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Submit only ONE copy of this form **for each PI/PD and co-PI/PD** identified on the proposal. The form(s) should be attached to the original proposal as specified in GPG Section II.B. Submission of this information is voluntary and is not a precondition of award. This information will not be disclosed to external peer reviewers. ***DO NOT INCLUDE THIS FORM WITH ANY OF THE OTHER COPIES OF YOUR PROPOSAL AS THIS MAY COMPROMISE THE CONFIDENTIALITY OF THE INFORMATION.***

PI/PD Name: Massimo DiPierro

Gender: ☒ Male ☐ Female

Ethnicity: (Choose one response) ☐ Hispanic or Latino ☐ Not Hispanic or Latino

Race: (Select one or more)
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☒ White

Disability Status: (Select one or more)
- ☐ Hearing Impairment
- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☐ Other
- ☒ None

Citizenship: (Choose one) ☐ U.S. Citizen ☐ Permanent Resident ☐ Other non-U.S. Citizen

Check here if you do not wish to provide any or all of the above information (excluding PI/PD name): ☒

REQUIRED: Check here if you are currently serving (or have previously served) as a PI, co-PI or PD on any federally funded project ☐

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Hispanic or Latino. A person of Mexican, Puerto Rican, Cuban, South or Central American, or other Spanish culture or origin, regardless of race.
Race Definitions:
American Indian or Alaska Native. A person having origins in any of the original peoples of North and South America (including Central America), and who maintains tribal affiliation or community attachment.
Asian. A person having origins in any of the original peoples of the Far East, Southeast Asia, or the Indian subcontinent including, for example, Cambodia, China, India, Japan, Korea, Malaysia, Pakistan, the Philippine Islands, Thailand, and Vietnam.
Black or African American. A person having origins in any of the black racial groups of Africa.
Native Hawaiian or Other Pacific Islander. A person having origins in any of the original peoples of Hawaii, Guam, Samoa, or other Pacific Islands.
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PI/PD Name: Panagiotis Spentzouris

Gender: ☐ Male ☐ Female

Ethnicity: (Choose one response) ☐ Hispanic or Latino ☐ Not Hispanic or Latino

Race: (Select one or more)
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
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- ☐ White

Disability Status: (Select one or more)
- ☐ Hearing Impairment
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- ☐ Mobility/Orthopedic Impairment
- ☐ Other
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List of Suggested Reviewers or Reviewers Not To Include (optional)

SUGGESTED REVIEWERS:
Not Listed

REVIEWERS NOT TO INCLUDE:
Not Listed

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PROGRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE/if not in response to a program announcement/solicitation enter NSF 04-2

NSF 04-012 **02/24/04**

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DePaul University

AWARDEE ORGANIZATION CODE (IF KNOWN)

0016717000

ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE

DePaul University
1 East Jackson Boulevard
Chicago, IL. 606042218

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TITLE OF PROPOSED PROJECT **Parallel Algorithms for Particle Beam Simulation**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ **341,983**	**48** months	**09/15/04**	

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PI/PD DEPARTMENT
CTI

PI/PD POSTAL ADDRESS
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CO-PI/PD **Panagiotis Spentzouris**	**PhD**	**1994**	**202-293-1382**	**spentz@fnal.gov**
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				

Electronic Signature

CERTIFICATION PAGE

Certification for Authorized Organizational Representative or Individual Applicant:

By signing and submitting this proposal, the individual applicant or the authorized official of the applicant institution is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding debarment and suspension, drug-free workplace, and lobbying activities (see below), as set forth in Grant Proposal Guide (GPG), NSF 04-2. Willful provision of false information in this application and its supporting documents or in reports required under an ensuing award is a criminal offense (U. S. Code, Title 18, Section 1001).

In addition, if the applicant institution employs more than fifty persons, the authorized official of the applicant institution is certifying that the institution has implemented a written and enforced conflict of interest policy that is consistent with the provisions of Grant Policy Manual Section 510; that to the best of his/her knowledge, all financial disclosures required by that conflict of interest policy have been made; and that all identified conflicts of interest will have been satisfactorily managed, reduced or eliminated prior to the institution's expenditure of any funds under the award, in accordance with the institution's conflict of interest policy. Conflicts which cannot be satisfactorily managed, reduced or eliminated must be disclosed to NSF.

Drug Free Work Place Certification

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Drug Free Work Place Certification contained in Appendix C of the Grant Proposal Guide.

Debarment and Suspension Certification

(If answer "yes", please provide explanation.)

Is the organization or its principals presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency? Yes ☐ No ☒

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Certification Regarding Lobbying

This certification is required for an award of a Federal contract, grant, or cooperative agreement exceeding $100,000 and for an award of a Federal loan or a commitment providing for the United States to insure or guarantee a loan exceeding $150,000.

Certification for Contracts, Grants, Loans and Cooperative Agreements

The undersigned certifies, to the best of his or her knowledge and belief, that:

(1) No federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, ''Disclosure of Lobbying Activities,'' in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, Title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

AUTHORIZED ORGANIZATIONAL REPRESENTATIVE	SIGNATURE	DATE
NAME **Douglas A Petcher**	**Electronic Signature**	**Feb 25 2004 1:25PM**

TELEPHONE NUMBER	ELECTRONIC MAIL ADDRESS	FAX NUMBER
773-325-2595	**dpetcher@depaul.edu**	**773-325-7574**

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COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

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B. Project Summary

This proposal describes a research effort whose primary objective is to develop and optimize parallel solvers for high-fidelity beam dynamics simulations which aim to model the many-body, three-dimensional, and non-linear aspects of present and future accelerators.

Merit Review Criteria: The proposed project is of crucial importance to the study of space-charge effects in high-intensity proton sources, such as the Fermilab Booster, and the study of beam-beam effects in hadron colliders, such as the Fermilab Tevatron. In order to accurately understand these effects, thousands of turns around the machines need to be simulated using millions of particles, thus the development of fast and efficient solvers is essential for the successful use of these models. The PI, Massimo Di Pierro, is a Professor of Computer Science at DePaul University and has been a Research Associate in the Fermilab Theory Group. He has developed FermiQCD, an open source library for parallel computations. The Co-PI, Panagiotis Spentzouris, is a leading scientist at Fermilab with extensive experience in the field of particle beam simulation. The PI and Co-PI have access to the resources required to complete this project.

Broader Impact: The effort described here will bring together Fermilab accelerator physicists who are developing such beam dynamics codes, and scientists from the School of Computer Science of DePaul University who have great expertise in the development of such solvers. The newly developed solvers will maximize the efficiency of the simulation, thus enabling researchers to better pursue accelerator design and performance studies while, at the same time, will provide an excellent research project for DePaul students. The project will support a graduate student and a new summer internship program for DePaul undergraduates, hosted at Fermilab.

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For font size and page formatting specifications, see GPG section II.C.

*Proposers may select any numbering mechanism for the proposal. The entire proposal however, must be paginated. Complete both columns only if the proposal is numbered consecutively.

D. Project Description

D.1. Background and Objectives

Particle accelerators constitute one of the most useful and complex research instruments available to scientists today. In High Energy Physics (HEP), experiments associated with accelerators have led to important discoveries about the fundamental forces of nature and to the discovery of new elementary particles. In order to keep exploring the frontier of HEP, it is necessary that accelerators provide higher energy, higher intensity, and higher luminosity beams. This leads to systems with higher complexity and more stringent performance tolerances than in the past. Simulation plays already a prominent role in the design and performance optimization of accelerators, and there is an increasing need for three-dimensional high-fidelity simulations of nonlinear collective beam effects. The performance of both existing accelerators, such as the Fermilab Tevatron and the Fermilab Booster[1] and future accelerators, some of which will come online in the next few years (such as the CERN Large Hadron Collider), will benefit from these computational models. The desirable final objective is that of understanding and controlling the collective beam effects. Some of these effects result in the development of the beam halo that eventually causes beam losses and irradiation from the accelerator complex; other effects result in the dilution of the beam phase space that causes a decrease in accelerator luminosity.

The dynamics of charged particles in accelerators, in absence of radiation, can be divided into two categories: effects due to the interaction of the beam particles with the electromagnetic fields produced by the magnets and the RF cavities of the accelerator (single-particle optics), and effects due to the interaction of beam particles with fields produced by the beam itself or by other beams in each vicinity (collective beam effects). A comprehensive accelerator simulation must include both types of effects. The problem of modeling linear and nonlinear single-particle dynamics in accelerators is addressed by the field of magnetic optics, a very mature research field that has reached great levels of accuracy. On

the other hand, modeling the evolution of a distribution of particles, such as a beam, is a less mature and much more computationally intensive endeavor, especially in the case of very intense charged beams, because the fields produced by the particles themselves affect the beam dynamics. The most widely used method to simulate these effects is the particle simulation approach. In this approach, the beam distribution is represented by a set of macro-particles that evolve according to the single particle equations of motion; the additional effects due to the electromagnetic fields are calculated by solving the Poisson-Vlasov equation at every time step. The most commonly used approach for solving this equation is the Particle-In-Cell (PIC) method. In this method, three operations are performed during the simulation at each time step: first, the particles are deposited on a spatial grid; second, the fields are calculated on the grid; third and final, the fields are interpolated back to the particles and used to push the particles. Since a large number of macro-particles (order a few million or more) is needed to obtain the required simulation accuracy, the use of massively parallel computers is necessary.

In the parallel PIC approach there are three main bottlenecks that affect parallel performances: a) inter-processor communication required by the fact that each particle affects grids points that may reside on a processing node other than the one where the particle resides; b) the distribution of particles among the processing nodes may become unbalanced; c) global communication or irregular communication may be required by the solver. A complete simulation, especially of circular accelerators, typically involves many thousands of steps. For this reason, the development of fast and efficient algorithms for the field solvers and the manipulation of particles is essential for an effective simulation of collective beam effects.

D.2. Technical Proposal

The Co-PI of this proposal is the leader of the Fermilab team which has developed the Synergia accelerator modeling package[2].

Synergia is an accelerator physics simulation framework that implements a fully three-dimensional space-charge model, with both circular and linear machine simulation capabilities. The implementation is fully parallelized. Synergia is a hybrid code and the primary accelerator physics components are taken from existing, although modified, codes.

In particular, Synergia uses IMPACT[3] for its parallel simulation of the prop-

agation of particles, the modeling of RF cavities and, most importantly, parallel calculations of space-charge effects. IMPACT contains a fully three-dimensional space charge model utilizing the split-operator technique. The split-operator technique takes a Hamiltonian of the form $H = H_{ext} + H_{sc}$, where H_{ext} is the Hamiltonian for the magnetic optics part of the problem and H_{sc} is the Hamiltonian for the space-charge part of the problem. If M_{ext} is the transfer map corresponding to H_{ext} and M_{sc} is the transfer map corresponding to H_{sc}, then $M(t) = M_{ext}(t/2)M_{sc}(t)M_{ext}(t/2) + O(t^2)$ is the transfer map for H to leading order in t. IMPACT is a FORTRAN90 code.

For the modeling of single-particle optics, Synergia uses the mxyzptlk/beamline libraries[4], which can perform a wide range of accelerator physics computations. This package is written in a modern style and its design principles are based on objects, encapsulation and well-considered application program interfaces. The libraries include a set of useful utility classes such as Vector, Matrix, etc., objects for modeling elements of a beamline including a full parser for the Methodic Accelerator Design (MAD) language, and a module for automatic differentiation and differential algebra. The Synergia code integrates the above packages using a framework written in C++ and Python. Synergia also provides easy-to-use users interface (Fig.D.1), analysis and visualization tools (Fig.D.2).

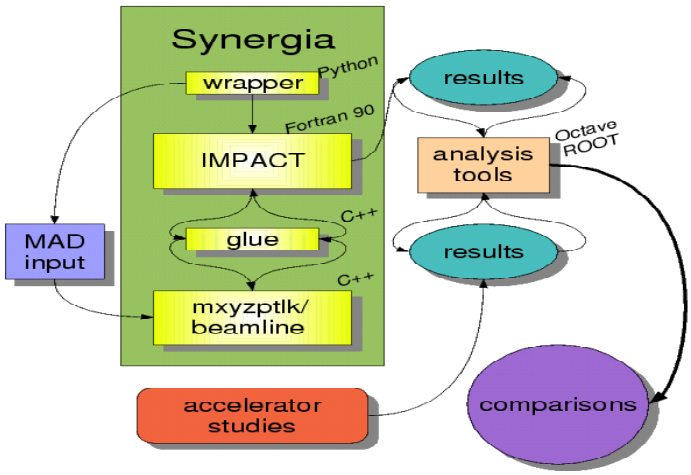

Figure D.1: Overview of the Synergia framework.

Synergia has been used, for example, to model the first few hundred turns

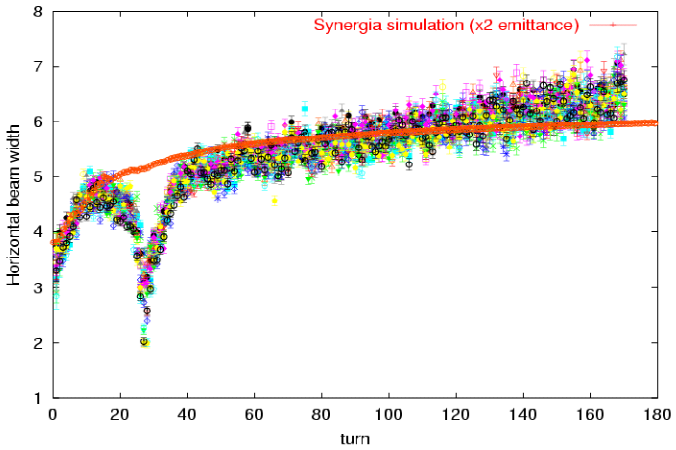

Figure D.2: The spatial beam distribution from a Booster simulation using the Synergia framework.

of beam circulation in the Fermilab Booster, after injection. There are many factors affecting the behavior of the Booster beam, including energy and remittance of the incoming beam, nonlinear field errors and space charge effects. The space-charge effects are believed to be responsible for a significant fraction of the observed losses in the Booster during the first 2ms of each cycle (injection, capture, and bunching phase). Synergia predictions, including space-charge, have been compared to measurements of the beam width as function of time and good qualitative agreement has been found (Fig.D.3).

The above simulations of the Fermilab Booster only cover 1% of the full Booster cycle (the beam performs a total of 20000 turns from injection to extraction). Although space-charge effects are most important at injection, it is desirable to be able to model the complete Booster. Using 128 processing nodes on the NERSC IBM SP super-computer, the IMPACT simulation of the entire Booster would take roughly 24 days.

As shown in Fig.D.4, the performance of the current code plateaus at around 128 processors, so it is clear that the current version of Synergia is not able to take advantage of a significant fraction of the full power of the IBM SP architecture. In addition, plans are underway to extend the Synergia framework to include beam-beam and electron cloud effects which are relevant to the ongoing Fermilab program and also will be very important for commissioning and oper-

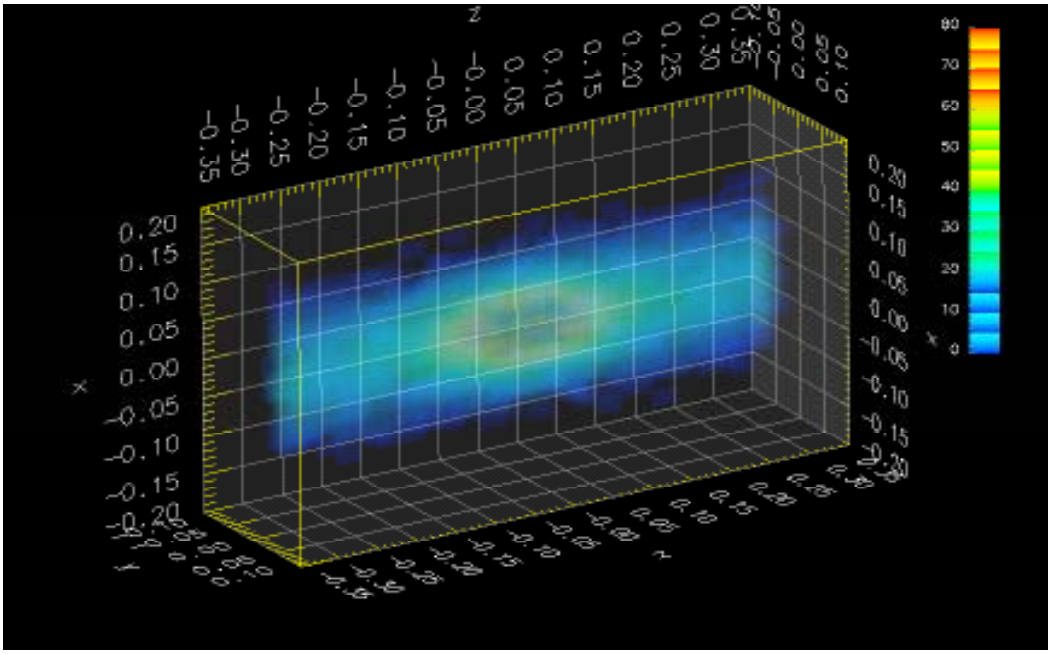

Figure D.3: Booster beam profile as a function of time (turn number) compared to the Synergia prediction. The "notch" close to injection is due to injection magnet effects not included in the simulation.

ating the LHC. These additional physics topics have very similar computational requirements. Thus, it is imperative to develop more scalable and efficient PIC implementations and solvers.

The Principal Investigator is the author of a software library called FermiQCD [5][6]. This library is written in C++ and was originally developed to perform Lattice Quantum Chromo Dynamics simulations. FermiQCD is based on Matrix Distributed Processing [7][8][9] also written and developed by the PI. The main task of the library is that of abstracting the description of high level algorithms from low level parallelization issues. Algorithms written in FermiQCD are automatically parallel. The parallelization is based on a distributed memory model and communications algorithms are optimized for distributed memory machines such as PC clusters. The actual communication functions are implemented in MPI[10] (Message Passing Interface). The basic classes that constitute the library are: the lattice, the site and the field. A lattice object (`lattice`) represents

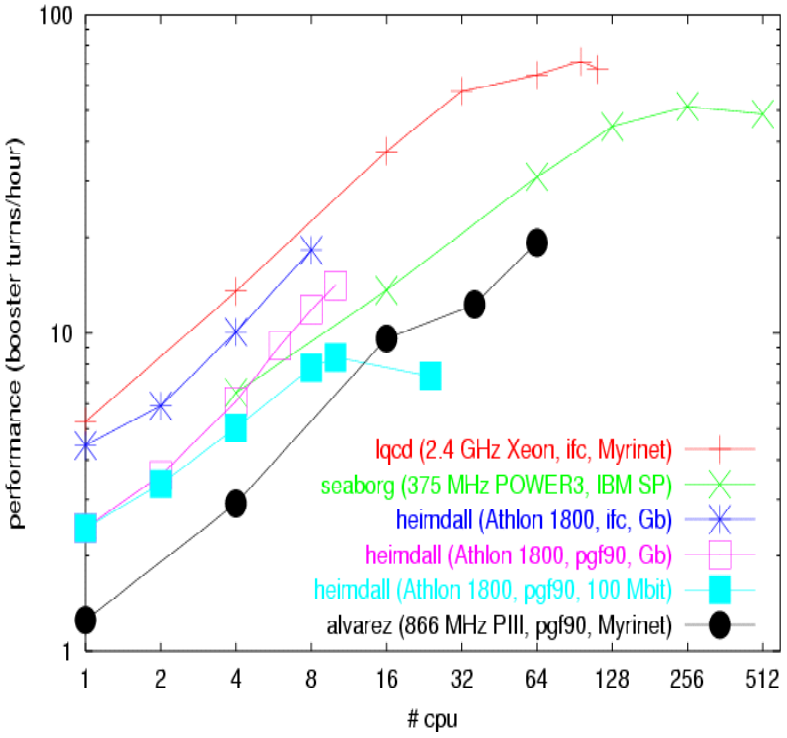

Figure D.4: Synergia performance modeling space charge effects in the FNAL Booster, on various platforms . The simulation used 2.7M particles on a 653 grid, with 100 space-charge kicks per cycle.

the discretized space over which the physical problem is defined. A lattice object can be represented as a graph; i.e. as a collection of points connected by some topology. A typical lattice has a mesh topology with periodic boundary conditions. A site object (`x`) is a variable representing a point on the lattice. Since any lattice is embeddable in a multidimensional space, any site object has methods to access its coordinates and to move along each space direction. A field object (`phi`) is a data structure that lives on the lattice. Each point of the lattice is associated to an instance of the data structure. For example a field of integers would correspond to allocating an integer variable for each point of the lattice. Each field variable can be accessed by referencing a field object and a site object on the lattice (`phi(x)`).

When a lattice object is declared it is automatically partitioned in parallel over the distributed memory architecture and each computing node determines its optimal communication patterns according to a heuristic algorithm based on some empirical rules. These rule require that a) node A and B communicate only if A and B contain sites that are neighbors according to the lattice topology; b) each node A is involved at most in one send and one receive at the same time; c) two nodes, A and B, never try to communicate with the same node C at the same time; d) if node A needs to communicate to node B, the data is packed and communication is done with a single send instruction; e) no temporary buffers are used when receiving data.

When a field object is defined each computing node allocates field variables of each site that is local to the node plus additional buffers for those neighbors of the local sites that reside on different nodes. The field variables stored in the buffers are updated only when required and communication is performed according to the communication patters determined by the underlying lattice object.

In the case of a computer simulation of the beam dynamics in a beam pipe the following objects can be identified: a) a lattice object describing the discretized space in the beam pipe, having periodic (or open, depending on the application) boundary conditions along the pipe direction; b) a field object representing the electromagnetic field in the pipe; c) a field object representing the particles of the beam in each cell (or box) of the discretized space. Additional auxiliary fields will be required to implement the solver algorithms and perform additional optimizations.

Once a logical map between the physical objects that represent the problem to be studied and the C++ objects implemented in FermiQCD is realized, the parallelization aspect of the problem is taken care of by the underlying library.

Our project consists of the following steps:

- Identify the optimal data structures to represent the particles and fields of the problem.
- Implement the relevant algorithms in FermiQCD.
- Implement a system for dynamically changing the parameters of the simulation in real time.
- Implement a crash/recovery system that allows a simulation program to resume automatically in case of crash.

- Benchmark and optimize the code.
- Develop analysis tools to extract real-time information from the simulation.

The solving algorithm can be summarized as follows:

```
1) compute E and B fields generated by the beam by solving the
   Poisson-Vlasov equation at fixed time (in parallel)

2) for each particle in the beam
   determine the electro-magnetic force acting on the particle
   interact with existing code that applies the transfer matrix

3) for each particle in the beam
   if the particle has moved outside its original cell
      transfer the particle to the appropriate cell
      if the appropriate cell resides on a different node
         perform an MPI communication

4) interact in real time with client programs,
   perform analysis of data,
   perform checks and IO to provide crash recovery
```

The first step involves solving the Poisson-Vlasov equation in parallel. This is a standard procedure and can be achieved by implementing a parallel PDE solver. FermiQCD already includes a parallel minimum residue and a parallel stabilized bi-conjugate inverter that can be extended for this scope (Fig.D.5).

The second step involves changing the momenta of particles and applying the external map, as prescribed by the split operator technique.

The third step of the simulation involves the following check. If a particle has moved outside the lattice cell where it was in the preceding iterations (Fig.D.6), the particle has to be moved into a new cell. In our simulation a particle will be an object allocated (within a field) on a lattice site. Moving a particle on a different cell means that a particle is de-allocated from one lattice site and is re-allocated on a different lattice site. If the old site and the new site reside on different processing nodes an explicit call to communication functions will be required.

The fourth step involves communication through a pipe or socket. In fact we envision a client-server architecture. The server program is the one just described. It runs in parallel on a cluster or other distributed memory machine and performs

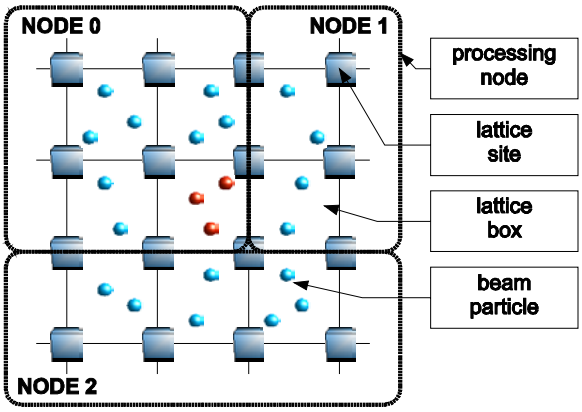

Figure D.5: Lattice schematics

the simulation. The client program provides a remote interface to the server program and communicates with it through a pipe or socket. Simulation parameters will be inserted through the client program. At the same time the server program will return information about the simulation (for example charge distributions, convergence precision, elapsed time) so that they can be displayed and analyzed in real time.

The server program will also perform memory checks and input/output in order to guarantee crash recovery capability. In a parallel environment there are many circumstances that may cause the computation to abort, for example a network failure or a node failure. In the event this occurs the client program should be able to resume the computation at (almost) the same point where it was interrupted without data loss and without requiring the intervention of the user.

The server program will be written in C++ on top of FermiQCD; the client program will be written in Java (in order to run on a web browser) and/or Python (to ensure compatibility with the present system).

D.3. Proposed Timetable and Merit Review Criteria

Year 1

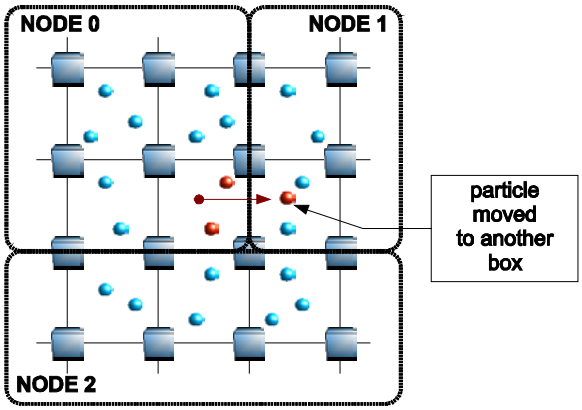

Figure D.6: Particle moves on a different cell

- Analysis of existing algorithms and software implementation, their strengths and weaknesses
- Development of an optimal parallel data-structure, appropriate for the description of the variables of the problem (particles and fields).
- Begin the development of an optimal parallel algorithms to solve the Poisson-Vlasov equation.

Year 2

- Finalize the development of an optimal parallel algorithms to solve the Poisson-Vlasov equation
- Implementation of the data-structure and the algorithms using C++ and FermiQCD
- Implementation of serialization algorithms for the data
- Begin integration with existing software.

Year 3

- Finalize integration with existing software

- Analysis of the possible crash cases
- Development of an optimal crash recovery algorithm
- Implementation of the crash recovery algorithm on top of the solver
- Intensive testing and benchmarks
- Write basic documentation.

Year 4

- Begin utilization of the software in real simulation applications
- Developing an appropriate client-server communication protocol
- Transform the solver program into a server program
- Develop a GUI-based client program to manage the solver
- Write more extensive documentation.

D.4. Requested Support

We estimate the completion of this project will require 4 years. In order to carry on this project we request funding for the 4 years that will support:

- one full time graduate student (tuitions plus salary)
- travel for the PI and the graduate student
- summer salary for the PI
- one summer internship at Fermilab (sub-awarded to Fermilab)
- travel for the Co-PI (sub-awarded to Fermilab)
- associated fringe benefits and overhead.

D.5. Educational Impact

The project will provide the opportunity for one graduate and some undergraduate students of diverse backgrounds to participate in solving a very practical computational expensive problem that encompasses many disciplines including physics, math, computer science, software engineering and distributed system.

DePaul University has grown to be one of the largest universities in the Chicago area and, according to 2002 data, DePaul CTI (Computer Science, Telecommunications, and Information Systems) offers the largest computer science program in the country. The undergraduate program enrolls 2,118 students and offers six different degrees. More than 1039 students are enrolled in the graduate program, which offers nine different master's degrees. DePaul CTI also features a Ph.D. program in computer science that currently enrolls about 50 students. DePaul CTI employs more than 80 full-time faculty and more than 150 part-timers.

The university has shown a growing commitment to cutting edge research and it therefore provides an ideal context for implementing this research project. Research labs include Software Engineering, Human-Computer Interaction, Multimedia, Programming Languages, and Artificial Intelligence labs.

Moreover DePaul University has a highly diverse student body, and in a 1999 Princeton Review was ranked 2nd out of 331 colleges surveyed in student diversity, and 7th in interaction between students of different races and socio-economic classes. DePaul was also recognized in a 2001 issue of "Black Issues in Higher Education" as one of the top 100 universities in America for awarding bachelor's degrees to minorities. DePaul has accomplished this through its ongoing commitment to providing a quality education to all students, by offering special programs such as the NSF funded scholarships for low-income students entering the IT field, and by creating a learning environment in which interaction between students and faculty members is highly valued. The investigators will make a significant effort to provide research opportunities for a broad range of student participants, and will provide active mentoring in order to facilitate their success.

The project will impact curriculum at DePaul in the Computer Science area. For example students interested in the Fermilab internship program (supported by this grant) will be trained at DePaul and will contribute to research activities while working for their degree.

This project may also have the effect to broaden access to education. In fact one undergraduate per year will have access to the internship and he/she may decide to use the salary to pay for his/her further studies. This opportunity will

be particularly appealing to low income students with no other sources of funding.

D.6. Results from previous NSF Support

The PI and Co-PI did not receive previous NSF support.

E. References Cited

[1] DoE Review 2003. http://www-bd.fnal.gov/doereview03/docs/DOE_closeout_23july03.pdf

[2] Synergia: a hybrid, parallel beam dynamics code with 3D space charge, by J. Amundson, P. Spentzouris (Fermilab). FERMILAB-CONF-03-126-E, Jul 2003. Presented at Particle Accelerator Conference (PAC 03), Portland, Oregon, 12-16 May 2003.

[3] J.Qiang, R.D.Ryne, S.Habib and V.Decyk, J. Comput. Phys. **163**, 434 (2000)

[4] L.Michelotti, FERMILAB-CONF-91-159 and FERMILAB-FN-535-REV

[5] www.fermiqcd.net by Massimo Di Pierro. Aug 2003. Proceedings of the Lattice 2003 conference, Tsukuba, Japan.

[6] FermiQCD: a Toolkit for Parallel Lattice QCD Applications. 19th International Symposium on Lattice Field Theory (Lattice 2001), Berlin, Germany, 19-24 Aug 2001. Published in Nuclear Physics Proc.Suppl.106:1034-1036,2002. e-Print Archive: hep-lat/0110116

[7] Matrix Distributed Processing and FermiQCD. 7th International Workshop on Advanced Computing and Analysis Techniques in Physics Research (ACAT 2000), Batavia, Illinois, 16-20 Oct 2000. e-Print Archive: hep-lat/0011083

[8] A bird's eye view of Matrix Distributed Processing, ICCSA Conference Proceedings, Springer Ed. e-Print Archive: cs.dc/0303031

[9] Matrix Distributed Processing. Computer Physics Communications 141, 2001. e-Print Archive: hep-lat/0004007

[10] P.S. Pacheco, Parallel Programming with MPI, San fancisco CA, Morgan Kaufmann, 1997

F.1. PI: Massimo Di Pierro

Address: School of Computer Science, Telecommunications and Information Systems, DePaul University, 243 S Wabash Av., Chicago, IL 60604 - Phone: 1-312-375-6536 - Fax: 1-312-362-6116 - Email: mdipierro@cs.depaul.edu - Web Page: http://www.phoenixcollective.org/mdp/index.html

F.1.1. Professional Preparation

• Ph.D. in Physics, June 1999. University of Southampton, Southampton, UK
• BS-MS in Physics, June 1996. University of Pisa, Pisa, Italy

F.1.2. Appointments

• Assistant Professor, DePaul University, School of Computer Science, Telecommunications and Information Systems, 2002-present
• Postdoctoral fellow, Fermilab, Theory Division (working on Lattice QCD), 1999-2002
• Graduate student, University of Southampton (Southampton, UK), 1996-1999

F.1.3. Related Publications

• www.fermiqcd.net by Massimo Di Pierro. Aug 2003. Proceedings of the Lattice 2003 conference, Tsukuba, Japan.
• A bird's eye view of Matrix Distributed ProcessingICCSA Conference Proceedings, Springer Ed. e-Print Archive: cs.dc/0303031
• FermiQCD: a Toolkit for Parallel Lattice QCD Applications. 19th International Symposium on Lattice Field Theory (Lattice 2001), Berlin, Germany, 19-24 Aug 2001. Published in Nuclear Physics Proc.Suppl.106:1034-1036,2002. e-Print Archive: hep-lat/0110116
• Matrix Distributed Processing and FermiQCD. 7th International Workshop on Advanced Computing and Analysis Techniques in Physics Research (ACAT 2000), Batavia, Illinois, 16-20 Oct 2000. e-Print Archive: hep-lat/0011083
• Matrix Distributed Processing. Computer Physics Communications 141, 2001. e-Print Archive: hep-lat/0004007

F.1.4. Other Publications

• High Precision Lattice QCD Confront Experiment by HPQCD Collaboration and UKQCD Collaboration and MILC Collaboration and Fermilab Lattice Collaboration

(C.T.H. Davies et al.). Apr 2003. 4pp. e-Print Archive: hep-lat/0304004
• Excited Heavy-Light Systems and Hadronic Transitions by Massimo Di Pierro, Estia Eichten (Fermilab). FERMILAB-PUB-01-033-T, Apr 2001. 42pp. Published in Physical Review D64:114004,2001. e-Print Archive: hep-ph/0104208
• An Exploratory Lattice Study of Spectator Effects in Inclusive Decays of Λ_b Baryon by UKQCD collaboration (Massimo Di Pierro et al.). 12pp. Published in Physics Letters B468:143,1999. e-Print Archive: hep-lat/9906031
• Toward a Lattice Determination of the $g_{B^*B\pi}$ Coupling by UKQCD Collaboration (G.M. de Divitiis et al.). 20pp. Published in Journal of High Energy Physics 9810:010,1998. e-Print Archive: hep-lat/9807032
• Mass, Confinement and CP Invariance in the Seiberg-Witten Model by Massimo Di Pierro and Kenichi Konishi. 11pp. Published in Physics Letters B388:90-96,1996. e-Print Archive: hep-th/9605178

F.1.5. Synergistic Activities

Massimo Di Pierro is author of the following computer programs/libraries:
• Matrix Distributed Processing. A C++ toolkit for fast development of parallel applications. Project web page: http://www.phoenixcollective.org/mdp/index_mdp.html
• FermiQCD. A collection of parallel programs and algorithms for Lattice Computations. The library is currently used at Fermilab and other research centers around the world. Project web page: http://www.fermiqcd.net
• Algorithm Animator. A didactic software distributed with the book "Algorithms" written by R. Johnsonbaugh and M. Schaefer, published by Prentice Hall, 2003. Project web page: http://www.phoenixcollective.org/mdp/index_csc321.html

Massimo Di Pierro has thought Object Oriented Programming in C++, Design and Analysis of Algorithms, Foundations of Computer Science II and has developed a class on Monte Carlo Simulations.

F.1.6. Collaborators & Other Affiliations

Chris Sachrajda, University of Southampton, Southampton, UK (Ph.D. advisor); Adriano Di Giacomo, University of Pisa, Pisa, Italy (Undergraduate advisor); Kenichi Konishi, University of Pisa, Pisa, Italy (Undergraduate thesis advisor); Other collaborators in alphabetic order: Christine Davies, Luigi Del Debbio, Giulia De Divitiis, Alex Dougall, Aida El-Khadra, Estia Eichten, Jonathan Flynn, Steven Gottlieb, Andreas Kronfeld, Peter Lepage, Paul Mackenzie, Masataka Okamoto, Mehmet Oktay, James Simone.

F.2. Co-PI: Panagiotis Spentzouris

Address: Fermilab CD/CEPA, MS 234, PO Box 500, Batavia, IL 60510 -
Phone: 1-630-840-4342 - Email: spentz@fnal.gov

F.2.1. Professional Preparation

• Ph.D. in Physics, 1994. Northwestern University, Evanston, IL. Experiment: E665, Fermilab. Thesis: Measurement of the cross-section ratio σ_n/σ_p.Advisor: Prof. Heidi Schellman
• Physics Diploma, 1987. University of Athens, Greece. Experiment: DELPHI, CERN. Thesis: Fast Monte Carlo for simulating events at the BARREL RICH detector of DELPHI Advisor: Prof. Christine Kourkoumelis

F.2.2. Appointments

• Group Leader, Simulation Group of the FNAL Computational Physics Department, 2000-present
• Scientist I, Fermilab. 2003-present
• Associate Scientist, Fermilab.1998-2003
• Research projects: Neutrino Factory, E815 (NuTeV), E898 (MiniBooNE) and study of collective effects in particle accelerators.
• Associate Research Scientist, Columbia University. 1997-1998
• Main Research Project: E815 (NuTeV) at Fermilab
• Postdoctoral Research Associate, Columbia University 1994-1997.
• Main Research Project: E815 (NuTeV) at Fermilab

F.2.3. Awards

• DOE SciDAC grant recipient, 2001-2003

F.2.4. Selected Publications

• Synergia: a hybrid, parallel beam dynamics code with 3D space charge, by J. Amundson, P. Spentzouris (Fermilab). FERMILAB-CONF-03-126-E, Jul 2003. Presented at Particle Accelerator Conference (PAC 03), Portland, Oregon, 12-16 May 2003.
• FNAL Booster: experiment and modeling, by P. Spentzouris, J. Amundson (Fermilab). FERMILAB-CONF-03-127, Jun 2003. Presented at Particle Accelerator Conference (PAC 03), Portland, Oregon, 12-16 May 2003.

• Beam modeling tools for Geant4 (and neutrino source applications), by V. Daniel Elvira, P. Lebrun, P. Spentzouris (Fermilab). FERMILAB-PUB-03-133-E, May 2003. 22pp. Submitted to JCTPA
• Report of the Snowmass T7 working group on high performance computing, By K. Ko (SLAC), R. Ryne (LBL, Berkeley), P. Spentzouris (Fermilab). SLAC-PUB-9477, SNOWMASS-2001-T7001, Jun 2001.
• Design and simulation of muon ionization cooling channels for the Fermilab neutrino factory feasibility study, by J. Monroe, P. Spentzouris, V. Balbekov, P. Lebrun (Fermilab), G. Penn, C. Kim, E.S. Kim (LBL, Berkeley), D.M. Kaplan (IIT, Chicago), Phys.Rev. ST Accel. Beams 4:041301,2001
• Calibration of the Fermilab Booster ionization profile monitor, by J. Amundson, J. Lackey, P. Spentzouris, G. Jungman, and L. Spentzouris, Phys. Rev. ST Accel. Beams 6, 102801 (2003)
• Precision Electroweak Measurements From Nutev, by P. Spentzouris [NuTeV Collaboration], Acta Phys. Polon. B 33, 3843 (2002).
• A precise determination of electroweak parameters in neutrino nucleon scattering, By NuTeV Collaboration (G.P. Zeller et al.), Phys.Rev.Lett. 88:091802, 2002
• Experiments at Fermilab after MINOS, P. Spentzouris, Nucl.Phys. Proc.Suppl. 100:204-206, 2001.
• Precise measurement of dimuon production cross-sections in $\nu\mu$-Fe AND $\overline{\nu\mu}$-Fe deep inelastic scattering at the Tevatron, by NuTeV Collaboration (M. Goncharov, P.Spentzouris et al.), Phys.Rev.D64:112006,2001

F.2.5. Professional Service

• Fermilab Computational Science Fellowship Selection Committee, Aug 2002
• Conference on Underground Service, Oct 2001. Co-convener of the Long Baseline Oscillation Working Group.
• Snowmass 2001. July 2001. Co-convener of the High Performance Computing Accelerator Simulation Working Group.
• Reviewer for the Kansas DOE-EPSCoR program, Oct 1999-Jan 2000
• DOE Strategic Simulation Initiative meeting, March 1999, and proposal writing.

SUMMARY PROPOSAL BUDGET YEAR 1

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION: **DePaul University**

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: **Massimo DiPierro**

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Massimo DiPierro - PI**	0.00	0.00	2.00	$ 19,227	$
2. **Panagiotis Spentzouris - Co-PI**	0.00	0.00	0.00	0	
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (2) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	2.00	19,227	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL ASSOCIATES	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (1) GRADUATE STUDENTS				13,500	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				32,727	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				1,471	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				34,198	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				1,500	
2. FOREIGN				1,500	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ 0					
2. TRAVEL 0					
3. SUBSISTENCE 0					
4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				12,682	
6. OTHER				13,104	
TOTAL OTHER DIRECT COSTS				25,786	
H. TOTAL DIRECT COSTS (A THROUGH G)				62,984	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **Salaries & Benefits (Rate: 52.0000, Base: 34198)**					
TOTAL INDIRECT COSTS (F&A)				17,783	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				80,767	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.)				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 80,767	$

M. COST SHARING PROPOSED LEVEL $ 0 AGREED LEVEL IF DIFFERENT $

PI/PD NAME: **Massimo DiPierro**

ORG. REP. NAME*: **Douglas Petcher**

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 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET YEAR 2

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PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION: **DePaul University**

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: **Massimo DiPierro**

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Massimo DiPierro - PI**	0.00	0.00	2.00	$ 19,996	$
2. **Panagiotis Spentzouris - Co-PI**	0.00	0.00	0.00	0	
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (2) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	2.00	19,996	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL ASSOCIATES	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (1) GRADUATE STUDENTS				14,040	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				34,036	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				1,529	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				35,565	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				1,500	
2. FOREIGN				1,500	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ 0					
2. TRAVEL 0					
3. SUBSISTENCE 0					
4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				13,147	
6. OTHER				13,628	
TOTAL OTHER DIRECT COSTS				26,775	
H. TOTAL DIRECT COSTS (A THROUGH G)				65,340	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **Salaries & Benefits (Rate: 52.0000, Base: 35565)**					
TOTAL INDIRECT COSTS (F&A)				18,494	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				83,834	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.)				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 83,834	$

M. COST SHARING PROPOSED LEVEL $ 0 AGREED LEVEL IF DIFFERENT $

PI/PD NAME: **Massimo DiPierro**

ORG. REP. NAME*: **Douglas Petcher**

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 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET YEAR 3

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION: **DePaul University**

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: **Massimo DiPierro**

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Massimo DiPierro - PI**	0.00	0.00	2.00	$ 20,795	$
2. **Panagiotis Spentzouris - Co-PI**	0.00	0.00	0.00	0	
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (2) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	2.00	20,795	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL ASSOCIATES	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (1) GRADUATE STUDENTS				14,601	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				35,396	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				1,591	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				36,987	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				1,500	
2. FOREIGN				1,500	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ 0					
2. TRAVEL 0					
3. SUBSISTENCE 0					
4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				13,634	
6. OTHER				14,173	
TOTAL OTHER DIRECT COSTS				27,807	
H. TOTAL DIRECT COSTS (A THROUGH G)				67,794	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **Salaries and Benefits (Rate: 52.0000, Base: 36987)**					
TOTAL INDIRECT COSTS (F&A)				19,233	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				87,027	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.)				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 87,027	$

M. COST SHARING PROPOSED LEVEL $ 0 AGREED LEVEL IF DIFFERENT $

PI/PD NAME: **Massimo DiPierro**

ORG. REP. NAME*: **Douglas Petcher**

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 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET YEAR 4

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION: **DePaul University**

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: **Massimo DiPierro**

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Massimo DiPierro - PI**	0.00	0.00	2.00	$ 21,627	$
2. **Panagiotis Spentzouris - Co-PI**	0.00	0.00	0.00	0	
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (2) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	2.00	21,627	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL ASSOCIATES	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (1) GRADUATE STUDENTS				15,185	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				36,812	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				1,654	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				38,466	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				1,500	
2. FOREIGN				1,500	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ 0					
2. TRAVEL 0					
3. SUBSISTENCE 0					
4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				14,147	
6. OTHER				14,740	
TOTAL OTHER DIRECT COSTS				28,887	
H. TOTAL DIRECT COSTS (A THROUGH G)				70,353	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **Salaries and Benefits (Rate: 52.0000, Base: 38466)**					
TOTAL INDIRECT COSTS (F&A)				20,002	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				90,355	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.)				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 90,355	$

M. COST SHARING PROPOSED LEVEL $ 0 AGREED LEVEL IF DIFFERENT $

PI/PD NAME: **Massimo DiPierro**

ORG. REP. NAME*: **Douglas Petcher**

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET

Cumulative

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION: **DePaul University**

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: **Massimo DiPierro**

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Massimo DiPierro - PI**	0.00	0.00	8.00	$ 81,645	$
2. **Panagiotis Spentzouris - Co-PI**	0.00	0.00	0.00	0	
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (**2**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	8.00	81,645	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL ASSOCIATES	0.00	0.00	0.00	0	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (**4**) GRADUATE STUDENTS				57,326	
4. (**0**) UNDERGRADUATE STUDENTS				0	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (**0**) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				138,971	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				6,245	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				145,216	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				6,000	
2. FOREIGN				6,000	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				53,610	
6. OTHER				55,645	
TOTAL OTHER DIRECT COSTS				109,255	
H. TOTAL DIRECT COSTS (A THROUGH G)				266,471	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				75,512	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				341,983	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.)				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 341,983	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME: **Massimo DiPierro**

ORG. REP. NAME*: **Douglas Petcher**

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

C ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

F. Budget

F.1. Budget Description

F.1.1. Senior Personnel

Dr. Massimo Di Pierro from DePaul University will direct the project. Dr. Massimo Di Pierro will be paid 2 month summer salary each year of the grant to supervise all aspects of the project. Through out the academic year, he will also devote time to the supervision of the graduate student and the undergraduate students. The summer salary is 2/9th of his current salary increased 4% each year to account for salary raises. In year 1 he will be paid $19,227; in year 2 he will be paid $19,996; in year 3 he will be paid $20,795 and in year 4 he will be paid $21,627

F.1.2. Graduate student

This project will require support for a graduate student pursuing a Ph.D. degree in Computer Science and working on the project. The duration of funding will be for 4 years. The student will be reimbursed course tuitions for 6 courses per year, a stipend for the nine months of the academic year. During the year 1 the student will receive $13,104 for tuition (budget item G.6) and $13,500 (budget item B.3) for total stipend (including summer salary). The support will be increased 4% each year. In year 2 the student will receive $13,628 for tuitions and $14,040 for stipend; in year 3 will he/she receive $14,173 and $14,601; and in year 4 he/she will receive $14,740 and $15,185.

F.1.3. Benefits

PI work will be completed over the summer. Fringe benefits rate for the summer is 7.65%

F.1.4. Travel

Each year the PI and Ph.D. student will travel to attend conferences in order to exchange ideas with colleagues and present the proposed project. We believe that other national laboratories that host particle accelerators may have an interest in the present project. $1500 per person per year is budgeted to cover all travel expenses, half will be national travel and half will be international travel.

F.1.5. Indirect costs

DePaul University's federally negotiated indirect cost rate is 52% of salaries, wages and benefits.

F.1.6. Sub-awards

This project will be carried out in collaboration with Fermilab. Panagiotis Spentzouris from Fermilab will be Co-PI for the project. Fermilab will receive a sub-award of $12,682 (budget item G.5) during year 1, $13,147 for during year 2, $13,634 for year 3, and $14,147 for year 4. The sub-award will cover travel expenses for the Co-PI, a three month summer internships for a DePaul undergraduate student and associate fringe benefits and indirect costs.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: **Massimo DiPierro**

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: **Parallel Algorithms for Particle Beam Simulation**

Source of Support: **NSF 04-146**

Total Award Amount: $ **341,983** Total Award Period Covered: **09/15/04 - 09/14/08**

Location of Project: **DePaul University CTI**

Person-Months Per Year Committed to the Project. Cal:**0.00** Acad: **0.00** Sumr: **2.00**

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: **High Performance Computing in the Classroom**

Source of Support: **NSF 04-001**

Total Award Amount: $ **540,030** Total Award Period Covered: **08/15/04 - 08/14/07**

Location of Project: **DePaul University**

Person-Months Per Year Committed to the Project. Cal:**0.00** Acad: **3.00** Sumr: **0.00**

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Summ:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: **Panagiotis Spentzouris**

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: **Parallel Algorithms for Particle Beam Simulation**

Source of Support: **NSF 04-146**
Total Award Amount: $ **341,983** Total Award Period Covered: **09/15/04 - 09/14/08**
Location of Project: **DePaul University - Fermilab**
Person-Months Per Year Committed to the Project. Cal: **0.00** Acad: **0.00** Sumr: **0.00**

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Summ:

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*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

 USE ADDITIONAL SHEETS AS NECESSARY

I. Facilities, Equipment and Other Resources

I.1. DePaul CTI

I.1.1. Laboratories

The School of Computer Science, Telecommunications and Information Systems operates specialized laboratories for research and instruction in artificial intelligence, computer-supported collaborative work, distributed systems, high performance computing, human-computer interaction, information systems and electronic commerce, networked multimedia, software engineering and languages and telecommunications. The school offers a total of approximately 800 student laboratory workstations - most of which are Pentium III or Pentium IV based. These workstations run Windows 2000, Windows XP, Red Hat Linux and Sun Solaris operating systems. The School also operates seven high-performance multi-processor Xeon-based servers with large RAID drives and an IBM ES 9000/9221.

Two laboratories may particularly be relevant for this project:

- The software research lab, which has been in existence for a few years, allows users to test experimental programs without jeopardizing the rest of the system. Currently, the lab has six PCs for installation and development of software.
- The Multimedia Networking Research Laboratory (MNLAB). This laboratory houses 20 Multimedia Workstations, including 14 Sun Ultra 10 workstations running Solaris 7 and 4 PCs running Window NT. The MNLAB workstations are connected with 100 Mbps switch which connects to the MBONE. The lab is supported in part by CTI, Sun Micro Systems and IONA Technologies

The IS division also provides printers and overhead projects for labs and residence halls. In addition to 750 lab workstations, information services maintains

over 1,200 residence halls workstations and hundreds of faculty and staff computing platforms

I.1.2. Computers and Networks

DePaul University maintains an extensive technological infrastructure available for students, faculty and staff. In addition, many departments maintain their own resources dedicated for use by its own constituents. The University's existing computer and information infrastructure is in an exceptionally strong position to support the proposed project.

DePaul University is connected by an OC3c ATM-based circuit to the Chicago SBC/AADS network access point (NAP) located in downtown Chicago. The Chicago NAP is one of the largest Internet exchanges in the world. DePaul University maintains approximately fifty peering sessions at the Chicago NAP with institutions of varying sizes and locations including the University's Internet2/Abilene connector MREN. DePaul was one of the first University's in the nation to deploy Juniper router technology at its Internet border, taking advantage of Juniper's award winning design and performance. DePaul University uses BGP, MBGP, PIM-SM and MSDP protocols with its external peering partners to support full line-rate IPv4 unicast and multicast routing.

DePaul University also maintains a physical and logically diverse backup Internet connection to UUNET approximately thirty-five miles north at its Barat Campus in Lake Forest, IL.

The DePaul University metropolitan area backbone network connects campuses at Chicago downtown, Chicago Lincoln Park, Barat campus, Lake Forest, Naperville and Rolling Meadows using Gigabit Ethernet service with a inter-campus speed of 1 gigabit/second.

Almost all of the wired local area networks (LANs) on each DePaul University campus run at 10 and 100 Mb/s switched Ethernet with gigabit uplinks to core backbone devices linking buildings and campuses together. There are also approximately thirty-five 802.11b wireless LAN access points deployed throughout the University network with more to come as demand increases.

Fully transparent IPv4 unicast and multicast connectivity is available by default for all end hosts using DePaul University's public 140.192.0.0/16 IP address block. There are over 250 subnets within the entire DePaul University network. Critical networks and services are protected with network firewalls, host firewalls or various intrusion detection systems.

All primary uplinks and interconnection points on the DePaul network are managed through SNMP. Monitoring of link utilization, packet drop rates, error rates, device environments, protocol usage and summarized flow statistics are collected. Links and devices are also monitored for availability with alerts sent to pagers or to monitored email accounts. DePaul University's internal Networks and Telecom Group (NTG) in Information Services is responsible for installing, managing and monitoring all internet devices and connections. NTG consists of over twenty full-time staff members performing support duties on a 24x7 on-call basis for routers, LAN switches, cabling, telephony, network security, groupware servers and other various network services.

Each staff member is provided with one desktop computer and one laptop computer.

I.1.3. Other resources

DePaul University provides library services at all campuses, with over 600,000 volumes and 8,000 serial holdings. Delivery of information and materials is linked through computer databases that are all available via Web-based interfaces. The Instructional Technology Development (ITD) Group is staffed with over a dozen members whose role is to help promote, train and develop technological solutions in support of education and research at the University. Library administrators and the ITD group are instrumental in helping bring technologies to faculty throughout the University.

The majority of classrooms are equipped with the latest recording and distance learning technologies including video cameras, document cameras, video cassette recorders, workstation screen capture software, white-board input and microphones. All online class content is automatically managed through the Black Board application including prerecorded video, audio and other multimedia materials used in class. DePaul University is undertaking numerous strides in developing next generation online course content that can be made accessible to students all over the country and throughout the world.

The School of Computer Science, Information Systems and Telecommunications is part of a large liberal-arts university including a School of Education, giving us ready access to the expertise of curriculum experts. Additionally, being centrally located in the Chicago metropolitan area provides ready access to the expertise of faculty from the University of Chicago, Northwestern, the University of Illinois at Chicago, Loyola University, and the Illinois Institute of Technology.

Further, DePaul and CTI enjoy a close relationship with corporations in Chicago, and either employ many IT professionals as adjunct faculty or have them as Alumni.

I.2. Fermilab

Fermilab is a DOE national laboratory and it is operated by the Universities Research Association, Inc., a consortium of 89 research universities in the U.S. and abroad. Fermilab is the largest high-energy physics laboratory in the United States, and is second in the world only to CERN, the European Laboratory for Particle Physics.

Fermilab's Tevatron is the world's highest-energy particle accelerator and collider. In the Tevatron, counter-rotating beams of protons and antiprotons produce collisions allowing scientists to examine the most basic building blocks of matter, and the forces acting on them. Particle physics research has grown into an international effort, with experiment collaborations numbering in the hundreds.

I.2.1. Computers and Networks

The Fermilab Computing Division furnishes and operates a laboratory wide network and several computing facilities, including central facilities in the Feynman Computer Center. These facilities include different types of parallel machine and, in particular, large computer clusters dedicated to simulation, reconstruction and analysis of scientific data. They also include data storage capacities of more than one Petabyte (in the form of robotic tape storage) and about hundreds of Terabytes of disk storage.

The Fermilab Computing Division leads more than 250 computer professionals, engineers, technicians and physicists in the Computing Division, whose work include R&D projects to prepare computing for future of High Energy Physics programs.

DEPAUL
UNIVERSITY

School of Computer Science, Telecommunications and Information Systems
Helmut P. Epp, Ph.D., Dean
243 South Wabash Avenue
Chicago, Illinois 60604-2301
312/362-8760
FAX: 312/362-5185

November 10, 2003

Dr. Massimo DiPierro
DePaul University
School of Computer Science, Telecommunications and Information Systems
243 South Wabash Avenue
Chicago, IL 60604

Dr. Panagiotis Spentzouris
Fermilab
P.O. Box 500
Batavia, IL 60510-0500

Dear Massimo and Panagiotis,

I write in support of your proposal "Parallel Algorithms for Particle Beam Simulation". DePaul CTI has a growing commitment to cutting edge research and strongly encourages cooperation between our faculty and national laboratories such as Fermilab. This project provides a concrete example of such cooperation that, by bringing together the different expertise of scientists from DePaul and from Fermilab, will contribute to solve scientific problems of national and international interests. This and similar projects will affect DePaul's curricula in a positive way by giving students greater access to frontier research and will confront them with new challenging problems.

I trust that the PI and Co-PI have the required expertise to complete the proposed project and deliver more than satisfactory results. DePaul CTI strongly endorses this project and will provide all required support to those DePaul faculty and students which are involved.

Sincerely,

Helmut Epp

Fermilab

Fermi National Accelerator Laboratory
Victoria A. White, • Head, Computing Division
MS370 • P.O. Box 500 • Batavia, IL 60510
Office: 630/840-3936 • Fax: 630/840-3785
Email: white@fnal.gov • Cell: 630/774-9552

computing.fnal.gov

November 7, 2003

Professor Massimo DiPierro
School of Computer Science
DePaul University
1 East Jackson Boulevard
Chicago, IL 606042218

Dear Massimo,

I am really very pleased to write in support of your proposal "Parallel Algorithms for Particle Beam Simulation" and to affirm strong support from Fermilab for this collaborative work between Fermilab and DePaul. From the Fermilab side the work will be led by one of our brightest and best scientists, Panagiotis Spentzouris.

Fermi National Accelerator Laboratory, also known as Fermilab, is a US Department of Energy National Laboratory dedicated to basic scientific research. Its mission is to advance the understanding of the fundamental nature of matter and energy by providing leadership and resources for conducting research on the frontiers of high energy physics and related disciplines. The Laboratory's Tevatron is the world's highest-energy particle accelerator. The collaborations utilizing our facilities involve research programs at over 150 top tier research universities and institutions throughout the world, and support the work of 2000+ researchers. Fermilab is also participating in the construction of the Large Hadron Collider, a particle accelerator which will turn on at CERN in 2007.

Simulation of an entire accelerator complex in order to understand and improve performance and, eventually, to design new and innovative accelerators more cost effectively is an exciting and ambitious goal that we all look forward to realizing in the future. Today, some extremely interesting work and insights are coming out of work on simulation of parts of accelerator complexes, both at Fermilab, SLAC and elsewhere. The simulations are complex and the ability to parallelize the computations effectively and perform calculations with sufficient accuracy to simulate, and thereby provide insights into, the current performance of parts of our accelerator complex requires a tightly coupled effort between theoretical accelerator science, computer science and the experimental accelerator science that instruments and measures accelerator performance. I believe that considerable strides have been made in understanding accelerator behavior

by getting computer scientists and accelerator scientists to "team up" and work together. During my three and one half years working as a program manager and computing advisor in the Department of Energy's Office Science I actively worked to encourage and fund such programs of work, under the SciDAC (Scientific Discovery through Advanced Computing) program. Since taking over as head of the Computing Division at Fermilab I have continued to support and encourage such work and hope to be able to provide more support from Fermilab in the coming years. There is a huge amount of work that could be done to develop and refine accurate simulations of parts of the Fermilab Accelerator complex. Much of this work, if done correctly, would provide a structure and tools for simulations of other complex accelerator systems. There are a large number of extremely challenging computer science issues and problems that must be solved in each of these potential programs of work.

This proposal focuses on one aspect of this work, namely the development and optimization of parallel solvers for high-fidelity beam dynamics simulations. The work will be immediately applicable to modeling the many-body, three-dimensional, and non-linear aspects of parts of our current accelerator complex. It will be applied to study space-charge effects in the Fermilab Booster and to developing a better understanding of beam-beam effects in the Fermilab Tevatron. However, the work will clearly have wider applicability and impact. I believe this to be an extremely worthwhile research area, with challenging problems from a computer science perspective.

I strongly support this work. I particularly encourage and support the interdisciplinary aspects of this work. I believe the educational opportunities for students to become involved in working at Fermilab on a real accelerator, solving problems that people really care about are exciting. At Fermilab we look forward to such involvement, especially from our neighboring universities and educational institutions and strive to provide opportunities for students to participate and learn.

Yours sincerely

Victoria A. White
Head, Computing Division
Fermilab

This is a notification of an ITR letter of intent submission. The information below was collected:

Letter of Intent ID: 834

Title: Parallel Algorithms for Particle Beam Simulation
Primary Division: PHY
Secondary Division: CNS
Tertiary Division: DGE

PI Name: Massimo Di Pierro
PI Affiliation: DePaul University - School of Computer Science, Telecommunications and Information Systems
PI Affiliation Type: Academic
PI Email: mdipierro@cs.depaul.edu

Co-Pi Name: Panagiotis Spentzouris
Co-Pi Affiliation: Fermi National Accelerator Laboratory
Co-Pi Affliation Type: Government Lab
Co-Pi Email: spentz@fnal.gov

Project Description:
The primary objective of our project is to develop and optimize parallel solvers for high-fidelity beam dynamics simulations which aim to model the many-body, three-dimensional, and non-linear aspects of present and future particle accelerators.

The proposed project is of crucial importance to the study of space-charge effects in high-intensity proton sources, such as the Fermilab Booster, and the study of beam-beam effects in hadron colliders, such as the Fermilab Tevatron. In order to accurately understand these effects, thousands of turns around the machines need to be simulated using millions of particles, thus the development of fast and efficient solvers is essential for the successful use of these models. The PI, Massimo Di Pierro, is a Professor of Computer Science at DePaul University and has been a Research Associate in the Fermilab Theory Group. He has developed FermiQCD, an open source library for parallel computations. The Co-PI, Panagiotis Spentzouris, is a leading scientist at Fermilab with extensive experience in the field of particle beam simulation. The PI and Co-PI have access to the resources required to complete this project.

This project will bring together Fermilab accelerator physicists who are developing such beam dynamics codes, and scientists from the School of Computer Science of DePaul University who have great expertise in the development of such solvers. The newly developed solvers will maximize the efficiency of the simulation, thus enabling researchers to better pursue accelerator design and performance studies while, at the same time, will provide an excellent research project for DePaul students.

The total requested funding, spread over a period of 3 years, amounts to $346,132. This will support the PI (summer salary and travel only) and one full-time Ph.D. student dedicated 100% to the project. Part of the funding, $53,610, will be sub-awarded to Fermilab and will support a 3 years summer internship

program for a DePaul undergraduate who will work on integrating the new parallel solver with existing Fermilab software.

This project is endorsed by Dr. Vicky White, Director of the Fermilab Computing Division, and Dr. Helmut Epp, Dean of the School of Computer Science of DePaul University.

Primary Priority Area: ASE

Primary Technical Focus Area: SIM

Fermilab sub-award budget

NSF 96-115 *Smith*

Total of 4 Years

	FOR NSF USE ONLY		
ORGANIZATION **Fermilab**	PROPOSAL NO.	DURATION (MONTHS) Proposed	Granted
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR	AWARD NO.		

A. SENIOR PERSONNEL: PI/PD, Co-PI'S, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets) 0. First Name M Last Name Title	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By Proposer	
Panagiotis Spentzouris Co-PI	4.80	0.00	0.00	$0	
( ) TOTAL SENIOR PERSONNEL (1-6)					
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. 0) POST DOCTORAL ASSOCIATES	0.00	0.00	0.00	$0	
2. 0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	$0	
3. 0) GRADUATE STUDENTS				$0	
4. 1) UNDERGRADUATE STUDENTS				$28,447	
5. 0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				$0	
6. 0) OTHER (ASSOCIATE RESEARCH SCIENTIST)				$0	
TOTAL SALARIES AND WAGES (A+B)				$2,276	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)					
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)					
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000)					
TOTAL EQUIPMENT				$0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				$6,000	
2. FOREIGN				$0	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $0					
2. TRAVEL $0					
3. SUBSISTENCE $0					
4. OTHER $0					
(0) TOTAL NUMBER OF PARTICIPANTS					
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				$0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				$6,000	
3. CONSULTANT SERVICES				$0	
4. COMPUTERS SERVICES				$0	
5. SUBAWARDS				$0	
6. OTHER				$0	
TOTAL OTHER DIRECT COSTS					
H. TOTAL DIRECT COSTS (A THROUGH G)					
I. INDIRECT COSTS (SPECIFY RATE AND BASE) Name of Indirect cost item — Amount — Rate Salaries $30,723 30.35% Equipment & Materials & Supplies $6,000 16.05% Travel $6,000 10.00%					
TOTAL INDIRECT COSTS					
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				$0	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.D.7.j.)				$53,610	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$0	
M. COST SHARING: PROPOSED LEVEL	AGREED LEVEL IF DIFFERENT $				

PI/PD TYPED NAME & SIGNATURE*	DATE	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
Panagiotis Spentzouris	11/6/2003			
INST. REP. TYPED NAME & SIGNATURE*	DATE	Date Checked	Date Rate of Sheet	Initials-ORG
Michael Witherell	11/06/03			

NSF Form 1030 (10/97) *Supersedes All Previous Editions*

*SIGNATURES REQUIRED ONLY FOR REVISED BUDGET (GPG III.B)

NSF 96-115 *Smith*

YEAR 1

ORGANIZATION	FOR NSF USE ONLY		
Fermilab	PROPOSAL NO.	DURATION (MONTHS) Proposed	Granted
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR	AWARD NO.		

A. SENIOR PERSONNEL: PI/PD, Co-PI'S, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months			Funds Requested By	
0. First Name M Last Name Title	CAL	ACAD	SUMR	Proposer	
Panagiotis Spentzouris Co-PI	1.20	0.00	0.00	$0	
( ) TOTAL SENIOR PERSONNEL (1-6)					
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. 0) POST DOCTORAL ASSOCIATES	0.00	0.00	0.00	$0	
2. 0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)		0.00	0.00	$0	
3. 0) GRADUATE STUDENTS				$0	
4. 1) UNDERGRADUATE STUDENTS				$6,600	
5. 0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				$0	
6. 0) OTHER (ASSOCIATE RESEARCH SCIENTIST)				$0	
TOTAL SALARIES AND WAGES (A+B)					
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				$528	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)					
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000)					
TOTAL EQUIPMENT					
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				$1,500	
2. FOREIGN				$0	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $0					
2. TRAVEL $0					
3. SUBSISTENCE $0					
4. OTHER $0					
(0) TOTAL NUMBER OF PARTICIPANTS					
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES					
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				$1,500	
3. CONSULTANT SERVICES				$0	
4. COMPUTERS SERVICES				$0	
5. SUBAWARDS				$0	
6. OTHER				$0	
TOTAL OTHER DIRECT COSTS					
H. TOTAL DIRECT COSTS (A THROUGH G)					
I. INDIRECT COSTS (SPECIFY RATE AND BASE)					
Name of indirect cost item / Amount / Rate					
Salaries $7,128 30.35%					
Equipment & Materials & Supplies $1,500 16.05%					
Travel $1,500 10.00%					
TOTAL INDIRECT COSTS					
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)					
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.D.7.j.)				$0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$12,682	
M. COST SHARING: PROPOSED LEVEL	AGREED LEVEL IF DIFFERENT $			$0	

PI/PD TYPED NAME & SIGNATURE*	DATE	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
Panagiotis Spentzouris	11/6/2003			
INST. REP. TYPED NAME & SIGNATURE* **Michael Witherell**	DATE 11/10/03	Date Checked	Date Rate of Sheet	Initials-ORG

NSF Form 1030 (10/97) *Supersedes All Previous Editions*

*SIGNATURES REQUIRED ONLY FOR REVISED BUDGET (GPG III.B)

NSF 96-115 *Smith*

YEAR 2

ORGANIZATION	FOR NSF USE ONLY		
Fermilab	PROPOSAL NO.	DURATION (MONTHS) Proposed	Granted
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR	AWARD NO.		

A. SENIOR PERSONNEL: PI/PD, Co-PI'S, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets) 0. First Name M Last Name Title	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By Proposer	
Panagiotis Spentzouris Co-PI	1.20	0.00	0.00	$0	
( ) TOTAL SENIOR PERSONNEL (1-6)					
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. 0) POST DOCTORAL ASSOCIATES	0.00	0.00	0.00	$0	
2. ( ) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)		0.00	0.00	$0	
3. 0) GRADUATE STUDENTS				$0	
4. 1) UNDERGRADUATE STUDENTS				$6,930	
5. 0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				$0	
6. 0) OTHER (ASSOCIATE RESEARCH SCIENTIST)				$0	
TOTAL SALARIES AND WAGES (A+B)					
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				$554	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)					
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000)					
TOTAL EQUIPMENT					
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				$1,500	
2. FOREIGN				$0	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $0					
2. TRAVEL $0					
3. SUBSISTENCE $0					
4. OTHER $0					
(0) TOTAL NUMBER OF PARTICIPANTS					
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				$0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				$1,500	
3. CONSULTANT SERVICES				$0	
4. COMPUTERS SERVICES				$0	
5. SUBAWARDS				$0	
6. OTHER				$0	
TOTAL OTHER DIRECT COSTS					
H. TOTAL DIRECT COSTS (A THROUGH G)					
I. INDIRECT COSTS (SPECIFY RATE AND BASE)					
Name of indirect cost item / Amount / Rate					
Salaries $7,484 30.35%					
Equipment & Materials & Supplies $1,500 16.05%					
Travel $1,500 10.00%					
TOTAL INDIRECT COSTS					
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)					
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.D.7.j.)				$0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$13,147	
M. COST SHARING: PROPOSED LEVEL AGREED LEVEL IF DIFFERENT $				$0	

PI/PD TYPED NAME & SIGNATURE*	DATE	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
Panagiotis Spentzouris	11/6/2003			
INST. REP. TYPED NAME & SIGNATURE* Michael Witherell K.C. Stanfield	DATE 11/10/03	Date Checked	Date Rate of Sheet	Initials-ORG

NSF Form 1030 (10/97) *Supersedes All Previous Editions*

*SIGNATURES REQUIRED ONLY FOR REVISED BUDGET (GPG III.B)

NSF 96-115 *Smith*

YEAR 3

ORGANIZATION	FOR NSF USE ONLY PROPOSAL NO.	DURATION (MONTHS) Proposed	Granted
Fermilab			
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR	AWARD NO.		

A. SENIOR PERSONNEL: PI/PD, Co-PI'S, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By Proposer	
0. First Name M Last Name Title					
Panagiotis Spentzouris Co-PI	1.20	0.00	0.00	$0	
( ) TOTAL SENIOR PERSONNEL (1-6)					
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. 0) POST DOCTORAL ASSOCIATES	0.00	0.00	0.00	$0	
2. ( ) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)		0.00	0.00	$0	
3. 0) GRADUATE STUDENTS				$0	
4. 1) UNDERGRADUATE STUDENTS				$7,277	
5. 0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				$0	
6. 0) OTHER (ASSOCIATE RESEARCH SCIENTIST)				$0	
TOTAL SALARIES AND WAGES (A+B)					
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				$582	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)					
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000)					
TOTAL EQUIPMENT					
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				$1,500	
2. FOREIGN				$0	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $0					
2. TRAVEL $0					
3. SUBSISTENCE $0					
4. OTHER $0					
(0) TOTAL NUMBER OF PARTICIPANTS					
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				$0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				$1,500	
3. CONSULTANT SERVICES				$0	
4. COMPUTERS SERVICES				$0	
5. SUBAWARDS				$0	
6. OTHER				$0	
TOTAL OTHER DIRECT COSTS					
H. TOTAL DIRECT COSTS (A THROUGH G)					
I. INDIRECT COSTS (SPECIFY RATE AND BASE)					
Name of Indirect cost item / Amount / Rate					
Salaries $7,859 30.35%					
Equipment & Materials & Supplies $1,500 16.05%					
Travel $1,500 10.00%					
TOTAL INDIRECT COSTS					
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)					
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.D.7.j.)				$0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$13,634	
M. COST SHARING: PROPOSED LEVEL	AGREED LEVEL IF DIFFERENT $			$0	

PI/PD TYPED NAME & SIGNATURE*	DATE	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
Panagiotis Spentzouris	11/6/2003			
INST. REP. TYPED NAME & SIGNATURE* Michael Witherell	DATE 11/10/03	Date Checked	Date Rate of Sheet	Initials-ORG

NSF Form 1030 (10/97) *Supersedes All Previous Editions*

*SIGNATURES REQUIRED ONLY FOR REVISED BUDGET (GPG III.B)

NSF 96-115 *Smith*

YEAR 4

ORGANIZATION	FOR NSF USE ONLY PROPOSAL NO.	DURATION (MONTHS) Proposed	Granted
Fermilab			
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR	AWARD NO.		

A. SENIOR PERSONNEL: PI/PD, Co-PI'S, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By Proposer
0. First Name M Last Name Title				
Panagiotis Spentzouris Co-PI	1.20	0.00	0.00	$0
([redacted]) TOTAL SENIOR PERSONNEL (1-6)				[redacted]
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)				
1. 0) POST DOCTORAL ASSOCIATES	0.00	0.00	0.00	$0
2. 0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	$0
3. 0) GRADUATE STUDENTS				$0
4. 1) UNDERGRADUATE STUDENTS				$7,640
5. 0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				$0
6. 0) OTHER (ASSOCIATE RESEARCH SCIENTIST)				$0
TOTAL SALARIES AND WAGES (A+B)				[redacted]
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				$611
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				[redacted]
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000)				
TOTAL EQUIPMENT				[redacted]
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				$1,500
2. FOREIGN				$0
F. PARTICIPANT SUPPORT COSTS				
1. STIPENDS $0				
2. TRAVEL $0				
3. SUBSISTENCE $0				
4. OTHER $0				
(0) TOTAL NUMBER OF PARTICIPANTS				[redacted]
G. OTHER DIRECT COSTS				
1. MATERIALS AND SUPPLIES				$0
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				$1,500
3. CONSULTANT SERVICES				$0
4. COMPUTERS SERVICES				$0
5. SUBAWARDS				$0
6. OTHER				$0
TOTAL OTHER DIRECT COSTS				[redacted]
H. TOTAL DIRECT COSTS (A THROUGH G)				[redacted]
I. INDIRECT COSTS (SPECIFY RATE AND BASE)				
Name of indirect cost item / Amount / Rate				
Salaries $8,252 30.35% [redacted]				
Equipment & Materials & Supplies $1,500 16.05%				
Travel $1,500 10.00%				
TOTAL INDIRECT COSTS				[redacted]
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				[redacted]
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.D.7.j.)				$0
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$14,147
M. COST SHARING: PROPOSED LEVEL	AGREED LEVEL IF DIFFERENT $			$0

PI/PD TYPED NAME & SIGNATURE*	DATE	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
Panagiotis Spentzouris	11/6/2003			
INST. REP. TYPED NAME & SIGNATURE* Michael Witherell	DATE 11/10/03	Date Checked	Date Rate of Sheet	Initials-ORG

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