

CERN'S ULTIMATE ACT OF OPENNESS

The seed that led CERN to relinquish ownership of the web in 1993 was planted when the Organization formally came into being.

At a mere 30 years old, the World Wide Web already ranks as one of humankind's most disruptive inventions. Developed at CERN in the early 1990s, it has touched practically every facet of life, impacting industry, penetrating our personal lives and transforming the way we transact. At the same time, the web is shrinking continents and erasing borders, bringing with it an array of benefits and challenges as humanity adjusts to this new technology.

This reality is apparent to all. What is less well known, but deserves recognition, is the legal dimension of the web's history. On 30 April 1993, CERN released a memo (pictured right) that placed into the public domain all of the web's underlying software: the basic client, basic server and library of common code. The document was addressed "To whom it may concern" – which would suggest the authors were not entirely sure who the target audience was. Yet, with hindsight, this line can equally be interpreted as an unintended address to humanity at large.

The legal implication was that CERN relinquished all intellectual property rights in this software. It was a deliberate decision, the intention being that a no-strings-attached release of the software would "further compatibility, common practices, and standards in networking and computer supported collaboration" – arguably modest ambitions for what turned out to be such a seismic technological step. To understand what seeded this development you need to go back to the 1950s, at a time when "software" would have been better understood as referring to clothing rather than computing.

European project

CERN was born out of the wreckage of World War II, playing a role, on the one hand, as a mechanism for reconciliation between former belligerents, while, on the other, offer-

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STATEMENT CONCERNING CERN W3 SOFTWARE RELEASE INTO PUBLIC DOMAIN

TO WHOM IT MAY CONCERN

Introduction

The World Wide Web, hereafter referred to as W3, is a global computer networked information system.

The W3 project provides a collaborative information system independent of hardware and software platform, and physical location. The project spans technical design notes, documentation, news, discussion, educational material, personal notes, publicity, bulletin boards, live status information and numerical data as a uniform continuum, seamlessly intergated with similar information in other disciplines.

The information is presented to the user as a web of interlinked documents .

Access to information through W3 is:

- via a hypertext model;
- network based, world wide;
- information format independent;
- highly platform/operating system independent;
- scalable from local notes to distributed data bases.

Webs can be independent, subsets or supersets of each other. They can be local, regional or worldwide. The documents available on a web may reside on any computer supported by that web.

Declaration

The following CERN software is hereby put into the public domain:

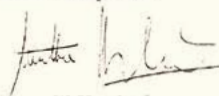
- W3 basic ("line-mode") client
- W3 basic server
- W3 library of common code.

CERN's intention in this is to further compatibility, common practices, and standards in networking and computer supported collaboration. This does not constitute a precedent to be applied to any other CERN copyright software.

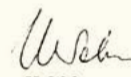
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Geneva, 30 April 1993



W. Hoogland
Director of Research



H. Weber
Director of Administration

copie certifiée conforme

fait à Genève le 03-05-93



FEATURE WEB AT 30

ing European nuclear physicists the opportunity to conduct their research locally. The hope was that this would stem the “brain drain” to the US, from a Europe still recovering from the devastating effects of war.

In 1953, CERN’s future Member States agreed on the text of the organisation’s founding Convention,

defining its mission as providing “for collaboration among European States in nuclear research of a pure scientific and fundamental character”. With the public acutely aware of the role that destructive nuclear technology had played during the war, the Convention additionally stipulated that CERN was to have “no concern

THE AUTHORS

Maarten Wilbers
and **Jonathan Drakeford**

CERN legal service.

with work for military requirements” and that the results of its work, were to be “published or otherwise made generally available”.

In the early years of CERN’s existence, the openness resulting from this requirement for transparency was essentially delivered through traditional channels, in particular through publication in scientific journals. Over time, this became the cultural norm at CERN, permeating all aspects of its work both internally and with its collaborating partners and society at large. CERN’s release of the WWW software into the public domain, arguably in itself a consequence of the openness requirement of the Convention, could be seen as a precursor to today’s web-based tools

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that represent further manifestations of CERN’s openness: the SCOAP3 publishing model, open-source software and hardware, and open data (see pp25–33).

Perhaps the best measure for how ingrained openness is in CERN’s ethos as a laboratory is to ask the question: “if CERN would have known then what it knows now about the impact of the World Wide Web, would it still have made the web software available, just as it did in 1993?” We would like to suggest that, yes, our culture of openness would provoke the same response now as it did then, though no doubt a modern, open-source licensing regime would be applied.

A culture of openness

This, in turn, can be viewed as testament and credit to the wisdom of CERN’s founders, and to the CERN Convention, which remains the cornerstone of our work to this day.

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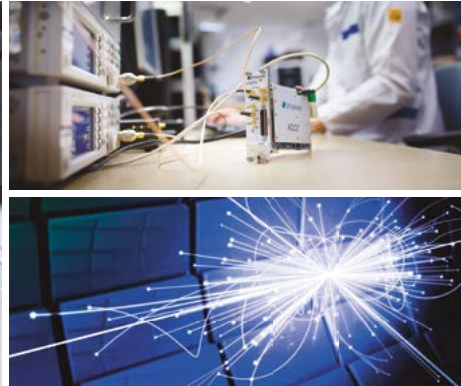
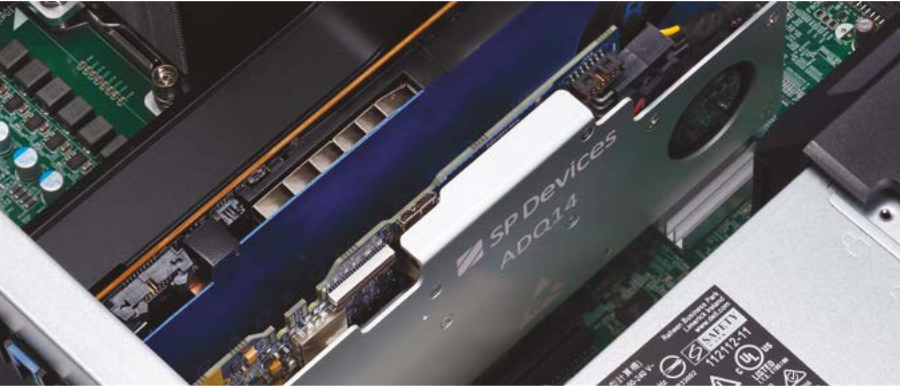


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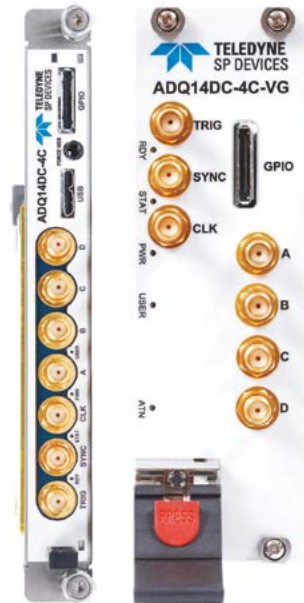


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OPINION VIEWPOINT

Harnessing the web for humanity

New technologies can be used to give every human being secure and sovereign control over their own digital identity, argues Monique Morrow.



Monique Morrow, a former CTO at Cisco, is president and co-founder of The Humanized Internet. This article is based on her forthcoming book *The Humanized Internet* (River Publishers, Denmark).

What would you do if you were thrust into a world where suddenly you lacked control over who you were? If you had no way to prove where you were from, who you were related to, or what you had accomplished? If you lost all your documentation in a natural disaster, or were forced to leave your home without taking anything with you? Without proof of identity, people are unable access essential systems such as health, education and banking services, and they are also exceedingly vulnerable to trafficking and incarceration. Having and owning your identity is an essential human right that too many people are lacking.

More than 68 million people worldwide have been displaced by war and conflict, and over 25 million have fled their countries and gone from the designation of "citizen" to "refugee". They are often prevented from working in their new countries, and, even if they are allowed to work, many nations will not let professional credentials, such as licences to practise law or medicine, follow these people across their borders. We end up stripping away fundamental human dignities and leaving exorbitant amounts of untapped potential on the table. Countries need to recognise not just the right to identity but also that identity is portable across nation states.

The issue of sovereign identities extends much further than documentation. All over the world, individuals are becoming commodified by companies offering "free" services because their actual products are the users and their data. Every individual should have the right to decide to monetise their data if they want. But the speed, scale and stealth of such practises is making it increasingly difficult to retain control of our data.

All of this is happening as we celebrate the 30th anniversary of the web. While there is no doubt that the web has been incredibly beneficial for humanity, it

The Humanized Internet



has also turned people into pawns and opened them up to new security risks. I believe that we can not only remedy these harms, but that we've yet to harness even a small fraction of the good that the web can do. Enter The Humanized Internet – a non-profit movement founded in 2017 that is working to use new technologies to give every human being secure, sovereign control over their own digital identity.

New technologies like blockchain, which allows digital information to be distributed but not copied, can allow us to tackle this issue. Blockchain has some key differences with today's databases. First, it allows participants to see and verify all data involved, minimising chances of fraud. Second, all data is verified and encrypted before being added to an individual block in such a way that a hacker would need to have exponentially more computing power to break in than is required in today's systems. These characteristics allow blockchain to provide public ledgers that participants trust based on the agreed-upon consensus protocol. Once data transactions are on a block, they cannot be overwritten, and no central institution holds control, as these ledgers are visible

to all the users connected to them. Users' identities within a ledger are known only to the users themselves.

The first implication of this technology is that it can help to establish a person's citizenship in their state of origin and enable registration of official records. Without this many people would be considered stateless and granted almost no rights or diplomatic protections. For refugees, digital identities also allow peer-to-peer donation and transparent public transactions. Additionally, digital identities create the ability to practise selective disclosure, where individuals can choose to share their records only at their own discretion.

We now need more people to get on board. We are already working with experts to discuss the potential of blockchain to improve inclusion in state-authenticated identity programmes and how to combat potential privacy challenges, in addition to e-voting systems that could allow inclusive participation in voting at all policy levels. We should all be the centre of our universe; our identity should be wholly and irrevocably our own.

Having and owning your identity is an essential human right that too many people in today's world are lacking

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OPINION INTERVIEW

In it for the long haul

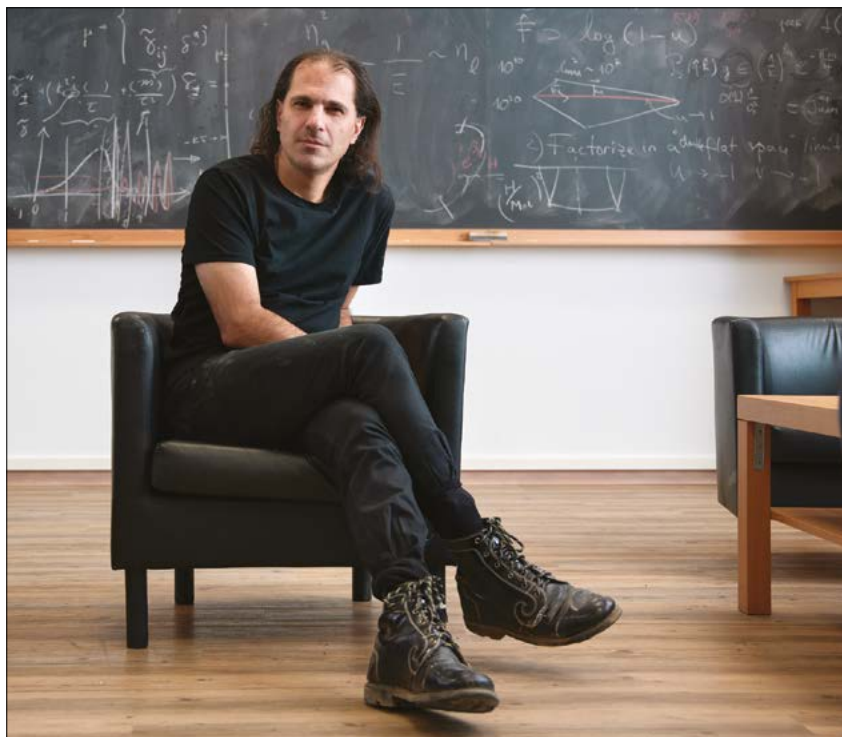
We have conquered the easiest challenges in fundamental physics, says Nima Arkani-Hamed. The case for building the next major collider is now more compelling than ever.

How do you view the status of particle physics?

There has never been a better time to be a physicist. The questions on the table today are not about this-or-that detail, but profound ones about the very structure of the laws of nature. The ancients could (and did) wonder about the nature of space and time and the vastness of the cosmos, but the job of a professional scientist isn't to gape in awe at grand, vague questions – it is to work on the *next* question. Having ploughed through all the “easier” questions for four centuries, these very deep questions finally confront us: what are space and time? What is the origin and fate of our enormous universe? We are extremely fortunate to live in the era when human beings first get to meaningfully attack these questions. I just wish I could adjust when I was born so that I could be starting as a grad student today! But not everybody shares my enthusiasm. There is cognitive dissonance. Some people are walking around with their heads hanging low, complaining about being disappointed or even depressed that we've “only discovered the Higgs and nothing else”.

So who is right?

It boils down to what you think particle physics is really about, and what motivates you to get into this business. One view is that particle physics is the study of the building blocks of matter, in which “new physics” means “new particles”. This is certainly the picture of the 1960s leading to the development of the Standard Model, but it's not what drew me to the subject. To me, “particle physics” is the study of the fundamental laws of nature, governed by the still mysterious union of space-time and quantum mechanics. Indeed, from the deepest



Nima Arkani-Hamed of the Institute for Advanced Study in Princeton (photographed at CERN) spoke to CERN Courier in February while attending the CERN Winter School on Supergravity, Strings and Gauge Theory.

theoretical perspective, the very definition of what a particle is invokes both quantum mechanics and relativity in a crucial way. So if the biggest excitement for you is a cross-section plot with a huge bump in it, possibly with a ticket to Stockholm attached, then, after the discovery of the Higgs, it makes perfect sense to take your ball and go home, since we can make no guarantees of this sort whatsoever. We're in this business for the long haul of decades and centuries, and if you don't have

the stomach for it, you'd better do something else with your life!

Isn't the Standard Model a perfect example of the scientific method?

Sure, but part of the reason for the rapid progress in the 1960s is that the intellectual structure of relativity and quantum mechanics was already sitting there to be explored and filled in. But these more revolutionary discoveries took much longer, involving a wide range of theoretical and experimental

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results far beyond “bump plots”. So “new physics” is much more deeply about “new phenomena” and “new principles”. The discovery of the Higgs particle – especially with nothing else accompanying it so far – is unlike anything we have seen in any state of nature, and is profoundly “new physics” in this sense. The same is true of the other dramatic experimental discovery in the past few decades: that of the accelerating universe. Both discoveries are easily accommodated in our equations, but theoretical attempts to compute the vacuum energy and the scale of the Higgs mass pose gigantic, and perhaps interrelated, theoretical challenges. While we continue to scratch our heads as theorists, the most important path forward for experimentalists is completely clear: measure the hell out of these crazy phenomena! From many points of view, the Higgs is the most important actor in this story amenable to experimental study, so I just can’t stand all the talk of being disappointed by seeing nothing but the Higgs; it’s completely backwards. I find that the physicists who worry about not being able to convince politicians are (more or less secretly) not able to convince *themselves* that it is worth building the next collider. Fortunately, we do have a critical mass of fantastic young experimentalists who believe it is worth studying the Higgs to death, while also exploring whatever might be at the energy frontier, with no preconceptions about what they might find.

What makes the Higgs boson such a rich target for a future collider?

It is the first example we’ve seen of the simplest possible type of elementary particle. It has no spin, no charge, only mass, and this extreme simplicity makes it theoretically perplexing. There is a striking difference between massive and massless particles that have spin. For instance, a photon is a massless particle of spin one; because it moves at the speed of light, we can’t “catch up” with it, and so we only see it have two “polarisations”, or ways it can spin. By contrast the Z boson, which also has spin one, is massive; since you can catch up with it, you can see it spinning in any of three directions. This “two not equal to three” business is quite profound. As we collide particles at ever increasing energies, we might think that their masses are irrelevant tiny

Had the LHC discovered supersymmetric particles, then the case for the next circular collider would be somewhat weaker

perturbations to their energies, but this is wrong, since something must account for the extra degrees of freedom.

The whole story of the Higgs is about accounting for this “two not equal to three” issue, to explain the extra spin states needed for massive W and Z particles mediating the weak interactions. And this also gives us a good understanding of why the masses of the elementary particles should be pegged to that of the Higgs. But the huge irony is that we don’t have any good understanding for what can explain the mass of the Higgs itself. That’s because there is no difference in the number of degrees of freedom between massive and massless spin-zero particles, and related to this, simple estimates for the Higgs mass from its interactions with virtual particles in the vacuum are wildly wrong. There are also good theoretical arguments, amply confirmed in analogous condensed-matter systems and elsewhere in particle physics, for why we shouldn’t have expected to see such a beast lonely, unaccompanied by other particles. And yet here we are. Nature clearly has other ideas for what the Higgs is about than theorists do.

Is supersymmetry still a motivation for a new collider?

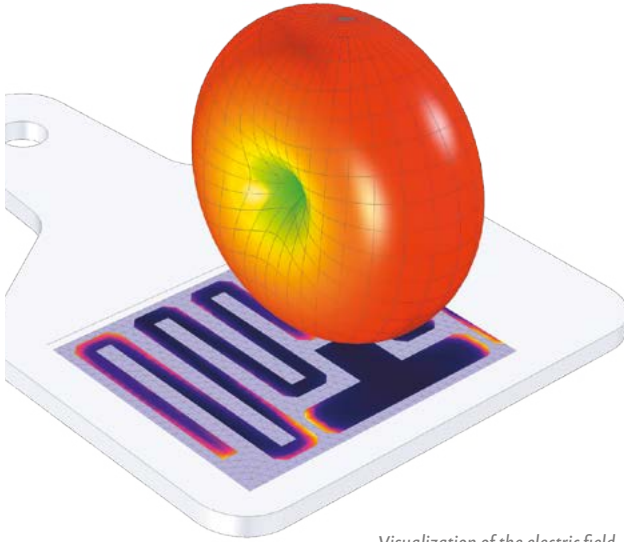
Nobody who is making the case for future colliders is invoking, as a driving motivation, supersymmetry, extra dimensions or any of the other ideas that have been developed over the past 40 years for physics beyond the Standard Model. Certainly many of the versions of these ideas, which were popular in the 1980s and 1990s, are either dead or on life support given the LHC data, but others proposed in the early 2000s are alive and well. The fact that the LHC has ruled out some of the most popular pictures is a fantastic gift to us as theorists. It shows that understanding the origin of the Higgs mass must involve an even larger paradigm change than many had

previously imagined. Ironically, had the LHC discovered supersymmetric particles, the case for the next circular collider would be somewhat weaker than it is now, because that would (indirectly) support a picture of a desert between the electroweak and Planck scales. In this picture of the world, most people wanted a linear electron-positron collider to measure the superpartner couplings in detail. It’s a picture people very much loved in the 1990s, and a picture that appears to be wrong. Fine. But when theorists are more confused, it’s the time for more, not less experiments.

What definitive answers will a future high-energy collider give us?

First and foremost, we go to high energies because it’s the frontier, and we look around for new things. While there is absolutely no guarantee we will produce new particles, we will definitely stress test our existing laws in the most extreme environments we have ever probed. Measuring the properties of the Higgs, however, is guaranteed to answer some burning questions. All the drama revolving around the existence of the Higgs would go away if we saw that it had substructure of any sort. But from the LHC, we have only a fuzzy picture of how point-like the Higgs is. A Higgs factory will decisively answer this question via precision measurements of the coupling of the Higgs to a slew of other particles in a very clean experimental environment. After that the ultimate question is whether or not the Higgs looks point-like even when interacting with itself. The simplest possible interaction between elementary particles is when three particles meet at a space-time point. But we have actually never seen any single elementary particle enjoy this simplest possible interaction. For good reasons going back to the basics of relativity and quantum mechanics, there is always some quantum number that must change in this interaction – either spin or charge quantum numbers change. The Higgs is the only known elementary particle allowed to have this most basic process as its dominant self-interaction. A 100 TeV collider producing billions of Higgs particles will not only detect the self-interaction, but will be able to measure it to an accuracy of a few per cent. Just thinking about the first-ever probe of this simplest possible interaction in nature gives me goosebumps.

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What are the prospects for future dark-matter searches?

Beyond the measurements of the Higgs properties, there are all sorts of exciting signals of new particles that can be looked for at both Higgs factories and 100 TeV colliders. One I find especially important is WIMP dark matter. There is a funny perception, somewhat paralleling the absence of supersymmetry at the LHC, that the simple paradigm of WIMP dark matter has been ruled out by direct-detection experiments. Nope! In fact, the very simplest models of WIMP dark matter are perfectly alive and well. Once the electroweak quantum numbers of the dark-matter particles are specified, you can unambiguously compute what mass an electroweak charged dark-matter particle should have so that its thermal relic abundance is correct. You get a number between 1–3 TeV, far too heavy to be produced in any sizeable numbers at the LHC. Furthermore, they happen to have minuscule interaction cross sections for direct detection. So these very simplest theories of WIMP dark matter are inaccessible to the LHC and direct-detection experiments. But a 100 TeV collider has just enough juice to either see these particles, or rule out this simplest WIMP picture.

What is the cultural value of a 100 km supercollider?

Both the depth and visceral joy of experiments in particle physics is revealed in how simple it is to explain: we smash things together with the largest machines that have ever been built, to probe the fundamental laws of nature at the tiniest distances we've ever seen. But it goes beyond that to something more important about our self-conception as people capable of doing great things. The world has all kinds of long-term problems, some of which might seem impossible to solve. So it's important to have a group of people who, generation after generation, give a concrete template for how to go about grappling with seemingly impossible problems, and who are driven by a calling far larger than themselves. Furthermore, suppose it's 200 years from now, and there are no big colliders on the planet. How can humans be sure that the Higgs or top particles exist? Because it says so in dusty old books? There is an argument to be made that as we advance we

The scientific issues at stake are more profound than they have been for many decades

should be able to do the things we did in the past. After all, the last time that fundamental knowledge was shoved in old dusty books was in the dark ages, and that didn't go very well for the West.

What about justifying the cost of the next collider?

There are a number of projects and costs we could be talking about, but let's call it \$5–25 billion. Sounds like a lot, right? But the global economy is growing, not shrinking, and the cost of accelerators as a fraction of GDP has barely changed over the past 40 years – even a 100 TeV collider is in this same ballpark. Meanwhile the scientific issues at stake are more profound than they have been for many decades, so we certainly have an honest science case to make that we need to keep going.

People sometimes say that if we don't spend billions of dollars on colliders, then we can do all sorts of other experiments instead. I am a huge fan of small-scale experiments, but this argument is silly because science funding is infamously not a zero-sum game. So, it's not a question of, "do we want to spend tens of billions on collider physics or something else instead", it is rather "do we want to spend tens of billions on fundamental physics experiments at all".

Another argument is that we should wait until some breakthrough in accelerator technology, rather than just building bigger machines. This is naïve. Of course miracles can always happen, but we can't plan doing science around miracles. Similar arguments were made around the time of the cancellation of the Superconducting Super Collider (SSC) 30 years ago, with prominent condensed-matter physicists saying that the SSC should wait for the development of high-temperature superconductors that would dramatically lower the cost. Of course those dreamed-of practical superconductors never materialised, while particle physics continued from strength to strength with the best technology available.

What do you make of claims that colliders are no longer productive?

It would be only to the good to have a no-holds barred, public discussion about the pros and cons of future colliders, led by people with a deep understanding of the relevant technical and scientific issues. It's funny that non-experts don't even make the best arguments for not building colliders; I could do a much better job than they do! I can point you to an awesomely fierce debate about future colliders that already took place in China two years ago: (*Int. J. Mod. Phys. A* **31**1630053 and 1630054). C N Yang, who is one of the greatest physicists of the 20th century and enormously influential in China, came out with a strong attack on colliders, not only in China but more broadly. I was delighted. Having a serious attack meant there could be a serious response, masterfully provided by David Gross. It was the King Kong vs Godzilla of fundamental physics, played out on the pages of major newspapers in China, fantastic!

What are you working on now?

About a decade ago, after a few years of thinking about the cosmology of "eternal inflation" in connection with solutions to the cosmological constant and hierarchy problems, I concluded that these mysteries can't be understood without reconceptualising what space-time and quantum mechanics are really about. I decided to warm up by trying to understand the dynamics of particle scattering, like collisions at the LHC, from a new starting point, seeing space-time and quantum mechanics as being derived from more primitive notions. This has turned out to be a fascinating adventure, and we are seeing more and more examples of rather magical new mathematical structures, which surprisingly appear to underlie the physics of particle scattering in a wide variety of theories, some close to the real world. I am also turning my attention back to the goal that motivated the warm-up, trying to understand cosmology, as well as possible theories for the origin of the Higgs mass and cosmological constant, from this new point of view. In all my endeavours I continue to be driven, first and foremost, by the desire to connect deep theoretical ideas to experiments and the real world.

Interview by **Matthew Chalmers** editor.



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OPINION REVIEWS

Political intrigue and the arms race

The Soviet Atomic Project: How the Soviet Union Obtained the Atomic Bomb

By Lee G Pondrom

World Scientific

"Leave them in peace. We can always shoot them later." Thus spoke Soviet Union leader Josef Stalin, in response to a query by Soviet security and secret police chief Lavrentiy Beria about whether research in quantum mechanics and relativity (considered by Marxists to be incompatible with the principles of dialectical materialism) should be allowed. With these words, a generation of Soviet physical scientists were spared a disaster like the one perpetrated on Soviet agriculture by Trofim Lysenko's politically correct, pseudoscientific theories of genetics. The reason behind this judgement was the successful development of nuclear weapons by Soviet physical scientists and the recognition by Stalin and Beria of the essential role that these "bourgeois" sciences played in that development.

Gripping account

Political intrigue, the arms race, early developments of nuclear science, espionage and more are all present in this gripping book, which provides a comprehensive account of the intensive programme the Soviets embarked on in 1945, immediately after Hiroshima, to catch up with the US in the area of nuclear weapons. A great deal is known about the Manhattan project, from the key scientists involved, to the many Los Alamos incidents – such as Fermi's determination of the Alamogordo test-blast energy using scraps of paper and Feynman's ability to crack his Los Alamos colleagues' safes – that are intrinsic parts of the US nuclear/particle-physics community's culture. On the contrary, little is known, at least in the West, about the huge effort made by the war-ravaged Soviet Union in less than five years to reach strategic parity with the US.



Pondrom, a prominent experimental particle physicist with a life-long interest in Russia and its language, provides an intriguing narrative. It is based on a thorough study of available literature plus a number of original documents – many of which he translated himself – that gives a fascinating insight into this history-changing enterprise and into the personalities of the exceptional people behind it.

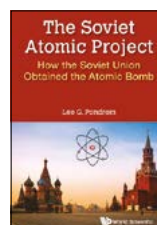
The success of the Soviet programme was primarily due to Igor Kurchatov, a gifted experimental physicist and outstanding scientific administrator, who was equally at ease with laboratory workers, prominent theoretical physicists and the highest leaders in government, including Beria and Stalin himself. Saddled with developing several huge and remotely located laboratories from scratch, he remained closely involved in many important nitty-gritty scientific and engineering problems. For example, Kurchatov participated hands-on and full-time in the difficult commissioning of Reactor A, the first full-scale reactor for plutonium-239

Catching up
The Soviets embarked on an intensive programme in 1945 to catch up with the US in the area of nuclear weapons.

production at the sprawling Combine #817 laboratory, receiving, along the way, a radiation dose that was 100 times the safe limit that he had established for laboratory staff members.

Beria was the overall project controller and ultimate decision-maker. Although best known for his role as Stalin's ruthless enforcer – Pondrom describes him as "supreme evil," Sakharov as a "dangerous man" – he was also an extraordinary organiser and a practical manager. When asked in the 1970s, long after Beria's demise, how best to develop a Soviet equivalent of Silicon Valley, Soviet Academy of Sciences president A P Alexandrov answered "Dig up Beria." Beria promised project scientists improved living conditions and freedom from persecution if they performed well (and that they would "be sent far away" if they didn't). His daily access to Stalin was critical for keeping the project on track. Most of the project's manual construction work used slave labour from Beria's gulag.

Both the US and Soviet projects were monumental in scope; Pondrom esti-



OPINION REVIEWS

mates the Manhattan project's scale to be about 2% of the US economy. The Soviet's project scale was similar, but in an economy one-tenth the size. The Soviets had some advantage from the information gathered by espionage (and the simple fact that they knew the Manhattan project succeeded). Also, German scientists interned in Russia for the project played important support roles, especially in the large-scale purification of reactor-grade natural uranium. In addition, there was a nearly unlimited supply of unpaid labourers, as well as German prisoners of war with scientific and engineering backgrounds whose participation in the project was rewarded by better living conditions.

The book is crisply written and well worth the read. The text includes a number of translated segments of official documents plus extracts from memoirs of some of the people involved. So, although Pondrom sprinkles his opinions throughout, there is sufficient material to permit readers to make their own judgements. He doesn't shirk from explaining some of the complex technical issues, which he (usually) addresses clearly and concisely. The appendices expand on technical issues, some on an elementary level for non-physicists, and others, including isotope extraction techniques, nuclear reaction issues and encryption, in more detail, much of which was new to me.

On the other hand, the confusing assortment of laboratories, their locations, leaders and primary tasks begged for some kind of summary or graphics. The simple chart describing the Soviet's complex espionage network in the US was useful for keeping track of the roles of the persons involved; a similar chart for the laboratories and their roles would have been equally valuable. The book would also have benefited from a final edit that might have eliminated some of the repetition and caught some obvious errors. But these are minor faults in an engaging, informative book.

Stephen L Olsen *University of Chinese Academy of Sciences.*

Advances in Particle Therapy: A multidisciplinary approach

By Manjit Dosanjh and Jacques Bernier (eds)

CRC Press, Taylor and Francis Group

A new volume in the CRC Press series on Medical Physics and Biomedical Engineering, this interesting book on particle therapy is structured in 19 chapters, each written by one or more co-authors out of a team of 49 experts (including the two editors). Most are medical physicists, radiation oncologists and radiobiologists who are well renowned in the field.

The opening chapter provides a brief and useful summary of the evolution of modern radiation oncology, starting from the discovery of X rays up to the latest generation of proton and carbon-ion accelerators. The second and third chapters are devoted to the radiobiological aspects of particle therapy. After an introductory part where the concepts of relative biological effectiveness (RBE) and oxygen-enhancement ratio are defined, this section of the book goes on to review the most recent knowledge gained in the field, from DNA structure to the production of radiation-induced damage, to secondary cancer risk. The conclusion is that, as biological effects and clinical response are functions of a broad range of parameters, we are still far from a complete understanding of all radiobiological aspects underlying particle therapy, as well as from a universally accepted RBE model providing the optimum RBE value to be used for any given treatment.

Chapter 4, and, later, chapter 18 are dedicated to particle-therapy technologies. The first provides a simple explanation of the operating principles

of particle accelerators and then goes into the details of beam delivery systems and dose conformation devices. Chapter 18 recalls the historical development of particle therapy in Europe, first with the European Light Ion Medical Accelerator (EULIMA) study and Proton-Ion Medical Machine Study (PIMMS), and then with the design and construction of the HIT, CNAO and MedAustron clinical facilities (CERN Courier January/February 2018 p25). It then provides an outlook on ongoing and expected future technological developments in accelerator design.

Extensive review

Chapter 5 discusses the general requirements for setting up a particle therapy centre, while the following chapter provides an extensive review of imaging techniques for both patient positioning and treatment verification. These are made necessary by the rapid spread of active beam delivery technologies (scanning) and robotic patient positioning systems, which have strongly improved dose delivery. Chapter 7 reviews therapeutic indications for particle therapy and explains the necessity to integrate it with all other treatment modalities so that oncologists can decide on the best combination of therapies for each individual patient. Chapter 8 reports on the history of the European Network of Light Ion Hadron Therapy (ENLIGHT) and its role in boosting collaborative efforts in particle therapy and in training specialists.

The central part of the book (chapters 9 to 15) reviews worldwide clinical results and indications for particle therapy from different angles, pointing out the inherent difficulties in comparing conventional radiation therapy and particle therapy. It analyses the two perspectives under which the dosimetric properties



of particles can translate into clinical benefit: decreasing the dose to normal tissue to reduce complications, or scaling the dose to the tumour to improve tumour control without increasing the dose to normal tissue.

Chapter 16 discusses the economic aspects of particle therapy, such as cost-effectiveness and budget impact, while the following chapter describes the benefits of a "rapid learning health care" system. The last chapter discusses global challenges in radiation therapy, such as how to bring medical electron linac technology to low- and middle-income countries (CERN Courier March 2017 p31). I found this last chapter slightly confusing as I did not understand what is meant by "radiation rotary" and I could not fully grasp the mixing-up of different topics, such as particle therapy and nuclear detonation-terror. This part also seemed too US-focussed when discussing the various initiatives, and I was not in agreement with some of the statements (e.g. that particle therapy has undergone a cost reduction by an order of magnitude or more in the past 10 years).

Overall, this book provides a useful compendium of state-of-the-art particle therapy and each chapter is supported by an extensive bibliography, meeting the expectations of both experts and readers interested in gaining an overview of the field. The essay is well structured, and enables readers to go through only selected chapters and in the order that they prefer. Some knowledge of radiobiology, clinical oncology and accelerator technology is assumed. It is disappointing that clinical dosimetry and treatment planning are not addressed other than in a brief mention in chapter 5, but perhaps this is something to consider for a second edition.

Marco Silari *CERN.*

A useful compendium of state-of-the-art particle therapy

Mad maths

Theatre, CERN Globe, 24 January 2019

Do you remember your maths high-school teachers? Were they strict? Funny? Extraordinary? Boring? The theatre comedy “Mad maths” presents the two most unusual teachers you can imagine. Armed with chalk and measuring tapes, Mademoiselle X and Mademoiselle Y aim to heal all those with maths phobia, and teach the audience more about their favourite subject.

On 24 January CERN’s fully booked Globe of Science and Innovation turned into a bizarre classroom. Marching along well-defined 90° angles, and meticulously measuring everything around them, the comedians Sophie Leclercq and Garance Legrou play with numbers and fight at the blackboard to make maths entertaining. The dialogues are juiced up with rap and music, spiced by friendly maths jargon, and seasoned with a hint



Math therapy
Mademoiselle X and Mademoiselle Y can cure any maths phobia.

of craziness. Bumping with trigonometry, philosophising about the number zero, and inventing new counting systems with dubious benefits, the rhythm grows exponentially. For example, did you know that some people’s mood goes up and down like a sine function? That you can make music with fractions? And that some bureaucratic steps are noncommutative?

This comedy show originated from an idea by Olivier Faliez and Kevin Lapin from the French theatre company *Sous un autre angle*. First studying maths at the university, then attending theatre school, Faliez combined his two passions in 2003 to create an entertaining programme based on maths-driven jokes and turns of event.

Perfect for families with children, this French play has already been performed more than 500 times, especially at science festivals and schools. The topics are customised depending on the level of the students. Future showings are scheduled in Castanet (15 March), Les Mureaux (22 March) and in several schools in France and other countries. Teachers and event organisers who are interested in the show are advised to contact Sophie Leclercq.

At times foolish, at times witty, it is worth watching if and only if you want to unwind and rediscover maths from a different perspective.

Letizia Diamante CERN.

The Life, Science and Times of Lev Vasilevich Shubnikov, Pioneer of Soviet Cryogenics

By L J Reinders

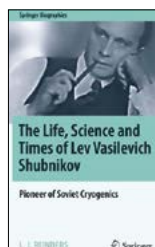
Springer

This book is a biography of Russian physicist Lev Vasilevich Shubnikov, whose work is scarcely known despite its importance and broad reach. It is also a portrayal of the political and ideological environment existing in the Soviet Union in the late 1930s under Stalin’s repressive regime.

While at Leiden University in the Netherlands, which at the time had the most advanced laboratory for low-temperature

physics in the world, Shubnikov co-discovered the Shubnikov–De Haas effect: the first observation of quantum-mechanical oscillations of a physical quantity (in this case the resistance of bismuth) at low temperatures and high magnetic fields.

In 1930 Shubnikov went to Kharkov (as it is called in Russian) in the Ukraine, where he built up the first low-temperature laboratory in the Soviet Union. There he led an impressive scientific programme and, together with his team, he discovered what is now known as type-II superconductivity (or the Shubnikov phase) and nuclear paramagnetism. In addition, independently of and almost simultaneously with Meissner and Ochsenfeld, they



observed the complete diamagnetism of superconductors (today known as the Meissner effect).

In 1937, aged just 36, Shubnikov was arrested, processed by Stalin’s regime and executed “for no other reason than that he had shown evidence of independent thought”, as the author states.

Based on thorough document research and a collection of memories from people who knew Shubnikov, this book will appeal not only to those curious about this physicist, but also to readers interested in the history of Soviet science, especially the development of Soviet physics in the 1930s and the impact that Stalin’s regime had on it.

Virginia Greco CERN.

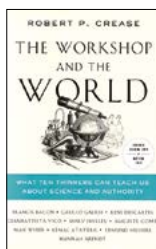
The Workshop and the World, what ten thinkers can teach us about science and authority

By Robert P Crease

W. W. Norton & Company

In this book, science historian Robert Crease discusses the concept of scientific authority, how it has changed along the centuries, and how society and politicians interact with scientists and the scientific process – which he refers to as the “workshop”.

Crease begins with an introduction about current anti-science rhetoric and science denial – the most evident man-



ifestation of which is probably the claim that “global warming is a hoax perpetrated by scientists with hidden agendas”.

Four sections follow. In part one, the author introduces the first articulation of scientific authority through the stories of three renowned scientists and philosophers: Francis Bacon, Galileo Galilei and René Descartes. Here, some vulnerabilities of the authority of the scientific workshop emerge, but they are discussed further in the second section of the book through the stories of thinkers like Giambattista Vico, Mary Shelley and Auguste Comte.

Part three attempts to understand the deeply complicated relationship between the workshop and the world, described through the stories of Max Weber, Kemal

Atatürk and his precursors, and Edmund Husserl. The final section is all about reinventing authority and is discussed through the work of Hannah Arendt, a thinker who barely escaped the Holocaust and who provided a deep analysis of authority as well as providing clues as to how to restore it.

With this brilliantly written essay, Crease aims to explore what practising science for the common good means and to understand what makes a social and political atmosphere in which science denial can flourish. Finally, Crease tries to suggest what can be done to ensure that science and scientists regain the trust of the people.

Virginia Greco CERN.

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PEOPLE CAREERS

Assessing CERN's impact on careers

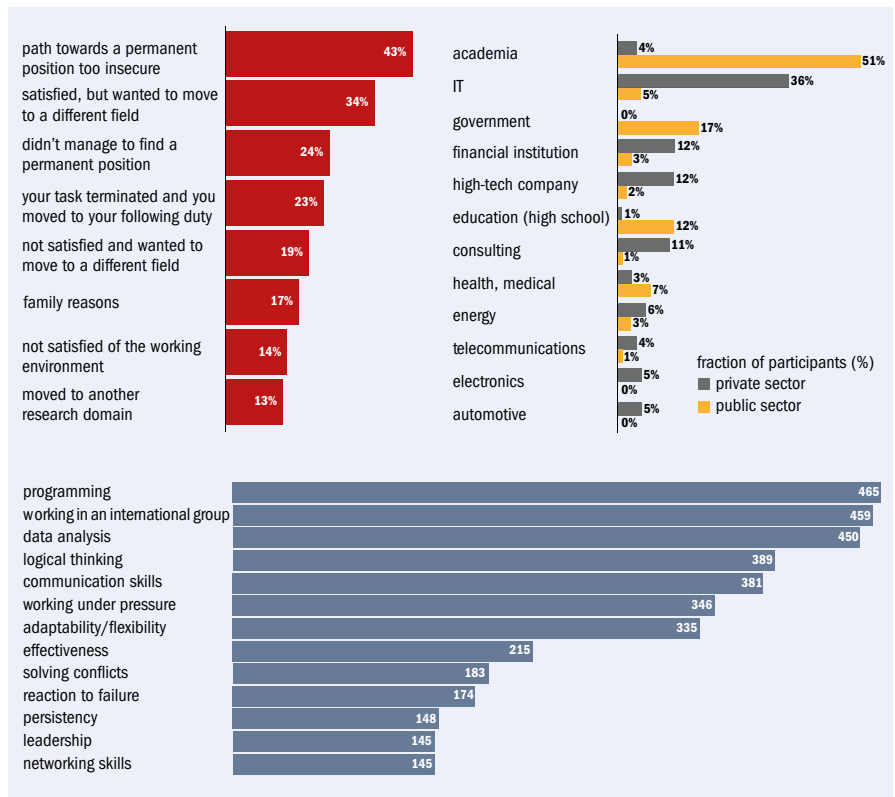
Results from a new survey show the important impact of working at CERN on an individual's career.

Since the advent of the Large Hadron Collider (LHC), CERN has been recognised as the world's leading laboratory for experimental particle physics. More than 10,000 people work at CERN on a daily basis. The majority are members of universities and other institutions worldwide, and many are young students and postdocs. The experience of working at CERN therefore plays an important role in their careers, be it in high-energy physics or a different domain.

The value of education

In 2016 the CERN management appointed a study group to collect information about the careers of students who have completed their thesis studies in one of the four LHC experiments. Similar studies were carried out in the past, also including people working on the former LEP experiments, and were mainly based on questionnaires sent to the team leaders of the various collaborator institutes. The latest study collected a larger and more complete sample of up-to-date information from all the experiments, with the aim of addressing young physicists who have left the field. This allows a quantitative measurement of the value of the education and skills acquired at CERN in finding jobs in other domains, which is of prime importance to evaluate the impact and role of CERN's culture.

Following an initial online questionnaire with 282 respond-



Moving on Top left: the reasons given for leaving high-energy physics, with multiple answers allowed.

Top right: the sectors in which former CERN users continue their career. Bottom: the skills acquired at CERN that are deemed important for working outside the field, with multiple answers allowed.

ents, the results were presented to the CERN Council in December 2016. The experience demonstrated the potential for collecting information from a wider population and also to deepen and customise the questions. Consequently, it was decided to enlarge the study to all persons who have been or are still involved with CERN, without any particular restrictions. Two distinct communities were polled with separate questionnaires: past and current CERN users

(mainly experimentalists at any stage of their career), and theorists who had collaborated with the CERN theory department. The questionnaires were opened for a

The latest study addressed young physicists who have left the field

period of about four months and attracted 2692 and 167 participants from the experimental and theoretical communities, respectively. A total of 84 nationalities were represented, with German, Italian and US nationals making up around half, and the distribution of participants by experiments was: ATLAS (994); CMS (977); LHCb (268) ALICE (102); and "other" (87), which mainly included members of the NA62 collaboration. ▶