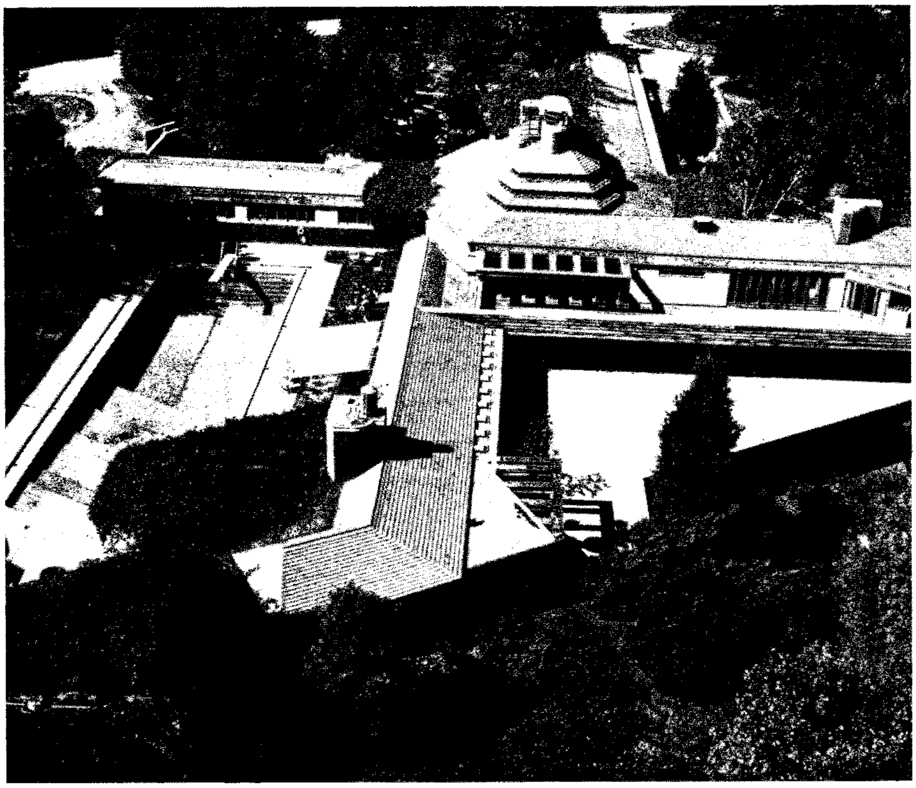
Physics monitor



Wingspread, Racine, Wisconsin, scene of the recent Magnetic Monopole Workshop.

Monopole Workshop

Some 90 physicists from 13 countries gathered in October to examine new evidence and theories concerning the magnetic monopole. The venue was Wingspread, the last, but by no means least, of architect Frank Lloyd Wright's marvellous prairie houses, located in Racine, Wisconsin.

While many physicists remain sceptical about magnetic monopoles, a growing number are speculating that they may have been made in the first blaze of creation. If found, monopoles would provide a profound clue as to the origin and nature of the universe.

In the last decade, scientific interest has focused on the possibility of extremely heavy monopoles. In the middle seventies, A. Polyakov and G.'t Hooft independently noted that such monopoles were a characteristic feature of a large class of gauge theories which now are most commonly used to perform the so-called Grand Unification of forces. The masses of monopoles associated with the standard Grand Unification model are very large indeed, about 10^{16} times larger than the proton. Such monopoles defy ordinary expectations — they are finite in size and reluctantly accelerated. Even in passing through the magnetic field of the entire galaxy they attain at most a speed a thousandth that of light. Stopping them is correspondingly difficult because of their enormous momentum.

Several years ago, J. Preskill (Harvard) examined monopole production in the early universe and discovered a puzzle. Monopoles should have been created with about the same abundance as protons and, therefore, should dominate the mass of the universe. On the other hand, conventional arguments about the measured rate of expansion of the universe limit their number to something like one monopole per 10^{18} protons. Nonobservation of monopoles further suggests that suppression is clearly needed to reduce the monopole population. One of the favorite approaches discussed at Wingspread was Guth's (MIT) inflationary universe, which although curing this and some other outstanding cosmological problems, introduces a few of its own.

In 1981, Lazarides, Shafi and Walsh (CERN) questioned lower limits on monopole abundances and argued that it was difficult to force the flux of monopoles much below 10^{-16} per square centimetre per second. Their flux limit was not very far below the now famous 'Parker bound', which notes that the measured galactic magnetic field places a limit on the monopole abundance — on the earth about one monopole per football field per year is to be expected.

By late 1981, theoretical interest in monopoles had reached the point where a meeting was organized at the International Centre for Theoretical Physics in Trieste. Those proceedings, now published, chronicle many curious mathematical conjectures about the properties of monopoles but contain just one solitary contribution which describes experimental efforts.

1982 was a year where the concrete problems of monopoles were confronted. These challenges have included Cabrera's (Stanford) tantalizing monopole candidate event (see July/August 1982 issue, page 220); the conjecture that monopoles might catalyze proton decay; a searching, but as yet inconclusive, struggle to predict energy loss for slow monopoles; a Grand Unification study of 'monium' with its cosmological con-

One of the speakers at the Wingspread workshop was Blas Cabrera of Stanford, one of the few people to have seen possible evidence for magnetic monopoles.

sequences; and an explosive growth in the number of monopole search experiments. The Wingspread workshop, convened as a clearing house for these activities, has produced a status report which provides guidance as to how to proceed.

There is no doubt that Cabrera's candidate event set the stage for the hectic and confused scene that led to the Wingspread workshop. Early in 1982, Cabrera, a Stanford low-temperature physicist, found a striking monopole-like signal in his superconducting detector — a two-inch diameter, four-strand loop of wire devoid of ambient magnetic field down to a very low billion level. Cabrera's detector works by induction and thus is only sensitive to the monopole's magnetic charge.

Suddenly, the tables were turned. This small detector suggested too large a flux and thus motivated scenarios which contrived to remove the Parker bound. Cabrera's limit was increasingly in conflict with those of ionization detector experiments. However, some questioned whether slow moving monopoles would ionize at all. An interesting diversion to this central theme at Wingspread was the unusual sight of a number of puzzled theorists trying to decide whether the recent idea of monopole catalysis of proton decay was valid. By the time of the Wingspread meeting, Cabrera, bereft of further monopole candidates despite the continuous running of his original detector and the inauguration of a new three-loop detector whose coverage was seven times larger, lowered his earlier flux limit by almost a factor of ten.

Representatives of more than 25 different inductive and ionization experiments in various stages of development were a major faction at Wingspread. Other inductive experiments generally paralleled Cabrera's technique but aimed toward larger detectors by expediently using less sophisticated shielding.

Investigations of ionization loss expected from slow moving monopoles remain inconclusive. S. Ahlen (Berkeley) was quick to point out that there is much concrete information on the energy loss for electrically charged particles moving at velocities expected for monopoles. Several current ionization experiment using sensitive detectors of about a square metre running for a year are reporting no candidates. The largest detector attacking the monopole problem is the gigantic Baksan cosmic ray detector in the Soviet Union.

At Wingspread, Curtis Callan argued persuasively for monopole catalysis, where a monopole passes through ordinary matter, converting protons to electrons, mimicking 'ordinary' proton decay and leaving a trail of detectable debris along its path. Arguments continue to evolve on the rate of the process; strong, weak, or never.

Another interesting aspect to the whole picture has been C. Hill's (Fermilab) study of the pole-antipole pair system, originally called monopolonium but sensibly shortened to monium. The unique aspect of monium is its incredibly slow de-excitation — if created in the Big Bang with a separation of an angstrom, it would still not have fallen to the ground state! However, monium decay products may be observable and plentiful. Because monium is magnetically neutral, it is exempt from the Parker bound.

After the Wingspread meeting it is still not possible to conclude whether magnetic monopoles do or do not exist. If anything, it was learnt that it will be harder to see monopoles than earlier results suggested. However, even if monopoles are not part of Nature's plan, the impact of the Wingspread workshop was no less important as it has helped to clarify some very critical and fundamental issues.

The Wingspread workshop was organized by P. Trower (Virginia

Soviet detector in action

A recent search at the big underground detector at the Baksan Neutrino Observatory in the North Caucasus revealed no magnetic monopoles. This four storey construction measures 16 metres by 16 by 11 and is beneath some 2000 metres of rock. It contains 3132 liquid scintillators each 70 x 70 x 30 cm and viewed by a photomultiplier.

Tech) and R. Carrigan (Fermilab), acting on the advice of G. Giacomelli (Bologna), D. Schramm (Chicago), Q. Shafi (Trieste) and F. Wilczek (Santa Barbara) with the support of the North Atlantic Treaty Organization, the US Department of Energy, the US National Science Foundation and the Johnson Foundation.

Continuing the hunt for the axion

While prediction is considered by some to be too strong a word, theoretical arguments certainly do not exclude the existence of 'axions' — very light, highly penetrating particles.

The most common light, penetrating particle is the neutrino, obtained in the laboratory from the weak decay of pions and kaons. In beam-dump experiments, the pions and kaons are first removed (usually by a thick metal block), so that the conventional copious supply of neutrinos is severely reduced. But the beam dump might not necessarily remove other light, penetrating particles, such as axions, which will have a better chance of showing up when they are not swamped by neutrinos.

A study at the far end of the electron beam from the SLAC linac has joined the ranks of these beam-dump experiments. The particles which survive after passing through the beam dump itself then have to pass through a 200-metre thick hill, and a distant downstream shower counter has been set up to catch any signs of photons coming from the decay of rare particles. An initial run early last year revealed no surprises.

The experimental team includes James D. Bjorken of Fermilab, generally considered to be a theoretician, but showing that now, just as in Fermi's day, theory and experiment are by no means mutually exclusive physics careers.

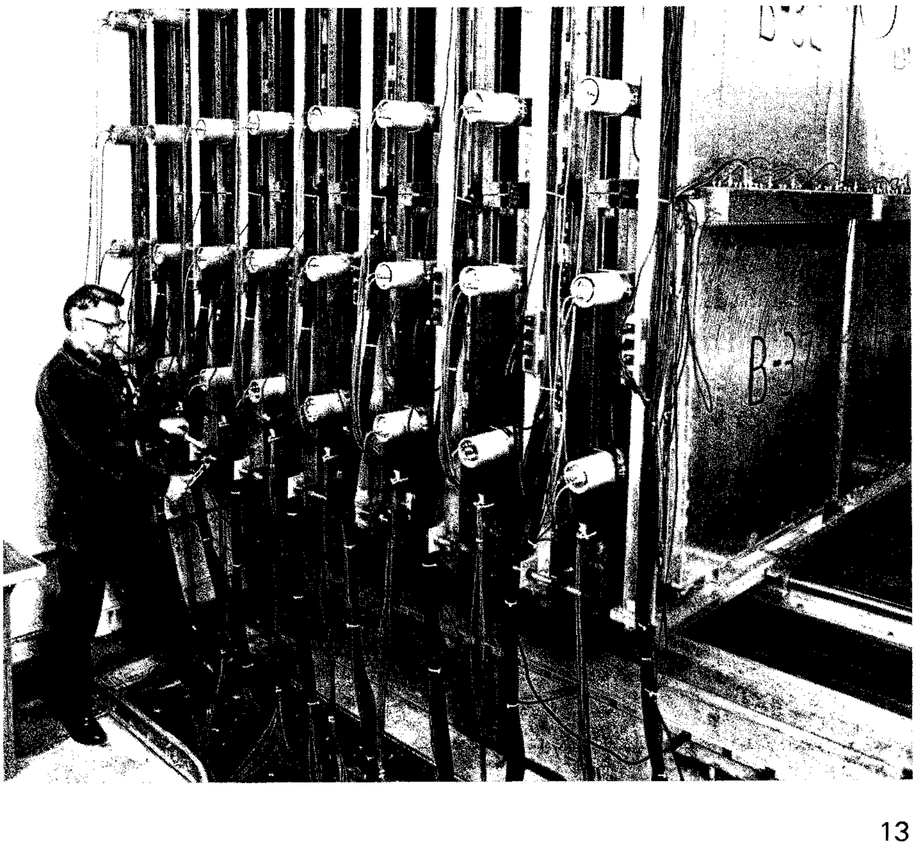
One experiment which has seen an unexplained effect in a beam dump is by an Aachen team, working at the Swiss SIN machine, which detected an excess of forward photon pairs in the particles emerging from the metal shielding (see May 1981 issue, page 161). After more extensive examination of the data and further consistency tests, the effect remains.

Some signals have also been reported in experiments studying the particles produced in nuclear reactors, but confirmation has not been possible. In the absence of a definite answer to the axion question, the experimenters (and theoreticians) keep looking for possible new particles.

The highest energy cosmic rays

A paper entitled 'Research into primary cosmic radiation at ultra-high energy' won a Lenin prize last year for the Soviet scientists Nikodim Efimov, Dmitri Skobeltsyn, Georgi Zatsepin, Sergei Nikolski, Dmitri Krassilnikov and Georgi Christiansen. Here Sergei Nikolski describes the scope of these studies.

The study of elementary particles and the proof of a hypothesis of the origin of cosmic rays requires a knowledge of the number and energy of the particles reaching Earth from cosmic 'accelerators', the com-



Finn Halbo adds a few final touches to the apparatus designed to look for signs of exotic new particles in a beam dump experiment at the Stanford linac.

(Photo Joe Faust)