Advanced Computational Tools for the Intensity Frontier

ComPASS SciDAC-3

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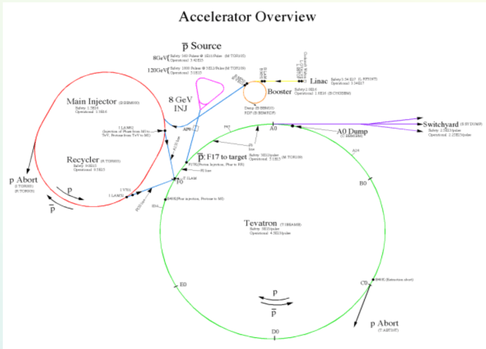
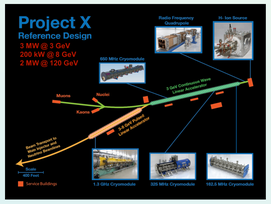
CONTEXT

***High-intensity accelerators** enable exploration of*

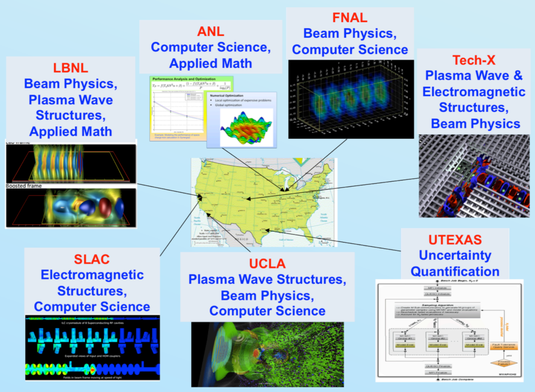




- neutrino interactions, to understand the origins of the universe, matter-antimatter asymmetry, force unification.
- rare processes, to probe energies at the unification scale

Modeling is essential for learning how to control instabilities to minimize beam losses and design, commission and operate these machines

ComPASS** under **SciDAC3** supports **Project-X** and the **FNAL Proton Improvement Plan



METHODS & TOOLS

***ComPASS SciDAC-3** is **advancing state-of-the-art modeling of Intensity Frontier accelerators**, using (developing if unavailable):*

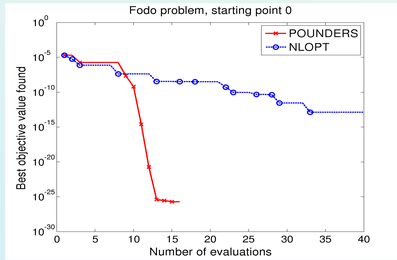
- the most advanced algorithms & performance optimization tools
- cutting-edge non-linear parameter optimization and uncertainty quantification (UQ) methods.

*Developing a **comprehensive set** of **codes** with **state-of-the-art electrostatic (ES) & electromagnetic (EM) field solvers:***

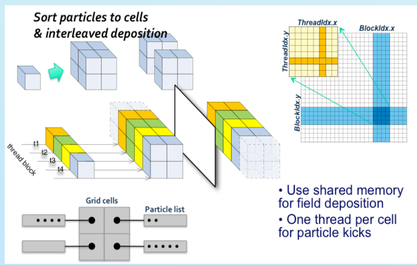
- ES-multigrid (**Synergia, Warp, FASTMath**), ES-AMR multigrid (**Warp, FASTMath**)
- EM-finite element (**ACE3P-FASTMath**),
- EM-extended stencil finite-difference (**Osiris, Vorpal, Warp**),
- EM-AMR finite-difference (**Warp, FASTMath**),
- Darwin-finite-difference (**QuickPIC**).

*Working **with SciDAC institutes:***

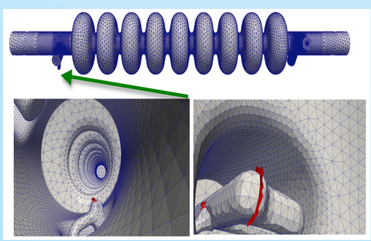
- **FASTMath:** field solvers (SuperLU, Chombo),
- **QUEST:** uncertainty quantification (QUESO),
- **SUPER:** performance analysis & optimization, non-linear parameter optimization.



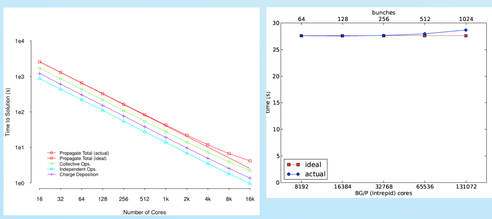
Synergia utilizing POUNDERS



Synergia on GPU based machines



ACE3P Cubit generated mesh with invalid elements (red), for a superconducting cavity



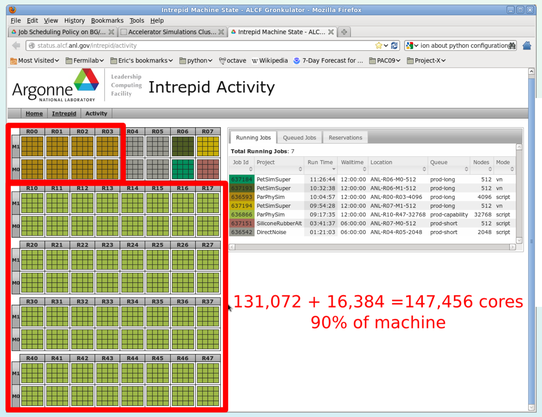
Synergia strong and weak scaling

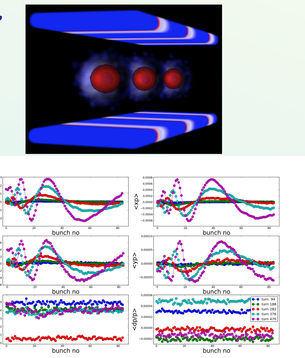
APPLICATIONS

***ComPASS tools** provide **unique capabilities** that are be used for:*

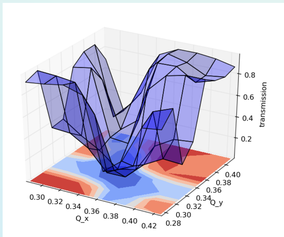
- understanding and mitigating beam losses for existing accelerators,
- optimizing new accelerator designs

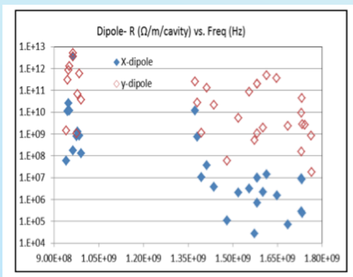
*The **ComPASS collaboration** has **extencive experience** in the modeling of **high-intensity proton drivers.** Under **SciDAC3** focus on **FNAL Proton Improvement Plan and Project-X accelerators.***

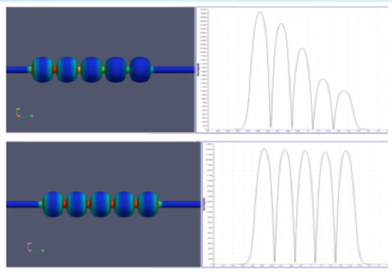




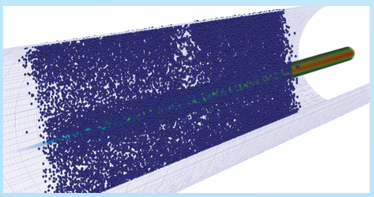
Synergia calculations of multi-bunch effects at the FNAL Booster and tune optimization at the Main Injector (for Project-X)

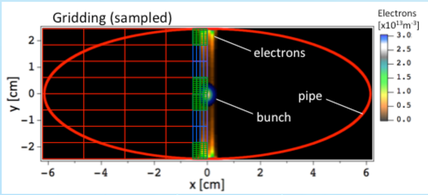






ACE3P studies of Project-X linac performance including cavity imperfections within mechanical tolerances.





Modeling of electron cloud effects at the Main Injector (Project-X): VORPAL (left), Warp-Posinst (right)

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