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The mirage of the "world accelerator for world peace" and the origins of the SSC, 1953–1983

DURING THE GLOBAL anxiety following World War II, a group of internationalist physicists conceived an optimistic vision of a cooperative world-wide particle accelerator, later nicknamed the "Very Big Accelerator," or VBA. They envisioned the ambitious project, which

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The following abbreviations are used: AAAS, American Association for the Advancement of Science; AEC, Atomic Energy Commission; AIP, American Institute of Physics; APS, American Physical Society; BNL, Brookhaven National Laboratory; CBA, Colliding Beams Accelerator (see ISABELLE); CERN, European Center for Nuclear Research; CESR, Cornell Electron Storage Rings; DESY, Deutsches Elektronen-Synchrotron; DOE, Department of Energy; ERDA, Energy Research and Development Administration; FHC, Fermilab History Collections; FNAL, Fermi National Accelerator Laboratory; HEPAP, High Energy Physics Advisory Panel; HERA, Hadron Elektron Ring Anlage (FRG); ICFA, International Committee for Future Accelerators; IHEP, Institute for High Energy Physics (USSR); ISABELLE, Intersecting Storage Accelerator (BNL); ISR, Intersecting Storage Rings (CERN); IUPAP, International Union of Pure and Applied Physics; JINR, Joint Institute for Nuclear Research (Dubna); KEK, Japanese National Laboratory of High Energy Physics; LBL, Lawrence Berkeley Laboratory; LEP, Large Electron-Positron; LHC, Large Hadron Collider; NRC, Nuclear Regulatory Commission; OMB, Office of Management and Budget; OPEC, Organization of Petroleum Exporting Counwas too expensive for any single nation, as a model for peaceful multinational collaborative ventures. This utopian concept, which stood in relief against the backdrop of the Cold War, took form slowly through three decades of negotiation among American, Asian, Western and Eastern European physicists. Developing this possibility was a primary concern of leading particle physicists between 1976 and 1983.

However, in July 1983, American physicists proposed the "Superconducting Super Collider," the SSC, to the U.S. Department of Energy. The SSC resembled the VBA physically; it was to be a hadron collider to probe the frontier energy range of 20 TeV on 20 TeV. But although the designs of both machines emerged from the same VBA technical workshops, the machines could hardly have differed more in their philosophies. From its inception, the SSC was planned as a means by which America might regain its international competitive edge in basic physics research and as a high-technology step in the nation's economic growth. This machine's nationalist definition occurred during the early Reagan administration, as part of the promised economic recovery. It was a period of reawakening in Washington, D.C., to the values placed on research and technology following World War II.

In this article, we examine the evolution of the VBA from the mid-1950s to the early 1980s and consider what brought the American physics community to propose the SSC in 1983. This study also offers a perspective on present difficulties in raising international funding for the SSC. The recent perils of the SSC in the Congress, the urging by many Americans that the SSC be built internationally, and the painful deliberations by ICFA (the International Committee for Future Accelerators) over what might be possible after the SSC, suggest the desirability of knowledge of the machine's early history. Why did the vision of the VBA espoused by ICFA in the 1970s fail?

1. BIRTH OF THE WORLD ACCELERATOR, 1955–75

During the Eisenhower administration (1953–61), following the icy first decade of the Cold War, relations between the Western and Communist powers began to thaw and several ambitious efforts began to rekindle the internationalist spirit among physicists. The Rochester Conferences, from 1950 on, had brought particle physicists from around the world together for scientific discussions. CERN, organized

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tries; *PT, Physics today*; SLAC, Stanford Linear Accelerator Center; SPS, Super Proton Synchrotron; *S$\bar{p}$pS*, Super Antiproton-Proton Synchrotron; SSC, Superconducting Super Collider; TeV, Trillion electron Volts; UNK, Accelerating and Storage Complex, at IHEP; VBA, Very Big Accelerator.

between 1950 and 1954, served as a prototype for international cooperation in physics. Inroads toward Western European cosmic-ray collaborations with Soviet physicists were achieved in June 1955 at the International Conference on High-Energy Physics in Pisa.[1] Two months later, these contacts were extended to American physicists at the Geneva *Atoms for Peace* Conference, one of the early steps in reopening scientific communication during the Cold War. Proposed to the UN General Assembly by Eisenhower in December 1953 as an effort to curb the nuclear arms race, the *Atoms for Peace* program, set up officially by the Atomic Energy Act of 1954, encouraged American scientists to pursue cooperative exchange with other nations "in the peaceful uses of the atom in industry, agriculture, medicine, and research."[2]

Similarly, the Pugwash Conferences on Science and World Affairs began in 1957 as an arena in which scientists could discuss international problems of nuclear weapons and world security. Also that year, the International Union of Pure and Applied Physics (IUPAP), stimulated by the Rochester Conferences for scientific exchange, established its Commission on High Energy Physics to "encourage international collaboration among the various high-energy laboratories to ensure the best use of the facilities of these large and expensive installations."[3] As the acknowledged forerunners in accelerator physics, it was natural for American physicists to pursue this cooperative initiative in high-energy physics, and keep alive their field's internationalist traditions.

1. The Joint Institute for Nuclear Research (JINR) at Dubna was the Soviet Union's model for international collaboration, when Luis Alvarez, Robert Marshak, Wolfgang Panofsky and Robert R. Wilson visited its new 10 GeV proton synchrotron in 1956 at the invitation of Vladimir Veksler. W. Panofsky to A. Kolb, 29 Mar 1991, FHC.

2. R.R. Wilson, "Toward a world accelerator laboratory," 16 Aug 1978, Fermilab TM-811; W. Owen Lock, "Origins and early years of the International Committee for future accelerators," Draft, Dec 1982, FHC; Robert E. Marshak, "The Khruschev détente and emerging internationalism in particle physics," *PT, 43:1* (1990), 34–42; the three volumes of the history of the Atomic Energy Commission, Richard G. Hewlett and Oscar E. Anderson, Jr., *The new world, 1939–1946* (University Park, 1962), Richard G. Hewlett and Francis Duncan, *Atomic shield, 1947–1952* (University Park, 1969), and Richard G. Hewlett and Jack M. Holl, *Atoms for peace and war, 1953–1961* (Berkeley, 1989); and David Dickson, *The new politics of science* (New York, 1984). Quote is from G. Seaborg, "Atoms for Peace Program," *Encyclopedia Americana, 2* (1987), 649.

3. The name was later changed to the Commission on Particles and Fields. Robert E. Marshak, "Scientific and sociological contributions of the first decade of the Rochester Conferences to the restructuring of particle physics (1950–60)," in International Conference on the Restructuring of Physical Sciences in Europe and the United States, 1945–60, *Proceedings* (Singapore, 1989), 745–786.

While American physicists were approaching international cooperation, Eisenhower's administration embarked on nationalist initiatives toward maintaining America's position of scientific advantage in the world. For example, when in 1957 the USSR challenged the U.S. with its successful *Sputnik* program, I.I. Rabi of Columbia advised Eisenhower to elevate the status of his scientific advisors and the president appointed the President's Science Advisory Committee (PSAC). Eisenhower named James R. Killian, then President of MIT, as his full-time science advisor and chairman of PSAC. Killian's first duty was to "keep himself informed on the progress of scientific endeavor in the various agencies of the government giving primary attention to the use of science and technology in relation to national security." Killian's introduction of a group of scientists into the government process began the tradition of having distinguished scientists offer advice directly to the President and contribute regularly to the formation of U.S. scientific policy.[4]

The novel idea of a "world accelerator for world peace" was discussed in July 1959, at the meeting of the IUPAP Commission on Particles and Fields held in Kiev in conjunction with the International Conference on High-Energy Physics (Rochester Conference) to consider questions relating to international cooperation on particle accelerators.[5] The discussants then formed a study committee of American and East and West European scientists. This committee began an international seminar that would meet for the next decade and a half, evolving in time into ICFA. The committee continued its discussions when it met in September 1959 at CERN.

Khrushchev's visit to the United States that same month and his successful meetings with Eisenhower further encouraged dialogue on cooperative scientific projects. Also in September, V.S. Emelyanov, head of the USSR Administration of Atomic Energy, met with John McCone, Chairman of the U.S. Atomic Energy Commission. On November 24, 1959, they signed an agreement providing for simultaneous, reciprocal short-term "exchanges of information and visits of three to five scientists." In particular, they considered "the design and construction of an accelerator of large and novel type."[6]

4. Daniel J. Kevles, *The physicists* (New York, 1977), 385; W.T. Golden, *Science and technology advice* (New York, 1988); J.R. Killian, *Sputnik, scientists, and Eisenhower* (Cambridge, 1977), XV–XIX, quote from "Terms of Reference for Proposed Appointment of Special Assistant to the President for Science and Technology," 275–276.

5. R.R. Wilson, "A world laboratory and world peace," *PT, 28:11* (1975), 120; Marshak (ref. 3), 120.

6. Memorandum, "Cooperation between the United States of America and the Union of Soviet Socialist Republics in the field of the utilization of atomic energy for peaceful purposes," 24 Nov 1959, FHC.

As a consequence of the Emelyanov-McCone Agreement, a delegation of five physicists, Robert Bacher, George Kolstad, Edward Lofgren, Robert Marshak, and Robert R. Wilson set out for the Soviet Union on May 11, 1960. They were briefed "specifically to explore the joint construction of a large accelerator."[7] Unfortunately, the opportunity was lost when on May 1, just prior to the visit, the Soviets shot down an unauthorized American U-2 reconnaissance plane over Russia. The U.S. refused to apologize and relations again turned hostile. Trust further diminished when the Paris summit meeting collapsed, shattering Eisenhower's hopes of resolving the Cold War.[8]

Yet even in the fearsome climate of the nuclear arms race, the dream survived among many physicists that "somehow," as Robert Wilson later wrote, "in building and operating a World Laboratory we would not only be exploring nature, but we also might be exploring some of the ingredients of peace."[9] In August 1960, at the tenth Rochester Conference, Wilson called some thirty leading physicists (including Werner Heisenberg and Robert Oppenheimer) to an unofficial meeting to explore "the need and practicality of ultrahigh-energy accelerators in a world-wide context."[10] The meeting concluded that a 1000 GeV machine was feasible at a "bargain" cost of about 1 billion dollars.

On June 5, 1961, John Adams, acting director-general of CERN, requested that Edoardo Amaldi of CERN's Scientific Advisory Council, D.I. Blokhintsev, director of Dubna, and Robert Marshak, secretary of IUPAP's High Energy Physics Commision, meet informally and consider the international accelerator. This discussion led to projected cooperation between CERN, the U.S., and the USSR, and identification of the best candidates to direct the effort. John Adams was suggested as a possible director, with associate director support from A. Kolomensky of the Lebedev Institute and Robert Wilson of Cornell, "a brilliant team," Marshak wrote in a memorandum, that "would guarantee the success of the project and success might pave the way to future fruitful international collaborative efforts."[11] Such optimism and idealism characterized the period that witnessed the election of John F. Kennedy.

7. Wilson (ref. 2).
8. Robert A. Divine, *Eisenhower and the Cold War* (New York, 1981), 143–152.
9. Wilson (ref. 2).
10. R.R. Wilson, "Ultrahigh-energy accelerators," *Science, 133* (1961), 1602–1607.
11. R.E. Marshak, Memorandum to Atomic Energy Commission, "Notes on Adams' meeting re: International Accelerator Laboratory," 7 Jul 1961, R.E. Marshak papers, AIP.

Consideration of the super-energy world machine continued at meetings of high-energy physicists—the 1961 Rochester Conference, the 1964 Vienna meeting, the Riga seminar in 1967, Semmering in 1968, Tbilisi in 1969, and Morges in 1971.[12] Wilson expressed the dominant ideal of a physics contribution to worldwide cooperation in 1968: "the greatest force of such an international laboratory will be in developing our common culture in physical science....particles, accelerators, and society may interact again—this time to provide a force for international harmony."[13] But during the Kennedy, Johnson, and Nixon administrations, escalating domestic pressures (relating to civil rights, assassinations, poverty), international political issues (the Berlin Wall, the Cuban missile crisis, the strategic arms buildup, China), and the ongoing Vietnam War kept the goal of building a world accelerator in suspension. Similarly, the Soviet's perception that supporting the international machine might affect progress in their national program damped the attempt made in 1964 for an accelerator-construction collaboration among the Soviets, Western Europeans, and the Americans.[14]

Scientific input to the White House diminished in the late 1960s and early 1970s owing to a strong emphasis on the application rather than the development of scientific knowledge. National priorities focused on economically attainable objectives, and, in this period, the 200–400 GeV NAL (National Accelerator Laboratory, renamed Fermi National Accelerator Laboratory, or Fermilab, in 1974) was built. Similarly in Europe the Soviets built the 76 GeV proton accelerator at the IHEP in Serpukhov and CERN built its ISR (Intersecting Storage Rings) and its 300 GeV SPS (Super Proton Synchrotron). Where regional accelerator efforts were large, international collaboration developed naturally within the scientific context. Just as CERN had been the paradigm for international collaboration in the 1950s and 1960s, in the 1970s NAL became acknowledged as the American standard by which to gauge cooperative efforts.[15]

A new window for discussing international cooperation opened in June 1973 as U.S. President Richard Nixon and Soviet Party General Secretary Leonid Brezhnev signed the historic accords addressing the

12. Lock (ref. 2); Wilson (ref. 2).

13. R.R. Wilson, "Particles, accelerators, and society," *American journal of physics 36:6* (June 1968), 490-495.

14. The attempt involved a delegation of physicists from Dubna, CERN, and the American laboratories, working with the International Atomic Energy Agency and the AEC, with the approval of the White House. W. Panofsky to A. Kolb, 29 Mar 1991 and 3 Apr 1991, FHC.

15. Wilson (ref. 2).

world's emerging energy problems. The agreement identified basic research on the fundamental properties of matter as one of three areas (behind thermonuclear fusion and breeder reactors) particularly useful for "expanded and strengthened cooperation for mutual benefit, equality and reciprocity between the U.S. and the USSR."[16] This remarkable pact was designed to help alleviate the critical economic and technological impact of the energy crisis of the time; OPEC had asserted its control over world oil supplies and jolted global economies.

In February 1974, the US-USSR Joint Committee on Cooperation in Peaceful Uses of Atomic Energy, called for in the Nixon-Brezhnev Accords, assembled for the first time. It met again in October, to address the implementation of programs for cooperation in research on the fundamental properties of matter. Meanwhile, other international developments improved the chances for successful cooperation. From September 1973 to July 1975, agreements were drafted for the Helsinki conference in August 1975 that would result in the signing of the Helsinki Accords, an understanding that placed scientific cooperation and the free flow of information within the context of human rights. A particular "linkage," which evolved out of the détente policy between the U.S. and USSR, began to exert influence. This linkage connected political policies with human rights and international law and proved effective as a means of addressing global economic problems, such as world-wide inflation. Cooperation went hand-in-hand with political behavior.

2. THE VBA, 1975–80

In 1975 the international climate seemed favorable for the elusive and quixotic world accelerator, and at the next international collaboration seminar, held in March 1975 in New Orleans, the VBA was born. Throughout the psychological warfare of the continuing Cold War, the physicists attending the seminar had maintained their optimism about the international collaboration. However, by the mid-1970s some were losing their patience. Like the stalemated Paris peace talks, the meetings on the world accelerator had produced only talk. The group that met in July 1974 in Abingdon, England, to plan the 1975 IUPAP international collaboration seminar agreed that this seminar "should be different...and really result in positive recommendations."[17]

16. "Atomic energy: Scientific and technical cooperation in the field of peaceful uses of atomic energy," 21 June 1973, Rolland P. Johnson Collection, FHC.

17. Lock (ref. 2); V. Weisskopf to R.P. Johnson, 13 Dec 1974, R.P. Johnson collection, FHC (quote).

They decided to hold the seminar for the first time at an American site, New Orleans. The AEC agreed to serve as host within the framework of the 1973 Nixon-Brezhnev agreement. In his invitations, organizing committee chairman Victor Weisskopf, former director-general of CERN (1961–65), expressed his conviction that the meeting would be "an important contribution to international collaboration in our science." Participants were encouraged to recommend types, size, cost, timing, and arrangements for an inter-regional accelerator.[18]

Sparks flew at this meeting in March 1975. Wilson, then director of Fermilab, recalls that the discussions were "spontaneously interrupted by a number of impassioned speeches to the effect that a world laboratory along the lines of a world-wide CERN would be necessary and desirable if we are to push into the multi-TeV region of proton energy."[19] Leon Lederman, then director of Columbia University's Nevis Laboratories, endorsed the plan, proclaiming in a position paper proposing a 5 TeV on 5 TeV collider that "the world community of high-energy physics [should] bite the bullet and organize together to bring this 10 TeV machine to realization."[20] He gave it its name, the "Very Big Accelerator," or VBA.

Other proponents emphasized the potential contribution of the international accelerator to world-wide cooperation. Edwin Goldwasser, deputy director of Fermilab and secretary of the IUPAP Commission on Particles and Fields, remarked: "If the world is to survive and flourish, its people, with their different cultures, politics and economics will have to work together much more closely than in the past. Many of us believe that high-energy physics may provide a small but useful prototype for the broadening and deepening of such cooperation activities."[21] French IUPAP commission chairman Bernard Gregory, former director-general of CERN (1966–70), helped to resolve the diplomatic difficulties and the participants then recommended the formation of a study group for the VBA, to be led by Weisskopf.

Over the next several years, physicists discussed the technical designs of the VBA at many meetings, while members of the study group continued to project its philosophical underpinnings to the broader scientific community. For example, Wilson wrote in *Physics today* in November 1975, "such an undertaking might well provide some of the experience in international living so necessary for human

18. Ibid.

19. R.R. Wilson, "A world organization for the future of high-energy physics," *PT, 37:9* (1984), 9 and 112.

20. Leon M. Lederman, "New Orleans—A proposal," undated document, FHC.

21. E.L. Goldwasser, "Normalization of inter-regional cooperations and communications," paper submitted to New Orleans Seminar, no date, FHC.

survival—a candle in the darkness."[22] Weisskopf commented in *Physics today* for May 1976, "a world collaboration on the Very Big Accelerator would have important significance besides the mere scientific advantages, as a symbol of human values beyond competition and strife, and as an example of intensive international collaboration across ideological frontiers."[23]

These were the uncertain years, not only of the Watergate scandal, Nixon's resignation, and the fall of Saigon, but of lines at the gasoline pumps, which drove home the reality of energy shortages following intensified Arab-Israeli conflicts. U.S. science policy responded. In 1975, the AEC was reorganized into the Energy Research and Development Administration (ERDA) and the Nuclear Regulatory Commission (NRC); there would be further reshuffling until the Department of Energy emerged in October 1977 to address the myriad of energy issues confronting the country. Meanwhile, after political outsider Jimmy Carter defeated Gerald Ford in November 1976, the Middle East conflict assumed a major significance. These transitions and fluctuations sidetracked serious American long-term commitment to an international accelerator aimed at purely fundamental research.

Yet at their meeting in Serpukhov in May 1976, the participants in the seminar on international collaboration pursued the general scale of the VBA, then conceived as a 10-20 TeV fixed target proton accelerator, or as at least 100 GeV e^+e^- storage rings.[24] They agreed that IUPAP should form an official subcommittee to organize future meetings. At the International (Rochester) Conference on High Energy Physics held at Tbilisi in July 1976, the IUPAP Commission on Particles and Fields agreed to sponsor this new committee, dubbed the "International Committee on Future Accelerators," or ICFA and Gregory of CERN was elected chairman.[25] The name was modified to the International Committee *for* Future Accelerators in early 1978. ICFA was charged with organizing workshops and meetings to study both the VBA and future regional facilities and collaborations. It was to be an international facilitator for scientific exchange and advancement. Membership would be determined by a nominating body consisting of the chairman of HEPAP, who would name three U.S. representatives;

22. Wilson (ref. 5), 120.

23. V. Weisskopf, "Group meets in USSR on Very Big Accelerator," *PT, 29:5* (1976), 19.

24. J.D. Bjorken, "Physics issues and the VBA," May 1976, FHC.

25. E.L. Goldwasser, "Report on the status and plans of the International Committee on Future Accelerators," 19th International Conference on High Energy Physics, *Proceedings* (Tokyo, 1979), 961–988. L.M. Lederman, "VBA," *IEEE transactions on nuclear science, NS-24-3*, June 1977, 1903–1908.

the chairman of CERN's Scientific Policy Council, who would nominate three Western Europeans to represent the member-states of CERN; the president of the Soviet Academy of Sciences, who would nominate three Soviet physicists; and the chairman of the IUPAP Commission on Particles and Fields (an *ex officio* member of the committee), who would name one Japanese physicist and one physicist from the Dubna member states other than the Soviet Union.

When Lederman told participants in the Particle Accelerator Conference held in Chicago in 1977 about the VBA, he emphasized the accepted ICFA argument that "world collaboration is essential if we are to realize the facilities that we perceive our subject requires." His trademark use of comic relief included proposing New York City (then in its near-bankruptcy crisis) as a potential site for the VBA (see Fig. 1). He joked that many necessary facilities were already in place: high-rise international headquarters, educational resources, pretunneled terrain, and the usual degree of inaccessibility.[26]

Further VBA planning took place at the first ICFA meeting, held on August 29, 1977, in Hamburg. After the sudden death in December 1977 of Gregory, who had been coordinating their activities, interim chairman Goldwasser organized and guided the second ICFA meeting, held at CERN in January 1978. Then Sir John Adams of Great Britain, director-general of CERN from 1976–80, was elected the new ICFA chairman. The members mobilized and planned a series of VBA technical workshops, the first held at Fermilab in October 1978, the second in Les Diablerets (near CERN) in October 1979. Many of those who would support the SSC effort in the 1980s contributed to these early VBA workshops.[27] The meeting at Les Diablerets set the size and energy specifications of a 20 TeV on 20 TeV proton collider, specifications later adopted for the SSC.[28]

26. L.M. Lederman, "VBA," *IEEE transactions on nuclear science, NS-24-3*, Jun 1977, 1903–1908. Lederman's map of the New York site, on p. 1908, was reprinted as a cartoon in *PT, 30:5* (1977), 20.

27. Attending the 1978 Fermilab workshop, which also provided stimulation for the linear collider project at SLAC were: B. Barish, E. Courant, R. Diebold, Goldwasser, Lederman, B. McDaniel, P. McIntyre, J. Rees, B. Richter, C. Rubbia, N. Samios, J. Sandweiss, J. Sanford, R. Stiening, L. Teng, M. Tigner, A. Tollestrup, G. Trilling, W. Willis and Wilson. Barish, Courant, Diebold, Richter, Samios, Stiening, Teng, Tigner, Tollestrup, and Willis also participated in the 1979 workshop. They represented an experienced and concerned cross-section of the U.S. community.

28. Lock (ref. 2); Possibilities and limitations of accelerators and detectors, 1978, *Proceedings*, ed., L. Teng (FNAL), Possibilities and limitations of accelerators and detectors, 1979, *Proceedings*, ed., U. Amaldi (CERN), and 20 TeV Hadron Collider Workshop, 1983, *Proceedings*, ed., M. Tigner (Cornell); see also R. Diebold, "The Desertron: Colliding beams at 20 TeV," *Science, 222* (7 Oct 1983), 13–19, and *Superconducting super collider reference designs study*, 8 May 1984, 3, FHC.

But as ICFA members refined the VBA's technical design over the next several years, the political intricacies and time required to achieve an egalitarian collaboration diplomatically caused the project to dissolve slowly into the distance, like a mirage. Scientific goals could not be fixed, since in each country regional plans for higher energy machines were constantly evolving. And while each region continued to express support for building the VBA, national policies and projects determined actual priorities. Western Europeans at CERN were committed to the $Sp\bar{p}S$, a proton-antiproton collider, and planning for the Large Electron-Positron Collider (LEP); PETRA (electron-positron accelerator-storage ring) at DESY (Deutsches Elektronen-Synchrotron) in Hamburg was also underway. Regarded by the U.S. as its most serious competitor, LEP was conceived in 1976–77 to examine the 150–300 GeV center-of-mass energy range; in 1981, the CERN member states approved it.[29] The U.S. was involved with ISABELLE at BNL (Brookhaven National Laboratory), PEP (Positron-Electron Project) at SLAC (Stanford Linear Accelerator Center), and transforming Fermilab's complex of accelerators into the TEVATRON. ISABELLE, conceived in 1974 with up to 200 GeV protons in each beam in order to achieve 60–400 GeV in the center of mass, was reconfigured in 1977 to double the energy of each beam, to compete with the SPS at CERN. Construction, at a cost of $275 million, was authorized in 1978. In the mid-1970s Fermilab had explored the possibility of a machine called POPAE, with 1000 GeV protons colliding on 20 GeV electrons, conceived as an interlaboratory collaboration with Argonne.[30] Japan was designing KEK, and Soviet and Eastern European facilities were emerging as serious competitors. Although all these facilities would be exploited on an international basis (except for ISABELLE, which was not completed), they were built regionally or nationally.

In addition, American politics hindered progress in physics. After Nixon's disbanded of the Presidential Science Advisory Council, President Ford had reassured American scientists that their policy interests would be heard by reinstating the science advisor's office. Although trust in the government during the 1976 Bicentennial temporarily diminished disillusionment with the political process, the Carter administration's focus on applied research during the energy crisis

29. CERN Annual report, 1977, 12–13; "LEP authorization," *CERN Courier* (Jan-Feb 1982), 20; and "Large Hadron Collider workshop," ibid., June 1984, 185–187.

30. R.R. Wilson, "Colliding beams at Fermilab," Fermilab TM-807, 11 Aug 1978; "POPAE: A design report for a 1000 GeV on 1000 GeV proton-proton colliding beam facility," Fermi National Accelerator Laboratory and Argonne National Laboratory, May 1976, FHC.

in the late 1970s placed basic research on hold and the authorization of ISABELLE tightened funding for the national high-energy physics program.[31] Wilson's resignation in 1978 as director of Fermilab was one response to the stagnant situation. Meanwhile, Washington's economic difficulties linked to the volatility of the Middle East and Eastern Europe and the increasing energy shortages, called the direction of the nation into question and contributed to the election of Ronald Reagan.

3. THE AMERICAN INITIATIVE, 1980–82

Whereas through the sixties and seventies the U.S. had retained its indisputable world leadership in high-energy physics, by the beginning of the 1980s the driving innovation and imaginative answers were coming from Europe. In response, an American movement to stimulate advanced accelerator projects began late in 1979.

Sidney Drell, chairman of HEPAP (the High Energy Physics Advisory Panel to the DOE) appointed several subpanels of physicists to review the U.S. high-energy program. He asked Sam Treiman of Princeton to coordinate a subpanel evaluating the program within existing financial constraints. Trieman's subpanel met in Woods Hole, Massachusetts in June 1980. The American physicists' attitude was summarized in Drell's letter transmitting their report to the DOE: without increased funding, "the U.S. program will inevitably lose its eminence" and its ability "to compete with Western Europe."[32] More American physicists were now voicing their concern about building new accelerators in discussions fueled, paradoxically, by limited government funding, which they interpreted as a reduced national commitment to the long-term value of basic research.

Drell had appointed Maury Tigner of Cornell to head a subpanel to evaluate the nation's accelerator R&D and to recommend appropriate funding. The subpanel's conclusion, summarized in Tigner's letter transmitting the final report to Drell, was that "we must redouble our efforts to improve the cost effectiveness of our accelerators if the needs of U.S. particle physics are to be met in the resource limited situation."[33] Tigner's subpanel saw a need for "continual and vigorous

31. James Everett Katz, *Presidential politics and science policy* (New York, 1978), 230–232.

32. HEPAP Subpanel on Review and Planning for the U.S. High Energy Physics Program, Report (Jul 1980), DOE/ER-0066, transmittal letter from Drell to Edward A. Frieman, 15 Jul 1980, 1–4,

33. HEPAP Subpanel on Accelerator Research and Development of the High Energy Physics Advisory Panel, Report (June 1980), DOE/ER-0067, transmittal letter, Tigner to Drell, 26 Aug 1980, iii.

improvement of existing technologies" and for devoting "more of our intellectual and monetary resources to high-energy accelerator R&D than is now our practice." In forwarding the report to the DOE, Drell described the document as "a 'call to arms' encouraging more attention on the part of the high-energy community to advanced accelerator R&D."[34]

Meanwhile, with a refined understanding of the Standard Model—the fundamental theory of particles and fields—many American physicists recognized that a far more powerful instrument was needed to investigate the emerging physics agenda and address the new European challenges. The theory of grand unification described a bleak desert of events between 300 GeV and 10^{15} GeV. In this desert, as Carlo Rubbia expressed it in March 1981 at the Particle Accelerator Conference in Washington DC, "*Nothing* happens...except a very slow logarithmic change of physical quantities until we reach the mass range of leptoquarks (10^{15} GeV). History does not encourage such a bleak view. Without experiments and without a comprehensive understanding of the physical origins of gauge invariance, this is merely an attractive and economical speculation."[35] Physicists estimated the minimum energy needed to penetrate this desert as 1 TeV in the center-of-mass frame. Unfortunately, the highest energy American accelerator then under construction, the Brookhaven collider ISABELLE, was aimed considerably lower.

At this point, the U.S. physics program faced competition from a multitude of aggressive European projects, most notably at CERN, now led by Adams' successor, Herwig Schopper, representing the German member state, and previously the director of DESY.[36] CERN's potential to confront the electron frontier with the LEP Collider posed a direct challenge to the VBA planners. LEP would contend for the electron machine parameters ICFA had identified for the object of world cooperation.

The Reagan administration was slow to recognize the need to support basic research, in particular high-energy physics. In his 1980 campaign Ronald Reagan had questioned the need for a Department of Energy and his first DOE Secretary, dentist James Edwards, planned to "preside over the demise of the DOE,"[37] a possibility that rattled the foundations of the national laboratories. Fortunately for the physicists, Congress did not support this plan, and the general outlook for

34. Ibid., i.

35. *IEEE transactions on nuclear science*, NS–28 (June 1981), 3.

36. "CERN elects Schopper as director," *PT, 33:6*, (June 1980), 84–85.

37. Constance Holden, "Former Carolina Governor to Head DOE," *Science, 211* (6 Feb 1981), 555.

basic research improved with later science advice from White House Science Advisor George Keyworth from Los Alamos, second Energy Secretary Donald Hodel, and Alvin Trivelpiece, director of DOE's Office of Energy Research.

In the economic environment of 1981, when the administration planned to balance the budget, declaring "relevance" and "pertinence" became crucial in the effort to secure funding for basic research. In March 1981, James Leiss, associate director for High-Energy and Nuclear Physics in the Office of Energy Research, did so when he spoke at the Particle Accelerator Conference in Washington, DC, of the need "to invest more in advanced accelerator R&D...and also to investigate radically new ideas, which might make major increases in energy economically possible."[38] Tigner emphasized to the conference the "dire necessity for America to fund new, economically efficient accelerating methods and technologies."[39]

In June, Keyworth addressed the AAAS, "We must strive to identify those disciplinary areas where vitality is required to support industrial, military and other essential technologies, as well as those with particular scientific promise....The principal criterion for the support of areas of research directed toward technology advances is pertinence."[40] The message: there would be research money from the OMB (Office of Management and Budget) for those who could justify their piece of the federal budget, supporting development and transferring technology to demonstrate a successful national economic investment. Projects to keep America strong and competitive without risk were a priority.

Keyworth's program paralleled that of his Los Alamos mentor, Edward Teller. Teller at this time was advising Reagan to develop the Strategic Defense Initiative (SDI), or "Star Wars," as defense against what Reagan described to the National Association of Evangelicals, in March 1983, as the "evil empire." Relations between the U.S. and the USSR became as difficult as they had been during the 1960s. The defense budget doubled in the 1980s as a priority of the Reagan administration, basic research funding increased along with it, although inflation, recession, and the growing costs of research and

38. James E. Leiss, "Relevance of accelerator/storage ring technological developments to U.S.A. science and technology—past, present, and future," *IEEE transactions on nuclear science* NS–28 (June 1981), 3553–3555, quote on 3555, and "Impact of accelerators on science and technology," *PT, 34:7* (1981), 70–72.

39. M. Tigner, "Accelerator R/D in the U.S. high energy physics program—past, present and future," *IEEE transactions on nuclear science* NS–28 (June 1981), 3549–3552.

40. "Keyworth says U.S. can't be tops in all R&D," D. Greenberg, ed., *Science and government report 11: 12* (15 Jul 1981), 8.

technology almost nullified it.[41]

By this time ISABELLE, having suffered serious delays owing to magnet failures and organization problems, had become a major concern to the high-energy physicists. By 1981 ISABELLE was showing marked improvement, both in its management and magnet development, and HEPAP's subpanel on long-range planning, chaired by George Trilling of Lawrence Berkeley Laboratory, addressed the issues of the machine's cost, schedule, and design energy. Because of its high budget, the panel worried that ISABELLE might "bleed the rest of the program," if continued. In November 1981 the subpanel offered two funding scenarios. In the first, ISABELLE would be completed by 1990, along with other high priority projects. In the second, premised on the hypothesis that support for high-energy physics might not continue at the level of $440 million per year, ISABELLE would be cancelled. The subpanel's interim report set up the eventual discontinuation of ISABELLE.[42]

The subpanel's final report, issued in January 1982, praised ICFA's preliminary work on a "world-wide super-accelerator project" as advantageous and worthwhile. Although it supported ICFA's efforts, the subpanel did "not recommend the commitment of significant U.S. resources to the ICFA project at the present stage of international collaboration," believing that to be premature until all preliminary "administrative and scientific preparatory work" had been explored. In addition, the report noted that improved opportunities for individual input to long-range planning were needed and they suggested that the American Physical Society Division of Particles and Fields make "a larger effort in the planning area." This effort would include "sponsorship of appropriate workshops...and increased scheduling at its meetings of invited talks in areas relevant to future planning."[43]

The recommendations for support at the highest level were strongly endorsed by HEPAP on February 19–20, 1982. If this support could not be forthcoming, HEPAP concluded that ISABELLE should be discontinued. To maintain a vigorous high-energy program in the 1980s, they recommended that "another major facility...be started in the mid-1980's so as to be available for research by 1990...less expensive...but...capable of supporting a broad physics program and of

41. For perspective on the Department of Defense's involvement with planning for the SSC in the late 1980s see Charles Schwartz, "The Department of Defense and the superconducting super collider," 24 Apr 1990, unpublished article, FHC.

42. HEPAP Subpanel on Long Range Planning for the U.S. High Energy Physics Program, Report, (Jan 1982), DOE/ER-0128, 46–60; S. Drell quoted in Gloria Lubkin, "Panel: Finish Isabelle if particle physics gets enough funds," *PT, 33:1* (1982), 51–52.

43. Ibid.

exploring new frontiers." HEPAP pointed to SLC (SLAC Linear Collider) as "an example of the type of relatively large R&D project which is now necessary," and identified appropriate utilization and support of existing facilities with prompt completion of Fermilab's superconducting accelerator (the Energy Doubler/Saver) and the Tevatron I and II programs as the "highest immediate priority."[44] These recommendations came just as dismantlement threatened the Department of Energy.

While the U.S. thus vacillated over the most prudent ways to distribute its research dollars, CERN focused on its mission. The initial operation of CERN's $\bar{p}p$ hadron collider in 1981, based on Simon van der Meer's stochastic cooling technique, enabled CERN to discover unchallenged, in January and June 1983, the predicted intermediate vector bosons, the $W^{\pm}$ and Z^0 particles, required by the theory of unifying the weak and the electromagnetic interactions. CERN's $\bar{p}p$ breakthrough sparked the revision in 1981/2 of the Tevatron-I project to develop Fermilab's antiproton source for its colliding beams program.[45]

Meanwhile planning for the international accelerator continued. In 1979 the Fermilab Program Advisory Committee, reporting to its new director, Leon Lederman, had recommended guidelines for the participation of foreign groups in Fermilab's experiments. ICFA incorporated these guidelines into its suggestions for inter-regional utilization of facilities; by 1981, the guidelines had been adopted by other major laboratories throughout the world.[46] By then ICFA was forming plans for long-term advanced accelerator research and development. ICFA chairman John Adams drafted an agreement defining the organization of the VBA facility,[47] but funding and administrative problems delayed progress.

44. Ibid.

45. G. Arnison et al, "Experimental observation of isolated large transverse energy electrons with associated missing energy at $\sqrt{s} = 540$ GeV," *Physics letters, 122B* (1983), 103-116; G. Arnison et al, "Experimental observation of lepton pairs of invariant mass around 95 GeV/c^2 at the CERN SPS collider," *Physics letters, 126B* (1983), 398–410; "*$\bar{p}p$ collisions yield intermediate boson at 80 GeV, as predicted,*" *PT, 36:4* (1983), 17–20; R. Diebold, "The desertron: Colliding beams at 20 TeV," *Science, 222* (7 Oct 1983), 13–19.

46. T.H. Groves, "Physics Advisory Committee summer meeting," *Fermilab report*, Jul 1979, 8, and L.M. Lederman, "International Committee on Future Accelerators," ibid., Jul 1980, 6.

47. J.B. Adams, "Framework of the construction and use of an international high-energy accelerator complex," 11 Feb 1981, deliberated at ICFA meeting, 21 Oct 1981, held at Serpukhov, "Minutes," Sixth ICFA Meeting, 5 Nov 1981, and "Minutes," Seventh ICFA Meeting, held in Paris, 27–28 Jul 1982, and 2 Sep 1982 (FHC).

4. THE SNOWMASS DESERTRON, 1982

In July 1982, American particle physicists gathered at Snowmass, Colorado, at the first of the major workshops of the American Physical Society's Division of Particles and Fields recommended by the Trilling subpanel. This summer study was organized by the chairman of the DPF/APS, Charles Baltay of Columbia University. At this critical meeting, Lederman rallied the American physics community with his proposal for the "Desertron." He pictured this "machine-in-the-desert" as an oasis between the weak energy scale (less than one TeV) and the unifying energy realm ($\sim 10^{14}$ GeV) described by the Grand Unification Theory.[48]

Still holding onto the romantic dream of an international collaborative accelerator, Lederman filled out the scenario with caravans of high-energy physicists from around the world joining at a scientific crossroads in some isolated region and demonstrating peaceful collaboration while revealing the fundamental truths at the heart of nature. His idealistic vision echoed the earlier dream for international harmony expressed by his kindred spirit Wilson. Lederman's world accelerator for world peace, however, had a decided American character. Instead of an accelerator in space, as Enrico Fermi had proposed in 1954,[49] this cooperative application of the peaceful atom might occupy a good piece of American land. Lederman believed that without technological breakthroughs, this next generation machine would have to be much larger than could fit even on Fermilab's 6800-acre site.[50]

Hoping to awaken the U.S. physics community to the impact of multi-faceted programs being developed in Europe, Lederman asked his audience: "Who will lead us to the green, intellectual pastures?...Are we, as a community growing old and conservative, and is there a danger of quenching the traditional dynamism we have surely enjoyed in the past three decades? How can we break out of the aging lab and inadequate lab site constraints—how can we creatively leapfrog the world and get to the multi TeV domain soon?" He described a long-range he termed "Slermihaven II," a pun suggesting the best features of SLAC, Fermilab, and Brookhaven contributing to a new collaboration that would begin exploration of $\bar{p}p$ collisions at 20 TeV

48. L.M. Lederman, "Fermilab and the future of HEP," DPF Summer Study on Elementary Particle Physics and Future Facilities, 1982, *Proceedings*, ed. R. Donaldson, R. Gustafson, and F. Paige (DPF/APS), 125–127.

49. E. Fermi, "What can we learn with high energy accelerators," speech delivered 22 Jan 1954, New York City, E. Fermi Papers, 7:1, Joseph Regenstein Library, University of Chicago.

50. Lederman (ref. 48).

and, over the decade 1986–1996, evolve to face the 40 TeV (center-of-mass) energy range. An exciting American machine utilizing the superconducting technology then being mastered at Fermilab held the dual promise of responding to the European developments, as well as of exploring the desert beyond the frontier, with a "great leap forward."[51]

Referring specifically to the European competitive initiatives, Lederman proclaimed the "greatest drawback is the resistance engendered by conservatism. But any program we choose must be compared to LEP...as well as HERA and UNK."[52] Lederman identified CERN's capability within a decade to "pave the LEP tunnel with superconducting magnets" (an insight into the grand scheme being devised for the LHC, Large Hadron Collider) in a "daring and imaginative thrust towards definitive tests of our current understanding." He argued that a bold and dramatic response was essential to put the U.S. back on track. One target to aim for was the Higgs particle, the key to understanding the mechanism of spontaneous symmetry breaking, concealed at then unreachable energies.[53]

The enthusiasm generated at Snowmass energized the American high-energy physics community. During the winter of 1982/3, Lederman began to plan a Fermilab workshop for early in 1983 to design the Desertron. But because of the rivalry and competition for funding between Fermilab and Brookhaven (in the superconducting accelerator race between the Doubler and ISABELLE), Tigner advised him to hold the meeting in a neutral, more politically palatable setting, Cornell.[54] Meanwhile, in January 1983, CERN announced its discovery of the $W^{\pm}$ particles and Schopper spoke at KEK in Japan about his next plan: to install a 20 TeV hadron collider (LHC) in the LEP tunnel. CERN's accomplishments intensified the American desire to meet the European challenge.

The first of many DPF technically-intensive, mini-workshops toward the next machine was held at Berkeley in late February and early March 1983; it focused on the capabilities and possibilities of collider detectors. The organizing chairman, Al Mann of Pennsylvania, spoke to the difficulty of competing while still cooperating. "Escalating costs of construction and operation of our facilities limit alternatives and force us to make hard choices," he said. "In

51. Ibid.

52. Rubbia, leading UA-1 in the SPS, and Schopper, new director-general of CERN enunciating the LEP plan, were the spokesmen for the ambitious European agenda. "Lisbon conference," *CERN courier*, Sep 1981, 283–288.

53. Lederman (ref. 50).

54. Lederman to Tigner, 7 Dec 1982, FHC.

conjunction with the need for increased manpower concentrations to build accelerators and mount experiments, [choosing] leads to complex social problems within the science;" "competition, much of which is usually healthy, now manifests itself with greater intensity on a regional basis within our country and also on an international scale." Decisions had to be made for scientific progress, yet at what cost? The eighty-nine American physicists and fifteen European physicists attending the brief meeting had to reach a consensus and then equip a new HEPAP subpanel with the strategy to take to Washington.[55]

Tigner hosted the 20 TeV Hadron Collider Technical Workshop at Cornell in late March and early April 1983. The meeting focused on establishing costs and technical designs for the Desertron. No technical problems were foreseen. Since CERN had already demonstrated the technique for $\bar{p}p$ hadron colliders, and since Fermilab had shown that superconducting magnets could be mass-produced with excellent properties, building on ICFA's workshop findings it appeared that the 20 TeV collider could be based on scaled-up technology existing at Fermilab. Extrapolating costs from the Doubler, then the only superconducting accelerator in the world, the conferees estimated the Desertron's price at about $2.7 billion (1983 dollars), and construction was underway by 1987. The estimate excluded detectors, equipment, contingency costs and pre-operating expenses.[56]

On March 18, 1983, the last superconducting magnet was installed in the Fermilab Energy Doubler and by May successful cooling to liquid helium temperatures had been achieved. The Doubler was ready to work. This superconducting technology implied reduced costs and a more habitable site for the Desertron, which now had its potential to be a "Prairietron."[57]

As a result of the Cornell meeting and the Doubler achievement, and with Keyworth's encouragement, HEPAP assessed the new proposed collider as affordable without international pooling of resources. Completion was projected by the early 1990s. From this point on, the evanescent mirage of the ICFA World Accelerator faded for American physicists, as their plans for an American 20 to 40 TeV collider came into focus.

55. A.K. Mann, "Introductory comments," DPF Workshop on Collider Detectors: Present Capabilities and Future Possibilities, 1983, *Proceedings*, ed. S. Loken and P. Nemethy (DOE/NSF), 3.

56. M. Tigner, *Report of the 20 TeV Hadron Collider Workshop* (Ithaca, 1983), 1–4, 52–9.

57. D. Jovanovic, "Logbook," 23 Apr 1983, FHC.

5. THE SSC PROPOSAL, 1983

In February 1983, a new HEPAP subpanel was formed under Stanley Wojcicki to offer advice on new facilities, to estimate funding, and to rank priorities for a forefront U.S. HEP program for the next five to ten years. The subpanel was to assess ISABELLE, by now treading water as the CBA (Colliding Beams Accelerator). Seven crucial factors were in play. The first was CERN's demonstration of $\bar{p}p$ collisions, resulting in the observation of jets in 1982, and the announcement of the $W^{\pm}$ in January 1983 followed by that of the Z^0 in June. Europe appeared to be overtaking the U.S. in HEP. The Americans felt compelled to respond with something boldly innovative. Second, by causing scientific strength to languish, inadequate financial support had paradoxically helped to stimulate the new initiative. Third, theory was dictating the need to explore the 1 TeV energy scale. For proton colliders this implied at least 10 TeV per beam. ISABELLE was to have only 0.4 TeV per beam. Fourth and fifth, in a period in which Washington was emphasizing the need for America to regain scientific leadership for economic competitiveness, American physicists reasoned that the VBA, although useful in formulating the 20 TeV concept, had little prospect of materializing. Sixth, Fermilab's recent demonstration of superconducting magnets working successfully in an accelerator helped to clinch the Washington decision to redirect some of the ISABELLE appropriation and apply it instead toward R&D for an American 20 TeV collider, free of the cumbersome political machinery of an international collaboration. Finally, just as the American economy was showing signs of recovering from its recession, superconductivity presented an opportunity to reduce the cost of the new super collider, which now appeared nationally affordable.

HEPAP's official imprimatur to the American 20 TeV on 20 TeV Superconducting Super Collider, in its endorsement of the report of the Wojcicki subpanel, surprised the ICFA members. The subpanel had met in June and July at Woods Hole and at Nevis. The report recommended: building the SSC (recommended unanimously), completing the Tevatron and SLC as well as upgrading CESR (Cornell Electron Storage Ring), not approving Fermilab's Dedicated Collider, stopping CBA (not unanimously), and strongly supporting advanced accelerator technology. The subpanel expected the SSC to be 30 kilometers in diameter, to have 10-20 TeV protons in each of its two colliding beams, and to cost less than two billion 1983 dollars spread over twelve years.[58]

58. HEPAP, Subpanel on New Facilities for the U.S. High Energy Physics Program, 1983, *Proceedings* (DOE, Office of Energy Research Division of High Energy Physics, Jul 1983), i, vii–viii, 5–6. John Adams and Carlo Rubbia were the international members

HEPAP Chairman Jack Sandweiss' letter transmitting the report to DOE emphasized that the SSC "would be the forefront high-energy facility of the world and is essential for a strong and highly creative United States high energy physics program into the next century." The executive summary stressed the view of its members that the SSC "provides the promise of important and exciting advances in the field of elementary particle physics." The report mentioned the "healthy competition from abroad" and stated that the project's technological feasibility was based on the Doubler's "more than 20 years of superconducting R&D." "Unit costs are therefore well known. This technology is now of age."[59] Keyworth supported the plan: "the nation—or group of nations—that builds the Superconducting Super Collider will become the new world center in high-energy physics."[60] With DOE's subsequent acceptance of the recommendations, Congress reprogrammed some of the ISABELLE funding for SSC planning.

ISABELLE's supporters were greatly disappointed. By the time of its cancellation, the machine's technical problems had been solved. But the Wojcicki panel decided that the needs of particle physics and the success of CERN's half-TeV collider made the CBA's energy too low to justify continuance.[61] Diverting funds and personnel to CBA would also delay the SSC, a machine with fifty times its energy, which they judged as necessary for the "next logical step" in the U.S. program.

HEPAP's recommendations also disenchanted other regional representatives of ICFA, who felt that the U.S. had co-opted the VBA. The European and Japanese representatives viewed the recommendation for the SSC as an obstacle to their international plans. Their regional efforts had been planned with the VBA as an international collaboration on the 20 TeV collider and they considered the Woods Hole recommendation a "'nationalistic approach'...detrimental to...high energy physics as a whole."[62] American members responded that the envisioned SSC would in fact be an international center, sited

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of the subpanel. The report includes a footnote on p.67 stating, "The two European members of the Subpanel took a full part in the discussions at the meetings and in reaching the recommendations but they are not to be associated with those remarks in the report concerning the relative position of U.S. high energy particle physics in the world and the attitudes expressed about international relationships."

59. Ibid.

60. K. McDonald, "Gigantic particle accelerator will have no modern rival—if it's built," *The chronicle of higher education 31:7* (1985), 1, 10–11.

61. Gloria B. Lubkin, "Panel says: Go for a multi-TeV collider and stop Isabelle," *PT, 36:9* (1983), 17–20.

62. B. Richter, Memorandum to Ralph DeVries and Wallace Kornack, 1 Sep 1983, 2, FHC.

within the U.S. but attracting large foreign contributions of manpower and scientific research, and technological, as well as financial resources. It would not simply be the patriotic project proclaimed by the Reagan administration.[63] Their argument did not persuade the foreign members, who clearly recognized their loss of economic and political voice in the machine.

Americans also tried the notion that a single-nation host for an internationally constructed machine would be a step toward the old vision of the world accelerator that some future environment would encourage. The Americans had hoped the SSC would enrich the U.S. high-energy physics program without affecting its programs or budgets and that it could become international without burdening the U.S. program, in the same way that construction and economic support of HERA (the Hadron Elektron Ring Anlage, at DESY) were achieved in 1981 within the region supporting CERN. Although from their point of view American physicists were trying to do for their region what CERN had done collectively within its, the fact that the U.S. is a single nation gave the SSC the air of a nationalistic plan to dominate the other ICFA members.[64] The Americans further emphasized in their

63. The Americans continued attempts to develop the SSC as an international program in the forum of high-level political-economic summits. The Williamsburg Summit in June 1983 included determined pursuit of international cooperation in high-energy physics. The following year, action at the London Economic Summit to form the Summit Working Group on high-energy physics was led by Trivelpiece. See David Dickson, "Scientific cooperation endorsed at summit," *Science, 220* (17 June 1983), 1252–1253; Irwin Goodwin, "DOE answers to Congress as it officially kills Brookhaven CBA," *PT, 36:12* (1983), 41–43; David Dickson, "Political push for scientific cooperation," *Science, 224* (22 June 1984), 1317–1319, and M. Mitchell Waldrop, "The Supercollider, 1 year later," *Science, 225* (3 Aug 1984), 490–491.

64. "Future accelerators seminar in Japan," *CERN courier*, Oct 1984, 319–322. HERA had been recommended in Europe in conjunction with CERN's program in 1981. See "HERA - Proton-electron colliding beam project at DESY," *CERN courier*, May 1980, 99–104; "DESY HERA ahead," *CERN courier*, June 1981, 205–206, and "Big projects in Federal Republic of Germany," ibid., 210–211. In 1967, five locations in western Europe were proposed as sites of a second CERN laboratory to house the larger SPS, then known as the 300 GeV project (in competition with Wilson's 200–400 GeV NAL machine). The CERN Council amended its Convention to allow the larger facility to be built outside of neutral Switzerland. The United Kingdom would not agree. Even in late 1968, when British John Adams was chosen to direct the SPS, the UK refused to support the plan, along with five other member states. As the UK was second only to Germany in contributing to the CERN budget this presented a challenge to the laboratory's future. By 1970 an arrangement was negotiated with the French government to site the SPS adjacent to CERN, crossing the French border and providing a more favorable extension of the laboratory. The physicists learned much about international diplomacy and politics in this experiment in pooling resources for advancing regional interests. See *CERN courier* (8 Mar 1968), 47–51, 56–8; Jun 1968, 123–124; Oct 1968, 235–236; Dec 1968, 308–310; ibid., Apr 1970, 107–111; May 1970, 146–147, 174–178; Sep 1970, 277–278; Oct 1970, 307–309, 375–378.

response to ICFA that the VBA had been conceived as a machine too costly for any one region. Since the U.S. appeared able to afford the SSC, by definition it could not be the VBA. The U.S. was creating the opportunity for a future, internationally-funded machine, just as CERN had pushed back the energy frontier for electron machines when it decided on the LEP project in 1980/1.[65]

The representatives of the other ICFA regions did not accept this rationale. They recalled that in its earliest phase the SSC was based on VBA design work and that some of the same physicists who pioneered the SSC had helped to conceive the VBA as the machine to bring particle physics into its next phase. Credit for their long-term efforts was lost in a blink. The disappointment eventually subsided, but has not yet vanished. It occasionally reappears and haunts efforts to obtain international participation in the SSC.

DOE accepted the HEPAP recommendation of July 1983, although it did not easily fit DOE's plan of maintaining a mutually supportive relationship in high-energy physics among its three major laboratories—Brookhaven, Fermilab and SLAC—in three states having powerful congressional delegations. The advice appeared however to be in resonance with Keyworth's plan to recapture American preeminence in high-energy physics. With DOE's acceptance of HEPAP's recommendations, Congress reprogrammed some of the CBA funding for planning the SSC by December. The SSC then moved into its phase of active research and development when DOE Secretary Hodel announced Phase 0 on January 9, 1984.

The history of the VBA and SSC highlights the tension between cooperation and competition as motivating goals in high-energy physics as well as the extent to which each thrives on the other. Competition sometimes drives the scientific agenda for large projects while cooperation is essential in realizing them. Did CERN's pioneering work from 1978 to 1983 yield discovery in response to earlier American dominance of the field?[66] This case study indicates that the causes of CERN's scientific successes and the diminished status of science in America by the early 1980s worked in tandem with global political events to motivate the improvement of U.S. funding and to begin this major project.

65. R.R. Wilson, "The next generation of particle accelerators," *Scientific American, 242:1* (1980), 42–57, and Y. Yamaguchi, "ICFA—Its history and current activities," International Symposium on Lepton and Photon Interactions at High Energies, 1985 *Proceedings* (Kyoto, 1986), 826–847.

66. The CERN historians support this argument for the 1960s. A. Hermann, J. Krige, U. Mersits, and D. Pestre, with L. Weiss, *History of CERN*, vol. 2, *Building and running the laboratory* (Amsterdam, 1990), 795.

The balance between cooperation and competition in planning the 20 TeV on 20 TeV collider was upset when prominent American physicists shifted their support from the VBA to the SSC. ICFA had become an international forum for information exchange, but without the economic support needed for more formal activity its potential to form a realistic collaboration diminished. The American review panels of 1980-83 helped smooth the decision to make the leap forward by emphasizing the need for a new innovative American accelerator to pursue the frontier and by recommending increased funding for high-energy accelerator technology in general.

When national politics and the economic climate made it seem possible for American physicists to fulfill their idyllic dream of scientific progress through an American accelerator proposal, they reached out for the brass ring.