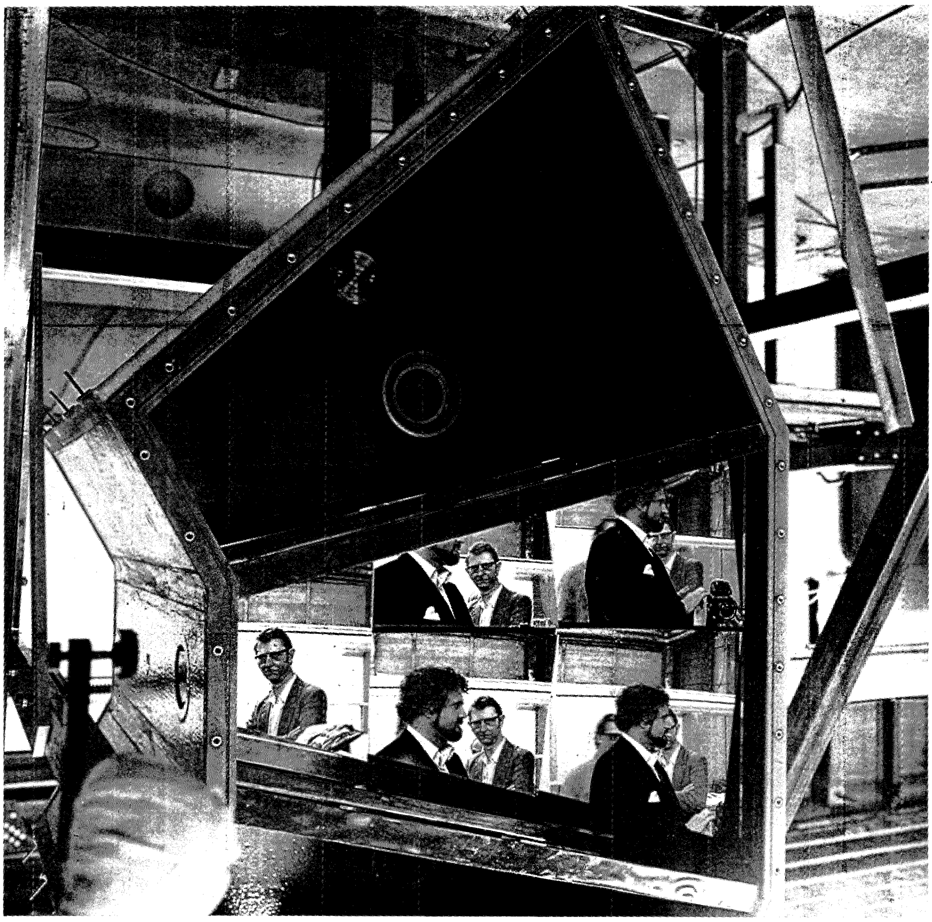
While work for the LEP machines forges ahead, the four big experiments keep step with the demanding schedule to be ready to intercept the first electron-positron collisions towards the end of 1988. Here is a prototype module of the Ring Imaging Cherenkov counter (RICH) for the DELPHI experiment. The DELPHI RICH, the largest example of this relatively new detector technique, will surround the central tracking chamber and will identify charged hadrons.

(Photo CERN X 757.5.85)



tion, transport, cabling, power transmission, vacuum, control systems,... — is moving steadily ahead ready to lock into the intricate planning of the project.

While the tunnel progresses and the machine components begin to arrive, preparations unfold to supply particles for LEP. Near the valiant 27 year-old 'Proton' Synchrotron (PS) which gives all CERN's particle beams their initial kick of high energy, a 100 metre linear accelerator — the LEP Injector Linac — is being built. Just before Christmas one sector of this machine accelerated electrons to 4 MeV and accelerator physicists anxiously studied the behaviour of the beam.

In these tests, a number of important functions (vacuum, power supplies, beam position) were monitored and controlled by elements of the new computer control system. This gave confidence for the task of integrating the remaining controls and process elements.

In June, the linac is scheduled to inject the first electrons into the new Electron-Positron Accumulator (EPA), which will store the particles prior to injection into the PS. Injection into the PS is planned for the end of the year, providing a Christmas present for the stalwart team who are also looking forward this year to handling oxygen ions.

At CERN and the hundred or so research institutes across the world collaborating in the four big experiments to use LEP, an intricately dovetailed effort ensures that the four huge detectors will be ready to intercept LEPs first collisions of electrons and positrons, opening a new era of particle physics.

Neutrino masses

Postulated in the early days of quantum mechanics by Wolfgang Pauli to make energy-momentum conservation in nuclear beta decay come out right, the neutrino has never strayed far from physicists' attention. The Moriond Workshop on Massive Neutrinos in Particle Physics and Astrophysics held recently in the French Alps showed that more than half a century after Pauli's prediction, the neutrino stubbornly refuses to yield up all its secrets.

Peter Rosen (Los Alamos) began the Workshop with the charge that since 'no simple principle demands that the neutrino is massless, it's up to the people in this room to determine the mass', and the participants eagerly took up the challenge.

The possible role of neutrinos in cosmology was discussed by a

Moriond for physics

Twenty years ago, J. Tran Thanh Vanh from Orsay gathered together a group of fifteen physicists at a rented house in Moriond in the French Alps for a unique week's blend of informal physics discussion, skiing, cooking and housework.

The meeting was such a success that Tran's colleagues urged for a follow-up the following year — the Moriond tradition had started. An annual three-session format emerged, with a January meeting covering a special topic and two Spring meetings given over to strong and electroweak interactions. Cooking and housework have disappeared from the daily schedules, but the venue is always an alpine skiing resort, almost always in France.

The Moriond meetings are supported by the French CEA (Commissariat à l'Energie Atomique) and CNRS (Centre National de la Recherche Scientifique), but the workshop held in Tignes (France) from 25 January to 1 February this year was also sponsored (for the first time) by a US Laboratory — Lawrence Livermore. The topic was Massive Neutrinos in Particle Physics and Astrophysics.

number of theorists including Klinghammer, Schramm, and Steigman. Studies of galaxy formation indicate that neutrinos could contribute to the large scale structure of the universe but are not good candidates for galaxy formation. On a slightly different topic, Glashow and Haxton gave stimulating and timely talks on 'The Fifth Force' (see also page 9).

There was considerable speculation whether a neutrino beam passing through matter may grossly alter its content, which might explain the riddle of the missing solar neutrinos. (The neutrino signal picked up on Earth is less than what is expected from the sun's thermonuclear furnace.) Smirnov discussed the recent suggestion by Mikcheyev and himself that the process has a resonant character. He explained that if the electron density in the sun varies slowly with radius, then neutrinos born as electron-type neutrinos in the solar core can change into nearly pure muon-type neutrinos before leaving the sun. The electron neutrino flux on earth would then be severely suppressed. Detailed numerical analyses of this matter-induced suppression of solar electron neutrinos were reported by Gelb and Rosen, by Hampel, and by Mikcheyev and Smirnov. Forthcoming experiments using gallium detectors will sample a different part of the electron neutrino energy spectrum than the classic chlorine (dry cleaning fluid) experiment and could check this possible suppression mechanism.

A number of experiments were discussed which will attack the solar neutrino problem by looking directly at the neutrinos from fusion. Kirsten reported on the newly approved GALLEX experiment which is scheduled to receive its final delivery of gallium in late 1989 with data acquisition commencing in 1994. Pomansky commented on another approved effort, a sixty-ton Soviet experiment which hopes to have its gallium by late 1987. In addition, other proposals using gallium, boron, molybdenum, and heavy water were discussed.

Observations of the Cygnus X-3 binary star using the Mont Blanc, Frejus, and Baksan underground detectors disagreed as to whether any remarkable signal had actually been seen (see September 1985 issue, page 264). Since the output of Cygnus X-3 in the X-ray region is very time-dependent (October 1984 had two weeks of more than 10 times normal X-ray activity), correlations between experiments could help.

Coming back to Earth, searches for neutrino oscillations (transitions between neutrino types) at both accelerators and reactors were discussed. Accelerator experiments were reviewed and several new experiments at Brookhaven and Los Alamos in the US and Rutherford in the UK were summarized. No definitive evidence for neutrino oscillations has been seen in the accelerator experiments. Some disagreement exists between the reactor neutrino oscillation experiments. Vuilleumier presented the data from the group working at the Swiss Goesgen reactor. No evidence for oscillations is found with the detector at three different distances from the reactor core. He pointed out that the conclusions are independent of the particular neutrino energy spectrum emitted from the reactor. The group working at the French Bugey reactor presented previously announced evidence for oscillations (see July/August 1984 page 244). Sobel showed preliminary results from a new reactor experiment at Savannah River (US) which ruled out most of the region allowed by the Bugey experiment. Hopefully this dilemma will soon be clarified, possibly with new data from the Savannah River group or with a new experiment proposed by the Bugey group.

Several impressive limits from searches for neutrinoless double beta decay were presented by the Milan, Caltech and Osaka underground studies using germanium. The implications for neutrino mass was the subject of a debate among the nuclear theorists Klapdor and Vogel. Other searches for neutrinoless double beta decay were reported by Pomansky and by Fiorini, who was enjoying a welcome relief from his 21 000 hour germanium measurement in the Mont Blanc tunnel. Fiorini pointed out that progress may result from novel detection methods.

It remains a puzzle that double beta decay accompanied by two neutrinos (a rare but allowed process) seems be slower than calculations predict. On the other hand, Hahn pointed out that the two neutrino decay rate now observed in selenium 82 is no longer inconsistent with the geochemical value.

Daum reported on the muon-type neutrino mass limits, the lowest of which is now 270 keV, while Koltick reviewed the work on the tau neutrino mass, which now has to be lighter than 56 MeV.

In the continuing effort to weigh the electron neutrino, exciting new tritium beta decay results were presented. These discussions filled two sessions and were started by Lubimov presenting new ITEP (Moscow) data. Still using tritium bound in valine, the group has reduced backgrounds and made a considerable effort to better understand the spectrometer resolution. Many fits to the data over different energy intervals yielded results in agreement with previous work, though with a smaller electron neutrino mass range. The previous mass range of 9-46 eV was reduced, albeit with different assumptions about molecular effects, to 17-40 eV, giving an even stronger indication of a non-zero neutrino mass. Lubimov's talk was followed by a spirited discussion. Bergkvist, in a lively interchange with Lubimov, pointed out some possible subtle pitfalls.

Petersen presented tritium data taken by the Zurich group working at the Swiss SIN Laboratory. The group has been working for over a year with a magnetic spectrometer, observing electrons from tritium bound in a thin carbon substrate. Preliminary measurements indicate that the (electron) neutrino mass is less than 9 eV, but including a generous estimate of systematic errors extends the limit to 20 eV.

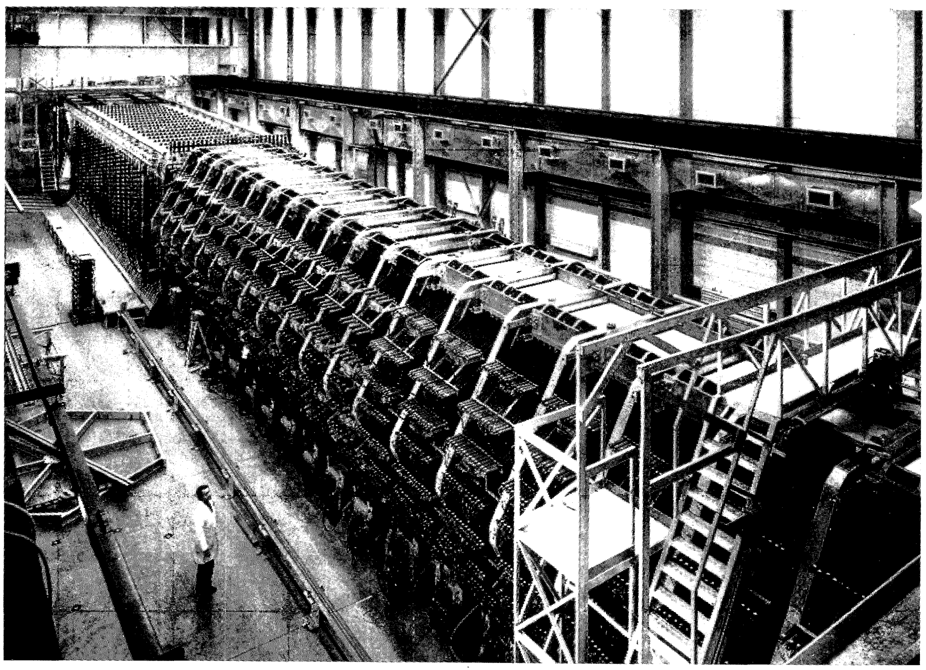
Two other groups also reported new data. Wilkerson presented Los Alamos data using gaseous tritium whose decay electrons were analysed in a magnetic spectrometer. Resolution was somewhat uncertain but a conservative choice gives a neutrino mass limit of 43 eV. Kawakami presented Tokyo data, preferring not to quote a preliminary result, but a comfortable limit could be drawn at 50 eV.

Several other groups expect to be taking data soon. Momentarily at least, the controversy surrounding the neutrino seems to be focused on the beta decay of tritium, and the excitement of the chase pervaded the whole Moriond meeting.

In his concluding remarks, Gary Steigman congratulated organizers Tran Thanh Van of Orsay and Orrin Fackler of the Lawrence Livermore Laboratory for a stimulating week of physics.

The original lineup of detectors in the CERN SPS neutrino beam. Accelerator experiments show no evidence for transitions between different types of neutrinos (neutrino oscillations), although results from studies at nuclear reactors do not entirely agree.

(Photo CERN 16.12.78)



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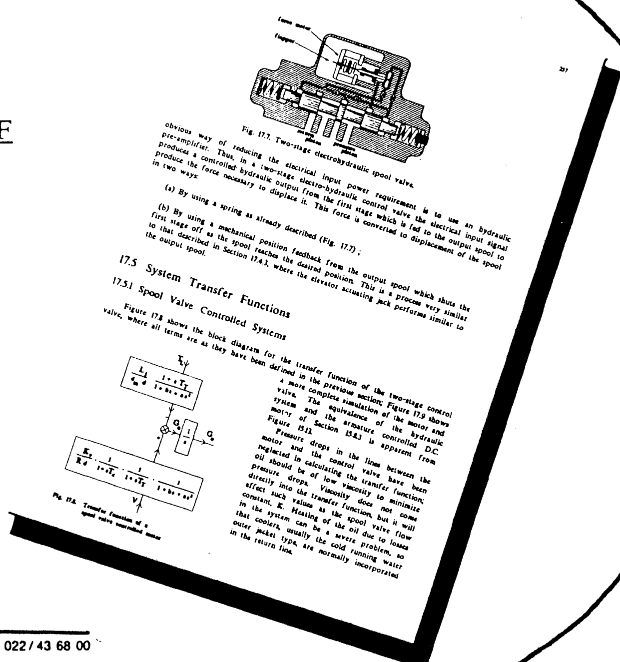

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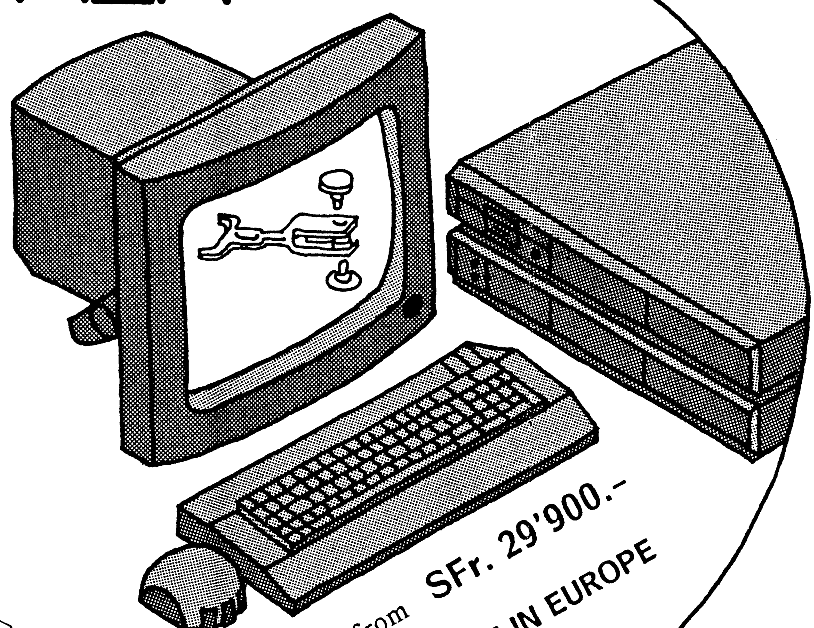

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