resolved definitively.

The relative deficit of muon to electron atmospheric neutrinos observed by the Kamiokande and IMB collaborations is confirmed by recent data from Soudan II experiment, albeit with large uncertainties. While the Kamiokande results are consistent with neutrino oscillations, IMB collaboration does not make such a claim, due to much larger systematic uncertainties (attributed mostly to simulations).

An experiment at a test beam at the Japanese KEK Laboratory is being set up in a joint IMB-Kamiokande effort using a 1-kiloton water Cherenkov detector. This should provide important information about electron-muon separation at low energies, crucial for correct interpretation of the Kamiokande and IMB data.

The Moscow-Heidelberg group searching for neutrinoless double beta decay of germanium-76 using an enriched sample detector now has, as reported by Piepke, a lower limit on the isotope lifetime of 1.6 x 10^{24} yrs, implying an upper limit on a Majorana mass of the electron neutrino of 1.2-1.4 eV (a Majorana particle is its own antiparticle - a Dirac particle has a distinct antiparticle).

Although an excess of events below the endpoint is seen, the shape of the electron spectrum rules out Majoron emission for a Majoron-neutrino coupling greater than 1.8 x 10^{-4}. This makes it rather unlikely that the excess of events in other experiments is due to Majorons.

Dark matter was covered by Larry Krauss and David Caldwell. The COBE and IRAS satellite data is best fitted by a mix of hot and cold dark matter containing 30% of 7 eV (tau?) neutrinos. Two groups searching for MACHOs (MAssive Compact Halo Objects) have seen nothing so far, but only a small fraction of the data has been analysed. A new generation of cryogenic detectors should soon be able to probe the region predicted for a supersymmetric dark matter candidate - the lightest neutralino.

Gravitation sessions concentrated mainly on current tests of the equivalence principle, and the theoretical significance of this effort. A special section reviewed the development of the STEP project for a satellite test of the principle. Theoretical talks underlined the challenge of measuring the extremely small effects of any such violation.

Covering such a wide range of different but interrelated areas of physics was a challenge. However in the informal Moriond atmosphere participants could ask even 'elementary' questions, increasing the scope, as well as the depth, of their physics knowledge.

The workshop was organized by J. Tran Thanh Van and his colleagues with the financial support from CNRS, CEA, NSF and the Observatoire de Paris.

Information from T.J. Bowles and P.S. Joshi

Mass-producing B mesons

Since the discovery of the upsilon resonances in 1977 the physics of the fifth quark - beauty - has played a vital role in establishing and consolidating today's Standard Model of particle physics.

In recent years, a wealth of data on B particle (containing the beauty quark) has emerged from the detectors ARGUS (at the DORIS ring, DESY, Hamburg) and CLEO (at the Cornell CESR ring) as well as from CERN's LEP electron-positron collider and the proton-antiproton colliders at CERN and Fermilab.

But the most challenging goal of this physics is to explore the mystery of CP violation, so far only seen in neutral kaon decays. This subtle mechanism - a disregard for the combined symmetry of particle-antiparticle switching and left-right reflection - possibly moulded the evolution of the Universe after the Big Bang, providing a world dominated by matter, rather than one where matter and antimatter play comparable roles.

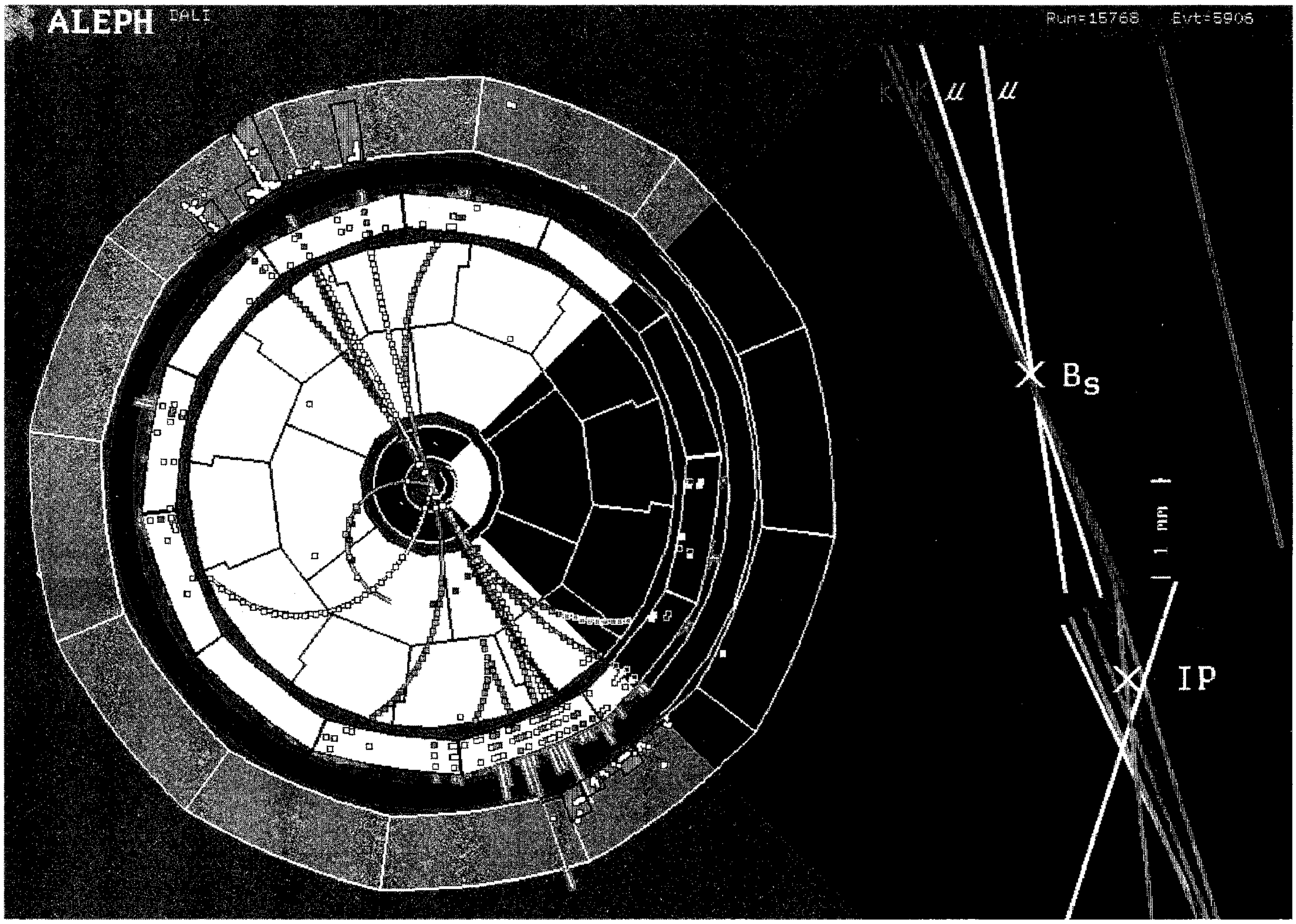
To fully explore CP violation in the laboratory needs a dedicated machine - a particle 'factory' - to mass produce B mesons. Only when this full picture of CP violation has been revealed will physicists finally be able to solve its mysteries.

As well as major proposals in the US and Japan, several ideas have been launched in Europe. Over the years, many working groups have accumulated an impressive amount of data and knowledge on the physics as well as on the machine and detectors.

The spearheads of experimental B physics are the ARGUS and CLEO collaborations. Highlights include the determination of the parameters of the (Cabibbo-Kobayashi-Maskawa, CKM) quark mixing matrix, testing the consistency of the Standard Model with six quarks and three leptons, and giving the first indirect hint that the as yet unseen sixth ('top') quark is very heavy, together with initial indications of how it should decay.

Valuable complementary informa-

A recent sighting at the Aleph experiment at CERN's LEP electron-positron collider was this beautiful fully reconstructed formation of a B_s meson and its subsequent decay into a psi prime (subsequently giving a muon pair) and a phi meson (giving a kaon pair). The B_s mass is 5.3746 GeV, in accord with theoretical predictions.



tion has come from proton-antiproton collider data and particularly from the LEP experiments at the Z resonance. Experiments at LEP have measured average and individual lifetimes of the various B hadron species as well as the weak neutral current properties of the b quark, while both electron-positron and proton-antiproton studies have been able to establish a significant signal for neutral B mixing. The B_s-meson (containing a strange antiquark and a b quark) and lambda-b baryon have been seen by experiments at CERN.

B physics information can be combined with results from CP violation in kaon decays to constrain the Standard Model. However, there are still large uncertainties, especially the top quark mass, which to the best of our knowledge is somewhere between 91 and 180 GeV.

Top quark particles will hopefully soon be found at Fermilab's Tevatron collider. However determination of the various quark couplings and form factors needs a reliable theoretical framework. Here lattice gauge theory calculations are promising. Although the present lattice-volumes are not sufficient to simulate B physics directly, reliable methods have been developed in extrapolating the results on charmed particles, and in the limiting case of an infinitely heavy quark system, both of which have been studied by lattice techniques. These methods are well on their way to providing fully quantitative predictions for many aspects of B decays.

Awaiting experimental determination of several important quark couplings, recent measurements of the D_s meson (strange antiquark and charmed quark) by the WA75 collaboration at CERN provide a useful check on a number of theoretical models and strengthen confidence in lattice results.

To match the precision and reach of

experiments at a B factory needs further development of theoretical tools. A particular goal is to perfect the lattice techniques needed to compute B decays with a precision of 10% or better.

In the same vein, the discovery of heavy quark symmetry by Isgur and Wise in 1989 and its subsequent consolidation has opened up reliable predictions for B decays. This approach exploits the big difference between quark masses, revealing powerful symmetries in heavy quark systems which facilitate computations. The approach has already paid handsome dividends, but data from B factory experiments would increase its usefulness.

Flavour changing neutral current transitions in B decays creep in as higher order (rare) processes and are dominated by virtual top quark contributions. Measurements would provide valuable constraints on the top quark mass and its inter-quark couplings. The recent observation by the CLEO collaboration at Cornell's CESR electron-positron collider of the decay of a B meson into a K* and a photon provides a good check of the strength of so-called 'penguin' processes (see page 1) and opens a new chapter in the study of weak decays. However exploiting the full potential of the B sector with its many rare decay possibilities requires a B factory. Precision measurements on all these B decays would provide full and stringent tests of the quark mixing matrix and probe any loopholes indicative of new physics.

CP violation in B decays is expected to happen through three mechanisms. The interference of two Feynman diagrams with different weak and strong phases gives so-called direct CP violation. The unequal probabilities for neutral B-mesons to transform into each other provide another possibility, while the interference of this effect with direct B decay gives a third. In the Standard Model, this latter class might exhibit large CP violating effects, much larger than those seen in kaon decays.

While the bulk of analysis so far uses a Standard Model context, B decays also provide a scenario for physics beyond the Standard Model. With high production rates for tau leptons, a B factory will allow searches for many decays at levels at least two orders of magnitude more sensitive than present limits.

The wide diversity of B decay channels needs to be exploited to improve our understanding of weak decays. Present measurements and theoretical analyses support the Standard Model, but consistency is not yet complete. Experiments at a B meson factory will pin this down.

In particular, the possibility of observing CP violation in B decays is an outstanding opportunity to finally get to grips with a fundamental physical phenomenon vital to our understanding of the evolution of universe.

Last but not least, there is the general dissatisfaction with the Standard Model, where masses and mixing patterns have to be put in by hand. Understanding this is one of the major challenges facing physicists today, and a B factory could provide the long-sought clue to what makes the Standard Model tick.

From Roy Aleksan (Saclay) and Ahmed Ali (DESY)

Physics and astrophysics of quark-gluon plasma

The quark gluon plasma - matter too hot or dense for quarks to crystallize into particles - played a vital role in the formation of the Universe. Efforts to recreate and understand this type of matter are forefront physics and astrophysics, and progress was highlighted in the Second International Conference on Physics and Astrophysics of Quark Gluon Plasma (ICPA-QGP 93), held in Calcutta from 19-23 January. (The first conference in the series was held in Bombay in February 1988).

Although primarily motivated towards enlightening the Indian physics community in this new and rapidly evolving area, in which India now plays an important role, the conference also catered for an international audience. Particular emphasis was placed on the role of quark gluon plasma in astrophysics and cosmology.

While Charles Alcock of Lawrence Livermore looked at a less conventional picture giving inhomogeneous ('clumpy') nucleosynthesis, David Schramm (Chicago) covered standard big bang nucleosynthesis. The abundances of very light elements do not differ appreciably for these contrasting scenarios; the crucial difference between them shows up for heavier elements like lithium-7 and -8 and boron-11.

Richard Boyd (Ohio State) highlighted the importance of accurate measurements of the primordial abundances of these elements for clues to the cosmic quark hadron phase transition. B. Banerjee (Bom-