signs of real variation in the flux.

**Blackbody radiation.** The Los Alamos group (A. G. Blair, J. G. Beery, F. Edeskuty, R. D. Hiebert, J. P. Shipley and K. D. Williamson Jr) reported in *Physical Review Letters*[1] their rocket-borne radiometer measurement in the wavelength interval 6–0.8 mm. Radiation from a blackbody at about 3 K peaks at around 1.5 mm; so this wavelength range covers the blackbody peak nicely. Their radiometer responds to about 65% of the energy in a 3-K spectrum. The average signal during the 110 sec of observations allowed by the rocket flight was equivalent to that from an isotropic blackbody with a temperature of $3.1(+0.5, -2.0)$K. (Big-bang cosmology suggests a blackbody background equivalent to 2.7 K.)

Earlier measurements by James Houck and Martin Harwit of Cornell[2] covered the range 0.5 to 1.3 mm, and caused some excitement by showing a flux in this range 50 times more than expected from longer-wavelength extrapolations. Perhaps the "blackbody" curve had a bump in it? The new data from the Los Alamos group does not show this excess flux. But, Blair told PHYSICS TODAY, this doesn't necessarily mean that the high flux is not there—it suggests that if there is a bump it occurs between 0.5 and 0.8 mm. Blair went on to point out that, although his group is in general agreement with Houck and Harwit, there is some disagreement with the observations of Dirk Muehlner and Rainer Weiss of Massachusetts Institute of Technology, who flew a radiometer with a similar filter to the Los Alamos one (cutting off at 0.8 mm) on a balloon flight.[3] Muehlner and Weiss reported a blackbody equivalent temperature of 8 K, which they could reduce to 7 K by making corrections—for example, to allow for the portion of the atmosphere above their balloon. L. J. Caroff and V. Petrosian[4] have suggested that further corrections could bring the equivalent temperature down further, to about 6 K, but this is still much higher than the 3.1 K of the new measurements.

**100-micron measurements.** Rocket observations at a much shorter wavelength, 100 microns (too short for the cosmic blackbody radiation to have any influence) have recently been reported in *Nature Physical Science* by D. P. McNutt and K. Shivanandan (E. O. Hulburt Center for Space Research, at the Naval Research Laboratory) with P. D. Feldman (Hulburt Center and Johns Hopkins University),[5] and also by Blair,[6] whose rocket flight took data in this wavelength range as well as in the 0.8 to 6-mm range mentioned above.

These two rocket flights bring to five the number of such measurements reported since 1969. Two are by Houck and Harwit's group at Cornell, two by McNutt's group at the Naval Research Laboratory, and the other is Blair's at Los Alamos. The five measurements divide into two groups. One set (including one of the Cornell flights and the recent NRL flight) shows a relatively high flux, about $10^{-9}$ watts cm$^{-2}$ sr$^{-1}$, whereas the other set (the other Cornell flight, the other NRL flight, and the one by Los Alamos) give a much lower flux—around $10^{-10}$ to $10^{-11}$ watts cm$^{-2}$ sr$^{-1}$. These numbers all refer to total flux integrated over the bandwidth of the detector, but referred to 100 microns. The Cornell and NRL work was done with gallium-doped germanium photodetectors, whereas the Los Alamos detector was gallium-doped germanium used in the bolometer mode, with a filter to determine the bandwidth. In each case the response is nonlinear, extending from about 40 microns up to 150 microns, with a peak at 100 microns.

The variation could perhaps be explained as a diurnal effect—maybe the observed flux depends on the time of day. The rockets that showed the higher background went up at around two or three hours after local sunset, and the low-background ones were launched between midnight and 2 a.m.

It is pointed out in the NRL paper[5] that the lack of appreciable variation in the flux as the rocket rose to 275 km, and the lack of any variation with zenith angle for angles less than 20 deg, prove that the radiation does not come from the ionosphere. It could come from the outer magnetosphere, however, or from the interplanetary medium near the Earth, where it could be subject to a diurnal variability.

Another possibility is that the magnitude of the 100-micron flux depends on the occurrence and extent of disturbances in the Earth's magnetic field—the so-called "magnetic storms." A definite effect of this kind has been observed by M. N. Markov,[7] who looked at 0.8–45-micron radiation originating in layers between 70 and 500 km altitude. The correlation was particularly marked for the wavelength band between 4.5 and 8.5 microns. At the longer wavelength, 100 microns, discussed by McNutt and Blair, some correlation exists for the five measurements reported so far—magnetic activity in general was high for the high-background flights and low for the low-background ones—but this might be merely coincidence. —JTS

#### References


1. A. G. Blair, *et al*, Phys. Rev. Lett. 27, 1154 (1971).
2. J. R. Houck, M. Harwit, Astrophys. J. 157, L245 (1969).
3. D. Muehlner, R. Weiss, Phys. Rev. Lett. 24, 742 (1970).
4. L. J. Caroff, V. Petrosian, Nature 231, 378 (1971).
5. D. P. McNutt, K. Shivanandan, P. D. Feldman, Nature Physical Science 234, 25 (1971).
6. A. G. Blair, Nature Physical Science 234, 26 (1971).
7. M. N. Markov, Kosmicheskie Issledovaniya (Cosmic Research) 8, 904 (1970).


## Progress at Stanford's superconducting linac

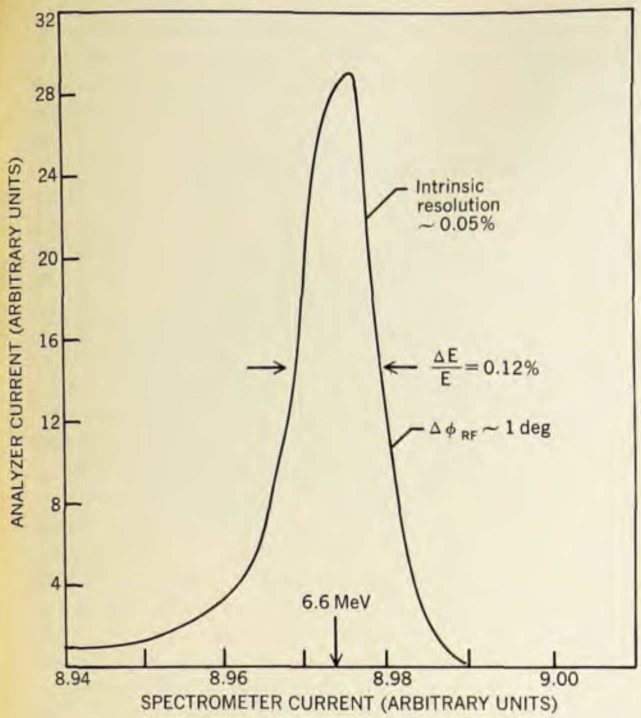
During the past year many problems connected with development of the superconducting linear accelerator at Stanford have been resolved, according to Alan Schwettman and William Fairbank of Stanford's High-Energy Physics Laboratory. When we recently visited the laboratory, the two men told us that in the past year they had demonstrated that an intense continuous electron beam can be produced in a superconducting accelerator with exceptional stability and energy resolution. But a critical problem remains—achieving the high energy gradients of 4 MeV/ft hoped for in the superconducting structures.

**Last summer** the Stanford group, which includes Michael McAshan, Larry Suelzle and John Turneaure, ran some tests on prototype sections of the superconducting accelerator, operating the 7-cell capture section and the 23-cell preaccelerator section.

In these tests a 50-microamp beam at 30% duty cycle was accelerated to an energy of 6.6 MeV, and the output beam characteristics were measured carefully. The accelerating fields in the two prototype structures were shown to be stable to better than 1 part in $10^4$ in amplitude and to better than 0.1 deg in phase; the energy spread of the emerging electron beam was less than 7 keV. Because the energy spread is expected to increase less rapidly than the electron beam energy in the remainder of the accelerator, these tests convinced the Stanford group that they can reach their design objective of one part in 10 000 energy resolution and stability.

The prototype accelerator tests also allowed the experimenters to explore the phenomenon of beam breakup in the superconducting accelerator and to operate the large-scale superfluid helium refrigerator for an extended period of time in conjunction with a significant portion of the cryogenic system for the accelerator. Results of these tests have been extremely encouraging to the Stanford group, and they are now making minor design modifications to lower the Q of the beam breakup modes and to improve the reliability and the operating convenience of the cryogenic system.

**Cavities.** The major technical prob-




**Energy spectrum from superconducting injector system.** Sharp high-energy edge of spectrum demonstrates that the accelerating fields are stable to better than one part in $10^4$ in amplitude and to better than 0.1 deg in phase. The 50-microamp beam at 30% duty cycle was accelerated to 6.6 MeV. Energy gradient was 0.9 MeV/ft.

lem confronting the Stanford group is that of achieving the energy gradient of 4 MeV/ft hoped for in the superconducting accelerator, which is designed to operate at L band, 1300 MHz. Although test cavities operating at X band have given gradients as high as 8 MeV/ft, and L-band test cavities have produced gradients between 1.5 and 2 MeV/ft, the most they have achieved in large accelerator structures is about 1 MeV/ft. Both magnetic breakdown, with a resulting loss of superconductivity, and electron loading caused by field emission have been found to limit the gradients in L-band structures. Schwettman and Fairbank pointed out that the gradient of 1 MeV/ft is higher than design gradients in other high duty-cycle machines such as the new MIT electron linac and the Los Alamos meson factory, which is a proton linac. However, they still hope that the gradient can be increased to 4 MeV/ft, and every effort is being made to accomplish this, they said. To resolve the gradient problems the HEPL group is collaborating with the Center for Materials Research at Stanford in a program exploring processing techniques and the resulting cavity performance. Recently a gradient exceeding 4.5 MeV/ft has been achieved in an S-band cavity.

The superconducting cavities are made of pure niobium. A sheet of niobium is hydroformed into a cup, which is stress relieved and machined to very high geometrical tolerances. The cups are electron-beam welded together to form a structure, which is then processed with a very high-temperature, high-vacuum furnace baking, and chemical polishing or electropolishing (and that is the crucial step where Schwettman feels that difficulty develops). The last step is to fire the cavity at high temperature in high vacuum once again before assembling.

All of the accelerator-structure construction is done at Stanford. We saw a variety of equipment, such as a UHV furnace, a controlled environment room with microwave instrumentation for tuning the substructures and a glove box for assembly of the 20-foot structures.

**Accelerator.** Fairbank and Schwettman hope that the remaining problems of the superconducting accelerator can be resolved by fall, and that the completion of the 500-foot-long machine can then proceed. Assuming the objective of 4 MeV/ft is achieved, the accelerator would produce 2-GeV electrons.

The machine consists of 24 accelerator sections, each 20 feet long. Sections are grouped in packages of four, which are then followed by a 10-foot space in which there are steering, focusing and collimating devices and some monitoring equipment. Each of the 20-foot sections is enclosed in a dewar module consisting of a 2-foot-diameter helium vessel, a 3-foot-diameter vacuum jacket and, in the annulus between, a nitrogen-cooled shield with multilayer insulation.

Within each 20-foot accelerator structure are seven $(7/2)\lambda$ substructures, each approximately 1-meter long.

Cooling is done with a large central refrigerator, which is designed to deliver 300 watts of refrigeration at 1.85 K; it will service the entire accelerator. Superfluid-helium is piped from the refrigerator to each of the accelerator sections. Heat generated in a section vaporizes some of the helium, and that vapor is carried back to the refrigerator, where it is reintroduced into the refrigeration cycle.

We discussed the possible consequences of a vacuum failure in the system, particularly degradation of the superconducting surfaces. Fairbank and Schwettman pointed out that the system is carefully designed to minimize the chance of vacuum failure, and furthermore incorporates fact-acting valves so that if there is a vacuum failure, the worst that would happen is that one or two sections might be degraded and have to be reprocessed. The most likely place for vacuum failure is in the experimental station, they explained. Because of the long vacuum pipe between the accelerator and the end station, there is sufficient time to close a fast-acting valve and prevent contamination of the accelerator section, according to Schwettman and Fairbank. —GBL

## Critical behavior

*continued from page 17*

actual values for the indices.

Over the years phase-transition workers had noticed that the critical exponents appeared to be identical for whole classes of physical systems. For example, D. D. Betts, A. J. Guttmann and G. S. Joyce have described[2] how all three-dimensional Ising models, independent of the type of lattice, seem to have the same critical index and the same critical behavior. This idea was