

Hai-Jun Yang - Curriculum Vitae

Personal Information:

Address: 450 Church Street, Department of Physics
University of Michigan, Ann Arbor, MI 48109
Telephone: (734)763-2329, Fax: 734-9366529
E-mail: yhj@umich.edu

Education:

- 1995.9-2000.7 Ph.D in Physics, 2000, Joint education of
Swiss Federal Institute of Technology (ETH, Zurich)
Institute of High Energy Physics (IHEP, Beijing)
Advisors: Prof. M. Pohl (University of Geneva)
Prof. X. Tang (Member of Chinese Academy of Sciences)
1991.9-1995.7 B.Sc., Hangzhou University (renamed as Zhejiang University)

Employment and Research Experience:

- 2005.8 - present Assistant Research Scientist, University of Michigan
- Principal Investigator (PI) of a DOE/LANL subcontract grant for MiniBooNE at the University of Michigan, to develop MiniBooNE electron/pion identification based on Boosted Decision Trees for electron neutrino oscillation search and to discover one of major backgrounds from outside of MiniBooNE tank (dirt events) with Prof. Byron P. Roe etc.
 - ATLAS physics analysis and search tool development for Diboson, SM $H \rightarrow WW$, $Z' \rightarrow t\bar{t}$, GMSB SUSY particle searches, and development of ATLAS electron identification & b-tagging using Boosted Decision Trees with Prof. Bing Zhou.
- 2000.8 - 2005.7 Research Fellow, University of Michigan
- Search for SM Higgs, MSSM Higgs with L3 detector at CERN/LEP
 - Development of an advanced pattern recognition technique, Boosted Decision Trees, for MiniBooNE physics analysis with Prof. Byron P. Roe and Prof. Ji Zhu (UM Statistics Department). This technique has wide applications at HEP data analysis to improve physics detection sensitivity.
 - Design and build high-precision optical alignment demonstration systems based on Frequency Scanned Interferometry (FSI) for ILC silicon tracker detector with Prof. Keith Riles.
 - Optimization of ILC tracker detectors through impact of tracker design on SM Higgs and SUSY particle measurements using various Monte Carlo simulations with Prof. Keith Riles.

Membership:

- 2001 - present: American Physical Society (APS)

Selected Publications

- MiniBooNE Collab., A.A. Aguilar-Arevalo et.al., *Unexplained Excess of Electron-Like Events From a 1 GeV Neutrino Beam*, accepted by Phys. Rev. Lett. (2009)
- **Hai-Jun Yang** et.al., *A Multivariate Training Technique with Event Reweighting*, JINST 3 P04004 (2008).
- ATLAS Collab. G. Aad et.al., *The ATLAS Experiment at the CERN Large Hadron Collider*, JINST 3:S08003,2008 (437 pp)
- ATLAS Collab. G. Ada et.al., *Expected Performance of the ATLAS Experiment, Detector, Trigger and Physics*, CERN-OPEN-2008-020, Geneva, 2008 (1852pp). I have made major contributions to ATLAS SM Diboson and $H \rightarrow WW$ analysis.
- K. Bachas, ..., **H. Yang** et.al., *Studies of Diboson Production with the ATLAS Detector*, Nucl. Phys. B(Proc. Suppl.)177-178 (2008) 255-257
- MiniBooNE Collab., A.A. Aguilar-Arevalo et.al., *First Observation of Coherent π^0 Production in Neutrino Nucleus Interactions with $E_\nu < 2$ GeV*, Phys. Lett. B. 664, 41 (2008)
- MiniBooNE Collab., A.A. Aguilar-Arevalo et.al., *Compatibility of high m^2 e and $e\bar{\nu}$ Neutrino Oscillation Searches*, Phys. Rev. D. 78, 012007 (2008).
- MiniBooNE Collab., A.A. Aguilar-Arevalo et.al., *The MiniBooNE Detector*, Nucl. Instr. & Meth. A599:28-46 (2008)
- MiniBooNE Collab., A.A. Aguilar-Arevalo et.al., *Measurement of muon neutrino quasi-elastic scattering on carbon*, Phys. Rev. Lett. 100, 032301 (2008)
- MiniBooNE Collab., A.A. Aguilar-Arevalo et.al., *A Search for Electron Neutrino Appearance at the $\Delta m^2 \sim 1$ eV² Scale*, Phys. Rev. Lett. 98, 231801 (2007)
- **Hai-Jun Yang**, Byron P. Roe, Ji Zhu, *Studies of Stability and Robustness for Artificial Neural Networks and Boosted Decision Trees*, Nucl. Instrum. & Meth. A 574:342-349 (2007)
- **Hai-Jun Yang**, Sven Nyberg, Keith Riles, *High-precision Absolute Distance Measurement using Dual-Laser Frequency Scanned Interferometry Under Realistic Conditions*, Nucl. Instrum. & Meth. A 575:395-401 (2007)
- M. Gataullin, S. Rosier, L. Xia and **H. Yang**, *Searches for gauge-mediated SUSY breaking topologies with the L3 detector at LEP*, AIP Conf. Proc. 903:217-220 (2007)
- Byron P. Roe, **Hai-Jun Yang**, Ji Zhu, "Boosted decision trees, a powerful event classifier", Proceedings of PHYSTAT05 (Statistical Problems in Particle Physics, Astrophysics and Cosmology), Oxford, UK, September 12-15, 2005.
- **Hai-Jun Yang**, Byron P. Roe, Ji Zhu, *Studies of boosted decision trees for MiniBooNE particle identification*, Nucl. Instrum. & Meth. A555:370-85 (2005)

- Byron P. Roe, **Hai-Jun Yang**, Ji Zhu, Yong Liu, Ion Stancu, Gordon McGregor, *Boosted decision trees as an alternative to artificial neural networks for particle identification*, Nucl. Instrum. & Meth. A543:577-584 (2005)
- **Hai-Jun Yang**, Jason Deibel, Sven Nyberg, Keith Riles, *High-precision absolute distance and vibration measurement by using frequency scanned interferometry*, Applied Optics, Vol.44:3937 (2005)
- **Hai-Jun Yang**, Sven Nyberg, Keith Riles, *Frequency Scanned Interferometry for ILC Tracker Alignment* Proceedings of 2005 International Linear Collider Workshop (LCWS 2005), Stanford, California, 18-22 Mar 2005, pp 0816.
- **Hai-Jun Yang**, Keith Riles, *Impact of tracker design on Higgs and slepton measurements*, Proceedings of 2005 International Linear Collider Workshop (LCWS 2005), Stanford, California, 18-22 Mar 2005, pp 0115.
- LEP Higgs Working Group, R. Barate et al., *Search for the standard model Higgs boson at LEP*, Phys. Lett. B565:61-75 (2003)
- L3 Collab., *Search for neutral Higgs bosons of the minimal supersymmetric standard model in e^+e^- interactions at \sqrt{S} up to 209 GeV*, Phys. Lett. B545:30-42 (2002)
- L3 Collaboration, *Standard model Higgs boson with the L3 experiment at LEP*, Phys. Lett. B517:319-331 (2001)
- L3 Collab., *Measurement of the topological branching fractions of the τ lepton at LEP*, Phys. Lett. B519:189-198 (2001)
- L3 Collab., *Production of single W bosons at $\sqrt{S} = 189$ GeV and measurement of $WW\gamma$ gauge couplings*, Phys. Lett. B487:229-240 (2000)
- American Linear Collider Working Group, T. Abe et al., LINEAR COLLIDER PHYSICS RESOURCE BOOK FOR SNOWMASS 2001. SLAC-R-570 (May 2001) 436p. Available as hep-ex/0106055 (part 1), hep-ex/0106056 (part 2), hep-ex/0106057 (part3), and hep-ex/0106058 (part 4).

Technical Notes for ATLAS Experiment at CERN

- ATL-COM-PHYS-2009-060, "Higgs Boson Searches in Gluon Fusion and Vector Boson Fusion using the $H \rightarrow WW$ Decay Mode", A. Armbruster, ..., **H. Yang** et.al.
- ATL-PHYS-INT-2009-007, "Diboson Physics Studies With the ATLAS Detector", T. Baber, ..., **H. Yang**, et.al.(long note 140 pages)
- ATL-COM-PHYS-2009-002, "Study of the SM Higgs Discovery Potential through W-pair Leptonic Decay Modes with Boosted Decision Trees", **H. Yang**, T. Dai, D. Levin, X. Li, A. Wilson, Z. Zhao, B. Zhou
- ATL-COM-PHYS-2008-237, "Discovery Potential of GMSB Supersymmetry with the $Z\gamma + MET$ Final State in ATLAS", N. Panikashvili, ..., **H. Yang** et.al.
- ATL-COM-PHYS-2008-179, "Diboson Physics in ATLSA", D. Levin, ..., **H. Yang**, et.al.
- ATL-COM-PHYS-2008-041, "Diboson Physics Studies With the ATLAS Detector", T. Baber, ..., **H. Yang**, et.al.(long note 140 pages)
- ATL-COM-PHYS-2008-036, "Diboson Physics Studies With the ATLAS Detector", T. Baber ..., **H. Yang**, et.al.(CSC note)
- ATL-COM-PHYS-2008-023, "ATLAS $H \rightarrow WW$ Detection Sensitivity with Boosted Decision Trees", **H. Yang**, T. Dai, D. Levin, X. Li, A. Wilson, Z. Zhao, B. Zhou

Internal Technical Notes for MiniBooNE Experiment at Fermilab

- BooNE-TN254, "Studies and Oscillation Fits with the New All-Hadronic Monte Carlo", R. Van de Water (for Low-E group), 7/8/08
- BooNE-TN214, "Estimation of Radiative Gamma Events Using CCBox and May06 DirtMC Samples", **Hai-Jun Yang**, 11/01/06.
- BooNE-TN213, "Proposal to Combine Boost and YBoost to Build the Final PID Variables", **Hai-Jun Yang**, G. Mills, 10/10/06.
- BooNE-TN211, "Studies of Stability and Robustness for Artificial Neural Networks and Boosted Decision Trees", **Hai-Jun Yang**, B. Roe, J. Zhu, 10/4/06.
- BooNE-TN203, "Measurement of Dirt Events", **Hai-Jun Yang**, 9/15/06.
- BooNE-TN197, "Proposal to Open DirtBox for Direct Measurement of Dirt Events", **Hai-Jun Yang**, T. Katori, 8/17/06.
- BooNE-TN189, "Boosting ParticleID for May06 Baseline", **Hai-Jun Yang**, 7/10/06.
- BooNE-TN180, "Effect of Dirt Events on nue Oscillation Sensitivity", **Hai-Jun Yang**, R. Van de Water, 04/27/2006.

- BooNE-TN170, "Proposal to Open Box with Less Than One Sigma Oscillation nue CCQE Events", by Byron P. Roe, **Hai-Jun Yang**, 11/15/2005.
- BooNE-TN163, "Studies of Boosted Decision Trees for MiniBooNE Particle Identification", by **Hai-Jun Yang**, Byron P. Roe, Ji Zhu, 07/08/2005.
- BooNE-TN151, "Retuning of R-Fitter & PID for Dec'04 Baseline", by Byron P. Roe, **Hai-Jun Yang**, 01/08/2005.
- BooNE-TN147, "The Performance of R-Fitter Particle Identification", by **Hai-Jun Yang**, Byron P. Roe, 11/18/2004.
- BooNE-TN127, "An Alternative Particle ID Technique: the Boosting Algorithm", by **Hai-Jun Yang**, Byron P. Roe, J. Zhu, 5/5/2004, Revised 6/7/2004, Revised 7/2/2004.
- BooNE-TN123, "Brief Manual for Using Boost Programs" , by Byron P. Roe, **Hai-Jun Yang**, 4/20/2004.
- BooNE-TN118, " $\nu_\mu \rightarrow \nu_e$ Oscillation Sensitivity in the MiniBooNE Experiment by using the Boosting Particle ID", by **Hai-Jun Yang**, Byron P. Roe, J. Zhu, 3/18/2004.
- BooNE-TN113, "Particle Identification in the MiniBooNE Experiment by using the Boosting Algorithm" , by **Hai-Jun Yang**, Byron P. Roe, J. Zhu, 2/4/2004, Revised 2/13/2004, Revised 2/23/2004.
- BooNE-TN112, " ν_e and π^0 separation in the MiniBooNE Experiment by using the Boosting Algorithm" , by Ji Zhu, **Hai-Jun Yang**, Byron P. Roe, 1/9/2004.

Proceedings and Technical Notes for International Linear Collider

- **Hai-Jun Yang**, Keith Riles, *High-precision Absolute Distance Measurement Using Dual-Laser Frequency Scanned Interferometry Under Realistic Conditions*, 09/21/2006. (Physics/0609187)
- Proceeding paper for 2005 ALCPG & ILC Workshop - Snowmass, USA, "Frequency Scanned Interferometry for ILC Tracker Alignment", by **Hai-Jun Yang**, Sven Nyberg, Keith Riles, 11/30/2005.
- Proceeding paper for 2005 International Linear Collider Workshop (LCWS05), "Frequency Scanned Interferometry for the ILC Tracker Alignment", by **Hai-Jun Yang**, Sven Nyberg, Keith Riles, 06/27/2005. (Physics/0506197)
- Proceeding paper for 2005 International Linear Collider Workshop (LCWS05), "Impact of Tracker Design on Higgs and Slepton Measurements", by **Hai-Jun Yang** and Keith Riles, 06/27/2005. (Physics/0506198)
- American Linear Collider Working Group, *Linear collider physics resource book for Snowmass 2001*, SLAC-R-570, May, (2001).
Part 1. Introduction, hep-ex/0106055

- American Linear Collider Working Group, *Linear collider physics resource book for Snowmass 2001*, SLAC-R-570, May, (2001).
Part 2. Higgs and Supersymmetry Studies, hep-ex/0106056
- American Linear Collider Working Group, *Linear collider physics resource book for Snowmass 2001*, SLAC-R-570, May, (2001).
Part 3. Studies of Exotic and Standard Model Physics: hep-ex/0106057
- American Linear Collider Working Group, *Linear collider physics resource book for Snowmass 2001*, SLAC-R-570, May, (2001).
Part 4. Theoretical, Accelerator, and Experimental Options, hep-ex/0106058
- "Impact of tracker design on Higgs mass and cross-section resolutions", by **Hai-Jun Yang** & Keith Riles. eConf C010630:E3040,2001.
- "Measurement of Higgs mass and cross-section at a linear collider", by **Hai-Jun Yang** & Keith Riles, eConf C010630:P112,2001.

Proceedings and Technical Notes for L3 Experiment at CERN

- "Searches for Gauge-Mediated SUSY Breaking Topologies with the L3 Detector at LEP", by M. Gataullin, S. Rosier, L. Xia, **Hai-Jun Yang**, to appear in Proceeding of SUSY06, the 14th International Conference on Supersymmetry and the Unification of Fundamental Interactions, UC Irvine, California, 12-17, June 2006. hep-ex/0611010.
- CERN-EP/2003-019, "Measurement of Branching Fractions of τ Hadronic Decays", by the L3 Collaboration.
- L3 note 2777, "Interpretation of Neutralino and Scalar Lepton Searches in minimal GMSB Model", by Marat Gataouline, Sylvie Rosier-Lees, Lei Xia, **Hai-Jun Yang**, 9/23/2002.
- L3 note 2735. "Search for Neutral Higgs Bosons of the Minimal Supersymmetric Standard Model in e^+e^- Interactions at $\sqrt{s} =$ up to 209 GeV", by R. Berbeco, S. Cucciarelli, A. Holzner, W. Lohmann, B. Musicar, A. Raspereza, J. Yamamoto, **Hai-Jun Yang**. 3/8/2002.
- L3 note 2700, "Searches for the neutral Higgs bosons of the MSSM: preliminary combined results using LEP data collected at energies up to 209 GeV", by the LEP Higgs Working Group, the Aleph, Delphi, L3 and Opal Collaborations, 7/4/2001
- L3 note 2692, "Search for Neutral Higgs Bosons of the Minimal Supersymmetric Standard Model in e^+e^- Interactions at \sqrt{s} up to 209 GeV", by S. Cucciarelli, A. Raspereza, **Hai-Jun Yang**, 7/2/2001.
- L3 note 2656, "Searches for the Neutral Higgs Bosons of the MSSM: Preliminary Combined Results Using LEP Data collected at Energies up to 209 GeV", by the LEP Higgs Working Group, the Aleph, Delphi, L3 and Opal Collaborations, 3/20/2001.

Selected Talks for Meetings, Workshops, Conferences & Seminars

- **Selected ATLAS Talks**

25. BNL Analysis Jamboree, "ATLAS electron id based on boosted decision trees", 12/18/08
24. ATLAS egamma Phone Conference, "Update on performance of BDTs for electron identification", 12/17/08
23. ATLAS North American egamma Meeting, "Implementation of BDT for electron-ID in Athena egammaRec Package", 11/20/08
22. ATLAS Higgs Meeting, "Implementation of BDT for electron-ID in Athena egammaRec Package", 11/19/08
21. Seminar talk at Southern Methodist University, "Search for New Physics at LHC with ATLAS Detector", 10/20/08
20. ATLAS Performance and Physics Workshop, "Higgs Detection Sensitivity from Gluon-Gluon-Fusion $H \rightarrow WW$ ", 10/01/08
19. ATLAS Performance and Physics Workshop, "ATLAS Electron Identification based on Boosted Decision Trees(v13)", 10/02/08
18. US-ATLAS ANL/BNL/LBNL Jamboree, "ATLAS Electron Identification based on Boosted Decision Trees(v12)", 09/10/08
17. US-ATLAS ANL/BNL/LBNL Jamboree, "Search for $Z' \rightarrow t\bar{t}$ at LHC with the ATLAS Detector", 09/09/08
16. LHC Physics Workshop in China, "Search for New Physics at LHC", 07/08/08
15. American Physical Society, April Meeting, "Study of Diboson Physics with the ATLAS Detector", 04/12/08
14. Seminar talk at Boston University, "Search for New Physics at Present and Near Future", 02/04/08
13. LHC New Physics Signature Workshop, "Search for $H \rightarrow WW$ with ATLAS Detector Based on Boosted Decision Trees", 01/11/08
12. ATLAS Higgs Meeting, "Analysis of $H \rightarrow WW \rightarrow \ell\nu\ell\nu$ ", 09/10/07
11. Seminar talk at Zhejiang University, "Large Hadron Collider - A Discovery Machine", 08/06/07
10. Seminar talk at Tsinghua University, "Large Hadron Collider - A Discovery Machine", 07/22/07
9. ATLAS Di-Boson Meeting, "Update of WW/WZ Analysis", 07/02/07
8. ATLAS Trigger and Physics Week, WW and WZ analysis based on Boosted Decision Trees", 06/07/07
7. ATLAS Di-Boson Meeting, "WW and WZ analysis based on Boosted Decision Trees", 05/11/07
6. ATLAS Di-Boson Meeting, "Particle Identification Based on Boosted Decision Trees", 05/04/07
5. ATLAS Di-Boson Meeting, "Update of ATLAS WW analysis", 11/20/06
4. CCAST Workshop on TeV Physics and the LHC, China Center for Advanced Science and Technology (CCAST), "Physics Analysis with Advanced Data Mining Techniques", Beijing, November 6-10, 2006.
3. ATLAS Di-Boson Meeting, "Application of ANN/BDT for ATLAS WW analysis", 09/25/06
2. ATLAS Di-Boson Meeting, "Application of ANN/BDT for ATLAS WZ analysis", 06/20/06
1. ATLAS Di-Boson Meeting, "Boosted Decision Trees, A New Technique for HEP Particle Identification", 10/4/05

- **Selected MiniBooNE Talks**

1. nue and NC pi0 separation in the MiniBooNE experiment Using Boosting Algorithm, MiniBooNE Meeting, January 16, 2004.
2. Particle ID in the MiniBooNE experiment Using Boosting Algorithm, MiniBooNE Meeting, February 27, 2004
3. Impact of the Systematic Errors on the $\nu_\mu \rightarrow \nu_e$ Oscillation Sensitivity, MiniBooNE Collaboration Meeting, April 9, 2004
4. Improvement of RoeFitter Particle ID Performance for February 2004 Baseline, MiniBooNE Collaboration Meeting, November 5, 2004
5. Reconstruction Performance of the Re-tuned R-Fitter for December 2004 Baseline, MiniBooNE Algorithm Meeting, December 14, 2004
6. Reconstruction/Particle ID Performance of the Re-tuned RoeFitter for December 2004 Baseline, MiniBooNE Collaboration Meeting, December 17, 2004
7. Reconstruction Performance of the Re-tuned R-Fitter and S-Fitter for December 2004 Baseline, MiniBooNE Algorithm Meeting, January 11, 2005
8. Update of the Reconstruction Performance from R-Fitter and S-Fitter for December 2004 Baseline, MiniBooNE Algorithm Meeting, January 11, 2005
9. Particle ID Performance of the RoeFitter and the StancuFitter for December 2004 Baseline, MiniBooNE Collaboration Meeting, January 28, 2005
10. Comparison of Particle ID Performance for March 2005 and December 2004 Baselines, MiniBooNE collaboration Meeting, April 22, 2005
11. Performance of YBoosts by Combining Stancu and Roe ParticleID Variables, MiniBooNE Algorithm Meeting, April 26, 2005
12. Current Particle ID Performance for March 2005 Madness MC Samples, MiniBooNE Analysis Meeting, May 12, 2005
13. Status of Roe Variables Translation and YBoost Particle Identification, MiniBooNE Collaboration Meeting, August 26, 2005
14. Performance of YBoost with the Latest Selected ParticleID Variables, MiniBooNE Monster Meeting, November 4, 2005
15. Proposal to Open Box with Less Than One Sigma Oscillation nue CCQE Events, MiniBooNE Collaboration Meeting, November 17, 2005
16. Dirt Events - An Important Background Source, MiniBooNE Monster Meeting, January 27, 2006
17. Status of Boosting PID, MiniBooNE Monster Meeting, March 10, 2006
18. Status of PID Box and Dirt Events, MiniBooNE Monster Meeting, March 10, 2006
19. Status of Boosting PID, Nue Osc. Sensitivity and Dirt Events, MiniBooNE Monster Meeting, March 24, 2006
20. Status of Boosting PID and Nue Osc. Sensitivity, MiniBooNE Monster Meeting, April 7, 2006
21. Update of Dirt Events and Nue Osc. Sensitivity, MiniBooNE Monster Meeting, April 22, 2006
22. Status of PID Tuning for May06 Baseline, MiniBooNE Monster Meeting, June 2, 2006
23. Update of PID Tuning for May06 Baseline, MiniBooNE Monster Meeting, June 16, 2006
24. Update of PID Tuning and Nue Osc. Sensitivity for May06 Baseline, MiniBooNE Monster Meeting, June 30, 2006
25. Comparison Plots for YBoosts using Antibox and May06 MC, MiniBooNE Monster Meeting, July 13, 2006
26. Update(II) of PID Tuning and Nue Osc. Sensitivity for May06 Baseline, MiniBooNE Monster Meeting, July 14, 2006

27. Comparison Plots for AntiBox and May06 MC, MiniBooNE Monster Meeting, July 28, 2006
28. Update(III) of PID Tuning and Osc. Nue Sensitivity, MiniBooNE Monster Meeting, July 28, 2006
29. Direct Measurement of NC Radiative Delta Using YBoost, MiniBooNE Monster Meeting, July 28, 2006
30. Comparison Plots for AntiBox and May06 MC, MiniBooNE Monster Meeting, August 11, 2006
31. Proposal to Open DirtBox for Direct Measurement of Dirt Events, MiniBooNE Monster Meeting, August 25, 2006
32. Measurement of Dirt Events, MiniBooNE Monster Meeting, September 8, 2006
33. Stability of Neural Networks and Boosted Decision Trees, MiniBooNE Monster Meeting, October 6, 2006
34. Comparison of CCBox and DirtMC with 2 Subevt, MiniBooNE Monster Meeting, October 6, 2006
35. Estimation of Radiative Events Using CCBox and May06 DirtMC, MiniBooNE Monster Meeting, October 20, 2006
36. MiniBooNE Event Reconstruction and Particle Identification, The Annual Meeting of the Division of Nuclear Physics of the American Physical Society , Nashville, TN, Oct. 25-28, 2006
37. Physics Analysis with Advanced Data Mining Techniques, IHEP, Beijing, 11/10/2006
38. Invited MiniBooNE talk for KEK Topical Conference, February 06, 2007
39. Measurement of Dirt Events, MiniBooNE Analysis Review, February 8, 2007
40. MiniBooNE Particle ID Based on Boosted Decision Trees, MiniBooNE Analysis Review, February 9, 2007
41. Search for Neutrino Oscillation with MiniBooNE Detector, Invited MiniBooNE talk at Institute of High Energy Physics, July 20, 2007
42. Search for Neutrino Oscillation with MiniBooNE Detector, Invited Colloquium talk at University of Nebraska, Lincoln, November 29, 2007

- **Selected Linear Collider Talks**

1. Measurement of Higgs Mass at NLC, Workshop on Higgs Physics at Linear Collider at University of California, Davis, January 27-28, 2001,
2. Measurement of Higgs Mass at NLC, SLAC LCD Meeting, Stanford University, January 30, 2001.
3. Impact of Tracker Design on Higgs Mass Resolution, Workshop on future e+e- Linear Collider at Johns Hopkins University, Baltimore, March 19-21, 2001
4. Measurement of Higgs Mass and Cross Section at NLC Workshop on future e+e- Linear Collider at Johns Hopkins University, Baltimore, March 19-21, 2001
5. Impact of Tracker Design on Higgs Mass Resolution and Cross Section, Snowmass 2001, June 30 - July 21, 2001.
6. Measurement of Higgs Mass and Cross Section at NLC, Snowmass 2001, June 30 - July 21, 2001.
7. A First Look at Track Reconstruction with High Random Backgrounds, American Linear Collider Workshop at University of Chicago, January 7-9, 2002.
8. Update on Higgs property measurement and Tracker Design Issue, Linear Collider Retreat at University of California, Santa Cruz, June 27-29, 2002
9. Constraints from Higgsstrahlung Signal, SLAC LCD Meeting, Stanford University, August 6, 2002
10. Search for Neutralino and Smuon, SLAC LCD Meeting, Stanford University, December 12, 2002

11. Search for Neutralino and Stau, American Linear Collider Workshop, University of Texas at Arlington, January 9-11, 2003
12. Frequency Scanned Interferometer for Tracker Alignment, American Linear Collider Workshop at Cornell University, July 13-16, 2003.
13. High-precision Absolute Distance Measurement by using Frequency Scanned Interferometry, ALCPG 2004 Winter Workshop at SLAC, Stanford University, January 7-10, 2004.
14. Frequency Scanned Interferometer for Linear Collider Tracker Alignment, SiLC International Tele-Conference, June 14, 2004
15. Frequency Scanned Interferometer for Linear Collider Tracker Alignment, DOE Review at University of Michigan, July 19, 2004
16. Frequency Scanned Interferometer for Linear Collider Tracker Alignment, Victoria Linear Collider Workshop, British Columbia, Canada, July 28-31, 2004.
17. Frequency Scanned Interferometer for International Linear Collider Tracker Alignment, SLAC LCD Meeting, February 17, 2005.
18. Frequency Scanned Interferometer for International Linear Collider Tracker Alignment, 8th International Linear Collider Workshop at SLAC, March 18-22, 2005.
19. Impact of Tracker Design on Higgs/SUSY Measurement, 8th International Linear Collider Workshop at SLAC, March 18-22, 2005.
20. Frequency Scanned Interferometer for ILC Tracker Alignment, International Linear Collider Physics and Detector Workshop at Snowmass, Colorado, August 14-27, 2005.
21. Frequency Scanned Interferometer for ILC Tracker Alignment, Vancouver Linear Collider Workshop, 19-22 July 2006
22. Impact of Tracker Design on Higgs/SUSY Measurement, SiD Benchmarking Meeting, September 19, 2006.
23. Impact of ILC Tracker Design on $e^+e^- \rightarrow H^0 Z^0 \rightarrow \mu^+ \mu^- X$ Analysis, SiD Benchmarking Meeting, December 19, 2006
24. Frequency Scanned Interferometer for ILC Tracker Alignment, SiLC International Tele-Conference, December 19, 2006

- **Selected L3 talks**

1. Identification of tau 3-prong Decays Using Backpropagation Neural Network, IHEP, Beijing, November, 1997.
2. Measurement of Branching Ratios of tau Hadronic Decays, IHEP, Beijing, June 1, 2000.
3. Structure Functions in tau Hadronic Decays, IHEP, Beijing, June 1, 2000.
4. Study of Single W & $WW\gamma$ Couplings, CERN, June 4, 1999,
5. Study of Single W & $WW\gamma$ Triple-Gauge-Boson Couplings, Fermilab, March 7, 2000.
6. Study of Single W & $WW\gamma$ Triple-Gauge-Boson Couplings, University of Michigan, March 14, 2000.
7. Search for Neutral Higgs of MSSM, L3 General Meeting, Balatonfured, Hungary, May 27 - June 1, 2001
8. Search for MSSM Higgs at LEP, Physics Seminar at University of Michigan on Feb. 4, 2002.
9. Interpretation of Neutralino and Stau Search in Minimal GMSB Model, L3 Analysis Meeting, April 24, 2002.
10. Search for Higgs Bosons in e^+e^- Annihilations at LEP (on behalf of the L3 Collaboration), American Physical Society April Meeting(APS-DPF03), Philadelphia, April 5-8, 2003.

Hai-Jun Yang's Research Summary and Future Plan

My research focus is on experimental high energy physics. Since 1997 I have worked on four particle physics projects, L3 (1997-2003) and ATLAS (2005 - present) at CERN, Booster Neutrino Experiment (MiniBooNE) at Fermilab (2003 - 2008), and R&D for the International Linear Collider (ILC) since 2000. My major interests in physics are driven by important fundamental questions such as the origin of mass (Higgs mechanism?), new symmetries (Supersymmetry?) and new physics beyond the Standard Model.

• Search for Higgs and SUSY Particles at LEP and LHC

One of the key questions in particle physics is the origin of mass. Based on the standard model Higgs mechanism, one or more Higgs bosons should exist which generate masses of other particles through electroweak symmetry breaking. However, the existence of the Higgs particle(s) has not yet been confirmed by experiments. Looking for the Higgs has become one of the major motivations for current and future high energy experiments. I have intensively participated in the Higgs search programs in L3 in the past. I am preparing now for the search/discovery of Higgs bosons at the LHC experiments, which will start taking data in 2008.

From 2000 to 2003, I worked with Prof. Keith Riles on the L3 experiment, focusing on the searches for the Standard Model, Minimal Supersymmetric Standard Model (MSSM) neutral Higgs bosons and Gauge Mediated Supersymmetric Breaking (GMSB) particles using data collected by L3 detector at LEP (Phys. Lett. B565:61-75,2003, Phys. Lett. B545:30-42,2002, Phys. Lett. B517:319-331,2001). No experimental signature for Higgs or Supersymmetry were found at LEP. The Higgs mass limit was set to be greater than 114.4 GeV at the 95% confidence level.

Although the Tevatron (Fermilab) has a small window to discover the Higgs before the LHC turn-on, physicists believe that the LHC will provide the best Higgs discovery potential due to its high energy (14 TeV) and high luminosity ($10^{34} \text{ cm}^{-2} \text{ s}^{-1}$). I joined the ATLAS experiment in 2005 at the University of Michigan. The UM ATLAS group is one of the largest groups in ATLAS collaboration. The UM group has played leading roles in muon detector construction, software development, Monte Carlo production and physics analysis etc. My effort in the UM ATLAS group is to lead the development of analysis techniques for new particle identification (PID). The goal of my work is to set the framework and tools in analysis to obtain the optimal signal acceptance and maximum background rejection. I started my work on di-boson (WW, ZW, ZZ, $W\gamma/Z\gamma$ etc.) physics studies to probe the ATLAS detection sensitivities on di-boson final states and to determine the ATLAS detector sensitivity to measure the anomalous triple-gauge-boson couplings. One of the main goals in studying di-boson final states is to pave the way to search for the Higgs boson and Supersymmetry particles that involve di-bosons in final states. For ATLAS di-boson physics studies, I demonstrated that BDT works very reliably to improve the signal to background ratio by at least a factor of two compared to a cut-based analysis (ATL-COM-PHYS-2008-036, ATL-COM-PHYS-2008-041).

The BDT PID technique I developed in the past five years has received considerable attention in high energy physics community. On-going experiments at the Tevatron and at SLAC have used it for physics analysis, and ATLAS physics groups are using

it for electron, tau and b-jet identifications. To me, BDT will be a powerful tool for new particle searches at the LHC particularly for Higgs and Supersymmetric particle searches. A recent study I have done has shown that ATLAS will have great discovery potential for SM Higgs decay to WW final states. If the Higgs mass is around 150 - 180 GeV, ATLAS could discover it within 10 fb^{-1} integrated luminosity. (ATL-COM-PHYS-2008-023).

Since the summer of 2008, I have led the effort to apply BDT for ATLAS electron identification. Electron identification based on BDT increases the electron efficiency from about 66% to 82% and reduces the faked electron from jets significantly. The electron identification based on BDT has been integrated into the ATLAS egamma reconstruction package and successfully tested. This is documented in my talk at the ATLAS performance and physics workshop on October 2, 2008.

(<http://indico.cern.ch/conferenceDisplay.py?confId=39296>)

• Search for Neutrino Oscillation in MiniBooNE Experiment at Fermilab

Since November, 2003, I have been involved in particle identification (PID) for the MiniBooNE experiment at the Fermi National Accelerator Laboratory which is designed to confirm or refute the evidence for $\nu_\mu \rightarrow \nu_e$ oscillations at $\Delta m^2 \sim 1 \text{ eV}^2/c^4$ seen by the LSND experiment. It is a crucial experiment which would imply new physics beyond the standard model if the LSND signal were confirmed. Together with Prof. Ji Zhu (Department of Statistics) and Prof. Byron P. Roe, I combined boosting algorithms with decision trees to build Boosted Decision Trees (BDT) and applied the BDT technique to the MiniBooNE PID to classify the events. We demonstrated that PID with the BDT is 20% to 80% better than that with our standard artificial neural network(ANN) PID technique. As far as we know, it was the first time the BDT has been applied to a particle physics experiment (Nucl. Instrum. & Meth. A 543:577-584, 2005). We also made comprehensive studies of BDT with various boosting algorithms for MiniBooNE particle identification (Nucl. Instrum. & Meth. A555:370-385, 2005), and studies of stability and robustness for ANN and BDT (Nucl. Instrum. & Meth. A574:342-349, 2007).

I have played a leading role in developing and maintaining the Boosting PID for the MiniBooNE data analysis since 2004. I uncovered the “dirt events”, background from secondary particles which are produced from neutrino interactions in the matter surrounding the detector. The discover of this background have significant impact on the $\nu_\mu \rightarrow \nu_e$ oscillation search, especially in the low energy region (BooNE-TN180,TN197,TN203). I proved that the excess of low energy events in MiniBooNE data does not come from dirt events.

On April 11, 2007, MiniBooNE announced the first $\nu_\mu \rightarrow \nu_e$ oscillation search results at Fermilab; there is no evidence for $\nu_\mu \rightarrow \nu_e$ oscillation (Phys.Rev.Lett.98:231801,2007).

I have been the PI of a DOE/LANL subcontract grant for the work on MiniBooNE event reconstruction, particle identification and neutrino oscillation analysis at the University of Michigan from 2005 - 2008. The total grant for FY05-FY08 was \$135K.

• Development of An Advanced Pattern Recognition Technique - Boosted Decision Trees

The new physics search sensitivities for high energy experiments would highly depend on the applications of advanced physics analysis methods once the detectors were built and fully functional. During my career development in experimental high energy physics field in the past decade, I have paid considerable attention to develop and apply the advanced data analysis tools such as probability density function, maximum likelihood, artificial neural networks in physics analysis to optimize the reaches of physics sensitivities for the experiments. My great effort in this regard has worked quite successfully and resulted in some important publications about search for SM Higgs, MSSM Higgs, Single W production, tau hadronic decay branching ratio measurement etc using L3 data.

Starting from 2004, together with Professor Roe and Professor Zhu, I have developed a new advanced analysis method, *boosted-decision-trees (BDT)* to improve the electron/pion separation for the MiniBooNE experiment. We demonstrated that BDT works significantly better than the well-known PID technique - the artificial neural networks in MiniBooNE.

The Boosted Decision Trees has two major components, decision trees and boosting algorithms. Decision trees were invented by L. Breiman etc. in 1984, they are known to be powerful but unstable, i.e., a small change in the training sample can give a large change in the tree and the results. The first boosting algorithm, Adaboost, was invented by Y. Freund etc. in 1996, it is one of the most powerful learning techniques introduced during the last decade. The boosting algorithm is a procedure that combines many “weak” classifiers to achieve a final powerful classifier. Boosting can be applied to any classification method.

Our major contribution in developing this technique is to combine decision trees and suitable boosting algorithms in particle identifications for high energy physics experiments. we successfully applied BDT technique for MiniBooNE data analysis (Nucl. Instrum. & Meth. A 543:577-584, 2005, Nucl. Instrum. & Meth. A555:370-385, 2005, Nucl. Instrum. & Meth. A574:342-349, 2007). I was invited to many meetings to describe this new method for high energy physics data analysis.

During the past three years, I intensively worked on LHC physics studies, the new development I made for LHC physics analysis is the event reweighting technique, which provides unbiased training for multivariate analysis methods (ANN and BDT). Furthermore, this technique can be used to significantly improve the separation of signal from background. This work has been documented in the paper (JINST 3 P04004 (2008), arXiv:0708.3635).

The BDT PID technique I developed in the past five years has received considerable attention in high energy physics community. On-going experiments at the Tevatron (single top event discovery) and at SLAC (Barbar experiment) have used it for physics analysis. ATLAS physics groups are using this technique for electron, tau and b-jet identifications and many physics analyses. We feel confident that BDT will be a powerful analysis tool for new particle searches at the LHC, particularly for Higgs and Supersymmetric particle searches etc.

• R&D of International Linear Collider

I have spent part-time working on the next generation e^+e^- Linear Collider (ILC) detector project with Prof. Riles since August, 2000. Our specific interests include physics and detector simulations for measurement of Higgs and Supersymmetric particle properties, for optimization of the tracking system (physics/0506198, eConf C010630:E3040, 2001, eConf C010630:P112, 2001) and for the design of a high-precision optical alignment system using Frequency Scanned Interferometry (FSI) for the ILC silicon tracker detector (Nucl. Instrum. & Meth. A 575:395-401,2007, physics/0506197, physics/0609187). The center-of-mass energies of the ILC will range from 350 GeV to 1000 GeV, enabling precise standard model measurements and studies of new particles which may include the Higgs bosons and supersymmetric particles.

Our group has constructed several demonstration Frequency Scanned Interferometer systems with the laser light transported by air or single-mode optical fiber, using single-laser and dual-laser scanning techniques for initial feasibility studies. Absolute distance was determined by counting the interference fringes produced while scanning the laser frequency. Two multiple-distance-measurement analysis techniques were developed to improve distance precision and to extract the amplitude and frequency of vibrations. In our recent studies, we combined our multi-distance-measurement analysis technique with the dual-laser scanning technique to improve the absolute distance measurement precision. The multi-distance-measurement technique is effective in reducing uncertainties from vibration effects and interference fringe determination, while the dual-laser scanning allows for cancellation of drift errors. A precision better than 0.2 microns was achieved for a distance of 0.41 meters under realistic conditions (Nucl. Instrum & Meth. A,575:395-401, 2007, Applied Optics, Vol.44:3937,2005).

With a precision that exceeds detector alignment requirements (~ 1 micron), this achievement confirms that the FSI technique is promising for the ILC detector alignment. This work was reported by ILC Newslines on April 6, 2006. (<http://www.linearcollider.org/newsline/archive/2006/20060406.html>)

• Future Research Interest

Based on research experience and background, my future research interest will be in areas of LHC physics and detector R&D for LHC upgrade and for ILC.

The LHC is scheduled to start operation for data taking in 2009. It is very exciting to do the LHC experiments which are expected to make revolutionary discoveries at the energy frontier that the most powerful collider can reach in this decade. With my intensive data analysis experience in high energy experiments I am confident that I can play a leading role in LHC physics analysis for new physics discoveries. In addition I also committed myself to contribute to the LHC detector upgrade efforts.

Once we make discoveries at the LHC, such as Higgs, Supersymmetric particles and so on, we will continue to make much deeper and more comprehensive studies of new physics with the ILC. For this reason, I would like to continue my efforts on the ILC physics and detector R&D in the coming years towards the construction and operation of the Linear Collider.

• Education - Teaching and Mentoring

To date my primary position has been fully research related and therefore I have no teaching responsibilities. However, I have served as mentor or help Professors to supervise some students in their research activities. The names of the students are listed below:

| | |
|-------------|--|
| 2008 - now | Alan Wilson, Ph.D student for ATLAS physics analysis |
| 2008 summer | Derek Moree, REU student for ATLAS tau ID |
| 2007 - now | Xuefei Li, Ph.D student for ATLAS electron ID |
| 2007 - 2008 | Alexander Harvey Nitz, undergraduate student for ILC |
| 2006 - 2008 | Eui-Min Jung, undergraduate student for ILC |
| 2006 summer | Ian Gallagher, undergraduate student for MiniBooNE |
| 2005 summer | Robert Hensley, REU student for MiniBooNE |
| 2004 summer | Laura Gladstone, REU student for MiniBooNE |
| 2003 - 2004 | Jason Deibel, graduate student for ILC |
| 2003 - 2005 | Sven Nyberg, undergraduate student for ILC |
| 2000 - 2001 | Ross Berbeco, Ph.D student for L3 Higgs Search |
| 2000 - 2001 | Jin Yamamoto, Ph.D student for L3 Higgs Search |

References:

- Prof. Bing Zhou, University of Michigan, 1-734-647-3760, bzhou@umich.edu
- Prof. Keith Riles, University of Michigan, 1-734-764-4652, kriles@umich.edu,
- Prof. Byron P. Roe, University of Michigan, 1-734-764-4441, byronroe@umich.edu
- Dr. William C. Louis, Los Alamos National Laboratory, 1-505-667-6723, louis@lanl.gov
- Dr. Richard Van De Water, Los Alamos National Laboratory, 1-630-840-2159, vdwater@fnal.gov