1. NAME OF INITIATIVE: Ultrascale Computing for Accelerator Physics

List of major collaborating institutions (including non-US partners).
A collaboration including FNAL, LBNL, SLAC, Tech-X Corp., U. Maryland, LANL, USC, UCLA, Stanford, UC Davis, BNL, TOPS, APDEC, TSTT and TOPS.

2. SCIENTIFIC JUSTIFICATION:

Physics goals. How does it fit into the global physics goals for the entire field.
The Ultrascale Computing for Accelerator Physics projects will develop high-fidelity simulations of the performance of particle accelerators, both to optimize the design, technology and cost of future accelerators and to use existing accelerators more effectively and efficiently. It will expand on the success of the SciDAC Advanced Computing for 21st Century Accelerator Science and Technology project to bring computational accelerator physics technology into the age of ultrascale computing. Developed to meet the needs of DOE/SC accelerator projects – especially its High Energy Physics and Nuclear Physics projects – the newly developed and enhanced tools will used by accelerator physicists and engineers to solve the most challenging problems in accelerator design, analysis, and optimization. Examples include finding the eigenmodes in extremely large and complex 3D electromagnetic structures, studying space-charge, beam-beam and electron cloud effects in storage rings and colliders, and self-consistent simulation of particle and field dynamics in plasma-based accelerators. This effort will bring together a large, multi-institutional, multi-disciplinary team of accelerator physicists, applied mathematicians, computational scientists, computer scientists, and other Information Technology experts.

The activities of the project will be organized into three application-specific focus areas: beam dynamics, electromagnetics , and advanced accelerators. Beam dynamics will focus on the dynamics of intense charged particle beams propagating through a variety of accelerator structures that make up an accelerator complex. Research will include beam-beam dynamics and electron cloud effects in the LHC and other machines, as well as space-charge effects in proton drivers and other high-intensity machines. The electromagnetics focus will be on precision modeling of complex electromagnetic structures, including those needed for the NLC. The advanced accelerator focus will include plasma accelerators and, possibly, other next-generation technology.

3. VALIDATIONS FOR SCIENTIFIC JUSTIFICATION:

Examples of recommendations and supporting statements from the committees, panels, and the community at large.
The validation for this project is based on the success of the original three-year SciDAC Advanced Computing for 21st Century Accelerator Science and Technology project and its subsequent two-year extension. The members of the original collaboration have demonstrated their ability to deliver the science and the software in our previous proposal.

4. DESIRED SCHEDULE:

List major milestones (month & year) such as design complete, construction start, construction complete, etc.
The project would start in 2006 and continue for three to five years.

5. ROUGH COST ESTIMATE:

Whatever the best information available (e.g. $M +/-30~50%, $150~250M, etc.). Total cost range including non-DOE funding (if any other funding sources are assumed and if known, state from where and how much. Also indicate remaining R&D cost to go.
The FNAL portion of the project will be in the range $350K - $650K. The costs cover a portion of the salary of the principle investigator, and 3-6 FTEs assigned to topics in beam dynamics and software development. A cost estimate for the entire project will require the cooperation of all the collaboration members.

6. NEAR TERM R&D:

Major activities needed to be completed before start construction.
The near-term R&D for the project comes from the SciDAC Accelerator project.

- Beam Dynamics: Activities in this focus area involve development of beam dynamics codes for a variety of accelerator systems (e.g. linacs, rings, transport lines, etc.), capabilities for modeling colliding beams (i.e. the self-consistent beam-beam interaction), modules to compute space charge subject to a variety of boundary conditions, and capabilities to treat additional effects such as wakefields, intrabeam scattering, and various types of beam cooling.

- Electromagnetics: This focus is developing a tool set consisting of solvers of Maxwell's equations that encompass electrostatics and magnetics, low frequency responses such as eddy currents, and high frequency responses in the frequency and time domains. These field solvers must have the ability to model complicated structures accurately using conformal meshes for high accuracy as was achieved for the RDDS with Omega3P.

- Advanced Accelerators: This portion of the project is developing Maxwell/Vlasov solvers that are needed, for example, to model plasma-based accelerators. In addition, specific capabilities are required, such as in modeling plasma accelerators where one needs the ability to efficiently model a drive beam which moves thousands of bunch lengths and the ability to treat multiple background gases and ionization.

7. BRIEF DESCRIPTION OF LABORATORY'S ANTICIPATED ROLE:

Expected unique capabilities to be provided by lab. Rough estimate of human resources from lab (#FTE in what type labor).
FNAL brings an enormous set of skills and facilities to the project. The project will

leverage the expertise in beam dynamics simulation that has already been developed through the current participation in the SciDAC project. The FNAL participation in the SciDAC project has grown during the project's duration due to the high degree of success we have had during that time. We anticipate further expansion of the FNAL effort for this project. In addition, the Lab provides substantial computational power, particularly in coordination with the current SciDAC Lattice QCD project. Furthermore, the availability of actual accelerators at FNAL provides us with the unique ability to do accelerator studies and compare simulations with experiment. We have already made good use of these opportunities and plan to do more in the future. Finally, cooperation and collaboration with the other Accelerator physicists at FNAL allows us to leverage a great deal of scientific and technical expertise. Since the beam dynamics work of the project is directly useful to the Accelerator Division, we expect to be able to leverage at least 3 FTEs in both scientific and technical/computing from the Lab.