# AC 2009-1964: RESEARCH ALLIANCE IN MATH AND SCIENCE (RAMS): AN EXCELLENT RESEARCH INTERNSHIP PROGRAM FOR MINORITY SCIENCE AND ENGINEERING STUDENTS

**Xiaoqing Qian, Alabama A&M University**

Dr. Xiaoqing (Cathy) Qian is an Associate Professor in the Mechanical Engineering Department of Alabama A&M University. Dr. Qian is also Director of High Performance Computing Research and Education project at Alabama A&M University.

**Zhengtao Deng, Alabama A&M University**

Dr. Z.T. Deng is a Professor in the Mechanical Engineering Department of Alabama A&M University.

**George Seweryniak, DoE Computational Science Division**

Dr. George Seweryniak is a program manager in the Office of Advanced Scientific Computing Research of DOE.

**Debbie McCoy, Oak Ridge National Lab**

# Research Alliance in Math and Science (RAMS) - An Excellent Research Internship Program for Minority Science and Engineering Students

Xiaoqing (Cathy) Qian, Z.T. Deng
Department of Mechanical Engineering
Alabama A&M University, Normal, Alabama

George Seweryniak
Office of Advanced Scientifc Computing Research, U.S. Department of Energy
Washington, D.C.

Debbie McCoy
Computing and Computational Sciences Directorate
Oak Ridge National Laboratory, Oak Ridge, Tennessee

## Abstract

The Research Alliance in Math and Science (RAMS) program is a twelve-week summer research internship program for under-represented students majoring in computer science, mathematics, engineering and technology. It is carried out through the Computing and Computational Sciences Directorate at Oak Ridge National Laboratory (ORNL). The objective of the RAMS program is to identify students and faculty members in computer sciences, mathematics, engineering, and technology disciplines for summer internships in support of the long-term goal of increasing the number of under-represented minorities with advanced degrees in the workforce. In the past eight years, more than 100 student interns have been appointed and mentored in the ORNL computing directorate. The RAMS program continues to create high impact on Historically Black Colleges and Universities (HBCU) and other minority educational institutions. Alabama A&M University (AAMU) has been collaborating with ORNL since 2001. This paper describes the RAMS program impact on undergraduate computational science activity in AAMU. The RAMS student research activities indicated that the RAMS summer intern research program provided excellent training for minority undergraduate science and engineering students at AAMU in the area of computational science. The RAMS program opened students' eyes to the fascinating world of scientific computing.

## Background

According to the 1990 U.S. census, the total U.S. population was 248,709,873. Of these, approximately 51% were women, 29,986,060 (or 12%) were African American, 22,354,059 (or 9%) Hispanic, and 1,878,285 (or 1%) were Native American. In 1995, of the total 132 million in the U.S. civilian labor forces, only 5500 African Americans who had Ph.D. degrees in Science, Mathematics, Engineering and Technology (SMET) were employed in the SMET field. Only 5.6% of the enrollment in graduate school SMET disciplines is African American, Hispanic American and Native American students. In 2004 African Americans

earned 1,869 doctoral degrees. This number has increased more than 9 percent from a year ago. Black doctorates now stand at the highest level in history. [1] However, 41.3 percent of all doctorates awarded to African Americans in 2004 were in the field of education. This large percentage of all African-American doctorates in the field of education has been the case for decades with only minor fluctuations. There is a serious weakness in minority participation in doctoral programs in the area of science, mathematics, engineering and technology.

To prepare and train minority students for graduate study in SMET field, the Office of Advanced Scientific Computing Research, Office of Science of the U.S. Department of Energy created an Alliance for Computational Science Collaboration in 2000. As a result, the RAMS program was initiated by ORNL in order to encouraging under-represented students to pursue advanced degrees in computational science, mathematics and engineering.

**RAMS Program at ORNL**

As described in *Oak Ridger* [2],

> *"… The RAMS program gives talented, highly motivated students an opportunity to put their fresh ideas and energetic drive into action on high-visibility, national-priority research projects, a press release stated. Funded by the Mathematical, Information and Computational Sciences Office of Advanced Scientific Computing Research under the U.S. Department of Energy, the program promotes collaborative efforts between national laboratories and universities to improve the quality and diversity of the U.S. workforce. The project is administered through the Computing and Computational Sciences Directorate at ORNL. RAMS participants gain cooperative research experience with students and faculty from other universities, as well as researchers from DOE's national laboratories. The program is aimed at increasing the number of under-represented populations in the workplace by encouraging students to pursue advanced degrees in computer science, computational science, mathematics, engineering, and technology. …"*

The RAMS program is a twelve-week summer research internship program at ORNL for undergraduate and graduate minority science, engineering and technology students. Application for the program is posted on the RAMS website (http://computing.ornl.gov/internships/rams/) January each year. Students who apply for the internship program are required to submit on-line applications, official transcripts, and an essay describing how to handle difficult situations or problems. Students were also required to work with his/her faculty advisor to develop a research proposal for the summer internship project. In the research proposal, the student is required to identify research of interest to ORNL, and describe their experience and educational background. This is a critical element of the application because it encourages student to become familiar with the ongoing research projects at ORNL.

To assist in identifying students and developing the research proposal, a faculty mentor workshop is offered for university faculty advisors each year prior to students RAMS application. As indicated in Figure 1, more than 13 HBCUs and Minority Institutions participated in the 2007 workshop. In the workshop, RAMS summer research internship applications and selection criteria are discussed. The DOE program managers offer updates on HBCU programs, ORNL mentors and scientists present their on-going research projects and their expectations from student interns. These workshops provide an excellent opportunity for faculty to learn on-going research activities at ORNL and a platform for faculty collaboration with ORNL scientists. Faculty advisors are also able to provide advice to students on research proposals.



Figure 1. RAMS Faculty / Mentor Workshop held at ORNL in December 2007 [3,4,5]. Research topics in climate modeling, computational science, and computational biology were discussed.

In addition to student applications, two faculty advisors recommendation letters are required. Once the complete application package is received, the RAMS program administrator and computational scientists review the application. Students are required to meet a minimum GPA of 2.8-3.0 to be eligible for RAMS internships. After a student is selected to participate in the summer research program, an agreement letter for commitment to full participation has to be signed by both the student applicant and a faculty advisor. The student has to accept the commitment of working at ORNL for 12 weeks during the specified summer term and to completion of all requirements of the program. A competitive stipend is also offered through RAMS internship agreement.

Elements of the RAMS program include the research project, a poster presentation, an oral presentation, and a summary paper, as well as site tours, workshops, and technical seminars. Research topics for RAMS summer internships at ORNL include computational biology,

modeling of aneurisms and medical devices, cluster computing, complex systems, dynamic traffic simulation, population distribution, visualization, virtual environments for homeland security applications, and a wide range of projects in algorithm development. More than 100 undergraduate and graduate student interns, majoring in mathematics, computer science, chemistry, biology and engineering, from more than two dozen colleges and universities in the nation have been supported from 2003 to 2008.

**Collaboration between AAMU and ORNL**

In 2001, the office of Advanced Scientific Computing at DOE awarded a grant to Alabama A&M University to conduct high-performance computational science research and education. In 2005, a continuation grant was awarded [6]. The objective of the project at AAMU was to enhance computational science research and education activities in AAMU. As indicated in Figure 2, AAMU's grant has four elements: (1) Establish a high Performance Computing laboratory; (2) Conduct a DOE Computational Science scholarship program; (3) Provide Minority undergraduate summer research interns at the computational science division of ORNL and (4) Conduct research in high performance computing and support graduate student research in the area of high performance computing. Twenty per cent of the grant was dedicated to support ORNL-RAMS internships. The goal of this collaboration is to use funding from AAMU and ORNL to support more undergraduate RAMS interns. From 2001-2008, 18 AAMU undergraduate students from computer science, chemistry and engineering have participated RAMS program.
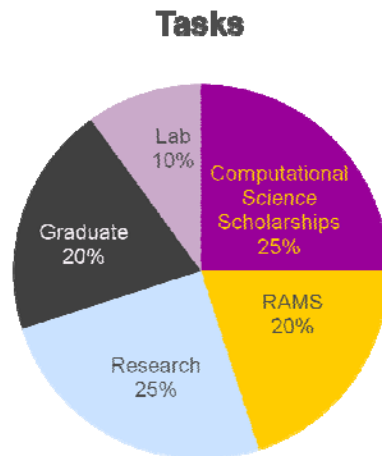


Figure 2. Research and Education Task distribution of DoE Grant at AAMU.

RAMS interns are recruited by AAMU faculty advisors. Students come from the department of physics, mathematics, chemistry, biology, mechanical engineering, electrical engineering, civil engineering and computer science. All AAMU applicants are evaluated by an AAMU faculty advisor before submitting RAMS applications. Applicants are introduced to ORNL on-going research activities and student summer research proposals are generated with the help of a faculty advisor. Applicants are also carefully reviewed by ORNL mentors. Once selected by RAMS, AAMU RAMS interns were provided support to participate in 12 weeks of research and study at ORNL. Student performance is closely monitored by the joint effort

of an AAMU faculty advisor and RAMS administrators and mentors. At the end of internship, the outcome of the research is evaluated by written report and oral presentation, which is judged by ORNL scientists and faculty mentors from HBCUs in Tennessee, Alabama, North Carolina and Georgia. Faculty advisors, mentors and parents are invited to the RAMS recognition event and award banquet where students make their project poster presentation again. Summer interns from AAMU are also required to present their research results at the workshop on AAMU campus.

**RAMS Program Impact to Computational Science Activity in AAMU**

AAMU does not have a computational science program. The computational science research activities are limited to faculty individual efforts. With the support of DoE, AAMU was able to award ten computational science scholarships each year to top science, engineering and mathematics undergraduate students at AAMU. Scholarship recipients provide a large pool of candidates for RAMS interns.

It was noticed that students with high GPAs are likely to receive summer internships from variety of sources. This is especially true in AAMU where many high-tech research companies are located nearby. In order to attract science and engineering students to computational science, we interviewed potential RAMS applicants prior to their application. Faculty evaluated the applicant's academic strength, the student's interest in computational science and the student's programming capability. If a student demonstrated a great potential and interest in computational science, but currently suffered by low GPA, we still recommend the student to apply for the summer research internship program.

It is important to know that computational science requires intensive training in mathematics, science and engineering as well as in programming. Through ORNL RAMS workshops, faculty at AAMU was trained in computational science. ORNL computational science activities were then introduced to undergraduate classes. In the past six years, the high-performance computing concept is introduced in the undergraduate curriculum through two classes: Mathematical Methods in Mechanical Engineering, and Heat Transfer. In the math methods class, numerical algorithms are introduced. In heat transfer class, students are required to develop a computer program to model two-dimensional heat conduction. Parallel computing concepts are introduced. As a result of this teaching effort, the summer interns of 2002 and 2003 at ORNL are able to extend the heat transfer computing project to conduct parallel computation for three-dimensional heat conduction.

The RAMS student research projects cover a wide range of leading edge computational science and engineering applications involving chemistry, computer science, engineering and decision making. As an evidence of improving minority student computational science training, AAMU RAMS interns have completed variety of research projects involving engineering, chemistry and computational science as listed in Table 1. Detailed project abstract and result discussion can be found on RAMS program website, http://computing.ornl.gov/internships/rams/. Examples of project results are shown in Figure 3. RAMS interns are also encouraged to submit their summer research findings to

professional meetings. In summer 2005, one RAMS undergraduate student from AAMU published a joint research paper with ORNL scientists entitled, "Discovery of New Global Minima for the Lennard – Jones Atomic Clusters Using TRUST Simulations."

Table 1. AAMU RAMS Internship Student Research Projects

| #1 | *"An Introduction to Parallel Cluster Computing using PVM for Computer Modeling and Simulation of Engineering Problems"* |
|---|---|
| #2 | *"Parallel Solution of 2-D Heat Equation Using Laplace Finite Difference"* |
| #3 | *"Modeling of Fiber Networks"* |
| #4 | *"3-D Heat Conduction on a LINUX Cluster using PVM"* |
| #5 | *"The Use of Object Oriented Languages to Make Interactive Web Pages"* |
| #6 | *"Parallel Exact Stochastic Simulator"* |
| #7 | *"Simulation Modeling of Medical Devices"* |
| #8 | *"Comparison Algorithm for Decent Speeds in Local Minimization Process for TRUST"* |
| #9 | *"Source Localization in a Moving Sensor Field"* |
| #10 | *"Three-Dimensional Grain Growth Model using Phase Field Approach"* |
| #11 | *"Computational Modeling of Scanning Microscopy"* |
| #12 | *"Porting the CESAR Source Localization of Underwater Targets Code to the Intel Visual Fortran Compiler"* |
| #13 | *"Fiber Bundle Modeling for Nacre Fracture Simulation"* |
| #14 | *"Regression Testing for NCCS Computers"* |
| #15 | *"Fast Algorithms for Flash Hyperspectral Image Reconstruction"* |
| #16 | *"Parallelization of a Non-Linear Analysis Code"* |
| #17 | *"Large Scale Simulations of Thin Film Grain Growth"* |
| #18 | *"Analysis of Negative Effects and Possible Contingency of the Northeastern Blackout in 2003"* |



(Project #17)

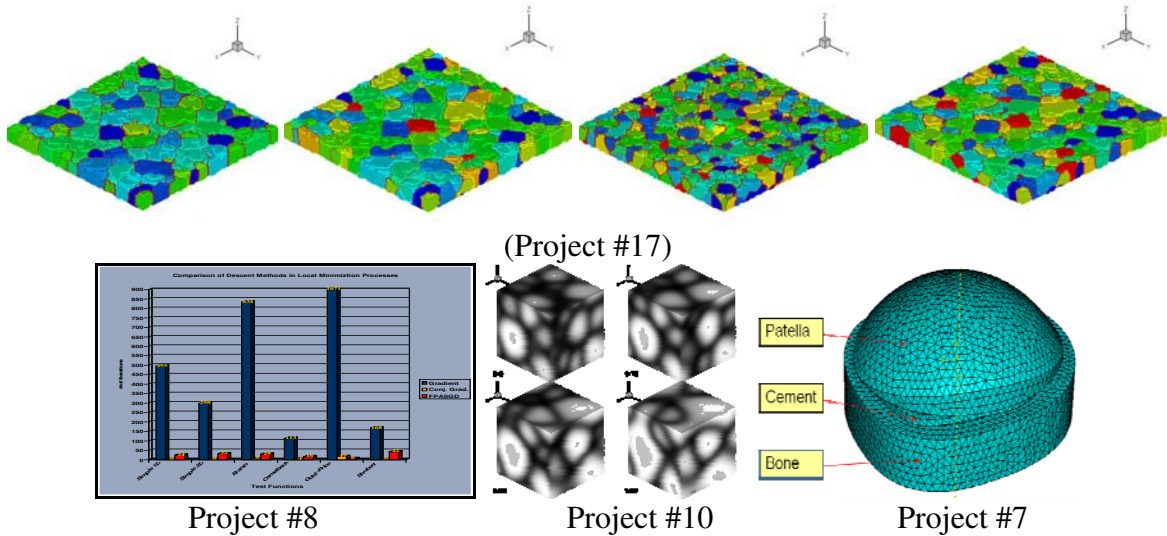Project #8          Project #10          Project #7

Figure 3. Examples of AAMU RAMS project results.

RAMS program is different from the traditional summer internship programs because the activity after RAMS internship have brought positive impact to AAMU science and

engineering students in the area of computational science. When RAMS interns return to school in the Fall semester, they bring their research papers and posters back to school. Their research posters are displayed at the school open house, high school senior day at AAMU, Science, Mathematics, Engineering and Technology (SMET) day at AAMU and high performance computing workshops at AAMU. Interns are provided a chance to present their research project and experience at ORNL to fellow science and engineering students. RAMS program brought computational science to life to undergraduate students at AAMU. All RAMS interns from AAMU expressed their interest to work in the computational science area. More importantly, six RAMS interns from AAMU are currently attending graduate schools and have continued their graduate study in the area of science and engineering. A 2008 RAMS intern is currently studying computational science in graduate mechanical engineering program in North Carolina.

**Assessment**

The RAMS program is evaluated by an external review panel periodically. Scientists and program managers working in the area of computational science research and education from different organizations are invited by DOE headquarters program sponsor to form the review panel. RAMS internship mentors, faculty advisors and interns make presentations about the RAMS program and the impact the program has had on them. RAMS student performance is closely monitored by joint effort of the AAMU faculty mentor and RAMS administrators and mentors. A success story about impact of RAMS on minority student was found in the article published in *Minority Science Network* [7], January 2005,

> *" [RAMS Intern Student Name] walks through the halls of Huntsville, Alabama's A&M University proudly carrying the souvenir bag he got from being an undergraduate researcher at the Oak Ridge National Laboratory (ORNL), the Department of Energy's (DOE) largest science laboratory, and one of the most prestigious government-run labs in the U.S. The summer he spent in Tennessee at ORNL's Research Alliance in Math and Science (RAMS) Program inspired him to include ORNL into his plans for graduate school in mechanical engineering. "As long as I can do research with them, I'll be happy no matter what university [I get into]," he says. This is music to the ears of … RAMS program administrator, because attracting more underrepresented minorities to careers in science is exactly what she's trying to do. "The long-term goal is to prepare [underrepresented minorities] to become those critical staff scientists that we need for the future workforce, hopefully here [at ORNL]."…."*

RAMS program is aimed at increasing the number of under-represented populations in the workplace by encouraging students to pursue advanced degrees in SMET field. RAMS program provide opportunities to both undergraduate and graduate students. The majority of the RAMS interns are undergraduate students. Graduate RAMS interns are recruited in the later years of the RAMS program. In order to quantitatively measure the impact of RAMS program on minority students taking advanced degree in SMET field, a long-term RAMS students tracking system has to be established.

## Conclusion

The RAMS summer intern research program and its impact to undergraduate computational science activity at AAMU was described. The RAMS program has provided more than 100 summer research internships to minority undergraduate and graduate science, mathematics and engineering students and continues to make impact on HBCUs and minority serving institutions. In collaboration with ORNL, AAMU was able to award 18 undergraduate RAMS internships in the past 8 years. Through RAMS training, undergraduate students learn computational science at ORNL, and conduct leading-edge research projects in computational science. Many interns return to ORNL in the following summer and work in the area of computational science. Six RAMS interns from AAMU are currently attending or have completed graduate school in the area of SMET. The RAMS program has created significant impact on student computational science training; RAMS interns become ambassadors in their schools to promote computational science; and more importantly, the RAMS experience has created a positive influence to fellow students in science and engineering. This dynamic, circular process continues.

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