Computational modeling needs of plasma-based accelerators towards future colliders

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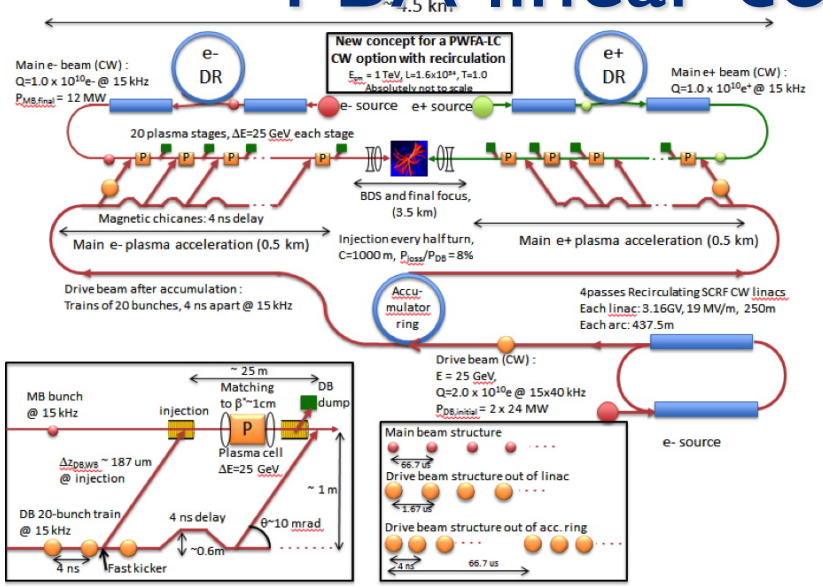
Goal: A PBA based linear collider or XFEL

PBA linear colliders based on stages



*Taken from E. Adli et al. arXiv:1308.1145, 2013

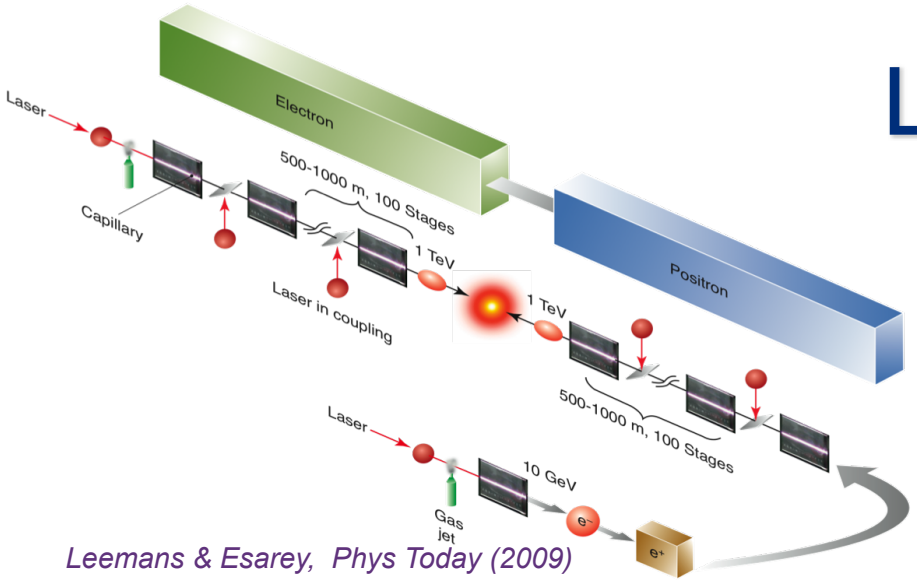
PWFA

Roadmap was developed in 2017 for experiments

This roadmap also requires high fidelity simulations for interpreting and designing experiments

Goal: Developing simulation capability to support experiments, explore concepts ,and design a linear collider before needed beam, laser, and plasma conditions are accessible experimentally.

LWFA



Leemans & Esarey, Phys Today (2009)

Parameters space is immense and experiments cannot examine all of them, while simulations can if the model includes the relevant physics.

What is needed to ensure this capability exists and that is used “effectively”?

Physics challenges for high fidelity PBA-LC designs

I. Wake excitation by lasers and particle beams

II. Injection of spin polarized electron or positron witness beams

III. Beam loading of wakes

IV. Evolution of driver and witness beam over pump depletion distances

V. Transporting beams into and out of stages

VI. Coupling multiple stages together

VII. Final focus

VIII. Collision point

IX. Plasma sources including heat extraction

Large parameter regime: linear regimes, nonlinear regimes, uniform plasmas, hollow plasmas, round beams, elliptical beams and each choice effects other elements.

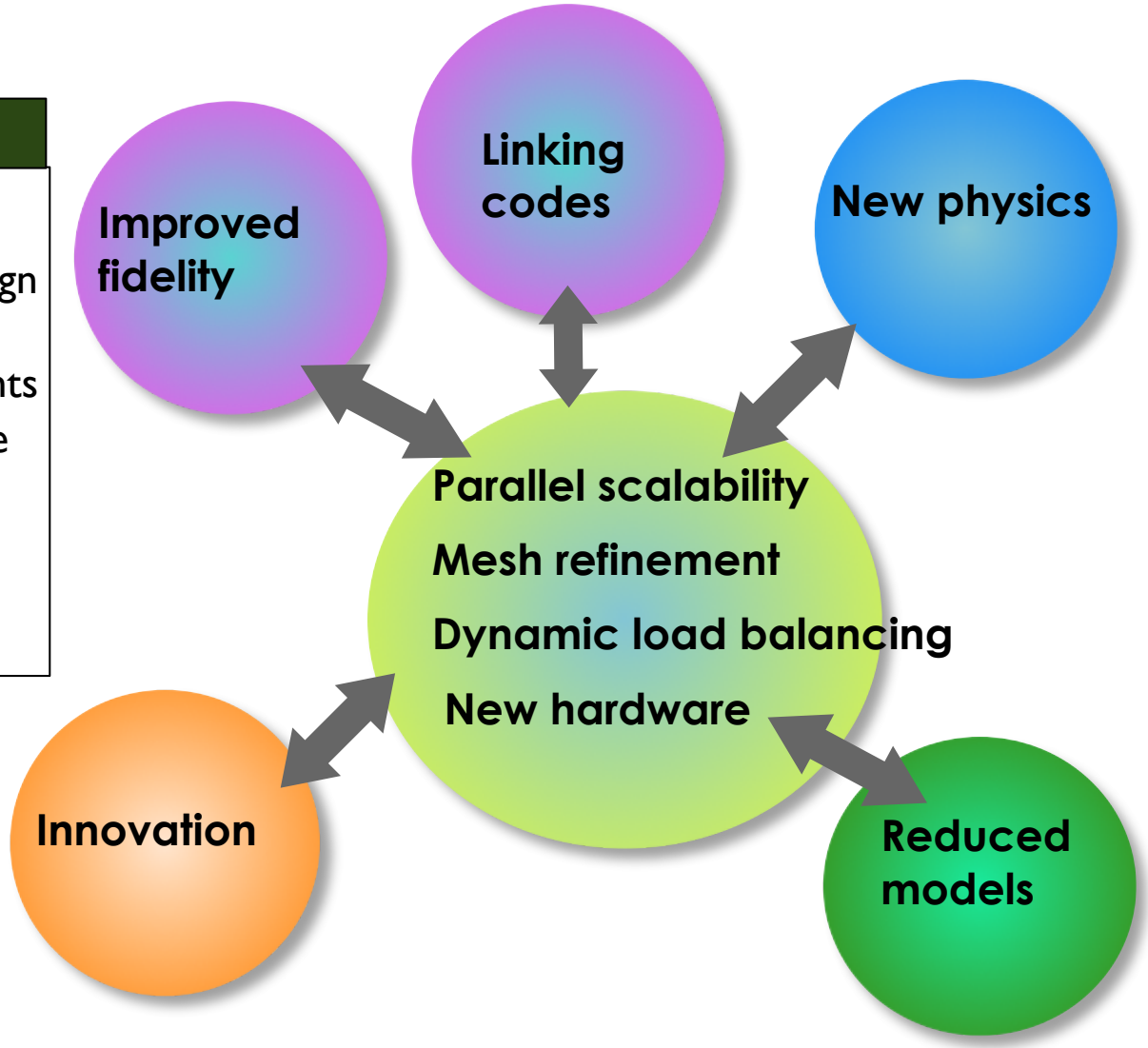
Requires fully nonlinear modeling capability as well as QED effects

Software challenges for high fidelity PBA-LC designs

MANY OBJECTIVES

- Study new concepts
- Support interpretation and design of experiments
- Real time steering of experiments
- Study parameters not accessible to current experiments
- Self-consistent design of a PBA-LC or a XFEL

Needs to run on exascale and beyond



Developing large and high fidelity code requires software engineering and innovation

Scale of problem requires vibrant ecosystem, community coordination, and pipeline of students

MANY OBJECTIVES

Improve efficiency without stifling innovation

Software for physics modules and numerical algorithms should be freely and widely available (through open source or other mechanisms)

Collaboration between universities groups and national labs need to be fostered

Funding mechanisms should be established to enable the formation of international consortia and collaborations

Funding and training of students is a high priority