ASU School of Earth & Space Exploration
Arizona State University

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NEWSLETTER OF THE SCHOOL OF EARTH AND SPACE EXPLORATION

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April 11

Solar Speckles

An artist's rendering of the Genesis spacecraft in collection mode. Image Credit: NASA/JPL-Caltech

Genesis returns fossils of the sun
By Matthew Button

The outer layer of the sun, the photosphere, burns at roughly 10,000 F, a temperature even native Arizonians would be impressed with. In addition to emitting an incredible amount of heat and light, the sun also releases tiny charged particles. These quick-moving clusters of protons can escape beyond the sun's gravity because of their high kinetic energy and high temperatures. The sun is continuously releasing these charged particles, known collectively as solar winds. Rippling and flowing through the complex gravitational webs that comprise the solar system, these solar winds become fractionated by the Earth's magnetic field, resulting in the northern and southern aurorae.

Amy Jurewicz, now in the ASU Center for Meteorite Studies, was the JPL scientist for NASA's Genesis Mission. Genesis was tasked with capturing some of these tiny bits of the sun and analyzing them. A massive team of collaborators, including Jurewicz, has been examining the sample retrieved by Genesis.

The space craft launched from Earth in August 2001, traveling to a location between Earth and sun where there is equal gravitational pull (Lagrange point

1). There it made five halo-like loops, catching the solar wind in specially designed instruments. An electrostatic mirror focused the solar wind ions onto a small area, concentrating them by a factor of ~20. Several disks, opening out of the craft in response to different solar events, exposed hexagonal collector tiles of various colors. This metallic honey-comb of tiles was made of the most curious and rare cast of synthesized films (gold on sapphire, diamond on silicate, silicon on sapphire and aluminum on sapphire), as well as silicon, germanium, and sapphire wafers.

While the sun is mostly made of hydrogen and helium, there are small amounts of all of the other elements which make up our solar system. Despite the low concentration of minor ions in the solar wind, they can be detected — but due to their dilution, purity of each tile with respect to an element of interest is a requirement. The variety of tiles assures that each solar wind element can be examined in some type of tile. For example, if someone wanted to measure gold or germanium in the solar wind and if the tiles had been all gold or all germanium, then those elements would have been impossible to see.

When Genesis faced the sun to collect samples, the charged ions bombarded the tiles at anywhere from 200 to 800 kilometers per second. "When they hit they hit hard, and they buried themselves in the tiles so that we can see what they are made of back on Earth," Jurewicz says.

In late 2004 Genesis had completed its sampling and was prepared to bring the samples home. September 8 was the expected landing date. Over the Utah desert, two helicopters hovered, waiting to capture the pod by the strings of its parachute. This grand mid-air retrieval was successfully rehearsed again and again before the craft even went into space. But the helicopters never got their chance to catch their target.

"My understanding is that it was a pressure switch that was put in backwards; they had an electrical engineer drawing plans for an electro-mechanical device and he didn't understand the instrument. Really it was a good lesson for SESE, that you have to understand systems you are designing," Jurewicz explains.

After 250 million dollars, and hours of planning and labor, Genesis crashed into the earth at 193 mph. You can view footage of the crash here in which tiles were shattered, foils torn, and the sampling chambers were breached. The solar wind collectors, although broken or rumpled, were only dirtied; the prized sample was implanted beneath the dirt.

Recovery of the solar-wind sample began from the moment the Genesis return capsule became safe to approach in the Utah desert. Jurewicz and her associates on the science team began to re-evaluate their samples. Shards of tiles with specks of desert stuck to them were the salvageable remains left to analyze, in addition to a few lucky tiles that somehow remained intact.

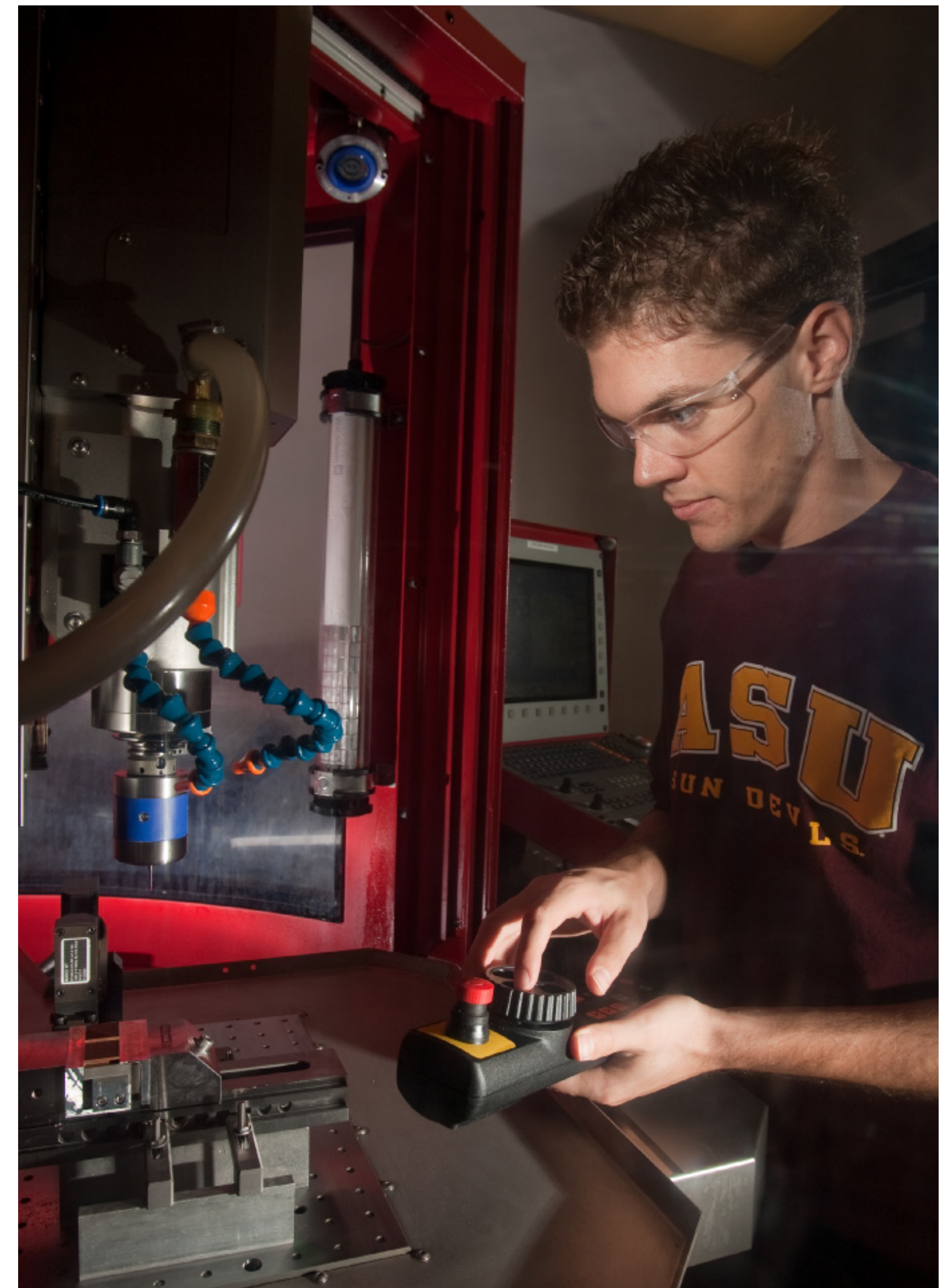
"We didn't have many really nice samples, but we don't necessarily need many when we're doing small area analysis. We can take a little fragment, work around the dirt, raster that spot, sputter away material sequentially, and actually get the solar wind," says Jurewicz. The areas she looks at are anywhere from 100 to 250 microns, and though tiles may have broken each one contains hundreds of potential samples. The researchers placed small tile fragments in a Secondary Ion Mass Spectrometry machine. This microprobe scans a focused ion beam over a sample, vaporizing the surface and analyzing the vapors for their content.

"If you were to put all the collected solar wind atoms altogether, the sample would amount to a few grains of salt, but we have the data of what the solar wind looks like from our spacecraft and other spacecraft as well as meteorite and lunar samples to compare our finding with so we are confident that we are moving in the right direction," Jurewicz explains. "Eventually, the role will reverse, and the Genesis data will be what the spacecraft and meteorite folks compare their data to… In fact, that is already starting to happen."

Before Genesis and similar missions were able to capture solar ions, meteorites were one of the only ways to examine solar wind. Meteorites in space are constantly bombarded by the solar winds. After the ions implant themselves into flying rocks, they can be traced and measured. However, erosion, and other issues make the implants into meteorites harder to interpret than the Genesis tiles. Still, they show that solar wind is comprised of the same elements as our sun: high levels of hydrogen with a little of everything else.

Though she may be the main constituent of ASU's involvement with Genesis, Jurewicz is part of a large, international Genesis science team. Genesis was but one mission designed to help us better understand the evolution of our Solar System.

Terahertz Telescopes



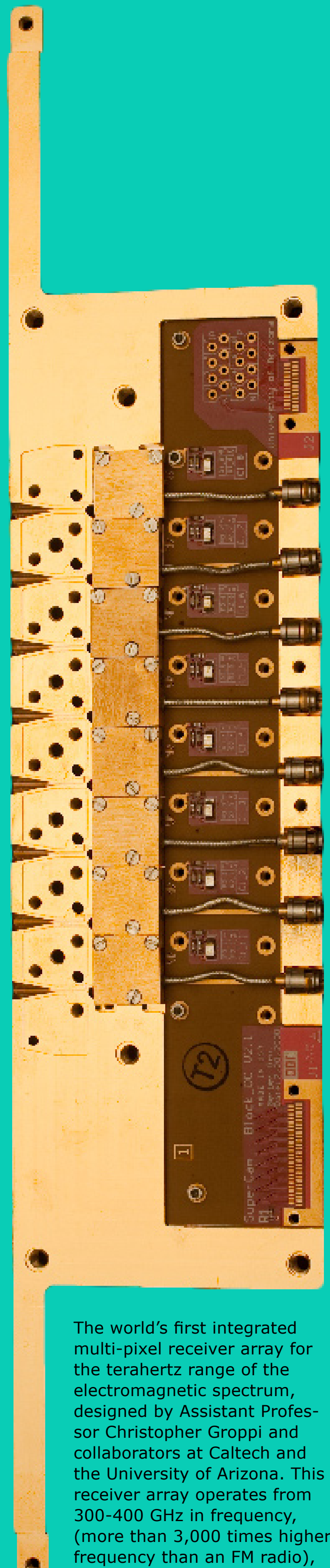
Undergraduate Matthew Underhill uses a Kern Model 44 computer numerically controlled micromilling system. This system is used in the School of Earth and Space Exploration terahertz laboratory to fabricate radio astronomy detectors with dimensions accurate to 1 micron, or about 1/100th the diameter of a human hair. Credit: Tom Story.

Professor and student push instrument beyond where any telescope has gone before.

By Matthew Button

While there was recent controversy about the intrusiveness of airport body scanners (and the abuses of unscrupulous TSA employees) what was not widely publicized was the unique technology behind one type of scanner: terahertz imaging. Much more than just technology capable of rendering awkward semi-nude photos of a nail clippers wielding passenger, the terahertz technology can see into portions of the universe where visible light cannot travel. ASU's Christopher Groppi is creating terahertz detectors that can look into the dark and dirty areas of space, where no telescope has gone before, to examine the making of the stars.

"A terahertz is a color of light in between radio waves and infrared. Redder than infrared and bluer than radio waves," explains Groppi, an assistant professor in SESE.



The world's first integrated multi-pixel receiver array for the terahertz range of the electromagnetic spectrum, designed by Assistant Professor Christopher Groppi and collaborators at Caltech and the University of Arizona. This receiver array operates from 300-400 GHz in frequency, (more than 3,000 times higher frequency than an FM radio), and combines eight receiver pixels into a single, integrated unit. Credit: Tom Story.

Groppi is interested in this part of the spectrum because there are dusty gaseous sections of the universe with extremely cold dense clouds of gas, and they're hard to see through. These clouds are so dense that molecules can form in these regions and eventually the gas collapses and form stars and planets.

"If you want to study how new stars form, you want to see the environments they form in. You want to see them right from the start, and see how the process happens. These clouds are opaque to visible and sometimes infrared light so it's very difficult," Groppi explains.

The complex dust particles in these clouds obstruct the view of normal telescopes as well as infrared sensors. Terahertz light is about 1,000 times redder than visible light, which allows it to penetrate dust particles. But as useful as terahertz radiation is, it is very hard to utilize and detect.

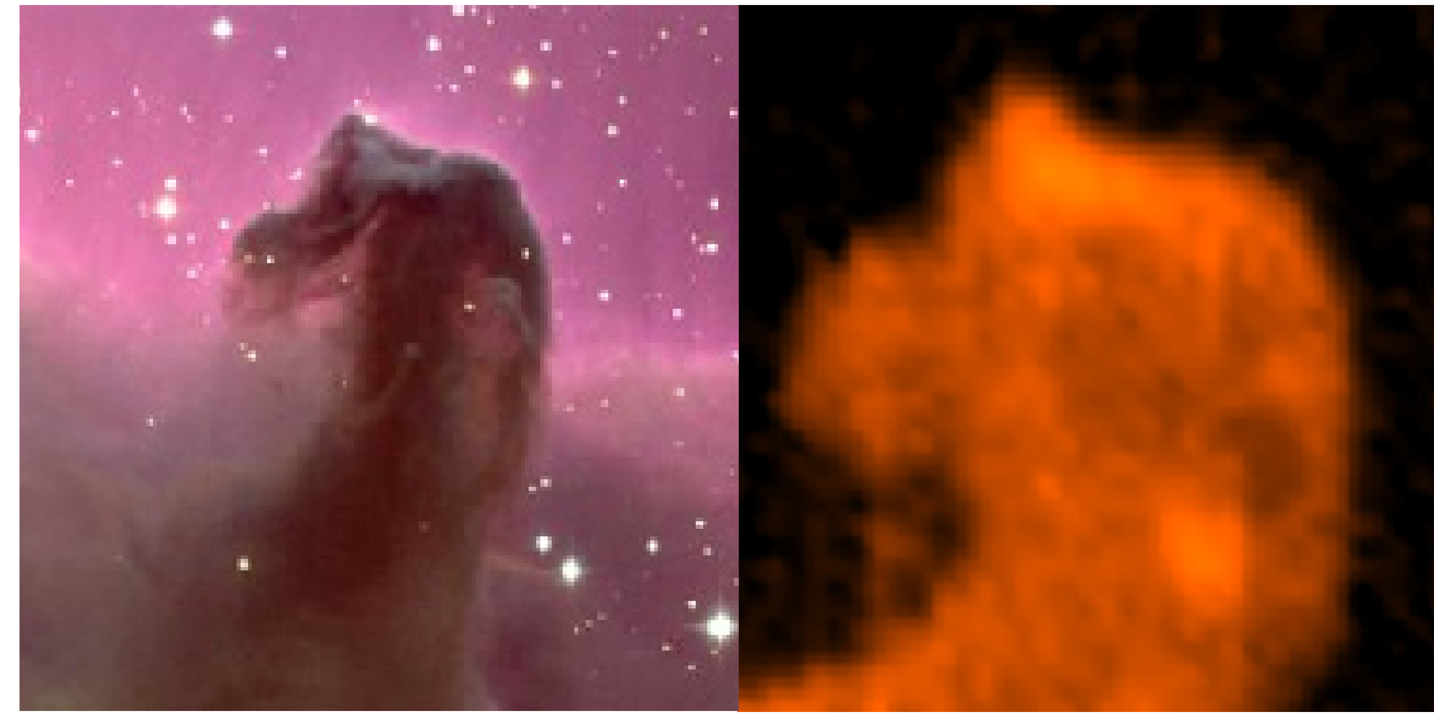
Scientists employ two main approaches to scan the skies with terahertz. Bolometers are a kind of super-sensitive thermometer that measure how light warms up the detector. But the downside to bolometers is they cannot differentiate colors so they take "black and white" images of the cloud.

Another instrument is a radio receiver; however, the difficulty with receivers is they have to work at a frequency roughly 3,000 times higher than FM radio. Only since the seventies has electronics technology been able to process the light at that speed. It is this type of receiver that Groppi has been busy building.

"We find ways to make receivers work at really high frequencies using special superconducting detectors and we have to make everything very, very small. The reason why is because you have to make parts of the receiver approximately how big the wavelength of the light is. For instance when you have an antennae on your car that antenna is about one-fourth the wavelength of FM waves at 100 megahertz; we have to do that same type of thing 3,000 times smaller," describes Groppi.

Groppi uses a German milling machine designed to make miniscule parts of high-end Swiss watches. The machine is operated by Matt Underhill, an ASU mechanical engineering technology undergraduate student. Underhill can make parts that are as small as 25 microns or about a fourth the size of a human hair. Nearly every component of the receiver is custom built. The National Science Foundation pays mostly for the labor of Groppi and his various associates who have to hand-make almost every part of the instruments.

Terahertz telescopes are not new but what is new is Groppi's approach to designing them. Previously, receivers could only scan the sky point by point, one pixel at a time to form a small image. Groppi's instruments are more like a camera than a single point sensor. He has combined sixty-four detectors into an array so that he can make a picture that is sixty-four times bigger in the same amount of time.



The image on the left is an optical light picture of the famous Horsehead Nebula. The dark horse's head is a cloud of cold gas and dust silhouetted against hot, glowing gas. Newly forming stars and planets are being born inside this dark region, but are undetectable in visible light. The image on the right shows the same region in the terahertz light emitted by the carbon monoxide molecule. In the terahertz, the dark regions glow, allowing astronomers to peer inside. The detectors built in the SESE terahertz lab allow astronomers to study these dark, cold regions to learn about how new worlds are formed. Credit: NASA (left), School of Earth and Space Exploration (right).

Terahertz telescopes work best in space but can be earthbound as well. Earth's atmosphere is made up of lots water molecules that absorb terahertz radiation so Groppi and his collaborators must place the receivers in high arid locations such as Antarctica, Atacama Desert, or Arizona's Mount Graham.

"What we've tried to study with this instrument is how stars and planets form. There is a very good theory as to how a star works can predict how its life will play out. But there is no theory as to how the star begins, how it goes from gas cloud to star, so we observe the clouds to find out," says Groppi.

The terahertz telescopes have the potential to connect characteristics of clouds to the type of stars that will form within them. The telescopes offer not only pictures but spectra of the gas so Groppi can determine what elements make up the cloud, how the cloud is moving and temperatures of areas of the cloud.

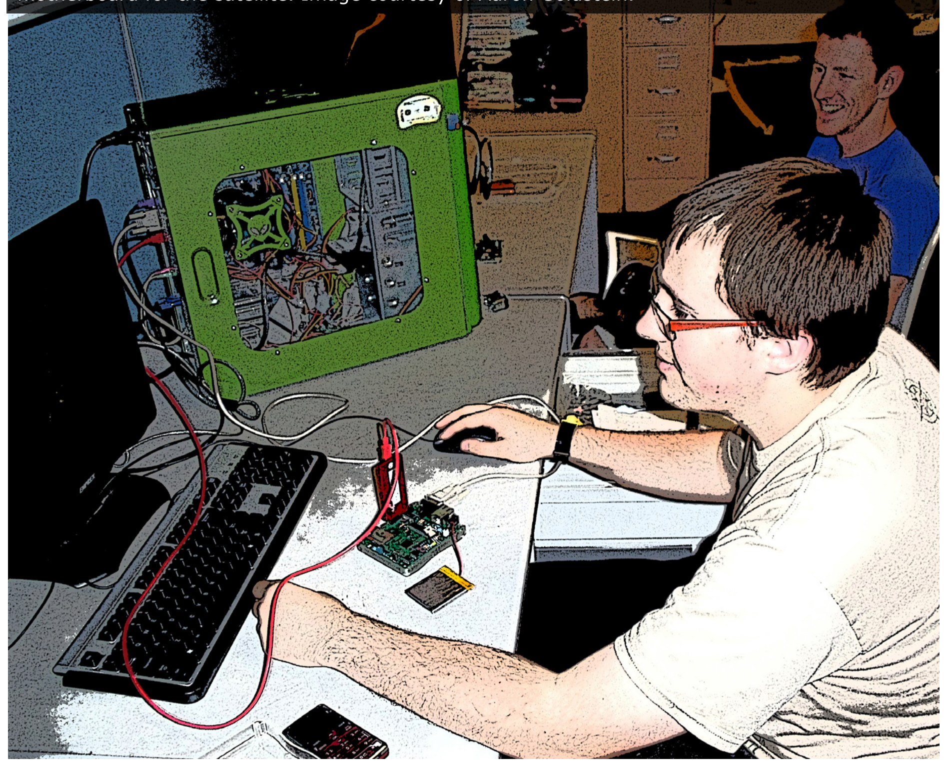
Groppi and his associates have begun pointing their telescopes at the dark patches of the sky; where there are no stars to be seen there is a cloud blocking optical light. Already they have found several young stars less than 100,000 years old, a success for Groppi and his team. The instrument has so far accomplished what it was designed to do.

What is most difficult for Groppi isn't finding the youngest stars of time, but instead having to create a whole new machine on his own: building new eyes for man to look toward the sky, and building them without instructions or a guide.

Sun Devil Satellites

Student-designed satellite prepares for lift off
By Meghan Fern

Team members Zach Gates (foreground) and Aaron Goldstein program the prototype motherboard for the satellite. Image courtesy of Aaron Goldstein.



On Monday evenings at five, when the crowds on the ASU Tempe campus are dwindling, members of the Sun Devil Satellite Laboratory (SDSL) meet in room 490 of the Engineering Research Center to discuss the progress of their ongoing project, a satellite designed primarily by undergraduate students. Aaron Goldstein, a junior majoring in Aerospace Engineering, is club president and founder, leading and organizing the weekly meetings.

The club's concept was sparked by an annual Spacecraft Design Competition, offered by the American Institute of Aeronautics and Astronautics (AIAA). By way of these design competitions, students are enabled to design and create satellite missions, gaining experience comparable to that of actual aerospace engineers. Goldstein, having been informed about the competition from a former roommate who participated and won a previous year, became invested, particularly upon learning that the hardware, a common impediment in aerospace engineering due to production cost, wasn't necessary in the design.

"With AIAA design competitions you can do aerospace engineering, albeit on your own time, for free," explains Goldstein. Additionally, students get exposure to different companies and associates.

The similarity between the work experience of the competition and the experience Goldstein had gained as an intern (at General Dynamic AIS and Orbital Science Corporation) prompted him to take the initiative to start a student organization that emphasizes the same concept — designing and manufacturing satellites. Goldstein spoke with SESE Professor Thomas Sharp, associate director of the NASA Arizona Space Grant Consortium, who then directed him to speak with Professor Srikanth Saripalli, who was similarly interested in starting a satellite lab on campus.

The students' mission: measure the sun's activity by consistently capturing solar flares in the images taken of the sun

The club began in August, 2010. The original SDSL members include: Aaron Goldstein, Tim Caine (Electrical Engineering), Hallie Gengl (Earth and Space Exploration: Systems Design), Zach Gates (Computer Science), and Matt Cunningham (Aerospace Engineering). While the number of participants in the mission has expanded, all of the original members are still actively involved, contributing much of the work. The fundamental importance of this club is the emphasis on student creation as opposed to assisting a professor or company in the design aspects.

"It gives the students a chance to experience what the process of building a space vehicle is like, and allows our advisors and sponsors to reach out to the next generation of employees," said Goldstein.

Originally, the goal was to design a satellite that performs thermal imaging of the Earth to measure the Urban Heat Island Effect. The intent was to receive funding to independently conduct a mission after gaining the monetary support to access hardware and construct it.

After contacting scientists at Goddard Space Flight Center, the opportunity to launch with an imaging instrument the scientists were designing was presented under the condition that SDSL's satellite function to the specifications of said instrument. The mission of SDS-1 is now to, while in orbit, measure the sun's activity by consistently capturing solar flares in the images taken of the sun. The images will help obtain short-term information regarding solar flares. The anticipated launch date is the third quarter of 2013.

Currently, SDS-1 is in the preliminary design phase. According to Goldstein, a large portion of their effort at the moment is going into developing hardware for the C&DH subsystem and analyzing potential components for the ACS subsystem. In the near future SDS-1 will have its preliminary design review, where SDSL's members will present the current status of SDS-1 to the mission's advisors.

ALL SYSTEMS GO

The current mission, Sun Devil Satellite 1 (SDS-1), has subdivisions that focus on specific areas of research. The following are the departments and their area of focus:

PAYLOAD SUBSYSTEM
(Payload) is the main component conducting the mission. All of the other subsystems must design their portions to comply with Payload.

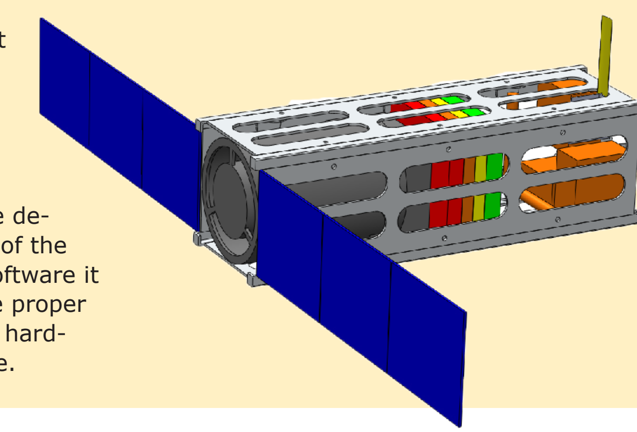
ATTITUDE AND CONTROLS SUBSYSTEM
(ACS) is a technical faction that monitors the motion of the satellite, verifying that it is pointing in the appropriate direction at the appropriate time.

ELECTRICAL POWER SUBSYSTEM
(EPS) is responsible for ensuring that it is powered on, guaranteeing the system has a sufficient number of solar panels and batteries to power itself.

COMMAND AND DATA HANDLING SUBSYSTEM
(C&DH) is responsible for the design of the central computer of the satellite, in addition to the software it uses. It is responsible for the proper function of all of the satellite hardware parts and software code.

COMMUNICATIONS SUBSYSTEM
(COMM) is responsible for ensuring that SDS-1 can efficiently transmit all collected data from Payload, as well as any other pertinent information, to the ground station. COMM is making certain the antennas utilized for bilateral communication are properly sized and oriented.

STRUCTURES AND MECHANISMS SUBSYSTEM
(SMS) is responsible for the design of the chassis of the system. Its purpose is twofold: to ensure that all of the components used for the other subsystems are positioned in the correct locations inside of the satellite chassis, and that physical integrity of the components is upheld.



Geologist Saddles Up

Richard Sherer trades in the rock hammer for leather-working tools **By Meghan Fern**

At one time, Richard Sherer was a dual career-man holding titles of research\exploration geologist and a part-time custom saddlemaker. Upon his retirement, Sherer traded in his geology tools to pursue his life-long hobby of designing and making custom saddlery.

Sherer graduated from ASU in 1965 with a Bachelor of Science in Geology. He graduated just two years after ASU received a large National Science Foundation (NSF) grant, a landmark that catalyzed the transformation of the geology department.

Early in his undergraduate career, Sherer, although holding onto his childhood dream of becoming a geologist, began taking engineering and high-level mathematics courses with the intent of later pursuing a master's degree in engineering. Sherer noted that the geology department, in his early years as a student at ASU, placed a greater emphasis on the transition of students into earth science teachers opposed to industry geologists.

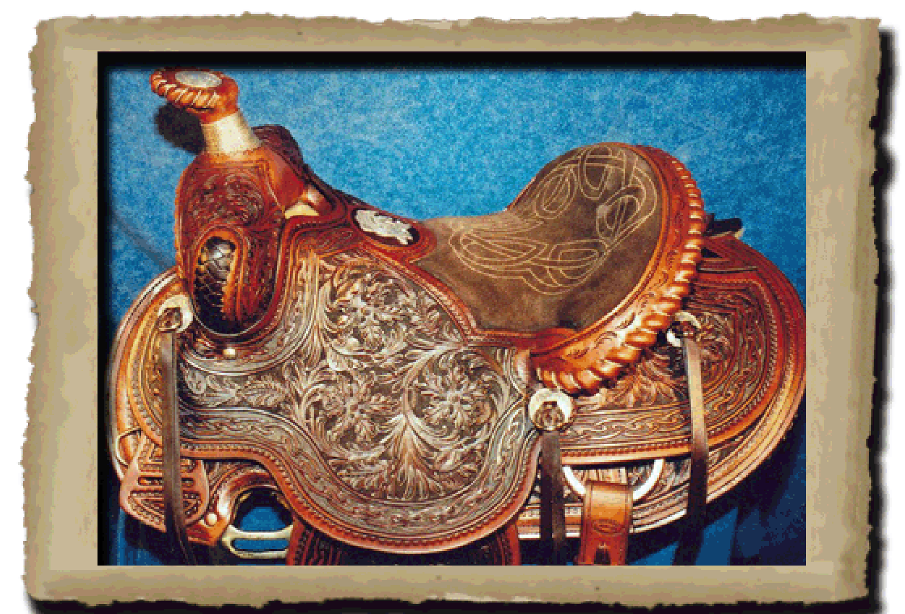
Following the receipt of a number of NSF and NASA grants, the geology department was restructured. Professor Carlton Moore and Professor Robert Lundin were introduced to ASU and heavily influenced and inspired Sherer to focus his studies on the geological sciences.

"My whole perspective changed with them," said Sherer, who spent the summers of 1964 and 1965 doing geological mapping in Baja California, Mexico.

After graduation, Sherer enrolled as a graduate student at the University of Wyoming, receiving an NSF Traineeship that provided him with a full scholarship. His dissertation, which focused on nephrite deposits in Wyoming, was an economic thesis funded by the state survey. After graduating with a Ph.D. in Geology in 1969, Sherer pursued work that emphasized exploration. He initially went to work for Bear Creek Mining Co. (Kennecott Copper Co.), doing Cu-Mo exploration, but left in 1971 to work for UNOCAL (Union Oil Co.), where he did Cu-Mo exploration in Arizona, New Mexico, and Nevada.

To help pay for his college tuition, Sherer made belts on his kitchen table in his basement apartment

In 1978, Sherer, sent to Mt. Pass, Calif., carried out a three-year research program in which he mapped and studied the carbonatite ore body and lanthanide mineralization. Following his completion of research in Mt. Pass, he transferred to Denver where he was an in-house consultant for worldwide specialty metal projects, and also, where he had a mineralogical lab for transmitted and reflected light microscopy and cathodoluminescence. Additionally, Sherer had a budget to use SEM/EDAX at Denver University and had his own field projects within the United States.



In 1990, Sherer retired, and began pursuing his artwork full time. It was at this point that Sherer Custom Saddles, established in 1973, became a full-time venture.

Sherer, who was initially introduced to leatherwork at the age of nine, began it as a childhood hobby in hopes of staying busy during the sweltering months that encompass an Arizona summer. According to him, harness makers and saddlers were part of his family's history dating back to the New England Colonies. His great uncle was a professional harness maker in the early 1900s, and his grandfather and great grandfathers built harness and shoes on their farms in Ohio.

In 1959, Sherer, looking to afford college expenses independently, started an apprenticeship in the saddlery trade that lasted until he graduated college in 1965. Throughout his studies, undergraduate, graduate, and even throughout his professional career, Sherer continued to work with leather. Upon arriving in Laramie for graduate school, Sherer took his belt pattern board to the high-end western store and negotiated, eventually building a relationship where he would provide them with custom handcrafted belts.

"I made belts on my kitchen table in my basement apartment in Laramie," he said. His range of work increased, and when The United States Geological Survey (USGS) and the Wyoming State Survey, which were located in the same building as the geology department in Wyoming, discovered that Sherer did leatherwork, he was asked to make field cases for geologists. He continued making field cases after receiving his doctorate and entering the mining and exploration field.

Sherer, a master of the sciences is now considered a master saddlemaker. His work goes beyond the saddles and horse gear of a typical western saddlemaker. He designs chaps and custom bridles for English riders; restores antique saddles; builds contemporary and historic reproduction gun leathers; and uses exotic leathers to make personal leather goods — and all his pieces exhibit a level of craftsmanship that is only achieved through decades of dedication to an art form. His works can be viewed at www.sherersaddlesinc.com.

The Case of SN 1054

Astronomer-turned-forensic scientist Allison Loll continues to study violent outbursts of the Crab nebula

By Nicole A. Cassis

While pursuing her Ph.D. in astrophysics at ASU, Allison Loll spent many hours in the lab running simulations, testing theories, and analyzing telescope observations related to her research on the Crab nebula. Loll still spends a good chunk of her day in the lab, but now instead of attempting to unravel the mysteries of the Crab, she is scrutinizing fingerprints in the Phoenix Police Crime Lab.

Although not part of her original career plan, Loll smoothly transitioned from astronomer to forensic scientist by applying her training as an astronomer, which mostly dealt with digital imaging, to fingerprint comparisons. [In *CSI/Criminal Minds* speak this is referred to as "latent print comparisons."]

"I truly believe that within 10 years all fingerprint evidence will be digital," says Loll. "Right now I'd say less than 30% of the prints we work with are digital, with the bulk being black powdered lifts that come to the lab."

Perhaps not immediately recognized, but certainly critical to her current career success, were the important communication skills she mastered while in the astrophysics program. By presenting scientific research to the astronomical community, serving as a T.A., and giving many public talks about her work, she was able to learn how to effectively convey scientific information in a way that a large variety of people could understand. Loll, who is called to testify as an expert witness about once a week in court, relies heavily on those skills because she often testifies to a jury that has no scientific background on how forensic scientists compare fingerprints.

But courtrooms aren't the only medium in which she communicates. Loll recently was interviewed by *Astronomy* magazine for the article "The Crab Nebula's everlasting mystery" in the March 2011 issue.

"I was fortunate enough to have a NASA Space grant for the summer prior to beginning my grad classes, and at the time I knew I wanted to work on a project that involved stars and/or interstellar dust," explains Loll, who began under the advisement of Jeff Hester, but finished her Ph.D. under the advisement of Steven Desch.

"I knew Jeff Hester's work, and he agreed to let me work with him. He suggested that I begin building the mosaics with the recently acquired HST data of the Crab nebula. I was ecstatic to do so, and since there is a wealth of information contained in those images, it was more than enough for me to build a dissertation from."

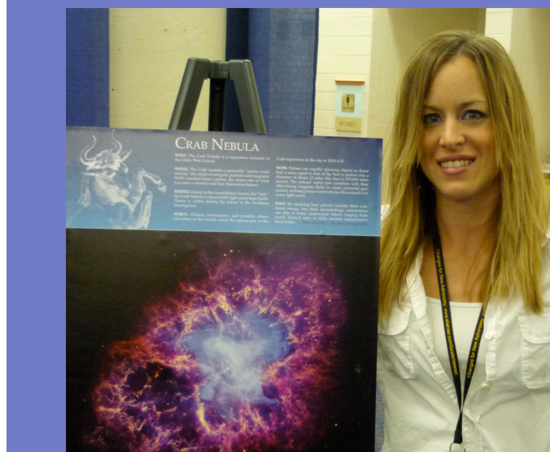
Loll completed her grad work in the physics department, being too far along to switch to SESE. Her entire dissertation and research dealt with the Crab Nebula.

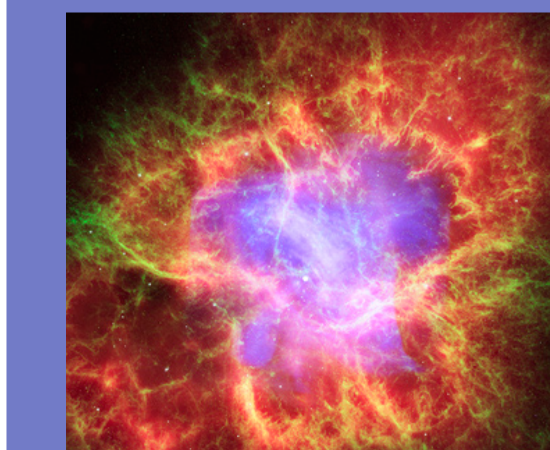
Since its light first reached Earth as a supernova in A.D. 1054 (known as SN 1054), the Crab nebula has remained a mystery. Arguably the most studied object in all of astrophysics, the Crab is close enough that it can be examined in detail, but unique enough that it keeps astronomers guessing. Astronomers' idea of how the nebula became what it is today has changed considerably over the years.

The author of the recent article, striving to re-cap what scientists have learned about the Crab nebula in recent years and how they presently understand it, found Loll to be a valuable resource. In addition to her dissertation work she had also been the P.I. on two successful proposals for observing time at the MMT Observatory where she collected high resolution spectra of the Crab.

"If I am known for anything it is the Hubble Space Telescope mosaics that make up the image of the Crab featured in this magazine article," says Loll.

This isn't the last you'll hear of Loll. She and Desch are currently writing another research paper, this time examining the strange shape of the boundaries between its various components.





(From top to bottom): Allison Loll, a forensic scientist, credits much of her current career success to the training she received in the astrophysics program and the help of her advisor, Steve Desch (pictured below). This stunning image of the Crab incorporates an X-ray image with an optical image. Credit: X-ray: NASA/CXC/ASU/J.Hester et al.; Optical: NASA/ESA/ASU/J. Hester & A.Loll; Infrared: NASA/JPL-Caltech/Univ. Minn./R.Gehrz.

News

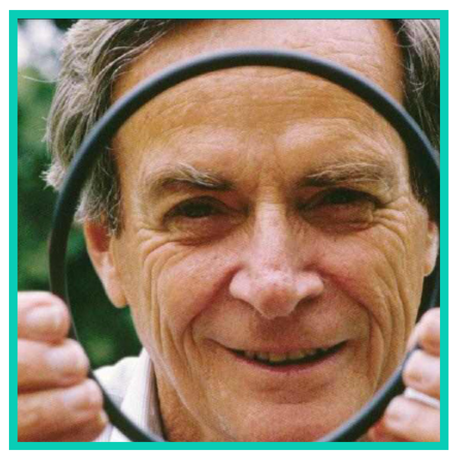
Mark Robinson and his talented LROC team have been pushing out several new images. This one of the lunar nearside was featured on NASA's Astronomy Picture of the Day.

Ramon Arrowsmith and 28 students used their spring break to map earthquake faults in the mountains near Superior, Ariz. Read the ABC15 story and watch the video here.

SESE ranks 17th among public and private graduate programs in the country, according to U.S. News & World Report's 2012 edition of "America's Best Graduate Schools."

Lynda Williams, co-author of the recently published paper "Abundant ammonia in primitive asteroids and the case for a possible exobiology," found ammonia in her analyses of Sandra Pizzarella's meteorite samples.

GeoClub's Student/Professional Meet and Greet held on March 9 was well-attended. About 25 professionals networked students, providing them with valuable information about their career paths.



Lawrence Krauss publishes a new scientific biography, "Quantum Man: Richard Feynman's Life in Science," due out March 21, that depicts the Nobel Prize winner as more than "just" a brain.