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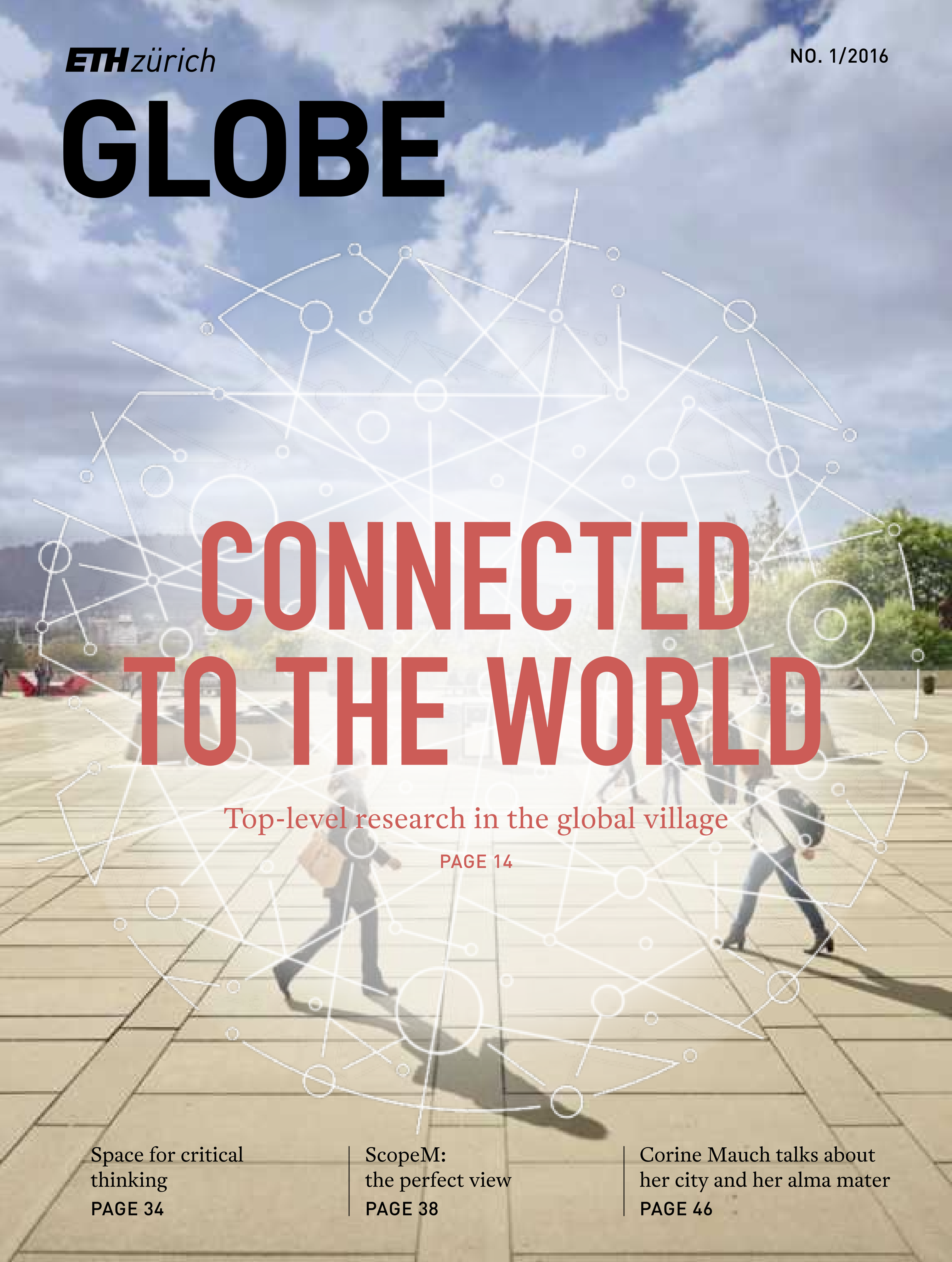

CONNECTED TO THE WORLD

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FROM GENIUS TO NETWORK

3,000 researchers are involved in the CMS experiment.

Teamwork is becoming ever more important in science. Research is increasingly being conducted through international collaboration. Particle physicist Felicitas Pauss and systems biologist Rudolf Aebersold discuss what forms of cooperation make sense in their respective fields.

INTERVIEW Martina Märki and Felix Würsten

Professor Pauss, you've been involved for many years now in the CMS experiment at the LHC particle accelerator at CERN, and you played a part in the discovery of the Higgs boson. How many people are there in the CMS team?

FELICITAS PAUSS – There are around 3,000 scientists in our team from roughly 40 countries and 200 institutes, so we list around 3,000 authors in alphabetical order in our publications.

Are major projects like that absolutely necessary in particle physics?

PAUSS – Of course, not all questions in particle physics require the same level of effort. But experiments involving particle accelerators have a long tradition of international collaboration. When CERN was founded over 60 years ago, it was recognised that the only way to guarantee long-term international competitiveness – and at the time all eyes were on the United States – was by working together and setting up a common laboratory. So it was that 12 European countries decided back then to set up an international research campus in Geneva in the interests of peaceful collaboration. Now CERN has almost twice as many member states, and our experimental programme at the Large Hadron Collider is one of the biggest and most ambitious scientific projects on a global scale.

> "At ETH we can afford to take the long-term perspective."
>
> RUDOLF AEBERSOLD

Would it still be possible to launch such a project today?

PAUSS – It's a huge challenge to obtain a binding, long-term financial commitment from so many nations. It took more than 20 years to get from the first conceptual study for the LHC to the start of operations in 2008. The CERN Council, which brings together representatives of member state governments, had to plan a budget for at least 20 years – and then approve it, too. Had confidence in the institution not been built up over many years, and had there been no compelling scientific goals, this could never have happened.

Rudolf Aebersold is one of the world's leading proteomics researchers and a systems biology pioneer. He co-founded the Institute for Molecular Systems Biology in Seattle in 2000. Since 2004 he has been a professor of systems biology at ETH Zurich and at the University of Zurich.

Felicitas Pauss is a particle physicist and was heavily involved in the design and construction of the CMS experiment at CERN's LHC. She also held important management positions at CERN. Since 1993 she has been a professor of particle physics at ETH Zurich.

Professor Aebersold, do you sometimes wish that systems biology had something similar?

RUDOLF AEBERSOLD – We're clearly interested to see what forms of collaboration are proving useful in the world of physics. But we're coming from a very different starting point. In biology, research groups are still very autonomous and publications are mainly produced in the traditional way by just a few authors. At the same time, our field of research is developing along lines that demand new organisational setups.

Why is that?

AEBERSOLD – Many of today's questions in systems biology or clinical research just can't be tackled in the traditional manner. To find answers, you need intricate animal or cell models, complex measurement technology, clinical cohorts, statistical methods and computer-aided analyses. There's no one group that can offer all that; perhaps it's even beyond the means of any one university. But the answer isn't to set up a giant "systems biology machine" somewhere. In our case, it's more a question of bringing together expertise and lots of data sets that have been collected by separate groups. So we're moving more towards a collaborative network – and ETH could play a pioneering role in this.

Are today's normal publishing arrangements a problem for networked research?

AEBERSOLD – They're a huge problem. When it comes to awarding grants or appointing faculty, it's generally the first- and last-named authors of a publication that are taken into account. We're really struggling to find a way to share out the credit for major interdisciplinary projects in a way that enables each researcher to show what their contribution was. Just listing authors in alphabetical order is not an approach that would be acceptable in biology today.

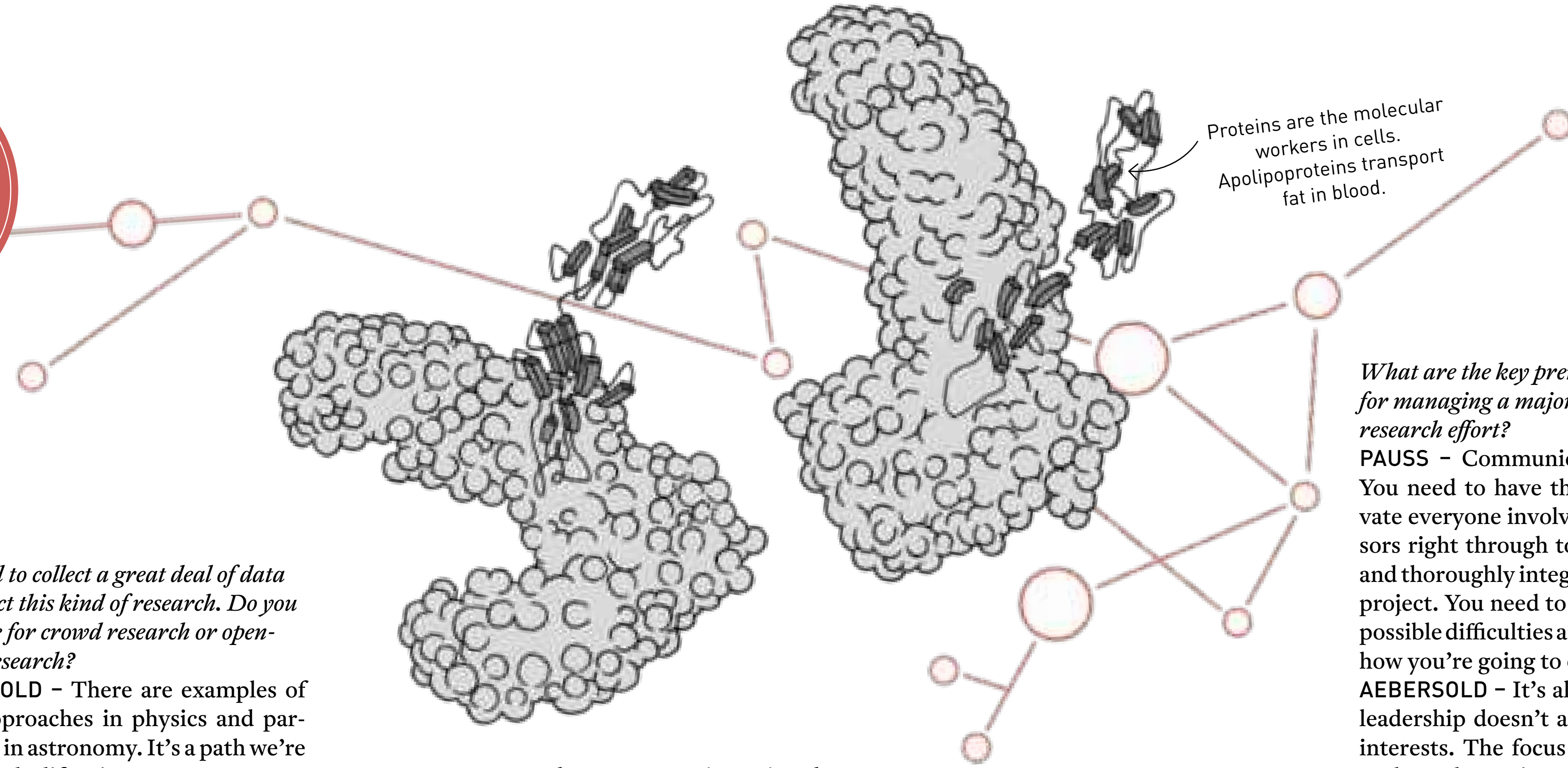
PAUSS – It's essential that a solution is found to this problem. We've set up special publication rules within the CMS collaborations. But even so, we often find ourselves having to explain that the number of publications to a researcher's name doesn't bear direct relation to the quality of their scientific work, because all major projects have long planning and development phases during which there's little for people to publish. This is a particularly important point when it comes to appointing faculty. One option would be for these selection procedures to switch to presenting only the contributions to the five most important publications, rather than simply drawing up a long list of all published work. That's one possible way to come up with a more sensible approach to assessment. ›

CERN

CERN (Conseil Européen pour la Recherche Nucléaire) near Geneva is one of the biggest centres for fundamental physics research. Its aim is to research the tiniest constituents of matter. Using data collected by the ATLAS and CMS experiments at the Large Hadron Collider (LHC), the world's largest particle accelerator, the Higgs boson was discovered in 2012.

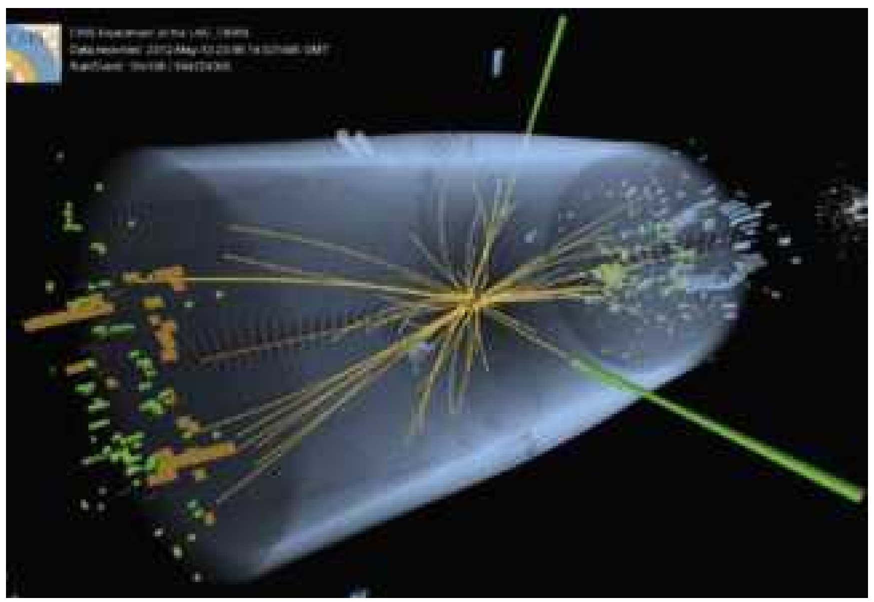
Photos: Giulia Marthaler (2)

20,300
proteins have been catalogued by systems biologists.



Are there any other aspects that stand in the way of a move to greater collaboration?
AEBERSOLD – Time horizons are a major issue. Whereas CERN was able to plan over decades, we operate in a world where time frames generally don't exceed two to five years. This is related to our dependence on third-party financing. If you work as a life sciences researcher in the United States, there's no such thing as longer-term funding from your institution, so you're always chasing the next grant. If you're in this system and you want to build up a project that won't let you publish anything for a period of five or six years because there's a lot of groundwork to cover first, then as a researcher you're dead. In contrast, at ETH and in Switzerland we can afford to take the long-term perspective. We really ought to be more aware of the opportunities this gives us.

Are you working on a project with a long-term perspective?
AEBERSOLD – Our field of research is proteins, which are the basis of all biochemical processes. There are thousands of different kinds of protein at work in every cell. One of our goals was to measure them all and draw up an inventory – and it's a goal we recently attained. Now we're trying to find out how these units organise themselves and how they cooperate in order to carry out the complex functions of living cells. In essence, this is the question at the heart of personalised medicine, a promising field that the ETH Board has designated as a strategic area of focus for research in the period 2017–2020. We would like to launch the Personalised Medicine initiative to tackle human diseases even more systematically. To do so we'll need a research network that motivates lots of researchers across different fields to work together on this topic.


Reconstruction of a Higgs boson decaying into two photons as observed in the CMS experiment

You need to collect a great deal of data to conduct this kind of research. Do you see a role for crowd research or open-source research?
AEBERSOLD – There are examples of these approaches in physics and particularly in astronomy. It's a path we're taking in the life sciences, too. One outstanding example is genomics, where the research community has agreed to grant open access to all the data collected before any work is published.

What does it take for different forms of collaboration to succeed?
PAUSS – In my experience, big collaborations can work well if their members are truly driven by scientific curiosity. If the motivation is more a question of career advancement, then I have my doubts.
AEBERSOLD – The CERN model works because it addresses a very clearly defined challenge. Genome research is similar: to fully sequence the genome of a population, whether of a thousand or a hundred thousand individuals, is a clear target that you can plan for and budget for. With open-ended issues – for instance the question of how an organism behaves as a complex system – the goal and the methods are much less easily defined. Of course we could just say we want a computer model that simulates the relevant system as accurately as possible; this is what the Human Brain Project in Lausanne has done. But we're light years away from this goal. That's why I believe we'll make better progress in my field by pursuing a network approach.

In the Human Brain Project there was debate as to which areas of research should be represented, and how to divide up the funding. Were there similar discussions at CERN, too?
PAUSS – In our search for the Higgs boson, our prior theoretical knowledge implied that we knew what it would take to obtain experimental evidence of this particle. So there was general agreement even back in the mid-1980s that we would need an LHC-type machine with very high beam energies of the colliding protons. Naturally, we too have to deal with critics who say that our projects are too big and cost too much money. But I think it was money very well spent, and I believe there's a strong chance that we'll make further fundamental discoveries in future.

How does collaborative working affect individual research freedom?
AEBERSOLD – I see no fundamental difference between working in a major cooperative project and working as a solo researcher. In each case I have to answer to the scientific community and to the bodies that fund the work, and I have to come up with convincing ideas. Every scientist is free to decide whether they want to work alone or participate in a wider network.

What role do the interests of individual countries play in international collaborations?
PAUSS – For us it's important, indeed it goes without saying, that what we publish is independent of any political system or opinion. Even if our experiments at CERN involve researchers from countries where that isn't always the case. I always find it very satisfying to see that this kind of scientific collaboration is possible.
AEBERSOLD – Politics has a major impact on the life sciences. For instance there are countries that forbid the export of clinical material. At the individual level, though, nationality is barely a factor in the composition of research groups.

> "Big collaborations work well if their members are truly driven by scientific curiosity."
> FELICITAS PAUSS

What are the key prerequisites for managing a major collaborative research effort?
PAUSS – Communication is the key. You need to have the ability to motivate everyone involved – from professors right through to technical staff – and thoroughly integrate them into the project. You need to be able to foresee possible difficulties and plan in advance how you're going to overcome them.
AEBERSOLD – It's also important that leadership doesn't act only in its own interests. The focus should always be on how the entire consortium is progressing. And there needs to be someone who is the face of the collaboration to the outside world. While this representational role is central, it doesn't necessarily follow that the researcher who speaks for the group must also be the one to lead the scientific work. ○

Photo: 2012 CERN, for the benefit of the CMS Collaboration