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The politics of big science in the Cold War: PSAC and the funding of SLAC

WHEN THE SOVIET Union launched the world's first artificial satellite, Sputnik, in 1957, the feat did more than propel the world into the space age. It also marked the beginning of a "total Cold War" in which science, technology, education, and the pursuit of national prestige ranked with military and economic strength as vital forces in the struggle between the Soviet-dominated East and the US-led West. The new prominence of American science found clear expression in two highly-publicized measures President Dwight Eisenhower undertook in response to Sputnik. He first appointed MIT president James Killian as his science advisor and brought a group of American scientists into the White House as the President's Science Advisory Committee (PSAC) to help the government make science and defense policy.[1] Then, on May 14, 1959, he announced dramatically at a high-profile "Symposium on Basic Research" in New York that he had decided, at his science advisors' recommendation, to ask the Congress to

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The following abbreviations are used: AEC, Atomic Energy Commission; BOB, Bureau of the Budget; DOD, Department of Defense; GAC, General Advisory Committee; JCAE, Joint Committee on Atomic Energy; KP, James Killian Papers, MIT Archives, Cambridge, MA; MURA, Midwestern Universities Research Association; NSF, National Science Foundation; ONR, Office of Naval Research; OSAST, Office of the Special Assistant for Science and Technology, White House Office collection, Eisenhower Library, Abilene, KS; PSAC, President's Science Advisory Committee; SLAC, Stanford Linear Accelerator Center; SSC, Superconducting Super Collider. WP/M, Wolfgang Panofsky papers, binder "Project M," in SLAC archives, Stanford, CA.

1. For the origin and early history of PSAC, see Zuoyue Wang, "American science and the Cold War: The rise of the US President's Science Advisory Committee" (unpublished PhD dissertation, University of California, Santa Barbara, 1994); Robert A. Divine, *The Sputnik challenge: Eisenhower's response to the Soviet satellite* (New York, 1993).

appropriate $100 million to build the largest scientific instrument in history, a two-mile long linear electron accelerator at Stanford University as a demonstration of American determination to excel in science in the aftermath of Sputnik.[2]

Both of Eisenhower's steps marked new milestones in the politics of American science during the Cold War. The appointment of the science advisor and PSAC for the first time brought about a formal channel between science and government at the highest level during peacetime. SLAC (Stanford Linear Accelerator Center), as the electron accelerator eventually became known, became one of the earliest Big Science projects to get entangled in national and international politics. Despite the rare show of presidential endorsement and PSAC's strong support, SLAC's path in Washington was not smooth either before or after Eisenhower's speech. The SLAC debate and PSAC's involvement in the controversy raised persistent questions about American science policy. These issues included, above all, why and how the government and society should fund intriguing but expensive and hardly useful research, what the role of scientific advisors in science policy-making should be, and, more generally, how American science and government should structure their relations.

Although several excellent studies touch on the history of SLAC and PSAC, neither has received a full-length treatment or a close examination of their interaction with the aid of archival materials.[3] Recently, the historiographical debate over American science in the Cold War has given the episode an added interest. In their pathbreaking studies of the political economy of American physics in the 1950s, Paul Forman and Daniel Kevles reach two radically different perspectives on the relationship between American scientists and the national security state. While Forman argues that American physicists enjoyed only "the illusion of autonomy" in pursuing basic research under military sponsorship and that they were "far more used *by* rather than using American society," Kevles believes that the integration of physics into the national security system actually represented a diversification of the field welcomed by a majority of

2. Dwight D. Eisenhower, "Science: Handmaiden of freedom," in Dael Wolfle, ed., *Symposium on basic research* (Washington, DC, 1959), 133–142, on 140–141; James R. Killian, Jr., *Sputnik, scientists and Eisenhower: A memoir of the first special assistant to the President for science and technology* (Cambridge, 1977), 220–221; David Z. Beckler to Killian, 27 Feb 1959, (KP, 80–8: 10).

3. The best accounts of the funding of SLAC to date are Peter Galison, Bruce Hevly, and Rebecca Lowen,"Controlling the monster: Stanford and the growth of physics research, 1935–1962," in Galison and Hevly, eds., *Big science: The growth of large-scale research* (Stanford, 1992), 46–77, and Daniel S. Greenberg, *The politics of pure science: An inquiry into the relationship between science and government in the United States* (New York, 1967), 209–245.

physicists who were not at all unhappy about their contributions to the national security state, especially after the start of the Korean War.[4] Their analyses mainly focus on the period before 1957, leaving the immense impact of Sputnik largely unaddressed. This study of SLAC and PSAC, based largely on recently opened archives, is intended as a contribution to this debate.

The origin of SLAC

Because electrons radiate large amounts of energy when accelerated in circular orbits, the cyclotron is not the machine of choice to bring them to high energy. To solve this problem, Stanford physicist W.W. Hansen and his colleagues developed the linear electron accelerator. By the mid-1950s, Stanford had built four such machines in the Mark series, all under the sponsorship of the Office of Naval Research (ONR). Robert Hofstadter, another Stanford physicist, who used Mark III to study electron-scattering in the early 1950s, won a Nobel prize in physics in 1961.[5]

The success of the Mark accelerators inspired Stanford physicists, under Edward L. Ginzton and Wolfgang "Pief' Panofsky, to devise a bigger machine. They called it "Project M," with "M" standing for both "multi-Bev" (billion-electron-volt) and "monster." After lengthy preliminary studies and continuous consultation with representatives of the Atomic Energy Commission (AEC), the Department of Defense (DOD), and the National Science Foundation (NSF) in Washington, Stanford sent, in April 1957, a proposal to build a two-mile-long linear accelerator to all three agencies. As Ginzton and Panofsky told Stanford president J.E.W. Sterling, the agency representatives had recommended this pluralistic approach because "at present no specific policy defines which would be the most appropriate source of funds."[6] The cost was then estimated at $78 million for construction and an annual $14 million for operating expenses following

4. Paul Forman, "Behind quantum electronics: National security as basis for physical research in the United States, 1940–1960," *HSPS, 18:1* (1987), 149–229; Daniel J. Kevles, "Cold war and hot physics: Science, security, and the American state, 1945–56," *HSPS, 20:2* (1990), 239–264.

5. Galison and Hevly, eds. (ref. 3), Stuart W. Leslie, "Playing the education game to win: The military and interdisciplinary research at Stanford," *HSPS, 18:1* (1987), 55–88, and Leslie, *The Cold War and American science: The military-industrial complex at MIT and Stanford* (New York, 1993), chapt. 6.

6. Ginzton and Panofsky to Sterling, 31 Jan 1957; Sterling to Alan T. Waterman of the NSF (and to Orr E. Reynolds of the DOD and Willard F. Libby of the AEC), 16 Apr 1957, all in WP/M. See also Panofsky, "The evolution of SLAC," *Physics today, 36* (Oct 1983), 34–41, and D.W. Dupen, "History and development," in R.B. Neal, ed., *The Stanford two-mile accelerator* (New York, 1968), 27–38.

completion. The proposal described the machine as "a very powerful instrument" needed in high energy physics and offered to make it "a national facility," available to qualified scientists from any institution.[7]

The proposal contained little to justify public funding of so huge a scientific project other than its unique value to high energy physics. Apparently, Stanford scientists took for granted that the government would support large-scale particle accelerators for their own sake. SLAC was just another machine in a long line of federally funded accelerators. By 1954, the AEC was planning to fund large accelerators at the rate of one per year.[8] The momentum in federal funding reinforced the physicists' tendency to concentrate on the intrinsic aspects of basic research. When they did occasionally promise technological applications, it was at best indirect.[9]

Cold War and turf battles

The physicists' apparent disregard, or lack of broad rationalization, for their claim to public funds did not, of course, extend to government agencies. The AEC, for example, had to justify its ever costlier high energy physics program to the powerful congressional Joint Committee on Atomic Energy (JCAE). Although the AEC Act of 1946 authorized it to conduct research and development on nuclear processes, the agency, under the chairmanship of Lewis Strauss, always charged such spending to the Cold War. Advances in the field helped show American superiority in science and its intention to use "Atoms for Peace." To keep the U.S. ahead of the Soviets in accelerator energy level, the AEC decided in 1956 to build a large accelerator at its Argonne laboratory near Chicago.[10] For similar reasons, the Soviets also pursued a crash program in accelerator development.[11]

In addition to Cold War competition, inter-agency rivalry also played an important role in American policy on high energy physics that has not received sufficient attention by historians. In the immediate post-war years,

7. Stanford University, "Proposal for a two-mile linear electron-accelerator," Apr 1957, in US Congress, Joint Committee on Atomic Energy, *Stanford linear electron accelerator* (USGPO, 1959), 283–526, esp. 288–289, 309.

8. Galison and Hevly, eds. (ref. 3), 46–78, on 65.

9. See, e.g., "Proposal for a program of nuclear physics and elementary particle studies at the California Institute of Technology involving the construction and use of a 1 Bev electron synchrotron," 15 Nov 1949, in Collection of the Caltech Synchrotron Laboratory, 1:1, Caltech Archives, Pasadena, Ca.

10. Richard Hewlett and Jack M. Holl, *Atoms for peace and war, 1953–1961: Eisenhower and the Atomic Energy Commission* (Berkeley, 1989), 257–260.

11. Panofsky to Frederick Terman, 11 Oct 1957, and enclosure, in WP/M.

the ONR monopolized government funding in nuclear physics, as in much of the rest of science; the Mark accelerators at Stanford are an example.[12] Starting in the late 1940s, the AEC began to compete and soon overtook the ONR in high energy physics, sponsoring several major accelerators at its own national laboratories. By the mid-1950s, the AEC dominated the field.[13] The AEC's hegemony drew resentment not only from the ONR, but also from the aspiring NSF, although it was seriously handicapped by its small budget.[14] The AEC also faced criticism from scientists for its micromanagement style and excessive red tape.[15] Thus, although the Stanford group was willing to accept funding from any of the three agencies, privately they preferred the ONR, which tended to give universities more autonomy.[16] Nevertheless, neither Stanford nor the ONR could make a move without the AEC's blessing. For its part, the AEC did not like to see its current monopoly broken, but neither did it want to undertake the project until assurance came from the White House that funding such an expensive accelerator would not hurt its other programs.[17]

The AEC limited new accelerators to its existing national laboratories. The policy was challenged not only by Stanford, but also by several other universities, which were represented by the Midwestern Universities Research Association (MURA). MURA clashed with the AEC's Argonne Laboratory in Chicago over management policy and tried for several years to get government funding for a huge proton accelerator of its own. The association, however, drew criticism from both science administrators and fellow scientists for using governors and congressional delegates from its states to lobby for it in the White House and in Congress.[18] Thus, by late 1957, the decision over the Stanford accelerator involved not only interagency entanglement but also competition from MURA. The matter stood at "dead center" and became one of the most pressing issues in science policy to be decided at the presidential level.[19]

12. Harvey M. Sapolsky, *Science and the Navy: The history of the Office of Naval Research* (Princeton, 1990), chapt. 3.

13. See the table of annual expenditure on high energy physics by government agencies in JCAE (ref. 7), 536.

14. J. Merton England, *A patron for pure science: The National Science Foundation's formative years. 1945–57* (Washington, D.C., 1982), 292–297.

15. F.V.L. Pindar, "Pindar and O'Neill trip to contracting agencies in the East—October 1957," undated, on p. 11; R.H. Moulton and Pindar to Terman et al., 16 Jul 1958; in WP/M.

16. Panofsky to Terman et al., 3 Apr 1959, in WP/M.

17. Panofsky, "Report on discussions concerning Project M held during my trip to Washington, 21–27 Jan 58," 28 Jan 1958, in WP/M.

18. Hewlett and Holl (ref. 10), 258-6; Greenberg (note 3), chapt. 10.

19. Fisk to Killian, 19 Dec 1957, in Robert Lester, ed., *The papers of the President's Science Advisory Committee, 1957–1961*, microfilm (Frederick, MD, 1986), reel 3, 974.

Shortly after Sputnik's launch and the establishment of the new science advisory system, high energy physics drew Eisenhower's attention. When considering the DOD's budget, he spotted an item on the construction of accelerators. Eisenhower questioned the role of the military in such basic research and asked Killian to examine the matter. Killian took the opportunity to initiate a general review of big accelerators, in the hope of reaching a consensus among AEC, DOD, and NSF. James Fisk, director of research at Bell Labs (and before that, at the AEC) and vice-chairman of PSAC, undertook the job for Killian and PSAC.[20]

Fisk soon focused on the Stanford proposal and strongly recommended it for government support on both its merits and its role in raising national prestige. The Stanford accelerator, Fisk found, enjoyed "enthusiastic endorsement" of the scientific community, was "thoroughly sound," both scientifically and technically, and was critical to American leadership in the field. In contrast, the MURA proposal, though supported by Frederick Seitz of the University of Illinois and T. Keith Glennan of Case Institute of Technology, appeared to Fisk "somewhat more daring and somewhat more speculative, but less advanced." Fisk proposed joint support of the Stanford accelerator by DOD, AEC, and NSF, arguing that the accelerator transcended the interests and present financial capabilities of any single government agency. Either of the first two agencies would administer the contract, he added, while any of the three could handle the operations of the accelerator once completed.[21] At its meeting on January 2, 1958, the full PSAC endorsed Fisk's proposal, which Killian transmitted to the relevant agencies.[22]

Reactions to Fisk's proposal were mixed. While DOD and NSF welcomed it, AEC vacillated between passive consent and active opposition to the joint funding plan.[23] Without the AEC's cooperation, ONR and NSF could hardly afford to fund the machine on their own, despite the NSF's new-found wealth in the wake of Sputnik.[24] Furthermore, all three agencies

20. Killian to Donald Quarles, 10 Jan 1958, in OSAST, I, box 11, folder "High Energy Physics;" Fisk to Killian, 9 Dec 1957 (ref. 19).

21. Fisk to Killian, 2 Mar 1958, and attachment, Science Advisory Committee, "Very high energy accelerators," undated; Frederick Seitz to Fisk, 27 Jan 1958; T. Keith Glennan to Killian, 28 Jan 1958; all in OSAST (ref. 20).

22. Actions taken at Science Advisory Committee meeting, January 2-3 1958," in Lester (ref. 20), reel 3, on 195; Killian to Strauss, 10 Jan 1958, and Killian to Donald Quarles, same date, both in OSAST (ref. 20).

23. Panofsky to files, 12 Dec 1957, in WP/M. The DOD's eagerness to run the project on behalf of all three agencies is expressed in Paul D. Foote, assistant secretary of defense for research and engineering, to Killian, 27 Jan 1958, and attached, in OSAST (ref. 20).

24. Panofsky to files, 12 Dec 1957; Terman, "Report on discussion on Project M held in Washington December 19, 1957," undated; Panofsky to files, "Visit of Alan T. Waterman of 12 January 1958," 13 Jan 1958; all in WP/M.

faulted Fisk's proposal because it failed to address the high energy physics program as a whole. They also opposed the stated principle of joint funding as limiting their future freedom of action.[25]

The Stanford physicists regarded Fisk's proposal ambivalently. On the one hand, they welcomed it as a sign of the new national and presidential attention to basic research. In his speech about Sputnik on November 13, 1957, Eisenhower had mentioned, at PSAC's suggestion and to physicists' delight, accelerators as a wise federal investment. Waterman also assured Panofsky that "things would move rapidly" in Washington.[26] On the other hand, Stanford physicists feared that the multi-agency plan would make it much more difficult to get congressional approval for the project, because many committees would be involved.[27] Panofsky especially worried that "the great men in Washington" were making premature decisions "without consulting the victims."[28] Through a network of contacts in ONR, AEC, and NSF, Panofsky kept abreast of "Project M politics" in Washington and expressed his own views. His job was made easier by his membership in many science advisory groups and, after the 1958 New Year, by his consultant work for PSAC.[29]

Although lukewarm toward Fisk's proposal, Panofsky nevertheless urged DOD to take the lead in moving forward the multi-agency scheme, which had already received NSF's endorsement.[30] Finally, in March 1958, Deputy Secretary of Defense Donald Quarles approved $3 million to start the Stanford project and asked AEC and NSF to match it.[31] But AEC continued to regard Fisk's proposal as "not only unnecessary, but also undesirable." It refused to participate in the tripartite agreement, ostensibly to give its new director of research, John Williams, time to study the matter.[32] AEC's stand received backing from the powerful Bureau of the Budget (BOB) in the Executive Office of the President, which believed in streamlining federal programs. The AEC's victory over PSAC came as a great disappointment to science administrators in DOD and NSF who had hoped to set a precedent by PSAC's over-riding an agency in science policy.[33]

25. Panofsky (ref. 17). AEC faulted Fisk's report for overlooking an accelerator proposal from its Oak Ridge Laboratory. See Strauss to Fisk, 16 Jan 1958, in OSAST (ref. 20).

26. Panofsky to files, 19 Nov 1957, in WP/M.

27. Panofsky to files, 13 Jan 1958 (ref. 24); Panofsky to Fisk, 28 Jan 1958, in OSAST (ref. 20).

28. Panofsky to Ginzton, and to files, 27 Nov 1957, in WP/M.

29. Panofsky to Ginzton, 21 Jan 1958, in WP/M.

30. Panofsky (ref. 17); Glennan to Killian, 28 Jan 1958 (ref. 21).

31. Panofsky to Project M Committee of Stanford, 10 Mar 1958, and to files, 18 Mar 1958, WP/M. Fisk to Killian, 27 Mar 1958, in OSAST (ref. 20).

32. Pindar, "Project M: Brief outline of discussion with Charles Falk," 21 Mar 1958, and Panofsky memorandum on "Project M," 23 Apr 1958, in WP/M.

33. Ginzton to M. Chodorow et al., 20 Mar 1958, in WP/M.

The AEC proposed to fund the Stanford accelerator on its own, but with two conditions. First, the commission demanded tight fiscal management to avoid such vast cost overruns as happened at the Princeton-Pennsylvania electron accelerator. With some revisions, Stanford accepted this condition. The second condition was that the White House should issue a comprehensive policy on high energy physics, broader than the Fisk proposal, so that AEC would not be burdened with a Big Science program without assurance of long-term endorsement from the administration.[34]

The ball was kicked back to PSAC. Although the AEC refused to request another study by PSAC—in the background was Strauss' increasing animosity toward PSAC over its support of a nuclear test ban—virtually everyone else agreed that PSAC was the key to getting a presidential policy on high energy physics.[35] In May 1958, PSAC, again spurred by Panofsky, agreed to reopen the subject of high energy physics.[36] Meanwhile, the departure of Strauss from the AEC made it possible for the AEC's scientific staff to communicate directly with PSAC.[37] In June 1958, Killian proposed the reconvening of an NSF panel on accelerators, which had met last in 1956. He promised to strive for an inter-agency consensus after this panel made its recommendations.[38]

Shortly before Killian received the NSF panel report, which endorsed the Stanford accelerator and argued for increased participation of DOD and NSF in high energy physics,[39] AEC took two steps to preempt its two rivals. John McCone, Strauss' successor as AEC chairman, proposed to Killian that the AEC's General Advisory Committee (GAC) and PSAC form a joint subcommittee to develop principles for a national high energy physics program.[40] Pending the budget bureau's approval, AEC also formally proposed that it sponsor the construction of the Stanford and other accelerators while DOD and NSF joined in operating them after completion.[41] Killian

34. Panofsky, "Discussion with John Williams...concerning Project M," 5 May 1958, and Panofsky to Terman et al., 26 May 1958, WP/M.

35. Panofsky to Chodorow et al., "Telephone conversation with Dr. Shirleigh Silverman of ONR...," 5 June 1958, and to M Committee, 17 Jul 1958, WP/M.

36. Panofsky, "Project M rumors," 12 May 1958, in WP/M.

37. Panofsky to M Committee, 21 July 1958, in WP/M.

38. David Beckler, "Record of action [from] PSAC meeting June 17, 18, 1958," in Lester (ref. 19), reel 3, 187–88; Panofsky to M Committee, 18, 21 and 29 Jul 1958, in WP/M.

39. "Supplement to the report of the advisory panel on high-energy accelerators to the National Science Foundation—August 7–8, 1958," in U.S., Congress Joint Committee on Atomic Energy, *High energy physics program: Report on national policy and background information* (USGPO, 1965), 143–50. The panel's reports, for 1954 and 1956 are on 151–164 and 165–69, resp.

40. McCone to Killian, 13 Aug 1958, in OSAST (ref. 20); Panofsky to Project M Committee, "Discussion with E. Piore, 10 September," 12 Sep 1958, in WP/M.

41. David Z. Beckler, "Minutes of meeting on high energy accelerators...August 19, 1958," undated, in OSAST (ref. 20).

accepted the idea of a PSAC-GAC subcommittee, and, to ensure pluralism in science funding, countered the AEC's second proposal by suggesting the establishment of a council on high energy accelerators with representatives from all three agencies.[42] McCone agreed, believing that the council would keep control of the program "in the hands of government officials and not the scientists."[43] An engineer by training, McCone distrusted scientists in government.[44]

The Piore panel

Killian and McCone soon established the joint PSAC-GAC panel to advise on government policy for high energy physics. PSAC named Emmanuel Piore, director of research and vice president of IBM, Hans Bethe of Cornell, and Leland Haworth of the AEC's Brookhaven National Laboratory as its representatives; the GAC sent Edwin McMillan of the University of California at Berkeley, and Jesse Beams of the University of Virginia. Piore became chair of the group.[45] Following Killian's instruction, the Piore panel went beyond the matter of the Stanford accelerator to evaluate the importance of high energy physics, its needs, and the role of the government in its funding. The panel was to compare the scientific merits of the Stanford and MURA proposals, consider the best administrative arrangements, and to explore possibilities for international cooperation.[46]

The choice of Piore as chairman of the panel favored the position of ONR. As a former chief scientist of ONR, Piore was naturally sympathetic to the agency's concern about losing the high energy physics program to AEC since 1953. The AEC, Piore privately complained, did not do a good job in supporting research. Partly due to his instigation, ONR soon countered the AEC's move with its own proposal to sponsor the Stanford accelerator solely, citing its previous support for the university's Mark accelerators and its electronics interests in the electron accelerator.[47] The ONR proposal received support from others in PSAC, including Killian, although they doubted it would pass the leadership of DOD, which was

42. Killian to McCone, 23 Aug 1958, in OSAST (ref. 20); Beckler (ref. 41).

43. Hewlett and Holl (ref. 10), 523.

44. George Kistiakowsky, *A scientist at the White House: The private diary of President Eisenhower's Special Assistant for Science and Technology* (Cambridge, 1976), 21.

45. Killian to McCone, 23 Aug 1958, in OSAST (ref. 20).

46. Killian to Piore, 1 Oct 1958, in OSAST (ref. 20). For Piore's initial desire to concentrate on the Stanford machine, see Panofsky M Committee, 9 Sep 1958, in WP/M, and Beckler to Killian, 11 Sep 1958, in Lester (ref. 19), reel 2, 985–986.

47. Panofsky to Project M Committee, 9 Sep 1958, in WP/M, and ref. 40.

wary of acquiring a Big Science project without apparent direct military relevance.[48]

As soon as the Piore group began its investigation, forces interacted and interests collided at both institutional and disciplinary levels. The panel's discussions provide a useful window for examining American policy-making after Sputnik. Not long into its deliberations the Piore panel seemed to lean toward DOD as sponsor for the Stanford accelerator, an unpleasant surprise to AEC. While this development pleased Stanford physicists, opposition to the accelerator on physical grounds by two of the most prominent physicists in the country stunned them. First, I.I. Rabi of Columbia, powerful protector of interests of physics on the East Coast and a member of PSAC, argued before the panel that the proposed scale of the Stanford project, 15–45 Bev, far exceeded the current needs in physics. Bethe, though not as critical as Rabi, agreed with him, arguing that 7 Bev was then the highest energy at which one "knows interesting things can be studied." Bethe considered 20 Bev a reasonable limit and regarded 45 Bev as unjustified. The panel authorized McMillan, the strongest advocate of the Stanford project and a close friend of Panofsky's, to convey these criticisms back to Stanford.[49]

The Stanford physicists had to respond to Rabi's and Bethe's questioning of the energy range of their accelerator.[50] As often was the case when scientists communicated among themselves, the Stanford physicists' appeal to the Piore panel was void of the Cold War rhetoric that scientists were wont to deploy in public discussion. They did not insist on 45 Bev to beat the European or Soviet efforts, but only expressed proper concern that accelerators should not cluster around the same energy level. For the most part, Panofsky and Ginzton concentrated on scientific and technical reasons for retaining 45 Bev as the final energy level. Conceding to Bethe that there was no specific scientific justification for 45 Bev as yet, they nevertheless argued strongly for retaining expansibility to such a level. They noted that past experiments had made use of scientific instruments in unexpected ways, and enumerated several fundamental problems in particle physics where further progress might well require energy at the 45 Bev level. In addition, they argued that a reduction in the final energy level would probably result in very little saving.[51]

48. Panofsky to Project M Committee, 1 Oct 1958, in WP/M.

49. Panofsky to Project M Committee, 6 and 8 Oct 1958, in WP/M.

50. Ginzton and Panofsky to Project M Committee, 10 Oct 1958, in WP/M.

51. Panofsky to Beckler, 13 Oct 1958, Ginzton and Panofsky to Piore, same date, in Lester (ref. 19), reel 1, 512–520.

The argument did not persuade Rabi, who continued to oppose the Stanford project. In a phone call to Piore, Rabi referred to an article on cosmic rays to show that high energy accelerators were no longer necessary. Both McMillan and Panofsky were "considerably upset;" "if a junior person had made such a statement [McMillan said] we would have thrown him out." Although cosmic rays could be used to simulate some of the work done with accelerators, they pointed out, the results were very crude and qualitative because cosmic rays provided only scanty and uncontrolled initial data. McMillan and Panofsky believed Rabi, not being a high energy physicist, simply did not know "the facts of life" in the field. They asked Robert Serber, another former Berkeley friend and a colleague of Rabi's at Columbia, to help enlighten Rabi on these matters.[52]

Despite Rabi's criticism, Stanford's argument won approval from the majority of the Piore panel. The panel completed its report in November 1958 and recommended go-ahead of the Stanford accelerator with 10 Bev as the starting energy as a compromise between Stanford's proposed 15 and Bethe's 7. Citing the use of advanced microwave technology in the proposed Stanford accelerator and the military interest in it, the Piore panel hinted that DOD might be the right agency to sponsor the project. This suggestion matched the thinking of Killian and his staff. A few months later, a paper apparently prepared by PSAC staff also argued DOD sponsorship, noting that "linear accelerators...have at times been suggested for military weapons applications such as defeating air dropped nuclear weapons or ballistic missiles. Although these possibilities have not materialized, they further illustrated the relevance of linear accelerator technology to the long-term interests of the DOD."[53]

The Piore report touched, as did the original Stanford proposal, only very briefly on the justification for continued federal financing of high energy physics. The panel argued that such support was warranted both because of the field's importance to science and because of its high cost, which was well beyond private resources. Although it cited the role of accelerators as "training ground" for young scientists in high energy physics and in other fields, it did not elaborate the case. Neither did it make any explicit promise of technological spin-offs.[54]

52. Panofsky to Project M Committee, "Telephone conversation with E.M. McMillan," 3 and 14 Nov 1958, in WP/M.

53. Panofsky, ibid. Piore panel, "U.S. policy and actions in high-energy accelerator physics: Report of a special panel of the President's Science Advisory Committee and the General Advisory Committee to the Atomic Energy Commission," included as "Appendix 3: Piore panel report—1958," in JCAE (ref. 39), 135–142; Anon., "Reason for assignment of responsibility to the Department of Defense for the construction of the Stanford accelerator," undated, attached to Beckler, "Notes on meeting of April 2, 1959, with the president re high energy accelerator policy," undated, in OSAST (ref. 20).

54. Piore report (ref. 53), 135–137.

The Piore panel also recommended that the high energy physics program be reviewed at the presidential level, both because of the desire of NSF and DOD to break AEC's monopoly, which it endorsed, and because of an expected leap in cost from $53 million in 1959 to $125 million in 1963. As to the MURA proposal and another from the AEC's Oak Ridge laboratory, the Piore panel report recommended continued support for study but rejection of construction. The panel also agreed with Killian's proposal for a high-level AEC-DOD-NSF council to coordinate the nation's high energy physics program and international cooperation.[55]

The Piore report gained wide support within the government. PSAC accepted it after a lively discussion during which Bethe withdrew his earlier reservation about the Stanford proposal and lent it strong support while Rabi sat silent. The AEC's GAC, the other sponsor of the panel, expressed concern about the balance in support of basic research, but nevertheless approved the Piore report. Without resolving the sponsorship question, ONR, AEC, and NSF also endorsed the report. The next move was for Killian to bring the report, with its specific recommendation on the Stanford accelerator, to President Eisenhower for approval.[56]

Killian initially hesitated to take this step, because the sponsoring agency was still undecided, notwithstanding the Piore report's suggestion of DOD. Especially troubling to ONR and the Stanford physicists was Quarles' coolness toward DOD's involvement.[57] When nuclear physicist Herbert York, the new director of defense research and engineering, replaced Quarles as the top DOD official on high energy physics in early 1959, he was also lukewarm about the Pentagon's role in such a big, pure science project.[58] In addition, the budget bureau refused to increase the FY 1960 budget; DOD and NSF had to try to find money for the first year of the Stanford project within existing funds if they wanted to sponsor it. When they finally did so, Killian decided to bring the Piore report to Eisenhower.[59]

55. Piore report (ref. 53).

56. Panofsky to M Committee, "Action of the Killian committee in its 17 November meeting," 19 Nov 1958, in WP/M. For GAC's attitude, see Warren C. Johnson, GAC chairman, to McCone, 3 Feb and 15 May 1959, in ref. 7, 22–23; and Richard Sylves, *The nuclear oracles: A political history of the General Advisory Committee of the Atomic Energy Commission 1947–1977* (Ames, IA, 1987), 219–237.

57. Panofsky (ref. 56), and Panofsky to Project M Committee, 23 Dec 1958, in WP/M.

58. Panofsky to Project M Committee, 30 Jan 1959, and to Terman et al., 3 Apr 1959, WP/M; Interview with Herbert York by the author, La Jolla, Ca, 18 Jul 1992.

59. Panofsky to Project M Committee, 2 Mar 1959, in WP/M.

On April 2, 1958, Eisenhower met in the White House with Killian, McCone, York, Waterman, Elmer Staas (deputy BOB director), and others to hear the Piore report and to determine a national policy for high energy physics. Killian opened the discussion by noting that PSAC endorsed the report and regarded the proposed program as the single most important way to strengthen American science. McMillan then gave a primer on high energy physics, which interested Eisenhower.[60] Inevitably, the Cold War entered the picture as McMillan emphasized Soviet progress in high energy physics. Killian urged the support of high energy physics to improve both American science and national prestige.[61] Killian told Eisenhower that he, McCone, Waterman, and York together recommended the immediate approval of the Stanford accelerator as the US's next major step forward in the field. To ensure its long-term prospect and public understanding, Killian also suggested that the project be specifically authorized by Congress. Finally, Killian reported that the sponsoring agency had not been decided. While most favored DOD's ONR, the budget bureau did not consider it a wise management policy to divide the AEC's responsibility in high energy physics with others.[62]

Eisenhower readily approved the Stanford proposal but raised several issues about process. He questioned whether it was necessary to get Congress to authorize it. Partisan politics and harmful publicity would surely distort and confuse the case, Eisenhower feared. He rather preferred to build the accelerator first and then announce it. McCone and Staats replied that so large a construction project needed special congressional authorization, and McMillan said it was simply impossible to conceal work on the two-mile long machine. Eisenhower had reservations about the DOD as sponsoring agency. He worried about "the psychological aspects of identification of the accelerator with military interest." But he also argued that if DOD became the sponsor, it might be easier to obtain funds from Congress because the armed services committees would handle it in a "more quiet and businesslike" fashion than the JCAE, which oversaw the AEC's budget. In the end, Eisenhower ordered further study of the agency matter.[63]

60. Andrew J. Goodpaster, "Memorandum of conference with the president, April 2, 1959," 3 Apr 1959 in Lester, ed., *The diaries of Dwight D. Eisenhower, 1953–1961*, 28 reels (Frederick MD, 1968), reel 21, 252–255; Anonymous, "A primer for elementary particle physics," 13 Feb 1959, 258–278, ibid.; "Inner atom seen key to universe: President's advisory panel says accelerators may smash old concepts," *New York Times*, 17 May 1959, 68.

61. Killian, "Notes for introduction of high-energy accelerator proposal to the president—April 2, 1959," undated, in OSAST; Killian (ref. 2), 220; interview (ref. 58).

62. Killian to Eisenhower, "National program for high energy accelerator physics," 2 Apr 1959, in OSAST (ref. 20).

63. Beckler, "Notes on meeting of April 2, 1959, with the president re high energy ac-

Eisenhower's enthusiasm for high energy physics appears remarkable in view of his pre-Sputnik criticism of "the tendency of Government in recent years to supply whatever funds might be requested for research."[64] To be sure, Sputnik worked to the scientists' favor, for many would see the Stanford accelerator as a necessary move to win the Cold War race in science and technology. But Eisenhower also tried to resist many projects in military R&D and in space even in the turbulent aftermath of Sputnik. There were probably other factors as well. Eisenhower was obviously grateful to Killian and PSAC for helping him put the government's space, science, and defense programs in order.[65] Thus, when Killian and PSAC recommended the high energy physics program as the single most important demonstration of government support of basic research, Eisenhower was willing to go along with them. Favorable public reaction confirmed the post-Sputnik popularity of federal support of basic research.[66] Another factor was Eisenhower's fascination with the exploratory aspect of high energy physics. Just as he enjoyed the earlier briefing by PSAC members Edward Purcell of Harvard and Herbert York on space, he seemed to derive great pleasure from learning about the "strangely beautiful" subatomic world, although it is doubtful that he understood much of the technicalities.[67]

As the battle moved from physicists to other scientists, to bureaucrats within the executive branch, and then to Congress, justification for the Big Science project likewise shifted. It evolved from learning about the inner structure of matter, to the status of particle physics as a frontier field in science and its benefits in training scientists in other fields, to the practical results incidental to such research, and, finally, to maintaining, or rather, restoring American scientific leadership.

In May 1959, as Eisenhower publicly endorsed the Stanford project at the "Symposium on Basic Research" described at the beginning of this paper, the budget bureau moved successfully to make AEC, rather than

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celerator policy," undated, in OSAST (ref. 20); Goodpaster, "Memorandum...," 3 Apr 1959, in Lester (ref. 60), reel 21, 252–253. Kistiakowsky (ref. 44), 307.

64. L.A. Minnich "Minutes of Cabinet meeting," and Maxwell M. Rabb, "Actions of the Cabinet," 11 Mar 1957, in Paul Kesaris and Joan Gibson, eds., *Minutes and documents of the Cabinet meetings of President Eisenhower (1953–1961)*, 9 reels (Washington, D.C., 1980), reel 5, 549–556; Wang (ref. 1), chapt. 2.

65. Wang (ref. 1), chapt. 5; see Eisenhower's letters to Killian upon the latter's resignation in spring 1959, in Killian (ref. 2), 208–212, and Killian (ref. 61).

66. "Support for basic research," editorial, *New York Times*, 16 May 1959, 22.

67. Killian (ref. 2), 220. In his press conference on 29 Apr 1959, Eisenhower defended the Stanford accelerator against a critical Midwestern reporter by saying that PSAC told him that the machine was "the most extraordinary thing that has yet been attempted." *Public Papers of the Presidents of the United States, 1959* (Washington, D.C., 1960), 348. On PSAC's space investigation, see Divine (ref. 1), chapt. 6, and Wang (ref. 1), chapt. 4.

DOD, the sponsoring agency, despite opposition from ONR and Killian and the private wishes of the Stanford physicists. York did not fight the decision, because he agreed with Eisenhower that DOD should not be looked upon as the primary agency to support science.[68] A *Science* editorial also questioned the DOD as the best place for the Stanford accelerator, especially in view of its requirements for security and secrecy. Killian, however, acquiesced in BOB's decision only most reluctantly; he insisted that the decision should not set a precedent for narrowing DOD's role in basic research.[69] For its part, the AEC sought and secured assurance from the BOB that the Stanford project would not hurt its other programs. It formally accepted the responsibility and requested congressional authorization of construction funds, now estimated at $105 million, to be spent in six years.[70]

Ways and means

When the Joint Committee on Atomic Energy opened hearings on the AEC's request for authorization of the Stanford accelerator on July 4, 1959, the fight over the "monster" moved to a new arena. For the remainder of the Eisenhower administration, the debate was no longer over agency assignment or scientific merit, but over financial and administrative arrangements, site suitability, and Stanford's conflict of interest with suppliers for the project. In the background were partisan politics and heightened concern about the rising cost of science within the AEC and elsewhere in the government.

In addition to McCone, several other AEC officials, and Ginzton as representative from Stanford, the JCAE also heard favorable testimony from Haworth of Brookhaven, Norman F. Ramsey of Harvard, Ragnar Rollefson of MURA, and Henry Smyth of Princeton. The AEC justified the project as part of its mandate, as expressed in the Atomic Energy Act of 1946, to conduct research and development as related to "nuclear processes." High energy physics was presented as a logical extension of nuclear physics whose importance was "evident." The scientists amplified the significance of the field and of the Stanford machine. They assured the congressmen that expensive accelerators were not scientific luxury, but rather, as Ramsey put it, "a very sad necessity which nature seems to be forcing upon scientists."

68. Panofsky to Terman et al., 3 Apr 1959, in WP/M; (ref. 7), 17; Pindar to M files, "Meeting...May 12, 1959," 2 Jun 1959, in WP/M; interview (ref. 58).

69. Joseph Turner, "Capital gain," *Science, 129* (12 Jun 1959), 1583; Killian to Maurice Stans, BOB director, 28 Apr 1959, in OSAST (ref. 20).

70. Ref. 7, esp. 1–13.

They cited examples from the history of science and technology, such as electricity and digital electronic circuits, to show how discoveries in basic research on the nature and structure of matter transformed industry and military directly and indirectly. By and large, however, they were preaching to the converted. Although irritated by the administration's failure to give advance notice of Eisenhower's announcement, the JCAE, which took a proprietary view of the AEC, seemed favorably impressed with the project. An "energy Cold War" with the Soviet Union was mentioned but did not figure prominently in the hearings.[71]

But the most neatly tied package can easily unravel on Capitol Hill. The vicissitudes of the Stanford project in Congress heralded, in many senses, the era of Big Science politics. On August 26, 1959, the JCAE voted to recommend authorization of the Stanford project. Before the bill was sent to the House and Senate for voting, however, the JCAE, especially its chairman, Senator Clinton Anderson (D-NM), had second thoughts. He claimed to have found "a number of uncertainties" in the original Stanford proposal. Specifically, he complained about the proposed site's vulnerability to earthquakes, the discrepancies in different cost estimates, and problems in design and construction approaches. Anderson then reached an agreement with McCone that the authorization be deferred.[72]

Through its own channels, Stanford learned that following a visit to the university over a month earlier, McCone had provided much of the ammunition for the JCAE and suggested the delay of authorization.[73] Meanwhile, the AEC continued to sponsor engineering and geological studies on the project. To McCone's and the JCAE's delight, the investigations did result in changes of both the site and the construction method, from tunnel-digging to the money-saving "cut and cover."[74]

71. Ref. 7, esp. 31, 36, 38, 203, 218–219.

72. US Congress, Joint Committee on Atomic Energy, *Amending the Atomic Energy Act and authorization of Stanford accelerator project* (USGPO, 1959), 16–29; *Background information on the high energy physics program and the proposed Stanford linear electron accelerator project*, report to the Joint Committee on Atomic Energy, 87th Congress, 1st Session (USGPO, 1961), v; Anon., "Cut in funds for Stanford accelerator more apparent than real," *Science, 131* (22 Apr 1960), 1196–1198.

73. Ginzton to file, "Project M politics," 4 Aug 1959, and Robert H. Moulton to file, "Visit by Messrs. McCone, Williams and Ink—July 18, 1959," 16 Oct 1959, both in WP/M; McCone to Kistiakowsky, 26 Feb 1960, and attached "Stanford linear accelerator project: Summary discussion and chronology of development," McCone, "Note to [AEC] general manager," 5 Aug 1959, and McCone, memo for AEC general manager, "Stanford accelerator," same date, all in Eisenhower Library, McCone Papers, box 2, folder "O&M 7-1 President's Science Advisory Committee (3)."

74. McCone to Kistiakowsky (ref. 73); JCAE, "Authorizing appropriations for the Atomic Energy Commission," 19 Apr 1960, in *Senate report*, 86th Congress, 2nd Session, serial volume 12234 (USGPO, 1960), report no. 1277, 9.

More than technical problems bothered McCone about the Stanford project. Increasingly, he resented the growing cost of science and the rising influence of scientists in government. Calling the Stanford machine "your accelerator," he told York and George Kistiakowsky, the Harvard chemist who had just replaced Killian as Eisenhower's science advisor and PSAC chairman in July 1959, that, in general, "scientists cause trouble in government."[75] He was disturbed by the possible conflict of interest suggested by the close ties between Stanford and Varian Associates, the company which was to supply klystrons, key parts in the accelerator. To complicate the matter, Edward Ginzton, designated director for the construction of the Stanford accelerator, became chairman of the board of Varian in the middle of the controversy, much to the displeasure of McCone and the JCAE. Communication between Stanford and the AEC, both now uneasy and suspicious, was obviously poor.[76] Eventually, Varian removed itself as a potential supplier of klystrons, Ginzton resigned from the project directorship, and Stanford formally waived its share of royalties from the sale of klystrons.[77] On a different front, McCone's anxiety was heightened by a letter from Eugene Wigner, a politically conservative physicist from Princeton, who denounced the Piore report as "irresponsible." Wigner claimed that SLAC would jeopardize national defense by drawing too many young scientists into particle physics, leaving too few for military research.[78]

The nature of the partnership between science and the state was also at issue in the debate. As a European immigrant, Panofsky was sensitive to the danger of state control of science. In the early 1950s, he left Berkeley for Stanford in protest against the loyalty oath imposed on members of the University of California. Although he had signed the oath himself, because he had signed similar oaths before to fulfill requirements of security clearance, he objected to the firing of several of his colleagues who refused to sign it.[79] Aware of the AEC's tendency to closely control projects it funded, Panofsky and his Stanford colleagues were determined to keep their autonomy in both the construction and operation of the accelerator. The AEC, for its part, was alarmed by cost overruns in other accelerator projects and felt the need to keep a tight rein over at least the construction and procurement process. In the background was, again, the difference between McCone and Panofsky over the matter of a nuclear test ban, the former

75. Hewlett and Holl (ref. 10), 524; Kistiakowsky (ref. 44), 21.

76. Moulton to R. Brown et al., "Discussion re Project M held November 4 in Washington, D.C.," 9 Nov 1959, in WP/M.

77. McCone to Kistiakowsky (ref. 73); Sterling to Paul McDaniel, 17 Sep 1959, and attached "Board of Trustees' Resolution, Sept. 17, 1959," in WP/M; Neal (ref. 6), 32.

78. Wigner, to whom it may concern, 15 Jul 1959, in McCone Papers (ref. 73).

79. Interview with Panofsky by author, SLAC, 5 Mar 1992.

being its main opponent in the administration and the latter becoming a principal advocate within PSAC. Their opposed political views inevitably colored the dispute between McCone and the Stanford scientists. Thus, even before the project was authorized by Congress, the AEC and Stanford were in sharp conflict.[80]

The project stagnated in AEC and Congress, and Kistiakowsky and PSAC could do little to expedite it. Finally, in December 1959, McCone reopened the question of priority to be accorded high energy physics in the government's support of basic research. Unexpectedly high costs of experimentation with the half-dozen or so existing accelerators had shocked McCone. He and Kistiakowsky agreed that a new look at the situation was warranted.[81]

PSAC's re-involvement did not solve McCone's problems, however. In January 1960, PSAC and AEC reconvened the Piore panel to update their 1959 report on accelerators.[82] Following a two-day meeting and briefing, the group increased its earlier estimate of costs in the field and reaffirmed its earlier recommendation to "start immediately" the Stanford accelerator.[83] Alarmed, McCone and budgeters in the budget bureau appealed to Kistiakowsky, hoping that he could get PSAC to dampen the Piore recommendations in view of the needs of all fields of science. Kistiakowsky, however, demurred, citing the incompetence of PSAC to judge scientific priorities and its lack of members from many fields, such as earth sciences, biochemistry, oceanography, and astronomy.[84] Nevertheless, Kistiakowsky did convey AEC's and BOB's worries to PSAC at its meeting on February 14 and 15. During discussion of the new Piore report, Rabi again objected to the recommendation of more accelerators. Another PSAC member, Glenn Seaborg of Berkeley, also expressed concern that high energy physics should not be expanded at the expense of low energy physics. In the end, however, the majority of PSAC firmly endorsed the second Piore report.[85] In this, PSAC differed markedly from the AEC's own General Advisory Committee, which now viewed the expansion of the field with growing misgivings.[86]

80. Ginzton to Panofsky, 3 Nov 1959, and Pindar, "Notes on meeting at AEC, Washington, December 9, 1959," undated, both in WP/M.

81. McCone to Kistiakowsky, 16 Dec 1959, and reply, 22 Dec 1959, in McCone Papers (ref. 73); Kistiakowsky (ref. 44), 47, 178–179.

82. Kistiakowsky (ref. 44), 223.

83. Piore to McCone and Kistiakowsky, 5 Feb 1960, in McCone Papers (ref. 73); Kistiakowsky (ref. 44), 47, 178–179.

84. Kistiakowsky (ref. 44), 249; Floberg to Kistiakowsky, 11 Feb 1960, in McCone Papers (ref. 73).

85. Kistiakowsky to Floberg, 19 Feb 1960, in McCone Papers (ref. 73).

86. McCone to Kistiakowsky, 10 Mar 1960, in McCone Papers (ref. 73).

Dissatisfied by the outcome of the second Piore report, the AEC demanded another presidential review of the high energy physics program. On 9 March 1960, McCone met with the White House staff and Maurice Stans, director of the budget, to review the matter. Reading a handwritten note from the president asking why the Stanford project was stalled, W.B. Persons, Eisenhower's chief of staff, urged action to get it going. Stans, however, criticized the scientists for over-selling their costly programs to Eisenhower. He suggested that neither the Stanford accelerator nor other projects be recommended to Congress in the budget request for fiscal year 1961.[87] At this point, Cold War rhetoric came to Kistiakowsky's rescue. He responded that the high energy physics program involved "national prestige." In the competition with the Soviet Union, the Stanford project presented a unique opportunity "to lead from strength rather than from weakness." The allusion to the Cold War worked the magic and all present agreed that Kistiakowsky and McCone should study the problem in more detail before they went to see Eisenhower on a later date.[88]

Despite his clever maneuvering on behalf of SLAC, Kistiakowsky was ambivalent about the rapid growth of high energy physics. As a chemist, Kistiakowsky had his reservations about the balance of US science policy, but nevertheless endorsed high energy physics both as a frontier field in science and as a symbol of American leadership in the Cold War competition for national prestige. In a subsequent letter to McCone, Kistiakowsky elaborated on his and PSAC's arguments in support of the high energy program. Kistiakowsky told about his own initial doubts about the wisdom of a large-scale expansion in high energy physics, as recommended by the Piore panel. But these doubts were "gradually dispelled," he wrote, by several considerations about American science policy during the Cold War. The federal government had committed itself to the support of science in order to further "national welfare, health, security *and* prestige," he noted. Soviet successes in several fields convinced him that the U.S. should "push selected areas of our own at the maximum possible pace." Kistiakowsky believed space and high energy physics were among these areas. While both contributed to national prestige, high energy physics, Kistiakowsky pointed out, enjoyed more scientific merit.[89]

In the end, Eisenhower agreed with Kistiakowsky's and PSAC's argument. At a meeting in the White House on March 23, 1960, he "spoke most emphatically" about getting the Stanford accelerator started.[90] He also

87. McCone to Kistiakowsky, 26 Feb 1960, in McCone Papers (ref. 73); Kistiakowsky (ref. 44), 264–265.

88. Kistiakowsky (ref. 44), 264–265.

89. Kistiakowsky to McCone, 16 Mar 1960, in OSAST (ref. 20).

90. Kistiakowsky (ref. 44), 280; Hewlett and Holl (ref. 10), 524–525. Eisenhower again

approved the rest of the high energy physics program as recommended by the Piore panel, with the condition that it be implemented at a slower pace.[91] Following this presidential directive, McCone incorporated the Stanford accelerator and several other items in high energy physics in AEC's FY 1961 budget and proposed them to JCAE.[92]

In April 1960, however, JCAE again turned down AEC's request for full appropriation of the Stanford project. Instead they recommended a one-year $3 million grant for design and engineering. Panofsky and Stanford at first strongly opposed this partial funding. They argued that, short of full authorization, the project's uncertain fate would deter top scientists from joining it. Kistiakowsky also lobbied JCAE members in favor of full authorization. To Kistiakowsky's dismay, however, AEC told JCAE that the one-year contract was acceptable. The Republicans on JCAE were resigned to inaction in face of a Democratic majority and in view of AEC's weak stand.[93]

Although JCAE cited various technical reasons for the delay of authorization, many observers, especially Republican members of the committee, pointed to politics as the real reason for Anderson's move. They believed that the Democrats blocked "the Republican accelerator" to make sure Richard Nixon would not have a photo opportunity at SLAC's groundbreaking ceremony during the heated presidential campaign.[94] They also pointed to Senator Henry M. Jackson's maneuver to use the Stanford accelerator as a lever to force the administration to accept the addition of power-generating facilities, costing $95 million, to a new plutonium-producing reactor at Hanford in his home state of Washington. As the first major Big Science project in politics, the Stanford accelerator was trapped in the conventional Capitol Hill give-and-take game.[95]

Finally, AEC and JCAE worked out a committee report that Stanford felt was favorable enough for it to accept the one-year authorization. The report allowed the AEC to "proceed from the present master plans" and take steps that "would lead to initiation of construction at the site with a

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asked about the Stanford project in July when he met with PSAC; Beckler to Goodpaster, "Stanford linear accelerator," 14 Jul 1960, in OSAST (ref. 20).

91. Kistiakowsky (ref. 44), 280; Hewlett and Holl (ref. 10), 524–525.

92. Kistiakowsky to McCone, 5 Apr 1960, in OSAST (ref. 20); Hewlett and Holl (ref. 10), 523.

93. Kistiakowsky (ref. 44), 298–300, 303–304.

94. JCAE (ref. 72), 8–9; Greenberg (ref. 3), 236; Howard Margolis, "Hanford and Stanford: The issue is clear but the politics are complex," *Science, 134* (21 Jul 1961), 177–178.

95. "Cut in funds for Stanford accelerator more apparent than real," *Science, 131* (22 Apr 1960), 1196–1198; Greenberg (ref. 3), 237–238; Goodpaster, "Memorandum of conference with the president, April 7, 1960," 9 Apr 1960, in Lester (ref. 60), reel 25, 548–550.

minimum of delay after full authorization of the project.'' As *Science* reported, the AEC seemed to have a go-ahead to proceed exactly as if the construction funds had been authorized.[96] Most importantly, Panofsky won the precious right for Stanford to control the design and, later, the construction of the accelerator.[97]

Yet, short of complete authorization, the Stanford project was still very much in limbo after being kicked around in Washington for three years, despite Eisenhower's and PSAC's strong support. Several factors contributed to the Stanford accelerator's difficulties. The most prominent one was what journalist Daniel Greenberg called the ''immunological reaction'' against Big Science.[98] The price tag shocked many. As one congressman pointed out at the JCAE hearings in 1959, SLAC cost almost as much as all the other accelerators up to that time.[99] Elsewhere, another Congressman found it hard to believe that a pure science project could be so expensive. ''I can build five or six nice blast furnaces for that type of money,'' he said incredulously, ''or almost a whole steel plant.''[100] As science entered the era of giantism, it had to contend with other elements in the equation of national political economy.

Another problem causing trouble for the Stanford accelerator was the internal division over the distribution of resources, both among high energy physicists and among scientists in general. As Kistiakowsky observed of one meeting of the Piore panel, ''those who have machines want the money to go to the existing machines and those that don't have them want the new ones.'' In late 1959, Rabi re-opened his campaign against large accelerators in general and the Stanford machine in particular by having his colleagues at Columbia write letters to McCone criticizing the project. In March 1960, Stanley Livingston, director of the joint Harvard-MIT Cambridge electron accelerator, attacked the Stanford project. Calling it ''premature, unwise, and probably useless,'' Livingston provided Stans a ''bombshell'' against Kistiakowsky.[101] When the Piore panel reconvened for a third time in the autumn of 1960 at McCone's request, its enthusiastic report on high energy

96. JCAE (ref. 74), 9; ''Cut'' (ref. 95), 1197.

97. McDaniel to Kistiakowsky, 13 Jul 1960, in OSAST (ref. 20); James T. Ramey, staff director of JCAE, to A.R. Luedecke, AEC general manager, 14 Nov 1960, Luedecke to Ramey, 3 Dec 1960, and attached Stanford University and AEC, ''Memorandum of understanding of contract requirements,'' undated, all in *Background information* (ref. 72), 2–5; Galison (ref. 3), 70.

98. Greenberg (ref. 3), 233.

99. *Stanford linear electron accelerator* (ref. 7), 14.

100. *Public works appropriations for 1961*, hearings before the subcommittees of the Committee on Appropriations, House of Representatives, 86th Congress, 2nd Session (USGPO, 1960), 264–265.

101. Kistiakowsky (ref. 44), 233, 217–218, 273.

physics contained a biting commentary by Wigner, who had become a member of the expanded panel, which made public his previous concern about the impact of an expanded high energy physics program on other sciences and on national defense efforts.[102] Kistiakowsky and PSAC, however, once again endorsed the Piore report, with the disclaimer that it represented an optimum program that had to be balanced against other programs in science and in government.[103] The question was who would do the balancing. In a concurrent proposal, Kistiakowsky and PSAC suggested that instead of PSAC, the National Academy of Sciences should be brought in to help make choices in science funding. But that initiative received only partial implementation because the BOB objected, echoing the debate in the 1940s over the establishment of the National Science Foundation, to private bodies and special interests shaping public policy.[104]

Eisenhower was disappointed by the lack of progress on SLAC. During his last official meeting with PSAC on December 19, 1960, just days before he left the White House, Eisenhower again asked about the status of the linear accelerator. When told by Panofsky that Congress had slowed its authorization, Eisenhower lamented strongly the meddling of partisan politics in science policy: "The Congress authorizes things we do not want or need, and denies what we do want or need, not hesitating, even in a scientific matter like this, to set its own judgment against that of the scientists."[105] Political resistance to a pure, but expensive, federal science project, in both Congress and the administration, proved formidable, and the internal division in the scientific community certainly did not help.

The Stanford project, nonetheless, had shown strength in several respects. Its technical feasibility was unquestioned and its scientific merit, though challenged by Rabi and Wigner, survived crucial tests in the Piore panel. Stanford emerged from World War II as a first-rank educational and scientific institution. Panofsky, SLAC's main proponent and later its first director, had high standing in the high energy physics community and on the Washington science and defense advisory scene.[106] Perhaps most

102. "Piore panel report—1960," and Wigner, "Commentary..." in (ref. 39), 122–134.

103. Kistiakowsky to McCone, 21 Dec 1960, in McCone Papers (ref. 73), reprinted in *Background information* (ref. 72), 6–8.

104. PSAC, "Government research and development: Summary conclusions and recommendations," 17 Oct 1960, in Eisenhower Library, White House collection, Papers of Office of Staff Secretary, Subject Series, Alpha Subseries, box 16, folder "Dr. Kistiakowsky;" BOB, "Organization of science in government," 16 Sep 1960, in OSAST, box 9, folder "Federal Council for Science and Technology;" Thomas D. Morris to Elmer B. Staas, 16 Sep 1960, in National Archives, Record Group 51 (BOB), series 52.1, box 6, folder "E4-1 1957-1/61."

105. Goodpaster, "Memorandum...December 19, 1960," in Lester (ref. 60), reel 28, 315.

106. See Leslie (ref. 3); Greenberg (ref. 3), 227–29, 235.

importantly, Sputnik brought to the White House science advisors such as Kistiakowsky and PSAC who kept the project alive in the Eisenhower administration. Under Kennedy they would try even harder to get it going.

The change of administration brought both new opportunities and challenges for SLAC advocates. With the Democrats back in the White House, the JCAE no longer posed an insurmountable barrier to the Stanford project. But new obstacles presented themselves, especially the BOB. As in the Eisenhower era, the scientist-administrators remained the most important force pushing the project along. Jerome Wiesner succeeded Kistiakowsky as presidential science advisor and PSAC chairman, while Glenn Seaborg assumed the helm at the AEC. Seaborg now supported SLAC and urged increased funding for other sciences to keep a reasonable balance. Together, Wiesner and Seaborg made good use of Cold War competition to move SLAC forward. Success, nevertheless, did not come without much behind-the-scene maneuvering.

From the beginning, David Bell, the new budget director, was suspicious about the priority of the Stanford accelerator in high energy physics and within science in general. In a memorandum for Kennedy on SLAC, Bell echoed Wigner's criticism of high energy physics as being "out of balance" with other disciplines: "I do not object to proceeding with the [Stanford] machine, but I think that, in so doing, it needs to be recognized by all concerned that this action represents a very substantial commitment of resources to the increased support of basic science and that the resources now allocated to an expansion of high energy physics cannot also be committed to other fields of science."[107] To counter rising skepticism about Big Science, its advocates again had recourse to Cold War rhetoric.

A few weeks after moving into the White House, Kennedy paid a visit to AEC headquarters in Germantown, Maryland. There he listened attentively to AEC's research director, Paul McDaniel, describe the high energy physics program and watched charts comparing accelerators in the US and in the rest of the world. Seaborg described one telling episode in his diary:[108]

> As the third chart was about to be snatched away, the President commented on the fact that the second chart had shown a 12.5 Bev accelerator (zgs [zero-gradient synchrotron]) as the United States effort compared with a 50.0 Bev accelerator as the Soviet effort. There were hasty explanations...that the ZGS was a superior machine in many other respects than the energy level shown

107. Bell to Kennedy, "Stanford linear electron accelerator," 9 Mar 1961, in National Archives, RG 359 (Records of the Office of Science and Technology), box 86, folder "High energy physics—Title folder 1961."

108. Glenn T. Seaborg, *Journal* (25 vols., Lawrence Berkeley Laboratory, 1989), *1*, 25.

> on the chart, that Soviet machines often do not perform as well as they are supposed to, and that we are in fact at the head of the parade in high energy physics.

This presidential, and indeed public, concern with the Bev numbers of accelerators bore a striking similarity to the world's interest in the diameters of astronomical telescopes half a century earlier. Both machines captured the public's imagination and became important measures of a country's international prestige. In the post-Sputnik era, space travel and particle smashing pushed telescope-making into the background.

A White House meeting was held shortly after President Kennedy's visit to the AEC. The Stanford project was the first item on the agenda. Bell, still unconvinced of its urgency, suggested postponement of the project to FY 1963, pending a full review by PSAC. Wiesner and Seaborg hurriedly countered Bell by saying that they both favored moving the project forward and giving increased funding to other research fields to avoid imbalance in science support. American scientists, they argued, generally agreed that the Stanford machine was needed "if we are to get ahead" in high energy physics. To that President Kennedy responded: "Let's go ahead with it." That, however, was apparently still not good enough for the budget bureau. Two weeks later, Bell told Seaborg that he would still postpone the Stanford project to FY 1963 after all. Seaborg disagreed and decided to appeal to the White House.[109]

The chance came when Kennedy met with heads of the JCAE on March 23, 1961, to discuss the AEC supplemental budget for 1962. Senator Anderson repeated his criticism of SLAC. He claimed he had heard "a lot of scientists" speak against the Stanford accelerator. Seaborg, rightly counting himself a spokesman for those concerned low-energy physicists, responded that he lately found "unanimous" support for the project among high energy nuclear physicists. Reflecting the changing White House-Capitol Hill relationship, Senator Anderson said then "that was good enough" for him. After the meeting, Anderson, urged by Seaborg, approached Kennedy to indicate that he (Anderson) thought the Stanford project should be supported.[110]

After the others left, Bell stayed with Kennedy to work out a final version of the AEC budget. He called Seaborg later to say that, in balancing the budget, Kennedy nearly threw out the Stanford accelerator, but Bell advised him to stay with Wiesner's and Seaborg's judgment on this matter. So it was kept.[111] The project, then estimated to cost $114 million, passed

109. Ibid., 74, 111.
110. Ibid., 130–131.
111. Ibid., 131.

Congress on September 15, 1961. In April 1962, Stanford and the AEC signed a contract. It took about four years to finish the main construction, under budget and within schedule—a rare accomplishment.[112]

SLAC has achieved spectacular successes. In May 1966, it accelerated electrons to 10 Bev and, two weeks later, to 18.4 Bev.[113] It found many new particles, including the tau lepton in 1975. SLAC experiments finished in 1978 provided strong evidence in support of the quark theory. Other SLAC experiments backed the "WSG theory," developed by Steven Weinberg, Abdus Salam, and Sheldon Glashow, which aimed at unifying the electromagnetic and weak interactions.[114] In the late 1980s, SLAC, with its new collider, became the US "Z factory" to compete with the then-leading European nuclear center, CERN, to produce the eagerly sought Z particles. Panofsky continued to direct SLAC until 1984.

Modern cathedral-builders

Robert R. Wilson, a renowned Cornell physicist who later became the first director of Fermilab, once compared particle accelerators to medieval cathedrals. The structures of both, he observed, were aesthetically appealing and intellectually exciting to their builders. They both also involved regional, national, and international competition. Most of all, they both were expensive. Yet, Wilson pointed out, there was one important difference. While the cathedrals served their communities, accelerator building, however exciting to the physicists, remains largely an elitist enterprise.[115] His observation fits many Big Science projects, including SLAC and the scuttled SSC.

Although the question of utility never played a key role in the battle over SLAC's approval, it assumed increased prominence as high energy physics came under the national political spotlight. John R. Pillion, a Congressman from New York who sat on the appropriations committee, raised questions about SLAC's practical applications in 1960. He asked:

112. JCAE, "Authorizing appropriations for the Atomic Energy Commission," 21 June 1961, in US Congress, *Senate Report*, 87th Congress, 1st session, serial volume 12323 (USGPO, 1961), report no. 441; Neal (ref. 6). Meanwhile, the Hanford reactor also made it into Kennedy's budgets and survived a legislative defeat in 1961 before finally passing Congress in 1962. See Howard Margolis, "Hanford and Stanford," *Science, 133* (21 Jul 1961), 177–178; Richard Wayne Dyke, *Mr. Atomic Energy: Congressman Chet Holifield and atomic energy affairs, 1945–1974* (New York, 1989), chapt. 7.

113. Neal (ref. 6), 36–37.

114. Panofsky (ref. 6); M. Mitchell Waldrop, "SLAC feels the thrill of the chase," *Science, 244* (19 May 1989), 771–773.

115. Robert R. Wilson, "Particle accelerators," *Scientific American, 198* (March 1958), 65–75.

> What is the practical result of this accelerator? What are the prospects of putting the knowledge that we will obtain from this accelerator into practical use? How will it aid our defense? How will it raise the standard of living of our people?

After all, he said, "we have to explain it back home." When McCone shrewdly invoked the connection between Ernest Lawrence's equally "pure" cyclotron and atomic energy, Pillion appeared calmed but hardly convinced.[116]

As the SLAC story makes clear, the dynamics of the political economy of high energy physics in this period hinged on the pull of international politics and the push of the scientists. President Eisenhower, President Kennedy, and Congress viewed the project as an important step forward for the US in the contentious parade of science. Eisenhower and Kennedy also supported it as a reward to their science advisors for help in the arms race and arms control. Strauss and McCone were suspicious of the project because it came from scientists who espoused defense policy disagreeable to them. PSAC remained the project's strongest backer because it fit the committee's goal of strengthening basic research, which, in the aftermath of Sputnik, had to compete with an avalanche of applied defense and space projects. Unable to make plausible utilitarian promises, however, Big Science practitioners such as the Stanford physicists had to use the Cold War competition for national prestige and rely on a network of scientists in government to achieve their scientifically meritorious but financially difficult goals. Sputnik marked a turning point in the politics of Big Science not only by creating a new popular enthusiasm for basic research and scientific exploration, but also by bringing scientists such as PSAC and its Piore panel into power. Finally, economic prosperity in the 1950s and 1960s made the expansion of high energy physics fiscally possible.

The return from such investment is, however, difficult to measure and controversial even among physicists themselves.[117] When pressed, spokesmen for high energy physics usually pointed to increase in national scientific vitality, international prestige, and potential technological spinoffs. The prominence of high energy physicists among government science advisors both reflected and reinforced the perception of the field's importance. Since the 1960s, critics such as Alvin Weinberg have lamented the isolation of high energy physics from other disciplines. In response, high energy physicists emphasized the value of their field in training scientists for other lines of work.[118] Without quantitative analyses, however, the

116. Ref. 100, 264–265.

117. See, for example, "Has particle physics fulfilled its promise?" *Physics today, 48* (Feb 1995), 13, 15.

118. See for example, *High energy physics research*, hearings before the Subcommittee on

argument is hard to prove or disprove. It has, in any case, become largely irrelevant as the debate in science policy shifted from the priority of high energy physics in science to science in society. Increasingly, the push toward higher energies became the special pleading of a powerful subdiscipline for public support of socially useless activities. No doubt most of Robert Wilson's colleagues were proud of his famous defense of their field in Congress that "it has nothing to do directly with defending our country except to help make it worth defending."[119] The inadequacy of such moving but vague justification can be seen in the rejection of the SSC at a time when economic competitiveness, rather than intellectual achievement, came to preoccupy the nation.

The examination of PSAC's involvement in the federal funding of SLAC points to the need to modify the terms of the debate over "who's using whom" in the relationship between American science and the national security state. Above all, the SLAC story shows that neither the government nor the scientific community was monolithic: there were opposing views not only between the executive branch and Congress, but also within the administration, and within the scientific community. The demarcation between science and government became further blurred as the Sputnik crisis brought about a deep intermixing: scientists, as represented by PSAC, rose as influential advisors in both "science in policy" and "policy for science," and the government assumed an increasingly more dominant role in science funding. The role of science advisors and science administrators, such as Killian, Fisk, Kistiakowsky, Wiesner, Seaborg, and other members of PSAC and other science advisory bodies, as "mediators" between science and government deserves closer study.

The limited evidence in this case study seems to support Kevles' view of "mutual dependence," although the enhanced status of basic research after Sputnik seems to have made scientists feel, and sometime act, less dependent on the military than they were in the pre-Sputnik period considered by Forman and Kevles. Sputnik not only brought bigger budgets for science, but also a psychological boost for scientists. As we have seen in the struggle for the funding of SLAC, defense institutions such as the ONR often had to appeal to the newly-powerful PSAC in their inter-agency competition for desirable programs. Indeed, to his discomfort Kistiakowsky learned at one point that "everybody in the Air Force from the secretary down now thinks that you control the entire military R&D program."[120]

Research, Development, and Radiation of the JCAE, 89th Congress, 1st session (USCPO, 1965), 39, 216.

119. Wislon is quoted by Marvin L. Goldberger in *Science and the Congress: The third Franklin conference* (Philadelphia, 1978), 138.

120. Kistiakowsky (ref. 44), 200.

SLAC was not the only success PSAC had in its effort to enhance basic research. At the same "Symposium on Basic Research" in 1959 in which Eisenhower announced the decision to build the Stanford accelerator, Killian observed that "since the Korean War, the amount of money for the development of 'things' has increased more, in proportion, than the funds available for basic research." "Happily," Killian continued, "in the past year-and-a-half, basic research has been gaining." PSAC became, in Killian's words during a committee meeting, the "beachhead" of science in government.[121] The "Golden Age" in science support in the late 1950s and early 1960s saw federal budgets for basic research at universities leap from $127 million in 1958 to $564 million in 1964, effecting an annual increase of between 20 and 40 percent and far surpassing the growth of either total research and development or gross national product.[122]

Yet, PSAC's frustrations during the campaign for SLAC shows the limits of the power of the new science advisors. While Sputnik and the Cold War had a strong accelerating effect on American science, more traditional forces, such as domestic partisan politics, bureaucratic turf wars, and competition within the scientific community continued to exert their influence in science policy. The further identification and analysis of these factors in the making of postwar science policy remains a challenge to historians of recent American science.

121. Killian, "Capsule conclusions," in Wolfle (ref. 1), 121–126, on 122; Beckler, "Excerpts from meeting of the President's Science Advisory Committee [on March 14, 15, 1960]: Discussion of the organization of science in government," in RG 359 (ref. 107), box 176, folder "Government R&D."

122. NSF, *Federal funds for research and development and other scientific activities* (Washington, 1971), 220. For a critical assessment of the "Golden Age," see Nathan Reingold, "Science and government in the United States since 1945," *History of science, 32* (1994), 361–386.