‘Iron Sun’ is not a rock band, Sandia researchers find

By Neal Singer

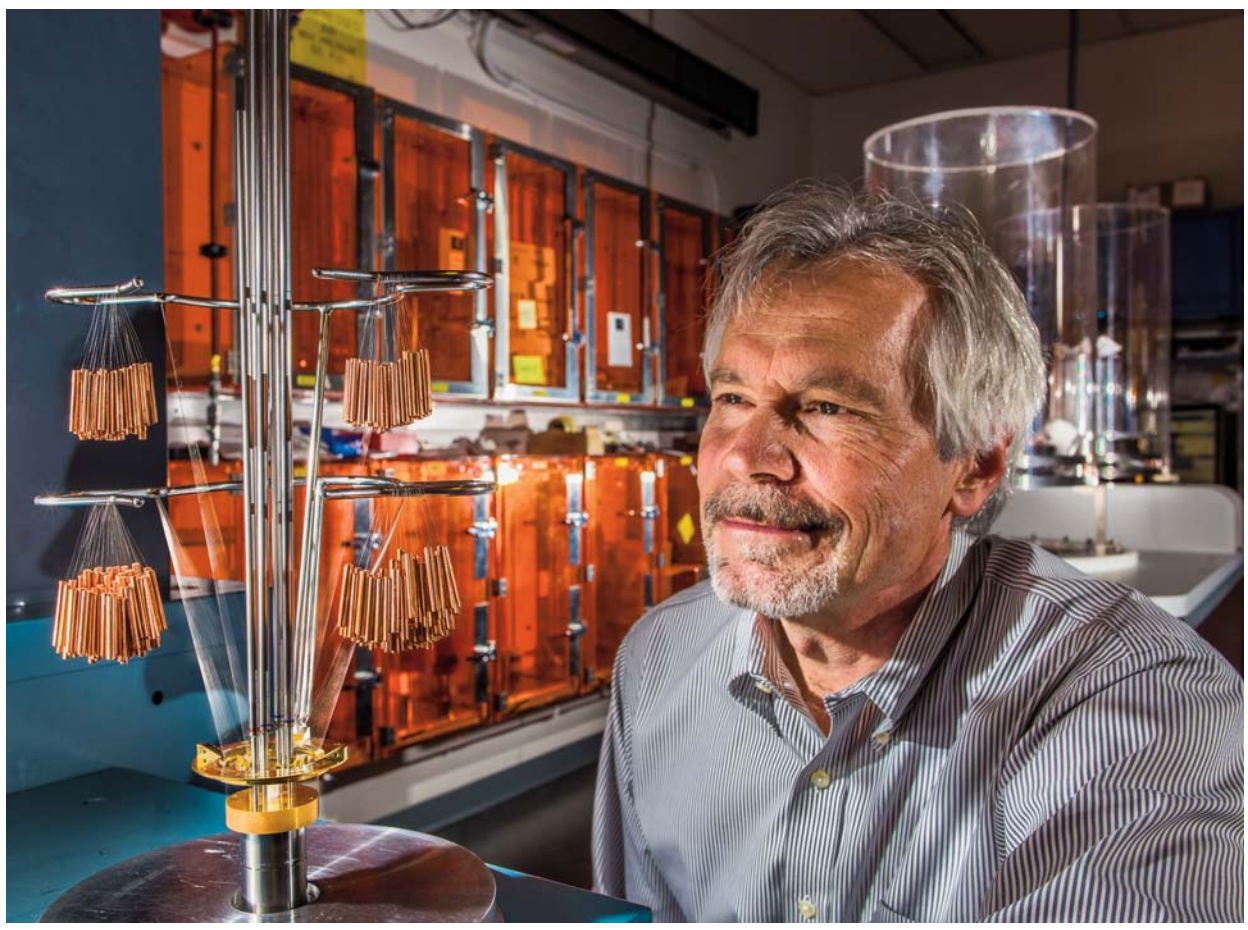
Working at temperatures matching the interior of the sun, researchers at Sandia’s Z machine have been able to determine experimentally, for the first time in history, iron’s role in inhibiting energy transmission from the center of the sun to near the edge of its radiative band.

Because that role is much greater than formerly surmised, the new, experimentally derived amount of iron’s opacity — essentially, its capacity for hindering the transport of radiative energy originating in nuclear fusion reactions deep in the sun’s interior — helps close a theoretical gap for a theory called the Standard Solar Model, widely used by astrophysicists as a foundation to model the behavior of stars.

“Our data, when inserted into the theoretical model, bring its predictions more closely into alignment with physical observations,” says lead investigator Jim Bailey (1683). His team’s work appeared Jan. 1 in the journal *Nature*.

The gap between the model and observations appeared in 2000 when analysis of spectra emerging

(Continued on page 4)



THE SUN NEVER LOOKED SO CLOSE — Physicist Jim Bailey observes a wire array that will heat foam to roughly 4 million degrees until it emits a burst of X-rays that heats a foil target to the interior conditions of the sun. Working at Sandia’s Z machine, Jim and his team have been able to determine experimentally, for the first time in history, iron’s role in inhibiting energy transmission from the center of the sun to near the edge of its radiative band. (Photo by Randy Montoya)

DuPont Safety Survey results show progress, opportunity

See page 2

Sandia LabNews

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Sandia National Laboratories

Predicting pressure-dependent chemical reaction rates

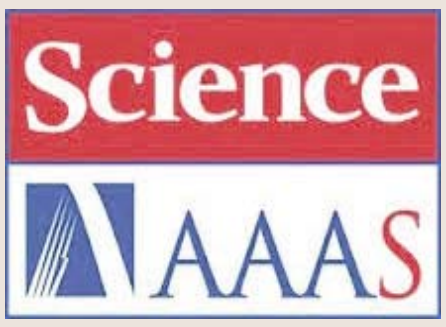
Breakthrough reported in Dec. 5 Science

By Mike Janes

Researchers at Sandia and Argonne national laboratories have demonstrated, for the first time, a method to successfully predict pressure-dependent chemical reaction rates, an important breakthrough in combustion and atmospheric chemistry that is expected to benefit auto and engine manufacturers, oil and gas utilities, and other industries that employ combustion models.

A paper describing the work, performed by researchers at Sandia’s Combustion Research Facility and Argonne’s Chemical Sciences and Engineering Division, is featured in the Dec. 5 edition of *Science*.

Combustion scientists have worked for years to better understand the thousands of chemical reactions that take place during the combustion process, says Sandia’s Ahren Jasper (8353), the paper’s lead author.



A PAPER DESCRIBING a method to predict pressure dependent chemical reaction rates, performed by researchers at Sandia’s Combustion Research Facility and Argonne’s Chemical Sciences and Engineering Division, is featured in the Dec. 5 edition of *Science*.

As they determine and understand the speeds and outcomes of more and more of these reactions, he says, they can use models to more fully characterize and predict what’s occurring inside an engine, leading to more accurate predictions regarding combustion efficiency and the emissions formed during the combustion process.

A more detailed fundamental understanding of the chemistry of combustion, in turn, may lead to cleaner and more efficient strategies in automotive vehicle and fuel design.

Pressure-dependent reactions historically a vexing problem

Many of the key steps underlying gas-phase

(Continued on page 3)

Sandia legend Ben Benjamin participated in Trinity test

BEN BENJAMIN, who worked on the Manhattan Project, is seen here at the Trinity site, a location he visited often as a senior mentor in Sandia’s Weapon Intern Program. Ben passed away in late November. Sandia historian Rebecca Ullrich shares highlights of Ben’s remarkable career in a story on **page 6.**

Sandia was a pioneer in dawn of a new, diverse workforce

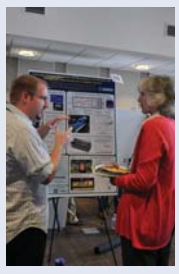
SANDIA PLAYED A KEY ROLE in the early years of the equal employment movement as one of the first organizations to sign on to the Plans for Progress, a program created by US employers to end discrimination and build job opportunities for minorities. Longtime Sandians Ken Holley and Ivory Alexander share their own experiences in a story on **page 8.**

Hydrogen CRADA

Sandia and industrial gas giant Linde LLC have signed an umbrella CRADA that is expected to accelerate the development of low-carbon energy and industrial technologies, beginning with hydrogen and fuel cells. Read about it on **page 3.**

Photometrics: Worth 1,000 words

Images are only a small part of what this team does. See **page 5.**



Postdocs shine

Sandia’s 8th annual Postdoc Technical Showcase featured technical posters from postdoctoral appointees across the Labs and honored both the winners of the poster session and distinguished postdoc mentors. See **page 4.**

That's that

Do you know the song *I Gotta Feeling* by the Black Eyed Peas? The signature lyric is "I gotta feeling/tonight's gonna be a good night." Over the past few years, that song has become a party anthem akin to Kool & the Gang's timeless *Celebration*. It's a happy-time song. You get a good feeling hearing it. All of this is by way of leading up to my point: I gotta feeling 2015 is gonna be a good year for Sandia.

Why the optimism? Well, for one thing, I've been compiling this year's Labs Accomplishment submissions for the document we'll publish sometime in March. And they look good, maybe the most impressive representation of the broad scope of our work I've seen in a while. We're on a roll and I feel it building. According to my Briggs-Myers score (for what it's worth) I am an "intuitive thinker" and my intuition tells me we're going to accomplish great things in 2015.

Then there's the fact that the nation needs us — I won't say more than ever; that would be a hard case to make when there was a time in living memory when the Soviet Union had 50,000 nuclear warheads with our name on them. But there's no doubt that the threats we face today are serious ones, as serious as they've been for some time. And we at Sandia do really well when asked to rise to a challenge. As Labs Director Paul Hommert says: "We don't do easy. We do hard."

We've seen a few leadership transitions over the past couple of months. I don't have any special insight and certainly no inside track on information, but the changes aren't all that surprising. That's the nature of an institution. By any fair description, some of the folks who are retiring have been titans at the Labs, the personal embodiment of the very best that Sandia can be. But as we begin the new year, I'm reminded of something Executive VP Kim Sawyer said about the subject in a recent interview: "Sandia's leadership team focuses a lot of attention on talent management and ensuring that we're preparing our employees for the next step and new opportunities."

I've been here long enough to know how right Kim is: At Sandia, there is always somebody ready to step up. The next generation of titans is already here. You may be one yourself. Or work next to one in your office or lab. I feel privileged to be a Sandia storyteller, writing about our great people and our great deeds on behalf of the nation.

George Jones, the legendary country singer, had a song a few years ago, called *Who's Gonna Fill Their Shoes?* In it, he laments the passing of a generation of country music giants: Johnny Cash, Merle Haggard, Hank Williams, Marty Robbins, Charlie Pride, Charlie Rich — a hall of fame of golden-age balladeers. In the song he asks, Who's gonna fill their shoes/Who's gonna stand that tall/Who's gonna play the Opry/And the Wabash Cannonball?/Who's gonna give their heart and soul/To get to me and you/Lord I wonder, who's gonna fill their shoes?

I think you see where I'm going with this: Even as Jones was singing this song, artists like George Strait, Randy Travis, Reba McIntire, and a whole lot of others were taking country music to new heights. The same is true here. Country music is fine. And so are we.

* * *

Speaking of transitions, I'm told a couple of hundred people showed up at the Steve Schiff Auditorium in late December for a pre-retirement seminar. These were folks who have not necessarily made the definitive decision to leave the Labs but are thinking seriously about it. Far be it from me to try to dissuade anyone from such a momentous life move, but let me pass along a conversation I had with a retiree friend just the other day.

He was a Cold War-era field test guy who was right in the thick of things when the Soviets posed an existential threat to us. When he left, the global threat thermometer had gone way down. But as things have heated back up, he has begun to feel restless. He knows he's too old now to return and, sadly, not in the best of health, but he says he'd give anything to be back in the saddle here. "I'd love to help take these guys down," he says of adversaries who have made global headlines with singular acts of cruelty against fellow Americans.

Anyhow, if you are thinking about retiring this year, I thought I ought to pass along that I've heard from more than one retiree over the years that looking back they feel that they left too soon. Just sayin'.

See you next time.

— Bill Murphy (MS 1468, 505-294-1778, wtmurph@sandia.gov)

2014 Safety Survey Results

By Janeen Miller

In August, Sandians were asked to share their thoughts about safety by taking the 2014 Safety Survey. The survey, fielded by DuPont, used employee responses from 30 questions to identify safety-related strengths and opportunities in three categories: leadership; structure; and process and actions. The results also were used to compare current survey results to the 2005 survey and against results from a set of industries meeting size and high safety performance criteria.

"I'd like to thank all who participated in the survey," says Sandia President and Laboratories Director Paul Hommert. "You feedback is invaluable and is the basis of the independent benchmark that guides our focus on improvements. I urge each of you to a look at the results and take the initiative to improve in an area that resonates with you."

The Bradley Curve

Since 1999, DuPont has tracked safety information and metrics from diverse industries, including other national labs, to better understand how an effective safety culture develops. In 2009, using information from more than 427,000 responses, DuPont created the Bradley Curve (see chart below) to demonstrate the correlation between the strength of an organization's safety culture and its injury frequency rate and sustainable safety performance.

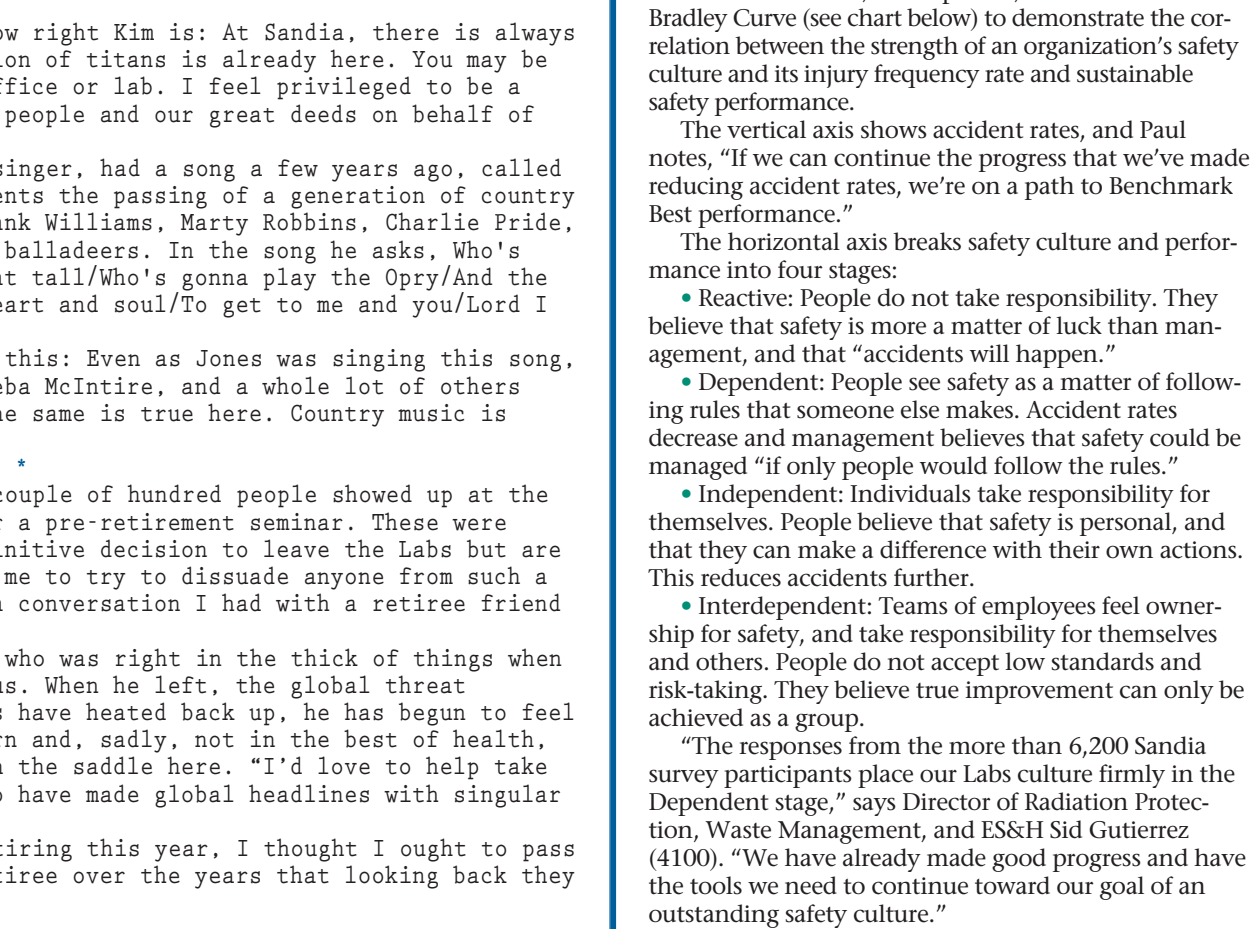
The vertical axis shows accident rates, and Paul notes, "If we can continue the progress that we've made reducing accident rates, we're on a path to Benchmark Best performance."

The horizontal axis breaks safety culture and performance into four stages:

- Reactive: People do not take responsibility. They believe that safety is more a matter of luck than management, and that "accidents will happen."
- Dependent: People see safety as a matter of following rules that someone else makes. Accident rates decrease and management believes that safety could be managed "if only people would follow the rules."
- Independent: Individuals take responsibility for themselves. People believe that safety is personal, and that they can make a difference with their own actions. This reduces accidents further.
- Interdependent: Teams of employees feel ownership for safety, and take responsibility for themselves and others. People do not accept low standards and risk-taking. They believe true improvement can only be achieved as a group.

"The responses from the more than 6,200 Sandia survey participants place our Labs culture firmly in the Dependent stage," says Director of Radiation Protection, Waste Management, and ES&H Sid Gutierrez (4100). "We have already made good progress and have the tools we need to continue toward our goal of an outstanding safety culture."

All VPs, directors, and senior managers have received results and employee comments pertinent to their division and will be discussing them with their teams in early 2015. To ensure confidentiality, no reports were generated for organizations with under 20 responses.



The DuPont Bradley Curve indicates Sandia's improvement in safety culture and recordable safety incident rates from the 2005 to the 2014 surveys, as well as what it takes to be considered among the benchmark best.

Sandia LabNews

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LOCKHEED MARTIN

Linde, Sandia partnership looks to expand hydrogen fueling network, boost H_2 research

By Mike Janes

Sandia and industrial gas giant Linde LLC have signed an umbrella cooperative research and development agreement (CRADA) that is expected to accelerate the development of low-carbon energy and industrial technologies, beginning with hydrogen and fuel cells.

The CRADA will kick off with two new research and development projects to accelerate the expansion of hydrogen fueling stations to continue to support the market growth of fuel cell electric vehicles proliferating among the major auto manufacturers. On Nov. 17, Toyota became the latest to unveil a fuel cell electric vehicle.

Last week, Linde opened the first-ever, fully certified commercial hydrogen fueling station near Sacramento with support from the California Energy Commission.

Kickoff projects will help increase H_2 fuel station openings

A recent Sandia study, funded by DOE's Fuel Cell Technologies Office in the Office of Energy Efficiency and Renewable Energy (EERE), determined that 18 percent of fueling station sites in high-priority areas can readily accept hydrogen fueling systems using existing building codes.

The development of meaningful, science-based fire codes and determinations, such as those found in that study, shows that focusing on scientific, risk-informed approaches can reduce uncertainty and help to avoid overly conservative restrictions to commercial hydrogen fuel installations.

Continuing down this path, the first project in the Sandia/Linde CRADA will demonstrate a hydrogen fuel station that uses a performance-based design approach allowable under the National Fire Protection Association hydrogen technologies code, NFPA 2. The project will include support from DOE.

California's Alternative and Renewable Fuel and Vehicle Technology Program states that Linde expects to open new fueling stations in late 2015.

SANDIA AND LINDE are partnering to accelerate the development of low-carbon energy and industrial technologies, beginning with hydrogen and fuel cells. To that end, Linde recently opened the first-ever, fully certified commercial hydrogen fueling station near Sacramento. (Photo courtesy of Linde)

NFPA 2 provides fundamental safeguards for the generation, installation, storage, piping, use, and handling of hydrogen in compressed gas or cryogenic (low temperature) liquid form and is referenced by many fire officials in the permitting process for hydrogen fueling stations.

"Sections of NFPA 2 are typically not utilized by station developers, as they instead have focused more on rigid distance requirements for fuel dispensers, air intakes, tanks, storage equipment, and other infrastructure," says Sandia risk expert and fire protection engineer Chris LaFleur (6231).

"We know we can get hydrogen systems into more existing fueling facilities if our risk analyses show how they meet the code," she says. "This will help boost the developing fuel-cell electric vehicle market significantly."

The project, Chris adds, will provide a foundation for the hydrogen fueling industry to implement the performance-based approach to station design and permitting, leading to sustained expansion of the hydrogen fueling network. The pilot demonstration, she says, will provide clear evidence that a performance-based design is feasible.

Infrastructure, safety the focus of second project

"Linde's business interests in building and operating more hydrogen fueling stations for retail use align perfectly with our research goals aimed at accelerating clean and efficient energy technologies into the marketplace," says Chris San Marchi (8367), lead researcher in Sandia's hydrogen safety, codes, and standards program.

"We expect our investment with Sandia will lead to a broader consortium of other commercial partners," says Nitin Natesan, business development manager at Linde. "We're happy to lead the way for industry, but ultimately we need others on board to join the effort to address barriers to entry of hydrogen fueling infrastructure."

The second project taking place under the new CRADA focuses on safety aspects of the NFPA code and entails modeling a liquid hydrogen release.

"With Linde's help, we're developing a science-based approach for updating and improving the separation distances requirements for liquid hydrogen storage at fueling stations," says Chris LaFleur. Previous work only examined separation distances for gaseous hydrogen, she says, so validation experiments will now be done on the liquid model.

Sandia's Combustion Research Facility, for years considered a pre-eminent facility for studying hydrogen behavior and its effects on materials and engines, is a key element of the research.

This focus on improving the understanding of liquid hydrogen storage systems, Chris LaFleur says, will result in more meaningful, science-based codes that will ensure the continued expansion of safe and available hydrogen fuel to meet fuel cell electric vehicle demands.

This work is aligned with Hydrogen Fueling Infrastructure Research and Station Technology (H_2FIRST), an EERE project established earlier this year, and builds on over a decade of DOE investments in developing meaningful codes and standards to accelerate hydrogen and fuel cell markets in the US.

Researchers report breakthrough in predictions of pressure-dependent combustion chemical reactions

(Continued from page 1)

combustion involve elementary chemical reactions that are strongly pressure-dependent, and a detailed description of these reactions is required for researchers who develop combustion models.

But, while significant progress has been made over the years in understanding combustion chemistry, the outcome and rates of pressure-dependent chemical reactions — those that depend on the pressure of the gas in the engine — have been very difficult to predict. These reactions depend on the pressure because the redistribution of energy that occurs when the reacting molecules collide with other gas molecules changes the outcome of the reaction.

Most previous research has focused on qualitative parametric studies to determine how energy transfer rates depend on various properties of a molecule, but no accurate method had ever been developed to make *a priori* predictions (those based on theoretical deduction rather than evidence-based observation) of the rate constants.

"We've desperately needed the ability to compute and calculate precisely how this important class of chemical reactions depends on temperature and pressure, and now we have that," says Ahren.

Focus on energy transfer leads to technical solution

In arriving at a technical solution, Ahren focused on modeling the collisions of molecules in atomistic detail and the characterization of energy transfer that takes place as a result of those collisions. "We succeeded by using more accurate models for describing the interaction of the colliding species and by focusing on only those aspects of energy transfer that are most relevant in determining the reaction rate," he says, which allowed the researchers to develop a detailed description of the outcomes of the collisions.

Ahren and his colleagues then were able to obtain that information using direct "classical trajectories" that explicitly describe the motion of the atoms in the molecules and to use this information in calculating chemical reaction rates.

A key step, Ahren says, was the development of a model for the collisional energy transfer function that both reproduced detailed features predicted by the trajectories and that was simple enough to be used in practical reaction rate calculations.

"Finding a way to accurately compute the energy transfer from these vibrationally excited molecules proved to be the final piece needed to solve the problem," says Ahren.

Inter-lab cooperation pays dividends

Ahren is quick to credit colleagues at Argonne National Laboratory and mentors at Sandia who contributed to the work.

The *Science* paper was co-authored by Stephen Klippenstein and Larry Harding, both Distinguished Fellows at Argonne, and the influential combustion modeler Jim Miller, a former Sandia staff member now at Argonne. This work continues the team's longstanding effort developing master equation and elementary reaction rate theories.

"A close but loose-knit working group was developed with these combustion modeling experts over the years, and we've developed excellent professional relationships that have led to this technical achievement," says Miller.

The work was supported by DOE's Office of Science.

Postdoc Showcase highlights postdoc technical contributions, outstanding postdoc mentors

By Sue Major Holmes

Sandia's 8th annual Postdoc Technical Showcase featured technical posters from postdoctoral appointees across the Labs and honored both the winners of the poster session and distinguished postdoc mentors.

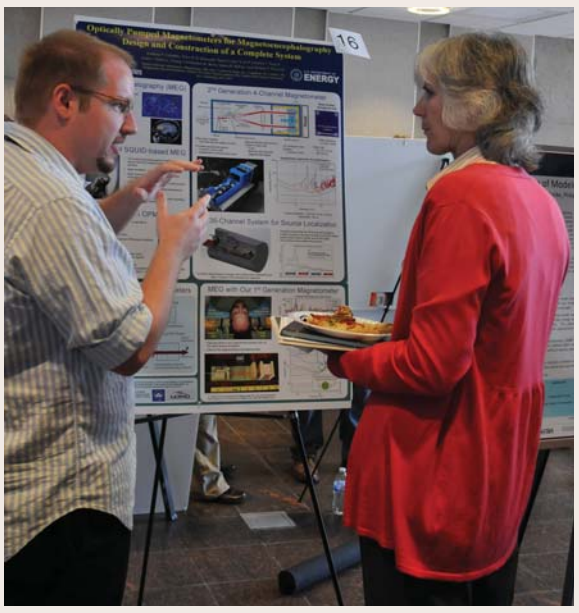
Sandia's Postdoctoral Professional Development Program (PD2P) sponsors the December showcase to highlight postdocs' work, create opportunities for them to advance professional skills, and help them move into research careers. Sandia has about 170 postdocs split between New Mexico and California. The breadth of research they contribute to the Labs was highlighted by the 25 entries in New Mexico and 10 in California, including three from Lawrence Livermore National Laboratory (LLNL), whose postdocs participated through a cross-laboratory collaboration.

Marianne Walck, director of Geosciences, Climate, and Consequence Effects Center 6900, welcomed those attending the New Mexico session Dec. 11. She said her department typically had postdocs when she was a Sandia manager in the mid-1990s.

"I found it to be a real win-win for Sandia and for the postdocs," bringing in new technical blood while introducing those new people to the Labs' "incredible technical capabilities" and giving them great research experience to draw on for their entire career, Marianne said. In addition, she said, "it offers Sandia the opportunity to look at the postdocs as potential future staff."

Malin Young, director of Engineering and Biological Sciences Center 8600, introduced the California poster session Dec. 15, saying former Sandia postdocs continue to augment the Labs' mission by remaining collaborators on research projects in their new positions and by accelerating technology transfer to industry.

MINSOUNG RHEE (8621), center rear, discusses his research on whole genome amplification of bacterial cells with Annette LaBauve (8621) at the annual postdoc poster session at Sandia/ California. Ethan Eagle (8362), far right, explains his work on local fuel-air mixing rates during diesel engine fuel injection processes to Jonathan Frank (8351) and Adam Ruggles (8351). (Photo courtesy of PD2P in California)



POSTDOC POSTER SESSION — Postdoc Anthony Colombo (1728) explains his research to Marianne Walck, director of Geosciences, Climate, and Consequence Effects Center 6900, during the Dec. 11 Postdoc Technical Showcase at Sandia/ New Mexico. Sandia's Postdoctoral Professional Development Program (PD2P) sponsored the showcase at the New Mexico and California campuses, drawing a total of 35 entries. (Photo by Sue Major Holmes)

Posters evaluated for content, quality

Judges from around Sandia evaluated the posters for scientific content, quality of the poster and the oral presentation, and how well the poster was presented. The Outstanding Poster winners in New Mexico are Andrew Leenheer (1132) for "Liquid Cell in-situ TEM Capabilities for Lithium Battery Materials," and Elizabeth Auden (1111), for "Probing the Structure of Damage Cascades with Ion Beam Induced Charge," and in California, Ethan Eagle (8362) for "How Do We Enhance Local Entrainment during Fuel-Injection Ramp-down." Peter DeVore of LLNL was named runner-up in California for "Demonstration of Vπ Reduction in Electro optic Modulators using Modulation Instability."

The showcase also recognized the nominees and winners of PD2P's annual Distinguished Mentor Award, which acknowledges the value Sandia places on mentoring postdoctoral employees and highlights outstanding mentorship. Postdocs' nomination letters described how mentors inspired them through a passion for research and problem-solving, maintained a positive and constructive attitude, ensured their postdoc was recognized as a strong technical collaborator at group/project meetings, and helped postdocs create strong networks.

"I am given freedom to do the work the way I think is best and make important decisions independently, but I am still given supportive advice when it's needed," read one nomination letter. Another said, "He acknowledges and recognizes me as a strong technical collaborator at group/project meetings."

Three winners were chosen from among the nine nominations this year: Mike Siegal (1114) and Michael B. Sinclair (1816), both in New Mexico, and Judit Zador (8353) in California.

PD2P hosts monthly workshops, social events, and research seminars between the New Mexico and California sites to promote postdoc career development. Non-postdocs who wish to receive event information should email Ann Dallman (6122) at ardallm@sandia.gov. For more information about PD2P contact Stephanie Teich-McGoldrick (6915), steichm@sandia.gov in New Mexico or Isaac Ekoto (8362), iekoto@sandia.gov, in California.

Iron sun

(Continued from page 1)

from the sun lowered the estimated amount of energy-absorbing elements such as oxygen, nitrogen, and carbon by 30 to 50 percent. The decreased abundances meant that, plugged into the model, energy would arrive at the sun's radiative edge more readily than before. This created a discrepancy between the star's theoretical and measured structure. (Structure here refers to the sun's varying temperatures and densities at different spatial locations.)

What was needed to reestablish the model agreement with observations was a way to balance the decrease in resistance to radiation transport caused by the lowered amounts of some elements.

Jim's experimental group, including Taisuke Nagayama, Guillaume Loisel, and Greg Rochau (all 1683), in painstaking experiments spanning a 10-year period, discovered that the worldwide astrophysical estimate of the wavelength-dependent opacity of iron should be increased between 30 to 400 percent. The variation does not represent a large uncertainty but merely that iron's opacity varies with the wavelength of the radiation.

"This represents roughly half the change in the mean opacity needed to resolve the solar problem, even though iron is only one of many elements that contribute," the authors write in their paper.

Previous difficulties in getting accurate data has been that "the inside of a star is one of the most mysterious places in the universe," Jim says. "It's too opaque for distant instruments to see inside and analyze reactions within it, and too hot to send a probe into it. It has also been too difficult to run tests under appropriate conditions in a laboratory.

So the physics that describes how atoms, embedded in solar plasma, absorb radiation, has never been experimentally tested. Yet that process dominates the way energy generated by nuclear reactions in the sun's interior is transported to the outside.

"The sun is a test bed to model other stars. . . To the extent we fail to understand the sun, then the workings of other stars are subject to some uncertainty."

— Team member Taisuke Nagayama

"Fortunately, in our Z experiments, we can create temperature and density conditions nearly the same as the region inside the sun that affects the discrepancy the most — the edge of the zone where radiative energy transport dominates — in a sample that's big enough, lasts long enough, and is uniform enough to test. We used that new capability to measure the opacity of iron, one of a few elements that plays the most important part in radiative energy transfer."

Iron is important because it maintains the highest number of bound electrons that are essential in radiative energy transfer of any element abundant in the sun.

Still, the upward revision of opacities as a solution is bound to be controversial.

"No matter what we do, we can't make measurements at all the different conditions we need to know," team member Taisuke says. "There are 20 elements present, and a large range of temperatures and densities. We study iron because its complex electronic structure is a challenge to represent in opacity theories. And it is important in solar physics. The sun is a test bed to model other stars. Without experimental tests we don't know if these models are accurate. To the extent we fail to understand the sun, then the workings of other stars are subject to some uncertainty."

The target design of the experiments most recently involves intermingled iron and magnesium, tamped by plastic and beryllium layers on both sides. Radiation streaming through the sample heats up the iron and magnesium, which expand. The plastic restrains the expansion to keep it more uniform for opacity measurements. Magnesium provides information about corresponding density and temperature.

As for Jim, he often can be found by the business end of Sandia's Z machine, which creates the temperature of the sun's interior — about 2.1 million degrees — in a target about the size of a grain of sand.

From that small sample, Jim is able to do what theorists cannot: He can hold tangible evidence for the way iron atoms behave inside stars in his hand.

The work was sponsored by NNSA and the DOE Office of Science.

Worth a thousand words (or gigabytes)

SANDIA'S PHOTOMETRIC TEAM uses imagery and other techniques to measure physical phenomena, temperatures, displacements, and deformation, in very small increments — for example, micron-sized displacements that happen over microseconds using cameras that capture one million frames per second. (Photo by Randy Montoya)

By Stephanie Hobby

It's admittedly one of the cooler jobs at Sandia. Tucked away in Tech Area3, a team of 12 regularly gets to witnesses nearly all the big — and the very small — shake, rattle, and roll tests the Labs has to offer. And while the photometrics team is perhaps most widely recognized for the unmatched images it produces, such as the well-known sequence of the F-4 screaming down the sled track and its ultimate annihilation, the images are really only a part of the product.

"A lot of people think photometrics is about photography, and it absolutely is not photography," says department manager Jody Smith (1535). "This truly is about measurement, and we're measuring using imagery."

Using imagery and other techniques, the team can measure physical phenomena, temperatures, displacements, and deformation in very small increments — for example, micron-sized displacements that happen over microseconds using cameras that capture one million frames per second.

The photometrics team spends a lot of time thinking of creative ways to capture data because so much of Sandia's work involves one-of-a-kind, often destructive experiments with irreplaceable devices that can cost millions of dollars. Often that means actually helping to design the experiment. When a researcher needed to measure the heating effects of drag on a wing section going Mach 2 down the sled track, he turned to the photometrics team. They put a thermal imager on a laser tracker and could explain exactly what was happening to the wing as a result of the drag.

Working in complex, unpredictable environments

"People come to us with a problem, and sometimes they don't know exactly where the problem is. We worked on the gel mylar capacitor, which is a perfect example. It was arcing someplace, but this happens at the speed of light. Byron Demosthenous (1535) came up with a strategy to image it to identify the precise location," Jody says.

Some of the work they do is in a controlled lab setting, but more often than not, they're working in more complex, unpredictable environments. From biting cold to fiery hot temperatures, to the notorious spring winds of New Mexico and the accompanying flying dust and dirt, the team has to be ready for it all, so there's no one-size-fits-all approach. The team consists of a mechanical engineer, an electrical engineer, an optical engineer, and experienced technicians, but Jody jokes that the department requires them to also be part MacGyver to handle the variety of issues they run into.

In addition to the team's immense creativity, technology has evolved considerably over the years and has added to their capabilities. Mark Nissen (1535) has been with the team since 1984, when film was king. High speed at that time was 400 frames per second, and capturing three-dimensional data points was all but impossible. The reason? The movement of the film through the camera was actually different enough between cameras that correlating the images to one another couldn't be precise. And in a world where data is gathered in microseconds, precision is everything.

Unexpected findings

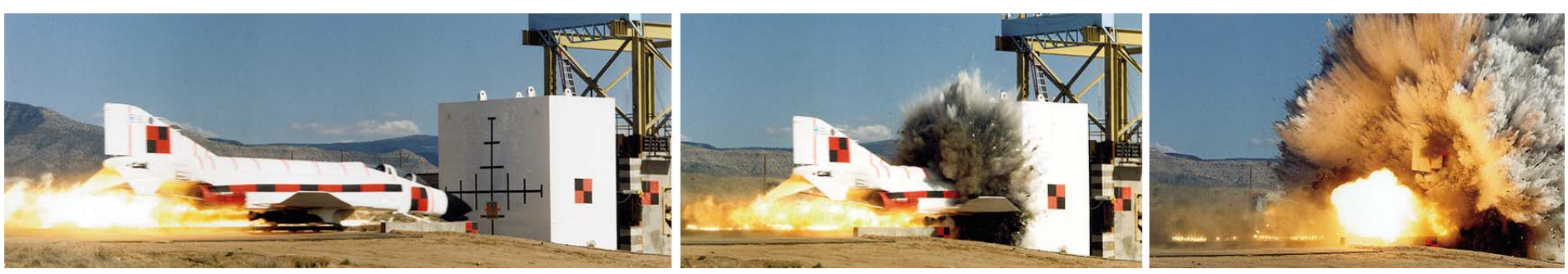
Today, with 3-D measurements and the ability to capture virtually every angle of an experiment, those concerns have diminished. "Previously, researchers had to make assumptions about where to place single-point detectors. Now, we're able to measure the entire surface in three dimensions," says Phillip Reu (1535). And that can lead to some unexpected findings. "It sometimes surprises people to see their data and see things they had just waved away or assumed weren't happening. Now, we can measure it and collect it, and that's impacting how experiments can be designed," says Phillip.

Today, more information can be produced from just one test, which takes less time and money, rather than running it many times as was done in the past. That also opens the door to more complex experiments.

Much of the team's work is used to validate models. Researchers have traditionally used single-point strain gauges to validate models, which doesn't always capture the full picture. "Single-point measurements using strain gauges are fine for certain measurements, but aren't able to validate a full-field model. It says nothing about what the model might be doing in other places," says Tim Miller (1535). "Presumably you put your gauge in the right spot, but you don't always know that. Particularly with blast-loading environments where you might have some bizarre effects and non-uniform loading, you wouldn't know about them without a full-field measurement. That's the approach that we bring to the table with being able to look at the entire surface."

They also can help quantify the uncertainty of data, which, when being measured in microns, is not a trivial matter. The team spends a lot of time understanding the details of the results and developing ways to put error bars on the measurements.

So the next time you need to know exactly what a sphere looks like as it's exploding, in increments that are a fraction of the width of a human hair, or really, measure anything you can't put a ruler up to, the photometrics team is ready to take on your challenge. "We have the ability to take amazing data. Our clients are used to having a few points to match to their model, and we can provide millions and millions," Jody says. "That's an area where we can really make a difference for Sandia."



THIS ICONIC SEQUENCE OF IMAGES produced by Sandia's Photometrics group in 1988 captures a test conducted at Sandia's rocket sled track. The test was designed to determine the impact force of a complete F-4 Phantom slammed into a reinforced concrete target 12 feet thick at 480 miles per hour. The test was not intended to demonstrate the performance or survivability of any particular type of concrete structure to aircraft impact. The mass of the jet fuel was simulated by water; the effects of fire following such a collision was not a part of the test. The test established that the major impact force was from the engines. The test was performed by Sandia under terms of a contract with the Muto Institute of Structural Mechanics Inc., of Tokyo, Japan.

Labs legend, original Trinity hand Ben Benjamin passes away

GROUND ZERO — Ben Benjamin started his career in the nation's nuclear weapon enterprise as a member of the Manhattan Project team. Here, Ben returns to the Trinity Site, where he witnessed the first atomic blast in July 1945.

TOUCHDOWN — Ben Benjamin, left, in the Bruneau Plateau country of central Idaho in 1965 as part of the Pre-Schoooner II test. Every morning three helicopters from a private contractor took Sandians from Twin Falls to the Pre Schooner site.

By Sandia Historian Rebecca Ullrich

Sandia pioneer Ben Benjamin, who passed away on Nov. 30, 2014, in Albuquerque, began his career at the dawn of the atomic age filming the detonation of the first nuclear test device at Trinity and ended it training the next generation of nuclear weaponeers as a senior mentor for Sandia's Weapon Intern Program. Ben was directly involved in both the creation and understanding of nuclear weapons history as a participant in the Manhattan Project, long-time Sandia field tester, docent on Trinity Site tours, and consultant to the Corporate Archives & History department at Sandia.

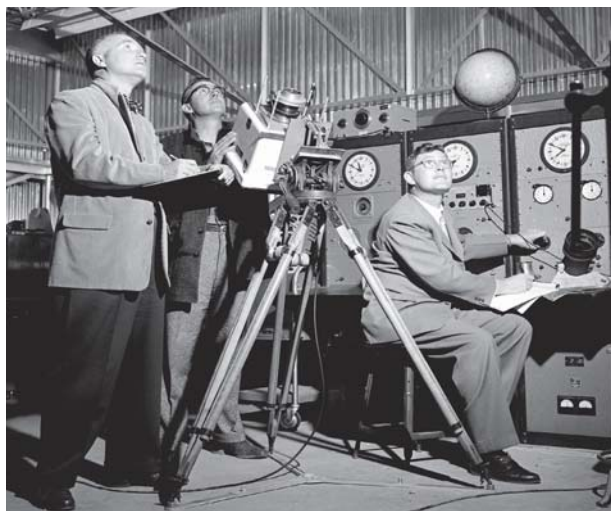
Ben ended up at Los Alamos during World War II through a fascination on his part with optics and a determination by the US Army to find individuals with appropriate skills to staff up the Manhattan Engineering District. During high school, Ben built a 6-inch telescope and mastered the optics to construct the eyepieces. After graduation, he attended the University of Minnesota and was involved in building optics, but he had trouble finding high-quality prisms so he and a friend decided they could learn to build them themselves. Using thick plate glass, they ground the prisms they needed, attaining a high degree of precision. They were subsequently recruited to build optics in a new Honeywell operation in Minneapolis, Minn.

ICEMAN — Ben Benjamin is appropriately bundled up during preparations for a test as part of Operation Deep Freeze at Upper Red Lake, Minn.

After the United States entered World War II, Ben enlisted in the Army, was sent for further technical training, and underwent "a very mysterious interview with a civilian" who was recruiting individuals to serve on a special project. Like everyone else brought into the Manhattan Engineer District, Ben was not given much information about the assignment until he arrived in Los Alamos.

He was placed in the Special Engineer Detachment (SED). The SED comprised soldiers working as technicians to support the civilian scientists. Assigned to Julian Mack, who oversaw the technical photographic group, Ben set to work grinding and polishing the locating prisms for high-speed cameras and developing experiments to set up at the Trinity shot.

In the months leading up to the July 16, 1945, test, Ben spent considerable time at the Trinity site, setting up equipment and experiments. He described the test shot itself as "brighter than 20 suns and the most spectacular sunrise ever seen." He was just 22 years old.



NEW MOON RISING — Ben Benjamin, seated, and colleagues track Sputnik using high-tech gear circa 1957.

At the war's end, he mustered out of the military and returned to the University of Minnesota to complete his degree in mechanical engineering, then moved to Pittsburgh for a job in optics. A colleague from the SED, H.C. "Curly" Barr, was by then working for Sandia in field test and asked Ben to come out and work for him. Ben was hired in August 1948 and a week after arriving was sent to Salton Sea Test Base (SSTB) in southern California to build optics equipment for testing.

He spent the next decade in optical measurements (later known as photometrics, see story on page 5), becoming a supervisor in 1957. Having seen the first atomic detonation at Trinity, he also witnessed the first nuclear test at the Nevada Test Site during Operation Ranger. As Sandia began to look for a permanent test site to replace SSTB, Ben became involved in the site selection process. On Sept. 12, 1956, he and Don Beatson staked out the control point area for Sandia's Tonopah Test Range and then did the surveying to position each of the original tracking stations at the Range.

Ben took a rotation as a supervisor in data reduction and then moved to the seismic and test effects division before taking over the instrumentation fielding division, where he spent the bulk of his career. He returned to the Trinity site on the 40th anniversary of test. He retired from Sandia two years later, but would return often to both the Labs and the stories of his Trinity experiences.

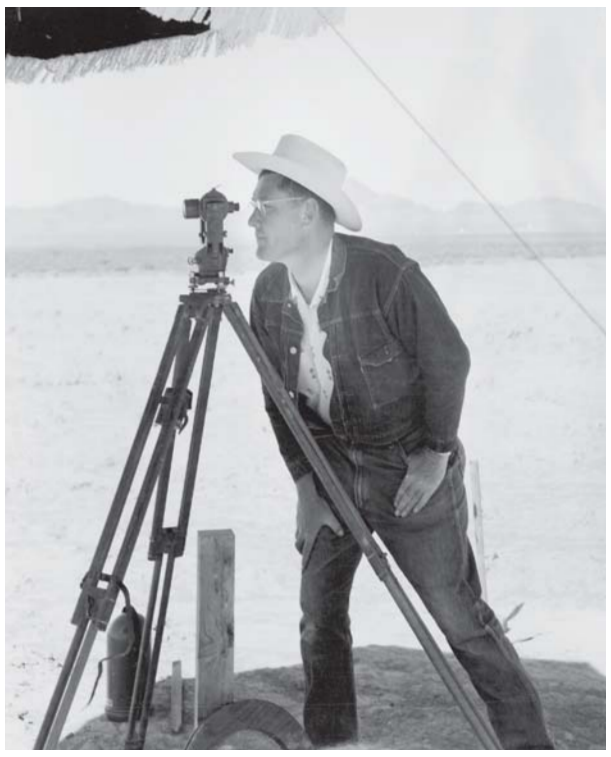
When John Hogan launched the Weapon Intern Program (WIP) at Sandia in 1998, his vision of knowledge preservation and transfer included a new generation of scientists and engineers learning directly from those who had gone before them in the nuclear weapons arena.

WIP, managed in its early years by Andy Rogulich (ret.), included senior mentors — weaponeers from earlier in Sandia's history, with a few, including Leon Smith and Ben, whose service reached right back into the Manhattan Project. They provided continuity to the interns' understanding of weapon design, testing, production, handling, and surveillance, offering a level of detail in how things were done that was not always apparent in the written record.

"Ben was such a remarkable guy," says Andy, "one that you would always want to have the privilege of working with, a true living embodiment of what it means to be a Sandian."

Known as a good storyteller with an important story to tell, Ben was also recruited to give lectures at the then-National Atomic Museum the evening before tours left for the Trinity site during its semi-annual openings.

Ben delighted in his time with the interns and Trinity tour participants, joking that he'd told "Oppy" how things should be done. He instinctively understood that Sandians benefit from knowing where we come from and who got us here. He spoke of his experiences at both Los Alamos and Sandia with humor and pride, giving clear insight into the development of the US nuclear weapons program.



SITE-LINES — In September 1956, Ben Benjamin, above, and colleague Don Beatson staked out the control point area for Sandia's Tonopah Test Range and then did the surveying to position each of the original tracking stations at the range.

He appeared in televised specials on PBS and the Discovery Channel and a presentation of his Trinity experiences is available in the Tech Symposium streaming video collection on Sandia's internal web at http://digitalmedia.sandia.gov/Mediasite/Play/299f7f1c378e4baabfda76d6307bfa9c1d.

A memorial service is scheduled for Monday, Jan. 12, 4-7 p.m. at the National Museum of Nuclear Science and History at 609 Eubank Blvd. SE.

Sandia Classified Ads

MISCELLANEOUS

QUEEN BED, IKEA, wood frame, Simmons Beautyrest mattress, excellent condition, photo available, $250. Motteler, 296-3259.

GIRL'S CLOTHING, sizes G12-juniors small, great condition, large box, list of items & photos available, $50. Willis, 286-1937.

SKI RACK, for SUV w/roof rails, $50; cross bar for Lexus RX 450, roof rails, $50. Gough, 822-0090.

TRUCK SEATS, front bucket, captain's chairs w/center console, rear 60/40 folding bench, for '00-'06 extended cab Toyota Tundra, $195. Harding, 977-0897.

SNOWSHOES, Redfeather PACE 500, weight up to 125-lbs., used twice, $90. Brewster, 238-4704, ask for Julie.

ADJUSTABLE BED, Ergomotion long twin, 36" x 80", head & knee lift, 2 massagers, excellent condition, $500. Hansche, 281-5623.

PRO BOWL TICKETS, sec. 443, row 13, 50-yd. line, must purchase even quantity, $155/ticket. Carrasco, 505-803-3831.

ELECTRIC WASHER & DRYER, Amana, good condition, $75 ea. Drebing, 293-3335.

GAMING CHAIRS, $35 ea. or $60/both; dining set, perfect condition, $10,000 new, asking $3,500; twin-sized futon, $75. Wimpy, 400-6101, ask for Sheri.

BARBIE COLLECTION, very rare, collectible, designers, holidays, all new-in-box, excellent condition. Chavez, 505-344-8746.

SCOTTSDALE, 5 days, Superbowl/PGA tournament, Jan. 28-Feb. 2, Diamond Resort "Links", 2-bdr., 2 bath, sleeps 6, $2,500. Shirey, 505-281-9455.

LASERJET 4L PRINTER, gently used, $45; Brother plain paper fax machine, $45. Molina, 292-4117.

TRANSPORTATION

'01 MAZDA B3000 PICKUP, new AC, new clutch, CD, camper shell, 187K miles, runs great, call or text, $3,300. Santos, 505-269-3461.

'78 CHEVY K20, 4x4, 71K original miles, documentation for proof, all original, runs great, $4,000 OBO. Martin, 623-687-7673.

'97 CHEVY CHEYENNE, extended cab, 2WD, cruise, towing, alarm, new Michelins, shocks, fuel pump, 116K miles, $5,250. Swanson, 506-0114.

'99 FORD EXPLORER, Eddie Bauer, white, tan interior, Michelin tires, complete service records, 107,700 miles, very good condition, $3,500. Witek, 505-296-5198, hmwitek@comcast.net.

'11 DODGE DURANGO CITADEL, black, leather, V8, sunroof, seats 7, 35K miles, excellent condition, $27,000. Webb, 505-221-8241.

'05 MERCEDES BENZ E55 AMG, AT, 469-hp V8 supercharged, white/black, loaded, 93.8K miles, $20,500 OBO. Sedillo, 505-890-2698.

How to submit classified ads

DEADLINE: Friday noon before week of publication unless changed by holiday. Submit by one of these methods:

- **EMAIL: Michelle Fleming (classads@sandia.gov)**
- **FAX: 844-0645**
- **MAIL: MS 1468 (Dept. 3651)**
- **INTERNAL WEB: On internal web homepage, click on News Center, then on *Lab News* link, and then on the very top of *Lab News* homepage "Submit a Classified Ad." If you have questions, call Michelle at 844-4902. Because of space constraints, ads will be printed on a first-come basis.**

Ad rules

1. Limit 18 words, including last name and home phone (If you include a web or e-mail address, it will count as two or three words, depending on length of the address.)
2. Include organization and full name with the ad submission.
3. Submit ad in writing. No phone-ins.
4. Type or print ad legibly; use accepted abbreviations.
5. One ad per issue.
6. We will not run the same ad more than twice.
7. No "for rent" ads except for employees on temporary assignment.
8. No commercial ads.
9. For active Sandia members of the workforce, retired Sandians, and DOE employees.
10. Housing listed for sale is available without regard to race, creed, color, or national origin.
11. Work Wanted ads limited to student-aged children of employees.
12. We reserve the right not to publish any ad that may be considered offensive or in bad taste.

'94 TOYOTA 4RUNNER, 5-spd., 4x4, V6, solid drivetrain, exterior shows wear, daily driver, runs smooth, 192K miles, $3,000. Wolfgang, 505-414-1483.

'06 GOLD LUXURY CADILLAC DTS, sunroof, Bose multi-CD, leather, heated/cooled seats, 100K miles, $10,500. Crenshaw, 440-3433.

'04 PONTIAC GRAND PRIX GTP, supercharged, loaded, heated seats, heads-up display, well-maintained, 100K miles, $7,000 OBO. Musgrove, 505-814-4122.

RECREATION

'07 EVOLUTION 1 FLEETWOOD, folding camping trailer, sleeps 6, off-road capable, very comfortable, $8,000. Green, 505-263-5179.

BOY'S BIKE, new, 26-in. street model, has everything, including 7-spd., $150. Hill, 205-1496.

'00 PACE ARROW MOTOR HOME, 37-ft., 2 slides, lots of power for towing, stored inside, $39,000 OBO. Hibray, 821-3455.

REAL ESTATE

10.7 ACRES, East Mountains, http://www.sanpedrocreekestates.com/12-vista-de-jemez-sandia/. Hanselmann, 254-1782.

3-BDR. HOME, 1,644-sq. ft., near base, move-in ready, 824 Pawnee NE, make offer, cash or refinance, $140,000. Sanchez, 505-400-0030.

3-BDR. HOME, 2-1/2 baths, 1,550-sq. ft., 3426 Mountainside Parkway NE, $179,000. Walker, 918-244-3898, ask for David.

3-BDR. HOME, 2-1/2 baths, 1,410-sq. ft., w/all appliances, stair elevator, MLS#818070, $149,000. Wright, 505-332-0773.

WANTED

CONCERT MUSICIANS, for community band, tuba players needed most, rehearsals on Tuesday evenings. Bliss, 259-0131 or 239-3505, ask for John.

LOVING HOME, beautiful female ragdoll kitty, 3 yrs. old, purebred, needs to be only pet. Harger, 238-7879.

WASHER, very good condition, not HE, <5 yrs. old, one owner preferred, owner's manual & repair receipts required. Rockwell, 505-250-3737.

MEN'S SANDIA 25-YR. AWARD RING, to buy, mine stolen. Moss, 505-307-1548, ericjudy@flash.net.

HANDYMAN, for miscellaneous household repairs. Kaplan, 298-7953.

Mileposts

New Mexico *photos by Michelle Fleming*
California *photos by Dino Vournas*

Gary Kirchner
45 8135

Len Napolitano
35 8900

Anthony Gomez
30 1522

Dave Jones
30 2953

Russ Skocypec
30 150

Dora Wiemann
30 5754

Mary Compton
25 9524

Max Decker
25 5780

Jeff Downs
25 2723

W. Philip Kegelmeyer
25 8900

Kevin Malone
25 5963

Nick Francis
20 1514

Christine Northrop
20 10615

Anita Reiser
20 4135

Gail Finley
15 5942

Aaron Hall
15 1832

Jonathon Zimmerman
15 8342

Recent Retirees

Karen Erickson
35 5546

John Hinton
33 8511

Cathy Anne Ehgartner
25 4122

Sherrie Trezza
24 1382

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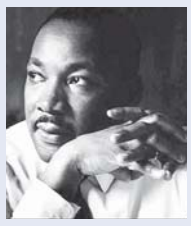
The ***Sandia Lab News*** is printed on 75 percent recycled content paper. Please recycle them in the yellow mixed paper bins.

‘A fascinating time’

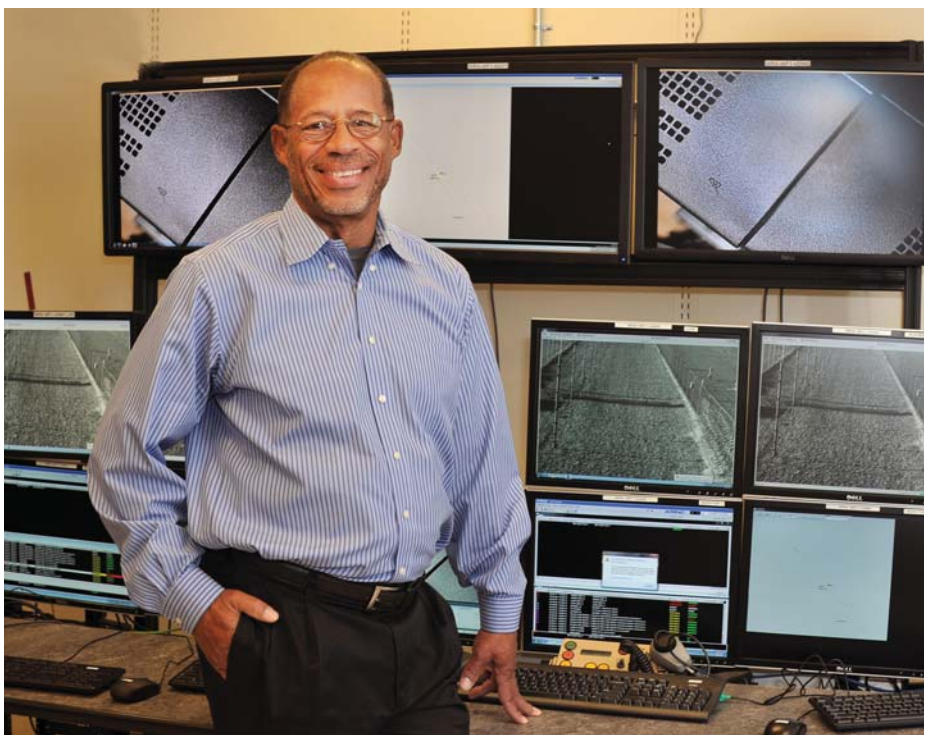
Sandia was a pioneer in the dawn of a new, diverse workforce

Martin Luther King Jr. Day will be celebrated this year on Monday, Jan. 19. The civil rights leader’s actual birthday was Jan. 15, but the federal holiday marking his birth is observed on the third Monday of January each year.



By Nancy Salem

Sandia played a key role in the early years of the affirmative action and equal employment movements as one of the first organizations to sign on to the Plans for Progress (PfP), a program created by US employers to end discrimination and build job opportunities for minorities.



IVORY ALEXANDER (6523) worked during his career to increase opportunities for African Americans at Sandia. His efforts coincided with affirmative action policies being put in place. “I was in the right place at the right time,” he says. (Photo by Randy Montoya)

“Sandia has been exceptional in its efforts to recruit and hire African Americans and other minorities,” says Ken Holley (35553), who joined the Labs in 1985 and devoted much of his career to recruiting. “We’ve been willing to hire the talent we helped produce through the early minority programs. To do what we have done to increase the number of minorities with graduate degrees in engineering and science is remarkable for a national laboratory. It was not easy, but Sandia was willing to push against the external and internal challenges. I’m very proud to have been part of it.”

The earliest record of a non-discrimination policy at Sandia Corp., then operated by Western Electric Co. for the US Atomic Energy Commission (AEC), came in a Jan. 25, 1951, letter. It read, “The management of Sandia Corporation has always made a sincere effort to select the best qualified candidate for each vacancy without regard to race, color, or creed. In the future, we will certainly continue to observe this policy and will make sure that no group is treated unfairly.”

A July 15, 1954, letter to Sandia holds the first reference to the policy being a requirement of AEC contractors: “The policy of the United States Government is to promote equal employment opportunity for all qualified persons seeking employment or employed in connection with government contracts.” It continued that contractors will “not discriminate against any employee or applicant for employment because of race, creed, color, or national origin.”

In 1961, President John F. Kennedy issued an executive order requiring that provisions of non-discrimination in employment be included in all new government contracts. The order included the first use of the term “affirmative action” to achieve non-discrimination. Around the same time, Western Electric became one of the original companies to join the PfP. Sandia moved from a policy of non-discrimination to one of affirmative action to address inequality. Sandia’s Plans for Progress was signed by Labs Director Sigmund Schwartz and President Lyndon Johnson in 1964 and announced to the workforce in the Oct. 9, 1964, *Lab News*.

A range of programs

Sandia and other PfP companies adopted a wide range of programs covering the recruitment, hiring, training, and promotion of African Americans and other minorities. A Sandia memo read, “In the area of affirmative action it has been said that advancing basic human rights to the full potential of our nation’s human resources capability even with the full cooperation of American business and industry will take many years. The problem is so great, so complex, so involved, and has been with us so long that change will be necessary for many years to come.”

Sandia went on to launch a variety of equal employment — a concept that became part of the Civil Rights Act of 1964 — and affirmative action activities including opening the Labs to tours by minority leaders, attending state and national conferences, organizing youth opportunity programs, and participating in community-based vocational guidance and training. Labs officials met with representatives of Bernalillo County, Job Corps, Manpower Development Training, and minority organizations to seek job candidates.

Ivory Alexander, manager of Network Centric Security System Design Dept. 6523, says among the most successful programs was One Year on Campus (OYOC), which allowed the Labs to recruit minorities with bachelor’s degrees, send them for a master’s, then bring them back as members of the technical staff. Ivory was recruited from Michigan State in 1974 and earned a master’s in electrical engineering from Stanford in 1975.

“OYOC, which evolved into the Master’s Fellowship Program and opened to more people, was exclusively for minority candidates at that time,” he says. “It was very attractive to me. I had a similar offer from Bell Labs but figured I’d give this place in the desert a try. That was 40 years ago.”

He says OYOC brought a large influx of African Americans to Sandia in the 1970s. “There was a small group of African American employees in the early 1970s who met with the Lab president about increasing the opportunities for African Americans at Sandia. That occurred in parallel with affirmative action policies being put in place. I was in the right place at the right time.”

Ivory recruited for Sandia the first 20 years of his career. The Labs had a list of Historically Black Colleges and Universities (HBCUs) where it focused recruiting efforts. HBCUs were established in the US in the mid-1800s to give African Americans access to higher education during the time of racial segregation. Sandia developed recruiting relationships with Prairie View A&M University in Texas, North Carolina A&T University, Howard University, and Tennessee State University.

Ivory says the Black Outreach Committee, now called the Black Leadership Committee, formed and helped recruits understand the Sandia culture. “While it wasn’t always easy in the early days to build a career at Sandia as an African American, the Labs environment has changed over time and a recognition exists today that the benefits of and contributions by a diverse workforce enable Sandia to fulfill its mission,” he says.

Lessons to learn

Shortly after joining Sandia, Ken became chairman of the Black Outreach Committee. He also headed up HBCU recruiting, which brought more African Americans to the Labs in the 1980s. “We hired a lot of talented students who have been here now over 20 years,” he says.

But there were lessons to learn. The first was that African Americans needed more than just a primer on Sandia to form a lasting bond. “We thought all we had to do was put in a program and people would come,” Ken says. “But coming to New Mexico for an African American was like going to the moon. We learned we had to develop social mentors in addition to technical mentors, or else they would come and leave and never come back.”

Mentors showed the students where to live, shop, and socialize, and how to get around town. “This was right after the Civil Rights Act, so many of these kids were the first in their families to go to college, and we were grabbing them right then,” Ken says. “A lot of them didn’t have cars. We learned that the technical part didn’t mean as much if you didn’t have a life. Mentorship brought them back, and kept them coming.”

Sandia was involved in other minority recruitment programs including the National Physical Sciences Consortium (NPSC), the National Consortium for Graduate Degrees for Minorities in Engineering and Science (GEM), and the Science and Technology Alliance.

“We used whatever program was necessary at the time to make it work. In the early years we were an unknown entity. The kids on campus knew about Los Alamos because of the history of the atomic bomb, but not Sandia. We had a job to do,” Ken says. “About 25 Sandians recruited at the HBCUs in the early days and brought dozens of African Americans to the Labs. We were hiring into the OYOC program every year. It was a fascinating time.”

Ivory says the years following the launch of affirmative action and equal opportunity were compelling at Sandia and set the stage for continuing efforts to build a diverse workforce.

“There was corporate buy-in and we built a reputation for diversity,” he says. “I’ve been technically challenged and it’s been enjoyable. If I had the chance to do it again, I would.”

KEN HOLLEY (3555-3) has been deeply involved in recruiting, hiring, and training at Sandia. “To do what we have done to increase the number of minorities with graduate degrees in engineering and science is remarkable for a national laboratory,” he says. (Photo by Randy Montoya)