Next Steps

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Closing talk at *Snowmass 2001:* a summer study on the future of particle physics.

1. Thanks!

We've come to the end of three weeks of intense work, and we have shattered all precedents for participation in a Snowmass summer study. We have numbered more than 1200, including more than eighty students, more than two hundred "young physicists," and more than two hundred colleagues from outside the United States. On behalf of the American Physical Society and its Division of Particles & Fields and Division of Physics of Beams, I thank you for coming to Snowmass in such great numbers, and with such optimism and appetite for hard work.

Throughout the planning and execution of *Snowmass 2001,* we have benefited from the wise counsel and manifold support of the leaders of the American Physical Society. I'd particularly like to acknowledge the rôles of Executive Officer Judy Franz, President George Trilling, and Past President Jim Langer.

It is also my great pleasure to express on your behalf our thanks and admiration to the people who made our work possible. You may know that we said we would define 500 participants as a successful summer study, we planned for about 800, and the people who make things happen have had to provide for the needs of 1200. I'd like to begin by saluting our friends in the *Snowmass 2001* conference office: Cindy Arnold, Jody Federwitz, Ray Fonseca, Michelle Gleason, Carolyn James, Wanda Newby, Marilyn Paul, Barb Perington, Patti Poole, Cynthia Sazama, Marilyn Smith, and Suzanne Weber; as well as Shefali Kubavat and Carol Kuc of Complete Conference Coordinators. Computing support, including the very helpful wireless network here in the Conference Center, was provided by Chuck Andrews, John Bellendir, Alden Clifford, Larry English, Steve Fry, Rick Hill, Kip Kippenham, Andy Rader, Cameron Smith, John Urish, and Jerry Zimmerman. The streaming-video archive of plenary sessions and other important events was made possible by Al Johnson, Jim Shultz, and Fred Ullrich.

All of the work behind the scenes was coordinated by the Local Organizing Committee led by Jeff Appel. I'm personally grateful to Jeff not only for making all the pieces fit together, but also for functioning with unfailing grace and impeccable judgment as a chief-of-staff throughout the workshop. For all of us, I want to thank Mike Witherell for making available to the summer study Fermilab's remarkable logistical support. I'm also grateful to Jonathan Dorfan for making SLAC's resources available to produce the *Proceedings,* and to Norman Graf for agreeing to serve as Editor. While *Snowmass 2001* is a creation of the DPF and DPB, it could not have happened without the leadership of our great laboratories.

It's a great pleasure to recognize again the marvelous contributions of my colleagues on the *Snowmass 2001* Organizing Committee, and to thank them for their wisdom, hard work, and community spirit: Ron Davidson (PPPL, co-chair), Alex Chao (SLAC), Alex Dragt (Maryland), Gerry Dugan (Cornell), Norbert Holtkamp (SNS), Chan Joshi (UCLA), Thomas Roser (BNL), Ron Ruth (SLAC), John Seeman (SLAC), and Jim Strait (Fermilab) from the DPB side; and Sally Dawson (BNL), Paul Grannis (Stony Brook), David Gross (ITP/UCSB), Joe Lykken (Fermilab), Hitoshi Murayama (Berkeley), René Ong (UCLA), Natalie Roe (LBNL), Heidi Schellman (Northwestern), and Maria Spiropulu (Chicago) from the DPF side.

It's also my happy task to thank the working group convenors for the extraordinarily rich program we've experienced at *Snowmass 2001*:

Accelerator Working Groups. M1: Muon-Based Systems. Kirk McDonald (Princeton), Andrew Sessler (LBNL); M2: e^+e^- Circular Colliders. K. Oide (KEK), J. Seeman (SLAC), S. Henderson (Cornell); M3: Linear Colliders. R. Brinkman (DESY), N. Toge (KEK), T. Raubenheimer (SLAC); M4: Hadron Colliders. S. Peggs

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(BNL), M. Syphers (Fermilab); M5: Lepton-Hadron Colliders. I. Ben-Zvi (BNL), G. Hoffstaetter (DESY); M6: High-Intensity Proton Sources. W. Chou (Fermilab), J. Wei (BNL).

Technology Working Groups. T1: Interaction Regions. T. Markiewicz (SLAC), F. Pilat (BNL); T2: Magnet Technology. S. Gourlay (LBNL), V. Kashikan (Fermilab); T3: RF Technology. C. Adolphsen (SLAC), N. Holtkamp (SNS), H. Padamsee (Cornell); T4: Particle Sources. J. Sheppard (SLAC), N. Mokhov (Fermilab), S. Werkema (Fermilab); T5: Beam Dynamics. M. Blaskiewicz (BNL), K.-J. Kim (Argonne), S. Y. Lee (Indiana); T6: Environmental Control. W. Bialowons (DESY), C. Laughton (Fermilab), A. Seryi (SLAC); T7: High-Performance Computing. K. Ko (SLAC), N. Ryne (Los Alamos); T8: Advanced Acceleration Techniques. C. Joshi (UCLA), P. Sprangle (NRL); T9: Diagnostics. R. Pasquinelli (Fermilab), M. Ross (SLAC).

Physics Working Groups. P1: Electroweak Symmetry Breaking. Marcela Carena (Fermilab), David Gerdes (Michigan), André Turcot (Brookhaven), Peter Zerwas (DESY); P2: Flavor Physics. Belén Gavela (Madrid), Boris Kayser (NSF), Clark McGrew (Stony Brook), Patricia Rankin (Colorado); P3: Scales beyond 1 TeV. Michael Dine (Santa Cruz), JoAnne Hewett (SLAC), Greg Landsberg (Brown), David Miller (UCL); P4: Astro/Cosmo/Particle Physics. Dan Akerib (Case-Western Reserve), Sean Carroll (Chicago), Mark Kamionkowski (Caltech), Steve Ritz (NASA/Goddard); P5: QCD & Strong Interactions. Brenna Flaugher (Fermilab), Ed Kinney (Colorado), Paul Mackenzie (Fermilab), George Sterman (Stony Brook).

Experimental Approaches Working Groups. E1: Neutrino Factories & Muon Colliders. Vernon Barger (Wisconsin), Debbie Harris (Fermilab), Yoshi Kuno (Osaka), Mike Zeller (Yale, HMO); E2: e^+e^- Colliders below the Z. Gustavo Burdman (BU), Ian Shipsey (Purdue), Hitoshi Yamamoto (Hawaii), Joel Butler (Fermilab, HMO); E3: Linear Colliders. Marco Battaglia (CERN), John Jaros (SLAC), James Wells (Davis),Ian Hinchliffe (LBNL, HMO); E4: Hadron & Lepton-Hadron Colliders. Uli Baur (Buffalo), Raymond Brock (Michigan State), John Parsons (Columbia), Bill Marciano (Brookhaven, HMO); E5: Fixed-Target Experiments. Krishna Kumar (UMass), Ron Ray (Fermilab), Paul Reimer (Argonne), Mark Strovink (Berkeley, HMO); E6: Astro/Cosmo/Particle Experiments. Kevin Lesko (LBNL), Suzanne Staggs (Princeton), Tim McKay (Michigan), Harry Nelson (UCSB, HMO); E7: Particle Physics & Technology. Stephan Lammel (Fermilab), Wesley Smith (Wisconsin).

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The exceptional program of engagement with the public here at Snowmass 2001 was constructed by the Outreach Coordinating Committee made up of Elizabeth Simmons (chair), Marge Bardeen, Martin Berz, Bill Frazer, Evalyn Gates, Joey Huston, Ronen Mir, Mel Month, Helen Quinn, Deborah Roudebush, Greg Snow, Ken Taylor, and Jeff Wilkes, with staff support from Melissa Clayton. More than a hundred of you took part in Science Weekend and the other outreach activities, which were notable for the great joy they brought both to the public and to the physicist participants. I'd especially like to recognize the contributions of Mayda Velasco (who animated *La Noche de la Ciencia*), Marko Popovic, Kevin Lynch, Shreyas Bhat, Lawrence Krauss, Leon Lederman, and Liz Quigg. Support for the *Snowmass 2001* outreach and education program was provided by the Division of Particles and FieldsÊ and the Division of Physics of Beams of the American Physical Society, the National Science Foundation, the U.S. Department of Energy, the ATLAS and CMS Collaborations, Universities Research Association, the IEEE Council on SuperConductivity, Maggie and Nick DeWolf, and by other public-spirited individuals and organizations. We appreciate very much the cooperation of Snowmass Village for giving us the run of the mall for Science Weekend and for other courtesies, and the collaboration of Explore Booksellers of Aspen, the Aspen Public Schools, Camp Snowmass (Sue Way), the Science Outreach Center of Carbondale (Linda Froning), and the Carbondale Community School.

Also making *Snowmass 2001* a public event—in the Roaring Fork Valley and around the world—was our full-time (which came close to 24/7) Press Room. I thank Judy Jackson, Mike Perricone, Kurt Riesselman, and Mieke van den Bergen (all of Fermilab) for all their contributions—visible and behind the scenes—to the success of our summer study.

Thanks again to our sponsors, the United States Department of Energy, the National Science Foundation, and NASA, and to the ten laboratories engaged in particle physics research in the United States who have supported our cause: Argonne National Lab, Berkeley Lab, Brookhaven National Lab / Brookhaven Science Associates, Cornell University / LNS / Wilson Synchrotron Lab, Fermilab / Universities Research Association, Jefferson Laboratory / SURA, Lawrence Livermore National Laboratory, Los Alamos National Laboratory, Oak Ridge National Lab / Spallation Neutron Source, Stanford Linear Accelerator Center / Stanford University.

2. Wonderful Things Have Been Happening Here

We have rediscovered our community and our sense of common destiny. We have celebrated the astonishing progress and remarkable promise of particle physics, broadly understood.

No one should miss the conclusion that ours is a community on the move, worldwide.

We have taken pleasure in the inventiveness and careful thought of our colleagues who dream, design, and build accelerators and the components that make them possible. We have mixed; we have engaged with each other's aspirations and significantly advanced a number of ideas. Every large future accelerator project is taken more seriously, and valued more highly, than it was when we assembled three weeks ago. That outcome is a testimony both to the superb work being done by our colleagues who create accelerator possibilities and to the generous and open spirit all of you brought to Snowmass.

Our conception of the scientific landscape has been enriched by the high level of participation by our astro/cosmo/particle colleagues, including those from communities that have not traditionally identified with particle physics.

We have relished the global reach of our science. We profited from the contributions—formal and informal—of international laboratory directors Alessandro Bettini (Gran Sasso), Luciano Maiani (CERN), Alexander Skrinsky (BINP), Hirotaka Sugawara (KEK), and Albrecht Wagner (DESY), as well as the spirited participation of the leaders of U.S. laboratories, Jonathan Dorfan (SLAC), Tom Kirk (BNL), Maury Tigner (Cornell), and Mike Witherell (Fermilab). Ian Corbett brought important insights into the work of the Global Science Forum, while Ferdi Willeke reported on the work of the ICFA Committees exploring the idea of a Global Accelerator Network. Lorenzo Foà and Satoru Yamashita presented conclusions of the European and Japanese planning exercises.

We have enjoyed an atmosphere of excellence and optimism and savored the inspiring promise of youth. Young physicists plunged into the activities of the working groups and also created a vigorous program of their own, which culminated in the Young Physicists Forum attended by many Snowmass participants of all ages. A Young Particle Physicists organization is taking shape. For the latest word, see the web site at http://ypp.hep.net; results of the survey carried out by the young physicists can be found at http://ypp.hep.net/ypp_survey.html.

Other special events included half-day "teach-ins" on opportunities in accelerator research and development and on the new world of astro/cosmo/particle physics, and communications workshops that brought together science writers, Washington communicators, public affairs professional from many laboratories in the US and abroad, and physicists. The HEPAP subpanel on long-range planning, led by Jonathan Bagger and Barry Barish, participated actively in the work of *Snowmass 2001*, and used the workshop to solicit and receive input of many kinds from the community. The NAS/NRC Committee on Physics of the Universe, led by Mike Turner, also met at Snowmass, as did the High Energy Physics Advisory Panel.

The main products of *Snowmass 2001* will, as always, be the individual contributions and the working group summaries to appear in the Proceedings. This year, we undertook two special projects as well. The Division of Particles and Fields has produced a twenty-page illustrated survey of the grand themes and aspirations of particle physics, called *Quarks Unbound,* which will soon appear in the mailboxes of all DPF members. *Quarks Unbound* was written by science writer Sharon Butler, based on her interviews and discussions with many members of the community. We owe a special debt of gratitude to two members of the Snowmass Organizing Committee, Joe Lykken and Maria Spiropulu, for their dedication to the project. We will be using *Quarks Unbound* widely to communicate the excitement and promise of particle physics. The Division of Physics of Beams has used the work at Snowmass to create a cogent blueprint for future accelerator research and development (see http://www.hep.anl.gov/pvs/dpb/Snowmass.pdf). All this is only the beginning; we planted many seeds at *Snowmass 2001*, and we will be harvesting their fruits for many years.

3. Reviewing the Goals for Snowmass 2001

We have made decisive progress on all the goals I set out three weeks ago, and I trust that you have discovered many new things to think about and to work on in the months and years to come.

We have made an excellent start toward surveying our aspirations for particle physics over 30 years by educating ourselves about the full range of possibilities before us. We were aided immeasurabl y in the Experimental Approaches working groups by the "High-Minded Outsiders," who served as friendly skeptics, probing and strengthening arguments. Our explorations were aided as well by the presence of string theorists who helped us look beyond our immediate goals to contemplate the shape of a more complete, more ambitious theoretical framework. On the machine front, the work carried out at Snowmass

has help us to understand the investment we must make (financial and human capital) to bring the most promising lines to maturity.

We need to continue the conversation about the degree of scientific diversity, including scale diversity, that we need to build a healthy and productive future for particle physics.

We must continue to work toward articulating a comprehensive vision of particle physics (and the sciences it touches) to make our case effectively to ourselves, to other scientists, and to society at large.

Three weeks ago, I observed that "the moment is upon us to probe, shape, and judge the idea of a linear collider as a possible next big step for particle physics. *Evaluating a linear collider and working to define a scientifically rich, technically sound, fiscally responsible plan is a homework problem for the entire community.* Everyone must come to an informed judgment."

At *Snowmass 2001*, a widespread feeling has emerged that the world community should move urgently to construct a TeV-scale linear collider as an international project. *These are ambitious machines and significant challenges remain: we must be certain of the costs and we must take the measure of technical risks. A phase change is needed to complete the design and development promptly.*

In the United States, another phase change is needed *soon* in the commitment of experimental physicists to the linear collider program. A few people have done valuable work, but outside the US, *many more people* have done much more comprehensive work. US participation in a linear collider will not be decisive without the engagement of a large and energetic cadre of superb experimenters to hone the physics case, participate in parameter choices, and work side-by-side with the machine builders. *If you wait, it will not happen!* It is also time for closer cooperation among physicists in different regions on linear collider issues: to coordinate R&D, to develop a unified physics document, and to make the scientific case to the governments of the world—perhaps it is the moment to form an International Linear Collider Users Group?

4. When you go home …

Continue to think about what you have heard and done at Snowmass.

Talk with your particle physics colleagues about what you have seen and heard and done here. Arrange seminars to share the *Snowmass 2001* experience with all your students and colleagues.

Write your advice to the HEPAP subpanel; If you wrote long ago, reread your letter to see how your thinking has evolved.

Talk with your colleagues in other fields of physics and astronomy about *Snowmass 2001.* Share your enthusiasm! Give a colloquium early in the school year about the future of particle physics.

Talk with your colleagues in other fields about their excitement and aspirations. Help your students appreciate the exciting futures all across physics and astronomy.

We've heard at *Snowmass 2001* from many gifted, articulate, and inspiring colleagues: Invite them to visit your department. Hire them!

No department is whole without some presence in experimental particle physics, particle theory that engages with experiment, accelerator physics, astro/cosmo/particle physics, string theory (to speak only of our immediate neighborhood). Make your institution stronger, and you strengthen our science.

5. Mike Holland's "Insulting" Questions

Members of Congress, Congressional Staff, and White House Staff are busy people. Their first response to any request is, "No." *If you go away and never come back, they gave the right answer.*

Their second response to any request is, "You don't have a plan." *If you go away and never come back, they gave the right answer.*

It is not unknown for our friends to ask hostile questions in hopes of learning whether we have answers they can use when they are asked hostile questions.

Some people in Washington and some scientists do not have our interests at heart. We must not let them seize the agenda and frame the debate, but when they ask easy questions for nefarious purposes, we should leap to give compelling answers. So when someone throws you a fat pitch, asking "Does particle physics require accelerators?" or "What is the value of particle physics to other sciences and to society?" do not squander time and adrenaline fulminating about the injustice, just smack the ball over the fence.

6. Ask More of the United States Government

The difficult environment for funding the physical sciences reflects, I believe, a deeper problem in our society. For more than a decade, the will to join together and undertake challenging and important causes for the general good has been too little in evidence. *This is an aberration in American history, and we must change it.*

In a time of unparalleled prosperity, every section of every appropriations bill seems to begin, "Because of severe budgetary constraints …" We are still waiting for the peace dividend.

What can we do? We must demand better! The public believes in science and exploration, and we are asking questions that engage the public's imagination. We must help people in government and the media to understand this.

Basic research (and not only particle physics) is a superb investment on many levels. Don't be timid (but be sensible). Many people are dining out on the World Wide Web, an unprogrammed dividend of a tiny fraction of the world's investment in particle physics. If people want to count beans, we must insist that they count *all* the beans.

Like every individual, every nation must decide what constitutes a meaningful life. Share your passions and your dreams, and lift the eyes of those who govern!

7. Onward and Upward!

Making a new world is not accomplished in three weeks or three months or three years, but we have made a wonderful start here at *Snowmass 2001.* Your passion, energy, creativity, and commitment truly did begin to change the world. Thank you!