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OMB Control No.
1910-1400
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TITLE OF PROPOSED RESEARCH:
University of Minnesota participation in the Pierre Auger Observatory

1. CATALOG OF FEDERAL DOMESTIC ASSISTANCE #
81.049

2. CONGRESSIONAL DISTRICT:
Applicant Organization's District: 5th
Project Site's District: 5th

3. I.R.S. ENTITY IDENTIFICATION OR SSN:
41-6007513

4. AREA OF RESEARCH OR ANNOUNCEMENT TITLE/#:
Outstanding Junior Investigator: High Energy Physics
DE-FG01-02ER02-26

5. HAS THIS RESEARCH PROPOSAL BEEN SUBMITTED TO ANY OTHER FEDERAL AGENCY?
☑ YES ☐ NO

PLEASE LIST National Science Foundation

6. DOE/OER PROGRAM STAFF CONTACT (if known):

7. TYPE OF APPLICATION:
- ☑ New
- ☐ Continuation
- ☐ Supplement
- ☐ Renewal
- ☐ Revision

8. ORGANIZATION TYPE:
- ☐ Local Govt.
- ☐ Non-Profit
- ☐ Indian Tribal Govt.
- ☐ Other
- ☐ For-Profit
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- ☐ State Govt.
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- ☐ Disadvan. Business
- ☐ 8(a)

9. CURRENT DOE AWARD # (IF APPLICABLE):

10. WILL THIS RESEARCH INVOLVE:
10A. Human Subjects ☑ No ☐ If yes
Exemption No. or
IRB Approval Date
Assurance of Compliance No: sd
10A. Vertebrate Animals ☑ No ☐ If yes
IACUC Approval Date or
Animal Welfare Assurance No:

11. AMOUNT REQUESTED FROM DOE FOR ENTIRE PROJECT PERIOD $ 289,074.00

12. DURATION OF ENTIRE PROJECT PERIOD:
06/01/03 to 05/31/07
MM/DD/YY MM/DD/YY

13. REQUESTED AWARD START DATE
06/01/03
MM/DD/YY

14. IS APPLICANT DELINQUENT ON ANY FEDERAL DEBT?
☐ Yes (attach an explanation) ☑ No

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SIGNATURE OF PRINCIPAL INVESTIGATOR/ PROGRAM DIRECTOR
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Date 11/1/02

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1 Science of the Highest Energy Cosmic Rays

1.1 Introduction and Current Understanding

The highest energy cosmic rays, the most energetic particles in the Universe, have an origin which remains a wide open questions in particle astrophysics. Since 1962, when the first cosmic-ray event with an energy approaching 10^{20} eV was observed at Volcano Ranch[1], only a handful of similarly energetic events have been detected world-wide, the maximum to date reported at 3.2×10^{20} eV ([2]-[5]). (That's about 50 Joules—a decent tennis serve or person walking—for a single particle.) Substantial progress has been made in understanding the nature of cosmic rays of relatively modest energy (beyond about 10^{15} eV) leading to the possibility that the highest energy primary particles (beyond about 10^{19} eV) have an entirely different physical origin. The nature of these highest energy particles, and the mechanisms by which they acquired such tremendous energy, remain as mysterious today as when they were first observed.

The flux of cosmic rays above 10^{19} eV is extremely low—on the order of one particle per square-kilometer per year with the spectrum falling with about three powers of the energy. This is illustrated in Figure 1, showing a compilation of experimental measurements of the cosmic-ray differential energy spectrum [6]. Only detectors of extremely large size, thousands of square-kilometers, can acquire a significant number of events at the highest energies. The properties and indentification of the primary particles must be inferred from properties of the air showers they initiate. There are two techniques which are typically used: surface arrays of detectors sample the lateral density profile of the muon and electromagnetic components of the air-shower front as it crosses the ground and atmospheric fluorescence detectors which observe the evolution of air showers—their growth and subsequent attenuation—as they develop. Theoretical understanding of the production and propagation of 10^{20} eV primaries is problematic as well. At these energies, the cosmic rays have a mean free path less than 50 Mpc —a short distance on a cosmological scale. Cosmic rays lose energy due to interactions with the 2.7K cosmic microwave background radiation and the IR background: protons photo-produce pions, nuclei photodisintegrate via the giant dipole resonance, photons pair produce e^+e^-, and only neutrinos propagate freely. Thus, if the highest energy cosmic rays are cosmological in origin, their observed energy spectrum is expected to exhibit a cut-off around 5×10^{19} eV, an effect known as the Greisen-Zatsepin-Kuz'min (GZK) cut-off [7, 8]. Consequently, the source or sources of any observed 10^{20} eV cosmic rays (other than neutrinos) must be relatively nearby, within 50 - 100 Mpc. We'll see that there are few potential sources within that distance.

1.2 Theoretical Basis

Models of the acceleration of protons or nuclei to 10^{20} eV have proven very difficult to construct. Few sufficiently energetic astrophysical environments lie within the allowed distance.

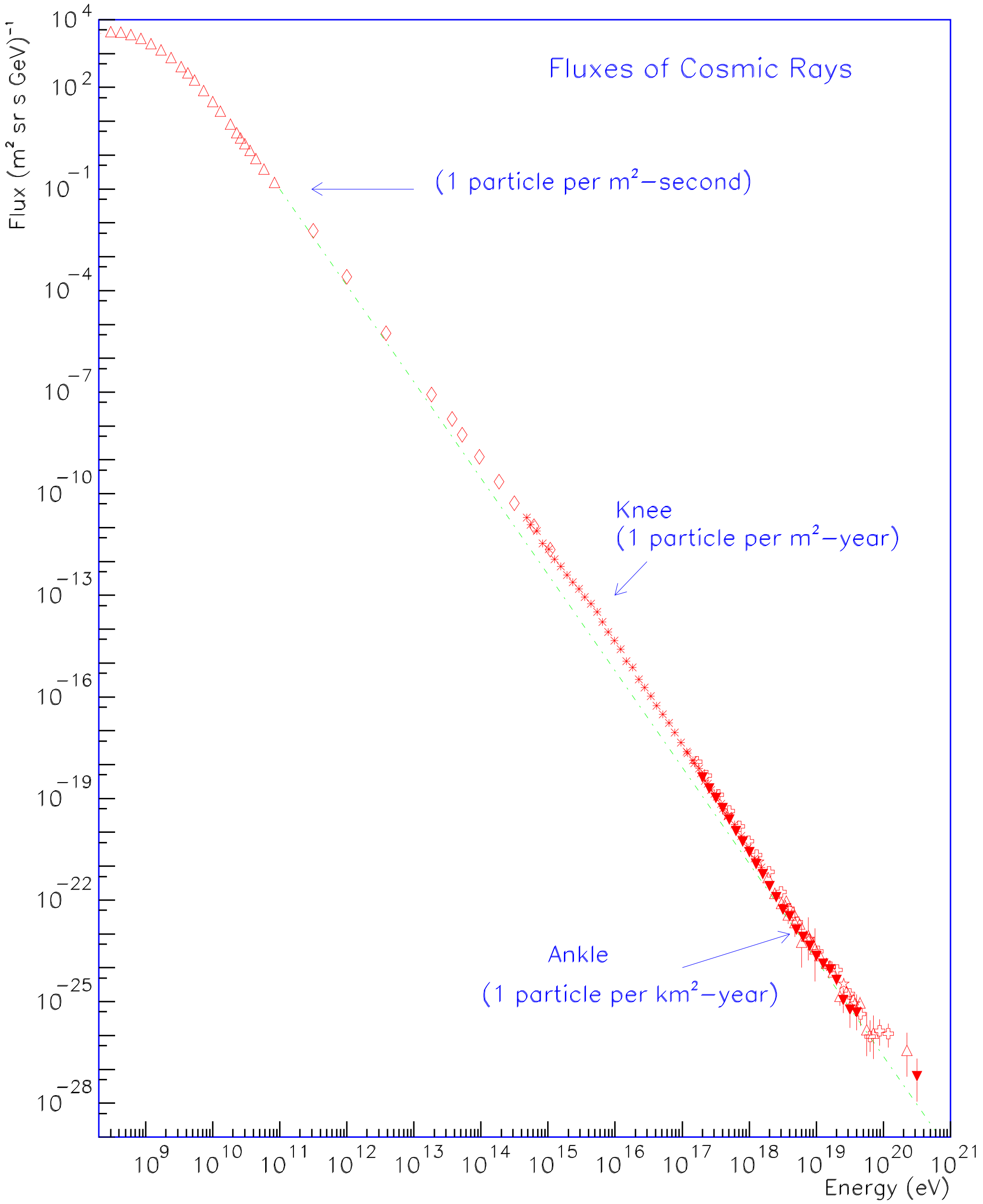

Figure 1: *Differential energy spectrum of cosmic rays. The dotted line is an* E^{-3} *spectrum to guide the eye. Approximate integral fluxes are indicated at places where changes occur in the behavior of the distribution. (These changes are difficult to see in this overview plot.)*

If particle acceleration proceeds by the Fermi shock-acceleration mechanism [9], i.e., high energies are achieved through repeated encounters with moving magnetized plasmas, then a maximum attainable energy is given by:

$$E_{max} \approx \beta c \times Z\,e \times B \times L. \tag{1}$$

In this equation, βc is the velocity of the shock associated with the moving plasma, Ze is the charge of the accelerated particle, B is the average magnetic field strength in the plasma, and L is the characteristic scale size of the accelerating region. Figure 2 illustrates the field strength B versus accelerating region size L for some potential astrophysical accelerators [10]. Objects below the diagonal lines, derived from Eq. 1, cannot accelerate particles to 10^{20} eV by shock acceleration. The dashed line is for iron nuclei and the solid line for protons, each case for $\beta = 1$ shocks. A value of $\beta = 1$ is unrealistically extreme. The top of the shaded region is for protons assuming $\beta = 1/300$, a more typical value for many astrophysical shocks. Only a few of the objects in Figure 2 appear able to generate particle energies above 10^{20} eV. Generally, only large structures associated with galaxies or groups of galaxies seem to have sufficient size and field strength to merit consideration as astrophysical acceleration sites.

Other possibilities for the origin of the highest energy cosmic rays lie in the direction of fundamental and particle physics rather than astrophysics. Such possible sources include topological defects formed during phase transitions in the early universe as it cooled, a product of spontaneous symmetry-breaking implicit in some Grand Unified Theories (GUTs) [11, 12]. Relic topological defects, such as ordinary and superconducting cosmic strings, domain walls, textures, or magnetic monopoles, are relatively stable topologically, but can release part of their energy in the form of X particles, if they collapse or annihilate. These X particles, with typical GUT scale masses on the order of 10^{24} eV, would subsequently decay into leptons and quarks. The spectrum of cosmic rays generated by this mechanism could extend to extraordinarily high energies, perhaps as much as 10^{24} eV. Alternatively, cosmologically distant sources of neutrinos, such as active galactic nuclei, have been proposed as the origin [13]. The ultrahigh-energy neutrinos would resonantly annihilate with dark matter neutrinos in the cosmological neighborhood (i.e. in the Galactic halo), producing 10^{20} eV protons pointing back to the source. It has been pointed out that the handful of 10^{20} eV events might be directionally consistent with radio-loud quasars [14].

2 The Pierre Auger Observatory

2.1 Science Objectives

The existence and origin of the highest energy cosmic rays are a puzzle, the solution to which will lead to new discoveries in astrophysics, particle physics, or both. The Auger Observatory is under construction [15] as a large-scale, international experiment whose primary goal is to solve this mystery. Two separate, essentially identical detector systems, one in the Northern Hemisphere (in Millard County, southern Utah) and one in the Southern Hemisphere (in

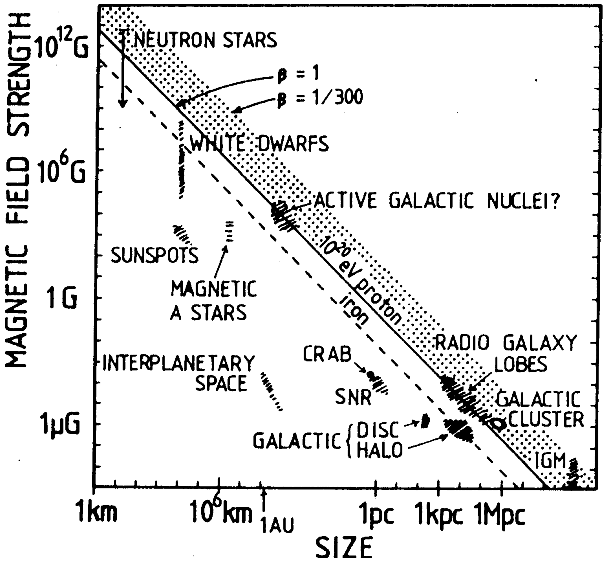

Figure 2: Size and magnetic field strength of possible sites of particle acceleration [10]. The dashed line is for 10^{20} eV iron nuclei and the solid one for protons, for shocks with $\beta = 1$ (most optimistic case). The top of the shaded region is for protons with $\beta = 1/300$ (realistic velocity for observed shocks).

the Province of Mendoza, Argentina, in the foothills of the Andes), will measure the arrival direction and energy of the highest energy primary particles, the muon content of the extensive air showers they induce, and, for a subset of events, the longitudinal development of the showers in the atmosphere. Analysis of these shower parameters, guided by extensive and detailed Monte Carlo simulations, can be used to select event samples enriched in either light ($A \leq 16$) or heavy ($A \geq 16$) primaries. Correlations among the various parameters – energy, arrival direction, and mass – may reveal that a number of different components contribute to the total observed cosmic-ray flux. For example, it is possible that a significant fraction of the primaries around 10^{19} eV are heavy nuclei produced in our Galaxy. If so, their arrival directions ought to be correlated with the Galactic mass distribution, i.e. they should appear to come from the direction of the plane, as opposed to the poles, of the Galaxy. This component, nearly unaffected by the cosmic microwave background radiation, would exhibit an energy spectrum directly reflecting the production mechanism within the Galactic accelerators. If the light primaries, including protons, are isotropic and exhibit a cut-off near 10^{20} eV, they would represent a universal extragalactic component which has suffered attenuation due to its interaction with the cosmic microwave background.

It is the origin of the very highest energy ($E \geq 10^{20}$ eV) cosmic rays that is most perplexing, and there is virtually no information as to their fundamental nature. It would be crucial to determine whether they are protons, nuclei, or perhaps exotic particles such as magnetic monopoles, and to determine how and where they acquire such enormous energies. The study of their arrival directions would determine whether they cluster about any known, particularly energetic astrophysical objects, or about any extended mass distribution such as the super-galactic plane. If they do not exhibit any directional anisotropy, then they could be among the products created in the decay of topological defects, in which case their energy distribution should be characteristic of a “top down” source: the product of a cascade from still higher energies. In the absence of a greatly increased statistical samples of such events, we have little with which to proceed theoretically.

2.2 Experiment Design

The Auger Observatory is a hybrid detector, employing two complementary and well established techniques to observe extensive air showers. An array of particle counters will measure the lateral and temporal distribution of shower particles at ground level. An optical air-fluorescence detector will measure the air-shower development in the atmosphere above the surface array. Operating together, the surface array and fluorescence detector characterize showers to a greater degree than either technique alone. The surface array resembles the one that was successfully employed by the Haverah Park group for over twenty years [5], although the Auger array of 1600 tanks covering 3000 km^2 in each hemisphere will be much larger. The optical system uses the fluorescence technique pioneered by the University of Utah’s Fly’s Eye detector [16]. Measurement of atmospheric fluorescence is possible only on clear, dark nights at the moment, although R & D efforts are underway to make the system partly moon-blind. About 10% (possibly more) of all Auger showers will be measured by both techniques simultaneously. The hybrid configuration proposed for the Auger Observatory is the most economical and robust method to obtain the necessary data, including a subset of events with especially high reconstruction resolution and independent cross checks. The decision to use the two techniques together is based upon the following considerations:

Intercalibration: Both methods measure shower energy, direction, and primary particle type in complementary ways, providing invaluable redundancy and cross checks. The two kinds of detector have not yet been operated in coincidence on a large scale. A hybrid device will reveal any systematic effects inherent to either method alone.

Enhanced composition sensitivity: Both detector techniques have sensitivity to primary particle type, but the two techniques together provide a much enhanced capability. Each method obtains information about the nuclear type of the primary cosmic ray by measuring air-shower quantities which correlate with it. In coincidence, these measurements are much less susceptible to fluctuations which could lead to misidentification.

Hadronic interactions: Measurements of both the muon and electromagnetic particle densities, together with the shower’s longitudinal development profile, impose tight constraints on hadronic interaction models. (The interaction energies of Auger events are well beyond the reach of accelerator based experiments.)

Uniform exposure: Cosmic-ray arrival directions, whether isotropic or not, provide the most compelling evidence for identifying their sources. Surface arrays in both hemispheres, operating 24 hours per day year-round, provide data with nearly uniform sky exposure. This allows for a straightforward search for excesses from discrete sources and also a sensitive large-scale anisotropy analysis.

	10^{19} eV		10^{20} eV	
	Surface	Hybrid	Surface	Hybrid
$\Delta\theta$	2.0°	0.35°	1.0°	0.36°
Δcore	80 m	29 m	40 m	29 m
$\Delta E/E$	18%	4.2%	7%	2.5%
ΔX_{max}		17 g/cm^2		15 g/cm^2

Table 1: Summary and comparison of reconstruction resolution for the surface array and for hybrid operation. Median errors are shown, from simulations of proton showers.

2.2.1 Hybrid Operation

Events which are observed by both the fluorescence and the surface detectors can be effectively reconstructed even if only two surface detectors have recorded signals. Thus, the event trigger for the hybrid arrangement can permit "sub-threshold" surface array triggers (i.e. less than the minimum of five stations for a normal air shower trigger in the surface array), if the fluorescence detector provides its own event trigger. The hybrid threshold therefore extends down to about 10^{18} eV. Events in this energy range can provide a valuable comparison with the extensive data of previous (and current) cosmic-ray experiments operating at energies below the energies of Auger's primary focus.

In the hybrid mode of operation, simulations indicate that the surface and fluorescence detectors together have a directional reconstruction resolution of about 0.36° for events near 10^{20} eV, and an energy resolution of 2.5%. The energy resolution is shown in Figure 3, for 10^{19} eV showers analyzed with a fluorescence detector only, and in hybrid combination with a surface array. The improvement in resolution of the hybrid configuration over a fluorescence detector alone is readily apparent. Table 1 summarizes the simulated angular, core position, energy and shower maximum resolutions for a surface array operating alone or in hybrid mode with a fluorescence detector. Again, a clear advantage obtains for hybrid operation over a surface array alone. All of the details of the simulations and event reconstructions used in obtaining the parameters in this table can be found in [15]. The resolutions are more than sufficient to address the scientific issues outlined in Section 1.

2.2.2 Surface Array

Each of the two surface arrays of the Auger Observatory consists of 1600 detectors spaced on a triangular grid with about 1.5 km separation between individual detectors. Each array encompasses an area of 3000 km^2 (see Figure 4). The angular and energy resolutions of a ground array alone (without coincident fluorescence data) are typically better than 1.5° and 20%, respectively. Event triggers of five detectors above threshold provide for the array to be fully efficient at 10^{19} eV. Each detector is solar powered (consuming less than 10 W) and

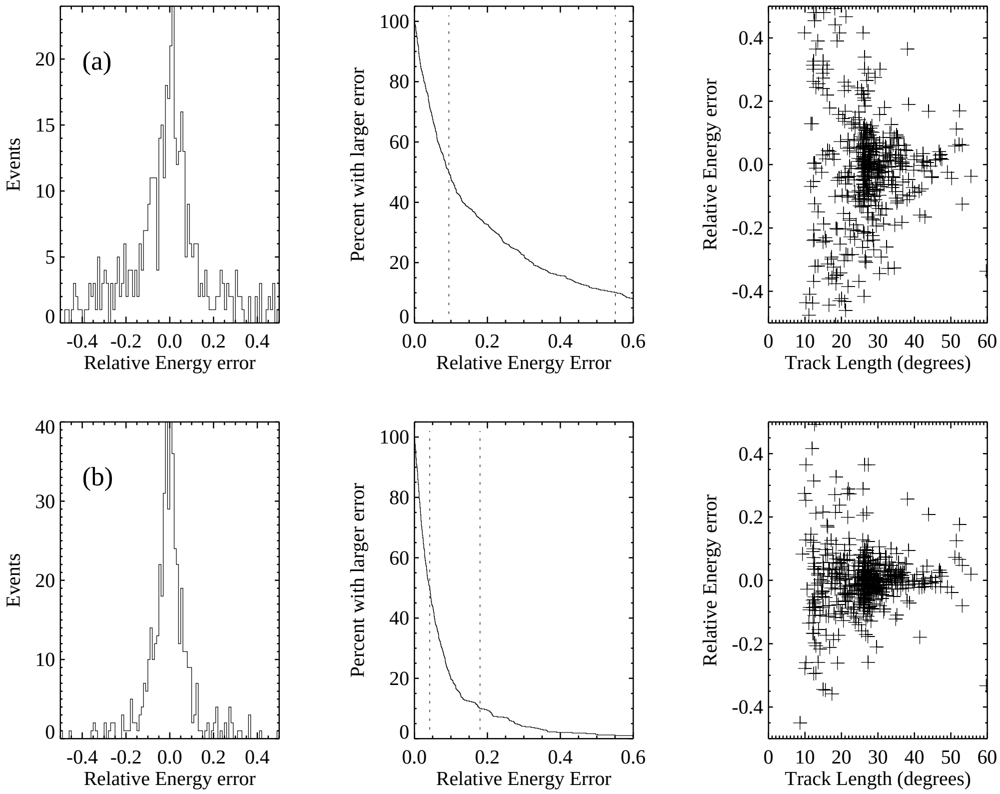

Figure 3: *Simulated energy resolution* $(E_{reconstructed} - E_{true})/E_{true}$ *for* 10^{19} eV *showers analyzed a) for a fluorescence detector alone, and b) for a hybrid configuration including a surface array. Shown are the distribution of the relative energy error (left panels), the percentage of events with larger errors as a function of energy error (middle panel), with the 50% and 10% marks indicated by dotted lines, and the distribution of energy error as a function of the length of the track viewed by the fluorescence detectors (right panels).*

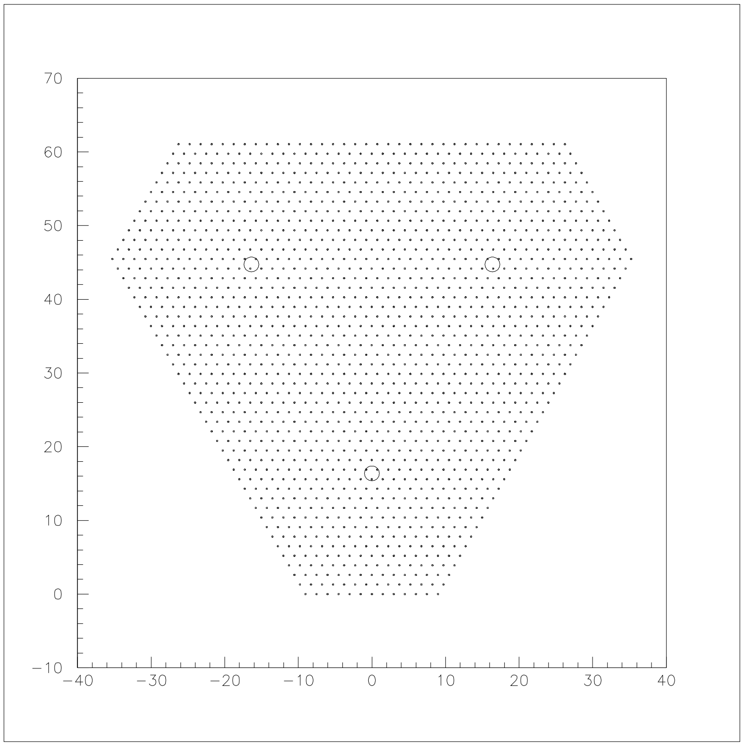

Figure 4: *Idealized layout of the Auger Observatory. Dots represent ground stations (about 1600 stations covering about 3000 km^2), and open symbols represent fluorescence detectors. The actual layout is slightly affected by ground terrain (wet areas in particular).*

will communicate via a wireless high-speed modem network. Inter-detector relative timing is accomplished by individual Global Positioning Satellite (GPS) receivers and Central Station GPS correction data.

Based on a study of a combination of cost, simplicity and performance, a Water Čerenkov Detector (WCD) design was selected for the surface stations. This detector is relatively simple, consisting of a cylindrical water tank of 10 m^2 area and 1.2 m depth with an efficient, diffusely reflective lining. (This detector looks a lot like the stock tanks common to the ranching areas in which both Northern and Southern Hemisphere sites are located.) The Čerenkov light produced by the shower particles is viewed by three downward-facing 8-inch photomultiplier tubes (PMTs). A WCD, in comparison to a scintillation detector or a gas chamber, is simple, stable, inexpensive, and has a significantly better sensitivity to showers at large zenith angles. Twenty years of WCD experience at the Haverah Park experiment provide an important confirmation of the sensibility of the design.

Air showers at 10^{19} eV contain about 10^{10} charged particles extending over an area of twenty square kilometers. Due to the 1.5 km detector separation in Auger, the properties of showers at a distance of a kilometer or more from the core of the air shower are the most relevant to the detector design. At such distances from the core, the particle density has decreased to a few per square meter, as illustrated in Figure 5. The electromagnetic particles (electrons, positrons, and photons) are 100 times more numerous than the muons at the core, and 10 times more numerous at 1 km. However, the electron mean energy is only 10 MeV, while that of the muons is about 1 GeV, as illustrated in Figure 6. The

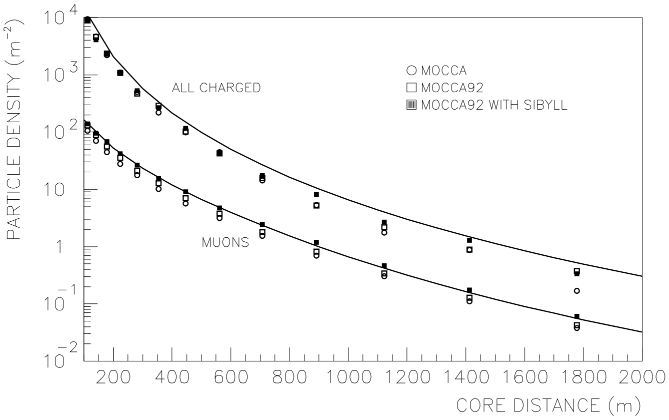

Figure 5: *Lateral distributions of muons and all charged particles, simulated for* 10^{19} *eV oxygen nuclei primaries with three different Monte Carlo algorithms: MOCCA [17], MOCCA92 (an updated version of MOCCA), and MOCCA92 with the SIBYLL hadronic interaction generator [18].*

thickness of the shower front, measured as the time it takes to pass through the detector, is several microseconds. The electrons in the shower front produce a large number of relatively small Čerenkov pulses whereas the muons produce a small number of large pulses. Given the spread of the arrival times, it is feasible, using only moderate speed flash-ADCs (40 MHz), to estimate the muonic and electromagnetic components of the shower independently. Similarly, the rise-time of the shower front signal is related to the relative proportion of muons in the shower (muons are typically "leading" particles within the shower front). The ratio of muons to the electromagnetic component (the "μ:em" parameter) is sensitive to the nuclear type of the primary cosmic-ray particle, as is apparent in Figure 7, showing the simulated distribution of the μ:em parameter for 5×10^{19} eV photon, proton oandiron showers.

2.2.3 Fluorescence Detector

The Auger fluorescence detectors consist of meter-sized mirrors, each of which is equipped with a cluster of about a hundred photomultiplier tubes. Each tube forms a 'pixel' on the sky. The fluorescence detectors mingle within the surface array as displayed in Figure 4. Each mirror, with its associated PMT cluster, views its own segment of the sky. Overall, the system of mirrors observes most of the sky above the surface array. The pulse height of the PMT signals yields the number of electromagnetic particles in the shower at a given point along the track across the sky, and the integral signal yields the energy. Fast timing of the sequence of signals gives the trajectory of air showers passing in the field of view of the detector. The measurement of the depth of shower maximum X_{max} yields sensitivity to the primary particle mass, as illustrated in Figure 8, showing the simulated distribution of X_{max} for iron, carbon and proton events of energy up to 3×10^{19} eV.

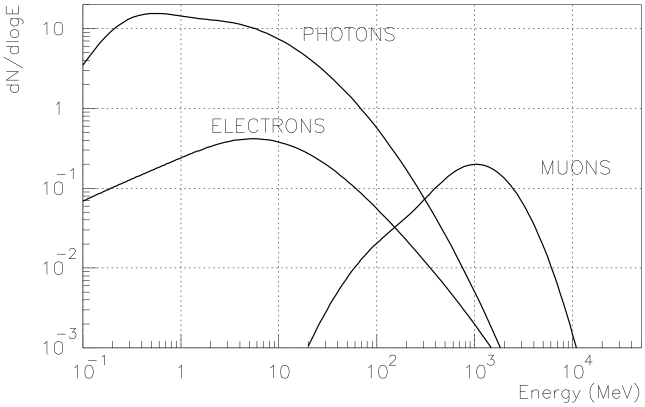

Figure 6: *MOCCA-simulated distribution of particle kinetic energies at an atmospheric depth of 1000 g/cm*^{2} *(approximately sea-level) and at a distance of 900 m from the core, for* 10^{19} *eV proton-induced air showers.*

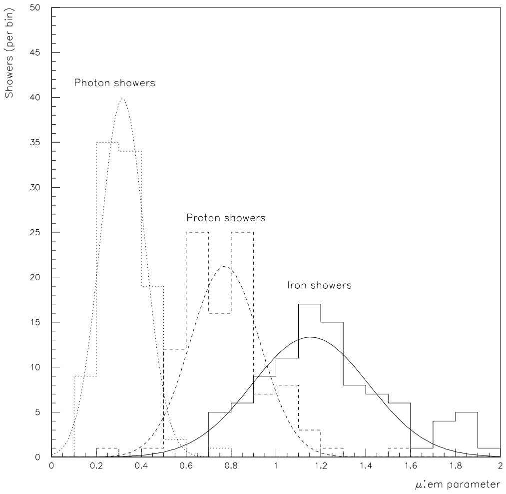

Figure 7: *Simulated distribution of the ratio of muons to electromagnetic content of air showers for* 5×10^{19} *eV photon, proton, and iron showers incident at* 30° *zenith angle.*

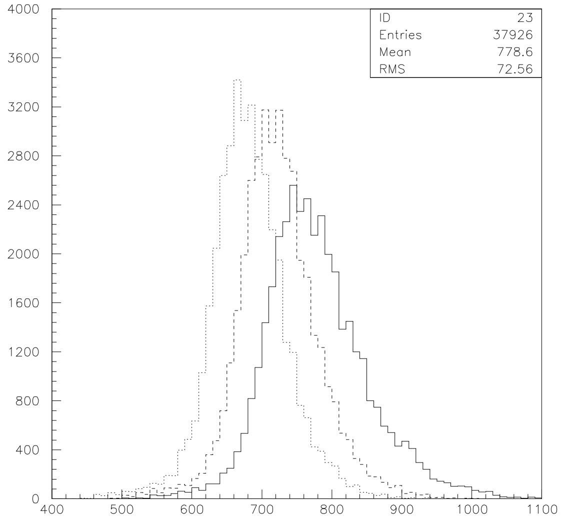

Figure 8: *Simulated distribution of the depth of shower maximum* X_{max} *for iron (dotted line), carbon (dashed line) and proton (solid line) primaries of energy up to* 3×10^{19} *eV. (Fluorescence mass resolution.)*

2.3 Status and operation of the Experiment

Detector systems at the southern site are currently under construction with important milestones reached in June and July 2001 with the first fluorescence events and first surface detector coincidences recorded. Preproduction tanks totalling 100 are currently being deployed using techniques which will allow for the rapid and efficient placement of the remaining mass produced detectors. Additional milestones can be seen in Table 2 and those affecting the University of Minnesota group are detailed in Section 3.

3 Work Plan

3.1 Introduction

For the four years of this Award, the finalized design of the Auger Observatory production systems will be implemented and the detectors built and placed in the field by a large international collaboration. The Southern Array in Argentina has been funded for initial construction with the possibility of additional funding to be requested for the Northern Site at some point during the Southern Site construction and early operation. After full data-taking has commenced, the experiment is expected (and designed) to run for two decades.

I have been a collaboration member for the past six years while at the Penn State University and at Minnesota. At Penn State I worked primarily on surface detector electronics, air shower simulations, and exotic particle signatures for the array. At the November 2000 Auger Collaboration meeting I petitioned the collaboration board for membership for the University of Minnesota. The collaboration has supported my membership and my search

Table 2: Auger Observatory Design and Construction Schedule.

2001	**Southern site** Engineering array construction. Fluorescence detector prototype. Complete critical design reviews of all detector systems. Complete Central Facility.
2002 (funding Year 1)	**Southern site** Complete deployment of (100) pre-production surface stations. Complete construction of Los Leones fluorescence detector. Deployment of first mass production units. **Northern site** Proposal stage.
2003 Year 2	**Southern site** Complete deployment of 400-500 surface detector stations. Begin construction of two additional fluorescence detectors. **Northern site** Prepare site surveys. Begin Central Facility.
2004 Year 3	**Southern site** Complete deployment of 400-500 surface detector stations. Complete construction additional fluorescence detectors. Partial array data collection statistics exceed sum of previous detectors. **Northern site** Begin detector deployment.
2005 Year 4	**Southern site** Full array in place—full scale data taking operations.
2006 Year 5	**Northern site** Full array in place—full scale data taking operations.

for group support. A formal Memorandum of Understanding between the University of Minnesota and the Pierre Auger Collaboration has been produced and is being signed by all of the relevant people.

3.2 Auger research participation

I propose to participate in several areas within the collaboration. These areas reflect my expertise and interest gained in previous cosmic ray experiments. My science interests lie in two areas: 1, the composition of the cosmic rays at the highest energies, and, 2, the detection of high energy neutrinos, through their production of horizontal air showers in the atmosphere, with the Auger Observatory. The former is a natural follow on to my thesis work in the chemical and isotopic composition of the cosmic rays [19] albeit in vastly different energy ranges. In addition, I'm currently involved with the CREAM balloon experiment which has as its primary goal the first direct measurements of cosmic-ray composition at the 'knee' of the spectrum ($\sim 10^{15}$ eV). The latter has been a recently evolving interest of mine. The atmosphere over the array provides an interaction volume for neutrinos at $10^{18}-10^{20}$ eV equivalent to several kilometers cubed of water. The resulting air showers can be observed in the ground array with a software neutrino trigger looking for neural-net pattern matches with the simulated neutrino physics. Implementing this trigger will not adversely affect the primary science goals of the Auger Observatory but are one way in which the general capabilities of the array can be used for different science goals.

During the construction of the Auger Observatory I have largely been involved with two detector construction tasks. The first is software work on the Central Data Acquisition System (CDAS) and the second is functional testing, quality assurance, and environmental testing of electronics components and boards. The former task is based at LPNHE (University of Paris VI) and currently there is no US participation at all in the CDAS until I joined this year. I have been particularly interested in working on the software Event Builder which collects the science data from individual tanks (after a trigger) and builds a full event database. (My work so far has concentrated on more pedestrian aspects of muon monitoring of gain and high voltages.) My own experience with balloon experiment software event collectors (including design work for a new system which is underway at the moment) should translate relatively well to this much larger code development project. It is in this area that I plan to get a postdoctoral student involved with the Auger Observatory. I have hired a postdoc with significant experience in both acquisition software and hybrid event reconstruction.

On the hardware side, in addition to the testing of current components which will go into the pre-production tanks and the slightly-altered production tanks, we also need to keep a running 'library' of spares, replacement parts, and testing procedures for the future. With a two decade experiment run time, the majority of electronics components will go through several generations of new products. It is likely that any repairs in the future which will exceed the initially produced spares inventory will need to be performed with different parts than originally used. The testing to ensure that such parts will meet the Auger requirements will be possible at the University of Minnesota with the test facility that I have built. My experience with low-power electronics for balloon experiments (including HEAT and CREAM) provide a good background for working with the low-power (solar powered) Auger surface detector tank electronics. Through judicious use of start up funds, I have setup a general-purpose test facility with which to support Auger electronics work.

Within the science analysis area, some initial work on production air-shower simulation and composition analysis is underway at Minnesota. We expect to make large contributions to the composition and neutrino analysis within the collaboration.

Throughout the course of the Award, I plan to employ a graduate student to work primarily on the software initially and transition to data analysis as the experiment comes online. Several students have expressed interest in Auger in general and the acquisition and analysis systems specifically.

If the Northern Hemisphere site is approved, I expect to split my time between the two sites—likely reducing my foreign travel in preference to domestic. The exact split in effort between the two arrays would be determined at a later date.

3.3 Education & outreach

During the next few years I plan on developing an educational program coupled to the Auger Project rather closely—the large participation in the experiment from South America makes Auger a unique experiment with which to with which to reach the Latino/Latina community. Already I have had good luck bringing an Argentine colleague (who was already in the States visiting) to speak before a minorities in science assembly. This is a seriously underrepresented group in the sciences and engineering. Having spoken with a number of community representatives in the Minneapolis and Chicago areas, it seems as though there is considerable interest for a series of public talks as well as some opportunities for less formal mentoring. Interest was high for anyone working extensively on the project and not just for Latin American scientists. I propose to organize about 3–4 talks per year directed at the Latino/Latina community in (initially) Chicago and Mineapolis. The speakers will initially be primarily Auger collaborators, but we plan to expand the focus but the goal remaining to be increasing the diversity of both those students looking at technical careers and those people with some non-professional science interest.

References

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U.S. Department of Energy

Budget Page

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OMB Control No.
1910-1400
OMB Burden Disclosure
Statement on Reverse

ORGANIZATION University of Minnesota	**Budget Page No:**	1 (YR 1)
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR Michael DuVernois	Requested Duration:	12 (Months)

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title; A.6. show number in brackets)	DOE Funded Person-mos. CAL	ACAD	SUMR	Funds Requested by Applplicant	Funds Granted by DOE
1. Michael DuVernois			1.00	7,000.00	
2.					
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. ( ) TOTAL SENIOR PERSONNEL (1-6)				7,000.00	0.00
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES					
2. ( ) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)					
3. (1) GRADUATE STUDENTS				19,631.00	
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL					
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				26,631.00	0.00
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				14,241.00	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				40,872.00	0.00
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.)					
TOTAL PERMANENT EQUIPMENT					
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				1,800.00	
2. FOREIGN				6,400.00	
TOTAL TRAVEL				8,200.00	0.00
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)					
2. TUITION & FEES					
3. TRAINEE TRAVEL					
4. OTHER (fully explain on justification page)					
TOTAL PARTICIPANTS ( ) TOTAL COST				0.00	0.00
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				1,200.00	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES					
5. SUBCONTRACTS					
6. OTHER					
TOTAL OTHER DIRECT COSTS				1,200.00	0.00
H. TOTAL DIRECT COSTS (A THROUGH G)				50,272.00	0.00
I. INDIRECT COSTS (SPECIFY RATE AND BASE) 48.5% (not on graduate student fringe)					
TOTAL INDIRECT COSTS				18,612.00	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				68,884.00	0.00
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES					
L. TOTAL COST OF PROJECT (J+K)				68,884.00	0.00

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U.S. Department of Energy

Budget Page

(See reverse for Instructions)

OMB Control No.

1910-1400

OMB Burden Disclosure

Statement on Reverse

ORGANIZATION University of Minnesota	**Budget Page No:** 2 (yr 2)
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR Michael DuVernois	Requested Duration: 12 (Months)

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title; A.6. show number in brackets)	DOE Funded Person-mos. CAL	ACAD	SUMR	Funds Requested by Applpicant	Funds Granted by DOE
1. Michael DuVernois			1.00	7,280.00	
2.					
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. ( ) TOTAL SENIOR PERSONNEL (1-6)				7,280.00	0.00
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES					
2. ( ) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)					
3. (1) GRADUATE STUDENTS				20,416.00	
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL					
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				27,696.00	0.00
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				14,811.00	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				42,507.00	0.00
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.)					
TOTAL PERMANENT EQUIPMENT					
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				1,800.00	
2. FOREIGN				6,400.00	
TOTAL TRAVEL				8,200.00	0.00
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)					
2. TUITION & FEES					
3. TRAINEE TRAVEL					
4. OTHER (fully explain on justification page)					
TOTAL PARTICIPANTS ( ) TOTAL COST				0.00	0.00
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				1,200.00	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES					
5. SUBCONTRACTS					
6. OTHER					
TOTAL OTHER DIRECT COSTS				1,200.00	0.00
H. TOTAL DIRECT COSTS (A THROUGH G)				51,907.00	0.00
I. INDIRECT COSTS (SPECIFY RATE AND BASE) 48.5% except graduate fringe					
TOTAL INDIRECT COSTS				19,174.00	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				71,081.00	0.00
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES					
L. TOTAL COST OF PROJECT (J+K)				71,081.00	0.00

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U.S. Department of Energy

Budget Page

(See reverse for Instructions)

OMB Control No.

1910-1400

OMB Burden Disclosure

Statement on Reverse

ORGANIZATION University of Minnesota				**Budget Page No:** 3 (yr 3)	
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR Michael DuVernois				Requested Duration: 12 (Months)	
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title; A.6. show number in brackets)	DOE Funded Person-mos.			Funds Requested by Applicant	Funds Granted by DOE
	CAL	ACAD	SUMR		
1. Michael DuVernois			1.00	7,571.00	
2.					
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. ( ) TOTAL SENIOR PERSONNEL (1-6)				7,571.00	0.00
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES					
2. ( ) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)					
3. (1) GRADUATE STUDENTS				21,233.00	
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL					
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				28,804.00	0.00
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				15,403.00	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				44,207.00	0.00
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.)					
TOTAL PERMANENT EQUIPMENT					
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				1,800.00	
2. FOREIGN				6,400.00	
TOTAL TRAVEL				8,200.00	0.00
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)					
2. TUITION & FEES					
3. TRAINEE TRAVEL					
4. OTHER (fully explain on justification page)					
TOTAL PARTICIPANTS ( ) TOTAL COST				0.00	0.00
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				1,200.00	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES					
5. SUBCONTRACTS					
6. OTHER					
TOTAL OTHER DIRECT COSTS				1,200.00	0.00
H. TOTAL DIRECT COSTS (A THROUGH G)				53,607.00	0.00
I. INDIRECT COSTS (SPECIFY RATE AND BASE) 48.5% except graduate fringe					
TOTAL INDIRECT COSTS				19,759.00	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				73,366.00	0.00
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES					
L. TOTAL COST OF PROJECT (J+K)				73,366.00	0.00

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U.S. Department of Energy

Budget Page

(See reverse for Instructions)

OMB Control No.

1910-1400

OMB Burden Disclosure

Statement on Reverse

ORGANIZATION University of Minnesota	**Budget Page No:** 4 (yr 4)
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR Michael DuVernois	Requested Duration: 12 (Months)

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title; A.6. show number in brackets)	DOE Funded Person-mos. CAL	ACAD	SUMR	Funds Requested by Applplicant	Funds Granted by DOE
1. Michael DuVernois			1.00	7,874.00	
2.					
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. ( ) TOTAL SENIOR PERSONNEL (1-6)				7,874.00	0.00
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES					
2. ( ) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)					
3. (1) GRADUATE STUDENTS				22,082.00	
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL					
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				29,956.00	0.00
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				16,020.00	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				45,976.00	0.00
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.)					
TOTAL PERMANENT EQUIPMENT					
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				1,800.00	
2. FOREIGN				6,400.00	
TOTAL TRAVEL				8,200.00	0.00
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)					
2. TUITION & FEES					
3. TRAINEE TRAVEL					
4. OTHER (fully explain on justification page)					
TOTAL PARTICIPANTS ( ) TOTAL COST				0.00	0.00
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				1,200.00	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES					
5. SUBCONTRACTS					
6. OTHER					
TOTAL OTHER DIRECT COSTS				1,200.00	0.00
H. TOTAL DIRECT COSTS (A THROUGH G)				55,376.00	0.00
I. INDIRECT COSTS (SPECIFY RATE AND BASE) 48.5% except graduate fringe					
TOTAL INDIRECT COSTS				20,367.00	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				75,743.00	0.00
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES					
L. TOTAL COST OF PROJECT (J+K)				75,743.00	0.00

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Budget Page

(See reverse for Instructions)

OMB Control No.
1910-1400
OMB Burden Disclosure
Statement on Reverse

ORGANIZATION University of Minnesota	**Budget Page No:** 5 (total)
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR Michael DuVernois	Requested Duration: 48 (Months)

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title; A.6. show number in brackets)	DOE Funded Person-mos. CAL	ACAD	SUMR	Funds Requested by Applpicant	Funds Granted by DOE
1. Michael DuVernois			4.00	29,725.00	
2.					
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. ( ) TOTAL SENIOR PERSONNEL (1-6)				29,725.00	0.00
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES					
2. ( ) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)					
3. (1) GRADUATE STUDENTS				83,362.00	
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL					
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				113,087.00	0.00
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				60,475.00	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				173,562.00	0.00
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.)					
TOTAL PERMANENT EQUIPMENT					
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				7,200.00	
2. FOREIGN				25,600.00	
TOTAL TRAVEL				32,800.00	0.00
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)					
2. TUITION & FEES					
3. TRAINEE TRAVEL					
4. OTHER (fully explain on justification page)					
TOTAL PARTICIPANTS ( ) TOTAL COST				0.00	0.00
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				4,800.00	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES					
5. SUBCONTRACTS					
6. OTHER					
TOTAL OTHER DIRECT COSTS				4,800.00	0.00
H. TOTAL DIRECT COSTS (A THROUGH G)				211,162.00	0.00
I. INDIRECT COSTS (SPECIFY RATE AND BASE) 48.5% except on graduate student fringe					
TOTAL INDIRECT COSTS				77,912.00	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				289,074.00	0.00
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES					
L. TOTAL COST OF PROJECT (J+K)				289,074.00	0.00

Budget justifications

Senior personnel: Michael DuVernois, summer salary support for the PI

Graduate student: Recruiting a student to work on Auger is expected this year.

Fringe benefits: Rates from the University of Minnesota Sponsored Projects (no overhead on graduate student fringe)

Salaries: 4% per year COLA assumed

Travel: Two domestic and four foreign (Argentina) trips per year assumed. Domestic trips for Auger collaboration meetings and working groups and Argentina travel for research, to work on the experiment on site.

Materials and supplies: Telephone, copying, fax, and teleconference for working with an international collaboration.

Equipment: None