Joshua Isaacson

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Research Interests: Lepton-Nucleus Interactions, Perturbative QCD,
Resummation, Precision Physics, Collider Phenomenology
Monte Carlo Event Generators, Machine Learning, Algorithmic Development

Education

Michigan State University, East Lansing, MI

Doctor of Philosophy, Physics, Fall 2017

- Thesis Topic: *Precision Resummation for the LHC Era*
- Advisors: C.-P. Yuan and Carl Schmidt

Master of Physics, Summer 2013

Case Western Reserve University, Cleveland, OH

B.S., Physics, *Cum Laude*, May 2011

Research Experience

Application Physicist I, August 2022 to present
Fermi National Accelerator Laboratory

Postdoctoral Researcher, October 2017 to July 2022
Fermi National Accelerator Laboratory

Research Assistant, September 2013 to September 2017
Department of Physics and Astronomy,
Michigan State University

Grants and Awards

SciDAC 5 Grant:
Next Generation Precision for Neutrino and Collider Computations
Key Contributor

Textbooks

1. **Quantum Computing for the Quantum Curious**
   C. Hughes, J. Isaacson, A. Perry, R. Sun, J. Turner
   Springer Nature (2021)

Publications

1. **"Event generation with Sherpa 3"**
   E. Bothmann, *et. al.*
   arxiv:2410.22148

2. **"Final-state interactions in neutrino-induced proton knockout from argon in MicroBooNE"**
   A. Nikolakopoulos, *et. al.*
   Accepted by PRC (arxiv:2406.09244)

3. **"Improving resbos for the precision needs of the LHC"**
   J. Isaacson, Y. Fu, C.-P. Yuan
   Phys. Rev. D 110 (2024) 7, 073002

4. **"A Portable Parton-Level Event Generator for the High-Luminosity LHC"**
   E. Bothmann, T. Childers, W. Giele, S. Höche, J. Isaacson, M. Knobbe
   SciPost Phys. 17 (2024) 081

5. **"Shedding light on the MiniBoone Excess with Searches at the LHC"**
   C. Herwig, J. Isaacson, B. Jayatilaka, P. A. N. Machado, A. Reinsvold Hall, M. Safdari
   Phys. Rev. D 109 (2024) 7, 075049

6. **"NuHepMC: A standardized event record format for neutrino event generators"**
   S. Gardiner, J. Isaacson, L. Pickering
   Submitted to SciPost Codebases (arxiv:2310.13211)

7. **"Efficient precision simulation of processes with many-jet final states at the LHC"**
   E. Bothmann, *et al.*
   Phys. Ref. D 109 (2024) 1, 014013

8. **"UFO 2.0 – The Universal Feynman Output Format"**
   L. Darmé, *et al.*
   Eur. Phys. J. C83 (2023) 7, 631

9. **"Tau Polarization and Correlated Decays in Neutrino Experiments"**
   J. Isaacson, S. Höche, F. Siegert, and S. Wang
   Phys. Rev. D 108 (2023) 9, 093004

10. **"Efficient phase-space generation for hadron collider event simulation"**
    E. Bothmann, T. Childers, W. Giele, F. Herren, S. Höche, J. Isaacson, M. Knobbe, and R. Wang
    SciPost Phys. 15 (2023) 169

11. **"MadNIS – Neural Multi-Channel Importance Sampling"**
    T. Heimel, R. Winterhalder, A. Butter, J. Isaacson, C. Krause, F. Maltoni, O. Mattelaer, T. Plehn
    SciPost Phys. 15 (2023) 141

12. **"Precision QCD, Hadronic Structure & Forward QCD, Heavy Ions: Report of Energy Frontier Topical Groups 5, 6, 7 submitted to Snowmass 2021"**
    M. Begel, *et al.*
    arxiv:2209.14872

13. **"Theory of Neutrino Physics – Snowmass TF11 (aka NF08) Topical Group Report"**
    A. de Gouvêa, *et al.*
    arxiv:2209.07983

14. **"Dark Sector Studies with Neutrino Beams"**
    B. Batell, *et al.*
    2022 Snowmass Summer Study (arxiv:2207.06898)

15. **"Introducing a novel event generator for electron-nucleus and neutrino-nucleus scattering"**
    J. Isaacson, W. Jay, A. Lovato, P. Machado, N. Rocco
    Phys.Rev.D 207 (2023) 3, 033007

16. **"ResBos2 and the CDF W Mass Measurement"**
    J. Isaacson, Y. Fu, C.-P. Yuan
    Accepted by PRD (arxiv:2205.02788)

17. **"Event Generators for High-Energy Physics Experiments"**
J.M. Cambell, *et al.*
SciPost Phys. 16 (2024) 5, 130
2022 Snowmass Summer Study

18. **"Theoretical tools for neutrino scattering: interplay between lattice QCD, EFTs, nuclear physics, phenomenology, and neutrino event generators"**
L. Alvarez Ruso, *et al.*
2022 Snowmass Summer Study (arxiv:2203.09030)

19. **"Electron Scattering and Neutrino Physics"**
A. Ankowski, *et al.*
J.Phys.G 50 (2023) 12, 120501
2022 Snowmass Summer Study

20. **"Machine Learning and LHC Event Generation"**
A. Butter, *et al.*
SciPost Phys. 14 (2023) 4, 079
2022 Snowmass Summer Study

21. **"Generators and the (Accelerated) Future"**
J. Isaacson
J.Phys.Conf.Ser. 2438 (2023) 1, 012001

22. **"Novel event generator for the automated simulation of neutrino scattering"**
J. Isaacson, S. Höche, D. Lopez-Gutierrez, N. Rocco
Phys.Rev.D 105 (2022) 9, 096006

23. **"Classifying Anomalies Through Outer Denisty Estimation (CATHODE)"**
A. Hallin, J. Isaacson, G. Kasieczka, C. Krause, B. Nachman, T. Quadfasel, M. Schlaffer, D. Shih, M. Sommerhalder
Phys.Rev.D 106 (2022) 5, 055006

24. **"Many-gluon tree amplitudes on modern GPUs: A case study for novel event generators"**
E. Bothmann, W. Giele, S. Höche, J. Isaacson, M. Knobbe
SciPost Phys. Codebases 3 (2022)

25. **"Beyond 4D Tracking: Using Cluster Shapes for Track Seeding"**
P. Fox, S. Huang, J. Isaacson, X. Ju, B. Nachman
JINST 16 (2021) 05, P05001

26. **"Summary of Workshop on Common Neutrino Event Generator Tools"**
J. Barrow *et al.*.
arXiv:2008.06566 [hep-ex]

27. **"A quantum Monte Carlo based approach to intranuclear cascades"**
J. Isaacson, W. Jay, A. Lovato, P. Machado, and N. Rocco
Phys. Rev. C 103 (2021) 1, 015502

28. **"Teaching Quantum Computing to High School Students"**
C. Hughes, J. Isaacson, A. Perry, R. Sun, and J. Turner
Phys. Teacher 60 (2022) 187-1989

29. **"Event Generation with Normalizing Flows"**
C. Gao, S. Höche, J. Isaacson, C. Krause, and H. Schulz
Phys. Rev. D **101** (2020) 7,076002

30. **"i-flow: High-Dimensional Integration and Sampling with Normalizing Flows"**
C. Gao, J. Isaacson and C. Krause
Mach.Learn.Sci.Tech. 1 (2020) 4, 045023

31. **"A study of the role of the PDF uncertainty on the LHC W-boson mass measurement"**
M. Hussein, J. Isaacson and J. Huston,
J. Phys. G **46**, no. 9, 095002 (2019)

32. **"Ultraheavy resonances at the LHC: beyond the QCD background"**
B. A. Dobrescu, R. M. Harris and J. Isaacson.
arXiv:1810.09429 [hep-ph]

33. **"New method for reducing parton distribution function uncertainties in the high-mass Drell-Yan spectrum"**
C. Willis, R. Brock, D. Hayden, T. J. Hou, J. Isaacson, C. Schmidt and C. P. Yuan.
Phys. Rev. D **99**, no. 5, 054004 (2019)

34. **"Stochastically sampling color configurations"**
J. Isaacson and S. Prestel.
Phys. Rev. D **99**, no. 1, 014021 (2019)

35. **"R_K anomalies and simplified limits on Z' models at the LHC"**
R. S. Chivukula, J. Isaacson, K. A. Mohan, D. Sengupta and E. H. Simmons.
Phys. Rev. D **96**, no. 7, 075012 (2017)

36. **"Minimal Dilaton Model and the Diphoton Excess"**
B. Agarwal, J. Isaacson and K. A. Mohan.
Phys. Rev. D **94**, no. 3, 035027 (2016)

37. **"Implications of CMS analysis of photon-photon interactions for photon PDFs"**
P. Obul, M. Ababekri, S. Dulat, J. Isaacson, C. Schmidt and C.-P. Yuan.
Chin. Phys. C **42**, no. 11, 113101 (2018)

38. **"Resummation of High Order Corrections in Higgs Boson Plus Jet Production at the LHC"**
P. Sun, J. Isaacson, C.-P. Yuan and F. Yuan.
Phys. Lett. B **769**, 57 (2017)

39. **"Factorization for substructures of boosted Higgs jets"**
J. Isaacson, H. n. Li, Z. Li and C.-P. Yuan.
Phys. Lett. B **771**, 619 (2017)

40. **"Nonperturbative functions for SIDIS and DrellYan processes"**
P. Sun, J. Isaacson, C.-P. Yuan and F. Yuan.
Int. J. Mod. Phys. A **33**, no. 11, 1841006 (2018)

Selected Conference Talks and Invited Seminars

- NuSTEC Cross Experiment Working Group Seminar, 3 October 2024,
  Title: Current Status of the Achilles Event Generator
- 25th International Workshop on Neutrinos from Accelerators, 17 September 2024,
  Title: *Achilles*
- LoopFest 2024, 22 May 2024,
  Title: *Towards Precision Calculations on Modern Computers*
- 14th International Conference on Neutrino-Nucleus Interactions, 15 April 2024,
  Title: *Achilles*

- Michigan State University HEP Seminar, 6 February 2024,
  Title: *Achieving Fast & Precise Theory Predictions for Collider Experiments*
- TAU2023, 7 December 2023,
  Title: *Tau Polarization and Correlated Decays in Neutrino Experiments*
- Argonne Mini-Workshop on Monte Carlo Methods, 18 May 2023,
  Title: *Monte Carlo for Theory and Event Generation in HEP*
- PITT PACC: Nu Tools for BSM at Neutrino Beam Facilities, 16 December 2022,
  Title: *Achilles: The BSM Pipeline*
- CTEQ Fall Meeting, 15 November 2022,
  Title: *Neutrino Event Generation*
- Wichita State University Seminar, 19 October 2023,
  Title: *Accelerating Event Generation*
- MSU & FRIB Theory Seminar, 4 October 2022,
  Title: *Achilles: A Modern Theorist-Driven Event Generator*
- Snowmass, 22 July 2022,
  Title: *Theory Perspectives on the W Mass*
- Snowmass, 18-19 July 2022,
  Titles: *Physics Generators*, *Event Generator for the LHC*
- LBNL Seminar, 6 July 2022,
  Title: *How to measure the W Mass: A Theory Perspective*
- KIAS: W Mass Workshop, 24 June 2022,
  Title: *How to measure the W Mass: A Theory Perspective*
- Neutrino Theory Network Workshop, 21 June 2022,
  Title: *Achilles: A Modern Theorist-Driven Event Generator*
- NuSTEC Cross Theory and Generators Working Group Seminar, 7 June 2022,
  Title: *Achilles: A Modern Theorist-Driven Event Generator*
- CERN Theory Seminar, 23 May 2022,
  Title: *How to measure the W Mass: A Theory Perspective*
- KEK Workshop: Precision Measurement of W boson mass, 10 May 2022,
  Title: *How to measure the W Mass: A Theory Perspective*
- Seminar at Rutgers University, 19 April 2022,
  Title: *How to measure the W Mass: A Theory Perspective*
- LPC Physics Forum, 14 April 2022,
  Title: *W Mass: A Theory Overview*
- Plenary at ACAT2021, 2 December 2021,
  Title: *Generators and the (Accelerated) Future*
- ML4Jets 2021, 7 July 2021,
  Title: *Matrix Element Calculations on the GPU*
- Theory Seminar, SLAC, 3 February 2021,
  Title: *Teaching a Computer to Integrate*
- PIKIMO 9, 24 October, 2020
  University of Kentucky, Lexington, KY,
  Title: *A quantum Monte Carlo based approach to intranuclear cascades*
- New Perspectives 2020, 20 July 2020,
  Fermi National Accelerator Laboratory, Batavia, IL,
  Title: *Event Generation with GPUs*
- LPC talk, 29 October 2019,
  Fermi National Accelerator Laboratory, Batavia, IL,
  Title: *Teaching a Computer to Integrate*
- Theory Seminar, Argonne National Laboratory, 13 February 2019,
  Title: *Effects of Subleading Color on Parton Showers*
- Theory Seminar, Monash University, 4 October 2018,
  Title: *Steps Toward a Full Color Parton Shower*
- Talk at Loop Fest 2018, 19 July 2018,

Michigan State University, East Lansing, MI,
Title: *Full Color Parton Showers*

- Talk at Parton Showers, Event Generators, and Resummation 2018, 4 June 2018, Department of Theoretical Physics and Astronomy, Lund University, Lund, Sweden, Title: *ResBos2 and Full Color Parton Showers*
- Seminar at Particle Theory Group, University of Buffalo, 7 March 2017, Title: *ResBos2*
- Seminar at Particle Theory Group, University of California, December 7, 2016, Irvine, CA, Title: *ResBos2*
- Advances in QCD and Applications to Hadron Colliders, October 28, 2016, Argonne National Lab, IL, Title: *ResBos2 for Drell-Yan and Higgs Boson productions*

Teaching Experience

Undergraduate Senior Thesis Co-Advisor:

- Automatic leptonic tensor generation for Beyond the Standard Model (BSM) theories
  Diego Lopeze Gutierrez, Macalester College Honors Program 2020-2021
- Tau Decay limits at DUNE
  Sherry Wang, Northwestern University 2023-2024

CTEQ Summer School: Summer 2022
Lecturer: 2 lectures on machine learning
Tutorial Leader: 2 tutorials on machine learning in HEP
https://indico.cern.ch/event/1131319/

Quantum Computing Internship for Physics Undergraduates: Summer 2022
Lecturer: 2 lectures on single-qubit gates
https://indico.fnal.gov/event/54760/

Quantum Computing Internship for Physics Undergraduates: Summer 2021
Lecturer: 3 lectures on single-qubit gates
https://indico.fnal.gov/event/49675/

TARGET Co-Mentor: Summer 2021
https://diversity.fnal.gov/target/

SULI Mentor: Summer 2021, Summer 2022
https://internships.fnal.gov/science-undergraduate-laboratory-internship-suli/

SIST Mentor: Summer 2020, Summer 2021, Summer 2022
https://diversity.fnal.gov/sist/

Teaching Assistant (Graduate Courses) at Michigan State University
PHYS851: Quantum Mechanics: Fall 2013

Teaching Assistant (Undergraduate Courses) at Michigan State University
ISP205L: Visions of the Universe Lab: Fall 2011, Spring 2012, Fall 2012, Spring 2012
PHYS251/252: Intro Physics Lab: Summer 2012, Summer 2013
PHYS215: Thermodynamics & Modern Physics: Fall 2013

Supplemental Instructor at Case Western Reserve University
PHYS102: Electricity and Magnetism: Fall 2010, Spring 2011

Service

Local Organizer: TOP2023,
Organizer: Workshop on Neutrino Event Generators March 2023,
Organizer: Labwide AI-Meetings, Oct. 2022 - Oct. 2023
Organizer: Fermilab Joint Neutrino Theory-Experiment Group,
August 2021 to present
HEP Funding Outreach to Congress, 2020-2022
Organizer: LoopFest XVIII, 12-14 August 2019
Organizer: Next steps in Quantum Science for HEP, 12-14 September 2018
Theory Seminar Organizer: August 2018 to August 2020

References

C.-P. Yuan
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Michigan State University
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E-mail: yuanch@msu.edu

Matthew Toups
Scientist
Neutrino Division
Fermi National Accelerator Laboratory
Phone: (630) 840-4492
E-mail: toups@fnal.gov

Stefan Höche
Senior Scientist
Theoretical Physics Division
Fermi National Accelerator Laboratory
Phone: (630) 840-3866
E-mail: shoeche@fnal.gov

Alessandro Lovato
Physicist
Physics Division
Argonne National Laboratory
Phone: (630) 252-3626
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Frank Siegert
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Institute of Nuclear and Particle Physics
TU Dresden
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Fermi National Accelerator Laboratory
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