Berkeley Balloon to Do High-Energy Physics Experiments

You can still do high-energy physics these days with cosmic rays, but the detectors are 15 meters high and you fly them with a balloon.

Since accelerators on earth will not be producing 1000-GeV protons for many years, Luis Alvarez, Michael Wahlig, William Humphrey, Larry Smith and Philip Dauber at Berkeley, in collaboration with Richard Eandi, Robert Golden, Donald Hagge and Richard Kurz of the Manned Spacecraft Center, NASA, Houston, are sending a huge superconducting magnet, Cerenkov counters, spark chambers, scintillation counters and other detectors aloft, 25 000–30 000 meters, to use cosmic-ray protons with momenta from 100 to 3000 GeV/c for high-energy experiments. With a 10-hour flight they expect to collect approximately 10 000 protons with energies that high.

We recently visited Alvarez and Wahlig at LRL (although the project is based at LRL and enjoys the use of some LRL personnel and facilities, it is funded by NASA through the University of California's Space Sciences Laboratory) to hear about HAPPE (High Altitude Particle Physics Experiment). The group has already launched several test flights (known as HAPPE 0, HAPPE 1/2, HAPPE 3/4 and HAPPE 7/8). We remarked that you could have an infinite number of steps between 0 and 1, but Wahlig said they had already launched HAPPE 1 last August.

The first real high-energy physics experiment, HAPPE 2 (see figure) is being prepared for launch in the summer of 1969. The apparatus is housed in an aluminum gondola (kept at ground level pressure) 7 meters high. At the top is an 8-meter-high Cerenkov counter, filled with Freon at 1/15 of an atmosphere; it has an energy threshold of 80 GeV for protons. An electron-shower detector at the bottom will tell whether the Cerenkov counter triggered on an electron or a proton.

The 9.5-kilogauss superconducting magnet, tested last month, has an effective length of 1.2 meters and an open center bore 1 meter in diameter. Built by Clyde Taylor and his group at Livermore, the magnet cost about $500 000.

Launch and flight. How does one get off the ground a 50-foot-high gondola that weighs 4–5 tons? Humphrey, together with John Sparkman of the National Center for Atmospheric Research, designed a launching system called "Stonehenge." (It's the latest scientific thing.) Above the main balloon, as in conventional launchings, the experimenters place a launch balloon that is much smaller but much stronger. On the ground the launch balloon is filled (until almost circular) with helium. As the balloon rises the helium expands through a coupling and fills the main balloon. The Stonehenge name comes from a circular array of anchor points surrounding the gondola. Cables attached to these points give the system stability in moderate winds, and more importantly, permit the orientation of the inflated balloon to be changed to accomodate a change in the wind direction in the long period between the start of inflation and the actual launch.

Early HAPPE flights tested launching, telemetry, tracking and recovery. Some of the data can be telemetered directly to the ground, but it is essential that the gondola be recovered, so that nuclear emulsions and spark-chamber film can be measured. Although it has been successfully re-

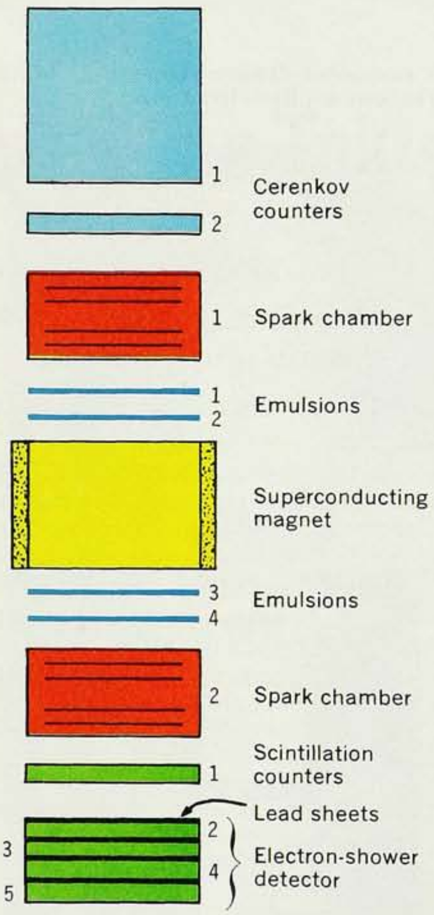
GONDOLA for high-altitude particle-physics experiment (known as HAPPE 1) being prepared for its move to the launch pad. The balloon was flown last August.

covered from the land, once the magnet is installed the gondola will be so topheavy that the group would prefer to recover it from water. HAPPE 7/8 successfully demonstrated that they could retrieve the gondola from the Pacific with the help of a big ocean-going derrick.

Experiment. HAPPE 2 is expected to collect about 1000 protons per hour and twice that many electrons.

The experiment will measure the momenta of charged secondary particles produced when cosmic-ray protons strike a lithium-hydride or beryllium target, which covers half the spark-chamber area. Since neutral particles will not be detected, one will get only a rough estimate of the primary proton energy.

Wahlig explained that the experiment will offer the first really high-energy check on various statistical models, which predict the number of secondaries, their angular distribution and their momentum distribution.



DETECTION APPARATUS for HAPPE 2, which will detect cosmic-ray protons with momenta from 100 to 3000 GeV/c. Electron-shower detector tells whether electron or proton triggered Cerenkov counter. 9.5-kG superconducting magnet has open center bore 1 meter in diameter. HAPPE 2 will be launched by balloon in the summer of 1969.

To define its high-energy beam, HAPPE 2 will measure proton and electron spectra. The group will also try to study the flux of particles with high atomic number (light output of the counters is proportional to Z^2), but for heavier particles it will be difficult to correct for the air above the gondola. The high-energy electron spectrum is of great interest because it is expected to be affected by inverse Compton scattering, in which the electrons are scattered by photons in the primordial blackbody radiation.

Future plans. Since the statistical theories are actually for proton-proton interactions, Wahlig noted, one really should have a hydrogen target; so in HAPPE 3 the group plans to put a small hydrogen target above the magnet. Then they can see how many rho mesons or f^0 mesons are produced, and they can study the invariant mass of pairs or triplets of particles, as well as getting statistical properties.

Below the magnet they expect to put a large H_2 target, about two meters long, to study p-p total cross sections. They may also be able to measure p-p elastic scattering, but this will depend on how bad the background is.

The HAPPE flights will search for antimatter in cosmic rays. Alvarez says that if they find just one antihelium particle, the experiment "will have paid for itself." (Such an observation would be strong evidence that some neighboring galaxies are made of antimatter.)

One possibility is to move HAPPE onto a satellite, where statistics of course would improve greatly. The Berkeley group has teamed up with a cosmic-ray group under Wilmot Hess, of the Manned Spacecraft Center, in making a formal proposal for a high-energy cosmic-ray laboratory in one of the Apollo Applications Program (AAP) satellites. —GBL

More on CP Violation: Experiments Disagree

Last fall many high-energy physicists felt that the phenomenological description of CP violation in K meson decay was at last complete (PHYSICS TODAY, November, page 73). Now the situation is up in the air again. At the Chicago APS meeting, in a special session on K^0 decay, two new experiments suggest that we still do not know the value of $|\eta_{00}|^2$, the ratio of the two-neutral-pion decay rate of K_2^0 to the two-neutral-pion decay rate of K_1^0.

When experiments at CERN (by Jean-Marc Gaillard and his collaborators) and at the Penn–Princeton accelerator (by James Cronin and his collaborators) were reported early last year, the preliminary value for $|\eta_{00}|$ appeared to rule out Lincoln Wolfenstein's superweak theory, which predicted a value half as great.

One new experiment, reported at the meeting by T. Kamae of Princeton, finds $|\eta_{00}|$ is 2×10^{-3} with error limits of $+0.7 \times 10^{-3}$ and -2×10^{-3}. The other experiment (jointly conducted by the U. of California, Berkeley and the U. of Hawaii), still in extremely preliminary stages, reported by Sherwood Parker, gives $(3.2 \pm 0.6) \times 10^{-3}$ (however, it is too early to estimate systematic errors). Earlier reported values were no smaller than 3.9×10^{-3}. Rumor has it that data from a new CERN bubble-chamber experiment are substantially smaller than last year's preliminary values.

Sentiments expressed at the Chicago meeting include: "It looks good for Wolfenstein again." "I never liked the Wolfenstein theory. It tells us that the only way the superweak force can be observed is in the CP-violating decay of K_2^0, and that's too frustrating." "The experiments still haven't ruled out the $\Delta S = -\Delta Q$ explanation for CP violation." "Let's wait and see."

Electric Field Suppresses Lambda Point in Helium

By applying a strong electric field to liquid helium Harris A. Notarys of Ford Scientific Laboratory, Newport Beach, Calif., has completely stopped superfluid flow. The only previous way to suppress the superfluid transition temperature T_λ was by applying pressure. Results are reported in *Phys. Rev. Letters* **20**, 258 (1968).

The helium flowed through a porous mica sample, 5 microns thick, that had diamond-shaped pores with sides 0.08 micron or 0.16 micron long. Notarys measured flow rate as a function of applied electric field.

For all pores and fields up to 2 MV/cm Notarys found strongly temperature-dependent effects within 15 millidegrees of T_λ. For the larger pores at 1.5 mdeg below T_λ, the superfluid flow was stopped completely by fields greater than 1.2 MV/cm.