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The Mirage of the World Accelerator for World Peace and the Origins of the SSC, 1953-1983

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The Mirage of the World Accelerator for World Peace and the Origins of the SSC, 1953-1983[1]

Adrienne Kolb and Lillian Hoddeson

The history of the ICFA/VBA machine in relation to the SSC is the story of a deserted vision of a world laboratory. What lessons does it offer for high-energy physics beyond the SSC?

In the mid-1950s, in the period of global anxiety following World War II, a group of internationalist physicists conceived an optimistic vision of a world-wide collaborative particle accelerator, later nicknamed the VBA, the "Very Big Accelerator." Too expensive for any one nation, this accelerator project was envisioned as a model for peaceful collaborative ventures among nations – a utopian *cooperative* image developed over three decades of negotiation by American, Asian, Western and Eastern European physicists and set in conspicuous relief against the backdrop of the icy Cold

[1]This article is based on research by the authors for what is presently conceived of as chapter 13 of a book in preparation with the other members of the Fermilab History Collaboration (Catherine Westfall, Mark Bodnarczuk, and Kyoung Paik) on Fermilab's history and the rise of big science. For critical comments on earlier drafts of this article, we are grateful to R. A. Carrigan, F. T. Cole, W. B. Fowler, E. L. Goldwasser, D. Jovanovic, L. M. Lederman, W. O. Lock, R. E. Marshak, J. R. Orr, W. Panofsky, J. Peoples, L. Pondrom, C. Quigg, and R. R. Wilson. We would also like to thank the Program in History and Philosophy of Science of the National Science Foundation for its generous support of our research (NSF Grant No. DIR - 90 15473) on the *History of Fermilab,* as a case study in the emergence of big science. The Government has certain rights in this material. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation. Fermi National Accelerator Laboratory (Fermilab) is operated by Universities Research Association, Inc. for the United States Department of Energy.

War. Carefully and creatively 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" (SSC) to the US Department of Energy, a machine resembling the VBA physically. Like the VBA, the SSC was pictured as a hadron collider to probe the frontier energy range of 20 on 20 TeV. But although the designs of both machines emerged from the same VBA technical workshops, these machines could hardly have differed more in their philosophy. The SSC, from its conception, was planned as a means by which America might regain its *competitive* international edge in basic physics research, and as a step toward high technology advances which would contribute to the nation's economic growth. The machine's chauvinist/nationalist definition occurred during the early years of the Reagan administration when economic recovery of the US was promised, in a period of reawakening in Washington, DC to the values placed on research and technology following World War II.

In this article, we examine the evolution of the VBA from the 1950s to the early 1980s and consider what brought the American physics community to propose the SSC in 1983. This study sheds light on present difficulties in raising international funding for the SSC. The perils of the SSC in the Congress, the criticism by many of the failure to have it built internationally, and the agonies of ICFA (International Committee for Future Accelerators) as to what comes after the SSC all point to a need to know the history. Why did the international ideas espoused by ICFA for the VBA fail? Will it ever be possible to have a world laboratory for basic research? More generally, these interrelated case histories highlight the tension between cooperation and competition as motivating goals in big science and the extent to which each thrives on the other. The account also offers insight into the role that long-term vision plays in the advancement of science, and the extent to which its realization can be affected by the political, social, and economic forces of the times. The history of the VBA in relation to the SSC is the story of a failed vision of a world laboratory. Are there lessons to be drawn from this poignant story for high-energy physics beyond the SSC?

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 (the European Organization for Nuclear Research), organizing from 1950 to 1954, served as a prototype for international cooperation in physics. In-roads toward Western European cosmic-ray collaborations with Soviet physicists were achieved in June 1955 at the International Conference on High-Energy Physics in Pisa.[2] Two months later, these contacts were extended to American physicists at the Geneva *Atoms for Peace* Conference,[3] one

[2]The Joint Institute for Nuclear Research (JINR) at Dubna became the Soviet Union's model for international collaboration in 1956. It was in Dubna, in 1956, that an overture in Soviet-US high-energy physics relations first occurred. On this occasion Luis Alvarez, Robert Marshak, Wolfgang Panofsky and Robert R. Wilson were members of a US delegation, hosted by Vladimir Veksler, visiting the new 10 GeV proton synchrotron at Dubna. W. Panofsky correspondence to A. Kolb, 29 March 1991.

[3]There is a wealth of background material on these fascinating developments. Chiefly we recommend: R. R. Wilson, "Toward a World Accelerator Laboratory," Fermilab TM-811, 16 August 1978; W. Owen Lock, "Origins and Early Years of the International Committee for Future Accelerators," Draft, December 1982; Robert E. Marshak, "Scientific and Sociological Contributions of the First Decade of the Rochester Conferences to the Restructuring of Particle Physics (1950-60)," in *Proceedings of the International Conference on the Restructuring of Physical Sciences in Europe and the United States, 1945-60,* (Singapore: World Scientific, 1989), 745-86; Marshak, "The Khruschev Détente and Emerging Internationalism in Particle Physics," *Physics Today 43:1,* January 1990, 34-42; A. Hermann, J. Krige, U. Mersits and D. Pestre, *History of CERN,* Vol. 1, (New York: Elsevier, 1987); 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: Pennsylvania State University Press, 1962), Richard G. Hewlett and Francis Duncan, *Atomic Shield, 1947-1952,* (University Park: Pennsylvania State University Press, 1969), and Richard G. Hewlett and Jack M.

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, allowed Americans to pursue cooperative exchange with other nations "in the peaceful uses of the atom in industry, agriculture, medicine, and research." 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 in 1957, the International Union of Pure and Applied Physics (IUPAP), stimulated by the Rochester Conference momentum for scientific exchange, established its Commission on High Energy Physics[4] to "encourage international collaboration among the various high energy laboratories to ensure the best use of the facilities of these large and expensive installations." As the acknowledged forerunner in accelerator physics, it was natural for American physicists to pursue this cooperative initiative in high energy physics, keeping the internationalist traditions of their field alive.

At the same time that these moves toward international cooperation were being taken, America embarked on a series of nationalist steps toward maintaining its position of scientific advantage in the world. For example, when in 1957 the USSR challenged the US with its successful *Sputnik* program, Eisenhower, advised by I. I. Rabi of Columbia to elevate the status of his scientific advisors, appointed the President's Science Advisory Committee and named James R. Killian, then President of MIT, as his full-time science advisor. Killian's introduction of a group of distinguished

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Holl, *Atoms for Peace and War, 1953-1961,* (Berkeley: University of California, 1989); and David Dickson, *The New Politics of Science,* (New York: Pantheon, 1984).

[4]The name was later changed to the Commission on Particles and Fields.See Robert E. Marshak, "Scientific and Sociological Contributions of the First Decade of the Rochester Conferences to the Restructuring of Particle Physics (1950-60)," in *Proceedings of the International Conference on the Restructuring of Physical Sciences in Europe and the United States, 1945-60,* (Singapore: World Scientific, 1989), 745-86.

scientists into the government process to expand the level of scientific advice offered directly to the President began the tradition of having scientists contribute regularly to the formation of US scientific policy.[5]

The novel idea of a "world accelerator for world peace"[6] was discussed in July 1959 in Kiev by the IUPAP Commission on Particles and Fields, meeting in conjunction with the International Conference on High-Energy Physics (Rochester Conference) to consider questions relating to international cooperation on particle accelerators.[7] They formed a Study Committee of American and East and West European scientists and continued their discussions when they 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 US Atomic Energy Commission. And on 24 November 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."[8]

In 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 11 May 1960, briefed "specifically to ex-

[5]Kevles, Daniel J., *The Physicists,* (Knopf: New York, 1977), 385; Golden, W. T., *Science and Technology Advice,* (Pergamon Press: New York, 1988); Killian, J. R., *Sputnik, Scientists, and Eisenhower,* (MIT: Cambridge, 1977).

[6]R. R. Wilson, "A World Laboratory and World Peace," *Physics Today,* November, 1975.

[7]Robert E. Marshak, "Scientific and Sociological Contributions of the First Decade of the Rochester Conferences to the Restructuring of Particle Physics (1950-60)," in *Proceedings of the International Conference on the Restructuring of Physical Sciences in Europe and the United States, 1945-60,* (Singapore: World Scientific, 1989), 745-86.

[8]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 November 1959, Fermilab History Collection (hereafter cited as FHC.)

plore the joint construction of a large accelerator." Unfortunately, the opportunity was lost when on 1 May, just prior to the visit, the Soviets shot down an unauthorized American U-2 reconnaissance plane over Russia. The US refused to apologize and relations turned hostile once again. Trust further diminished when the Paris summit meeting collapsed, shattering Eisenhower's hopes to resolve the Cold War.

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 30 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." One of the meeting's technical conclusions was that a 1000 GeV machine was feasible at a "bargain" cost of about $1 billion.[10] On 5 June 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, m eet informally and consider the international accelerator. This discussion led to projected cooperation between CERN, the US and the USSR, and identification of the best candidates to direct the effort.[11] Such international optimism and idealism were characteristic of the period that witnessed the election of John F. Kennedy.

Consideration of the super-energy world machine continued at numerous meetings of high-energy physicists – e.g., the 1961 Rochester Conference, the 1964 Vienna

[9] R. R. Wilson, "Toward a World Accelerator Laboratory," Fermilab TM-811, 16 August 1978.

[10] R. R. Wilson, "Ultrahigh-Energy Accelerators," *Science 133,* May 1961, 1602-7.

[11] John Adams was suggested as a possible director, with associate director support from A. Kolomensky of the Lebedev Institute and Robert Wilson of Cornell. This trio was so highly regarded that their success in the sensitive endeavor was assured. R. E. Marshak papers, 7 July 1961, AIP.

meeting, the Riga seminar in 1967, Semmering in 1968, Tbilisi in 1969, and Morges in 1971.[12] But during the Kennedy, Johnson, and Nixon administrations, escalating domestic pressures (relating, e.g., to civil rights, assassinations, poverty) and international and political issues (e.g., the Berlin Wall, the Cuban missile crisis, the strategic arms buildup, China) entangled with the ongoing Vietnam War kept the goal of building a world accelerator suspended.[13]

Scientific input to the White House declined in the late 60s and early 70s in an atmosphere calling for more emphasis on applying the scientific knowledge whose development had been supported by the government. National priorities focused on economically attainable objectives and in this period the 76 GeV proton accelerator at the IHEP in Serpukhov, the American 200-400 GeV NAL (National Accelerator Laboratory, renamed Fermi National Accelerator Laboratory, or Fermilab, in 1974), the CERN ISR (Intersecting Storage Rings), and the 300 GeV CERN SPS (Super Proton Synchrotron) were built. In cases where such 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 60s, in the 1970s NAL became acknowledged as the American standard by which to gauge cooperative efforts.[14]

A new window for discussing international cooperation opened in June 1973 as US President Richard Nixon and Soviet Party General Secretary Leonid Brezhnev signed

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[12] W. O. Lock, "Origins and Early Years of the International Committee for Future Accelerators," Draft, December 1982; R. R. Wilson, "Toward a World Accelerator Laboratory," Fermilab TM-811, 16 August 1978.

[13] In 1964 there was an attempt made for a joint accelerator construction collaboration between the Soviets, Western Europe and the US. It 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. This ideal was not realized in part due to the Soviet perception that supporting the international machine might prohibit their national program. W. Panofsky correspondence to A. Kolb, 29 March 1991 and 3 April 1991.

[14] R. R. Wilson, "Toward a World Accelerator Laboratory," Fermilab TM-811, 16 August 1978.

the historic accords addressing the 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 US and the USSR."[15] This remarkable pact was designed to help alleviate the critical economic and technological impact of the energy crisis of the time; OPEC (the Organization of Petroleum Exporting Countries) 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, and met again in October 1974, to address the implementation of programs for cooperation in research on the fundamental properties of matter. Meanwhile, other international developments improved the climate for such utopian 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 which affected 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 US 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 the unchecked inflation and recession which were affecting the nations' resources. Cooperation went hand-in-hand with political behavior.

THE VBA, 1975-80

[15] "Scientific and Technical Cooperation in the Field of Peaceful Uses of Atomic Energy," June 1973, FHC.

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 in the seminar had maintained their optimism while meeting to discuss the international collaboration. However by the mid-70s 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."[16]

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 and former director-general of CERN (in 1961-65) expressed his conviction that the meeting would be "an important contribution to international collaboration in our science." Participants were encouraged to look into types, size, cost, timing and arrangements for an inter-regional accelerator.

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."[17] Leon Lederman, then director of Columbia University's Nevis Laboratories, endorsed the plan, proclaiming in a position paper proposing a 5 TeV

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[16]W. O. Lock, "Origins and Early Years of the ICFA," Draft, December 1982; V. Weisskopf to R. P. Johnson, 13 December 1974, R. Johnson collection, FHC.

[17]R. R. Wilson, "A World organization for the future of high-energy physics," *Physics Today*, September 1984, pp. 9 and 112.

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."[18] He bestowed its name, the "Very Big Accelerator," or VBA.

Other proponents emphasized the potential contribution of the international accelerator to world-wide cooperation. For example, 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."[19] French IUPAP commission chairman Bernard Gregory, former director-general of CERN (from 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 potential 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 survival – a candle in the darkness." Weisskopf commented in the May 1976 issue of *Physics Today*, "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."

These were the years of the Watergate scandal and Nixon's resignation, the fall of

[18]Leon M.Lederman, "New Orleans – A Proposal," undated document, FHC.

[19]E. L. Goldwasser, "Normalization of Inter-Regional Cooperations and Communications," paper submitted to New Orleans Seminar, no date, FHC.

Saigon, and lines at the gasoline pumps, driving home the reality of energy shortages following intensified Arab-Israeli conflicts. Gerald Ford, appointed vice-president after Spiro Agnew's resignation, succeeded Nixon in 1974, and restored some national confidence in this ambiguous period. In 1975, the AEC was reorganized into ERDA (Energy Research and Development Administration) and the NRC (Nuclear Regulatory Commission); there would be further reshuffling as the Department of Energy emerged in October 1977 to address the myriad of energy issues confronting the world. Meanwhile, after Ford's defeat in November 1976 by political outsider Jimmy Carter, the Middle East conflict assumed a major significance. These transitions and fluctuations helped to sidetrack long-term planning.

But at their meeting in Serpukhov in May 1976, the international collaboration seminar participants actively 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.[20] 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, which was named the "International Committee on Future Accelerators," or ICFA.[21] ICFA was charged with organizing workshops and meetings to study both the VBA and future regional facilities and collaborations. Membership of the committee would be determined by a nominating body consisting of the chairman of HEPAP naming three US representatives, the chairman of CERN's Scientific Policy Council would nominate three Western Europeans to represent the

[20] J. D. Bjorken, "Physics Issues and the VBA," May 1976, FHC.

[21] The name was modified to the International Committee *for* Future Accelerators in early 1978. Goldwasser delivered a summary of the Serpukhov meeting, including its conclusions and recommendations, at the August 1978 Rochester Conference, E. L. Goldwasser, "Report on the Status and Plans of the International Committee on Future Accelerators," *Proceedings of the 19th International Conference on High Energy Physics*, (Tokyo: Physical Society of Japan, 1979), pp. 961-8; L. M. Lederman, "VBA," *IEEE Transactions on Nuclear Science, NS-24-3,* June 1977, 1903-8.

member-states of CERN, three Soviets would be nominated by the president of the Soviet Academy of Sciences, and one Japanese physicist and one physicist from the Dubna member states other than the Soviet Union would be named by the chairman of the IUPAP Commission on Particles and Fields, who would also serve as an ex officio member of the committee. (See figure for membership.)

When Lederman informed participants of the 1977 Particle Accelerator Conference in Chicago about the VBA, he underlined 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 as a potential site for the VBA. He pointed out (tongue in cheek) that many necessary facilities were already in place: for example, high-rise international headquarters, educational resources, pre-tunneled terrain, and the usual degree of inaccessibility.[22] (See figure for Lederman's New York City machine drawing, *Physics Today,* May 1977, 19-20.)

Further VBA planning took place at the first ICFA meeting, held on 29 August 1977 in Hamburg. After the sudden death in December 1977 of Gregory, who had thus far been coordinating activities as ICFA's first chairman, interim ICFA 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 as the new ICFA chairman.

The members planned a series of VBA technical workshops, the first held at Fermilab in October 1978, and 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.[23] The Les Diablerets meeting set the size and energy

[22] *Physics Today,* May 1977, 19-20.

[23] 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.

specifications of a 20 TeV on 20 TeV proton collider, specifications later adopted by the SSC.[24]

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 VBA dream to dissolve into the distance, as if a mirage. Scientific goals were difficult to fix, 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 S$\bar{p}p$S and planning for the LEP (Large Electron-Positron) Collider;[25] and PETRA (electron-positron accelerator-storage ring) at DESY (Deutsches Elektronen-Synchrotron) in Hamburg was also underway. The US 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.[26] Japan was designing KEK. Soviet and Eastern European facilities were emerging as serious competitors. Although all these facilities would eventu-

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Tollestrup, G. Trilling, W. Willis and Wilson were among those at the 1978 Fermilab workshop, which also provided stimulation for the linear collider project at SLAC. 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 US community.

[24]W. O. Lock, "Origins and Early Years of the ICFA," Draft, December 1982, and the Proceedings of the two ICFA Technical Workshops from 1978 and 1979, and the Proceedings of the 1983 20 Tev Hadron Collider Technical Workshop; see also R. Diebold, "The Desertron: Colliding Beams at 20 TeV," *Science 222,* 7 October 1983, 13-9 and *Superconducting Super Collider Reference Designs Study,* 8 May 1984, p. 3.

[25]LEP was conceived in 1976-77 to examine the 150-300 GeV center of mass energy range and was pursued until 1981 when it was approved by the CERN member states. *CERN 1977 Annual Report,* p. 12-3; "LEP authorization," *CERN Courier,* January-February 1982, 20; and "Large Hadron Collider workshop," *CERN Courier,* June 1984, 185-7.

[26]Fermilab had also explored the possibility of a machine with proton-electron collisions in the mid-70s: POPAE. Its design, 1000 GeV protons on 20 GeV electrons, was conceived by Tom Collins and Don Edwards with a 1976 design report by Richard Carrigan and Robert Diebold from Argonne as an inter-laboratory collaboration submitted to ERDA. See R. R. Wilson, "Colliding Beams at Fermilab," Fermilab TM-807, 11 August 1978. Paper submitted to the 1978 LBL Workshop on Cooling Antiprotons.

ally be exploited on an international basis (except for ISABELLE, which was not completed), they were built regionally or nationally.

President Ford reassured American physicists that their interests would be heard by reinstating the science advisor's office, thus providing scientists access for dialogue on science policy. Trust in the government during the Bicentennial temporarily improved earlier disillusionment with the political process. But the Carter administration's focus on applied research during the energy crisis in the late 1970s placed basic research on hold and reduced funding for accelerators; Wilson's resignation in 1978 as director of Fermilab was one result. Washington's difficulties with the economy, linked with the volatile flashpoints of the Middle East and Eastern Europe and the increasing energy shortages, called the direction of the nation into question. In high-energy physics, whereas the US had earlier provided indisputable world leadership, by the turn of the 80s driving innovation and imaginative answers were coming from Europe.[27]

THE AMERICAN INITIATIVE, 1980-82

An American movement to gain greater national commitment to advanced accelerator projects began late in 1979 when chairman of HEPAP (the High Energy Physics Advisory Panel to the DOE) Sidney Drell appointed several physicist subpanels to review the US high-energy program. He asked Sam Treiman of Princeton to coordinate a subpanel evaluating the US high-energy physics 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

[27]One example of the type of international scientific-cultural-political entanglement characteristic of this period was Soviet physicist Andrei Sakharov calling on Carter in 1977 to help the dissidents in the USSR and Eastern Europe. Sakharov enunciated human rights concerns, for which he had won the 1975 Nobel Peace Prize. The 1979 Soviet invasion of Afghanistan forced the US out of the 1980 Olympics and, along with Sakharov's 1980 exile to Gorky, stalled the third ICFA technical workshop on superconducting magnets until 1981.

transmitting their report to the DOE: without increased funding, he wrote, "the US program will inevitably lose its eminence," and its ability "to compete with Western Europe."[28]

By then many American physicists were voicing their concern about building new accelerators, partly in response to limited government funding, which they interpreted as a reduced national commitment to the long-term value of basic research. Inflation and higher costs were also seriously impeding research. Paradoxically, this unfavorable funding situation fueled new regional accelerator discussions.

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 US particle physics are to be met in the resource limited situation."[29] Tigner's subpanel saw a need for "continual and vigorous 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."[30]

Meanwhile, with a refined understanding of the Standard Model – the fundamental theory of particles and fields – many American physicists recognized that a far

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[28] *Report of the 1980 Subpanel on Review and Planning for the US High Energy Physics Program,* July 1980, Transmittal letter from Sidney D. Drell to Edward A. Frieman, 15 July 1980, 1-4, DOE/ER-0066.

[29] *Report of the Subpanel on Accelerator Research and Development of the High Energy Physics Advisory Panel,* June 1980, DOE/ER-0067, Transmittal letter, M. Tigner to S. Drell, 26 August 1980, iii.

[30] Ibid., i.

more powerful instrument was needed to investigate the emerging physics agenda and address 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 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), [$\sim 10^{-29}$ cm]. 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."[31] 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 at a lower energy.[32] At this point, the US physics program was being confronted by 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.[33] CERN's potential to confront the electron frontier with LEP, the Large Electron-Positron Collider, posed a direct challenge to the VBA planners as LEP would contend for the electron machine parameters ICFA had identified for a world cooperation effort.

The Reagan administration was in its first year 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,"[34]

[31] IEEE Trans on Nuc. Science, NS-28, 3, June 1981.

[32] ISABELLE was conceived in 1974 with up to 200 GeV protons in each beam, producing 60-400 GeV in the center of mass, but in 1977 ISABELLE was reconfigured 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.

[33] "CERN elects Schopper as director," *Physics Today*, June 1980, 84-5.

[34] Constance Holden, "Former Carolina Governor to Head DOE," *Science 211*, 6 February 1981,

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 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 1981 economic environment, 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, 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 that might make major increases in energy economically possible."[35] Tigner emphasized to the Conference the "dire necessity for America to fund new, economically efficient accelerating methods and technologies."[36]

Similarly, in June, Keyworth addressed the AAAS stating, "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."[37] 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

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[35]James E. Leiss, "Relevance of Accelerator/Storage Ring Technological Developments to USA Science and Technology – Past, Present, and Future," *IEEE Transactions on Nuclear Science NS-28, 3*, June 1981, 3553-5 and "Impact of Accelerators on Science and Technology," *Physics Today 34*, July 1981, 70-2.

[36]M. Tigner, "Accelerator R/D in the US High Energy Physics Program - Past, Present and Future," in *IEEE Transactions on Nuclear Science NS-28*, June 1981, 3549-52.

[37]"Keyworth Says US Can't Be Tops in all R&D," *Science and Government Report XI: 12*, 15 July 1981, 8.

to demonstrate a successful national economic investment. Projects to keep America strong and competitive without risk were a priority.

Keyworth's practical research orientation was linked with that of his Los Alamos mentor, Edward Teller. Teller at this time was advising Reagan to develop the Strategic Defense Initiative (SDI), which the media called "Star Wars," after the popular Hollywood film trilogy (1977-83) portraying a tale of good versus evil in the universe and employing spectacular prospective offensive and defensive technologies in battles in space. In a later speech to the National Association of Evangelicals, in March 1983, Reagan inflamed international tensions by calling the Soviet Union an "evil empire," borrowing language from the film series. Relations between the US and the USSR became as difficult as in the 60s. The defense budget doubled in the 1980s as a priority of the Reagan administration and, in conjunction with this, basic research funding increased, although inflation, recession, and the growing costs of research and technology made the increased amounts barely effective.

By this time ISABELLE, having suffered serious delays due to magnet failures and organization problems, had become a major concern to the high energy physicists. Although by 1981 this project was showing strong signs of improvement, both in its management and magnet development, the 1981 HEPAP subpanel on long-range planning, chaired by George Trilling of Lawrence Berkeley Laboratory, was concerned by the machine's high cost and insufficient design energy.

The subpanel prepared an interim report in November 1981 offering two funding scenarios. In the first, ISABELLE would be completed by 1990, along with other high priority projects. In the second, should it not be possible to arrange support for high-energy physics at the level of $440 million per year, beginning in the 1982 fiscal year, ISABELLE would be cancelled. By questioning the continuation of ISABELLE, this interim report set in motion the machine's eventual denouement.

The subpanel's final report, issued in January 1982, referred specifically to ICFA's preliminary work on a "world-wide super-accelerator project," recognizing this work as advantageous and worthwhile. Although it supported ICFA's efforts, the subpanel did "not recommend the commitment of significant US resources to the ICFA project at the present stage of international collaboration," believing that to be premature until all opportunities for "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 APS Division of Particles and Fields make "a larger effort in the planning area." This effort included "sponsorship of appropriate workshops...and increased scheduling at its meetings of invited talks in areas relevant to future planning."[38]

The recommendations for support at the highest level were then strongly endorsed by HEPAP on 19-20 February 1982. If support at this level could not be forthcoming, HEPAP concluded that ISABELLE must be discontinued. But toward maintenance of a vigorous high-energy program in the 1980s, they recommended "another major facility must 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 exploring new frontiers." SLC (SLAC Linear Collider) was recognized as "an example of the type of relatively large R&D project which is now necessary," and 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, were identified as the "highest immediate priority." These recommendations were made just as the Department of Energy was in a preliminary approach toward dismantlement, a process threatened but never accomplished.

[38] *Report of the Subpanel on Long Range Planning for the US High Energy Physics Program of the High Energy Physics Advisory Panel,* January 1982, DOE/ER-0128, 46-60.

While the US was thus vacillating over the most prudent ways to distribute its research dollars, CERN advanced scientifically, with vision and the focus on its mission. The initial operation of CERN's $\bar{p}p$ hadron collider, 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 and Z particles.[39]

Meanwhile plans for the international accelerator also continued. In 1979 the Fermilab Program Advisory Committee, reporting to its new director, Lederman, had recommended guidelines for the participation of non-US groups in Fermilab's experiments. ICFA incorporated these into its thorough guidelines for inter-regional utilization of facilities and they were adopted for use in the major laboratory programs of the world by 1981,[40] when ICFA was forming plans for long-term advanced accelerator research and development.[41] By 1981-82 ICFA chairman John Adams had prepared a draft of an agreement defining the organization of the VBA,[42] but funding and administrative problems were delaying progress.

THE SNOWMASS DESERTRON, 1982

In this context, American particle physicists gathered at Snowmass, Colorado in July 1982, at the first of the APS Division of Particles and Fields major workshops recommended by the Trilling subpanel, a summer study organized by DPF/APS

[39]Their breakthrough would also spark the 1981-82 revision of the Tevatron-I project to develop Fermilab's antiproton source for its colliding beams program.

[40]T. H. Groves, "Physics Advisory Committee Summer Meeting," *Fermilab Report*, July 1979, p.8 and L. M. Lederman, "International Committee on Future Accelerators," *Fermilab Report*, July 1980, p.6.

[41]US representation in ICFA was then in flux; Wilson's term expired in December 1981, Lederman's term would expire in December 1982, Burton Richter had succeeded Weisskopf in 1978, and Boyce McDaniel succeeded Wilson in 1982. Goldwasser's term as IUPAP chairman expired in 1981.

[42]J. B. Adams, "Framework of the Construction and Use of an International High-Energy Accelerator Complex," 11 February 1981, deliberated at ICFA meeting, 21 October 1981, held at Serpukhov, see Minutes of the Sixth ICFA Meeting, Draft, 5 November 1981, and Minutes of the Seventh ICFA Meeting, held in Paris on 27-28 July 1982, Draft, 2 September 1982, FHC.

Chairman Charles Baltay of Columbia University. At this critical meeting, Lederman rallied the American physics community into action with his convincing proposal of the "Desertron." He pictured this "Machine-in-the-Desert" as an oasis in the barren desert between the weak energy scale (less than one TeV) and the unifying energy realm ($\sim 10^{14}$ GeV) described by the Grand Unification theory.

Still holding on to the romantic dream of an international collaborative accelerator, Lederman filled out the scenario with caravans of high-energy physics 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 of his kindred spirit Wilson, who said, "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."[43]

However Lederman's *will-o'-the-wisp* world accelerator for world peace had a decided American character. Instead of an accelerator in space, as Enrico Fermi had dreamed in 1954, this cooperative application of the peaceful atom could occupy an expanse 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.

Hoping to awaken the US physics community to the magnitude of 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

[43]R. R. Wilson, "Particles, Accelerators, and Society," *American Journal of Physics 36:6,* June 1968, 490-5.

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 worked up a long-range plan he termed "Slermihaven II," a pun suggesting the best of SLAC, Fermilab and Brookhaven contributing to a new laboratory that would begin exploration of $\bar{p}p$ collisions at 20 TeV 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."[44]

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."[45] 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." A bold and dramatic response was essential to put the US 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.

The enthusiasm generated at Snowmass then acted as a catalyst to energize the American high-energy physics community, which soon began to develop the Desertron concept technically, thus drawing benefit from the opportunity sensed in the air. Dur-

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[44]L. M. Lederman, "Fermilab and the Future of HEP," *Proceedings of the 1982 DPF Summer Study on Elementary Particle Physics and Future Facilities*, eds. R. Donaldson, R. Gustafson, and F. Paige, (DPF/APS), 125-7.

[45]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*, September 1981, 283-8.

ing the winter of 1982-83, Lederman began to plan an early 1983 Fermilab Workshop 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 holding the meeting in a neutral, more politically palatable setting, Cornell. Meanwhile in January 1983, CERN announced its discovery of the $W^{\pm}$, and Schopper spoke at KEK in Japan about his next plan: to install a 20 TeV hadron collider in the LEP tunnel. CERN's vantage point 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 on the capabilities and possibilities of collider detectors. The salient issue of competing while still cooperating was addressed by organizing chairman Al Mann of Pennsylvania. "Escalating costs of construction and operation of our facilities limit alternatives and force us to make hard choices...The necessity to be highly selective in the choice of facilities, in conjunction with the need for increased manpower concentrations to build accelerators and mount experiments, leads to complex social problems within the science. As the frontier is removed ever further, serious technical difficulties and limitations arise. Finally, 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 were driven by the physics needs and in accommodating the required diplomatic protocol they first had to reach a consensus and then equip a new HEPAP subpanel with the strategy to take to Washington.[46]

Tigner hosted the 20 TeV Hadron Collider Technical Workshop at Cornell, in

[46]Proceedings in FHC.

late March and early April 1983. The meeting focused on establishing costs and technical designs for the Desertron. No obvious technical problems were foreseen. Since CERN had already demonstrated the $\bar{p}p$ hadron collider technique, 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 simply 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 cost at about $2.7 billion (1983 dollars), with construction by 1987. (This estimate excluded detectors, equipment, contingency costs and pre-operating expenses.)[47]

On 18 March 1983, the last superconducting magnet was installed in the Energy Doubler, and by May, successful cooling to liquid helium temperatures had been achieved indicating that the Doubler was ready to work. This superconducting technology implied reduced costs and a more habitable site for the Desertron – afterall it might be a "Prairietron".[48]

As a result of the Cornell meeting and the Doubler achievement, HEPAP – with Keyworth's encouragement – 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.

THE SSC PROPOSAL, 1983

In February 1983, a new HEPAP subpanel had been formed under Stanley Woj-

[47] M. Tigner, *Report of the 20 TeV Hadron Collider Workshop*, (Ithaca: Cornell University, 1983), 1-4 and 52-9.

[48] D. Jovanovic logbook, 23 April 1983, FHC.

cicki to offer advice on new facilities, to estimate funding, and to rank priorities for a forefront US HEP program for the next five to ten years. In particular, the subpanel was to assess ISABELLE, by now treading water as the CBA (Colliding Beams Accelerator). The crucial factors operating at this critical moment included 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; the Z would follow in June. The fact that Europe seemed to be overtaking the US in making exciting physics discoveries gave Americans an intense desire to respond with something boldly innovative. At the same time, theory was dictating the need to explore the 1 TeV energy scale. For proton colliders this implied at least 10 TeV per beam. ISABELLE however was designed with only 0.4 TeV per beam. In a period in which Washington was emphasizing the need for America to regain scientific leadership for economic competitiveness, it was apparent to some American physicists that the VBA, although useful in formulating the 20 TeV concept, had little prospect of materializing in the forseeable future. Fermilab's Doubler demonstration of superconducting magnets working in an accelerator then 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. As the American economy showed signs of recovering from its recession, superconductivity was economically viable, so the new national collider appeared affordable. Paradoxically, by causing scientific strength to languish, inadequate financial support had actually helped to stimulate the new initiative.

The other ICFA members were suddenly surprised when HEPAP gave the official imprimatur to the American 20 on 20 TeV Superconducting Super Collider, in their July 1983 report of the Wojcicki subpanel.[49] The subpanel had met in June and July

[49]The European and Japanese members of ICFA viewed the Woods Hole recommendation for the

at Woods Hole and at Nevis.[50] The report recommended: 1) building the SSC – a recommendation on which the subpanel was unanimous, 2) completing the Tevatron and SLC as well as upgrading CESR (Cornell Electron Storage Ring), 3) not approving Fermilab's Dedicated Collider, 4) stopping CBA – on this the panel was not unanimous, and 5) strongly supporting technology R & D, particularly advanced accelerator technology. The subpanel described the SSC as roughly 30 kilometers in diameter, with 10-20 TeV protons in each of its two colliding beams and the machine's cost of less than $2 billion (1983) spread over twelve years. HEPAP Chairman Jack Sandweiss's 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," which implied that "unit costs are therefore well known. This technology is now of age."[51] Keyworth supported the plan saying, "...the nation – or group of nations – that builds the Superconducting Super Collider will become the new world center in high-energy physics."[52] With DOE's subsequent acceptance of the recommendations, Congress reprogrammed some of the ISABELLE funding for SSC planning.

SSC as an obstacle to their future international plans. B. Richter, Memorandum to Ralph DeVries and Wallace Kornack, 1 September 1983, p.2.

[50] John Adams and Carlo Rubbia were the international members of this subpanel.

[51] *Report of the 1983 HEPAP Subpanel on New Facilities for the U.S. High Energy Physics Program*, U. S. Department of Energy (DOE, Office of Energy Research Division of High Energy Physics, July 1983), pp. i, pp. vii-viii, 5-6.

[52] K. McDonald, "Gigantic Particle Accelerator Will Have No Modern Rival – If It's Built," *The Chronicle of Higher Education XXXI: 7*, 16 October 1985, 1, 10-11.

Those who had invested in ISABELLE were greatly disappointed. The irony was that by this time ISABELLE's technical problems had been solved. But the Wojcicki panel felt that in view of present particle physics needs and the success of CERN's half-TeV collider, the CBA's energy was too low to justify continuance.[53] Diverting funds and personnel to CBA would also delay the SSC, a machine with fifty times the energy of CBA, which they judged as necessary for the "next logical step" in the US program.

The HEPAP recommendations also disenchanted other regional representatives of ICFA, who felt that the US had co-opted the VBA. 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"[54] When the American members responded that the envisioned SSC would in fact be an international center, sited within the US while attracting large foreign contributions of manpower and scientific research and technological as well as financial resources,[55] and not simply the patriotic project the

[53]Gloria B. Lubkin, "Panel says: Go for a multi-TeV collider and stop Isabelle," *Physics Today*, September 1983, 17-20.

[54]B. Richter, Memorandum to Ralph DeVries and Wallace Kornack, 1 September 1983, p.2.

[55]There had been the hope that the complementary SSC could indeed become international without burdening the US program. See "Future Accelerators Seminar in Japan," *CERN Courier*, October 1984, 319-22. However it is difficult for nations to pursue and financially support the construction of a facility within the country of a competitor. HERA (*Hadron Elektron Ring Anlage* at DESY) was 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, 205-6 and "Big projects in Federal Republic of Germany," *CERN Courier*, June 1981, 210-1. When a location in the FRG was proposed for the site of a second laboratory, distinct from the Meyrin location and providing a base for the SPS in 1967, then known as the 300 GeV project (in competition with Wilson's 200 to 400 GeV NAL machine), the United Kingdom decided not to participate in the project. The CERN Council amended the CERN Convention to allow this change. Even in late 1968, when John Adams was chosen to direct the SPS, the UK would not support the new plan. As the UK was second only to Germany in providing support to the budget of CERN, 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 guanteeing the continuation of CERN in its original location. See *CERN Courier 8*, 56-8, 123-4, 235-6, 308-10 and *CERN Courier 10*, 107-11, 146-7, 174-8, 277-8, 307-9, 375-8. Following the 1982 Versailles Summit, the Williamsburg Summit discussions in June

Reagan administration proclaimed, this argument was disparate to the other regions, who clearly recognized their loss of economic and political voice in the machine. The Americans also emphasized that the ICFA VBA had been conceived as a machine too costly for any one region. Since America appeared able alone to afford the projected cost of the SSC, this machine was, by definition, not the VBA. From this American perspective the US was not co-opting the VBA, but only preempting it as a proton machine and creating the opportunity for a later, internationally-funded machine, just as CERN had pushed back the energy frontier for electron machines when it decided on the LEP project in 1980-81.[56] Then too, the notion was broached that a single-nation host for an internationally constructed machine would be a step toward the world accelerator that some future environment would encourage.

However, the representatives of the other ICFA regions did not accept this American rationale. They felt that they had not been informed of this change in American direction. They recalled that in its earliest phase the SSC was based on VBA design work – the machines were technically joined. They were also joined sociologically, for some of the same physicists who pioneered the SSC, had helped conceive the VBA, as the machine that would bring particle physics into its next phase. In time the disappointment subsided, but it has not yet vanished. It reappears and echoes in present efforts to attain international participation in the SSC.

DOE accepted the HEPAP recommendation, although it raised the possibility of

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1983 included renewed pursuit of international cooperation through high-energy physics. This was followed by action at the London Economic Summit in May 1984 forming the Summit Working Group on high-energy physics led by Trivelpiece. See David Dickson, "Scientific Cooperation Endorsed at Summit," *Science 220*, 17 June 1983, 1252-3; Irwin Goodwin, "DOE answers to Congress as it officially kills Brookhaven CBA," *Physics Today*, December 1983, 41-3; David Dickson, "Political Push for Scientific Cooperation," *Science 224*, 22 June 1984, 1317-9 and M. Mitchell Waldrop, "The Supercollider, 1 Year Later," *Science 225*, 3 August 1984, 490-1.

[56]R. R. Wilson, "The Next Generation of Particle Accelerators," *Scientific American 242:1*, January 1980, 42-57 and Y. Yamaguchi, "ICFA - Its History and Current Activities," *Proceedings of the 1985 International Symposium on Lepton and Photon Interactions at High Energies*, (Kyoto: Nissha, 1986), 826-47.

difficulty fitting into DOE director of High Energy Physics William Wallenmeyer's plan of maintaining a mutually supportive relationship in high-energy physics among its coalition of 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 9 January 1984.

CONCLUSION

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, with competition sometimes driving the scientific agenda for large projects and cooperation essential in realizing them. Did CERN's pioneering work from 1978-83 yield discovery in response to earlier American dominance of the field?[57] This case study indicates that the forces of CERN's scientific successes and the diminished status of science in America by the early 80s worked in tandem with global political events to motivate the improvement of US funding and begin this major project.

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

[57] The CERN historians support this argument for the 1960s. A. Hermann, J. Krige, U. Mersits and D. Pestre, with L. Weiss, **History of CERN. Volume II, Building and Running the Laboratory** (Amsterdam, North Holland, 1990), e.g., p. 795.

potential to form a real world 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 and by recommending increased funding for high-energy accelerator technology in general.

The VBA and SSC, based on conflicting ideologies of international cooperation and national or regional competition, respectively, were in 1983 tugging at opposite ends of one rope comprised of limited resources and personnel in a context in which national competitiveness took priority. When national politics and the economic climate made it seem possible for American physicists to fulfill their idyllic dream for scientific progress through an American accelerator proposal, they reached out for the brass ring.

Like ISABELLE, which was discontinued largely because its schedule was delayed, the VBA faded because the ponderous international network grew so time consuming that it was repeatedly overtaken by competing regional projects. While in the 1960s and 70s, an international collaborative accelerator had appealed to idealist high-energy physicists, partly because its costs appeared too great to achieve otherwise, when technological breakthroughs and more optimistic political and economic conditions in 1983 helped make the cost seem regionally affordable, competition and regional loyalties promised more rapid scientific progress. The Americans saw the SSC as their next move. In the tradition of regional interchanges between competitors making scientific discoveries, America hoped to take advantage of its superconducting magnet technology innovations. Although hopes for world cooperation had provided "a candle in the darkness" during the Cold War years, the mirage of the utopian world collaboration had all but vanished by the middle of 1983 for American physicists, leaving within reach a regional project responsive to the forces operating on high-energy physics: a high technology project promising America's revival as an aggressive international competitor in the power-charged Reagan world.

ICFA is presently reconsidering the prospects of its role as facilitator for future world collaborations. Will the need for pooling resources allowing scientific advances prevail over the reluctance to tackle the associated awesome bureaucratic problems? Is is possible that some more successful approach for world collaboration will inspire physicists and world leaders to suspend their short term interests and join one another to overcome the obstacles of a global venture toward a world laboratory?