

he says, their combined output would increase by enough to offset about 40% of Russian imports to the US and the EU. Sondgeroth says the degree to which overfeeding could supplant Russian imports depends on the demand for non-Russian LEU from elsewhere in the world, how quickly centrifuge manufacturing resumes, and adequate supplies of UF_6 .

DOE says a combination of new enrichment capacity, the elimination of underfeeding at existing enrichment plants, and drawdowns from the strategic inventory are all needed to make up the shortfall in the event of complete disruption of Russian LEU supplies to the West.

Conversion is a second potential choke point in the fuel cycle. Cameco's Ontario facility was the sole North American conversion plant until last month, when ConverDyn reopened a facility in Metropolis, Illinois, that was closed in 2017. Von Hippel says the two plants should provide enough UF_6 feed to cover Russian imports. Doug True, a senior vice president with the Nuclear Energy Institute, notes that overfeeding would exacerbate any shortfall in conversion capacity.

The prospects for EU independence from Russia are clouded by the 19 Russian-

made VVER-440 reactors operating in eastern EU countries. Non-Russian-made fuel assemblies for those do not currently exist, although Westinghouse is close to producing substitutes. "That makes it virtually impossible for Europe to implement sanctions," Sondgeroth says. A partial EU ban with the 19 exceptions could cause Russia to retaliate by halting shipments to those reactors, she adds.

An inconvenience?

Edwin Lyman, director of nuclear power safety at the Union of Concerned Scientists, says the US nuclear industry has made little effort to lower its dependence on Russian LEU. "Industry came out of the gates saying no, we can't do it. I didn't see any kind of effort on the part of the US industry to get together and say let's see how we can do this."

If Constellation could do without Russian uranium, "the question is why didn't they just do it?" says Lyman. "They don't want any perturbation of their Russian supply that could inconvenience them or raise costs. I find that kind of outrageous." A Constellation spokesperson says the Russian supply contracts were negotiated before the Ukraine invasion,

and none have been made since then.

The US nuclear industry has long urged the federal government to subsidize new domestic enrichment capacity, arguing that all the world's enrichment plants are essentially government-owned enterprises. The options seem limited, however. Centrus Energy, the remnants of the once federally owned enrichment enterprise, will this year begin producing under DOE contract a relatively tiny quantity of high-assay, low-enriched uranium, a specialty product needed for advanced reactors that's enriched up to as much as 19.75% in ^{235}U . But Centrus has built just 16 centrifuges. A commercial enrichment plant has thousands.

In his Senate testimony, Constellation's Dominguez plugged laser enrichment technology in development by North Carolina-based Global Laser Enrichment. Part-owned by Cameco, GLE is preparing a commercial-scale pilot demonstration of technology developed in Australia. With DOE providing timely and modest cost-share support, Dominguez said, GLE could accelerate to 2028 the commercialization of its technology at a proposed site in Paducah, Kentucky.

David Kramer

Hybrid scientific conferences: An ongoing experiment

Duplicating or replacing serendipitous encounters in virtual environments is a challenge.

"I've seen you on Zoom, but we've never met." Mark Neubauer, a high-energy physicist at the University of Illinois at Urbana-Champaign, has heard such comments repeatedly since in-person scientific conferences began making a comeback. In 2020, when COVID-19 was declared a pandemic, Neubauer, like most researchers, started spending a lot of time on Zoom for conferences and other activities. He organized a May 2021 workshop on the future of meetings (a summary is available at <https://arxiv.org/abs/2106.15783>).

By late 2021, many conferences were offered in hybrid formats, with some people participating in person and others logging in from afar. Before the pandemic, remote participation in conferences was often frowned on, Neubauer says. But now "the genie is out of the bottle" for remote participation in meet-

ings, which can have the advantage of accessibility and sustainability. Hybrid formats are here to stay, he says, even as "there is a lot of pressure to get back to how we held meetings prepandemic."

The purposes of scientific conferences include sharing knowledge, providing visibility for early-career scientists, and maintaining and extending networks. Hybrid options could improve some traditional conferences, which may not always deliver what scientists want from them. "Sessions are held back-to-back, and there is little time for discussion," says Astrid Eichhorn, a University of Southern Denmark professor whose research is in quantum gravity. And, she adds, often conference goers sit in a presentation checking their phones and working rather than paying attention to the talk. "Overall, we do not have the ideal format yet."

"Conferences need to change"

Julia Marks Peterson says that until recently, she "only knew online conferences." She began her PhD studies at

Oregon State University in 2020, during the lockdown phase of the pandemic. Last October she went to an ice-core science conference in Crans-Montana, Switzerland, with about 500 attendees. "When I went to my first in-person conference, I realized what I had missed out on," she says. "I hadn't realized how productive a conference could be." The informal feeling of the gathering gave her confidence to approach leaders in her field. Besides forming connections with people, Marks Peterson says she was more likely to attend sessions that did not sound relevant to her own research than she would have been online. "When it's all in the same place, why not?"

Marks Peterson also appreciates the hybrid aspect of conferences. Last December, for example, she couldn't attend the fall meeting of the American Geophysical Union because she was doing fieldwork in Antarctica. So she prerecorded a talk, which was presented as part of an otherwise live session. "It was a nice way for me to get my work out there," she says.

"And I got feedback on the questions. The pandemic has helped us to be more flexible." And now that she's been to an in-person meeting, she adds, "I realize how valuable the networking aspect is—especially for early-career researchers."

The option to attend a conference remotely eases participation for people with travel constraints because of schedules, health, money, visa restrictions, or other reasons. Not having to pay for travel especially benefits scientists in low-income countries and graduate students and postdocs. The remote option also means presenters and attendees can pop in briefly to a meeting they would not have traveled to.

And online meetings have a lower carbon footprint. Eichhorn points to a May 2022 report by the European Federation of Academies of Sciences and Humanities, where she is active on its committee for climate sustainability, that says virtual meetings create just 2% to 6% the greenhouse gas emissions created by in-person meetings. (The federation's report is available at <https://doi.org/10.26356/climate-sust-acad>.)

"Conferences need to change, and they need to always be hybrid," says Andrea Armani, a University of Southern California materials science professor who has organized in-person and virtual conferences. A major focus of the efforts to reimagine scientific meetings is finding ways to facilitate networking and person-to-person engagement in virtual environments. "It's very important to be inclusive of all scientists at all career stages," she says.

Hybrid options

"We are learning that some things work well in hybrid format, and others do not," says Jen Ives, director of meetings for the American Meteorological Society. "We will pursue the things that work well." At its annual meeting in Denver last January, the society offered Zoom rooms centered on scientific or other themes. But uptake was spotty, Ives says, as were informal interactions between people who were on-site and online. The meeting, which was attended by around 6000 people in person and 1000 online, featured both virtual and in-person poster sessions. But not all of the live posters were uploaded digitally, and for remote presenters in a virtual room, she says, "if no one stops by, the lack of interest is amplified, whereas



CONFERENCE GOERS GET TOGETHER at the American Physical Society's 2023 March Meeting in Las Vegas, Nevada. Attendance reached a record high.

a physical venue may still feel full." Virtual posters and networking need to be reworked, says Ives. "If we are not successful, we will probably drop them."

This year, the American Physical Society (APS) held separate in-person and remote components of its major meetings. That followed the abrupt cancellation of the 2020 APS March Meeting (see "APS cancels March Meeting due to coronavirus concerns," *PHYSICS TODAY* online, 2 March 2020), a fully remote event in 2021, and a hybrid format in 2022. "We learned that it was difficult for presenters to have their talks ready to upload ahead of time," says Hunter Clemens, APS's director of meetings. The intention was to be able to play them in in-person sessions or on demand for virtual audiences, he explains. But the in-person crowd didn't want to watch prerecorded talks when they knew they could catch them later online, he says. "They wanted to see live talks, ask questions, and network."

APS "can't afford to live stream 75 concurrent sessions" from the in-person meeting, Clemens says. A few high-profile talks were live streamed; the rest were captured and later uploaded. He notes that the cost of running the large APS meetings "increases significantly" from the remote portions. The required internet bandwidth plus the labor to run audio and video technology add up, he says, such that the cost per participant this year was slightly higher for the March Meeting's remote component than for the in-person one.

"The in-person meeting was a home run. There was incredible buzz," says Clemens. A record 12 567 people attended this year's in-person APS March Meeting in Las Vegas, Nevada. Two weeks later, a crowd of 2293 logged into the remote meeting; nearly half of those had also attended in person. About 900 people presented virtually, he says. Some attendees gathered to watch and present talks and

posters at regional hubs in Brazil, India, Jordan, Rwanda, and South Africa.

"We can never re-create online the same networking experience that people have in person. We shouldn't expect it to be the same," says Clemens. Still, the remote attendees also reported having a better experience in the fully remote format than last year in the simultaneous hybrid mode. APS is assessing the meeting costs and analyzing participant surveys, but Clemens says that the society is likely to stick with separate remote and in-person meetings.

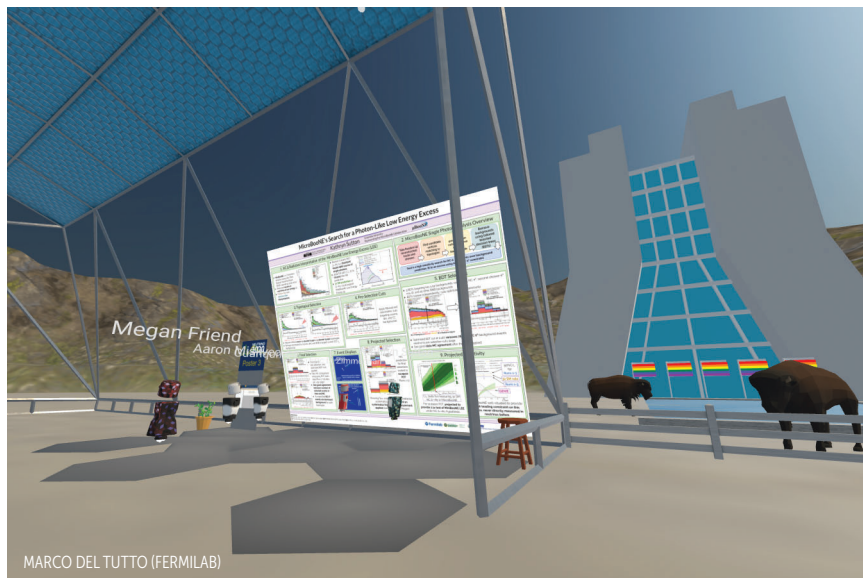
Remote participation in meetings generally was enthusiastic at first, says Kevin Marvel, executive officer of the American Astronomical Society (AAS). People "who would never have shown up in Wisconsin" for AAS's 2020 June conference attended from far-flung countries. But people are now "less willing to sit in remote meetings modeled on in-person meetings." Marvel notes that AAS has tried to foster interactions using the virtual reality platform gather.town, virtual chat rooms, and Slack channels. Everything failed, he says. "It's impossible to duplicate the interactions that take place outside of the official program."

Another twist, Marvel says, is that many remote participants want to attend for free. But while they don't use the exhibition halls, go to the registration desks, eat the doughnuts, or need the people who run around changing signs in front of lecture rooms, "you have to provide a different type of infrastructure for digital meetings."

Despite the challenges, Marvel says that "a fully virtual meeting can be fantastically successful—everyone is on the same field." That's true for in-person meetings too, but not for hybrid, which can feel like they have "two classes of attendees." AAS sees "a future where at least one of its two major annual meetings is fully virtual," he says. "We want to have a big impact on reducing our carbon footprint. And we don't want to lose the spontaneous interactions that people value in person."

Digital first

"If you care about diversity and inclusion, meetings should be remote or hybrid. In person should only be used when it has value," says Vanessa Moss, head of science operations at Australia's ASKAP radio telescope and lead of the



VIRTUAL REALITY is one way to connect, as in this poster session from the Neutrino 2020 conference. But enthusiasm for such approaches is fading as conferences resume in person.

Future of Meetings group. "If you ask people what they miss about in-person conferences, no one mentions listening to talks. What they miss is the social interactions and the unstructured stuff

that is harder to do in Zoom."

Moss and the Future of Meetings group don't claim to have all the answers. But a "digital-first" approach will work better than trying to retrofit traditional



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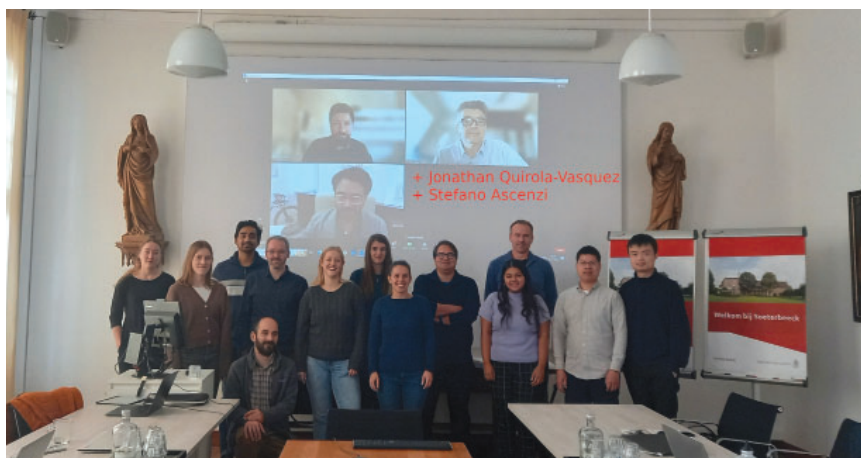
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meetings with a remote component, she says. For example, a remote meeting may work better stretched out over more days than its in-person precedent. And grouping scientific sessions into blocks of a couple of hours and building in breaks can combat computer fatigue and accommodate participants in different time zones.

Moss recommends that funding slated for physical travel be redirected to improve the digital conference experience. For example, money for conference travel could go instead to better headsets or internet. As for online networking, she says it's easiest when participants share a specific goal, such as discussing methods to improve remote meetings, sustainability in science, or a narrow scientific topic. Advances in technology will help with networking, too, she says. "Virtual reality will get better. There are some very creative things that can be done virtually that we are just scratching the surface of."

Some meetings with a digital-first approach were getting started even before the pandemic. The first Photonics Online Meetup took place in January 2020. The motivations were to meet with colleagues without creating a large carbon footprint and in an accessible form that reduced the burden of participation on people with families, says Rachel Grange, one of the organizers and a professor at ETH Zürich in Switzerland. Some 1100 people participated, with many of them gathering in local hubs of 5–80 people. They presented posters via Twitter. The organizers bought a software license to permit 1000 people online. "It was cheap, but not free, to organize," and it was free for participants, Grange says. "Online is a way to share knowledge, but for networking, you need to be on-site."

"Most online conferences are not that great," says Shaun Hotchkiss, a theoretical cosmologist who is based in Auckland, New Zealand. With a handful of colleagues, he launched Cosmology from Home. The online conference emerged pre-pandemic, he says, from the idea that "we have all these tools. We must be able to use them better. Let's build from the ground up." (See the interview with Hotchkiss at <https://physicstoday.org/hotchkiss>, in which he tells about his move from research to starting a business to help researchers share their work through online meetings and other means.)



SCIENTISTS ATTEND a small astronomy conference on fast x-ray transients hosted at Radboud University in Nijmegen, the Netherlands, in November 2022. The remote attendees were from Chile, Israel, and the UK. (Courtesy of Peter Jonker.)

The first rule is to design online events such that nothing is passive, says Hotchkiss. "There is no boring sitting around and passively staring at a screen, unable to interact." Even when people are engaged by a 45-minute talk, he adds, by the end they are tired. Cosmology from Home is run like a flipped classroom: Talks are uploaded to YouTube, people watch on their own time and then, when they meet, "they jump straight into real discussions." The annual conference is run over a two-week period, with scheduled interaction time usually capped at six hours a day in two blocks of time that are chosen to best work for people participating from different time zones. Attendance has ranged from 200 to 350 in the three events to date.

Hotchkiss's second rule is that discussions need to be managed. "Otherwise, they can be a disaster," he says. Even in person, he adds, the more assertive, confident people tend to dominate discussion, and that can be amplified online. "We have a well-thought-out structure. If you want to say something on the current topic, you put up a predetermined symbol, and for new topics, you put up a hand."

In the social arena, Hotchkiss and his team have tried to match people up with mentors, and they've introduced games. He doesn't have data on the mentoring, but the games and other social events, which have 10–40% uptake, are "clearly very valuable to those who do come."

Reimagining conferences

Many questions remain as to what works best for meetings. Are hubs a good idea?

Should hybrid be simultaneous? Does meeting size play a role? Can networking and serendipitous conversations be reproduced in online formats? Armani, one of the Photonics Online Meetup founding organizers, favors hubs: "We are trying to encourage networking at the local scale, including with industry. Most students want jobs locally," she says. Moss likes the reduced carbon footprint that hubs offer but worries that they "reinforce boundaries and insularity."

As far as networking, agreement is widespread that it's better in person than online. But, says Neubauer, "somehow technology should make it seamless for virtual and in-person people to interact. I'm talking futuristically—maybe in 10 or 20 years."

Even in its current forms, remote conference attendance offers benefits for lowering carbon footprints and raising accessibility. Ezequiel Treister, who heads a group in galaxy evolution at the Pontifical Catholic University of Chile, used to fly 10 to 12 times a year to attend conferences and administrative meetings. He's pared that down to 3 or 4 times a year. Telescope allocation and other board meetings work well online, he says. His students and postdocs now attend more meetings with the online option. But if they are presenting important work, he says, "I still send them in person."

"The way we look at meetings for now is that it's an experiment," says APS's Clemens. "We are trying to get it right."

Toni Feder **PT**