University of California

Multicampus Research Programs and Initiatives

Grant Application

Proposal Type:

If renewal, current grant:

Resubmission? | Prior App:

RFA? | RFA Title:

TITLE OF PROJECT *(Titles exceeding 81 characters, including spaces and punctuation, will be truncated.)*

High Performance AstroComputing Center

APPLICANT NAME

Primack, Joel R

HIGHEST DEGREE(S)

Ph.D.

POSITION TITLE: Professor

ACADEMIC RANK: Full Professor

DIVISION: Physical and Biological Sciences

DEPARTMENT: Physics

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United States

PROGRAM ELIGIBILITY INFORMATION: *(Responses to selected fields displayed below. For some grant programs this section may be blank.)*

DATES OF PROPOSED PROJECT *(MM/DD/YYYY)*

From: 1/1/2010 Through: 12/31/2014

PROPOSED BUDGET

2001107

Name The Regents of the University of California, Santa Cruz

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1156 High Street
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Tel: 831-459-5278 Fax: 831-459-4989

EIN 94-1539563

DUNS 12-508-4723

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Title Contract & Grant Officer

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HUMAN SUBJECTS ☐ No ☐ Yes

Human Subjects Assurance No. FWA00002797 IRB Status: IRB Date:

VERTEBRATE ANIMALS ☐ No ☐ Yes

Animal welfare assurance no. A-385901 IACUC Status: IACUC Date:

APPLICANT ASSURANCE: I certify that the statements herein are true, complete and accurate to the best of my knowledge. I am aware that any false, fictitious, or fraudulent statements or claims may subject me to criminal, civil, or administrative penalties. I agree to accept responsibility for the scientific conduct of the project and to provide the required progress reports if a grant is awarded as a result of this application.

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Applicant: Primack, Joel R

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ABSTRACT

APPLICANT NAME	DATE SUBMITTED
Primack, Joel R	4/15/2009 12:36:31 PM
TITLE OF PROJECT *(Titles exceeding 81 characters, including spaces and punctuation, will be truncated.)*	
High Performance AstroComputing Center	

This Abstract will become public information; therefore, do not include proprietary/confidential information.

As computing power continues to increase rapidly, the most difficult problems in astrophysics are now coming within reach – including the formation and evolution of stars and supermassive black holes, and their interactions with their galactic environments. The UC faculty + labs is arguably the largest and most powerful computational astrophysics faculty in the world. UC can become the acknowledged leader in this highly visible area. The purpose of HIPACC is to realize the full potential of UC's world-leading computational astrophysicists by fostering their interaction with each other and with the rapidly increasing observational data, and by empowering them to utilize efficiently the new supercomputers with hundreds of thousands of processors both to understand astrophysical processes through simulation and to analyze the petabytes and soon exabytes of data that will flow from the new telescopes and supercomputers. This multidisciplinary effort links theoretical and observational astrophysicists, physicists, earth and planetary scientists, applied mathematicians, and computer scientists on all twelve UC astrophysics labs and campuses, and exploits California's leadership in computers and related fields. HIPACC's outreach activities will include developing educational materials, publicity, and websites, and distribution of simulation outputs including visualizations that are beautiful as well as educational.

Individual UC and Lab teams are fairly well funded, but we do not routinely share knowledge, postdocs, students, or computing resources. Because of our broad and complementary expertise, much could be gained by promoting cross-fertilization and also by fostering a tradition of systemwide collaborations. This would increase not only our scientific success but also our opportunities to attract very significant support. A long term goal is the creation of one or more major science institutes for projects such as the Thirty Meter Telescope and/or Large Synoptic Survey Telescope that would bring together theorists and observers to collaborate more closely in designing programs and instrumentation and that would feature California's role in these projects.

HIPACC would sponsor working groups of UC scientists from multiple campuses pursuing joint projects in computational astrophysics, including supporting travel and lodging for working meetings. It would also sponsor workshops and conferences on various computational astrophysics topics (one in Northern CA and one in Southern CA each year) and an annual summer school open to UC grad students and postdocs and also participants from beyond UC. HIPACC would foster interdisciplinary collaboration to advance the state of the art in computation and data storage and analysis, and it would develop industrial partnerships with CA companies such as Intel, Nvidia and Google.

APPLICANT: Primack, Joel R

PROPOSED BUDGET					
Start Dates:	Jan 01, 2010				
End Dates:	Dec 31, 2014				
2009-10 Request:	198874				
Total Request (for all remaining years)	1802233				
Total Request (all years):	2001107				
	2001107				
	0				
TOTAL COSTS	2001107				

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DATE 4/14/09

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DATE

Applicant Principal Investigator/MRPI Director: Joel R. Primack

Proposed Program and Activities:

High-Performance AstroComputing Center (HIPACC): Proposed Program and Activities

The University of California has invested tremendously in astrophysics. We built the world's largest optical telescopes and are building two unique state-of-the-art radio telescopes. We operate three major observatories and two major space science laboratories. We've become increasingly involved in major satellite observatories such as the Fermi Gamma-ray Space Telescope and are developing adaptive optics capable of replacing and even surpassing the Hubble Space Telescope when its reign is over. But just as important as hardware is our extraordinary investment in computational astrophysics and computer simulations. Indeed, the UC campuses and national laboratories are home to what is easily the largest and most powerful computational astrophysics faculty in the world…at a key moment when astro-simulations are just now reaching their full power to explain and interpret the universe.

The goal of HIPACC is to realize the full potential of these twin streams by bringing together computational astrophysicists, computer scientists, computer hardware engineers, and, most especially, the builders and users of UC telescopes. In the process, we will empower this team to A) utilize the next generation of supercomputers, hosting hundreds of thousands or millions of processors, to understand astrophysical processes through simulation, and B) analyze the petabytes (soon to be exabytes) of data that will flow from new telescopes and supercomputers. Our individual UC and Lab astrocomputation groups are relatively well funded but lack the tradition of sharing knowledge, students, postdocs, or computing resources to meet this new challenge. HIPACC will realize the "Power of Twelve" by fostering ***a new tradition of systemwide collaborations****,* and will do so with an expenditure of funds that is tiny compared to our already huge investments.

This strategy has many benefits: 1) it will instantly propel the UC computational astrophysics group to public prominence by projecting a single powerful image, which will be helpful for fundraising; 2) it will quickly and cheaply raise our smaller groups and campuses to world-class status by providing critical mass through collaborations; 3) it will cross-fertilize the labs and campuses, opening unique expertise at the labs to students while at the same time helping lab scientists to recruit student and faculty collaborators from the campuses; 4) it will permit powerful UC-wide teams to take ownership of certain key astrophysics problems, establishing dominance and increasing opportunities to attract support; and finally 5) it will lay the groundwork for creating one or more major science institutes for projects such as the Thirty Meter Telescope (TMT) and the Large Synoptic Survey Telescope (LSST). Such institutes will be essential components of efficient science management in the future by bringing theorists and observers together to identify major astrophysics problems and design unified strategies to solve them, from instrumentation and statistically sophisticated design of observational programs through to data reduction and final analysis. In other words, we foresee a convergence between observers and theoreticians owing to the ability of both groups to access *parallel universes*, observers accessing the real one but astrocomputation specialists creating ever more realistic renderings of their own, to be observed like the real universe. This historic convergence will revolutionize astrophysics, with synergy making the whole greater than the sum of its parts. UC will be left behind if it does not surf, and indeed master, the coming tsunami. HIPACC is the first step toward leadership in this new field.

HIPACC is wide-ranging and comprehensive. It links astrophysicists, physicists, earth and planetary scientists, applied mathematicians, and computer scientists on all nine UC campuses (not including UCSF) and all three UC national laboratories – the Power of Twelve. The budget proposed for HIPACC is mainly to develop and support interaction between these groups, especially for graduate student and postdoc travel, meetings, and schools; for education of students at all levels; and also for outreach so that funding agencies and the public become more aware of UC scientific progress. In

short, the comparatively small budget of HIPACC provides vital “lubrication” funds needed to get the massive power of UC astrophysics moving in new ways.

HIPACC’s activities are in several parts. First, it will support small, focused ***working groups*** of UC scientists from multiple campuses to pursue joint projects in computational astrophysics by providing travel and lodging. It will sponsor ***workshops and conferences*** on computational astrophysics topics (one in northern California and one in southern California each year) and an ***annual summer school*** open to grad students and postdocs within UC and internationally. It will actively promote the production and dissemination of **UC simulation outputs** including **videos**, becoming a “one-stop-shopping” site for the world’s best “astromovies,” and it will develop **industrial partnerships** with California companies such as Intel, Nvidia and Google to shape and utilize the computational hardware and software needed for the new millennium. We describe each of these in turn.

Working Groups

Working groups are the heart of HIPACC. These groups will consist of two to a dozen people, in practice mostly students and postdocs, who travel to another campus to collaborate. Periods would typically range from a few days to a few weeks. This is a career-shaping opportunity for students in which they learn from other leading faculty members, master skills not taught on their own campus, line up writers for crucial letters of recommendation, and form other contacts and alliances that can powerfully shape their future careers. Some meetings will also bring together senior astrophysicists with computer scientists and engineers to extend the state of the art in computation and data analysis. Many of these meetings will last only a few days and involve only a few scientists, but some will be longer, especially for longer-term stays by students. We propose to try novel ideas such as renting “astrohouses” to facilitate longer visits. In order to keep bureaucracy to a minimum, we would like to award small grants on a first-come-first-served basis although we do propose to track the success of such efforts (see Accountability).

Semi-Annual Meetings

HIPACC will sponsor two large meetings each year especially (but not exclusively) for scientists working on computational astrophysics and related topics at the UC campuses and labs. Unlike the more specialized meetings of working groups, we expect that these larger meetings will be broad, with the purpose of bringing theoretical astrophysicists together with computer science specialists, computer hardware experts, and observational astronomers. One meeting will be in northern California and the other in southern California to promote maximum participation. In addition to sharing new information, these meetings will highlight problems needing attention to advance the state-of-the-art and introduce participants to potential colleagues and begin collaborations.

Schools

An annual school aimed at graduate students and postdocs will greatly enhance the visibility of UC efforts in astrocomputing. Students at this age are highly impressionable and will carry forever their positive memories of formative experiences at UC, spreading our influence throughout the world. The recent high-level international schools in computational astrophysics held at the Astrophysical Institute Potsdam in 2006 and to be held at the Princeton Institute for Advanced Study in 2009 evidence high demand for such schools, but no other institution has yet captured the branding opportunity for an ***annual school***. HIPACC hegemony in hosting such a school will not only benefit our own students and faculty, it will also advertise our intellectual position to a world-wide audience. The schools will feature the best speakers and attract the best students internationally (but HIPACC funds will be used to support only UC students plus a small number of competitive scholarships). Lectures will be broadcast on the web so that they can be useful even for students who cannot attend the schools. In addition, SDSC, LANL, LBNL, and LLNL all give tutorials on high-performance computing, and HPC courses are being organized at several UC campuses. These tutorials and courses will be woven into the HIPACC calendar, broadening them to a wider range of scientific and engineering areas.

Examples of Participation and Collaboration (see also attached letters of support)

There is a large group of computational astrophysicists at **UCSC**, including Eric Asphaug, Gary Glatzmaier, and Francis Nimmo (Department of Earth and Planetary Sciences) and Nic Brummell and Pascale Garaud (Applied Math), who work on planet formation and solar and planetary; Jonathan Fortney, Greg Laughlin, Douglas Lin, and Adriane Steinacker (Astronomy), planets and planetary systems; Mark Krumholz (Astronomy), star formation; Enrico Ramirez-Ruis and Stan Woosley (Astronomy), stellar explosions and compact objects; and Piero Madau (Astronomy) and Anthony Aguirre, Joel Primack, and Stefano Profumo (Physics), cosmology, galaxy formation, and high-energy astrophysics. Primack's postdoc Patrik Jonsson developed the ***Sunrise*** code to generate images of simulated galaxies, including scattering, absorption, and re-emission by dust. UCSC is the UCO/Lick headquarters, and many UCSC observational astronomers, including co-I Sandra Faber, are involved in computational astrophysics. In addition, several Physics faculty are involved in gamma ray astronomy with the Fermi spacecraft and the VERITAS array of atmospheric Cherenkov telescopes. There are more than 20 UCSC postdocs in related areas. UCSC also has an 800+ processor mini-supercomputer for astrophysics, which is used by both theorists and observers.

The **UC Irvine** Center for Cosmology hosts 21 full-time faculty members with interests that range from theoretical particle physics in the early universe to astronomical observations of high-redshift galaxies, to understanding the formation of the Milky Way galaxy. Three Center for Cosmology faculty members (co-I Bullock, Cooray, and Kaplinghat) and ten to fifteen postdoctoral researchers and graduate students per year are actively involved in high-performance computer simulations to study the assembly of galaxies and galaxy interactions, to analyze large data sets in order to measure the clustering of galaxies in the early universe, and to study the large-scale clustering properties of different types of dark matter candidates. The astrophysics group at Irvine also interacts frequently with Wayne Hayes from the Computer Science Department at UC Irvine.

At **UC Merced**, Wil van Breugel studies distant massive galaxies, Lilian Davila interstellar dust, co-I Michael Sprague astrophysical fluid dynamics and high-performance computing, and Mayya Tokman computational science especially applied to plasma physics. The UC Merced graduate program in applied mathematics focuses on scientific computing, and they say that HIPACC will have a strong and lasting impact on success at this newest UC campus.

The **UCSD** Laboratory for Computational Astrophysics (LCA), directed by co-I Michael Norman, is currently developing the adaptive mesh refinement hydrodynamic cosmology code **ENZO** for petascale platforms. Research applications are being made to precision simulations of the Lyman alpha forest, the formation and evolution of the first galaxies, and cosmic reionization. The LCA is also active in the International Virtual Observatory Alliance (IVOA) Theory Data Working Group, and is developing access protocols for astrophysical simulation data. Other UCSD computational astrophysicists include Paolo Padoan, Aleixi Kritsuk, and several postdocs and other staff.

UCSB computational astrophysicists include Omer Blaes (MHD and accretion disks) and co-I S. Peng Oh (simulations of the first stars and the intergalactic medium). The focus at **UC Riverside** is on observational astronomy, including galaxy formation and evolution. They say that the regular workshops, conferences, and summer schools proposed here will be of particular value to the students and postdocs at UC Riverside.

UCLA co-I Steve Furlanetto focuses on the formation of the first galaxies in the universe, research that is particularly relevant to NASA James Webb Space Telescope and to the Thirty Meter Telescope. Other faculty at UCLA, including both theoretical and observational astronomers, use high-performance computing to study areas from planet formation and the dynamics of the solar system to supermassive black holes.

At **UC Berkeley**, computational astrophysicists associated with HIPACC include Richard Klein and co-I Chris McKee, who are working on star formation, and cosmologists Chung-Pei Ma and Martin White. White is involved in major collaborations with LANL; there are also collaborations with LBNL.

The **LBNL** Physics and Computational Research Divisions have formed the Computational Cosmology Center (C^3), a focused collaboration of astrophysicists and computational scientists whose goals are to develop the tools, techniques and technologies to meet the analysis challenges posed by present and future cosmological data sets including the Planck and JDEM satellite missions, which will gather data sets so massive that their analysis requires leading-edge high performance computing resources. Among the senior people involved in these efforts are computational astrophysicists Julian Borrill and co-I Peter Nugent, computational scientists John Bell and Phil Colella, and observational cosmologists David Schlegel and Saul Perlmutter.

LANL and **LLNL** have a long history in cutting-edge supercomputing. LANL astrophysical and cosmological simulations cover areas such as the large scale structure of the universe, cosmological hydrodynamics, astro-MHD simulations, stellar astrophysics including simulations of supernova explosions and light curves, nuclear astrophysics, simulations of the first stars, planet formation, space plasma simulations, the Lyman-alpha forest, and the epoch of reionization. Observational areas include astrophysical transients, high-energy astrophysics, X-ray astronomy, optical surveys, space exploration, and radio astronomy. LANL people involve in this include Chris Fryer, co-I Salman Habib, Katrin Heitmann, and Mike Warren; LLNL people include co-I Peter Anninos, Rob Hoffman, Stephen Murray, and Jay Salmonson.

Of course we want to link with Caltech and Stanford/KIPAC in efforts like the conferences and summer school, with each institution paying its share.

HIPACC Administration and Outreach

The main roles of the HIPACC administration are to organize the annual meetings and summer school, manage the travel grants, create and maintain websites, and facilitate education and outreach. The Director is responsible for overseeing these activities and for hiring qualified people to carry them out. A varied skill set is needed, including budget tracking, event planning, PR and media outreach, and web design. The budget is not large, but the total scope of activities is complex. We therefore envision hiring a few people part-time to fill these roles, amounting to ~2 FTE in total.

Disseminating astrosimulation outputs, including visualizations, is one of the most important things that HIPACC can do. Several UC groups are producing world-leading, awe-inspiring simulations, including the *Via Lactea* simulations of Milky-Way-size dark matter halos led by Piero Madau (UCSC), cosmological simulations led by Salman Habib (LANL) and Martin White (UCB), the Santa Fe Light-Cone Simulation Project involving Eric Hallman (LANL) and Mike Norman (UCSD), the *Bolshoi* cosmological simulation led by Joel Primack (UCSC), as well as gamma-ray burst and supernovae simulations led by Stan Woosley (UCSC), and simulations of the Earth's magnetic field by Gary Glatzmaier (UCSC). "Academy Awards" in scientific simulations are springing up, and we want UC to capture them! We will work with world-leading visualization groups at NERSC and NASA Ames Research Center, partner with Google for database management and data distribution, and provide authentic simulation materials for use by Pixar, Lucasfilm, and other California digital film-makers. The rewards of investing in movie-making were demonstrated by the Virgo Consortium's aggressive promotion of their *Millennium* cosmic simulation from Germany, which is now advertised in astronomy talks all over the world. Actually sharing data from such simulations would be scientifically useful, but most faculty need assistance to create and manage the necessary websites. Dissemination of such simulation outputs should be done in a way consistent with Virtual Observatory protocols, to facilitate their use by groups around the world. Mike Norman and his colleagues at UCSD/SDSC could be the UC hub for this effort, with a system-wide working group to plan and implement it.

A crucial goal of HIPACC outreach is to give back to the public through UC computational astrophysics research and education. A beautiful HIPACC website will help with this. The HIPACC administration will make links to print and broadcast media and facilitate the use of material from UC in TV documentaries. The HIPACC administration will also collaborate with planetaria, science museums, and other organizations that reach the astronomy-interested public. Many planetaria are augmenting their traditional star projectors with fabulously capable new digital projectors having

resolutions of 4000 pixels across the dome; even 3D is coming. These venues are IMAX theatres of the future, and they will need UC. A major goal for the HIPACC administration is to help researchers prepare material in forms that will facilitate use in outreach and education, including in the classroom, on the internet, in planetaria, and for broadcast media. This will require part-time personnel with appropriate experience and skills: a **webmaster** who is also expert in data management and access, an **education specialist** who can help prepare materials and make contacts with educators, planetaria, science museums, and other venues, and a **publicist** who will help with outreach in all forms. Several UC campuses have major programs in digital arts and new media, and HIPACC will promote collaborations with such groups. The HIPACC staff will coordinate web distribution of relevant lectures, seminars, meetings, and regularly updated web pages on relevant topics. The staff will also actively pursue fundraising in collaboration with groups at the UC campuses and labs in order that HIPACC can grow into a scientific center largely supported by outside funds. It is expected that the staff will work out of both the HIPACC headquarters at UCSC and also another center in southern California such as SDSC/UCSD.

Funding and Computational Opportunities Facilitated by HIPACC

Note that this proposal does not include funding for computing hardware, graduate students, or postdocs. Such funding will certainly be required for scientific progress, but rather than including it here, we expect that HIPACC will help its members raise such funds from other sources – for example, by facilitating powerful collaborations with computer scientists and engineers and with educators. Helping UC and lab faculty become more adept at using the new generation of computers with > 100,000 cores and/or novel architectures will also help them become much more competitive for allocations of supercomputer time. Over the longer term, our larger ambition is for HIPACC to grow into a major scientific institute, perhaps associated with the TMT or LSST, and supported largely by outside funding. Potential sources for such funding include the NSF Cyber-Enabled Discovery and Innovation (CDI) program starting in 2010 for $5 M/yr for up to 10 years, the DOE Scientific Discovery Through Advanced Computing (SciDAC) program, the Keck Foundation (like the new Keck Institute for Space Science at Caltech), and the Moore Foundation (e.g., for a TMT Science Institute). A potential source for computing resources is the new UC Shared Research Computing Pilot Program at SDSC/UCSD and eventually NERSC/LBNL. First users include Martin White (UCB), Peter Nugent (LBNL), and Gary Glatzmaier (UCSC).

New Directions in Scientific Computation and Data Analysis

Although this proposal focuses on computational astrophysics, it has broader implications. We now live in the early stages of a revolution in computer-aided discovery, with ever-more-realistic simulations and with increasing ability to manipulate and extract hidden meanings in enormous sets of data. Within five years, exascale will be the frontier and petascale commonplace. Astrophysics is an ideal testbed for such computer-aided discovery because the data are clean, large, and growing rapidly; the data are non-commercial and largely non-proprietary; and astrophysics is interesting to both scientists and the public. What happens in HIPACC can thus be a model for other fields.

As the evolutionary growth in data and computation occurs, two fundamental thresholds are being crossed. First, data sets are becoming so large as to render impractical the communication-intensive approaches that have been the mainstay in scientific computing thus far. The speed of data transmission – both within multiprocessor systems as well as over large networks – lags far behind the growth in data acquisition and computing speed. We need to re-think how scientific computing is organized and make it possible to collocate computations with the data. We also need ways to adapt Internet service technologies for broad access to large long-lived data sets and the tools to mine them. Second, the rapidly growing size and complexity of astronomical data are such that verifying models and simulations, discovering new patterns, and finding optimal designs for science missions will all require a new generation of machine intelligence techniques. At the same time, new dynamic visualization tools that allow much greater interactivity will be key to aiding scientists' understanding. HIPACC scientists will be grappling with all of these challenges, and in so doing help UC lead the way into this new data- and computation-intensive regime.

Accountability

Governance: The Center will be governed by an Executive Committee consisting of the Director, the Associate Director, and two Coordinators, one each from northern and southern California. This core will be augmented by a Council that contains one representative from each node, plus the Director, for a total of thirteen members in all. Since a prime goal of the Center is to empower faculty and enhance their productivity, the governance procedures of the Center will be simple, aimed at putting Center funds directly into the hands of faculty with a minimum of bureaucracy and proposal writing.

The Council will meet once a year at a one-day meeting held at a convenient airport. The Council will apportion the budget into its major categories: small travel; large travel; workshops, conferences and the summer school; and other initiatives as may arise. Workshop, conference, and summer school proposals will be solicited from all Center nodes prior to the meeting, and the best ones will be selected by the Council to determine the program plan for the coming year. Special initiatives involving outreach and coordination with other major entities, such as telescopes, planetaria, museums, etc., will also be selected. Council members are chosen by their campuses, and the Coordinator positions rotate every two years.

Small travel grants enable Center scientists, grads, and postdocs to travel easily and spontaneously between Center nodes. We propose to grant all travel grants up to $1000 per person on a first come-first-served basis simply by submitting a brief letter to the Director describing the plan and purpose of the travel. Grants above this amount and group travel grants to support larger working groups will be evaluated by the Executive Committee via email or electronic meetings. Starting in Year 2, applicants must state whether they have previously received travel funds and the benefits that were realized.

Evaluation, metrics: Center faculty and senior scientists will be polled annually to state what difference the Center is making in the following areas, with the goal of seeing measurable upticks within three years.

Collaborations, workshops, meetings, conferences, summer schools:

- The Center should meet its annual goal of hosting two major workshops and one summer school.
- The number of scientists involved in Center-supported travel and travel days will be tracked.
- The number of publications co-authored by scientists from different Center nodes should grow.
- The number of PhD theses with co-advisors from multiple Center nodes should increase markedly.

Scientific impact, success:

- Significant scientific discoveries and achievements enabled by the Center are a prime goal.
- Major projects spun off from Center support are a second prime goal, including eventual evolution into a permanent science institute.
- Evidence that the Center is enhancing the scientific vitality of the smaller campuses is also key.
- Media prominence and invited talks by senior Center scientists should increase.
- Prizes, honors, prime grad job placements, and number of prize postdocs attracted will be noted.

Resource generation:

- Federal grants attributable to the Center will be tracked.
- Major grants of supercomputer time to Center scientists should increase.
- The success of individual campuses leveraging the Center to attract private donations will be noted.

Human resources and training:

- Place 10% of Center graduate students and graduating postdocs in private industry by fifth year.

Public education and outreach:

- The demand for Center media should measurably increase, as demonstrated by use in planetaria, movies, textbooks, You Tube, and hits on the Center's website.

Ultimate goal: in five years, the Center will have morphed into a self-supporting science institute for one or more major science projects.

Applicant Principal Investigator/MRPI Director: _____Joel Primack_____

Timeframe and Budget

Limit is one-half page

Please specify the start date and proposed period of the award and the total budget.
(The total budget request should match the amount on the budget workbook. Applicants may request 2-5 years of support. ***Existing MRUs*** *(those that currently receive funds from UCOP Office of Research) may request only 1 year of support if that is more suitable to their program goals.*
Proposals from existing MRUs requesting support to extend activities under this new MRPI funding opportunity may propose start dates of July 1, 2009. All newly constituted MRPIs should propose start dates of January 1, 2010, or July 1, 2010 as most appropriate for their proposed activities. The UC Office of the President will make final determinations of award start dates of successful proposals based on the availability of funding, but no later than July 1, 2010.)

In paragraph form, briefly describe *how* the monetary level of the award and the proposed program will allow you to make a significant impact in the field. Describe how the program will either end or transition to non-UCOP funds at the end of the funding period, if appropriate. Successful MRPIs may reapply for additional funds at the end of their award period. *Please note: this is not a budget justification to accompany the Excel budget workbook, it is a statement of feasibility.*

The minimum font size is 11 point. The minimum margin size is 1 inch. There is no required font style, but Times New Roman or Arial are recommended. Please delete these instructions before converting this form to a PDF and uploading it to proposalCENTRAL.

The proposed starting date is January 1, 2010, with an end date five years later.

HIPACC will foster closer coordination between computational astrophysicists, astrophysical observers, earth and planetary scientists, applied mathematicians, and computer scientists and engineers at UC campuses and national laboratories. It will do this by supporting travel and expenses for science working groups collaborating between campuses and labs, for conferences, and for an annual summer school. The HIPACC administration will coordinate all these activities, and also develop websites and databases for distribution of simulation outputs including visualizations, develop and distribute educational materials, and coordinate outreach and fund raising.

The Budget Justification describes the expected annual expenditures and how they were estimated. Of the $400,000 proposed annual budget, only about $140,000 is for salaries and fringe benefits; the remaining $260,000 is for intercampus/lab workshops, conferences, and the annual summer school.

With the design finishing and construction beginning on major astronomical facilities associated with UC, including the Thirty Meter Telescope and the Large Synoptic Survey Telescope, the time is ripe to propose and raise funds for one or more major science institutes to help plan instruments and observations, and eventually compare observational results with theory. From the beginning, HIPACC will devote effort to proposing and raising funds for such science institutes, with the expectation that they will be supported by outside funds within the five year horizon of this MRPI proposal.

Applicant Principal Investigator/MRPI Director: Joel Primack

Budget Justification

Budget Justification. Complete this section in accordance with the instructions in the excel **MRPI Budget Workbook**. The host campus should provide basic space and administrative support to support the proposed MRPI. Explain other direct costs of the MRPI that appear in your budget. Justification is required for all direct costs incurred by collaborating campuses that propose to incur 30% or more of direct costs at that campus.

The minimum font size is 11 point. The minimum margin size is 1 inch. There is no required font style, but Times New Roman or Arial are recommended. Please delete the instructions before converting this form to a PDF and uploading it to proposalCENTRAL.

UCSC will provide office space for the following individuals. The Administrator, Webmaster/Database Manager, Education Coordinator, and Outreach Coordinator/Fund Raiser are all 1/2 FTE positions. Some of these people may also work out of the Southern California headquarters of HIPACC, which could be at the San Diego Supercomputer Center (SDSC)– as suggested by Michael Norman, Chief Scientific Officer of SDSC at UCSD. The responsibilities of each of these individuals are spelled out in the Proposed Program and Activities text.

Director and PI – Joel Primack, UCSC – annual stipend $8547 + $1453 fringe benefits = $10,000
Research **Administrator** Analyst – to be selected – 50% salary $30,768 + $9230 fringe = $39,998 1st year, increasing to $34,630 + $10,389 = $45,019 5th year
Webmaster and Database Manager – to be selected – 50% salary $22,500 + $6750 fringe = $29,250
Education Coordinator – to be selected – 50% salary $22,500 + $6750 fringe = $29,250
Outreach Coordinator / Fund Raiser – to be selected – 50% salary $22,500 + $6750 fringe = $29,250
Total stipends and fringe benefits = $137,748 1st year, increasing to $142,769 5th year

The rest of the budget is for travel and meetings, as follows:

Science working group meetings, with annual expenses estimated as follows:
Per Diem: 5 persons x 5 days x 20 workshops (=500 person-days) x ($40 per diem) = $20,000
Travel: 5 persons x 20 workshops (= 100 trips) x ($200 average cost per trip) = $20,000
Lodging: 500 person-days x $80 per night = $40,000
Total annual expenses for science working group meetings: $80,000

Conferences
Annual Conferences – one each in N and S California
2 x 10 speakers x $2000 average travel, food, and lodging expenses = $40,000 (note: some of these speakers will be coming from the East Coast or foreign countries)
2 x 20 UC campus/lab attendees x $1000 average travel, food, and lodging expenses = $40,000
Informal Conferences ("Research Jamborees")
2 x $10,000 each = $20,000
Total annual expense for Conferences = $100,000

Annual Two-week Summer School
10 speakers x $3000 average travel, food, and lodging = $30,000 (note: some of these lecturers will be coming from the East Coast or foreign countries)
20 supported UC campus/lab students and postdocs x $1500 travel, food, and lodging = $30,000
Summer school organization and facilities = $20,000
Total for Annual Summer School = $80,000

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OFFICE OF RESEARCH

1156 High Street, Santa Cruz, CA 95064
Phone: (831) 459-2425 FAX: (831) 459-2210

April 14, 2009

Dear Colleagues:

I write to endorse the submission of the Multicampus Research Programs and Initiatives (MRPI) proposal *High-Performance AstroComputing Center (HIPACC).* The Principal Investigator is Professor Joel Primack, and UCSC is the lead campus.

The purpose of HIPACC is to realize the full potential of UC's world-leading computational astrophysicists by fostering their interaction with each other and with the rapidly increasing observational data, and by empowering them to utilize efficiently the new supercomputers with hundreds of thousands of processors both to understand astrophysical processes through simulation and to analyze the petabytes and soon exabytes of data that will flow from the new telescopes and supercomputers. This multidisciplinary effort links astrophysicists, physicists, earth and planetary scientists, applied mathematicians, and computer scientists on all nine UC academic campuses and three labs, and exploits California's leadership in computers and related fields. UCSC has the strongest computational astrophysics program of any UC campus, and it is also the home of UCO/Lick; UCSC is therefore the most appropriate campus to lead this effort.

Should this proposal be selected, UCSC will provide suitable space for the work.

Sincerely,

Bruce Margon
Vice Chancellor, Research

Applicant Principal Investigator: **Joel Primack**

BIOGRAPHICAL SKETCH and OTHER SUPPORT

Limit to 3 pages per person

NAME	**POSITION TITLE**
Joel R. Primack	Professor of Physics

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, and include postdoctoral training.)*

INSTITUTION AND LOCATION	**DEGREE** *(if applicable)*	**YEAR(s)**	**FIELD OF STUDY**
Princeton University	A.B.	1966	Physics
Stanford University	PhD	1970	Physics

A. Positions and Honors.

Academic Positions:
Junior Fellow, Society of Fellows, Harvard University 1970-73
Assistant Professor of Physics, UCSC 1973-1977; Associate Professor of Physics, UCSC, 1977-1983; Professor of Physics, UCSC 1983-present

Professional Positions:
Advice: SAGENAP advisory panel to DOE/NSF 2000-2001; NSF Astronomy Theory Review Panel 2000; DOE Lehman Review of SNAP Proposal 2001; Chair, NASA Cosmology panel on LTSA and ADP 2001; Cosmology Panel, Hubble Space Telescope Time Allocation Committee 2003; Editorial Board, Journal of Cosmology and Astroparticle
Physics 2003-06; National Academy Beyond Einstein panel, 2006-07.
American Physical Society activities: Executive Committee, APS Division of Astrophysics, 2000-2002; APS Panel on Public Affairs (POPA) 2002-2004; Chair, POPA Task Force on NASA Moon-Mars Program and Funding for Astrophysics 2004; Chair, APS Forum on Physics and Society 2005; Candidate, Chair of APS Division of Astrophysics
Outreach: Smithsonian National Air and Space Museum, Advisory Committee on *Cosmic Voyage* IMAX film, 1994-1996. Co-organizer, "Cosmic Questions" Conference, Smithsonian National Museum of Natural History, Washington, DC, April 14-16, 1999. Co-author of popular book *The View from the Center of the Universe* (2006). Over 100 public lectures on cosmology, including Sackler Lecture (UC Berkeley, 2006), J. Robert Oppenheimer Memorial Lecture (Los Alamos, 2007), APS Public Lecture (St. Louis, 2008).

Honors (partial list):
A. P. Sloan Foundation Research Fellowship, 1974-1978
American Physical Society Forum on Physics and Society Award, 1977; Fellow, 1988
American Association for the Advancement of Science, Fellow, 1995
Humboldt Senior Award of the Alexander von Humboldt Foundation, 1999-2004

B. Selected peer-reviewed publications (in chronological order).

Supersymmetry, cosmology, and new physics at teraelectronvolt energies 1982, *Phys. Rev. Letters* **48**, 223. Pagels, Heinz, and **Primack, Joel R.** (348 citations in SPIRES High Energy Physics database, *253 citations in NASA Astrophysics Data System*)

Formation of galaxies and large-scale structure with cold dark matter 1984, *Nature* **311**, 517. Blumenthal, G. R.; Faber, S. M.; **Primack, J. R**.; Rees, M. J. (471 SPIRES cites, *747 ADS cites*)

Contraction of dark matter galactic halos due to baryonic infall 1986, *ApJ* **301**, 27. Blumenthal, G. R.; Faber, S. M.; Flores, R.; **Primack, J. R. (**299 SPIRES, *382 ADS***)**

Dynamical effects of the cosmological constant 1991, *MNRAS* **251**, 128. Lahav, Ofer; Lilje, Per B.; **Primack, Joel R.**; Rees, Martin J. (268 SPRES, *327 ADS*)

Semi-analytic modeling of galaxy formation: the local Universe 1999, *MNRAS* **310**, 1087. Somerville, Rachel S.;

Primack, Joel R. (431 SPIRES, *509 ADS*) *
The nature of high-redshift galaxies 2001, *MNRAS* **320**, 504. Somerville, Rachel S.; **Primack, Joel R.**; Faber, S. M. (336 SPIRES, *385 ADS*) *
Profiles of dark haloes: evolution, scatter and environment 2001, *MNRAS* **321**, 559. Bullock, J. S.; Kolatt, T. S.; Sigad, Y.; Somerville, R. S.; Kravtsov, A. V.; Klypin, A. A.; **Primack, J. R.**; Dekel, A. (723 SPIRES, *792 ADS*) *
Generating Hot Gas in Simulations of Disk Galaxy Interactions 2004, ApJ, 607, L87-L90. T.J. Cox, **Joel R. Primack**, Patrik Jonsson, & Rachel Somerville *
A New Non-Parametric Approach to Galaxy Morphological Classification 2004, AJ, 128, 163-182. Jennifer M. Lotz, **Joel Primack**, and Piero Madau *
Dark-Matter Haloes in Elliptical Galaxies: Lost and Found 2005, Nature, 437, 707. A. Dekel, F. Stoehr, G.A. Mamon, T.J. Cox, G.S. Novak, & **J.R. Primack ***
The Effects of Feedback in Simulations of Disk Galaxy Major Mergers 2006, MNRAS, 373, 1013. T. J. Cox, Patrik Jonsson, **Joel R. Primack**, and Rachel S. Somerville *
Simulations of Dust in Interacting Galaxies I: Dust Attenuation 2006, ApJ, 637., 255. Patrik Jonsson, T. J. Cox, **Joel R. Primack**, Rachel S. Somerville *
AEGIS: Host Galaxy Morphologies of X-ray and Infrared-selected AGN at 0.2 < z < 1.2 2007, ApJ Letters, 660, L19, C. Pierce, J. M. Lotz, , et al. *
Predicting the Properties of the Remnants of Dissipative Galaxy Mergers 2008, MNRAS, 384, 94. M. Covington, A. Dekel, T. J. Cox, P. Jonsson, and **J. R. Primack ***
The effect of galaxy mass ratio on merger–driven starbursts 2008, MNRAS, 384, 386. T. J. Cox, P. Jonsson, R. S. Somerville, **J. R. Primack**, and A. Dekel

* These papers are based on PhD dissertation research supervised by **Joel Primack**

C. Research Support.

Include all current and pending support. Also list grants completed within the last three years. For current and pending support specify if there is any overlap with this application.

JOEL PRIMACK COMPLETE		
AST-0521566 (PI: Stan Woosley, UCSC) Source: NSF MRI Title of Project: Acquisition of Beowulf Cluster for a Center for Computational Astrophysics at UCSC Role: Primack was one of four co-I's The major goals of this project are…to support astrophysical computation at UCSC (especially for code development and grad student use). OVERLAP: none, since MRPI proposal requests no hardware	09/01/2005-08/31/2008 Total Direct Costs $1,100,000.	Percent Effort 0%

JOEL PRIMACK ACTIVE		
Project Number NNX07AG94G (PI: Joel Primack, UCSC) Source: NASA ATP Title of Project: Galaxy Interactions and the Formation and Structure of Elliptical Galaxies Role: PI The major goals of this project are…to simulate galaxy mergers and compare structure and kinematics with galaxy mergers and remnants, and to develop new methods and codes to do this. OVERLAP: none (except that outputs from this work are relevant inputs to the proposed MRPI)	Dates 02/06/2007-02/05/2010 Total Direct Costs: $230,000.	Percent Effort 1 summer month is supported

JOEL PRIMACK ACTIVE		
Project Number AST-0607712 (PI: Manoj Kaplinghat, UCI) Source: NSF Title of Project: Structure Formation on Small Scales and the Nature of Dark Matter Role: Co-I (head of UCSC collaboration) The major goals of this project are…to simulate structure formation with warm dark matter, both thermal and non-thermal, and compare with data on small galaxies and galactic satellites. OVERLAP: none (except that this is an example of intercampus collaboration)	Dates: 09/01/2006- 08/31/2009 Total Direct Costs: $29,000.	Percent Effort 0 supported (grant supports a UCSC grad student)

JOEL PRIMACK ACTIVE		
Project Number NNX08AW37G (PI: Joel Primack) Source: NASA Fermi Gamma-ray Space Telescope Title of Project: Modeling Gamma Ray Attenuation Role: PI (co-I: Piero Madau, UCSC) The major goals of this project are…use semi-analytic models to calculate the extragalactic background light from the far UV to the far IR, and use this to calculate high energy gamma ray attenuation compared to observations OVERLAP: none	Dates: 10/01/2008-09/30/2009 Total Direct Costs: $42,000.	Percent Effort 0 supported (grant supports a UCSC grad student)
JOEL PRIMACK ACTIVE		
Project Number none (PI: Joel Primack) Source: UCSC UARC Aligned Research Program Title of Project: Simulation and Visualization for Astronomy and Public Education Role: PI The major goals of this project are…to run and visualize simulations of large scale structure, galaxy formation, and galaxy mergers; outreach in collaboration with planetariums. OVERLAP: none (but outputs are inputs for proposed MRPI)	Proposed Dates 02/07/2009-09/31/2010 Total Direct Costs: $50,000.	Percent Effort 0 (grant supports students)
JOEL PRIMACK SUBMITTED		
Project Number none (PI: Joel Primack) Source: NSF AST Title of Project: Formation and Evolution of Galactic Spheroids Role: PI The major goals of this project are…simulate large scale structure for improved semi-analytic modeling, and simulate galaxy mergers in cosmological context. OVERLAP: none (but outputs are inputs for proposed MRPI)	Proposed Dates 08/01/2009-07/31/2012 Annual Direct Costs: approximately $90,000.	Percent Effort 1 supported summer month

Applicant Principal Investigator/MRPI Director: Joel Primack

Attachments:

(Maximum 5 pages)

Please list attachments:

1. Letter of Support from Jamee Bullock, UC Irvine
2. Letter of Support from Michael Sprague, UC Merced
3. Letter of Support from S. Peng Oh, UCSB
4. Letter of Support from Gillian Wilson et al., UC Riverside
5. Letters of Support from Salman Habib, LANL, and Peter Nugent, LBNL

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SCHOOL OF PHYSICAL SCIENCES
DEPARTMENT OF PHYSICS AND ASTRONOMY
CENTER FOR COSMOLOGY

IRVINE, CALIFORNIA 92697-4575
4154 FREDERICK REINES HALL
Phone (949) 824-7727 Fax (949) 824-2174

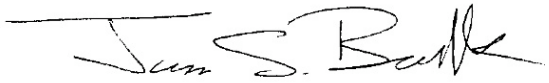
April 13, 2009

Re: MPRI on Astronomical Computing

Dear Professor Primack,

I am writing verify my strong support for the proposed High-Performance AstroComputing Center (HIPACC). We have a large, active group of researchers at UC Irvine who are involved with various aspects of cosmological supercomputer simulations (including faculty members Asantha Cooray and Manoj Kaplinghat, in addition to myself). The Irvine cosmology group is very enthusiastic about the enhanced likelihood of collaboration with other campuses and labs offered by HIPACC. Such a center would be particularly valuable for the students and postdocs at UC Irvine who would benefit greatly from the workshops, summer schools, and enhanced mentorship possibilities.

Yours Sincerely,



James S. Bullock
Associate Professor
Director, Center for Cosmology
UC Irvine

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School of Natural Sciences
University of California
P.O. Box 2039
Merced, CA 95344
13 April 2009

Re: MRPI on Astrophysical Computing

Dear Prof. Primack,

This letter is to verify my support of the proposed High-Performance AstroComputing Center (HIPACC). We have a small group of faculty interested in computational astrophysics and/or astronomy. Below I list four individuals who would benefit directly from the HIPACC; also listed are their relevant research interests and websites:

- Wil van Breugel, Adjunct Professor: Distant massive galaxies, the effects of their central super-massive black holes on the galaxy-formation process, and the formation and evolution of the largest structures known in the Universe: clusters of galaxies
  http://faculty1.ucmerced.edu/wvanbreugel
- Lilian Davila, Assistant Professor: Computational materials science, interstellar dust
  https://eng.ucmerced.edu/soe/people/ldavila
- Michael Sprague, Assistant Professor: Computational mechanics, high-performance computing, astrophysical fluid dynamics (rotating convection)
  http://faculty.ucmerced.edu/msprague
- Mayya Tokman, Assistant Professor: Computational science, numerical analysis, mathematical modeling applied to plasma physics
  http://faculty.ucmerced.edu/mtokman

UC Merced is the tenth UC campus, and is the first American research university built in the 21st century. UC Merced was founded with a focus on interdisciplinary research and a commitment to diversity. Of the current student population (2,534 students), 50% are attempting to be the first in their families to graduate from college, and 37% are underrepresented minorities.

Our graduate program in applied mathematics, for which I am coordinator, is heavily focused on scientific computing. While we have access to a computational cluster on site, the proposed HIPACC will provide many additional opportunities for our students and our faculty. These opportunities will include providing access to expertise and facilities not found at our new campus. Because of our newness and limited resources, these opportunities will have a strong and lasting impact on our success here at UC Merced.

Sincerely,

Michael A. Sprague
Assistant Professor, Coordinator for Graduate Studies in Applied Mathematics
office: (209) 228-4179; email: msprague@ucmerced.edu

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DEPARTMENT OF PHYSICS SANTA BARBARA, CALIFORNIA 93106-9530

April 14, 2009

Professor Joel R. Primack
Physics Department
University of California
Santa Cruz, CA 95064
USA

Re: MPRI on Astronomical Computing

Dear Professor Primack,

I am writing to express my support for the proposed High-Performance AstroComputing Center (HIPACC). Faculty members Omer Blaes and myself, as well as our students and postdocs, frequently collaborate with numericists on astrophysical computations on MHD aspects of accretion disk theory and formation of the first stars and reionization respectively. We look forward to collaborations with other campuses and labs, as offered by HIPACC, and the enhanced learning opportunities for our students and postdocs at the various summer schools and workshops.

Yours sincerely,

Siang Peng Oh
Associate Professor
UC Santa Barbara

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DEPARTMENT OF PHYSICS AND ASTRONOMY
PHYSICS BUILDING, ROOM 3041
RIVERSIDE, CALIFORNIA 92521-0413
(951) 827- 6274
Email: gillian.wilson@ucr.edu

April 14, 2009

Dear Professor Primack,

We are writing to pledge our enthusiastic support to the proposed High-Performance AstroComputing Center (HIPACC). Our focus at UC Riverside is on Observational Astronomy. We are broadly involved in observational studies of galaxy formation and evolution (AGN host galaxies and environments, galaxy interactions, high redshift galaxies, and high-redshift clusters of galaxies). The computational supercomputing opportunities offered by HIPACC will complement our observations, providing state-of-the-art numerical simulations, with which to compare. The regular workshops, conferences and summer schools will allow rapid transfer of expertise, and foster system-wide collaborations. The working groups will be of particular value to the students and postdocs at UC Riverside who will have the opportunity to gain valuable research and mentoring experience at a range of UC nodes. We strongly and unreservedly support this proposal.

Sincerely,

Gabriela Canalizo, Assistant Professor
Bahram Mobasher, Professor
Gillian Wilson, Associate Professor

Department of Physics and Astronomy
University of California, Riverside

Los Alamos
NATIONAL LABORATORY

T-2 Elementary Particles & Field Theory
Theoretical Division
P.O. Box 1663, B285
Los Alamos, New Mexico 87545
(505) 667-5265/Fax (505) 665-3700

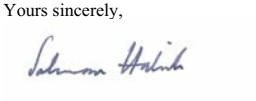
Date: April 13, 2009

Re: MPRI on AstroComputing

Dear Prof. Primack,

I am writing to confirm my support for the proposed High-Performance AstroComputing Center (HIPACC). We have a large number of astronomers, astrophysicists, computer scientists, cosmologists, physicists, and space scientists at Los Alamos National Laboratory who are involved in a broad variety of advanced numerical simulations relevant to various aspects of astrophysics, cosmology, and space science. We would welcome the opportunity for enhanced collaboration with other Labs and UC campuses as enabled by HIPACC. In particular, opportunities for attending workshops, summer schools, and student and post-doc exchanges would be highly beneficial.

Yours sincerely,



Salman Habib
Theoretical Division
Los Alamos National Laboratory

&

Center Leader
Astrophysics and Cosmology Center (ACCent)
Institute for Advanced Studies
Los Alamos National Laboratory

April 14, 2009

Professor Joel Primack
Department of Astronomy and Astrophysics
Interdisciplinary Sciences Building
UCSC
Santa Cruz, CA 95064

Dear Joel,

This is to express my strong support and commitment to the proposal for the High-Performance AstroComputing Center (HIPACC). I have read the proposal and am excited at the prospect of working closely with some of the best computational astrophysicists in the UC system and at the national laboratories. I know that this proposal will go a long way in improving the efficiency and scientific potential of several current and planned cosmology programs. At LBNL over 20 staff scientists are involved directly or indirectly in the experimental and/or computational research for several cosmology projects including Planck, the Joint Dark Energy Mission, the Dark Energy Survey, the Palomar Transient Factory and the Baryon Oscillation Spectroscopic Survey.

Sincerely,

Peter Nugent

Ernest Orlando Lawrence Berkeley National Laboratory
One Cyclotron Road | Berkeley, California 94720 | Tel: 510.486.4000