**Advanced Computation for High Intensity Accelerators**

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The 2014 Particle Physics Project Prioritization Panel (P5) report identifies three accelerator-enabled science drivers. ComPASS is modeling high-intensity accelerators in support of all three:

1. **The physics of neutrino mass**
   - Fermilab Proton Improvement Plan (PIP)

2. **New particles and interactions**
   - Fermilab Debuncher (Mu2e), LHC injector upgrades

3. **Higgs Boson as a tool for discovery**
   - LHC injector upgrades

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, Vorpal, 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)
- EM embedded boundary (Vorpal) for both metals and dielectrics
- Darwin-finite-difference (QuickPIC).

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

- understanding and mitigating beam losses for existing accelerators,
- optimizing new accelerator designs
- understanding interaction with structures and generated plasmas

**The ComPASS collaboration has extensive experience in the modeling of high-intensity proton drivers. The focus is on FNAL PIP-II under SciDAC.**

**Simulations in support of the LHC Injector upgrades have lead to the largest-ever PIC beam dynamics simulations**

- Simulated spectrum showing side bands from frequency modulation, that are generated by harmonic modulation of electron cloud density (dielectric tensor)

**Multiphysics modeling with PIC/Plasma provides understanding of Dielectric Resonant Cavity Diagnostics of Electron Cloud Effect**

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**Synergia-driven simulation efforts have determined the optimal ramping profile in the Fermilab Debuncher for Mu2e**

**Large-scale Synergia multi-bunch studies of slip-stacking in the Fermilab Recycler are preparing for the higher intensities of PIP-II**

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**ComPASS tools include:**

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

**ComPASS includes national labs, university groups and Industry**

- **SciDAC institutes:**
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  - QUEST: uncertainty quantification (QUESO),
  - SUPER: performance analysis & optimization, non-linear parameter optimization.

**ComPASS and SUPER are working together on optimization tools for new lattice designs**

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**Large-scale Synergia multi-bunch studies of slip-stacking in the Fermilab Recycler are preparing for the higher intensities of PIP-II**

**Communication avoidance in Synergia enhances scalability on traditional architectures as well as GPU/MIC-enabled hybrid machines**

Explicit vectorization of Synergia single-particle routines leads to a large performance enhancement across architectures.

**GPU-enhanced Synergia achieves better overall performance with 4 GPUs than an entire Linux cluster**

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