CURRICULUM VITAE

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EDUCATION

1982 Bachelor of Arts	1984 Master of Science	1988 Doctor of Philosophy
Major: Physics	Major: Physics	Experimental High Energy Physics
University of Colorado	Brown University	Brown University
Boulder, CO 80503.	Providence, RI 02912.	Providence, RI 02912

Ph.D. Thesis Title : *"A Study of the Weak Neutral Current and the Electromagnetic Properties of the Muon Neutrino"*

Thesis Professor : Prof. Robert E. Lanou

Other study

June 1986, International Center For Theoretical Physics, Trieste, School for instrumentation.
June 19-30, 1989, US Particle Accelerator School, University of California, Berkeley,CA

Major Achievements

- I am an internationally known experimental scientist with a large array of skills and responsibilities. I have worked on scientific and engineering projects that range from a few to hundreds of millions and have led teams that range from a few to hundreds of people. My experience makes me an ideal candidate for research direction in private and public enterprises.
- Responsible for initiating, proposing, and organizing the ambitious long-baseline neutrino program in the US based on the high intensity FNAL Main Injector broad band beam and a massive underground detector at the Sanford Underground Research Facility. The plan I developed and promoted is now the highest priority fundamental science project in the US.

- Responsible for many innovations in particle physics experiments including important measurements in neutrino physics as well as rare kaon decays. My contributions span development of analysis, software, and hardware techniques. I am known for organizing ambitious science and engineering projects with high efficiency.

TEACHING AND MENTORING EXPERIENCE

- Various teaching and grading duties in college.
- Laboratory teaching assistant, Undergraduate tutor.
- I have given numerous lectures at the undergraduate level for the BNL Office of Educational Programs and as a visiting professor at other institutions.
- I have mentored many graduate students since my time as a postdoc. Many of them are now recognized leaders with faculty positions. For example, Karl Ecklund (now, faculty at Rice). Bipul Bhuyan (now, faculty at the Indian Institute of Technology).
- Several postdocs who have worked with me at BNL now have permanent positions. For example, Brett Viren (physicist at BNL), Lisa Whitehead (faculty at Houston), Jiajie Ling (faculty at Sun Yat-sen University, China)
- I was supervisor and mentor of Mary Bishai who is a tenured scientist and APS fellow at BNL.
- I have mentored many young people in the field as spokesperson and leader in particle physics. Some of the notable individuals are: Christopher Mauger (University of Pennsylvania), Greg Pawloski (University of Minnesota), Elizabeth Worcester (BNL), Xin Qian (BNL), Chao Zhang (BNL)
- I have served on the Junior Staff Committee in the BNL physics department for many years. This committee is charged with making sure that all of the junior staff in our large department get proper guidance about their careers.
- I am responsible for hiring and promoting women scientists in our group. It was my initiative that has expanded the diversity of our group. Our group has produced internationally well-known women scientists such as Mary Bishai, Elizabeth Worcester, Lisa Whitehead.

EMPLOYMENT and OTHER EXPERIENCE

- 2016 Visiting Professor, University of Campinas, Brazil
- 2016 Visiting Faculty, SLAC national accelerator laboratory, CA
- 2015 Visiting Scientist, University Degli Studi Di Catania, Italy
- 2009 Senior Scientist, Brookhaven National Laboratory, Upton, NY
- 2009 Deputy Group Leader: Electronic Detector Group, BNL
- 1999 Physicist, Brookhaven National Laboratory, Upton, NY
- 1996 Associate Physicist, Brookhaven National Laboratory, Upton, NY
- 1994 Assistant Physicist, Brookhaven National Laboratory, Upton, NY
- 1992 Scientist, Super-conducting Super Collider, Dallas, TX
- 1988 Research Associate, Stanford University, Stanford, CA

AWARDS AND DISTINCTIONS

- 2015 Co-recipient Break Through Prize for Daya Bay collaboration. "For the fundamental discovery and exploration of neutrino oscillations, revealing a new frontier beyond, and possibly far beyond, the standard model of particle physics."
- 2015 Sociedade Brasileira de Fisica (SBF) and American Physical Society (APS) award for visiting professorship.
- 2009 APS Fellow
- 2000 Awarded Tenure at BNL for "Talent and Achievement in High Energy Physics."
- 1988 Sigma Xi (Brown University) Award for outstanding thesis research.
- 1982 Phi Beta Kappa (University of Colorado at Boulder)
- 1982 Sigma Pi Sigma (Physics Honor Society), American Institute of Physics.

ACTIVITIES

- Research: Analysis leader in many collaborations: rare kaon decays and neutrino physics. First measurement of differential cross section in neutrino-electron elastic scattering, Improved sensitivity to extremely rare kaon decays, Analysis of first measurement of $K^+ \to \pi^+ \nu\bar{\nu}$, One of the primary proponents of the measurement of $\nu_\mu \to \nu_e$. The key proponent and leader for an ambitious long-baseline neutrino program in the US with focus on CP violation.
- Collaborations: E734(BNL), E791(BNL), GEM(SSC), E787-949(BNL), E889(BNL, co-spokesman), MINOS(FNAL), P923(BNL, co-spokesman), Daya Bay, Elected co-spokesperson of LBNE (2010, 2012, 2014).
- Organizing committee, AGS2000, Workshop on AGS experiments for the 21st Century, May 13-17, 1996. Convener of the muon polarization group.
- HEPAP sub-panel on planning for the future of U.S. high energy physics, 1997, Chaired by Prof. F. J. Gilman. Report DOE/ER-0718.

- MINOS (Fermilab Long Baseline Neutrino Oscillation Experiment) physics review committee, chaired by Prof. Charles Baltay. This committee met on May 26-27, 1998 and reported on the physics capabilities of the MINOS experiment.
- MINOS (Fermilab Long Baseline Neutrino Oscillation Experiment) technical review committee chaired by Dr. Gary Sanders (Caltech). April 27-29, 1998, Report to the Fermilab director, Dr. John Peoples, on the technical progress made by the MINOS collaboration.
- TRIUMF-E614 (Precision Measurement of the Michel Parameters of mu+ decay) technical progress review committee. Chaired by Dr. Hans Mess (Carleton University, Ottawa, Canada), January 14-15, 1999.
- Committee to examine the future of HEP at BNL, chaired by Dr. W. Marciano. The committee met several times from March to April 1999. The report was submitted to the chairman of the physics department: Dr. M. Murtagh.
- Co-organizer with Prof. Chang Kee Jung of the International Workshop on Next Generation Nucleon Decay and Neutrino Detector (NNN99), Sep. 23-25, 1999, SUNY at Stony Brook.
- Co-leader with Dr. William Marciano and Dr. Bill Weng of the Neutrino Working Group at BNL. 2001-2005.
- Co-organizer of the BNL/UCLA workshops on Neutrino Super-beam, Detectors, and Proton Decay. Workshops were held at UCLA ((December 2003), and BNL (March, 2004) jointly with the APS neutrino study.
- Executive committee for Homestake DUSEL proposal, 2005-2007. Participated in the creation of the DUSEL concept, co-authored the Homestake DUSEL proposal. Homestake was chosen as the final choice for the DUSEL site by the NSF.
- Co-leader with Dr. Regina Rameika of the U.S. Long Baseline Neutrino Oscillation Study. 2006-2007, Report submitted to Directors of FNAL and BNL.
- Organizer of workshop on "Underground Detectors Investigating Grand Unification", October 16-17, 2008.
- Co-chair of Helicity 50. 2008. Symposium to celebrate the 50th anniversary of the Goldhaber, Grodzins, Sunyar experiment at BNL.
- Program Committee of XXIV International Conference on Neutrino Physics and Astrophysics, NEUTRINO 2010, Athens, Greece.
- Numerous BNL committees: BNL Lecture committee from 2001 to 2007, BNL Physics Department Committee on Junior staff, BNL tenure committees, etc.
- Elected co-spokesperson of the Long-Baseline Neutrino Experiment during 2010-2011, a national effort. The spokespersons are responsible for articulating the science, organizing the collaboration to construct and run the experiment, and fostering communication between the collaboration, the national laboratories, and the funding agencies.
- Gave testimony before U.S. House Committee on Space, Science, and Technology on particle physics in the U.S. (2012)
- Co-chair of ISOUPS 2013, 2013. International Symposium on Underground Physics in Asilomar, California.

- Re-elected co-spokesperson of the Long-Baseline Neutrino Experiment for 2012-2013 and in 2014-2015, an international effort. During this time we grew the collaboration to over 90 institutions and 580 collaborators. The spokespersons are responsible for articulating the science, organizing the collaboration to construct and run the experiment, and fostering communication between the collaboration, the national laboratories, and the funding agencies.
- Judge in BNL and Long Island Science Fair competitions.
- Chair of the Environment Safety Security and Health (ESSH) committee (BNL Physics) in 2016.

GRANTS AND ADMINISTRATIVE EXPERIENCE

Department of Energy grants to laboratories are administered through laboratory research groups. In addition to this funding channel, laboratory scientists can apply for competitive laboratory directed research and development grants. As principal investigator for accelerator neutrino research group, I have managed a total effort ranging from \$100k/year to approximately \$500k/year over the last 10 years, and also obtained separate grants in total range of \$1.5M.

- 1994-1995 Laboratory Directed Research and Development grant. \$50,000/year. T-violating muon polarization in kaon decays. Grant was used to design and develop concepts for the E923 experiment. Grant supported a research year for an undergraduate student, a technician, and mechanical engineering.
- 1999-2010 Principal investigator for accelerator neutrino effort on MINOS at BNL. ∼\$100000/year. Part of BNL base program used for postdoc support.
- 2004-2006 Laboratory Directed Research and Development grant: Very Long-Baseline Neutrino Oscillations, Granted at approximately \$110000/year for 3 years. This grant was used for support of a new Assistant Physicist and a Postdoc as well as engineering consultants. This grant is considered one of the most successful LDRD grant in the DOE Office of Science.
- 2003 SBIR Phase I. Proposal on Large Avalanche Photo-Diodes. Proposal in collaboration with Radiation Monitoring Devices Inc. Total grant: \$100000. Cooperative Research and Development Grant to BNL: \$30000.
- 2004-2005 SBIR-II. Large Diameter Avalanche Photo-Diodes. Proposal in collaboration with Radiation Monitoring Devices Inc. Total Grant: \$750,000. Cooperative Research and Development Grant to BNL: \$223,000.
- 2006-2008 Laboratory Directed Research and Development grant: Detector development for the Very Long-Baseline Neutrino Oscillations. \$120000/year for 3 years. This grant was used for support of an Assistant Physicist, underground engineering consultants, technicians, and building up a laboratory for photo-multipliers and optics.
- 2007 Equipment loan agreement with IPN-Orsay, France. Total value of equipment and purchases \$10000. This was a collaboration on pressure performance of photo-multiplier tubes. It needed an international agreement between laboratories.
- 2009-2016 Deputy Group leader for the Electronic Detector Group with responsibilities for the MINOS and LBNE accelerator neutrino effort. The Electronic Detector Group has about 12 Ph.D. scientists, several engineers and technicians. The group leader is Steve Kettell and I am the deputy. Approximately 6 scientists are on the accelerator neutrino effort. The group has 4 tenured members

who are share responsibility for hiring and scientific direction. Total budget for the group is roughly \$4.5M with about \$2.0M dedicated to accelerator neutrinos.

- 2009-2010 The LBNE water Cherenkov detector subproject was within the Electronic Detector Group at BNL with Jim Stewart as the project manager. I have taken the responsibility for R&D on pressure and mechanical performance of photo-multiplier tubes. This is a subproject with a budget of approximately \$700k for the first year. I have managed this budget for engineering and hardware development.
- 2010-2011 Cooperative Research and Development Agreement with Naval Undersea Warfare Center (Newport, Rhode Island). Total cooperative grant from Brookhaven Research Associates to NUWC \$417,000. This was a complex inter-agency arrangement for underwater photo-multiplier tube work that I initiated and managed.
- 2010-2015 As co-spokesperson for the Long-Baseline Neutrino Experiment one of my duties has been communicating the funding needs of the collaboration to the DOE office of high energy physics. In this capacity, I have routinely managed very detailed funding data from my collaborators and communicated our priorities to the DOE so that the collaboration base program remains strong. This has proven to be a difficult task in this time of constant budgetary pressures.
- 2013-2014 LBNE R&D coordination plan, LBNE software and computing coordination: at the request of the Department of Energy, I created two teams within the collaboration to coordinate detector R&D and software and computing. These resulted in a number of funding documents for the DOE. Numerous detector R&D proposals were coordinated through this process.

RESEARCH EXPERIENCE

2015-2016

- I was invited as a visiting professor at the University of Catania in Italy in 2015, and at the Univesity of Campinas in Brazil in 2016. I gave a set lectures on neutrino physics and the technology of detectors at both of these universities. The lectures were part of an advanced particle physics course for graduate students. These lectures are available on my website.
- During my time at SLAC, I completed a major review article on neutrino oscillations for the Annual Review for Nuclear and Particle science.
- I was invited for a sabbatical leave at SLAC national accelelator laboratory. SLAC is developing a new group focused on neutrino physics. I was asked to interact with the group and find avenues of collaboration.
- Creation of the process of requirements documentation: I decided to take advantage of the transition between LBNE and LBNF and complete the requirements documentation and make it complete from science goals down to level 2 requirements. I worked very closely with the project engineers and made these completely linked. This work was repeatedly cited during the DOE CD reviews. *All the high level requirements for LBNF/DUNE were written or edited by me in consultation with the team of engineers.*
- LBNF/DUNE CD1R: after the intenationalization of the long-baseline neutrino experiment, the DOE needed to perform second CD1(refresh) review with the expanded scope. The LBNF/DUNE configuration is exactly the same as the vision in the science document for LBNE. I was responsible for this vision and setting it clearly in the requirements and the conceptual design report.

- Liquid Argon R&D at BNL: An R&D effort for understanding the basic properties for charge drifting in liquid argon is on-going at BNL. Two publications have resulted from this effort.
- Mu2E R&D: I decided to explore the physics and technical issues regarding the $\mu \rightarrow e$ conversion experiment. I started R&D on a Germanium detector for detecting x-rays from the muon stopping target. We have found interesting radiation effects in such a detector which have been documented in a technical article.

2013-2014

- LBNE CD1 review: I was central to the planning and completion of the 2012 LBNE CD1 review. The absolutely crucial CD1 approval for $\sim \$900M$ came in Dec. 2012. This is the same approval being used for LBNF/DUNE since CD1 approval is the approval for site selection.
- LBNE international growth: After LBNE CD1 approval we needed to work on building the international collaboration. I traveled to numerous countries during this time to promote and expand the LBNE collaboration internationally. At the end of this period, we increased the collaboration by large factor and had more than 25 institutions from abroad out of a total of 90. With a total collaboration membership of 550 people.
- Clarification of LBNE mass hierarchy reach and baseline optimization: Xin Qian pointed out that the mass hierarchy measurement is a classic 2-hypothesis test and needs to be framed in terms of rejection of the wrong hypothesis versus acceptance of the correct one. A more sophisticated statistical framework as well as clarification of its dependence on the baseline length was needed. We wrote a PRD publication to examine the optimization of the baseline. This was internally reviewed by an extremely capable team. *This paper is crucial for creating the world-wide acceptance for the LBNE (and LBNF/DUNE) configuration.*
- Community Summer Study and P5 process: As a result of both the Higgs and θ_{13} discoveries, particle physics community decided to have a year-long study and then a new P5 process to plan the next steps. It was very clear that P5 needed a full scope scientific vision from the LBNE collaboration to give a positive report.

  Under my leadership a science vision document was prepared and printed. This is an elegant 288 page document for the US long-baseline neutrino enterprise. It was provided to the Community Summer Study, the DOE, and P5. It provides the detailed justification for an underground liquid argon TPC detector and a broad band beam with the best known neutrino parameters.

  The LBNE science document was the basis for the decision by P5 to make the Long-Baseline Neutrino Facility the highest priority domestic high energy physics project for the US.
- Daya Bay sterile neutrino search: I made an important observation and calculated that Daya Bay would be able to provide the best limit on sterile neutrino mixing in the $\sim 0.1eV^2$ range. This has resulted in a number of publications and ongoing analysis.
- LBNE R&D coordination plan: After the CD1 review in 2012, many groups started R&D activities. Some of these were independent experiments apart from the LBNE collaboration. These needed to be coordinated. I got the collaboration, FNAL management, and DOE to agree to a mechanism. This generated a number of reports for the DOE and were reviewed for funding.

- LBNE Software and Computing plan: At the request of the Department of Energy, I organized the software and computing organization for LBNE. This organization continues for LBNF. A successful DOE review was held in May 2014 to properly fund this organization.

  Leading up to this review an enormous amount of technical work was completed which directly went into physics optimization for LBNE.

2011-2012

- For LBNE it was necessary to come to a conclusion on the technology for the far detector. It was decided that we could not afford to continue the design of both water Cherenkov and Liquid Argon technologies. The process for choosing this technology was very difficult as there were strong feelings on both sides. The project manager, Jim Strait, Bob Svoboda, and myself created a step by step procedure involving reviews and the collaboration executive board. The final recommendation was to be drafted by the collaboration executive board, but the decision was to be in the hands of the Project Manager and Fermilab because he was financially responsible to the DOE and Fermilab.
- We guided the collaboration through creating two documents called case studies that detailed the scientific case for LBNE with each type of detector. The writing of these case studies was initiated by me and the editors were chosen by the co-spokespersons.
- After a series of reviews, the collaboration executive board met and recommended that the water Cherenkov detector was favored mainly because of cost and schedule considerations. However, this recommendation had a narrow margin. The Project Manager with concurrence from Fermilab management and the DOE management overturned the collaboration executive board and decided on the Liquid Argon technology. As co-spokespersons we have had the difficult job of keeping the collaboration together during this process. We have now instituted a process to bring the collaboration together to work on a single technology.
- I was re-elected co-spokesperson of LBNE during the process of technology selection.
- We anticipated that LBNE will face considerable financial pressures. As anticipated the DOE called for a phased approach to LBNE. This process was called reconfiguration. A steering committee was created with a cost and a physics subcommittee. I chose to be a member of the physics committee run by Prof. Mel Shochet. The committee needed to consider the best approach to Long-Baseline physics and the question of doing the experiment with the existing NuMI beamline to fall within the DOE cost boundaries. I wrote an influential policy paper recommending that we retain the longest possible distance (baseline) for this physics to Homestake. This paper is BNL-107903-2012-IR or OSTI-1188223. My argument was accepted and the recommendation was accepted by the DOE to configure the beam towards Homestake.
- After the technology choice for LBNE, I decided to spend more time on the Daya Bay analysis. I created my own analysis fits and rate calculations to understand the full analysis of Daya Bay. I went to the analysis workshop in China in February and worked with the group of postdocs to refine the analysis of the first two papers from Daya Bay. The paper on the measurement of θ_{13} is extremely important and has strengthened the scientific case for LBNE.
- The Daya Bay analysis as presented is very sound, however I have identified interesting features in the neutrino spectrum from the reactor. These have never been seen before. At BNL we are attempting to understand these features. It is possible that the modeling of reactor neutrino spectra

has never had to be confronted with data as precise as the Daya Bay data and new modeling is needed.

- During this busy period we completed a large R&D program on photo-multiplier mechanical performance. Instrumentation papers are being published and prepared.

2009-2011

This was an extraordinarily busy period for LBNE and our research group at BNL. The number of activities we carried out are listed:

- Daya Bay experiment optimization: our group participated in optimization of the Daya Bay experiment during this period. Critical issues were the size and number of detectors versus the various reactor sites at Daya Bay, the requirements on the muon veto system, and the performance of the antineutrino detectors and the liquid scintillator.
- Collaboration Management: I was elected one of the co-spokespersons (with Prof. Svoboda) of the Long Baseline Neutrino Experiment (LBNE), which consists of an accelerator neutrino beam from Fermilab, a near detector on the Fermilab site, and a very large far detector at a site at least 1000 km away. As the first spokespersons, we worked with the Institutional Board to draft the rules and responsibilities within the large collaboration. We kept the focus on the science while keeping the technology choice for the far detector (either water Cherenkov or liquid argon) open. We completed the physics working group report and a draft CDR during this period.
- Detector R&D: One of the key technical challenges in building a large water Cherenkov counter is the development of appropriate photo-multiplier tubes. The tubes must have good quantum efficiency and timing characteristics, and they must be mechanically robust for the ultra-pure water environment. I decided to take responsibility for the mechanical aspects of these tubes. We have developed a large technically capable team from many diverse institutions and skills and facilities.
- Group expansion: we expanded the Electronic Detector Group considerably both in terms of scientific and technical manpower. The scientific manpower was increased by 4 postdocs and a new assistant physicists. The hiring process had to be efficient, yet we needed very good talent because we needed to hire both scientific and project personnel for Daya Bay and LBNE.
- Organization of the Water Cherenkov project: I worked with Jim Stewart (new hire) to organize the water Cherenkov project. The project was organized to take maximum advantage of the NSF contribution to DUSEL as well as the NSF grants for detector design. We ramped up this effort with great efficiency by using resources from collaborating universities. We organized almost a dozen engineering grants to university collaborators.
- The Photomultiplier R&D project: We organized a large R&D effort that involved the PMT vendors, material experts at universities, the Naval Undersea Warfare Center in Newport Rhode Island, and our own technical people. This effort has culminated in several published papers important for next generation detectors. Most importantly, this effort has resulted in two large new high pressure high quantum efficiency photomultipliers that have been thoroughly tested. The new Hamamatsu 12 inch high quantum efficiency tube was directly funded through this project.
- During this period there were two important reviews: the NRC panel review on underground physics and the DOE's review on options for underground physics (so called Marx committee).

These reviews needed extensive preparation from the collaboration and the project. As a result of this, I took on the role of the liaison between the scientists and the engineering staff to develop the extensive documentation needed for the reviews. The reviews were very successful in reaffirming the importance of the science goals and vetting the cost and schedule estimates.

- During this period the National Science Board that governs the NSF decided to discontinue supporting the DUSEL at Homestake. This was a great blow to the LBNE project. I believe we were very successful at keeping the collaboration together and productive during this process as the DOE attempted to take over the science agenda in its entirety.
- Daya Bay construction: my activities on LBNE had to be balanced against the extraordinary amount of work going on in our group on Daya Bay construction. The priorities of people's travel schedules and times needed to be managed so that the same folks could be productive on LBNE also.

2006-2009 During this period I was engaged in the activities of the MINOS experiment. I was one of the leaders of the analysis for extracting electron type neutrinos from the data to obtain the first accelerator based limit on θ_{13}, the last mixing angle in the neutrino mixing matrix.

During this period, a number of community-wide activities were launched to select the next steps for neutrino physics. I was a co-leader (with Gina Rameika) on the joint Fermilab-Brookhaven study on long baseline neutrino physics. This effort culminated in a widely cited report that was used by the Neutrino Science Advisory Group and the Particle Physics Priority Panel. The high energy physics road-map (P5) developed in 2008 was greatly influenced by my work on the joint study. One of the key recommendations was to develop a world leading accelerator neutrino experiment with a beam from FNAL and a very large underground detector.

In response to the recommendations from High Energy Physics Advisory Panel, the Long Baseline Neutrino Experiment collaboration was organized in a series of meetings. One of the first tasks performed by the collaboration leadership was to agree on the depth required for the underground detector. The report ("The Depth Document") was edited by me and used by the National Science Foundation to start the planning and geotechnical exploratory work at the Homestake site. The joint study is the key document cited by the DOE to launch the LBNF/DUNE project.

An additional development during this time in my research group at BNL was the Daya Bay experiment. As the principal investigator of the neutrino group, I initiated the participation in the Daya Bay group. However I personally focused on MINOS and LBNE. The initiation of the Daya Bay group at BNL was very important because of the termination of the Rare Symmetry Violation Project (RSVP).

2003-2006 During this period my effort on accelerator neutrino physics increased as MINOS was constructed and commissioned. My group expanded with the addition of Mary Bishai and a postdoc. Our main effort at BNL was a detailed data monitoring and quality effort for the MINOS neutrino beam. We were part of the commissioning of the beam and were first to analyze the rate of neutrino events in the near detector. This effort resulted in extraordinary precision on neutrino beams, an important outcome for the field of accelerator neutrino physics. As data in MINOS was accumulated, I decided to concentrate on the $\nu_\mu \rightarrow \nu_e$ analysis, since it was clearly the most important topic in neutrino physics. I was the convener of this analysis group in MINOS for this period.

I initiated a close relationship with the BNL chemistry department with the group of Richard Hahn and Minfang Yeh. Minfang Yeh, myself, and a graduate student have invented a device and methods

with high precision in measuring optical properties of liquid scintillators over long distances. The BNL nuclear chemistry group has the world's foremost expertise on liquid scintillators and materials pure from radioactivity. This collaboration has resulted in a strong combined BNL neutrino physics group with expertise ranging from physics, instrumentation, and materials.

I initiated an industrial partnership with an R&D company to examine large area photo-sensors using silicon. This resulted in a cooperative research (CRADA) grant for hardware. This grant was used to build a laboratory at BNL for photo-sensors.

The ideas for a next generation experiment with a super neutrino beam became more serious when it was clear that the solar neutrino oscillation mixing angle was also large. We quickly published a widely cited paper in 2003, and started work on an experimental project design. In 2004 a plan for a beam-line from BNL to a Western detector site over 2500 km away was proposed. At the same time, I proposed that similar ideas be examined from Fermilab. In 2005, we had a complete conceptual design for upgrading the BNL AGS for high intensity and a beam to be built on a hill pointing toward the Homestake mine in South Dakota. A complete proposal was submitted to the Department of Energy.

1995-2002

In the Electronic Detector Group headed by Lawrence Littenberg, I joined the E787/E949 program to detect the long sought rare decay $K^+ \to \pi^+\nu\bar{\nu}$. This was a very complex detector with many advanced technologies and electronic systems of that time. Besides the day-to-day running and calibration of the experiment, I performed three critical analysis for E787/E949: first I analyzed, with Jim Frank, the scintillating fiber target patterns of the stopping kaon and found that we could reconstruct the trajectory of the kaon to reject backgrounds, second I analyzed the energy resolution of the detector, and third, I invented a new analysis method to find $K^+ \to \pi^+\nu\bar{\nu}$ events with pions of momentum lower than 200 MeV/c. BNL granted me tenure based on this analysis work.

In 1996 there was a workshop (AGS-2000) on the use of the BNL-AGS for high intensity proton operations. In the course of this workshop, I became interested in measurement of muon polarization in kaon decays. This interest led to a proposal for an experiment in which $K^+ \to \pi^0\mu^+\nu$ could be measured with great precision. Hong Ma, Bob Adair, and myself developed an interesting method using a separated kaon and built considerable prototype hardware. While studying the phenomenology of muon polarization, we discovered and published that in the decay $K_L \to \pi^0\mu^+\mu^-$ the longitudinal parity-violating polarization actually led to an unambiguous measurement of the CP phase in the quark sector, a unique result.

The MINOS experiment was fully funded after the Super-Kamiokande discovery. We joined MINOS and I became the principal investigator of the BNL accelerator neutrino effort. We at BNL decided to take a role in the development of the neutrino beam-line. We used the accelerator test facility (ATF) for development of beam-line detectors in collaboration with University of Pittsburgh and University of Wisconsin. We also took a leading responsibility for the analysis and monitoring of the beam-line.

After the discovery of atmospheric neutrino oscillation from the Super-Kamiokande experiment and confirmation of the Solar neutrino oscillations by SNO, it became very clear that the next step was an ambitious accelerator neutrino program that focused on the appearance signal of $\nu_\mu \to \nu_e$. At BNL, Tom Kirk launched the Neutrino Working Group under the leadership of Bill Marciano, Bill Weng, and myself. We were tasked to organize a community towards a proposal for an intense neutrino beam and associated detector.

We worked on the idea of a very long baseline experiment in a series of DOE reports and publications starting in 2001 in which we proposed the idea for a super neutrino beam aimed at a detector more than 1000 km away. This is the origin of the LBNF/DUNE project for the US.

The central argument for our proposal was that if we aim for CP violation in neutrinos, the project configuration was mostly independent of neutrino parameters and quite flexible in terms of the length of the baseline. We took an enormous intellectual risk and it has paid off for the US community.

1993-1995 After the termination of the SSC, I came to Brookhaven National Laboratory to work on a new proposal for a neutrino experiment (E889). At this time, there were hints that muon neutrinos from the atmosphere were disappearing before reaching the detectors built at that time. Alfred Mann had started promoting a major accelerator experiment to test this phenomena. When I came to BNL, a conceptual idea for such an experiment existed including the novel idea for an off-axis beam. I took the responsibility for authoring a complete scientific proposal justifying the off-axis beam, the detector sites on Long Island, and a complete simulation of the beam, detectors, and the sensitivity. This was accomplished while building up a capable collaboration.

The Department of Energy requested that similar ideas at FNAL and BNL be compared by a national high energy physics advisory subpanel (with Prof. Frank Sciulli as chair). This shootout completed with the decision that the program be funded at FNAL after Super-kamiokande came out with its first results. Nevertheless, the outcome of my work was that a real program in accelerator neutrino physics in the US was launched; the idea of the off-axis beam is now being used both in Japan and for the NOνA experiment at FNAL. The definitive reference for the off-axis beam is the BNL-E889 proposal.

1992-1993 I was a physicist at the Super Conducting Super Collider laboratory in the physics division headed by Prof. Fred Gilman. At the SSC I joined the GEM experimental project was put in charge of developing a design for the radiation shielding of the experiment. Although I had no background in this subject, I had the ability to address a wide range of issues: accelerator, detector performance, personnel safety, and interfacing with civil construction managers. I produced the conceptual design with a team of about 10 people in time for the various reviews. At the SSC I also started a noble liquids detector R&D laboratory.

1988-1992 I was a postdoc in the group of Prof. Stanley Wojcicki at Stanford. I worked on three different experiments during this period and also built substantial hardware at SLAC where the group was located.

E791 was an experiment designed to search for the rare decays of neutral K_L particles. The innovation for this experiment was the use of modern electronics and microcomputers (which were new at that time) to select events online. As a postdoc my responsibilities ranged from the calibration of the lead glass array to analysis of the data. I decided to become an expert at the online trigger and found software techniques to improve the trigger by a very large factor. This was a major contribution to the success of E791 as well as the follow-on experiment E871. For E871, I designed and built a set of large trigger counters with special requirements. These experiments set the best limits on $K_L \to \mu e$, measured $K_L \to \mu^+\mu^-$ and also detected $K_L \to e^+e^-$, the rarest decay.

During this period an opportunity emerged to use the E791 apparatus for a short run to search for the H-dibaryons, predicted to be present in the same neutral kaon beam-line. The detector was rearranged to find dissociation of these particles in a specially constructed scintillation target. I performed most of the simulations for the proposal, and created the tricky pattern recognition software with a graduate

students (Karl Ecklund) at Stanford. We ran the experiment for several months, and set a rather stringent limit on the production of these particles.

1982-1988 As a Brown university graduate student I worked on the E734 experiment at Brookhaven. I worked in the group of Bob Lanou and in collaboration with BNL, University of Pennsylvania, Osaka, and KEK in Japan. The experiment focused on the detection of neutral current elastic scattering of electrons by muon neutrinos and antineutrinos, processes that are very sensitive to the weak mixing angle or the Weinberg angle. I performed the final analysis from this experiment. I introduced a number of innovations to the analysis; the most important was the analysis of the angular distribution of the elastic scattering to extract g_V and g_A in a model independent way. I also found new ways to analyze the low energy neutrino spectrum. This experiment produced a series of highly cited publications.

COMPUTING EXPERIENCE

Early experience with 3081e emulator programming, Expertise with C, FORTRAN, programming languages, UNIX and Windows operating systems, PAW (Physics Analysis Workstation), HTML, and TeX. Extensive use of Mathematica.

I have become an expert with Mathematica. I have been performing a lot of Daya Bay analysis and liquid argon TPC calculations with it.

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CONFERENCE PROCEEDINGS AND INVITED TALKS

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61. Neutrinos: a new tool for precision interferometry, Colloquium at Virginia Tech, April 4, 2011.
62. The LBNE collaboration, talk at the DOE review of options for underground science, April 12, 2011.
63. Detector Development for Long-Baseline Neutrino Experiment, Seminar, University of California, Irvine, May 25, 2011.
64. Overview of Long-Baseline Neutrino Physics Experiments, Workshop for Giant Liquid Argon Detector,GLA2011, Jyvaskyla, Finland, June 7 2011.

65. Mechanical Issues Concerning Photo-multipliers, Talk at workshop on Advances in Neutrino Technology, ANT11, Drexel University, Chemical Heritage Foundation, Philadelphia, October 10-12, 2011.
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68. Physics of the Intensity Frontier, talk to the US-China meeting, Brookhaven National Lab., Nov. 2, 2011.
69. Status of the Long-Baseline Neutrino Experiment, Seminar at TRIUMF, Vancouver, CA, Mar. 14, 2012.
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DEPARTMENT COLLOQUIA and OTHER PROFESSIONAL ACTIVITIES

I have given many colloquia to numerous university and laboratory departments. I have given lectures to undergraduates, high school students and the general public on particle physics.

I have made numerous presentations to laboratory and funding agency advisory committees.

I am a member of the APS, Division of Particles and Fields, Division of Beams, and Division of Astrophysics.

I am a member of the AAAS.

LABORATORY REPORTS, ANALYSIS NOTES, AND OTHER PUBLICATIONS

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