Saturday Morning Physics: A Report Card

Drasko Jovanovic, Barbara Grannis, and Marjorie Bardeen

Saturday Morning Physics (SMP), a ten-week program for high school students, has been held three times a year at Fermilab since 1980. The purpose of the program is to further the understanding and appreciation of modern physics among high school students who have demonstrated an ability and interest in mathematics, physics, chemistry, and science in general.

Conceived by Fermilab Director Leon M. Lederman, and formulated with the aid of several Fermilab physicists, the program has been directed by Fermilab physicist Drasko Jovanovic for the past four years. Each Saturday morning session lasts for three hours and consists of a 1-1/2 hour lecture, and a 1/2-hour tutorial and tour of Fermilab's accelerator, research, and industrial facilities. Fermilab scientists and engineers serve on a volunteer basis as lecturers and tutorial group leaders for the program. The lecture topics for the ten-week session are listed at the close of this article.

The popularity of the program is evidenced by the continuing high rate of applicants, the interest of the participating schools and their principals, and the enthusiasm of the students and their families. Nearly 2000 students have "graduated" from SMP since its inception.

In April 1986 a survey was mailed to students who participated in the program during the years 1980-81 and 1981-82 in an attempt to ascertain the long-range impact of the program. Five hundred questionnaires were mailed with a stamped envelope enclosed. Of these, 150 were returned as undeliverable (addresses were up to six years old) reducing the survey group size to 350. The response rate (58%- 202/350) was extremely high. In addition, the vast majority of the respondents paid considerable interest in the survey, writing several paragraphs in response to those questions which required a brief essay-type answer. The first five questions covered the respondents' careers, the last three dealt with the impact of the program.

Question 1 ("If you attended college, what field did you major in?") assumed that all SMP graduates attended college. This was indeed the case. There was not

a single response indicating a college drop-out or non-attendance of college/ university. The group continuing on to graduate school is smaller (26/202). However, 79 of the respondents are still in college and so have not yet had to make a decision on graduate education.

Question 3 ("Are you now employed?") was answered positively by 94 respondents, with an overall breakdown as follows:

employed:	94
undergraduates:	79
graduate students:	27
unemployed:	2
	202

The career choices of the respondents indicate a highly motivated professional group. Almost 43% chose an engineering field and a further 10% chose computer science or business/marketing. Mathematics, physics, and related disciplines were chosen by a further 15% of the group; thus, almost 80% are working toward careers in challenging fields important to current U.S. goals in science and technology leadership.

Question 2 ("What school/university did you attend?") reveals that SMP graduates are attending or have attended some of the most prestigious institutions of higher education in the U.S. These include several "Ivies," MIT, Chicago, Northwestern, Stanford, the Air Force and Naval Academies, and highly selective midwestern state schools such as the University of Illinois at Urbana-Champaign, University of Wisconsin-Madison, and the University of Michigan. Seventy-four per cent of the students chose schools located in Illinois.

Questions 6 through 8 dealt with the impact of SMP on career choices and requested suggestions on changes to the SMP curriculum. Question 6 ("Did the lectures have some impact on your scholastic career?") was answered positively by 148 students, approximately 70% of the group.

Question 7 continued from Question 6, requesting information on what that impact was. Quotations from the surveys can best illustrate the students' responses:

"The lectures really turned me on to science and technology - I decided to go for engineering rather than business."

"Made me learn to see beyond my fingertips."

Even those who responded negatively to Question 6, that is those who chose fields unrelated to science or technology, answered the question enthusiastically:

"The lectures introduced me to a new discipline," (economics major).

"My involvement in the program excited my curiosity about new ideas and technologies - made me a more rounded individual," (accounting major).

The response to Question 8 ("Would you have any advice for us as to how to make SMP more valuable, now that you can look back with some perspective?") proved most gratifying to SMP staff. Only one criticism emerged: that some of the lectures were at too high a level for some students. A few of the most illustrative comments are listed below.

"I will be a high school physics teacher by fall. The program at Fermilab was very valuable, and was valuable to both students and teachers that attended. Often college physics courses tend to lose some of the excitement and become quite dry. Hearing from scientists who were excited about their fields was a great experience. Speaking with those people one on one was also good. ...I was just thinking about your program last week and wishing there was one like it around here that I could attend again as a teacher. Thanks!" (graduate student, Winona State University).

"The tours were very interesting but the lectures were often above our level of understanding since many of the students had an introductory high school physics class as background," (student, psychology/economics, University of Illinois).

"I thought the classes were FANTASTIC! It was a part of my high school education that I am proud of," (credit analyst, commercial bank)

In order to extend the impact of the SMP experience to students and the general public who are unable to attend the course in person, the Friends of Fermilab Association initiated the Saturday Morning Physics Videotape Library project in 1983. The project was funded by a grant from the Aurora Foundation, Aurora, Illinois. Nine of the SMP lectures were condensed to 55 minutes for taping. A viewer's guide was developed to accompany the tapes. Videotapes were duplicated in both 1/2-in. and 3/4-in. format and distributed to ten institutions including central public libraries and museum libraries. Brochures advertising the availability of the tapes were distributed widely to schools and colleges throughout northeastern Illinois. Although the videotapes do not substitute for personal attendance, they do assist substantially in introducing viewers to topics in modern physics. Arrangements may be made for obtaining videotapes by contacting:

Friends of Fermilab Association
Fermilab MS 107
P.O. Box 500
Batavia, IL 60510
(312) 840-3211

Lecture Topics:

Introduction: What is an Elementary Particle? From Molecules to Quarks with a Pause at the Hydrogen Atom.

Special Theory of Relativity

How Do We See Particles? Interaction of Radiation with Matter; Detectors.

Conservation Laws and Symmetry Principles: Energy, Momentum, Rotation, Left-Handedness and Right-Handedness, Time, and Antimatter.

Quantum Theory; Particles and Waves; Quantum Numbers and the Intrinsic Properties of Elementary Particles, i.e., Charge, Spin, Mass, Strangeness, etc.

How Do We Make Particles? Accelerators, Beam Transport, and Assorted Technologies.

Leptons and Quarks; Electrons, Muons, Taus, and Neutrinos of the Lepton World, Mesons and Baryons and Their Constituents: the Quark Model.

The Forces of Nature and Their Carriers: Photons, W's, and Gluons.

The Connections of Particles with Cosmology: How the World Began, Massive Neutrinos, Pulsars, Neutron Stars, and Black Holes.

Particle Physics Spin-Offs: Technology and Applications to Other Fields, Current Problems, and Future Prospects.

M. Stanley Livingston
1905 - 1986

M. Stanley Livingston, a giant in the development of particle accelerators and a former associate director of Fermilab, passed away at the age of 81 in August.

Livingston was a student under Ernest Lawrence, the inventor of the cyclotron, the first circular accelerator. Another student of Lawrence's had built a cyclotron, but failed to demonstrate the basic principle of the device. Then Livingston came to the task. Together, he and Lawrence built a tiny cyclotron in 1931 and 1932 and showed that it operated in accord with Lawrence's concept. They then went on and built the "27 inch" cyclotron, which later became the "32 inch" and had a long and splendid career, ending up at UCLA in the 1960s. It is now in the Smithsonian Museum in Washington.

Livingston left Berkeley and went to Cornell. In his years there he wrote, with Hans Bethe and Robert Bacher, a definitive series of articles in the *Reviews of Modern Physics* that have been described as "making nuclear physics a science." He also built another cyclotron, which continued in operation well into the 1950s; Bethe once commented that "pound for pound, that machine did more research and trained more students than any accelerator ever built."

Livingston moved on to MIT and built another fine cyclotron. After war work on radar, he participated in the formation of Brookhaven Laboratory and was the first head of the Accelerator Department, helping to lead the design and construction of the Cosmotron, the first accelerator to go beyond a GeV. When the cosmotron began to operate in 1952, Livingston raised questions about focusing to Ernest Courant and the answers led them, with Hartland Snyder, to the conception of alternating gradient focusing, the foundation of all modern accelerator technology. Livingston collaborated in the early stages of design of the Alternating Gradient Synchrotron at Brookhaven, but his heart was still at MIT and he returned there to design and build the Cambridge Electron Accelerator, the first alternating gradient electron synchrotron. Livingston was director of the CEA laboratory until 1967, when Fermilab began. During these years, he and John Blewett wrote the classic book *Particle Accelerators*, still in use today after 25 years.

He came to our laboratory in the early days and worked to help in the setting up of many laboratory policies and practices. He described his own role as an "elder statesman." "Wise counselor" and "friend to all" would be equally appropriate names. Stan Livingston retired from Fermilab and moved to Santa Fe, where he and his wife had bought land for a house many years before. In retirement, he was active as an advisor to the Los Alamos Laboratory and as an administrative judge for the Nuclear Regulatory Commission. He also pursued his silversmithing avocation, producing pieces which reflected a strong Southwestern aesthetic. He had been ill for much of the last year before he died.

Certainly M. Stanley Livingston left his technical mark on the field of particle accelerators. He played major roles in the two most important developments of accelerators, the circular accelerator and alternating gradient focusing. He will be remembered with great respect for these contributions. He will also be remembered with great affection by all those who knew him and benefited from his friendship and wisdom.

F.T. Cole