The Community Project for Accelerator Science and Simulation 4: Advancing Accelerator Physics through High-performance Computing

ComPASS4

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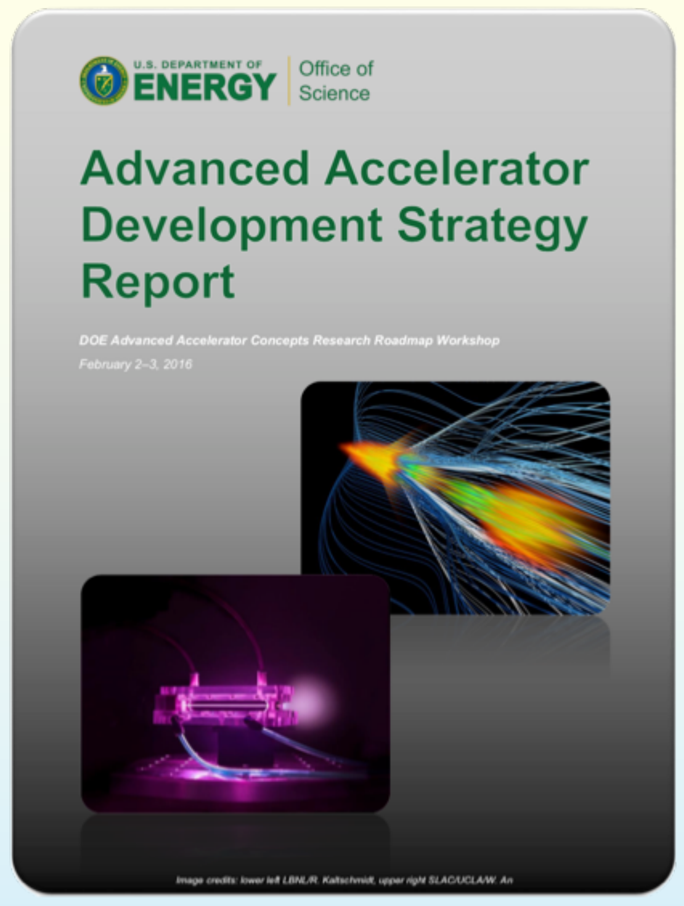
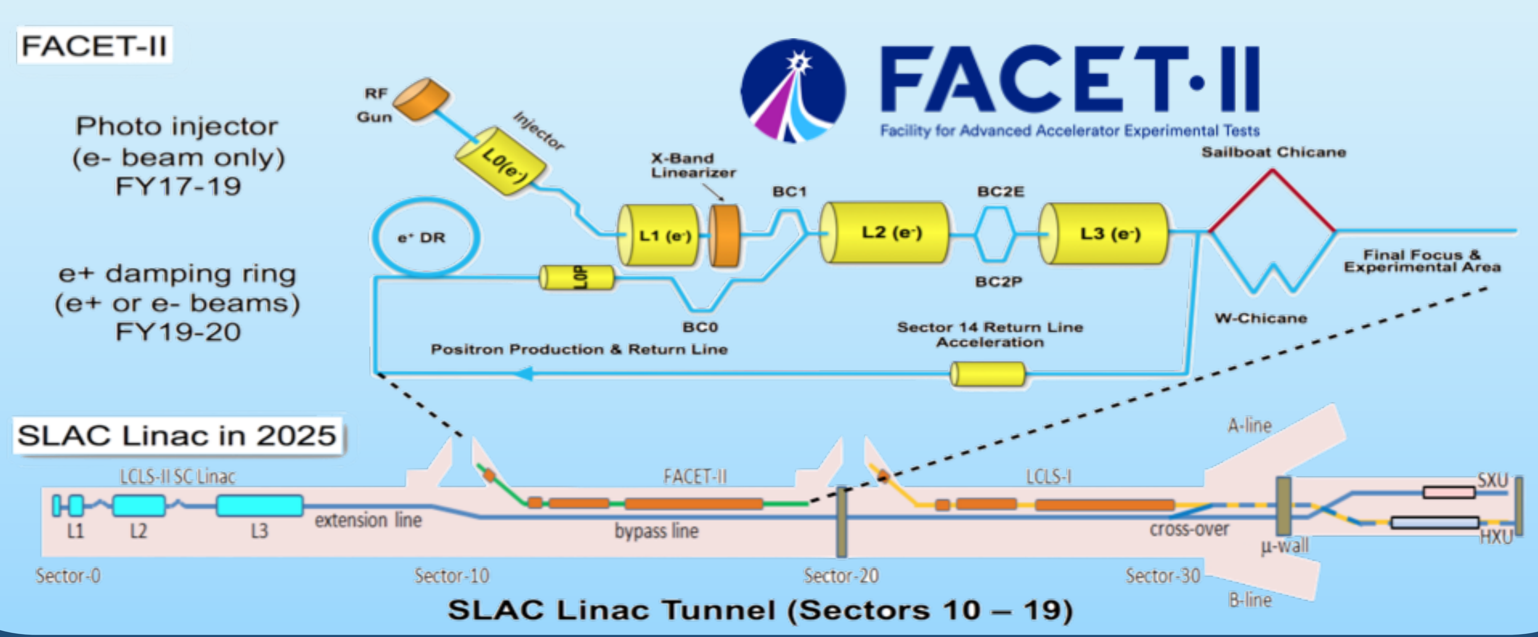
ComPASS4

Introduction

The next ten years of Advance Accelerator research should focus on addressing common challenges:

- Higher energy staging of electron acceleration with independent drive beams, equal energy, and 90% beam capture.
- Understanding mechanisms for emittance growth and developing methods for achieving emittances compatible with colliders.
- Completion of a single electron acceleration stage at higher energy
- Demonstration and understanding of positron acceleration
- Continuous, joint development of a comprehensive and realistic operational parameter set for a multi-TeV collider, to guide operating specifications for Advance Accelerator.

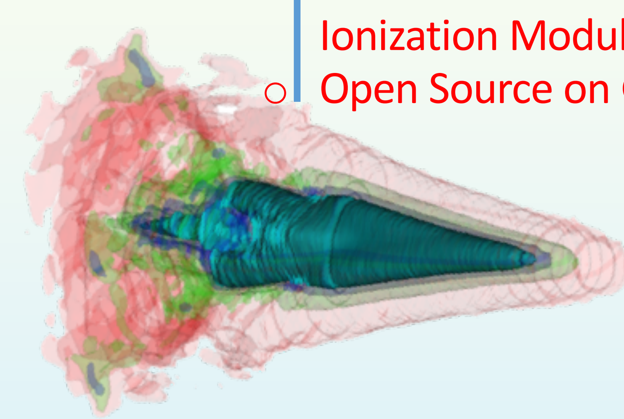




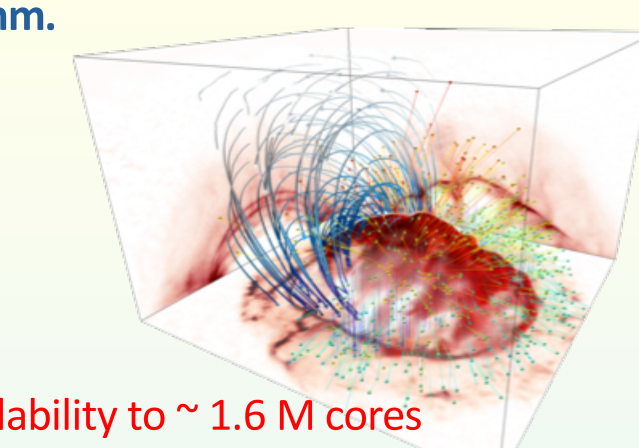
QuickPIC & Osiris

QuickPIC is a 3D parallel Quasi-Static PIC code, which is developed based on the framework UPIC.

- Scalability to ~ 128 K cores
- Pipeline Parallelization in z
- MPI + OpenMP +Vectorization (For Intel Phi)
- Laser Module and Field Ionization Module
- Open Source on Github



Osiris is a full parallel PIC code with state-of-art relativistic EM-PIC algorithm.



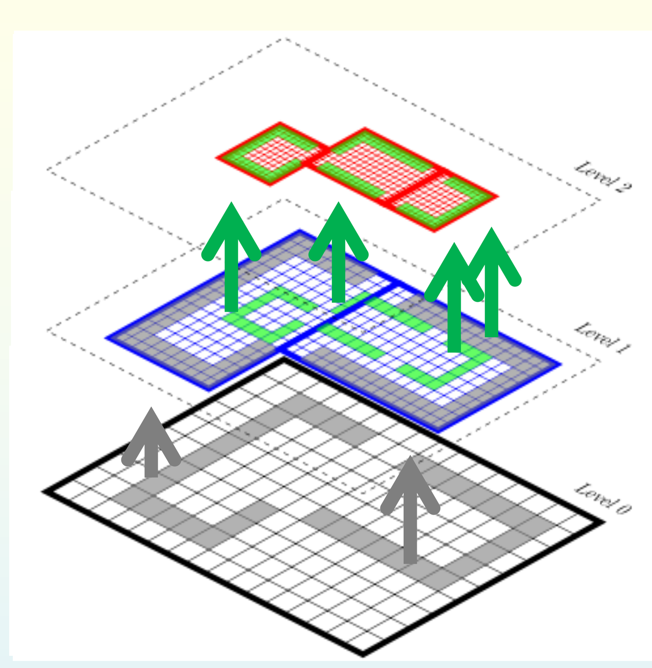
- Scalability to ~ 1.6 M cores
- SIMD hardware optimized
- Dynamic Load Balancing
- QED module
- Particle merging
- GPGPU and Xeon Phi support

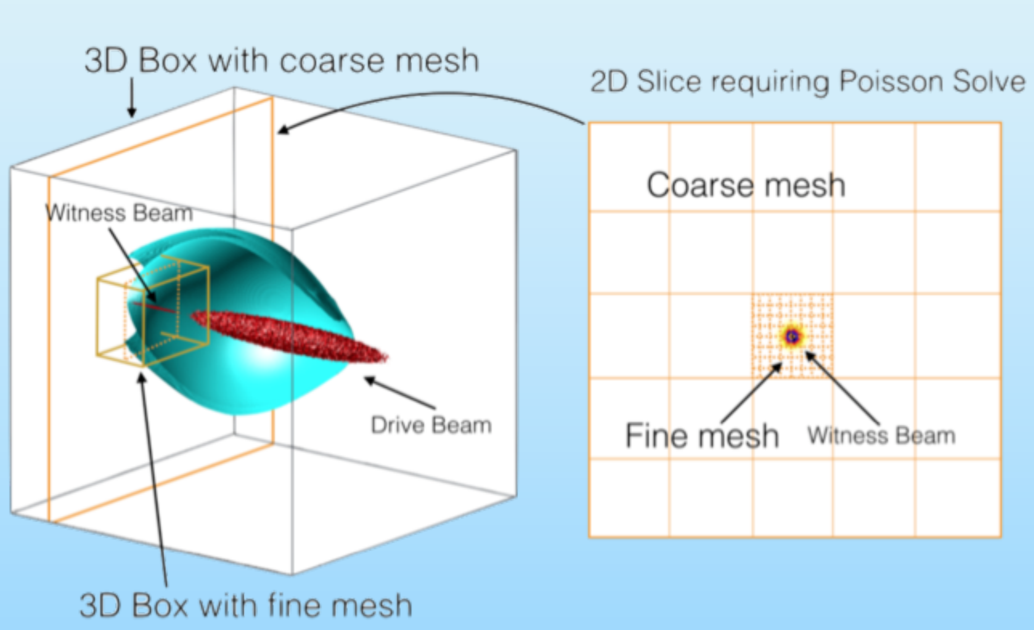
OSIRIS and QuickPIC have been used to model FFTB and FACET for past 20 years:

- Design experiments.
- Interpret experiments.
- Study physics inaccessible to experiments.

QuickPIC+AMRex

- **AMReX is an ECP-funded software framework to support the development of block-structured AMR applications for current and next-generation architectures.**
- **As part of the HEP ComPASS project, mesh refinement – both static and adaptive – will be added to QuickPIC to enable faster, more efficient simulation.**
- **FASTMath support of AMReX provides source code and expertise to enable quick prototyping of multilevel algorithm and eventual optimization on new HPC architectures of the multilevel algorithm in the context of QuickPIC.**



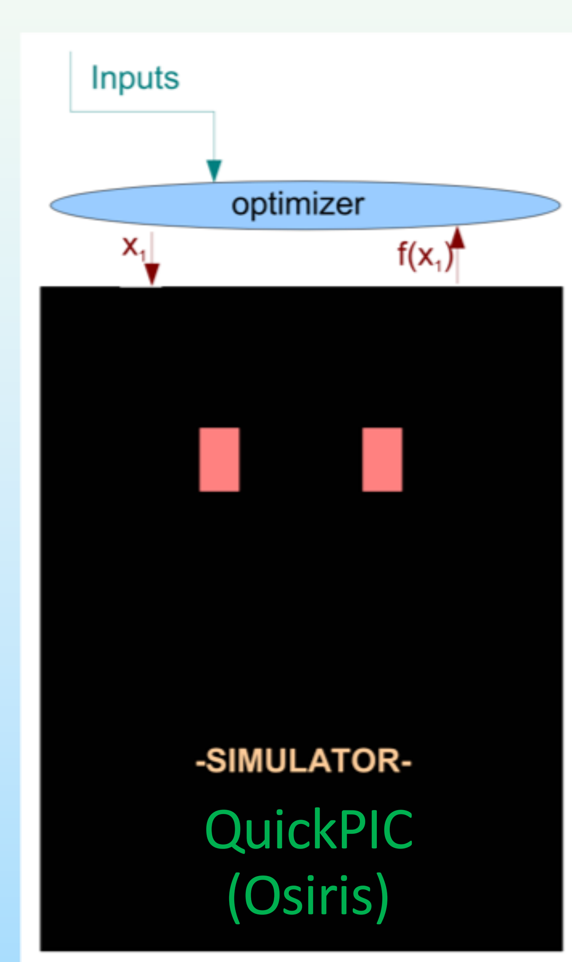


QuickPIC 3D Simulation Big Challenge: Ion Motion Induced Emittance Growth of Matched Electron Beams in Plasma Wakefields ($\sigma_r = 0.1$ µm, $\sigma_z = 10.0$µm, $N = 1.0 \times 10^{10}$, $n_b/n_p = 63500 >> m_{ion}/m_e = 1836$)

QuickPIC+POPAS

Platform for Optimization of Particle Accelerators at Scale

- Integrated platform for coordinating the evaluation and numerical optimization of accelerator simulations on leadership-class DOE computers.
- Orchestrate concurrent evaluations of OSIRIS, QuickPIC, Synergia, and MARS (or combinations thereof) with distinct inputs/parameter values.
- Account for resource requirements of the above.
- API will allow the user to describe the mapping from simulation outputs and the derived quantities of interest used to define objective and constraint quantities.



There are five parameters we want to optimize in a PWFA problem:

- **Energy spread (minimize)**
- **Energy transfer efficiency (maximize)**
- **Hosing growth (minimize)**
- **Emittance growth (minimize)**
- **Loaded transformer ratio (maximize or within a range)**

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