BNL 35979

Talk given at the 4th International Conference on: Physics in Collision held in Santa Cruz, CA, August 22-24, 1984.

CONF-8408141--4

# The Search for Proton Decay - Status Report 1984

BNL--35979

DE85 008283

Reported by Maurice Goldhaber
Brookhaven National Laboratory, Upton, NY

For the IMB Collaboration: R.M. Bionta, G. Blewitt, C.B. Bratton, B.G. Coretz, S. Errede, G.W. Foster, W. Gajewski, M. Goldhaber, J. Greenberg, T.J. Haines, T.W. Jones, D. Kielczewska, W.R. Kropp, J.G. Learned, E. Lehmann, J.M. LoSecco, P.V. Ramana Murthy, H.S. Park, F. Reines, J. Schultz, E. Shumard, D. Sinclair, D.W. Smith, H.W. Sobel, J.L. Stone, L.R. Sulak, R. Svoboda, J.C. van der Velde and C. Wuest

**DISCLAIMER**

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

The part of this work done at Brookhaven National Laboratory has been authored under contract DE-AC02-76CH00016 with the Division of Basic Energy Sciences, U.S.Department of Energy. Accordingly, the U.S. Government retains a nonexclusive, royalty-free license to publish or reproduce the published form of this contribution, or allows other to do so, for U.S. Government purposes.

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

From the various ongoing searches for proton decay (Kolar Goldfields, Nusex, IMB, Kamiokande and HPW experiments) about twenty "candidate events" for proton decay have so far been reported. Nevertheless, definite evidence for proton decay has not been claimed. Why? There are two main reasons:

1. For any particular candidate event we cannot exclude the possibility that it is due to the interaction of an atomospheric neutrino.

2. Because of the limited resolution of existing detectors each candidate event can usually not be interpreted as a definite "candidate decay branch". If we consider only decay branches in which no neutrino is emitted, the ambiguities in interpretation lead to nearly as many candidate decay branches as there are candidate events.

Thus, only consistency, good statistics and reproducibility of some candidate decay branches could be considered definite evidence of proton decay.[1] We can already say that for most two-body branches the partial lifetime is $> 10^{31}$y. Since the present detectors, including improvements in progress, as well as new detectors under construction, are sensitive only to partial decay times $< 10^{33}$y, one can hope to decide in the next few years whether or not proton decay takes place within this window of opportunity ($10^{31}$-$10^{33}$y). The minimal SU(5) theory which predicts the lifetime for the branch $p \to e^+ + \pi^0$ is contradicted by our work[2]; more recently this has also been confirmed by Kamiokande. Even if certain refinements are taken into account SU(5) does not look hopeful unless there is "new physics"[3].

Table I shows our results for 204 live days of observation with no neutrino background subtracted in the calculation of lifetime limits.

Much attention has been paid to the candidate branch $p \to \mu^+ + K^0$, because it would be compatible with expectations from supersymmetric theory. Recently, Campbell, Ellis and Nanopolous[4] have shown that in supersymmetric theories the

ratio $(n \to \nu K^0)/(p \to \mu K^0)$ is > 1 and can be as high as $\sim 10^4$, depending on assumptions about the Higgs sector. If some of the $p \to \mu + K^0$ candidates should correspond to real proton decay, we can exclude some formulations of supersymmetric theories, since we find only a comparable number of candidate branches $p \to \mu^+ + K^0$ and $n \to \nu + K^0$.

References:


1. M. Goldhaber, "The Phenomenology of Gauge Theories", J. Tran Tank Van, Ed., p.621, 1984 and Europhysics Conference on Flavor Mixing in Weak Interactions, Erice, Italy, 1984, L.L. Chau, Ed.,to be published by Plenum, New York.

2. R.M. Bionta, G. Blewitt, C.B. Bratton, B.G. Coretz, S. Errede, G.W. Foster, W. Gajewski, M. Goldhaber, J. Greenberg, T.J. Haines, T.W. Jones, D. Kielczewska, W.R. Kropp, J.G. Learned, E. Lehmann, J.M. LoSecco, P.V. Ramana Murthy, H.S. Park, F. Reines, J. Schultz, E. Shumard, D. Sinclair, D.W. Smith, H.W. Sobel, J.L. Stone, L.R. Sulak, R. Svoboda, J.C. van der Velde and C. Wuest, Phys. Rev. Lett. 51, 27 (1983), and later work.

3. For a review, see M. Goldhaber and W.J. Marciano, to be published by the Institute of Theoretical Physics, University of Miami, Coral Gables, Florida, in a volume honoring the memory of P.A.M. Dirac.

4. B.A. Campbell, J. Ellis, and D.V. Nanopoulos, Phys. Lett. 141B, 229 (1984).

TABLE I

| Decay Branch | Limit on $\tau/B$ ($\times 10^{31}$ yr) 90% C.L. |
|---|---|
| $p \to e^+\gamma$ | 18 |
| $p \to e^+\pi^0$ | 12 |
| $p \to e^+K^0$ | 4.9 |
| $p \to e^+\eta^0$ | 12 |
| $p \to e^+\rho^0$ | 2.5 |
| $p \to e^+\omega^0$ | 4 |
| $p \to \mu^+\gamma$ | 14 |
| $p \to \mu^+\pi^0$ | 5.1 |
| $p \to \mu^+K^0$ | 2.9 |
| $p \to \mu^+\eta^0$ | 3.1 |
| $p \to \mu^+\rho^0$ | 1.2 |
| $p \to \mu^+\omega^0$ | 2.1 |
| $p \to \nu K^+$ | 0.7 |
| $p \to \nu \rho^+$ | 1.1 |
| $p \to \nu K^{*+}$ | 0.7 |
| $p \to e^+e^+e^-$ | 25 |
| $p \to \mu^+\mu^+\mu^-$ | 9 |
| $n \to e^+\pi^-$ | 2.5 |
| $n \to e^+\pi^+$ | 2.5 |
| $n \to e^+\rho^-$ | 1.2 |
| $n \to e^-\rho^+$ | 1.2 |
| $n \to \mu^+\pi^-$ | 3.8 |
| $n \to \mu^-\pi^+$ | 2.7 |
| $n \to \mu^+\rho^-$ | 0.9 |
| $n \to \mu^-\rho^+$ | 0.9 |
| $n \to \nu\gamma$ | 1.1 |
| $n \to \nu\pi^0$ | 0.7 |
| $n \to \nu K^0$ | 1. |
| $n \to \nu\eta^0$ | 1.8 |
| $n \to \nu\rho^0$ | 0.2 |
| $n \to \nu\omega^0$ | 1.6 |
| $n \to \nu K^{*0}$ | 0.7 |
| $n \to e^+e^-\nu$ | 2.6 |
| $n \to \mu^+\mu^-\nu$ | 1.9 |