Heng-Ye Liao

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EDUCATION

Ph.D., Physics   **2016**
Ludwig-Maximilians-Universität, München, Germany
Advisor: Dr. Béla Majorovits. Dissertation Title: "Development of Pulse Shape Discrimination Methods for BEGe detectors".
Magna cum laude (Very good)

M.S., Astrophysics   **2006**
National Taiwan University, Taipei, Taiwan
Advisor: Professor Tsz-king Wong. Dissertation Title: "A Search of Neutrino-Induced Nuclear Transitions in ^{73}Ge at the Kuo-Sheng Nuclear Power Plant with a High-Purity Germanium Detector".
GPA: 3.7, Major GPA: 3.7. Ranked 2nd in graduating class.

B.S., Physics   **2003**
Soochow University, Taipei, Taiwan
GPA: 3.5, Major GPA: 3.8. Ranked 1st in graduating class.

SCIENTIFIC LEADERSHIP

- ProtoDUNE-SP Hadron Analysis Group Co-Convener, 2021-Present
- Joint HEP Seminar Coordinator, 2020-Present
  (University of Kansas, Kansas State University, and University of Nebraska, Lincoln)
- Integration/installation Coordinator of the DUNE CISC Consortium, 2019

HONORS AND AWARDS

- Intensity Frontier Fellow - Fermilab, Batavia, U.S., 2018.
  Awarded to outstanding researchers in the areas of neutrino physics, muon physics, and other topics in the Intensity Frontier. Winner for one year fellowship (2018 to 2019)[1]..
- Grade A Performance Award - Institute of Physics, Academia Sinica, Taipei, Taiwan, 2008 - 2010.
  3-time winner from 2008 to 2010, for consistently outstanding performance in research and development.
- Graduate Representative - Department of Astrophysics, National Taiwan University, 2006.
  Represented graduating class during university convocation to accept award from the President of National Taiwan University.
- Departmental Citation - Soochow University, Taipei, Taiwan, 2003.
  Only top 3 students in the graduating class from each college nominated for membership.
- Presidential Award - Department of Physics, Soochow University, Taipei, Taiwan, 2000 - 2003.
  Awarded to the top 3% of students from each department. Winner for EIGHT consecutive semesters (2000 to 2003).

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[1] http://www.fnal.gov/pub/forphysicists/fellowships/intensity_frontier/past_and_current/index.html

RESEARCH	**Postdoctoral Fellow**	**2017 - Present**
EXPERIENCE	Kansas State University (Stationed at Fermilab since 2017)	

Expertise in Data Analysis & Simulation

- Proton-Argon Cross-Section Analysis.
  Performed the $1\,\text{GeV/c}$ proton-argon cross-section analysis for ProtoDUNE-SP.
  Completed development of proton-argon cross section determination methods
  using the thin-slice method and the reweighting technique. Developed the entire
  analysis tools for both data and MC, including identification of beam protons,
  event selection, and calorimetric reconstruction. Developed likelihood-based
  method for the successful selection of inelastic-scattering protons with very
  high purity (90 %). Developed the convolutional neural network (CNN) for the
  interaction vertex recognition. The result using CNN boosted the efficiency
  by 16 % for the elastic scattering vertices and 8 % for the inelastic ones. My
  analysis and the implemented tools were regarded as the benchmark for devel-
  oping another analysis framework, High Level Analysis at a Neutrino Detector
  (HighLAND) for DUNE.
- Proton Analyses.
  Lead a team of two postdocs to work on the recombination analysis using the
  stopping protons and the $2\,\text{GeV/c}$ proton-argon inclusive cross-section analysis.
- ProtoDUNE-SP Detector Performance.
  Performed the S/N analysis using cosmic muon tracks and the particle identific-
  ation analysis for ProtoDUNE-SP. Successfully demonstrated that ProtoDUNE-
  SP exhibits great S/N performances and an excellent muon/proton separation
  capability.
- Hit Disambiguation for DUNE Far Detector.
  Performed root cause analysis on the DUNE track disambiguation algorithm,
  necessary for identifying the side of an anode plane on which a track is located.
  Efficiency was improved from 96% to 99%.

ProtoDUNE-SP Detector Construction (Stationed at CERN: Jan./2018 - Sep./2018)

- ProtoDUNE-SP Ground Plane Monitoring System.
  -Assumed full responsibility for the ProtoDUNE-SP high voltage (HV) ground
  plane monitoring (GPM) system. Co-designed the signal readout PC Board,
  designed the data acquisition system using the customized multi-channel ana-
  lyzer, cable management, and software for off-line data processing.
  -Managed the schedule of installation, devised and performed QA tests during
  different construction stages, communicated with collaborators across the U.S.
  and Europe, coordinated among groups (high voltage, cryogenics, and slow con-
  trol) at CERN, and ensured that the system become operational as scheduled
  and run smoothly as designed. The GPM system was proven to be one of the
  key devices enabling the HV system to run stably. The design of the GPM
  system has been adapted for DUNE.
- ProtoDUNE-SP Liquid Argon TPC Construction.
  Contributed to team efforts enabling completion of the field cage assembly and
  performed the associated quality assurance (QA) tests. Served as a HV system
  expert for the duration of commissioning and data taking for ProtoDUNE-SP
  experiment.

Hardware Design & Test

- DUNE High Voltage Test
  Substantially contributed to the testing of the DUNE field cage, cathode plane,

and HV designs in the DUNE HV test at Fermilab [2] and at CERN. Independently designed and built the temperature sensor arrays to monitor the liquid nitrogen level, light detection system using Silicon Photomultipliers (MicroFB-60035), prototype GPM system at detecting HV discharge, and the RPi camera system for visualization.

Ph.D. Research Assistant   **2012 - 2017**
Max-Planck-Institut für Physik(Werner-Heisenberg-Institut)
Expertise in Data Analysis
- Pulse Shape Discrimination (PSD) for the GERDA Phase I.
  Main developer for the Phase I A/E normalization procedure. Team work for the Phase I BEGe analysis group. Determined a final PSD cut for the Phase I BEGe data. The result was published in *Physical Review Letters* [3].
- Optimzation of the GERDA Phase I BEGe filter.
  Conducted systematic studies to determine the optimal window size of the Phase I MA filter. Demonstrated that the selected window size of the MA filter boasted the best S/N ratio.

  Developed wavelet de-noising algorithms for Phase I BEGe data. Effected further improvements by suppressing $\sim 50\,\%$ of the background events compared to the results using the standard Phase I filter.
- Characterizations of the GERDA Phase II BEGe detectors in vacuum cryostats tested in the HADES underground facility.
  Designed semi-automated analysis tools for A/E PSD. Independently completed the data analysis on PSD characterization for the 30 Phase II BEGe detectors. Analysis schemes subsequently distributed among and adopted by GERDA colleagues.
- Data analysis for a novel n-type BEGe detector with 4-fold segmentations developed by the GEDET collaboration.
  Collaborated with colleagues on the complete data analysis including cross-talk corrections, energy calibrations for multi-channels, crystal axes orientation, segment boundaries determination, and event position reconstruction.

Simulation
- Assumed full responsibility for the development of pulse shape simulation software for the segmented BEGe detector.
  Completed the entire simulation tools including the generation of hit positions using GEANT4, field calculation, pulse shape simulation, and folding in the preamp response functions to the simulated pulses.

Research Assistant   **2008 - 2012**
Institute of Physics, Academia Sinica, Taipei, Taiwan

Expertise in Data Analysis
- Senior staff member with full responsibility for data acquisition development and leadership of all data analysis including software code design, data management, and mass production. Experienced in data analysis utilizing point contact germanium (PCGe), Ultra-Low-Energy germanium (ULEGe), Segmented Ge, High Purity germanium (HPGe), CsI(Tl) crystal scintillation detector array, NaI(Tl) anti-Compton detector, Cosmic-Ray plastic scintillators, and Thermal Neutron Detectors for broad ranging scientific goals.

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[2] http://nus2surf.dunescience.org/2018/02/veni-vidi-experimentum-feci/
[3] The current best limit of $T_{1/2}^{0\nu}$ for ^{76}Ge isotopes.

- Designed and developed almost all the related software codes for different periods of data acquisition (P-V to P-IV). Comfortable with writing related software codes in C and C++ languages.

Pulse Shape Discrimination
- Developed algorithms to calculate the efficiencies of surface and bulk events of the point contact germanium detector in the sub-keV region. The result was published in *Physical Review Letters.*
- Implemented PSD methods for the successful selection/rejection of surface and bulk events, based on a wavelet denoising filter technique capable of suppressing 50% background with >95% efficiency from several hundred eV to 100 keV energy regime. Results reported to National Science Council (NSC), Taiwan for citation as the breakthrough research development of the year.
- Developed and improved figure of merit (FOM) of PSD for the extraction of physics signals in the sub-keV energy region.
- Oversaw project on the measurement of neutron abundance on the experimental site with a hybrid structure neutron detector consisting of a BC501A liquid scintillator and a BC702 thermal neutron detector. Implemented PSD cuts to differentiate fast/slow neutrons, and gammas with 100% efficiency (> 200 keV) for the hybrid neutron detectors.
- Implemented and optimized various selection criteria, e.g. for Cosmic-Ray Vetoes, Anti-Compton Vetoes, as well as for position - with >90% efficiency and 90% suppression factor.

Simulation
- Developed simulation codes through the use of GEANT4 for understanding the surface/bulk behaviour of PCGe detector.

China Jin-Pin Laboratory (CJPL) Construction
- Invited to establish both hardware and software setups in China Jin-Pin laboratory, currently the deepest underground lab with 2400+ m vertical rock overburden.

Hardware Design and Installation
- Designed and built *Cosmic Ray Veto system* using plastic scintillation detectors. Independently designed logic circuits and installed on site during year 2008 to 2011 data acquisition (P-V/IV) Cosmic Ray Veto system. New system recorded a factor of two improvement for background suppression.
- *Logic Circuit Design and Installation.* Designed and developed logic circuits by utilizing different modules for VME and PXI crate in different data acquisition period along with various colleagues.
- Mechanically designed and installed detachable shielding structure made of OFHC copper for the anti-Compton detectors, as well as heavy weight- lifting-tools for a single piece of NaI(Tl)-3 anti-Compton detector with a mass of 125 kg.

Alternative Military Service   **2007 - 2008**
Banqiao City, Taiwan
Firefighter.
Proposed a commercially available satellite positioning program, subsequently adapted by the Banqiao Municipal Government, for monitoring all fire hydrants in the Banqiao City during fire drills.

Graduate Research Assistant   **2003 - 2007**
Institute of Physics, Academia Sinica, Taipei, Taiwan

Data Analysis
- Independently designed all the related software codes of *On-line Remote Monitoring System* for detector status and data monitoring.
- Performed background analysis and mass productions for Neutrino Magnetic Moments [4].
- Conducted thorough study of neutrino-induced nuclear transition in ^{73}Ge, ^{133}Cs and ^{127}I.
- Actively involved in the cross section calculations for axions in the Sun, energy calibration and background analysis for High/Low energy of HPGe.
- Led extensive study of $\beta-\alpha$ decay mode for intrinsic impurity in CsI(Tl) crystal scintillation detector array.
- Studied possible $0\nu\beta\beta$ decay from ^{76}Ge and conducted search for charge non-conserving β^- decay of ^{73}Ge [unpublished].
- Developed software tools and data productions for neutrino-electron scattering in CsI(Tl) crystal scintillation detector array.

TEACHING EXPERIENCE
- Supervised graduate student for a summer project of the proton mass production - Kansas State University
- Supervised graduate student on detector characterization and data analysis of a novel segmented BEGe detector - Max-Planck-Institut für Physik
- Supervised summer intern for the temperature dependence study of the coaxial germanium detector - Max-Planck-Institut für Physik RISE (Research Internships in Science and Engineering) program
- Supervised graduate students on detector calibration, mass production, and background analysis for the PCGe detectors - Institute of Physics, Academia Sinica
- Lecturer, Cosmic Ray telescope demonstration - Institute of Physics, Academia Sinica High School Student Program
- Lecturer, Bubble Chamber demonstration - Institute of Physics, Academia Sinica High School Student Program

SOFTWARE SKILLS
- Proficient in C, C++, shell scripts, Python, GIT, ROOT, GEANT4, LaTeX, Mathematica, and common packages for Linux and Windows platforms.

ACADEMIC ACTIVITIES AND PRESENTATIONS
- Hadron-argon Cross Section Measurements in ProtoDUNE, Presented at International Conference on High Energy Physics (ICHEP), Bologna, Italy (2022)
- Cross-section physics with ProtoDUNE-SP - Invited talk, Physics colloquium at South Dakota School of Mines and Technology, Rapid City, U.S.A (2021)
- Elastic-inelastic Handling in ProtoDUNE-SP Proton Data - Invited presentation at SuperFGD test beam analysis meeting, New York, U.S.A (2021)
- Measuring the proton-argon cross-section at ProtoDUNE-SP - Poster session presented at NuFact 2021, Cagliari, Italy (2021)
- Hadron-argon cross-section measurements in ProtoDUNE-SP - Presented at 40th International Conference on High Energy Physics (ICHEP), Prague, Czech Republic (2020)
- Participant, Neutrino Physics and Machine Learning (NPML), SLAC National Accelerator Laboratory, CA, U.S.A (2020)

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[4] The best limit of μ_ν, Particle Data Group, 2008, page 52.

- Participant, Deep Learning for Science School (DL4Sci), Lawrence Berkeley National Laboratory, Berkeley, CA, U.S.A (2020)
- Measuring the proton-argon cross section at ProtoDUNE-SP - Poster session presented at the Neutrino 2020, Chicago, U.S.A (2020)
- ProtoDUNE-SP Proton Analysis - Presented at the Meeting of the Division of Particles & Fields (DPF) of the American Physical Society, Boston, U.S.A (2019)
- ProtoDUNE Proton Analysis - Presented at the American Physical Society (APS) April Meeting, Denver, U.S.A (2019)
- Participant, Workshop on Calibration and Reconstruction for LArTPC Detectors, Batavia, U.S.A (2018)
- Member, the **Deep Learning Club at FNAL** (using machine learning techniques to solve physics problems)
- Participant, DS@HEP 2017, Batavia, U.S.A (2017)
- GERDA for the neutrinoless double beta decay - Invited talk, Karlsruher Institut für Technologie (KIT), Karlsruhe, Germany (2016)
- Participant, Meeting on the Next Generation ^{76}Ge Experiment, Munich, Germany (2016)
- MPI Pulse Shape Simulation - Presented at GDT Symposium at Ringdberg Castle, Kreuth, Germany (2015)
- Segmented BEGe Detector: Characterization - Presented at GDT Symposium at Ringdberg Castle, Kreuth, Germany (2015)
- GERDA: The search for Neutrinoless Double Beta Decay - Presented at INFO15, Santa Fe, U.S.A. (2015)
- Segmented Broad Energy Germanium Detector - Presented at the DPG Frühjahrstagung, Wuppertal, Germany (2015)
- Segmented Broad Energy Germanium Detector - Presented at the IMPRS, Munich, Germany (2015)
- Normalization Procedure of Pulse Shape Discrimination for Broad Energy Germanium Detector - Presented at the DPG Frühjahrstagung, Mainz, Germany (2015)
- Participant, Computational Pulse Shape Simulation Workshop - Heidelberg, Germany (2014)
- A/E Discrimination for the GERDA Experiment - Presented at the Sino-German Germanium Workshop, Beijing, China (2014)
- Participant, "Interdisciplinary Workshop on Statistical and Analysis Methods in Nuclear, Particle and Astrophysics", Villazzano, Italy. (2014)
- A/E PSD for the GERDA experiment - Presented at the IMPRS, Munich, Germany (2014)
- Participant, Monte Carlo Methods in Advanced Statistics Applications and Data Analysis, Munich, Germany (2013)
- A/E PSD for the GERDA experiment - Presented at the Academic Exchanges of the Sino-German GDT cooperation, Beijing, China (2013)
- Pulse Shape Analysis A/E for GERDA experiment - Presented at the Symposium of the Sino-German GDT cooperation, Tübingen, Germany (2013)
- Consistency check of Pulse Shape Discrimination for Broad Energy Germanium Detectors using double beta decay data - Presented at the DPG Frühjahrstagung, Dresden, Germany (2013)
- Participant, International School on AstroParticle Physics (ISAPP 2013), Canfranc, Spain (2013)
- Consistency Check of A/E using $2\nu\beta\beta$ and calibration data - Presented at the GERDA Collaboration Meeting, LNGS, Italy (2013)
- General guide for the open house day of Max-Planck-Institut für Physik (2012-2014)