The discovery of the J/Ψ particle at AGS/BNL - my personal recollection

(On the occasion of 50 years of J/Ψ discovery)

This same talk was given in AGS-RHIC Users Meeting Brookhaven National Laboratory, July 29, 1999 (On the occasion of 25 years of J/Ψ discovery)

Sau Lan Wu
Physics Department, University of Wisconsin-Madison

52nd SLAC Summer Institute
SLAC, August 9, 2024

This talk should have been given by Professor Samuel C.C.Ting.

It was his physics insight, his single mindedness, his tremendous dedication and his strong leadership that made it possible to discover the J/Ψ particle at the AGS/BNL experiment.

AGS: Alternating Gradient Synchrotron

50 Years ago, on November 11, 1974, the High Energy Physics Community of the whole world was stunned by the joint announcement by Sam Ting and Burt Richter of the discovery of the J particle observed at the Brookhaven National Laboratory and the Ψ particle at SLAC.

The charm quark was discovered!

In the December 2, 1974 issue of PRL, three papers on the discovery of the J/Ψ particle by MIT/BNL, SLAC/LBL, and ADONE/FRASCATI were published back to back.

Experimental Observation of a Heavy Particle J *MIT/BNL*

VOLUME 33, NUMBER 23 PHYSICAL REVIEW LETTERS 2 DECEMBER 1974

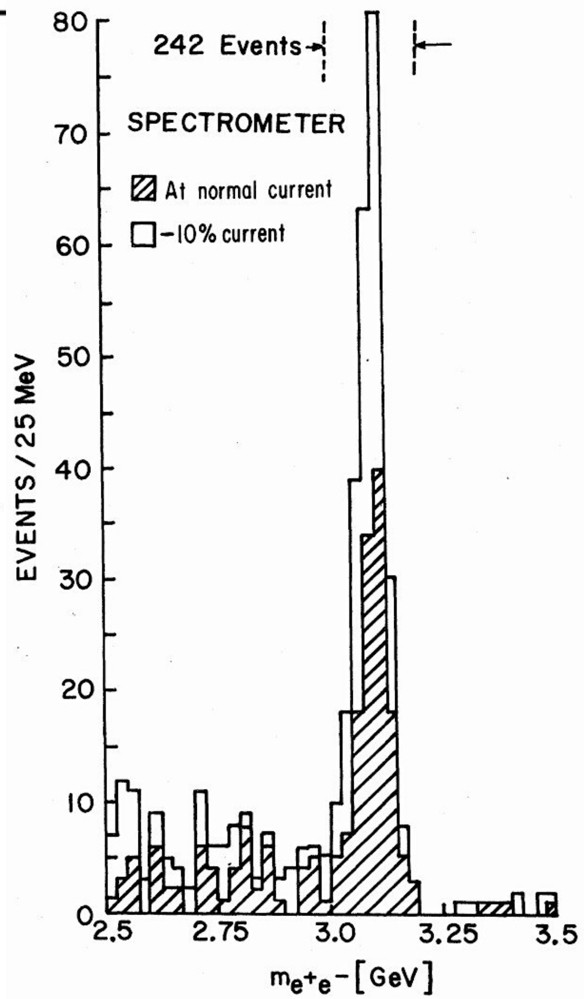
Experimental Observation of a Heavy Particle J†

J. J. Aubert, U. Becker, P. J. Biggs, J. Burger, M. Chen, G. Everhart, P. Goldhagen, J. Leong, T. McCorriston, T. G. Rhoades, M. Rohde, Samuel C. C. Ting, and Sau Lan Wu
Laboratory for Nuclear Science and Department of Physics, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139

and

Y. Y. Lee
Brookhaven National Laboratory, Upton, New York 11973

(Received 12 November 1974)



Discovery of a Narrow Resonance in e^+e^- Annihilation *SLAC/LBL*

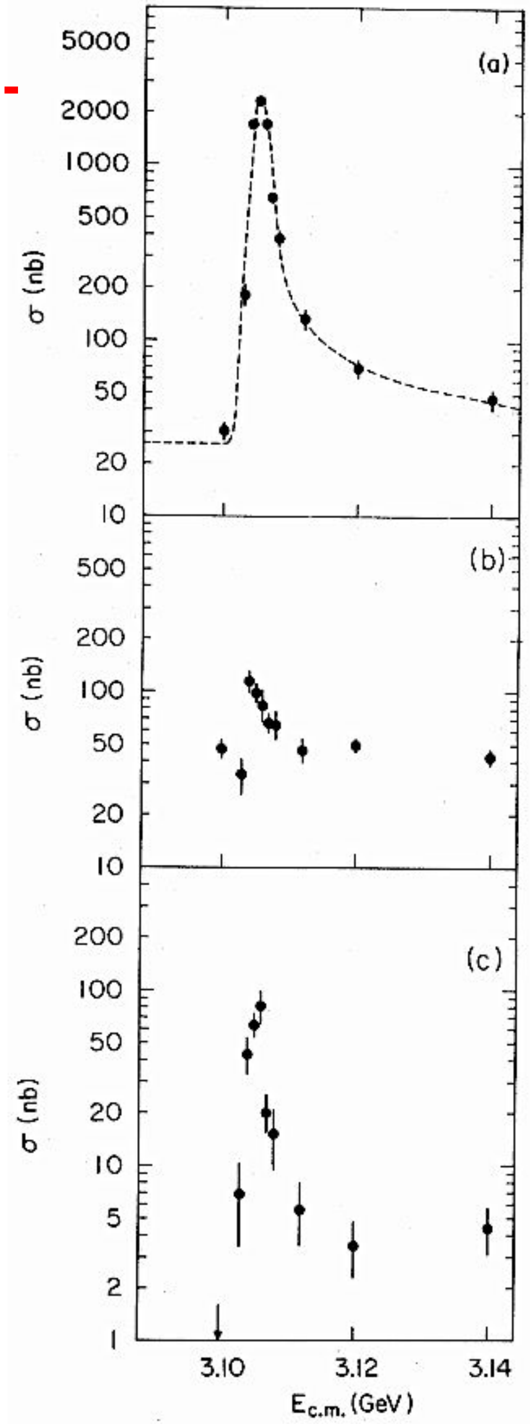
Discovery of a Narrow Resonance in e^+e^- Annihilation*

J.-E. Augustin,† A. M. Boyarski, M. Breidenbach, F. Bulos, J. T. Dakin, G. J. Feldman, G. E. Fischer, D. Fryberger, G. Hanson, B. Jean-Marie,† R. R. Larsen, V. Lüth, H. L. Lynch, D. Lyon, C. C. Morehouse, J. M. Paterson, M. L. Perl, B. Richter, P. Rapidis, R. F. Schwitters, W. M. Tanenbaum, and F. Vannucci‡
Stanford Linear Accelerator Center, Stanford University, Stanford, California 94305

and

G. S. Abrams, D. Briggs, W. Chinowsky, C. E. Friedberg, G. Goldhaber, R. J. Hollebeek, J. A. Kadyk, B. Lulu, F. Pierre,§ G. H. Trilling, J. S. Whitaker, J. Wiss, and J. E. Zipse
Lawrence Berkeley Laboratory and Department of Physics, University of California, Berkeley, California 94720

(Received 13 November 1974)



Final states

multi -hadron

e^+e^-

$\mu^+\mu^-$
$\pi^+\pi^-$
K^+K^-

On Nature of a New 3.1-GeV Particle Produced in e^+e^- Annihilation *ADONE / Frascati*

Preliminary Result of Frascati (ADONE) on the Nature of a New 3.1-GeV Particle Produced in e^+e^- Annihilation*

C. Bacci, R. Balbini Celio, M. Berna-Rodini, G. Caton, R. Del Fabbro, M. Grilli, E. Iarocci, M. Locci, C. Mencuccini, G. P. Murtas, G. Penso, G. S. M. Spinetti, M. Spano, B. Stella, and V. Valente
The Gamma-Gamma Group, Laboratori Nazionali di Frascati, Frascati, Italy

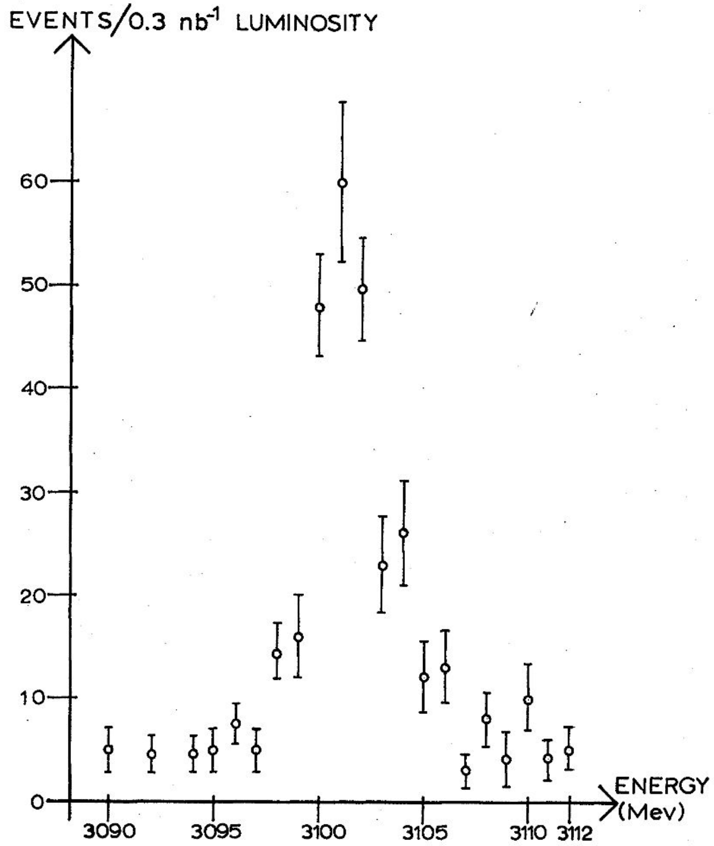
and

B. Bartoli, D. Bisello, B. Esposito, F. Felicetti, P. Monacelli, M. Nigro, L. Paolufi, I. Peruzzi, G. Piano Mortemi, M. Piccolo, F. Ronga, F. Sebastiani, L. Trasatti, and F. Vanoli
The Magnet Experimental Group for ADONE, Laboratori Nazionali di Frascati, Frascati, Italy

and

G. Barbarino, G. Barbiellini, C. Bemporad, R. Biancastelli, F. Cevenini, M. Celvetti, F. Costantini, P. Lariccia, P. Parascandalo, E. Sassi, C. Spencer, L. Tortora, U. Troya, and S. Vitale
The Baryon-Antibaryon Group, Laboratori Nazionali di Frascati, Frascati, Italy

(Received 18 November 1974)

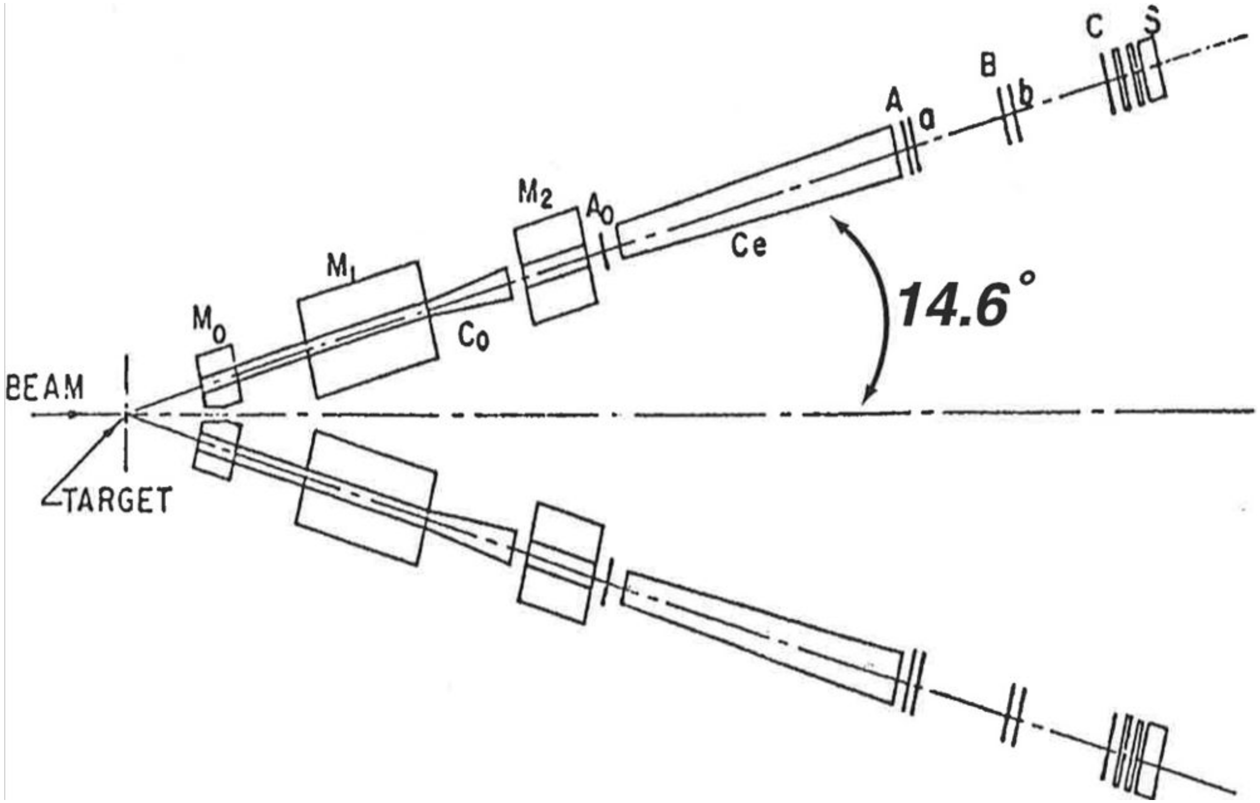


In 1972, on my birthday, May 11, Sam Ting, I and others drove from. M.I.T. to Brookhaven to present the proposal next day for measuring

$$p + Be \rightarrow e^{+} + e^{-} + X$$

with a precision pair spectrometer at the BNL's 30 GeV AGS. The purpose of this experiment was to determine the $e^{+}e^{-}$ mass spectrum to look for new particles.

We thank the Brookhaven leadership for their insight to accept our proposal quickly. Similar proposals were previously rejected elsewhere.



At T.T. Wu's suggestion, each spectrometer was set at 14.6° w.r.t beam. This corresponds to the new particle being produced at rest in the C.M. system and its decay products (e^+ and e^-) are at 90° – to maximize the acceptance.

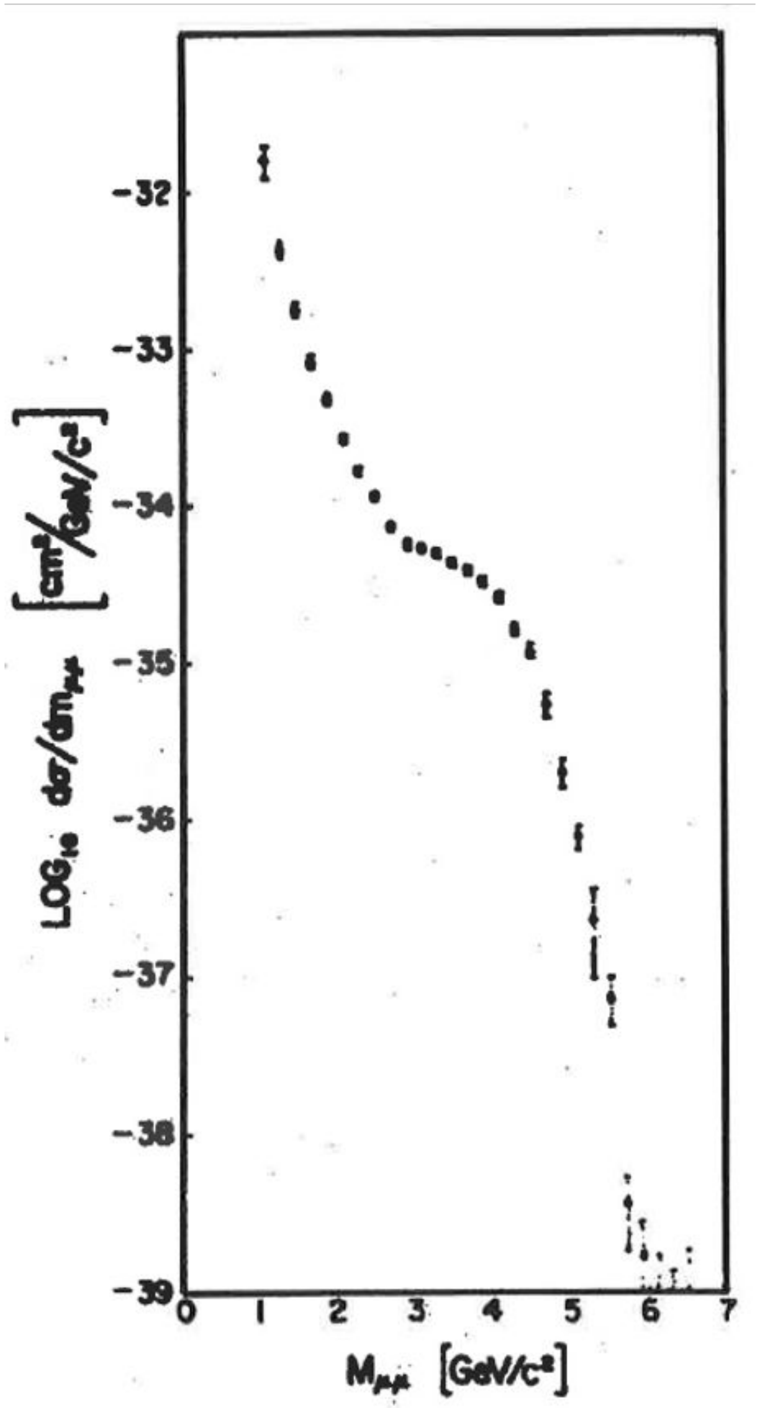
Tai Tsun Wu (T.T. Wu), my husband, passed away at 10:48 PM on July 19 2024.

The Lederman shoulder

In 1970, Lederman and his collaborators performed an experiment at AGS/BNL to measure:

$$p + U \rightarrow \mu^+ + \mu^- + X$$

A shoulder was seen around 3** GeV **invariant mass spectrum of $\mu^+\mu^-$.



It was by replacing the scintillation counter hodoscopes (used by Lederman in 1970) with the new technology of multiwire-proportional chambers invented by Charpak that makes the difference.

The high resolution of the multiwire proportional chambers, constructed under the leadership of Ulrich Becker of MIT, played a crucial role in this discovery of the J particle.

The chambers and the magnets yield a mass resolution of ±5 MeV and a mass acceptance of 2 GeV. The good mass resolution makes it possible to identify very narrow resonances.

The Cherenkov counters together with the shower counters enable one to have a rejection against a pair of strongly interacting particles by a factor of >> 1×10^8.

With up to $2x10^{12}$ protons per pulse there are $\sim 10^{11}$ interactions per pulse.

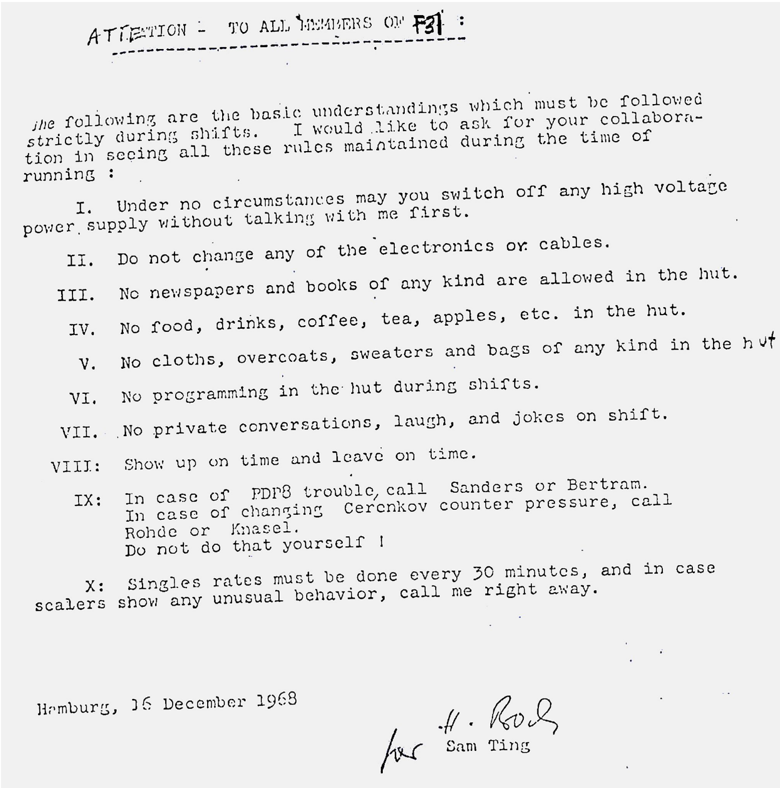
The total shielding used:

- ***10,000 tons of concrete***
- ***100 tons of lead***
- ***5 tons of uranium and***
- ***5 tons of borax soap (to absorb neutrons; the cleanest experiment in the world!)***

During data taking, we worked 16 hours per day and seven days per week.

Sam Ting arranged a men's room trailer next to our counting room trailer to save time. Being a woman, I had to climb through the concrete shielding to go to the lady's room next to the AGS control room. When I returned, Sam Ting often asked:

"Why do you take so long?"


ATTENTION - TO ALL MEMBERS OF F31 :

The following are the basic understandings which must be followed strictly during shifts. I would like to ask for your collaboration in seeing all these rules maintained during the time of running :

I. Under no circumstances may you switch off any high voltage power supply without talking with me first.

II. Do not change any of the electronics or cables.

III. No newspapers and books of any kind are allowed in the hut.

IV. No food, drinks, coffee, tea, apples, etc. in the hut.

V. No cloths, overcoats, sweaters and bags of any kind in the hut

VI. No programming in the hut during shifts.

VII. No private conversations, laugh, and jokes on shift.

VIII: Show up on time and leave on time.

IX: In case of PDP8 trouble, call Sanders or Bertram.
In case of changing Cerenkov counter pressure, call Rohde or Knasel.
Do not do that yourself !

X: Singles rates must be done every 30 minutes, and in case scalers show any unusual behavior, call me right away.

Hamburg, 16 December 1968

for M. Rohde
Sam Ting

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Hamburg, 16 December 1968

M. Rohde
for Sam Ting

By the end of August 1974, we tuned the magnets to accept an invariant mass of 2.5 to 4.0 GeV.

In the first half of September, a bump around 3.1 GeV in the e^+e^- invariant mass was seen.

Ting then asked Ronald Rau, Director of High Energy Physics at BNL, for more beam time.

Between September and November Mel Schwartz got 4 weeks, and we got 6 weeks of beam time.

The peak at 3.1 GeV persisted during this run. Many checks were made, and the most important one was that the magnet current was reduced by 10%, ruling out the possibility of a spectrometer acceptance effect.

The narrowness of the peak was mind-boggling. I showed Ting a copy of the preprint by Gaillard, Lee, and Rosner: "Search for the charm". We asked "Can this peak have something to do with charm?"

Rumors at Brookhaven of a new finding were flying.Towards the second half of October, Mel Schwartz(from Stanford) walked into our counting room trailer one day and said to Sam Ting:

"I heard that you have found a narrow peak at 3 GeV." **I was the witness that *they bet $10 if it was true. As soon as Mel Schwartz walked out the trailer, Ting pinned a note on the bulletin board "I owe Mel Schwartz $10."***

Many of us urged Ting to publish but his mind was more occupied by the possible wealth of physics this peak might bring.

"Let us find out more about it and find more of them," he said.

He had planned to have his secretary at MIT come down to BNL to type the paper on Thanksgiving.

The November Revolution

On November 10, 1974, I was on evening shift with Min Chen. A young physicist with black beard walked into our trailer and said to us: "Have you heard that SPEAR has found a narrow resonance at 3.1 GeV with a width of less than 2 MeV? People at SLAC are celebrating with champagne!" I had never met him before or after.

Min Chen and I looked at each other with tears in our eyes. Call Sam! But he was on a TWA flight to SLAC for a Program Advisory Committee meeting on November 11.

I called TWA to leave an urgent message for Ting at the SF Airport to call us. By the time he called at 1 am, I convinced myself that it was a practical joke by Mel Schwartz to collect his $10 bet. I went back to the women's dorm - the Curie House - to sleep.

At 2:30 AM, a loud knock at my door by Ingrid Schultz, Sam's loyal technical assistant, "Come back to the trailer; it is true !"

A plea from me in 1999

In the last 25 years, physics has greatly progressed forward but the women's dorm "Curie House" stays behind.

My Plea: to the BNL management and DOE: "Please fund the women's dorm to make it a more pleasant place to stay."

Update: I have been informed by Dr. Dmitri Denisov from BNL that, since then, the Curie House has been renovated.

Soon after Sam Ting got to his motel, Flamingo Motel (now called Creekside Inn) in Palo Alto, he received a call from Martin Deutsch of MIT.

Deutsch confirmed the news from SLAC.

All through the night, the operator at Flamingo was bombarded with requests to connect calls to Ting's room. Sam had me call the Directors of CERN, DESY, and FRASCATI.

November 11, 1974

With bloodshot eyes, I and others joined the BNL Director for a press conference in the morning.

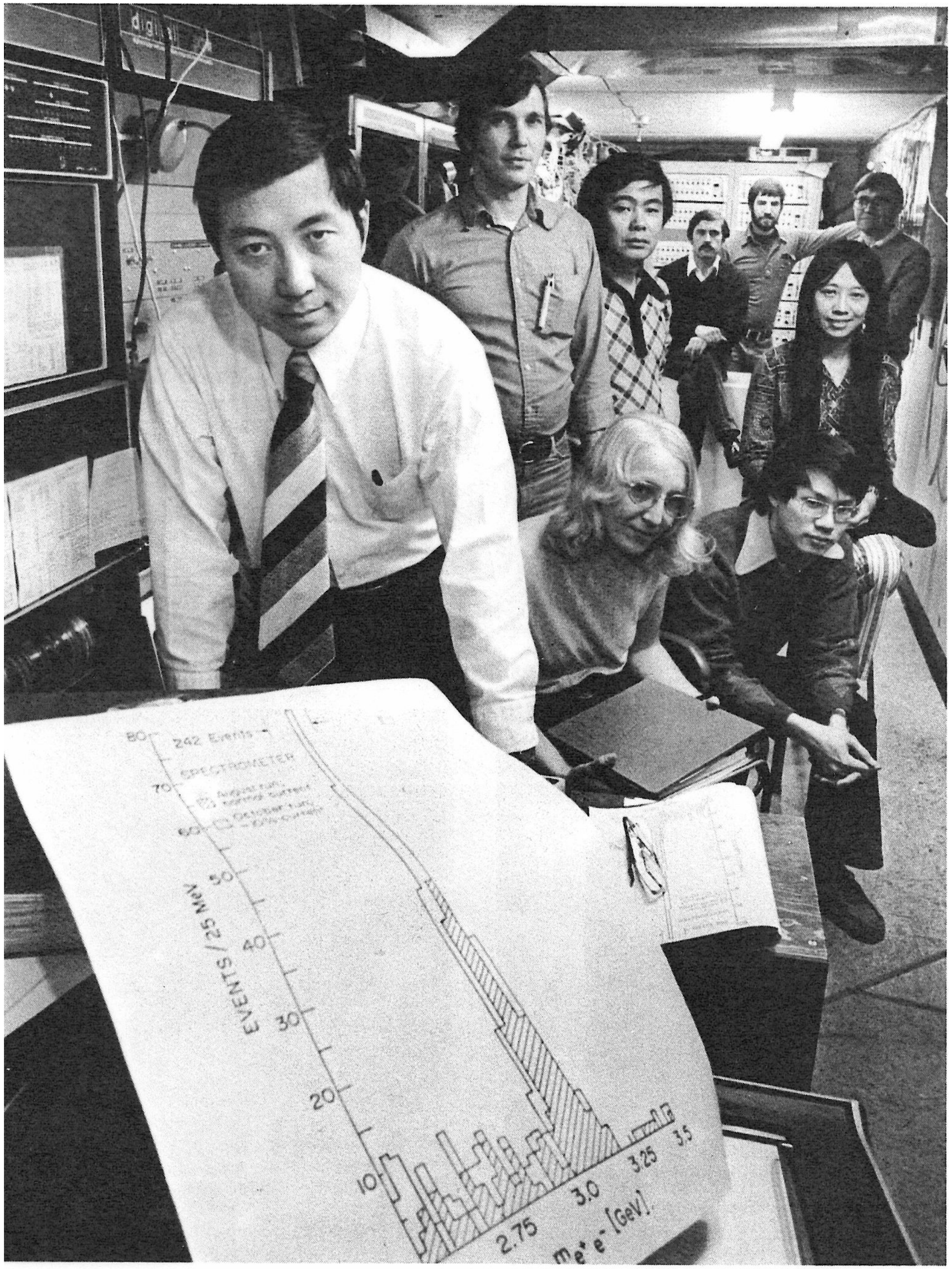
3,000 miles away at SLAC, Sam Ting went to Panofsky's office and met Burt Richter there.

"Burt," Ting said to Richter, "I have some interesting physics to tell you."

"Sam," Richter said to Ting, "I have some interesting physics to tell you. "

J/Ψ was born!

This led to the 1976 Nobel Prize shared by Burt Richter and Sam Ting.



Inside the trailer "where it all happened" are (standing left to right) Samuel Ting, Gary Krey, Y.Y. Lee, Peter Biggs, Paul Goldhagen, and Bruce Bailey. Seated in the foreground (left to right) are Ingrid Schulz, Joseph Leong and Sau Lan Wu. A graphic representation of the J-particle event is seen.

Photos by Humphrey

November 22, 1974

Laboratory Director George Vineyard (right) with Y.Y. Lee, Sau Lan Wu and Samuel Ting (left to right) in the MIT trailer where the J-particle was discovered.

The e^+e^- Collider Adone at Frascati was designed with a maximum energy of 3 GeV. On Nov. 13, they raised the energy and by Nov. 15, the J/Ψ peak was seen.

George Trigg, the editor of PRL, requested the three papers to be published together. Giorgio Bellettini read off the Adone paper on the phone to me. In this paper, Georgia Salvini became the initials of G.S.M. Spinetti. In a later paper, they acknowledged the Bell Telephone Company.

Still in an excited state, Sam Ting, I and others made a stop at Greenwich Village in NY City on our way to Brookhaven one day.

We saw a shop which provided custom-made T-shirts. We had 3 T-shirts made with the sign:

J

3.1GeV

When we got to Brookhaven, they were instant hits.

For two weeks in my lifetime, I practiced changing my profession by selling T-shirts with J/3.1 GeV on them, $10 per piece.

"We have had a tradition at Brookhaven of very good relations with the user community; we provide them with protons and they provide us with T-shirts. "

- Mark Barton Brookhaven Bulletin

July 18, 1975

BROOKHAVEN BULLETIN

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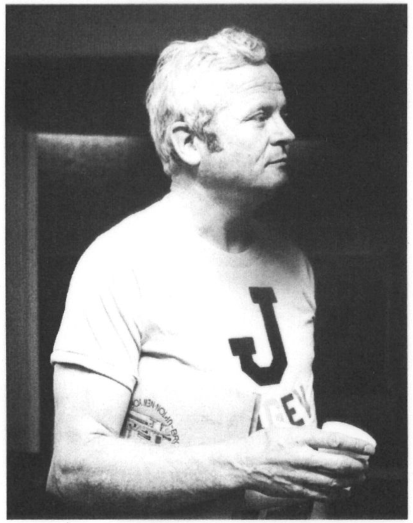
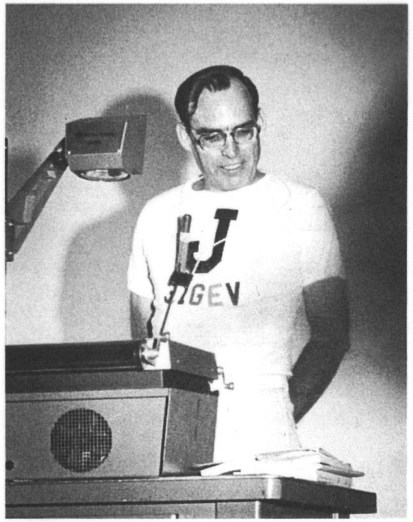




"We have had a tradition at Brookhaven of very good relations with the user community; we provide them with protons and they provide us with T-shirts." —Mark Barton, during first day of ISABELLE Summer Study.

Isabelle Study Gets Underway

On Monday over 100 representatives from nearly every high energy physics facility in the world and many universities gathered in Berkner Hall for the start of the ISABELLE Summer Study. They were welcomed to the Laboratory by Director George Vineyard, and heard remarks by various speakers on the past, present and future status of the giant accelerator.

Aihud Pevsner, of Johns Hopkins and Chairman of the Summer Study Organizing Committee, introduced the participants to the summer study. He stressed the importance of presenting the status of the machine to both those who might use it, and to the rest of the physics community that must support the proposal if ISABELLE is

An Ancient Art In Modern Forms

If a magician waved a wand and all the glass vanished from the face of the earth, mankind would have a tremendous readjustment to make. Glass has played an important role in daily living since natural glass called obsidian, formed in volcanos, was first made into arrow and spear heads.

Little is known about the origins of glass-making, but man knew how to make glass at least 3500 years ago. Glass beads were made in Egypt as far back as 2500 B.C. The first glass vessels, made by building layers of glass on a clay core, were manufactured in Egypt around the 15th or 14th centuries B.C.

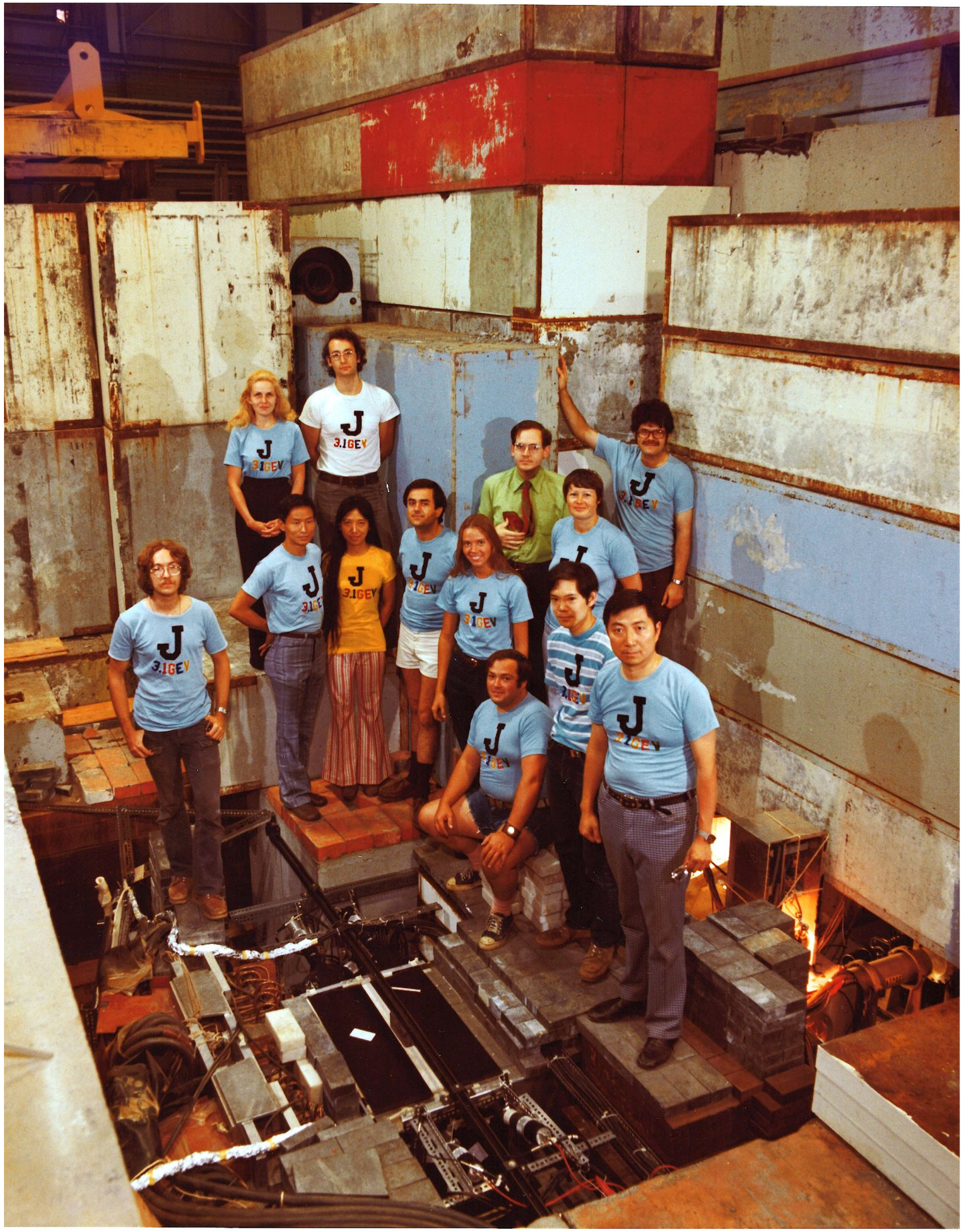
Since these primordial times, glass has developed into an extremely versatile material. Thousands of different kinds of glass have been produced, each characterized by its inorganic ingredients or physical properties.

In Brookhaven's glass shop approximately 30 different types of glass are fashioned into a large array of scientific glassware, ranging in size and complexity from tiny glass tubes to large glass dewars containing intricate masses of tubing. Located in the basement of the Chemistry Building, the shop is staffed by three glassblowers: Karl Walther, Paul Roman and Irving Meyer. Because most of Meyer's work is done for the Department of Applied Science, he operates out of Building 318, the Radiation Division of DAS.

This month, the American Scientific Glassblowers Society presented Karl Walther with one of its highest awards, the Achievement Award, given each year to one member. Walther was one of the founding members of the Society, created in 1952


J
3.1GEV


J
3.1GEV
MAXWELL


J
3.1GEV

Newsweek
December 2, 1974

Newsweek
December 2, 1974

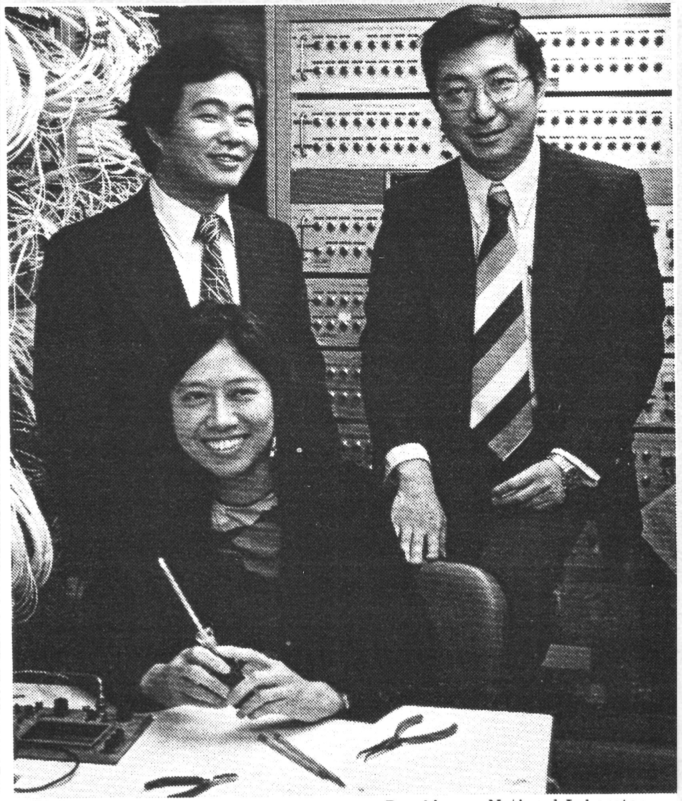
Left: Y.Y. Lee, Samuel Ting, Sau Lan Wu

Right: Burt Richter

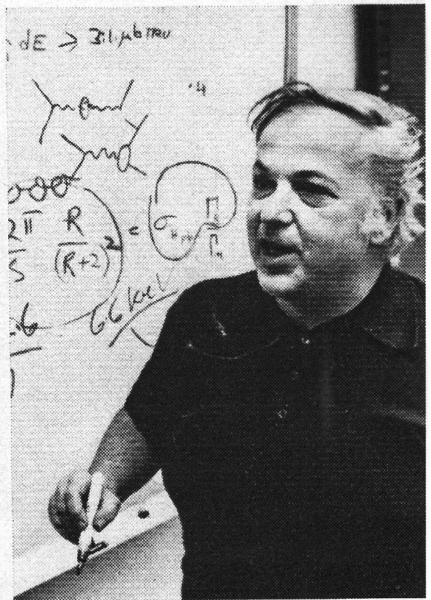
SCIENCE

A Particle of Difference

For almost half a century, physicists have struggled to understand the four basic forces that exist in nature, and to find a single "unified field theory" that would relate them all. The forces are gravity; the electromagnetic force, involved in both electrical and magnetic attraction; the strong nuclear force, which binds together particles inside the atomic nucleus; and the weak nuclear force, which is related to the process of radioactive decay. The weak nuclear force has proved to be one of the most difficult to understand in theoretical terms. But last week, particle physicists billionths of a billionth of a second after it forms. Brief as this time span is, the survival period is 1,000 times longer than any particle that heavy is expected to survive according to normal theoretical precepts. In addition, the new particle may be the first to possess a combination of mathematical properties rather unscientifically known as "charm" (a term, first coined by Harvard physicist Sheldon Glashow and Stanford's James Bjorken, that involves such basic characteristics as the way in which the particle is produced and the means by which it splits up into other particles). "The suddenness of the discovery [and] the totally unexpected properties of the particle are



Brookhaven National Laboratory



James D. Wilson—Newsweek

Teamwork: Ting (in spectacles) and colleagues, Richter

As a young postdoc in 1974, I was very fortunate to be able to take part in this historical event. We were indebted to the strong support of BNL and the funding agents - Bill Wallenmeyer and Bernie Hildebrand of AEC.

AGS, with its great improved intensity in 1974, deserves the lion share of the credit for the J/Ψ discovery at BNL - one of the most important discoveries in High Energy Physics.

Photo taken on the occasion of 25 years of J/Ψ discovery,
at the AGS/RHIC Users' Meeting in July 1999,
where I gave the same talk 25 years ago.

(Mel Schwartz, Sau Lan Wu and T.D. Lee are present in the photo)