Bare Bottom; Naked Charm: Booms-a-daisy Physics

This may indeed have been the summer in which the gluons are becoming real (SN: 9/1/79, p. 156). Considering their crucial position in modern physical theories, they probably deserve a summer. They are the mortar that binds the stones in the structure, so to speak, and their importance is capital. But the vaulting of the modern theory of subatomic particles has a number of important nodal points, and some of the particles representing these had if not their summer at least their day at the International Symposium on Lepton and Photon Interactions at High Energies held at the Fermi National Accelerator Laboratory.

The first of these perhaps is more of a concept than a particular particle. Around the corridors at Fermilab it was known as "bare bottom," though at the CERN laboratory in Geneva where the discovery was made the more elegant term "naked beauty" is current.

The terms have to do with the fifth of the six quarks. Those who follow this subject will remember that current theory postulates that nearly all the subatomic particles known to physics are built of varying combinations of basic entities called quarks. The theory current right now requires six varieties — "flavors" is the technical term — of quarks and six antiquarks to match. One of the most widespread experimental pursuits of recent years has been the search for evidence of the quark flavors beyond the three that were evident in particles known at the time the theory was elaborated.

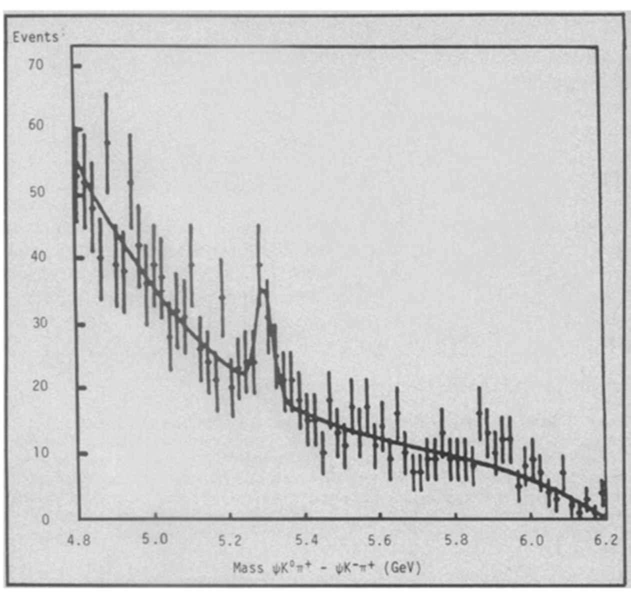
The b quark is the fifth in the order of search. (The initial may represent "bottom" or "beauty" according to what is in the eye of the beholder.) Evidence for the b was first found in the upsilon particles discovered about two years ago. The upsilons are examples of what is called hidden beauty. They are made of a b quark and an anti-b quark, and therefore in a sense they are subject to internal cancellation: The qualities of the b quark are matched and therefore masked by their opposite numbers in the anti-b.

To study the nature of the b quark, to find out how beauty is and does, physicists look for naked beauty, a particle in which a b quark is attached to a quark of another flavor and so can manifest its properties more or less unmasked. Such a thing seems to have been found in a particle with a mass of about 5.3 billion electron-volts (5.3 GeV) that manifested itself in the spectrometer called Goliath at CERN. The collaborators who did the experiment, including physicists from the Saclay laboratory in France, Imperial College, London, the University of Indiana and the University of Southampton in England, prepared an oral report for the Fermilab Symposium. Now there is a written account in the September CERN COURIER.

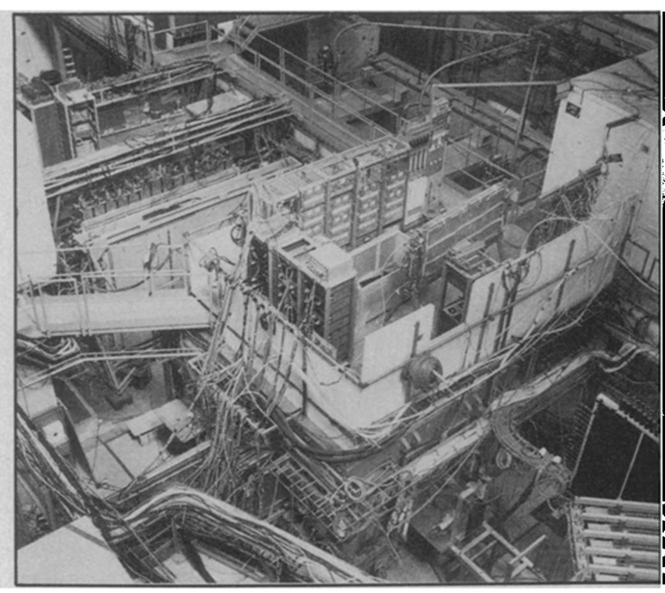
The experiment actually started out looking among the activities of psi particles for evidences of naked charm. (Charm is the fourth quark, discovered in 1974.) When evidences of unveiled beauty began to show up, the charm search was temporarily shelved. It is not surprising that bare bottom should turn up in a search for naked charm. There are theoretical schemes that would have one flavor of quark changing into another flavor and so forth. Specifically the hidden charm represented by the psi particles, which are the charm analogue of the upsilons (psi's consist of a charm quark and an anticharm quark), is supposed to be produced by a decay of the b quark. Whether this new particle is in fact "beauty uncovered" (the title of CERN COURIER's article) remains for future and much closer investigations.

Meanwhile, on the charm front itself, a new particle has been discovered that may be an important member of the charm particle family. It was reported by Eliott Bloom of the Stanford Linear Accelerator Center, and it comes from a detector called Crystal Ball that records events in the SPEAR apparatus, which collides electrons and antielectrons (positrons) with each other to see what happens when matter and antimatter annihilate each other at high energy.

What they have found is a new particle with a mass of about 2.976 GeV that appears in the products of such annihilations. "We don't know quite what it is yet," Bloom says. But it does seem to be a psionium system; that is, a member of the family of psi particles. A murmur about what it might be went around the meeting, and Haim Harari of the Weizmann Institute in Israel pronounced it from the platform. It could be the long-sought eta-c meson, the charm meson state with spin zero. The charm particles can be formed into a spectroscopic hierarchy according to their mass (in spectroscopic terms their energetic excitement). Studying the radioactive decays from more excited to less excited states can teach much about the nature and dynamics of the flavor known as charm. The eta-c is particularly important because it would come in at the bottom of this arrangement. Harari's suggestion is that this new particle, which is being called U (for unknown) until its nature is better determined, is most likely produced by a decay of the lowest-mass known psi into a U, with the release of a gamma ray by the side to take away some



Goliath detector (right). Graph shows increase in production of the particle combination psi-K-pi as the energy went through 5.3 GeV, indicating a particular source, presumably the bare bottom particle, of which psi-K-pi is a possible decay product.



of the psi's energy.

Also on the charm front is a suggestion by Vera Luth of SLAC that the Mark II detector, also installed to watch annihilation events at SPEAR, may have found "evidence for charm baryons." Ever since charm particles were first found in 1974, physicists have been asking how come no charm baryon can be found. All the charm particles found so far have been mesons, quark-antiquark combinations. A baryon is made of three quarks (neutrons and protons are the most prominent baryons in physics), and charm should be found in baryon structures. Finding it there would bring out more about the nature of charm and also more about the nature of baryons.

The charm baryons in question would be the electrically positive and negative F particles, which are supposed to be composed of charm and strange quarks. (Strange is another quark flavor. The six postulated flavors go: up, down, strange, charm, bottom and top.) The evidence is indirect, coming from the production of pairs of positive and negative tau leptons in the electron-positron annihilations. Harari seemed to approve of the evidence and said that its confirmation should be given high priority.

The tau leptons bring us to the possible new lepton of great importance. Leptons are particles that are not made out of quarks. Leptons are regarded as being as fundamental as quarks and forming a kind of parallel series in the overall economy of matter. There is a theoretical link between the two called the Glashow-Illiopoulos-Maiani rule. According to this, the number of possible kinds of neutrinos (which are leptons with zero rest mass) determines the whole number of leptons there can be. This in turn determines the number of quark flavors there can be, and that determines the numbers of different kinds of hadrons (as the particles built of quarks are called) that can exist.

Part of the GIM rule says that for every kind of lepton that possesses mass there must be a kind of neutrino and vice versa. All was well as long as there were four known leptons, the electron, the electron neutrino, the muon and the muon neutrino. A few years ago the tau was discovered. Physicists immediately knew they had to find a neutrino for the tau or throw away the GIM rule that does so many neat things for them. After many fruitless searches that tau neutrino now may be found.

The result was reported at the Fermilab Symposium by Klaus Winter of CERN. It concerns an experiment that exhibited a flux of anomalous neutrinos — that is, neutrinos that did not appear to come from any process that is a known source of neutrinos. The most probable interpretation, says Winter, is tau neutrinos, but the production mechanism is unclear. "It needs confirmation," he says. "We intend to continue the study." □

Burning question: From whence dioxin?

More fuel has been added to the fire of argument over whether the synthetic chemical industry is responsible for environmental pollution by specific toxic organic compounds. Two scientists reported in Washington at the national meeting of the American Chemical Society that smokestack emissions from a coal-fired power plant contain no detectable traces of dioxins, one class of chemicals including extremely hazardous compounds. That finding implies that dioxins are not a ubiquitous by-product of combustion, as scientists at the Dow Chemical Co. have proposed.

The argument began more than a year ago when Dow scientists detected the most toxic dioxin, 2,3,7,8-TCDD, in a fish in a river near the Midland, Mich., plant. They believed that the contamination did not come from discharges of the plant, which produced a pesticide and two other chemicals that inevitably contain a small amount of 2,3,7,8-TCDD. So they looked for another source and announced finding dioxins from a wide variety of combustion processes including municipal incinerators and fossil-fueled powerhouses (SN: 12/9/78, p. 409).

At the meeting last week, European chemists Christoffer Rappe and Hans-Rudolf Buser stressed consideration of the materials being burned. Those scientists had previously reported that municipal incinerators emit dioxins and dibenzofurans, a class of similar compounds also containing toxic members (SN: 7/8/78, p. 21). The individual chemicals produced by combustion can be identified and quantified with sophisticated analytical techniques. They find that most of the dioxins and dibenzofurans in fly ash, flue gas and other environmental samples are formed from industrially produced organic chemicals — PCB's, chlorinated phenols, chlorinated diphenyl ethers and benzenes. The pattern of dioxins and dibenzofurans after combustion could be used to identify the precursor chemicals. "The hypothesis of ubiquitous formation of PCDD's in burning processes must be checked by careful control for suitable precursors in the material being burned," Rappe and Buser say.

Now Brenda J. Kimble of the University of California at Davis and Michael L. Gross of the University of Nebraska report no dioxin in the emissions of one coal-burning power plant. "We would not want to extrapolate to every power plant," Gross says, pointing out that the one they sampled burned low sulfur, high ash Western coal. Gross adds that the coal burning plant uses fossil fuels about a million years old and therefore presumably not contaminated with synthetic organic chemicals.

The Dow scientists did not do an analysis of the fuel or air at the power plant they sampled, which burned mostly oil, Warren Crummet of Dow said. So they do not know whether precursor organic chemicals, such as PCB's, were present. The Dow scientists said that differences in sampling procedures might also explain the disagreement between their results and those of Kimble and Gross. □

More feed additives on the spot

Livestock feed additives increase the efficiency with which feed is converted into poultry, beef or pork. Two additive classes, however, have recently been implicated in human health problems. Antibiotic use in feeds may contribute to increasing drug resistance among disease causing bacteria (SN: 6/30/79, p. 422) and DES use may increase cancer incidence (SN: 7/7/79, p. 4). Now, at the meeting of the American Chemical Society in Washington, Berton C. Pressman expressed concern about a third type of additive, called ionophores. "While we wish to stress that there is no clearcut evidence of danger at the moment, in light of their powerful pharmacological effects, there is an urgent need to ascertain the consequences of the increasing exposure of man and animals to ionophores," he says.

Ionophores are chemicals that carry ions across barriers such as cell membranes. The compounds used as feed additives — monensin and salinomycin — exchange one positively charged ion for another. In his research at the University of Miami, Pressman finds that the ionophores can produce profound pharmacological effects. By raising sodium content inside cells (by exchanging sodium for potassium ions), the chemicals can dilate the coronary arteries and stimulate heart contractions. Pressman finds that ionophores can affect dogs at quantities as low as 1 part per billion. Pressman believes that ionophores may prove useful as drugs to treat shock and heart failure, but if they enter the food supply they might be harmful to a small proportion of people.

With a new and more sensitive assay Pressman has obtained evidence that ionophores fed to dogs spread throughout their tissues. "The prevailing belief is that carboxylic ionophores remain in the gastrointestinal tract of treated livestock," he says. His assay, which he says is sensitive to 10 parts per billion monensin, detects the ionophore by its ability to bind radioactive sodium. Because ionophores are relatively stable, Pressman is concerned that they may contaminate eggs and milk for human consumption. □