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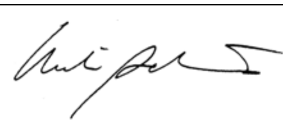
MELVIN SCHWARTZ

1932-2006

A Biographical Memoir by

N. P. SAMIOS AND P. YAMIN

Courtesy of Brookhaven National Laboratories.



MELVIN SCHWARTZ

November 2, 1932–August 28, 2006

BY N. P. SAMIOS AND P. YAMIN

MEL SCHWARTZ DIED ON August 28, 2006, in Twin Falls, Idaho. He was born on November 2, 1932, in New York City. He grew up in the Great Depression, but with a sense of optimism and desire to use his mind for the betterment of humankind. He entered the Bronx High School of Science in the fall of 1945. It was there that his interest in physics began and that he recognized the importance of interactions with peers in determining his sense of direction in life. One of his classmates and future colleagues recalled that "even then" he wanted a Nobel Prize. Mel noted:

My interest in physics began at the age of 12 when I entered the Bronx High School of Science. The four years I spent there were certainly among the most exciting and stimulating in my life, mostly because of the interaction with the other students of similar background, interest, and ability.

On Sunday afternoons he attended a school run by the secular and Zionist Yiddish Nationaler Arbeter Farband (Jewish National Workers Alliance). He spent a summer at their Camp Kinderwelt in upstate New York. The summer that he was 16 he met his future wife, Marilyn, at another camp run by the Labor Zionist Youth Organization. She was 15.

Mel Schwartz's life can be considered an American success story: immigrant parents, educated in New York public schools in an era when all schools, kindergarten through 12, provided a first-rate education for all children of the City of New York. From high school he went on to Columbia College, majored in physics, and graduated with an A.B. in 1953. He cherished his days at the college and especially appreciated the core courses, Humanities and Contemporary Civilization. In September of 1953 Mel entered the Columbia Graduate School of Arts and Sciences and in November married Marilyn.

This was a most auspicious time for Physics at Columbia. Among the faculty were I. I. Rabi, T. D. Lee, C. H. Townes, P. Kusch, J. Rainwater, N. Kroll, V. Hughes, C. S. Wu, L. Lederman, R. Serber, and J. Steinberger, who became Mel's thesis adviser. This group was augmented by visitors, including M. Gell-Mann and A. Pais, and by superlative postdocs and graduate students including V. Fitch, L. Cooper, G. Feinberg, S. Weinberg, and many others. As Mel commented, "This faculty [was] at this time unmatched by any in the world, largely a product of the late I. I. Rabi." It was during this time, the mid-1950s, that Gell-Mann introduced the concept of strangeness as a new quantum number for particles and Donald Glaser invented the bubble chamber. In this environment Jack Steinberger decided to pursue both of these new developments with a group of new graduate students, Mel Schwartz, Jack Leitner, and one of us (N.P.S.). This group conducted the first bubble chamber experiment at the Brookhaven National Laboratory in 1956 and produced much important and exciting physics, including the discovery of the $\Sigma 0$ hyperon, the observance of parity violation in Λ-decay, the properties (masses, lifetimes, branching ratios) of strange particles, as well as the parity of the $\pi 0$ meson.

Mel received his Ph.D. in 1958, was employed as a research scientist at Brookhaven National Laboratory 1956-1958 and joined Columbia University as an assistant professor in 1958. He was subsequently promoted to associate professor in 1960 and professor in 1963. During this period Marilyn and Mel had three children: David, born in 1956, Diana in 1958, and Betty in 1962.

It was during the standard afternoon coffee at the Columbia physics department that Mel came up with the idea of producing high energy neutrino beams. This was in response to a question posted by T. D. Lee: "All we know about the weak interaction is based on observations of particle decay, and therefore very limited in energy. Could there be another way towards progress?" Mel provided the answer. In fact, this episode is an excellent example of the enormous value of afternoon coffee and cookies in affording a forum for the exchange of ideas among physicists.

Mel had an intuitive feel for physics. This can be seen in the development of the experiment for which he shared the Nobel Prize in Physics for 1988. In the process of radioactive beta decay, a nucleus emits either an electron or positron, a neutron in the nucleus becomes a proton, or vice versa, and the atomic number changes by one unit. Because the electron or positron emitted in these processes was observed not to have a unique energy, an electrically neutral, weakly interacting, and unobserved "neutrino" was hypothesized to be emitted as well. We can describe the basic interaction as

$n \rightarrow p + e^- + \bar{\upsilon}$

or $p \rightarrow n + e^+ + \upsilon$

where υ or $\bar{\upsilon}$ indicates neutrino or antineutrino, respectively.

The existence of the neutrino was experimentally verified by Frederick Reines and Clyde Cowan (1956). Near a nuclear reactor, where there is a high flux of antineutrinos coming from the radioactive decay of fission fragments, they observed the production of positrons in the inverse reaction, $\bar{\upsilon} + p \rightarrow n + e^+$.

Since the 1950s, it was known that the muon, produced in the decay of the pion,
$\pi^\pm \rightarrow \mu^\pm + (\upsilon/\bar{\upsilon})$, principally decays into an electron, a neutrino, and an antineutrino:

$\mu^\pm \rightarrow e^\pm + \upsilon + \bar{\upsilon}$.

But the decay $\mu^\pm \rightarrow e^\pm + \gamma$ should also have been observed. It was not. Something was inhibiting the reaction, perhaps a new conservation law. This led to the hypothesis that muon number and electron number are separately conserved and that there are two types of neutrinos: one associated with the muon, υ_μ and one with the electron, υ_e . $\mu^\pm$ carry muon number ± 1, and $e^\pm$ carry electron number ± 1, as do their respective neutrinos and antineutrinos. This would imply that the processes are more complicated than indicated above, for example,

$p \rightarrow n + e^+ + \upsilon_e$, $\pi^+ \rightarrow \mu^+ + \upsilon_\mu$ and
$\upsilon_\mu + n \rightarrow p + \mu^-$. The subscript on the neutrino, e or μ, indicates its origin or "flavor." Mel thought of a way to test this experimentally.

On February 23, 1960, he submitted a one-page paper to *Physical Review Letters* (Schwartz, 1960) suggesting that a beam of high-energy neutrinos could be produced at any of several new accelerators then under construction. His idea was quite simple. Protons from the accelerator strike a target, producing $\pi^\pm$. These travel some distance and then decay into $\mu^\pm$ and either a muon neutrino or antineutrino, where the neutrino/

antineutrino has a relatively high energy. Subsequently, the muons and remaining pions are stopped in a massive shield, through which most of the neutrinos/antineutrinos pass unimpeded. Rare interactions of the neutrinos or antineutrinos would be observed in an unspecified detector situated in the middle of the shielding. The scheme is illustrated in Figure 1, taken from Schwartz (1960, p. 306).

If the neutrinos and antineutrinos arising from the decay of pions into muons carry the “flavor” of the parent muon when they interact with neutrons or protons in a detector, they would produce only muons. If they don’t carry the flavor, they could also produce electrons. The concept is simple. Observe the interactions of neutrinos emanating from pion decay. If only muons are produced, there are two types of neutrinos, υ_μ and υ_e. If both electrons and muons are produced, there is only one type of neutrino and the absence of $\mu \rightarrow e + \gamma$ remains a mystery.

On May 26, 1960, Jean-Marc Gaillard, Leon Lederman, Mel Schwartz, and Jack Steinberger submitted a proposal to Brookhaven, siting the experiment at the newly-constructed Alternating Gradient Synchrotron (AGS), and using a propane bubble chamber as the detector. By September 22 of that year the concept had evolved to a different design. The

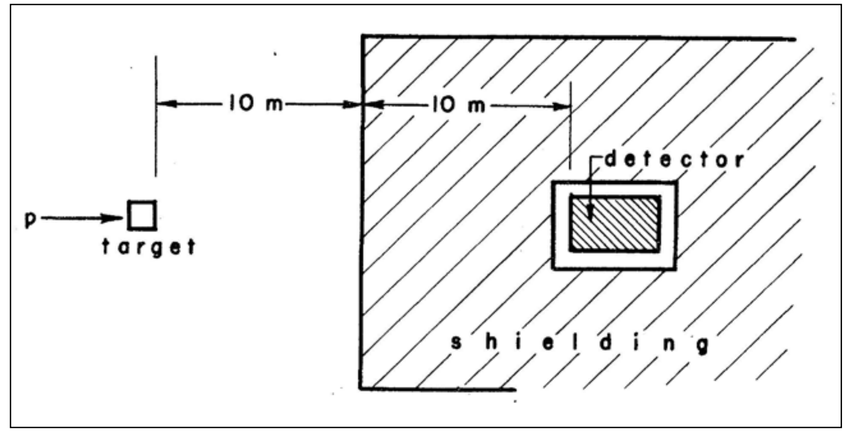


FIGURE 1 Schwartz’s initial neutrino beam concept.

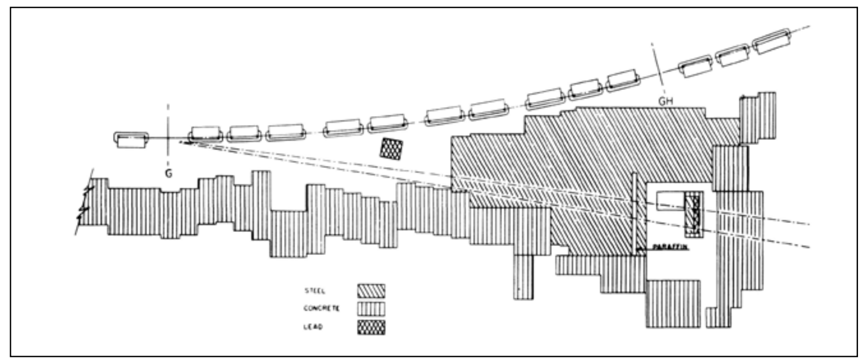


FIGURE 2 The design of the neutrino experiment at the Brookhaven Alternating Gradient Synchrotron.

bubble chamber was replaced by the newly-invented spark chamber, in which electrons are clearly distinguishable from muons. Mel built the spark chambers.

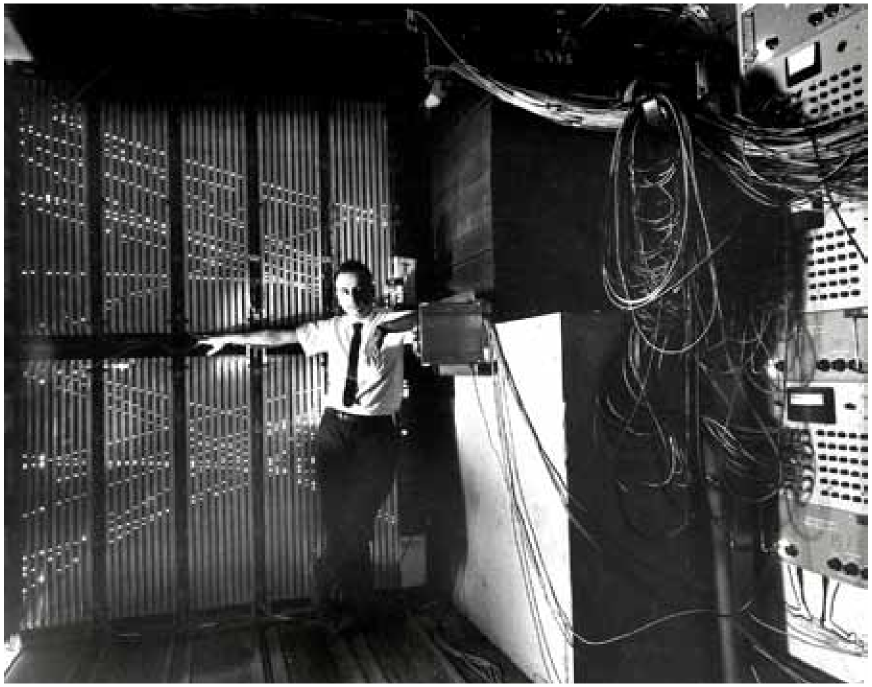
On June 15, 1962, the above four authors, joined by Gordon Danby, Konstantin Goulianos, and Nari Mistry submitted their results to *Physical Review Letters* (Danby et al., 1962). The layout of the experiment is shown in Figure 2 and can immediately be recognized as an elaboration of Schwartz's original concept.

Analysis of the tracks in the spark chambers showed predominantly muons, whose tracks are clean. A small number of "fuzzy" electron tracks were attributable to background processes. The experiment confirmed the two-neutrino hypothesis. (Subsequently, a third neutrino flavor was discovered. It is associated with the tau lepton.)

Lederman, Schwartz, and Steinberger shared the 1988 Nobel Prize in Physics for this work. Mel was a generous man. Although the concept of a neutrino beam produced at an accelerator was his, he made the following acknowledgment in his acceptance speech:

> Jack [Steinberger] was my teacher, my mentor and my closest colleague during my years at Columbia. Whatever taste and judgment I have ever had in the field of Particle Physics came from Jack. Third of course is T. D. Lee. He was the inspirer of this experiment and the person who has served as a constant sounding board for any ideas I have had. He has also become, I am proud to say, a dear personal friend. And finally, my close collaborator, Leon Lederman. If there is any one person who has served as the sparkplug for high energy physics in the U.S. it has been Leon. I am proud to have been his collaborator."

After several more years of activities at Columbia, Schwartz decided that a change might be fruitful and beneficial. This was not unexpected, since Jack Steinberger had gone to CERN and Leon Lederman would soon go to Fermilab. In 1966 Mel went to Stanford University where the SLAC 30 GeV linear accelerator was nearly completed. During this period, he performed two experiments at SLAC and one at Brookhaven. The first involved the search for a charge asymmetry in the decay $K_L^0 \to \pi^{\pm} + \mu^{\mp} + \bar{\upsilon} / \upsilon$. At first Mel was delighted by the early data, which indicated a very large asymmetry, in contradiction to all expectations. On closer inspection it was found that some of the iron in the detector was magnetized, thereby contributing to this enormous asymmetry. After correcting this flaw, the final experimental result came in at a few tenths of a percent, contributing to the understanding of CP violation. The second experiment was pure vintage Schwartz: a beam dump experiment. It involved a search for something new and unexpected. Mel proposed guiding the full-energy electron beam onto an iron target followed by an absorber that stopped all the hadrons and muons. A detector behind the beam dump would look for



A pleased Mel Schwartz, standing by the spark chambers that he built. The tracks in the spark chambers are a multiple exposure of cosmic-ray muons, which show the same "clean" straight character as muons arising from neutrino interactions.

(Courtesy of Brookhaven National Laboratory)

something new, which he called "strange light." He found two events. In retrospect these probably were neutrino-induced neutral current reactions, which were discovered three years later at the European laboratory, CERN.

The third experiment involved the search for an atom consisting of a pion and muon emitted from the decay of a K_L^0. This was conducted at Brookhaven and Fermilab, where a total of 155 such events was observed with a branching ratio of 4×10^{-7}. During the time that Mel was active on the AGS floor, Sam Ting was also there searching for heavy vector mesons and Burt Richter was observing electron-positron collisions at SLAC. In his own puckish way Mel became a communications link between the east and west coasts, disclosing Ting's preliminary experimental results. The J/ψ was discovered in 1974, almost simultaneously at Brookhaven and SLAC. Priorities were nicely resolved when both Ting and Richter shared the Nobel Prize in Physics in 1976.

In 1972 Mel published the textbook, *Principles of Electrodynamics*. He began its preface by saying, "Electromagnetic theory is beautiful! When looked at from the relativistic point of view where electric and magnetic fields are really different aspects of the same physical quantity it exhibits an aesthetically pleasing structure…." He then went on to show that all of electromagnetism follows from electrostatics and special relativity. The

Left to right: Jack Steinberger, Konstantin Goulianos, Jean-Marc Gaillard, Nathan Mistry, Gordon Danby, Warner Hayes, Leon Lederman, and Melvin Schwartz in 1962.

(Fermilab Visual Media Services, courtesy AIP Emilio Segre Visual Archives)

book was reprinted in paperback in 1987 and a Greek translation was published in 1979. Although *Principles of Electrodynamics* is not widely used in the U.S. (perhaps because Mel's idosyncratic approach necessitated Gaussian units), the paperback is still available and rave reviews of it are posted on Amazon.com.

During Mel's tenure at Columbia and Stanford he supervised about ten graduate students. Many of them did not pursue careers in high energy physics. Among the best-known who did are Konstantin Goulianos (Columbia), now at Rockefeller University; and Robert Cousins (Stanford), now at UCLA.

Frustration with inadequate support from SLAC as well as the increasingly bureaucratic nature of high energy physics—theoretically driven program advisory committees, large detectors, and large teams—led Mel to alter his career. In 1970 he and Len Birkwood, an engineer in the SLAC "G" Group, founded Digital Pathways, a company devoted to computer security. Mel was responsible for marketing and Birkwood for product design. Their initial product was a battery-operated calendar and clock for PDP-11 computers. This evolved into a security device interposed between a modem and a computer to make sure that users logging in remotely were legitimate.

Mel was not always prescient. Steve Jobs had been auditing one of Mel's classes at Stanford, and they became friends. Because Jobs and his Apple cofounder, Steve Wozniak, were having trouble acquiring parts from their distributors, Mel, as a favor, had Digital Pathways buy their parts. During the winter of 1975-1976 at a lunch in a Palo Alto Chinese restaurant, Jobs and Wozniak showed Mel and Birkwood a "hacked together" prototype PC board and asked for a $25,000 investment in Apple from Digital Pathways. Mel declined, saying that "personal computers won't go too far and that Apple is a bad name." He wished them the best of luck and they remained friends. Jobs was present at the memorial service for Mel at Stanford.

Mel secured venture capital funding for Digital Pathways, but he did not hand over technical control. In 1980 the firm had about seven employees and a business of about $1 million a year. (Mel's daughter, Betty, was the part-time receptionist and Mel collected the mail to check for orders.) In 1983 Mel left Stanford to devote himself full-time to Digital Pathways; by 1987 the firm had 45 employees and a business of $30 million per year. He began looking toward an IPO. Mel took out a $500,000 mortgage on his house, and while in London in pursuit of additional funding suffered chest pains. Nevertheless, he retained active control of the company until 1990, and remained on its board afterward. However, plans for an IPO did not pan out and in 1993 Digital Pathways was sold. None of the investors lost money, but it was not the spectacular success for which Mel had hoped.

Mel embarked on such a venture not only because of the challenge of succeeding in a new arena but also because of the remote prospect of accumulating sufficient wealth to enable him to go to any lab and fund any experiment he desired without the ordeal of needing the approval of any committees. It was the latter part of the period 1983-1991 that one of us (N.P.S.) approached Mel about the possibility of coming back to physics

Left to right: Jack Steinberger, Melvin Schwartz, and Leon Lederman in 1988.

(Courtesy of Brookhaven National Laboratory)

at Brookhaven. There were several reasons why this approach succeeded: eight years in industrial life was enough and it was time to try something new; the experimental program at the AGS was well suited to Mel's taste, relatively small, clearly relevant, and with opportunities for some clever experiments. In 1991 Brookhaven had started building the Relativistic Heavy Ion Collider (RHIC), designed to be a machine with a high discovery potential that could greatly benefit by guidance from a

Mel was told that he would have to shut down the AGS program in a few years. This seemed unreasonable to him, and he strongly objected. Mel told the official to "go fly a kite," but in earthier New Yorkese.

person with Mel's interests and tastes. This proved to be true. Mel joined Brookhaven as Associate Director for High Energy and Nuclear Physics in 1991 and molded both programs. At the AGS he fostered the search for new K-decays at sensitivities of 10^{-7}–10^{-10} and the tour de force measurement of the anomalous magnetic moment of the muon, g-2. The original 11 RHIC proposals were rejected by Schwartz and his advisory committee. He then reconfigured them into four unique and ultimately productive experiments. These, indeed, discovered something new and unexpected: the strongly interacting quark-gluon plasma, a "perfect fluid" and one of the major discoveries at RHIC.

During this time Mel demonstrated his disdain for bureaucrats. At an annual Department of Energy review of the Brookhaven high-energy physics program, there was a heated exchange between Mel and a high-level Department of Energy official. Mel was told that he would have to shut down the AGS program in a few years. This seemed unreasonable to him, and he strongly objected. Mel told the official to "go fly a kite," but in earthier New Yorkese. It is ironic that the AGS physics program that Mel advocated in 1991, using intense beams to study rare processes, has become a centerpiece of the U.S. high-energy physics program in the 2010s. It is now called the "Intensity Frontier." The AGS was closed down for high-energy physics in 2003.

After a fruitful tenure as Associate Director of High-Energy and Nuclear Physics at Brookhaven, Mel returned to his alma mater, Columbia University, in 1994, where he taught and was I. I. Rabi Professor of Physics. Columbia honored him with the John Jay Award and the Alexander Hamilton Medal. He retired in 2000 and moved to Ketchum, Idaho, where he spent his final years. Among Schwartz's attributes was his ability to get along with and befriend a large portion of the high-energy physics community. Amazingly, he was on close terms with a diverse group of strongly opinionated individuals, among them L. Alvarez, L. Lederman, V. Telegdi, and M. Veltman. We have all benefited from having known Mel Schwartz, and it is refreshing to note a smile appearing on faces when his name is mentioned.

The authors are grateful for the assistance of Marilyn Schwartz and would like to acknowledge helpful discussions with Elliot Auerbach about Mel's high school years, and with Len Birkwood (deceased 2011) and Ainsley Mayberry about Mel's time at Digital Pathways.

HONORS AND FELLOWSHIPS

Phi Beta Kappa

National Science Foundation Fellowship 1953-1954, 1955-1956

Quincy Ward Boese Fellowship 1954-1955

American Physical Society Hughes Prize 1964

Fellow, American Physical Society 1964

Alfred P. Sloan Fellowship 1959-1963

Guggenheim Fellowship 1966-1967

Member, National Academy of Sciences 1975

Nobel Prize in Physics 1988

D.Sc., Columbia University 1991

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