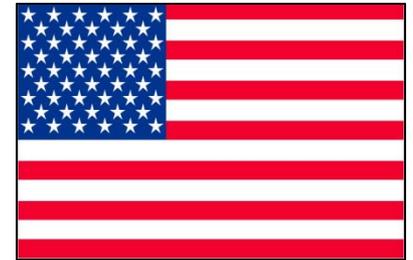
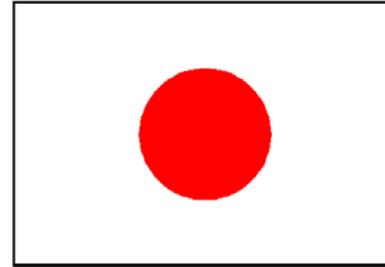
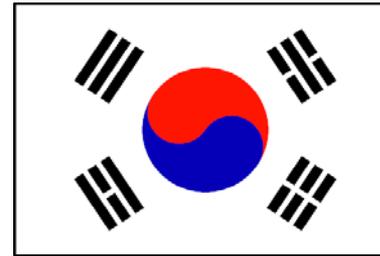


Super-Kamiokande Collaboration

Initially (1992): Japan, USA



Now Includes: S. Korea,
China, Poland, Spain



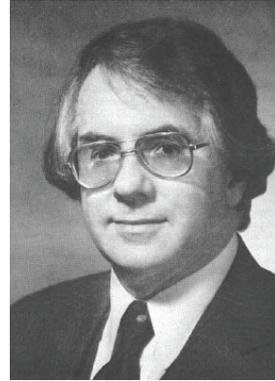
~ 130 Scientists

~ 36 Institutions



Still Together After 18 Years ...

How it all began ...



A group of theorists H. Georgi, S. Glashow, J. Pati, A. Salam and Others ...

Grand Unification Theory SU(5)

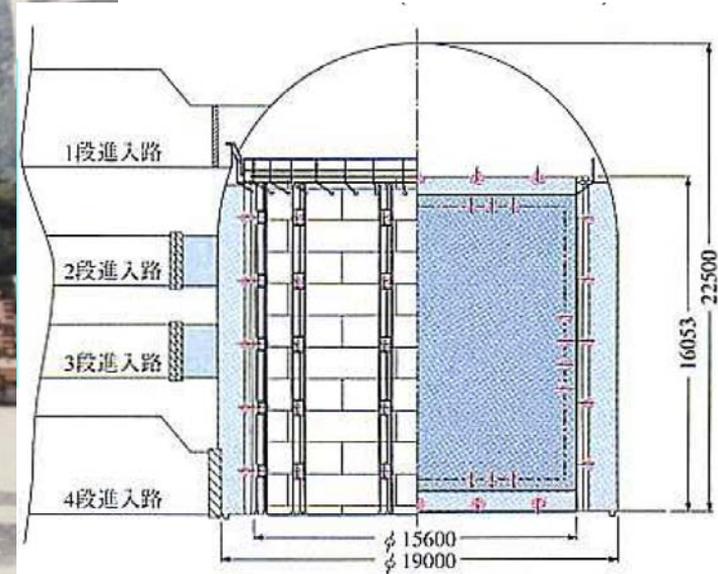
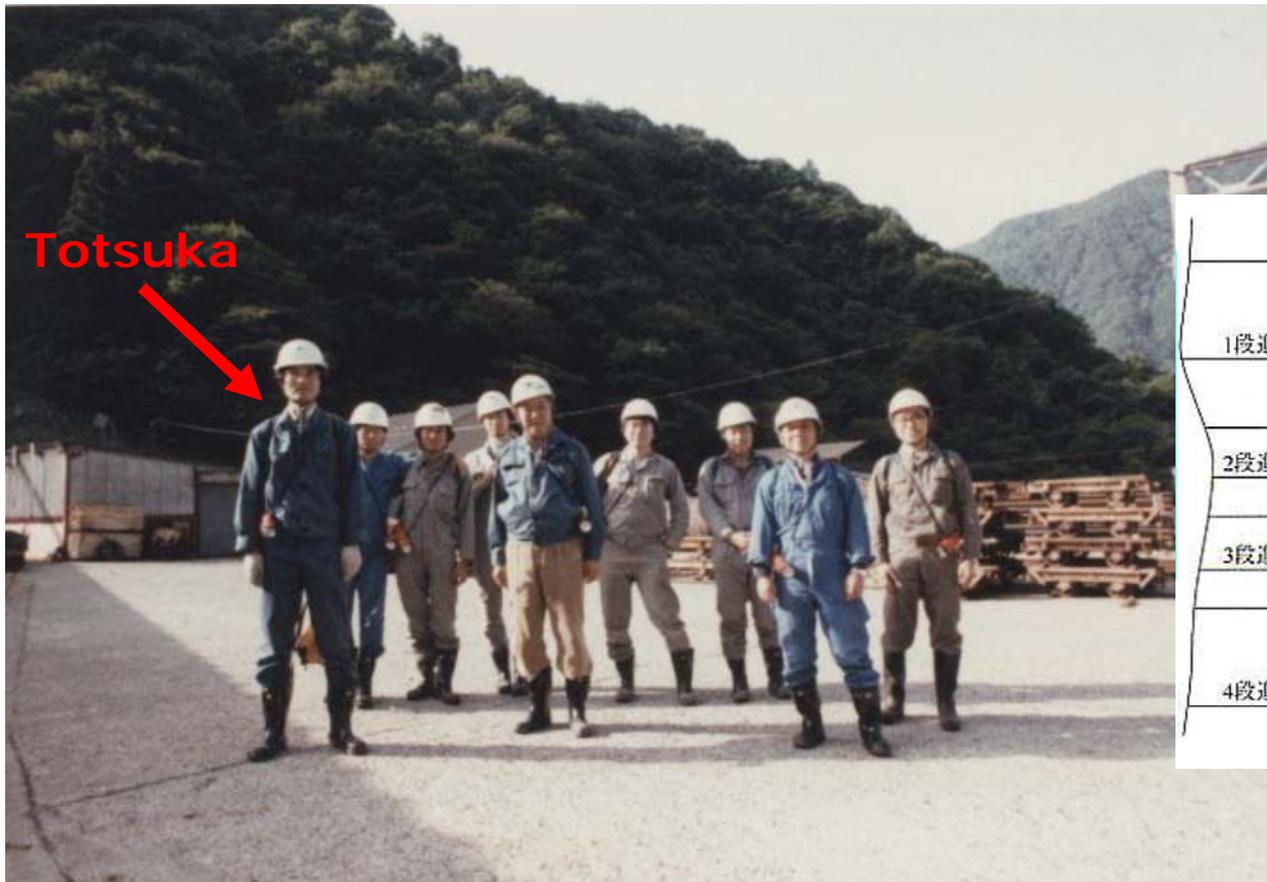
Proton Lifetime predicted to be $\sim 10^{29} \pm 1.7$ years

Kamioka Nucleon Decay Experiment = Kamiokande

Irvine, Michigan, Brookhaven = IMB

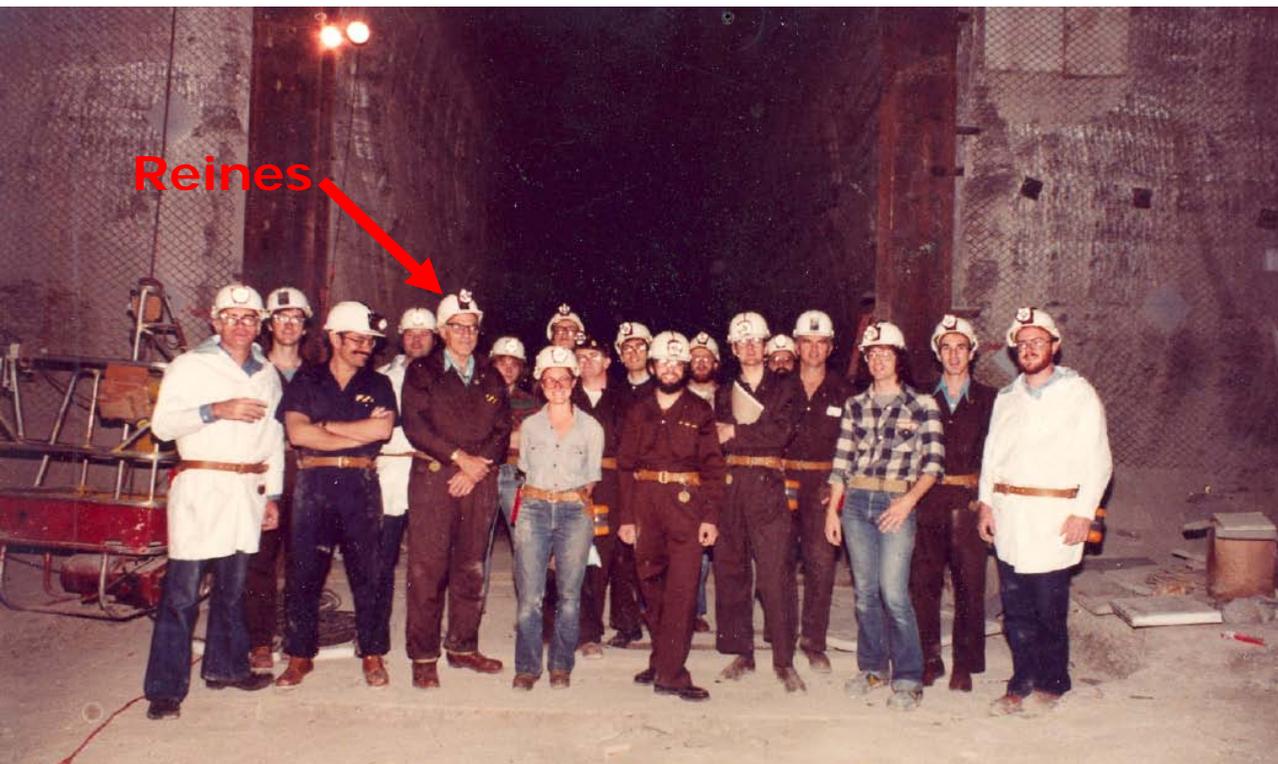
Kamiokande Detector

circa 1980 built by ICRR University of Tokyo



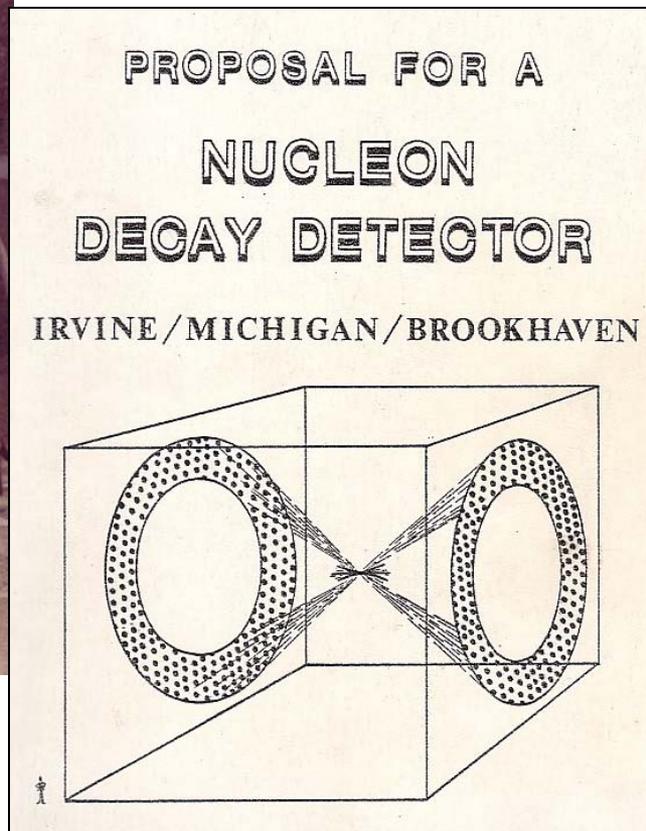
IMB Detector

Circa 1980 funded by US DOE



Reines

1980 in the Morton Salt Mine



The 1980's ...

- **Both IMB and Kamiokande Collaborations published many papers on the same topics.**
- **Scientific competition spanned a decade.**
- **Independent scientific results made a strong impact on the physics community.**

Search for Proton Decay into $e^+ \pi^0$

R. M. Bionta, G. Blewitt, C. B. Bratton, B. G. Cortez,^(a) S. Errede, G. W. Forster,^(a) W. Gajewski,
M. Goldhaber, J. Greenberg, T. J. Haines, T. W. Jones, D. Kielczewska,^(b) W. R. Kropp,
J. G. Learned, E. Lehmann, J. M. LoSecco, P. V. Ramana Murthy,^(c) H. S. Park,
F. Reines, J. Schultz, E. Shumard, D. Sinclair, D. W. Smith,^(d) H. W. Sobel,
J. L. Stone, L. R. Sulak, R. Svoboda, J. C. van der Velde, and C. Wuest

*The University of California at Irvine, Irvine, California 92717, and The University of Michigan,
Ann Arbor, Michigan 48109, and Brookhaven National Laboratory, Upton, New York 11973,
and California Institute of Technology, Pasadena, California 91125, and Cleveland State
University, Cleveland, Ohio 44115, and The University of Hawaii, Honolulu, Hawaii
96822, and University College, London WC1E 6BT, United Kingdom*

(Received 13 April 1983)

Observations were made 1570 meters of water equivalent underground with an 8000-metric-ton water Cherenkov detector. During a live time of 80 d no events consistent with the decay $p \rightarrow e^+ \pi^0$ were found in a fit that the limit on the lifetime for bound p (ratio is $\tau/B > 6.5 \times 10^{31}$ yr; for free proton). Observed cosmic-ray muons an

PACS numbers: 13.30.Eg, 11.30.Ly, 14.

Journal of the Physical Society of Japan
Vol. 54, No. 9, September, 1985, pp. 3213-3216

IMB

Kamiokande

LETTERS

Proton Decay

~~SU(5)~~

$\tau/B > 6.5 \times 10^{31}$ yr.

Search for Nucleon Decay into Charged Lepton + Mesons

Katsushi ARISAKA, Takaaki KAJITA, Masatoshi KOSHIBA,
Masayuki NAKAHATA, Yuichi OYAMA, Atsuto SUZUKI,
Masato TAKITA, Yoji TOTSUKA, Tadashi KIFUNE,[†]
Teruhiro SUDA,[†] Kasuke TAKAHASHI^{††} and Kazumasa MIYANO^{†††}

*Department of Physics and ICEPP, University of Tokyo, Tokyo 113
†Institute for Cosmic Ray Research, University of Tokyo, Tokyo 188
††KEK, National Laboratory for High Energy Physics, Ibaraki 305
†††Department of Physics, University of Niigata, Niigata 950-21*

(Received July 19, 1985)

With a 3000 ton water Cherenkov detector operated 2700 m.w.e. underground, 103 fully contained events were observed during a live time of 343 days. Most of the events are well interpreted as due to ν interactions. Four multi-ring events survive after applying criteria for nucleon decay. The lower limits on τ/B obtained from these data exceed 10^{31} yr (90% C.L.) for most of the possible decay modes.

Observation of a Neutrino Burst from the Supernova SN1987A

K. Hirata,^(a) T. Kajita,^(a) M. Koshiba,^(a,b) M. Nakahata,^(b) Y. Oyama,^(b)
 N. Sato,^(c) A. Suzuki,^(b) M. Takita,^(b) and Y. Totsuka^(a,c)
University of Tokyo, Tokyo 113, Japan

T. Kifune and T. Suda

Institute for Cosmic Ray Research, University of Tokyo, Tokyo 118, Japan

K. Takahashi and T. Tanimori

National Laboratory for High Energy Physics (KEK), Ibaraki 305, Japan

K. Miyano and M. Yamada

Department of Physics, University of Niigata, Niigata 950-21, Japan

E. W. Beier, L. R. Feldscher, S. B. Kim, A. K. Mann, F. M. Newcomer, R. Van Berg, and W. Zhang
Department of Physics, University of Pennsylvania, Philadelphia, Pennsylvania 19104

and

B. G. Cortez^(d)

California Institute of Technology, Pasadena, California 91125

(Received 10 March 1987)

A neutrino burst was observed in the Kamiokande II detector on 23 February 1987, 7:35:35 UT (± 1 min) during a time interval of 13 sec. The signal consisted of eleven electron events of energy 7.5 to 36 MeV, of which the first two point back to the Large Magellanic Cloud with angles $18^\circ \pm 18^\circ$ and $15^\circ \pm 27^\circ$.

Kamiokande

Supernova 1987A

IMB

Observation of a Neutrino Burst in Coincidence with Supernova 1987A in the Large Magellanic Cloud

R. M. Bionta,⁽¹²⁾ G. Blewitt,⁽⁴⁾ C. B. Bratton,⁽⁵⁾ D. Casper,^(2,14) A. Ciocio,⁽¹⁴⁾ R. Claus,⁽¹⁴⁾ B. Cortez,⁽¹⁶⁾
 M. Crouch,⁽⁹⁾ S. T. Dye,⁽⁶⁾ S. Errede,⁽¹⁰⁾ G. W. Foster,⁽¹⁵⁾ W. Gajewski,⁽¹⁾ K. S. Ganezer,⁽¹⁾
 M. Goldhaber,⁽³⁾ T. J. Haines,⁽¹⁾ T. W. Jones,⁽⁷⁾ D. Kielczewska,^(1,8) W. R. Kropp,⁽¹⁾ J. G. Learned,⁽⁶⁾
 J. M. LoSecco,⁽¹³⁾ J. Matthews,⁽²⁾ R. Miller,⁽¹⁾ M. S. Mudan,⁽⁷⁾ H. S. Park,⁽¹¹⁾ L. R. Price,⁽¹⁾
 F. Reines,⁽¹⁾ J. Schultz,⁽¹⁾ S. Seidel,^(2,14) E. Shumard,⁽¹⁶⁾ D. Sinclair,⁽²⁾ H. W. Sobel,⁽¹⁾ J. L. Stone,⁽¹⁴⁾
 L. R. Sulak,⁽¹⁴⁾ R. Svoboda,⁽¹⁾ G. Thornton,⁽²⁾ J. C. van der Velde,⁽²⁾ and C. Wuest⁽¹²⁾

⁽¹⁾The University of California, Irvine, Irvine, California 92717

⁽²⁾The University of Michigan, Ann Arbor, Michigan 48109

⁽³⁾Brookhaven National Laboratory, Upton, New York 11973

⁽⁴⁾California Institute of Technology, Jet Propulsion Laboratory, Pasadena, California 91109

⁽⁵⁾Cleveland State University, Cleveland, Ohio 44115

⁽⁶⁾The University of Hawaii, Honolulu, Hawaii 96822

⁽⁷⁾University College, London WC1E6BT, United Kingdom

⁽⁸⁾Warsaw University, Warsaw, Poland

⁽⁹⁾Case Western Reserve University, Cleveland, Ohio 44106

⁽¹⁰⁾The University of Illinois, Urbana, Illinois 61801

⁽¹¹⁾The University of California, Berkeley, California 94720

⁽¹²⁾Lawrence Livermore National Laboratory, Livermore, California 94550

⁽¹³⁾The University of Notre Dame, Notre Dame, Indiana 46556

⁽¹⁴⁾Boston University, Boston, Massachusetts 02215

⁽¹⁵⁾Fermi National Accelerator Laboratory, Batavia, Illinois 60510

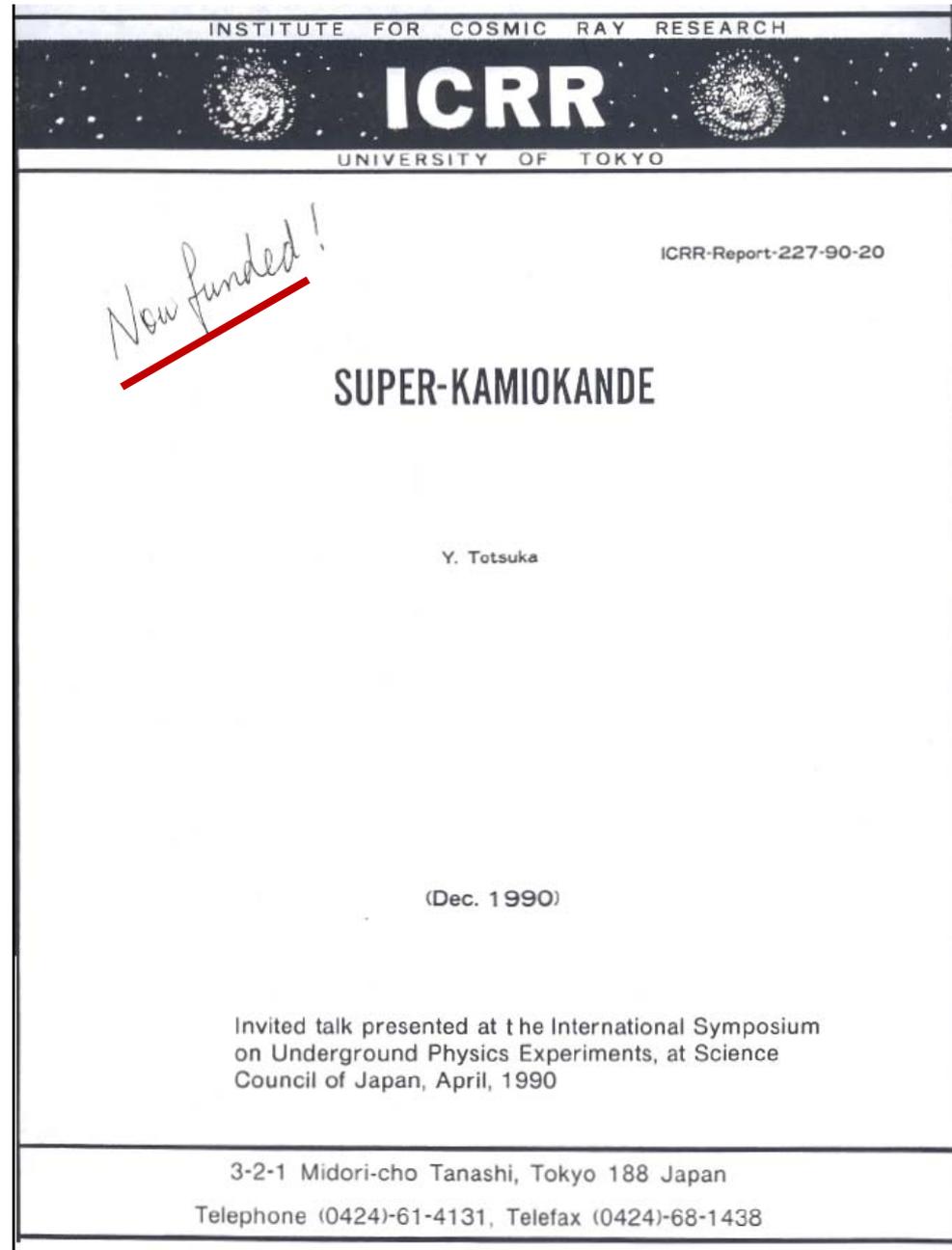
⁽¹⁶⁾AT&T Bell Laboratories, Summit, New Jersey 07910

(Received 13 March 1987)

A burst of eight neutrino events preceding the optical detection of the supernova in the Large Magellanic Cloud has been observed in a large underground water Cherenkov detector. The events span an interval of 6 s and have visible energies in the range 20–40 MeV.

The Early 1990's ...

- IMB collaboration unsuccessful in getting funding for a next generation detector in the U.S.
- In 1991, IMB tank developed a fatal leak.
- Super-Kamiokande funded in Japan



First Contact

Email sent to Professor Totsuka on January 23, 1992 follows a conference phone call with Y. Suzuki.

IMB proposed:

- Merge forces on Super-Kamiokande
- Use IMB PMTs to build anti-detector (outer)
- Independent simulations and analysis
- Work on KEK beam test

```
#1 23-JAN-1992 15:55:26.85 NEWMAIL
\address
Professor Y. Totsuka
Institute for Cosmic Ray Research
University of Tokyo
5-1-1 Midori-Cho Tanashi
Tokyo 188, Japan

\body
Dear Professor Totsuka:

\baselineskip=15pt
We were very pleased to talk with you today about the future plans of
Super-Kamiokande and the future possibilities of IMB.
Let me take this opportunity to reiterate to you, on behalf of the IMB
collaboration, the possible collaboration that has been discussed at our
recent IMB group meeting. We are truly impressed with the promise
presented by your proposed Super-Kamiokande detector. This detector
offers a natural extension of the beautiful results from Kamiokande,
particularly the proton decay limits, the solar neutrino observations

Press RETURN for more...

MAIL> #1 23-JAN-1992 15:55:26.85 NEWMAIL
and the discovery of supernova neutrinos. Although the IMB
collaboration has also had the pleasure of setting significant limits on
proton decay, astrophysical point sources, monopoles, wimps, etc. as
well as observing the neutrinos from the supernova, we recognize the
superior capabilities of Super-Kamiokande. Seven times the fiducial
volume of IMB would extend our reach in the search for proton decay, etc
way beyond our current hopes. What you have done so well already in
Kamiokande clearly will be much better done at Super-Kamiokande and we
wonder if merging forces to develop together the world's largest
detector might even hold more promise.

At this point in the evolution of IMB, considerable resources could be
brought to a new collaborative effort. We have in hand 2000
characterized, well-working phototubes housed for high pressure water
operation. High voltage, electronics and readout are all completely
operational. These, for example, could be put to service either at a
test beam or as the active veto for your large detector.

Super-Kamiokande will not be duplicated. As you know, we have developed

Press RETURN for more...

MAIL> #1 23-JAN-1992 15:55:26.85 NEWMAIL
a detailed knowledge of the very same technology that you use. Two
independent simulations and double checks of detector performance could
be extremely valuable. In IMB, we currently lack a crucial Monte Carlo
ingredient, a detailed neutrino calibration at an accelerator.
Therefore, we look eagerly toward your proposed study of  $e\bar{\nu}_e$  and  $\tau$  neutrino interactions at KEK. Since we are limited by our
knowledge of the neutrino interactions, your topology and cross section
measurements, particularly for multi-ring events, are a project that we
would dearly like to participate in.

MAIL> #1 23-JAN-1992 15:55:26.85 NEWMAIL
April 29. We would like to extend an invitation to you to come to Boston
at that time and see our technical and analysis facilities. We would be
pleased to arrange for your travel from Philadelphia or whatever may be
appropriate. For the IMB Collaboration, we look forward to discussing this
with you. Thank you very much for taking the time to discuss these
prospects with us today.
\closing

Sincerely,
\vskip 1cm
S.T. Dye
Associate Professor
\vskip 1cm
J.L. Stone
Professor
```

Response from Professor Totsuka

Excerpted from letter dated: 2/17/92

The summary of our discussions are;

(1) We are in general quite positive to organize an international collaboration for the Super-Kamiokande experiment, especially to collaborate with the IMB group, which we greatly respect for their excellent achievements on proton decay and neutrino physics.

(2) Obviously the collaborating people must agree on the importance of the physics goals, and the design of the Super-Kamiokande detector.

(3) It is indeed a very good idea to have the anti-counters from the beginning by help of the foreign participation. In this respect we welcome your proposal of bringing the IMB inventories to Kamioka.

(4) Of course there are many technical details that have to be worked out. Therefore, we welcome some of you from Boston and Irvine to come to the ICRR, Tokyo and to see the Kamioka facility. We like to discuss the matters that were already addressed in your conversation with Yoichiro Suzuki.

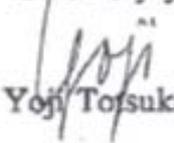
(5) Also we would like to discuss with you on the initial beam-test experiment (with e and μ beams) scheduled in 1993 (construction in 1992).

(6) Sometime later when we are agreeable on the technical points, we would like to discuss the issues related to

(i) a possible contract between your institute(s) and ours.

(ii) a structure of the collaboration, such as the role of the collaboration meeting, etc.

Sincerely yours


Yoji Totsuka

Collaboration Agreement Signed October 18, 1992 in Takayama

SuperKamiokande Collaboration Agreement Between the Collaborating Groups

Purpose

The purpose of this document is to define the terms and conditions under which the collaborating groups (at present Japanese and American) agree to work together in building and operating a 50,000 ton water Cherenkov detector at the Kamioka mine. The experiment shall be known as SuperKamiokande. The goals of the experiment include a search for nucleon decay, atmospheric neutrino studies, solar neutrinos, and studies of/searches for other astrophysical and particle physics phenomena. It is agreed that all collaborating groups are free to participate in all aspects of the experiment.

History

The SuperKamiokande (SK) project was initially considered and later materialized in a detailed form by M. Koshiba and his collaborators in 1984. After many years of intense effort, the full project was funded by the Japanese Ministry of Education, Science, and Culture in 1991. The final design and production of various detector parts started the same year.

In February 1992, some members of the IMB Collaboration called the SK Spokesman (Y. Totsuka) and expressed an interest in joining the SK Collaboration.

Several meetings and discussions have followed the initial February 1992 contact by the IMB group. This agreement is the result of our efforts to merge the two largest water Cherenkov groups in the world for the purpose of building and operating SuperKamiokande.

Organization of the Collaboration

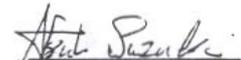
The SK Collaboration has 4 levels of organization:

- 1) Spokesman (Yoji Totsuka)
- 2) Executive Committee (Initially, Y. Totsuka, K. Nakamura, A. Suzuki, H. Sobel, and J. Stone)
- 3) Collaboration Council (Defined below)
- 4) Collaboration Meeting (All Collaborators)

Signatures

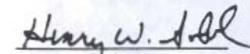
 10/18/92
Date

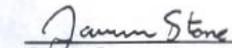
Yoji Totsuka
Institute for Cosmic Ray Research - University of Tokyo
Spokesman for the SuperKamiokande Collaboration

 10/18/92
Date
Atsuto Suzuki
KEK

 10/18/92
Date
Kenzo Nakamura
Institute of Cosmic Ray Research
University of Tokyo

Members of the Executive Committee

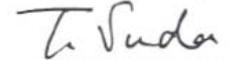
 10/18/92
Date
Henry Sobel
University of California - Irvine

 18 Oct 92
Date
James Stone
Boston University

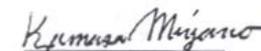
Members of the Executive Committee

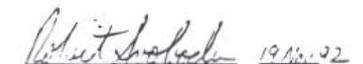
 Oct. 18, 92
Date
Masatoshi Koshiba
Tokai University

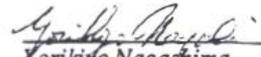
 18
Date
John Learned
University of Hawaii

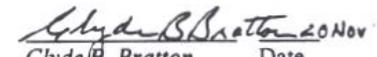
 Oct 20, '92
Date
Teruhiro Suda
Kobe University

 20 Nov 92
Date
Todd Haines
University of Maryland

 10/18/92
Date
Kazumasa Miyano
Niigata University

 19 Nov 92
Date
Robert Svoboda
Louisiana State University

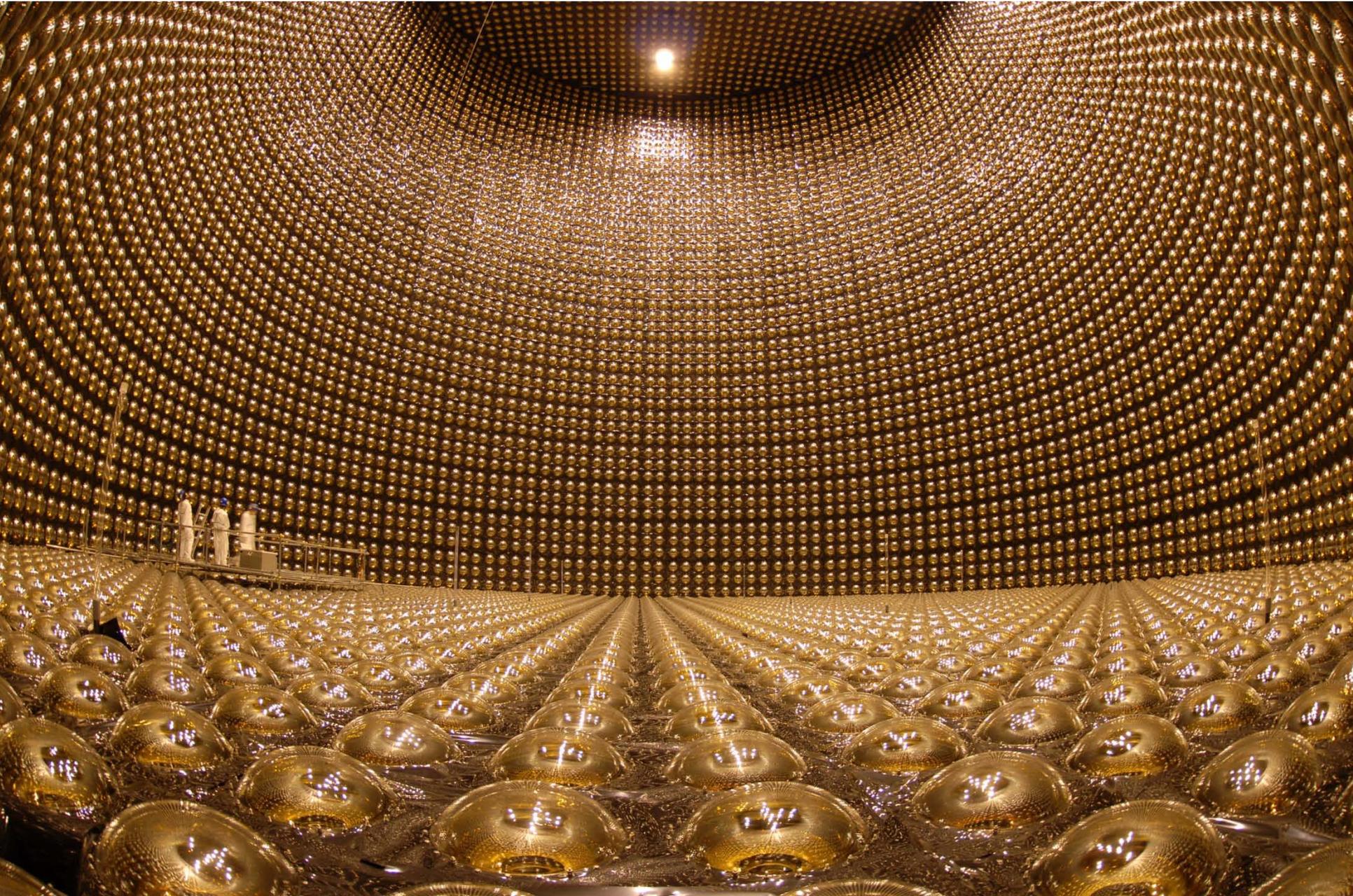
 10/18/92
Date
Torikayo Nagashima
Osaka University

 20 Nov
Date
Clyde B. Bratton
Cleveland State University

Completion of Super-K I 1996



Current View of Super-K



By Any Measure, A Tremendous Success

VOLUME 81, NUMBER 8

PHYSICAL REVIEW LETTERS

24 AUGUST 1998

Evidence for Oscillation of Atmospheric Neutrinos

Y. Fukuda,¹ T. Hayakawa,¹ E. Ichihara,¹ K. Inoue,¹ K. Ishihara,¹ H. Ishino,¹ Y. Itow,¹ T. Kajita,¹ J. Kameda,¹ S. Kasuga,¹ K. Kobayashi,¹ Y. Kobayashi,¹ Y. Koshio,¹ M. Miura,¹ M. Nakahata,¹ S. Nakayama,¹ A. Okada,¹ K. Okumura,¹ N. Sakurai,¹ M. Shiozawa,¹ Y. Suzuki,¹ Y. Takeuchi,¹ Y. Totsuka,¹ S. Yamada,¹ M. Earth,² A. Hatbig,² E. Kearns,² M. D. Messier,² K. Scholberg,² J. L. Stone,² L. R. Sulak,² C. W. Walter,² M. Goldhaber,² T. Barczczak,⁴ D. Casper,⁴ W. Gajewski,⁴ P. G. Halverson,⁴ J. Hsu,⁴ W. R. Kropp,⁴ L. R. Price,⁴ F. Reines,⁴ M. Smy,⁴ H. W. Sobel,⁴ M. R. Vagins,⁴ K. S. Ganezer,⁵ W. E. Keig,⁵ R. W. Ellsworth,⁵ S. Tasaka,⁷ J. W. Flanagan,⁸ A. Kibayashi,⁸ J. G. Learned,⁸ S. Matsuno,⁸ V. J. Stenger,⁸ D. Takemori,⁸ I. Shih,⁹ J. Kanzaki,⁹ T. Kobayashi,⁹ S. Mine,⁹ K. Nakamura,⁹ K. Nishikawa,⁹ Y. Oyama,⁹ A. Sakai,⁹ M. Sakuda,⁹ O. Sasaki,⁹ S. Echigo,¹⁰ M. Kohama,¹⁰ A. T. Suzuki,¹⁰ T. J. Haines,¹¹ E. Blaufuss,¹² B. K. Kim,¹² R. Sanford,¹² R. Svoboda,¹² M. L. Chen,¹³ Z. Conner,¹³ J. A. Goodman,¹³ G. W. Sullivan,¹³ J. Hill,¹⁴ C. K. Jung,¹⁴ K. Martens,¹⁴ C. Mauter,¹⁴ C. McGrew,¹⁴ E. Sharkey,¹⁴ B. Viren,¹⁴ C. Yanagisawa,¹⁴ W. Doki,¹⁵ K. Miyano,¹⁵ H. Okazawa,¹⁵ C. Saji,¹⁵ M. Takahata,¹⁵ Y. Nagashima,¹⁶ M. Takita,¹⁶ T. Yamaguchi,¹⁶ M. Yoshida,¹⁶ S. B. Kim,¹⁷ M. Etoh,¹⁸ K. Fujita,¹⁸ A. Hasegawa,¹⁸ T. Hasegawa,¹⁸ S. Hatakeyama,¹⁸ T. Iwamoto,¹⁸ M. Koga,¹⁸ T. Maruyama,¹⁸ H. Ogawa,¹⁸ J. Shirai,¹⁸ A. Suzuki,¹⁸ F. Tsushima,¹⁸ M. Koshiha,¹⁹ M. Nemoto,²⁰ K. Nishijima,²⁰ T. Futagami,²¹ Y. Hayato,²¹ Y. Kanaya,²¹ K. Kaneyuki,²¹ Y. Watanabe,²¹ D. Kielewicz,²² R. A. Doyle,²² J. S. George,²² A. L. Stuchlya,²³ L. L. Wai,²³

R. J. Wilkes,²³ and K. K. Young²³
(Super-Kamiokande Collaboration)

¹Institute for Cosmic Ray Research, University of Tokyo, Tanashi, Tokyo, 188-8502, Japan

²Department of Physics, Boston University, Boston, Massachusetts 02215

³Physics Department, Brookhaven National Laboratory, Upton, New York 11973

⁴Department of Physics and Astronomy, University of California at Irvine, Irvine, California 92697-4575

⁵Department of Physics, California State University, Dominguez Hills, Carson, California 90747

⁶Department of Physics, George Mason University, Fairfax, Virginia 22030

⁷Department of Physics, Gifu University, Gifu, Gifu 501-1193, Japan

⁸Department of Physics and Astronomy, University of Hawaii, Honolulu, Hawaii 96822

⁹Institute of Particle and Nuclear Studies, High Energy Accelerator Research Organization (KEK), Tsukuba, Ibaraki 305-0801, Japan

¹⁰Department of Physics, Kobe University, Kobe, Hyogo 657-8501, Japan

¹¹Physics Division, P-23, Los Alamos National Laboratory, Los Alamos, New Mexico 87544

¹²Department of Physics and Astronomy, Louisiana State University, Baton Rouge, Louisiana 70803

¹³Department of Physics, University of Maryland, College Park, Maryland 20742

¹⁴Department of Physics and Astronomy, State University of New York, Stony Brook, New York 11794-3800

¹⁵Department of Physics, Niigata University, Niigata, Niigata 950-2181, Japan

¹⁶Department of Physics, Osaka University, Toyonaka, Osaka 560-0043, Japan

¹⁷Department of Physics, Seoul National University, Seoul 151-742, Korea

¹⁸Department of Physics, Tohoku University, Sendai, Miyagi 980-8578, Japan

¹⁹The University of Tokyo, Tokyo 113-0033, Japan

²⁰Department of Physics, Tokai University, Hiratsuka, Kanagawa 259-1292, Japan

²¹Department of Physics, Tokyo Institute of Technology, Meguro, Tokyo 152-8551, Japan

²²Institute of Experimental Physics, Warsaw University, 00-681 Warsaw, Poland

²³Department of Physics, University of Washington, Seattle, Washington 98195-1560

(Received 6 July 1998)

We present an analysis of atmospheric neutrino data from a 33.0 kton yr (535-day) exposure of the Super-Kamiokande detector. The data exhibit a zenith angle dependent deficit of muon neutrinos which is inconsistent with expectations based on calculations of the atmospheric neutrino flux. Experimental biases and uncertainties in the prediction of neutrino fluxes and cross sections are unable to explain our observation. The data are consistent, however, with two-flavor $\nu_\mu \leftrightarrow \nu_\tau$ oscillations with $\sin^2 2\theta \approx 0.8$ and $\Delta m^2 = 10^{-3} \text{ eV}^2$ at 90% confidence level. (SUD-98-01)

Evidence for oscillation of atmospheric neutrinos-1998

4th highest ranked experimental paper in top 50 cited articles of all time >3318 citations (2009)

- Important papers with positive physics results published...small selection of results in Y. Suzuki's talk.
- Advancement of young physicists in their scientific careers.
- Continuing to work together on current experiments making use of this amazing multi-purpose detector.