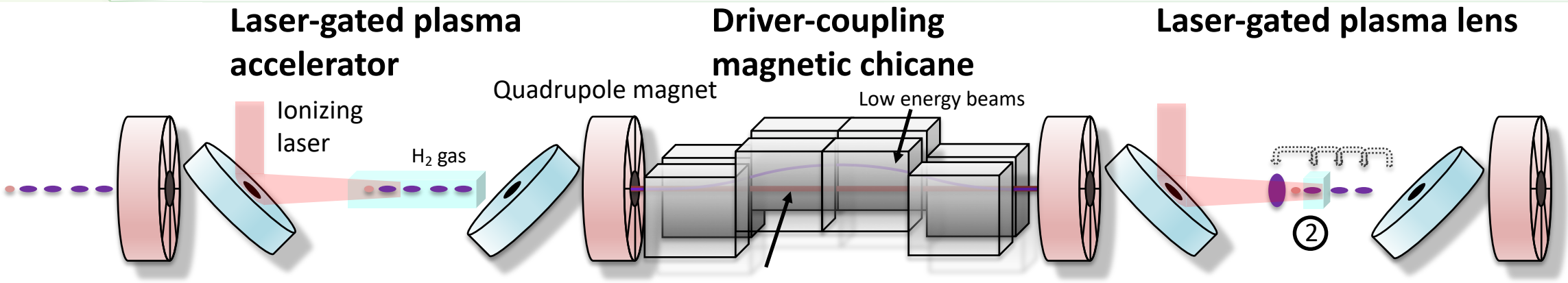
J. Pfingstner, et al. No. *CERN-ACC-2016-211 (*2016)



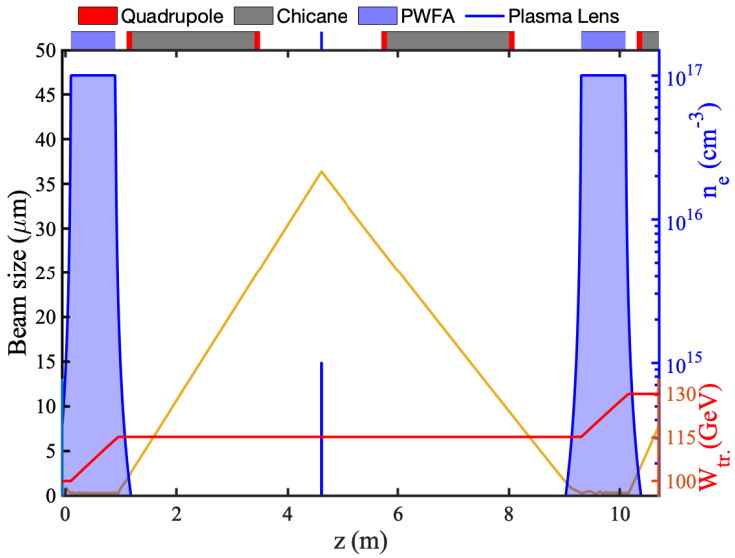
Source: B. Foster, R. D'Arcy, C.A. Lindstrom *arXiv preprint arXiv:2303.10150* (2023)

- Average gradient is one of **several** staging challenges.
- **But:** Development of compete solutions forces us to work on all of them simultaneously

Simulation study: Laser-gated staging



- Design allows for machines with GeV/m average gradient
- Average gradient throughout accelerator can be improved with better RF systems



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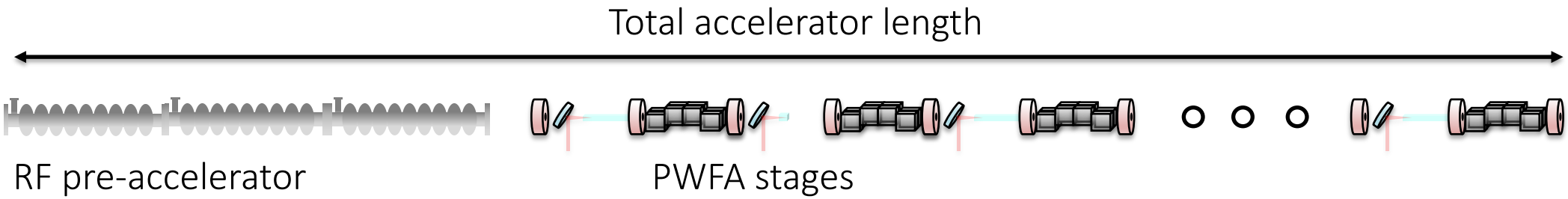

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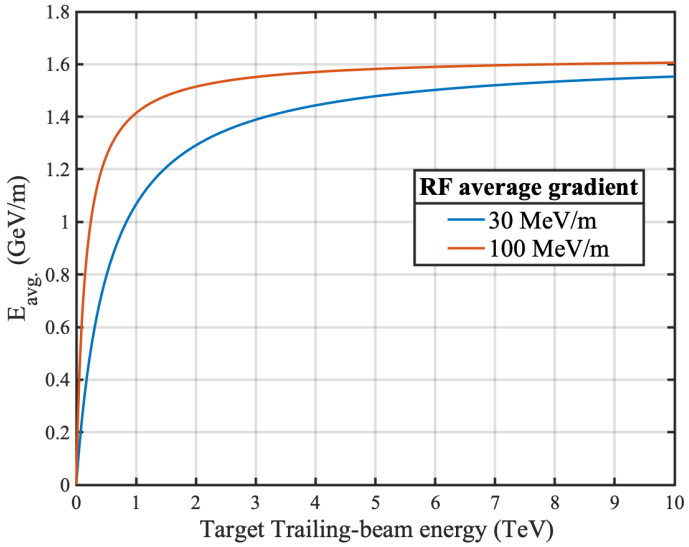
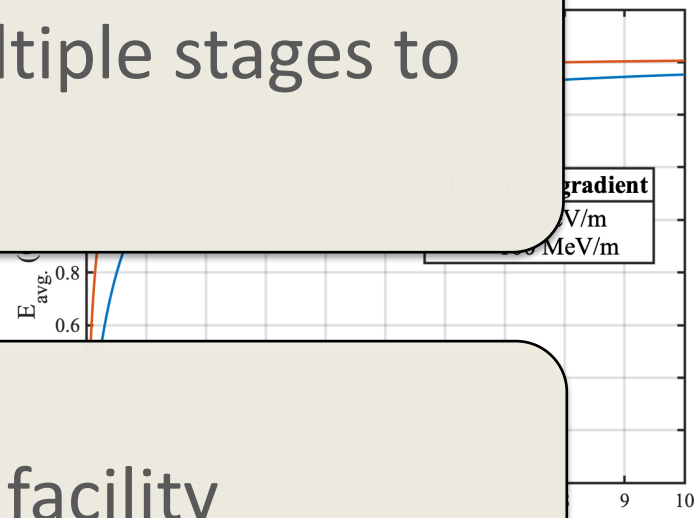


Final remark

Single-stage PWFAs are improving, because experiments require complete solution

We should start experimental tests with multiple stages to make progress

- Design allows for machines with GeV/stage
- Average gradient throughout accelerator can be improved with better RF systems



C^3 demo at SLAC might be a suitable facility