Top Ten Physics News Stories in 2014

Every year, APS News looks back to see which physics news stories grabbed the attention of the public. This list is not necessarily a compilation of the most important advances or discoveries of the year, but rather the ones that seemed to garner the most headlines and column-inches. In (roughly) chronological order, the top ten physics stories of 2014 were:

**Fusion Milestone**

Physicists at Lawrence Livermore National Laboratory announced in February that they reached an important milestone: At the National Ignition Facility, 192 simultaneous laser pulses blasted tiny hydrogen pellets, and the resulting fusion reactions emitted slightly more energy than was initially absorbed—a key first step in inertial confinement fusion. However, there is still a long way to go before the machine produces a net gain in energy, since the pellets absorbed only a small fraction of the incoming laser energy.

**BICEP2 searches for inflation.**

BICEP2 searches for inflation.

**BICEP2 in March**

The scientific team behind the BICEP2 telescope at the South Pole made the sensational announcement that they had seen the first evidence of “B-mode” polarization in the cosmic microwave background (CMB) radiation. At the time it was held up as “the smoking gun” for evidence of gravitational waves left over from a period of rapid inflation in the early universe. However, soon after the announcement, doubts about the data started to emerge, and it was unclear if the team could definitively rule out the effect of cosmic dust. In the resulting scientific paper, published in *Science*, the team acknowledged that dust may have affected the observations, but nevertheless they still felt the gravitational wave signal was real. In September a new report from the ESA’s Planck satellite reinforced concerns about the initial results, but the two teams are continuing to work together to resolve the discrepancies. Also in December, independent of the BICEP2 research, Planck’s team announced that they had finished processing the data from the satellite’s fourth year and had created the most detailed map of the CMB. *Intergalactic Neutrinos* In 2013, the IceCube neutrino detector at the South Pole observed additional highly energetic neutrinos, which provided further evidence of neutrinos from outside our galaxy. A new event announced in April, dubbed “Big Bird,” unseated the reigning champs “Bert” and “Ernie.” At more than two petavolt-electronvolts, it’s twice as energetic as the previous record-holders, but because it’s not anything like an order of magnitude greater, investigators think that they might be close to seeing the upper limit of cosmic neutrino energies. **Physics in Movies** 2014 was a blockbuster year for science on film and TV. Premiering in March, *Neil deGrasse Tyson’s highly anticipated follow-up to Carl Sagan’s TV series Cosmos captivated audiences and took them on a journey into the universe.*

ICECUBE's big find

**IceCube Collaboration**

In *Science*, the IceCube Collaboration announced that they had observed three new events, at energies of 5.8 and 7.5 teraelectronvolts, that must be very distant events, perhaps from outside our galaxy. One of the events was found in the deep ice in the Antarctic, while the other two were found in the deep ice of the Arctic. In December, the collaboration announced that they had observed additional highly energetic neutrinos, which provided further evidence of neutrinos from outside our galaxy. A new event announced in April, dubbed “Big Bird,” unseated the reigning champs “Bert” and “Ernie.” At more than two petavolt-electronvolts, it’s twice as energetic as the previous record-holders, but because it’s not anything like an order of magnitude greater, investigators think that they might be close to seeing the upper limit of cosmic neutrino energies.

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**Welcome to the future of supercomputing!**

**Future of supercomputing: Top computers are funded by the Department of Energy.**

**Top TEN continued on page 6**

**Wanted: Input from Physicists on the Future of Computing**

By Michael Lucibella

The National Research Council is developing a report for the National Science Foundation on advanced computing, and is looking for input from the physics community. The report, “Future Directions For NSF Advanced Computing Infrastructure to Support U.S. Science and Engineering in 2017-2020,” will review what the NSF is doing to get scientists access to the advanced computing hardware and software they need, and what can be improved.

“This is an activity that the NSF conducts every five years or so,” said Robert Harrison, co-chair of the committee putting the report together. “It assists them in creating a roadmap, a set of priorities for the next five years.” He likened it to a smaller version of the surveys carried out every ten years by the atmospheric community to plan a decade’s worth of scientific projects.

To help promote discussion in the scientific community, the committee released an in-person version of its report this summer, which outlined the direction the full report will take. “It’s really a list of questions we’re considering,” Harrison said.

The NSF supports 16 sites across the country that let researchers use supercomputing hardware for computation-heavy research. The writers of the report are in part engaging to see how high-education, top?
This Month in Physics History

January 1, 1925: Cecilia Payne-Gaposchkin and the Day She Changed Everything
By Richard Williams

Cecilia Payne made a long and lonely journey from her childhood in England to prominence in a scientific community that braggadocied a place for women. She began her scientific career with a scholarship to Cambridge University. Her 1925 thesis, entitled Stellar Atmospheres, was famously described by astronomer Otto Struve as “the most brilliant PhD thesis ever written in astronomy.” By analyzing the abundance of chemical elements from stellar spectra, her work began a revolution in astrophysics.

Harlow Shapley liked to say that “no one could earn a PhD unless he had suffered in the process.” As she neared the end of her doctoral project on stellar spectra, Cecilia Payne wrote, “I have followed months, almost a year as I remember, of utter bewilderment. Often I was in a state of exhaustion, despair and work all day and late into the night” [1]. The physical and mental strain of suffering graduate students is perhaps best expressed by a line from poet Percy Bysshe Shelley: “Like the poets, they learn through their suffering what they teach in their songs.”

When Cecilia Payne began her study of stellar spectra, scientists believed that the relative abundance of elements in the atmospheres of the Sun and the stars was similar to that in Earth’s crust. Many of the strong lines of the solar spectrum came from the elements most abundant on Earth. The pre-eminent American physicists at the time, Henry Norris Russell and Henry Rowland, believed that the elemental abundances on Earth and the Sun were substantially identical. Russell wrote [2] “The agreement of the solar and terrestrial lists is such as to confirm very strongly the view that, if the Earth’s crust should be raised to the temperature of the Sun’s atmosphere, it would give a very similar absorption spectrum.” Many of the spectral lines of the Sun and other stars were similar, so it appeared that the relative abundance of elements in the universe was like that in Earth’s crust. Payne had a better knowledge of atomic spectra than most astronomers at the time. She also knew the 1920 work of physicist Mehlgan Saha on the theory of ionization of atoms. He showed how to use an equilibrium equation from physical chemistry to calculate the ratio of excited states to ground states, and the fraction of ionized states to the temperature, electron concentration, ionization potential, and other properties of the stellar atmosphere. Payne met Saha when he visited Harvard, just as his work was becoming known to astronomers.

Payne’s thesis [3] confirmed the view of Russell and Rowland on the abundance of the heavier elements in stellar atmospheres. She then applied Saha’s equilibrium to the Balmer series absorption in hydrogen, which originates from atoms in the first excited state. She was the first to appreciate that, in the atmosphere of the Sun at 5700 K, only about one in 200 million of the hydrogen atoms in this excited state was not.

The total quantity of hydrogen is grossly underrepresented by the Balmer absorption. A similar argument holds for helium. She found similar results for other stars. Payne concluded that, unlike on Earth, hydrogen and helium are the dominant elements of the Sun and stars. Henry Norris Russell strongly opposed this conclusion and convinced her to omit it from her thesis. However, current averages give mass fractions for the mass fraction of elements in the Milky Way Galaxy as: 74% hydrogen, 24% helium; all the remaining elements, 2% confirming Payne’s result. Her discovery of the true cosmic abundance of the elements profoundly changed what we know about the universe. The giants — Copernicus, Newton, and Einstein — each in his turn, brought a new view of the universe. Payne’s discovery of the cosmic abundance of the elements did no less.

In 1934 Payne visited the observatory in Lenin-grad, at a time of great Soviet-German tension, hard living conditions, and suspicion of foreigners. She continued on to visit Germany, where conditions were equally tense, and met a young Russian astronomer, Sergei Gaposchkin. Despite hardships and persecution in the Soviet Union because of his political views, he had achieved success as an astronomer. Now he faced persecution because he was Russian. He asked her to help him get to America. She was moved by his story, and, after returning home, she worked hard to get him a visa as a stateless person. In 1935, after they were married and she became Cecilia Payne-Gaposchkin.

On completing her doctorate, after considering it was out of the solar system, some of the work has been forgotten, but as time passed, it became more important. It was a great contribution to science.

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* Members of the APS Board of Directors
Physicist Nominated to Lead Pentagon

By Michael Lucchella

Physicist and former defense department official Ashton Carter is President Obama's pick to be the next secretary of defense, the White House announced in early December. If confirmed, Carter will succeed former Nebraska Senator Chuck Hagel as the head of the department. Carter had been a long-time faculty member at Harvard University specializing in technology and security policy and previously served as the deputy secretary of defense from October 2011 through December 2013, the same period he was serving as CERN's Director General, lecturing at Stanford in October of this year as a visiting scholar.

President Obama said at the press conference announcing his nomination. “He’s an innovator who helped create the program that has dismantled weapons of mass destruction around the world — programs that he had a direct hand in creating.” The former defense secretary had been a strong advocate for innovation and for pushing the U.S. military to adopt new technologies to stay ahead of its adversaries. Carter is also known for his work on the development of a space-based anti-missile system, which he helped to advance while serving at the Pentagon.

Digital Archives Grow in Size and Usefulness

By Michael Lucchella

Historians, scientists, and the public now have more access to digitized raw materials than ever before. In the last few years, two large libraries of historical science documents were posted online, freely accessible to the public. Though online archives like these are becoming more common, the challenge of digitizing tens or hundreds of thousands of documents has kept the pace of uploads relatively slow.

In September, CERN began posting its massive photo archive (cds.cern.ch/collection/Photos) to the web. The group has posted nearly 40,000 of its more than 120,000 black and white photos negatives from the 1950s through the early 1980s. Then in December, the Einstein Papers Project (einsteinpapers.org) located at Caltech, started posting scribed versions of Albert Einstein’s correspondence up to 1927. “What we put online is an evolving scholarly annotated papers that have been collected,” said Diana Kormos Ash. The group has posted 219 of its more than 1,500 pages of Einstein’s letters, from 1904 to 1926. Already the group has posted nearly 500,000 of its more than 120,000 black and white photos negatives from the 1950s through the early 1980s.

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Use Judgment Instead of Impact Factors

The Back Page essay by Carlton Caves, “High-impact-factor syndrome,” (APS News, November 2014) is a much-needed clarion call for more thoughtful evaluation of researchers and research institutions. The wisdom and truth of Caves’ analysis should be self-evident, but is sadly and widely ignored. His proposed test of one’s ‘impact factors relating to HIFS’—asking if the same publication/citation record looks more impressive if the papers appeared in Nature and Nature Physics than if they appeared in PRL and PRA—is compelling and sobering. We would all be well advised to treat important decisions like hiring and promotion with laborious (but substantive) judgment rather than lary (and near-empty) ‘objectivity.’

William D. Phillips
Gaithersburg, Maryland

HIFS and Related Diseases

I enjoyed Carlton Caves’ recent Back Page article on HIFS: high impact factor syndrome (APS News, November 2014). Having excellent scientific work is no guarantee that this can only improve our discipline. Like many of my colleagues, I also find it annoying when someone talks about ‘the impact factors of high-impact journals’ as defining greatness. There are excellent papers published elsewhere.

I am often the only person near

Voting is Fundamental

In APS News (November 2014) several distinguished physicists took exception to the new Constitution & Bylaws because they felt their voting participation was being denied. In response, 2014 APS President Beasley explained that the APS Council deliberated this issue but in the end chose the Council to approve amendments, partly because APS voting participation was perceived as low.

Beasley and the Council may be correct, but more importantly we need to rectify our abominable voting record. We cannot maintain a healthy APS if most of us shirk our voting responsibilities. The world faces challenges, most of which will require the expertise found in APS. We can be of little service to our Society in being underrepresented in its proper functioning. Voting is crucial to our health, on par with the role of a constitution in any system. No excuse is valid. “I don’t have time; I’m too busy with research and teaching; my vote won’t mat-

ter anyway.” I recently spent a half hour reviewing Forum on Education candidates. As a former teacher, I wanted to understand what challenges they face and maintained my response. I voted and benefited from the experience.

Nature Publishing Group Starts “Free to Read” Link Sharing

By Tamael Maciel

Nature and 48 other academic journals in the Nature Publishing Group (NPG) have made all of their articles past and present “free to read” online, provided a subscriber or approved media outlet shares a link. But some open access advocates were skeptical.

As of December 2014, anyone with a subscription to Nature or one of NPG journals can, with the click of a button, send friends or colleagues an email with a link to the online article. Property software called ReadCube keeps track of links shared in a web browser for reading, but sharing requires an online account. NPG’s publisher, Macmillan Science and Education, took a majority stake in ReadCube through its technology division, Digital Science.

“We know researchers are already sharing and linking behind hidden corners of the Internet or using clumsy, time-consuming prac-

tices,” said Timo Hannay, managing editor of Digital Science, in a press release. “At Digital Science we have the technology to provide a convenient, legitimate alternative that encourages researchers to access the information they need and the wider public’s access to scientific knowledge, from the definitive, original source.”

Hannay is referring to the com-

mon practice on academic sites of sharing their papers online, either by emailing PDFs of published-embargo papers or by allowing authors to share access to crowdsourced free copies. Since this “dark sharing,” as NPG calls it, happens by default, some online allowances are easy to wrongly use is the amount of PDF sharing among scientists, according to a recent blog post by Michael Eisen, University of California, Berkeley biologist and open access proponent.

A larger effort might come from the 100 media outlets and blogs that can also share these links. If the practice is widespread, the public will have increased access to NPG research and, as Eisen pointed out, NPG will be able to track what is shared and better understand the impact on social networks.

This comes at a time when governments and funding agen-

cies such as the National Institutes of Health and the Bill & Melinda Gates Foundation are calling for increased open access to research results. Many advocates want full open access — free access to research immediately upon publication — but faced with the need to cover publication costs, many publishers, including APS, implement a hybrid open access policy. Some open access advocates are unconvinced that NPG’s “free to read” initiative is the right move. “More access is always prefer-
able to less access. But Nature’s convoluted, read-only access is insufficient … because it adds an arbitrary embargo that runs counter to the principles of open access to scientific knowledge, from the definitive, original source.”

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New Brookhaven Light Source Debuts in 2015

By Michael Lucchella

Brookhaven National Laboratory’s new synchrotron Light Source-II (NSLS-II) is nearing completion, and the lab will put out a call for experimental proposals in October. The new, third-generation light source passed its accelerator readiness review on September 22, 2014 and is on schedule to start its first “early science” programs in winter.

The NSLS-II will succeed Brookhaven’s current National Synchrotron Light Source, which has been operating since 1984. Once completed, the new facility will be the brightest x-ray light source in the world, ranking it as the nation’s premier synchrotron user facility.

“I look forward to the exciting science and benefits that NSLS-II will deliver to the U.S. Department of Energy and the nation,” Steve Dierker, Brookhaven’s associate lab director for research operations, said in a statement.

The accelerator readiness review approved the synchrotron’s request to start routine operations. It covers the lab’s safety, security, environmental management, documentation and personnel policies. The first tests to characterize the x-ray beams will start running this winter, while experiments selected from October’s call will likely start in early 2015.

“Synchrotron light sources serve a very diverse user community — condensed matter physics, material science, chemistry, nanotechnology, structural biology,” said Sam Aronson, the 2015 APS President and former director of Brookhaven Lab. “The new capabilities will provide access to experiments which are currently impractical or even impossible with current light sources.”

Overall construction of the machine is about 98 percent complete. There are thirty initial beamlines in various stages of development that will come online between now and 2017. Ultimately 120 to 130 beamlines will be home to more than 60 beamlines as more are designed and installed over the life of the facility. Construction began on the NSLS-II in 2009.
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March, the documentary Particle Fever was released across the country, offering an intimate look at the lives of CERN’s researchers hunting for the Higgs Boson. The life of Stephen Hawking got the Hollywood treatment in the critically acclaimed film The Theory of Everything. And did mathematician Alan Turing in The Imitation Game. After years of development, the film Interstellar hit the big screen. Inspired by physicist Kip Thorne’s theories of gravitation and relativity, it wowed audiences with its production values and arrays of black holes and time dilation.

Element 117

Unnecessarily, the placeholder name for element 117, was spotted for an instant in Germany in May. At the GSI Helmholtz Centre for Heavy Ion Research in Darmstadt, scientists bombarded a beryllium target with accelerated calcium atoms to create the short-lived artificial element. This follows up on an experiment in Russia in 2010 that first created the element, confirming its existence and likely paving the way for its official inclusion on the periodic table of the elements. In addition, one of the isotopes of lawrencium discovered in that experiment had a half-life of nearly 11 hours, giving physicists hope that experiments might be bringing them closer to the hypothetical shores of the “Island of Stability” for super-heavy elements.

Gargantuan Black Hole

In 2012, astronomers discovered a massive mysterious object falling towards the giant black hole at the center of the Milky Way galaxy. They predicted that its observed elliptical orbit would bring it closest to the black hole around mid-summer and were primed to watch the predicted fireworks of the object being ripped apart. Instead, it was more of a fizzle. Originally thought to be a giant gas cloud, the object might actually harbor a large star in its center, which would have held the gravitational pull to keep the enormous gravitational tidal forces. Based on its trajectory, there’s a chance that in a few decades the object will collide with the cloud together in the face of the enormous gravitational tidal forces. If that happens, it could be a good time for a dust and gas surrounding the black hole, and maybe then scientists can take astronauts into Earth orbit.

Ebolavirus

Vesugian of Northeastern University used computer models to simulate the movement of people throughout the world and the ways they could be infected within over 6000 deaths.

Prize Offers

Without winning the Nobel prize in their own field, physicists did well in October anyway. The physics prize went to two engineers who originated one of the most celebrated theories in the United States and two from Japan, for their work developing the blue light emitting diode. After the quick invention of the red and green LED, an efficient blue device took nearly twenty years to develop. Three young day physicists from the United States and Germany won the chemistry prize for the development of super-fast fluoroscopes, which pushed the limits of optical microscopy down to the nanoscale.

Space Exploration

This fall, interplanetary exploration was a central focus of the world’s space agencies. In October, India made headlines by successfully placing a small satellite into Martian orbit, only the fourth space agency to do so and more cheaply than any other Mars mission to date. In November, the European Space Agency’s Rosetta space probe dropped the tiny Philae lander on the surface of the comet 67P/Churyumov-Gerasimenko, and its operational life was cut short after the lander bounced off its planned landing zone into a shaky crater. Without functioning solar panels, the reserve battery discharged, but not before the lander carried out 90 to 90 percent of its scientific mission. This included a startling discovery announced in December that the isotopic content of the comet’s water molecules didn’t match that on Earth, rekindling questions about where our planet’s water originated. Also in December, NASA announced the successful landing of InSight on Mars, its new spacecraft designed to take astronauts into Earth orbit.

Tabletop Accelerator

In December, scientists at Lawrence Berkeley National Laboratory announced a new world record for a compact particle accelerator. The team used a tabletop-sized laser-plasma accelerator to energize electrons up to 4.25 GeV. Though not nearly as powerful as the massive LHC, the tiny BELLA accelerator can do in about one meter what would take CERN’s 1000 meters. Physicists hope that this emerging compact accelerator technology will pave the way to new generations of tabletop particle accelerators.

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comes in many forms; the research, education, and physics careers we advocate for or the impact of policies that we talk about in our public statements. There are a number of ways in which we can influence the public’s opinion of the work of the physics community and its role in the larger society. I think these are the main things that we need to be focused on.

What do you see as the Society’s role on international issues?

Science is so international now, and the Society has no effort into coordinating on some issues with other physics societies and scientific publications. I think probably the majority, of the scientific publications in our journals do not originate in the United States; they originate all around the world with big components in Europe and Asia. I am in fact an international society and its publications are international physics publications. We have a role and responsibility on the international scene just in the course of doing our normal business. We serve a much bigger base than the American physics community.

In recent years, APS has been increasing its focus on education and outreach. What do you think of these efforts and how will you continue to support them?

I think they’re very important for the reasons I mentioned earlier regarding the pipeline of physicists that is generated in this country and elsewhere, and that does the research in which the U.S. would like to maintain leadership. Education has two features. One is raising the awareness and general knowledge of the population at large on scientific matters. The other is helping to build the most robust and most diverse pipeline of people who want to work in STEM fields or fields where a physics degree turns out to be an important asset, and that can be in a very large variety of fields. How do you think we can increase the participation of a lot of different people in aspiring to these fields?

How will you guide APS through the current period of corporate reform transition?

We will all have to implement the reforms that we’ve worked on over the past couple of years and our progress and our outreach efforts. Concerns and opportunities where this Society and the physics community can provide benefit to society overall.

How do you think you can help APS refine its mission statement?

It is the role of leaders to help refine the mission statement as it evolves. I think I can definitely work harder to help refine and develop the mission statement.

How do you see the Society’s role in public policy?

I think it’s important for us to advocate in voice in scientific matters and we need to continue to exercise it in our public policy and outreach efforts. Concerns and opportunities where this Society and the physics community can provide benefit to society overall.

How do you plan to implement a new corporate governance structure?

I think we have the right people at APS to implement the reforms that we’ve worked on over the past couple of years and our progress and our outreach efforts. Concerns and opportunities where this Society and the physics community can provide benefit to society overall.

In what ways would you like to see APS programs be enhanced?

First of all, the fact that we’re doing something that has to be done on the biggest computers. How will you continue to support these programs?

I think it’s important that they be done on the biggest computers. How will you continue to support these programs?

What do you think the Society is serving its members?

Are there any areas where you think APS programs could be enhanced?

In general the Society is serving its members very well.

What about the perception of the Society’s role in the larger society?

The membership wants access to scientific publications in high quality journals, which the Society provides. Our journals are the benchmark journals of physics in the world. The membership wants to ensure that the Society continues to provide active and attention-worthy meetings and conferences, which we also do. Those I think are the main services that the membership expects. I have some concerns that as a Society our communications internally and externally may be getting them more information more specific to the American Physical Society, could be improved and we’re doing some work to look at whether that’s so or not. That work will continue to improve our communications internally.

Something maybe not so visible to our members, but still important, is the strategic budgeting of the Society’s operations. This ensures we’re good stewards of the Society’s assets and efficient providers of publications and services with the funds available. The Society’s staff and its governance bodies — the Board of Directors and the Council of Representatives — are responsible for the execution and the oversight of such functions. I think that’s a little bit off the radar screen and not the most visible forms of the services that we provide.

How do you see as the Society’s role in public policy?

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I think it’s important for us to advocate in voice in scientific matters and we need to continue to exercise it in our public policy and outreach efforts. Concerns and opportunities where this Society and the physics community can provide benefit to society overall.
sites and time periods, including the Revolutionary War era sites of Old Fort Johnson and Fort Klock in New York, Contact-period Native American sites in New York, an 8th-to-12th-century Irish monastic site, the Klondike Gold Rush city of Dyea, as well as several sites to locate unmarked burials,” he says, just to name a few. He has also conducted fieldwork in Maine, New Hampshire, and Vermont.

For a project in Cyprus, Bodhi Rogers and his team surveyed a 23-square-meter area dating to the late Bronze Age (approximately 3,000 years old). He explains, “The goal was to map the remaining city walls to try to understand the layout and see how people express power through urban design… We still have to excavate, because archaeological geophysics doesn’t tell us how old things are or what the function of the buildings was.” But his efforts “make the archaeological excavation much more efficient and focused, since we already know where to dig and what questions to ask.” Using ground-penetrating radar and magnetometry, he was able to reveal the pattern of the city. Ever the physicist, Bodhi has also examined how to improve ground-penetrating radar, especially under wet conditions, and has published studies on this topic.

The appeal of a dual career that unites these fields is clear. For Bodhi Rogers, it means “being able to work on intellectual challenges never ceased, especially since, given his knowledge, he can easily navigate a diversity of archaeological sites and time periods. “I get to travel the world and visit cultures most people don’t get to experience,” adds Hanauer. “It’s a phenomenal job that is incredibly interdisciplinary and extremely rewarding.” It’s amazing what can happen when one explores an “interesting combination of subjects.”

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We need a full-time/needed. Tethered to the university, our partnered definition on high-tech steroids.) Program students have capstones bent. Together with burgeoning business collaborations, physics PhD’s have graduated, many with entrepreneurial science departments as well as industry, two-dozen industrial in industry who recruited me for product modeling. New to our work. Such basic research seemed impractical, but put that time into disciplines that include social sciences and (Full STEAM ahead!) Author Malcolm Gladwell says that help us to be entrepreneurs, and not only in science, tech - is often distinguished from it, innovation. Are entrepreneurs made, not born? In the proposal \[2\] While dictionary definitions refer to starting a business at job, too. Nonetheless, there is a path to getting S

How We Define Stay-Put Entrepreneurship

An early connection came from former students employed in industry who recruited me for product modeling. New students were trained as the modeling opportunity grew, and we created an imaging course and an industrial PhD track. With a healthy thirty-year run serving engineering and science departments as well as industry, two-dozen industrial physics PhD’s have graduated, many with entrepreneurial bents. Together with burgeoning business collaborations, groundwork was laid for our start-ups.

In support of collaborations, we pioneered an award-winning professional master’s Science and Technology Entrepreneurship Program (STEP) serving physics, mathematics, biology, and chemistry departments, and now in its fifteenth year with dozens of alumni. (Think of an MBA on high-tech steroids.) Program students have capstones involving a start-up company or an internship in industry.

How We Define Stay-Put Entrepreneurship

While dictionary definitions refer to starting a business at some risk, a Harvard quotation [1] called “the best answer ever,” says “Entrepreneurship is the pursuit of opportunity because opportunity, not because of wealth which finance yourself and remain entrepreneurial, but outside help is usually needed. Tethered to the university, our partnered definition small but critical change: A full-time faculty entrepreneur is one who collaboratively pursues opportunity beyond the resources controlled. We need a full-time business partner.

FROM EXPERIENCE: Creativity and Innovation

Are entrepreneurs made, not born? In the proposal [2] that incorporates entrepreneurship in an “ESTEAM” K-16 education (or K-18 with a step), we suggest including professors as students. As noted, universities comprise mentors, advisors, partners, funding sources, and accounting help; programs like STEP study the “valley of death” (running out of money between incubation and commercialization), valuation (product/service pricing), marketing, salesmanship, and understanding the marketplace. Creativity has been defined as “inside the box” in an approach [3] called “Systematic Inventive Thinking” (SIT). Consider system components, like in a computer. To improve it, the SIT rule is to avoid considering any outside, unconnected components; it is not creative to go “outside the box,” which is to combine unrelated systems.

Consider a square of nine dots and familiar puzzle of neeaboling all dots with only four straight lines along one path. Needing external interconnections is usually regarded as a metaphor for thinking outside the box. Yet when students are told to consider outside intersections, most still fail to solve it. SIT suggests it is not thinking outside the box but rather the original straight-line components applied in a novel way. The famous outside-the-box example is actually an inside job. To use SIT, make a list of system parts and perform one or more of the following operations: SUBTRACT one of the parts, ARRANGE them, COPY one but with a new role for it, make a NEW TASK for one, and/or find NEW RELATIONSHIPS among them. Afterwards, assess the benefits of the new system, and ask, “Is it possible?” Many examples of all five techniques can be found. Although we have not been conscious of SIT, we can find common ground in our work, and, besides, “staying inside the box” resonates as a metaphor for an entrepreneur staying at the university. SIT focuses on “innovation,” which includes inventiveness and commercialization. It emphasizes combining the acronym [4] NABC — the Needs (the problems), Approach (to show feasibility), Benefits per costs, Competition — with the “Champion,” an outsider who helps from the内izations. As satisfied customers, OEM’s (Original Equipment Manufacturers) have been champions for us. With this background, we turn next to the results.

The Best of the Story: Six Key Points

1. Ideas for business? Many ideas come from a collabora- tion on a new product or a problem with a present product. Having a need to out-source work provides opportunities for start-ups.
2. Multiple start-ups. A former student came back to co-start an award-winning radiofrequency-cool manufacturing business years ago, growing to 220 employees. Another mentee was likewise the brains and brawn behind a company to make the whole MRI system, now with over 100 employees and $100M in investment; a different former student was the key technologist in a new image-guided radiotherapy company. We have formed a partnership with one more new company making high-temperature superconductor MRI systems. My roles have been co-founder, recruiter, the aforementioned “Champion” in attracting investors, grant writer, and doing the myriad tasks sprinkled all over this essay. Dozens of former students are employees of these start-ups.
3. Patenting, Publishing, and Proprietary. Start-ups need intellectual property (IP) to protect products and buttress their valuation. Co-sharing IP depends on whose facilities and funding have been utilized, but schools are looking at this touchy issue more broadly now, recognizing the value in nurturing businesses. Interestingly, patenting may be delayed to avoid divulging trade secret details. (However, U.S. patent law does not protect business ideas.)
4. Idea to product. To deal with patent infringement, an entrepreneur may undergo a legal deposition (i.e., mercies, grilling by attorneys). To avoid this, you prepare for it like a final exam you can win that battle.

Publications are good for business. For example, radiolo- gists influence their hospitals’ purchasing; they read clinical journals, as well as industry journals. Publications are also critical for successful grant writing and funding pro- posals. Funding agencies with a forest of acronyms (SBRIR

5. Tenure Tracks. Will faculty entrepreneurs get tenure? Entrepreneurship can wait until tenure is earned, as I chose to do. But assistant professors can and do have business ideas and take on the juggling act. Someday, entrepreneurship may be a standard tenure track.

6. Risks versus Benefits. Entrepreneurship may force a career change, leaving faculty reluctant to try it. Much history beyond mine has shown, however, that the partnered faculty entre- preneur can successfully combine the new and old careers.

The Stay-Home Message

In summary, the following steps, I believe, can be taken to manage the risk for the partnered faculty entrepreneur:

• Obtain a tenure-track position in traditional STEAM or disciplines.
• Master a discipline anywhere in STEAM, training stu- dents as you go.
• Grow a network of former students, colleagues, and collaborators in scholarship/research.
• Learn from ESTEAM mechanisms: internships, business schools, master’s programs, etc.
• Create a commercialization venture from connections with industry, networks, SIT, etc.
• Choose a business partner from your network (or have them choose you) who can lead.
• Get help inside or outside the university to write busi- ness plans, determine shares, manage IP, get financing, and ... learn how to charge for your product/service.
• Establish a conflict of interest management plan with the university.
• Contribute as an interim president, recruiter, researcher, grant writer, advisory board member, and so forth.
• Spend time consistent with the university’s policy of allowing other outside activities such as consulting or book writing.

And you can gain the pride of ownership, of creating new jobs — and of maintaining the rewarding closeness of your former students.

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The Back Page

Start Up But Staying Put

By Robert Brown

Thinking outside the box?

Particle physics is “a The Big Bang Theory”

APS News welcomes and encourages letters and submissions from its members responding to these and other issues. Responses may be sent to: letters@aps.org